EMEP MSC-W model: History, Principles

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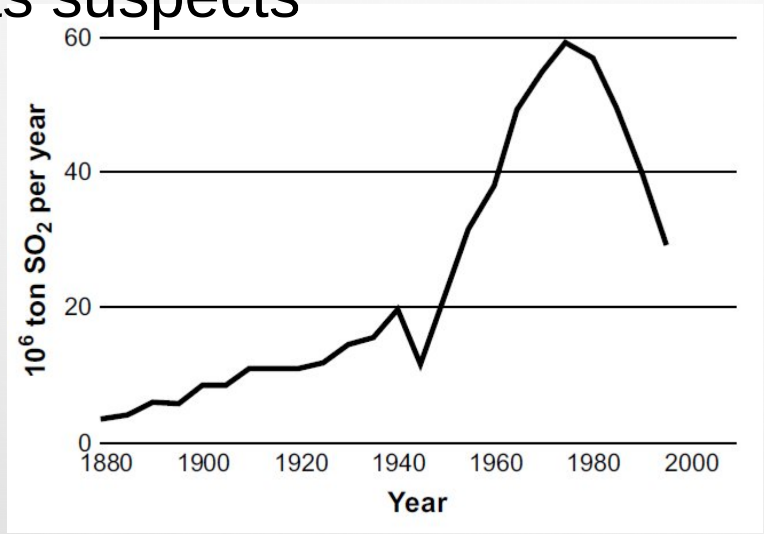
Outline:

- Brief history
- Aims
- Code design + principles

In the beginning: acid rain!

- Swedish/Norwegian scientists found major damage to fish stocks … suggested SO2 pollution from long-range transport was to blame….. with e.g. UK, Germany, Eastern Europe as suspects
   -

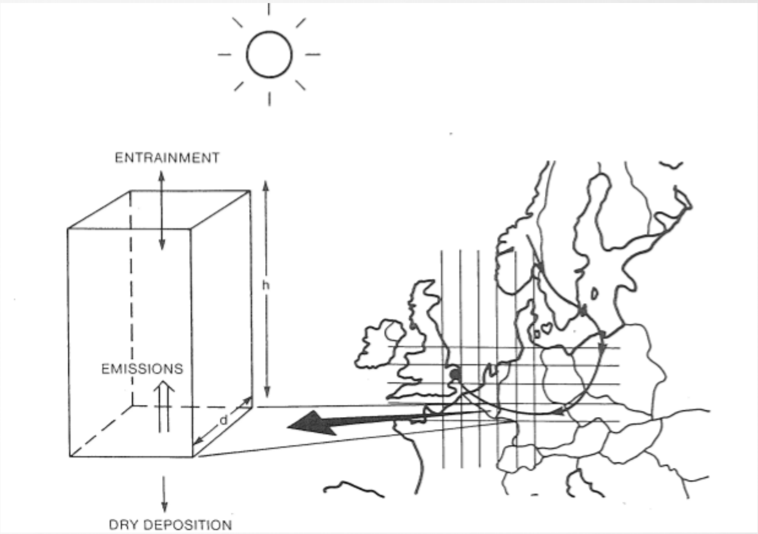


(Fenger 2009)

In the beginning: N=2 (Eliassen& Saltbones)

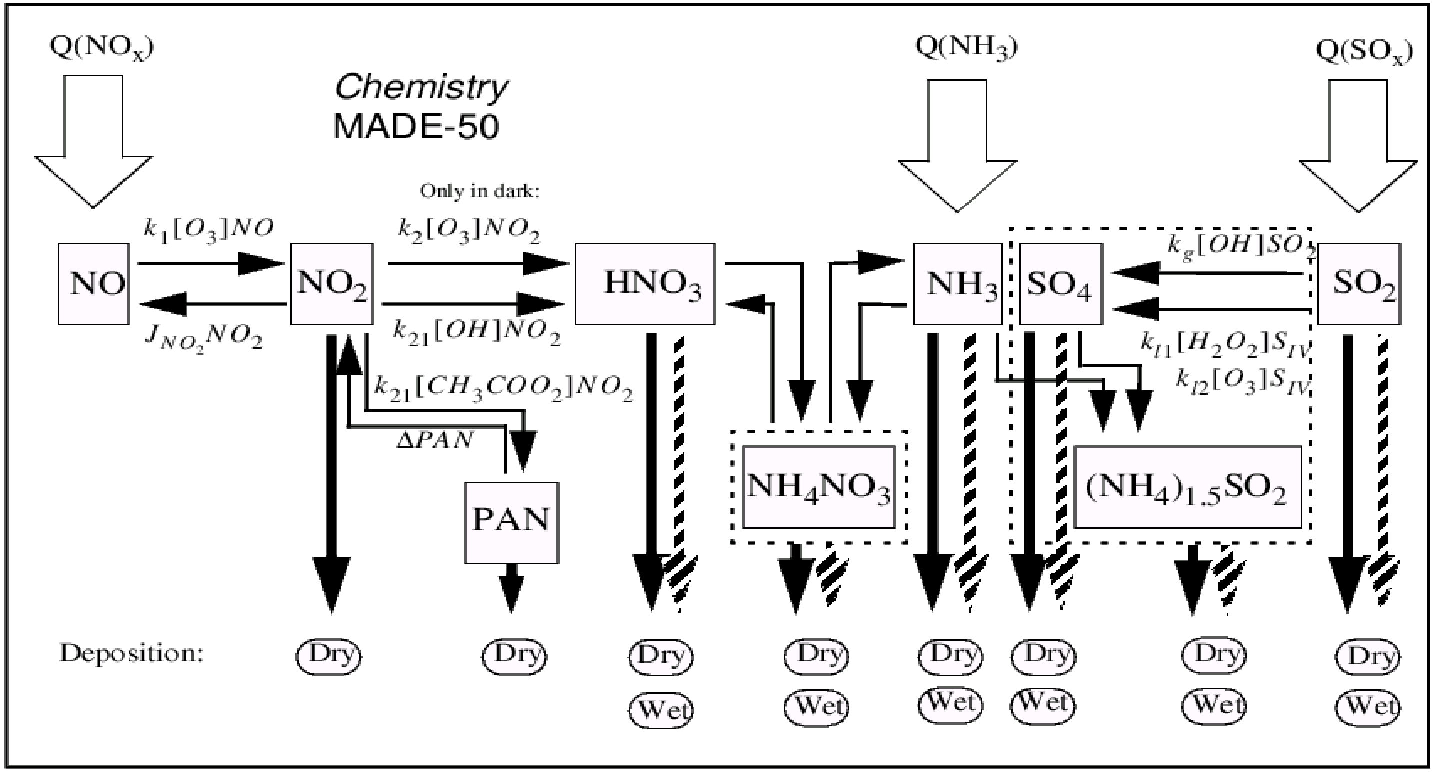
- OECD project
  - Lagrangian model – enabled «fair» calculations of transport betwee countries
  - First long-range transport model
  - Used to calculate “blame” matrix
  - Sulphur

  => EMEP (MSC-E, MSC-W and CCE)
  -



Next step: NOx

N=5 Hov et al.



- NOx model, 1985 ...
  - Lagrangian, performed rather well. Basis of 1st Gothenburg multi-pollutant multi-effect Protocol

Onwards to Ozone (German forests...)

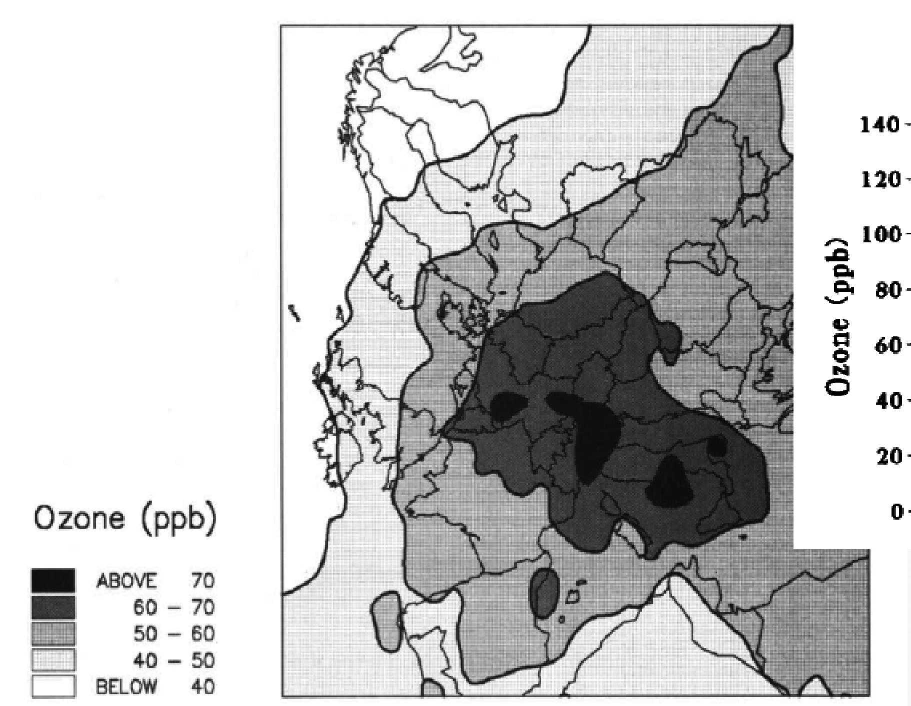
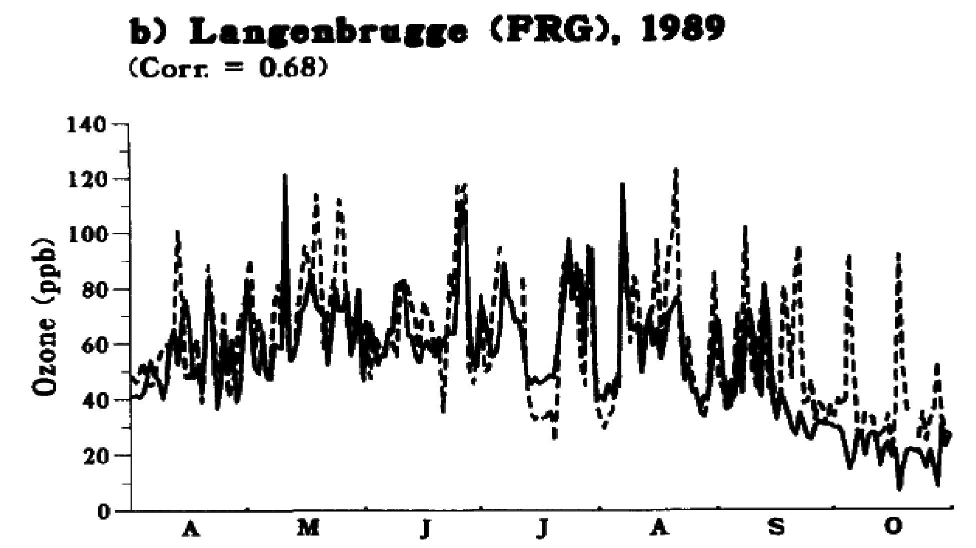


Fig. 8. Calculated mean of daily maximum ozone concentrations (ppb) July 1985.



- O3 model, Simpson & Hov 1992 ...
  - Lagrangian- also performed rather well!

Eulerian: 1990s

N~7

- Eulerian acid deposition model
  - Erik Berge and Roar Skaalin
- Designed from scratch for parallel computing
  - Basis of today's fast code
  - EMEP models are almost perfectly scalable
- Eulerian acid deposition – mid 1990s (Berge et al.)
- Eulerian ozone – late 1990s (Jonson et al.)

'Unified' model: 2003

N-> 9

- Achieved 2003
- Merged Eulerian acid deposition and ozone codes, also using routines (chemistry, emissions) from Lagrangian O3 code.
- Nearly 100% pure F90/F95
- Aims:
  - To attain one model structure
  - To avoid divergence

Public domain:

- First: 2007
- Why?
  - EMEP is funded by ~50 countries – should have a community model
  - To encourage use of EMEP model among Parties/scientists
  - To help improve model through cooperations
-

Pros and Cons:

- Cons:
  - MSC-W has few resources for documentation and follow-up, …. we are usually overwhelmed with work
  - Aids `competitors'
  - Possibility of “mis-use”'
-

Pros and Cons:

- Pros:
  - Involves more scientists, better evaluation and acceptance of model
  - Encourages better coding and science within MSC-W
  - Possibility of users to influence model development, and hence policy results
  - Build community (as with e.g. WRF)
-

Examples:

- EMEP4HR:
  - Application of EMEP model to Croatia
  - Focus on evaluation of turbulence and Hmix → new routines in core EMEP
- EMEP4UK
  - Application in UK, originally at 5km scale
  - Now down to 1km
  - Development of WRF+EMEP link
  - Extensive evaluation
  - Productive! (Vieno et al. papers)

Code design 1

- Fortran 90/95

  - but now with traces of F2003+F2008 (as allowed by intel & gfortran compilers)

- Modular
  - > 95% of code in modules (_ml suffix)
  - Strong safety checking:
    - Implicit none, public, private at top of all modules
    - Use of 'uses', e.g.
      - use PhysicalConstants_ml, only : RGAS_KG
    - intent(in,out) in all functions/subroutines
  -

Code design 2

- Aims to 'hide' parallel coding
    - Concentrate on physics/chemistry, not MPI where possible
    - Use of generic routines such as ReadField_CDF to read global input fields – assigns to local domain 'invisibly'
- Aim to enable offline testing ('box model'
    - Encouraged by ESX 1-D model needs
- Flexible
    - Global to 1 km scale
    - Meteorology from PARLAM, ECMWF, WRF, Aladin
    - See talks by Peter, Massimo

Code flaws?

- Yes, there are some ;-)
  - The MSC-W team has a heavy workload, with a constant need to extract special outputs, add new components, etc,.. often leading to ad-hoc solutions
  - e.g. system for outputs is rather messy - needs clean
  - Several parallel systems to do similar jobs (eg new system started but not completed)
  - Contributions to code improvement very welcome!

Philosphy, concepts?

- G.E.P. Box
  - All models are wrong, but some are useful

- Einstein:
  - Models should be as simple as possible, but no simpler
  - (not sure we follow this one these days!)

Philosphy, concepts?

- Main ideas:
  - to capture the main atmospheric processes, keeping a balance between different components.
  - Make sure model is grounded in measurements!
  - … but, prefer sound science over best-possible result for specific compounds – avoid tuning.
  - Make sure the model is useful!

Philosophy, concepts, cont.

- Open:
  - The code is public domain, and documented.
  - Model performance is assessed continuously, with results (good and bad) published on the web and in report
  - We are open to model changes – e.g. recent WRF compatabilty encouraged by EMEP4UK process
  - Is building a community ….
- So, here we are!

Some EMEP papers of historical interest..

- Eliassen, A. The OECD study of long-range transport of air pollutants.., Atm. Env., 1978, 12, 479-487
- Eliassen, A. & Saltbones, J. Modelling of long-range transport of sulphur over Europe..., Atm. Env., 1983, 17, 1457-1473
- Eliassen, A.; Hov, Ø., et al. A Lagrangian long-range transport model with atmospheric boundary layer chemistry J. Appl. Met., 1982, 21, 1645-1661
- Hov, Ø.; Eliassen, A. & Simpson, D. Isaksen, I. (Ed.) Calculation of the distribution of NO$_x$ compounds in Europe..., Regional and global scale interactions, D. Reidel, 1988, 239-262
- Simpson, D. Long period modelling of photochemical oxidants in Europe. Calculations for July 1985 Atmos. Environ., 1992, 26A, 1609-1634
- Simpson, D. Biogenic emissions in Europe 2: Implications for ozone control strategies J. Geophys. Res., 1995, 100, 22891-22906
- Berge, E. & Jakobsen, H. A. A regional scale multi-layer model for the calculation of long-term transport and deposition of air pollution in Europe Tellus, 1998, 50, 205-223
- Jonson, J.; et al., EMEP Eulerian model for atmospheric transport and deposition of nitrogen species over Europe Environ. Poll., 1998, 102, 289-298
- Jonson, J.; et al.,Model calculations of present and future levels of ozone and ozone precursors with a global and a regional model. Atm. Env., 2001, 35, 525-537
- Simpson, D.; et al., The EMEP MSC-W chemical transport model -- technical description Atmos. Chem. Physics, 2012, 12, 7825-7865

    - BUT SEE www.emep.int (or Simpson et al., 2012) for many more!!!

The end.