PACE Science Team 2018:

Atmospheric Correction over Bright Water Targets with Non-negligible Radiances in the Near Infrared

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Photo by Bill Lindsay

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

- Fogarty, M.C., M.R. Fewings, A.C. Paget, **H.M. Dierssen**. 2018. The influence of a sandy substrate, seagrass, or highly turbid water on albedo and surface heat flux. JGR-Oceans.

- Garaba, S. and **H.M. Dierssen**. 2018. An airborne remote sensing case study of synthetic hydrocarbon detection using short wave infrared absorption features identified from marine-harvested macro- and microplastics. Remote Sensing of the Environment.

- Khan, A., **H. Dierssen**, J. Schwarz, C. Schmitt, A. Chlus, M. Hermanson, T. Painter, and D. McKnight. 2017. Impacts of coal dust from an active mine on the spectral reflectance of Arctic surface snow in Svalbard, Norway. J. Geophys. Res. Atmos. 122(3):1767-1778. 10.1002/2016JD025757

- Randolph,K**, H.M. Dierssen,** A. Cifuentes, E. Monahan, W. Balch, and C. Zappa**.** 2017. Novel methods for optically measuring whitecaps under natural wave breaking conditions. J. Atmosph. & Oceanic Tech. 34(3): p. 533-554. DOI: http://dx.doi.org/10.1175/JTECH-D-16-0086.1

- Hedley, J. *B. Russell, *K. Randolph, R.M. Vásquez-Elizondo and H. Dierssen. 2017. Hyperspectral mapping of seagrass leaf area index and species by a physics-based approach: do sensitivity analyses and practical application agree? Frontiers in Marine Science.

Submitted or In prep

Perry, R., J. Vaudrey, and **H.M. Dierssen**. Submitted. Nutrient dynamics and long range transport of floating seagrass wracks in Greater Florida Bay. Estuaries and Coastal Shelf Science.

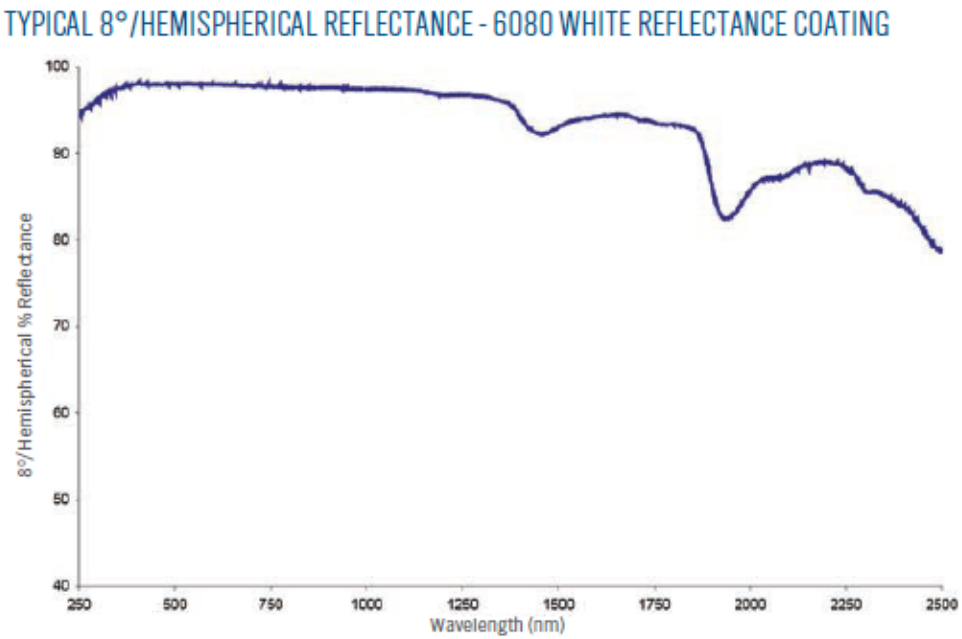
PACE Atmospheric Correction Report. In prep. Frontiers in Marine Sciences

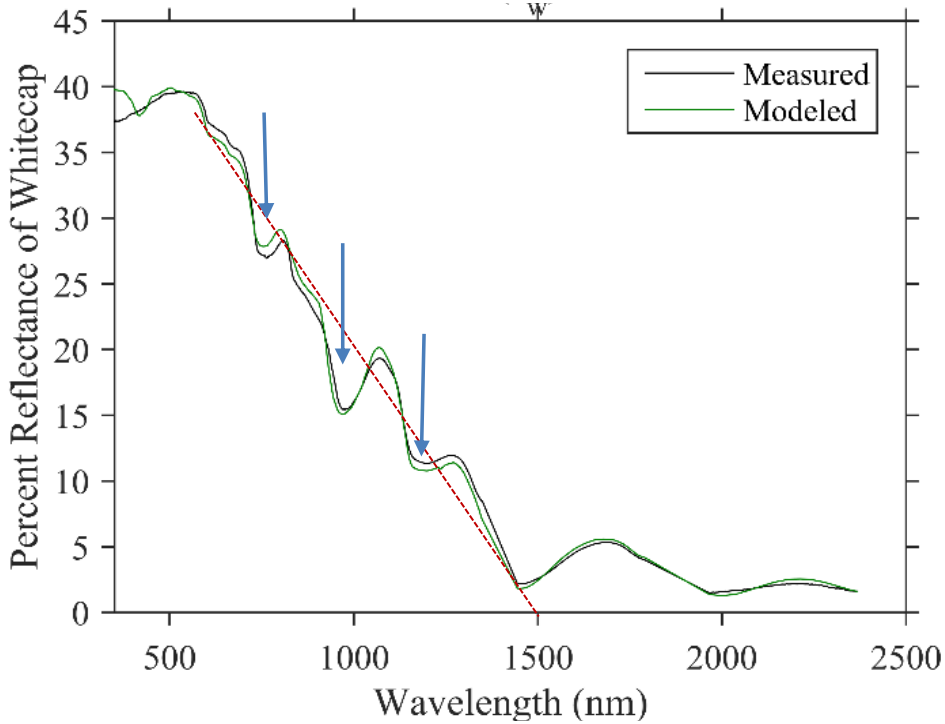
Atmospheric correction of whitecaps and bubbles. In prep. Frontiers in Marine Sciences

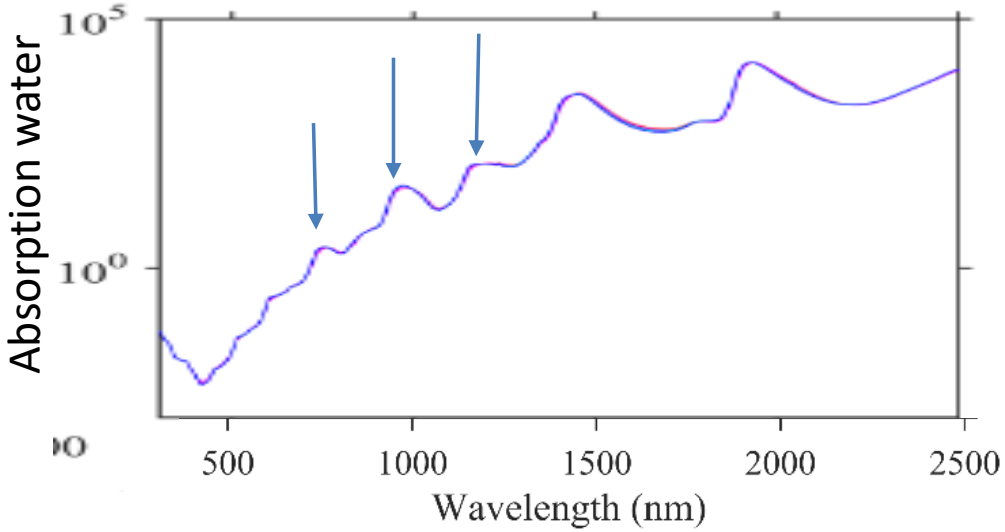
Be careful using Whitlock whitecaps!

Reflectance standard

- Used Standard barium sulfate as a standard assuming 100%
  - 94-99% reflectance.
  - Newer data shows reflectance is 60-80% heading into SWIR wavelgnth




Measured
Modeled
Percent Reflectance of Whitecap
Wavelength (nm)
0
5
10
15
20
25
30
35
40
45
500
1000
1500
2000
2500


Absorption water
Wavelength (nm)
500
1000
1500
2000
2500

Whitlock also used incorrect water absorption in visible.

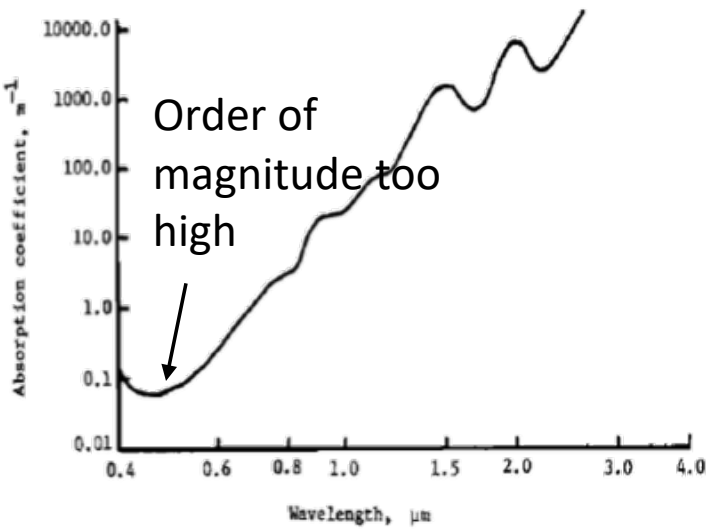
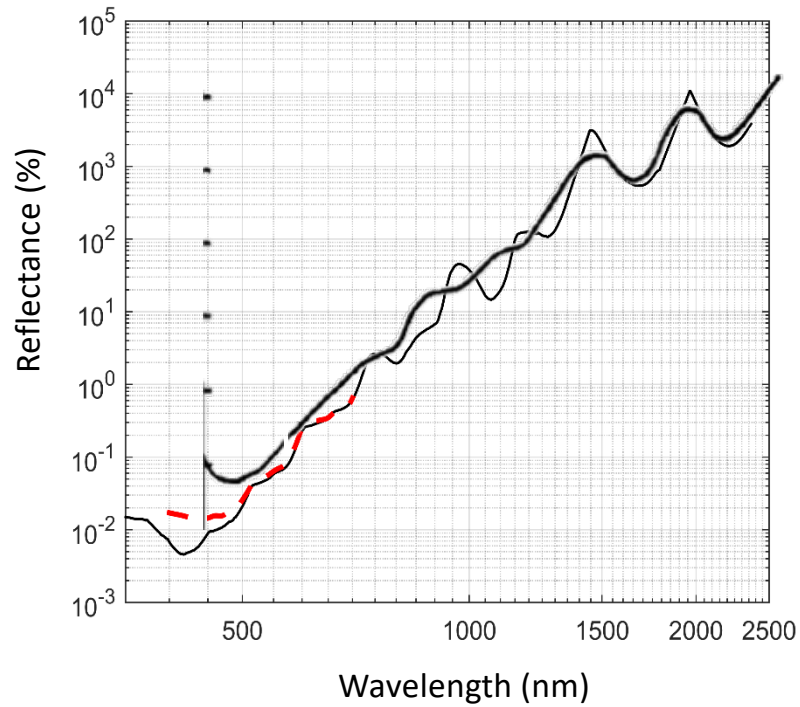


Fig. 2b Whitlock (1982). Says they used Smith and Baker water absorption (1981) in visible, but that is the red line above and not the values used in the paper.



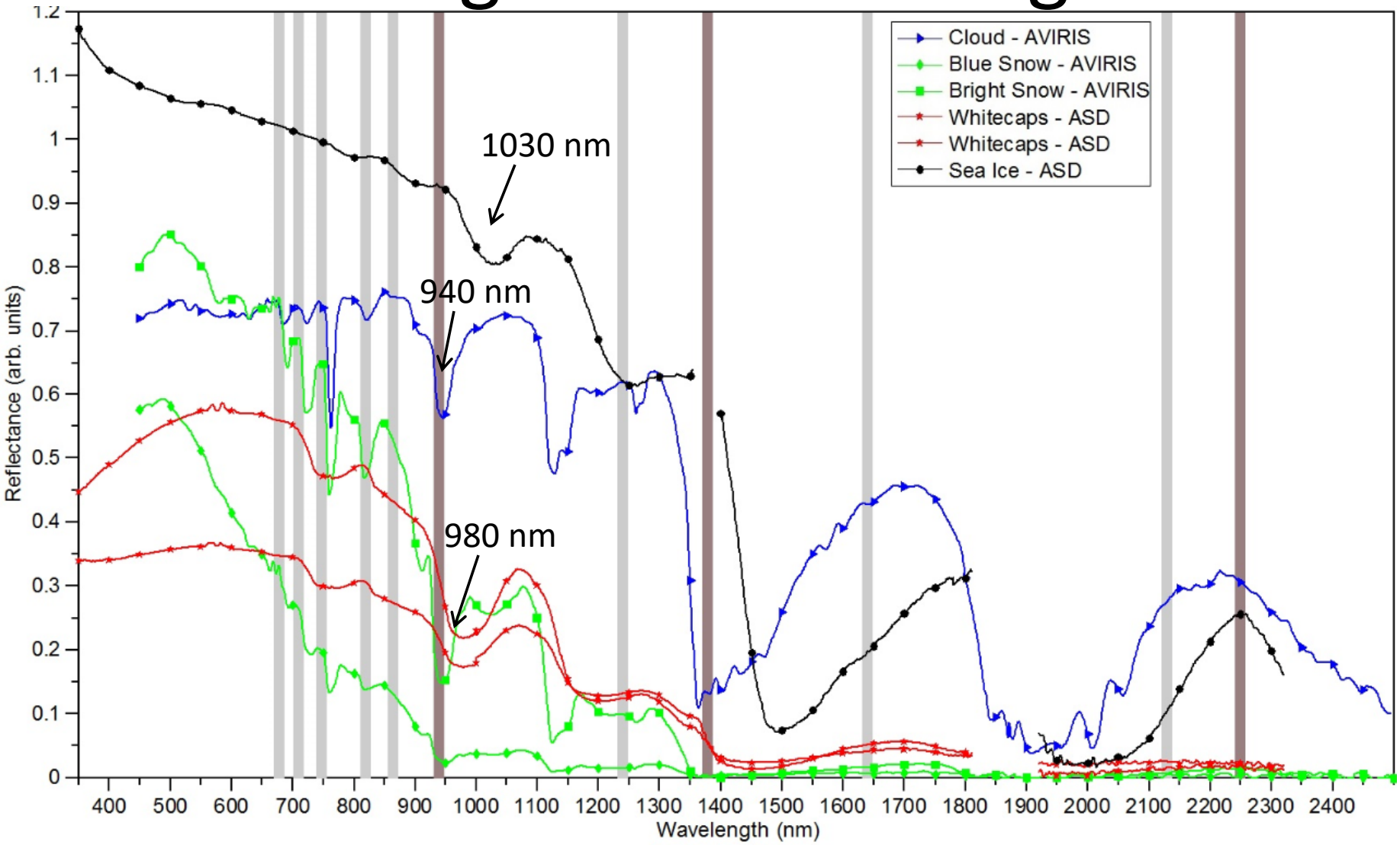
Water Optical Properties Processor
(34 ppt, 20 deg C)
Rüdiger Röttgers

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



=[940 1378 2250] nm OCI+

=[678 710 748 820 865 1240 1640 2130] 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

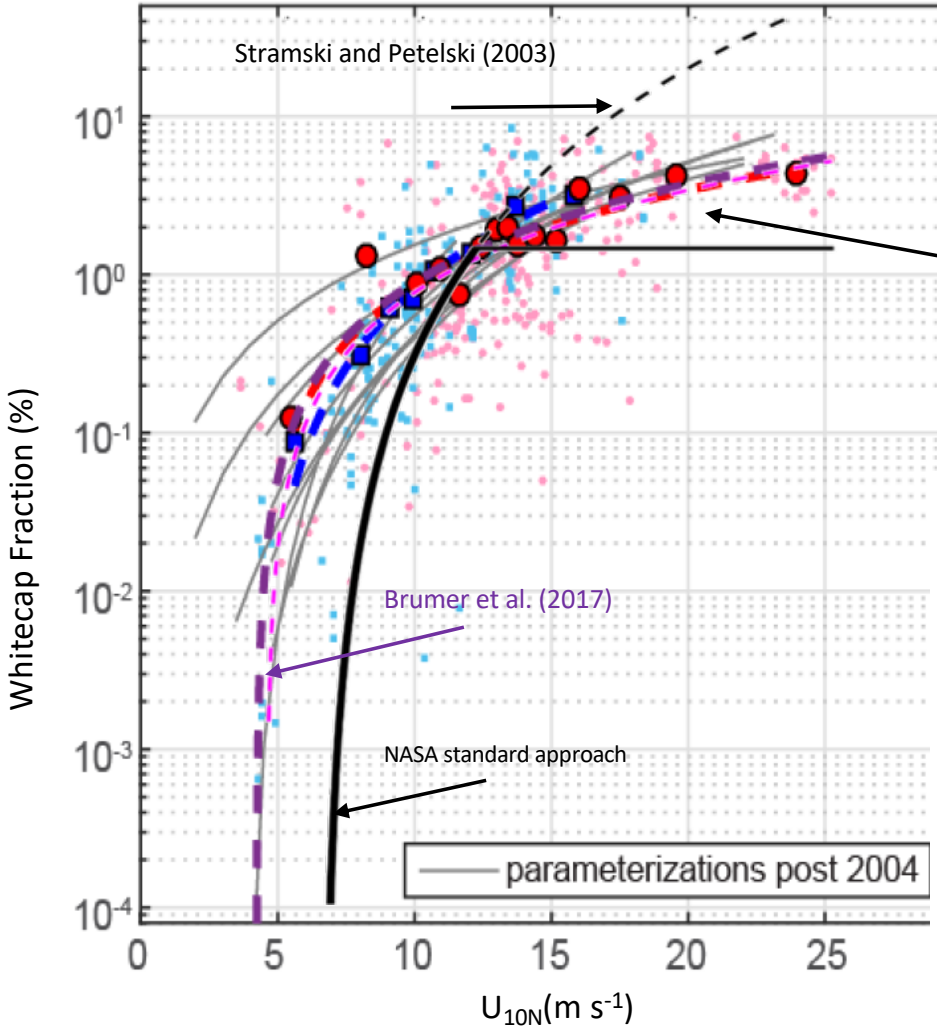
Atmospheric Correction Approaches

Ocean community dumps error into the aerosol pool

Atmospheric community dumps 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



Adapted from Brumer et al. 2017

Much of the whitecap/bubble plume under high wind speeds is removed as aerosol

Limnol. Oceanogr., 47(6), 2002, 1751–1763

Impact of sea grass density on carbonate dissolution in Bahamian sediments

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Richard C. Zimmerman
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Abstract

Carbonate dissolution has been widely observed in shallow water tropical sediments. However, sediment budgets have generally not been closed with respect to the amount of acid required to produce the observed carbonate dissolution. Recently it has been suggested that enhanced oxygen transport into sediments through the roots and rhizomes of sea grasses might play a role in resolving this mass balance problem. We conducted studies of sea grass–carbonate sediment interactions around Lee Stocking Island, Exuma Islands, Bahamas to further examine this problem. Our studies showed that alkalinity, total dissolved inorganic carbon (ΣCO_2) and Ca^{2+} increased with depth in the pore waters, while pH and calculated carbonate ion concentration decreased with depth. These observations are consistent with the occurrence of carbonate dissolution in these sediments. The magnitude of pore water alkalinity, ΣCO_2, and Ca^{2+} changes was also related to sea grass density, with the largest gradients seen in the sediments of dense sea grass beds. Calculations suggested that less than ~50% of the O_2 needed to drive aerobic respiration (and ultimately carbonate dissolution via CO_2 production) could be supplied by transport processes such as diffusion, bioturbation, and physical pore water advection. Furthermore, the O_2 needed to balance the carbonate dissolution budget could be provided by the transport of <15% of the photosynthetically derived O_2 to the sediments through sea grass roots and rhizomes without enhancing the removal of carbonate dissolution end products. Thus sea grasses play an important role in controlling the rates of carbonate dissolution in shallow water tropical marine sediments.

The dissolution of calcium carbonate in marine sediments is an important component of the oceanic and global carbon

This consumption of CO_3^{2-} by Eq. 2 lowers the sat state of the pore waters. Once the pore waters becom

Optical methods for measuring whitecaps under natural wave breaking conditions

Randolph, K. L., et al. 2017. *J. Atmos. Oceanic Tech.*, doi:10.1175/JTECH-D-16-0086.1.

Background

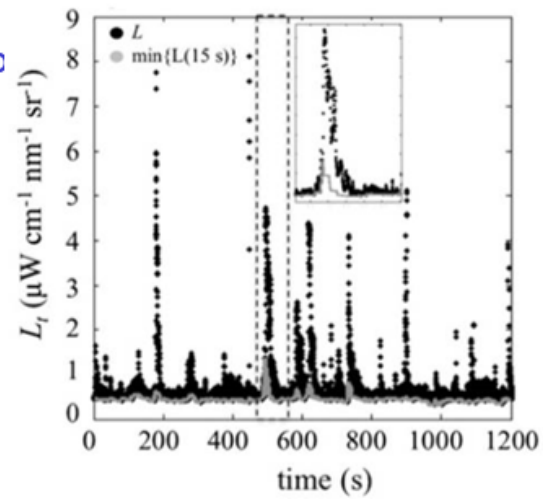
- Whitecaps on the ocean surface are features o significant importance to air-sea interaction.
- Traditional methods of measuring whitecap coverage (i.e., digital video systems) can miss whitecap features that do not produce a high enough contrast to the background.

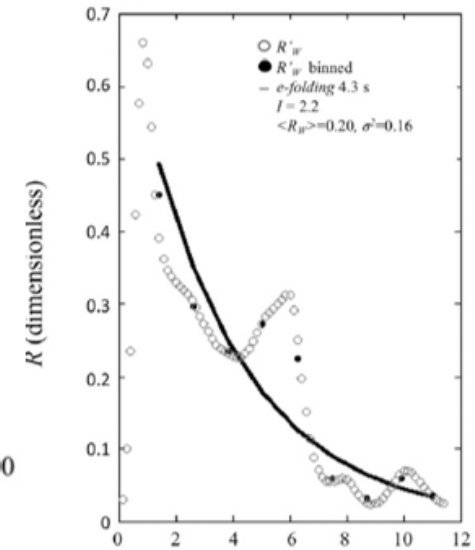
Analysis

- 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.

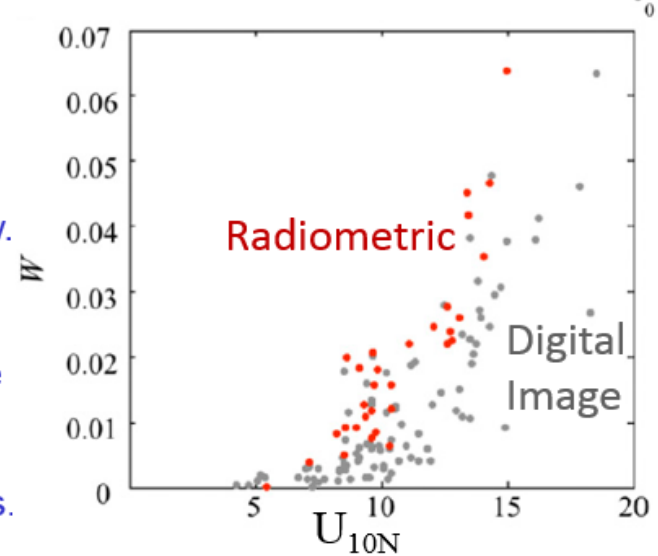
Significance

- 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.



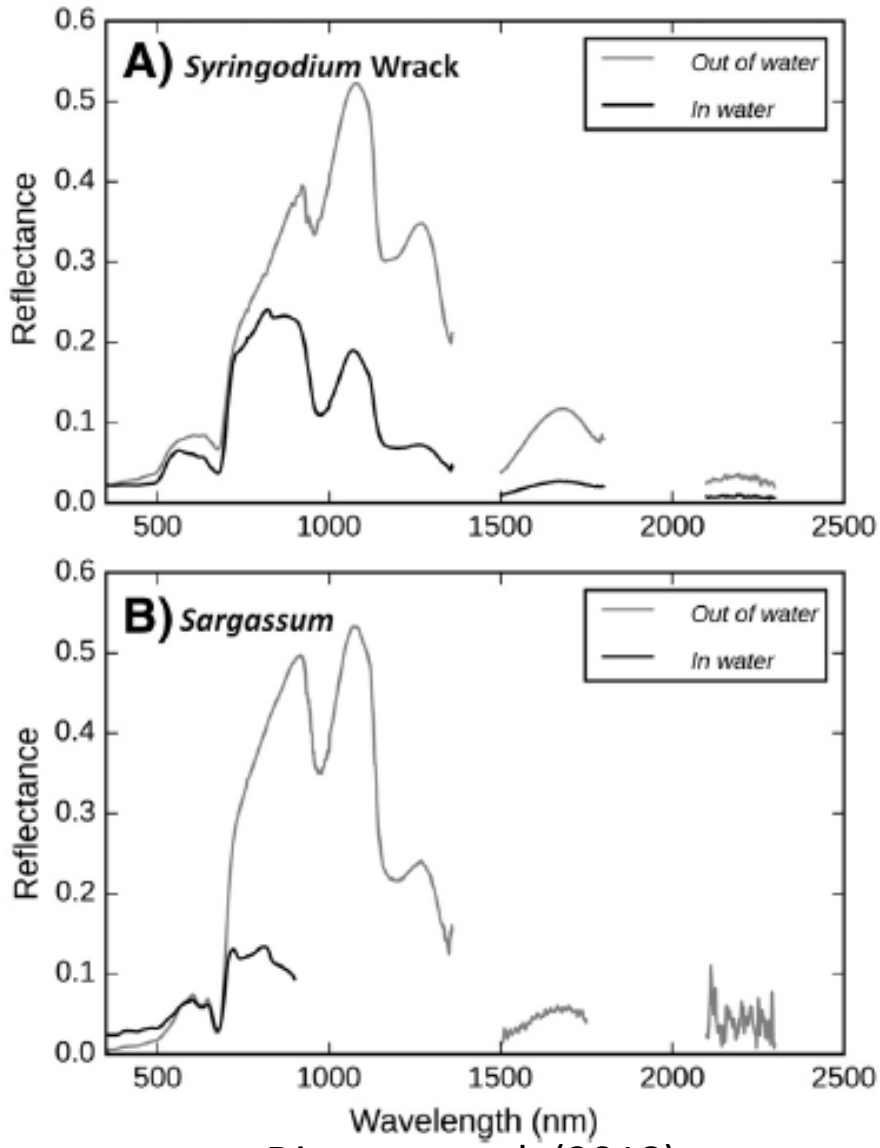


Time(s)

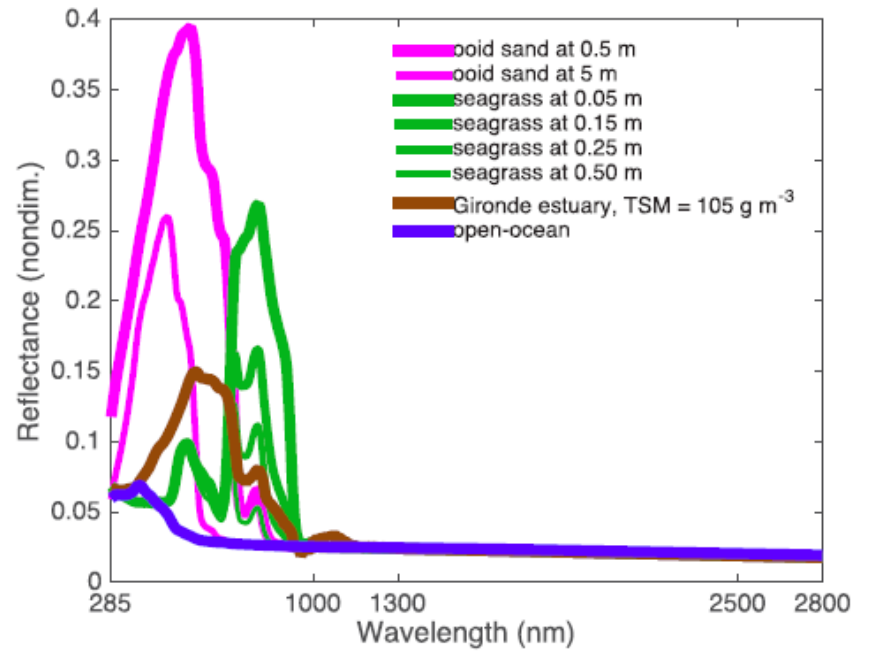


- Furthermore, these measurements of ocean color can also be used to estimate the in-water constituents (e.g., CDOM, surfactants, phytoplankton concentration and composition) affecting the evolution of foam and bubbles.

Working to differentiate water absorption bands in whitecaps from other bright targets



Dierssen et al. (2018)



ally resolved reflectance for the same cases shown in Figure 4a as well as ooid sand at 5 m
0.25, and 0.50 m.

Fogarty 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

sand, seagrass, or turbid water

Fogarty, M.C, M.R. Fewings, A.C. Paget, and H.M. Dierssen. 2017. *J. Geophys. Res. Oceans*

Background

- Albedo of marine waters is generally is 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

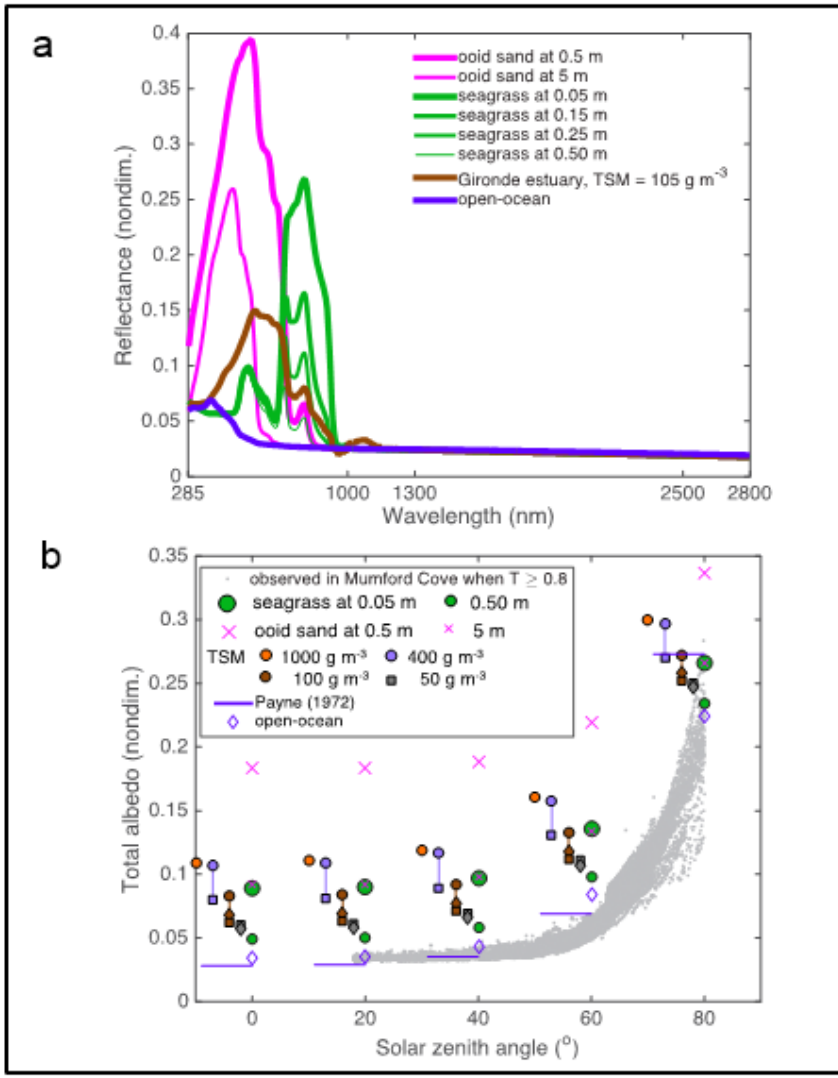
- Utilized MODTRAN and HydroLight models and field data to estimate the increase in albedo for three test cases: bright sand bottom, seagrass canopy, turbid water.

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 th water surface for several test cases, and (b) tot albedo as a function of solar zenith angle for al 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

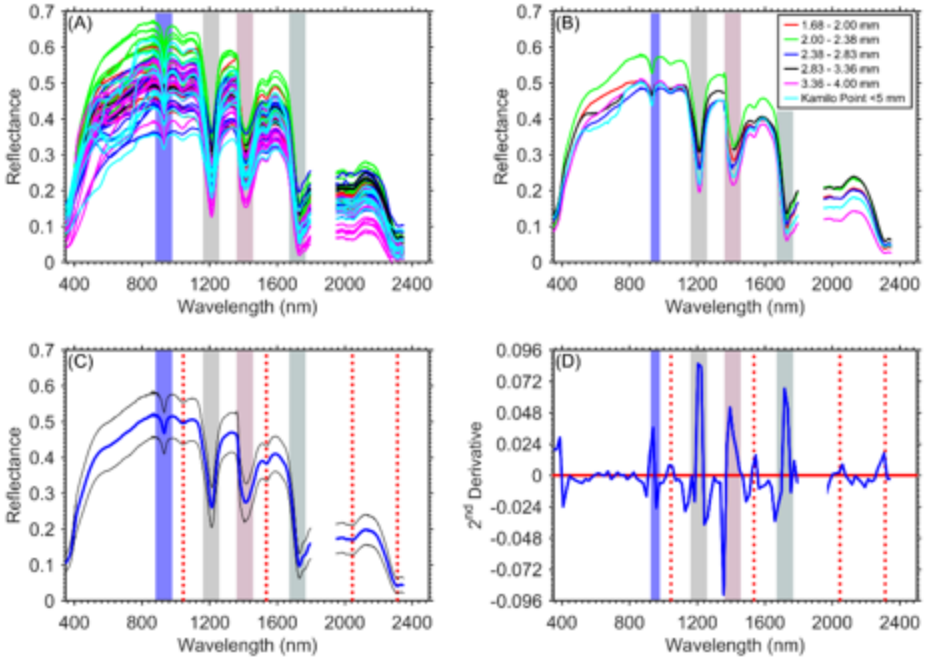
- Measured spectral properties of marine-harvested micro- and macroplastics 350 to 2500 nm.
- Investigated location of inherent absorption features of dry and wet marine-harvested plastics.
- Used AVIRIS imagery to test hydrocarbon detection algorithms over land.

Findings

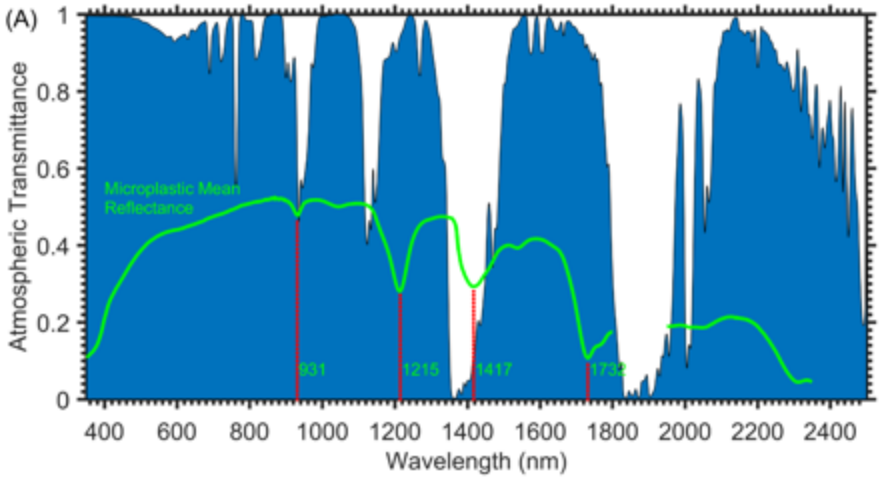
- Dry and wet marine harvested microplastics have similar absorption features but lower reflectance when wet.
- Major absorption features observable with an intervening atmosphere were identified at 1215 and 1732 nm.

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.

AGU PUBLICATIONS

JGR

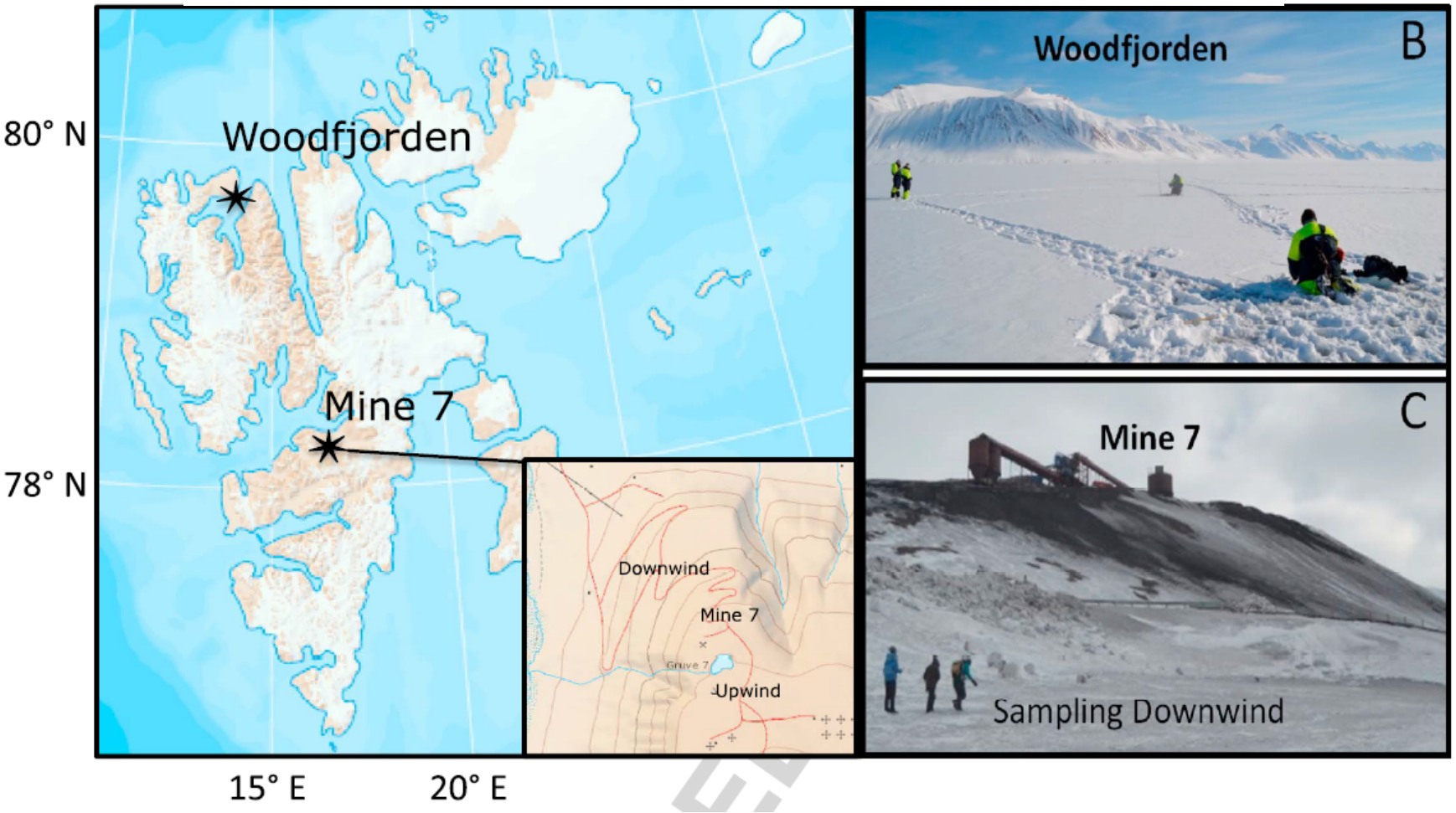
Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE
10.1002/2016JD025757

Impacts of coal dust from an active mine on the spectral reflectance of Arctic surface snow in Svalbard, Norway

Alia L. Khan[1,2], Heidi Dierssen[3], Joshua P. Schwarz[4], Carl Schmitt[5], Adam Chlus[3], Mark Hermanson[6], Thomas H. Painter[7], and Diane M. McKnight[1]

Key Points:
- An active coal mine in the Norwegian Arctic has a measurable and



Light absorbing particles in snow
Refractory and effective black carbon

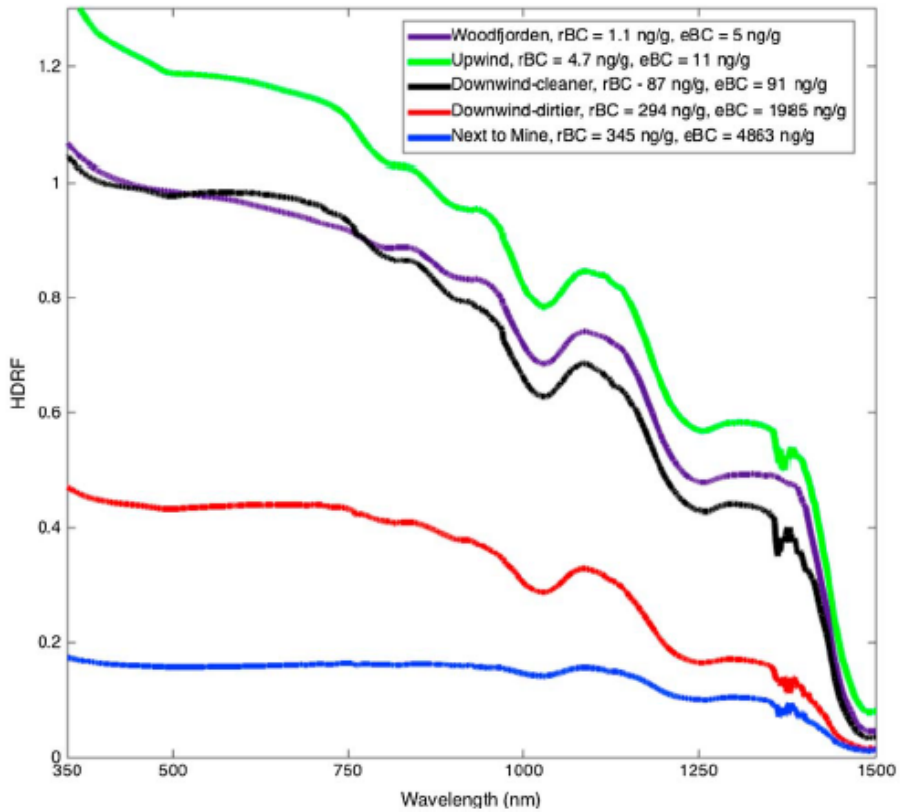


Figure 3. Mean spectral hemispherical directional reflectance factor (HDRF) at nadir generally decreases across all wavelengths with increasing rBC concentrations located downwind and adjacent to the mine.