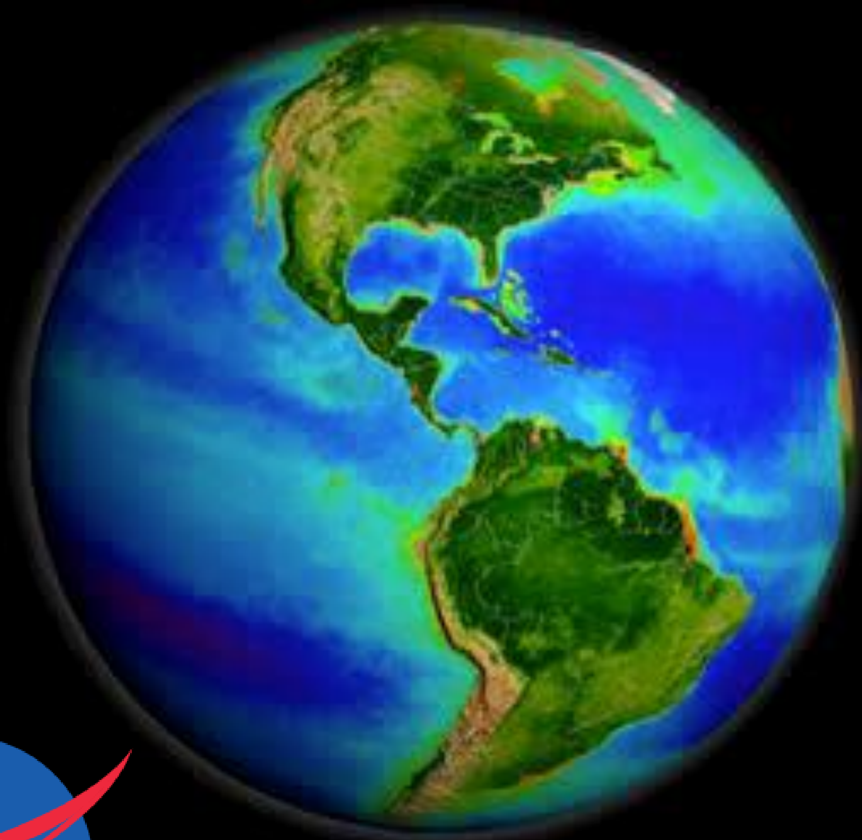
Atmospheric correction of hyperspectral ocean color sensors: application to HICO



Amir Ibrahim

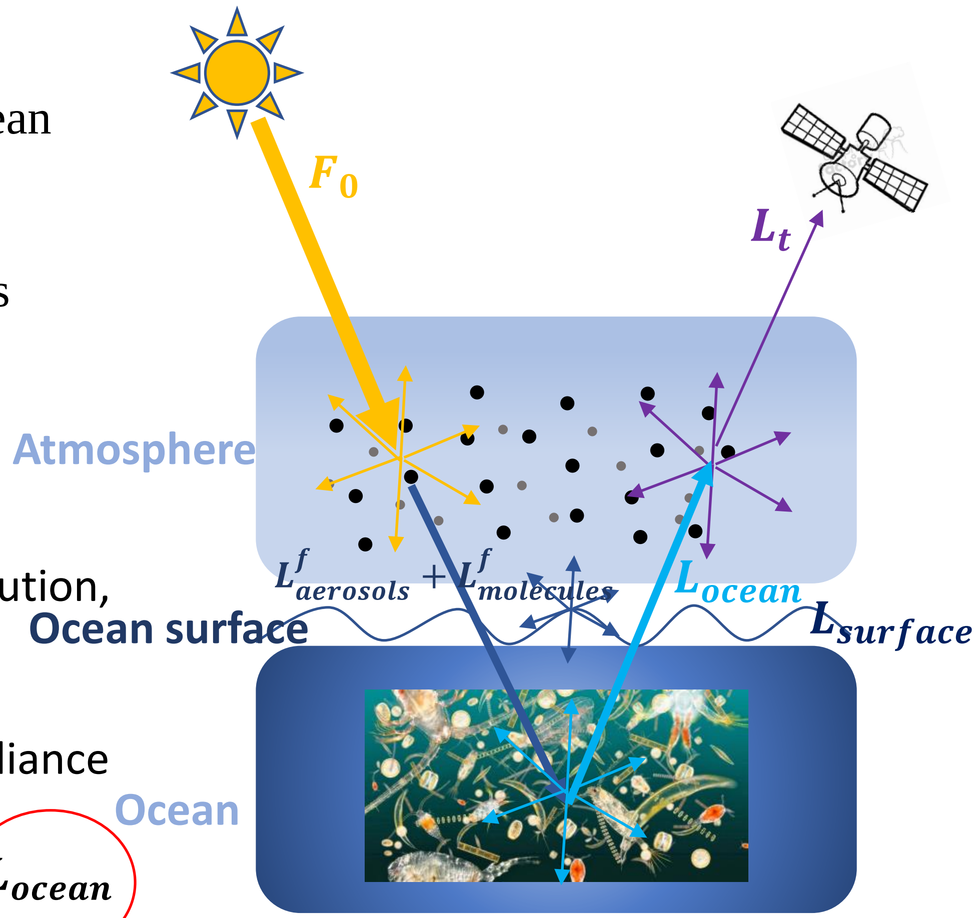
NASA GSFC / USRA

Bryan Franz, Zia Ahmad, Kirk knobelspiesse
(NASA GSFC), and Bo-Cai Gao (NRL)

Remote sensing of the Atmosphere-Ocean system

Solar Light interacts with the Atmosphere-Ocean system according to the following principles:

- Scattering by Aerosols, hydrosols and gases
- Absorption by Aerosols, hydrosols and gases
- Reflection and refraction of the air-sea interface



For simplicity, we assume the radiance contribution, $\boldsymbol{L}$, of every component of the AO system to be additive:

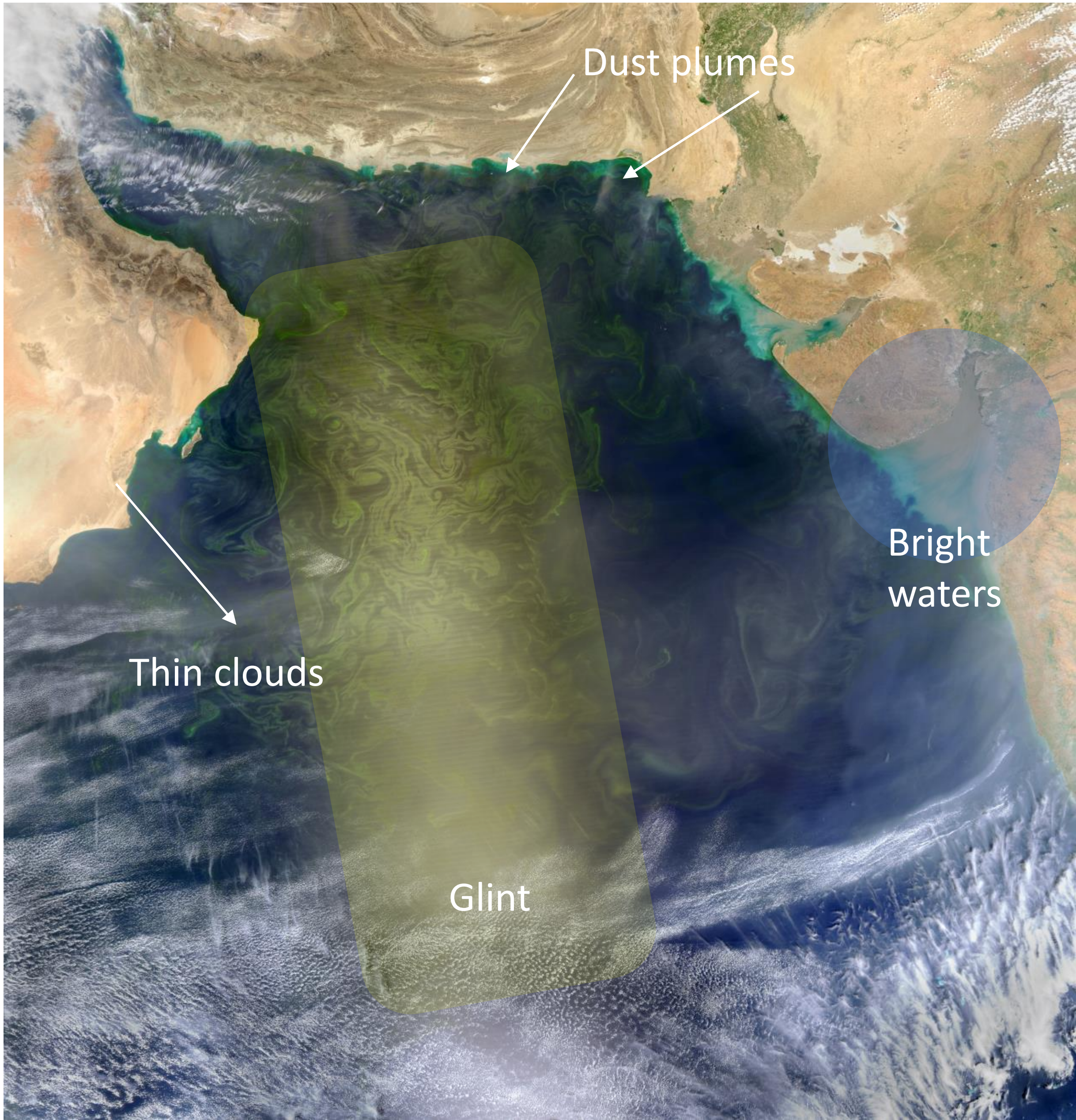
- Satellite observations measure the total radiance at the top of atmosphere, L_t
- $L_t = L_{aerosols} + L_{molecules} + L_{surface} + L_{ocean}$

Ocean color enthusiasts need to measure this signal. Is that simple? ….. NO

MODIS Aqua scene of the Arabian sea

- Natural scenes acquired from space can be complex:
    - Absorbing aerosols
    - Strong Sun glint
    - Bright waters
    - Thin clouds

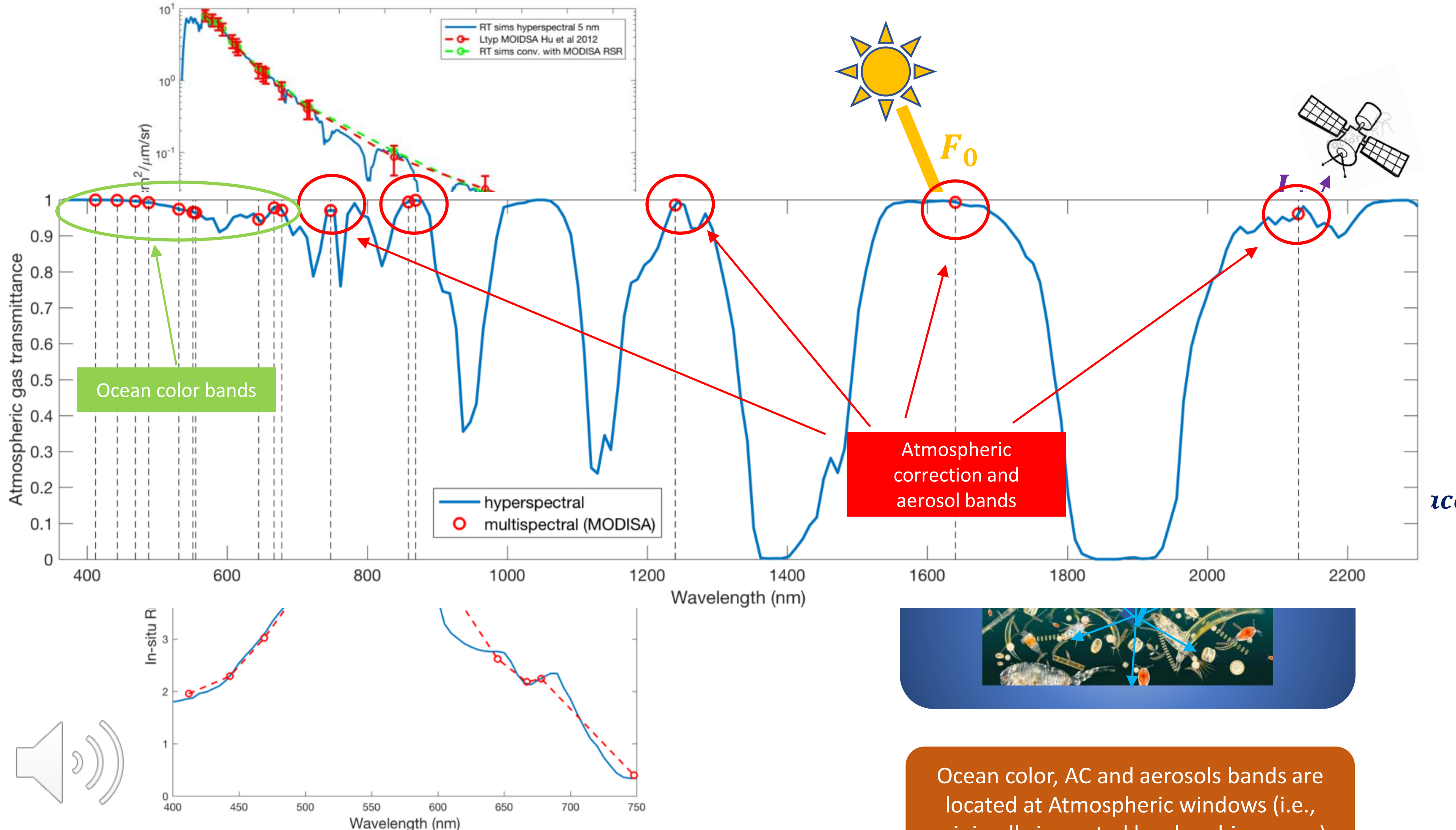
- Several atmospheric correction techniques are used in NASA's ocean color operational algorithm to mitigate these problems



Heritage Multi-spectral spaceborne sensors

MODIS Aqua example:

- Spectral information content:



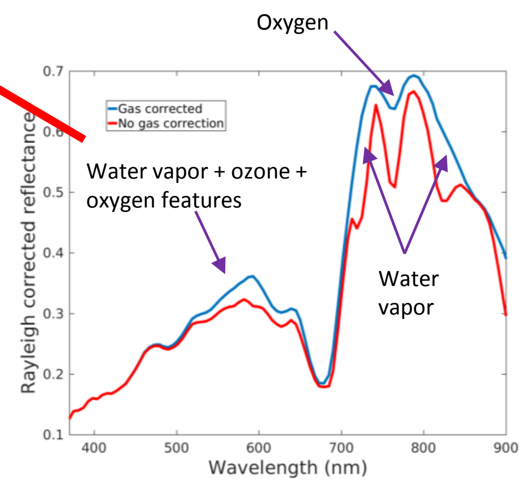
Ocean color, AC and aerosols bands are located at Atmospheric windows (i.e., minimally impacted by absorbing gases)

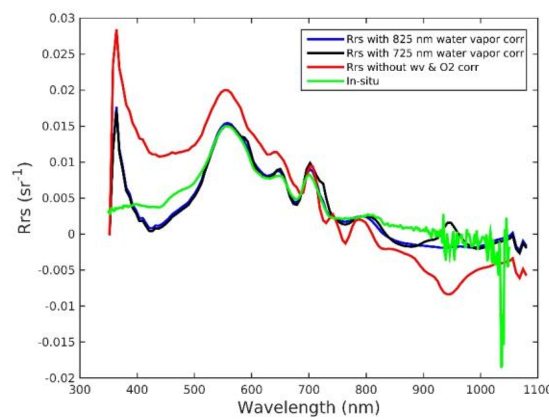
Why do we need to compensate for absorbing gases in the AC?

- Absorbing gases including: water vapor, oxygen, ozone and nitrogen dioxide modulate the measured TOA radiance significantly within the visible spectrum.

- A correction algorithm for gases is need to removed the unwanted spectral features in ocean reflectance.

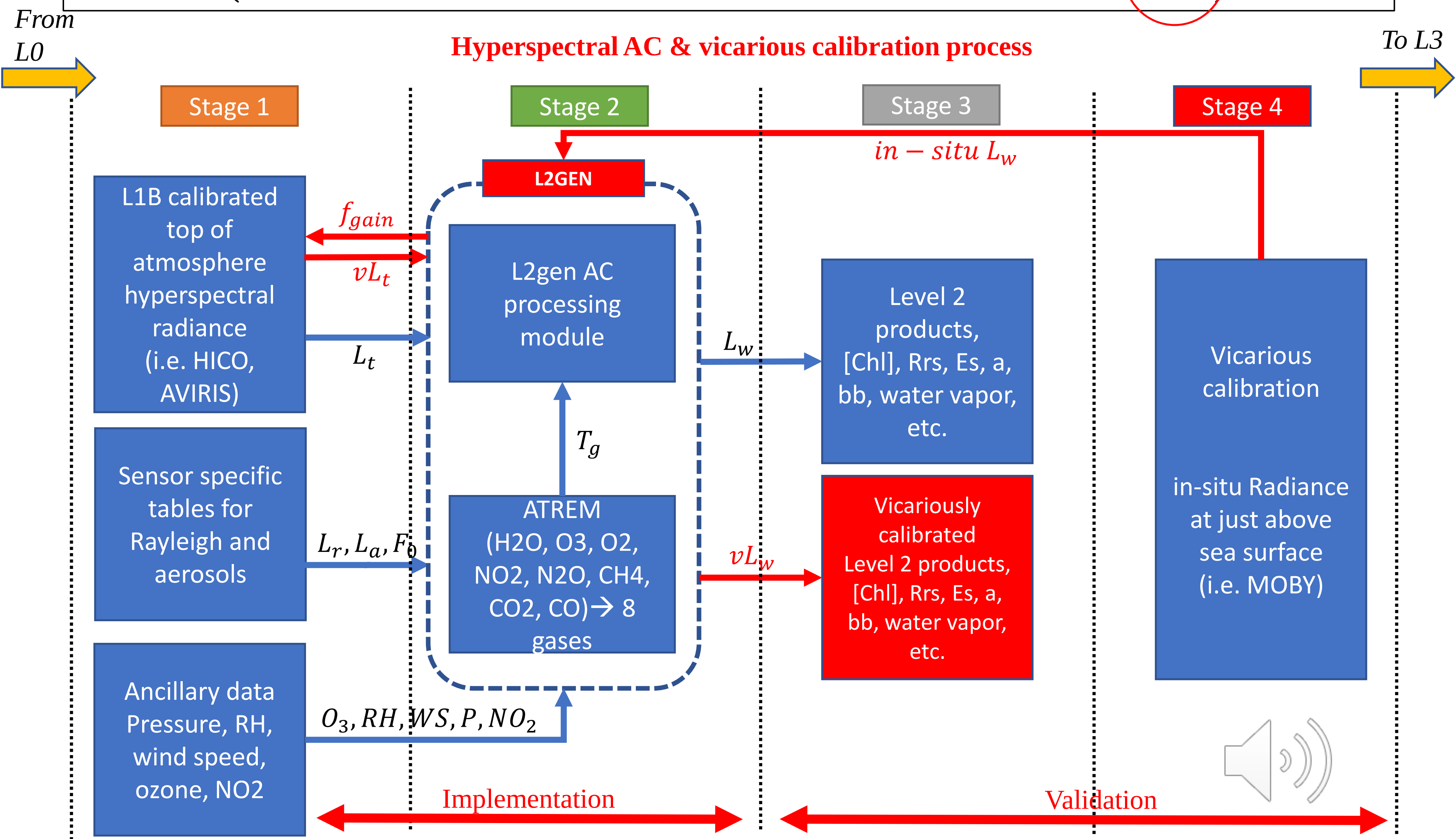
- Erroneous correction of gases can significantly degrade ocean color data quality and plankton type algorithms.



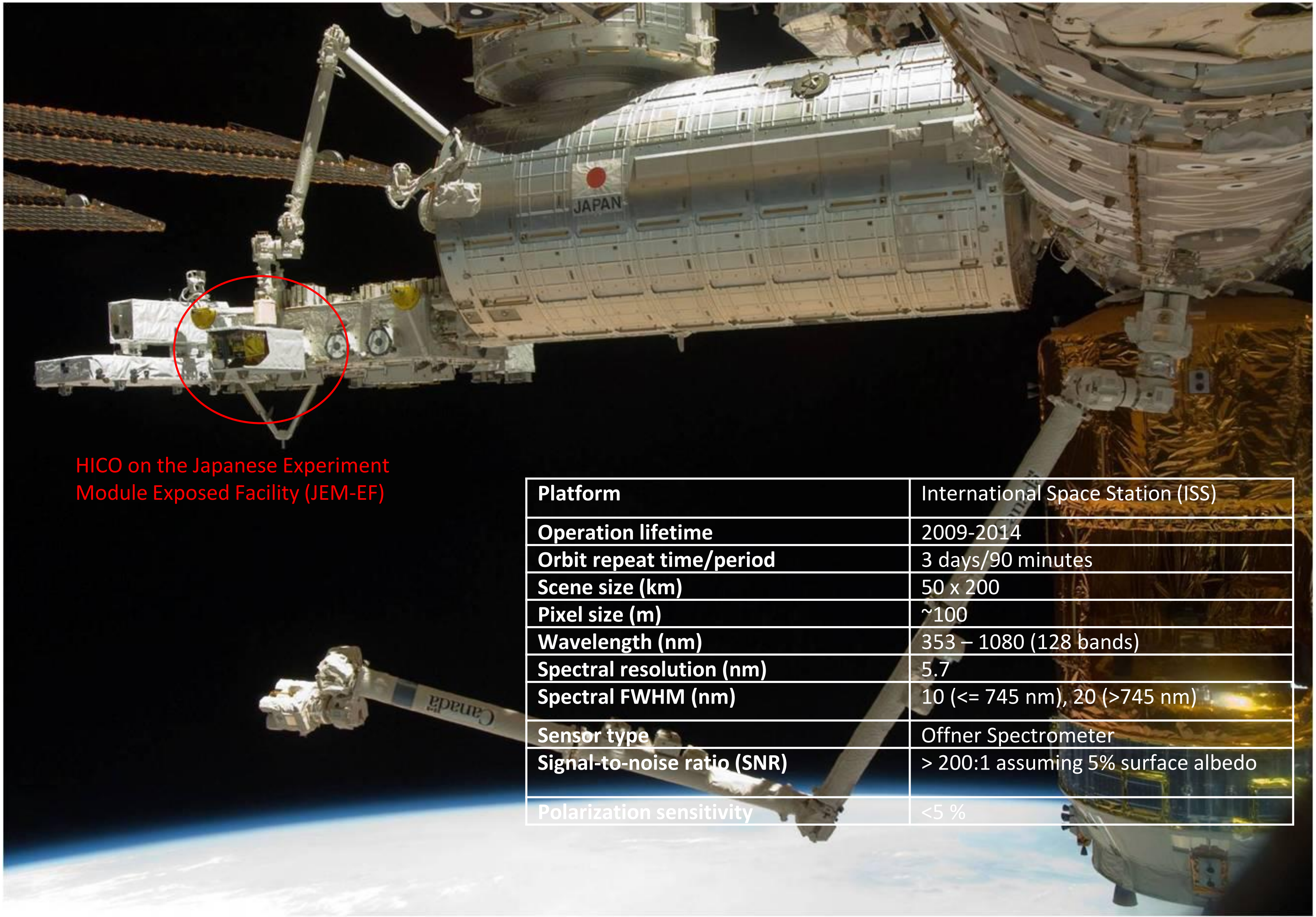


NASA's operational multispectral AC algorithm extended to hyperspectral

$$L_t(\lambda) = \left(L_r(\lambda) + L_a(\lambda) + L_{ra}(\lambda) + t(\lambda)L_f(\lambda) + T(\lambda)L_g(\lambda) + t(\lambda)L_w(\lambda)\right) \times T_g(\lambda)$$



Hyperspectral Imager for Coastal Ocean (HICO)



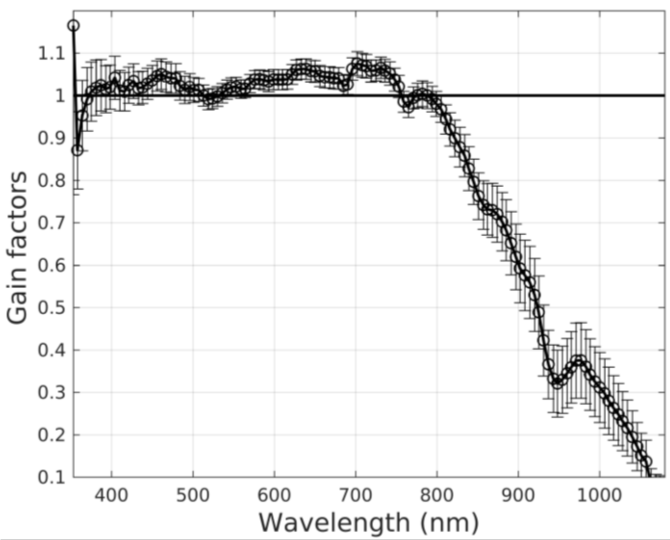
HICO on the Japanese Experiment Module Exposed Facility (JEM-EF)

Platform	International Space Station (ISS)
Operation lifetime	2009-2014
Orbit repeat time/period	3 days/90 minutes
Scene size (km)	50 x 200
Pixel size (m)	~100
Wavelength (nm)	353 – 1080 (128 bands)
Spectral resolution (nm)	5.7
Spectral FWHM (nm)	10 (<= 745 nm), 20 (>745 nm)
Sensor type	Offner Spectrometer
Signal-to-noise ratio (SNR)	> 200:1 assuming 5% surface albedo
Polarization sensitivity	<5 %

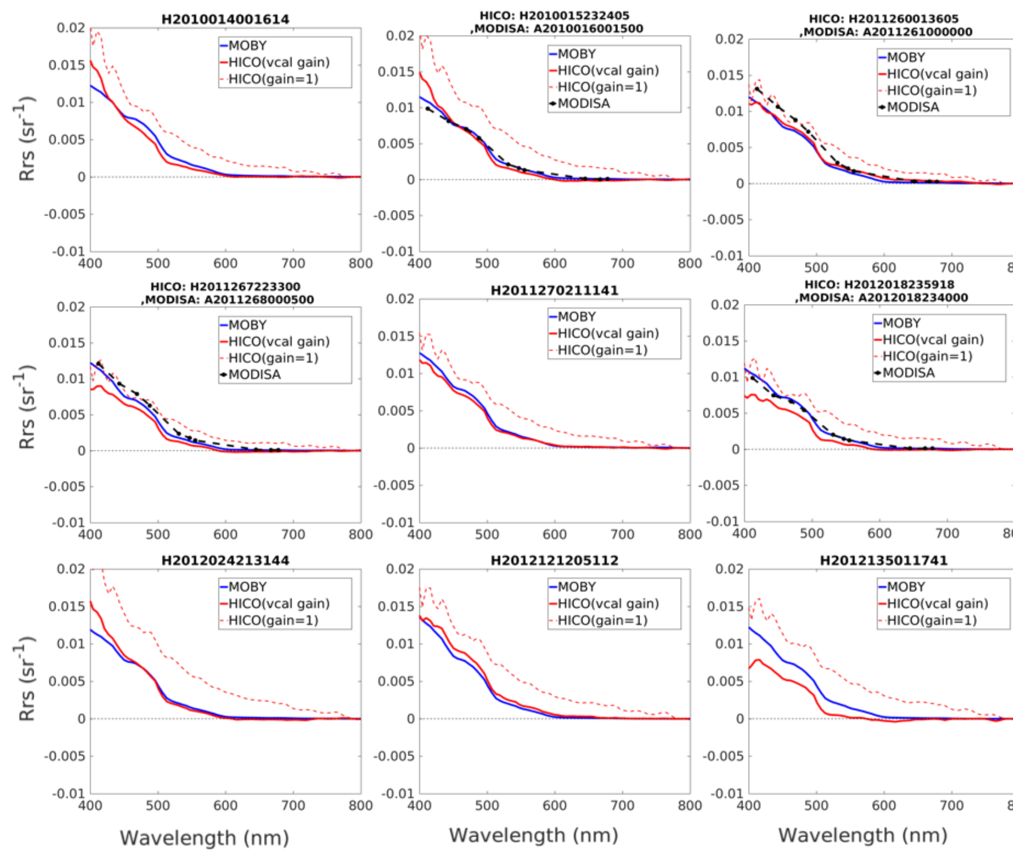
Vicarious calibration of HICO

- Because of HICO’s calibration problems, such as thermal instability, second order diffraction effects, and lack of an on-board calibration system, a vicarious calibration of HICO is needed to improve ocean color data quality

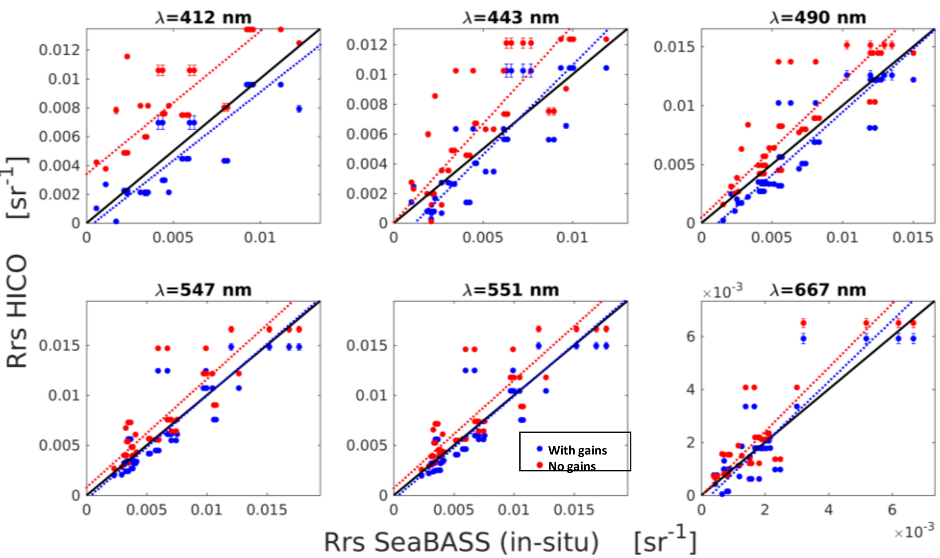
Based on co-incident, co-located in-situ MOBY data, vicarious gains were derived



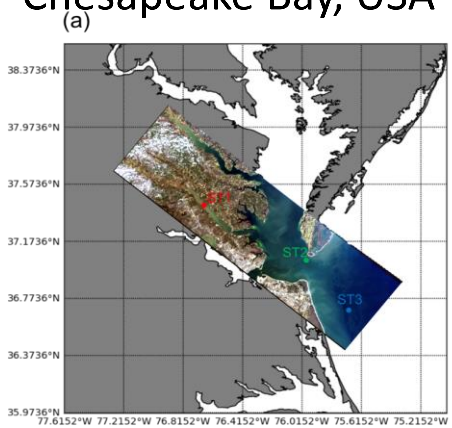
At MOBY

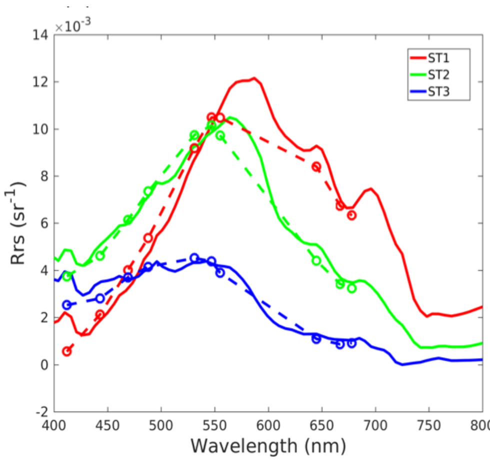


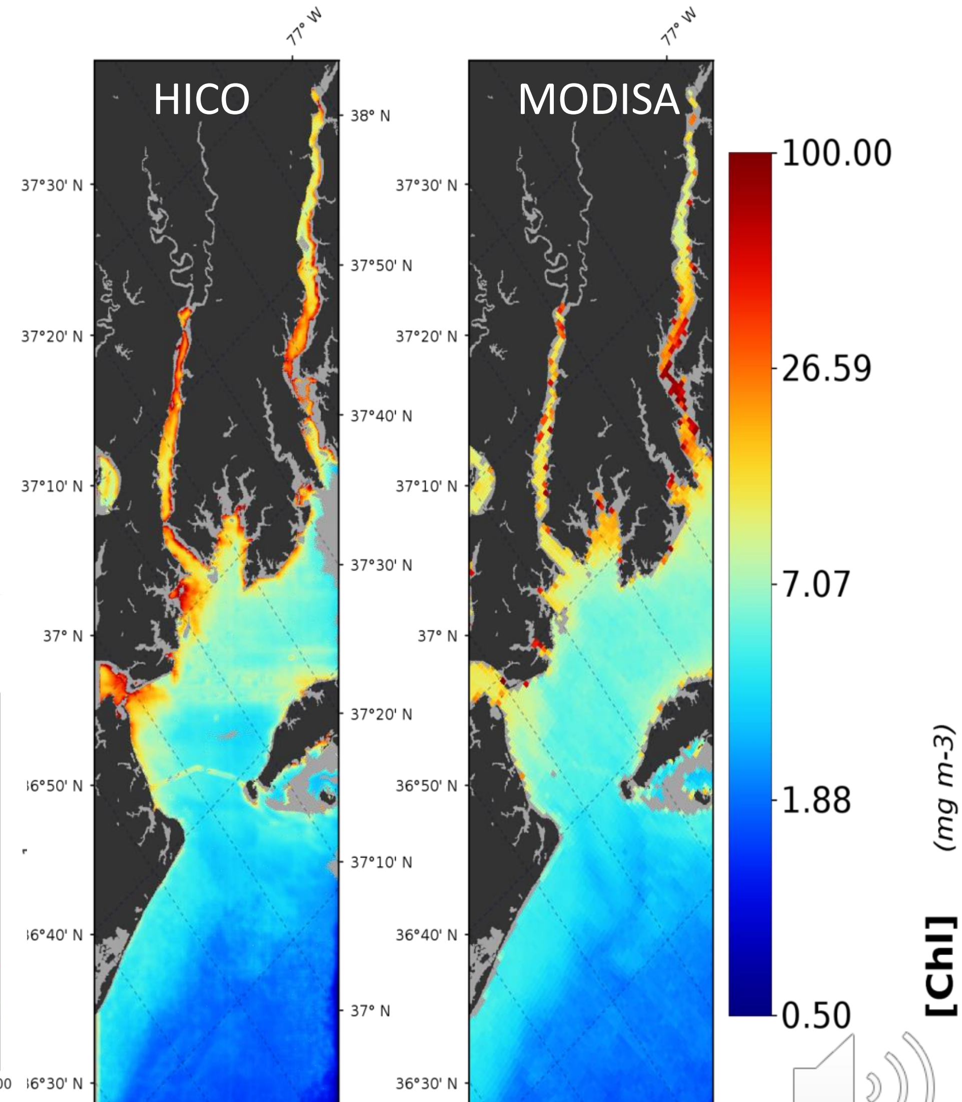
Global in-situ to HICO validation and MODISA to HICO comparison



Chesapeake Bay, USA







2.5 hours difference

Conclusion

- Hyperspectral ocean color remote sensing requires a proper compensation for absorbing gases in the atmosphere.
- NASA's operational multispectral AC algorithm has been extended to hyperspectral to include compensation of all gases, especially water vapor and oxygen.
- After the vicarious calibration of HICO, derived ocean color products were improved.
- The hyperspectral AC algorithm for HICO is currently available through SeaDAS version 7.4 on https://oceancolor.gsfc.nasa.gov

Thank you for listening!