First steps in the creation of a Joint MISR/MODIS Ocean Color Atmospheric Correction algorithm A11H-2720

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We are creating a new algorithm that combines observations from MISR and MODIS (both on the NASA Terra spacecraft) to improve atmospheric correction and coverage for ocean color data products. The algorithm utilizes information rich, multi-angle MISR observations for atmospheric correction, applied to MODIS. Our goal is to produce atmospherically corrected Remote Sensing Reflectance from MODIS with enhanced coverage and accuracy, for input to downstream bio-optical ocean parameter retrieval algorithms.

An important aspect of this work is the utilization of multi-angle views of the reflected ocean surface sun glint. Usually, such observations are avoided, since the intensity of the glint overwhelms any contribution from the ocean body. However, MISR's multi-angle observations see varying degrees of glint, which means they can be used to better determine aerosol optical properties (Kaufman et al., 2002, Ottaviani et al., 2013), and to identify surface wind speeds that govern the glint pattern. The latter could be utilized to replace the wind speeds taken from ancillary sources that are currently used to conservatively mask potential glint contamination in MODIS observations.

To assess this capability, and to identify the appropriate parameterization, we present an analysis using the Generalized Nonlinear Retrieval Analysis (GENRA, Vukicevic et al., 2009) information content assessment. This technique is also easily modified to act as a Bayesian retrieval algorithm, for which initial results are discussed. Finally, we describe the status of integrating MISR data into the processing capabilities of the Ocean Biology Processing Group (OBPG) at NASA, and show the first ocean color vicarious calibration (Franz et al., 2007) of the MISR instrument.

Fox, D., et al., 2007. Near-surface wind speed retrieval from space-based, multi-angle imaging of ocean Sun glint patterns. Remote Sens. of Env., 107(1-2), pp.223-231.

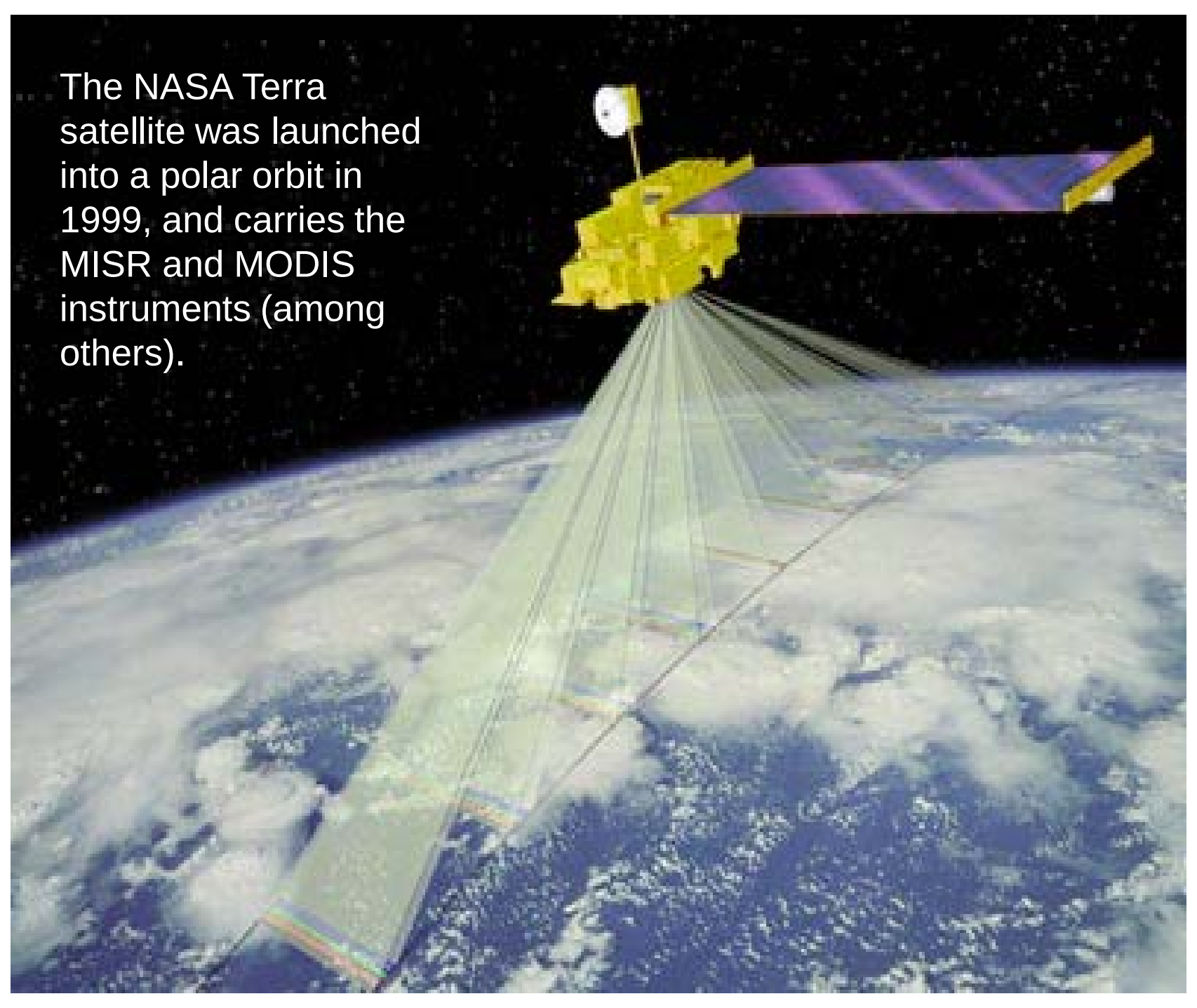
Franz, B. A., et al., 2007. Sensor-independent approach to the vicarious calibration of satellite ocean color radiometry. Appl Opt, 46 (22): 5068-5082.

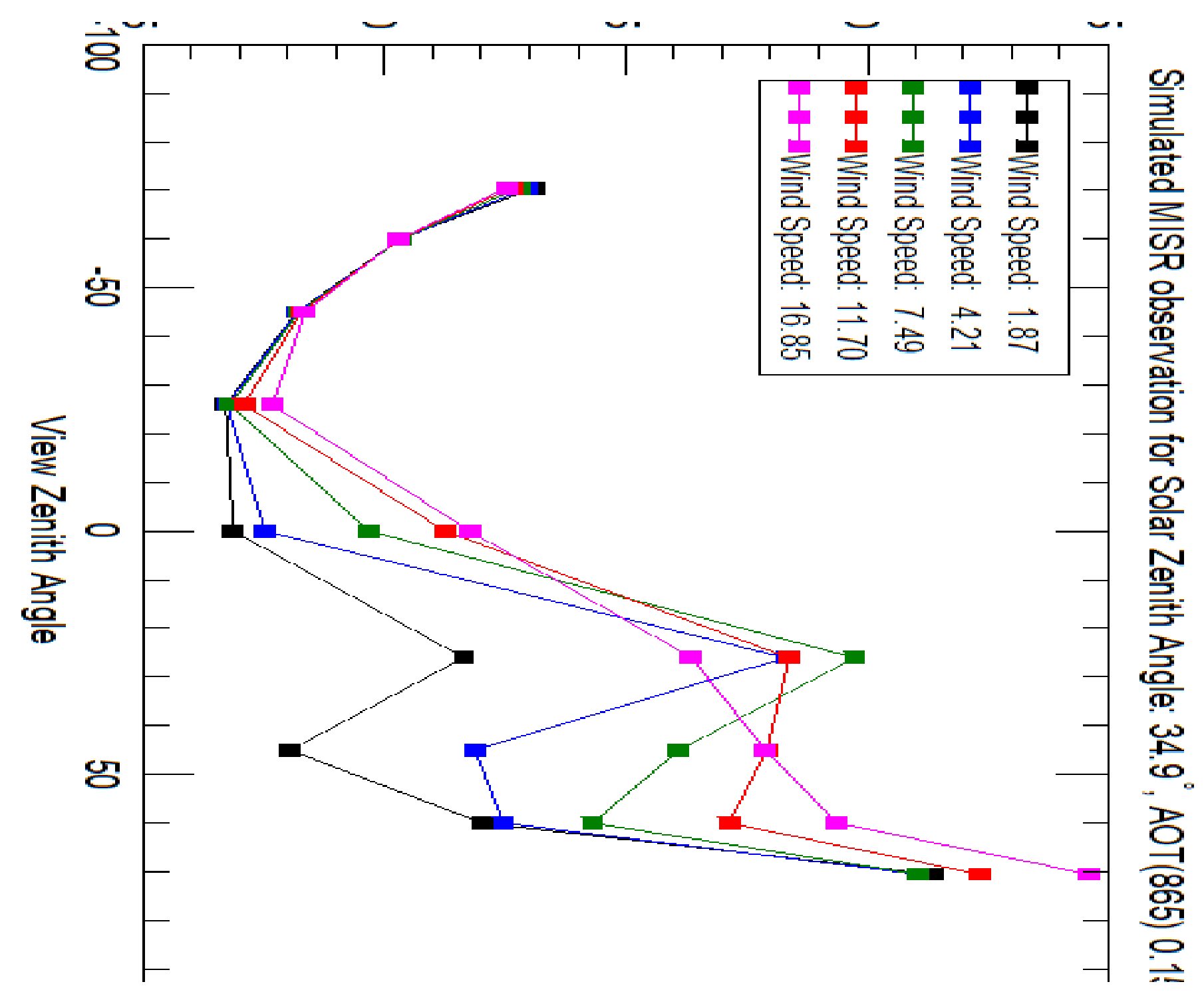
Kaufman, Y. J., et al., 2002. Satellite retrieval of aerosol absorption over the oceans using sunglint, Geophys. Res. Lett., 29, 34–1.

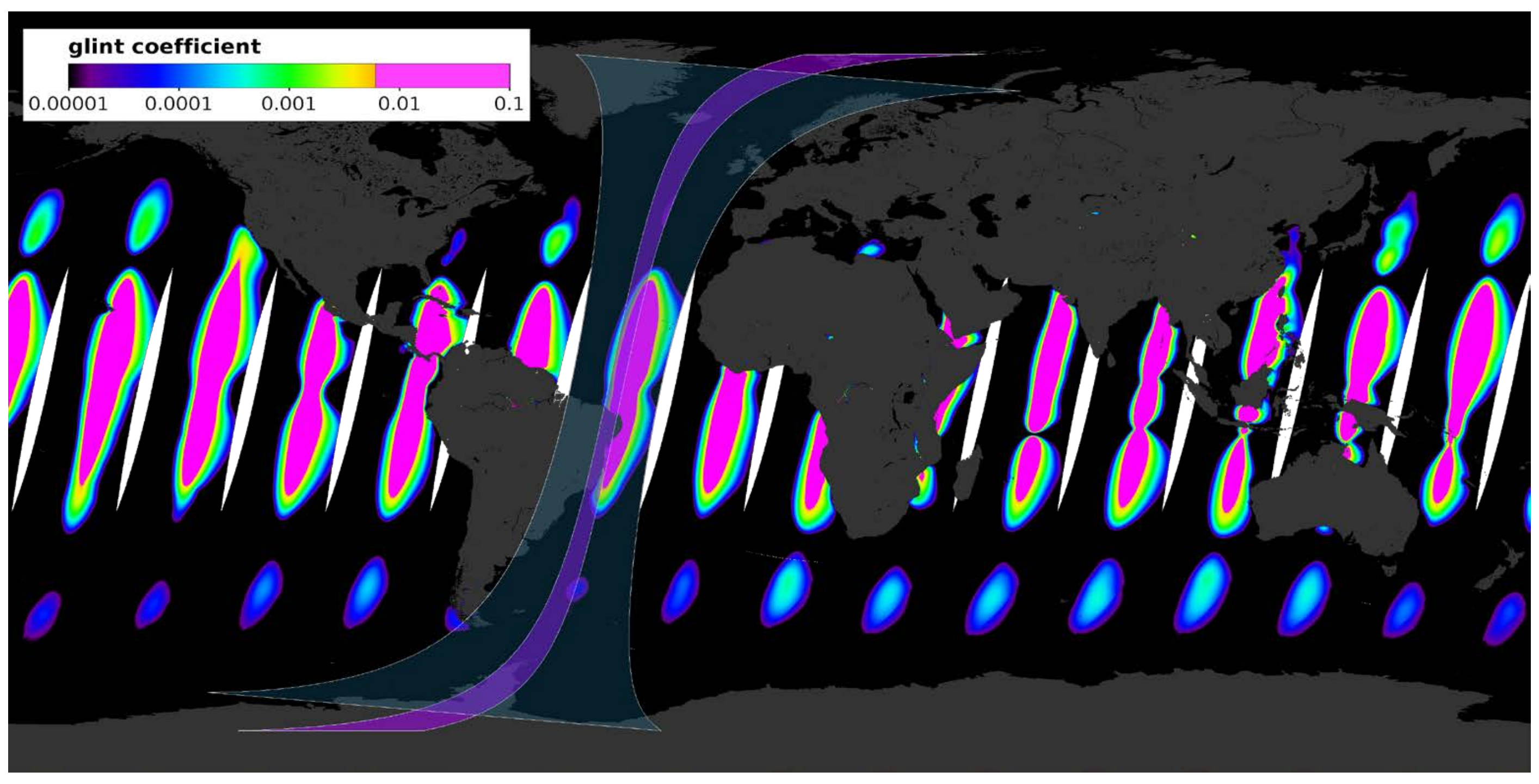
Ottaviani, M., et al., 2013. Information content of aerosol retrievals in the sunglint region. Geophys. Res. Lett., 40(3), 631-634.

Vukicevic, T., et al., 2010. Characterizing the retrieval of cloud properties from optical remote sensing. J. of Geophys. Res.: Atmospheres, 115(D20).

MODIS Ocean Color with MISR Atmospheric Correction (MOCMAC) project overview


The NASA Terra satellite was launched into a polar orbit in 1999, and carries the MISR and MODIS instruments (among others).





Our goal: create a research algorithm that provides an atmospheric correction to MODIS-Terra observations within the MISR swath.

This will use MISR's unique multi-angle observations to:
- better constrain wind-driven reflected sun glint (ancillary wind speed products are currently used),
- confidently extend MODIS retrievals closer to glint at low latitudes
- Provide improved aerosol selection / atmospheric correction

The algorithm will be created and tested at the Ocean Biology Processing Group (OBPG) at the NASA Goddard Space Flight Center. OBPG creates ocean color products from MODIS, VIIRS, SeaWiFS and other multi-spectral sensors.

MODIS and MISR characteristics. *only MODIS channels with high SNR for ocean color purposes are listed.

Instrument	**Channels (nm)**	**View zenith angles** (& labels)	**Swath width (km)**
MODIS	412, 443, 488, 531, 547, 555, 667, 678, 748, 869*	Nadir	2330
MISR	447, 558, 672, 866	Da: -70.5˚, Ca: -60˚, Ba: -45.6˚, Aa: -26.1˚, An: 0.0˚, Af: 26.1˚, Bf: 45.6˚, Cf: 60˚, Df: 70.5˚	380

The study is also relevant to the upcoming NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission, which will combine an ocean spectrometer instrument with two multi-angle polarimeters. see : https://pace.gsfc.nasa.gov

Do MISR observations have the information content to do this? Analysis with Generalized Nonlinear Retrieval Analysis (GENRA)

We use the Generalized Nonlinear Retrieval Analysis (GENRA, Vukicevic et al., 2010) technique to estimate the posterior distribution of simulated observations given MISR measurement uncertainty.

Posterior *Prior* *Data* *Theory*

$$p_m(m) = \int_D \frac{1}{\gamma^*}\left[p_p(m)p_d(y)p_t(\phi(m)|m)\right]dy$$

Measurement space *Normalization constant* $\phi(m) = y$

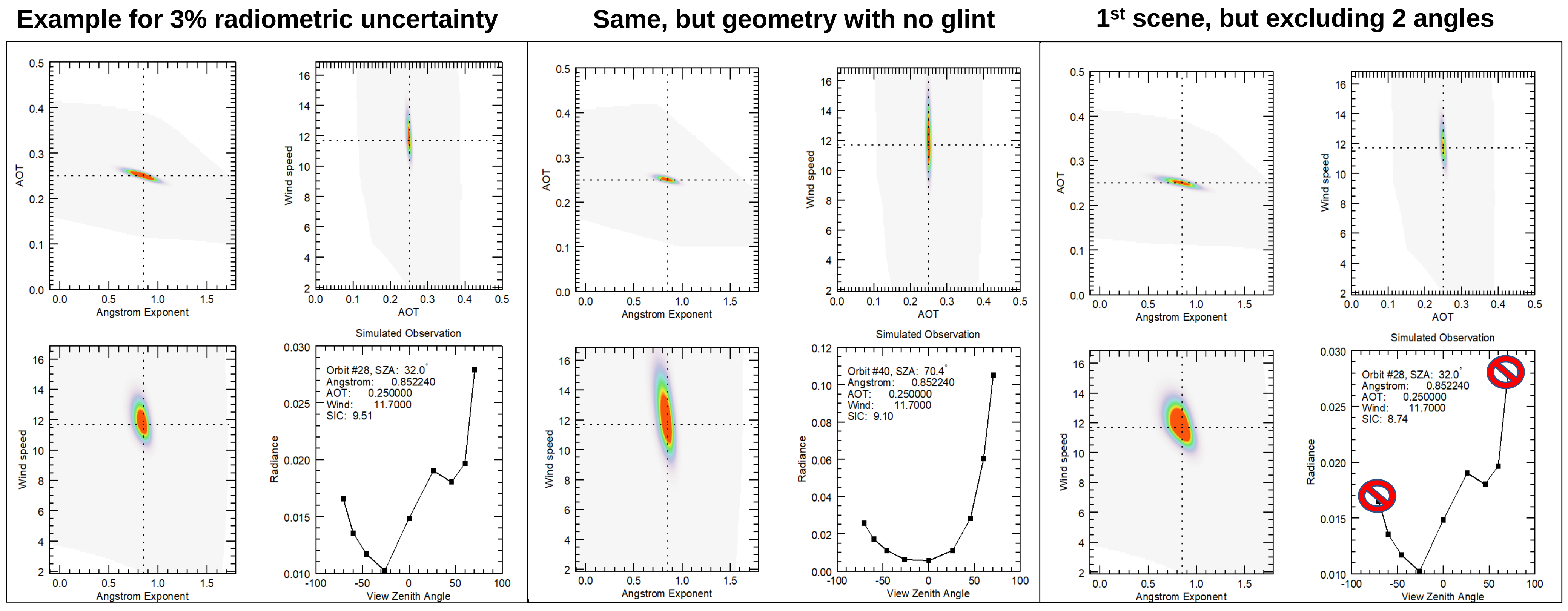
Parameter space (m) dimensions:

1. Aerosol Optical Thickness
2. Aerosol Ångström exponent
3. Surface wind speed

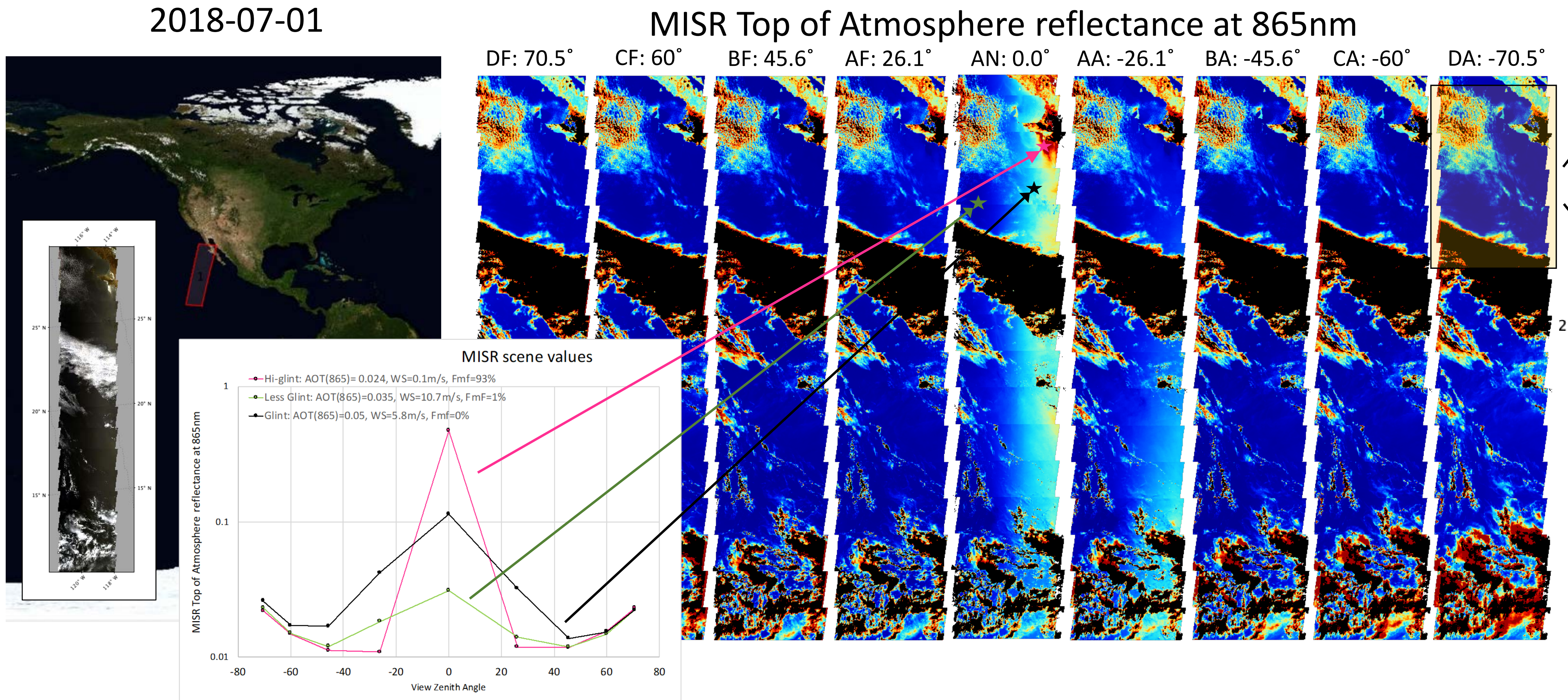
Lookup table (LUT) typically used for retrieval is repurposed for GENRA.

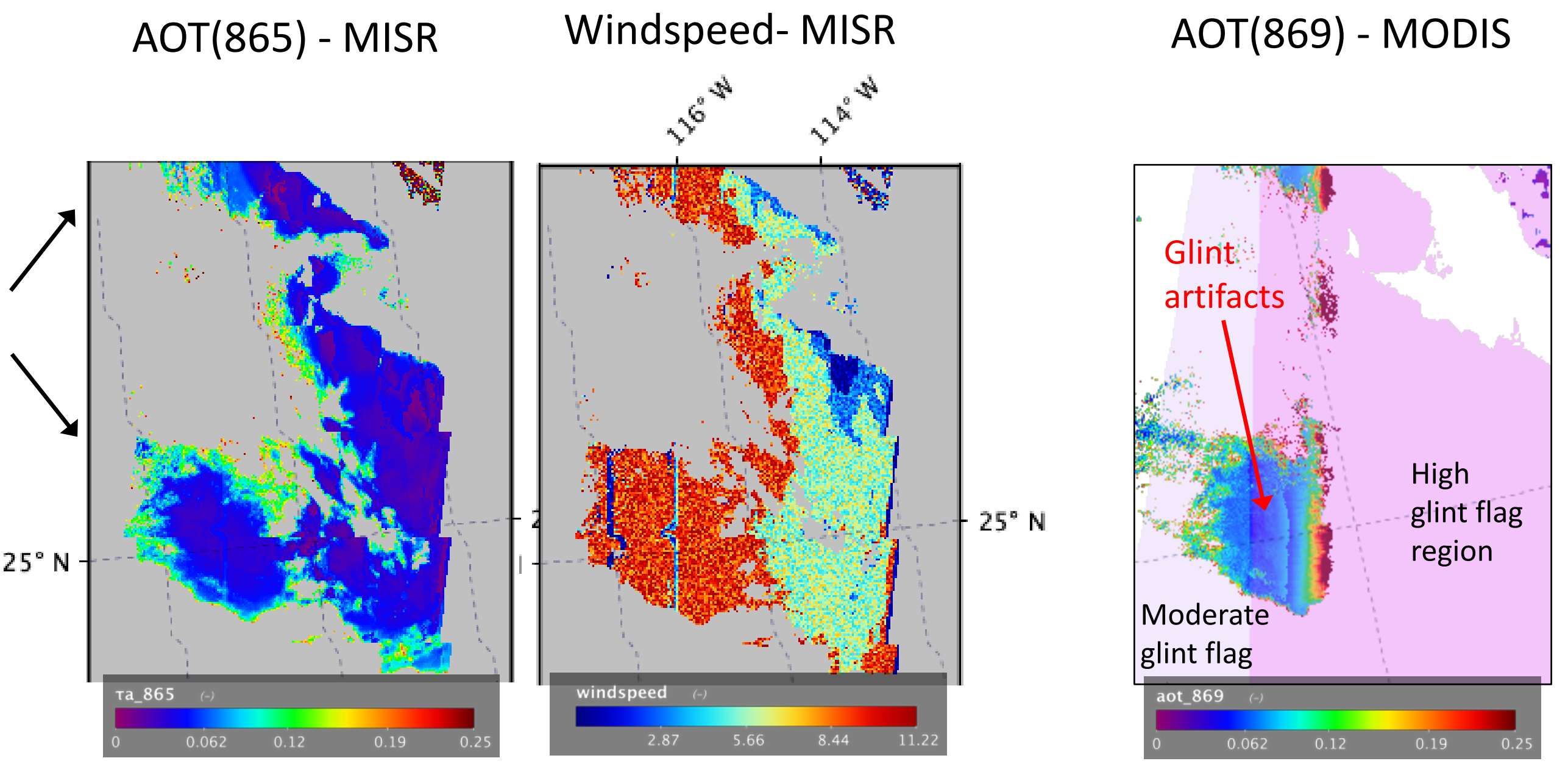
Measurement space (y) dimensions:

1. TOA radiance at 865nm
2. MISR cameras (9 view zenith angles)


Example for 3% radiometric uncertainty **Same, but geometry with no glint** **1st scene, but excluding 2 angles**

Initial retrieval using MISR 865nm data





This first demonstration shows the potential for reasonable results, but with interpolation artifacts. Compared to (Ocean Color) MODIS retrievals, MISR works in otherwise glint contaminated regions, and retrieves wind speed, rather than ingesting ancillary values.

Next steps
- Resolve interpolation/geolocation issues indicated above.
- Using GENRA as a tool, refine LUT so it appropriately parameterizes our problem.
- Apply Ocean Color standard vicarious calibration to MISR.
- Investigate application of MISR retrieval to MODIS atmospheric correction
- Process results for comparison to SeaBASS in situ results.

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