Beyond Chlorophyll: Ocean color ESDRs and new products

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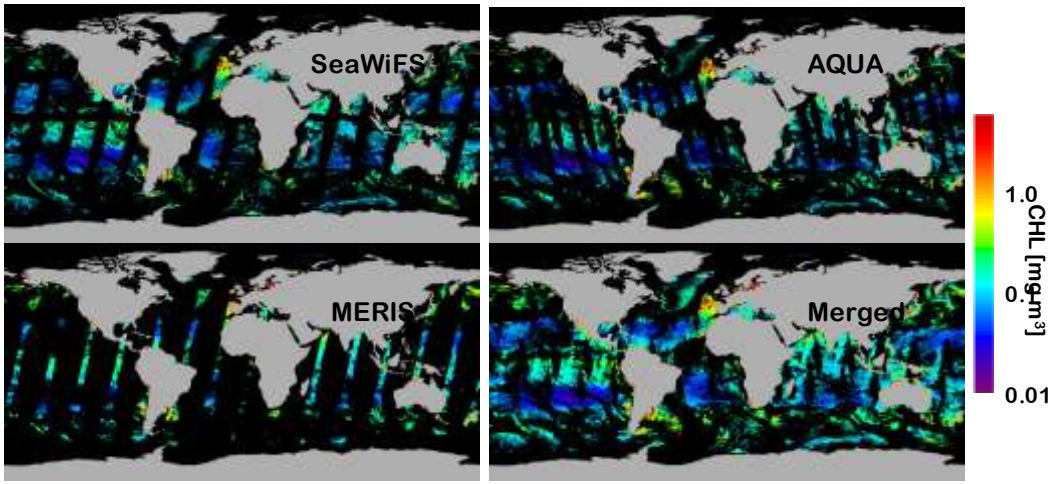
Motivations and rationale.

- CHL is the historical product derived from satellite ocean color observations
- Progress in ocean color modeling and improved sensors now allow various other variables to be retrieved from satellite-measured normalized water-leaving radiance spectra.
- Because more and more bio-optical and biogeochemical variables are now routinely measured at sea, it is possible to evaluate and validate some of these products.
- Once validated this products have the potential to become Earth Science Data Records (ESDR).
- Some other products cannot be directly validated, generally because there is no or few validation data currently available but it is conceivable that they can be validated in the next decade.
- Through our participation in NASA's EOS, REASoN CAN and MEaSUREs programs we have or are developing new ocean color products. These products are described and some are presented here.

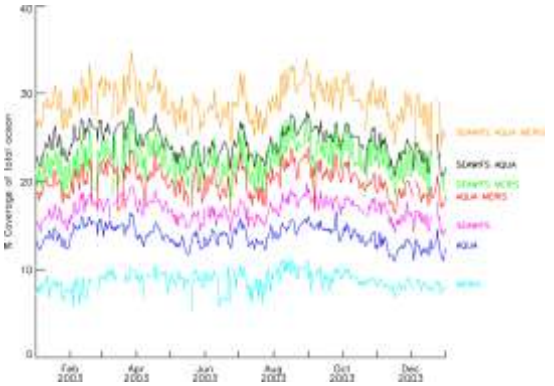
Ocean color products (REASoN, MEaSUREs and EOS programs)

Product	Link to biogeochemistry	Algorithm
Chlorophyll-a	Phytoplankton biomass; Primary Production	GSM semi-analytical model
$a_{cdm}(\lambda)$	Photochemistry; Heterotrophic production; Light budget	GSM & QAA algorithms
$a_{ph}(\lambda)$	Physiology and type of phytoplankton; Primary Production; trophic state	GSM & QAA algorithms
$b_{bp}(\lambda)$	Particulate material; POC	GSM & QAA Loisel et al. (2006)
S - $a_{cdm}(\lambda)$ spectral slope	Photochemistry, CDOM origin & bleaching history	GSM semi-analytical model QAA algorithm
η - $b_{bp}(\lambda)$ spectral slope	Particle size distribution Export flux	Loisel et al., (2006)
$K_d(\lambda_{UV})$	Light Budget, Photochemistry	Siegel et al. (2007)
Phytoplankton Functional Types	Primary Production Carbon fluxes	Alvain et al. (2004, 2006)
Net Primary Production	Primary Production Carbon fluxes	VGPM & CbPM
Merged products (chl, $a_{cdm}(443)$, $b_{bp}(443)$	Phytoplankton biomass, Primary & secondary production, Particulates, POC, Photochemistry	Maritorena & Siegel (2005)

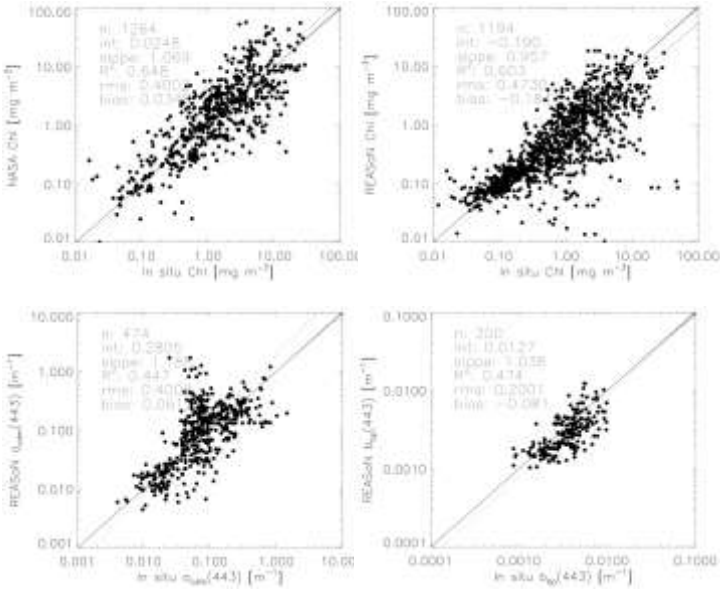
Merged data sets



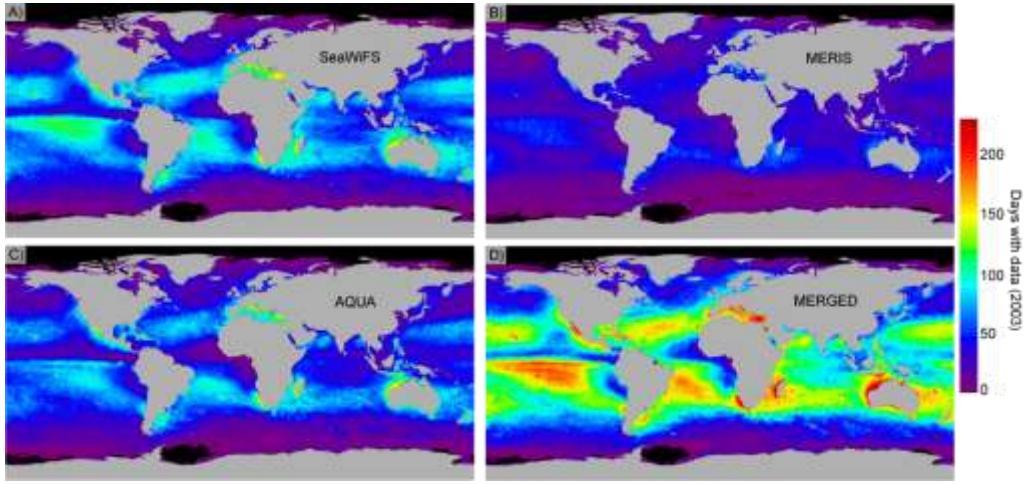
Spatial coverage



Matchups



Temporal coverage



- ftp:ftp.oceancolor.ucsb.edu/pub/org/oceancolor/REASoN/
- OPeNDAP server: http://dap.oceancolor.ucsb.edu/cgi-bin/nph-dods/data/oceancolor/

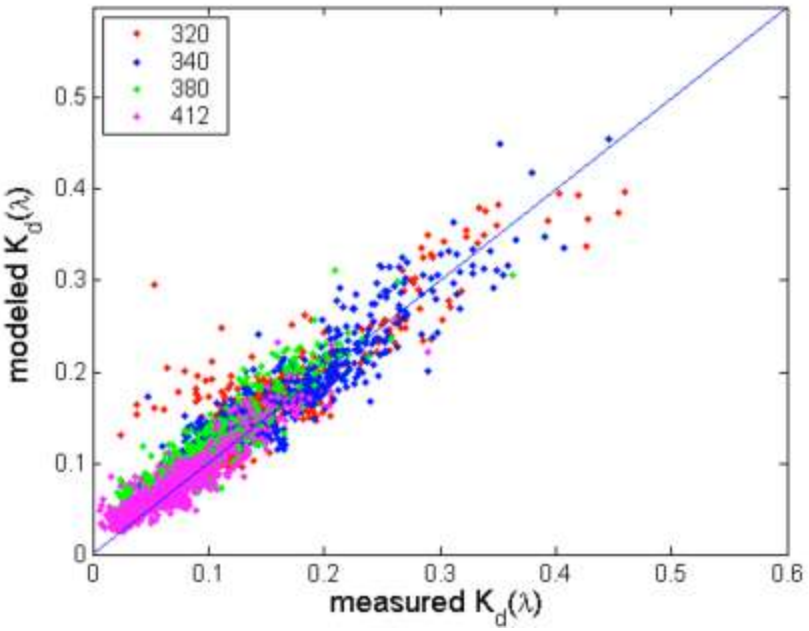
New products = Kd(UV)

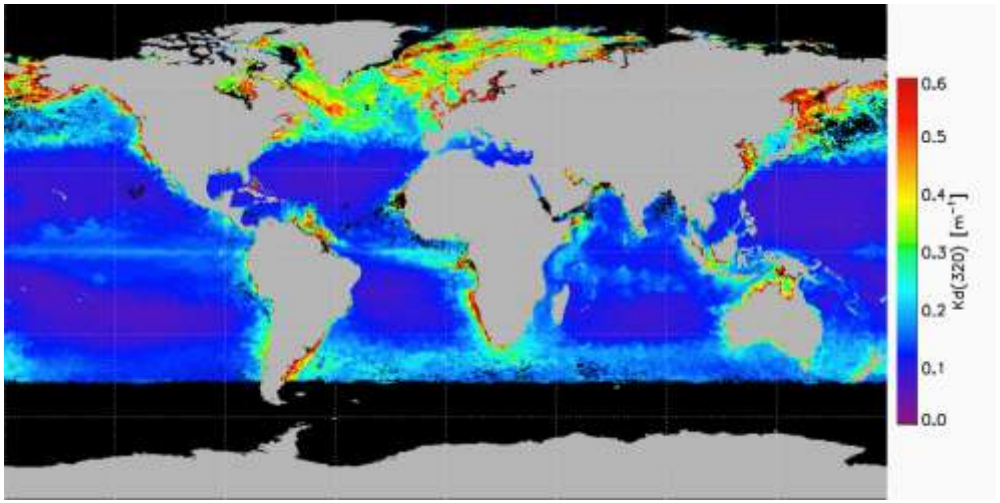
- **Model development relies on 2 main assumptions:**
  - **$K_d(\lambda_{UV})$ can be modeled using the single scattering approximation.**

    $$K_d(\lambda_{UV}) = f[a(\lambda_{UV}), b_b(\lambda_{UV})]$$
  - **CDOM is mostly responsible for $Kd(\lambda_{UV})$ variability**

- **Model uses the products from the GSM model (CHL, CDM, BBP) in the visible (443 nm) to predict $K_d(\lambda_{UV})$**

$$K_d(\lambda_{UV}) = K_w(\lambda) + CC(CDM)\exp(-S(CDM)(\lambda-443)) + a_{ph}^*(\lambda_0) + \beta_0\, BBP\, (\lambda-443)^{-1}$$





New products - PSD (Tiho Kostadinov)

$N(D) = N_0 (D/D_0)^{-\xi}$ PSD follows a Junge distribution

Mie theory provides a link between measurable optical properties and the Junge PSD!

$$b_{bp}(\lambda) = \int_{D_{min}}^{D_{max}} \frac{\pi}{4} D^2 Q_{bb}(D, \lambda, m) N_o \left(\frac{D}{D_o} \right)^{-\xi} dD$$

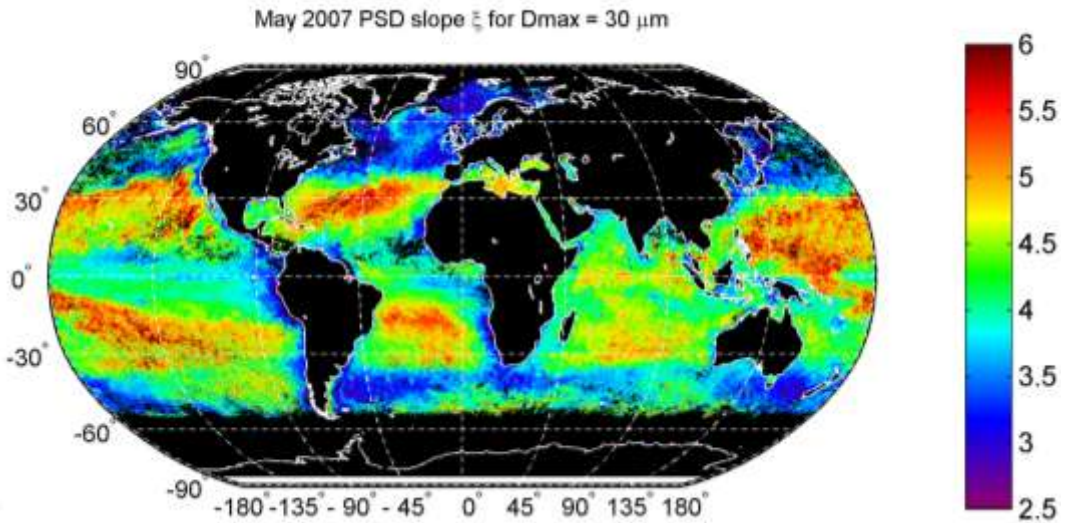
Measured

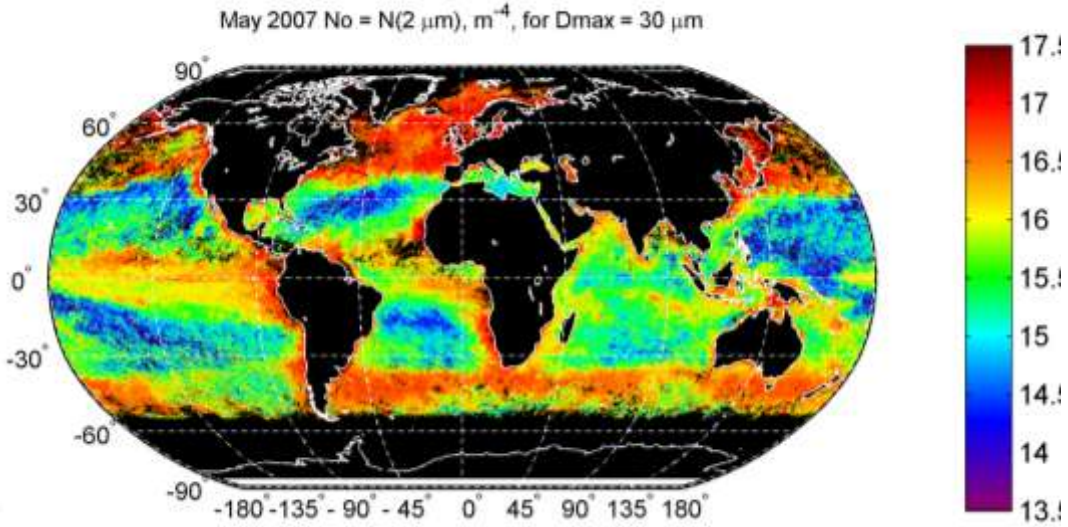
$b_{bp}(\lambda)$ efficiency solved by Mie theory

Retrievals

m = n – ik = Complex index of refraction
ξ = Junge slope of the PSD
D = particle diameter [m]
D_0 = reference diameter (2 µm)
$N_0 = N(D_0)$ = number of particles per volume of seawater normalized by the bin size width (m^{-4}) for the reference Diameter

New products - PSD





log10(particles/m^{-4})

Associated products:

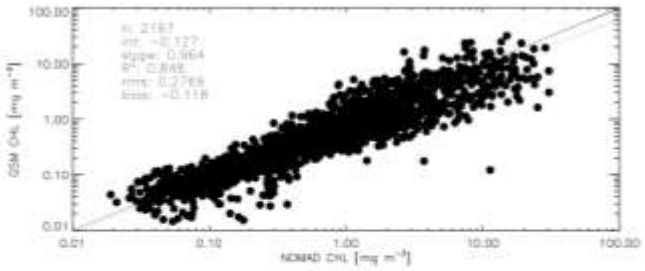
- Total Biovolume
- Partitioned Biovolumes (phytoplankton size classes)
- Partitioned Number concentration

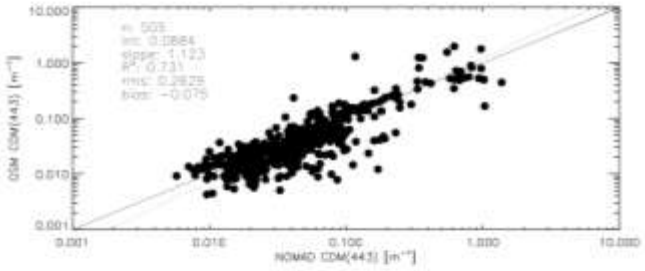
Current Plans

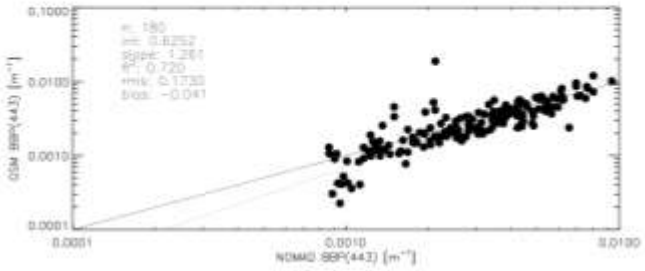
- Validation – need more PSD & $b_{bp}(\lambda)$!!!
- Complete error and sensitivity analysis

GSM model development - Global

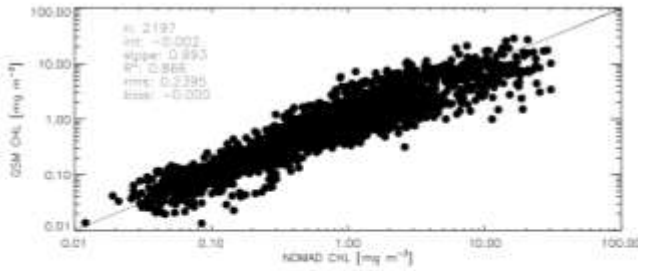
Original GSM01 with NOMAD data
aph(λ) parameterization is not ideal

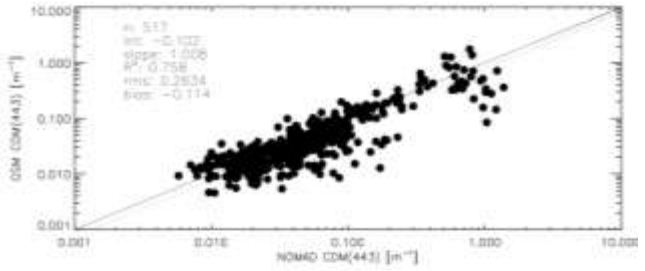


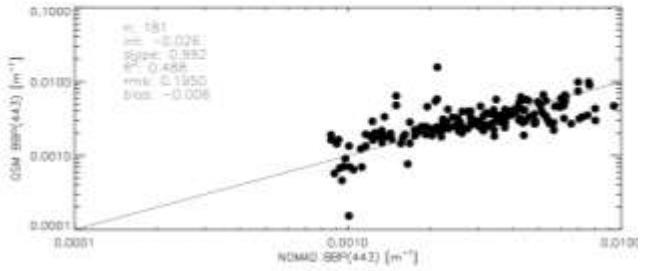




"Improved" GSM tuned with NOMAD data
aph(λ) parameterization is more realistic





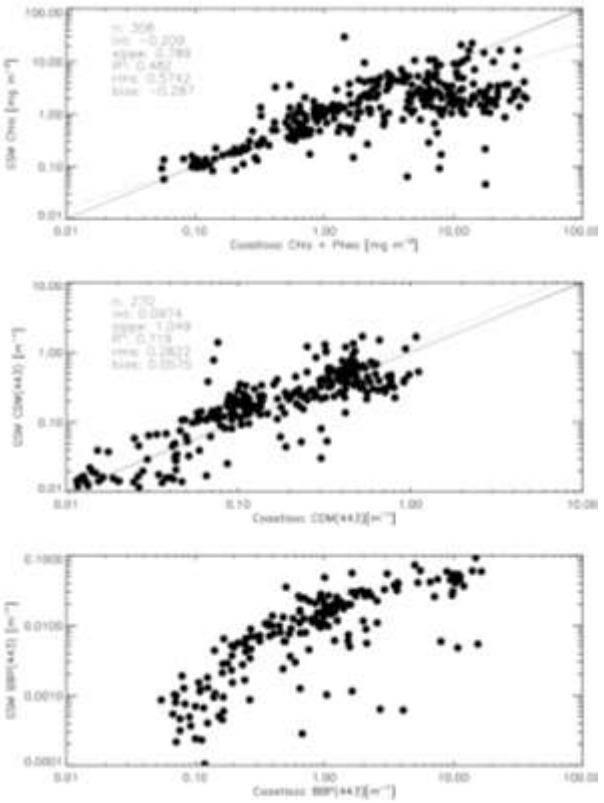


Working on solving for CDOM slope, backscattering slope
Drop the quadratic formulation
IOP workshop

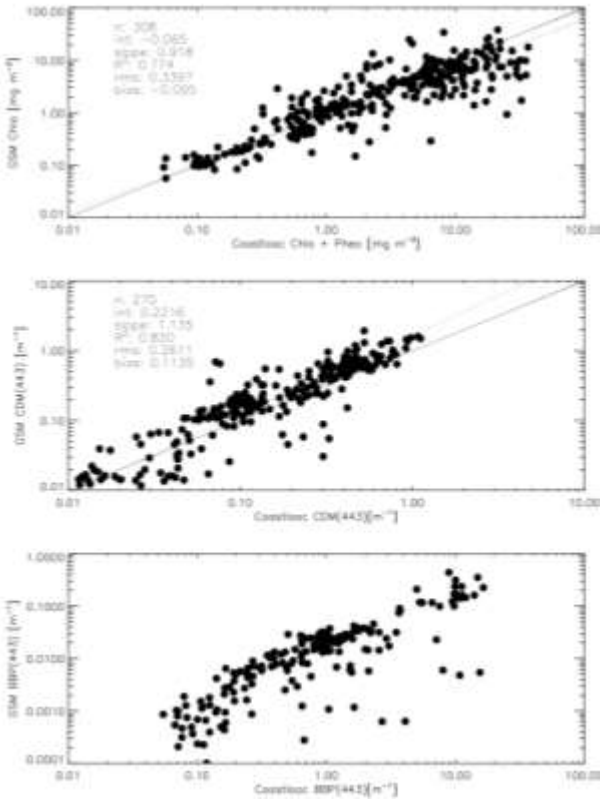
GSM model development – Coastal waters

-**Use of Coastlooc data (European coastal waters)**

- **Run original GSM model**
- **Adapt the model so it can handle any wavelength**
- **Use bands in the 570-700 nm range**



Original 5 bands version



All bands version

Thank you.