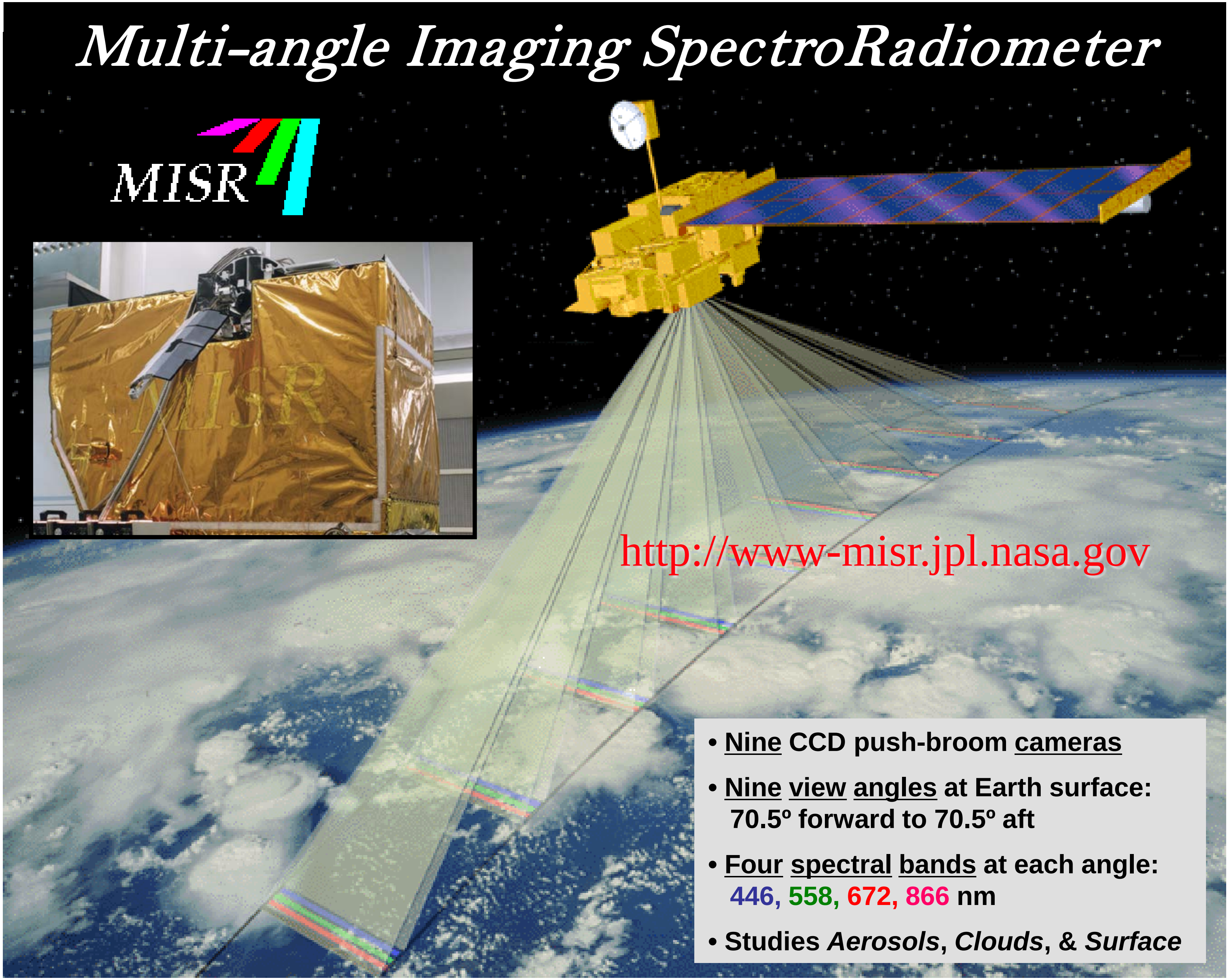
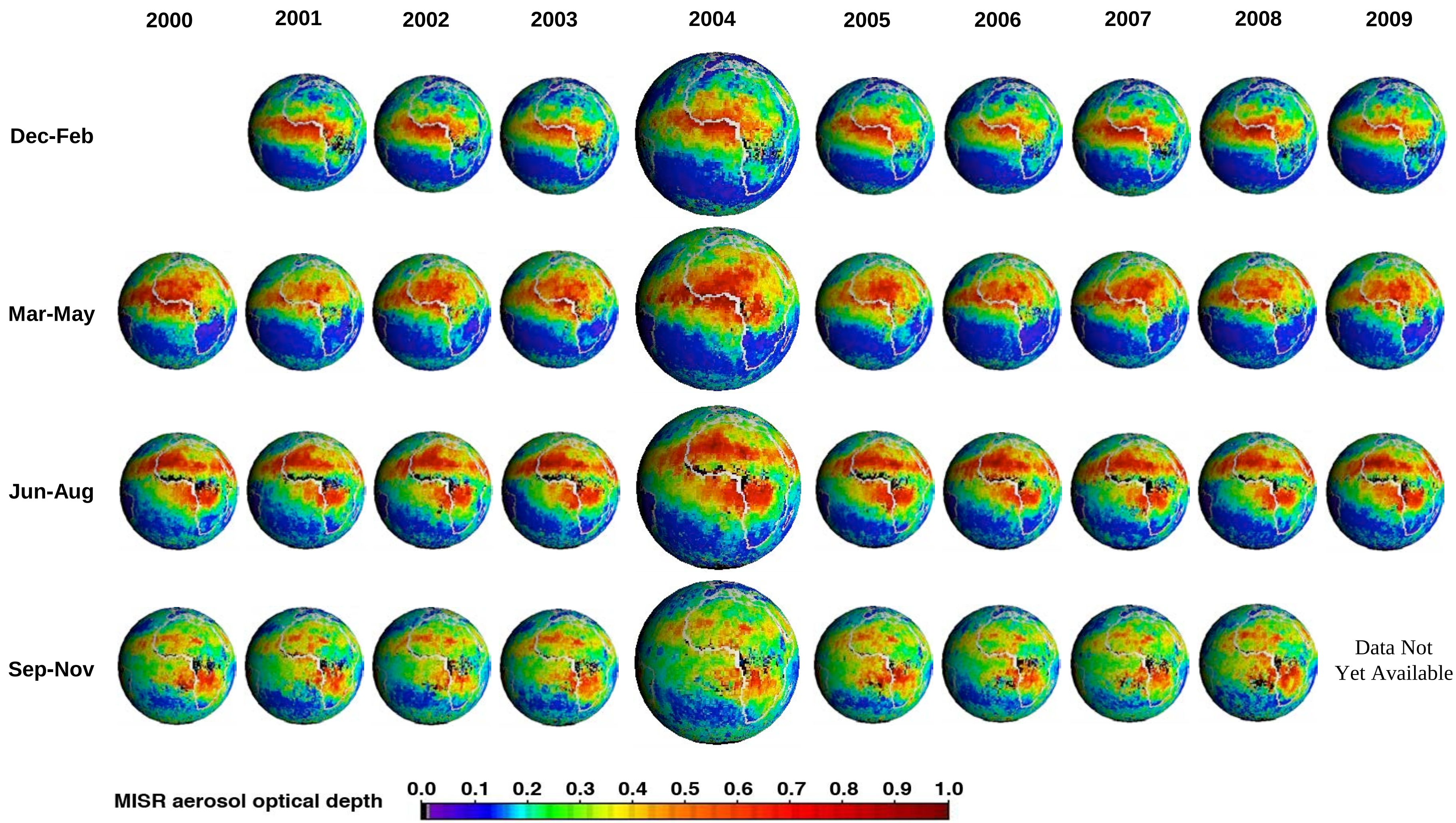

Multi-angle Imaging SpectroRadiometer
MISR
MISR
http://www-misr.jpl.nasa.gov
• Nine CCD push-broom cameras
• Nine view angles at Earth surface: 70.5º forward to 70.5º aft
• Four spectral bands at each angle: 446, 558, 672, 866 nm
• Studies *Aerosols*, *Clouds*, & *Surface*

Ten Years of Seasonally Averaged Mid-visible Aerosol Optical Depth from **MISR**

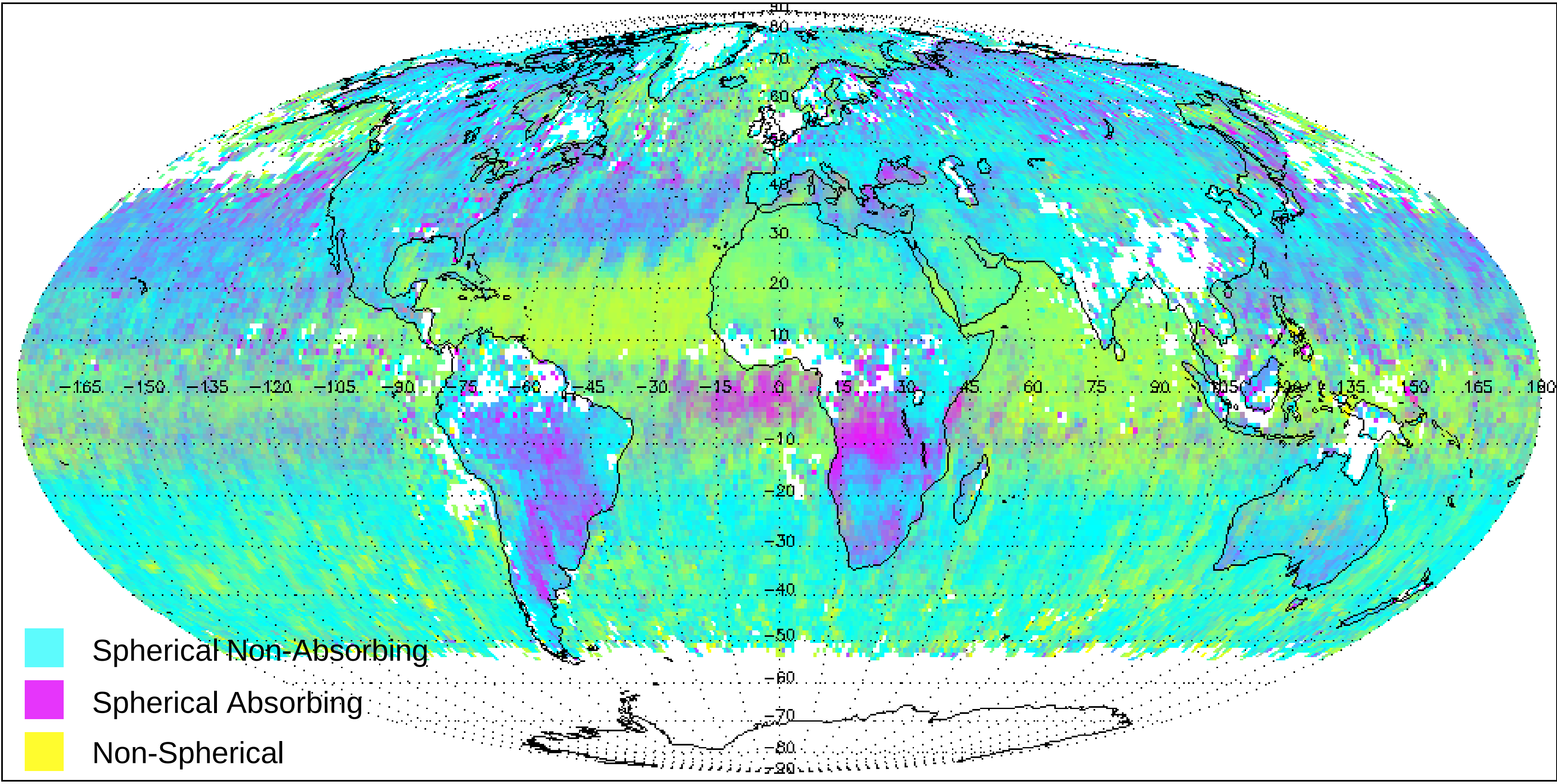


…includes bright desert dust source regions

MISR Team, JPL and GSFC

MISR *Aerosol Type* Distribution

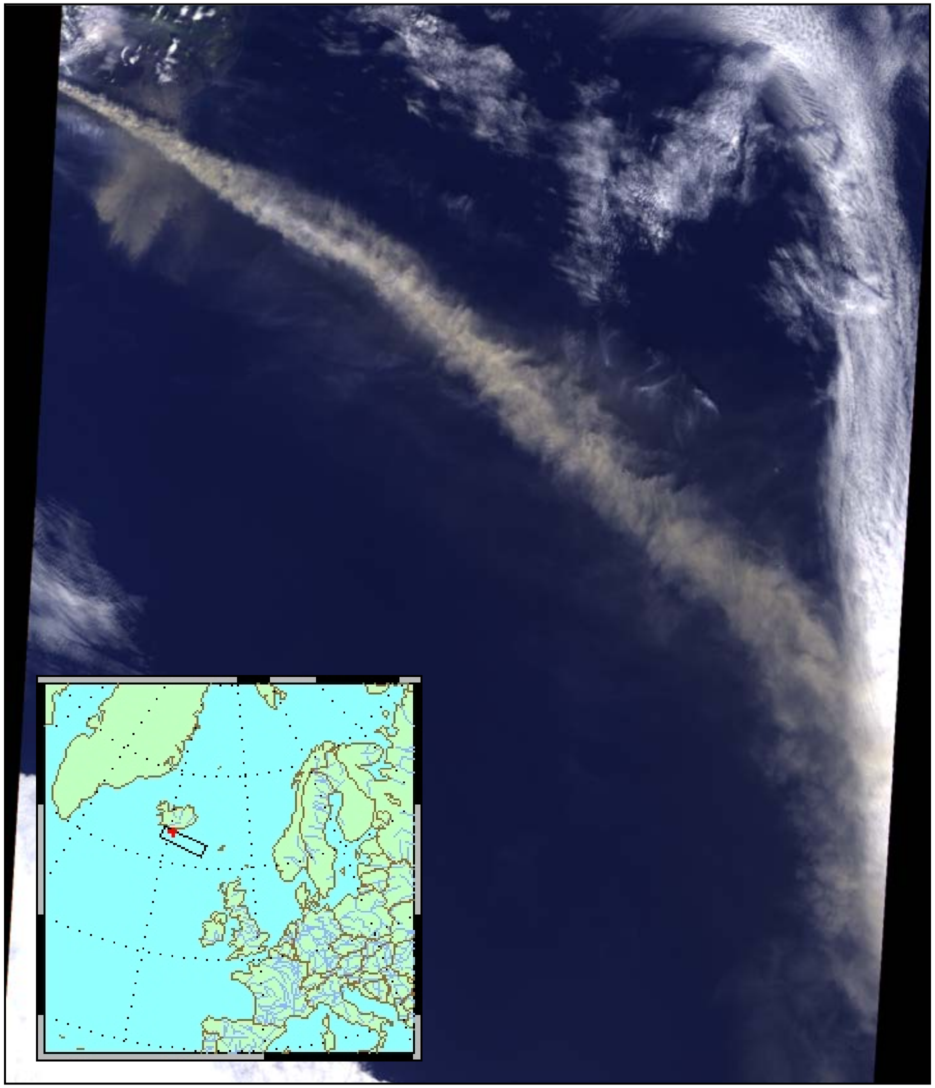
MISR Version 22, July 2007

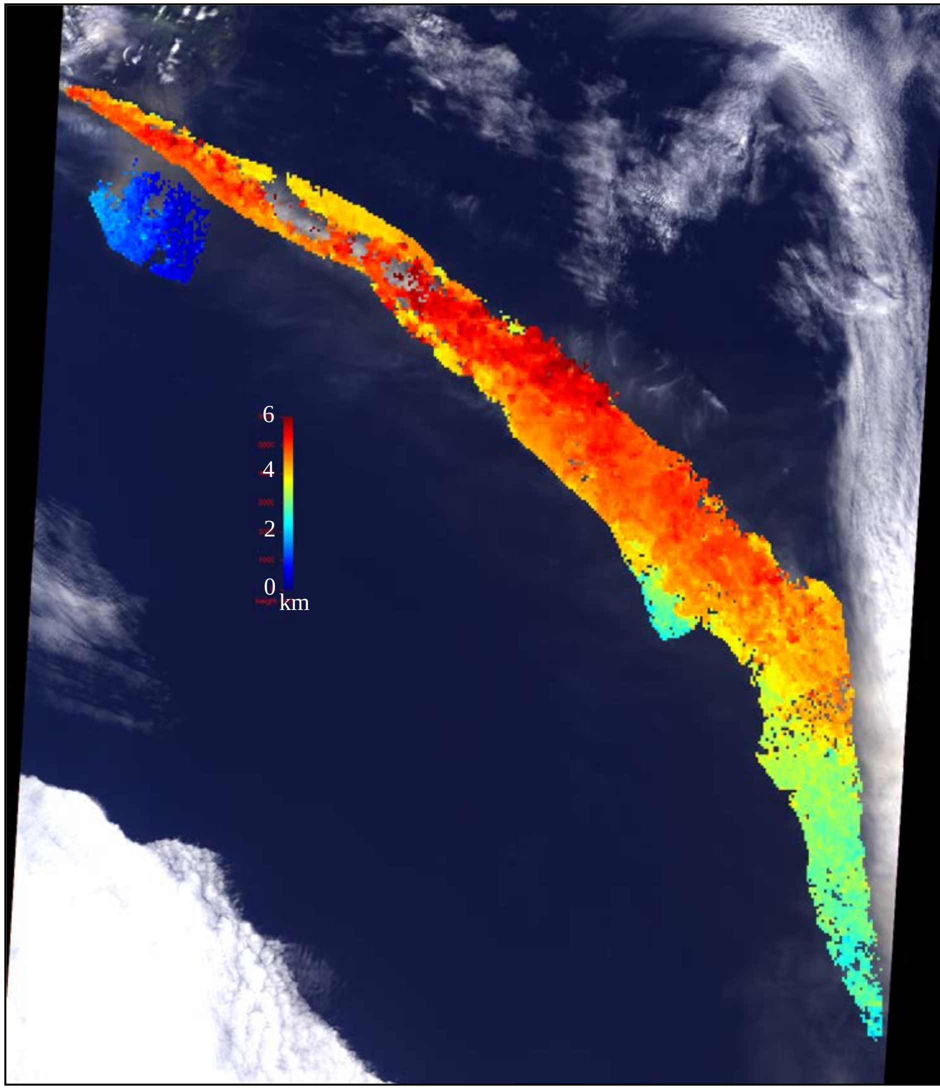


Kahn, Gaitley, Garay, et al., JGR 2010

MISR Stereo-Derived ***Plume Heights***

07 May 2010 ***Orbit 55238 Path 216 Blk 40 UT 12:39***





D. Nelson and the MISR Team, JPL and GSFC

MISR Verions 22 ***Aerosol Component Optical Models***

No.	Component Name	r_1 (μm)	r_2 (μm)	r_c (μm)	σ	SSA (446)	SSA (558)	SSA (672)	SSA (866)	AOD(446)/ AOD(558)	AOD(672)/ AOD(558)	AOD(867)/ AOD(558)	g (558)	Particle Size/Shape Category
1	sph_nonabsorb_0.06	0.001	0.4	0.03	1.65	1.00	1.00	1.00	1.00	1.95	0.55	0.23	0.352	Small spherical
2	sph_nonabsorb_0.12	0.001	0.75	0.06	1.7	1.00	1.00	1.00	1.00	1.54	0.66	0.35	0.609	Small spherical
3	sph_nonabsorb_0.26	0.01	1.5	0.12	1.75	1.00	1.00	1.00	1.00	1.18	0.82	0.58	0.717	Medium spherical
6	sph_nonabsorb_2.80	0.10	50.	1.0	1.9	1.00	1.00	1.00	1.00	0.99	1.02	1.06	0.776	Large spherical
8	sph_absorb_0.12_ssa_green_0.9	0.001	0.75	0.06	1.7	0.91	0.90	0.89	0.85	1.50	0.68	0.37	0.612	Small spherical, moderately absorbing
14	sph_absorb_0.12_ssa_green_0.8	0.001	0.75	0.06	1.7	0.82	0.80	0.77	0.72	1.47	0.69	0.40	0.614	Small spherical, strongly absorbing
19	Medium_grains	0.10	1.00	0.5	1.5	0.92	0.98	0.99	1.00	0.90	1.06	1.08	0.711	Medium dust
21	Coarse_spheroids	0.10	6.0	1.0	2.0	0.81	0.90	0.97	0.98	0.99	1.02	1.05	0.772	Coarse dust

[a]AOD, aerosol optical depth; SSA, single-scattering albedo. These aerosol optical models apply to the MISR standard level 2AS aerosol product, Versions 16 through 22. A number-weighted, log-normal particle size distribution function is adopted for all components. Aerosol components are named based on particle shape (spherical grains, nonspherical grains, or spheroids), SSA (nonabsorbing or absorbing), and effective radius (μm). For absorbing aerosols the green-band SSA is also given. Single-scattering properties were calculated using a Mie code for spherical particles; dust component properties were calculated using the discrete dipole and T-matrix approaches for medium and coarse modes, respectively [*Kalashnikova et al.*, 2005]. Wavelength (nm) is specified in parentheses where appropriate. r_1 and r_2 are the upper and lower limits of the size distribution; r_c and σ are the characteristic radius and width parameters in the log-normal distribution. The asymmetry parameter (g) will generally represent particle scattering phase functions poorly for the purpose of calculating MISR multiangle radiances and is given here only in the MISR green band for reference; full phase functions are available in the MISR standard product "ACP_APOP" files. All spherical components are assumed to be distributed vertically within 10 km of the surface and have scale heights of 2 km. Medium and coarse dust are confined to the lowest 10 km.

Kahn et al., JGR 2010

Key Attributes of the MISR **Version 22** Aerosol Product

- **AOT Coverage** – ***Global but limited sampling*** on a monthly basis
- **AOT Accuracy** – Maintained even when particle property information is poor
- **Particle Size** – ***2-3 groupings reliably***; quantitative results vary w/conditions
- **Particle Shape** – ***spherical vs. non-spherical robust***, except for coarse dust
- **Particle SSA** – useful for ***qualitative*** distinctions
- **Aerosol Type Information** – diminished when ***AOT < 0.15*** or 0.2
- **Particle Property Retrievals** – ***improvement expected*** w/algorithm upgrades
- **Aerosol Air-mass Types** – ***more robust*** than individual properties

PLEASE READ THE QUALITY STATEMENT!!!

… and more details are in publications referenced therein

MISR Aerosol Algorithm Upgrade Priorities
Supporting Dust, Smoke, & Aerosol Pollution Applications

- Based on ***10+ Years of Validation*** Data

-- ***Low-light-level*** gap & quantization noise

-- ***High-AOD underestimation*** of AOD (*missing* ***low-n_r, SSA, algorithm issues***)

-- Very ***Low-AOD aerosol type*** (compare with, or assume, type from climatology)

-- Missing ***Medium-mode*** particles (r_{eff} ~ 0.57, 1.28 μm)

-- More spherical, ***absorbing particles*** (*SSA* ~ 0.94, 0.84, maybe 0.74), ***cirrus*** analogs

-- Lack of a good ***Coarse-mode Dust Optical Analog*** remains an issue

-- ***Higher spatial resolution*** product

+ ***Algorithmic Issues***

Kahn, Gaitley, et al., JGR 2010

Current MISR & MODIS Mid-Visible AOD Sensitivities

- MISR: **0.05 or 20% * AOD** overall; ***better over dark water***

[*Kahn et al*., 2005; 2010]

- MODIS: **0.05 or 20% * AOD** over land
  0.03 or 5% * AOD over dark water

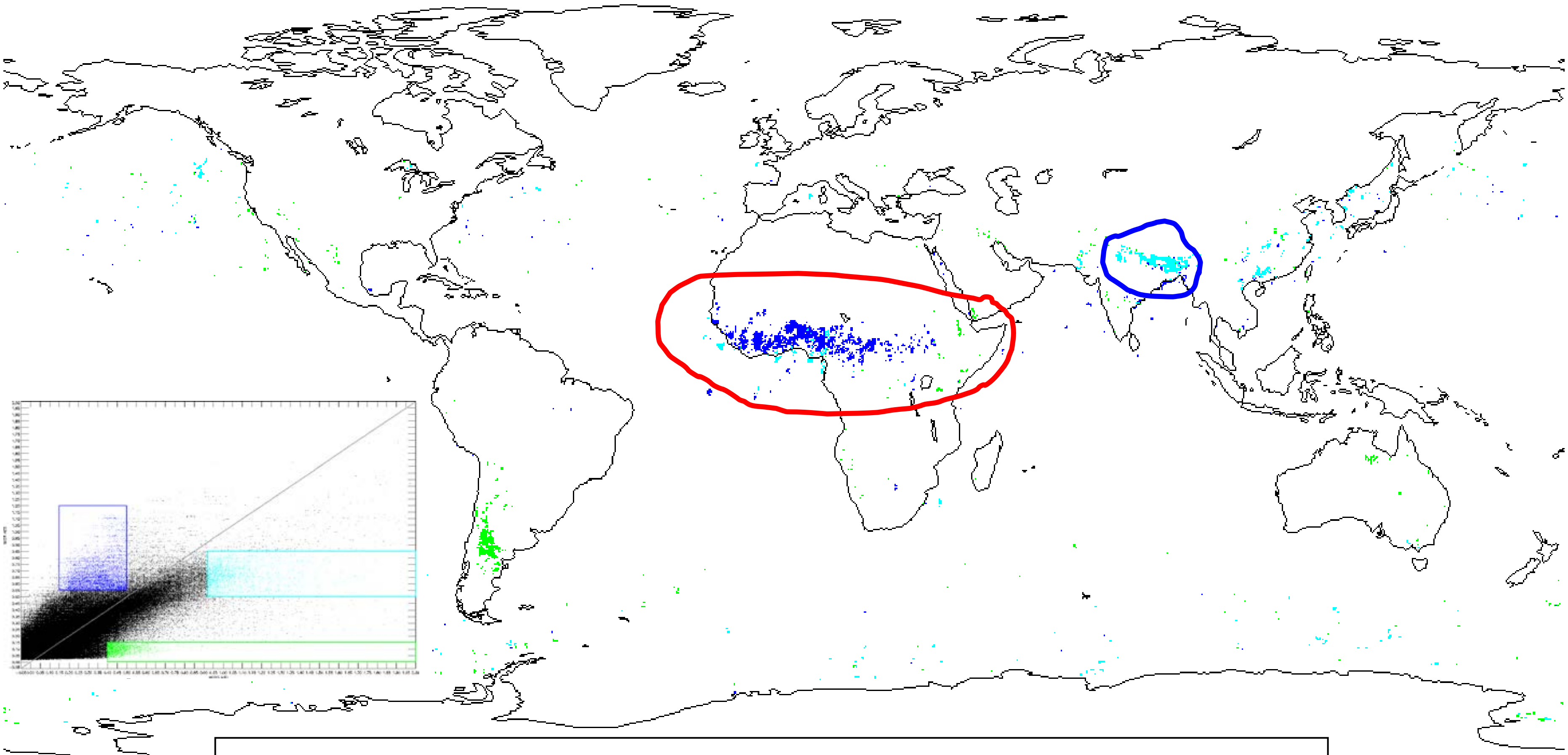
[*Remer et al*. 2005; 2008; *Levy et al*. 2010]

Based on AERONET coincidences (cloud screened by ***both*** sensors)

- ***Direct Aerosol Radiative Forcing (DARF): Need AOD to <~ 0.02***
- ***Particle Properties are Categorical rather than continuous Quantities***

- Some factors that, if refined, can help ***improve aerosol retrieval accuracy***:
  - Radiometric Calibration
  - Lower Boundary Condition Assumptions/ Constraints
  - Aerosol Component Assumptions/ Constraints
  - Cloud Screening
  - Other Algorithm Upgrades

Needed Aerosol Mixtures – ***Dust + Smoke***



MISR-MODIS Coincident AOT ***Outlier Clusters***

Dark Blue [MISR > MODIS] – N. Africa ***Mixed Dust & Smoke***

Cyan [MODIS > MISR, AOD large] – Indo-Gangetic Plain ***Dark Pollution Aerosol***

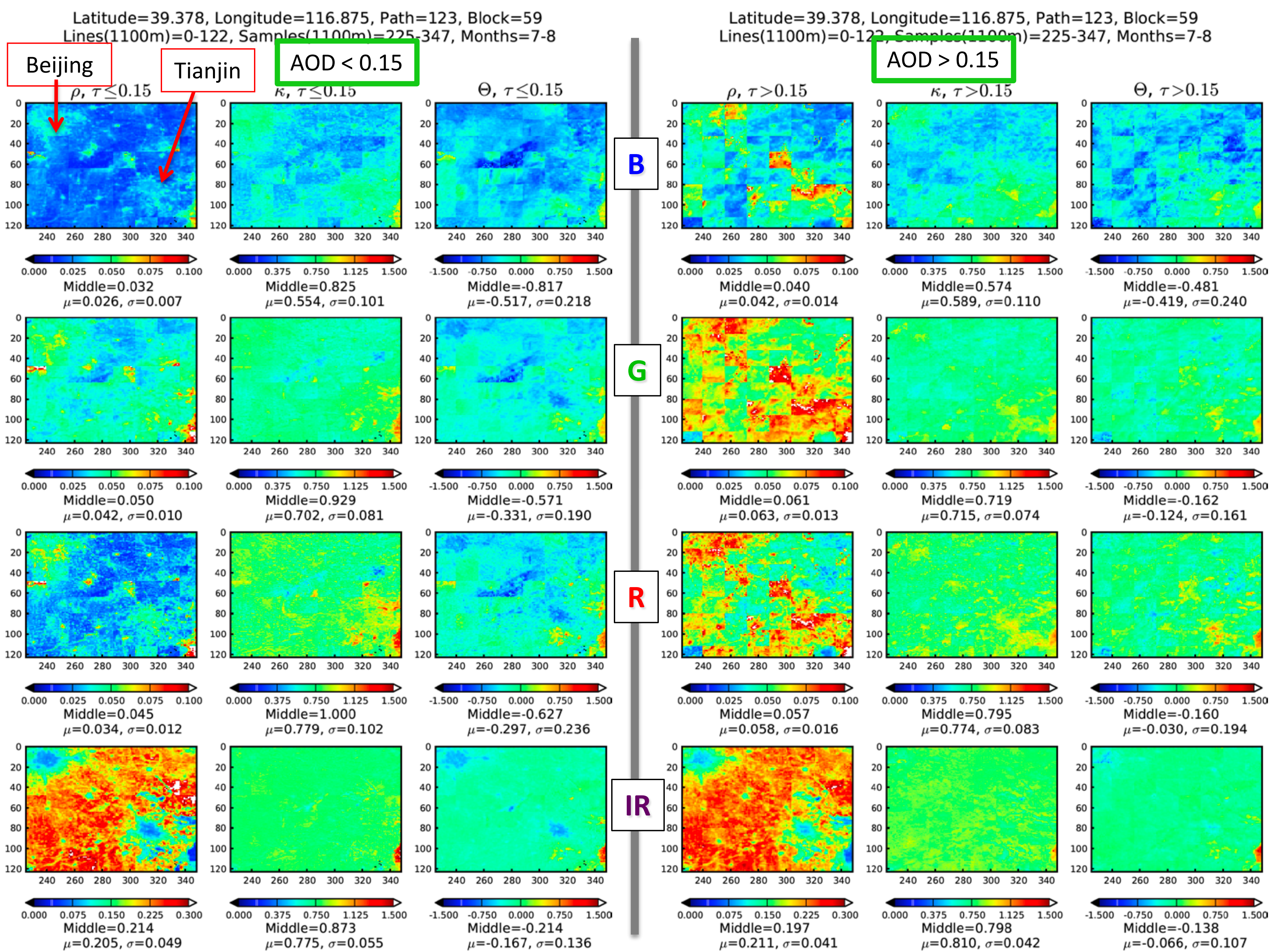
Green [MODIS >> MISR] – Patagonia and N. Australia ***MODIS Unscreened Bright Surface***

Kahn et al., TGARS 2009

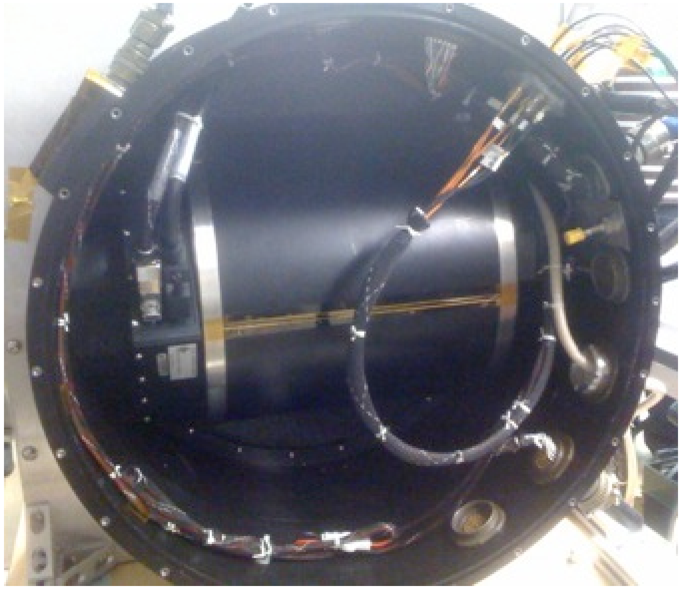
High AOD ***Underestimation***

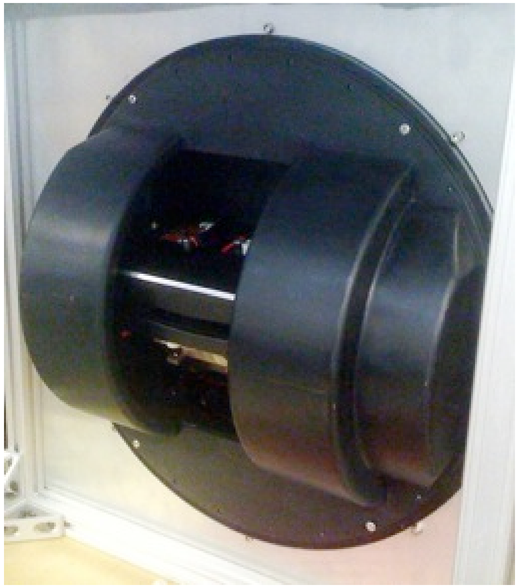
MISR-retrieved Surface BRDF – ***Urban China***

Orbit 30374, Blocks 59-59, 2005-09-03


Latitude=39.378, Longitude=116.875, Path=123, Block=59
Lines(1100m)=0-122, Samples(1100m)=225-347, Months=7-8
Beijing
Tianjin
AOD < 0.15
AOD > 0.15
ρ, τ≤0.15
κ, τ≤0.15
Θ, τ≤0.15
ρ, τ>0.15
κ, τ>0.15
Θ, τ>0.15
B
G
R
IR
Middle=0.032
μ=0.026, σ=0.007
Middle=0.825
μ=0.554, σ=0.101
Middle=-0.817
μ=-0.517, σ=0.218
Middle=0.040
μ=0.042, σ=0.014
Middle=0.574
μ=0.589, σ=0.110
Middle=-0.481
μ=-0.419, σ=0.240
Middle=0.050
μ=0.042, σ=0.010
Middle=0.929
μ=0.702, σ=0.081
Middle=-0.571
μ=-0.331, σ=0.190
Middle=0.061
μ=0.063, σ=0.013
Middle=0.719
μ=0.715, σ=0.074
Middle=-0.162
μ=-0.124, σ=0.161
Middle=0.045
μ=0.034, σ=0.012
Middle=1.000
μ=0.779, σ=0.102
Middle=-0.627
μ=-0.297, σ=0.236
Middle=0.057
μ=0.058, σ=0.016
Middle=0.795
μ=0.774, σ=0.083
Middle=-0.160
μ=-0.030, σ=0.194
Middle=0.214
μ=0.205, σ=0.049
Middle=0.873
μ=0.775, σ=0.055
Middle=-0.214
μ=-0.167, σ=0.136
Middle=0.197
μ=0.211, σ=0.041
Middle=0.798
μ=0.810, σ=0.042
Middle=-0.138
μ=-0.066, σ=0.107

AirMSPI

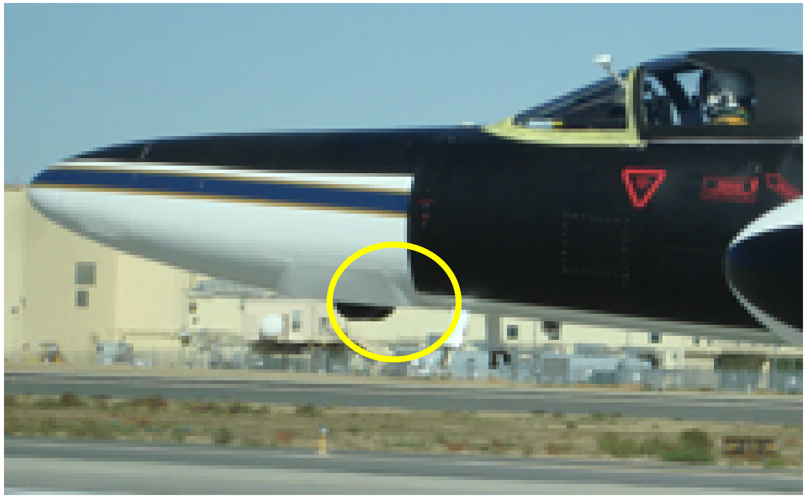




Spectral bands:

355, 380, 445, 470*,555, 660*, 865*, 935 nm (*polarimetric)

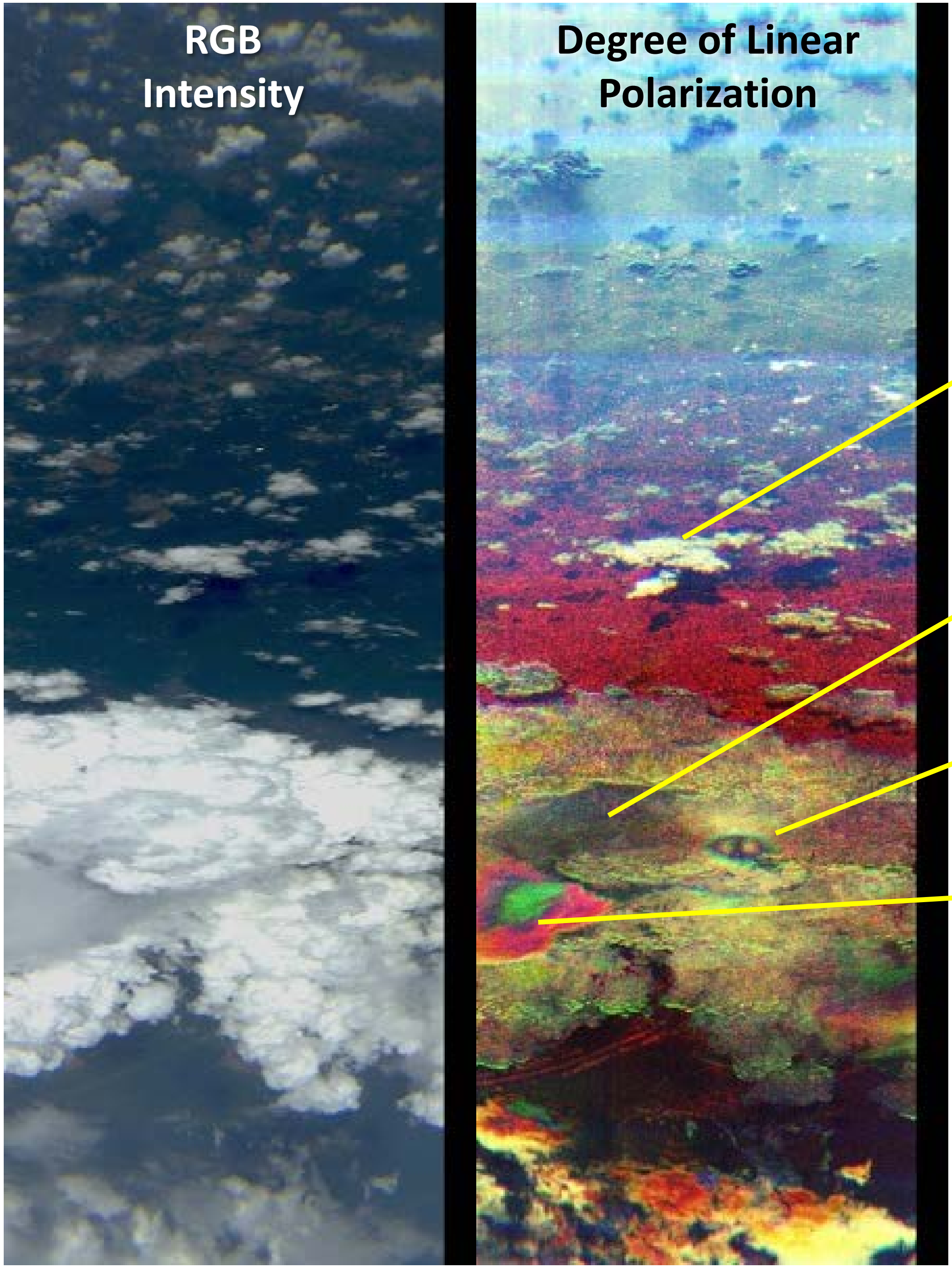
Campaigns to date:
PODEX (Jan/Feb 2013)
HyspIRI (Apr/May 2013)
SEAC4RS (Jul-Sep 2013)



The AirMSPI camera flies in the nose of NASA's ER-2

It is mounted in a gimbal for multi-angle viewing

Diner et al., SEAC^{4}RS, 2013



High DOLP is cloudbow suggesting liquid drops

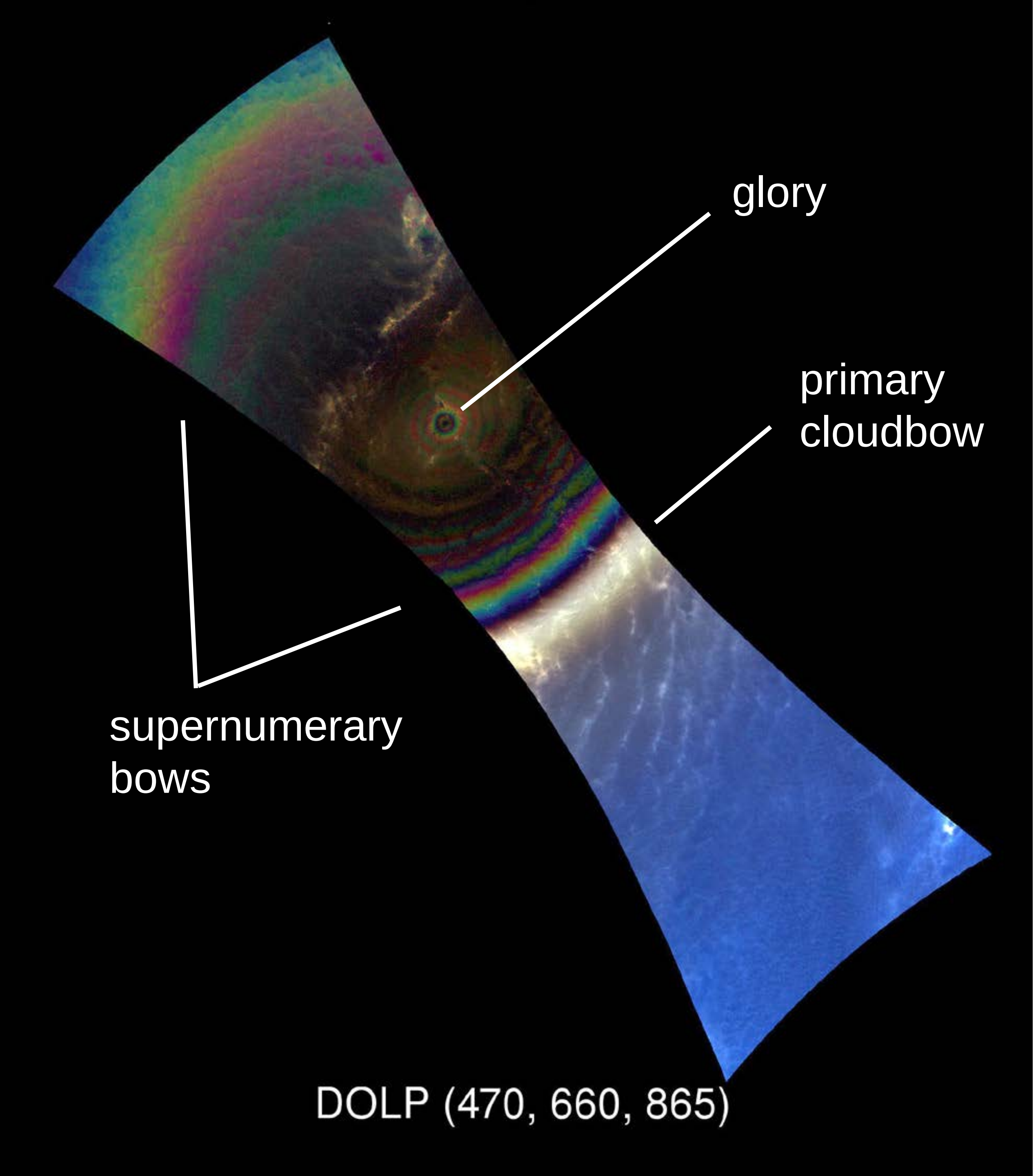
Reduced DOLP suggests potentially glaciation

Glory (180° Backscatter)

DOLP is high and colorful, suggesting liquid drops

AirMSPI Forward Sweep Quicklook Image 2013-09-02 17:09 to 17:10 UTC

Garay et al., SEAC[4]RS, 2013



Over Liquid Water Clouds

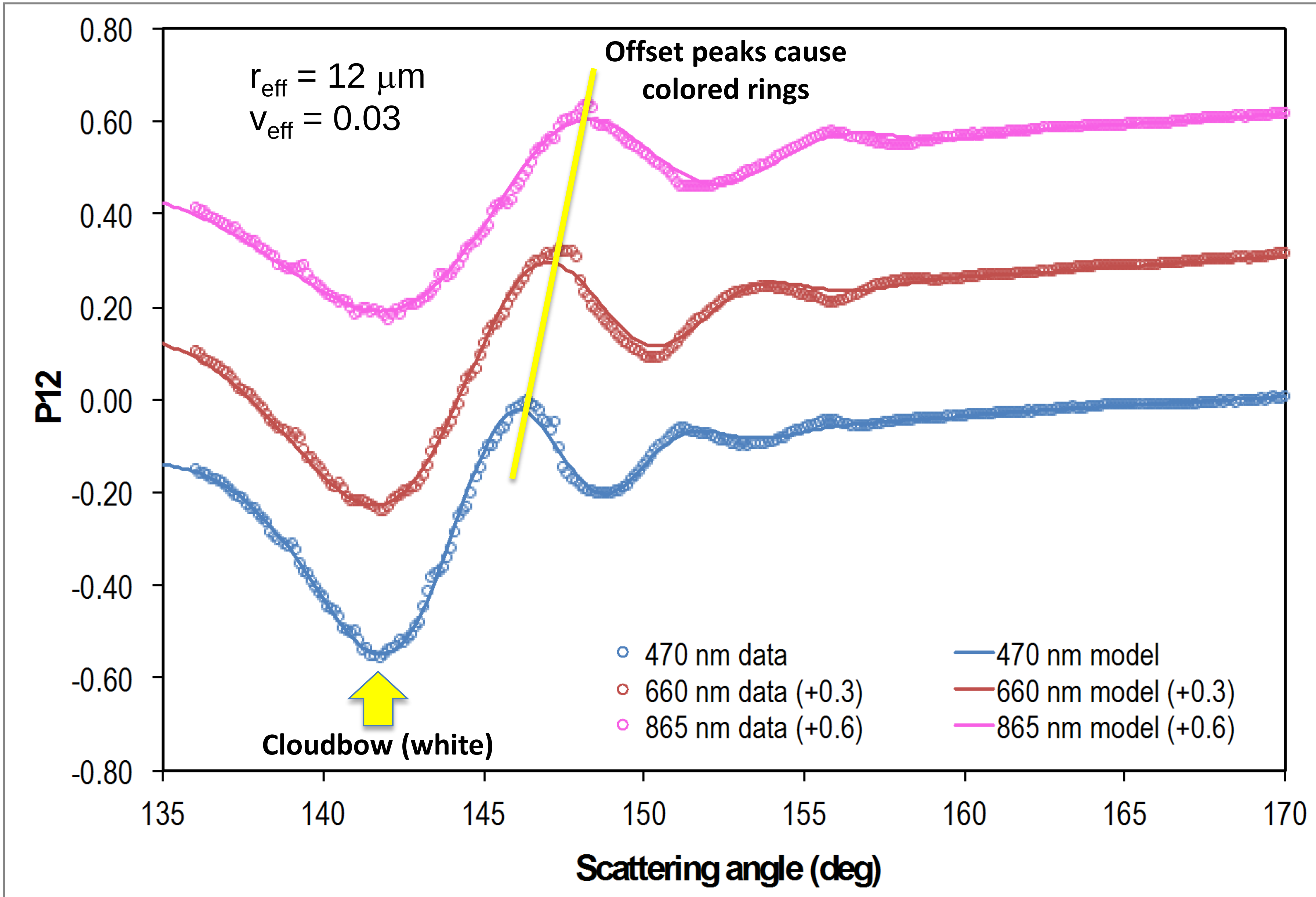
The cloudbow, glory, and supernumeraries indicate spherical drops

The supernumerary bows are interference fringes

Their angular positions and relative magnitudes are governed by the particle size distribution at the cloud top

Garay et al., SEAC[4]RS, 2013

12 μm droplets with wider droplet size dispersion fits well

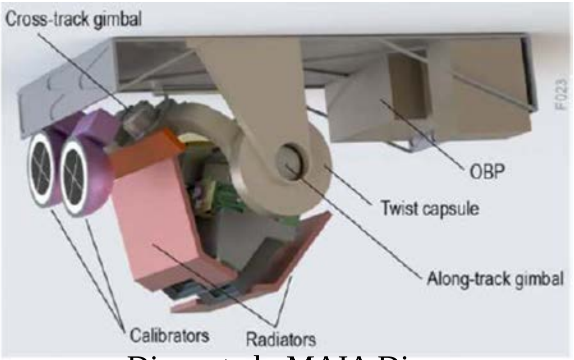


Garay et al., SEAC[4]RS, 2013

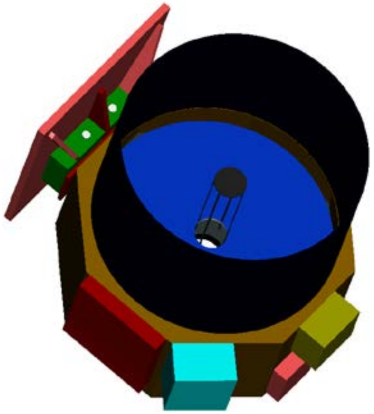
Next Generation Spacecraft Aerosol Instruments

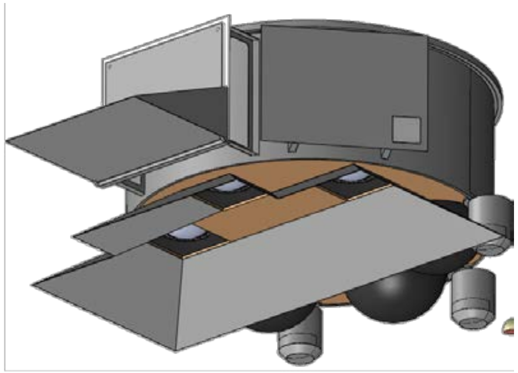
- ***Multi-angle, Multi-spectral, Polarimeter Imager***

-- Sensitivity to the real part of aerosol ***refractive index***
-- Sensitivity to one additional moment of the particle ***size distribution***
-- Ability to retrieve ***AOD to ~0.02*** over a broader range of ***conditions***



Diner et al., MAIA Diagram


Hostetler et al., HSRL Diagram


Martins et al., PACS Diagram

- ***High-Spectral-Resolution Lidar (HSRL)***

-- Ability to retrieve the ***lidar ratio*** (related to particle properties)

Aiming For Future Missions…

SAM-CAAM

[Systematic Aircraft Measurements to Characterize Aerosol Air Masses]

{This is currently just a ***concept-development effort***, not yet a project}

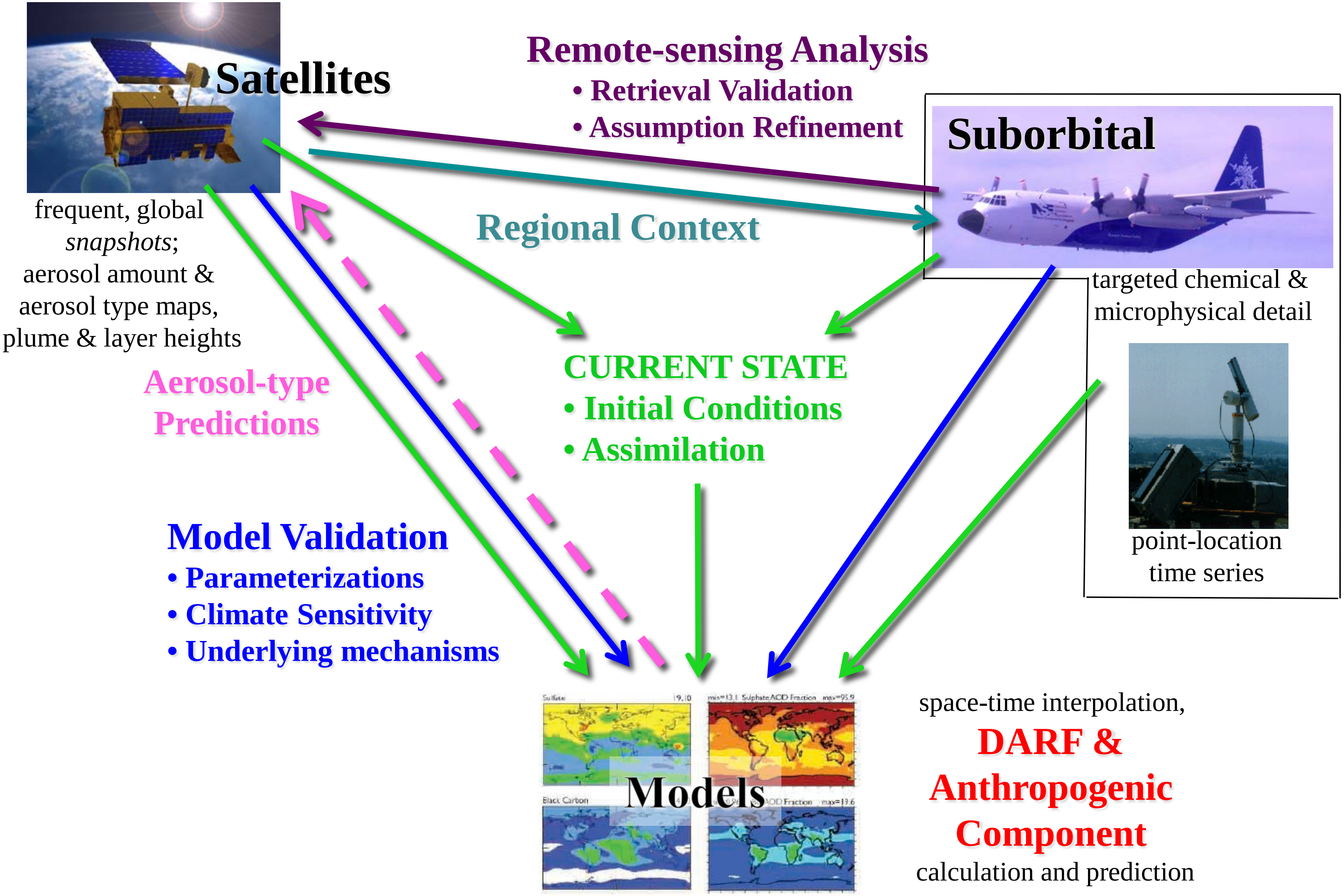
***Primary Objectives*:**

- **Interpreting and *enhancing satellite aerosol-type retrieval* products**
- ***Characterizing statistically particle properties* for the major aerosol types,**

providing detail unobtainable from space, but needed to improve:

-- Satellite aerosol *retrieval algorithms*

-- The *translation between satellite-retrieved aerosol optical properties and* species-specific aerosol mass and size tracked in *aerosol transport and climate*



Kahn, Survy. Geophys. 2012