NASA Update

GEOS-5 Model and Data Assimilation System: Aerosols and Clouds

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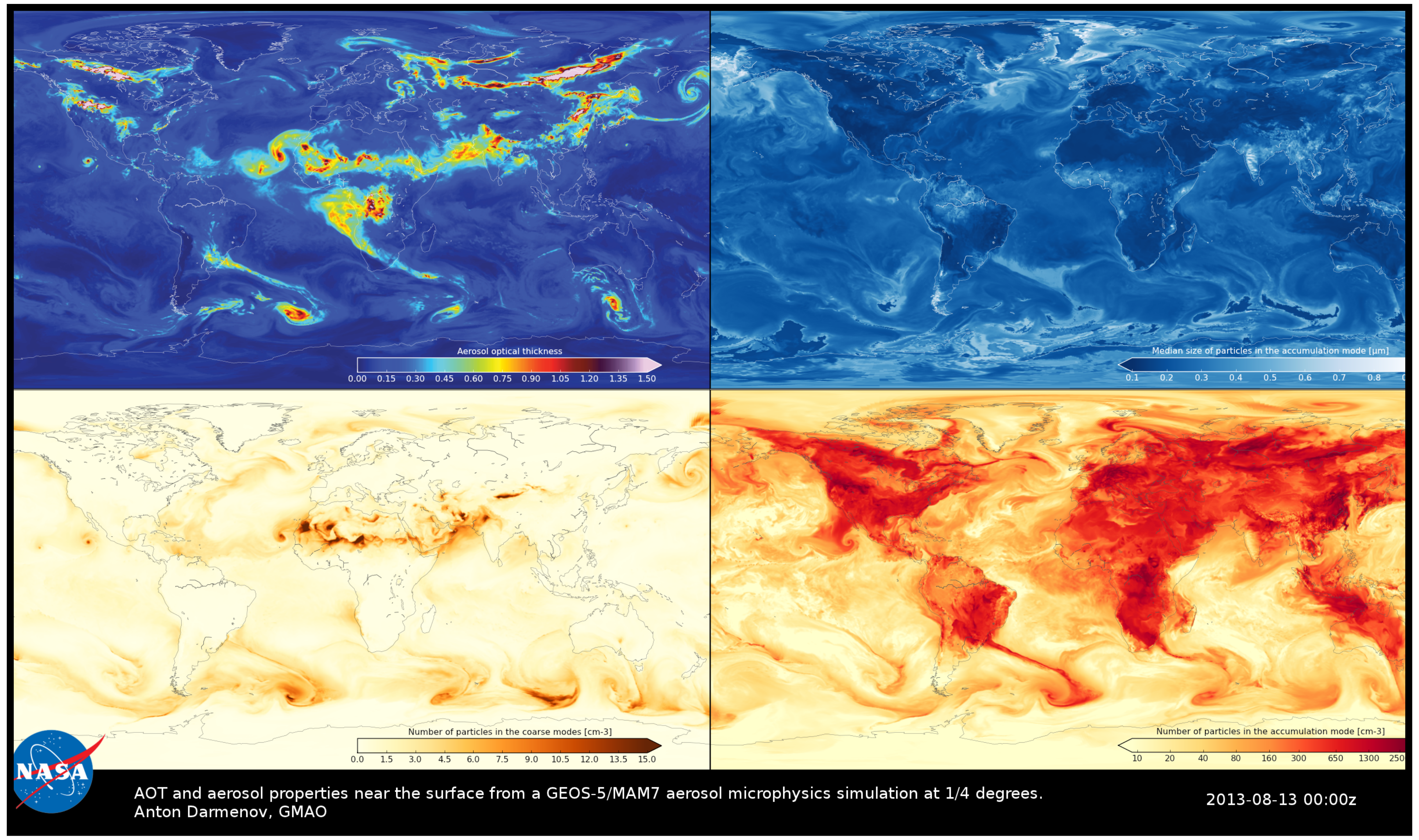
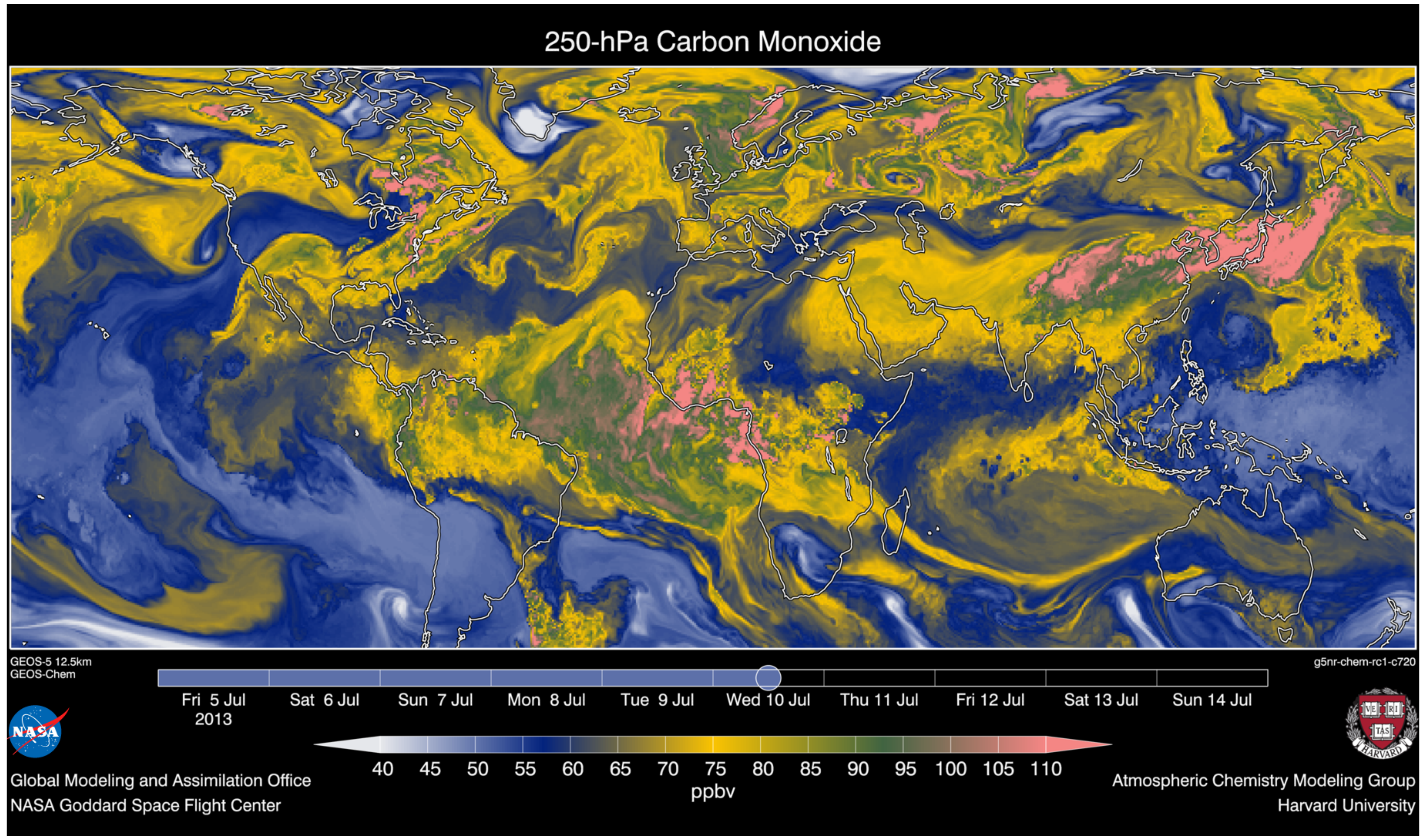
3. GESTAR
4. UMBC

Outline

- Current NRT system
- Field campaigns
    - KORUS-AQ
- Ongoing work and future plans
    - AGCM and ADAS
    - New components
    - MAM7
- Chemistry and aerosol visualizations

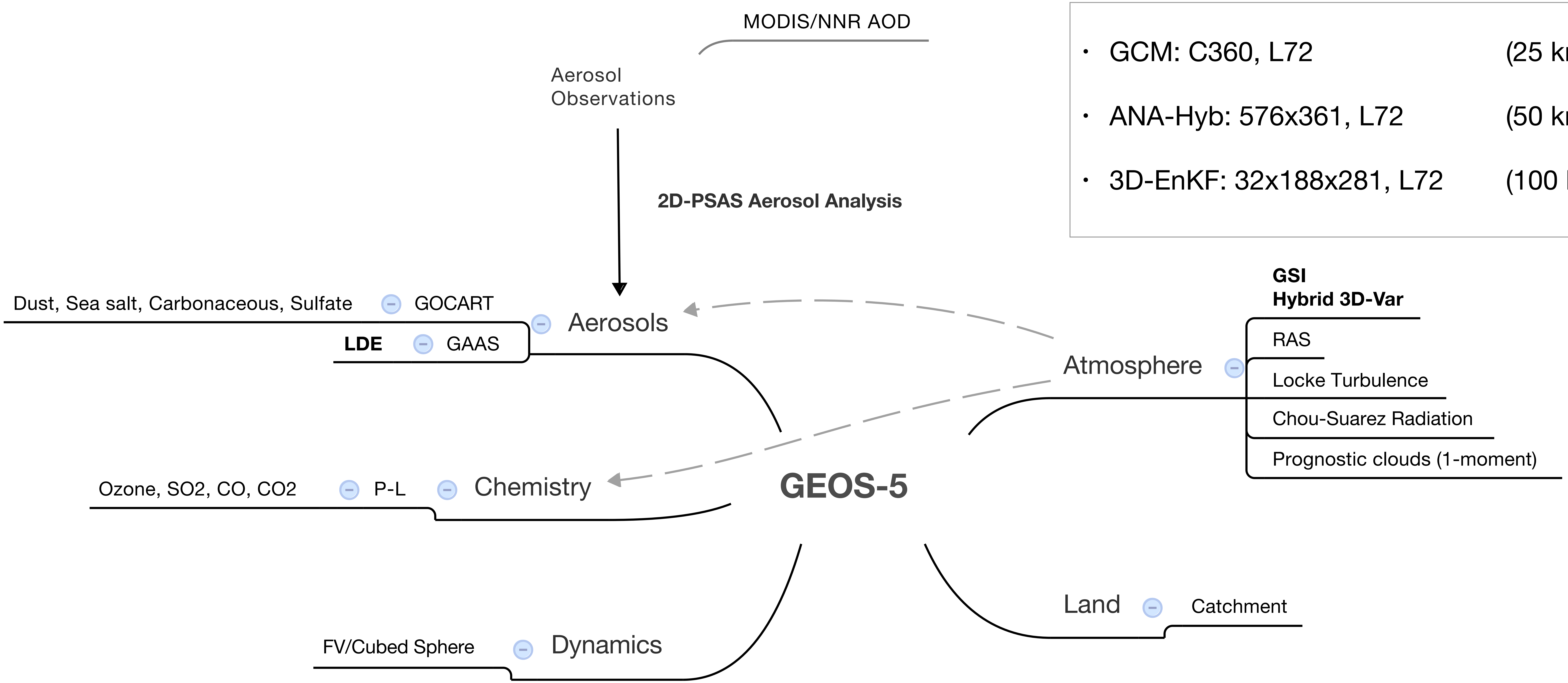




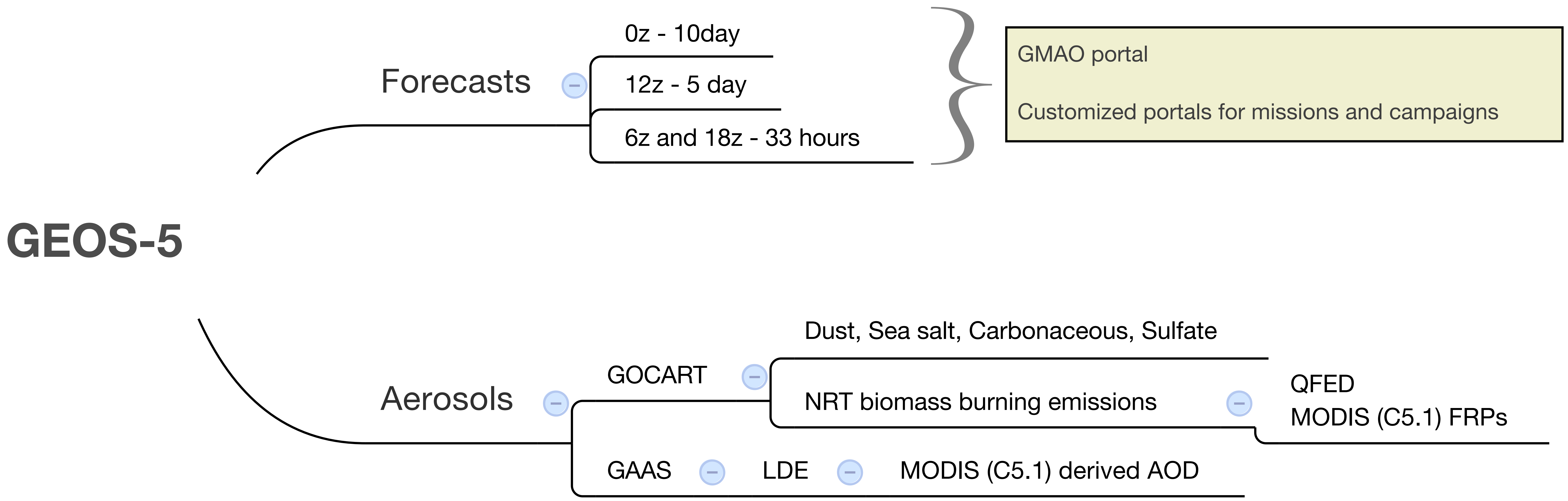
Current NRT Configuration

Current GEOS-5 NRT (forward processing) configuration

- GCM: C360, L72 (25 km)
- ANA-Hyb: 576x361, L72 (50 km)
- 3D-EnKF: 32x188x281, L72 (100 km)

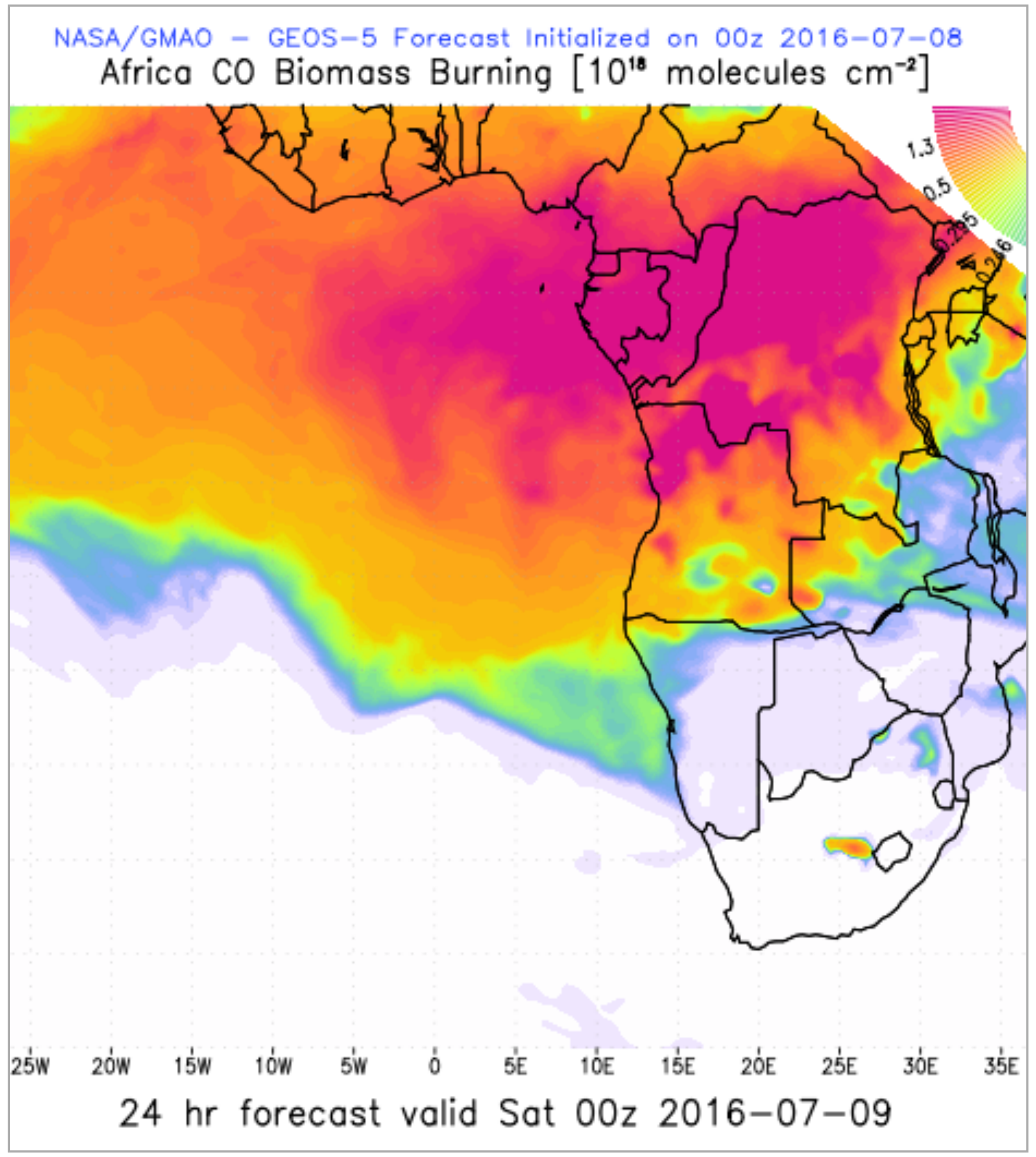


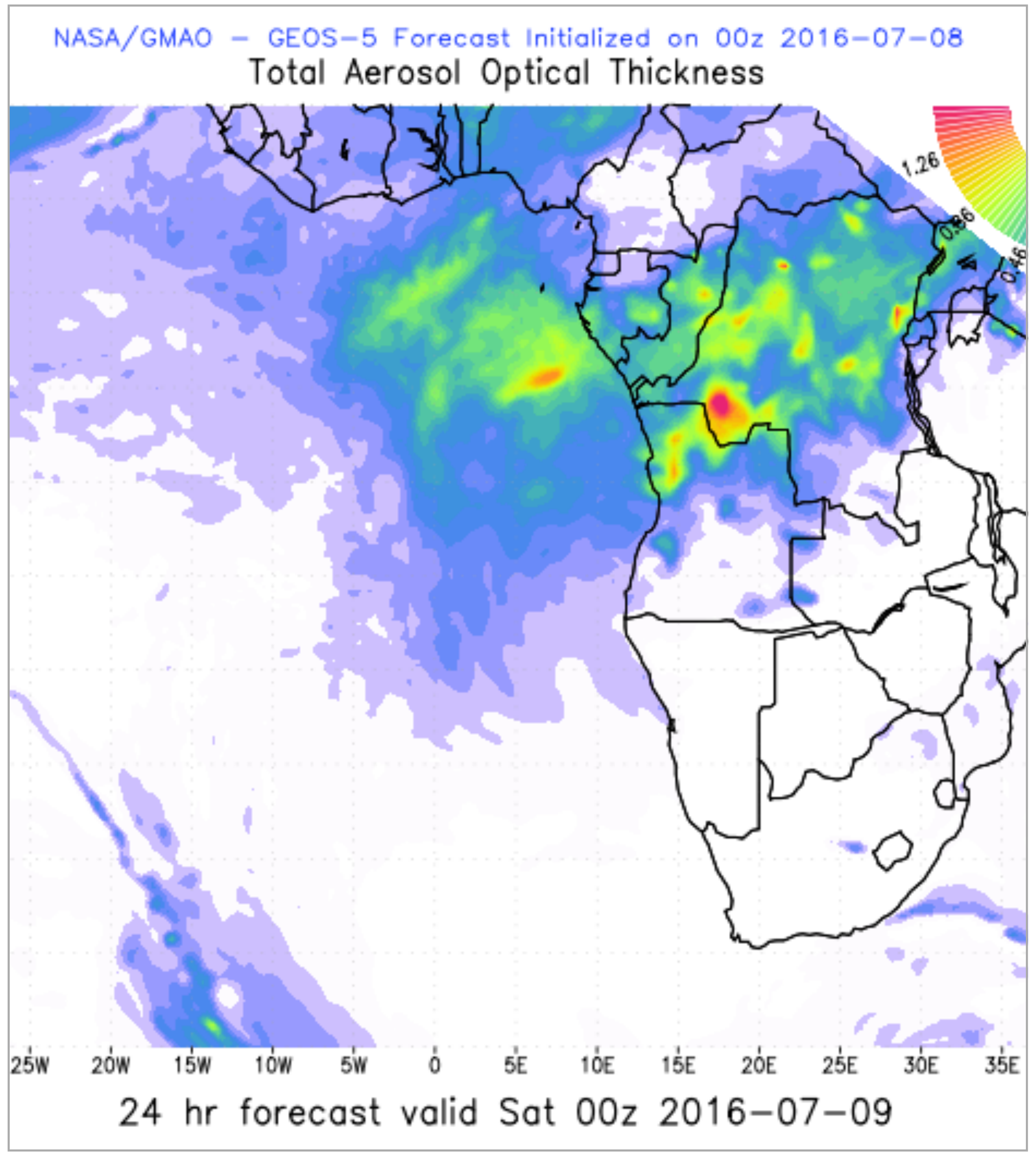
GMAO experimental forecasts



Field campaigns

- VIRGAS: Volcano-plume Investigation Readiness and Gas-phase and Aerosol Sulfur
- 7-SEAS: The Seven SouthEast Asian Studies
- NAAMES: The North Atlantic Aerosols and Marine Ecosystems Study
- KORUS-AQ: International Cooperative Air Quality Field Study in Korea
- ORACLES: ObseRvations of Aerosols above CLouds and their intEractionS



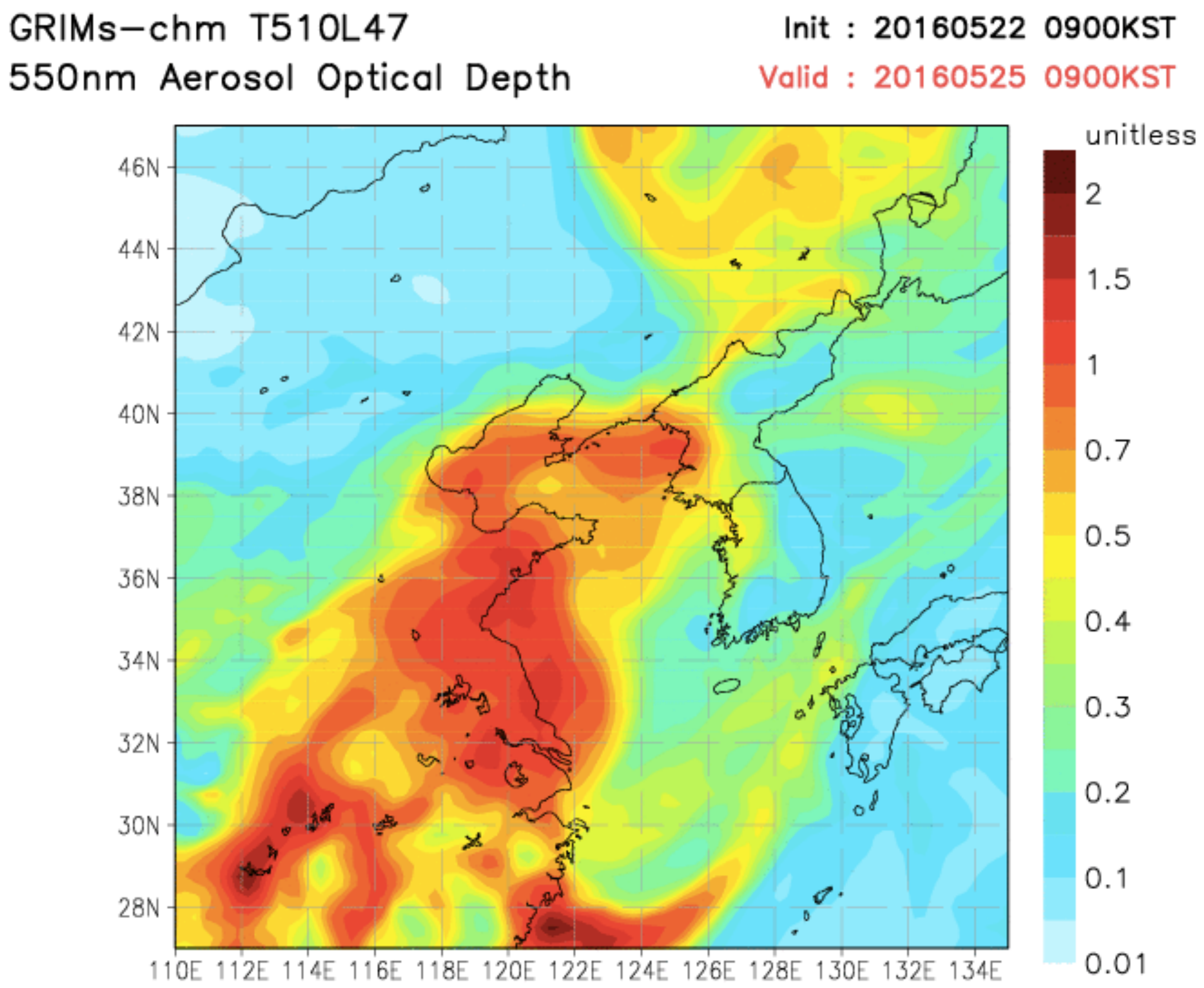


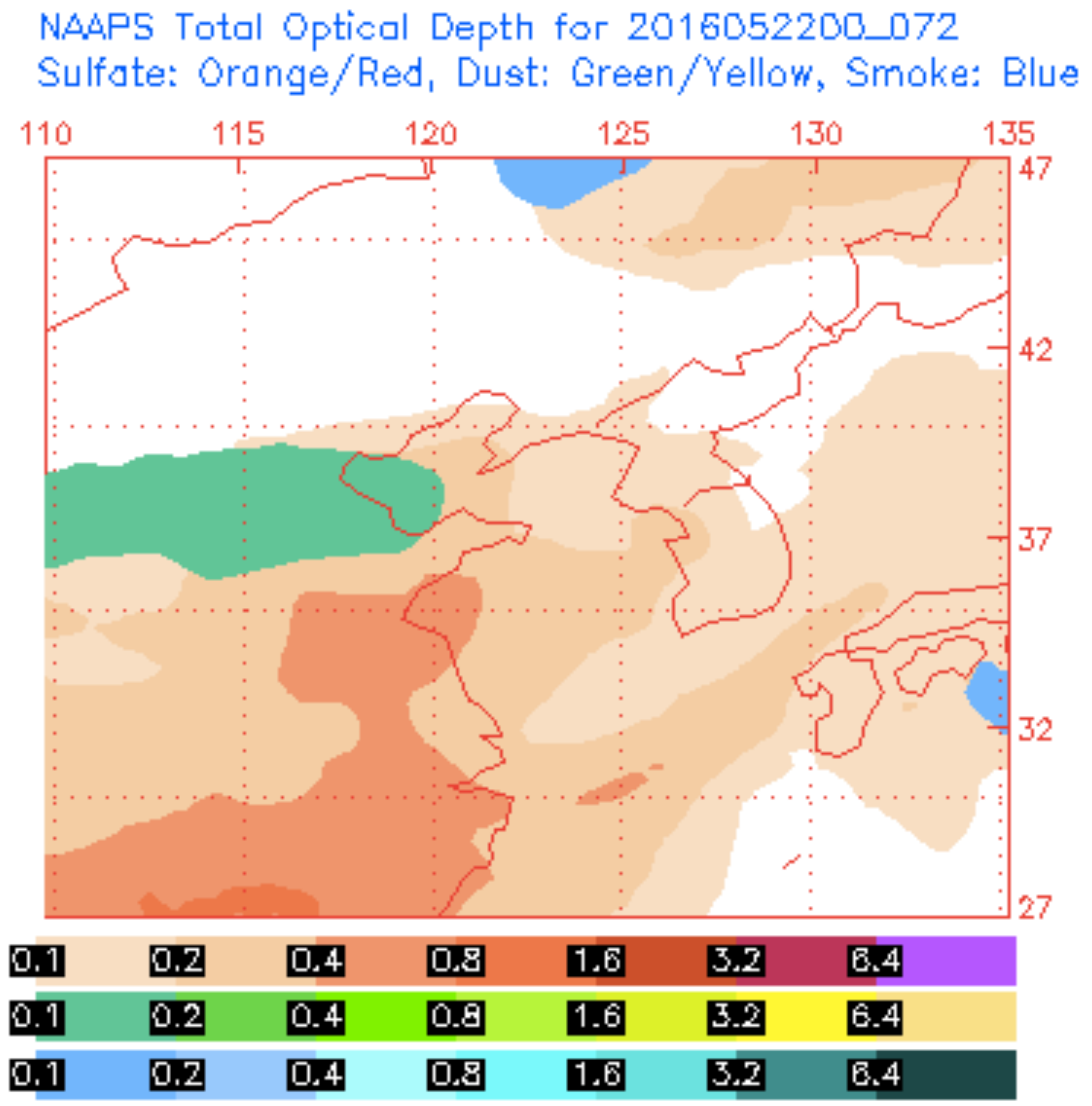
Chemical weather maps of forecasted CO from fires in Africa and AOD in the ORACLE domain.

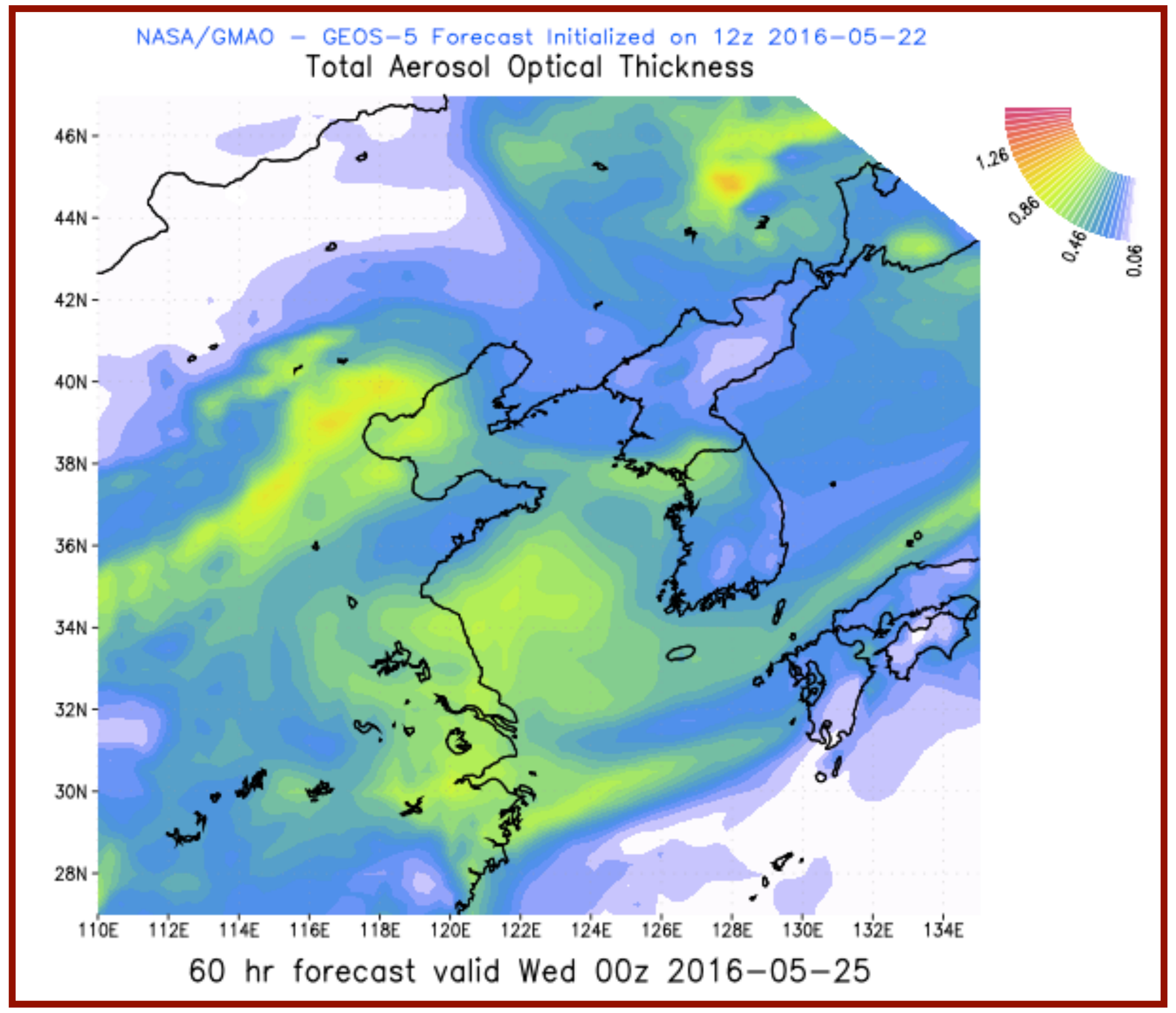
http://gmao.gsfc.nasa.gov/field_campaigns/

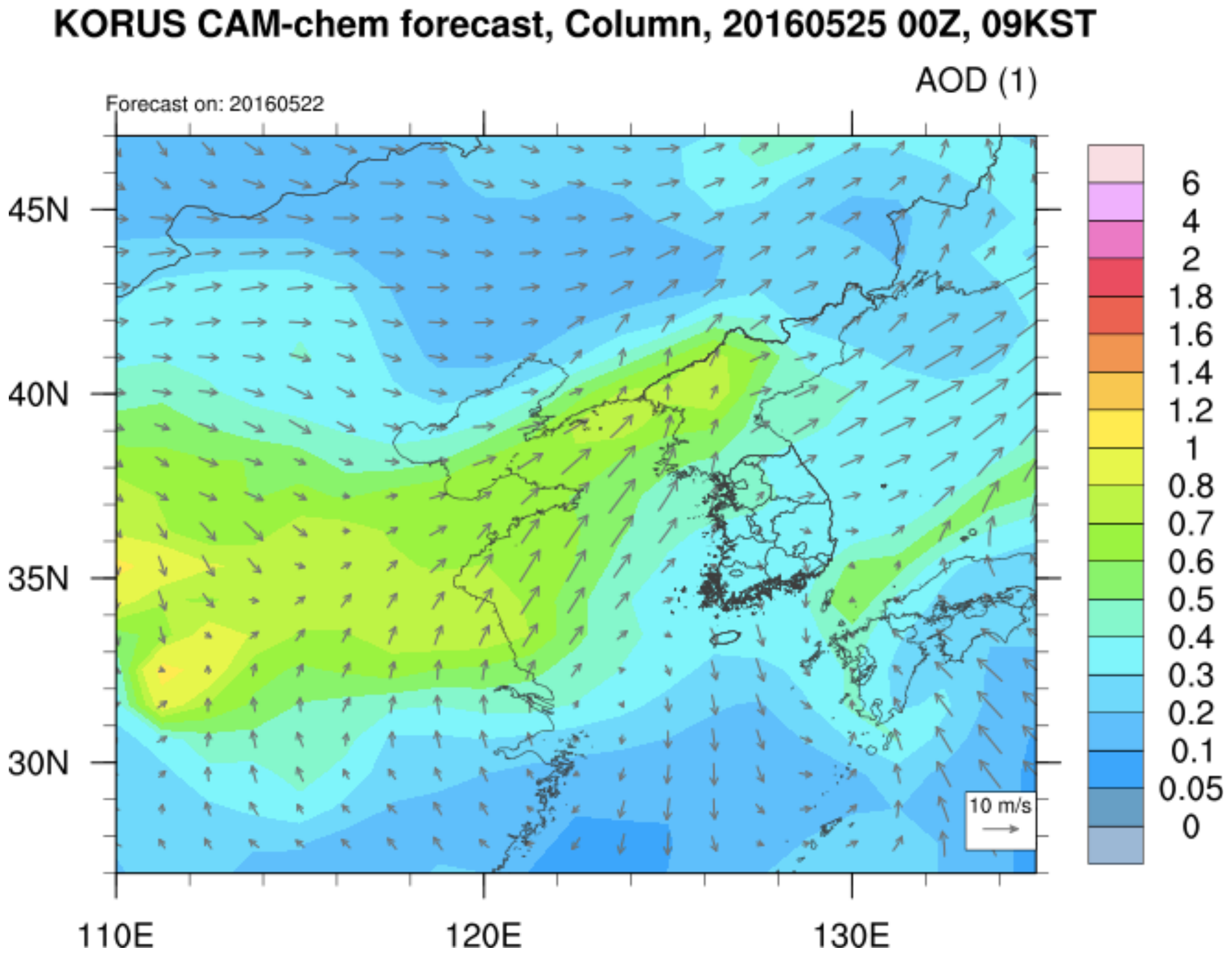
KORUS-AQ: 60-hr forecast for 25 May 2016

- Multi-model aerosol and weather forecasts are used for flight planning
- Aerosol optical depth from four different modeling systems, including GEOS-5
- The 60-hr forecasts from all the models suggest an inflow of pollution from China over the Yellow Sea

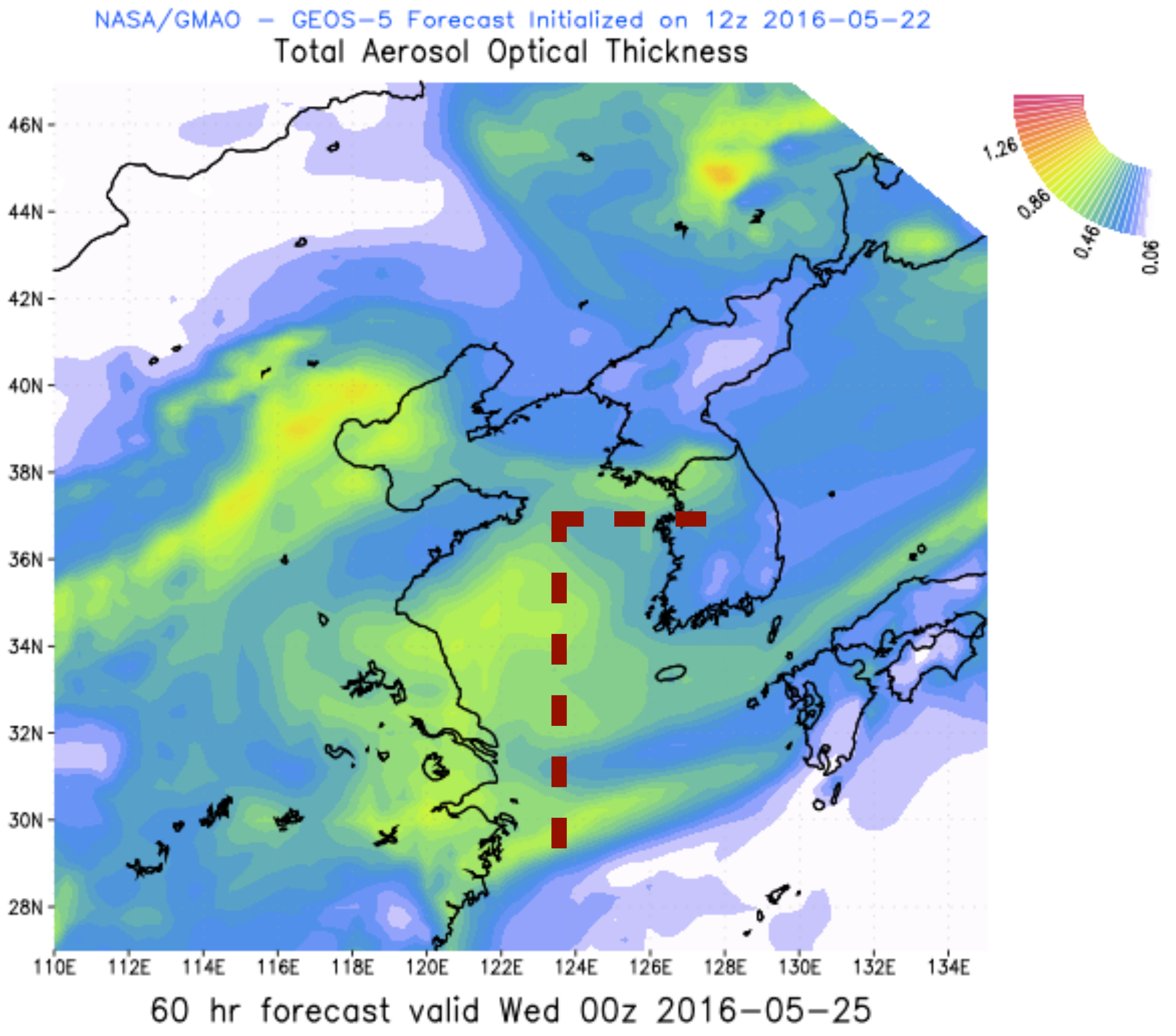


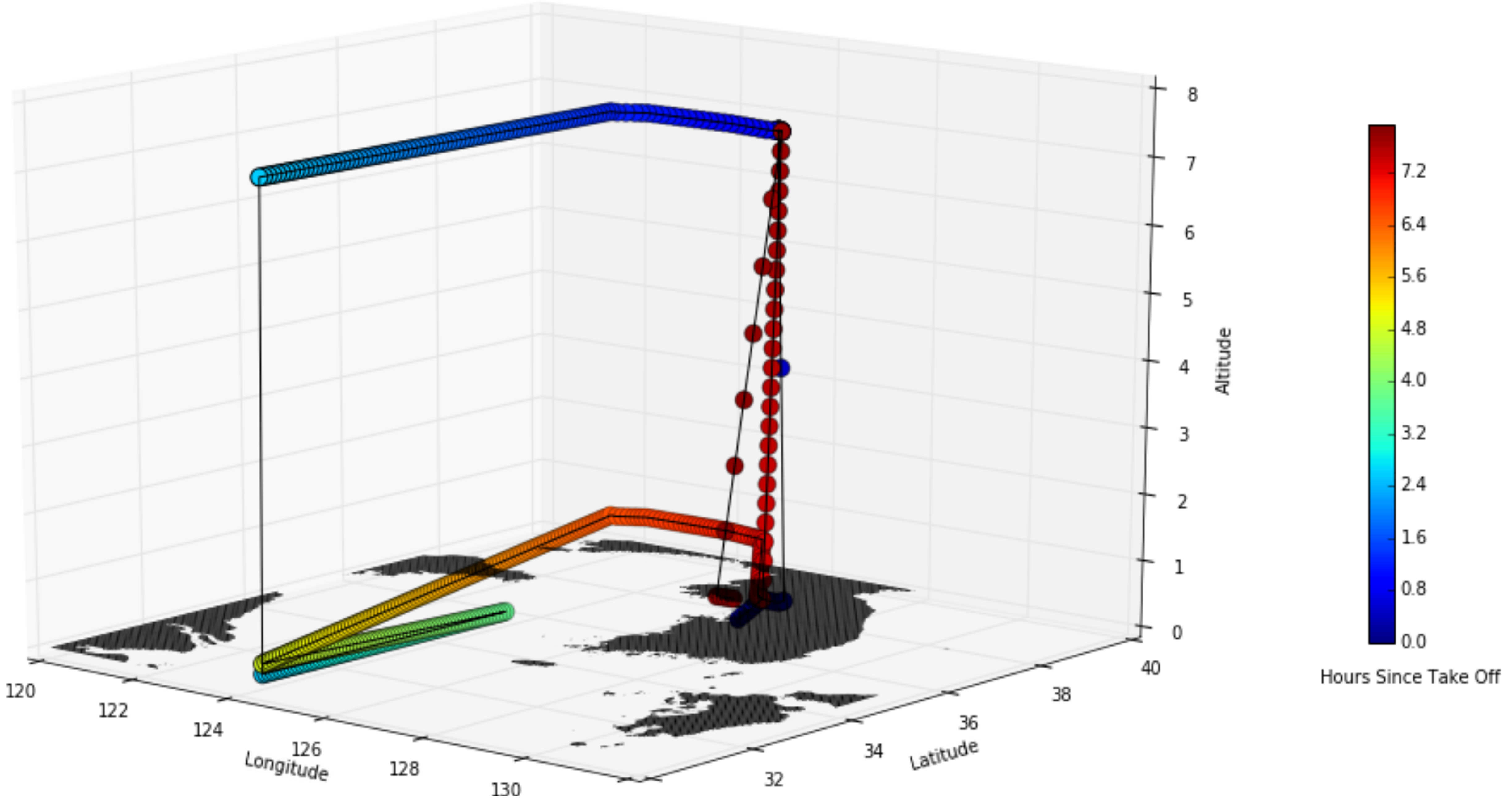




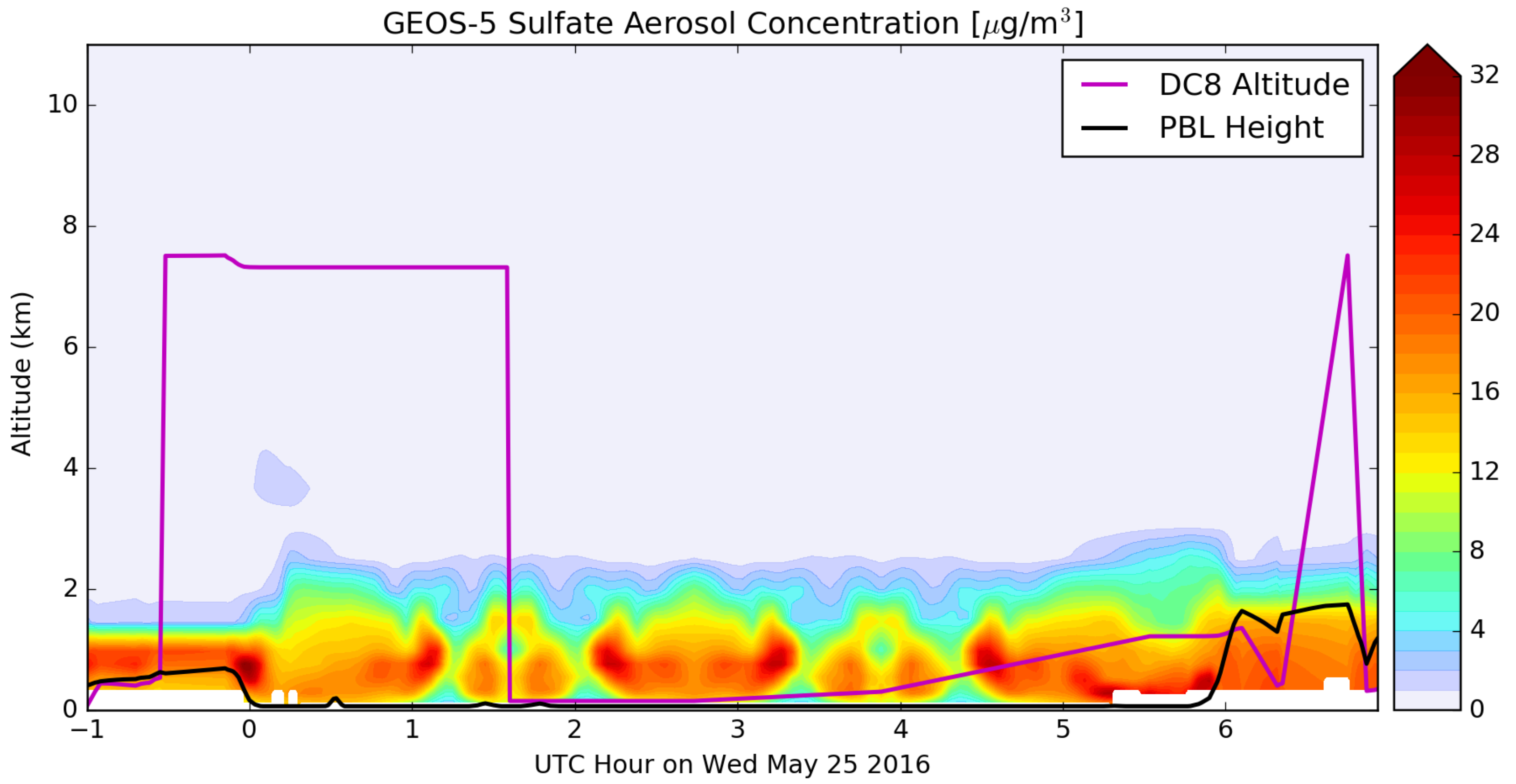


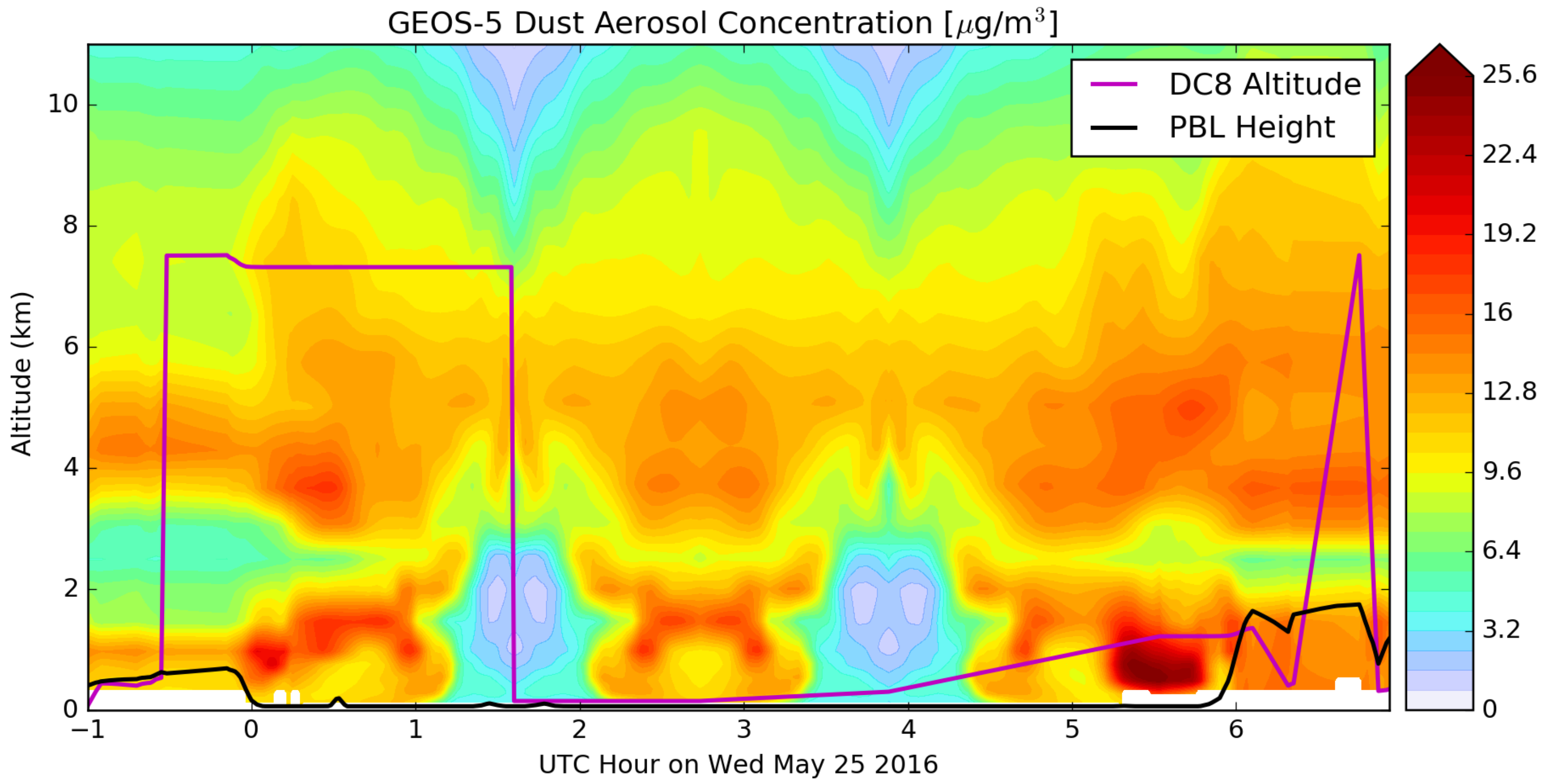
DC8 flight plan for 25 May





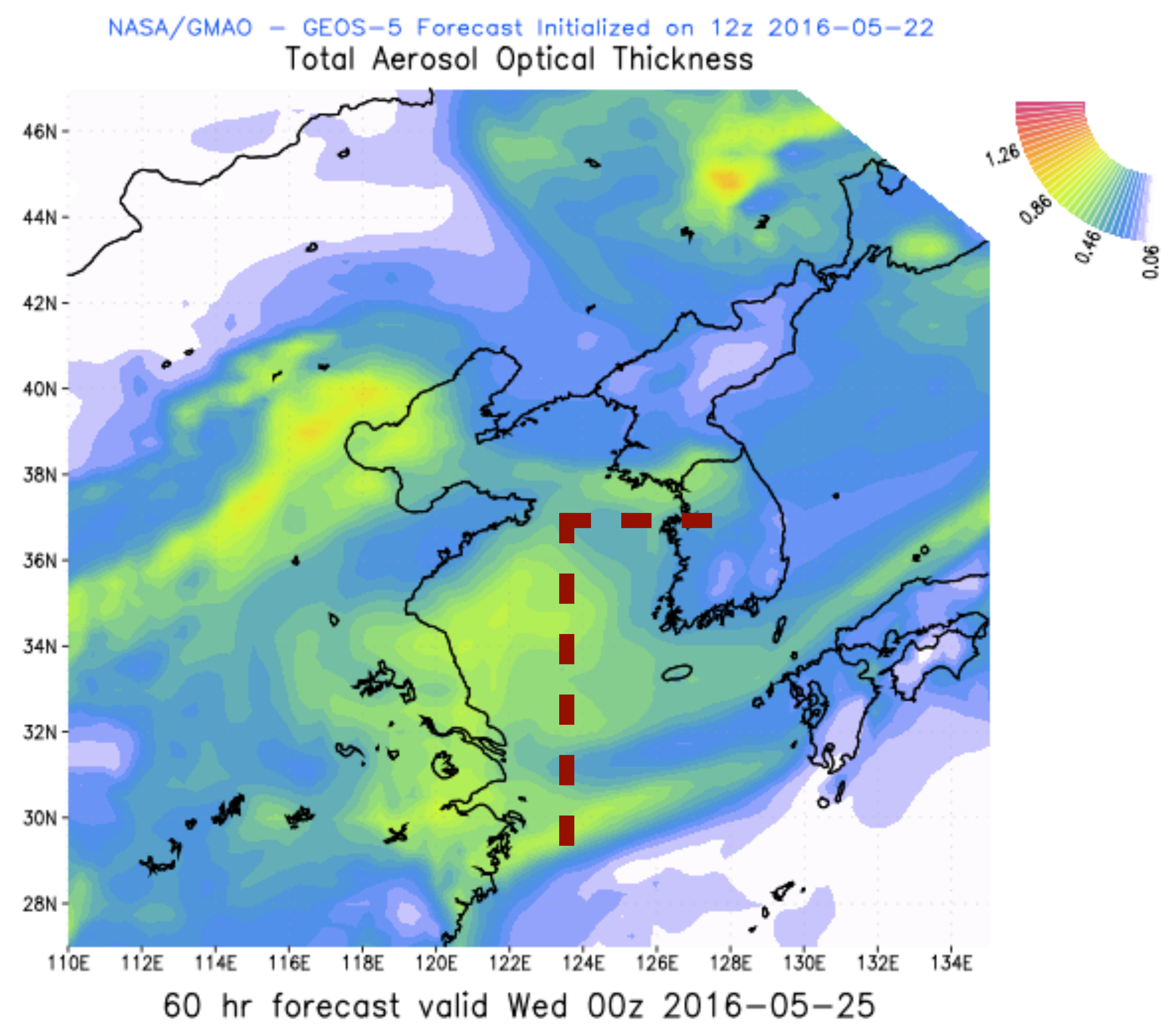
Flight plan for 25 May, 2016 aiming to capture both the pollution inflow from China and long-range transport of dust in the upper troposphere.

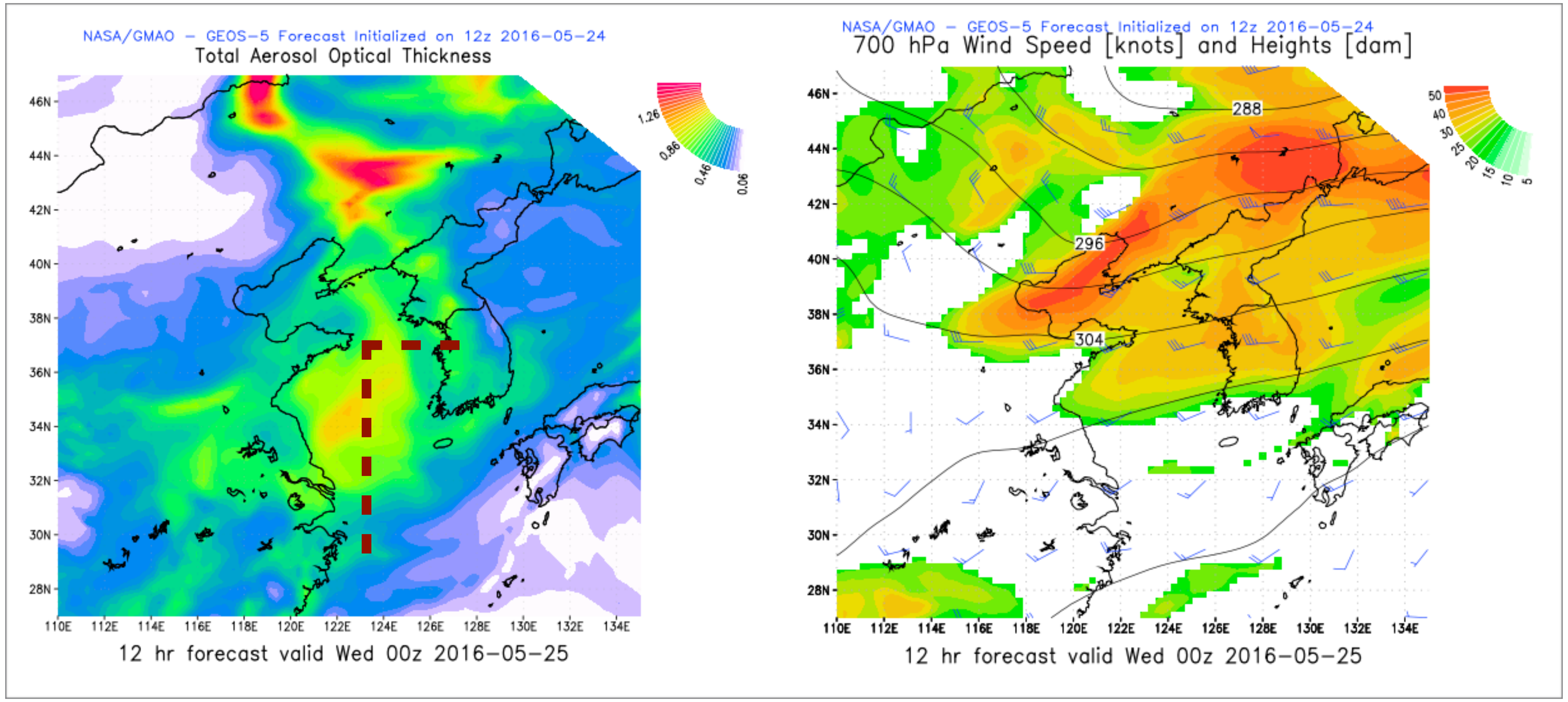




Data from this flight will help constrain the production mechanism of secondary organic aerosols, as well as dust emissions and settling velocities.

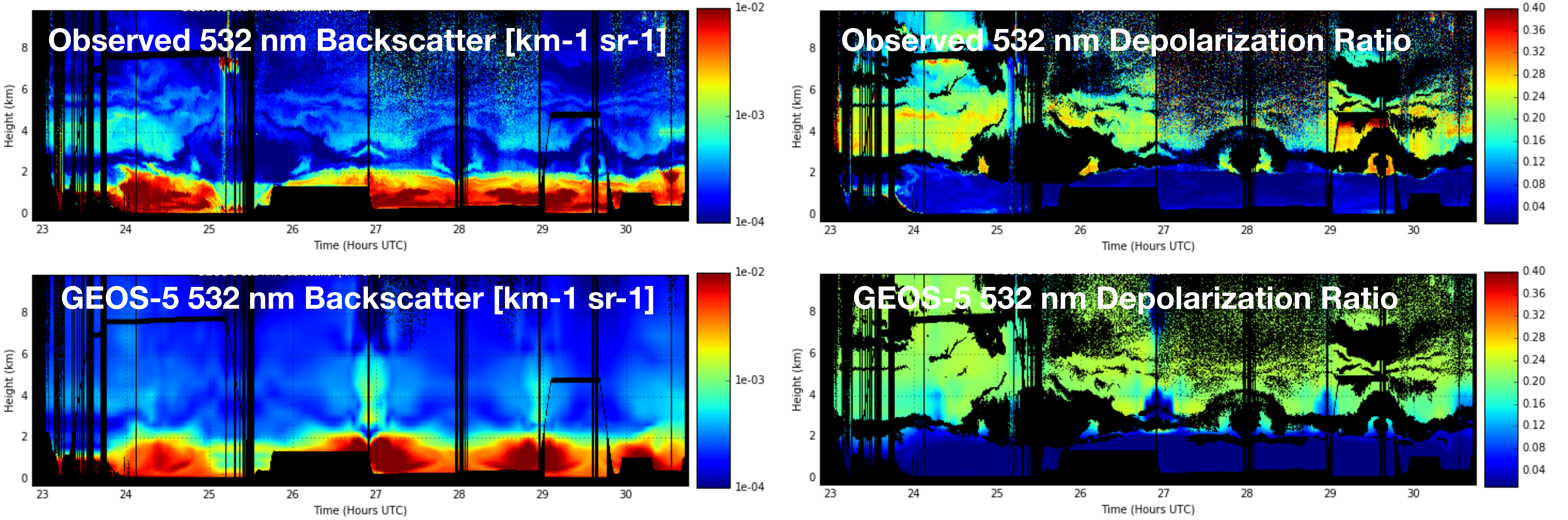
12-hr Forecast for 25 May 2016: Inflow Intensified





- The GEOS-5 12-hr forecast indicated an intensification of the pollution inflow from China compared to the 60-hr forecast.
- Aerosol optical depth values above 1.0 were forecasted over the Yellow Sea, related to strong easterly wind flow.

Comparison of DIAL-HSRL observations and GEOS-5: 25 May 2016



GEOS-5 data assimilation results reproduced the general character-istics of the vertical column of the atmosphere.

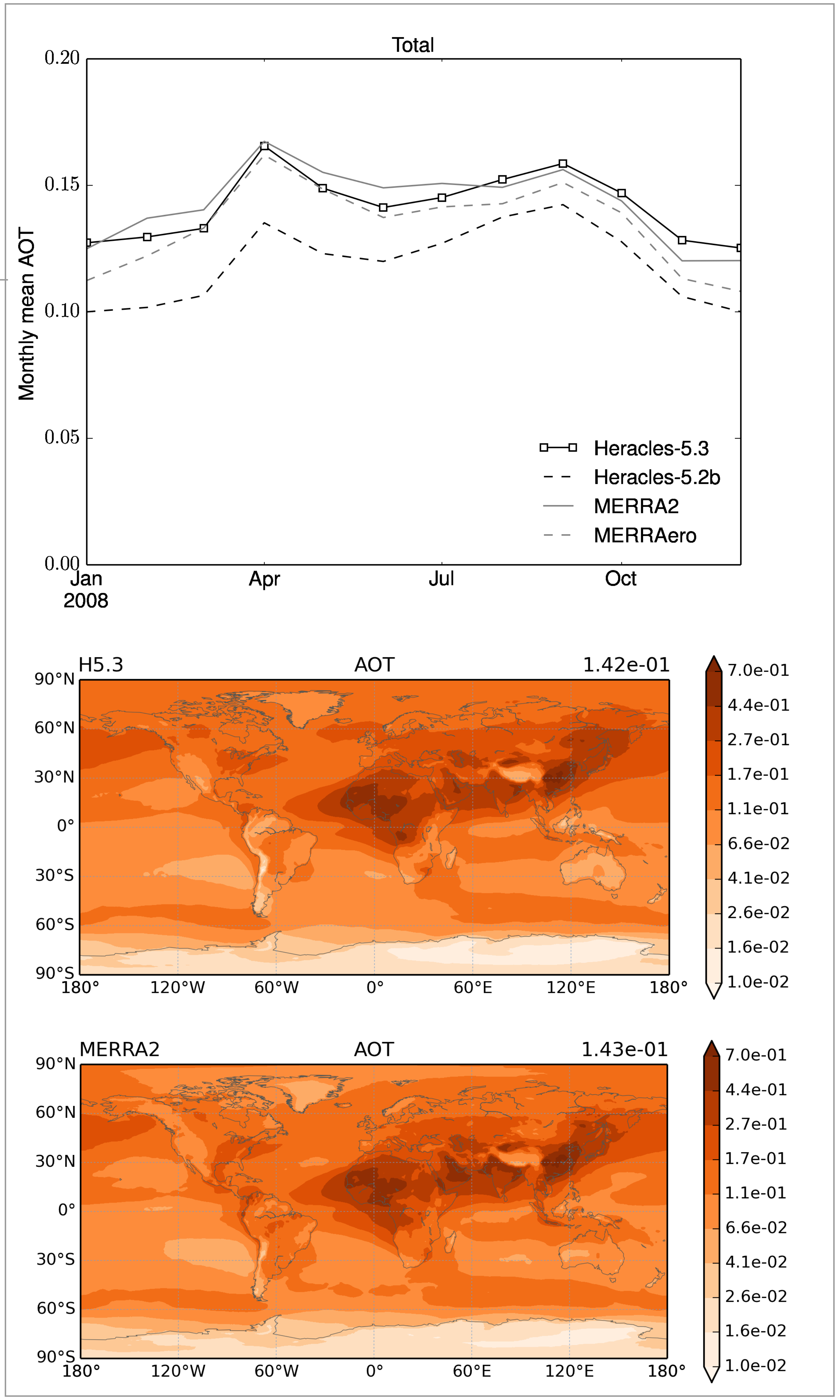
The high values of backscatter and low values of depolarization ratio below 2 km are an indication of small spherical particles originating from urban/industrial sources. Between 3-5 km, GEOS-5 indicates the presence of dust, although it underestimates the intensity.

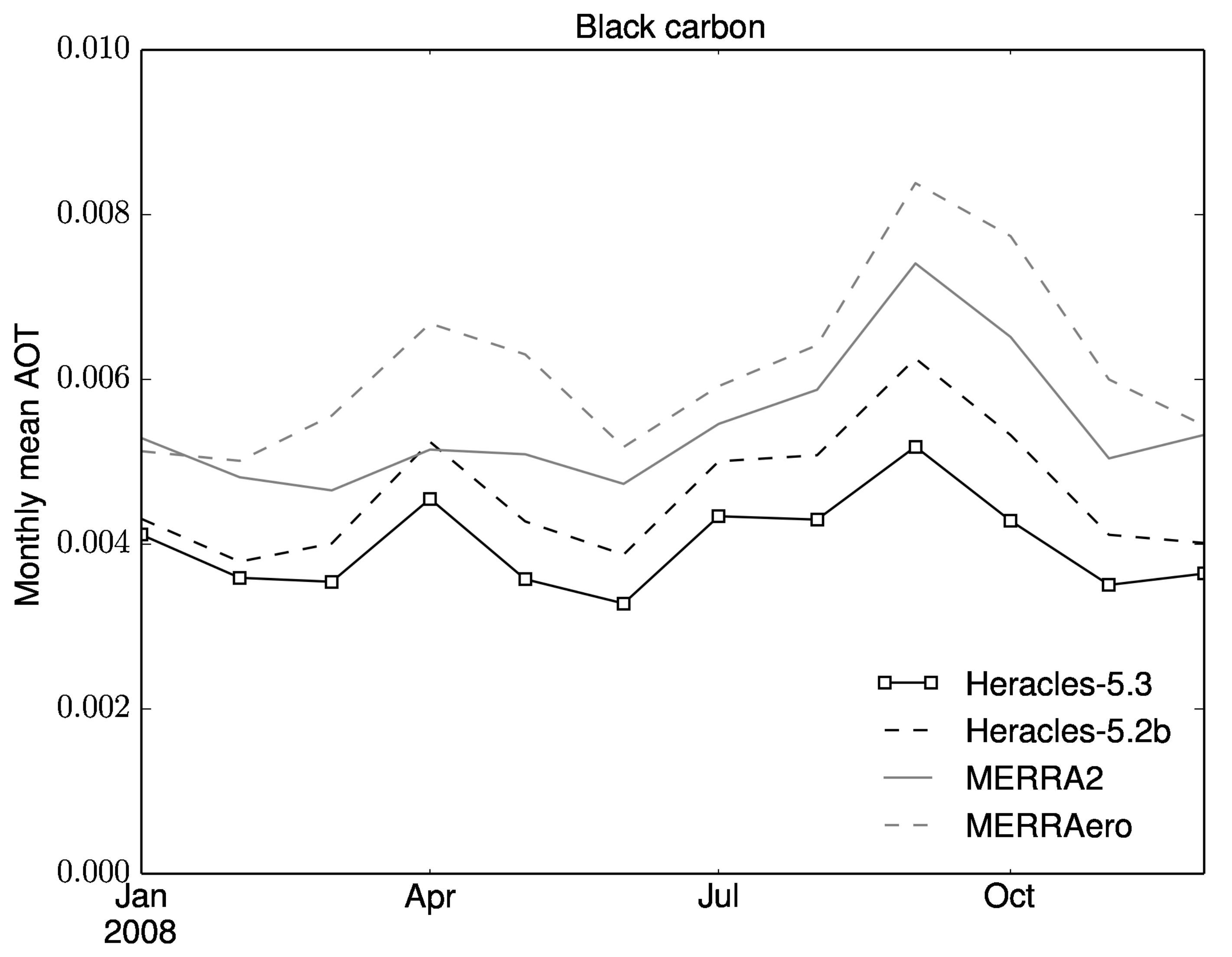
Model and DAS updates

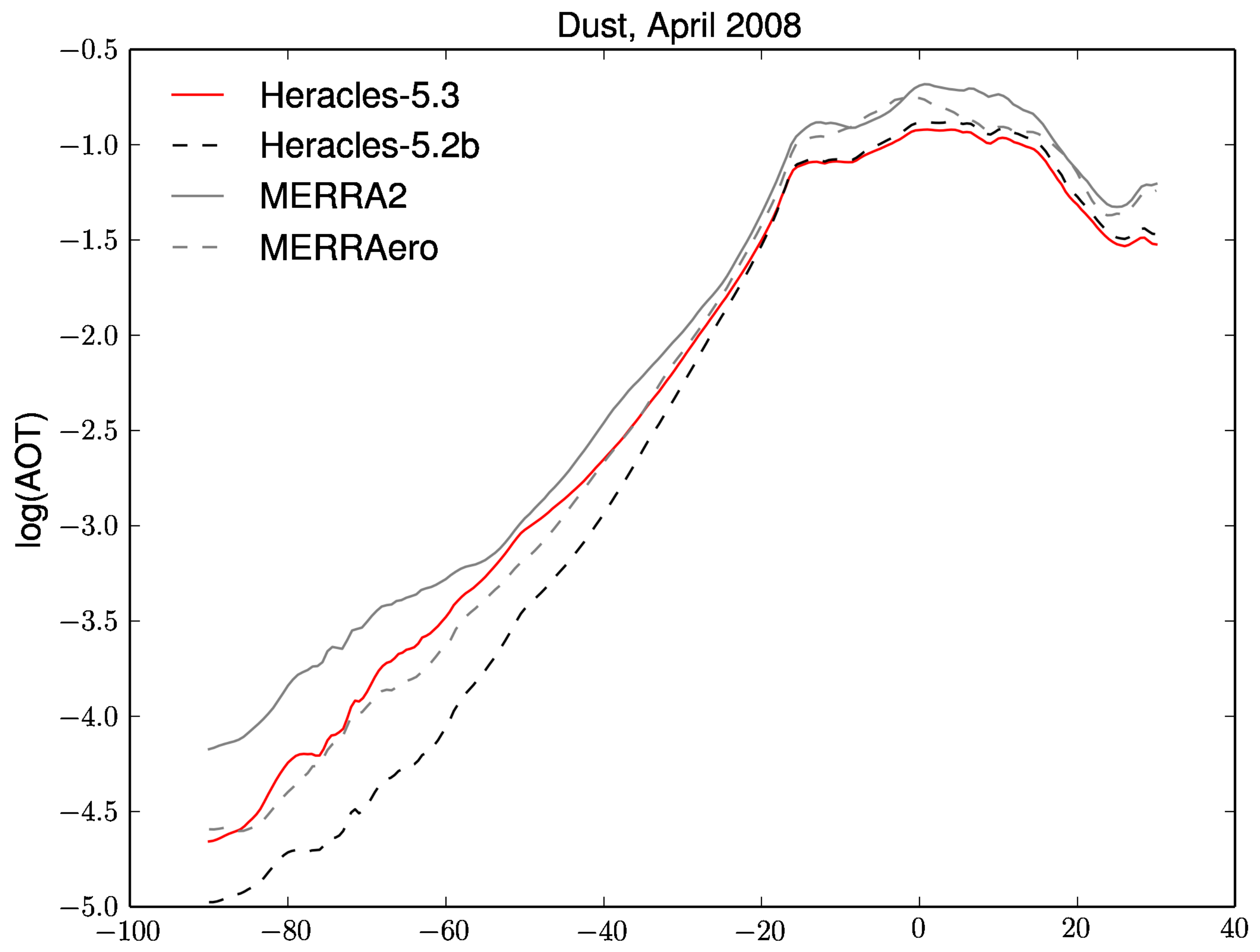
GOCART updates

Objectives:

- **Wet removal**: address high BC concentrations and overestimated dust removal frequency
- Model that is stable across the 50km - 10km range of resolutions
- Add nitrate aerosol







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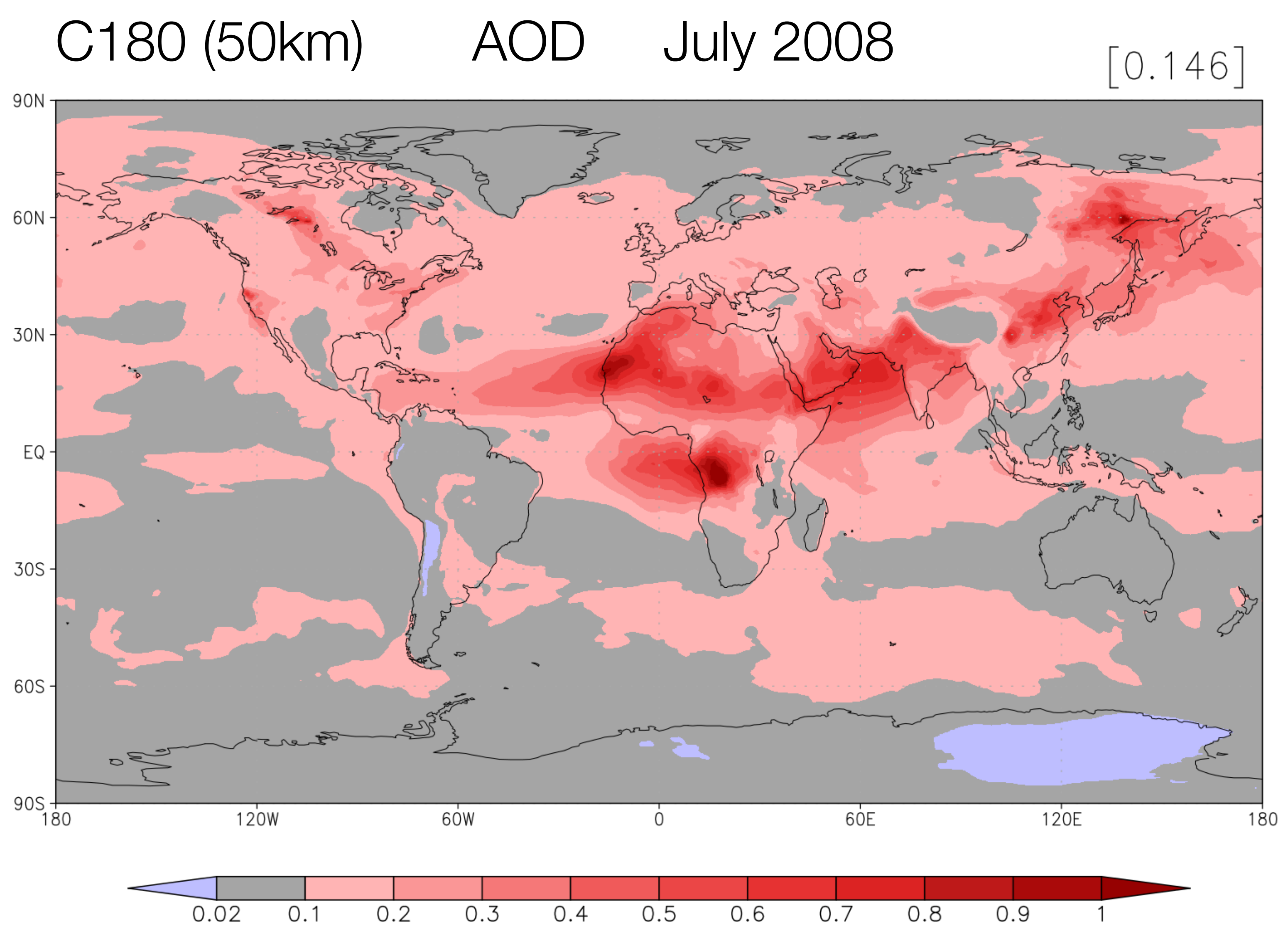
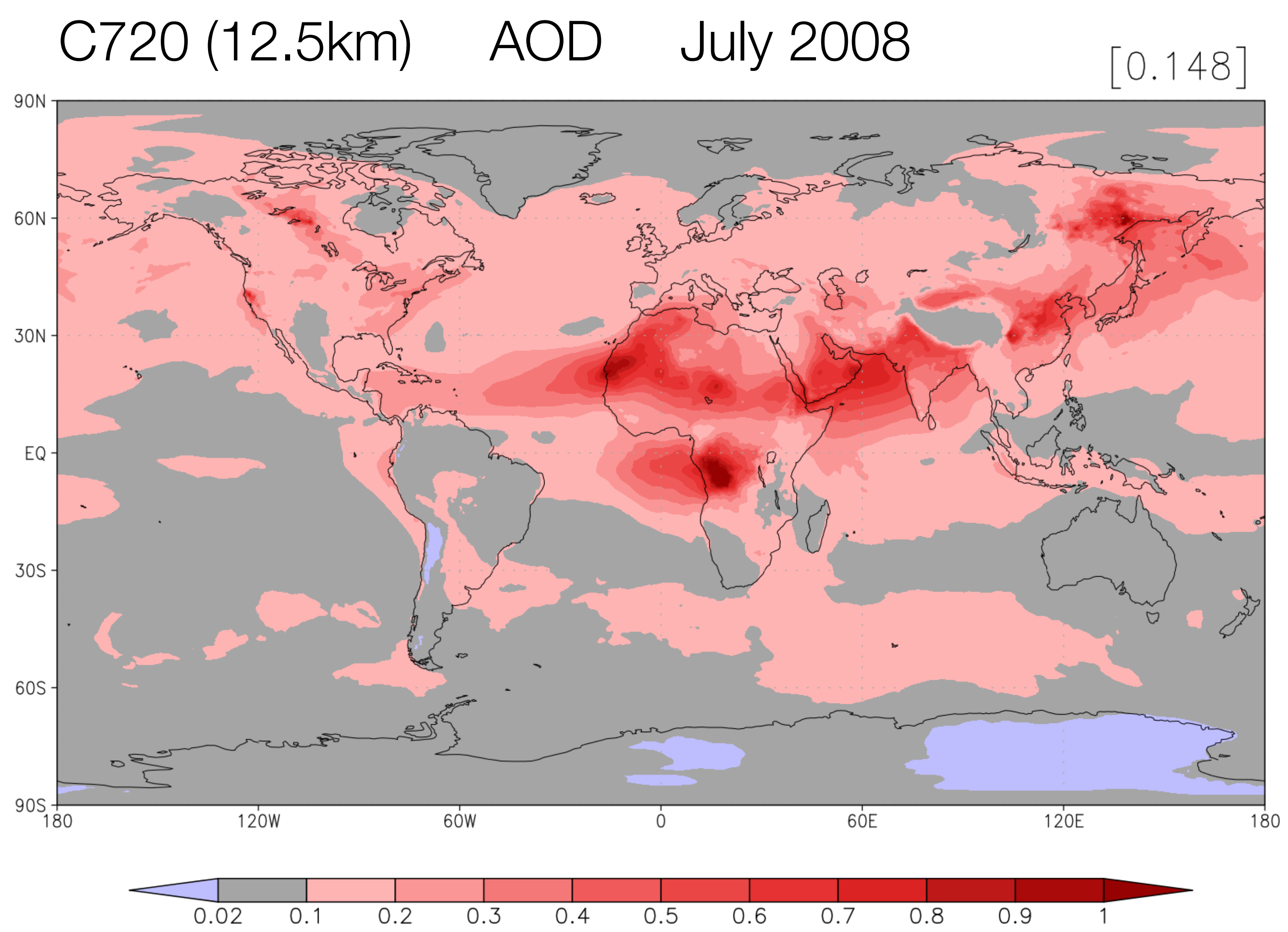
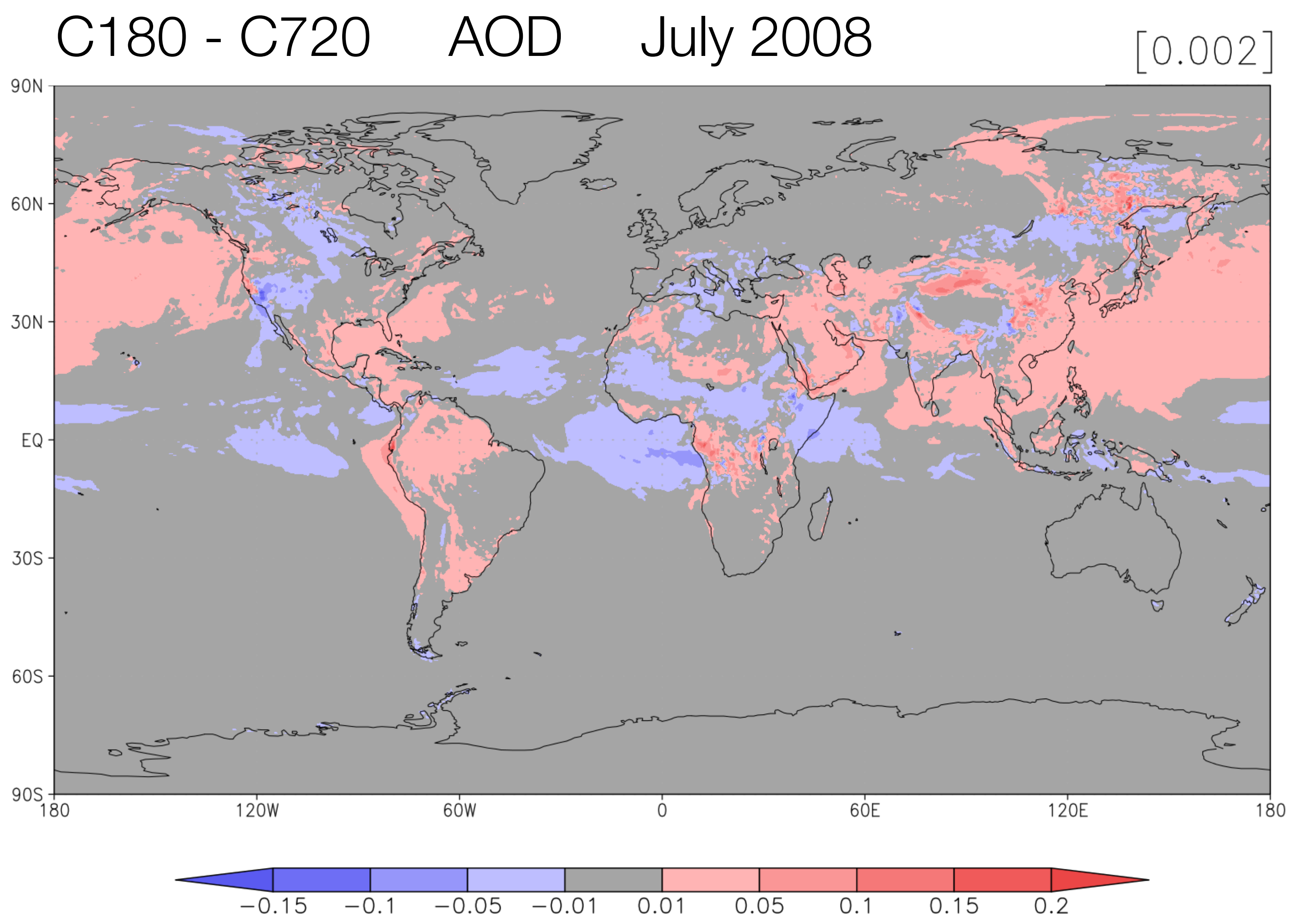
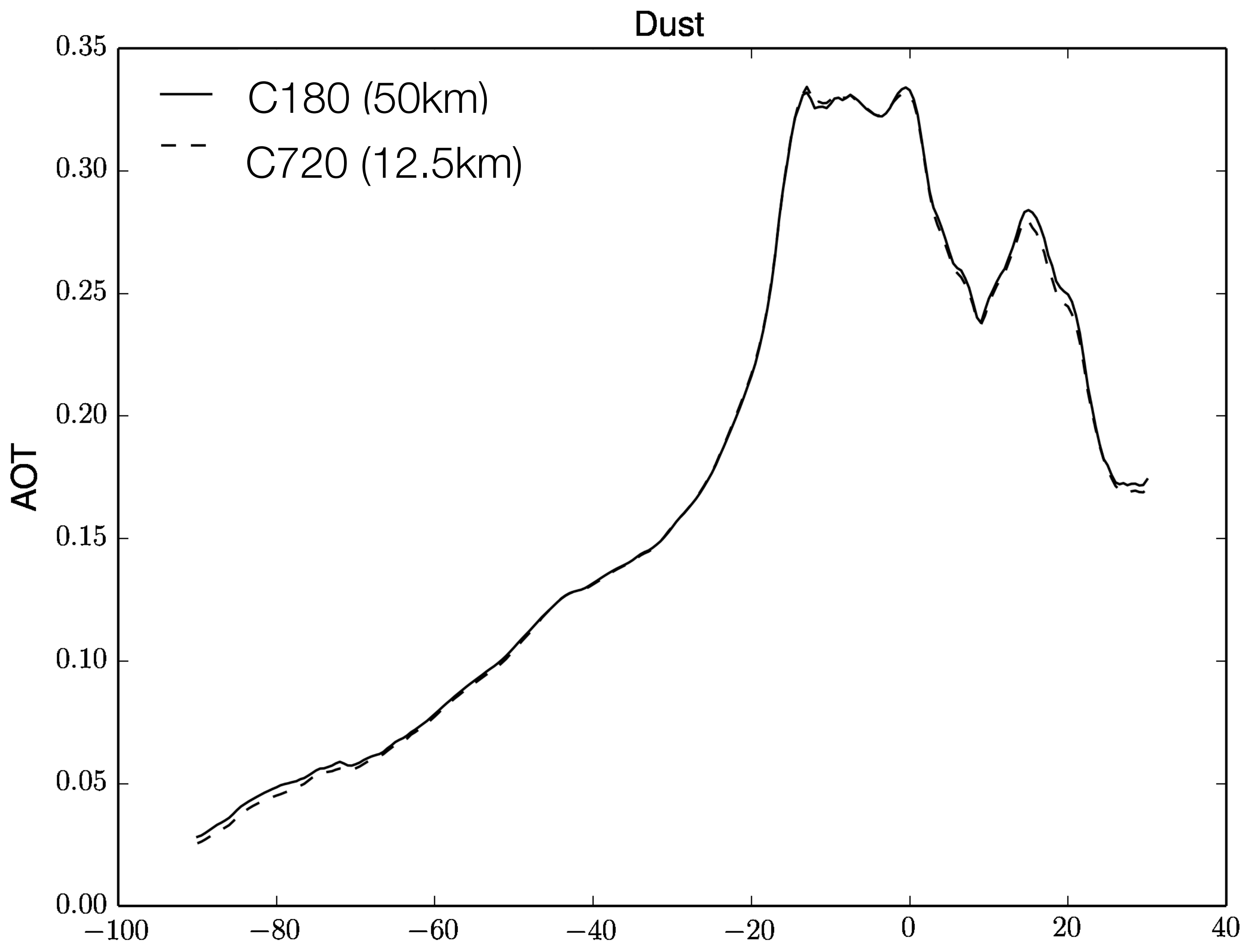








GOCART updates

Objectives: Add Nitrate aerosols

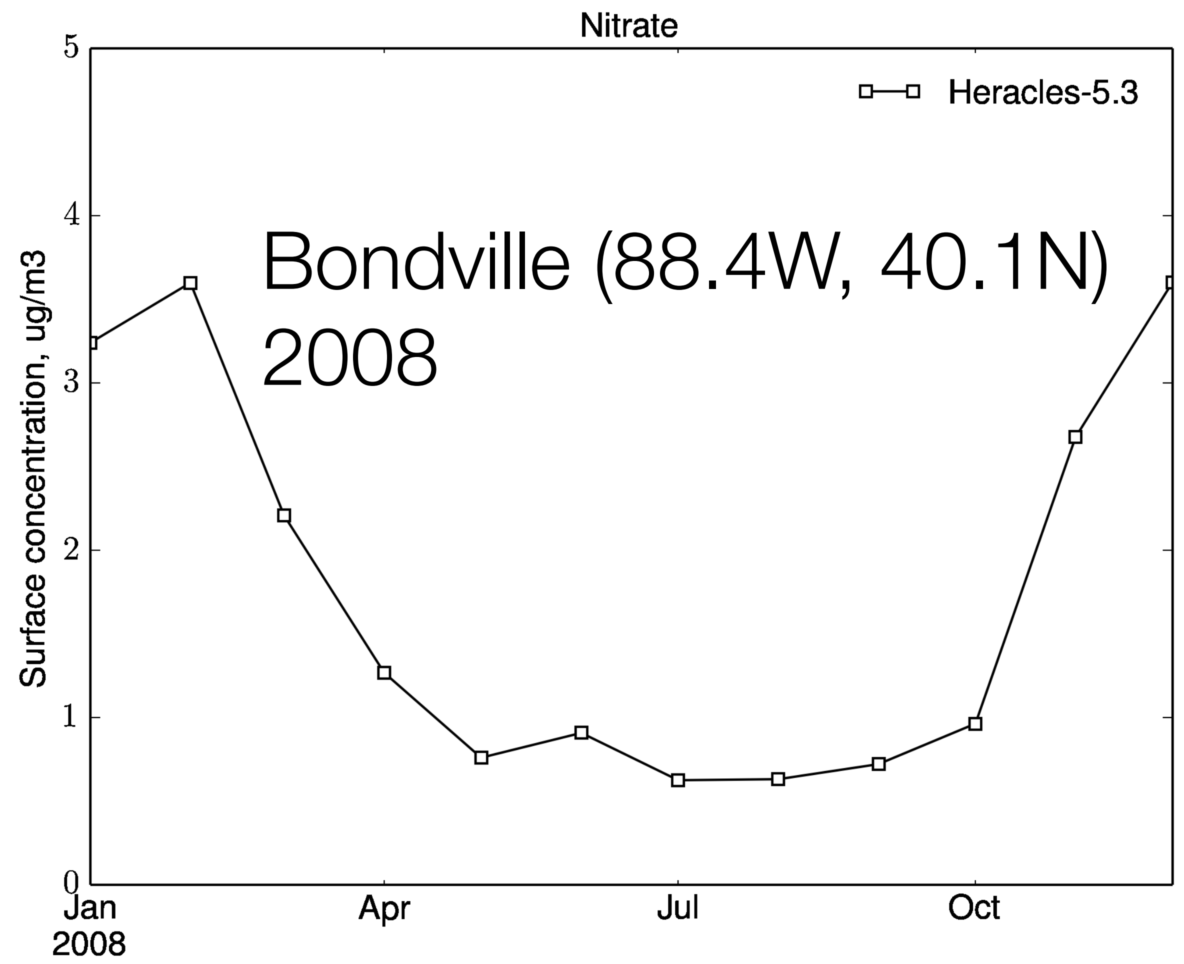
- Five new tracers (NH_3, NH_4, aerosol nitrate/NO3an: 0-0.5 um, 0.5-4um, 4-10um)
- Nitric acid is read from archived monthly output from a GMI chemistry run
- Uses RPMARES (SO_4-NO_3-NH_4-H_2O)

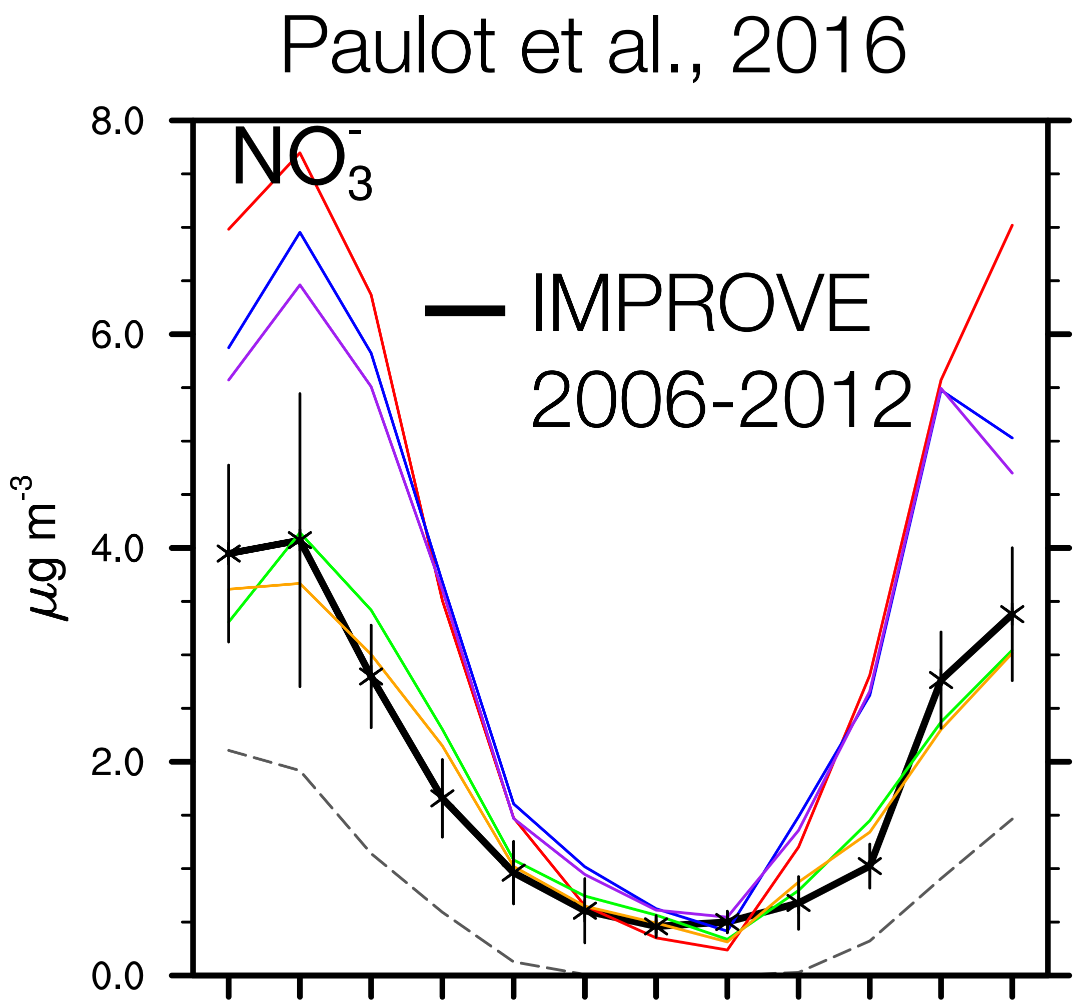
  inputs: RH, T, SO4, NHO3, NH3, NH4, NO3an

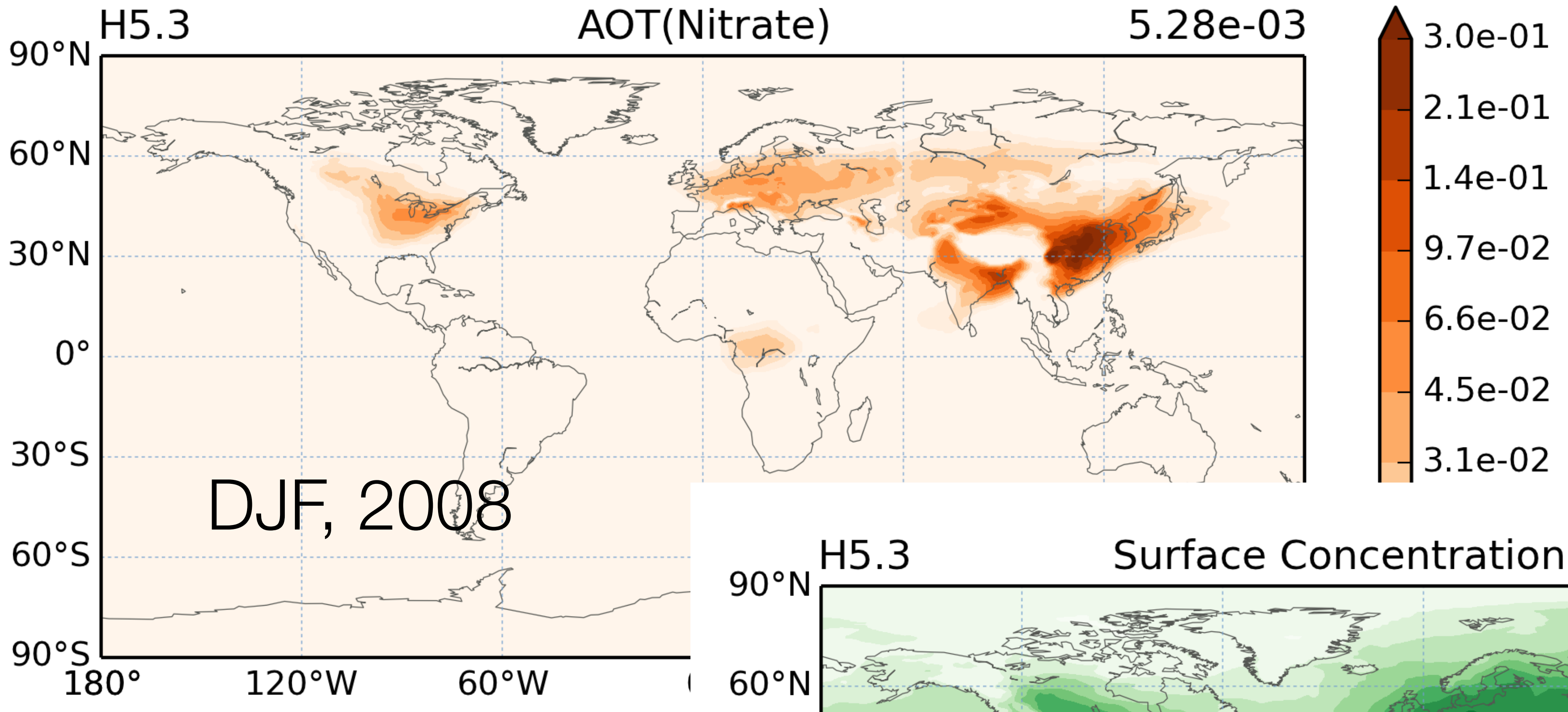
  outputs: HNO3, NH3, NH4, NO3an1
- Heterogeneous reactions on Dust and Sea salt particles

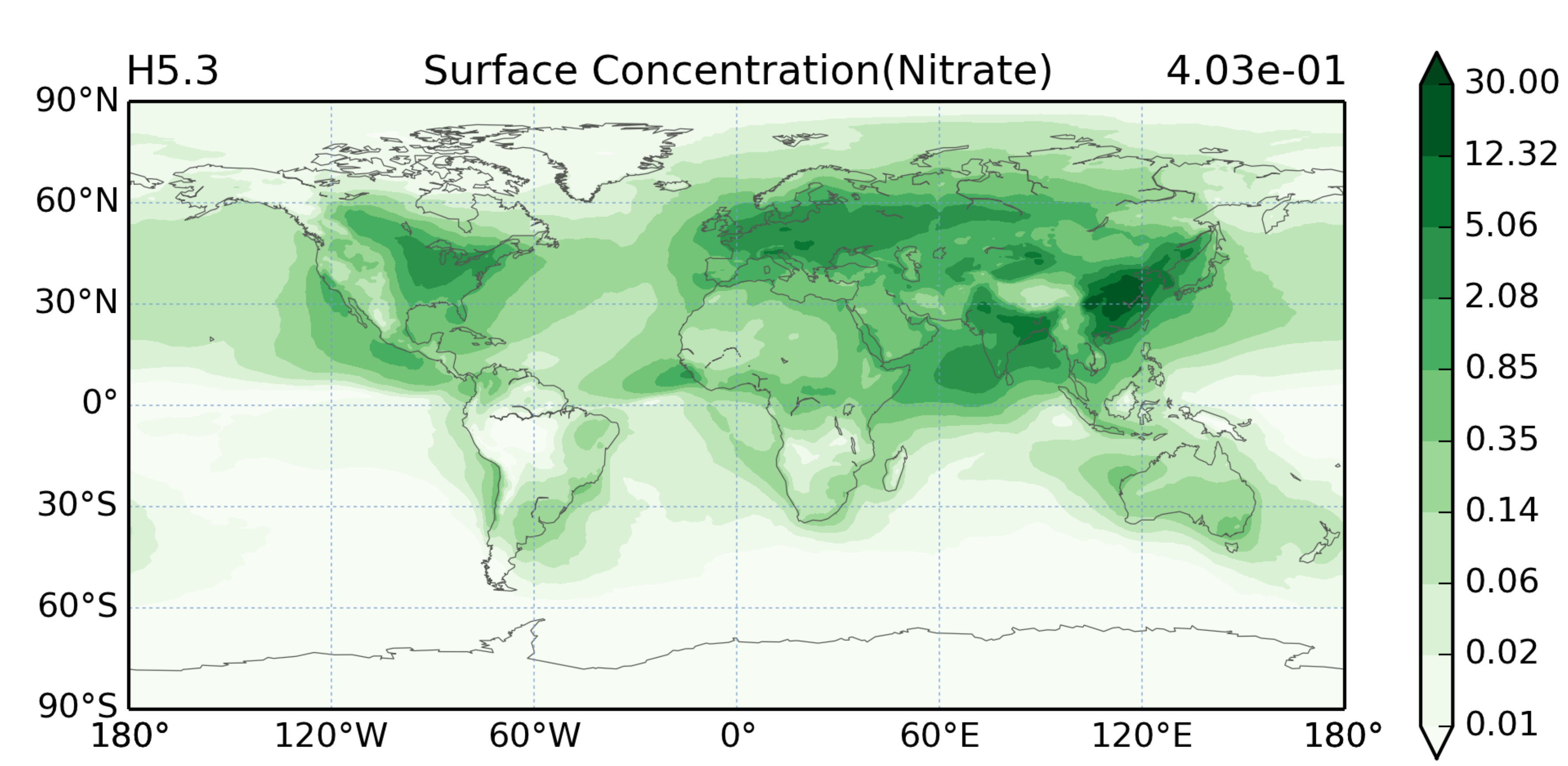
  inputs: RH, T, NHO3, Dust, Sea salt

  outputs: NO3an1, NO3an2, NO3an3
- Refractive indices of NH_4NO_3 from Lacis et al., (1997)



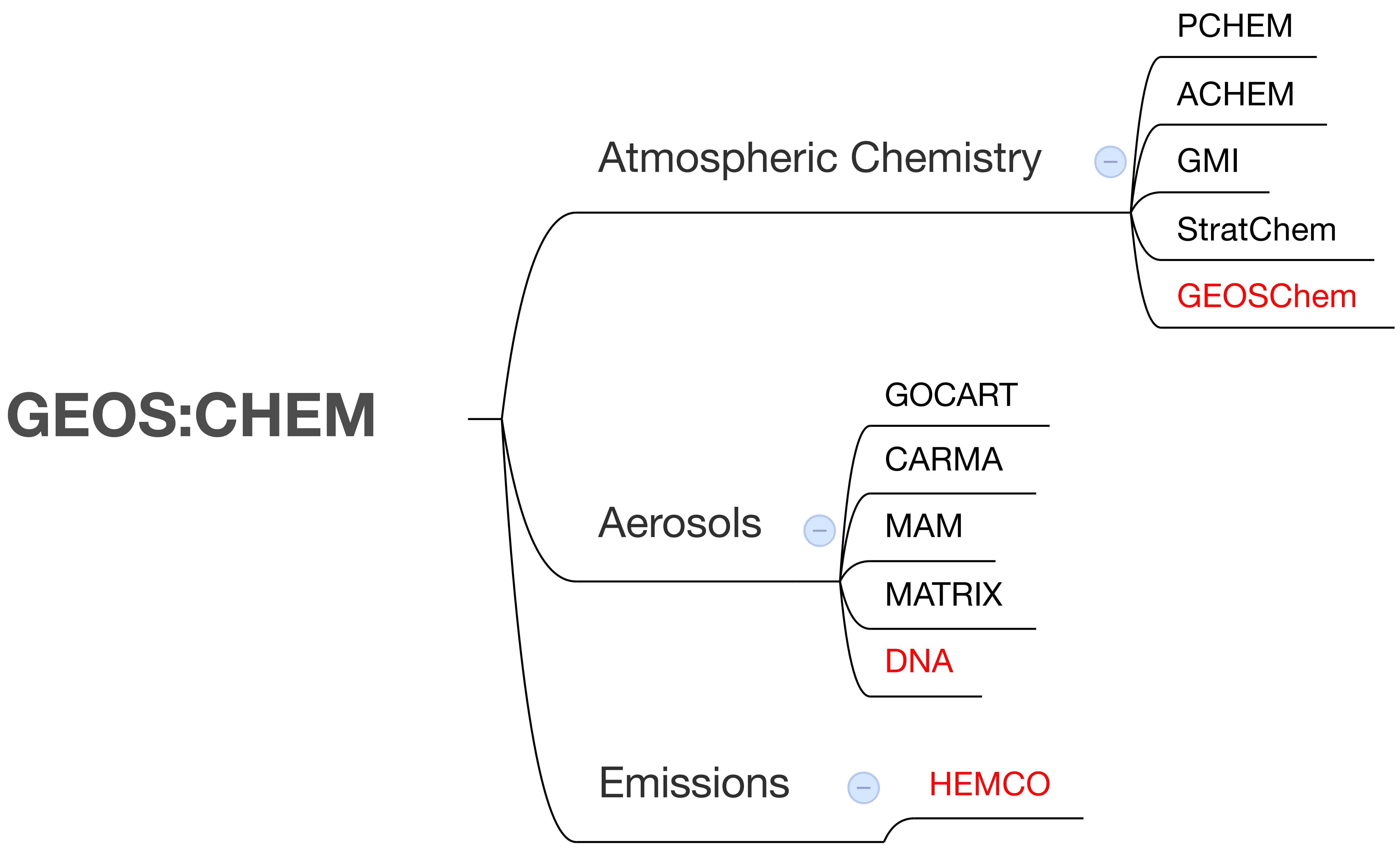






New GEOS:CHEM components

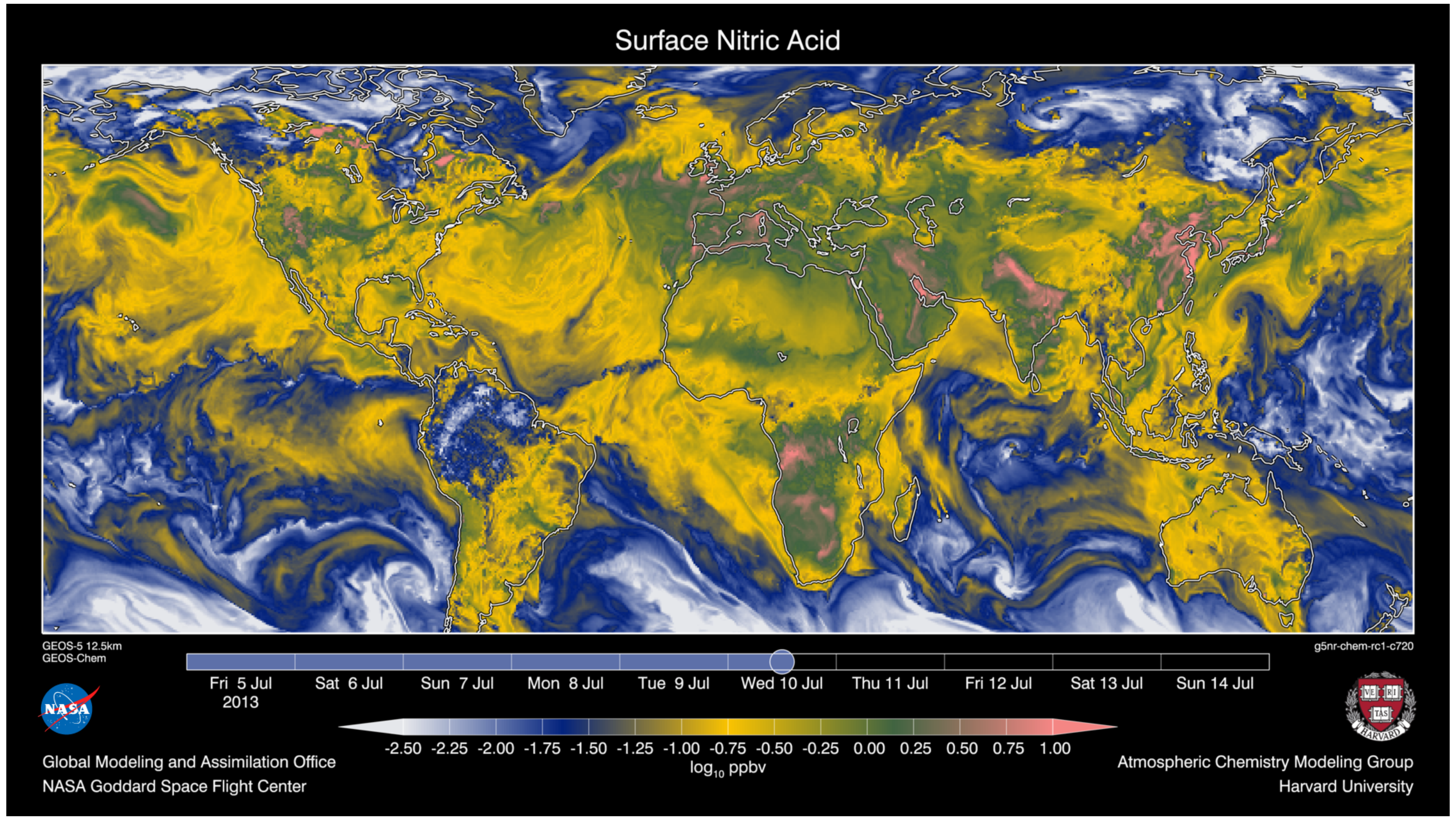
- **GEOSChem** - online version of the GEOS-Chem community model (3D atmospheric composition)
- **HEMCO** - flexible grid independent emission component controlled by a configuration file:
    - ➡ MEGAN-v2.1
    - ➡ Impose weekly and hourly cycles on temporary coarse emissions
    - ➡ Overlay emissions from different datasets
- **DNA** - a component that can be used to specify aerosol radiative properties from archived model output enabling model inter-comparison or sensitivities studies

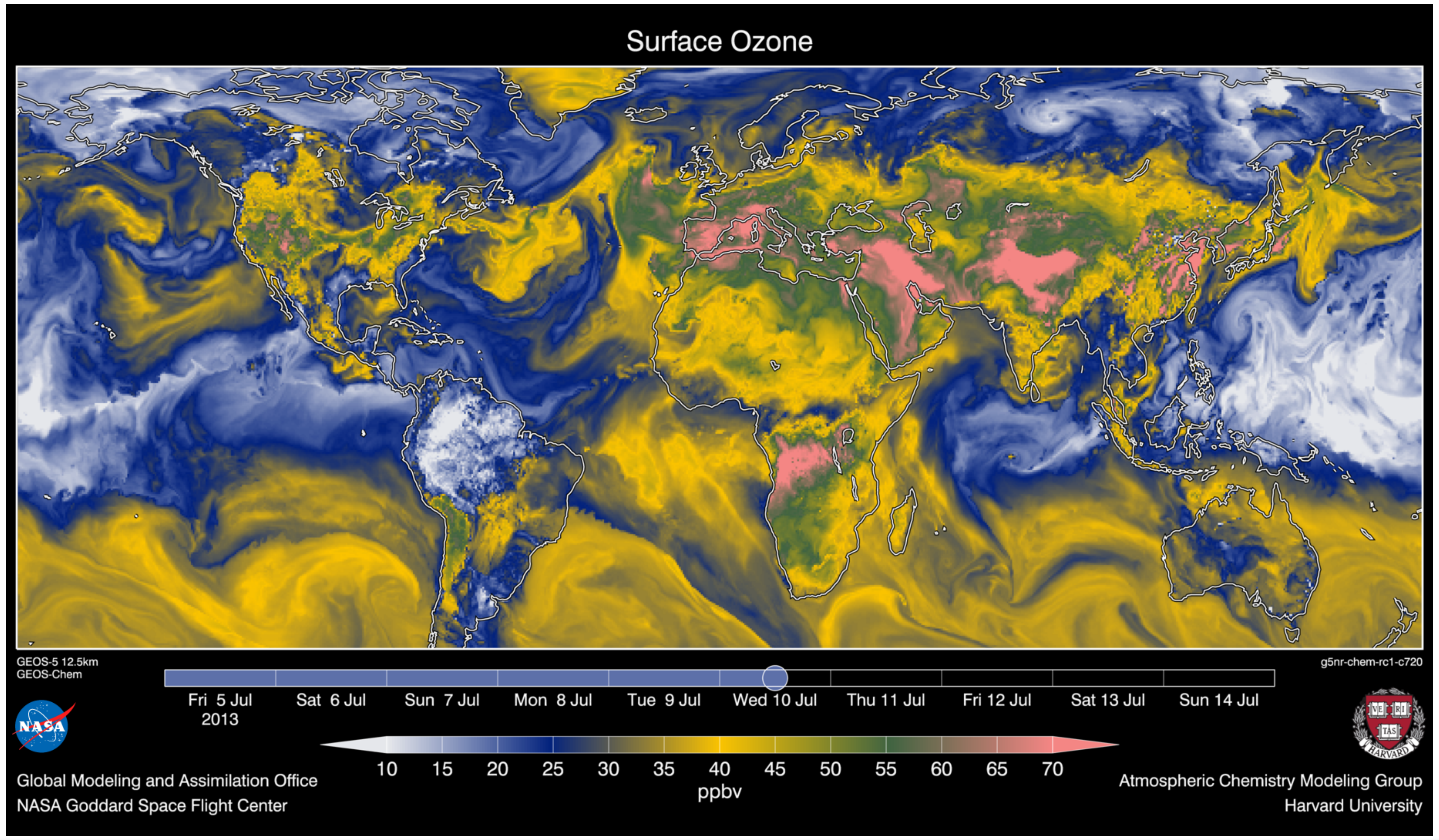


The GEOS-5 Nature Run with full chemistry

Objective: Provide realistic chemical state for OSSEs (geostationary atmospheric composition satellites TEMPO, GEMS, SENTINEL-4)

- Atmospheric chemistry (run passively) is modeled with the online GEOS-Chem component
- Aerosols are modeled with GOCART
- Replay meteorology from the MERRA2 dynamical downscaling run
- Resolution: 12.5 km, 72 levels
- Period: July 2013 - July 2014 (SEAC4RS, DISCOVER-AQ)
- Output is being produced at 2880x1441

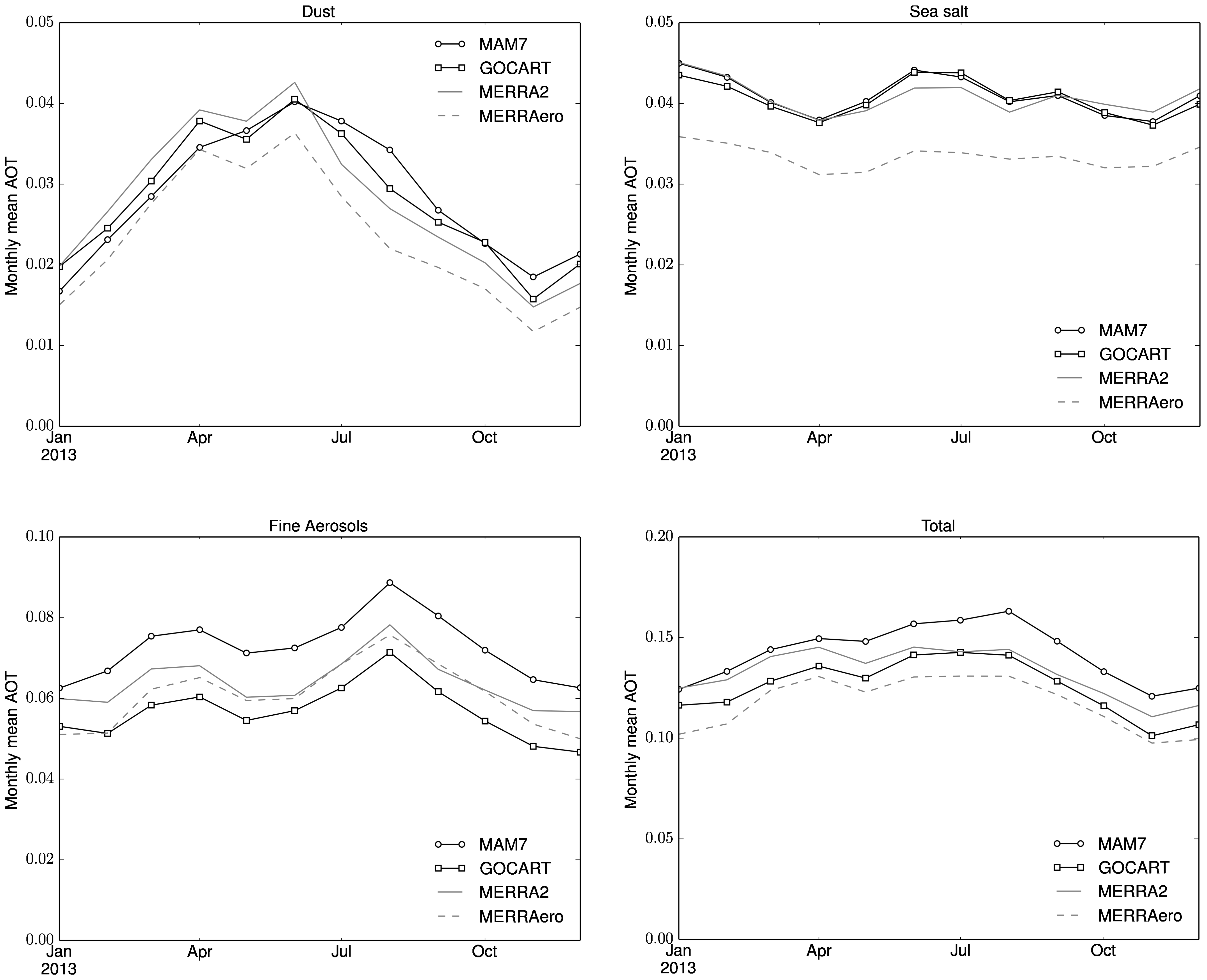




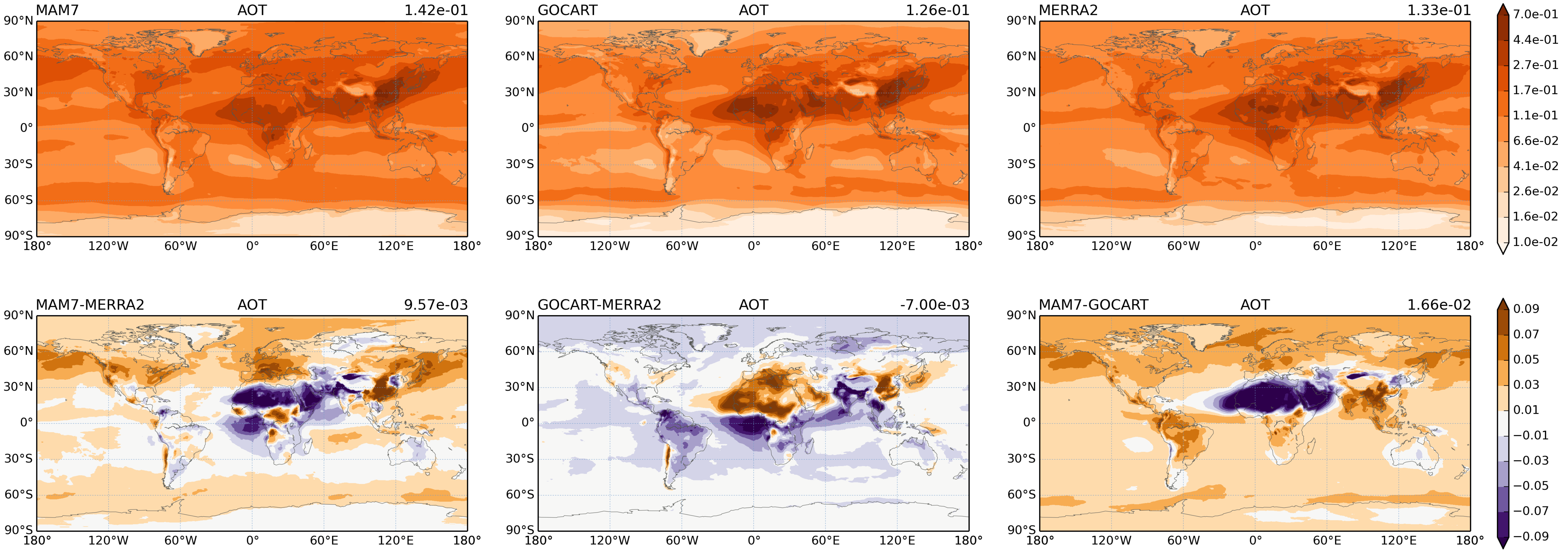
Coupled aerosol-clouds-radiation experiments with GEOS/MAM7

Objective: Compare aerosols and clouds from GEOS-5/MAM7 and GEOS-5/GOCART runs

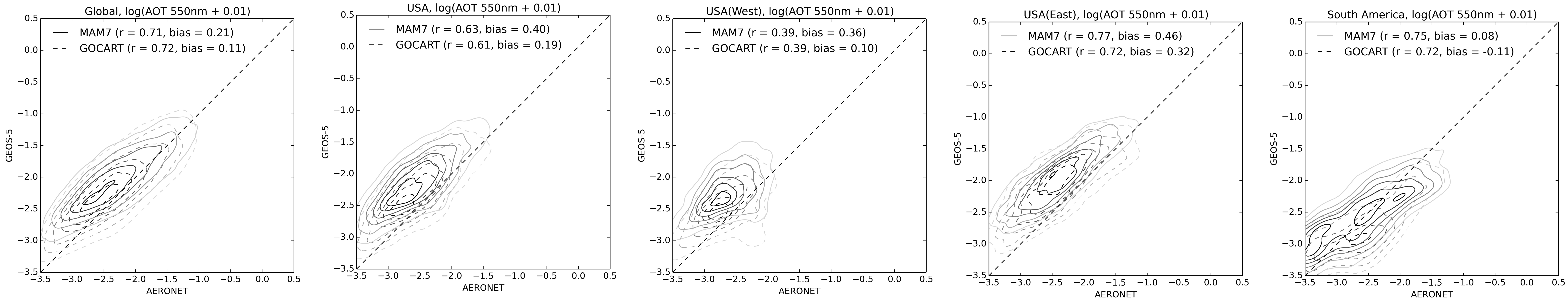
- Aerosols are coupled with the radiation and with the 2-moment cloud microphysics.
- Strength of sea salt and dust emissions are tuned to match MERRA2 sea salt and dust aerosol optical thickness.
- Replaying MERRA2 meteorology of 2013.

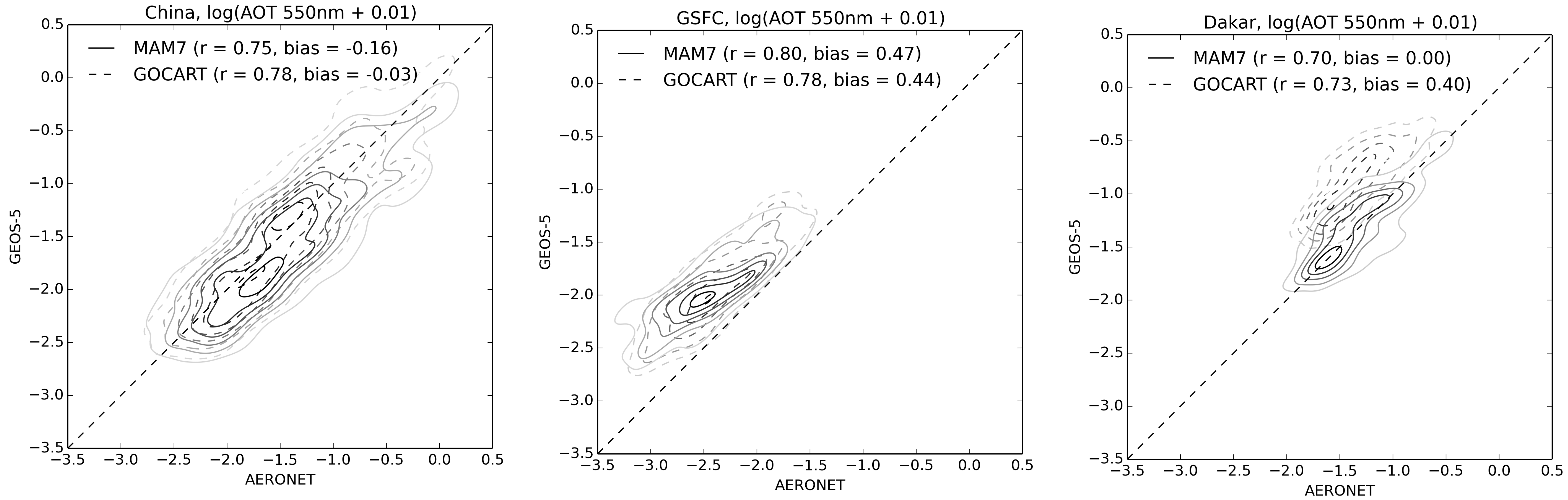


Aerosol optical thickness



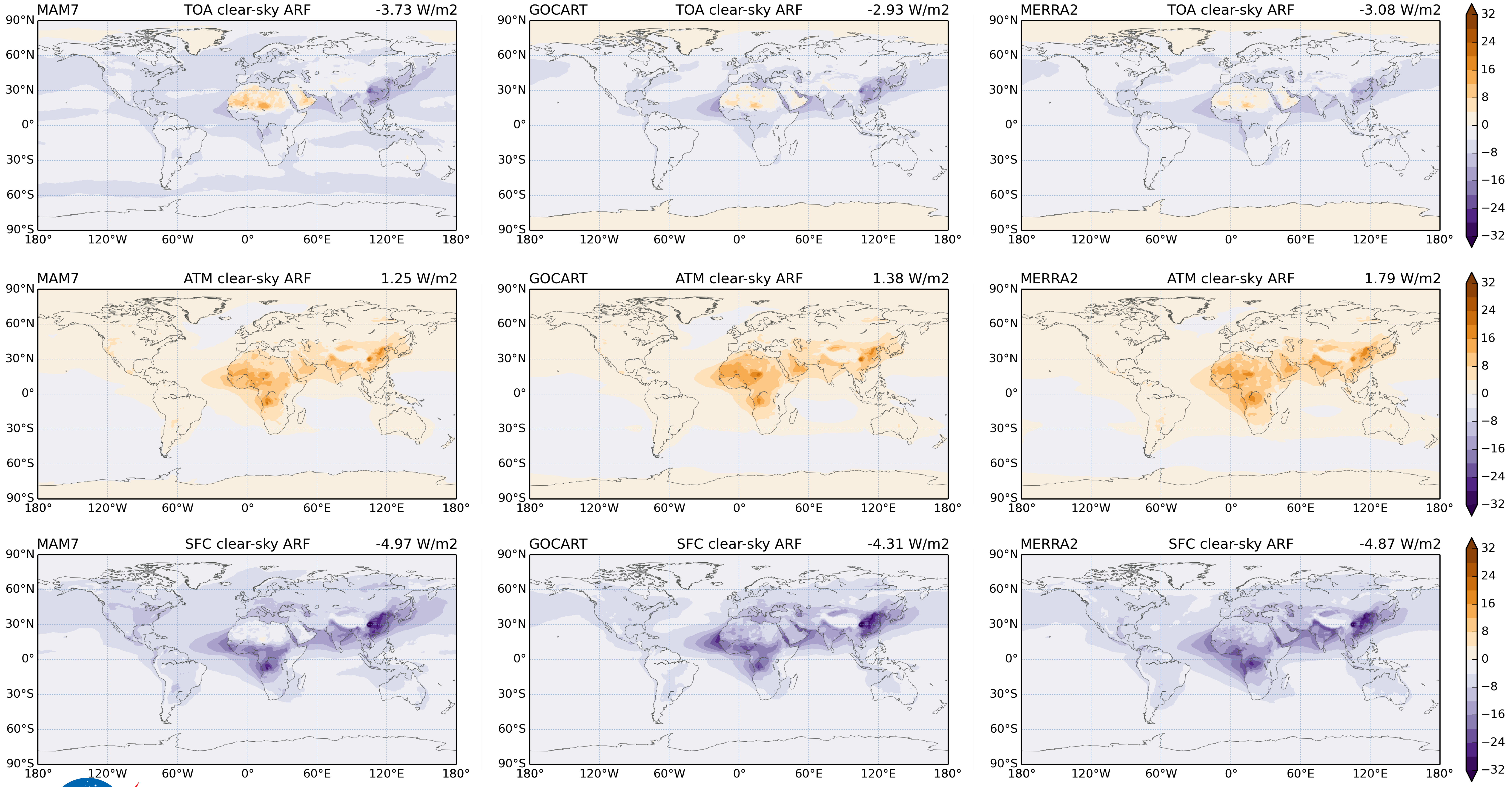
Comparison with AERONET





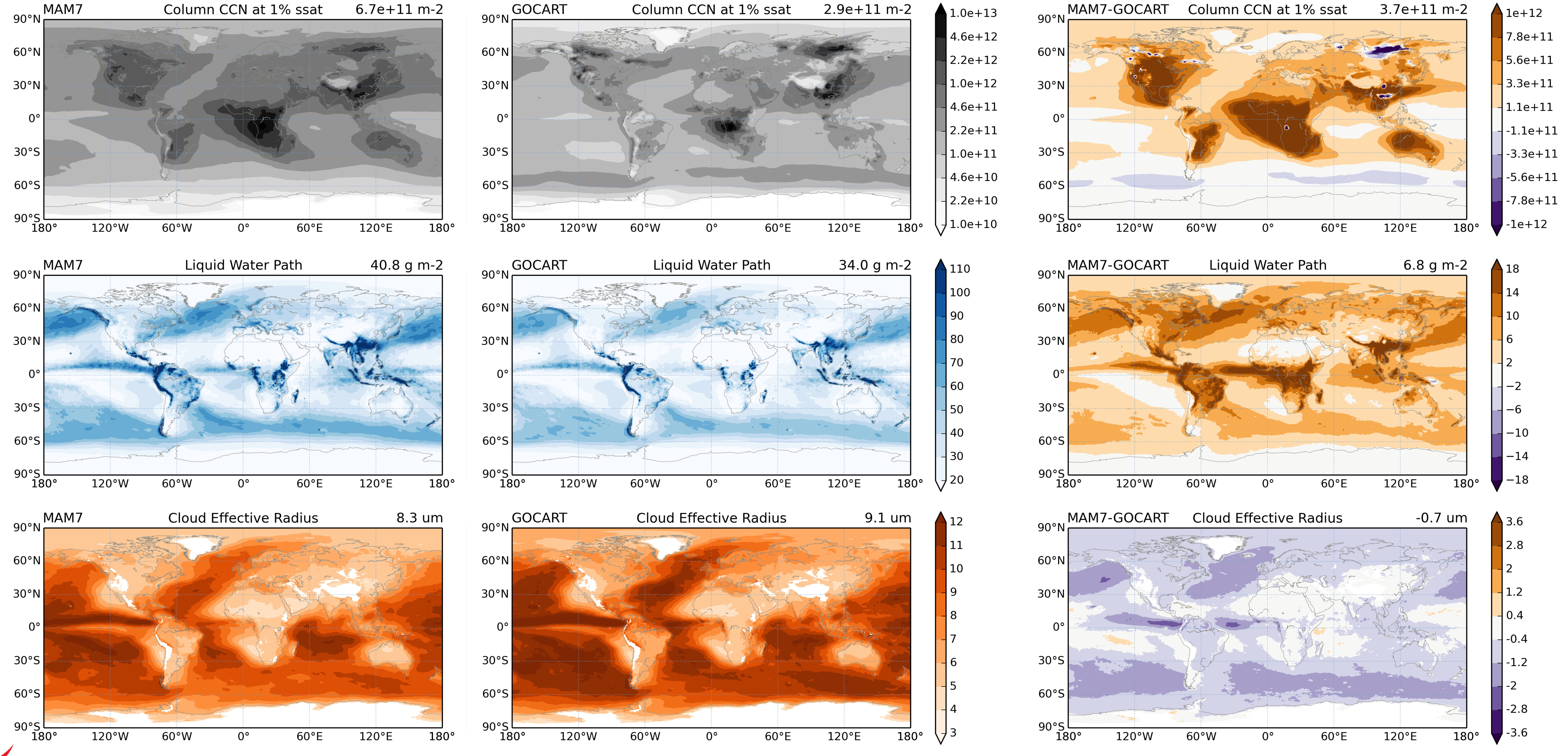
- In respect to MERRA2, MAM7 AOT is biased high globally, whereas GOCART is biased low.
- AOT from the MAM7 experiment is higher than the GOCART results except for regions dominated by dust. The difference in the dust AOT is due to the assumed refractive indexes and size distributions in the two aerosol models.
- Comparison with AERONET showed that MAM7 and GOCART are correlated well with the observations. sad

Clear-sky aerosol radiative forcing

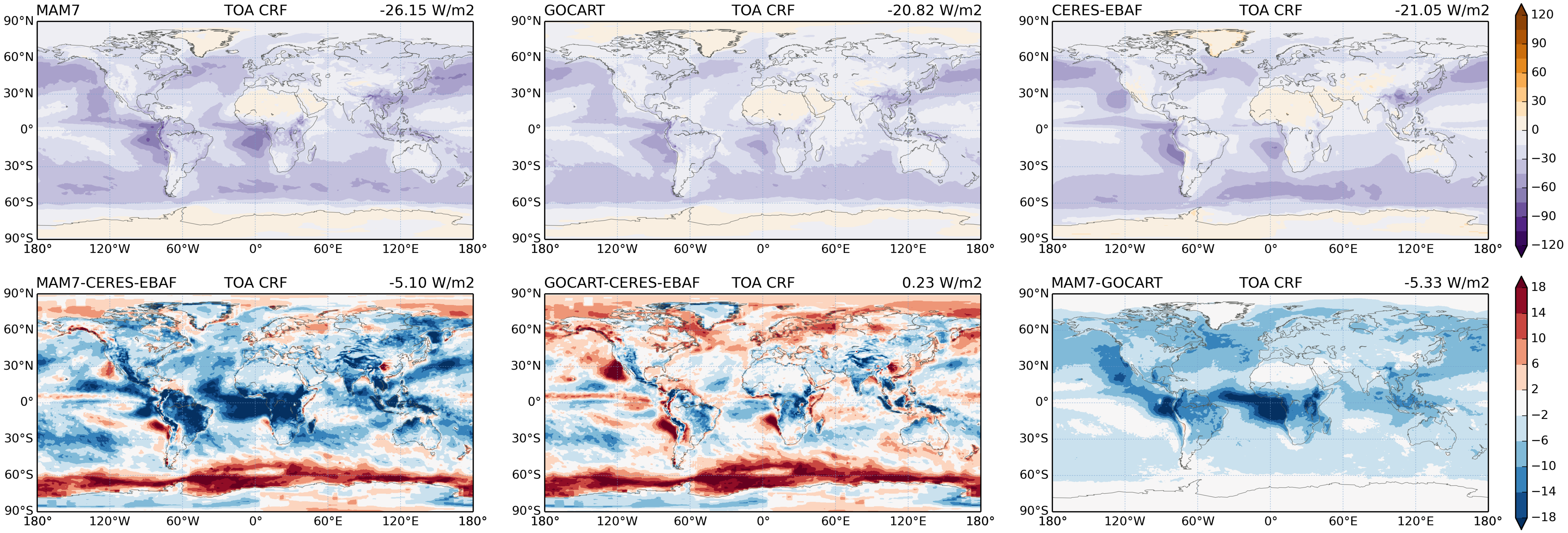


- MAM7 aerosols have stronger than GOCART clearsky shortwave and longwave forcings at TOA with global net difference of about -0.8 Wm-2.
- MAM7 shortwave forcing at TOA is underestimated but agrees better with previously reported global estimates of -5±0.2 Wm-2 than the GOCART results.

Aerosol effects on clouds



Cloud radiative forcings - comparison with CERES-EBAF climatology



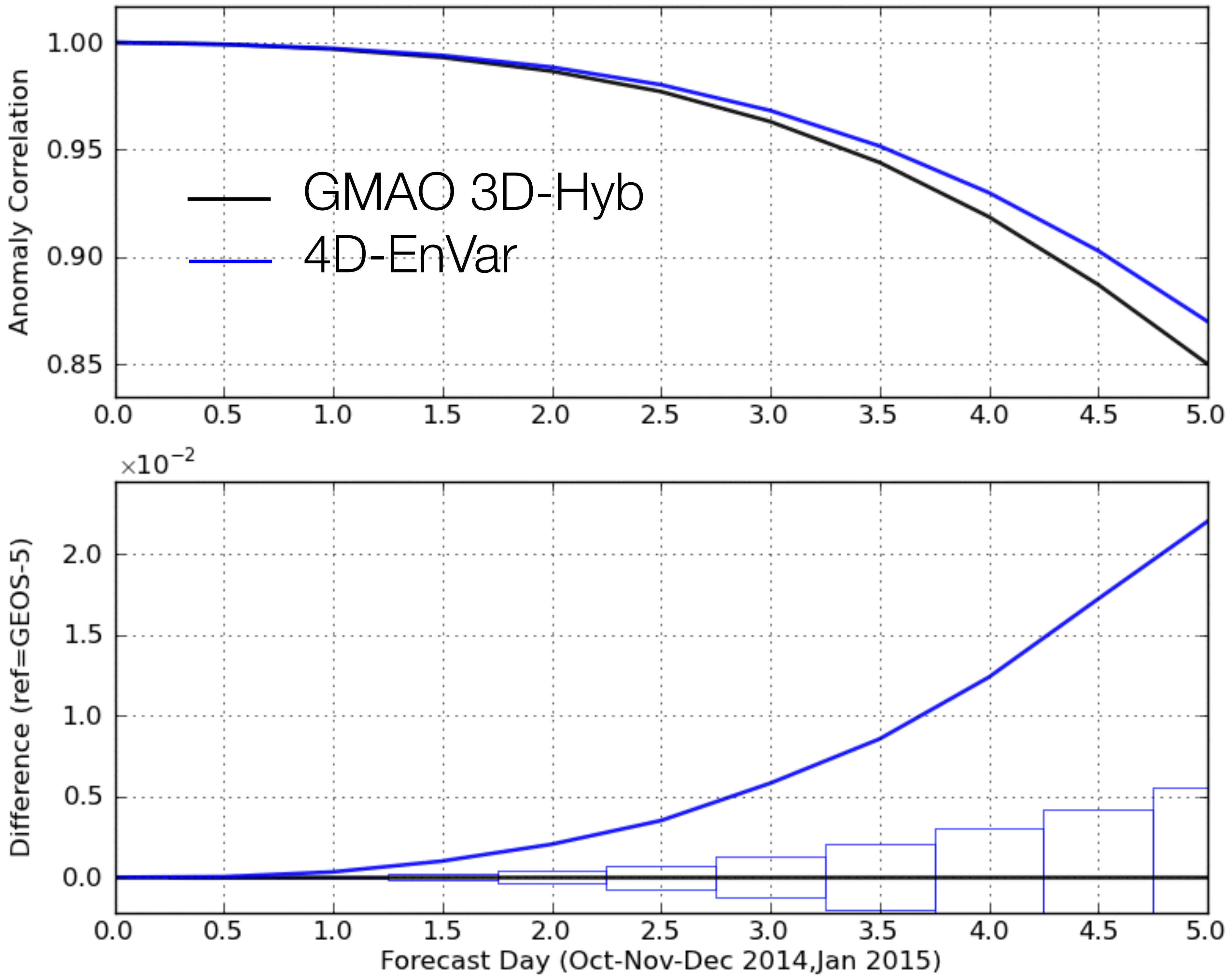
Brighter clouds in the MAM7 simulation lead to bias of -4.5 W m-2 in the shortwave forcings at TOA.

Planed upgrade to the GEOS NRT system

3Q-2016

- GEOS **4D-EnVar**
- GCM: **C720** L72 (**12.5 km**)
- ANA-**EnVar**:**1152x721** L72 (**25 km**)
- 3D-EnKF: 32x**576x361** L72 (**50 km**)
- 2D PSAS Aerosol Analysis
- **FVCOR updates**
- **Semi-Coupled Skin SST Analysis**
- **GOCART**

500 hPa Height Northern Hemisphere, Oct 2014 – Jan 2015



The candidate NRT system has better forecast skill.

Ongoing work and future plans

NWP

Mature

- 4D EnVar + 4D IAU
- GSI 'split' observer (multi-resolution, OMF on native grid, …)
- Semi-coupled skin SST assimilation
- All-sky assimilation of MW radiances (imagers and sounders)
- Correlated observation error for hyperspectral IR
- EnKF update for aerosol analysis (formerly PSAS)
- EnKF update for skin SST analysis (formerly none)
- Aerosol effects on radiance assimilation (CRTM)

Trace gases

- Generalized trace gas assimilation capability
- STRATCHEM and GEOS-Chem for ozone assimilation

Land Surface

- Off-line EnKF (SMAP L4 soil moisture, carbon fluxes)
- Inline EnKF weakly coupled to GEOS

Aerosol analysis with EnKF update

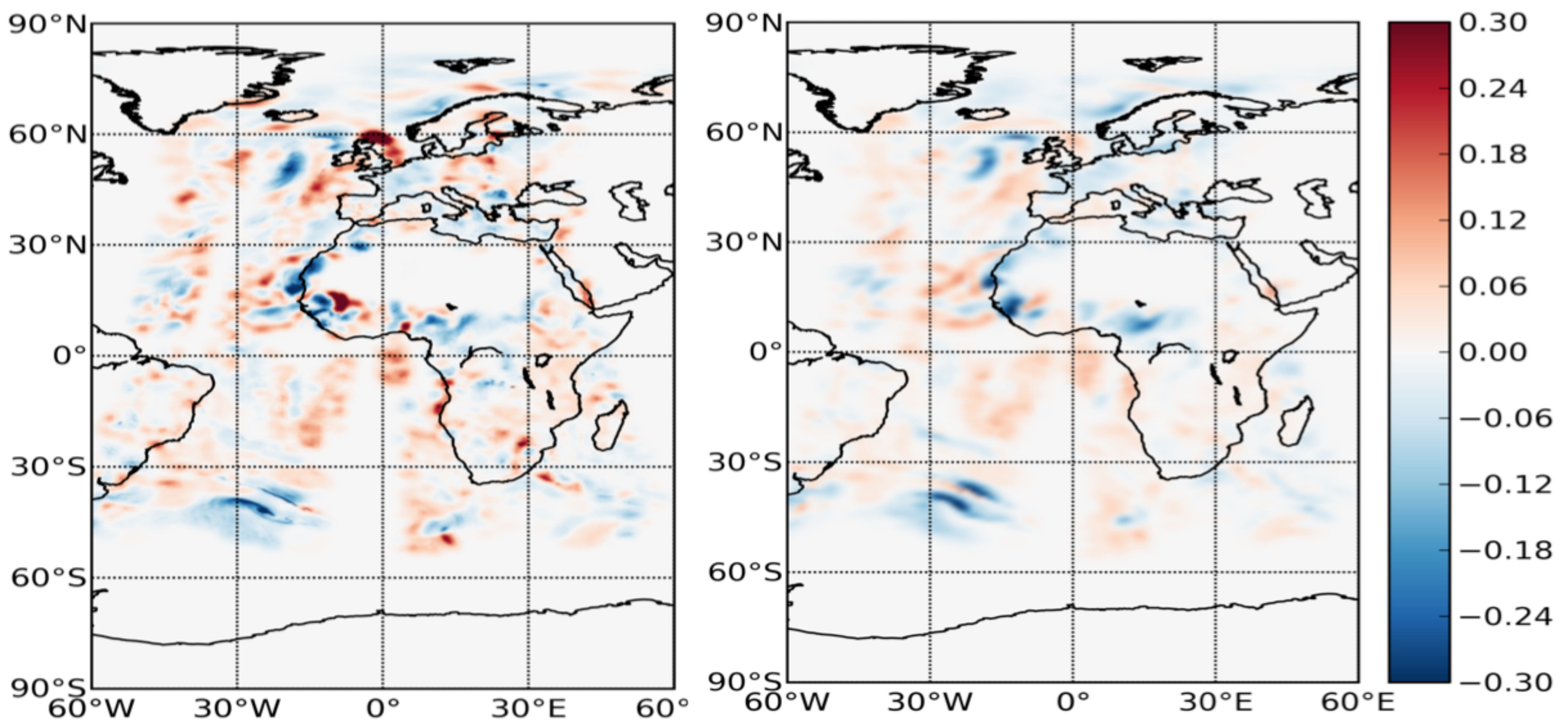
- GMAO is transitioning to an EnKF-based aerosol assimilation to enable use of 3D lidar observations from CATS and CALIOP, in addition to current 2D AOD observations from MODIS, MISR, AERONET

- Framework development advanced

- Assimilation of AOD in testing

GAAS AOD increment

EnKF AOD increment ensmean



Current GEOS GAAS (0.5°)

EnKF based on GEOS EnVar (1.0°)

EnKF-based scheme recovers the AOD increments at similar locations, however the smaller AOD increments suggest insufficient ensemble spread.

MERRA2: Documentation and Products

- Official data released via the NASA Goddard Earth Sciences (GES) Data Information Services Center (DISC):

  http://disc.sci.gsfc.nasa.gov/daac-bin/FTPSubset2.pl

  http://disc.sci.gsfc.nasa.gov/uui/#/search/%22MERRA-2%22

- Completed 1980 – present, now running as a continuing climate analysis with 2 – 3 week latency

- NASA Tech Memos documenting the MERRA-2 meteorological and aerosol validation exercise will soon be available at: http://gmao.gsfc.nasa.gov/pubs/tm/

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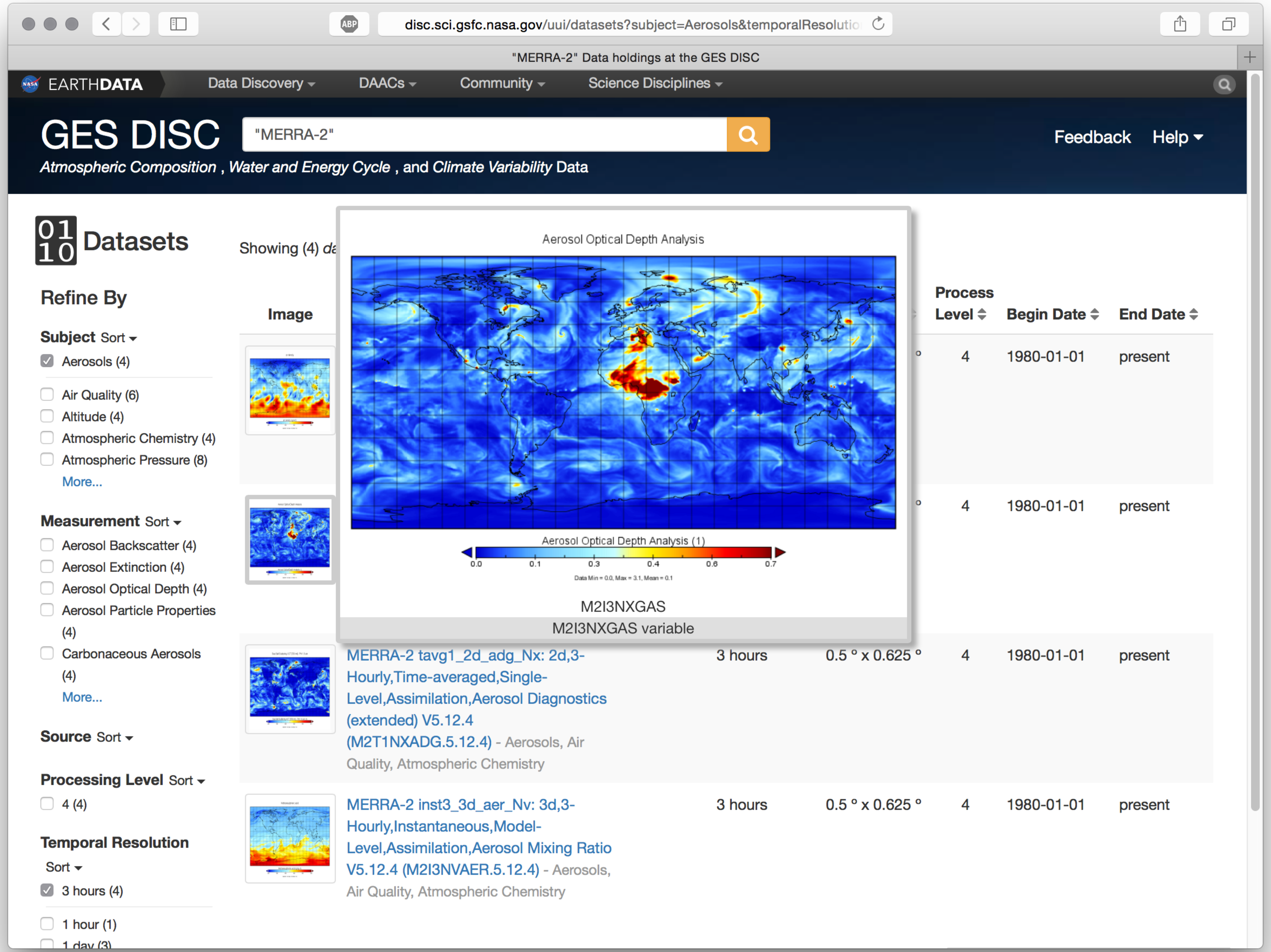

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Visualizations