Baltic-C

WP 5

Uppsala University

Topic 4: Atmospheric forcing and deposition

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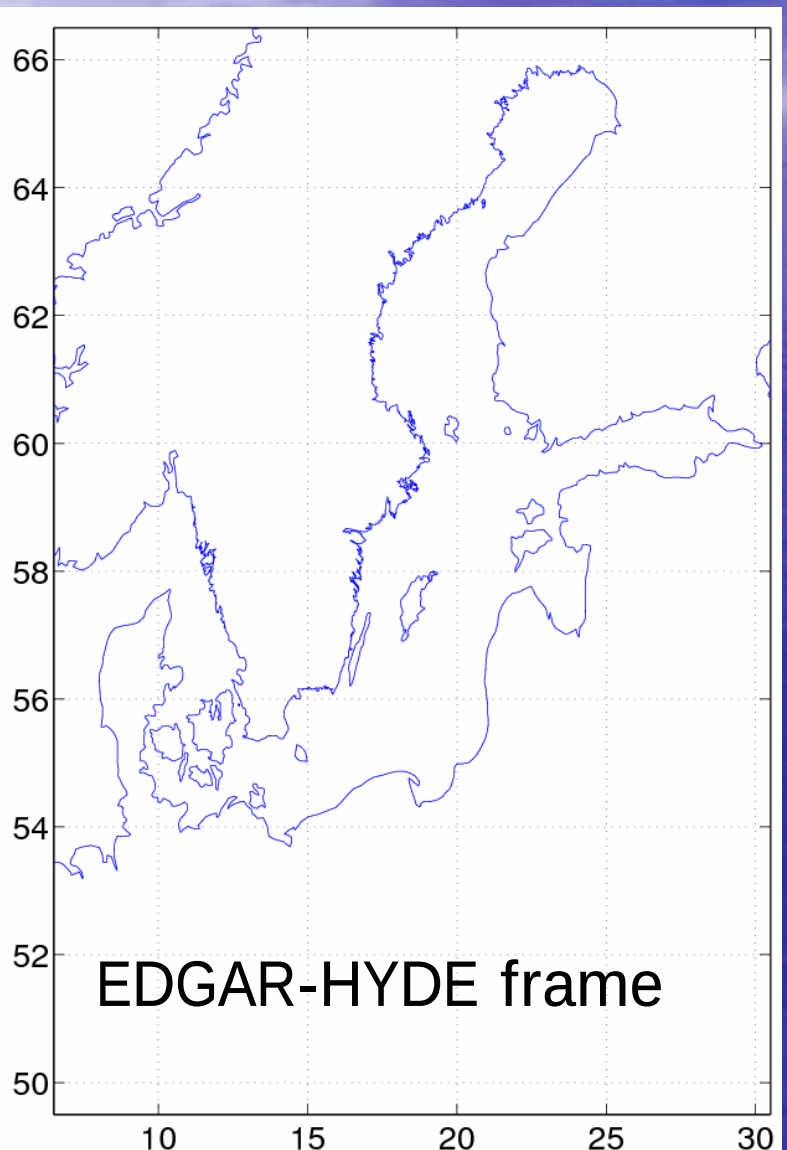
Tasks

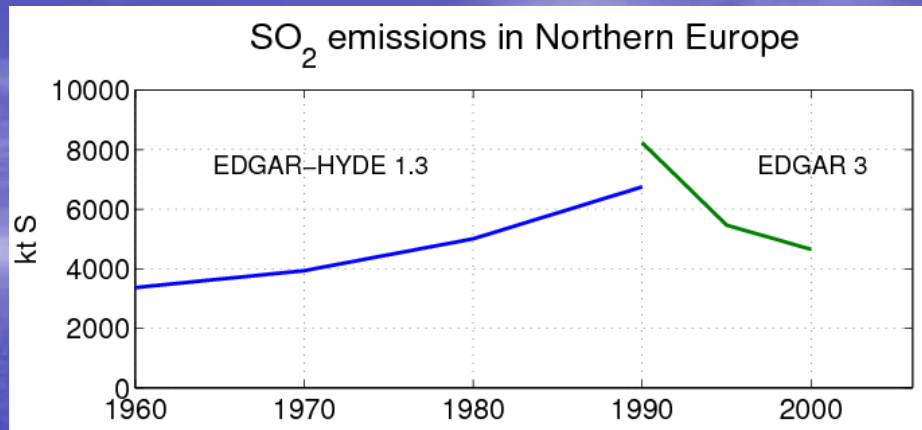
- Forcing data to
  - Ocean model (PROBE-Baltic) (basins)
  - Catchment model (CSIM) (grid)
  - Ecosystem model (LPJ GUESS) (grid)
    - only climate
- Data types
  - Monthly depositions (mg/m^2) (deliverable 26)
    - NOx, NHx, and SOx
    - Minerals (Na, Mg, K, Ca) for catchment areas
    - pH in precipitation over Baltic Sea
  - Meteorological forcing from different scenarios (deliverable 27)

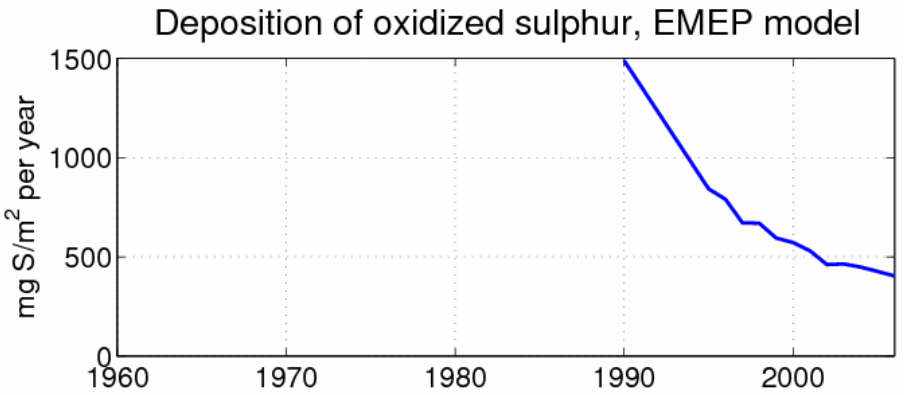
Summary deposition

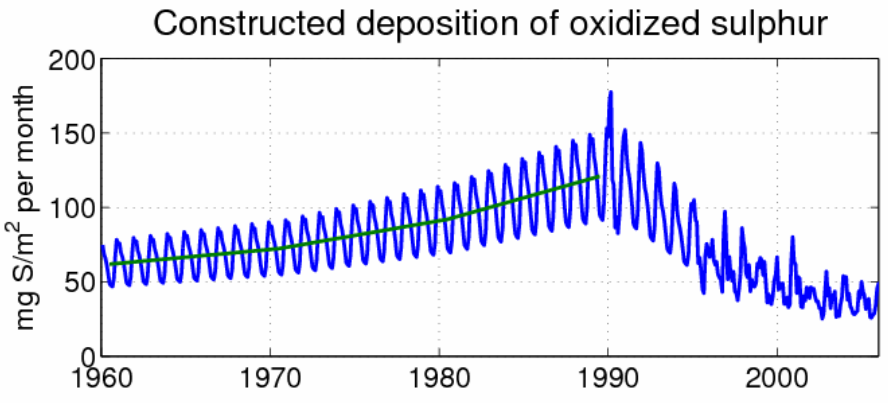
- Reconstructed depositions of minerals and acidifying compounds using
  - EMEP model
  - Spatially interpolated EMEP measurements
  - Historical emissions for acidifying compounds
  - No trend assumed for minerals (not true, certainly not for Ca)
- Reconstructed pH before measurements started
  - Simple pH model with the acidifying compounds and minerals as input
- Scientific paper in manuscript

Acid depositions: extrapolation method



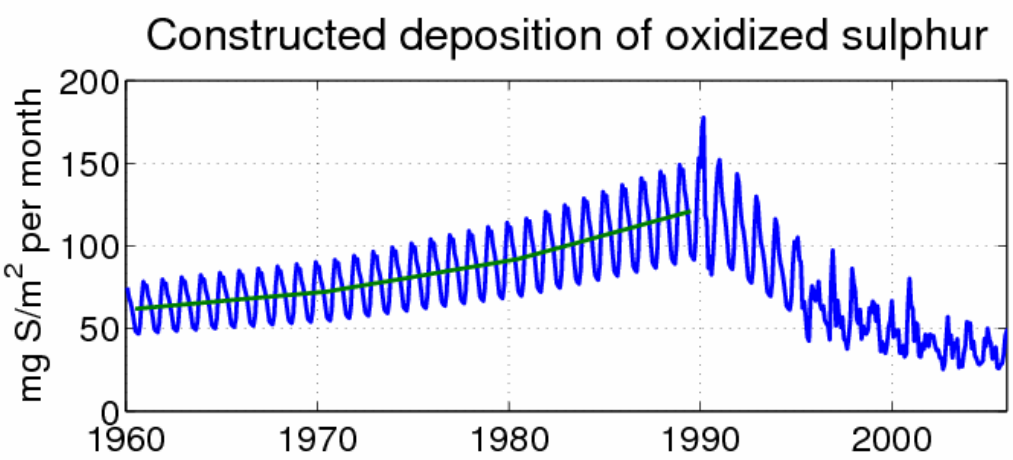


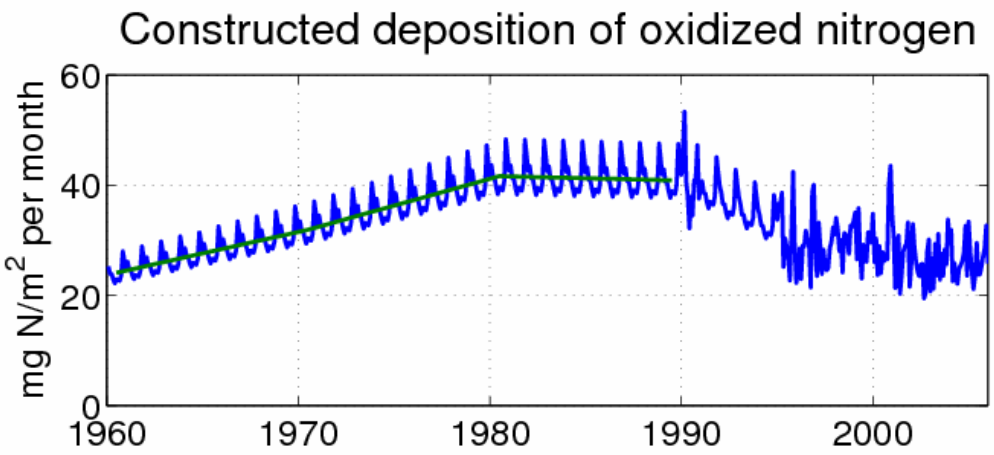


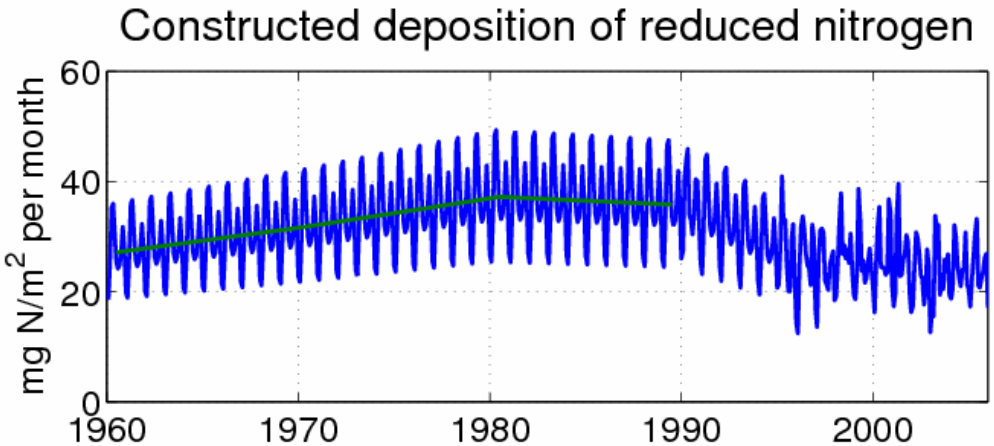


Acid deposition

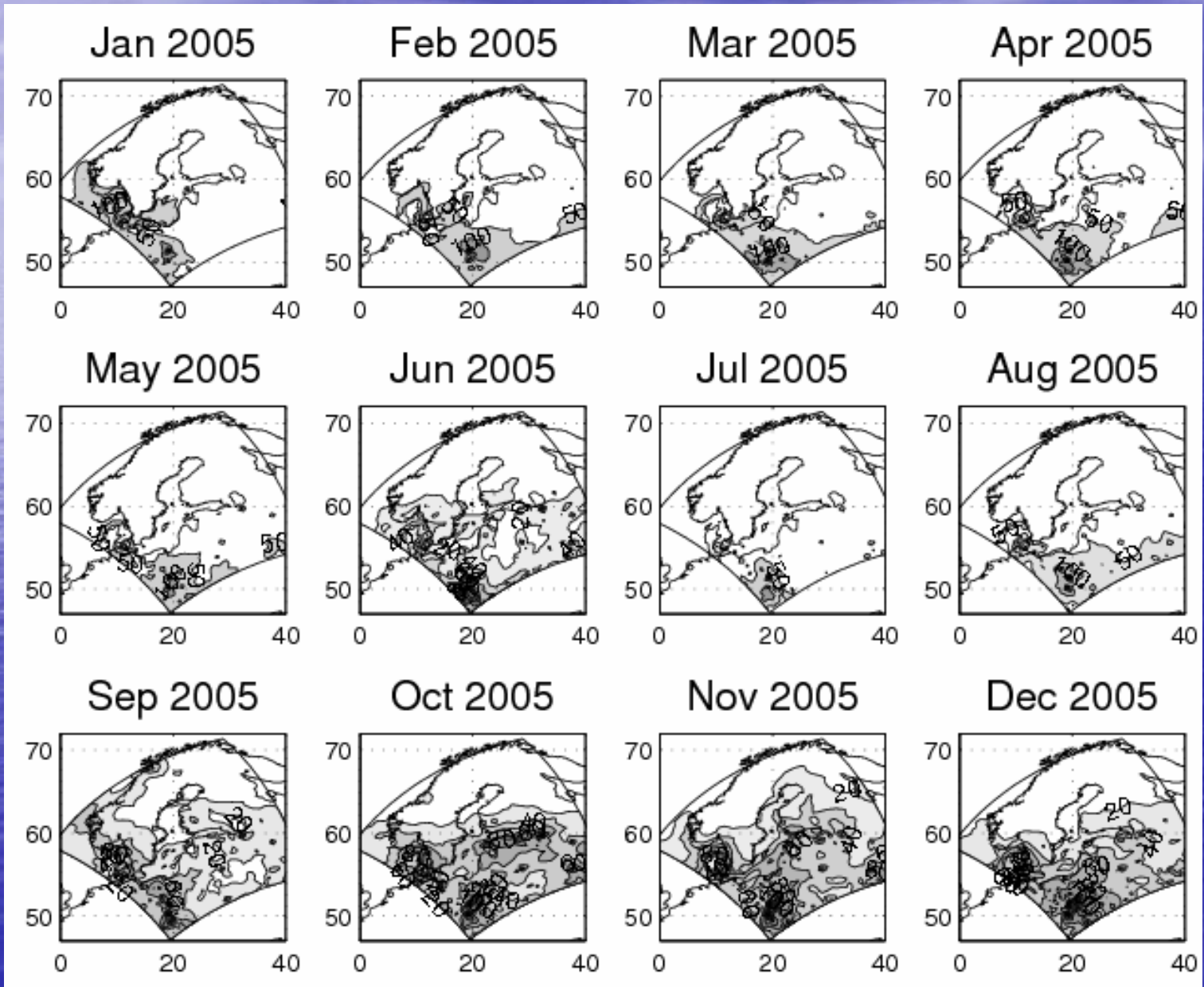
- Upward trends until 1980s
- Then decreasing
- Using the presented extrapolation method underestimates variability when no measurements





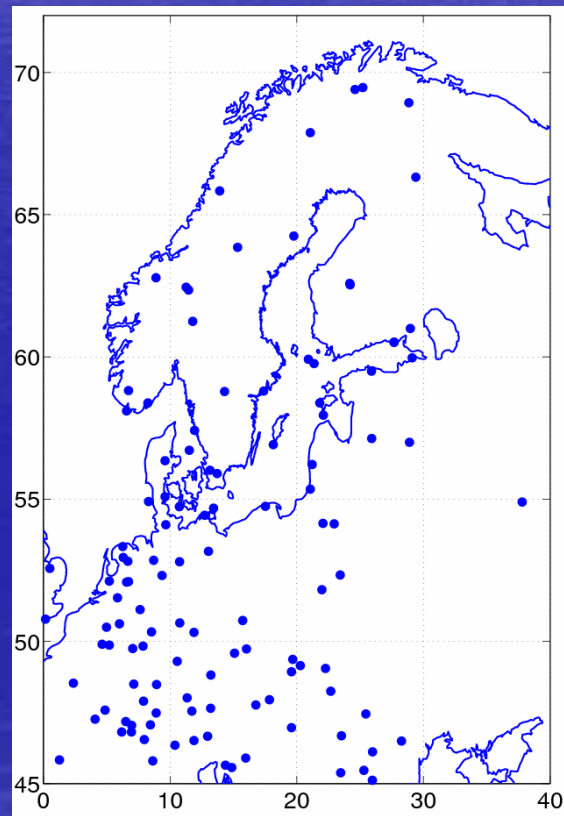


Variation of deposition of sulphur

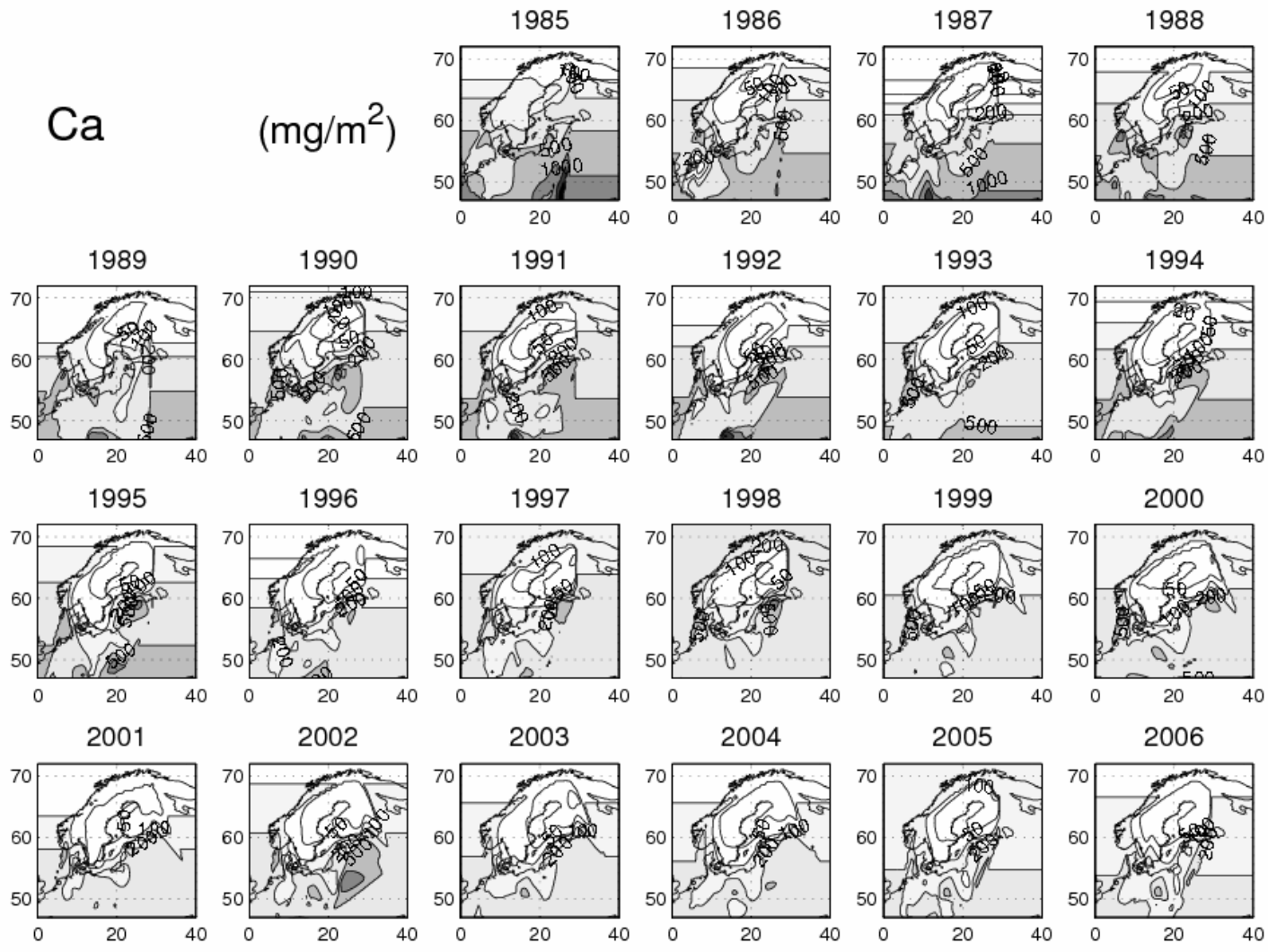


Deposition (wet) of “minerals” (land areas)

- EMEP (co-operative programme) measurements
  - Monthly concentrations in precipitation of Na, Mg, K, Ca, Cl, (SO4, NO3 and NH4)
  - Sources: sea salt, except K which is mostly from forest fires and wood burning and Ca from cement industry, steel production, power generation
- Period 1960–2006
  - 1990–2006 (limited number of stations before)
    - Spatial interpolation
  - Earlier years
    - Assume no trend (though not valid for Ca (Likens et al., 1984;))
    - Mean annual cycle, including spatial distribution from measurements 1990-2006.



Yearly measured and interpolated wet deposition of Ca (mg/m^2)



Not good at boundaries

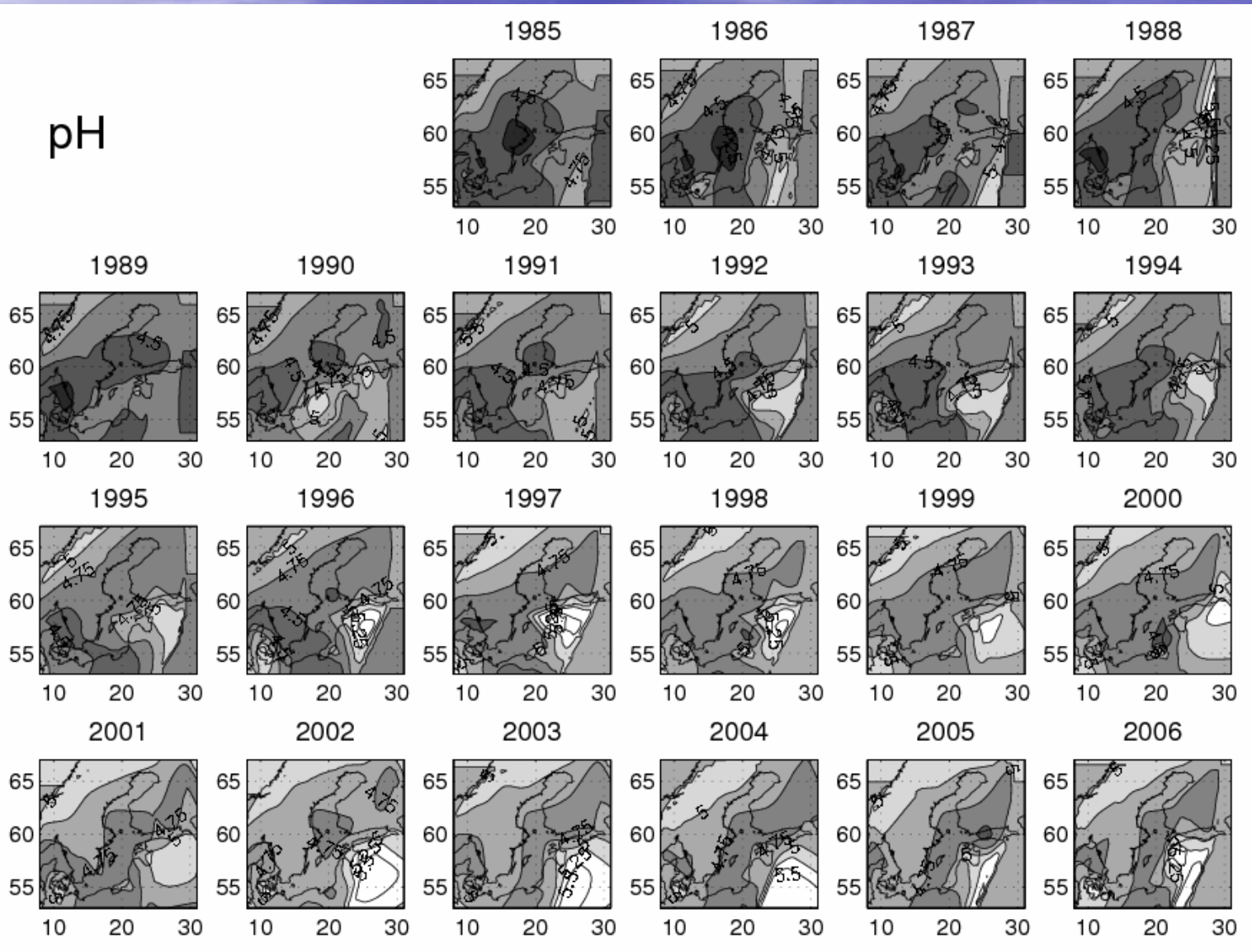
Similarly for the other minerals but east west mean gradient for sea salt (Na, Mg, Cl)

Ca might have to be updated

pH in precipitation (Baltic Sea)

- EMEP measurements
  - Weighted monthly averages
- Period 1960–2006
  - 1990–2006
    - Spatial interpolation
  - Earlier years
    - simple model modified from Rodhe et al. (2002), using concentrations of ions in precipitation

Yearly mean measured and interpolated pH in precipitation



pH model

- Assume charge balance in precipitation and that the only not measured ions are bicarbonate and hydrogen ions

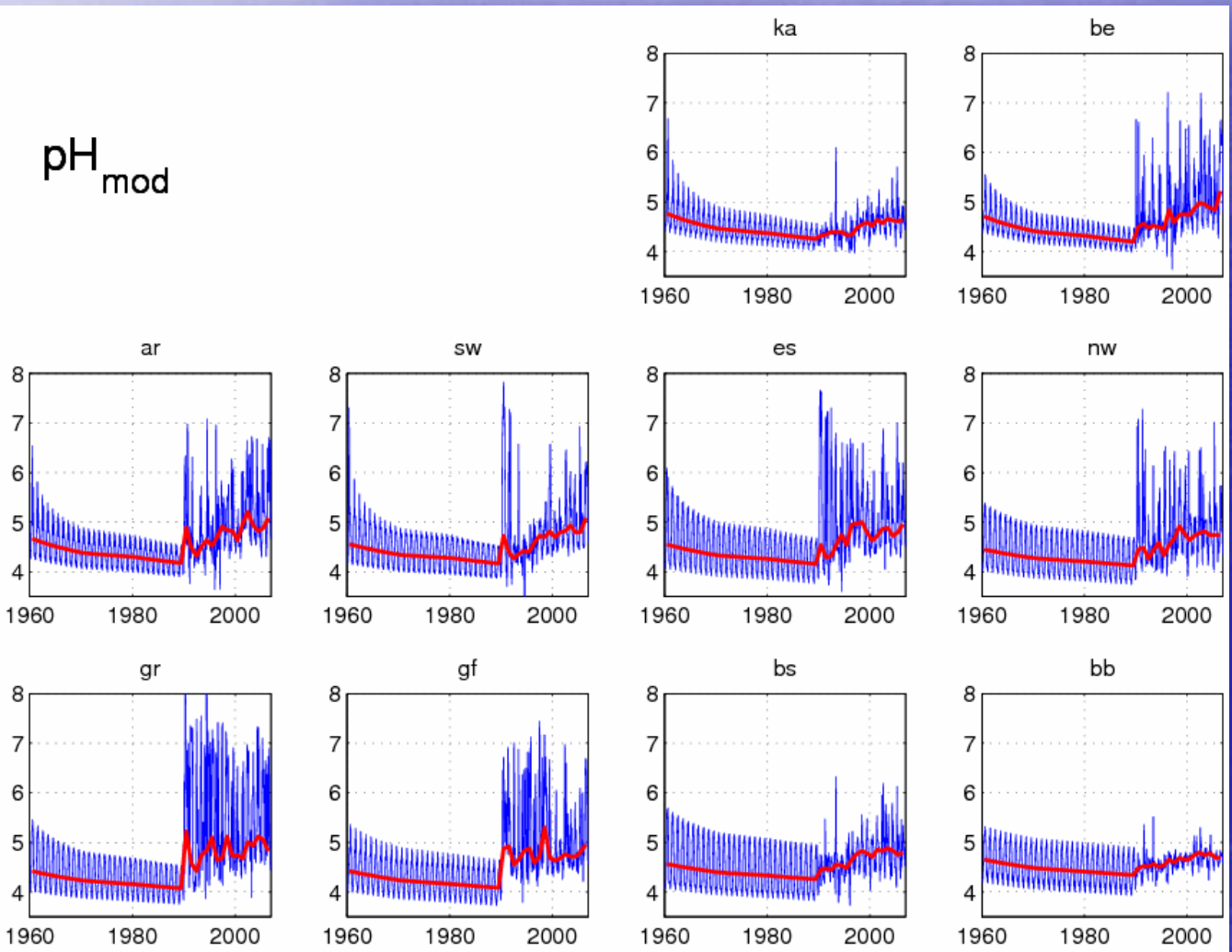
$$\left[H^+\right]-\left[HCO_3^-\right]=2\left[SO_4^{2-}\right]+\left[NO_3^-\right]+\left[Cl^-\right]-\left(\left[NH_4^+\right]+\left[Na^+\right]+\left[K^+\right]+2\left[Ca^{2+}\right]\right)$$

- Assume that CO_2 is in equilibrium with the atmosphere
- Then

$$\left[H^+\right]=\frac{K_1\cdot\left[CO_2\right]}{\left[HCO_3^-\right]},\quad \left[CO_2\right]\approx K_0\cdot pCO_2$$

- Then define $pH=-\log_{10}([H^+])$.
- Problems: K_0 and K_1 are highly temperature sensitive (assumed mean temperature cycle)

Constructed trend of pH in different Baltic Sea basins



- The sudden jump in pH at 1990, is probably due to the simple assumption that there is no trend in mineral (Ca) depositions.
- Needs some adjustments

Climate scenarios

- Storyline A1: Rapid economic growth, population peaks in mid-century, new technologies, reduction in regional differences.
  - A1B-balance across energy sources.
- Storyline A2: Heterogeneous world, continuously increasing populations, economic developments regionally oriented.
- Storyline B2: Emphasis on local solutions and environmental sustainability. Continuously growing population (at lower rate than A2)

Global coupled atmosphere–ocean general circulation models (AOGCMs)

- ECHAM4: Max Planck-Institute, Germany.
  - Based on ECMWF model, modified for climate
  - 2.8º resolution
- ECHAM5: improved cloud parameterisation and land surface scheme
  - 1.875º resolution
- HadCM3: Hadley centre, UK
  - 1.25° resolution
- CCSM (The Community Climate System Model): Developed at NCAR
  - 4 separate coupled models: atmosphere, ocean, land surface and sea-ice.
  - 1° resolution

Regional climate model (RCM)

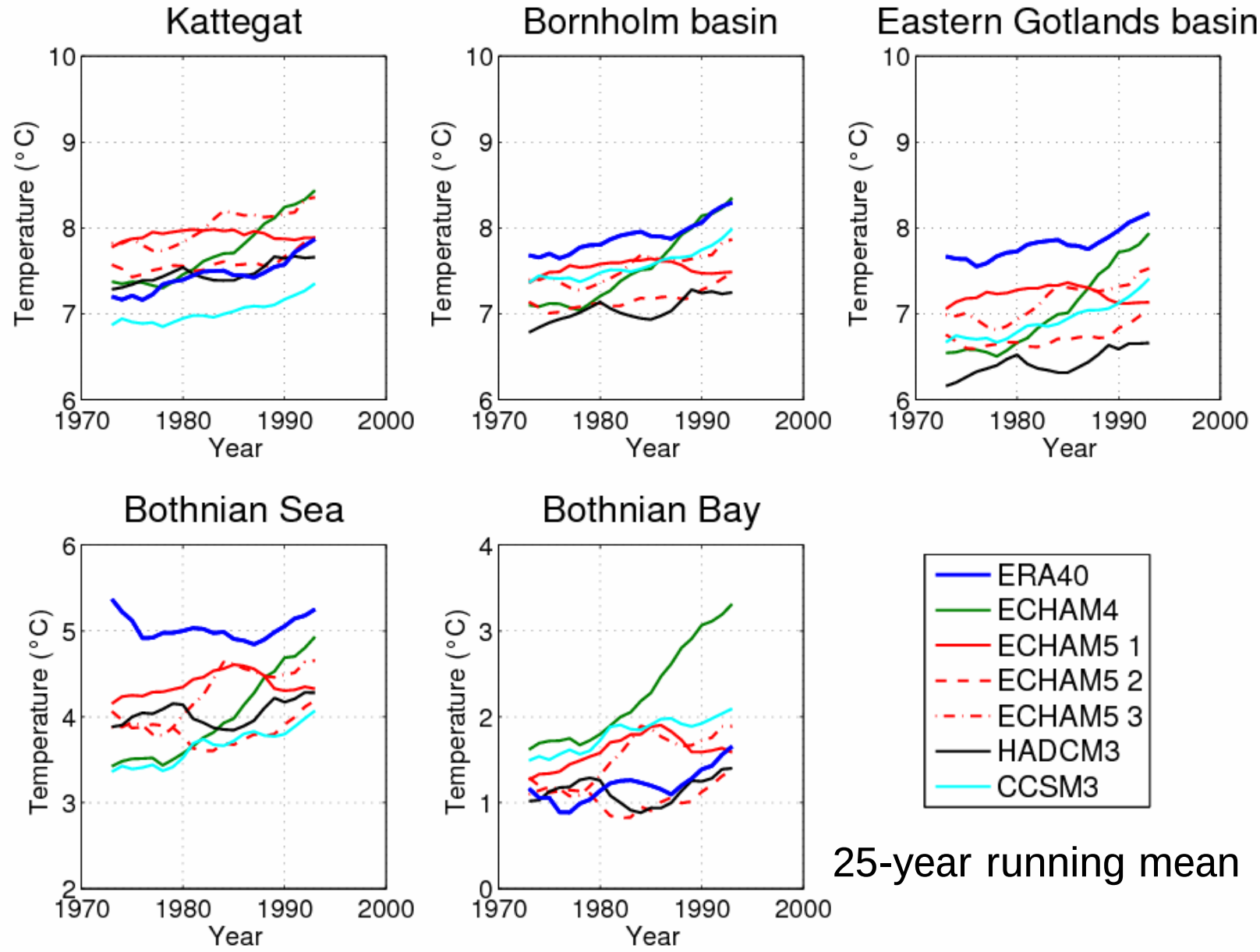
- The AOGCM simulation is dynamically downscaled by RCA3 without the ocean component (Rossby Centre, SMHI). Available from Ensembles EU-project.
- Different RCM:s are relatively similar. Parameters with a larger variability (extreme precipitation, daily cycle etc) more sensitive.

Available runs (used in ECOSUPPORT)

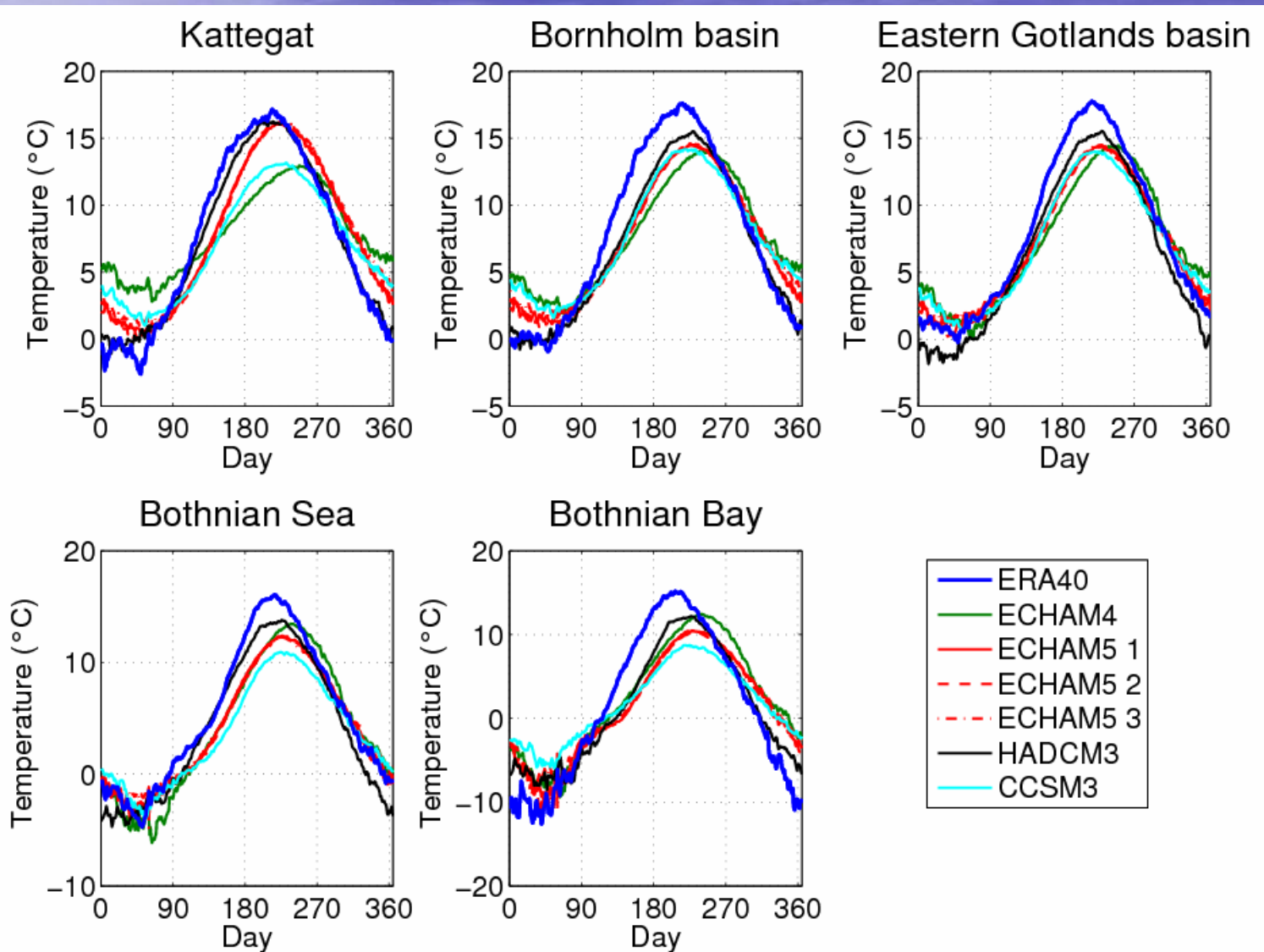
- ECHAM4: A2, B2
- ECHAM5: A1B (3 runs), A2, B1
  - Run 1 has same initialization as for other scenarios, run 2 and 3 performs better in the control period
- HADCM3: A1B
- CCSM3: A1B, B2

- Model spread: A1B (3 models)
- Scenario spread: ECHAM5 (3 scenarios)
- Performance in control period (1961–2005)?
  - Some preliminary results and methods

Tests of runs in present climate

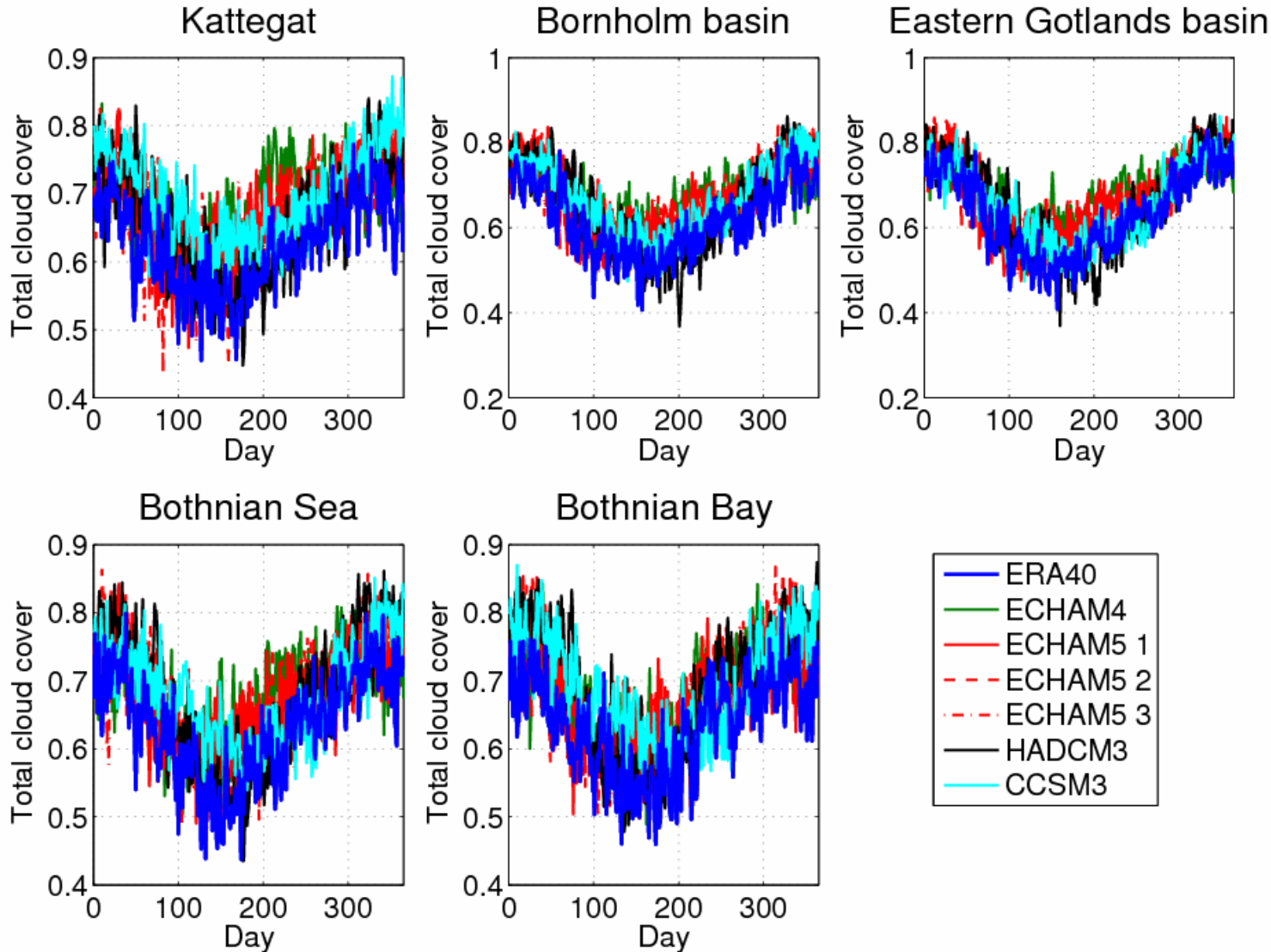


Temperature cycle (first tests)



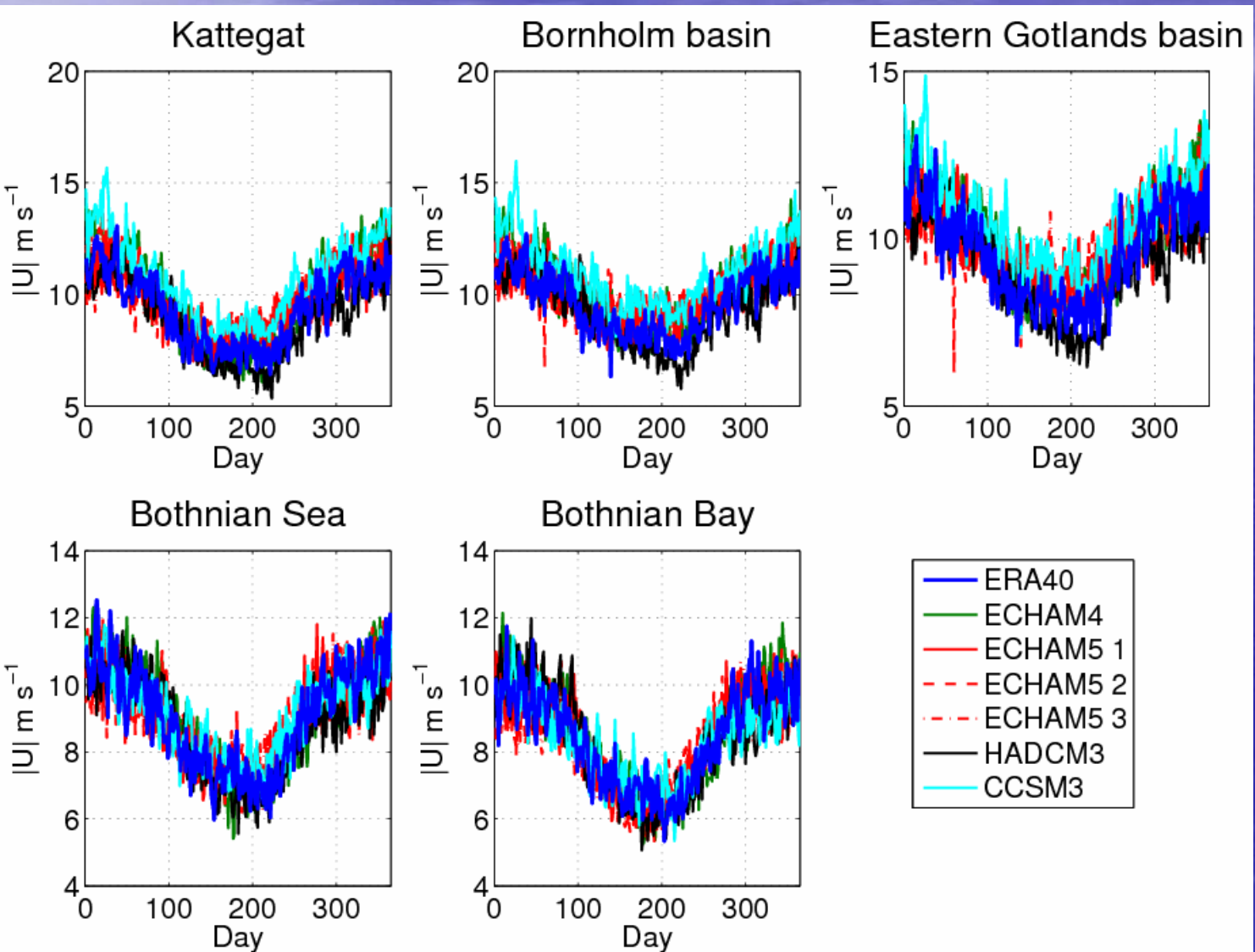
Several models under-estimate variability

Total cloud cover cycle



Models over-estimate total cloudness

Wind speed cycle



Climate data format

- Over sea every 3H, derived at one point representing each basin:
  - T2, Geostrophic wind, RH2, Total cloudiness,
  - Precipitation
  - Sea level pressure at Debilt and Oksoya.
- LPJ Guess/CSIM 24H averages, gridded:
  - T2 forest and open land
  - Precipitation
- LPJ Guess also:
  - CO_2 (method from Rutgersson et al. 2009)
  - shortwave radiation