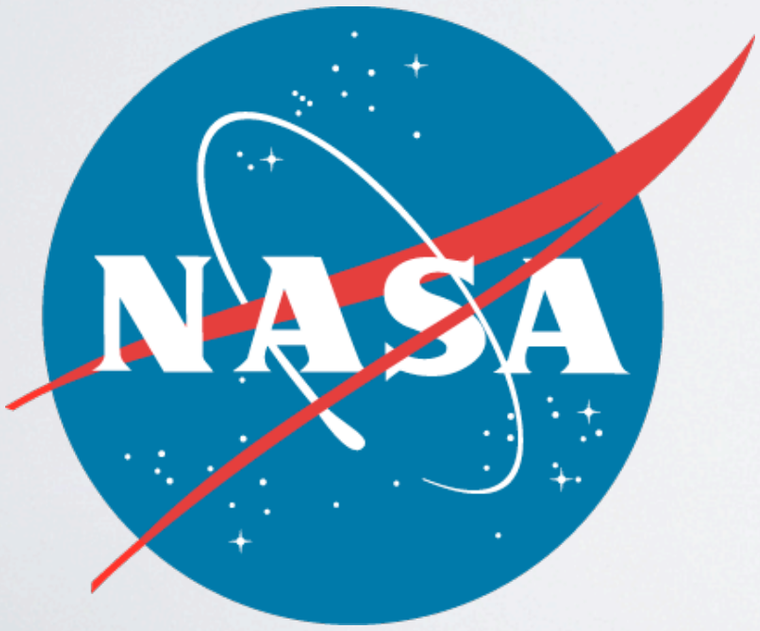
UPDATE ON THE NASA GEOS-5 AEROSOL FORECASTING SYSTEM



Peter Colarco[1], Arlindo da Silva[2], Anton Darmenov[2], Virginie Buchard[2], Cynthia Randles[1], Ed Nowottnick[3], Ravi Govindaraju[2]

[1]NASA GSFC, Atmospheric Chemistry and Dynamics Branch
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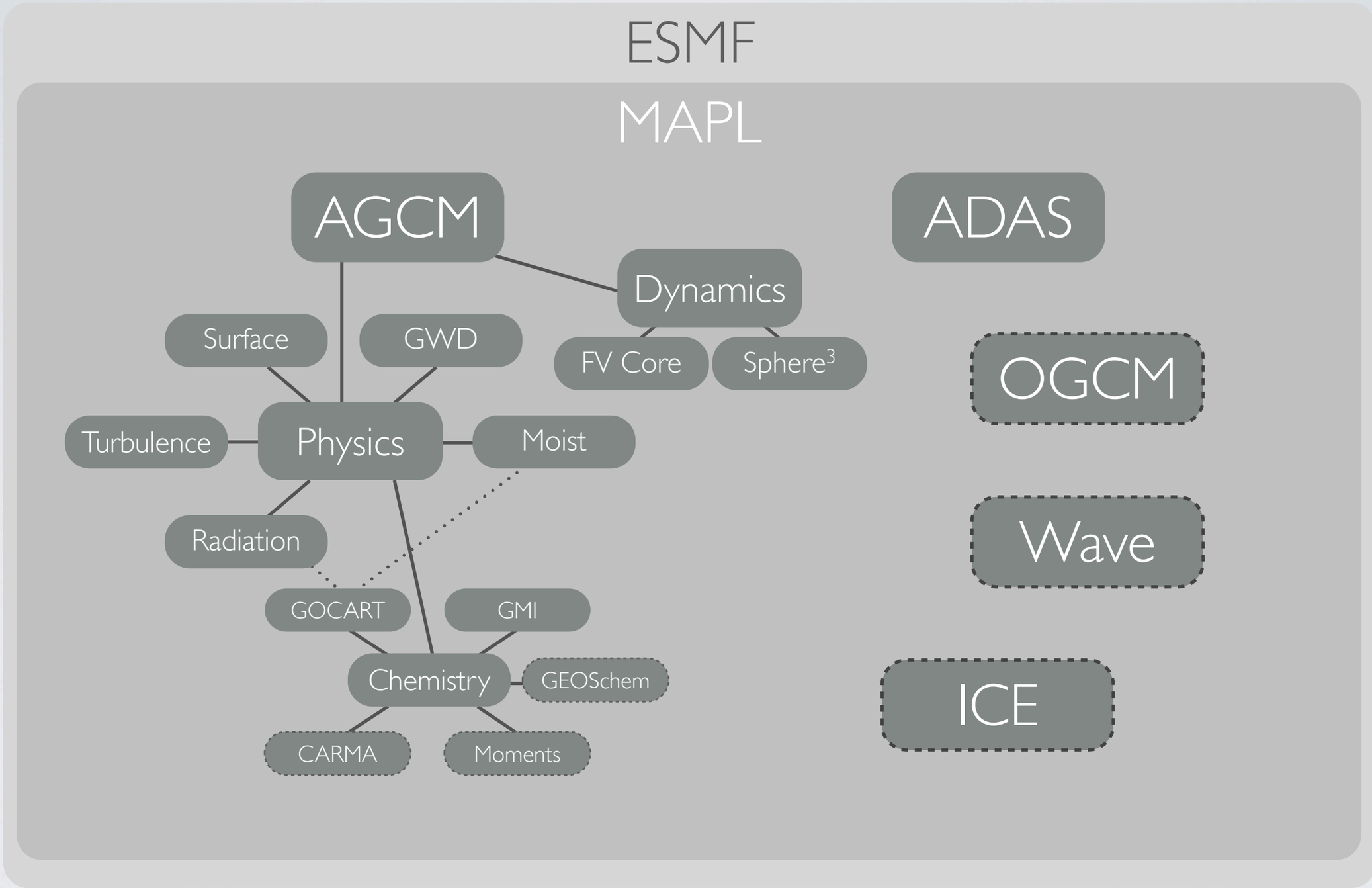
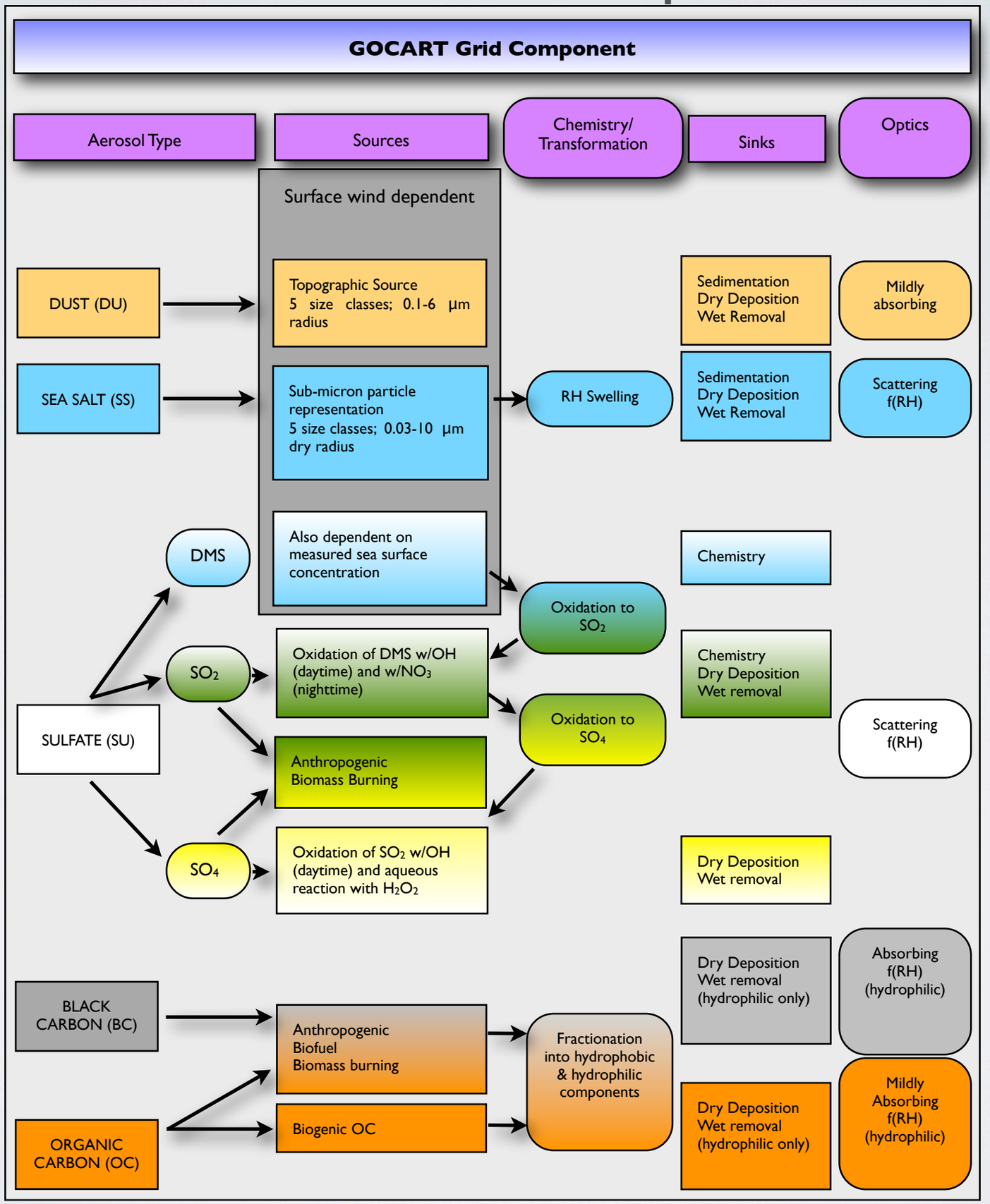
[3]University of Maryland, Atmospheric and Oceanic Sciences

GEOS-5 Structure



NASA GMAO is the model custodian
NASA ACDB collaborates with GOCART, GMI components
NASA ACDB/CU/NCAR collaborates with CARMA components
NOAA collaborates with ADAS

Aerosol Component



Recent Developments

1. Improved NRT biomass burning emissions
2. Model evaluation
3. Aerosol assimilation
4. Satellite simulator

Recent Developments

1. **Improved NRT biomass burning emissions**
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Quick Fire Emission Dataset (QFED)

- NRT estimates of biomass burning based on MODIS products
- Earlier version calibrated against GFEDv2 inventory using fire detections (hot spots) or fire radiative power (FRP)
- Newer version uses FRP and determines separate emissions per biome (possibly multiple biomes per grid box):

$$E_{species}(x,y,t) = \sum_{biome} C_{biome,species} \cdot FRP(x,y,t,biome)$$

- Biomes from high resolution (~1 km) data set

  tropical forest, extratropical forest, savanna, grasslands

- Tuning is relative to older GFEDv2 calibrated emissions via suite of model runs, where AOT is decomposed by component and compared to MODIS AOT:

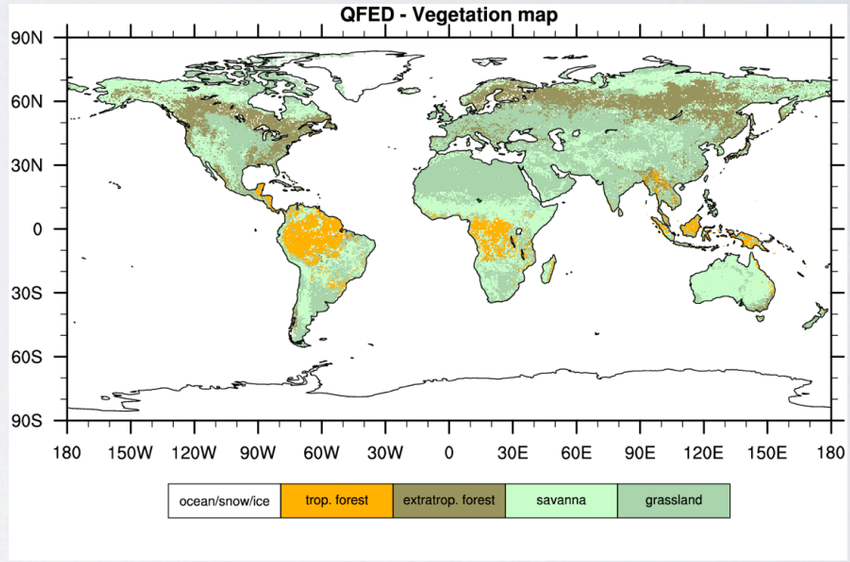
$$\tau_{obs} = \alpha_{BB}\tau_{BB} + \tau_{dust} + \tau_{seasalt} + \tau_{anthro} + \tau_{etc} + \ldots$$

  where

$$\alpha_{BB}\tau_{BB} = C_{TF}\tau_{TF} + C_{XF}\tau_{XF} + C_{S}\tau_{S} + C_{G}\tau_{G}$$

- Separate tuning for Aqua and Terra (redundancy)
- Final product is merged sensor 0.25° daily emissions of:

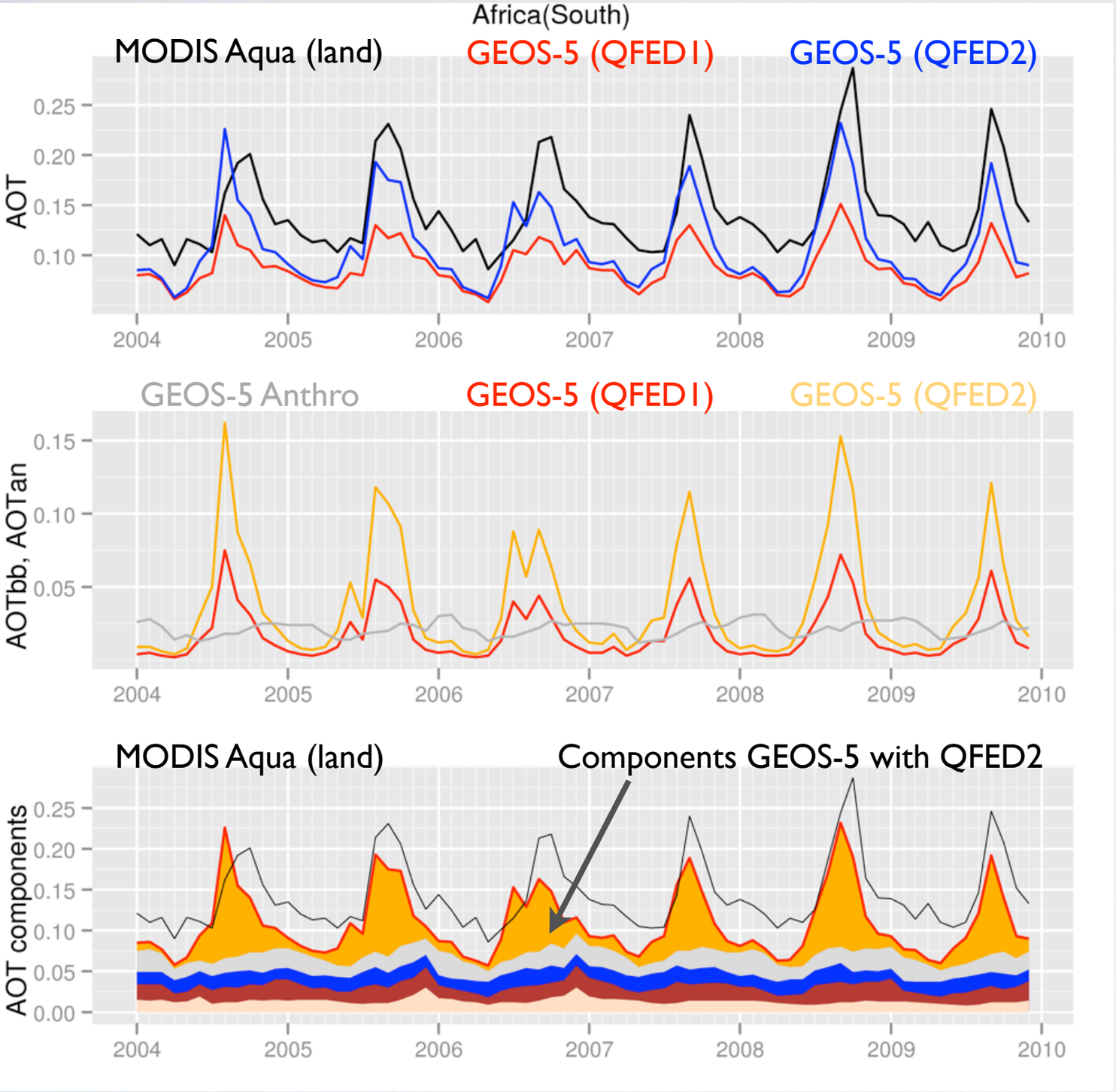
BC, OC, SO_2, CO, CO_2, $PM_{2.5}$

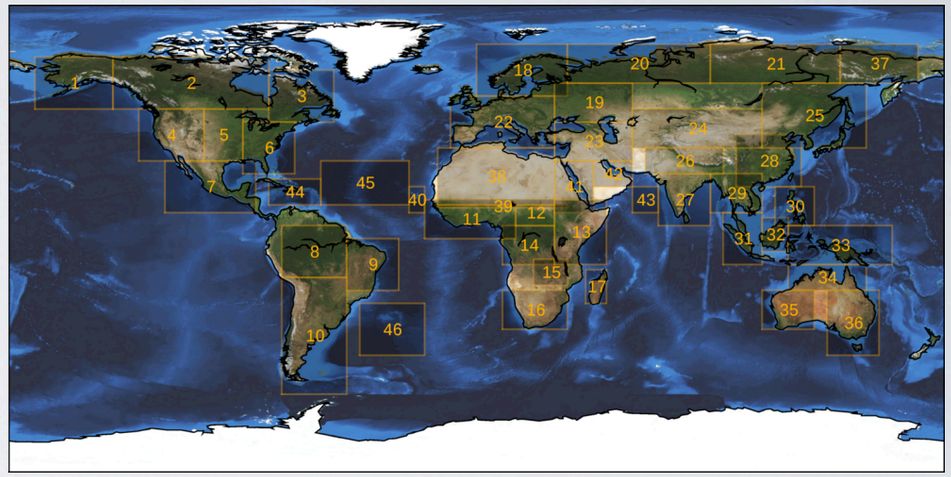


Biome	C
Tropical Forest	2.5
xTropical Forest	4.5
Savanna	1.8
Grassland	1.8

Tuning relative to QFED1

QFED Tuning





- QFEDv1 (and predecessor GFED) emissions led to anemic biomass burning AOT in model
- Simulations w/ and w/out specific biome biomass burning emissions used to tune QFED2
- Results are looked at systematically over ~ 40 regions
- Approach has greatly improved fidelity in regions where biomass burning is dominant over dust

Recent Developments

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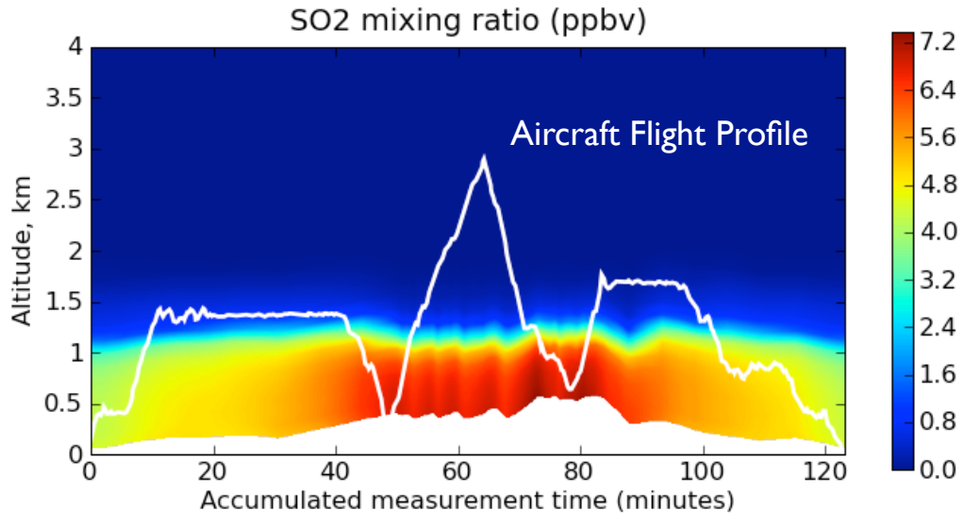
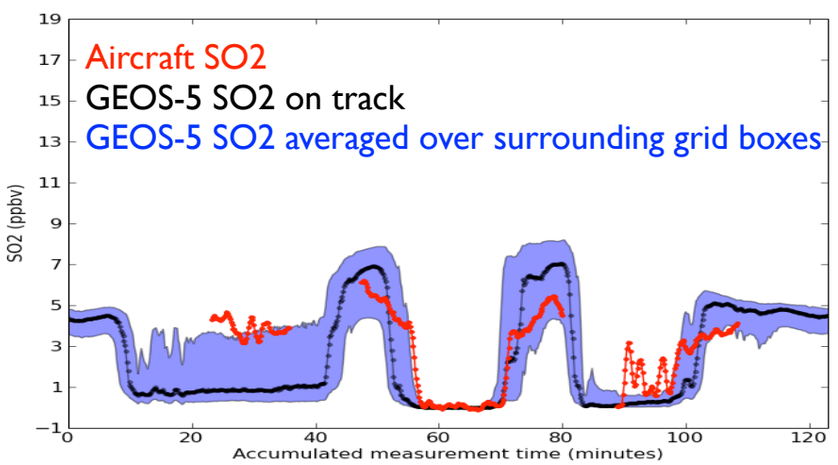
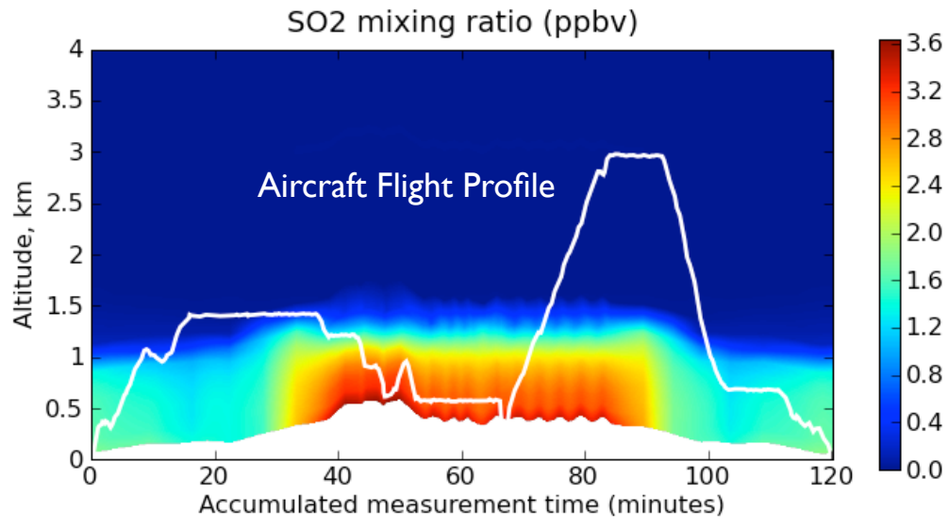
SO2 Comparisons to Aircraft

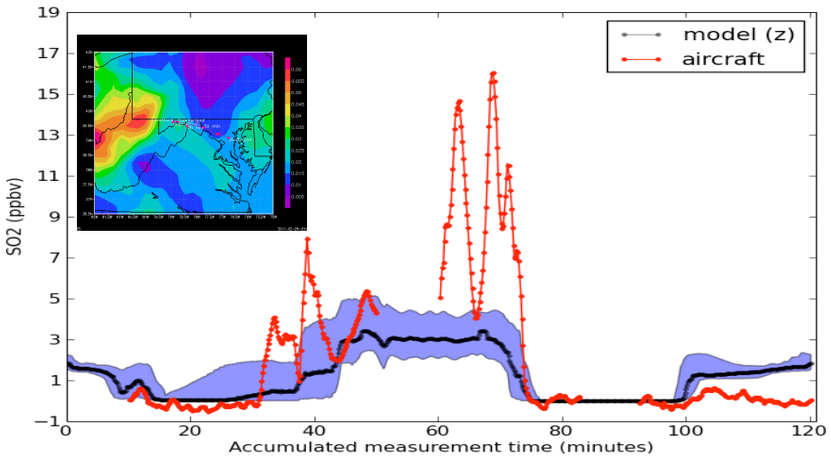
Nov. 8, 2010





Nov. 9, 2010





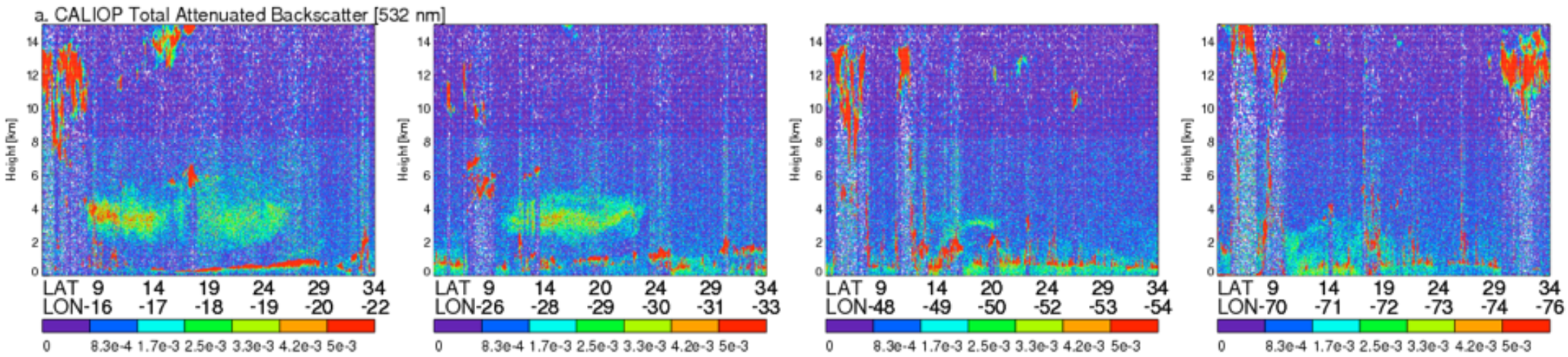
Aircraft data from the URF Cessna 402B provided by Jeff Stehr et al. (UMCP)

Evolution of Saharan Dust Event

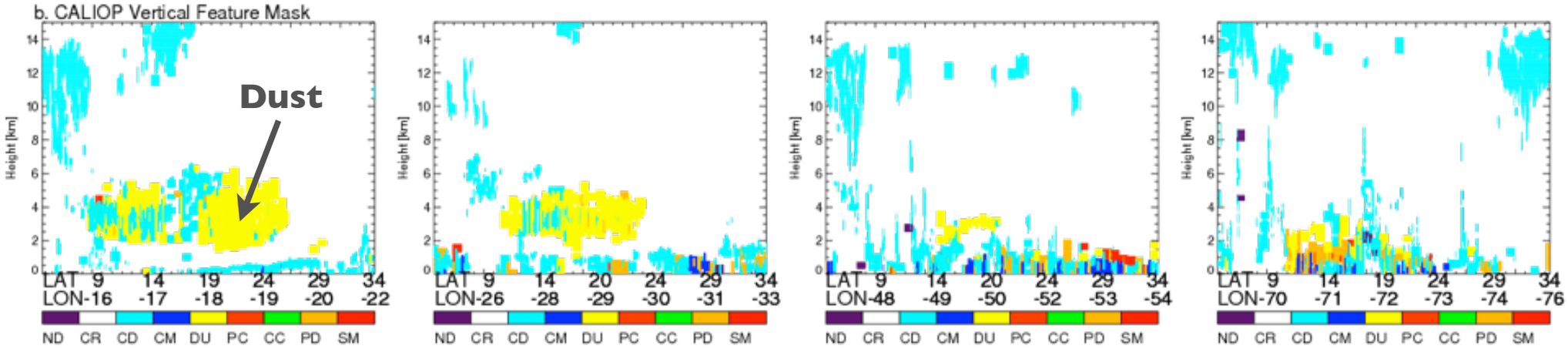
Africa → **Central America**

July 14, 2007 | July 15, 2007 | July 17, 2007 | July 19, 2007

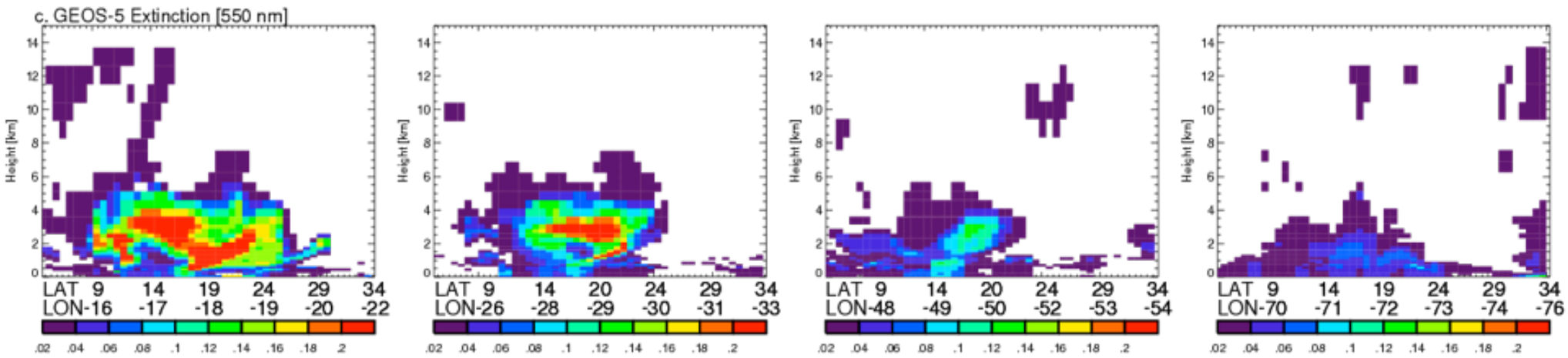
CALIOP Backscatter



CALIOP Feature Mask



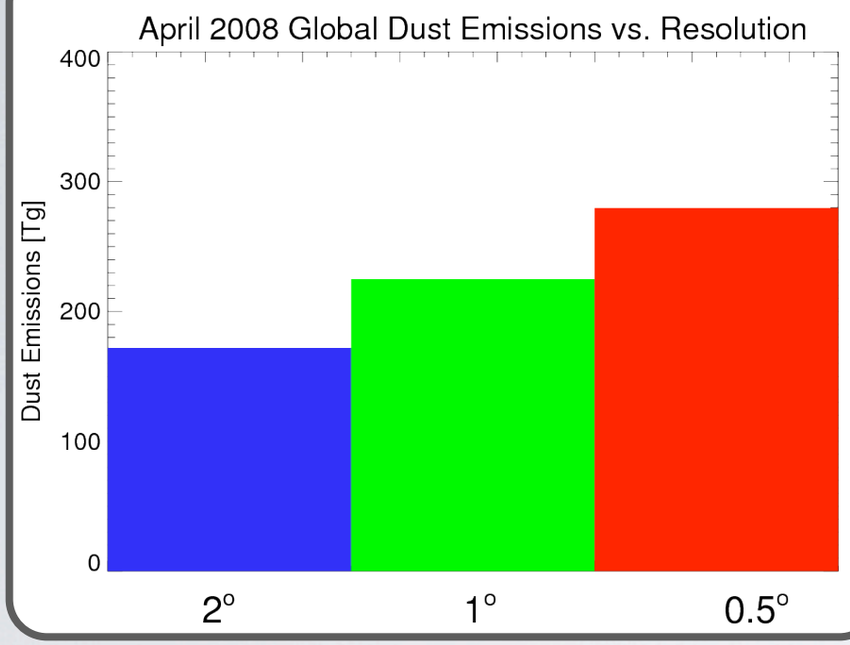
GEOS-5 Extinction



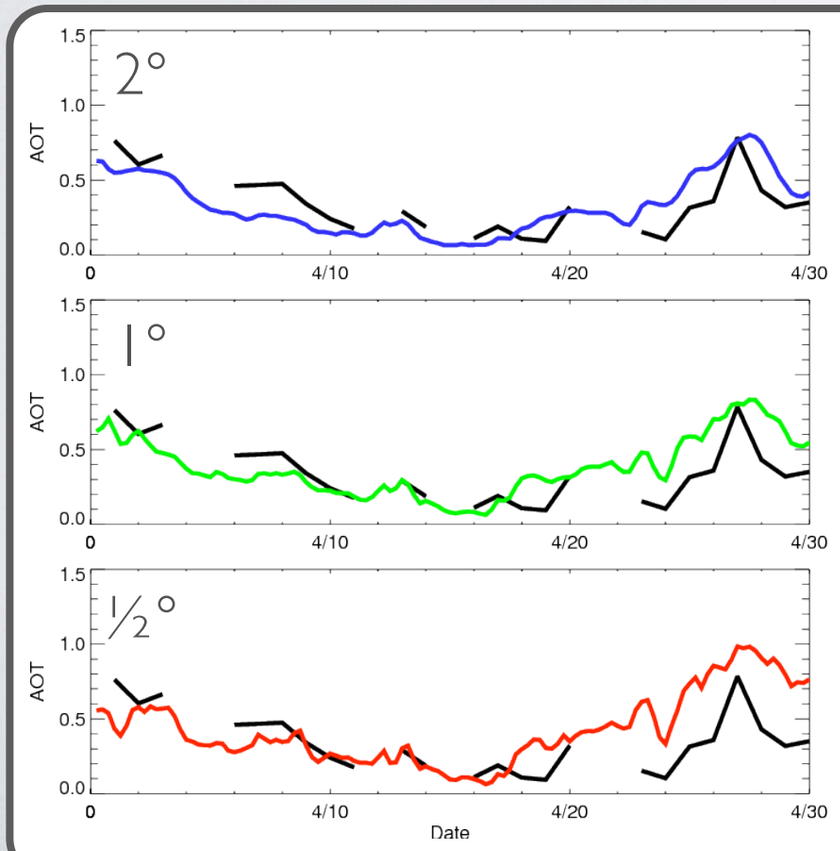
Ed Nowottnick, submitted to ACPD

Impact of Model Resolution

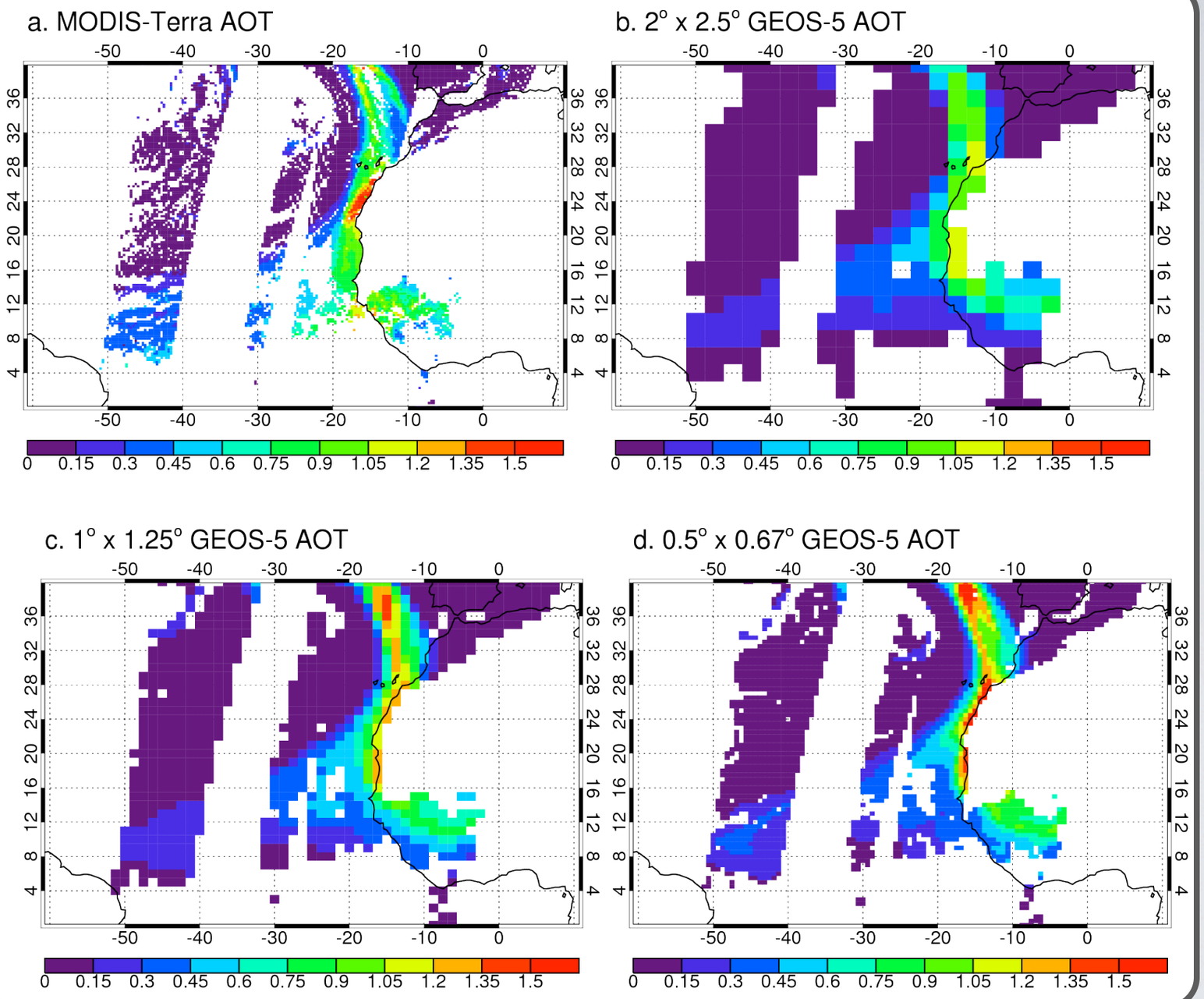
1. Global Dust Emissions



2. AOT Time Series at Capo Verde

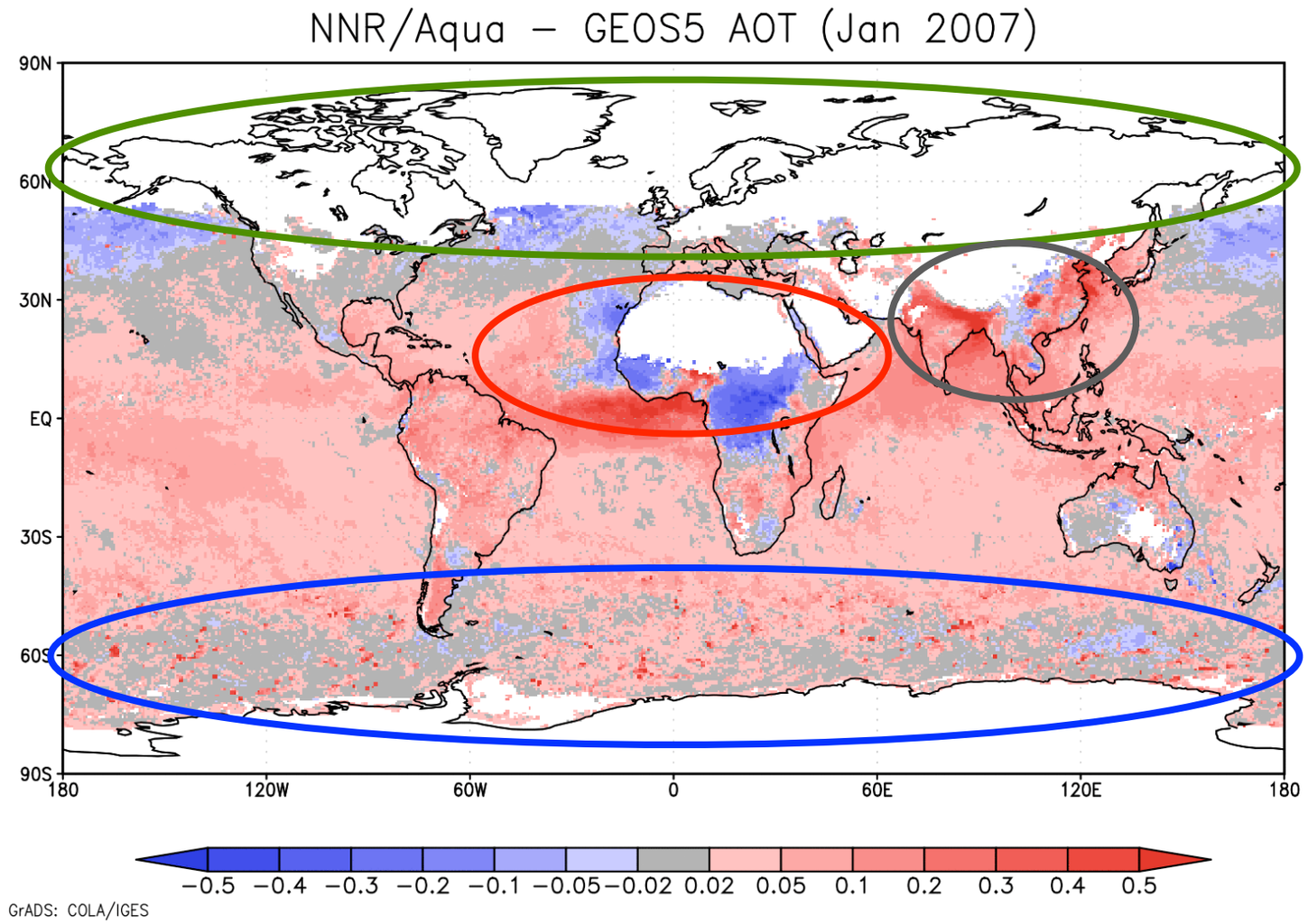


3. A Saharan Dust Event on 4/4/2008



- Computational costs dictate that most model tuning is done at coarse spatial resolution
- Operational systems run at higher spatial resolution

Baseline Replay Simulation



Model has

- High bias in African dust
- High bias in Southern Ocean
- High bias in autumn NH AOT; somewhat low bias in spring
- Low bias in Asian anthropogenic

- Global 0.5° x 0.625° replay from MERRA analyses
- QFED2 biomass burning emissions
- EDGAR4.1 SO_2 anthropogenic emissions
- Other inventory emissions from AeroCom

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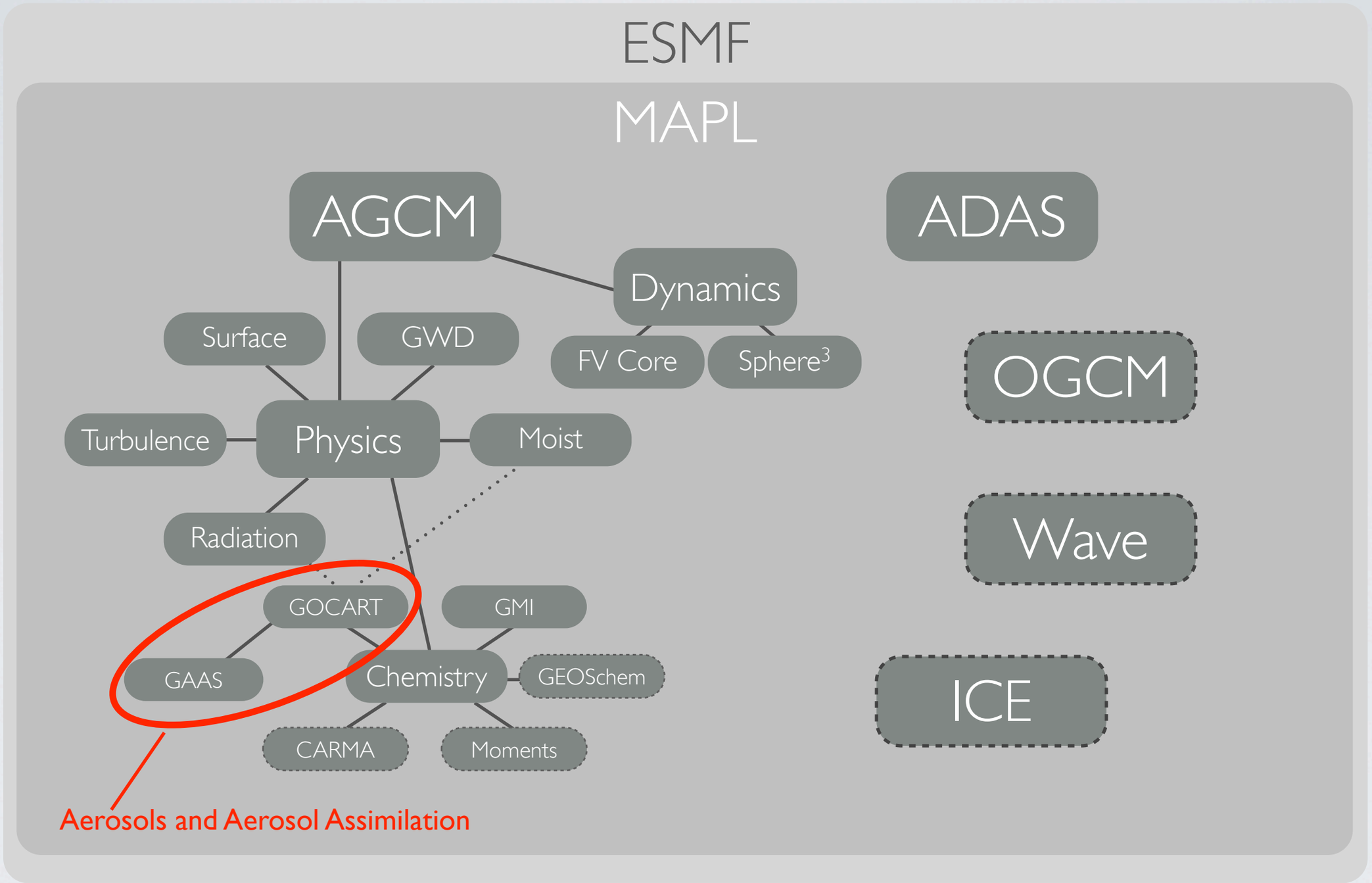
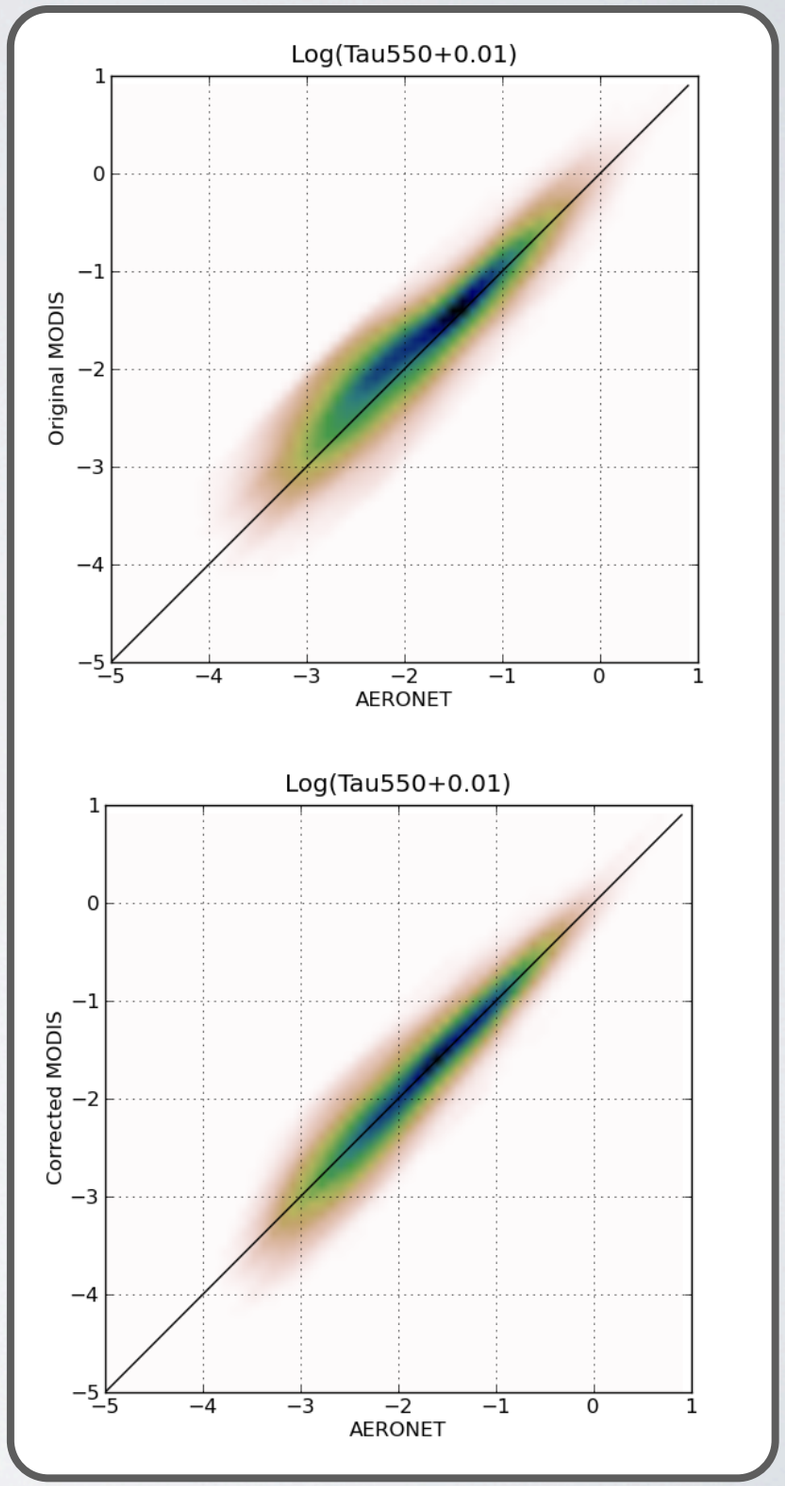
GEOS-5 Structure



Quality Control MODIS AOT

- MODIS AOT product has errors and biases
- A new AOT is developed by training a neural net based retrieval (NNR)
- Predictors are (at MODIS L2 retrieval points):
  - MODIS TOA radiances
  - Viewing geometry
  - Glint angle (ocean)
  - Cloud fraction
  - Wind speed (ocean)
  - Surface albedo (land, climatological)
- Target is historical co-located AERONET record of AOT (log-transformed to normalize statistics)
- Product is 8 x day, 0.25° 550 nm AOT (Aqua/Terra, Land/Ocean)

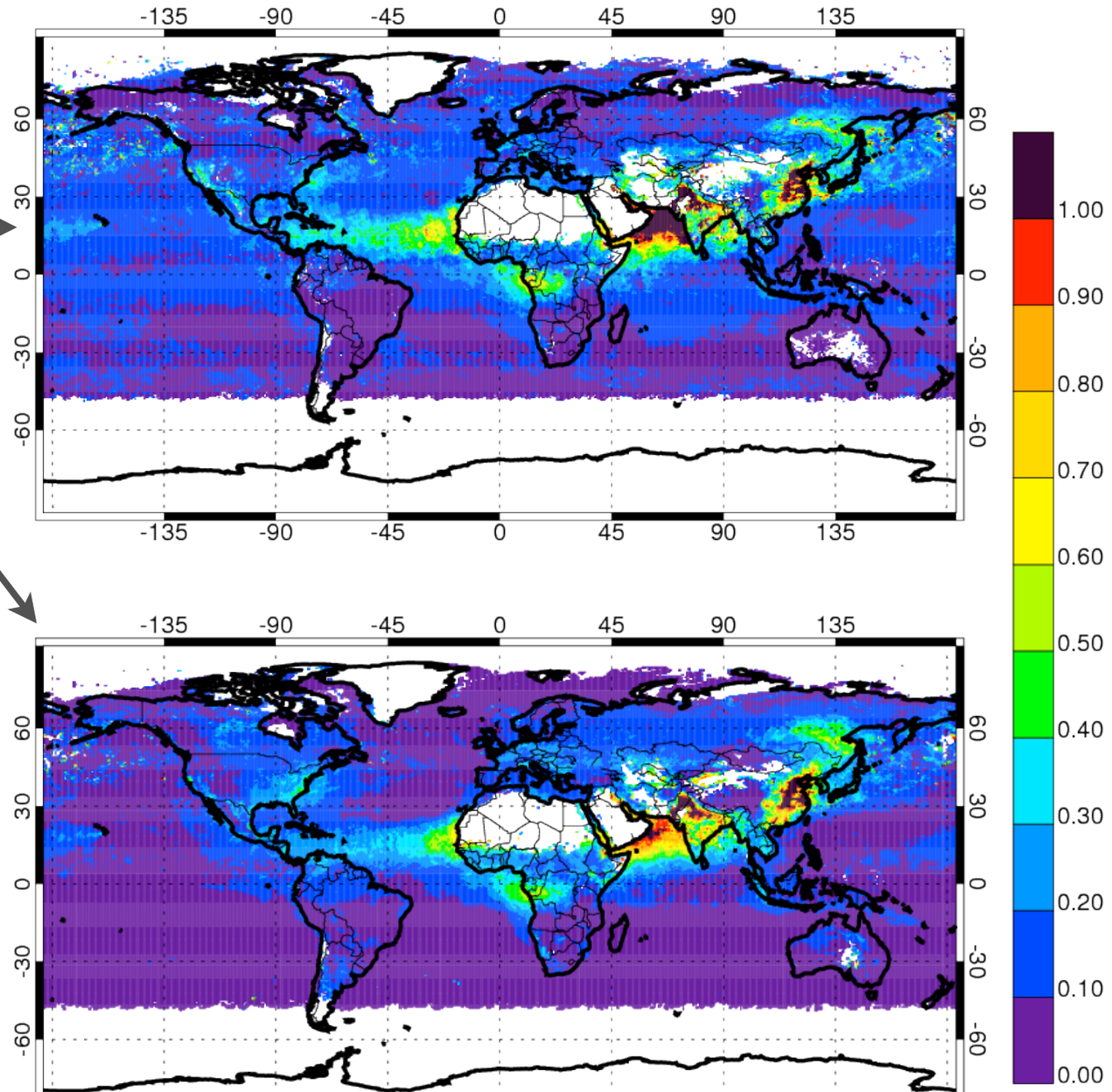


Right: Joint PDF comparison of original MODIS AOT to co-located AERONET (top) and result of NNR (bottom). Results for MODIS Terra over ocean; similar comparisons made for other.

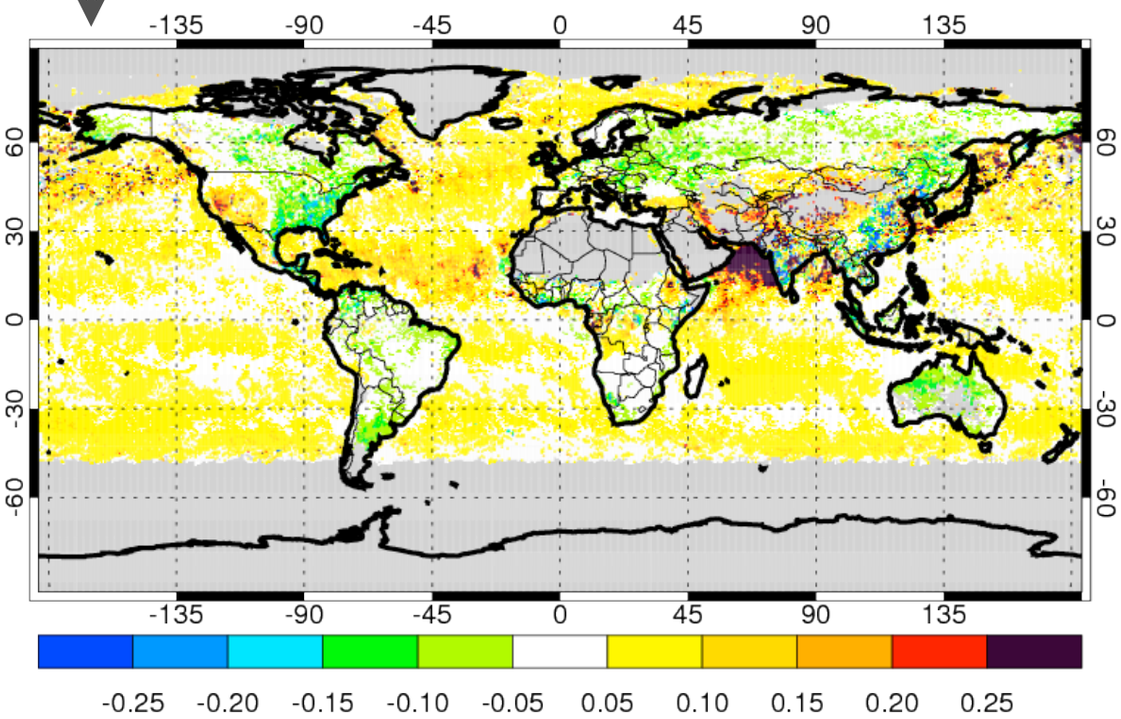
Comparison of NNR to MYD04

June 2008

MODIS Aqua



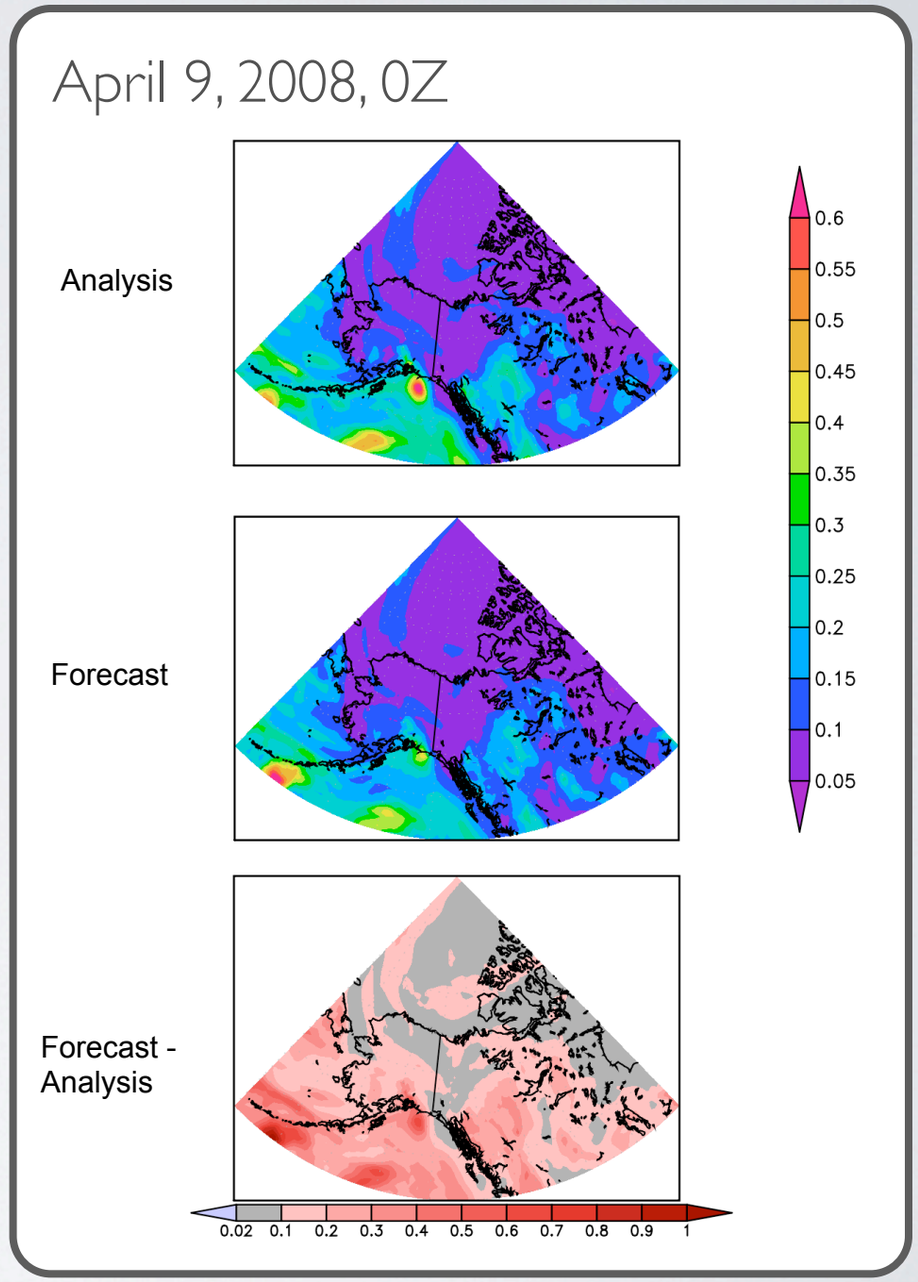
MODIS Aqua - MODIS Aqua NNR



MODIS Aqua (NNR)

Assimilation Methodology

- GEOS-5 Aerosol Assimilation System (GAAS) assimilates AOT from MODIS (land/ocean, Terra/Aqua)
  - Other sensors (e.g., MISR for hindcast) in development
- Simultaneous estimates of background bias (Dee and da Silva, 1998)
- Adaptive statistical quality (Dee et al., 1999)
  - State dependent, adapts to error of the day
  - Background and buddy check based on log-transformed AOD
- Error covariance models (Dee and da Silva, 1999)
  - Innovation based
  - Maximum likelihood
- Lagrangian displacement ensemble technique captures, e.g., plume misplacements



GEOS-5 Comparisons to MODIS

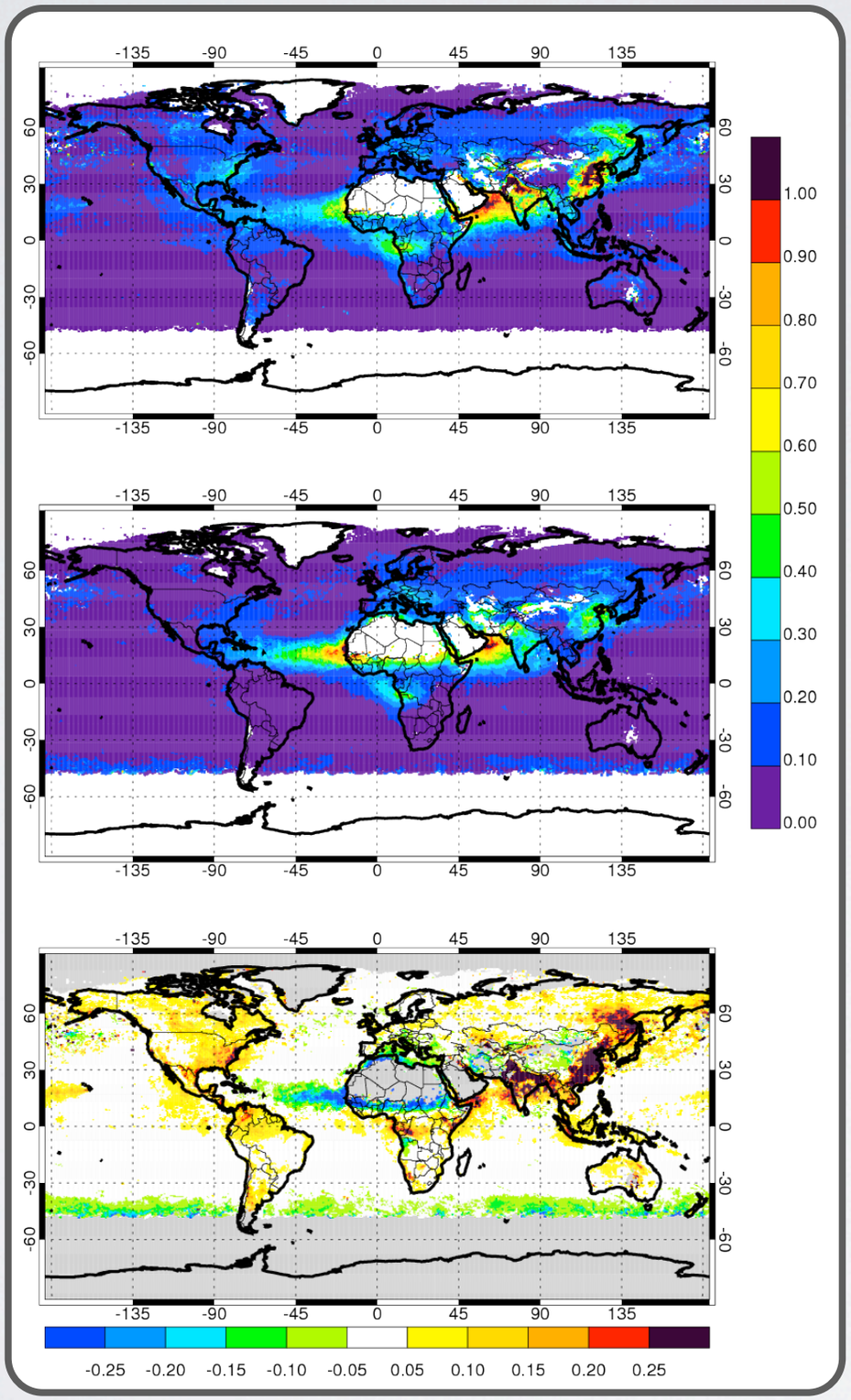
June 2008

MODIS Aqua

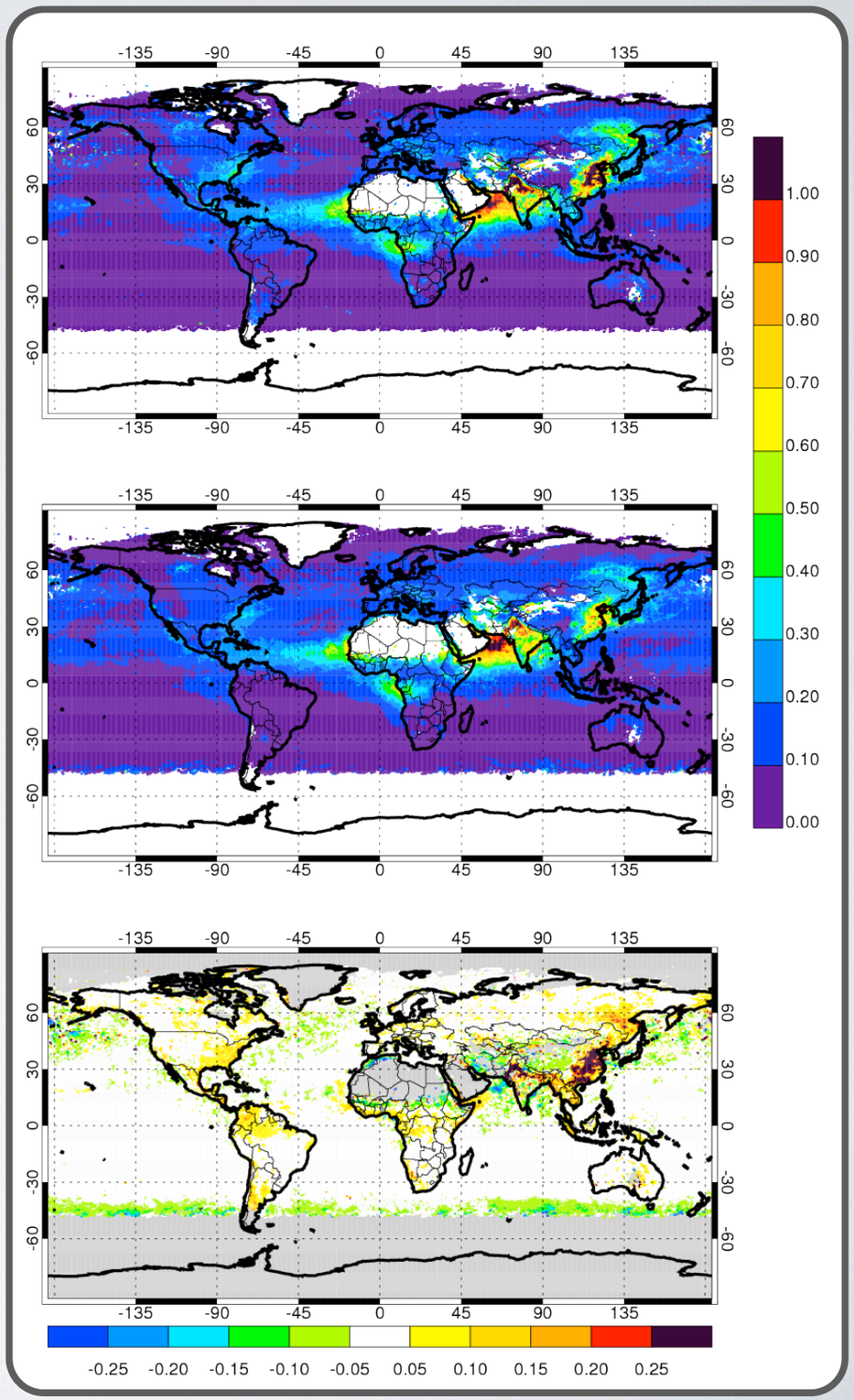
GEOS-5

MODIS - Model

Baseline

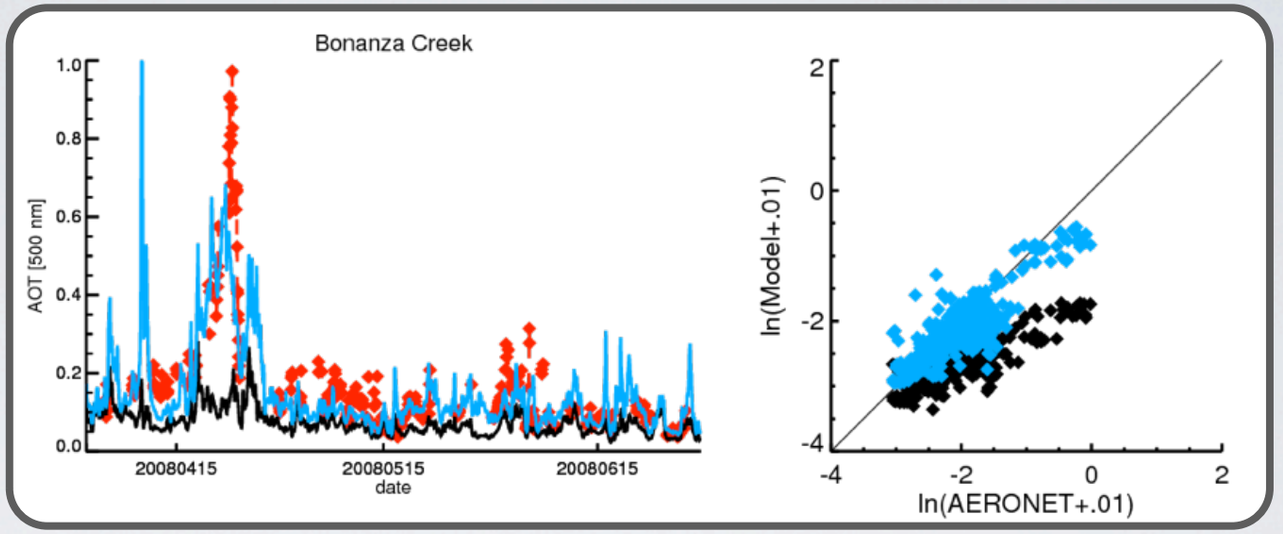


Assimilation



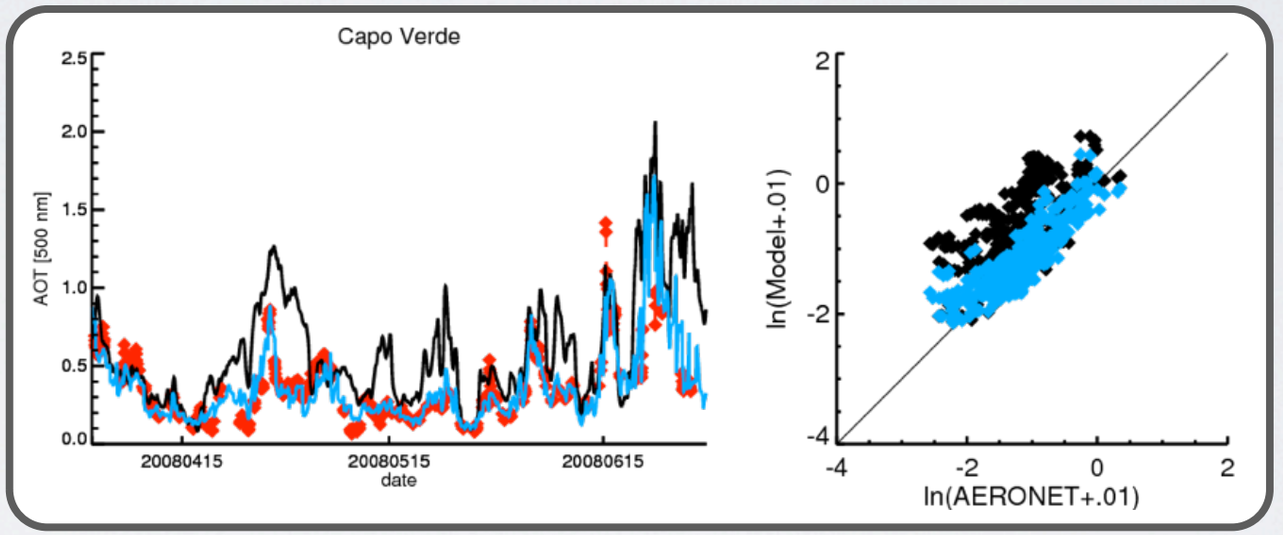
GEOS-5 Comparisons to AERONET

Bonanza Creek, AK

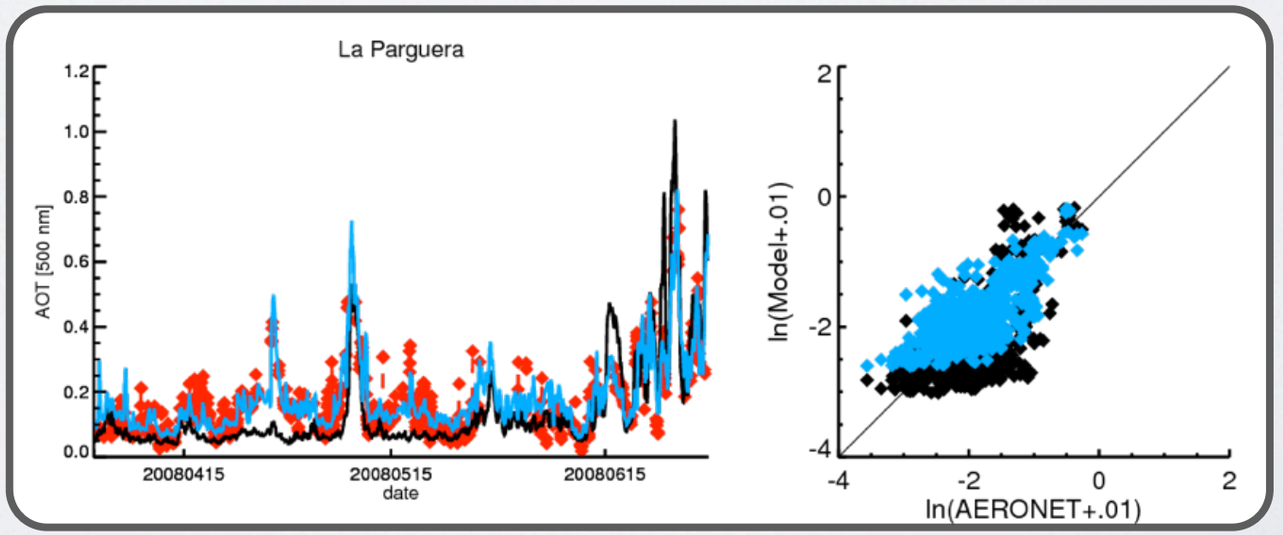


AERONET
Baseline
Assimilation

Capo Verde, Sal Island



La Parguera, Puerto Rico



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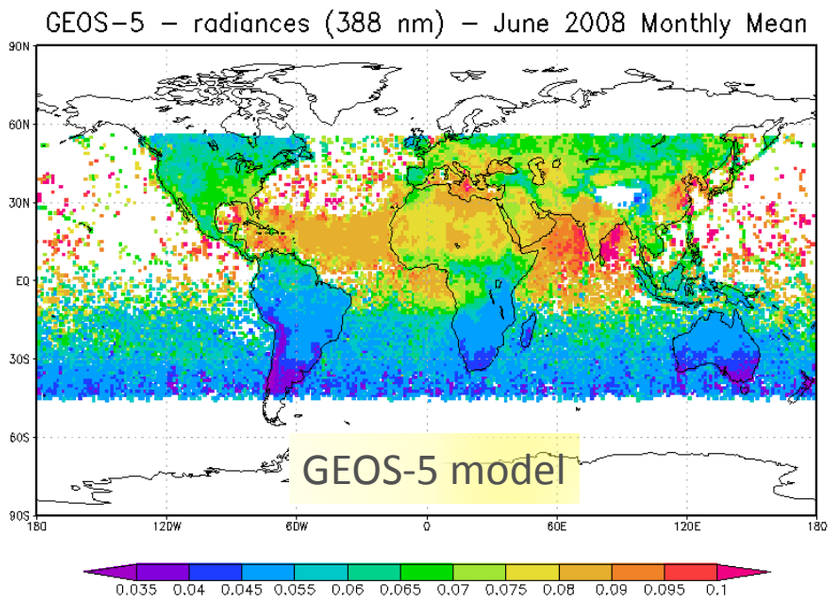
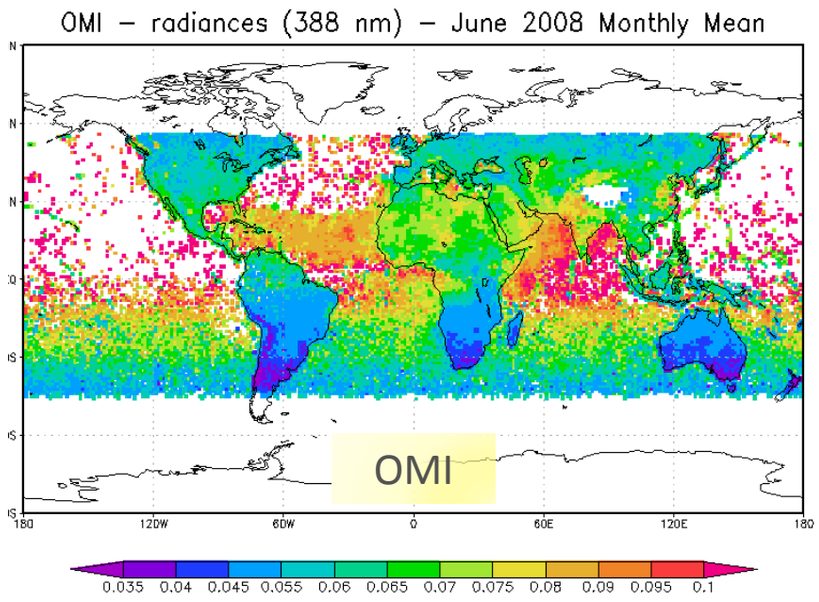
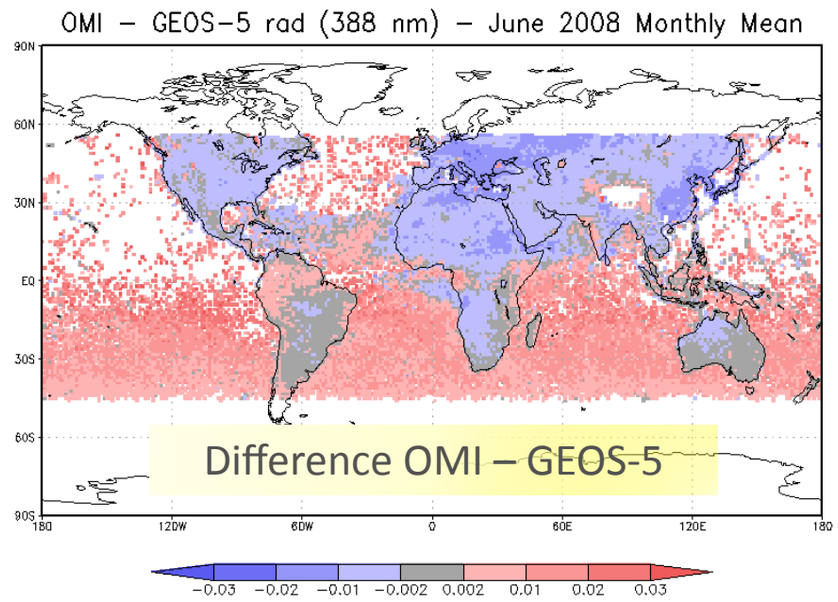
VLIDORT Simulations

- GEOS-5 simulates aerosol mass
- Optical properties (τ, ϖ_0, P(Θ)) from pre-computed size/composition/humidity dependent LUT
- VLIDORT vector radiative transfer code (Rob Spurr) takes input profile of model optical properties at OMI locations/view geometry
- Spectral TOA radiances computed for direct comparison to OMI
  - Surface albedo (Lambertian) from TOMS UV climatology
  - No clouds in calculation (for now)
  - Aerosol Index (AI) computed from 354 nm and 388 nm radiances

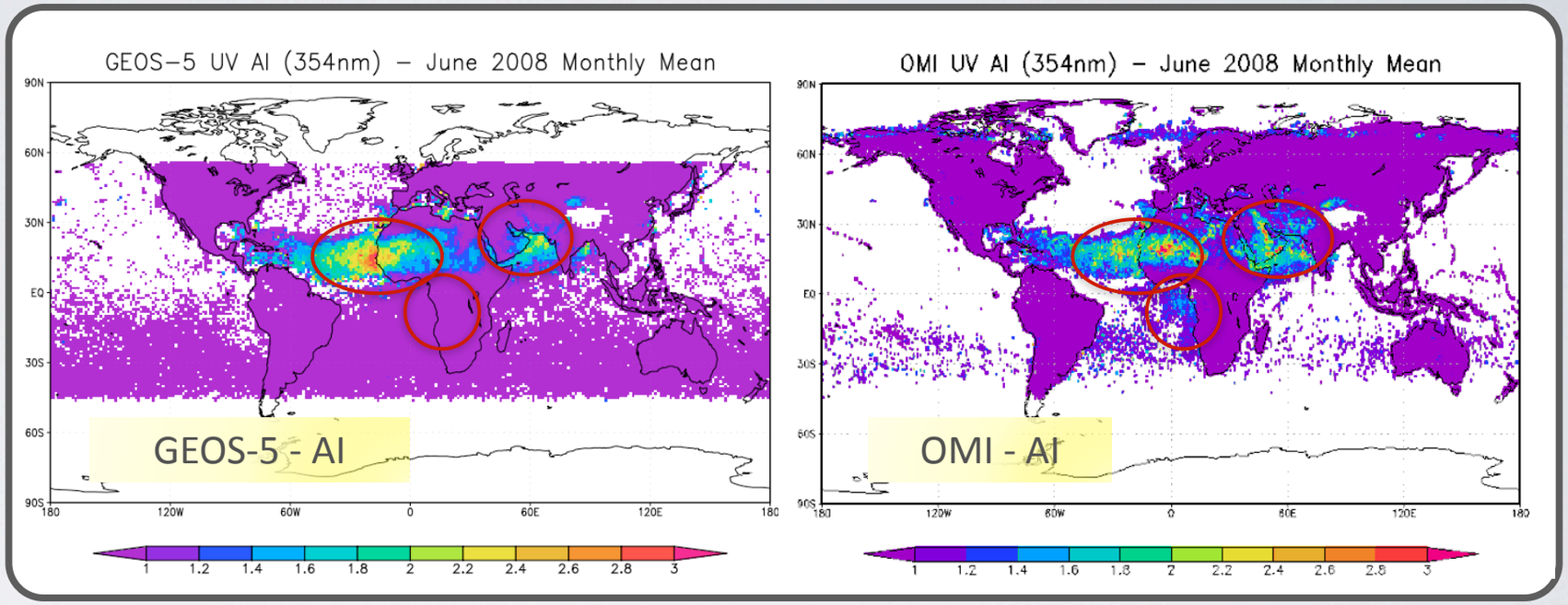




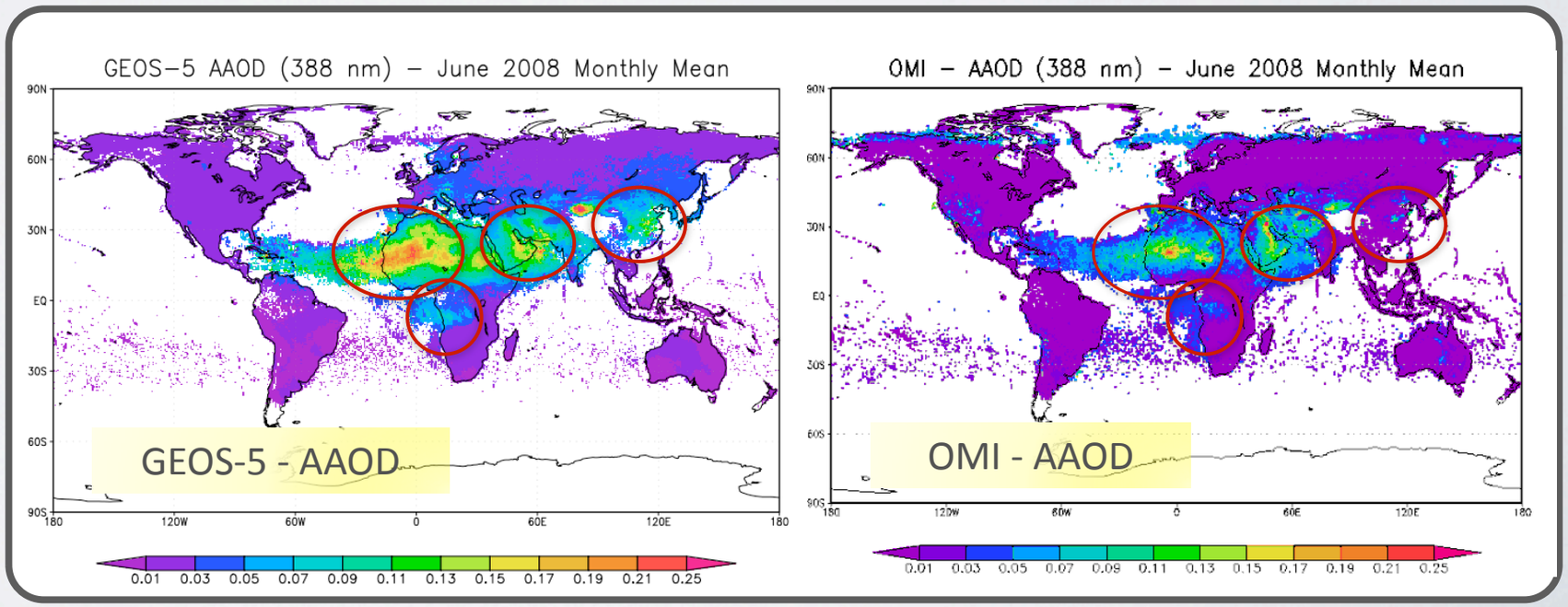


OMI AI and AAOD Comparisons

Aerosol Index



Absorbing Aerosol Optical Depth



Future Directions

- Completion of high resolution baseline run through 2010
- Evaluation of baseline run
- Replay with assimilation of aerosols; evaluation
- GMAO: Plan is to run assimilation operationally June 1
- How does this contribute to ICAP?