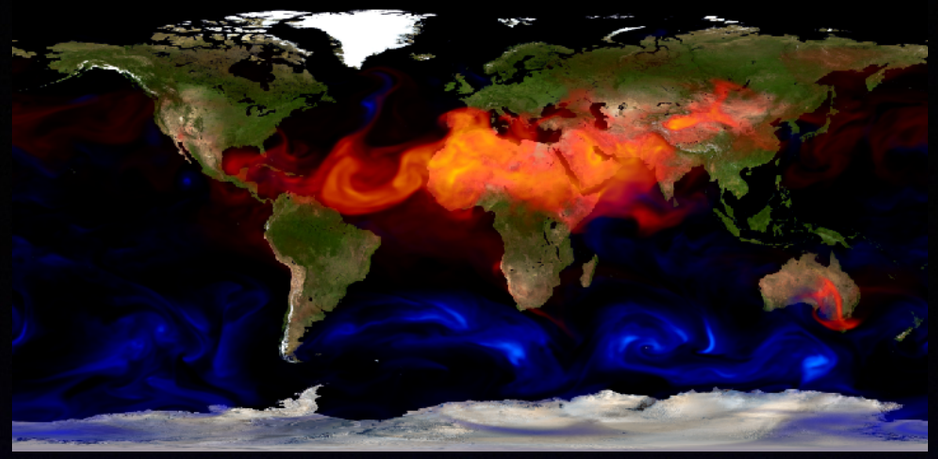
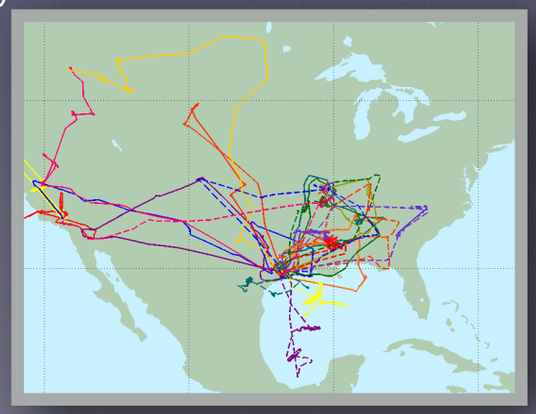


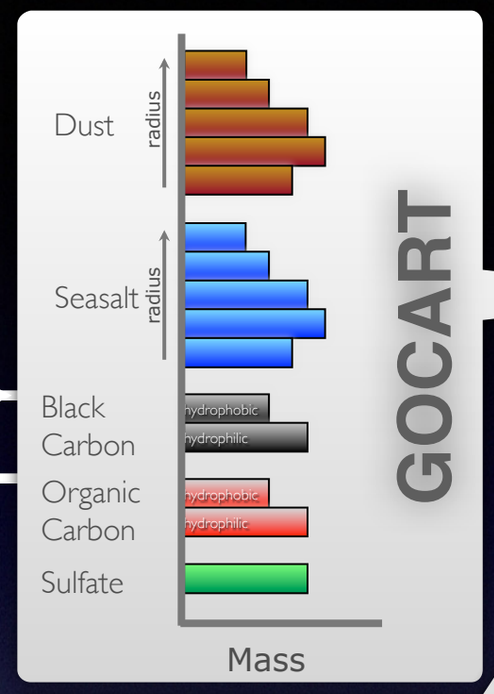
Use of the NASA GEOS-5 SEAC^{4}RS Meteorological and Aerosol Reanalysis for Assessing Simulated Aerosol Optical Properties as a Function of Smoke Age

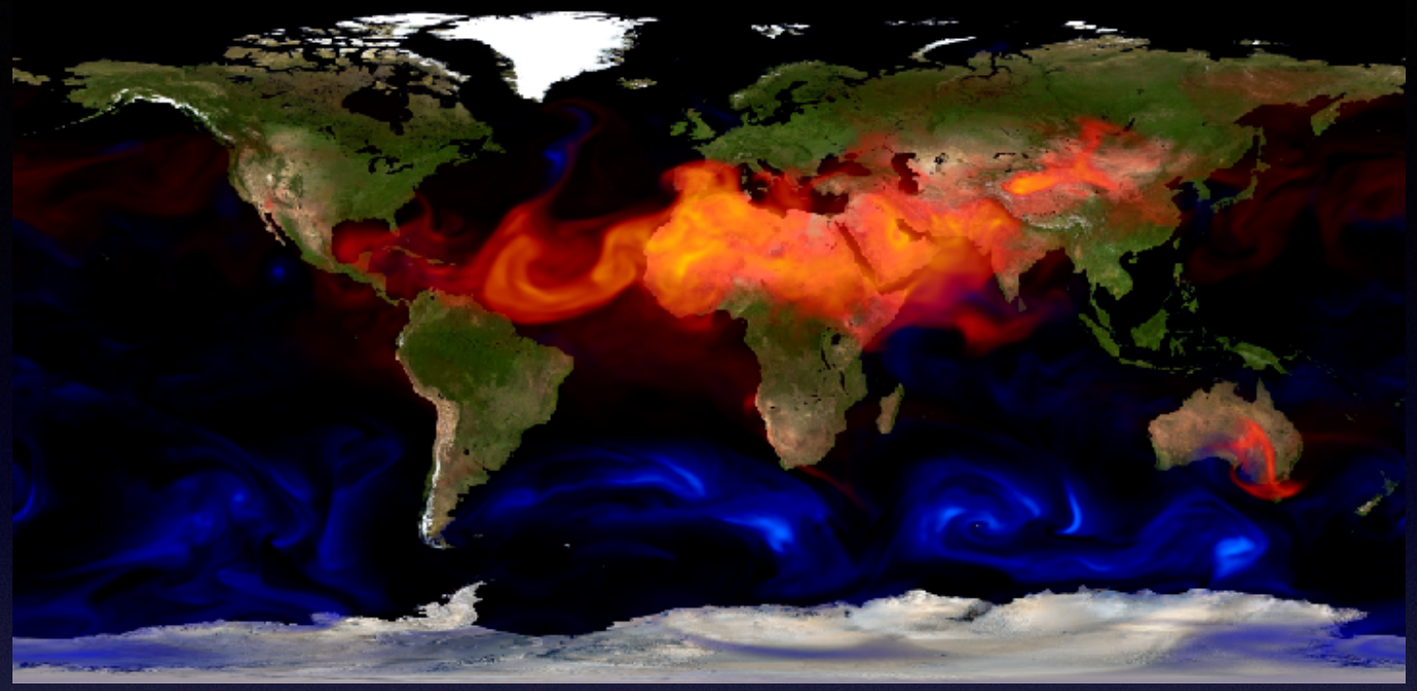
C. A. Randles[1,2], Arlindo da Silva[2], Peter R. Colarco[3], Anton Darmenov[2], Virginie Buchard[2,4], Ravi Govindaraju[2,5], Gao Chen[6], John Hair[6], Philip B. Russell[7], Yohei Shinozuka[7,8], Nick Wagner[9], Daniel Lack[9], Jose Jiminez[10], Pedro Campuzano-Jost[10]

1. GESTAR/Morgan State University
2. NASA Global Modeling and Assimilation Office
3. NASA Atmospheric Chemistry and Dynamics Laboratory
4. GESTAR/USRA
5. SSAI
6. NASA Langley Research Center
7. NASA Ames Research Center
8. Bay Area Environmental Research Institute
9. NOAA ESRL/CSD
10. UC Boulder



GEOS-5 Atmospheric Data Assimilation System (GAAS)





AeroChem

P&L: CO, CO_2, RATS

Advection

FV Dynamics

Hydro-dynamics

Forecast Model

GEOS-5

Atmospheric Data Assimilation (DAS)

u, v, t, p, q, AOT

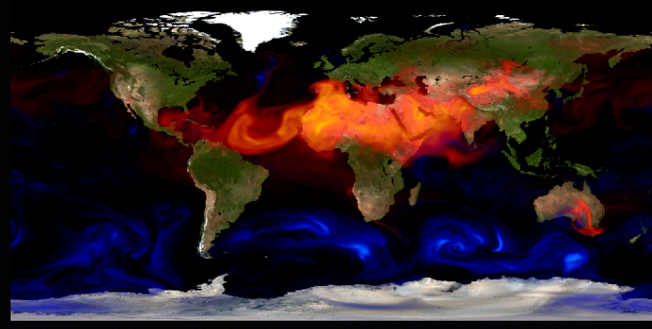
Biomass Burning Emissions (QFEDv2)

- Chou/Suarez Radiation
- RAS Convection
- Locke Turbulence
- Prescribed SST/sea ice
- Catchment Land
- Prognostic Clouds

Physics

Global, ~25 km, 72 levels, top 0.01 hPa

Overview



- **GEOS-5 SEAC4RS Mini-Reanalysis:**
  - Overview of meteorological and aerosol reanalysis
  - Observing system used for AOT assimilation
  - Smoke “Age” Tracers
- **Independent Validation of AOT:**
  - DIAL/HSRL, HSRL2
  - 4-STAR
- **In-Situ Data Comparison and Smoke Age**
  - LARGE
  - AMS and HDSP2

Aerosol Assimilation: Forecast and Updates

Short-term forecast

Obs. - Forecast AOT

$$q^a = q^f + K \times (\tau^o - \tau^f)$$

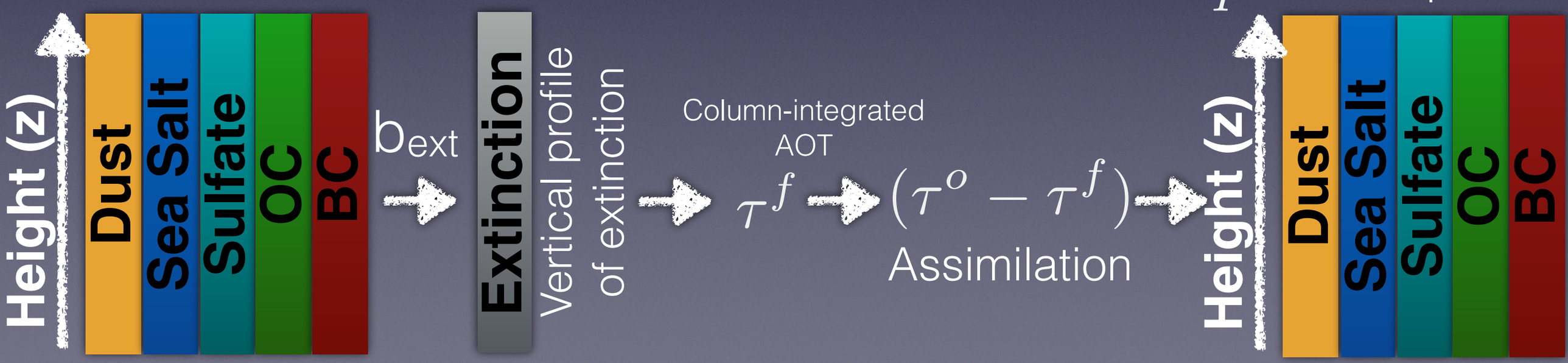
Mass-mixing ratio updated

Operator

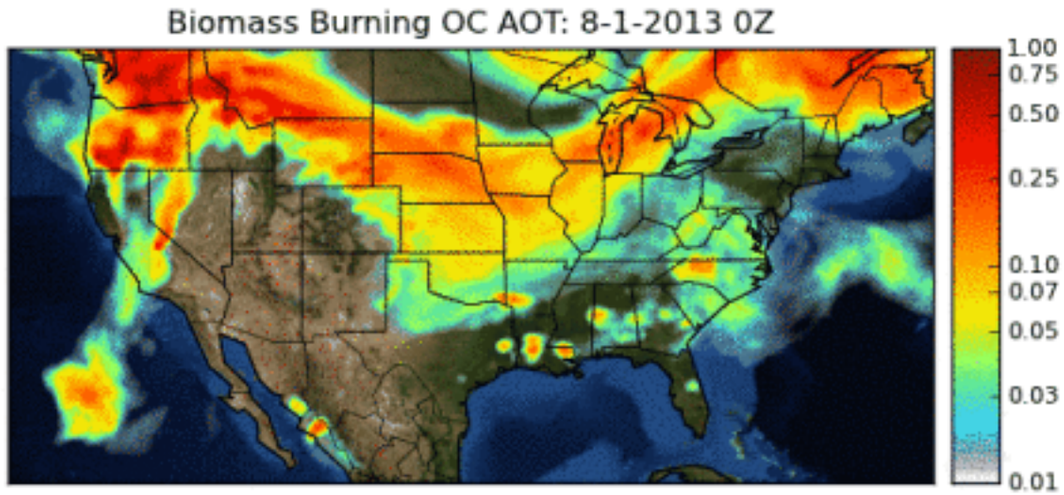
Optics Assumptions

$$\tau^f = \sum q^f \times \rho \times b_{ext}$$

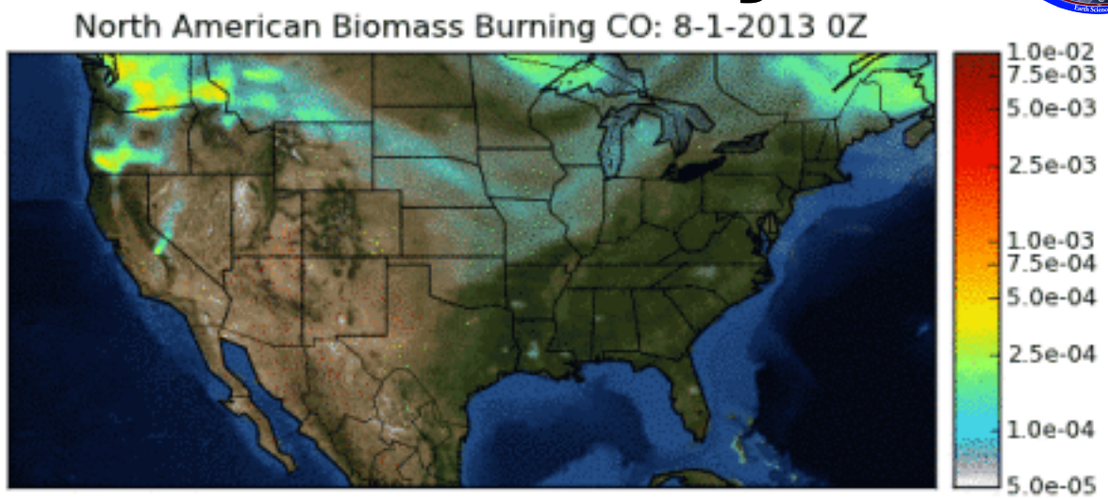
q^a MMR Update



GEOS-5 SEAC^{4}RS Mini-Reanalysis



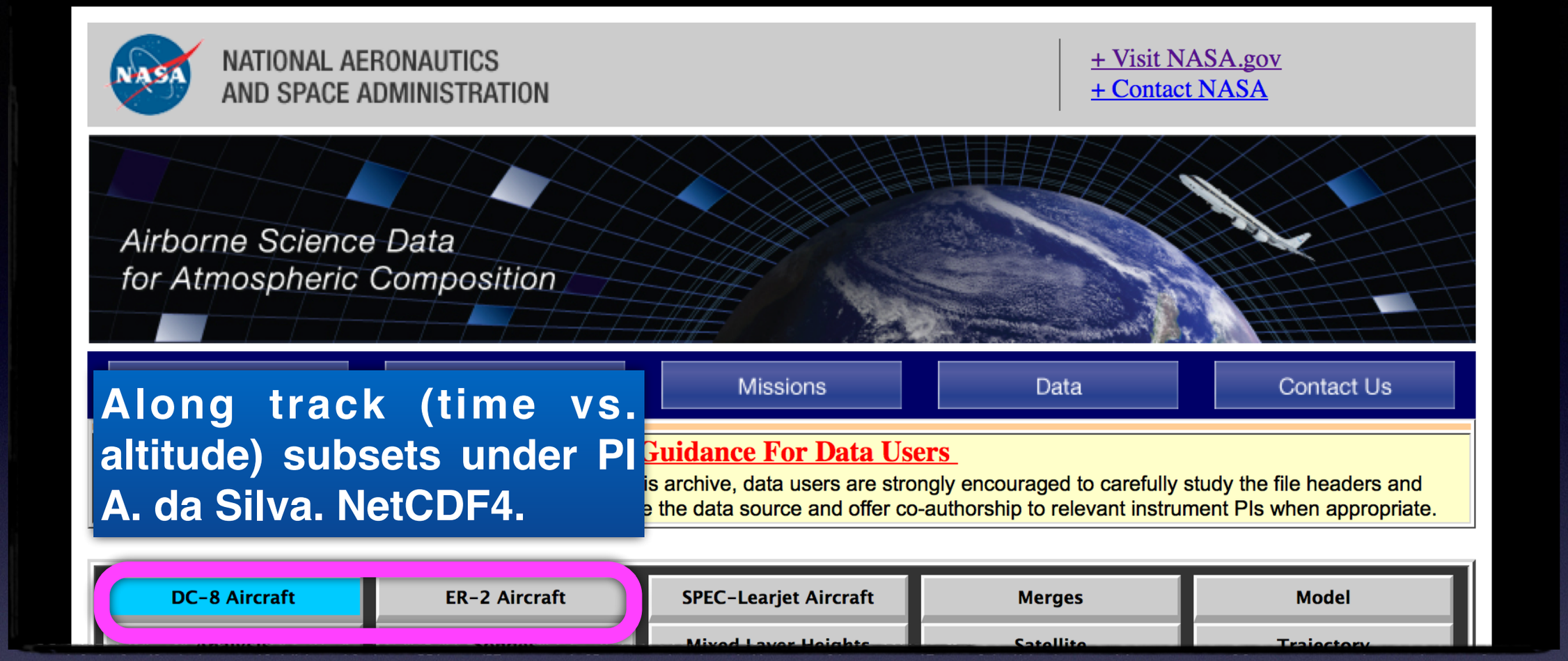
GEOS-5 Biomass Burning OC AOT



GEOS-5 Biomass Burning CO from N. America

Feature	Description
Model	**GEOS-5** Earth Modeling System with **GOCART** aerosols coupled to radiation parameterization
Fire Emissions	**QFED: Daily, NRT, MODIS FRP based**
Met. Data Assimilation	Full NWP observing system (uses GSI)
Aerosol Data Assimilation	**Assimilates 550 nm AOT, Local Displacement Ensembles (LDE), Adaptive Buddy Check**
Aerosol Observing System	**MODIS: Aqua & Terra Neural Net Retrievals (NNR)** **MISR: Bright surfaces only (albedo > 15%)** **AERONET: Level 2**
Resolution	**Global!** ~25 km (0.25° x 0.3125° latitude x longitude), 72 layers, top ~85 km
Aerosol Species	Dust (DU), sea-salt (SS), sulfates (SO
Carbon Species	CO_2, CO with several geographically tagged tracers
Smoke "Age" Tracers	**Provides "age" of un-assimilated biomass burning OC AOT with 1 day time resolution (smoke "age" histogram)**

Mini-Reanalysis: How to get it (Shameless



Along track (time vs. altitude) subsets under PI A. da Silva. NetCDF4.

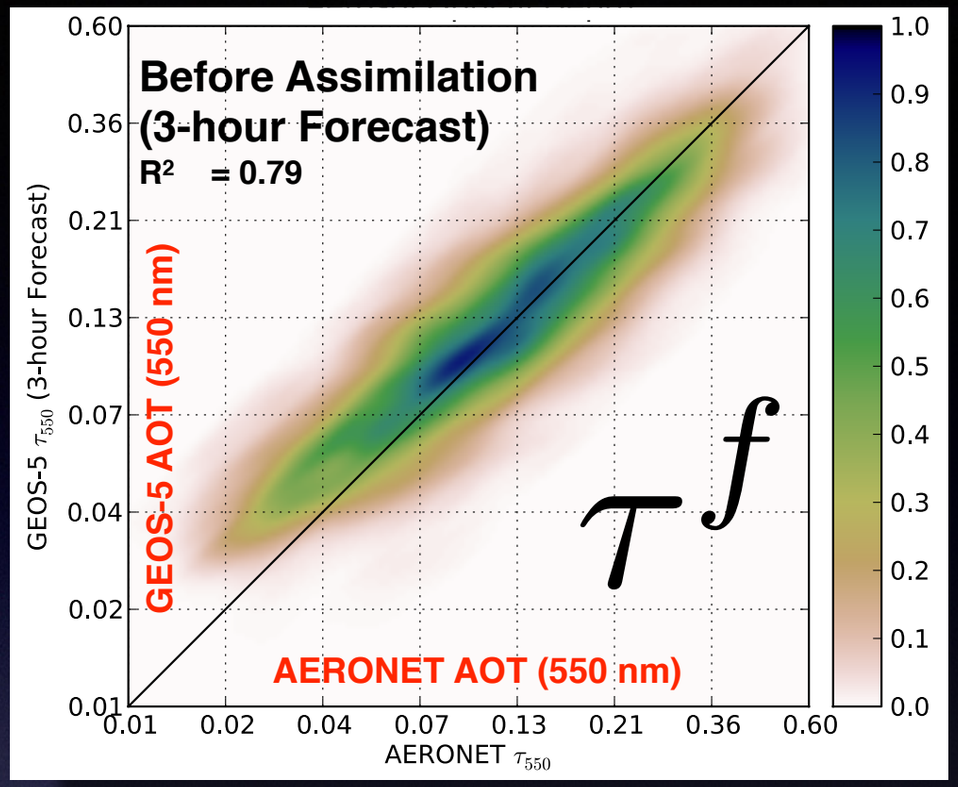
- Output including meteorology, aerosol properties (mass, optics, etc.), smoke "age" tracers, and tagged CO tracers (e.g. CO from biomass burning or from Asia).
- Along-track subsets (based on lat/lon and time from 60-second merge) available on ArcView.
- Full (global) model output available on ftp and opendap:

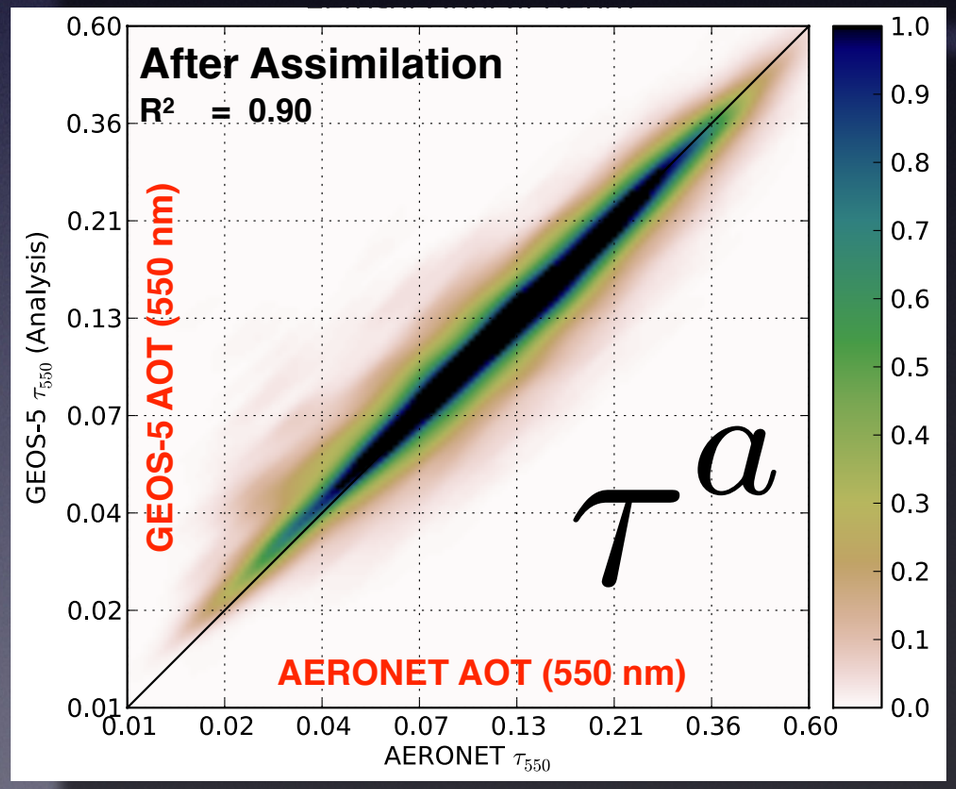
ftp://ftp.nccs.nasa.gov/aerosol/seac4rs_01/data/seac4rs_01/

ftp://ftp.nccs.nasa.gov/aerosol/seac4rs_01/opendap/

Sanity Check: AOT Observing System Statistics

Observing System	GEOS-5 AOT	Statistics (130°W-60°W, 24°N-55°N) R	1000 × stderr	Bias (Obs-GEOS5)
AERONET N = 102,552	Background	**0.79**	1.25	-0.06
	Analysis	**0.9**	0.92	-0.02
MISR N = 494,743	Background	**0.66**	0.9	0.06
	Analysis	**0.83**	0.58	0.02
MODIS Terra N = 24,504,880	Background	**0.72**	0.1	-0.12
	Analysis	**0.92**	0.05	-0.01
MODIS Aqua N = 23,300,505	Background	**0.74**	0.1	-0.08
	Analysis	**0.93**	0.05	0

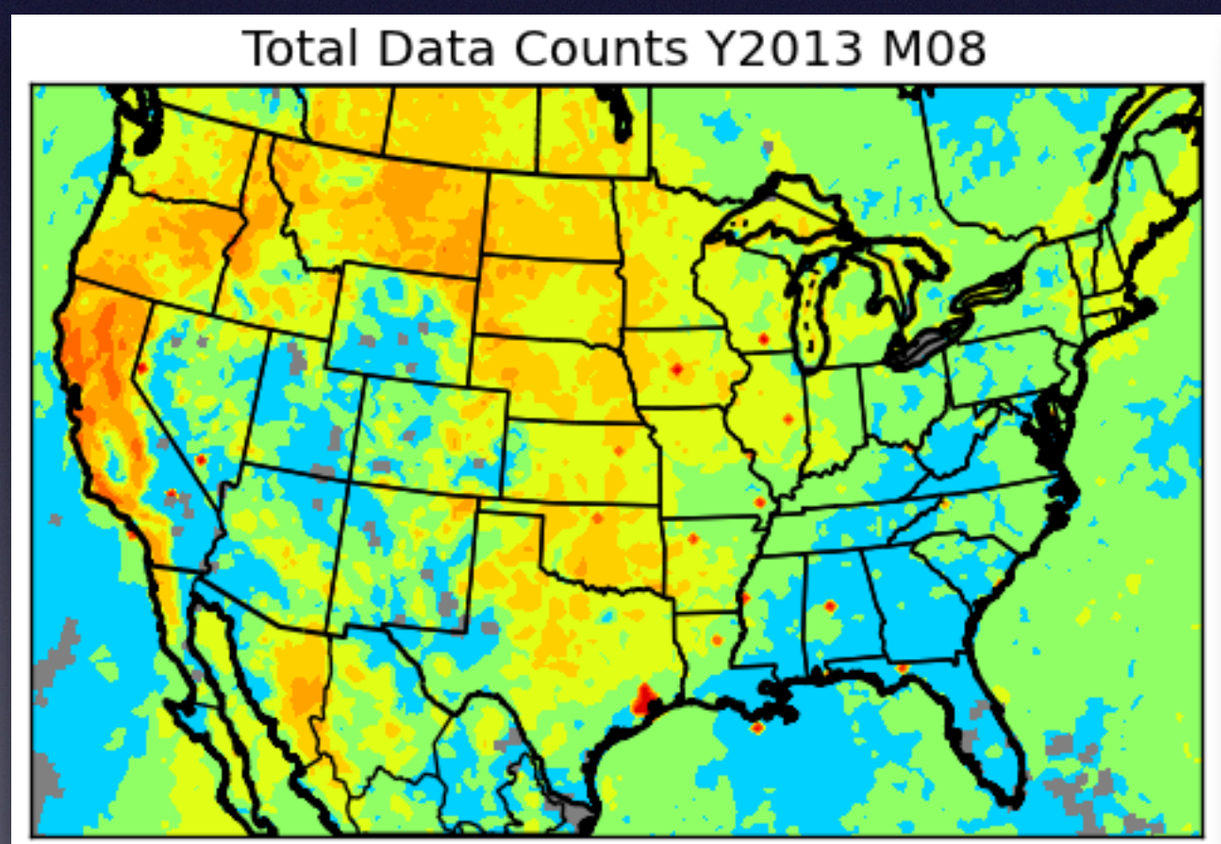


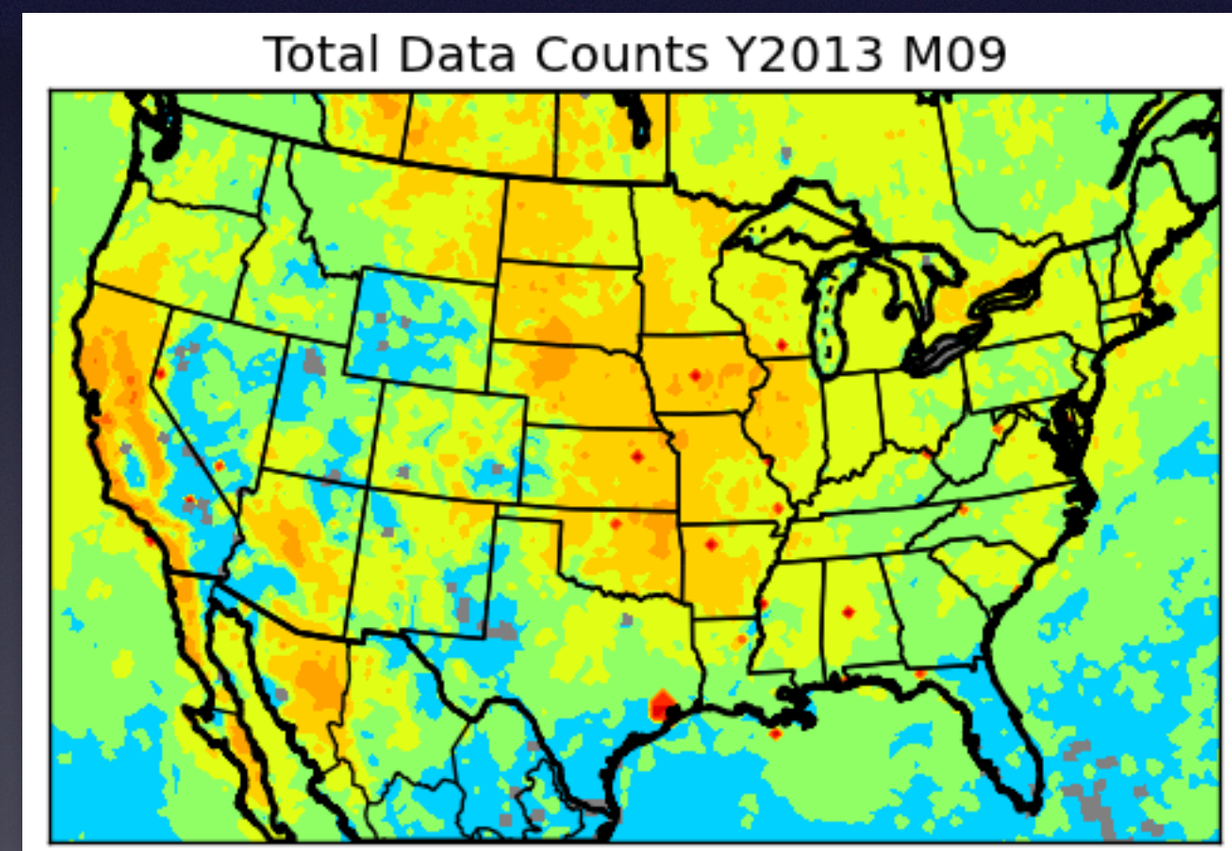


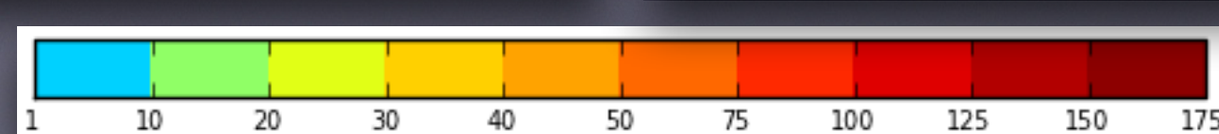
- Effect of observing system on the 3-hr forecast skill (**N.B.:** 3-hr forecast informed by previous assimilation step)
- After assimilation, comparison is not 1-to-1 because of impact of other sensors.

Data Availability: AOT Observing System Statistics

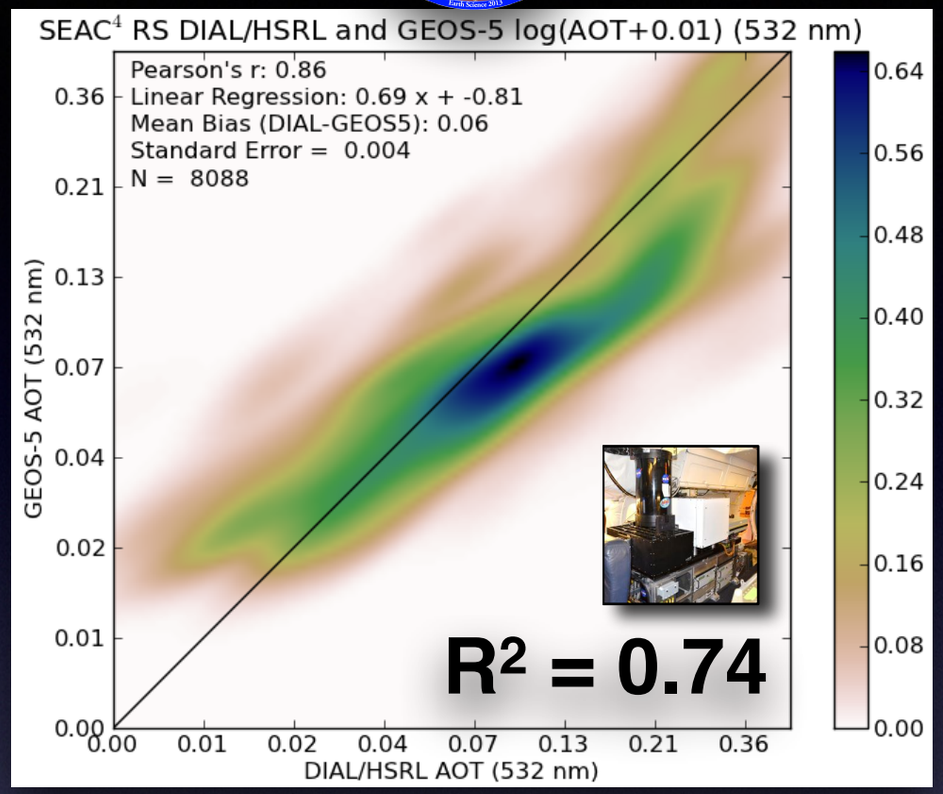
- AOT observation counts from MODIS NNR, MISR, and AERONET for campaign period.
- MISR primarily augments data coverage over western US desert regions, while AERONET (DRAGON) provides needed data coverage particularly over Houston.

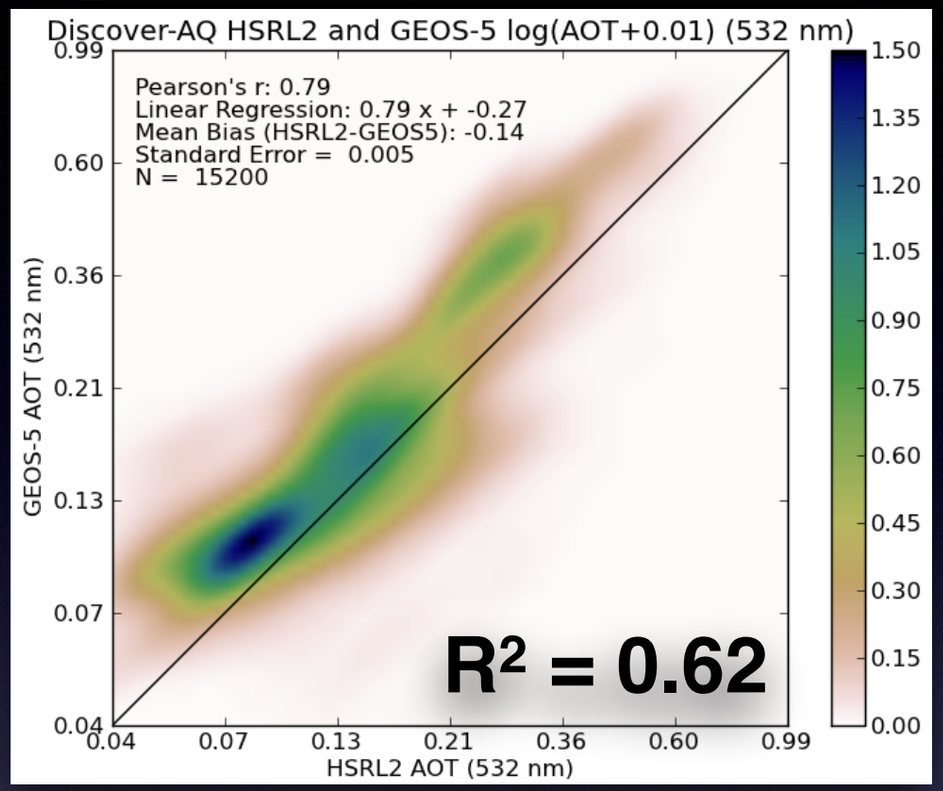


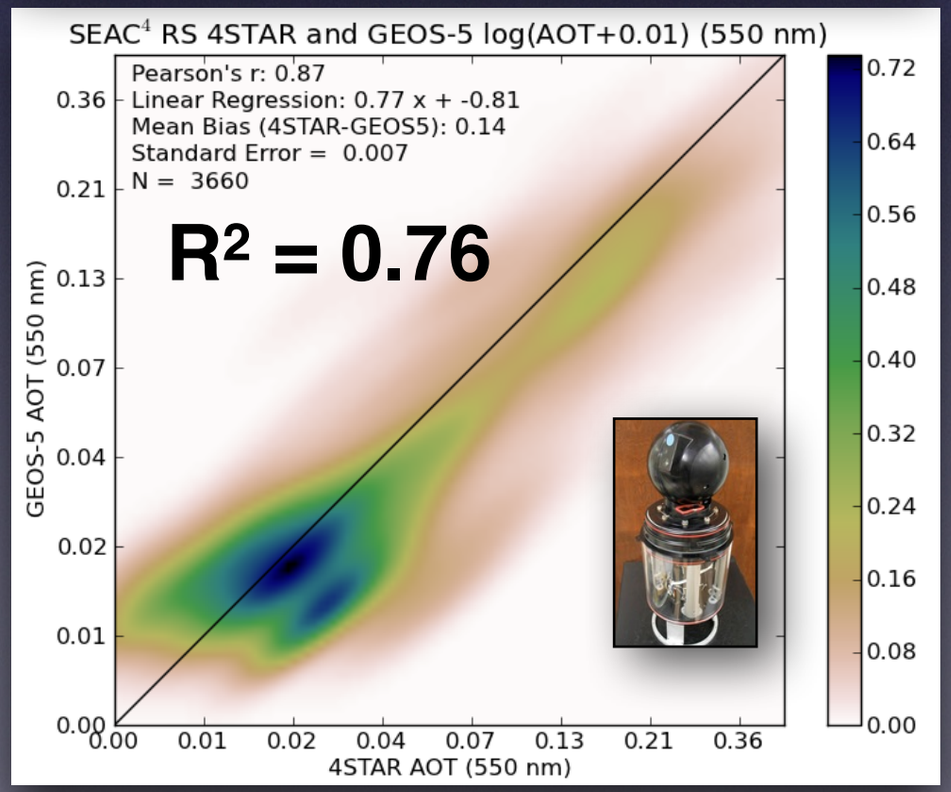




Independent Validation: SEAC^{4}RS DIAL/HSRL, 4STAR and DAQ HSRL2

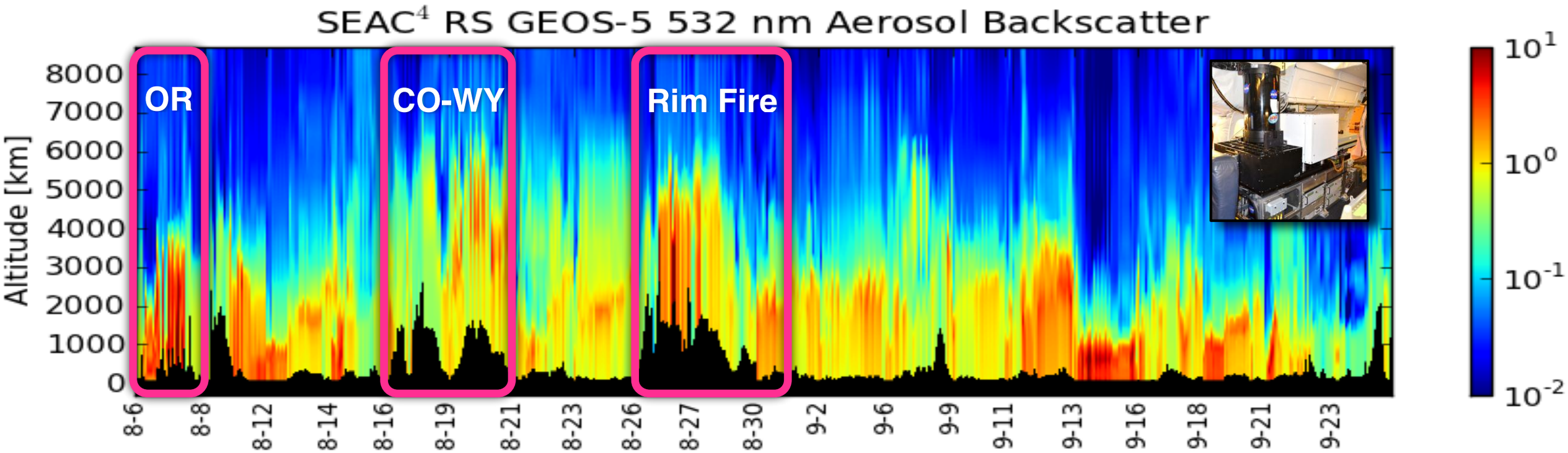


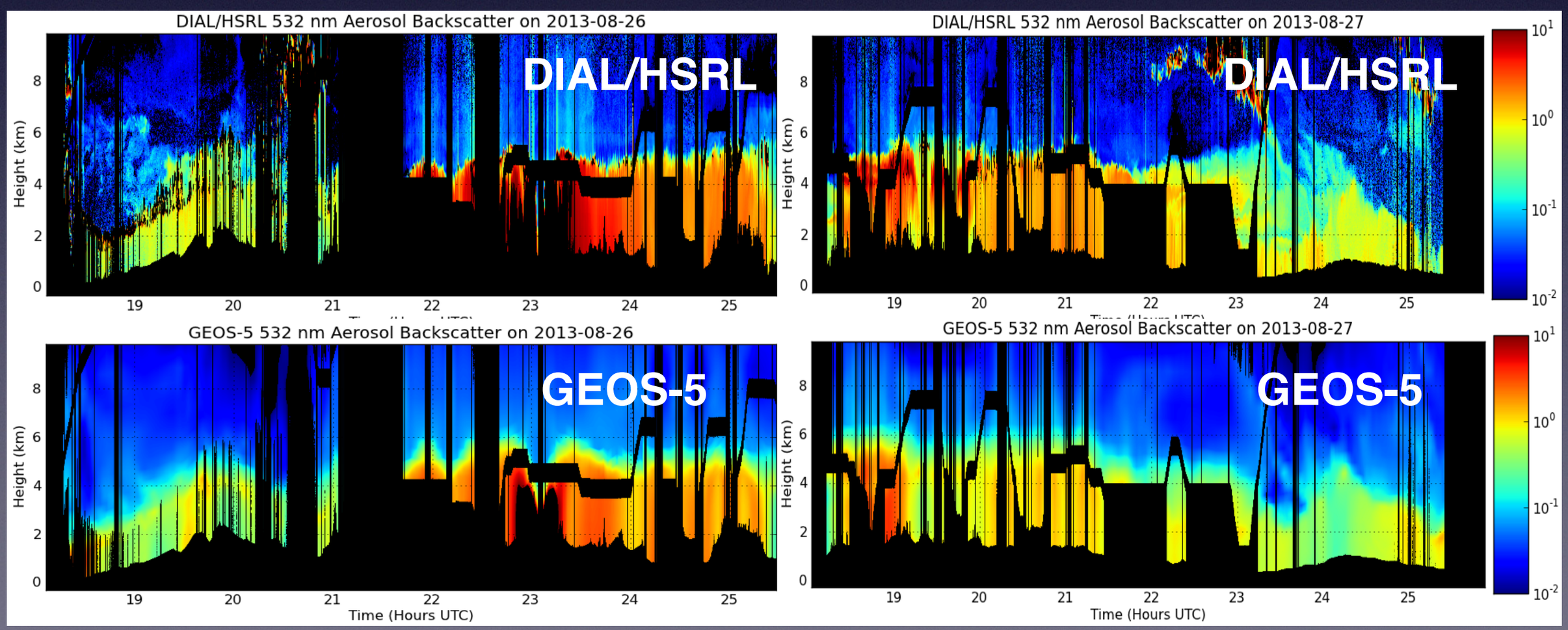
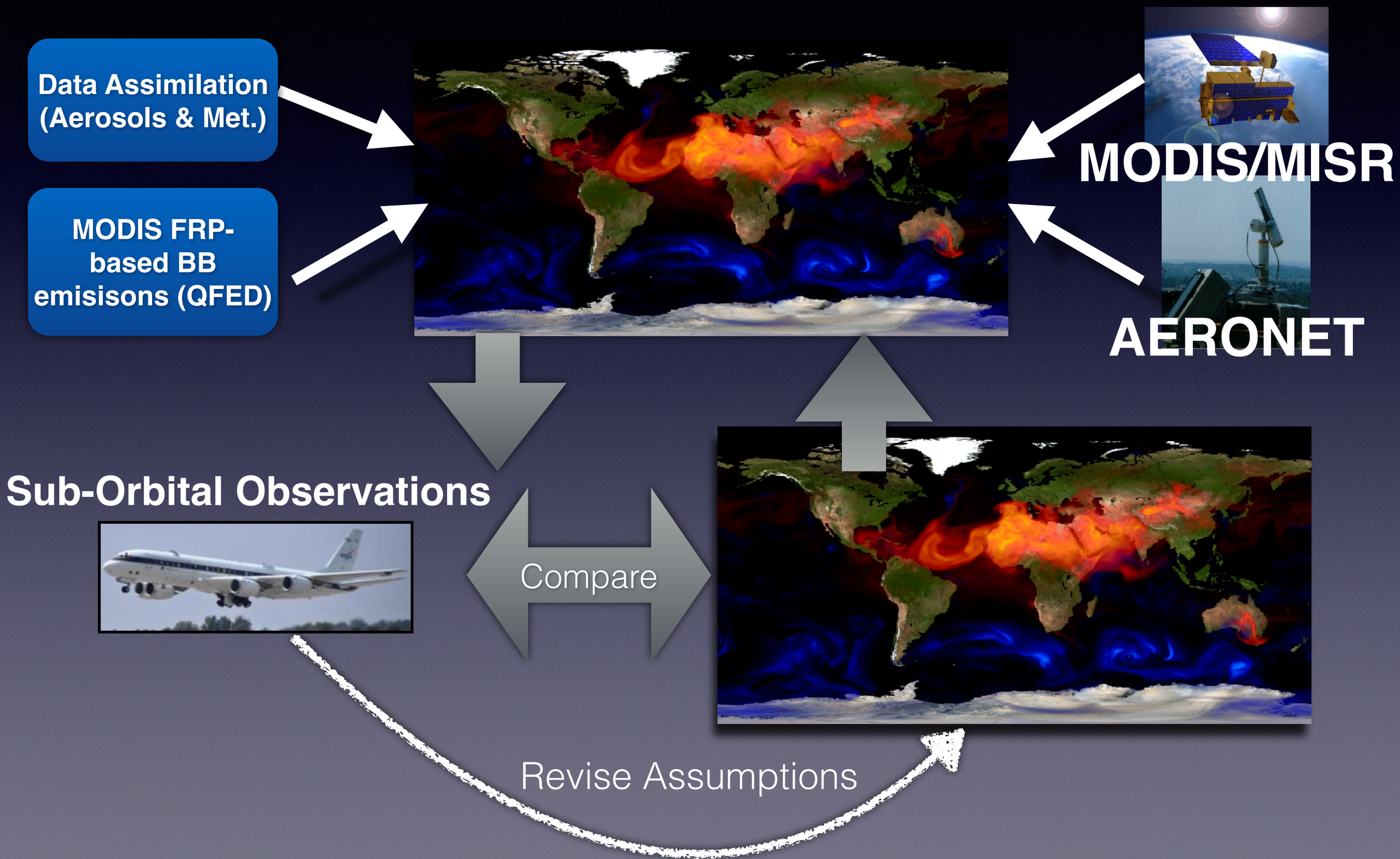




- We assimilate many of the global satellite- and ground-based observations of AOT.
- Aircraft observations of AOT serve as an important independent means of validating assimilated AOT.
- **N. B.** These comparisons are sensitive to vertical distribution of aerosol, since whole column is not sampled

Vertical Distribution: DIAL/HSRL 532 nm Backscatter





Iterative Process of Model Validation & Improvement