MISR Update

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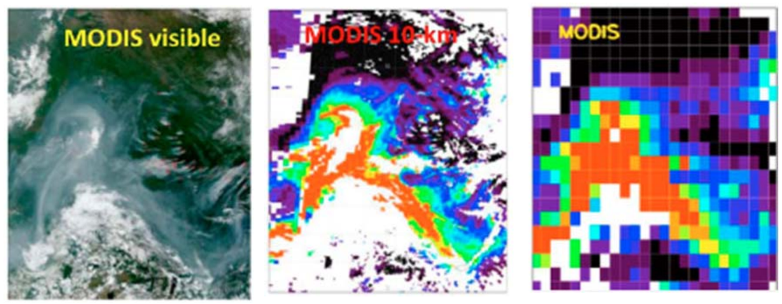
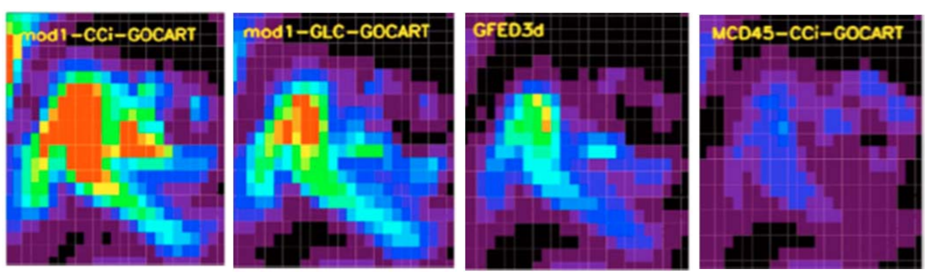
Falguni Patadia, Mariya Petrenko, Mian Chin, Maria Val Martin

NASA Goddard Space Flight Center & JPL/Caltech



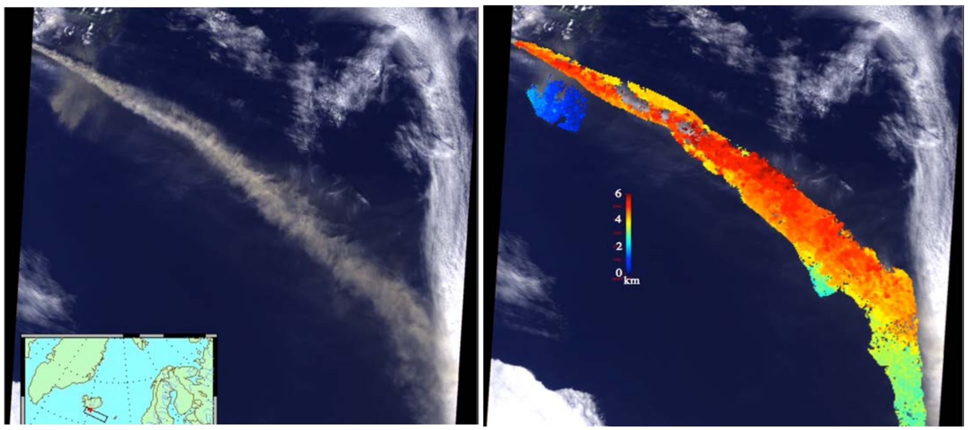
Measurements



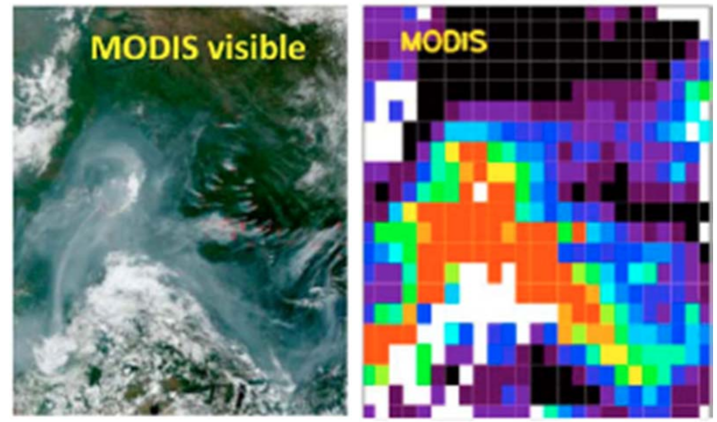
Model

Petrenko et al., JGR 2012

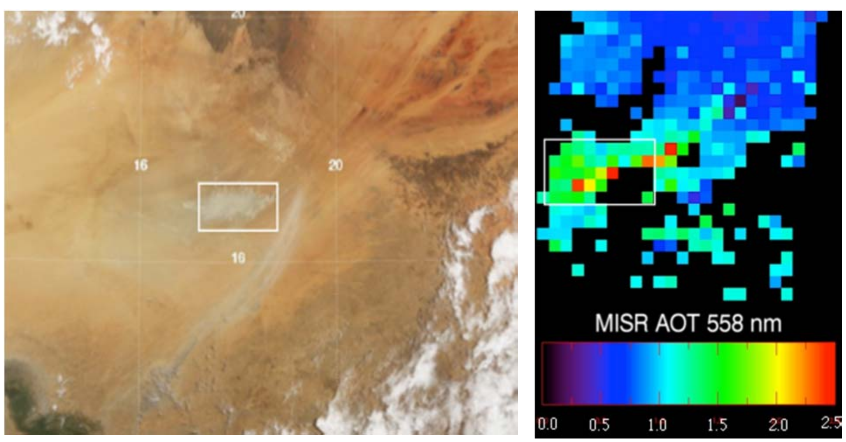
From Case Studies Toward Climatology…



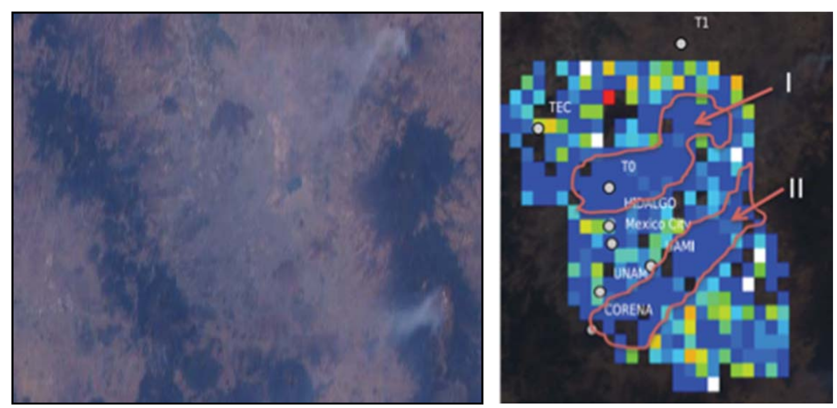
Volcanic Ash



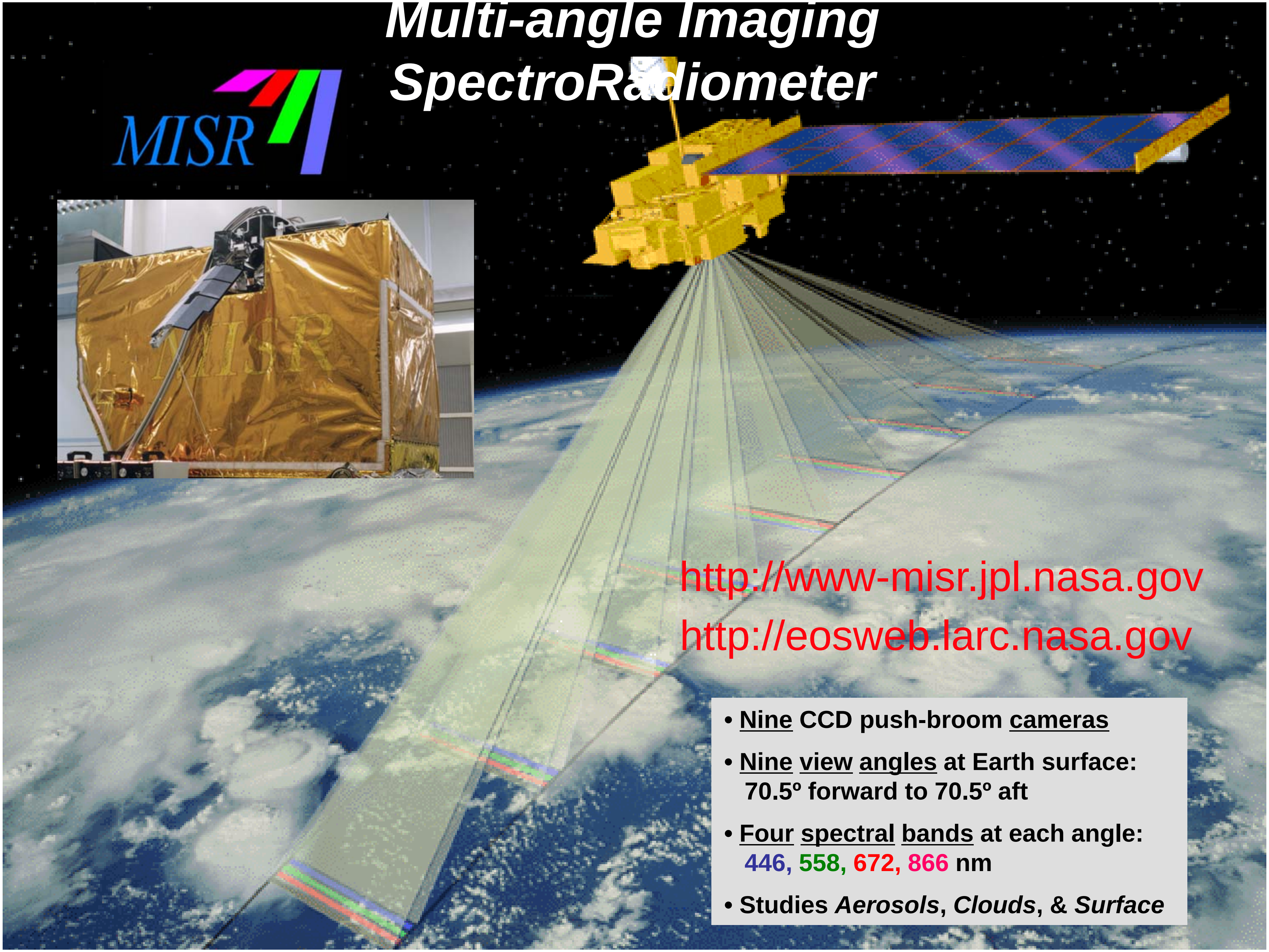
Wildfire Smoke



Desert Dust

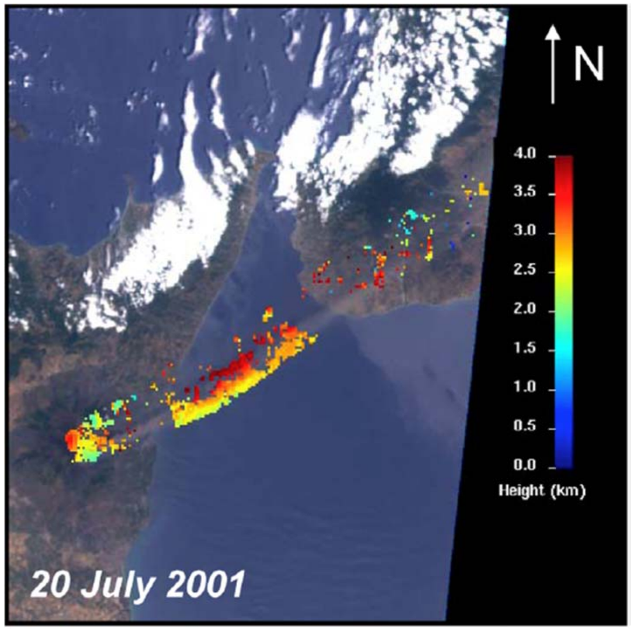


Urban Pollution Particles


Multi-angle Imaging
SpectroRadiometer
MISR
MISR
http://www-misr.jpl.nasa.gov
http://eosweb.larc.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

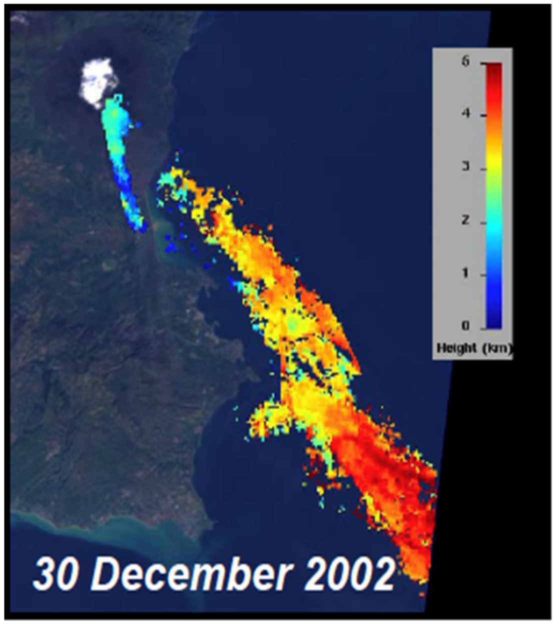
Mount Etna Plume Height and Eruption Style from MISR

Scollo, S. R.A. Kahn, D.L. Nelson, M. Coltelli, D.J. Diner, M.J. Garay, and V.J. Realmuto
MISR observations of Etna volcanic plumes. *J. Geophys. Res*. 2012



MISR nadir-viewing, true-color image showing Etna, with stereo-derived plume height superposed

29 Sept. 2006 – MISR retrieved mostly small spherical particles, indicating a sulfate/water-dominated plume



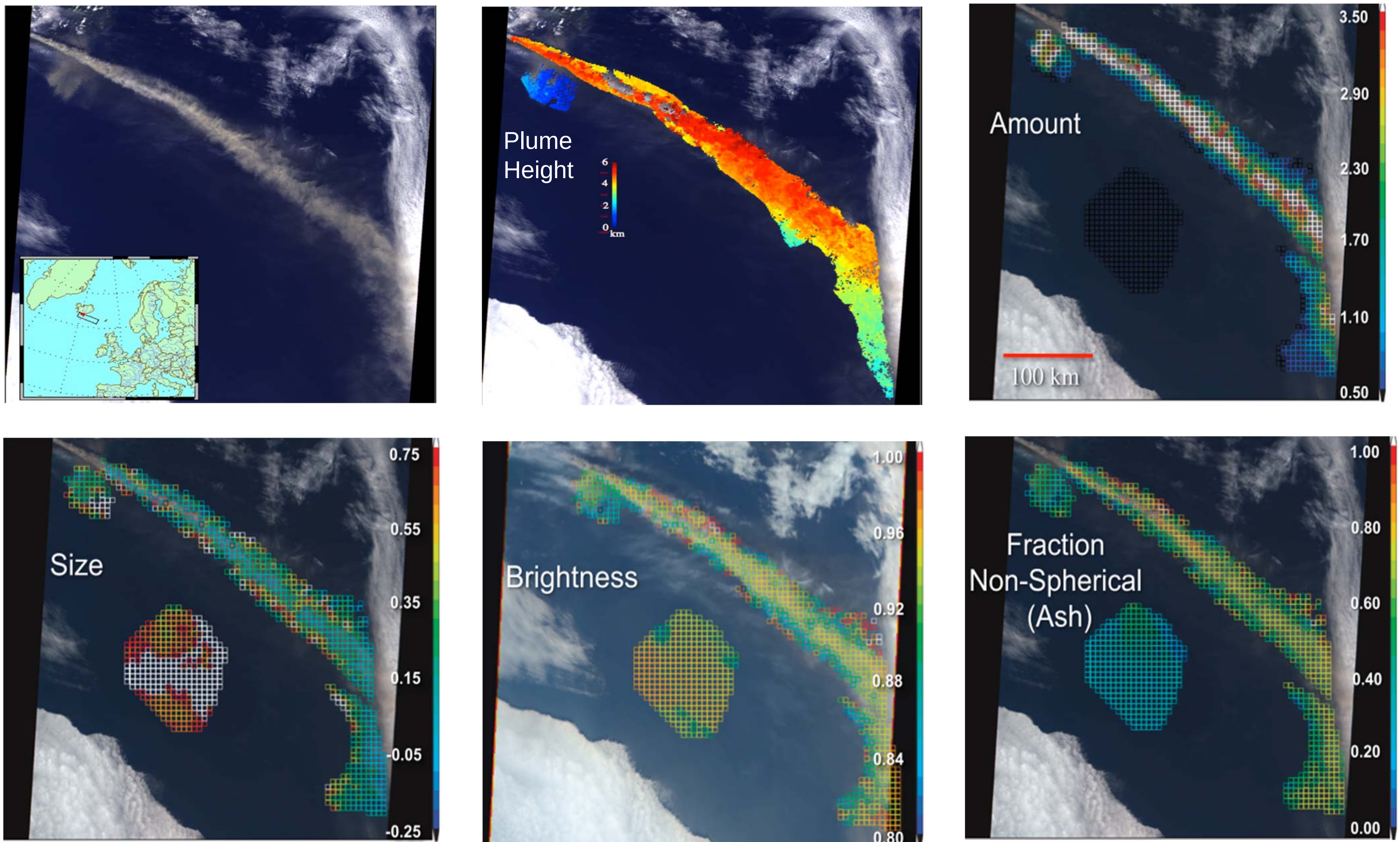
MISR stereo heights for the ash-dominated plume on 30 December 2002

Indications of Eruption Strength:

- ***Plume Height*** from MISR stereo imaging
- ***Ash to Sulfate/Water particle AOD ratio*** from MISR-retrieved particle shape and size

Volcanic Plume Properties: Height, Particle Size, Shape, Brightness

MISR Observations – Iceland Volcano Eruption ***07 May 2010***



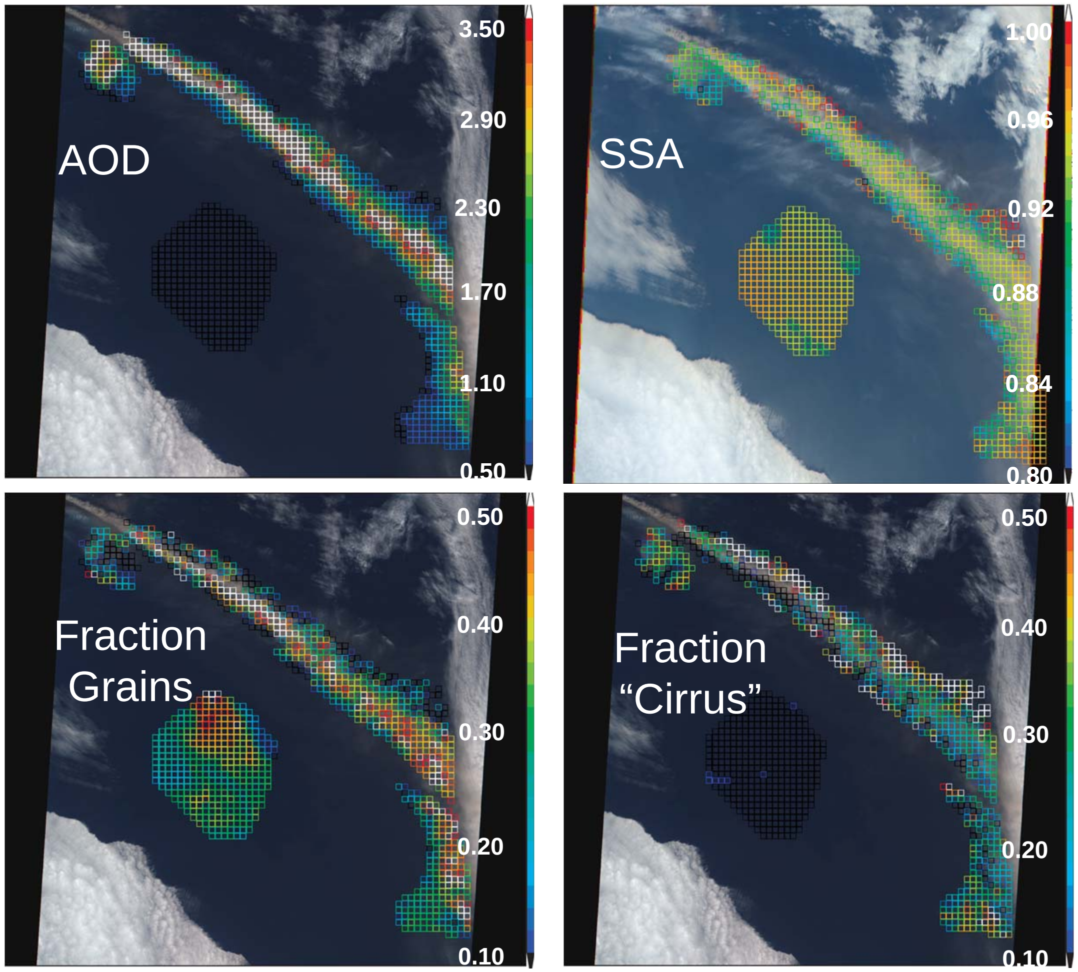
Kahn & Limbacher, ACP 2012

Plume Particles vs. Background:

Larger, ***darker***, ***more non-spherical***, ***much more abundant***; ***Brighten & decrease in size downwind***

Eyjafjallajökull Volcanic Plume Properties

07 May 2010 plume, Orbit 55238, Path 216, 12:39 UTC



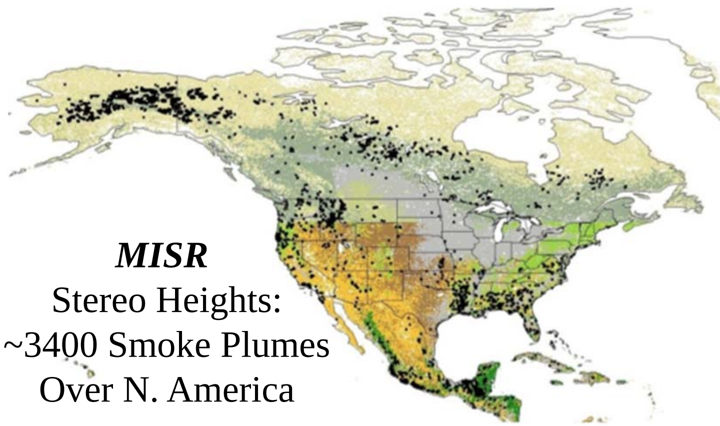
Climatology begins with case studies

- **Volcanic Ash:** Retrieved as a mix of ***Grains***, ***Cirrus***, and ***Spherical Absorbing*** optical analogs
- **Global 13⁺-year Data Set:** About a dozen volcanoes active around the globe at any one time
- **Retrieval Validation:** Need coincident ground-truth particle amount & type data

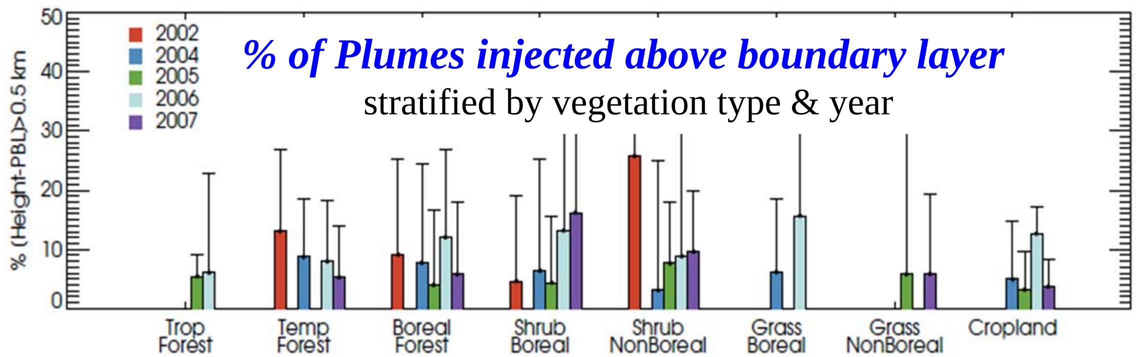
Kahn & Limbacher 2012

Wildfire Smoke *Injection Heights* & *Source Strengths*

[These are *the two key parameters* representing aerosol sources in climate models]

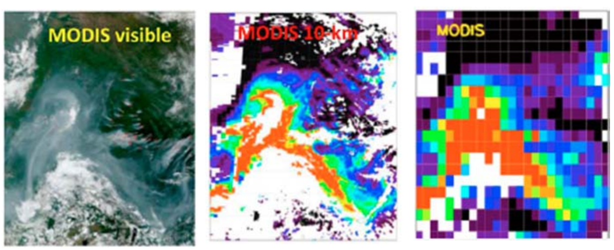


MISR
Stereo Heights:
~3400 Smoke Plumes
Over N. America

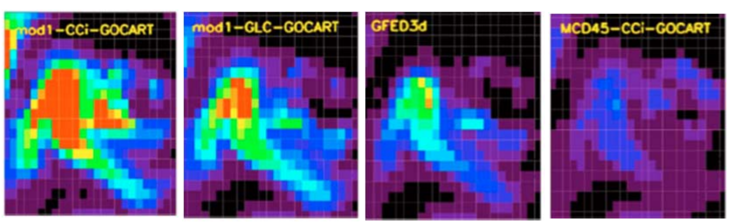


% of Plumes injected above boundary layer
stratified by vegetation type & year

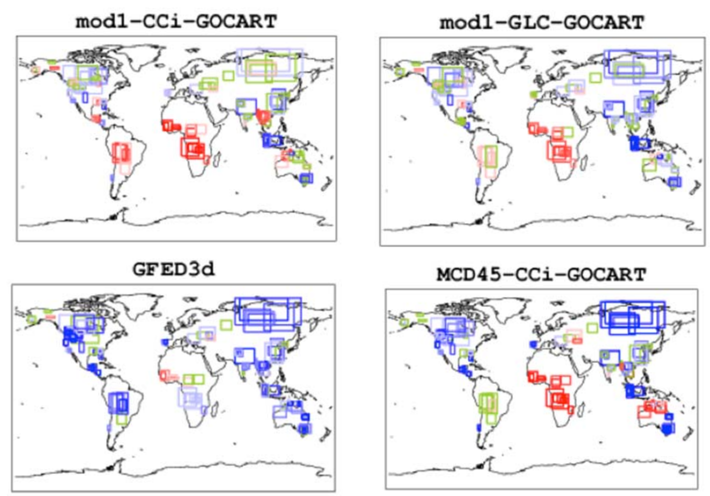
Val Martin et al. ACP 2010



MODIS Smoke Plume Image & Aerosol Amount Snapshots



GoCART Model-Simulated Aerosol Amount Snapshots
for *Different Assumed Source Strengths*

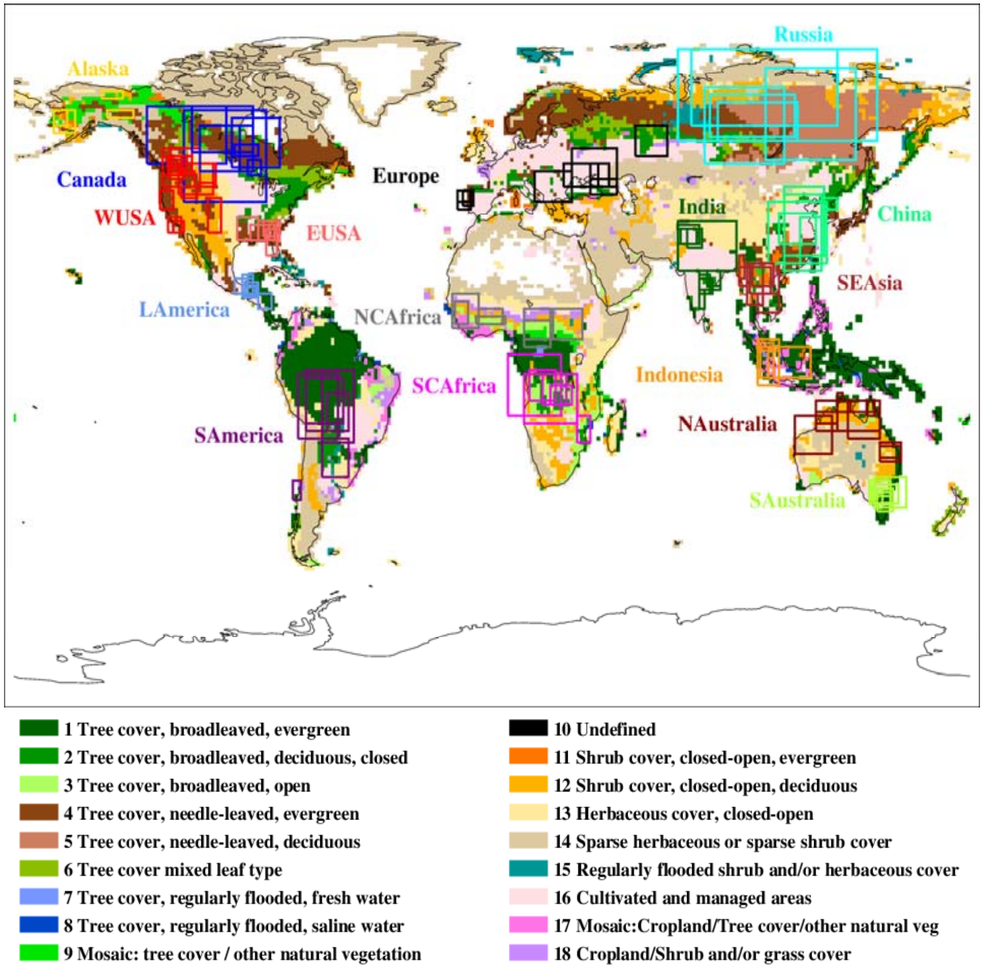


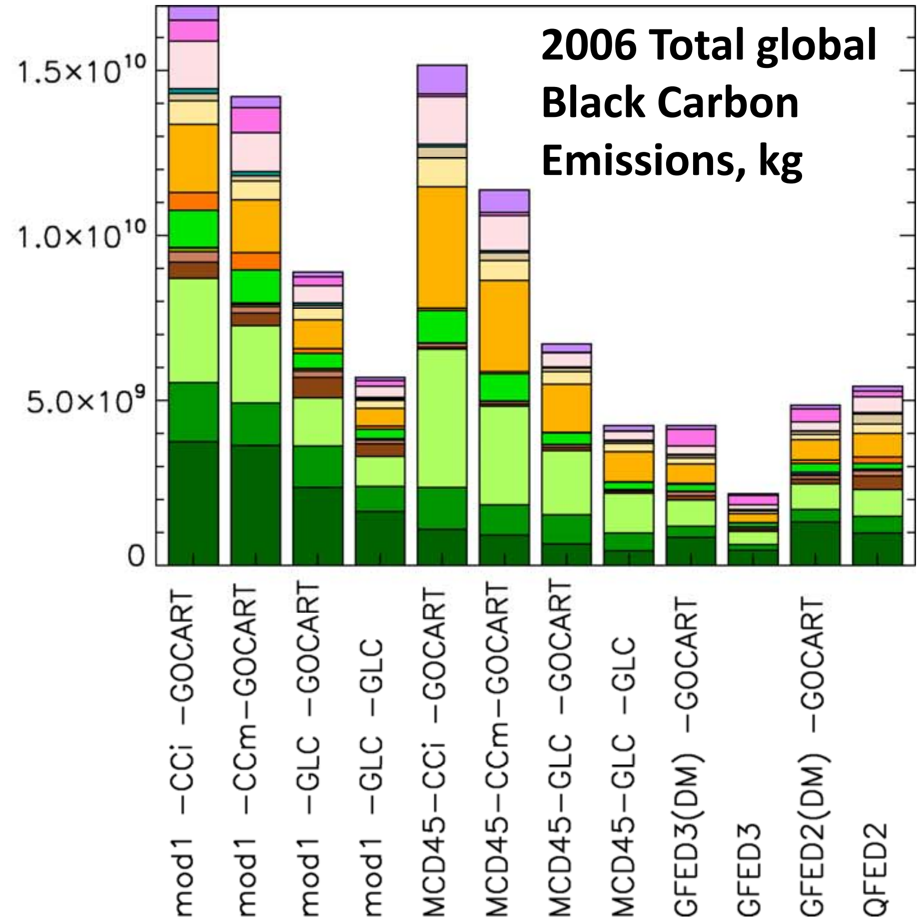
Different Techniques for *Assuming Model Source Strength*
Overestimate or ***Underestimate*** Observation
Systematically in Different Regions

Petrenko et al., JGR 2012

Satellite AOD snapshots constrain biomass burning emissions *source strength*

Black Carbon (BC) emissions in 2006

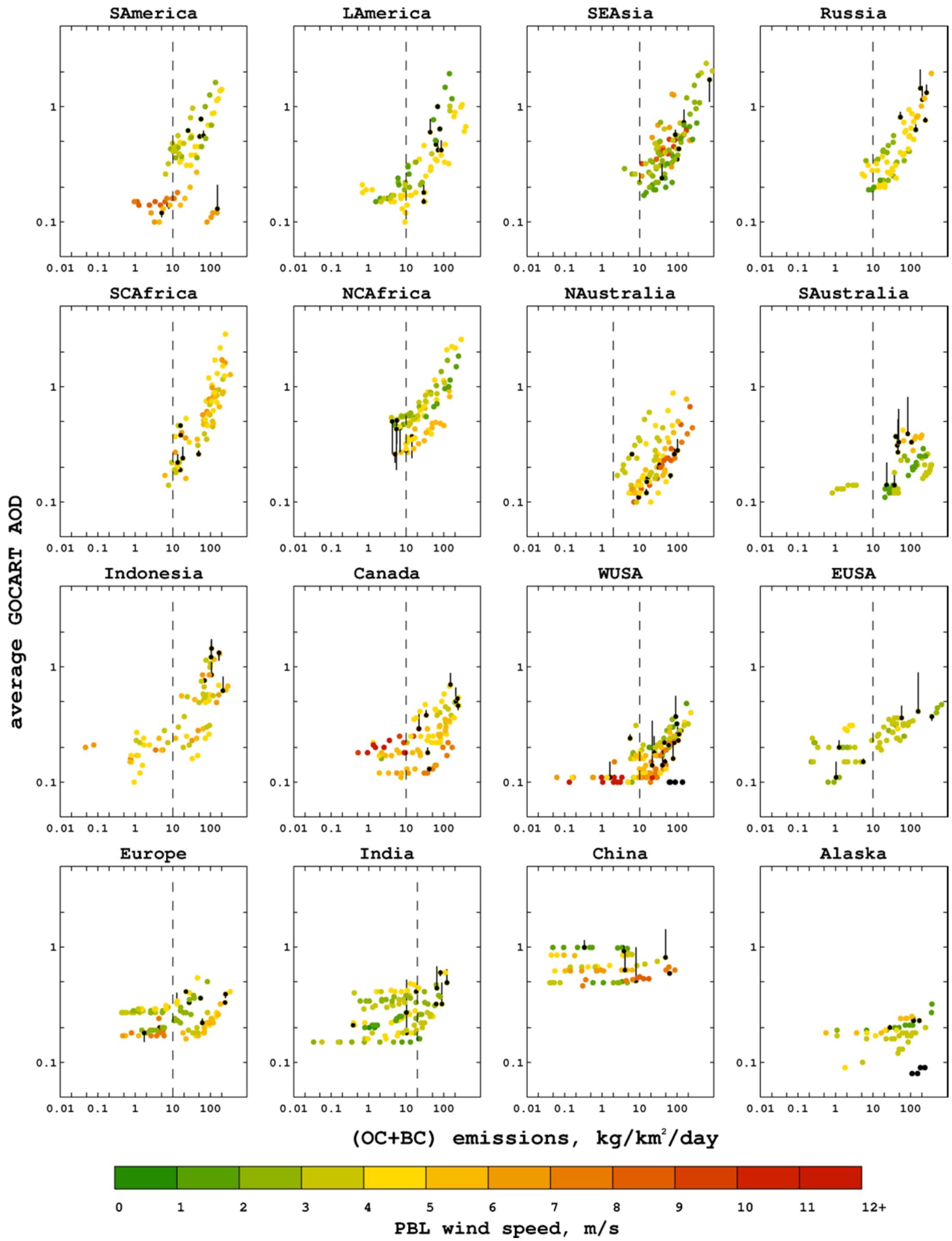




13 global BB aerosol emission estimates

→ The first time these inventories are compared, the details suggest the source of discrepancies

Petrenko, Kahn, Chin, et al., JGR 2012



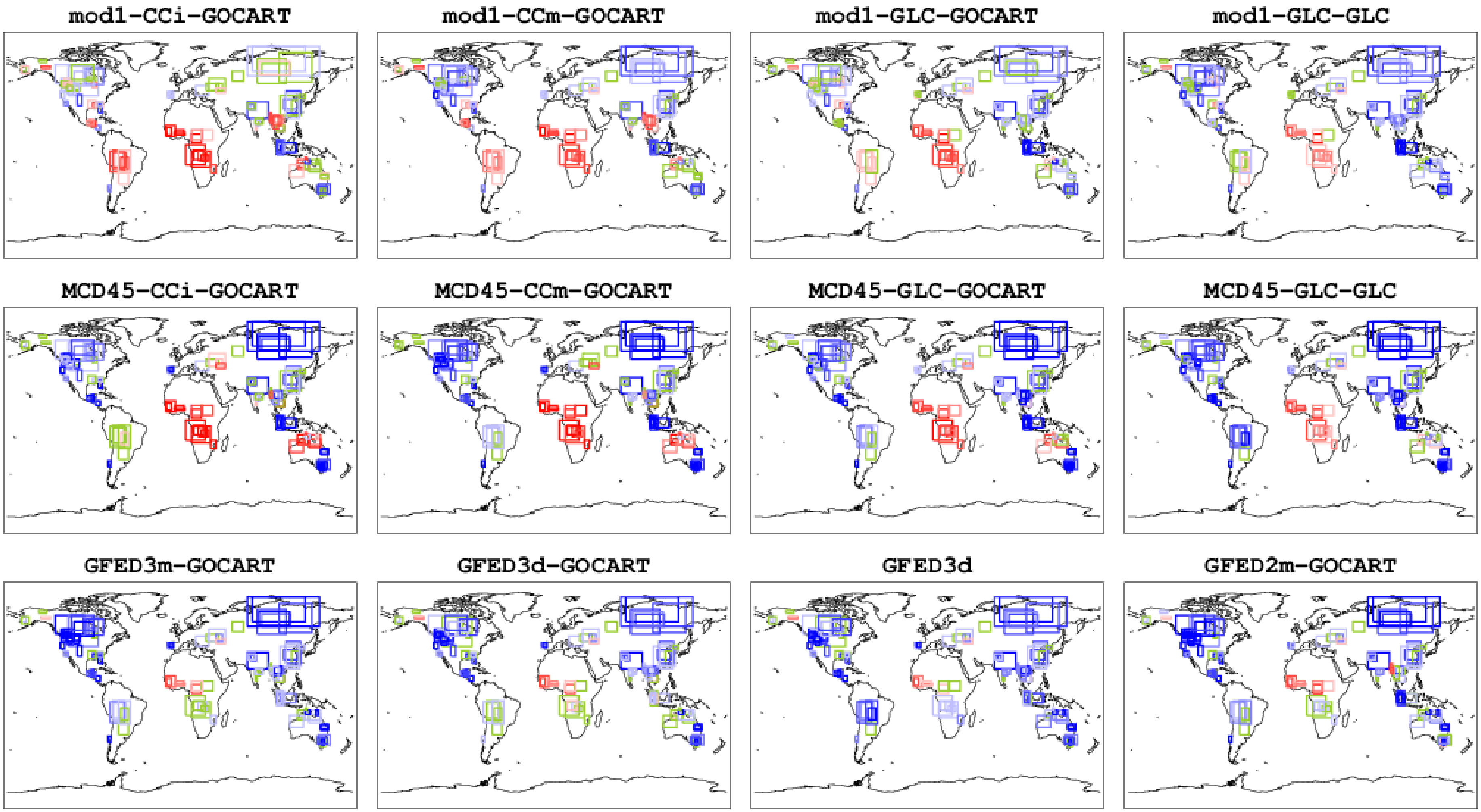
Wind speed at the source defines the AOD-emissions relationship

→Quantitative relationship between aerosol emission rate and AOD is explored,
→and can be used to correct biases at the level of individual plume.

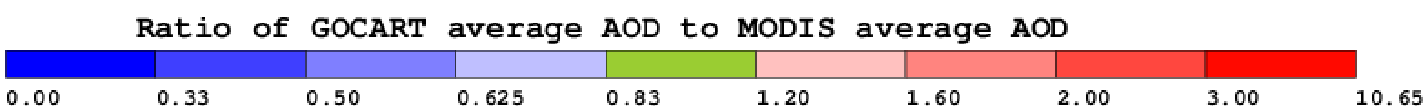
Petrenko et al. 2012

Ratio of GOCART to MODIS average AOD

For each case, for 12 emission estimates

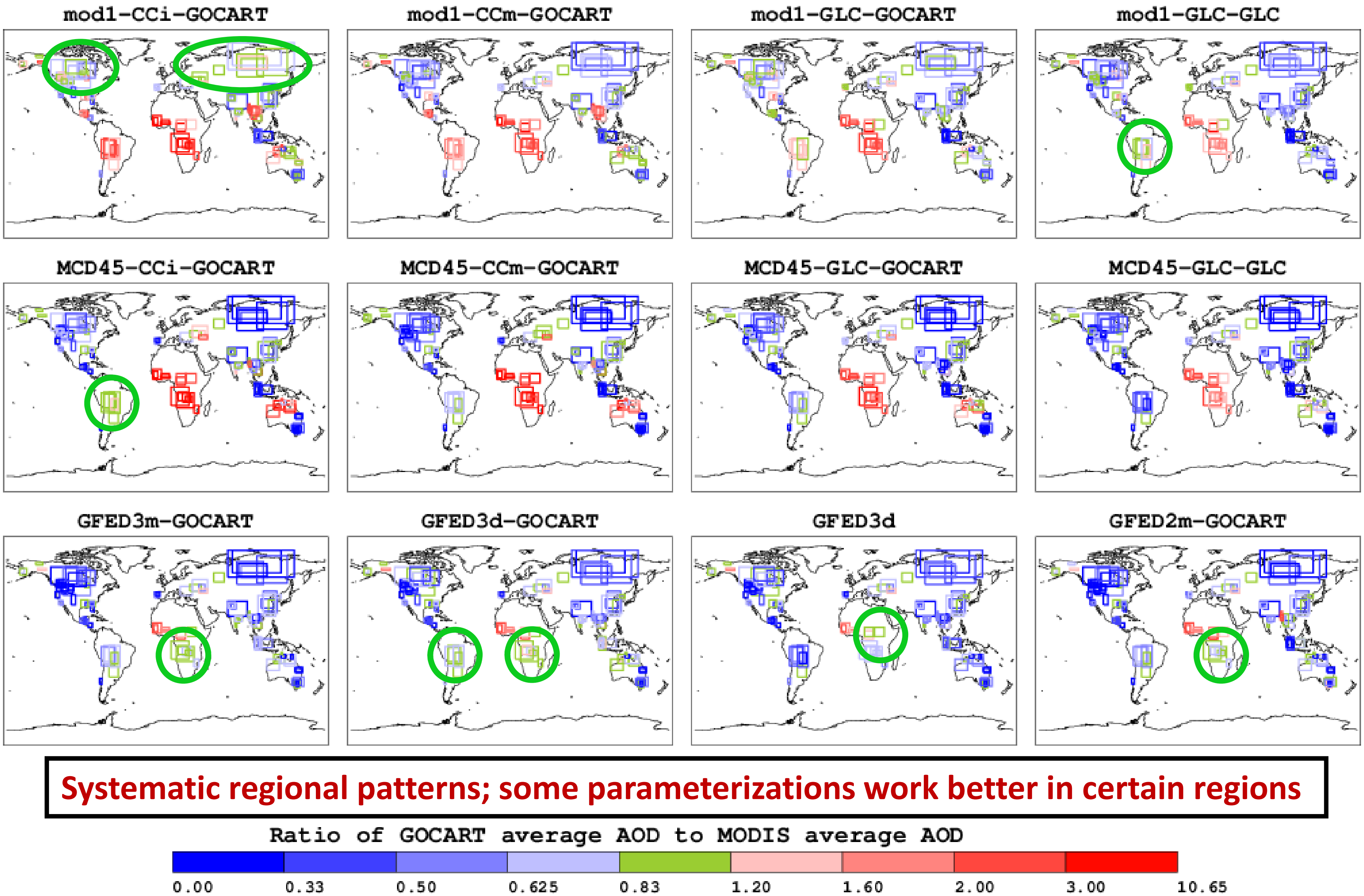


→ Biases are exposed at a regional scale, to improve BB aerosol emissions correction



Ratio of GOCART to MODIS average AOD

For each case, for 12 emission estimates

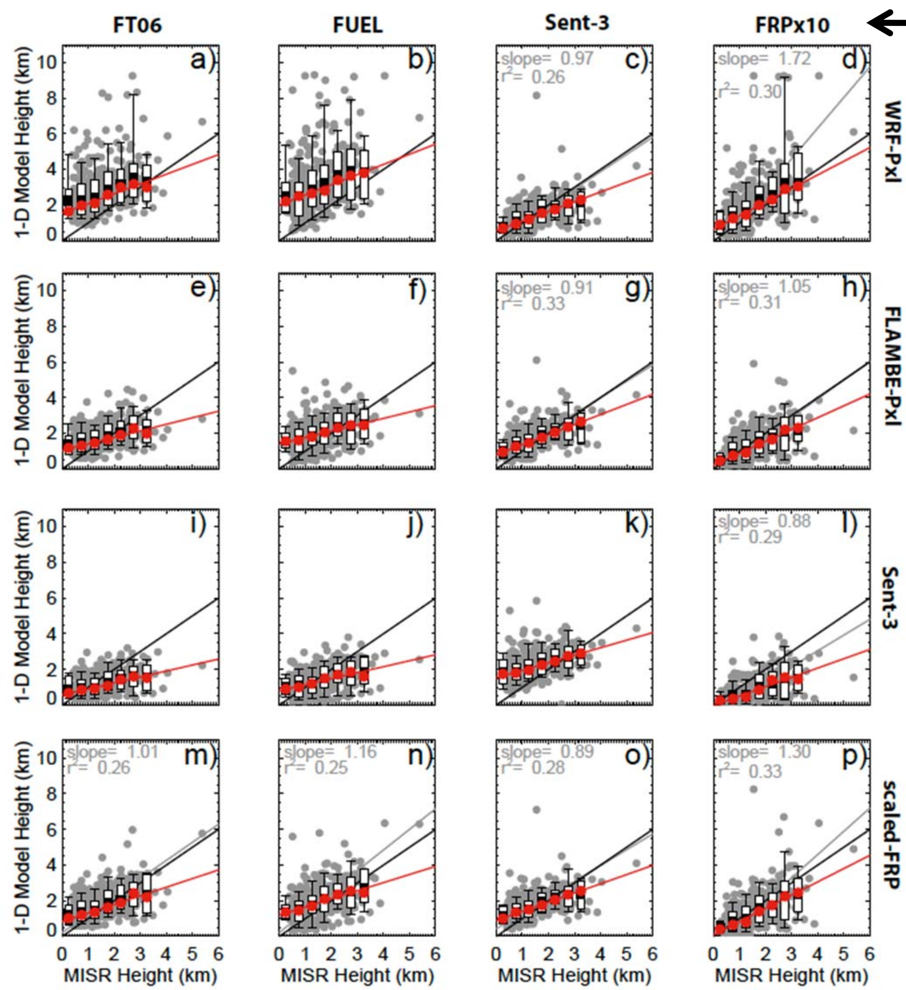


Systematic regional patterns; some parameterizations work better in certain regions

Evaluation of a 1D plume-rise model: Towards a parameterization of smoke *injection heights*

Heat Flux Options

Active Fire Area Options



<u>To Constrain models</u>:

Need to assess the

Parameterizations

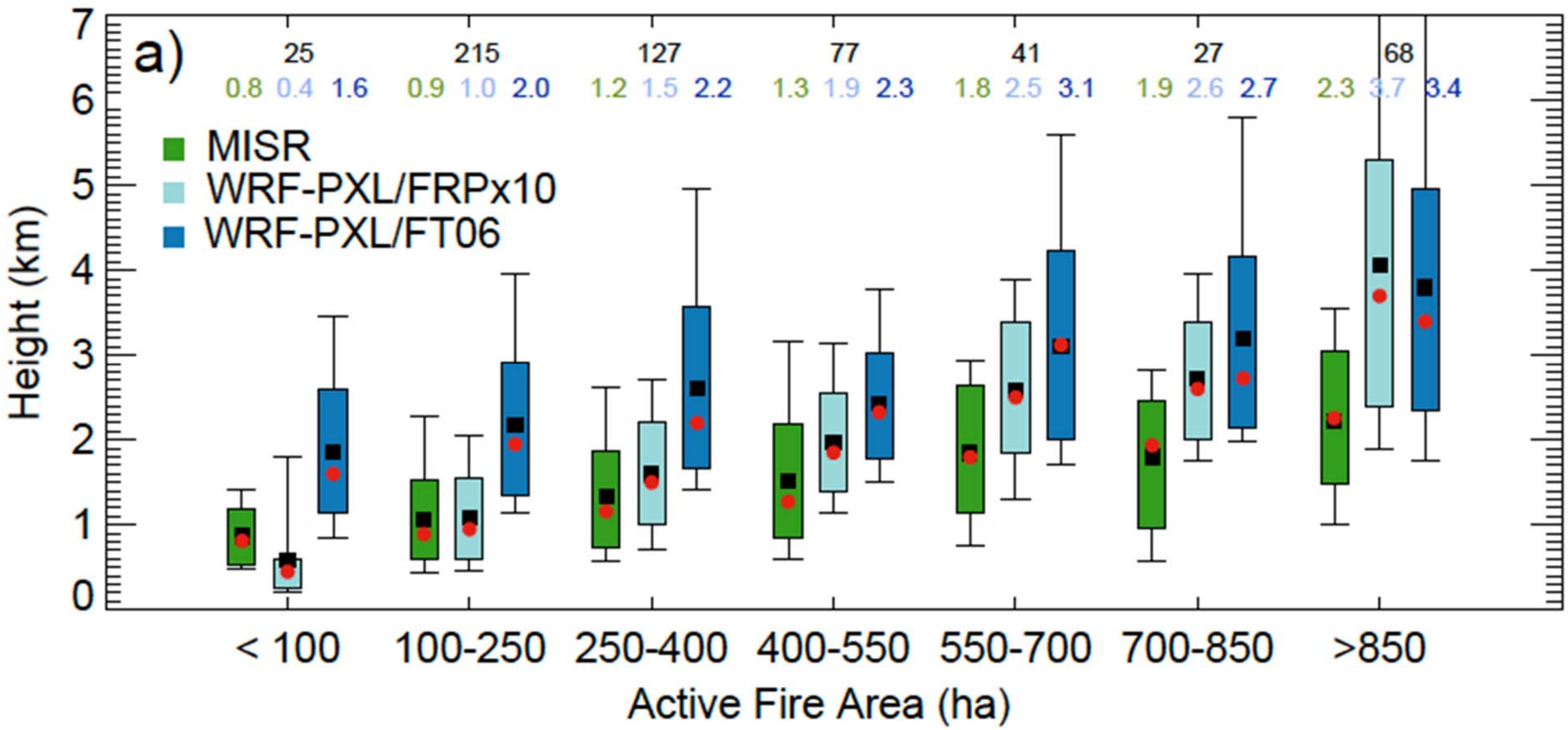
actually used

1-D Plume-rise model heights vs. MISR-observed max. plume heights

-- Models have ***lower dynamic range than observed***, but very variable

Val Martin et al., JGR 2012

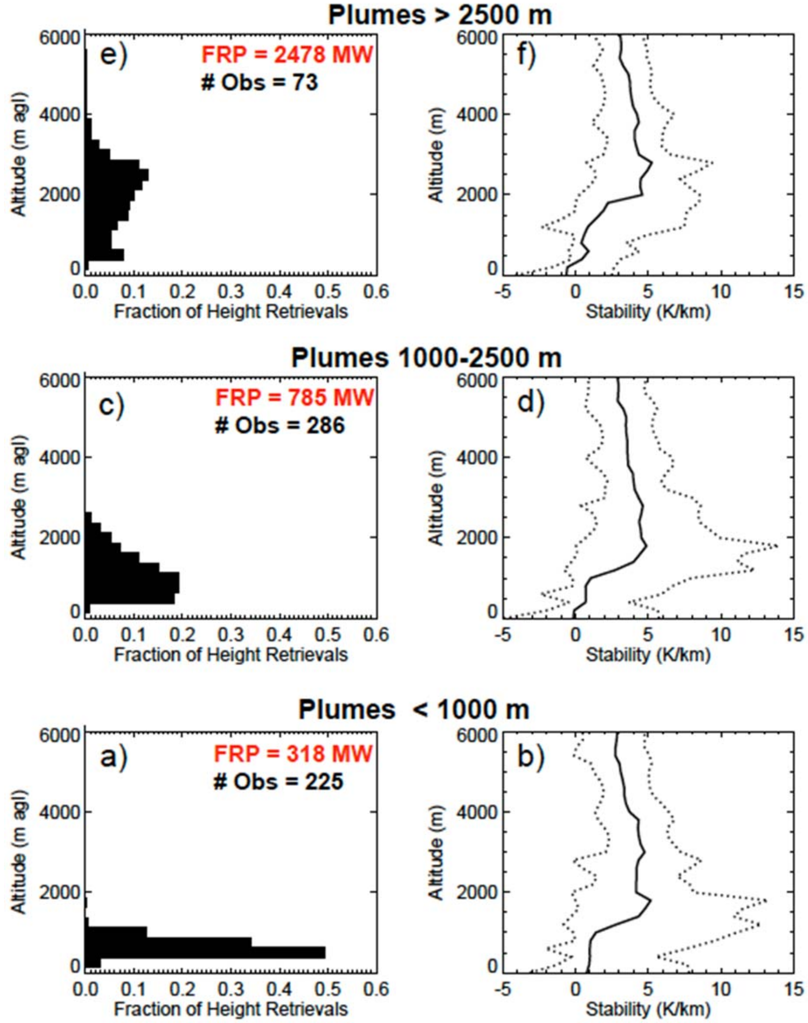
Evaluation of a 1D plume-rise model: Towards a parameterization of smoke *injection heights*



Plume height increases systematically as ***Active Fire Area*** Increases
(Active fire area is estimated from MODIS FRP for these models)

Val Martin et al., JGR 2012

Evaluation of a 1D plume-rise model: Towards a parameterization of smoke *injection heights*



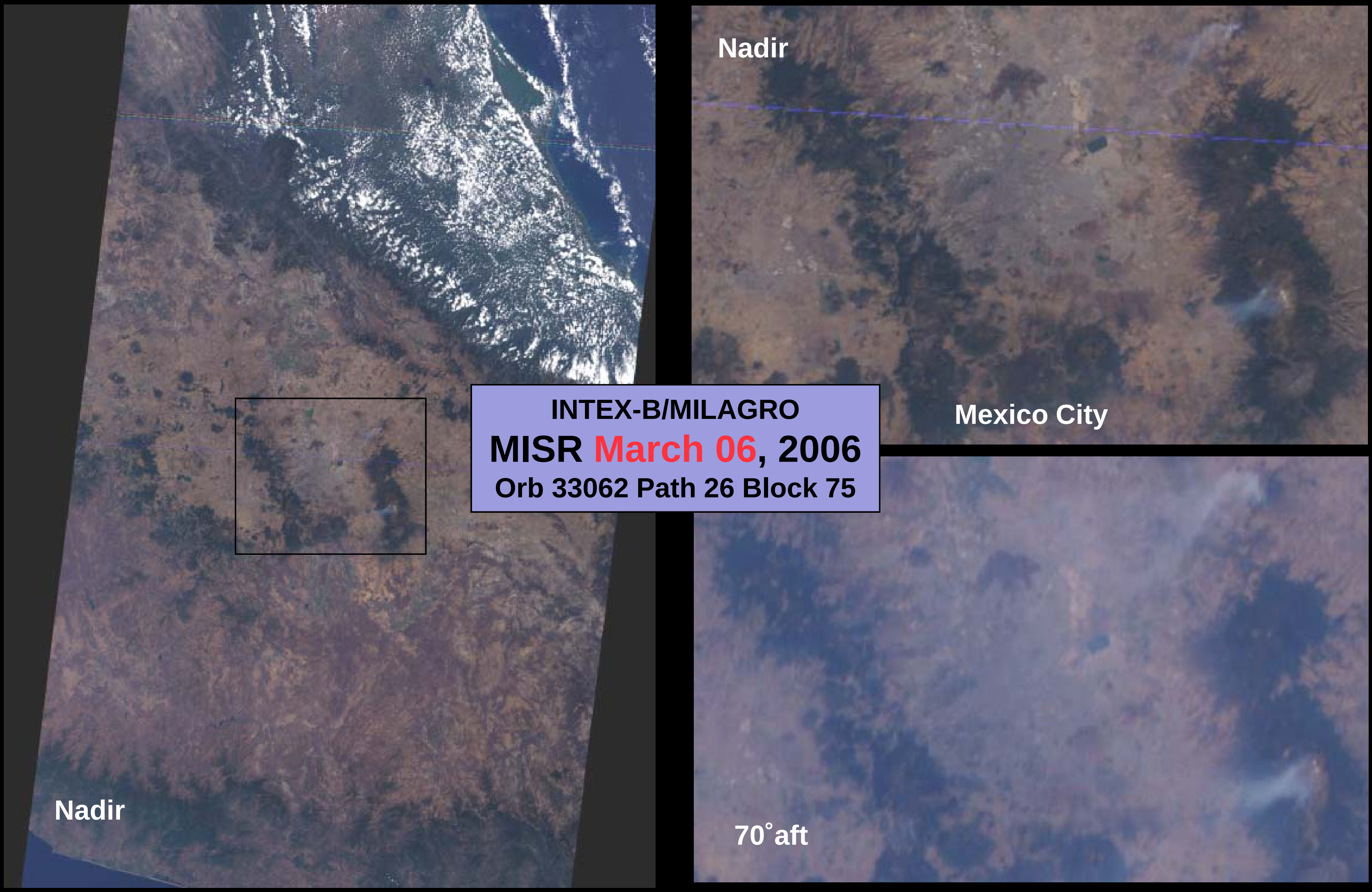
The key factors:

- ***Fire Energy*** (fire area; heat flux, FRP)
- ***Atmospheric Stability***
- ***Entrainment***

Plume height increases systematically as ***FRP*** increases and ***Atmospheric Stability*** decreases

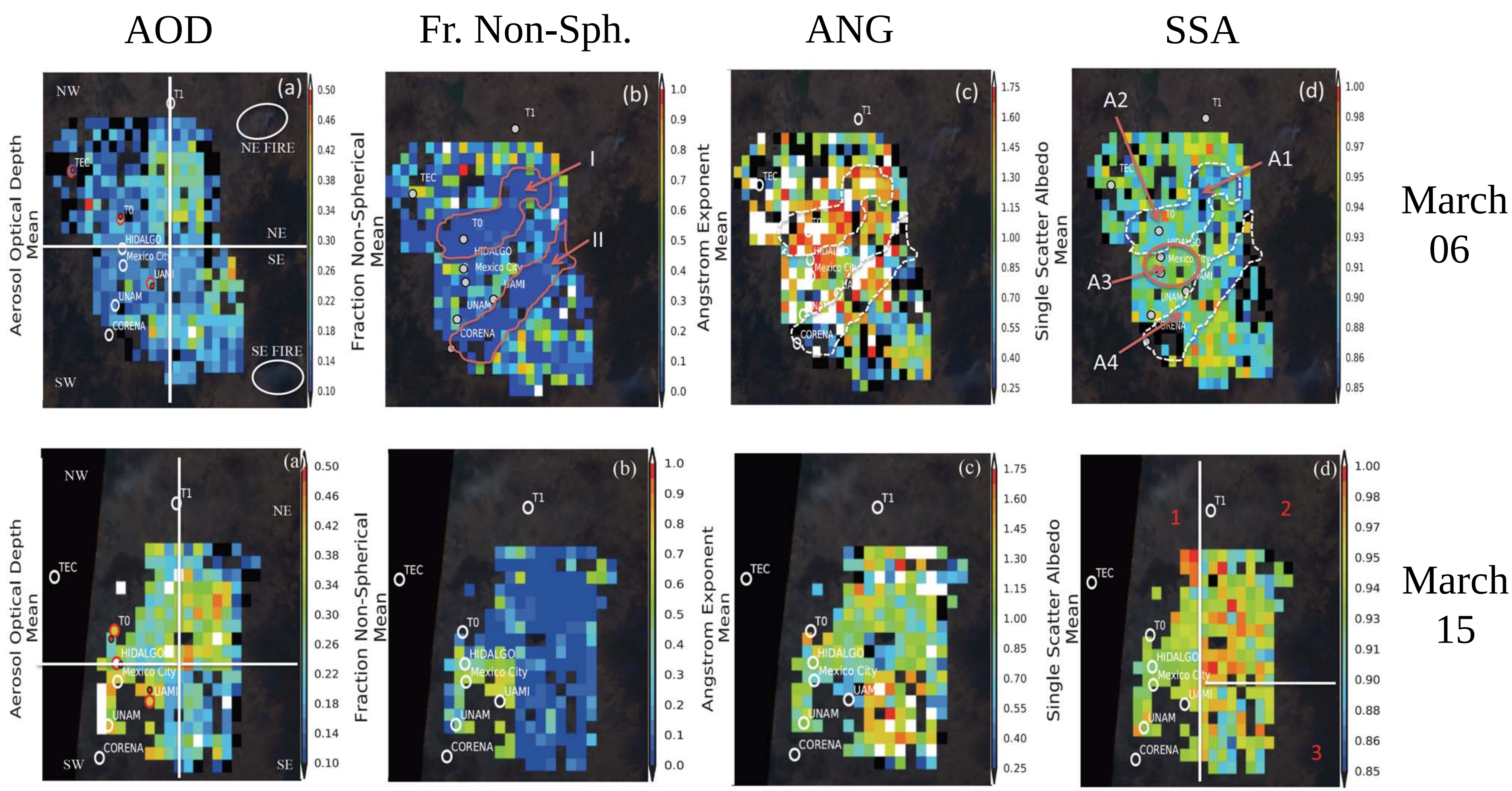
Val Martin et al., JGR 2012

Mapping AOD & Aerosol Air-Mass-Type in Urban Regions



Patadia et al.

Urban Pollution AOD & Aerosol Air Mass Type Mapping
INTEX-B, 06 & 15 March 2006

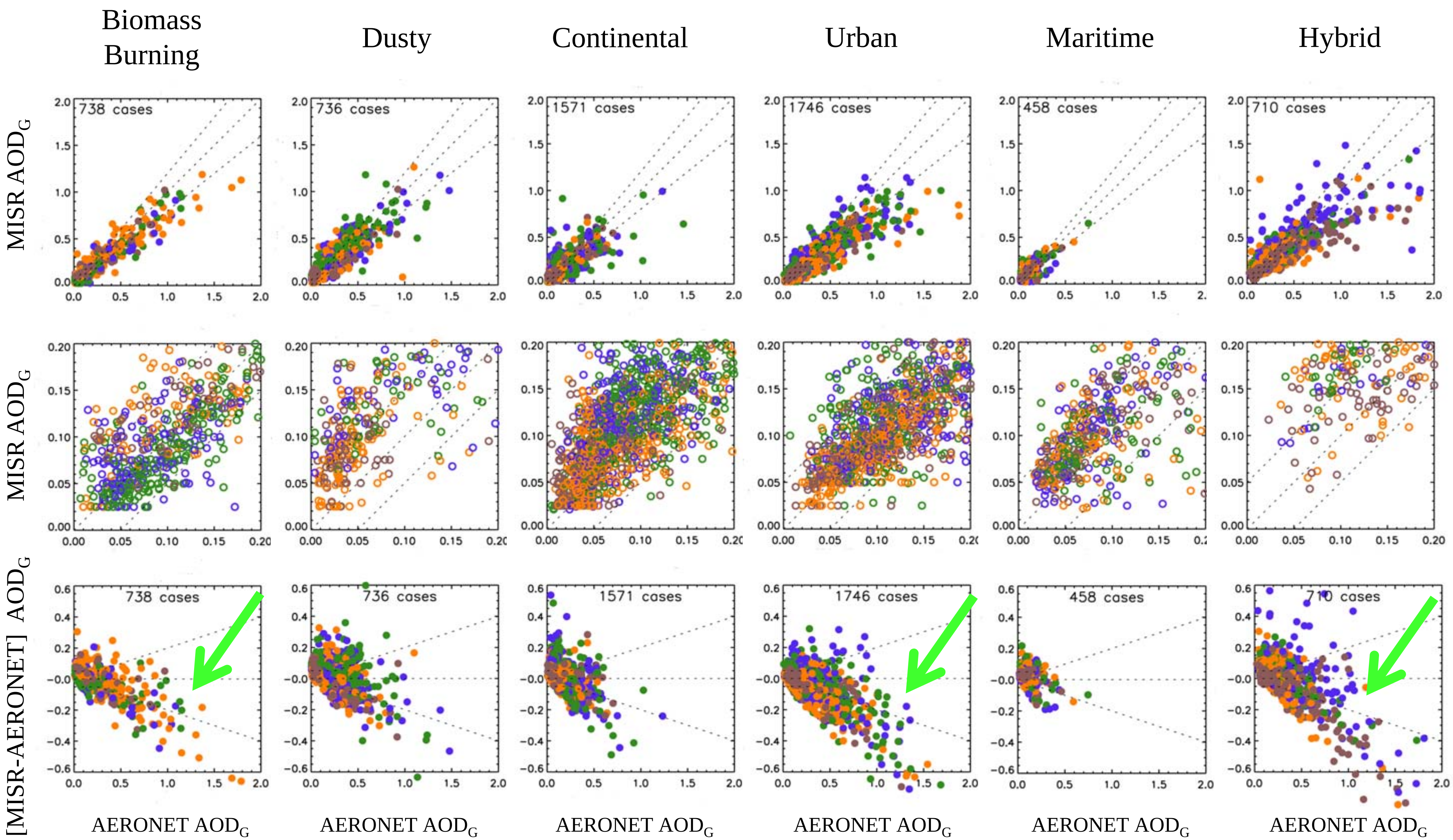


Aerosol Air Masses: ***Dust*** (non-spherical), ***Smoke*** (spherical, spectrally steep absorbing), and ***Pollution*** particles (spherical, spectrally flat absorbing) dominate specific regions

Patadia et al. 2013

MISR-AERONET AOD Comparison for 5,156 Coincidences

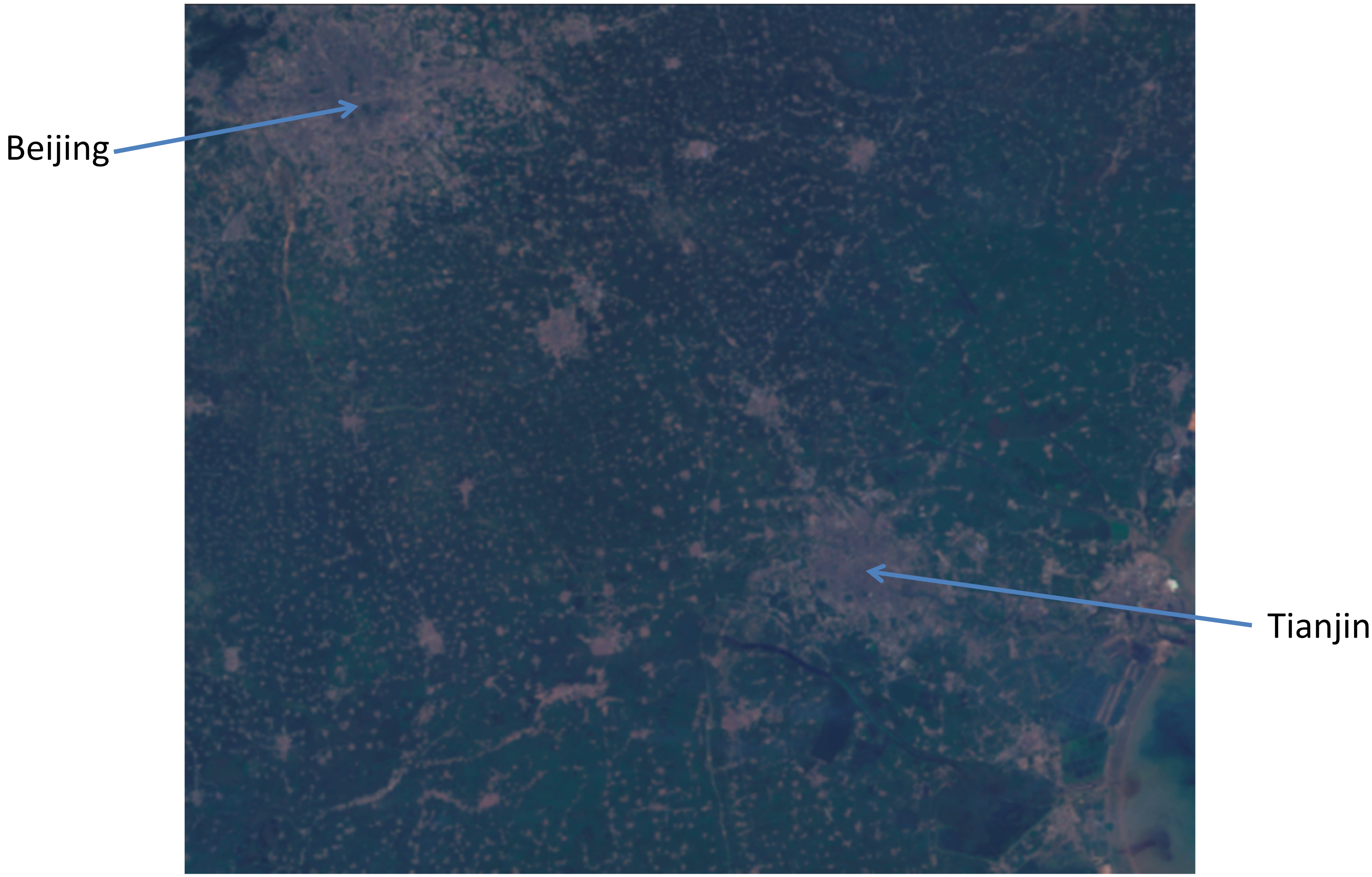
MISR Version 22 – Stratified by expected aerosol air mass type



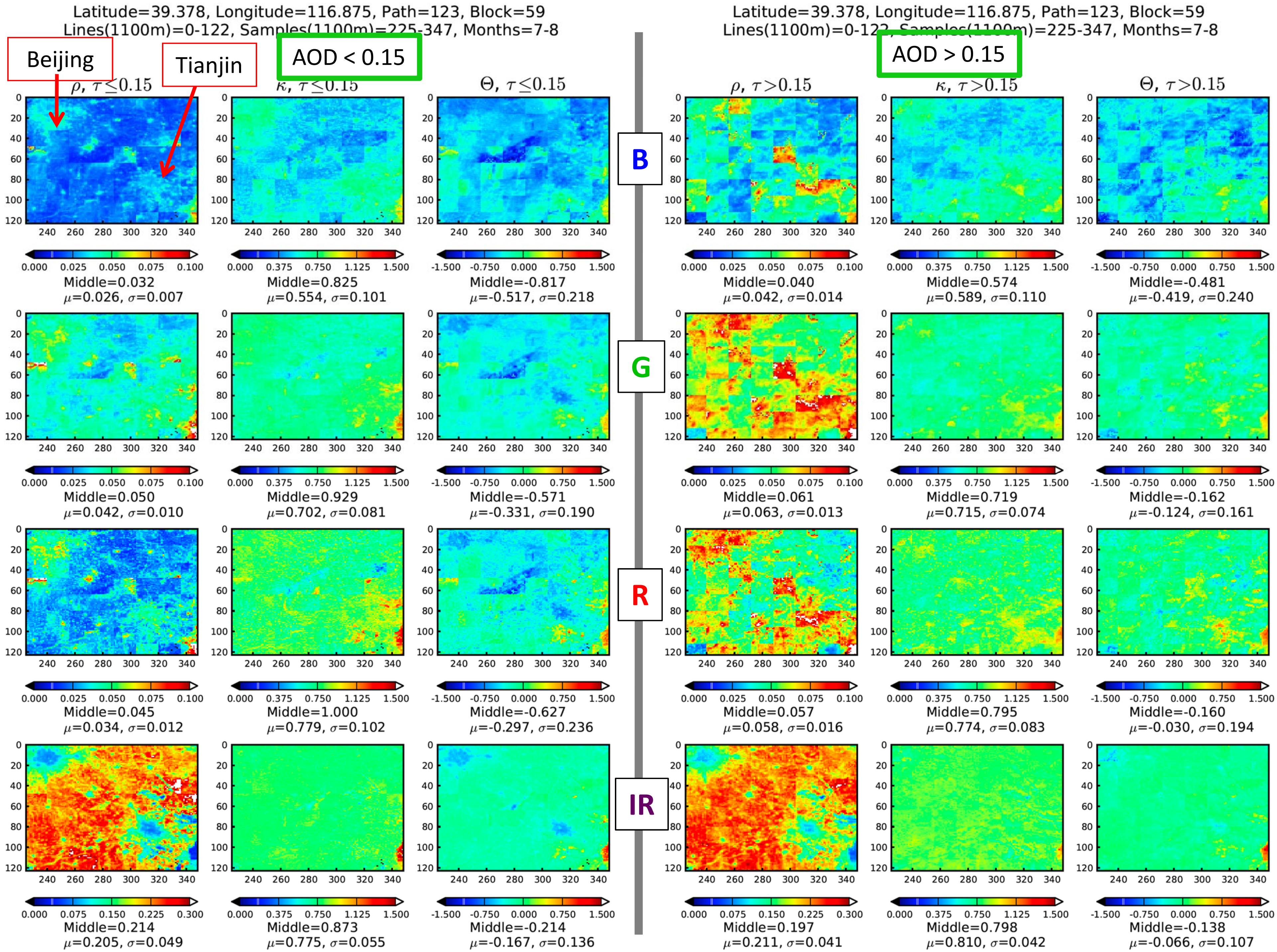
Kahn, Gaitley et al., JGR 2010

High AOD *Underestimation*

MISR-retrieved Surface BRDF – *Urban China*



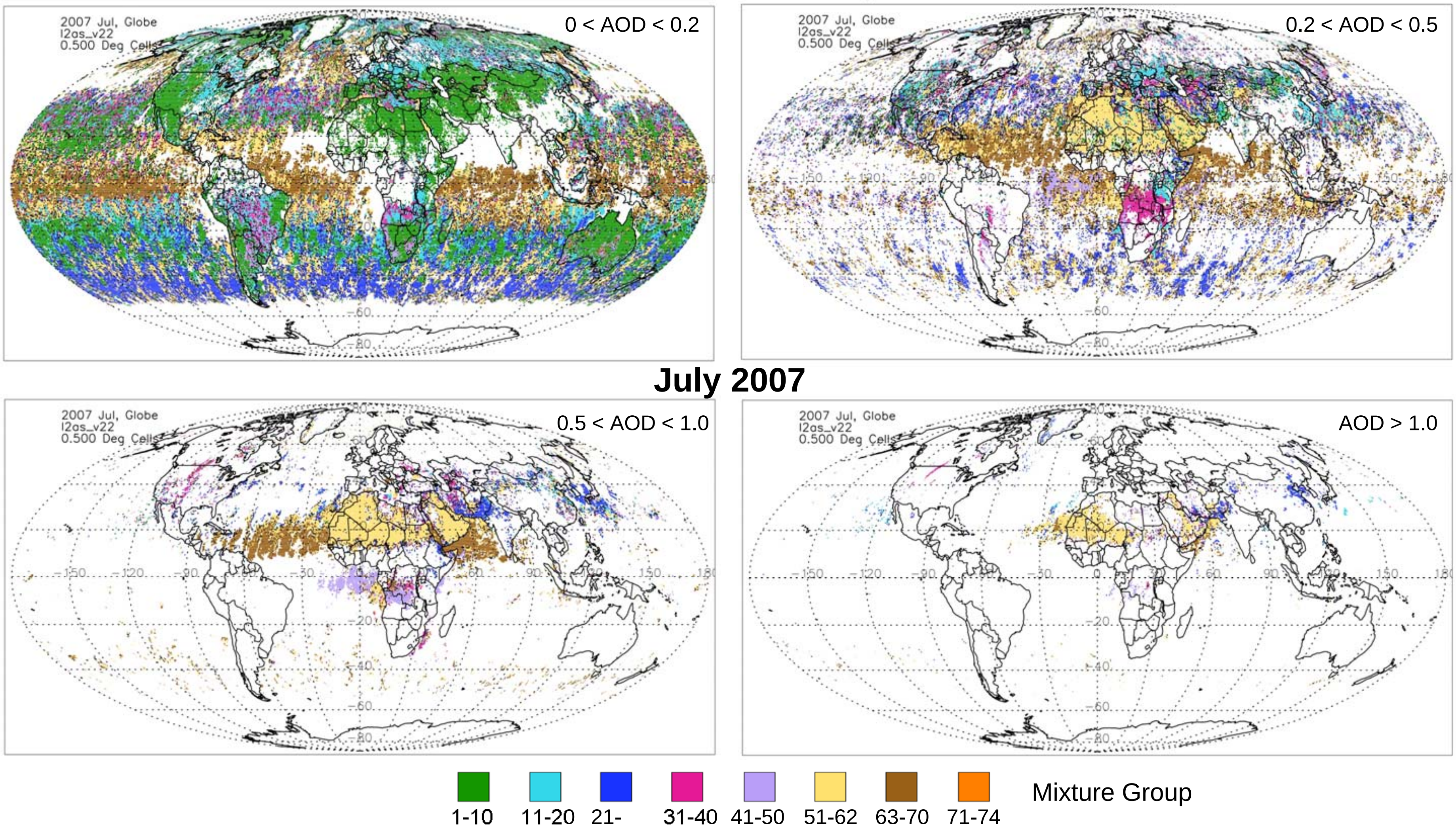
Orbit 30374, Blocks 59-59, 2005-09-03



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
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

Toward a Quality Flag for MISR Aerosol Type

Global Distribution of MISR Most Frequently Retrieved Mixture Group



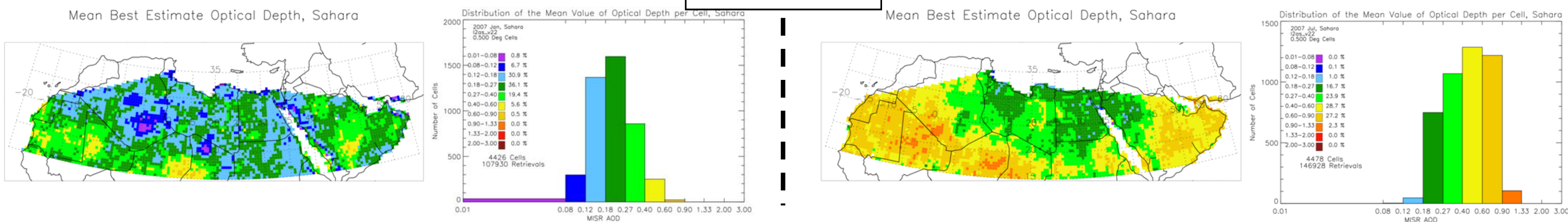
Spherical, non-absorbing

Spherical, absorbing

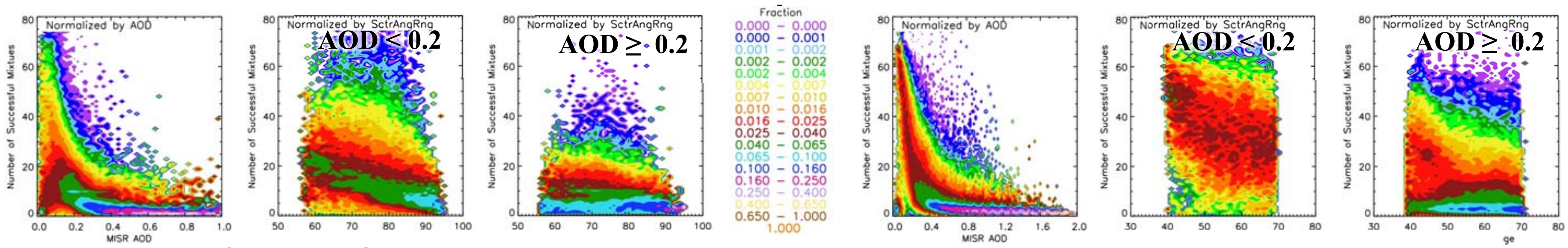
Non-spherical

Kahn, Gaitley, et al. in preparation

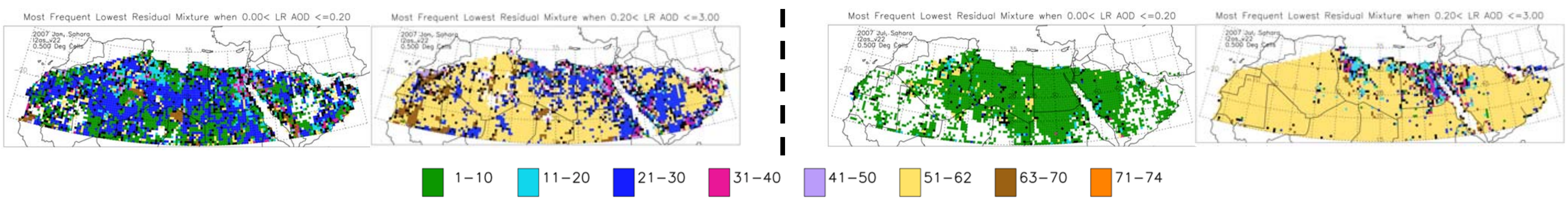
January 2007 **Sahara** **July 2007**



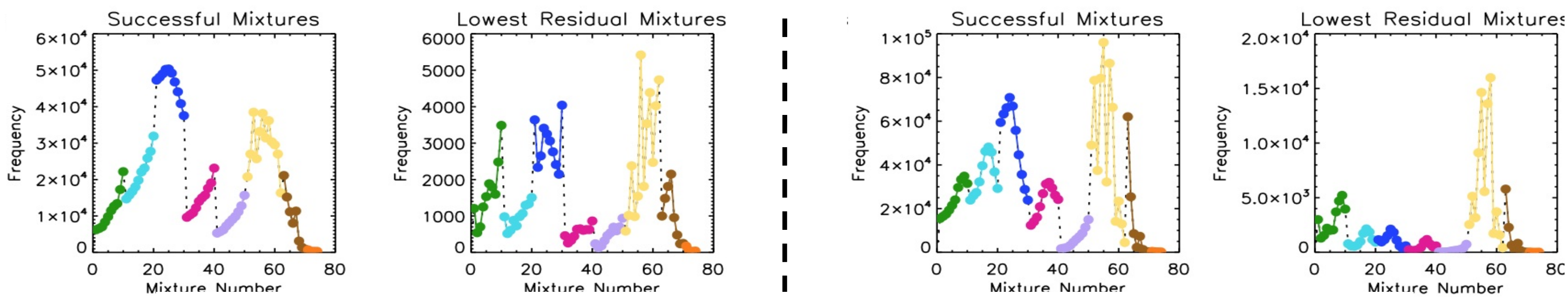
Mean Best Estimate AOD Map & Histogram Distribution



Number of Successful Mixtures vs. Normalized AOD & vs. Normalized Scattering Angle Range



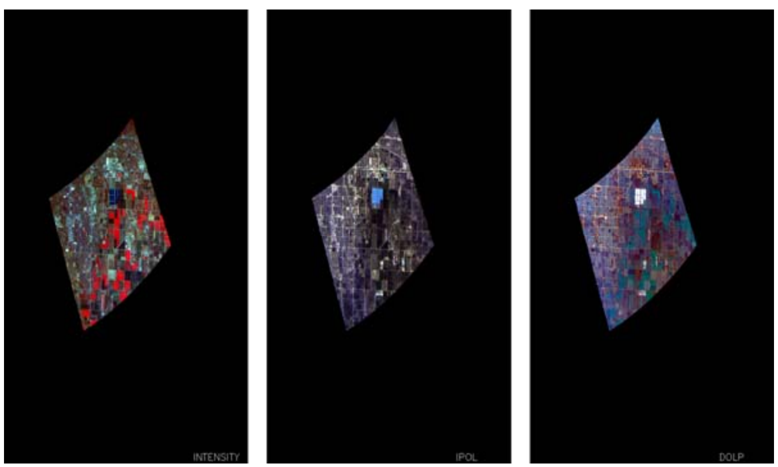
Most Frequent Lowest Residual Aerosol Type Mixture Group, Stratified by AOD



Histograms of Lowest Residual & All Successful Aerosol Type Mixture Groups

And Aiming For Future Missions…

AirMSPI



Bakersfield CA 18 January 2013 (+47.5° View)

SAM-CAAM

[Systematic Aircraft Measurements to Characterize Aerosol Air Masses]

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