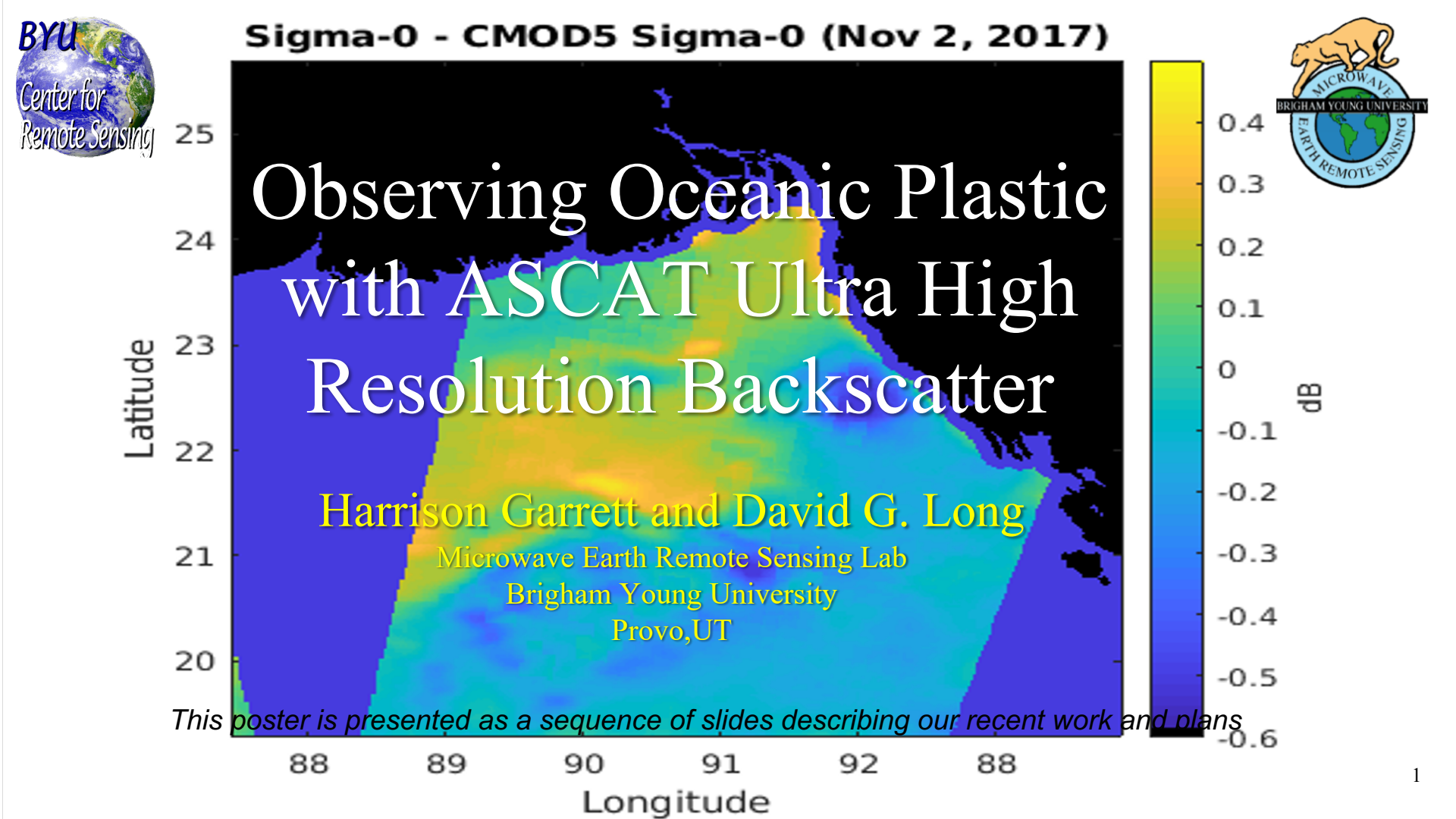

Observing Oceanic Plastic with ASCAT Ultra High Resolution Backscatter

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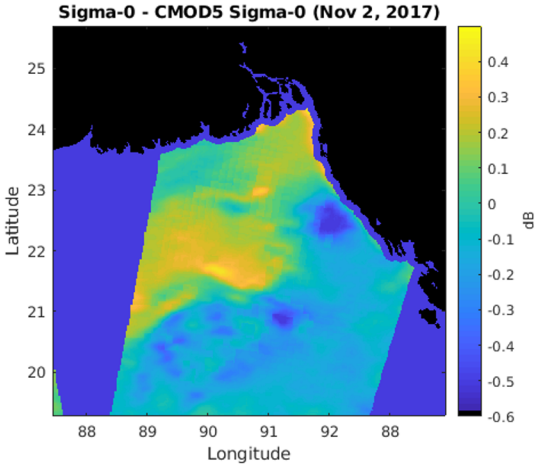
This poster is presented as a sequence of slides describing our recent work and plans

Abstract

Differences between scatterometer measured sigma-0 and the value of sigma-0 computed from ECMWF winds using a geophysical model function can highlight areas of possible surfactants. Using C-band ASCAT scatterometer measurements processed using BYU's ultra-high resolution (UHR) reconstruction algorithm (Hutchings et al., 2020), we study the possible presence of large concentrations of plastic surfactants near the Ganges River (see Figure 1). The images show the difference between the 2.5km/pixel UHR measured sigma-0 and the sigma-0 value computed using the CMOD5 geophysical model function and collocated ECMWF winds. UHR provide finer resolution for isolating surface features associated with the plastics.

To investigate the use of UHR ASCAT measurements in tracking high concentrations of oceanic plastic, we test various metrics and features of areas with a large difference in predicted and measured sigma-0. Then we then consider the causes of the observations such as due to high concentrations of oceanic plastic or spatial variations from unmodelled effects to the wind and ocean backscatter.



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Surfactants and Radar Backscatter

Several factors can corrupt radar scattering or alter the ocean's surface roughness, primarily land contamination, rain, and oceanic surfactants.

Biological and manufactured surfactants generally attenuate the surface response induced by oceanic winds and reduce radar scattering.

Large concentrated oil spills have been identified as one such surfactant observable by spaceborne radar instruments (Lindsley and Long, 2011).

Due to the large volume of plastic being dumped into the ocean, it has been assumed that large concentrations of oceanic plastic should also be observable (Evans and Ruf, 2021) .

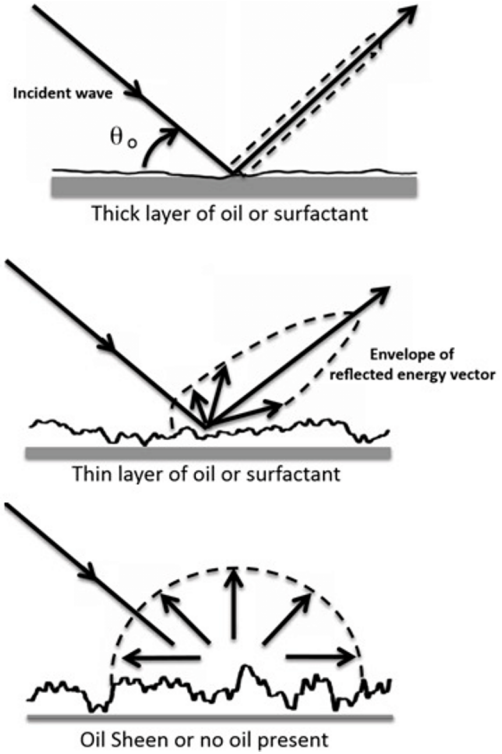

Figure 1. Surfactant effects on radar backscatter of the ocean's surface

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Plastic Detection using ECMWF and ASCAT UHR

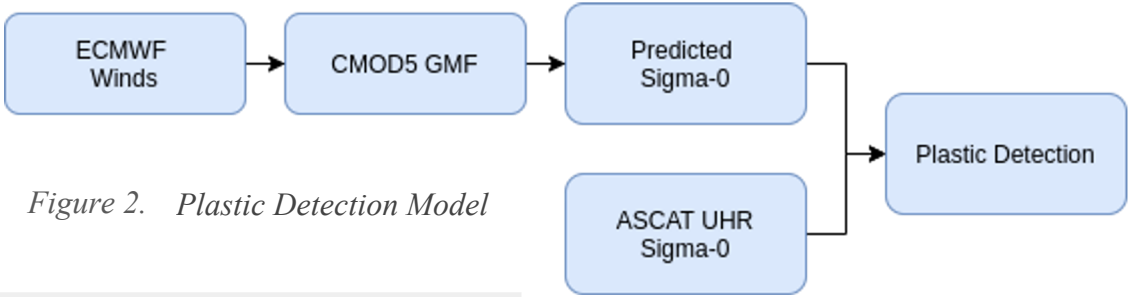

Figure 2. Plastic Detection Model

$$\mathbf{M} = \frac{\mathrm{CMOD5(ECMWF)} - \mathrm{UHR}}{\mathrm{CMOD5(ECMWF)}}$$

$$\mathbf{P} = \mathbf{M} > \mathrm{Threshold}$$

M: a normalized difference between ECMWF predicted and UHR measured σ^o.

P: A simple threshold test for identifying possible plastic surfactants, assuming plastic surfactants attenuate σ^o more than other unmodelled factors.

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Bay of Bengal

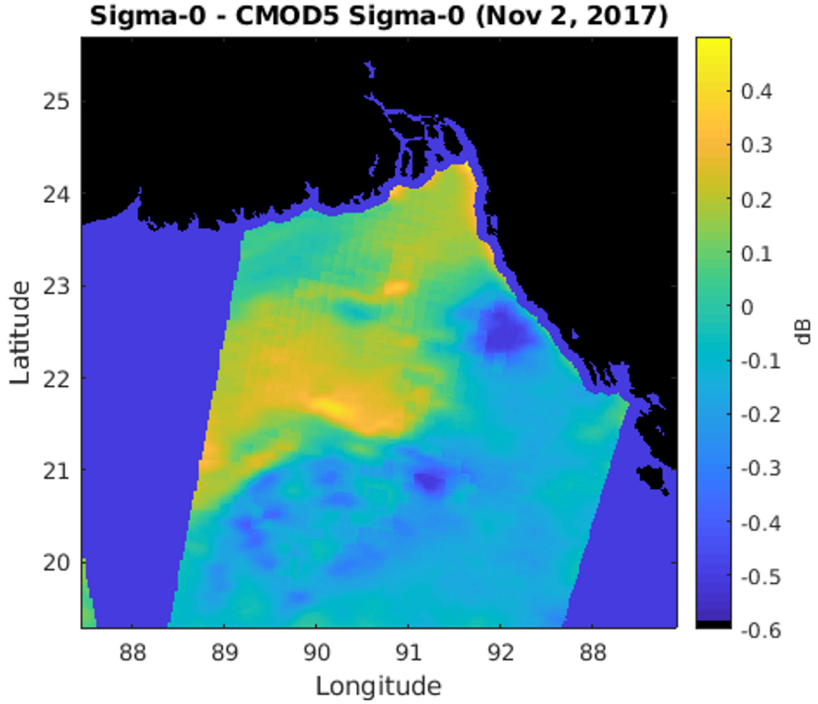

Figure 3. Difference between measured and ECMWF-predicted sigma-0

An example difference image between σ^o computed from ECMWF winds using the CMOD5 geophysical model function and scatterometer measured σ^o, on Nov 2, 2017 ASCAT METOP B, over the bay of Bengal. A positive difference indicates an atennation in the expected sigma-0. The land mask is shown in black. A flow of possible plastic surfactants can be seen originating from the mouth of the Ganges River.

This outflow was tagged as plastic in study using CYGNSS low Earth orbiting bi-static radars (Evans and Ruf, 2021).

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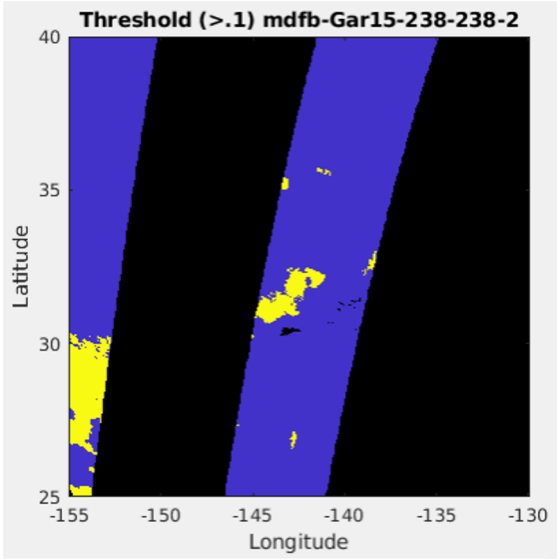
Great Garbage Patch



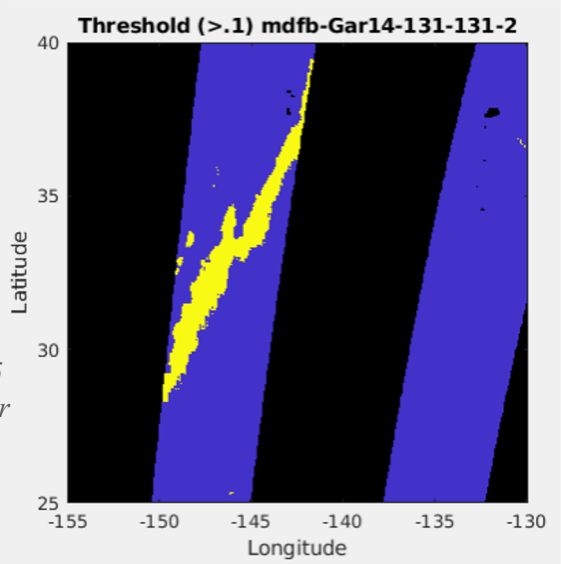


Fig. 5. Thresholded sigma-0 differences. (above) time series from Aug. 25-27, 2015 of large attenuation patches. (right) similar diagonal patch observed May 11, 2014.

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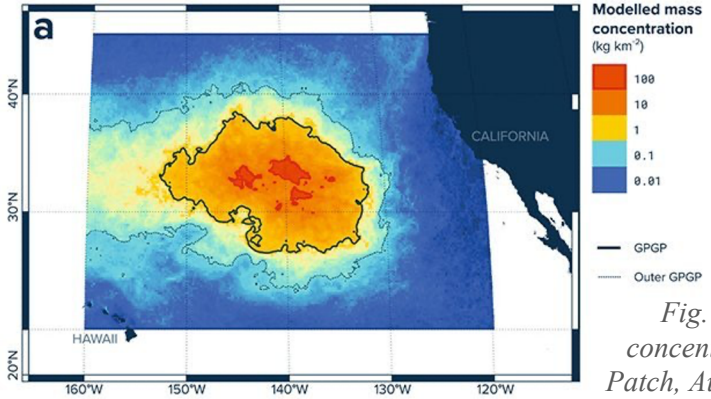

Fig. 4. Modelled micro-plastic concentrations in the Great Garbage Patch, Aug. 2015 (Lebreton et al. 2018).

Observations

- Patches inconsistent from day to day
- Patch movement faster than expected for plastic clusters
- Many regions outside the Great Garbage Patch display a similar intensity and frequency of attenuation patches
- A trend of SW to NE diagonals appear at various locations and intervals

Summary

Observations

- The attenuation of UHR winds provides high resolution observations of possible plastic outflows from major rivers.
  - The observed attenuation from the Ganges river outflow only persists for a few days.
  - The outflow is not observed to maintain shape or move outside the bay of Bengal.

- Attenuations in the Great Garbage Patch may not correlate with concentrations of microplastics.
  - Most observations have small and infrequent patches of attenuation.
  - Large attenuation patches only persist for a few days, then disappear.

Possible Conclusions

- Large clusters of surface plastics may be detectable but become difficult to track when dispersed.
- The attenuation effect of microplastics may be too small to consistently observe.
- Other unmodelled effects may be important.

Future Work

- Investigate if high concentrations of microplastics are observable at lower thresholds.
- Attempt to collocate large attenuation patches with storm cells, wind fronts, and other phenomena.

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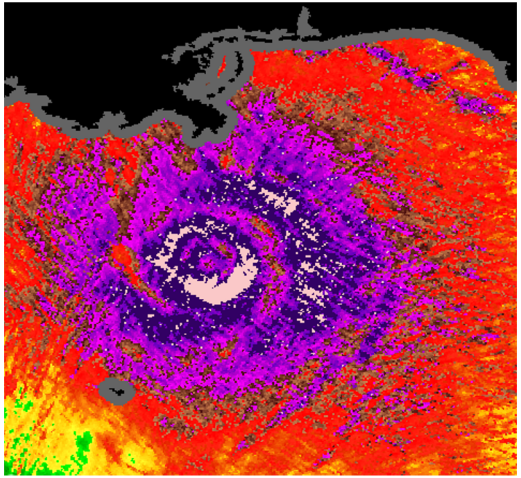
ASCAT, UHR Winds, ECMWF

ASCAT Illustration

Advanced Scatterometer (ASCAT) measurements of surface backscatter (σ^o).

- Operating Frequency: 5.255 GHz
- Incidence Angles: 45°, 90° and 135°
- Swath Width: 550 km



Katrina: Ultra-High Resolution winds (Aug. 28, 2005)

Ultra High Resolution (UHR) Winds

- Wind retrieval using enhanced SIR σ^o
- Wind Vector cells ~2.5 km grid

European Centre for Medium-Range Weather Forecasts (ECMWF): interpolated near-surface wind speed and direction

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