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?
What is the 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??

- TRANSPORT FEWER TRACERS
- LOOK UP SIZE DISTRIBUTION AFTER GROWTH

CONCEPT
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
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

NorESM1: avg = -0.908 W m\(^{-2}\)

NorESM2: 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
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?