PACE Science Team 2018:
Atmospheric Correction over Bright Water Targets with Non-negligible Radiances in the Near Infrared

Heidi Dierssen, UCONN
Kate Randolph, Postdoc
Shungu Garaba, Postdoc
Brandon Russell, Postdoc
Tim Bateman, Undergraduate student
How to Differentiate “Bright Targets”

- Whitecaps & Foam
- Sea Ice
- Floating Vegetation
- Floating Plastics etc.
- Bubbles
- Cyanobacteria, Trichodesmium, Red Tides
- Sediment (turbid water)
- Calcite (PIC): Coccoliths
- Seafloor (Optically Shallow)
Research Progress in 2017-2018


Submitted or In prep


PACE Atmospheric Correction Report. In prep. Frontiers in Marine Sciences

Atmospheric correction of whitecaps and bubbles. In prep. Frontiers in Marine Sciences
Be careful using Whitlock whitecaps!

Reflectance standard
• Used Standard barium sulfate as a standard assuming 100%
  – 94-99% reflectance.
  – Newer data shows reflectance is 60-80% heading into SWIR wavelength
Whitlock also used incorrect water absorption in visible.

Fig. 2b Whitlock (1982). Says they used Smith and Baker water absorption (1981) in visible, but that is the red line above and not the values used in the paper.
Why have a hyperspectral whitecap model?

• Differentiate between other white targets like thin clouds, sea ice, vegetation.

• Important for missions like HyspIRI
  – (VSWIR: 380 nm - 2500 nm) in 10 nm contiguous bands and a multispectral
White targets with heritage bands

1030 nm

940 nm

980 nm
Approach to Atmospherically Correct for Whitecaps

• Differentiate between the white manifestations of whitecap – True Reflectance

• Bubbles plumes which make the sea surface “whiter” -- Enhanced Reflectance
Atmospheric Correction Approaches

Ocean community reduces error into the aerosol pool

Atmospheric community reduces error into ocean

- This creates confusion in derived aerosol products and atmospheric community
- Problematic when spectral shape of whitecap is different from aerosol
- Not accurate when modeling Rrs in NIR and SWIR
Wind speed is only a “climatological” predictor of whitecaps and can never predict the instantaneous whitecap fraction.

Much of the whitecap/bubble plume under high wind speeds is removed as aerosol.
Optical methods for measuring whitecaps under natural wave breaking conditions


**Background**
- Whitecaps on the ocean surface are features of significant importance to air-sea interaction.
- Traditional methods of measuring whitecap coverage (i.e., digital video systems) can miss whitecap features that do not produce a high enough contrast to the background.

**Analysis**
- A simple, efficient, automated and robust radiometric method for accurately measuring whitecap quantities (e.g., fractional coverage, optical intensity, decay time, and albedo) was developed for a wide range of wind and wave conditions.
- The method is flexible and objective; viewing geometry can be tuned to optimize the measurement of a particular whitecap quantity.

**Significance**
- Unlike with digital imaging, the radiometric approach allows the subsurface bubble plume to be measured, which contributes to the transfer of lower solubility gases at deeper depths and the production of sea salt aerosols.

- Furthermore, these measurements of ocean color can also be used to estimate the in-water constituents (e.g., CDOM, surfactants, phytoplankton concentration and composition) affecting the evolution of foam and bubbles.
Working to differentiate water absorption bands in whitecaps from other bright targets

Fogarty et al. (2018)

Dierssen et al. (2018)
Conclusions

• More accurate estimates of whitecap reflectance into SWIR
  – Related to Water absorption features

• Working towards different algorithms to use besides wind speed
  – Exploit liquid water absorption bands
  – can be related to magnitude of whitecap reflectance
  – can be measurable at the Top of the Atmosphere
Background
• Albedo of marine waters is generally based on data from open-ocean environments where water-leaving irradiance contributes less than 15% of the total albedo (e.g. Payne, 1972).
• In coastal systems, bottom substrate or suspended particulate matter increases water-leaving irradiance and therefore albedo, and decreases net shortwave heat flux.

Analysis
• Utilized MODTRAN and HydroLight models and field data to estimate the increase in albedo for three test cases: bright sand bottom, seagrass canopy, turbid water.

Findings
• Albedo is significantly increased, particularly for waters with bright sediments, dense horizontal seagrass canopies < 0.25 from the sea surface, or highly turbid waters with total suspended matter (TSM) concentration ≥ 50 g m⁻³.

Significance
• Enhanced albedo in highly scattering waters can decrease heat flux and must be incorporated in models of coastal and estuarine dynamics.

(a) Spectrally resolved reflectance just above the water surface for several test cases, and (b) total albedo as a function of solar zenith angle for all cases, field data, and the Payne (1972) lookup.
Remote sensing of plastic debris
Garaba and Dierssen, 2018, Remote Sensing of Environment
University of Connecticut

Background
- As plastic pollution continues to rise there is need to remotely detect and track debris in the natural environment.
- Technology that allows non-invasive, unmanned and automated detection such as remote sensing becomes a major source of information.

Analysis
- Measured spectral properties of marine-harvested micro- and macroplastics 350 to 2500 nm.
- Investigated location of inherent absorption features of dry and wet marine-harvested plastics.
- Used AVIRIS imagery to test hydrocarbon detection algorithms over land.

Findings
- Dry and wet marine harvested microplastics have similar absorption features but lower reflectance when wet.
- Major absorption features observable with an intervening atmosphere were identified at 1215 and 1732 nm.

Significance
- Remote detection and identification of dry plastics is feasible, but in the aquatic environment spectral mixing simulations suggest there is potential in detection of floating plastics.

Reflectance of aggregated dry marine-harvested microplastics

Atmospheric Transmittance and microplastic mean reflectance.
Impacts of coal dust from an active mine on the spectral reflectance of Arctic surface snow in Svalbard, Norway

Key Points:
- An active coal mine in the Norwegian Arctic has a measurable and
Light absorbing particles in snow
Refractory and effective black carbon

Figure 3. Mean spectral hemispherical directional reflectance factor (HDRF) at nadir generally decreases across all wavelengths with increasing rBC concentrations located downwind and adjacent to the mine.