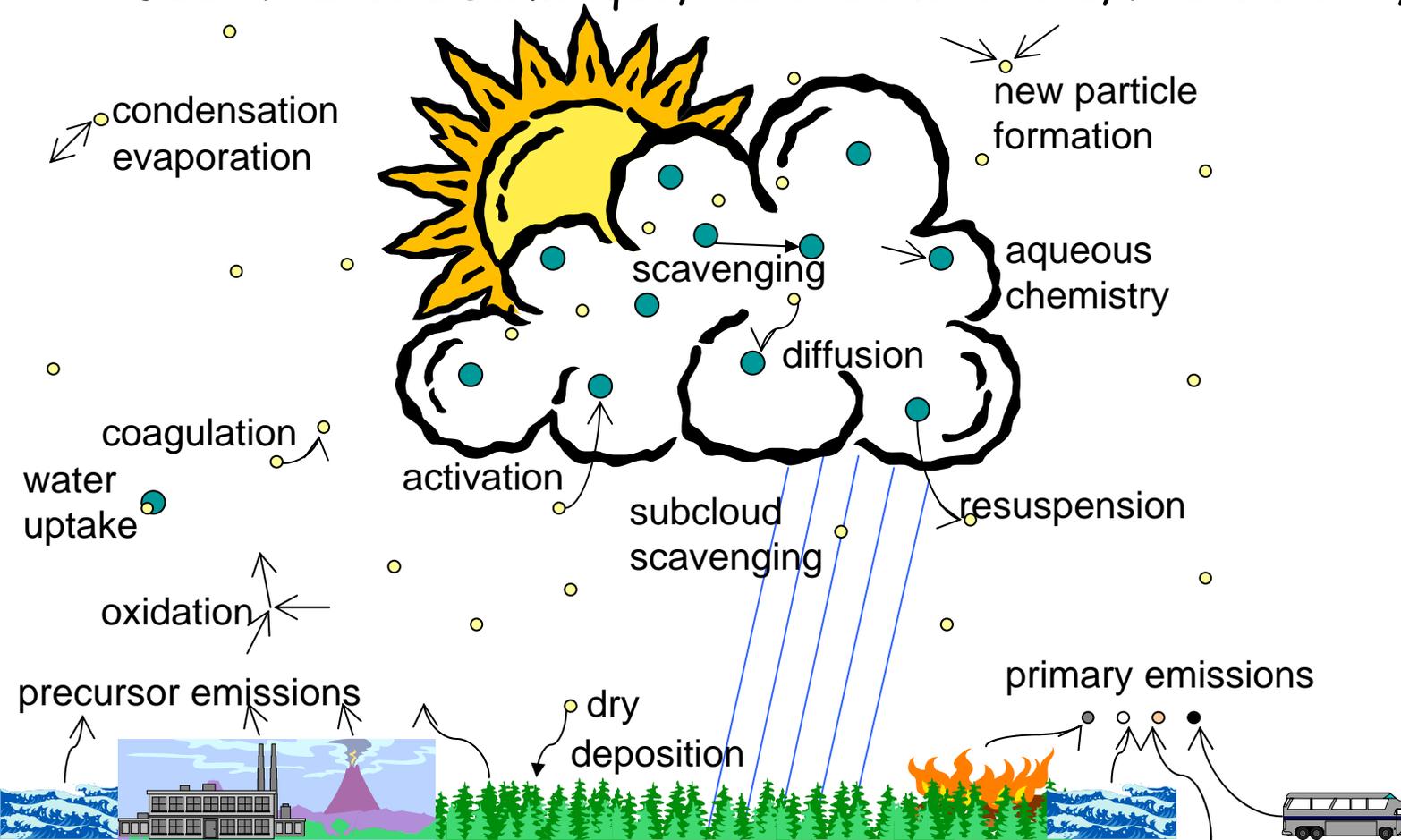


# Proposed Aerosol Treatment for CAM4

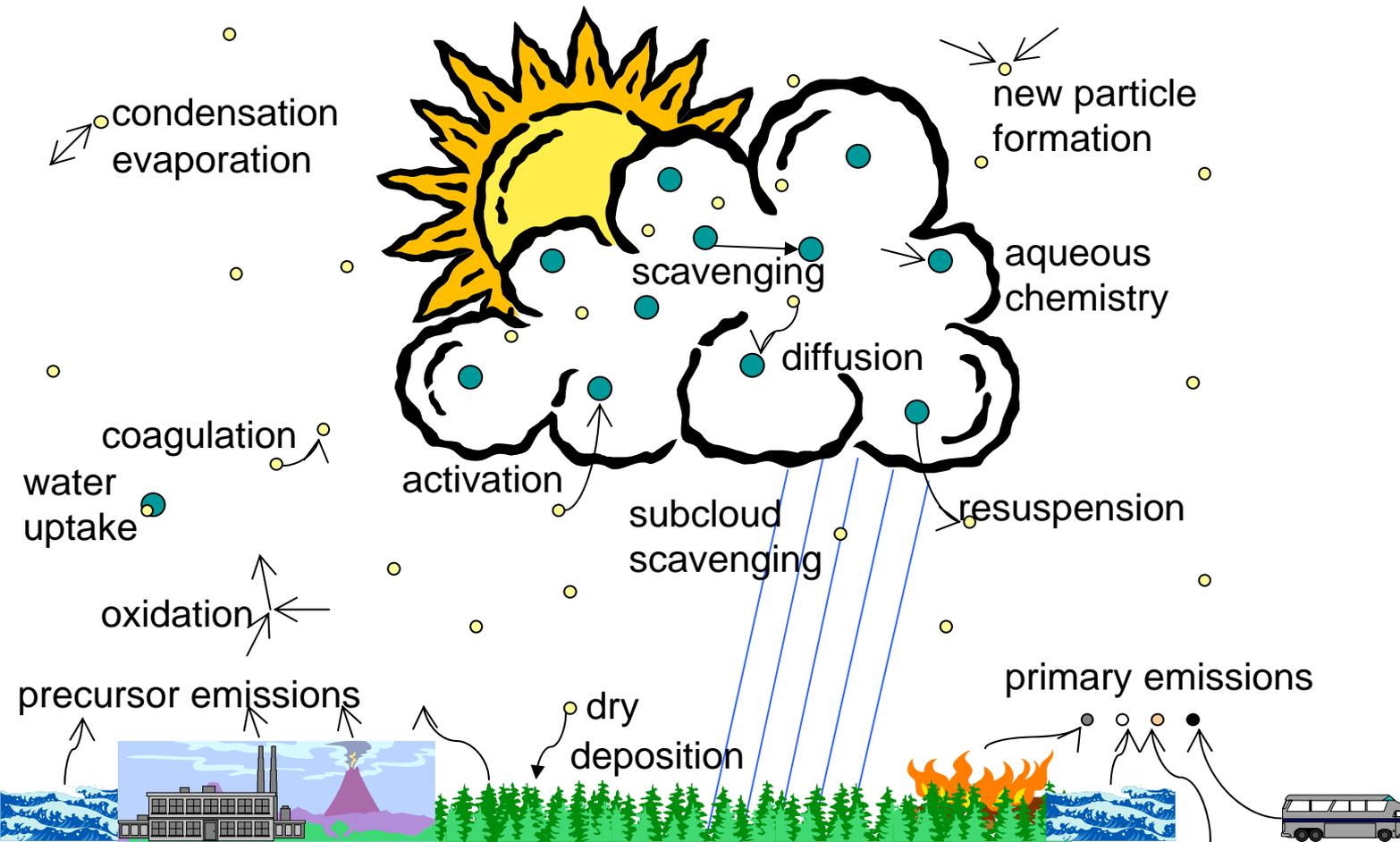
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Goal: Develop a complete and computationally efficient representation of the aerosol for exploring the competing and complementing mechanisms by which natural and anthropogenic aerosols influence clouds and the cycles of water and energy.



# Current Aerosol Treatment in CAM

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

# Current Weaknesses in CAM

- Aerosol species are externally mixed (individual particles are composed of only a single species).

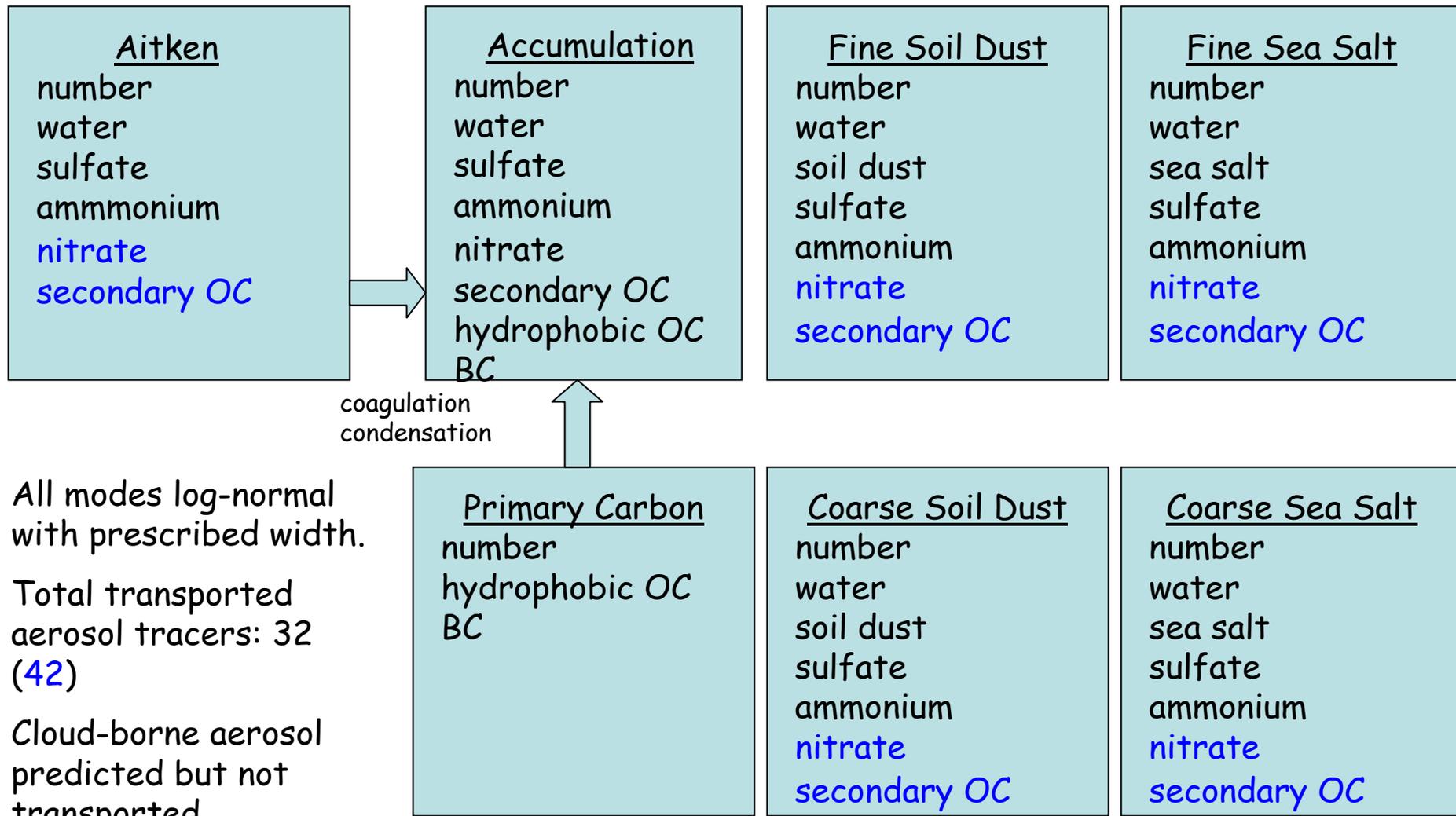
# Current Weaknesses in CAM

- Aerosol species are externally mixed (individual particles are composed of only a single species).
- Their size distribution is prescribed (number is diagnosed from the predicted mass).
  - Processes that should only affect mass (condensation, chemistry) also affect number.
  - Processes that only affect number (nucleation, coagulation) are neglected.

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  - Processes that should only affect mass (condensation, chemistry) also affect number.
  - Processes that only affect number (nucleation, coagulation) are neglected.
- Hydrophobic carbon ages to hydrophilic with prescribed timescale

# Proposed Benchmark Aerosol Treatment for CAM4



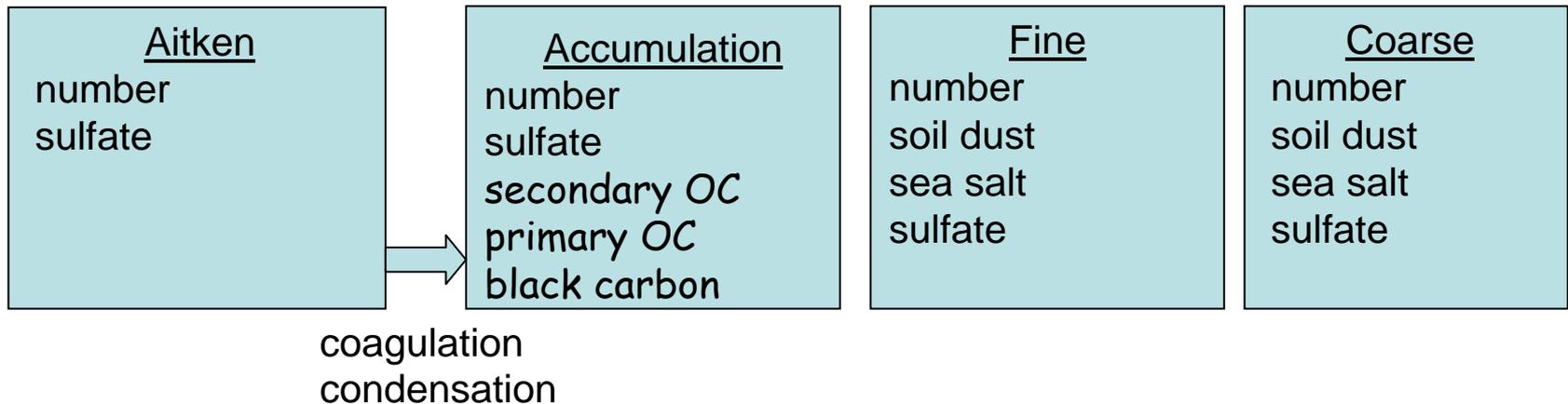
# Proposed Simplest Aerosol Treatment for CAM4

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.

# 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.
- 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.

# CAM-Only 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 ( interpolation from monthly mean of on-line benchmark) by comparing with on-line benchmark treatment.