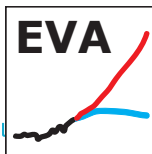# Production-tagged aerosols in NorESM

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Norwegian Earth System Model (NorESM)

What is this "Norwegian Earth System Model"?

- It is heavily based on CESM
- Using Production tagged aerosol scheme for aerosol dynamics developed since 1995 at University of Oslo
- Using a modified version of the MICOM ocean model co-developed in Bergen
- NorESM permits efficient cooperation on climate research in Norway (and Nordic countries)
- Used in CMIP5 and several AEROCOM intercomparisons

Some history of the "production tagged" scheme

- First versions were implemented by Ø. Seland, A. Kirkevåg and T. Iversen in the late 1990s

- Improved and refined several times during last 15 years

- Used in CCM3, CAM3 and CAM4 (NorESM1) and predicted climate effect of man-made pollutants mixing with "background aerosol"

- The concept is still:
  - How do different physical/chemical processes change properties of the aerosol size distribution
  - What is optical and cloud microphysical properties
 - What is impact on climate?

Concept of "Production tagged aerosol dynamics" ?

- It is a "poor man's bin scheme"
- A sectional model calculates properties off-line and stores results in **look up tables**
- The atmospheric model can request properties of aerosol mixtures at run time based on the tables.
- For example: What is Single Scattering Albedo (SSA) based on X amount of condensate and Y amount of coagulate?
- "Production tagged" means tracers are added based on their "production mechanism", e.g. "sulfate produced in gas phase chemistry" is a tracer.
- The different tracers change the size distribution differently (in the off-line sectional model).
- 21 tracers in 13 separate mixtures

Look-up tables??

CONCEPT

- TRANSPORT FEWER TRACERS
- LOOK UP SIZE DISTRIBUTION AFTER GROWTH
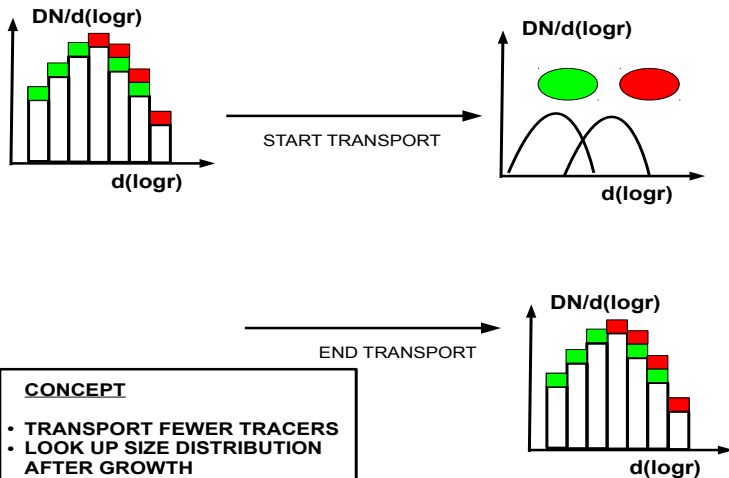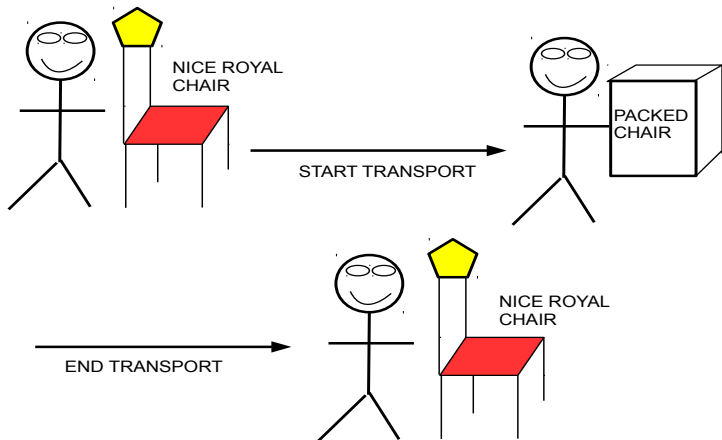
Look-up tables??

Production-tagged algorithm

- **Off-line**: Pre-calculate change in initial size-distribution due to addition of "production tagged" tracers
- **Off-line**: Store the result of several physical properties in look up tables
- **In climate model**: Transport original aerosol distribution separately from the "pollutants" (production tagged tracers)
- **In Climate model**: Based on tables: Look up mixture properties during model run

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Going from CAM4-Oslo to CAM5-Oslo (and further)

- CAM4 did not have on-line size resolved aerosols, but CAM5 has MAM!
- Why do we need the Production tagged aerosols?
  - PT-aerosols are programmed to be an *alternative*, not a replacement for MAM
  - Using the off-line sectional model, we calculate other size-distribution features than MAM
- The code is made so that changing from MAM to bulk aerosols is similar to changing from MAM to PT-aerosols
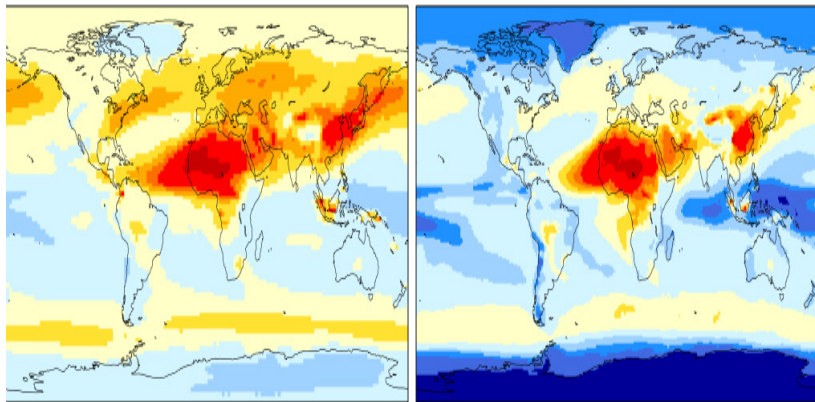
Aerosol optical depth , year 2000

NorESM1 (CAM4-Oslo) left, early NorESM2 (CAM5-Oslo) right

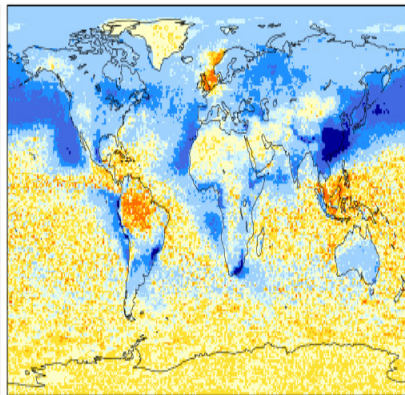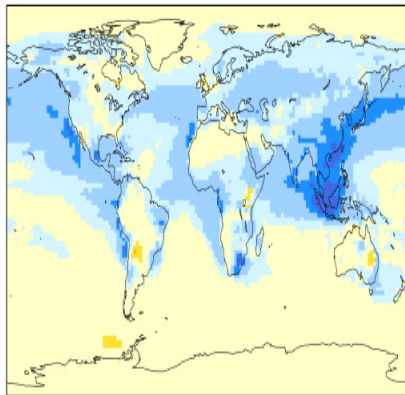AOD   avg = 0.1353   AOD   avg = 0.0913

SW Cloud Effective radiative forcing 1850-2000

NorESM1 (CAM4–Oslo) left, early NorESM2 (CAM5–Oslo) right

SW cloud radiative forcing at TOA   avg = -0.908 W m^{-2} SW cloud radiative forcing at TOA   avg = -1.303 W m^{-2}

New features in NorESM2

- Nucleation as function of low volatile organic vapours (in cooperation with University of Helsinki, Finland)
- Investigate semi-volatile aerosol (nitrate and SOA)
- Hopefully based on CAM5.5

Conclusion

- We have a "production tagged" aerosol dynamics scheme
- We have ported our scheme from CAM4 to CAM5
- The production-tagged aerosols interact with surface / radiation / clouds in the same way (but differently ☺) as MAM3/MAM7
- We are very grateful to all support from NCAR and CESM!!

Questions?