Relating the Optical and Acoustical Properties of Oceanic Particles

Emmanuel Boss
School of Marine Sciences
5706 Aubert Hall
University Of Maine
Orono, Maine, USA 04469-5706
phone: (207) 581-4378 fax: (207) 581-4388 email: emmanuel.boss@maine.edu

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http://misclab.umeoce.maine.edu/index.php

LONG-TERM GOALS

- To develop improved predictive capabilities for the distribution of particulate material in the coastal ocean.
- To develop predictive models for optical properties from measurements of acoustical properties and vice versa.

OBJECTIVES

To understand the relationship between acoustical and optical properties of suspended particles as a function of the particle's composition, size distribution and degree of aggregation.

APPROACH

Laboratory experiments of aggregation have been taking place at the University of Maine MISC Lab. The experiments are designed to measure the optical and acoustic response to inorganic aggregates, namely induced clusters of flocculated clays. The experiments are conducted in a large sink to allow for simultaneous measurements by several instrument all focused on the same depth.

Measurements include near forward optical scattering (providing information of cross-sectional area, and thus size, of aggregates, LISST, Sequoia Scientific), optical transmission and backscattering (WET Labs' BB(RT)) and acoustical backscattering at 4.5MHz (Nortek's VECTOR). Concentrations of clays are siphoned out from the sampling volumes of the sensors and measured using suspended sediment (TSS) analysis protocols.

These data are used to contrast the optical and acoustical responses to temporal changes in particle's concentration and size as a result of settling and aggregation. Collected material for mass and analysis of the time dependent signal allow us to study the change in acoustical and optical backscattering per mass as function of aggregate size.

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Field data from the OASIS deployments which includes an extensive data set of optical and acoustical properties are investigated to find relationships between acoustical and optical properties as well as link them to processes identified in the water.

WORK COMPLETED

We have conducted extensive analysis of both lab and field data. Two manuscripts, one detailing the link between acoustical backscattering and particulate mass and the other detailing the use of acoustical and optical backscattering to assess the degree of aggregation of sediments are in near final form and will be submitted shortly (one will be submitted to a special issue of Continental Shelf Research this week). Some results will be presented at the Ocean Optics conference.

RESULTS

The most significant result we found from the lab experiments is that aggregation result in a *decrease* of acoustic backscattering per mass despite the fact that the aggregate size increases towards the resosnant frequency (ka~1) where maximal response is expected (Fig. 1). The physical explanation for this behavior (suggested to us by Dr. Ken Foote and supported by the literature) is that the bonds formed between particles during the formation of aggregates absorb acoustic energy (damping their oscillation) decreasing the scattered intensity.

This behavior is also observed in the field where we find, following resuspension events, that acoustic backscattering decreases much more rapidly than optical backscattering (Fig. 2 and Fig. 3). Since a rapid period of aggregation follows after resuspension, these results are consistent with that observed in the controlled conditions of the lab.

IMPACT/APPLICATIONS

Acoustics result challenge the common view that particle with ka~1 will have the strongest acoustic backscattering signal per mass. The latter is only true for solid particle. However, resuspended oceanic single grain particles most often have ka<1 for acoustics systems used to study sediments, while is aggregates that are in the range of ka~1. In that case acoustic backscattering per mass actually decreases as aggregate form. This means that in interpreting field data calibrated with solid beads (as with the widely used ABS type systems), aggregate population mass will be significantly *underestimated*.

RELATED PROJECTS

This project is closely linked to the OASIS project (N000141010508 to E. Boss) which provides field data.

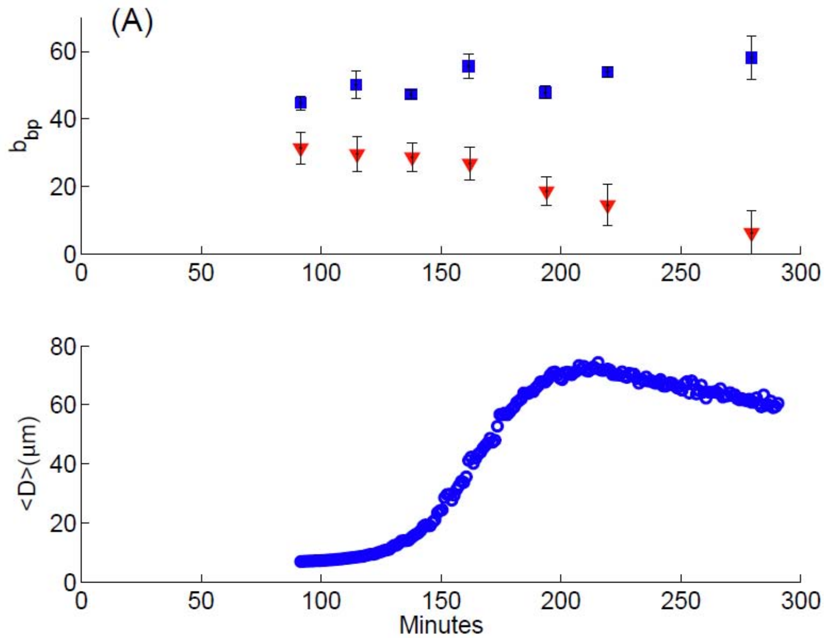

Figure 1. Time series of mass normalized optical (blue squares) and acoustical backscattering during the aggregation experiment (top panel) and averaged particle size as inferred from the LISST (bottom panel). Not that while the mass normalized optical signal changes little the acoustical signal monotonically decreases as aggregation takes place.

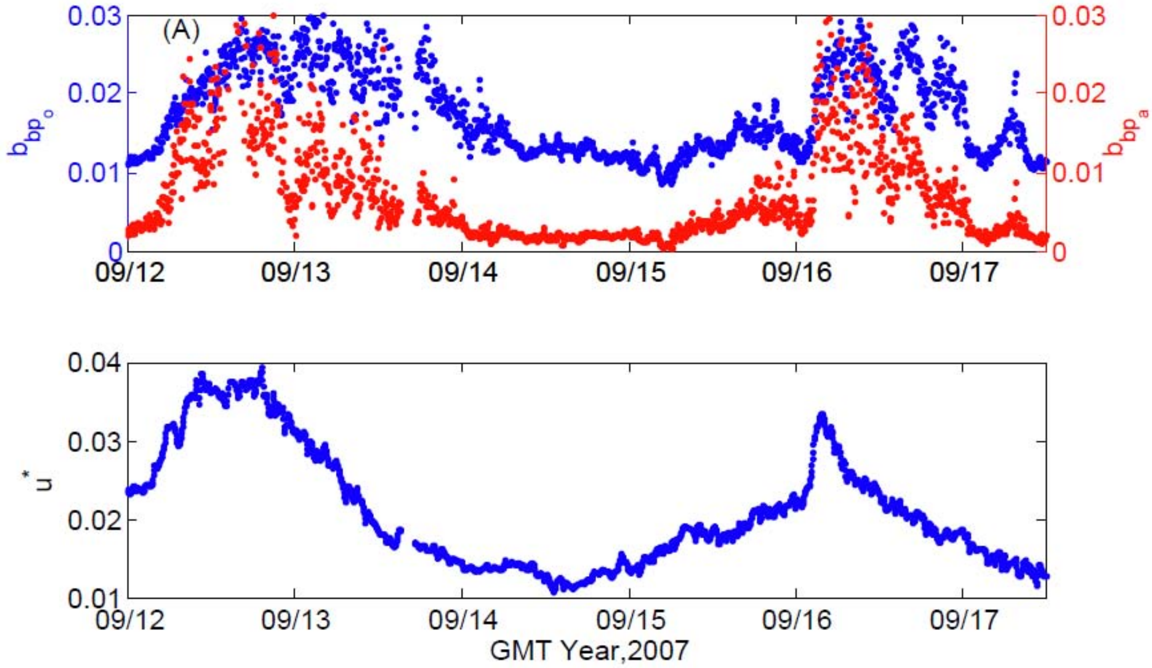

Figure 2. Time series of acoustic and optical backscattering (top panel) and stress (bottom panel). Notice the rapid decrease of the acoustic signal following high stress event (when aggregation takes place).

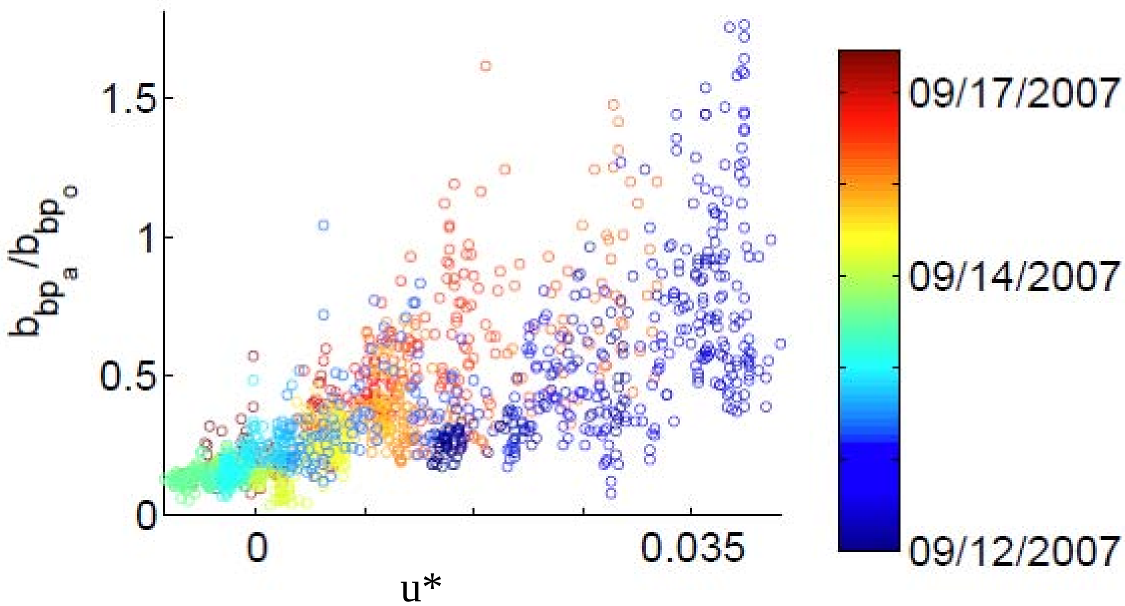

Figure 3. Ratio of acoustic to optical backscattering as function of shear stress with time denoted by color (same data as in Fig. 2). The positive correlation is supportive of the idea that when aggregates abound there is a decrease in the mass specific acoustic backscattering.