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Updated MISR over-water research aerosol retrieval algorithm – Part 2: A multi-angle aerosol retrieval algorithm for shallow, turbid, oligotrophic, and eutrophic waters

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Supplement

Here we include several additional figures to provide further demonstration of the upgraded MISR RA retrieval quality under variable aerosol loading and ocean surface conditions. Because the RA uses all four MISR bands for the aerosol/surface retrieval, the ocean color must be discernable in at least two MISR bands (in at least one glint-free camera) for any possibility of valid surface/atmosphere separation. Therefore, the RA AOD upper-limit is highly dependent on aerosol size, as smaller particles tend to produce much lower extinction in the red and NIR than at shorter wavelengths, whereas larger particles (such as dust) tend to have more spectrally neutral extinction.

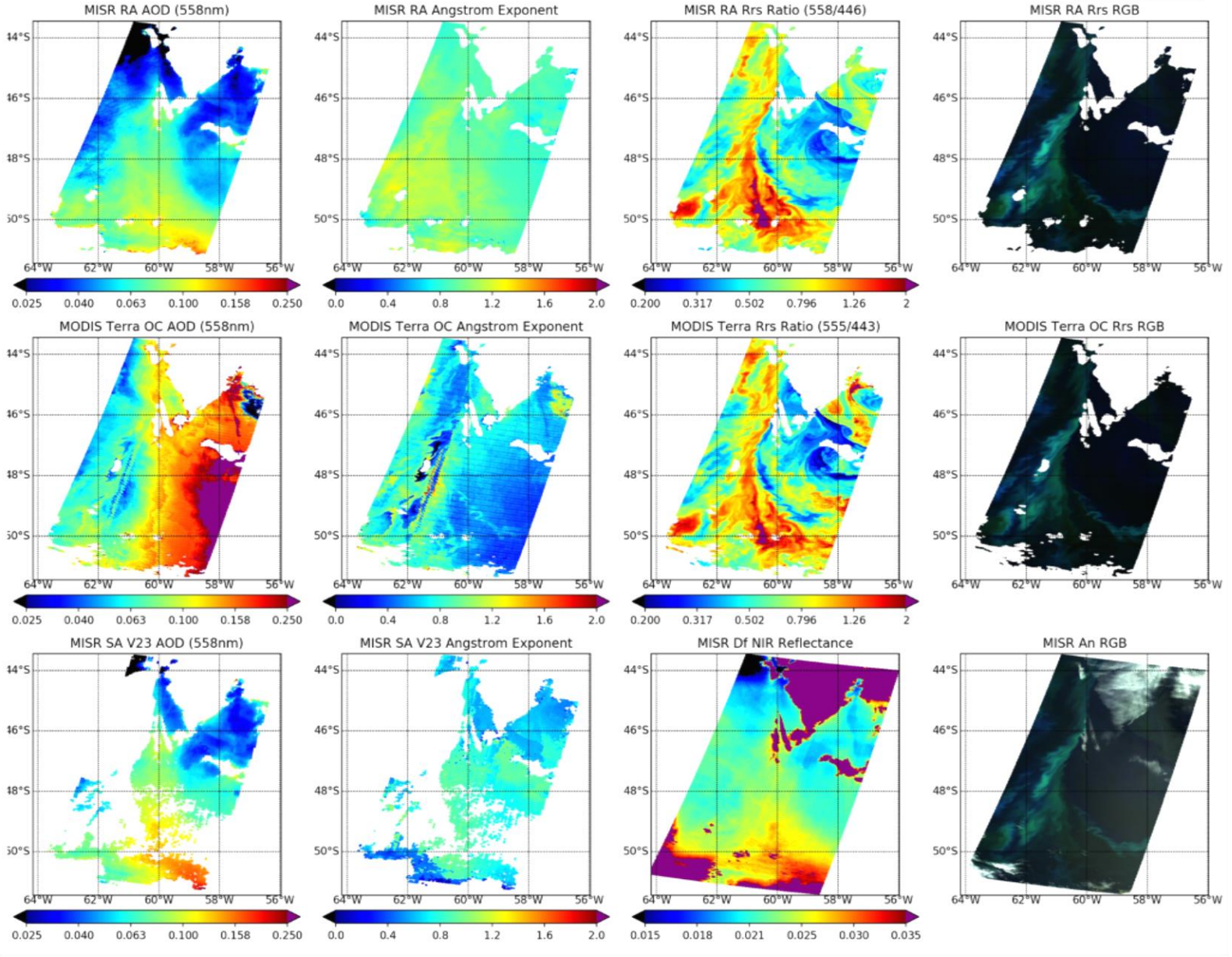
Figure S1 compares results from the MISR Research Algorithm (RA), MODIS Terra Ocean Color (OC) product, and the MISR Standard Algorithm (SA), for a region of high biological productivity in the East Argentine Sea. The MISR SA has no high-quality aerosol retrievals over the bloom, but the SA-retrieved AOD and ANG agree well with the RA in the less productive portions of the scene. Comparing ocean surface reflectance (R_{rs}) green/blue ratios, the MISR RA and MODIS agree remarkably well with each other, especially considering the differences in the retrieved AOD and ANG. This difference is likely caused by sun-glint (clearly seen in the MISR nadir-camera (An) RGB image), which was not screened out by the level-2 data quality flags (level-3 would likely flag this case). Not only do the MISR RA and MODIS OC R_{rs} ratios agree well, but the R_{rs} RGB images look nearly identical. This is impressive, given the amount of glint in the scene, and is indicative of the substantial effort put into the MODIS OC algorithm.

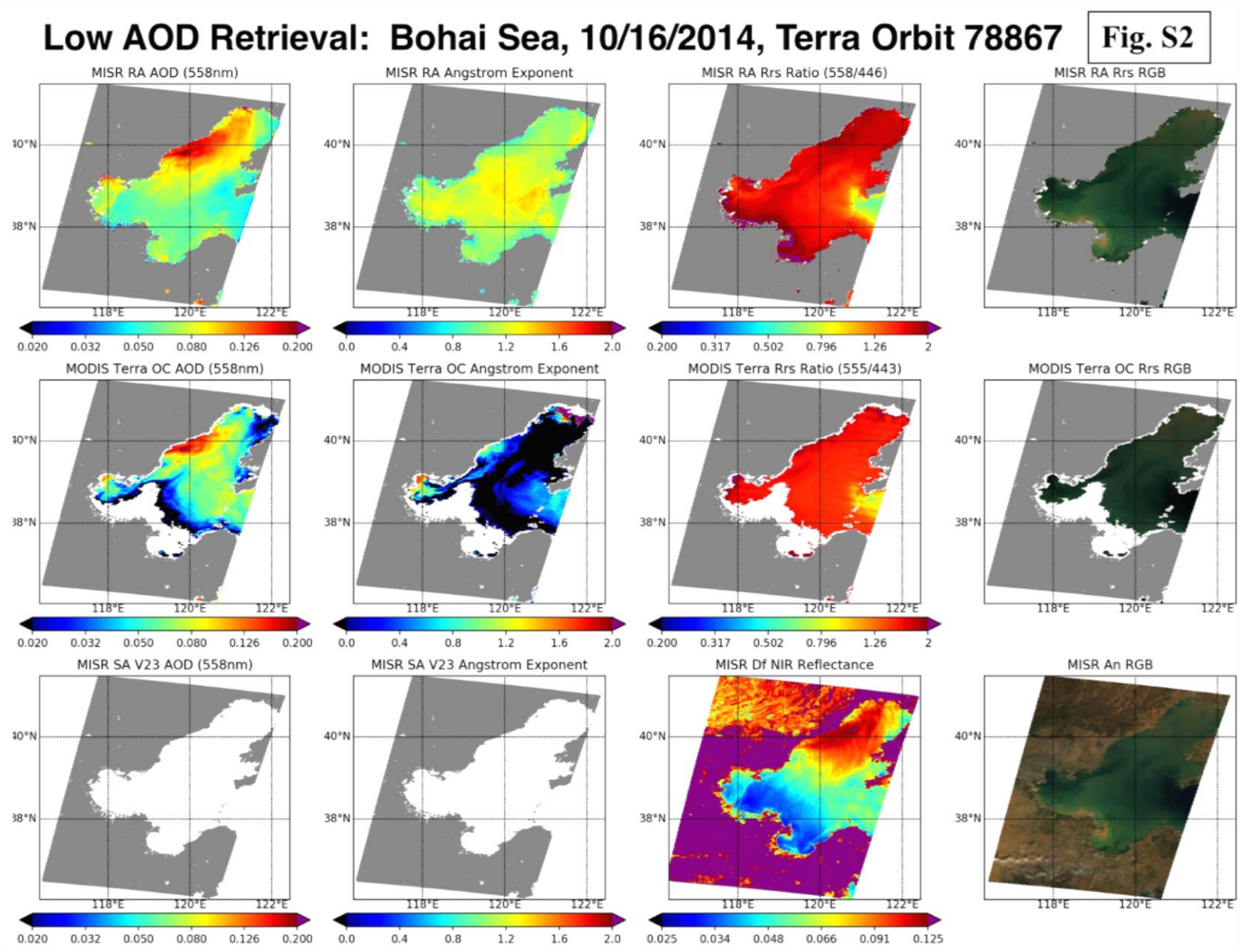
Figures S2-S6 demonstrate MISR aerosol/R_{rs} retrievals over the Bohai Sea east of Beijing China, under varying levels of aerosol loading. This is a region where the MISR SA does not typically provide coverage, as the water is both shallow and generally turbid. Because these figures all correspond to the winter months in the Northern Hemisphere, the MISR Df (70.5° forward-viewing) camera observes scattering angles well under 90°, greatly enhancing that camera's sensitivity to retrieved AOD and aerosol type.

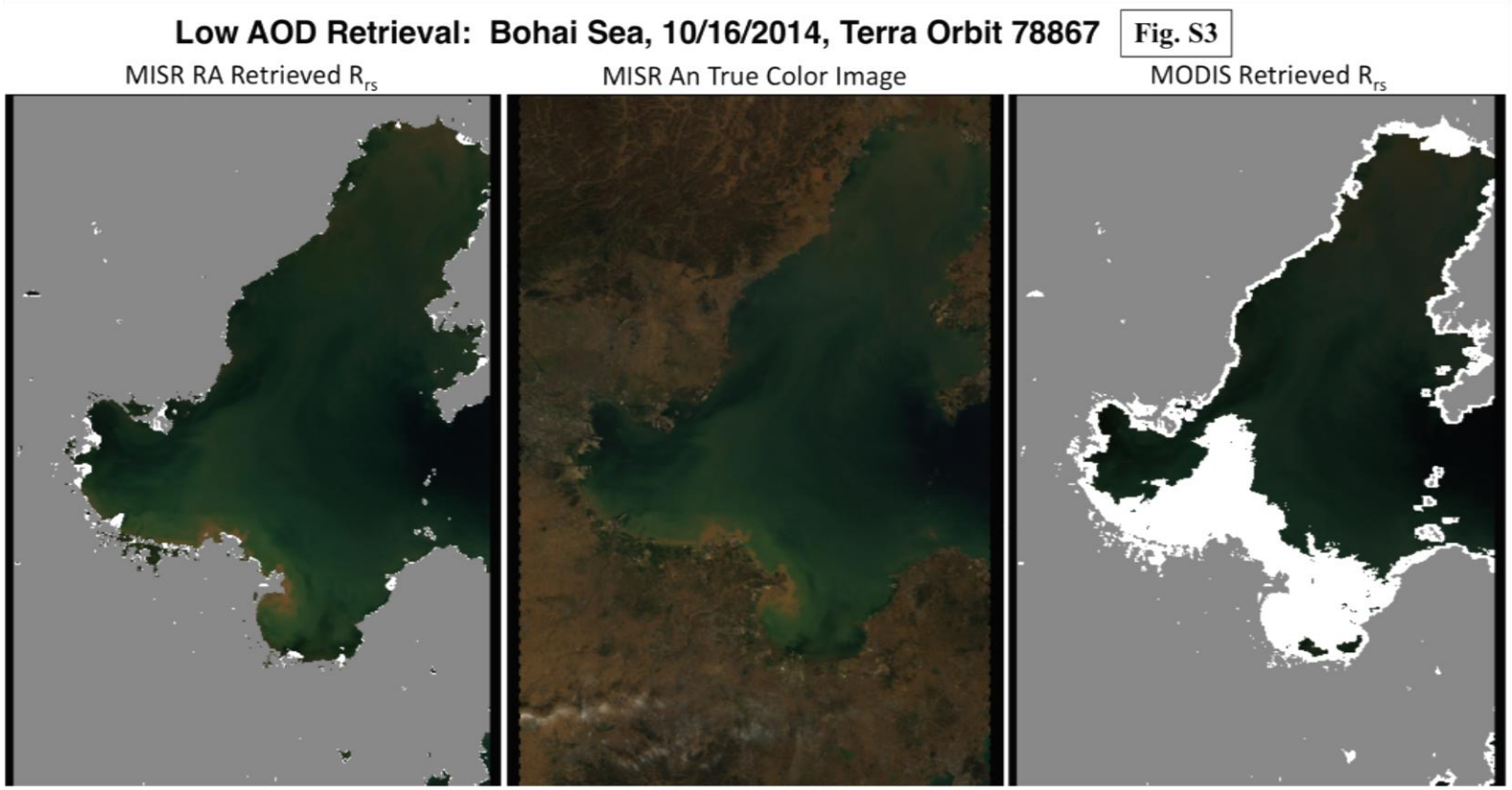
Figures S2 and S3 compare MISR RA retrievals to MODIS OC retrievals over the Bohai Sea on a day when the aerosol loading was quite low. MISR-retrieved AOD agrees well with MODIS AOD, and MISR retrieved ocean-color agrees well with MODIS retrieved ocean-color, even though MISR and MODIS show stark discrepancies in retrieved ANG. Figure S4 shows results from the MISR RA during a time of moderate aerosol loading (retrieved 558 nm AOD reaches ~ 0.5), and Figure S5 shows results when aerosol loading is high. Although not surprising, the quality of retrieved R_{rs} diminishes with increasing AOD; Figure S5 clearly shows some aliasing of the atmospheric signal into the retrieved surface reflectance, including what appear to be gravity waves. However, the MISR RA still reproduces both the general color of the surface (seen on the left side of S6) and retrieved aerosol loading spatially consistent with MISR observations from the Df NIR channel (Figure S5).

Bloom: East Argentine Sea, 10/16/2014, Terra Orbit 37079

Fig. S1

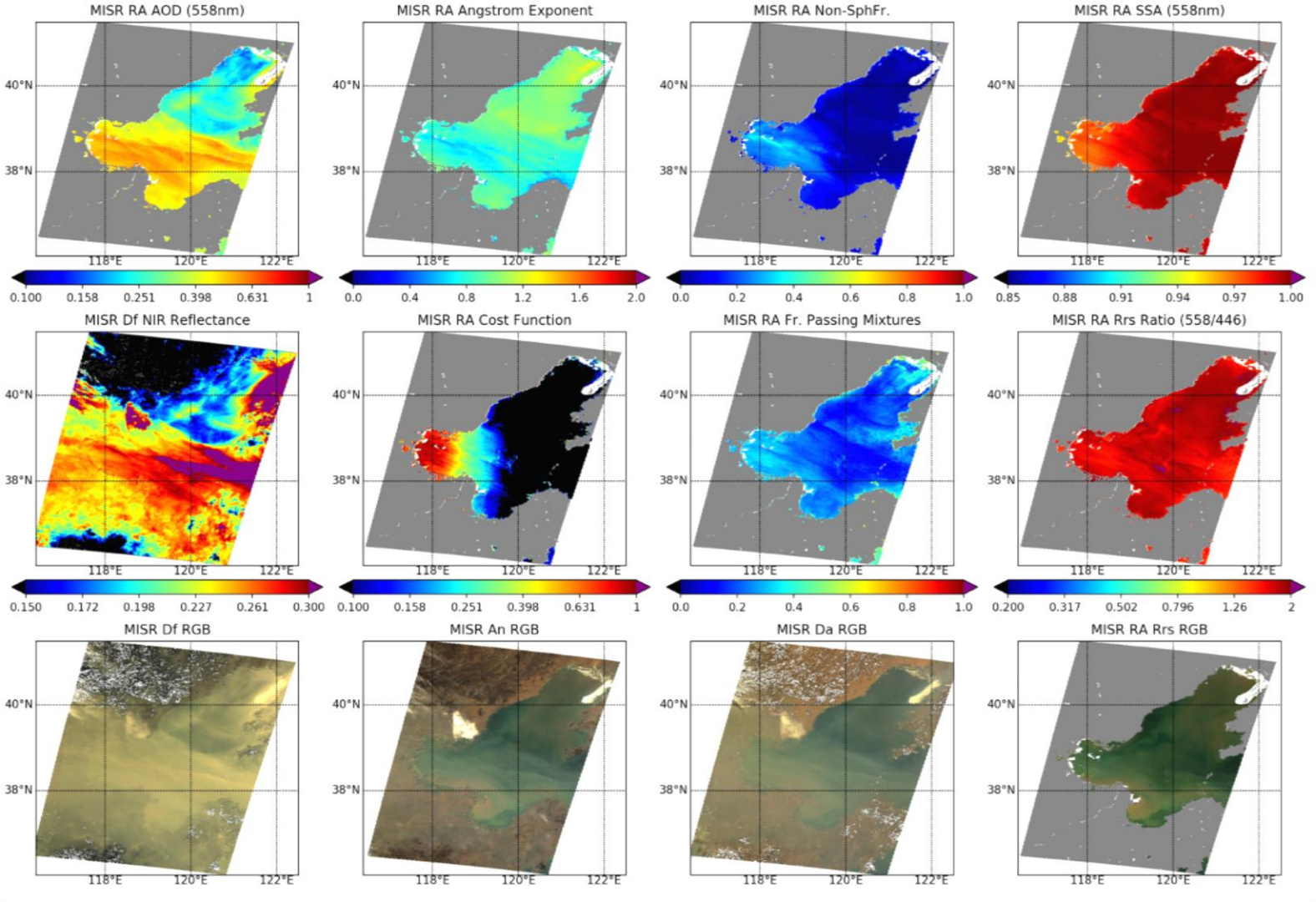


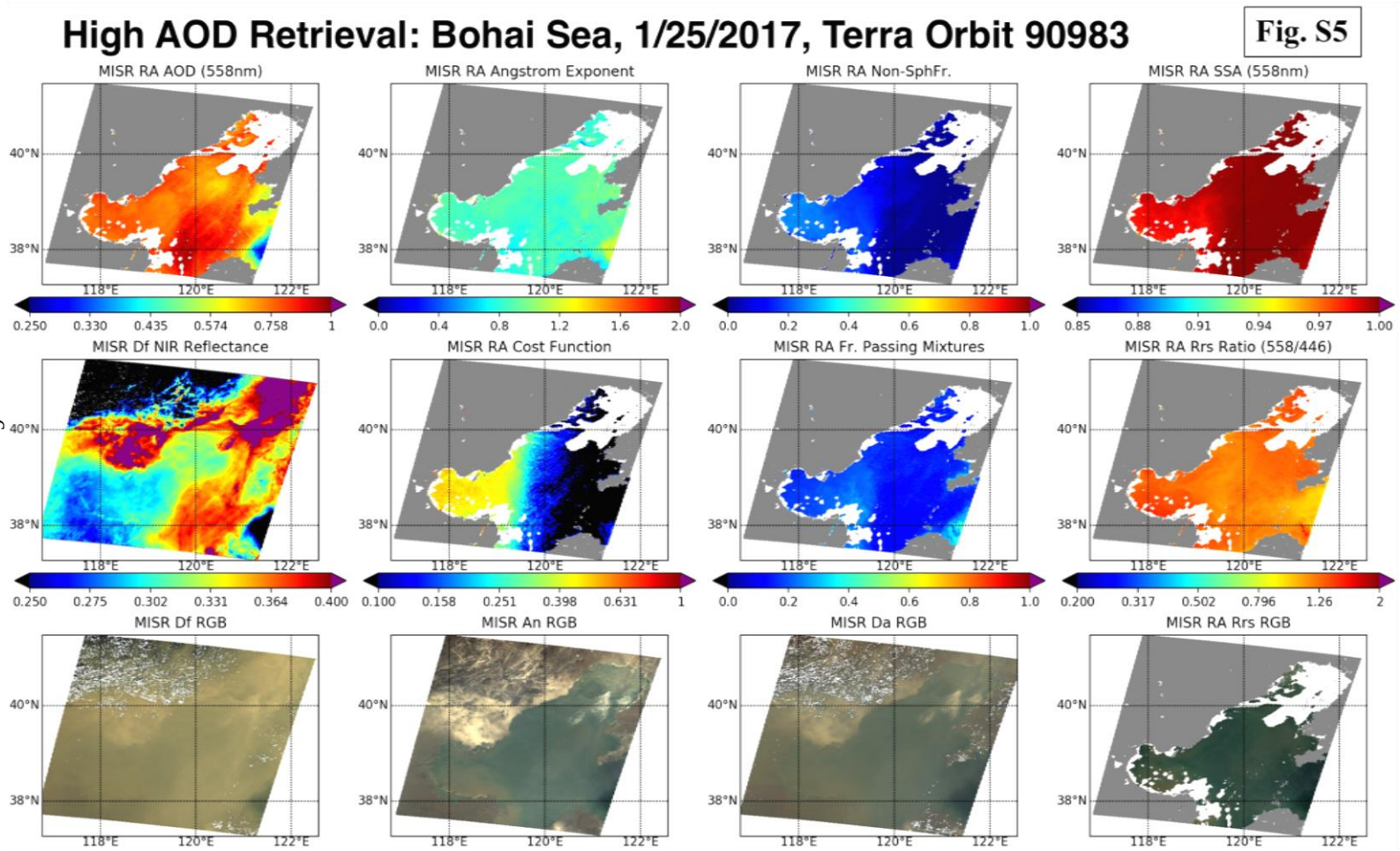

Low AOD Retrieval: Bohai Sea, 10/16/2014, Terra Orbit 78867
Fig. S2
MISR RA AOD (558nm)
MISR RA Angstrom Exponent
MISR RA Rrs Ratio (558/446)
MISR RA Rrs RGB
MODIS Terra OC AOD (558nm)
MODIS Terra OC Angstrom Exponent
MODIS Terra Rrs Ratio (555/443)
MODIS Terra OC Rrs RGB
MISR SA V23 AOD (558nm)
MISR SA V23 Angstrom Exponent
MISR Df NIR Reflectance
MISR An RGB
40°N
38°N
118°E
120°E
122°E
0.020 0.032 0.050 0.080 0.126 0.200
0.0 0.4 0.8 1.2 1.6 2.0
0.200 0.317 0.502 0.796 1.26 2
0.025 0.034 0.048 0.066 0.091 0.125


Low AOD Retrieval: Bohai Sea, 10/16/2014, Terra Orbit 78867
Fig. S3
MISR RA Retrieved R_{rs}
MISR An True Color Image
MODIS Retrieved R_{rs}

Moderate AOD Retrieval: Bohai Sea, 1/4/2015, Terra Orbit 80032

Fig. S4




High AOD Retrieval: Bohai Sea, 1/25/2017, Terra Orbit 90983
Fig. S5
MISR RA AOD (558nm)
MISR RA Angstrom Exponent
MISR RA Non-SphFr.
MISR RA SSA (558nm)
MISR Df NIR Reflectance
MISR RA Cost Function
MISR RA Fr. Passing Mixtures
MISR RA Rrs Ratio (558/446)
MISR Df RGB
MISR An RGB
MISR Da RGB
MISR RA Rrs RGB
40°N
38°N
118°E
120°E
122°E
0.250 0.330 0.435 0.574 0.758 1
0.0 0.4 0.8 1.2 1.6 2.0
0.0 0.2 0.4 0.6 0.8 1.0
0.85 0.88 0.91 0.94 0.97 1.00
0.250 0.275 0.302 0.331 0.364 0.400
0.100 0.158 0.251 0.398 0.631 1
0.0 0.2 0.4 0.6 0.8 1.0
0.200 0.317 0.502 0.796 1.26 2

High AOD Retrieval: Bohai Sea, 1/25/2017, Terra Orbit 90983 **Fig. S6**

MISR An True Color Image

MISR RA Retrieved R_{rs}

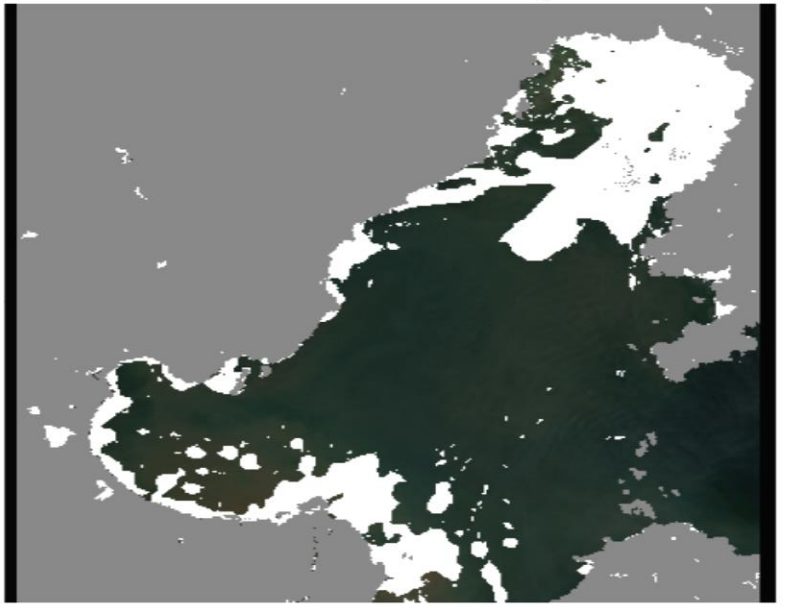


FIGURE CAPTIONS

Figure S1. Similar to Figure 1, for waters that include a ***biologically productive plume in the East Argentine Sea*.** MISR (and MODIS) imagery acquired on December 7, 2006, 13:54Z: Terra Orbit 37079, Blocks 58-61. RGB images have been brightness-enhanced. Titles for each panel describe the parameter plotted. Note that although the RA provides good-quality AOD and ANG retrievals over the biological plume, the SA does not produce good-quality retrievals over that region.

Figure S2. ***Low aerosol loading case over the Bohai Sea***. Same as Figure 1, except over ***shallow and generally turbid waters*** in the Bohai Sea in eastern China on a ***low-AOD day***. MISR and MODIS imagery acquired on October 16, 2014,02:56Z: Terra Orbit 78867, Blocks 58-61. Titles for each panel describe the parameter being plotted. RGB images have been brightness-enhanced. Note that there is no MISR SA data over the Bohai Sea for this day.

Figure S3. ***Retrieved surface detail for low aerosol loading case over the Bohai Sea.*** MISR (and MODIS) retrieval imagery acquired on October 16, 2014, 02:56Z: Terra Orbit 78867, Blocks 58-61. RGB images have been brightness-enhanced. The center plot represents the MISR nadir (An) True-color Rayleigh-corrected RGB for the scene. The left plot represents the MISR RA retrieved R_{rs} RGB image, and the right plot represents the MODIS retrieved R_{rs} RGB image.

Figure S4. ***Moderate aerosol loading case over the Bohai Sea***. MISR imagery acquired on January 4, 2015, 03:00Z: Terra Orbit 80032, Blocks 58-61. RGB images have been brightness-enhanced. Titles for each panel describe the parameter being plotted. Note that there is no MODIS OC or MISR SA data over the Bohai Sea on this day.

Figure S5. ***High aerosol loading case over the Bohai Sea***. MISR imagery acquired on January 25, 2017, 03:00Z: Terra Orbit 90983, Blocks 58-60. RGB images have been brightness-enhanced. Titles for each panel describe the parameter being plotted. Note that there is no MODIS OC or MISR SA data over the Bohai Sea on this day.

Figure S6. ***Retrieved surface detail for high aerosol loading case over the Bohai Sea***. MISR imagery acquired on January 25, 2017, 03:00Z: Terra Orbit 90983, Blocks 58-60. RGB images have been brightness-enhanced. The left panel represents MISR An True-color Rayleigh-corrected RGB for the scene, and the right panel represents the MISR RA retrieved R_{rs} RGB image.