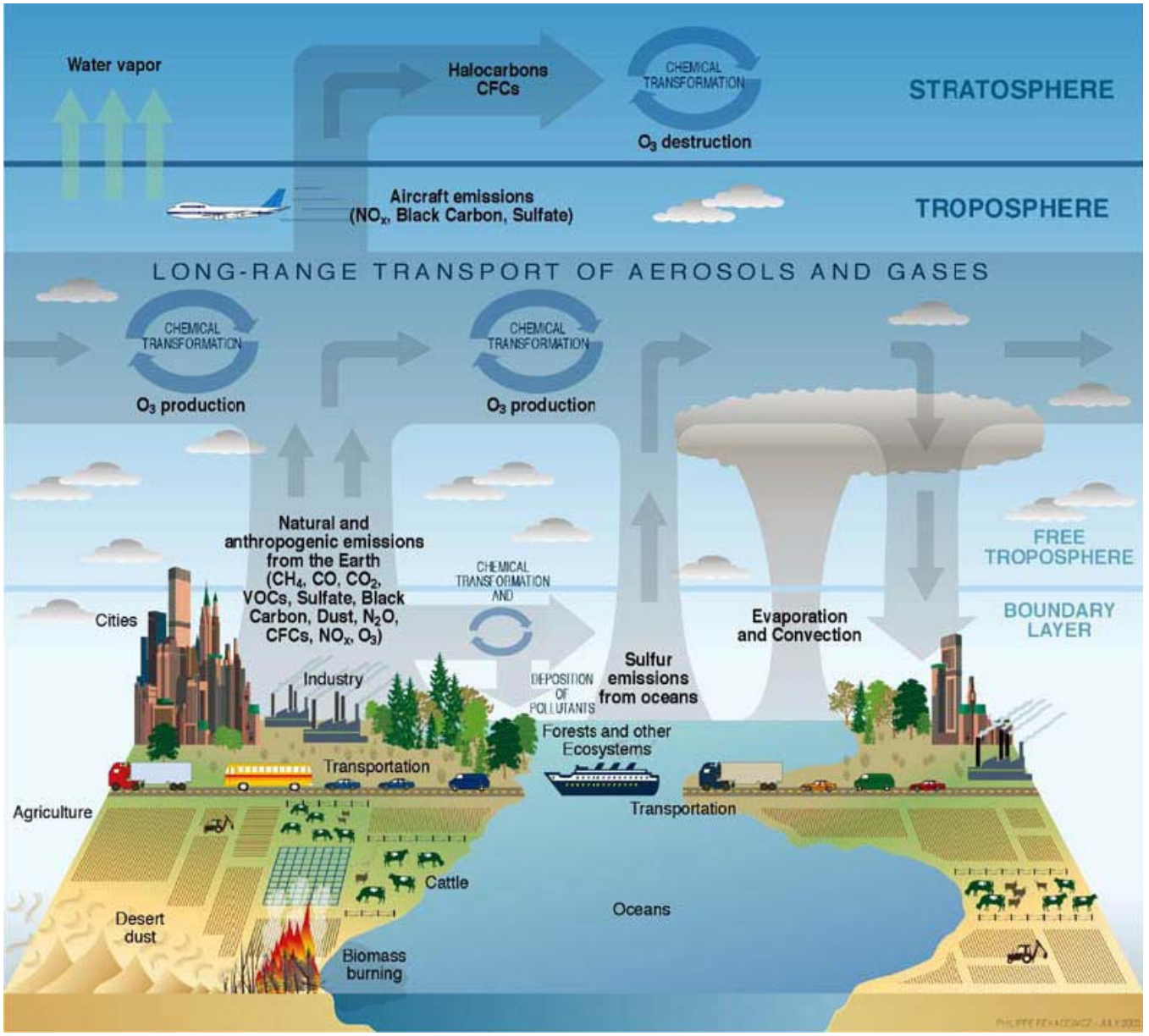
Le Prospettive della Ricerca sull'Inquinamento Atmosferico

Nicola Pirrone
CNR-Istituto sull'Inquinamento Atmosferico, Rende
n.pirrone@cs.iia.cnr.it


Water vapor
Halocarbons
CFCs
CHEMICAL TRANSFORMATION
O_3 destruction
STRATOSPHERE
Aircraft emissions
(NO_x, Black Carbon, Sulfate)
TROPOSPHERE
LONG-RANGE TRANSPORT OF AEROSOLS AND GASES
CHEMICAL TRANSFORMATION
O_3 production
CHEMICAL TRANSFORMATION
O_3 production
Natural and anthropogenic emissions from the Earth (CH_4, CO, CO_2, VOCs, Sulfate, Black Carbon, Dust, N_2O, CFCs, NO_x, O_3)
CHEMICAL TRANSFORMATION AND
FREE TROPOSPHERE
BOUNDARY LAYER
Evaporation and Convection
Cities
Industry
DEPOSITION OF POLLUTANTS
Sulfur emissions from oceans
Forests and other Ecosystems
Transportation
Transportation
Agriculture
Cattle
Oceans
Desert dust
Biomass burning

Inquinanti di Interesse per la Qualità dell'Aria

Sulla base della Air Quality Strategy (DETR et al. 2000):

- Benzene; 1,3-butadiene; CO; Pb; NO2; O3; PM10; SO2

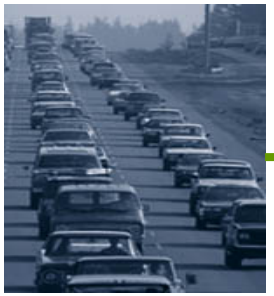
Sommando i precursori (AQEG 2004) sono da considerare in aggiunta:

- NO come precursore di NO2
- VOCs, NO e NO2 come precursori di O3

Considerando AQEG 2005 sono da considerare in aggiunta:

- SO2, NO, NO2, VOCs come precursori del PM10

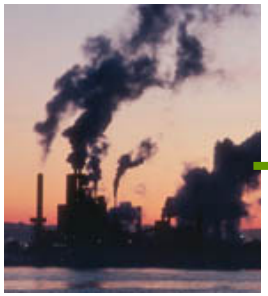
Sistem of Multi Pollutants – Multiple Impacts



Mobile Sources

NOx, VOC, PM, Toxics

(Cars, trucks, planes, boats, etc.)



Industrial Sources

NOx, VOC, SOx, PM, Toxics

(Power plants, refineries/ chemical plants, etc.)

Area Sources

NOx, VOC, PM, Toxics

(Residential, farming commercial, biogenic, etc.)

Chemistry

Meteorology

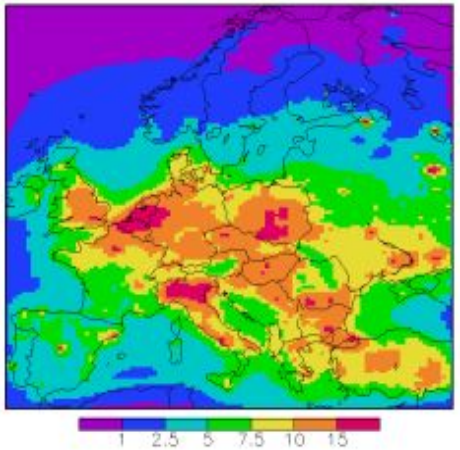
- Ozone
- PM
- Acid Rain
- Visibility
- Air Toxics
- Atmospheric Deposition
- Climate Change

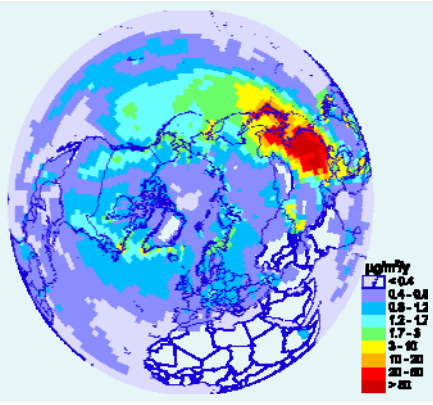
Air Pollution Control in 21st Century

Act Locally — *Think Globally*

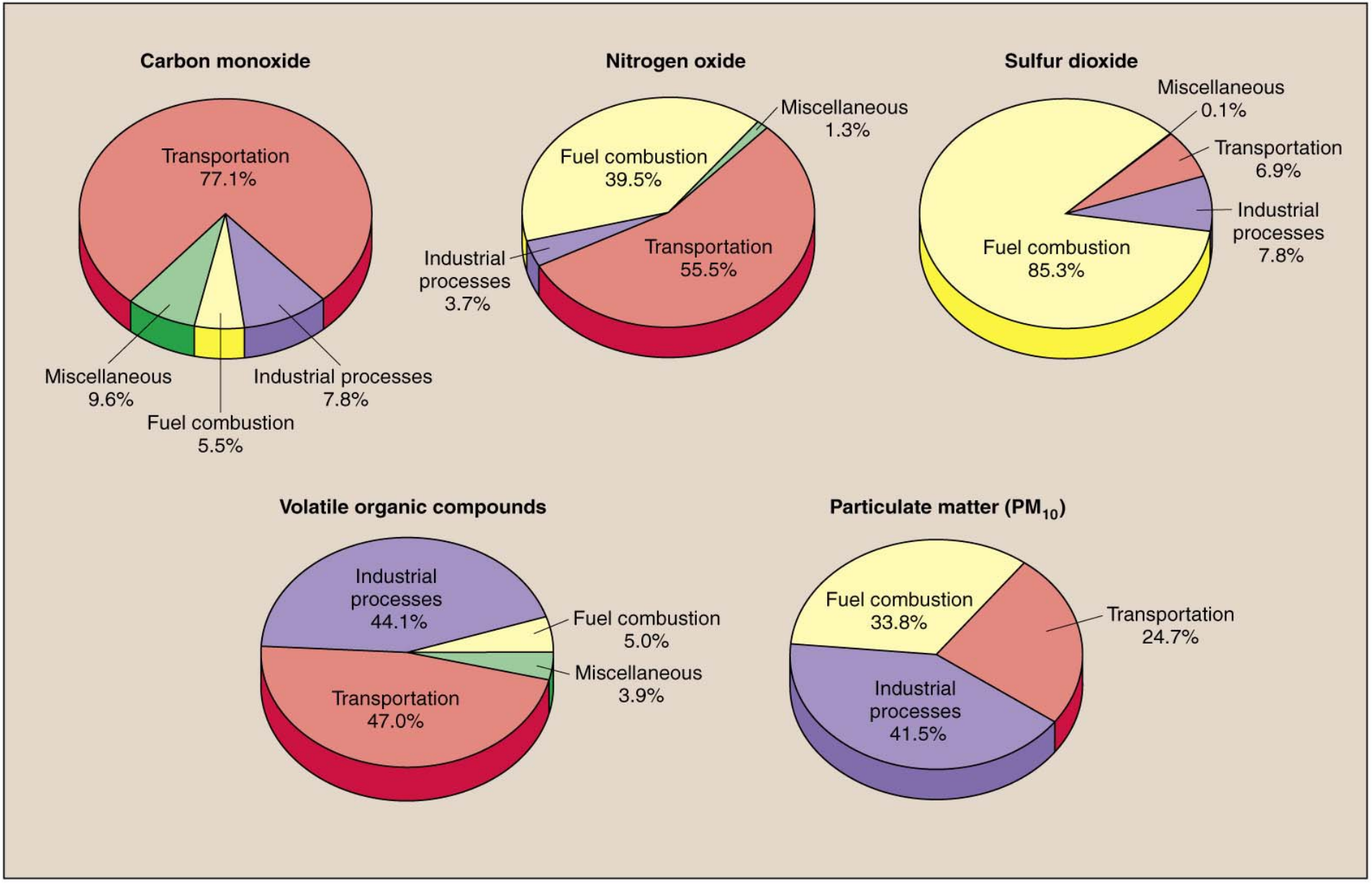
City → Country → Continental → International

1920 1950 1970 1980 1990 2000

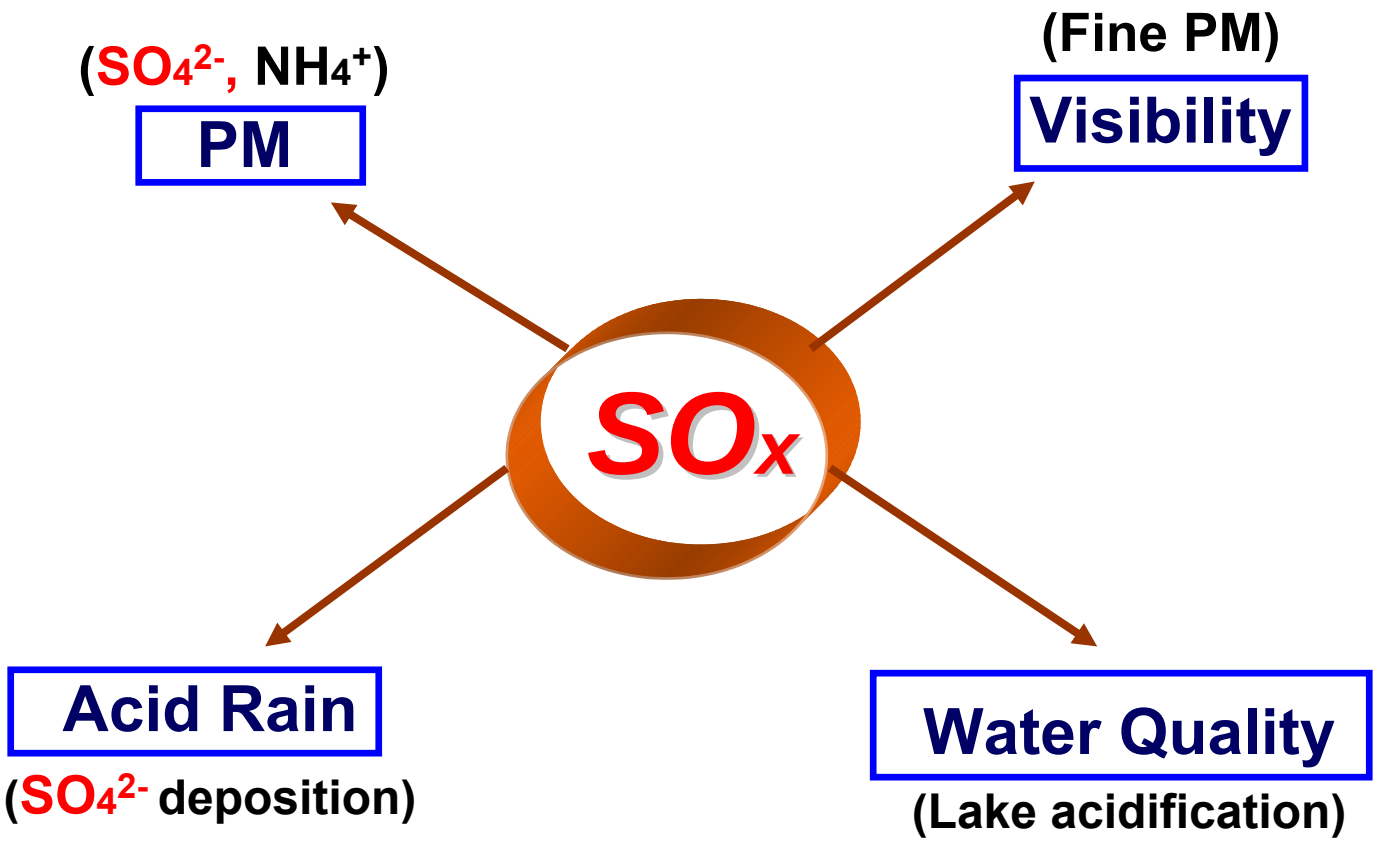




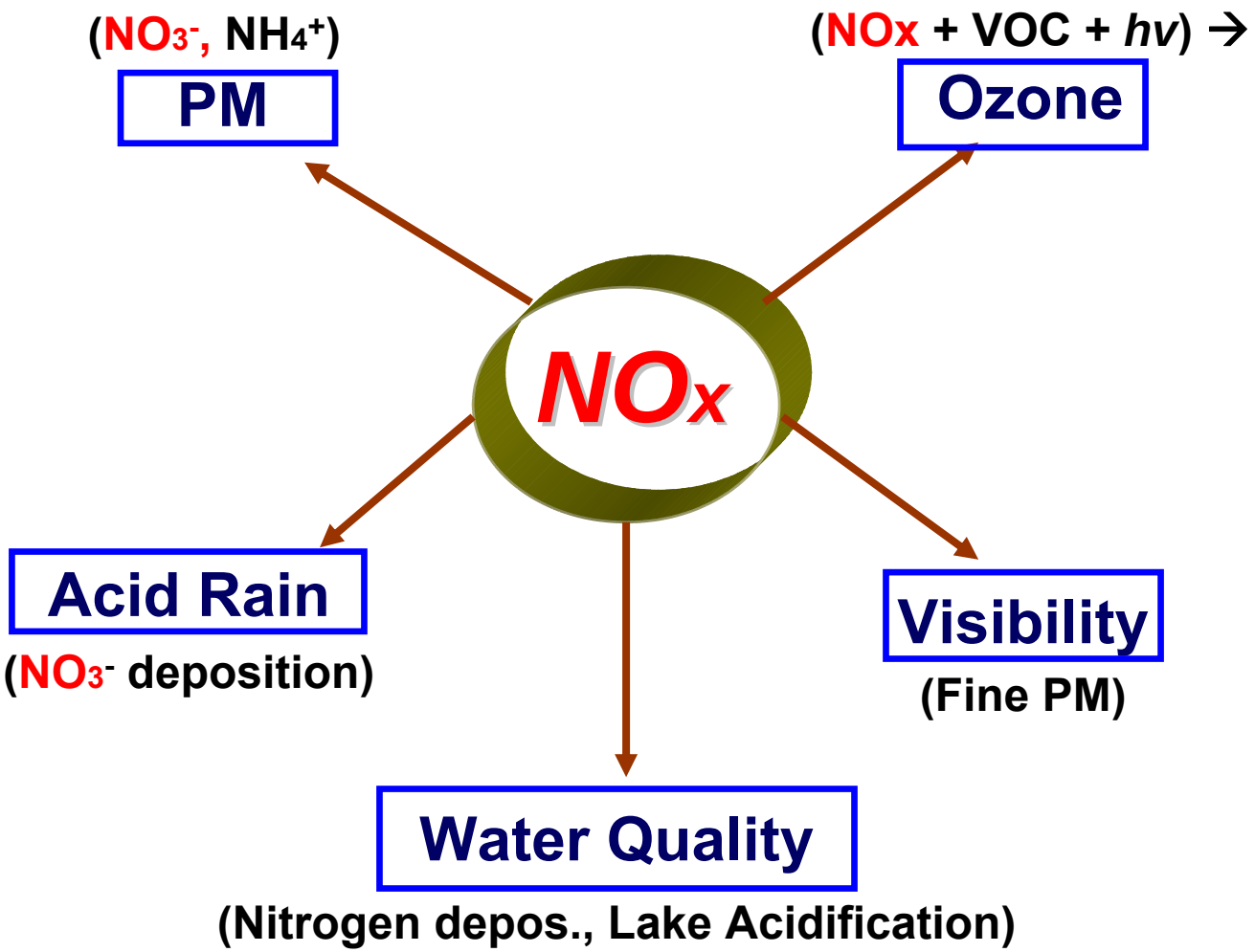
Pollutant [a]	Main anthropogenic sources	Lifetime in the atmosphere	Potential effects:				
			AQ/health effects	Acid deposition/ Eutrophication	Tropospheric O_3 [b]	Radiative forcing /climate	Oxidising capacity of atmosphere
SO_2 ($\rightarrow SO_4^{2-}$)	Fossil fuel combustion	~ days	SO_2 & SO_4^{2-} aerosol	Acid deposition		SO_4^{2-} short-term cooling	
NO_x ($NO+NO_2$) ($\rightarrow NO_3^-$)	Stationary combustion and transport	~ days	NO_2 & NO_3^- aerosol	Acid depostion and eutrophication	✓	NO_x indirect effect on CH_4 and O_3 NO_3^- short-term cooling	✓
NH_3 ($\rightarrow NH_4^+$)	Agriculture	~ days	(NH_4^+ aerosol)	Acid depostion and eutrophication		NH_4^+ short-term cooling	
N_2O	Soils, biomass	>100 years				Warming	
CO_2	Combustion	50 – 200 years				Warming	
CH_4	Fossil fuel, agriculture, landfills	12 years (adjustment time)			✓	Warming	✓
CO	Traffic	~1 month	Yes		✓	Indirect effect on CH_4 and O_3	✓
VOCs	Fuel combustion, solvents, traffic	Varies by compound	Some species		✓	Indirect effect on CH_4 and O_3	✓
Primary particles $PM_{10}/PM_{2.5}$	Combustion, traffic and grinding/dusty process	~ days	Yes in combination with secondary PM: SO_4^{2-}, NO_3^-, organic, etc.			Short-term warming and cooling	


Carbon monoxide
Transportation 77.1%
Miscellaneous 9.6%
Fuel combustion 5.5%
Industrial processes 7.8%
Nitrogen oxide
Miscellaneous 1.3%
Fuel combustion 39.5%
Industrial processes 3.7%
Transportation 55.5%
Sulfur dioxide
Miscellaneous 0.1%
Transportation 6.9%
Industrial processes 7.8%
Fuel combustion 85.3%
Volatile organic compounds
Industrial processes 44.1%
Fuel combustion 5.0%
Miscellaneous 3.9%
Transportation 47.0%
Particulate matter (PM_{10})
Fuel combustion 33.8%
Transportation 24.7%
Industrial processes 41.5%

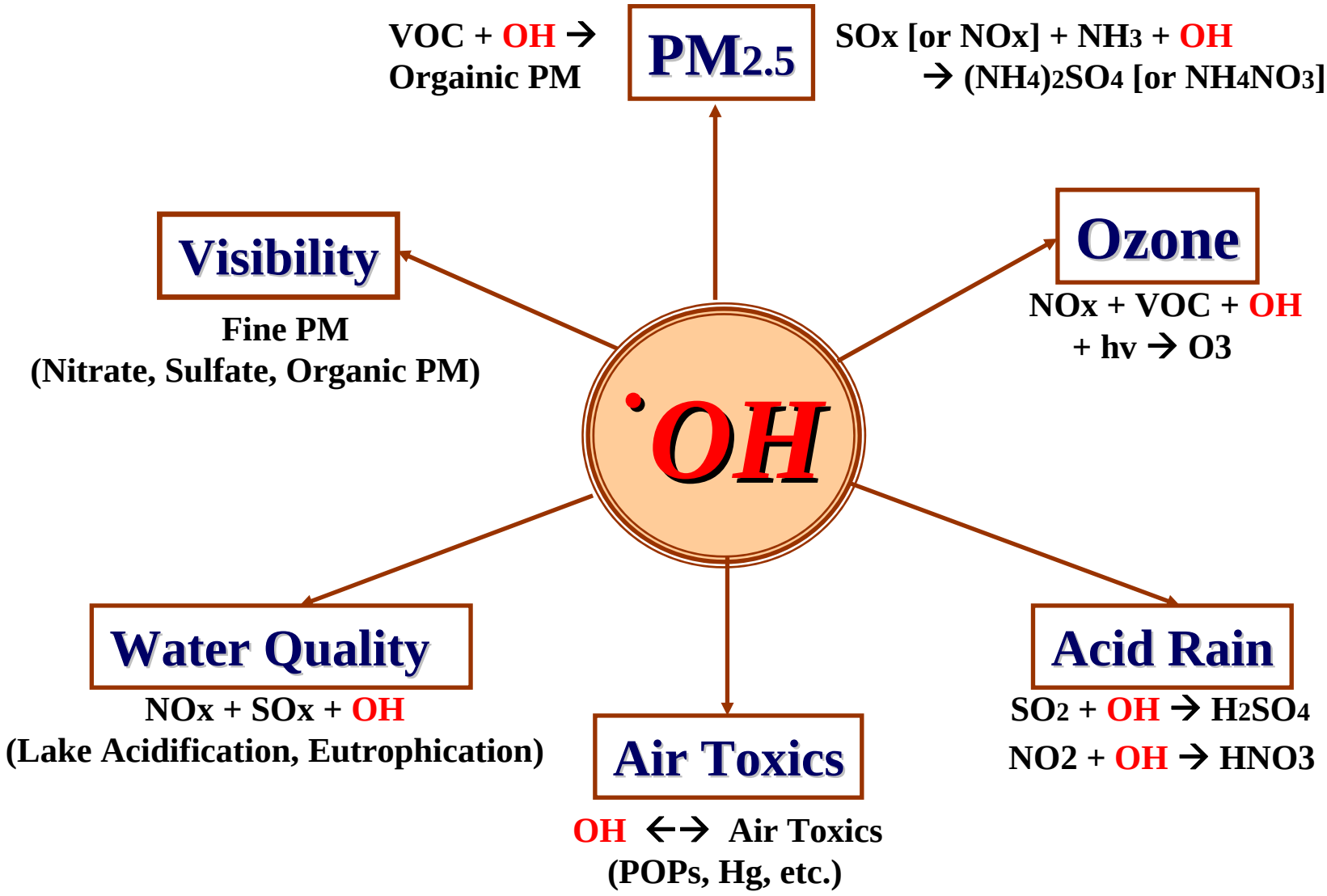
SOx Related Air Quality Issues



NOx Related Air Quality Issues



·OH Role in Linking Pollutants Formation



Beijing Air Quality Contrast

October 29, 2005

- Air Pollution Index: 48
- Primary Pollutant: PM10
- Concentration ~50 μg/m3
- Winds blowing N to S

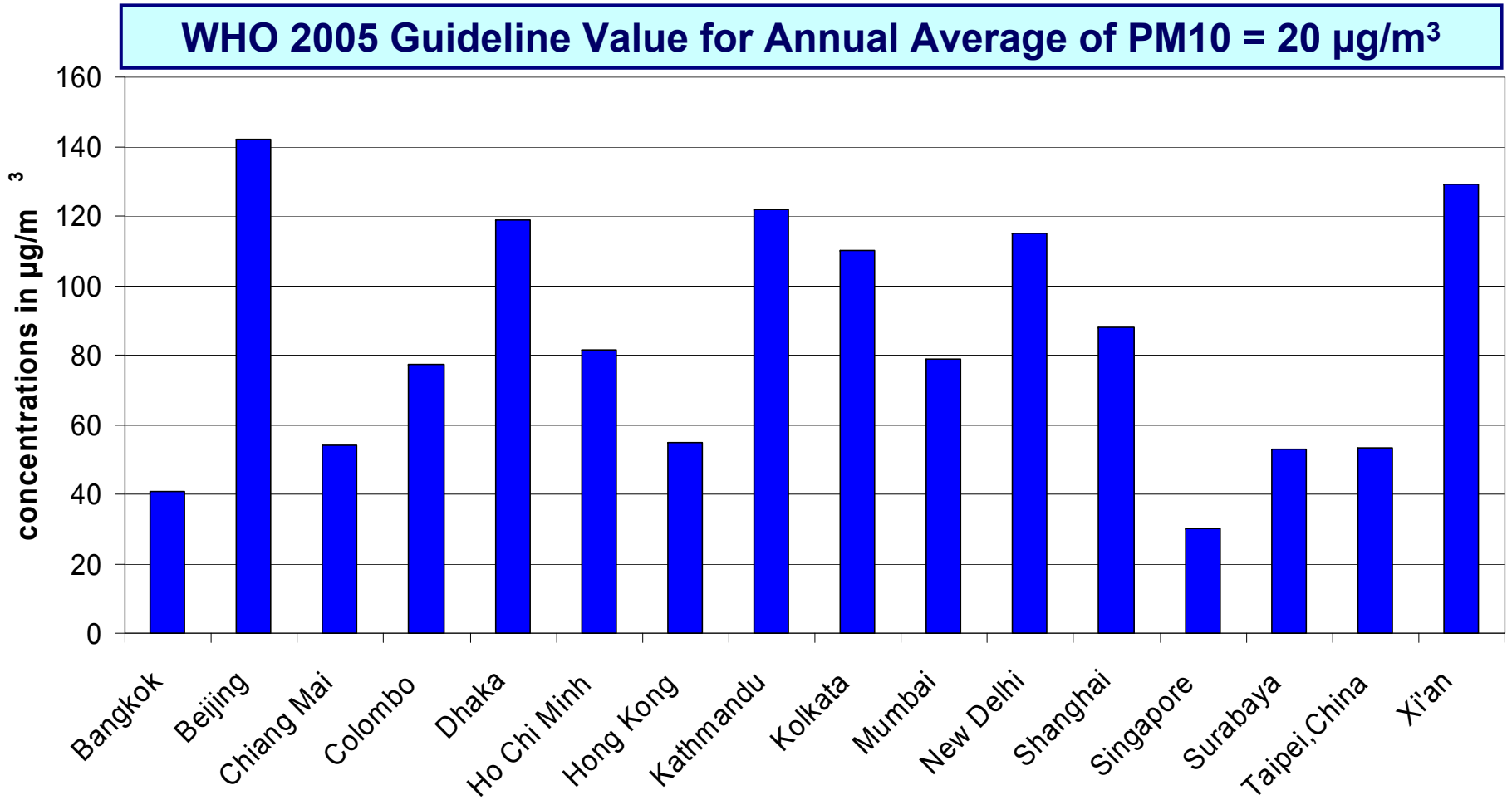
October 26, 2005

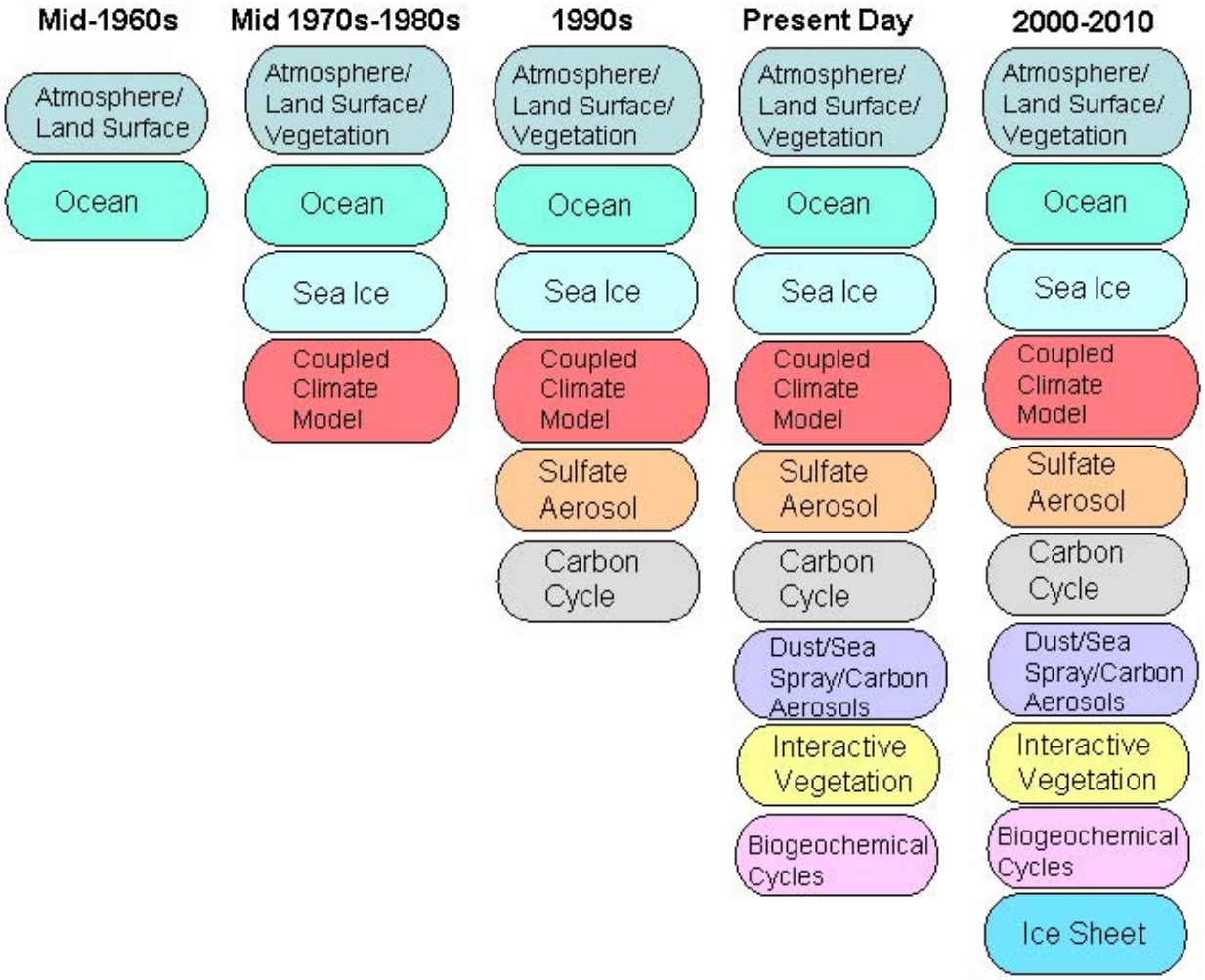
- Air Pollution Index: 176
- Primary Pollutant: PM10
- Concentration ~300 μg/m3
- Breezy or no wind

High Levels of PM_{10} in Many Asian Cities

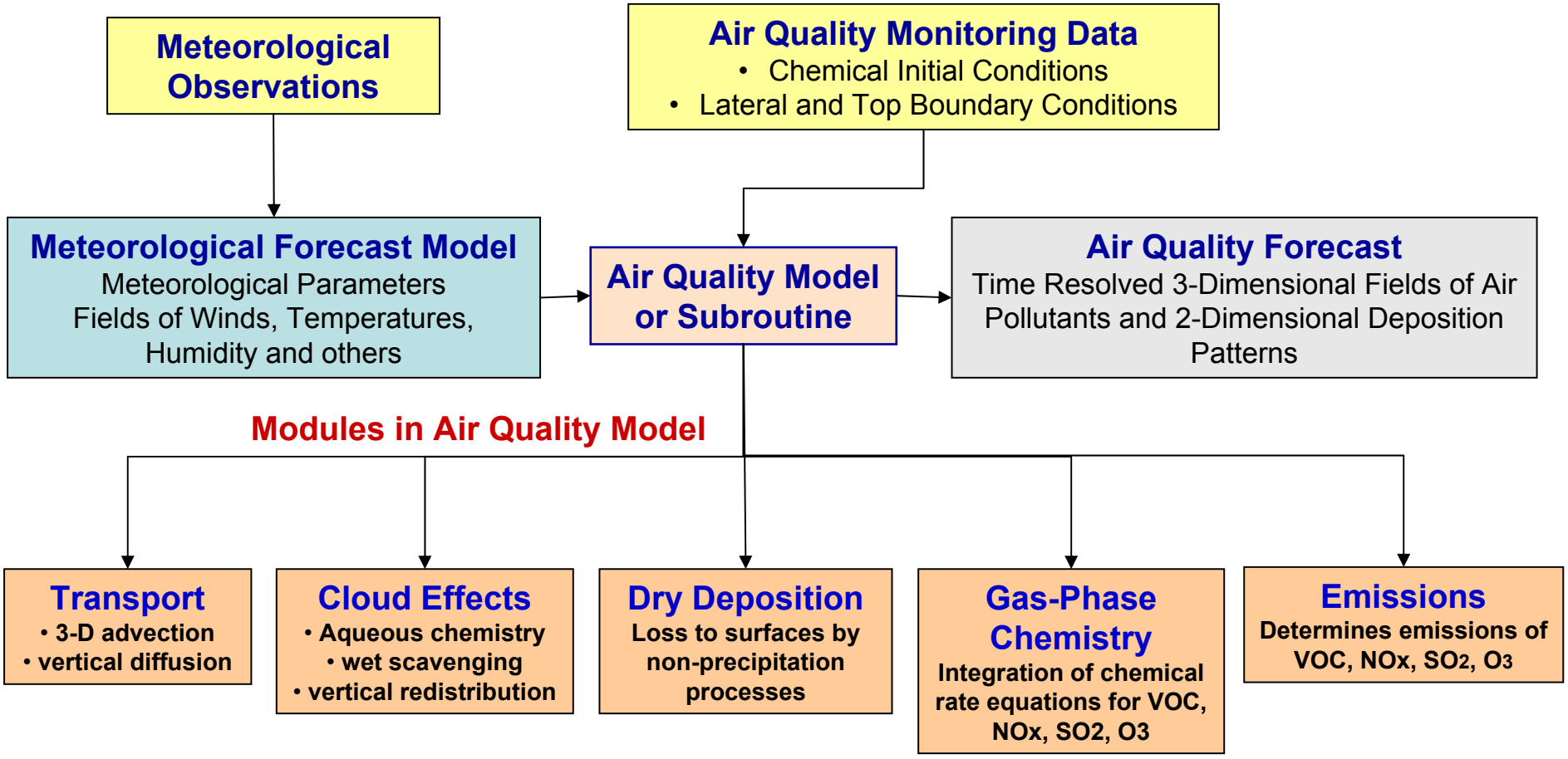
Annual Ambient Concentrations Exceed WHO Guidelines (2005)

(WHO has also set interim targets 30, 50, 70)




Mid-1960s
Atmosphere/ Land Surface
Ocean
Mid 1970s-1980s
Atmosphere/ Land Surface/ Vegetation
Ocean
Sea Ice
Coupled Climate Model
1990s
Atmosphere/ Land Surface/ Vegetation
Ocean
Sea Ice
Coupled Climate Model
Sulfate Aerosol
Carbon Cycle
Present Day
Atmosphere/ Land Surface/ Vegetation
Ocean
Sea Ice
Coupled Climate Model
Sulfate Aerosol
Carbon Cycle
Dust/Sea Spray/Carbon Aerosols
Interactive Vegetation
Biogeochemical Cycles
2000-2010
Atmosphere/ Land Surface/ Vegetation
Ocean
Sea Ice
Coupled Climate Model
Sulfate Aerosol
Carbon Cycle
Dust/Sea Spray/Carbon Aerosols
Interactive Vegetation
Biogeochemical Cycles
Ice Sheet

Air Quality Models

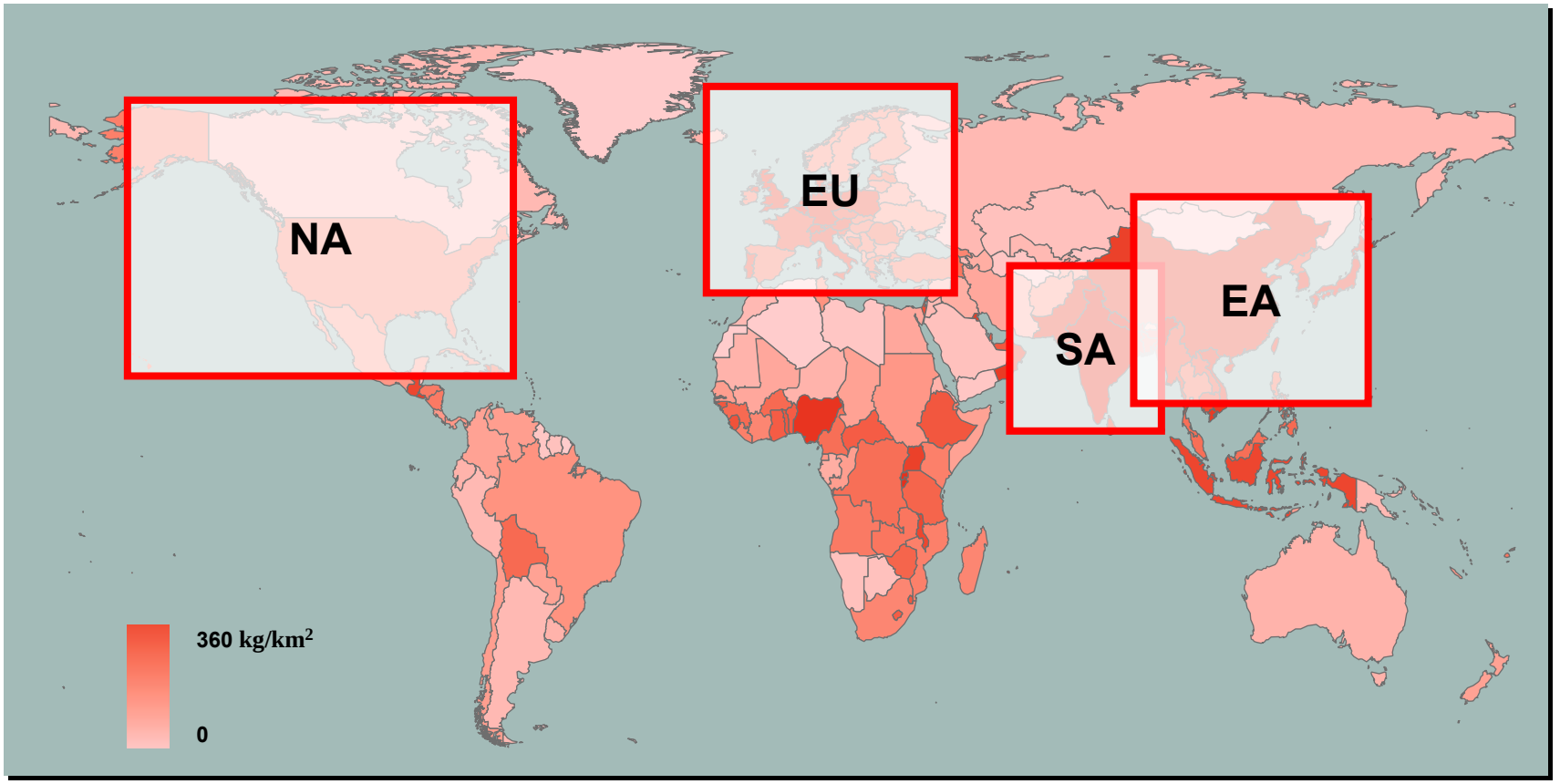


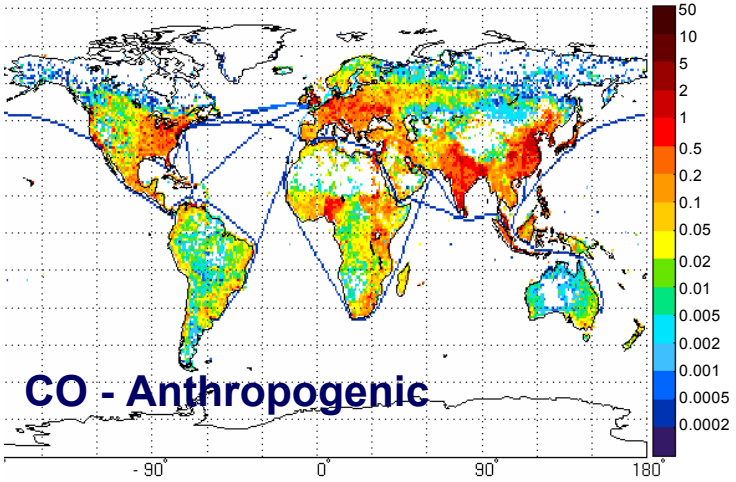
Inventari delle Emissioni

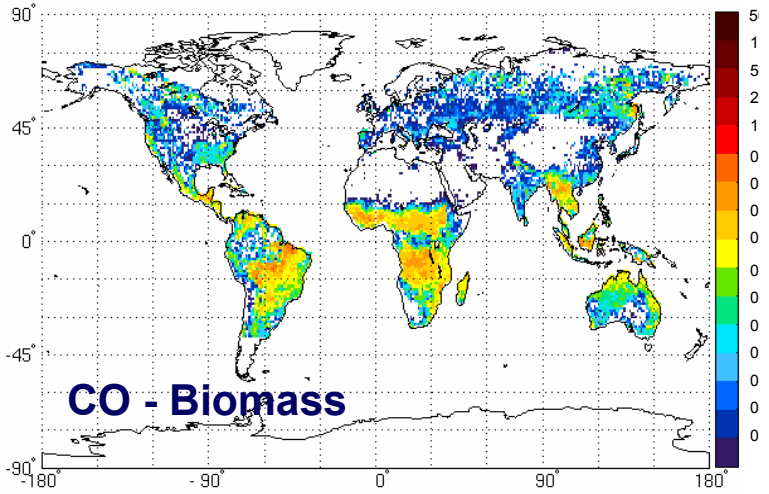
- ✓ **La valutazione del trasporto degli inquinanti atmosferici su scala emisferica e globale richiede Inventari di Emissione (IE) georeferenziati per categoria di sorgente, SO_2, NO_x, NMVOC, NH_3, CH_4, PM, CO, OC, BC.**
- ✓ **La qualità degli IE varia molto da inquinante ad inquinante e per area geografica.**
- ✓ **Per i Paesi sviluppati, alcuni degli IE sono di alta qualità in quanto sono stati verificati da misure sul campo e in laboratorio e con modelli di QA.**
- ✓ **Per i Paesi in via di sviluppo e quelli con forte industrializzazione la qualità degli IE è molto inferiore in quanto:**
  - ❑ Mancano misure alla sorgente e nell'aria ambiente circostante l'impianto;
  - ❑ Scarsa competenza tecnica per lo sviluppo di IE;
  - ❑ Cambiameni rapidi del sistema economico e sociale.

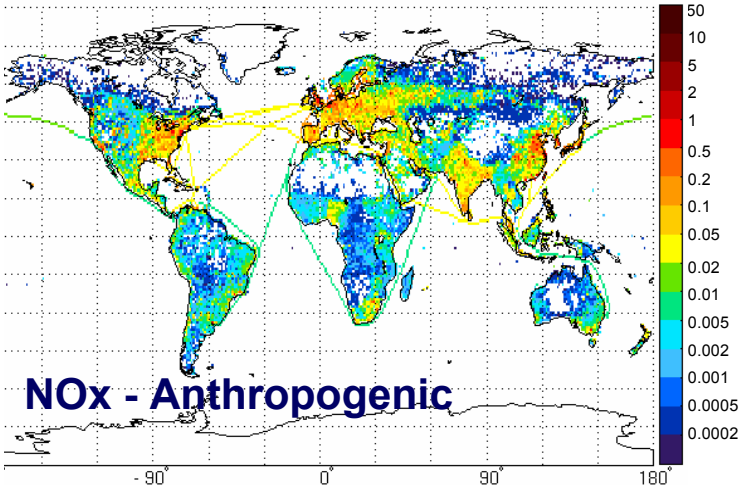
Global PAH Emission → UNECE – TF HTAP

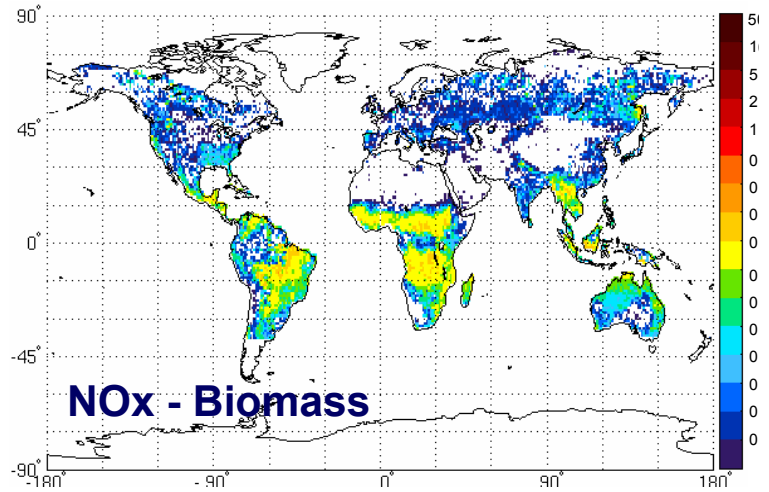
- **Global annual emission (2004): 522,000 Mg**




CO - Anthropogenic
50
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
0.0005
0.0002
- 90
0
90
180

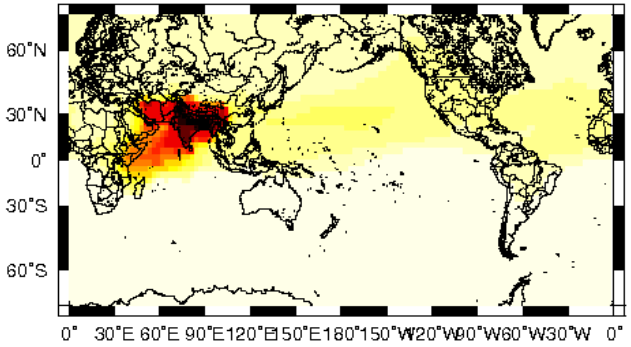

CO - Biomass
90
45
0
-45
-90
-180
- 90
0
90
180


NOx - Anthropogenic
50
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
0.0005
0.0002
- 90
0
90
180

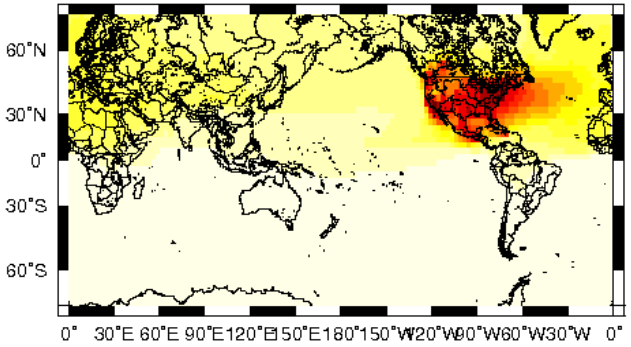

NOx - Biomass
90
45
0
-45
-90

ECHMERIT
Tracer Transport Studies – CO (Jan 2001)
CO lifetime = 50 days – spinup = 1 yr

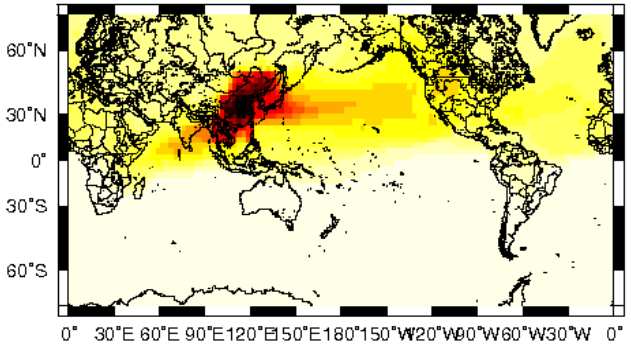
South Asia



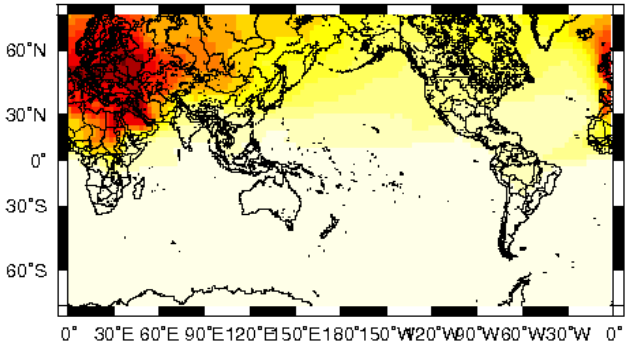
North America

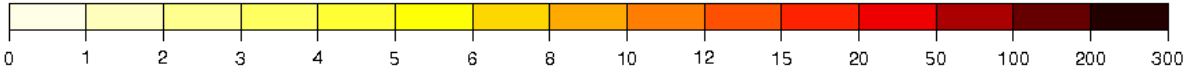


East Asia



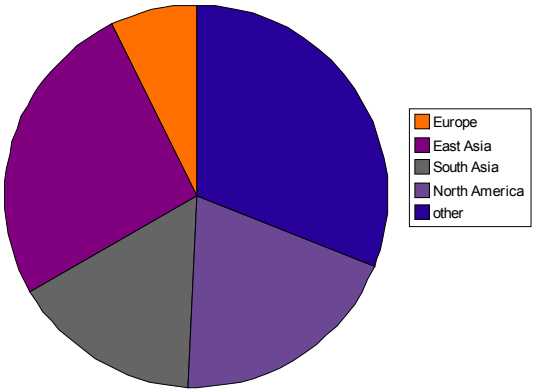
Europe



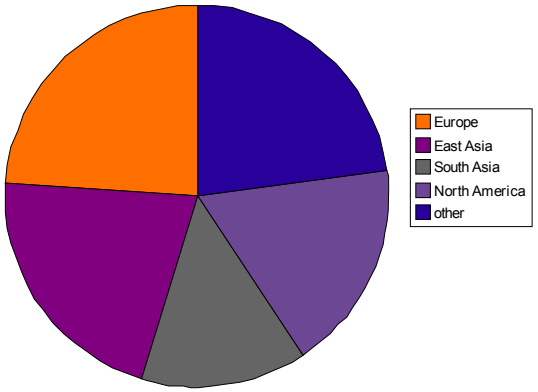


ECHMERIT
Tracer Transport Studies – CO (Jan 2001)
CO lifetime = 50 days – spinup = 1 yr

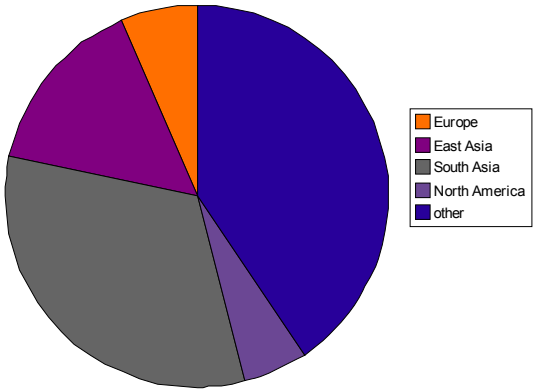
January 2001, North America



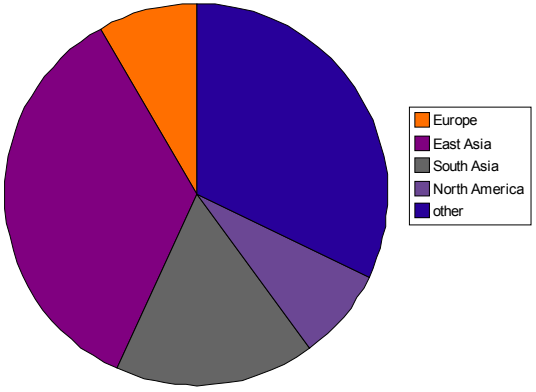
January 2001, Europe



January 2001, South Asia



January 2001, East Asia



→ “other” regions' sources > 1/4

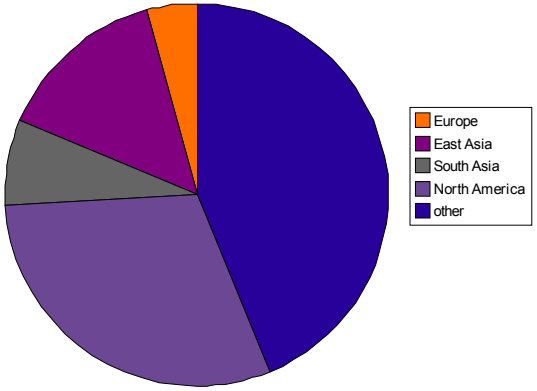
→ apart from NA: largest impact “homemade”

→ South Asia: small influence of other 3 HTAP regions

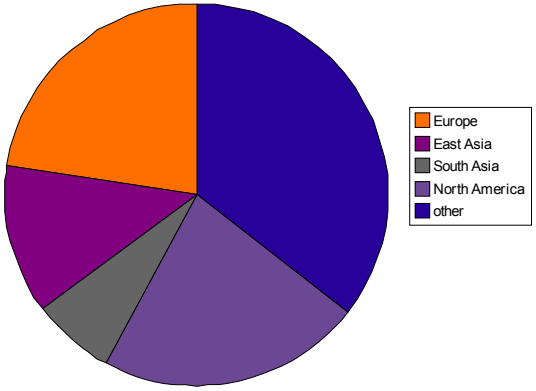
→ strong influence of east asian emissions to all receptor regions

ECHMERIT
Tracer Transport Studies – CO (July 2001)
CO lifetime = 50 days – spinup = 1 yr

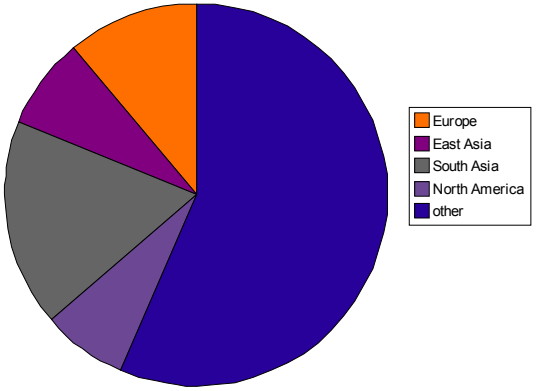
July 2001, North America



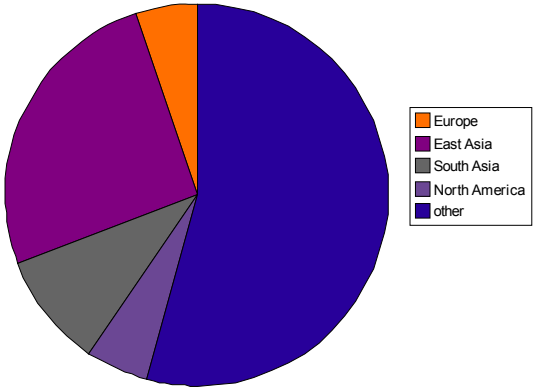
July 2001, Europe



July 2001, South Asia



July 2001, East Asia

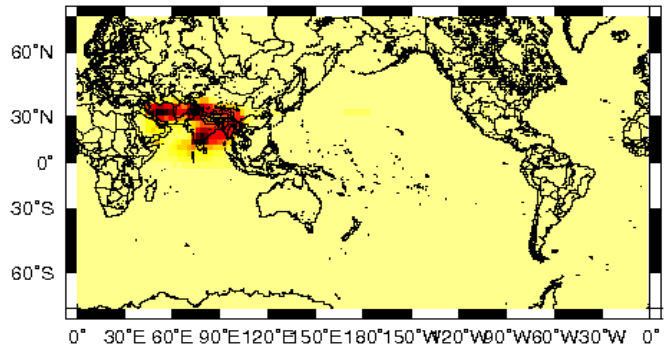


→ influence of "other" regions (SH) in northern larger in summer (emissions from Africa and South America)

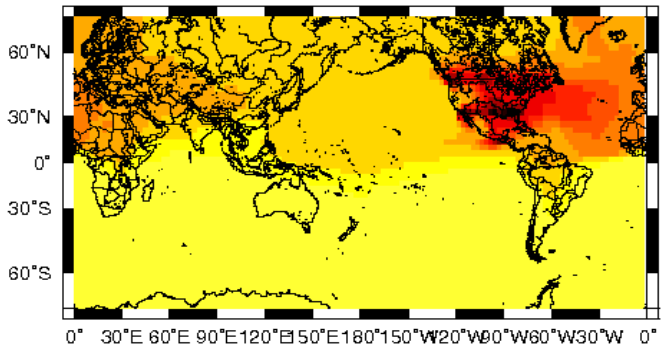
→ influence of East asian sources to receptor regions smaller in summer (less emissions)

ECHMERIT
Tracer Transport Studies – Hg (Jan 2001)

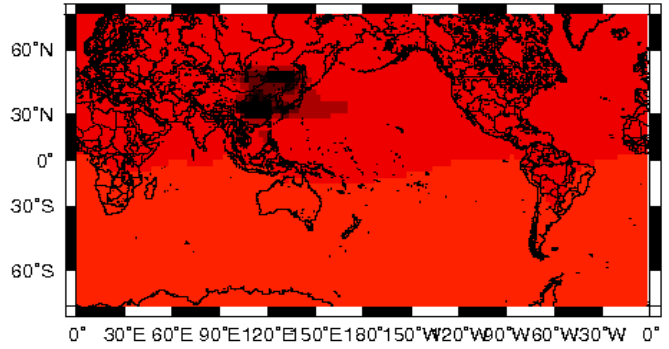
South Asia



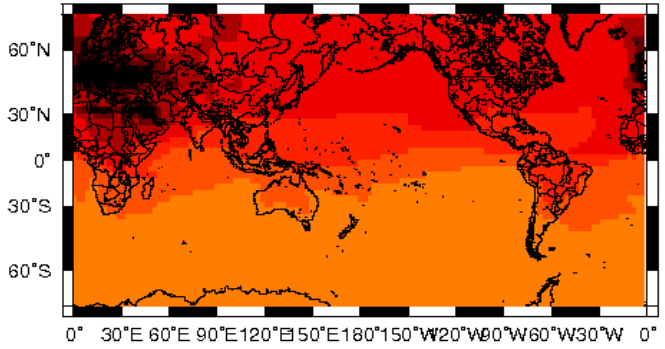
North America

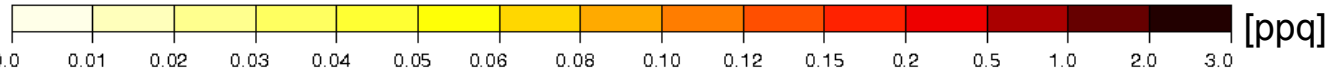


East Asia



Europe

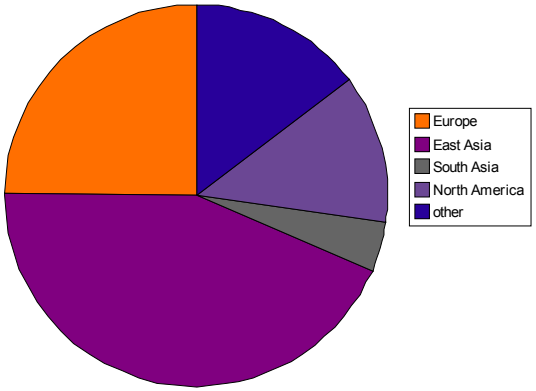




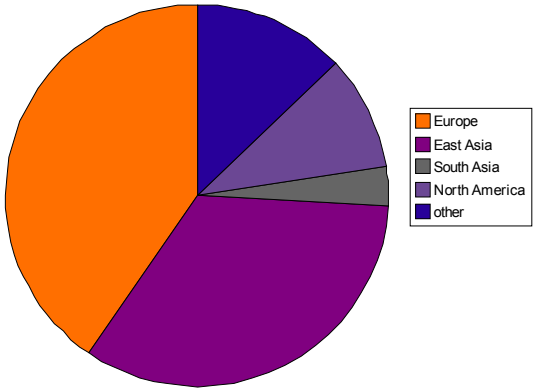
January 2001, surface layer, Hg (lifetime 360 days) concentrations according to source regions

ECHMERIT
Tracer Transport Studies – Hg (Jan 2001)

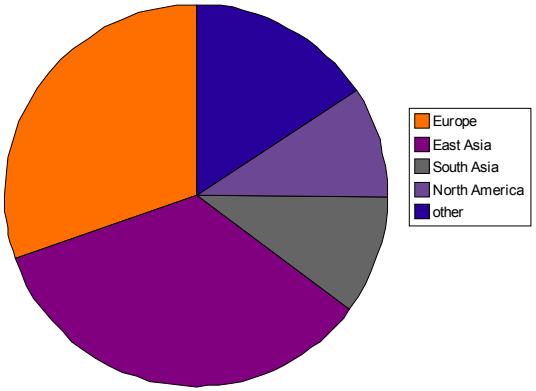
January 2001, North America



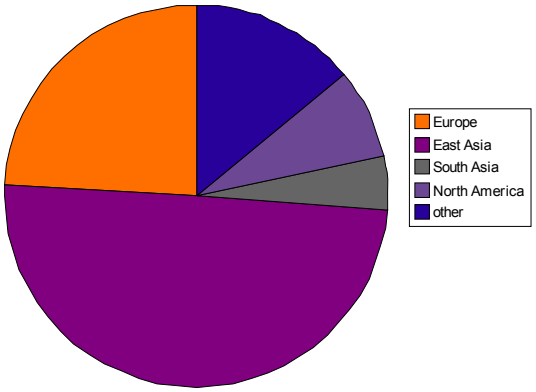
January 2001, Europe



January 2001, South Asia



January 2001, East Asia



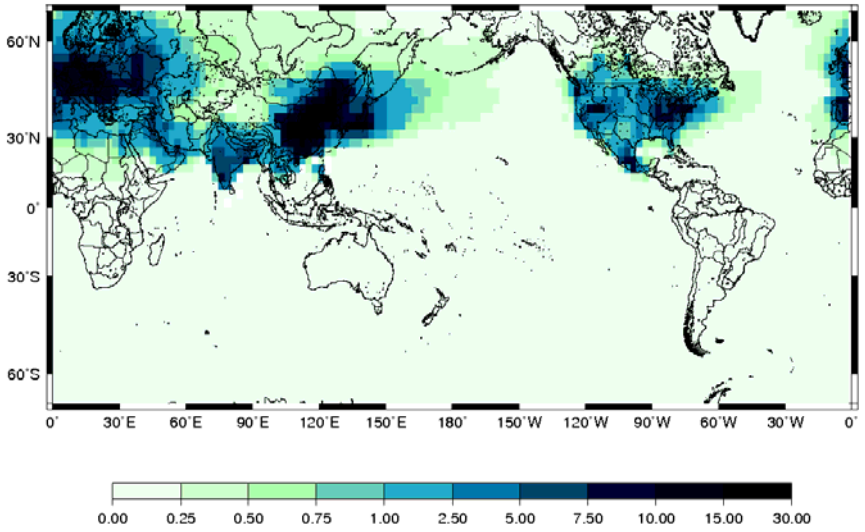
=> most important source regions:
East Asia & Europe

=> smaller differences between seasons than for CO
(longer lifetime & constant emissions)

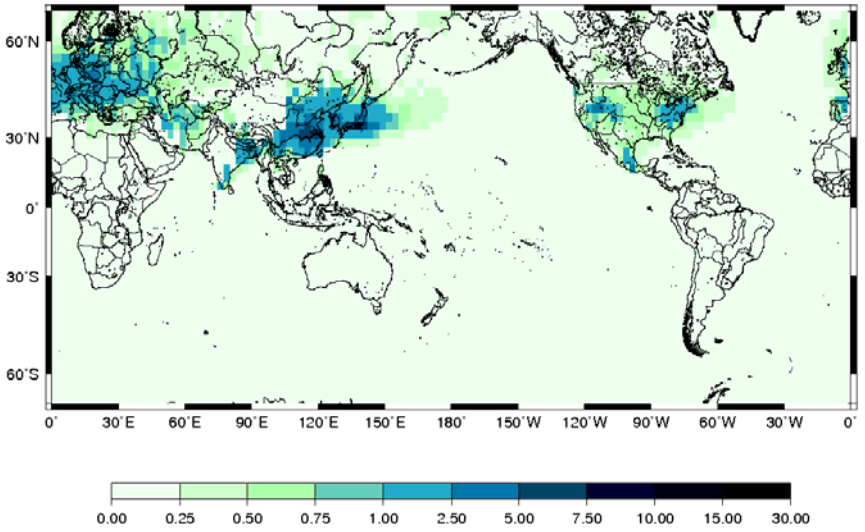
ECHMERIT
Emission Reduction Experiment – Hg (March 2001)
- Deposition Changes (%) -

Full chemistry simulations:
Emission reduction: 20% in all source regions

dry deposition change [%]

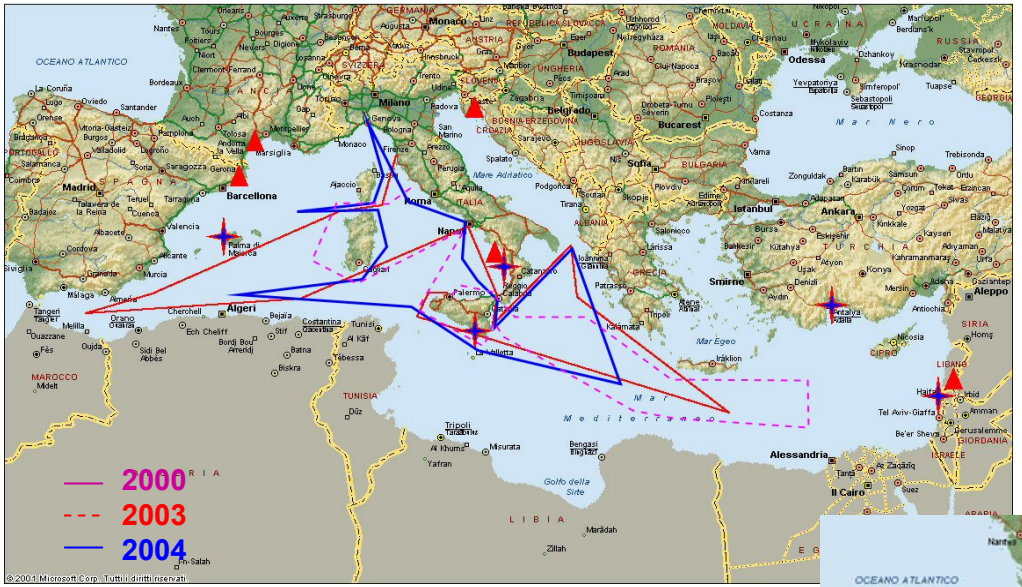


wet deposition change [%]



=> larger change in dry deposition →more direct response in surface layer

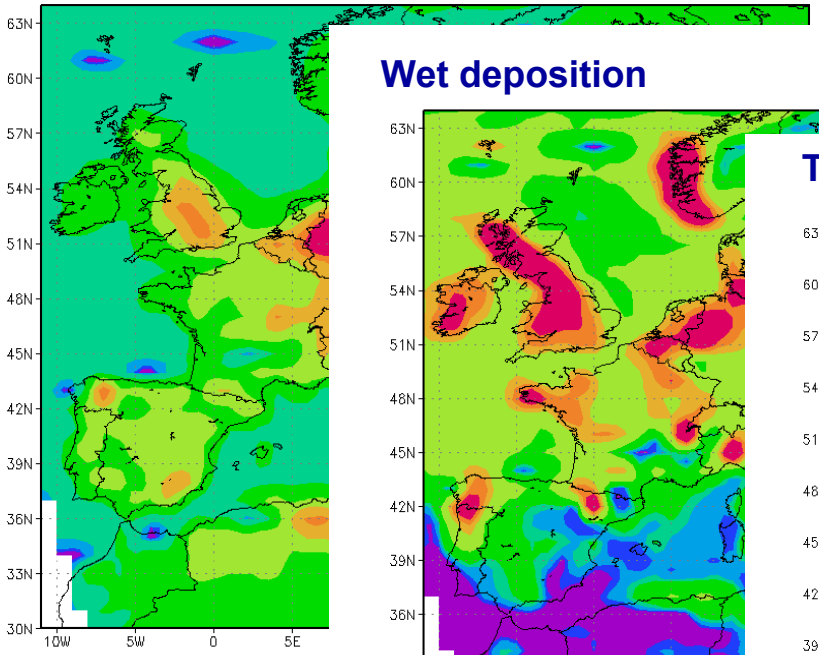
Integrated Atmospheric & Air-Water Interface Measurements since 2000



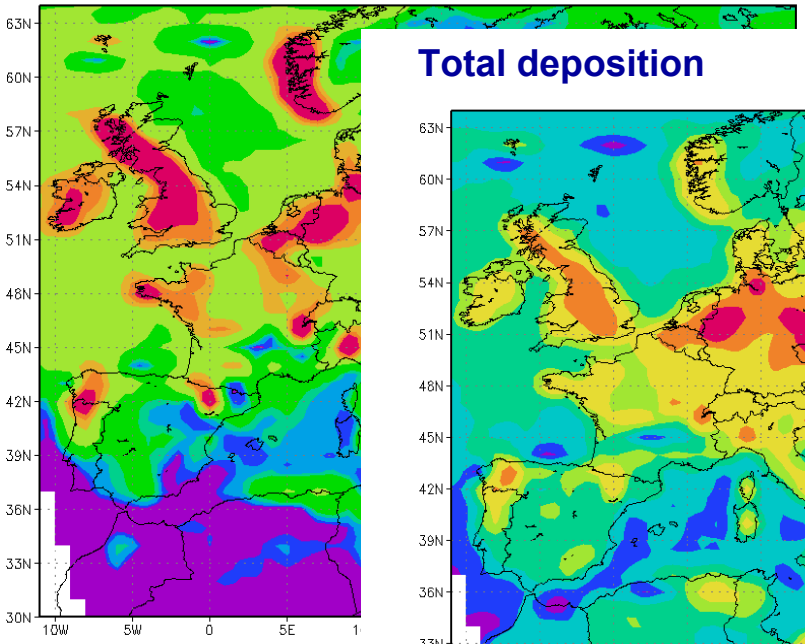
- MAMCS (FP4)
- GLOBALSOC (FP4)
- AME (FP5)
- MERCYMS (FP5)
- ESPREME (FP6)
- ELME (FP6)

Annual Modelled Hg Deposition - MECAWEx model -

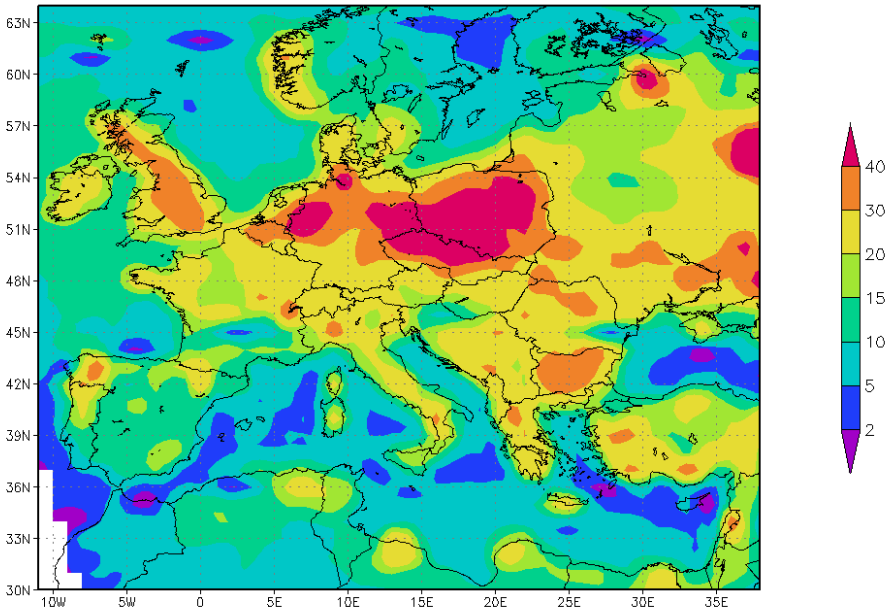
Dry deposition



Wet deposition

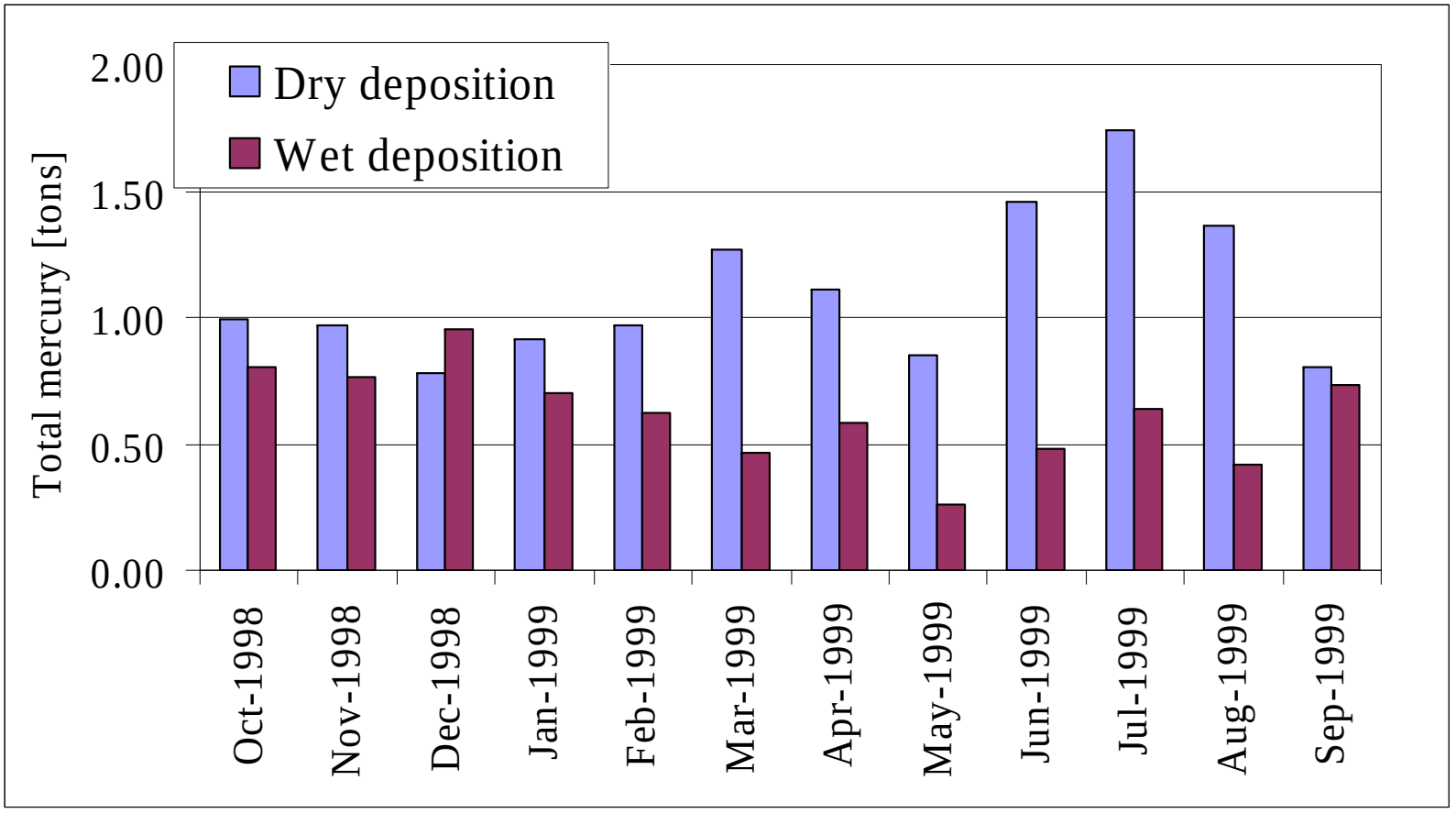


Total deposition



Source: Hedgecock et al., JGR (2006); Pirrone et al., Atmos. Environ. (2005).

Wet & Dry Deposition Loads of Hg to the Mediterranean Sea



Source: Hedgecock et al., JGR (2006).

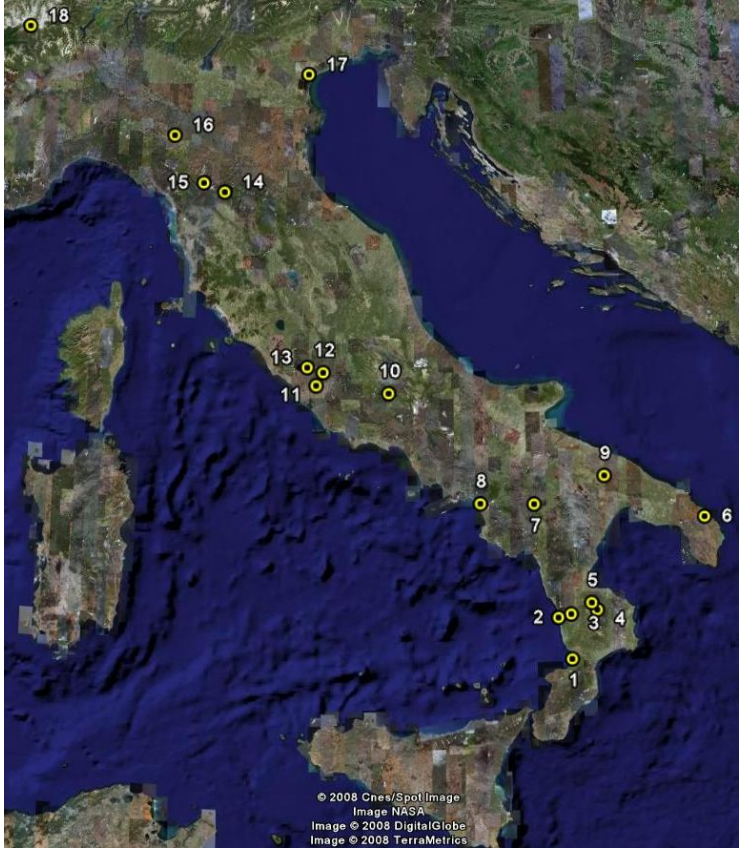
Potenziamento Infrastrutture

CLIMPOLNET:

Rete di Osservazione per lo Studio dei Cambiamenti Climatici e delle Dinamiche degli Inquinanti Atmosferici nell'area del Mediterraneo

Istituti proponenti:

- IIA
- ISAC
- IMAA
- IBAF
- ISAFOM
- IDPA
- IFAC



Numero Sito	Istituto Afferente	Numero Sito	Istituto Afferente	Numero Sito	Istituto Afferente
1	ISAC	7	IMAA	13	ISAC
2	IIA	8	ISAFOM/ IBAF	14	ISAC
3	IIA	9	IBAF/ ISAFOM	15	ISAC
4	IIA	10	IBAF/ ISAFOM	16	IBAF/ ISAFOM
5	ISAFOM/ IBAF	11	IIA	17	IDPA
6	ISAC	12	IIA	18	ISAC

Future Research on Air Quality

- **Air-Sea Exchange of Atmospheric Pollutants**
- **Pollutant chemistry in the troposphere**
- **Polar tropospheric chemistry including air-snow interface mechanisms**
- **Developelopment of source apportionment methods / models for Primary and Secondary Aerosols**
- **Influence of halogens on the tropospheric chemistry of pollutans:**
  - ✓ Halogen release from sea-salt aerosol, MBL / Coastal Zones
  - ✓ Stratospheric intrusions of reactive species
  - ✓ Polar bromine explosion

Future Research on Air Quality

- **Biomass Burning –** release of Hg, aerosols, other pollutants
- **Use of biofuels:** assess the issues related to NH_3 / N_2O / Isoprene
- **Aviation emissions** → impact on regional / global scale
- **Lab scale kinetic studies → will help improve AQ models**
- **Ships emissions with aim to assess the influence on:**
  - ✓ SO2 (formation of PM)
  - ✓ NOx (formation of PM & O_3)
  - ✓ Impact area: local → regional
- **Land use changes:**
  - ✓ Slurry, etc. → NH_3 emissions (Secondary Aerosols)
  - ✓ Biogenic emissions → O_3 and Secondary Organic Aerosols)

Opportunità Future – EC FP7

- ✓ **Sviluppo di modelli e strumenti integrati di analisi per la messa a punto di strategie idonee per la gestione della qualità ambientale;**
- ✓ **Analisi costi-benefici e valutazione di eventuali rischi inerenti ad un incremento dell'uso di biocarburanti e del trasporto marittimo;**
- ✓ **Valutazione dell'impatto dei CC sulla qualità degli ecosistemi ambientali.**
- ✓ **Valutazione dell'impatto sulla qualità dell'aria per diversi scenari futuri nei sistemi di produzione dell'energia;**
- ✓ **Sviluppo di metodologie integrate (ambiente-salute) per la valutazione del rischio.**
- ✓ **…….. + Bandi PON & POR (Regioni Obiettivo-1)**

Grazie…