Ocean Colour Climate Change Initiative

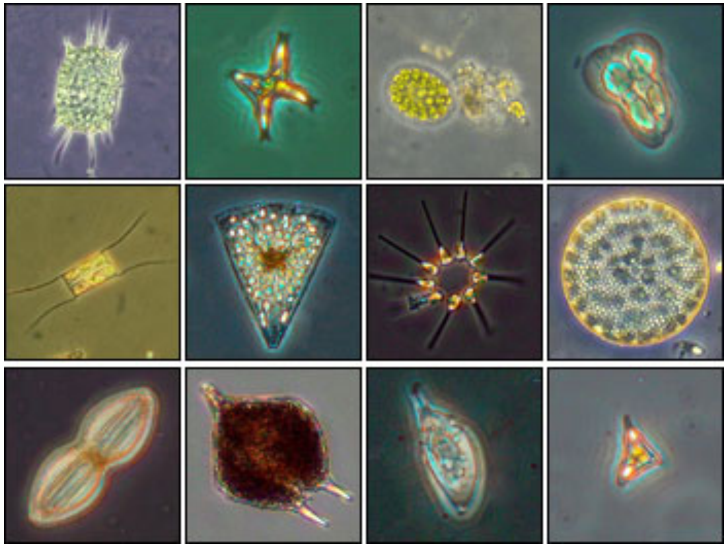
Integration Meeting 14 – 16 May 2012 Toulouse

European Space Agency

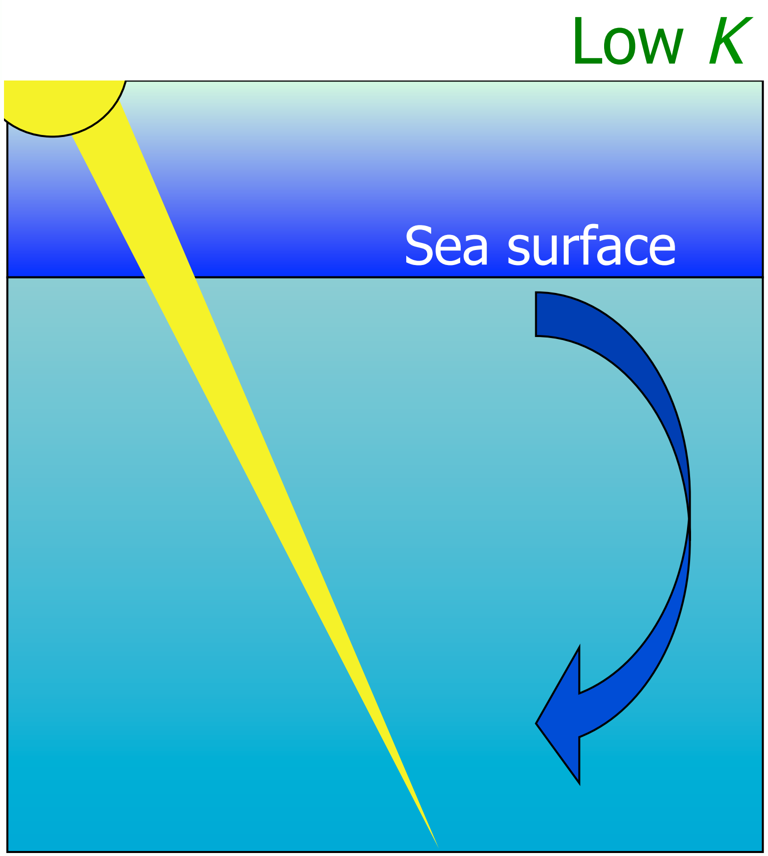
Why do we need an OC-ECV?
Primarily to detect phytoplankton, a key player in Earth's climate

- Predominantly single-celled and microscopic (0.5 to 250μm)
- Green plants (chlorophyll pigments, photosynthesis)
- Mostly confined to the surface (illuminated) layer
- Ubiquitous and abundant (up to 10^5 cells ml^{-1})
- Control colour of water (detectable from space)
- Consume carbon dioxide (ocean carbon cycle, climate change)
- Collective metabolism enormous (50×10^9 tonnes per annum)
- Slightly negatively buoyant
- At the base of the marine food chain: marine living resources depend on them

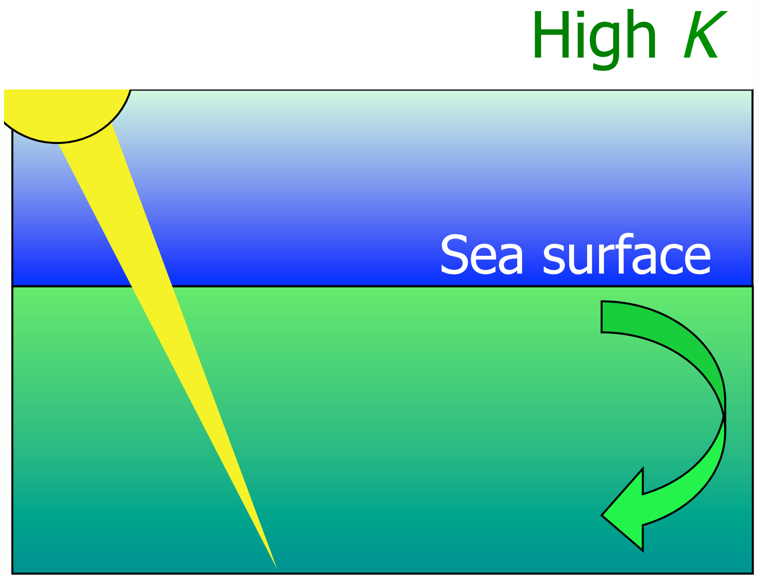
Phytoplankton bloom in the North Sea off the coast of Scotland. MERIS Image, 7 May 2008.



A less recognised role of phytoplankton: A factor in Earth's Radiation Budget



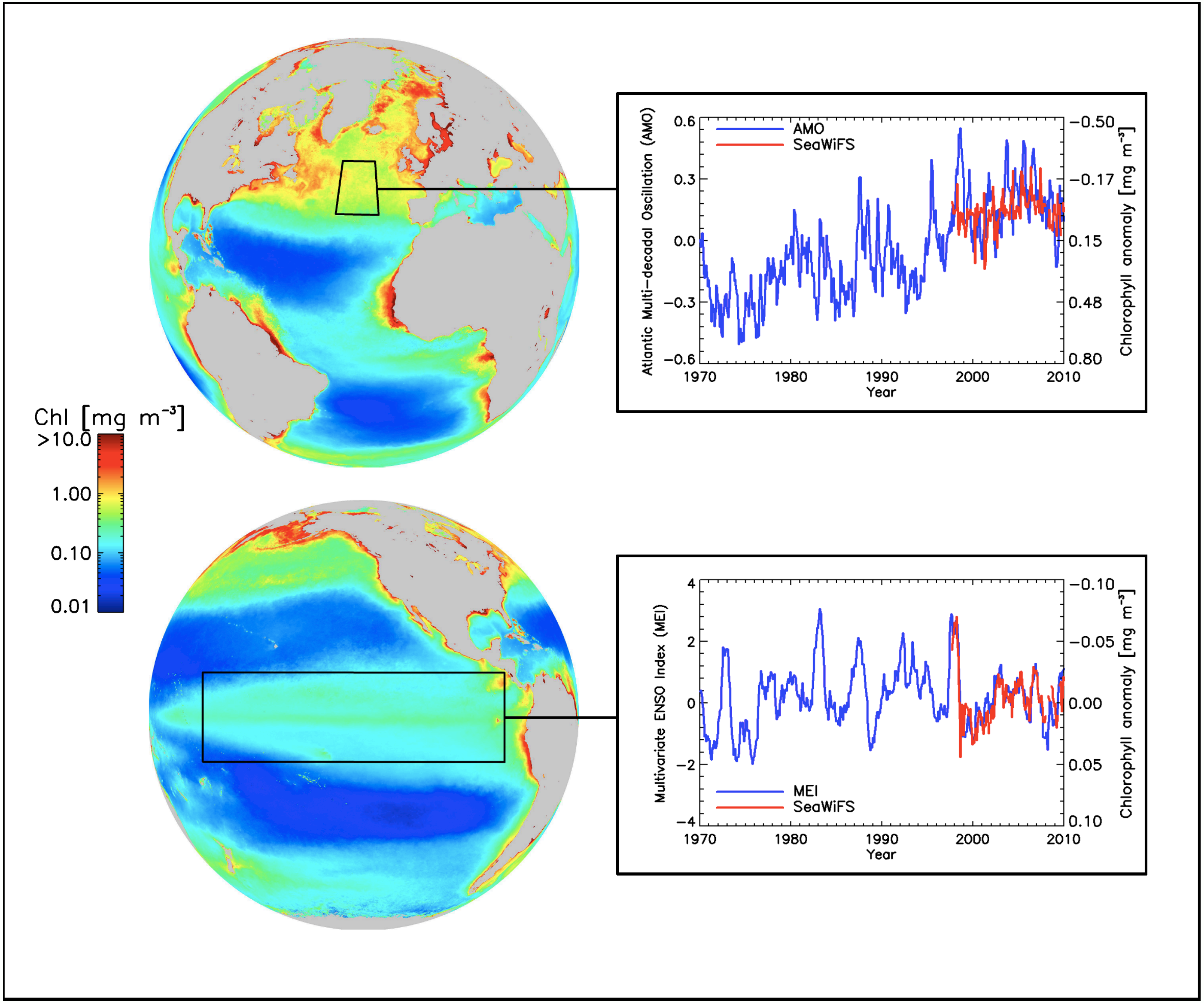
Deep photic layer
Favours deep mixed layer



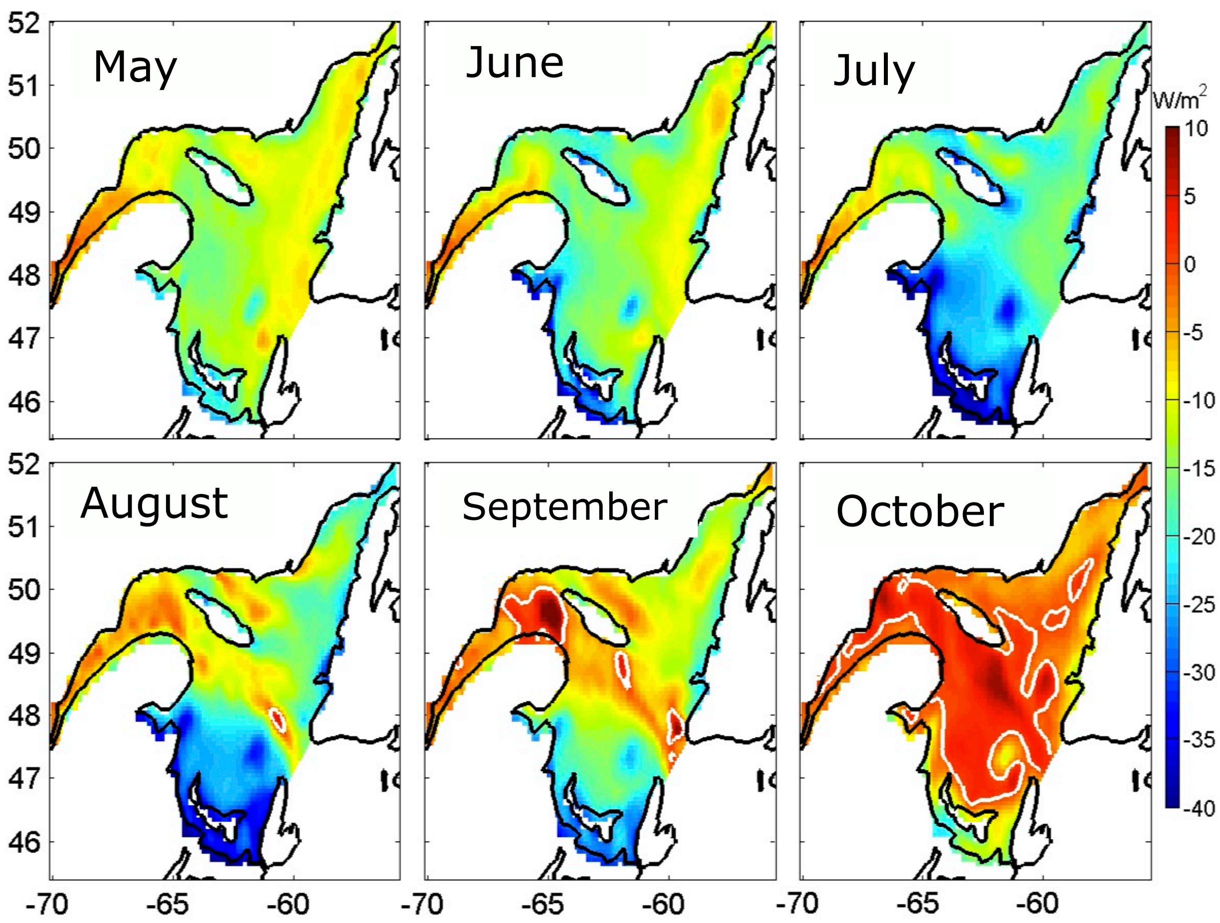
Shallow photic layer
Favours shallow mixed layer

Diffuse attenuation coefficient *K* a strong function of phytoplankton pigment

Sensitive to changes in physical environment …



... but also a player in the heat budget of the ocean and air-sea heat fluxes



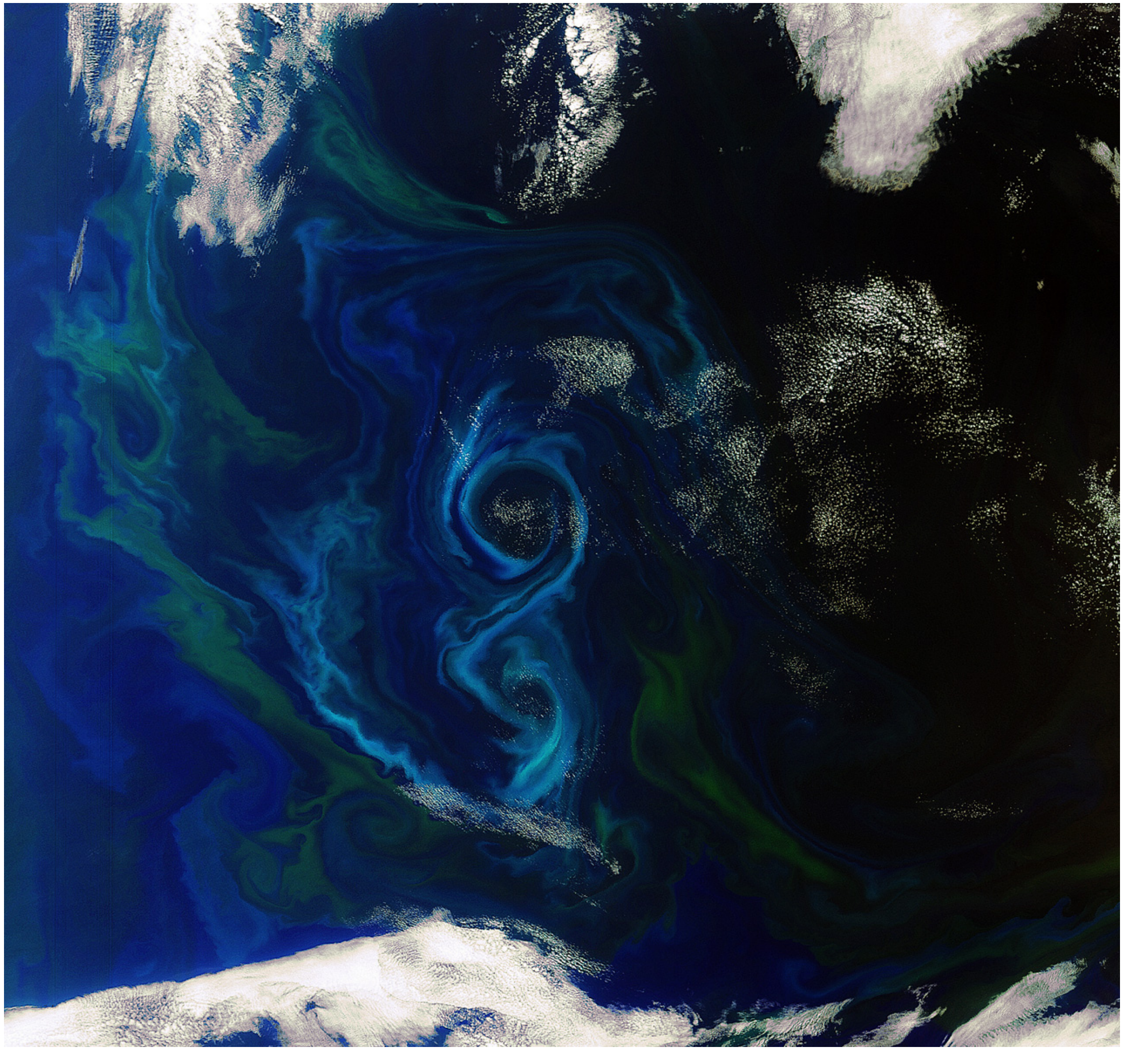
The difference in air-sea heat fluxes is between -40 and 15 W/m^2. Phytoplankton enhances the heat loss from the ocean to the atmosphere mainly through latent and sensible fluxes.

Gulf of Saint Laurence: Model Output: Monthly Difference in Air-Sea Heat Fluxes between Phytoplankton run and No-phytoplankton Run

Zhai et al. 2011

Phytoplankton therefore important to two key attributes of Earth's Climate implicated in the Climate Change Debate: Carbon Cycle and Heat Budget

Both composition and concentration of phytoplankton are vulnerable to climate change



Ocean colour algorithms now exist for retrieving information on phytoplankton composition (in addition to concentration indexed as chlorophyll concentration), using changes in their inherent optical properties (IOPs).

MERIS image, 2 December 2011, South Atlantic Ocean about 600 km east of the Falkland Islands

GCOS Ocean Colour requirements: a major challenge

Goal: create the most complete and consistent possible error-characterized time series of multi-sensor global satellite ECV products for climate research and modeling meeting GCOS requirements

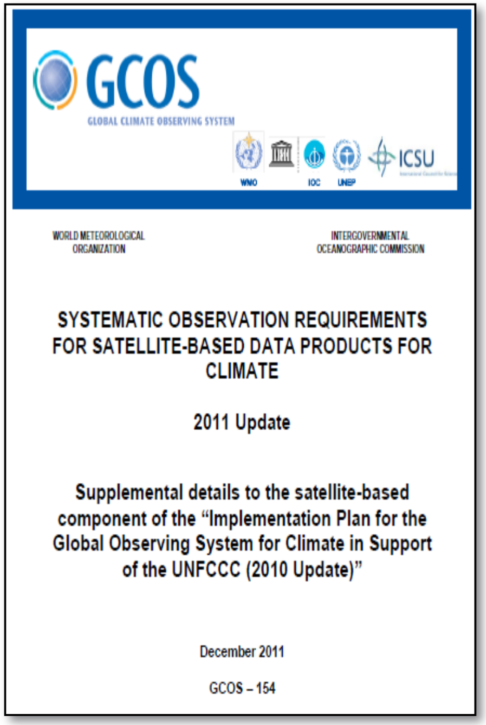
Note: OC-CCI to create time series of IOPs as well.

GCOS-107 **September 2006 SYSTEMATIC OBSERVATION REQUIREMENTS FOR SATELLITE-BASED PRODUCTS FOR CLIMATE**

Variable/ Parameter	Horizontal Resolution	Vertical Resolution	Temporal Resolution	Accuracy	Stability
Water Leaving Radiance	**1km**	**N/A**	**daily**	**5%**	**1.%**

GCOS-154 **updated December 2011**

Variable/ Parameter	Horizontal Resolution	Vertical Resolution	Temporal Resolution	Accuracy	Stability
Water Leaving Radiance	**4km**	**N/A**	**daily**	**5%**	**0.5%**
Chlorophyll-a concentration	**30km**	**N/A**	**weekly averages**	**30%**	**3%**


GCOS
GLOBAL CLIMATE OBSERVING SYSTEM
WMO IOC UNEP ICSU

WORLD METEOROLOGICAL ORGANIZATION
INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

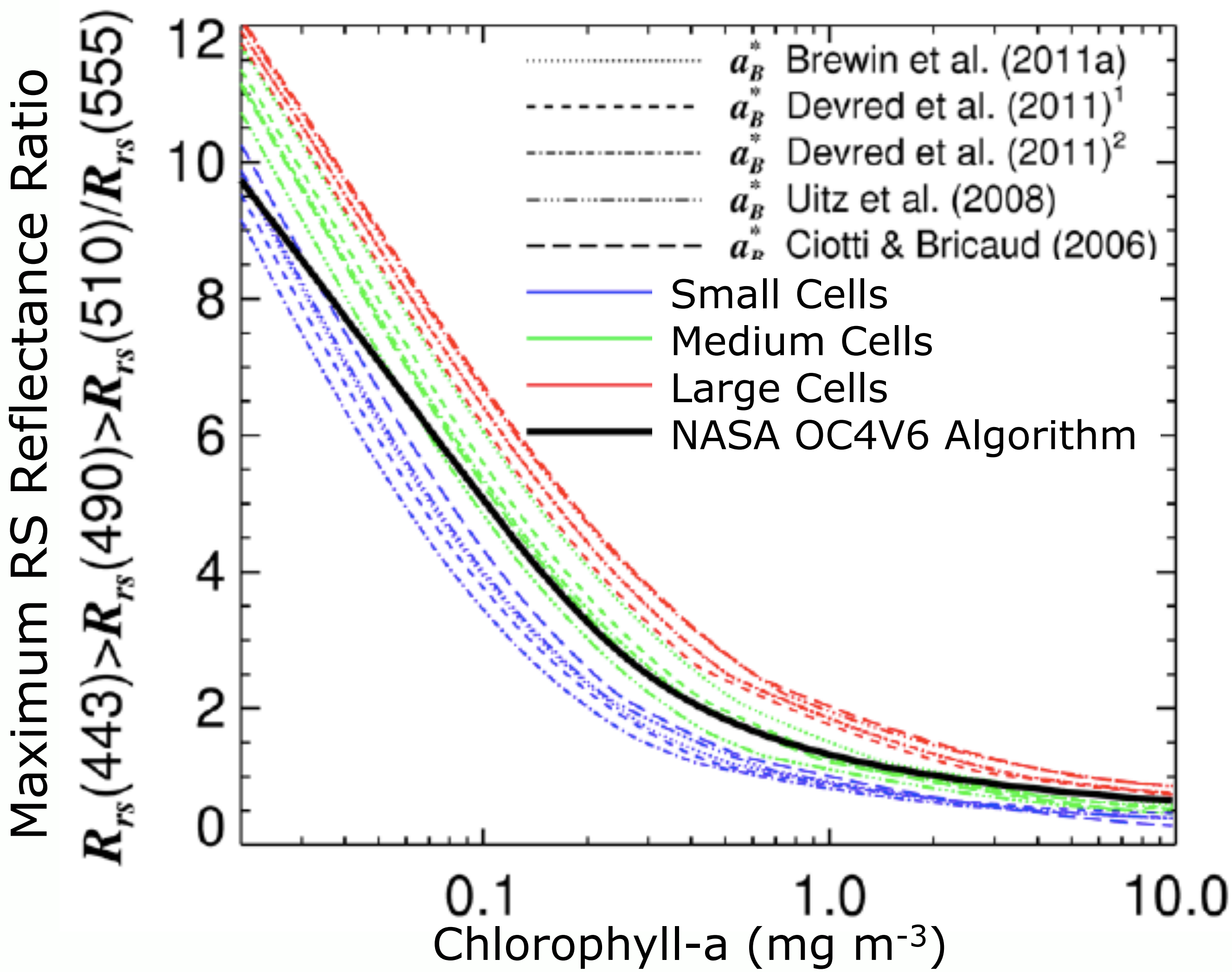
SYSTEMATIC OBSERVATION REQUIREMENTS FOR SATELLITE-BASED DATA PRODUCTS FOR CLIMATE

2011 Update

Supplemental details to the satellite-based component of the "Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (2010 Update)"

December 2011

GCOS – 154



Reflectance Ratio changes not only with chlorophyll concentration, but also with the type of phytoplankton cells present.

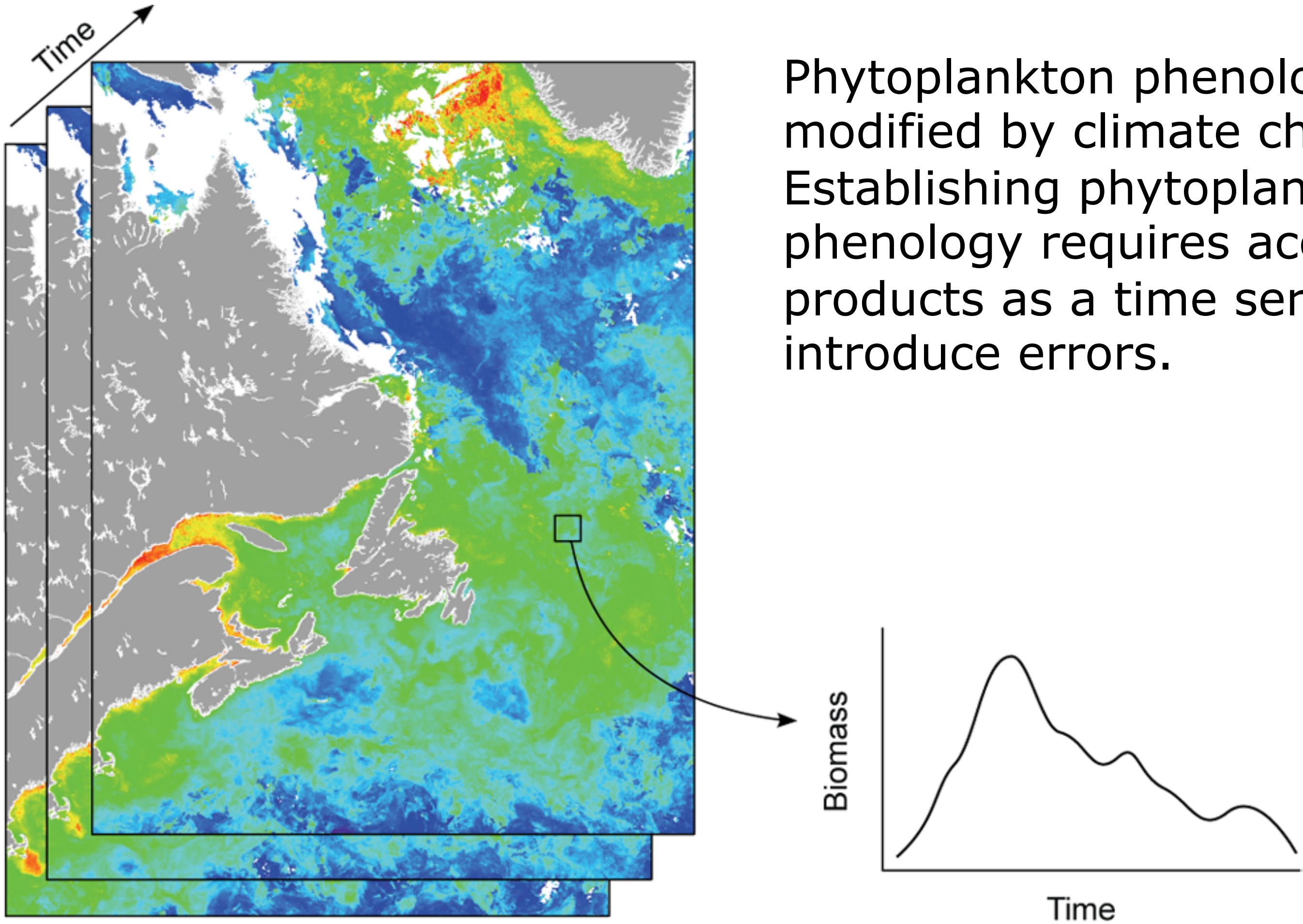
Under climate change, phytoplankton composition as well as concentration is vulnerable to change.

So if a reflectance ratio changes, we cannot be sure what is changing.

Implication: Simple band ratios may not be appropriate for climate-change studies

Figure by Brewin

Construction of time series



Phytoplankton phenology may be modified by climate change. Establishing phytoplankton phenology requires access to products as a time series. Gaps introduce errors.

Charge to OC-CCI: Create time series of multiple ocean-colour products designed for climate-change studies

First Step: Identify required qualities of algorithms:

- Requirement 1: Algorithms used have to be suitable for detecting impact of climate change on phytoplankton, if any.
- Requirement 2: Change has to be attributed correctly: concentration or composition?
- Requirement 3: Minimise gaps in data (but not at the cost of increased errors)
- Requirement 3: Products have to be consistent with each other (must satisfy radiative budget consideration, when considered as an ensemble)
- Requirement 4: Strive to meet GCOS requirements
- Requirement 5: Characterise errors on a pixel-by-pixel basis

Second Step: Formulate quantitative tests to evaluate algorithm performance against validation data

Intercomparison Criteria

(1) Atmospheric correction or (2) In-water algorithms

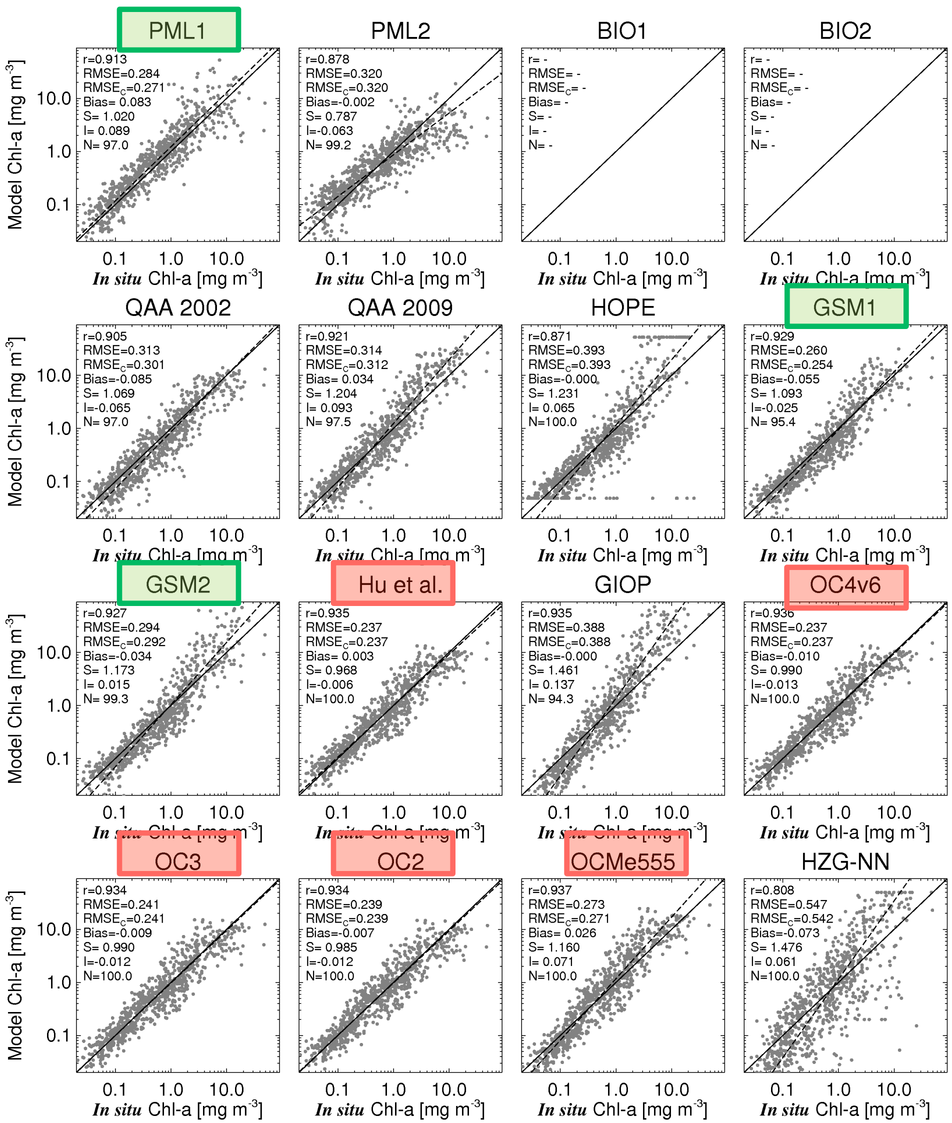
Qualitative intercomparison
(Questionnaire)
Does the algorithm suit the requirements of OC-CCI?
Ranking

Quantitative intercomparison
(Validation)
How well does the algorithm perform?
Ranking

Additional criteria
Sensor specific performance? Algorithm tradeoffs? Time-series comparsion?

Algorithm selection

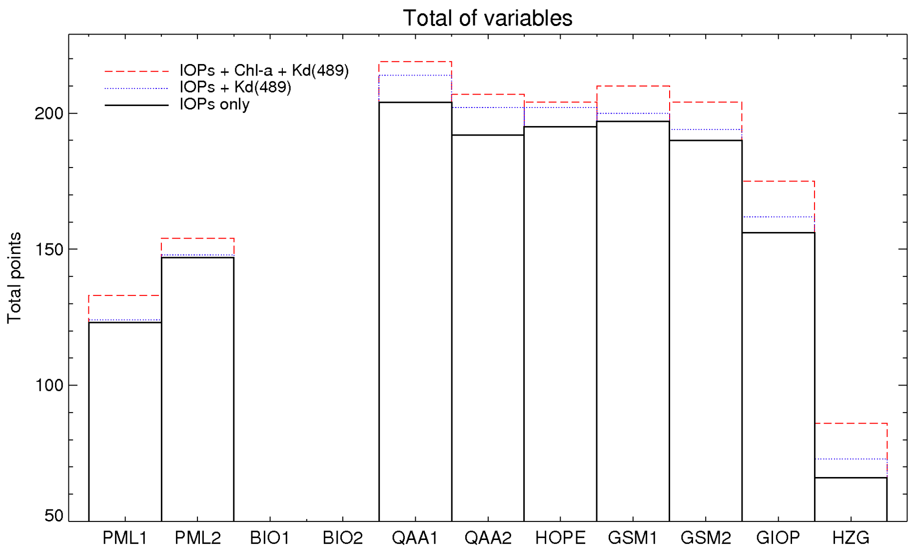
Note: Some qualitative criteria are now being converted to quantitative tests

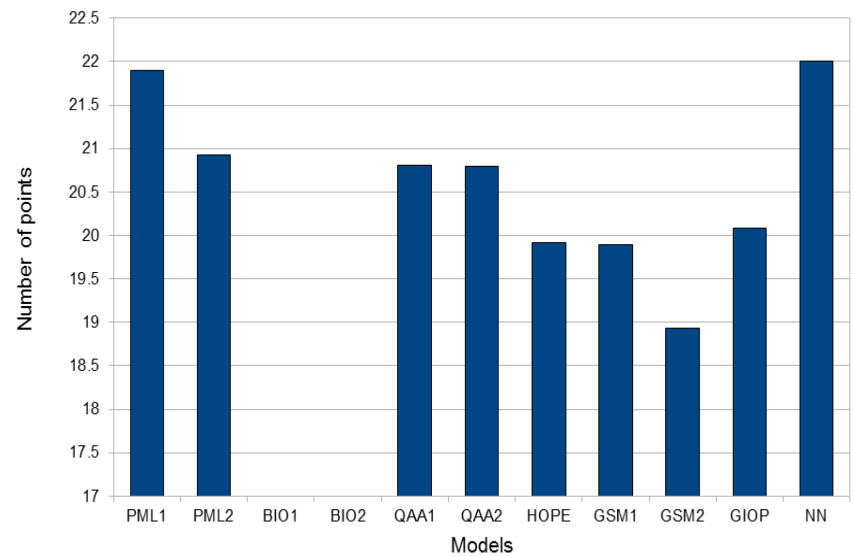


Results for Chl-a

- all algorithms perform well (r>0.8)
- the band-ratio algorithms (OC series) and the Hu et al. algorithm have high accuracy
- for the model-based (IOP) approaches the GSM1 & GSM2 and PML algorithms perform with the highest accuracy

First in-water RR





- It was recommended that band-ratio (chl-a algorithms) form part of the OC-CCI product portfolio.

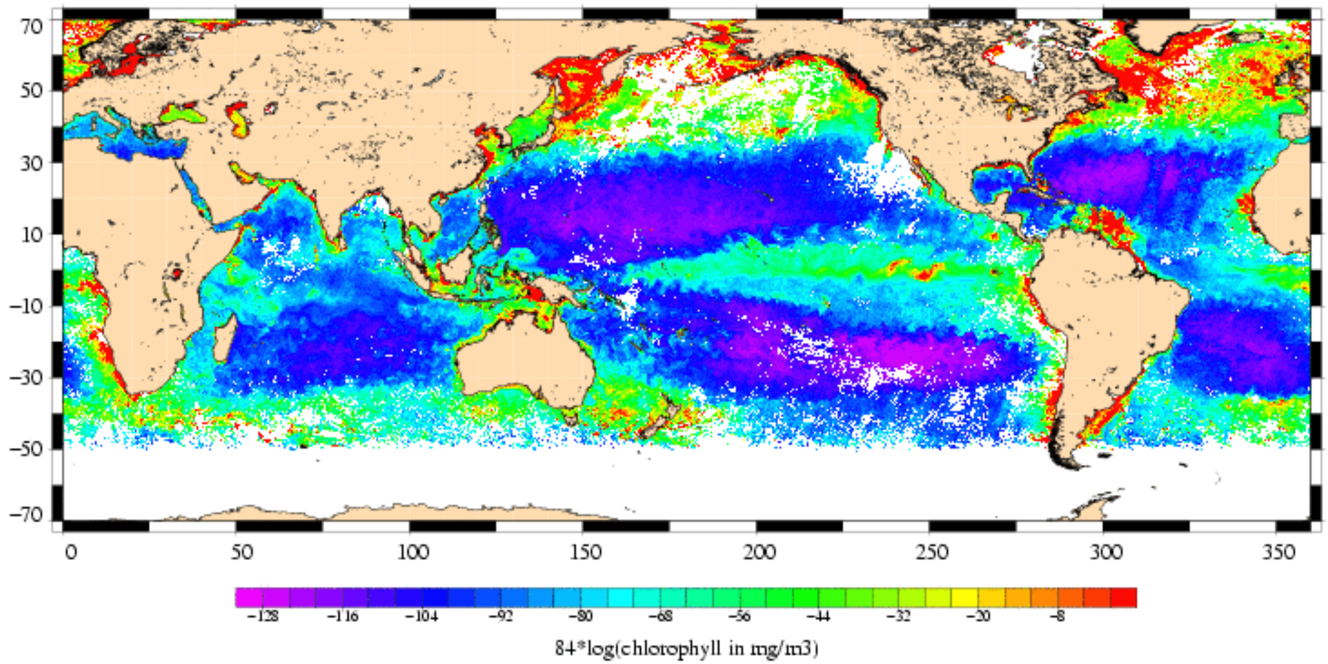
- Recommended that QAA be selected as the OC-CCI in-water algorithm.

- Recommended that the possibility of further improvements to the OC-CCI algorithm be explored, by combining the best features of various algorithms.

- Difficult to evaluate the impact of the NOMAD dataset, therefore recommended that an independent dataset be used to evaluate algorithms further (AMT, BIO, Benguela data) **2nd RR**.

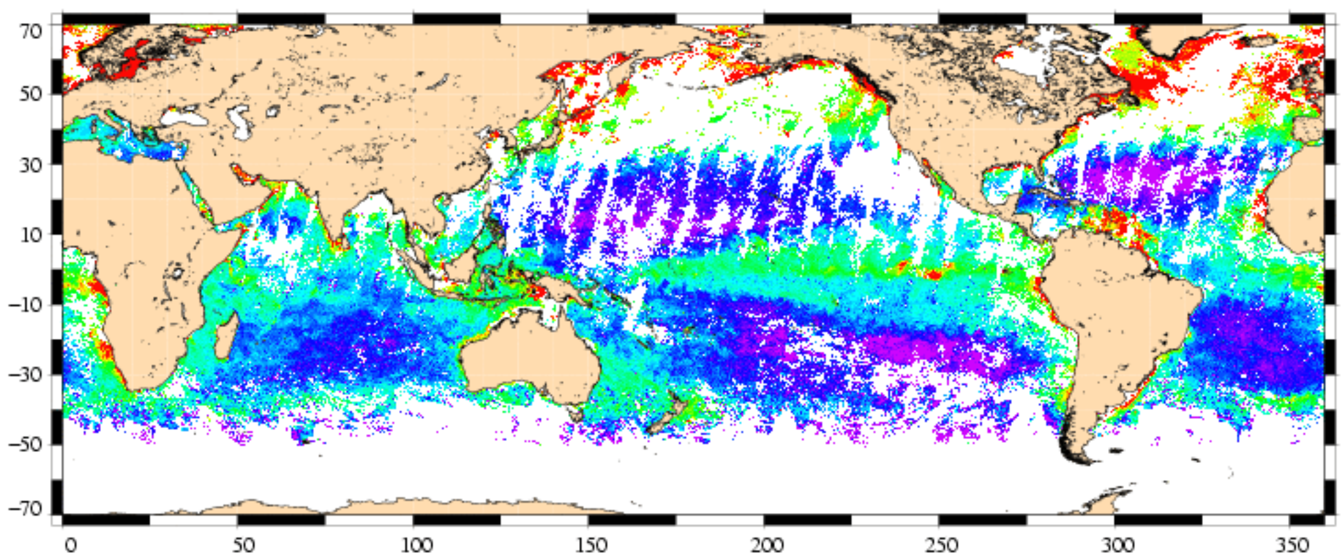
- The OC-CCI strategy has to be open to the possibility that better algorithms will emerge in the future, and the plans for OC-CCI should include periodic re-evaluations of algorithms, adoptions of new algorithms

POLYMER: Selected Atmospheric Correction Algorithm for MERIS



POLYMER 10 day composite

69% coverage

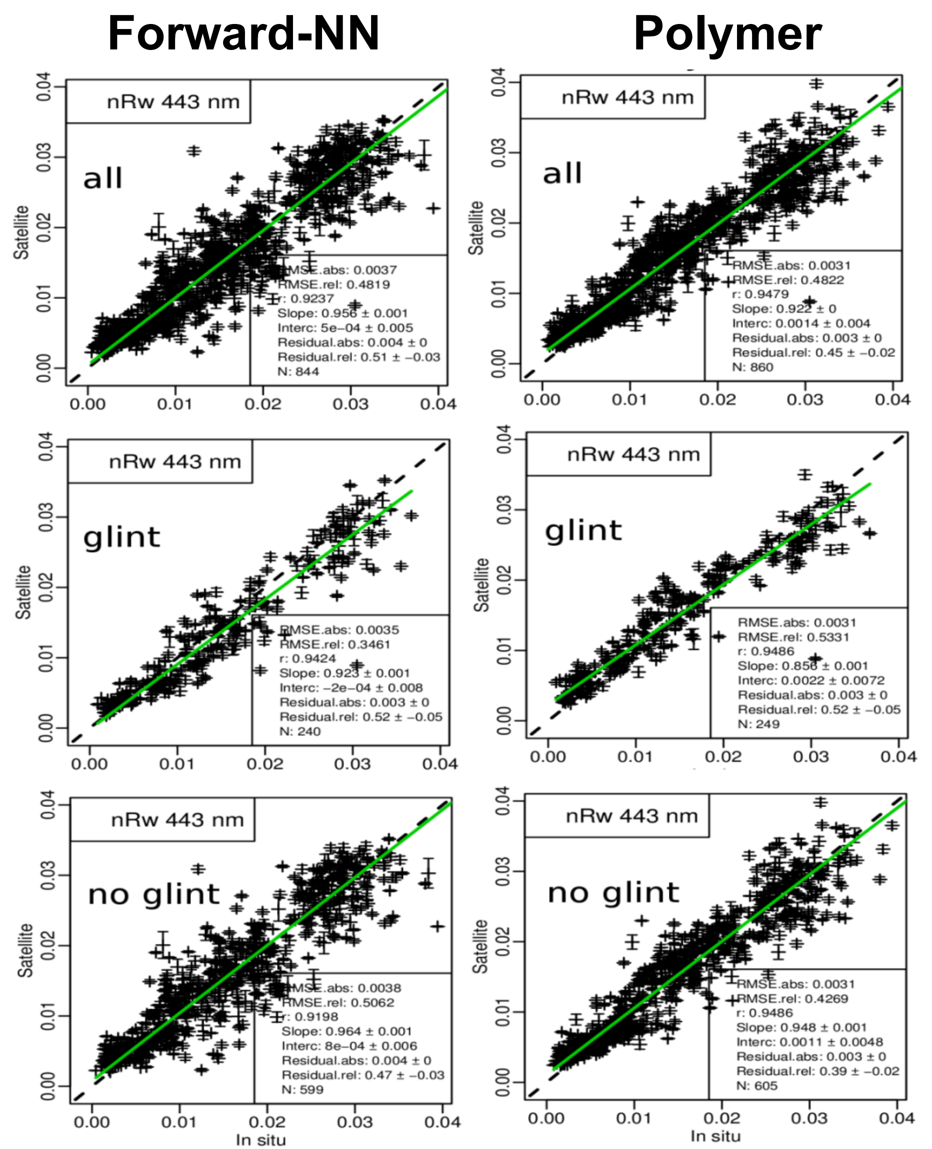


MEGS 10 day composite

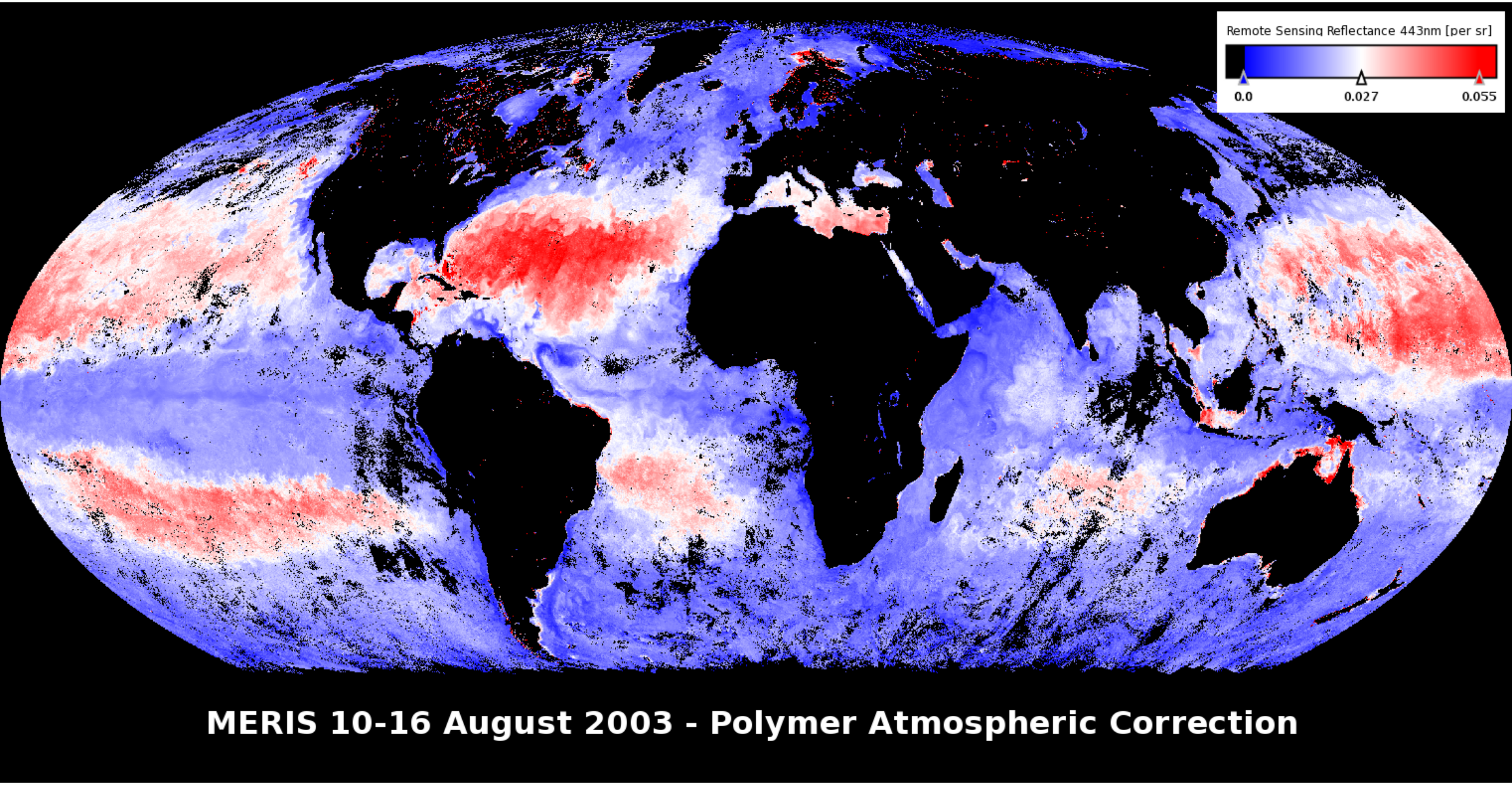
49% coverage

Atmospheric correction: performance with glint

- Forward-NN & POLYMER are able to analyse pixels highly affected by glint.
- 'glint'-pixels are of comparable quality and considerably increase the amount of available data.
- Using 'glint'-pixels provides almost complete & homogeneous coverage of the MERIS instrument over space and time.
- Discarding 'glint'-pixels results in a changing usage of different parts of the instrument, in the case of MERIS using different cameras
- ➔may result in seasonal artefacts in time-series.



Processing Status: Preliminary processing of MERIS data for 2003 using POLYMER is complete, evaluation under way



OC-CCI: What have we achieved so far?

- Established qualitative and quantitative criteria for evaluating algorithms for generation of products for climate-change studies
- First round robin completed for atmospheric correction and in-water algorithms
- Second round robin is being prepared: will include new data (independence of data for algorithm development and algorithm validation), and automated procedures will be in place
- Preliminary processing of MERIS data for 2003 completed, using POLYMER, evaluation under way
- Processing of MERIS data for 2008 (golden year) started, using POLYMER
- Merging procedures established, taking into consideration requirements, will incorporate correction for inter-sensor bias
- External consultations (IOCCG) have begun