Impacts of Climate-Induced Changes in Extreme Events on Ozone and PM Air Quality

(Early Career project for EPA-G2011-STAR-D2)

Shiliang Wu (PI) (Michigan Tech)

Jessica McCarty (Michigan Tech)
R. Chris Owen (EPA)

with help from Pei Hou, Aditya Kumar
and Yaoxian Huang at Michigan Tech

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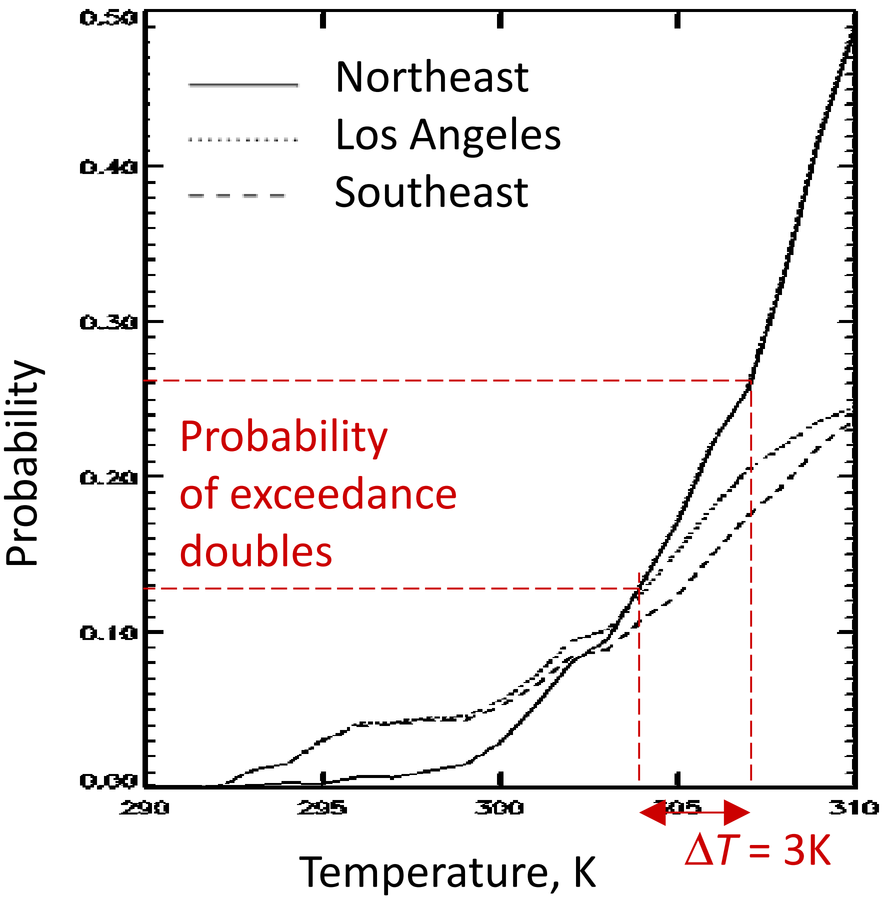
Research objectives

- Examine how climate change has been and will be affecting extreme air pollution meteorology (including heat waves, T inversion, atmospheric stagnation, lightning and wildfires)
- Investigate the consequences for ozone and PM air quality associated with these changes in air pollution meteorology

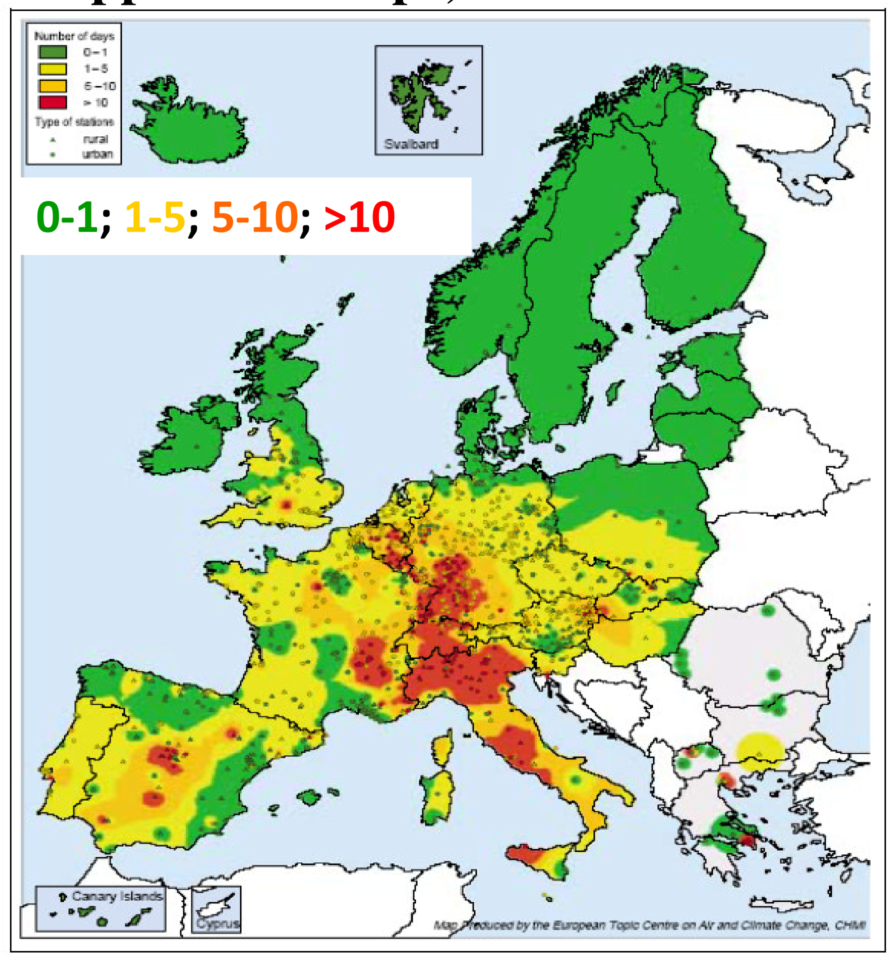
Heat waves and air pollution

Probability of max 8-h O_3 > 84 ppbv vs. daily max. temperature



[Lin et al., 2001]

# of days with ozone exceeding 90 ppbv in Europe, summer 2003

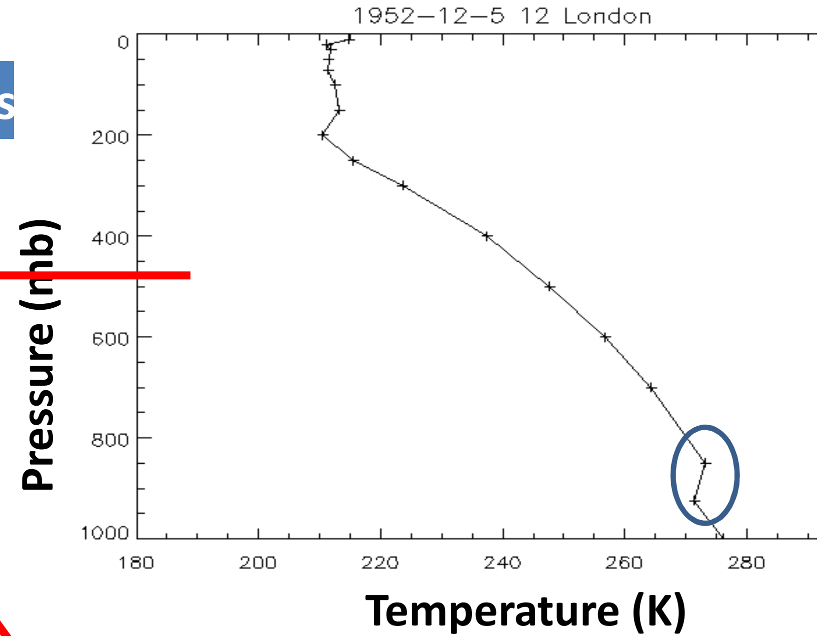


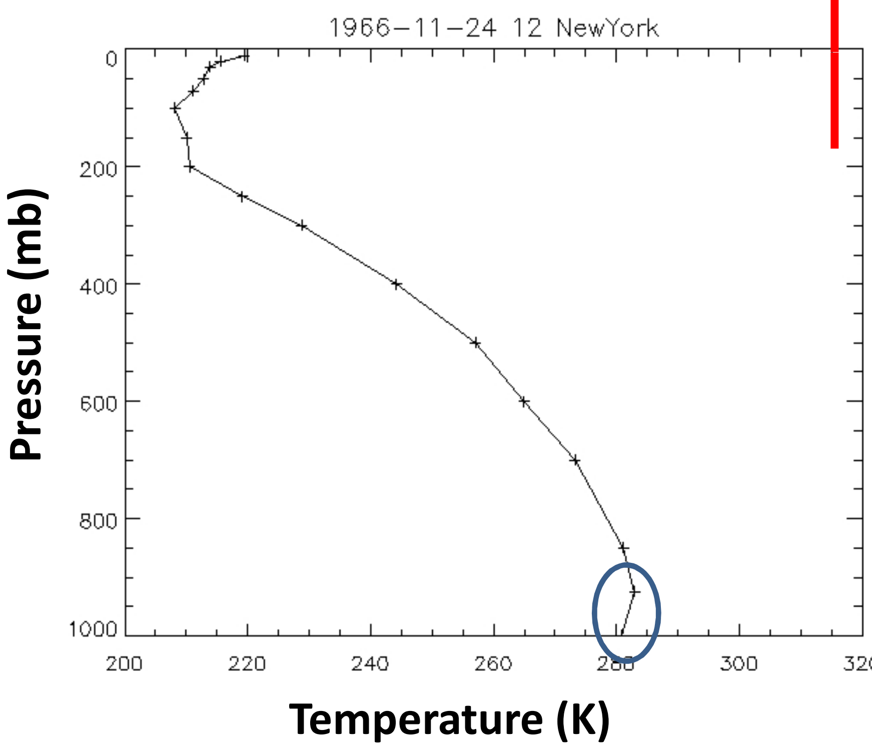
www.eionet.europa.eu/events/

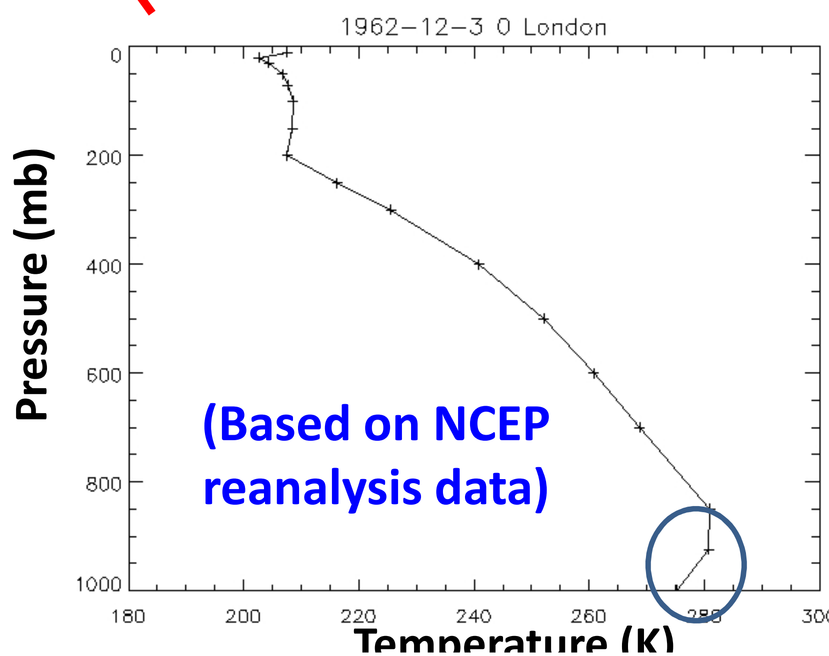
Atmospheric stagnation and air pollution

Temperature inversion and air pollution

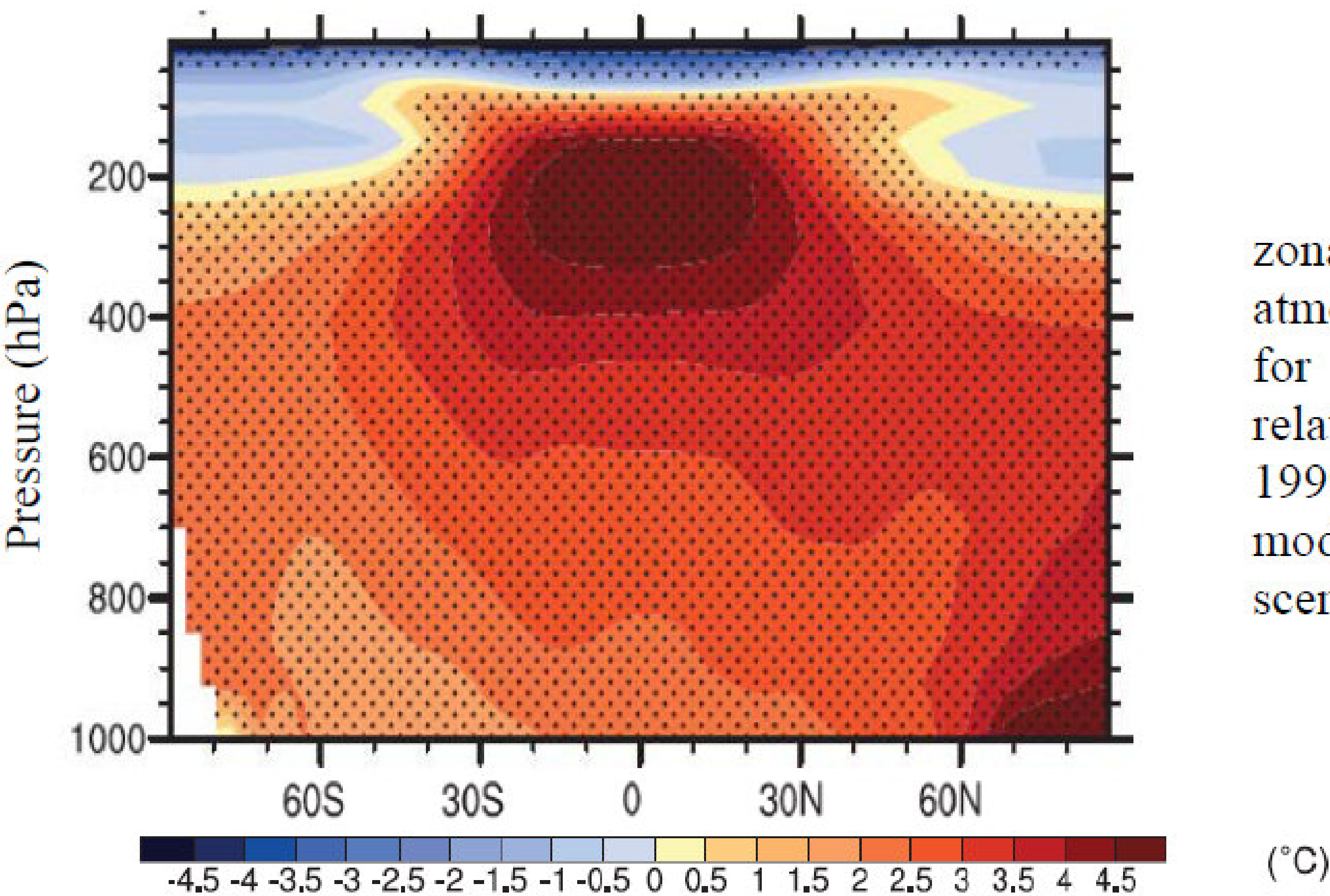
Year	Location	Excess deaths
1948	Denora, Pennsylvania	20
1952	London	4,000
1962	London	700
1966	New York	160







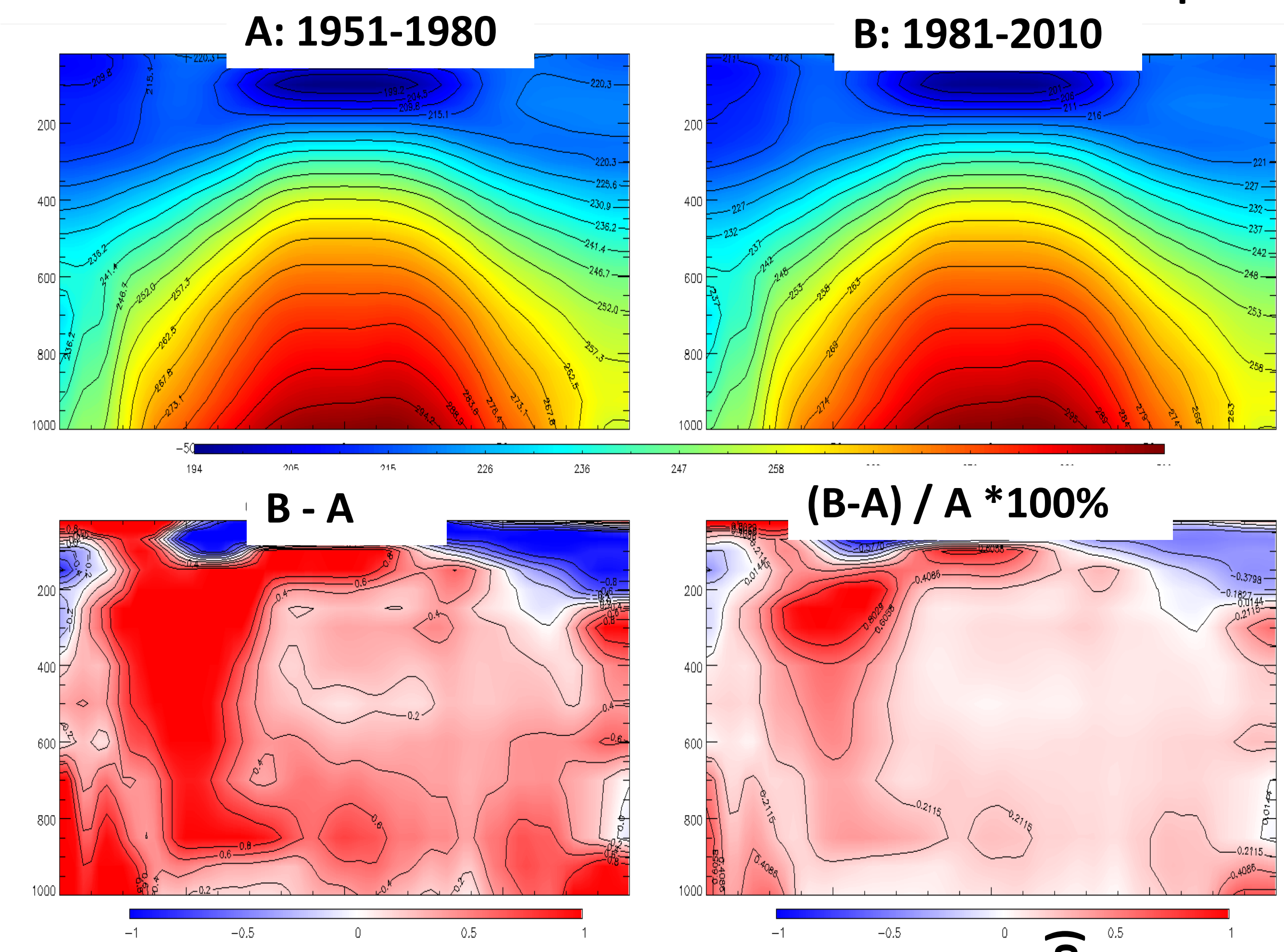
What’s the implication of climate change for T inversion?



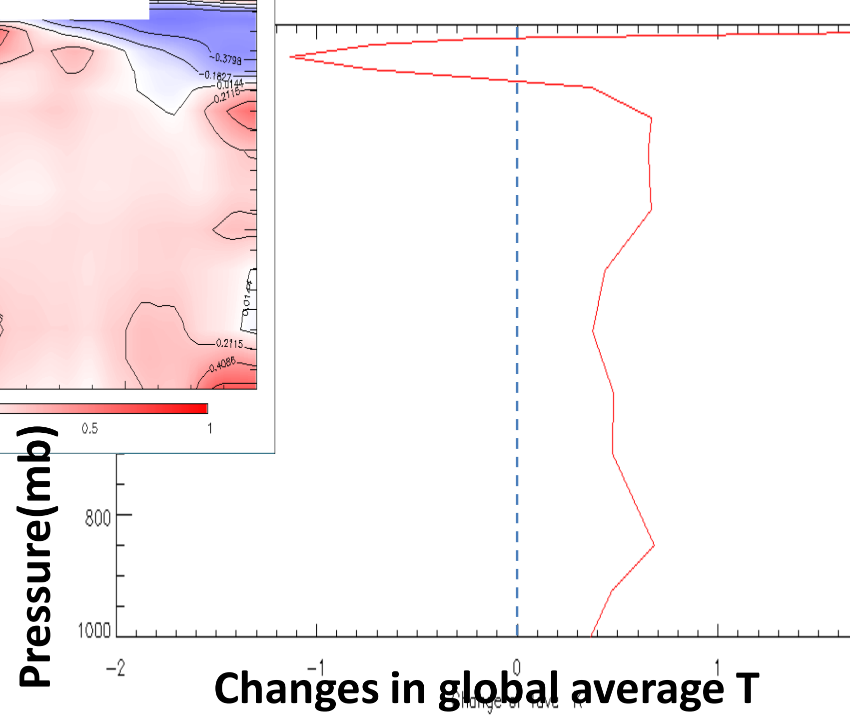
Model simulated zonal mean changes in atmospheric temperature for the period 2080-2099 relative to the period 1980-1999. Values are multi-model means for the A1B scenario. (IPCC, 2007).

Observed changes in temperature for 1950-2010

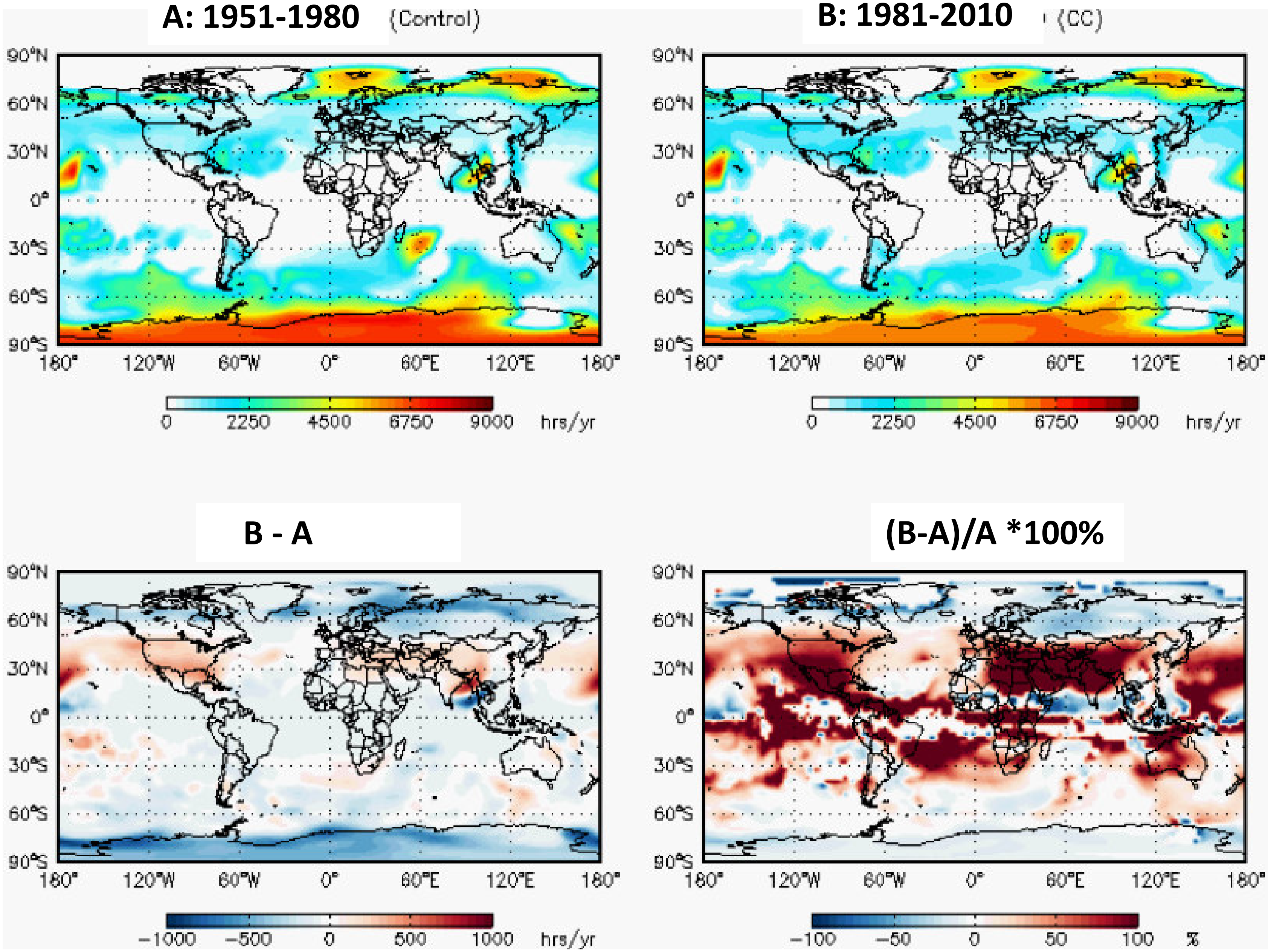
(zonal mean and vertical profile)



Vertical profile (B – A)

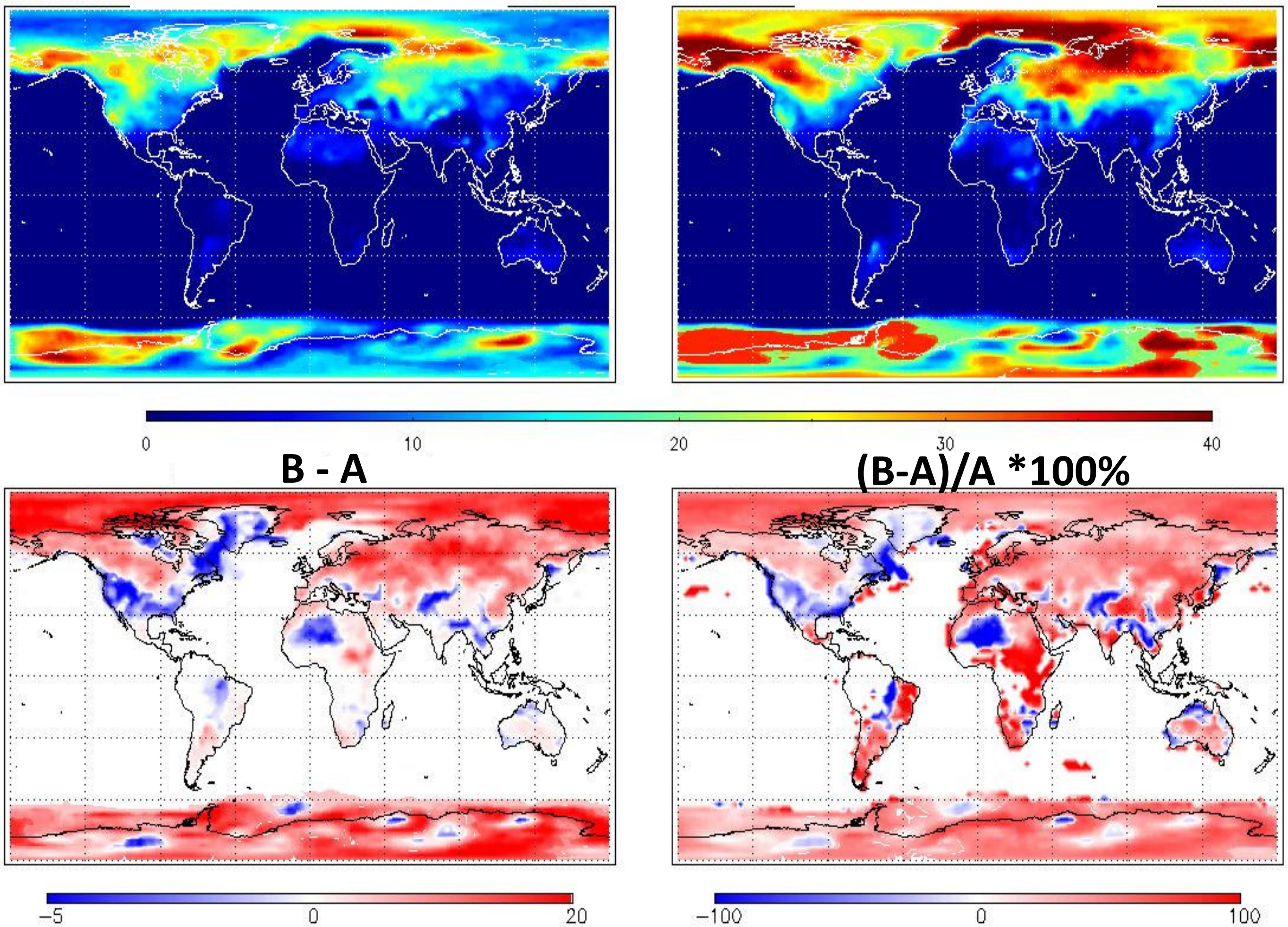


Change in temperature inversion (1950-2010)

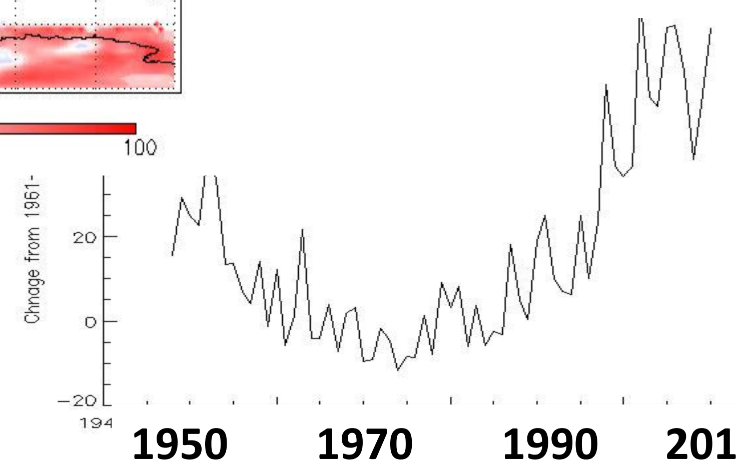


1950-2010 changes in heat waves (days/yr)

A: 1951-1980 **B: 1981-2010**

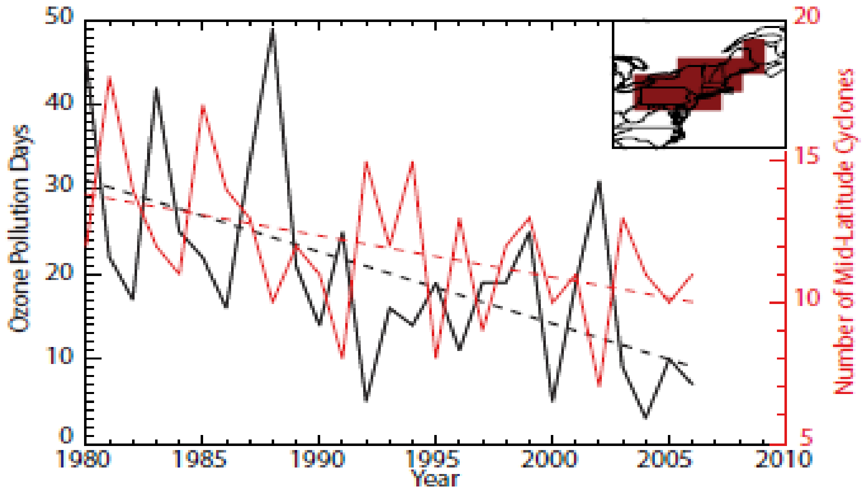


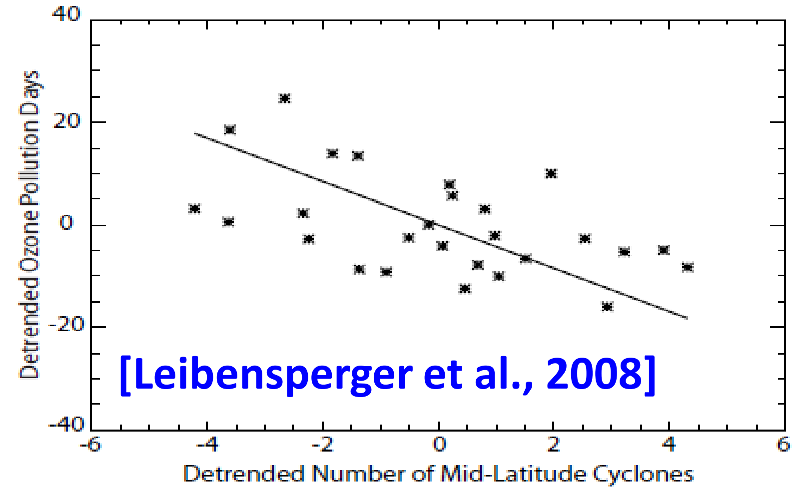
Time series for global heat wave anomalies



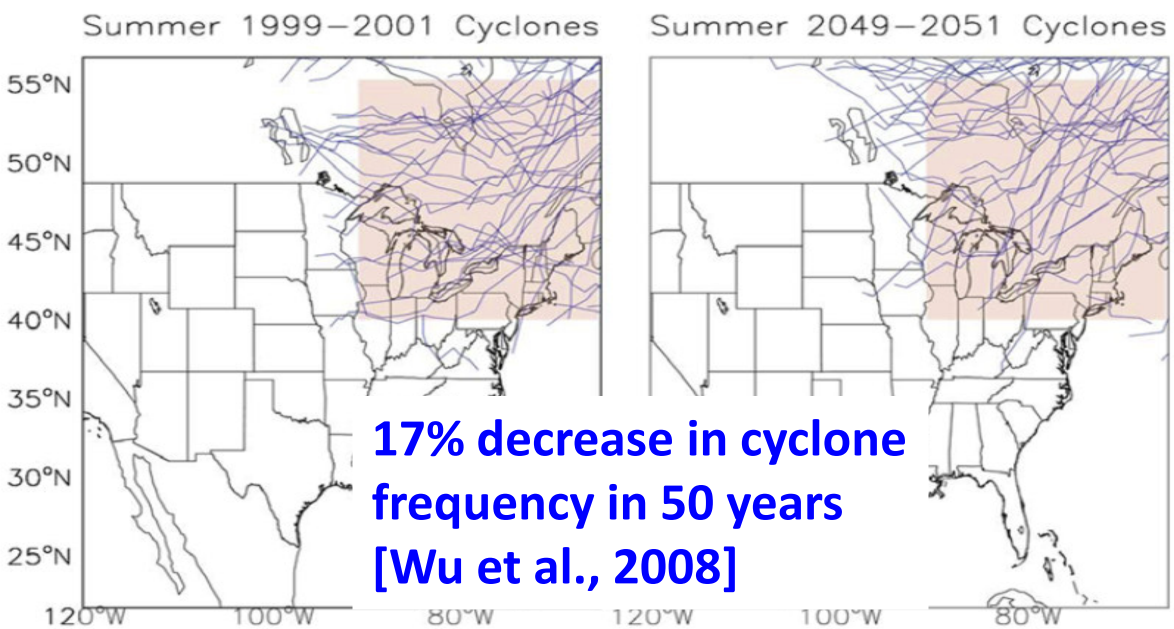
Changes in atmospheric stagnation

Observed 1980-2006 trends in O3 pollution days and mid-latitude cyclones

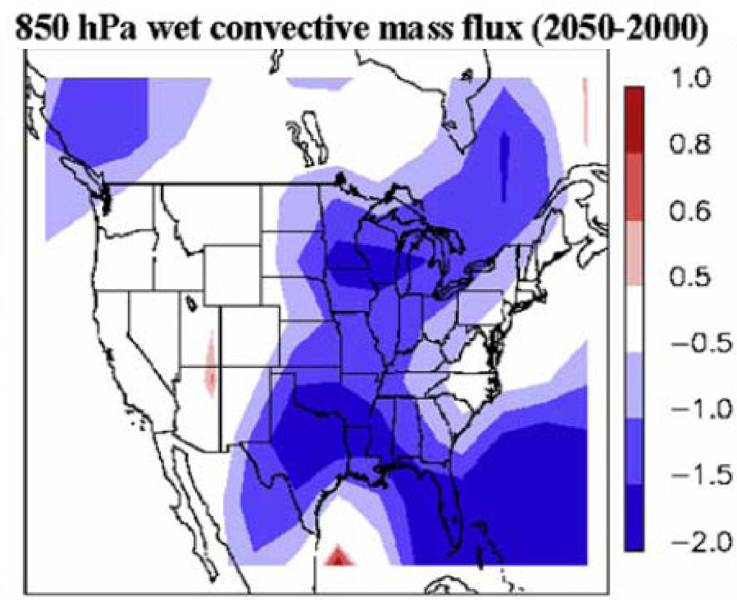




Model simulated 2000-2050 changes in mid-latitude cyclones and convection



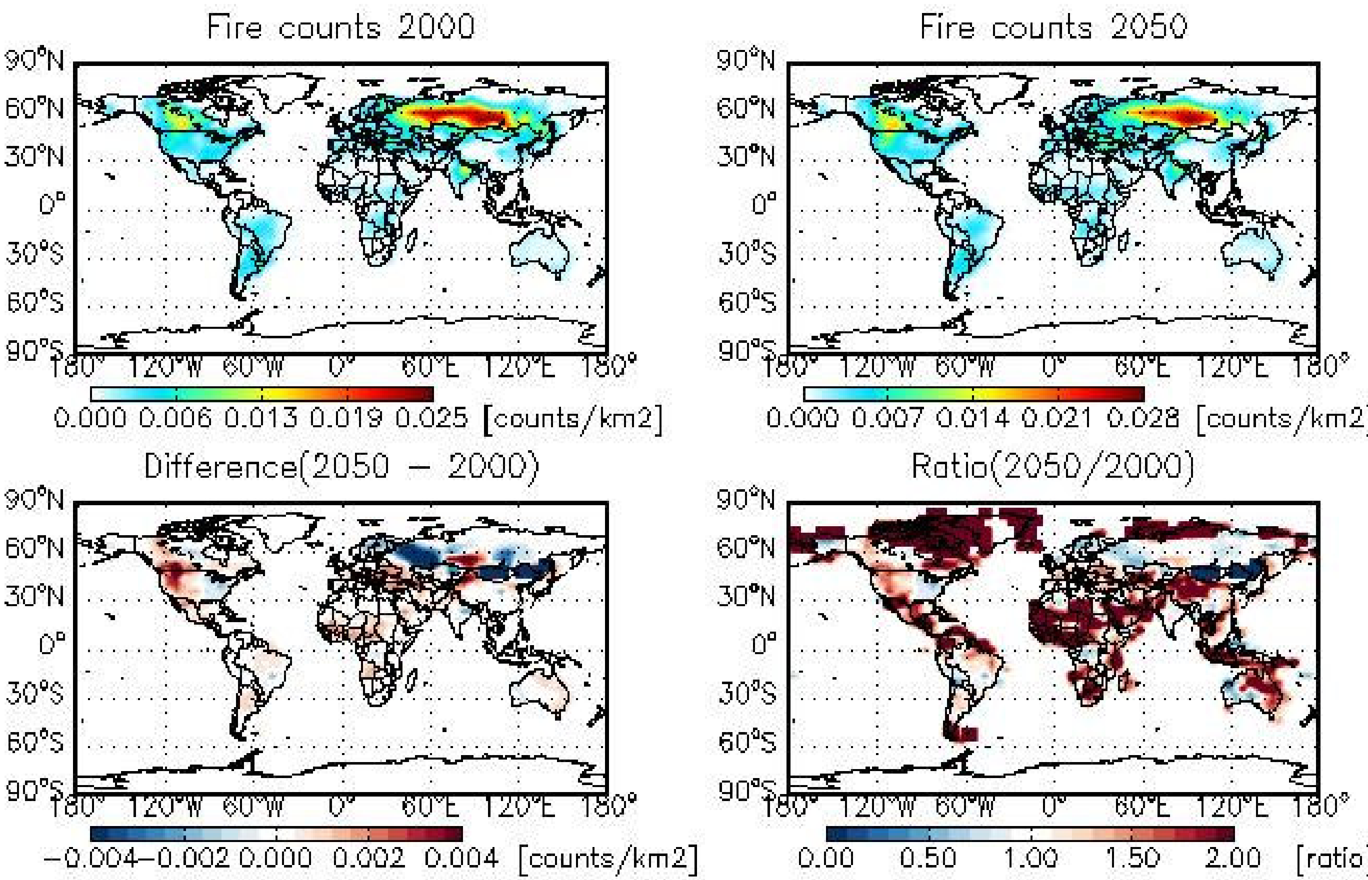
17% decrease in cyclone frequency in 50 years [Wu et al., 2008]



Changes in wildfires and biomass burning emissions

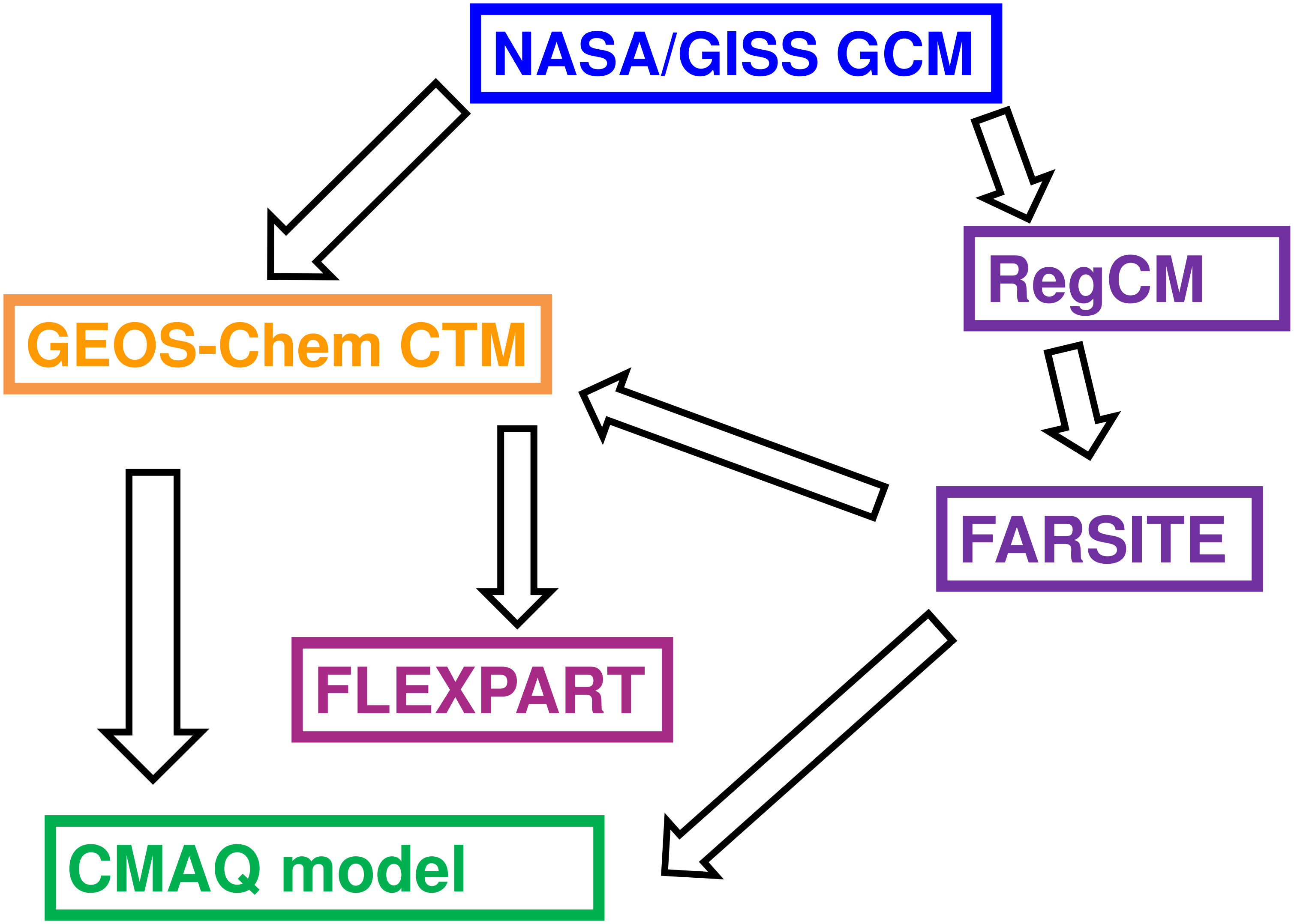
Changes in Lightning

Changes in LU/LC

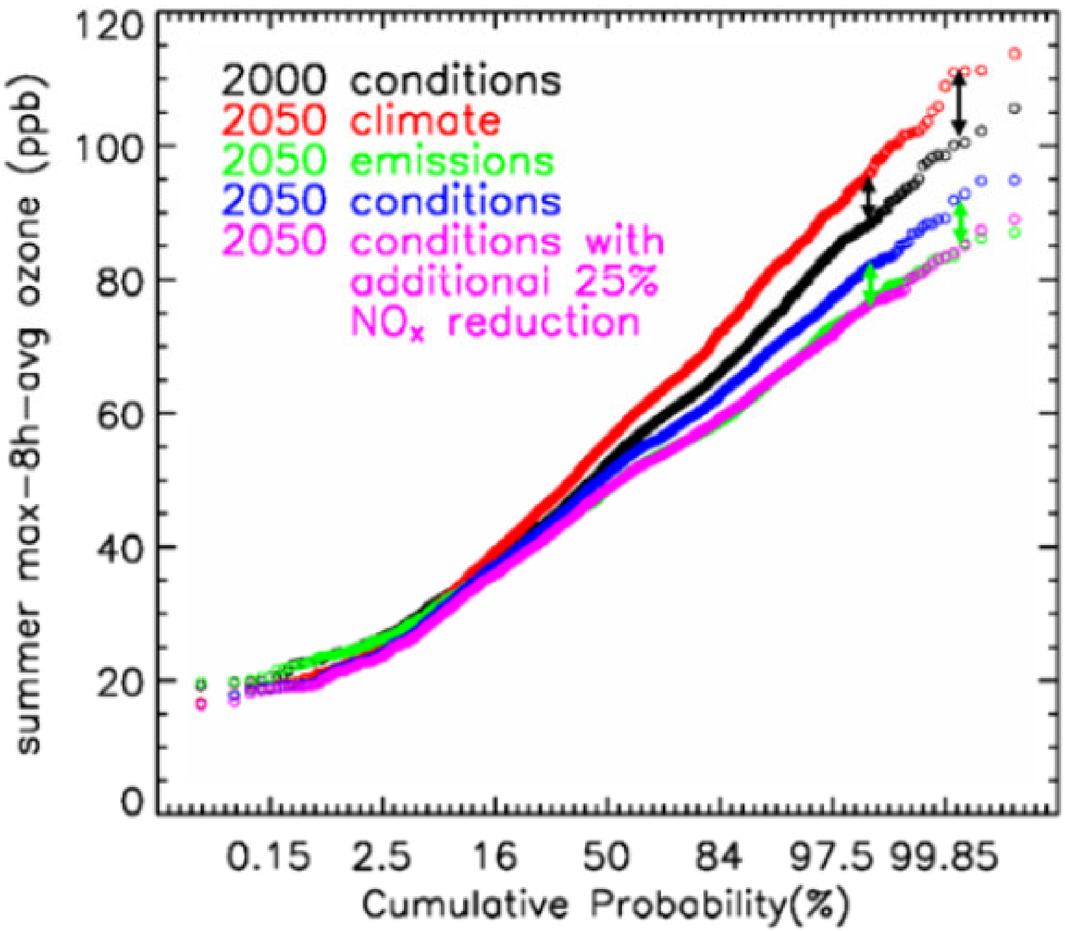


Simulated 2000-2050 changes in fire counts driven by changes in land use and land cover [Preliminary results]

Modeling system

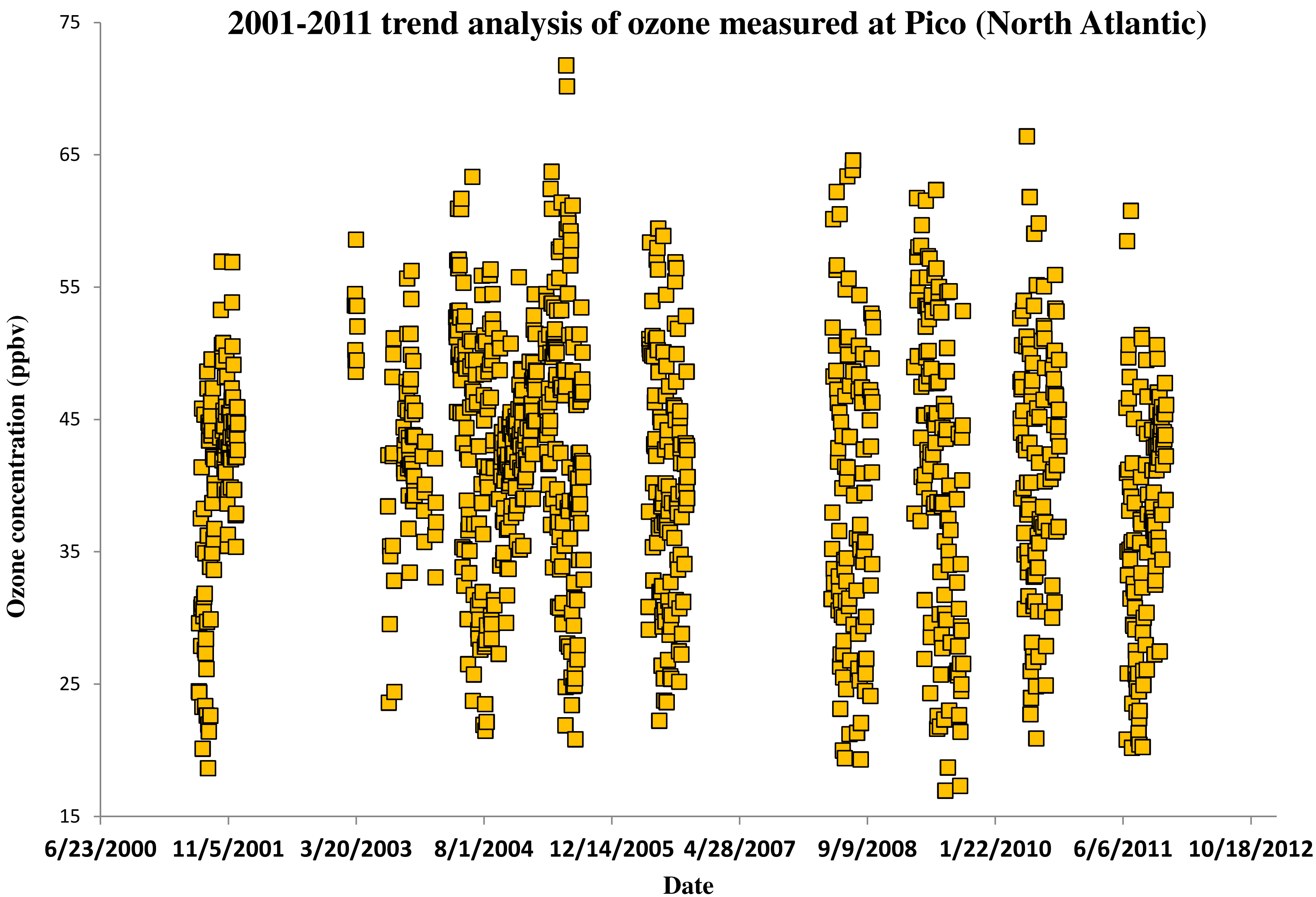


Evaluation of air pollution meteorology impacts on air quality –focusing on extreme pollution episodes



Simulated cumulative probability distributions of summer maximum 8-hour average surface ozone over the Midwest for 2000 climate and anthropogenic emissions (black); 2050 climate and 2000 anthropogenic emissions (red); 2000 climate and 2050 anthropogenic emissions (green); 2050 climate and anthropogenic emissions (blue). Results are plotted on a normal probability scale such that a normal probability distribution would appear a straight line. The high tails (top right ends of the curves) of the probability distribution represent extreme ozone pollution episodes (Wu et al., 2008a).

Statistical analysis to identify the trends



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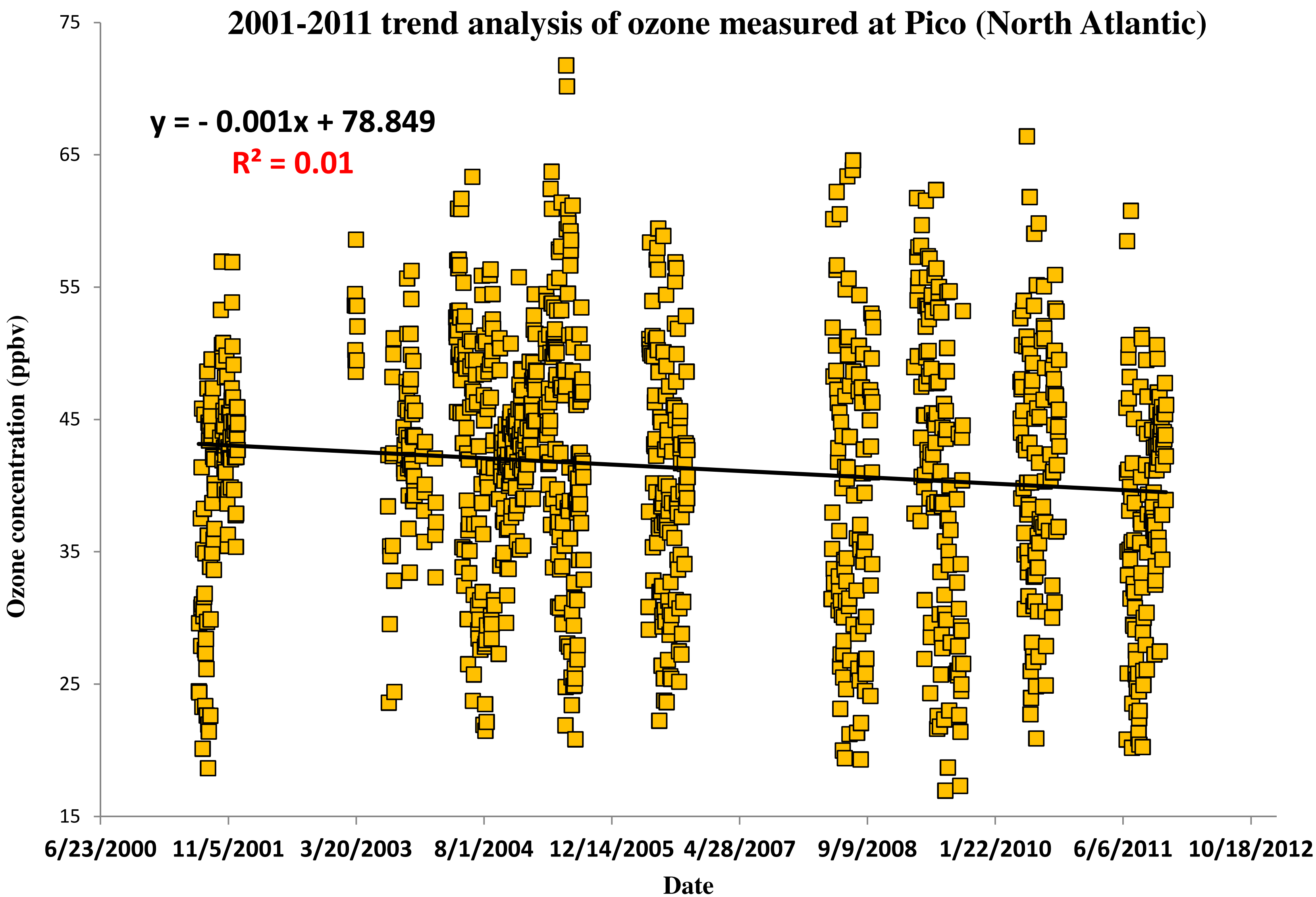
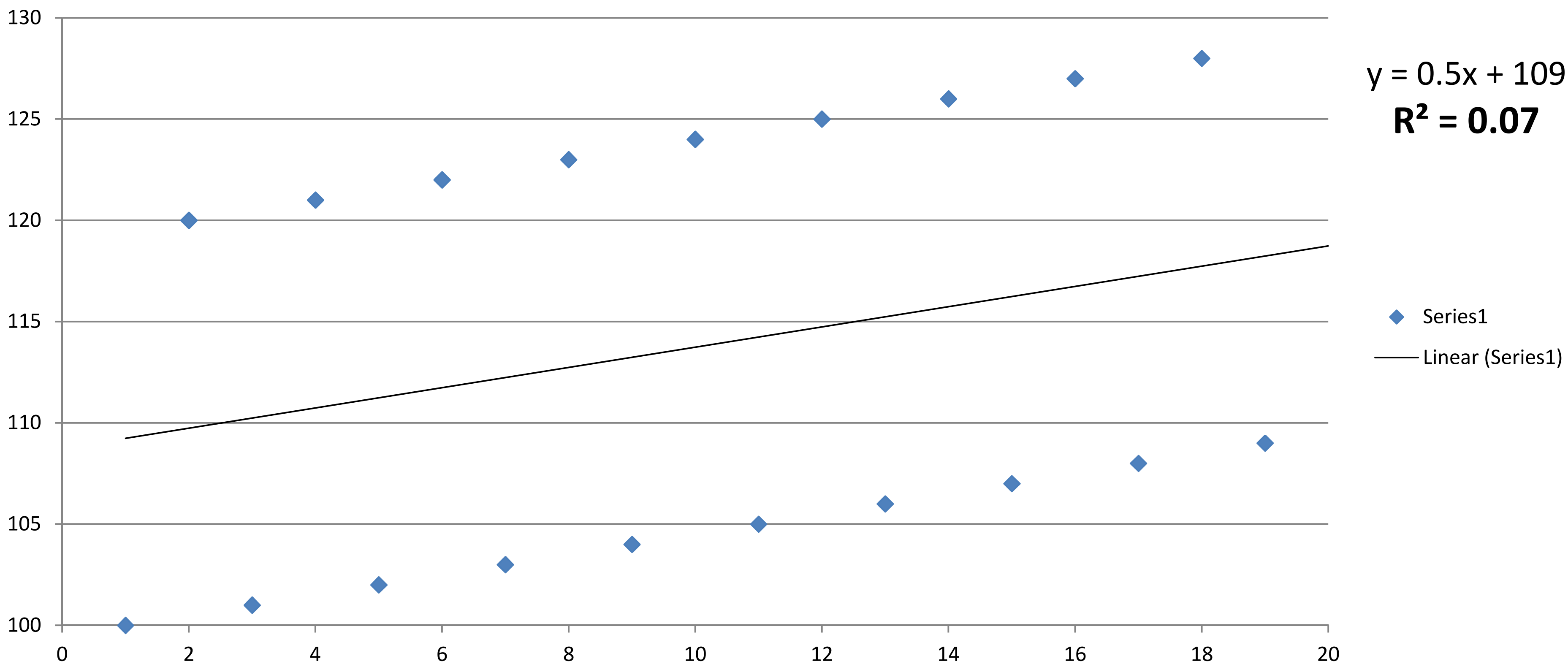
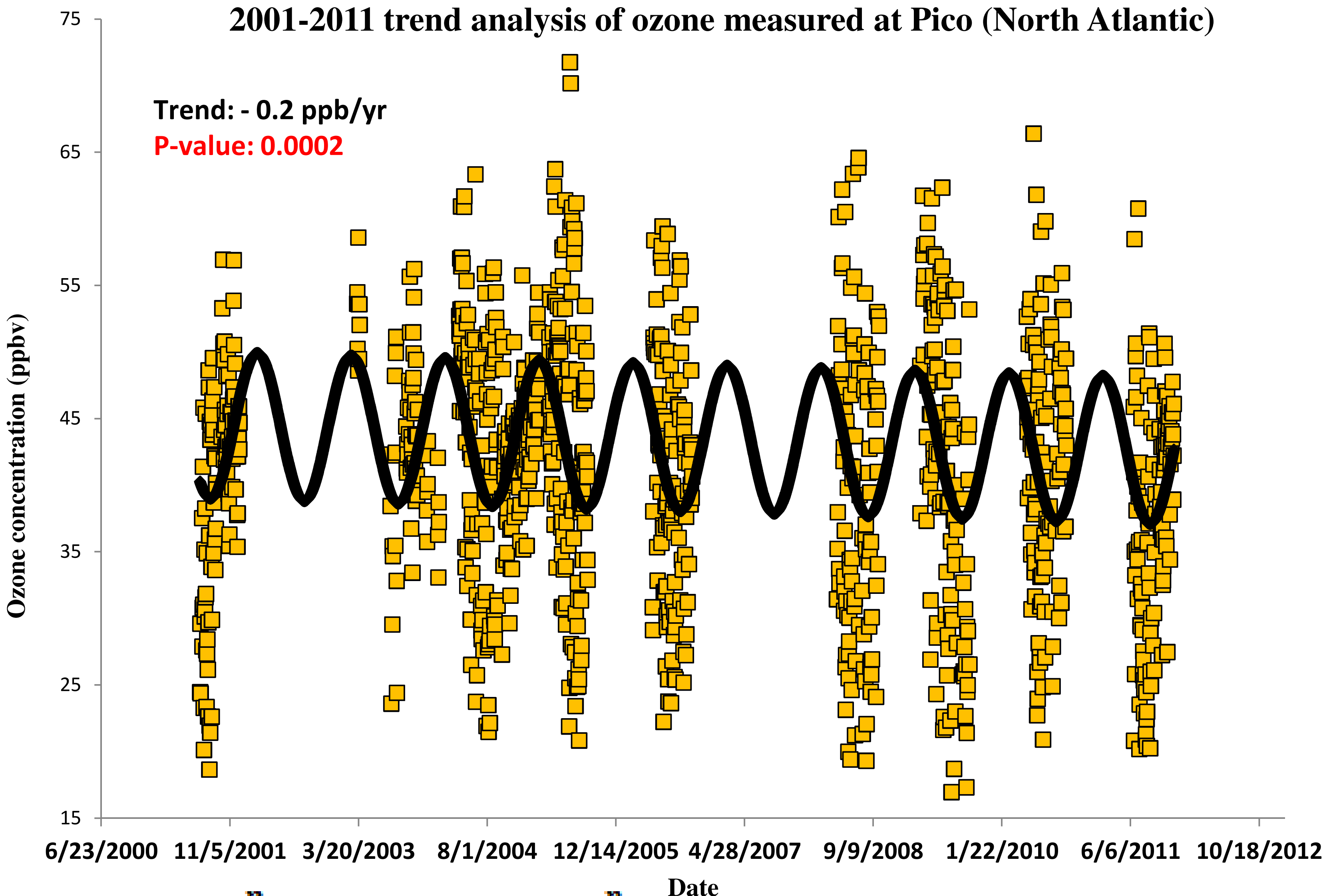


Good trend with small R^2



Statistical analysis to identify the trends



$$C_t = a_0 + a_1 t + \sum_{i=1}^{n} b_i \sin\left(\frac{2\pi i t}{365}\right) + \sum_{i=1}^{n} c_i \cos\left(\frac{2\pi i t}{365}\right) + \varepsilon_t$$

Thank you!