The Impact of Long Range Atmospheric Transport from Out-of-Basin Sources of PBTs on the Great Lakes Basin and Implications for Lake Superior

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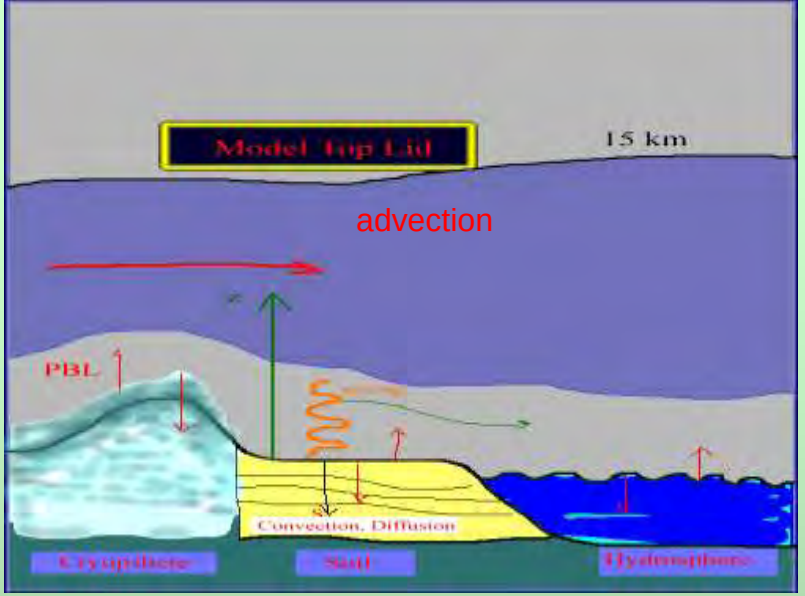
Outline

- Regional transport of PBTs (Toxaphene, HCB)
  - Impacts on Lake Superior
- Global Transport of PBTs (Lindane, Mercury)
- Climate fluctuations and air concentrations of PBTs over the GLs

Atmospheric Transport Models for PBTs

- Canadian Model for Environmental Transport of Organochlorine Pesticides (CanMETOP)
- Global/Regional Atmospheric Heavy Metals Model (GRAHM)



A schematic view of multi-compartment PBT models

Model Description

	CanMETOP	GRAHM
Atmosphere model	3-D Eulerian transport	3-D Eulerian transport
Soil model	Fugacity/mass balance	No
Horizontal resolution	24/35 km, $1^o \times 1^o$ lat/lon	$1^o \times 1^o$ lat/lon
Vertical resolution	Surface-11000 m	Surface-15000 m
Atmospheric chemistry	No	Gas and aqueous phase

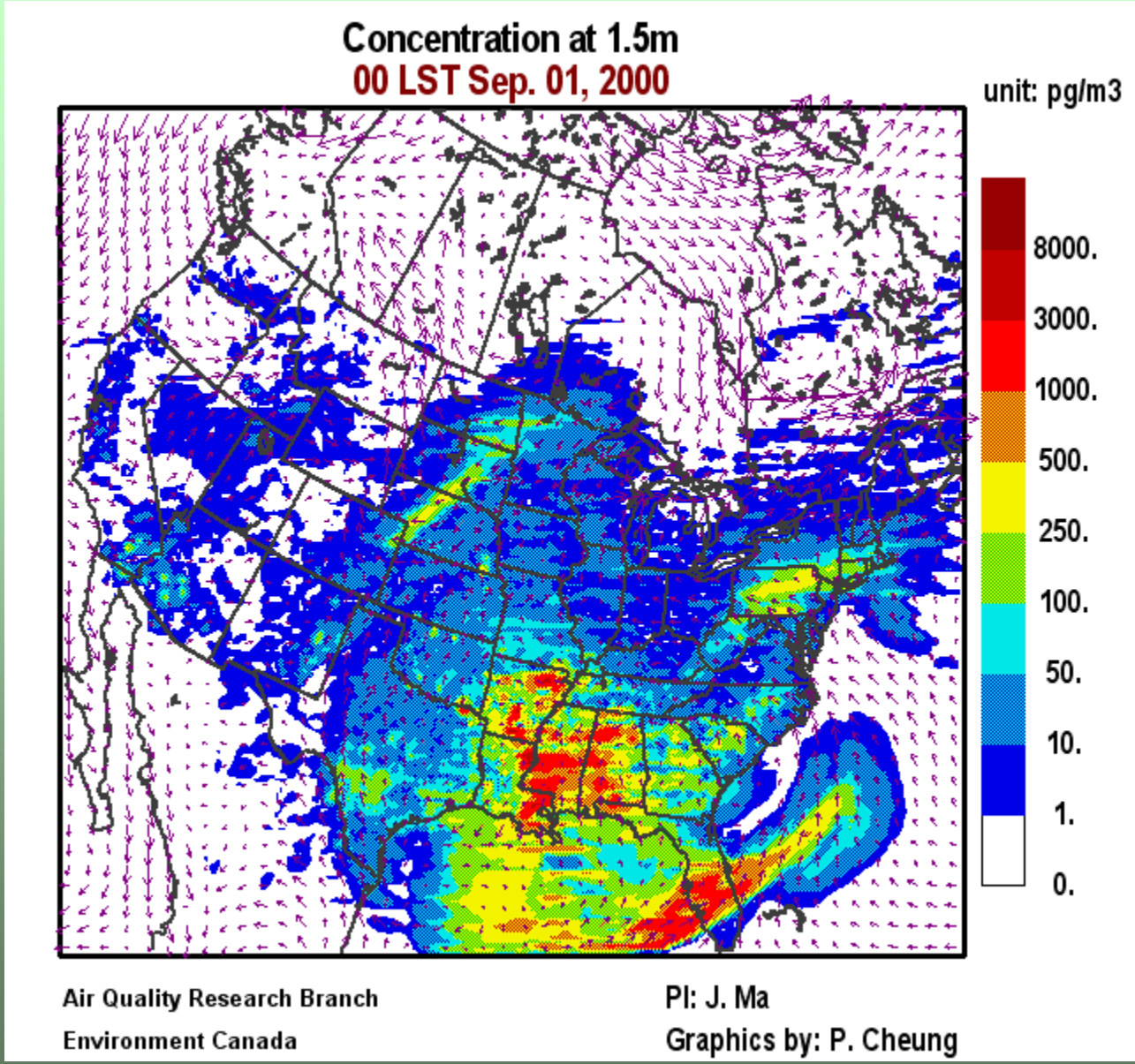
Regional transport of PBTs

Persistent

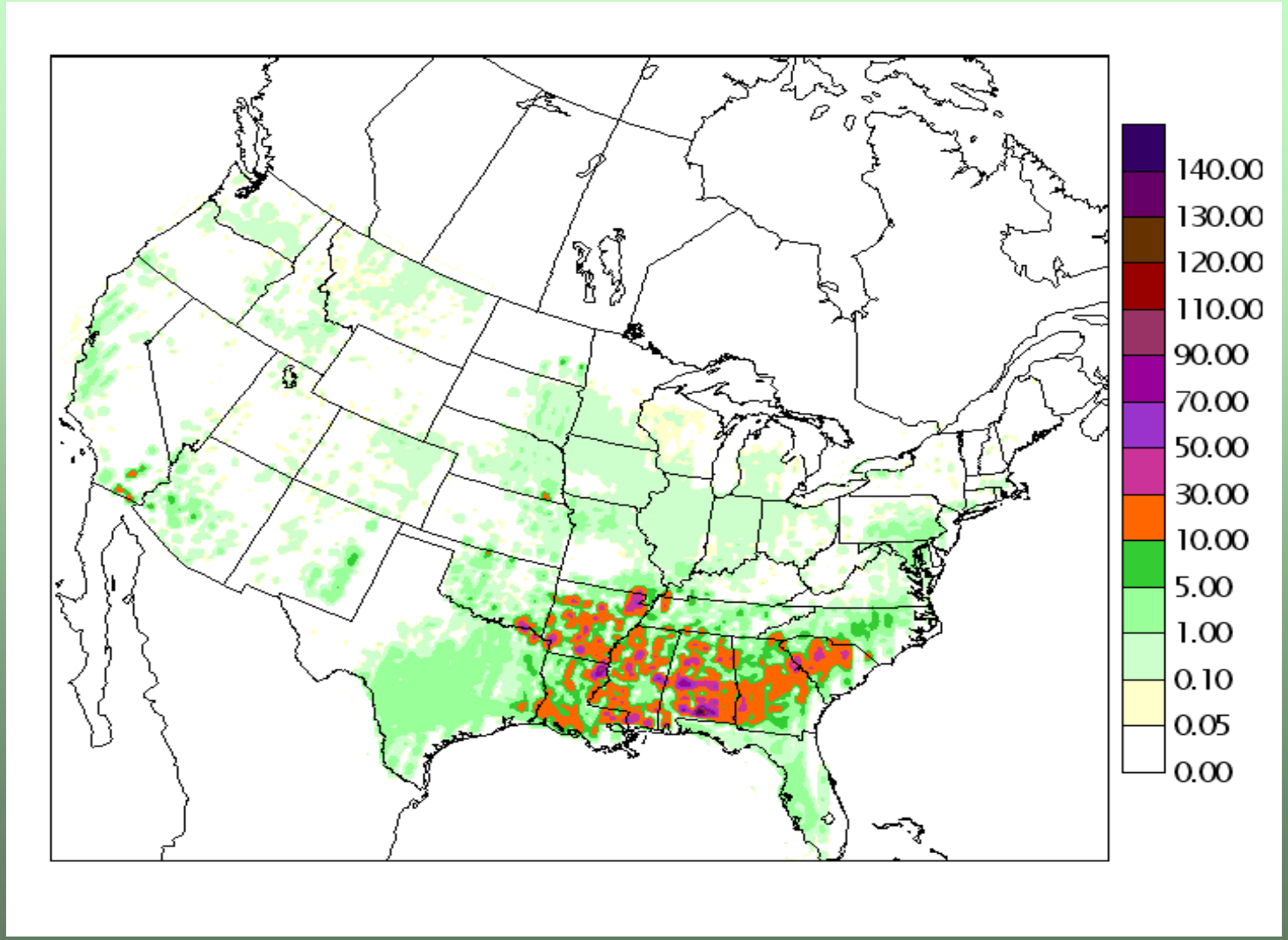
Bio-accumulative

Toxic

Episodic long-range atmospheric transport of toxaphene from the southeast US to the Great Lakes

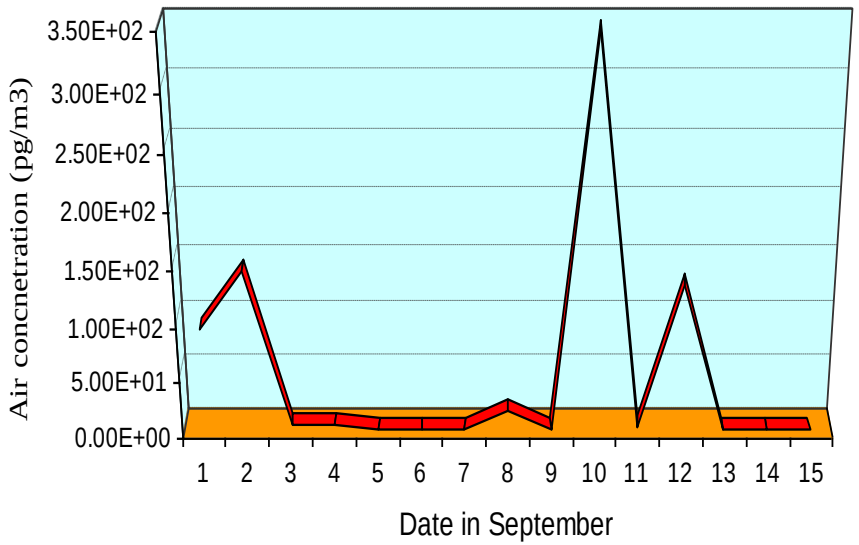


Soil residues of toxaphene in the US in 2000 (tonnes/cell, 1 cell = 24 km × 24 km)

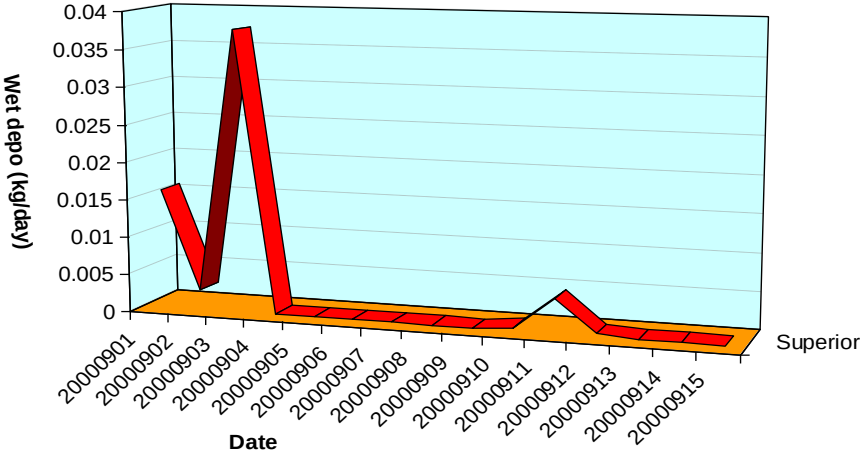


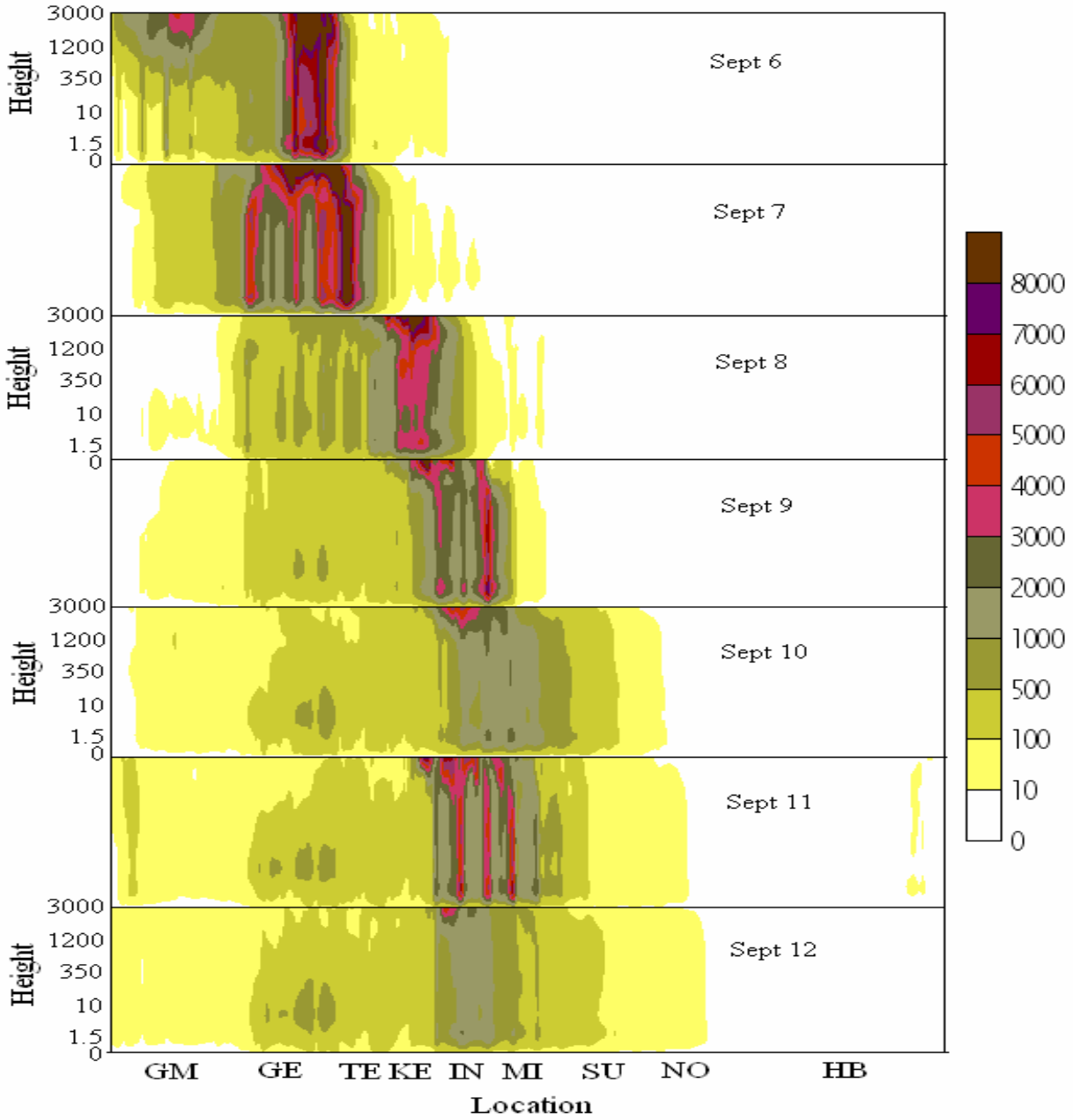
CanMETOP Modeled Daily air concentration (pg m^{-3}) and wet deposition (kg day^{-1}) of Toxaphene over Lake Superior for September 1-15, 2000.

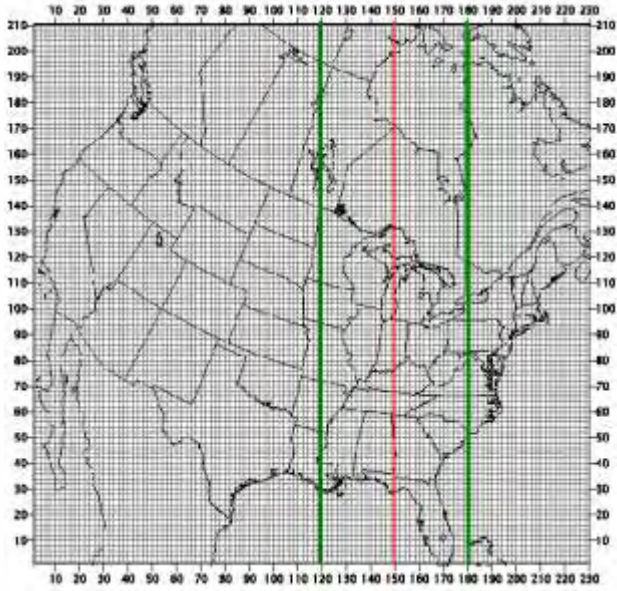
Air Concentration



Wet Deposition







GM-Gulf of Mexico

GE-Georgia/Alabama

TE-Tennessee

KE-Kentucky

IN-Indiana

MI-Michigan

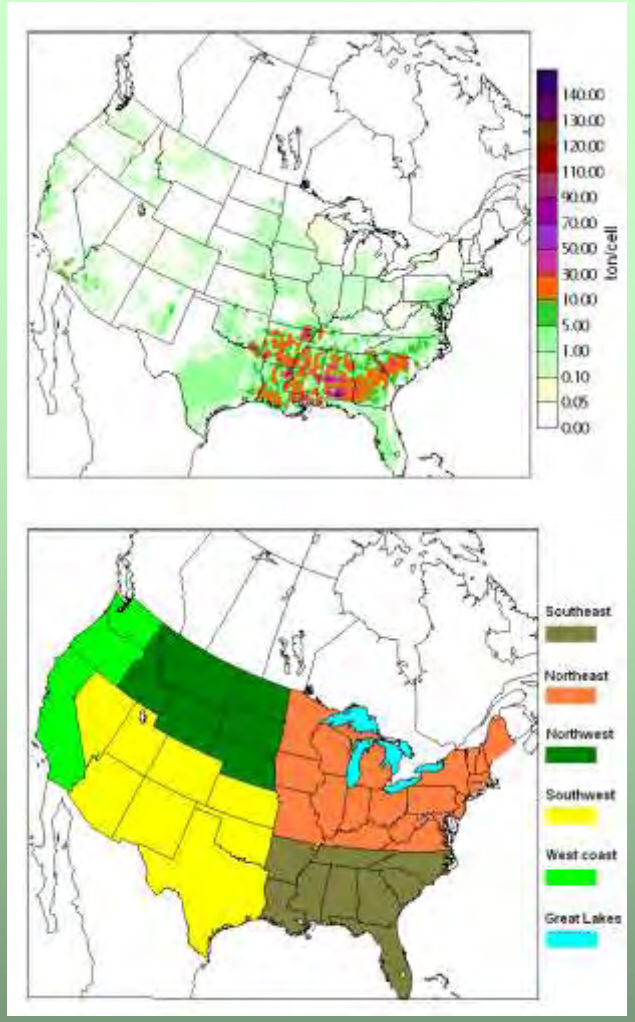
SU-Lake Superior

NO-Northern Ontario

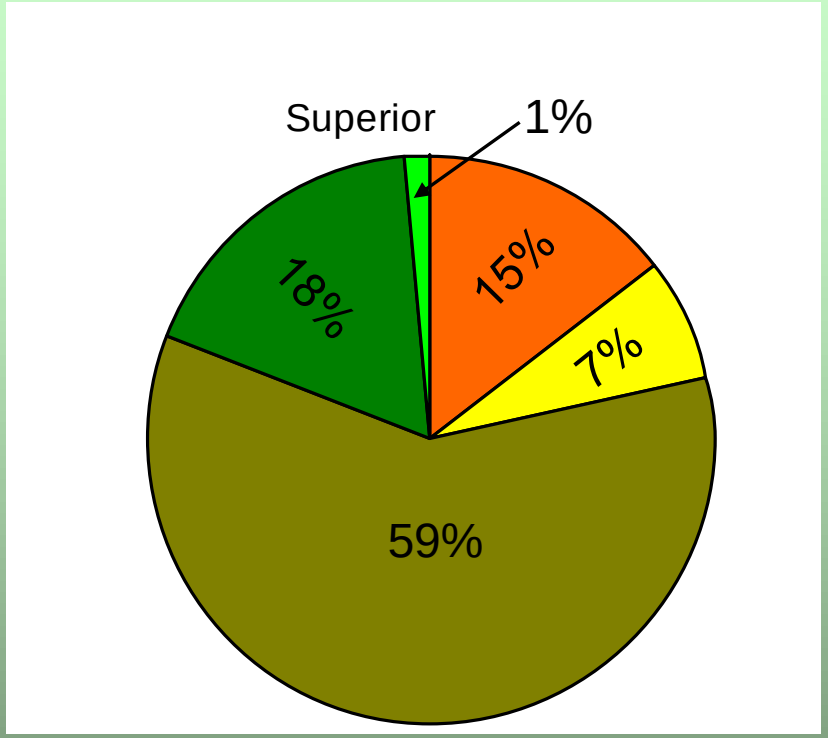
HB-Hudson Bay

Cross-section/vertical profile of air concentration indicating northward transport of toxaphene

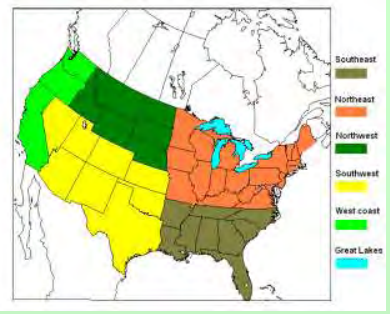
Soil residue (tonnes cell^{-1})
of toxaphene in 2000

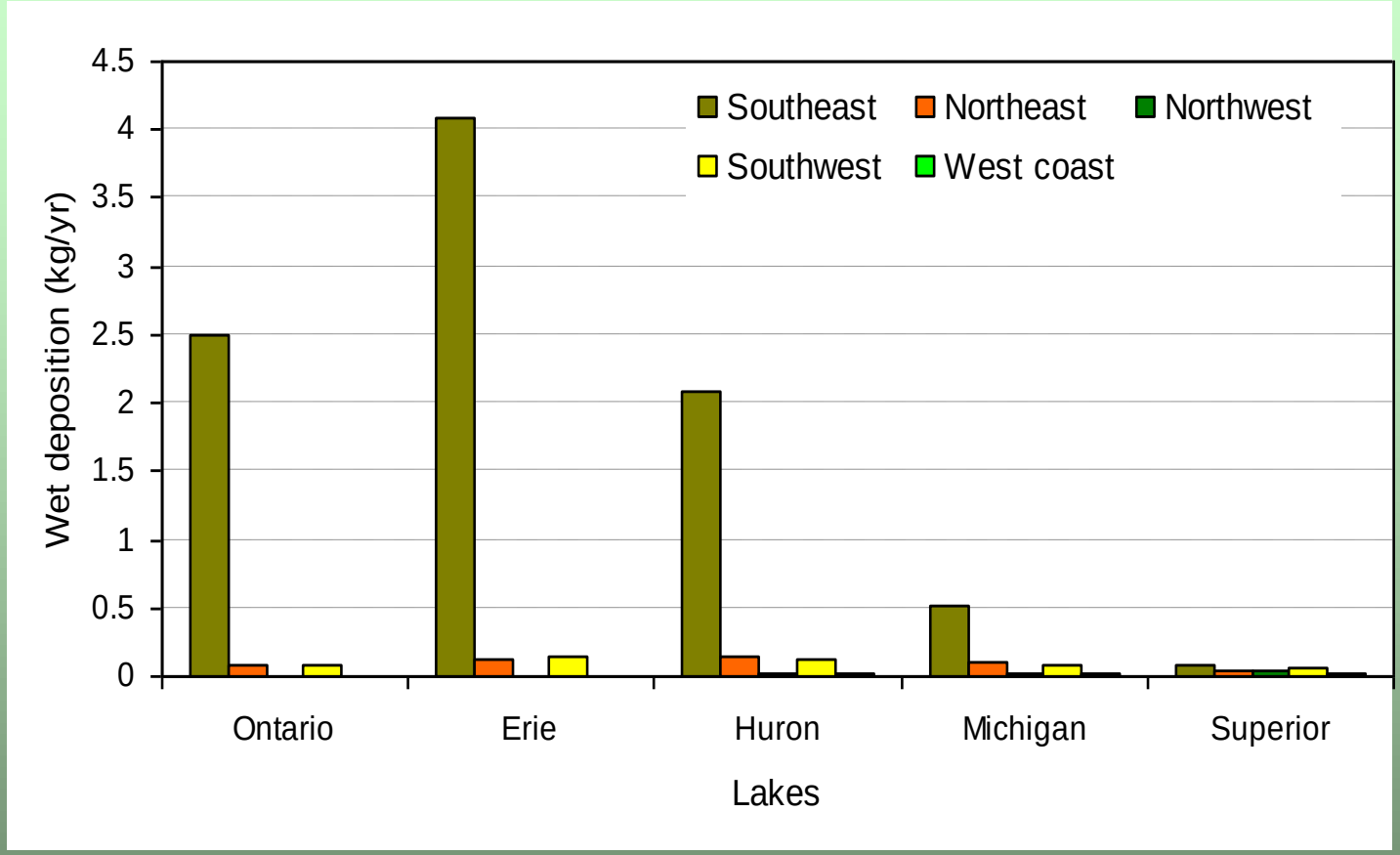


Source Regions



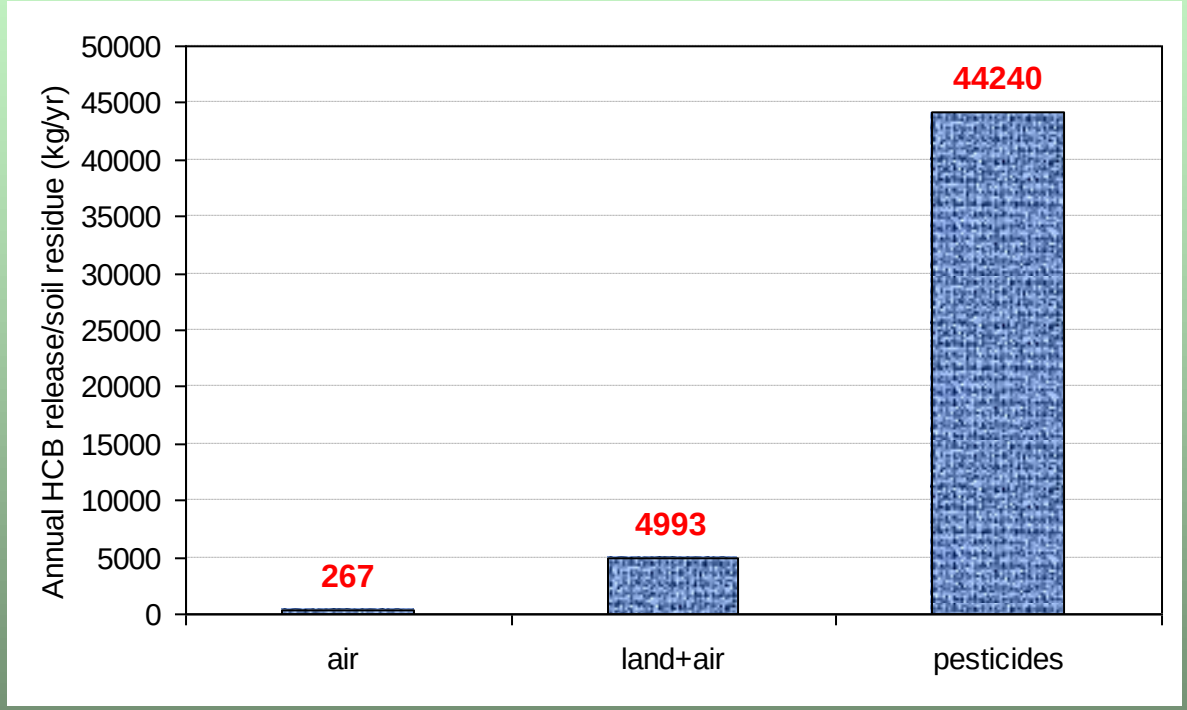
Modeled contribution of toxaphene sources to annually averaged daily air concentration over Lake Superior in 2000



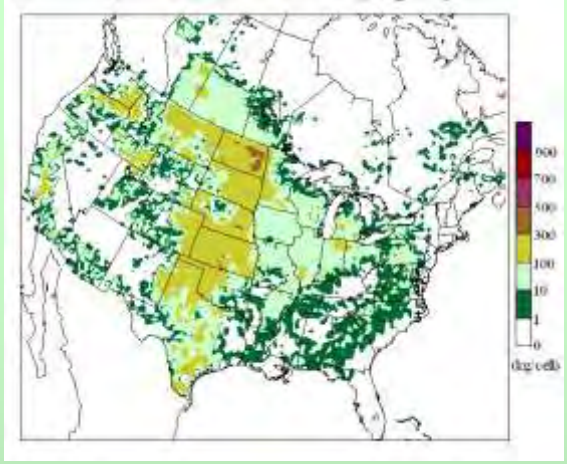


Modeled contribution of toxaphene sources to annually averaged wet deposition over the Great Lakes in 2000

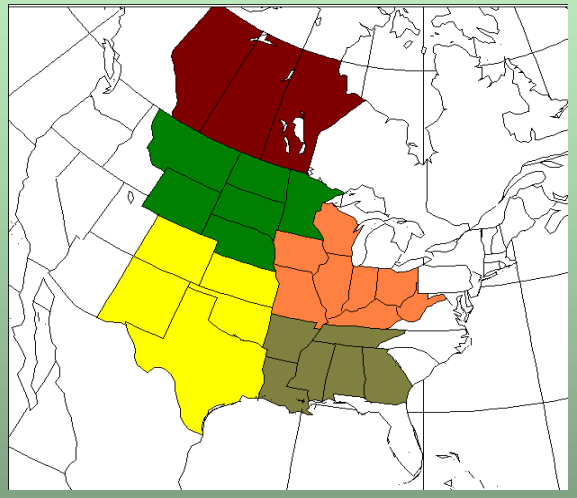
HCB
A Chemical of Concern



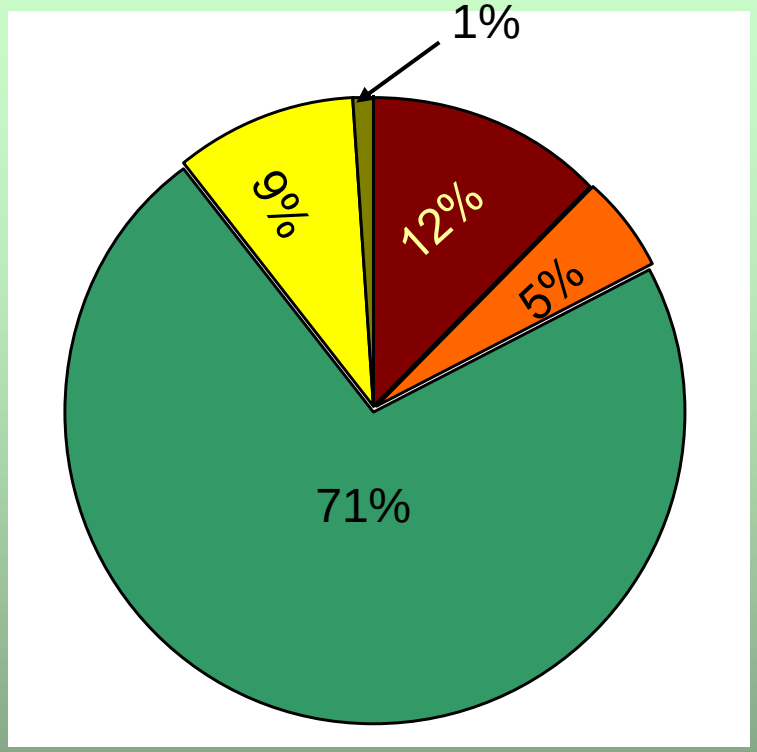
Annual air/land release of HCB (kg yr^{-1}) in the US (Source: USEPA TRI emission inventory) and annual soil residue in 2001 of HCB in the US from historical pesticides application



Soil residue (kg cell^{-1}) of HCB in 2001



Source Regions



Modeled contribution of HCB sources to annually averaged daily air concentration of HCB in 2001 over Lake Superior.

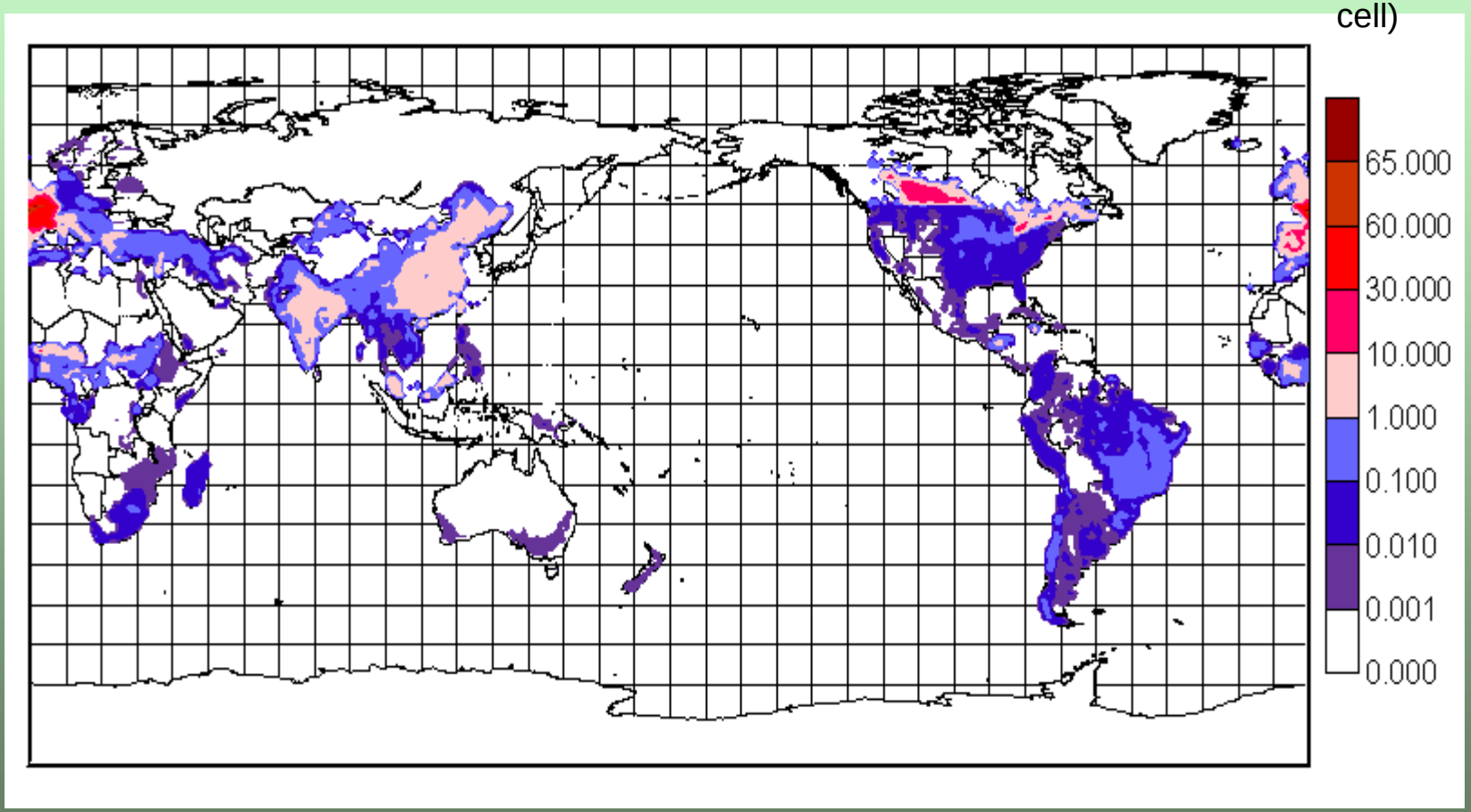
Source strength and proximity play a key role in contributing to the budget of HCB over the lake

Global transport of PBTs

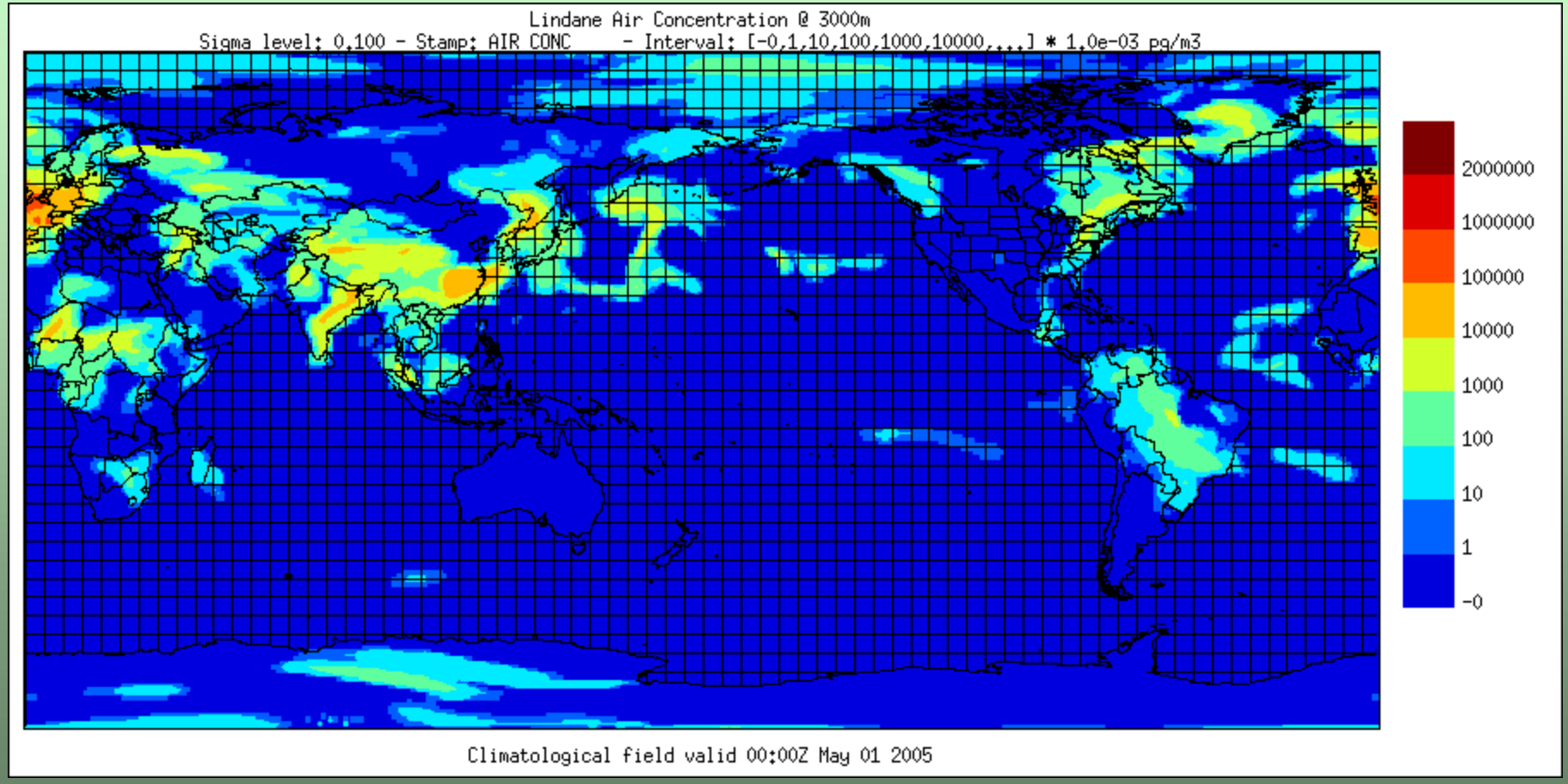
Lindane

Global soil residues in 2005

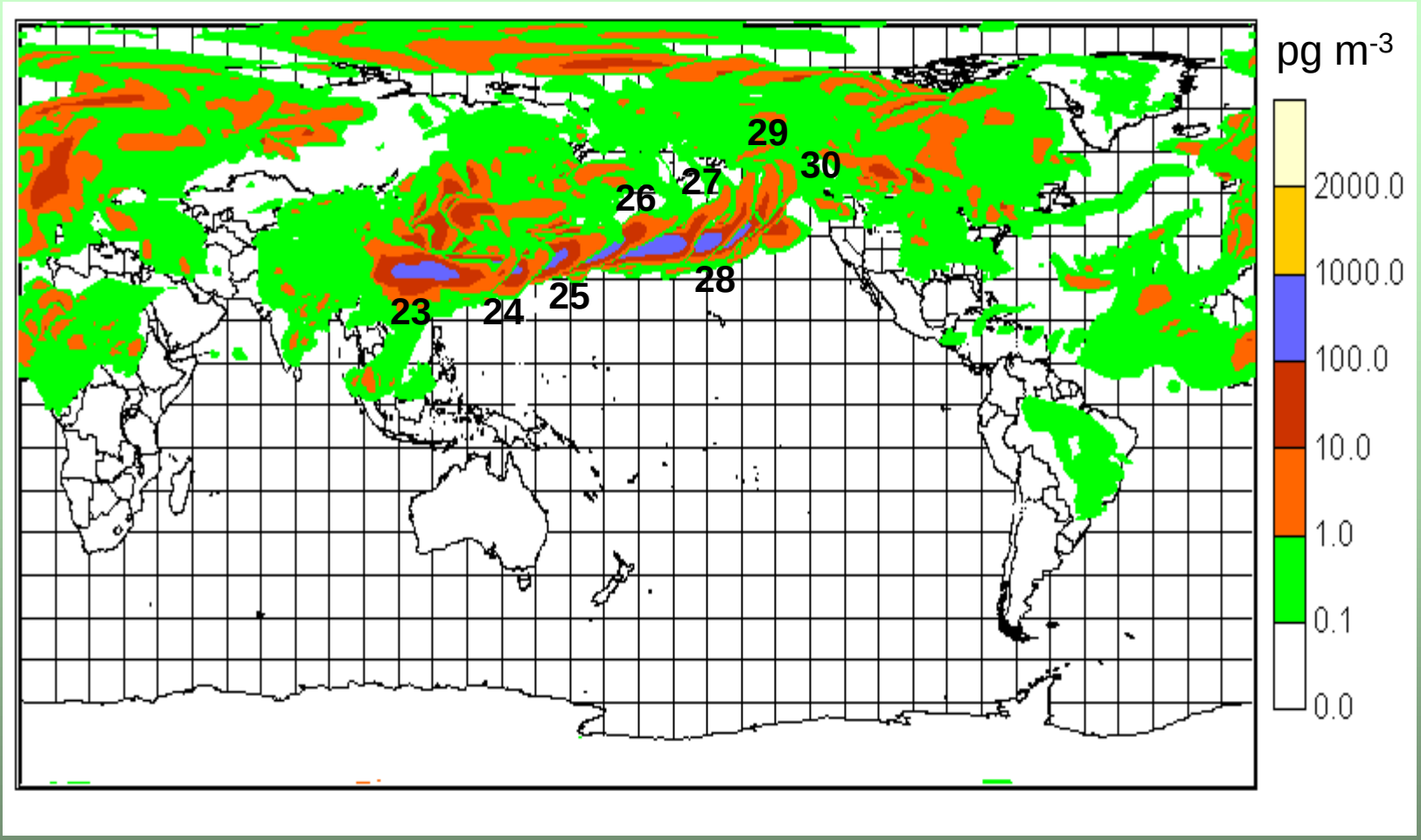
1 cell = $1^o \times 1^o$ lat/lon



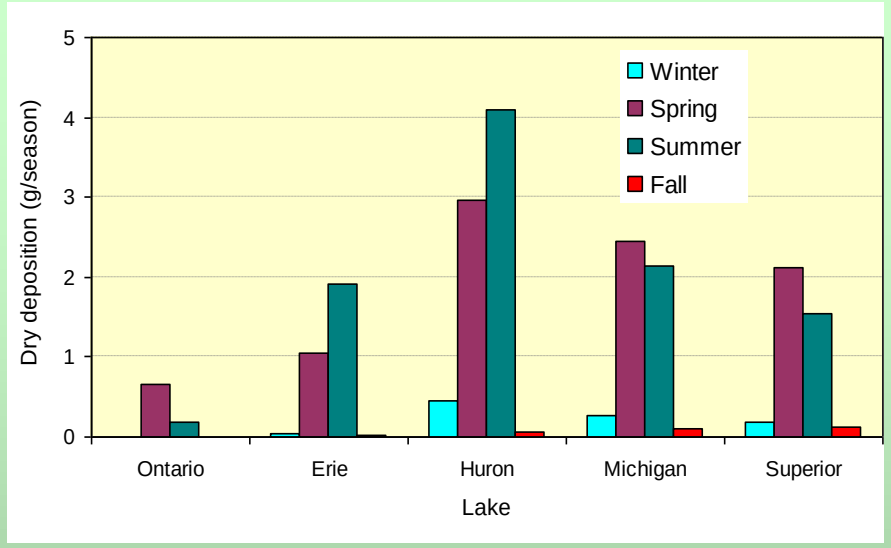
CanMETOP modeled lindane daily air concentration (pg m^{-3}) at 3000 m height for 2005 (animation)



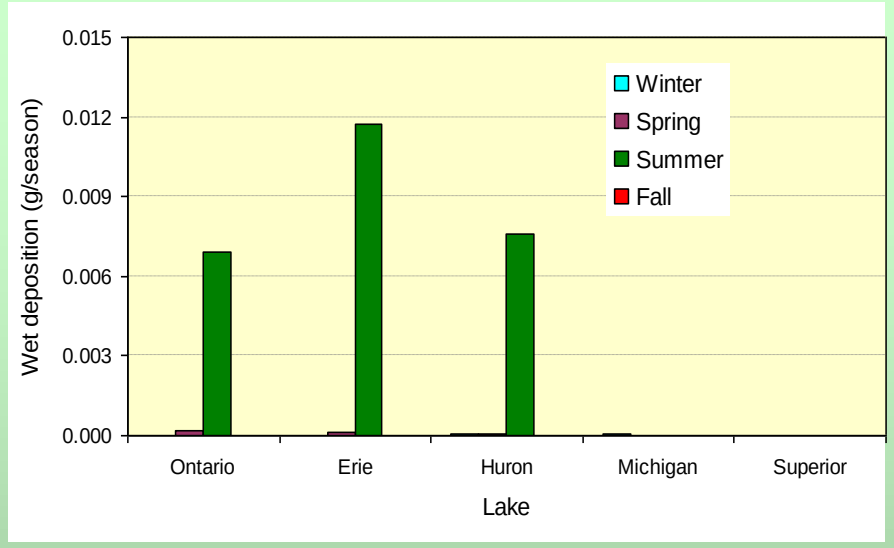
Trans-Pacific transport



Atmospheric Transport of Lindane (pg m^{-3}) from May 23–30, 2005 at 3000 m height



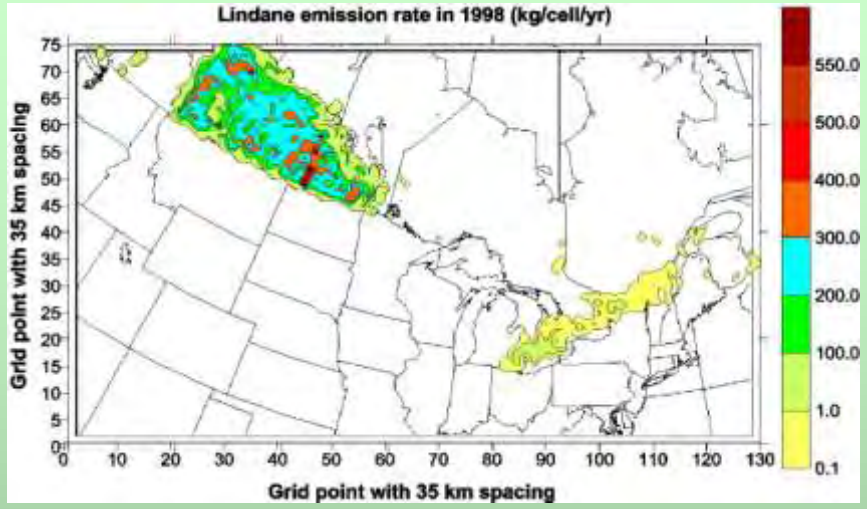
Lindane dry deposition flux



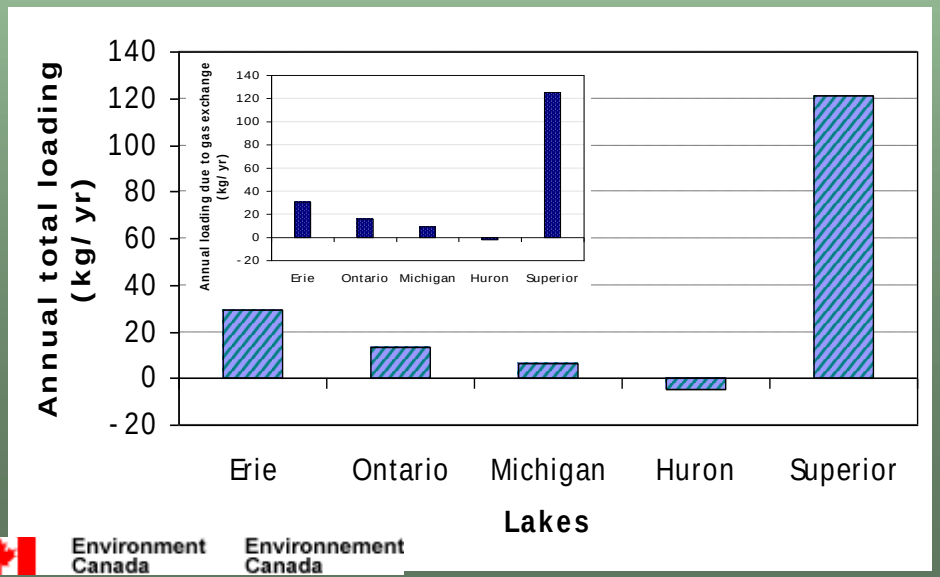
Lindane wet deposition flux

Global CanMETOP modeled lindane deposition flux to the Great Lakes in 2005, (Note units of g/season)

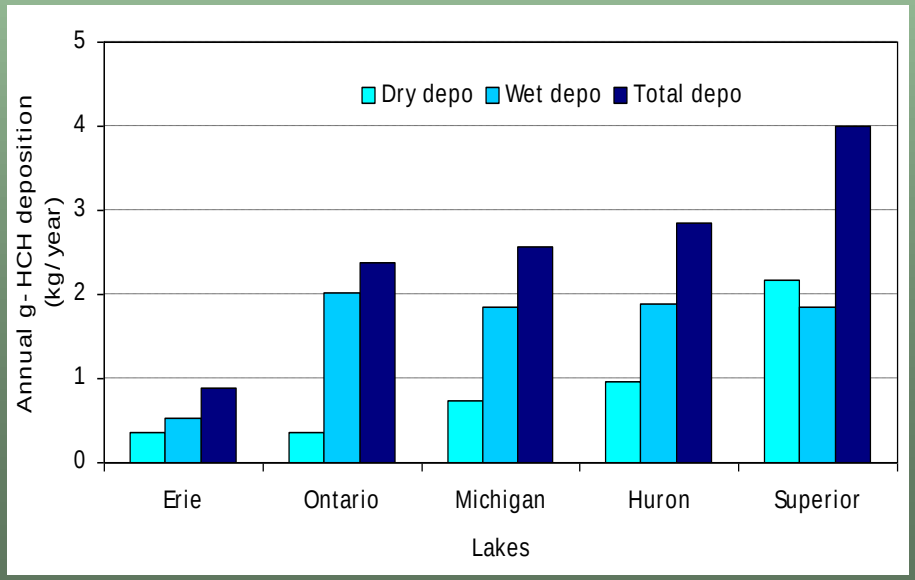
Model simulations of the Impact of lindane emissions from the Canadian Prairie provinces on the Great Lakes in 1998



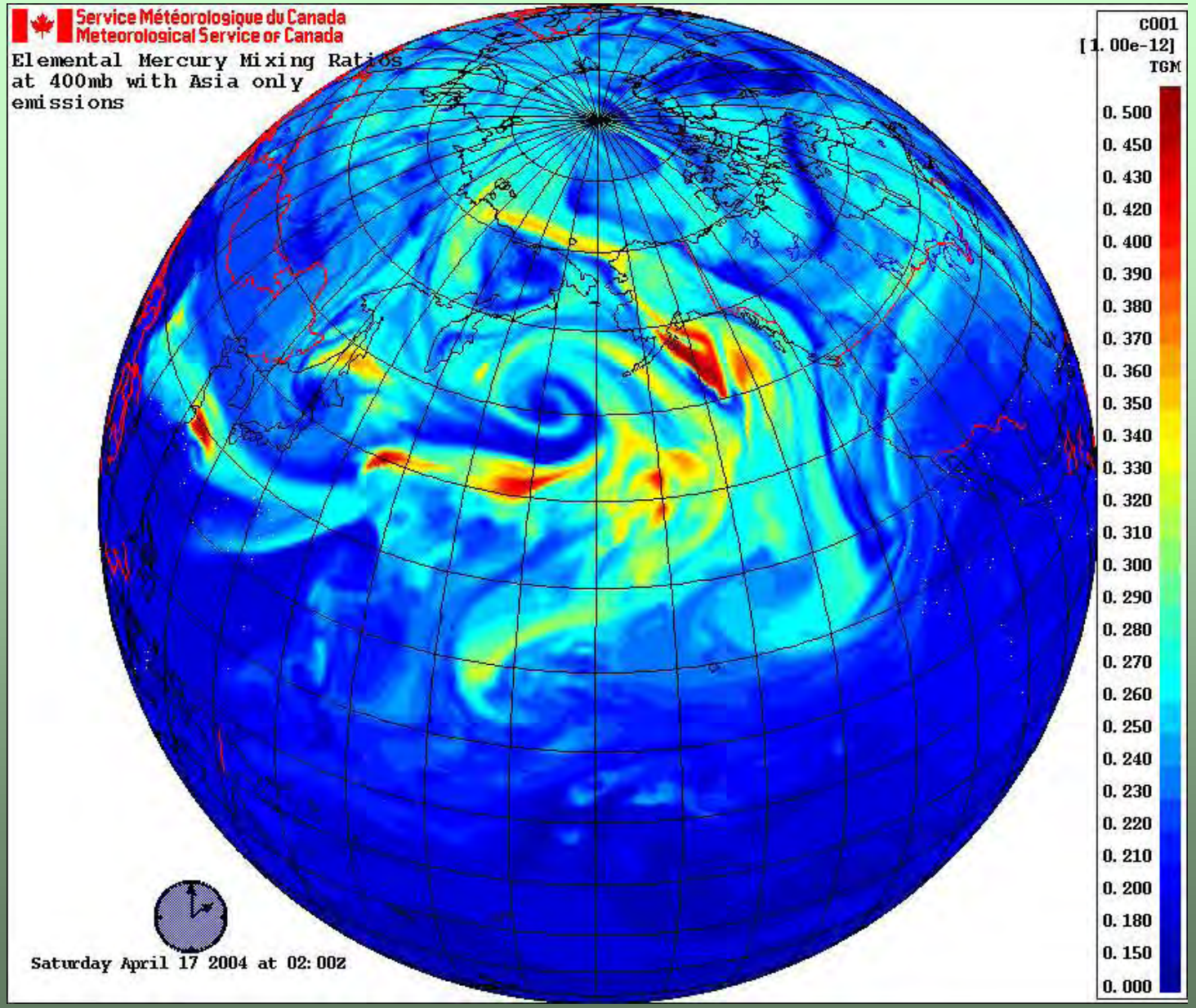
Modeled annual total loading (dry dep + wet dep + net gas flux, kg yr^{-1}) to the Great Lakes. (See inset for Annual loading (kg yr^{-1}) due to net gas exchange)



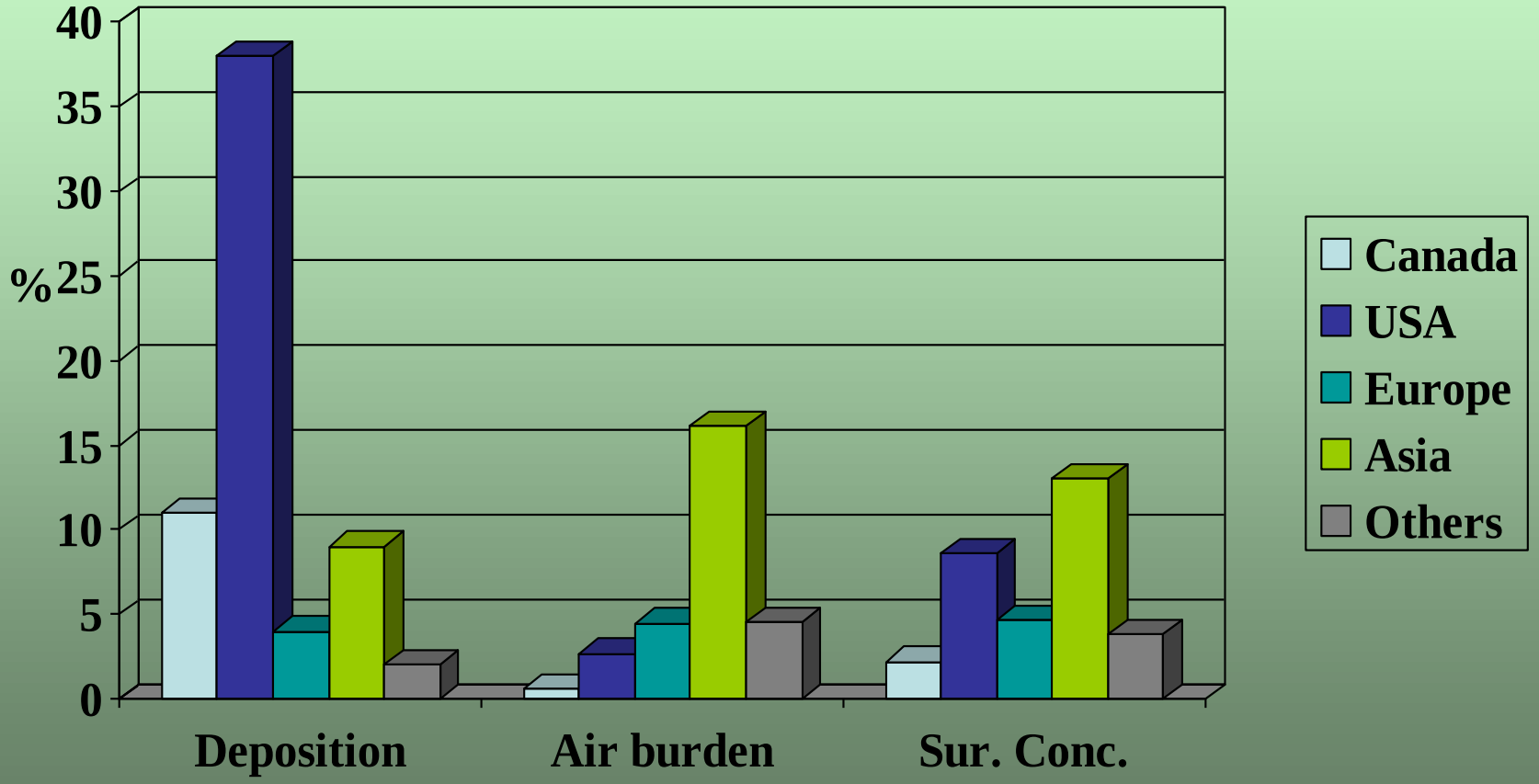
Modeled annual (5/1/1998-4/30/1999) γ-HCH dry, wet and total depositions



Global Mercury Transport (April 17-30, 2004)

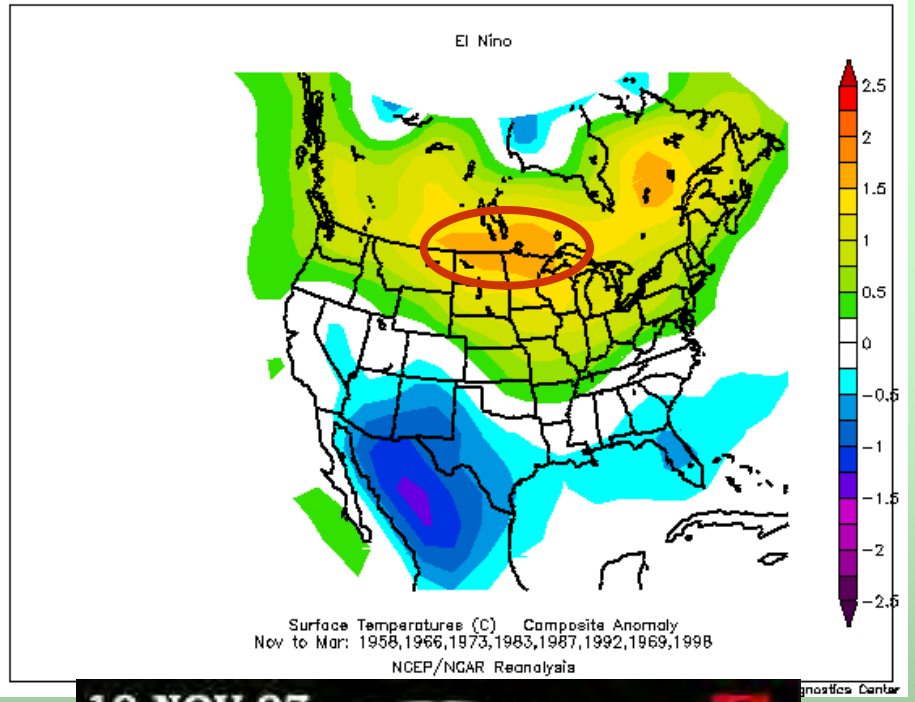


Annual average contributions to the Great Lakes from 1995 Anthropogenic emissions of Mercury

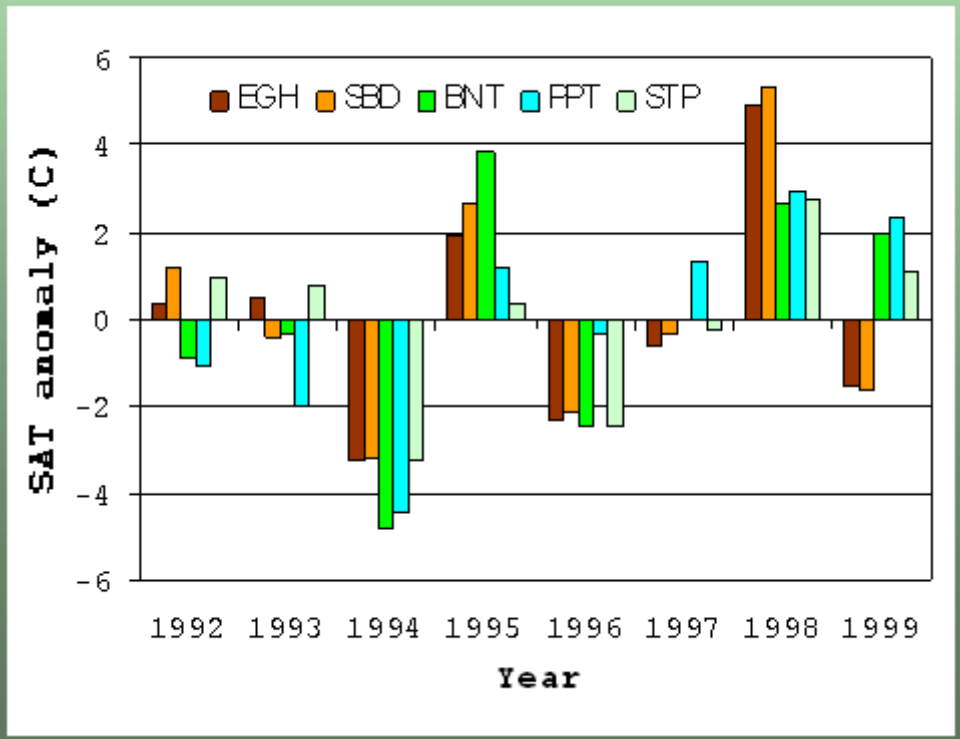


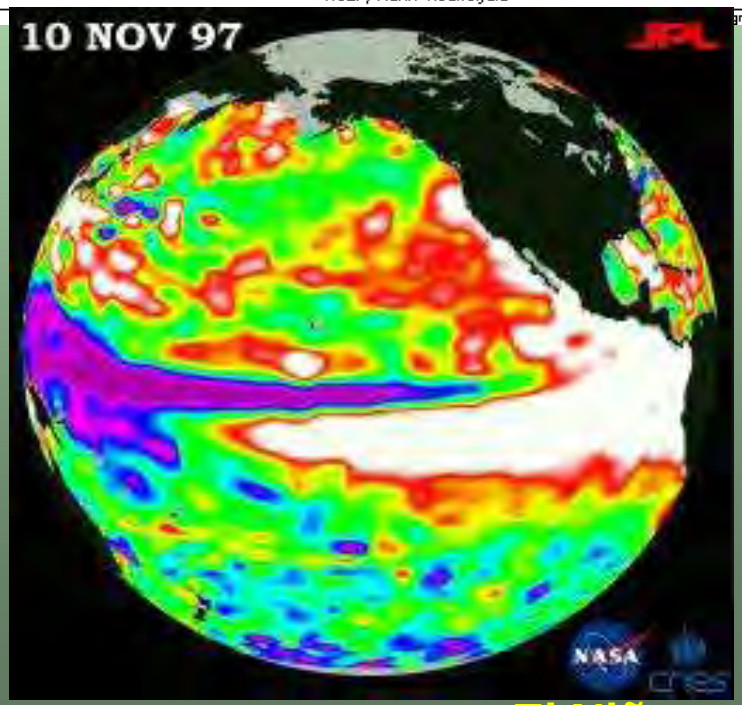
Climate fluctuations and air concentrations of PBTs

Surface air temperature (SAT) anomaly in North America associated with 8 strong El Niño episodes in November to March from 1948 to 2002.



Averaged SAT anomaly in winters during 1990s at IADN master stations





El Niño

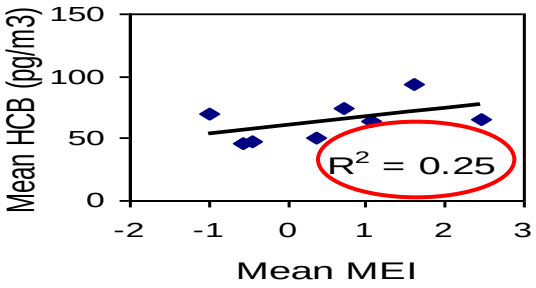
Environment Canada Environnement Canada

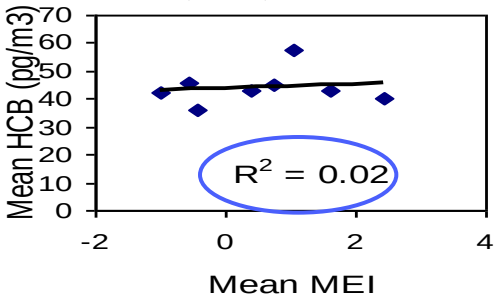
IADN monitored mean annual HCB air concentration vs Multivariate ENSO index (MEI)

Eagle Harbor (EGH) at Lake superior

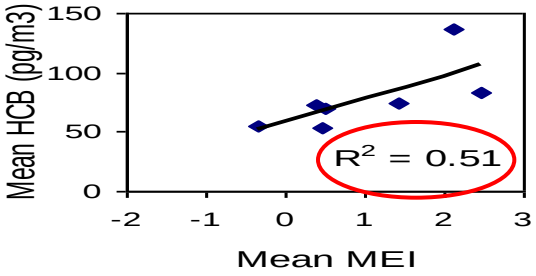
Point Petre (PPT) at Lake Ontario

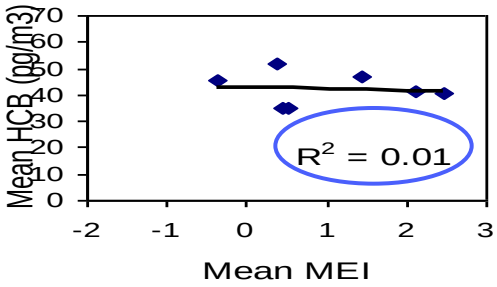
Winter



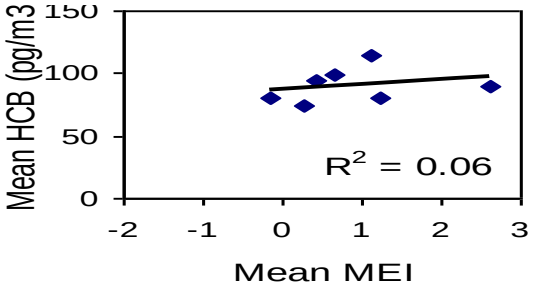


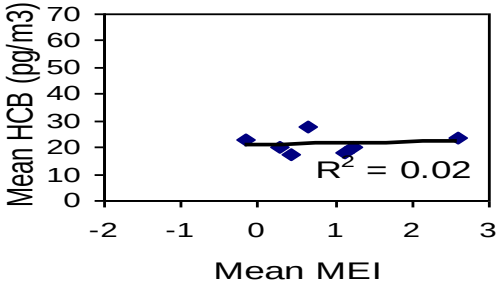
Spring



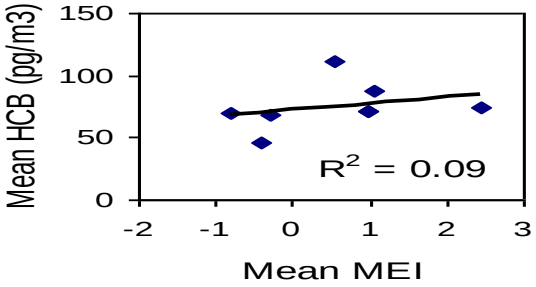


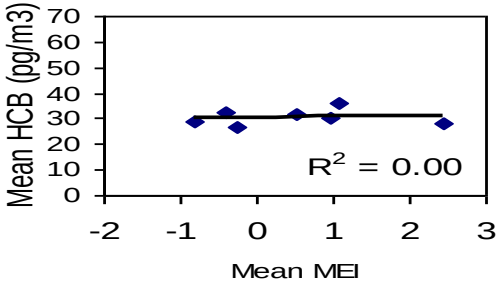
Summer





Fall





Thank you