RAPIDC
Regional Air Pollution in Developing Countries

Monitoring and Modelling in the Malé Declaration

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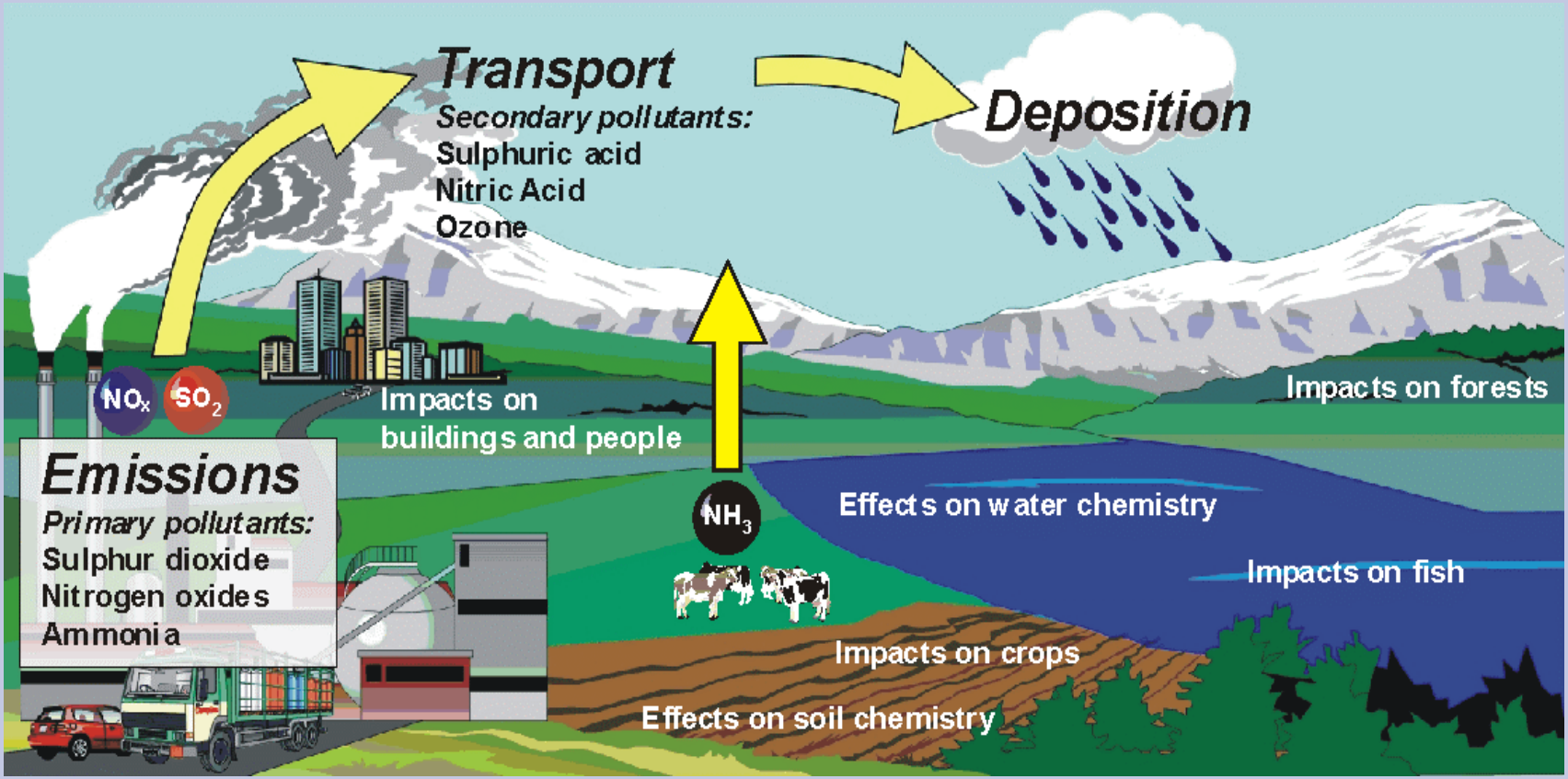
Bangkok, March 2008

Malé Declaration 6th Monitoring Training Course

Aims

- Introduce the concept of atmospheric transport and integrated assessment models and what they can be used for;
- Show how Malé monitoring results compare with modelled values to date and highlight the usefulness of such comparisons;
- Introduce the use of trajectory analysis
- Demonstrate the importance of site selection and impact studies



- Health impacts caused by gases, particulates and heavy metals
- Environmental effects (acidification, eutrophication, global climate change, ecosystem and material damage)
- Economic loss (crop yields, corrosion of materials, lost work days)

Prevention and Control of Air Pollution

-The European experience was one of controlling air pollution once it had happened

- South Asia is now experiencing impacts of air pollution

- But, there is an opportunity to prevent air pollution reaching levels where it causes widespread impacts

As emissions in Asia are increasing rapidly the Malé Monitoring network is essential to demonstrate the increasing concentrations of air pollution

Producing Information for Policy Makers

The Malé Declaration is developing an Integrated Information and Assessment System (IIAS):

- A way to integrate the different Malé Declaration activities and data and provide additional information for policy makers;

- 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 the regional background air pollution to different receptors;

- A tool to investigate the implications of scenarios including different policy interventions.

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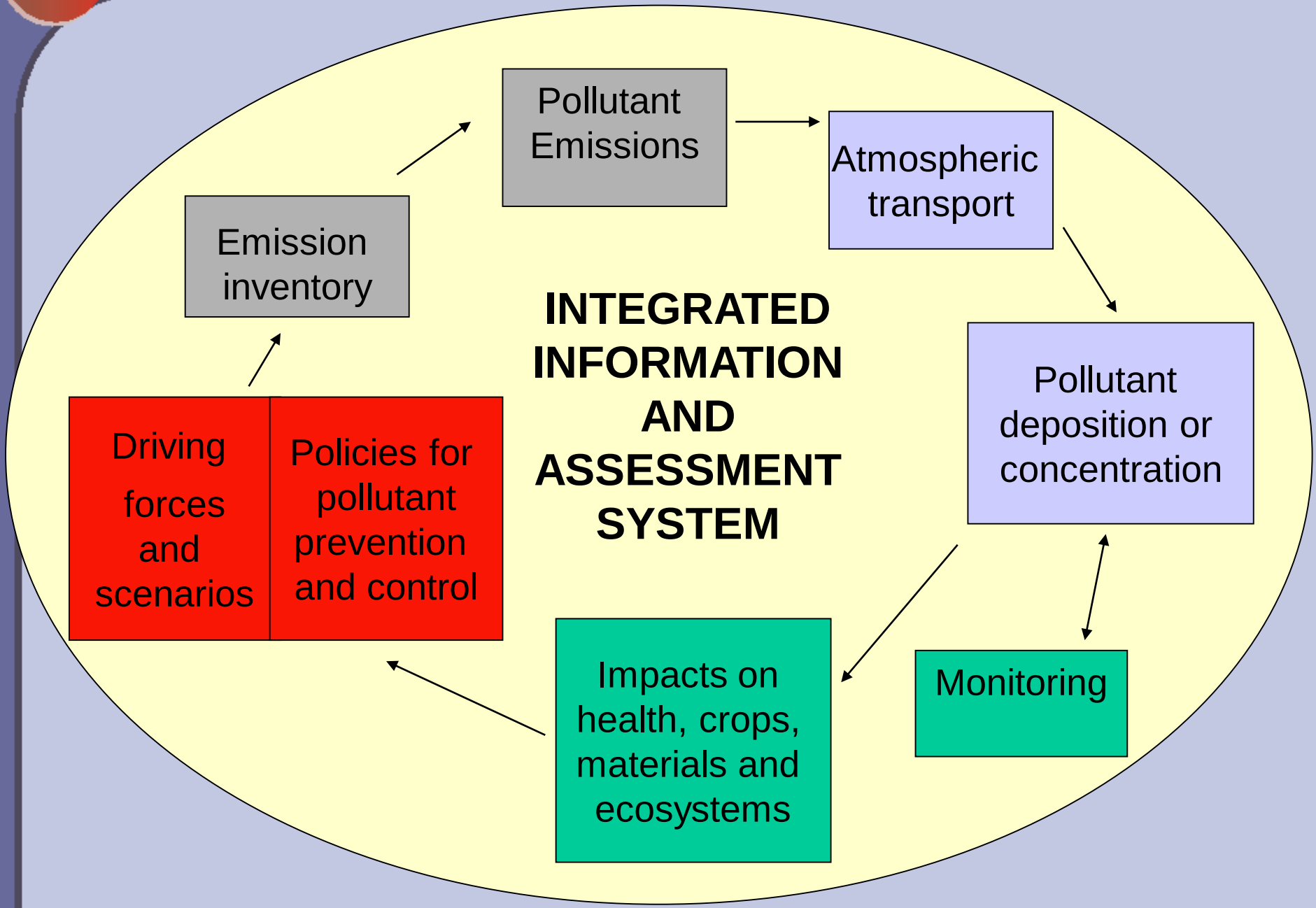
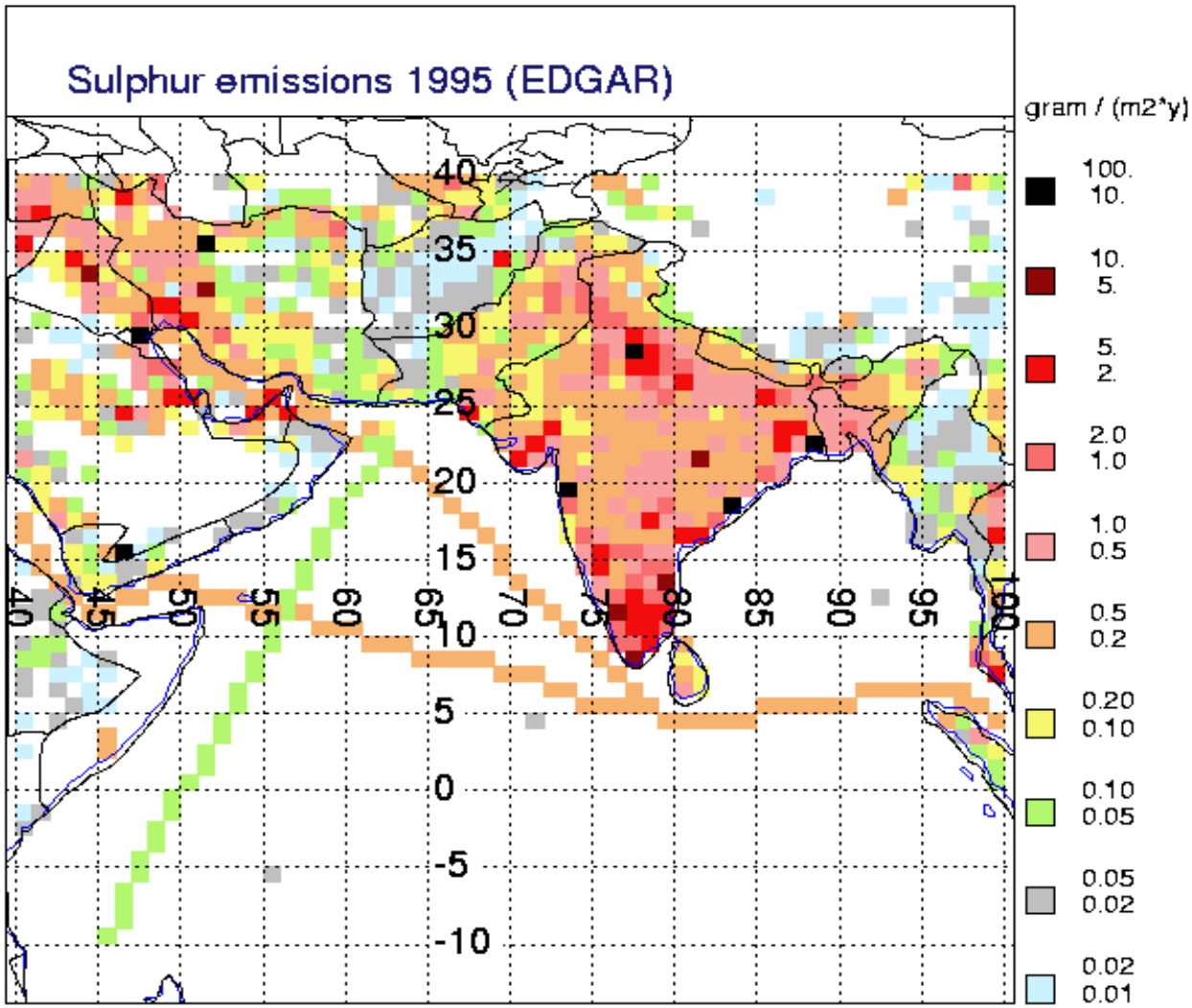
Scientific knowledge to underpin the policy process





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

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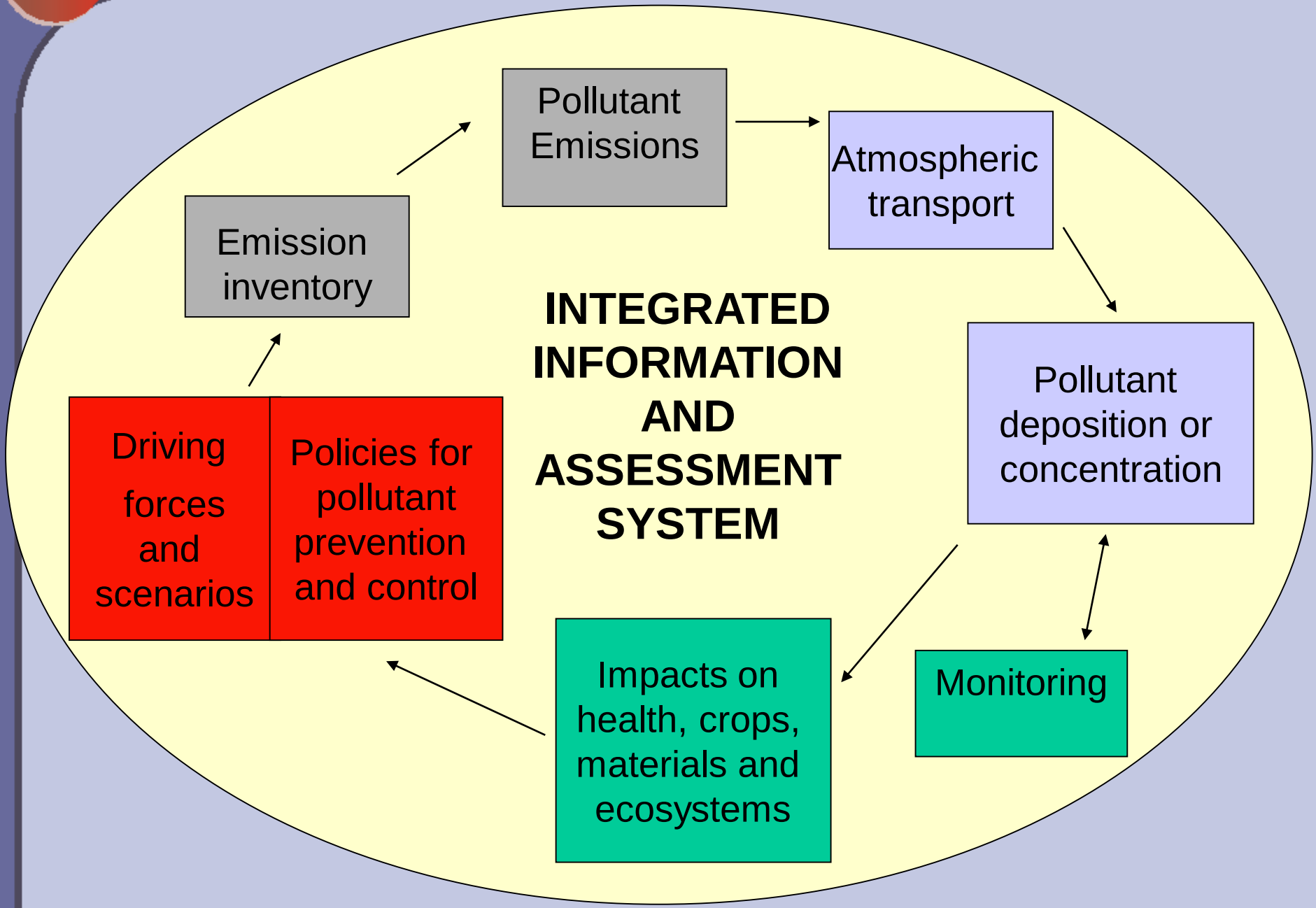


Atmospheric transport models

• Simulate the transport and chemical transformation of pollutants from emission to deposition.

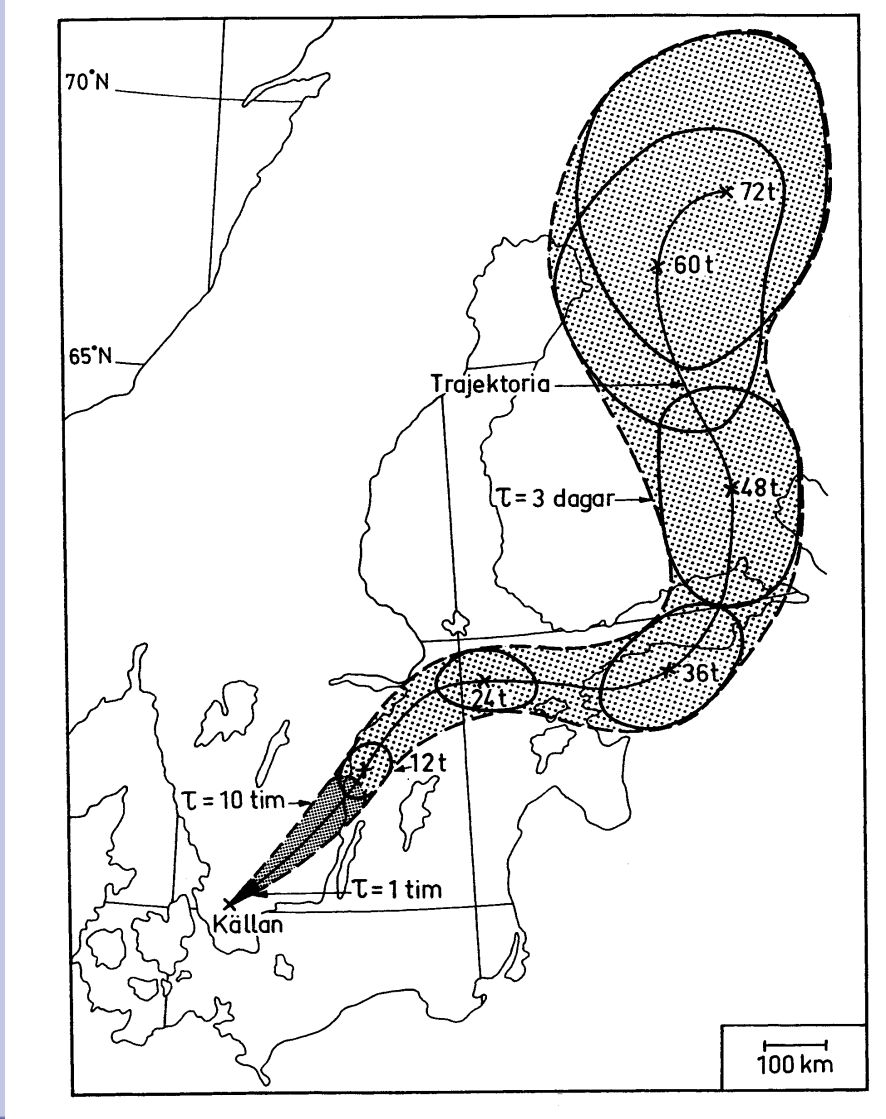
• Transport direction and duration is determined by meteorology.

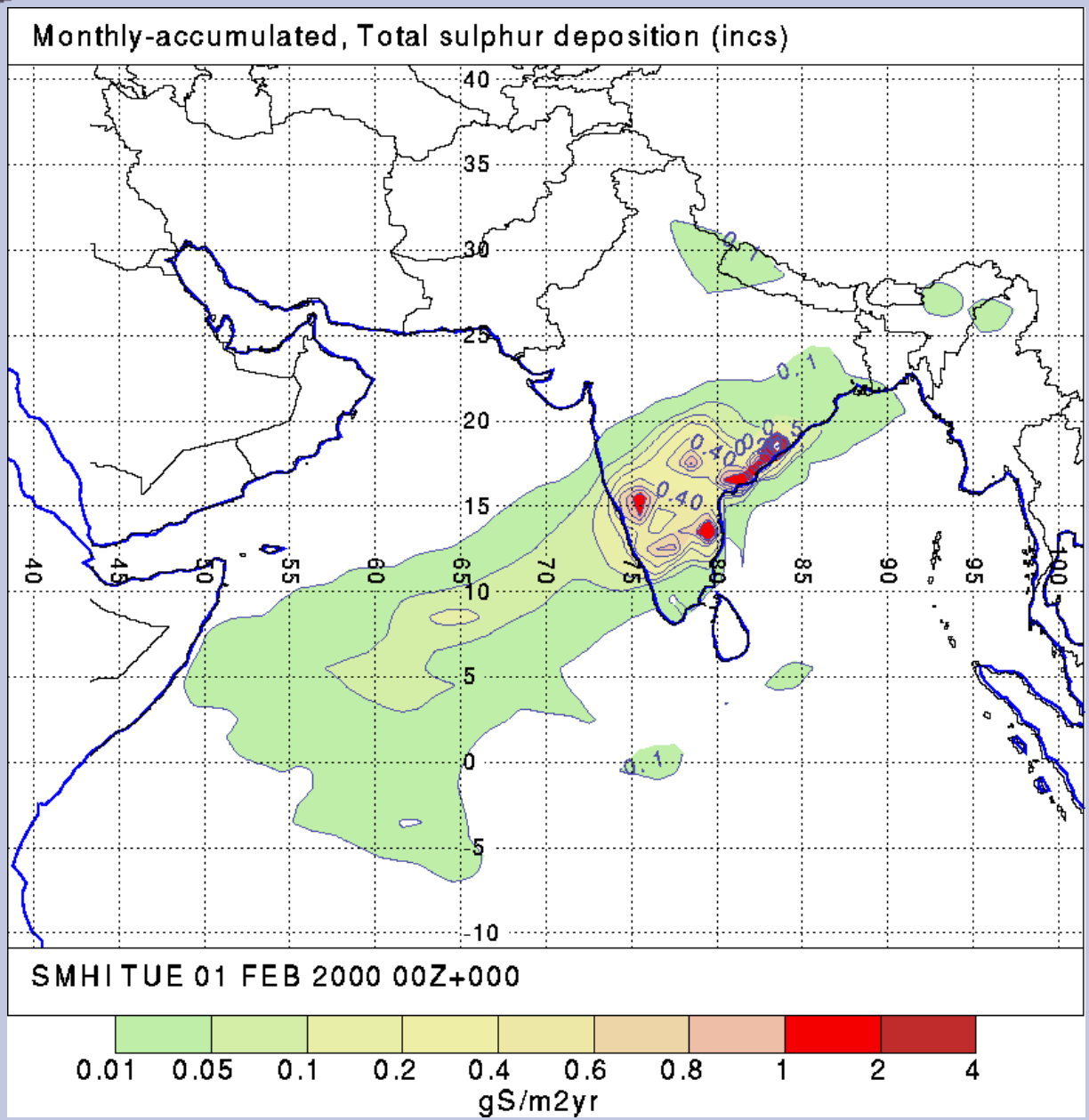
• Atmospheric chemistry is important as the chemical form of a pollutant will determine how far it can travel before deposition e.g. small particles travel further

Use of atmospheric transport models

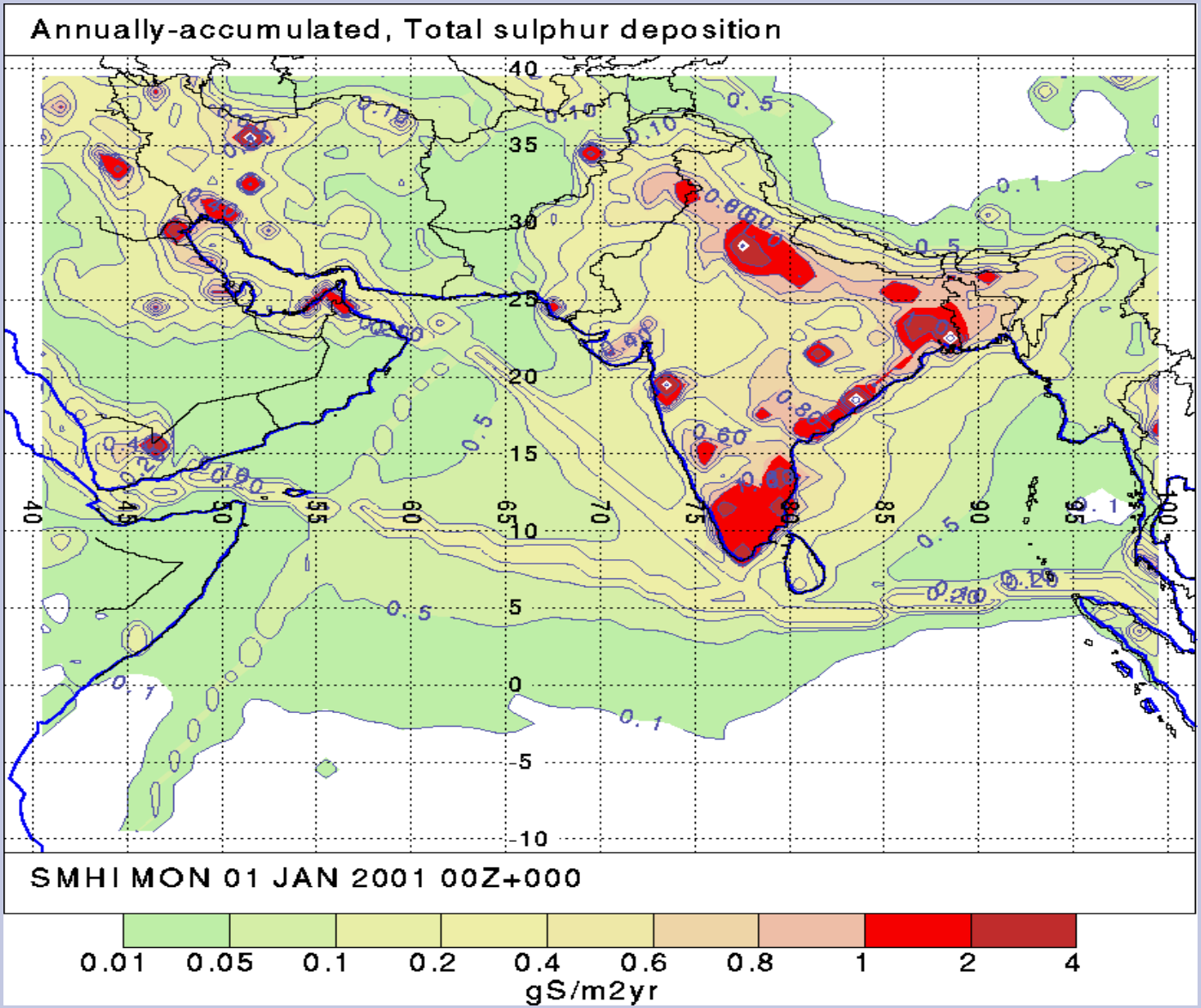
Atmospheric trajectories:

- Can be used to find out where pollutants are going
- Can be used to investigate the cause of an episode
- Can be used to classify air arriving at a site from different “sectors”



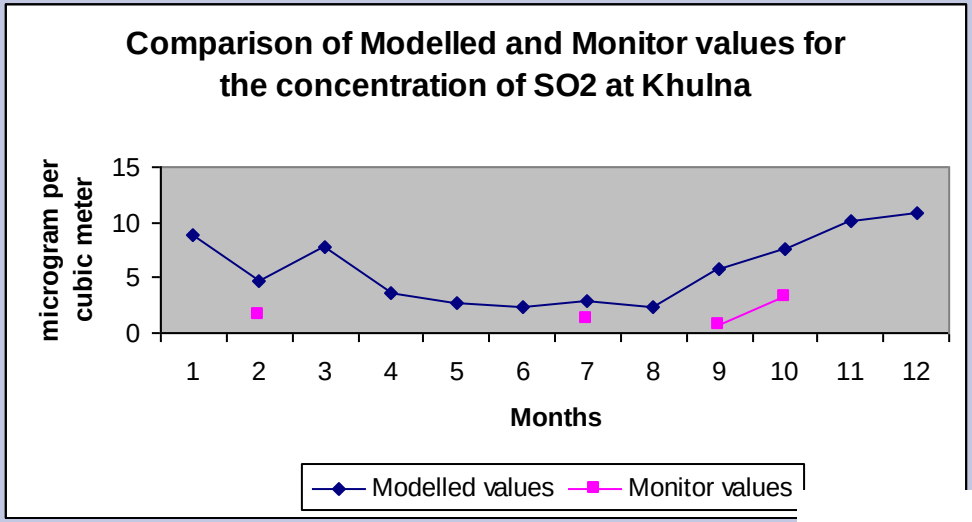


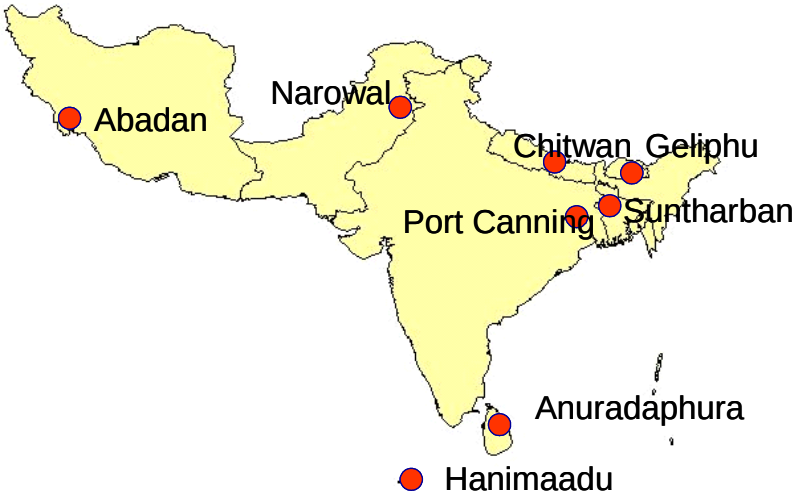
MATCH model run for emission region ‘India south-central’ (Andhra Pradesh + Karnataka + Goa)

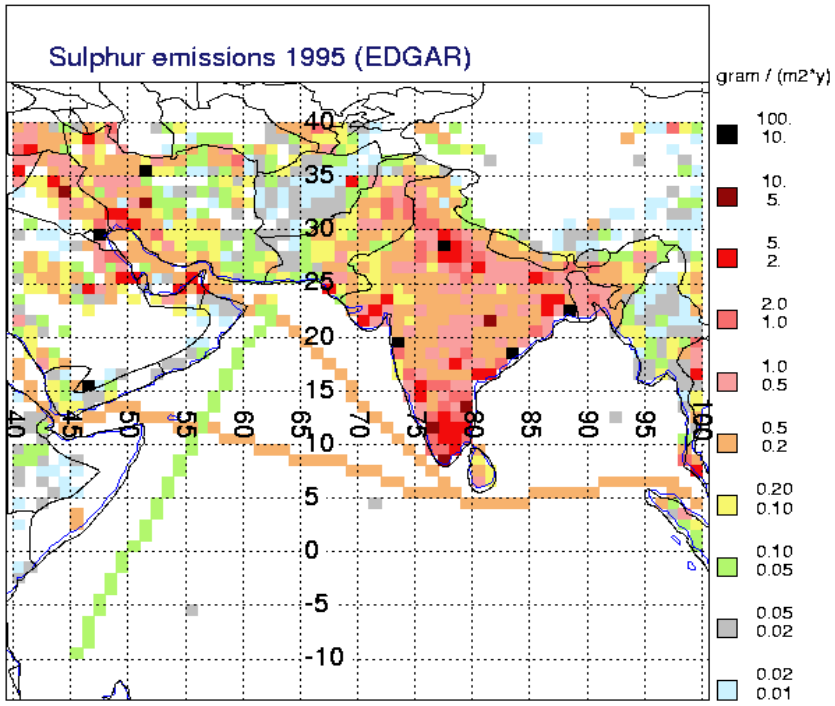


Deposition of sulphur in S Asia using the MATCH model

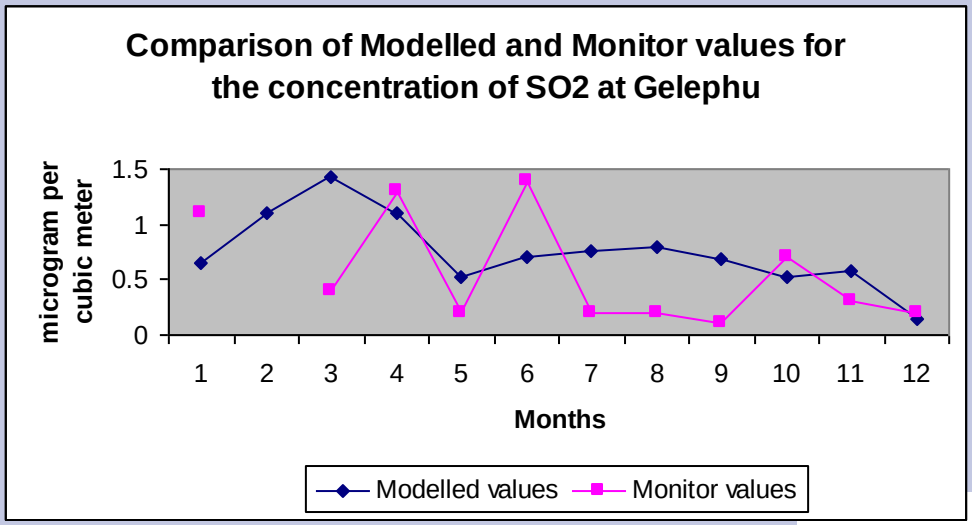
Bangladesh

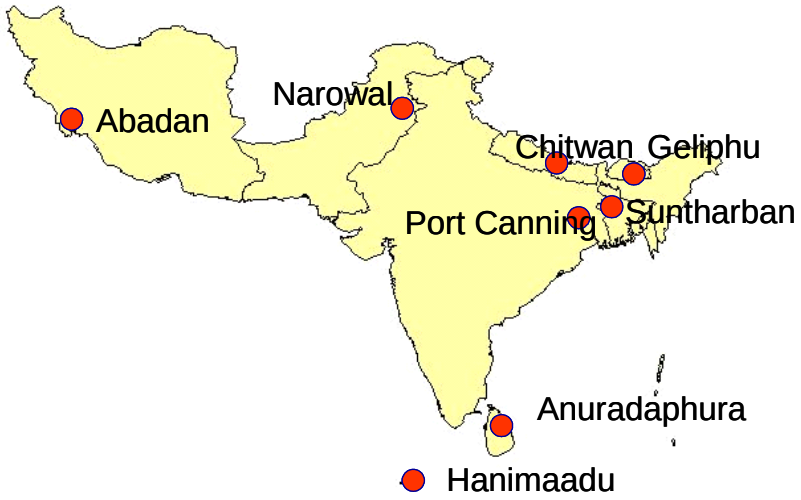

Comparison of Modelled and Monitor values for the concentration of SO2 at Khulna
microgram per cubic meter
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
Modelled values
Monitor values


Abadan
Narowal
Chitwan
Geliphu
Port Canning
Suntharban
Anuradaphura
Hanimaadu


Sulphur emissions 1995 (EDGAR)
gram / (m2*y)
100.
10.
10.
5.
5.
2.
2.0
1.0
1.0
0.5
0.5
0.2
0.20
0.10
0.10
0.05
0.05
0.02
0.02
0.01
40
35
30
25
20
15
10
5
0
-5
-10
40
45
50
55
60
65
70
75
80
85
90
95
100

Bhutan


Comparison of Modelled and Monitor values for the concentration of SO2 at Gelephu
microgram per cubic meter
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
Modelled values
Monitor values


Abadan
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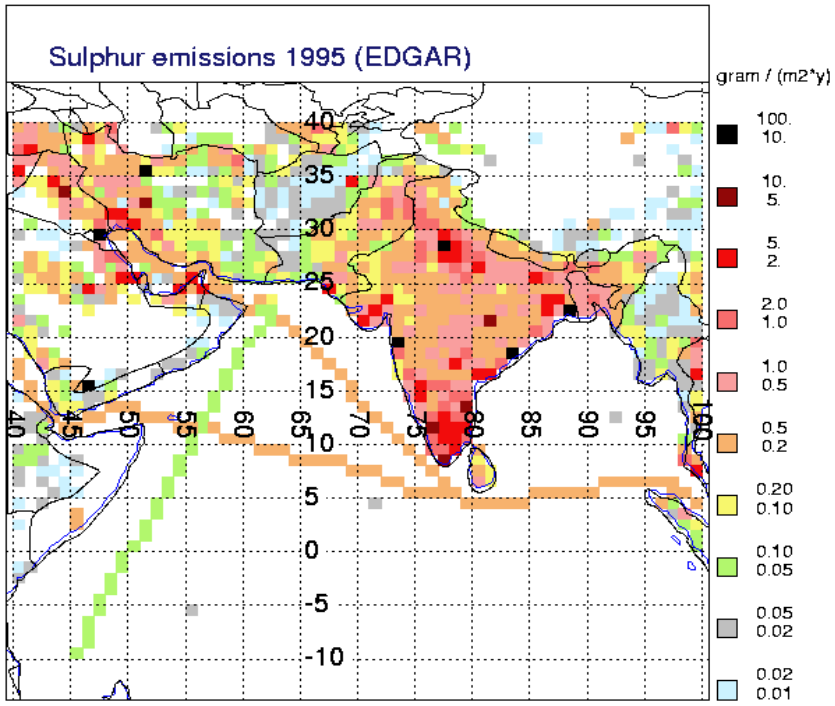
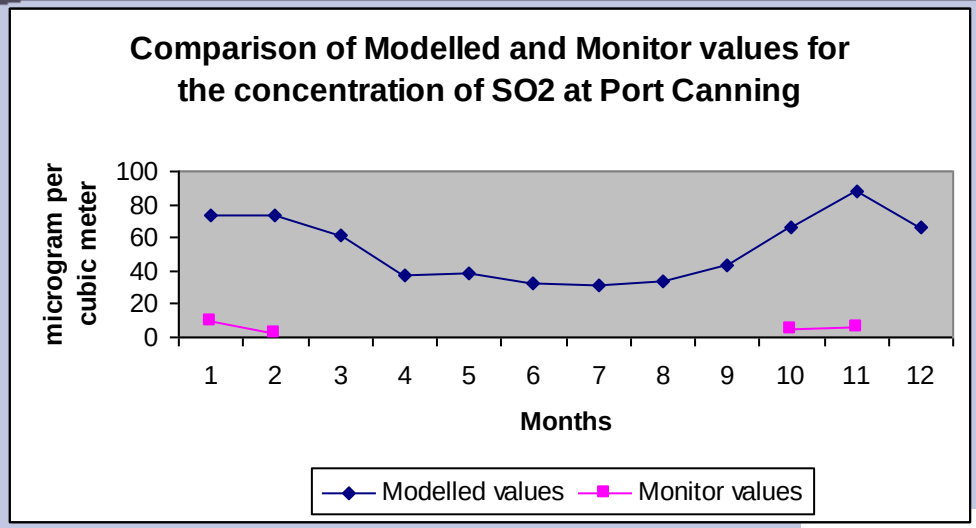
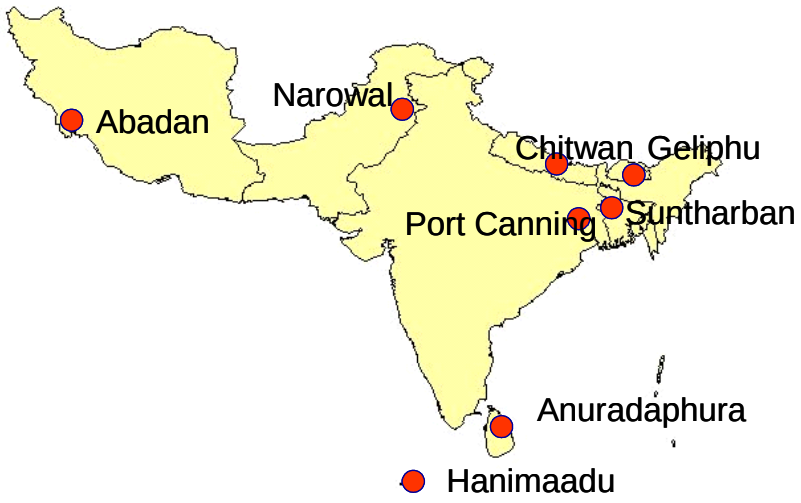
Geliphu
Port Canning
Suntharban
Anuradaphura
Hanimaadu


Sulphur emissions 1995 (EDGAR)
gram / (m2*y)
100.
10.
10.
5.
5.
2.
2.0
1.0
1.0
0.5
0.5
0.2
0.20
0.10
0.10
0.05
0.05
0.02
0.02
0.01
40
35
30
25
20
15
10
5
0
-5
-10
40
45
50
55
60
65
70
75
80
85
90
95
100


Comparison of Modelled and Monitor values for the concentration of SO2 at Port Canning
microgram per cubic meter
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
Months
Modelled values
Monitor values

India


Abadan
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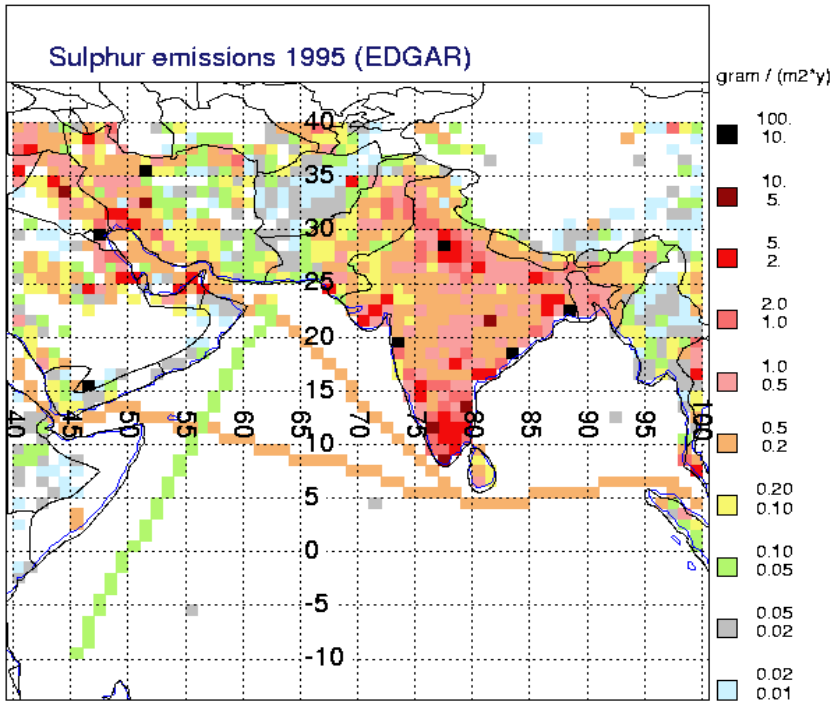
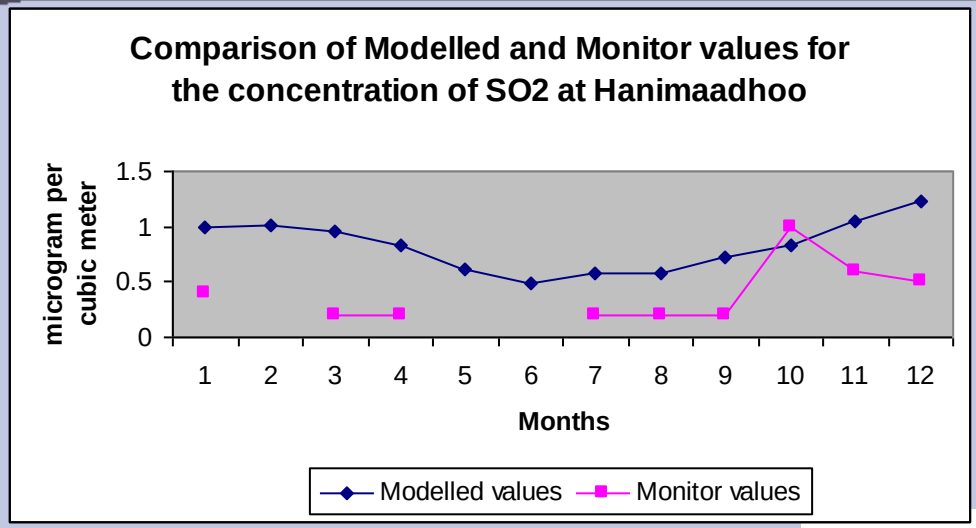
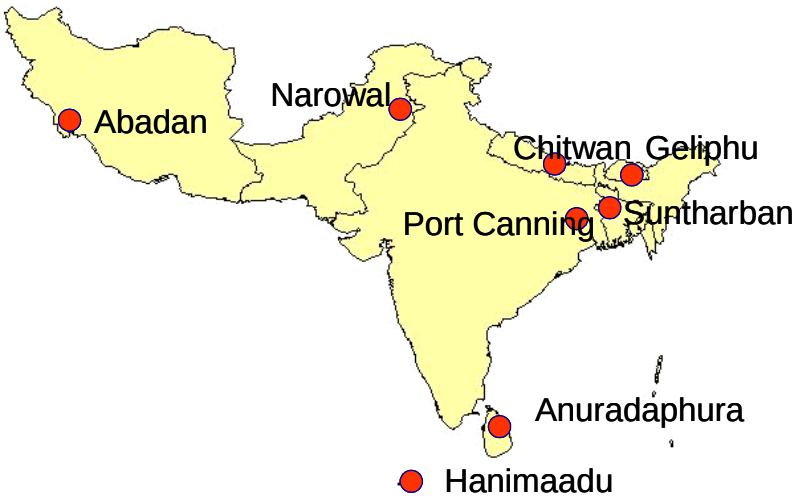
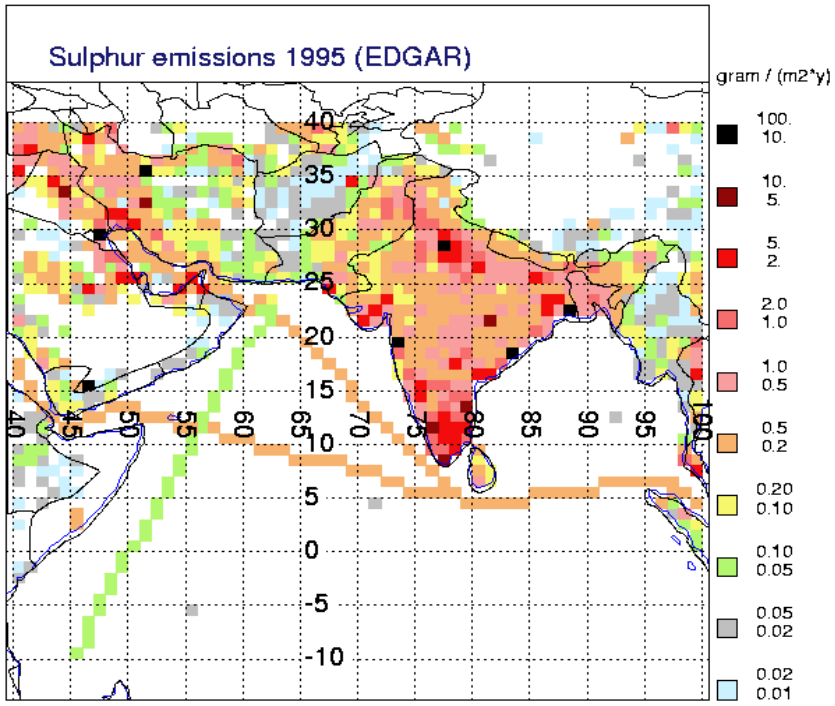
Port Canning
Suntharban
Anuradaphura
Hanimaadu

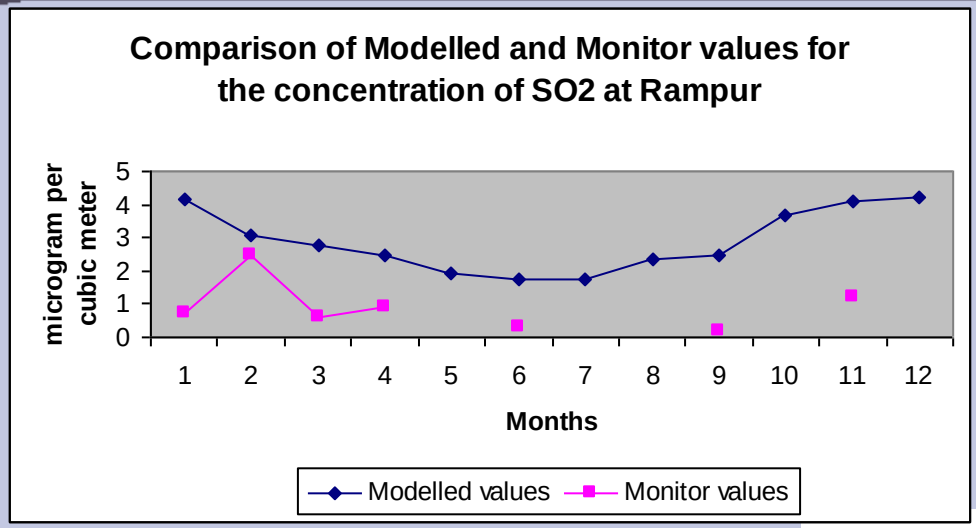

Sulphur emissions 1995 (EDGAR)
gram / (m2*y)
100.
10.
10.
5.
5.
2.
2.0
1.0
1.0
0.5
0.5
0.2
0.20
0.10
0.10
0.05
0.05
0.02
0.02
0.01



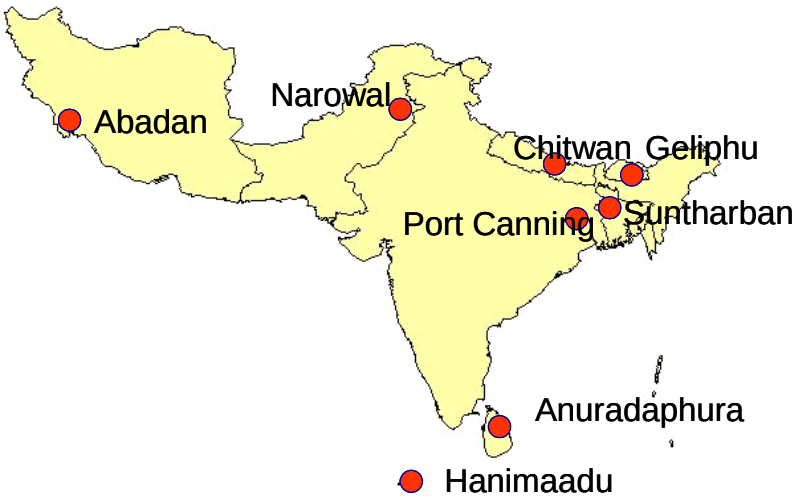
The Maldives






Comparison of Modelled and Monitor values for the concentration of SO2 at Rampur
microgram per cubic meter
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
11
12
Months
Modelled values
Monitor values

Nepal


Abadan
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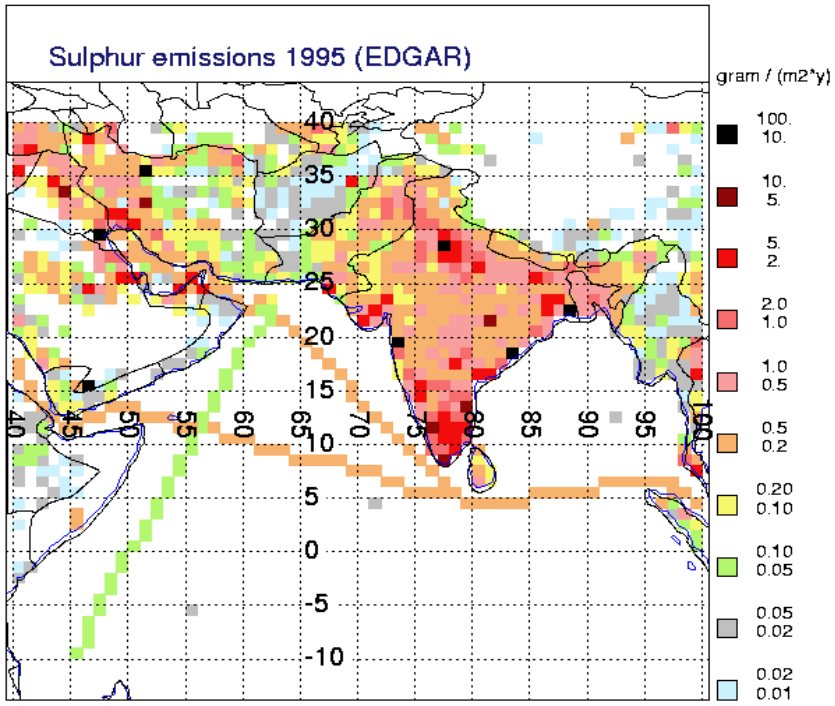
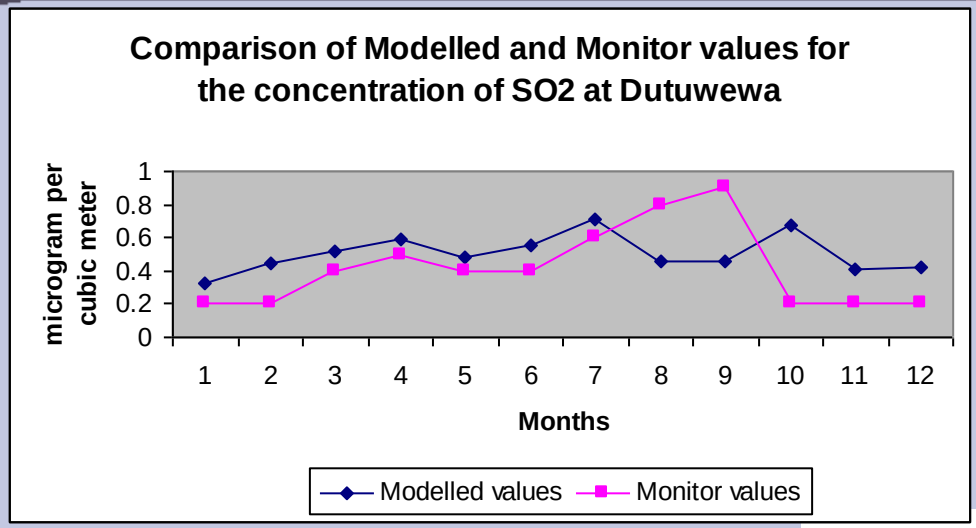
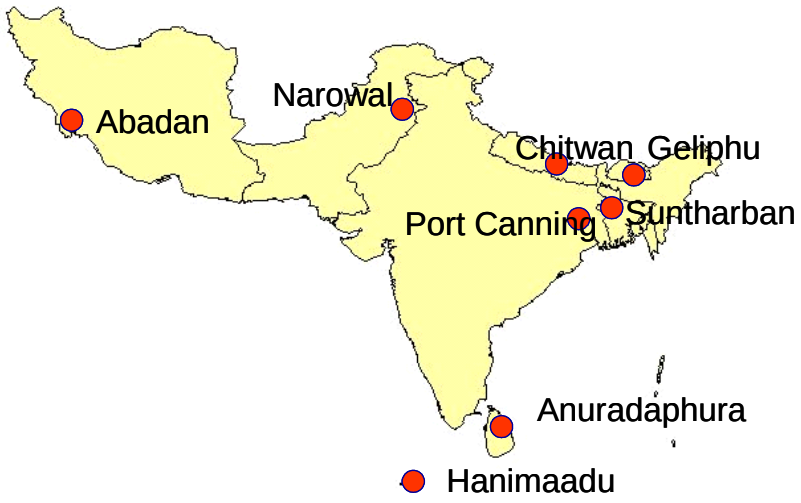

Sulphur emissions 1995 (EDGAR)
gram / (m2*y)
100.
10.
10.
5.
5.
2.
2.0
1.0
1.0
0.5
0.5
0.2
0.20
0.10
0.10
0.05
0.05
0.02
0.02
0.01

Sri Lanka


Comparison of Modelled and Monitor values for the concentration of SO2 at Dutuwewa
microgram per cubic meter
1
0.8
0.6
0.4
0.2
0
1 2 3 4 5 6 7 8 9 10 11 12
Months
Modelled values
Monitor values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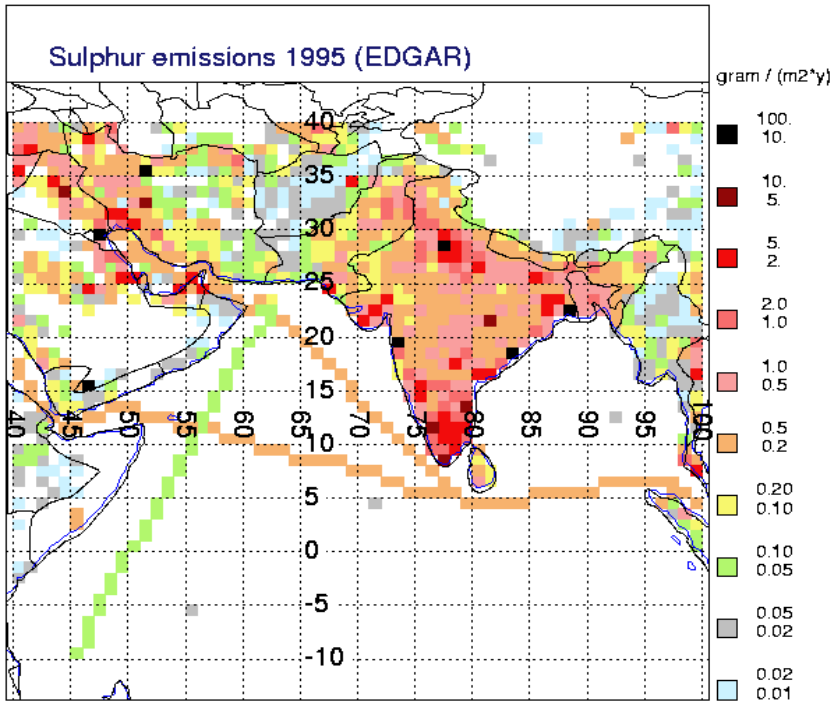
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gram / (m2*y)
100.
10.
10.
5.
5.
2.
2.0
1.0
1.0
0.5
0.5
0.2
0.20
0.10
0.10
0.05
0.05
0.02
0.02
0.01

Advantages of using models

-Regional maps of air pollution deposition can be produced which would not be possible with monitoring efforts alone;

- Modelled deposition maps can be validated with monitoring data – ***site selection is therefore very important***;

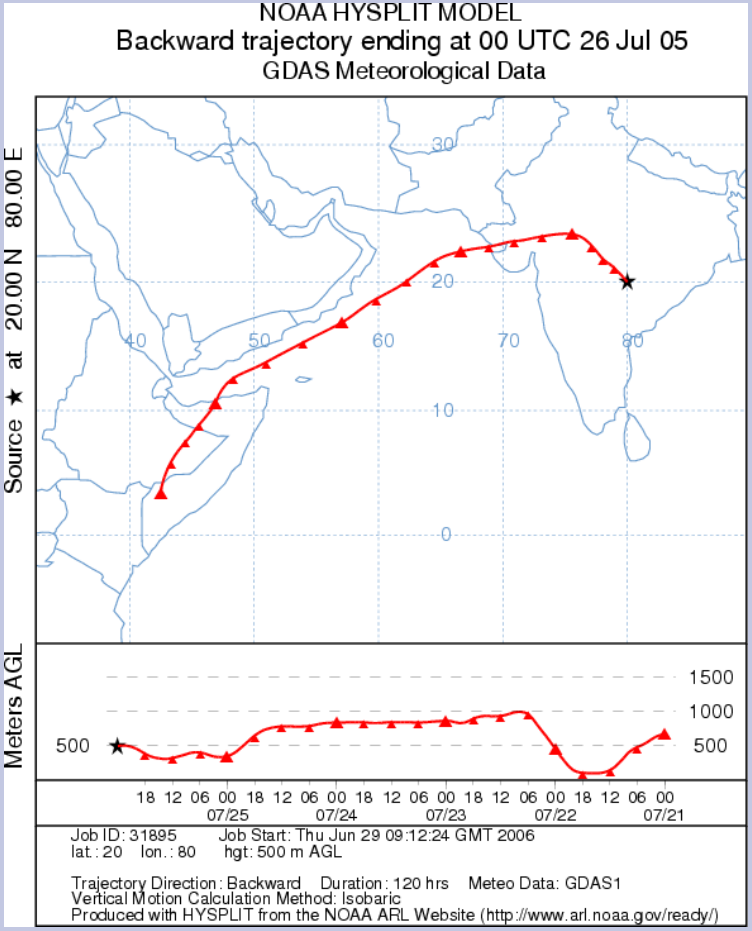
- The emission inventory fields can be changed to show what may happen in the future.

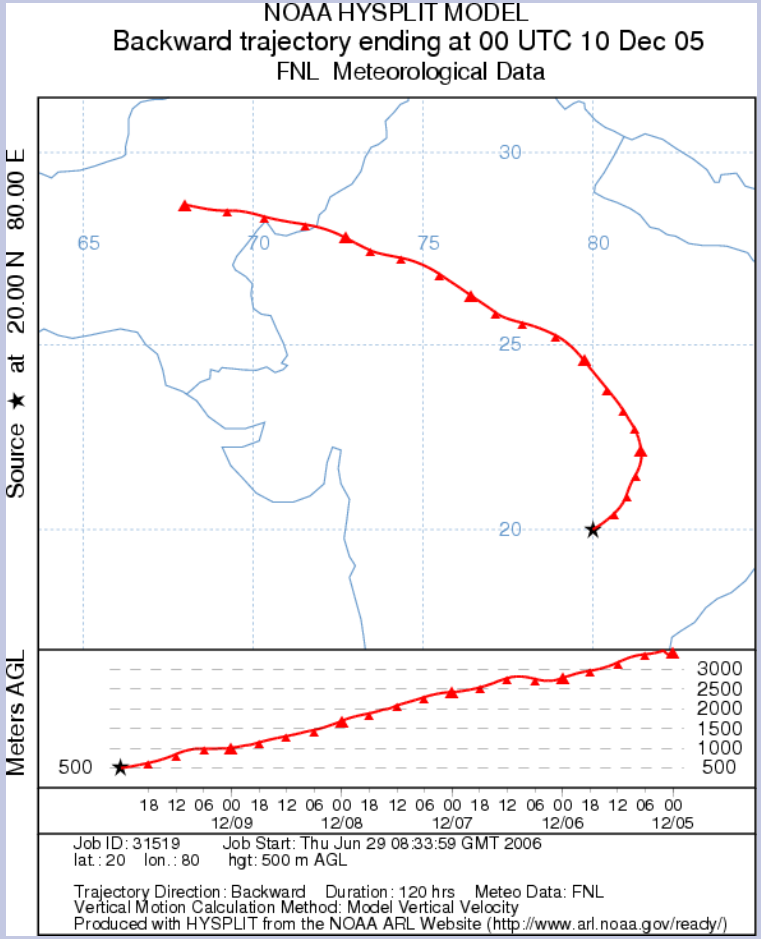
Understanding pollution events at your sites

In order to interpret the data collected at the Malé monitoring stations:

- You can calculate 5-day, back-trajectories to the monitoring station in your respective country;
- The trajectories will tell you something about the history of the air arriving at your station;
- Remember that the “life-time” of many pollutants that we are concerned with (NO_X, SO_X, NH_X, O_3, PM2.5, etc.) is on the order of 3-5 days.

Use the NOAA HYSPLIT web-page (www.arl.noaa.gov/ready/hysplit4.html) and calculate on-line trajectories





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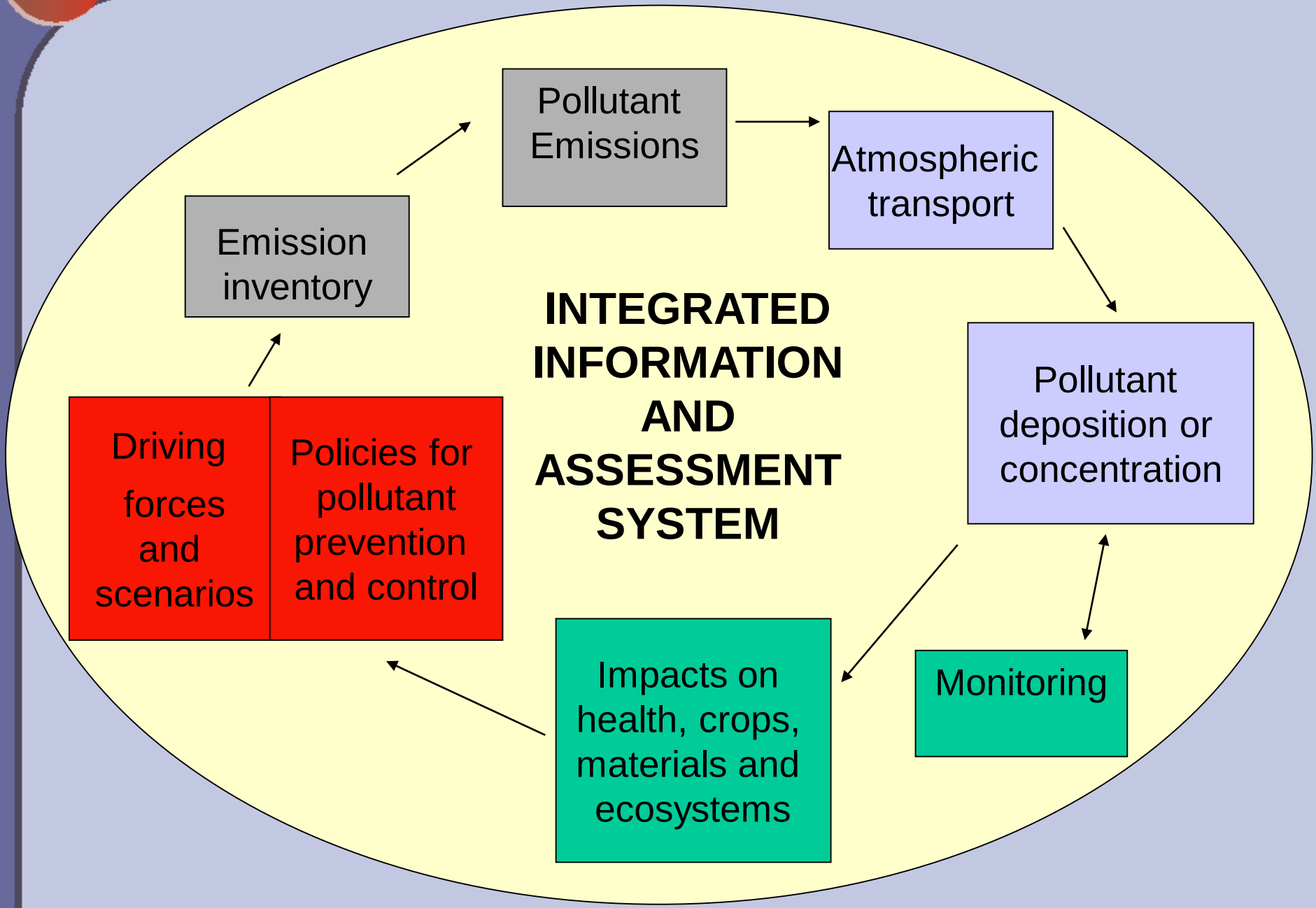
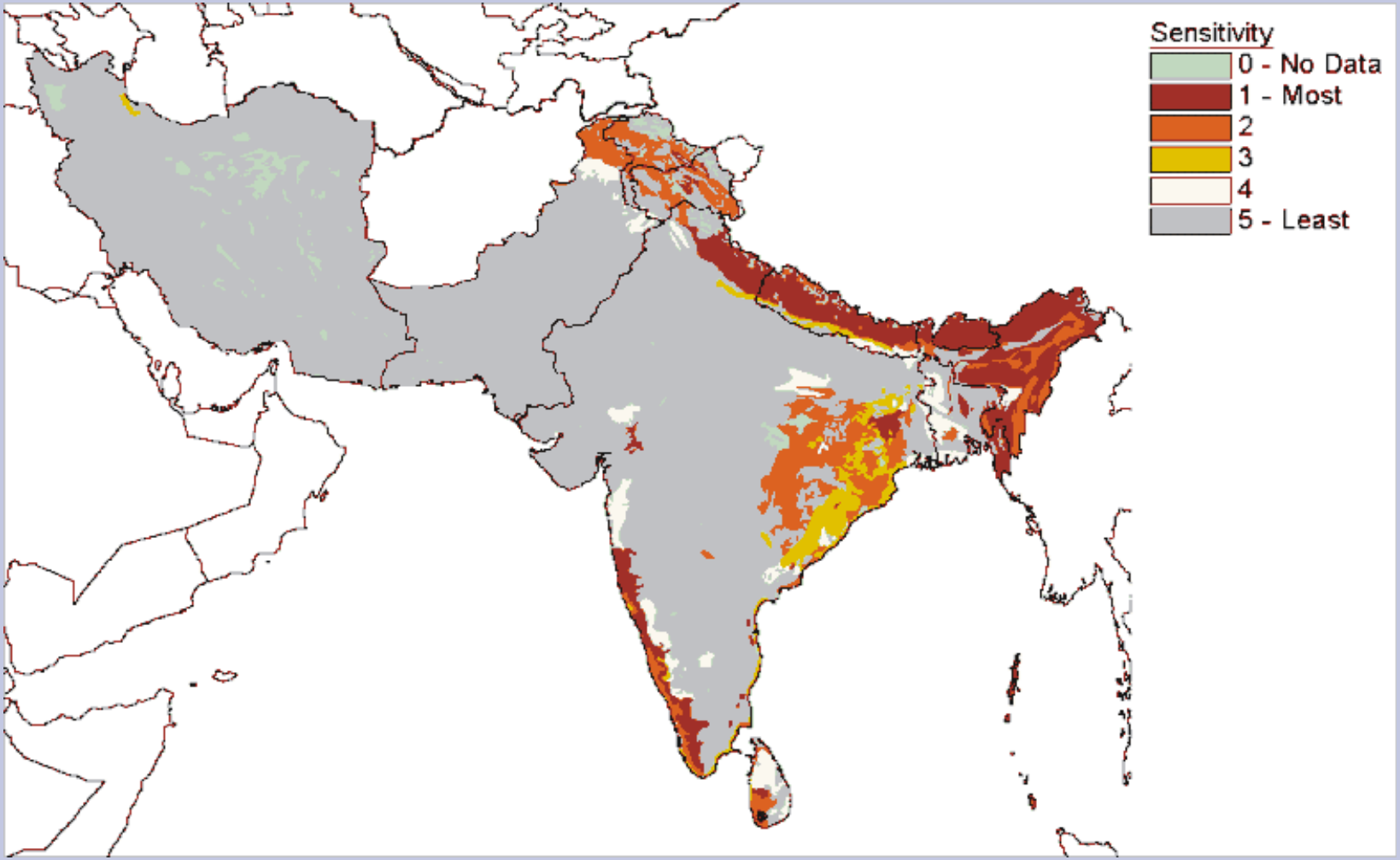
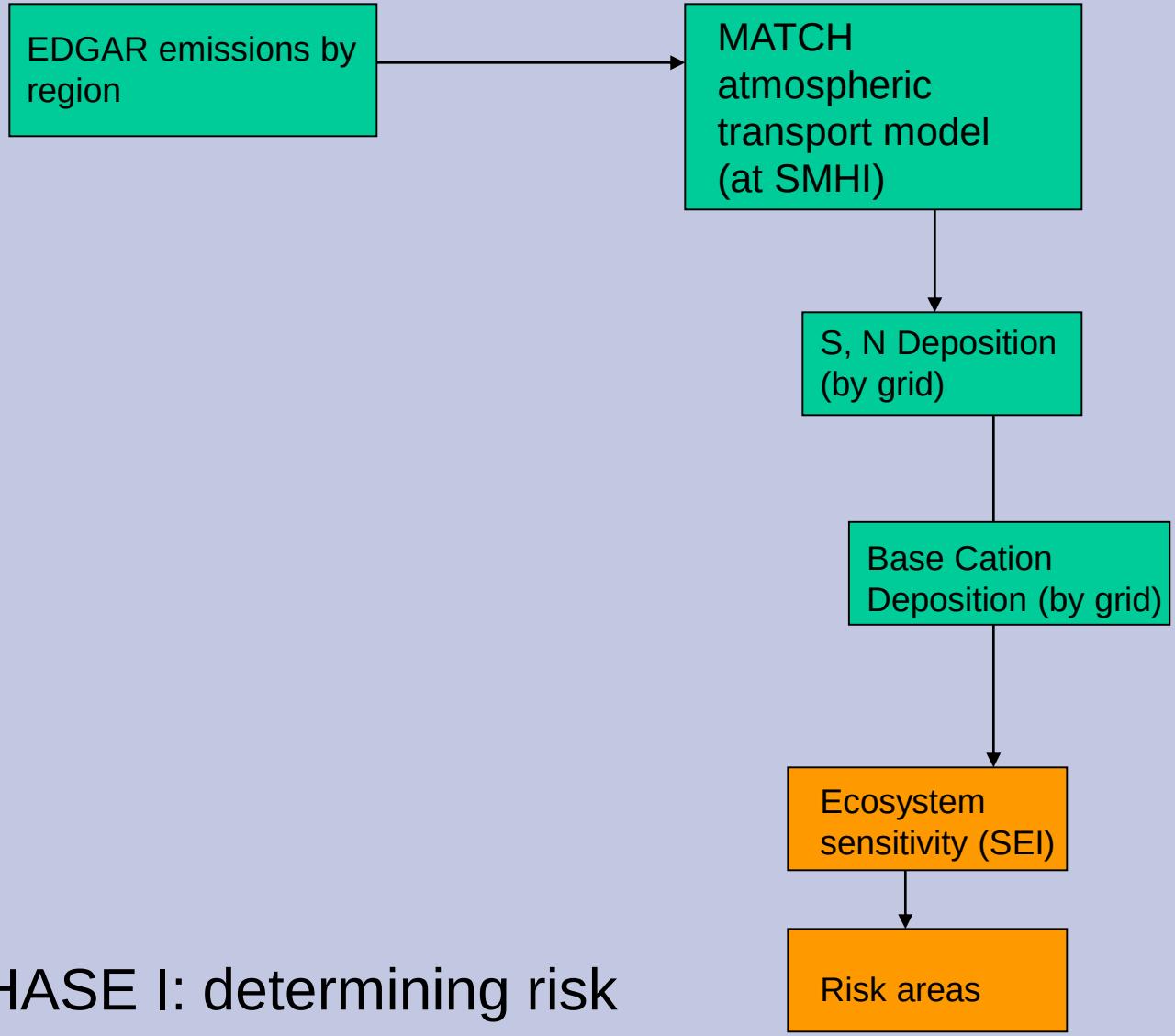


Terrestrial Ecosystem Sensitivity to Acidic Deposition in South Asia

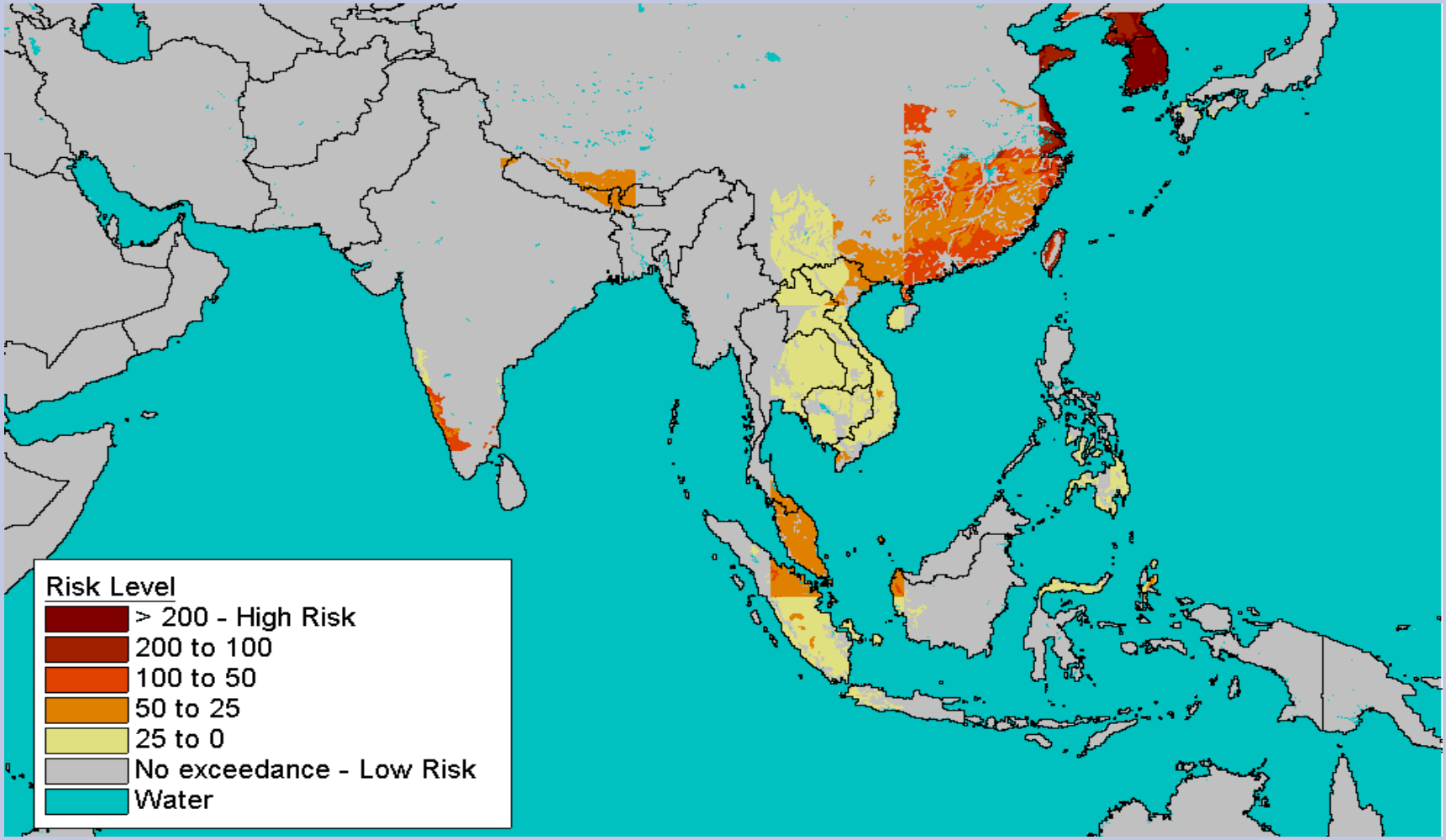


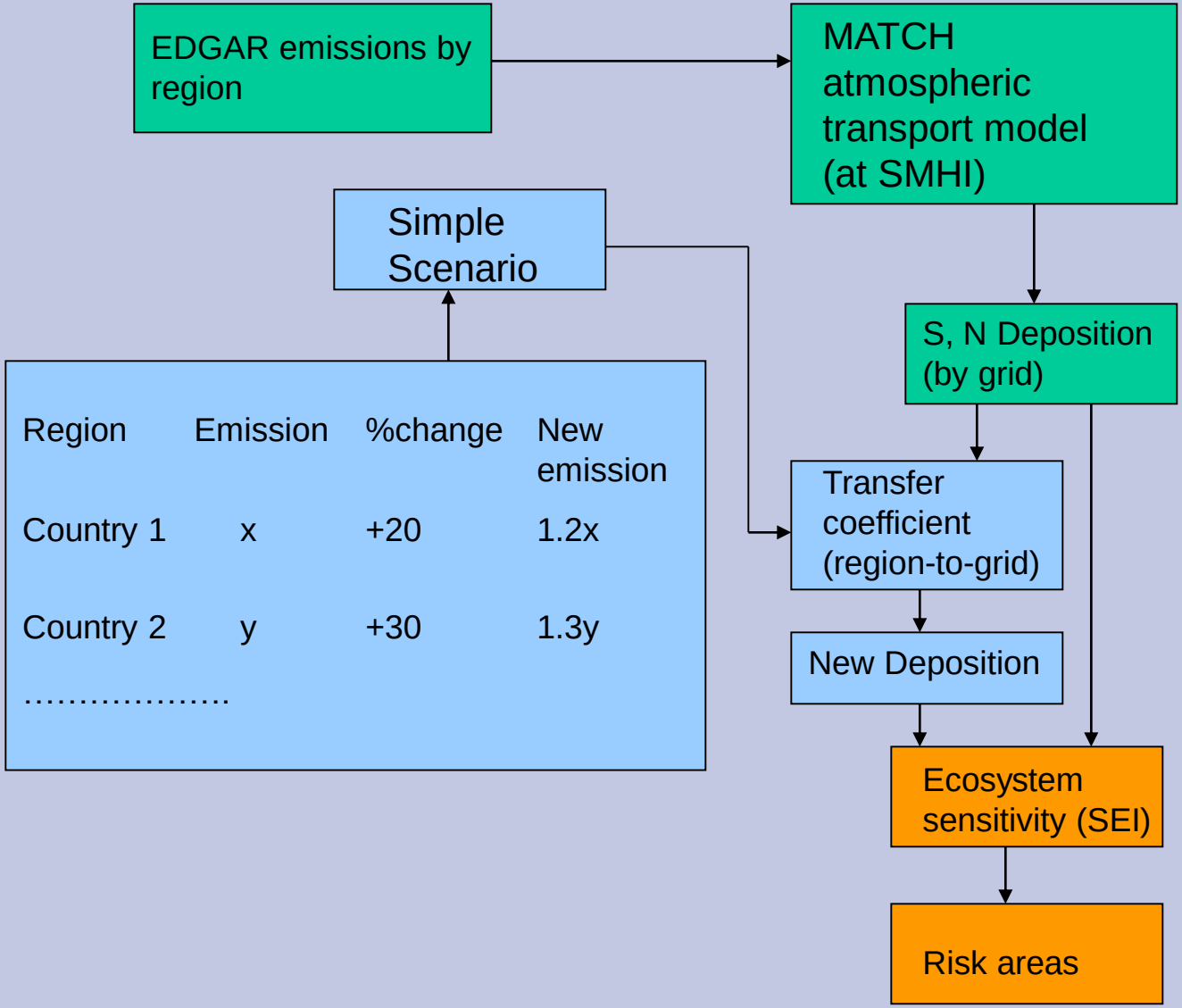
Source: Kuylenstierna *et al*. 2001



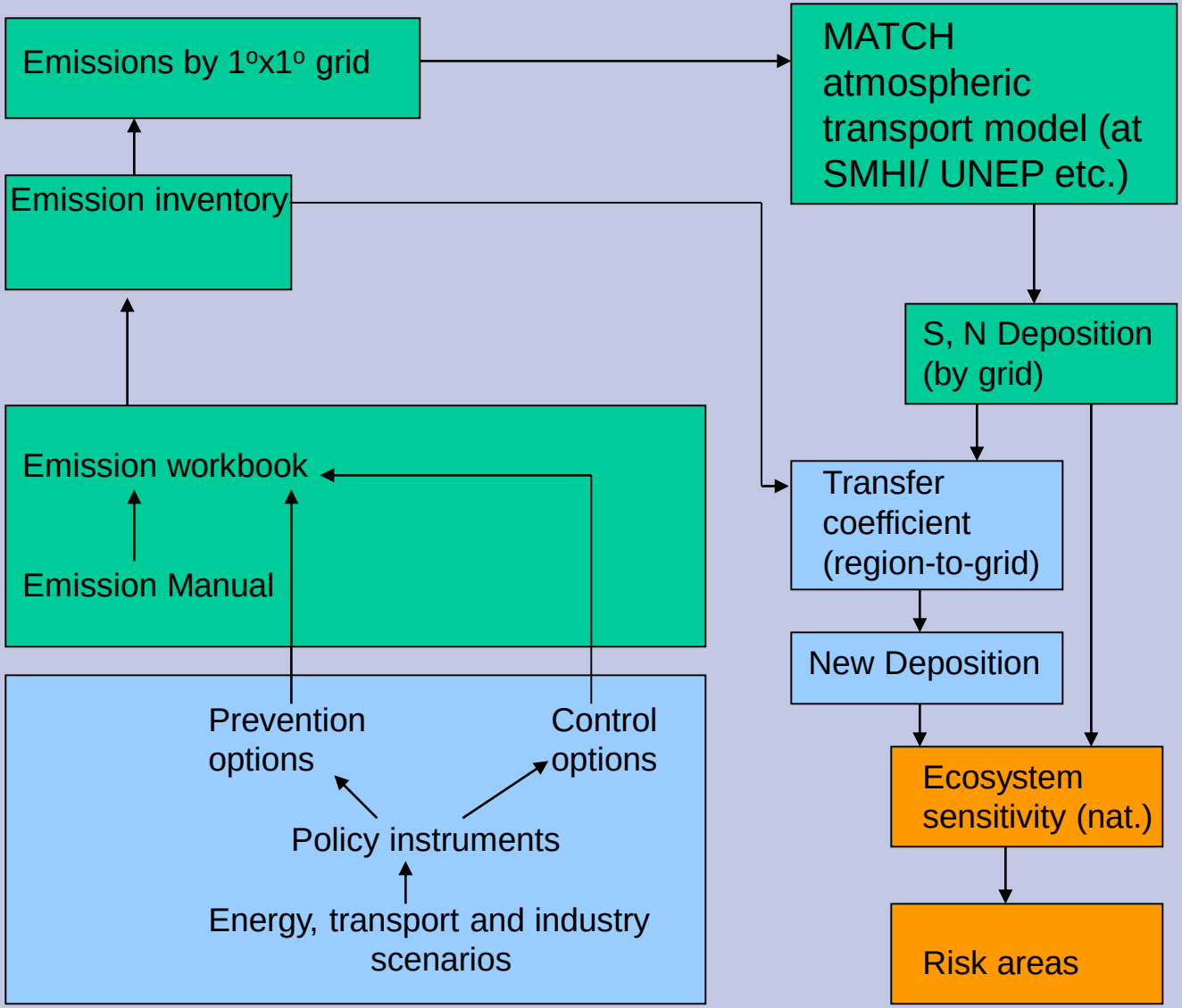
PHASE I: determining risk from available maps

Estimated Risk of acidification





PHASE I: Investigating simple scenarios



PHASE II: Investigating national scenarios

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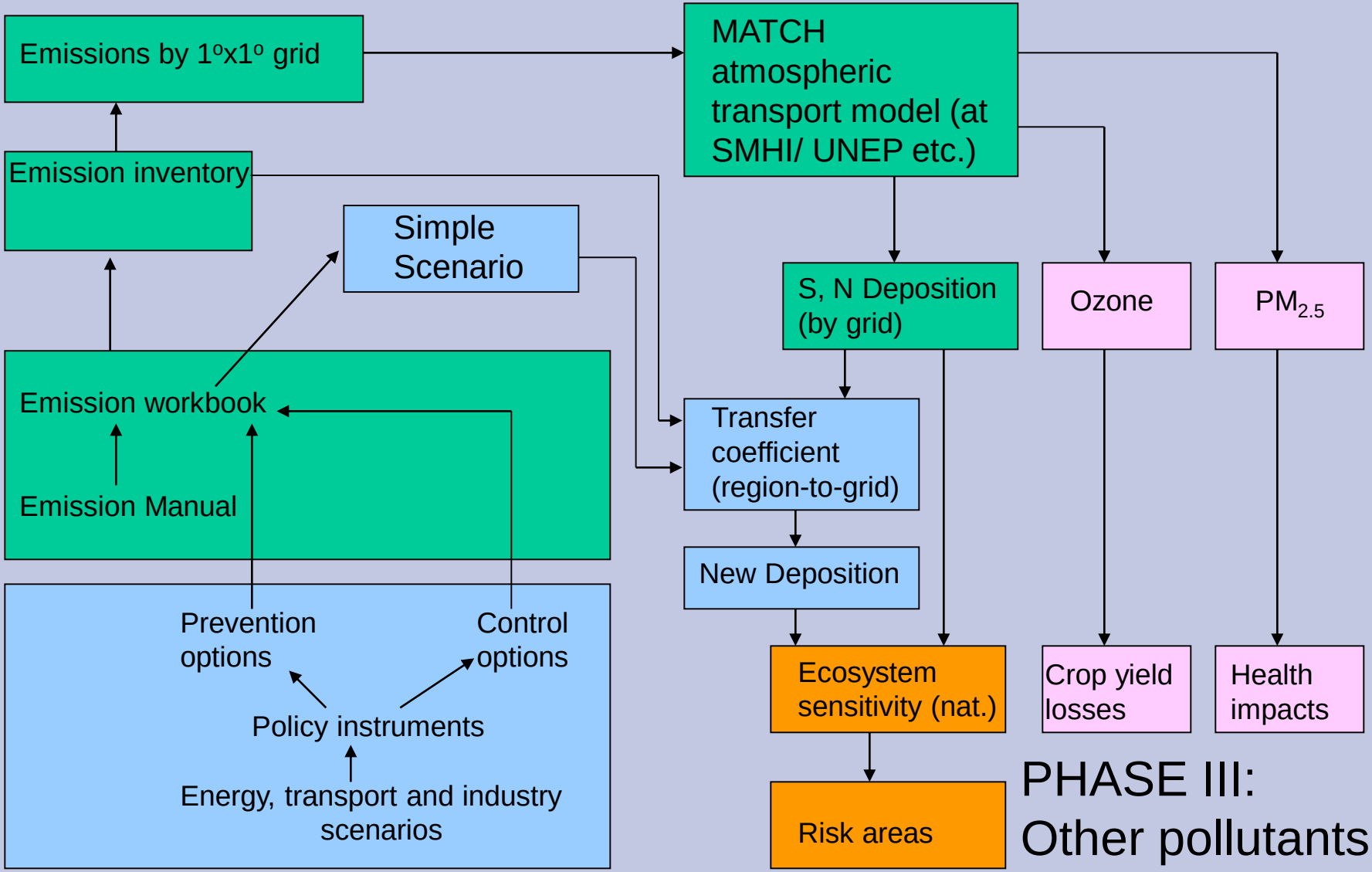

PHASE III: Other pollutants and impacts

Summary

- Modelling results will improve when the Malé emission inventory replaces the use of international data.
- It is important that modelling and monitoring efforts develop together and that new Malé sites can also assist with model validation;
- Individual countries can use trajectory analysis to assess where pollution is coming from.
- Impact studies are now required to investigate potential for impacts with present deposition levels in South Asia

Let's get our heads together for cleaner air!

Thank you