RAPIDC
Regional Air Pollution In Developing Countries

Malé Declaration IIAS

Integrated Information and Assessment System

Training Session, January 2008

Pwint: programming the system

Johan Kuylenstierna: structure of the system/ impacts

Magnuz Engardt: atmospheric transport modelling

Harry Vallack: emission and scenario spreadsheets

Lars Strupeit/Philip Peck/ Ram Shrestha: scenarios and policy options

Malé Declaration IIAS

Integrated Information and Assessment System

Aims of the IIAS

- A way to integrate the different Malé Declaration activities manuals and data and provide additional information
- A tool to investigate the linkages between emissions, concentrations and deposition of major pollutants and compare to monitoring values
- A tool to look at the risks of impacts of the regional-scale air pollution to different receptors (crops, people etc.)
- A tool to investigate the implications of scenarios including different policy interventions

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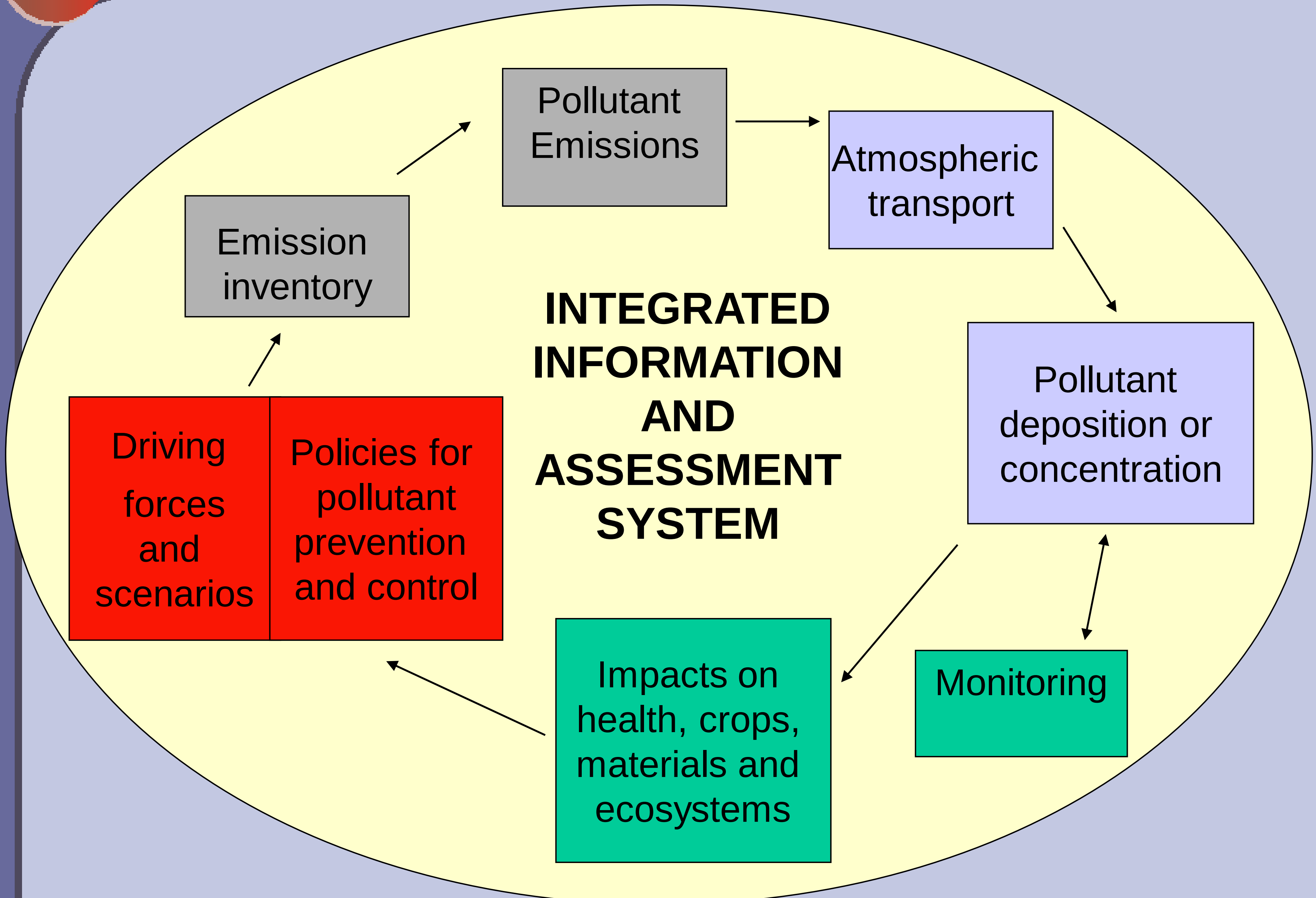
Scientific knowledge to underpin the policy process



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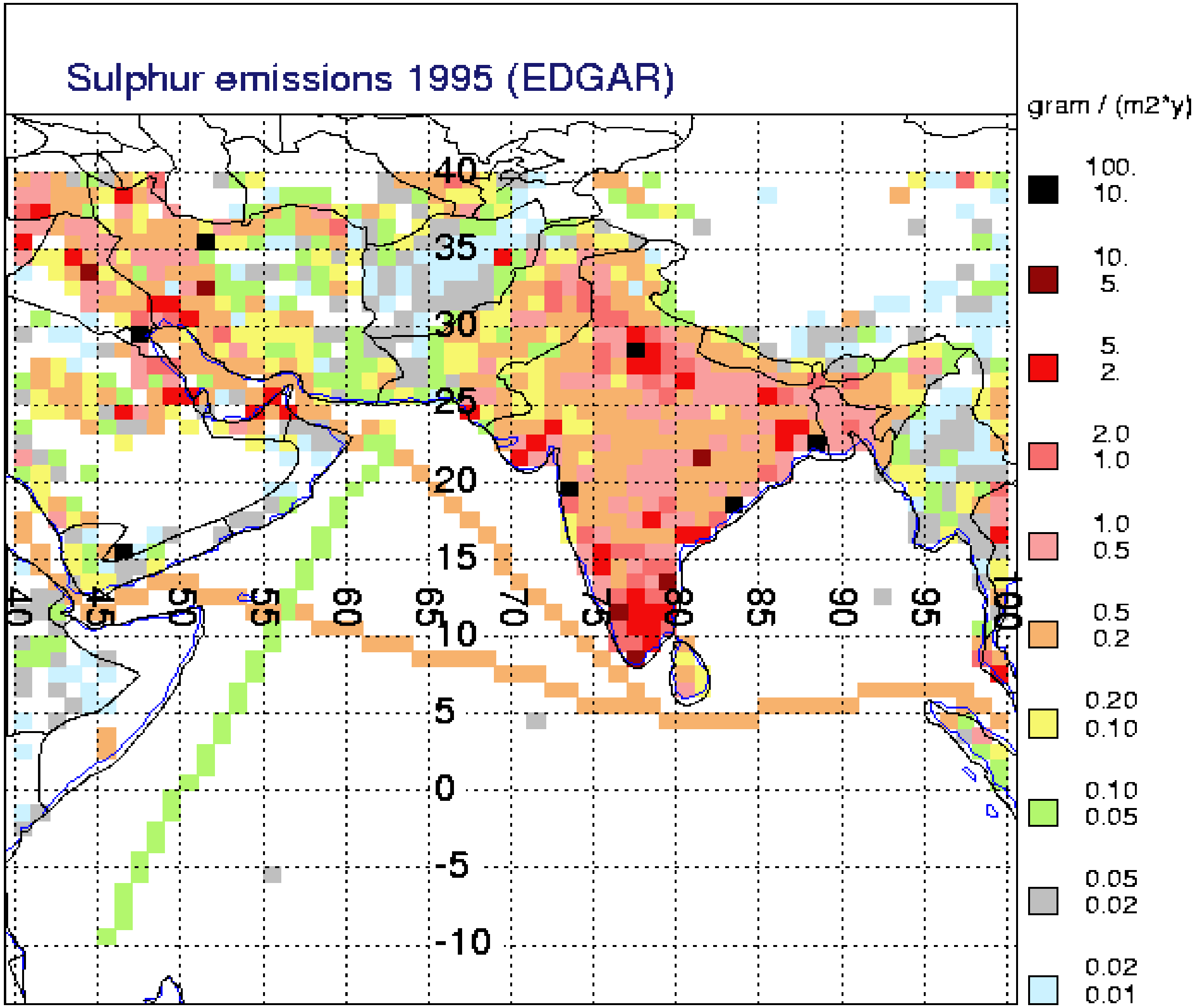
Regional Air Pollution In Developing Countries

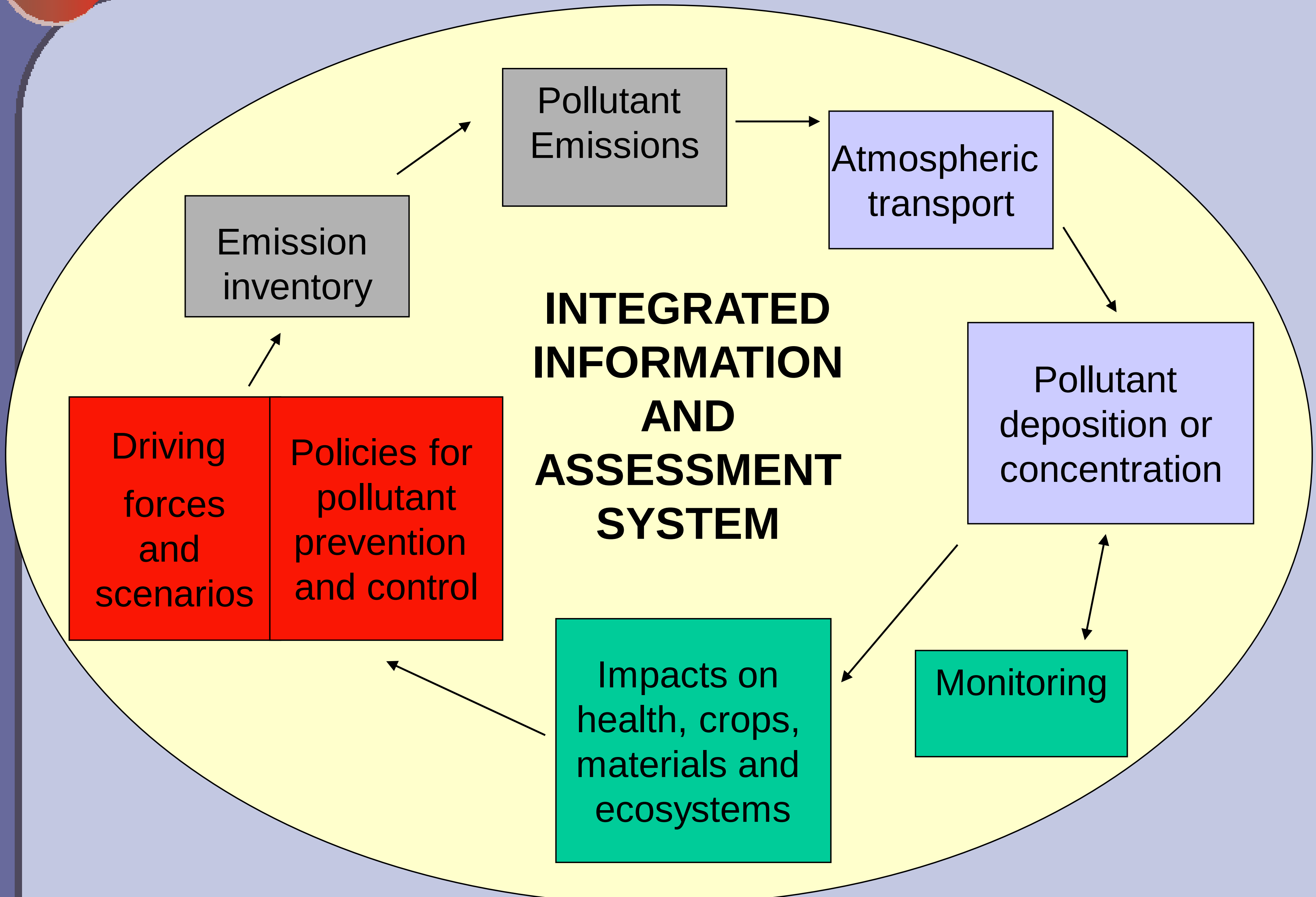


EDGAR emissions of sulphur in S Asia

Emission Regions in IIAS

Emission region IAM code	Emission region name	Provinces or states included within the emission region
BDAA	Bangladesh	Whole country
BTAA	Bhutan	Whole country
INCC	India Central	Madhya Pradesh + Chhattisgarh
INEC	East-Central	Bihar + Jharkhand
INEE	India East	Assam – NE Highlands (Arunchal Pradesh; Manipur; Meghalaya; Mizoram; Nagaland; Sikkim; Tripura)
INNC	India North-Central	Uttar Pradesh + Uttaranchal
INNN	India North	Chandigarh - Punjab; Himachal Pradesh -Jammu and Kashmir; Haryana; Delhi
INSC	India South-Central	Andra Pradesh; Karnataka - Goa
INSE	India South-East	West Bengal + Calcutta; Orissa ; Andaman and Nicobar islands
INSS	India South	Kerala - Lakshadweep; Tamil Nadu - Pondicherry
INSW	India South-West	Maharashtra; Dadar and Nagar Haveli -Daman and Diu + Bombay
INWC	India West-Central	Gujarat; Rajasthan
IREE	Iran East	East Azarbayejan; West Azarbayejan; Ardebil; Ilam; Tehran; Chaharmahal & Bakhtiyari; Khuzestan; Zanjan; Qazvin; Qom; Kordestan; Kermanshah; Kohgiluyeh & Boyerahmad; Gilan; Lorestan; Mazandaran; Markazi; Hamadan
IRWW	Iran West	Esfahan; Bushehr; Semnan; Sistan & Baluchestan; Khorasan; Fars; Kerman; Golestan; Hormozgan; Yazd
MVAA	Maldives	Whole country
NPAA	Nepal	Whole country
PKEE	Pakistan East	Northwest Frontier Provinces - FATA -Islamabad; Punjab (incl. Lahore)
PKWW	Pakistan West	Sindh (incl. Karachi); Baluchistan
LKAA	Sri Lanka	Whole country

Scientific knowledge to underpin the policy process



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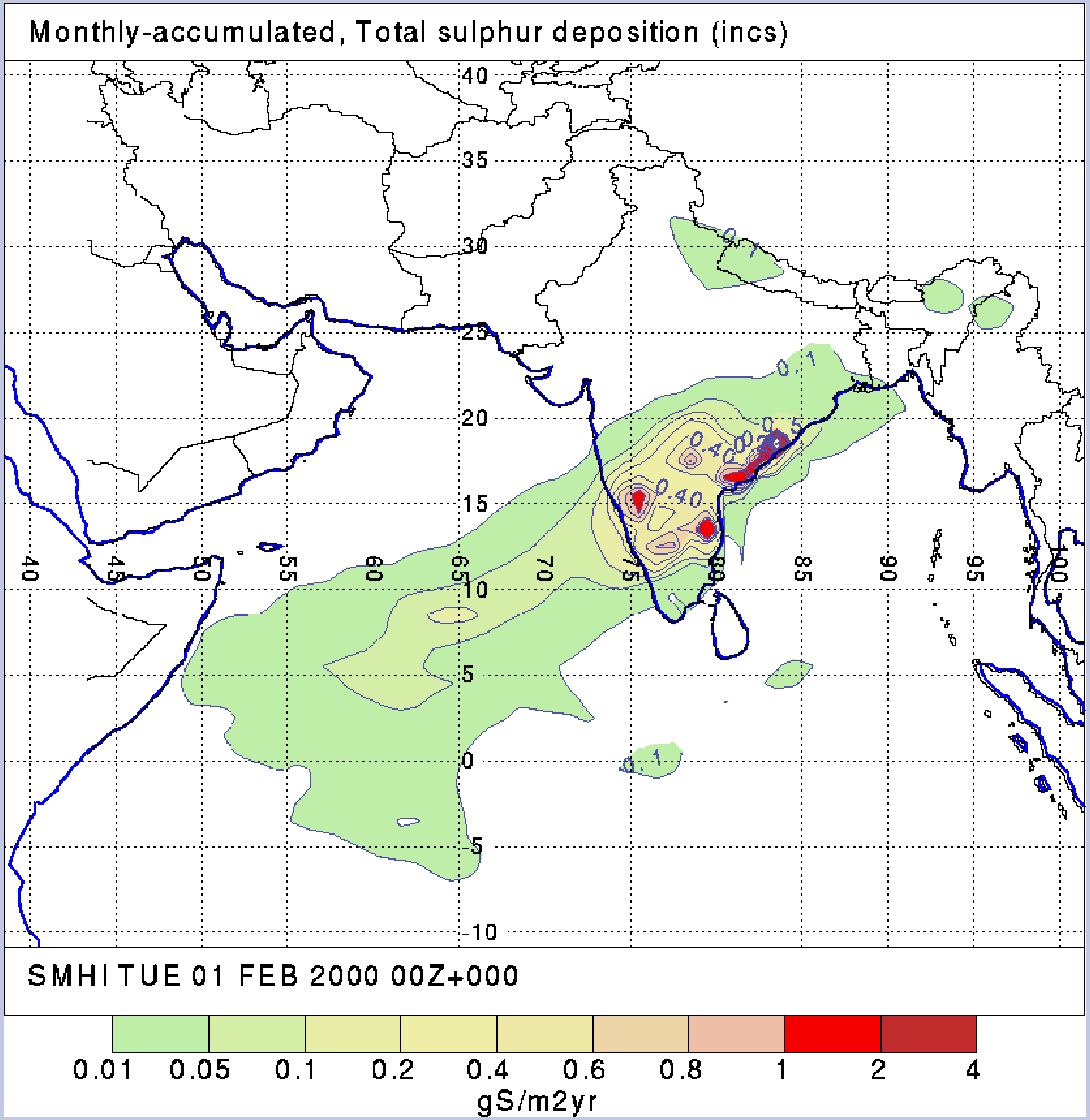

MATCH model run for emission region 'India south-central' (Andhra Pradesh + Karnataka + Goa)

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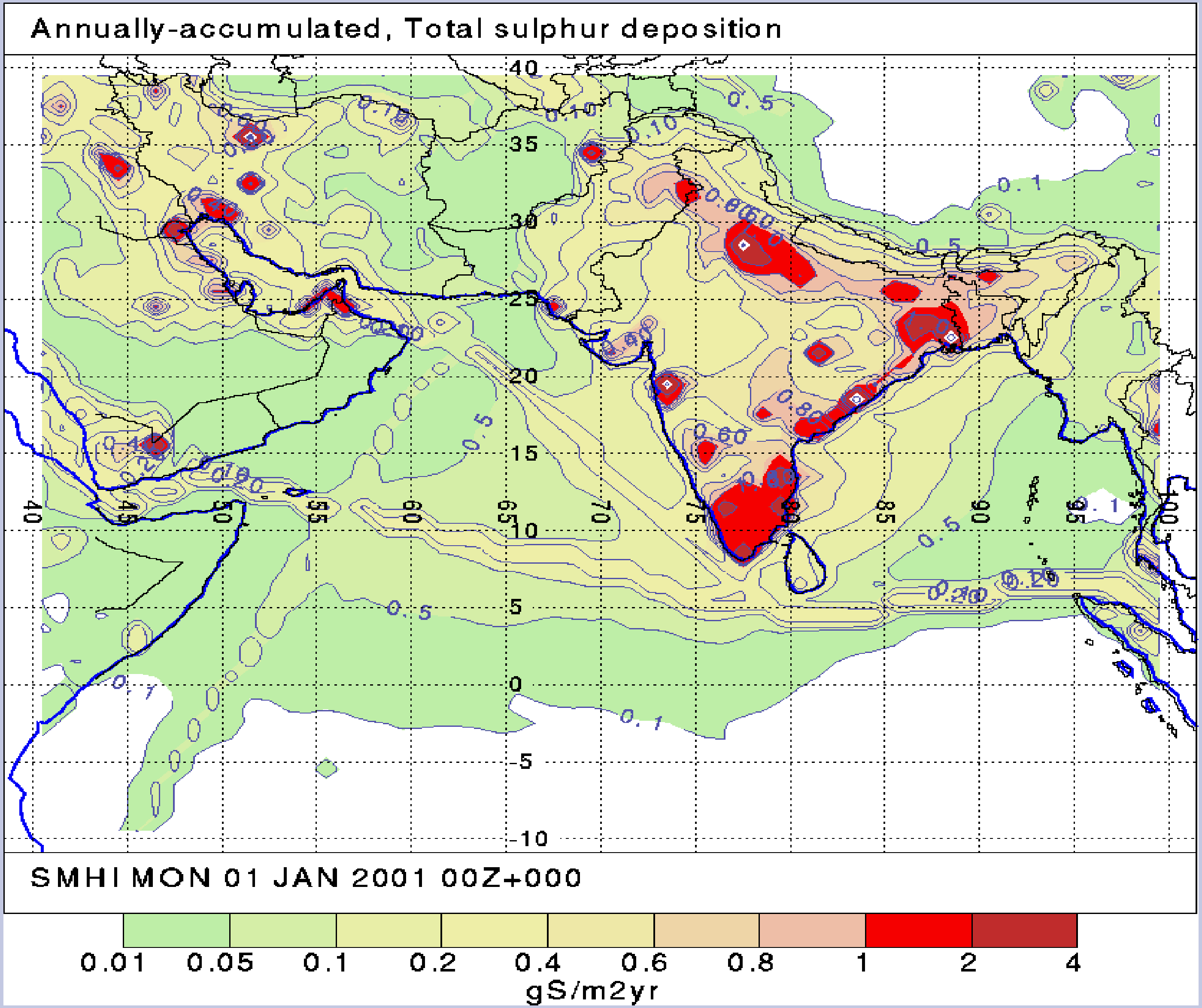
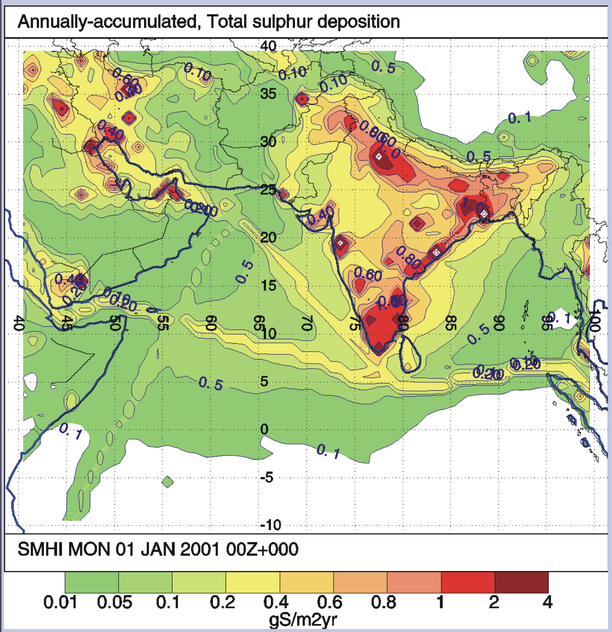
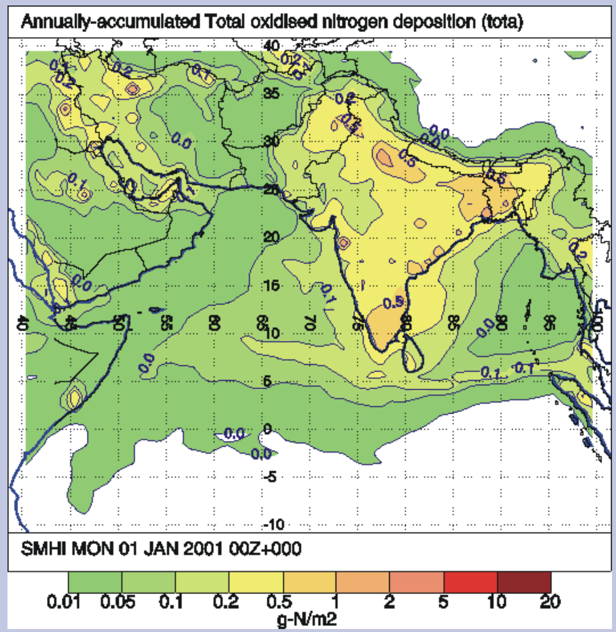


Deposition of sulphur in S Asia using the MATCH model

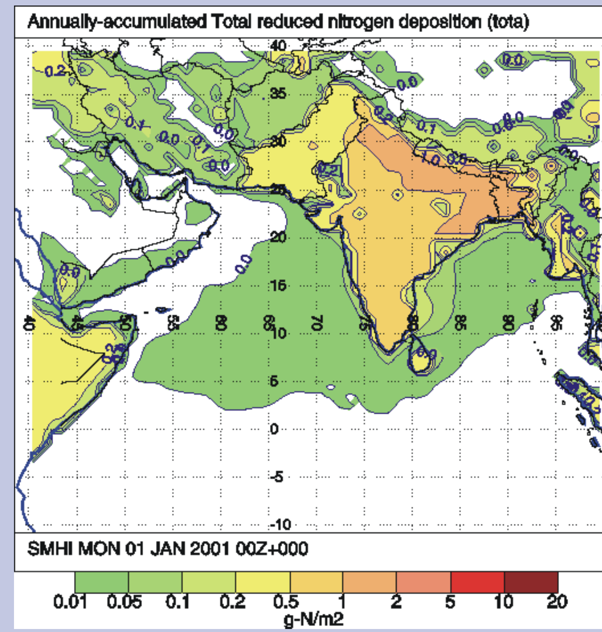
Acidic deposition in South Asia during using the MATCH model



Sulphur

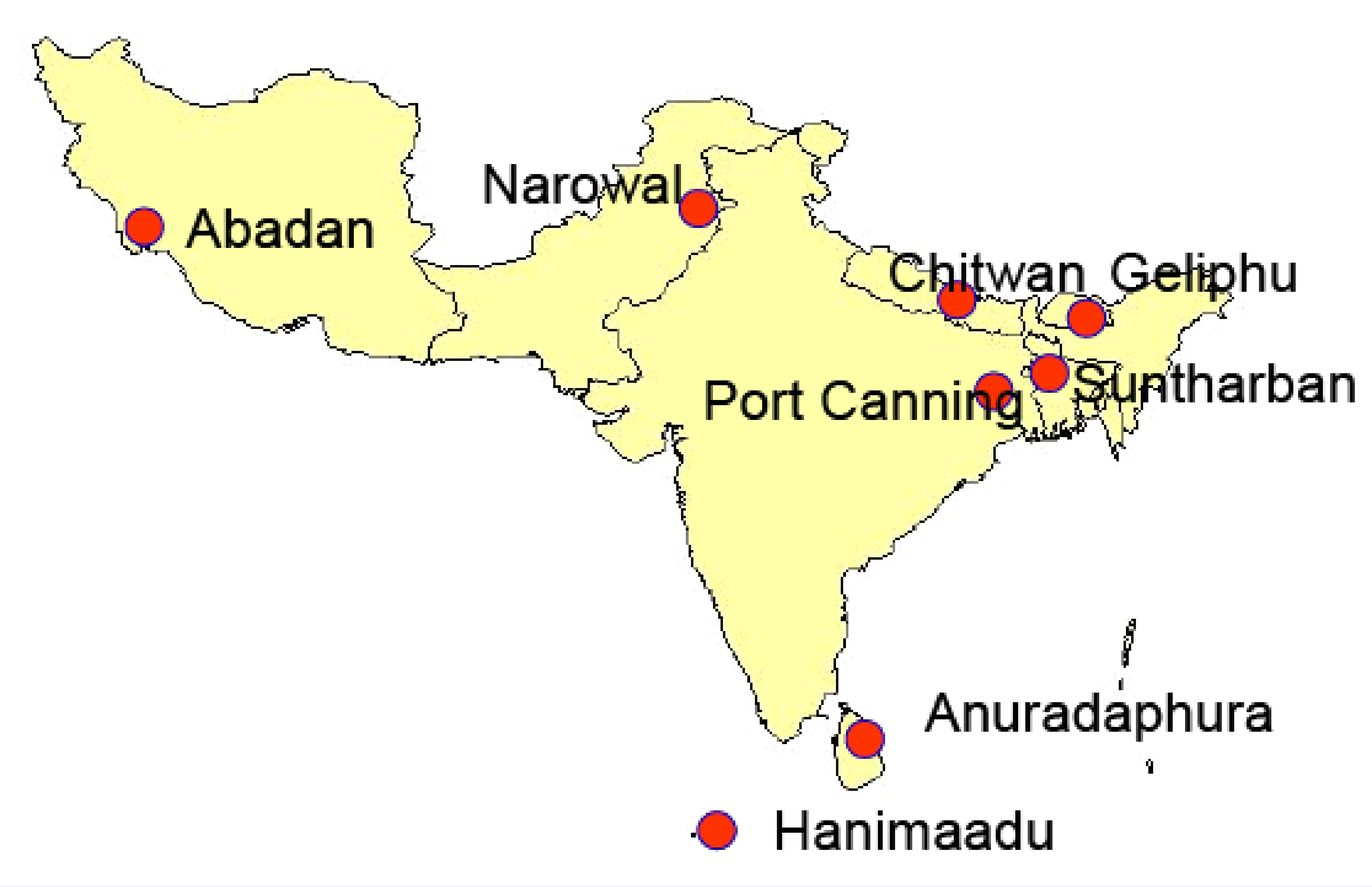


Oxidized Nitrogen

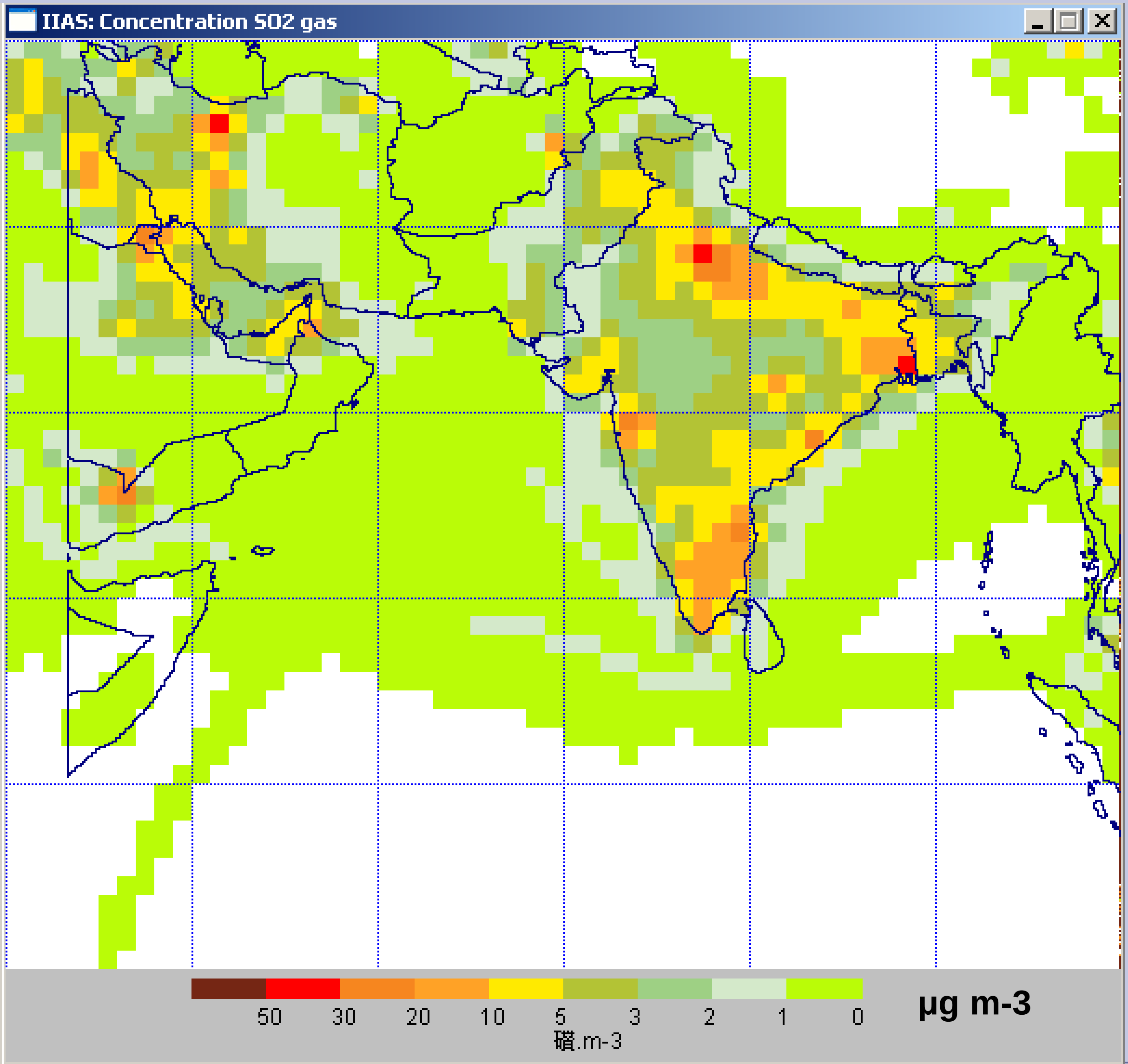


Ammonium

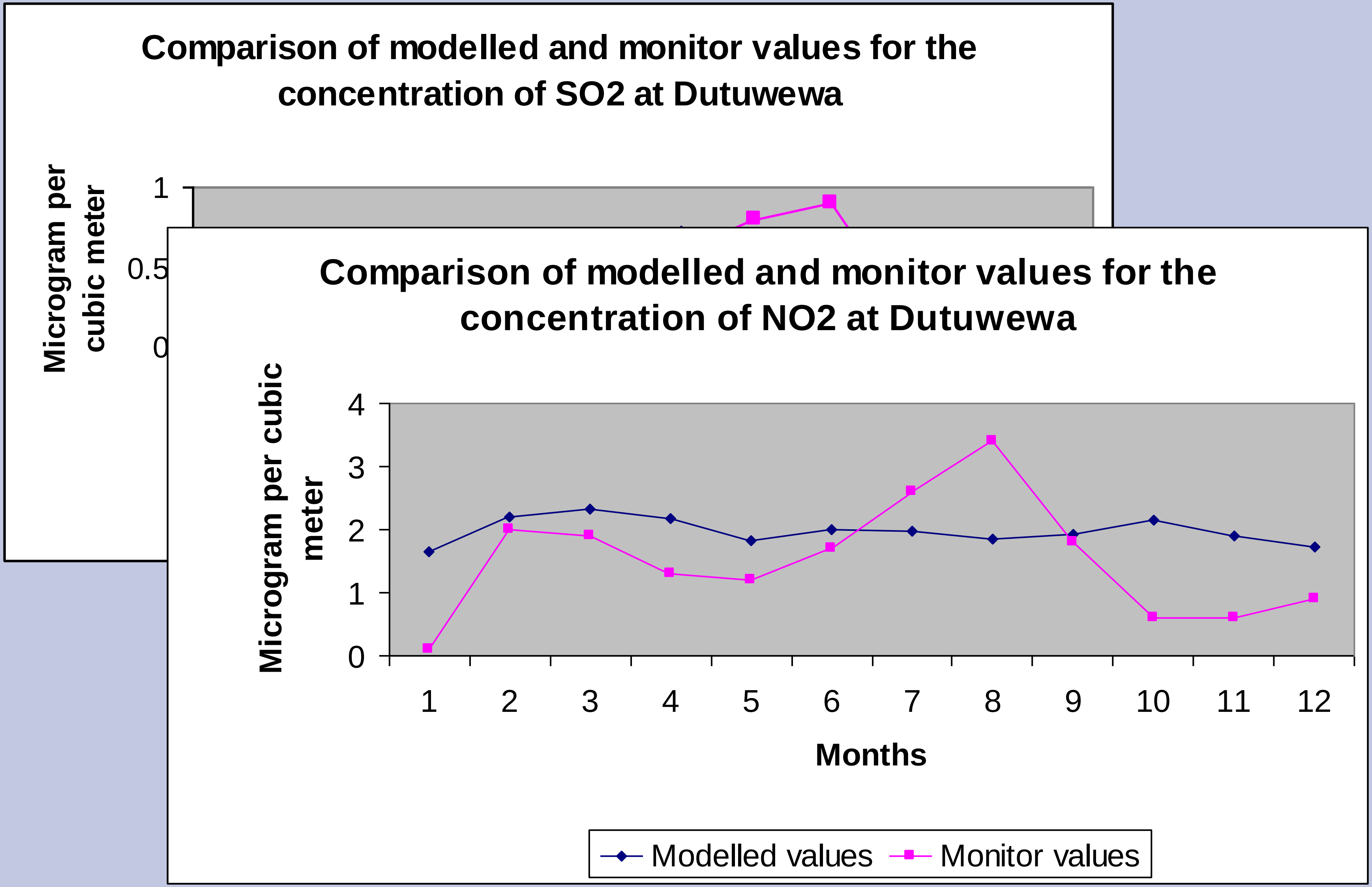
Location of Malé Declaration Monitoring Sites



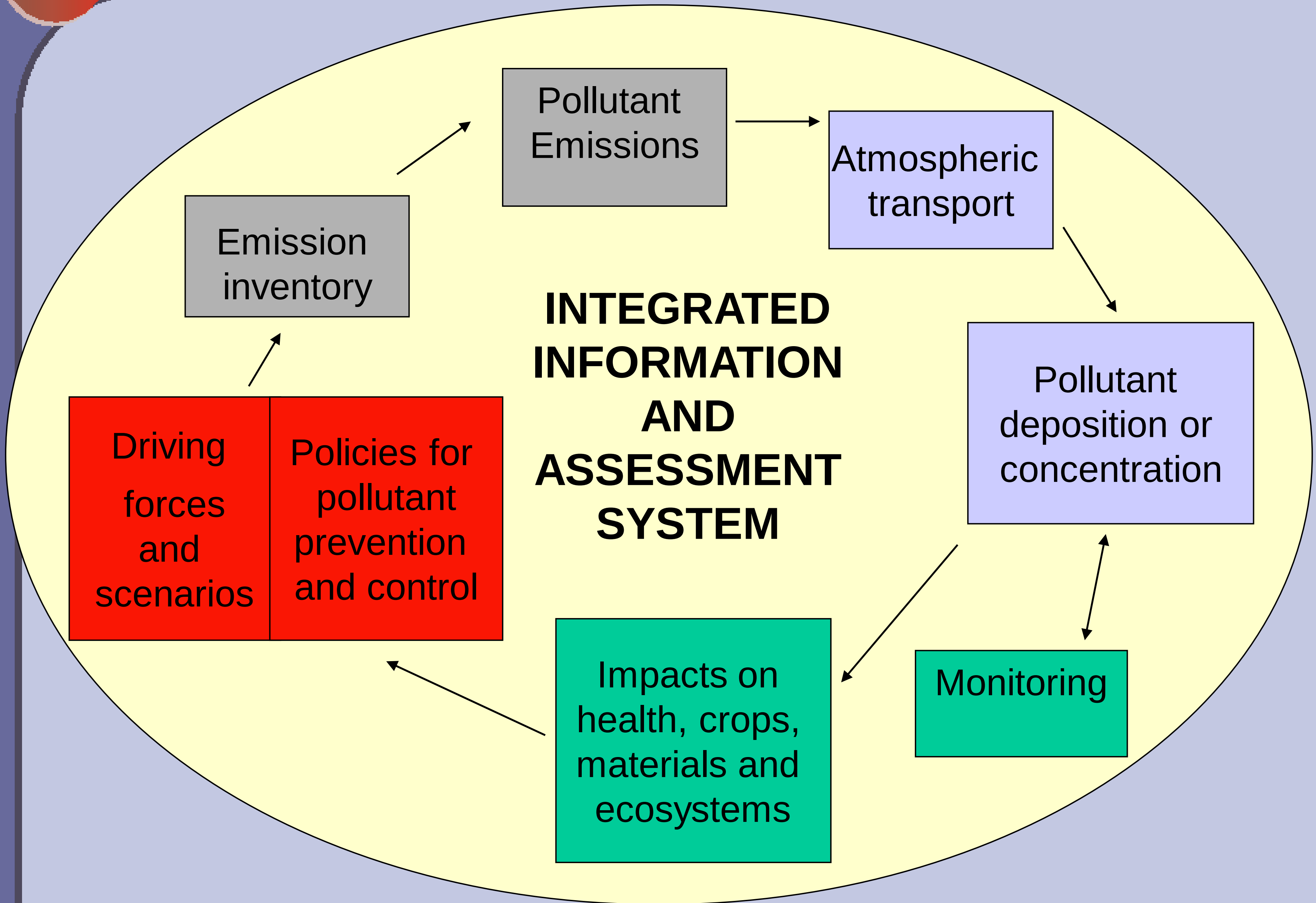
Sulphur Dioxide Concentrations (results from using EDGAR 1995 emissions in MATCH model using 2000 weather data)



Location of Malé Declaration Monitoring Sites



Scientific knowledge to underpin the policy process



ACIDIFICATION RISKS FROM S AND N DEPOSITION

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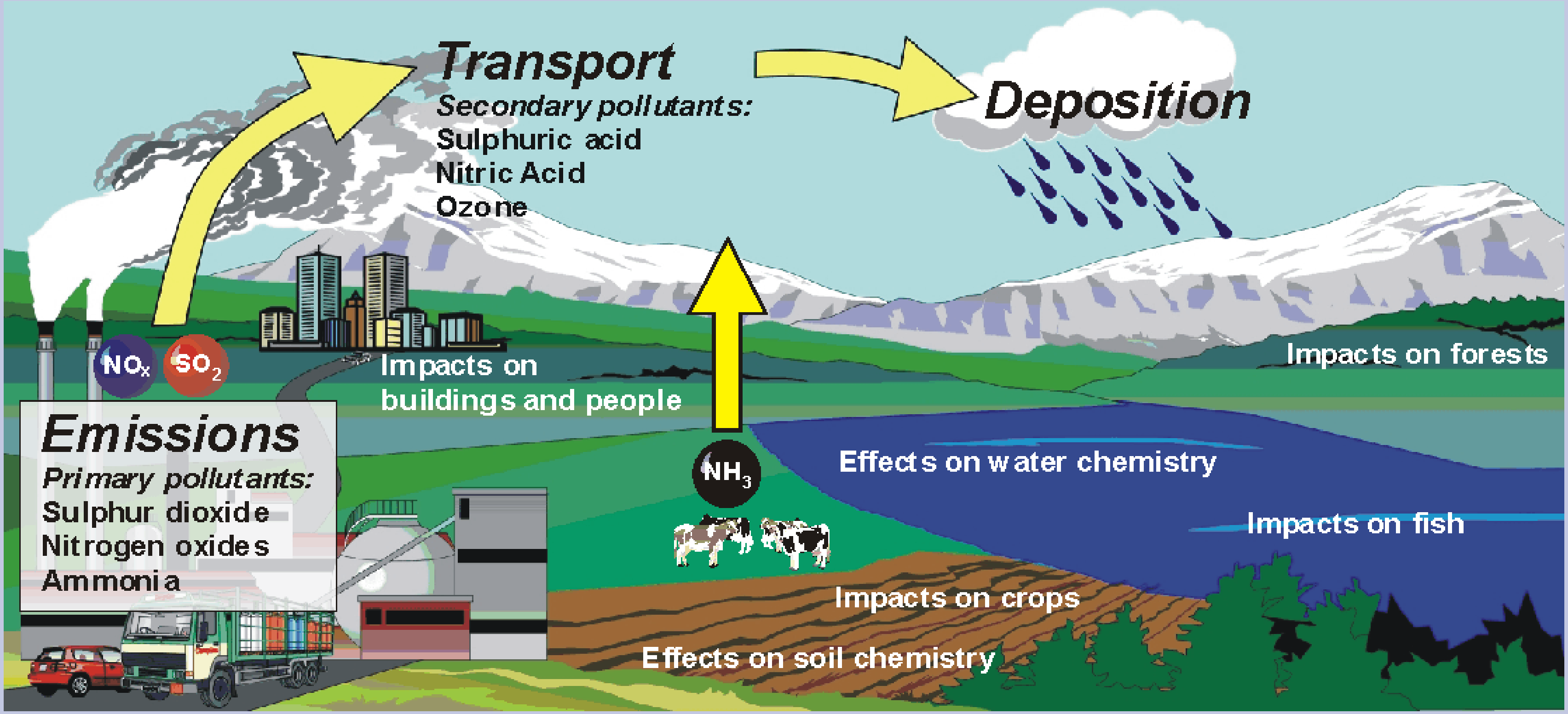
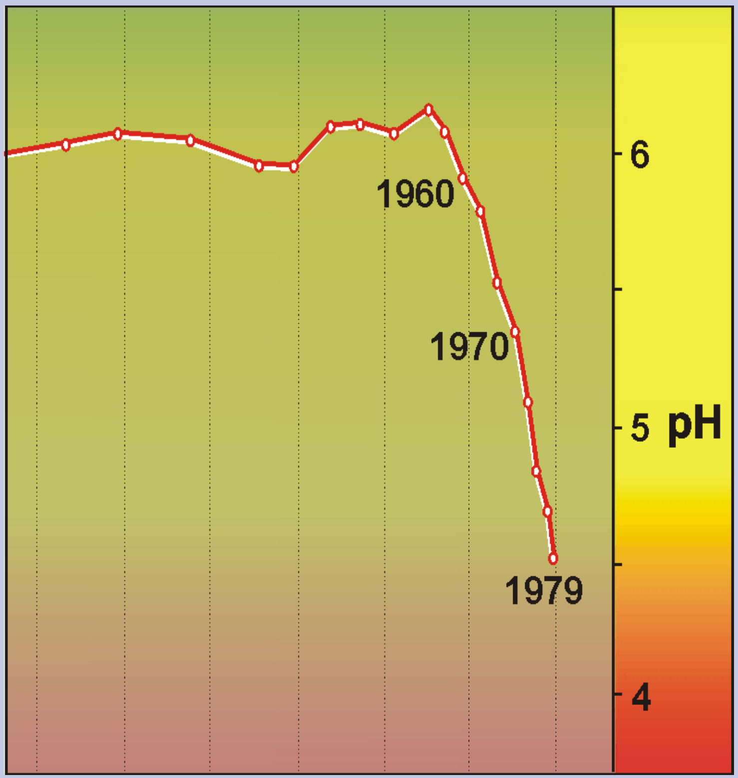
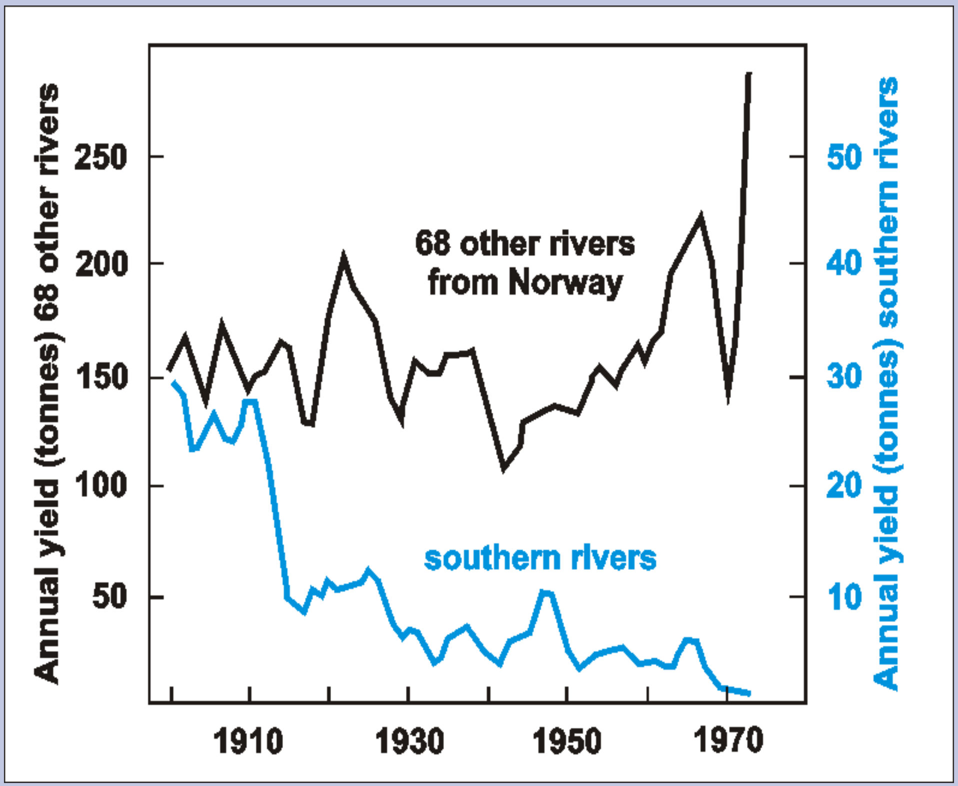
Transboundary impacts of air pollution



Effects of 'Acid Rain' in Europe



The pH of lake Gårdsjön, SW Sweden



Salmon decline in the acidified waters of southern Norway

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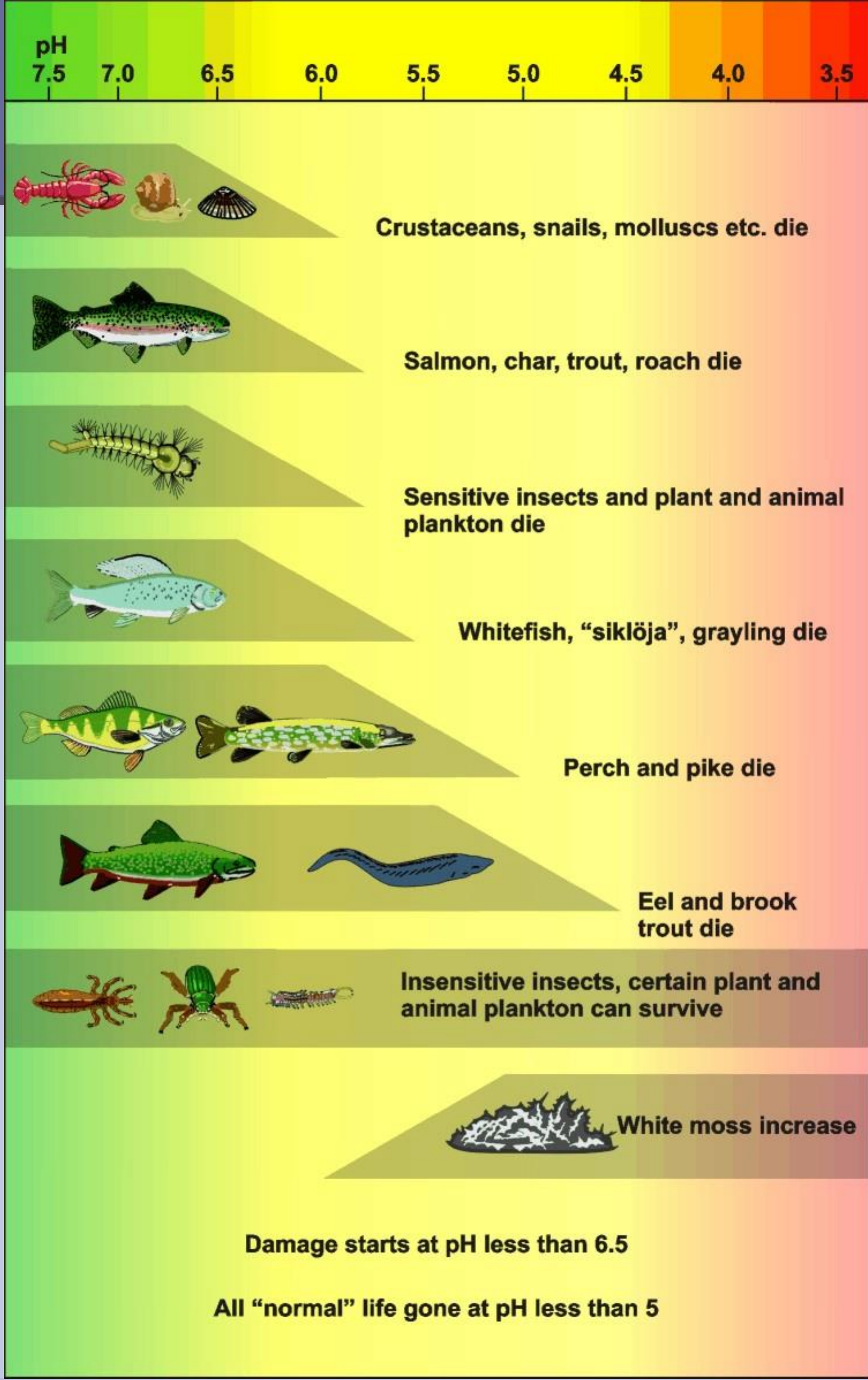
The sensitivity of aquatic organisms to a lowered pH in freshwater



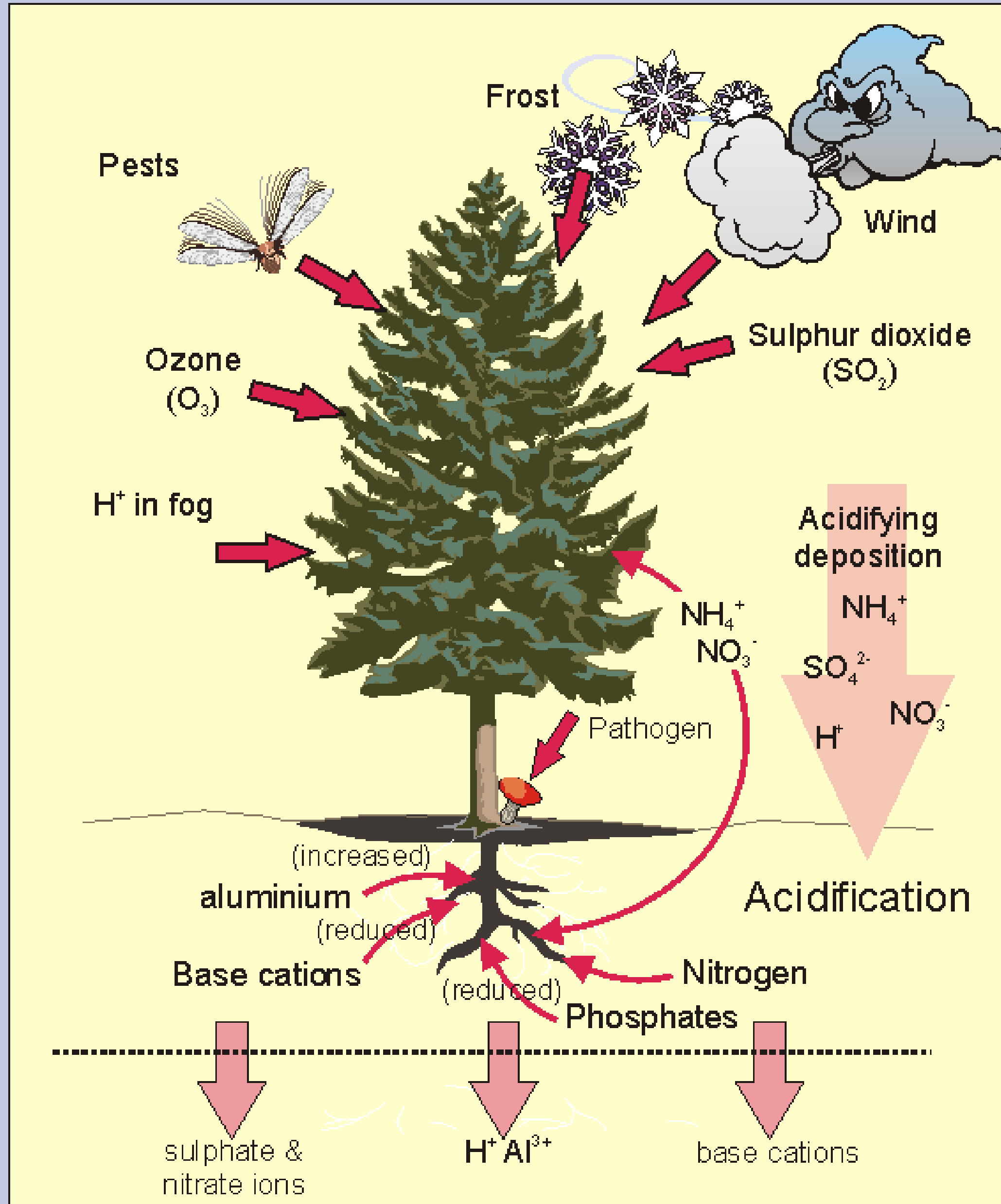
Lake acidification

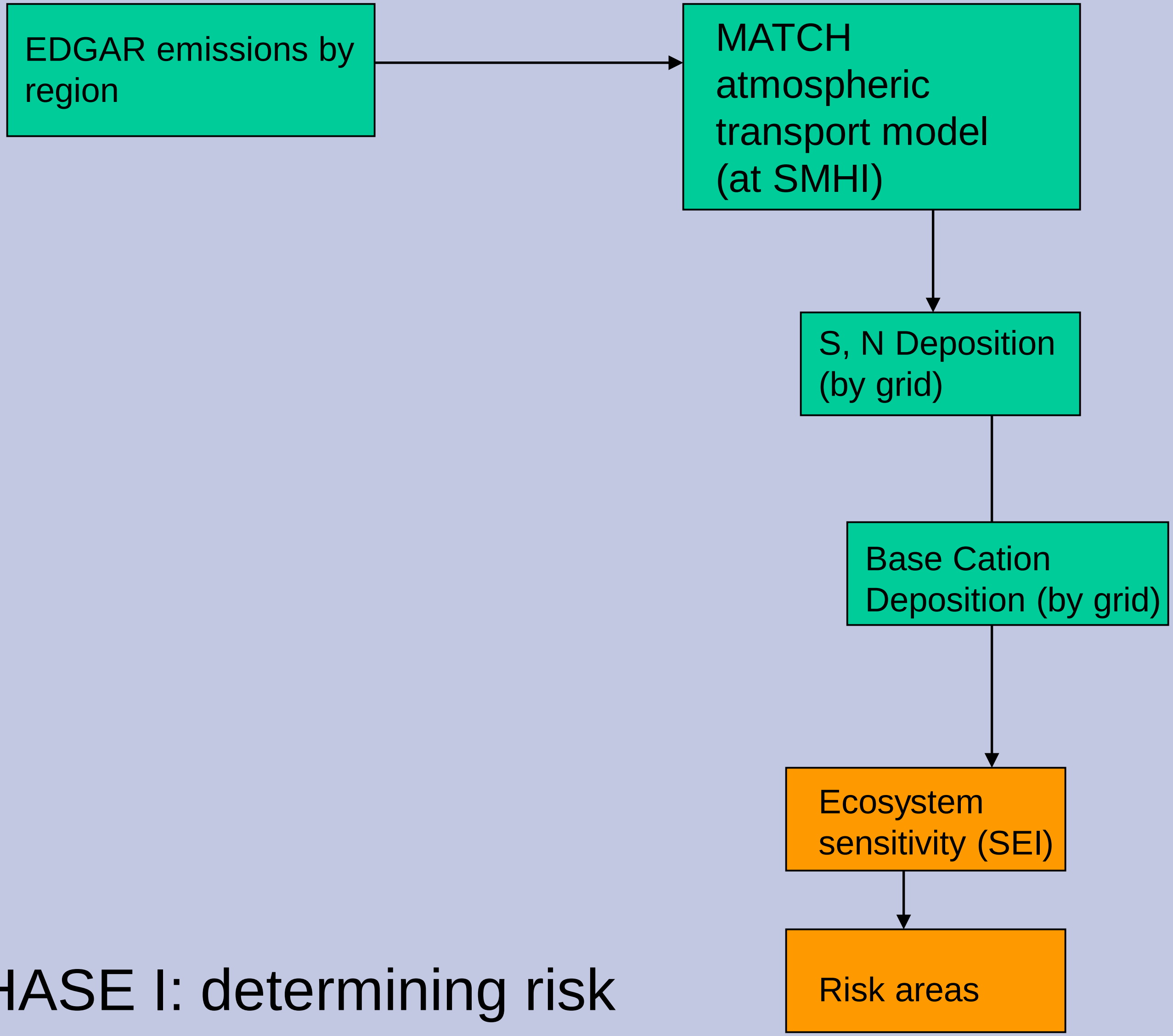
85% of all acidified lakes in six countries: Sweden, Norway, Scotland, Finland, Canada, U.S.A.,

In Europe, about 50 000 – 100 000 lakes have been affected by acidification

This occurred in acid-sensitive regions where the soils have a low ability to neutralize continuous inputs of strong acids

Various factors contributing to forest decline

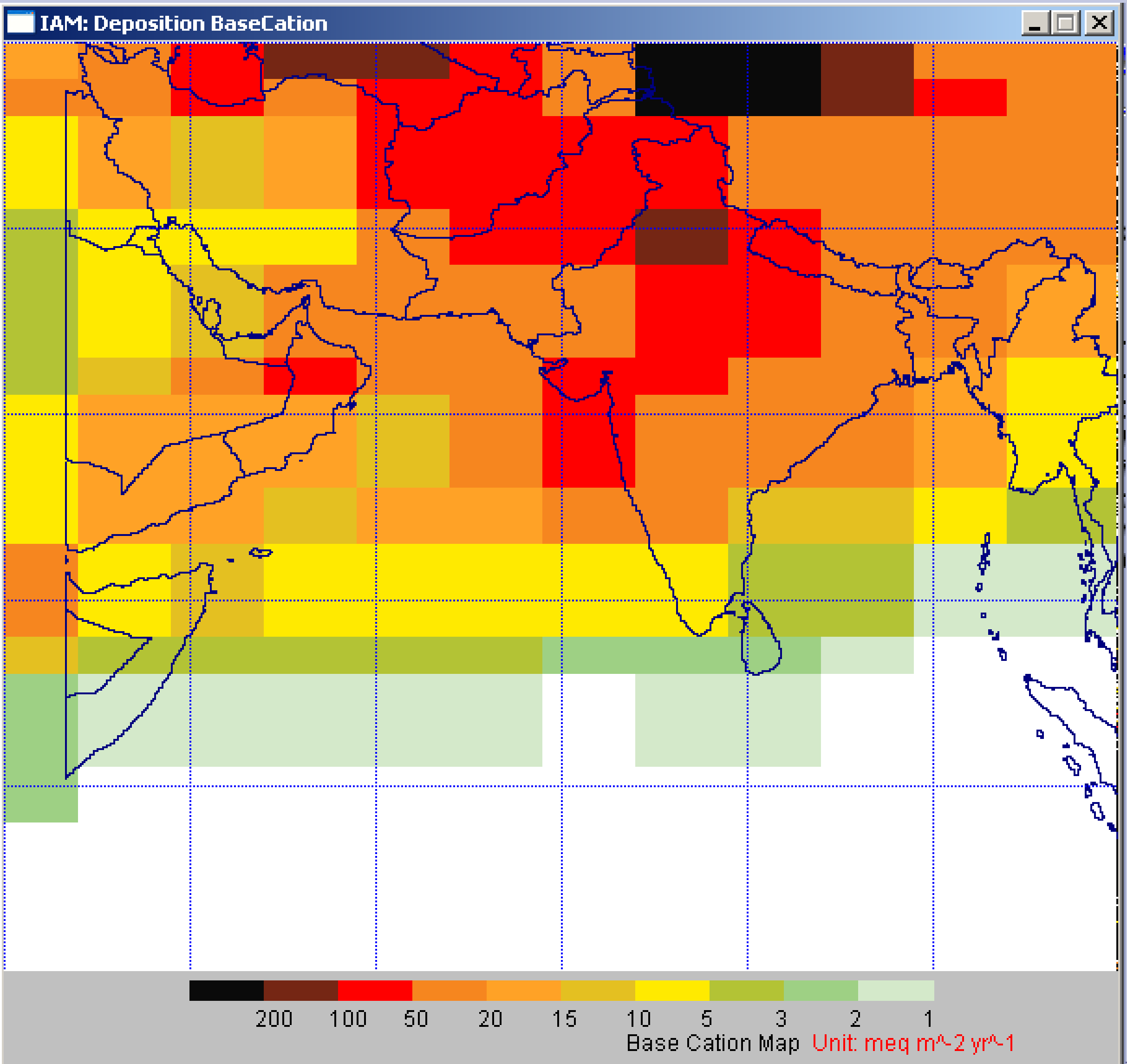




PHASE I: determining risk from available maps

Estimating the Risk of acidification

Neutralising Base Cation Deposition from Soil Dust



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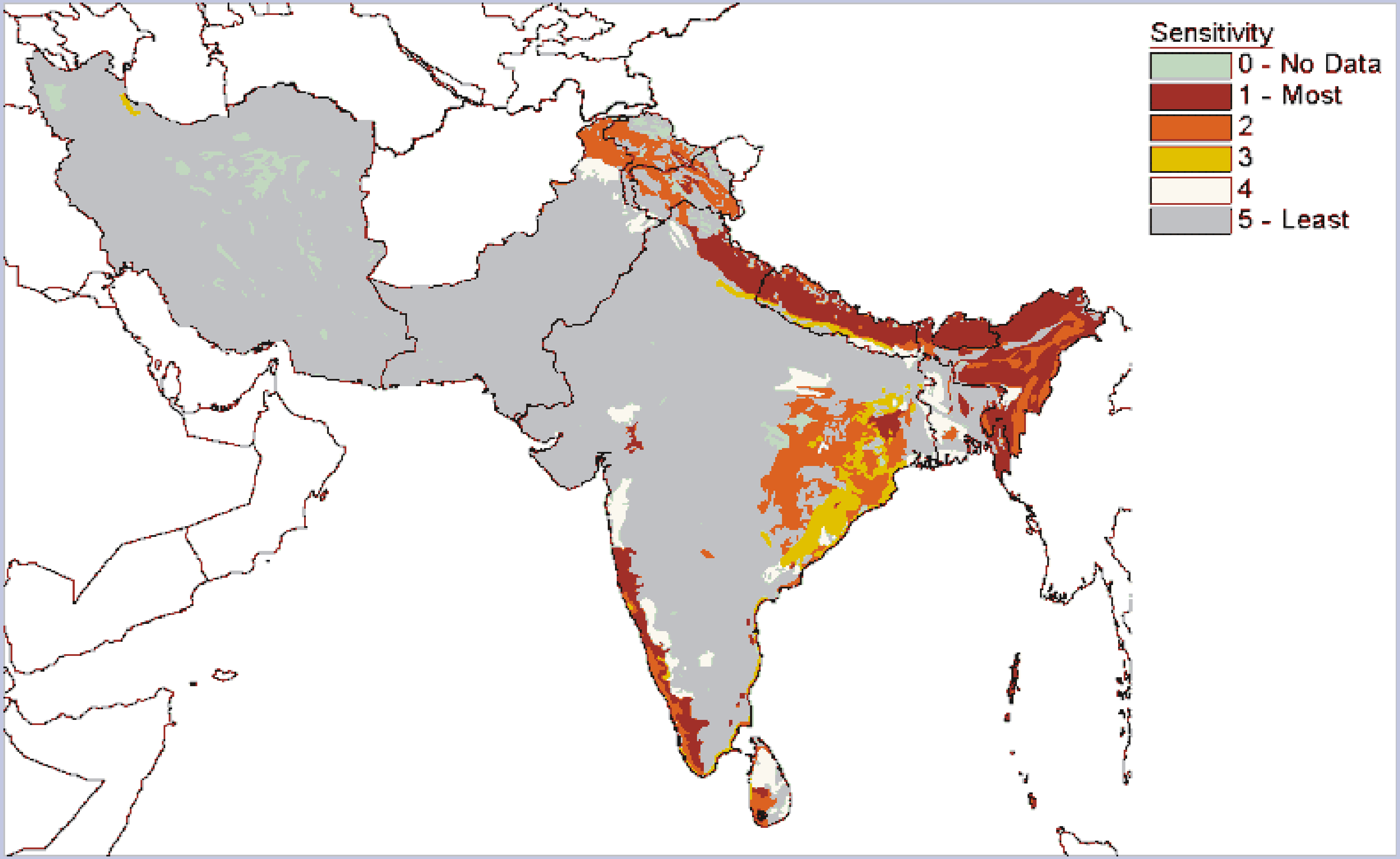
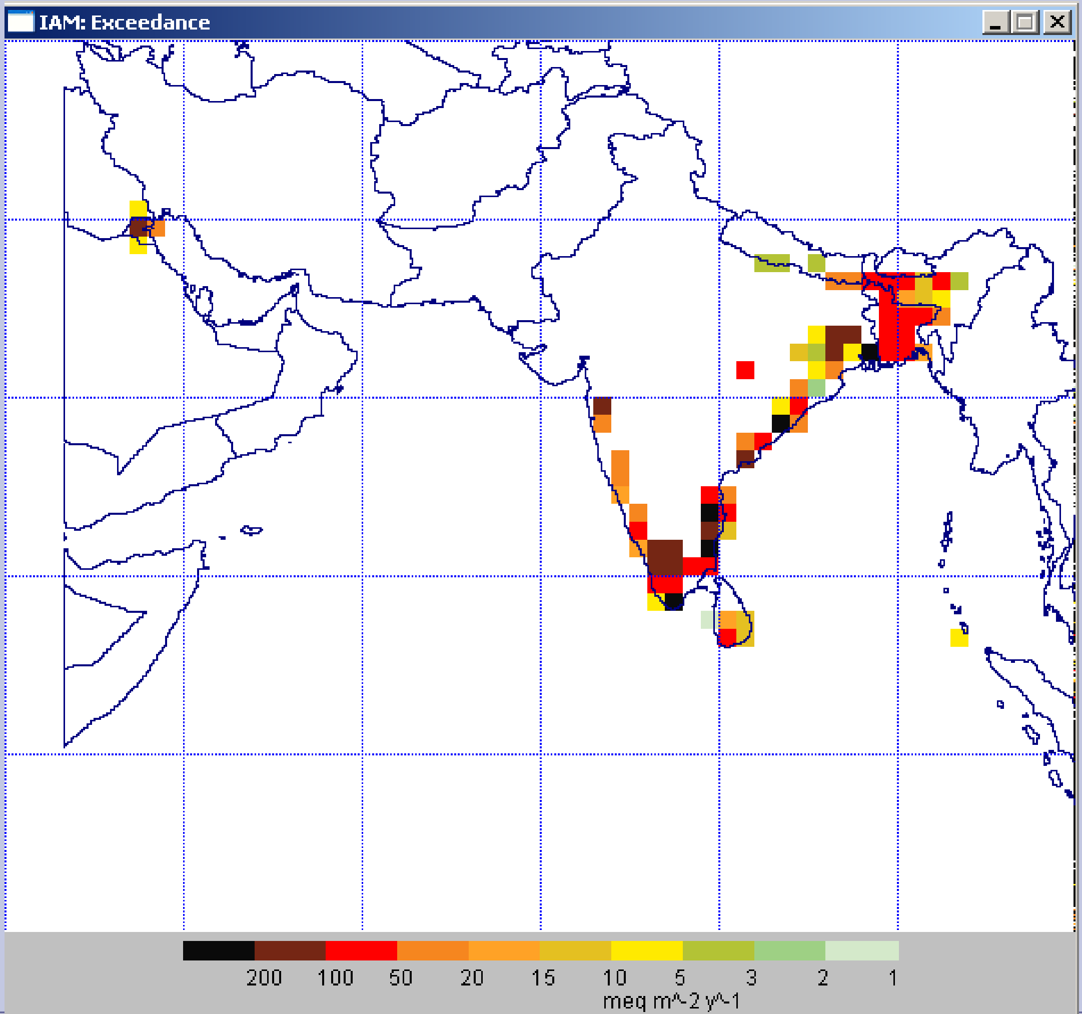
Terrestrial Ecosystem Sensitivity to Acidic Deposition in South Asia



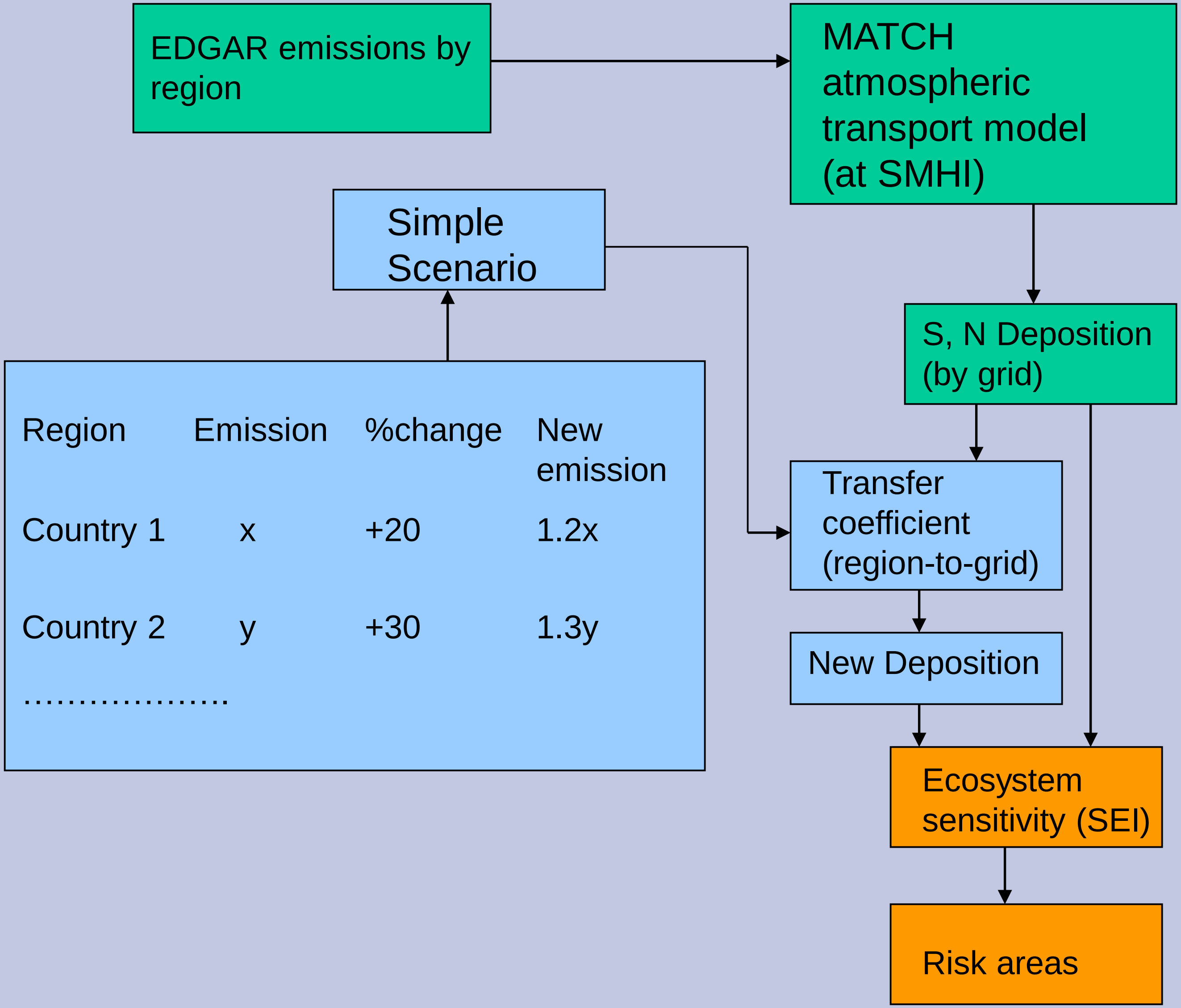
Source: Kuylenstierna *et al*. 2001

Estimated Risk of acidification

=SOx(dep)+0.3NOx(dep)+0.3NHx(dep)
- Base Cation(dep) – Critical Load(soil)



ACIDIFICATION RISK SCENARIOS



PHASE I: Investigating simple scenarios

** Default means emission from EDGAR 1995.
** You can change in the %Change column by increased or decreased percentage value or ch
Please note that after you create a new scenario value, you should save it i

	SOx Unit: kt S			NOx Unit:	
	Curr	%Change	New	Curr	%Change
Bangladesh (BDAA)	121.0	25	151.25	122.0	0
Bhutan (BTAA)	2.8	25	3.50	2.1	0
India (Total)		25	4062.3		0
India: Central (INCC)	241.5	25	301.88	139.2	0
India: East (INEE)	77.2	25	96.50	39.2	0
India: East-Central (INEC)	178.5	25	223.13	84.7	0
India: North (INNN)	192.5	25	240.63	110.7	0
India: North Central (INNC)	426.9	25	533.63	216.3	0
India: South-Central (INSC)	666.0	25	832.50	319.5	0
India: South-East (INSE)	350.5	25	438.13	159.4	0
India: South (INSS)	521.2	25	651.50	251.9	0
India: South-West (INSW)	303.5	25	379.38	162.2	0
India: West Central (INWC)	292.0	25	365.00	159.9	0
Iran (Total)		25	882.5		0
Iran: East (IREE)	269.4	25	336.75	152.9	0
Iran: West (IRWW)	436.6	25	545.75	193.4	0
Maldives (MVAA)	9.1	25	11.38	7.3	0
Nepal (NPAA)	31.7	25	39.63	26.7	0
Pakistan: (Total)		25	380.3		0
Pakistan: East (PKEE)	176.3	25	220.38	105.7	0
Pakistan: West (PKWW)	127.9	25	159.88	89.1	0
Sri Lanka (LKAA)	21.9	25	27.38	23.3	0
REST (REST)	1720.4	25	2150.5	1045.0	0

Save

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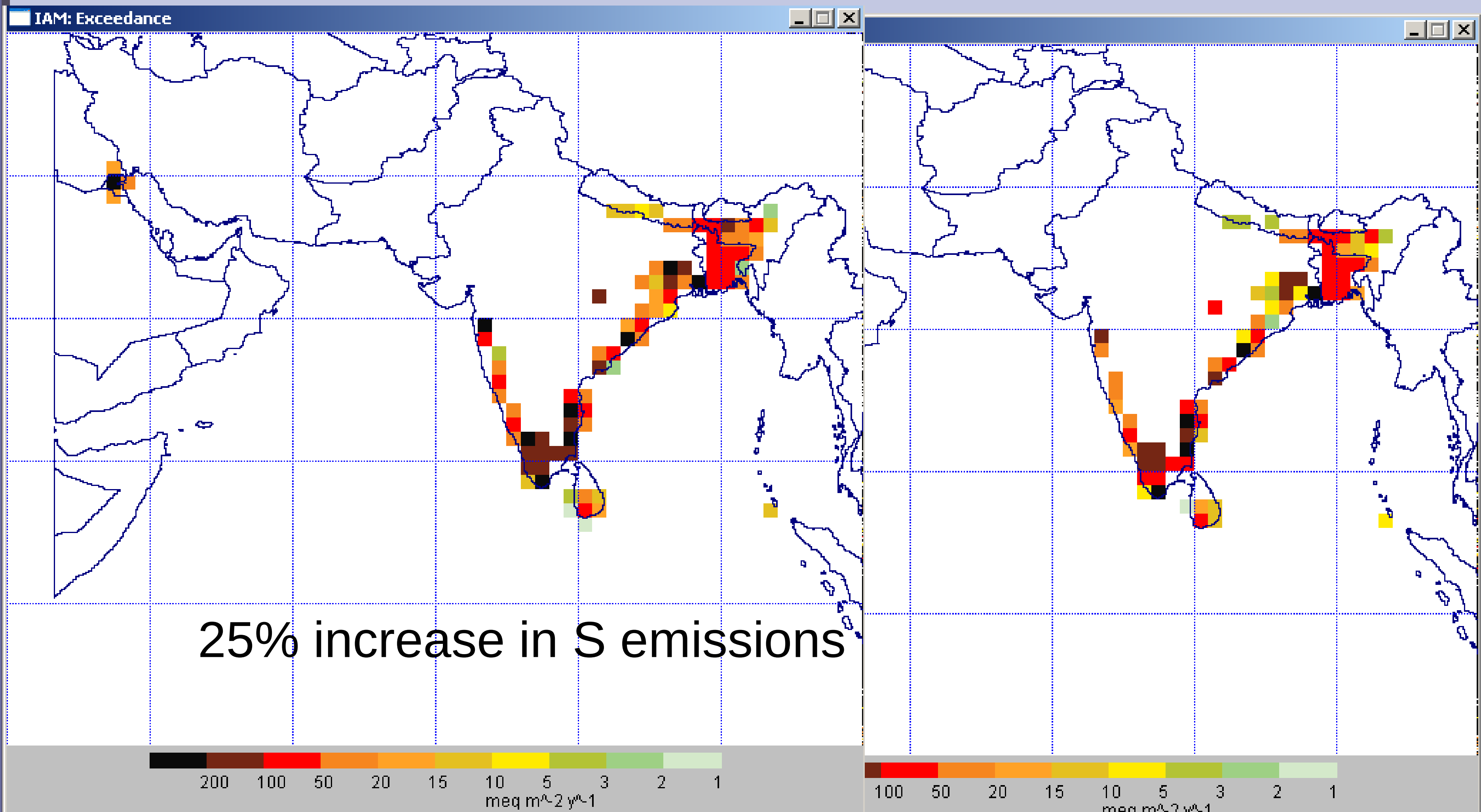
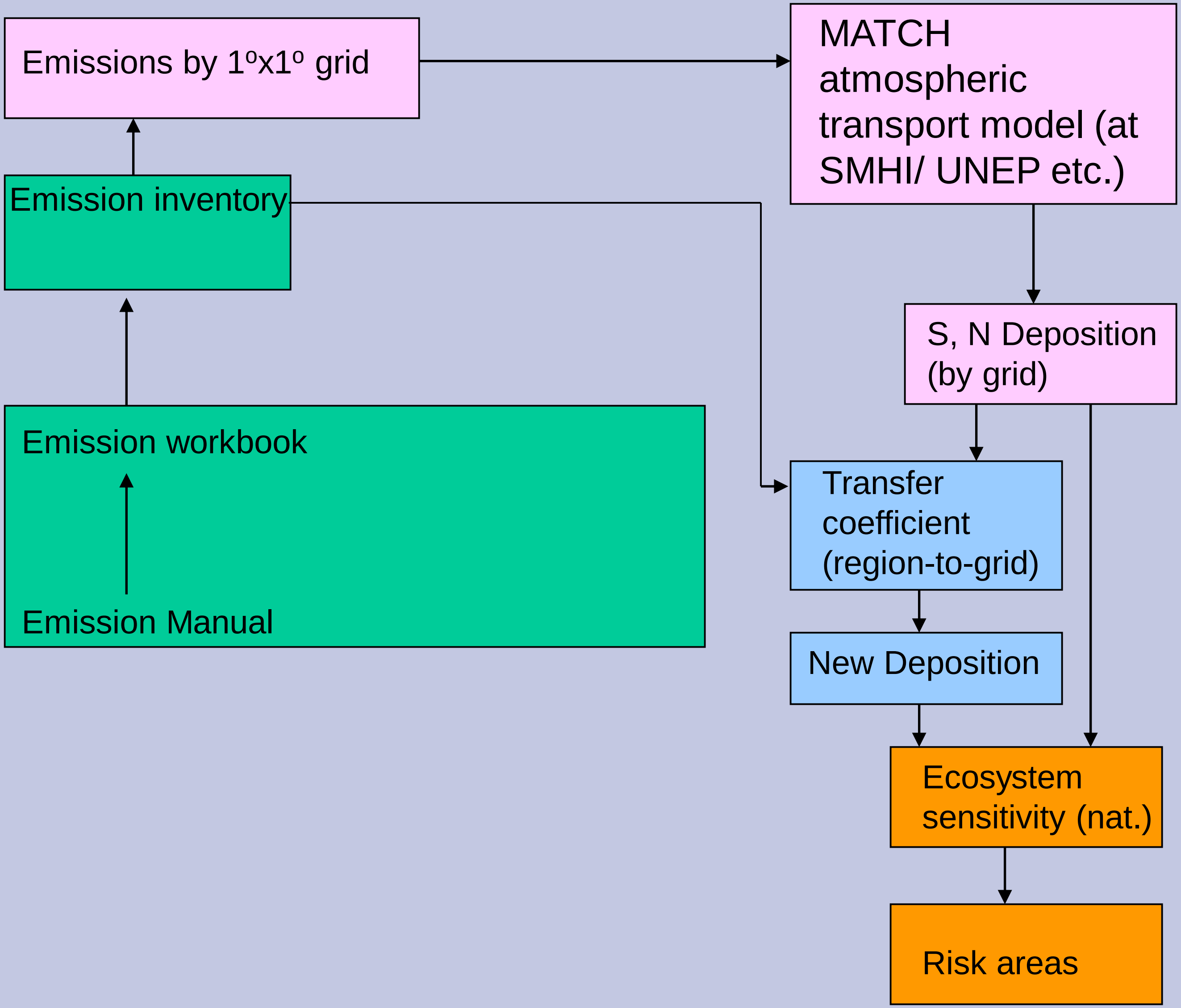
Workbook – Scenario of 25% increase in S emissions in all regions

Estimated Risk of acidification





Using national Emission estimates

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Malé Emissions baseline summary sheet

	SOx Unit: kt S			NOx Unit: kt N			NHx Unit: kt N			PM2.5 Unit:	
	Curr	%Change	New	Curr	%Change	New	Curr	%Change	New	Curr	%Change
Bangladesh (BDAA)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Bhutan (BTAA)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India (Total)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: Central (INCC)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: East (INEE)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: East-Central (INEC)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: North (INNN)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: North Central (INNC)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: South-Central (INSC)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: South-East (INSE)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: South (INSS)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: South-West (INSW)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
India: West Central (INWC)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Iran (Total)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Iran: East (IREE)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Iran: West (IRWW)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Maldives (MVAA)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Nepal (NPAA)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
Pakistan: (Total)	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0

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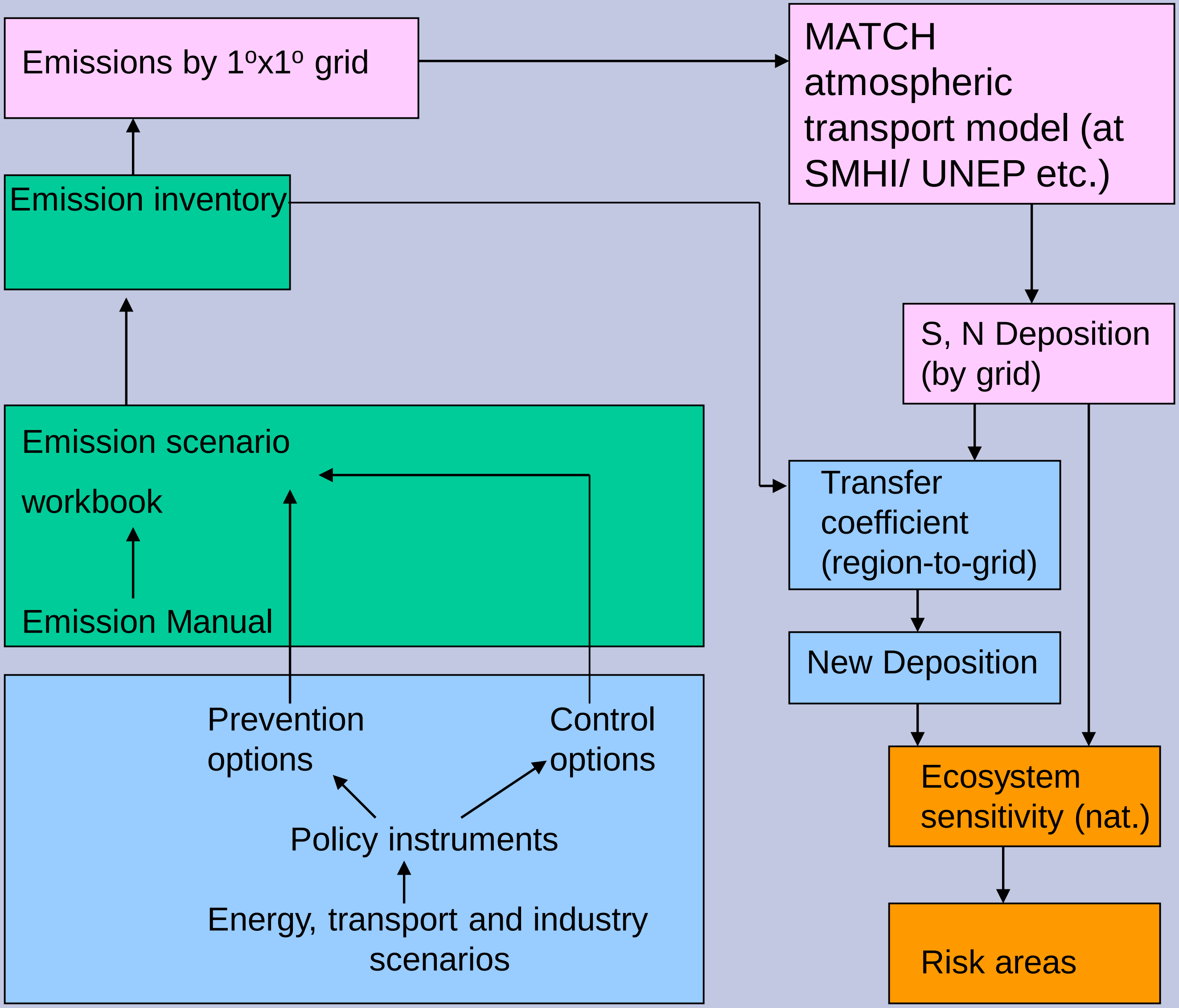

PHASE II: Investigating national scenarios

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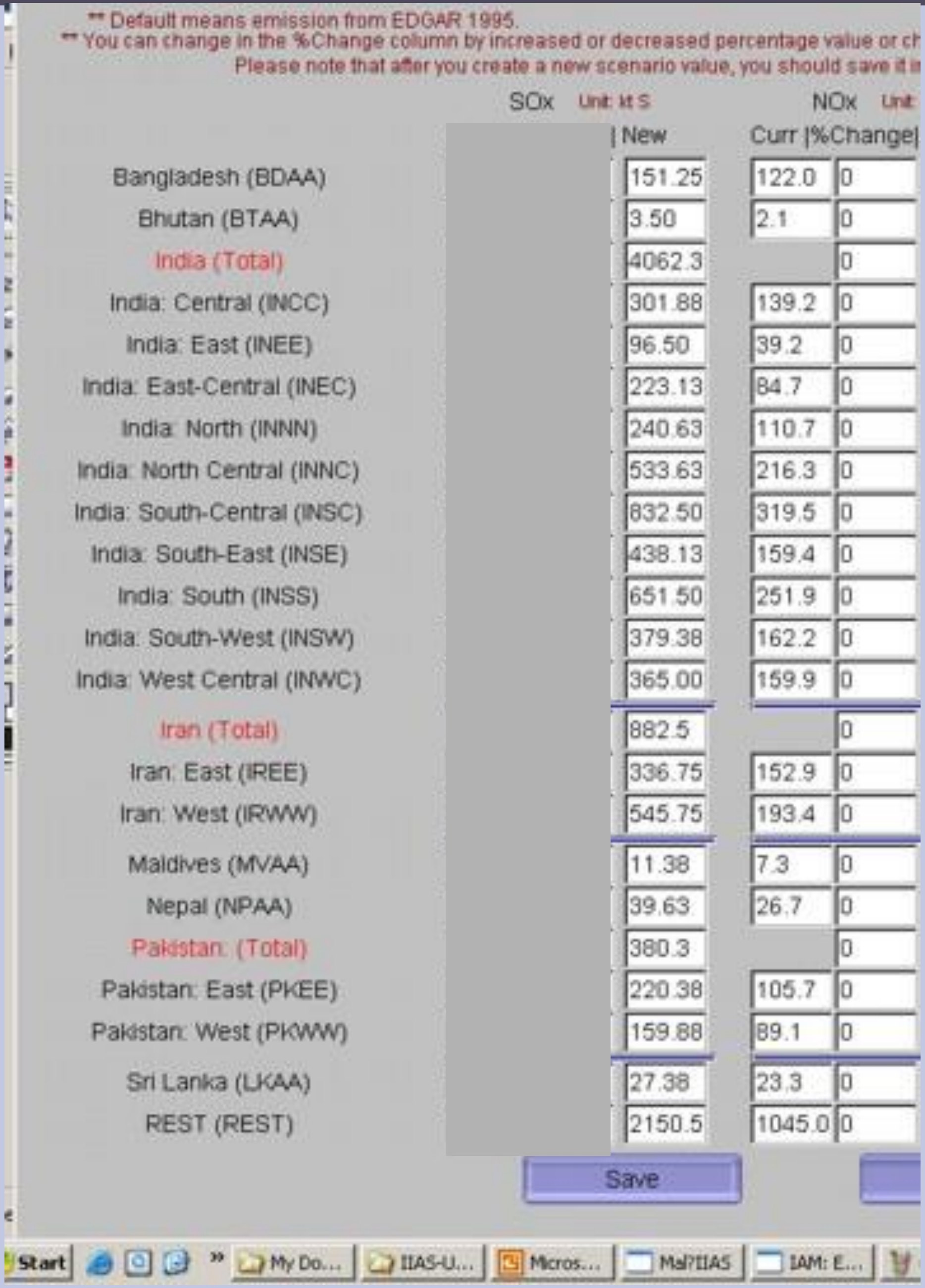
Malé Scenario input sheet



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	SOx Unit: kt S	NOx Unit	
	New	Curr	%Change
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Bhutan (BTAA)	3.50	2.1	0
India (Total)	4062.3		0
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India: South-West (INSW)	379.38	162.2	0
India: West Central (INWC)	365.00	159.9	0
Iran (Total)	882.5		0
Iran: East (IREE)	336.75	152.9	0
Iran: West (IRWW)	545.75	193.4	0
Maldives (MVAA)	11.38	7.3	0
Nepal (NPAA)	39.63	26.7	0
Pakistan: (Total)	380.3		0
Pakistan: East (PKEE)	220.38	105.7	0
Pakistan: West (PKWW)	159.88	89.1	0
Sri Lanka (LKAA)	27.38	23.3	0
REST (REST)	2150.5	1045.0	0

Save

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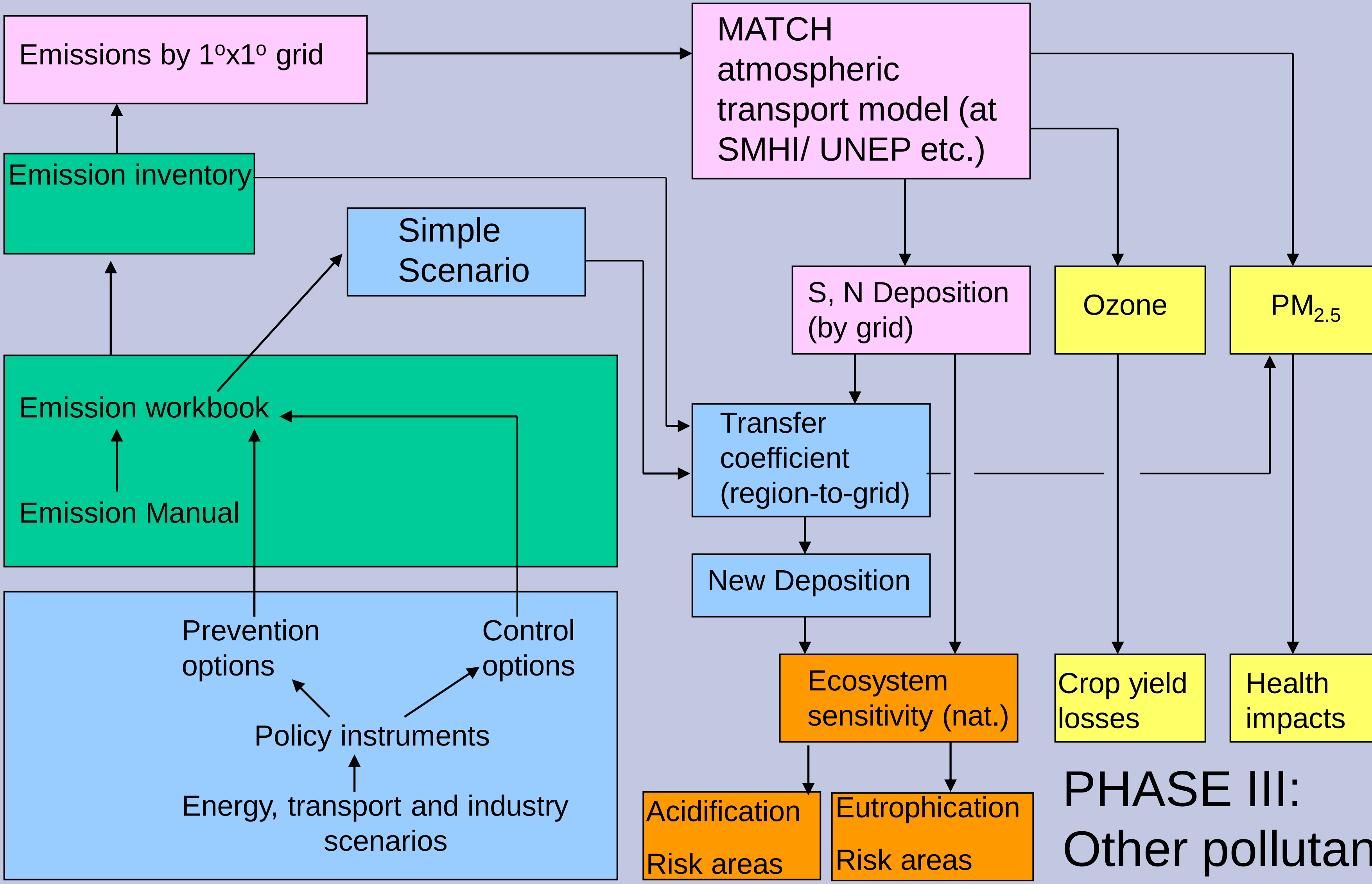


PHASE III: Other pollutants and impacts

HEALTH RISKS FROM PARTICULATE MATTER

Composition of PM

PM is mainly:

i. inorganic ions:

SO_4^{2-}, NO_3^-, NH_4^+,

Cl^- , Na^+, K^+, Ca^{2+}, Mg^{2+}

ii. organic and elemental carbon

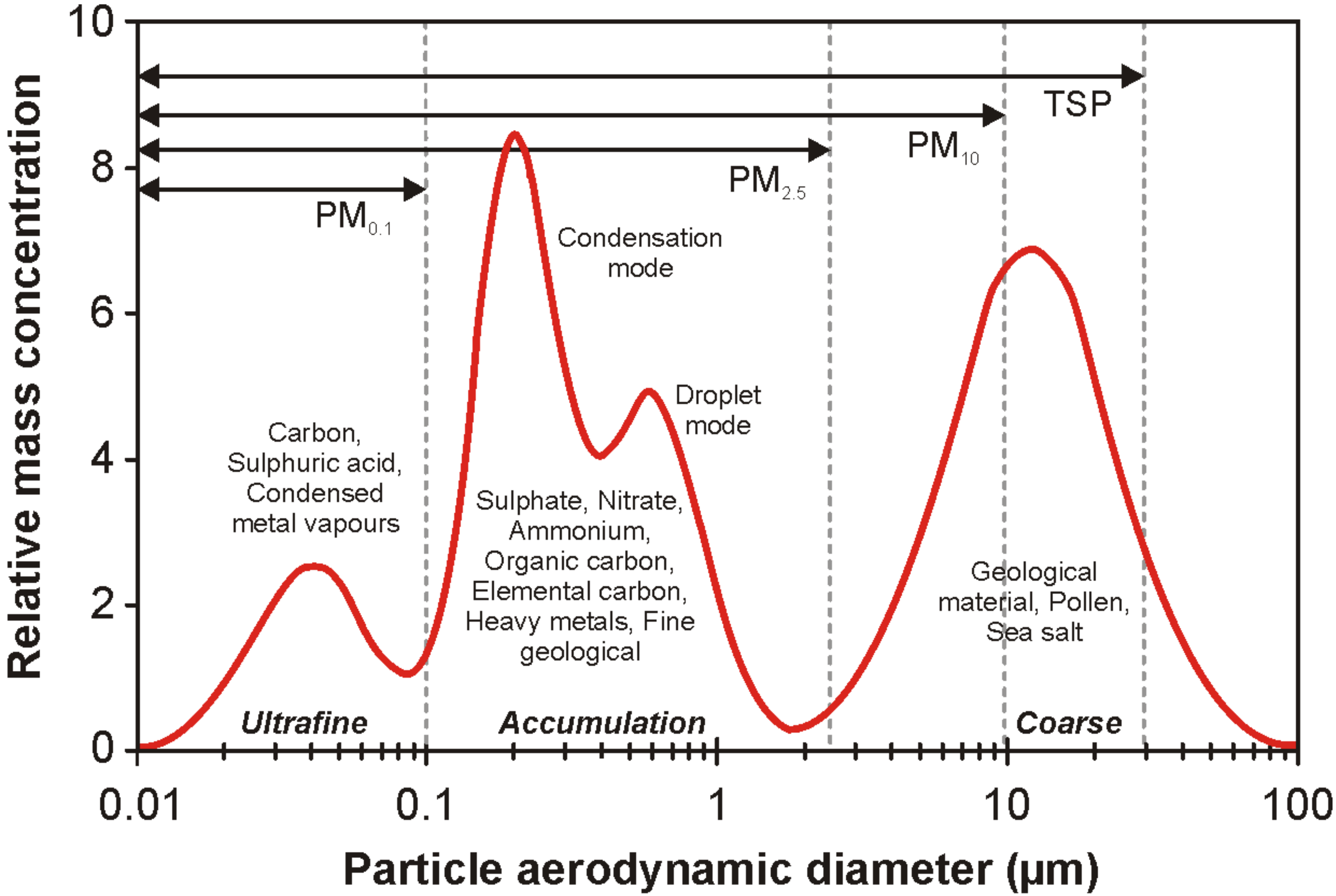
iii. soil particles

iv. particle-bound water

v. heavy metals

Coarse fraction (PM_{10}-$PM_{2.5}$) contains the crustal materials and fugitive dust from industry and roads.

Composition of PM



Source: *Judith Chow, Desert Research Institute, USA, redrawn from* Guttikunda et al (in press)

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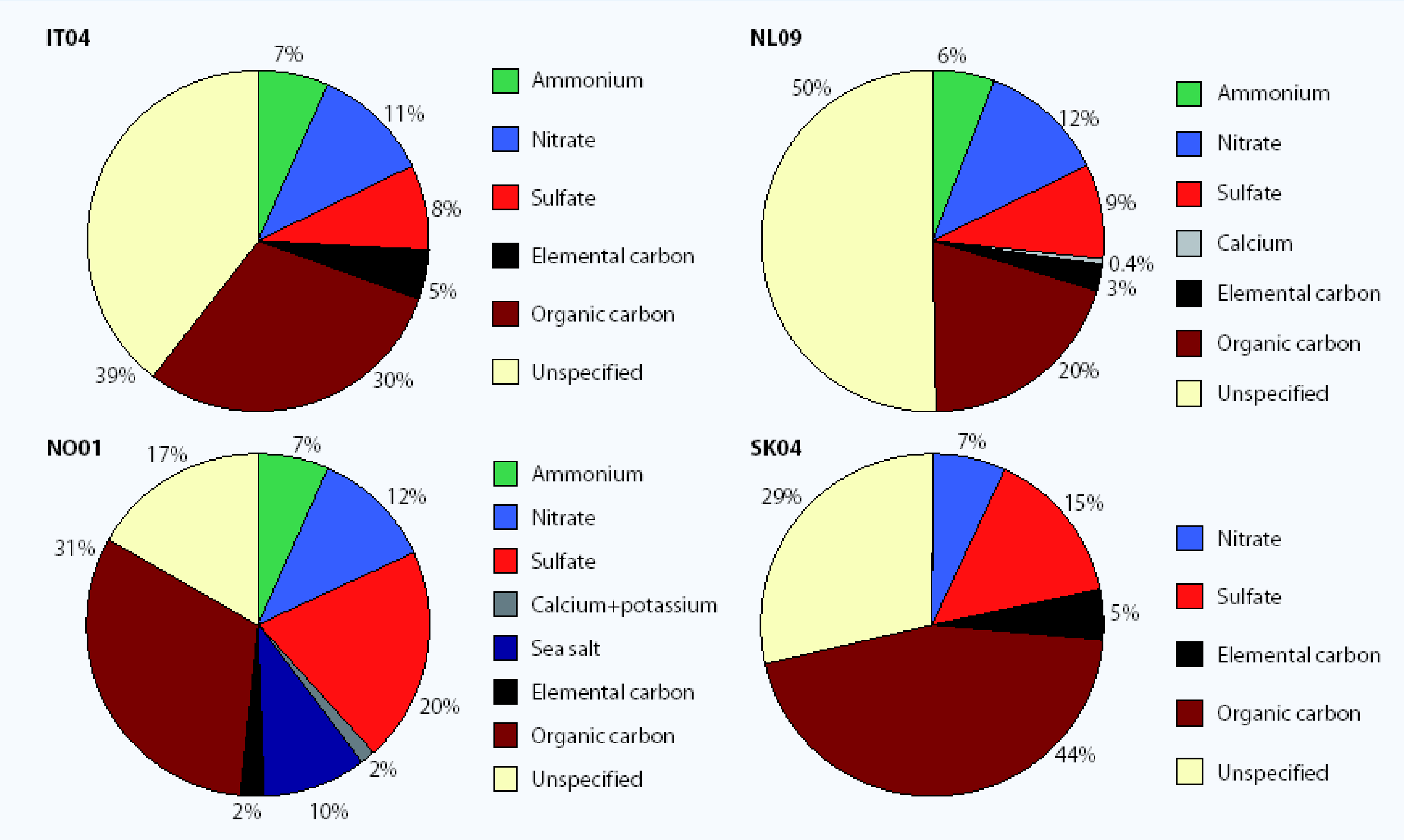
Composition of PM

Fig. 5.21. Speciation of PM_{10} mass concentrations from the measurement campaign for the period 1 July 2002–1 July 2003



Note: Organic matter is OC multiplied by a factor of 1.6. (IT04) or 2.0 (SK04, NO01, NL09). The concentrations of inorganic ions are from 2002.

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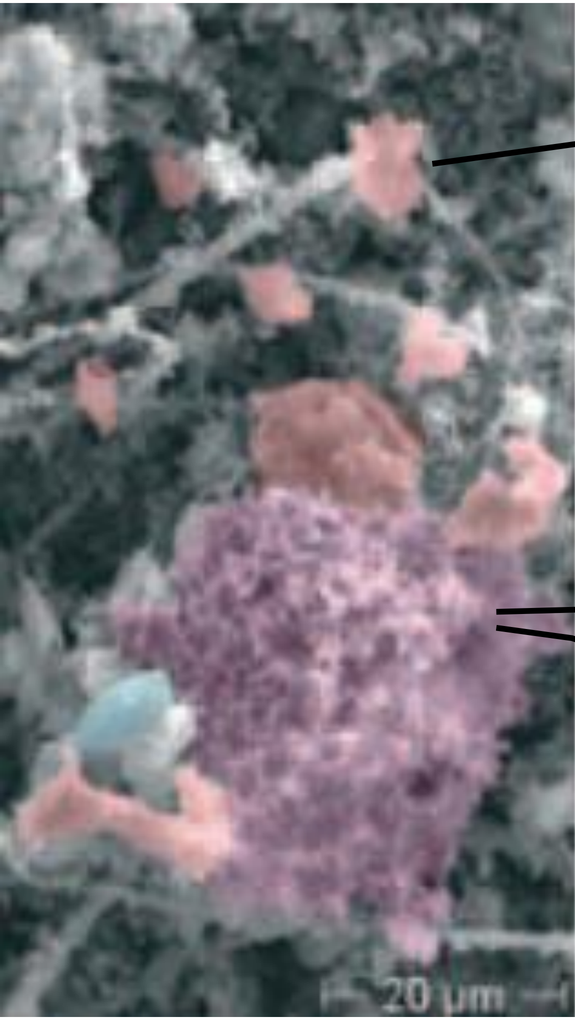
FORUM

Source: Joint WHO / Convention Task Force on the Health Aspects of Air Pollution, WHO, 2006

Atmospheric Transport of PM



PM_1-$PM_{0.1}$ can travel 1000s of kilometres

PM_{10}-$PM_{2.5}$ – sometimes uplifted by storms and travels >1000km

PM_{10}-$PM_{2.5}$ – generally deposited within 10km of emission

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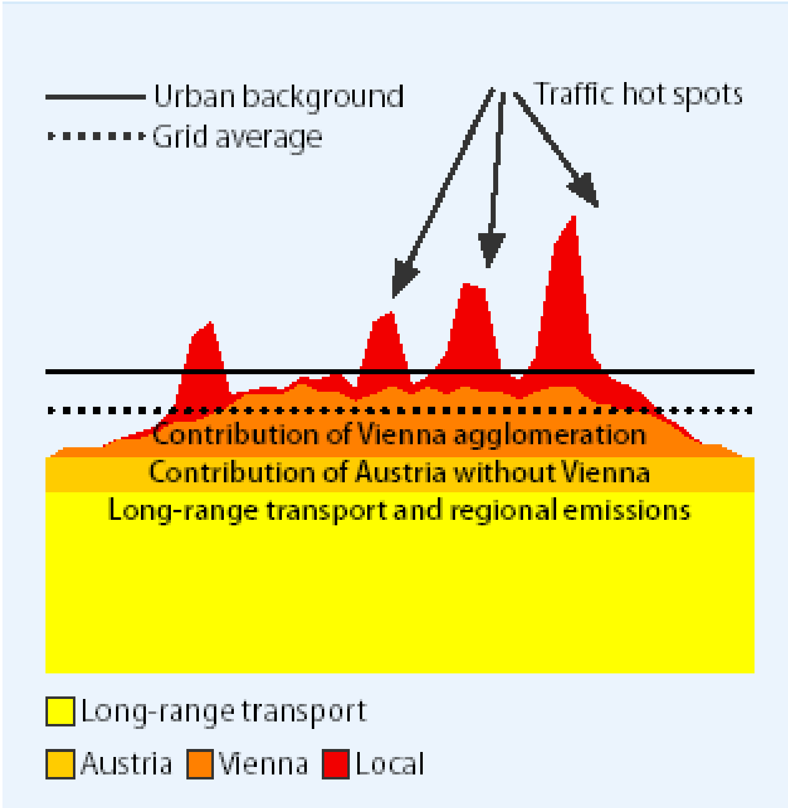
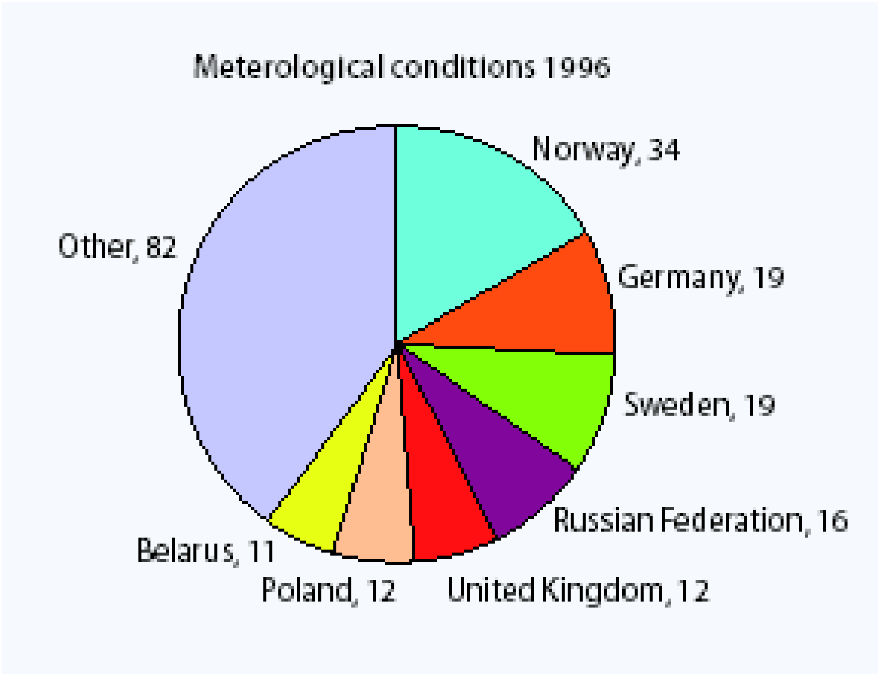
Atmospheric Transport of PM

Fig. 1.1. Schematic illustration of different PM_{10} levels in different locations for Vienna



Note: The black line illustrates the city background used to estimate health effects. The dotted line provides the grid average that would be expected from a regional model, and includes all anthropogenic and nonanthropogenic sources of PM.

Contribution to $PM_{2.5}$ Concentrations over Norway in 2010



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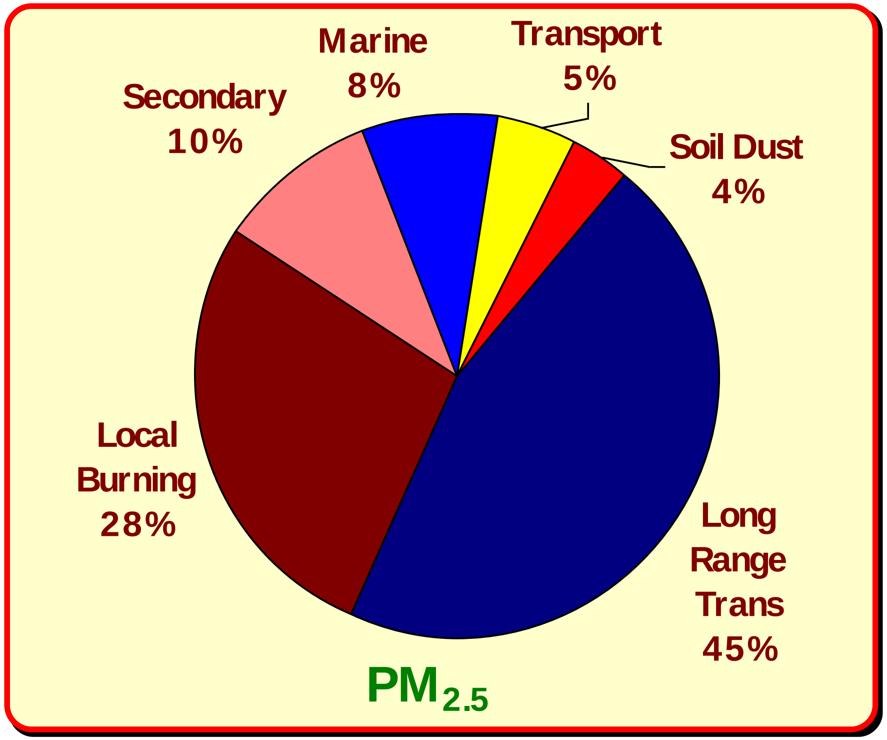
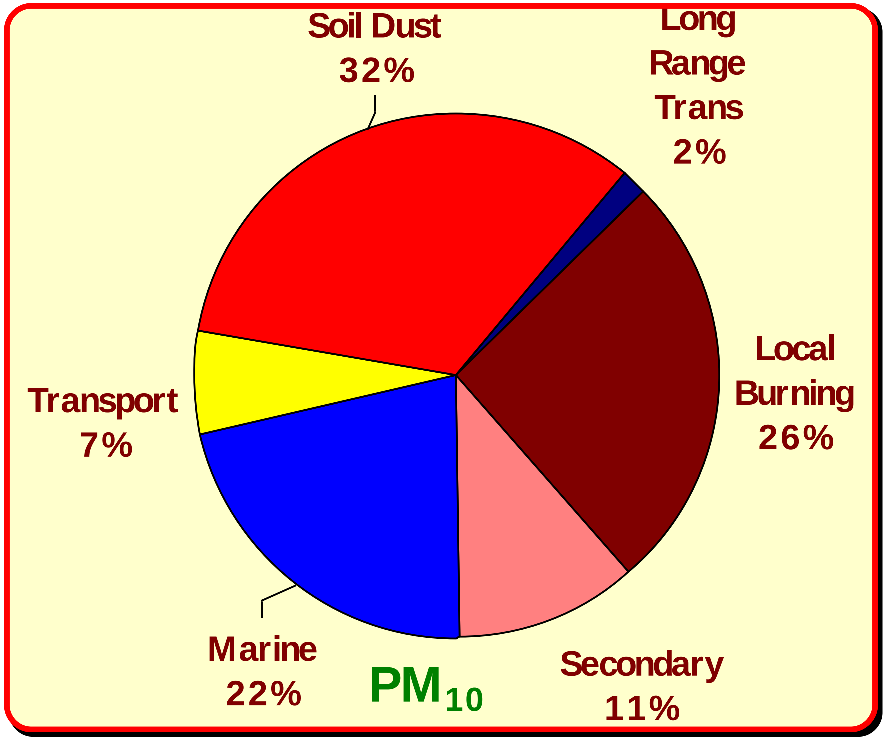
Source: Joint WHO / Convention Task Force on the Health Aspects of Air Pollution, WHO, 2006

Long range transport of PM in Asia

Source Apportionment Results for Hanoi, Vietnam



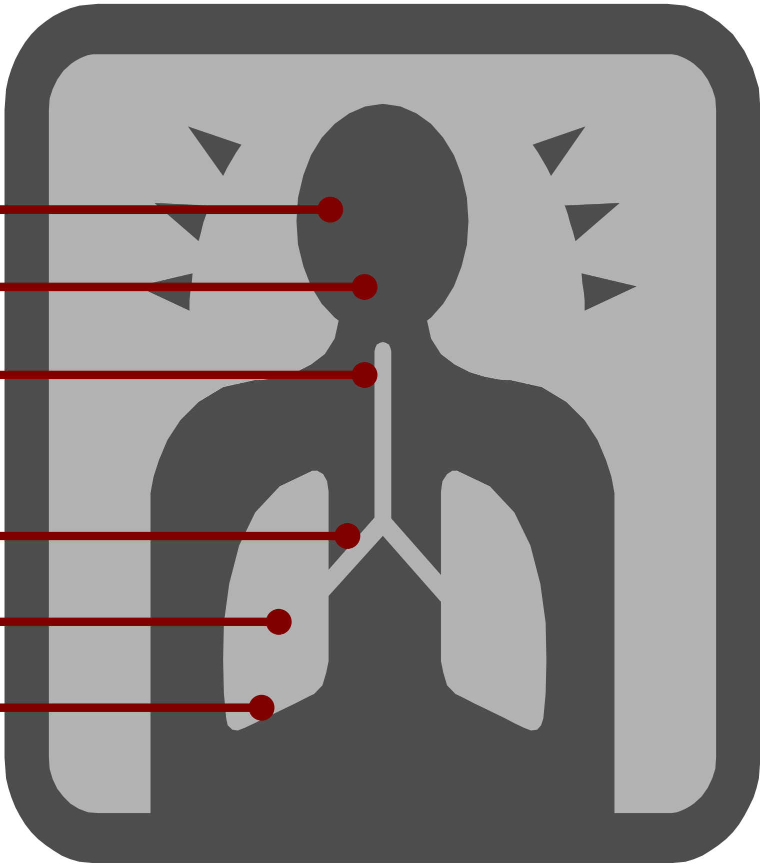


GLOBAL ATMOSPHERIC POLLUTION FORUM

Source: As shown in Guttikunda et al (in press)

Impacts of Air Pollution

Particle Size (µm)	Effect
9.2 to 30	Visible Pollution
5.5 to 9.2	Lodges in nose/throat
3.3 to 5.5	Main breathing passages
2.0 to 3.3	Small breathing passages
1.0 to 2.0	Bronchi
0.1 to 1.0	Air sacs



Source: Guttikunda et al (in press)

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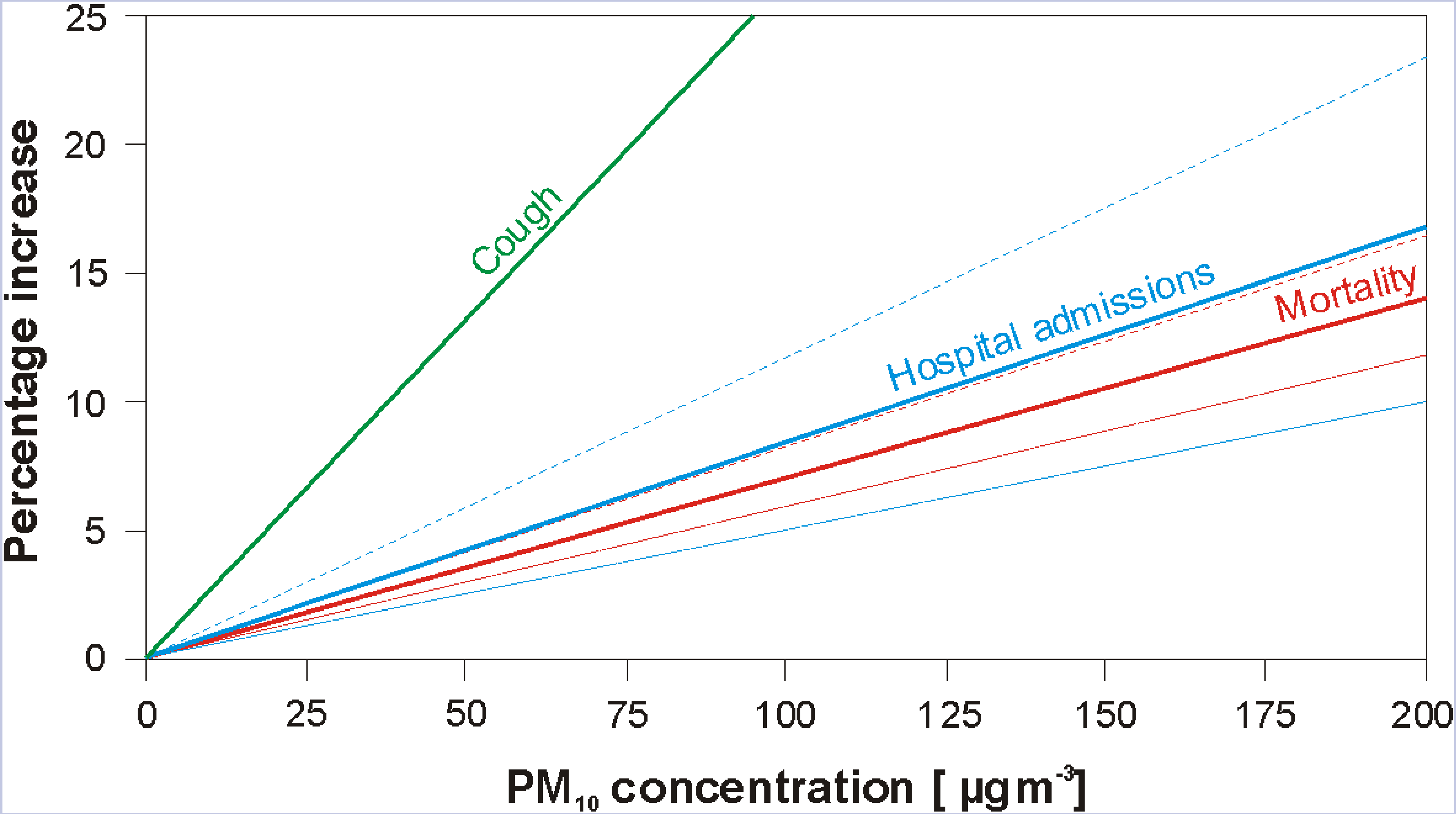


Dose-response relationship for PM10 and health impacts

Impacts of PM on Health

Dose-Response Functions[1] of PM_{10} and Human Health

Health Impact	*Dose Response Function* *Effects/Capita/$\Delta\mu g/m^3$*
Premature Mortality	0.000014
Adult Chronic Bronchitis	0.00004026
Respiratory Hospital Admission	0.0000057
Cardiac Hospital Admission	0.000005
Emergency Room Visit	0.00024
Child Acute Bronchitis	0.000544
Asthma Symptom Day	0.0029
Restricted Activity Day	0.03828
Acute Respiratory Symptom Day	0.30172

Source: Lvovsky, 2001 as shown in Guttikunda et al (in press)

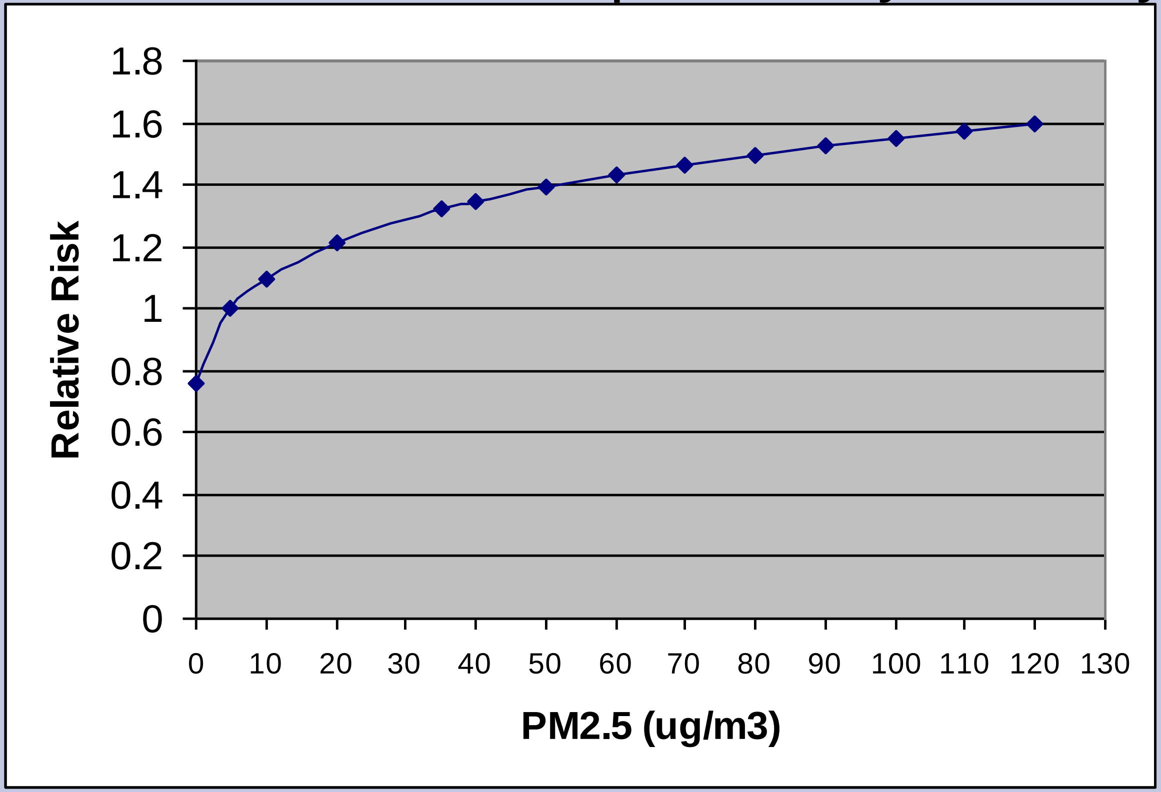
In this table, the function is defined as number of effects per year incurred per unit change in concentrations ($\mu g/m^3$) per capita.

GLOBAL ATMOSPHERIC POLLUTION FORUM

RAPIDC
Regional Air Pollution In Developing Countries

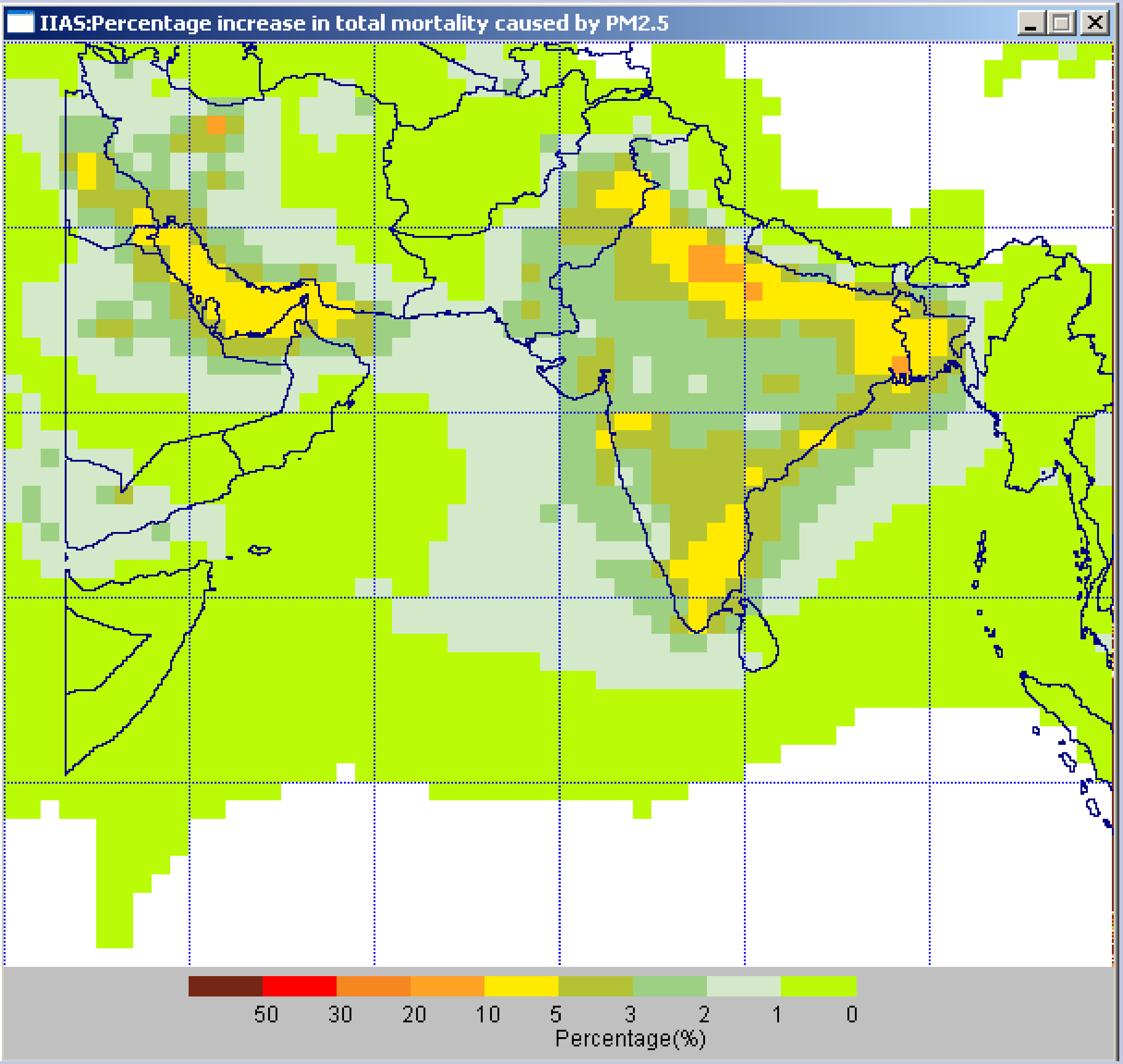
Health Dose-response relationships for the IIAS

Relative risk of cardiopulmonary mortality from $PM_{2.5}$



In IIAS we use WHO study in Europe method = 6% increase in total mortality per 10 μg m^{-3} increase in $PM_{2.5}$

Per cent increase in total mortality from $PM_{2.5}$ (inorganic fraction only)



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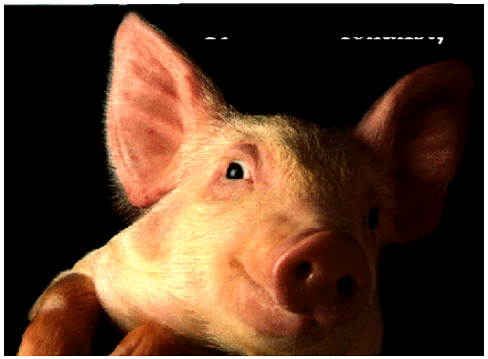
EUTROPHICATION OF ECOSYSTEMS BY N DEPOSITION

SEI

Atmospheric Environment Programme

Eutrophication by N: causes and consequences



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European Response: Critical Loads and Nitrogen Saturation

UN/ECE CLRTAP: Critical loads to avoid N saturation or avoid diversity change based on empirical studies

European Critical Loads Based Upon Empirical Observations

Vegetation Type	**Kg N ha^{-1}**
Raised and blanket bogs	5-10
Forest ground vegetation	10-15
Dry heaths	10-20

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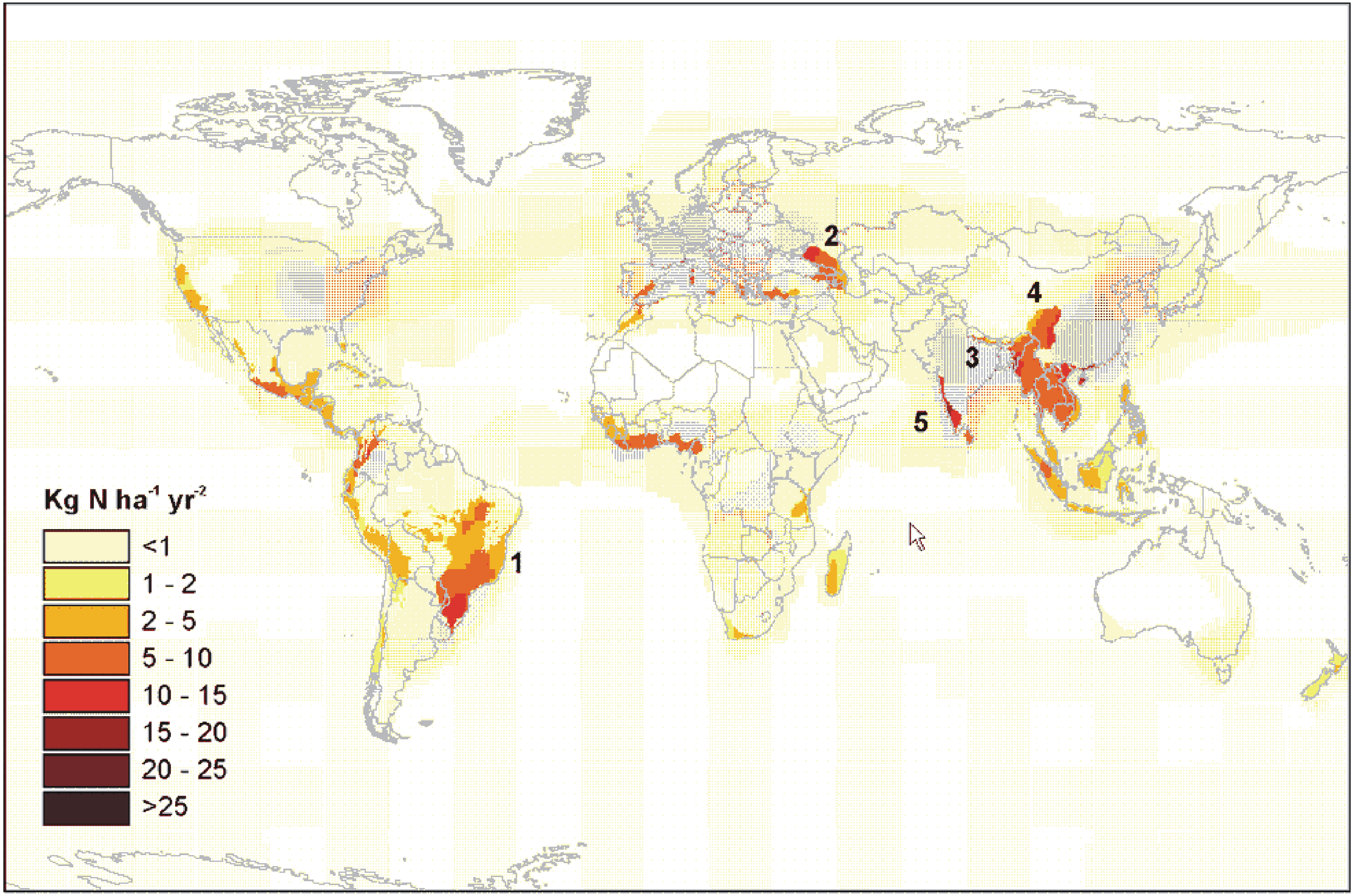
Regions of High Biodiversity Importance (highlighted) and Modelled Global Nitrogen Deposition (colours)



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Biodiversity hotspots: Myers *et al*, 2003

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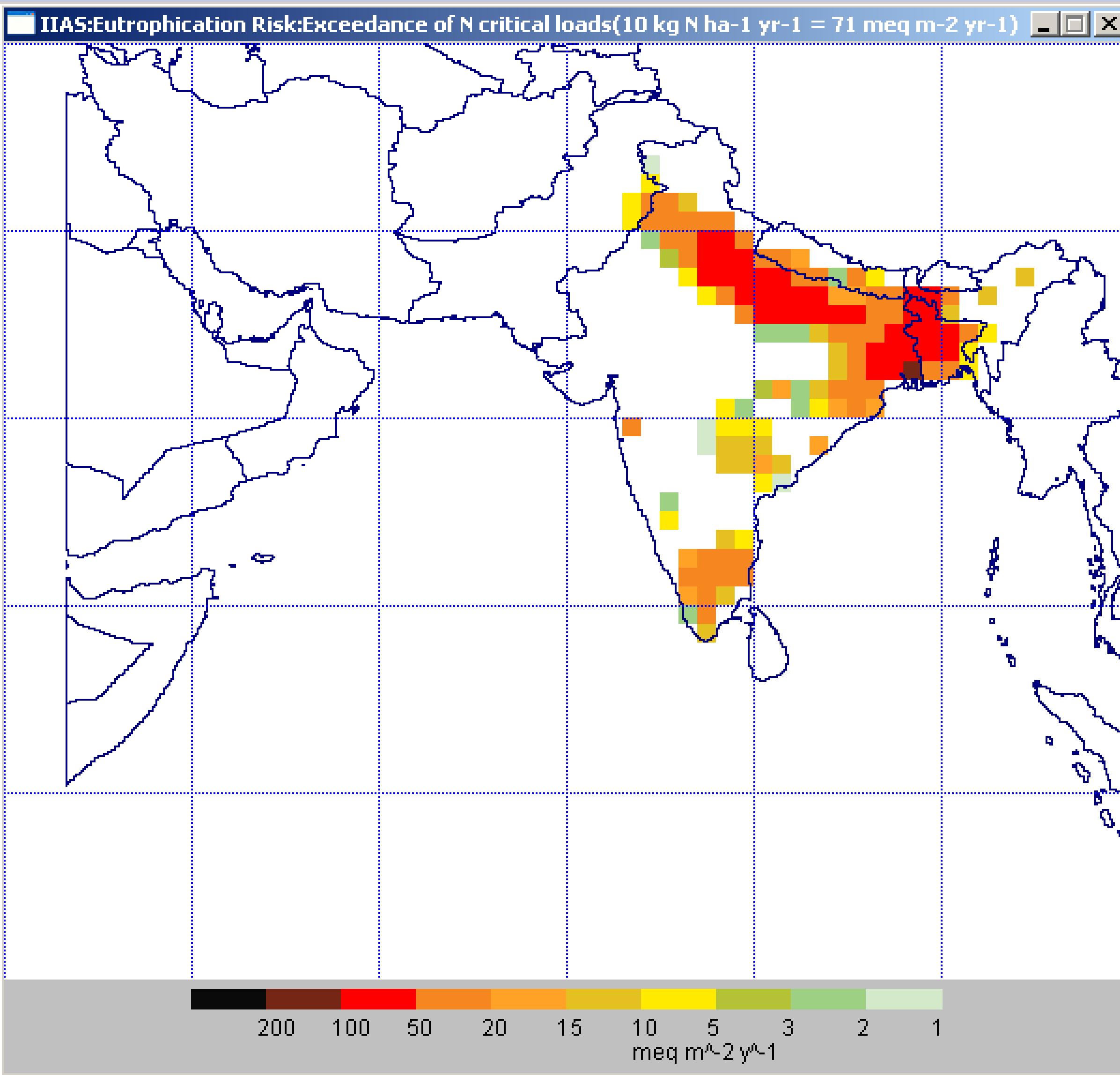
Risk of Eutrophication of Terrestrial Vegetation in IIAS



Showing areas with total NOx + NHx deposition greater than 10 g N ha^{-1} yr^{-1} (71 meq m^{-2}.yr^{-1})

CROP YIELD LOSSES DUE TO OZONE

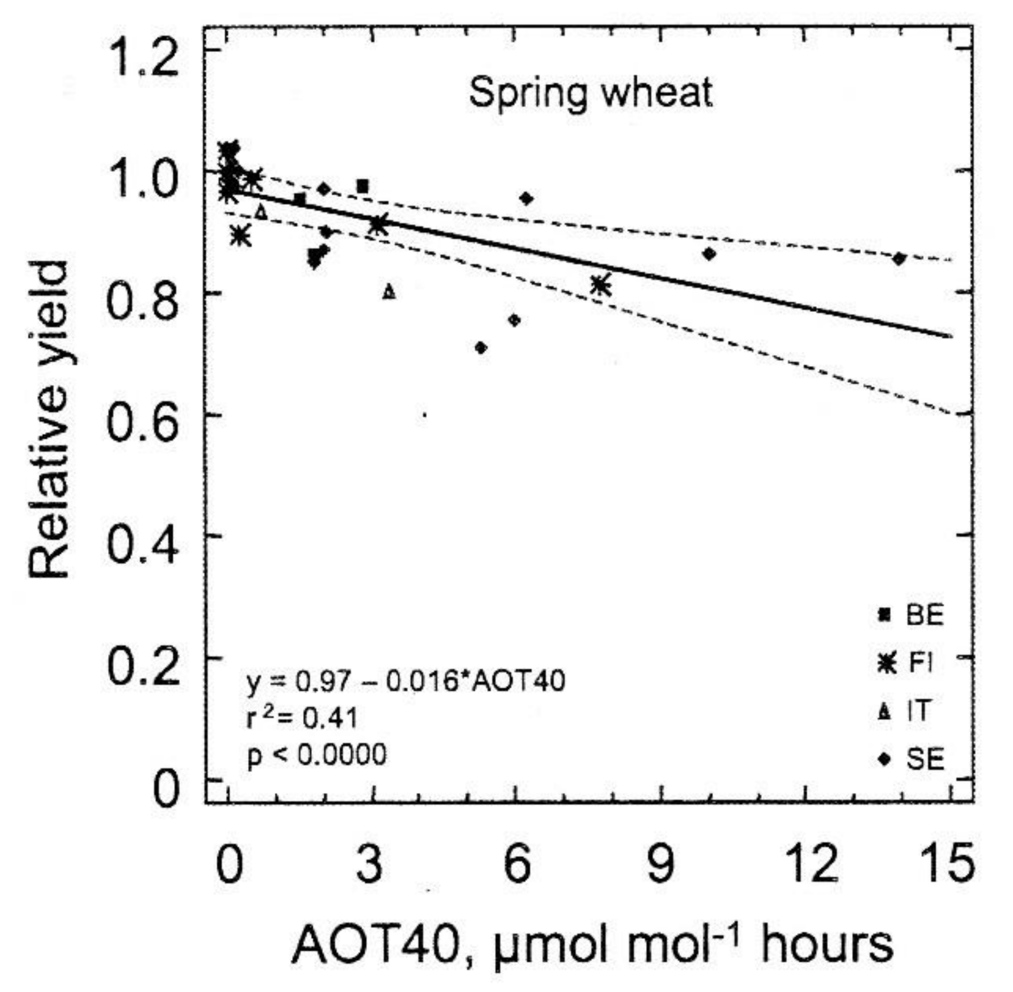
Invisible Injury: as shown by filtration experiments

O_3 injury to wheat whole plant growth, Pakistan (courtesy of A. Wahid)

Open Top Chamber Facilities. Lahore, Pakistan

Risk of Yield Loss in Spring Wheat caused by Ozone

Dose-response relationship from Europe



Risk of Yield Loss in Spring Wheat caused by Ozone

AOT40 Calculations for (from MATCH model - Magnuz)