

# Navigating CAM5 physics in WACCM

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WACCM Liaison

Whole Atmosphere Working Group Meeting  
Monday, February 11, 2013

- CAM5 Physics
  - RRTMG radiative scheme
  - Boundary layer scheme
  - Shallow convection scheme
  - Cloud macrophysics & microphysics
  - Modal aerosol module (MAM)
- CARMA microphysics
- Spectral element
- Thanks to Andrew Conley, Chuck Bardeen, Sean Santos, Dan Marsh, David Williamson, Sungsu Park, Pengfei Yu, Francis Vitt, Hanli Liu

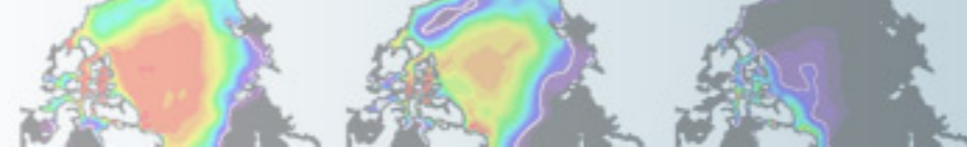


NCAR is funded by the National Science Foundation



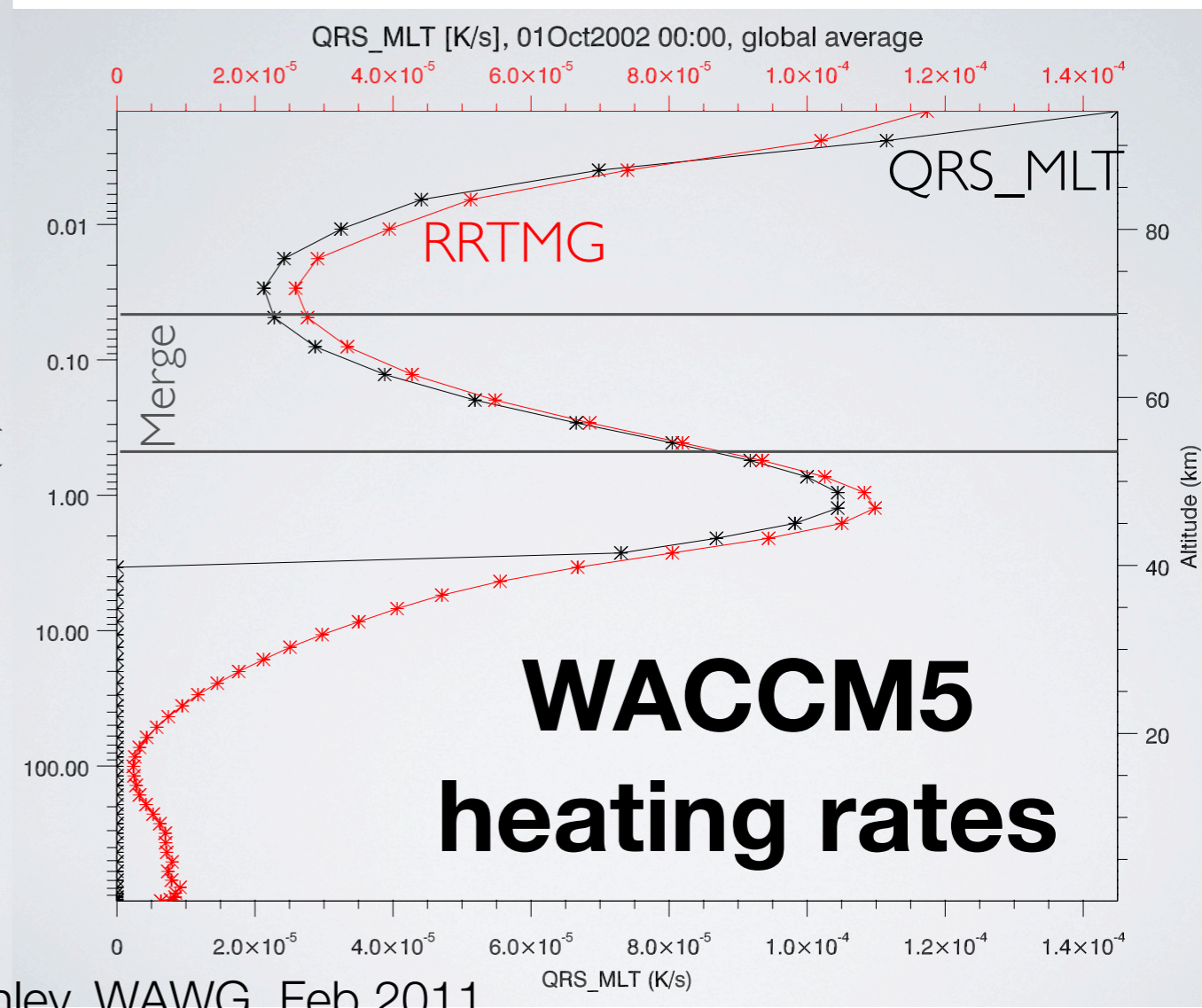
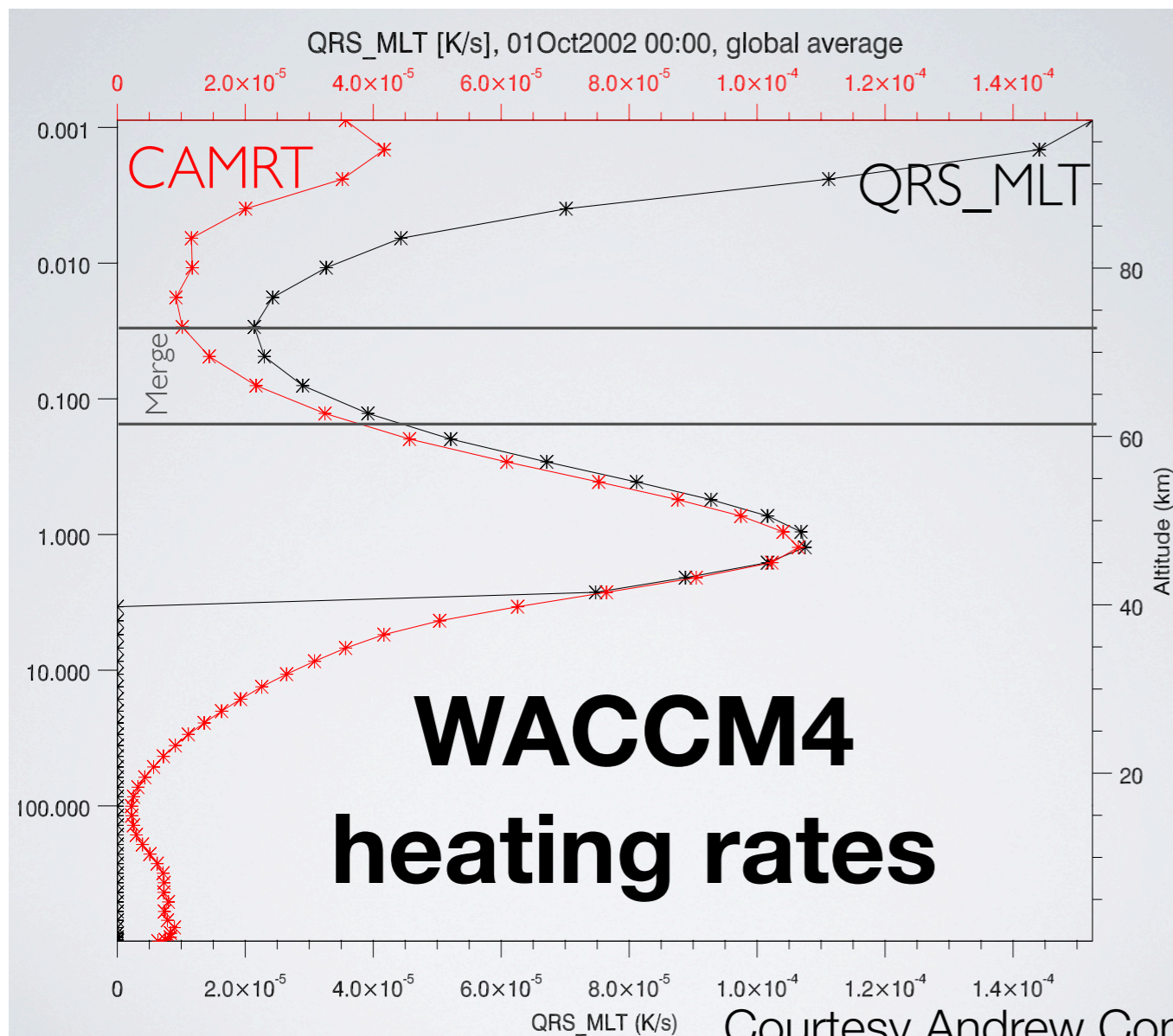
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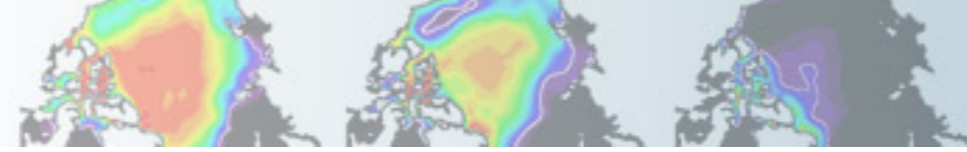


# RRTMG Radiative Scheme

- Merging with upper atmosphere (MLT) radiative scheme
  - SW merge zone moved slightly downward based on overlapping heating rates

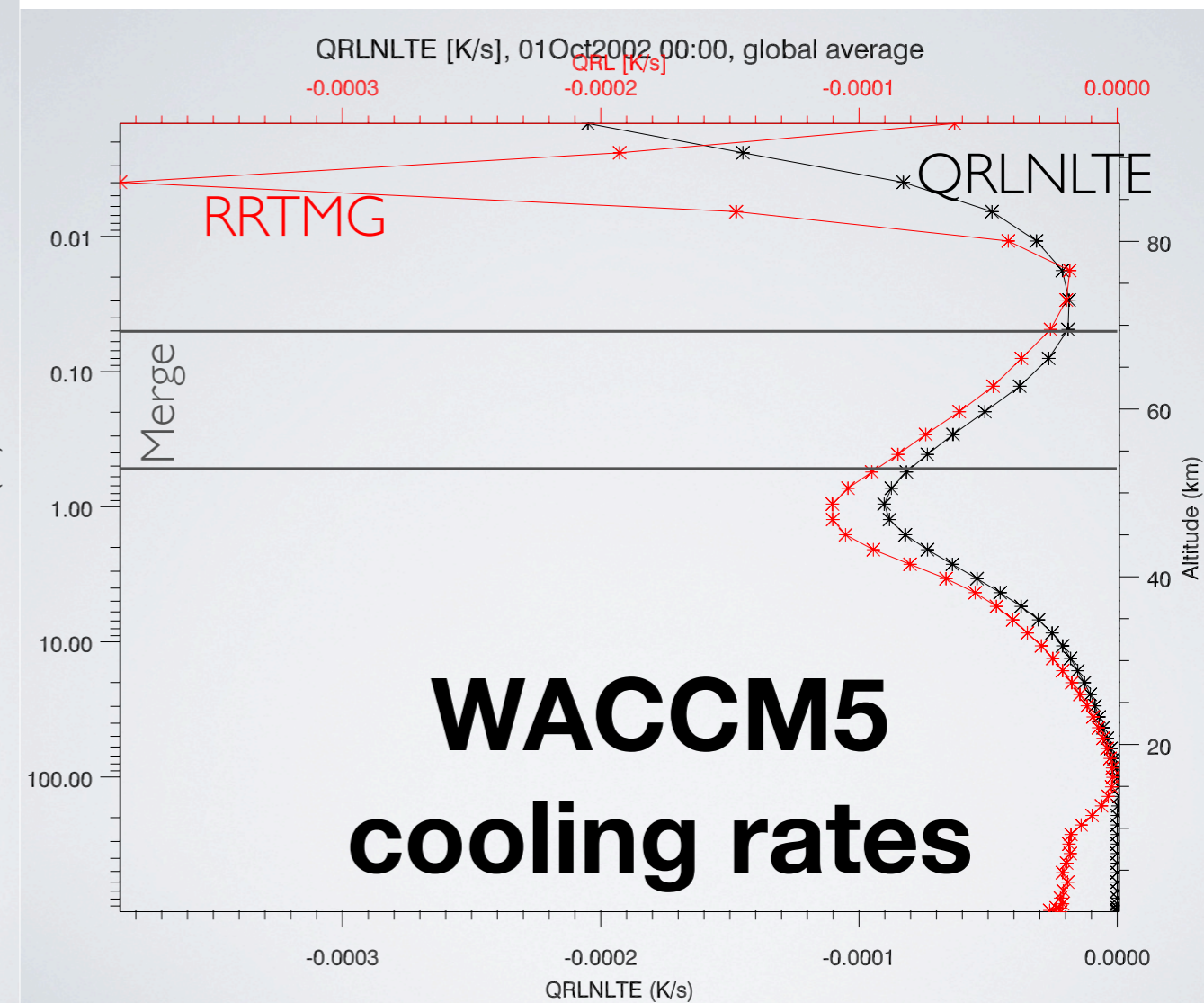
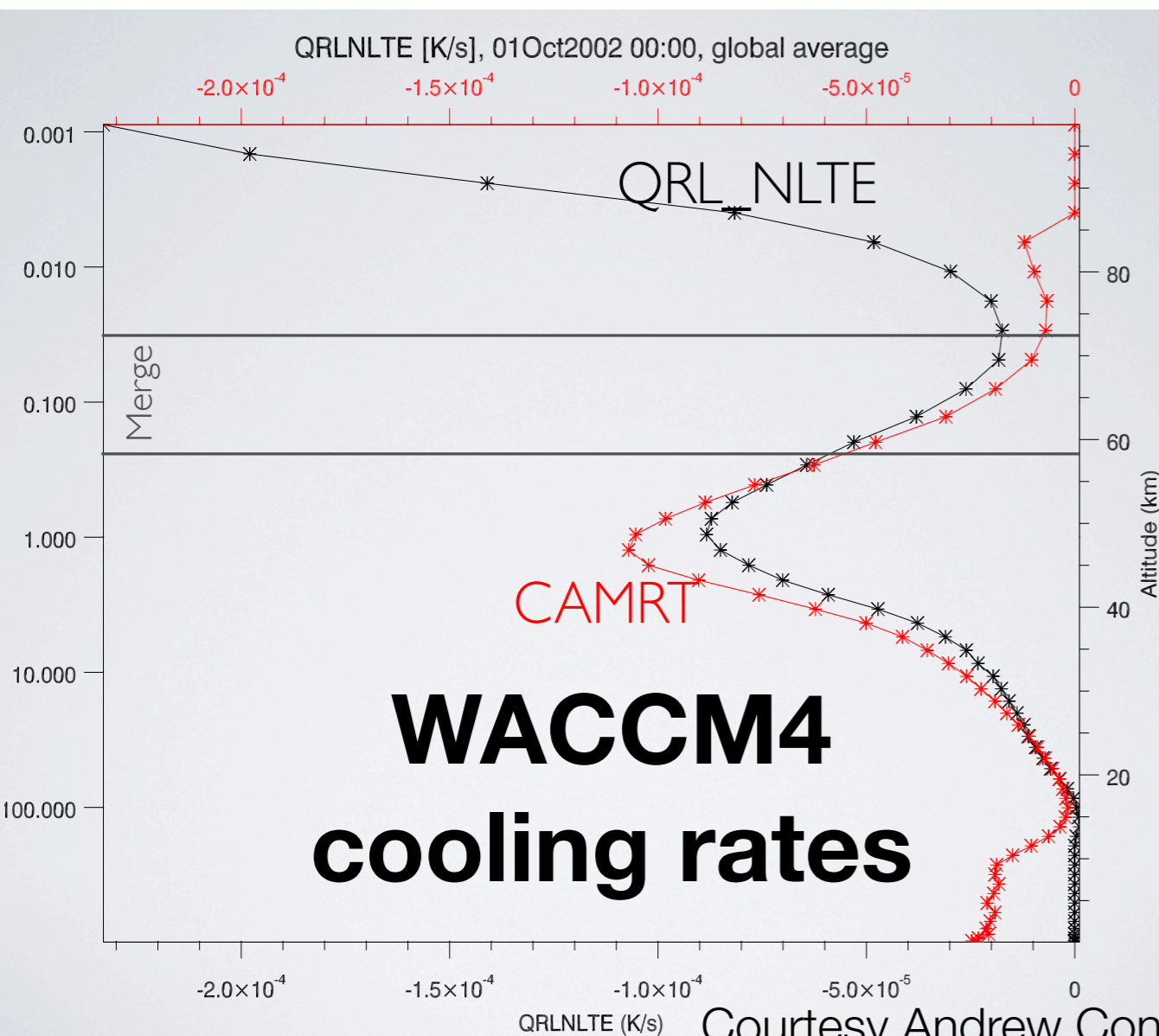


Courtesy Andrew Conley, WAWG, Feb 2011

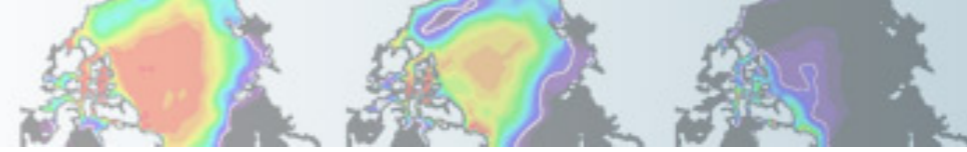


# RRTMG Radiative Scheme

- Merging with upper atmosphere (MLT) radiative scheme
  - LW merge zone moved slightly downward based on overlapping cooling rates



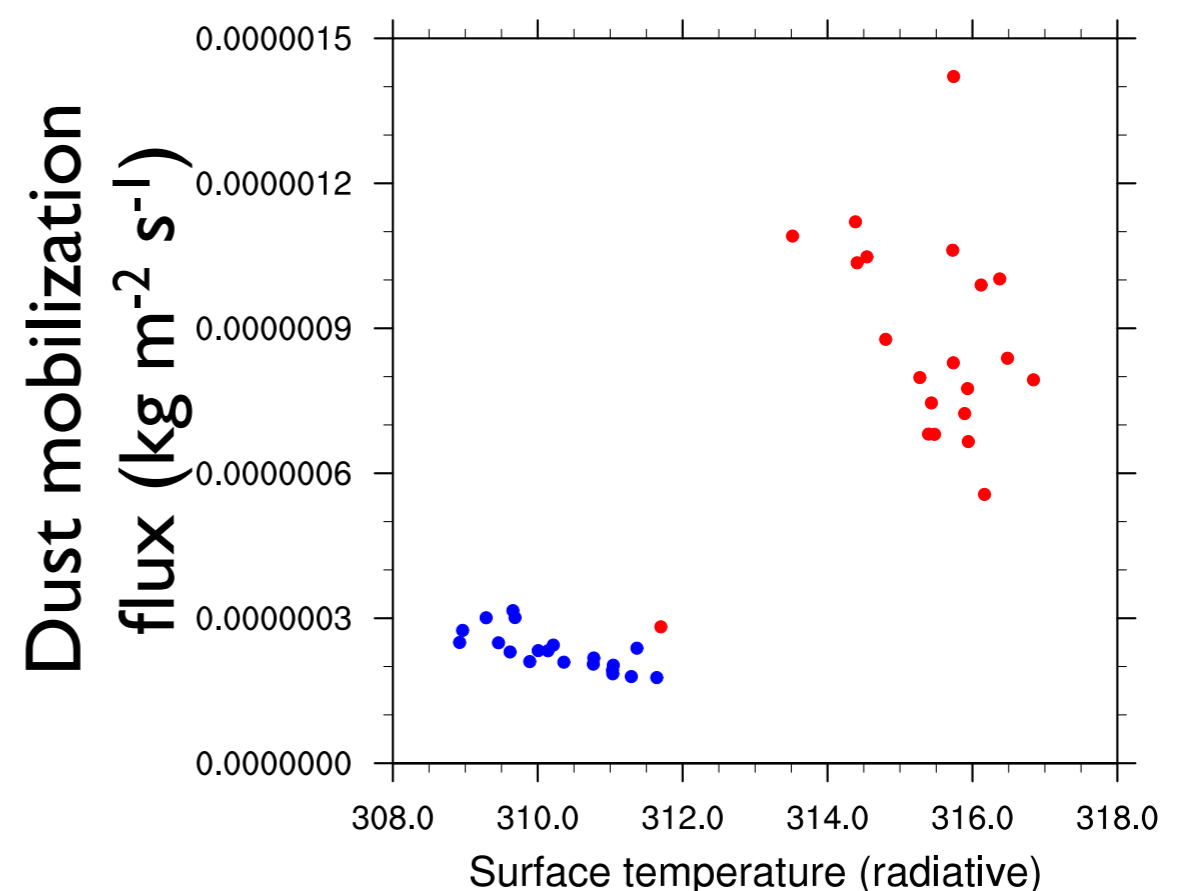
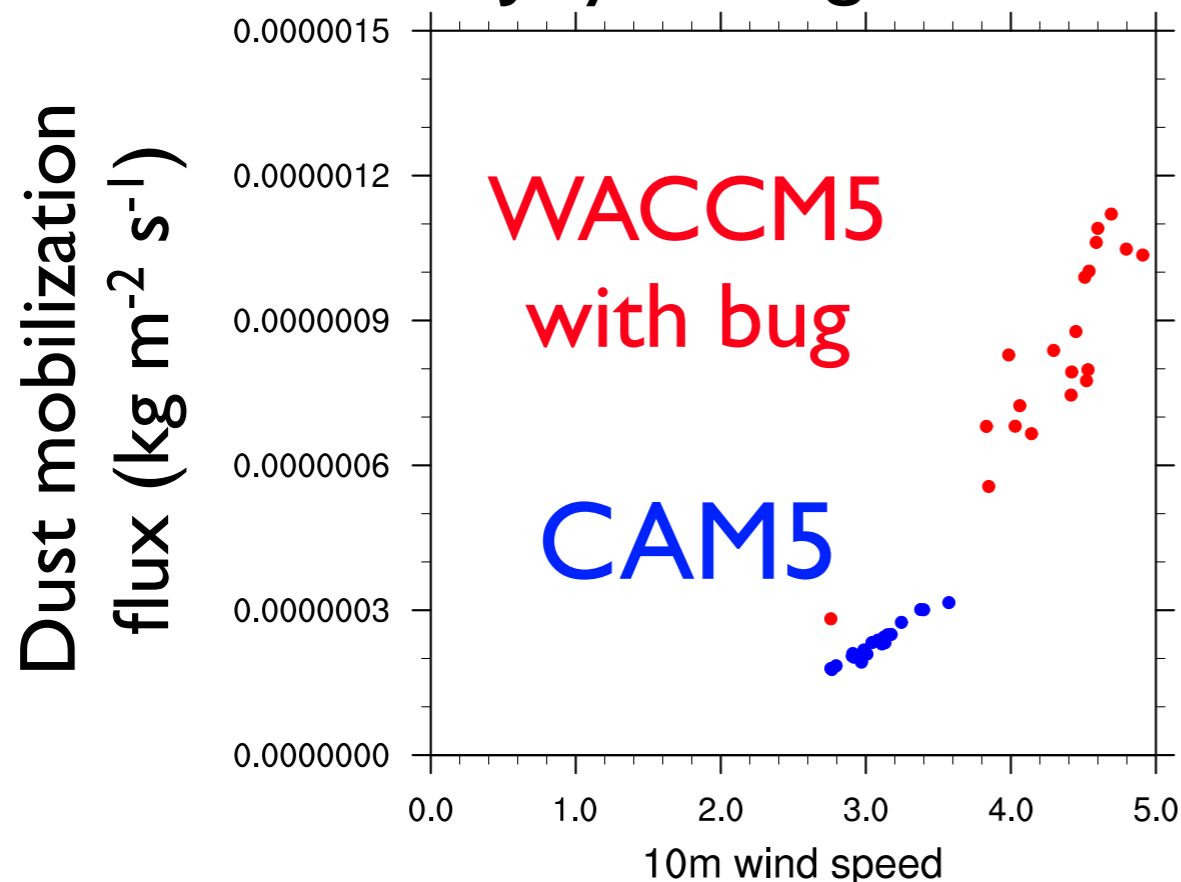
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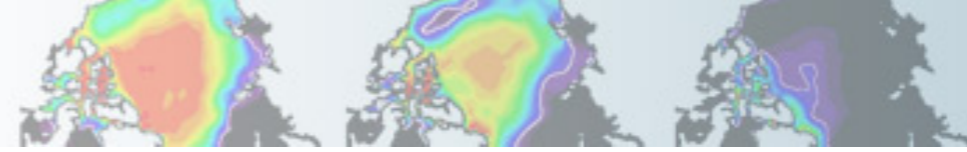


# RRTMG Radiative Scheme

- Bug found in RRTMG that affected only WACCM
  - levels were misaligned for SW calculations with aerosols
  - produced anomalously high surface winds, dust, and temperatures
    - 45% increase in global average dust AOD
- Bug fixed (November 2012)

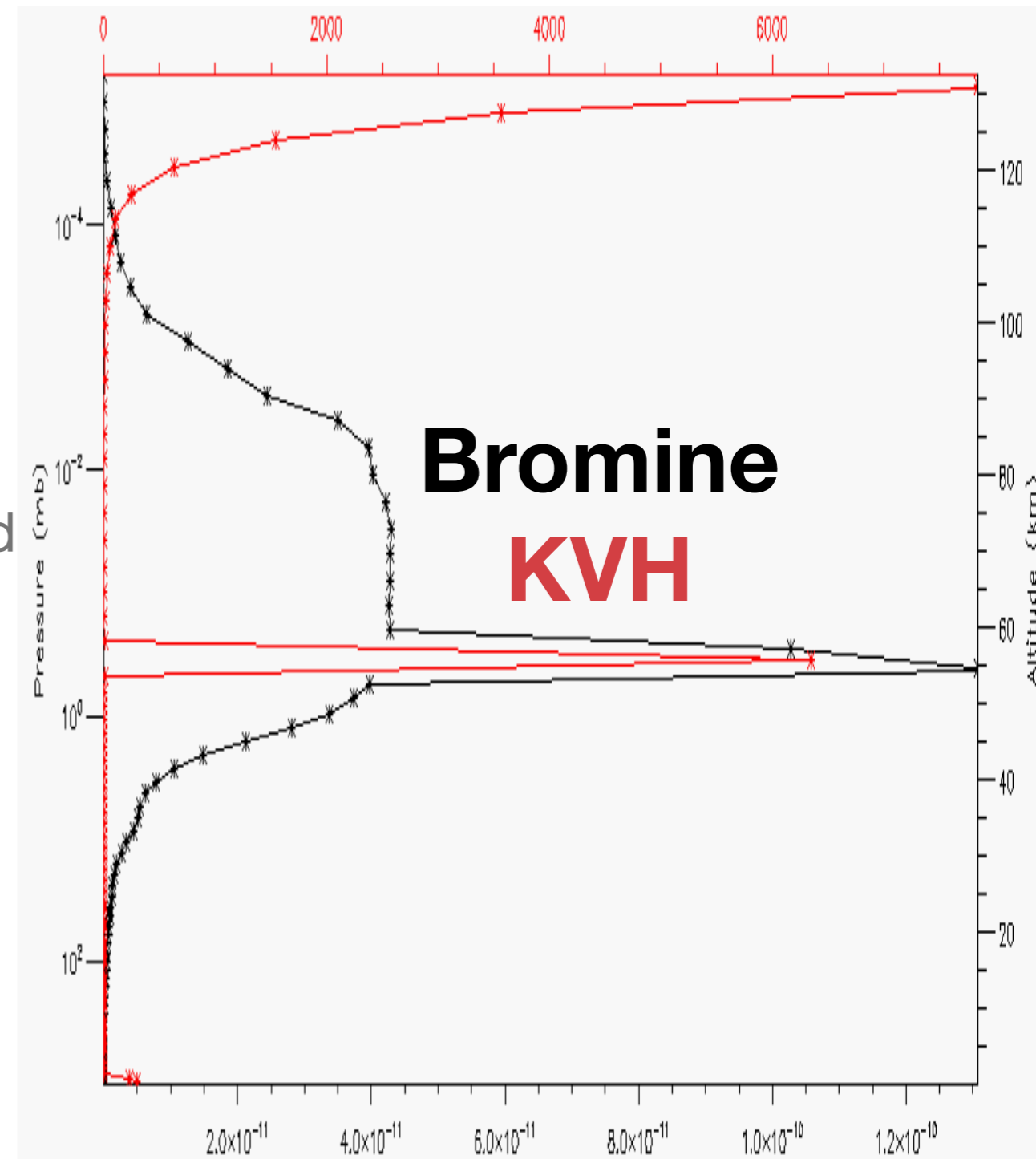
July averages over 20-year runs at 32.5°E, 25.5°N

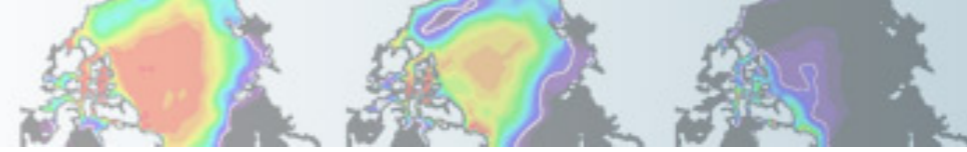




# UW Boundary Layer Scheme

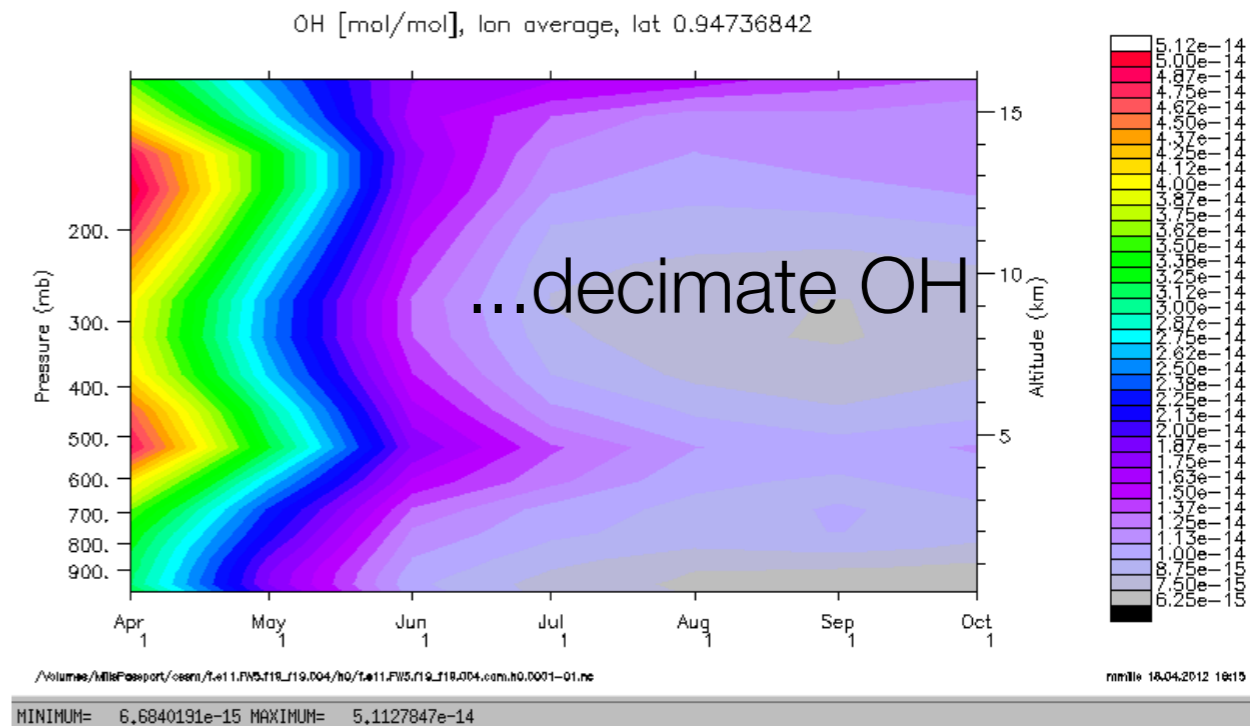
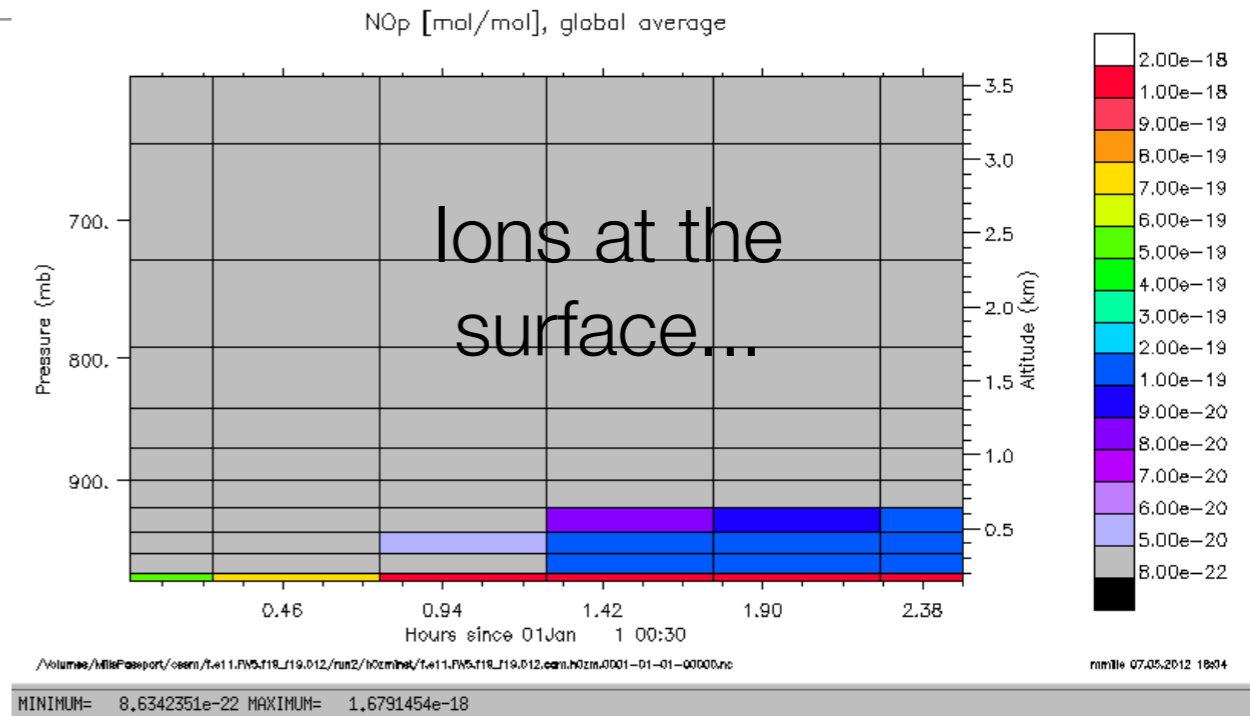
- Scheme extends through entire model domain
- Produces spikes in eddy diffusion coefficient (KVH) in the stratosphere
- Bug in WACCM molecular diffusion scheme produced spikes in some species when KVH spikes corresponded to a particular level (~55 km)
  - Bug fixed
- Impact of KVH spikes on gravity waves, stratospheric dynamics unclear
- Limiters on BL length scale implemented above 100 hPa to reduce the magnitude of KVH spikes





# UW Shallow Convection Scheme

- Bug: fixer in fluxbelowinv avoids division by zero by creating a minimum flux across the BL of  $1 \times 10^{-13}$  mol/mol/s
- assumption based on CAM aerosols that no tracer would have a mixing ratio smaller than  $1 \times 10^{-12}$  mol/mol
- WACCM has many chemical species with much smaller mixing ratios
- Scheme produced at the surface, ion species that should only be in the upper atmosphere at  $\sim 1 \times 10^{-19}$  mol/mol
- Highly reactive ions decimated OH
- Bug fixed: May 2012



# Clouds and Aerosols

- Consistent upper level limit, trop\_cloud\_top\_lev, instituted on:
  - Cloud macrophysics (Park)
  - Cloud microphysics (Morrison-Gettelman)
  - Modal aerosol module (MAM)
- namelist parameter, trop\_cloud\_top\_pres, set to 10 Pa = 0.1 hPa
- MAM species advected passively above upper limit
- WACCM5 run with MAM3 for 25 years
  - 1 crash in year 14:
    - Courant (CFL) condition violation in level 7
    - increased nsplit from 8 to 10 for 1 month to reduce dynamical timestep, got through crash
- WACCM5 ready for use with prognostic MAM3 in CESM1.2 release, May 2013
- Prescribed MAM? Rasch update tomorrow at 9:15AM



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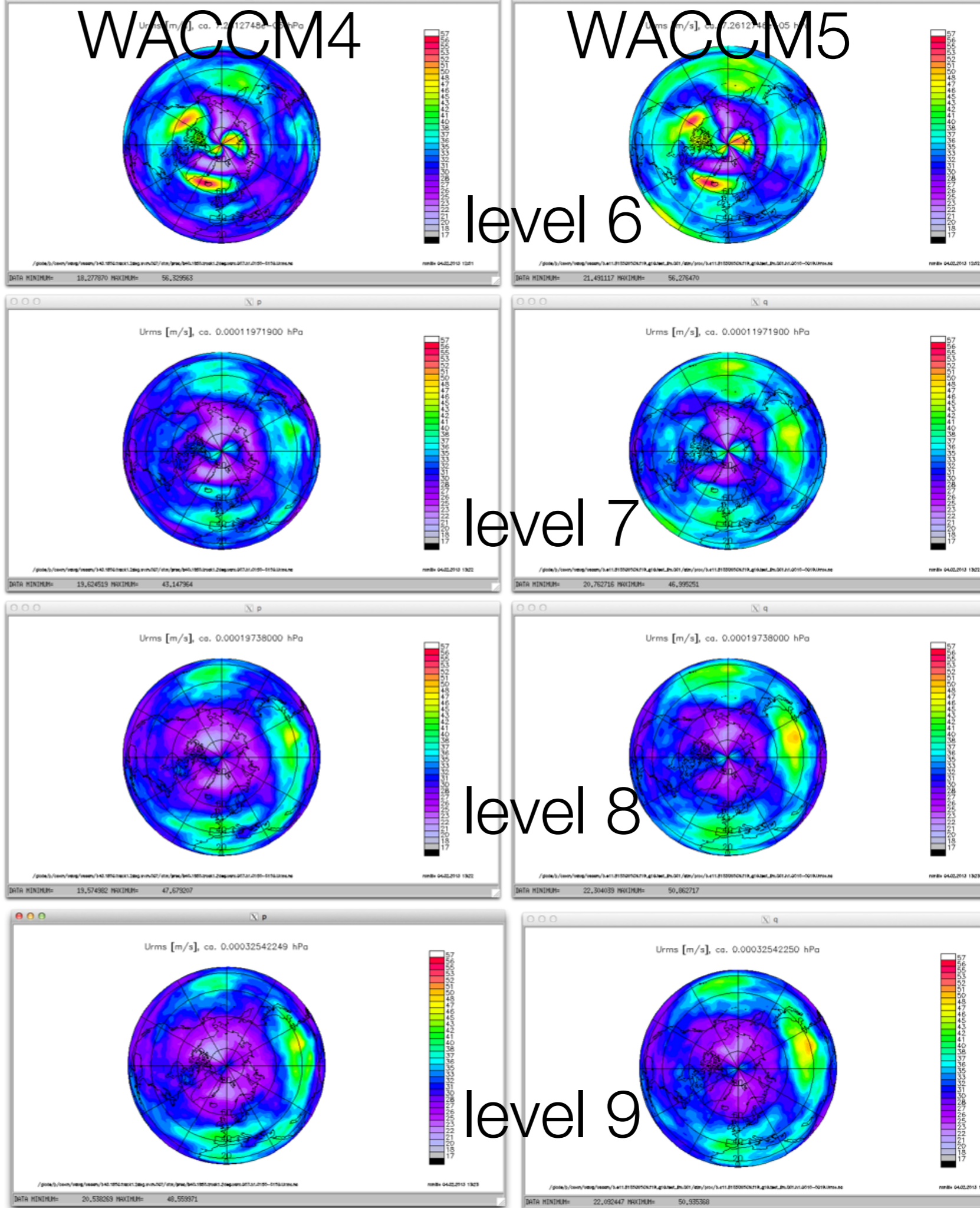


# WACCM

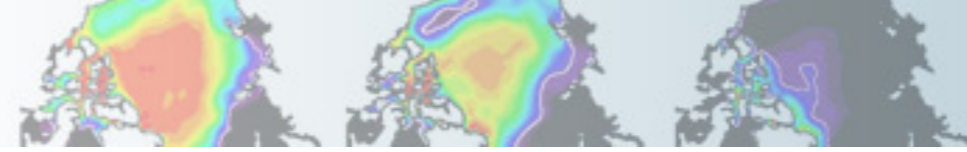
Whole Atmosphere  
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# CFL investigation

- 10-year RMS of 10-day instantaneous zonal wind anomaly from the zonal mean
- Crash occurred at level 7
- RMS plots look remarkably similar at each level between WACCM4 and WACCM5
- Levels 7, 8, & 9 do have some noticeably higher RMS regions over Asia, the Pacific, and Europe.

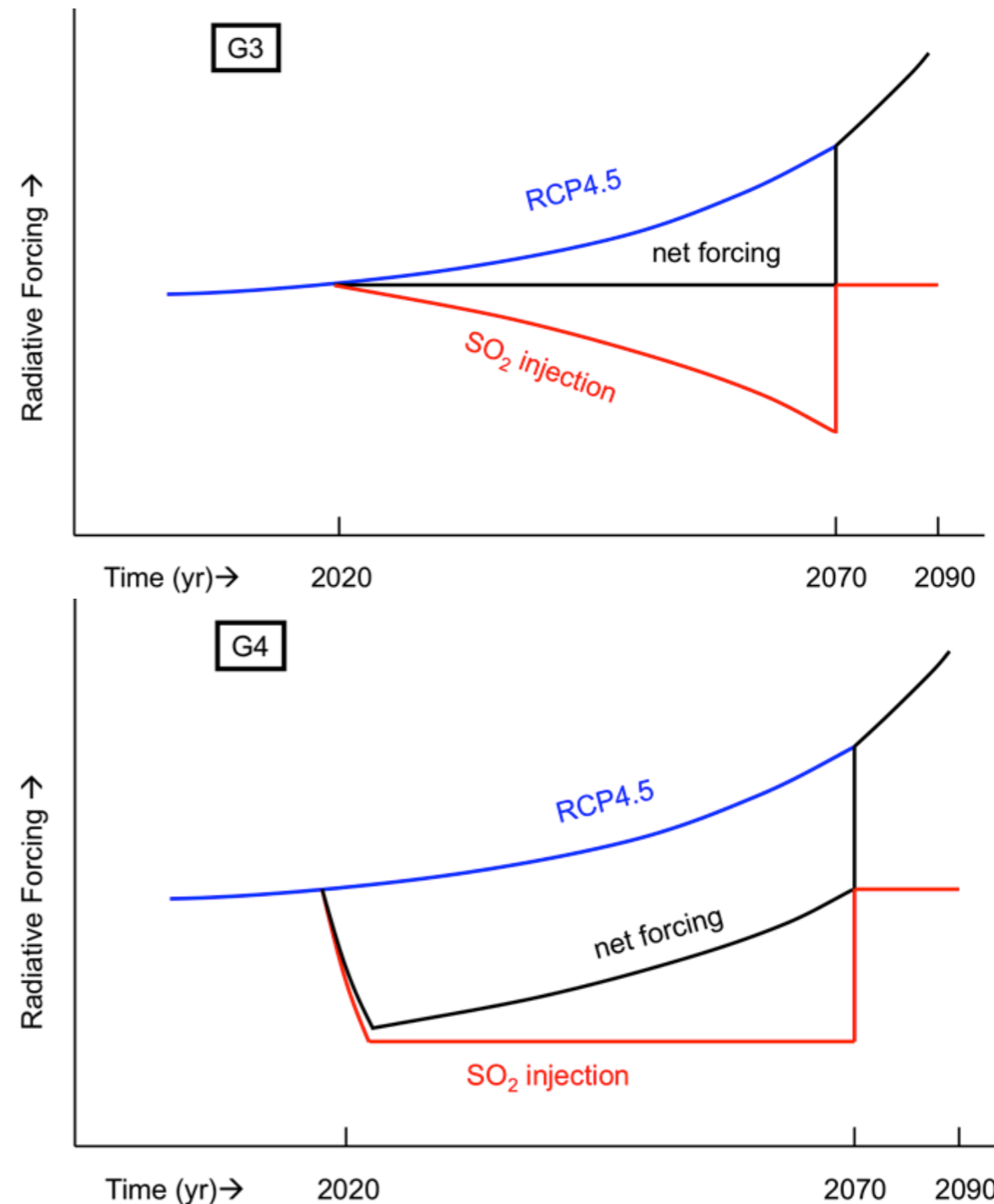


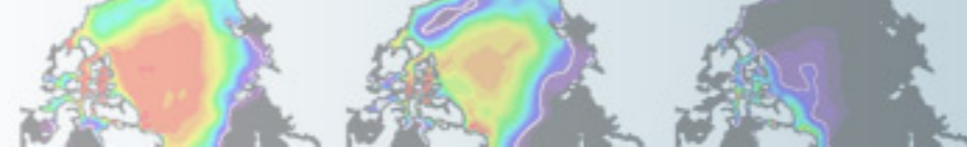




# WACCM5-MAM3 for stratospheric sulfate

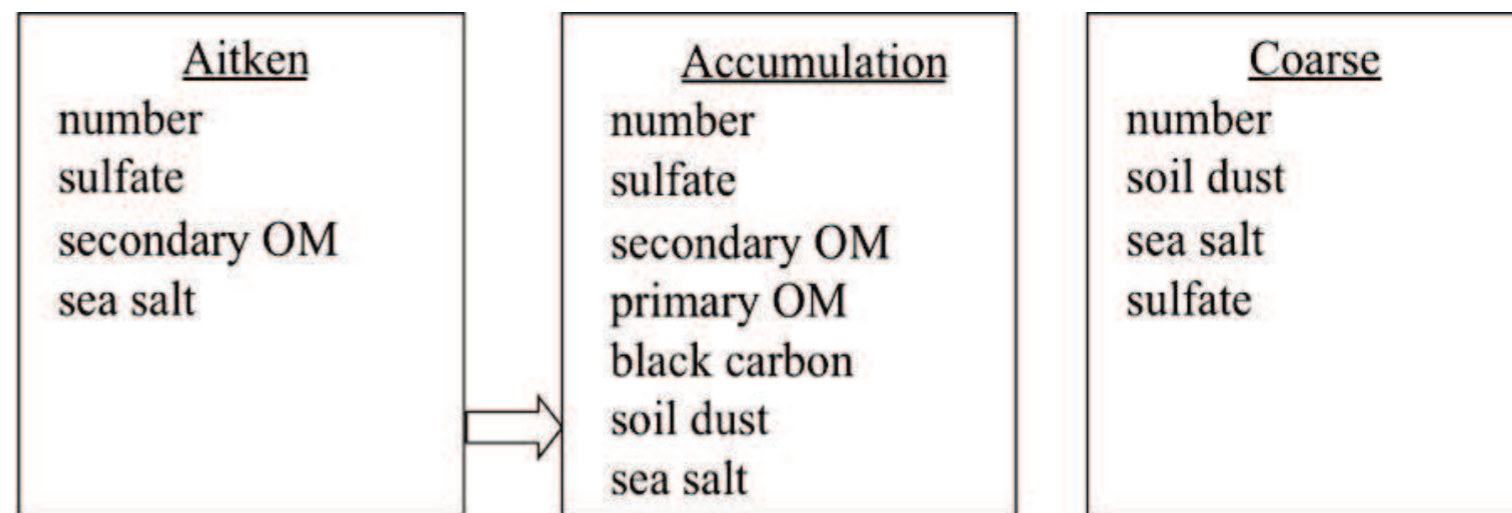
- GeoMIP: Geoengineering Model Intercomparison Project
- G3 & G4 experiments to offset anthropogenic RF with stratospheric sulfates
- Can MAM3 + RRTMG be used for stratospheric sulfates?
  - add OCS to chemistry for source of stratospheric sulfur
  - create SO<sub>2</sub> external forcing file with stratospheric levels to simulate geoengineering
- Would MAM7 be better?
- Can we use MAM consistently for volcanic forcing in CAM5 and WACCM5?



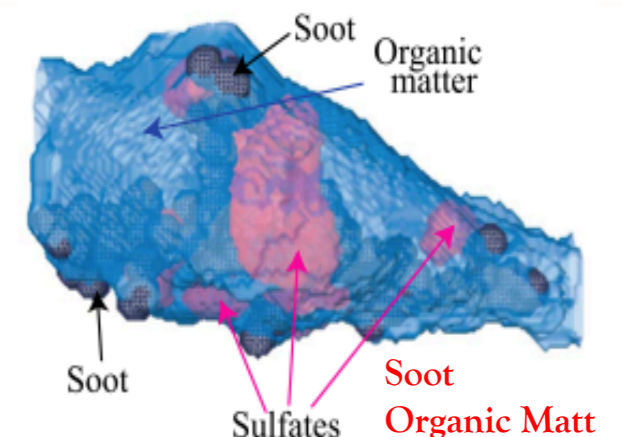


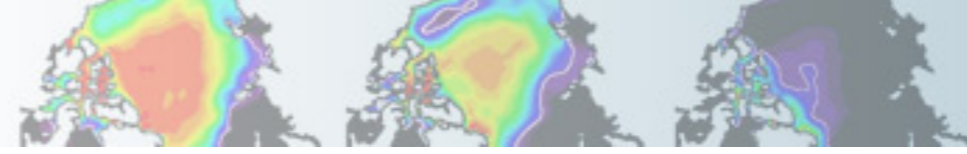
# Development: CARMA microphysics

- WACCM4-CARMA used to study one or more types of aerosols with detailed bin microphysics
  - models: black carbon, cirrus, dust, meteor smoke, PMCs, sea salt, sulfate
  - non-CARMA aerosols treated with default prescribed bulk
- MAM treats aerosols as internal mixtures of all aerosol types
- Single aerosol types are not easily replaced with CARMA
- Strategy: replace all MAM aerosols with CARMA bins for detailed aerosol studies
- Pengfei Yu (CU) has developed CAM5-CARMA with bins for
  1. internal mixture of organics, BC, sulfate, sea salt, dust
  2. sulfate



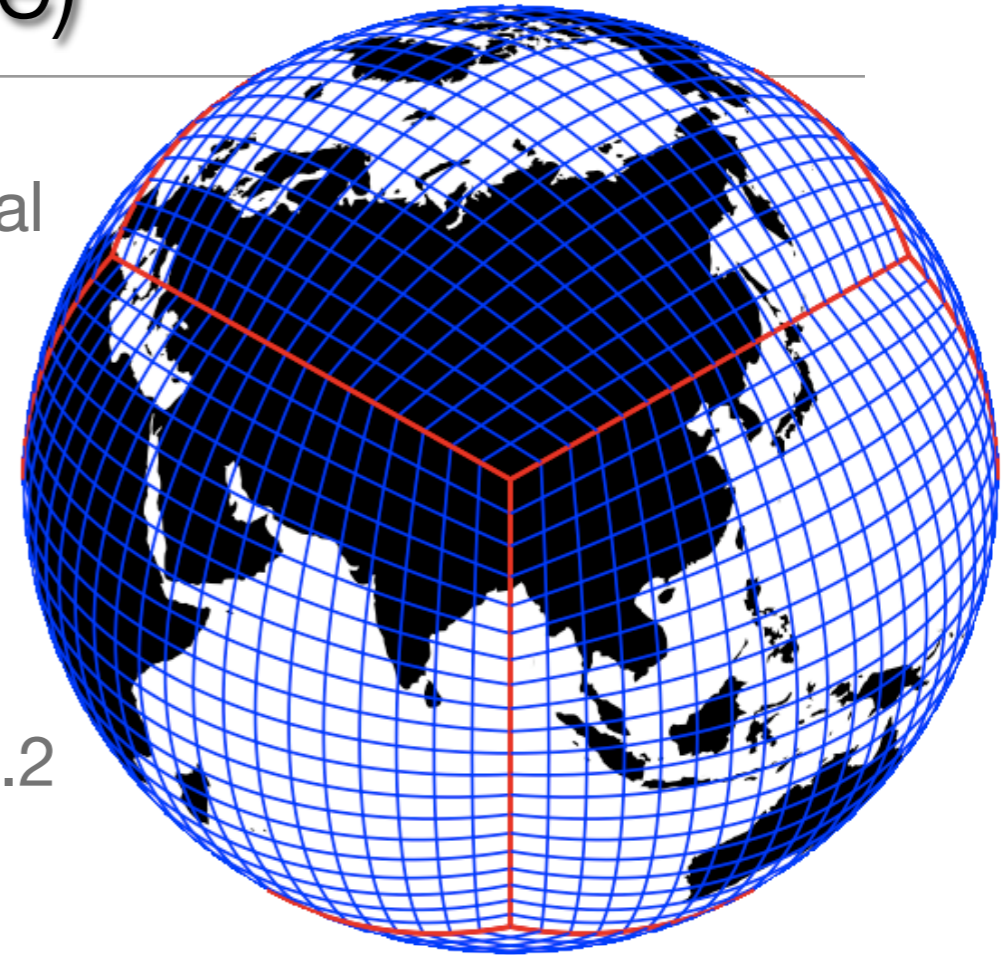
coagulation  
condensation

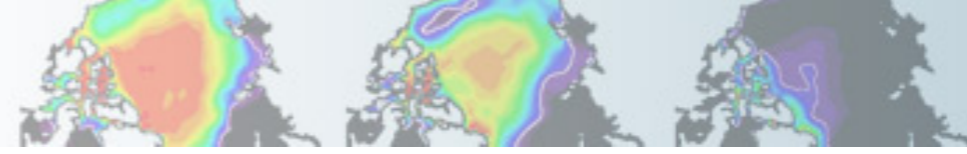




# Spectral Element (HOMME dycore)

- WACCM4 has been run with cubed sphere spectral element (SE) dycore with specified chemistry (SC)
  - Model interpolates SC data file from FV to SE
  - Validated against FV-SC run
  - To be included in CESM1.2 release, May 2013
- Vertical advection for SE to be updated in CESM1.2
  - effects on WACCM-SE to be tested
- Conservative Semi-Lagrangian Advection for Models (CSLAM) being developed for full chemistry
  - Cost of advection independent of number of tracers
  - Peter Lauritzen will give CSLAM update at AMWG, Tuesday 9AM





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