ANALYSIS AND APPLICATIONS OF MISR AEROSOL PRODUCTS TO DUSTY REGIONS

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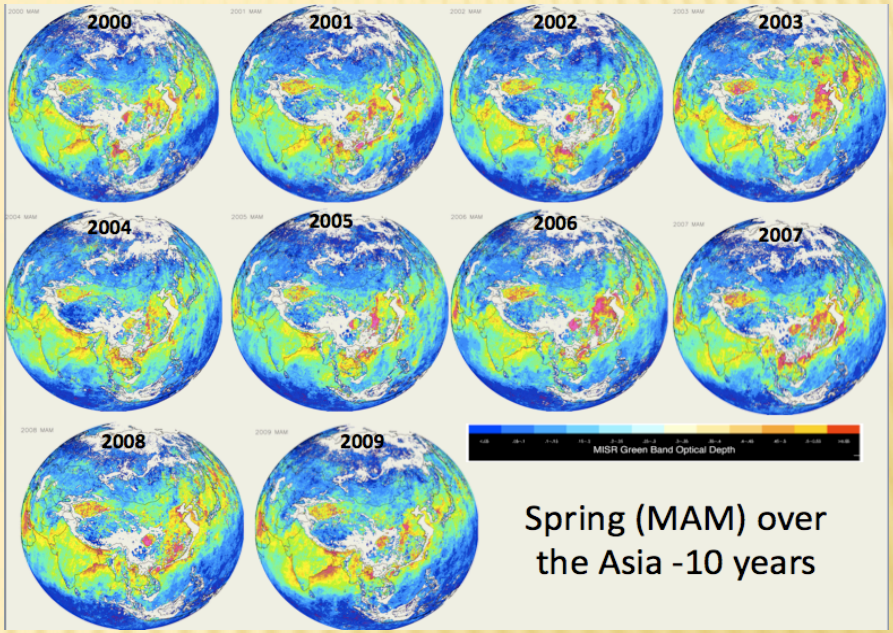
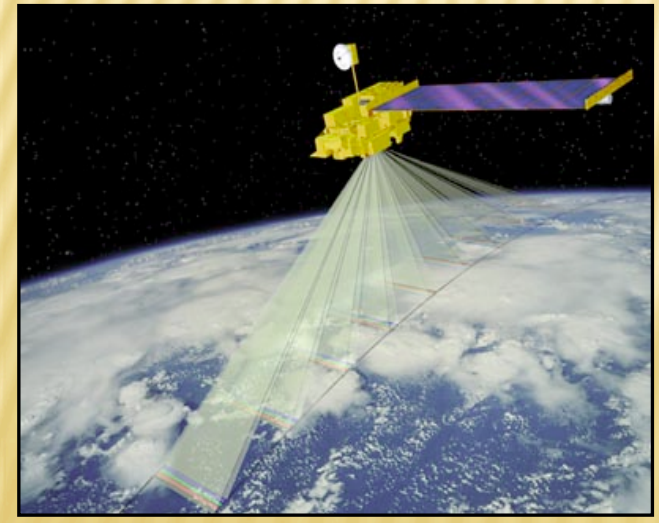
MISR CAPABILITIES IN DUSTY REGIONS

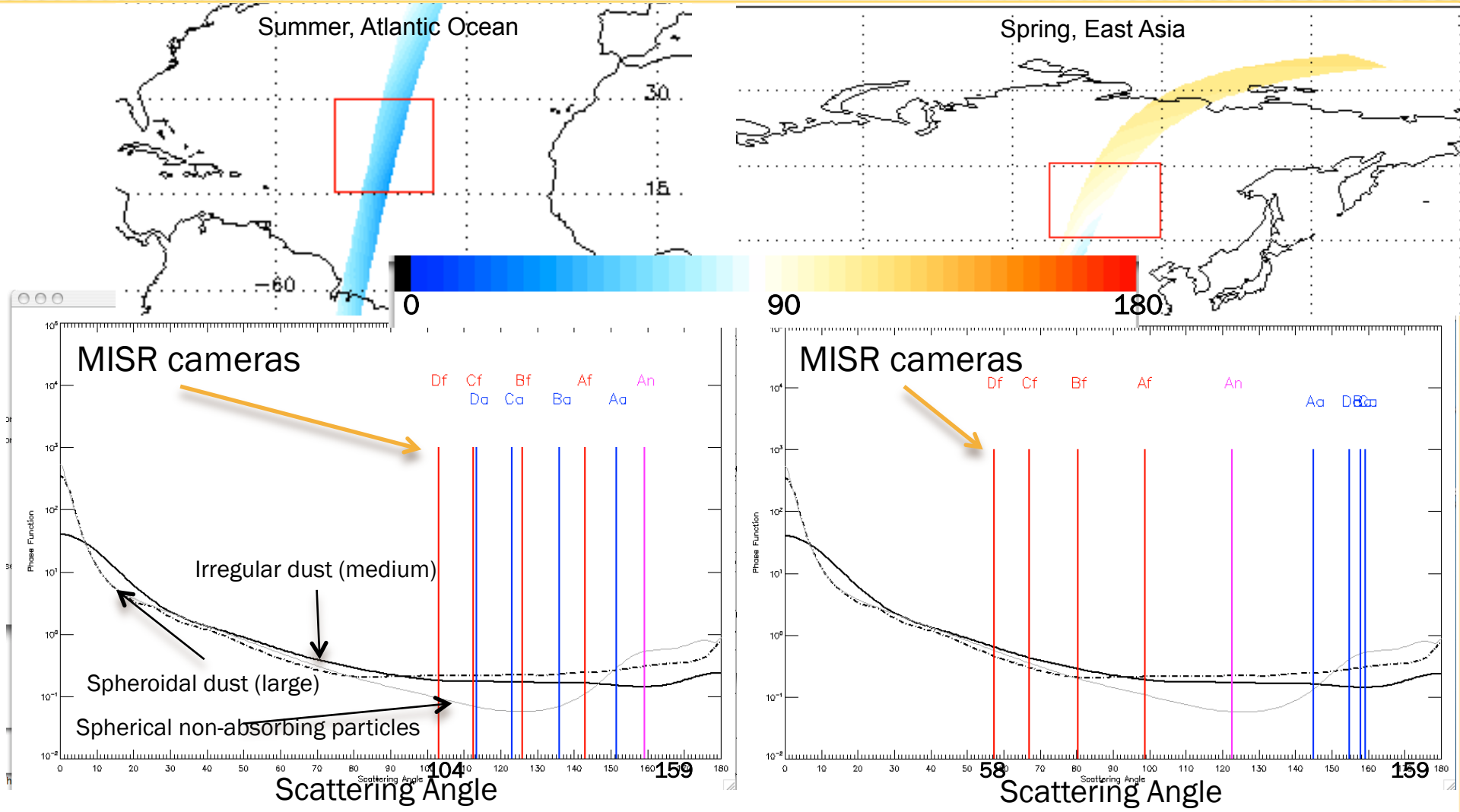
- Qualitative aerosol products:
  - UV Aerosol Index – AI (TOMS, OMI)
  - IR Dust Mask (AIRS, MODIS, Meteosat , SEVIRI)
- Quantitative aerosol products:
  - AOD (MODIS Deep Blue, OMI, MISR, SEVIRI, IASI)
  - SSA (OMI, MISR)





- ❑MISR has 11+ years of aerosol data record
- ❑MISR simultaneously retrieves AOD and surface BRF
- ❑MISR provides reliable AOD over bright desert sources (*Martonchik et al., 2004, Kahn et al., 2010, Christopher et al., 2008, 2009; Frank et al., 2007; Koven and Fung, 2008; Xia et al., 2008, 2009*)
- ❑MISR retrieves dust heights and winds in source regions
- ❑MISR is able to separate dust from spherical aerosols through multi-angular sensitivity to aerosol phase function (*Kahn et al., 1998, Kalashnikova et al., 2005*)

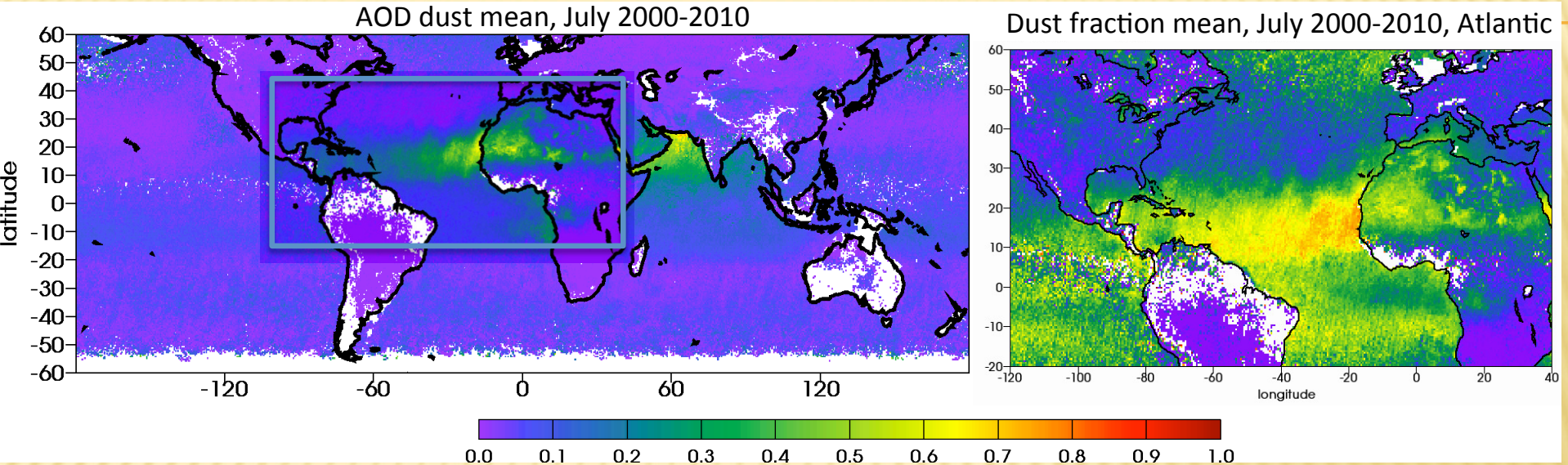
MISR AEROSOL DISCRIMINATION



Scattering angle range covered with nine MISR cameras in different viewing conditions

The MISR viewing geometry allows discrimination of dust from other aerosol types

MISR NON-SPHERICAL FRACTION CLIMATOLOGY



MISR aerosol product identifies dust in the regions where dust is expected.

Some land-water discontinuity in the dust fraction is apparent.

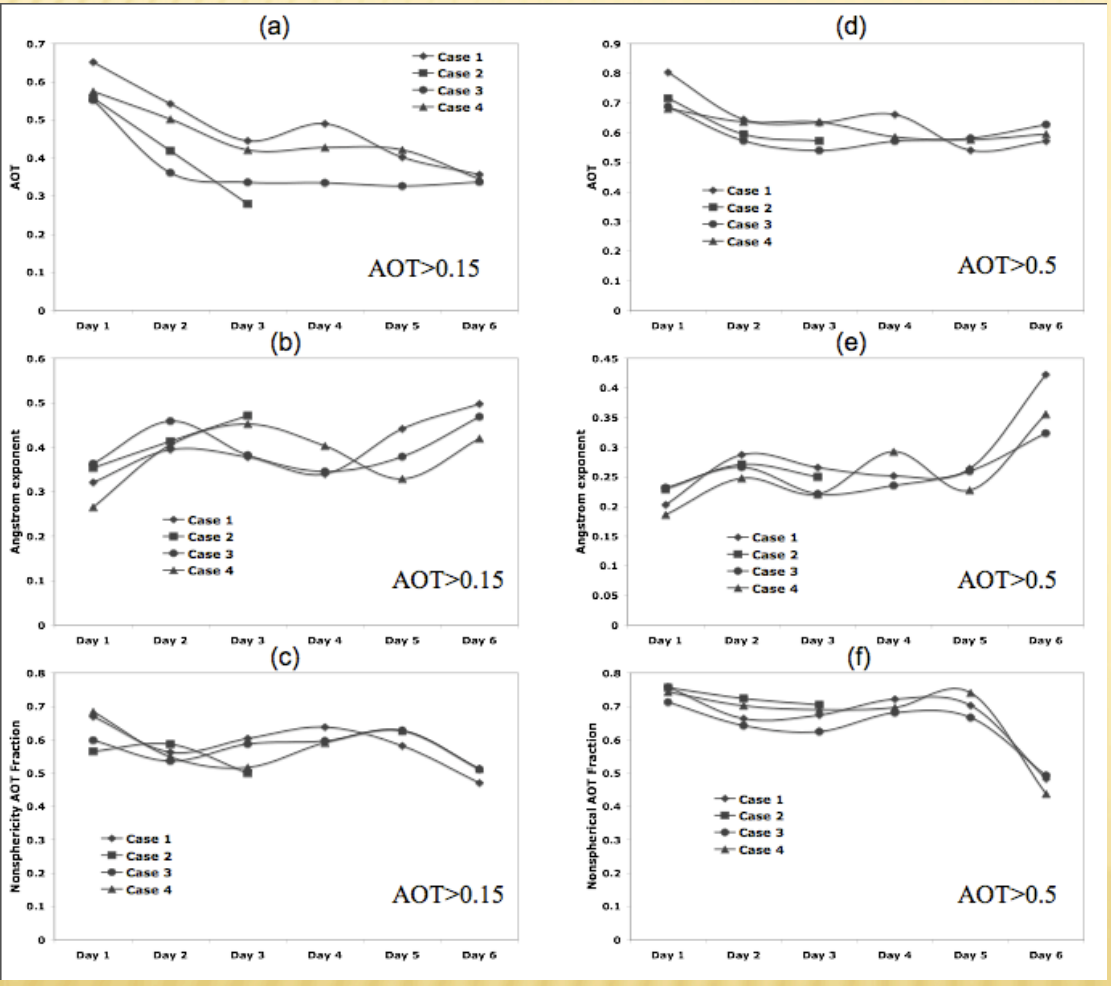
MISR dust model was developed and evaluated for MISR water retrievals that uses two longest MISR wavelengths (672nm and 866nm) (Kalashnikova et al., 2005; Kalashnikova and Kahn, 2006). The model assumes:

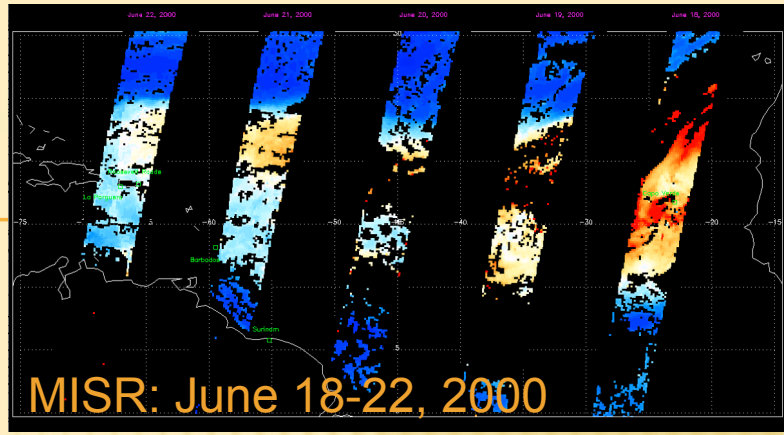
- Fixed refractive index (there is no sensitivity to dust refractive index in red and NIR)
- Fixed size distribution representative for the long-range transported dust
- Dust is placed in elevated 2-5km layer (characteristic for transported dust)

- MISR land retrievals uses 4 MISR bands –

  - the richer set of dust models is needed to fit MISR radiances (there is sensitivity to dust refractive index and elevation in blue and green channels)

DUST EVOLUTION (CASE STUDIES)





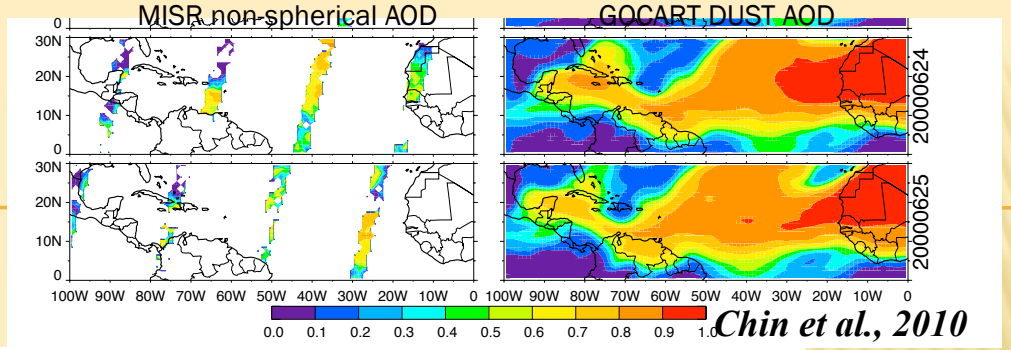
- MISR-retrieved Angstrom exponent & AOD spherical fraction are ~30% lower in the optically thicker parts of the plume compared to the total plume
- SSA~0.97
- Dust fraction remains unchanged during 5 days of Trans-Atlantic transport
- For AOD >0.5, Angstrom exponent increases ~30%, and AOD spherical fraction increases over 50% past Puerto Rico

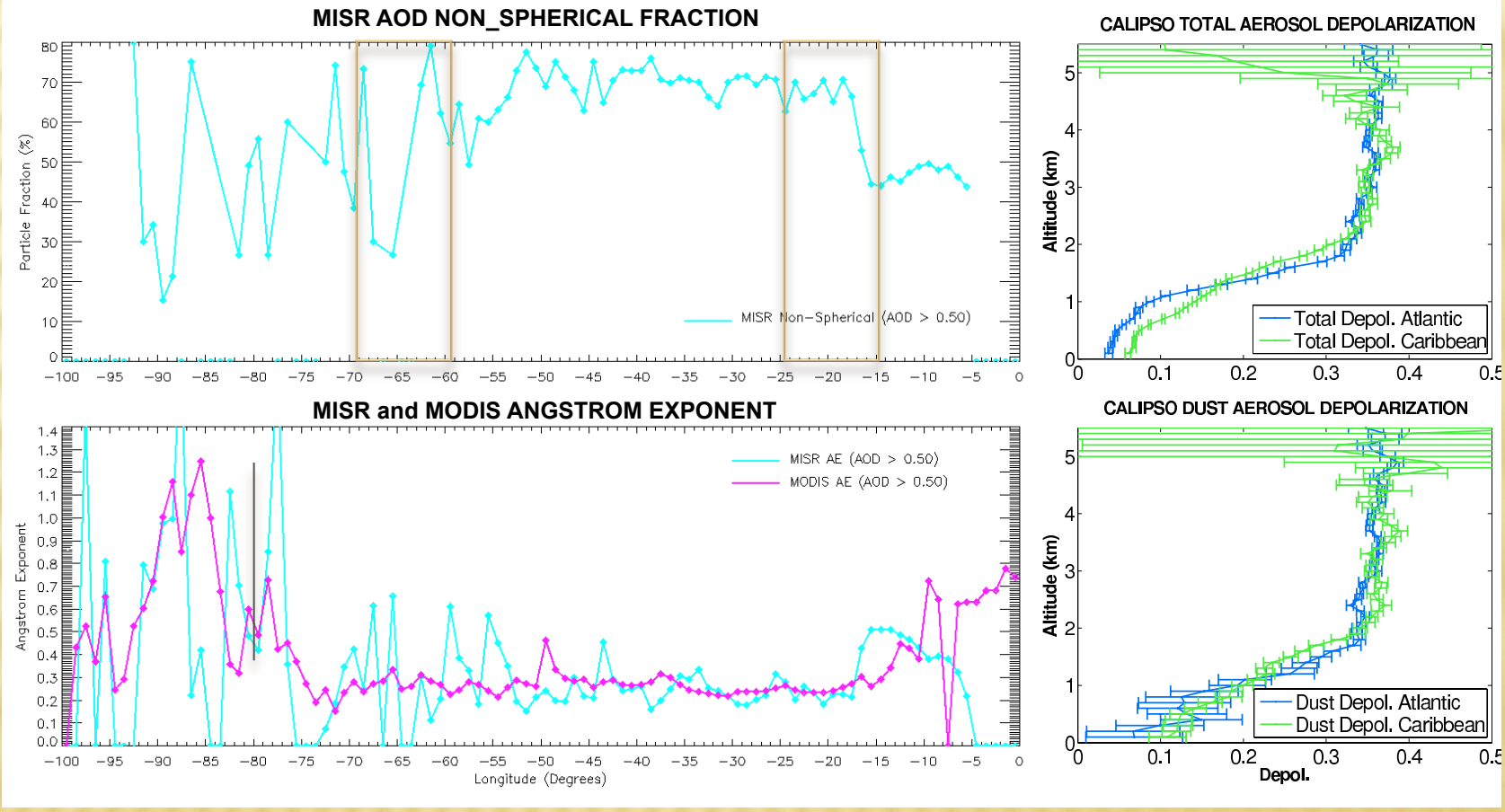
Non-monotonic behavior of MISR retrieved-properties is due to gaps in satellite coverage, since parts of the plume were not imaged on all days

Kalashnikova and Kahn, 2008

DUST EVOLUTION (CLIMATOLOGY)

JULY 2007



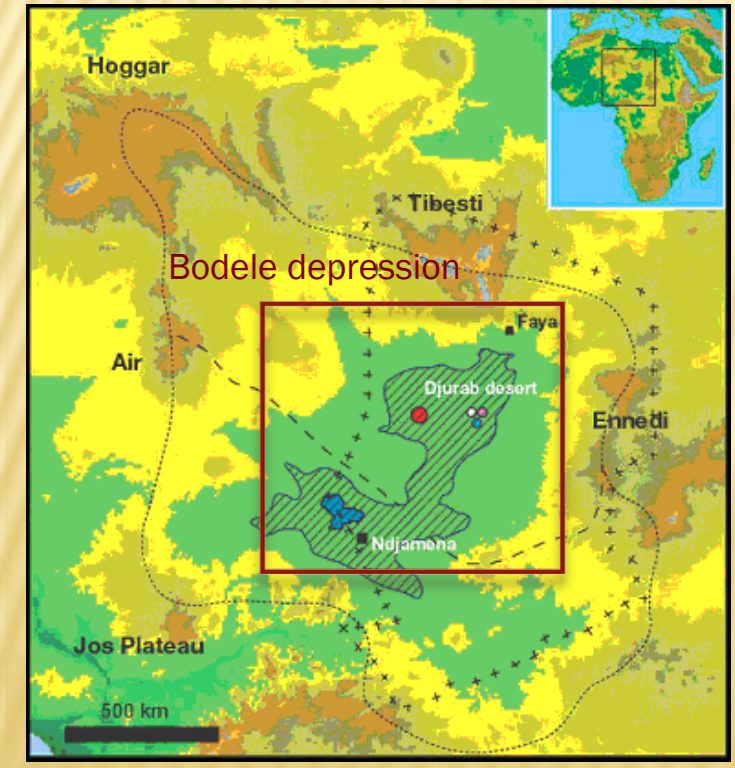


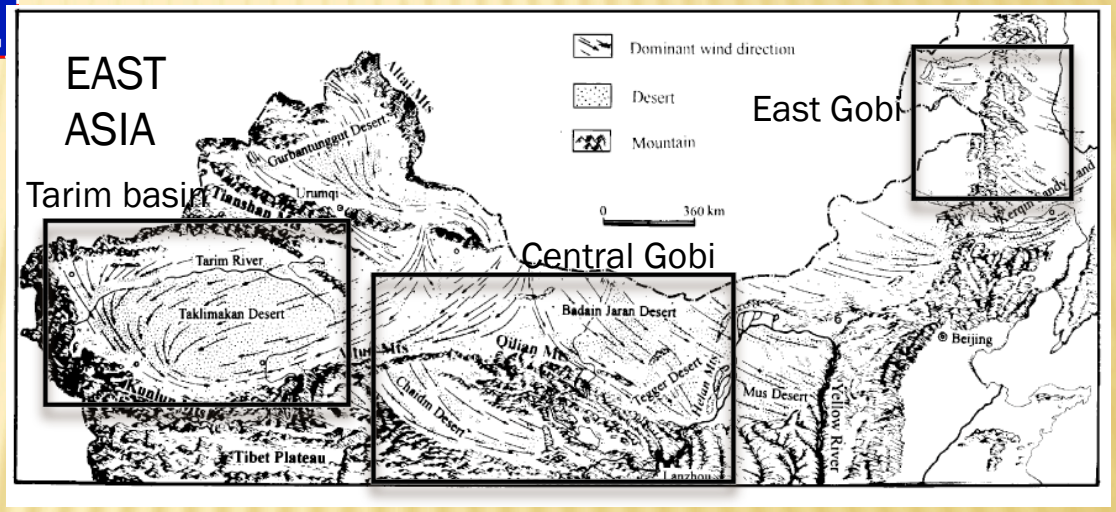
MISR, MODIS and CALIPSO — dust properties do not change across Atlantic. **MISR dust property retrievals produce a picture of dust evolution that we can use to critically test transport model performance.**

DUST SOURCES

African and East Asian deserts provide 90% of transported atmospheric mineral dust

Modeling of **Dust** emission remains a challenging problem (large biases between the models)





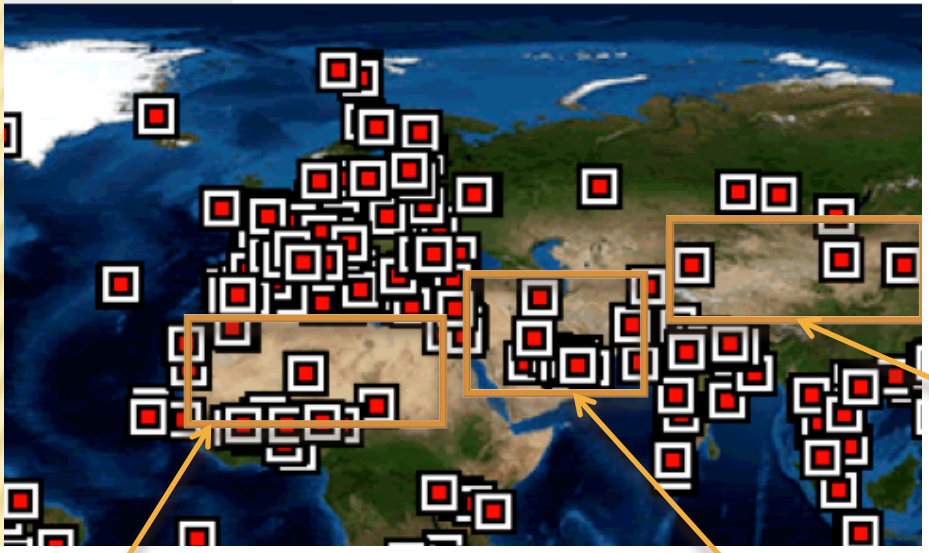
Satellite observations can provide:

- Constraints on dust emission fluxes
- Constraints on dust spatial distribution
- Constraints on dust temporal variability

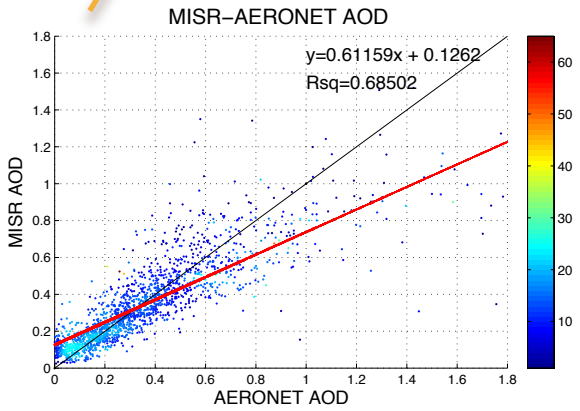
<u>Satellite retrievals are challenging over deserts</u>

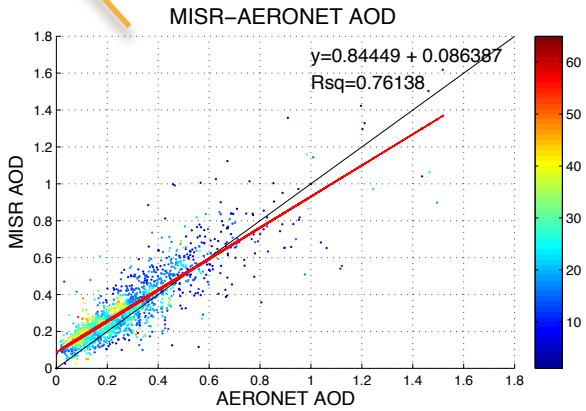
MISR-AERONET COMPARISON

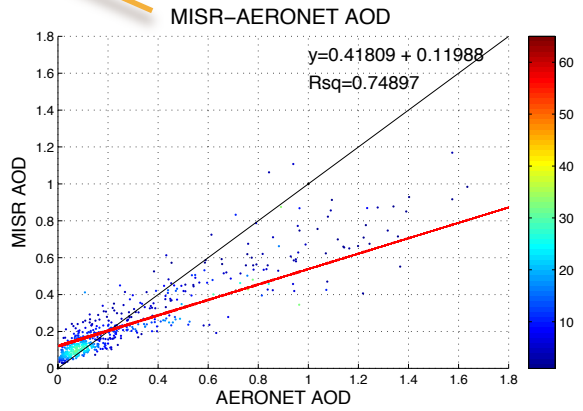
Globally: 70% to 75% of MISR AOD retrievals fall within 0.05 or 20% AOD, and about 50% to 55% are within 0.03 or 10% * AOD *[Kahn et al., 2010]*.



West Africa	East Asia	East Africa and Middle East
Agoufou,Banizoumbou	Beijing	Abu Al Bukhoosh, Abu Dhabi
Capo Verde, DMN Maine Soroa	Dalanzadgad	Al Dhafra, Al Ain
Dahkla, Dakar	Inner Mongolia	Al Khaznah, Al Qlaa
IER Cinzana, Izana	PKU PEK	Bahrain, Cairo EMA
La Laguna, Niamey	XiangHe	Cairo University, Dalma
Ouagadougou	Xinglong	Dhabi, Dhadnah
Praia	Yufa PEK	Eilat, Hamim
Quarzazate		Jabal Hafeet, Mezaira
Ras El Ain		Muscat, Mussafa
Saada		Nes Ziona, SEDE BOKER
Santa Cruz Tenerife		SMART,SMART POL
Tamanrasset INM		Saih Salam, Sir Bu Nuair
Zinder DMN		Solar Village,Umm Al Quwain



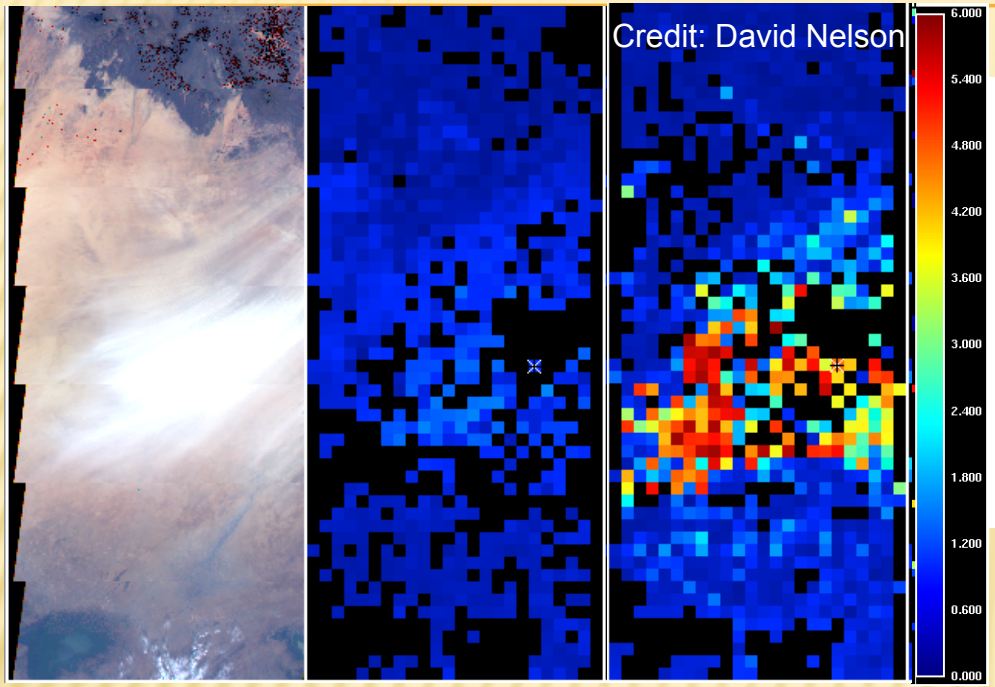




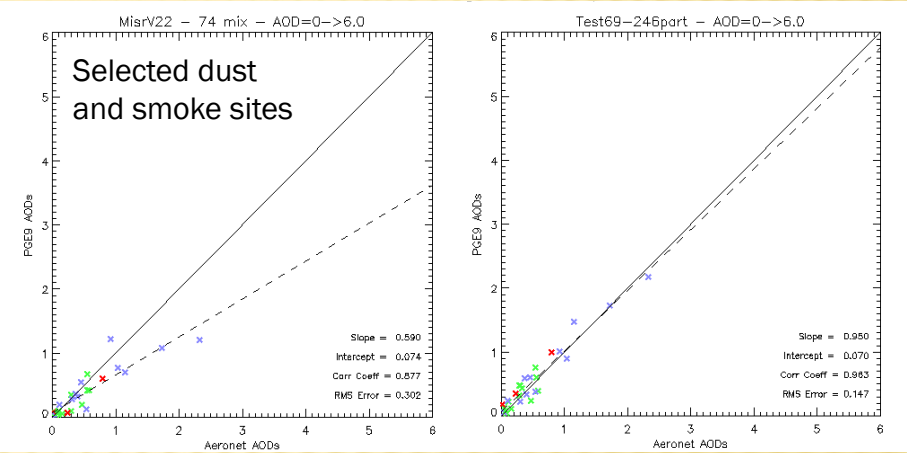
MISR overestimates AOD at low AOD range and underestimates AOD at high AOD range over bright surfaces; similar results are found in global validations (*Kahn et al., 2010).*

MISR LAND ALGORITHM

V22 No homog.mask



V22 No homog. mask



MISR land algorithm assumes:

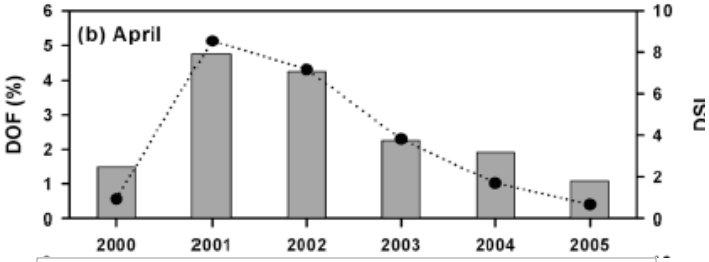
- Aerosol homogeneity over 17.6 km retrieval regions
- Smooth angular shape of TOA reflectance
- Spectrally invariant angular shape of surface reflectance
- Max AOT=3

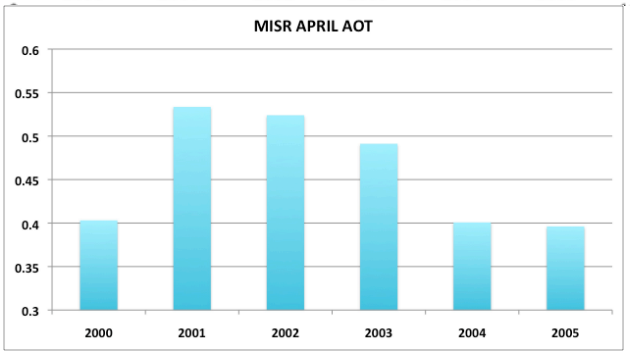
Dust sources are:

- Bright
- Highly inhomogeneous
- High in dust loadings (AOT often higher than 3)

MISR AOD TEMPORAL VARIABILITY

H. Kim and K. Kai, SOLA, 2007





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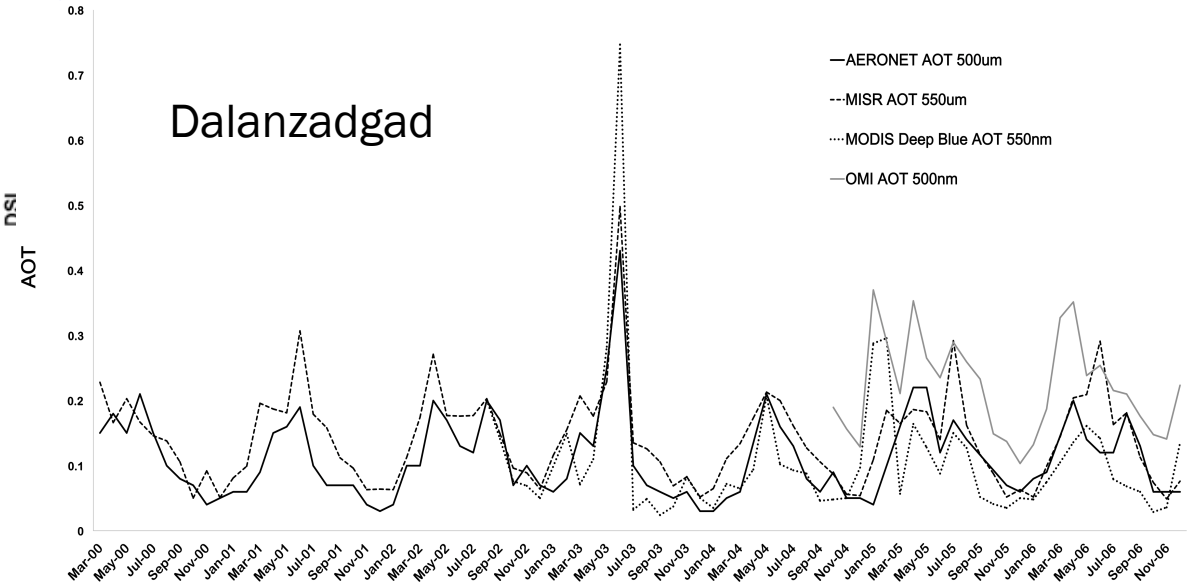
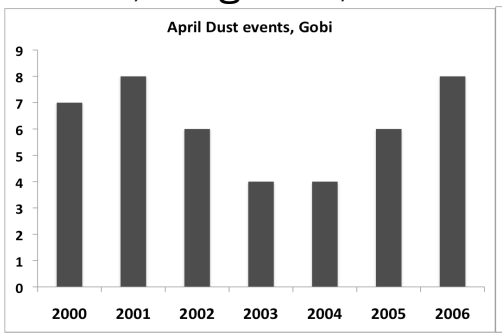
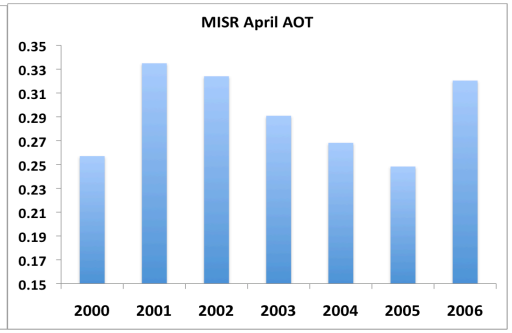
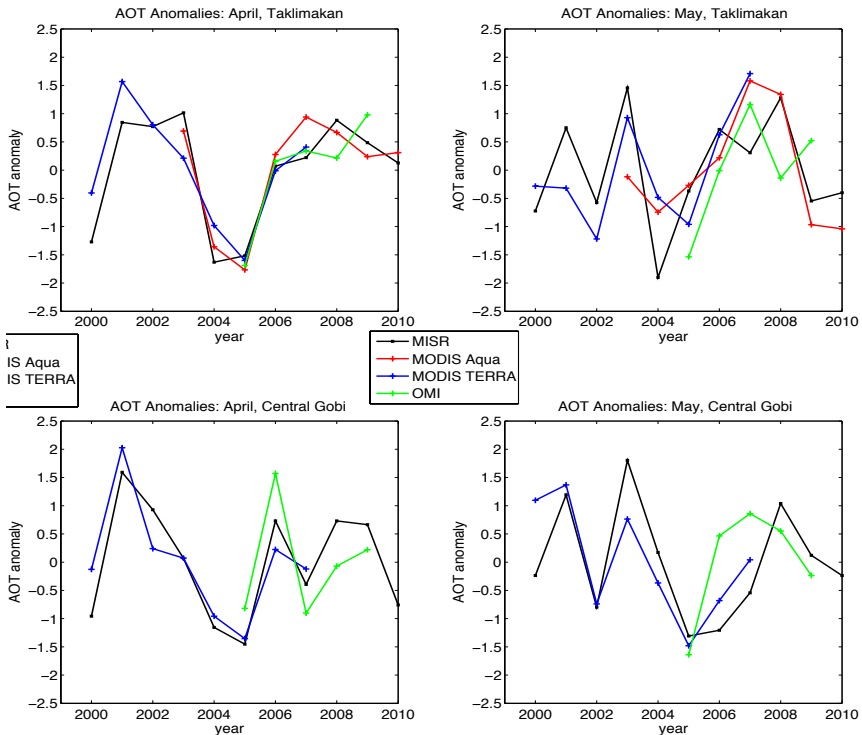


SDS, Yang et al., 2008



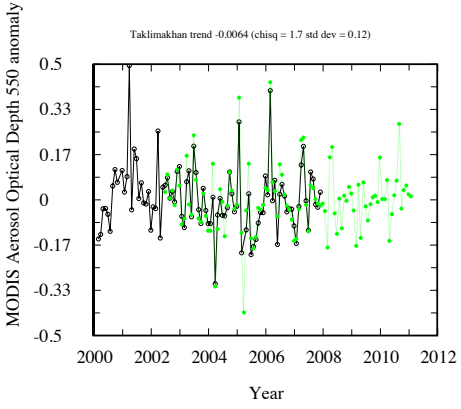




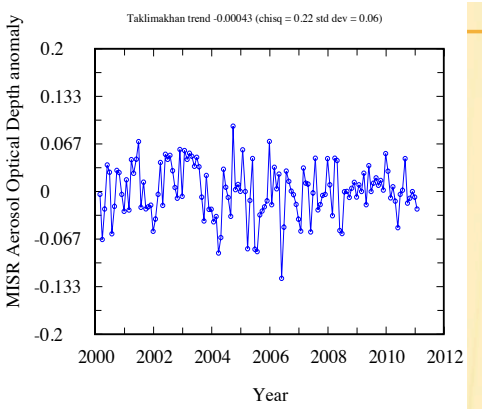
MISR AOT temporal variability in Asia is in good agreement with independent data

ASIAN DUST DECADAL VARIABILITY

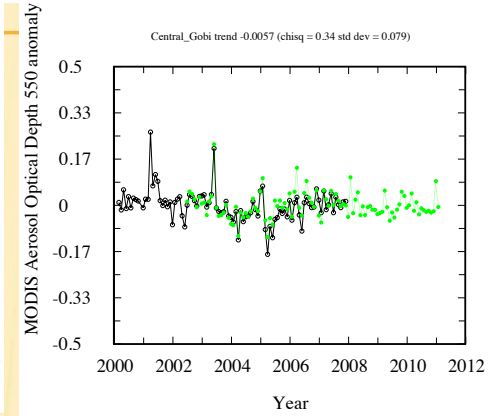
Taklimakan MODIS



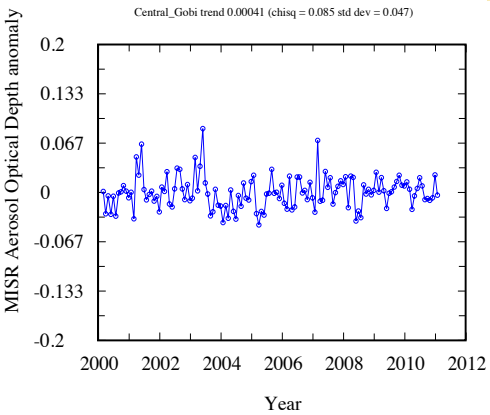
Taklimakan MISR



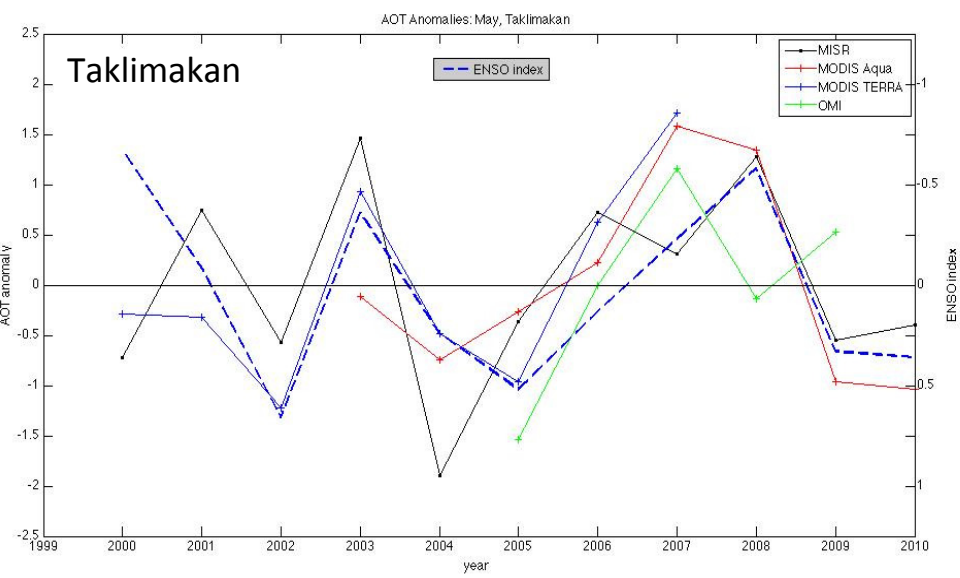
Central Gobi MODIS

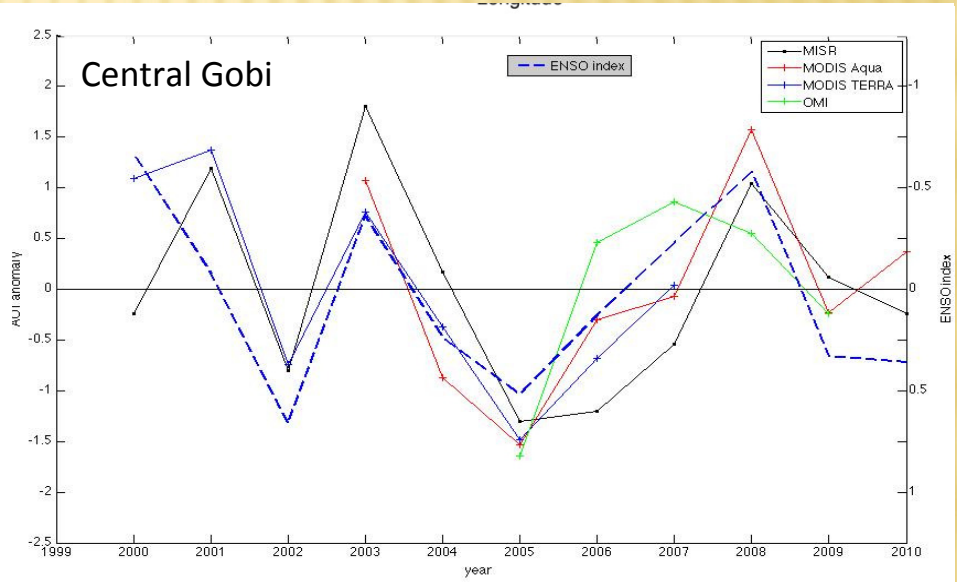


Central Gobi MISR



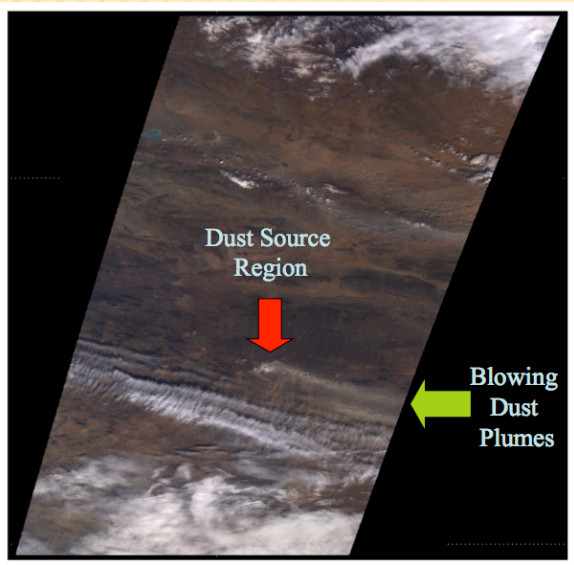
MISR and MODIS monthly anomalies trends in Asian dust sources are less than the error measured in the fit's Chi-square or its standard deviation from the observed values.

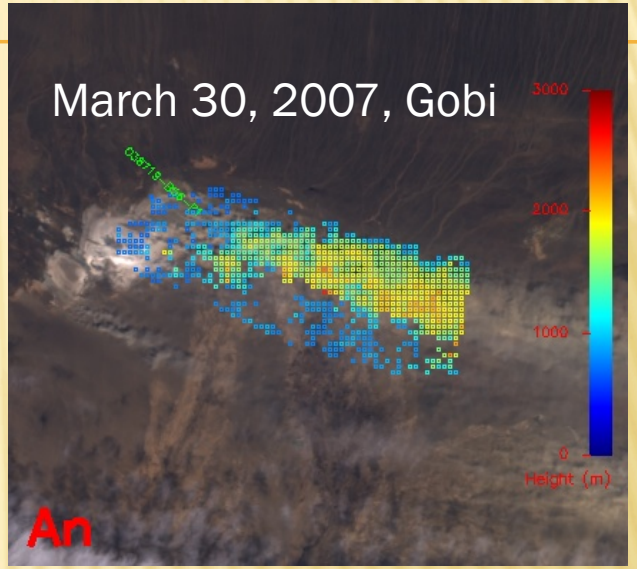




MISR and MODIS support model suggested *(Gong et al., 2006)* relationship between dust and ENSO; MISR April and May AOT anomalies in Asia provide information on dust-regional meteorology connections

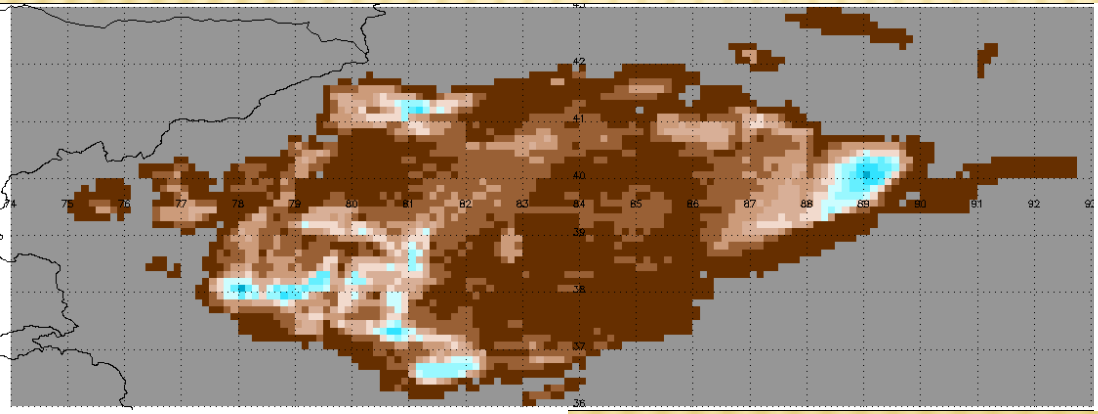
SOURCE DISTRIBUTION FROM MISR STEREO

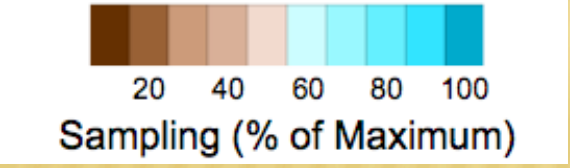


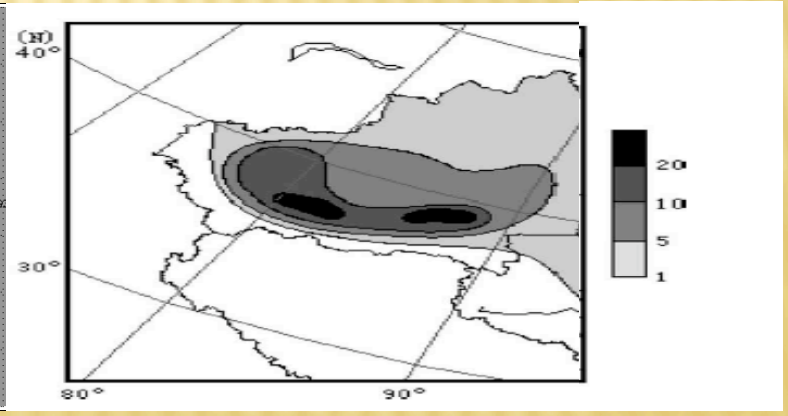


MISR observed dust plumes, 2001-2003

Dust storm occurrence (1954-2002)



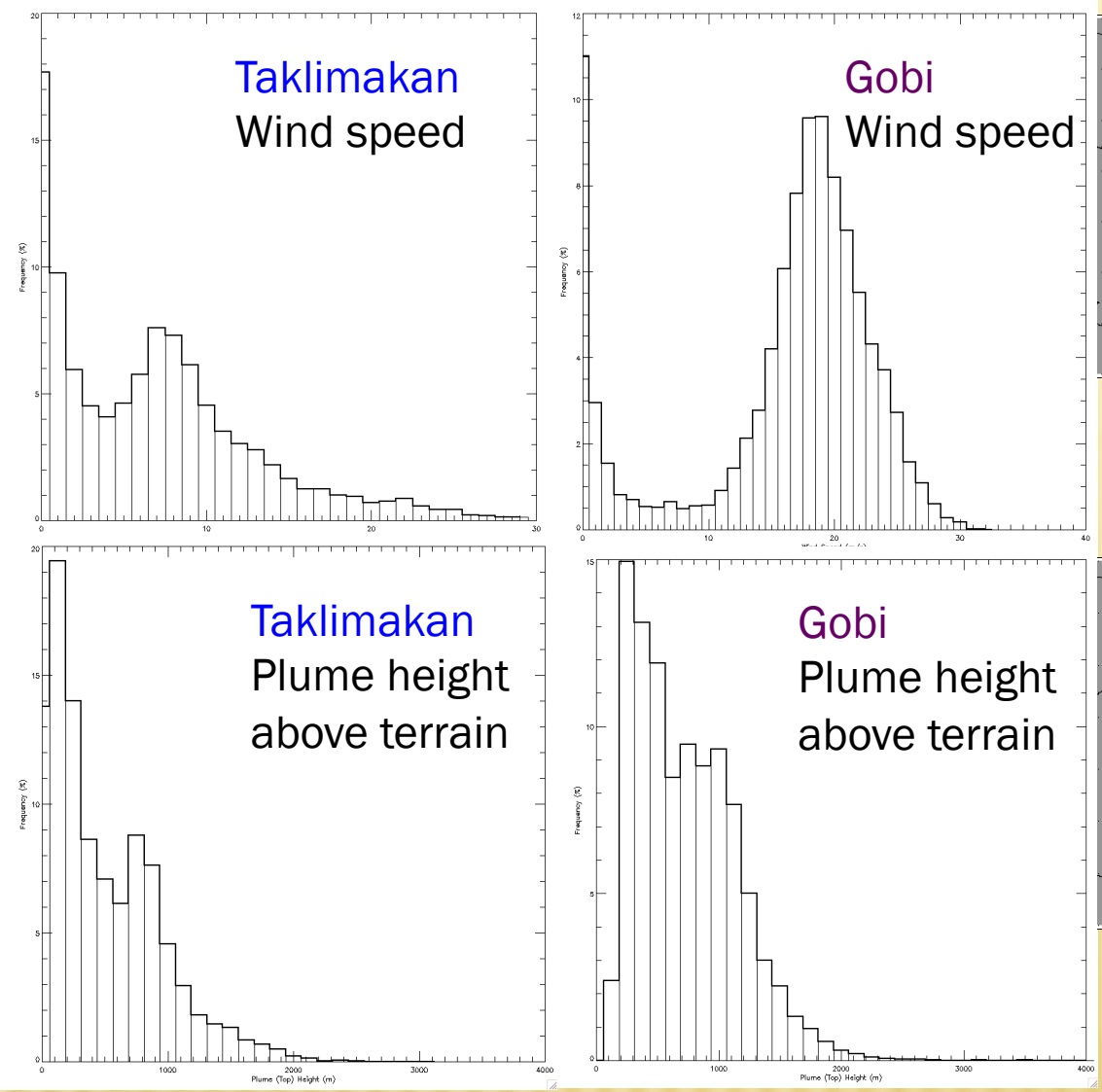


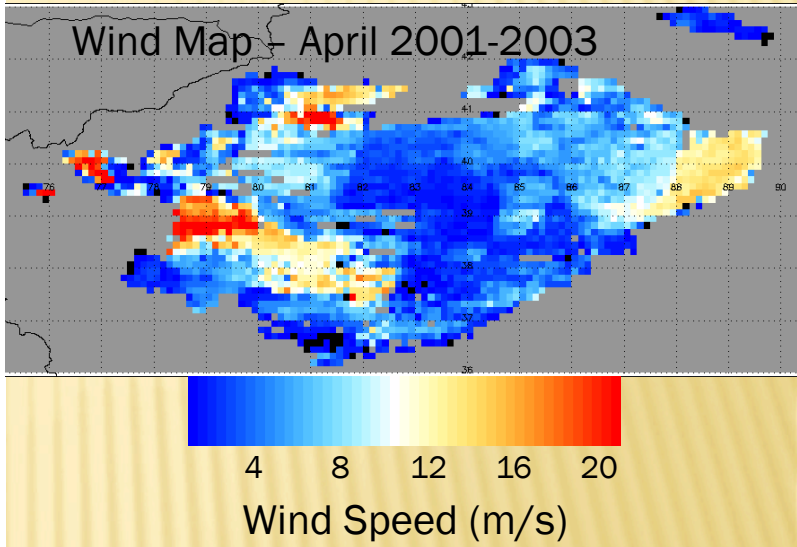


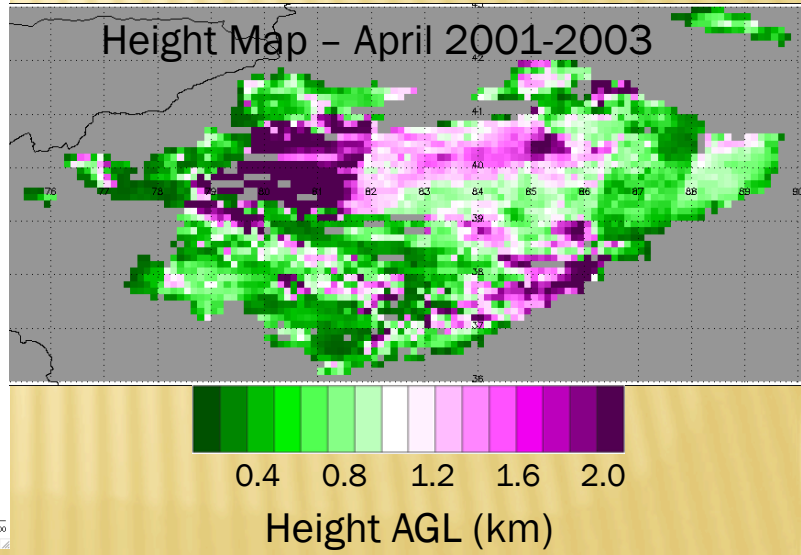
Zhao et al., 2006

MISR stereo imagery produces a picture of dust source distributions

MISR STEREO PLUME HEIGHTS AND WINDS







MISR stereo retrievals quantify dust-moving winds and dust heights that are used to constrain WRF-DuMo regional dust transport model

CONCLUSIONS

- MISR provides qualitative constraints on dust trans-Atlantic transport through retrievals of nonspherical fraction over the water.
- MISR AOD is reasonable for low-to-medium aerosol loadings over dust affected areas; underestimation biases occur at high dust concentrations due to reduced sensitivity to surface reflectance angular shape and its assumed spectral invariance.
- MISR AOD temporal variability in Asian dust sources is in good agreement with ground-based observations and is used to constrain climate connections between dust and meteorological indices.
- MISR stereo dust statistics in Asia is used to constrain source distributions and provides valuable constrains for regional models

Future work:

- Improve MISR land retrievals for thick heterogeneous plumes over bright surfaces