Final Report
Site OK4A
Pork Production Facility

for the

NATIONAL AIR EMISSIONS MONITORING STUDY

to

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Contents

1 Overview 6
1.1 Introduction 6
1.2 Procedures 6
1.3 Farm description and operation 8
1.4 Operational events and changes 10
1.5 Measurement layout 10
2 Monitoring activities 13
2.1 Measurement periods 13
2.2 Site visits 13
2.3 Instrumentation QA/QC 13
2.4 Audits 14
2.5 Repair trips 14
2.6 Remote site checks 14
2.7 Measurement data acquisition 14
3 Data Processing and analysis 16
3.1 QA/QC software procedures 17
3.2 Data exclusions 18
3.3 Data correction procedures 20
3.4 Data validation procedures 20
3.4.1 NH_3 concentration measurements 20
3.4.2 H_2S concentration measurements 22
3.4.3 S-OPS sampling 22
3.4.4 Wind component measurements 22
3.5 Emission calculations 22
3.5.1 NH_3 emissions by RPM 22
3.5.2 NH_3 emissions by bLS 23
3.5.3 Validation of bLS emissions model 23
3.5.4 H_2S emissions by Ratiometric 24
3.5.5 H_2S emissions by bLS 24

4 Results ... 25
4.1 Farm activity ... 25
4.2 Weather conditions ... 25
4.2.1 Synoptic weather events ... 25
4.2.2 Variation in barometric pressure, solar radiation, air temperature and wetness ... 26
4.2.3 Variation in air temperature and relative humidity ... 26
4.2.4 Wind conditions ... 27
4.3 Lagoon conditions ... 31
4.3.1 Lagoon appearance, liquid depth and sludge depth ... 31
4.3.2 Temperature, pH and oxidation-reduction potential ... 32
4.3.3 Lagoon Chemistry ... 33
4.4 Emissions measurements ... 33
4.4.1 NH_3 Emissions ... 33
4.4.2 H_2S Emissions ... 38
4.4.3 Estimation of emission measurement errors ... 41
5 References ... 43
6 Appendices ... 45
6.1 TDLAS NH_3 calibrations ... 45
6.2 TEC 450i analyzer H_2S calibrations ... 63
6.3 Sonic anemometer calibrations ... 68
6.4 pH probe calibrations ... 80
6.5 ORP probe calibrations ... 84
6.6 S-OPS operational checks ... 88
6.7 Miscellaneous meteorological and lagoon calibrations ... 94
6.7.1 Air temperature/ humidity ... 94
6.7.2 Barometric pressure ... 95
6.7.3 Solar radiation ... 95
6.7.4 Lagoon water temperature ... 96
6.7.5 Sludge gun ... 96
6.7.6 CR1000 data logger ... 97
6.7.7 CR800 data logger ... 100

6.8 Site Activity 101

6.9 Site weather 117

6.10 Daily weather conditions 145

6.11 Daily lagoon conditions 150

6.12 Daily site emissions and data completeness 155

6.12.1 Daily NH_3 emission using RPM emissions model 155

6.12.2 Daily NH_3 emission using bLS emissions model 161

6.12.3 Daily H_2S emission using Ratiometric emissions model 166

6.12.4 Daily H_2S emission using bLS emissions model 169

1 Overview

1.1 Introduction

The primary goals of the National Air Emissions Monitoring Study (NAEMS) were to: 1) quantify aerial pollutant emissions from dairy, pork, egg, and broiler production facilities, 2) provide reliable data for developing and validating emissions models for livestock and poultry production and for comparison with government regulatory thresholds, and 3) promote a national consensus on methods and procedures for measuring emissions from livestock operations. NAEMS consists of two components: a barn component and an open source component. Open source emissions measurements were conducted at a total of 10 different farms in the continental US. Farms chosen for monitoring were selected based on location (relative to climate and typical practice), method of manure collection, method of manure storage, and physical configuration of the buildings and lagoons/ basins relative to the surrounding terrain.

The NAEMS was managed by Purdue University, in its role as Independent Research Contractor (IRC) to the Agricultural Air Research Council (AARC). The Purdue Applied Meteorology Laboratory (PAML) maintained and calibrated equipment, collected samples, conducted all other on-site activities, and analyzed the data for all open sources.

The objective of this report is to present the quality-assured measurements of ammonia (NH_3) and hydrogen sulfide (H_2S) emissions from the waste lagoon open source at the western hog finisher facility. Within that objective, this report will:

- Describe the farm and the lagoon/basin monitored for the NAEMS
- Describe the monitoring methods and quality assurance
- Present tabulated daily averages of emissions

1.2 Procedures

To meet these objectives, gaseous emissions of NH_3 and H_2S from open sources were measured at a number of farm operations with a range of characteristics. Emissions were measured at a total of 10 farms over the course of two and one-half years.

The emissions from the lagoon were measured to determine the variation in emissions with time of year, stability of the atmosphere, and facility operation. Emissions were measured using models that rely on concentration and wind flow measurements. Lagoon emissions were measured for up to 21 days (d) each season over two years. The duration of measurement periods designated ‘up to 21 d’ depends on the weather conditions during the 21-d interval for measurement. The DQO for completeness stipulates a 75% completeness of 10 d per quarter. Setting aside 21 d per quarter to acquire at least 7.5 d of valid data (75% of 10 d) minimized the risk of not meeting this completeness DQO due to instrumentation problems associated with unfavorable weather conditions.

Atmospheric concentrations of NH_3 around the lagoon were measured using narrow-bandwidth open path tunable-diode laser absorption spectroscopy (TDLAS). Atmospheric measurements of H_2S concentrations were made using pulsed fluorescence (PF) technology from air collected from 50 m synthetic open path systems (S-OPS) and sampled from a gas sampling system (GSS) that drew the air through the S-OPS. Emissions of NH_3 were determined from the difference in upwind and downwind concentration measurements from the TDLAS open path systems using two emissions models: a Gaussian plume fit model (Radial Plume Mapping: *RPM*; Arcadis Inc, Denver, CO) and a backward Lagrangian Stochastic (bLS) model (*Windtrax*; Thunder Beach Scientific, http://www.thunderbeachscientific.com). Emissions of H_2S were determined using the concentration measurements from the PF analyzer from air sampled by the air inlets of the S-OPS using two emissions models: a Ratiometric model using the ratio of these concentrations to NH_3 concentrations along the same path with the corresponding *RPM* NH_3 emissions measurement, and the bLS model. The critical measurements needed to make the emissions measurements are described in Table 1-1.

Measurements of the lagoon pH, oxidation-reduction potential, and temperature at 0.3 m depth were also measured from a float located at least 30 m from the lagoon inlet (Table 1-2). Measurements of the atmospheric temperature, relative humidity, barometric pressure, solar radiation and wetness were measured and recorded at an automated weather station established on the lagoon berm (Table 1-2).

Table 1-1: Critical measurements.

Measurement	Method/ Instrument	Required operating range	MDL	Minimum sample frequency	Final data-aggregation
NH_3	TDLAS/ Boreal Laser, Inc. GasFinder2™	1-800 ppb	5 ppm-m	1.2 s dwell	30 min & 24 h
H_2S	PF/Thermo Environmental 450i analyzer	1-800 ppb	2 ppb	60 s averaging	30 min & 24 h
Wind speed	3D Sonic anemometer/ RM Young 81000	0-60 ms^{-1}	0.01 ms^{-1}	160 Hz sampling/16 Hz averaging	30 min & 24 h
Wind direction	3D Sonic anemometer/ RM Young 81000	0^o -360^o	0.1^o	160 Hz sampling/16 Hz averaging	30 min & 24 h
3D turbulence wind components	3D Sonic anemometer/ RM Young 81000	0-40 ms^{-1}	0.01 ms^{-1}	160 Hz sampling/16 Hz averaging	30 min
Temperature variability	3D Sonic anemometer/ RM Young 81000	-50 to +50^{o}C	0.01^{o}C	160 Hz sampling/16 Hz averaging	30 min
GSS sample flow rate	GSS/S-OS	10 L min^{-1}	0.1 L min^{-1}	30 s	30 min
GSS sampling manifold pressure	GSS/SOP-S	±60,000 Pa	±500 Pa	30 s	30 min
NH_3 emissions	Radial Plume Mapping Model	N/A	N/A	30 min	30 min, 24 h
H_2S emissions	Backward Lagrangian Stochastic Model	N/A	N/A	30 min	30 min, 24 h
NH_3 emissions	Backward Lagrangian Stochastic Model	N/A	N/A	30 min	30 min, 24 h
H_2S emissions	Ratiometric to RPM Model	N/A	N/A	30 min	30 min, 24 h

All measurements from around the lagoon (TDLAS, barometric pressure, air temperature and relative humidity, wetness, solar radiation, lagoon pH, lagoon oxidation-reduction potential, lagoon temperature, and wind) were telemetered to an instrumentation trailer on site via radio communications. The instrumentation trailer also housed the GSS (with associated pressure, flow, temperature, and humidity measurements) and PF analyzer for the measurement of H_2S in the S-OPS collected air and two computers that controlled the two TDLAS scanners and collected measurements made by the two TDLAS units. All measurements were then stored on a computer in the trailer and downloaded daily by file transfer protocol (FTP) via the internet to a computer located at the PAML.

Additional information concerning farm operations and the United States Department of Agriculture National Resource Conservation Service (USDA NRCS)-required analysis of wastewater used to irrigate nearby fields were routinely collected from the producers.

Table 1-2: Non-critical measurements.

Measurement	Method/Instrument	Required operating range	MDL	Minimum sample frequency	Final data-aggregation
Ambient temperature	Thermistor/ Campbell Scientific Inc HMP45C (Vaisala)	-40 to 50°C	0.1°C	5 min	30 min, 24 h
Relative humidity	Hygrometer/ Campbell Scientific Inc HMP45C (Vaisala)	0-100%	5%	5 min	30 min, 24 h
Barometric pressure	Aneroid barometer/ Setra 278	600 to 1100 hPa	600 hPa	5 min	30 min, 24 h
Surface wetness	VAC resistance grid/ Campbell Scientific Inc.	(binary)	(binary)	5 min	30 min & 24 h
Solar radiation	Silicon pyranometer/ LiCOR 190SB	0- 1200 Wm^{-2}	10 Wm^{-2}	5 min	30 min & 24 h
Lagoon solids depth	Sludge level detector/ SludgeGun 10HD, Markland Specialty Eng.	0-10 m	0.05 m	1/ measurement period	1 time
Lagoon/ basin pH	Campbell Scientific Inc CSIM11 (Innovative Sensors, Inc)	0-14 units	0.2 unit	5 min	30 min & 24 h
Lagoon/ basin oxidation-reduction potential	Campbell Scientific Inc CSIM11-ORP (Innovative Sensors, Inc)	-800 - +1100 mV	20 mV	5 min	30 min & 24 h
Lagoon/ basin temperature	Thermistor/ Campbell Scientific Inc 107-L	-35 - +50°C	0.5°C	5 min	30 min & 24 h

1.3 Farm description and operation

The facility measured was a sow lagoon located in Oklahoma. The elevation at the farm was 905 m. The sow farm consists of three barns and one office (Fig. 1-1). The facility has a capacity of 1225 breeding and gestation sows in each of two breeding and gestation units, and 384 farrowing sows in one farrowing unit. Construction of the sow farm was completed in 1994.

Manure from the barns was transferred weekly from the two gestation units and every 2.5 weeks from the farrowing unit to the lagoon by pull plug and lagoon water recharge. Waste water from the two gestation units combined into one inlet (the southerly inlet in Fig. 1-1), while wastewater from the farrowing unit entered the lagoon from the northerly inlet (Fig. 1-1). The rectangular waste lagoon was located to the east and was separated by a drainage swale from the barns. The clay-lined lagoon was 119 m wide and 193 m long, and was oriented north-south. The lagoon bank was rocky with a berm slope of 4:1. Liquid depth was approximately 5.5 m, with an inner berm-to-water distance of 1.2 to 3 m. The lagoon volume was approximately 72,800 m^3. Sludge from the lagoon has not been removed since construction (20-yr sludge removal cycle).

Lagoon liquid analysis was contracted by the producer every year for all nitrogen components. Lagoon liquid was applied through center-pivot irrigation when liquid levels reached maximum lagoon capacity (minimum freeboard). Additional liquid analyses for all nitrogen compounds occurred at the time of field applications (0-2 times annually based on rainfall).

Figure 1-1: Configuration of the OK4A farm.

1.4 Operational events and changes

The producer modified the feed ratio during the study (Table 1-3).

Table 1-3: Operational changes during the study.

Period	Events during period
1: 6/27 - 8/29/2007	N/A
2: 11/6-28/2007	11/6 Gestation ration changed from milo to corn.
3: 11/28 - 12/19/2007	12/17 Gestation ration changed from corn to milo.
4: 4/22 - 5/6/2008	N/A
6: 9/30 - 10/15/2008	N/A
7: 1/7-27/2009	N/A
8: 4/1-21/2009	N/A
9: 6/22 - 7/14/2009	N/A

1.5 Measurement layout

The NH_3 emissions from the basin were monitored for 8 to 20 days each quarter of the year for two years using scanning Tunable Diode Laser Absorption Spectrometer (TDLAS) open-path instruments and 3-dimensional (3D) sonic anemometers, in conjunction with meteorological measurements and the radial plume mapping (*RPM*) and backward Lagrangian Stochastic (bLS) emissions models. The H_2S emissions from the lagoon were monitored using pulsed-florescence (PF) of air sampled through a Synthetic Open Path System (S-OPS) and 3-dimensional (3D) sonic anemometers, in conjunction with meteorological measurements and both the bLS emissions model and the *RPM* emissions model in combination with the ratiometric relationships of measured NH_3 and H_2S concentrations.

The path-integrated concentrations (PICs) of NH_3 were measured by TDLAS along optical paths defined by TDLAS/scanner systems and retro-reflectors. The scanning TDLAS instruments (TDLAS/scanner) were mounted at 1-m height above the lagoon berm (abl) at the northeast and southwest corners (Figure 1-2). Towers for mounting retro-reflectors were located off the northwest and southeast corners of the lagoon (Figure 1-2). A description of the position and path length of the optical paths along each side of the lagoon follows:

- North side: Retro-reflectors were located on anchored tripods at 1 m abl at distances of 44 m and 80 m from the northeast TDLAS/scanner. Three retro-reflectors were mounted on the northwest tower 125 m from the TDLAS/scanner at heights of 1 m, 7.3 m, and 14.7 m abl.
- East side: Retro-reflectors were located on anchored tripods at 1 m abl at distances of 66 m and 132 m from the northeast TDLAS/scanner. Three retro-reflectors were mounted on the southeast tower 209 m from the TDLAS/scanner at heights of 0.7 m, 7.8 m, and 13.5 m abl.
- South side: Retro-reflectors were located on anchored tripods at 1 m abl at distances of 54 m and 82 m from the southwest TDLAS/scanner. Three retro-reflectors were mounted on the southeast tower 131 m from the TDLAS/scanner at heights of 0.7 m, 7.8 m, and 13.5 m abl.

- West side: Retro-reflectors were located on anchored tripods at 1 m abl at distances of 66 m and 132 m from the southwest TDLAS/scanner. Three retro-reflectors were mounted on the northwest tower 210 m from the TDLAS/scanner at heights of 1 m, 7.3 m, and 14.7 m abl.

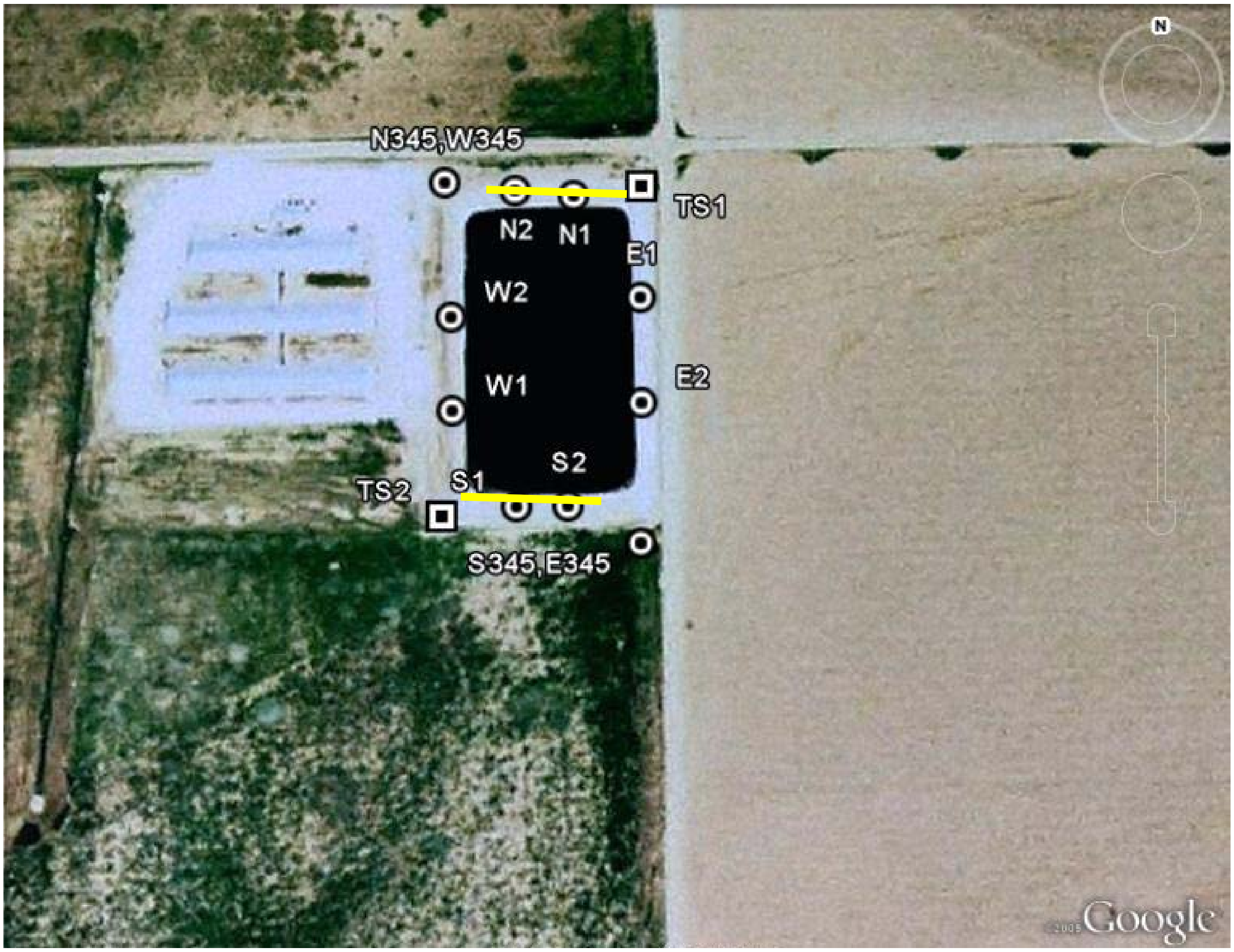

Figure 1-2: Locations of instrumentation around the lagoon under measurement.

Retro-reflectors are indicated according to side (north, south, east, and west) with 345 indicating the location of a tower. TDLAS/scanner locations are indicated by TS. The location of the two S-OPS is indicated by the solid yellow lines. The instrumentation trailer was located on the east side of the lagoon.

Two synthetic PICs of H_2S were measured by PF from air sampled from linear S-OPS positioned at 1-m abl. A 50-m length S-OPS path at 1 m abl. began at the northeast berm corner and extended west parallel to the north berm (Figure 1-2). The second 50-m long S-OPS was parallel to and 5 m south of the south lagoon berm and began at the southwest berm corner and extended to the east along the south berm (Figure 1-2). The flow through the S-OPS was maintained and sampled by a gas sampling system (GSS) located in the on-site instrumentation trailer. The temperature and humidity of the air flowing through the GSS, as well as the flow rate through and the suction in the negative-pressure portion of the GSS were measured and recorded on a data logger (Model CR800, Campbell Scientific, Logan, Utah).

Meteorological measurement sensors, including barometric pressure, air temperature and relative humidity, solar radiation, and surface wetness were located 5 m west of the NE berm corner, on the berm (Fig. 1-2). The data from these meteorological measurements were ~~collected by and also~~ telemetered to the on-site instrumentation trailer. The 3D sonic anemometers were located on the meteorological tower at 2.5 m heights and on the SE corner tower (Fig. 1-2) at 4.2 m and 15 m heights abl (Fig. 1-2).

The barns located 53 m to the west of and 1.2 m above the lagoon berm had a ridge height of 5.8 m agl. Therefore, the nearest building obstruction is 7 m above the berm, resulting in a fetch ratio to the west of 8:100. Fetch in all other directions is better than 1:100 (Fig. 1-2). Due to the proximity of the barns, emissions from wind direction of 225^{o} to 315^{o} were excluded from analysis.

Lagoon measurements (pH, oxidation-reduction potential, and temperature) were made from a float located in the NE corner of the lagoon.

2 Monitoring activities

2.1 Measurement periods

This location was measured as part of an approximately 20 d rotation between three other farms. The equipment was on site a total of 188 d over eight measurement periods (Table 2.1-1). Setup calibrations and site takedowns reduced the number of measurement days from the total number of days on site. NH_3 emissions were measured 181 d and H_2S emissions were measured 72 d.

Table 2.1-1: Period of measurements

Period	Start date	End date	# days
1	6/27/2007	8/29/2007	63
2	11/7/2007	11/27/2007	20
3	11/28/2007	12/18/2007	20
4	4/23/2008	5/6/2008	13
6	10/1/2008	10/15/2008	14
7	1/8/2009	1/27/2009	19
8	4/1/2009	4/21/2009	20
9	6/25/2009	7/14/2009	19

2.2 Site visits

The Field operation team visited this farm 38 d (Table 2.2-1). Visits to set up the site instrumentation and conduct calibration verification checks of instruments typically lasted 3 d, while visits for calibration verifications and take-down of the equipment on site typically lasted~~needed~~ 2 d.

Table 2.2-1: Dates of site visits

OK4A	Spring	Summer	Fall	Winter
2007		Jun 27,28 Jul 9,18,19,30,31 Aug 1,2,3,4,15,16,28,29	Nov 7,8,27,28	Dec 18,19
2008	Apr 23,24 May 6		Oct 1,2,14,15,	Jan 7,8,27
2009	Apr 1,2,21	Jun 23,24,25, Jul 14		

2.3 Instrumentation QA/QC

Calibration verification checks of the instruments making the critical measurements and some of the non-critical measurements most susceptible to deterioration were generally conducted within 21 d intervals on site. Instruments checked during these visits (with indication of Section documenting the instrument performance and calibration verification check results) included:

- GasFinder2™ NH3 TDLAS serial number (s/n) 1026, 1027, 1028, 1029, 1031 and 1032 (Section 6.1)
- TEC 450i H_2S Analyzer s/n 0733825128 (Section 6.2)
- RM Young 81000 3D sonic anemometers s/n 1920, 1921, 1927, 1928, 1932, 1936 and 1938 (Section 6.3)
- lagoon pH probes s/n 002, 0008, and 009 (Section 6.4)
- lagoon ORP probe s/n 020, 030 and 050 (Section 6.5)
- GSS/ S-OPS s/n 4-0017 (Section 6.6)

In addition, the instruments making the critical measurements were calibrated at least semi-annually. During the semi-annual calibrations, multipoint calibrations were conducted on the TDLAS (Section 6.1) and TEC 450i (Section 6.2) instruments and an inter-comparison conducted on the sonic anemometers (Section 6.3) with three unused 'standard' anemometers.

2.4 Audits

One internal audit was conducted at this location on 11/27/2007 with particular attention to documentation and sonic anemometer inter-comparison. There was an USEPA Technical Systems Audit on 6/25/2009 at this location.

2.5 Repair trips

Two repair trips were made to this location: 7/9/2007 and 7/18/2007.

2.6 Remote site checks

Over the course of measurements, there were 50 remote checks made through the computer for instruments operating at this location.

2.7 Measurement data acquisition

Data from the TDLAS units (Model GasFinder2™ NH3-OP, Boreal Laser Inc., Spruce Grove, Alberta, Canada) were acquired using the Boreal Laser *GasView MP* software (Boreal Laser Inc., Spruce Grove, Alberta, Canada) program running on laptops dedicated to this purpose (one laptop per TDLAS unit). The TDLAS units sent back data through 2.4 GHz wireless modems about every 1.2 s. This software also controlled the movements of the scanner (Model PTU-D300, Directed Perception Inc., Burlingame, CA) that aimed the TDLAS units.

Weather and lagoon data were saved to the internal memory of the data logger (Model CR1000, Campbell Scientific Inc, Logan, UT) at 5-min intervals. Optimally, these data were transferred to the trailer through 2.4 GHz wireless modem at intervals of 10 min using *Loggernet* software (Campbell Scientific Inc, Logan, UT). However, communications interference at a number of sites significantly impeded this regular data transfer. Thus, it was sometimes necessary to download data directly to a laptop during site visits. The data were then transferred from the laptop to the trailer computer using a USB thumb-drive. As a backup, all data were also stored on a compact flash memory card that was brought back to Purdue and downloaded after each period.

Data from the gas sampling system (GSS) were saved to a data logger (Model CR800, Campbell Scientific Inc, Logan, UT) located in the trailer at intervals of 30 s. These data included the line currently being sampled and the mass flow rate. The data were transferred through a serial cable to the trailer computer every 10 min using *Loggernet*.

Data from the H_2S analyzer (Model 450i, Thermo Fisher Scientific, Franklin, MA) were downloaded in real-time through a serial cable to the trailer computer using the *iPort* (Thermo Fisher Scientific, Franklin, MA) software program. The *iPort* software frequently disconnected from the analyzer, so that during our daily status checks from PAML it was frequently necessary to reconnect *iPort* to the analyzer, download data back to the time when *iPort* had crashed and stopped collecting data, and restart real-time data collection

Data from the 3D sonic anemometers (Model 81000, RM Young Inc., Traverse City, MI) were downloaded to the data acquisition computer in the trailer using custom built *Visual Basic* software. Binary data from up to four anemometers were transferred at 16 Hz through 900 MHz wireless modems to a single polling modem connected to the data acquisition computer in the trailer. The software time stamped and stored each 16 Hz data point and calculated 100-s and 300-s averages, variances, and covariances for each component of the wind and the sonic anemometer temperature.

Files were transferred from the instrument trailers to the PAML FTP server using the program *rsync* in the *cygwin* environment (open source programs). This transfer took place every six h, as long as the internet connection was available. The program was set up so that only new or modified files were transferred each time, so that only the updated data were transferred. A log of each file transferred was produced by the *rsync* program. The *rsync* program was used to transfer data daily from the PAML FTP server to the PAML data computer. This transfer was performed early each morning before the automated quality control software runs. Two copies of the data were stored on the Data computer. One copy was placed in the directory “FTP” and was never modified. This copy represents the original data as transferred from the trailers. The other copy of the data was placed in the directory “Data”. The data processing and quality control programs used this copy of the data, and modifications and corrections were made to this copy of the data as needed to allow the data to be processed. These modifications will be described below. It is important to note that no actual data numbers were changed during these modifications.

In addition to the copies of the data transferred over the internet, a copy of the data for each period was produced on a CD and DVD. To ensure complete and accurate data transfer, a data comparison program was used to compare the data on the CD/DVDs with the data in the “FTP” directory.

3 Data Processing and analysis

Before final data processing, the data files were examined to ensure that they were ready to be processed. Modifications to the files were required due to human error, issues related to changing from one site or period to another, and bugs in the data collection software. None of the actual data were modified in this file preparation, only filenames and/or the file in which the data appeared were changed. A detailed log was kept of each modification.

Deleting empty files: Data files created but not filled with data occurred as a byproduct of the data collection systems. The sonic anemometer data collection program was set up to start automatically when the trailer LAN server computer (hereafter termed LAN) was started. As a result, when the LAN was started at a new location empty files were often created because the sonic anemometers were not yet in place. If the location and/or period were not adjusted in the sonic anemometer parameter input file before the computer was shut down at the previous site, these empty files would be present in the directory from this previous location or period. These empty files contain no data and were deleted. Empty files also sometimes occurred for the TDLAS units if the TDLAS laptop was still logging but no data were being transferred from the TDL. These empty files were generally deleted, although they were sometimes retained since empty files can be handled by the data analysis and QC software. Even if deleted from the "data" directory, these empty files will still be present in the "FTP" directory, and in some cases these empty files will be useful in determining whether missing TDLAS data are due to problems with the TDLAS unit itself or with the TDLAS data collection laptop computer. Empty files in other data sets were also deleted.

Moving/deleting data from surrounding periods: When moving from one site to another or switching periods during a "back-to-back" site visit, several changes needed to be made for the data to be saved in the directories for the new site or period. If these changes were not made when the LAN was first started or before the computer was shut down at the preceding site , data for the new site was often saved in the directory for the preceding site. Data were moved from the file for one site to the file for the correct site. Data to be moved were identified by breaks in the data timestamps corresponding to the period when the equipment was shut down and in transit from one site to the next. Data were most often moved in the files for the CR1000 data logger and GSS (CR800 data logger), as these data files started adding new data immediately when the LAN was turned on, and it was easy to forget to immediately make the directory and file name change in *Loggernet*.

Combining data files: The *iPort* software that was used to collect data from the H_2S analyzer occasionally lost its connection with the analyzer and caused the data collection to stop. These events were noticed during the daily site checks from PAML at which time the missing data were filled from the internal memory on the analyzer and a new data file was started to collect the data in real-time. To allow the quality control software to run most efficiently, these multiple data files were combined into a single file at the conclusion of the period. The files that were included in this single file were placed in a subdirectory of the H_2S data folder named "Pieces". On isolated occasions, the CR1000-logged or CR800-logged data for a period were split into more than one file, and these data files were generally combined into a single file for the period, unless a change was made to the data stream in between the files (e.g. adding temperature and relative humidity probe to the gas sampling system output).

Renaming files: On some occasions, files had to be renamed due to human error in naming the files or, in the early days of the project, because of the lack of a finalized file structure in which the field operations staff had been trained. These changes were primarily to the TDLAS data files, when the files on the TDLAS laptops were not named appropriately or else TDLAS1 and TDLAS2 were reversed. Various files for other instruments also had to be renamed for a variety of reasons.

Data Processing and Quality Control Input Files: The data processing and quality control software programs require inputs that describe the data to be analyzed. The input parameters for a given site and period are in a single *Excel* workbook consisting of a separate worksheet for each component of the data processing software. These parameter files were produced and then independently double-checked for errors.

3.1 QA/QC software procedures

The valid data times were produced by examining the data in a preliminary run through the data and finding in the records the times when the instrument was calibrated and times when the instrument was known to be malfunctioning. The data excluded as being from a calibration or period of instrument malfunction were placed in separate columns in the output files and plotted in a different color on the output graphs.

Because measurements were acquired on various data acquisition systems, time synchronization of the various systems was critical. The time synchronization data were obtained from the remote site visits conducted as part of the daily status checks. Time corrections were only included if the instrument time was more than one minute off from the LAN. In the end, corrections were made only to the TEC 450i H_2S analyzer as this instrument would infrequently be out of sync by several minutes due to issues with its automatic time updates. The time synchronization is especially important for the TEC 450i because it samples from lines located on both sides of the lagoon and the time difference could lead to H_2S concentrations being recorded for the wrong S-OPS line (side of source).

One worksheet in the *Excel* parameter workbook for each site contains a list of the times of valid data for each data stream and one worksheet indicates when an instrument was out of time synchronization with the LAN as well as the time correction required to bring the data stream into time synchronization with the LAN.

Once the data files were prepared for final processing and the input parameter files were produced for each site and period, the data were processed through the custom designed software for this purpose. Through the duration of the project, each data stream was processed through a separate program, but in preparation for the final data processing these individual programs were combined into a single program to allow for more efficient data processing and easier debugging, as processes that were previously done multiple times in the earlier software versions are now done only once.

The order in which the various data streams were processed was determined by the dependencies in the data processing and quality control between the various instruments: a given data stream may depend on one or more of the preceding streams, but not on following data streams. For each data stream, the data were first loaded into arrays and any corrections for time synchronization applied. The flags were then assigned based on the QAPP. After this, the data exclusion times were applied and the data appropriately broken up into columns. Finally, the data were loaded into *Excel*, plots were produced, and the final data files were saved.

3.2 Data exclusions

Data were excluded from processing due to equipment and calibration failures, and because calibration checks were in progress. Periods of invalidated measurements associated with the calibration check failures are documented in the calibration reports in Section 6. Significant data exclusions of greater than one-day duration are indicated below by instrument with all time references in Coordinated Universal Time (UTC):

TDLAS measurement exclusions: Exclusions include problems with the TDLAS units and the scanners. Exclusions are summarized in Table 3.2-1.

Table 3.2-1: TDLAS measurement exclusions

Begin		End		Reason
8/1/2007	15:10	8/2/2007	17:00	TDLAS 1 Calibration Check
8/1/2007	15:05	8/2/2007	20:30	TDLAS 2 Calibration Check
8/3/2007	17:59	8/4/2007	06:00	Program glitch, data not saved TDLAS1
8/4/2007	17:59	8/5/2007	18:00	Program glitch, data not saved TDLAS1
8/6/2007	05:59	8/7/2007	06:01	Program glitch, data not saved TDLAS1
8/7/2007	17:59	8/8/2007	18:01	Program glitch, data not saved TDLAS1
8/10/2007	17:59	8/11/2007	18:00	Program glitch, data not saved TDLAS1
11/18/2007	23:58	11/22/2007	00:02	TDLAS 1 Concentration data shows a shutter problem
11/23/2007	23:59	11/27/2007	16:00	TDLAS 1 Concentration data shows a shutter problem
12/8/2007	21:00	12/18/2007	15:30	TDLAS 2 Scanner misaligned by 45 degrees
4/24/2008	21:00	5/6/2008	14:00	Scanner malfunction entire period for TDLAS2
1/8/2009	21:00	1/27/2009	17:00	Scanner malfunction entire period for TDLAS2

Air temperature and relative humidity measurement exclusions: Exclusions are summarized in Table 3.2-2

Table 3.2-2: Air temperature and relative humidity measurement exclusions

Begin		End		Reason
8/14/2007	13:10	8/15/2007	17:20	Calibration check
7/11/2009	17:25	7/14/2009	16:35	No power at meteorological station when FOS arrived

Solar radiation exclusions: Exclusions are summarized in Table 3.2-3

Table 3.2-3: Solar radiation measurement exclusions

Begin		End		Reason
8/14/2007	13:10	8/15/2007	17:20	Calibration check
7/11/2009	17:25	7/14/2009	16:35	No power at meteorological station when FOS arrived

Wetness measurement exclusions: The only exclusion was between 7/11/2009 at 17:25 and 7/14/2009 at 16:35 due to loss of power on site.

Pressure measurement exclusions: Exclusions are summarized in Table 3.2-4

Table 3.2-4: Pressure measurement exclusions

Begin		End		Reason for exclusion
11/7/2007	19:00	11/28/2007	15:50	Barometer was sent back for repairs. Not on site.
11/28/2007	15:55	12/19/2007	18:35	Barometer was sent back for repairs. Not on site.
7/11/2009	17:25	7/14/2009	16:35	No power at meteorological station when FOS arrived

Sonic anemometer measurement exclusions: Sonic anemometers experienced communications interference throughout the study. Excluded measurements are summarized in Table 3.2-5.

Table 3.2-5: Sonic anemometer measurement exclusions

Begin		End		Reason
8/14/2007	15:05	8/15/2007	14:05	Calibration check
7/24/2007	12:45	7/31/2007	19:55	All Sonic anemometers have no data for unknown reason
7/31/2007	21:20	8/1/2007	13:40	Calibration check
8/1/2007	14:25	8/3/2007	13:55	Zero check sonic anemometers not started until FOS left site 8/3
12/7/2007	22:30	12/10/2007	17:20	All Sonic anemometers entirely flagged; icing?
12/11/2007	13:45	12/12/2007	06:25	All Sonic anemometers entirely flagged; icing?
12/13/2007	09:05	12/13/2007	15:35	All Sonic anemometers entirely flagged; icing?
12/14/2007	15:25	12/15/2007	06:20	All Sonic anemometers entirely flagged; icing?
10/4/2008	18:00	10/15/2008	06:00	Sonic anemometer 1 has several episodes of extensive flagging
7/11/2009	17:25	7/14/2009	16:35	Power failure at farm stopped operation

Lagoon temperature, pH, and ORP measurement exclusions: Lagoon measurements were not made during the winter due to expected lagoon freezing before next 20 d visit. Rocks along the berm damaged the probe cables in 11-12/2007: all probes (pH, oxidation-reduction, T) were replaced. Excluded measurements are summarized in Table 3.2-6.

Table 3.2-6: Lagoon temperature, pH, and ORP measurement exclusions

Begin		End		Reason
Lagoon temperature exclusion times				
8/1/2007	15:45	8/3/2007	14:10	Wiring was switched for probes
8/14/2007	12:55	8/15/2007	17:20	Calibration check
11/28/2007	15:55	12/19/2007	18:35	Probes failed. Tried to repair on site, but this did not work. Float was taken out entire period.
10/8/2008	02:20	10/15/2008	16:25	Probes stopped working
1/8/2009	15:45	1/27/2009	22:05	Did not install for winter
7/11/2009	17:25	7/14/2009	16:35	No power at meteorological station when FOS arrived
Lagoon pH exclusion times				
8/1/2007	15:45	8/3/2007	14:10	Wiring was switched for probes
8/14/2007	12:55	8/15/2007	17:20	Calibration check
11/28/2007	15:55	12/19/2007	18:35	Probes failed. Tried to repair on site, but this did not work. Float was taken out entire period.
4/25/2008	00:45	5/6/2008	20:50	Did not pass calibration
10/2/2008	17:20	10/15/2008	16:25	Did not pass calibration
1/8/2009	15:45	1/27/2009	22:05	Did not install for winter
7/11/2009	17:25	7/14/2009	16:35	No power at meteorological station when FOS arrived
Lagoon ORP exclusion times				
8/1/2007	15:45	8/3/2007	14:10	Wiring was switched for probes
8/14/2007	12:55	8/15/2007	17:20	Calibration check
11/28/2007	15:55	12/19/2007	18:35	Probes failed. Tried to repair on site, but this did not work. Float was taken out entire period.
10/8/2008	02:20	10/15/2008	16:25	Probes stopped working
1/8/2009	15:45	1/27/2009	22:05	Did not install for winter
7/11/2009	17:25	7/14/2009	16:35	No power at meteorological station when FOS arrived
8/1/2007	15:45	8/3/2007	14:10	Wiring was switched for probes

3.3 Data correction procedures

Calibration adjustments based on the multipoint calibrations and calibration verifications were made to the NH_3 and H_2S gas concentration measurements. All concentration measurements were normalized to 101.325 kPa and 20°C (STP) within the instruments. The measured system response corrections used the entire record of calibration verifications and adjusted for a bias associated with the sampling system defined by the EPA Method 301 S-OPS validation by using a correction factor of 0.98. No corrections were required for the sonic anemometer measurements.

3.4 Data validation procedures

3.4.1 NH_3 concentration measurements

Because of the nature of the TDLAS data, the TDLAS routine is the most complicated portion of the data processing and quality control software. It is broken into several subroutines. The first subroutine flags pan/tilt locations that are likely to be in super-saturated "holes" in the retro-reflector array. The TDLAS instrument contains a sensor that detects the intensity of the energy returned from the retro-reflector in arbitrary units. Light levels of between 500 and 12000 are required for data to be considered valid. The light level sensor in the TDLAS instrument has a maximum value of 16368 (arbitrary units). Additional returned energy causes the light level to decrease. This creates a super-saturated condition in which the light levels appear valid, but in reality the returned energy is much greater than the allowable threshold for a valid reading. This leads to erroneous instrument readings, frequently indicated by low r^2 values that are associated with large path integrated concentrations (PICs). The term “hole” refers to a region of light levels that appear valid surrounded by maximized light levels. A hole is a region where the instrument will give faulty data, even though the light levels appear valid. The hole-finding algorithm goes through all the data points defined in “optimize” strings output by the instrument each time the scanner moves to a new location and determines data points that either have maximized light levels (16368) on the current day or else are surrounded above and below or to the left and to the right by points that have maximized light levels on the current day. The routine produces a list of locations (pan and tilt) and days that are probably super-saturated.

The next subroutine inputs all the concentration data and calculates averages over each dwell on a retro-reflector array. A scanner moved the TDLAS from one retro-reflector to another, dwelling for about 15 s on each retro-reflector array. The *GasView MP* program produced a flag that indicated when the scanner was moving. Once this flag indicated that the scanner had stopped its movement, one additional 1-s value was ignored, and then the remaining points were averaged to produce the dwell averages. The additional ignored value helped reduce the occurrence of data from the preceding path leaking into the current path because of communications delays.

On the next pass, concentration data from pan/tilt locations and days that were determined to be super-saturated were flagged as super-saturated. However, it was found that simply using the light levels as the super-saturation criteria resulted in the removal of much data that was clearly not super-saturated. To determine which points truly were super-saturated and which were not, a threshold curve of PIC as a function of r^2 was produced (for valid data, r^2 generally increases as PIC increases). As part of the determination of this PIC vs. r^2 threshold, a record was kept for each retro-reflector array of the ten largest PIC corresponding to each r^2 value from pan/tilt locations that were not determined from the initial hole-finding routine to be super-saturated. Based on this top-ten record, the PIC vs. r^2 threshold was determined by searching for outlying values that might indicate a PIC value that should have been indicated as super-saturated but were not.

Once the PIC vs. r^2 threshold curve was determined, a final pass was made through the data, this time comparing the PIC value for each data point with the threshold value at the current r^2. This resulted in four categories of points depending on whether or not super-saturation was indicated by the hole-finding algorithm and whether or not super-saturation was indicated by the hole-finding routine.

In a final pass through the data, data from the individual dwells was averaged up to the 30-min time intervals required by the *WindTrax* and *RPM* emissions models.

3.4.2 H_2S concentration measurements

The H_2S data processing routine first loaded all the H_2S data into an array. Based on the GSS data array, the data were then sorted by source side and a determination was made whether the GSS had been sampling that side long enough and whether enough time remained until the end of sampling that side for the H_2S data to be considered valid. The data were then sorted and averaged into 30-min intervals for placement into the *WindTrax* input file.

3.4.3 S-OPS sampling

The GSS software routine imported the CR800 data and produced two separate arrays of the data. The time grid for one array was based on when the S-OPS changed from one line to the other line. This array was later used when separating the H_2S data according to which S-OPS line was being measured and determining whether enough time had elapsed since the previous line-switch and enough time remained before the next line switch to consider the data valid. The other array was based on a regular 30-min grid. This array was used to produce output over the intervals required as input to *WindTrax*. Output from the GSS were also used to ensure that adequate flow was present for the instruments, that condensation was not a problem inside the GSS, and that there were no major issues with the S-OPS lines (leaks, etc.).

3.4.4 Wind component measurements

The sonic anemometer software imported the 300-s sonic anemometer data files and produced the final sonic anemometer QC output file and also arrays of data at 30-min intervals for use by the *WindTrax* and *RPM* emissions models. The *WindTrax* arrays contain the turbulence statistics required as inputs to *WindTrax* and also flags used for characterizing the output from the *WindTrax* or else the reason that sonic anemometer data were not suitable for use by *WindTrax* during a particular data interval. The *RPM* arrays contained the wind direction and wind speed averaged over a 30-min interval and interpolated to 10 levels from the surface to 20 m above the surface.

At some sites and during some periods one or more sonic anemometers experienced intermittent communications interference. This interference reduced the number of 16-Hz data points recorded in the trailer and also led to some spurious data points that resulted in some outlying, unphysical data points. These spurious data had little impact on the mean wind speeds, but did impact the variances, sometimes significantly. It was found that the spurious variances were nearly always associated with sonic anemometer temperature variance of greater than 2.5 K^2, while realistic variances never exceeded this same value. To be considered a valid 300-s period, at least 90% (4320) of the possible 4800 16-Hz values had to be present and the sonic temperature variance had to be less than 2.5 K^2. To be considered a valid 30-min interval, at least 3 of the 6 possible 300-s intervals were required to be valid. This acceptance scheme caught most of the unacceptable variances.

3.5 Emission calculations

3.5.1 NH_3 emissions by RPM

The *RPM* model was used to estimate the NH_3 emission rates based on the TDLAS and sonic anemometer data. Running the supplied version of *RPM* was very time consuming and inefficient and produced data at short intervals on the order of several minutes (time for a scan through all the paths). To make *RPM* processing much quicker and efficient, the sonic anemometer and TDLAS data processing programs were used to skip the first two stages of *RPM* data processing by producing data in the proper format and with the proper filenames for level 3 processing by the *RPM*. These files were produced at an interval of 30 min with all the data for a site and period contained in a single *RPM* input file. This allowed an entire period of data to be *RPM* processed with just a few clicks of the mouse, instead of with many clicks just for each individual day. The 30-min time interval was appropriate because the focus of the NAEMS study is on the long-term emissions over the course of the day rather than on the minute-by-minute emissions. In addition, the 30-min interval also allowed for a higher percentage of data capture since not all paths were necessarily required to be present for the entire 30-min interval.

3.5.2 NH_3 emissions by bLS

Data input into the *WindTrax* model were produced by combining output from the sonic anemometer and TDLAS portions of the data processing software. The *WindTrax* program was run by a portion of the data processing software that assigned values to the concentrations and wind statistics required by the model and told the model to run depending on whether or not the u_* and L values were acceptable.

GoogleEarth® was used extensively in producing the site maps required by *WindTrax*. By the end of the project, each site had a high-resolution image on *GoogleEarth*® sufficient to see the outline of the source area. A GPS was used to obtain precise latitudes and longitudes for the TDLAS units and each of the retro reflectors. Labeled location markers were then placed at these coordinate locations. When the locations were obviously wrong (the accuracy indicated by the GPS was generally on the order of 4 m or so), either because the path crossed the lagoon or because it was not correctly placed relative to the corner, the markers were moved slightly to the approximate proper location. The image was then saved and loaded into *WindTrax*, where it was used to define the source areas and measurement paths.

All data required for post-processing the *WindTrax* output were placed into the *WindTrax* output file.

3.5.3 Validation of bLS emissions model

All ½ hourly emissions calculated using the *WindTrax* bLS emissions model in which there was a corresponding *RPM* emissions measurement were compared by pairs using EPA Method 301. The precision of the bLS method for each pair of bLS and *RPM* measurements of emissions was assessed assuming the *RPM* method was the reference. The F-test was used to determine if the precision of the bLS method was significantly different from that of the *RPM* method under a range of meteorological conditions. The experimental *F*-value was calculated according to

$$F = \frac{S^2_{bLS}}{S^2_{RPM}}$$

where S^2_{bLS} is the variance of the bLS measurement method determined from all PICs, and S^2_{RPM} is the variance of the *RPM* measurement method determined from five to ten PICs (depending on the incidence angle) on a given downwind side (and possibly an upwind side) for the paired 30-min measurement periods. The experimental *F*-value was compared to the critical range of *F* at a 95% confidence level for the appropriate degrees of freedom associated with the number of measurements used in the variance calculations in both the numerator and denominator. If the experimental *F* was above the critical range, the precision of the bLS method was significantly greater than the *RPM* method. If the experimental *F* was below the critical range, the precision of the bLS method was accepted as equivalent to the *RPM* method.

The bias of the bLS method was determined from the measurement periods and beam lines used in the precision determination. Bias was determined by t-test of the mean differences in emissions calculations for each meteorological condition evaluated for precision. An 80% confidence interval was used (t=1.397). The correction factor was calculated if the difference was significant. If the correction factor was more than 1.10 or less than 0.90, then the bLS method was considered biased accordingly relative to the *RPM* emissions measurements for the location but not invalidated.

3.5.4 H_2S emissions by Ratiometric

Ratiometric H_2S emissions were determined by first finding 30-min intervals for which all the following conditions were satisfied: the *RPM* calculated a valid emission, one of the S-OPS lines was downwind (angle < 60 degrees) and both S-OPS lines had valid H_2S readings, and the TDLAS path corresponding to the downwind H_2S path had a valid concentration. An upwind TDLAS concentration was not used in the calculations. If the preceding conditions were met, then the H_2S emission was estimated as:

$$Flux_{H2S} = Flux_{RPM-NH3} \frac{34.0818\left([H_2S]_{downwind} - [H_2S]_{upwind}\right)}{17030.4[NH_3]_{downwind}}$$

The yield for the Ratiometric method for determining H_2S emissions was limited significantly by the generally poor yield for the *RPM* emissions method for NH_3.

3.5.5 H_2S emissions by bLS

Data input into the *WindTrax* model were produced by combining output from the sonic anemometer, GSS, and H_2S portions of the data processing software. The *WindTrax* program was run by a portion of the data processing software that assigned values to the concentrations and wind statistics required by the model and told the model to run depending on whether or not the u_* and L values were acceptable.

GoogleEarth® was used extensively in producing the site maps required by *WindTrax*. By the end of the project, each site had a high-resolution image on *GoogleEarth*® sufficient to see the outline of the source area. A GPS was used to obtain precise latitudes and longitudes for the ends of the S-OPS lines. Labeled location markers were then placed at these coordinate locations. When the locations were obviously wrong (the accuracy indicated by the GPS was generally on the order of 4 m or so), either because the path crossed the lagoon or because it was not correctly placed relative to the corner, the markers were moved slightly to the approximate proper location. The image was then saved and loaded into *WindTrax*, where it was used to define the source areas and measurement paths. All data required for post-processing the *WindTrax* output were placed into the *WindTrax* output file.

4 Results

4.1 Farm activity

Pertinent activities affecting the lagoon include transfer of waste from barns into the lagoon (Table 5.1-1) and lagoon pump-outs for irrigation. Once every 2 weeks, usually on Wednesday, pit draining of the breeding or gestation barns starts around mid morning and lasts for 1.5 h with draining alternating weekly between gestation and breeding barns. There are 16 rooms in the farrowing barn with five or six cleaned every week when pigs are weaned (usually 2 rooms on Monday, 1 on Tuesday, 1 on Thursday, and 1 or 2 on Friday). Pits under the farrowing barn rooms start to drain around 8 A.M. local time and take up to 2 h. Before noon the pits are back filled with recycle water from the lagoon.

The lagoon was not pumped-out during the study periods. Animal inventories for the calculation of lagoon loading rates are indicated in Table 4.1-1.

Table 4.1-1 Producer activities

Period	Activity	Animal inventory
1: 6/27 - 8/29/2007	No events	2748
2: 11/6-28/2007	11/6 Gestation ration changed from milo to corn	2712
3: 11/28 - 12/19/2007	12/17 Gestation ration changed from corn to milo	2712
4: 4/22 - 5/6/2008	No events	2777
6: 9/30 - 10/15/2008	No events	2720
7: 1/7-27/2009	No events	2731
8: 4/1-21/2009	No events	2762
9: 6/22 - 7/14/2009	No events	2777

4.2 Weather conditions

4.2.1 Synoptic weather events

Weather conditions during the measurement periods varied widely as expected for midlatitude climates (Table 4.2-1). Twenty-three percent of the days had extra-tropical frontal systems overhead while 77% of the days were under the general influence of extra-tropical high pressure. The Daily Weather Maps for the measurement days are found in Section 6.9.

Table 4.2-1: Synoptic weather events during measurements

Measurement period	# days	# warm front passages	# cold front passages	# days stationary front	# days tropical storm
1	63	3	4	3	0
2	20	0	2	1	0
3	20	1	2	1	0
4	13	0	2	1	0
6	14	1	6	0	0
7	19	1	3	0	0
8	20	1	4	2	0
9	19	1	3	3	0

4.2.2 Variation in barometric pressure, solar radiation, air temperature and wetness

Over the course of the measurement periods, the mean daily air temperature varied from -11.7 ^{o}C to 37.1 ^{o}C while the barometric pressure varied from 89.38 kPa to 92.66 kPa (Section 6.10). Sky conditions ranged from clear skies with maximum ½ hr solar irradiance of 1191 Wm^{-2} to overcast conditions with maximum ½ hr solar irradiance of 55 Wm^{-2} (Section 6.10). The wetness sensor failed frequently due to corrosion issues.

4.2.3 Variation in air temperature and relative humidity

The relationship between the daily mean air temperature and humidity compared to the monthly climatology is indicated in Figure 4.2-1. Temperatures were generally within the climatological normal conditions throughout the study measurement periods at this location.

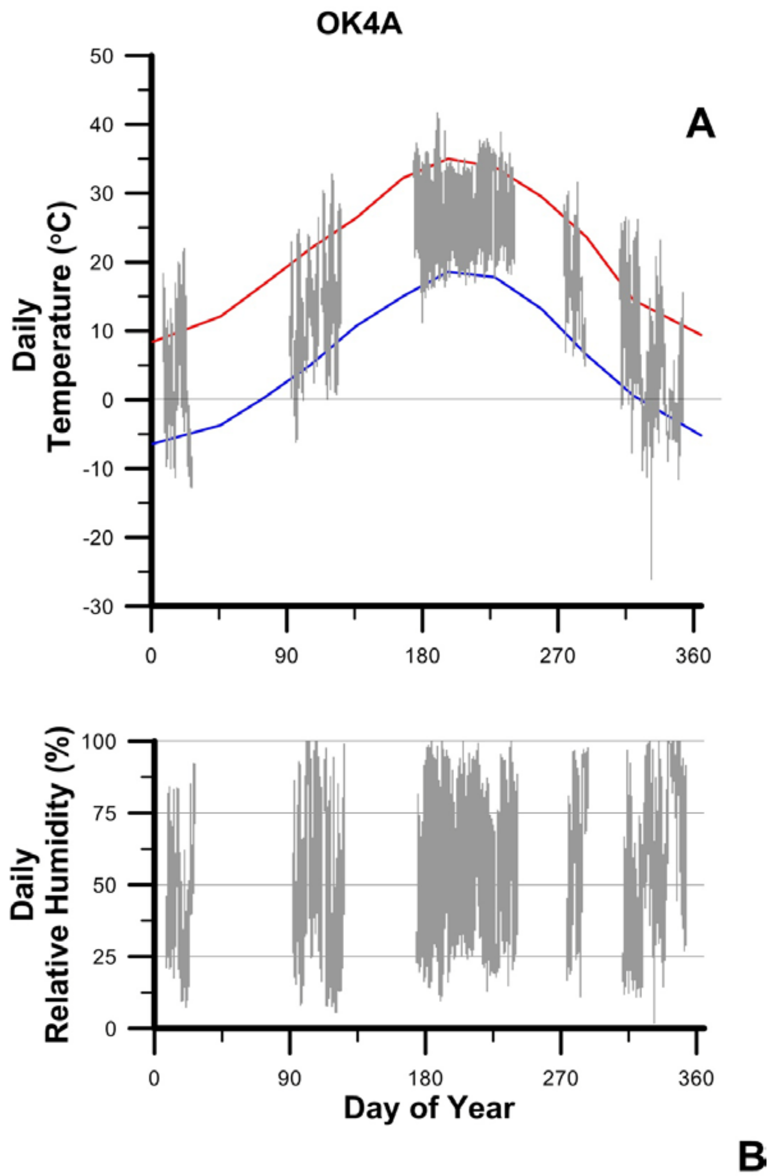

Figure 4.2-1: Variation in daily temperatures and relative humidity during measurements. The mean monthly climatological maximum (red solid line) and minimum (blue solid line) temperature are compared against the daily maximum and minimum temperatures for measurement days (grey bars) in panel A. The maximum and minimum relative humidities for measurement days are indicated by the grey bars in panel B.

4.2.4 Wind conditions

Wind conditions for each measurement period are illustrated in Figure 4.2-2 through 4.2-5. Emission calculation exclusion regions due to surrounding sources (wind directions of 225^{o} through 315^{o}) are indicated as a grayed region in the figure. Winds were generally from the north during periods 2 (Fall), 3 (Winter), 4 (Spring), 7 (Winter), and 8 (Spring) and from the south or southwest during periods 1 (Summer) and 6 (Fall). Winds speeds were commonly greater than 5 ms^{-1}.

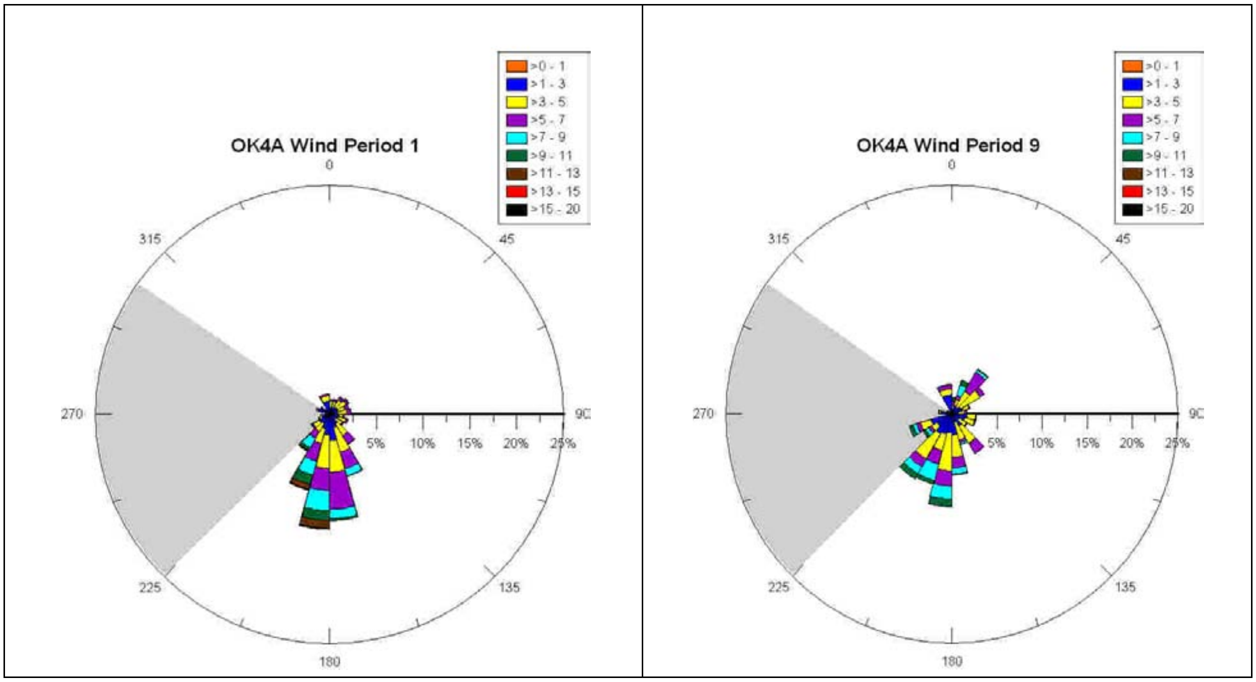

Figure 4.2-2: Wind roses for ½ hourly wind measurements during the Summer Measurement Periods. The periods which measurements were made are indicated. The relative portion of time in which the wind was from a given direction is indicated by the length of the triangle pointing in that direction. The fraction of time in which the winds were in the binned speed ranges (units of ms^{-1}) is indicated by colors within each triangle. The shaded region defines the wind directions excluded due to upwind influence of the barns.

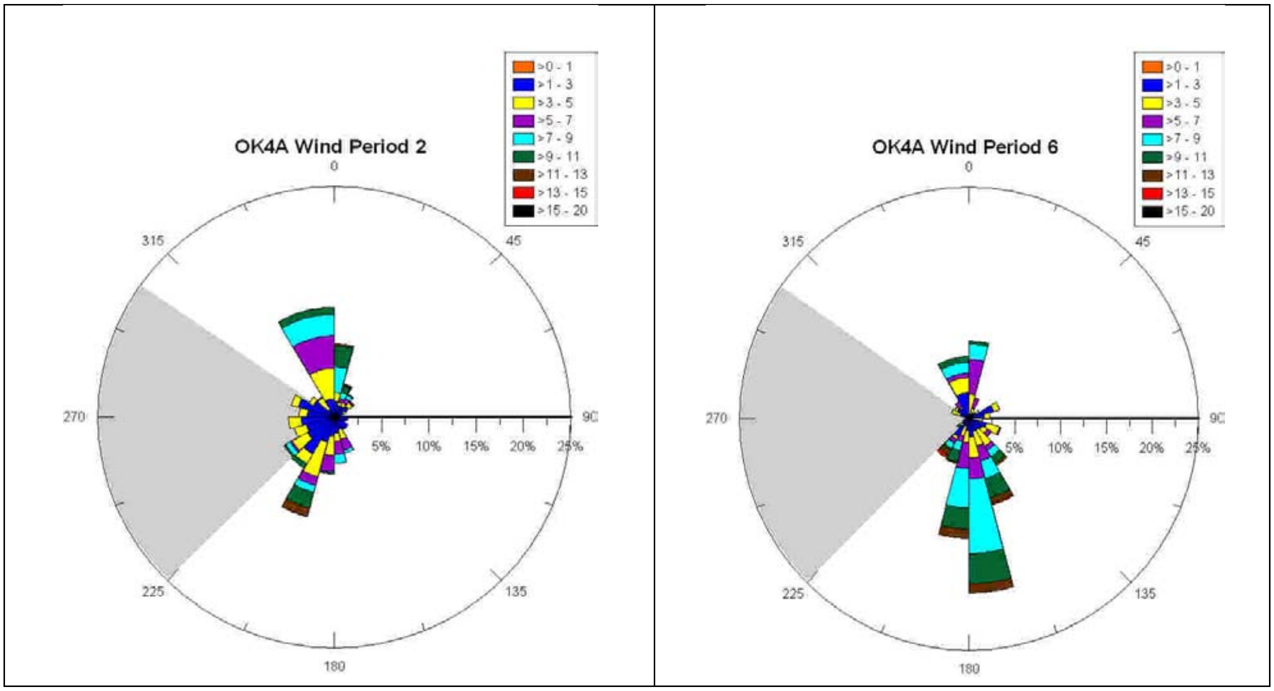

Figure 4.2-3: Wind roses for ½ hourly wind measurements during the Fall Measurement Periods. The periods which measurements were made are indicated. The relative portion of time in which the wind was from a given direction is indicated by the length of the triangle pointing in that direction. The fraction of time in which the winds were in the binned speed ranges (units of ms^{-1}) is indicated by colors within each triangle. The shaded region defines the wind directions excluded due to upwind influence of the barns.

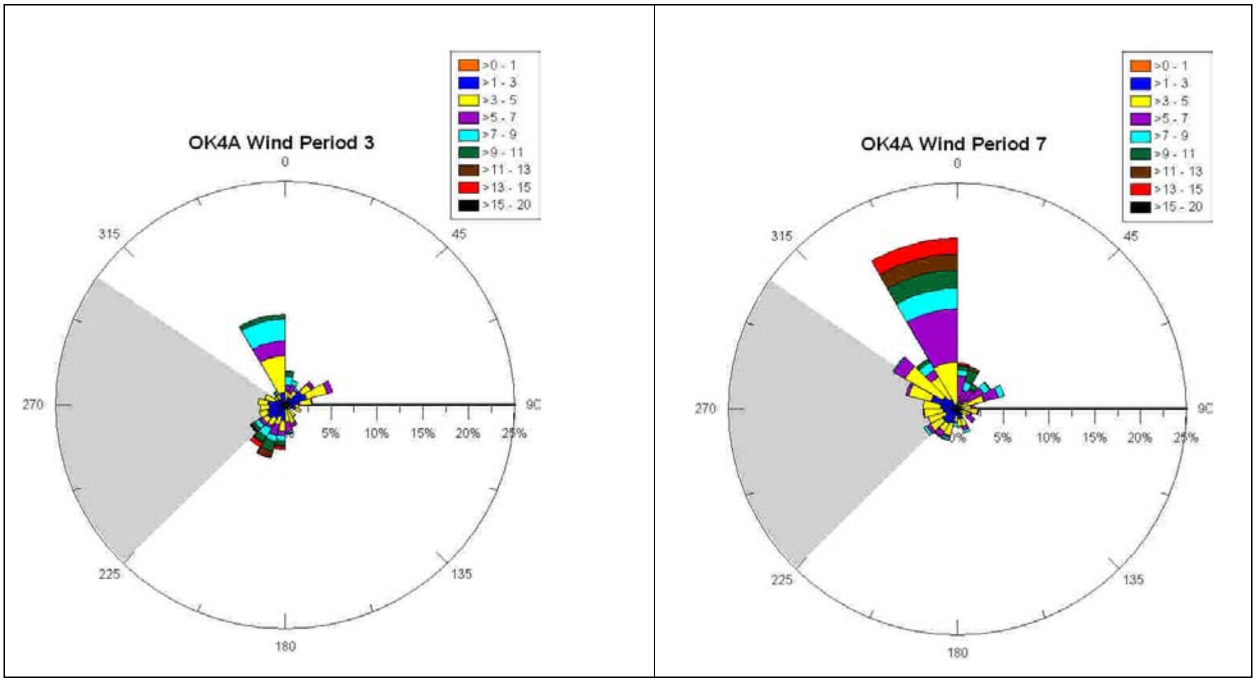

Figure 4.2-4: Wind roses for ½ hourly wind measurements during the Winter Measurement Periods. The periods which measurements were made are indicated. The relative portion of time in which the wind was from a given direction is indicated by the length of the triangle pointing in that direction. The fraction of time in which the winds were in the binned speed ranges (units of ms^{-1}) is indicated by colors within each triangle. The shaded region defines the wind directions excluded due to upwind influence of the barns.

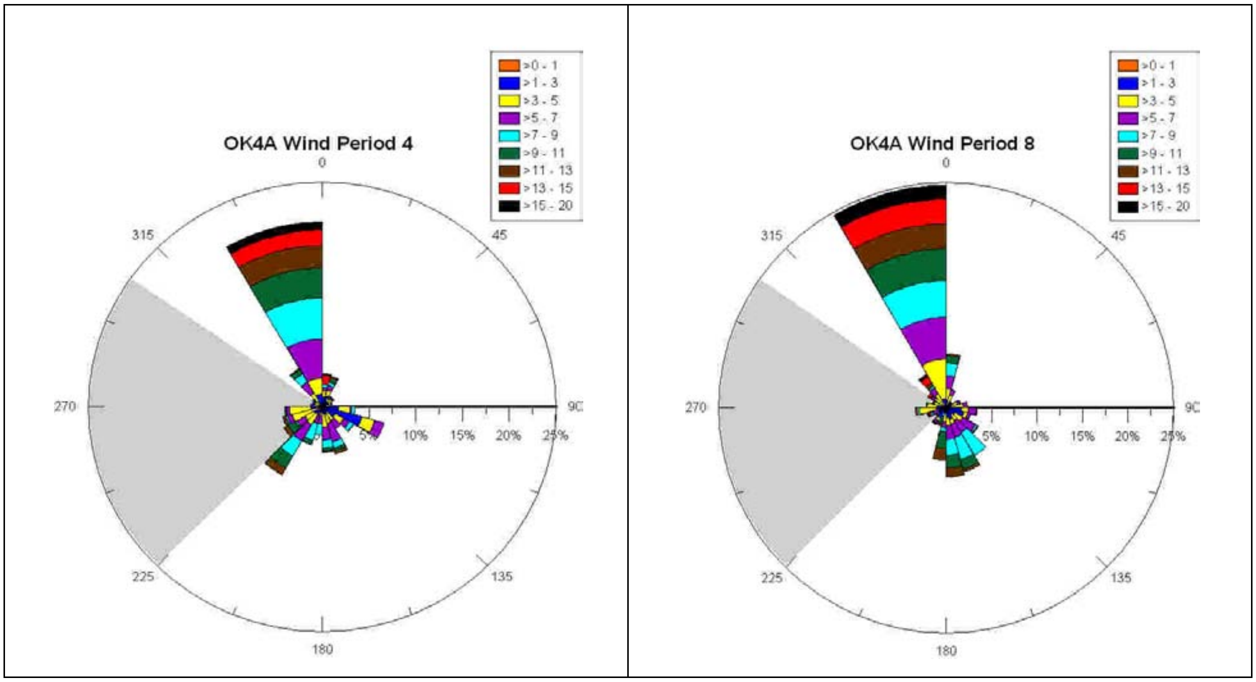

Figure 4.2-5: Wind roses for ½ hourly wind measurements during the Spring Measurement Periods. The four periods which measurements were made are indicated. The relative portion of time in which the wind was from a given direction is indicated by the length of the triangle pointing in that direction. The fraction of time in which the winds were in the binned speed ranges (units of ms^{-1}) is indicated by colors within each triangle. The shaded region defines the wind directions excluded due to upwind influence of the barns.

4.3 Lagoon conditions

4.3.1 Lagoon appearance, liquid depth and sludge depth

The appearance of the lagoon was recorded on almost every site visit (Table 4.3-1). The lagoon generally appeared brown with surface characteristics ranging from frozen during the winter to free of crust during the remainder of the year.

Table 4.3-1: Lagoon physical characteristics

Period	Appearance color/crust	Liquid depth (m)	Sludge depth (m)	Source of meas.*
1: 6/27 - 8/29/2007	6/27 brown/ no crust 6/28 brown/ no crust 7/9 brown/ no crust 7/18 brown/ no crust 7/19 brown/ no crust 7/30 brown/ 5% Crust 7/31 brown/ 5% crust 8/1 brown/ 5% crust 8/2 brown/ no crust 8/3 brown 20% crust 8/4 brown/ 5% crust 8/18 brown/ 5% crust 8/16 brown/red/ no crust 8/28 brown/red/ no crust 8/29 brown/dark red/ no crust	Lagoon level below gauge	N/A	Producer
2: 11/06 - 11/28/2007	11/7 brown/red/ 2% crust 11/8 brown/red/ 1% crust 11/27 brown/red/ no crust 11/28 brown/red/ no crust	11/8 2.98	11/8 0.44	Sludge Gun
3: 11/28 - 12/19/2007	11/28 brown/red/ no crust 12/18 brown/red/ no crust 12/19 brown/red/purple/ no crust	Lagoon level below gauge	N/A	Producer
4: 4/22 - 5/6/2008	4/23 brown/no crust 4/24 brown/ no crust 5/6 brown/no crust	Lagoon level below gauge	N/A	Producer
6: 9/30 -10/15/2008	10/1 brown/no crust 10/2 brown/no crust 10/14 brown/ no crust 10/15 brown/no crust	Lagoon level below gauge	N/A	Producer
7: 1/7 - 1/27/2009	1/7 black/ no crust 1/8 brown/ no crust 1/27 snow covered/frozen	Lagoon level below gauge	N/A	Producer
8: 4/1 - 4/21/2009	4/1 brown/ 10% ice 4/2 brown/ no crust 4/21 brown/ no crust	Lagoon level below gauge	N/A	Producer
9: 6/22 - 7/14/2009	6/23 brown/ no crust 6/24 brown/ no crust 6/25 brown/ no crust 7/14 brown/ no crust	Lagoon level below gauge	N/A	Producer

4.3.2 Temperature, pH and oxidation-reduction potential

The measured lagoon liquid temperature varied from 3.3 ^{o}C to 28.8 ^{o}C with the lowest temperatures just prior to when the sensors were removed in anticipation of the lagoon freezing during the winter (Section 6.11). The measured lagoon pH varied from 6.5 to 8.4 (Section 6.11) while the oxidation-reduction potentials varied from -249 mV to -545 mV over the entire study period (Section 6.11).

4.3.3 Lagoon Chemistry

Lagoon water chemical analyses were not conducted by the project but analyses required by the NRCS at the time of water removal for field application were available for applications during the overall project period. Due to the drought conditions present at the site, water was only removed once (Table 4.3-3).

Table 4.3-3: Record of lagoon chemistry

			Percent (wet weight basis)			
Date	**n**	**pH (SU)**	**Nitrogen**	**Solids**	**Ammonia**	**Sulfur**
11/1/2008	1	8.28	0.44	0.20	0.33	0.03

4.4 Emissions measurements

Emissions data were calculated on a ½ hour basis since this was the interval over which the S-OPS system sampled both sides of the lagoon and since this interval is in the range over which turbulence statistics are often calculated. To account for the longer term manure storage of the lagoon, emissions reported on a head basis were scaled by the animal population for which the facility was designed and not the animal population at the time of measurements. Emissions reported on an animal unit (AU) basis (1 AU = 500 kg) assumed the typical animal weight values reported by the producer. Emissions reported on an area basis are based on the surface area of the lagoon.

Comparison of RPM and bLS emissions models

The comparison between the RPM and bLS emissions models was conducted according to the USEPA Method 301 ‘Field Validation of Pollutant Measurement Method’ using NH_3 emissions measurements. The comparison was based on 1760 ½ h measurement periods over the entire measurement time at this location. Results show that the bLS emissions had a significantly different precision (F=1.33, critical F=1.0) and a significant bias over the *RPM* emissions (t=11.43, $t_{0.2}$=1.29) with a corresponding correction factor for the bLS of 1.10 (Table 4.4-1). Consequently, the ½ h bLS emissions measurements were biased high by 9% compared with the *RPM* measurements.

Table 4.4-1: Comparison of the bLS and RPM NH_3 emissions

	RPM	bLS	bLS-RPM
Mean emission (gs^{-1})	2.15	2.36	0.21
Standard deviation (gs^{-1})	1.16	1.33	
Variance of the mean (gs^{-1})	1.34	1.78	

4.4.1 NH_3 Emissions

4.4.1.1 Mean daily NH_3 emissions

An annual trend in the daily NH_3 emissions based on the *RPM* model was indicated (Figure 4.4.1-1) with a summer emission of approximately 100 g NH_3 $d^{-1}hd^{-1}$. The daily emissions during the winter decreased to approximately 10 g NH_3 $d^{-1}hd^{-1}$. In contrast to the large number of measurements with more than 75% of the day’s emissions measured during the spring and summer, there were no days during the winter in which at least 75% of the daily emissions were measured for any given day. This was largely due to low concentrations resulting in failures to compute the emissions using the *RPM* model. There was a relatively wide range in emissions from day to day. The daily NH_3 emissions and the number of valid measurements used in the mean daily emissions estimate calculated using the *RPM* model are listed in Section 6.12.1.

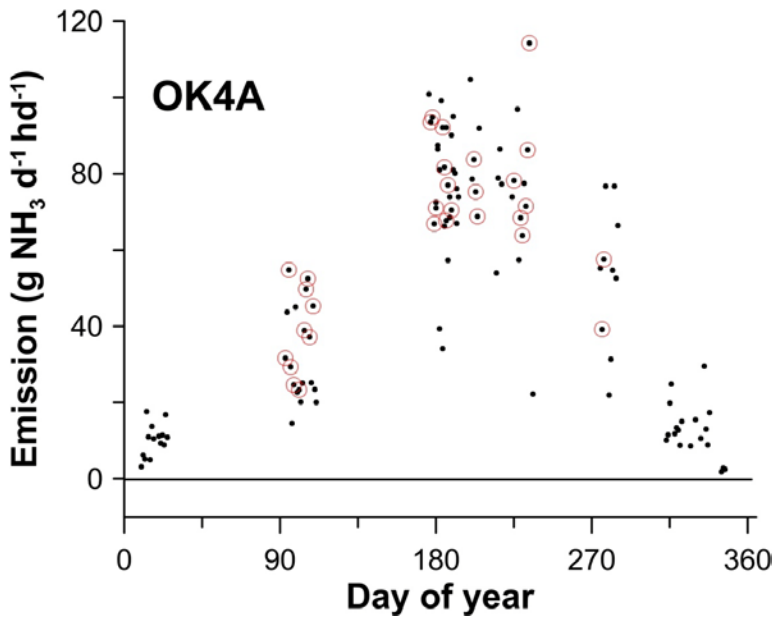

Figure 4.4.1-1: Annual variation in RPM-computed daily NH_3 emissions. Days with a red circle indicate there are measurements for greater than 75% of the continuous day.

An annual trend in the daily NH_3 emissions based on the bLS model was also evident (Figure 4.4.1-2) with a summer emission of approximately 120 g NH_3 $d^{-1}hd^{-1}$. The daily emissions during the winter decreased to near zero. Winter emissions of approximately 5 g NH_3 $d^{-1}hd^{-1}$ are likely a result of barn effluent entering the lagoon on top of the frozen surface. Measurements with more than 75% of the day's emissions measured include days in summer, fall, and winter, providing good confidence that the emission measurements are representative. There was, however, still a relatively wide range in emissions from day to day. The daily NH_3 emissions and the number of valid measurements used in the mean daily emissions estimate calculated using the bLS model are listed in Section 6.12.2.

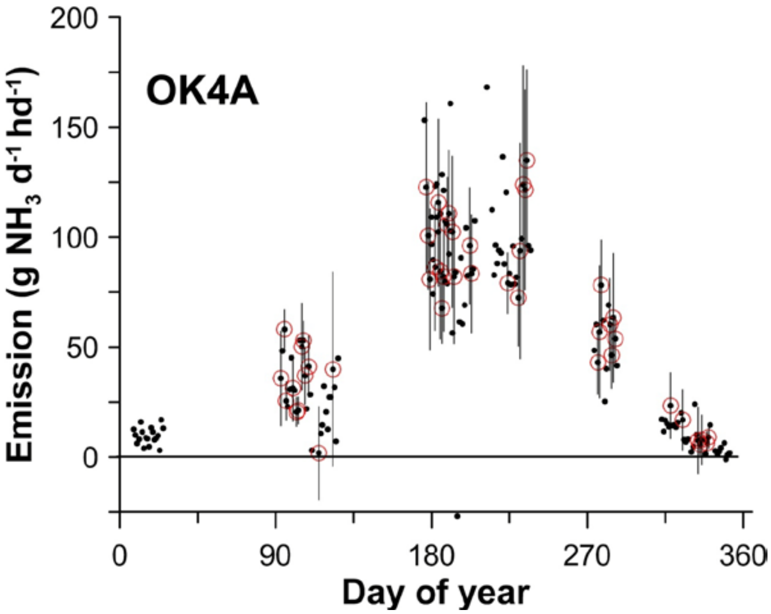

Figure 4.4.1-2: Annual variation in bLS-computed daily NH_3 emissions. Days with a red circle indicate there are measurements for greater than 75% of the continuous day. The bars represent the standard deviation of emissions based on individual ½ hr values when at least 75% of the day had valid measurements.

The bLS model was influenced by the calculated background concentrations. Results indicated that the background concentration of NH_3 was generally less than 0.05 ppm (Figure 4.4.1-3). Given that the typical path length around the lagoon was 100 m and the typical background concentration is less than 0.05 ppm, this corresponds to a background PIC of less than 5 ppm-m. This is approximately the MDL for the TDLAS instruments of 2 ppm-m (Section 6.1) and therefore represents essentially no background concentration. The greatest background concentrations occurred around day of year 200 to 230. The high background values correspond to high measured emissions (Figure 4.4.1-2). Since higher background values will tend to reduce emissions, the emissions measured during the summer may be underestimates of the true emissions. These measurements were made at the very beginning of the study and the cause for the high background is not known.

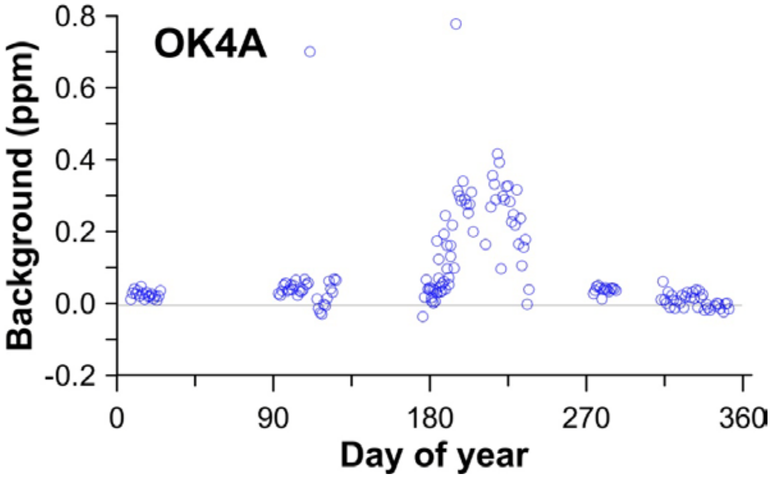

Figure 4.4.1-3: Annual variation in bLS-computed mean daily background concentration of NH_3.

4.4.1.2 Diurnal variation in NH_3 emissions

In general, there was not a strong diurnal pattern to the NH_3 emissions. A diurnal pattern in the emissions was evident for only two of the eight measurement periods (Figure 4.4.1-4). This was likely due to the generally high winds at the location.

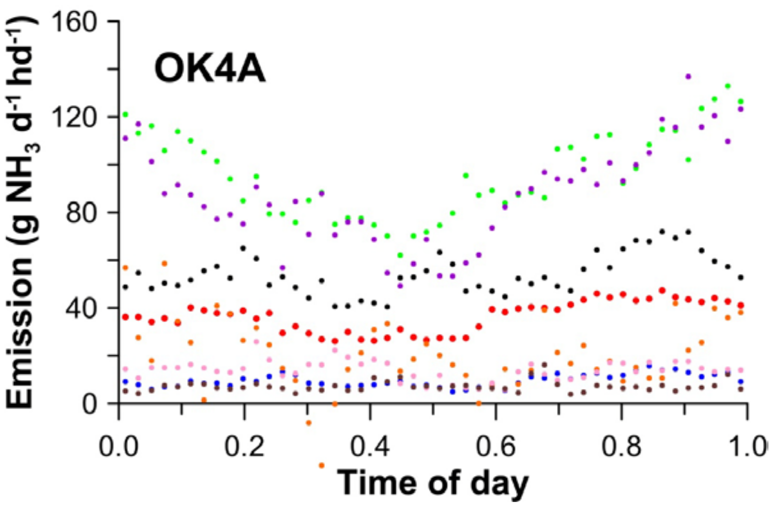

Figure 4.4.1-4: Diurnal variation in bLS-computed NH_3 emissions. Time based on UTC. The mean emission for each half-hour of the day within a given measurement period (Period 1-Summer (green), Period 2-Fall (pink), Period 3-Winter (brown), Period 4-Spring (orange), Period 6-Fall (black), Period 7-Winter (blue), Period 8-Spring (red), and Period 9-Summer (purple)) are indicated.

4.4.1.3 NH_3 emissions data completeness

Unless otherwise indicated, emissions completeness and failure totals are given in number of days corresponding to the total number of ½ h intervals for which the indicated condition was true. This number of days does not indicate the data completeness for any individual day. Therefore, an additional value giving the total number of days with at least 36 valid ½ h periods (corresponding to 75% completeness on a daily basis) is given. The completeness statistics by measurement period are summarized in Table 4.4.1-2.

Table 4.4.1-2: Completeness statistics for NH_3 emissions measurements

	Period								
Model / Parameter	**1**	**2**	**3**	**4**	**6**	**7**	**8**	**9**	**Total**
RPM Model									
Valid 1/2 hour measurements (d)	14.6	1.5	0.6	0.0	5.6	1.8	12.3	11.8	**48.2**
Measurements excluded due to wind direction (d)	0.6	2.0	1.1	0.0	0.6	3.0	1.6	1.1	**10.1**
Measurements excluded because at least one downwind path is missing or invalid (d)	30.7	14.5	11.8	11.6	6.3	13.3	3.6	2.1	**94.0**
Number of days with ≥ 36 valid 1/2 h periods (d)	9	0	0	0	2	0	10	9	**30**
bLS Model									
Valid 1/2 h measurements (d)	26.4	8.1	7.9	5.8	8.2	5.9	14.0	11.1	**87.4**
Measurements excluded due to wind direction (d)	2.3	2.3	1.9	1.8	0.6	3.9	1.8	1.9	**16.4**
Measurements excluded because touchdown fraction < 0.1 (d)	3.2	0.4	0.5	1.2	0.6	1.6	0.0	0.0	**7.5**
Measurements excluded because $u_* < 0.15$ ms^{-1} or $\|L\| < 2$ m (d)	8.1	6.0	3.7	1.5	1.9	2.9	2.4	2.7	**29.2**
Number of days with ≥ 36 valid 1/2 h periods (d)	12	2	5	2	7	0	10	8	**46**

In total, 48 d of valid NH_3 emissions were determined from the 188 measurement days using the *RPM* model, with 30 d having at least 36 valid ½ h NH_3 emissions. The absence or invalidation of at least one downwind path led to 94 days for which emissions could not be calculated.

Eighty seven days of valid NH_3 emissions were determined from the 188 measurement days using the bLS model, with 73 d having at least 36 valid ½ h NH_3 emissions. Invalid turbulence statistics ($u_* < 0.15$ ms^{-1} or $|L| < 2$ m) led to 29 d for which emissions could not be calculated. A touchdown fraction of less than 0.1 led to the exclusion of 7.5 d of data. Low touchdown fractions indicated that little, if any, downwind data was available. This corresponded to either when the downwind TDLAS was not present or else the downwind paths were lost because of invalid light levels.

The *RPM* model requires all 5 or 10 (depending on the wind direction) downwind paths to have valid concentration readings for at least a portion of the ½ h interval. This contrasts with the bLS model which requires only 1 downwind surface path to have valid concentration readings. This difference is largely responsible for the much greater completeness for the bLS model than the *RPM* model. The *RPM* model uses ½ h mean wind speed and direction, in contrast to the bLS model that requires extensive turbulence statistics over this same period. As a result, there are times that the *RPM* model produces a valid emissions estimate that the bLS model does not. However, these times are overwhelmed by the times that the *RPM* model is missing concentration data for one or more paths, while the bLS model is able to run.

4.4.2 H_2S Emissions

4.4.2.1 Mean daily H_2S emissions

Emissions of H_2S calculated using the Ratiometric model were highest in the spring and decreased throughout the rest of the year (Figure 4.4.2-1). Peak emissions were approximately 14 g H_2S d^{-1} hd^{-1}. There was however wide variability in H_2S emissions from day to day during the spring and summer (Figure 4.4.2-1). The trend for high spring emissions followed by continual decrease through the rest of the year is also evident considering only those days in which 75% of the day had valid emission measurements. The daily H_2S emissions and the number of valid measurements used in the mean daily emissions estimate calculated using the Ratiometric model are listed in Section 6.12.3.

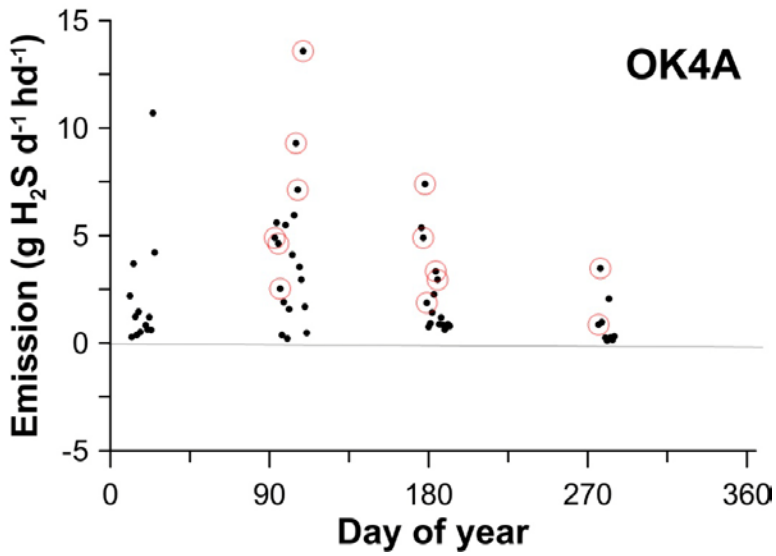

Figure 4.4.2-1: Annual variation in Radiometric-computed daily H_2S emissions. Days with a red circle indicate there are measurements for greater than 75% of the continuous day.

Emissions of H_2S determined using the bLS model suggest that emissions during the winter and spring are high with emissions decreasing throughout the rest of the year (Figure 4.4.2-2). Peak emissions were approximately 10 g H_2S d^{-1} hd^{-1} with wide variability in H_2S emissions from day to day during the spring and summer (Figure 4.4.2-2). A near-zero emission during the fall is strongly indicated. The winter, spring and summer emissions are similar in magnitude and variability when considering only those days in which 75% of the day had valid emission measurements. The daily H_2S emissions and the number of valid measurements used in the mean daily emissions estimate calculated using the bLS model are listed in Section 6.12.4.

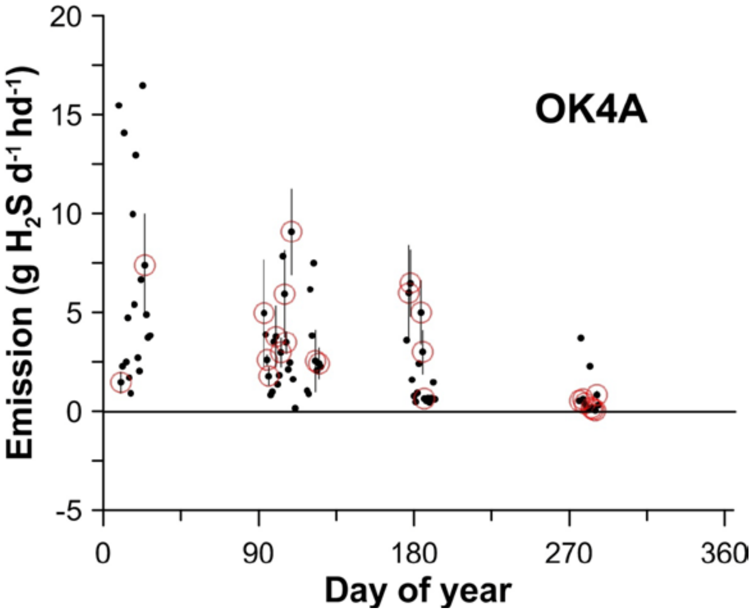

Figure 4.4.2-2: Annual variation in bLS-computed daily H_2S emissions. Days with a red circle indicate there are measurements for greater than 75% of the continuous day. The bars represent the standard deviation of emissions based on individual ½ hr values when at least 75% of the day had valid measurements.

The bLS emission model depends on a good estimate of the background H_2S concentration. Results indicate that the background concentration was generally less than ± 2.5 ppb (Figure 4.4.2-3). This background is consistent with an equivalent zero value since the instrument MDL was 3.4 ppb (Section 6.2).

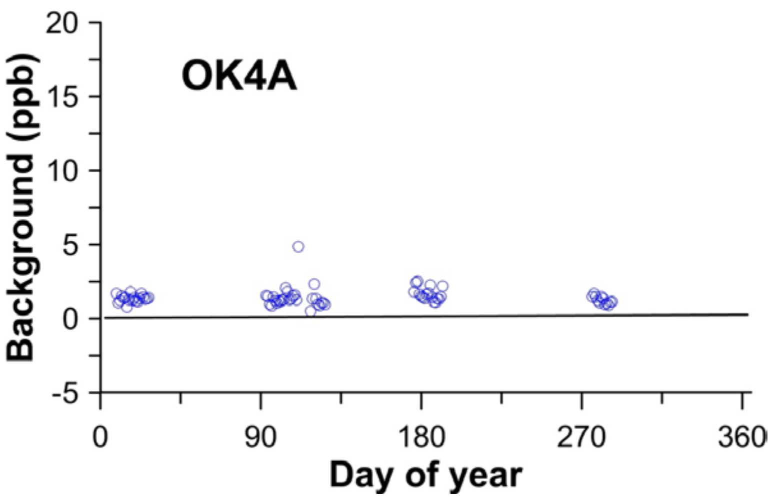

Figure 4.4.3-3: Annual variation in bLS-computed mean daily background concentration of H_2S.

4.4.2.2 Diurnal variation in H_2S emissions

The H_2S emissions calculated using the bLS model generally showed no diurnal trend (Figure 4.4.2-4). The one period indicating a strong diurnal trend was period 7 with the highest emissions occurring during the day.

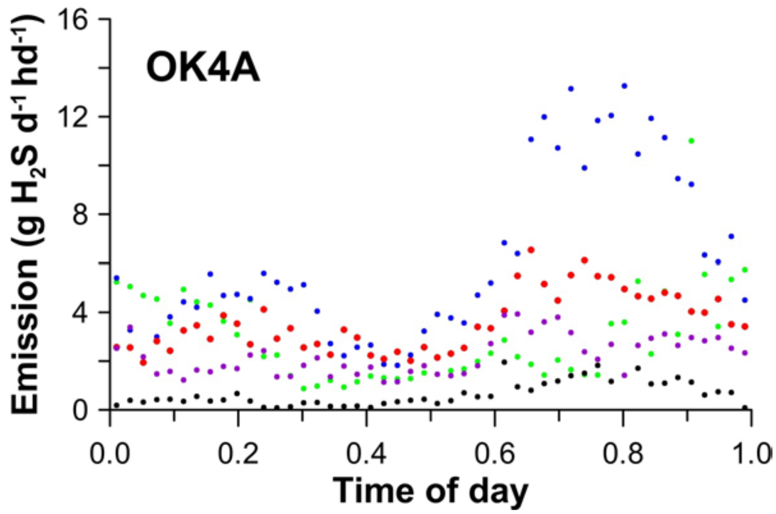

Figure 4.4.2-4: Diurnal variation in bLS-computed H_2S emissions. Time based on Universal Time Coordinates. The mean emission for each half-hour of the day within a given measurement period [Period 4-Spring (green), Period 6-Fall (black), Period 7-Winter (blue), Period 8-Spring (red), and Period 9-Summer (purple)] are indicated.

4.4.2.3 H_2S emissions data completeness

H_2S Measurements were begun in Period 4. Consequently there were no measurements possible until Spring 2008. As described for the NH_3 emissions, emissions completeness and failure totals are given in number of days corresponding to the total number of ½ h intervals for which the indicated condition was true. This number of days does not indicate the data completeness for any individual day. The completeness statistics by measurement period are summarized in Table 4.4.2-1.

Table 4.4.2-1: Completeness statistics for H_2S emissions measurements

	Period								
Model / Parameter	**1**	**2**	**3**	**4**	**6**	**7**	**8**	**9**	**Total**
H_2S Ratiometric									
Valid 1/2 h measurements (d)	[redacted]			0.0	4.8	1.8	10.5	10.2	**27.3**
Number of days with ≥ 36 valid 1/2 h periods	[redacted]			0	2	0	6	5	**13**
H_2S bLS									
Valid 1/2 h measurements (d)	[redacted]			4.9	8.8	9.5	12.5	9.8	**45.6**
Measurements excluded due to wind direction (d)	[redacted]			1.6	0.6	3.8	1.6	1.8	**9.5**
Measurements excluded because angle of attack < 60° (d)	[redacted]			0.6	0.6	1.8	1.3	1.2	**5.4**
Measurements excluded because $u_* < 0.15$ ms^{-1} or $\|L\| < 2$ m (d)	[redacted]			1.1	1.5	2.9	2.4	2.9	**10.8**
Number of days with ≥ 36 valid 1/2 h periods	[redacted]			2	7	2	8	5	**24**

In total, 27 d of valid H_2S emissions were determined using the Ratiometric emission method, with 13 d having at least 36 valid ½ h H_2S emissions. Forty-five d of valid H_2S emissions were determined using the bLS model, with 24 d having at least 36 valid ½ h H_2S emissions. Invalid turbulence statistics ($u_* < 0.15$ ms^{-1} or $|L| < 2$ m) and excluded wind directions contributed equally to the invalidation of measurements.

4.4.3 Estimation of emission measurement errors

Errors in the response of the TDLAS due to atmospheric moisture limited the accuracy of the TDLAS serial numbers 1026, 1027, and 1028 prior to 7/21/2008. TDLAS 1026 was used at OK4A from 4/23/2008 to 5/6/2008 (Measurement period 4). Under the calibration verification checks, the TDLAS error of all units was 10% accuracy. However due to the short path length of the calibration verification, these checks did not assess water vapor interferences experienced in the long path lengths around the area sources. Inter-comparisons between various TDLAS units experiencing atmospheric moisture interference and units without apparent interference revealed reduced responses with the moisture-affected units of 28%, 68%, 36% and 31% for atmospheric moisture varying from dew point temperatures of -2 ^{o}C to 20 ^{o}C. A conservative estimate of the bias of all of the above TDLAS units with evident moisture interference was -40%.

4.4.3.1 Error in RPM-measured NH_3 emissions

Tracer releases studies indicated that the RPM emissions measurement has an error in accuracy of approximately ±15% (Hashmonay et al., 2001; Verma et al., 2005; USEPA, 2007). The TDLAS measurement error was 10% (Section 6.1). Combining errors results in an expected error in the RPM-measurement of NH_3 emissions of ± 18%. In addition, the NH_3 measurements made using the TDLAS units with moisture interference had a bias of -40%.

4.4.3.2 Error in bLS-measured NH_3 and H_2S emission

Tracer studies using TDLAS concentration measurements in combination with the bLS emissions model averaged over roughly 2 h periods indicated the bLS method error for a given 15-min period varied with stability: overestimated by 12% under near neutral conditions, underestimated by 13% under unstable conditions, and overestimated by 38% under stable conditions (Flesch et al., 2004). Under conditions when Monin Obukhov similarity theory was valid, the bLS-calculated emission rate was biased 6% high with a standard deviation of 16%. Laubach and Kelliher (2005) evaluated the theoretical errors of the bLS model. The breakdown of their 22% model error included a 12% error for the estimate of the Monin-Obukov Length (L) derived from measurements, a 5% error in turbulence statistics (10% error for the normalized variability statistics in the x and y directions and 5% in the z direction), a 15% error associated with the roughness length (z_o) estimate, and a 10% error due to the stochastic methodology. This was consistent with tracer-estimated errors of the bLS emission calculation method, when constrained by the data quality indicators of the bLS method, of between 5% and 36%.

For this study, we assumed the above theoretical random error of 22% for the bLS emissions measurements. The TDLAS measurement error was 10% (Section 6.1). At this location the daily mean bLS emissions bias from the RPM emissions measurement was +10% (from the RPM/bLS method comparison in Section 4.4). As previously stated, the TDLAS units with moisture interference had a bias of -40%. Combining errors resulted in an expected error in the RPM-measurement of NH_3 emissions of ± 24% with a bias of -30% for TDLAS NH_3 measurements made by units with moisture interference and a bias of +10% for TDLAS NH_3 measurements made by units without moisture interference.

The H_2S PF instrument measurement error was 10% (Section 6.2). Given the expected error in the bLS measurement of emissions of 22%, the H_2S emissions error was estimated as ± 24%

4.4.3.3 Error in Ratiometric-measured H_2S emission

The Ratiometric method of H_2S emissions measurement depends on the RPM measurement of NH_3 emissions. The RPM emissions measurement had an error of approximately ±15%. Since the Ratiometric method ratios the emissions and concentrations of NH_3, there was no effect of the moisture interference in the TDLAS measurement on the H_2S emissions calculation. Given the H_2S PF instrument measurement error of 10% (Section 6.2), the combined error for the Ratiometric measurement of H_2S emissions was ± 18%.

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6 Appendices

6.1 TDLAS NH_3 calibrations

Six TDLAS units (Model GasFinder2™ NH3OP, Boreal Laser Inc., Spruce Grove, Alberta, Canada) were used for measurements at this location: TDLAS 1026, TDLAS 1027, TDLAS 1028, TDLAS 1029, TDLAS 1031 and TDLAS 1032.

TDLAS 1026 was multipoint calibrated seven times during the study (Figure 6.1-1). The response is non-linear and consequently a third-order polynomial was used to correct the instrument measurements for the instrument response. The multipoint calibration on 1/17/2007 was used for the entire study period. The offset of the equation was determined from a least squares fit of the entire record of calibration verifications made at 50 ppm-m applied to the first, second, and third order terms derived from the multipoint calibration. The regression equation was:

$$\text{ppm-m} = -0.97 + 1.0197 * X - 4.410E\text{-}5 * X^2 + 1.591E\text{-}8 * X^3$$

where X is the instrument response. The response of the sensor was influenced by humidity until 7/21/2008 due to an error in the factory settings for the spectral waveband analysis window. At that time, factory personnel corrected the spectral waveband used for analysis. The effect of this error was to 1) reduce the maximum possible linear correlation with the internal reference cell resulting in unusually low r^2 values under conditions in which the concentration of NH_3 was more than three times of the MDL, and 2) reduce the reported concentration. Adjustments made on the instrument at this time did not appear to affect the calibration (conducted before and after adjustments) but did change the maximum r^2 reached by the instrument when in the field for long path lengths and high humidity.

A zero concentration is not reportable by this instrument because the concentration is based on the correlation of the measured NH_3 absorption to a reference gas. No measured absorption at zero concentration results in no correlation and consequently no reportable measurement. The MDL of the instrument was determined from the mean of the variability (3 times the standard deviation) experienced at the verification concentration during each calibration verification. Since the calibration verifications were conducted in a very short path length, the water vapor effect on the instrument response was generally not detectable. The MDL was calculated to be 2.04 ppm-m prior to the July 2008 modification and 1.77 ppm-m after the modification. The instrument performance was within the MDL DQI that required the MDL to be less than 10 ppm-m. The calibration equation offset was less than the requisite DQI MDL.

Instrument performance calibration checks (Figure 6.1-2) were made at the beginning and end of each measurement period. The majority of calibration checks were made within 21 d (Figure 6.1-3). The large fraction of checks made within 7 d is the result of calibration checks made at the end and beginning of sequential measurement periods. The standard deviation of the verifications about that predicted by the calibration equation was 8.27 ppm-m. The precision DQI was ±10% RSD at 100 ppm-m. All verifications resulted in less than 10% RSD for 50 ppm-m (Figure 6.1-2) and well within the precision DQI. The accuracy DQI was ± 10% of the 1000 ppm-m range of the measurements. A positive bias in the calibration verification exceeding the DQI occurred on 4/28/2009 and 11/10/2009 while negative biases exceeding the DQI occurred over the period 4/2/2008 through 7/1/2008 (Figure 6.1-2). The 4/28/2009 and

11/10/2009 bias exceedences were followed the same or next day with a passing verification and was deemed to be a result of operator error. The negative bias over the period 4/2/2008 through 7/1/2008 was not a result of calibration cylinder certification error (three different cylinders were used). During operations the bias was only intermittently evident because to different multipoint calibration was applied to the calibration verification measurements during the progress of the study than finally applied during the analysis. Repeated calibrations within 24 h often showed biases differing by more than 10 ppm-m suggesting operator errors. Although this instrument had a bias associated with water vapor interference, the instrument was in use in dry climates during this time. The measurements made during this period are considered valid and the error assumed to be due to the calibration verification operator.

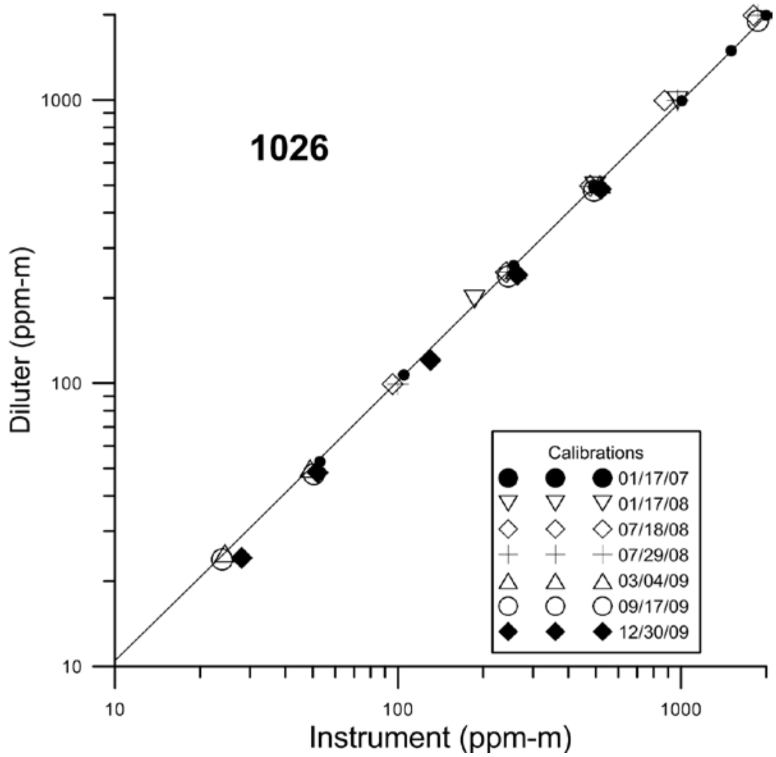


Figure 6.1-1: Multipoint calibrations of the GasFinder2 TM s/n NH3OP-1026. The solid line is the 3rd order polynomial regression for the chosen multipoint calibration.

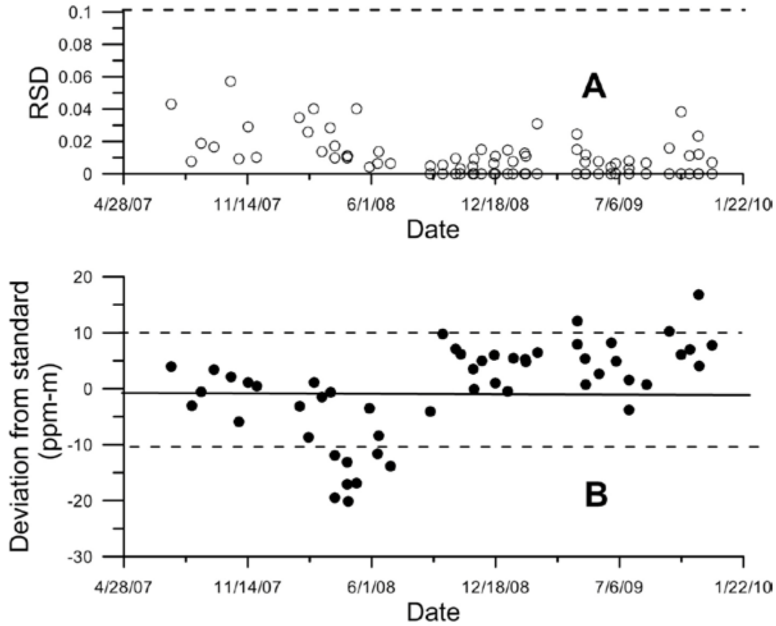


Figure 6.1-2: Control charts of the GasFinder2 TM s/n NH3OP-1026

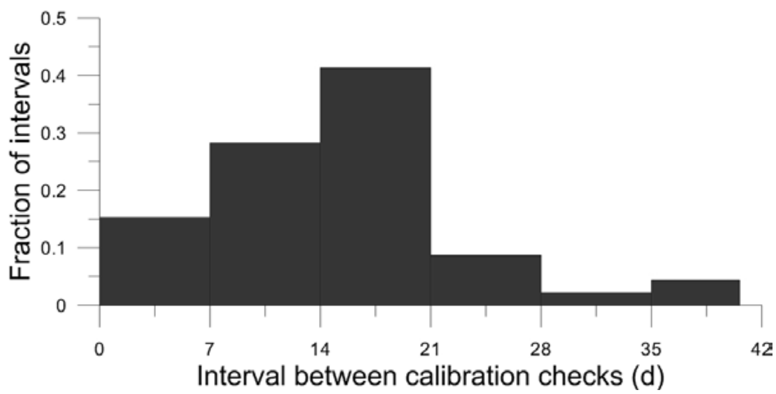


Figure 6.1-3: Calibration check intervals of the GasFinder2 TM s/n NH3OP-1026

TDLAS 1027 was multipoint calibrated eight times during the study (Figure 6.1-4). The response is non-linear and consequently a third-order polynomial was used to correct the instrument measurements for the instrument response. The multipoint calibration on 6/18/2008 was used for the entire study period. The offset of the equation was determined from a least squares fit of the entire record of calibration verifications made at 50 ppm-m applied to the first, second, and third order terms derived from the multipoint calibration. The regression equation was:

$$\text{ppm-m} = 2.24 + 0.9936 * X - 3.59E\text{-}5 * X^2 + 6.230E\text{-}8 * X^3$$

where X is the instrument response. The response of the sensor was influenced by humidity until 7/21/2008 due to an error in the factory settings for the spectral waveband analysis window. At that time, factory personnel corrected the spectral waveband used for analysis. The effect of this error was to 1) reduce the maximum possible linear correlation with the internal reference cell resulting in unusually low r^2 values under conditions in which the concentration of NH_3 was more than three times of the MDL, and 2) reduce the reported concentration. Adjustments made on the instrument at this time did not appear to affect the calibration (conducted before and after adjustments) but did change the maximum r^2 reached by the instrument when in the field for long path lengths and high humidity.

A zero concentration is not reportable by this instrument because the concentration is based on the correlation of the measured NH_3 absorption to a reference gas. No measured absorption at zero concentration results in no correlation and consequently no reportable measurement. The MDL of the instrument was determined from the mean of the variability (3 times the standard deviation) experienced at the verification concentration during each calibration verification. Since the calibration verifications were conducted in a very short path length, the water vapor effect on the instrument response was generally not detectable. The MDL was calculated to be 2.13 ppm-m prior to the July 2008 modification and 1.83 ppm-m after the modification. The instrument performance was within the MDL DQI that required the MDL to be less than 10 ppm-m. The calibration equation offset was less than the requisite DQI MDL.

Instrument performance calibration checks (Figure 6.1-5) were made at the beginning and end of each measurement period. The majority of calibration checks were made within 21 d (Figure 6.1-6). The large fraction of checks made within 7 d is the result of calibration checks made at the end and beginning of sequential measurement periods. The standard deviation of the verifications about that predicted by the calibration equation was 5.36 ppm-m. The precision DQI was ± 0% RSD at 100 ppm-m. All verifications resulted in less than 10% RSD for 50 ppm-m (Figure 6.1-5) and well within the precision DQI. The accuracy DQI was ± 10% of the 1000 ppm-m range of the measurements. A positive bias in the calibration verification exceeding the DQI occurred on 9/26/2008 and 9/24/2009 (Figure 6.1-4). No negative biases exceeding the DQI occurred. Since both positive bias exceedences were followed by a DQI compliant verification on the subsequent calibration verification without intervention, it is assumed that operator error was the cause for the non-compliance.

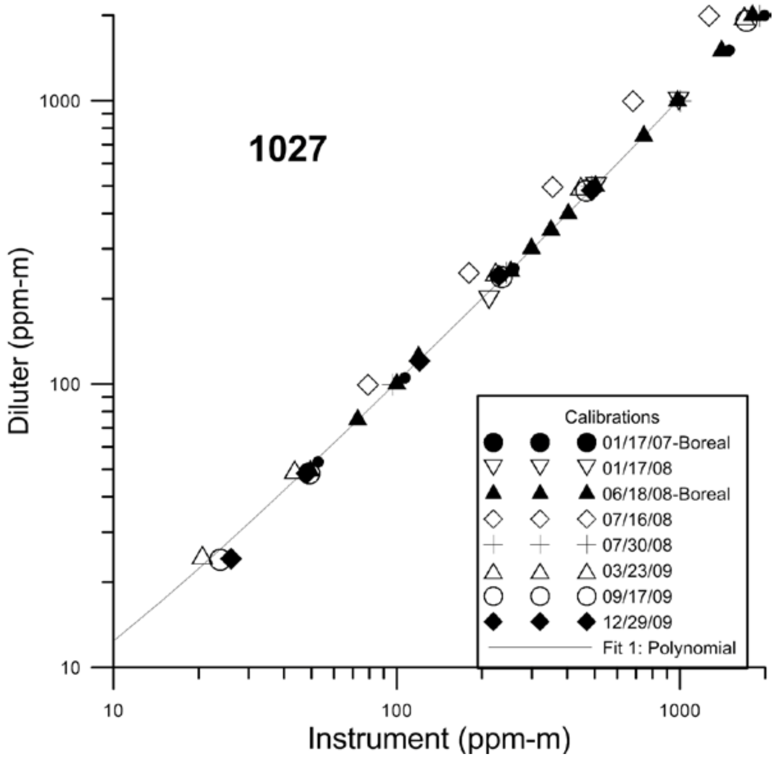


Figure 6.1-4: Multipoint calibrations of the GasFinder2 ™ s/n NH3OP-1027. The solid line is the 3rd order polynomial regression for the chosen multipoint calibration.

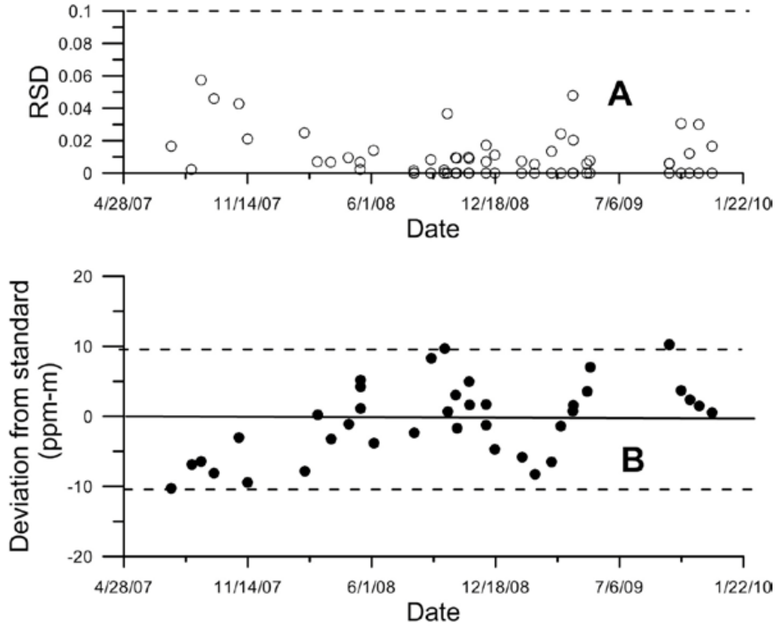


Figure 6.1-5: Control charts of the GasFinder2 ™ s/n NH3OP-1027

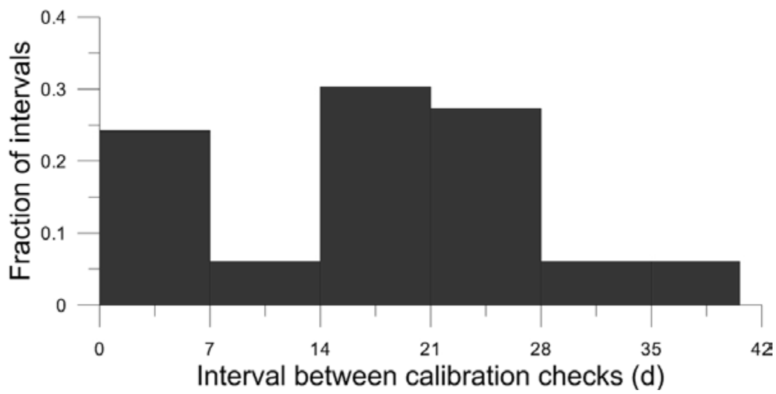


Figure 6.1-6: Calibration check intervals of the GasFinder2 ™ s/n NH3OP-1027

TDLAS 1028 was multipoint calibrated six times during the study (Figure 6.1-7). The response is non-linear and consequently a third-order polynomial was used to correct the instrument measurements for the instrument response. The multipoint calibration on 5/23/2007 was used for the entire study period. The offset of the equation was determined from a least squares fit of the entire record of calibration verifications made at 50 ppm-m applied to the first, second, and third order terms derived from the multipoint calibration. The regression equation was:

$$\text{ppm-m} = 1.46 + 0.985 * X + 8.465E\text{-}6 * X^2 + 3.879E\text{-}8 * X^3$$

where X is the instrument response. The response of the sensor was influenced by humidity until 7/21/2008 due to an error in the factory settings for the spectral waveband analysis window. At that time, factory personnel corrected the spectral waveband used for analysis. The effect of this error was to 1) reduce the maximum possible linear correlation with the internal reference cell resulting in unusually low r^2 values under conditions in which the concentration of NH_3 was more than three times of the MDL, and 2) reduce the reported concentration. Adjustments made on the instrument at this time did not appear to affect the calibration (conducted before and after adjustments) but did change the maximum r^2 reached by the instrument when in the field for long path lengths and high humidity.

A zero concentration is not reportable by this instrument because the concentration is based on the correlation of the measured NH_3 absorption to a reference gas. No measured absorption at zero concentration results in no correlation and consequently no reportable measurement. The MDL of the instrument was determined from the mean of the variability (3 times the standard deviation) experienced at the verification concentration during each calibration verification. Since the calibration verifications were conducted in a very short path length, the water vapor effect on the instrument response was generally not detectable. The MDL was calculated to be 2.48 ppm-m prior to the July 2008 modification and 1.91 ppm-m after the modification. The instrument performance was within the MDL DQI that required the MDL to be less than 10 ppm-m. The calibration equation offset was less than the requisite DQI MDL.

Instrument performance calibration checks (Figure 6.1-8) were made at the beginning and end of each measurement period. The majority of calibration checks were made within 21 d (Figure 6.1-9). The large fraction of checks made within 7 d was the result of calibration checks made at the end and beginning of sequential measurement periods. The standard deviation of the verifications about that predicted by the calibration equation was 6.46 ppm-m. The precision DQI was ±10% RSD at 100 ppm-m. All verifications resulted in less than 10% RSD for 50 ppm-m (Figure 6.1-8) and well within the precision DQI. The accuracy DQI was ± 10% of the 1000 ppm-m range of the measurements. A positive bias in the calibration verification exceeding the DQI occurred on three dates (9/26/2008, 10/1/20008 and 9/24/2009) while negative biases exceeding the DQI occurred on 12/16/2008 (Figure 6.1-8). In all cases except the short 9/24/2008 through 10/1/2008 period, subsequent calibration verifications did not indicate the same exceedence bias and it is concluded that operator error resulted in the exceedences rather than instrument failure.

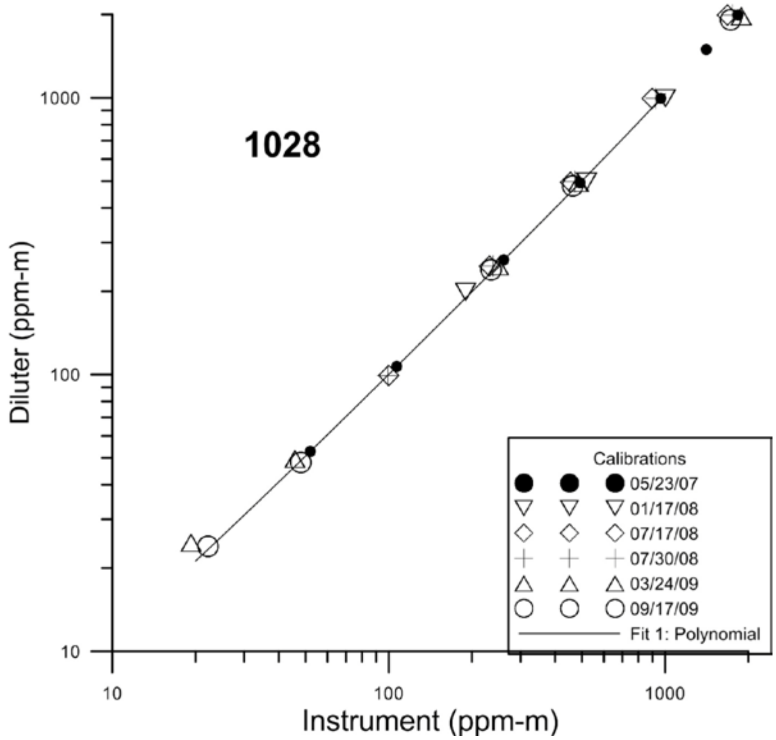


Figure 6.1-7-Multipoint calibrations of the GasFinder2 ™ s/n NH3OP-1028. The solid line is the 3rd order polynomial regression for the chosen multipoint calibration.

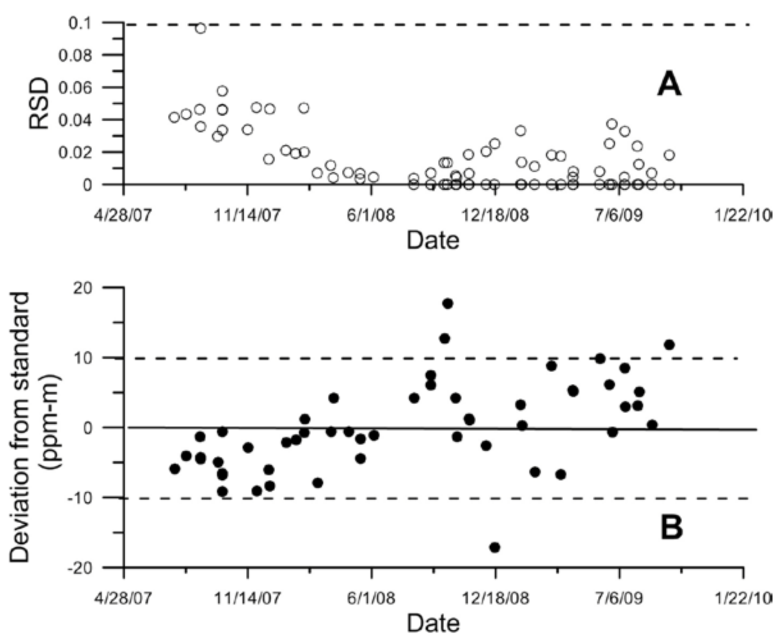


Figure 6.1-8 – Control charts of the GasFinder2 ™ s/n NH3OP-1028

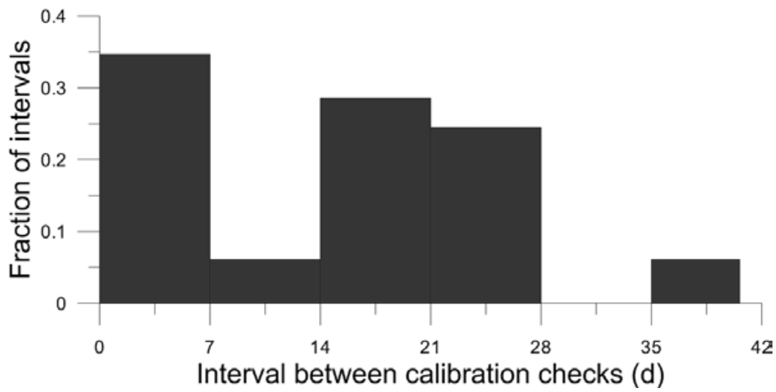


Figure 6.1-9- Calibration check intervals of the GasFinder2 ™ s/n NH3OP-1028

TDLAS 1029 was multipoint calibrated seven times during the study (Figure 6.1-10). The response is non-linear and consequently a third-order polynomial was used to correct the instrument measurements for the instrument response. Table 6.1-1 indicated the multipoint calibrations used during different periods in the study.

Table 6.1-1- Multipoint calibration application

Period of applicability (mm/dd/yyyy)		
Begin	**End**	**Multipoint calibration**
6/24/2007	3/1/2008	5/24/2007
3/24/2008	7/15/2008	3/24/2008
7/31/2008	8/3/2009	3/4/2009
8/4/2009	12/2/2009	12/29/2009

The offsets of the calibration equations were determined from a least squares fit of the appropriate period (Table 6.1-1) of calibration verifications made at 50 ppm-m applied to the first, second, and third order terms derived from the multipoint calibrations. The regression equations were:

5/24/2007: ppm-m = $-1.48 + 0.967 * X + 4.842E\text{-}005 * X^2 - 7.312\text{-}009 * X^3$

3/24/2008: ppm-m = $-2.58 + 0.998 * X - 1.611E\text{-}004 * X^2 + 7.449E\text{-}008 * X^3$

3/4/2009: ppm-m = $4.36 + 1.069 * X + 1.128\text{-}004 * X^2 - 1.206E\text{-}007 * X^3$

12/29/2009: ppm-m = $5.48+ 1.268 * X - 6.072E\text{-}005 * X^2$

where X is the instrument response. In July 2008 factory representatives adjusted the response of this unit. Adjustments made on the instrument at this time did not appear to affect the calibration (conducted before and after adjustments).

A zero concentration is not reportable by this instrument because the concentration is based on the correlation of the measured NH_3 absorption to a reference gas. No measured absorption at zero concentration results in no correlation and consequently no reportable measurement. The MDL of the instrument was determined from the mean of the variability (3 times the standard deviation) experienced at the verification concentration during each calibration verification. Since the calibration verifications were conducted in a very short path length, the water vapor effect on the instrument response was generally not detectable. The MDL was calculated to be 2.74 ppm-m prior to the July 2008 modification and 1.66 ppm-m after the modification. The instrument performance was within the MDL DQI that required the MDL to be less than 10 ppm-m. The MDL prior to the July 2008 modification was greater than the offset in the calibration regression equations but less than the offset in the calibration equations after the modification. The calibration equation offset was less than the requisite DQI MDL.

Instrument performance calibration checks (Figure 6.1-11) were made at the beginning and end of each measurement period. The majority of calibration checks were made within 21 d (Figure 6.1-12). The large fraction of checks made within 7 d was the result of calibration checks made at the end and beginning of sequential measurement periods. The standard deviation of the verifications about that predicted by the calibration equations was 4.65, 4.15, 5.23, and 4.27 ppm-m respectively. The precision DQI was ±10% RSD at 100 ppm-m. All verifications resulted in less than 10% RSD for 50 ppm-m (Figure 6.1-11) and well within the precision DQI. The accuracy DQI was ± 10% of the 1000 ppm-m range of the measurements. A negative bias exceeding the DQI threshold occurred on two dates (Figure 6.1-11). No positive bias exceeding the DQI threshold occurred. In all cases subsequent calibration verifications did not indicate the same exceedence bias and it is concluded that operator error resulted in the exceedences rather than instrument failure.

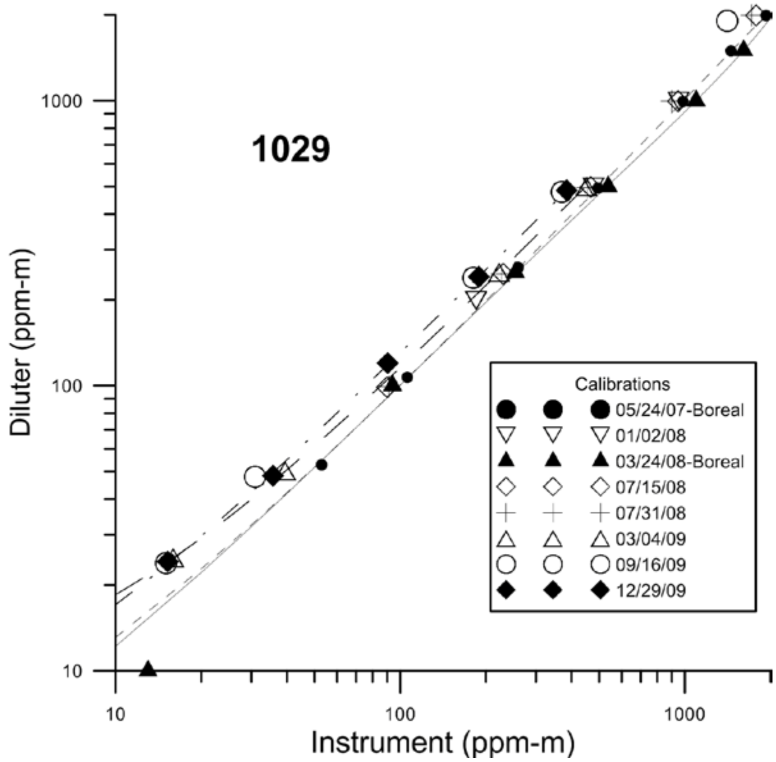


Figure 6.1-10: Multipoint calibrations of the GasFinder2 ™ s/n NH3OP-1029. The solid (5/24/2007), dotted (3/24/2008), dashed (3/4/2009) and dash-dot (12/29/2009) lines are the 3rd order polynomial regression for the chosen multipoint calibration.

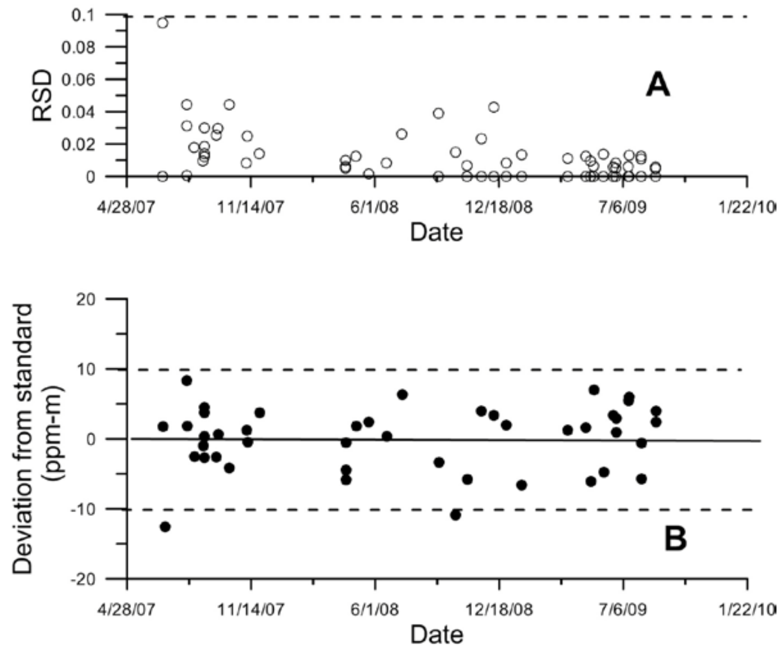


Figure 6.1-11: Control charts of the GasFinder2 TM s/n NH3OP-1029

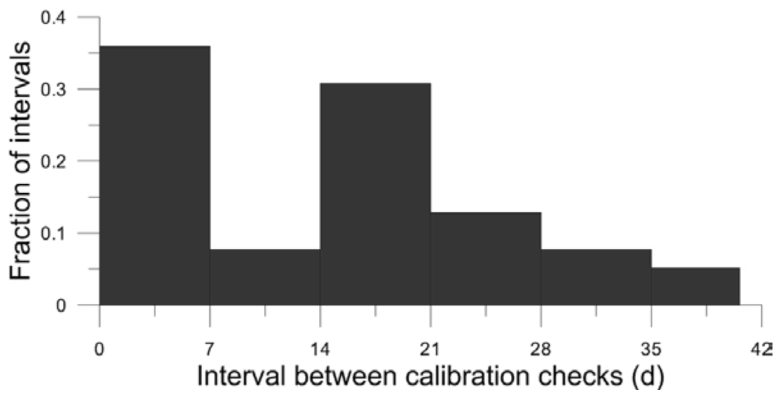


Figure 6.1-12: Calibration check intervals of the GasFinder2 TM s/n NH3OP-1029

TDLAS 1031 was multipoint calibrated six times during the study (Figure 6.1-13). The response is non-linear and consequently a third-order polynomial was used to correct the instrument measurements for the instrument response. The multipoint calibration on 5/30/2007 was used for the entire study period. The offset of the equation was determined from a least squares fit of the entire record of calibration verifications made at 50 ppm-m applied to the first, second, and third order terms derived from the multipoint calibration. The regression equation was:

$$\text{ppm-m} = -4.43 + 1.0120 * X - 5.7496\text{E-}005 * X^2 + 6.0196\text{E-}008 * X^3$$

where X is the instrument response. In July 2008 factory representatives adjusted the response of this unit. Adjustments made on the instrument at this time did not appear to affect the calibration (conducted before and after adjustments).

A zero concentration is not reportable by this instrument because the concentration is based on the correlation of the measured NH_3 absorption to a reference gas. No measured absorption at zero concentration results in no correlation and consequently no reportable measurement. The MDL of the instrument was determined from the mean of the variability (3 times the standard deviation) experienced at the verification concentration during each calibration verification. Since the calibration verifications were conducted in a very short path length, the water vapor effect on the instrument response was generally not detectable. The MDL was calculated to be 5.70 ppm-m prior to the July 2008 modification and 1.92 ppm-m after the modification. The instrument performance was within the MDL DQI that required the MDL to be less than 10 ppm-m. The average MDL was approximately equal to the offset indicated in the calibration regression. The calibration equation offset was less than the requisite DQI MDL.

Instrument performance calibration checks (Figure 6.1-14) were made at the beginning and end of each measurement period. The majority of calibration checks were made within 21 d (Figure 6.1-15). The large fraction of checks made within 7 d was the result of calibration checks made at the end and beginning of sequential measurement periods. The standard deviation of the verifications about that predicted by the calibration equation was 15.60 ppm-m. The precision DQI was ±10% RSD at 100 ppm-m. All verifications resulted in less than 10% RSD for 50 ppm-m (Figure 6.1-14) and well within the precision DQI. The accuracy DQI was ±10% of the 1000 ppm-m range of the measurements. A negative bias exceeding the DQI occurred in the calibration verifications between 8/2/2007 and 9/18/2007 (Figure 6.1-14). Positive DQI bias exceedences occurred on 6/28/2007, 9/11/2008, 4/8/2009 and 8/12/2009. Verification failures in the 6/28/2007 to 9/18/2007 interval were a result of un-anticipated optical noise in the calibration procedure which was later corrected. The 4/8/2009 exceedence was preceded and followed by DQI-compliant verifications and the 8/12/2009 verification was preceded by a compliant verification and followed by a multi-point indicating no problem with instrument performance. The instrument was taken out of service between 9/11/2008 and 12/31/2008.

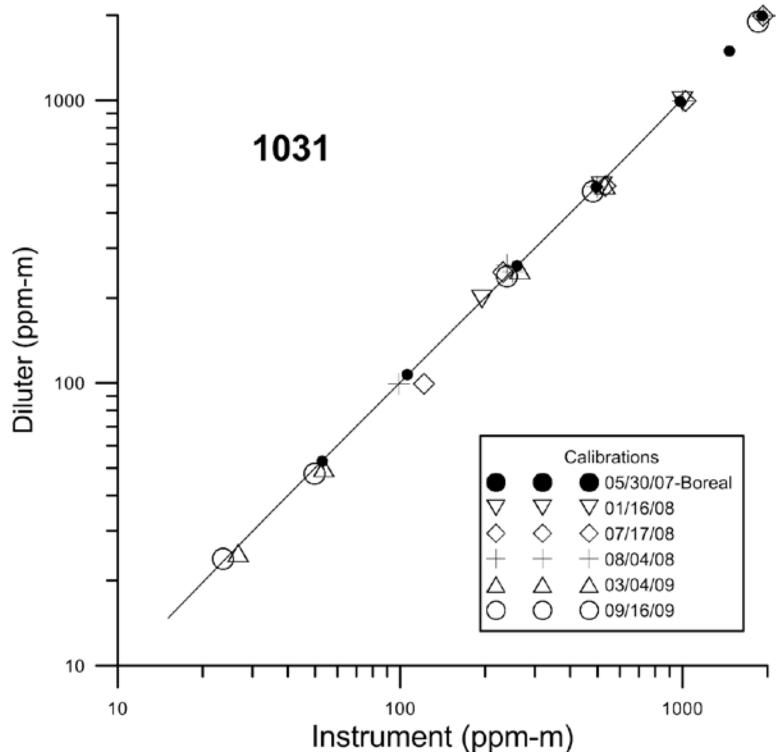


Figure 6.1-13: Multipoint calibrations of the GasFinder2 ™ s/n NH3OP-1031. The solid line is the 3rd order polynomial regression for the chosen multipoint calibration.

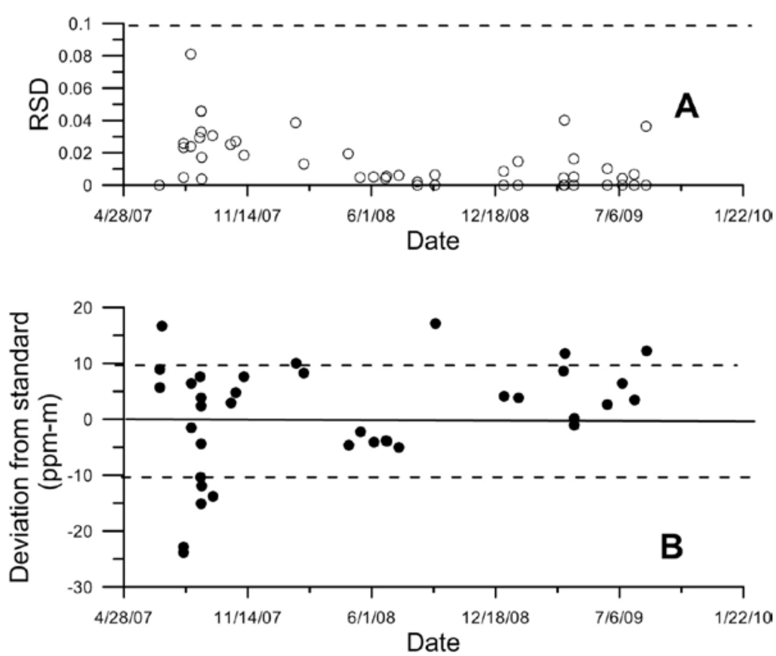


Figure 6.1-14: Control charts of the GasFinder2 ™ s/n NH3OP-1031

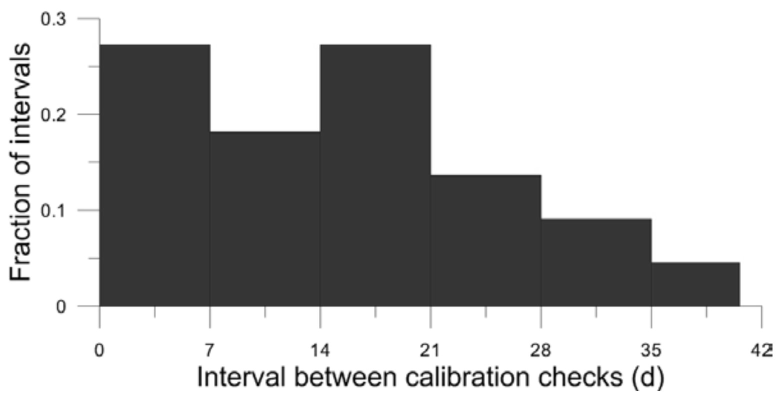


Figure 6.1-15: Calibration check intervals of the GasFinder2 ™ s/n NH3OP-1031

TDLAS1032 was multipoint calibrated six times during the study (Figure 6.1-16). The response is non-linear and consequently a third-order polynomial was used to correct the instrument measurements for the instrument response. Table 6.1-2 indicates the multi-point calibrations used during different periods in the study.

Table 6.1-2- Multi-point calibration application

Period of applicability (mm/dd/yyyy)		
Begin	**End**	**Multipoint calibration**
9/21/2007	8/1/2008	9/12/2007
8/27/2008	8/18/2009	3/4/2009

The offset of the calibration equation was determined from a least squares fit of the appropriate period (Table 1) of calibration verifications made at 50 ppm-m applied to the first, second, and third order terms derived from the multipoint calibrations. The regression equations were:

9/12/2007: $\text{ppm-m} = -4.35 + 1.005 * X + 3.563\text{ E-005} * X^2 - 2.618\text{ E-008} * X^3$

3/4/2009: $\text{ppm-m} = -0.69 + 0.995 * X - 2.3298\text{ E-004} * X^2 + 2.891\text{ E-007} * X^3$

where X is the instrument response. In July 2008 factory representatives adjusted the response of this unit. Adjustments made on the instrument at this time did not appear to affect the calibration (conducted before and after adjustments). The laser was found on 7/21/2008 to not be internally grounded properly, resulting is the inclusion of responses at very low light levels. The no-return light levels were above the minimum light level threshold considered for a valid instrument measurement.

A zero concentration is not reportable by this instrument because the concentration is based on the correlation of the measured NH_3 absorption to a reference gas. No measured absorption at zero concentration results in no correlation and consequently no reportable measurement. The MDL of the instrument was determined from the mean of the variability (3 times the standard deviation) experienced at the verification concentration during each calibration verification. Since the calibration verifications were conducted in a very short path length, the water vapor effect on the instrument response was generally not detectable. The MDL was calculated to be 2.60 ppm-m prior to the July 2008 modification and 1.36 ppm-m after the modification. The instrument performance was within the MDL DQI that required the MDL to be less than 10 ppm-m. The MDL was greater than the offset in the calibration equation for measurements prior to July 2008 and less than that after July 2008. The calibration equation offset was less than the requisite DQI MDL.

Instrument performance calibration checks (Figure 6.1-17) were made at the beginning and end of each measurement period. The majority of calibration checks were made within 21 d (Figure 6.1-18). The large fraction of checks made within 7 d is the result of calibration checks made at the end and beginning of sequential measurement periods. The standard deviation of the verifications about that predicted by the calibration equation was 6.13 and 5.61 ppm-m respectively. The precision DQI was ±10% RSD at 100 ppm-m. All verifications resulted in less than 10% RSD for 50 ppm-m (Figure 6.1-17) and well within the precision DQI. The accuracy DQI was ±10% of the 1000 ppm-m range of the measurements. A positive bias exceeding the DQI occurred on 3/26/2008 and 9/10/2008 (Figure 6.1-17). These exceedences were preceeded and followed by valid calibration verifications and it is assumed that since no modifications of the instrument were made that the exceedences are due to operator error. A negative bias exceeding the DQI was indicated in the calibration verifications on 5/6/2008 (Figure 6.1-17). The grounding problem found on 7/21/2008 (described above) may have been the cause for the period of consistently negative verifications after 4/21/2008 when the background light levels exceeded the minimum acceptable light level. However since the 5/6/2008 exceedence was followed by compliant verifications (although low) without correction of the grounding problem it is assumed that the measurements are valid throughout the period of the grounding problem.

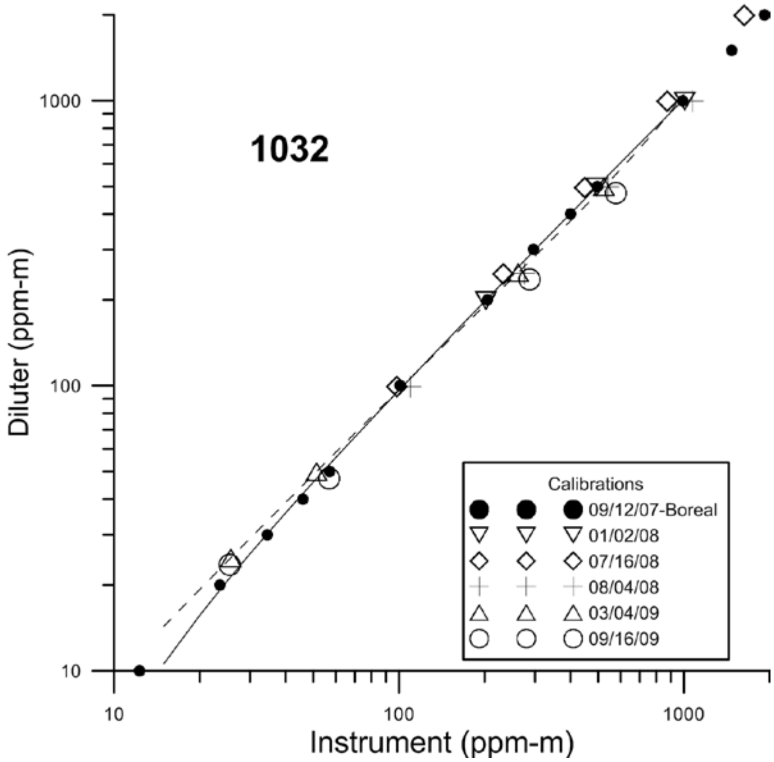


Figure 6.1-16: Multipoint calibrations of the GasFinder2 ™ s/n NH3OP-1032. The solid (9/12/2007) and dashed (3/4/2009) lines are the 3rd order polynomial regressions for the chosen multipoint calibration.

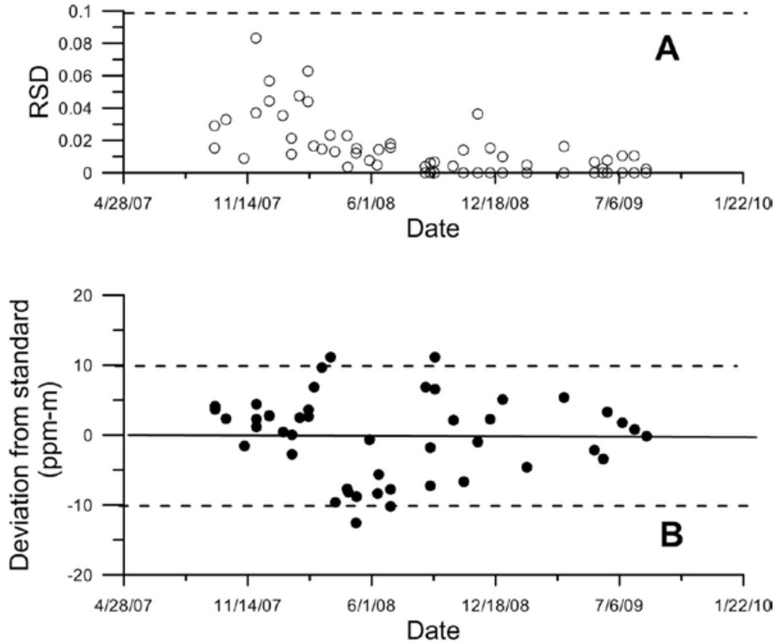


Figure 6.1-17: Control charts of the GasFinder2 TM s/n NH3OP-1032

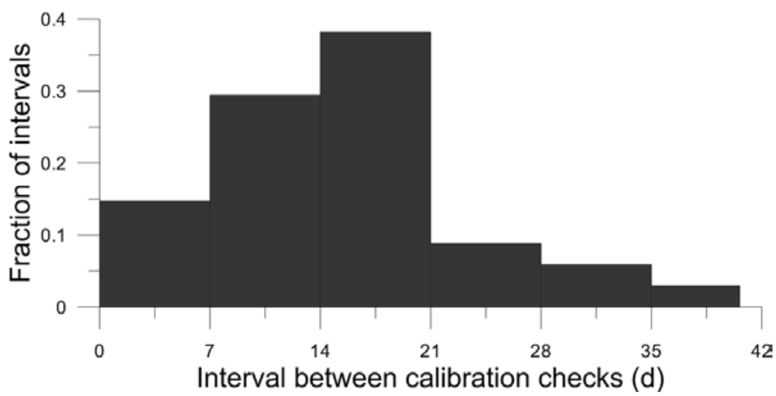


Figure 6.1-18: Calibration check intervals of the GasFinder2 TM s/n NH3OP-1032

6.2 TEC 450i analyzer H_2S calibrations

The H_2S Analyzer (Model TEC 450i, Thermo Fisher Scientific, Franklin, MA) with serial number 0733825128 was multipoint calibrated eight times during the study (Figure 6.2-1). The coefficient of determination (r^2) for linear fits to the calibration values were never less than 0.999 although the slope of the linear regression equation varied from 0.73 to 1.38 (Table 6.2-1). Part of the variation in slope was a result of the H_2S calibration cylinders used. The initial multipoint calibration was conducted prior to the complete burn-in of the converter and consequently differs greatly from the other calibrations.

Table 6.2-1: Multipoint H_2S calibrations

Date	Slope (ppb/response)	Intercept (ppb)	r^2
12/12/2007	1.38	0.0220	0.999
7/11/2008	0.99	0.0034	0.999
8/13/2008	1.18	-0.0045	0.999
9/4/2008	1.22	0.0065	0.999
3/25/2009	0.73	0.0068	0.999
6/19/2009	1.14	-0.0037	0.999
6/24/2009	0.75	0.0075	0.999
9/9/2009	1.14	-0.0052	0.999

The standard deviation of instrument response with CEM zero air measured over a one hour period was 0.83 ppb (10/19/2009). The instrument MDL, defined as 3σ was 2.5 ppb and is indicated in Figure 2A with dashed lines. This is much less than the mean absolute multipoint calibration intercept concentration of 7.5 ppb.

Instrument performance calibration checks (Figure 6.2-2, 6.2-3) were made at the beginning and end of each measurement period. The majority of calibration checks were made within 21 d (Figure 6.2-4). The large fraction of checks made within 7 days is the result of calibration checks made at the end and beginning of sequential measurement periods. Instrument response was converted into measured concentrations by multiplying the instrument response by the long-term mean ratio of diluted calibration gas by instrument reading. The long-term mean ratio for this instrument was 0.788. The mean zero concentration was +1.7 ppb, less than the MDL.

The instrument measurement accuracy DQI was 10% of full scale (FS; 1 ppm). Three major periods of instrument bias that exceeded the ± 10% of FS are evident (Figure 6.2-2). The first period extends from the beginning of the measurements until 9/5/2008. Based on the correlation of instrument performance and the calibration cylinder used, it was determined that the concentration of H_2S in the SGAL053 cylinder, which could not be independently verified, was significantly below indicated specification. This resulted in unusually high ratios of diluter concentration versus instrument response (1.01 to 1.18) up until when the cylinder was replaced. The second period was from 11/4/2008 to 12/16/2008 when the calibration checks were inconsistent. Checks conducted on 11/04 and 12/16 at the end of measurement periods failed while checks made two days later at the set up of the next site passed. Since no modifications/repairs of the instruments were done in the interim between these calibrations, we assume that the FOS must have erred in their procedures.

The third period of calibration check failures occurred after April 2009. High zero checks (Figure 6.2-2A) and low reference checks (Figure 6.2-2B) occurred throughout this time. The instrument response time was found to be unusually long (11 min versus typical 5 min) when specifically checked in July 2009. After the prescribed 10 min interval specified in the S-OPS the response was only 59% of the span value when the long time constant was discovered. Given the S-OPS reference value of 0.5 ppm, the 59% response after 10 min corresponds to approximately 0.2 ppm less than the stabilized reference value. The control chart of the calibration checks (Figure 6.2-2) show a shift in response of approximately -0.2 ppm occurring in May 2009 and continuing through July 2009 but appeared to return to normal operation in August 2009. This change in time response occurred during dusty conditions when the equipment was at WA5A. The change in response resulted in two multipoint calibrations in the field (Table 6.2-1).

The instrument measurement precision DQI was 10% of FS. Precision DQI exceedences (Figure 6.2-3) occurred on 9/5/2008, 6/4/2009 and 8/4/2009. The failure on 9/5/2008 was associated with a change in calibration cylinder (from SGAL053 to FF27944). As previously discussed, it is believed that the certified concentration in SGAL053 was low, resulting a significant shift in the measured diluter concentration when the new cylinder was begun to be used. The failure on 6/4/2009 and 8/4/2009 are probably associated with variable response the instrument during the period of the shift in response time of the instrument.

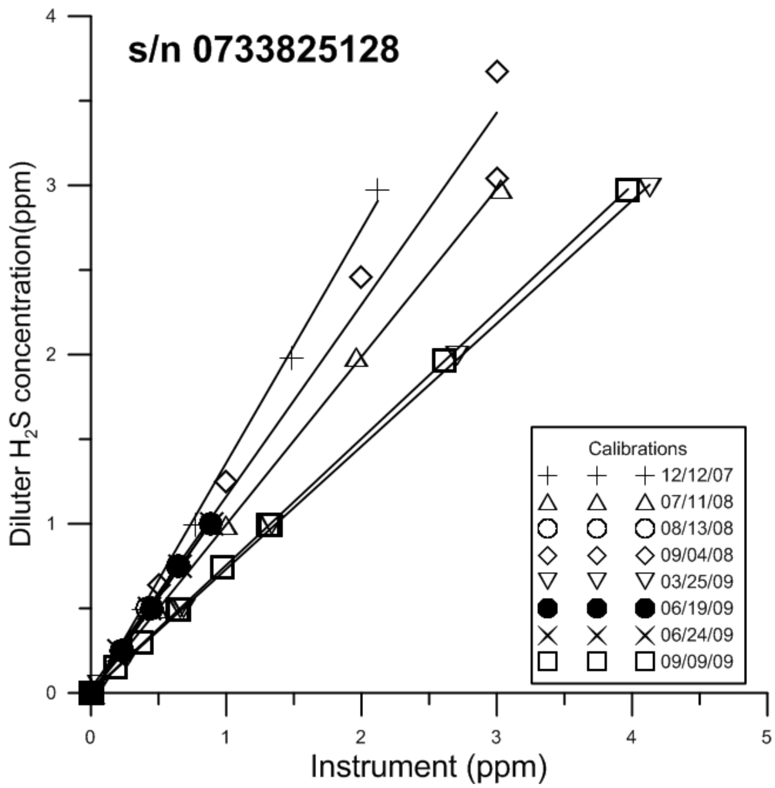


Figure 6.2-1: Multipoint calibrations of the 450i SO_2/H_2S Analyzer

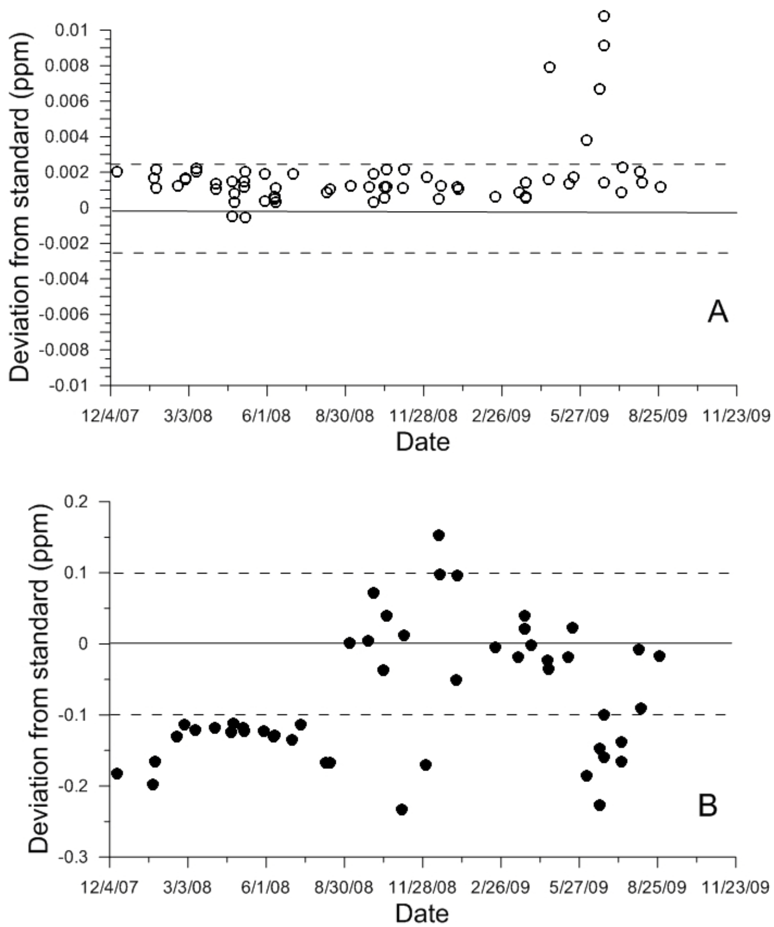


Figure 6.2-2: Instrument Control Charts.

The zero check (panel A) and span check (panel B) are indicated. The dashed lines in panel A represent the MDL. The dashed lines in panel B represent 10% of the Full Scale value (1 ppm).

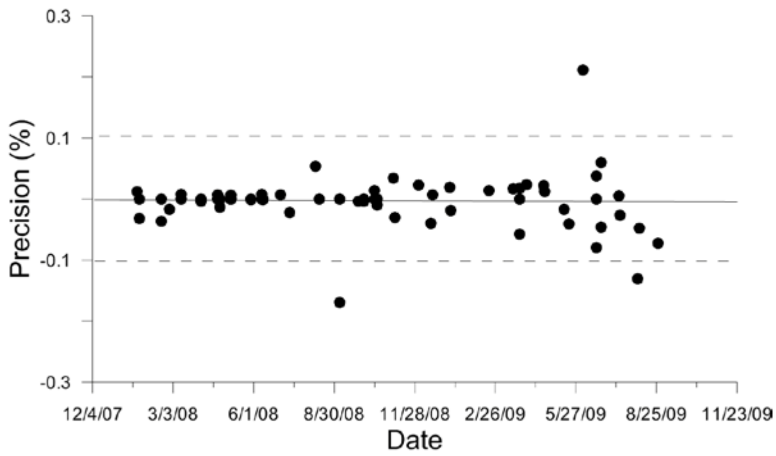


Figure 6.2-3: Instrument Precision

The precision of span checks are indicated. The dashed lines in panel A represent the MDL. The dashed lines represent 10% of the Full Scale value (1 ppm).

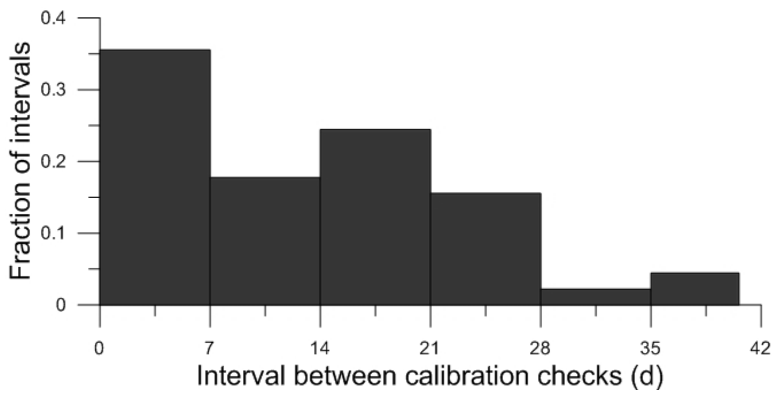


Figure 6.2-4: Calibration check intervals

6.3 Sonic anemometer calibrations

Six sonic anemometers (Model 81000, RM Young Inc., Traverse City, MI) were used at this location: serial numbers 1920, 1921, 1927, 1928, 1932, and 1936.

Sonic anemometer 1927 was inter-compared with three standard anemometers of identical design five times during the study (Table 6.3-1). No absolute turbulence calibration is possible with this instrument. To assure proper performance and comparability in the wind measurements, the anemometer was inter-compared on-site with those used during a given measurement period at the beginning and end of a measurement period. This instrument was inter-compared with the co-located anemometer sensors on site 35 times (Figure 6.3-1). The majority of calibration checks were made within 21 d (Figure 6.3-2). The large fraction of checks made within 7 d is the result of calibration checks made at the end and beginning of sequential measurement periods.

The accuracy DQI for the on-site inter-comparisons required the individual instruments to have the mean wind speed within 0.2 ms^{-1} of the grand mean value of the three (or four) on-site instruments (Figure 6.3-1B). This instrument passed this check on all checks except 9/23-25/2008 and was taken out of service. Laboratory testing indicated wetness in the sensor. The sensor was dried, tested, and put back in use.

The precision DQI for the on-site inter-comparisons required each wind component (x, y, and z) of the individual instruments to be within 0.3 ms^{-1} of zero (Figure 6.3-1A). Records of the zero checks made before 12/2007 were recorded as pass/fail- not indicating the actual measurements. The instrument always passed this DQI.

Table 6.3-1: Standards inter-comparisons

Calibration date		Mean difference from reference anemometers (ms^{-1})	
Alignment 1	**Alignment 2**	**Alignment 1**	**Alignment 2**
6/8-12/2007	6/12-14/2007	-0.025	-0.043
1/21/2008	1/23/2008	-0.051	-0.033
7/16-17/2008	7/17-18/2008	+0.042	+0.029
3/23-25/2009	3/25-27/2009	-0.050	-0.028
9/1-2/2009	9/2-3/2009	-0.035	-0.023

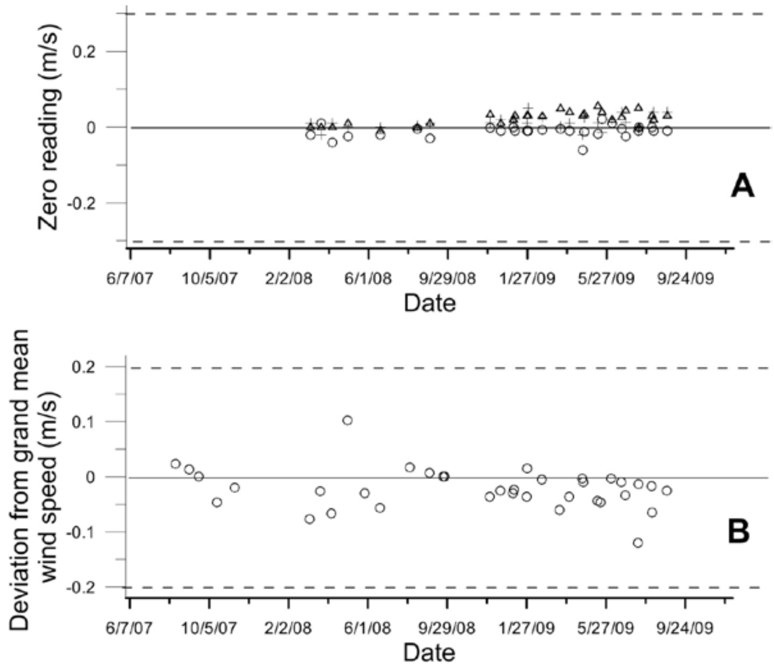


Figure 6.3-1: On-site quality assurance, s/n 1927. The DQI for the zero and inter-comparisons are indicated by the dashed lines. The zero check in the x (open circle), y (open triangle) and z (cross) components are indicated in panel A.

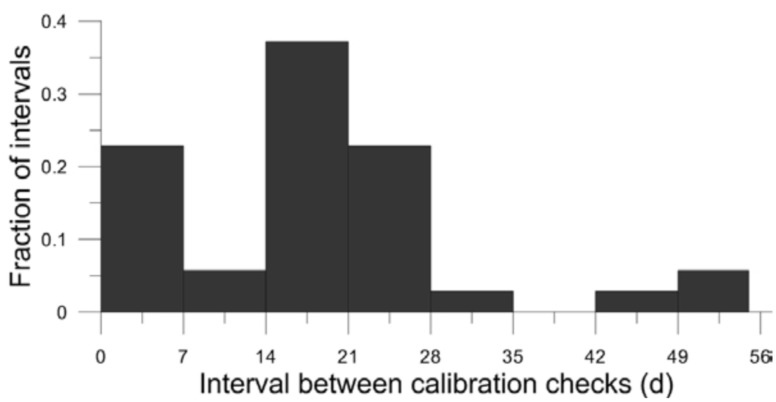


Figure 6.3-2: Inter-comparison check intervals, s/n 1927

Sonic anemometer 1920 was inter-compared with three standard anemometers of identical design five times during the study (Table 6.3-2). No absolute turbulence calibration is possible with this instrument. To assure proper performance and comparability in the wind measurements, the anemometer was inter-compared on-site with those used during a given measurement period at the beginning and end of a measurement period. This instrument was inter-compared with the co-located anemometer sensors on site 51 times (Figure 6.3-3). The majority of calibration checks were made within 21 d (Figure 6.3-4). The large fraction of

checks made within 7 d is the result of calibration checks made at the end and beginning of sequential measurement periods.

The accuracy DQI for the on-site inter-comparisons required the individual instruments to have the mean wind speed within 0.2 ms^{-1} of the grand mean value of the three (or four) on-site instruments (Figure 6.3-3B). This instrument passed this check at all times. However this instrument developed intermittent problems during operation and was sent to the factory for repair 10/10/2008.

The precision DQI for the on-site inter-comparisons required each wind component (x, y, and z) of the individual instruments to be within 0.3 ms^{-1} of zero (Figure 6.3-3A). Records of the zero checks made before 12/2007 were recorded as pass/fail- not indicating the actual measurements. The instrument always passed this DQI.

Table 6.3-2: Standards inter-comparisons

Calibration date		**Mean difference from reference anemometers (ms^{-1})**	
Alignment 1	**Alignment 2**	**Alignment 1**	**Alignment 2**
6/19-22/2007	6/29 - 7/2/2007	+0.001	+0.002
1/17-19/2008	1/20-21/2008	+0.045	+0.003
7/18-21/2008	7/21-22/2008	+0.017	-0.006
3/23-25/2009	3/25-27/2009	-0.036	-0.033
9/1-2/2009	9/2-3/2009	-0.046	-0.025

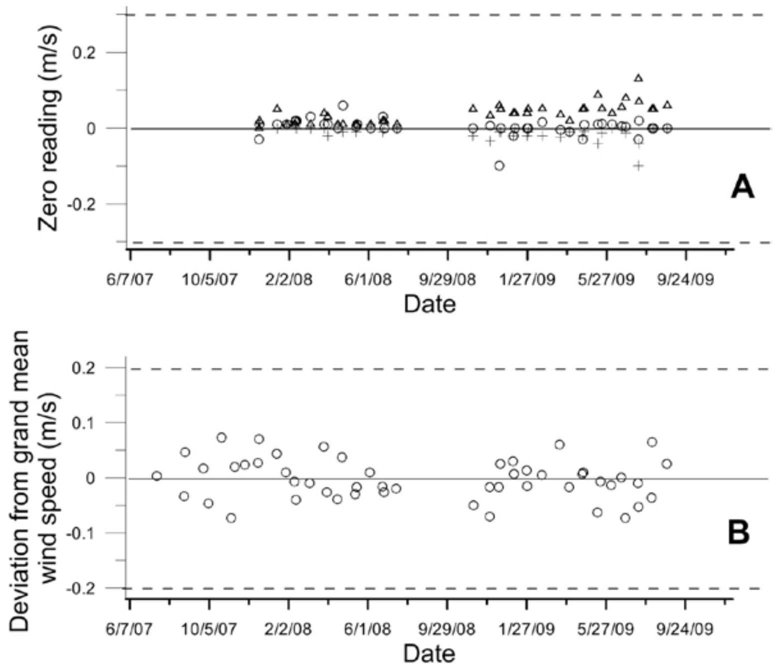


Figure 6.3-3: On-site quality assurance, s/n 1920. The DQI for the zero and inter-comparisons are indicated by the dashed lines. The zero check in the x (open circle), y (open triangle) and z (cross) components are indicated in panel A.

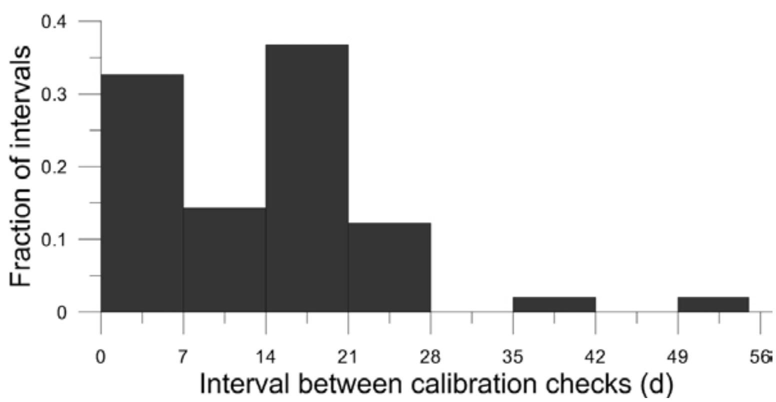


Figure 6.3-4: Inter-comparison check intervals, s/n 1920

Sonic anemometer 1928 was inter-compared with three standard anemometers of identical design six times during the study (Table 6.3-3). No absolute turbulence calibration is possible with this instrument. To assure proper performance and comparability in the wind measurements, the anemometer was inter-compared on-site with those used during a given measurement period at the beginning and end of a measurement period. This instrument was inter-compared with the co-located anemometer sensors on site 48 times (Figure 6.3-5). The majority of calibration checks were made within 21 d (Figure 6.3-6). The large fraction of

checks made within 7 d is the result of calibration checks made at the end and beginning of sequential measurement periods.

The accuracy DQI for the on-site inter-comparisons required the individual instruments to have the mean wind speed within 0.2 ms^{-1} of the grand mean value of the three (or four) on-site instruments(Figure 6.3-5B). This instrument passed this check all but one time. On this one date, the inter-comparison was rerun and the instrument passed the check.

The precision DQI for the on-site inter-comparisons required each wind component (x, y, and z) of the individual instruments to be within 0.3 ms^{-1} of zero (Figure 6.3-5A). Records of the zero checks made before 12/2007 were recorded as pass/fail- not indicating the actual measurements. The instrument always passed this DQI.

Table 6.3-3: Standards inter-comparisons

Calibration date		**Mean difference from reference anemometers (ms^{-1})**	
Alignment 1	**Alignment 2**	**Alignment 1**	**Alignment 2**
6/15-18/2007	6/18-19/2007	+0.004	+0.019
12/27-28/2007	12/29-31/2007	+0.003	-0.005
7/10-11/2008	7/11-14/2008	+0.022	+0.007
3/3-4/2009	3/5-6/2009	+0.070	-0.027
9/16-17/2009	9/17-18/2009	+0.056	+0.022
12/18-19/2009	12/21-23/2009	+0.094	-0.077

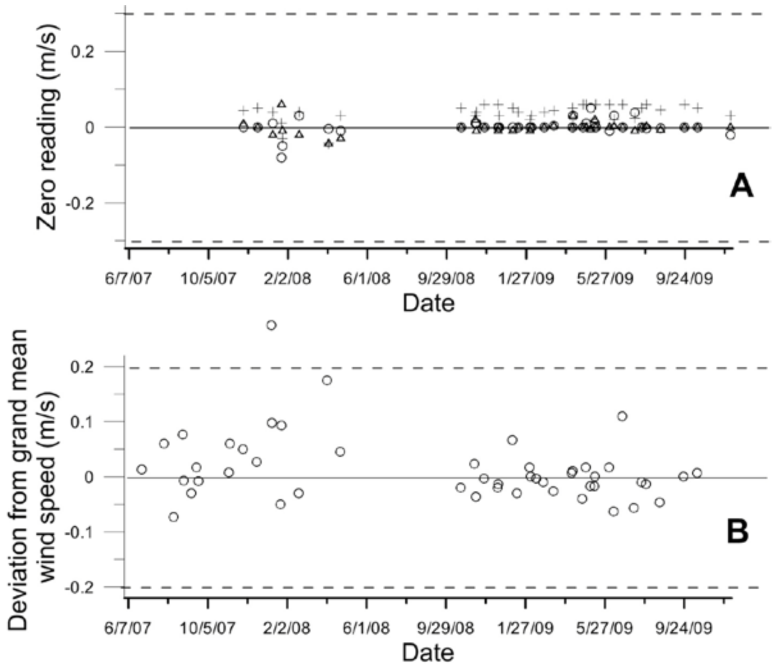


Figure 6.3-5: On-site quality assurance, s/n 1928. The DQI for the zero and inter-comparisons are indicated by the dashed lines. The zero check in the x (open circle), y (open triangle) and z (cross) components are indicated in panel A.

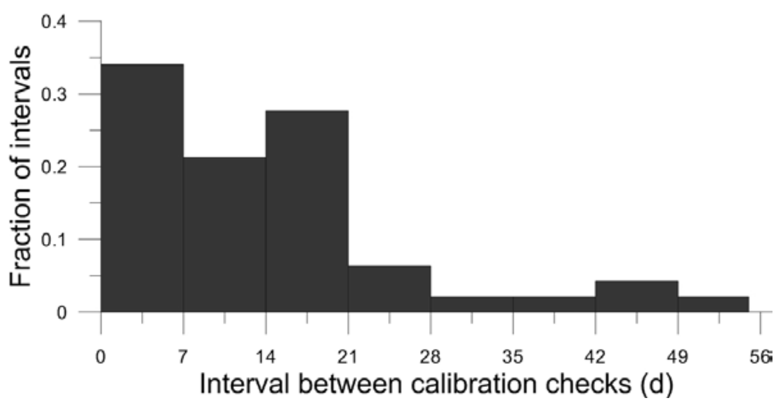


Figure 6.3-6: Inter-comparison check intervals, s/n 1928.

Sonic anemometer 1921 was inter-compared with three standard anemometers of identical design six times during the study (Table 6.3-4). No absolute turbulence calibration is possible with this instrument. To assure proper performance and comparability in the wind measurements, the anemometer was inter-compared on-site with those used during a given measurement period at the beginning and end of a measurement period. This instrument was inter-compared with the co-located anemometer sensors on site 43 times (Figure 6.3-7). The majority of calibration checks were made within 21 d (Figure 6.3-8). The large fraction of

checks made within 7 d is the result of calibration checks made at the end and beginning of sequential measurement periods.

The accuracy DQI for the on-site inter-comparisons required the individual instruments to have the mean wind speed within 0.2 ms^{-1} of the grand mean value of the three (or four) on-site instruments (Figure 6.3-7B). This instrument passed this check at all times. However this instrument developed intermittent problems during operation and was sent to the factory for repair 12/9/2008.

The precision DQI for the on-site inter-comparisons required each wind component (x, y, and z) of the individual instruments to be within 0.3 ms^{-1} of zero (Figure 6.3-7A). Records of the zero checks made before 12/2007 were recorded as pass/fail- not indicating the actual measurements. The instrument always passed this DQI.

Table 6.3-4: Standards inter-comparisons

Calibration date		**Mean difference from reference anemometers (ms^{-1})**	
Alignment 1	**Alignment 2**	**Alignment 1**	**Alignment 2**
6/15-18/2007	6/18-19/2007	+0.008	-0.003
12/27-28/2007	12/29-31/2007	-0.034	+0.001
7/10-11/2008	7/11-14/2008	+0.029	-0.022
3/23-25/2009	3/25-27/2009	-0.021	-0.040
9/8-14/2009	9/15-16/2009	+0.028	+0.038
12/18-19/2009	12/21-23/2009	+0.078	+0.002

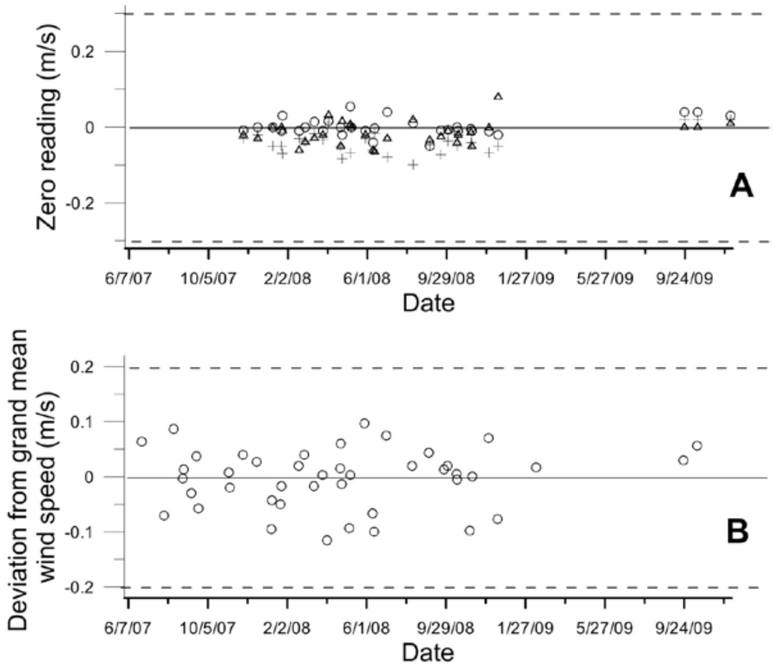


Figure 6.3-7: On-site quality assurance, s/n 1921. The DQI for the zero and inter-comparisons are indicated by the dashed lines. The zero check in the x (open circle), y (open triangle) and z (cross) components are indicated in panel A.

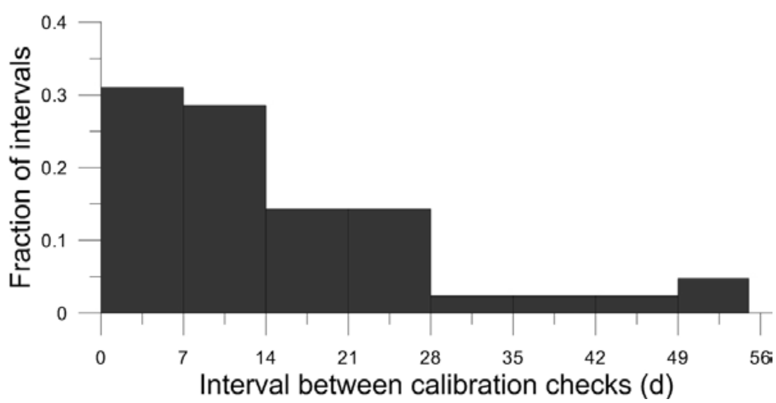


Figure 6.3-8: Inter-comparison check intervals, s/n 1921

Sonic anemometer 1932 was inter-compared with three standard anemometers of identical design six times during the study (Table 6.3-5). No absolute turbulence calibration is possible with this instrument. To assure proper performance and comparability in the wind measurements, the anemometer was inter-compared on-site with those used during a given measurement period at the beginning and end of a measurement period. This instrument was inter-compared with the co-located anemometer sensors on site 55 times (Figure 6.3-9). The majority of calibration checks were made within 21 d (Figure 6.3-10). The large fraction of checks made within 7 d is the result of calibration checks made at the end and beginning of sequential measurement periods.

The accuracy DQI for the on-site inter-comparisons required the individual instruments to have the mean wind speed within 0.2 ms^{-1} of the grand mean value of the three (or four) on-site instruments (Figure 6.3-9B). This instrument passed this check on all checks except 10/15-16/2008 and was taken out of service. Laboratory testing indicated wetness in the sensor. The sensor was dried, tested, and put back in use.

The precision DQI for the on-site inter-comparisons required each wind component (x, y, and z) of the individual instruments to be within 0.3 ms^{-1} of zero (Figure 6.3-9B). Records of the zero checks made before 12/2007 were recorded as pass/fail- not indicating the actual measurements. The instrument always passed this DQI.

Table 6.3-5: Standards inter-comparisons

Calibration date		Mean difference from reference anemometers (ms^{-1})	
Alignment 1	**Alignment 2**	**Alignment 1**	**Alignment 2**
6/15-17/2007	6/18-19/2007	+0.004	+0.160
12/27-28/2007	12/29-31/2007	+0.014	-0.009
7/10-11/2008	7/11-14/2008	+0.008	+0.031
3/3-5/2009	3/5-6/2009	-0.024	-0.005
9/8-14/2009	9/15-16/2009	-0.025	-0.044
1/7-9/2010	1/23-24/2010	+0.020	-0.016

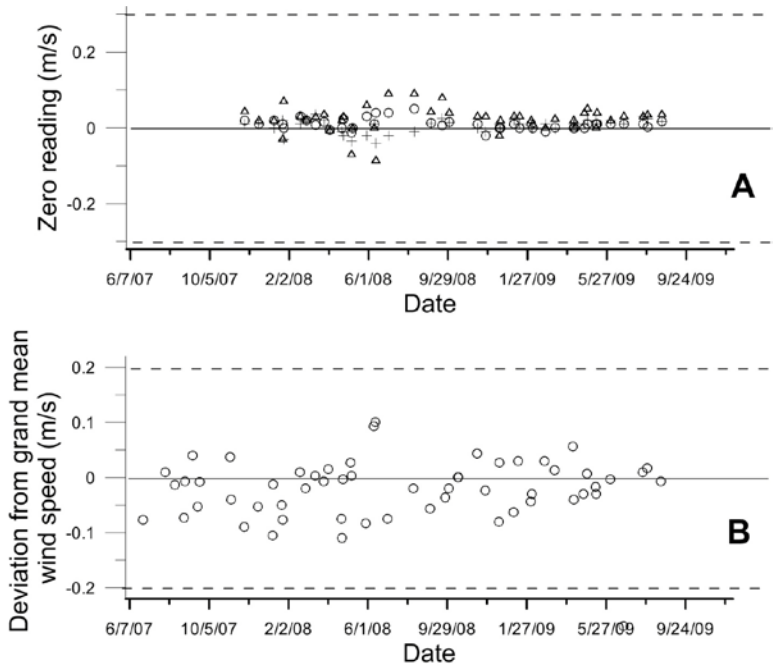


Figure 6.3-9: On-site quality assurance, s/n 1932. The DQI for the zero and inter-comparisons are indicated by the dashed lines. The zero check in the x (open circle), y (open triangle) and z (cross) components are indicated in panel A.

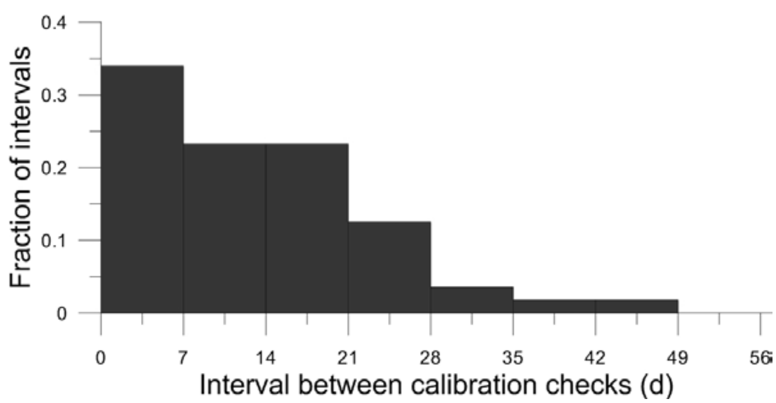


Figure 6.3-10: Inter-comparison check intervals, s/n 1932

Sonic anemometer 1936 was inter-compared with three standard anemometers of identical design five times during the study (Table 6.3-5). No absolute turbulence calibration is possible with this instrument. To assure proper performance and comparability in the wind measurements, the anemometer was inter-compared on-site with those used during a given measurement period at the beginning and end of a measurement period. This instrument was inter-compared with the co-located anemometer sensors on site 41 times (Figure 6.3-11). The majority of calibration checks were made within 21 d (Figure 6.3-12). The large fraction of checks made within 7 d is the result of calibration checks made at the end and beginning of sequential measurement periods.

The accuracy DQI for the on-site inter-comparisons required the individual instruments to have the mean wind speed within 0.2 ms^{-1} of the grand mean value of the three (or four) on-site instruments (Figure 6.3-11B). This instrument passed this check at all times.

The precision DQI for the on-site inter-comparisons required each wind component (x, y, and z) of the individual instruments to be within 0.3 ms^{-1} of zero (Figure 6.3-11A). Records of the zero checks made before 12/2007 were recorded as pass/fail- not indicating the actual measurements. The instrument always passed this DQI.

Table 6.3-6: Standards inter-comparisons

Calibration date		Mean difference from reference anemometers (ms^{-1})	
Alignment 1	**Alignment 2**	**Alignment 1**	**Alignment 2**
6/15-18/2007	6/18-19/2007	+0.011	-0.036
12/27-28/2007	12/29-31/2007	-0.022	-0.009
7/10-11/2008	7/11-14/2008	+0.021	-0.019
3/23-25/2009	3/25-27/2009	+0.018	+0.047
9/1-2/2009	9/2-3/2009	-0.029	-0.016

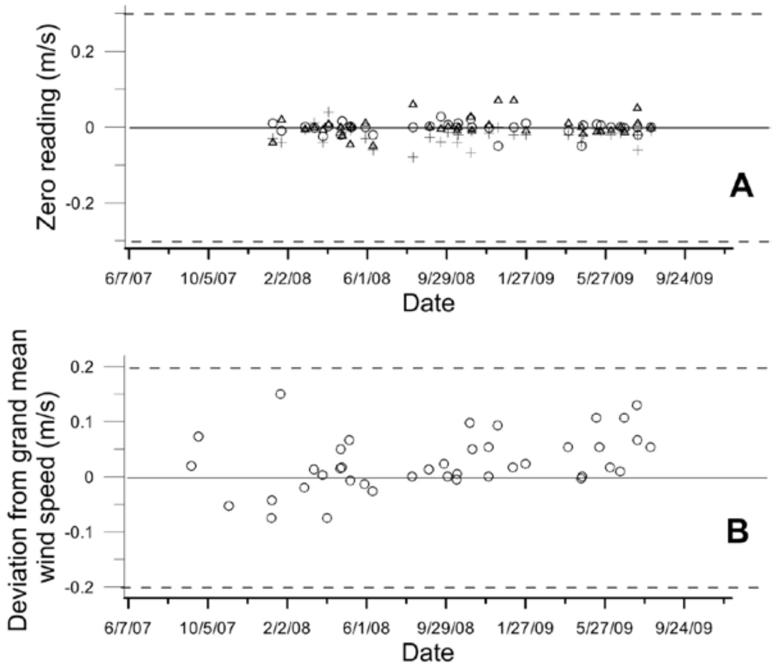


Figure 6.3-11: On-site quality assurance, s/n 1936. The DQI for the zero and inter-comparisons are indicated by the dashed lines. The zero check in the x (open circle), y (open triangle) and z (cross) components are indicated in panel A.

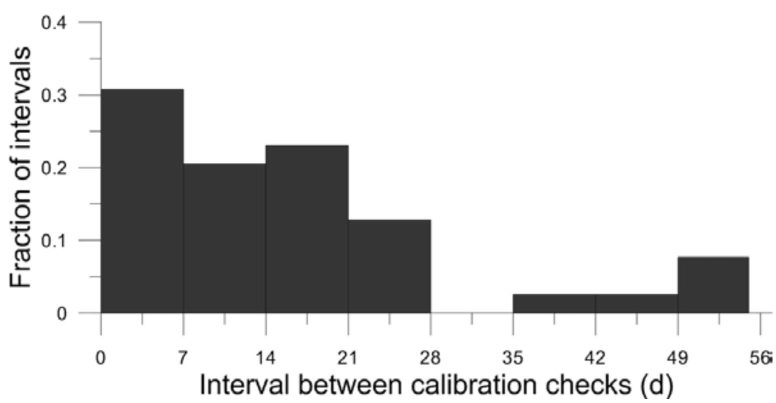


Figure 6.3-12: Inter-comparison check intervals, s/n 1936

6.4 pH probe calibrations

Three pH probes (Model CSIMM-ph, Innovative Sensors, Inc., Anaheim, California) were used at this location: serial numbers 002, 008 and 009.

Probe 002 was first used 6/27/2007 and last used 10/2/2008. The probe was calibrated 16 times. The pH probe DQI specified an accuracy of ± 0.3 pH units, corresponding to a difference between the calculated and measured pH of 17.7 mV of signal. Figure 6.4-1A illustrates the control chart for the three pH standards used (pH 4, 7, and 10) relative to the mV error. Each sensor was also checked for stability using QCCS solution, with the requirement that the sensor be within 0.05 pH units, or 3 mV. The history of the probe stability check is illustrated in Figure 6.4-1B. Problems with freezing of the electrolyte in the reference electrode during the winter reduced the frequency of these checks. The accuracy check exceeded the DQI on 4/24/2008, 5/6/2008, and 10/2/2008. The DQI exceedences on 4/24/2008 and 5/6/2008 were followed with a valid accuracy check without sensor modification or repair so it is assumed that the checks failed due to inadequate probe cleaning. The accuracy check failure on 10/2/2008 was a result of probe failure. The stability check failed on 11/28/2007, 12/19/2007, 6/10/2008, and 10/2/2008. The failed stability checks on 11/28/2007 and 12/19/2007 did not correspond with accuracy check failures and were assumed to be operator error. The stability check on 6/10/2008 was indicative of the probe failure noted in the following accuracy check.

Probe 003 was first used 7/24/2007 and last used 11/15/2007. The probe was calibrated seven times. The pH probe DQI specified an accuracy of ± 0.3 pH units, corresponding to a difference between the calculated and measured pH of 17.7 mV of signal. Figure 6.4-2A illustrates the control chart for the three pH standards used (pH 4, 7, and 10) relative to the mV error. Each sensor was also checked for stability using QCCS solution, with the requirement that the sensor be within 0.05 pH units, or 3 mV. The history of the probe stability check is illustrated in Figure 6.4-2B. Problems with freezing of the electrolyte in the reference electrode during the winter reduced the frequency of these checks. The probe always passed both the accuracy DQI and the stability checks.

Probe 009 was first used 4/23/2009 and last used 8/4/2009. The probe was calibrated seven times. The pH probe DQI specified an accuracy of ± 0.3 pH units, corresponding to a difference between the calculated and measured pH of 17.7 mV of signal. Figure 6.4-3A illustrates the control chart for the three pH standards used (pH 4, 7, and 10) relative to the mV error. Each sensor was also checked for stability using QCCS solution, with the requirement that the sensor be within 0.05 pH units, or 3 mV. The history of the probe stability check is illustrated in Figure 6.4-3B. Problems with freezing of the electrolyte in the reference electrode during the winter reduced the frequency of these checks. The probe always passed the stability check but failed the accuracy DQI for pH 7 and pH 10 four times: 7/14/2009, 7/15/2009, 8/4/2009 and 9/17/2009. These accuracy failures were likely due to operator error.

In general, the probe calibrations were conducted at the beginning and end of each measurement period. Since lagoon pH measurements were not made at several locations the interval between calibrations can be large when locations that did not have lagoon pH measurements were visited between locations where the measurements were made. Since freezing conditions damage the probe, the probes were not used during the winter at many locations

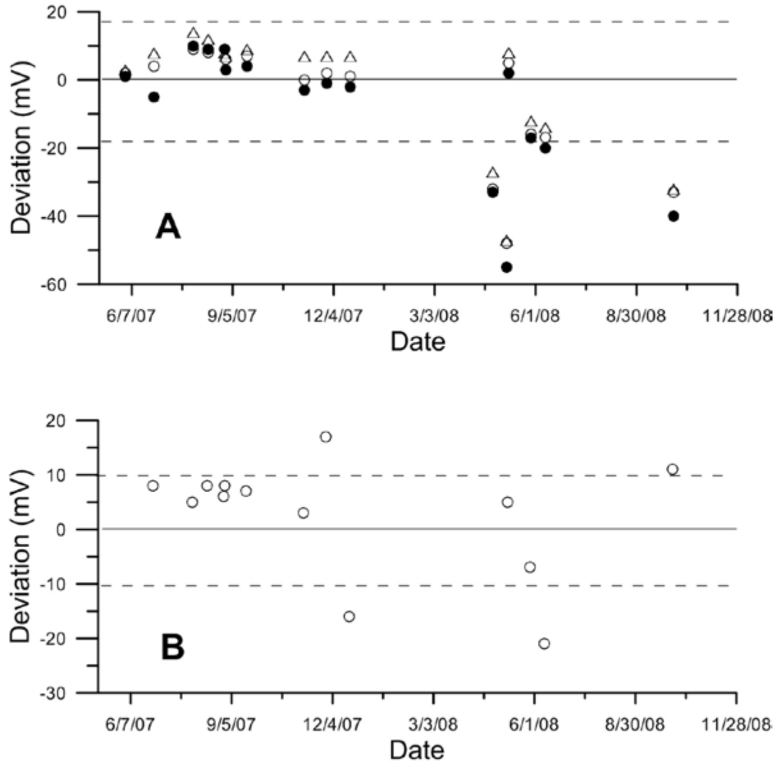


Figure 6.4-1: Accuracy and stability calibration checks of CSIM11 pH probe, s/n 002. The absolute deviation in mV of the pH 4 (closed circle), pH 7 (open circle), and ph 10 (solid triangle) tests are indicated in panel A. The dashed lines define the DQI limits. The time history of the absolute stability is indicated in panel B where the dashed lines indicate the desired bounds of the stability.

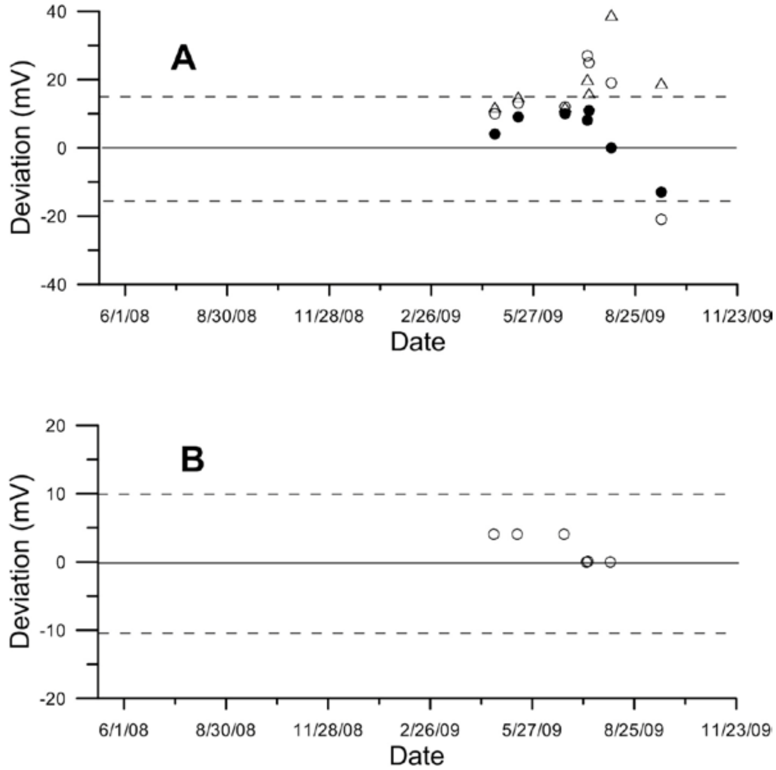


Figure 6.4-2: Accuracy and stability calibration checks of CSIM11 pH probe, s/n 009. The absolute deviation in mV of the pH 4 (closed circle), pH 7 (open circle), and ph 10 (solid triangle) tests are indicated in panel A. The dashed lines define the DQI limits. The time history of the absolute stability is indicated in panel B where the dashed lines indicate the desired bounds of the stability.

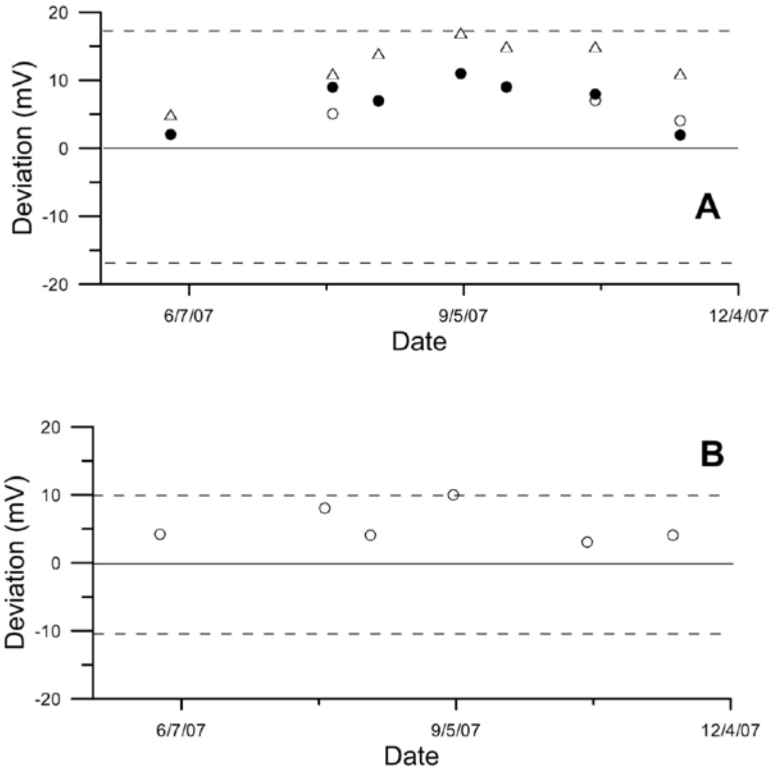


Figure 6.4-3: Accuracy and stability calibration checks of CSIM11 pH probe, s/n 003. The absolute deviation in mV of the pH 4 (closed circle), pH 7 (open circle), and ph 10 (solid triangle) tests are indicated in panel A. The dashed lines define the DQI limits. The time history of the absolute stability is indicated in panel B where the dashed lines indicate the desired bounds of the stability.

6.5 ORP probe calibrations

Three oxidation-reduction potential (ORP) probes (Model CSIM11-ORP, Innovative Sensors Inc., Anaheim, California) were used at this location: serial numbers 020, 030 and 050.

Probe 020 was first used 7/18/2007 and last used 9/3/2008. The probe was calibrated 16 times. The ORP probe DQI specified an accuracy of ±20 mV (Figure 6.5-1A). Each sensor was also checked for stability using a KCl solution, with the requirement that the sensor be within 1 mV of the reference solution. The history of the probe stability check is illustrated in Figure 6.5-1B. Problems with freezing of the electrolyte in the reference electrode during the winter reduced the frequency of these checks. The probe passed the accuracy check DQI on all but 3/27/2008, 4/2/2008, and 8/14/2008. Subsequent accuracy check however met the accuracy DQI without probe modification so the prior failures were assumed to be due to operator error. The stability deviated significantly from the normal range on 4/2/2008 and 8/14/2008 indicating a possible partially-plugged probe.

Probe 030 was first used 6/27/2007 and last used 6/24/2009. The probe was calibrated 19 times. The ORP probe DQI specified an accuracy of ± 20 mV (Figure 6.5-2A). Each sensor was also checked for stability using a KCl solution, with the requirement that the sensor be within 1 mV of the reference solution. The history of the probe stability check is illustrated in Figure 6.5-2B. Problems with freezing of the electrolyte in the reference electrode during the winter reduced the frequency of these checks. The stability checks indicated variability in the response but the accuracy check passed the DQI except for the first check (6/27/2007) which was assumed to fail due to operator error since the probe passed the accuracy check subsequent to the first check without modification.

Probe 050 was first used 4/24/2008 and last used 2/23/2009. The probe was calibrated 11 times. The ORP probe DQI specified an accuracy of ± 20 mV (Figure 6.5-3A). Each sensor was also checked for stability using a KCl solution, with the requirement that the sensor be within 1 mV of the reference solution. The history of the probe stability check is illustrated in Figure 6.5-3B. Problems with freezing of the electrolyte in the reference electrode during the winter reduced the frequency of these checks. The probe always passed the accuracy DQI although showed wide response variation to the stability check. The cause of this instability is unknown.

In general, the probe calibrations were conducted at the beginning and end of each measurement period. Since lagoon ORP measurements were not made at several locations the interval between calibrations can be large when locations that did not have lagoon ORP measurements were visited between locations where the measurements were made. Since freezing conditions damage the probe, the probes were not used during the winter at many locations.

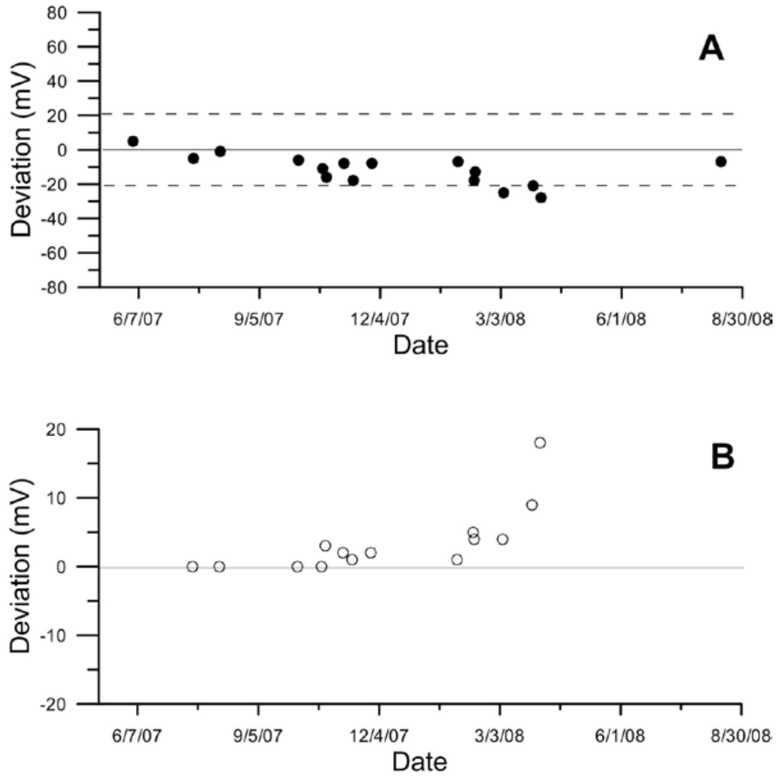


Figure 6.5-1- Accuracy and stability calibration checks of CSIM11 ORP probe, s/n 020. The stability check of the probe (Panel B) and the absolute deviation in mV of the probe (panel A) are indicated. The dashed lines define the DQI limits in panel A.

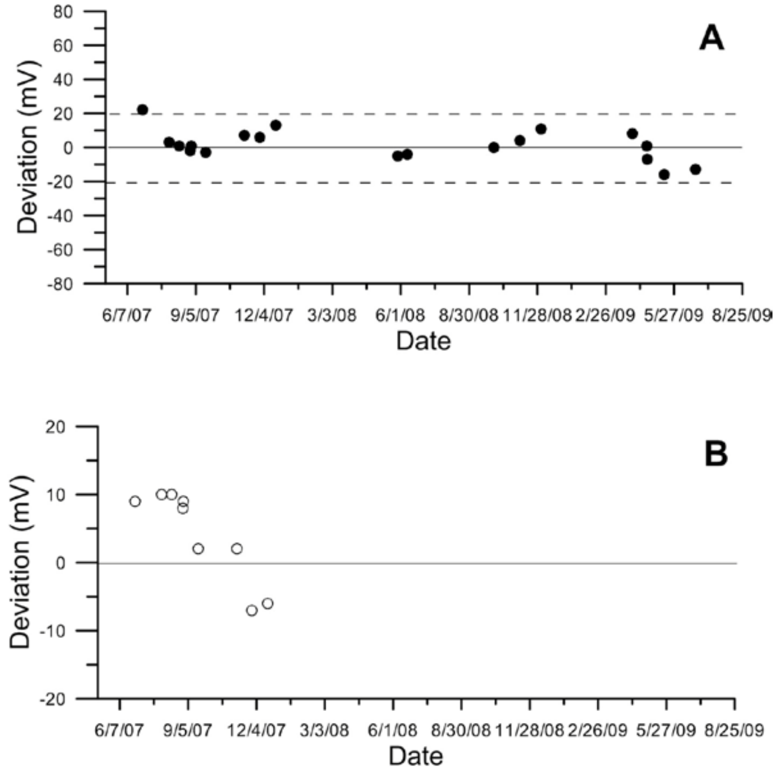


Figure 6.5-2: Accuracy and stability calibration checks of CSIM11 ORP probe, s/n 030. The stability check of the probe (Panel B) and the absolute deviation in mV of the probe (panel A) are indicated. The dashed lines define the DQI limits in panel A.

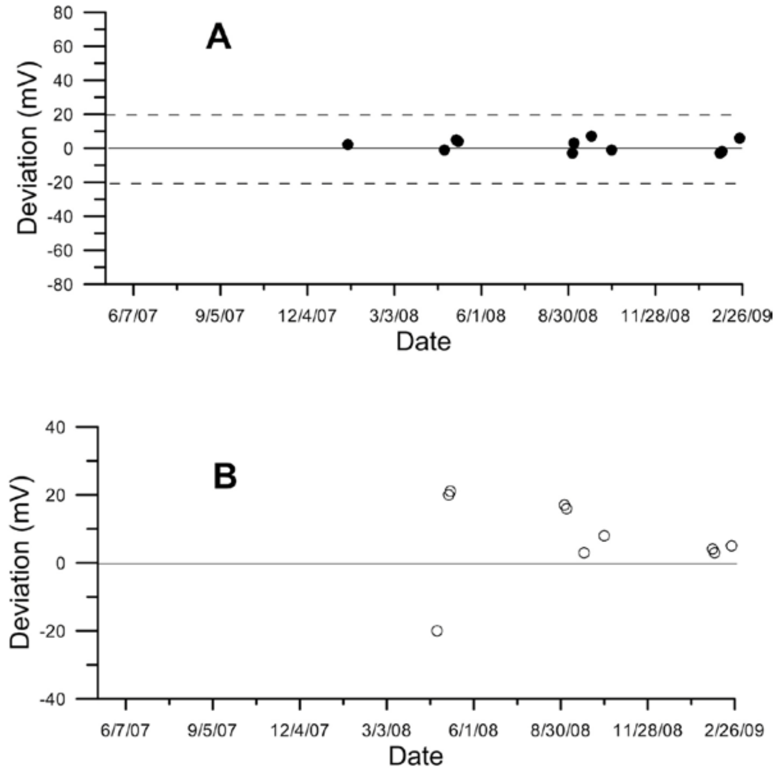


Figure 6.5-3: Accuracy and stability calibration checks of CSIM11 ORP probe, s/n 050. The stability check of the probe (Panel B) and the absolute deviation in mV of the probe (panel A) are indicated. The dashed lines define the DQI limits in panel A

6.6 S-OPS operational checks

The Synthetic Open Path Systems (S-OPS; s/n B and E) and the Gas Sampling System (GSS s/n 4-0017) were checked at the beginning and end of every measurement period. A leak check and maximum flow check were made for both the S-OPS in combination with the GSS and for the GSS alone. In addition, the balance of flow into each inlet in the S-OPS was checked before and after each measurement period.

Results of the leak tests for both the GSS and the Combined GSS/S-OPS are indicated in sequence in Table 6.6-1. Consequently records of the checks at a given measurement site are interspersed according to the sequence of measurements for this trailer. Leaks in the GSS rarely occurred, however leaks in the S-OPS occurred several times in the study. These leaks were apparently a result of vibration within the GSS. The permissible leak in the S-OPS/GSS or GSS alone was 10% of the maximum flow. Details of the leak check failure follow:

- S-OPS leak check failure of single lines on 9/3/2008, 10/2/2008, 12/6/2008, 5/14/2009, 8/4/2009, 10/29/2009 were not resolved during the site visit due to time constraints. Repairs to the S-OPS were made on the subsequent visit.
- GSS leak check failure on 1/6/2009 was a result of pump diaphragm failure.

The impact of leak check failures in the S-OPS lines (with the exception of those at the GSS inlet filters) was minimal as the leaks were at junctions of tubing and tubing/inlet filters and would allow air into the lines that differ only from height above the berm from the air sampled along the inlets themselves. The impact of GSS leak check failures associated with pump diaphragm failures would only influence the volume of flow available to the H_2S analyzer. In all cases flow available to the analyzer greatly exceeded that used by the analyzer (1.5 L min^{-1}) (Table 6.6-1).

Table 6.6-1: Record of leak checks for GSS and GSS/S-OPS

Date (mm/dd/yyyy)	Site	GSS solenoid	GSS mass flow (L min^{-1})	GSS pressure (kPa)	GSS check result	S-OPS max flow (L min^{-1})	S-OPS mass flow (L min^{-1})	S-OPS pressure (kPa)	S-OPS check result
3/13/2008	WA5A	2	0.08	-41.29	Pass	8.0	0.56	-41.19	Pass
		3	0.01	-41.46	Pass	10.1	0.43	-39.25	Pass
4/3/2008	TX5A	2	0.00	-37.94	Pass	9.3	0.46	-40.07	Pass
		3	-0.01	-40.41	Pass	9.7	0.34	-40.19	Pass
4/22/2008	TX5A	2	0.09	-31.84	Pass	9.2	0.50	-32.48	Pass
		3	0.04	-40.85	Pass	9.6	0.36	-39.59	Pass
4/24/2008	OK4A	2	0.07	-30.69	Pass	8.4	0.44	-31.03	Pass
		3	0.01	-28.52	Pass	9.7	0.63	-28.70	Pass
5/6/2008	OK4A	2	0.14	-24.42	Pass	8.5	0.65	-26.20	Pass
		3	0.17	-24.74	Fail	9.8	0.66	-23.07	Pass
5/8/2008	OK3A	2	-0.14	-32.28	Pass	9.7	0.11	-30.99	Pass
		3	-0.14	-31.16	Pass	9.2	0.51	-30.83	Pass
5/29/2008	OK3A	2	0.15	-30.98	Fail	9.8	0.31	-32.07	Pass
		3	0.27	-30.89	Fail	9.2	0.58	-32.37	Pass
6/10/2008	OK3A	2	0.07	-39.64	Pass	9.7	0.37	-38.89	Pass
		3	0.06	-40.66	Pass	N/A	N/A	N/A	N/A
6/11/2008	TX5A	2	0.19	-39.52	Fail	9.4	0.19	-38.31	Pass
		3	0.00	-38.50	Pass	9.5	0.77	-38.43	Pass
7/1/2008	TX5A	2	0.15	-31.62	Fail	9.3	0.28	-31.17	Pass
		3	0.15	-31.69	Fail	9.3	1.00	-32.02	Pass

Date (mm/dd/yyyy)	Site	GSS solenoid	GSS mass flow (L min^{-1})	GSS pressure (kPa)	GSS check result	S-OPS max flow (L min^{-1})	S-OPS mass flow (L min^{-1})	S-OPS pressure (kPa)	S-OPS check result
8/10/2008	WA5A	2	0.09	-40.90	Pass	7.5	0.44	-40.50	Pass
		3	0.07	-40.35	Pass	10.5	0.75	-38.31	Pass
9/3/2008	WA5A	2	0.27	-32.88	Fail	8.0	6.86	-23.56	Fail
		3	0.30	-32.92	Fail	10.5	0.53	-34.62	Pass
9/3/2008	WA5A	2	0.20	-32.22	Fail	8.0	0.43	-32.51	Pass
		3	0.30	-32.36	Fail	10.5	0.52	-32.73	Pass
9/26/2008	WA5A	2	0.53	-38.99	Fail	8.1	0.33	-40.01	Pass
		3	0.19	-37.03	Fail	10.5	0.41	-39.44	Pass
10/2/2008	OK4A	2	0.23	-40.69	Fail	9.6	0.95	-0.43	Pass
		3	0.23	-39.56	Fail	8.6	0.87	-0.04	Fail
10/15/2008	OK4A	2	0.17	-41.03	Fail	9.8	0.32	-38.14	Pass
		3	0.18	-38.71	Fail	8.5	0.32	-38.90	Pass
10/16/2008	TX5A	2	0.20	-39.65	Fail	9.7	0.28	-39.72	Pass
		3	0.23	-40.98	Fail	9.5	0.59	-39.55	Pass
11/4/2008	TX5A	2	0.33	-41.59	Fail	9.4	0.31	-39.62	Pass
		3	0.32	-41.56	Fail	9.3	0.50	-40.62	Pass
11/6/2008	OK3A	2	0.33	-39.79	Fail	8.7	0.73	-42.34	Pass
		3	0.32	-38.77	Fail	9.3	0.47	-39.46	Pass
12/3/2008	OK3A	2	0.79	-40.32	Fail	8.4	0.65	-39.24	Pass
		3	0.83	-39.05	Fail	9.2	0.43	-40.53	Pass
12/16/2008	OK3A	2	0.72	-37.70	Fail	8.6	1.05	-40.13	Fail
		3	0.79	-36.81	Fail	9.5	0.91	-40.65	Pass
12/18/2008	TX5A	2	1.98	-38.41	Fail	9.4	0.92	-37.74	Pass
		3	2.09	-38.03	Fail	9.4	0.90	-37.46	Pass
1/6/2009	TX5A	2	0.12	-40.60	Pass	9.1	2.09	-37.63	Fail
		3	0.13	-40.35	Pass	8.9	2.12	-37.72	Fail
1/8/2009	OK4A	2	0.11	-38.95	Pass	9.8	0.41	-39.67	Pass
		3	0.11	-37.59	Pass	7.2	0.30	-41.91	Pass
1/27/2009	OK4A	2	0.09	-38.64	Pass	9.4	0.36	-40.34	Pass
		3	0.09	-38.15	Pass	8.3	0.20	-41.46	Pass
1/29/2009	TX5A	2	0.05	-37.73	Pass	9.8	0.37	-38.37	Pass
		3	0.17	-38.46	Fail	9.6	0.24	-37.24	Pass
2/19/2009	TX5A	2	0.19	-36.64	Fail	9.9	0.92	-39.35	Pass
		3	0.04	-36.77	Pass	9.7	0.64	-38.72	Pass
3/18/2009	TX5A	2	0.15	-38.19	Fail	9.3	0.65	-37.14	Pass
		3	0.07	-39.28	Pass	9.8	0.45	-37.54	Pass
4/21/2009	OK4A	2	0.15	0.06	Fail	10.2	0.55	-40.07	Pass
		3	0.01	-39.72	Pass	9.0	0.24	-37.98	Pass
4/22/2009	OK3A	2	0.14	-40.11	Pass	9.7	0.30	-38.44	Pass
		3	0.05	-38.69	Pass	8.8	0.77	-27.92	Pass
5/14/2009	OK3A	2	0.20	-39.22	Fail	9.7	0.26	-38.46	Pass
		3	0.09	-39.13	Pass	8.6	0.88	-38.07	Fail
5/21/2009	WA5A	2	0.17	-37.70	Fail	7.9	0.18	-39.69	Pass
		3	0.02	-39.60	Pass	10.5	0.96	-39.37	Pass
6/4/2009	WA5A	2	0.18	-40.86	Fail	8.6	0.24	-40.49	Pass
		3	0.04	-38.48	Pass	10.5	0.97	-38.07	Pass
6/19/2009	WA5A	2	0.33	-39.50	Fail	8.7	0.25	-38.74	Pass
		3	0.14	-39.60	Pass	10.5	0.95	-37.89	Pass
6/23/2009	OK4A	2	0.07	-39.89	Pass	9.7	0.37	-39.37	Pass
		3	0.04	-38.56	Pass	8.8	0.60	-40.96	Pass
7/14/2009	OK4A	2	0.25	-39.85	Fail	8.5	0.14	-40.79	Pass
		3	0.08	-38.49	Pass	9.7	0.13	-39.51	Pass

Date (mm/dd/yyyy)	Site	GSS solenoid	GSS mass flow (L min^{-1})	GSS pressure (kPa)	GSS check result	S-OPS max flow (L min^{-1})	S-OPS mass flow (L min^{-1})	S-OPS pressure (kPa)	S-OPS check result
7/15/2009	OK3A	2	0.02	-38.14	Pass	8.7	0.63	-38.59	Pass
		3	0.04	-36.71	Pass	9.9	0.08	-39.75	Pass
8/4/2009	OK3A	2	0.06	-38.09	Pass	8.5	2.25	-37.22	Fail
		3	0.11	-34.41	Pass	9.7	0.09	-39.78	Pass
8/6/2009	TX5A	2	0.05	-38.30	Pass	9.8	0.75	-39.40	Pass
		3	0.00	-40.36	Pass	9.9	0.14	-38.93	Pass
8/27/2009	TX5A	2	0.02	-39.89	Pass	9.7	0.65	-37.52	Pass
		3	0.05	-40.26	Pass	9.5	0.11	-38.95	Pass
9/23/2009	NC3A	2	0.06	-40.15	Pass	10.1	0.34	-39.61	Pass
		3	0.07	-38.33	Pass	0.0	-0.60	-0.05	Pass
10/13/2009	NC3A	2	0.17	-39.38	Fail	9.6	0.41	-39.03	Pass
		3	0.04	-37.77	Pass	10.0	0.20	-41.33	Pass
10/27/2009	NC3A	2	0.08	-41.29	Pass	10.0	0.26	-39.30	Pass
		3	0.01	-41.46	Pass	9.3	1.45	0.11	Fail
10/27/2009	NC3A	2	0.00	-37.94	Pass	10.0	0.26	-39.30	Pass
		3	-0.01	-40.41	Pass	9.3	0.51	-40.26	Pass
11/11/2009	NC3A	2	0.04	-39.92	Pass	10.0	0.79	-40.71	Pass
		3	0.04	-39.74	Pass	9.6	0.27	-40.26	Pass

The inlet flow balance checks are summarized in sequence in Tables 6.6-2A and 6.6-2B. Consequently records of the checks at a given measurement site are interspersed according to the sequence of measurements for this trailer. While the inlet flow balance was measured at the beginning and end of each measurement period, results showed that the balance throughout the period was not assured if the balance test indicated an adequate balance. Balance across the inlets at any time during a period or at the beginning or end of a period was limited due to wetness of the inlet filters associated with fog, ice, snow, or rain. In addition dust on the inlet filters contributed to an undetermined rate of flow degradation of individual inlets over a period. Spider webs would also restrict flow across the inlet filters. The allowable tolerance in the inlet balance was that the flow through any inlet was within 10% of the expected flow for the inlet.

Condensation or liquid water intrusion into the Teflon tubing of the S-OPS occurred often in the tubing around the area sources. Analysis of the problem revealed that condensation occurred as the air cooled in transit from the inlet to the trailer through tubing under a negative net radiation balance (particularly at night). In addition, water intrusion occurred during the leak testing if any water had accumulated along the junction between the filter/inlet and the S-OPS tubing. The impact of the liquid water in the S-OPS tubing on the measured concentration of H_2S was minimal due to the low solubility of H_2S.

Table 6.6-2A: Record of flow balancing- side 1 (s/n B)

			Delta inlet flow (beginning-end) (L min⁻¹)										
Start date	**End date**	**Site**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Check results**
3/13/2008	4/3/2008	WA5A	-0.20	-0.21	-0.06	-0.14	-0.20	-0.24	-0.21	-0.04	-0.20	-0.23	**Fail**
4/3/2008	4/22/2008	TX5A	-0.08	-0.07	-0.08	-0.09	-0.07	-0.09	-0.13	-0.09	-0.12	-0.14	**Pass**
4/24/2008	5/6/2008	OK4A	-0.02	-0.04	-0.01	-0.14	-0.02	-0.03	-0.09	-0.10	-0.07	-0.12	**Fail**
5/8/2008	5/29/2008	OK3A	0.01	0.02	0.02	0.02	0.02	0.03	0.01	0.03	0.01	0.04	**Pass**
5/29/2008	6/10/2008	OK3A	M	M	M	M	M	M	M	M	M	M	**M**
6/11/2008	7/1/2008	TX5A	-0.01	-0.01	-0.02	-0.01	-0.02	-0.02	-0.01	-0.01	-0.02	-0.02	**Pass**
7/1/2008	8/10/2008	TX5A	0.35	0.38	0.11	0.39	0.27	0.31	0.30	0.18	0.34	0.31	**Pass**
8/10/2008	9/3/2008	WA5A	0.00	-0.10	0.11	-0.20	0.00	0.00	-0.10	0.00	-0.10	0.00	**Fail**
9/3/2008	9/26/2008	WA5A	0.00	-0.10	-0.10	0.10	0.00	-0.20	-0.10	0.10	0.00	0.00	**Fail**
10/2/2008	10/15/2008	OK4A	0.02	-0.02	0.01	0.01	-0.03	0.06	0.06	0.05	0.04	0.02	**Fail**
10/16/2008	11/4/2008	TX5A	0.02	0.00	0.00	-0.01	-0.02	-0.05	-0.05	0.00	0.01	0.03	**Pass**
11/6/2008	12/3/2008	OK3A	0.03	0.00	0.00	0.01	-0.02	0.03	0.04	0.05	0.05	0.05	**Pass**
12/3/2008	12/16/2008	OK3A	-0.02	-0.01	-0.01	0.00	0.04	-0.06	0.04	-0.04	-0.03	-0.03	**Pass**
12/18/2008	1/6/2009	TX5A	-0.02	-0.06	-0.03	0.00	-0.04	-0.02	-0.02	0.00	0.01	-0.01	**Fail**
1/8/2009	1/27/2009	OK4A	-0.02	-0.04	-0.04	0.00	-0.05	-0.01	0.00	0.00	0.00	0.01	**Pass**
1/29/2009	2/19/2009	TX5A	-0.04	-0.02	0.00	0.06	0.00	-0.06	0.00	-0.02	-0.02	0.00	**Pass**
2/19/2009	3/18/2009	TX5A	0.01	-0.02	0.01	0.01	0.01	-0.02	0.00	0.00	0.00	-0.01	**Fail**
3/18/2009	4/2/2009	TX5A	0.06	0.06	0.05	0.06	0.04	0.08	0.06	0.10	0.05	0.11	**Pass**
4/2/2009	4/21/2009	OK4A	0.02	0.05	0.04	0.04	-0.03	0.01	0.02	0.01	-0.01	-0.01	**Pass**
4/22/2009	5/14/2009	OK4A	-0.03	-0.04	-0.02	-0.03	-0.02	-0.14	-0.02	-0.01	-0.02	-0.03	**Pass**
5/14/2009	5/21/2009	OK4A	0.23	0.24	0.27	0.28	0.17	0.28	0.23	0.26	0.17	0.29	**Pass**
5/21/2009	6/4/2009	WA5A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**Pass**
6/4/2009	6/19/2009	WA5A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**Pass**
6/23/2009	7/14/2009	OK4A	0.00	-0.02	-0.03	-0.01	-0.04	0.01	0.01	0.00	-0.01	-0.04	**Pass**
7/15/2009	8/4/2009	OK3A	0.05	0.04	0.13	0.09	0.13	0.20	0.16	0.14	0.14	0.18	**Pass**
8/6/2009	8/27/2009	TX5A	0.05	0.05	0.01	0.00	0.01	0.03	0.02	0.03	0.06	0.04	**Pass**
8/27/2009	9/24/2009	TX5A	-0.10	-0.06	-0.05	-0.06	-0.08	-0.01	-0.04	-0.05	-0.14	-0.01	**Pass**
9/24/2009	10/13/2009	NC3A	0.00	-0.03	0.00	-0.05	-0.03	-0.08	87.39	-0.11	-0.12	0.06	**Pass**
10/13/2009	10/27/2009	NC3A	-0.02	-0.05	-0.04	-0.03	-0.04	-0.04	-0.03	-0.03	-0.05	0.00	**Pass**
10/27/2009	11/11/2009	NC3A	0.00	-0.02	-0.01	-0.01	-0.01	0.00	-0.02	0.00	-0.04	0.02	**Pass**
11/11/2009	12/2/2009	NC3A	0.02	0.04	-0.11	-0.01	0.01	0.00	-0.03	-0.08	0.37	0.03	**Fail**

M: missing measurements.

Table 6.6-2B: Record of flow balancing- side 2 (s/n E)

			Delta inlet flow (beginning-end) (L min^{-1})										
Start date	**End date**	**Site**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Check results**
3/13/2008	4/3/2008	WA5A	0.19	0.18	0.11	0.19	0.14	0.14	0.15	0.17	0.15	0.21	**Fail**
4/3/2008	4/22/2008	TX5A	-0.03	-0.03	0.01	-0.04	-0.09	-0.06	0.00	0.01	0.00	0.00	**Pass**
4/24/2008	5/6/2008	OK4A	0.00	0.00	0.00	-0.03	-0.02	-0.05	0.06	-0.01	-0.03	0.06	**Fail**
5/8/2008	5/29/2008	OK3A	0.02	0.01	0.04	0.00	0.05	0.02	0.01	0.04	0.02	0.02	**Pass**
5/29/2008	6/10/2008	OK3A	-0.01	-0.01	-0.02	0.00	0.00	-0.02	0.01	-0.04	-0.02	0.00	**Pass**
6/11/2008	7/1/2008	TX5A	0.01	0.00	0.00	0.01	-0.01	-0.02	-0.02	-0.02	-0.01	-0.03	**Pass**
7/1/2008	7/29/2008	TX5A	-0.03	-0.09	0.00	-0.05	-0.03	-0.06	0.02	-0.03	-0.02	0.00	**Pass**
8/10/2008	9/3/2008	WA5A	0.05	0.14	0.09	0.10	0.16	0.14	0.12	0.15	0.18	0.15	**Pass**
9/3/2008	9/26/2008	WA5A	-0.04	-0.06	-0.02	-0.01	0.00	0.00	0.02	-0.04	0.02	0.00	**Pass**
10/2/2008	10/15/2008	OK4A	0.00	0.01	-0.02	0.00	-0.01	0.01	0.03	0.03	0.11	0.00	**Pass**
10/16/2008	11/4/2008	TX5A	-0.02	-0.05	-0.03	-0.04	0.00	0.00	-0.04	-0.04	-0.01	-0.02	**Pass**
11/6/2008	12/3/2008	OK3A	-0.01	0.01	0.00	-0.02	0.14	-0.07	0.01	0.02	0.02	0.02	**Fail**
12/3/2008	12/16/2008	OK3A	0.01	-0.02	-0.01	-0.02	-0.01	0.02	0.00	0.00	-0.02	-0.01	**Pass**
12/18/2008	1/6/2009	TX5A	-0.03	-0.08	-0.05	-0.05	-0.06	-0.05	-0.06	-0.04	-0.07	-0.02	**Pass**
1/8/2009	1/27/2009	OK4A	-0.04	-0.03	-0.03	-0.04	-0.04	-0.02	-0.03	-0.02	-0.02	-0.01	**Pass**
1/29/2009	2/19/2009	TX5A	0.00	-0.05	0.00	0.01	-0.02	-0.05	0.02	0.02	0.12	-0.01	**Pass**
2/19/2009	3/18/2009	TX5A	0.03	0.03	0.04	0.03	0.02	0.04	0.01	0.02	0.03	0.01	**Fail**
3/18/2009	4/2/2009	TX5A	-0.14	-0.12	-0.13	-0.12	-0.14	-0.16	-0.14	-0.12	-0.15	-0.14	**Pass**
4/2/2009	4/21/2009	OK4A	0.00	0.05	0.05	0.04	0.04	0.07	0.05	0.03	0.01	0.02	**Pass**
4/22/2009	5/14/2009	OK3A	-0.06	0.00	0.00	-0.01	0.01	0.02	0.01	0.03	0.03	0.00	**Pass**
5/14/2009	5/21/2009	OK3A	-0.07	-0.11	-0.13	-0.11	-0.21	-0.10	-0.19	-0.16	-0.17	-0.18	**Pass**
5/21/2009	6/4/2009	WA5A	0.01	0.00	0.00	0.01	0.07	-0.03	0.05	0.02	0.00	0.00	**Pass**
6/4/2009	6/19/2009	WA5A	0.01	0.01	-0.04	-0.03	-0.03	-0.03	-0.02	-0.01	-0.02	0.00	**Pass**
6/23/2009	7/14/2009	OK3A	-0.02	-0.02	0.00	-0.02	-0.02	0.03	-0.03	-0.02	-0.02	0.01	**Pass**
7/15/2009	8/4/2009	OK3A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**Pass**
8/4/2009	8/6/2009	OK3A	0.00	-0.01	0.01	0.01	-0.01	0.01	-0.01	0.02	0.01	0.00	**Pass**
8/6/2009	8/27/2009	TX5A	0.00	-0.03	-0.05	-0.04	-0.02	-0.02	-0.01	0.01	0.01	0.03	**Pass**
8/27/2009	9/23/2009	TX5A	0.05	0.05	0.08	0.11	0.22	0.22	0.21	0.25	0.22	0.21	**Fail**
9/24/2009	10/13/2009	NC3A	0.02	0.03	0.00	0.02	0.00	0.00	0.00	-0.03	0.00	0.16	**Fail**
10/13/2009	10/27/2009	NC3A	0.00	-0.01	0.12	-0.05	-0.02	-0.12	-0.04	-0.05	-0.06	0.00	**Pass**
10/27/2009	11/11/2009	NC3A	0.15	0.06	0.18	0.10	-0.05	0.25	0.25	0.05	0.21	-0.60	**Fail**

The nominal planned interval between S-OPS checks was 20 d (three weeks). S-OPS checks were conducted at this long-term measurement location a relatively few times with the period of time between checks varying from one to three weeks (Figure 6.6-1). Shorter intervals between checks occurred due to work on the systems.

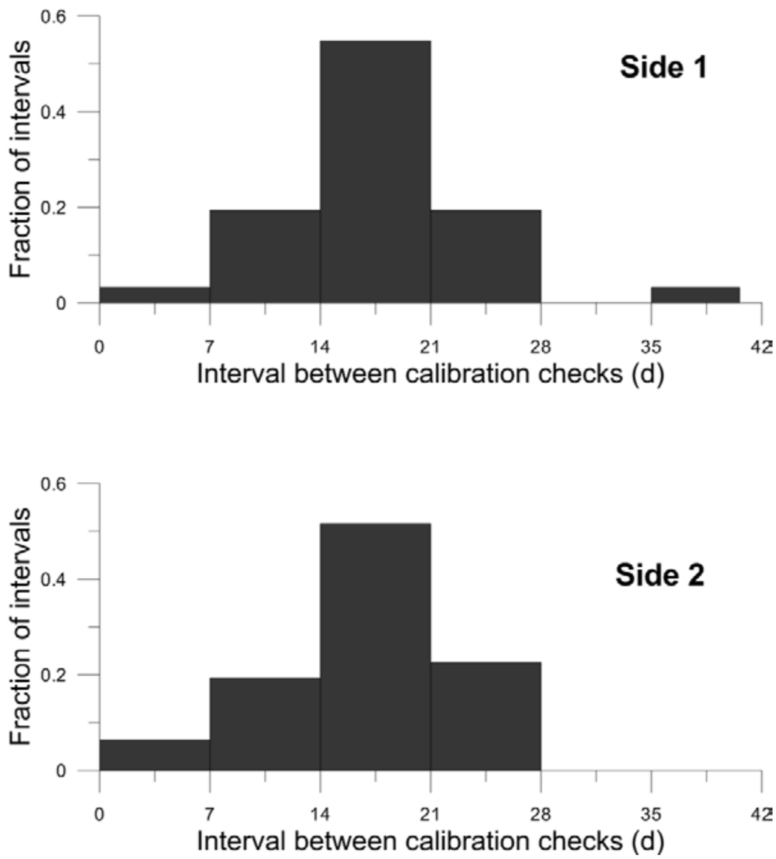


Figure 6.6-1: Intervals between checks

6.7 Miscellaneous meteorological and lagoon calibrations

6.7.1 Air temperature/ humidity

A hygrothermometer (Model HMP45C, Vaisala Inc., Helsinki, Finland) measured both air temperature and relative humidity. Calibration of this sensor was conducted at least annually. Initial calibrations were conducted by the factory. The record of calibration checks are documented in Table 6.7-1.

Table 6.7-1: Calibration record of Vaisala HMP45C, s/n 4410015

Relative humidity (RH)					
Calibration date	**Expected RH (%)**	**Measured RH (%)**	**Deviation from expected RH (%)**	**Average deviation RH (%)**	**Action**
2/17/2010	21	19	2		
	50	48	2		
	98	94	4		
				3	Accept
9/18/2009	11	20	-9		
	50	50	0		
	98	85	13		
				7	Adjust
	11	11	0		
	98	95	3		
	50	37	13		
	11	11	0		
	50	42	8		
				5	Accept
3/26/2009	23	20	3	3	Pass

Temperature (T)					
Calibration date	**Expected T (°C)**	**Measured T (°C)**	**Deviation from expected T (°C)**		**Action**
2/17/2010	24.3	24.5	-0.1		Pass
9/18/2009	26.5	26.9	-0.4		Pass
3/26/2009	24.9	24.9	0.0		Pass

6.7.2 Barometric pressure

An aneroid barometer (Model 278, Setra Inc., Boxborough, MA) with serial number 3033740 was used to measure barometric pressure. Calibration of this sensor was conducted at least annually. Initial calibrations were conducted by the factory. The record of calibration checks are documented in Table 6.7-2.

Table 6.7-2: Calibration record of Setra 278, s/n 3033740

Calibration date	Expected value range (hPa)	Number of comparisons	Mean difference from reference (hPa)	Action
2/11-12/2010	998.6-992.5	5	1.5	Pass
9/16-17/2009	997.5-1000.1	6	0.9	Pass
3/24-25/2009	986.0-992.0	6	1.4	Pass
7/9-11/2008	993.1-996.8	6	1.5	Pass
1/3-4/2008	1018.4-1001.7	6	2.5	Pass

6.7.3 Solar radiation

A pyranometer (Model 200SB, LiCOR Inc., Lincoln, NE) was used to measure solar radiation. Calibration of this sensor was conducted at least annually. Initial calibrations were conducted by the factory. The record of calibration checks are documented in Table 6.7-3.

Table 6.7-3: Calibration record of LyCOR 200SB Pyranometer, s/n PY55449

Calibration date	Mean difference from reference (Wm^{-1})	Mean difference from reference (%)	Action
3/5/2010	4.84	0.91	Retry
3/6/2010	1.40	0.37	Pass
8/30/2006			Factory calibration

6.7.4 Lagoon water temperature

A thermistor (Model 107-L Campbell Scientific Inc., Logan, UT) was used to measure lagoon temperature. Calibration of this sensor was conducted at least annually. Initial calibrations were conducted by the factory. Three thermistor probes were used at this location. The record of calibration checks are documented in Table 6.7-4.

Table 6.7-4: Calibration record of thermistor CSI 107-L

Calibration date	Expected value (°C)	Difference from expected (°C)	Action
Thermistor CSI 107-L, s/n 0020 (8888)			
6/18/2007	25.0	0.3	Accept
6/18/2007	24.5	0.4	Accept
6/18/2007	24.0	0.6	Accept
Thermistor CSI 107-L, s/n 0040			
6/18/2007	25.0	0.5	Accept
6/18/2007	24.5	0.7	Accept
6/18/2007	24.0	0.6	Accept
Thermistor CSI 107-L, s/n I			
2/15/2010	1.1	1.2	Accept
2/15/2010	35.7	2.9	Accept
9/14/2009	0.1	0.0	Pass
3/27/2009	-0.1	0.0	Pass

6.7.5 Sludge gun

The Marklin 20176 Sludge gun was used to measure sludge depth in the lagoon. Calibration of this sensor was conducted at least annually. Initial calibrations were conducted by the factory. The record of calibration checks are documented in Table 6.7-5.

Table 6.7-5: Calibration record of Marklin sludge un s/n 20176C

Calibration date	Mean (mm)	Standard deviation (mm)	Accuracy (mm)	Action
2/26/2010	69.70	0.51	1.70	Action
3/24/2009	78.11	1.05	-0.11	Action
7/23/2008	75.38	0.51	1.10	Action
1/4/2008	39.67	2.06	0.67	Action
3/23/2007	81.56	0.73	1.56	Action

6.7.6 CR1000 data logger

The CR1000 data logger (Campbell Scientific Inc., Logan, UT) was used to log all lagoon measurements (pH, oxidation-reduction potential, and temperature) and air temperature, relative humidity, barometric pressure, and wetness. Calibration check of this unit was conducted at the beginning and end of the study. Initial calibrations were conducted by the factory. The record of calibration checks are documented in Table 6.7-6.

Table 6.7-6: Calibration record of Campbell Scientific CR1000 data logger s/n 7677

Factory calibration						
Calibration date: 1/18/2007			**Single-ended**		**Differential**	
Channel	**Input (mV)**	**Tolerance (mV)**	**Measured mV**	**Error (mV)**	**Measured (mV)**	**Error (mV)**
13	5000	± 3	5000.48	-0.48	5001.02	-1.02
13	-5000	± 3	-5001.56	-1.56	-5001.02	-1.02
13	2500	± 1.5	—	—	2500.34	-0.34
13	250	± 0.15	—	—	250.042	-0.042
13	25	± 0.015	—	—	25.004	-0.004
13	7.5	± 0.0045	—	—	7.49724	0.00276
13	2.5	± 0.0015	—	—	2.49923	0.00077
13	-2.5	± 0.0015	—	—	-2.49906	0.00094
13	5000	± 6	4999.31	1.31	4998.64	2.64
13	5000	± 6	5000.58	-0.58	5001.02	-1.02
13	5000	± 6	—	—	—	—
13	5000	± 6	—	—	—	—

PAML calibration						
Calibration date: 2/5/2007			**Single-ended**		**Differential**	
SE Channel	**Input (mV)**	**Tolerance SE|DE (mV)**	**Measured mV mean value**	**Error (mV)**	**Measured (mV)**	**Error (mV)**
1	4950	±6.96| 4.97	4951.7	-1.7	—	—
2	4950	±6.96| 4.97	4951.7	-1.7	—	—
3	4950	±6.96| 4.97	4951.7	-1.7	—	—
4	4950	±6.96| 4.97	4951.7	-1.7	—	—
5	4950	±6.96| 4.97	4951.7	-1.7	—	—
6	4950	±6.96| 4.97	4951.7	-1.7	—	—
7	4950	±6.96| 4.97	4951.7	-1.7	—	—
8	4950	±6.96| 4.97	4951.7	-1.7	—	—
9	4950	±6.96| 4.97	4951.7	-1.7	—	—
10	4950	±6.96| 4.97	4951.7	-1.7	—	—
12	4950	±6.96| 4.97	4951.7	-1.7	—	—
13	4950	±6.96| 4.97	4951.7	-1.7	—	—

PAML calibration						
Calibration date: 2/5/2007			**Single-ended**		**Differential**	
SE Channel	**Input (mV)**	**Tolerance SE|DE (mV)**	**Measured mV mean value**	**Error (mV)**	**Measured (mV)**	**Error (mV)**
14	4950	±6.96| 4.97	4951.7	-1.7	—	—
15	4950	±6.96| 4.97	4951.7	-1.7	—	—
16	4950	±6.96| 4.97	4951.7	-1.7	—	—

Calibration date: 3/10/2010			**Single-ended**		**Differential**	
Channel	**Input (mV)**	**Tolerance SE | DE (mV)**	**Measured (mV)**	**Error (mV)**	**Measured (mV)**	**Error (mV)**
1	100	± 2.06 | 1.06	99.37	0.63	—	—
2	100	± 2.06 | 1.06	99.37	0.63	99.71	0.29
3	100	± 2.06 | 1.06	99.37	0.63	—	—
4	100	± 2.06 | 1.06	99.37	0.63	—	—
5	100	± 2.06 | 1.06	99.37	0.63	99.71	0.29
6	100	± 2.06 | 1.06	99.37	0.63	99.71	0.29
7	100	± 2.06 | 1.06	99.37	0.63	99.71	0.29
8	100	± 2.06 | 1.06	99.37	0.63	99.71	0.29
9	100	± 2.06 | 1.06	99.37	0.63	—	—
10	100	± 2.06 | 1.06	99.37	0.63	—	—
11	100	± 2.06 | 1.06	99.37	0.63	—	—
12	100	± 2.06 | 1.06	99.37	0.63	—	—
13	100	± 2.06 | 1.06	99.37	0.63	—	—
14	100	± 2.06 | 1.06	99.37	0.63	—	—
15	100	± 2.06 | 1.06	99.37	0.63	—	—
16	100	± 2.06 | 1.06	99.37	0.63	—	—
Calibration date: 3/10/2010			**Single-ended**		**Differential**	
Channel	**Input (mV)**	**Tolerance SE | DE (mV)**	**Measured (mV)**	**Error (mV)**	**Measured (mV)**	**Error (mV)**
1	0	± 2.06 | 1.06	0	0	—	
2	0	± 2.06 | 1.06	0	0	0	0
3	0	± 2.06 | 1.06	0	0	—	—
4	0	± 2.06 | 1.06	0	0	—	—
5	0	± 2.06 | 1.06	0	0	0	0
6	0	± 2.06 | 1.06	0	0	0	0
7	0	± 2.06 | 1.06	0	0	0	0
8	0	± 2.06 | 1.06	0	0	0	0
9	0	± 2.06 | 1.06	0	0	—	—

Calibration date: 3/10/2010			Single-ended		Differential	
Channel	**Input (mV)**	**Tolerance SE | DE (mV)**	**Measured (mV)**	**Error (mV)**	**Measured (mV)**	**Error (mV)**
10	0	± 2.06 | 1.06	0	0	—	—
11	0	± 2.06 | 1.06	0	0	—	—
12	0	± 2.06 | 1.06	0	0	—	—
13	0	± 2.06 | 1.06	0	0	—	—
14	0	± 2.06 | 1.06	0	0	—	—
15	0	± 2.06 | 1.06	0	0	—	—
16	0	± 2.06 | 1.06	0	0	—	—

6.7.7 CR800 data logger

The CR800 data logger (Campbell Scientific Inc., Logan, UT) was used to log all GSS measurements (air temperature and relative humidity, flow rate, and pressure). A calibration check of this unit was conducted only at end of the study. Initial calibrations were conducted by the factory. The record of calibration checks are documented in Table 6.7-7.

Table 6.7-7: Calibration record of Campbell Scientific CR800 data logger s/n 3698

Calibration date: 3/10/2010			**Single-ended**	
Channel	**Input (mV)**	**Tolerance SE (mV)**	**Measured (mV)**	**Error (mV)**
1	100	± 2.061	99.23	0.77
2	100	± 2.061	99.23	0.77
3	100	± 2.061	99.23	0.77
4	100	± 2.061	99.23	0.77
5	100	± 2.061	99.23	0.77
6	100	± 2.061	99.23	0.77
Calibration date: 3/10/2010			**Single-ended**	
Channel	**Input (mV)**	**Tolerance SE (mV)**	**Measured (mV)**	**Error (mV)**
1	0	± 2.061	0	0
2	0	± 2.061	0	0
3	0	± 2.061	0	0
4	0	± 2.061	0	0
5	0	± 2.061	0	0
6	0	± 2.061	0	0

6.8 Site Activity

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
6/24/2007	22:18-22:57	Calibration	Calibration verification of TDLAS 1029; instrument passes, 1031 fails with RSD 8.5%; still working on proper procedure
6/27/2007		Setup	Retro-reflectors mounted and prepped with plastic, holes, and back plates. Sonic anemometers tested and mounted. Electrical finished (except for missing outlet on met trailer).
6/27/2007		Setup	No DSL internet communication established (No means to remotely check operations)
6/27/2007	23:00-23:10; 21:40-22:40	Setup	Zero and Inter-comparison Sonic Anemometers, instruments pass
6/27/2007	22:27	Setup	Calibrate Barometer, instrument passes
6/27/2007	1:48	Setup	Calibrate ORP Sensor, instrument passes
6/27/2007	0:29	Setup	Calibrate pH sensor, instrument passes
6/27/2007		Setup	Lagoon temperature Check
6/28/2007		Setup	Tower height measurements taken. ORP and pH probe caps empty when placed into lagoon for measurements (no KCL solution)
6/28/2007	15:50; 15:38	Setup	Calibration verification of TDLAS 1029, 1031; instruments fail; still working on proper procedure
7/9/2007		Repair	Calibrate TDLAS 1031
7/9/2007		Repair	TDLAS's have light values below 2000 for retro-reflectors 1-2 & 4-8/TDLAS 1031. 1-4 & 6-10/ TDLAS 1029. Retro-reflectors 3, 9-10/ TDLAS 1031 and 5/ TDLAS 1029 have Light levels just above 2000.
7/9/2007		Repair	Checked all retro-reflectors; all seemed to be in good shape/not damaged except 1/1029 where condensation was found inside retro-reflector box. Opened up retro-reflector box to dry out and lined up and ran again.
7/9/2007		Repair	Meteorological data was not logged between 7/2/2007 and 7/9/2007. Power outlet used for met. tower is same as output used for retro-reflector 1 of TDLAS 1029. Thought power outlet was bad, but power is running though outlet. *Loggernet* program, running meteorological/lagoon measurements, was closed on LAN computer. Restarted program and data started to flow again.
7/18/2007		Repair	Installed DSL internet modem (dynamic dns) Reset optimization to every 6 h. Scanner not responding each time when sending pan/tilt commands from *GasView MP* program to realign scanner with retro-reflectors. Tried stopping scan, closing then reopening pan-tilt unit in *GasView MP* program. Now scanner will not respond at all, gives "Pan-Tilt Error" message. Called Boreal Laser. Viewed pan-tilt data in *GasView MP* program (none was showing when sending pan-tilt commands). Tried unplugging scanner and plugging it back in; started correctly but still giving "pan-tilt"

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
			error. Checked to see if optimization changes affected scanner, but when resetting to original optimization time, still gave same error.
7/18/2007		Repair	Scanners still reading "Pan-Tilt" error this morning. Turned off scanner modem inside trailer, closed pan-tilt unit in *GasView MP* program, turned modem back on, and opened pan-tilt unit in *GasView MP* program. This worked successfully.
7/19/2007		Repair	Retro-reflectors with condensation include: TDLAS 1031 retro-reflector 1 & 5, and TDLAS 1029 retro-reflector 1 & 6. Dried condensation in retro-reflectors and sealed with duct seal around windows. When opened retro-reflector doors, water poured out. Assumed most likely a leak where rain was able to drain in.
7/30/2007		Repair	Sealed retro-reflector windows (on ground) with silicone seal/caulk. Retro-reflectors with water on previous trip have no water after using duct electronic seal Lagoon is starting to crust over-- may indicate dry weather recently.
7/30/2007		Repair	No functioning internet DSL communications. Communications lost when Purdue changed parameters (from dynamic dns to fixed dns) with DSL provider without asking us. Automatic updating of DSL modem by provider did not happen due to trailer location being outside provider's service range (roving).
7/31/2007	20:15-21:15	Setup	Sonic anemometer inter-comparison, instruments pass
7/31/2007		Setup	Sludge depth measurements made but affected by wind.
8/1/2007	14:02-14:17	Setup	Sonic anemometer zero check, instrument passes
8/1/2007	17:07	Setup	ORP Calibration, instrument passes
8/1/2007	16:54	Setup	pH Calibration, instrument passes
8/2/2007	19:03	Setup	Calibration verification of TDLAS 1031: Measurements were too high for zero and calibration verification gas on first trial. Second background also too high, but third gave valid measurements. Second calibration verification gas was not very steady and gave large (invalid) accuracy. Assumed diluter was working improperly, so flowed calibration gas directly into calibration chamber instead of indirectly and thru diluter--gave valid measurements for third trial. Still noticed when fan was running and door was open, concentrations increased and were unstable.
8/1/2007	19:38	Setup	Calibration verification of TDLAS 1029: first background was valid, but calibration verification gas gave an invalid accuracy value. Second background trial was done without diluter and calibration gas flowed directly thru calibration chamber. Gave valid accuracy and calibration values. Port C of TEC 146i diluter gave the invalid readings; port A used and gave valid readings, but still found that if fan was turned on, concentrations would increase and be unstable
8/3/2007		Setup	pH and ORP values did not seem valid. Wiring was switched for both probes; rewired and fixed problem.
8/3/2007		Setup	Installed new *GasView MP* software version

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
8/3/2007		Setup	Drove to Colorado to upgrade internet radio. Worked on laptop in Colorado but not when brought back to site. Need to bring back to Lafayette for upgrade with correct area code.
8/14/2007		Inspection	DSL modem re-installed, operational
8/14/2007	19:25-20:25	Inspection	Sonic anemometer inter-comparisons, instruments fail. Anemometer calibration inter-comparison had to be redone because values were slightly off the first time. Anemometers' boxes switched 1-1928 2-1921 3-1932, instruments pass.
8/14/2007	21:43-21:54	Inspection	Sonic anemometer zero check, instruments pass.
8/14/2007		Inspection	pH Calibration, instrument passes
8/14/2007		Inspection	ORP Calibration, instrument passes
8/14/2007	20:36	Inspection	Calibrate TDLAS 1031: TDLAS calibrations went smoothly; redid calibration gas for 1031 because values took a while to stabilize, instrument passes
8/14/2007	21:17	Inspection	Calibrate TDLAS 1029, instrument passes
8/15/2007		Inspection	Anemometers are mounted and working well.
8/15/2007		Inspection	Scanner 5 retro-reflector 3 distance changed from 1 to 125m
8/15/2007		Inspection	Noted that putting window of sliver tape around nearest retro-reflectors helped with light values.
8/15/2007		Inspection	Connection on failed UPS was loose; made connection improvement and UPS works.
8/15/2007		Inspection	Spiders found in meteorological power box. Added duct/electrical putty to wire inlet to prevent in future.
8/16/2007		Inspection	Sludge depth measurements taken, not calculated; possibly affected by wind
8/28/2007		Takedown	Did TDLAS and sonic anemometer calibrations/acceptance. Sonic anemometers 1 and 3 were giving values greater than 1 ms^{-1} for bias check. Chris closed boxes more tightly which gave values accepting numbers.
8/28/2007	18:20	Takedown	Sonic anemometer inter-comparison, instrument passes
8/28/2007	19:18	Takedown	Calibration verification of TDLAS 1029, instrument passes
8/28/2007	20:29	Takedown	Calibration verification of TDLAS 1031, instrument fails accuracy measurements
8/28/2007	21:15	Takedown	Zero Check Sonic anemometers, instrument passes
8/29/2007		Takedown	Loaded up trailer and got ready to move to OK3A. pH/ORP acceptance passed
8/29/2007		Takedown	Calibrate pH probe, instrument passes
8/29/2007		Takedown	Calibrate ORP probe, instrument passes
8/30/2007		Takedown	Calibrate pH probe
11/7/2007		Setup	Could not perform barometer audit because it was sent to manufacturer for repair and has not been installed.
11/7/2007		Setup	Too windy to perform sludge depth measurements.
11/7/2007		Setup	Measured chemicals for QCCS and KCl solutions.
11/7/2007		Setup	Mounted retro-reflectors and installed anemometers. Could not install anemometer 2 because threads were not working properly. Need to take to hardware store to fix.
11/7/2007		Setup	Calibrate Wetness Sensor

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
11/8/2007		Setup	Too windy to perform sludge depth measurements in morning. Measurements done in afternoon.
11/8/2007		Setup	Broken head on tripod.
11/8/2007		Setup	Fixed bolt on SE tower.
11/8/2007		Setup	Mounted sonic anemometer 2 and swapped antennas on units 5 and 6 due to orientation.
11/8/2007		Setup	Calibrate pH probe
11/8/2007		Setup	Calibrate ORP probes
11/8/2007		Setup	Take sludge depth measurements
11/9/2007	16:40	Remote	Check out sonic anemometer program after call from Chris indicating it had crashed. Logged onto LAN
11/9/2007	16:40	Remote	Check out sonic anemometer program. Crashed at second line in initial summing routine (subscript out of range). Counter=4001. Crashed around 1540Z. Messed up time stamps in 300-s data around this time
11/12/2007		Remote	Re-aim one path on TDLAS and change parameters. Logged onto LAN, TDLAS 1 (1029), and TDLAS 2 (1031)
11/12/2007		Remote	TDLAS 2 (192.168.0.102). TDLAS (1032) path 8 not aligned. Changed obstruction level from 500 to 100. Both TDLAS's now working.
11/16/2007		Remote	Check status and modify *GasView MP* parameters
11/16/2007		Remote	Changed timeout from 3600 s to 900 s on both TDLAS's. At 1445Z, observed "xxxx" on TDLAS 2 (1032) while on path 2 (during optimization). It eventually corrected itself.
11/27/2007		Calibration	Blew off (with dust remover spray) the temp/RH filter. It's still dirty and needs to be cleaned.
11/27/2007		Calibration	Another bolt on SE tower loose. Will fix tomorrow.
11/27/2007		Calibration	Could not get stable measurements for TDLAS 1032 tests 1 and 2.
11/27/2007		Calibration	Could not check barometer; sent back to manufacturer for repair.
11/27/2007	16:55-17:55	Calibration	Inter-comparison calibration for sonic anemometers
11/27/2007	18:43	Calibration	Zero calibrate sonic anemometers
11/27/2007	20:41	Calibration	Calibrate TDLAS 1029
11/27/2007	21:19	Calibration	Calibrate TDLAS 1032
11/27/2007	21:19	Calibration	Could not get stable measurements for calibration gas tests #1 and 2.
11/28/2007		Calibration	Calibrate pH
11/28/2007		Calibration	Calibrate radiation (noted on open site notes but no record found)
11/28/2007		Calibration	Calibrate ORP probe
11/28/2007		Calibration	Calibrate wetness sensor
11/28/2007		Calibration	Tightened bolt on SE tower that was loose
11/28/2007		Calibration	Installed probe float. pH and ORP were reading valid measurements; temp probe was reading between 20C and 83C. Removed probe float and unwired temp. pH probe and temp probe started reading "NAN" in *Loggernet* at same time. Checked pH probe with pH 7 solution. Read 5mV (7.08 pH units). Reinstalled/wired pH probe; still NAN in *Loggernet* in

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
			lagoon. Checked temp probe resistance at room temp. Read about 1000 olms. Returning temp. probe to office. Noticed nicks in temp proble cables. Worsened on sharp rocks in lagoon berm bank when installed probe float in lagoon. Temp probe was working properly before launched. Other probes (pH/ORP) have small nicks but nothing through the casing. pH and ORP wire casings have a heavier rubber.
11/28/2007		Calibration	Status LED light on CRM100 showing orange. Tried to restart data logger and remove/reinstall memory card to no success. Looked at CFM100 manual to find meaning for orange status LED light. Manual said it only signified an error. Overall removed lagoon probe float 3 times for testing/difficulties.
11/28/2007		Calibration	Calibrate wetness sensor
12/18/2007		Takedown	Too windy to perform sludge depth measurements.
12/18/2007		Takedown	Tightened bolts on NW tower.
12/18/2007		Takedown	Communications with data logger were not working properly. Tried adjusting position of NEMA box and antenna--still not working. Memory card contained no data. Will bring met tower closer to trailer tomorrow to establish communication (West laptop no longer has *Loggernet* to download from data logger).
12/18/2007	18:05-19:05	Takedown	Sonic anemometer inter-comparison
12/18/2007	19:31	Takedown	Zero Calibrate Sonic anemometers
12/18/2007	20:40	Takedown	Calibrate TDLAS 1032
12/18/2007	20:40	Takedown	TDLAS 2 was not aligned-was aimed 45 degrees to the right
12/19/2007		Takedown	Calibrate pH probe
12/19/2007		Takedown	Calibrate ORP probes
12/19/2007		Takedown	Calibrate wetness sensor
12/19/2007		Takedown	1. Too windy to perform sludge depth measurements. 2. Moved met. Tower near trailer to download data on LAN. Data from met station is on CD. Could not append data file. 3. Packed trailer. 4. Truck oil change, topped fluids. 5. Made new Zobells. 5. Used distilled water in pH and ORP caps--will change solution in lab.
4/23/2008		Setup	While performing 2nd background calibration on TDLAS 1032, TDLAS kept losing connection to Panasonic; checked wire connections but still showed communication problems.
4/23/2008		Setup	Tied down trailer; powered up trailer, and started sonic anemometer inter-comparison before storms hit.
4/23/2008		Setup	Inter-comparison was performed during storm with mean wind speeds greater than 11.5 ms^{-1}. Inter-comparison did not pass (most likely due to high wind speeds). Will run sonic anemometer program overnight and calculate inter-comparison in the morning.
4/23/2008		Setup	Calibrated TDLAS 1032 – Mean: 50.83 - SD: 0.18 - RSD: 0.4% - Bias: 2.1% - Notes: Could not get it to completely zero, but r^2 values were below 84% (~40-55). Directly hooked up, lost connection during second background calibration.

Date (mm/dd/yyyy)	Time (HH:MM)	Activity (setup, takedown, calibration, repair, remote)	Event
4/23/2008	20:41-20:46	Setup	Calibrated TDLAS 1026 – Mean: 52.76 - SD: 0.57 - RSD: 1.0% - Bias -1.2%
4/23/2008	20:45-21:45	Setup	Sonic anemometer inter-comparison: All pass. Notes: Storm was approaching and sonic anemometer 2 stopped working (gave values of zero) before an hour of measurements were taken. Water may have gotten into the sonic anemometer; will still mount sonic anemometer for measurement period (values for half hour of inter-comparison passed); saw this problem before and it usually dries within a day approx. Will perform full inter-comparison at takedown.
4/24/2008		Setup	Too windy to perform sludge depth measurements.
4/24/2008		Setup	Checked sonic anemometer values to perform inter-comparison after running overnight. Sonic anemometer 2 was giving zero values (could be from rain). Storm was approaching and sonic anemometer 2 stopped working (gave values of zero) before an hour of measurements were taken. Water may have gotten into the sonic anemometer; will still mount sonic anemometer for measurement period (values for half hour of inter-comparison passed); saw this problem before and it usually dries within a day approx. Will perform full inter-comparison at takedown.
4/24/2008		Setup	Made KCl, Zoebell's, and QCCS solutions. pH and ORP probes calibrations and acceptance had invalid values. Changed reference solution, cleaned probes with soap and water, shook probes about 10 times. Will install probes into lagoon and check readings at end of period.
4/24/2008		Setup	Motherboard on 450i no longer failing.
4/24/2008		Setup	Pulling scanner in SW corner. Grinding/not moving properly. Sent high-power command--still not working. Power-cycled (2x)--worked temporarily, then started grinding/shaking again.
4/24/2008		Setup	Checked battery on CR800 with mulitmeter voltage--read the same values.
4/24/2008		Setup	Site setup map included with site notes.
4/24/2008		Setup	Wetness sensor calibration: accepted.
4/24/2008		Setup	ORP Calibration: pass
4/24/2008		Setup	pH Calibration: pass
4/24/2008		Setup	S-OPS Installation map made.
4/24/2008	14:13	Setup	Zero sonic anemometer calibration: all pass. Note: Sonic anemometer 2 started working when taken down from inter-comparison mount.
4/24/2008	14:35-15:35	Setup	Sonic anemometer inter-comparison: All pass. Notes: Second trial after sonic anemometer 2 stopped giving zero values--successful.
4/24/2008	16:04	Setup	Barometer audit: accepted.
4/25/2008	14:00	Remote	Daily Status Check from PAML– Notes: Seeing some sonic anemometer flagged points in all three sonic anemometers. pH is about 8.7. Closed log file for TDLAS 2 since unit is not present (bad scanner). Updated *rsync* for new site and transferred data.

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
4/25/2008	14:00	Remote	Daily Status Check from PAML – Notes: No H_2S motherboard failures. There were failures before takedown at TX5A but not during setup at OK4A.
4/29/2008	13:47	Remote	Daily Status Check from PAML – Notes: Lagoon temperature jumped about 5°C but is currently back to where it was previously. Will monitor temperature carefully
4/30/2008	12:30	Remote	Daily Status Check from PAML – Notes: Lagoon temperature jumped around the same time it did previous day. Currently the temperature is back to normal.
5/1/2008	12:23	Remote	Daily Status Check from PAML – Notes: TDLAS 2 not present due to scanner issues.
5/2/2008	14:00	Remote	Daily Status Check from PAML – Notes: Temp/ORP spikes at same time but return to normal.
5/2/2008	12:30	Remote	Daily Status Check from PAML – Notes: pH around 9. Firewall turned off. More than a week since last backup. Not enough space to perform backup. Enabled Windows Firewall for all network connections.
5/5/2008	12:30	Remote	Daily Status Check from PAML. Notes: pH around 9.0. Issues with alignment on retro-reflectors 3 and 4 on TDLAS 1. Minor issues intermittently with TDLAS1 calibration worksheet graphs. Reference r^2 sometimes drops; CDC sometimes drops. TDLAS 2 not present due to scanner failure. Firewall turned off. More than a week since last backup. Not enough space to perform backup. Enabled Windows firewall for all network connections.
5/6/2008		Takedown	Too windy to perform sludge depth measurements.
5/6/2008		Takedown	UPS switched to battery power at 1:13:43 and AC restored message was sent at 1:13:48.
5/6/2008		Takedown	Only calibrated TDLAS 1032 because 1026 was not used this measurement period.
5/6/2008		Takedown	Checked retro-reflectors for TDLAS 1032; looked clean and facing at good angle.
5/6/2008		Takedown	Performed pH/ORP calibrations. ORP values were reasonable. pH values not acceptable but will replace current 1M KCl solution with 3.5 M KCl solution before installing in OK3A.
5/6/2008		Takedown	Packed up trailer and moved to OK3A.
5/6/2008		Takedown	GSS Leak Test: pass
5/6/2008		Takedown	S-OPS inlet flow verification: Fail
5/6/2008		Takedown	ORP Calibration: pass
5/6/2008		Takedown	pH calibration: Fail Note: Will make new KCl solution.
5/6/2008	17:45-18:45	Takedown	Sonic anemometer inter-comparison: Pass
5/6/2008	18:31	Takedown	Calibrated TDLAS 1032 – Mean: 53.4 - SD: 0.64 - RSD: 1.2% - Bias: 7.1% - Notes: During first background, distance was set to 66 meters, but values were zero during background period. Changed path distance to 1 meter by multiplying concentration column by 66 to achieve PIC during background.
5/6/2008	18:45	Takedown	Barometer audit: accepted.
5/6/2008	18:59	Takedown	Wetness sensor calibration: accepted.

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
5/6/2008	19:09-19:29	Takedown	TEC 450i Instrument Operating Parameters
5/6/2008	19:09-19:29	Takedown	TEC 450i Calibration Verification Check
5/6/2008	19:36	Takedown	Sonic anemometer zero calibration: Pass
10/1/2008		Setup	Made QCCS, KCl, and Zobells solutions
10/1/2008		Setup	Barometer reading high when manually taking voltage reading, but values in *Loggernet* program seem accurate (~9.84 kPa); will keep in field/
10/1/2008		Setup	Could not do lagoon probe calibrations due to faulty battery in multimeter (24 V supply shows ~29.5 V on multimeter). Will purchase 9V battery to perform calibrations tomorrow.
10/1/2008		Setup	Zero gas pressure too low to perform H_2S calibration. Had regulator turned off (zero off), but gas must have leaked out (tank pressure now 0.0 psi).
10/1/2008		Setup	Lagoon site layout made
10/1/2008	14:50-15:50	Setup	Sonic anemometer inter-comparison: all pass.
10/1/2008	15:40	Setup	Wetness sensor calibration: accepted.
10/1/2008	16:28	Setup	Zero sonic anemometer calibration
10/1/2008	18:42	Setup	Calibrated TDLAS 1028
10/1/2008	19:20	Setup	Calibrated TDLAS 1027
10/2/2008		Setup	There are only two calibration files for the H_2S /SO_2 calibration. They are both saved in the H_2S control chart.
10/2/2008		Setup	Had to restart sonic anemometer program in order to start *iPort*.
10/2/2008		Setup	pH probe was not replaced during six months calibrations. Current probe is stable but reading ~30-40 mV lower than expected. Still launched probe but need to bring new probe during next visit.
10/2/2008		Setup	Refrigerator does not seem to be working so Zobell's solution may not be good during next visit.
10/2/2008		Setup	Maintenance list completed.
10/2/2008		Setup	pH sensor acceptance and stability Notes: Did not bring new probe; passed stability but not acceptance; will still launch probe but will bring new one during next visit.
10/2/2008		Setup	TEC 450i Calibration Verification Check – See Control Chart for details.
10/2/2008		Setup	GSS Leak Test: pass
10/2/2008		Setup	GSS No Flow Test
10/2/2008		Setup	GSS Max Flow Test
10/2/2008		Setup	S-OPS Max Flow Test
10/2/2008		Setup	S-OPS/GSS Leak Test: Fail
10/2/2008	14:26	Setup	Barometer audit: accepted.
10/2/2008	14:45	Setup	ORP Calibration: pass
10/2/2008	14:53	Setup	TEC 450i Instrument Operating Parameters
10/2/2008	14:55	Setup	pH quality assurance. Notes: Did not bring new probes and did not pass; will still launch (passed stability), but will bring new probe next time.
10/2/2008	15:11	Setup	TEC 450i Reference Precision Check

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
10/2/2008	16:21	Setup	SO_2 calibration
10/2/2008	17:15	Setup	Launched lagoon probes.
10/2/2008	19:30	Setup	Started GSS.
10/3/2008	12:50	Remote	Daily Status Check from PAML – Notes: Five "backup" files were present in GSS data. Merged all these into the file CR800_OK4A_20081001.dat and deleted to neaten up directory. CR 1000 file contained all data from preceding period (WA5A P6). Saved a backup of this file and removed this data. Sonic anemometer 1 had up to 370 flagged points around 641.81. All three sonic anemometers had 1 point at 642.017 with about 9500 data points (missed a time; made up for low values during previous two periods). H_2S sample flow is 0.96 LPM.
10/6/2008	12:07	Remote	Daily Status Check from PAML – Notes: Lots of flagged data on sonic anemometer 1 on day 644. TDLAS QC program has crashed. Innova flag 16. Rain and fog has caused loss of many paths on both TDLAS's.
10/7/2008	12:30	Remote	Daily Status Check from PAML - Notes: TDLAS 1 and 2 had retro-reflectors that were not aligned, most likely due to high winds. Was able to find all paths, but when running TDLAS 1 scanner could not find paths 6, 7, and 8. Tried re-aiming multiple times and paths were still not found while program was running (when aiming, scanner was only off about one step from finding valid light level). Will let program run awhile and will check on again later today. Missing data for sonic anemometer one between 643.7 and 645.2; w values not averaging zero. Sonic anemometers 2 and 3 have same w trend but not as severe. Sonic anemometer 3 spiked about 646.1 but not back to normal with 160 spike points. Innova flag 16.
10/8/2008	12:30	Remote	Daily Status Check from PAML – Notes: TDLAS 1 paths 6 and 7 are still not staying aligned. pH values have increased (jumped up but not a drastic amount. Innova flag 16.
10/14/2008		Takedown	TDLAS 1 *GasView MP* program was frozen and had a pan/tilt error. Scanner did not appear to be moving. TDLAS 2 did not really have any path aligned due to heavy rain. Many of the tripod legs on the ground retro-reflectors were sinking several inches into the ground causing the retro-reflector to tilt a bit (no grass on the berm).
10/14/2008		Takedown	When taking lagoon float, all three lagoon probe wires (pH, ORP, and temperature) were cut in several places by the sharp rocks along the edge of the lagoon. One of the ropes holding the lagoon in place. Cause must have been high winds and large waves on the lagoon pulling the wires back and forth over the sharp rocks.
10/14/2008		Takedown	TEC 450i Calibration Verification Check – See Control Chart for details.
10/14/2008	16:22	Takedown	Barometer audit: accepted.
10/14/2008	16:23	Takedown	Wetness sensor calibration: accepted.
10/14/2008	17:36	Takedown	Calibrated TDLAS 1027

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
10/14/2008	18:15	Takedown	Calibrated TDLAS 1028
10/14/2008	22:33	Takedown	TEC 450i Reference Precision Check
10/14/2008	22:44	Takedown	TEC 450i Instrument Operating Parameters
10/14/2008	23:04	Takedown	SO_2 calibration
10/15/2008		Takedown	Road very muddy last evening. Rain stopped in late evening. Road a little better this morning but still poor in places.
10/15/2008		Takedown	Maintenance list completed.
10/15/2008		Takedown	GSS Leak Test: pass
10/15/2008		Takedown	GSS No Flow Test
10/15/2008		Takedown	GSS Max Flow Test
10/15/2008		Takedown	S-OPS Max Flow Test
10/15/2008		Takedown	S-OPS/GSS Leak Test: Pass
10/15/2008	12:00-13:00	Takedown	Sonic anemometer inter-comparison Notes: Sonic anemometer 2 (1932) is passing values of all 0's with flag 2. May be due to wet weather yesterday.
10/15/2008	16:26	Takedown	Zero sonic anemometer calibration – Notes: Sonic anemometer 2 (1932) not working. Passing all 0's with flag 2.
1/7/2009		Setup	Reached site at 1:15 pm local time. Hooked up trailer with power and tied down.
1/7/2009		Setup	Hooked up trailer with power and tied down.
1/7/2009		Setup	Set up all ground retro-reflectors.
1/7/2009		Setup	There was no NH_3 gas cylinder, so TDLAS calibration could not be done.
1/7/2009		Setup	Too windy to perform sludge depth measurements.
1/7/2009		Setup	Leak in 590 (CGA) zero gas regulator; will take back to PAML.
1/8/2009		Setup	Too windy to perform sludge depth measurements.
1/8/2009		Setup	Not installing lagoon sensors due to possibility of lagoon freezing during measurement period.
1/8/2009		Setup	Could not replace desiccant in NEMA box because airport security found it to be explosive and threw them out; will replace next time.
1/8/2009		Setup	Had PTU/TDLAS system aligned in SW corner (TDLAS 1027, PTU 1315/unit 6, TDLAS 2) and working properly.
1/8/2009		Setup	Tried aligning TDLAS 1028, PTU 1206/unit 5, TDLAS 1, but could not get scanner to move; tried restarting scanner by unplugging to outlet. Plugged back in but no power to modems (performed no initialization).
1/8/2009		Setup	Switched power cords used on SW and NE corners; system on SW still working, but NE corner still without power.
1/8/2009		Setup	Switched power supply/modem boxes (6 now on NE corner). There is power to both modems, but the scanner not moving when sending commands. "Pan-Tilt Link" not sending any data to Panasonic when commands sent. Found heat sink was touching metal post and was brownish/black where contact was made (indicating short in past). Found small post loose inside box touching metal plate (not sure but could cause problems?).
1/8/2009		Setup	Placed scanner from SW corner (1315) on NE corner with box

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
			#6. System working properly.
1/8/2009		Setup	Will bring scanner, power supply, and modem box to PAML for further investigation.
1/8/2009		Setup	Lagoon site layout made
1/8/2009		Setup	Maintenance list completed.
1/8/2009	15:45-16:45	Setup	Sonic anemometer inter-comparison; all pass.
1/8/2009	15:46	Setup	Wetness sensor calibration: accepted.
1/8/2009	17:08	Setup	Zero sonic anemometer calibration; all pass.
1/8/2009	18:30	Setup	Started collecting H_2S data.
1/9/2009	19:10	Remote	Daily Status Check from PAML – Notes: Changed dwell from 0 sec to 15 sec for TDLAS 1 paths 2, 4, 5, 7 and re-aimed slightly. This was causing 0 light level values for these paths. No lagoon probes. (Note: Paper copy is missing. DWS: 2/26/2009)
1/12/2009	14:10	Remote	Daily Status Check from PAML – Notes: TDLAS 2 is not running at site. H_2S sample flow low at 0.8 LPM; steady at this rate. (Note: Paper copy is missing. DWS: 2/26/2009)
1/13/2009	13:40	Remote	Daily Status Check from PAML – Notes: TDLAS 2 is not running at site. H_2S sample flow low at 0.8 LPM; steady at this rate. QC files stop at 20:45 UTC on 1/12/2009 for GSS/ H_2S data. (Note: Paper copy is missing. DWS: 2/26/2009)
1/14/2009	14:00	Remote	Daily Status Check from PAML – Notes: TDLAS 2 is not running at site. H_2S sample flow low at 0.8 LPM; steady at this rate. Difficult to check time synch because of slow internet connection. (Note: Paper copy is missing. DWS: 2/26/2009)
1/15/2009	13:55	Remote	Daily Status Check from PAML – Notes: TDLAS 2 is not running at site. H_2S sample flow low at 0.8 LPM; steady at this rate. (Note: Paper copy is missing. DWS: 2/26/2009)
1/16/2009	14:26	Remote	Daily Status Check from PAML – Notes: H_2S sample flow steady at about 0.8 LPM. No TDLAS 2 at this site.
1/20/2009	14:15	Remote	Daily Status Check from PAML
1/21/2009	13:00	Remote	Daily Status Check from PAML– Notes: TDLAS 2 not present due to scanner issues.
1/22/2009	13:40	Remote	Daily Status Check from PAML - Notes: TDLAS 2 not present due to scanner issues. Approximately 50% of the time, 9 paths are aligned on TDLAS 1 (~96% of the time, 9-10 paths aligned). No lagoon measurements.
1/23/2009	13:20	Remote	Daily Status Check from PAML – Notes: No QC file update. TDLAS 2 is not present due to scanner problems.
1/26/2009	16:15	Remote	Daily Status Check from PAML – Notes: *iPort* error. Stopped sonic anemometer program to restart *iPort* program. Connected to H_2S analyzer. Filled data starting at 15:08 on 1/24/2009. All H_2S QC data is fine through that time. Second data fill starting at 11:19 on 1/26/2009. Had to create a couple new files. Restarted sonic anemometer program. TDLAS 2 is not present due to power supply/scanner issue. No lagoon probes.
1/27/2009		Takedown	Luggage lost which contained the zero gas regulator; cannot perform H_2S 450i calibration. The tank concentration is too high

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
			for 450i to read (i.e. cannot do zero or span calibrations).
1/27/2009		Takedown	UPS giving year as 1970 in records. See open site notes for details.
1/27/2009		Takedown	Special form made showing OK4A period 7 S-OPS tubing extension layout.
1/27/2009		Takedown	Maintenance list completed.
1/27/2009	19:10	Takedown	Sonic anemometer inter-comparison; all pass.
1/27/2009	19:20	Takedown	Calibrated TDLAS 1028
1/27/2009		Takedown	Zero sonic anemometer calibration; all pass.
1/27/2009	20:39	Takedown	Barometer audit: accepted.
1/27/2009	20:40	Takedown	Wetness sensor calibration: accepted.
4/1/2009		Setup	Set up all ground retro-reflectors, tower retro-reflectors, met station (not plugged in), scanners/scanner tripods, and scanner power supply boxes.
4/1/2009	21:25-:21:45	Setup	Sonic anemometer inter-comparison; all pass.
4/1/2009	23:00	Setup	Zero sonic anemometer calibration; all pass.
4/2/2009		Setup	SO_2 regulator still not working properly. It's showing zero (0.0) for tank pressure.
4/2/2009		Setup	Outlet on SW corner not working. Replaced with new outlet.
4/2/2009		Setup	UPS History: 4/2/2009: 10:23:22: UPS switched to battery power. 10:23:22: UPS bypass unavailable. 10:23:26: AC restored message sent to registered clients connected to Load Segment 2.
4/2/2009		Setup	Too windy to perform sludge depth measurements.
4/2/2009		Setup	Maintenance list completed.
4/2/2009		Setup	Lagoon site layout made
4/2/2009		Setup	ORP sensor: calibration and acceptance pass
4/2/2009	15:45	Setup	Calibrated TDLAS 1028
4/2/2009	16:14	Setup	Calibrated TDLAS 1027
4/2/2009	16:15	Setup	Wetness sensor calibration: accepted.
4/2/2009	16:15	Setup	Barometer audit: accepted.
4/2/2009	17:00-17:44	Setup	TEC 450i single point calibrations: pass
4/2/2009	17:15-22:40	Setup	S-OPS/GSS calibrations: all pass
4/2/2009	21:22	Setup	pH sensor: acceptance, calibration, and inspection: all pass
4/3/2009	16:45	Remote	Daily Status Check from PAML – Notes: CR 1000 file was not present. Forced a "collect now" and it caught up.
4/6/2009	13:30	Remote	Daily Status Check from PAML – Notes: Not enough space to perform backup. Deleted all previous backups to make room for new backups. *Microsoft Visual C++* runtime error (program: C:\ProgramFiles\Genie-Soft\GBMPro7\GBM7.exe). Not sure why there was a runtime error. Will check to see if there is a runtime error again tomorrow. Had to realign TDLAS 1 paths 5, 7, and 8. Could not get path 7 realigned. Light level instantly dropped around 14:30 UTC on 4/4/2009. Texas A&M engineering group were on site Wednesday and will check with them to see if retro-reflector got knocked down to the ground or

Date (mm/dd/yyyy)	**Time** (HH:MM)	**Activity** (setup, takedown, calibration, repair, remote)	**Event**
			if something is blocking it. Also realigned TDLAS 2 paths 7, 9, and 10. See attached TDLAS pan/tilt log sheet. All sonic anemometers w are below zero around same time' shows that perhaps readings are accurate.
4/7/2009	13:00	Remote	Daily Status Check from PAML – Notes: Not enough space to perform backup. Forgot to delete old backups yesterday; deleting today. TDLAS 1 path 7 still not aligned. Texas A&M engineering group were on site Wednesday and will check with them to see status of retro-reflector. TDLAS 1 path 1 was not aligned. When aligning/aiming, path was aligned but moved 3 steps up and 1 step right to achieve better light levels.
4/8/2009	13:30	Remote	Daily Status Check from PAML – Notes: *Microsoft Visual C++* runtime error (program: C:\ProgramFiles\Genie-Soft\GBMPro7\GBM7.exe). "This application has requested the Runtime to terminate it in an unusual way. Please contact the applications support team for more information." In back up summary says that backup completed successfully (despite runtime error). "Backup Started: 4/7/2009 18:10:30" "Backup Ended: 4/8/2009 01:27:06" No hard errors. TDLAS 1 path 7 still not found. Al from TX A&M was on site today and tomorrow and will contact us about retro-reflector status. Later: Al called and said retro-reflector tripod looked as if it had been knocked a little out of whack (wind? vehicle?); the ratchet strap was loose as well. Al moved tripod upright and tightened strap. Al said one leg looked like it had been moved--the other two looked stationary. Sonic anemometer u,v, w, and T graphs did not look normal around 829.3715972 (sonic anemometer 1), 829.371856 (sonic anemometer 2), and 829.3715972 (sonic anemometer 3). Temperatures were not in agreement (Sonic anemometer 1: 277.24735K; sonic anemometer 2: 280.94117K; sonic anemometer 3: 284.95057K). Will monitor.
4/9/2009	13:00	Remote	Daily Status Check from PAML – Notes: Not enough space to perform backup. Deleted all previous backups to make room for new backups. Changed pan/tilt options specs for minimum acceptable light levels from 1000 to 2000 to see if it will improve fraction of time with all ten paths aligned; saved new setups (backup and running). Flag 4 in H_2S data.
4/10/2009	17:00	Remote	Daily Status Check from PAML– Notes: Realigned TDLAS 1 paths 7 and 8. See report for details. Changed TDLAS minimum acceptable light levels from 2000 to 1000 to prevent excessive optimization. Data file not up to date, so after remote login, forced data shipment. Very windy conditions, this period will lead to loss of *RPM* data.
4/13/2009	13:40	Remote	Daily Status Check from PAML – Notes: Re-aimed path 2 on TDLAS 2. Tried to re-aim path 7 on TDLAS 1 but could not find it. Average w on sonic anemometers 1 and 3 is -0.2 ms^{-1}. Some flagging on sonic anemometer 3 on day 833.
4/14/2009	13:20	Remote	Daily Status Check from PAML– Notes: Cannot remotely

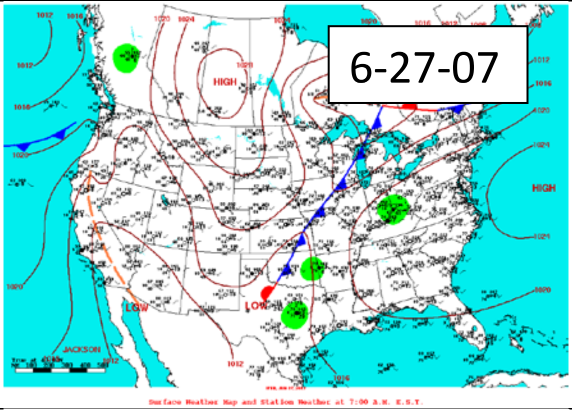
Date (mm/dd/yyyy)	Time (HH:MM)	Activity (setup, takedown, calibration, repair, remote)	Event
			connect to site. No QC data since 4/13/2009.
4/17/2009	12:30	Remote	Daily Status Check from PAML – Notes: TDLAS 1 paths 7 and 9 were off. Path 9 needed to be moved up 10 steps and 10 steps to the right. Cannot get path 7 aligned; may be on the ground or knocked way out of place. We're heading to this site on 4/21/2009; engineering group will not be on the site to fix it. TDLAS 2 path 1 not aligned; moved 15 steps right and 15 steps down to re-aim.
4/20/2009	12:25	Remote	Daily Status Check from PAML – Notes: Re-aimed path 1 on TDLAS 1; all paths are now aligned. H_2S sample flow is low but steady at 0.85 LPM.
4/21/2009		Takedown	On arrival found the lagoon water level to be low; the probe float was almost submerged beneath the sludge.
4/21/2009		Takedown	When calibrating pH and ORP probes found small rocks were stuck inside near the glass bulb. The bulb seems to be broken. pH failed calibration; changed the reference solution, but it still failed.
4/21/2009		Takedown	Maintenance list completed.
4/21/2009		Takedown	ORP sensor: calibration and acceptance pass
4/21/2009	17:15-18:15	Takedown	Sonic anemometer inter-comparison; all pass.
4/21/2009	17:40	Takedown	pH sensor: acceptance, calibration, and inspection: Calibration fails.
4/21/2009	19:15	Takedown	S-OPS/GSS calibrations: all pass
4/21/2009	20:40	Takedown	Calibrated TDLAS 1028
4/21/2009	21:00-21:43	Takedown	TEC 450i single point calibrations: pass
4/21/2009	21:18	Takedown	Zero sonic anemometer calibrations; all pass.
6/23/2009		Setup	Set up all outside equipment except putting sonic anemometers on tower and aligning the TDLAS units.
6/23/2009		Setup	Cannot find the 900 Mhz; Dr. Grant will bring new one on Thursday. Will calibrate sonic anemometers on Thursday (6/25/2009).
6/23/2009		Setup	Did not finish S-OPS/GSS leak test on north side of lagoon. Changed all inlet filters. Found a leak but did not have enough time to find its location. Will continue tomorrow.
6/23/2009		Setup	Too windy to perform sludge depth measurements.
6/23/2009	20:45-16:15 (6/24/2009)	Setup	GSS/S-OPS calibrations – Notes: Could not completely plug a leak. S-OPS extension-to-inlet connection was cut through at connector. Inlet #10 holder threads were stripped. Changed the filter holder, but kept the old filter (clean enough) to keep the inlets balanced.
6/24/2009		Setup	Finished S-OPS/GSS calibration. Connection at S-OPS/extension tubing was clamped off at the connector. Inlet #10 holder stripped, replaced with new holder. Kept same filter so inlets would be balanced.
6/24/2009		Setup	Burned missing/corrupted data from OK3A period 8 onto a new disc.
6/24/2009		Setup	Changed pump on TEC 450i pump bladder after performing a

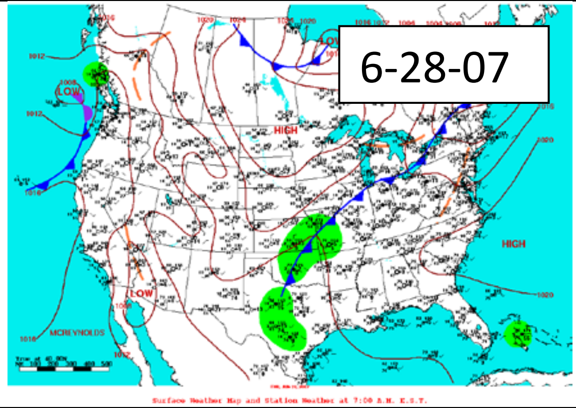
Date (mm/dd/yyyy)	Time (HH:MM)	Activity (setup, takedown, calibration, repair, remote)	Event
			leak test that failed. Flow increased to ~0.956 LPM. Performed new calibration and multipoint calibration.
6/24/2009		Setup	Performed NH_3 inter-comparison with TDLAS 1029 – OLD: bias= -3.64% - NEW: bias=-3.98%
6/24/2009		Setup	UPS history: 6/23/2009 16:18:25: Communication with UPS restored. 16:21:49: UPS output power has been restored to Load Segment 1. 16:21:53: UPS output power has been restored to Load Segment 2.
6/24/2009		Setup	Too windy to perform sludge depth measurements.
6/24/2009		Setup	Maintenance list completed.
6/24/2009		Setup	Lagoon site layout made
6/24/2009		Setup	ORP sensor: calibration and acceptance pass
6/24/2009	15:00	Setup	pH probe: QA, calibration, and inspection completed.
6/24/2009	16:06-16:52	Setup	TEC 450i leak test: failed. Changed pump bladder; will perform new calibration.
6/24/2009	16:31	Setup	Wetness sensor calibration: accepted.
6/24/2009	16:35	Setup	Barometer audit: accepted.
6/24/2009	18:26-19:09	Setup	Performed TEC 450i single point calibrations: pass. Notes: Actual single point calibration performed during multipoint calibration. New leak test performed: Passed.
6/24/2009	18:36-19:40	Setup	TEC 450i multipoint calibration
6/24/2009	20:20-20:51	Setup	Calibrated TDLAS 1029
6/24/2009	21:01-21:18	Setup	Calibrated TDLAS 1028
6/25/2009		Setup	EPA officials audited the site today.
6/25/2009		Setup	Changed AC filter. Noticed old filter was not dirty at all because it was the wrong size.
6/25/2009		Setup	Too windy to perform sludge depth measurements.
6/29/2009	13:30	Remote	Daily Status Check from PAML – Notes: Error message upon login: "Not enough space to perform backup." No TDLAS QC because the data did not ship due to AutoCopy not being edited correctly; will try again tomorrow. No Innova at site.
6/30/2009	12:30	Remote	Daily Status Check from PAML – Notes: TDLAS 1 paths 1, 3, and 9 were not aligned; moved each path about up ten steps and to the right ten steps to get all the paths aligned. Cannot aligned TDLAS 2 path 7. Had problems with path 7 last time at this site as well. Ground under retro-reflector is very unstable, and strong winds and rain were detected at this site last night. Technician from TX A&M were on site Friday to check the status of this retro-reflector. Will still continue to monitor path and occasionally attempt to re-aim the path. No Innova at site. TDLAS 2 CDC occasionally drops about 40 points then comes back to normal levels.
7/1/2009	12:30	Remote	Daily Status Check from PAML – Notes: Error message upon login: "Not enough space to perform backup." Deleted previous

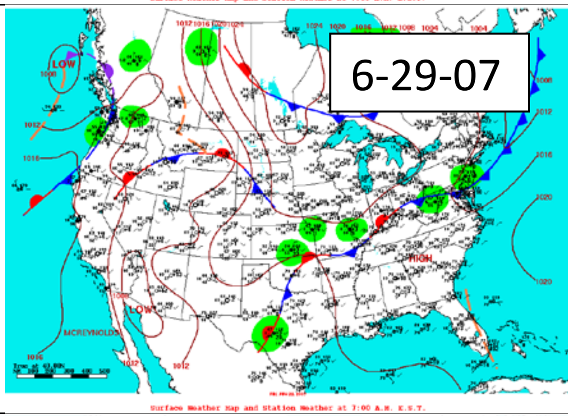
Date (mm/dd/yyyy)	**Time (HH:MM)**	**Activity (setup, takedown, calibration, repair, remote)**	**Event**
			backups to make room for a new backup. TDLAS 2 path 7 is still not aligned. Barn technician from TX A&M will check retro-reflector for us on Friday (7/3/2009) to if it is on the ground or dismounted/moved.
7/6/2009	12:56	Remote	Daily Status Check from PAML – Notes: Not enough space to perform backups. Deleted all necessary files.
7/7/2009	12:15	Remote	Daily Status Check from PAML – Notes: "*iPort* has encountered an error and needs to close…." Stopped sonic anemometer program, filled missing data, started new data file, and restarted the sonic anemometer program. Last H_2S data point was at 13:49 UTC 7/6/2009; filled missing data from 13:30 UTC to present. File name: FillOK4A450I0707091229.dat. TDLAS 1 paths 1, 2, 3, and 8 were not aligned. Could not get valid light levels; all are near the ground, and dew/fog could be causing low light levels. Will check later. TDLAS 2 is optimizing a lot too, probably from the same causes.
7/8/2009	12:15	Remote	Daily Status Check from PAML – Notes: Not enough space to perform backups. Deleted all necessary files.
7/9/2009	12:50	Remote	Daily Status Check from PAML – Notes: Both TDLAS's CDC dropped to 133 temporarily but now back to normal.
7/10/2009	12:20	Remote	Daily Status Check from PAML – Notes: Lagoon pH around 6.5
7/13/2009	12:50	Remote	Daily Status Check from PAML – Notes: Stopped and restarted sonic anemometer program twice, but there is still no data. Data stopped collecting at 923.729 (7/11/2009 17:30 UTC). Last CR 1000 data at 7/11/2009 17:30 UTC
7/14/2009		Takedown	Too windy to perform sludge depth measurements.
7/14/2009		Takedown	Sonic anemometer values were not as close as normal; probably caused by high winds.
7/14/2009		Takedown	No power at met station for CR 1000 and sonic anemometer 1 data collection or calibrations. Ran extension cord to NE corner outlet.
7/14/2009		Takedown	Several UPS history entries recorded on Open Site Notes.
7/14/2009		Takedown	pH/ORP probes were in sludge and probe heads were filled with sludge. pH probe failed in two buffers (10 and 7). Changed the reference solution. Will use at next site as it did not fail badly.
7/14/2009		Takedown	ORP sensor: calibration and acceptance pass
7/14/2009		Takedown	pH sensor: QA fails. Notes: pH probe failed in two buffers (10 and 7). Changed the reference solution, but instrument still fails.
7/14/2009		Takedown	Maintenance list completed.
7/14/2009	16:45-17:40	Takedown	Sonic anemometer inter-comparison: Pass
7/14/2009	17:28-17:48	Takedown	Calibrated TDLAS 1029
7/14/2009	17:59-18:19	Takedown	Calibrated TDLAS 1028
7/14/2009	18:30	Takedown	S-OPS/GSS calibrations: all pass
7/14/2009	18:35-19:03	Takedown	TEC 450i single point calibrations: pass
7/14/2009	18:40	Takedown	Bias/zero sonic anemometer calibration Notes: too windy
7/14/2009	20:57	Takedown	Wetness sensor calibration: accepted.
7/14/2009	20:57	Takedown	Barometer audit: accepted.

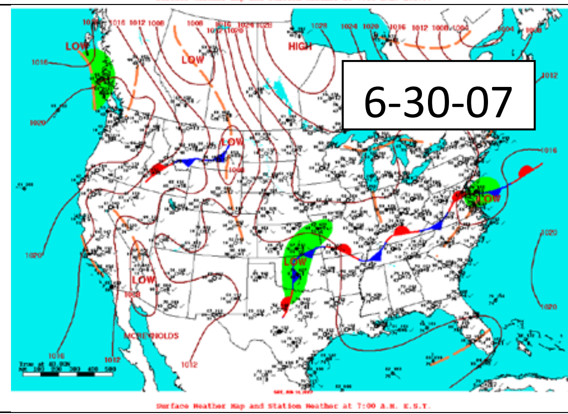
6.9 Site weather

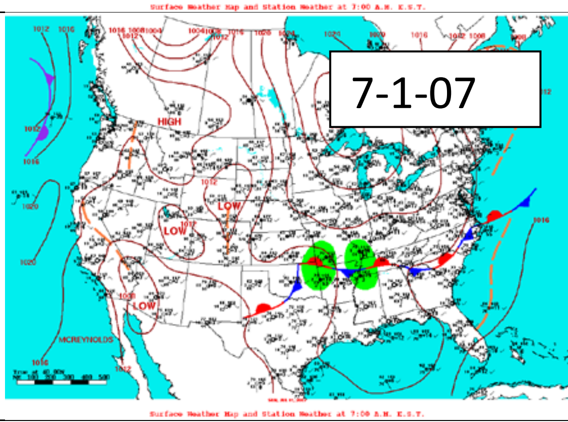
Period 1

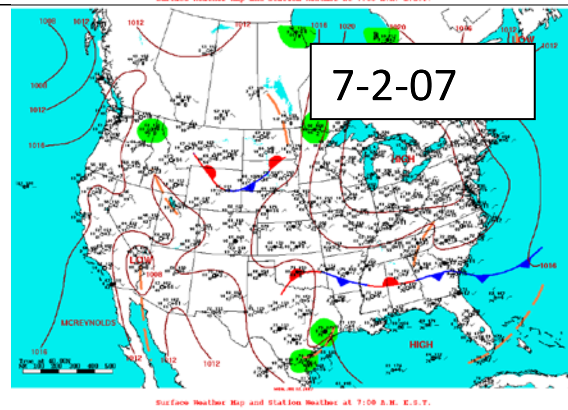


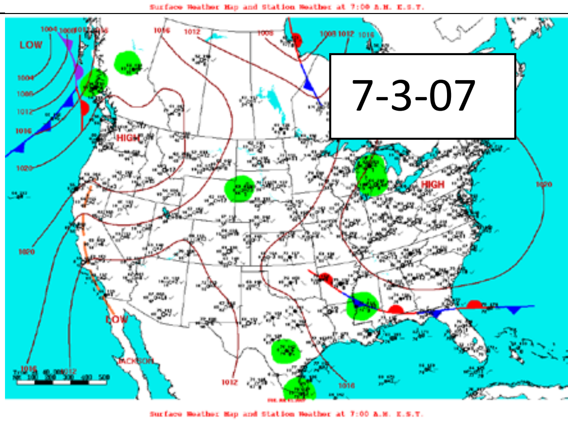


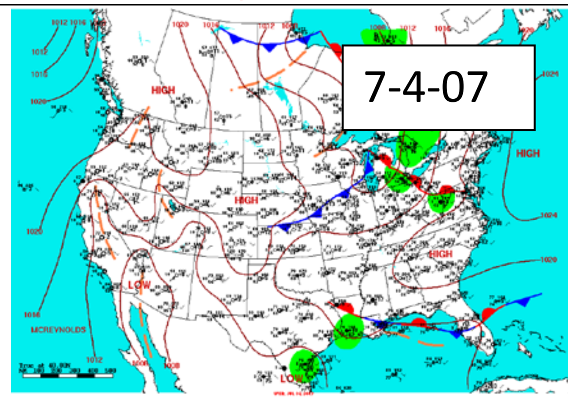


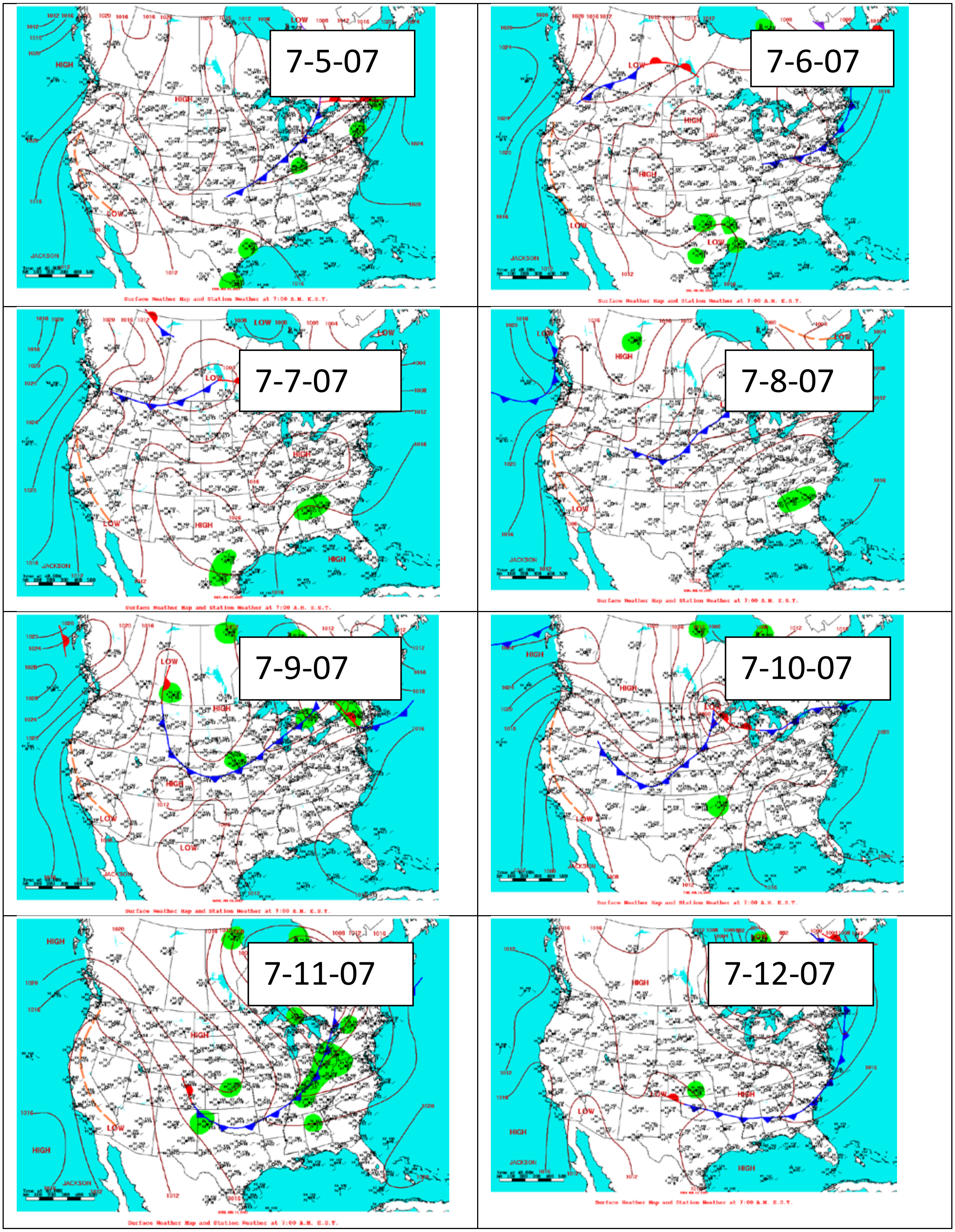








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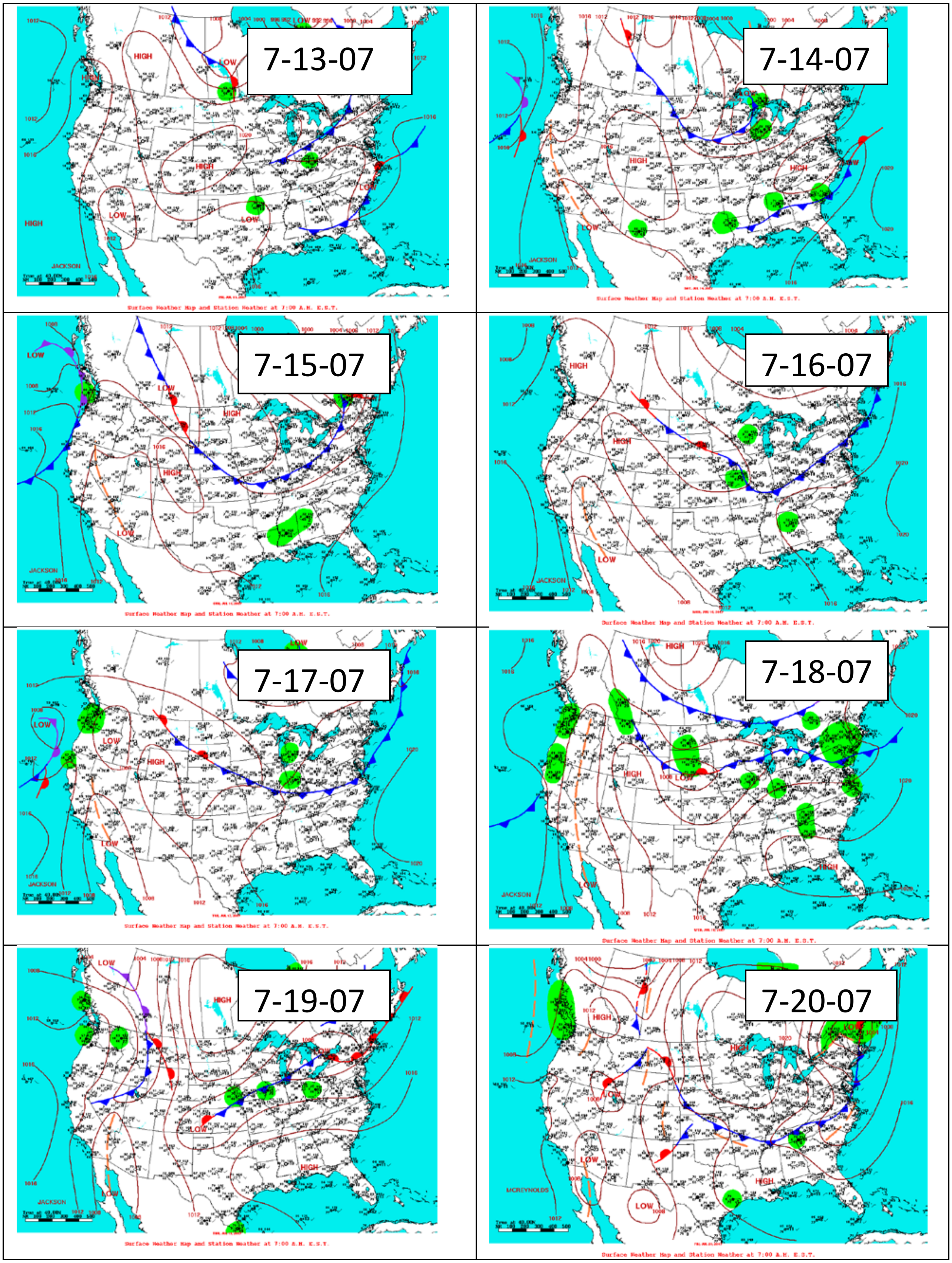
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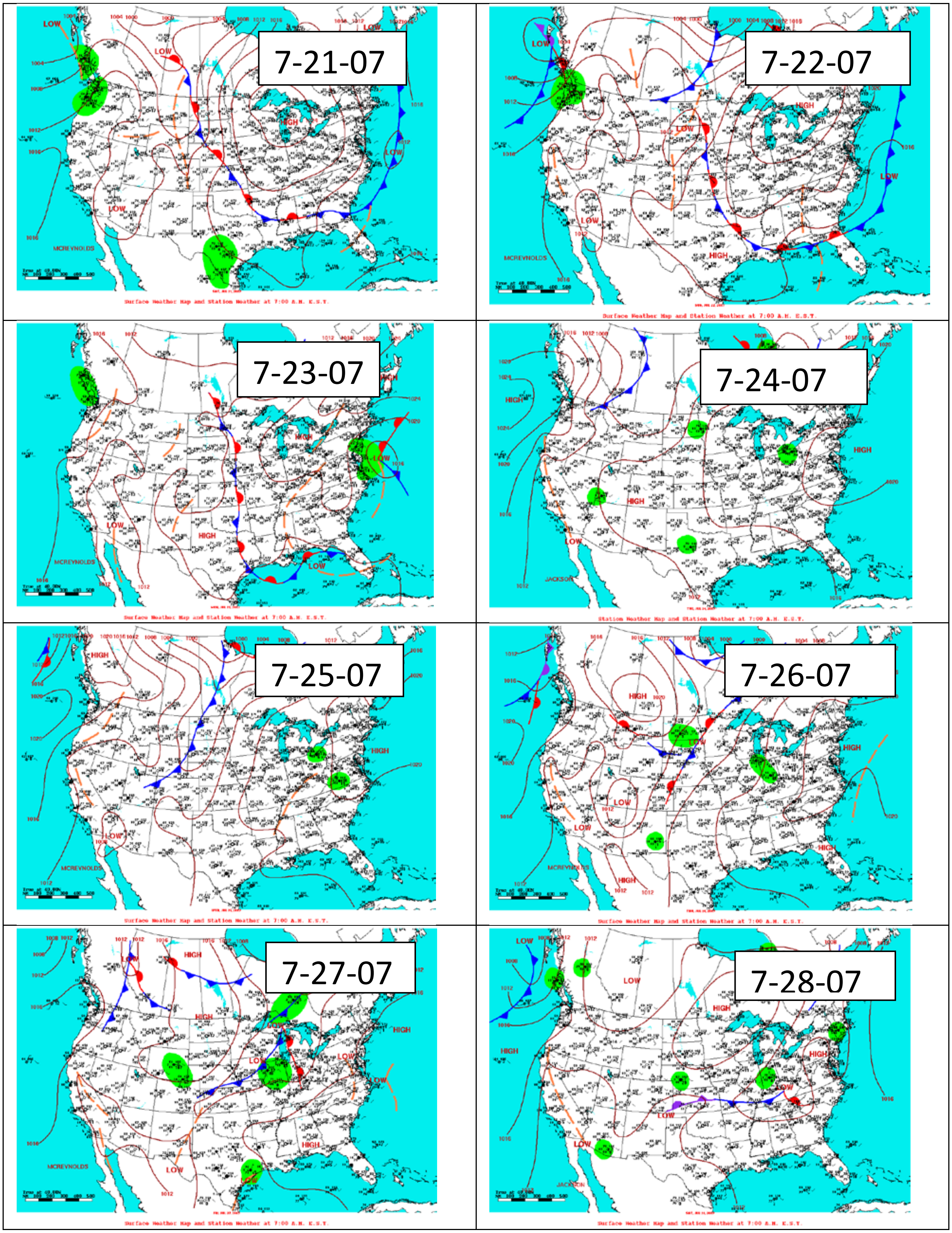
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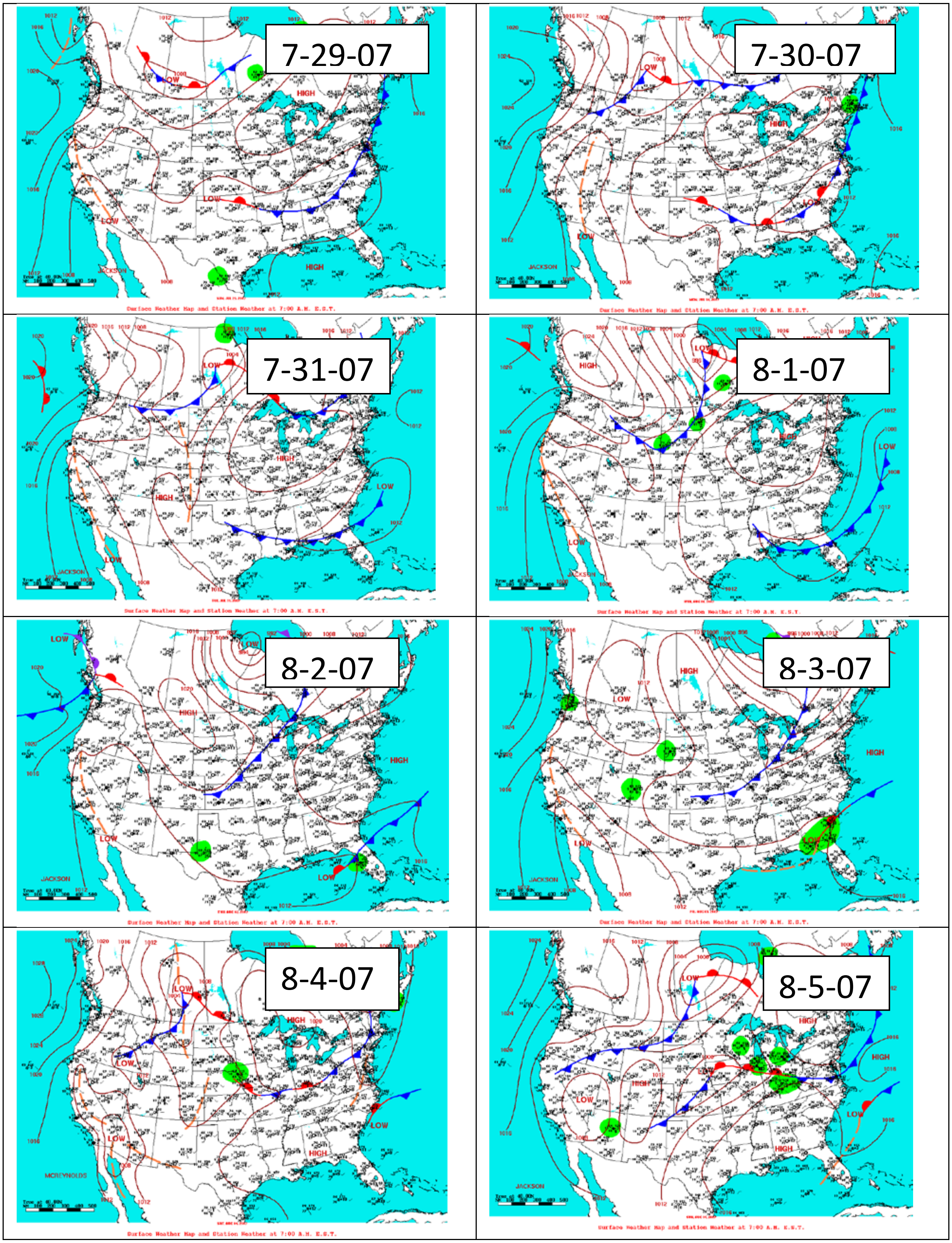
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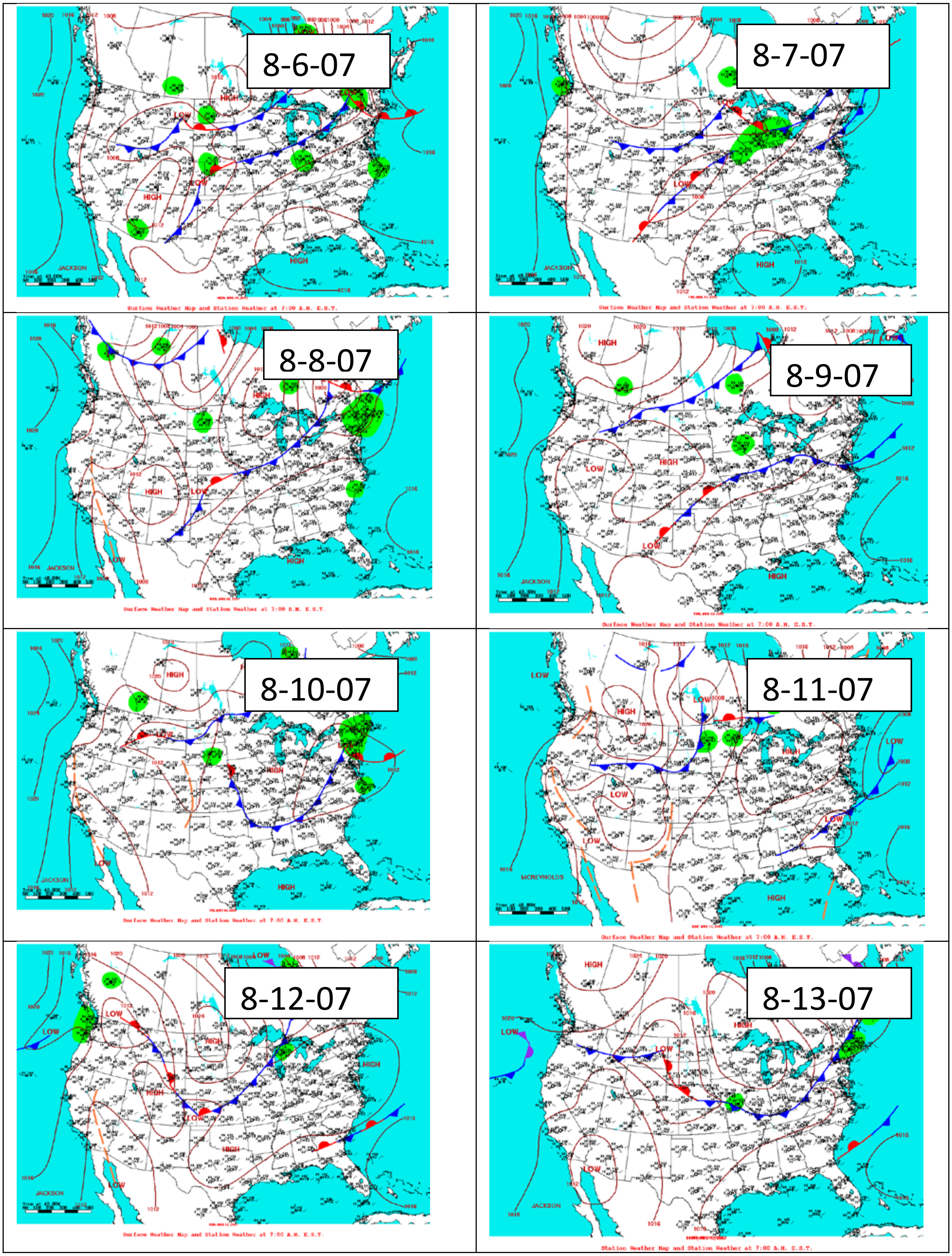
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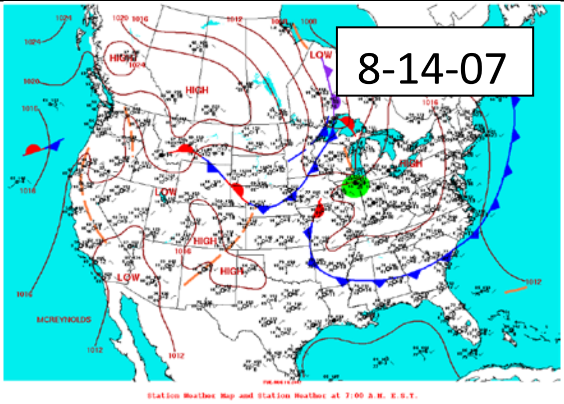
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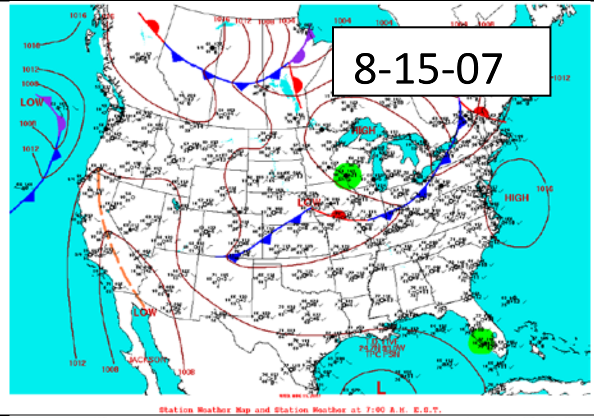
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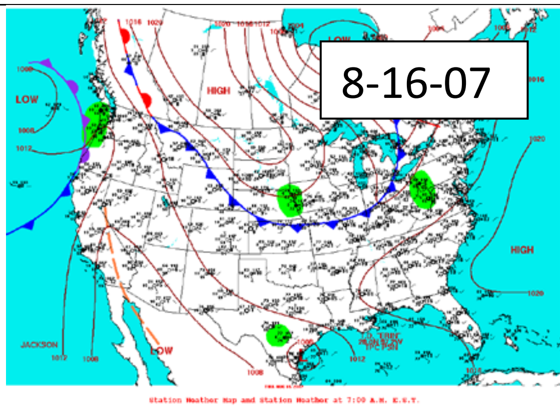
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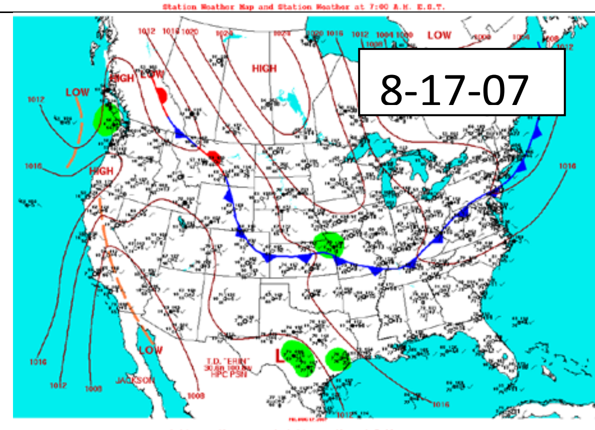
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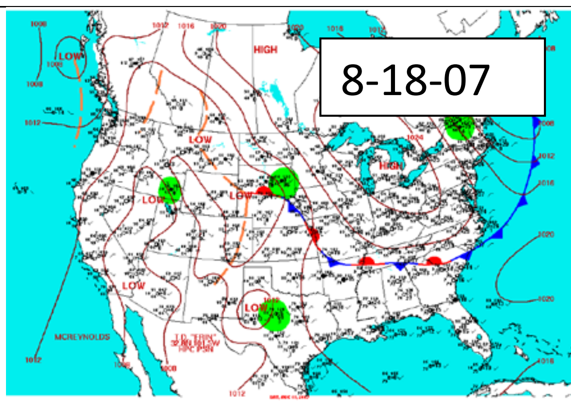
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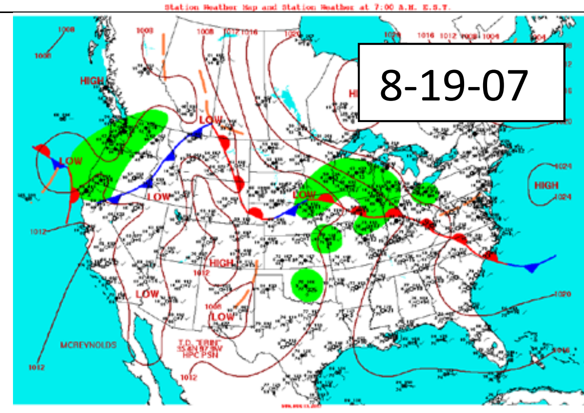
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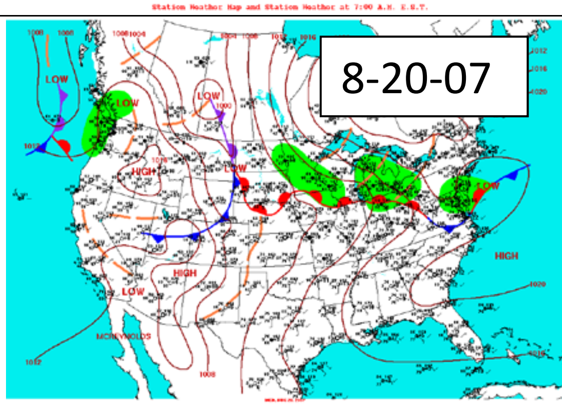
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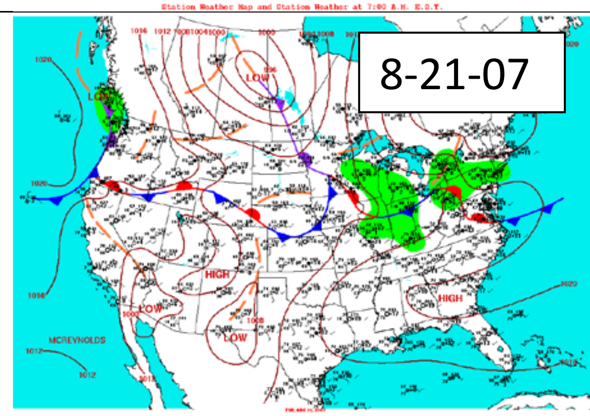
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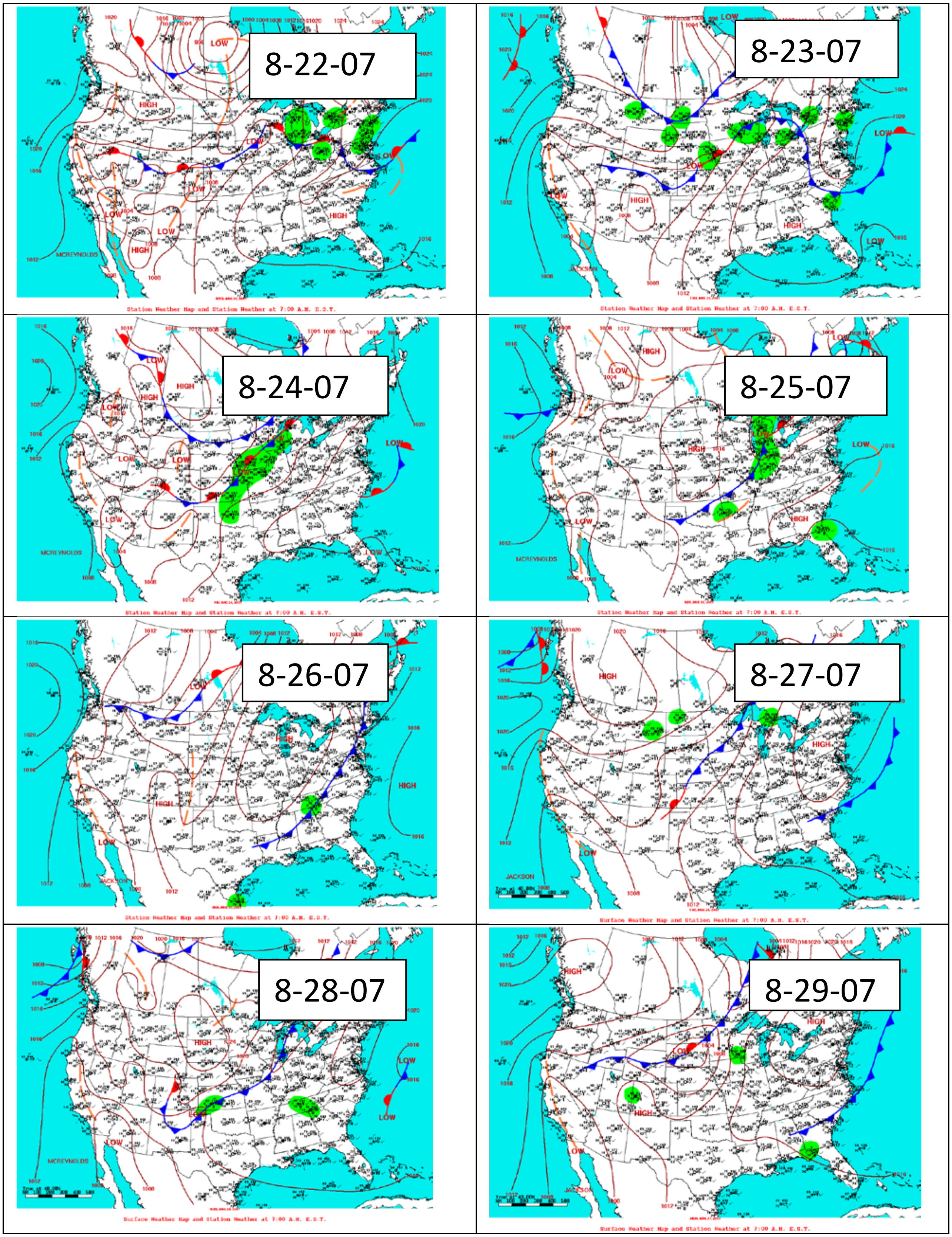
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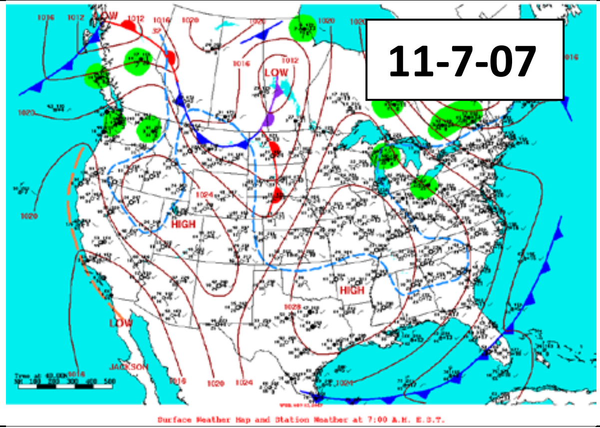
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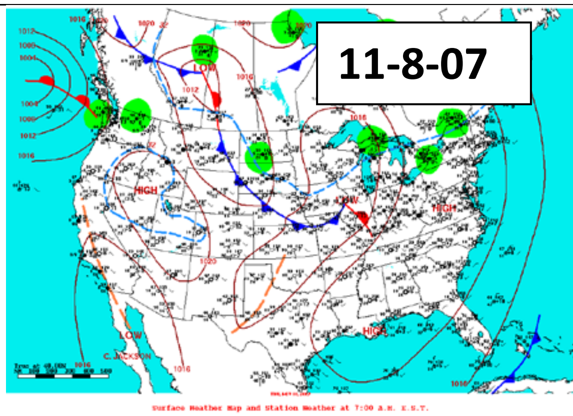
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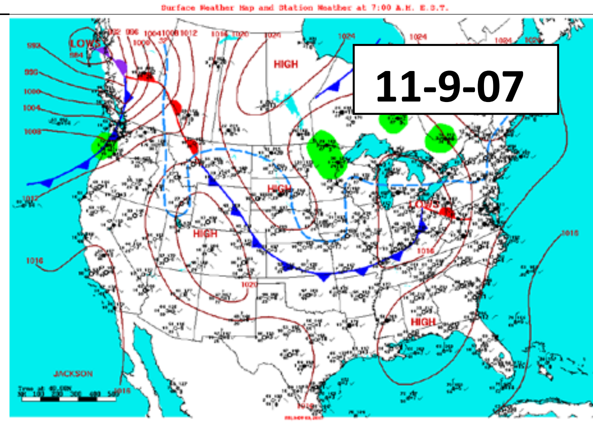
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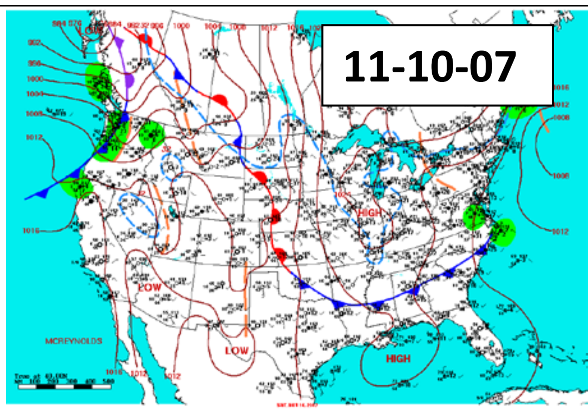
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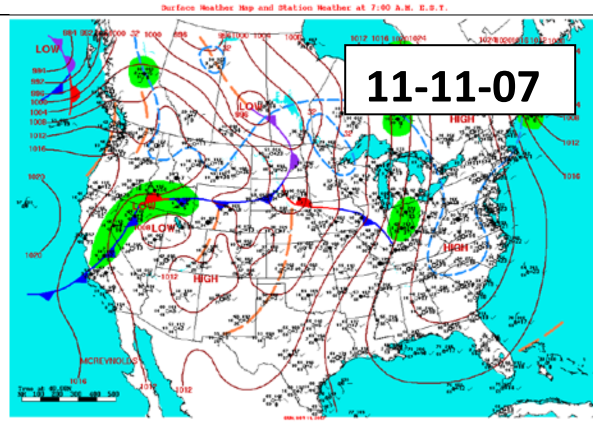
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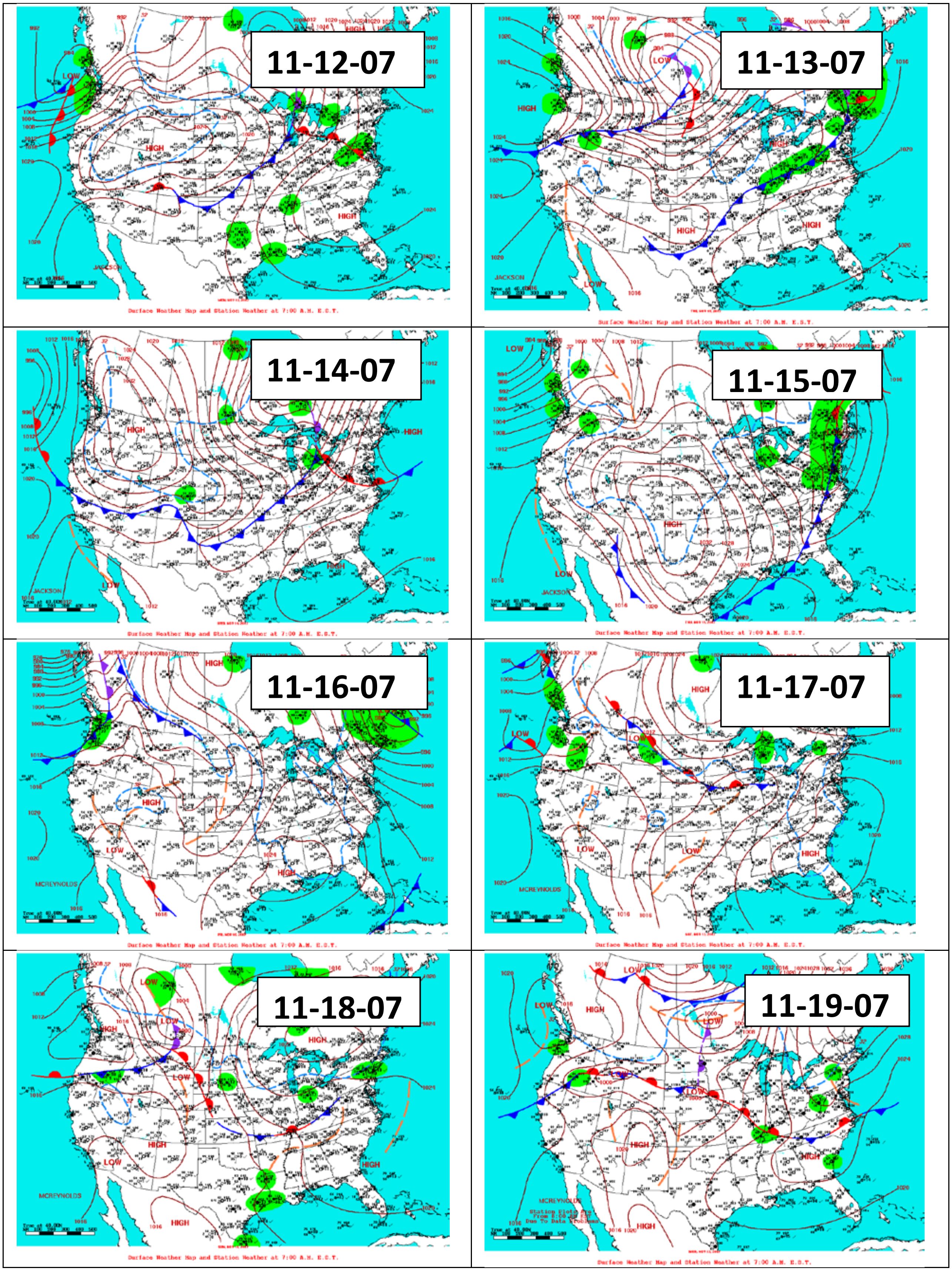
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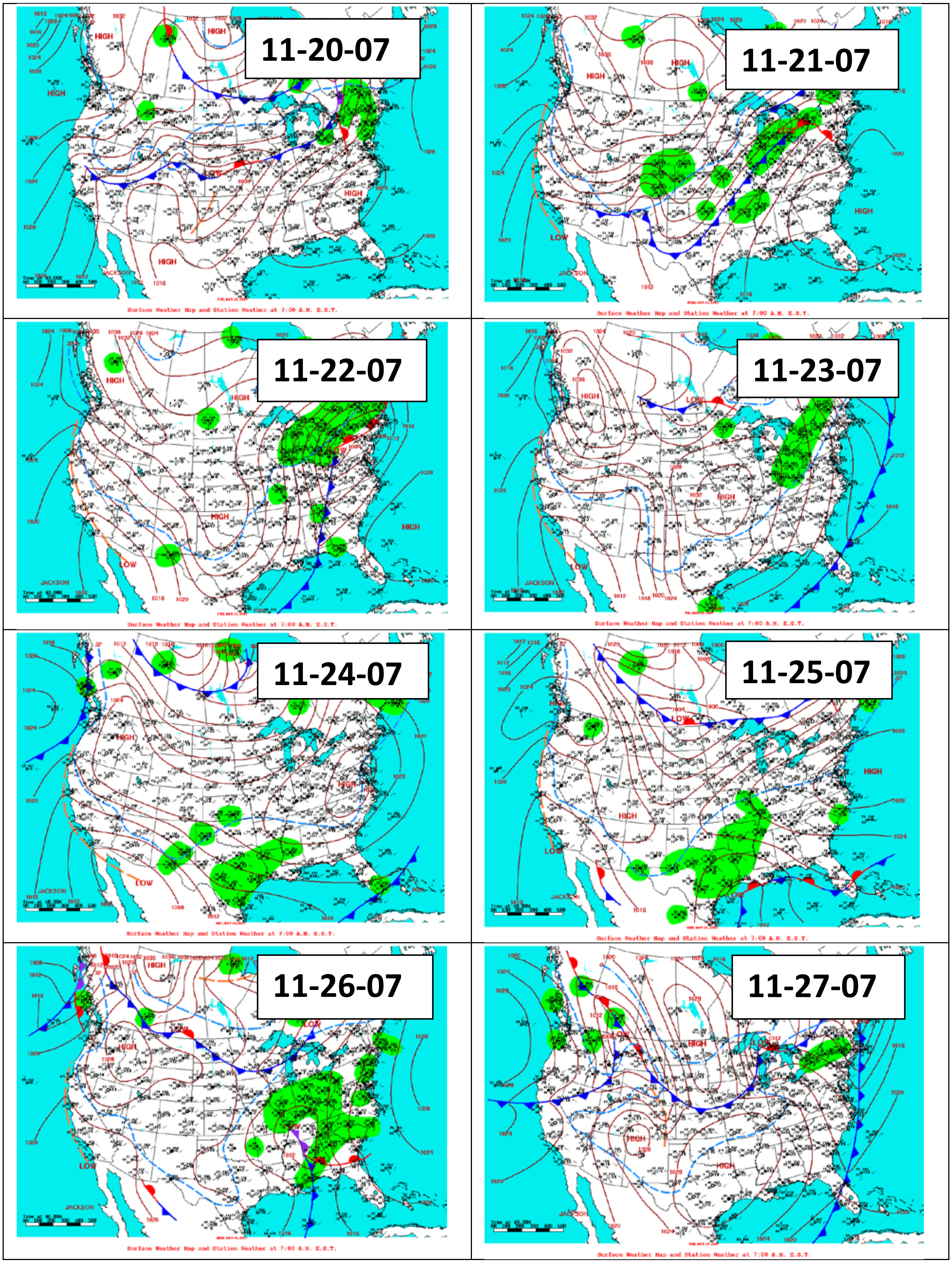
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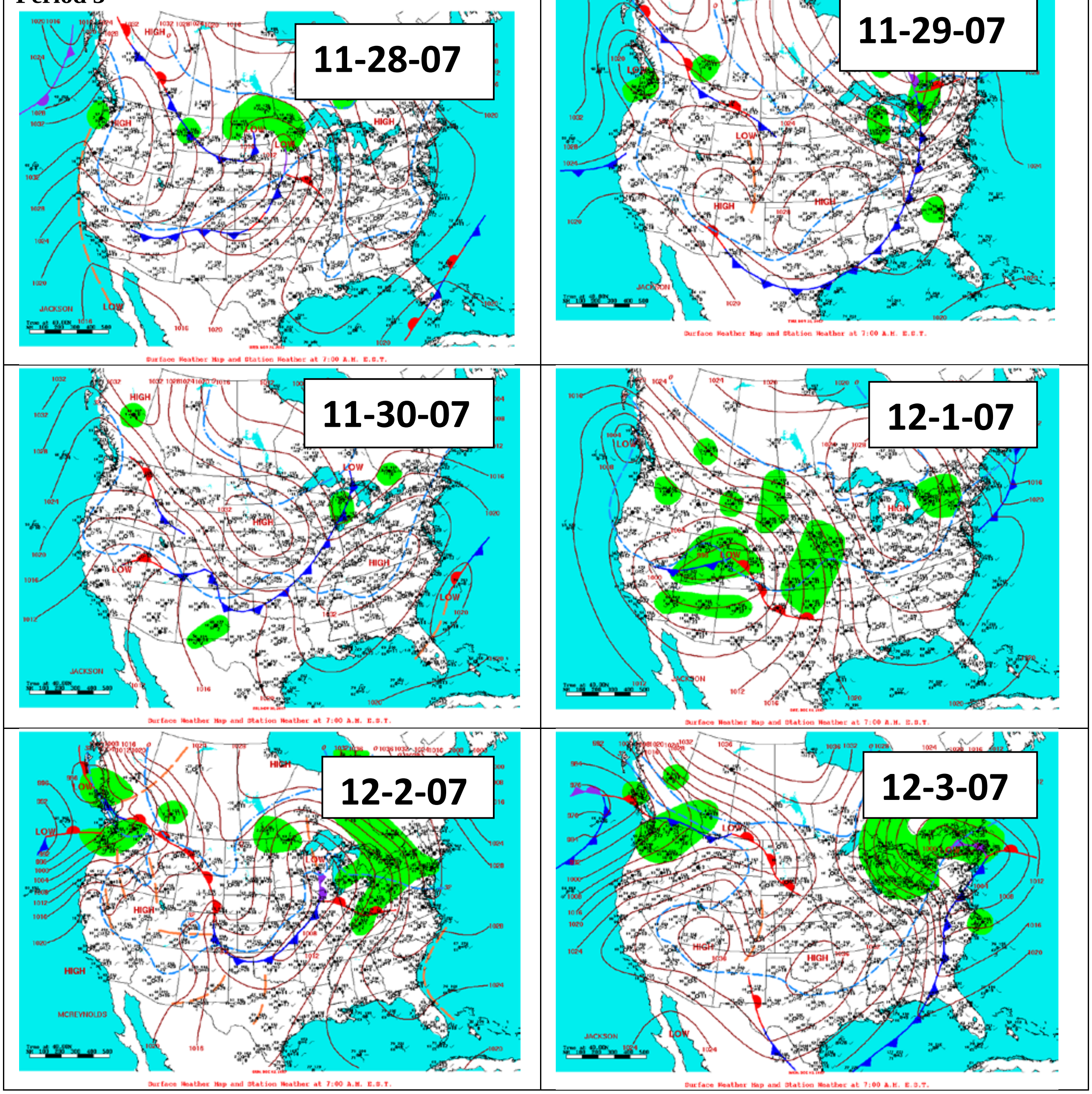
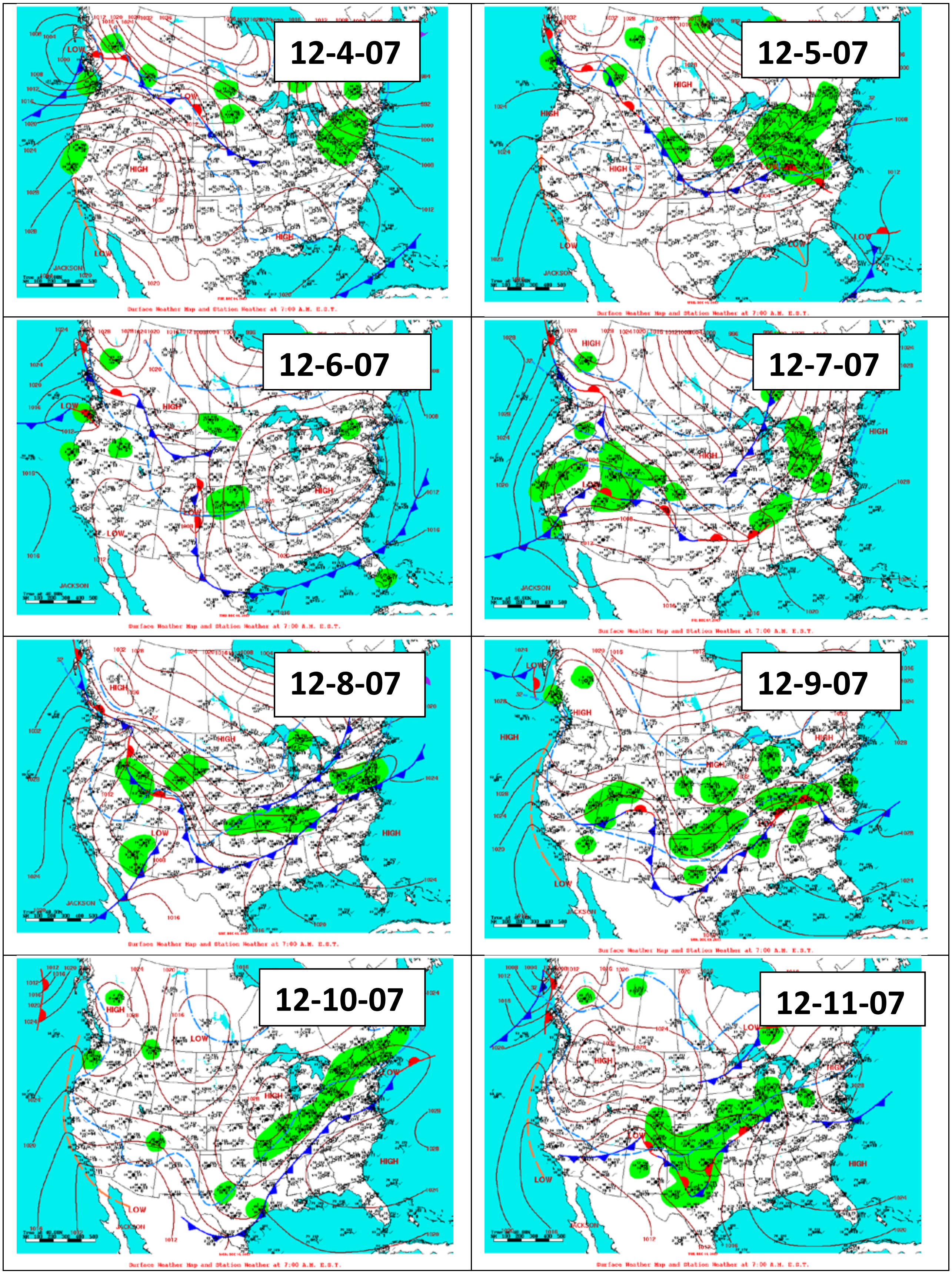
Period 3

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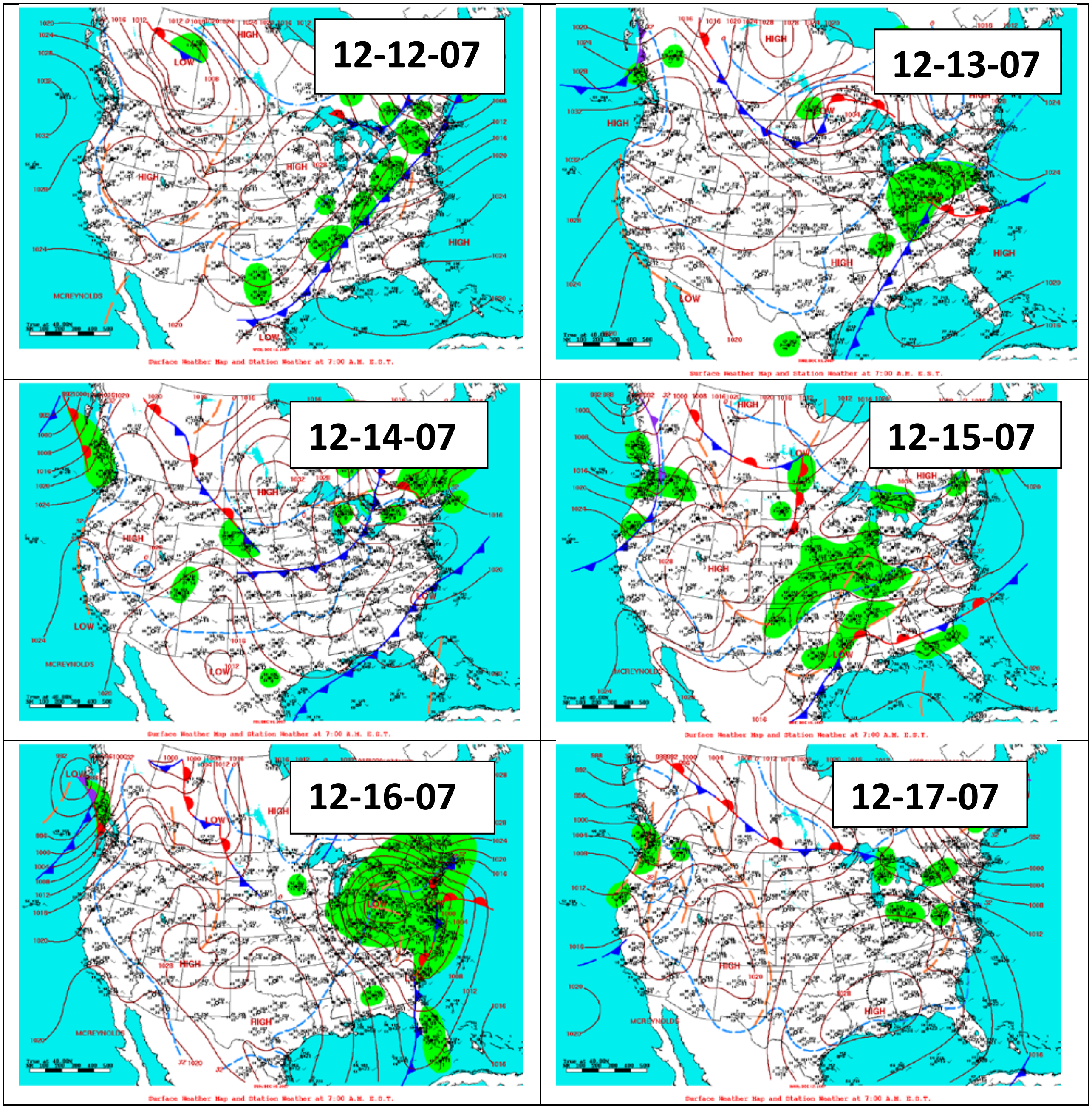
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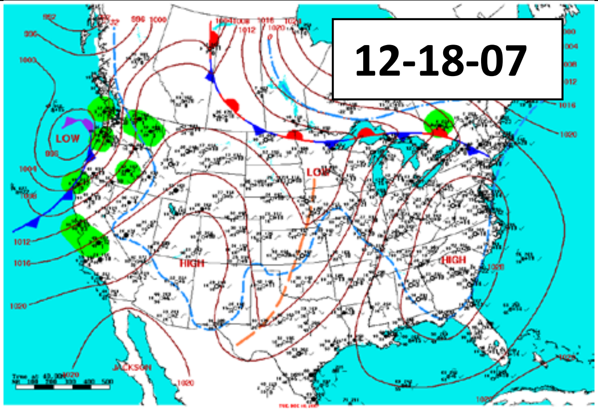

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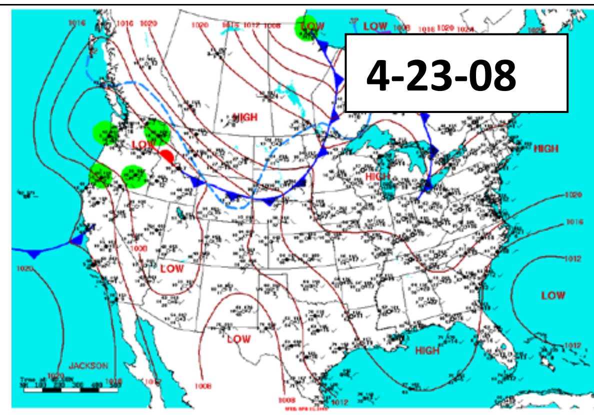

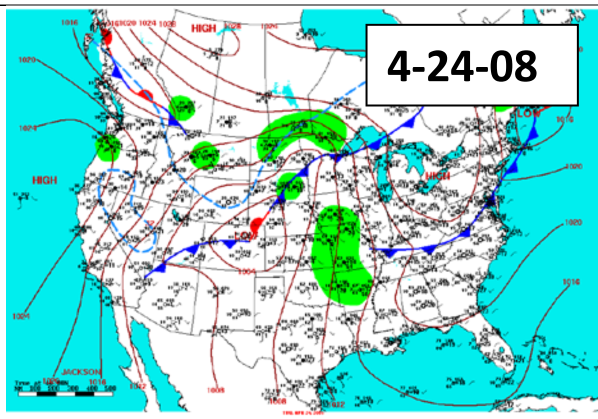

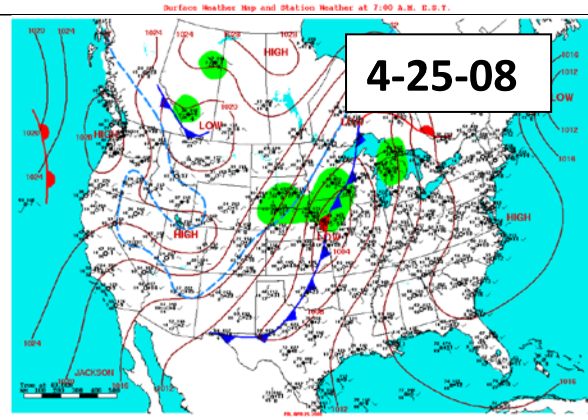

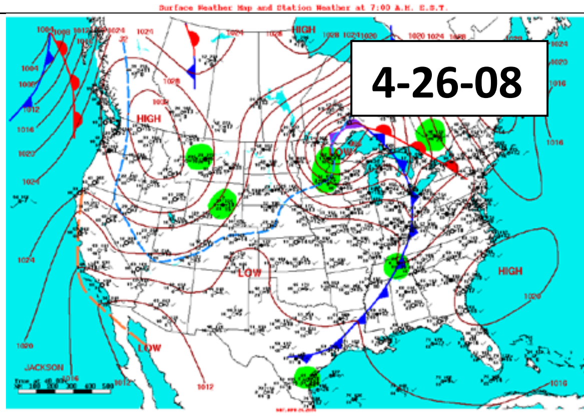

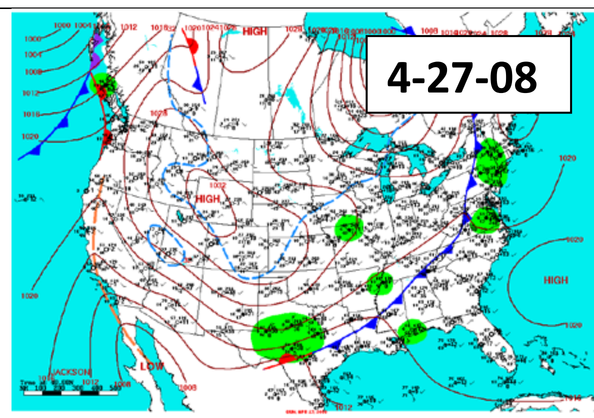

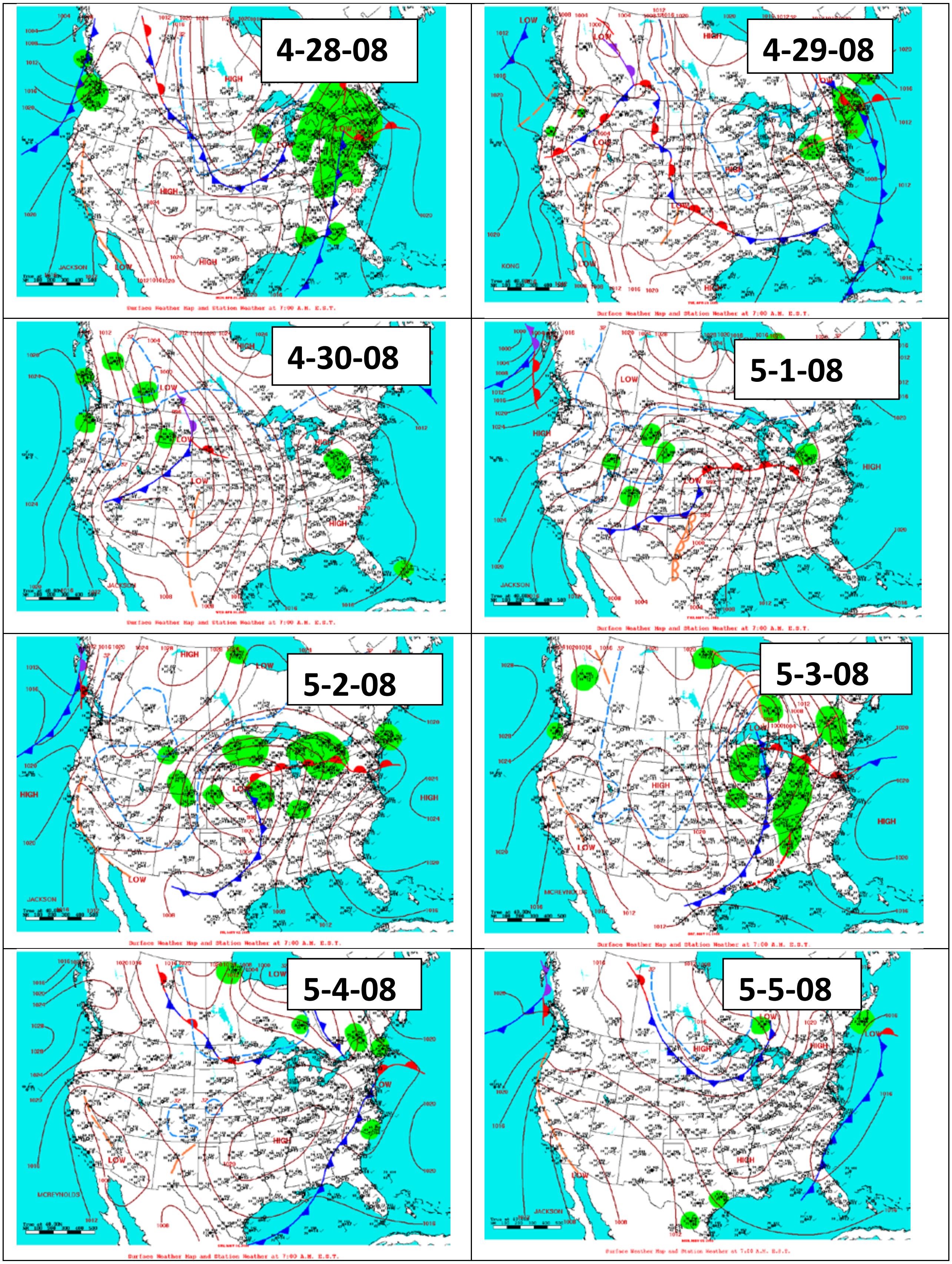
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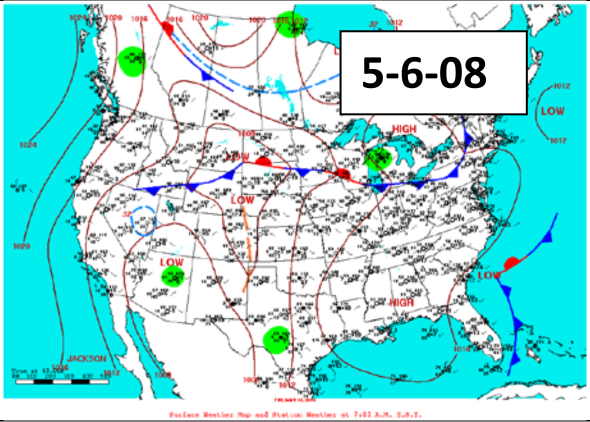

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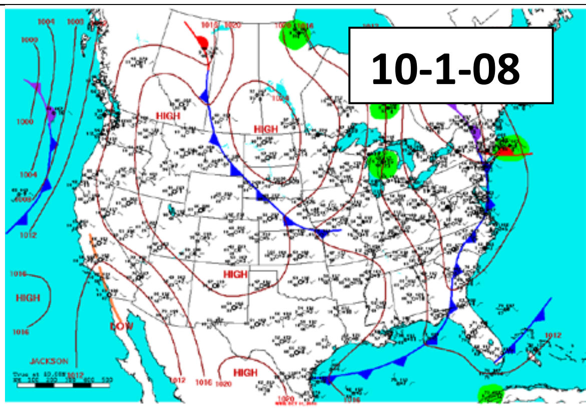

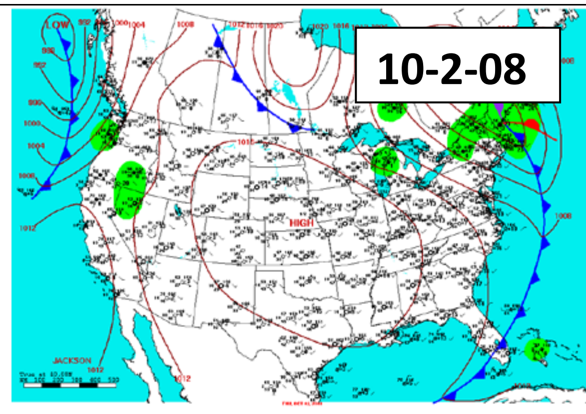

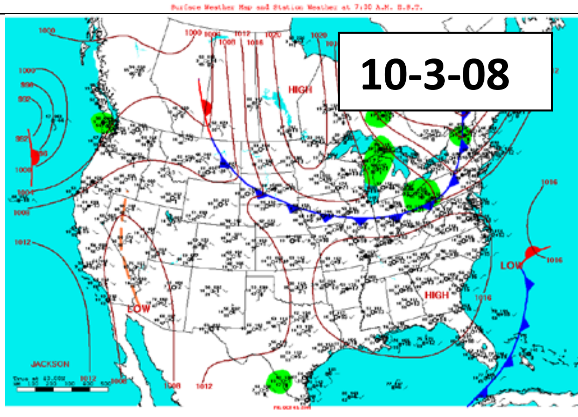

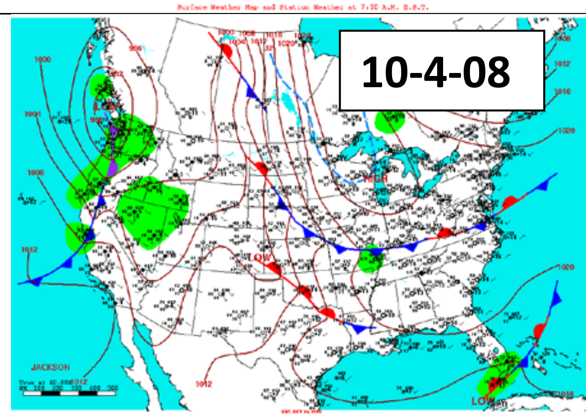

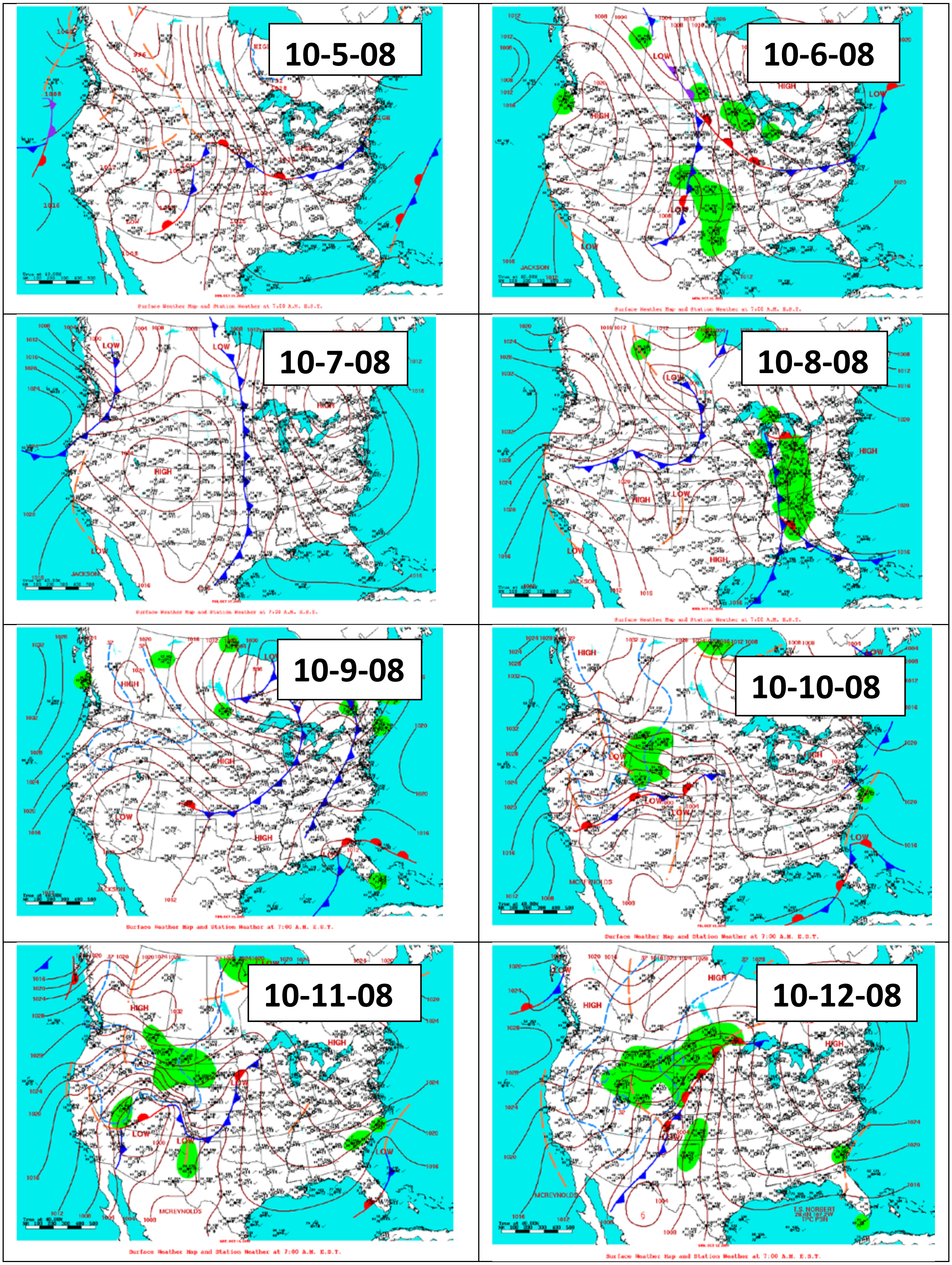
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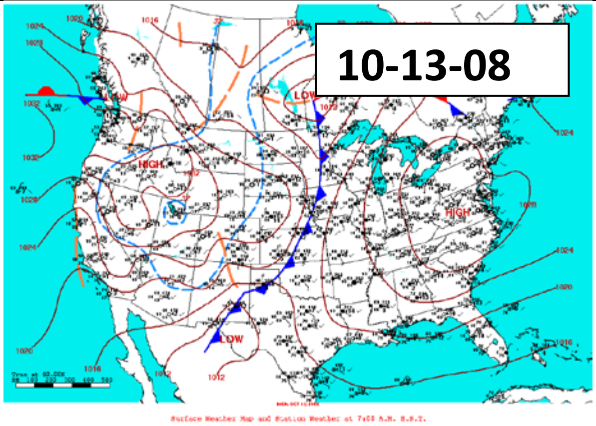
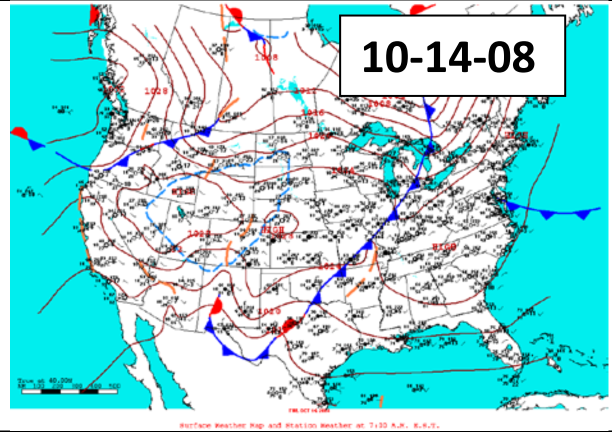
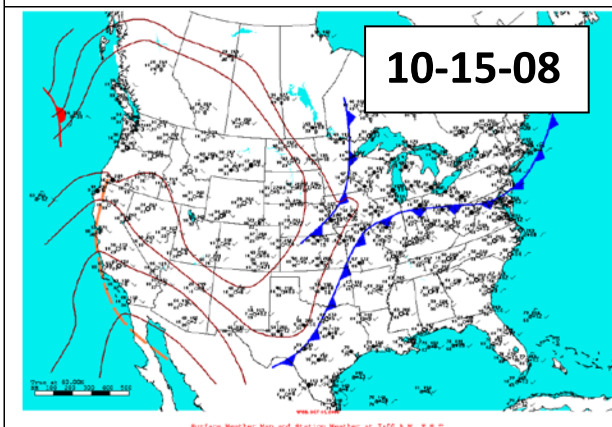
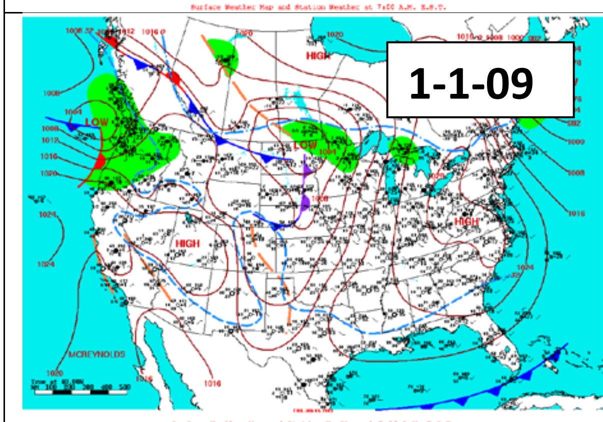
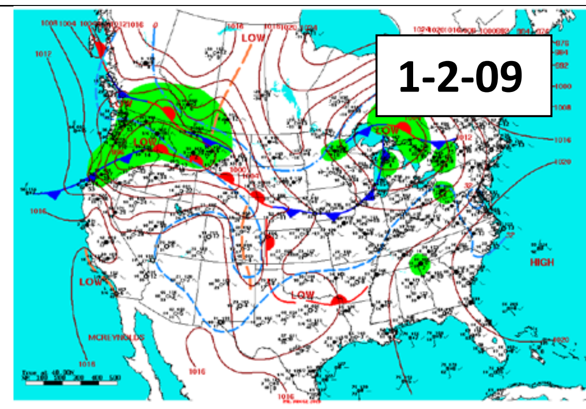


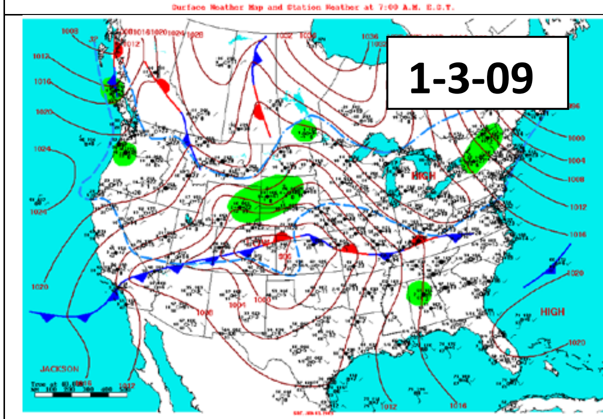


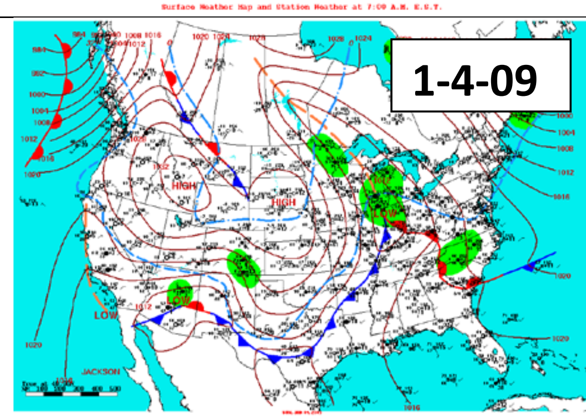


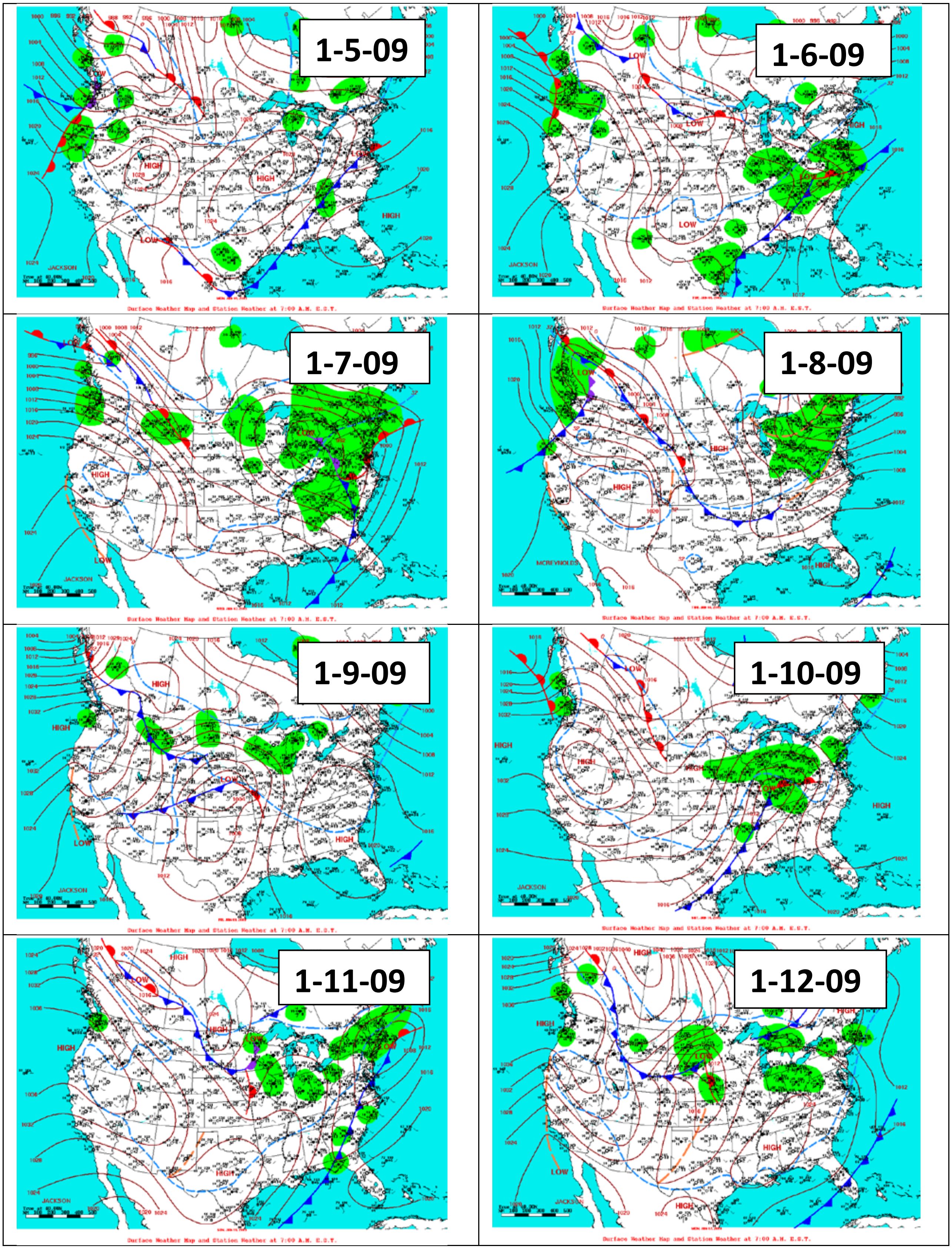
Period 7







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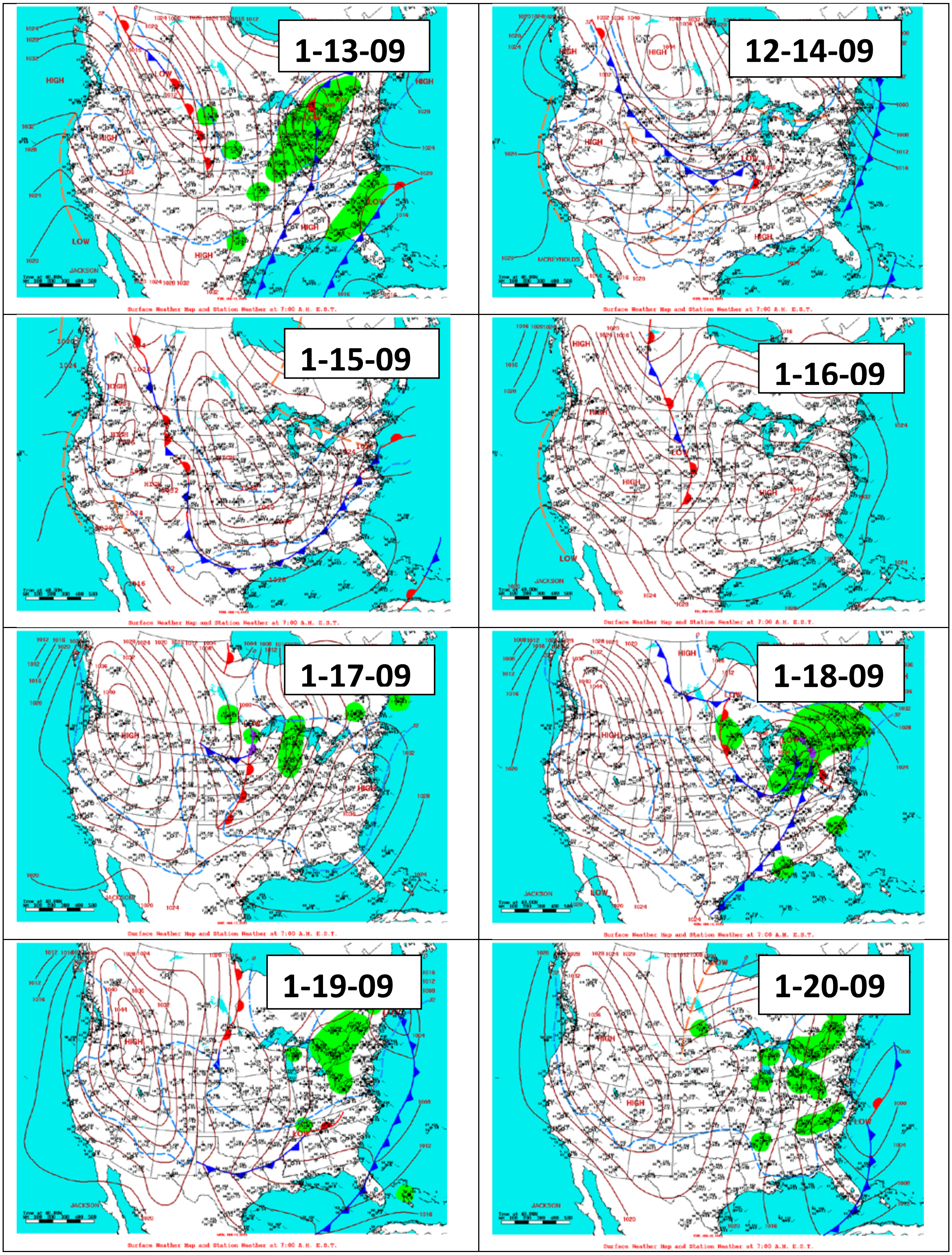
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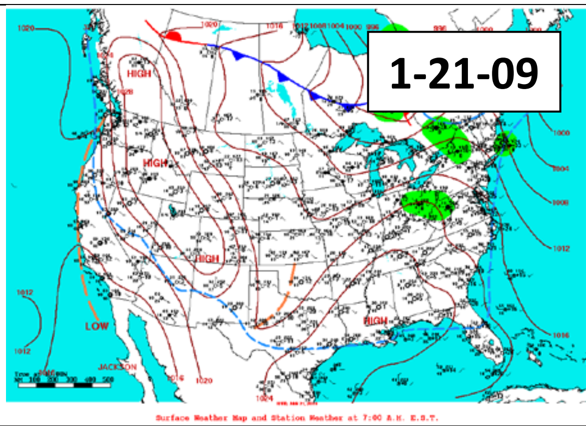
Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.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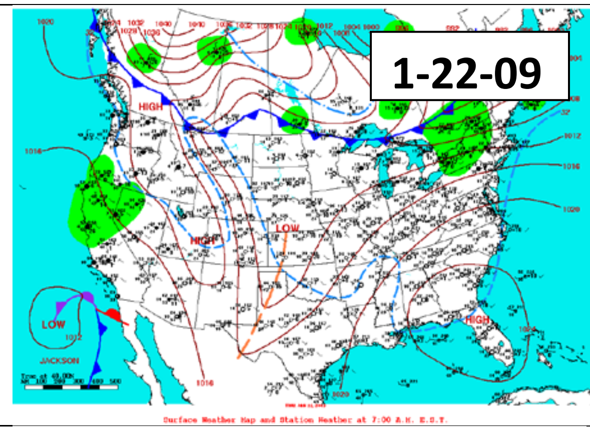
Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.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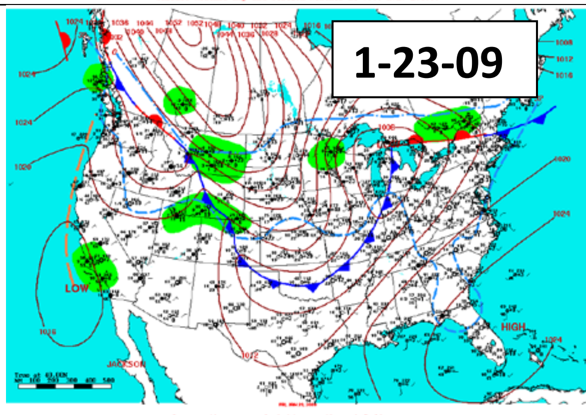
Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.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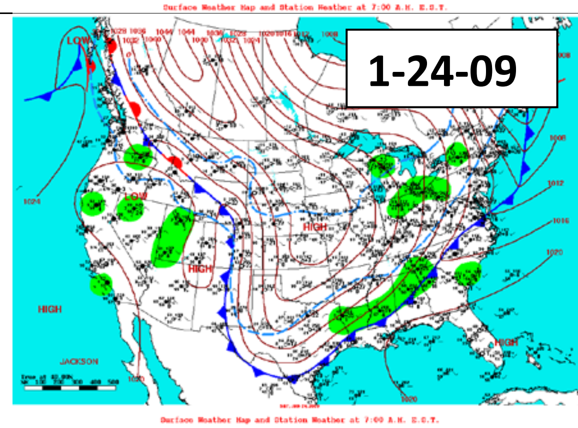
Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.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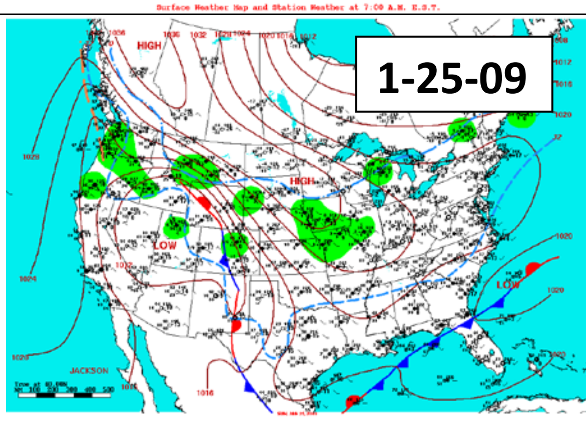
Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.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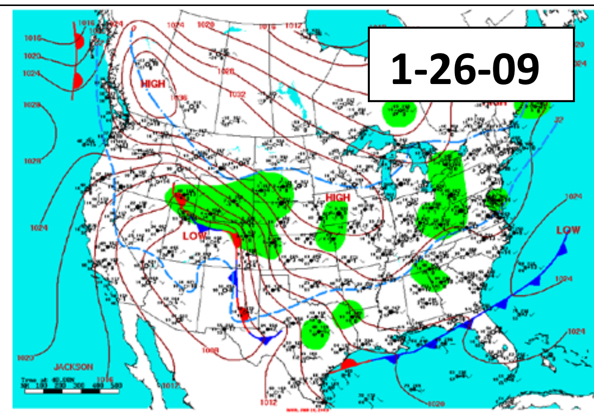
Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.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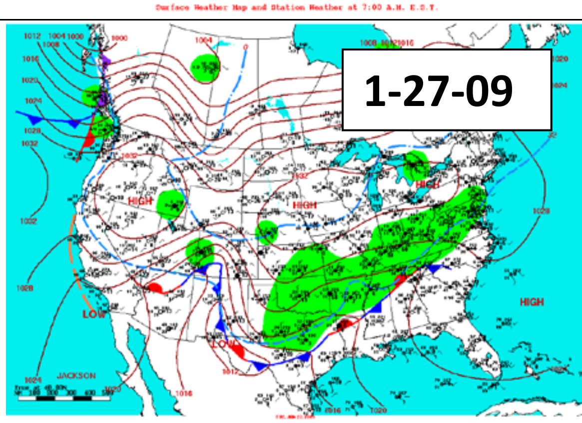
Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.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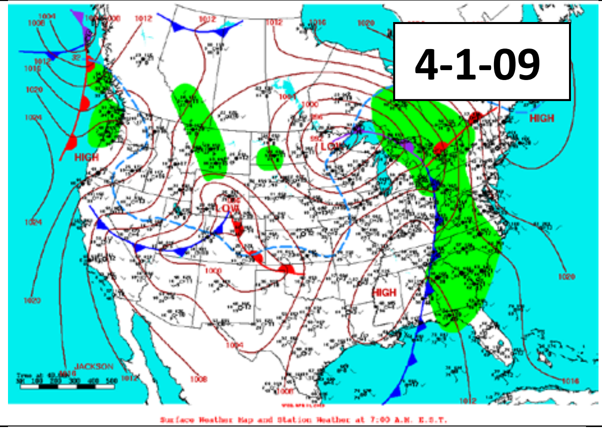
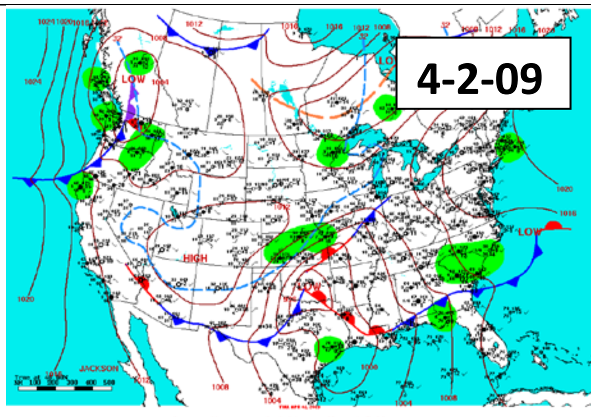
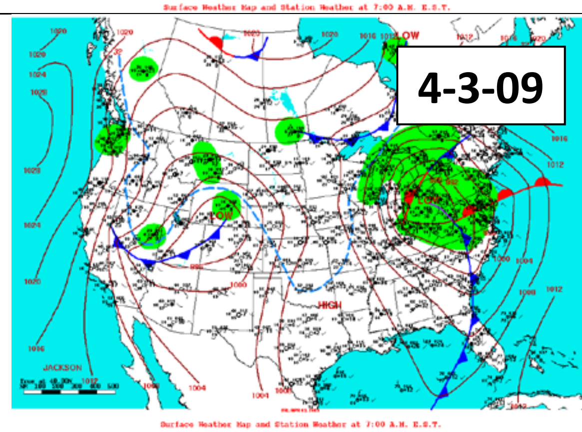
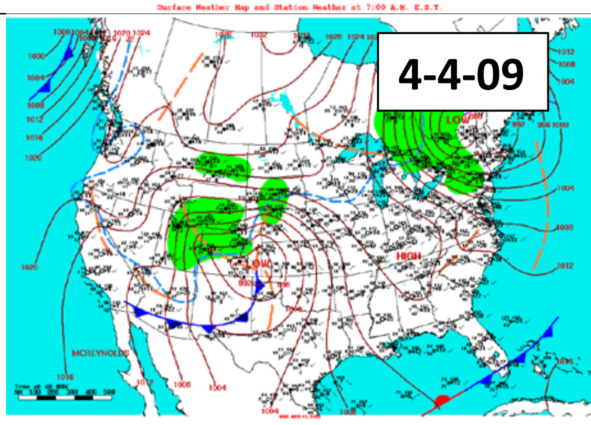
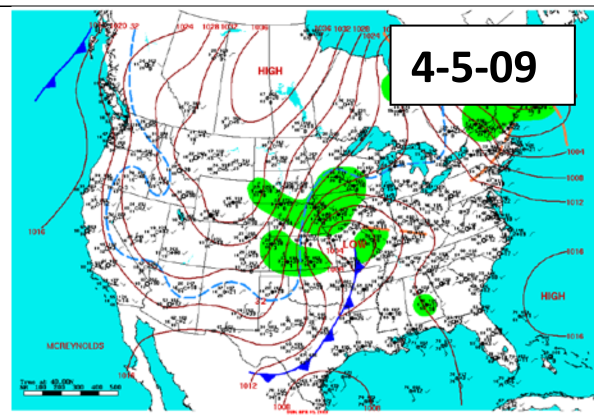
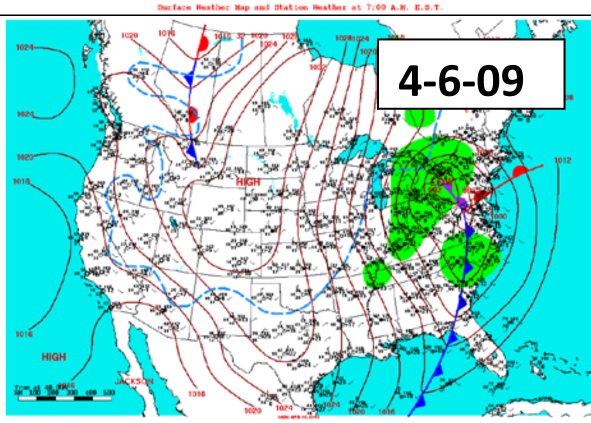
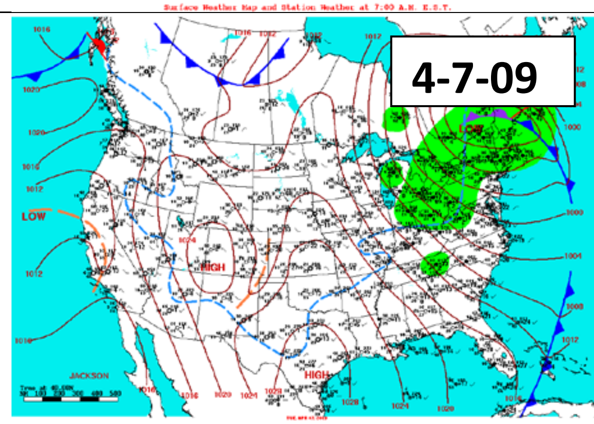
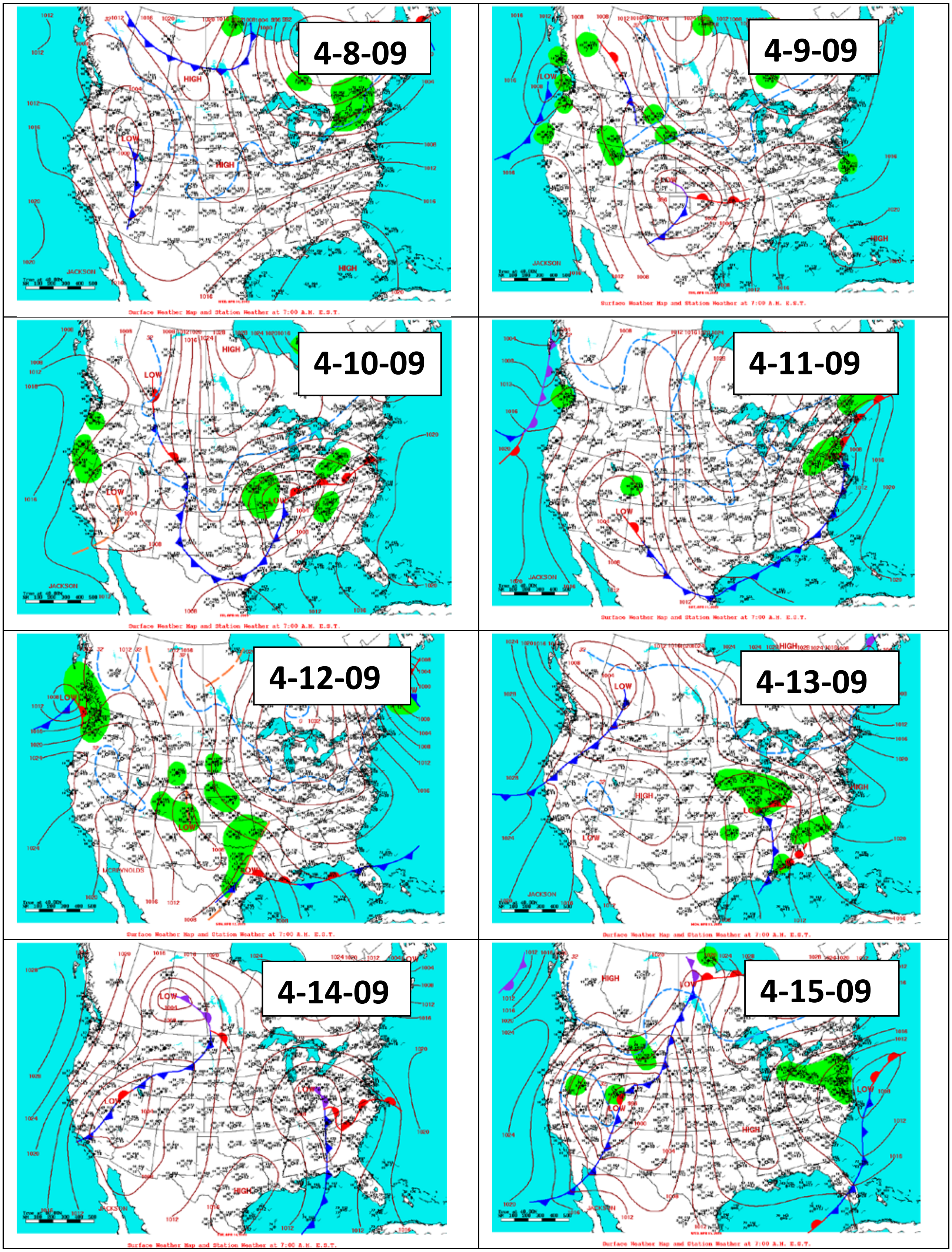
Surface Weather Map and Station Weather at 7:00 A.M. E.S.T.

Period 8	
	
	
	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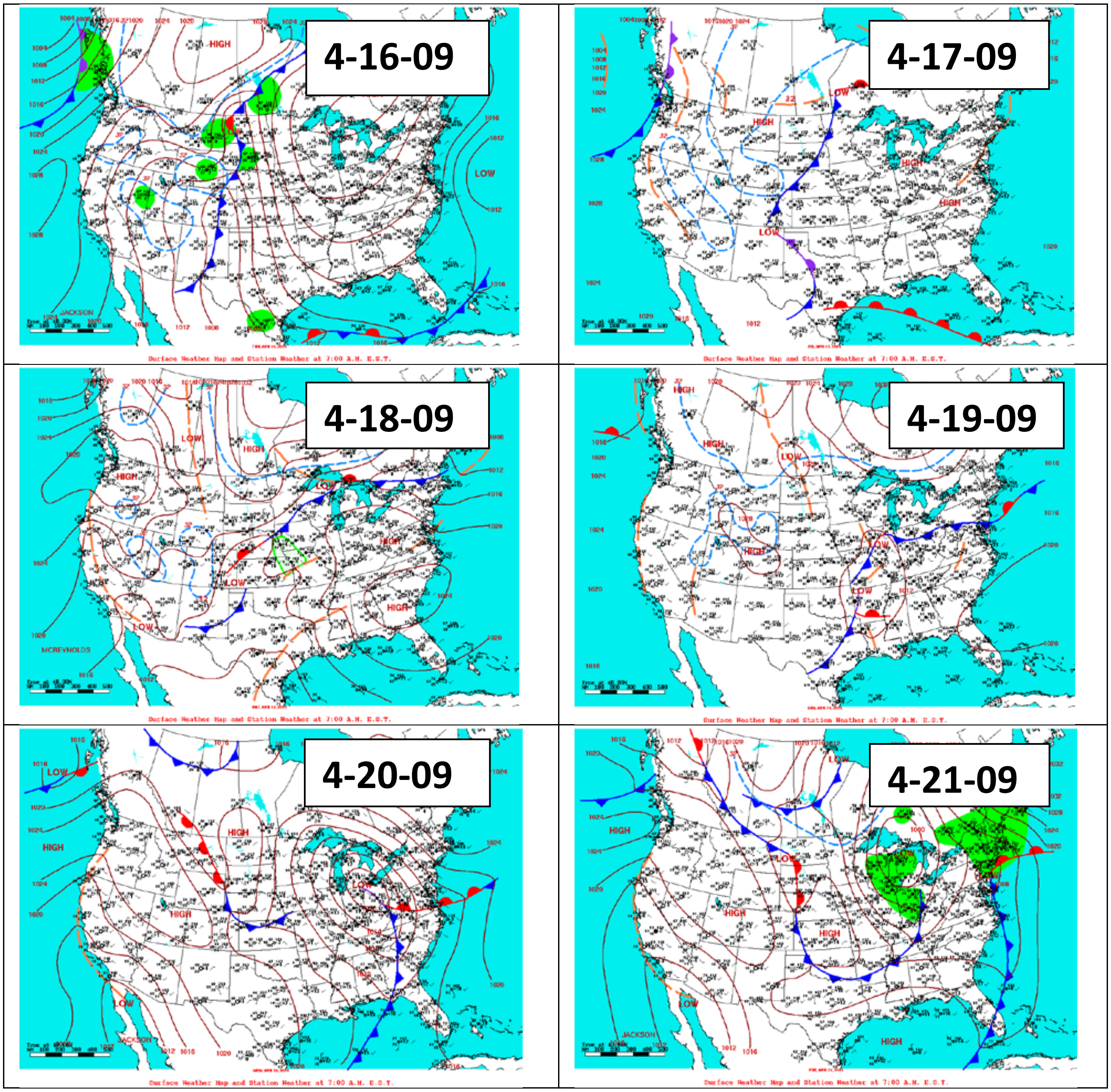

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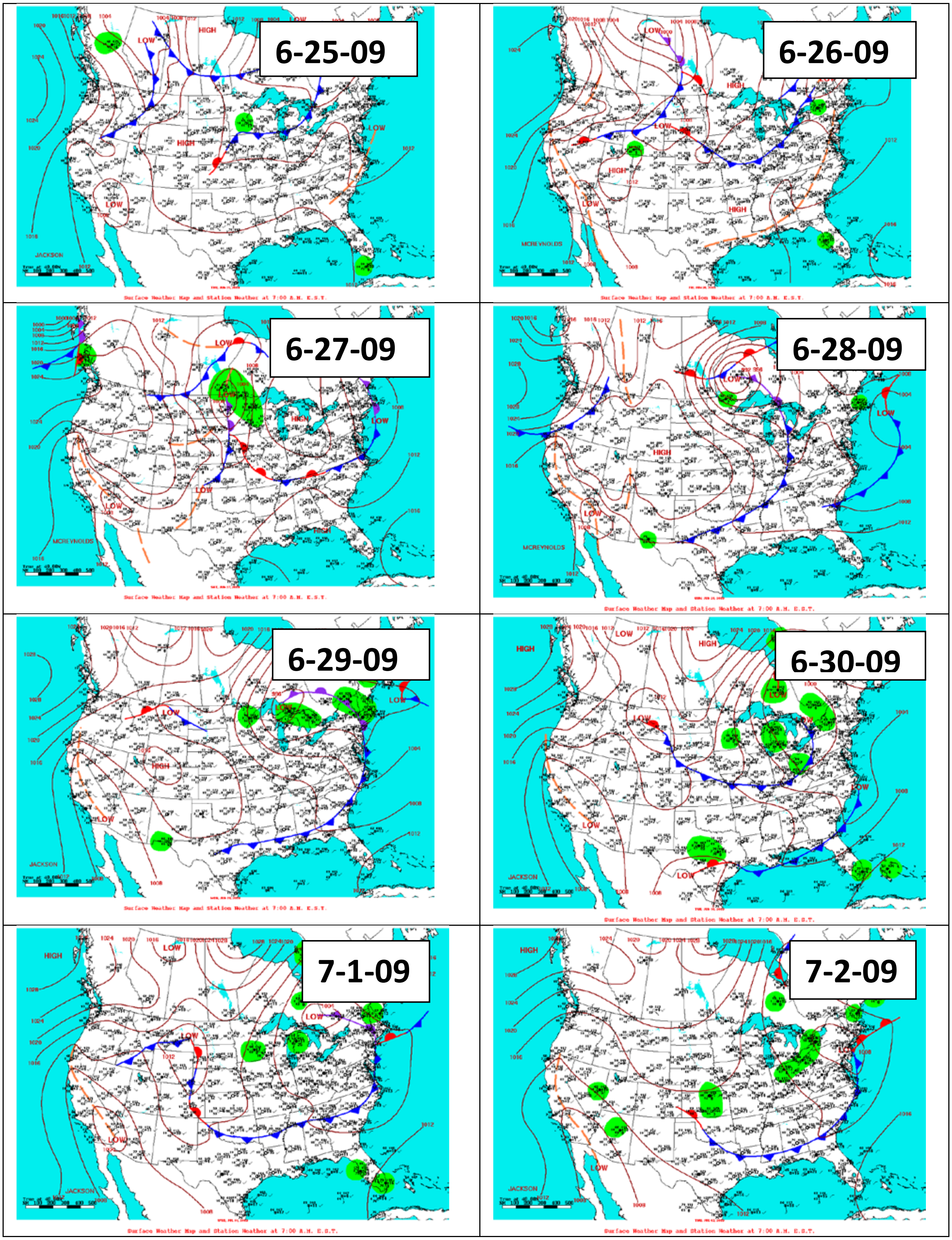
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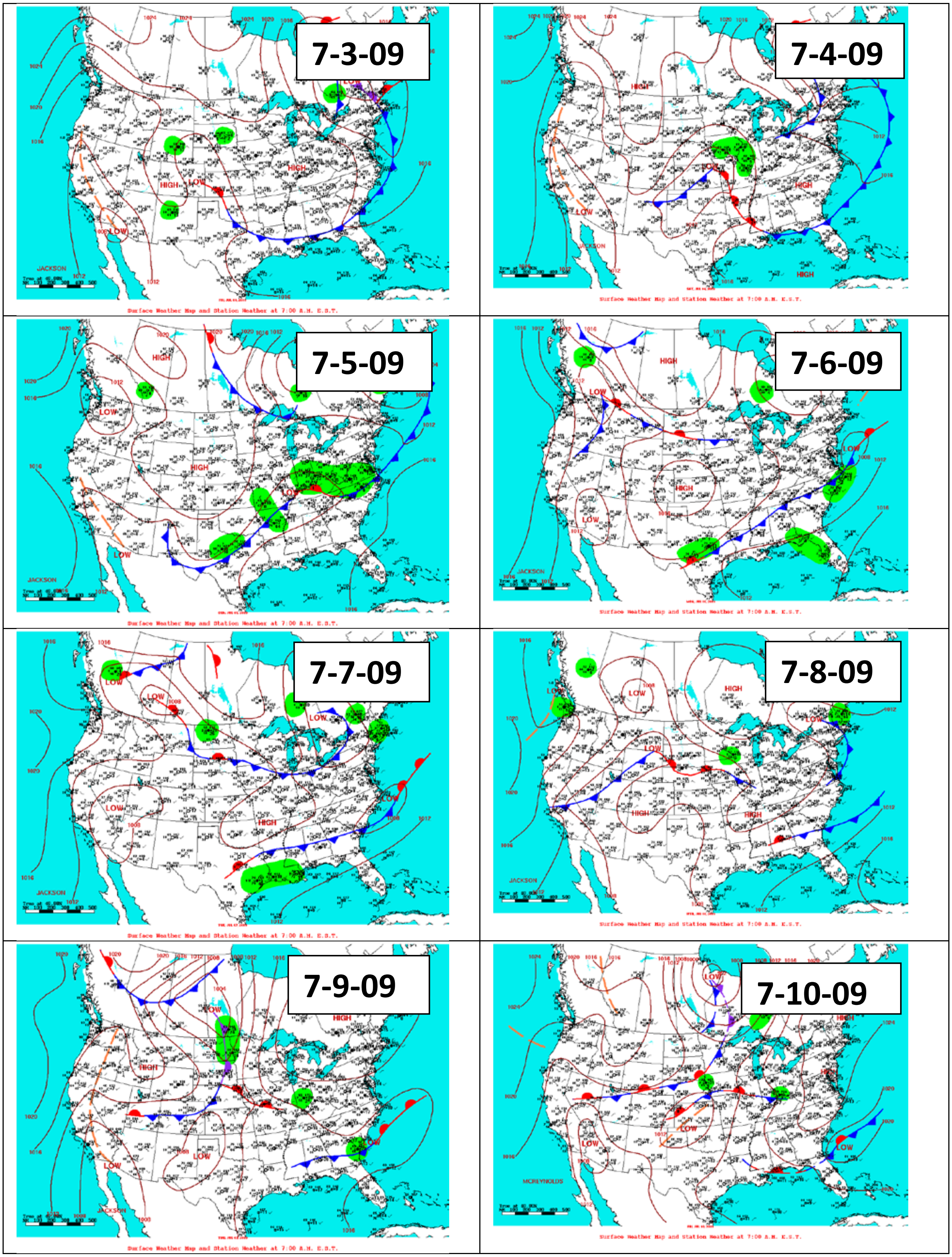
7-2-09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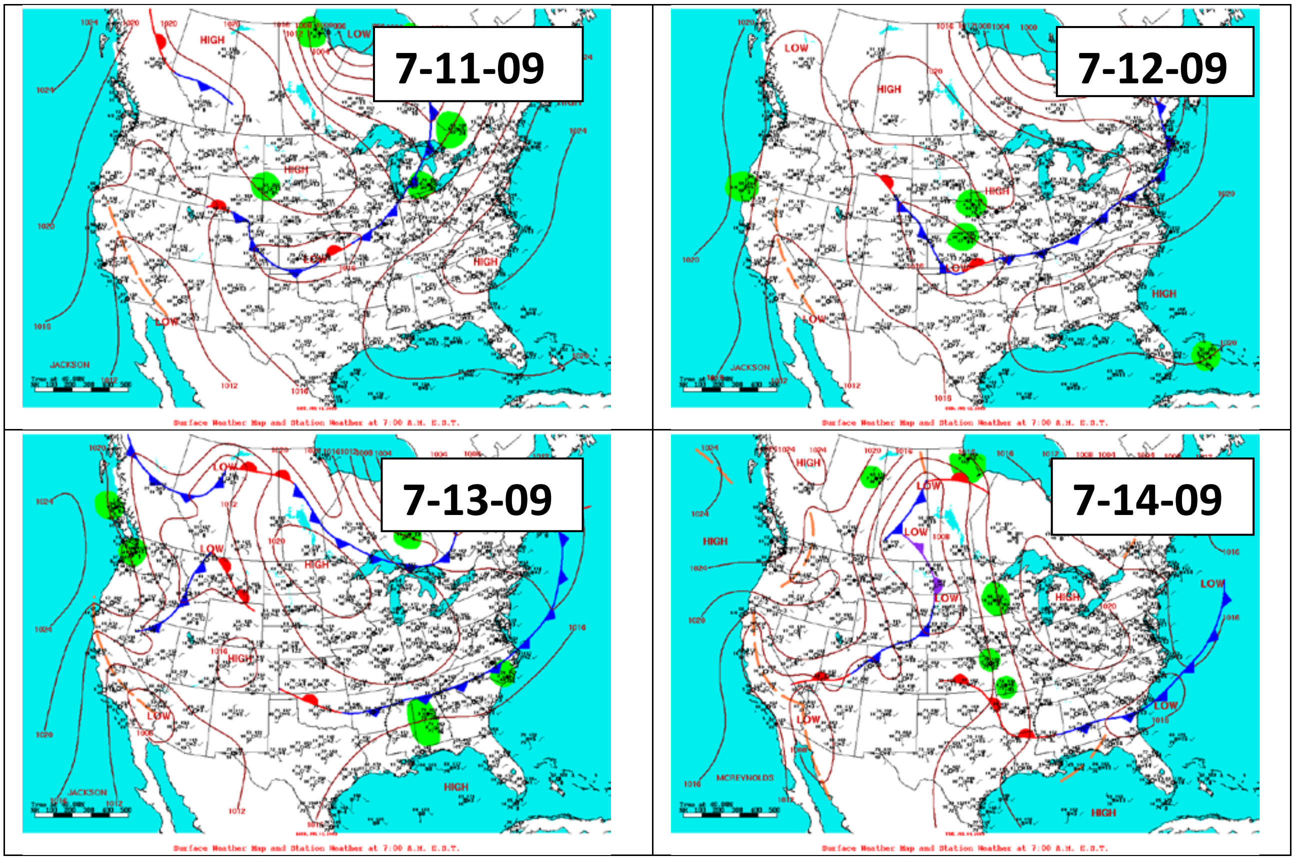
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7-13-09
7-14-09

6.10 Daily weather conditions

Date	Barometric pressure (kPA)	Max solar radiation (Wm^{-2})	Wetness (%)	Air temperature (°C)
Period 1				
6/28/2007	91.50	438	0%	25.5
6/29/2007	91.59	995	52%	19.6
6/30/2007	91.43	1171	64%	21.6
7/1/2007	91.47	990	62%	21.3
7/2/2007	91.55	1189	59%	22.5
7/3/2007	91.44	966	93%	23.4
7/4/2007	91.50	955	61%	26.2
7/5/2007	91.71	897	56%	23.1
7/6/2007	91.85	976	51%	23.9
7/7/2007	91.44	1029	42%	25.3
7/8/2007	90.76	955	20%	27.5
7/9/2007	90.80	930	19%	25.9
7/10/2007	91.11	912	37%	24.8
7/11/2007	91.66	998	31%	23.1
7/12/2007	91.37	1018	51%	25.0
7/13/2007	91.64	1156	34%	21.3
7/14/2007	91.39	1065	0%	24.5
7/15/2007	91.24	972	6%	25.4
7/16/2007	91.13	953	0%	26.8
7/17/2007	91.18	949	0%	26.1
7/18/2007	91.11	948	0%	27.4
7/19/2007	90.97	982	0%	27.3
7/20/2007	91.19	1107	0%	26.9
7/21/2007	91.41	1057	69%	26.4
7/22/2007	91.57	1098	63%	26.1
7/23/2007	91.43	1058	46%	27.2
7/24/2007	91.25	1027	49%	25.6
7/25/2007	91.14	1063	44%	26.1
7/26/2007	91.12	941	18%	26.2
7/27/2007	91.19	946	28%	26.5
7/28/2007	91.10	1058	32%	25.8
7/29/2007	91.05	1050	27%	26.5
7/30/2007	91.12	1073	29%	26.7
7/31/2007	91.14	1091	28%	26.4
8/1/2007	91.07	1037	41%	25.6
8/2/2007	91.40	1074	62%	23.2
8/3/2007	91.55	1084	36%	23.3
8/4/2007	91.19	937	20%	26.6

Date	Barometric pressure (kPA)	Max solar radiation (Wm^{-2})	Wetness (%)	Air temperature (°C)
8/5/2007	90.94	979	22%	28.5
8/6/2007	90.74	979	71%	29.9
8/7/2007	90.70	997	54%	29.5
8/8/2007	90.72	923	64%	28.9
8/9/2007	91.06	938	52%	28.6
8/10/2007	91.25	922	56%	28.1
8/11/2007	91.14	923	38%	29.1
8/12/2007	91.49	943	38%	29.7
8/13/2007	91.56	919	34%	29.9
8/14/2007	91.38	244	25%	25.8
8/15/2007	91.11	933	0%	35.2
8/16/2007	91.23	913	0%	27.4
8/17/2007	91.42	933	0%	27.3
8/18/2007	91.27	1007	38%	24.6
8/19/2007	90.95	892	41%	25.6
8/20/2007	90.65	885	26%	29.6
8/21/2007	90.94	886	5%	28.2
8/22/2007	90.98	885	0%	26.9
8/23/2007	90.61	1109	0%	28.1
8/24/2007	90.94	620	50%	21.3
8/25/2007	91.33	874	49%	22.2
8/26/2007	91.13	897	0%	26.9
8/27/2007	91.12	908	0%	27.2
8/28/2007	91.12	997	0%	27.1
8/29/2007	91.53	750	0%	23.9
Period 2				
11/7/2007	N/A	628	0%	19.8
11/8/2007	N/A	631	0%	11.6
11/9/2007	N/A	614	0%	12.2
11/10/2007	N/A	638	37%	14.6
11/11/2007	N/A	602	0%	14.8
11/12/2007	N/A	435	2%	10.2
11/13/2007	N/A	579	0%	9.5
11/14/2007	N/A	697	0%	9.5
11/15/2007	N/A	583	0%	1.8
11/16/2007	N/A	593	0%	9.2
11/17/2007	N/A	594	0%	12.2
11/18/2007	N/A	560	0%	12.4
11/19/2007	N/A	574	0%	13.5
11/20/2007	N/A	575	0%	10.6
11/21/2007	N/A	594	0%	2.3
11/22/2007	N/A	568	23%	-4.2

Date	Barometric pressure (kPA)	Max solar radiation (Wm^{-2})	Wetness (%)	Air temperature (°C)
11/23/2007	N/A	291	46%	-4.3
11/24/2007	N/A	661	64%	-3.0
11/25/2007	N/A	568	70%	-4.0
11/26/2007	N/A	623	1%	1.4
11/27/2007	N/A	551	57%	1.8
11/28/2007	N/A	166	0%	8.9
Period 3				
11/29/2007	N/A	518	0%	-0.4
11/30/2007	N/A	338	0%	-0.9
12/1/2007	N/A	477	33%	6.2
12/2/2007	N/A	534	0%	6.5
12/3/2007	N/A	539	0%	2.3
12/4/2007	N/A	529	0%	10.1
12/5/2007	N/A	562	0%	8.8
12/6/2007	N/A	434	2%	3.9
12/7/2007	N/A	94	63%	0.5
12/8/2007	N/A	109	100%	-2.2
12/9/2007	N/A	513	99%	-6.8
12/10/2007	N/A	331	95%	-3.1
12/11/2007	N/A	214	100%	0.0
12/12/2007	N/A	545	78%	-2.5
12/13/2007	N/A	583	52%	-1.0
12/14/2007	N/A	55	55%	-3.9
12/15/2007	N/A	532	77%	-4.0
12/16/2007	N/A	527	0%	-5.0
12/17/2007	N/A	543	0%	-0.3
12/18/2007	N/A	523	0%	3.9
12/19/2007	N/A	506	0%	1.8
Period 4				
4/23/2008	90.65	383	29%	15.5
4/24/2008	90.32	832	71%	17.0
4/25/2008	90.80	968	0%	15.4
4/26/2008	91.25	917	0%	11.1
4/27/2008	92.16	966	8%	8.1
4/28/2008	91.59	1041	0%	13.7
4/29/2008	90.91	1038	26%	14.1
4/30/2008	89.75	1054	0%	20.3
5/1/2008	89.38	994	0%	19.8
5/2/2008	90.29	1096	0%	9.9
5/3/2008	91.60	984	0%	7.8
5/4/2008	91.27	978	0%	12.8

Date	Barometric pressure (kPA)	Max solar radiation (Wm^{-2})	Wetness (%)	Air temperature (°C)
5/5/2008	91.15	1035	3%	19.1
5/6/2008	90.78	1009	49%	18.5
Period 6				
10/1/2008	91.64	787	0%	25.4
10/2/2008	91.37	775	13%	16.4
10/3/2008	90.83	794	60%	19.6
10/4/2008	90.69	769	52%	20.5
10/5/2008	90.62	125	80%	18.1
10/6/2008	90.67	703	73%	14.7
10/7/2008	91.76	782	53%	13.8
10/8/2008	91.31	779	25%	15.1
10/9/2008	90.93	760	22%	17.9
10/10/2008	90.39	766	0%	21.0
10/11/2008	90.87	144	38%	16.8
10/12/2008	90.77	96	100%	16.7
10/13/2008	91.56	356	54%	11.2
10/14/2008	92.03	104	52%	8.0
10/15/2008	91.82	587	90%	6.7
Period 7				
1/8/2009	90.84	478	0%	15.2
1/9/2009	90.39	479	37%	6.1
1/10/2009	92.01	499	61%	0.0
1/11/2009	92.04	497	9%	0.9
1/12/2009	91.57	442	2%	2.3
1/13/2009	92.01	499	43%	-0.8
1/14/2009	91.62	516	0%	3.2
1/15/2009	92.66	436	35%	-7.2
1/16/2009	92.39	508	56%	-1.8
1/17/2009	91.78	521	0%	6.7
1/18/2009	91.99	597	0%	7.0
1/19/2009	91.57	526	0%	11.5
1/20/2009	91.99	530	0%	6.9
1/21/2009	91.45	553	0%	8.3
1/22/2009	90.84	667	0%	8.0
1/23/2009	91.17	611	0%	6.3
1/24/2009	92.33	523	31%	-5.8
1/25/2009	91.29	558	0%	-6.4
1/26/2009	91.49	186	44%	-9.9
1/27/2009	91.80	503	94%	-11.7
Period 8				
4/2/2009	90.58	905	0%	10.1
4/3/2009	90.05	891	45%	8.7

Date	Barometric pressure (kPA)	Max solar radiation (Wm^{-2})	Wetness (%)	Air temperature (°C)
4/4/2009	89.38	904	0%	14.2
4/5/2009	91.46	902	0%	1.9
4/6/2009	92.43	973	24%	1.8
4/7/2009	91.67	937	13%	7.0
4/8/2009	90.73	940	0%	13.6
4/9/2009	89.56	840	0%	13.1
4/10/2009	91.19	973	42%	6.6
4/11/2009	91.46	851	51%	5.7
4/12/2009	90.72	405	98%	6.5
4/13/2009	91.00	1073	61%	8.3
4/14/2009	90.85	991	36%	13.4
4/15/2009	90.60	1050	0%	16.4
4/16/2009	90.77	764	42%	13.2
4/17/2009	91.01	1123	71%	12.0
4/18/2009	90.99	1112	43%	8.4
4/19/2009	91.68	1006	54%	10.7
4/20/2009	91.67	956	5%	13.2
4/21/2009	91.42	967	1%	15.3
Period 9				
6/23/2009	90.97	1055	0%	33.8
6/24/2009	91.15	1080	16%	28.5
6/25/2009	91.17	973	1%	29.1
6/26/2009	90.96	977	0%	29.1
6/27/2009	90.94	1190	0%	27.4
6/28/2009	91.58	1009	31%	24.1
6/29/2009	91.15	987	0%	26.0
6/30/2009	91.00	995	49%	25.5
7/1/2009	91.08	979	28%	25.9
7/2/2009	91.17	970	62%	28.0
7/3/2009	91.21	1100	68%	28.9
7/4/2009	91.12	1105	57%	26.8
7/5/2009	91.51	1191	19%	23.0
7/6/2009	91.36	1121	17%	23.0
7/7/2009	90.90	965	46%	24.7
7/8/2009	90.61	970	27%	28.3
7/9/2009	90.65	987	7%	31.1
7/10/2009	90.97	1061	0%	32.9
7/11/2009	91.44	884	7%	26.8
7/12/2009	N/A	N/A	N/A	N/A
7/13/2009	N/A	N/A	N/A	N/A
7/14/2009	90.75	997	0%	37.1

6.11 Daily lagoon conditions

Date	Air temperature (°C)	Lagoon temperature (°C)	Lagoon pH	ORP (mV)
Period 1				
6/28/2007	25.5	25.7	7.9	-468
6/29/2007	19.6	25.0	7.9	-478
6/30/2007	21.6	25.2	7.9	-500
7/1/2007	21.3	25.3	7.9	-504
7/2/2007	22.5	26.4	7.9	-498
7/3/2007	23.4	27.7	7.9	-486
7/4/2007	26.2	27.5	7.9	-505
7/5/2007	23.1	26.3	7.8	-517
7/6/2007	23.9	27.1	7.8	-506
7/7/2007	25.3	27.4	7.8	-494
7/8/2007	27.5	26.3	7.8	-456
7/9/2007	25.9	26.0	7.8	-507
7/10/2007	24.8	26.5	7.8	-518
7/11/2007	23.1	26.5	7.8	-507
7/12/2007	25.0	27.2	7.8	-495
7/13/2007	21.3	26.7	7.9	-492
7/14/2007	24.5	28.4	7.8	-510
7/15/2007	25.4	28.1	7.8	-505
7/16/2007	26.8	27.4	7.8	-467
7/17/2007	26.1	26.4	7.8	-492
7/18/2007	27.4	26.2	7.8	-489
7/19/2007	27.3	25.9	7.8	-488
7/20/2007	26.9	27.2	7.8	-506
7/21/2007	26.4	27.6	7.8	-510
7/22/2007	26.1	27.5	7.8	-510
7/23/2007	27.2	28.3	7.8	-513
7/24/2007	25.6	28.3	7.8	-527
7/25/2007	26.1	28.0	7.8	-511
7/26/2007	26.2	26.8	7.8	-503
7/27/2007	26.5	26.9	7.8	-520
7/28/2007	25.8	28.0	7.8	-525
7/29/2007	26.5	28.8	7.8	-518
7/30/2007	26.7	28.2	7.8	-515
7/31/2007	26.4	27.5	7.8	-514
8/1/2007	25.6	26.6	7.8	-518
8/2/2007	23.2	N/A	N/A	N/A
8/3/2007	23.3	28.1	7.8	-435
8/4/2007	26.6	26.8	7.8	-413
8/5/2007	28.5	27.0	7.8	-438

Date	Air temperature (°C)	Lagoon temperature (°C)	Lagoon pH	ORP (mV)
8/6/2007	29.9	27.5	7.8	-454
8/7/2007	29.5	28.1	7.8	-453
8/8/2007	28.9	27.3	7.8	-510
8/9/2007	28.6	27.4	7.8	-536
8/10/2007	28.1	27.7	7.8	-499
8/11/2007	29.1	26.8	7.8	-491
8/12/2007	29.7	27.1	7.8	-504
8/13/2007	29.9	27.3	7.8	-501
8/14/2007	25.8	26.6	7.8	-526
8/15/2007	35.2	27.4	7.8	-334
8/16/2007	27.4	26.7	7.9	-446
8/17/2007	27.3	27.3	7.9	-444
8/18/2007	24.6	26.3	7.9	-454
8/19/2007	25.6	27.0	7.9	-484
8/20/2007	29.6	28.8	7.9	-458
8/21/2007	28.2	27.2	7.9	-478
8/22/2007	26.9	26.5	7.9	-435
8/23/2007	28.1	25.4	7.9	-360
8/24/2007	21.3	25.0	7.9	-517
8/25/2007	22.2	25.6	7.9	-518
8/26/2007	26.9	26.0	7.9	-491
8/27/2007	27.2	24.8	7.9	-498
8/28/2007	27.1	24.7	7.9	-513
8/29/2007	23.9	24.5	7.9	-525
Period 2				
11/7/2007	19.8	N/A	N/A	N/A
11/8/2007	11.6	10.4	8.2	-345
11/9/2007	12.2	9.6	8.2	-397
11/10/2007	14.6	9.8	8.2	-402
11/11/2007	14.8	10.6	8.2	-433
11/12/2007	10.2	10.6	8.2	-459
11/13/2007	9.5	9.5	8.2	-416
11/14/2007	9.5	9.4	8.2	-466
11/15/2007	1.8	8.2	8.2	-431
11/16/2007	9.2	7.4	8.3	-467
11/17/2007	12.2	7.8	8.3	-494
11/18/2007	12.4	8.2	8.3	-475
11/19/2007	13.5	9.1	8.3	-456
11/20/2007	10.6	8.3	8.2	-510
11/21/2007	2.3	7.7	8.3	-468
11/22/2007	-4.2	6.3	8.3	-489

Date	Air temperature (°C)	Lagoon temperature (°C)	Lagoon pH	ORP (mV)
11/23/2007	-4.3	5.2	8.3	-469
11/24/2007	-3.0	3.8	8.3	-428
11/25/2007	-4.0	3.6	8.3	-464
11/26/2007	1.4	3.4	8.3	-504
11/27/2007	1.8	3.3	8.3	-408
11/28/2007	8.9	4.0	8.3	-249
Period 3				
11/29/2007	-0.4	N/A	N/A	N/A
11/30/2007	-0.9	N/A	N/A	N/A
12/1/2007	6.2	N/A	N/A	N/A
12/2/2007	6.5	N/A	N/A	N/A
12/3/2007	2.3	N/A	N/A	N/A
12/4/2007	10.1	N/A	N/A	N/A
12/5/2007	8.8	N/A	N/A	N/A
12/6/2007	3.9	N/A	N/A	N/A
12/7/2007	0.5	N/A	N/A	N/A
12/8/2007	-2.2	N/A	N/A	N/A
12/9/2007	-6.8	N/A	N/A	N/A
12/10/2007	-3.1	N/A	N/A	N/A
12/11/2007	0.0	N/A	N/A	N/A
12/12/2007	-2.5	N/A	N/A	N/A
12/13/2007	-1.0	N/A	N/A	N/A
12/14/2007	-3.9	N/A	N/A	N/A
12/15/2007	-4.0	N/A	N/A	N/A
12/16/2007	-5.0	N/A	N/A	N/A
12/17/2007	-0.3	N/A	N/A	N/A
12/18/2007	3.9	N/A	N/A	N/A
12/19/2007	1.8	N/A	N/A	N/A
Period 4				
4/23/2008	15.5	N/A	N/A	N/A
4/24/2008	17.0	N/A	N/A	N/A
4/25/2008	15.4	15.7	N/A	-428
4/26/2008	11.1	15.3	N/A	-474
4/27/2008	8.1	14.1	N/A	-485
4/28/2008	13.7	14.6	N/A	-466
4/29/2008	14.1	14.9	N/A	-513
4/30/2008	20.3	15.0	N/A	-442
5/1/2008	19.8	15.6	N/A	-435
5/2/2008	9.9	14.3	N/A	-459
5/3/2008	7.8	12.7	N/A	-478
5/4/2008	12.8	13.8	N/A	-460
5/5/2008	19.1	14.8	N/A	-452

Date	Air temperature (°C)	Lagoon temperature (°C)	Lagoon pH	ORP (mV)
5/6/2008	18.5	16.1	N/A	-455
Period 6				
10/1/2008	25.4	N/A	N/A	N/A
10/2/2008	16.4	19.5	N/A	-416
10/3/2008	19.6	19.2	N/A	-475
10/4/2008	20.5	19.0	N/A	-456
10/5/2008	18.1	18.1	N/A	-330
10/6/2008	14.7	17.2	N/A	-477
10/7/2008	13.8	17.0	N/A	-525
10/8/2008	15.1	18.6	N/A	-528
10/9/2008	17.9	N/A	N/A	N/A
10/10/2008	21.0	N/A	N/A	N/A
10/11/2008	16.8	N/A	N/A	N/A
10/12/2008	16.7	N/A	N/A	N/A
10/13/2008	11.2	N/A	N/A	N/A
10/14/2008	8.0	N/A	N/A	N/A
10/15/2008	6.7	N/A	N/A	N/A
Period 7				
1/8/2009	15.2	N/A	N/A	N/A
1/9/2009	6.1	N/A	N/A	N/A
1/10/2009	0.0	N/A	N/A	N/A
1/11/2009	0.9	N/A	N/A	N/A
1/12/2009	2.3	N/A	N/A	N/A
1/13/2009	-0.8	N/A	N/A	N/A
1/14/2009	3.2	N/A	N/A	N/A
1/15/2009	-7.2	N/A	N/A	N/A
1/16/2009	-1.8	N/A	N/A	N/A
1/17/2009	6.7	N/A	N/A	N/A
1/18/2009	7.0	N/A	N/A	N/A
1/19/2009	11.5	N/A	N/A	N/A
1/20/2009	6.9	N/A	N/A	N/A
1/21/2009	8.3	N/A	N/A	N/A
1/22/2009	8.0	N/A	N/A	N/A
1/23/2009	6.3	N/A	N/A	N/A
1/24/2009	-5.8	N/A	N/A	N/A
1/25/2009	-6.4	N/A	N/A	N/A
1/26/2009	-9.9	N/A	N/A	N/A
1/27/2009	-11.7	N/A	N/A	N/A
Period 8				
4/2/2009	10.1	7.2	8.4	-433
4/3/2009	8.7	7.4	8.2	-515

Date	Air temperature (°C)	Lagoon temperature (°C)	Lagoon pH	ORP (mV)
4/4/2009	14.2	8.3	7.9	-520
4/5/2009	1.9	7.7	7.9	-520
4/6/2009	1.8	6.7	7.9	-537
4/7/2009	7.0	6.6	7.8	-531
4/8/2009	13.6	7.6	7.7	-464
4/9/2009	13.1	8.7	7.6	-453
4/10/2009	6.6	8.8	7.7	-458
4/11/2009	5.7	9.6	7.6	-483
4/12/2009	6.5	9.2	7.6	-513
4/13/2009	8.3	8.8	7.7	-533
4/14/2009	13.4	9.3	7.8	-535
4/15/2009	16.4	10.8	7.6	-513
4/16/2009	13.2	11.5	7.7	-514
4/17/2009	12.0	11.6	7.8	-499
4/18/2009	8.4	11.9	7.6	-527
4/19/2009	10.7	11.5	7.5	-538
4/20/2009	13.2	11.6	7.5	-536
4/21/2009	15.3	12.6	7.2	-544
Period 9				
6/23/2009	33.8	N/A	N/A	N/A
6/24/2009	28.5	27.2	7.9	-400
6/25/2009	29.1	26.6	7.7	-448
6/26/2009	29.1	26.1	7.4	-502
6/27/2009	27.4	25.1	7.2	-521
6/28/2009	24.1	24.5	6.9	-536
6/29/2009	26.0	25.0	6.8	-538
6/30/2009	25.5	25.4	6.7	-542
7/1/2009	25.9	25.3	6.6	-545
7/2/2009	28.0	25.8	6.6	-545
7/3/2009	28.9	25.1	6.7	-541
7/4/2009	26.8	24.7	6.9	-477
7/5/2009	23.0	24.6	6.7	-496
7/6/2009	23.0	24.6	6.6	-520
7/7/2009	24.7	24.8	6.6	-521
7/8/2009	28.3	25.7	6.5	-525
7/9/2009	31.1	26.3	6.5	-529
7/10/2009	32.9	26.1	6.7	-514
7/11/2009	26.8	25.3	6.6	-452
7/12/2009	N/A	N/A	N/A	N/A
7/13/2009	N/A	N/A	N/A	N/A
7/14/2009	37.1	25.8	6.6	-540

6.12 Daily site emissions and data completeness

6.12.1 Daily NH_3 emission using RPM emissions model

Column headings for the following table are:

Date: Month/Day/Year
Valid: Number of ½ h periods with valid emissions data
Direction limited: Number of ½ h periods invalidated because wind was from an excluded wind direction
Angle limited: Number of ½ h periods invalidated because angle of attack to the downwind side was greater than 60 degrees
Turbulence limited: Number of ½ h periods that the bLS model was not run because either u_* < 0.15 ms^{-1} or |L| < 2 m
Background (ppb): bLS model calculated daily average background concentration (ppb); average is over the ½ h periods included in the valid column
Emission average ($\mu gm^{-2}s^{-1}$): Daily average emission calculated from the valid ½ h periods
Emissions SD ($\mu gm^{-2}s^{-1}$): Daily emission standard deviation of the valid ½ h periods
Emission minimum ($\mu gm^{-2}s^{-1}$): Daily minimum emission of the valid ½ h periods
Emission maximum ($\mu gm^{-2}s^{-1}$): Daily maximum emission of the valid ½ h periods
Emission average (kgd^{-1}): Daily average emission calculated from the valid ½ h periods; totaled over the source area
Emission average ($gd^{-1}hd^{-1}$): Daily average emission calculated from the valid ½ h periods; totaled over the source area on a per head basis
Emission average ($gd^{-1}AU^{-1}$): Daily average emission calculated from the valid ½ h periods; totaled over the source area on a per animal unit basis

	Valid values	Cause for invalid values		Emission						
Date		Direction limited	Missing downwind NH_3	Average ($\mu gm^{-2}s^{-1}$)	SD ($\mu gm^{-2}s^{-1}$)	Minimum ($\mu gm^{-2}s^{-1}$)	Maximum ($\mu gm^{-2}s^{-1}$)	Average (kgd^{-1})	Average ($gd^{-1}hd^{-1}$)	Average ($gd^{-1}AU^{-1}$)
Period 1										
6/29/2007	5	0	15	124.1	10.8	112.8	138.8	201.7	72.4	164.3
6/30/2007	10	0	34	149.7	84.9	44.1	285.6	243.2	87.4	198.1
7/1/2007	2	0	45	67.6	2.3	66.0	69.1	109.7	39.4	89.4
7/2/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/3/2007	3	0	43	58.5	6.8	51.1	64.4	95.0	34.1	77.4
7/4/2007	8	0	40	113.5	26.3	54.8	139.4	184.4	66.2	150.2
7/5/2007	20	0	28	157.8	32.3	77.1	219.7	256.4	92.1	208.8
7/6/2007	2	0	46	98.1	25.2	80.3	116.0	159.4	57.3	129.8
7/7/2007	13	0	34	117.4	32.4	60.1	155.9	190.7	68.5	155.4
7/8/2007	35	0	13	154.3	24.9	110.6	211.2	250.7	90.1	204.2
7/9/2007	13	0	35	138.7	35.4	77.1	183.5	225.4	81.0	183.6
7/10/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/11/2007	10	0	38	130.3	62.1	13.3	199.5	211.7	76.0	172.4
7/12/2007	1	0	47	126.6	N/A	126.6	126.6	205.6	73.9	167.5
7/13/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	Valid values	Cause for invalid values		Emission						
Date		Direction limited	Missing downwind NH_3	Average ($\mu gm^{-2}s^{-1}$)	SD ($\mu gm^{-2}s^{-1}$)	Minimum ($\mu gm^{-2}s^{-1}$)	Maximum ($\mu gm^{-2}s^{-1}$)	Average (kgd^{-1})	Average ($gd^{-1}hd^{-1}$)	Average ($gd^{-1}AU^{-1}$)
7/14/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/15/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/16/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/17/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/18/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/19/2007	7	0	41	179.6	42.2	84.0	201.1	291.7	104.8	237.6
7/20/2007	31	8	7	134.6	68.0	26.1	259.6	218.7	78.6	178.1
7/21/2007	43	0	5	143.5	47.1	89.4	351.1	233.1	83.7	189.9
7/22/2007	36	0	12	128.9	37.7	79.8	270.2	209.4	75.2	170.6
7/23/2007	37	3	8	117.9	48.8	29.8	283.5	191.4	68.8	155.9
7/24/2007	7	0	19	157.6	149.8	47.3	386.7	256.0	92.0	208.5
7/25/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/26/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/27/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/28/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/29/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/30/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/31/2007	2	0	2	393.6	108.3	317.0	470.2	639.4	229.7	520.8
8/1/2007	0	0	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/2/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/3/2007	3	0	18	92.4	24.0	66.5	113.8	150.0	53.9	122.2
8/4/2007	22	0	26	135.1	19.3	110.1	186.2	219.4	78.8	178.7
8/5/2007	12	0	36	148.0	41.8	64.4	197.9	240.5	86.4	195.9
8/6/2007	12	0	36	132.4	26.1	58.5	159.0	215.1	77.3	175.2
8/7/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/8/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/9/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/10/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/11/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/12/2007	15	0	33	126.5	28.9	76.1	162.8	205.5	73.8	167.4
8/13/2007	37	0	11	134.1	23.1	71.8	178.2	217.8	78.2	177.4
8/14/2007	0	0	31	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/15/2007	18	2	0	166.0	51.4	78.7	240.4	269.7	96.9	219.7
8/16/2007	20	12	12	98.3	49.7	11.7	187.2	159.6	57.3	130.0
8/17/2007	40	2	3	117.3	49.4	39.4	266.5	190.5	68.4	155.2
8/18/2007	46	0	2	109.4	31.4	26.1	192.6	177.6	63.8	144.7
8/19/2007	22	0	23	132.7	92.9	11.7	294.7	215.5	77.4	175.5
8/20/2007	47	0	1	122.5	48.0	62.2	269.1	198.9	71.4	162.0
8/21/2007	36	0	12	147.8	35.8	99.5	249.5	240.1	86.2	195.5
8/22/2007	48	0	0	195.7	71.8	85.6	334.6	317.9	114.2	259.0
8/23/2007	33	0	15	209.3	79.1	103.7	383.5	339.9	122.1	276.8
8/24/2007	3	0	45	38.1	7.5	29.8	44.1	61.9	22.2	50.4
8/25/2007	0	0	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	Valid values	Cause for invalid values		Emission						
Date		Direction limited	Missing downwind NH_3	Average ($\mu gm^{-2}s^{-1}$)	SD ($\mu gm^{-2}s^{-1}$)	Minimum ($\mu gm^{-2}s^{-1}$)	Maximum ($\mu gm^{-2}s^{-1}$)	Average (kgd^{-1})	Average ($gd^{-1}hd^{-1}$)	Average ($gd^{-1}AU^{-1}$)
8/26/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/27/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/28/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 2										
11/8/2007	0	0	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/9/2007	5	8	27	17.4	4.2	11.7	21.3	28.3	10.2	23.1
11/10/2007	21	0	25	19.7	5.7	5.9	27.7	32.0	11.5	26.1
11/11/2007	10	25	10	34.0	13.2	16.0	65.4	55.2	19.8	45.0
11/12/2007	1	0	46	42.6	N/A	42.6	42.6	69.1	24.8	56.3
11/13/2007	0	8	38	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/14/2007	1	1	45	20.2	N/A	20.2	20.2	32.8	11.8	26.7
11/15/2007	7	8	32	22.9	3.4	18.1	27.7	37.2	13.3	30.3
11/16/2007	8	12	27	21.9	5.8	16.0	31.4	35.5	12.8	28.9
11/17/2007	3	7	38	15.1	11.4	7.4	28.2	24.5	8.8	19.9
11/18/2007	6	16	25	25.8	13.7	12.2	50.5	41.9	15.1	34.1
11/19/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/20/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/21/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/22/2007	0	13	30	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/23/2007	7	0	32	14.7	3.8	10.1	21.8	23.9	8.6	19.5
11/24/2007	0	0	46	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/25/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/26/2007	1	0	45	26.6	N/A	26.6	26.6	43.2	15.5	35.2
11/27/2007	0	0	32	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/28/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 3										
11/29/2007	8	6	18	18.2	5.8	9.6	26.6	29.6	10.6	24.1
11/30/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/1/2007	4	1	34	50.5	25.2	19.7	81.4	82.1	29.5	66.9
12/2/2007	5	1	32	22.2	7.4	13.3	30.9	36.1	13.0	29.4
12/3/2007	5	8	20	15.2	2.4	13.3	19.1	24.7	8.9	20.1
12/4/2007	2	26	16	29.8	4.5	26.6	33.0	48.4	17.4	39.4
12/5/2007	0	5	42	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/6/2007	0	2	45	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/7/2007	0	0	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/8/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/9/2007	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/10/2007	0	0	14	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/11/2007	1	0	25	3.2	N/A	3.2	3.2	5.2	1.9	4.2
12/12/2007	1	3	21	4.8	N/A	4.8	4.8	7.8	2.8	6.3
12/13/2007	1	1	30	4.3	N/A	4.3	4.3	6.9	2.5	5.6
12/14/2007	0	0	30	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/15/2007	0	1	36	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	Valid values	Cause for invalid values		Emission						
Date		**Direction limited**	**Missing downwind NH_3**	**Average ($\mu g m^{-2} s^{-1}$)**	**SD ($\mu g m^{-2} s^{-1}$)**	**Minimum ($\mu g m^{-2} s^{-1}$)**	**Maximum ($\mu g m^{-2} s^{-1}$)**	**Average ($kg d^{-1}$)**	**Average ($g d^{-1} hd^{-1}$)**	**Average ($g d^{-1} AU^{-1}$)**
12/16/2007	0	1	38	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/17/2007	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/18/2007	0	0	31	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 4										
4/24/2008	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/25/2008	0	0	47	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/26/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/27/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/28/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/29/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/30/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/1/2008	0	0	47	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/2/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/3/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/4/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/5/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/6/2008	0	0	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 6										
10/1/2008	0	0	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/2/2008	22	0	22	94.7	21.4	52.7	139.4	153.9	55.3	125.3
10/3/2008	43	4	0	67.2	25.4	20.7	120.2	109.2	39.2	89.0
10/4/2008	47	0	1	98.7	40.8	8.0	190.4	160.3	57.6	130.6
10/5/2008	35	0	13	131.4	23.6	76.6	183.5	213.5	76.7	173.9
10/6/2008	0	4	44	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/7/2008	10	10	25	37.6	13.3	18.1	55.9	61.0	21.9	49.7
10/8/2008	22	7	19	53.7	20.1	26.1	89.9	87.3	31.3	71.1
10/9/2008	31	0	17	93.7	47.0	25.5	168.6	152.1	54.7	123.9
10/10/2008	21	2	25	131.4	42.4	70.7	213.8	213.4	76.7	173.9
10/11/2008	31	2	15	90.1	29.1	9.0	169.7	146.4	52.6	119.2
10/12/2008	9	0	39	113.8	22.8	64.9	137.2	184.9	66.4	150.6
10/13/2008	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/14/2008	0	0	30	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 7										
1/8/2009	0	0	7	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/9/2009	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/10/2009	1	2	43	5.3	N/A	5.3	5.3	8.6	3.1	7.0
1/11/2009	7	19	20	10.8	5.0	4.8	17.6	17.5	6.3	14.3
1/12/2009	6	11	28	8.8	3.3	6.4	13.8	14.3	5.1	11.6
1/13/2009	14	16	12	30.2	9.9	17.6	54.8	49.1	17.6	40.0
1/14/2009	2	15	30	18.9	1.9	17.6	20.2	30.7	11.0	25.0
1/15/2009	3	0	45	8.5	1.9	6.4	10.1	13.8	5.0	11.3
1/16/2009	19	6	21	23.6	12.3	8.5	42.0	38.4	13.8	31.3
1/17/2009	3	16	27	18.1	12.0	8.0	31.4	29.4	10.6	23.9

	Valid values	Cause for invalid values		Emission						
Date		Direction limited	Missing downwind NH_3	Average ($\mu gm^{-2}s^{-1}$)	SD ($\mu gm^{-2}s^{-1}$)	Minimum ($\mu gm^{-2}s^{-1}$)	Maximum ($\mu gm^{-2}s^{-1}$)	Average (kgd^{-1})	Average ($gd^{-1}hd^{-1}$)	Average ($gd^{-1}AU^{-1}$)
1/18/2009	0	19	29	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/19/2009	0	1	47	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/20/2009	1	3	42	19.1	N/A	19.1	19.1	31.1	11.2	25.3
1/21/2009	4	18	21	16.0	3.6	11.7	19.1	25.9	9.3	21.1
1/22/2009	9	11	21	19.6	9.1	9.0	35.6	31.8	11.4	25.9
1/23/2009	9	9	30	15.2	8.4	6.9	32.4	24.8	8.9	20.2
1/24/2009	9	0	39	28.8	5.2	17.0	34.6	46.8	16.8	38.1
1/25/2009	1	0	47	18.6	N/A	18.6	18.6	30.2	10.9	24.6
1/26/2009	0	0	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/27/2009	0	0	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 8										
4/2/2009	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/3/2009	45	0	0	54.2	33.3	4.8	128.2	88.0	31.6	71.7
4/4/2009	25	6	17	74.9	16.7	51.1	112.8	121.7	43.7	99.1
4/5/2009	47	0	1	93.8	15.4	60.6	122.3	152.4	54.7	124.1
4/6/2009	39	0	9	50.2	13.7	23.4	77.1	81.6	29.3	66.4
4/7/2009	16	0	31	25.0	8.4	12.8	44.7	40.6	14.6	33.1
4/8/2009	37	0	3	42.2	27.0	6.9	108.5	68.6	24.6	55.8
4/9/2009	21	16	9	77.1	51.6	12.8	210.1	125.2	45.0	101.9
4/10/2009	10	0	29	38.9	15.1	23.4	70.7	63.2	22.7	51.5
4/11/2009	42	0	5	40.0	14.0	14.9	68.1	65.0	23.3	52.9
4/12/2009	25	0	17	34.5	12.4	21.8	77.7	56.0	20.1	45.6
4/13/2009	10	0	36	42.9	12.4	22.3	56.4	69.7	25.0	56.8
4/14/2009	36	2	6	66.7	34.2	12.2	126.1	108.3	38.9	88.2
4/15/2009	47	0	1	85.2	37.4	33.0	155.9	138.3	49.7	112.7
4/16/2009	46	0	1	89.9	28.6	29.8	138.8	146.1	52.5	119.0
4/17/2009	39	0	9	63.6	18.2	35.6	101.1	103.3	37.1	84.2
4/18/2009	35	11	1	43.1	14.7	20.2	69.1	70.1	25.2	57.1
4/19/2009	47	0	0	77.6	22.0	40.4	127.7	126.1	45.3	102.7
4/20/2009	20	25	0	40.1	16.6	18.1	86.2	65.1	23.4	53.0
4/21/2009	2	16	0	34.3	32.7	11.2	57.4	55.7	20.0	45.4
Period 9										
6/24/2009	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6/25/2009	10	0	0	172.8	68.8	49.5	275.0	280.7	100.8	228.6
6/26/2009	48	0	0	160.3	53.1	76.1	295.2	260.3	93.5	212.0
6/27/2009	39	6	0	162.4	34.5	93.6	250.0	263.8	94.8	214.9
6/28/2009	47	0	0	114.6	38.1	21.8	203.2	186.1	66.9	151.6
6/29/2009	37	7	1	121.7	38.3	32.4	215.4	197.6	71.0	161.0
6/30/2009	21	0	22	148.2	67.5	68.6	342.6	240.6	86.4	196.0
7/1/2009	33	0	11	138.8	52.5	36.2	317.0	225.4	81.0	183.6
7/2/2009	24	0	22	169.9	37.7	80.9	236.7	276.0	99.1	224.8
7/3/2009	43	0	3	157.9	41.0	83.0	246.8	256.5	92.1	208.9
7/4/2009	43	4	0	140.0	42.9	33.0	268.6	227.4	81.7	185.2

	Valid values	Cause for invalid values		Emission						
Date		Direction limited	Missing downwind NH_3	Average ($\mu gm^{-2}s^{-1}$)	SD ($\mu gm^{-2}s^{-1}$)	Minimum ($\mu gm^{-2}s^{-1}$)	Maximum ($\mu gm^{-2}s^{-1}$)	Average (kgd^{-1})	Average ($gd^{-1}hd^{-1}$)	Average ($gd^{-1}AU^{-1}$)
7/5/2009	40	0	0	116.0	30.7	55.3	176.1	188.5	67.7	153.5
7/6/2009	47	0	0	131.9	40.7	51.1	213.8	214.3	77.0	174.6
7/7/2009	27	8	10	126.6	55.3	31.9	227.7	205.6	73.9	167.5
7/8/2009	38	0	7	120.7	43.2	20.7	195.2	196.1	70.4	159.7
7/9/2009	30	7	7	162.7	95.8	55.9	475.5	264.3	94.9	215.3
7/10/2009	21	9	16	137.3	23.8	86.2	184.0	223.0	80.1	181.7
7/11/2009	20	12	0	114.8	43.8	33.5	182.4	186.5	67.0	151.9
7/12/2009	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/13/2009	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/14/2009	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A

6.12.2 Daily NH_3 emission using bLS emissions model

Column headings for the following table are:

Date: Month/Day/Year
Valid: Number of ½ h periods with valid emissions data
Direction limited: Number of ½ h periods invalidated because wind was from an excluded wind direction
Touchdown limited: Number of ½ h periods invalidated because fraction of source area surface covered by particle touchdowns was less than 0.1
Turbulence limited: Number of ½ h periods that the bLS model was not run because either u_* < 0.15 ms^{-1} or $|L| < 2$ m
Background (ppm): bLS model calculated daily average background concentration (ppm); average is over the ½ h periods included in the valid column
Emission average ($\mu gm^{-2}s^{-1}$): Daily average emission calculated from the valid ½ h periods
Emissions SD ($\mu gm^{-2}s^{-1}$): Daily emission standard deviation of the valid ½ h periods
Emission minimum ($\mu gm^{-2}s^{-1}$): Daily minimum emission of the valid ½ h periods
Emission maximum ($\mu gm^{-2}s^{-1}$): Daily maximum emission of the valid ½ h periods
Emission average (kgd^{-1}): Daily average emission calculated from the valid ½ h periods; totaled over the source area
Emission average ($gd^{-1}hd^{-1}$): Daily average emission calculated from the valid ½ h periods; totaled over the source area on a per head basis
Emission Average ($gd^{-1}AU^{-1}$): Daily average emission calculated from the valid ½ h periods; totaled over the source area on a per animal unit basis

Date	Valid	Direction limited	Touch-down limited	Turbulence limited	Back-ground (ppm)	Emission average ($\mu gm^{-2}s^{-1}$)	Emission SD ($\mu gm^{-2}s^{-1}$)	Emission minimum ($\mu gm^{-2}s^{-1}$)	Emission maximum ($\mu gm^{-2}s^{-1}$)	Emission average (kgd^{-1})	Emission average ($gd^{-1}hd^{-1}$)	Emission average ($gd^{-1}AU^{-1}$)
Period 1												
6/29/2007	20	0	0	0	0.04	186.4	34.3	124.2	246.4	303.7	109.1	247.4
6/30/2007	22	0	6	16	0.01	126.7	94.8	8.8	456.5	206.4	74.1	168.1
7/1/2007	24	1	4	16	0.00	210.4	67.0	90.5	300.9	342.8	123.1	279.2
7/2/2007	26	0	2	18	0.01	211.9	71.0	105.1	461.4	345.3	124.0	281.2
7/3/2007	24	1	2	21	0.17	174.8	50.7	101.1	308.4	284.9	102.3	232.0
7/4/2007	25	3	3	8	0.12	189.1	44.3	94.2	300.6	308.1	110.7	250.9
7/5/2007	34	0	3	9	0.03	2 19.4	74.6	102.4	519.8	357.4	128.4	291.1
7/6/2007	19	2	12	14	0.06	207.3	99.1	4.9	360.2	337.7	121.3	275.1
7/7/2007	25	10	0	12	0.19	183.2	52.4	92.3	276.5	298.4	107.2	243.1
7/8/2007	45	0	0	0	0.24	180.4	36.8	115.2	271.3	294.0	105.6	239.4
7/9/2007	37	4	2	1	0.16	189.2	49.0	103.8	314.3	308.3	110.8	251.1
7/10/2007	16	0	11	18	0.05	274.8	127.2	142.9	632.2	447.8	160.8	364.7
7/11/2007	41	0	2	2	0.13	175.0	58.9	31.6	274.3	285.1	102.4	232.2
7/12/2007	42	1	1	2	0.22	139.9	51.9	9.7	256.2	228.0	81.9	185.7
7/13/2007	31	5	3	6	0.10	144.0	74.9	-0.4	323.8	234.6	84.3	191.1
7/14/2007	9	9	8	20	0.78	-45.9	204.4	-531.5	114.9	-74.8	-26.9	-60.9
7/15/2007	8	4	8	24	0.31	105.1	97.1	-5.7	253.3	171.2	61.5	139.4
7/16/2007	25	0	5	5	0.30	154.6	40.1	79.7	229.5	251.9	90.5	205.2
7/17/2007	14	0	5	8	0.29	103.3	19.4	81.3	151.4	168.3	60.5	137.1
7/18/2007	20	0	11	2	0.34	118.0	18.7	70.2	149.6	192.2	69.0	156.6

Date	Valid	Direction limited	Touch-down limited	Turbulence limited	Back-ground (ppm)	Emission average ($\mu gm^{-2}s^{-1}$)	Emission SD ($\mu gm^{-2}s^{-1}$)	Emission minimum ($\mu gm^{-2}s^{-1}$)	Emission maximum ($\mu gm^{-2}s^{-1}$)	Emission average (kgd^{-1})	Emission average ($gd^{-1}hd^{-1}$)	Emission average ($gd^{-1}AU^{-1}$)
7/19/2007	10	0	0	0	0.29	178.0	35.7	118.9	232.2	290.1	104.2	236.3
7/20/2007	33	7	0	6	0.28	140.8	52.0	4.2	242.0	229.3	82.4	186.8
7/21/2007	40	0	0	3	0.25	164.2	45.2	77.8	267.0	267.5	96.1	217.9
7/22/2007	37	0	0	7	0.28	142.4	45.9	73.7	254.2	232.1	83.4	189.0
7/23/2007	26	3	2	14	0.31	146.1	59.1	-3.2	273.6	238.1	85.5	193.9
7/24/2007	11	0	0	13	0.20	183.5	75.6	113.8	332.9	299.0	107.4	243.5
7/25/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/26/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/27/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/28/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/29/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/30/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/31/2007	3	0	0	0	0.16	287.3	146.3	118.4	376.0	468.1	168.1	381.3
8/1/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/2/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/3/2007	10	0	6	0	0.27	192.1	107.7	92.9	377.1	313.0	112.4	254.9
8/4/2007	24	0	3	3	0.36	141.2	34.6	91.8	215.0	230.1	82.6	187.4
8/5/2007	13	0	2	3	0.33	164.7	23.1	123.1	204.8	268.3	96.4	218.5
8/6/2007	12	0	5	1	0.29	150.4	19.9	125.1	181.7	245.0	88.0	199.5
8/7/2007	14	11	9	3	0.42	160.4	91.0	-5.4	337.7	261.3	93.9	212.8
8/8/2007	11	9	6	7	0.39	158.5	71.4	56.4	253.1	258.2	92.8	210.3
8/9/2007	32	1	2	13	0.10	233.2	72.0	102.2	360.8	380.0	136.5	309.5
8/10/2007	10	0	10	21	0.30	150.1	72.7	92.3	340.9	244.5	87.8	199.2
8/11/2007	13	0	16	6	0.29	205.6	67.2	98.4	343.6	335.1	120.4	272.9
8/12/2007	36	0	0	10	0.33	135.1	23.6	76.3	179.4	220.1	79.1	179.3
8/13/2007	35	2	0	10	0.33	142.7	21.3	90.9	174.6	232.5	83.5	189.4
8/14/2007	21	7	0	2	0.28	133.9	23.1	92.1	179.2	218.2	78.4	177.7
8/15/2007	18	2	0	0	0.23	163.8	32.5	126.7	249.6	266.8	95.8	217.3
8/16/2007	18	18	0	9	0.25	134.5	63.2	0.0	278.9	219.1	78.7	178.5
8/17/2007	32	0	0	15	0.22	139.7	51.4	61.0	318.6	227.7	81.8	185.5
8/18/2007	38	1	0	9	0.32	123.9	37.7	50.5	208.4	201.9	72.5	164.5
8/19/2007	37	6	0	5	0.17	160.2	83.8	3.0	416.9	261.0	93.8	212.6
8/20/2007	35	0	0	12	0.24	169.7	63.5	87.8	332.0	276.6	99.3	225.3
8/21/2007	47	0	0	0	0.11	211.6	92.5	118.4	702.6	344.8	123.8	280.8
8/22/2007	48	0	0	0	0.16	207.6	77.6	89.0	382.1	338.3	121.5	275.6
8/23/2007	48	0	0	0	0.18	230.4	70.6	115.6	447.6	375.4	134.9	305.8
8/24/2007	35	2	3	6	0.00	164.1	61.1	37.6	324.1	267.3	96.0	217.7
8/25/2007	14	0	1	8	0.04	160.6	26.9	106.9	198.9	261.6	94.0	213.1
8/26/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/27/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8/28/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 2												
11/8/2007	0	0	0	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/9/2007	17	8	0	20	0.01	29.1	12.9	0.6	48.9	47.5	17.0	38.7
11/10/2007	24	1	0	22	0.06	19.8	8.6	5.1	40.3	32.2	11.6	26.2
11/11/2007	18	26	0	3	0.01	28.3	17.3	7.3	63.6	46.1	16.5	37.5

Date	Valid	Direction limited	Touch-down limited	Turbulence limited	Back-ground (ppm)	Emission average (μgm^{-2}s^{-1})	Emission SD (μgm^{-2}s^{-1})	Emission minimum (μgm^{-2}s^{-1})	Emission maximum (μgm^{-2}s^{-1})	Emission average (kgd^{-1})	Emission average (gd^{-1}hd^{-1})	Emission average (gd^{-1}AU^{-1})
11/12/2007	30	5	0	12	0.00	26.0	17.6	-9.9	57.2	42.3	15.2	34.4
11/13/2007	11	13	0	23	0.03	23.4	8.0	13.4	35.6	38.1	13.7	31.0
11/14/2007	39	0	0	7	-0.01	39.9	25.7	-3.6	103.1	65.1	23.4	53.0
11/15/2007	23	18	0	7	0.02	24.4	14.0	1.2	52.5	39.7	14.3	32.4
11/16/2007	20	9	0	19	0.01	24.8	8.8	9.7	41.9	40.5	14.5	33.0
11/17/2007	28	1	0	17	-0.01	22.9	17.1	5.0	71.0	37.4	13.4	30.4
11/18/2007	12	10	0	22	0.01	26.8	22.8	-1.6	66.1	43.6	15.7	35.5
11/19/2007	0	0	0	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/20/2007	16	0	1	15	0.00	34.2	16.8	1.3	54.4	55.7	20.0	45.4
11/21/2007	48	0	0	0	0.02	28.9	23.6	-21.6	58.6	47.1	16.9	38.3
11/22/2007	17	12	0	17	-0.01	13.5	12.3	-0.2	37.7	22.0	7.9	17.9
11/23/2007	24	0	0	22	0.02	11.7	3.3	4.3	18.4	19.0	6.8	15.5
11/24/2007	25	3	8	7	0.03	13.6	19.9	-20.2	54.1	22.1	7.9	18.0
11/25/2007	0	0	8	21	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/26/2007	34	3	3	8	0.02	3.9	15.3	-23.5	37.9	6.3	2.3	5.1
11/27/2007	2	0	1	23	0.03	8.0	3.2	5.8	10.3	13.1	4.7	10.7
Period 3												
11/28/2007	4	0	1	0	0.01	41.3	36.5	8.3	75.1	67.3	24.2	54.8
11/29/2007	19	1	0	23	0.04	17.3	10.5	-8.0	31.6	28.2	10.1	23.0
11/30/2007	46	0	0	2	-0.01	13.0	25.9	-2.0	156.8	21.2	7.6	17.3
12/1/2007	37	3	0	0	0.04	9.7	8.1	-8.1	28.5	15.9	5.7	12.9
12/2/2007	37	10	0	1	0.02	13.3	19.4	-13.8	74.4	21.6	7.8	17.6
12/3/2007	26	4	0	15	0.02	13.3	6.5	0.5	26.8	21.7	7.8	17.7
12/4/2007	8	29	0	10	-0.02	2.2	5.2	-4.2	11.1	3.6	1.3	2.9
12/5/2007	37	5	0	6	0.00	10.8	9.1	-26.9	30.2	17.6	6.3	14.4
12/6/2007	39	4	3	2	-0.01	15.6	8.5	-9.2	28.8	25.3	9.1	20.6
12/7/2007	29	0	0	14	-0.02	24.7	10.7	7.2	47.5	40.2	14.4	32.7
12/8/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/9/2007	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/10/2007	14	0	0	0	-0.01	4.7	2.5	-1.2	8.3	7.7	2.8	6.3
12/11/2007	17	0	4	2	0.00	2.2	2.0	-1.8	5.6	3.7	1.3	3.0
12/12/2007	10	1	0	14	0.00	4.3	2.2	0.5	7.8	7.0	2.5	5.7
12/13/2007	7	0	5	12	-0.01	7.2	2.6	4.1	11.9	11.8	4.2	9.6
12/14/2007	0	0	1	11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12/15/2007	28	0	6	2	-0.02	10.9	2.2	5.5	17.0	17.8	6.4	14.5
12/16/2007	1	19	2	24	0.00	-1.9	N/A	-1.9	-1.9	-3.1	-1.1	-2.5
12/17/2007	13	2	0	32	0.00	1.6	5.0	-3.1	12.1	2.6	0.9	2.1
12/18/2007	6	14	0	9	-0.01	3.0	2.3	1.9	7.7	4.8	1.7	3.9
Period 4												
4/24/2008	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/25/2008	37	6	3	0	0.01	3.0	36.3	-76.2	96.1	4.8	1.7	4.0
4/26/2008	16	1	5	18	-0.01	18.4	34.0	-23.3	81.6	29.9	10.7	24.4
4/27/2008	29	0	1	2	-0.03	24.8	26.0	-11.3	99.8	40.3	14.5	32.8
4/28/2008	14	26	2	5	-0.03	55.1	84.6	-6.2	326.9	89.9	32.3	73.2
4/29/2008	11	1	8	12	0.00	34.9	49.0	-17.5	113.7	56.8	20.4	46.3
4/30/2008	18	14	4	11	-0.01	21.5	28.4	-12.3	94.5	35.0	12.6	28.5

Date	Valid	Direction limited	Touch-down limited	Turbulence limited	Back-ground (ppm)	Emission average (μgm⁻²s⁻¹)	Emission SD (μgm⁻²s⁻¹)	Emission minimum (μgm⁻²s⁻¹)	Emission maximum (μgm⁻²s⁻¹)	Emission average (kgd⁻¹)	Emission average (gd⁻¹hd⁻¹)	Emission average (gd⁻¹AU⁻¹)
5/1/2008	35	13	0	0	0.01	46.4	57.9	-30.4	190.8	75.7	27.2	61.6
5/2/2008	26	22	0	0	0.06	46.5	96.5	-152.3	244.7	75.7	27.2	61.7
5/3/2008	38	3	7	0	0.04	68.2	75.6	-143.3	189.8	111.2	39.9	90.6
5/4/2008	21	1	2	21	0.03	54.1	26.2	14.7	98.8	88.2	31.7	71.8
5/5/2008	27	0	16	4	0.07	12.1	28.3	-32.7	73.2	19.7	7.1	16.0
5/6/2008	8	0	10	0	0.06	76.7	77.9	-64.6	221.6	125.0	44.9	101.8
Period 6												
10/1/2008	3	0	0	0	0.03	82.9	9.0	72.5	88.3	135.1	48.5	110.1
10/2/2008	17	0	0	25	0.04	102.7	22.1	52.5	131.3	167.3	60.1	136.3
10/3/2008	40	4	0	2	0.05	73.4	24.7	41.1	136.6	119.5	42.9	97.4
10/4/2008	39	0	0	9	0.05	97.2	51.3	37.2	203.5	158.4	56.9	129.0
10/5/2008	36	0	5	0	0.04	133.7	34.9	67.9	236.0	217.9	78.3	177.5
10/6/2008	17	3	2	5	0.01	106.2	30.5	53.1	172.8	173.1	62.2	141.0
10/7/2008	25	15	0	6	0.04	43.2	10.2	26.3	65.4	70.3	25.3	57.3
10/8/2008	22	6	0	19	0.04	68.5	21.2	37.6	109.6	111.7	40.1	91.0
10/9/2008	24	0	0	24	0.04	117.9	53.0	34.0	186.7	192.1	69.0	156.5
10/10/2008	46	2	0	0	0.03	102.9	35.8	55.1	192.5	167.7	60.2	136.6
10/11/2008	44	1	0	1	0.04	79.0	25.7	23.6	131.2	128.8	46.2	104.9
10/12/2008	36	0	8	0	0.04	108.1	50.1	-74.8	186.9	176.2	63.3	143.5
10/13/2008	45	0	3	0	0.04	91.8	18.3	52.9	137.9	149.7	53.8	121.9
10/14/2008	1	0	9	0	0.04	71.2	N/A	71.2	71.2	115.9	41.6	94.4
Period 7												
1/8/2009	1	0	0	1	0.01	21.4	N/A	21.4	21.4	34.8	12.5	28.4
1/9/2009	17	8	10	11	0.03	16.9	4.8	8.1	29.3	27.5	9.9	22.4
1/10/2009	26	5	6	2	0.04	10.6	4.5	-0.1	19.1	17.2	6.2	14.0
1/11/2009	15	2	3	23	0.03	13.7	7.8	3.0	25.2	22.3	8.0	18.2
1/12/2009	20	18	2	8	0.04	27.4	11.5	7.3	48.3	44.6	16.0	36.3
1/13/2009	22	16	0	10	0.02	19.4	12.0	4.4	47.9	31.6	11.4	25.7
1/14/2009	11	12	1	8	0.05	7.0	3.0	2.5	11.3	11.3	4.1	9.2
1/15/2009	10	0	13	2	0.03	14.9	4.5	9.4	23.8	24.3	8.7	19.8
1/16/2009	17	12	1	15	0.01	14.2	5.3	3.5	19.4	23.1	8.3	18.8
1/17/2009	14	13	12	9	0.03	8.0	3.9	-3.6	12.6	13.1	4.7	10.7
1/18/2009	16	27	0	3	0.02	22.6	6.6	12.2	35.9	36.9	13.2	30.0
1/19/2009	31	13	4	0	0.02	19.6	9.7	5.9	35.8	32.0	11.5	26.1
1/20/2009	22	18	3	3	0.03	13.2	3.8	2.8	19.1	21.5	7.7	17.5
1/21/2009	10	30	0	8	0.01	14.5	3.4	10.2	22.3	23.6	8.5	19.2
1/22/2009	18	12	2	14	0.02	16.6	6.4	2.1	27.1	27.1	9.7	22.1
1/23/2009	3	1	1	19	0.01	5.2	1.5	3.6	6.6	8.4	3.0	6.9
1/24/2009	16	0	3	0	0.02	28.9	7.5	17.7	39.6	47.1	16.9	38.4
1/25/2009	16	0	13	0	0.04	22.3	2.6	17.6	25.7	36.4	13.1	29.7
1/26/2009	0	0	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/27/2009	0	0	4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 8												
4/2/2009	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/3/2009	39	0	0	9	0.03	61.1	36.9	16.4	125.3	99.5	35.7	81.1
4/4/2009	31	17	0	0	0.02	82.6	14.9	54.8	117.7	134.5	48.3	109.6

Date	Valid	Direction limited	Touch-down limited	Turbulence limited	Back-ground (ppm)	Emission average (μgm^{-2}s^{-1})	Emission SD (μgm^{-2}s^{-1})	Emission minimum (μgm^{-2}s^{-1})	Emission maximum (μgm^{-2}s^{-1})	Emission average (kgd^{-1})	Emission average (gd^{-1}hd^{-1})	Emission average (gd^{-1}AU^{-1})
4/5/2009	48	0	0	0	0.03	99.3	15.2	71.2	133.2	161.8	58.1	131.8
4/6/2009	43	5	0	0	0.05	43.6	14.8	14.3	72.9	71.0	25.5	57.9
4/7/2009	14	13	0	20	0.06	39.1	12.2	20.4	60.5	63.7	22.9	51.8
4/8/2009	29	0	0	14	0.03	52.4	26.8	13.0	92.0	85.4	30.7	69.5
4/9/2009	32	15	0	1	0.04	77.0	41.1	2.2	164.0	125.4	45.0	102.1
4/10/2009	48	0	0	0	0.05	53.5	25.7	8.9	119.1	87.1	31.3	71.0
4/11/2009	27	0	0	21	0.04	51.8	19.6	20.0	85.0	84.4	30.3	68.8
4/12/2009	48	0	0	0	0.05	35.1	11.3	7.0	74.7	57.1	20.5	46.5
4/13/2009	48	0	0	0	0.07	36.1	10.5	15.9	53.8	58.8	21.1	47.9
4/14/2009	28	1	0	18	0.02	90.6	33.2	23.0	137.6	147.7	53.1	120.3
4/15/2009	47	0	0	1	0.03	85.9	33.7	32.1	162.0	139.9	50.3	114.0
4/16/2009	48	0	0	0	0.03	90.6	14.9	53.4	119.1	147.6	53.0	120.3
4/17/2009	48	0	0	0	0.04	63.0	22.1	0.5	92.7	102.7	36.9	83.7
4/18/2009	24	11	0	10	0.07	37.6	13.3	1.6	65.8	61.3	22.0	49.9
4/19/2009	47	1	0	0	0.05	70.3	23.7	31.6	127.9	114.6	41.2	93.3
4/20/2009	20	18	0	10	0.06	48.6	8.9	33.9	62.8	79.2	28.4	64.5
4/21/2009	1	3	0	13	0.70	5.2	N/A	5.2	5.2	8.4	3.0	6.9
Period 9												
6/24/2009	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6/25/2009	11	0	0	0	-0.04	261.4	127.4	105.1	480.2	426.0	153.0	347.0
6/26/2009	38	0	0	7	0.02	209.5	66.0	91.8	330.7	341.4	122.6	278.1
6/27/2009	36	5	0	7	0.07	172.2	41.7	82.9	284.2	280.6	100.8	228.5
6/28/2009	36	0	0	12	0.04	137.9	54.9	45.1	305.6	224.7	80.7	183.0
6/29/2009	24	3	0	21	0.04	165.4	66.4	25.3	322.1	269.5	96.8	219.5
6/30/2009	30	5	0	12	0.02	153.4	59.3	41.7	280.9	249.9	89.8	203.5
7/1/2009	38	3	0	6	0.04	147.4	49.0	74.6	285.1	240.1	86.3	195.6
7/2/2009	28	16	1	2	0.04	186.1	54.2	107.3	302.6	303.3	108.9	247.0
7/3/2009	41	0	0	6	0.03	197.6	64.9	89.0	381.8	322.0	115.7	262.3
7/4/2009	40	4	0	3	0.07	144.0	52.4	21.6	312.0	234.7	84.3	191.1
7/5/2009	44	0	0	4	0.05	115.4	27.1	59.8	187.4	188.0	67.5	153.1
7/6/2009	37	0	0	11	0.03	140.1	42.4	71.6	252.3	228.3	82.0	186.0
7/7/2009	31	6	0	11	0.06	135.8	56.2	-6.0	217.7	221.3	79.5	180.3
7/8/2009	33	2	0	12	0.04	134.9	50.5	16.2	239.1	219.7	78.9	179.0
7/9/2009	29	10	0	7	0.10	157.8	59.9	40.5	284.5	257.2	92.4	209.5
7/10/2009	18	22	0	6	0.07	175.6	60.9	101.5	271.4	286.1	102.8	233.1
7/11/2009	17	13	0	4	0.16	96.4	40.7	34.3	156.3	157.1	56.4	127.9
7/12/2009	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/13/2009	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/14/2009	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

6.12.3 Daily H_2S emission using Ratiometric emissions model

Column headings for the following table are:

Date: Month/Day/Year
Valid: Number of ½ h periods with valid emissions data
Emission average ($\mu gm^{-2}s^{-1}$): Daily average emission calculated from the valid ½ h periods
Emissions SD ($\mu gm^{-2}s^{-1}$): Daily emission standard deviation of the valid ½ h periods
Emission minimum ($\mu gm^{-2}s^{-1}$): Daily minimum emission of the valid ½ h periods
Emission maximum ($\mu gm^{-2}s^{-1}$): Daily maximum emission of the valid ½ h periods
Emission average (kgd^{-1}): Daily average emission calculated from the valid ½ h periods; totaled over the source area
Emission average ($gd^{-1}hd^{-1}$): Daily average emission calculated from the valid ½ h periods; totaled over the source area on a per head basis
Emission average ($gd^{-1}AU^{-1}$): Daily average emission calculated from the valid ½ h periods; totaled over the source area on a per animal unit basis

Date	Valid	Emission average ($\mu gm^{-2}s^{-1}$)	Emission SD ($\mu gm^{-2}s^{-1}$)	Emission minimum ($\mu gm^{-2}s^{-1}$)	Emission maximum ($\mu gm^{-2}s^{-1}$)	Emission average (kgd^{-1})	Emission average ($gd^{-1}hd^{-1}$)	Emission average ($gd^{-1}AU^{-1}$)
Period 4								
4/24/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/25/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/26/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/27/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/28/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/29/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/30/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/1/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/2/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/3/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/4/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/5/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5/6/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 6								
10/1/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/2/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/3/2008	39	1.5	8.8	-4.5	8.4	2.4	0.9	1.9
10/4/2008	37	5.9	17.0	0.1	24.8	9.7	3.5	7.9
10/5/2008	35	1.7	9.4	-0.3	7.1	2.7	1.0	2.2
10/6/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/7/2008	10	0.4	5.0	0.1	1.1	0.7	0.2	0.6
10/8/2008	17	0.2	3.3	-0.1	0.8	0.3	0.1	0.3
10/9/2008	30	3.5	13.5	-0.2	19.3	5.8	2.1	4.7
10/10/2008	21	0.5	5.0	-0.3	1.6	0.7	0.3	0.6
10/11/2008	31	0.2	3.6	-2.8	4.9	0.4	0.1	0.3
10/12/2008	9	0.5	5.7	-0.4	1.8	0.9	0.3	0.7

Date	Valid	Emission average (µgm^{-2}s^{-1})	Emission SD (µgm^{-2}s^{-1})	Emission minimum (µgm^{-2}s^{-1})	Emission maximum (µgm^{-2}s^{-1})	Emission average (kgd^{-1})	Emission average (gd^{-1}hd^{-1})	Emission average (gd^{-1}AU^{-1})
10/13/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/14/2008	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 7								
1/8/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/9/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/10/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/11/2009	6	3.8	14.9	0.3	6.9	6.1	2.2	5.0
1/12/2009	6	0.5	5.5	0.0	1.0	0.8	0.3	0.6
1/13/2009	14	6.3	17.9	2.0	14.8	10.3	3.7	8.4
1/14/2009	2	2.1	14.8	1.9	2.3	3.4	1.2	2.8
1/15/2009	3	0.7	7.2	0.5	0.9	1.1	0.4	0.9
1/16/2009	19	2.5	11.6	0.5	5.2	4.1	1.5	3.3
1/17/2009	3	0.9	8.4	0.1	2.4	1.4	0.5	1.1
1/18/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/19/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/20/2009	1	1.4	0.0	1.4	1.4	2.3	0.8	1.9
1/21/2009	4	1.1	8.6	0.7	1.5	1.7	0.6	1.4
1/22/2009	9	2.1	10.9	0.1	5.1	3.4	1.2	2.8
1/23/2009	9	1.0	7.9	0.0	2.5	1.7	0.6	1.4
1/24/2009	9	18.3	27.8	2.8	27.1	29.8	10.7	24.3
1/25/2009	1	7.2	0.0	7.2	7.2	11.7	4.2	9.5
1/26/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1/27/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Period 8								
4/2/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/3/2009	41	8.4	19.8	0.0	36.9	13.6	4.9	11.1
4/4/2009	24	9.6	20.9	1.2	17.5	15.6	5.6	12.7
4/5/2009	46	7.9	19.2	-0.6	26.5	12.9	4.6	10.5
4/6/2009	37	4.3	14.8	0.6	9.9	7.0	2.5	5.7
4/7/2009	16	0.6	6.0	0.1	3.0	1.1	0.4	0.9
4/8/2009	33	3.3	13.0	-0.6	9.7	5.3	1.9	4.3
4/9/2009	21	9.4	21.3	0.1	49.9	15.3	5.5	12.4
4/10/2009	4	0.4	5.1	-1.0	2.2	0.6	0.2	0.5
4/11/2009	22	2.7	12.0	-0.3	12.5	4.4	1.6	3.6
4/12/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/13/2009	10	7.0	19.0	1.6	15.2	11.4	4.1	9.3
4/14/2009	32	10.2	21.6	0.0	22.6	16.5	5.9	13.5
4/15/2009	47	15.9	24.7	0.5	54.7	25.9	9.3	21.1
4/16/2009	46	12.2	22.7	2.5	27.1	19.8	7.1	16.2
4/17/2009	25	6.1	17.4	0.2	15.0	9.9	3.5	8.0
4/18/2009	33	5.0	16.2	0.2	26.7	8.2	2.9	6.7
4/19/2009	47	23.3	26.8	7.1	65.5	37.8	13.6	30.8
4/20/2009	20	2.9	12.4	0.1	7.1	4.7	1.7	3.8
4/21/2009	2	0.8	9.3	0.4	1.2	1.3	0.5	1.1
Period 9								

Date	Valid	Emission average ($\mu gm^{-2}s^{-1}$)	Emission SD ($\mu gm^{-2}s^{-1}$)	Emission minimum ($\mu gm^{-2}s^{-1}$)	Emission maximum ($\mu gm^{-2}s^{-1}$)	Emission average (kgd^{-1})	Emission average ($gd^{-1}hd^{-1}$)	Emission average ($gd^{-1}AU^{-1}$)
6/24/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6/25/2009	8	9.2	21.9	0.0	21.6	14.9	5.4	12.2
6/26/2009	48	8.4	19.7	0.6	25.4	13.6	4.9	11.1
6/27/2009	39	12.7	23.0	-0.1	27.1	20.6	7.4	16.7
6/28/2009	36	3.2	12.8	0.1	10.8	5.2	1.9	4.2
6/29/2009	31	1.3	8.4	0.0	5.7	2.1	0.8	1.7
6/30/2009	10	1.6	9.5	0.1	6.0	2.6	0.9	2.1
7/1/2009	25	2.4	11.4	-0.1	9.9	4.0	1.4	3.2
7/2/2009	24	3.9	14.3	1.0	9.5	6.3	2.3	5.1
7/3/2009	43	5.7	16.7	1.9	15.6	9.3	3.3	7.6
7/4/2009	43	5.0	15.8	0.1	22.3	8.2	2.9	6.7
7/5/2009	35	1.5	8.9	-0.2	4.0	2.4	0.9	2.0
7/6/2009	30	2.0	10.4	-0.3	7.0	3.3	1.2	2.7
7/7/2009	25	1.4	8.8	-0.6	4.7	2.3	0.8	1.9
7/8/2009	27	1.1	7.6	-1.6	4.6	1.7	0.6	1.4
7/9/2009	25	1.3	8.3	-0.2	3.9	2.1	0.7	1.7
7/10/2009	21	1.5	9.0	0.4	4.5	2.4	0.9	2.0
7/11/2009	20	1.4	8.6	-1.9	4.2	2.2	0.8	1.8
7/12/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/13/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7/14/2009	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A

6.12.4 Daily H_2S emission using bLS emissions model

Column headings for the following table are:

Date: Month/Day/Year
Valid: Number of ½ h periods with valid emissions data
Direction limited: Number of ½ h periods invalidated because wind was from an excluded wind direction
Angle limited: Number of ½ h periods invalidated because angle of attack to the downwind side was greater than 60 degrees
Turbulence limited: Number of ½ h periods that the bLS model was not run because either u_* < 0.15 ms^{-1} or |L| < 2 m
Background (ppb): bLS model calculated daily average background concentration (ppb); average is over the ½ h periods included in the valid column
Emission average ($\mu gm^{-2}s^{-1}$): Daily average emission calculated from the valid ½ h periods
Emissions SD ($\mu gm^{-2}s^{-1}$): Daily emission standard deviation of the valid ½ h periods
Emission minimum ($\mu gm^{-2}s^{-1}$): Daily minimum emission of the valid ½ h periods
Emission maximum ($\mu gm^{-2}s^{-1}$): Daily maximum emission of the valid ½ h periods
Emission average (kgd^{-1}): Daily average emission calculated from the valid ½ h periods; totaled over the source area
Emission average ($gd^{-1}hd^{-1}$): Daily average emission calculated from the valid ½ h periods; totaled over the source area on a per head basis
Emission average ($gd^{-1}AU^{-1}$): Daily average emission calculated from the valid ½ h periods; totaled over the source area on a per animal unit basis

Date	Valid	Direction limited	Angle limited	Turbulence limited	Back-ground (ppb)	Emission average ($\mu gm^{-2}s^{-1}$)	Emission SD ($\mu gm^{-2}s^{-1}$)	Emission minimum ($\mu gm^{-2}s^{-1}$)	Emission maximum ($\mu gm^{-2}s^{-1}$)	Emission average (kgd^{-1})	Emission average ($gd^{-1}hd^{-1}$)	Emission average ($gd^{-1}AU^{-1}$)
Period 4												
4/28/2008	13	26	1	1	0.5	1.8	0.9	0.2	3.1	2.9	1.0	2.3
4/29/2008	21	1	13	12	1.3	1.5	0.8	-0.2	2.9	2.4	0.9	2.0
4/30/2008	18	14	3	11	2.4	10.5	8.9	-0.7	29.5	17.1	6.2	13.9
5/1/2008	35	13	0	0	1.3	6.5	4.8	0.0	19.4	10.6	3.8	8.7
5/2/2008	26	21	0	0	1.0	12.8	8.4	3.1	34.9	20.8	7.5	17.0
5/3/2008	43	3	2	0	0.9	4.3	4.7	-0.1	16.5	7.1	2.5	5.8
5/4/2008	23	1	0	23	1.1	3.5	2.6	0.0	9.0	5.8	2.1	4.7
5/5/2008	43	0	0	5	1.1	4.1	3.0	0.4	11.0	6.7	2.4	5.5
5/6/2008	13	0	10	0	0.9	3.9	2.4	1.2	7.9	6.3	2.3	5.1
Period 6												
10/3/2008	37	4	2	3	1.5	0.9	0.8	-0.4	2.7	1.5	0.5	1.2
10/4/2008	31	0	6	9	1.7	6.3	5.5	0.0	18.5	10.2	3.7	8.3
10/5/2008	47	0	0	0	1.5	1.1	1.7	-0.2	6.6	1.7	0.6	1.4
10/6/2008	37	2	1	5	1.2	0.7	1.1	-0.3	5.0	1.1	0.4	0.9
10/7/2008	25	15	0	8	1.1	0.4	0.4	0.0	1.3	0.7	0.2	0.6
10/8/2008	13	5	9	20	1.5	0.1	0.2	-0.2	0.6	0.2	0.1	0.2
10/9/2008	20	0	3	24	1.4	3.9	3.9	0.1	12.7	6.3	2.3	5.1
10/10/2008	46	2	0	0	0.9	0.3	0.4	-0.2	1.4	0.5	0.2	0.4
10/11/2008	41	1	3	1	1.0	0.2	0.5	-1.0	1.9	0.3	0.1	0.2

Date	Valid	Direction limited	Angle limited	Turbulence limited	Back-ground (ppb)	Emission average ($\mu gm^{-2}s^{-1}$)	Emission SD ($\mu gm^{-2}s^{-1}$)	Emission minimum ($\mu gm^{-2}s^{-1}$)	Emission maximum ($\mu gm^{-2}s^{-1}$)	Emission average (kgd^{-1})	Emission average ($gd^{-1}hd^{-1}$)	Emission average ($gd^{-1}AU^{-1}$)
10/12/2008	45	0	3	0	0.9	0.1	0.4	-1.0	0.9	0.1	0.0	0.1
10/13/2008	46	0	0	0	1.1	1.4	3.7	-0.3	24.5	2.3	0.8	1.9
10/14/2008	35	0	0	0	1.1	0.5	0.4	0.0	1.7	0.8	0.3	0.7
Period 7												
1/9/2009	29	8	0	11	1.7	26.4	30.0	0.3	100.7	43.0	15.5	35.1
1/10/2009	40	5	0	2	1.1	2.5	1.9	-0.1	7.7	4.0	1.4	3.3
1/11/2009	16	2	5	24	1.2	3.9	1.7	1.1	7.4	6.4	2.3	5.2
1/12/2009	22	18	0	8	1.5	24.1	21.2	0.0	84.0	39.2	14.1	31.9
1/13/2009	22	16	0	10	1.4	4.3	4.8	0.7	17.4	7.0	2.5	5.7
1/14/2009	24	10	3	8	1.4	8.1	5.3	0.3	25.7	13.2	4.7	10.7
1/15/2009	15	0	28	3	0.8	2.9	2.8	0.5	11.0	4.7	1.7	3.9
1/16/2009	17	12	2	15	1.3	1.5	0.7	0.1	2.7	2.5	0.9	2.1
1/17/2009	24	13	0	9	1.8	17.1	9.9	0.0	36.0	27.8	10.0	22.6
1/18/2009	16	27	0	5	1.2	9.2	8.3	2.5	33.6	15.0	5.4	12.2
1/19/2009	35	13	0	0	1.4	22.1	18.9	1.9	65.3	36.1	13.0	29.4
1/20/2009	27	18	0	3	1.2	4.6	3.3	0.3	15.1	7.6	2.7	6.2
1/21/2009	9	29	0	8	1.1	3.5	2.3	0.7	8.4	5.7	2.0	4.6
1/22/2009	20	12	0	14	1.4	11.4	6.8	0.0	23.1	18.6	6.7	15.1
1/23/2009	27	1	0	19	1.7	28.2	17.4	0.0	59.6	45.9	16.5	37.4
1/24/2009	43	0	5	0	1.5	12.6	10.1	1.5	38.7	20.5	7.4	16.7
1/25/2009	28	0	18	0	1.3	8.4	4.1	2.7	15.0	13.6	4.9	11.1
1/26/2009	19	0	27	1	1.3	6.4	4.2	2.5	19.6	10.4	3.7	8.4
1/27/2009	23	0	0	0	1.4	6.5	5.2	0.1	14.6	10.6	3.8	8.7
Period 8												
4/3/2009	38	0	0	3	1.6	8.5	8.6	0.1	28.8	13.8	5.0	11.2
4/4/2009	30	17	0	0	1.5	6.6	3.4	0.7	13.6	10.8	3.9	8.8
4/5/2009	47	0	0	0	1.0	4.4	3.5	-0.4	17.0	7.2	2.6	5.9
4/6/2009	41	5	0	0	0.9	3.0	1.7	0.5	8.2	4.9	1.8	4.0
4/7/2009	15	12	0	20	1.5	1.4	1.4	0.1	5.5	2.2	0.8	1.8
4/8/2009	27	0	2	17	1.2	1.7	1.4	-0.5	5.1	2.7	1.0	2.2
4/9/2009	32	13	0	1	1.0	6.0	7.8	0.0	30.7	9.7	3.5	7.9
4/10/2009	42	0	6	0	1.2	6.5	5.6	-0.6	24.1	10.5	3.8	8.6
4/11/2009	21	0	6	21	1.1	2.3	2.2	-0.2	8.1	3.7	1.3	3.1
4/12/2009	16	0	30	0	1.3	3.1	2.1	0.4	6.0	5.1	1.8	4.2
4/13/2009	48	0	0	0	1.3	5.1	3.0	1.1	13.2	8.2	3.0	6.7
4/14/2009	28	1	0	18	2.1	13.4	7.1	0.3	25.4	21.8	7.8	17.7
4/15/2009	47	0	0	1	1.8	10.1	9.1	0.9	39.0	16.5	5.9	13.4
4/16/2009	48	0	0	0	1.3	5.9	2.4	1.4	13.7	9.7	3.5	7.9
4/17/2009	30	0	16	0	1.3	3.6	2.7	0.1	11.6	5.9	2.1	4.8
4/18/2009	23	11	1	10	1.5	4.2	4.3	0.3	15.7	6.8	2.5	5.6
4/19/2009	47	1	0	0	1.6	15.5	11.3	2.3	44.9	25.3	9.1	20.6
4/20/2009	20	18	0	10	1.3	2.7	1.7	0.0	6.1	4.5	1.6	3.6
4/21/2009	1	1	0	14	4.9	0.2	N/A	0.2	0.2	0.4	0.1	0.3
Period 9												
6/25/2009	10	0	0	0	1.8	6.1	4.1	0.0	12.1	10.0	3.6	8.1
6/26/2009	38	0	0	8	2.4	10.2	8.0	1.3	24.1	16.6	6.0	13.5

Date	Valid	Direction limited	Angle limited	Turbulence limited	Back-ground (ppb)	Emission average ($\mu gm^{-2}s^{-1}$)	Emission SD ($\mu gm^{-2}s^{-1}$)	Emission minimum ($\mu gm^{-2}s^{-1}$)	Emission maximum ($\mu gm^{-2}s^{-1}$)	Emission average (kgd^{-1})	Emission average ($gd^{-1}hd^{-1}$)	Emission average ($gd^{-1}AU^{-1}$)
6/27/2009	36	5	0	7	2.5	11.1	5.4	0.3	23.0	18.0	6.5	14.7
6/28/2009	26	0	10	12	1.7	2.7	2.4	0.2	9.9	4.4	1.6	3.6
6/29/2009	24	3	0	21	1.5	1.3	1.8	-0.1	6.1	2.1	0.8	1.7
6/30/2009	18	5	11	12	1.4	0.8	1.1	0.1	4.7	1.3	0.5	1.1
7/1/2009	29	3	8	6	1.4	1.6	1.9	-0.1	6.9	2.6	0.9	2.1
7/2/2009	29	16	0	3	1.7	4.1	3.2	0.7	11.9	6.7	2.4	5.5
7/3/2009	41	0	0	7	1.7	8.5	6.1	1.6	27.7	13.9	5.0	11.3
7/4/2009	40	4	0	4	2.3	5.1	5.6	0.0	26.1	8.3	3.0	6.8
7/5/2009	40	0	4	4	1.4	1.1	0.9	-0.3	2.8	1.8	0.6	1.4
7/6/2009	24	0	12	11	1.1	0.9	0.6	-0.2	2.8	1.5	0.5	1.2
7/7/2009	29	6	2	11	1.1	1.1	1.4	-0.1	5.2	1.8	0.7	1.5
7/8/2009	26	2	7	12	1.3	0.8	1.1	-0.5	3.8	1.2	0.4	1.0
7/9/2009	27	10	2	8	1.3	1.1	1.3	-0.3	3.9	1.8	0.6	1.5
7/10/2009	18	22	0	8	1.5	2.5	1.9	0.3	7.3	4.0	1.4	3.3
7/11/2009	17	11	0	5	2.2	1.0	1.0	-0.5	3.3	1.7	0.6	1.3