Comprehensive evaluation of satellite based aerosol products: The GEWEX and NRL Aerosol Assessments.

ICAP Rehash……

GEWEX Panel: Sundar Christopher, Richard Ferrare, Paul Ginoux, Stefan Kinne, Gregory Leptoukh, Jeffrey Reid, Paul Stackhouse

Navy Team: Jianglong Zhang, Edward Hyer, Jeffrey Reid, Doug Westphal, James Campbell, Yingxi Shi, Peng Xian, Walter Sessions

Comments on this presentation:
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- The field hosts dozens of both products and applications.

- But, most products are in the twilight zones of "research," "development," and "production."

- This is reinforced with the funding situation where money for product development, maintenance, and verification is limited. Developers spend more time "using" their products than "supporting."

- By the time the wider community figures out how a product is doing, a new version is released.

- The user community does not have the time or funding to really understand the ins and outs of specific products. The "It's the only thing out there" attitude is prevalent.

- Situation: Confusion and some rancor in the community as to the proper efficacy and applications of these data.

Sensors Under Investigation

Reformed GEWEX Aerosol Panel (GAP)

AVHRR-GACP
AVHRR-NOAA
MISR
MODIS Col 5
MODIS Deep Blue
OMI
Polder/Parasol

NRL Aerosol Assessment Effort

AVHRR-NOAA
CALIOP/CALIPSO
MISR
MODIS Col 5 (NRTPE and Std)
MODIS Deep Blue (NRTPE and Std)
VIIRS
Soon….
OMI
Geostationary

Types of Bias
Each a talk in themselves

- **<u>Radiometric Bias:</u>** Biases due to uncharacterized or ill applied sensor calibration.

- **<u>Retrieval Bias:</u>** Biases related to shortcomings in the retrieval itself.

- **<u>Sampling/Contextual Bias:</u>** Biases related to where a retrieval is/is not performed or contextually related uncertainty in a scene. This leads to a skewed data population relative to what is thought to have been collected.

- **<u>Aggregation/Data Reduction Bias:</u>** Loss of required information during conversion to a gridded product or during analysis.

- **<u>Cognitive Bias:</u>** We, the investigators, misinterpret, withhold, or frame data/results contrary to full nature of the data. Statistics are the rhetoric of science…..

- **<u>Other Considerations:</u> a) Correlated error-**"Independent" products that share similar biases; **b) Tautology -**Circular reasoning or treating non-independent data as independent.
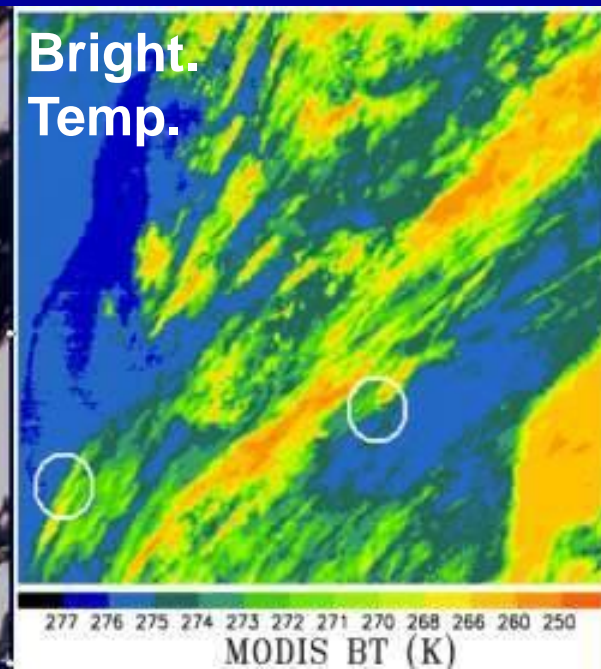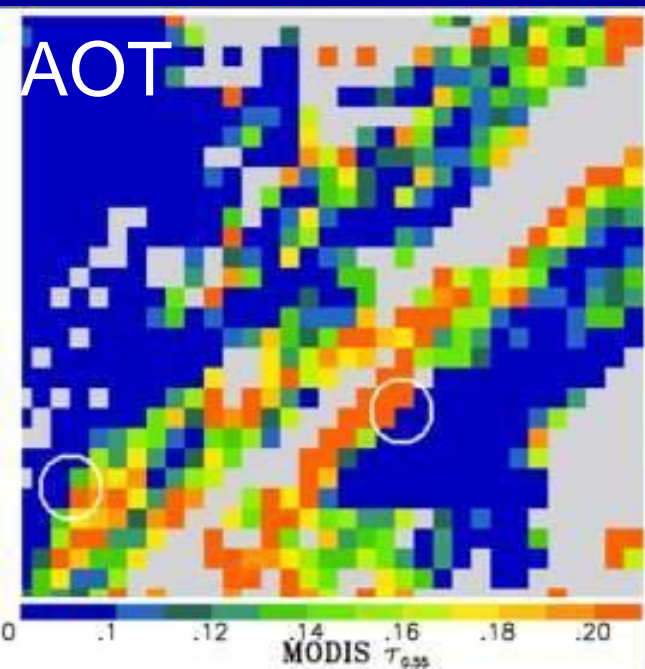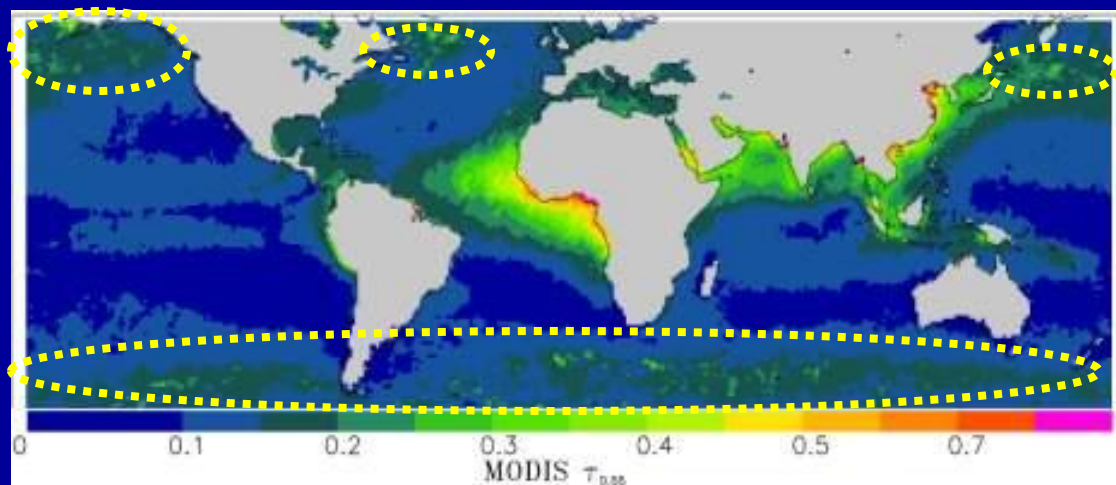
And we wonder why modelers want to assimilate radiances….

- Southern ocean aerosol anomaly: Fact or cloud bias?

- Northern oceans have same problem, but people quickly attributed it to China and CONUS.
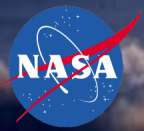
- Spatial tests get rid of it.

MODIS $\tau_{0.55}$

AOT

MODIS $\tau_{0.55}$

RGB

Zhang et al., 2005

Bright. Temp.

277 276 275 274 273 272 271 270 268 266 260 250
MODIS BT (K)

- Can be as simple as RMSE as a function of AOD

- AOD can be from AERONET (diagnostic) or own AOD (prognostic).

  - But, RMSE is symmetric, includes BOTH noise and bias, and it does not easily address massive outliers which are often the problem for DA.

- Terms include:

  - Differential Signal to Noise: Lower boundary minus total, including view angle/optical path length.

  - Lower Boundary Condition:

    - Ocean: Wind/glint/whitecap, class 2 waters, sea ice

    - Land: Surface reflectance model, snow, view angle/BRDF/hotspot

  - Cloud mask

  - Microphysical: Fine coarse/partition, $P(q)/g$, w_o, AOD

- Biases are often folded into "random" error models. If they are known, why not correct for them?

- Radiance Calibration: Individual wavelengths propagate non-linear through retrievals and are not easy to incorporate.
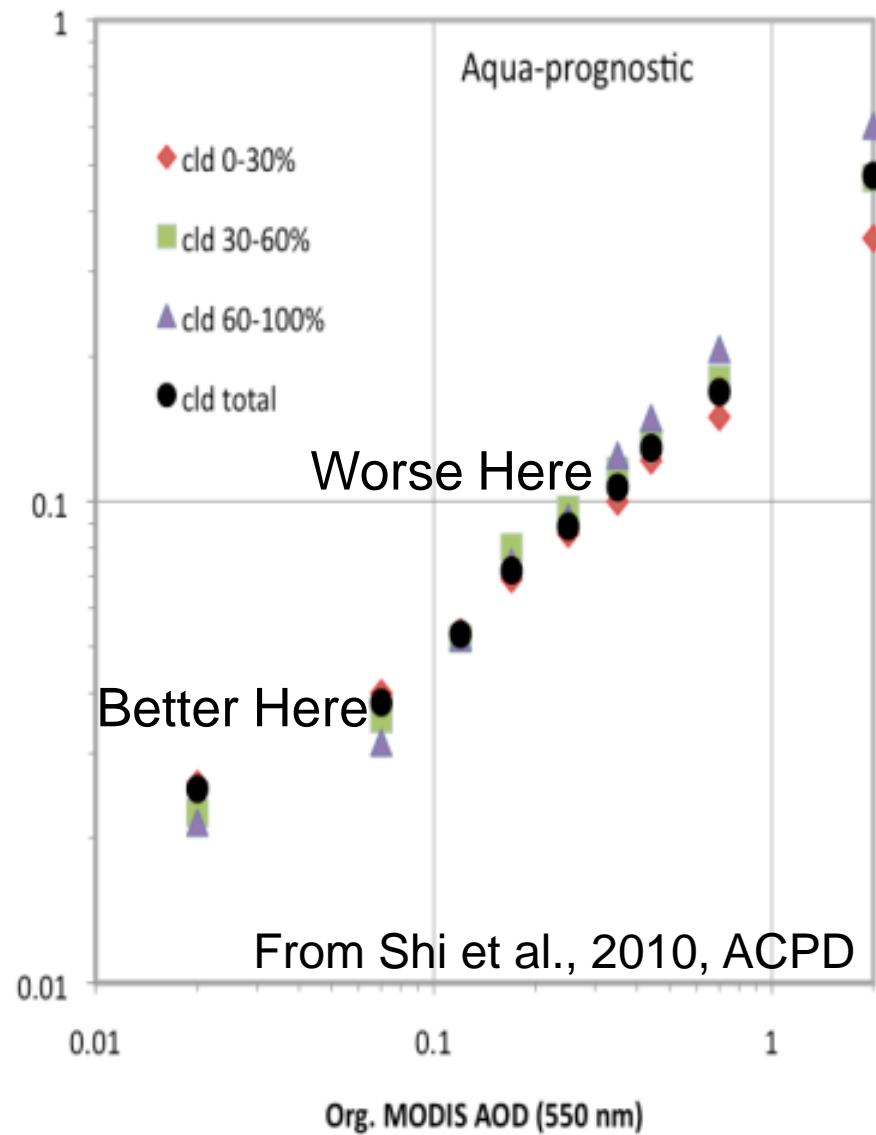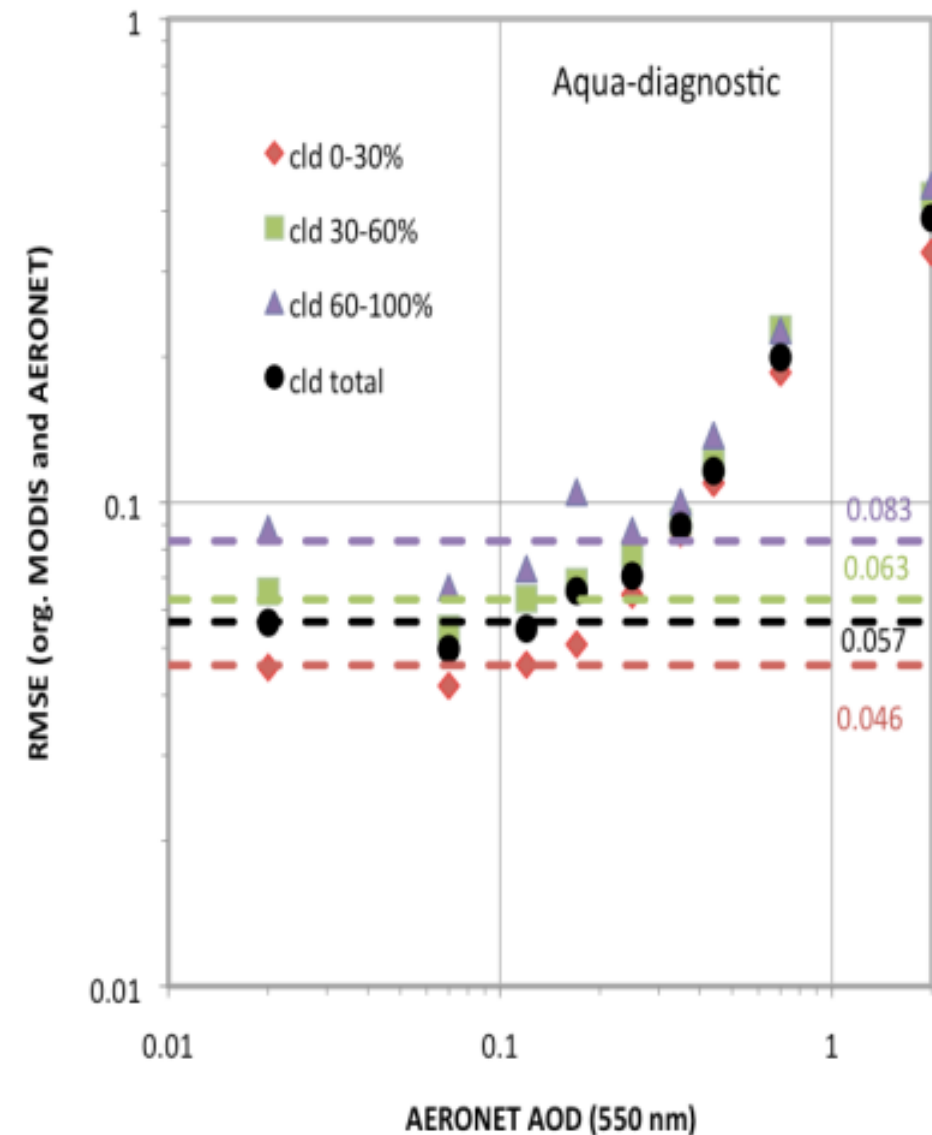
From Shi et al., 2010, ACPD

•Appropriate consideration of "What the satellite is actually seeing" is often overlooked in the field.

•Performing even the most basic matchups between sensors is not trivial.

•The core retrieval biases related to clouds, lower boundary condition, and microphysics are non-random, but spatially and temporally correlated-invalidating most commonly used V&V method.
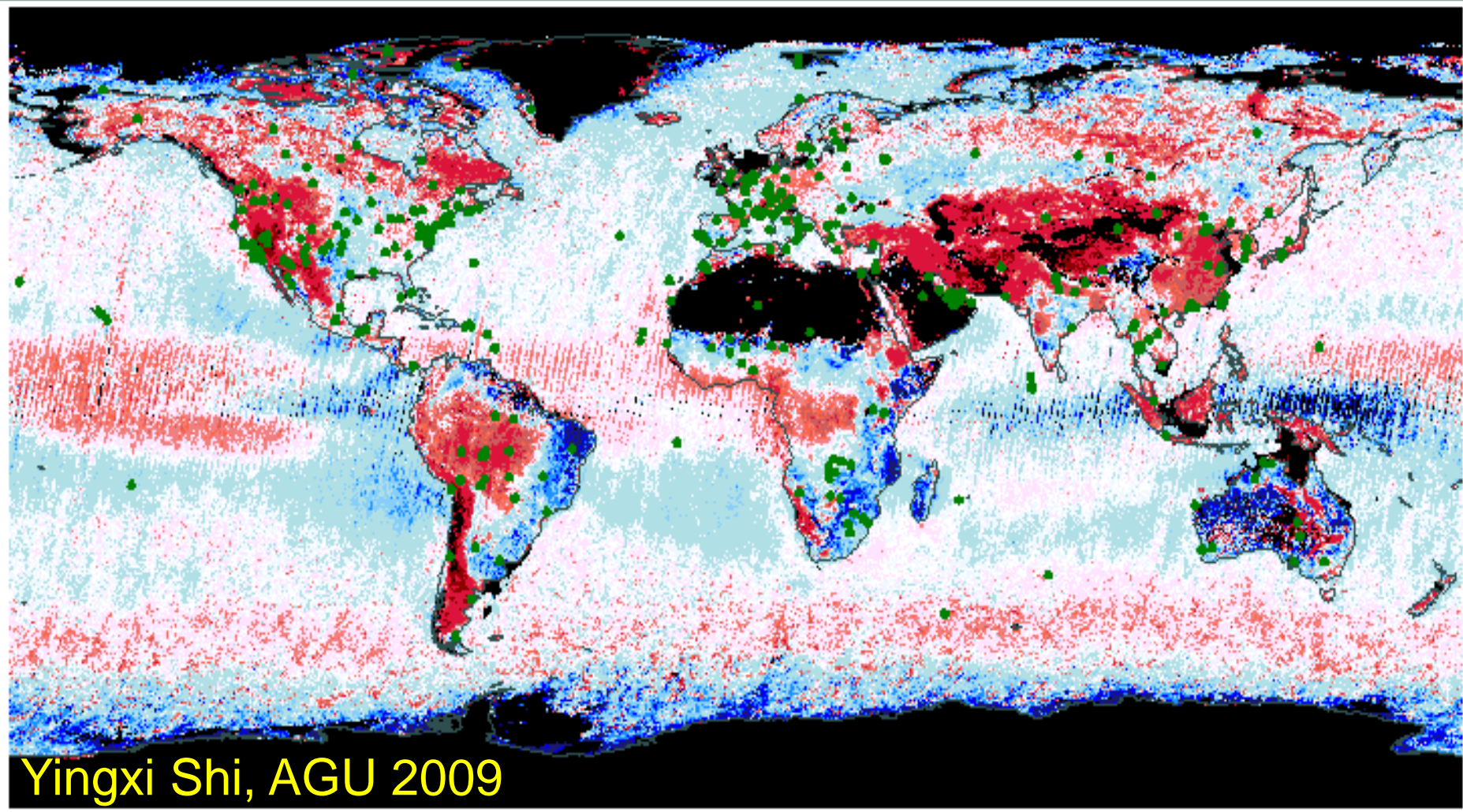
ASO Clear Sky Bias, Zhang and Reid 2009
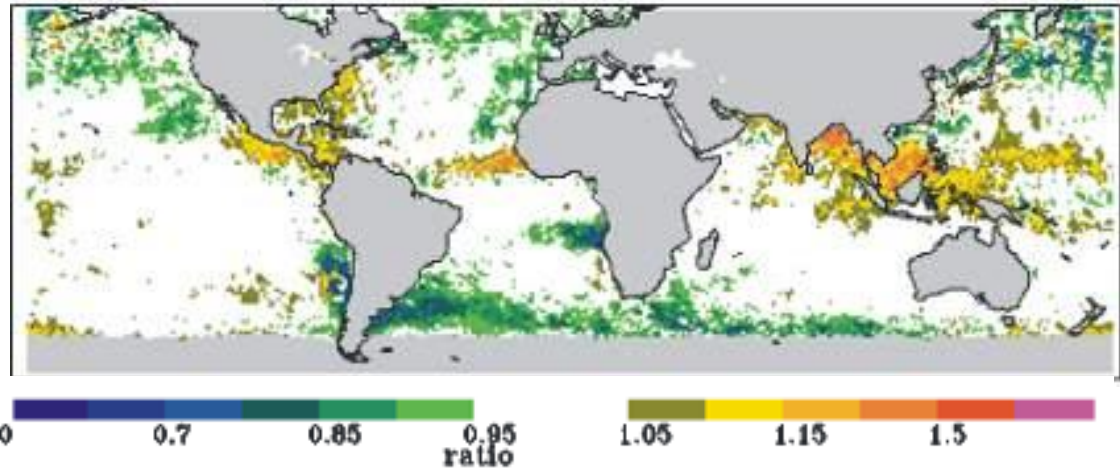
MODIS Versus AERONET Summary Statistics, AOD>0.2
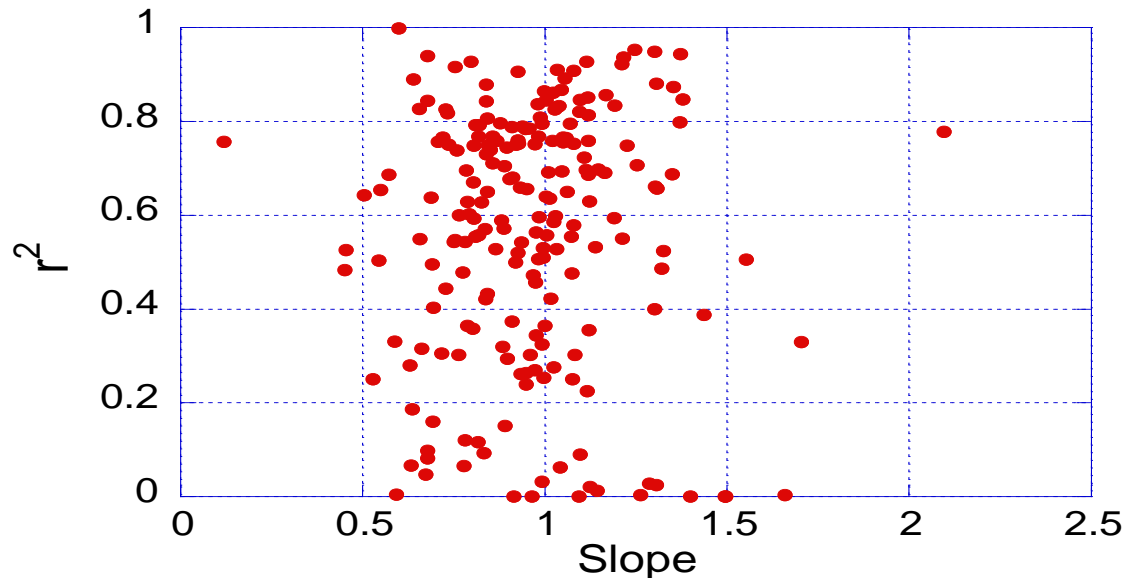
More on correlated bias: Ratio of MODIS to MISR. These features dominate innovation vectors and hence any inverted quantity
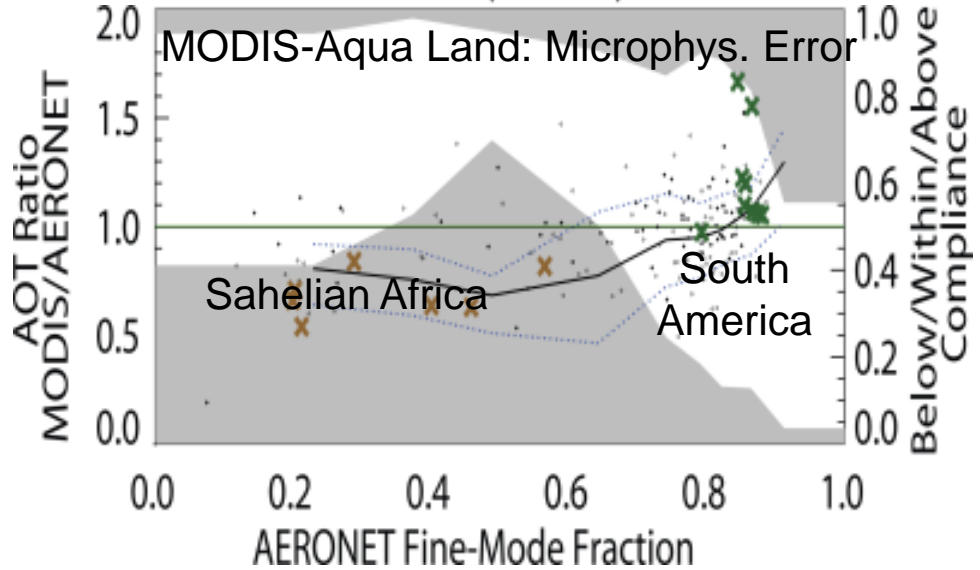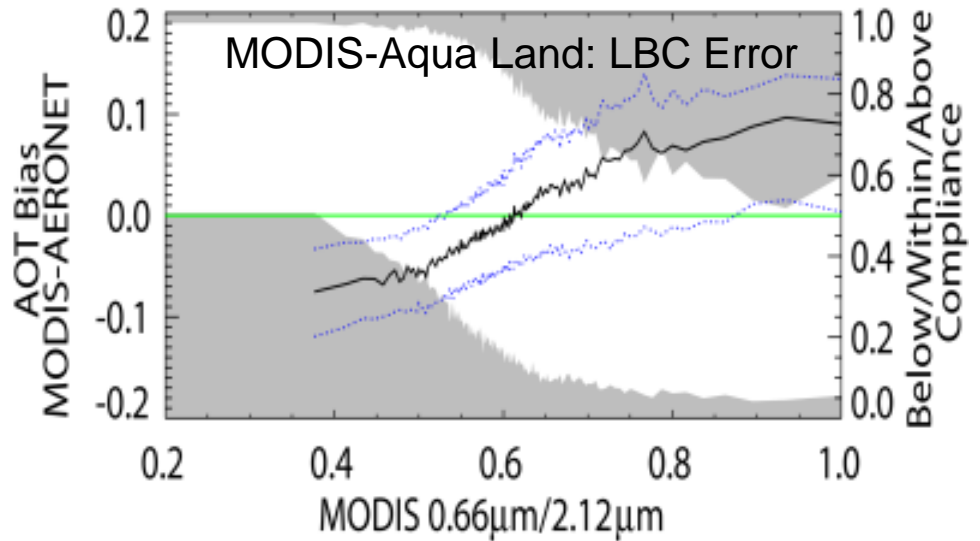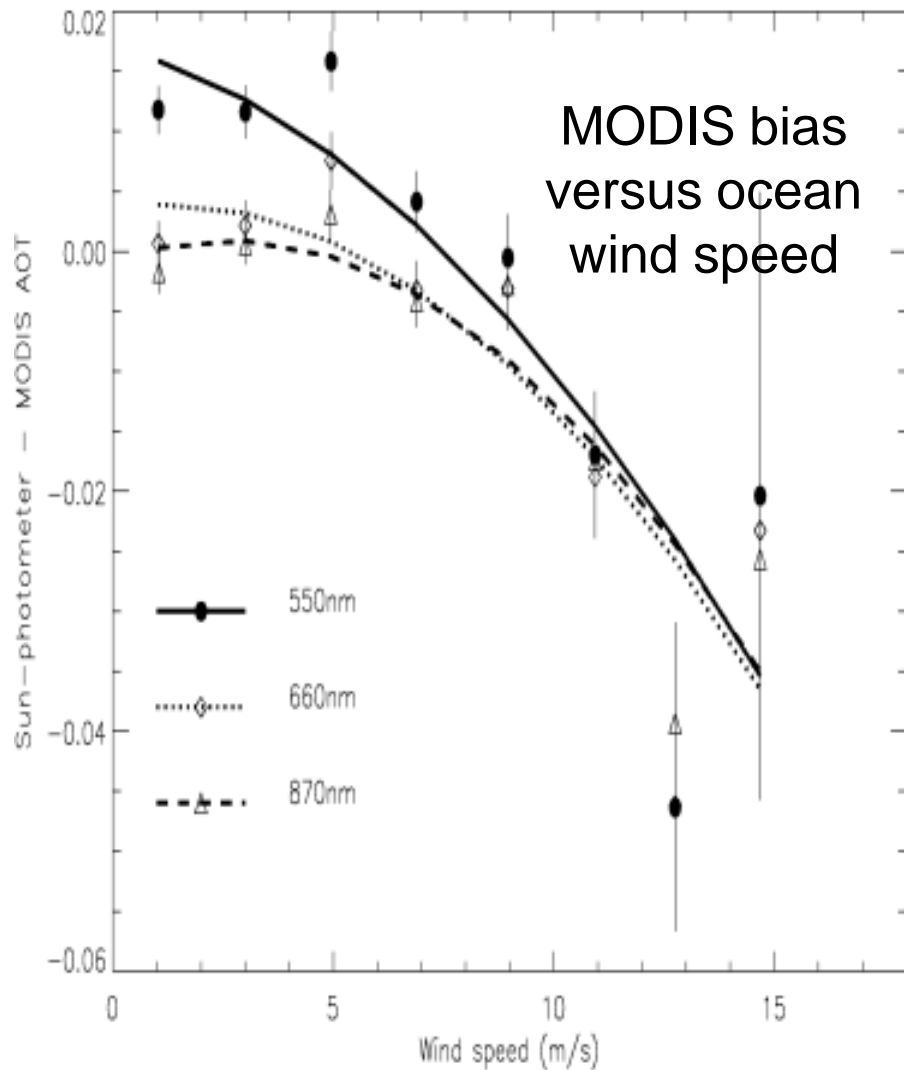

Yingxi Shi, AGU 2009

| .2 | 0.5 | 0.7 | 0.95 | 1.1 | 1.3 | 3.0 |

MODIS/MISR AOD (0.55 μm)

MODIS bias versus ocean wind speed

MODIS-Aqua Land: LBC Error

MODIS-Aqua Land: Microphys. Error

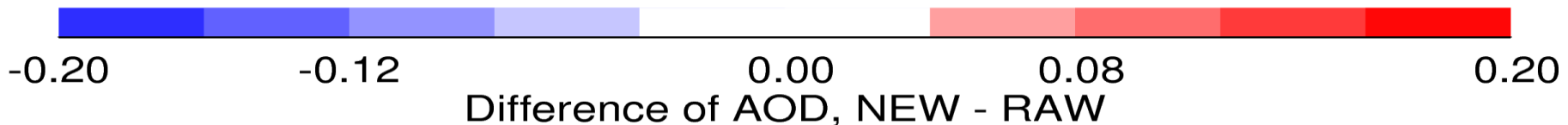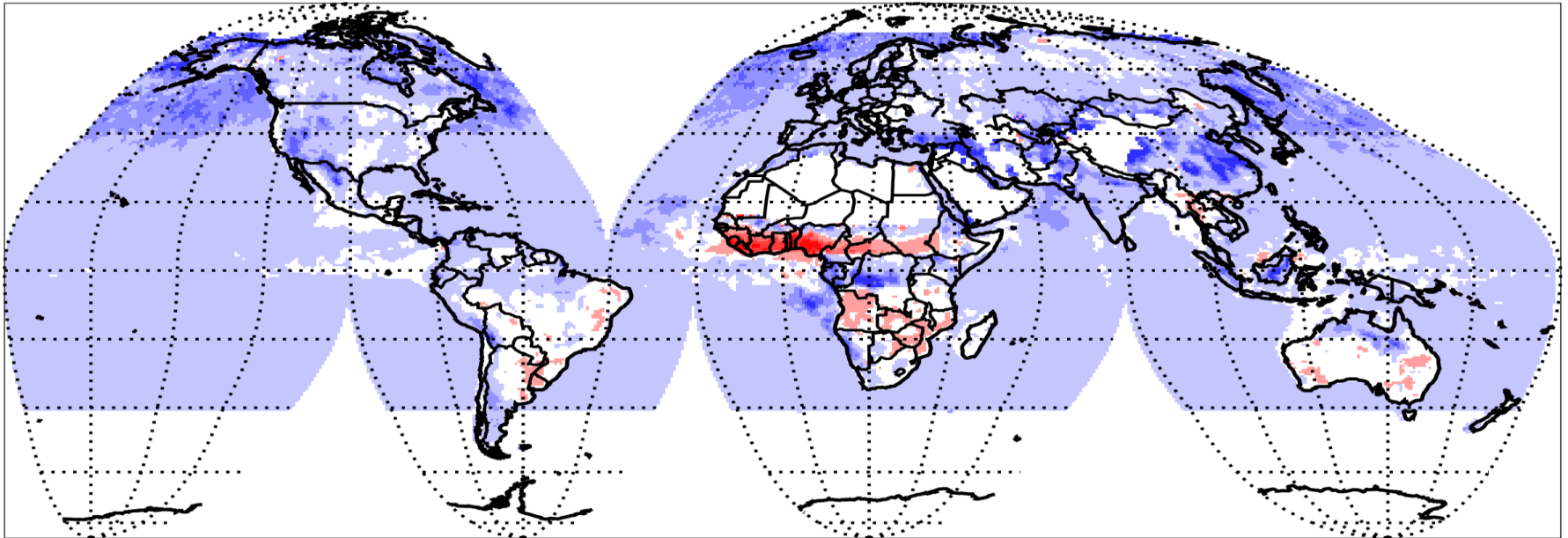Sahelian Africa

South America

Bottom line product-2009 Annual Differences.
Be warned, there is some cancellation of errors and
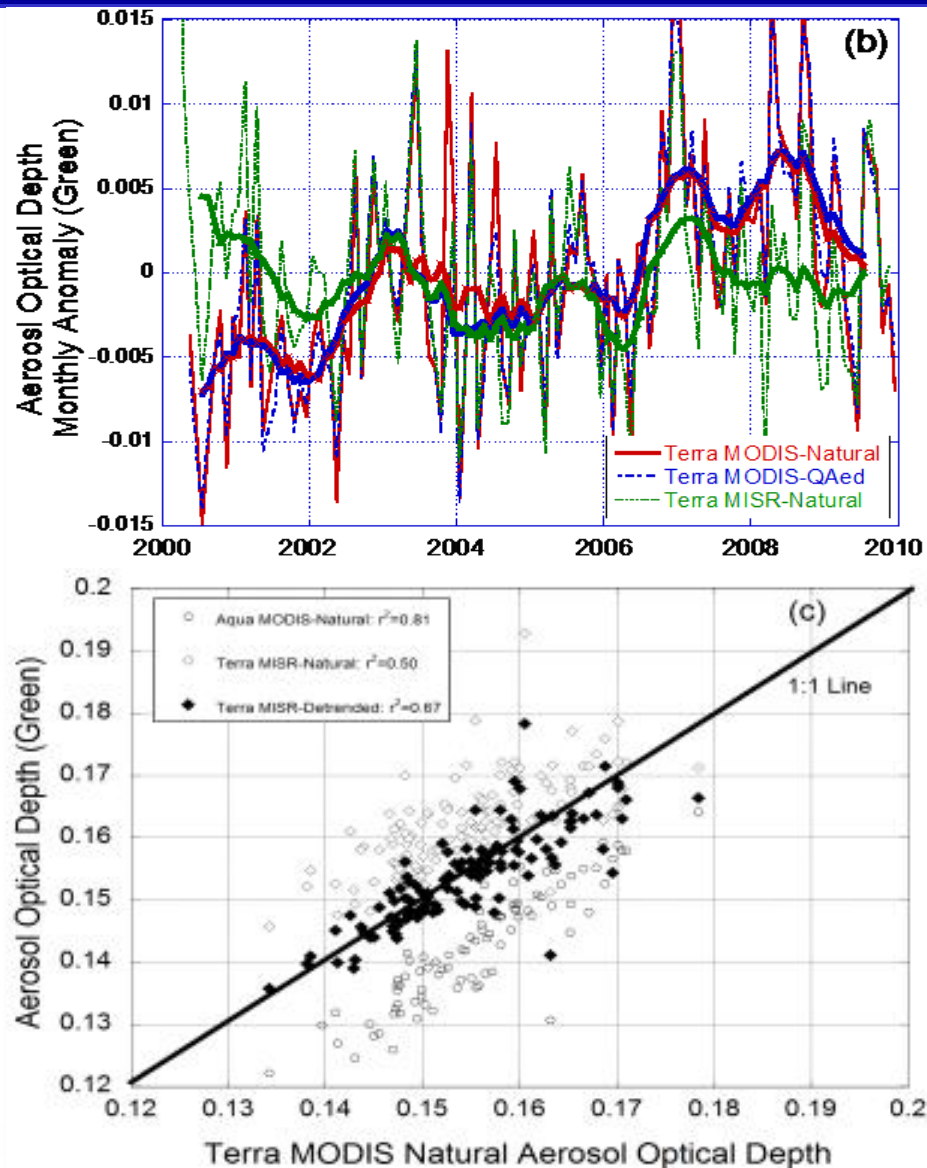we are still not entirely happy.
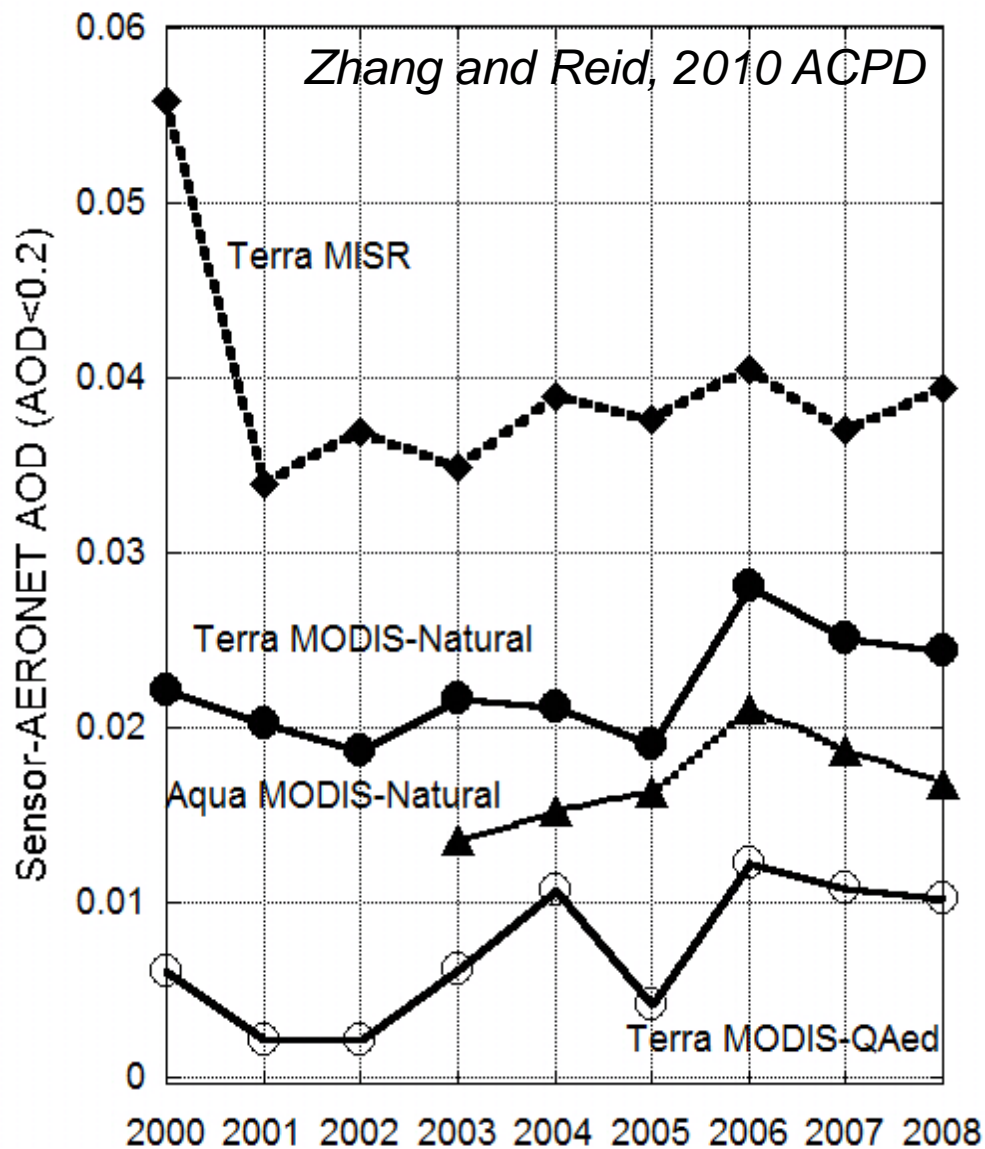
2009all NEW - RAW Difference of AOD

Zhang and Reid, 2010 ACPD

- We examined 10 years MODIS and MISR trends over ocean.

- The first step was to assign areas of statistical significance.

- The next, step was to debias calibration errors.

- Bottom line no trend over ocean except around Arabian Gulf, India and China.

Trend $100 \times AOD/year$ $(0.55 \mu m)$

ω / σ_ω
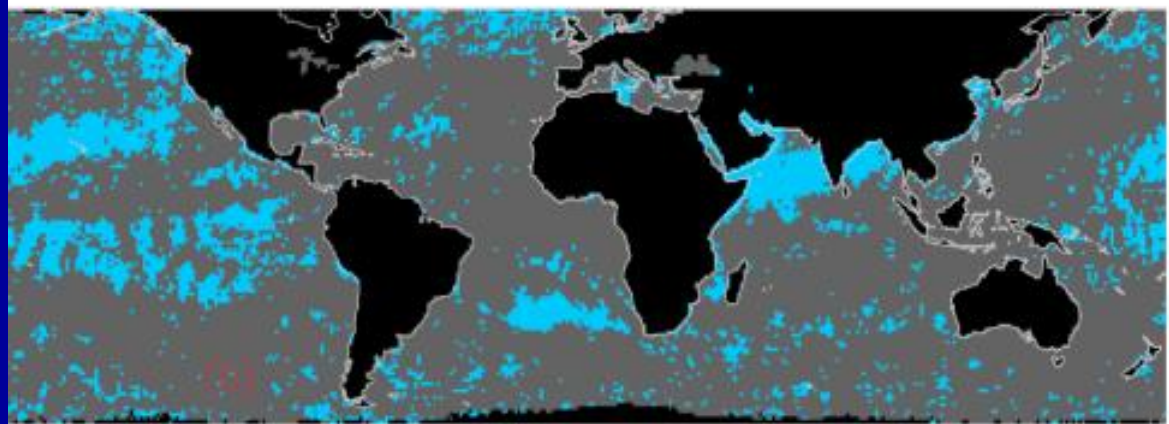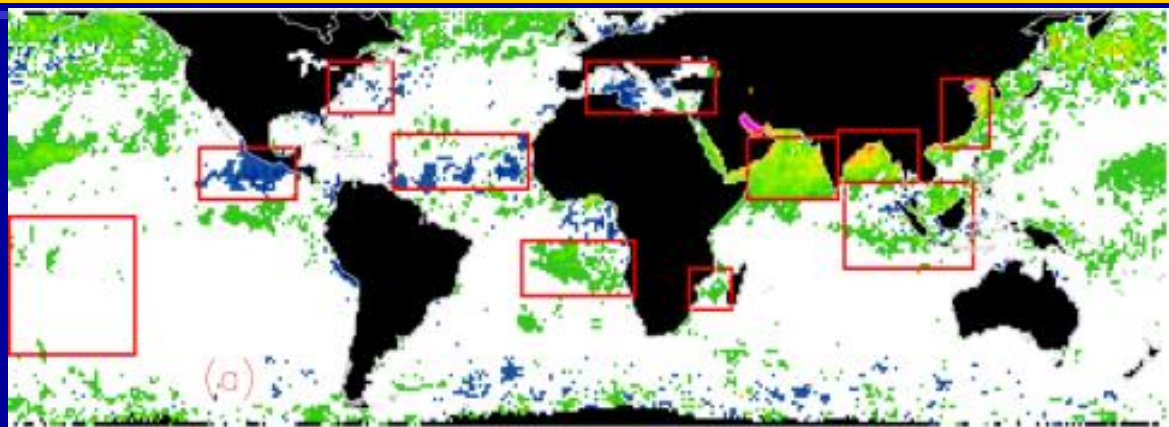
- Images can always be found on the NRL aerosol webpage: http://www.nrlmry.navy.mil/aerosol/

- The big data repository for NRL and Navy is GODAE and the product will appear there as soon. http://www.usgodae.org/

- Also data will appear on Jianglong Zhang's website. http://bobcat.aero.und.edu/jzhang/index.php

- We are trying to push it to LANCE.

- AERONET stats in Hyer's ancillary materials at AMTD. http://www.atmos-meas-tech-discuss.net/3/4091/2010/

- If you need something specific ask….

- Validating against satellite when we are already assimilating everything we can get our hands on (own analysis to be discussed earlier)

- Use of MISR, but takes 72 hours, and has a narrow swath.

- Satellite clipper: MISR is the best for climatology, but the obs come from MODIS. Do we need to further debias MODIS?

- SEVERI dust products for event verification?