The MODIS Ocean Product for Particulate Inorganic Carbon (MOD
Refinement of calcium carbonate estimates in the global ocean

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Abstract

This research focuses on three areas of refinement of the MODIS particulate inorganic carbon algorithm (MOD 25): 1) validation of particulate inorganic carbon (PIC; otherwise known as calcium carbonate) concentrations from a wide variety of environments, 2) elucidation of the magnitude of error in MODIS-derived PIC estimates that are caused by suspended biogenic silica (associated principally with diatom frustules), and 3) comparison of the current MODIS two-band PIC algorithm with a three-band PIC algorithm. An objective comparison of the two and three-band algorithms, using data from a wide range of geographic locations, is critical for interpreting PIC algorithm results from different satellite platforms.

Data for this work will be principally derived from three Atlantic Meridional Transect (AMT) cruises which traverse between the UK and Cape Town, South Africa. Each AMT cruise covers a wide variety of environments, providing the most globally-representative validation for the MODIS PIC algorithm. Moreover, the AMT cruises cross sub-polar mesoscale regions of elevated PIC (already observed by MODIS-Terra and Aqua). If validated, the PIC in these regions would be of major significance to the global carbonate budget. Given the possibility of suspended biogenic silica in these sub-polar regions (as well as many other areas), it is important to confirm that these sub-polar regions of elevated PIC are not simply artifacts due to intense scattering associated with biogenic silica in diatom blooms. We also have cruise efforts planned in the Gulf of Maine and Equatorial Pacific. We would use these opportunities for further collection of PIC and biogenic silica data for refinement of the PIC algorithm. The results of this work will significantly advance global-scale validation of the PIC product (MOD 25) and provide a suite of potential improvements for more accurate retrievals.

Objectives

•1) Validate MODIS-derived PIC estimates during three Atlantic Meridional Transect (AMT) cruises.

•2) Parallel sampling for biogenic silica during AMT cruises to examine potential errors due to this mineral.

•3) Validation work associated with Gulf of Maine cruises (involving both PIC and biogenic silica measurements and concurrent ship and satellite measurements of normalized water-leaving radiance).

•4) Partition variance in backscattering between POC, PIC and biogenic silica

•5) Perform objective comparison to test the accuracy of 2-band and 3-band PIC algorithms.

2-band PIC algorithm (Balch et al., 2005, in press).

This is a backscattering-based algorithm that uses water-leaving radiance in the blue and green plus the scattering cross-section of calcite coccoliths and chlorophyll-containing cells to iteratively solve for calcite and chlorophyll concentration.

3-band PIC algorithm (Gordon et al. , 2001)

Algorithm is based on 670, 765, and 865nm bands.

•Interference from chlorophyll and cDOM minimized in red and near-IR.

•Absorption coefficient of water is so high in red and near IR that added phytoplankton and cDOM absorption is negligible.

•nLw much lower in red and near-IR, thus these bands are less likely to saturate.

•Must assume background b_b term (i.e. "all other" b_b), which is subtracted from $b_{b\,tot}$ to estimate PIC b_b.

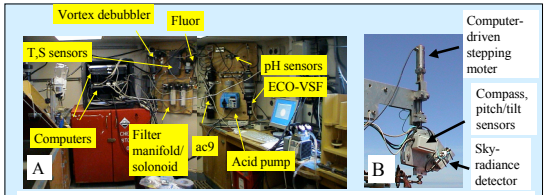

Fig. 1A) AMT underway system aboard RRS Discovery. This measures surface $a_{pg}(\square)$, $c_{pg}(\square)$, $a_g(\square)$, $c_g(\square)$, $b_b(543)$, acid-labile backscattering [bb'(543)], fluorescence, temperature, salinity. B) Satlantic Micro-SAS radiometers used to collect along-track radiance data (Lt, Lsky (from ship's bow), and Ed (from ship's mast)). Values of nLw will be used as input to the two PIC algorithms. To maximize data quality, our sensor mount automatically compensates for changes in sun's azimuth relative to ship heading.

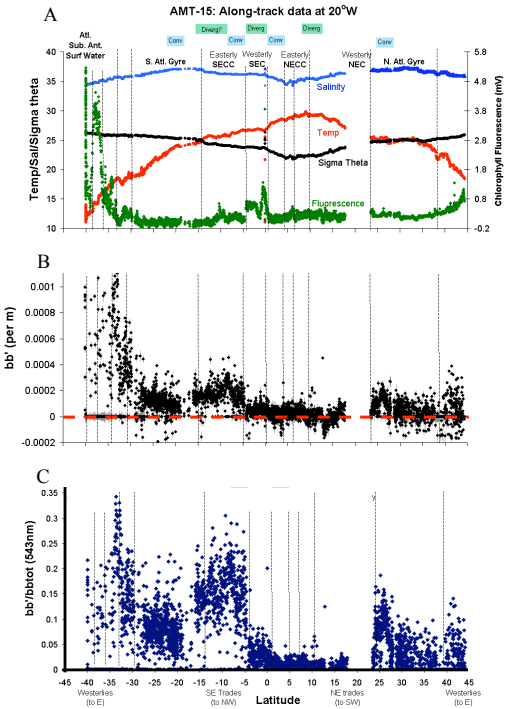

Fig 2 A) Along-track surface results from AMT-15 showing temperature, salinity, density and fluorescence results. Dashed lines represent water mass changes (associated with hydrographic or bio-optical changes. B) Acid-labile backscattering (from calcium carbonate coccoliths) along transect. Note highest values from >35oS. Also, note elevated values in South Equatorial Counter Current,, entering into South Atlantic Gyre. C) Fraction of total backscattering which is attributable to calcium carbonate. Note how in south Atlantic Gyre, calcite contributes 5-15% of total backscattering while in S. Equatorial Counter Current, calcite contributes up to 25% of total backscattering. Prevailing wind directions are shown at bottom, and water mass names shown at top.

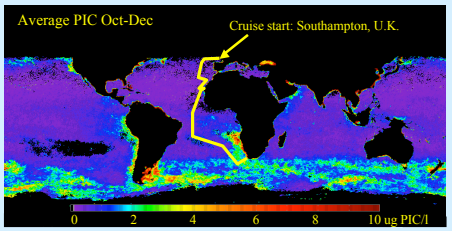

Fig. 3 Cruise track for AMT-15 of *RRS Discovery*, between 13 September and 29 October, 2004, shown superimposed on MODIS-derived seasonal average calcite concentration (based on 2 band algorithm for October-December). Color bar for PIC concentration shown at lower right. Note, high concentrations in sub-Antarctic regions of south Atlantic and in Namibian upwelling regions off west Africa.

Project Status (year 1 start 22 April '04):

-Collected and processed underway samples for PIC, biogenic silica, POC and chlorophyll from Spring '04 AMT cruise #14 (Falklands to U.K.; samples collected every 2h).
-Constructed systems for continuous collection of above-water radiance data and various bio-optical variables during cruises #15-17 of AMT series.
-Participated in 6.5 week AMT-15 cruise.
-Collected PIC and biogenic silica data in the Gulf of Maine for validation activities(12 cruises in 2004).
-Collected PIC validation data from 30d cruise in Equatorial Pacific (Dec'04-January '05).

Future activities:

-Processing above-water radiances along with match-up satellite scenes for various samples.
-AMT cruises #16 aboard *RRS Discovery* (6.5 week) will begin mid-May in Cape Town, South Africa.
-twelve cruises planned in '05 in the Gulf of Maine for PIC algorithm validation activities.
-One month Equatorial Pacific cruise (Sept'05-Oct '05) in which PIC and coccolith count data will be collected.
-AMT cruises #17 (Sept.-Oct. 2005).

References

Gordon, H.R., Boynton, G.C., Balch, W.M., Groom, S.B., Harbour, D.S., and Smyth, T.J., 2001, Retrieval of coccolithophore calcite concentration from SeaWiFS imagery: **Geochemical Research Letters**, v. 28, p. 1587-1590.

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