From UV to fluorescence, a semi-analytical ocean color model for MODIS and beyond

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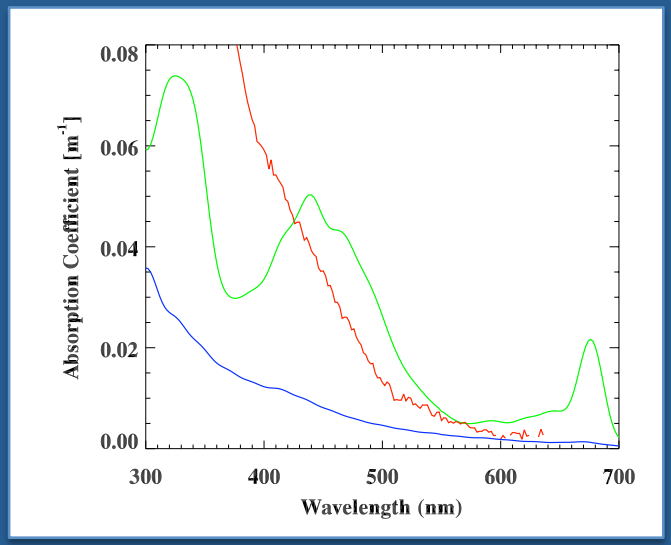
Objective:
Add new or improved features to the GSM model

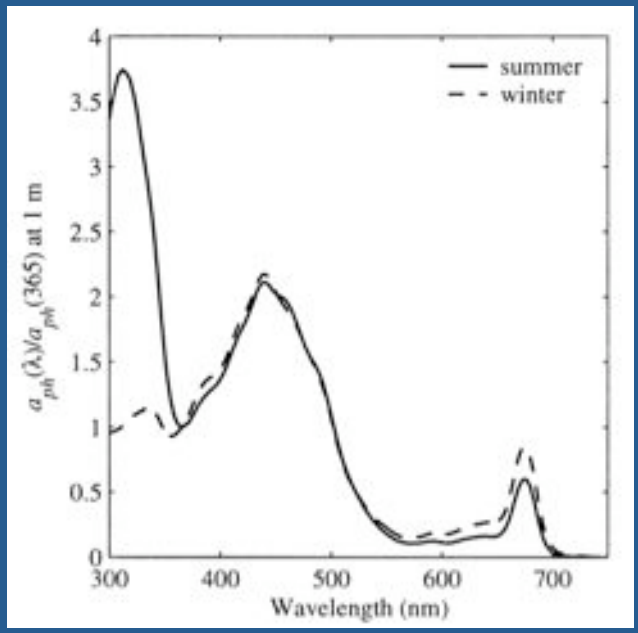
- - Develop a fluorescence module
- - Investigate and add a UV component
- - Make the GSM model hyperspectral and adaptable to multispectral sensors like MODIS
- - Develop a complete end-to-end error budget (inputs, model, outputs)
- - Apply the model and error budget to the MODIS data

Expand GSM into the UV

- ✧ 412 nm channel in OC sensors is designed to detect CDOM.
- ✧ Phytoplankton and CDOM absorption can be of similar magnitude around 412 nm
- ✧ UV bands have the potential to better separate CDOM and phytoplankton absorption

No UV bands in MODIS or VIIRS. HyspIRI, ACE, GEO-CAPE

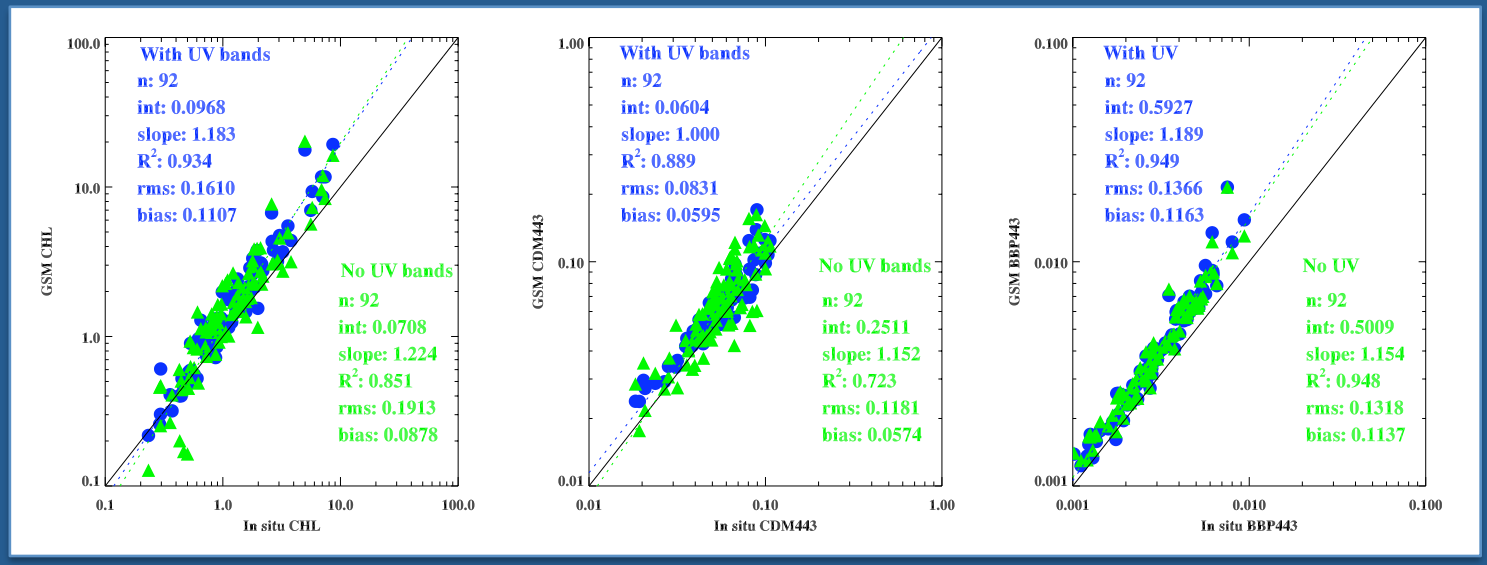




From Morrison & Nelson (2004)

GSM and UV – Preliminary results

- Synthetic data set created from the SeaBAM
- Inversion using GSM with and without the UV bands (a_{ph}(UV) coefficients from a small data set, spectral shape of CDM and b_{bp} expanded in the UV)



- The CDM and CHL retrievals are generally better when the UV is used.
- The use of the UV bands does seem to influence the BBP retrievals much.

GSM and UV – The Plan

- Put together a large in situ data set with radiometry and IOPs in the UV

    SeaBASS, U.S. CO2 CLIVAR Repeat Hydrography project, Bermuda Bio-optical Project (BBOP) and the Plumes & Blooms project.

- QC the data set
- Seasonality, MAA, photoprotection in a_{ph}(UV)
- Tune GSM (350-650 nm ?)

GSM and Fluorescence

Preliminary tests using the Huot et al. (2005, 2007) model

- Uses the strong relationship between fluorescence line height (FLH) and phytoplankton absorption in the blue.
- In the ~620 to 710 nm range, reflectance is parameterized as a "classic", no-fluorescence, $b_b(\lambda)/a(\lambda)$ term + a "fluorescence" term:

$$R(\lambda) = f(b_b(\lambda)/a\lambda)) + Rf(\lambda)$$

- The fluorescence term is a function of $a_{ph}(443)$, $K_d(443)$, the attenuation of the fluorescence signal, $kf(\lambda)$ and incident irradiance:

$$Rf = f(a_{ph}(443), K_d(443), kf(\lambda), E_d(\lambda))$$

Fluorescence model (Huot et al., 2007)

$$R(\lambda) = \frac{M_1\left(\frac{\lambda}{620}\right)^{-M_2}}{a_w(\lambda) + a_\phi(\lambda) + M_3 \exp(-0.0176\,(\lambda - 620))} + \frac{M_4\,\tilde{f}(\lambda)\,a_\phi(443)}{K_d(443) + a_w(\lambda) + a_\phi(\lambda) + M_3 \exp(-0.0176\,(\lambda - 620))}\,\frac{E_d(443)}{E_d(\lambda)}$$

$$K_d(443) = (1+0.005\,\Theta_s)\,(a_w(443) + a_{CDM}(443) + a_\Phi(443) + 4.18[1-0.52\,\exp(-10.8(a_w(443) + a_{CDM}(443) + a_\Phi(443))]\,(b_{bw}(443)+b_{bp}(443))$$

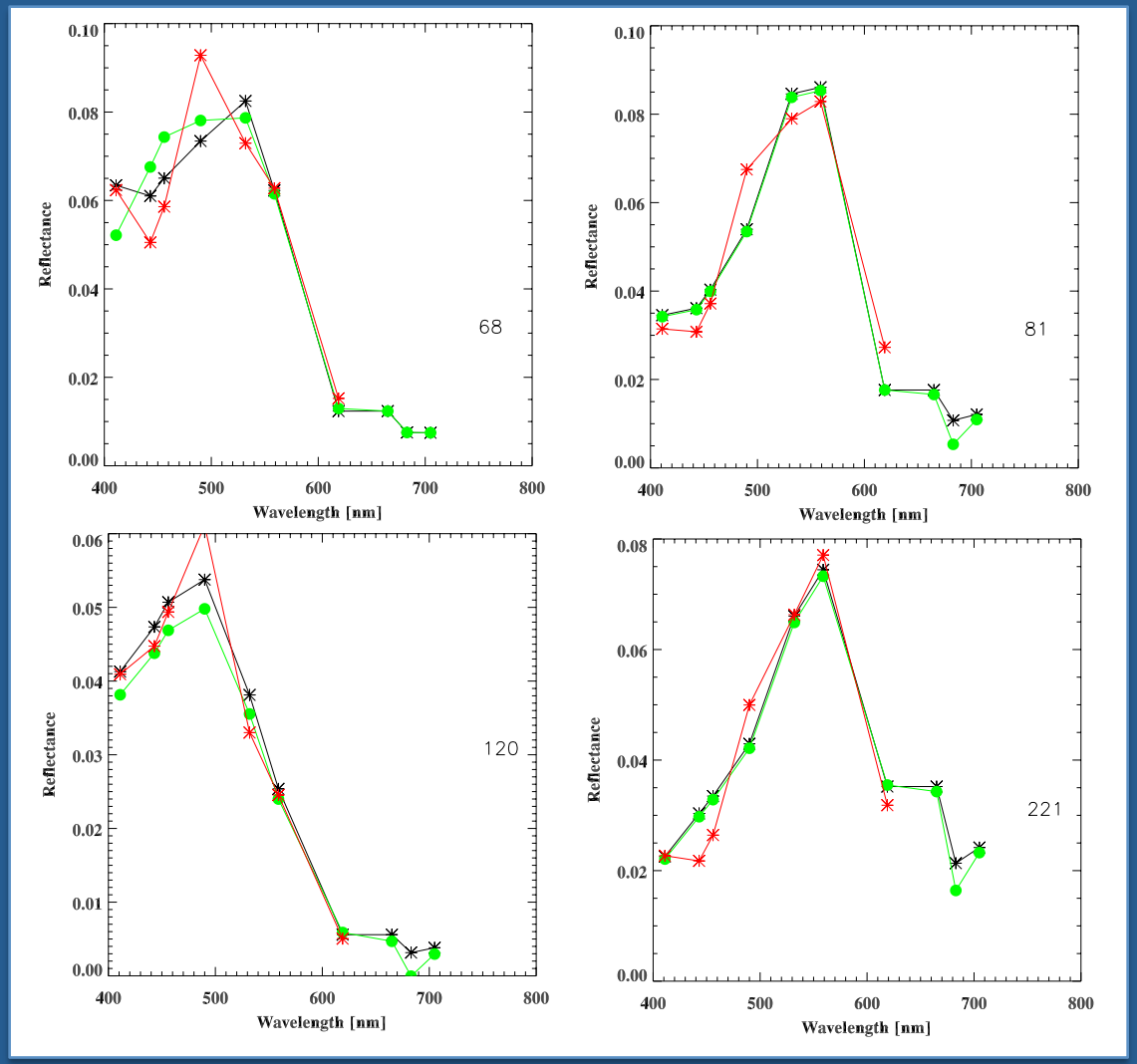
$$a_\phi(\lambda) = A(\lambda)\left(\frac{a_\phi(443)}{A(443)}\right)^{B(\lambda)/B(443)}$$

$a_\Phi(443)$, $b_{bp}(443)$, $a_{cdm}(443)$: unknowns common with GSM

Original bands: 620, 665, 683 and 709 nm

M1, M2, M3: unknowns (M4 is a constant)

Preliminary results GSM w/ Fluorescence

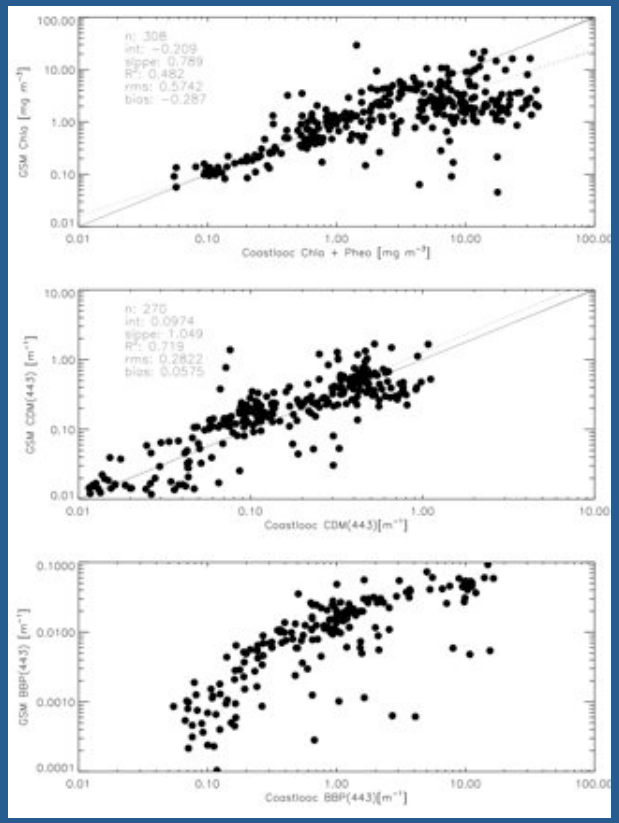


Coastlooc data set

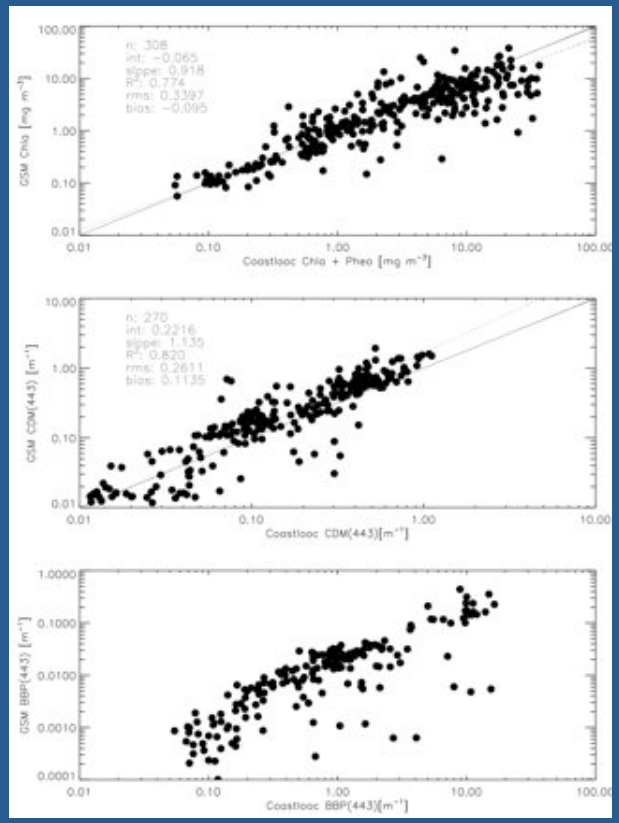
- 2 modes:
  - -Full spectrum inversion (needs band weighting)
  - - 2 steps: 1) “Classic” GSM run for visible bands then 2) Run fluorescence module
- Other data sets
- Better Chls? Better aph? Quantum yield?

Flexible bands GSM

- **Original tuning was for SeaWiFS 6 visible bands**
- **Parameters can be adapted for other bands**
- **Adapt the future model so it can handle any wavelength**

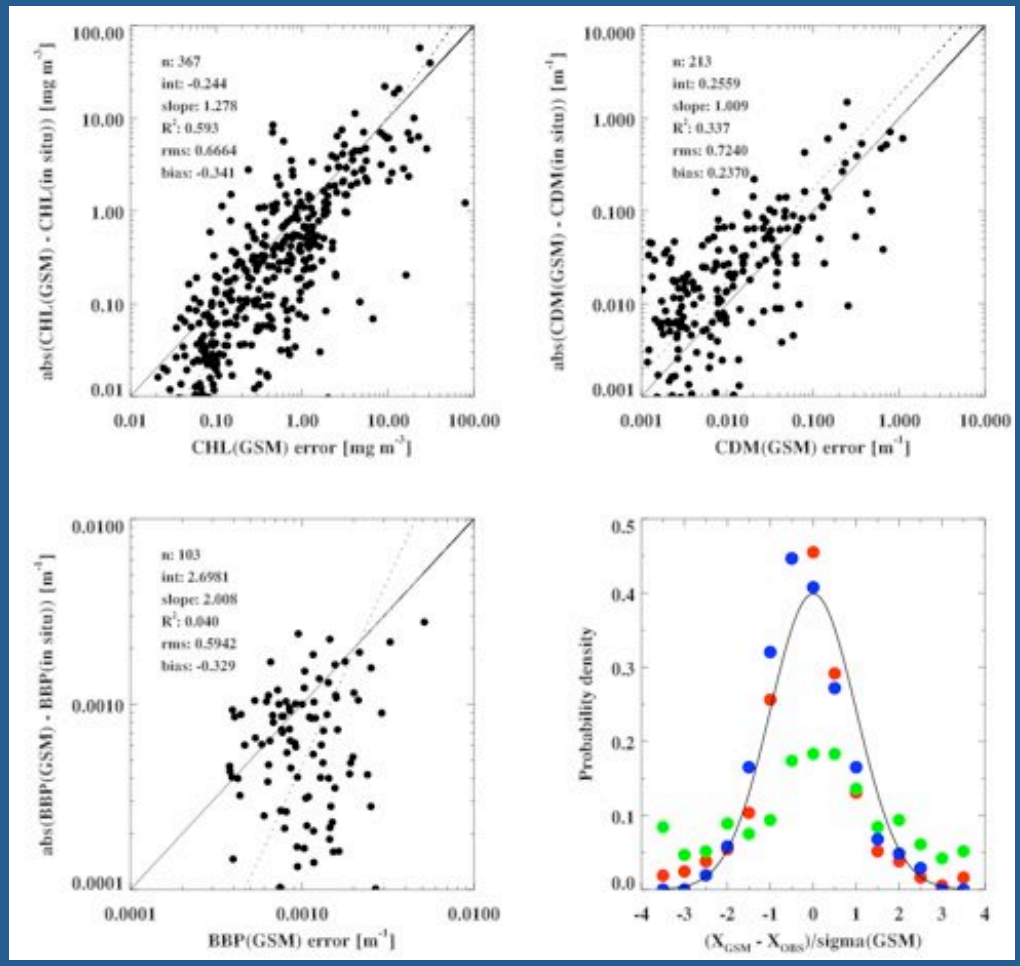


Original 5 bands version



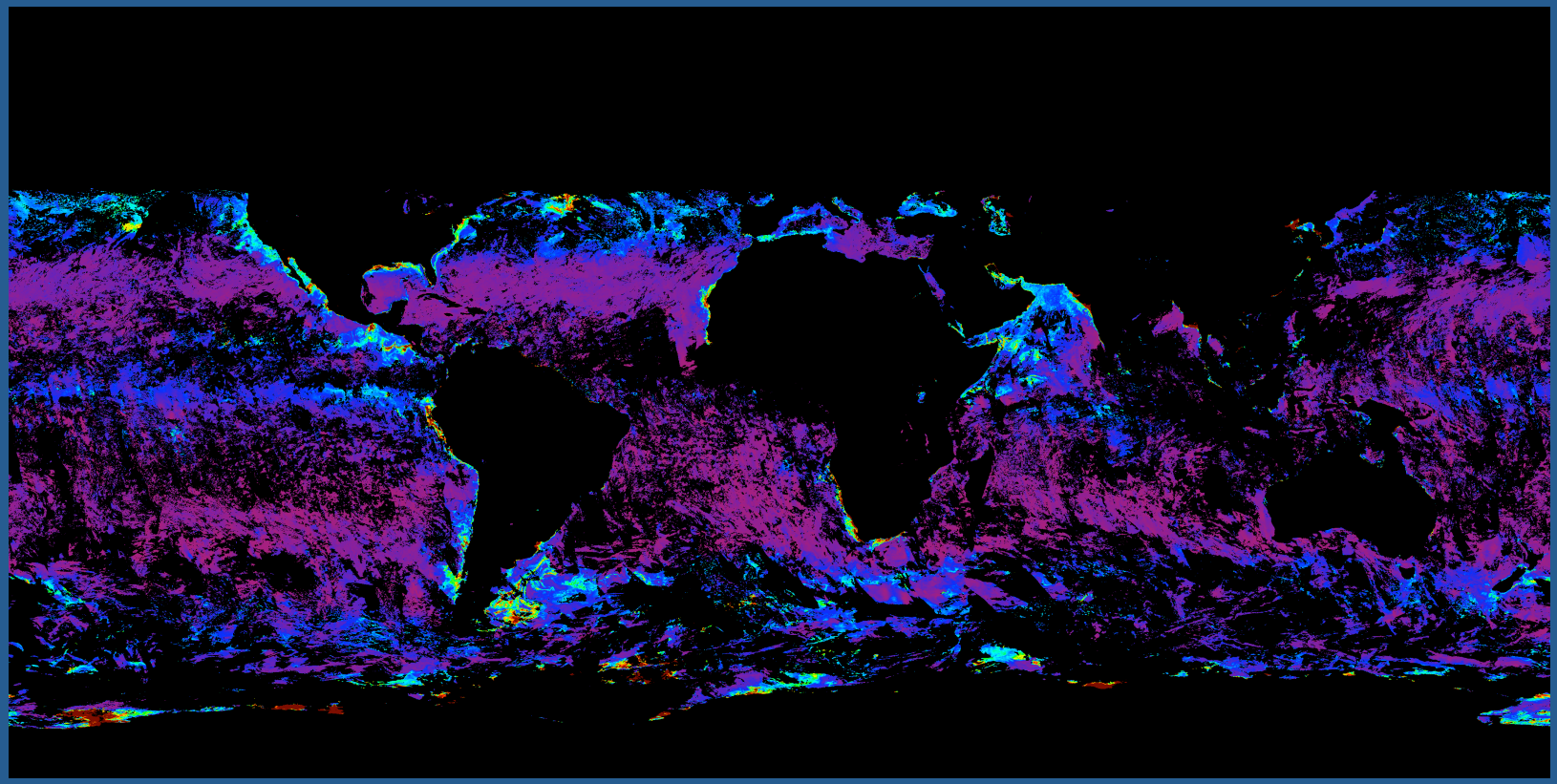
All bands version

Error budget (input, model, output)



Maritorena et al. (2010)

Apply the new model to MODIS data



Summary

Expand GSM in the UV

Add a Fluorescence module

Update parameterization in some components

Make the model “wavebands flexible”

Uncertainty budget

Apply to MODIS data