

Modelling of Acid deposition in South Asia

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- **Introduction to Acid deposition modelling**
- **Description of the adopted acid deposition modelling tool
- MATCH**
- **Presentation of sample results (comparisons with
measurements and animations)**
- **Conclusions**

Measurements and Modelling

Measure or calculate concentrations and depositions ?

- **Models and measurements both have uncertainties**
- **Models and measurements should be used together to explore their full potential – and to increase the quality of each other**
- **Some features are particular to either method**
- **Models and measurements are both needed**

Why modelling?

- Mapping of remote regions (incl. areas without measurements)
- Source-Receptor calculations
- Scenarios (future / history / siting of emitters, receptors)
- Understand processes in the atmosphere
- Check emission inventories
- Verify measurements
- ...

What is a model ?

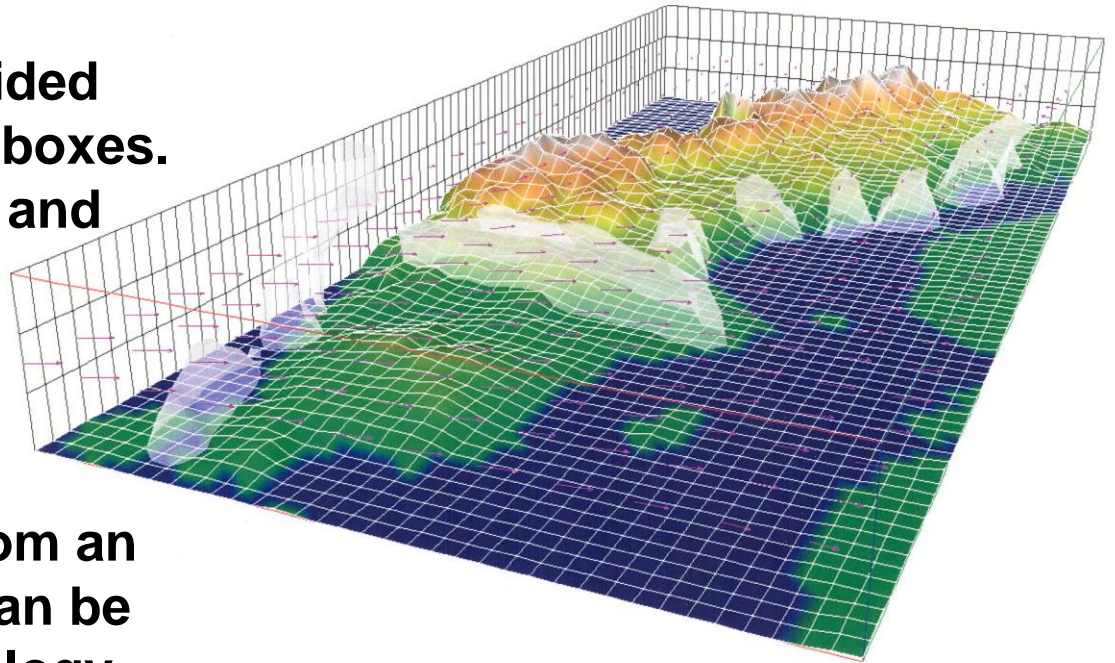
Mathematical relations based on empirical or physical laws

Models are used everywhere In our field we have, for example, in society

- Economical models
- Population models
- Technological models
- ...
- Numerical weather forecast models
- Climate change models
- Dispersion models including emissions, transport, deposition, chemical conversion etc.
- Emission inventories
- Integrated Assessment Models
- ...

Terminology (dispersion modelling)

- ***“Eulerian model”***
The atmosphere is divided into a large number of boxes. Fluxes between boxes and processes inside boxes are taken into account.
- ***“Off-line model”***
Meteorological data from an auxiliary driver. Data can be from archived meteorology or weather forecasts, or climate scenarios.



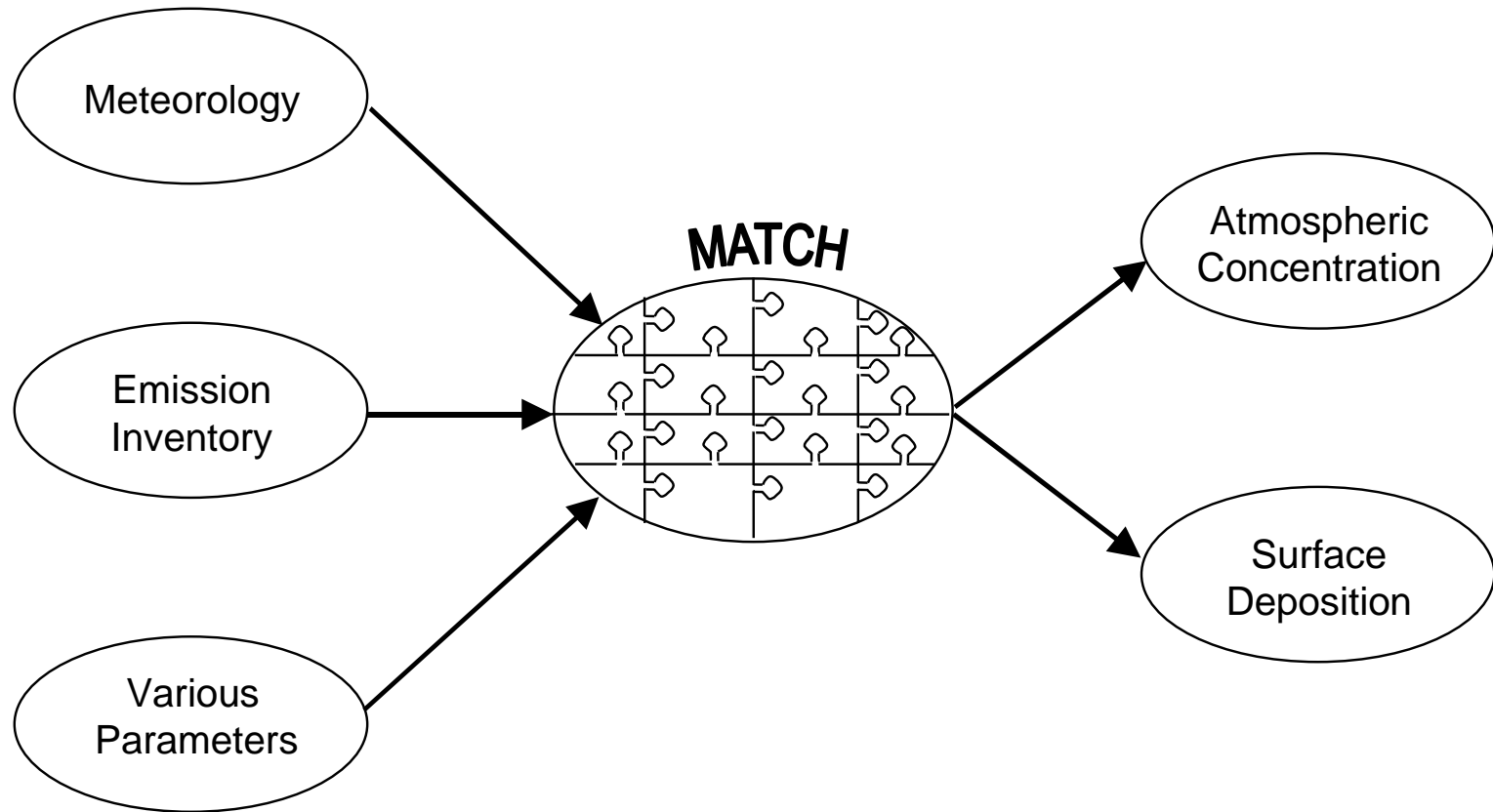
MATCH

Multiple-scale Atmospheric Transport and Chemical model

- **A Eulerian off-line model**
- **Suitable for regional scale applications**
- **Present study:**
 - Grid resolution $1^{\circ} \times 1^{\circ}$ (100km \times 100km)
 - 43 layers up to ca. 26 km (lowest model layer ~20m thick, increasing to ~800m)
 - Meteorology from ECMWF (12 months of data, every 6 h)
 - Emissions from EDGAR (standard, global emission inventory)

Quality of model output

never better than the input to the model



Processes included in the model

MATCH

$$\text{CONC. CHANGE} = \text{EMIS} + \text{ADV}_{XY} + \text{ADV}_Z + \text{CONV}_Z + \text{TURB}_Z + \text{CHEM} + \text{DRYDEP} + \text{WETDEP}$$

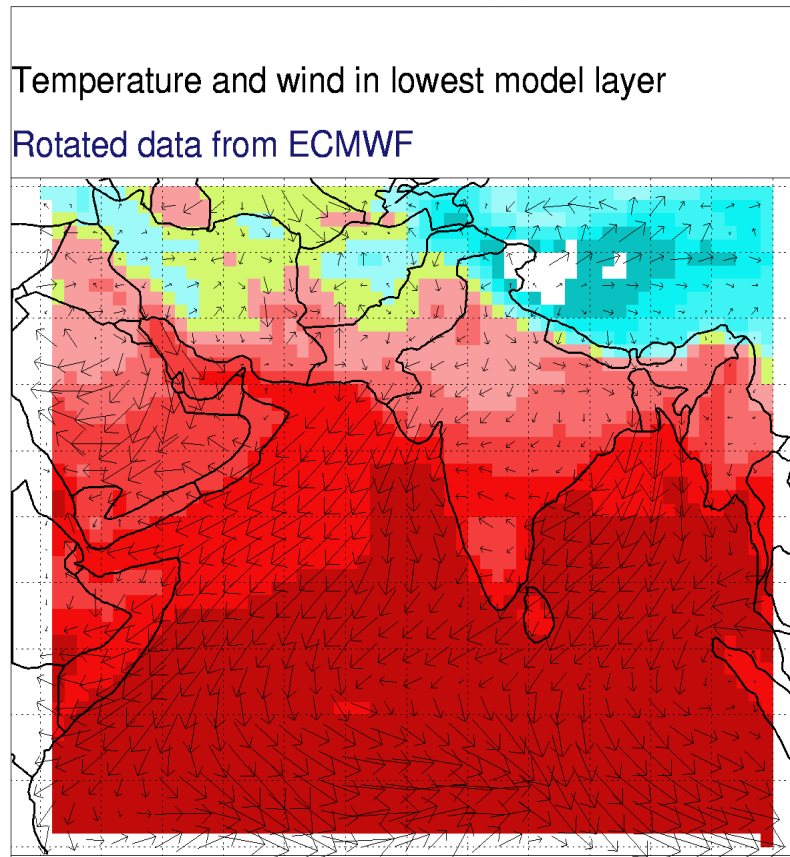
Minimum set of input meteorological and “*physiographical*” information needed to run MATCH.

- Topography (mountains etc.)
- Surface classification (land/sea, forest, desert, rice paddies, ..., etc.)
- Surface state (snow/ice etc.)
- Surface roughness
- Surface albedo (=reflectivity)
- Surface pressure
- Surface temperature
- 2 m temperature
- 2 m dew point temperature (moisture content)
- 10 m wind
- Total cloud cover
- Total surface precipitation
- Mean layer temperature*
- Mean layer wind*

* Must be provided for whole atmosphere (Three-dimensional fields: all model layers). Other data is “two-dimensional”.

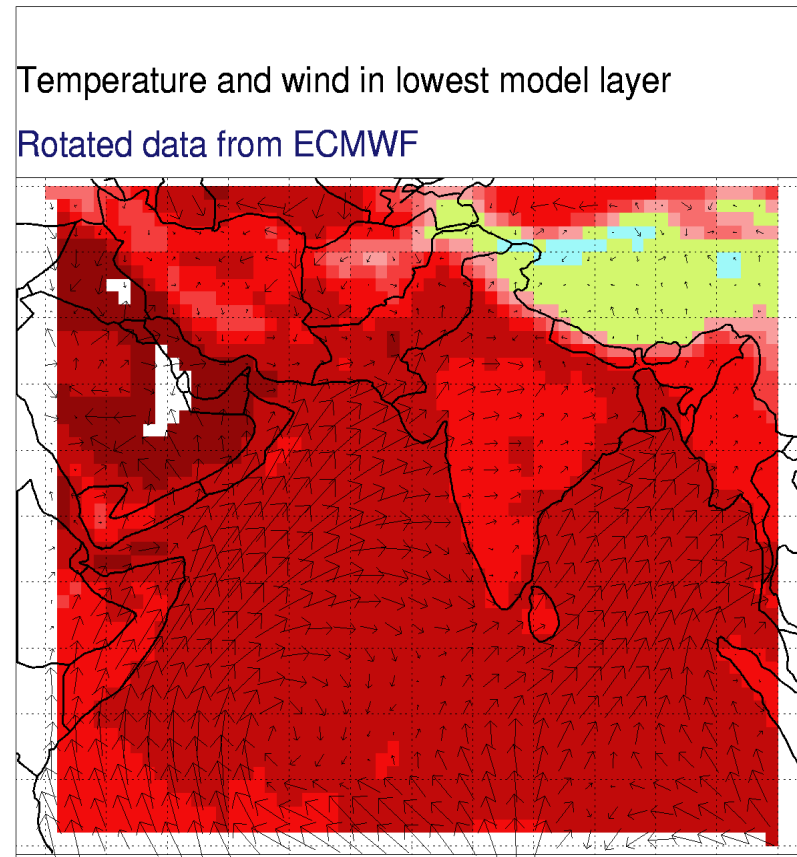
All meteorological data are updated every 6 hours during the 12-month period January-December 2000.

Illustration of model domain and type of meteorology available



15 February, 2000 00Z

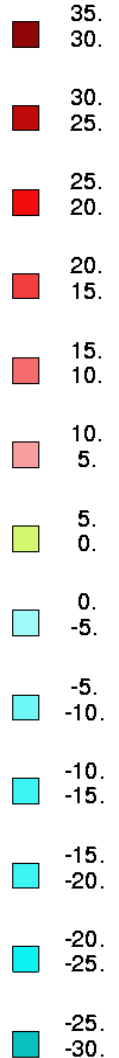
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15 August, 2000 00Z

SMHI

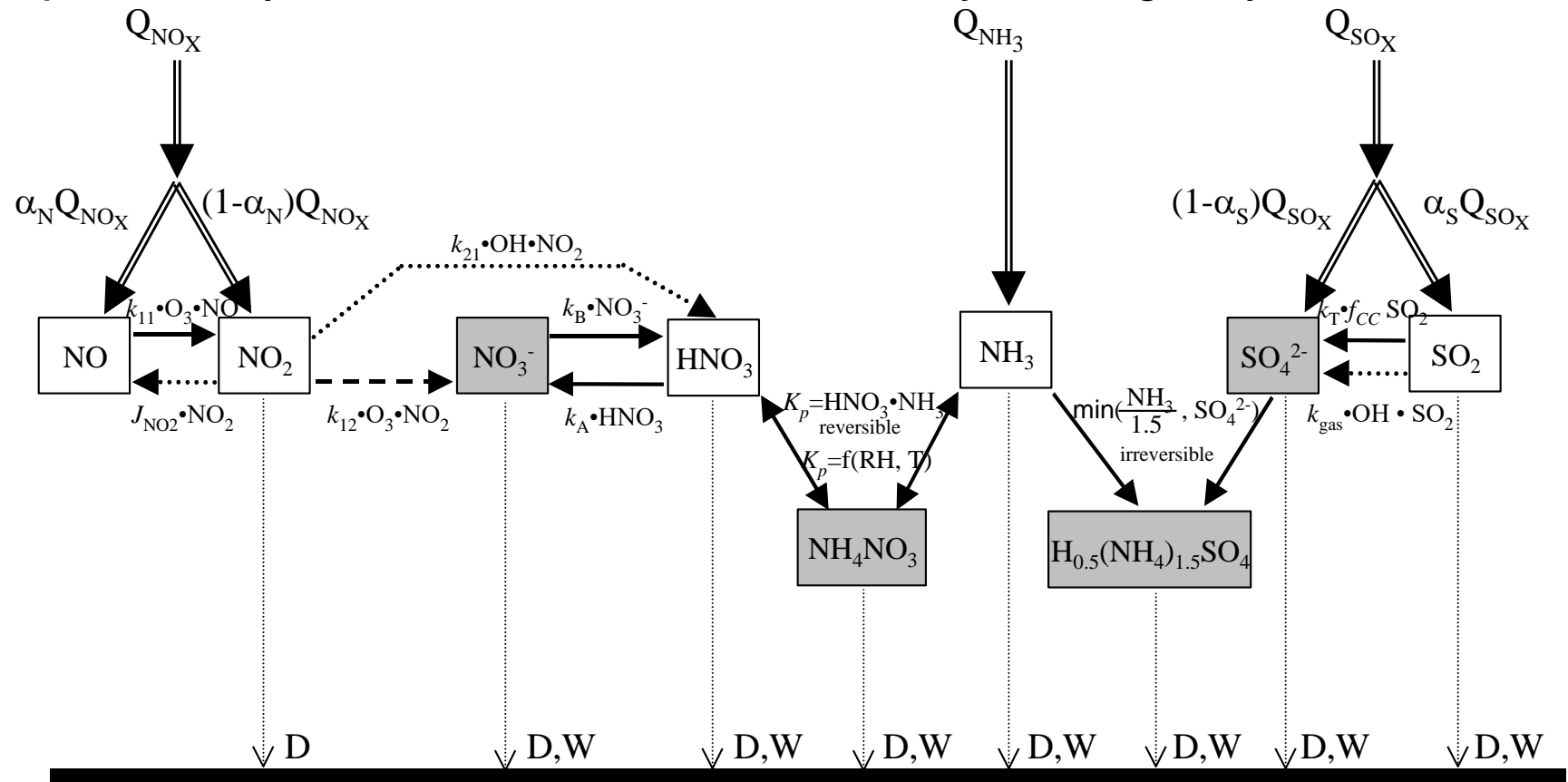
deg. Celcius



Chemistry

in the current model study

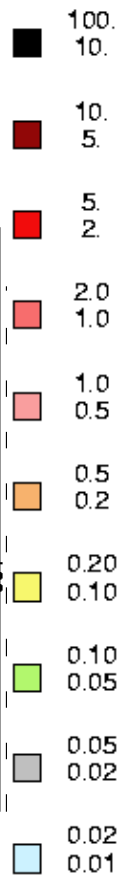
Species may be converted from the form they are originally emitted as



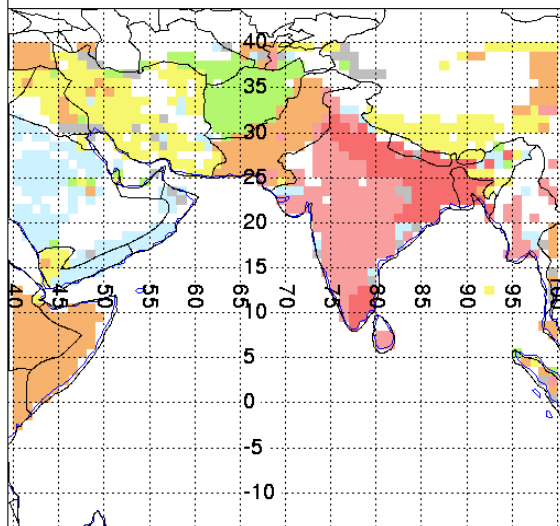
Emissions from EDGAR database

(Inventory valid for 1995; includes all anthropogenic sources)

gram / (m2*y)

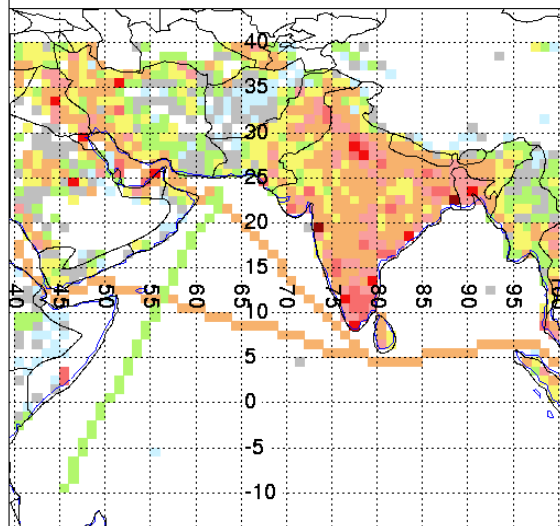


NHx-N emissions 1995 (EDGAR)



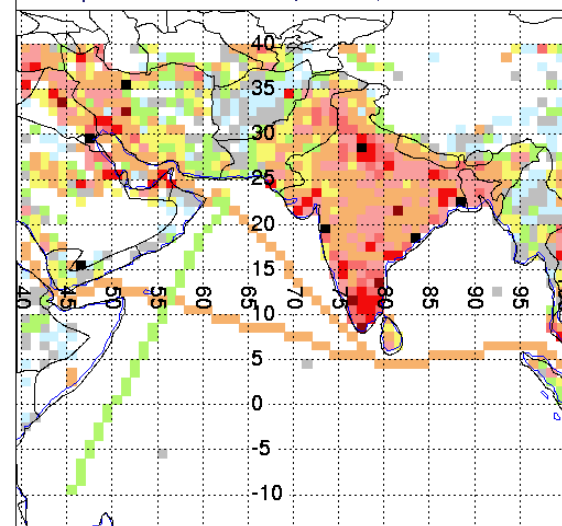
Reduced nitrogen

NOx-N emissions 1995 (EDGAR)



Oxidised nitrogen

Sulphur emissions 1995 (EDGAR)



Total sulphur

Deposition

in the current model study

Deposition = tracers leaving the atmosphere and end up at the surface of the earth

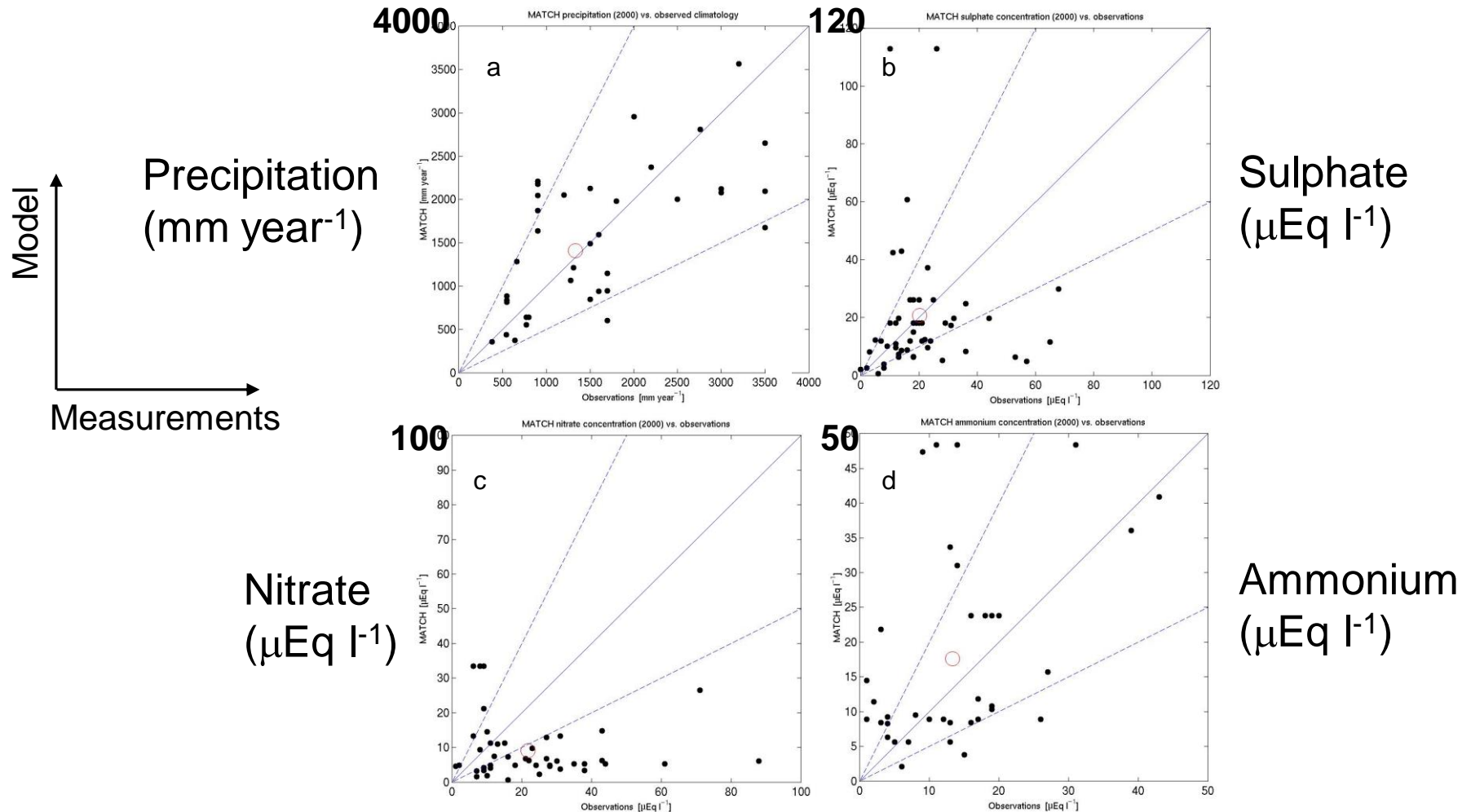
- **Wet deposition** $WETDEP = \Lambda_k \times \text{precipitation} \times \text{concentration in air}$
Deposition of tracer when precipitation occur.
Species dependent “*scavenging coefficient*”, Λ_k , that varies with height
- **Dry deposition** $DRYDEP = v_d \times \text{near surface concentration in air}$
Particles settle through gravity and gases affix to various surfaces.
Deposition is a function of a “*dry deposition velocity*”, v_d , that varies with surface type

Model performance / requirements

- The MATCH-model has been set-up on a number of computer platforms, including ordinary PCs (LINUX).
- Simulation times depends on computer and varies from a few hours (multi-CPU supercomputer) to several days (PCs).
- Input data occupies several Gigabyte of disk.
- MATCH is typically operated as flexible research tool, which requires plenty of experience, and computer knowledge, to use.
- MATCH can also be “packed” into a user friendly interface where the user can change and modify only a few pre-defined options.

Sample results

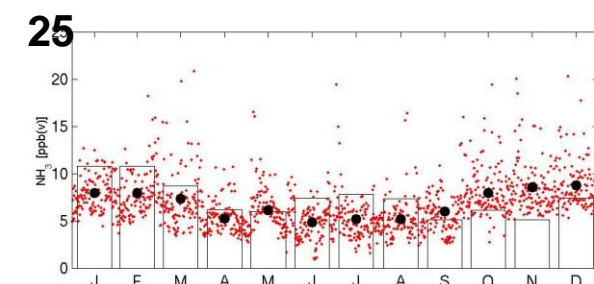
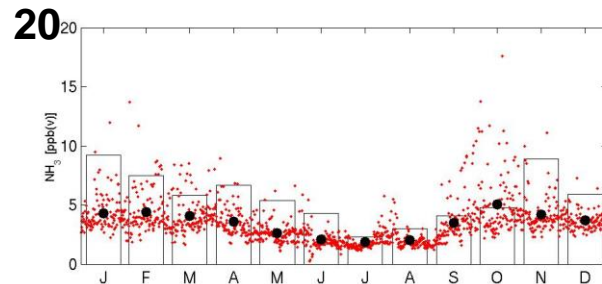
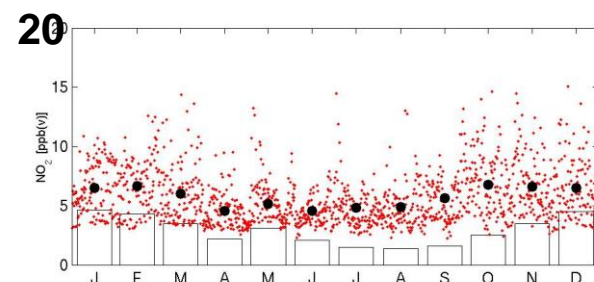
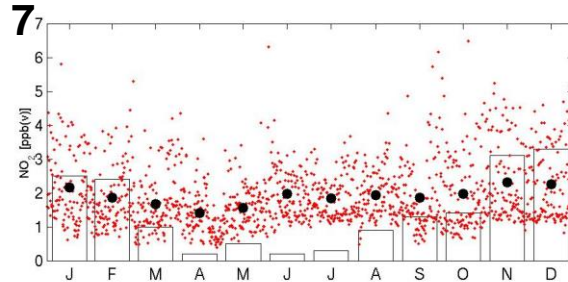
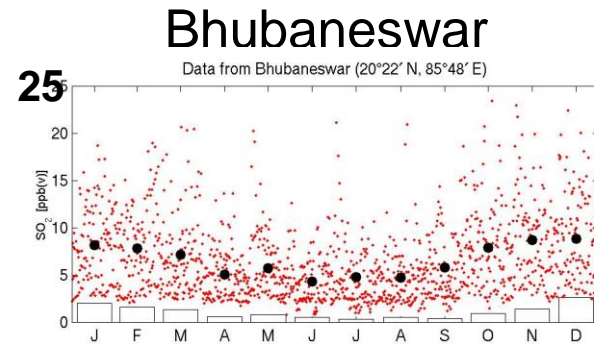
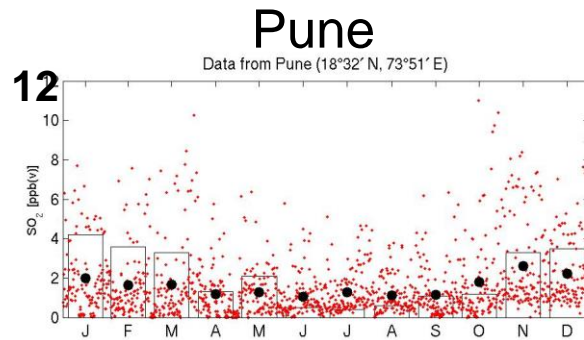
Annual-mean concentration in precipitation (several Indian sites)



Sample results

Time-series of atmospheric concentrations (2 Indian sites)

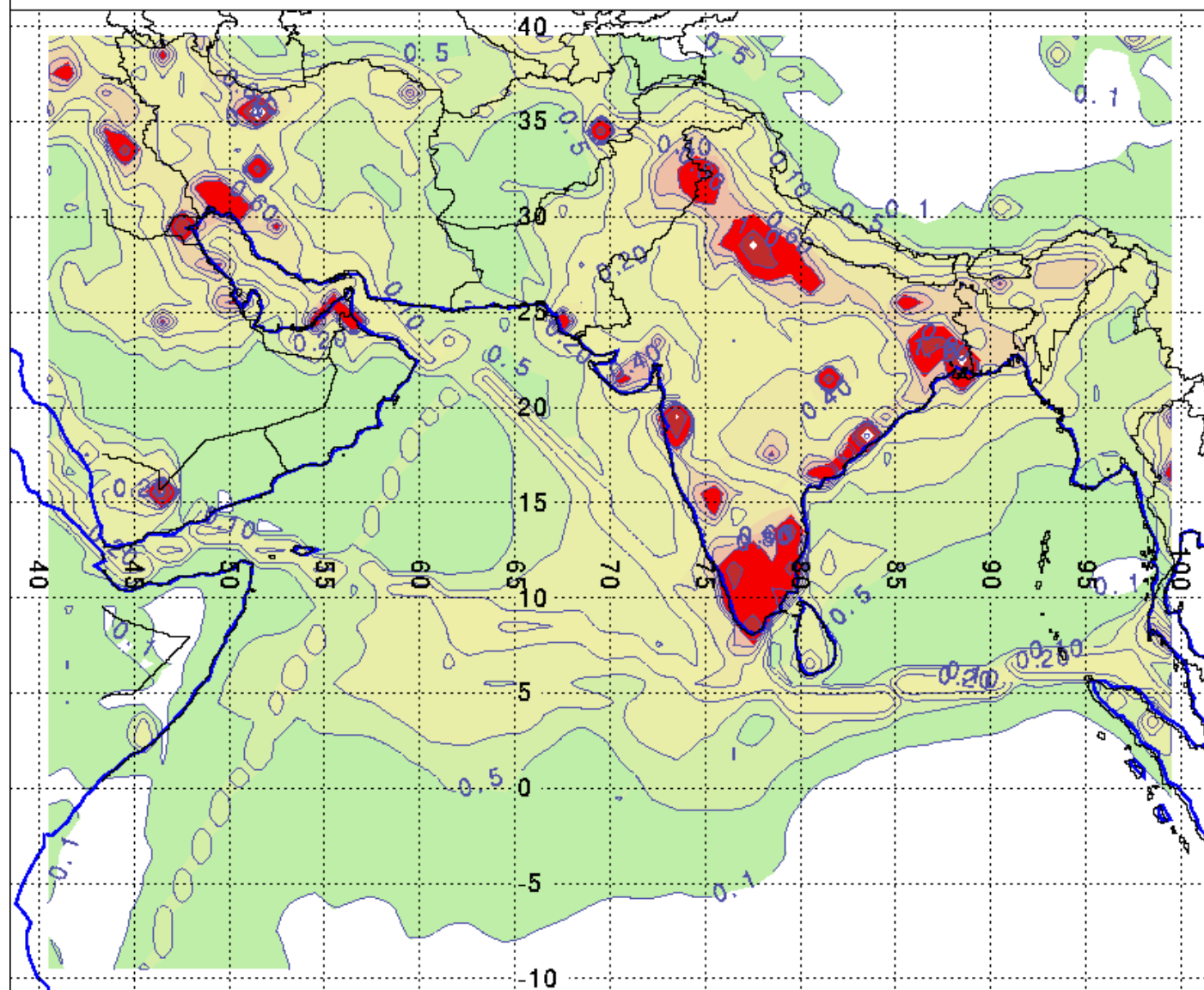
- Model
- Model
- Measurements



Conclusions

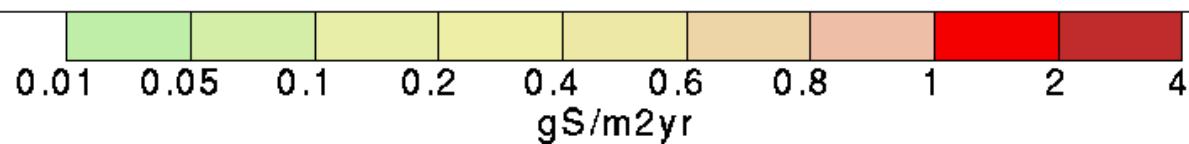
- **Modelling can e.g. be used to locate the origin of the deposited pollutants and to investigate future depositions based on assumed changes in emissions.**
- **Measurements are needed to check the quality of the model (and vice versa).**
- **Modelled and measured data compare fairly well**
 - **The results are reasonably robust, but can of course always be improved. The largest uncertainty is always the emissions inventory**
- **MATCH is detailed and complex –thus slow.**
- **At present the MATCH-model runs as a research tool in Sweden**
 - **can of course be run at an South Asian institute**

Monthly-accumulated, Total sulphur deposition (total)

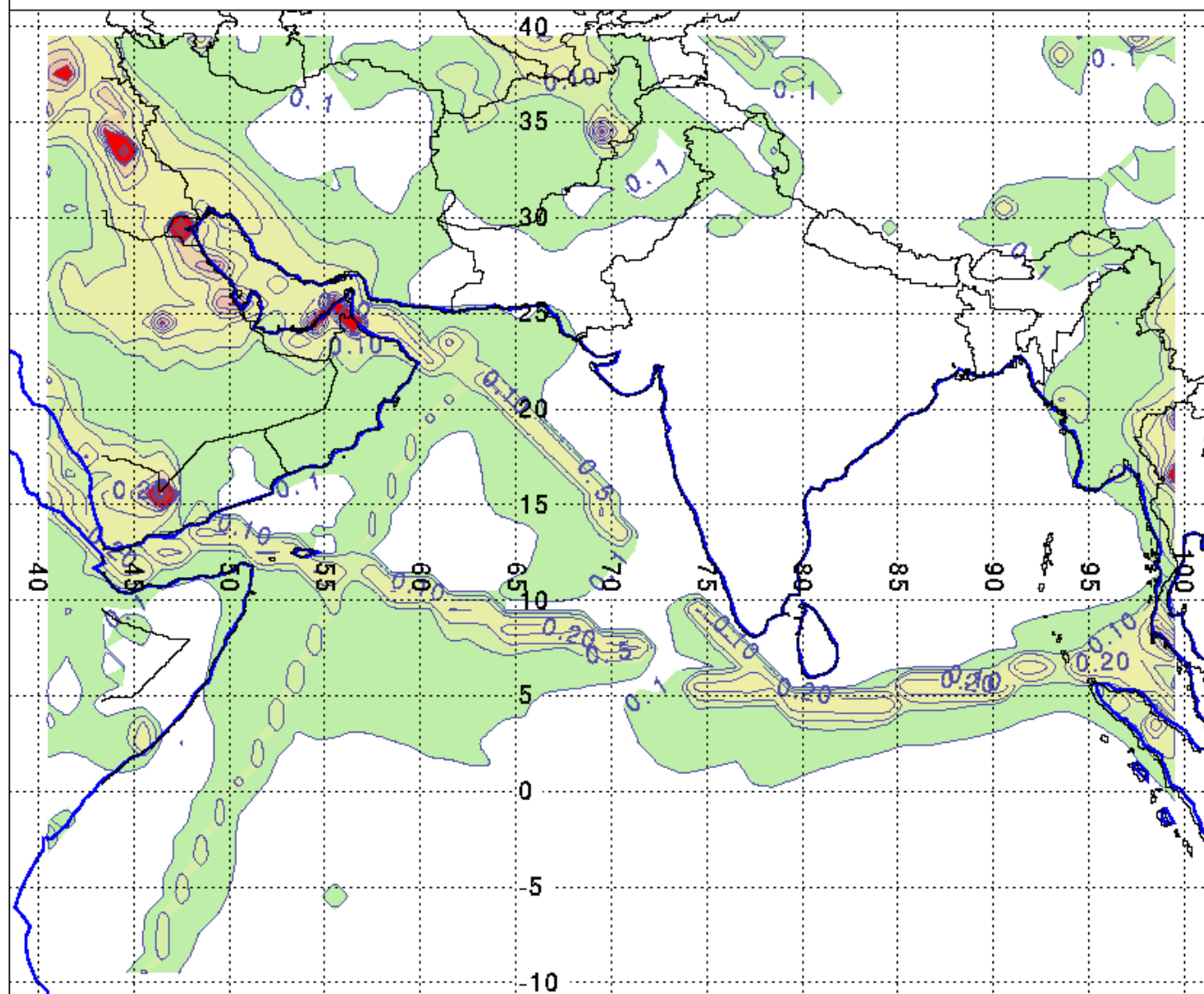


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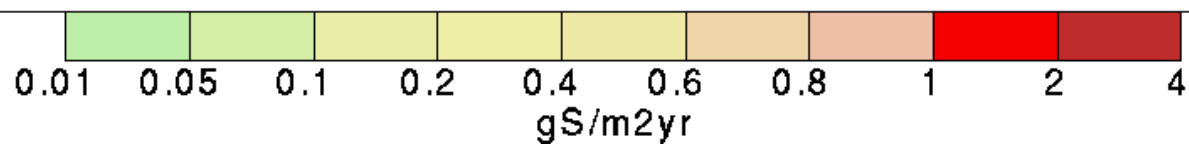


Monthly-accumulated, Total sulphur deposition (rest)

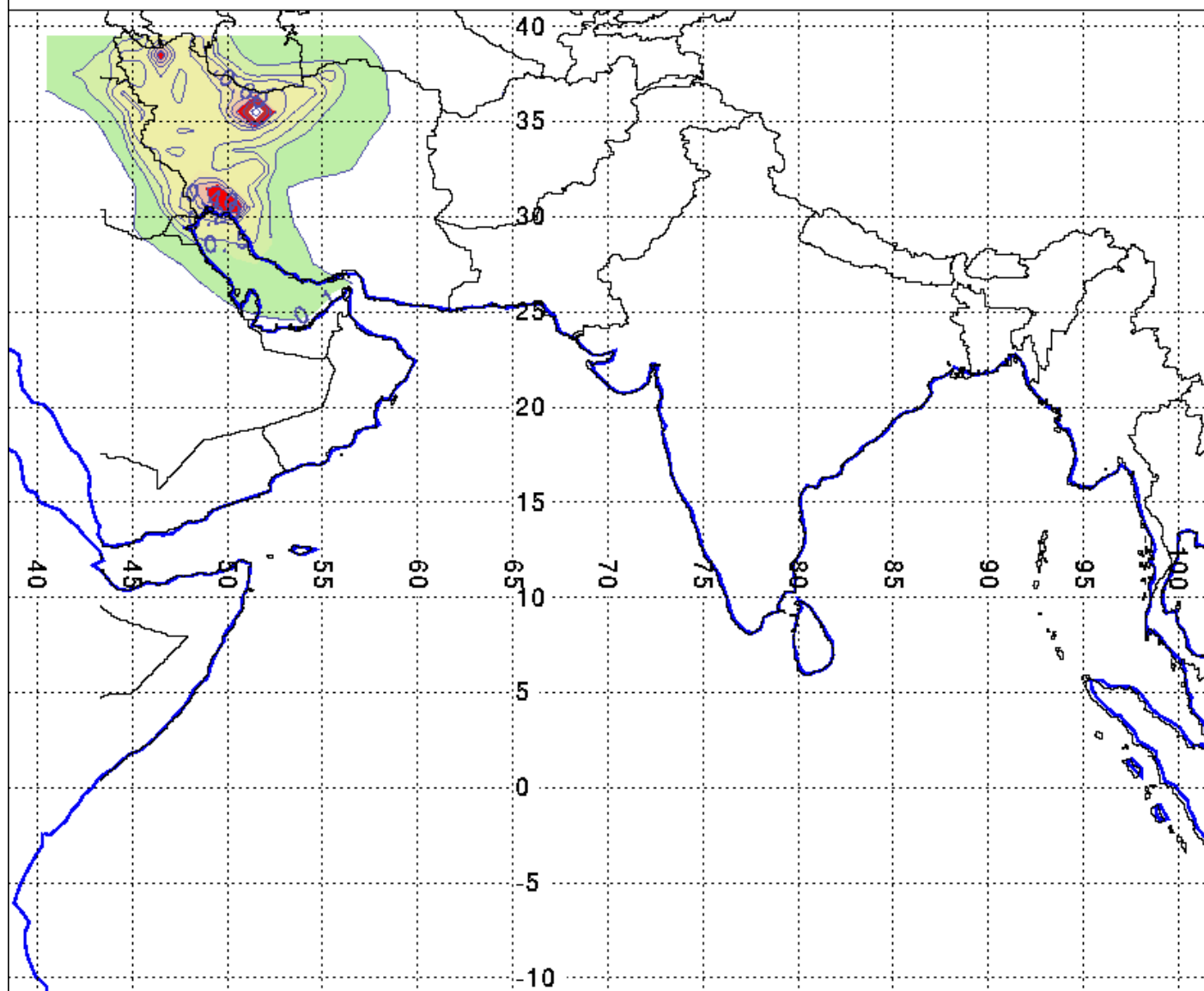


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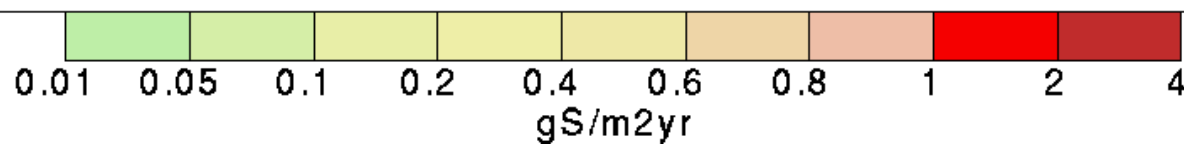


Monthly-accumulated, Total sulphur deposition (irww)

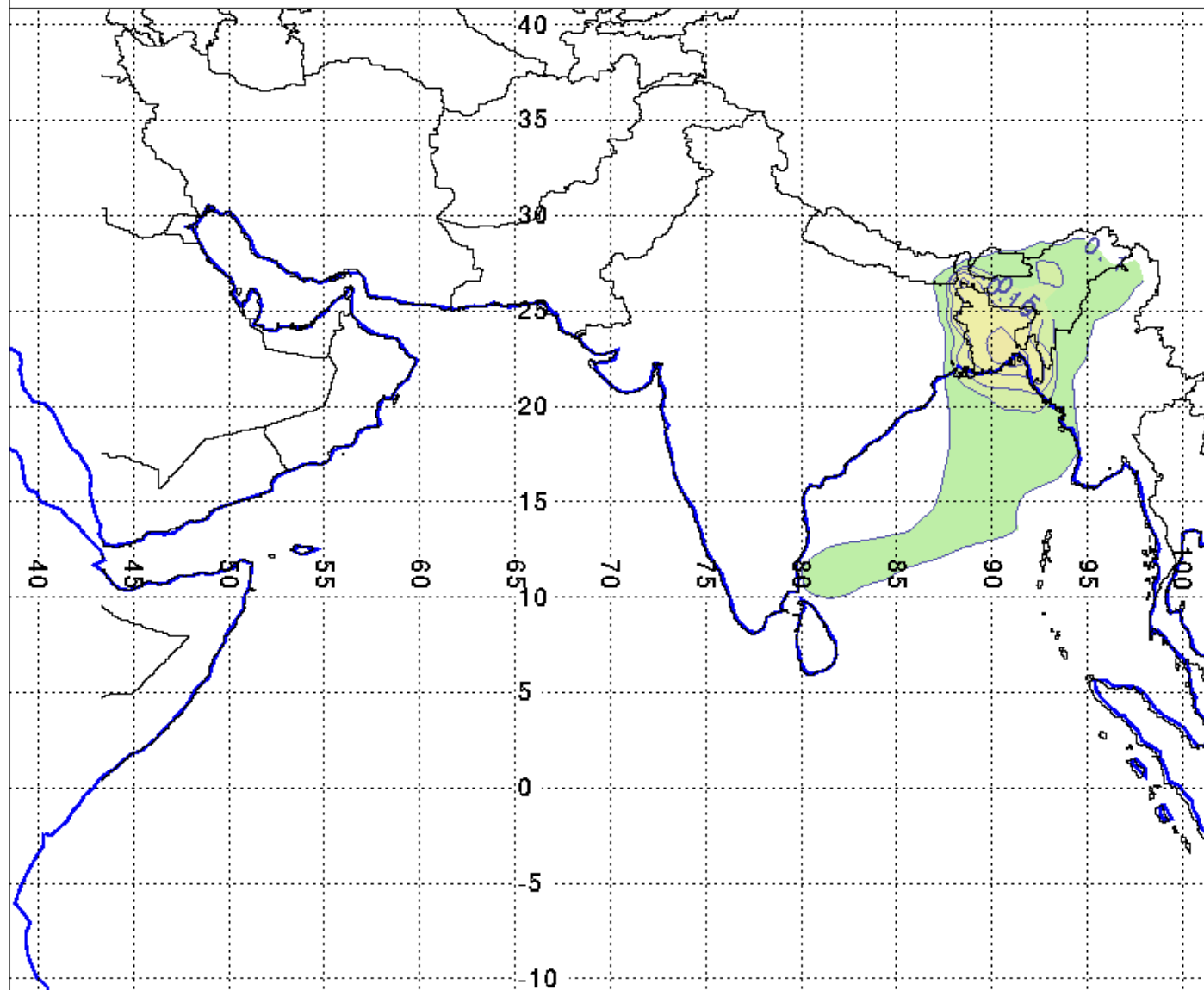


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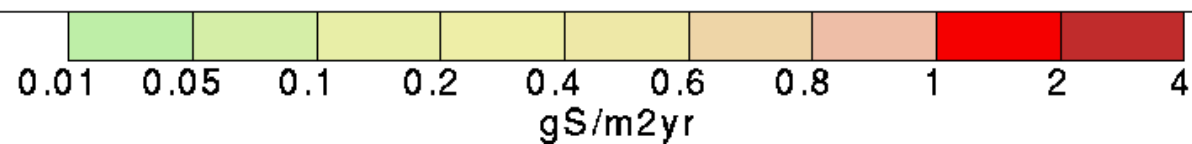


Monthly-accumulated, Total sulphur deposition (bdaa)

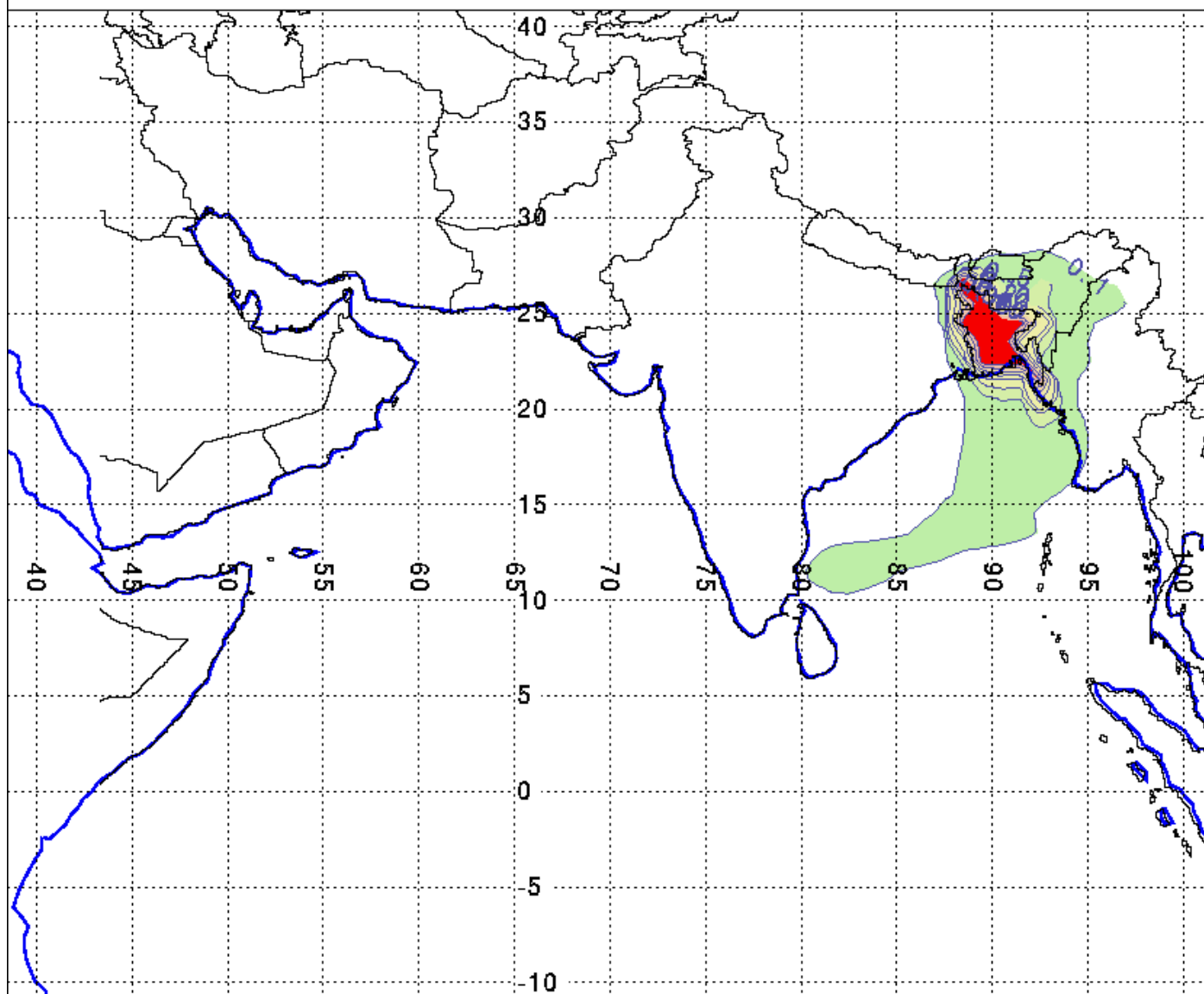


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Monthly-accumulated, Total reduced nitrogen deposition (bdaa)



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