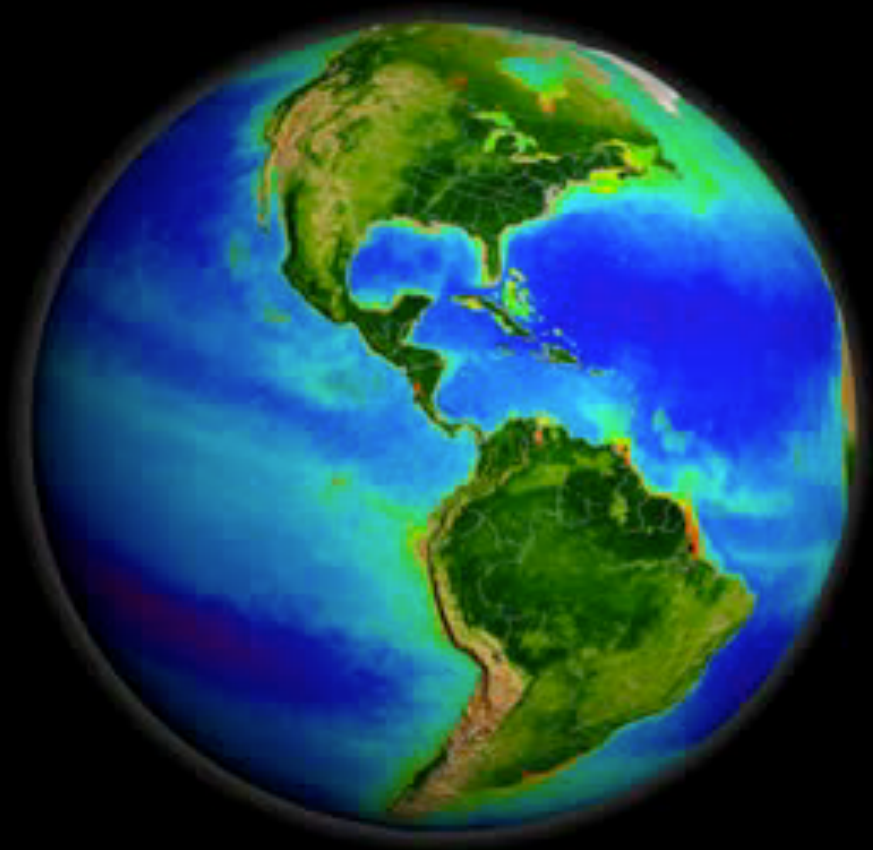
Atmospheric correction of hyperspectral ocean color sensors of *Trichodesmium* bloom



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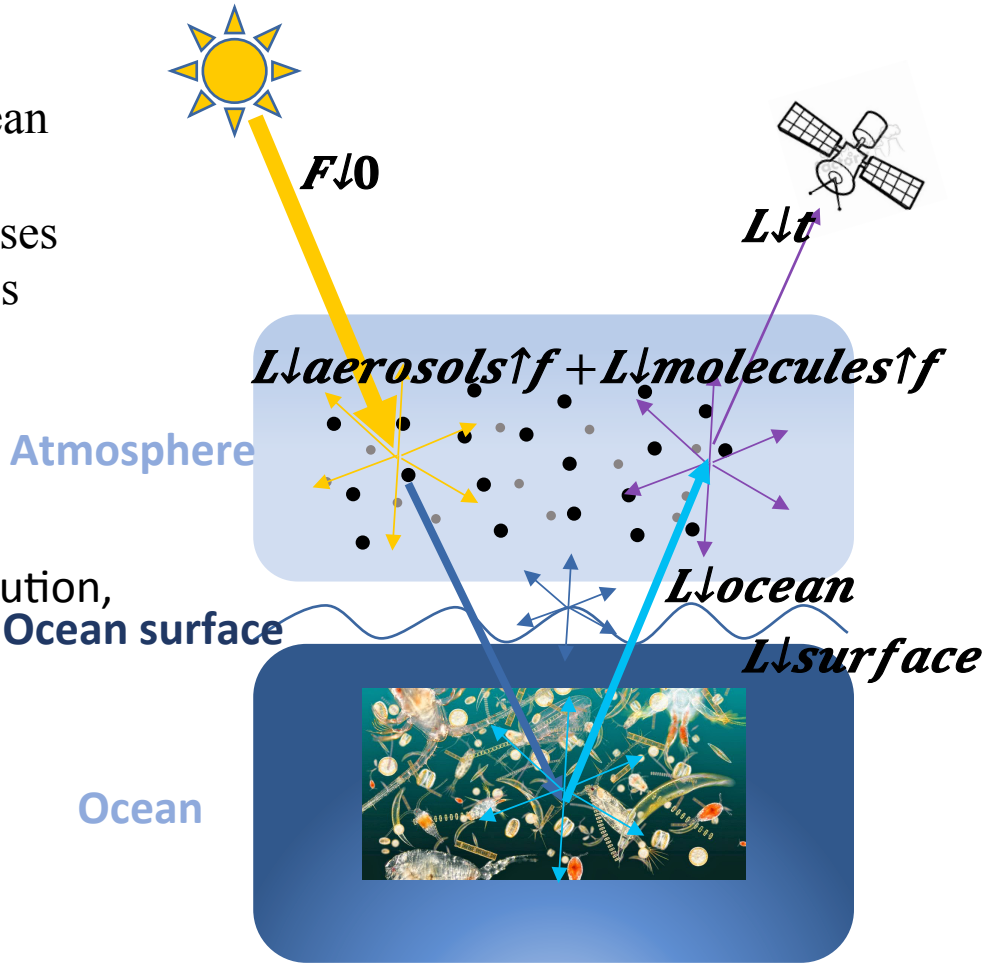
Remote sensing of the Atmosphere-Ocean system

Solar Light interacts with the Atmosphere-Ocean system follows principals:

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



For simplicity, we assume the radiance contribution, L, of every component of the AO system to be additive:

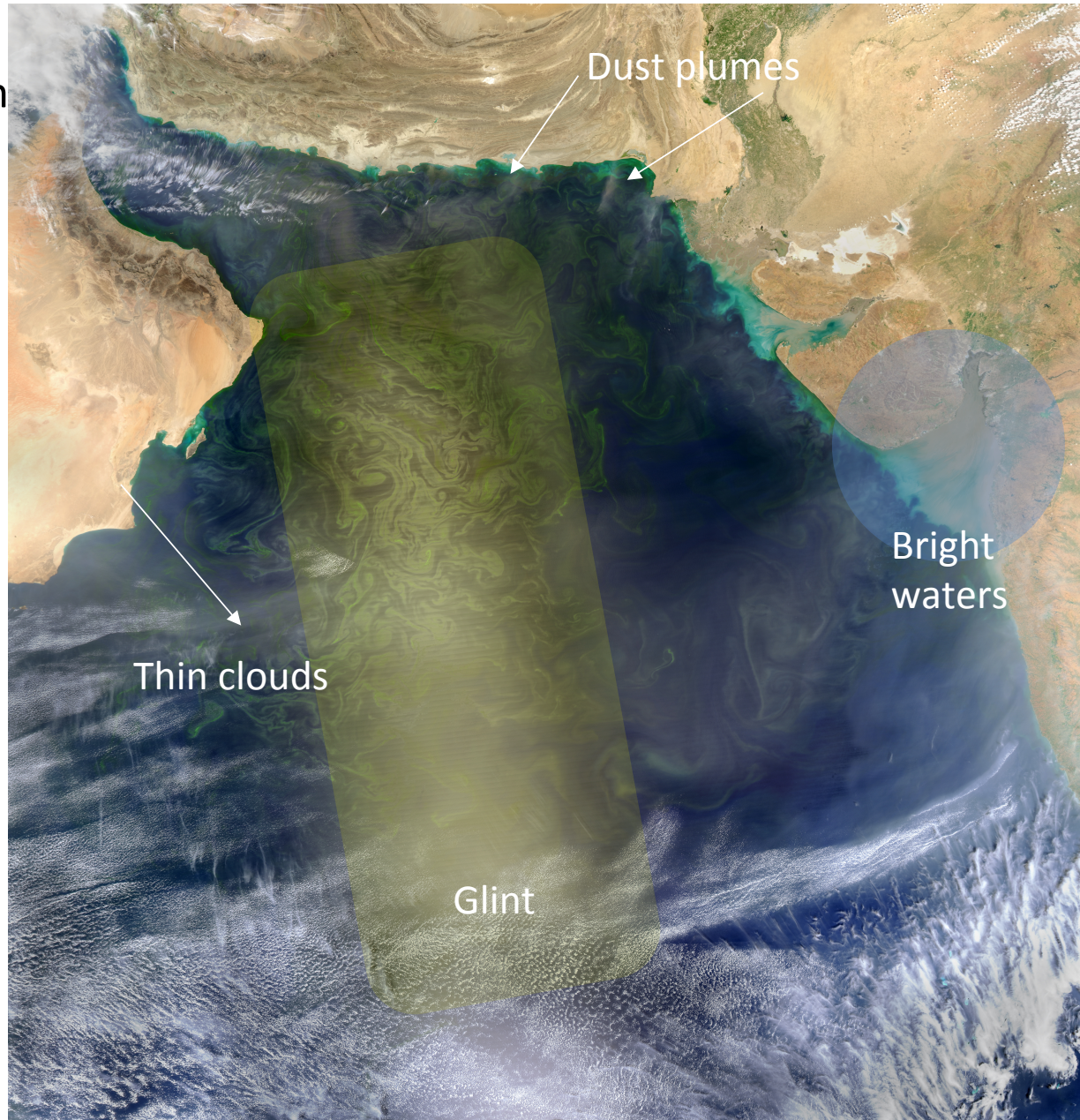
- Satellite observations measures the total radiance at the top of atmosphere, $L\downarrow t$
- $L\downarrow t = L\downarrow aerosols + L\downarrow molecules + L\downarrow surface + L\downarrow ocean$

Ocean color enthusiasts need to measure this signal. Is 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

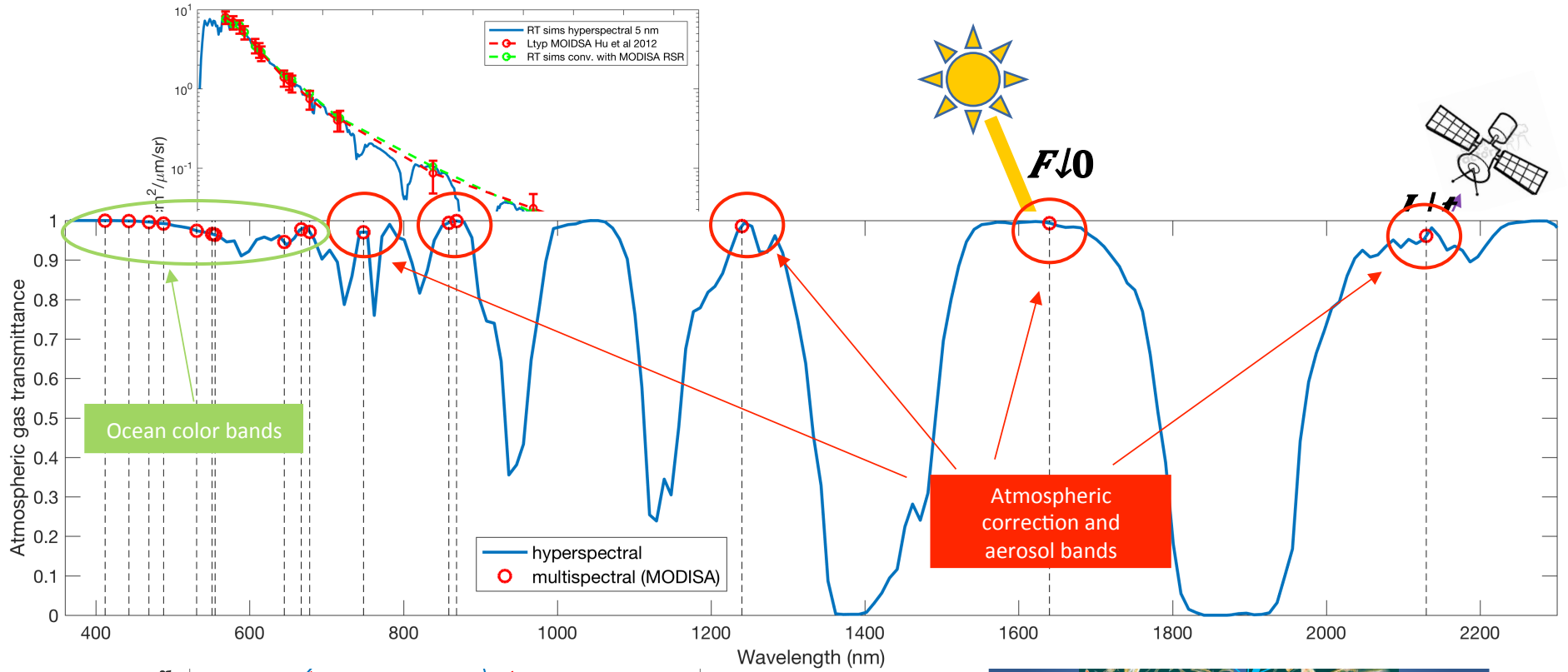
- Several atmospheric correction techniques are used in NASA's ocean color operational algorithm to mitigate these problems

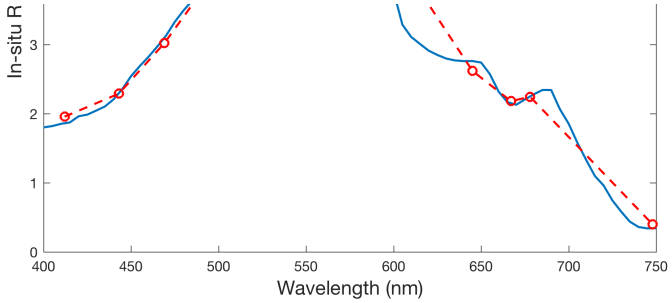


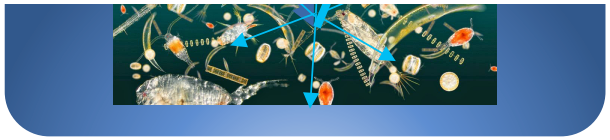
Heritage Multi-spectral spaceborne sensors

MODIS Aqua example:

- Spectral information content:



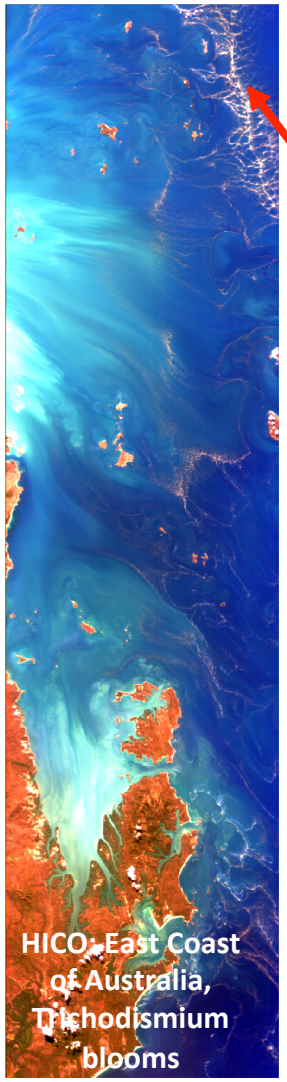


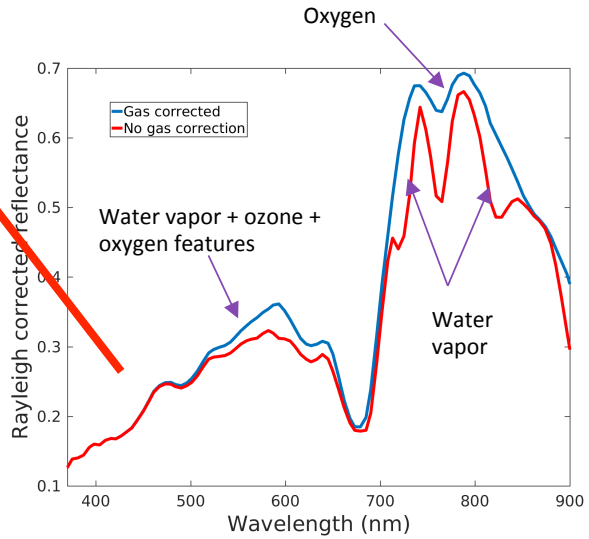


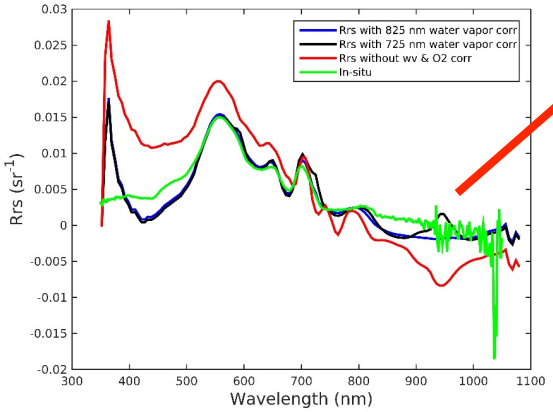
Ocean color, AC and aerosols bands are located at Atmospheric windows, (i.e. minimally impacted by absorbing gases)

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

- Absorbing gases including: water vapor, oxygen, ozone and nitrogen dioxide modulates the measured TOA radiance significantly within the visible spectrum.
- A correction algorithm for gases is need to remove the unwanted spectral features in ocean reflectance.
- Erroneous correction of gases can significantly degrade ocean color data quality and plankton type algorithms







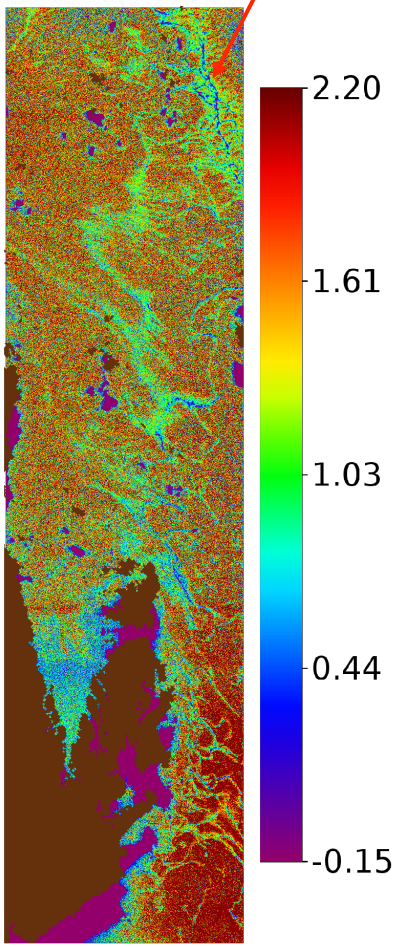
HICO Example

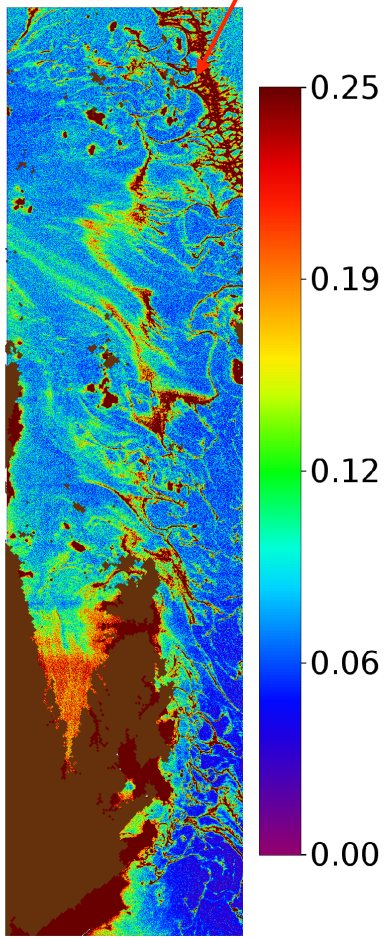
Surface Trichodesmium blooms

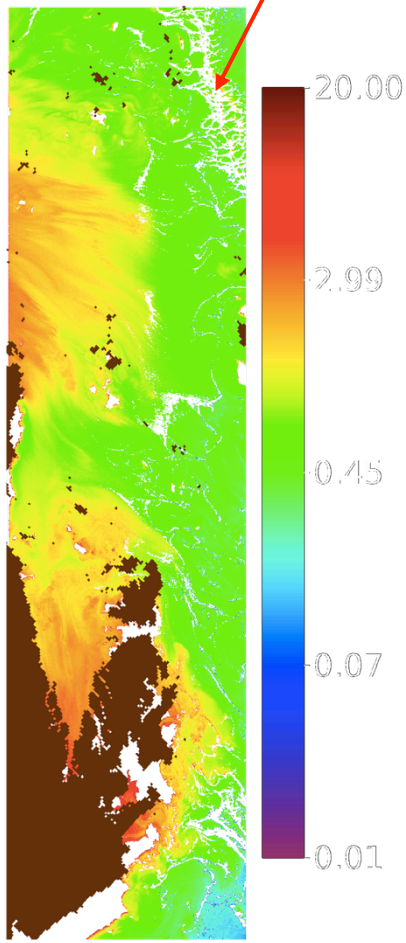
Erroneous aerosol model selection

Over estimation of aerosol optical thickness

CHL product because of negative Rrs







If the AC algorithm does not flag bright pixels as clouds, the algorithm treats the bright water as an increased in aerosols concentration in the atmosphere, and therefore over correcting for aerosols leading to negative reflectance of the ocean

Standing problems with AC

- AC typically fails over bright surfaces such as extreme turbidity and surface blooms
- NASA's operational AC algorithm relies on the dark pixel assumption when detecting light in the near infrared (NIR)
- To mitigates bright ocean problems, an iterative NIR correction based on radiative transfer model is successfully utilized
- In extreme bloom conditions or surface blooms such as *Trichodesmium*, the NIR correction method fails due to improper modeling of the bloom spectral signature.
- Also the AC algorithm tend to flag bright surface blooms as clouds.
- In some cases ocean color detectors (bands) saturates, rendering these bands useless for detection due to loss of sensitivity

Future outlook

- Hyperspectral information can improve the flagging that can discriminate between clouds and extreme blooms or floating vegetation.
- The appropriate flagging of *Trichdesmium* would allow an improved AC capabilities based on an improved radiative transfer modeling of NIR reflectance in bloom conditions.
- Future efforts are needed to improve the radiative transfer modeling of bloom conditions and surface vegetation