Meteorological variability and climate trends affecting air pollution in Europe
- results from dispersion model scenarios

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Air pollution modeling

- **Dispersion modeling**
  - **Eulerian modeling (urban-global)**
    - **MATCH, EMEP…**
  - Lagrangian modeling (box/column, meso-regional)
  - Gaussian modeling (urban)
  - CFD modeling (Street canyon-urban)
- Process modeling (box)
- Emission modeling
  - e.g. Source apportionment (PMF etc), emission factor modeling, emission inventory modeling, …

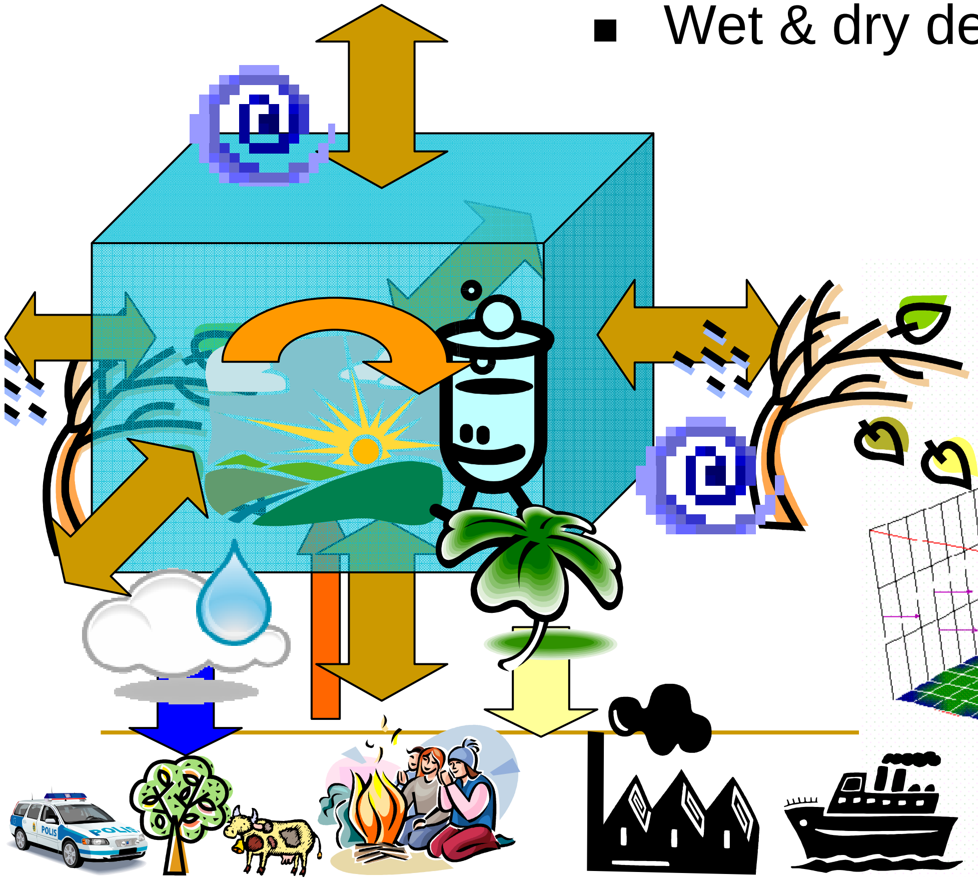
- Application?
  - Chemistry
  - Physics
  - Scale
  - Meteorological data available

Main reasons for using and developing regional scale dispersion models

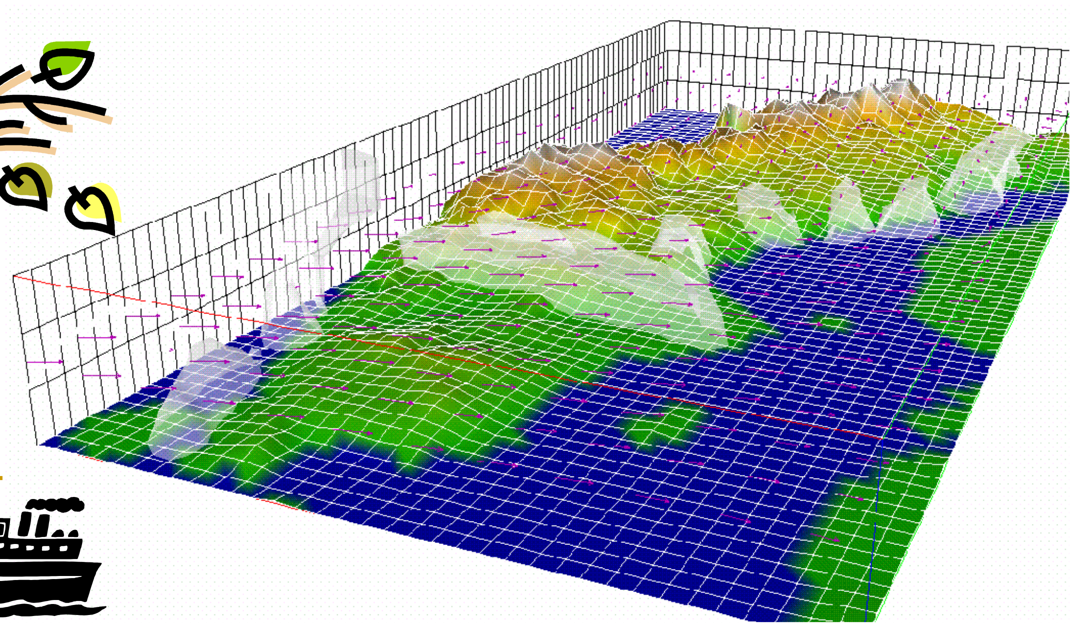
- Air quality monitoring
- Prognostic modelling of air pollutants
- Scenario calculations (policy, science)
- Measure on general understanding, but…
- …

Method

- Three-dimensional Eulerian chemistry and transport model called MATCH
- Domain covers whole Europe with a resolution of ~50 km
- Chemistry: 60+ species
- Wet & dry deposition



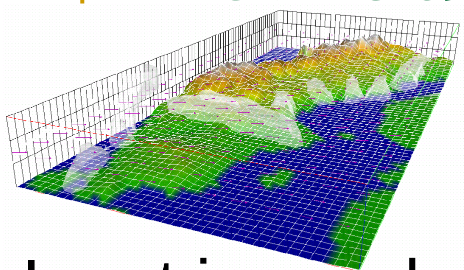
100x100x20=
200 000 boxes



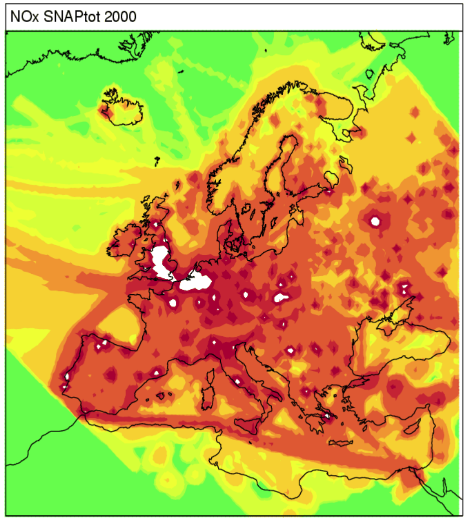
The need for super computers

- Between cubes: transport ca. 6x6x70=2500 flops/h&cube
- Within cube
  - Chemical ca. 150x3=450 flops/h&cube
  - Emission/Deposition ca. 10+40 flops/h&cube
- Number of cubes 100x100x20 = 200 000.
- In total 200000x(450+50+2500)=600 M flops/h
- This is a great underestimation!

Method (cont'd)



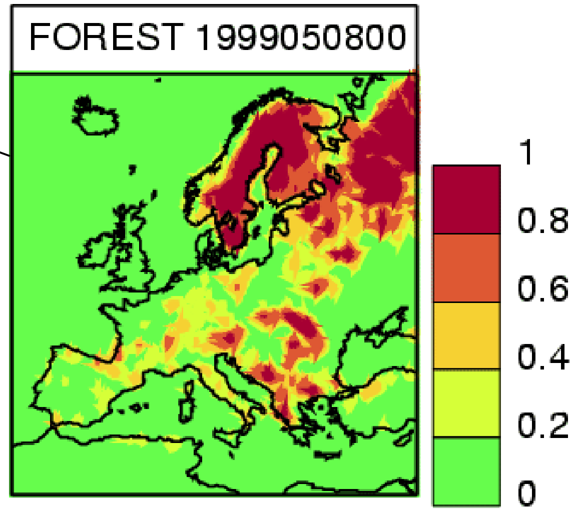
Input is needed emissions, physiography, meteorology (dynamic models).

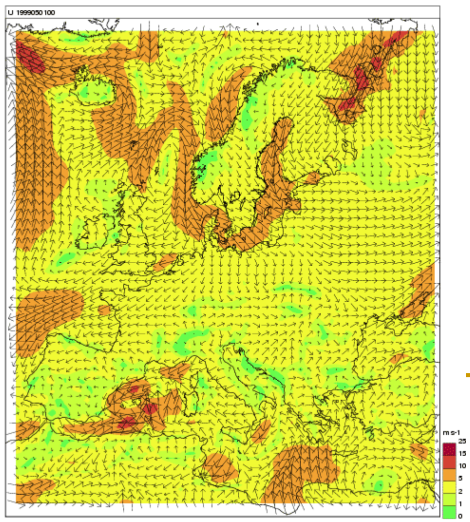


Emissions

- NOx, SOx, CO, NMVOC, NH3, PPM
- Isoprene, seasalt on-line

Land use, e.g. forest, vegetation





Meteorology

- T, U, V, Q, CC, CWC, etc.

Motivation

- Classical pollutants
  - Ozone
  - Particulate components
  - Acidification
  - Eutrophication

Overview

1) CTM forced by ECMWF-reanalysis (ERA40): variability and past trend due to meteorology in Europe
2) CTM forced by regional climate model data (RCA3): future trend due to climate change in Europe

Past and present study (I):

Aim

1) Can we identify any trend in air pollutants due to a trend in meteorology?
2) What is a typical annual air pollution situation, taking meteorological variability into account?

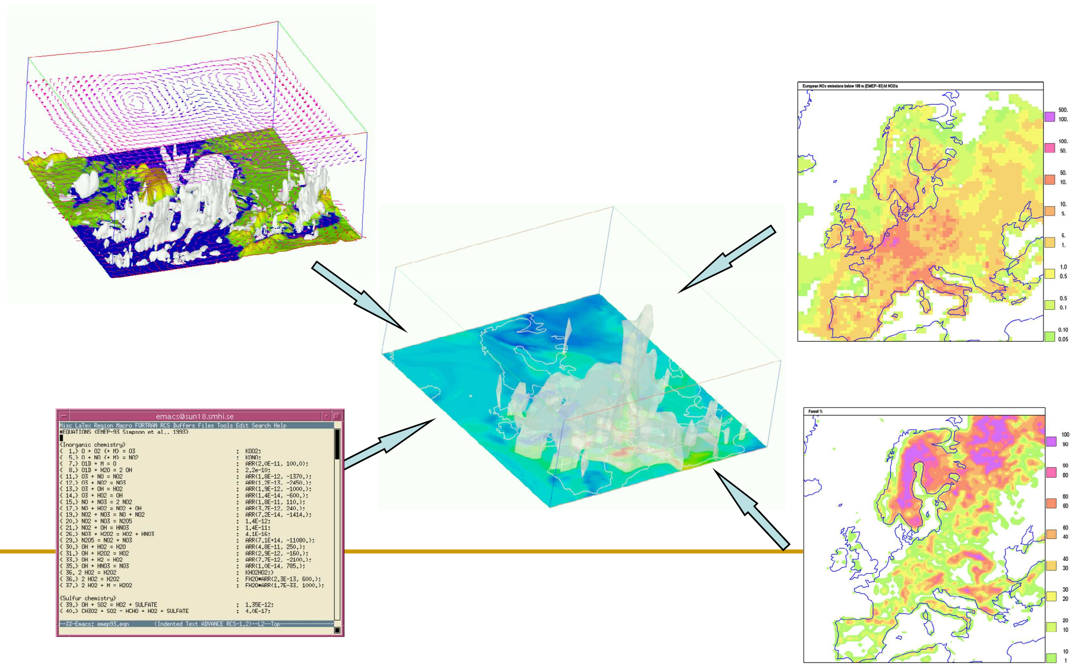
Motivation

1) Discrepancies between emission changes and concentration changes
2) Year 2003 had exceptionally high ozone concentrations

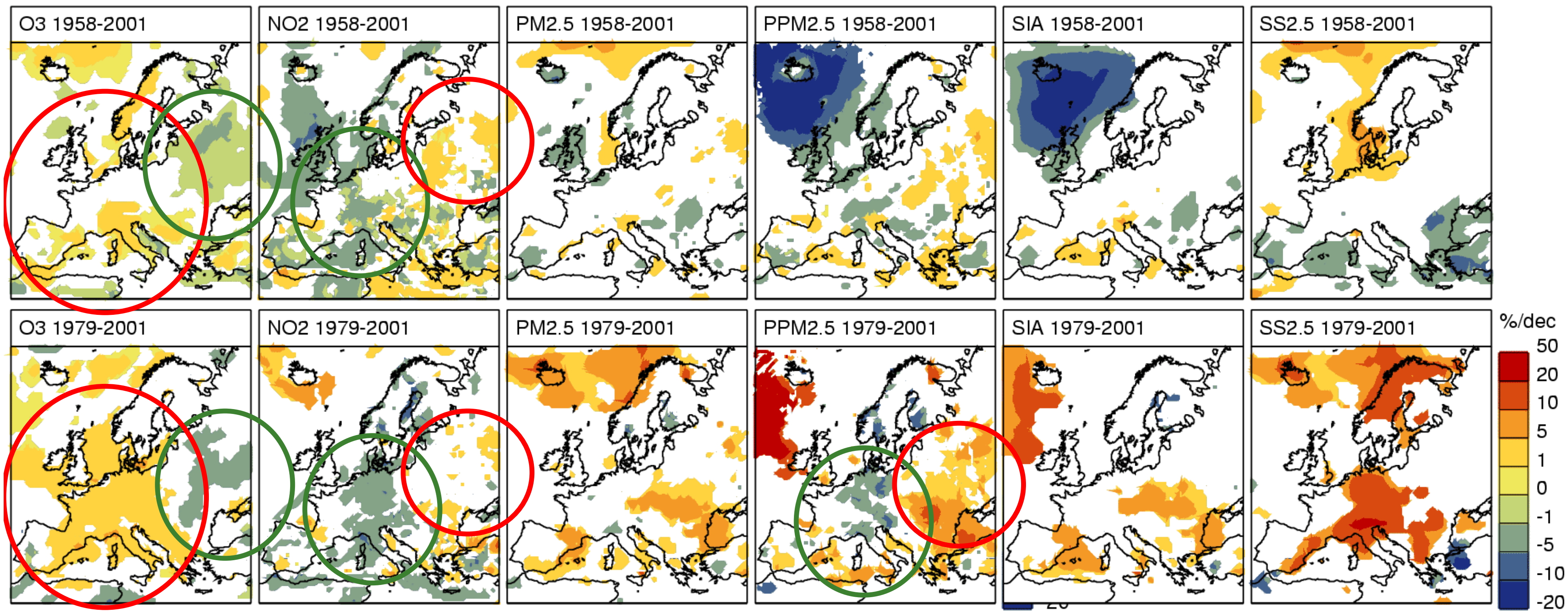
Past and present study (I): Set-up

- ERA40: ECMWF reanalysis
  years 1958-2001
- Horisontal: 125 km -> 40 km
  Vertical: 5 km 21 layers (eta)
  Temporal: 6-hourly temporal resolution
  interpolated to 1-hour
- Europe only
- EMEP expert emissions
  year 2000
  constant boundaries
  => variation in meteorology
  & natural emissions only

- No change (either in RCA3 or MATCH) in lower boundary: e.g.
  - albedo (except snowcover)
  - surface roughness
  - vegetation type



Past and present study (I): Change in concentration per decade



Andersson and Langner, 2007, Tellus B

Climate change study (II):

Aim

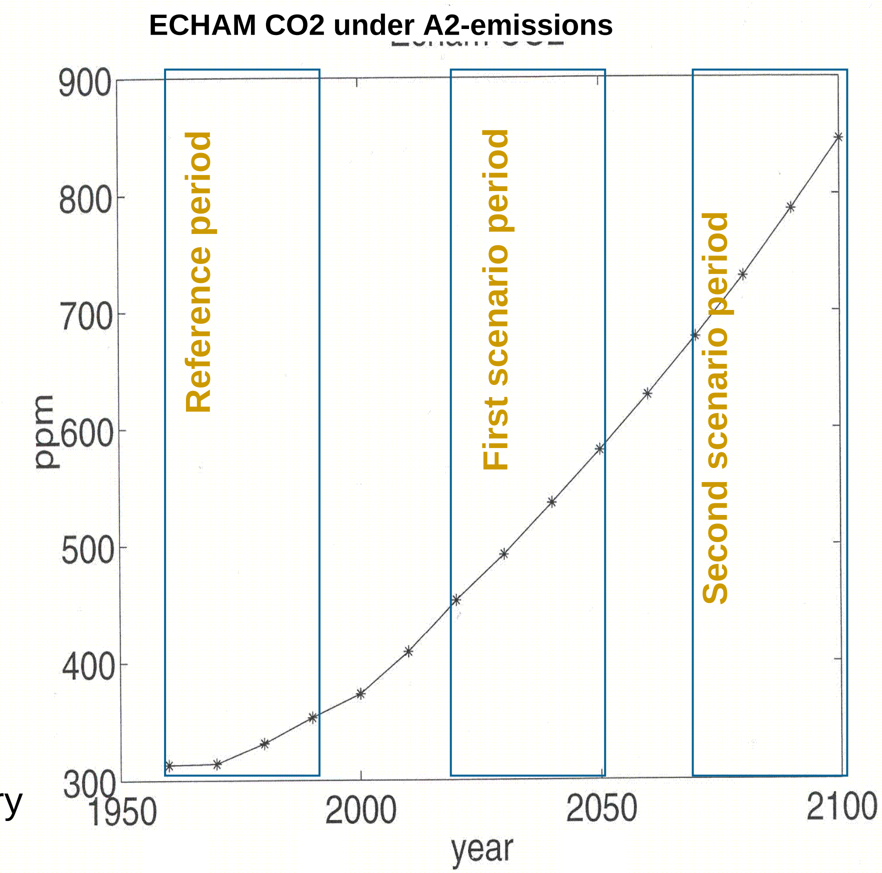
Can we identify any trend in air pollutants due to climate change?

Motivation

Fear of climate trends affecting the air pollution in the future negatively

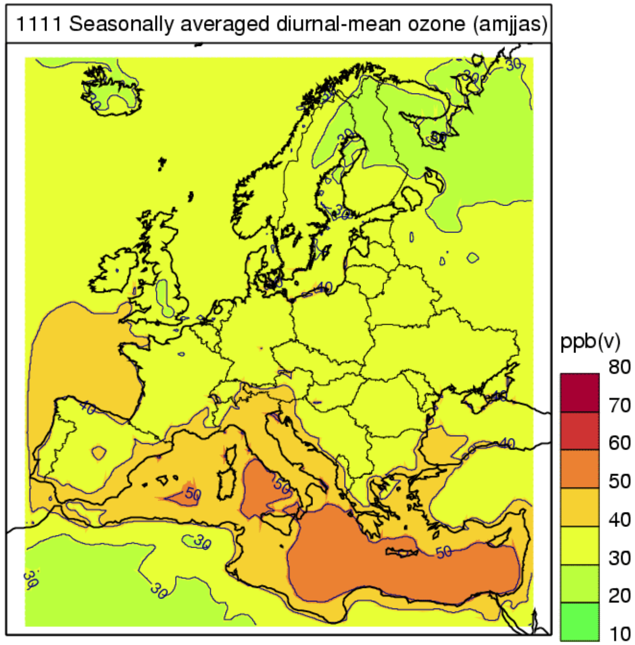
Climate change study (II): Set-up

- RCA3
  140-year
  transient regional climate-change downscaling
  50 km
- Boundaries from global climate model (ECHAM)
  Emission scenario A2 (and B2, not shown)
- 3 time windows (reference, scenario1, scenario2)
- EMEP expert emissions of year 2000
  & constant boundaries
  => variation in meteorology
  & natural emissions only
- No change (either in RCA3 or MATCH) in lower boundary
  (i.e. albedo, surface roughness, vegetation type, …)
- Off-line CTM-climate model: can not take into accound
  indirect effect of aerosol or GHG trends in the CTM

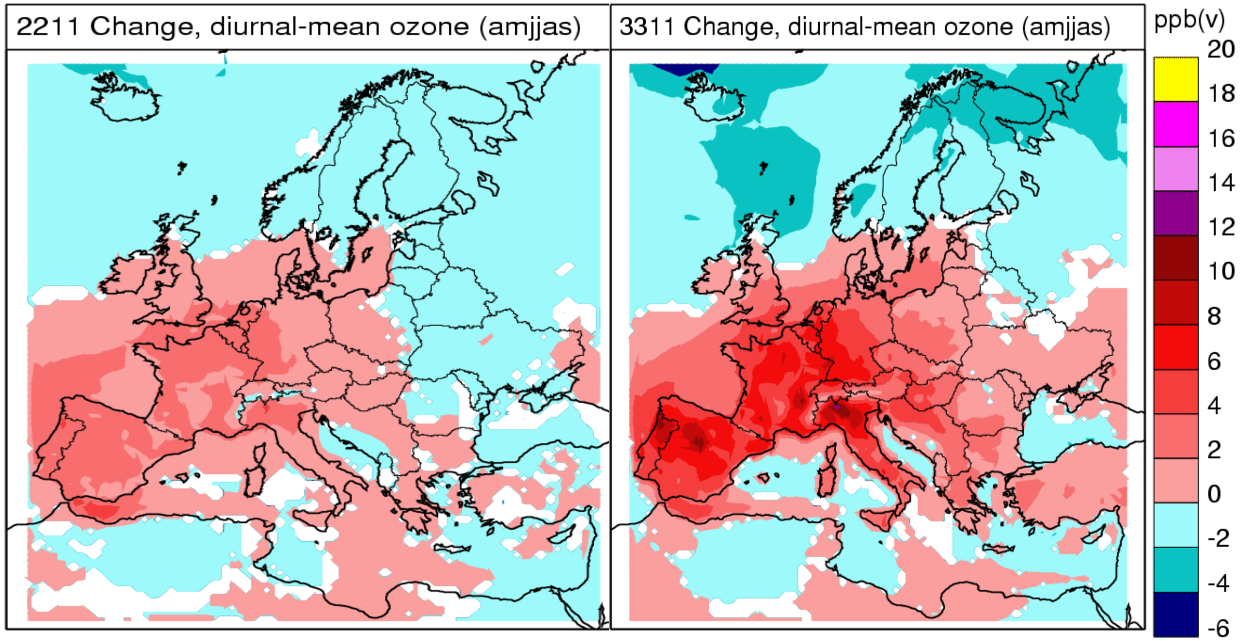


Climate change study (II): Current and future near-surface O_3

Summer-time (amjjas) daily-mean, near-surface, ozone concentration during present climate.



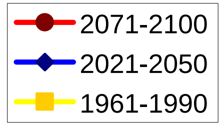
Change in daily-mean concentration due to changes in climate.

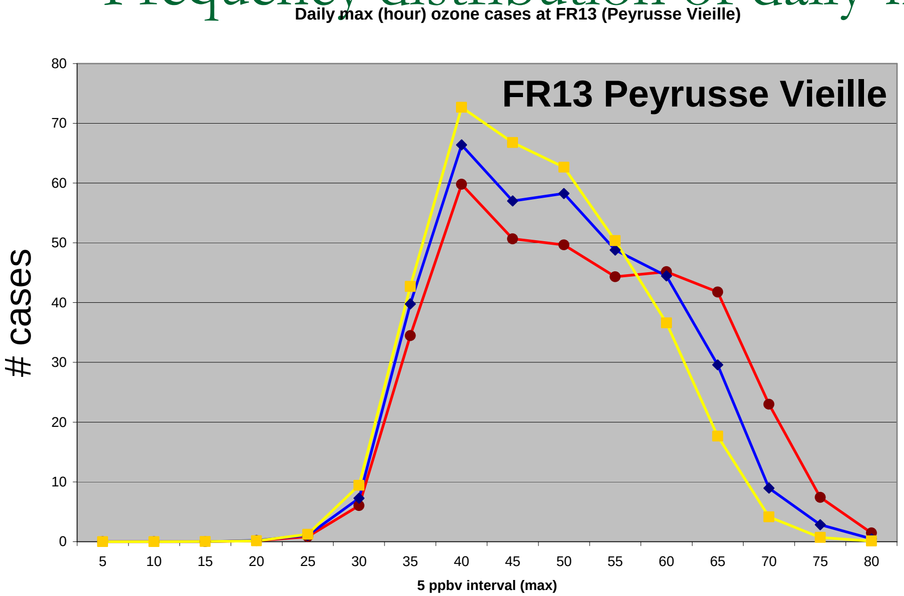


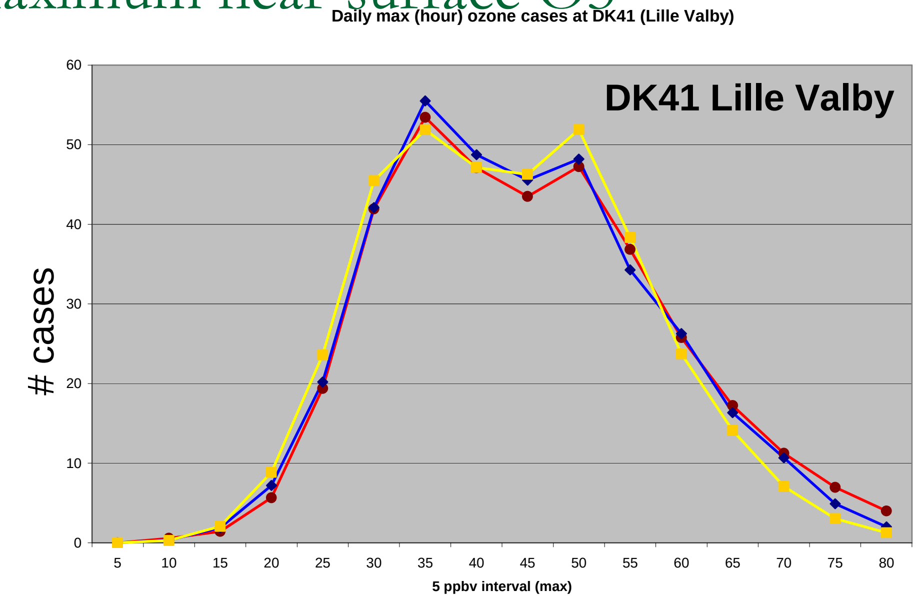
1961-1990 **1961-1990 to 2021-2050** **1961-1990 to 2071-2100**

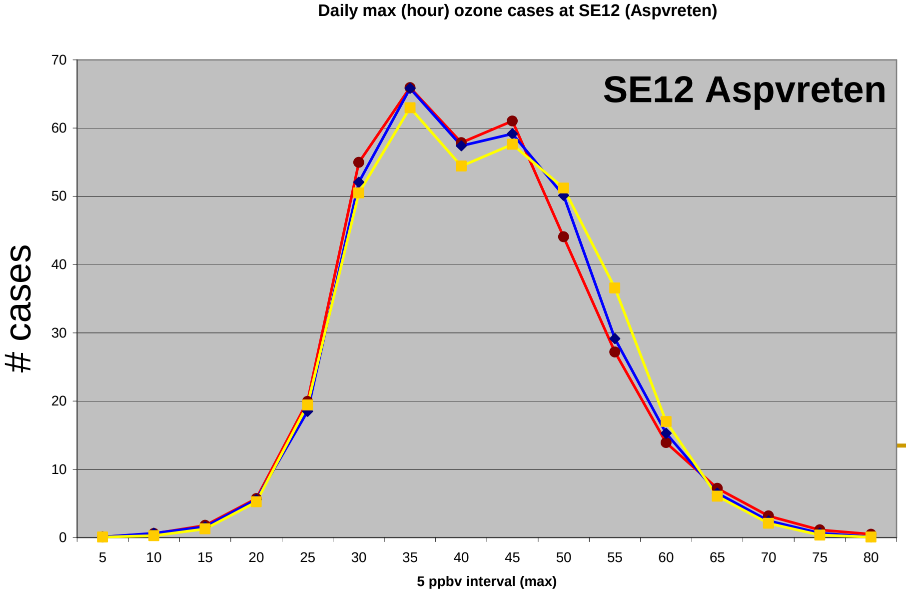
Climate change study (II):

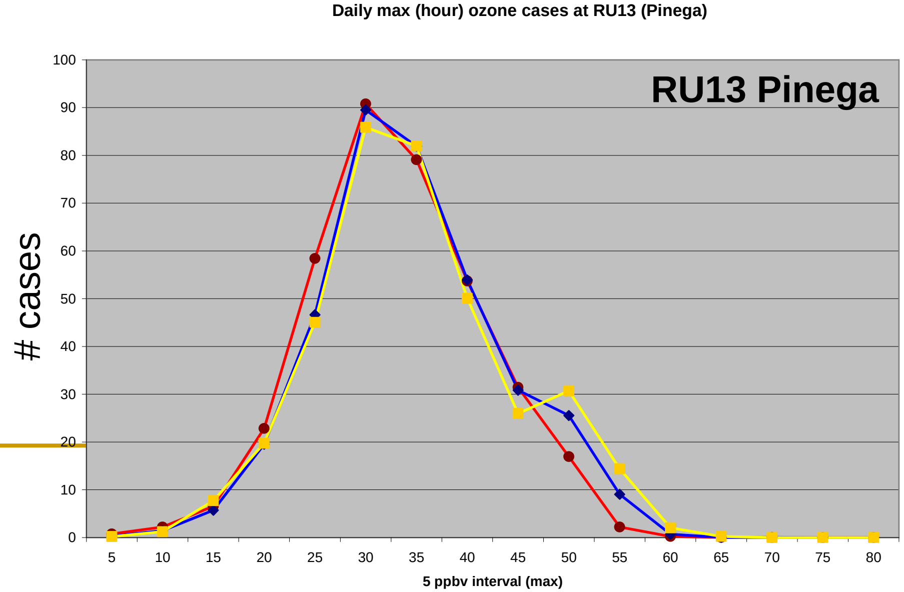
Frequency distribution of daily-maximum near-surface O3











Conclusions (take home messages)

- Climatic trends and meteorological variability affects air pollution concentrations and deposition over Europe, based on modelling studies, on long time scales (year-to-year and longer). Therefore it is important with long-term measurements for monitoring changes as well as for model evaluation.

- For modeling applications it would be useful with a better understanding of chemical content of organic aerosol and the emissions leading to them. Clusetering of compounds of similar behaviour is necessary to take them into account in dispersion models.

Thank you…

- Collegues and co-workers, especially:
  - Robert Bergströms
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- Y’all 4 listening!