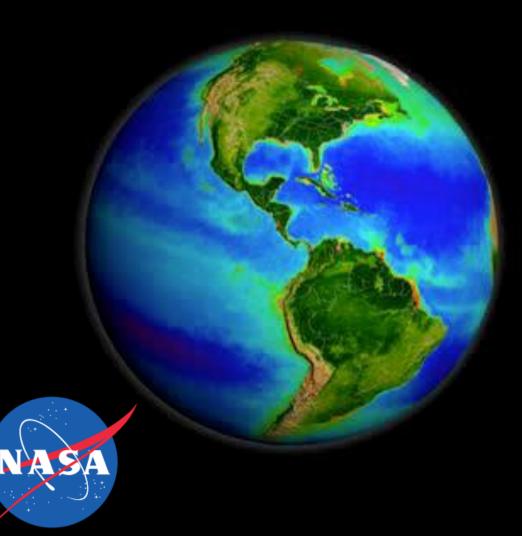
Atmospheric correction of hyperspectral ocean color sensors: application to HICO



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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

Atmosphere

 $L'_{aerosols}$ +

molecules

Locean

Lsurface

For simplicity, we assume the radiance contribution, L_a , of every component of the AO system to be **Ocean surface** additive:

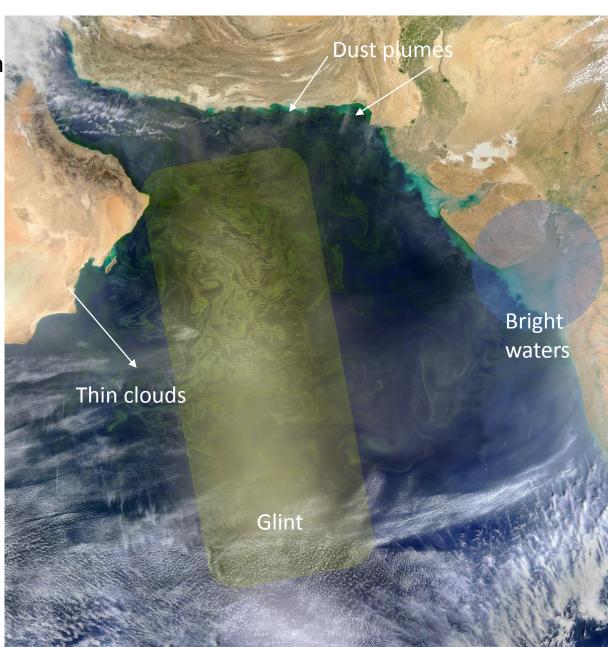
Satellite observations measure the total radiance at the top of atmosphere, L_t

$$\succ L_t = L_{aerosols} + L_{molecules} + L_{surface} + L_{ocean}$$

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

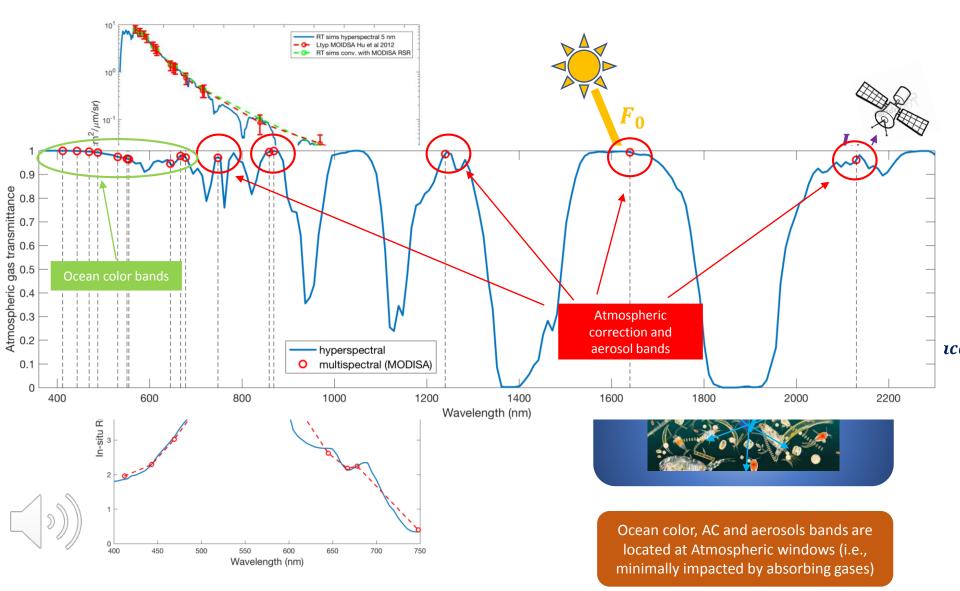
MODIS Aqua scene of the Arabian sea

- 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:



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

- Absorbing gases \succ 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.

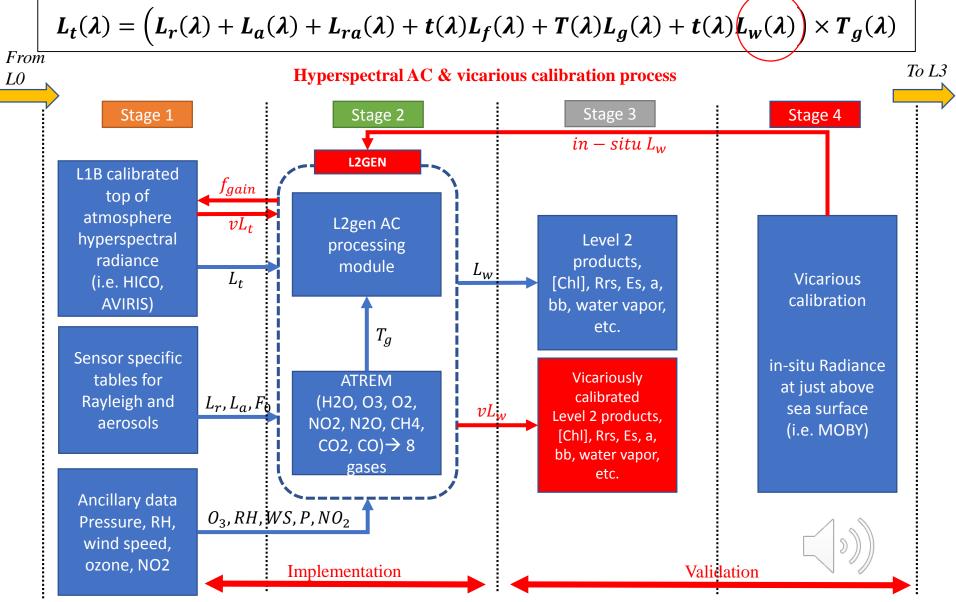
Oxygen 0.7 Gas corrected No gas correction Rayleigh corrected reflectar Water vapor + ozone + oxygen features Water vapor 400 500 600 700 800 Wavelength (nm) 0.03 Rrs with 825 nm water vapor corr 0.025 Rrs with 725 nm water vapor co Rrs without wy & O2 com 0.02 0.015 Rrs (sr⁻¹) 0.01 -0.005 **HICO: East Coast** -0.01 of Australia, -0.015 hodesmium -0.02 300 400 500 900 1000 800 Wavelength (nm) olooms



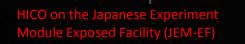
900

1100

NASA's operational multispectral AC algorithm extended to hyperspectral



Hyperspectral Imager for Coastal Ocean (HICO)



6 0

epeue

Platform	International Space Station (ISS)
Operation lifetime	2009-2014
Orbit repeat time/period	3 days/90 minutes
Scene size (km)	50 × 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



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

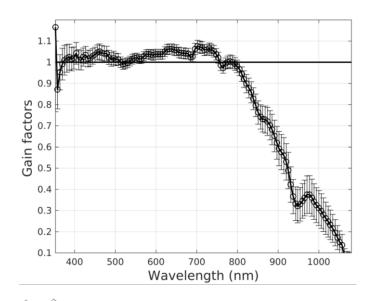
500

Wavelength (nm)

700

800

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



HICO: H2010015232405 H2010014001614 HICO: H2011260013605 0.02 MODISA: A2010016001500 ODISA: A201126100000 0.02 0.02 -MOBY -MOBY MOBY HICO(vcal gain) 0.015 -HICO(vcal gain) 0.015 0.015 HICO(vcal gain) HICO(gain=1) HICO(gain=1) HICO(gain=1) Rrs (sr⁻¹) 0.01 MODISA MODISA 0.01 0.0 0.005 0.005 0.005 -0.005 -0.005 -0.005 -0.01 400 -0.01 400 -0.01 400 500 600 800 500 600 700 800 600 700 800 HICO: H2011267223300 HICO: H2012018235918 H2011270211141 MODISA: A2012018234000 MODISA: A2011268000500 0.02 0.02 0.02 -MOBY MOBY -MOBY -HICO(vcal gain) 0.015 0.015 -HICO(vcal gain) HICO(vcal gain) 0.015 HICO(gain=1) HICO(gain=1) HICO(gain=1) Rrs (sr⁻¹) MODISA 0.01 MODISA 0.01 0.01 0.005 0.005 0.005 -0.005 -0.005 -0.005 -0.01 -0.01 500 600 700 800 400 500 600 700 800 200 500 600 700 800 H2012024213144 H2012121205112 H2012135011741 0.02 0.02 0.02 MOBY -MOBY MOBY HICO(vcal gain) -HICO(vcal gain) -HICO(vcal gain) 0.015 0.015 0.015 HICO(gain=1) HICO(gain=1) HICO(gain=1) Rrs (sr⁻¹) 0.01 0.01 0.01 0.005 0.005 0.005 -0.005 -0.005 -0.005 -0.01 400 -0.01

500

600

Wavelength (nm)

700

800

500

600

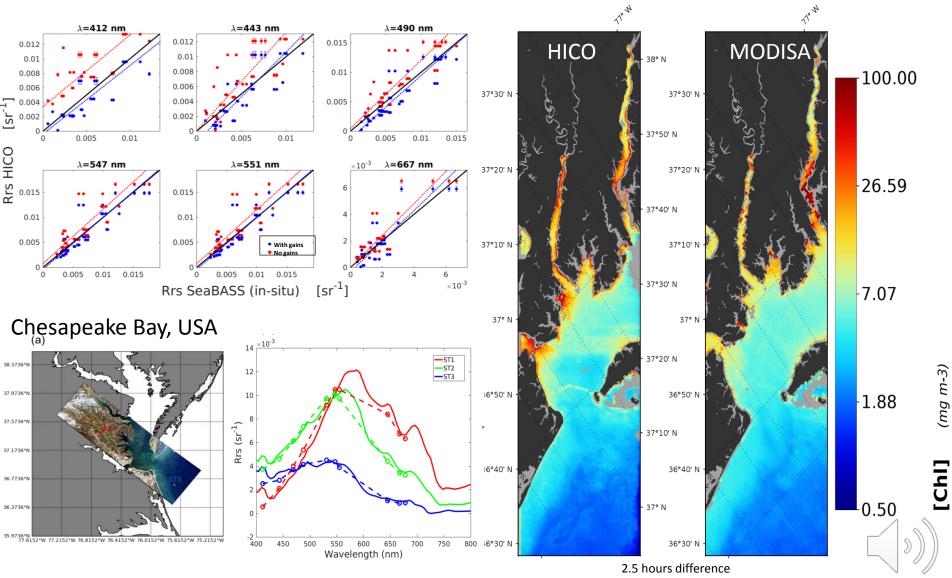
Wavelength (nm)

700

800

At MOBY

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



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!