Impact of intercontinental atmospheric transport of lindane on North American environment

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Canada

Outlines

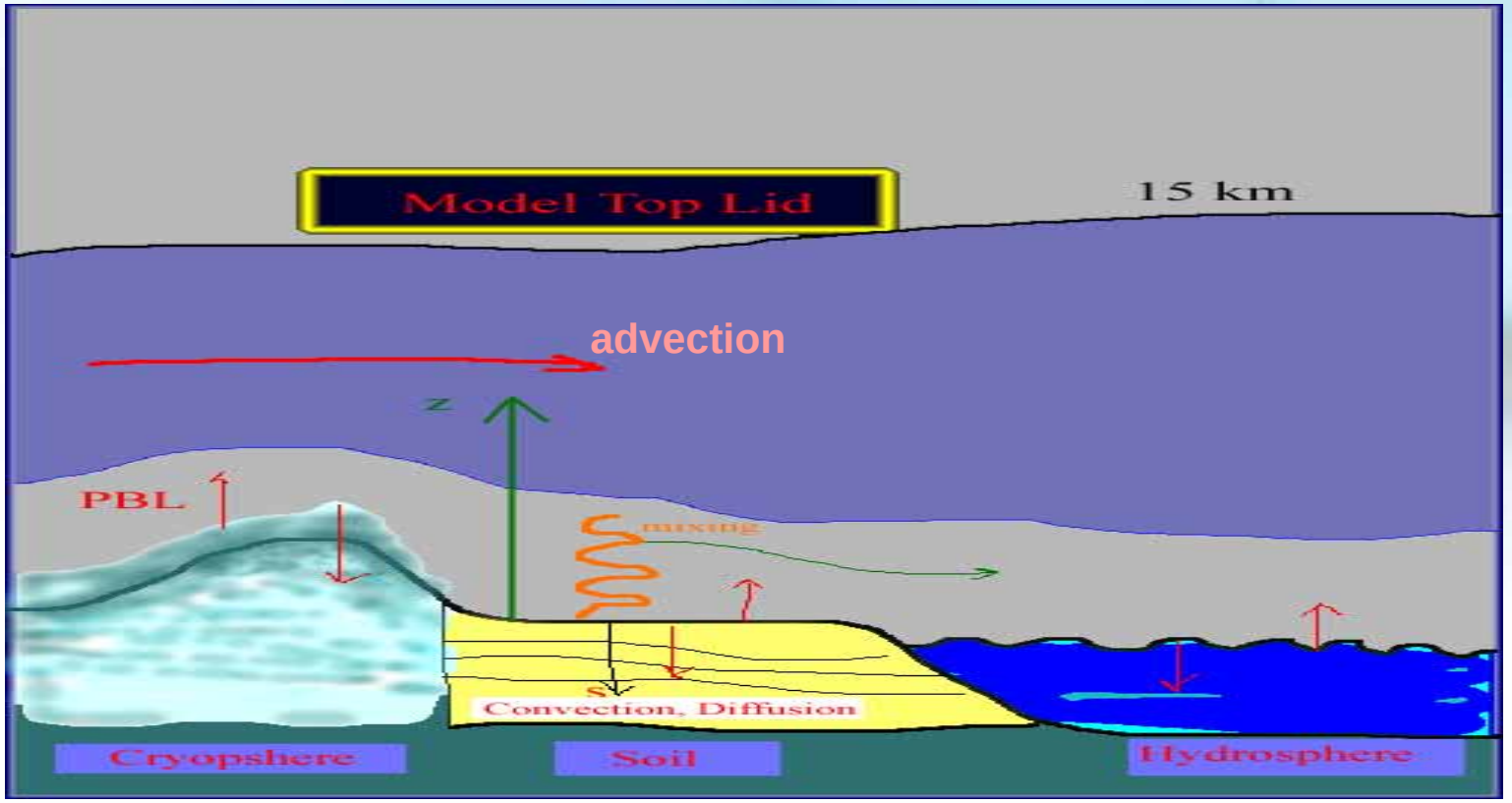
- **Background**
- **Global lindane budget**
- **Transpacific atmospheric transport**
- **Transatlantic atmospheric transport**
- **Impact on the Great Lakes**

Background-Atmospheric transport models

Canadian Model for Environmental Transport of Organochlorine Pesticides
Multi-compartment Environmental DIagnostics and Assessment

	CanMETOP	MEDIA
Atmosphere model	3-D Eulerian transport	3-D Eulerian transport
Soil model	Fugacity/mass balance	1-D dynamic diffusion
Horizontal resolution	24/35 km, 1°×1° lat/lon	1°×1° lat/lon
Vertical resolution	Surface-11000 m, terrain following z-coordinate	Surface-15000 m, terrain following Gal Chen coordinate

Background-Atmospheric transport models



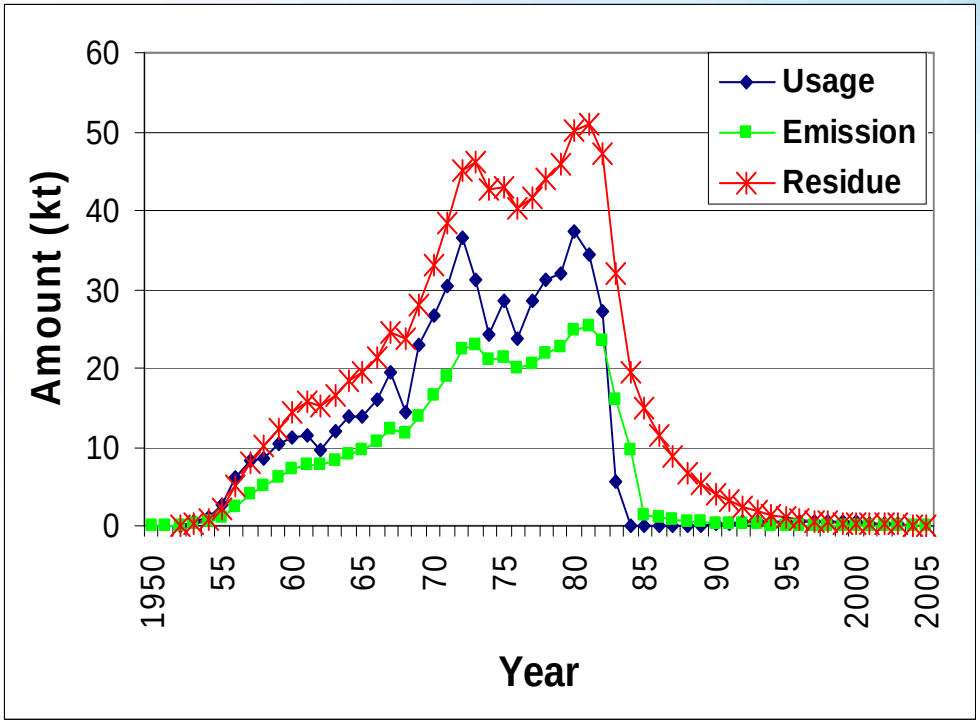
A schematic view of multi-compartments of two models

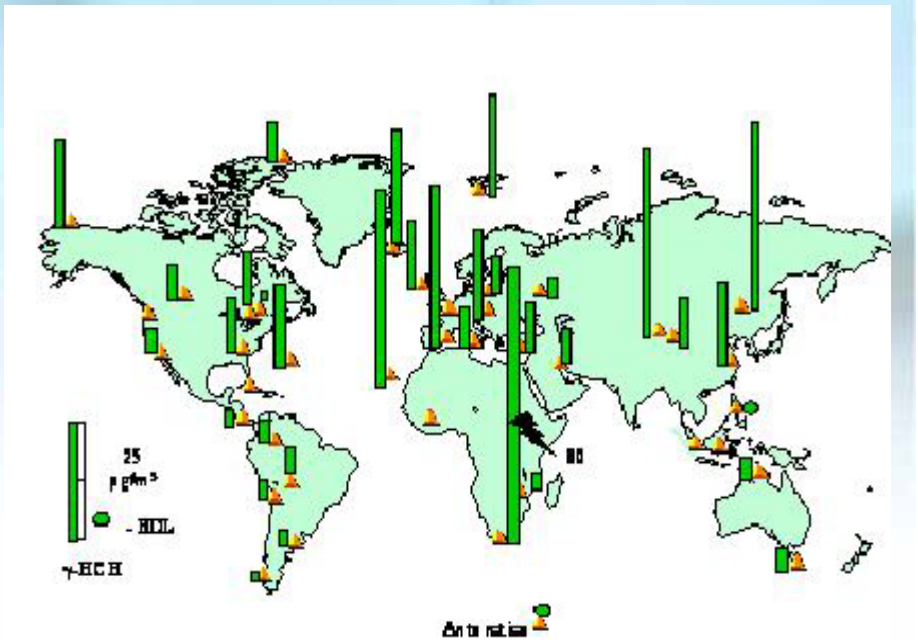
Background-Lindane & GAPS projects

- **China – Canada Joint Project on Reduction of Lindane Usage in China and its Impact on North America 2005 – 2008, funded by NACEC, EPA and EC**

- **Global Air Passive Sampling, funded by EC**

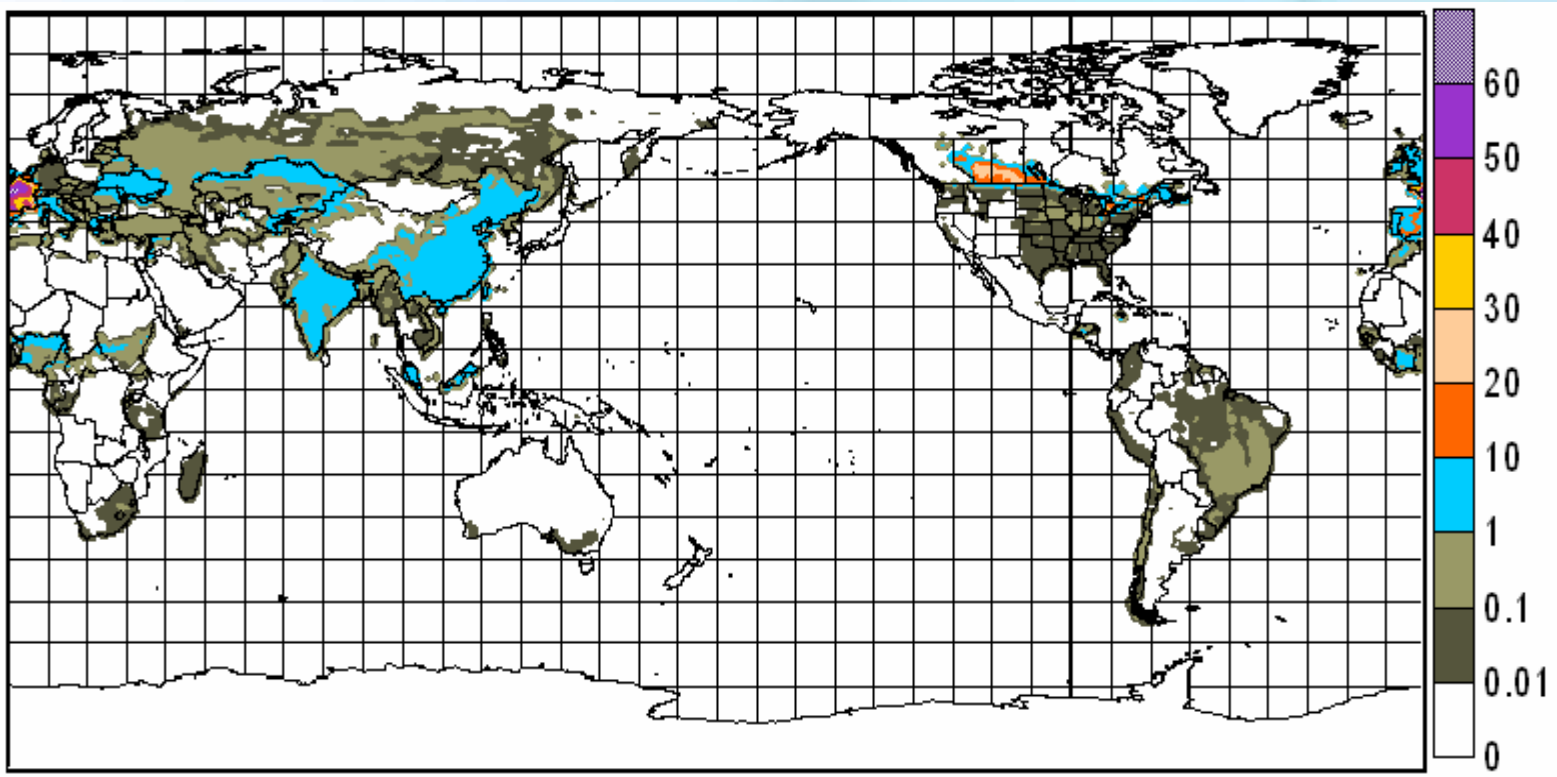
Background-Lindane & GAPS projects





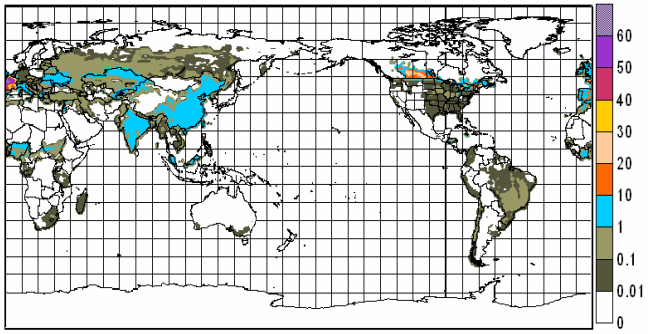
Left panel: Temporal trends of usage, emissions, and residues of lindane in China.
Right panel: Air concentrations (pg/m3) of lindane between Dec 2004 and Mar 2005 at GAPS sites (Pozo et al., *ES&T*, 2006)

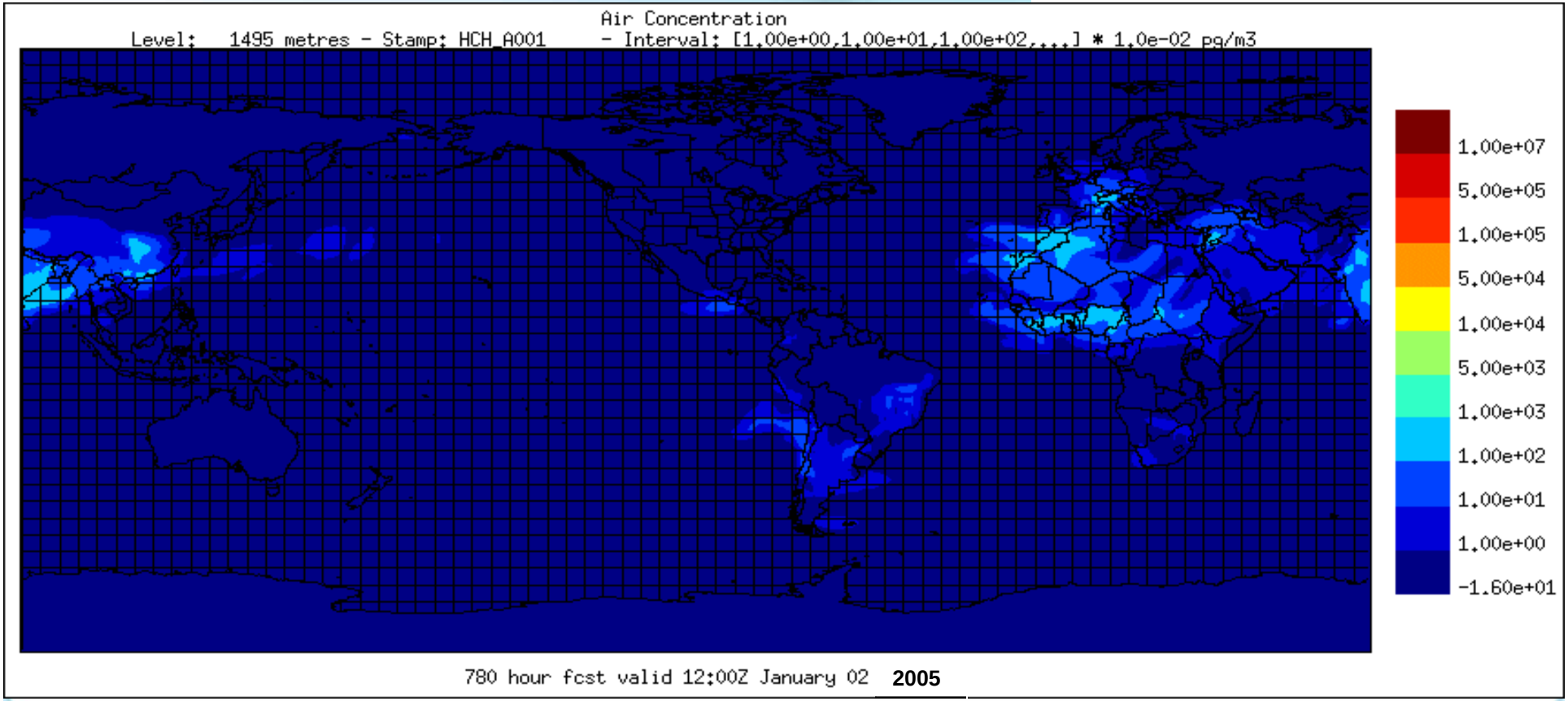
Global lindane soil residues



Global lindane soil residues in 2005 (t cell^{-1}, 1 cell = 1^{o} × 1^{o} lat/lon)

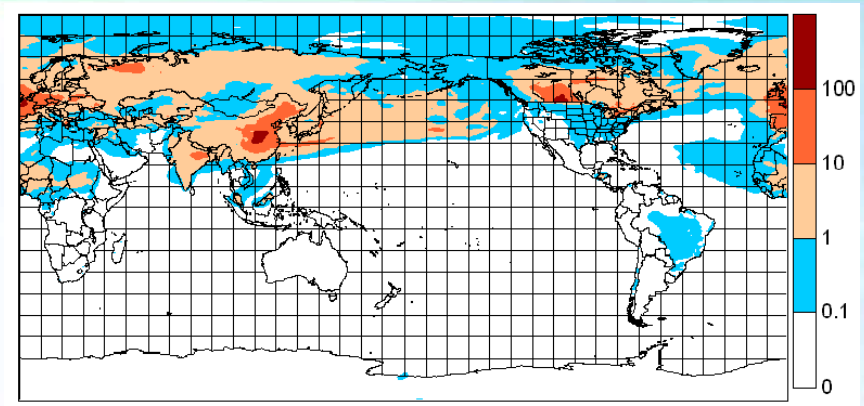
Global lindane budget

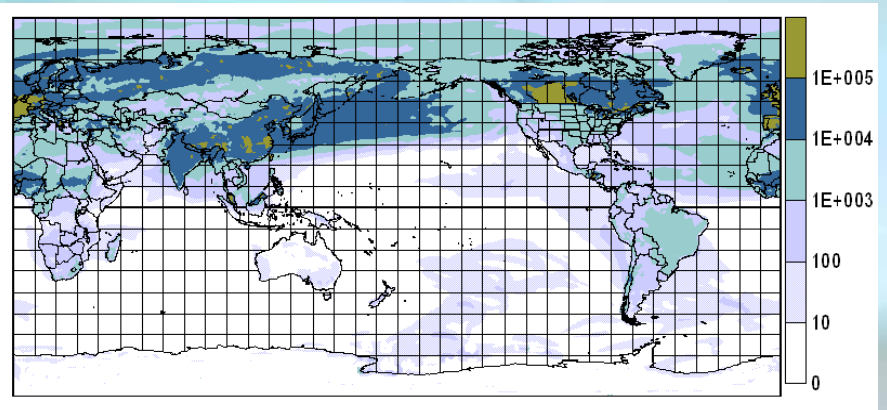


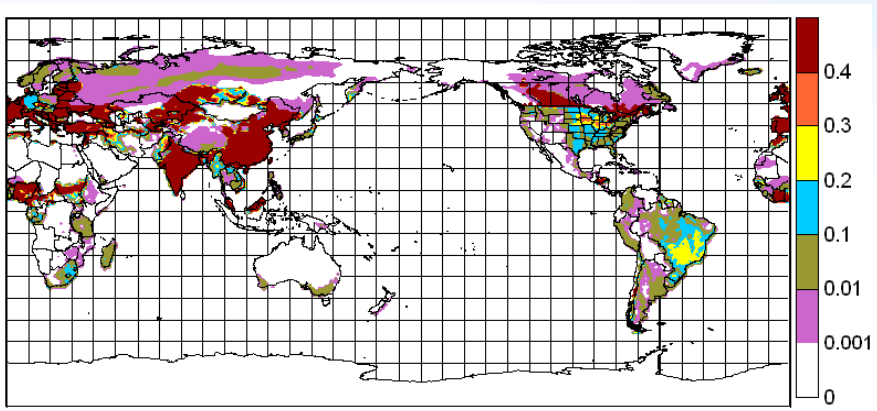


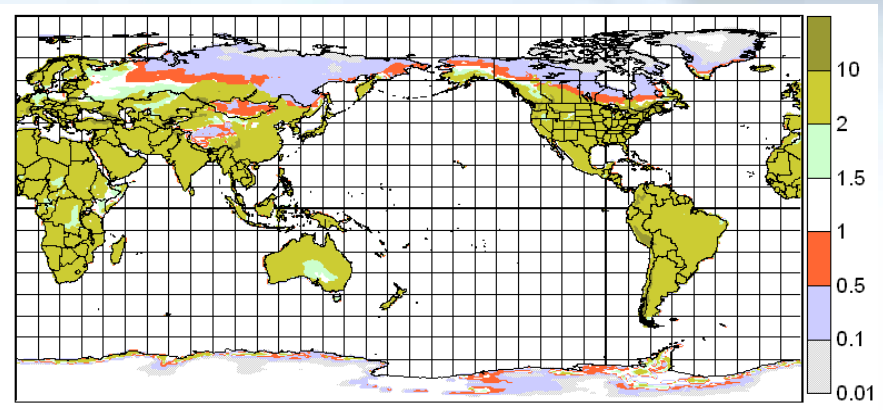
Modeled daily air concentration (pg m^{-3}) at 1500 m height

Global lindane budget





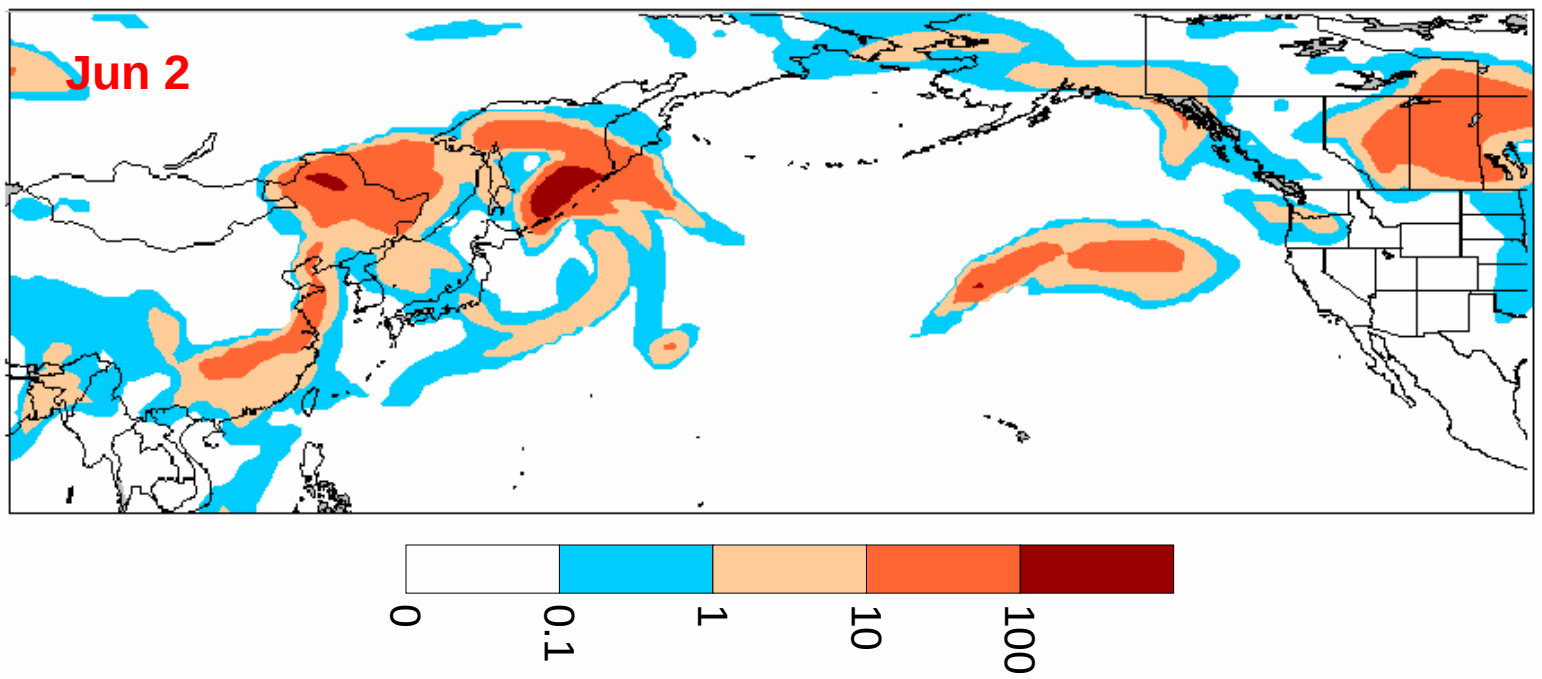




Modeled annually averaged lindane air concentration (surface, pg m^{-3}), soil concentrations (1 – 10 cm, ng g^{-1}), total deposition (pg m^{-2}), and soil/air fugacity ratio.

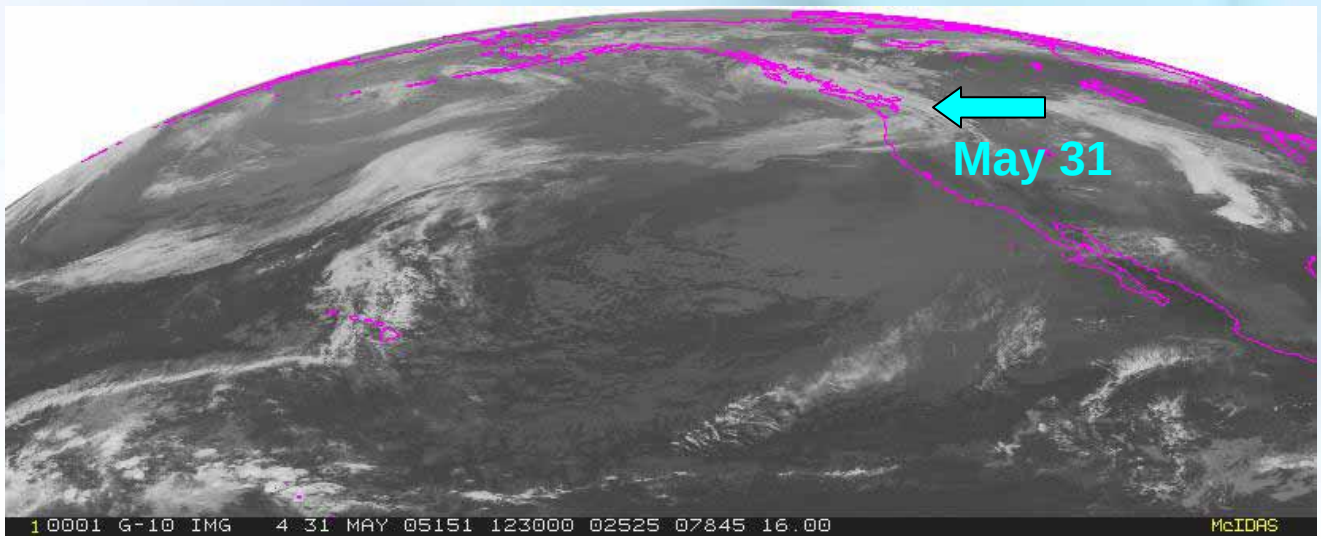
Transpacific atmospheric transport

A episodic transpacific transport event
from May 21st to June 2nd 2005



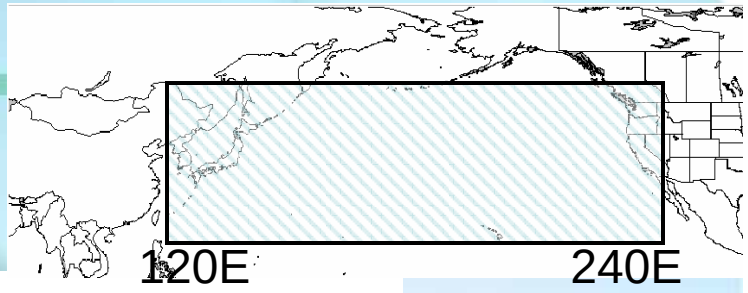
Modeled daily lindane air concentration (pg m^{-3}) at 3000 m height

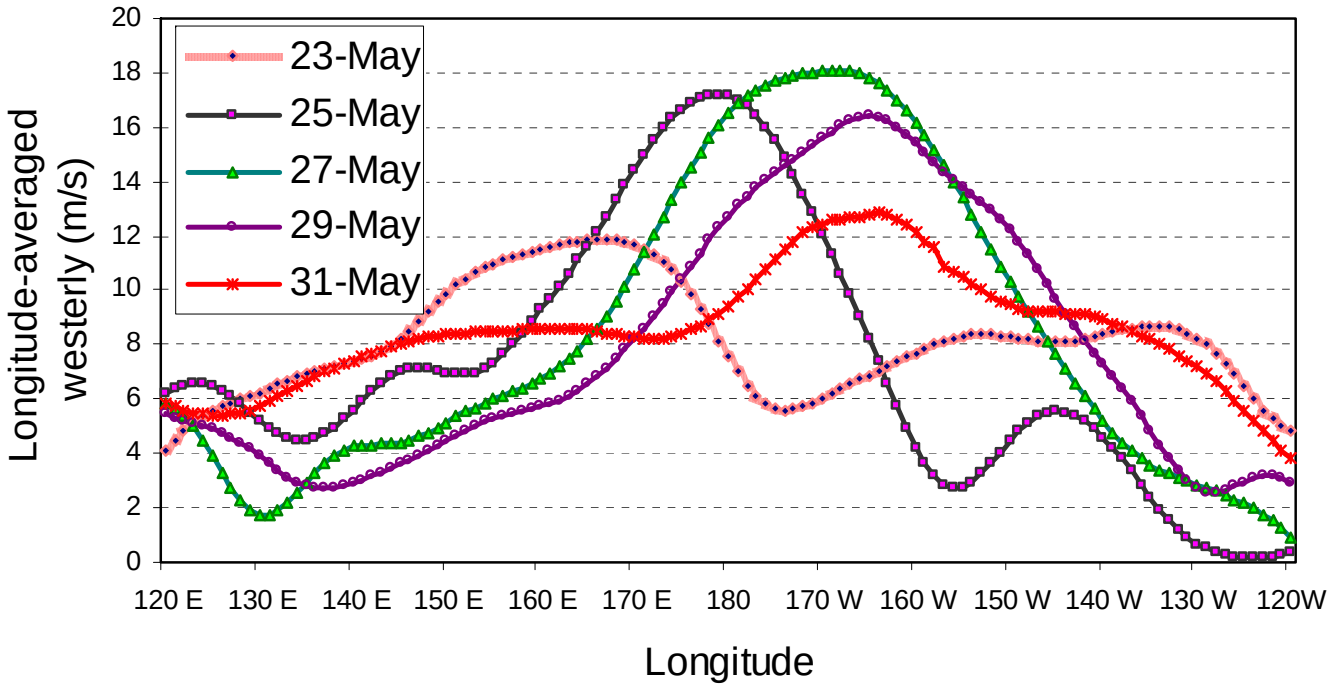
Transpacific atmospheric transport



Metosat-8 visible cloud satellite image from May 23rd to 31st, at 13:15 UTC

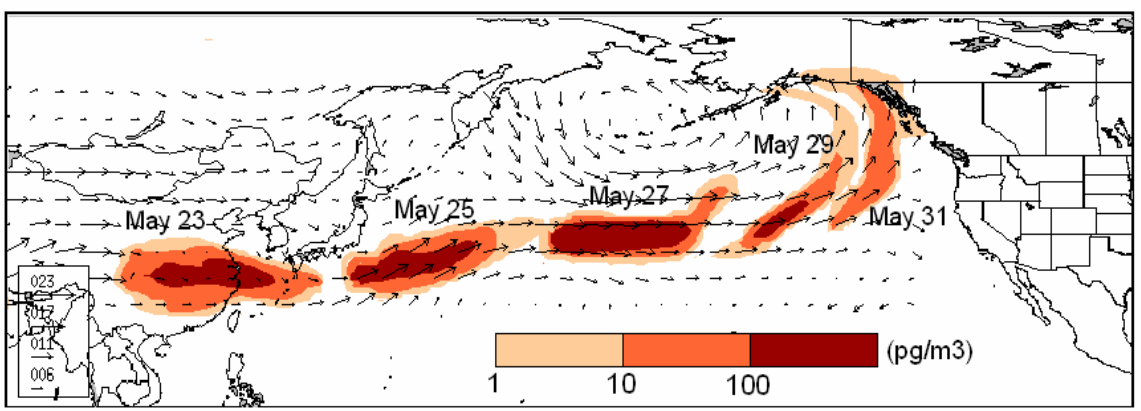
Transpacific atmospheric transport





Daily mean westerly wind component (*steering flow*) during the event for 23 – 31 May at 3000 m height, meridionally averaged over 20º – 50ºN.

Transpacific atmospheric transport



- Large soil residues in sources
- Warm conditions to enhance volatilization
- Strong convections to bring toxics to higher atmospheric level
- Strong westerly winds (steering flows) for the eastward transport across north Pacific.

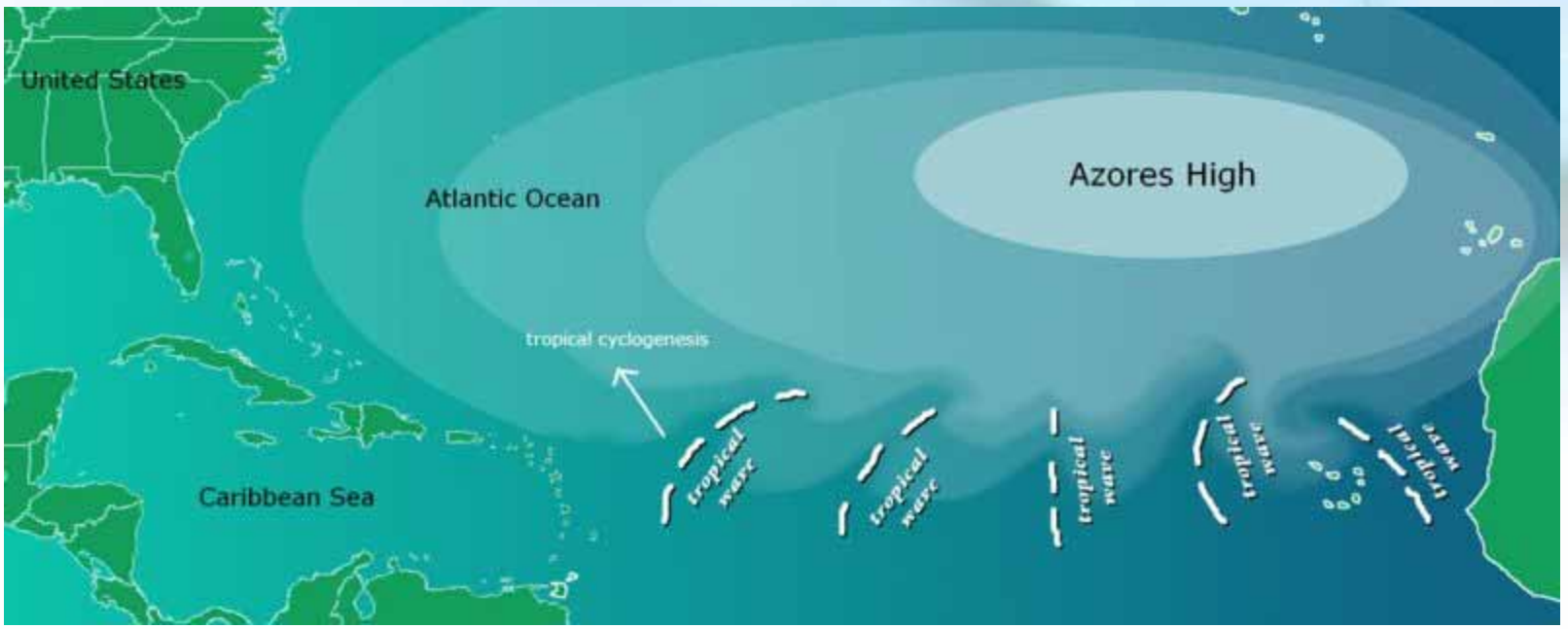
Transatlantic atmospheric transport

Two **easterly wind regimes** at relatively low atmospheric levels (at and below **3000 m**) across North Atlantic, extending from West Africa - the subtropical eastern Atlantic to the Caribbean - the southern United States:

Ø **West African easterly jet / wave**

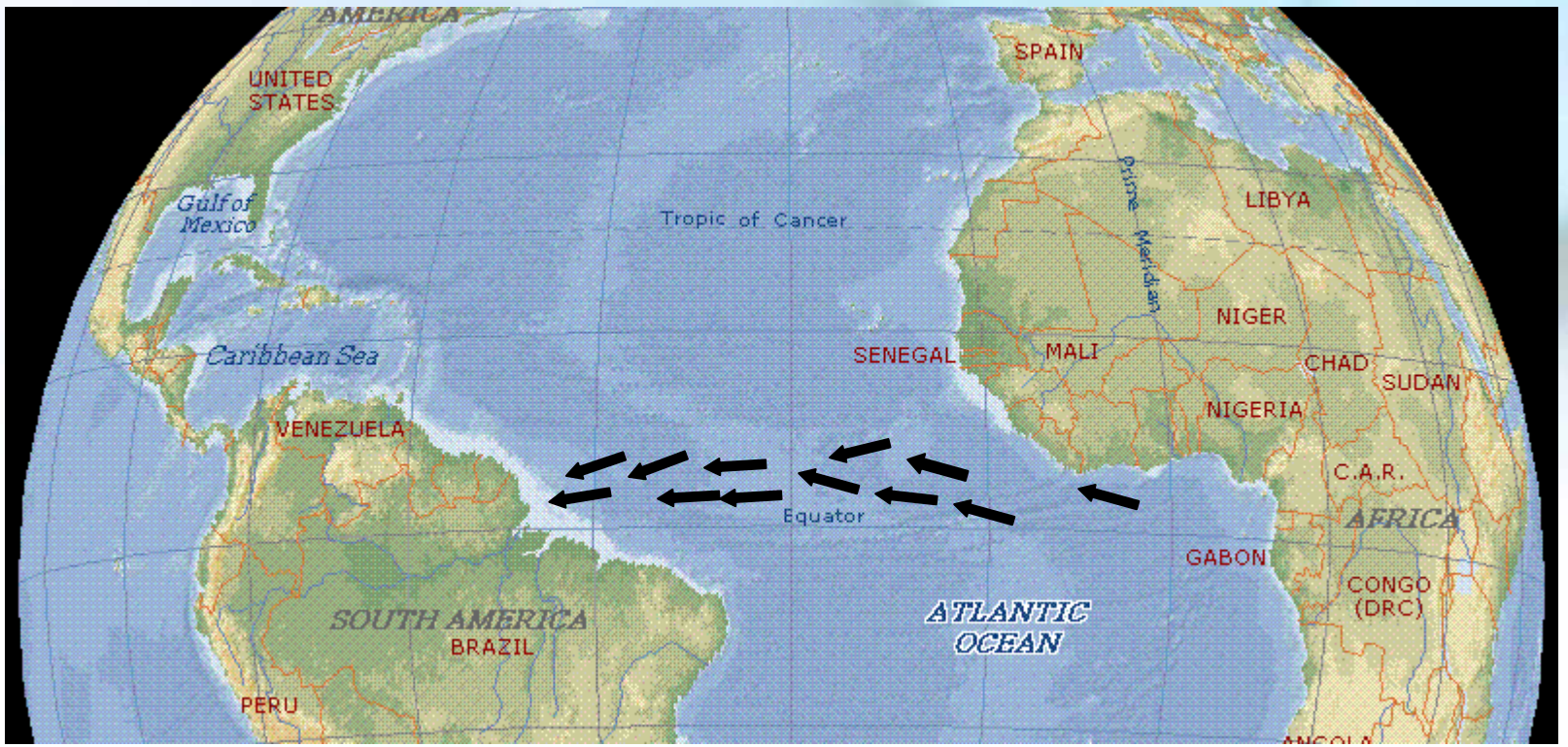
Ø **North Atlantic easterly trade winds**

West African low level easterly jet / waves

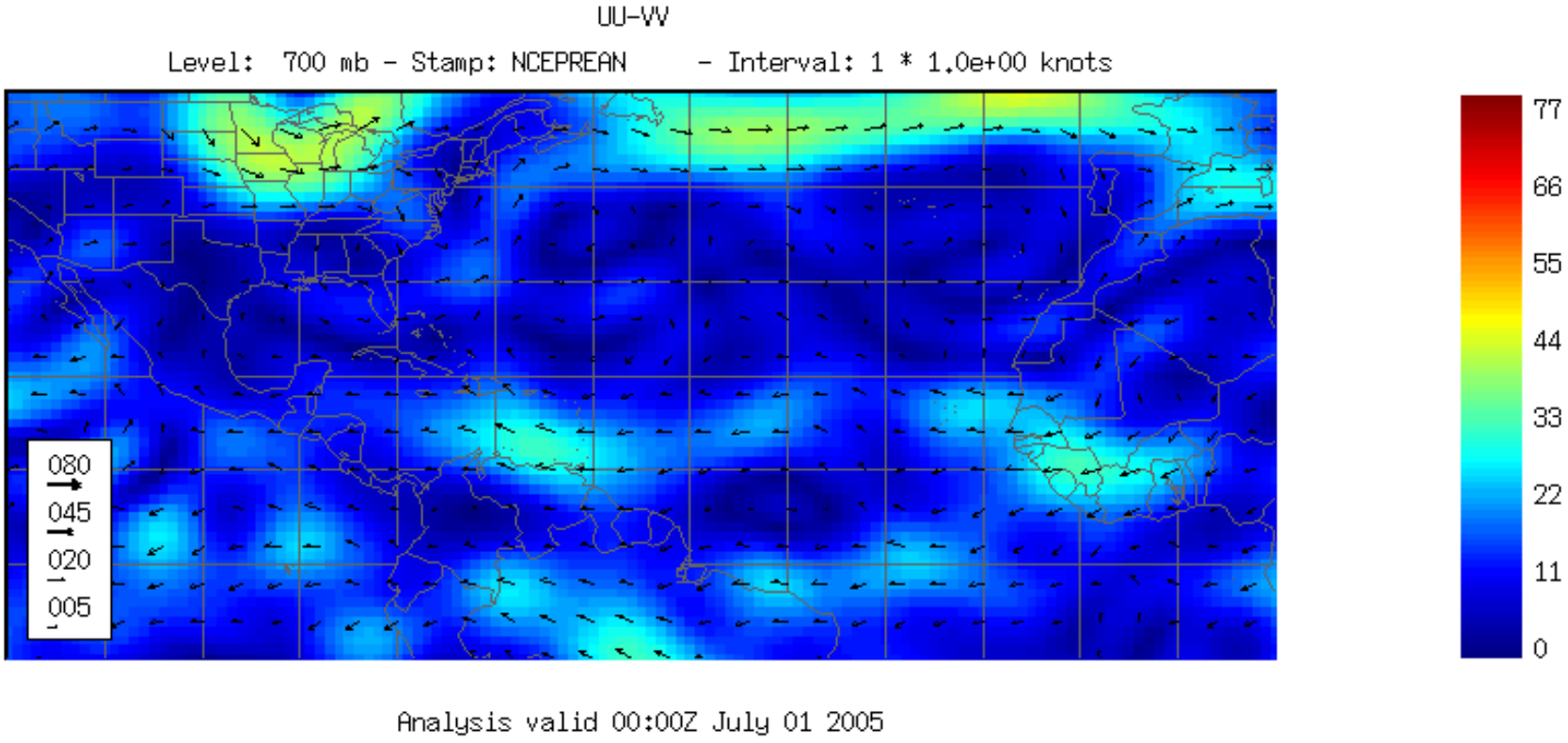


Courtesy NASA

North Atlantic easterly trade winds

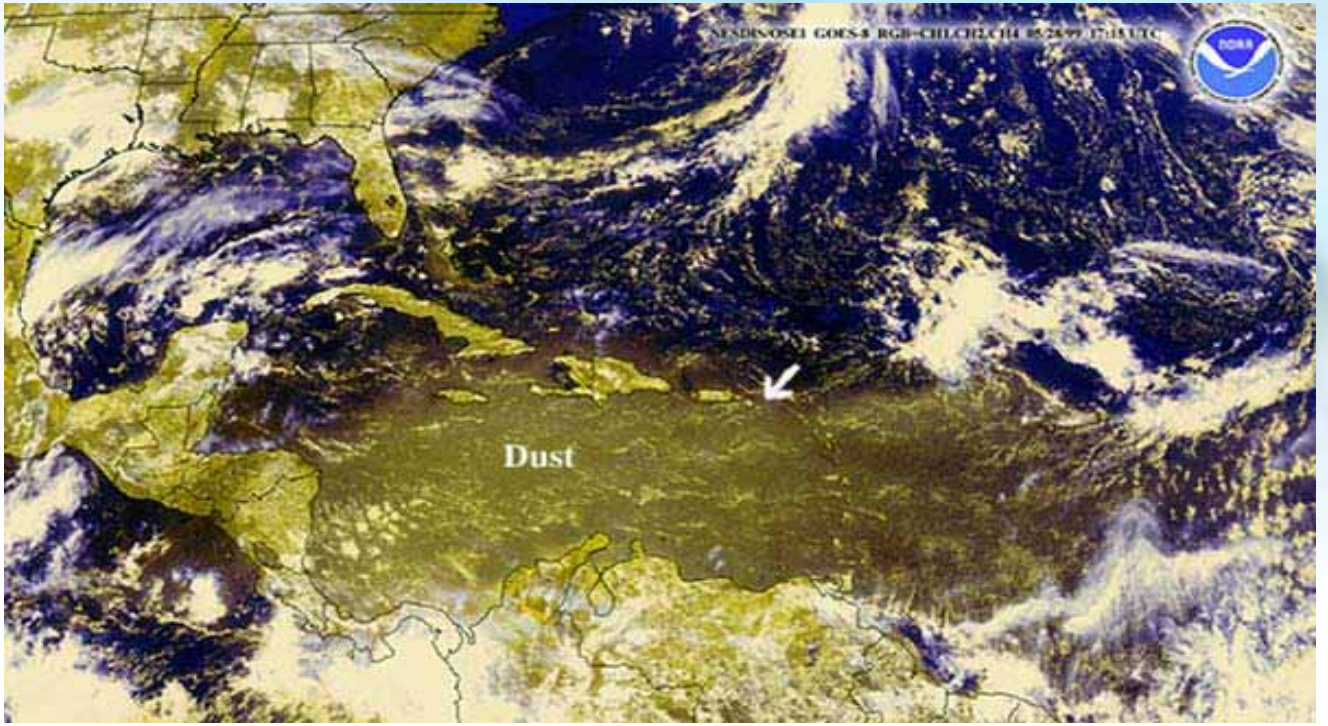


Model input 6 hourly winds



Objectively analysed wind vectors (knots) at 00, 06, 12 and 18 Z at 700 hPa (~ 3000m)

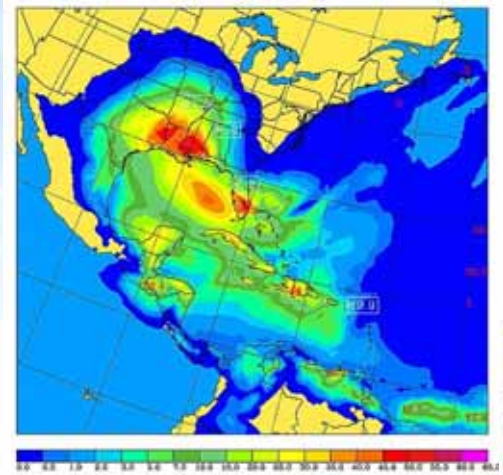
Saharan dust storm affects the US



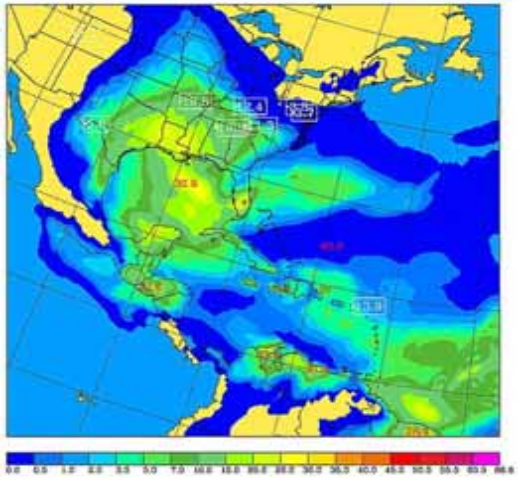
This NOAA satellite image shows a dust storm, moving from the Sahara into the the Caribbean (Courtesy NOAA)

Saharan dust storm affects the US

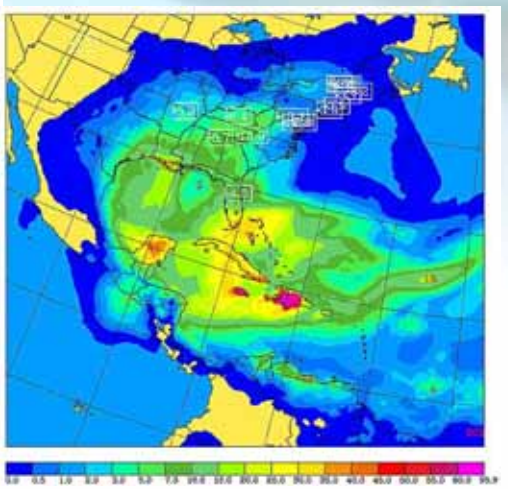
June 30 1993



July 3 1993



July 7 1993



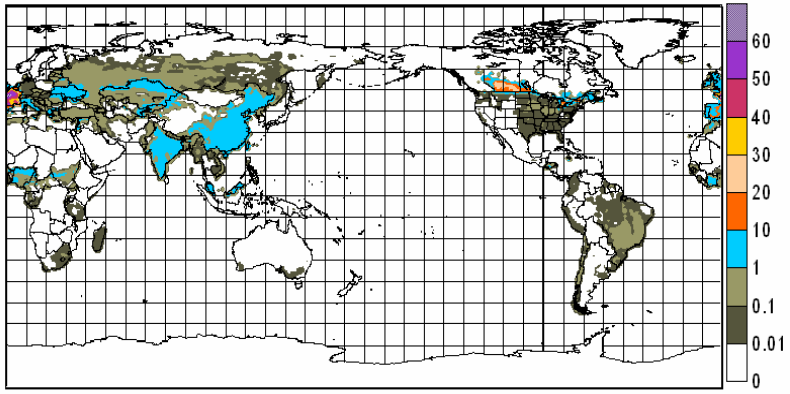
Modeled daily averaged surface dust concentration ($\mu g\ m^{-3}$) of dust particles with centered diameter of 1.5 μm (Kallos et al., JGR, 2006)

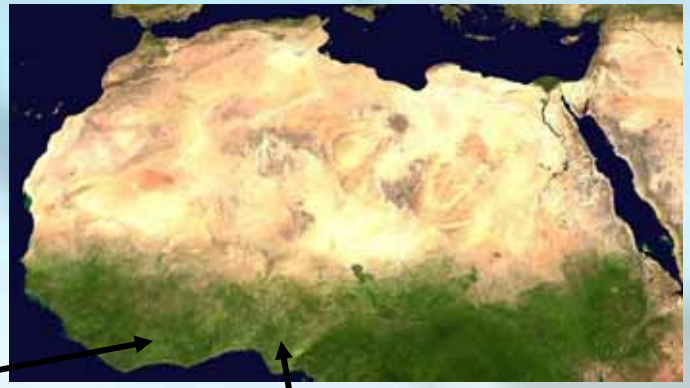
Lindane in West Africa

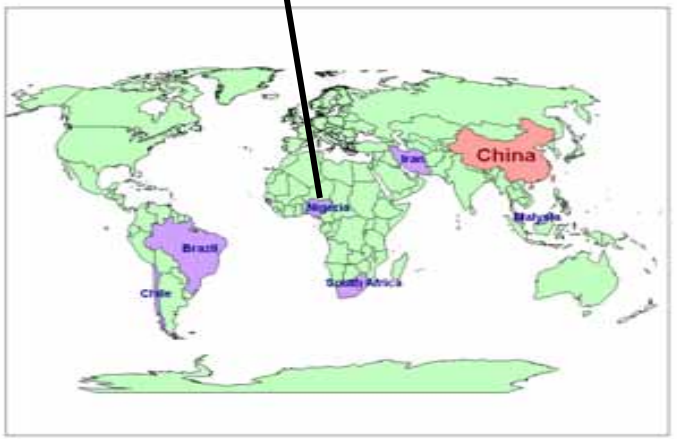
Lindane appeared not used in Saharan desert

Nigeria has been importing lidnane from China

GAPS monitored lindane in Ghana (rural site): 40-90 pg m^{-3} in 2005

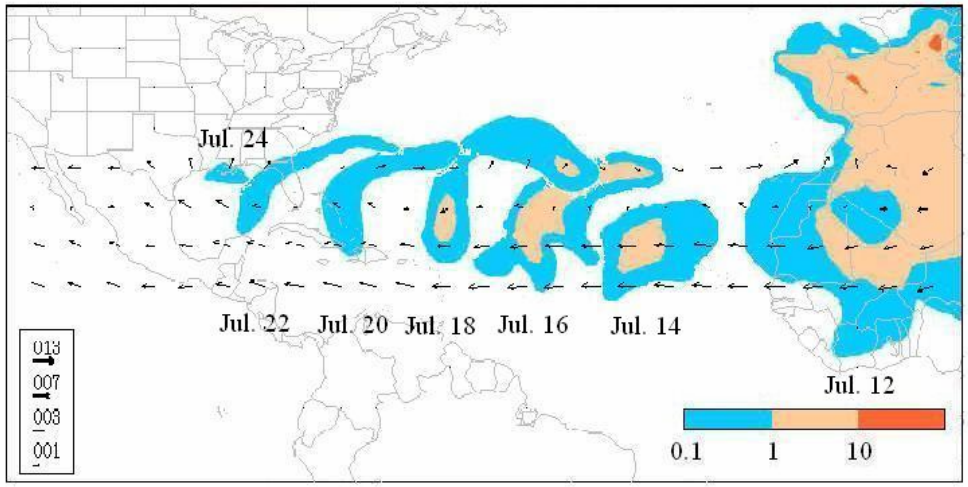






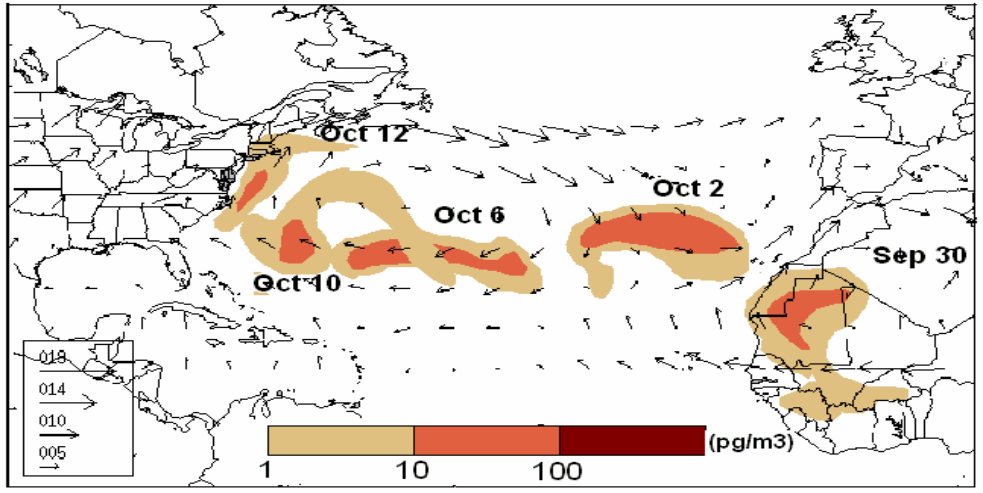
Li & Ren 2007

Snapshots of daily air concentrations during two events

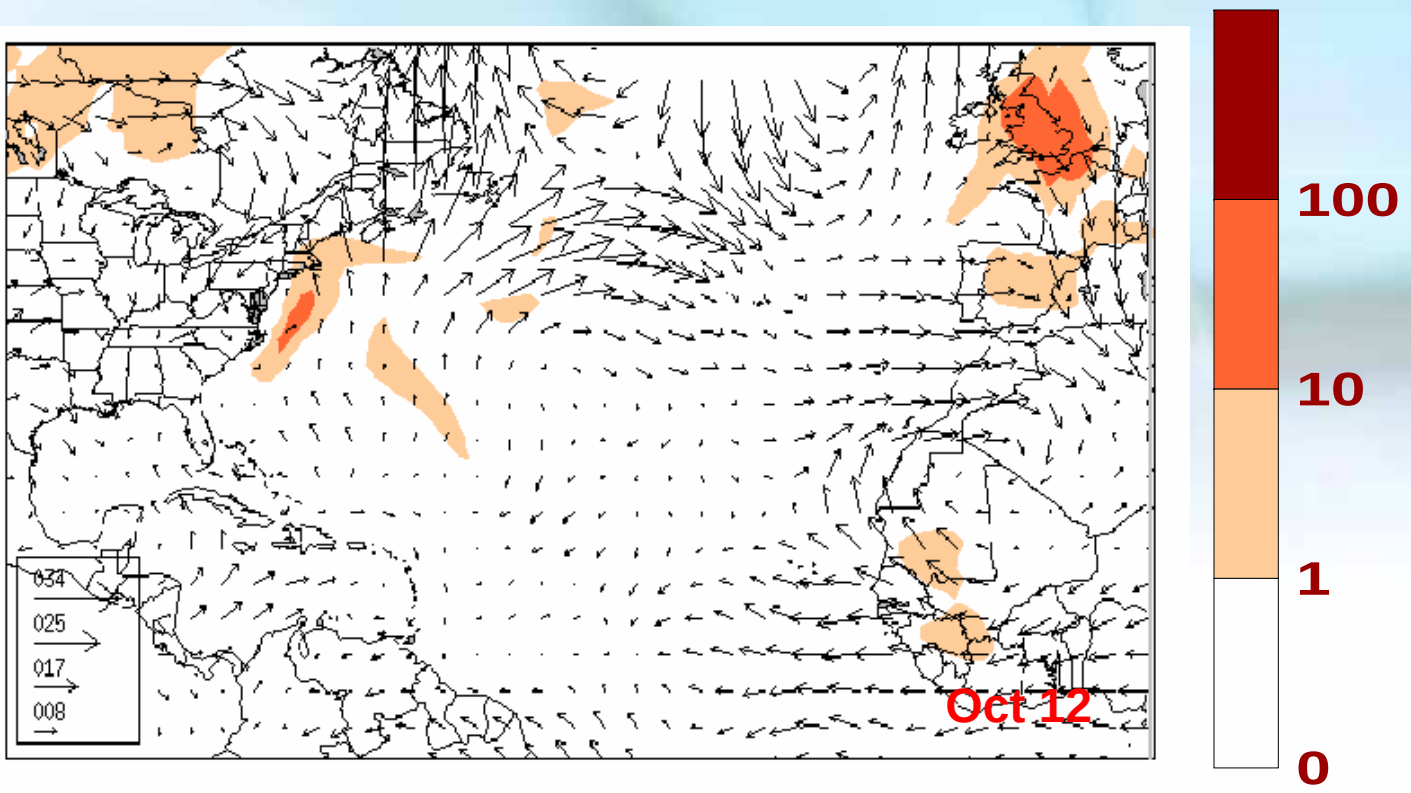


July event

October event

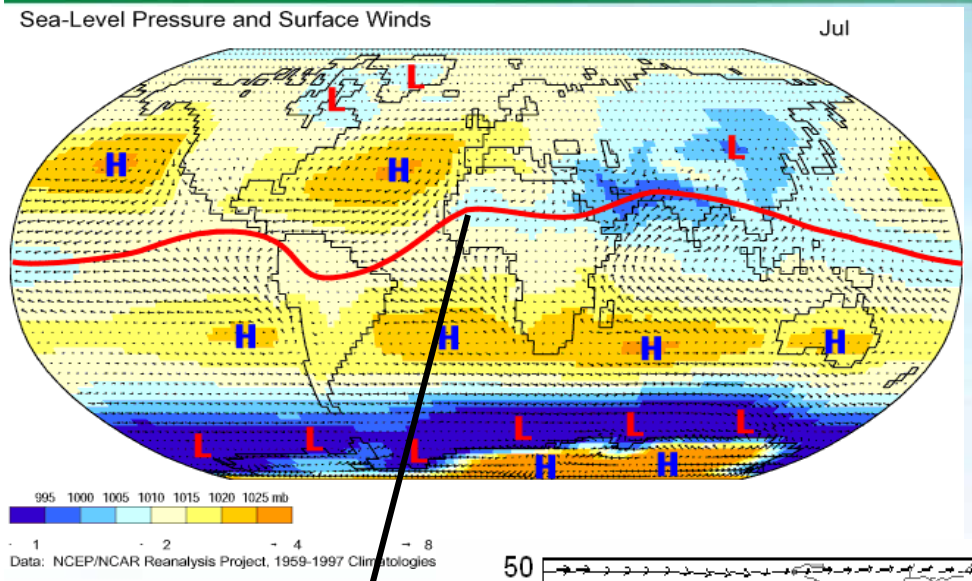


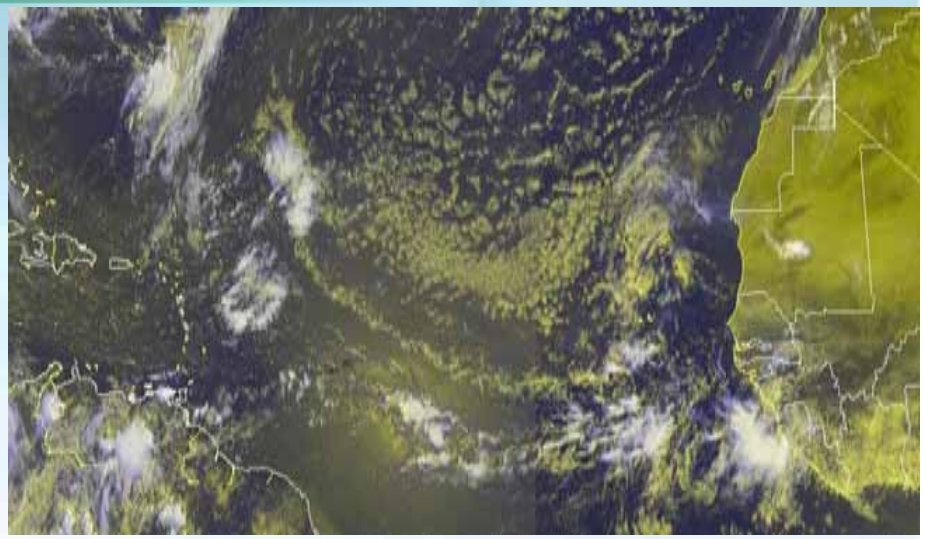
Transatlantic transport – October event



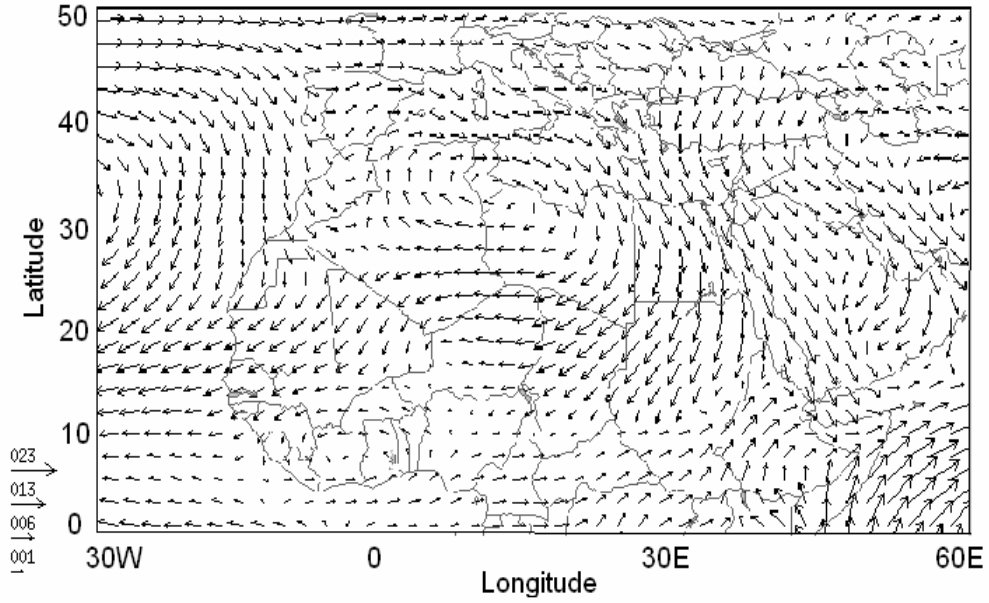
Modeled daily lindane air concentration at 3000 m from Sep 30 – Oct 12 2005

Potential effect of West European sources via ITCZ / Hadley Cell and West Africa





Inter-Tropical Convection Zone



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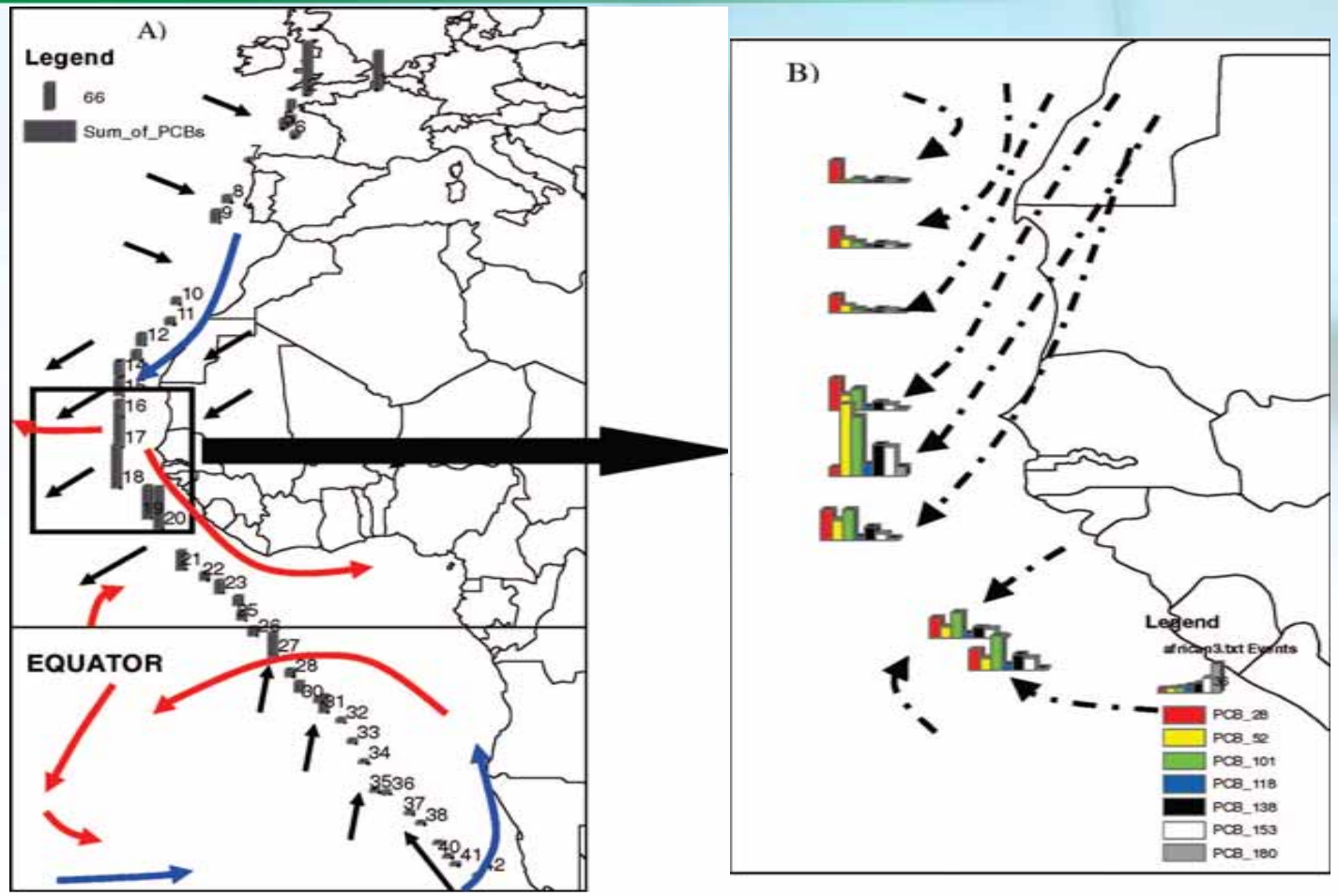
Air / seawater sampling during a cruise (2005) along the west coast of Europe and Africa



Black arrow: origin of the air masses
Blue arrow : cool sea surface currents
Red arrow : warm sea surface currents.

Gioia et al., *ES&T*. 2008

washingtonpost.com

WHO Urges Use of DDT in Africa

Call for Applications of Pesticide Changes 30-Year Policy

By David Brown

Washington Post Staff Writer

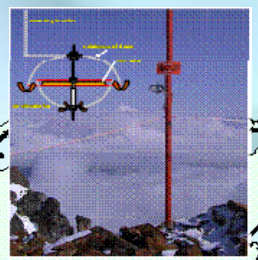
Saturday, September 16, 2006; Page A09

The World Health Organization reversed a 30-year-old policy yesterday and declared its support for indoor use of the pesticide DDT to control mosquitoes in regions where malaria is a major health problem.

The Geneva-based WHO, which provides advice to many developing countries, believes the benefits of the long-acting pesticide far outweigh any health or environmental risk it may pose……

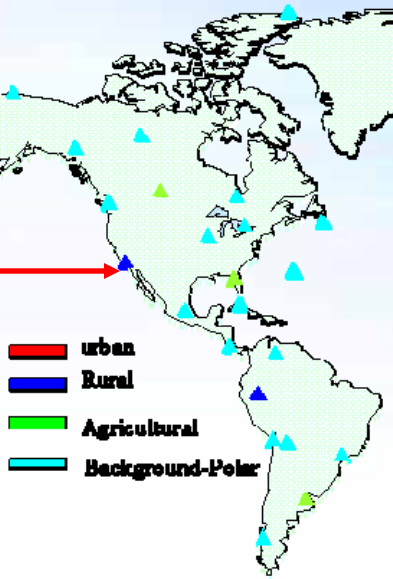
GAPS sampled DDT and Dieldrin

Paris. Dieldrin: 40-100



China. DDT: 300

California. DDT: 210-460



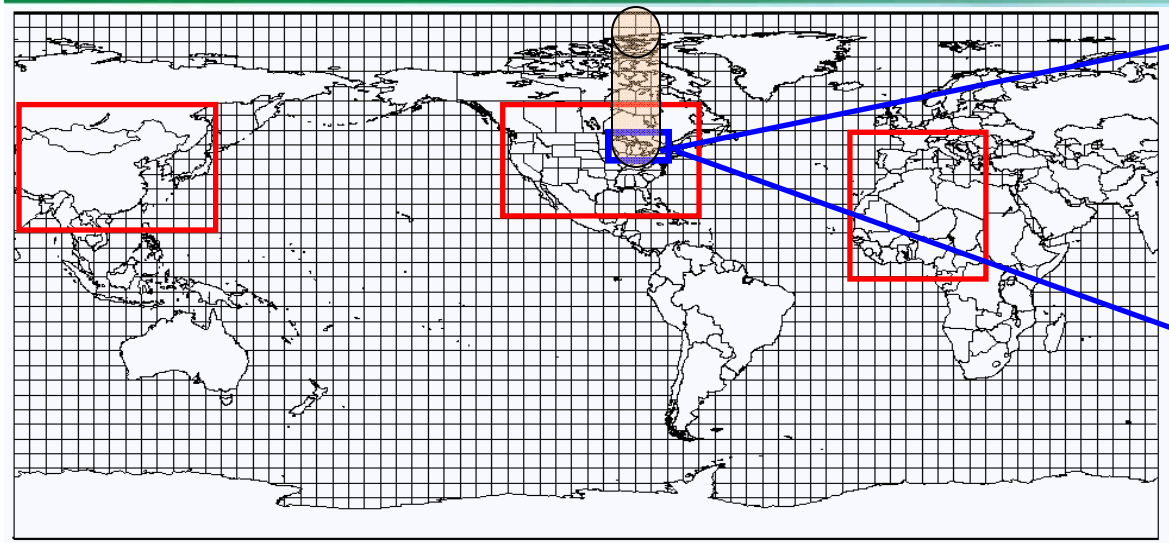
Philippines. Dieldrin: 130-190

India. DDT: 3600-6600
Dieldrin: 40-100

Canary Islands. DDT: 190-`250; Dieldrin: 190-260

Pozo et al., 2008

Impact on the Great Lakes-model scenarios



Total residue

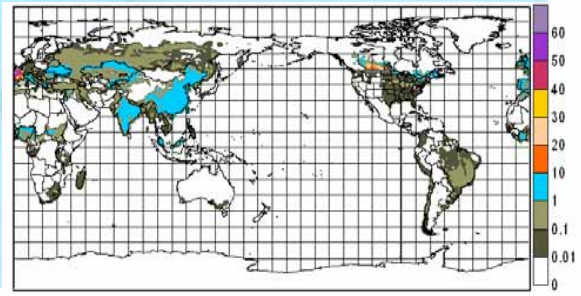
Asia: 2900 t
NA: 2300 t
Africa: 600 t
EU: 4200 t

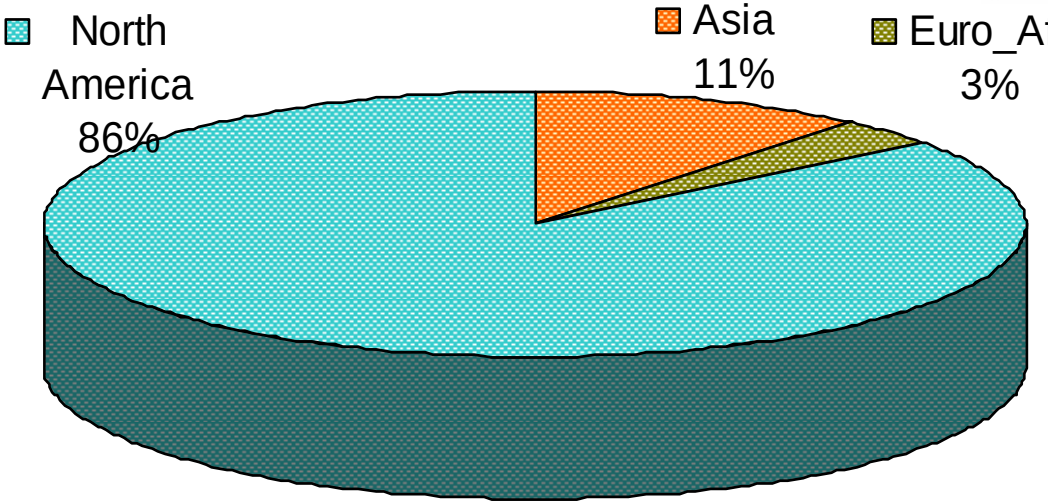
Model scenarios:

$$r_{c1} = \frac{\sum \bar{c}_1}{\sum \bar{c}_0}$$

- **Asian source with North American source**
- **African-Euro source with North American source**
- **Asian source without North American source**
- **African-Euro source without North American source**

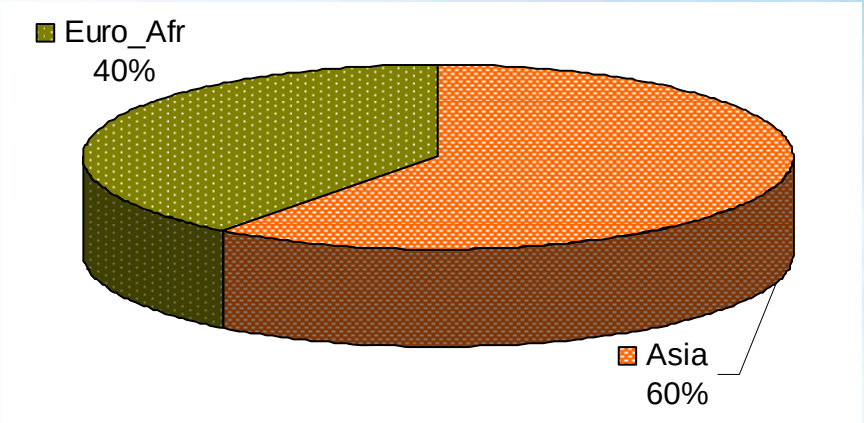
Impact on the Great Lakes-Scenarios 1 & 2



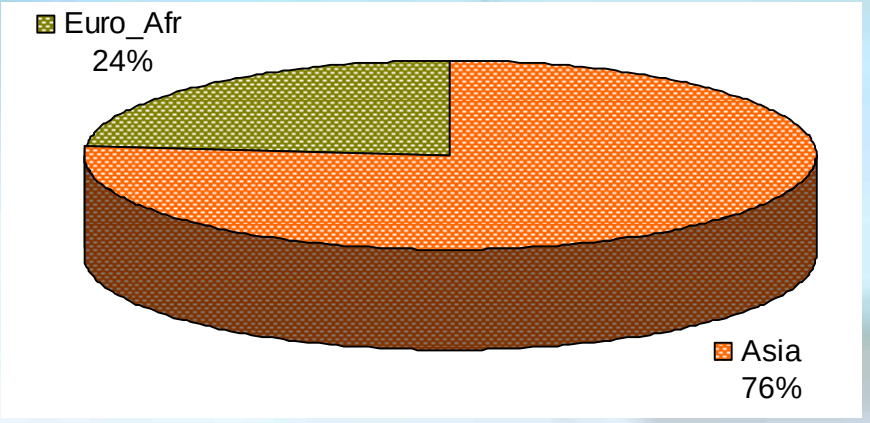


Scenarios 1 & 2 with North American source (~ 3000 m height)

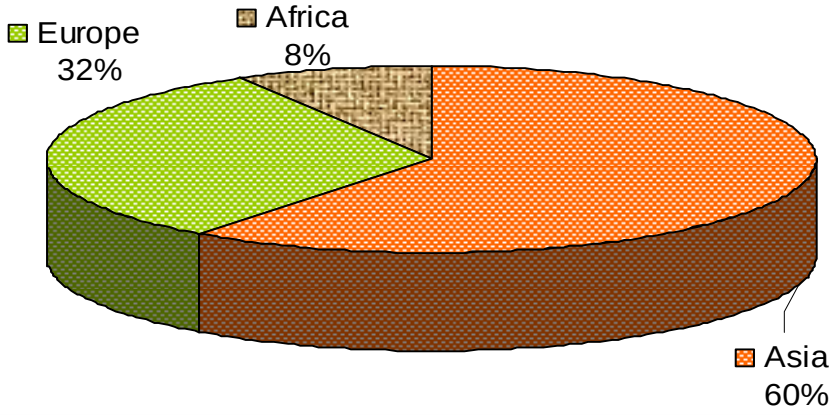
Impact on the Great Lakes-Scenarios 3 & 4



Scenarios 3 & 4 without North American source (surface)

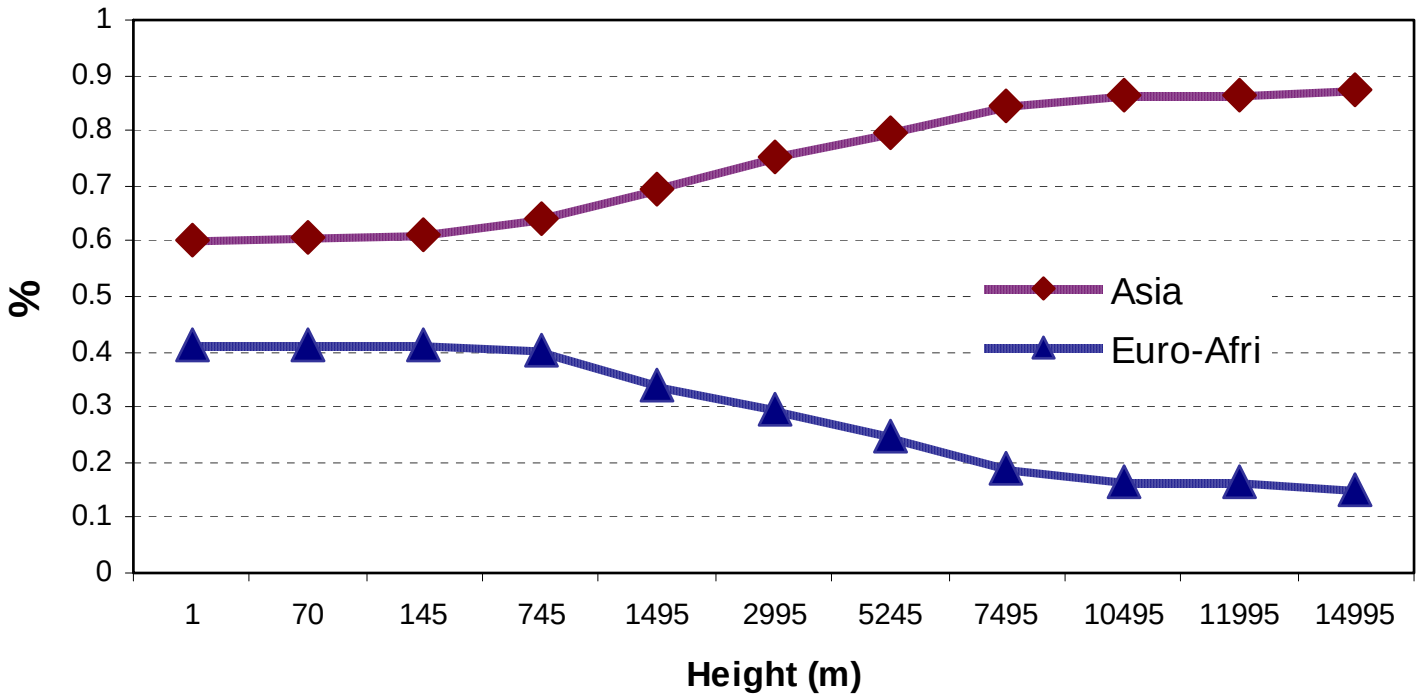


Scenarios 3 & 4 without North American source (~ 3000 m height)



Scenario without NA source (surface) with input soil residues at Asia: 2900 t, EU: 4200 t, Africa: 600 t

Impact on the Great Lakes



Change in ratios with height from model scenario 3 and 4

Implication – “Sandwich effect” on NA