Challenges of Absorbing Aerosols

HyspIRI Aquatic Studies Group – 3rd Annual Aquatic Forum

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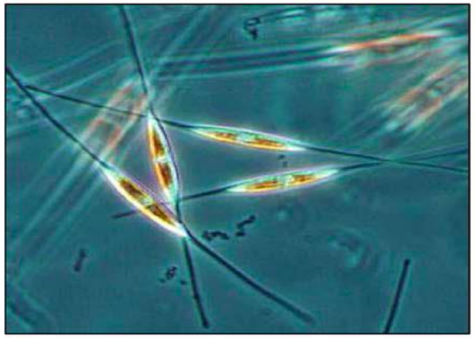
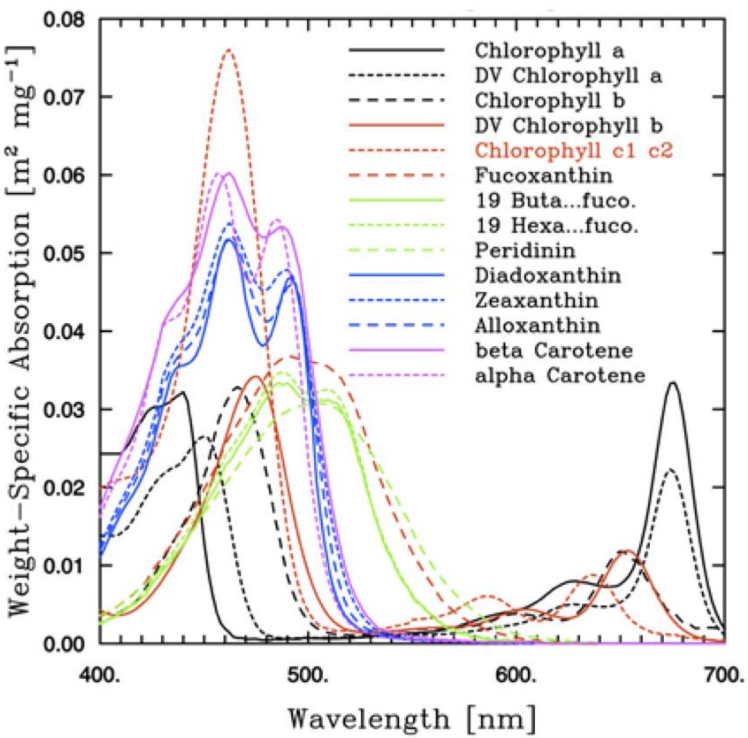
June 5, 2015

PACE opens new vistas in aquatic biology…





Devred et al. [2013]

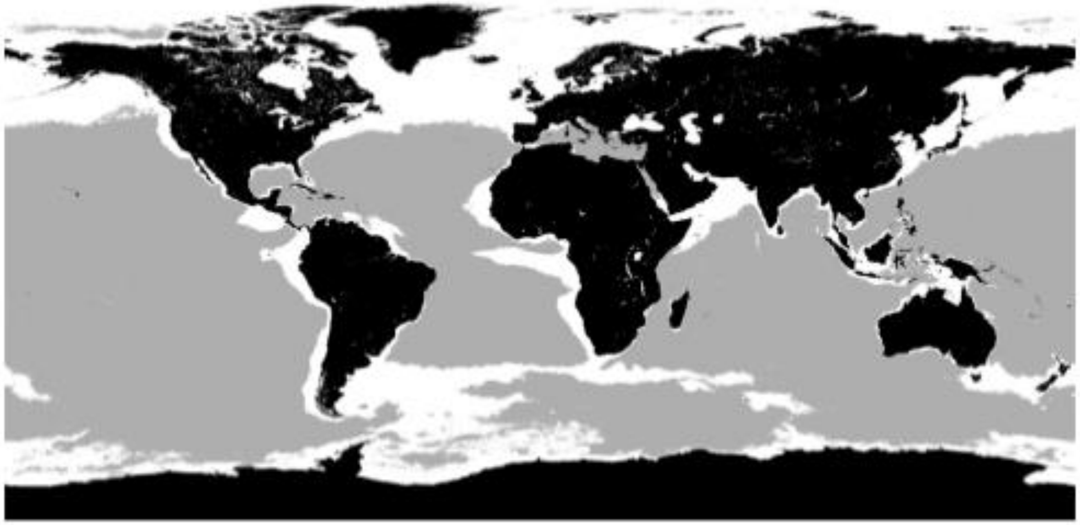
Blue and near-UV spectra from the OCI will measure accessory (non-chlorophyll) pigments, separate chlorophyll and colored dissolved organic matter, and characterize phytoplankton taxonomy.

…but atmospheric interference might make this challenging

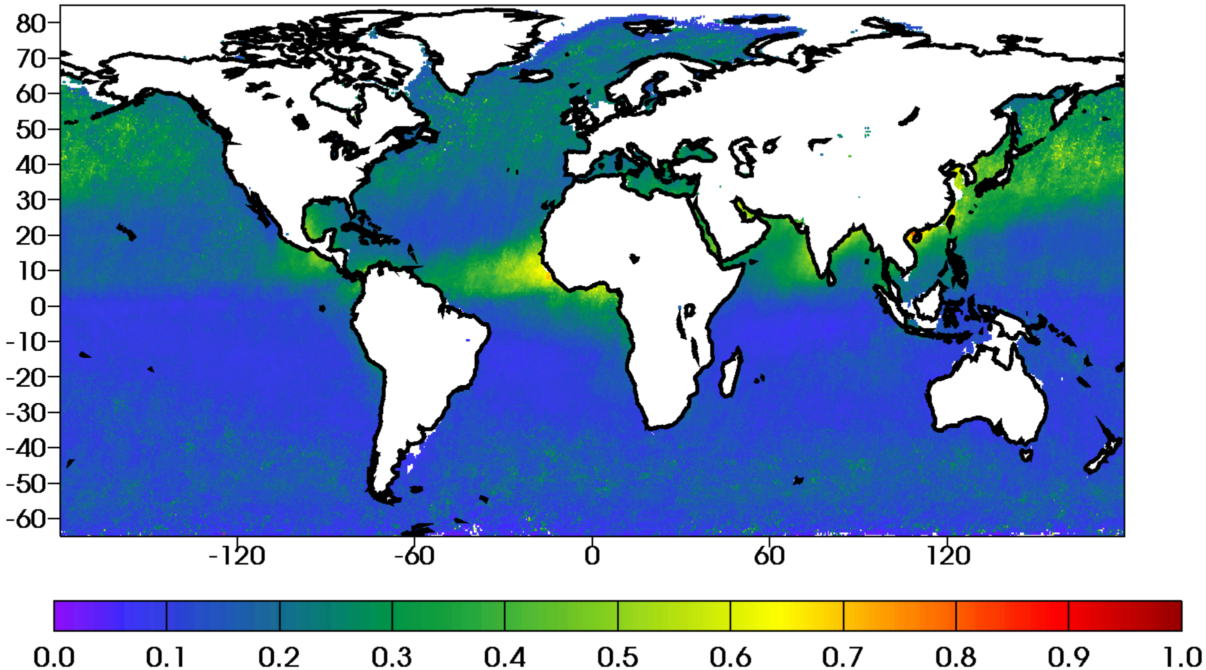
B. Mitchell, UCSB: Retrieving UV-absorbing mycosporine amino acids, algal proteins, and particle size distributions is needed to specify phytoplankton functional groups and plankton ecosystem structure.

S. Maritorena, UCSB: Dissolved organic matter and absorbing aerosols both absorb in the UV, which may limit the ability to differentiate them.

Aerosol is transported over many ocean regions



SeaWiFS mission cumulative climatology of chlorophyll-a concentration (C_a). White shows locations where $C_a > 0.3$ mg m^{-3}, and the assumption of a black surface in the NIR is likely to be violated [*Bailey et al., 2010*]



MISR April aerosol optical depth (AOD) climatology 2000-2012, [*Kalashnikova et al., 2013*]

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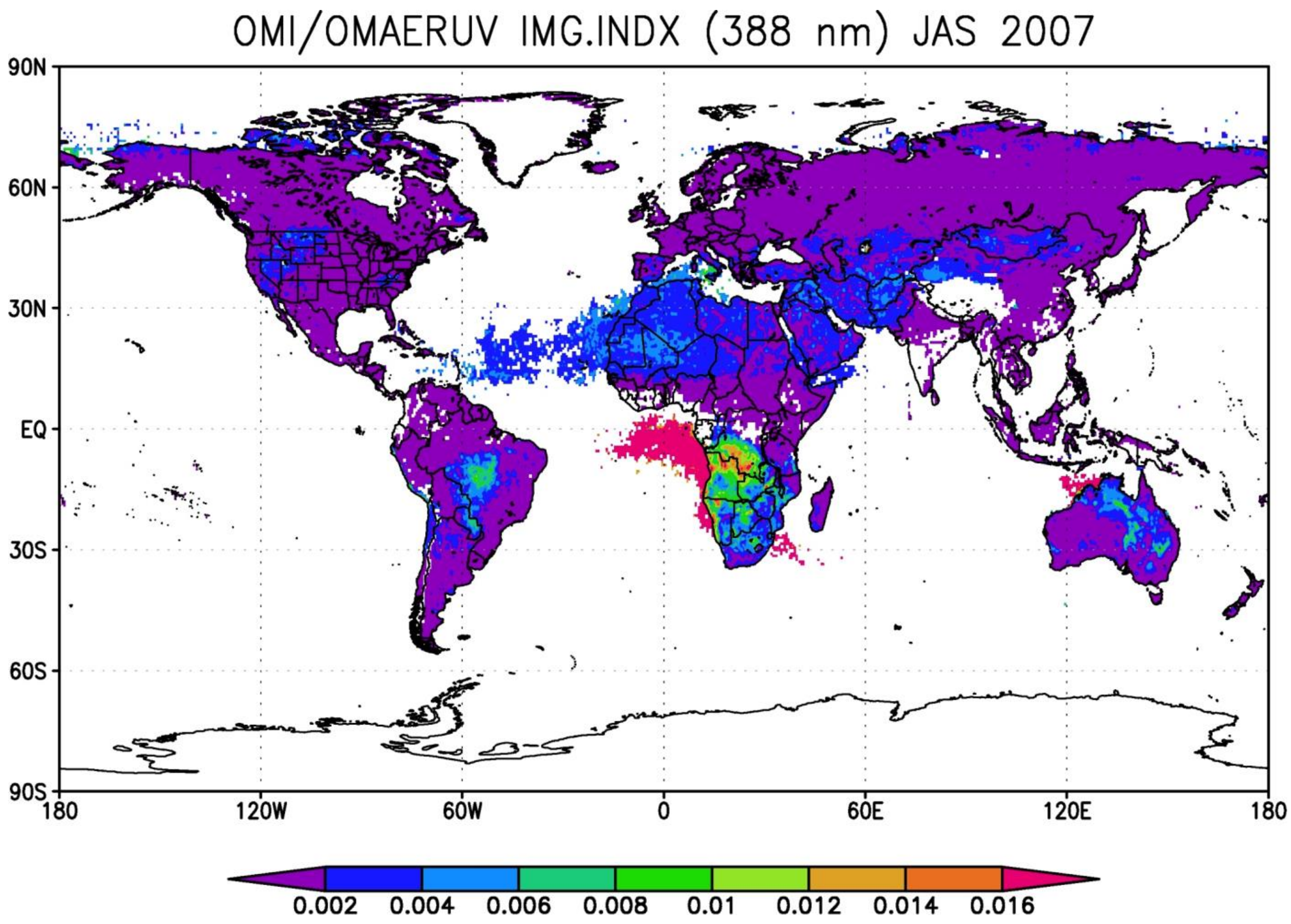
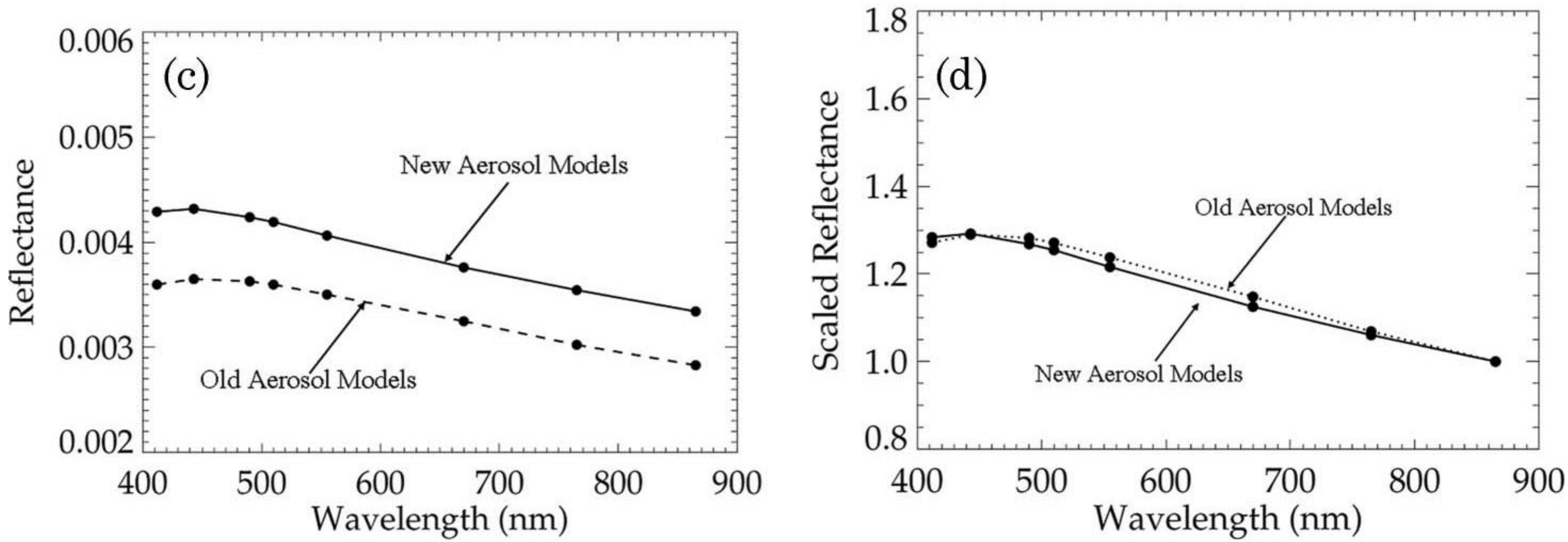


OMI absorbing aerosol climatology, [*Courtesy of Omar Torres*]

Is aerosol really a problem?

The goal of atmospheric correction (AC) is to convert observed top-of-atmosphere spectral radiance to water-leaving reflectance (Rrs) over the NUV-VIS spectral regime



TOA reflectance computed from old (M70) and new (Rh80M06) aerosol models

Ahmad et al. [2010]

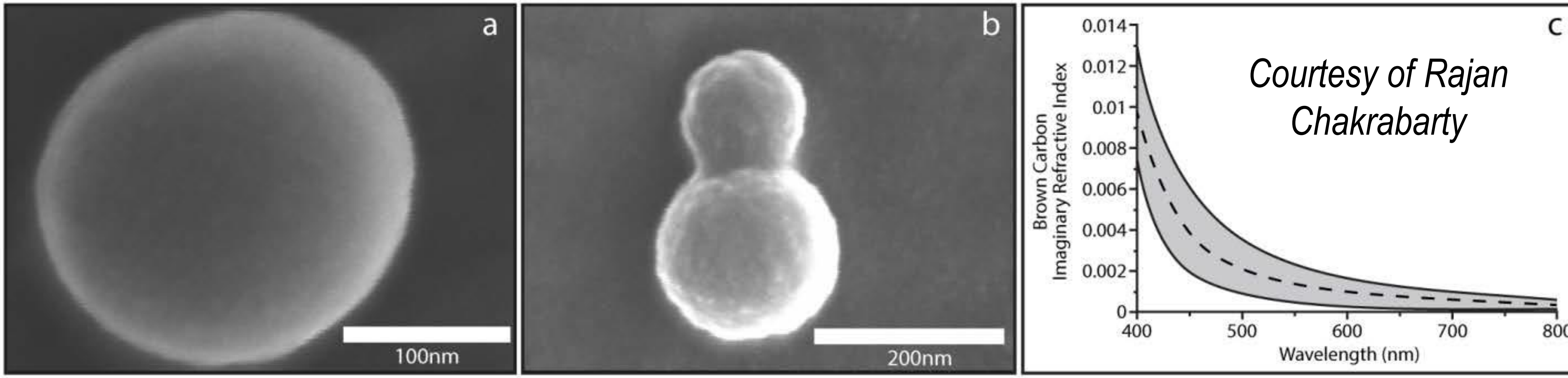
<u>Current NASA atmospheric correction approach</u>

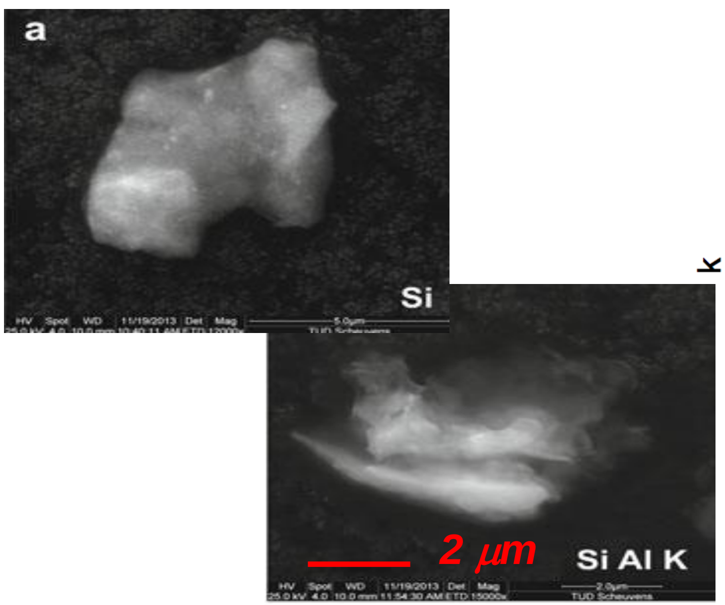
- Obtain AOD and Aerosol Type from Red-NIR bands
- Extrapolate to Blue, UV (for next-generation instrument)
- Correlate with surface reflectivity at (MOBY) surface buoy

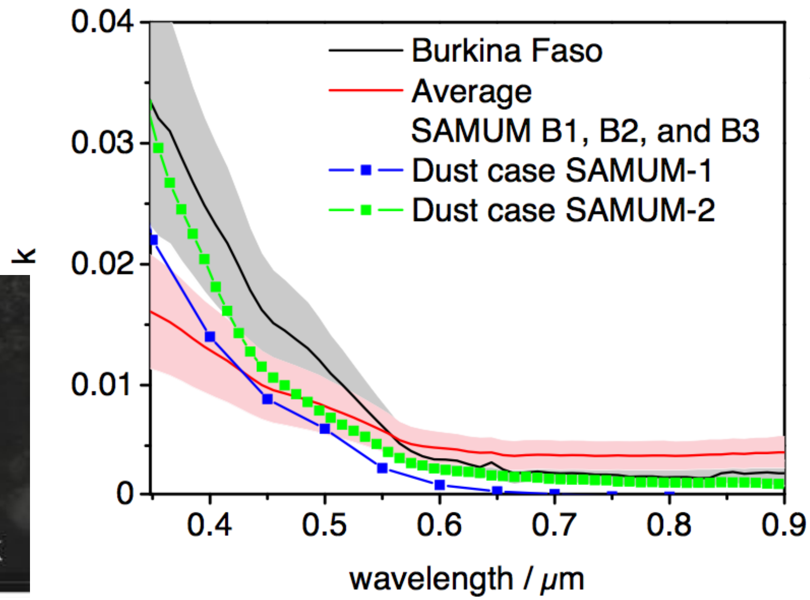
works well for spectrally flat aerosols

“Complicated” aerosols

Dust and brown carbon strongly absorb toward UV

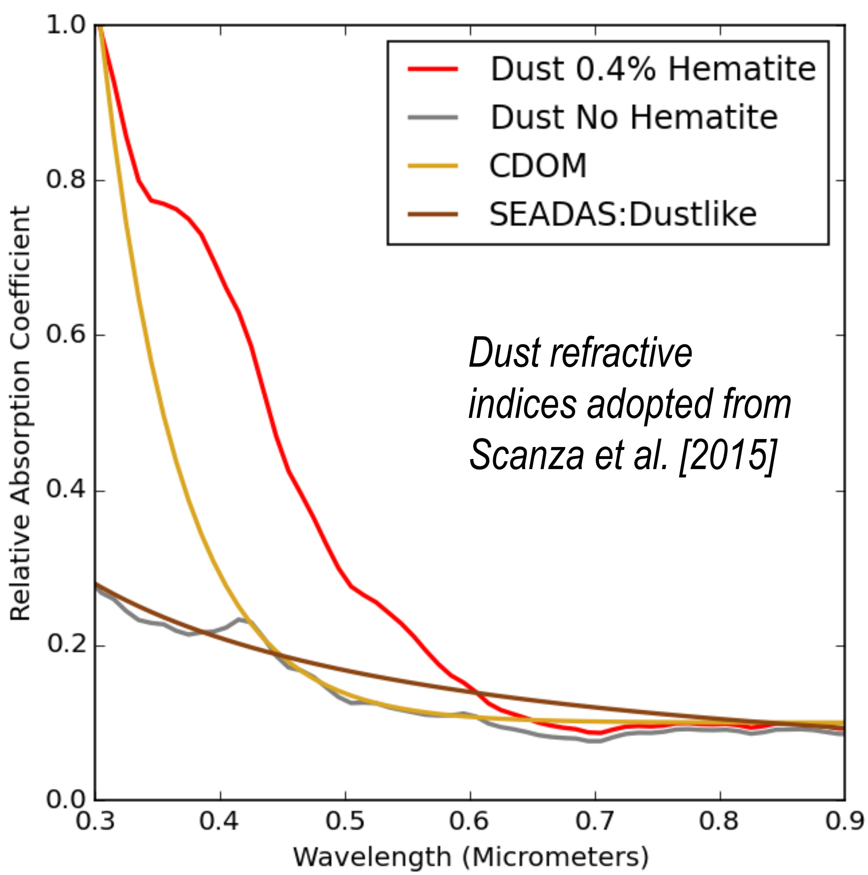


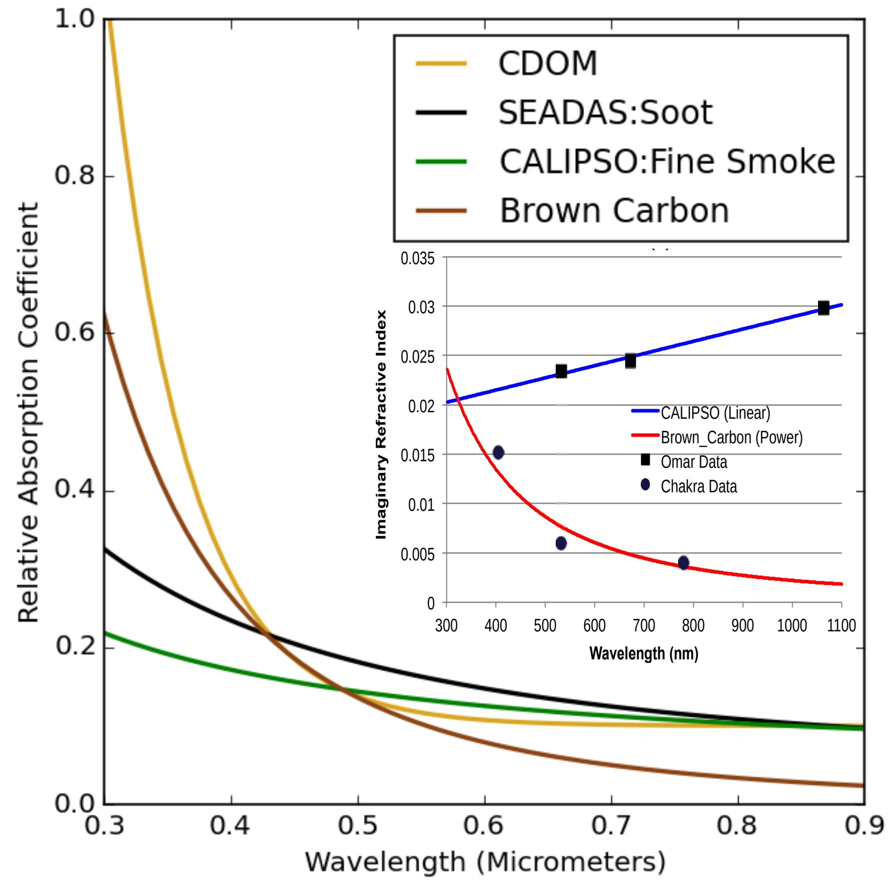




Wagner et al. [2012]

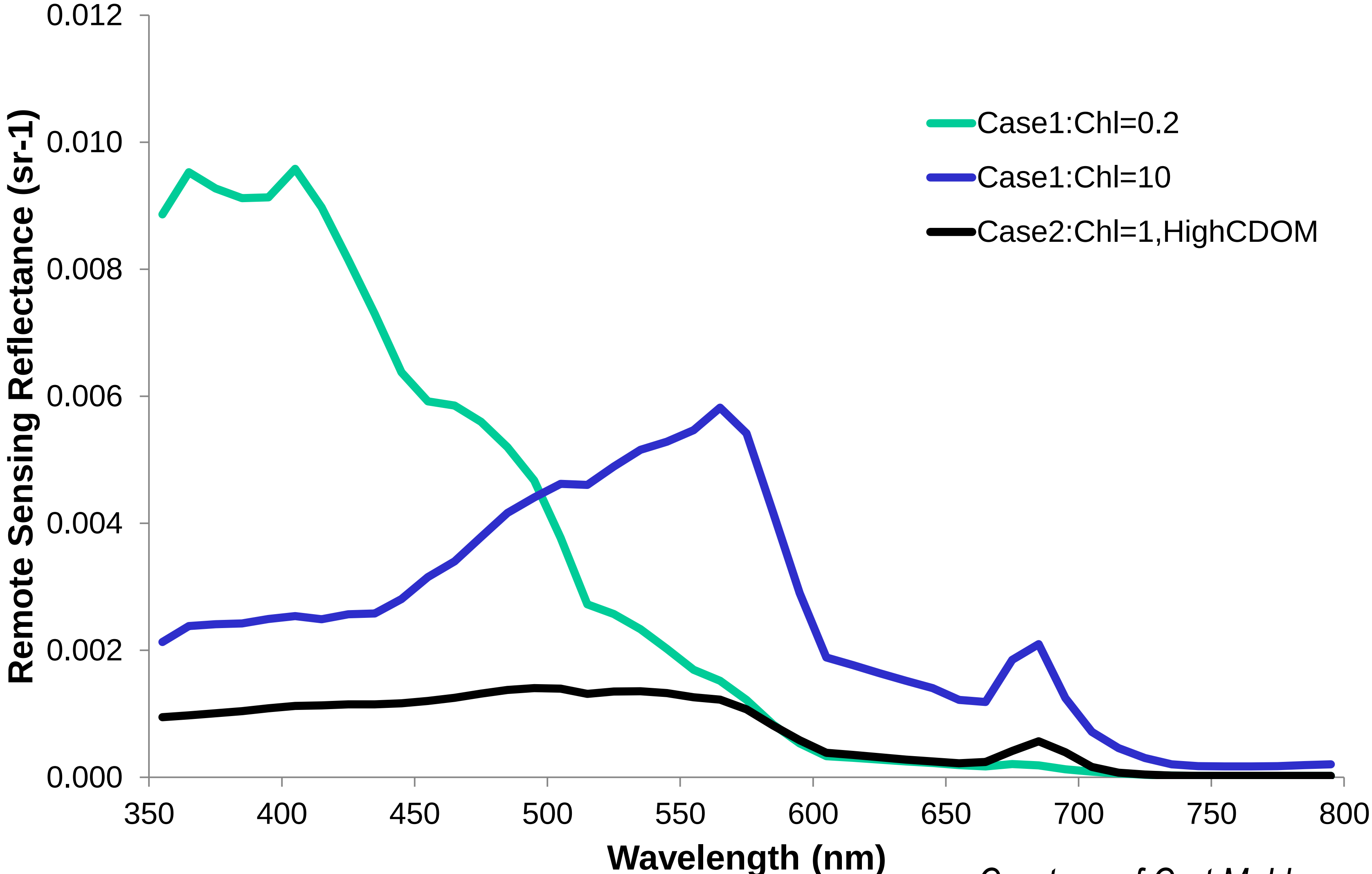
Relative comparison to CDOM





Dust and BC absorption features might be misinterpreted as CDOM absorption

Remote sensing reflectance for various water types



Courtesy of Curt Mobley

Theoretical sensitivity to absorption

- ***Compared atmospheres with Ahmad dustlike fine mode particles with same particle with hematite n_i***
  - ***Dry particles (r_v = 0.149, r_n = 0.084)***
  - ***Ahmad = "dustlike"***
  - ***Adjusted = "dustnihem"***
- ***"Two-stage atmospheric correction"***
  - ***$Lu_\lambda - x_\lambda = Lw_\lambda / Ed_\lambda = Rrs_\lambda$***
  - ***Scaling at to Rrs at 555***

•SOS vector model

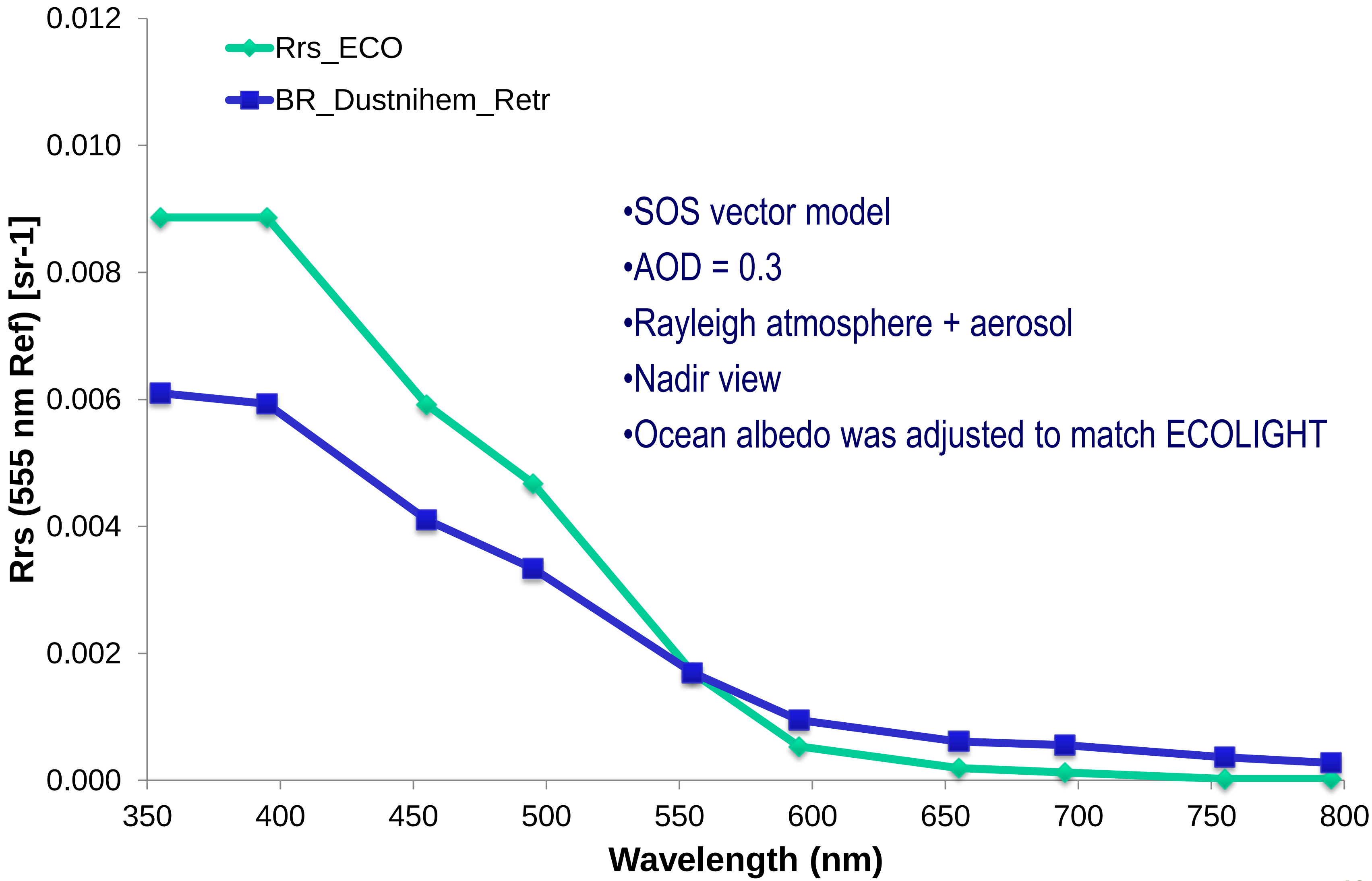
•AOD =0.3

•Rayleigh atmosphere + aerosol

•Nadir view

•Ocean albedo was adjusted to match ECOLIGHT

Retrieved and scaled Rrs vs. “true” Rrs



- SOS vector model
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Delta Rrs vs. Requirements

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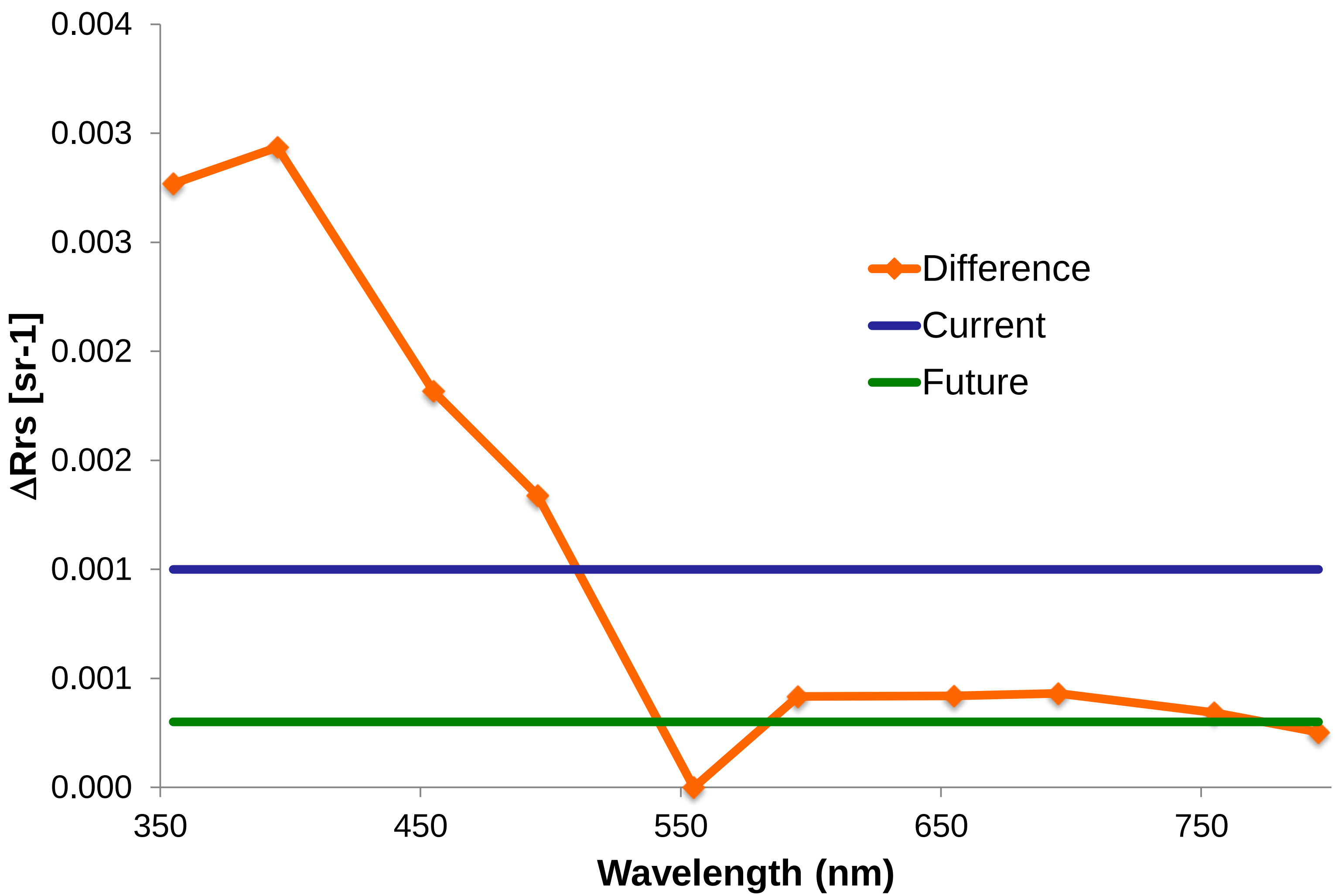
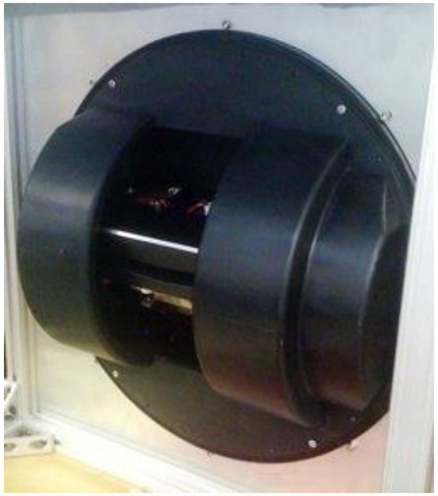


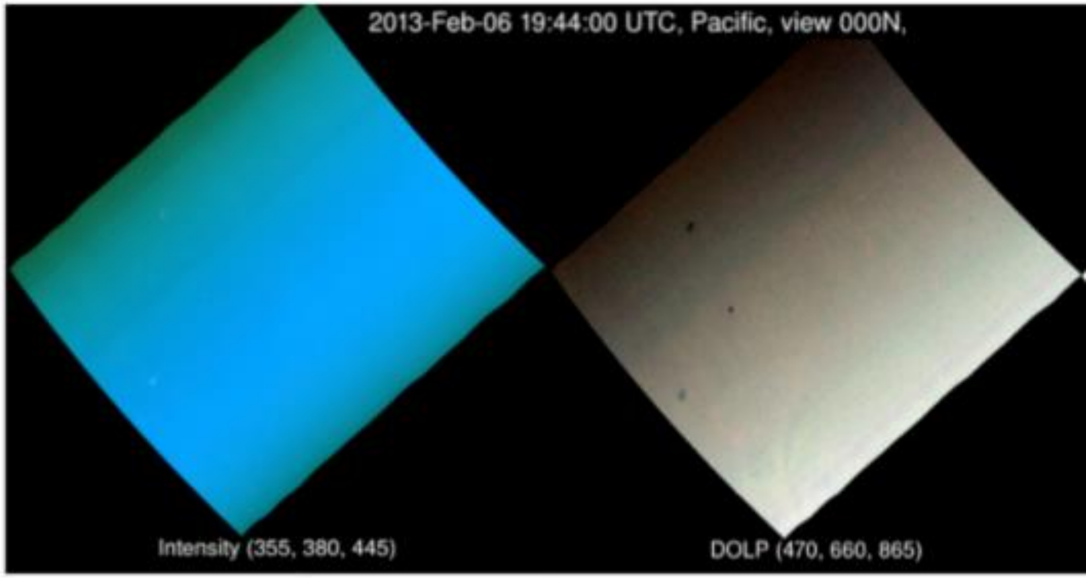
Neglecting hematite dust aerosols leads to errors outside of the PACE Rrs retrieval requirement

Using AirMSPI to explore the value of a polarimeter

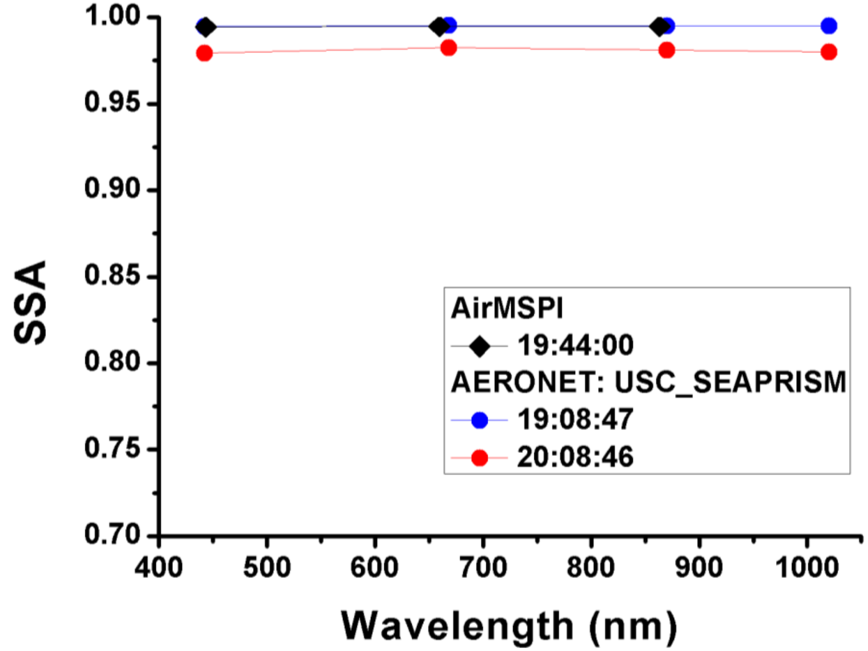


AirMSPI data were acquired over the USC SeaPRISM AERONET-OC site on the Eureka platform on February 6, 2013

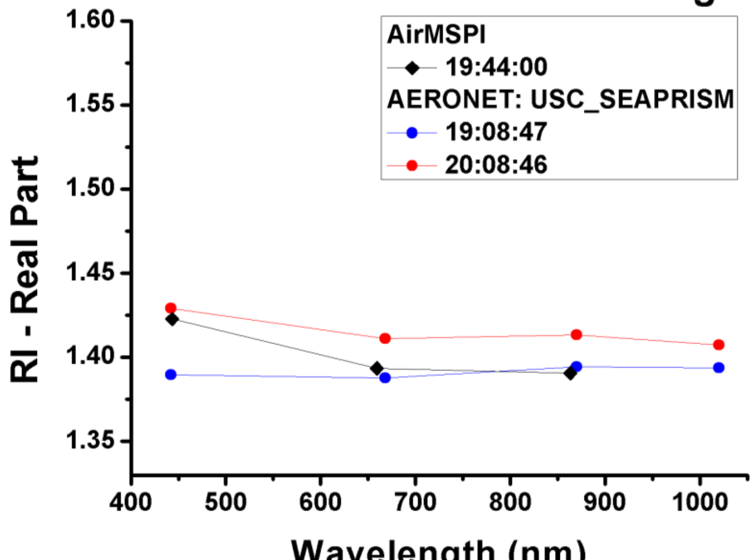
Spectral bands	355, 380, 445, 470*, 555, 660*, 865*, 935 nm (*polarized)
Flight altitude	20 km
Multiangle viewing	Between ±67º using single-axis gimbal

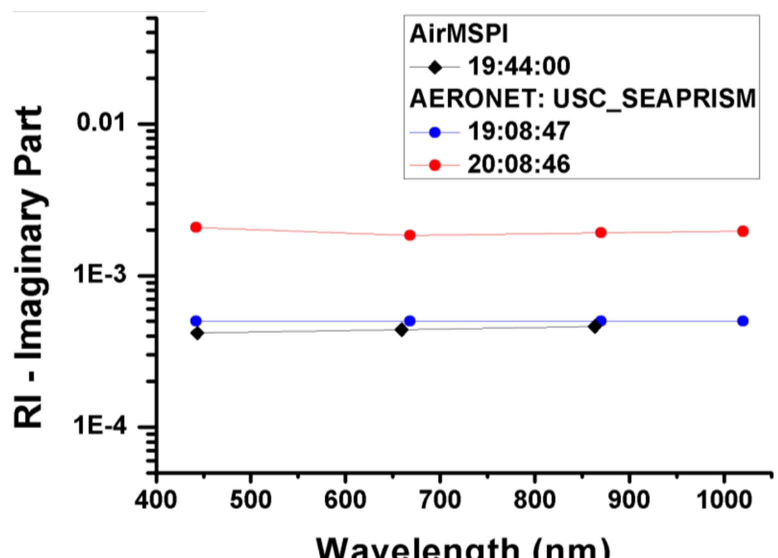


AERONET observations vs. AirMSPI optimized coupled aerosol-surface retrieval (no look up tables)

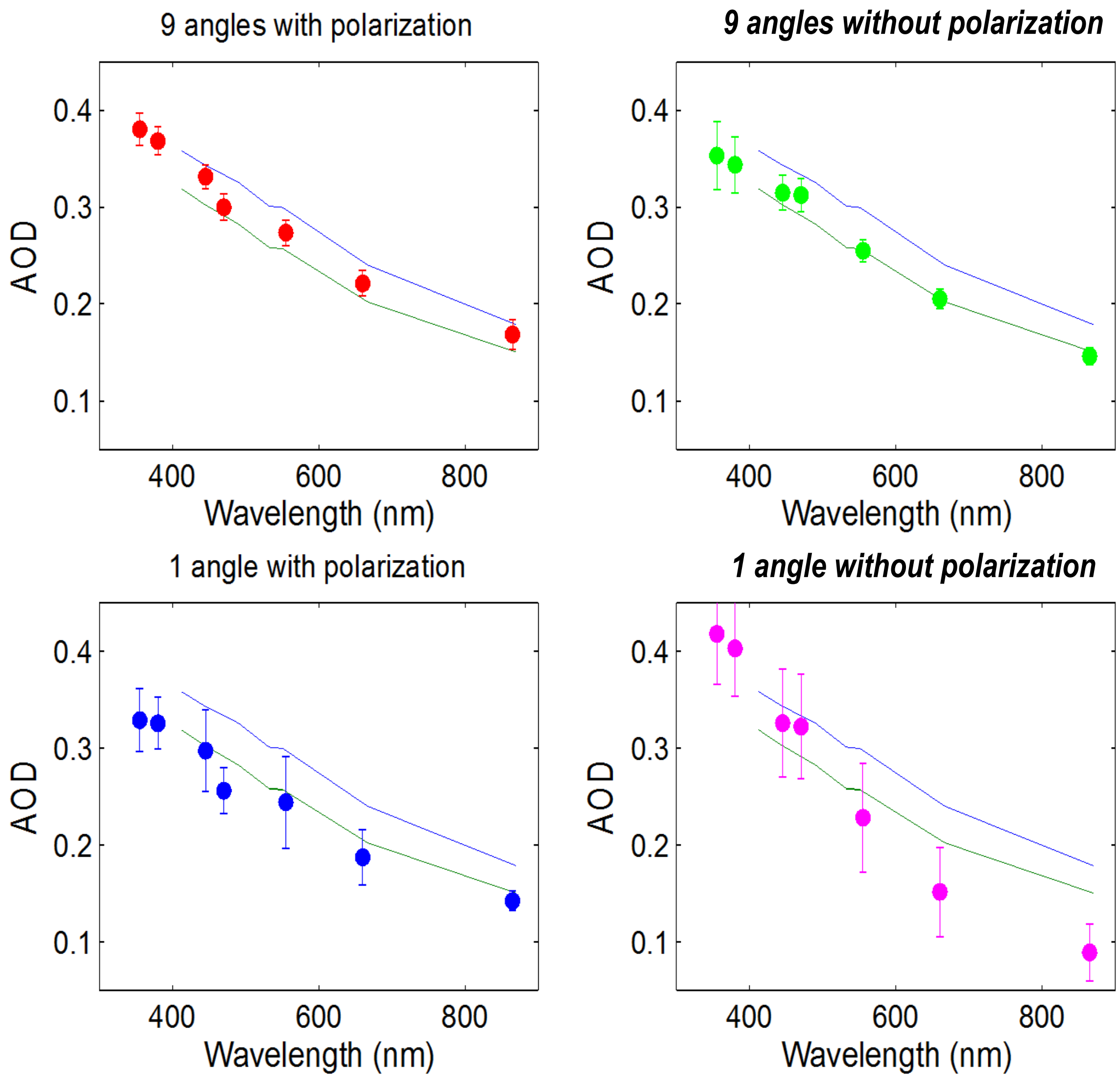


Weakly-absorbing spectrally flat aerosols





Aerosol optical depth retrieval sensitivity to measurement information content



- ❖ Colored dots: Mean AirMSPI retrieval results based on 8 initial guesses at 19:43 UTC.
- ❖ Colored error bars: Spread of these 8 results.
- ❖ Blue and green lines: SeaPRISM observation at 19:08 and 20:08 UTC.

Normalized water-leaving radiance sensitivity to measurement information content

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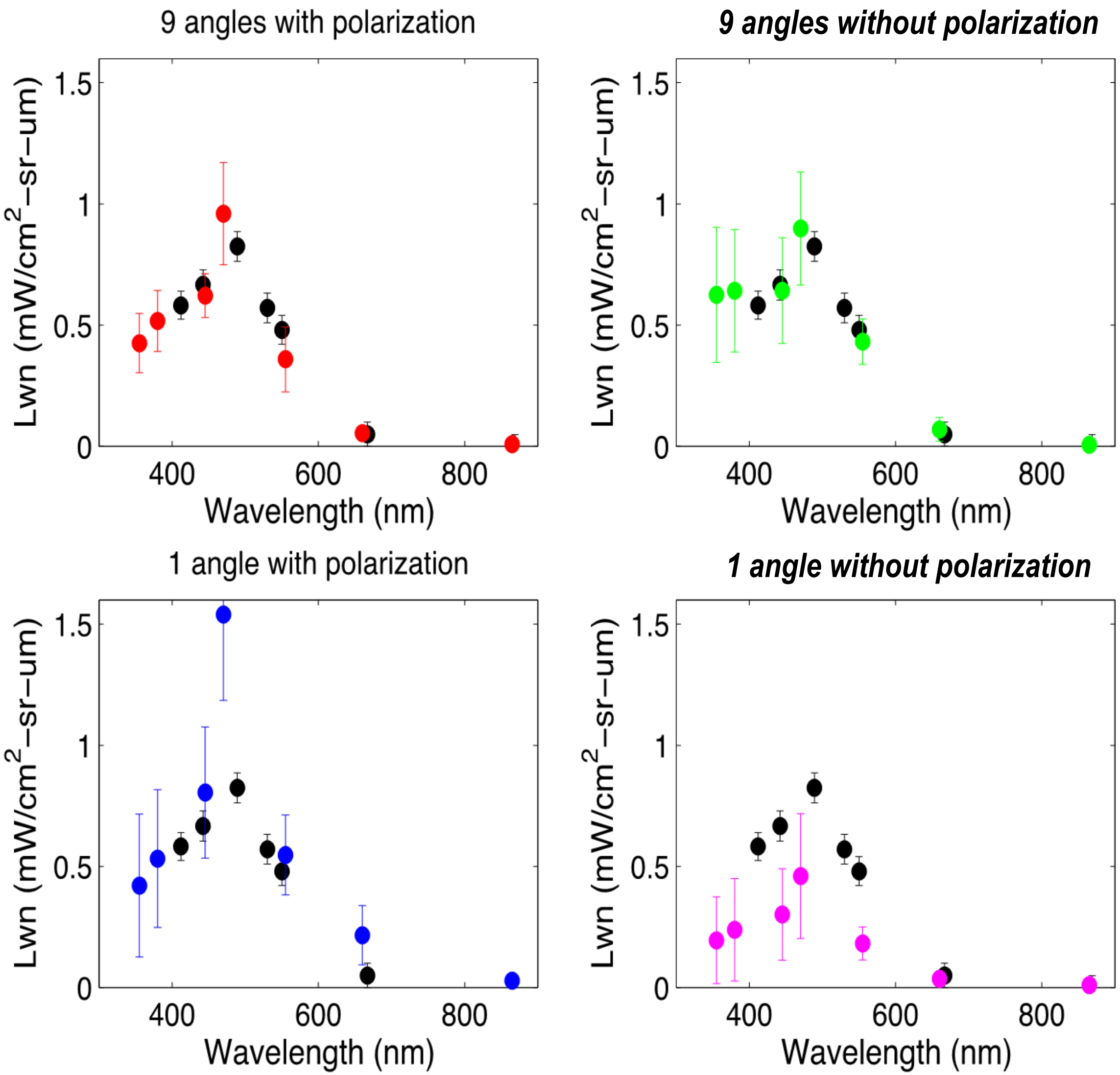
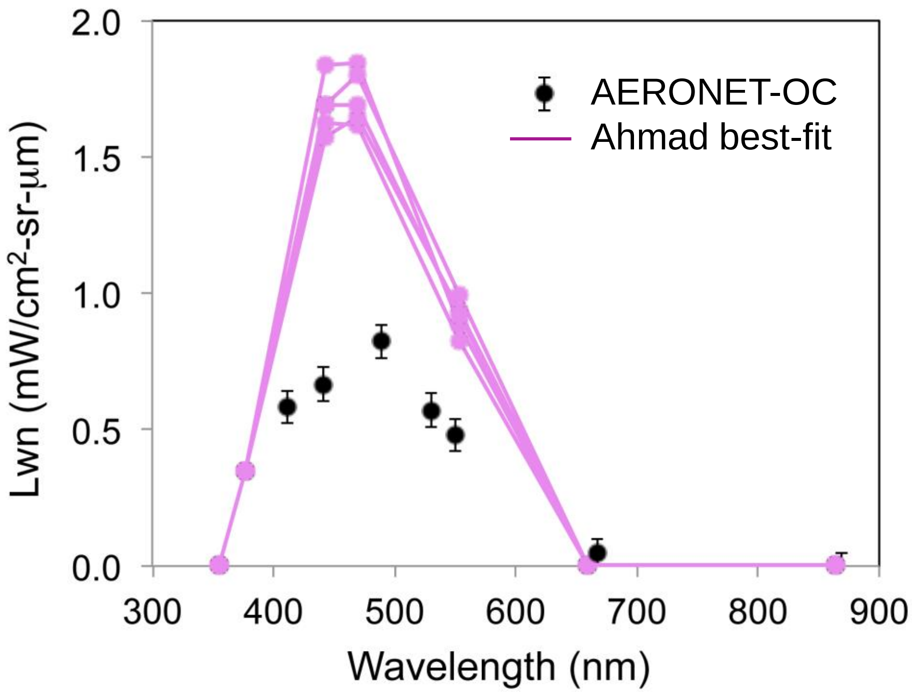
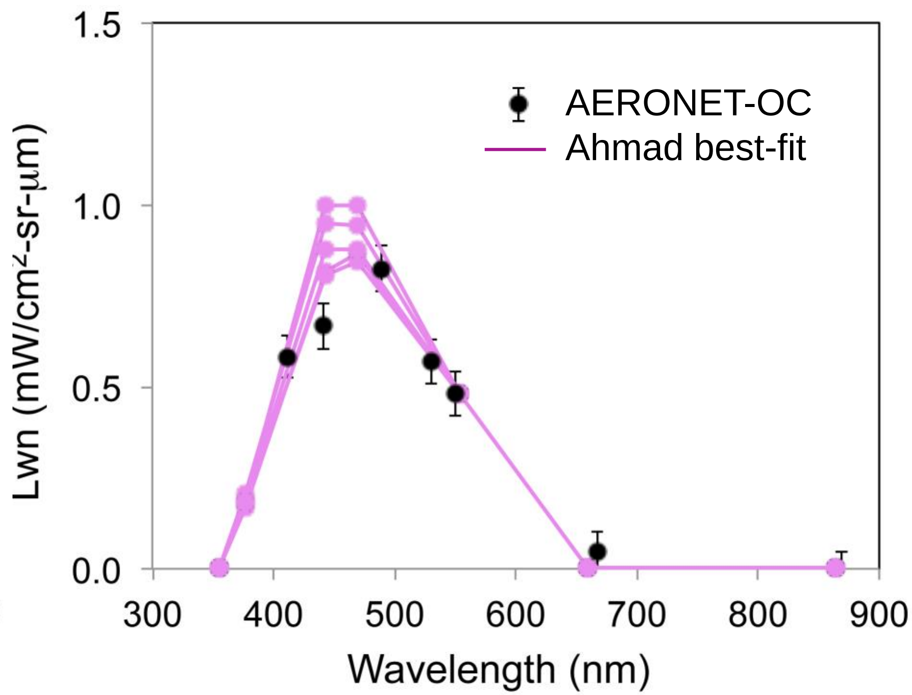


- ❖ Colored symbols: Mean and spread of AirMSPI retrieval results based on 8 initial guesses.
- ❖ Blacks symbols: SeaPRISM observations with error bars denoting PACE SDT uncertainty target.

Effect of scaling normalized water leaving radiances





Since standard Chl-a retrievals use band ratios of blue to green, retrievals were normalized by the 555 nm value.

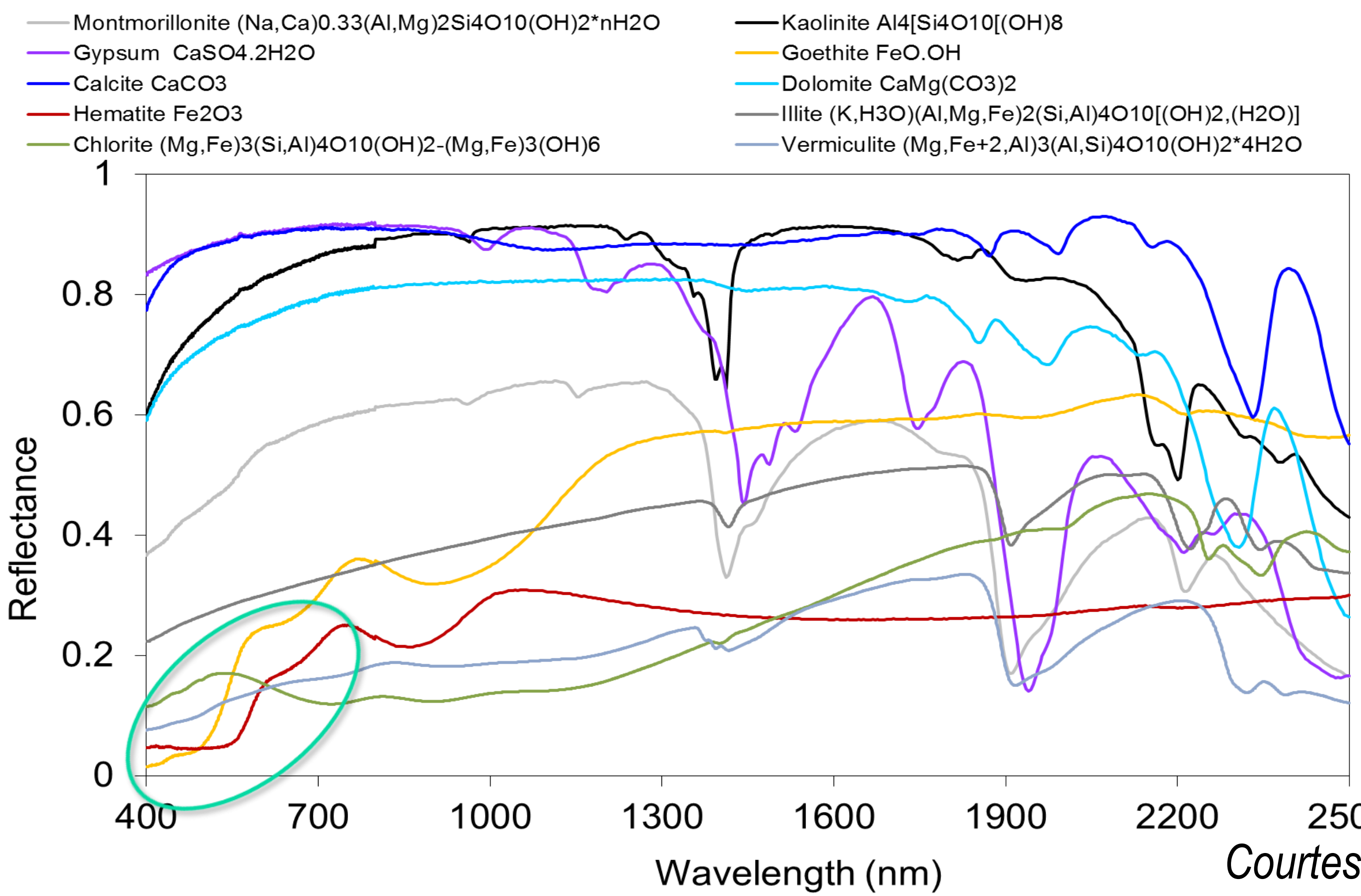
- The band-ratio approach works well for spectrally flat, absorbing aerosols
- Coupled atmosphere-ocean retrievals from a multi-angle polarimeter would help in cases of “complicated” aerosols, and in the case where the surface spectrum is not simply modeled by a chlorophyll concentration only

Discussion points

- Dust and Brown Carbon strongly absorb in the UV, similar to CDOM absorption
- Unaccounted aerosol absorption at near-UV and blue can lead to Rrs biases beyond PACE defined threshold of maximum of 20% or 0.004 over the λ of 350 – 395 nm, and the maximum of 5% or 0.001 over the λ of 400 – 600 nm
- Aerosol absorption features vary significantly depending on aerosol internal and external mixing, and cannot be approximated by a simple spectral model at UV and blue wavelengths
- Multiangle polarimetry distinguishes atmosphere and surface absorption in the UV-VNIR
- We expect a polarimeter to provide a risk reduction for PACE's Rrs retrievals at short wavelengths and for coastal waters

Feedback is welcome

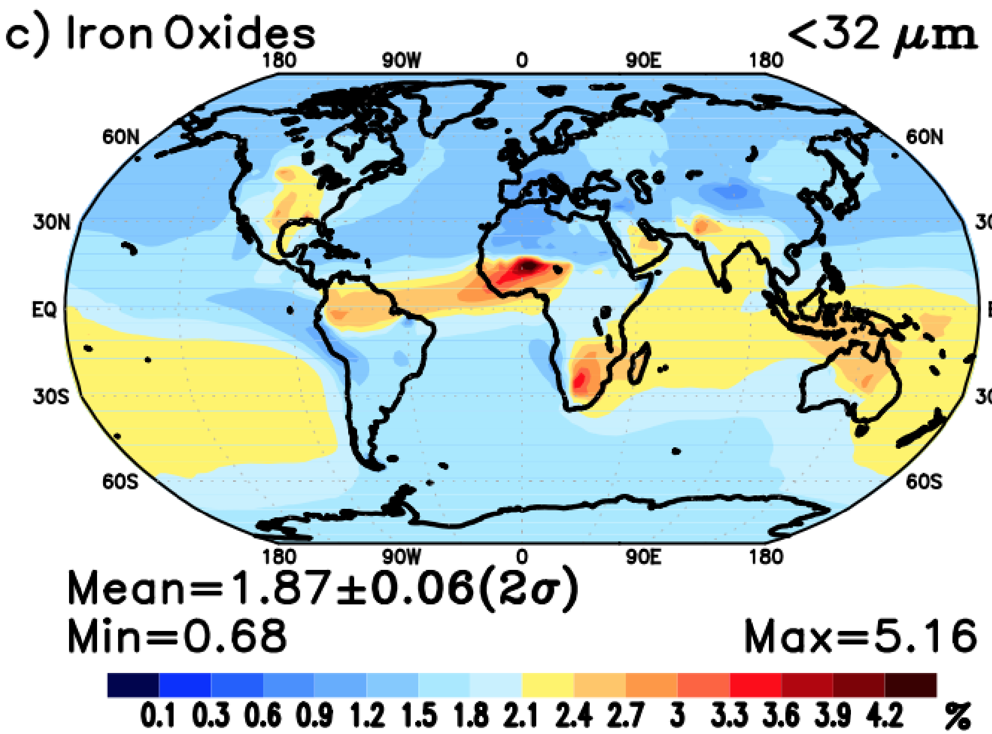
Dust spectral features



Courtesy of Rob Green

Dust aerosols are composed of *internal and external mixtures* of different minerals. Iron oxides dominate dust short VIS-UV absorption spectra.

Atmospheric dust spectra cannot be easily approximated



Perlwitz et al., [2015]

Iron Oxide content of the atmospheric mineral dust varies globally from 1 to 10%