Norwegian Meteorological Institute

Use of look-up tables (LUT) for aerosol optics and activation to cloud droplets

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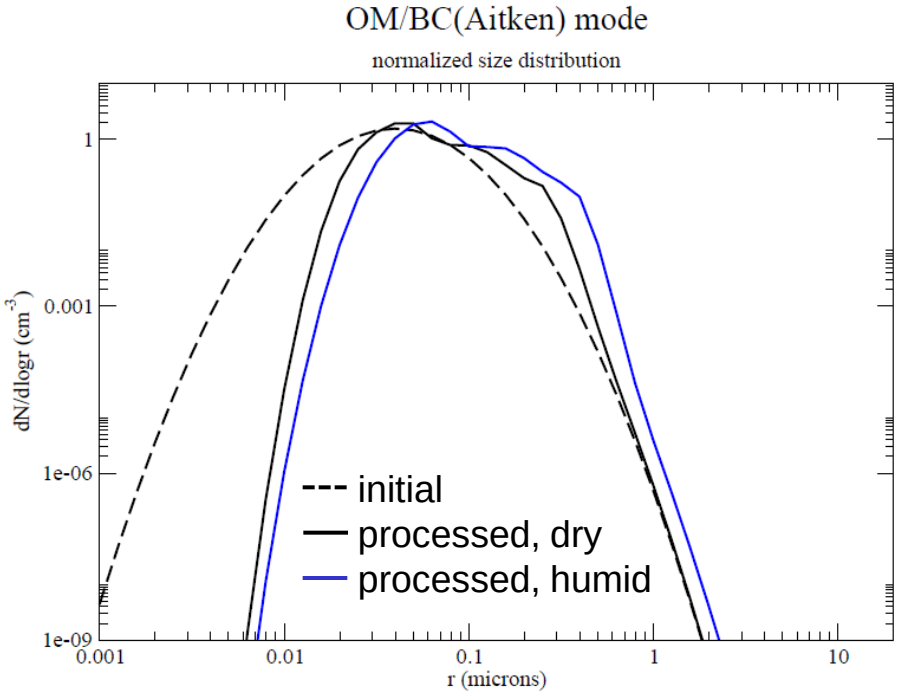
Aerosol growth by:

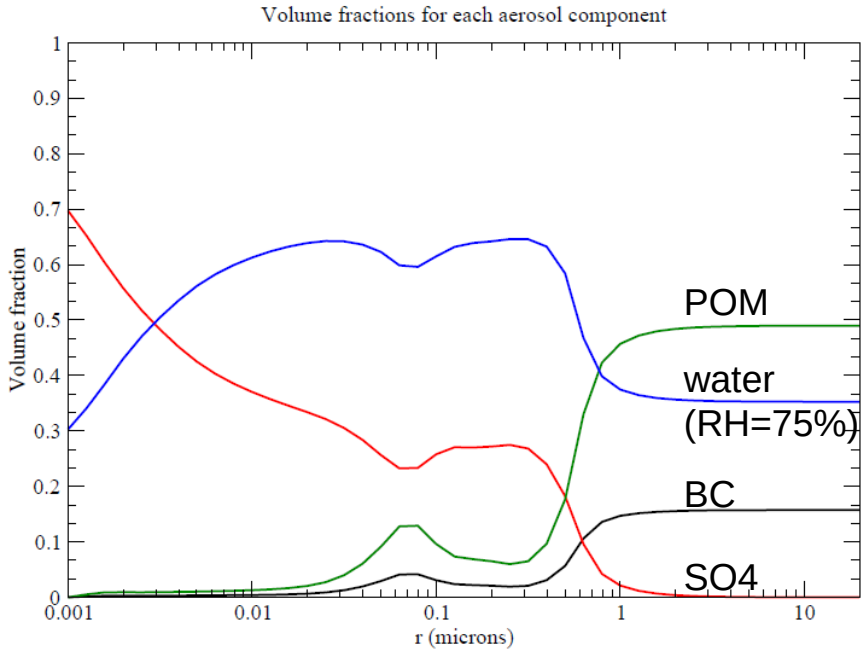
- condensation of H_2SO_4

- coagulation of Aitken particles
  onto larger pre-existing particles

- cloud-processing/wet phase chemistry

- hygroscopic growth

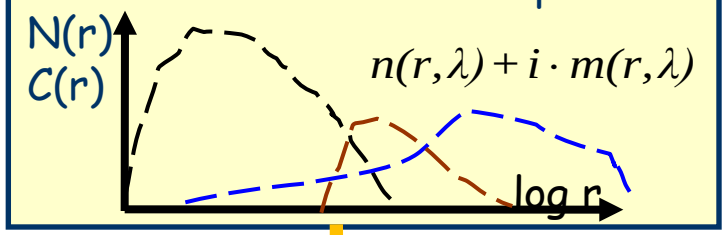




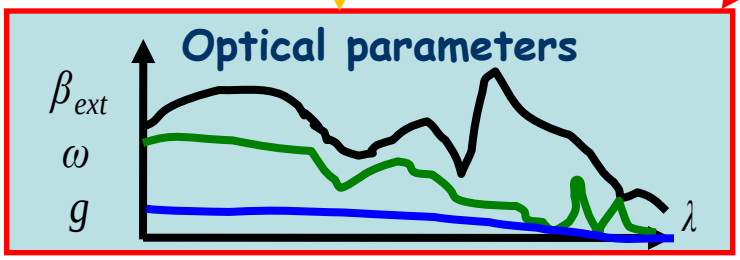
From life cycle calculations:
DU, SS and process specific SO_4, BC, OC
+ relative humidity RH

Cond., coag. + cloud processing
(solve continuity eq.)

Size distribution and composition



Mie theory



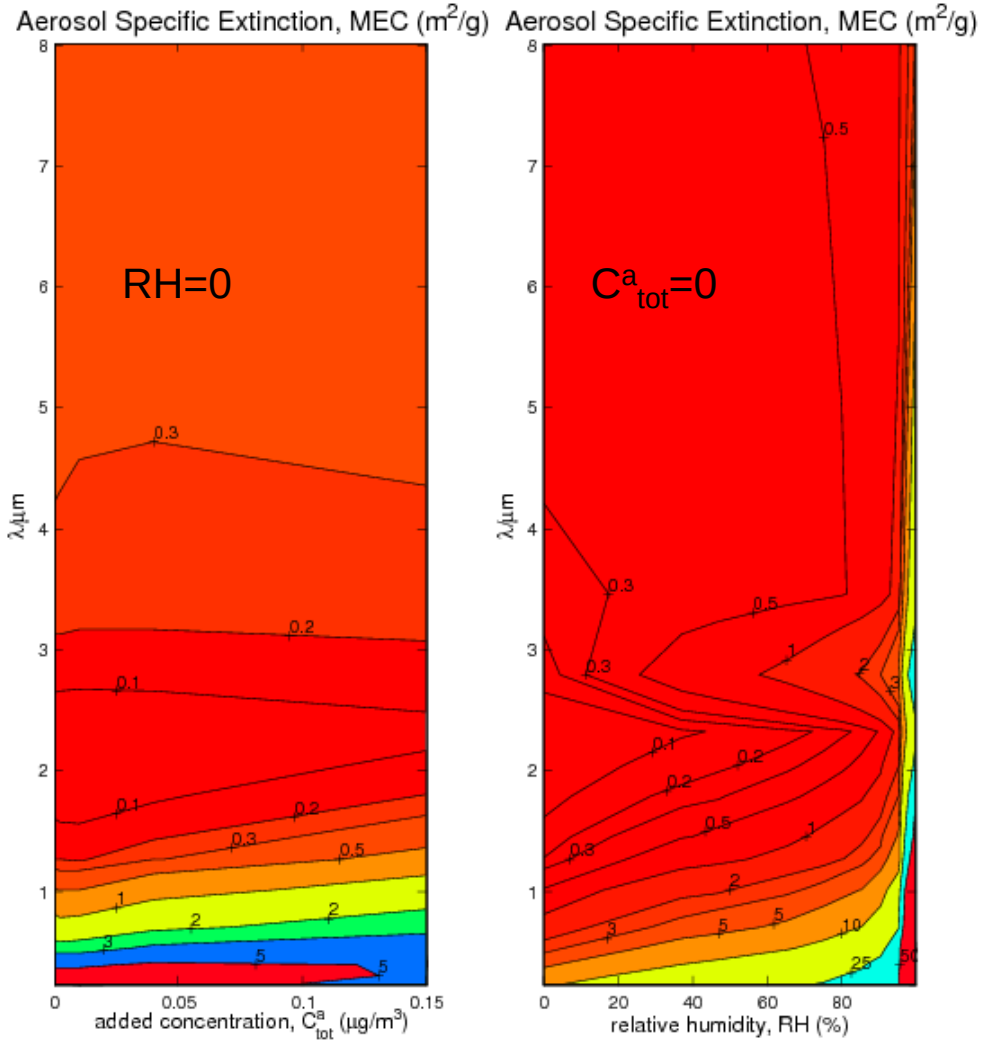
Look-up tables

Radiative forcing, W/m²

Principle: Scheme for parameterized optical parameters

Seland et al. (2008)
Kirkevåg et al. (2008)

Example use of output from look-up tables for SO4(a) mode



Mass specific extinction coefficient:

$MEC = \beta_{ext} / C_{tot}$ (without water)

MEC's dependence on 2 of 5 input parameters (pluss λ): total internally mixed mass, and RH

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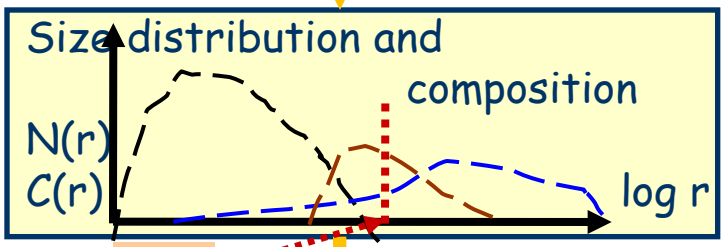
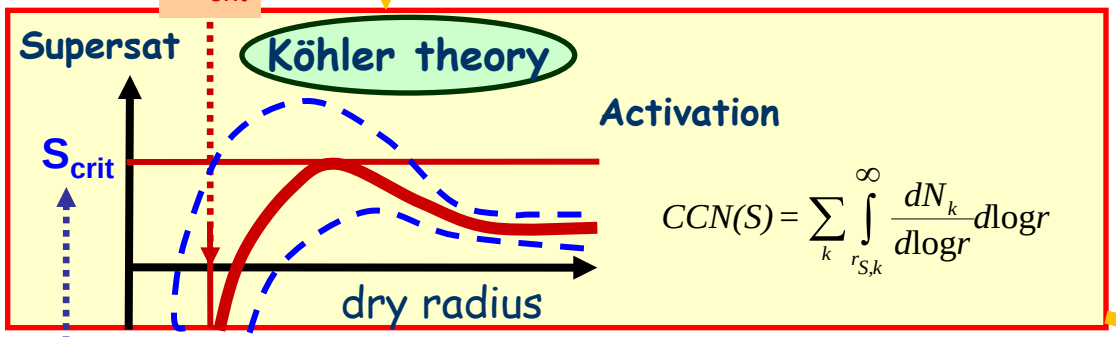
From life cycle calculations:
DU, SS and process specific SO_4, BC, OC
+ assumed supersaturation S

Cond., coag. + cloud processing
(solve continuity eq.)



R_{crit}



Prescribed S:
0.10% Stratiform clouds
0.15% Conv. clouds over land
0.80% Conv. cluds over ocean

Look-up tables

Principle: Scheme for *diagnostic* cloud droplet number concentrations (CDNC)

Seland et al. (2008)
Kirkevåg et al. (2008)

This CAM(3)-Oslo *diagnostic* option is not fully implemented in CAM4-Oslo !

CDNC=CCN(S)

effective droplet radii, liquid water content

Radiative forcing, W/m^2

From life cycle calculations:
DU, SS and process specific SO_4, BC, OC

Cond., coag. + cloud processing
(solve continuity eq.)

Size distribution and composition

N(r)
C(r)

log r

R_{crit}

Supersat

Köhler theory

Activation

S_{crit}

dry radius

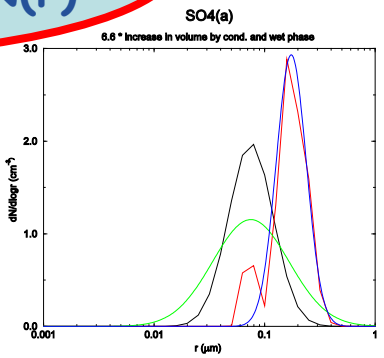
$$CCN(S) = \sum_k \int_{r_{S,k}}^{\infty} \frac{dN_k}{d\log r} d\log r$$

Calculated/realized S:
from adiabatic lifting, assuming equilibrium between the particles and the environment
(Abdul-Razzak and Ghan, 2000)

Principle: Scheme for *prognostic* cloud droplet number concentrations (CDNC)

Storelvmo et al. (2008)
Hoose et al. (2009)

Look-up tables:
lognormally fitted N(r)

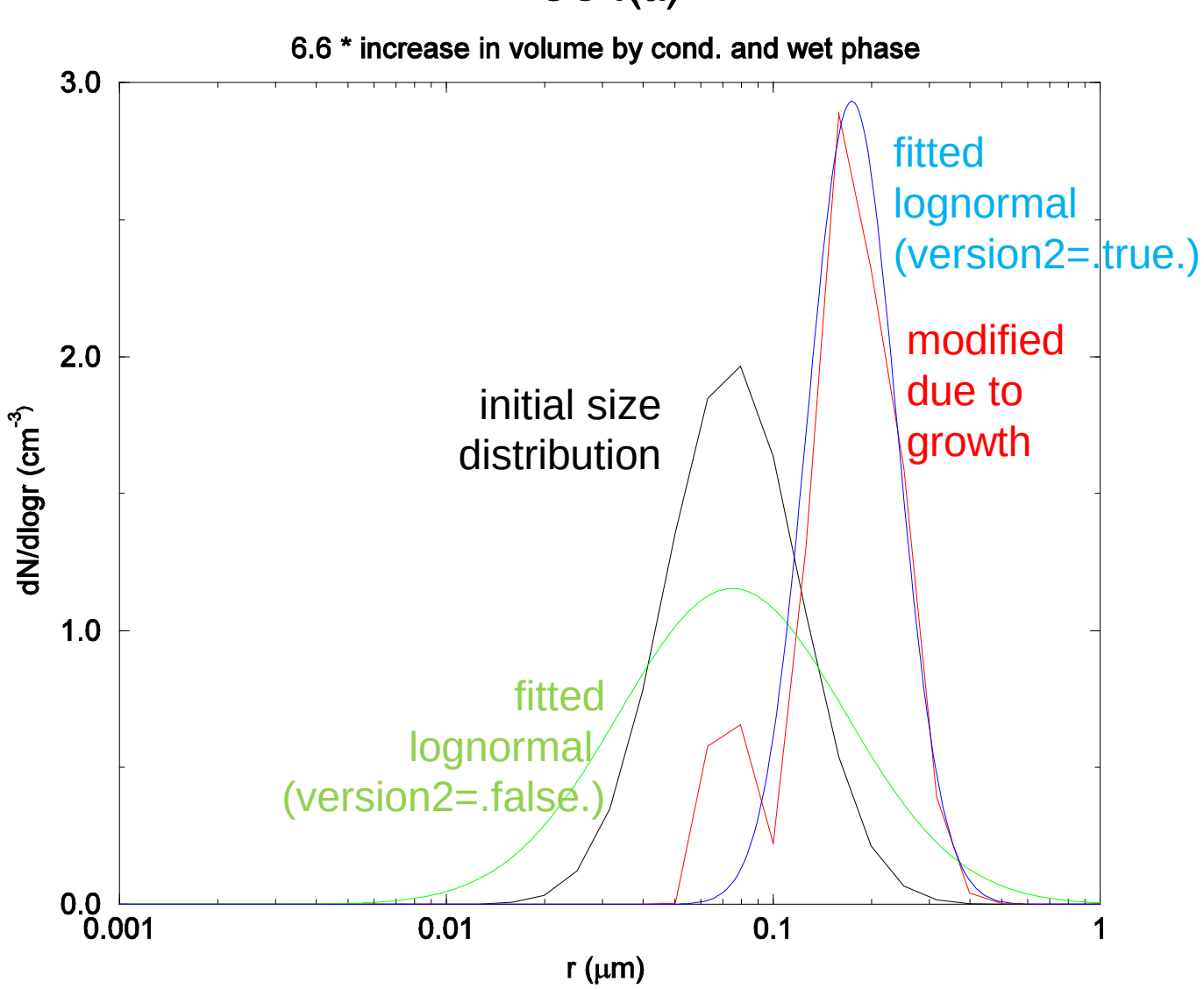


CCN(S) → cont.eq. for CDNC

effective droplet radii, liquid water content

Radiative forcing, W/m²

Example of lognormal fitting (LUT for r and σ) for use in the activation code



All look-up tables (LUT) are calculated by use of a separate model code ('mccnpar'), soon to be available on subversion under NorESM Tools!

- Typical time needed for producing new LUT with this code: ~ a few days on a LINUX PC. Not yet ported to and tested on a super-computer.

Examples of code changes which require new LUT (→ NorESM2):

- New modal size parameters for sea-salt to better fit Mårtensson et al. (2003)
  → modest changes to LUT code and NorESM.

- Include explicit SOA (by condensation/evaporation): test version already made for SOA nixed with the SO4 Aitken mode
  → Larger changes due to complexity of internal mixing + added process

- Include Nitrate aerosols
  → Large changes: added complexity for several particle modes (unless refractive indices and of hygroscopic growth are assumed to be as for sulfate)

Which parts of NorESM need to be modified before using new LUT?

For just small changes (e.g. new size parameters or scavenging efficiencies)

- Code for CAM4-Oslo-specific constants
  constants.F90, aerosoldef.F90

If the LUT have changed format (due to level of complexity) or input-info, then also:

- Code for reading in the new look-up tables
  opttab.F90, initlogn.F90 for standard model configuration
  initaeropt.F90, initdryp.F90 for extra AeroCom diagnostics
- 'Common blocks' and constants
  const.F90, aerocopt.h, aercopt2.h, aerodry.h, constants.F90, aerosoldef.F90
- Table look-up and interpolation code
  optinterpol.F90, intlogn.F90,
  intfrh.F90, intaeropt*.F90, intdrypar*.F90 (where * = 0, 1to3, 4, 5to10)
- Other CAM4-Oslo-specific microphysics (processes)
  pmxsub.F90, parmix_progncdnc.F90, modalapp.F90, modalapp2d.F90

But: Some changes, e.g. in refractive indices, only requires new LUT.

(This overview is a first attempt: I may have missed some sub-routines…)

Note: NorESM may work (run) without these changes, but it will give wrong aerosol optics and aerosol-cloud interactions.

The life-cycle module can be run without these changes if CAM4 optics and CDNC is used instead (i.e. in offline-simulations).