Southern Ocean AOD maximum: MISR, MAN and Aeronet perspectives

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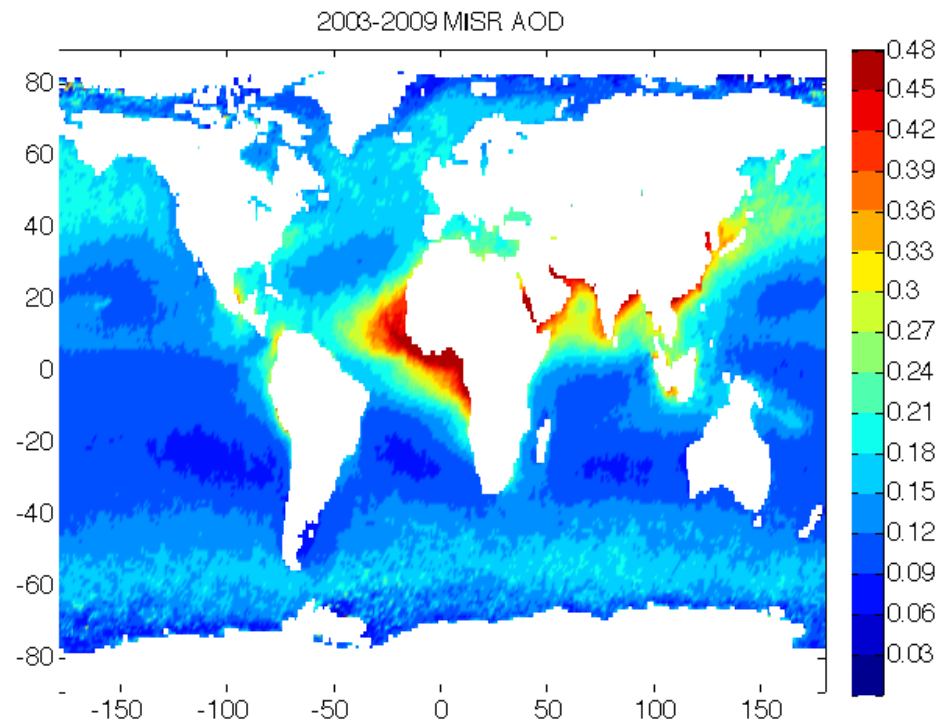
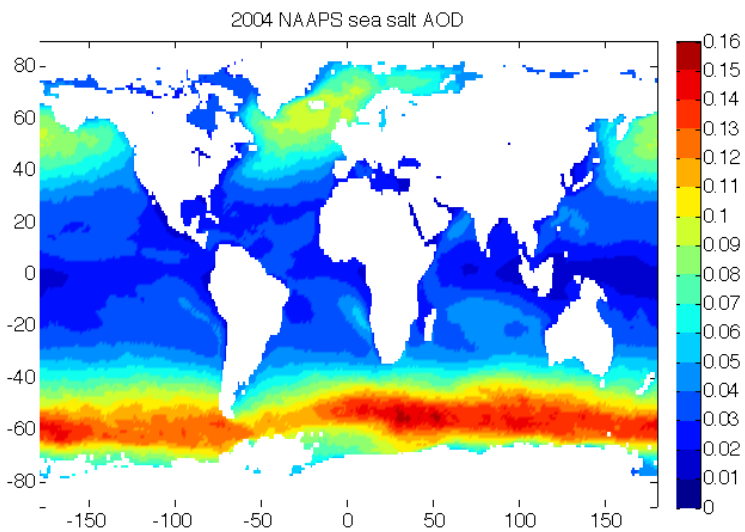
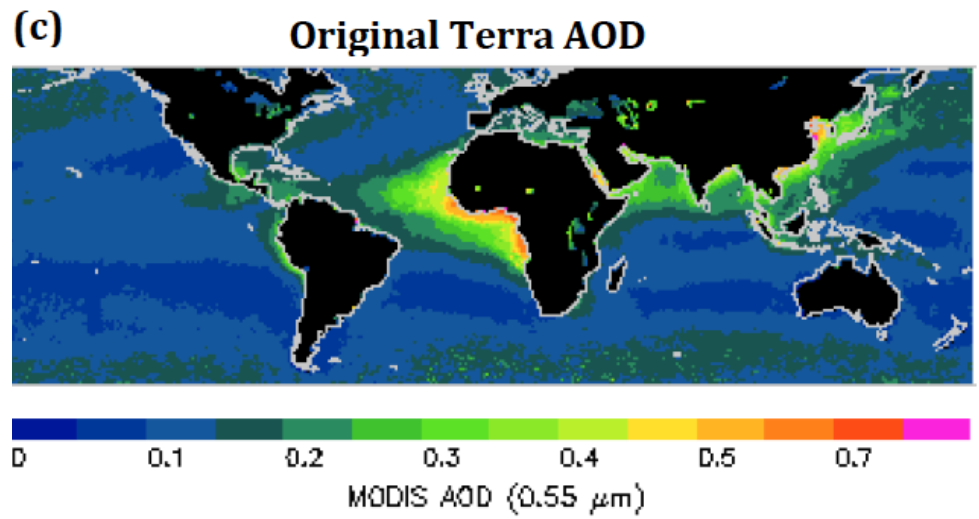
Problem statement

There is a distinct maximum in aerosol optical depth (AOD) over Southern Oceans at around 55^0 S latitude band.

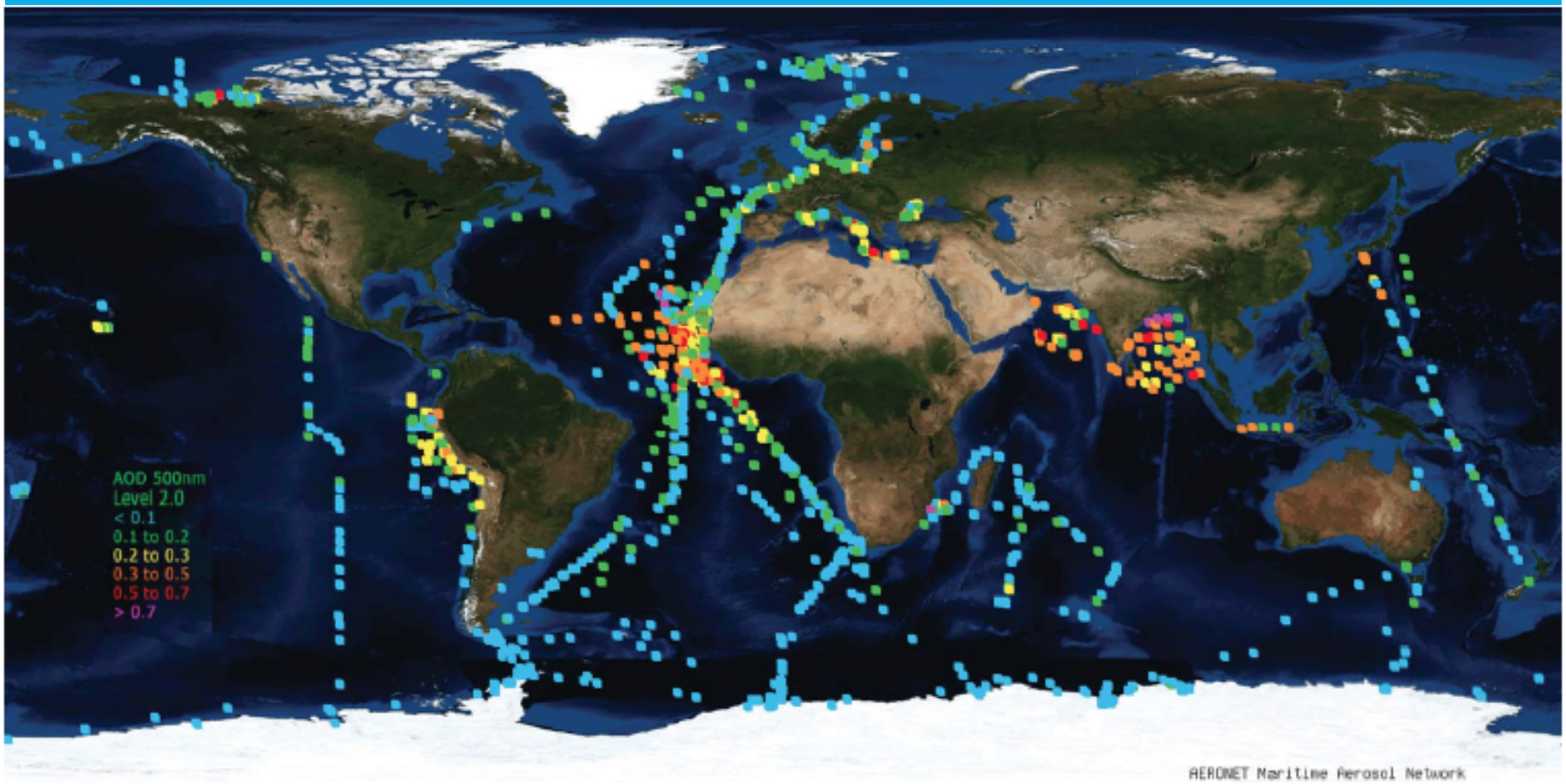
It is observed in satellite retrievals (MISR, MODIS) and simulated in global aerosol transport models (related to enhanced sea salt emission due to strong surface winds)







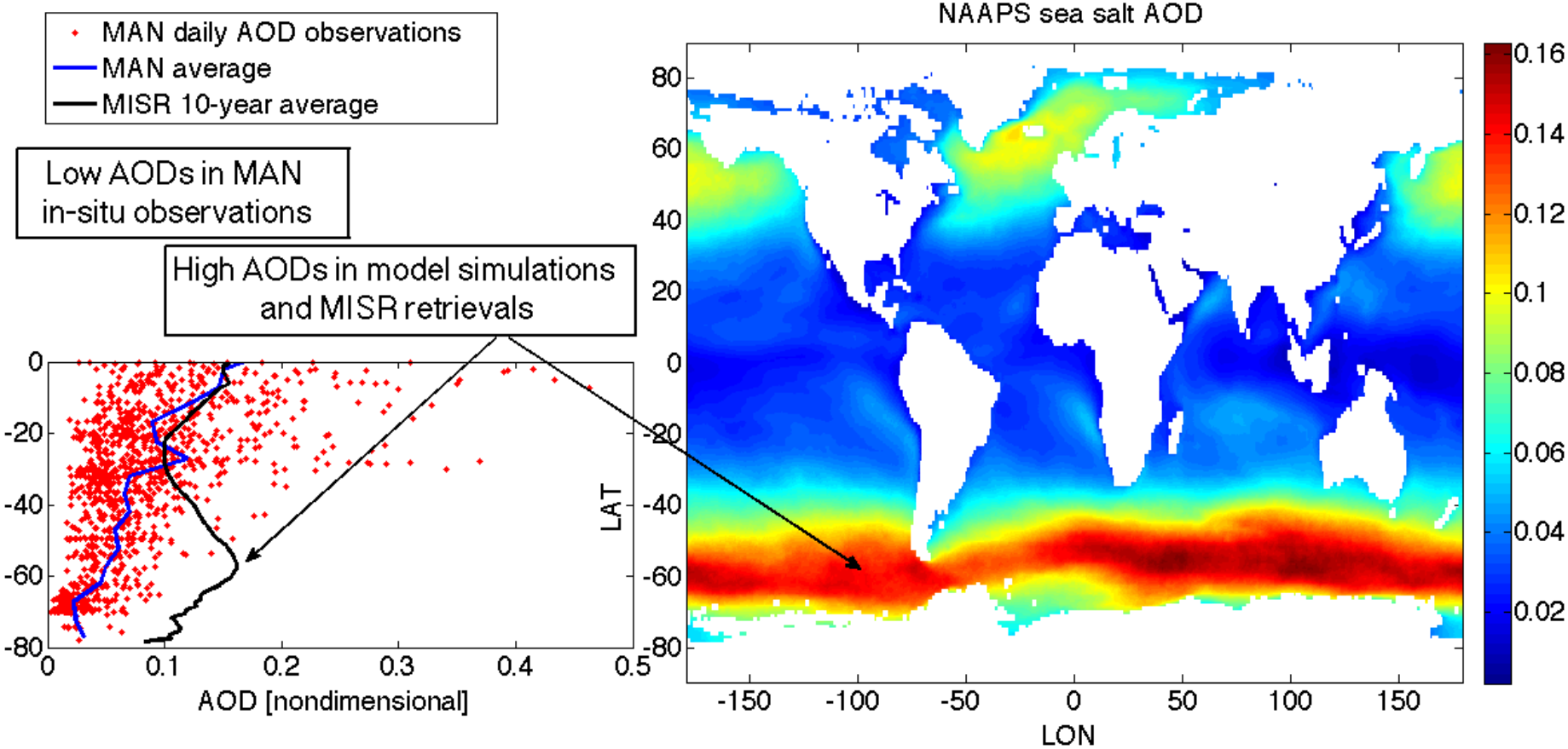
Problem statement



Marine Aerosol Network (MAN) AOD observations from 2004 onward

dAOD = ±0.02

Problem statement



MAN is right vs. MISR & transport models are right

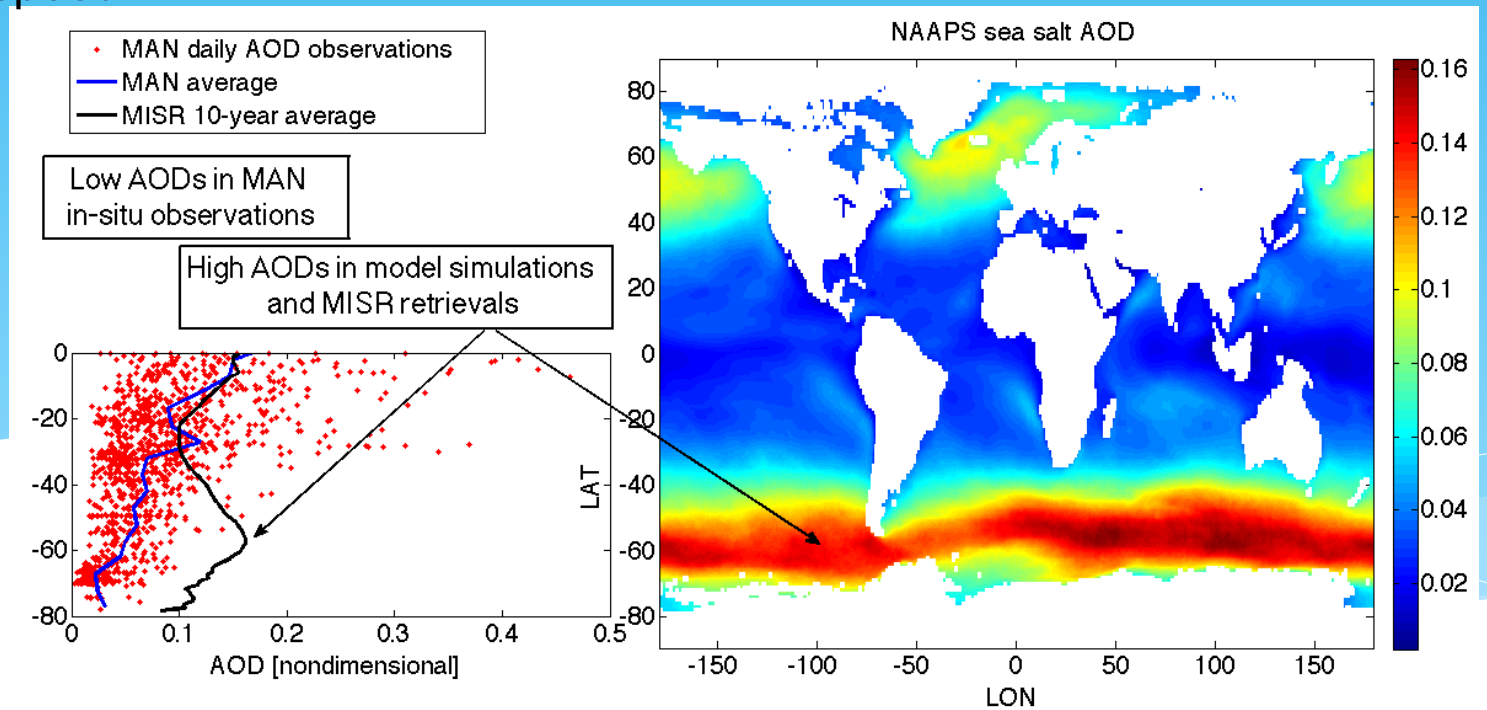
Reliable information about

AOD (±0.02) but …

Relatively small number of measurements

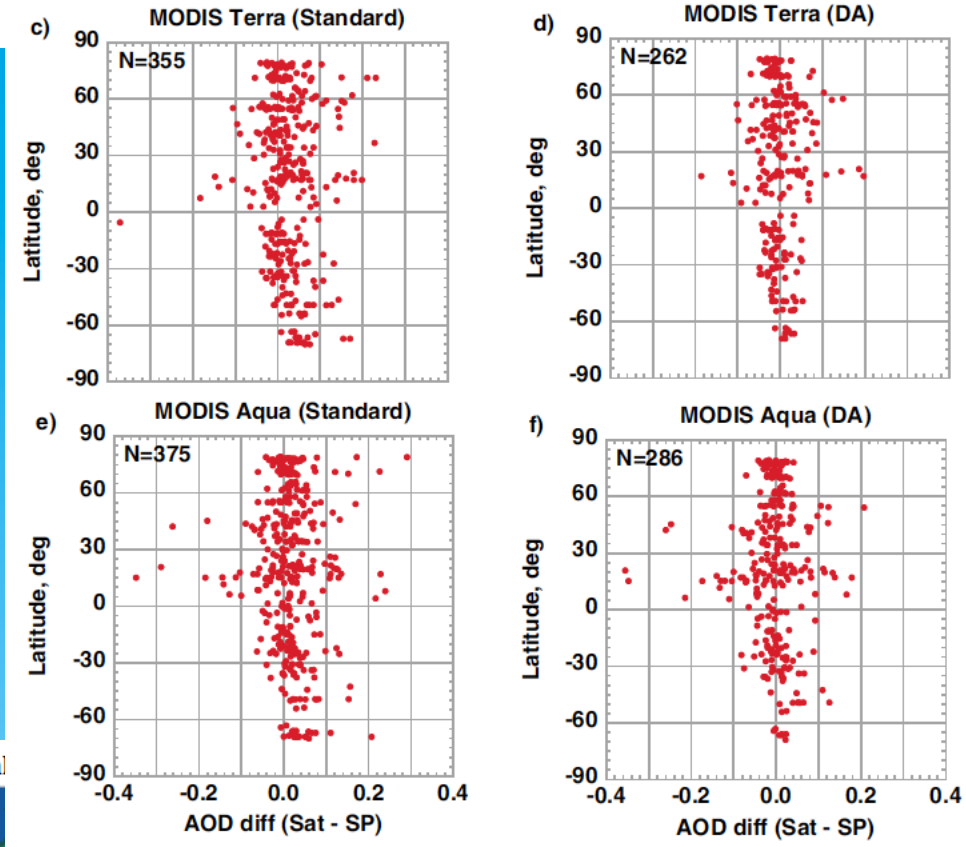
Direct observations might be biased towards cleaner conditions with lower wind speed

There are certain challenges with satellite retrievals and model simulations …

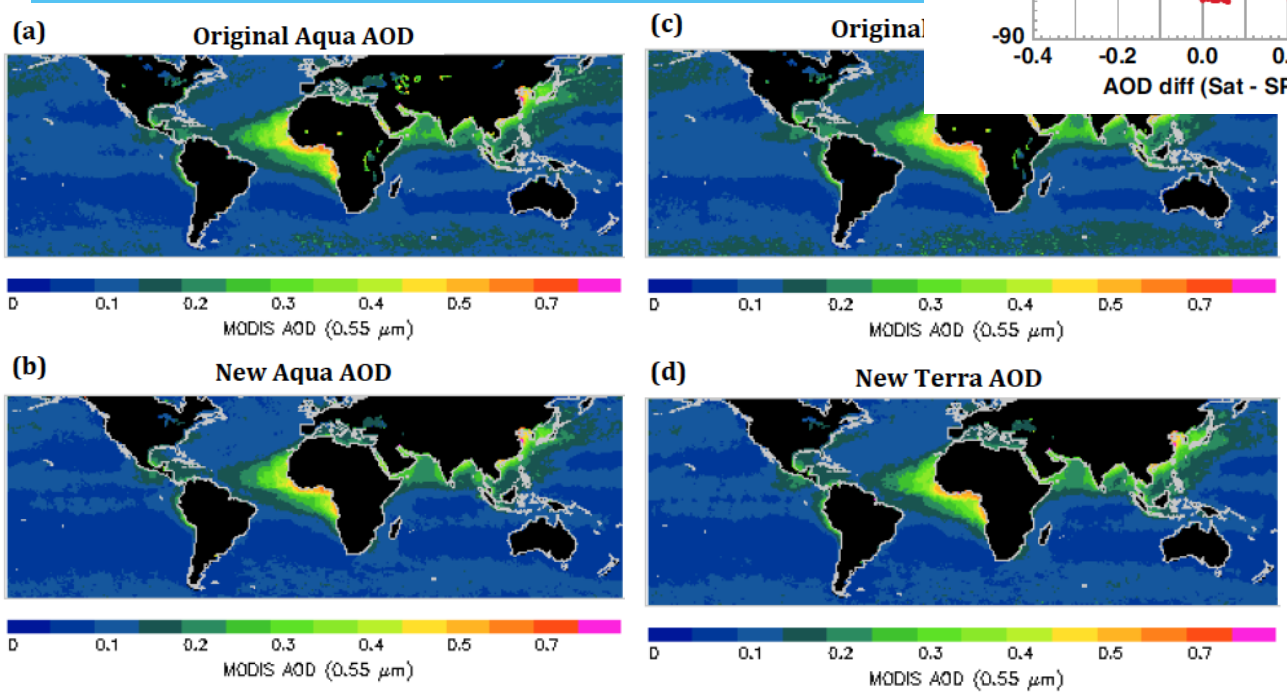


Satellite retrievals

1. Cloud screening
2. Constraining surface conditions: climatological wind speed, whitecap coverage, sunglint
3. Other…



(Smirnov et al., 2011)



(Shi et al., 2011)

Multi-angle Imaging SpectroRadiometer (MISR)

Nine view angles at Earth surface: 70.5º forward to 70.5º backward

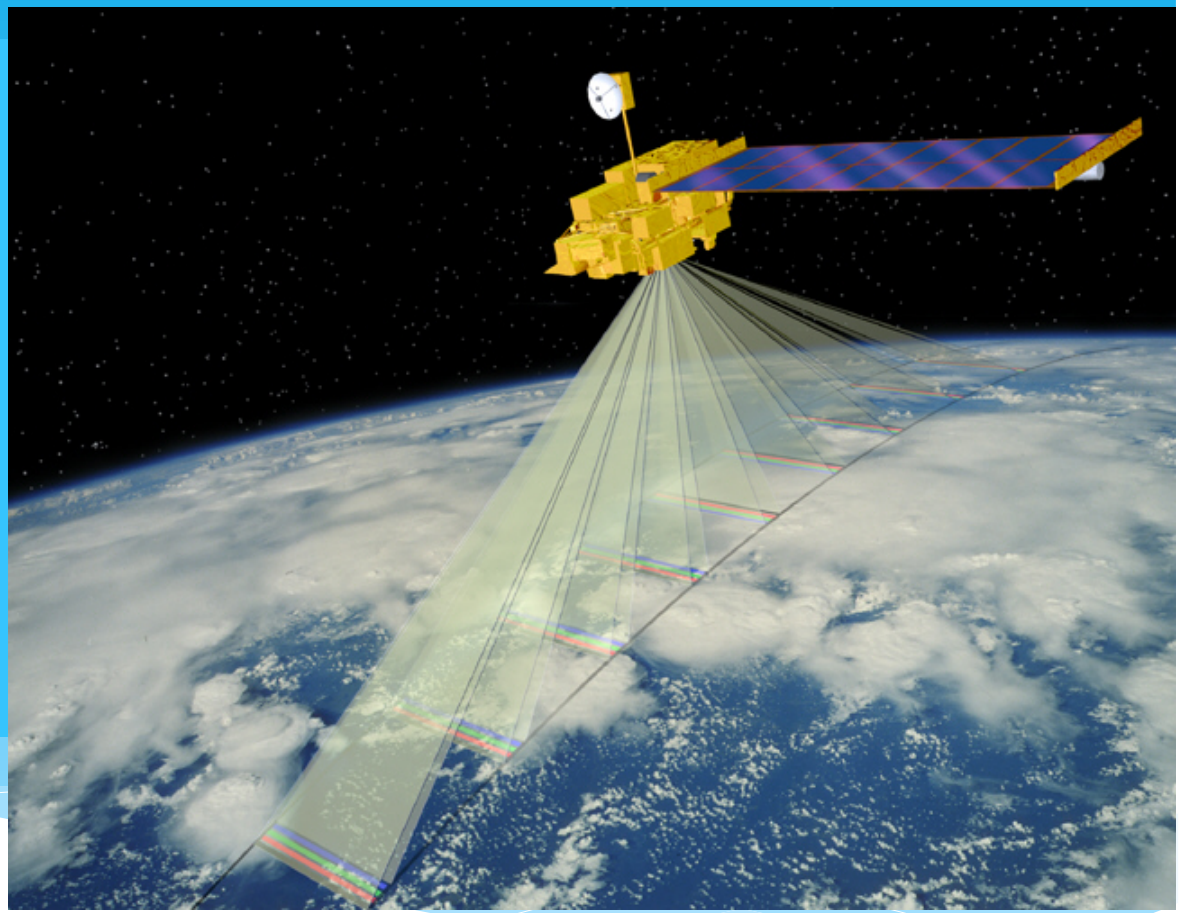
Nine 14-bit pushbroom cameras

275 m - 1.1 km sampling

Four spectral bands at each angle: 446, 558, 672, 866 nm

400-km swath: 9-day coverage at equator, 2-day at poles

7 minutes to observe each scene at all nine angles



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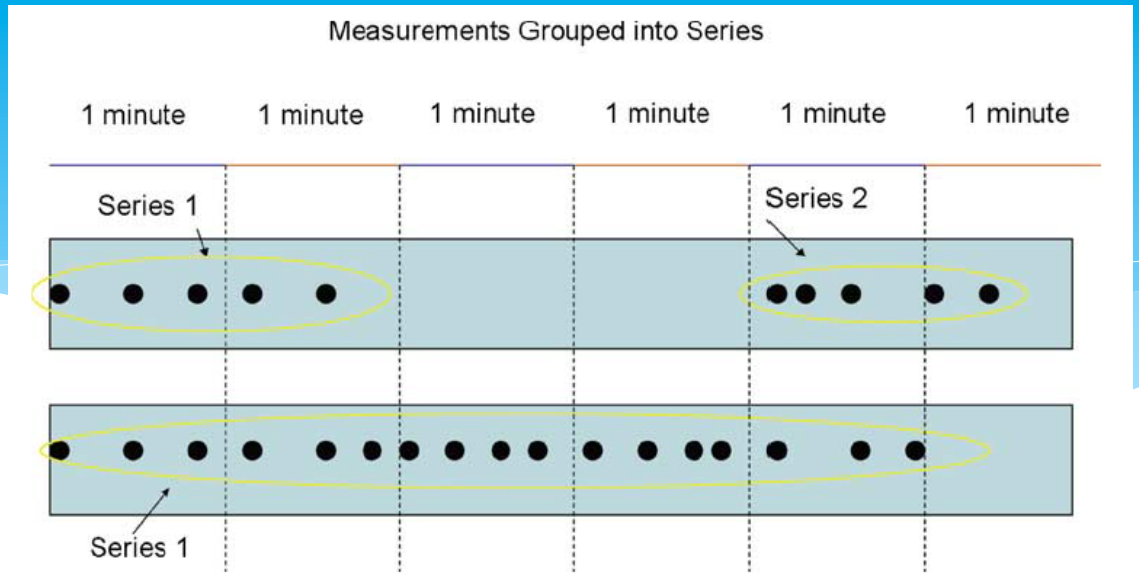
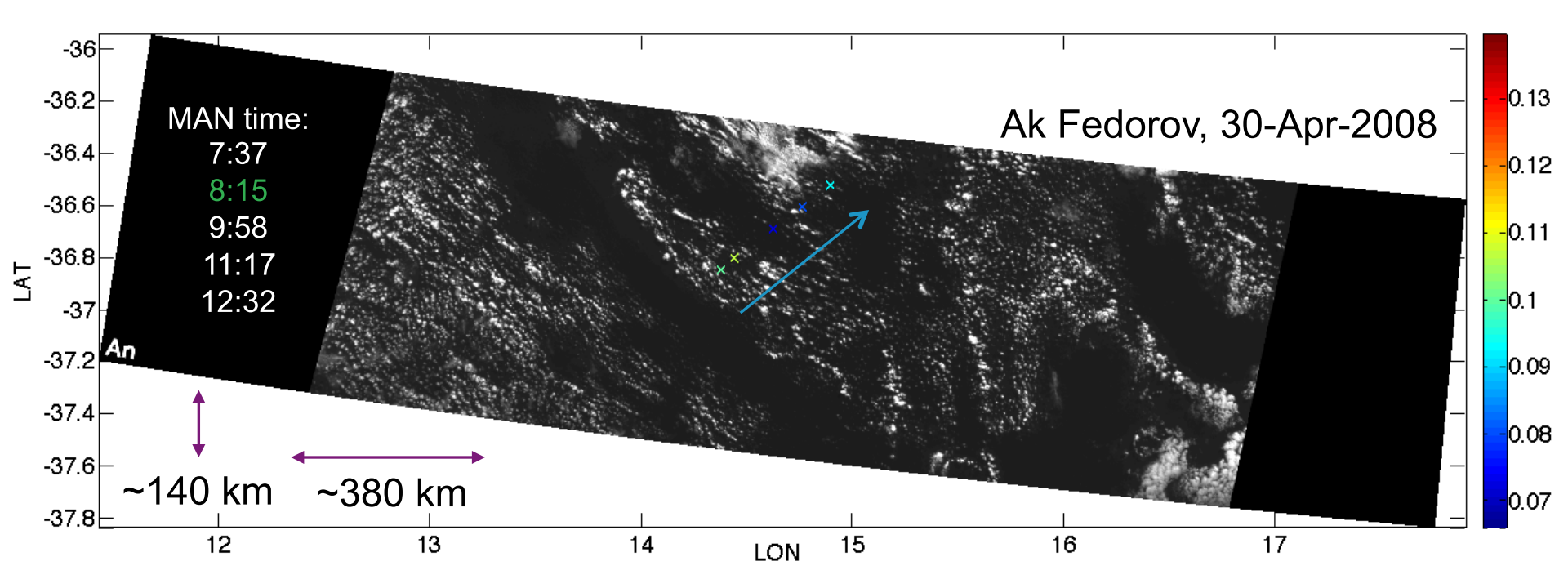
MAN data format

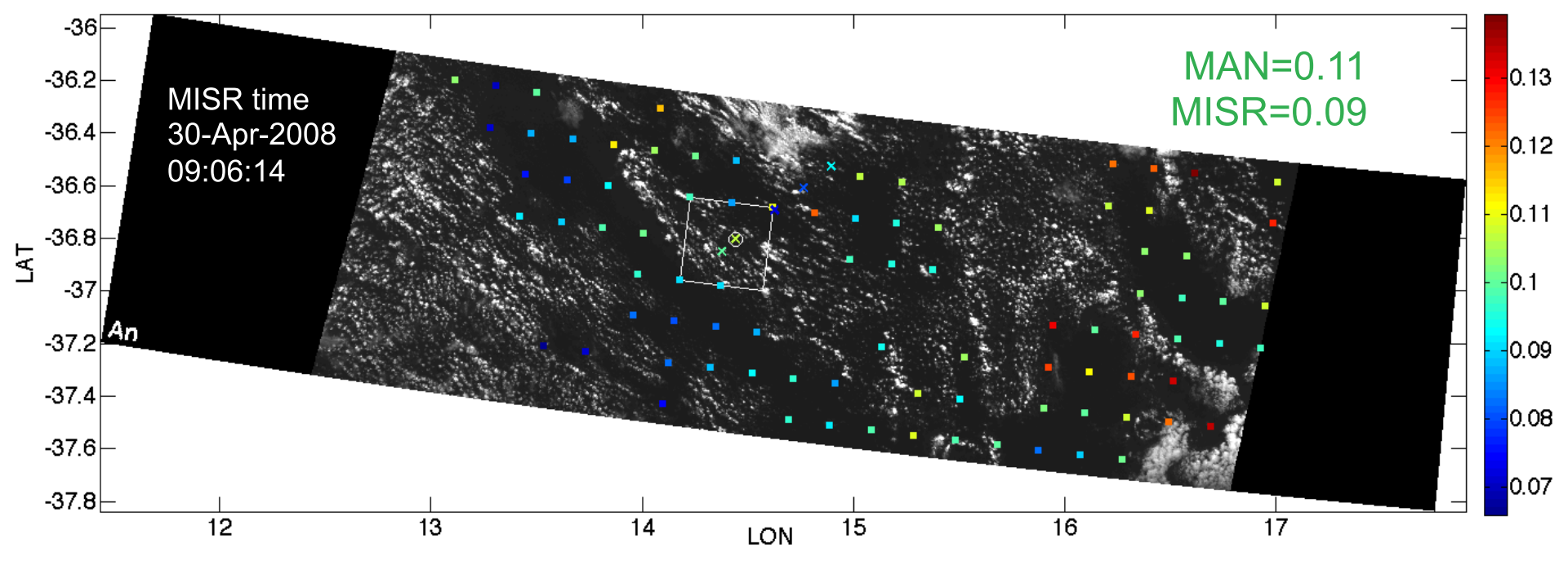
- all points
- **series**
- daily values

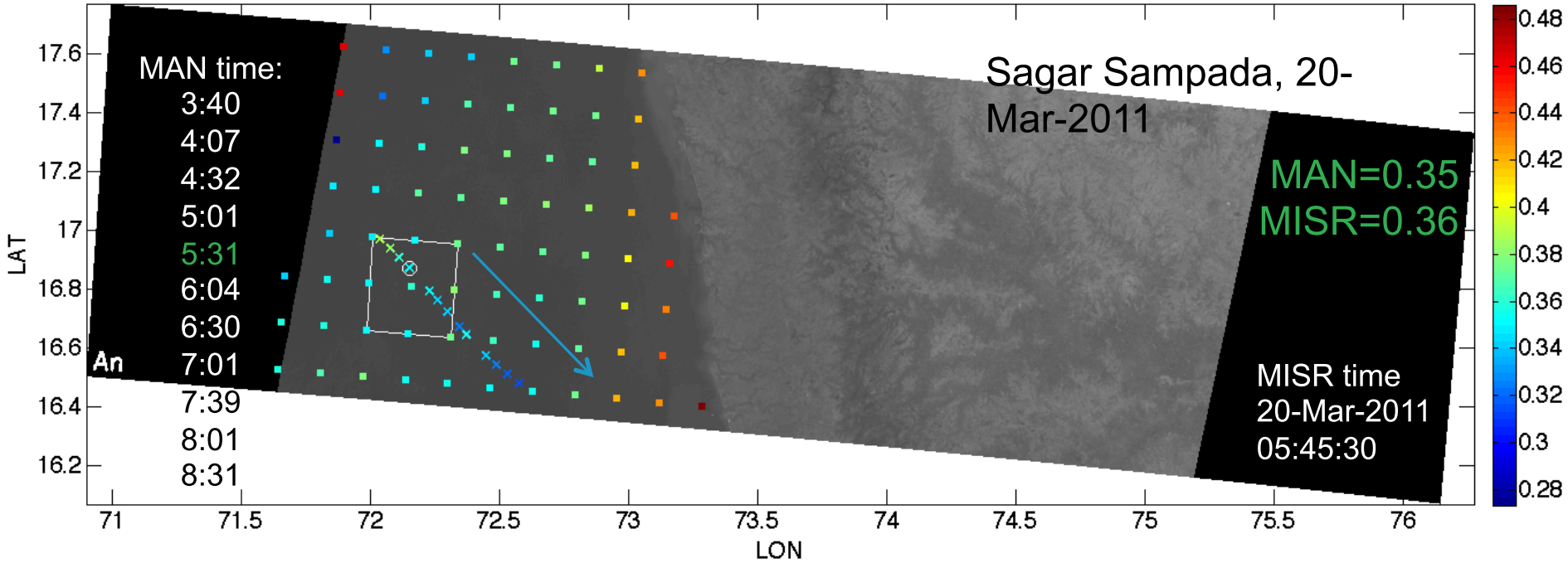


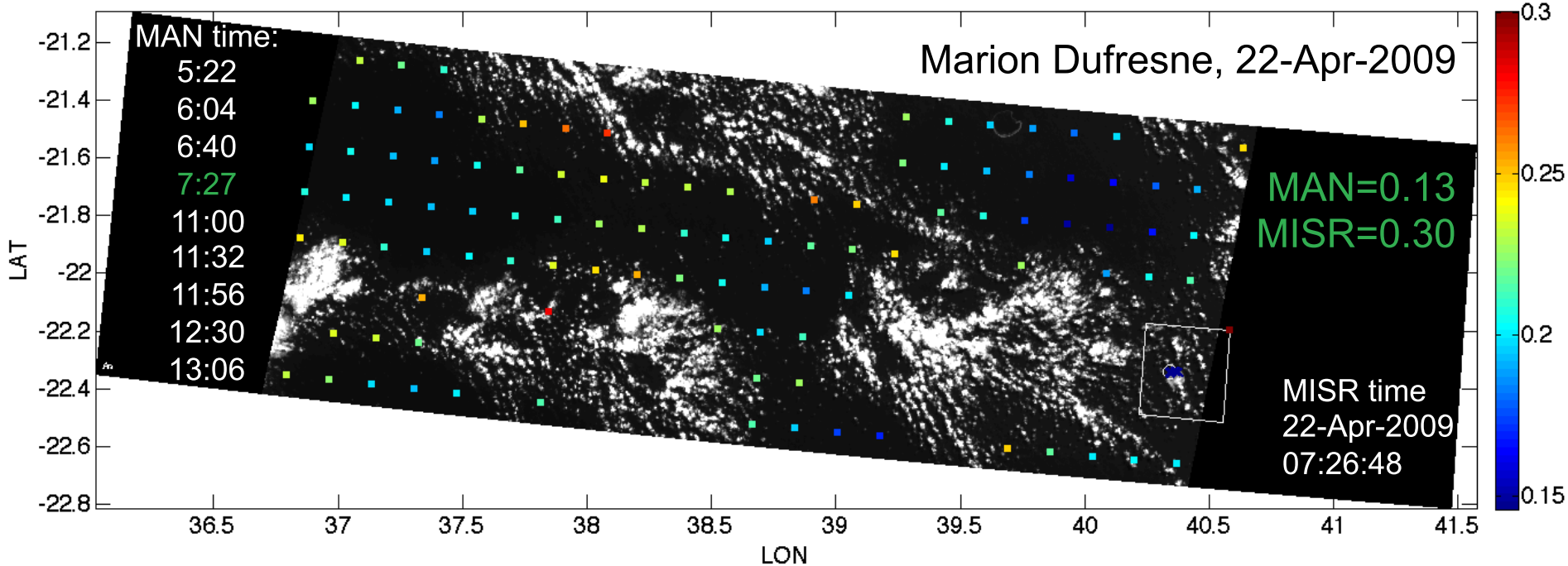
Collocation criteria

- Central point: closest MISR lat/lon region
- Central point not further than 17.6 × 3 km from MAN
- If central region NaN: average from 3x3 points
- Closest MAN time within ± 1h to MISR
- Exceptions made for MAN series separated by < 4h and having similar location (6 cases)
- MAN interpolated linearly in the log(AOD) vs. log(wavelength) space

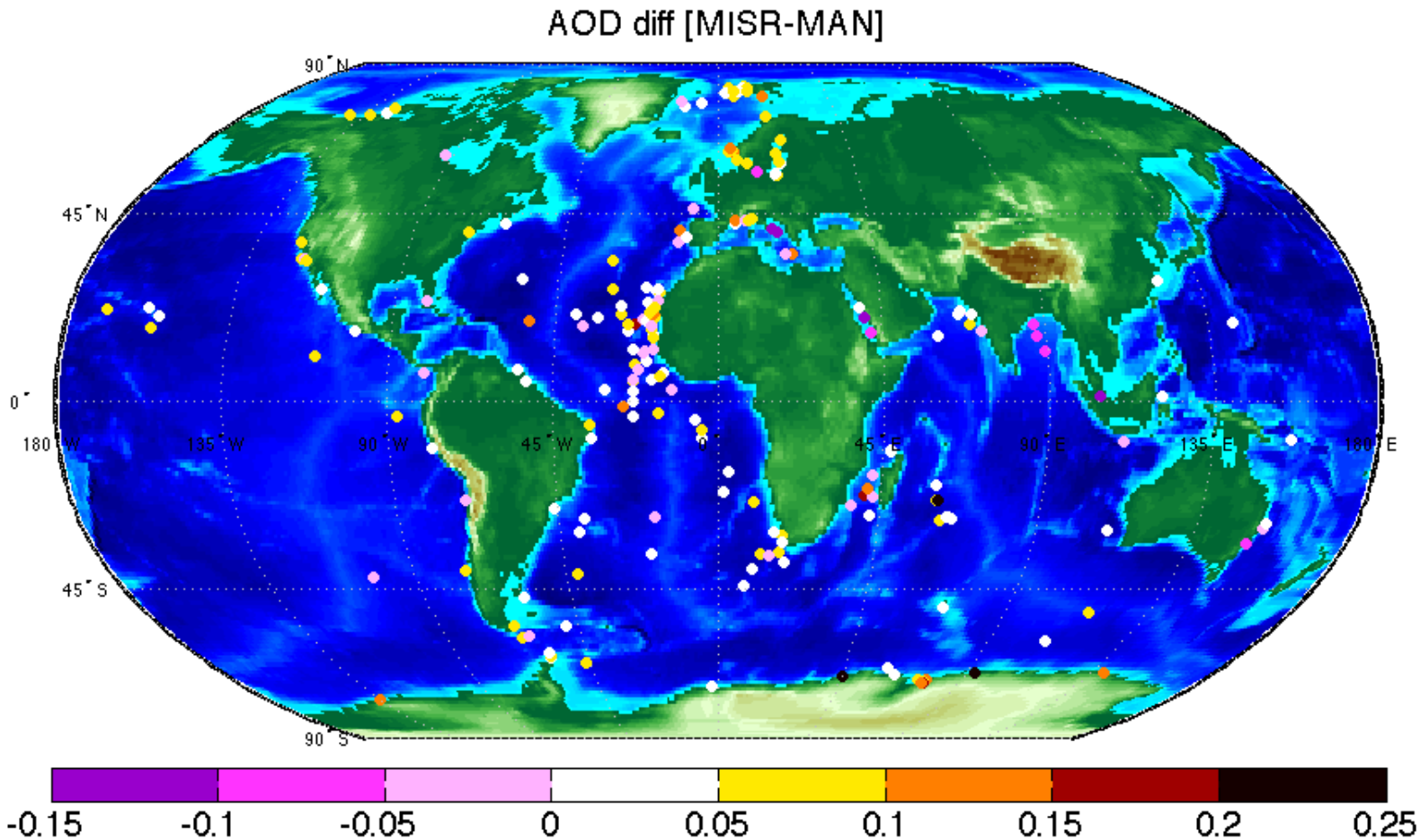

MAN time:
7:37
8:15
9:58
11:17
12:32
Ak Fedorov, 30-Apr-2008
An
~140 km
~380 km
LAT
LON
-36
-36.2
-36.4
-36.6
-36.8
-37
-37.2
-37.4
-37.6
-37.8
12
13
14
15
16
17
0.13
0.12
0.11
0.1
0.09
0.08
0.07


MISR time
30-Apr-2008
09:06:14
MAN=0.11
MISR=0.09
An
LAT
LON
-36
-36.2
-36.4
-36.6
-36.8
-37
-37.2
-37.4
-37.6
-37.8
12
13
14
15
16
17
0.13
0.12
0.11
0.1
0.09
0.08
0.07


Sagar Sampada, 20-Mar-2011
MAN time:
3:40
4:07
4:32
5:01
5:31
6:04
6:30
7:01
7:39
8:01
8:31
MAN=0.35
MISR=0.36
MISR time
20-Mar-2011
05:45:30
LAT
LON
17.6
17.4
17.2
17
16.8
16.6
16.4
16.2
71
71.5
72
72.5
73
73.5
74
74.5
75
75.5
76
0.48
0.46
0.44
0.42
0.4
0.38
0.36
0.34
0.32
0.3
0.28


Marion Dufresne, 22-Apr-2009
MAN time:
5:22
6:04
6:40
7:27
11:00
11:32
11:56
12:30
13:06
MAN=0.13
MISR=0.30
MISR time
22-Apr-2009
07:26:48
LAT
LON
-21.2
-21.4
-21.6
-21.8
-22
-22.2
-22.4
-22.6
-22.8
36.5
37
37.5
38
38.5
39
39.5
40
40.5
41
41.5
0.3
0.25
0.2
0.15

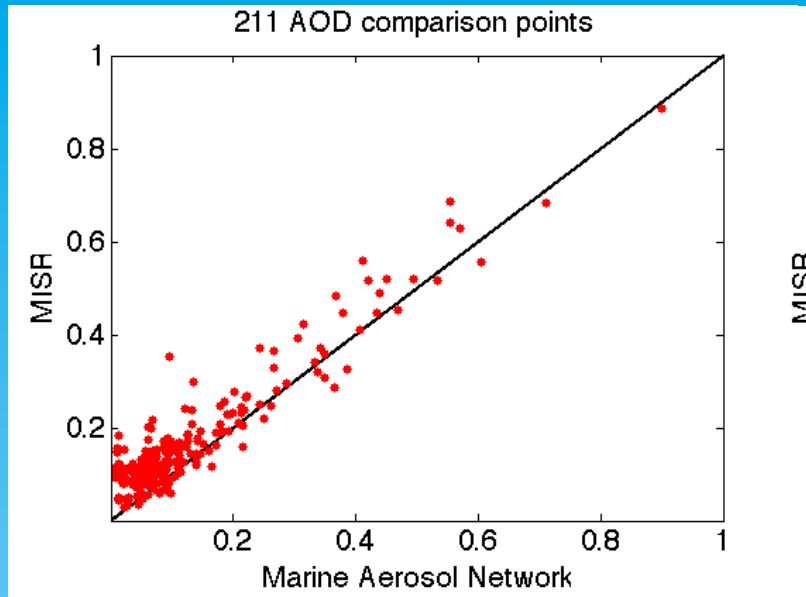
211 MISR-MAN comparison points

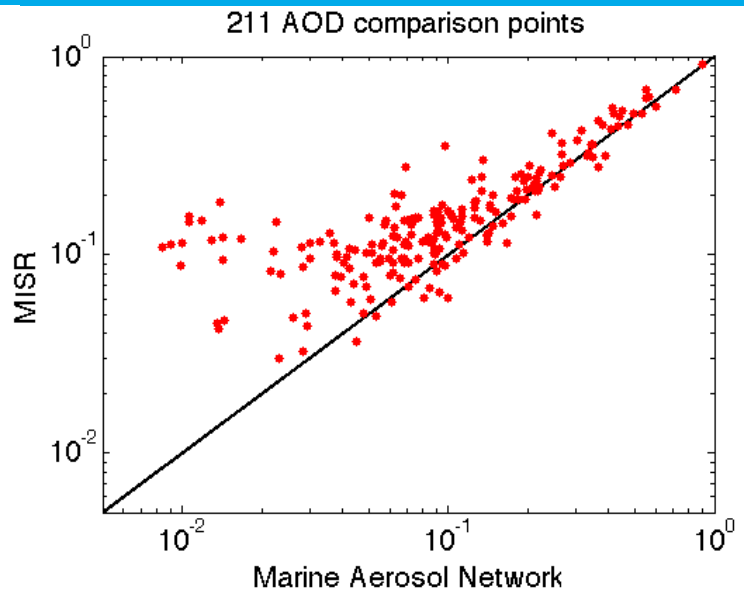


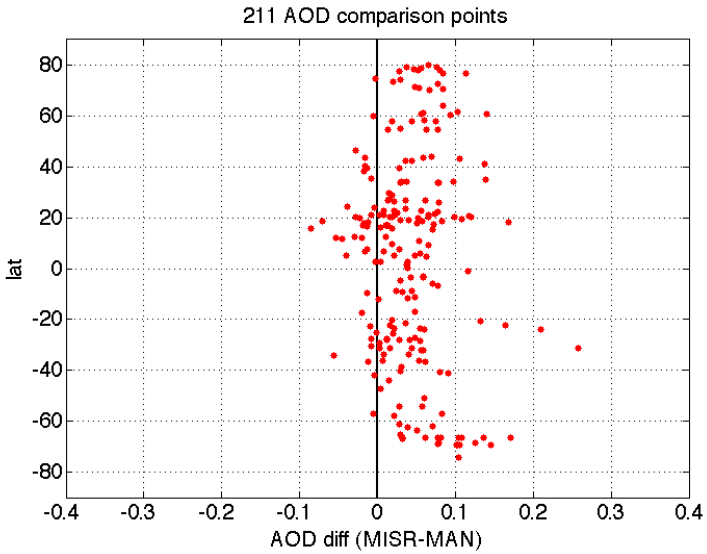
Average difference: 0.043 RMSE = 0.064

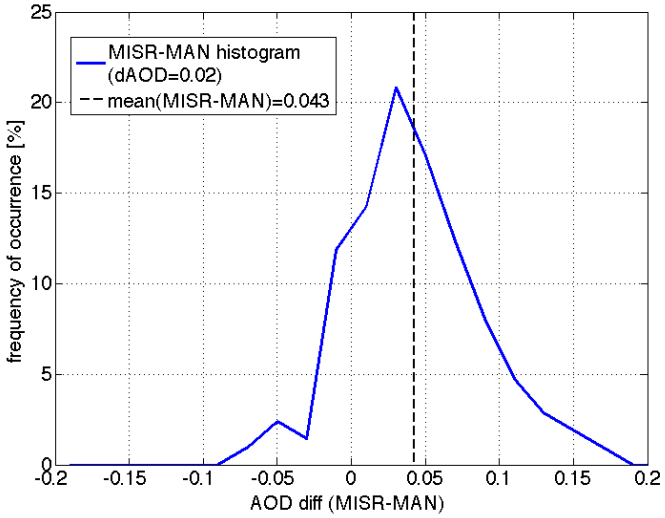
Acceptable difference ~0.02 ?

Investigating MISR-MAN biases





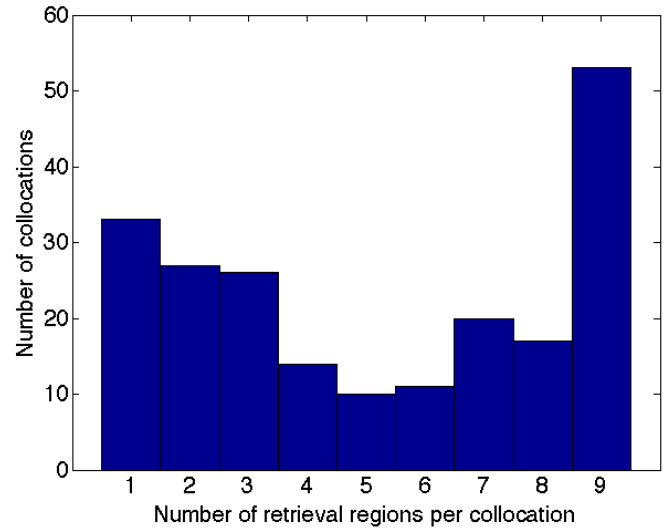


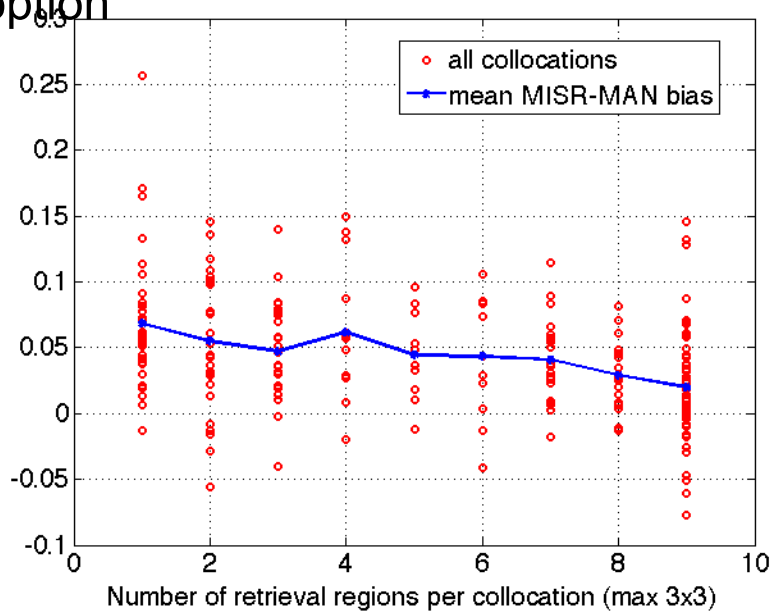


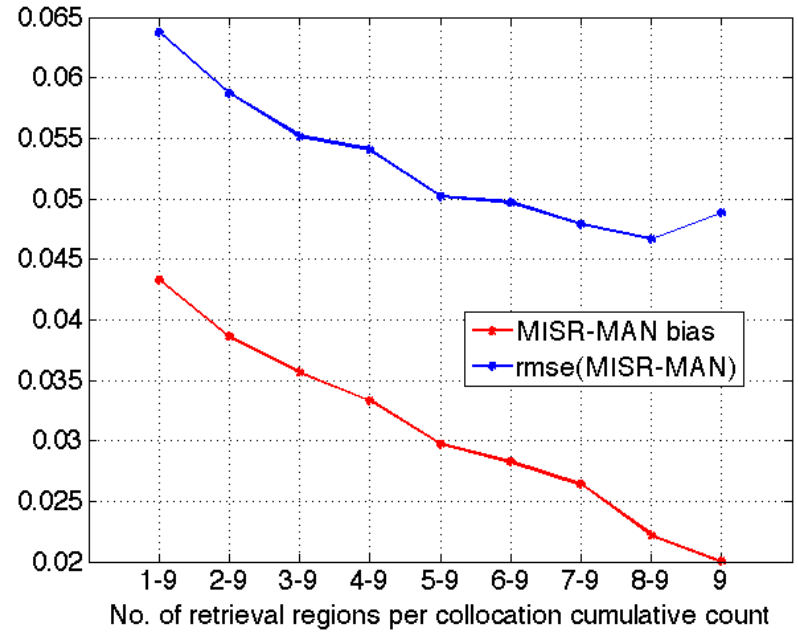
MISR-MAN differences depend on the number of successful retrievals within the 3 × 3 collocation area

The more retrievals the cleaner and less cloudy the scene

In the end we want to characterize each region and cloud fraction seems a good option



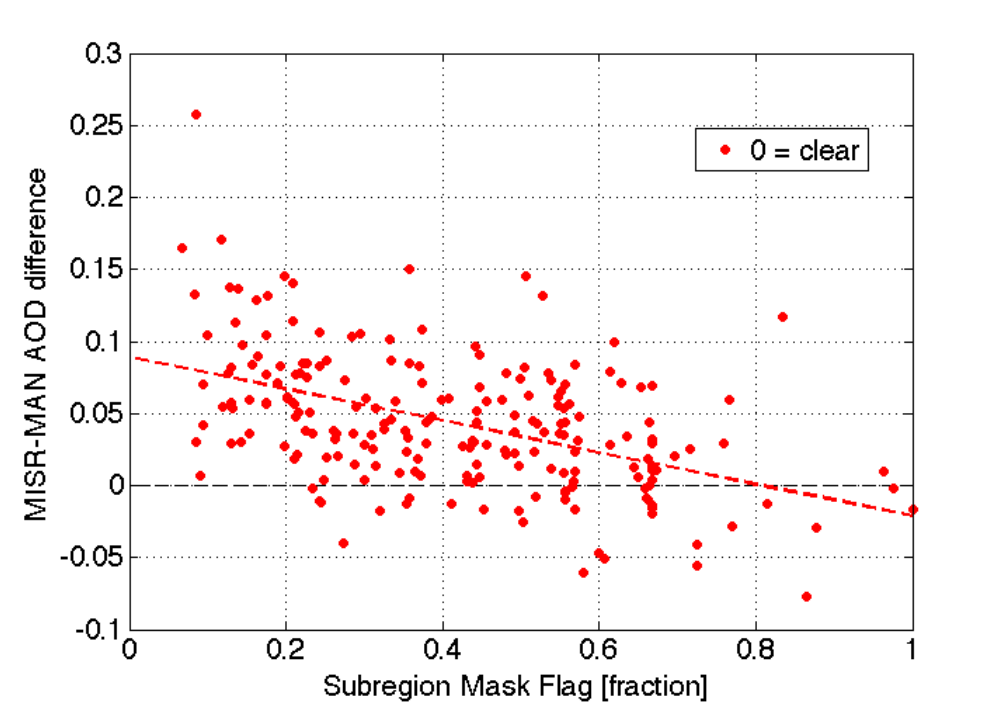




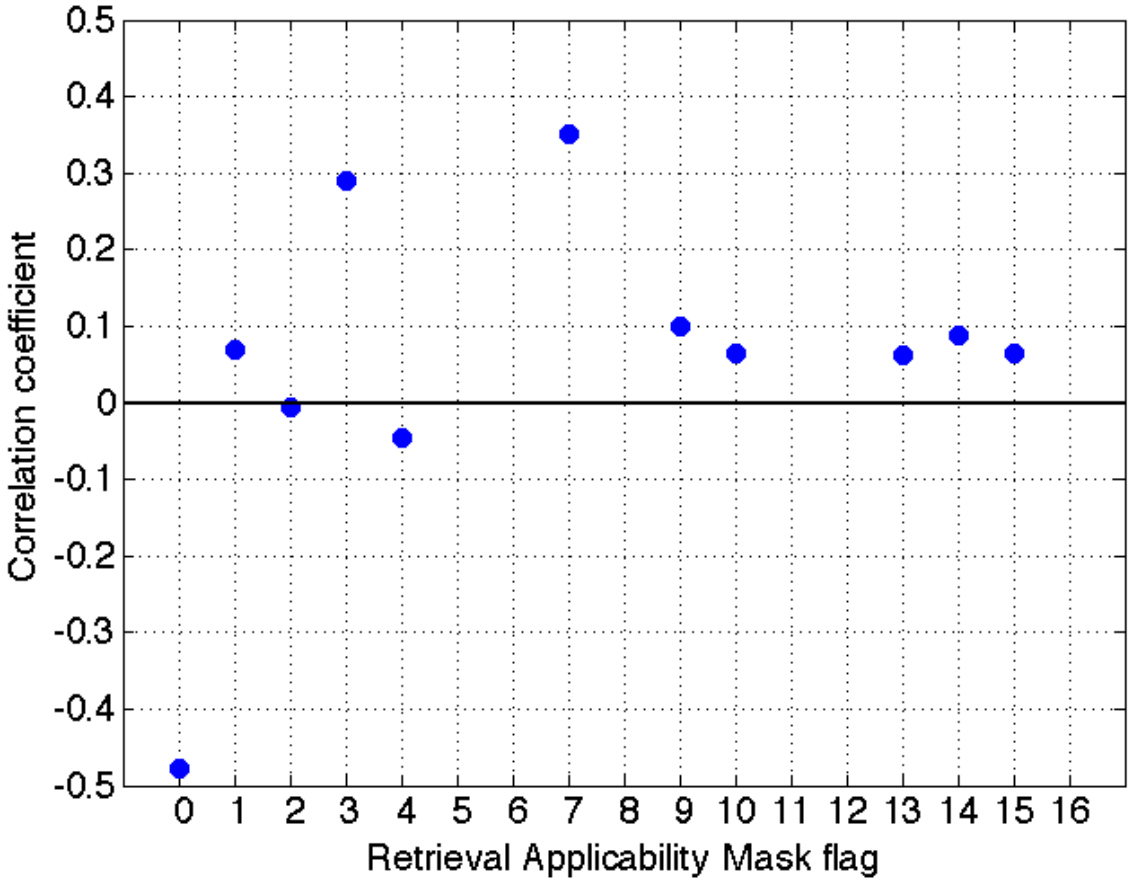
Region characteristics in MISR retrievals: Retrieval Applicability Mask

0 = clear
1 = missing data
2 = poor quality
3 = glitter-contaminated
4 = topo. obscured
5 = topo. shadowed
6 = topo. complex
7 = cloudy
8 = cloud shadow
9 = not smooth
10 = not correlated
11 = region not suitable
12 = -
13 = too bright
14 = cloudy other camera
15 = bright other camera
16 = -

Each region contains 16×16 subregions, each subregion is seen by 9 cameras: 16×16×9 = 2304 retrieval applicability masks



Correlation between different retrieval masks and MISR-MAN differences



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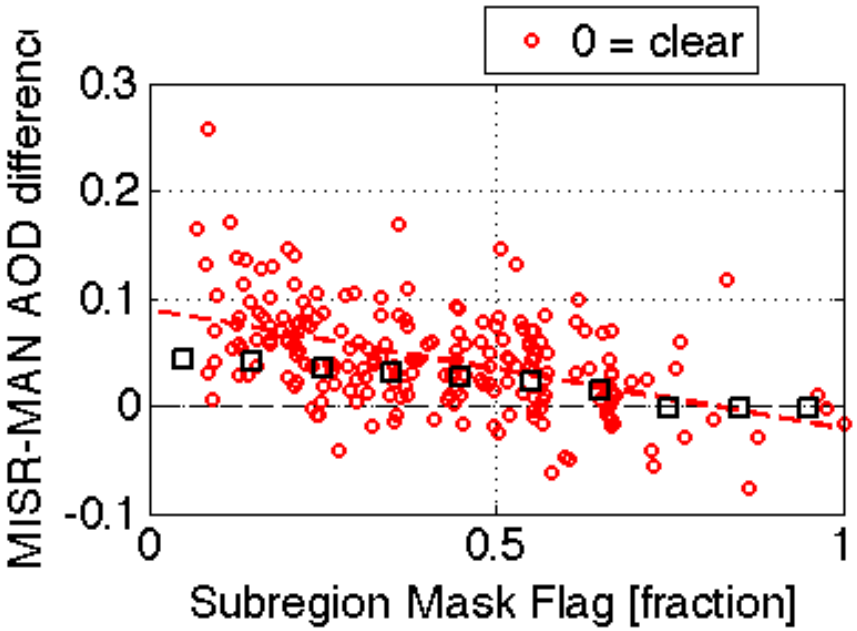
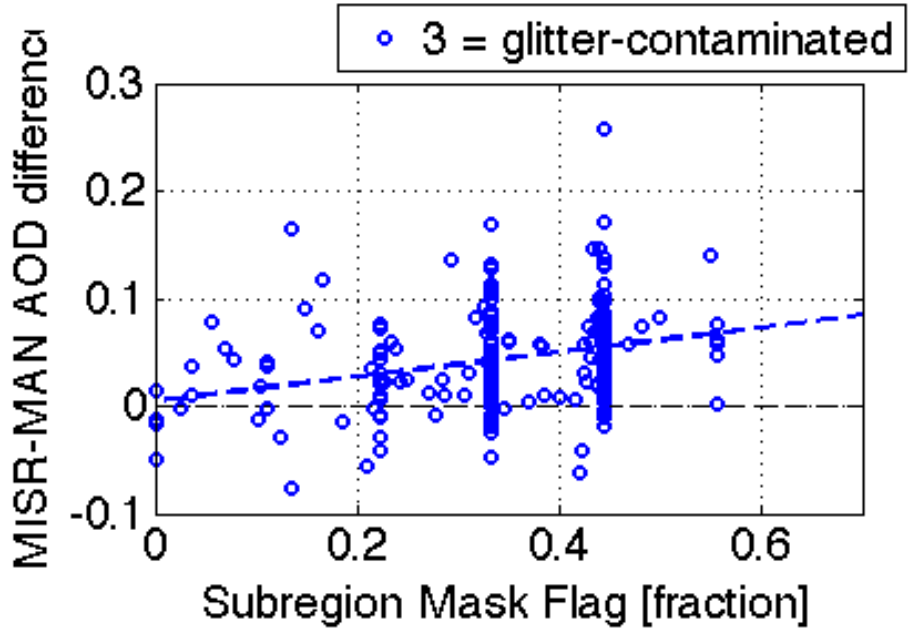
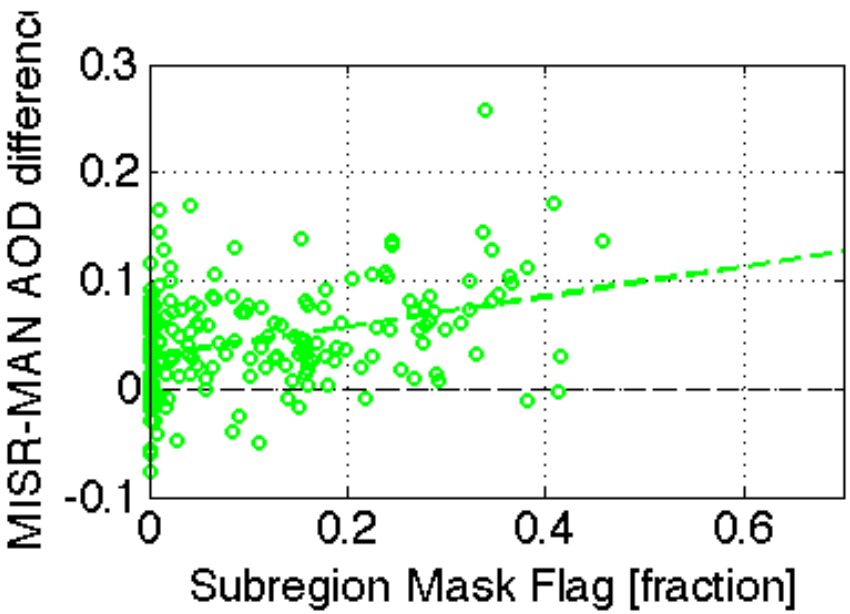
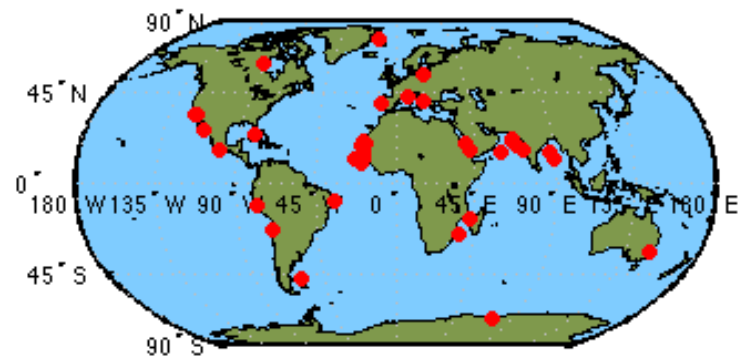
16 = -

Best correlation with clear mask fraction, then cloudy, then glitter contaminated







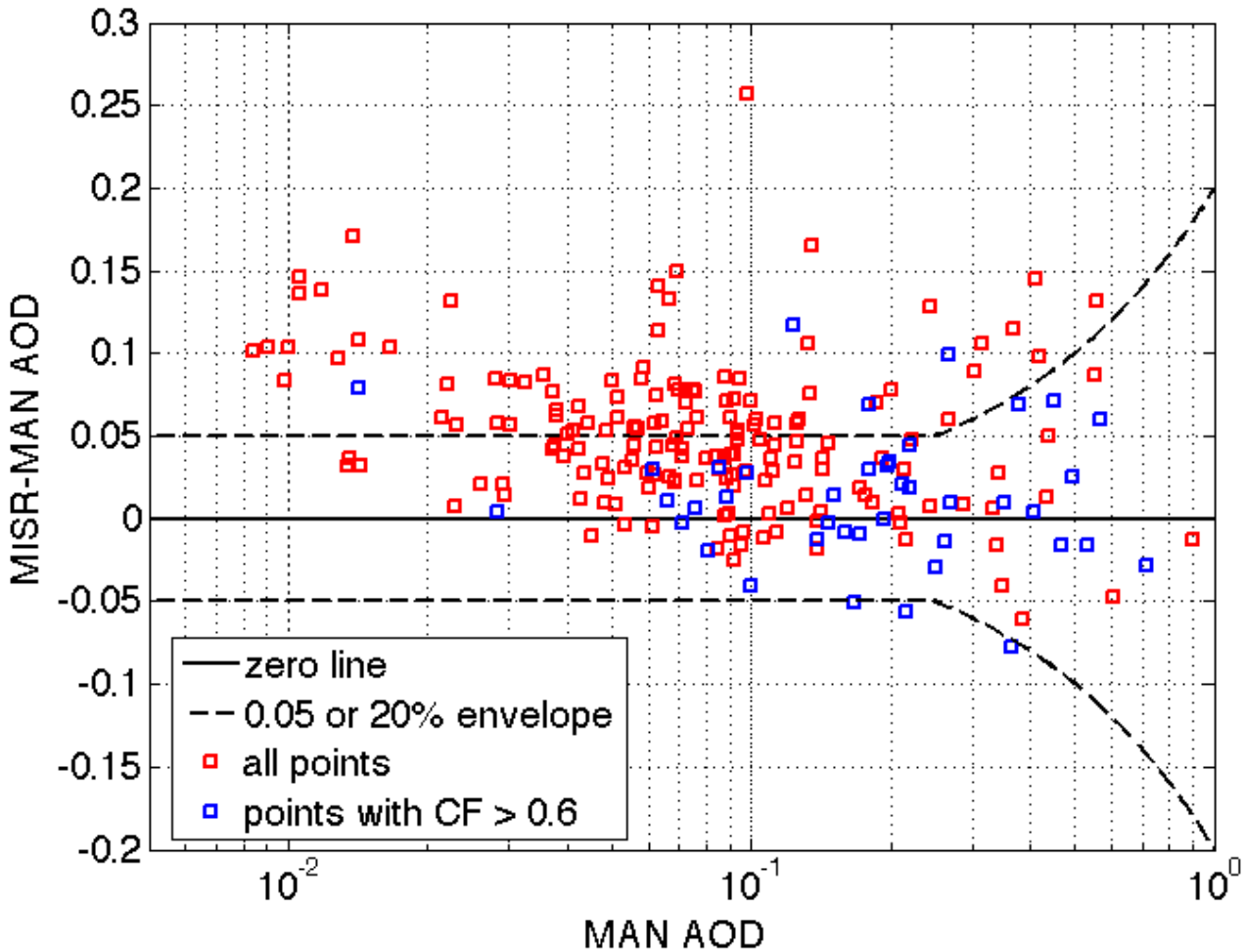


7 = cloudy

Red dots:
clear fraction > 0.6
MISR-MAN bias = 0.0135
number of points: 41

We reduce the bias, but also exclude many comparison points (41 out of 211)

Low statistics makes the analysis less reliable



Marine AERONET vs. MISR comparison

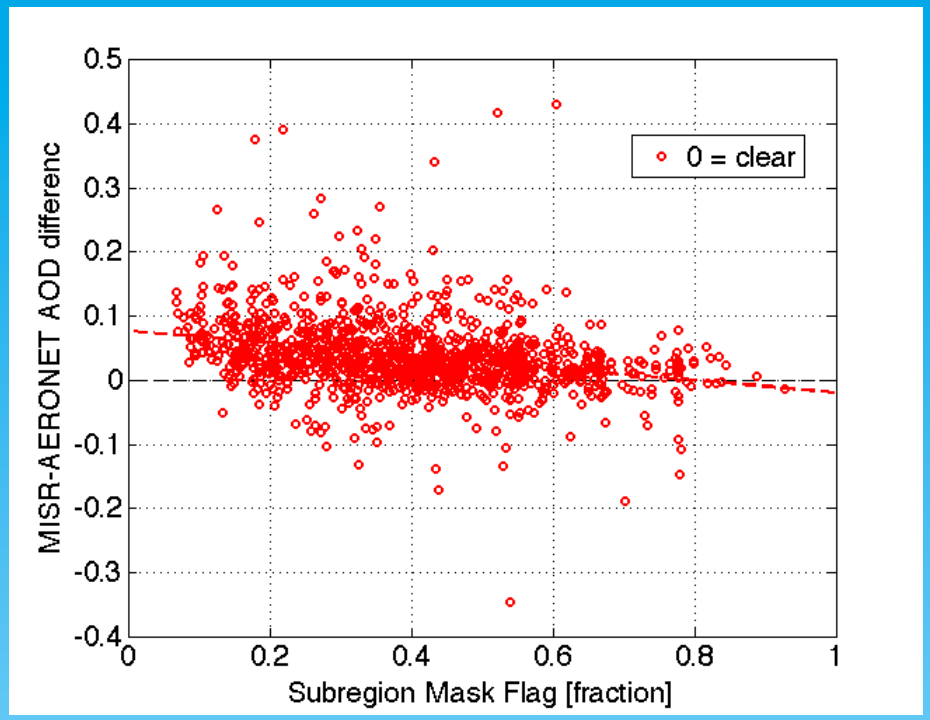
19 maritime Aeronet stations

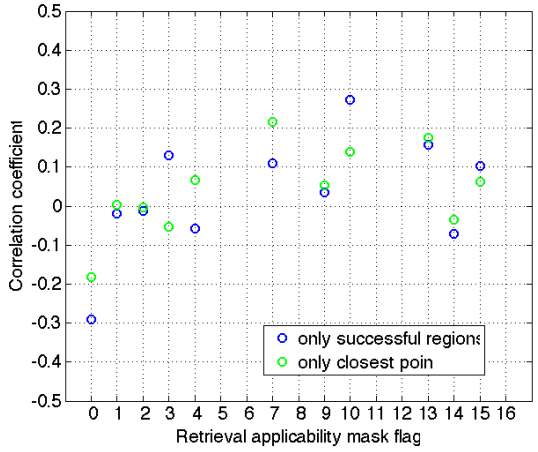
1195 collocated points

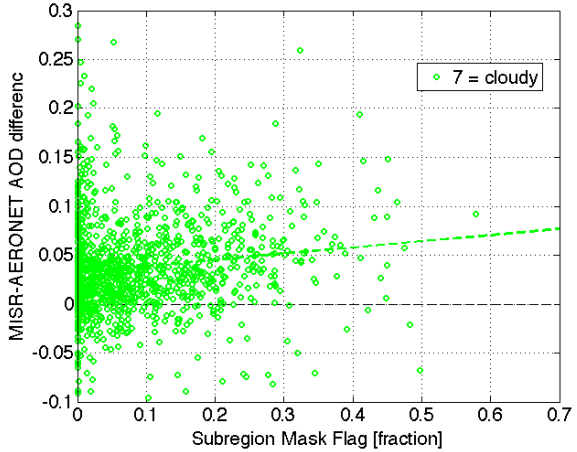
370 collocated points with only central

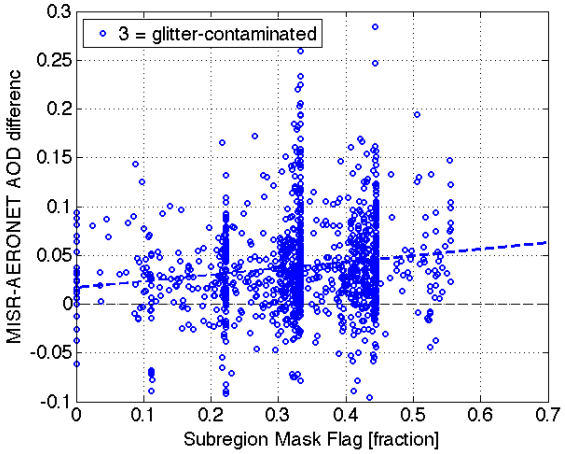
(the closest) MISR retrieval

- Correlations generally below 0.3
- Trends similar to MAN data
- Clear mask fraction seems good for correcting biases





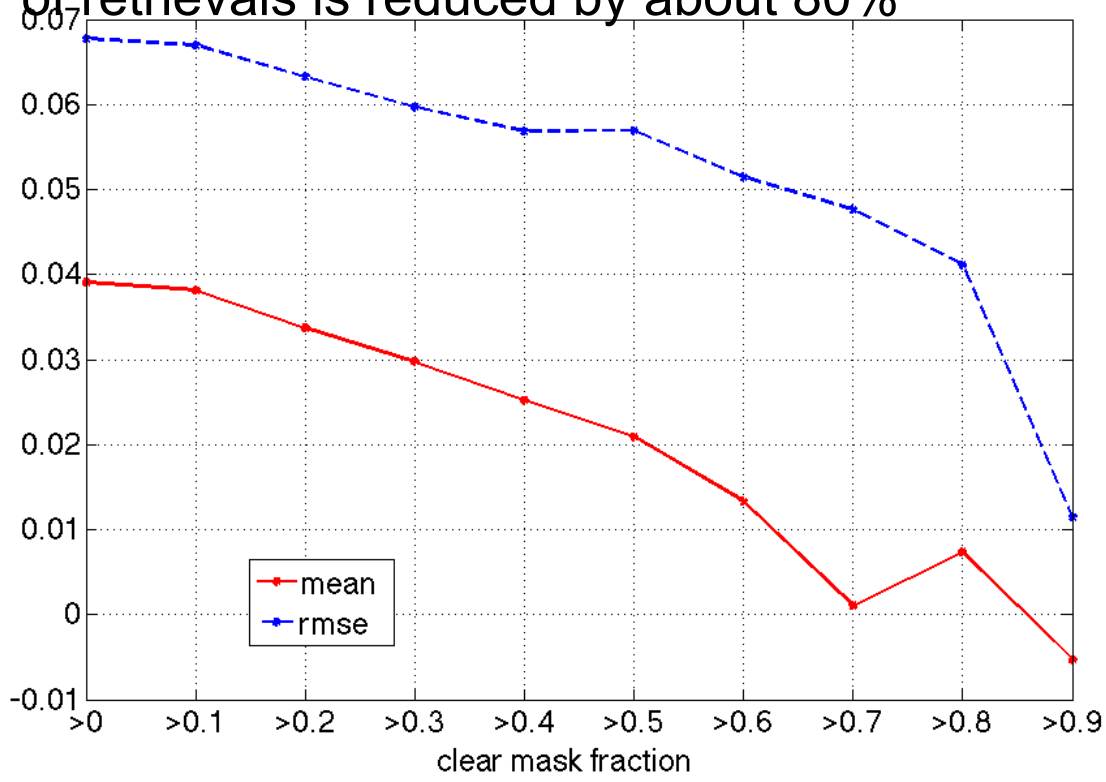




- Combined MAN and Aeronet comparison points (~1400)
- Selecting clear mask fraction > 0.6 reduces the bias from 0.04 to 0.013
- Root mean square error is reduced by almost 0.02, to 0.05
- However, the number of retrievals is reduced by about 80%

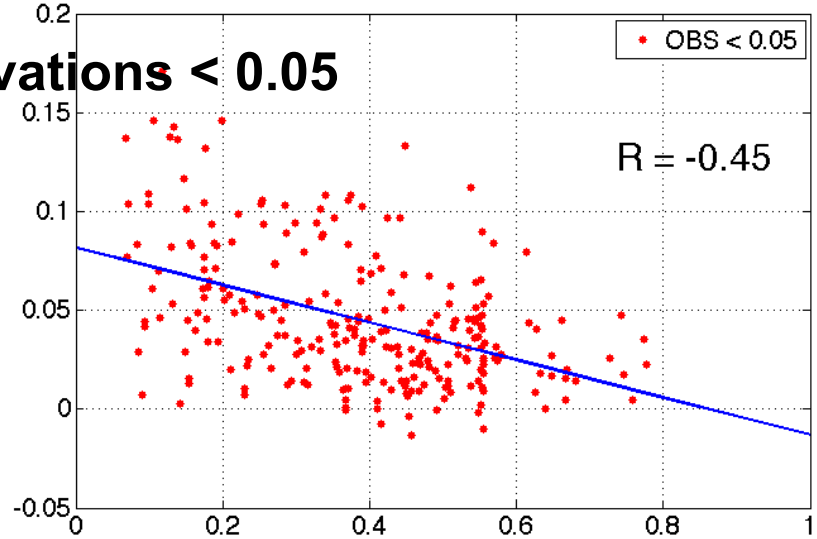
Question:

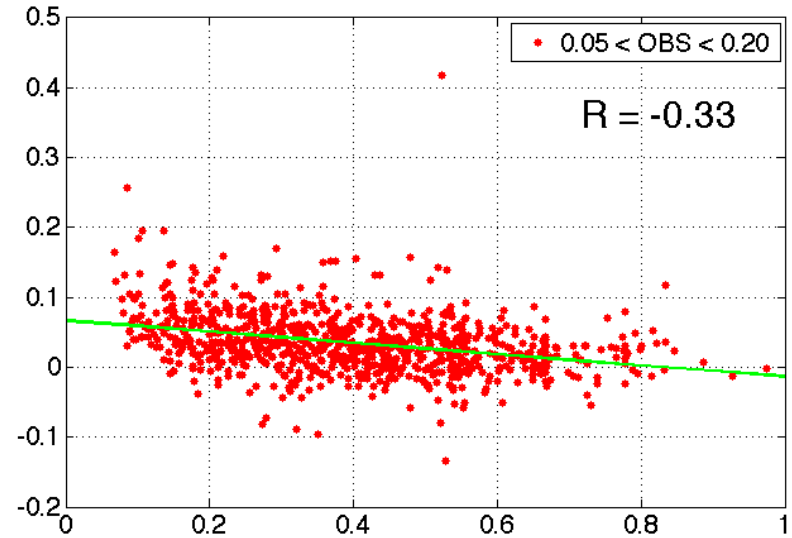
Do we see bias reduction in low AOD scenarios?

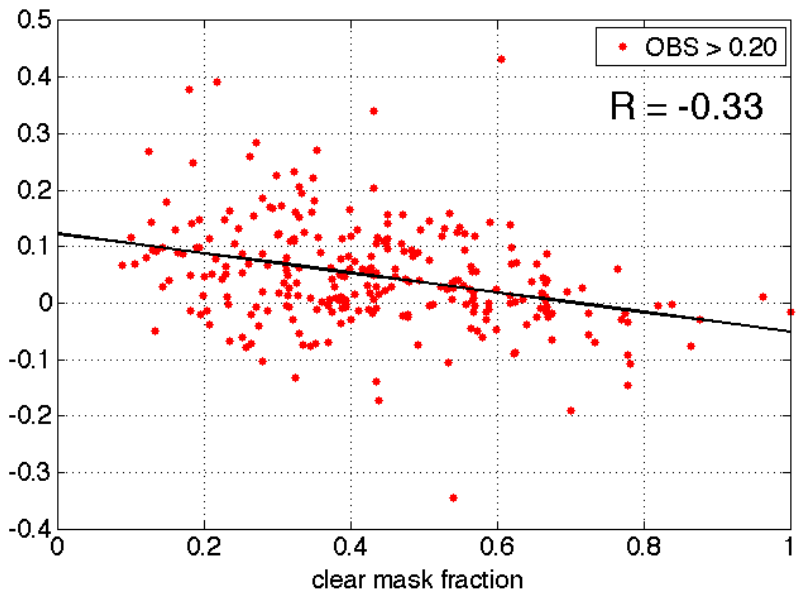


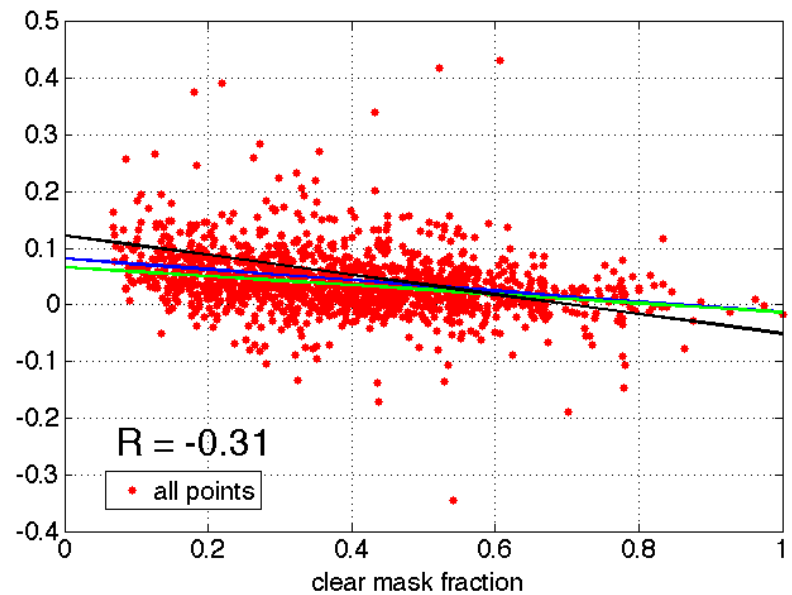
Observations > 0.05 & < 0.2

Observations < 0.05









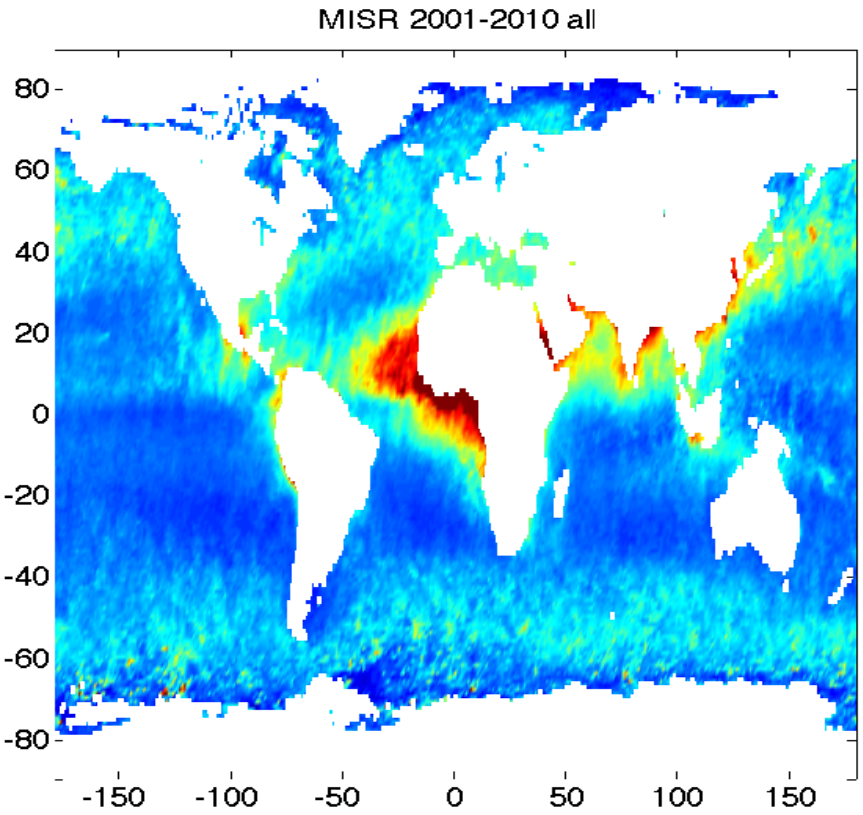
Observations > 0.2

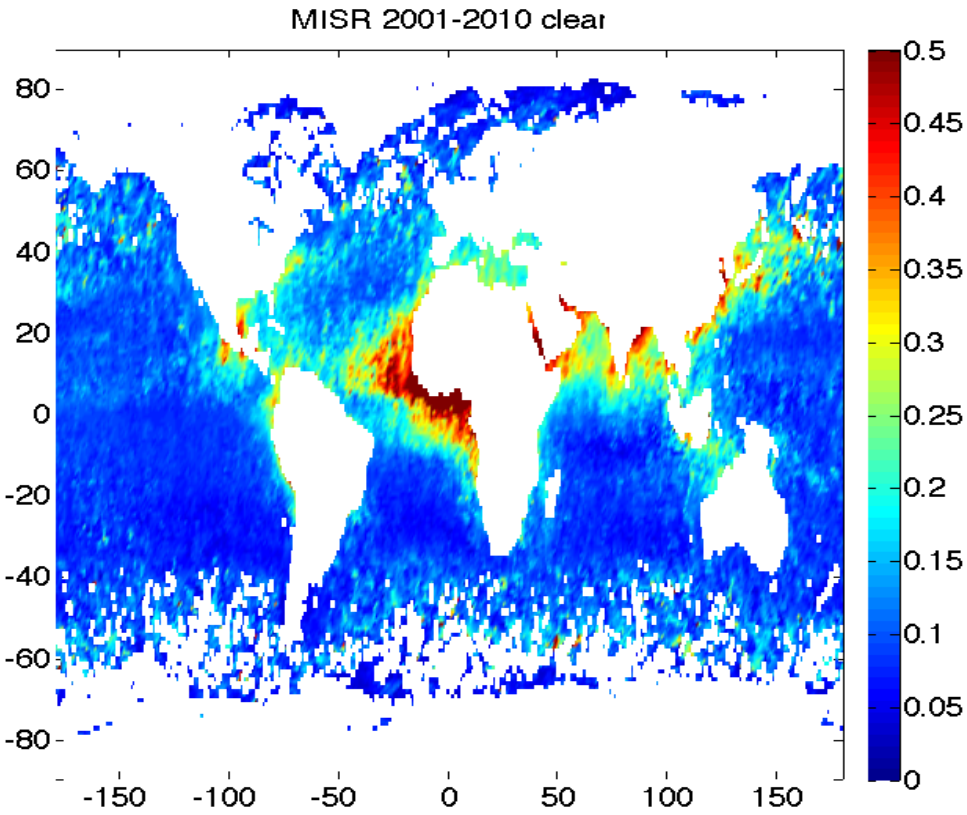
All points

11 year of MISR retrievals

Original V22 product

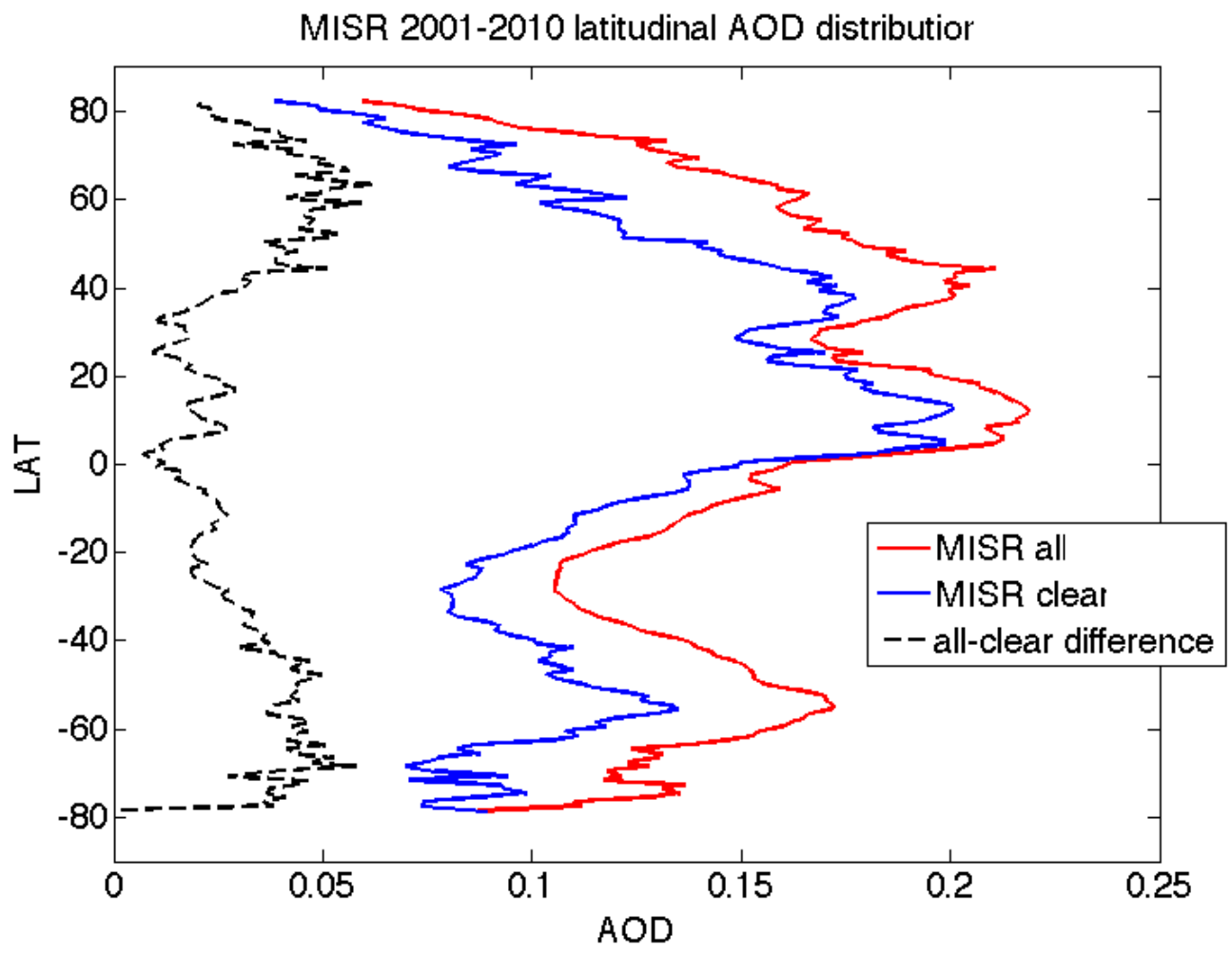
V22 product with clear mask fraction > 0.6



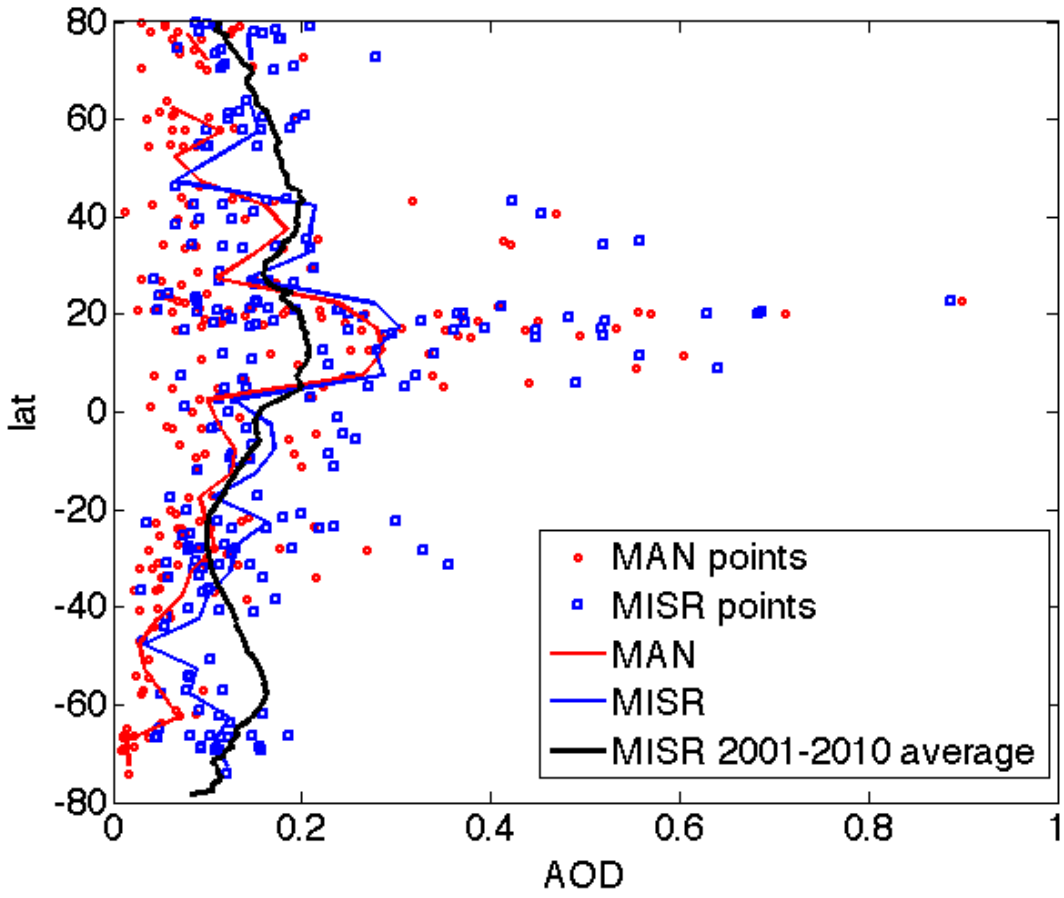


“clear” – only regions with the clear mask fraction higher than 0.6

- The multiyear global average AOD is lower by 0.03
- Even after reducing MISR biases the 55°S AOD maximum is still present



Collocated MISR-MAN points over the Southern Ocean suggest MAN might be favoring lower AOD conditions



Summary

- MISR AOD retrievals are collocated with MAN and Aeronet observations (~200 and ~1200 points, respectively)
- MISR errors are inversely correlated with the clearness of retrieval region
- Error and bias corrections work for all AOD ranges
- Setting the clear mask fraction > 0.6 reduces the total average AOD by ~0.03
- MISR suggests there is still a local AOD maximum over the Southern Ocean

- Correction procedures eliminate too many valid retrievals
- Other retrieval issues are still evident and need to be corrected for