Assessing atmospheric pathways and sources of Polybrominated diphenyl ethers (PBDEs) in Canadian environments and effect of climate on POPs over the Great Lakes

Jianmin Ma
Air quality Research Division, Environment Canada

GLBTS2009, Chicago

Environment Canada Environnement Canada

Canada

Acknowledgement

Dr Yifan Li – compile global penta-BDE emission

Dr Lisheng Zhang – perform model simulations and visualize results

CMP – funding PBDE modeling

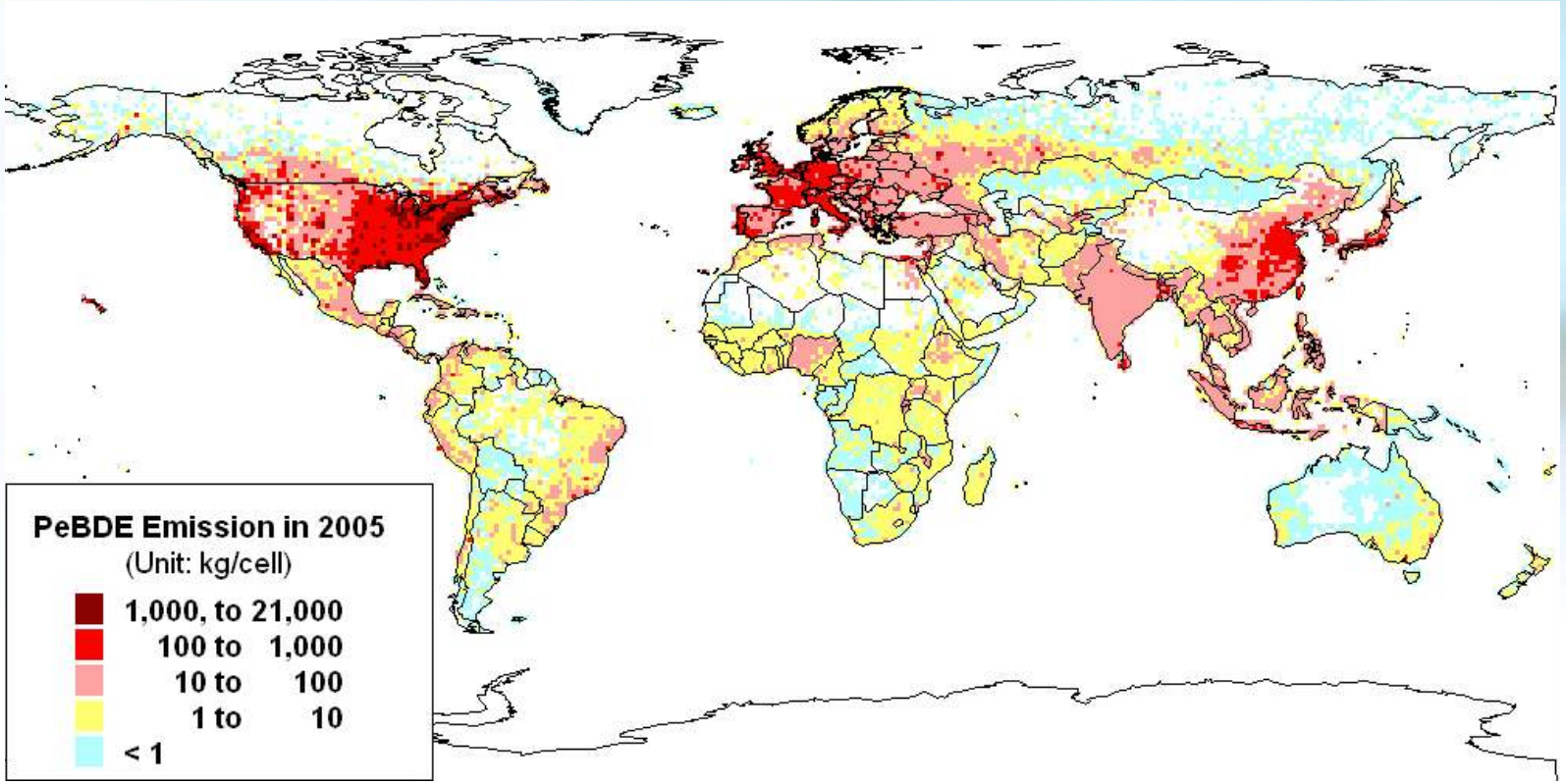
Outlines

- Global modeling of penta-BDE
- Climate signals in the temporal trend of organochlorine pesticides (OCPs) over the Great Lakes

Why modeling penta-BDE?

- Phase out in Europe
- Extensively used in North America, especially in the US among other PBDEs
- Part of penta-BDE (~10%?) found in the environment arises from the degradation of deca-BDE
- Undergo long-range atmospheric transport

Global pente-BDE emissions in 2005



Global gridded PeBDE emissions in 2005 on a 1º latitude by 1º longitude resolution. Total PeBDE emission in this year was 820 t.

Modeling scenarios – impact on Canada (2005)

Atmospheric transport model - Canadian Model for Environmental Transport of Organochlorine Pesticides (CanMETP)

Scenarios:

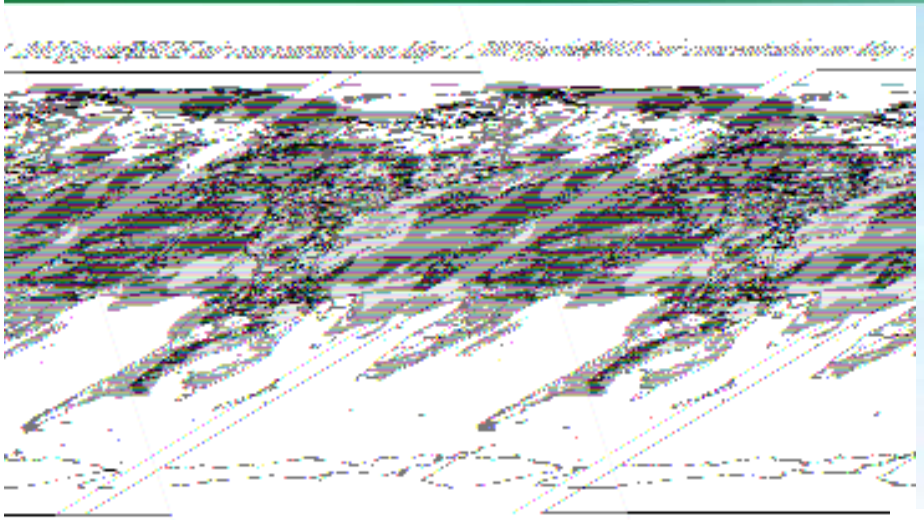
Impact of US emissions

Impact of China emissions

Impact of India emissions

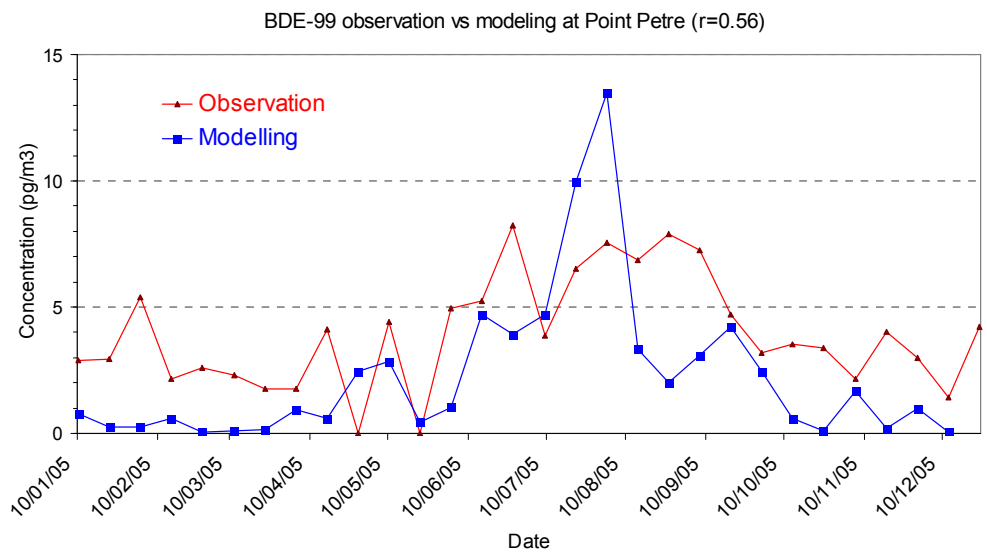
Impact of European emissions

Preliminary results – annual concentration and verification

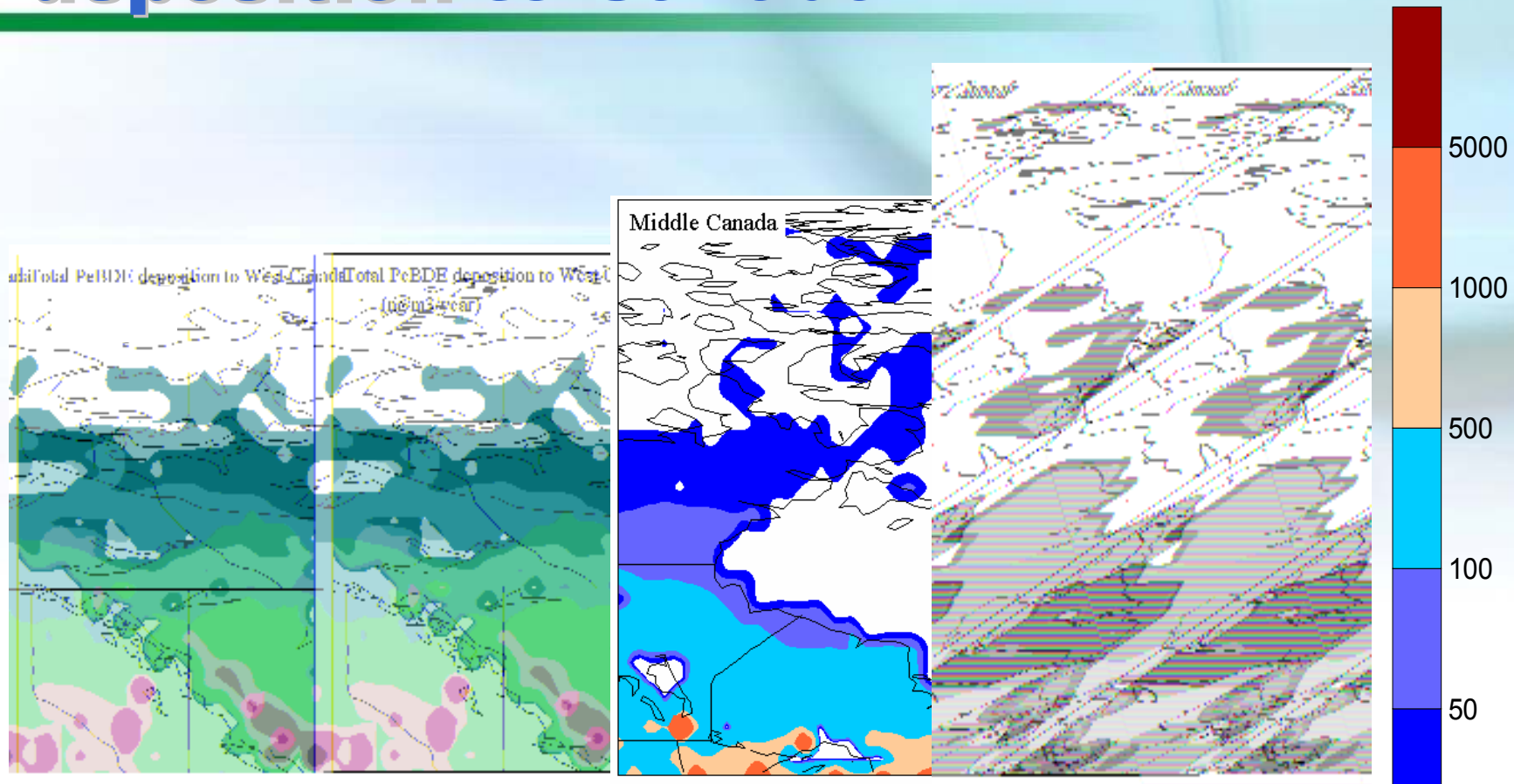


Modeled annual averaged daily air concentration of penta-BDE (pg m^{-3}) in 2005

Modeled vs measured daily air concentration of BDE-99 at Point Petre (shore of Lake Ontario) in 2005

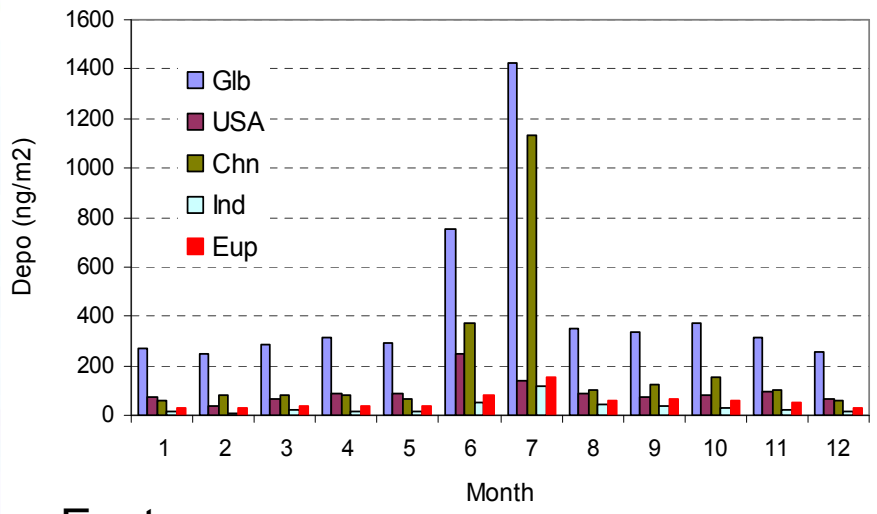


Preliminary results – annual deposition to Canada

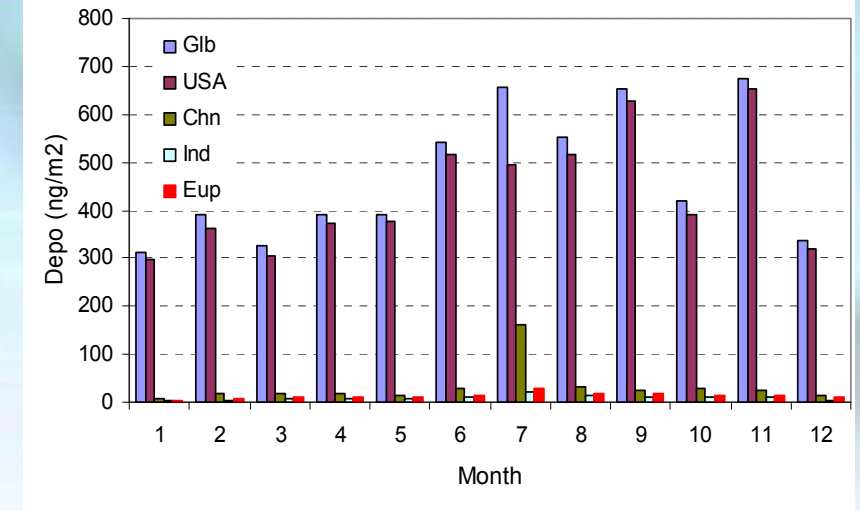


Annual penta-BDE total deposition (dry + wet) (ng m^{-2} yr^{-1}) to Canada

Preliminary results – monthly total deposition



Eastern Canada



Western Canada

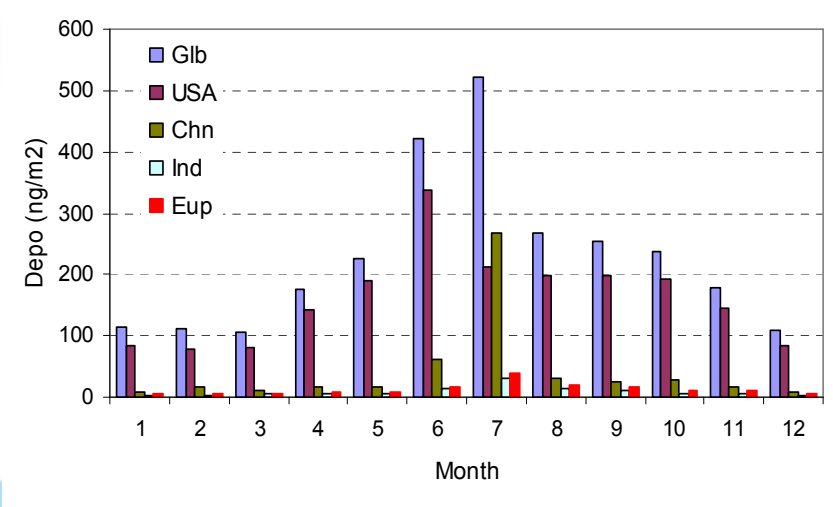
GLB- global

USA – United States

Chn-China

Ind- India

Eup-Europe



Mid Canada

Preliminary results – monthly change in deposition (departure from annual)

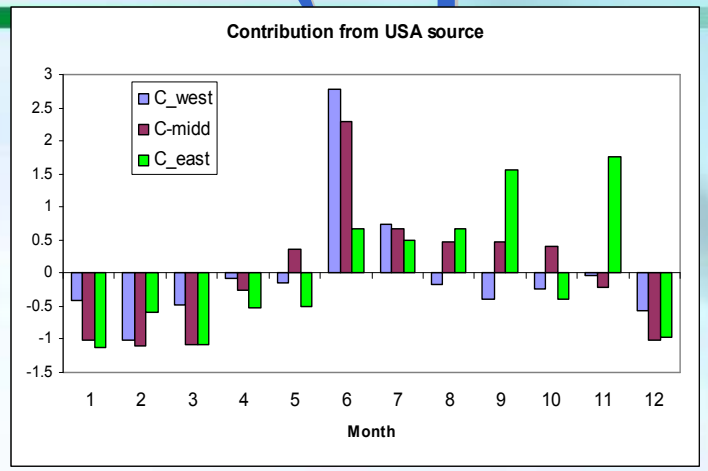
$$Dv = \frac{Dm - Da}{S}$$

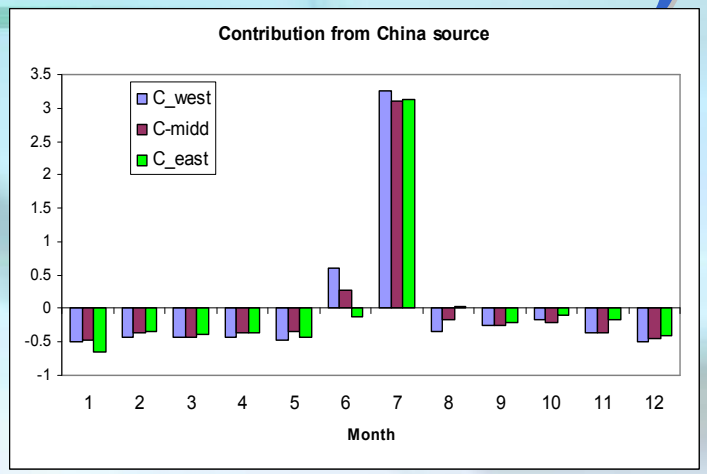
Dv: Monthly deposition anomaly

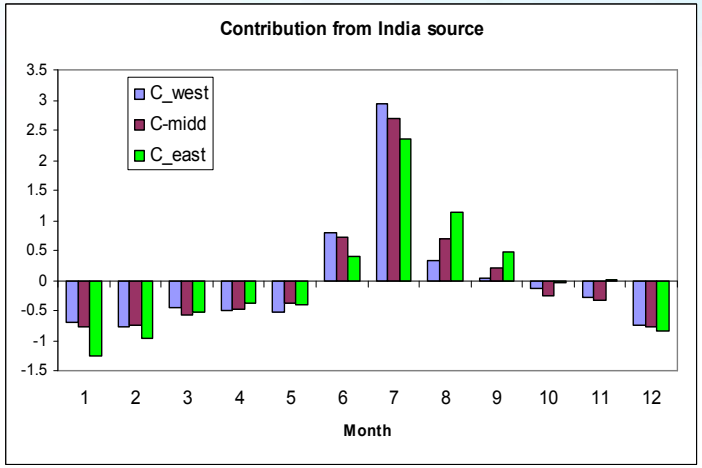
Dm: monthly averaged daily deposition

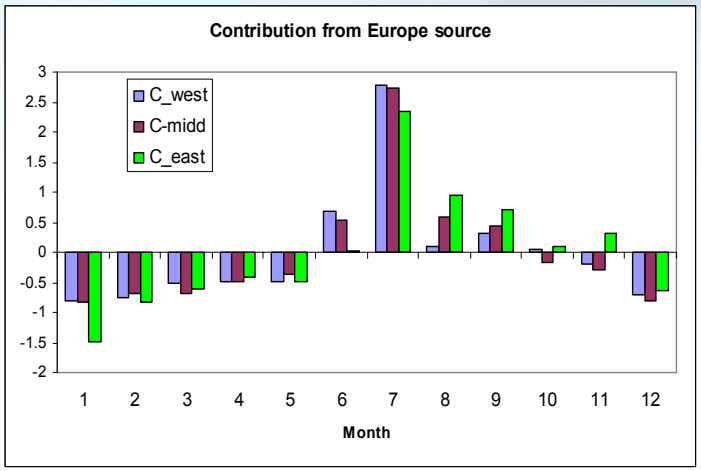
Da: annual averaged daily deposition

S: Standard deviation



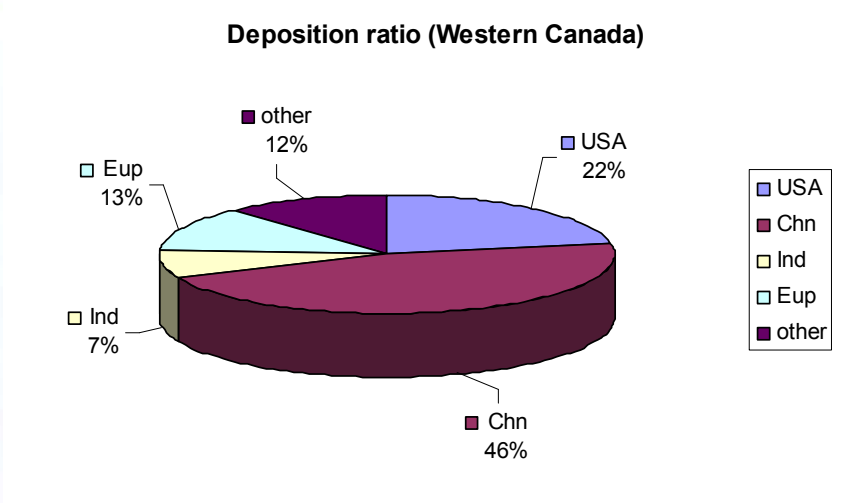


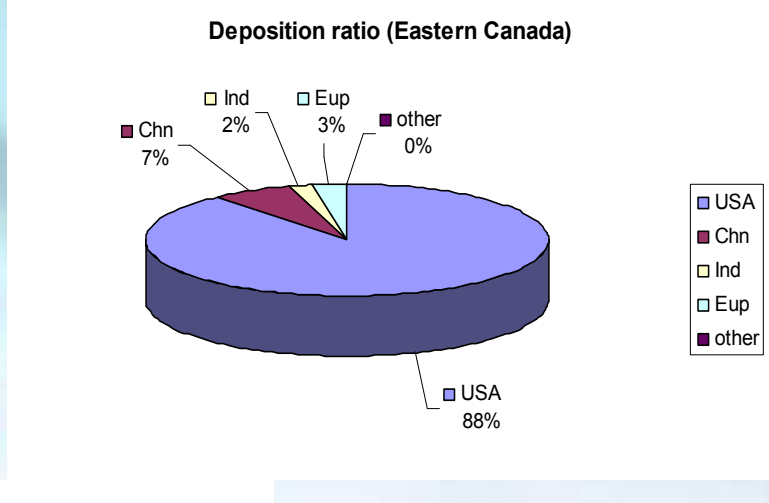


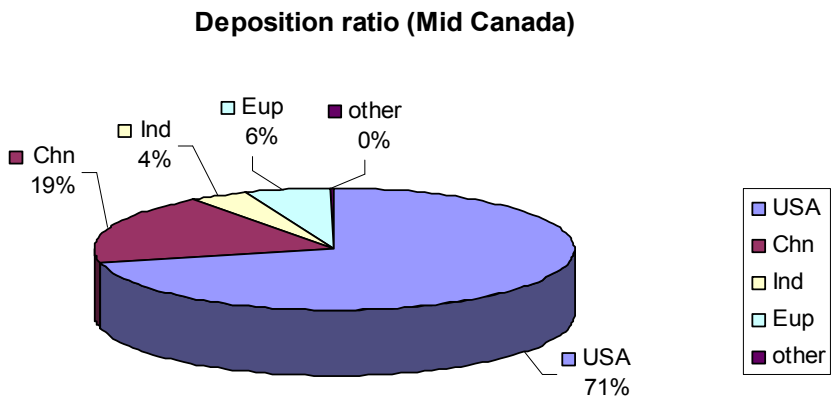


Normalized monthly change in total deposition to Canada from 4 foreign sources

Preliminary results – source contribution to deposition to Canada







GLB- global

USA – United States

Chn-China

Ind- India

Eup-Europe

Climate signals in trend of OCPs over the Great Lakes

Two recent ongoing international efforts on climate and POPs

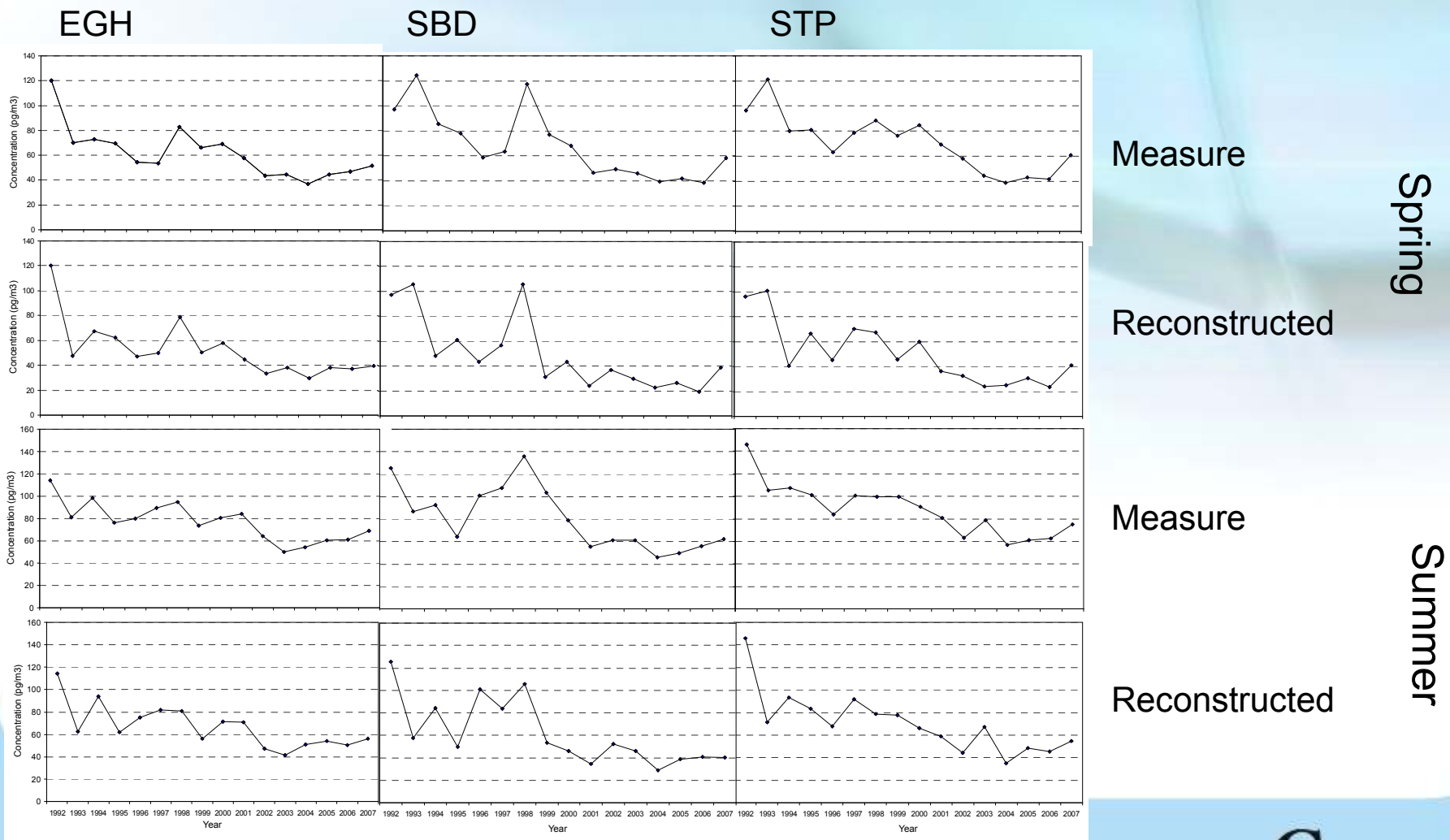
- Climate issues in HTAP 2010 POPs assessment report
- Stockholm Convention Secretariat's review project for climate and POPs

Temporal trend of OCPs over the Great Lakes

Regional Mann-Kendall (MK) statistical test for trend of OCPs in IADN

- Examine statistical significance of OCPs trend
- Remove effect of temporal (serial) correlation to increase the effective sample size of OCPs time series
- Remove effect of spatial (cross) correlation to reduce duplication of information at each IADN site
- Detrend OCPs time series to detect stronger climate signals

Temporal trend of OCPs over the Great Lakes-HCB

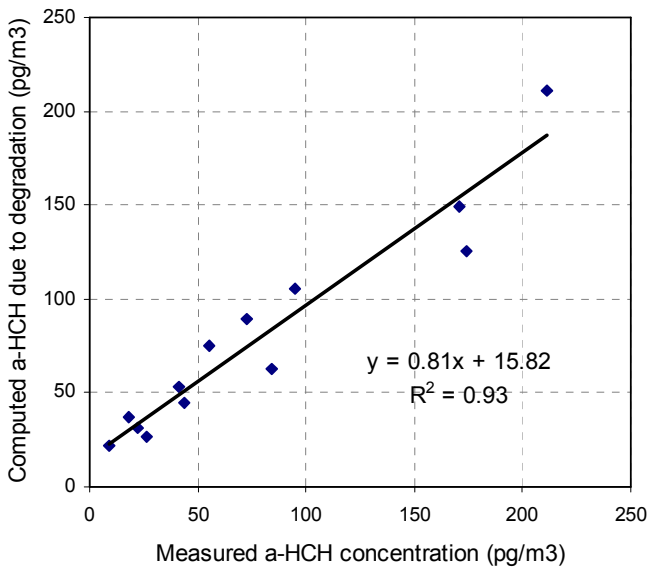


Temporal trend of OCPs over the Great Lakes-significance

	α-HCH	γ-HCH	HCB	α-endosulfan
Spring				
EGH	-4.10	-3.38	-2.93	0.67
SBD	-4.37	-4.01	-3.29	-0.92
STP	-4.28	-3.56	-3.26	1.04
Summer				
EGH	-3.29	-3.20	-3.02	-1.89
SBD	-3.65	-4.10	-3.20	-3.11
STP	-4.01	-3.47	-3.56	-2.38

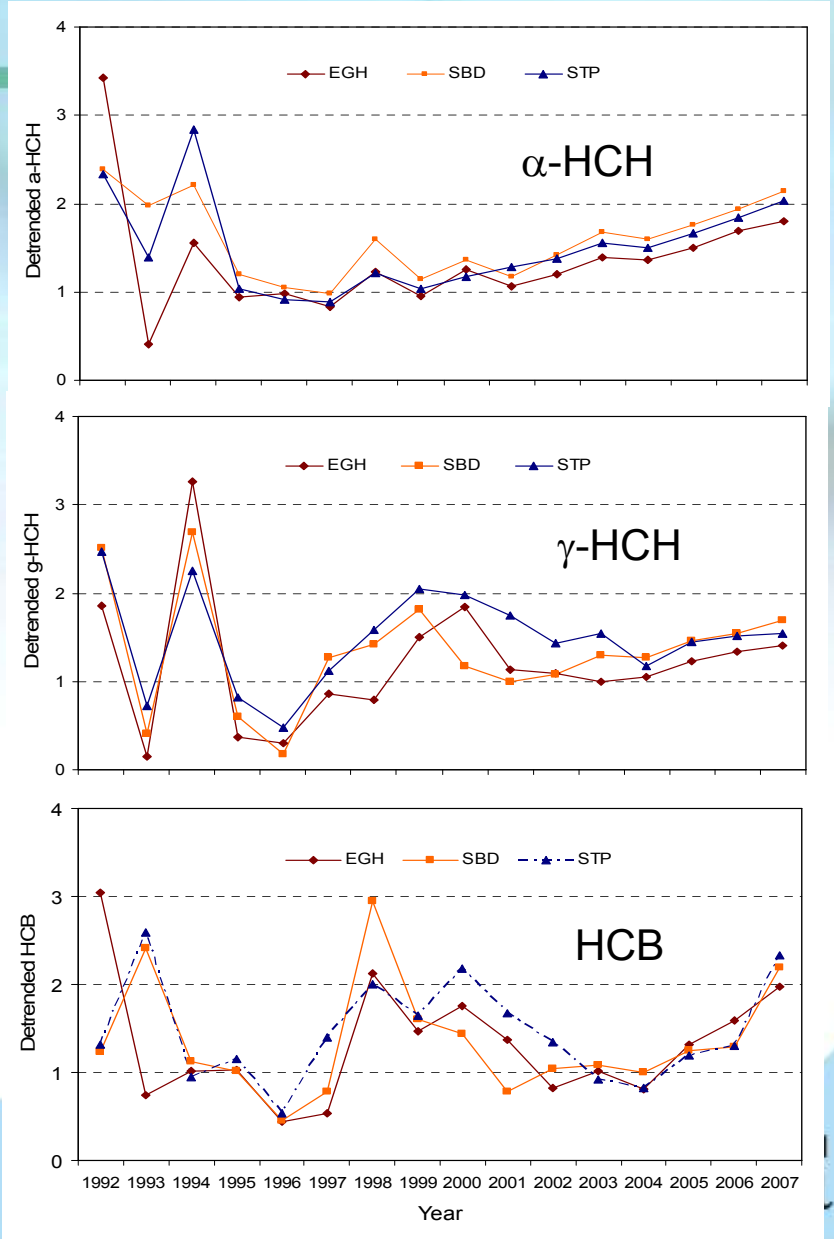
Z statistics in Mann-Kendall test for trend detection of mean air concentration of α-HCH, γ-HCH, HCB and α-endosulfan (1992-2007). |Z| > **1.96** indicate trend is statistical significance at 95% level

Climate signals in OCPs trend - detrending

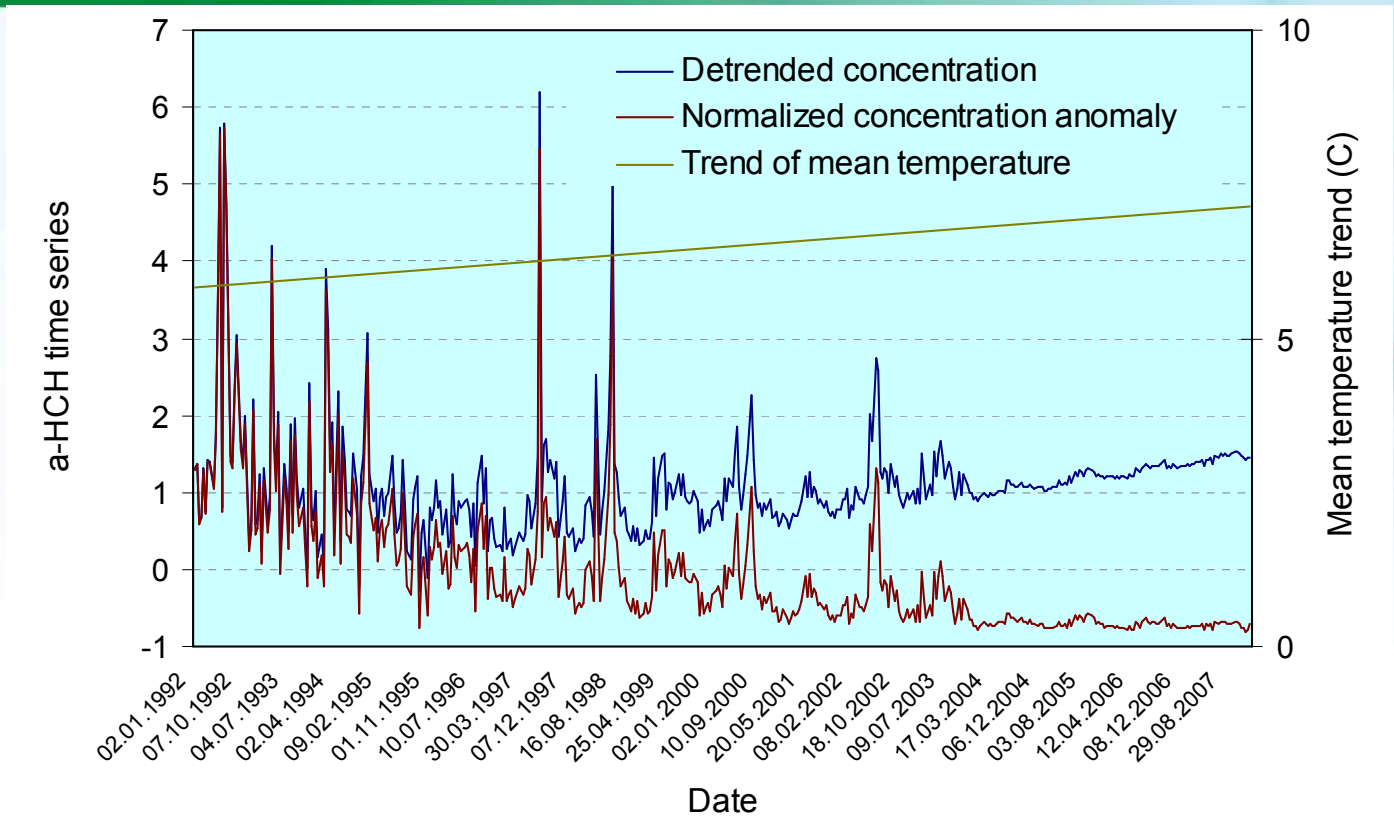


Measure spring air concentration vs. computed spring air concentration of α-HCH at SBD due to degradation, suggesting downward trend is driven by degradation

After detrending (spring)

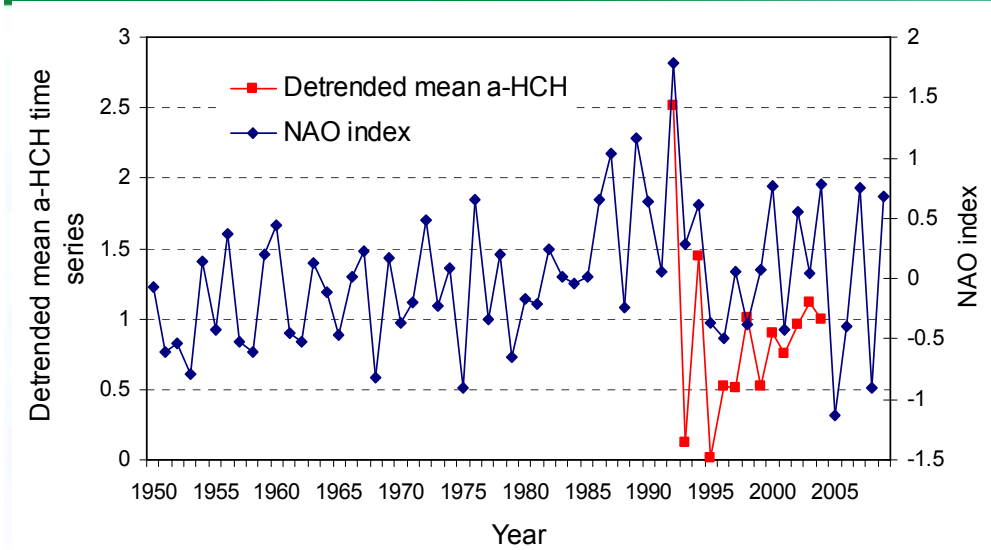


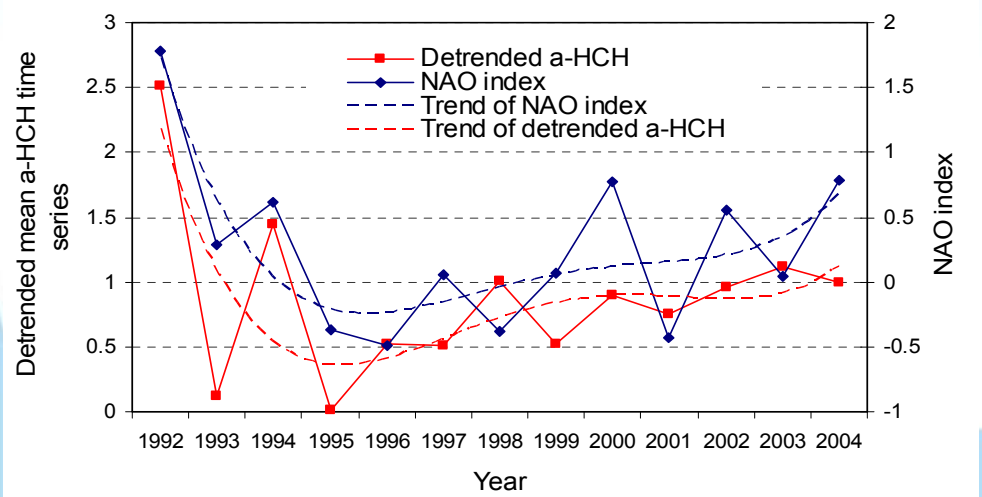
Climate signals in OCPs trend - detrending



Measured and detrended daily α-HCH concentration time series at SBD from 1992 through 2007, and trend of mean air temperature over the Great Lakes: link with climate warming?

Climate signals in OCPs trend - detrending





Detrended spring α-HCH time series over the Great Lakes vs North Atlantic Oscillation (NAO)

HCHs vs NAO (r)

	EGH	SBD	STP
α−HCH	0. 56	0. 40	0. 43
After detrend	0. 61	0. 68	0. 62
γ−HCH	0. 48	0. 50	0. 44
After detrend	0. 51	0. 55	0. 56