Assessing Satellite Inter-Mission Consistency in the Retrieval of Particulate Organic Carbon Concentration in Ocean Surface Waters from Ocean Color Observations

(ID 120)

Ishan D. Joshi[1], Dariusz Stramski[1], Rick A. Reynolds[1], Dale H. Robinson[2]
[1]Scripps Institution of Oceanography, University of California San Diego, La Jolla, California 92093-0238, USA
[2]Univesity of California Santa Cruz, affiliated with NOAA CoastWatch at NOAA Southwest Fisheries Science Center, Santa Cruz, California 95060, USA

Ocean Carbon From Space Workshop 2022

New optical remote-sensing algorithms were developed to estimate surface POC concentrations in the global ocean (Stramski et al., 2022; DOI: 10.1016/j.rse.2921.112776)

Hybrid POC algorithm for SeaWiFS sensor

Band ratio difference index (*BRDI*) algorithm

$$BRDI = \left(\frac{R_{rs}(443) - R_{rs}(555)}{R_{rs}(490)}\right)$$

$$POC_{BRDI} = 10^{(1.5407+0.8586\,BRDI-0.0787\,BRDI^2-1.8571\,BRDI^3+1.5738\,BRDI^4-0.3839\,BRDI^5)}$$

$$w_{BRDI} = \begin{Bmatrix} 0\ if\ POC_{BRDI} > 25\ mg\ m^{-3} \\ 1\ if\ POC_{BRDI} < 15\ mg\ m^{-3} \\ 0\ \le\ \log_{10}[0.9\ POC_{BRDI} - 12.5] \le 1\ if\ 15 \le POC_{BRDI} \le 25\ mgm^{-3} \end{Bmatrix}$$

Maximum band ratio (*MBR*) algorithm

$$MBR = maximum\left(\frac{R_{rs}(443)}{R_{rs}(555)}, \frac{R_{rs}(490)}{R_{rs}(555)}, \frac{R_{rs}(510)}{R_{rs}(555)}\right)$$

$$POC_{MBR} = 10^{(2.5037-2.1297\,\log(MBR)+1.8727\,[\log(MBR)]^2-0.9554\,[\log(MBR)]^3)}$$

$$w_{MBR} = \begin{Bmatrix} 1\ if\ POC_{MBR} > 25\ mg\ m^{-3} \\ 0\ if\ POC_{MBR} < 15\ mg\ m^{-3} \\ 0\ \le 1 - log_{10}[0.9\ POC_{MBR} - 12.5] \le 1\ if\ 15 \le POC_{MBR} \le 25\ mgm^{-3} \end{Bmatrix}$$

Final hybrid algorithm weighting between POC_{MBR} and POC_{BRDI}

BRDI < 1 POC = POC_{MBR}

BRDI ≥1 POC = $POC_{MBR}W_{MBR} + POC_{BRDI}W_{BRDI}$

where $W_{MBR} = 0.5[w_{MBR} + (1 - w_{BRDI})]$ and $W_{BRDI} = 1 - W_{MBR}$

Hybrid POC algorithm for MODIS sensor

Band ratio difference index (*BRDI*) algorithm

$$BRDI = \left(\frac{R_{rs}(443) - R_{rs}(547)}{R_{rs}(488)}\right)$$

$$POC_{BRDI} = 10^{(1.6876+0.0936\,BRDI+1.6170\,BRDI^2-3.9144\,BRDI^3+2.8003\,BRDI^4-0.6633\,BRDI^5)}$$

$$w_{BRDI} = \begin{Bmatrix} 0\ if\ POC_{BRDI} > 25\ mg\ m^{-3} \\ 1\ if\ POC_{BRDI} < 15\ mg\ m^{-3} \\ 0\ \le\ \log_{10}[0.9\ POC_{BRDI} - 12.5] \le 1\ if\ 15 \le POC_{BRDI} \le 25\ mgm^{-3} \end{Bmatrix}$$

Maximum band ratio (*MBR*) algorithm

$$MBR = maximum\left(\frac{R_{rs}(443)}{R_{rs}(547)}, \frac{R_{rs}(488)}{R_{rs}(547)}, \frac{\boldsymbol{R_{rs}(510v)}}{R_{rs}(547)}\right)$$

where $R_{rs}(510v) = 0.5\,R_{rs}(510A) + 0.5\,R_{rs}(510B)$; $R_{rs}(510A) = -0.00008 + 1.085\,R_{rs}(488)$; $R_{rs}(510B) = -0.00041 + 1.104\,R_{rs}(531)$.

[$\boldsymbol{R_{rs}(510v)}$ is used only when $R_{rs}(510v)/R_{rs}(547) < 1.2$, $R_{rs}(510v) > R_{rs}(443)$, and $R_{rs}(510v) > R_{rs}(488)$]

$$POC_{MBR} = 10^{(2.5155-2.5893\,\log(MBR)+2.8241\,[\log(MBR)]^2-1.5640\,[\log(MBR)]^3)}$$

$$w_{MBR} = \begin{Bmatrix} 1\ if\ POC_{MBR} > 25\ mg\ m^{-3} \\ 0\ if\ POC_{MBR} < 15\ mg\ m^{-3} \\ 0\ \le 1 - log_{10}[0.9\ POC_{MBR} - 12.5] \le 1\ if\ 15 \le POC_{MBR} \le 25\ mgm^{-3} \end{Bmatrix}$$

Final hybrid algorithm weighting between POC_{MBR} and POC_{BRDI}

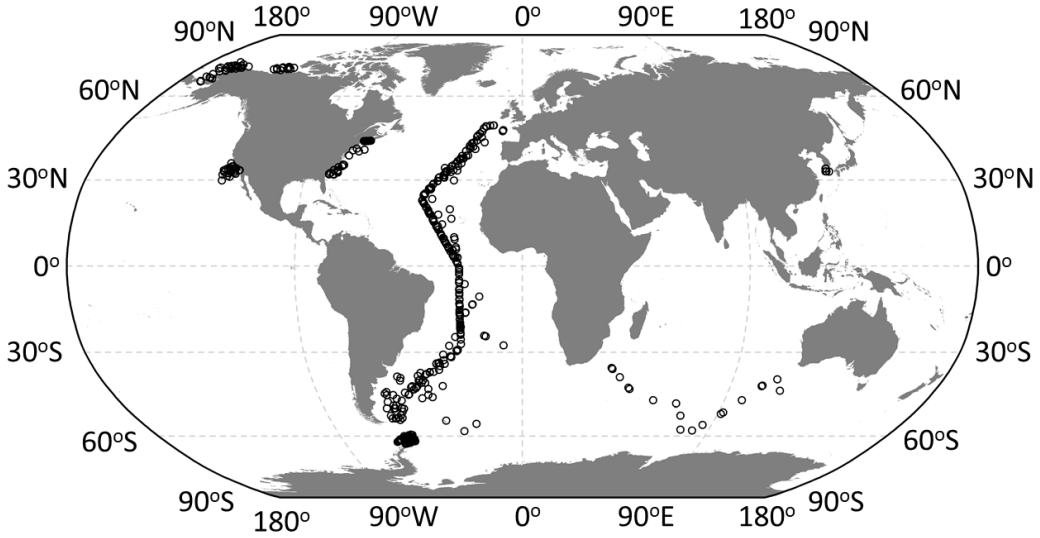
BRDI < 1 POC = POC_{MBR}

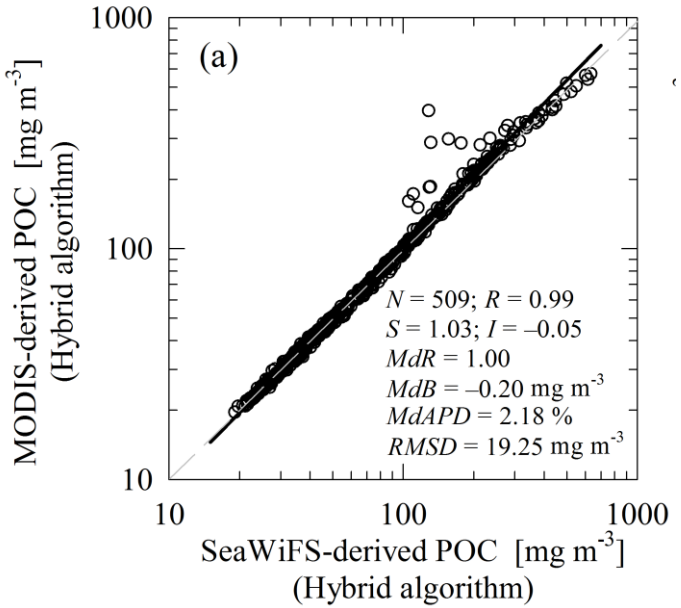
BRDI ≥1 POC = $POC_{MBR}W_{MBR} + POC_{BRDI}W_{BRDI}$

where $W_{MBR} = 0.5[w_{MBR} + (1 - w_{BRDI})]$ and $W_{BRDI} = 1 - W_{MBR}$

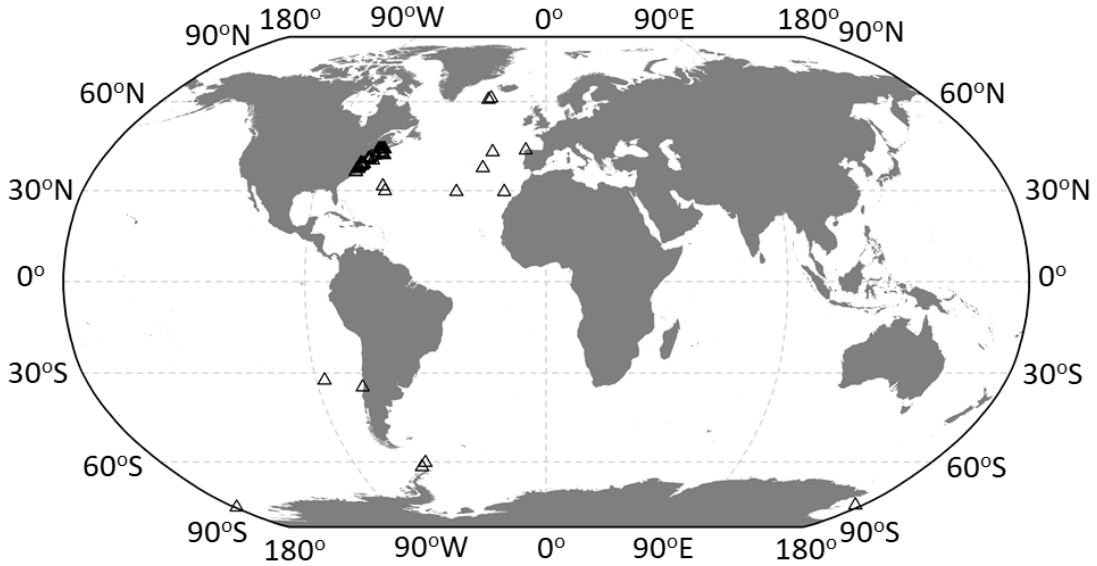
SeaWiFS and MODIS-specific hybrid POC algorithms show no significant bias relative to one another when the two algorithms use remote-sensing reflectance inputs from in situ and satellite measurements at the common field stations

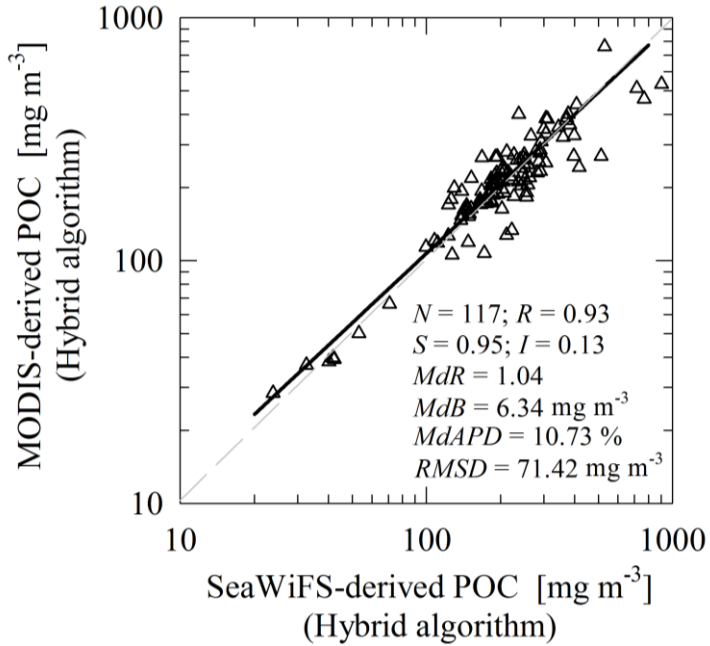
In situ POC & $R_{rs}(\lambda)$ measurements



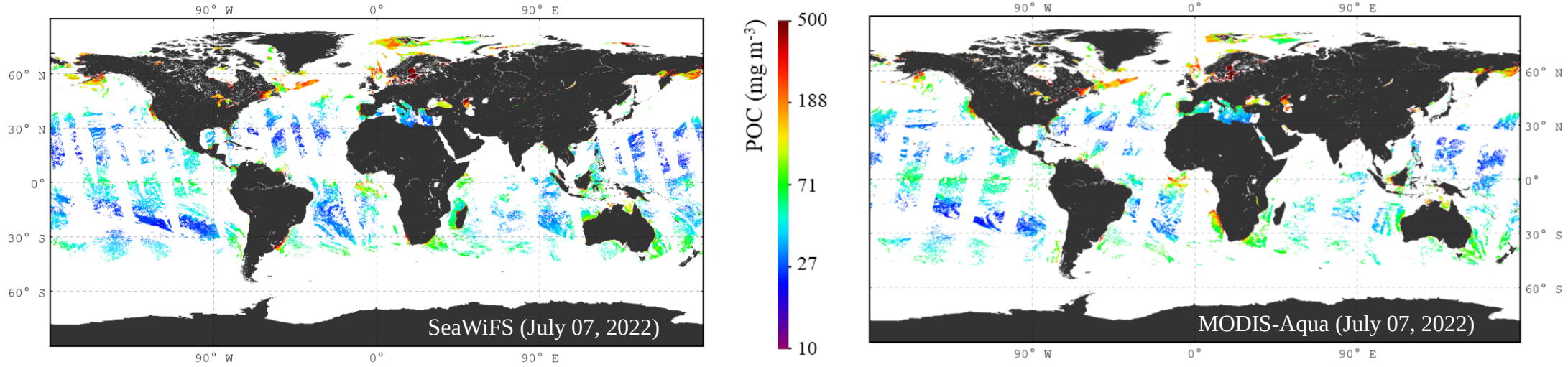


In situ POC and satellite $R_{rs}(\lambda)$ measurements

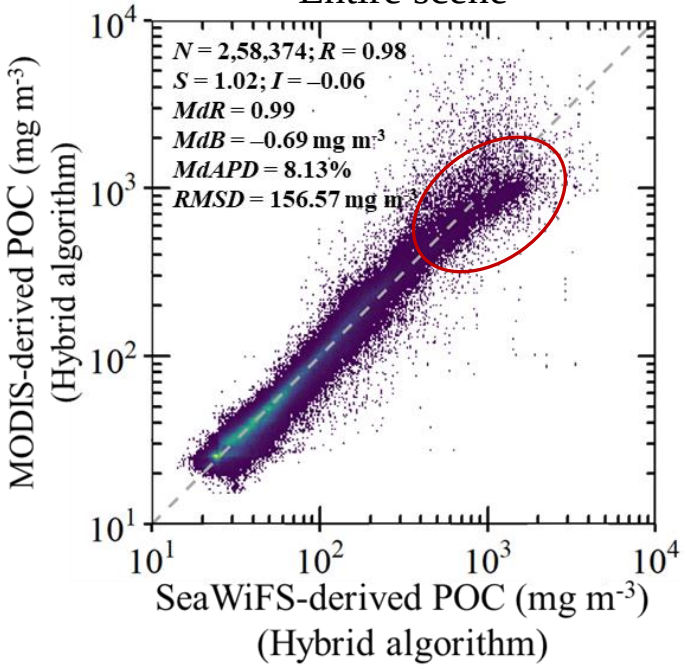




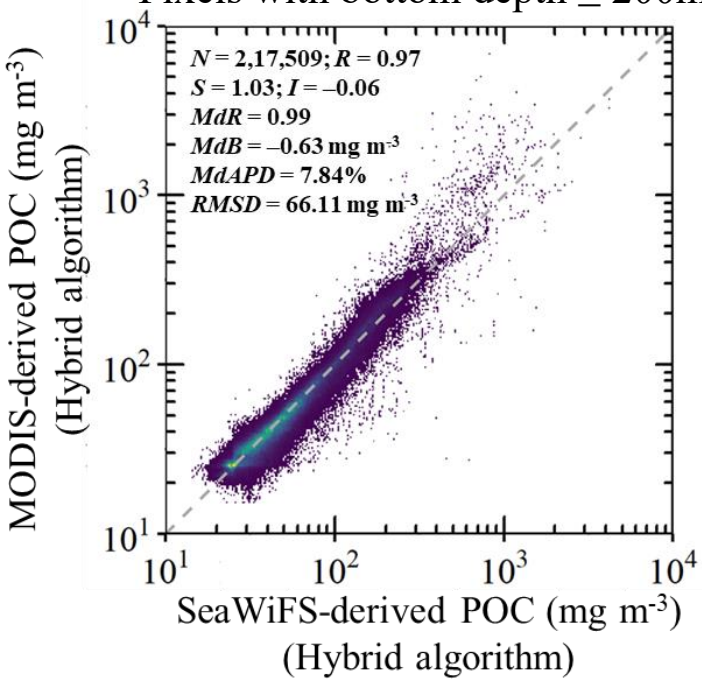
SeaWiFS and MODIS-specific hybrid algorithms show consistent POC retrievals in open ocean and shelf environments when the two algorithms use Level-3 daily satellite remote-sensing reflectance products (9 km resolution)



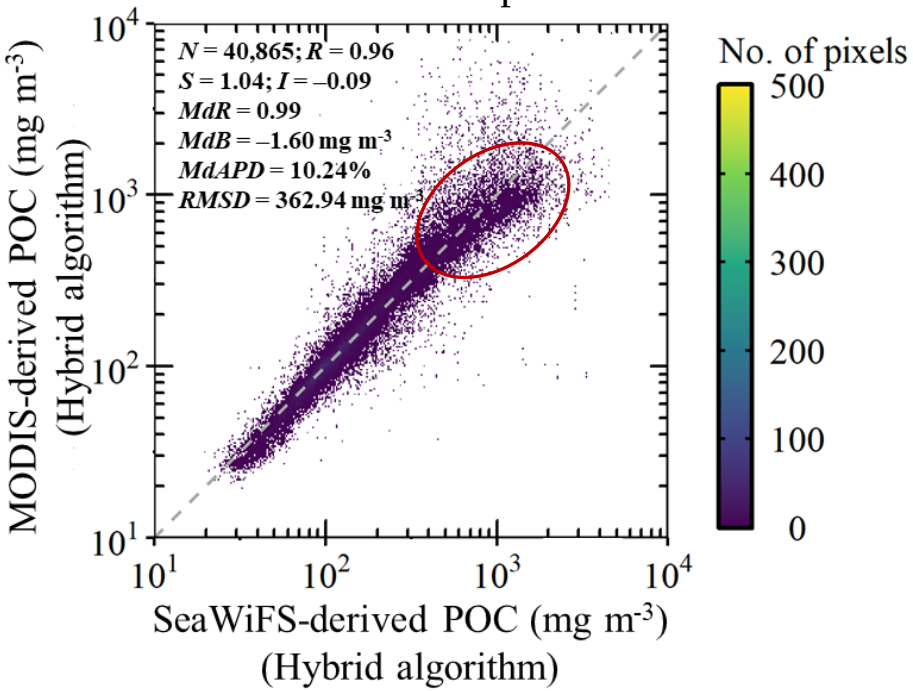
Entire scene



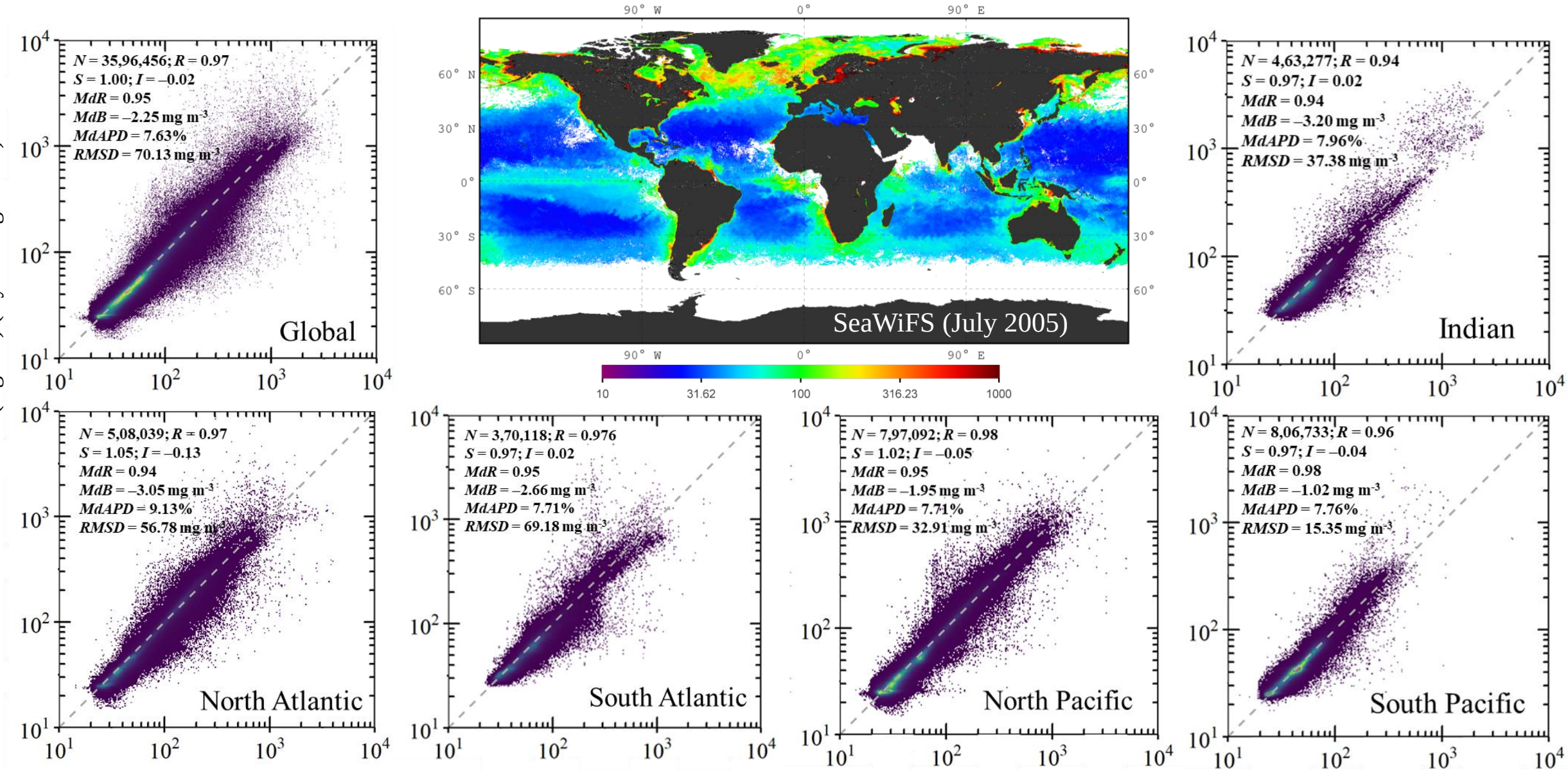
Pixels with bottom depth ≥ 200m



Pixels with bottom depth < 200m



SeaWiFS and MODIS-specific hybrid POC algorithms show consistent POC retrievals at global and ocean basins scales when the two algorithms use Level-3 monthly satellite remote sensing reflectance products (9 km resolution)



Summary and Future Direction

- Sensor-specific global POC algorithms were developed using high-quality field observations from diverse oceanic environments ranging from tropical to polar regions. The new algorithms have a broader dynamic range (from about 10 to 1000 mg m^{-3}) and better performance in high POC waters than the current standard global POC algorithm used by NASA.

- Despite the use of a virtual 510-nm band in MODIS-specific hybrid algorithm as opposed to the actual 510-nm band in the SeaWiFS-specific hybrid algorithm, both algorithms provide highly consistent estimates of POC for the quality-controlled independent in situ validation data.

- Preliminary inter-sensor comparison of hybrid algorithms based on Level-2 (1 km resolution), global daily Level-3 (9 km resolution), and monthly composite satellite reflectance products demonstrate a high degree of performance consistency across open-ocean pelagic waters of the global ocean as well as within individual ocean basins including shelf environments.

- MODIS-Aqua-derived POC values are typically very similar to those derived from SeaWiFS although notable differences can be observed in waters exhibiting high POC concentration generally outside the intended range of algorithm applicability (i.e., beyond 1000 mg m^{-3}).

- Ongoing work is focused on means to merge data from different satellite missions into a consistent time series for analysis of long-term global and regional trends of POC within the oceanic surface layer.