Ocean Color Data Merging Using Normalized Water Leaving Radiances. Preliminary Results with SeaWiFS, MOS and MODIS Data

Stephane Maritorena & David A. Siegel

ICESS

University of California Santa Barbara

Special thanks to: Bryan Franz (SAIC, GSFC), Jeremy Werdell (SSAI, GSFC), SIMBIOS Project, David Court (ICESS, UCSB), Brian Langston (ICESS, UCSB)

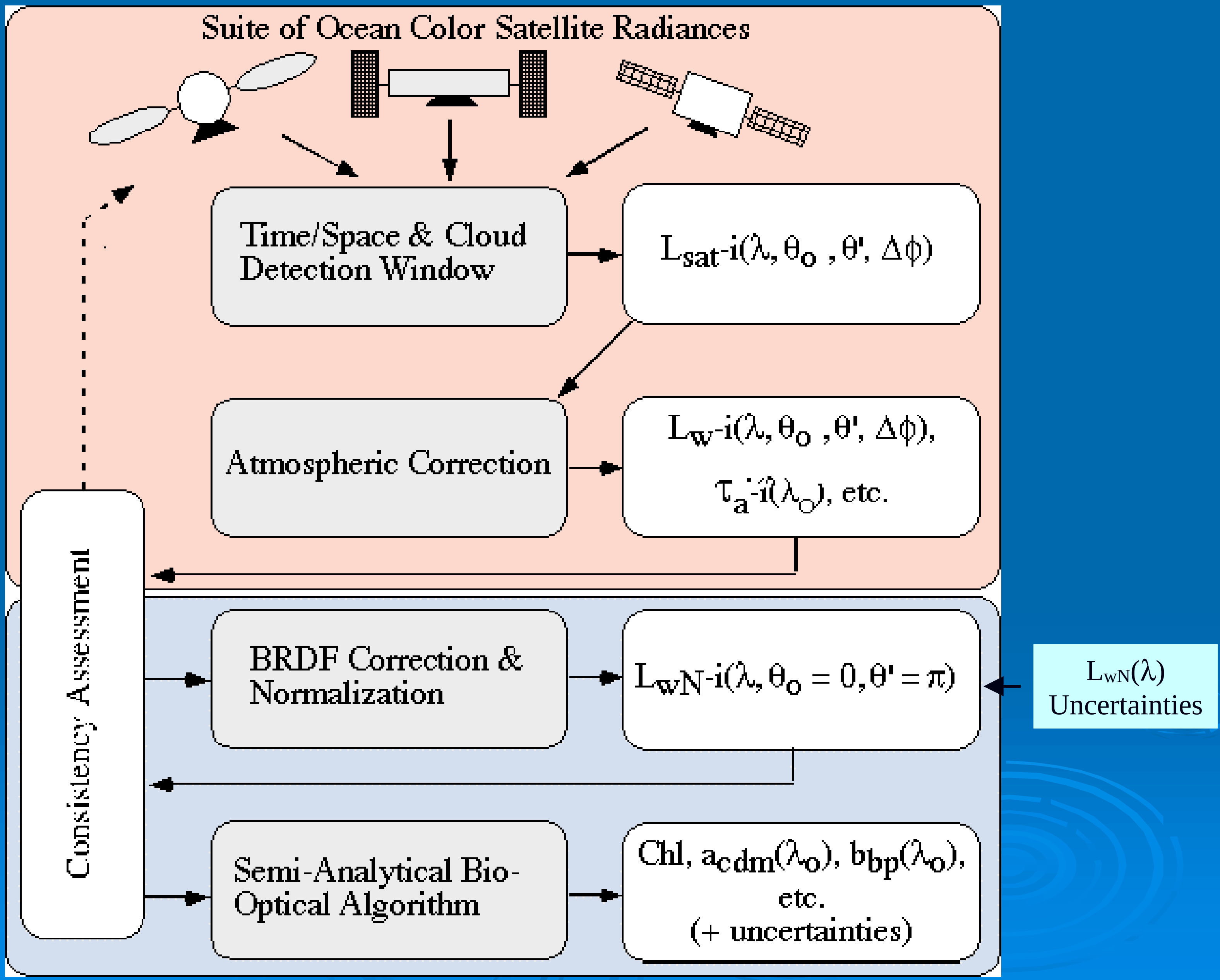
Approach:

Merge data from different satellites at the Normalized Water-leaving Radiance (LwN) level using a semi-analytical ocean color model to derive Chl and inherent optical properties (IOPs).

Benefits:

- Consistency in the derivation of products
- Can handle data sources with different bands
- Can exploit band redundancies and band differences
- Can account for uncertainties in the input data
- Provides uncertainty estimates for the output products
- Provides simultaneous retrievals (Chl, a_{cdm}, b_{bp})
- Improved diversity & utility of products

COMPLETE MERGING PROCEDURE



THE GSM01 INVERSION MODEL

Maritorena et al. (In Press)

- **GSM01** is an optimized version of the Garver & Siegel (1997) semi-analytical model

$$\hat{L}_{wN}(\lambda) = \frac{t\,F_0(\lambda)}{n^2} \sum_{i=1}^{2} g_i \left(\frac{b_b(\lambda)}{b_b(\lambda) + a(\lambda)} \right)^i$$

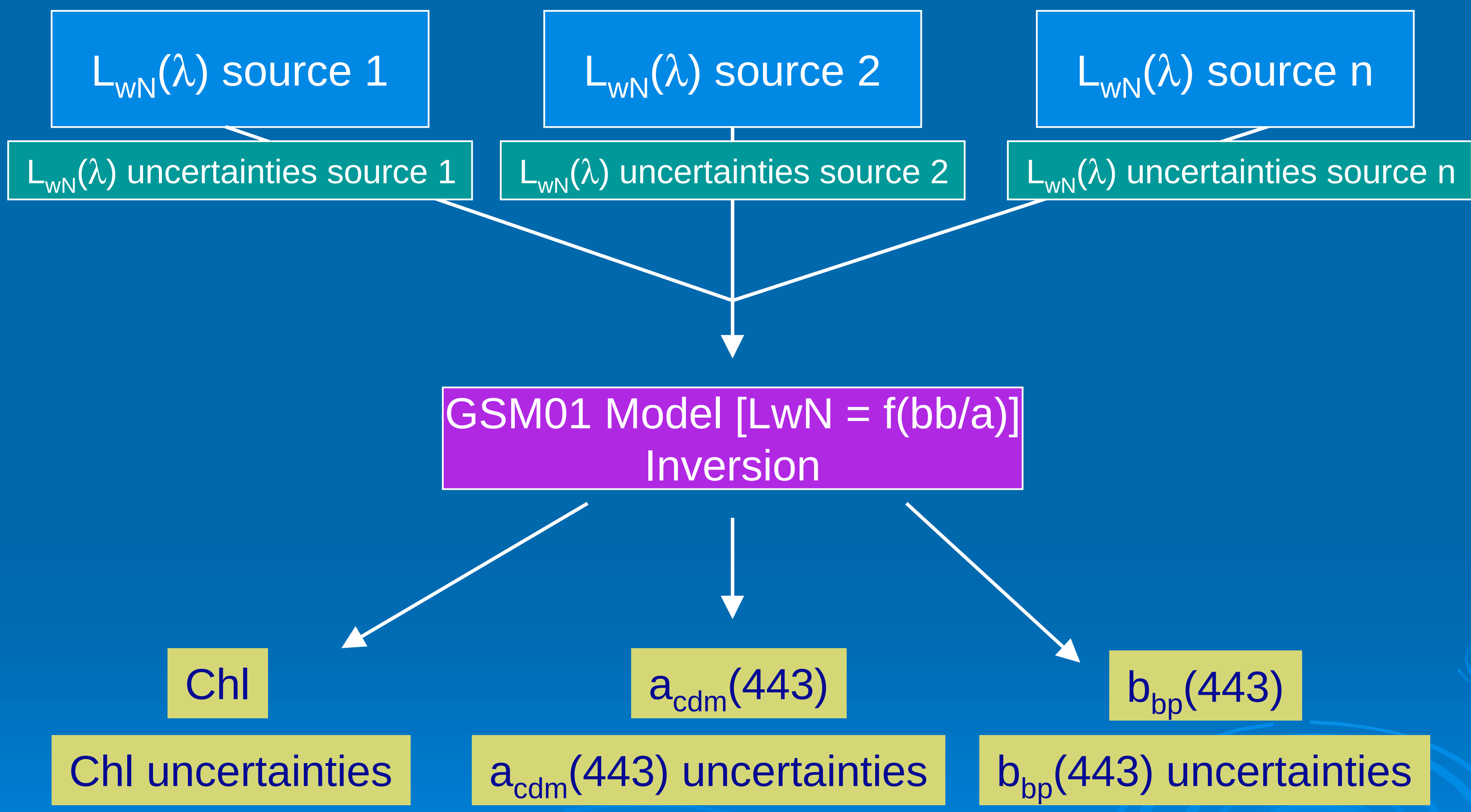
(Gordon et al., 1988)

- $a(\lambda)$ and $b_b(\lambda)$ spectra: know shape, unknown magnitude

- Uses a non-linear least-squares technique to solve for the unknowns : **Chl**, $\mathbf{a_{cdm}(\lambda o)}$ and $\mathbf{b_{bp}(\lambda o)}$ when 3 or more bands are available.

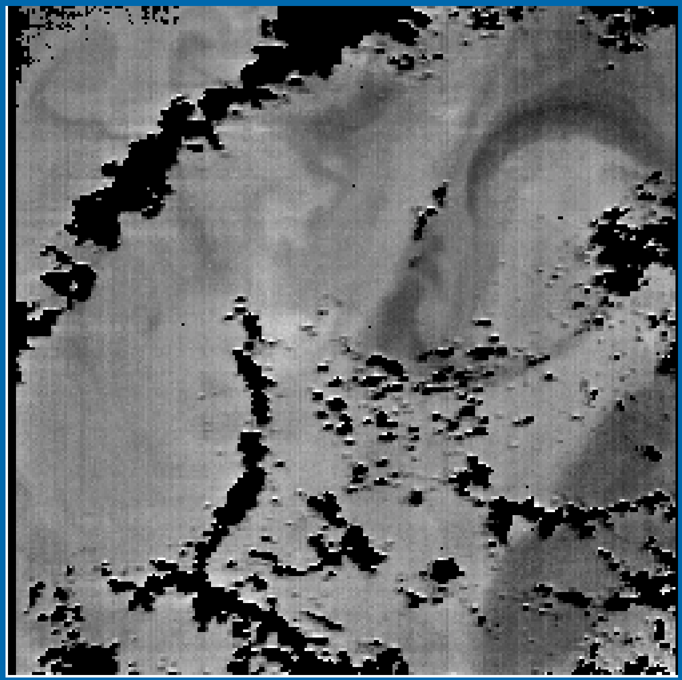
- Optimized for global applications using an “improved” SeaBAM data set (Chl, R_{rs}, K_d, $a_{cdm}(443)$, $b_{bp}(443)$) and an minimization technique (simulated annealing).

MERGING USING THE GSM01 MODEL

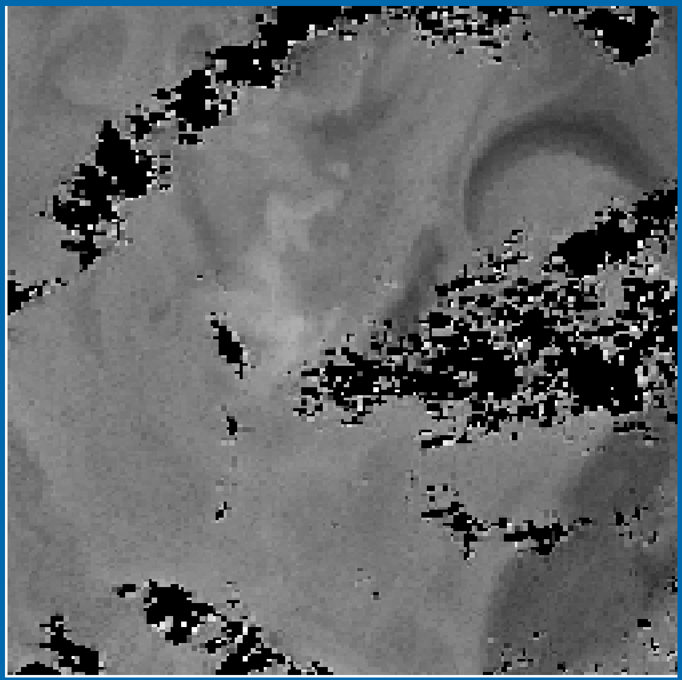


Product uncertainties: Linear approximation of non-linear regression inference region

MERGING SeaWiFS and MOS



λ	λ
408	412
443	443
485	490
	510
520	
	555
570	

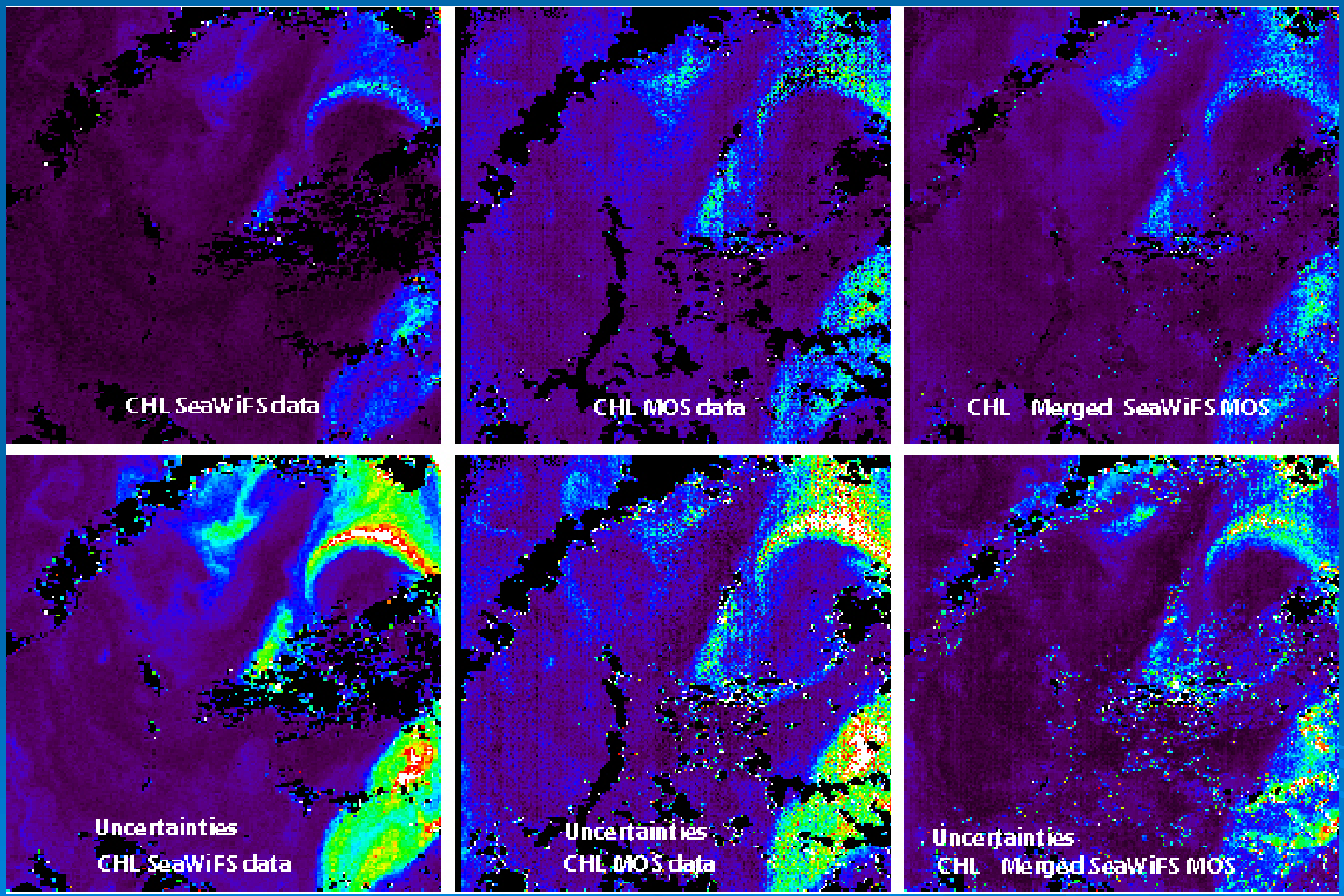


MOS $L_{wN}(490)$

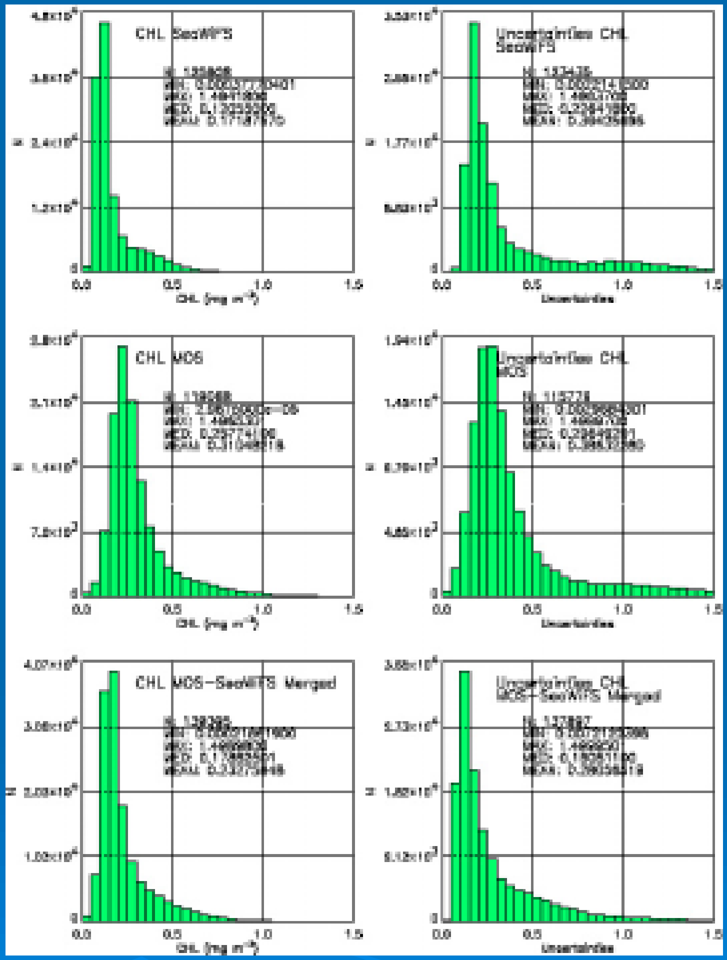
SeaWiFS $L_{wN}(490)$

Date : January 18, 2000

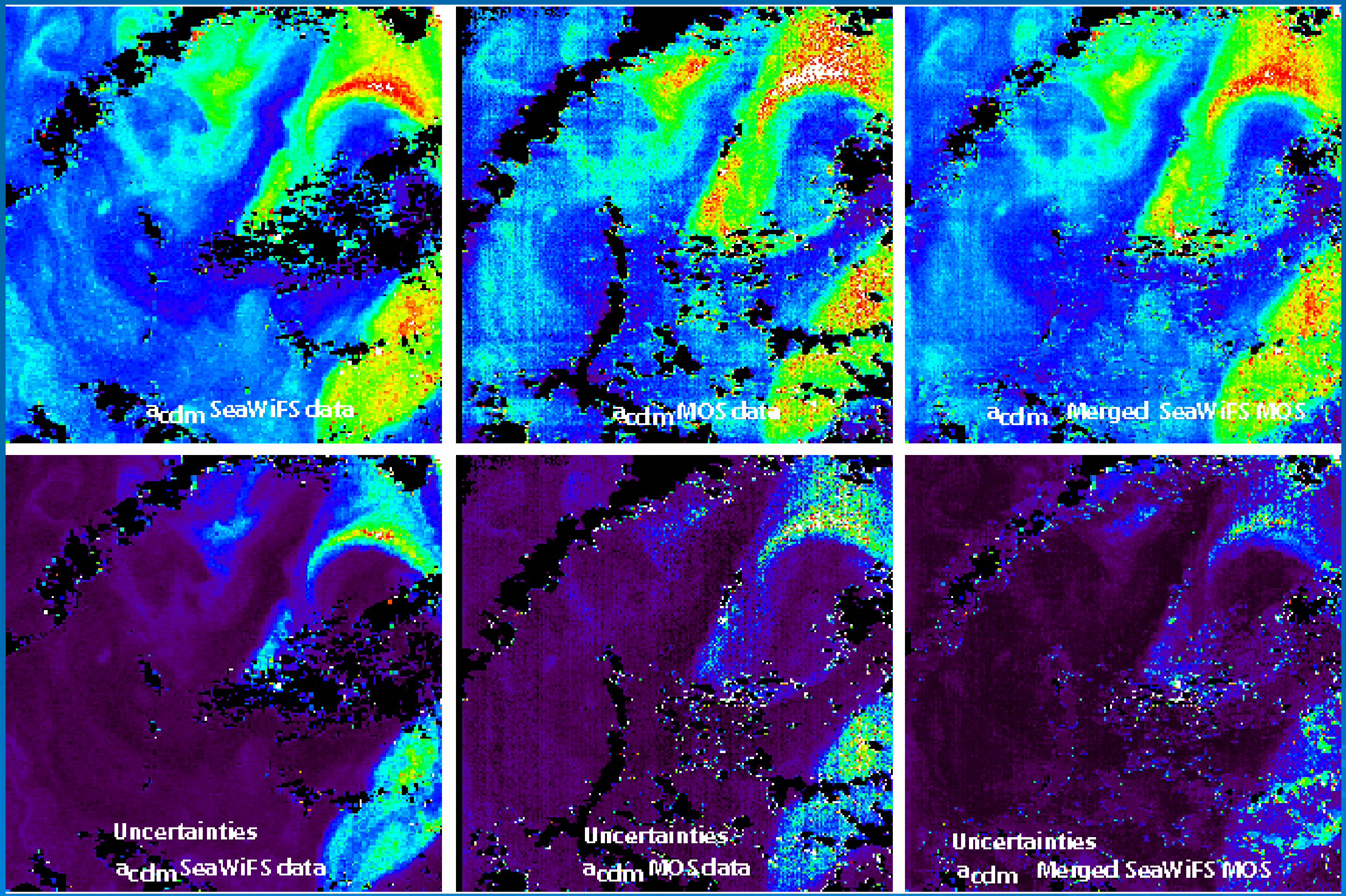
MERGING SeaWiFS and MOS RETRIEVED CHL (GSM01 model)



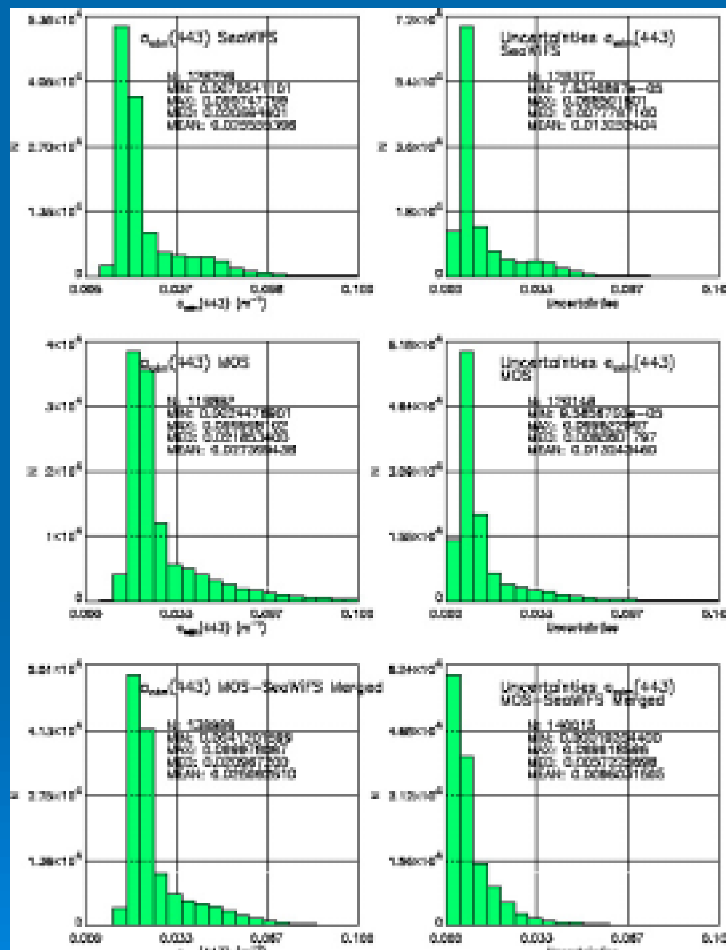
MERGING SeaWiFS and MOS RETRIEVED CHL (GSM01 model)



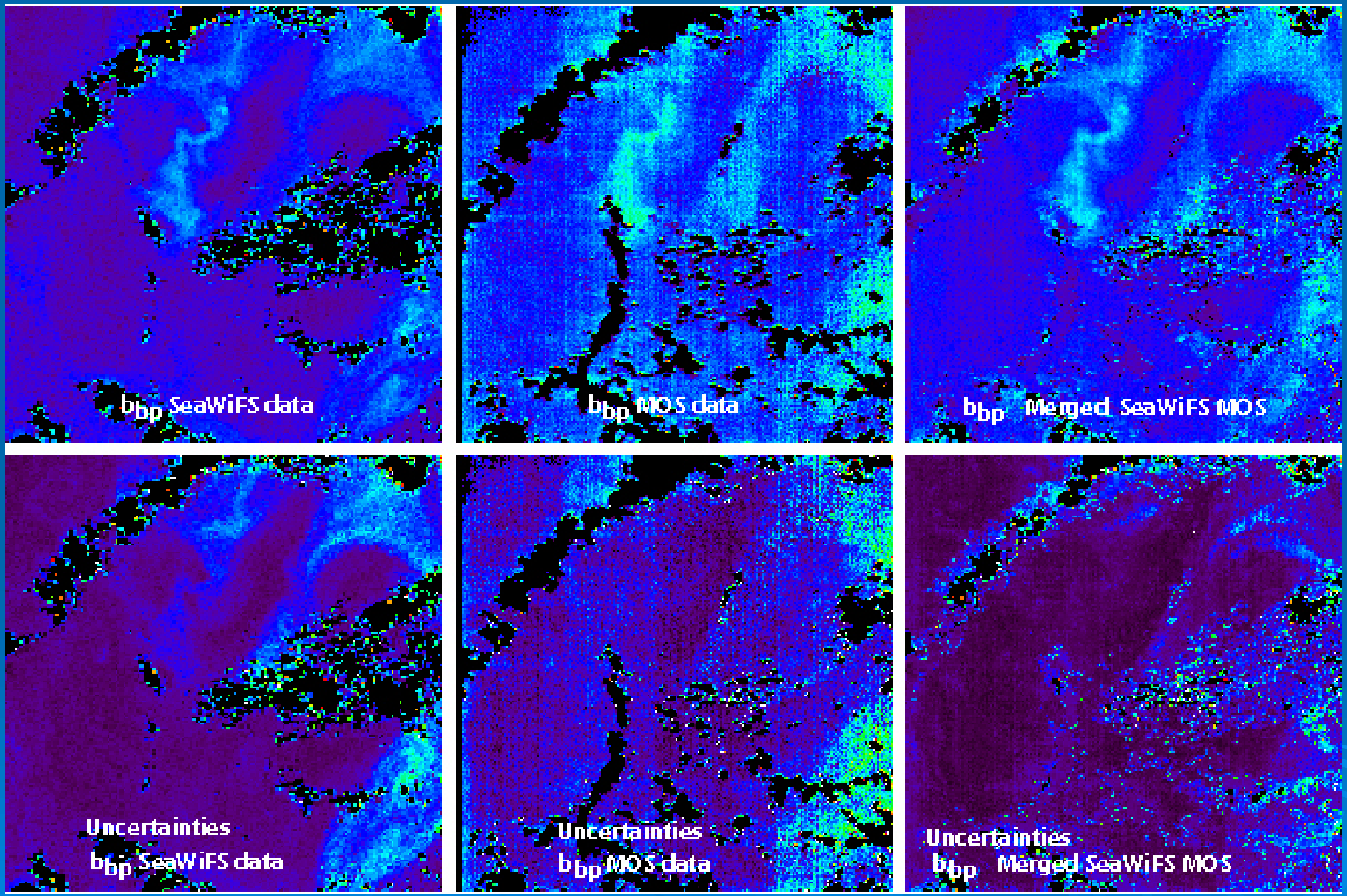
MERGING SeaWiFS and MOS RETRIEVED $a_{cdm}(443)$ (GSM01 model)



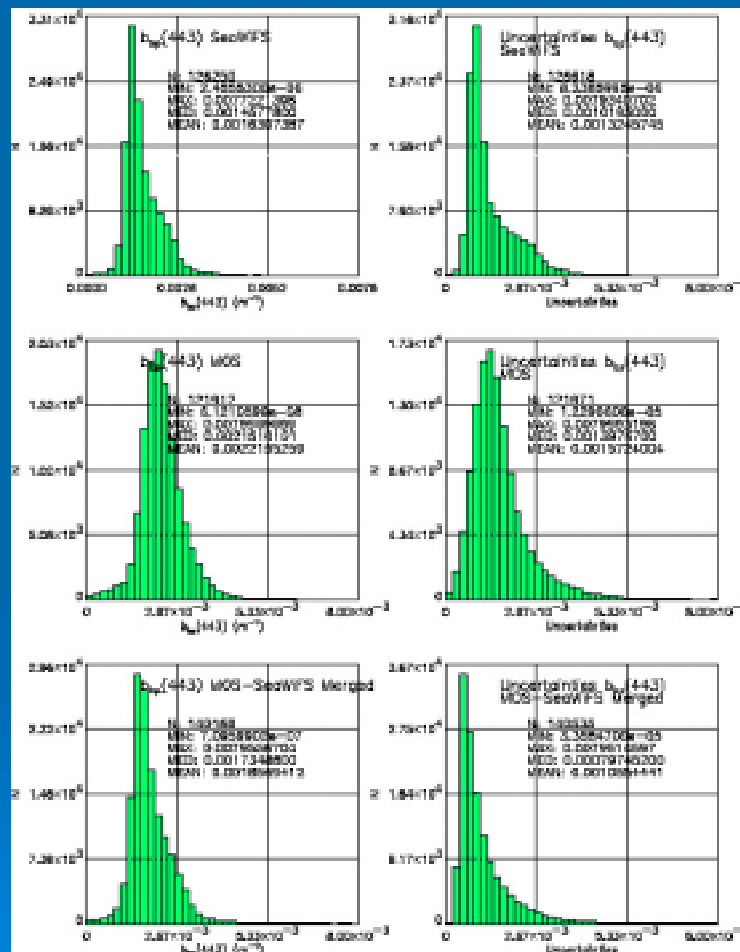
MERGING SeaWiFS and MOS RETRIEVED $a_{cdm}(443)$



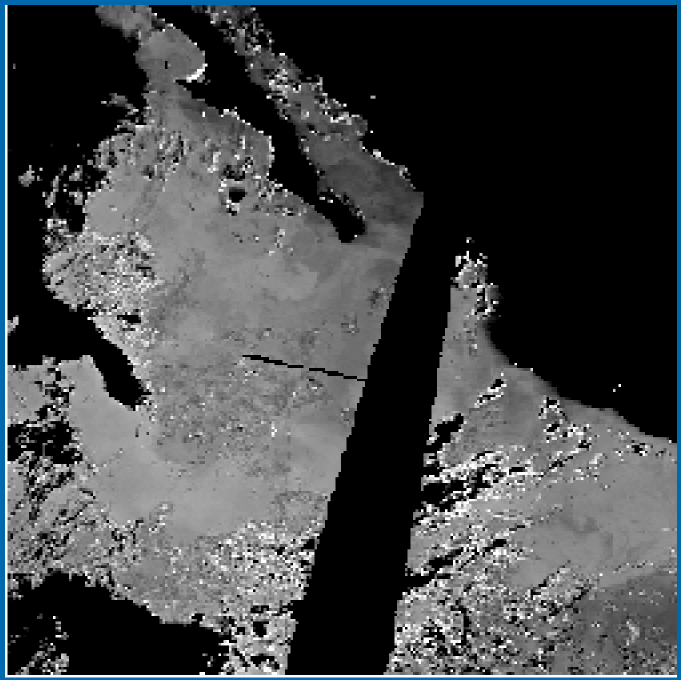
MERGING SeaWiFS and MOS RETRIEVED b_{bp}(443) (GSM01 model)



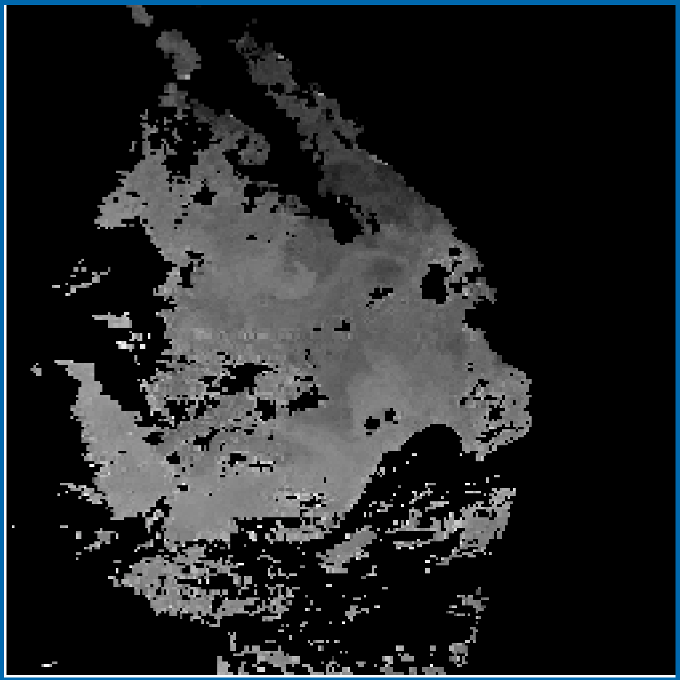
MERGING SeaWiFS and MOS RETRIEVED $b_{bp}(443)$



MERGING SeaWiFS and MODIS



λ	λ
412	412
443	443
488	490
	510
531	
551	555

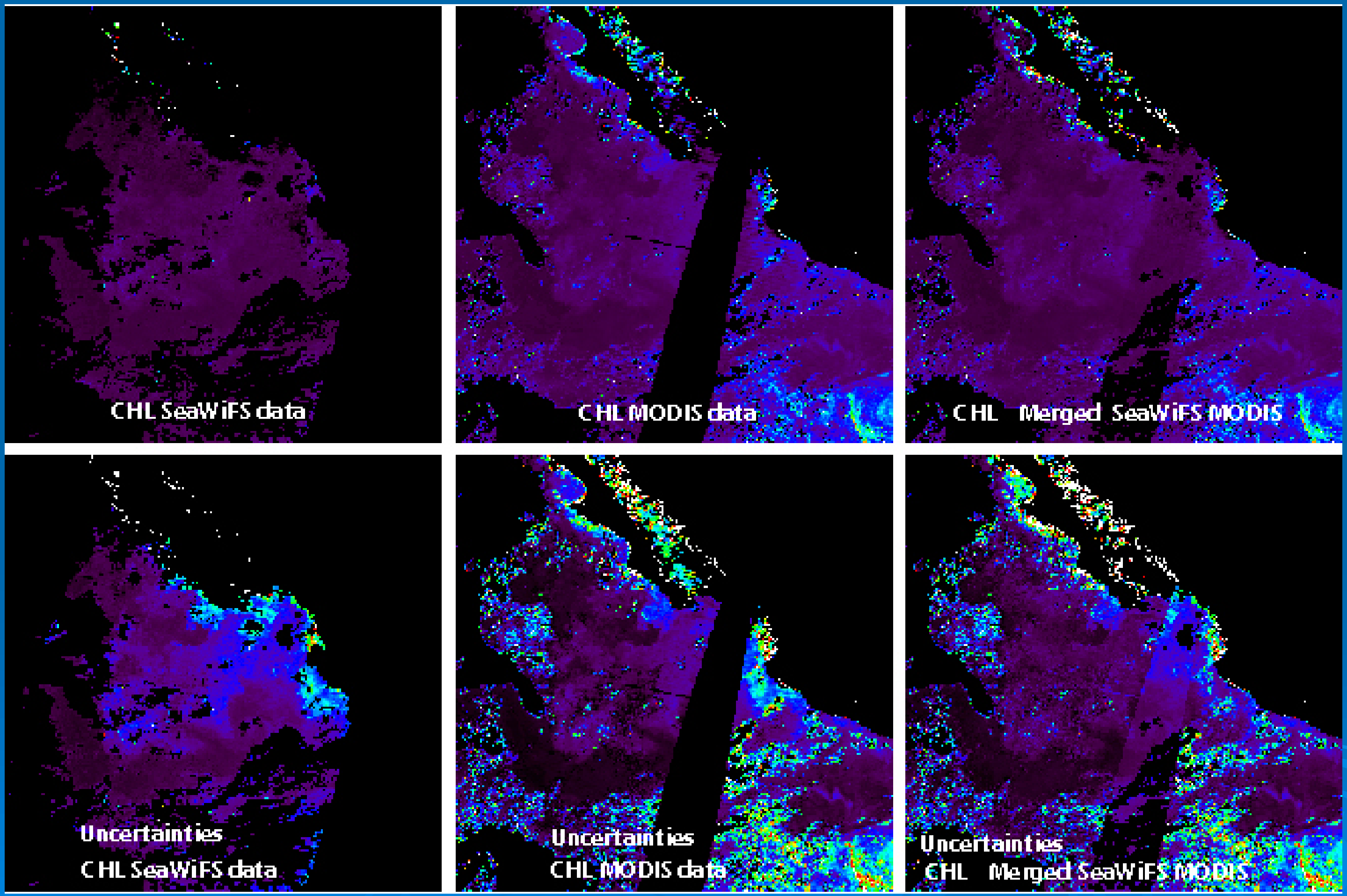


MODIS $L_{wN}(490)$

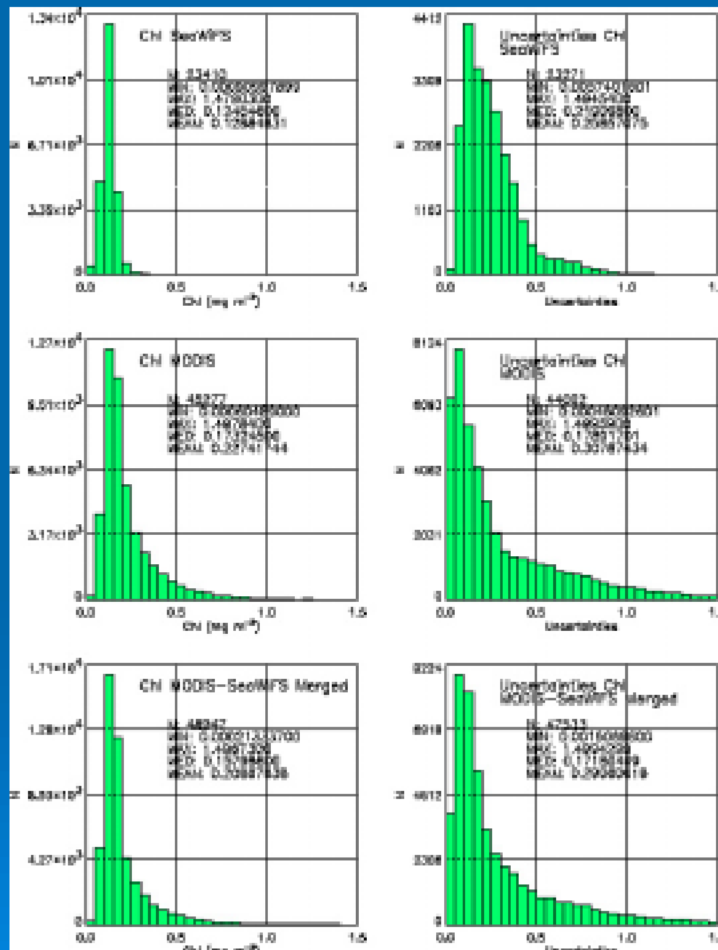
SeaWiFS $L_{wN}(490)$

Date : 2000_039

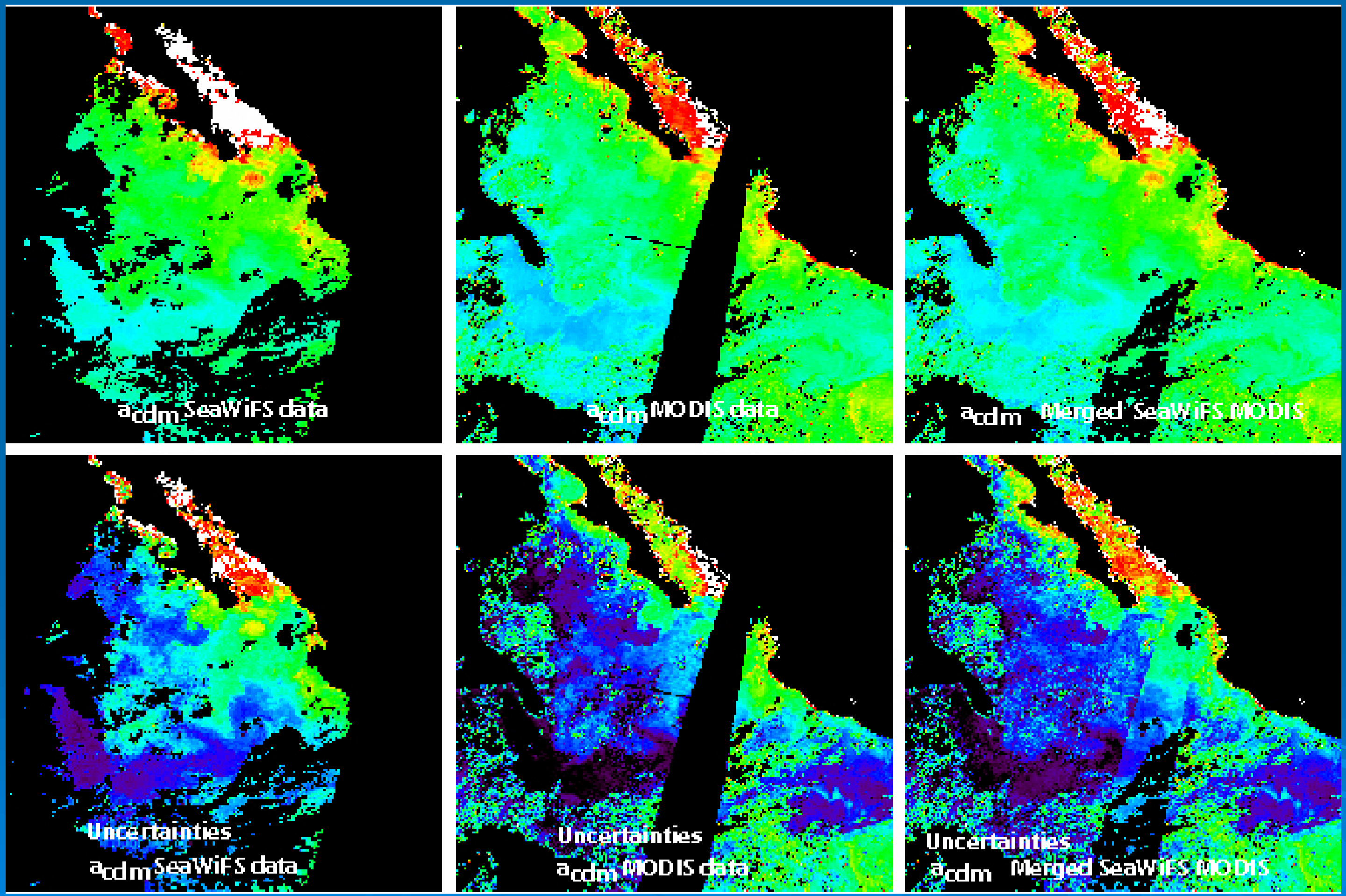
MERGING SeaWiFS and MODIS RETRIEVED CHL



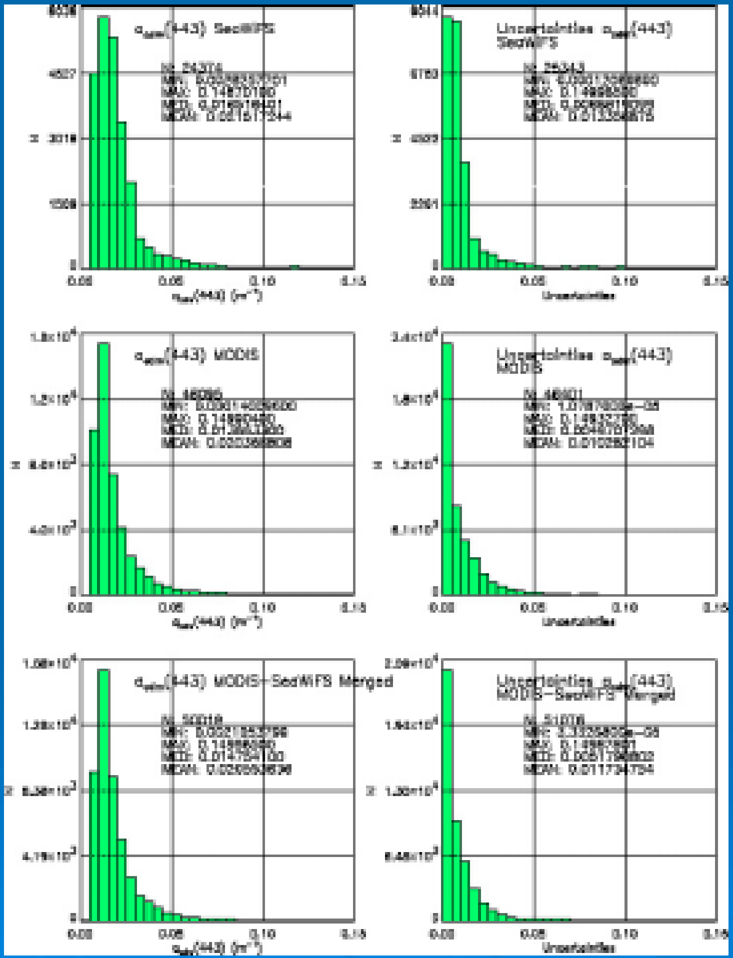
MERGING SeaWiFS and MODIS RETRIEVED CHL



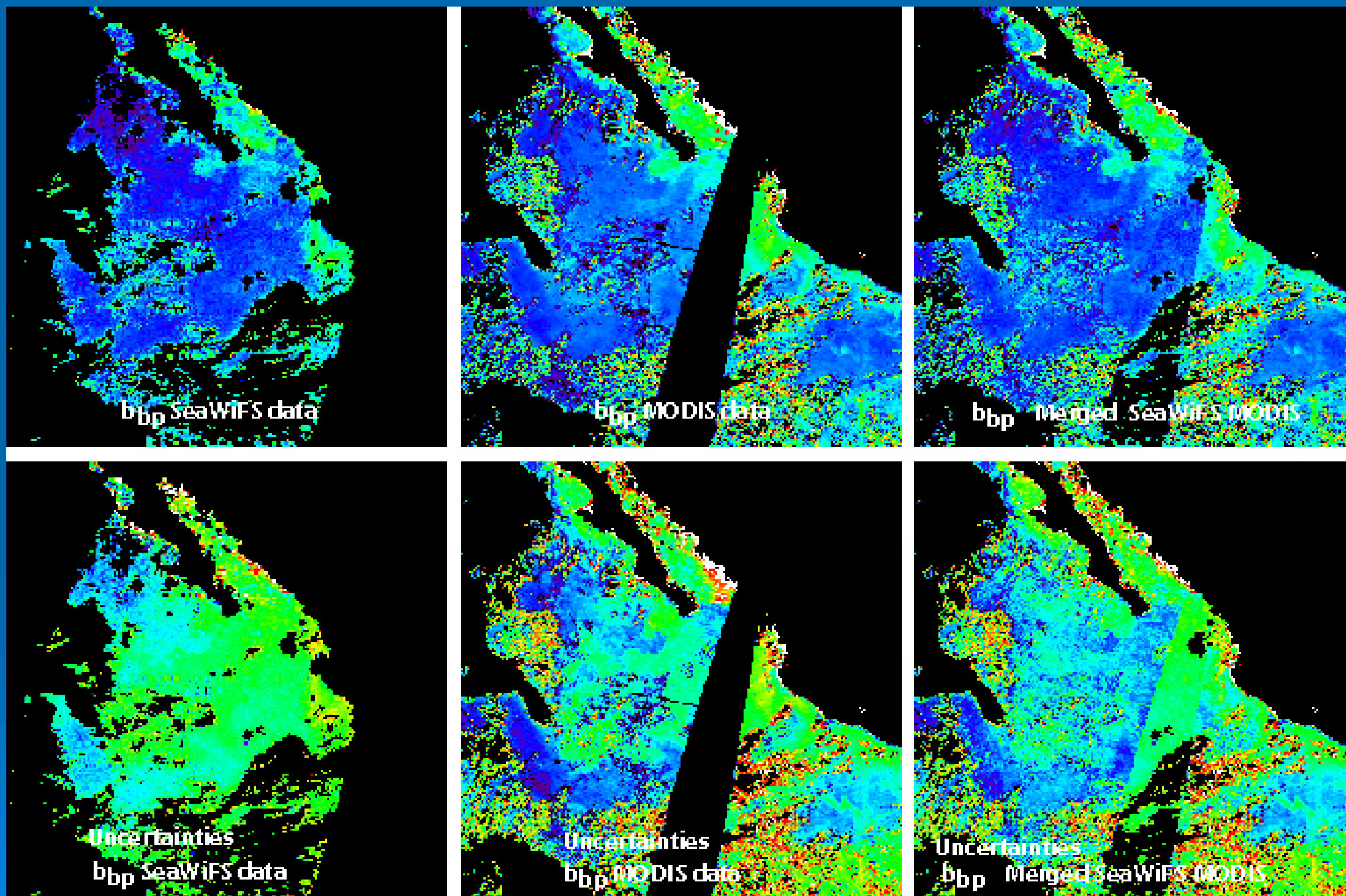
MERGING SeaWiFS and MODIS RETRIEVED $a_{cdm}(443)$



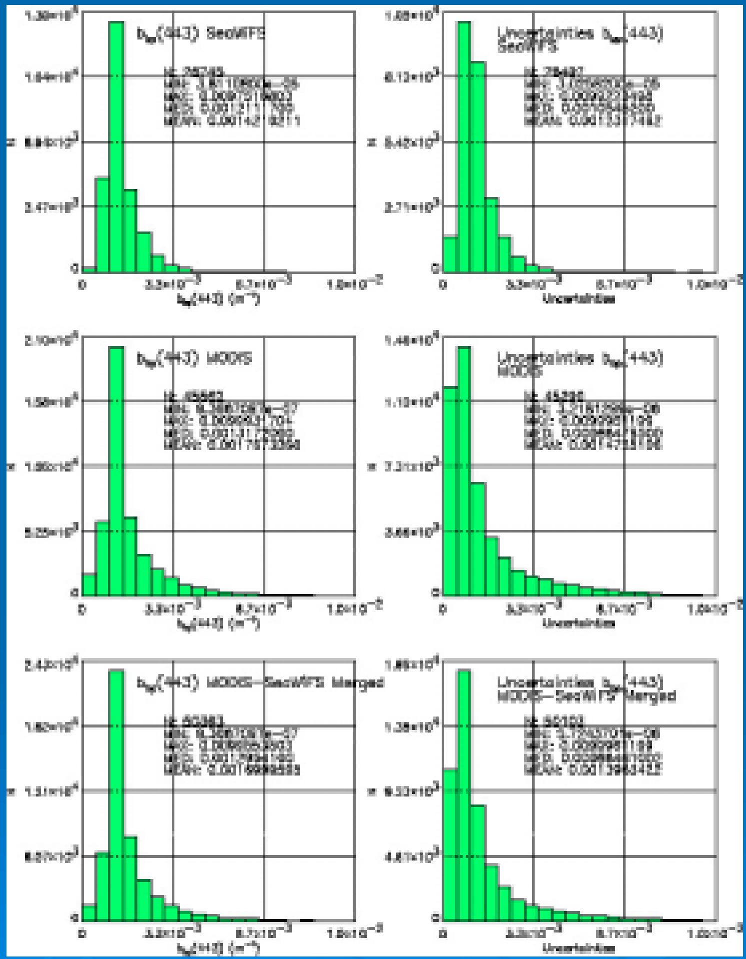
MERGING SeaWiFS and MODIS RETRIEVED $a_{cdm}(443)$



MERGING SeaWiFS and MODIS RETRIEVED b_{bp}(443)



MERGING SeaWiFS and MODIS RETRIEVED $b_{bp}(443)$



(VERY) PRELIMINARY RESULTS

- Very encouraging, it works !
- No major artifacts in the merged images
- Merged products look reasonable
- Band complementarity worked
- Band differences worked
- Uncertainties in products decrease in merged images

However a lot of work is still needed….

STEPS BEFORE THE PROCEDURE CAN BE CONSIDERED OPERATIONAL

GSM Model

- Bandless formulation of the GSM model
- Development of a complete Chl, $L_{wn}(\lambda)$, $a_{cdm}(443)$, $b_{bp}(443)$ data set
- Retuning of the GSM model

Data selection and processing

- Time-space windowing, scales
- BRDF correction for each data source

SIMBIOS activities

- Knowledge of the uncertainties in $L_{wN}(\lambda)$ for each satellite used
  - Development of matchup data sets
  - Satellite Intercomparisons
  - Diagnostic data sets
- Calibration/Validation activities (need good LwNs, no biases)

THE GSM01 Model

$$\hat{L}_{wN}(\lambda) = \frac{t\,F_0(\lambda)}{n^2} \sum_{i=1}^{2} g_i \left(\frac{b_b(\lambda)}{b_b(\lambda) + a(\lambda)} \right)^i$$

$$a(\lambda) = a_w(\lambda) + a_{ph}(\lambda) + a_{cdm}(\lambda)$$

$$b_b(\lambda) = b_{bw}(\lambda) + b_{bp}(\lambda)$$

$$a_{ph}(\lambda) = C\, a_{ph}^*(\lambda)$$

$$a_{cdm}(\lambda) = a_{cdm}(\lambda o) \exp(-S(\lambda - \lambda o))$$

$$b_{bp}(\lambda) = b_{bp}(\lambda o)\, (\lambda/\lambda o)^{-n}$$

Weighting of data based on their uncertainty level [$\sigma i(\lambda j)$] insures the best observations are given a higher weight in the inversion.

$$\varepsilon = \sum_{i=1}^{N_{sat}} \sum_{j=1}^{N_{\lambda i}} \left(\frac{L_{wN-i}(\lambda_j) - f(\theta, \lambda_j, \psi)}{\sigma_i(\lambda_j)} \right)^2$$