Biases In The In Situ Measurement Of Particulate Organic Carbon And Its Effect On The Calibration And Validation Of Ocean Color Sensors

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Background

Particulate organic carbon (POC) plays an oversize role, relative to its standing stock in the global carbon (C) cyle.

Accurate measurement of POC is central to understanding the ocean C flux and its sensitivity to climate forcing.

POC is a standard NASA ocean color data product, which lacks a consensus, quality-assured measurement protocol for satellite validation. Thus, algorithms based on field measurements lacking verified uncertainties have limited applicability towards climate data records.

Different sampling and filtration protocols, and blank corrections, introduce biases in the magnitude of POC measured from the field.

A significant filter blank attributable to dissolved organic C (DOC) adsorption that, until recently has been seldom corrected for, likely has introduced biases in POC global datasets

Questions

*** Is there a measurable bias in satellite-derived POC relative to in situ validation observations corrected for all known errors?**

*** If so, is this bias attributable to the DOC blank?**

Methods

We measured POC during three field campaigns:

GO-SHIP P06 (Aug 22-Sept 30, 2017):
South Pacific Gyre, Chile Upwelling.

GO-SHIP P16S (March 23-May 4, 2014):
Southern Ocean, South Pacific Gyre

NOAA-JPSS VIIRS 2015 (Dec 2-13, 2015)
South Atlantic Bight

All samples were corrected for the filtrate blank associated with DOC.

For the P16S samples, a DOC correction was derived from the average C measured on re-filtered filtrate volumes of 1L. The average (14.6 µg) was subtracted from the C measured on the filter samples.

On the other campaigns, DOC blanks were collected for each individual sample with second in-line filter simultaneously during filtration. Each blank filter was analyzed as a sample, and the C measured was subtracted from its corresponding sample.

Preliminary Findings

For all campaigns, in situ surface POC was generally lower than contemporaneous L3 MODISA POC (Fig. 1).

The largest discrepancy was seen on the VIIRS campaign, where the estimated bias was 51% for MODISA POC above DOC corrected in situ POC.

Better agreement was seen between the in situ and satellite POC during the P16S campaign, with a bias of 4% higher MODISA POC and a mean absolute error of 18%.

For the P06 campaign, all in situ POC values were always lower than their matching L3 MODISA value, which resulted in a positive bias of 43%.

Taken as a whole, all three campaigns show a positive bias of 33% for L3 MODISA POC, and an overall absolute difference of 39%.

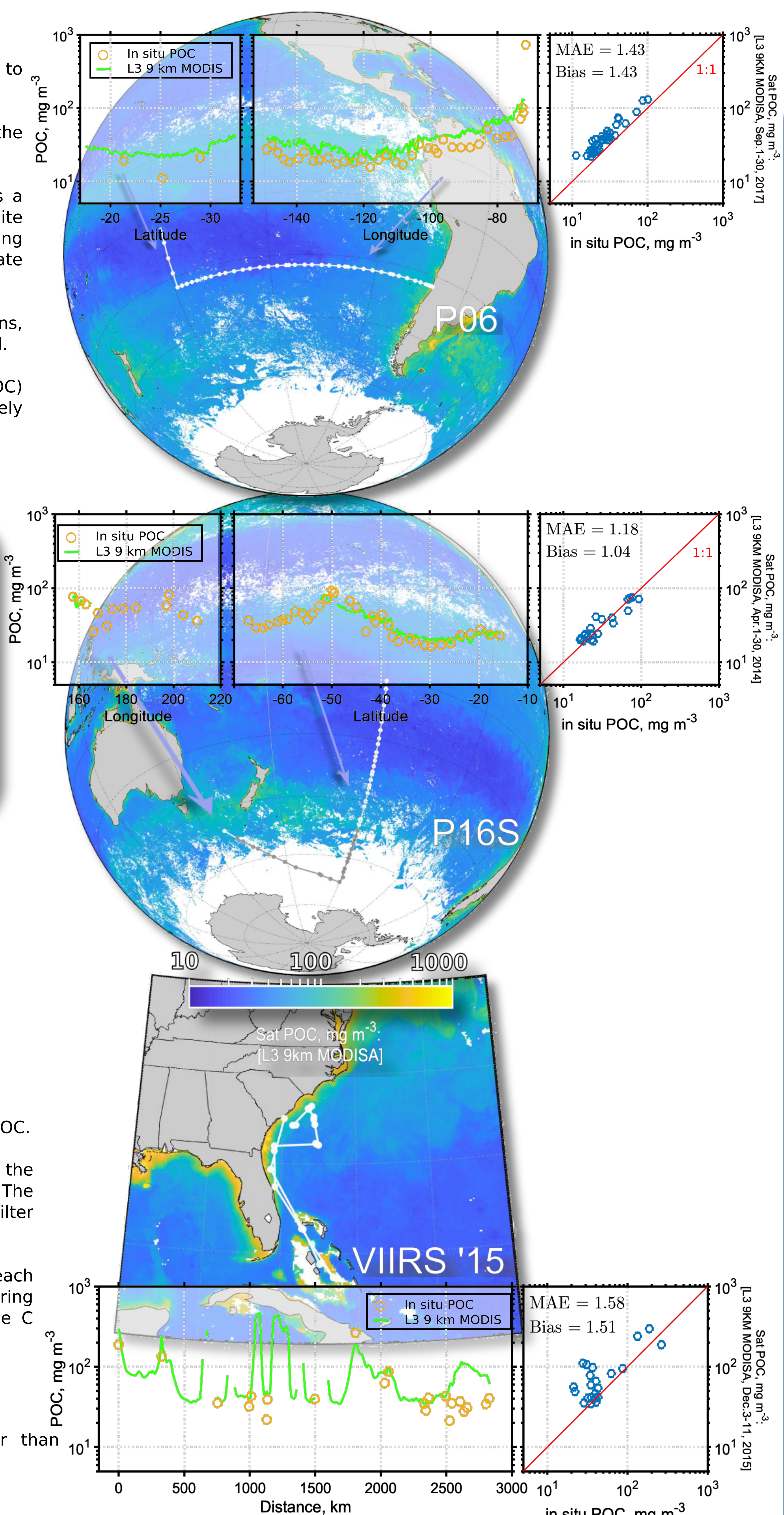

Fig. 1: Contemporaneous L3 MODISA POC for (top to bottom) the P06, P16S (monthly), and VIIRS '15 oceanographic field campaigns. Plots show the surface in situ POC, and the along-track MODISA POC. The rigth panel, shows the satellite POC vs. in situ. The performance metrics are the multiplicative mean absolute error (MAE) and bias, which are log10 scaled so that, for example, a MAE of 1.2 means a 20% difference and a bias of 1.1 means that, in this case, satellite POC is 10% higher than in situ (see Seegers et al. 2018)

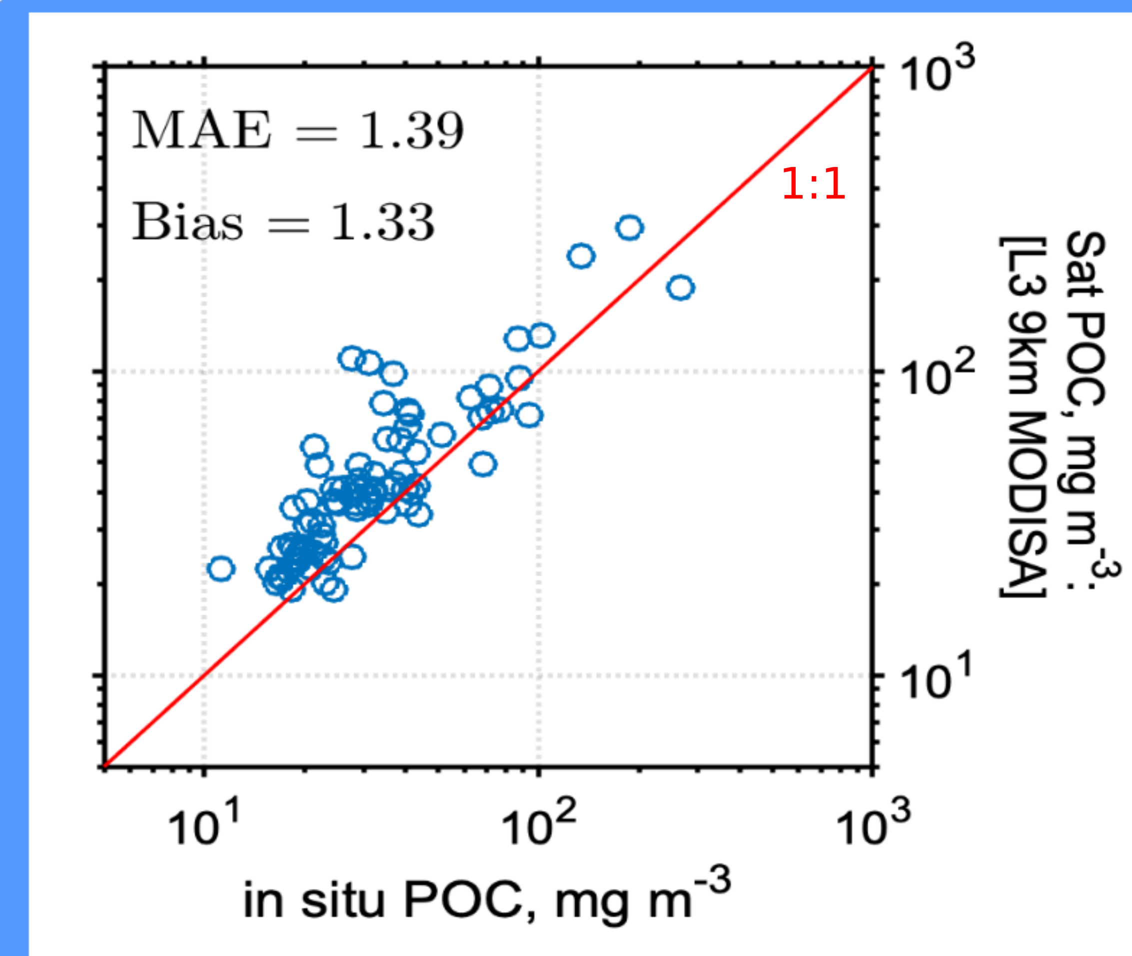

Fig.2. Contemporaneous MODISA L3 9km POC vs. in situ surface POC for the three oceanographic campaigns depicted in Fig. 1. See Fig.1 caption for the definition of multiplicative MAE and bias.

Discussion

These results suggest of a sizable bias in the measurement of POC from orbital ocean color sensors.

Albeit, these results are limited in their scope given that they are based on data from only three oceanographic campaigns, and the satellite data used are L3 composites, they do provide preliminary evidence of considerable error in early POC algorithms.

These results at least warrant a more thorough review of current POC algorithms and the available data for their refinement.

These findings also highlight the need to implement consensus protocols for the in situ measurement of POC for the purposes of ocean color validation, and global C cyle science.

Efforts are currently underway among the scientific community to address these concerns and generate methodology for the measurement of POC that can elevate the quality of the field measurement, and in turn that derived from orbital sensors, to that a of climate data records.

Under the auspices of NASA and IOCCG, a draft community consensus POC protocol is available online for review and public comment at the link below:

https://bit.ly/2HmkTkX

References

Seegers, B. N., Stumpf, R. P., Schaeffer, B. A., Loftin, K. A., Werdell, P. J., Schaeffer, B. A., ... Seegers, B. N. (2018). Performance metrics for the assessment of satellite data products: an ocean color case study. Opt Express, 26(6), 7404–7422. https://doi.org/10.1364/OE.26.007404