Developing An Aerosol Package for NCAR CAM4

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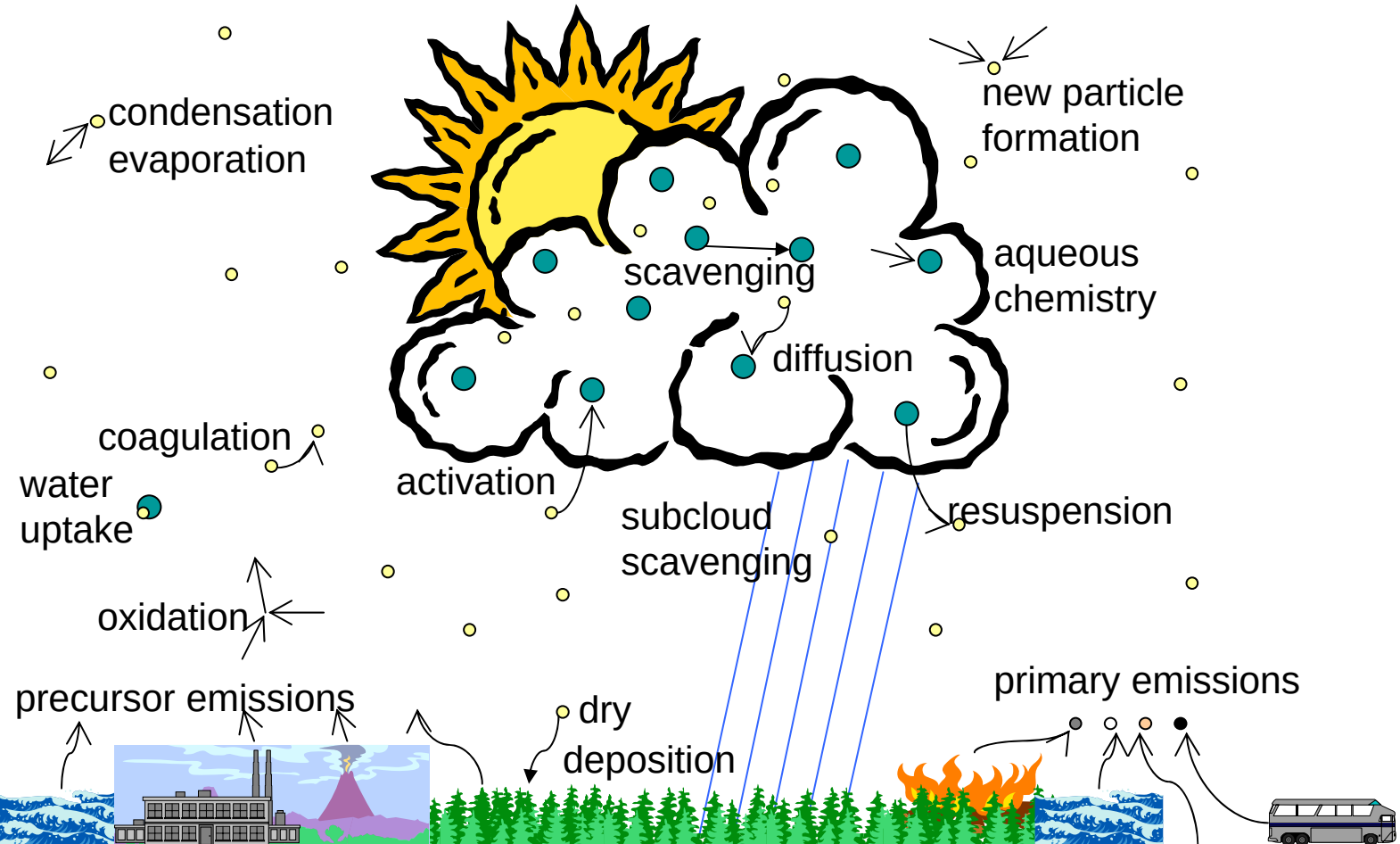
Goal: Develop a complete and computationally efficient representation of the aerosol for exploring the competing and complementing mechanisms by which natural and anthropogenic aerosols influence clouds and the cycles of water and energy.



Current Aerosol Treatment in CAM3

sulfate	hydrophobic black carbon	sea salt 1	soil dust 1
ammonium	hydrophobic organic carbon	sea salt 2	soil dust 2
nitrate	hydrophilic black carbon	sea salt 3	soil dust 3
secondary organic carbon	hydrophilic organic carbon	sea salt 4	soil dust 4

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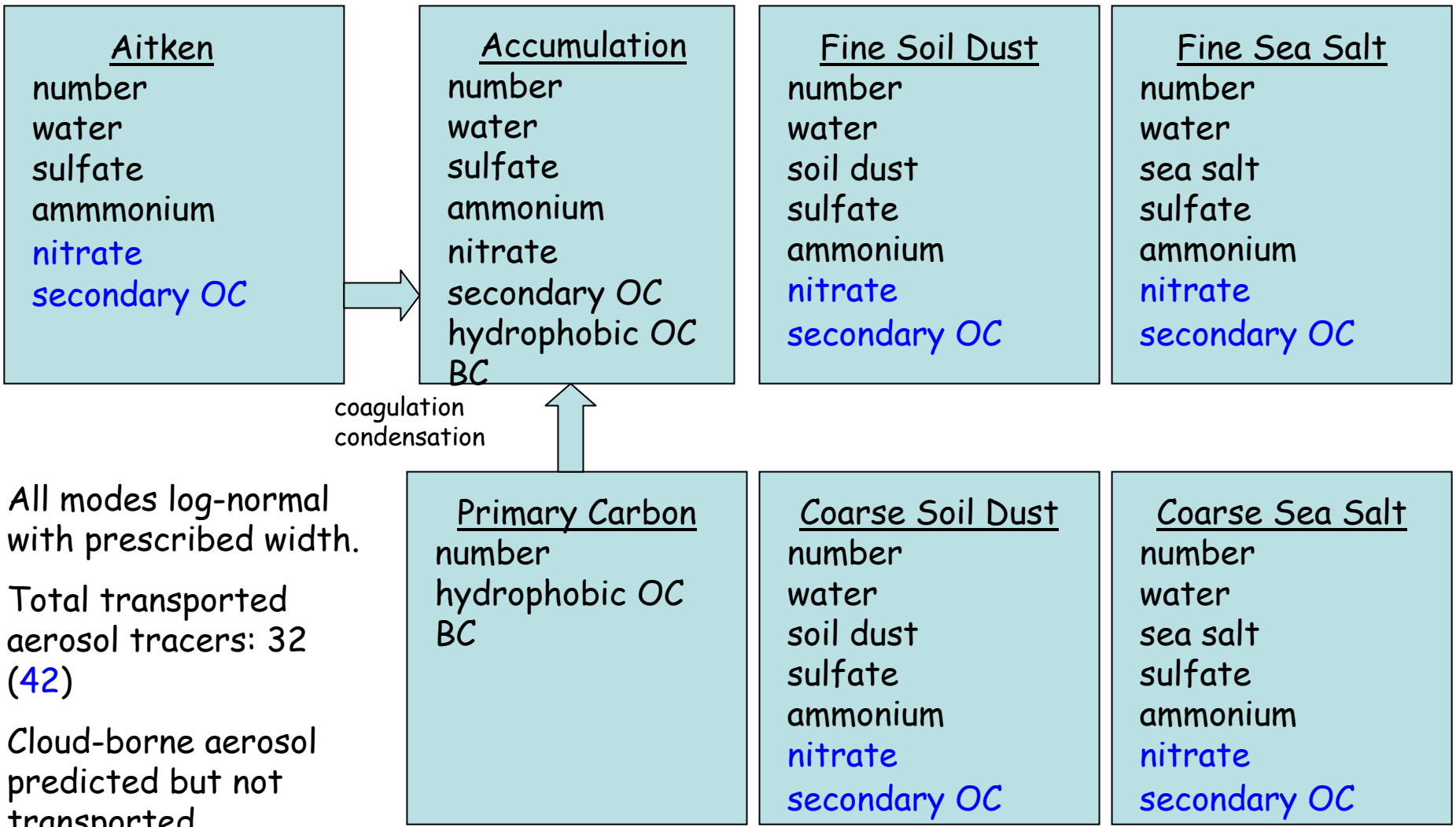
- Hydrophobic carbon ages to hydrophilic with prescribed timescale

Proposed Benchmark Aerosol Treatment for CAM4



All modes log-normal with prescribed width.

Total transported aerosol tracers: 32 (42)

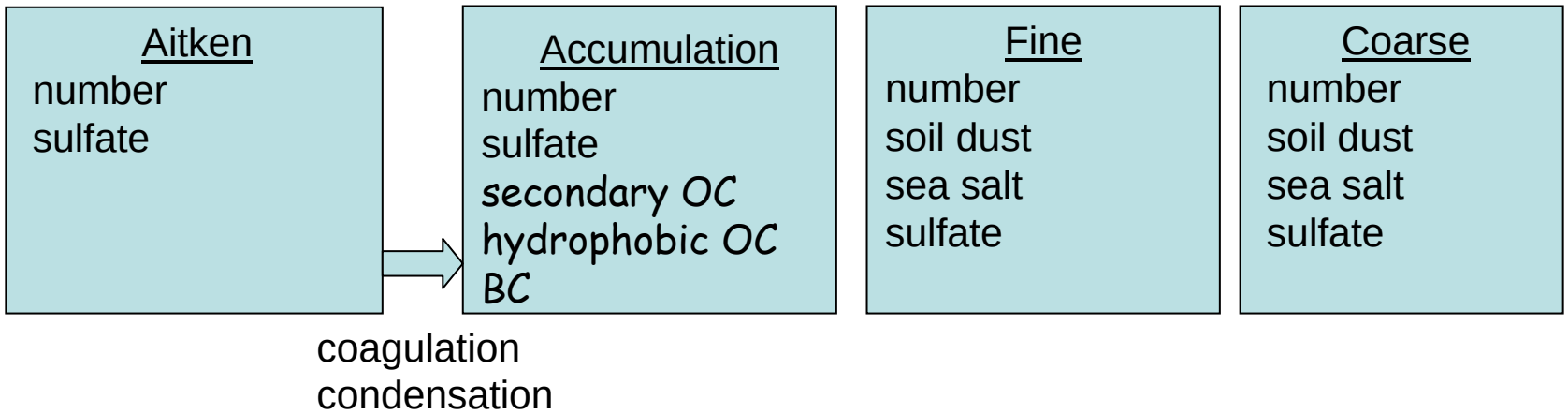
Cloud-borne aerosol predicted but not transported.

Process and Property Treatment

- Primary emissions: size-resolved.
- New particle formation: ternary homogeneous nucleation.
- VOC oxidation and condensation separated.
- Condensation: mass transfer theory.
- Cloud chemistry: current CAM3 treatment (pH dependent)
- Coagulation: Brownian within, between modes.
- Intermode transfer due to condensation, coagulation, and cloud chemistry.
- Scavenging: in-cloud -- activation of number and mass for each mode, number depletion by droplet collision/coalescence; below-cloud -- by impaction; dry deposition
- Water uptake: Kohler theory for internal mixture, with hysteresis dependent on previous aerosol water.
- Optical properties: parameterization in terms of wet refractive index and wet surface mode radius.

Proposed Simplest Aerosol Treatment for CAM4

Assume aerosol are hydrated for RH > crystalization RH.
Carry soil dust and sea salt in same mode because sources are separate.
Assume primary carbon is internally mixed with secondary aerosol.
Assume ammonium neutralizes sulfate, and neglect nitrate.



All modes are log-normal with prescribed width.

Total transported aerosol tracers: 15

Cloud-borne aerosol are predicted but not transported.

CAM Simulations

- Benchmark modal present day
  - On-line oxidants
  - Off-line oxidants
- Benchmark modal pre-industrial
- Simplified modal present day
- Simplified modal pre-industrial
- Offline benchmark present day
- Offline benchmark pre-industrial

Testing

- Evaluate on-line benchmark treatment using *in situ* (surface and aloft) and remote aerosol measurements (mass, number, size, CCN, AOD, ...). Utilize AEROCOM and other model evaluation efforts.
- Evaluate approximations used in on-line simple treatment by comparing direct and indirect aerosol effects with on-line benchmark treatment.
- Evaluate off-line benchmark treatment by comparing with on-line benchmark treatment.

Collaboration

- PNNL: aerosol microphysics
  - Xiaohong Liu: integration, emissions, intermode transfer, simulations
  - Steve Ghan: scavenging, optics, simple treatment
  - Richard Easter: nucleation, coagulation, convection
  - Rahul Zaveri: water uptake, mass transfer, condensation
  - Yun Qian: evaluation, off-line treatment
- LLNL: evaluation
  - Cathy Chuang and Philip Cameron-Smith: AEROCOM diagnostics, satellite & other data
  - Cyndi Atherton, Peter Connell: VOC oxidation (leveraging ASP)
- NCAR: chemistry
  - Jean-Francois Lamarque: VOC oxidation and SOA formation
  - Natalie Mahowald: sea salt and soil dust emissions
  - Francis Vitt: preprocessor, merging

Schedule

- March 2007: Complete application and first benchmark simulation
- September 2007: Complete evaluation and refinement of benchmark
- December 2007: Complete evaluation of simplified and off-line treatments
- March 2008: Merge with developmental trunk