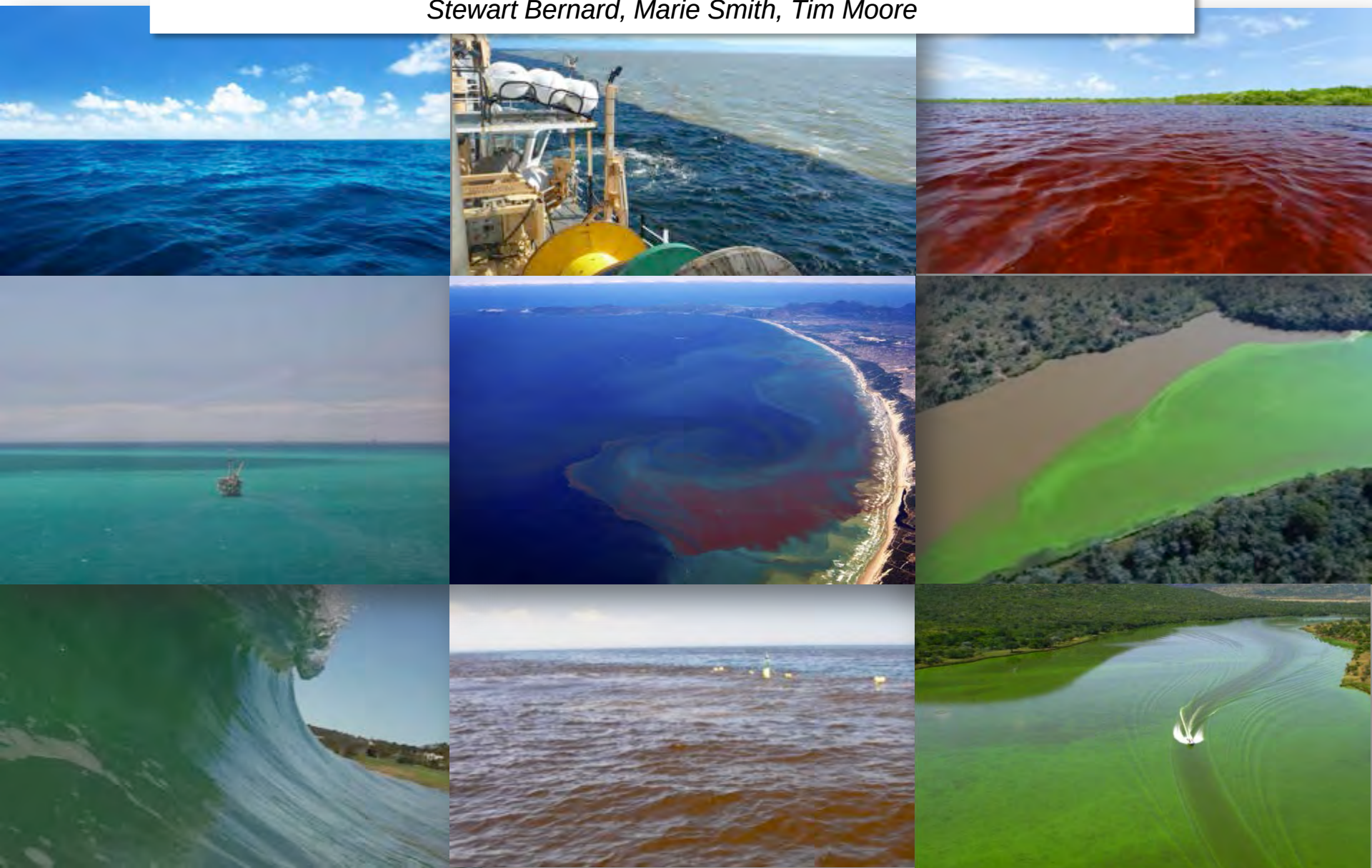
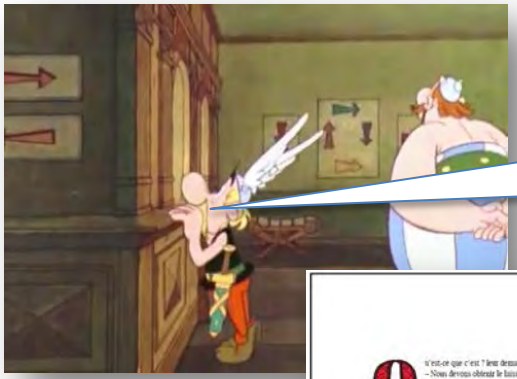
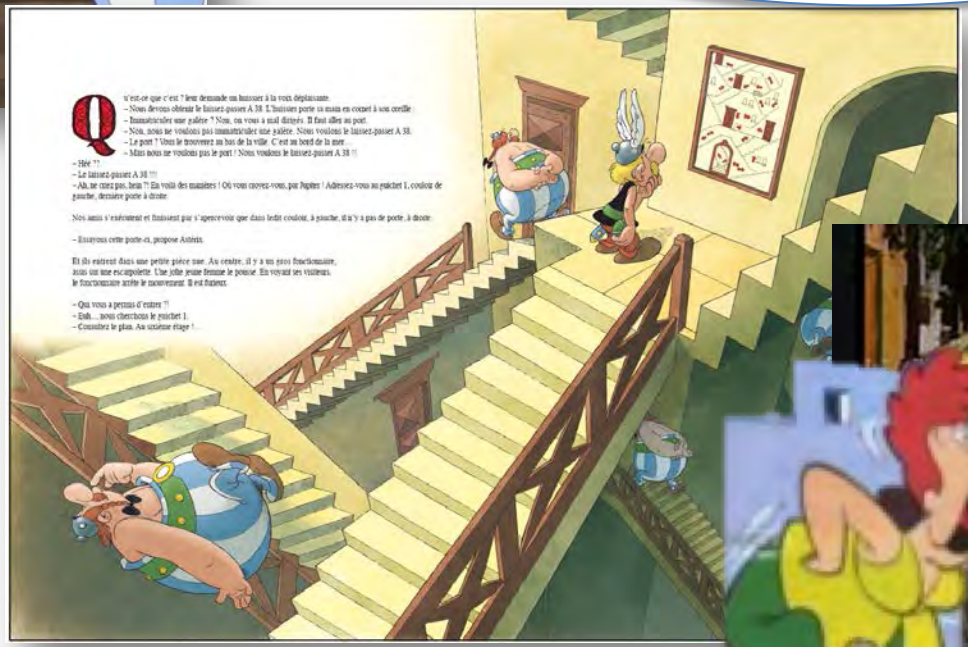
Multiwater Algorithms and Performance: User Requirements

Stewart Bernard, Marie Smith, Tim Moore





I'd like a nice simple ocean colour chlorophyll product please, one that works everywhere?



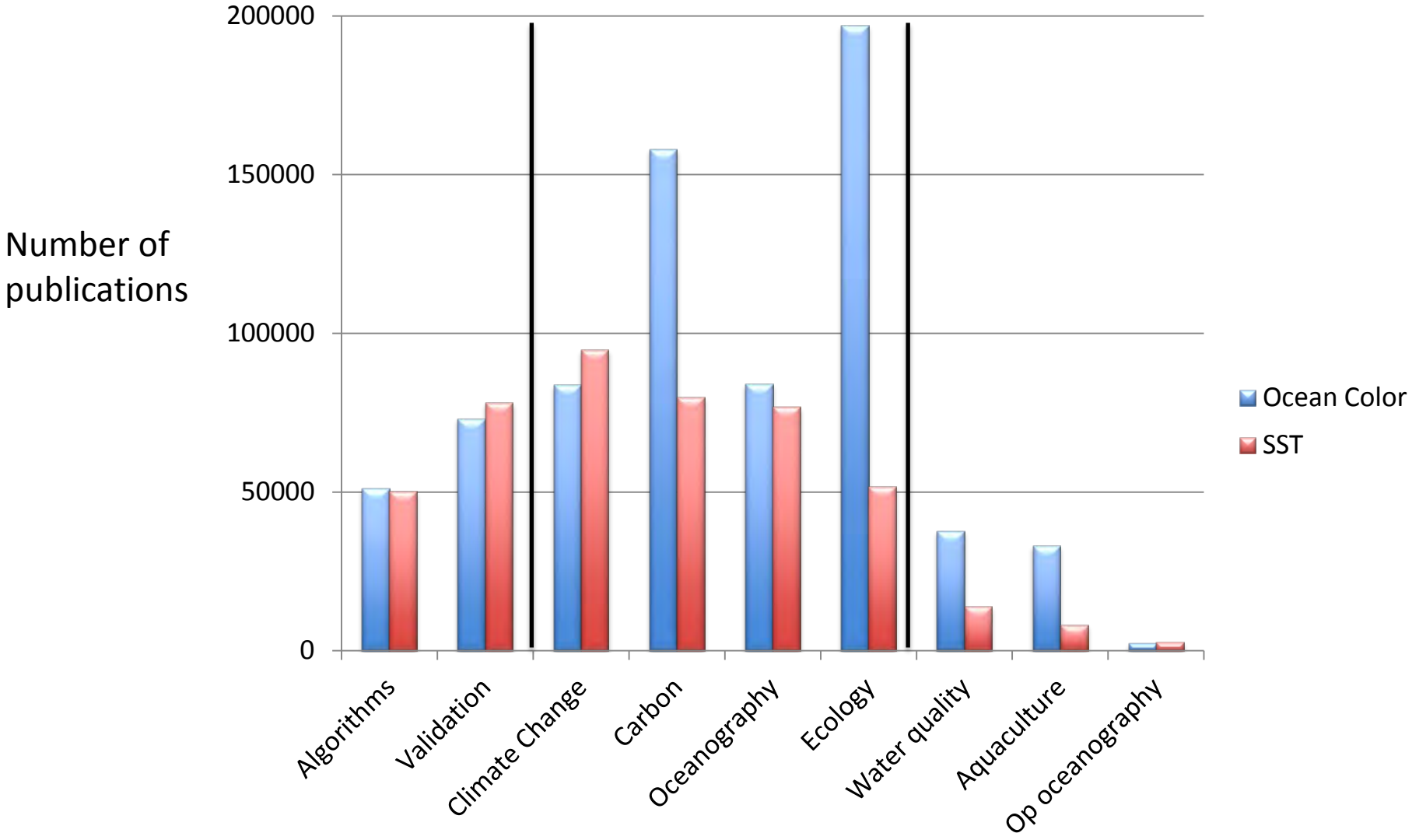
Apologies to Goscinny & Uderzo

Multiwater Algorithms and Performance: User Requirements

Stewart Bernard, Marie Smith, Tim Moore

- There is a substantial and growing operational and scientific user community needing ocean colour data…
- This community needs simple, easily understood products that provide optimal data seamlessly across all water types, regardless of phytoplankton biomass, sediment content etc (ideally)…
- The Optical Water Type approach offers a very powerful algorithm framework to dynamically classify water types, apply a range of water type specific and optimal algorithms, and seamlessly blend algorithm output (including uncertainties) in a single product…
- The Optical Water Type classification provides maps of water types, which are very useful and powerful products in their own right…

There is a substantial and growing operational and scientific user community requiring ocean colour data…



… who are the users?…

…better idea of key user archetypes and their requirements needed by the ocean colour community....

Ocean - Shelf Sea

Climate Change : Modeling community & ultimately IPCC; regionally downscaled policy evaluation; science community…

Ecosystem state & Carbon Cycling : modelling & science community; operational oceanography initiatives; regional ocean governance & policy makers…

Fisheries Support & Management : regional ecosystem & resource based fisheries management; compliance agencies; private sector…

Benthic Habitat Mapping: regional conservation & ocean governance managers; policy makers….

Shelf Sea - Near Coastal

Ecosystem state: operational oceanography initiatives; national & regional ocean governance; science community…

Fisheries Support & Management: as above; regional regulatory bodies e.g. Commission for the Conservation of Antarctic Marine Living Resources; private sector…

HABs, Aquaculture Support, Water Quality, Sediment Dynamics : ocean governance initiatives; facility, municipal, regional & conservation managers; private sector…

Conservation, Marine Spatial Planning, Pollution Monitoring: MPA policy makers & managers; municipal managers & planners; disaster management agencies…

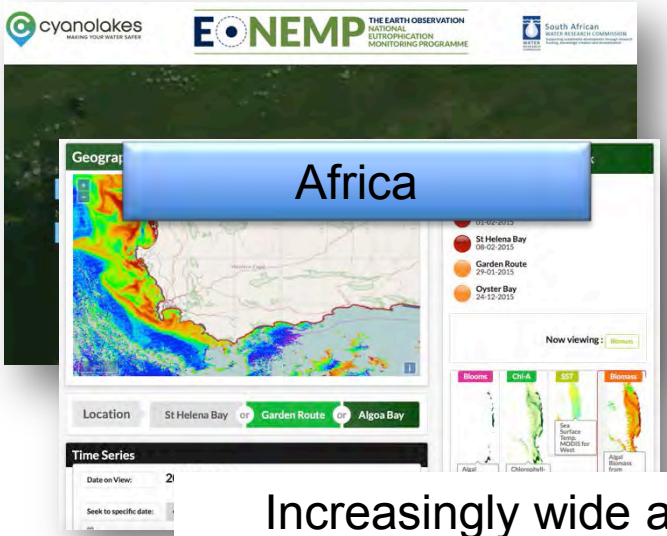
Near Coastal – Inland

Ecosystem state: hydrological modellers; water management authorities; regional climate modelling initiatives…

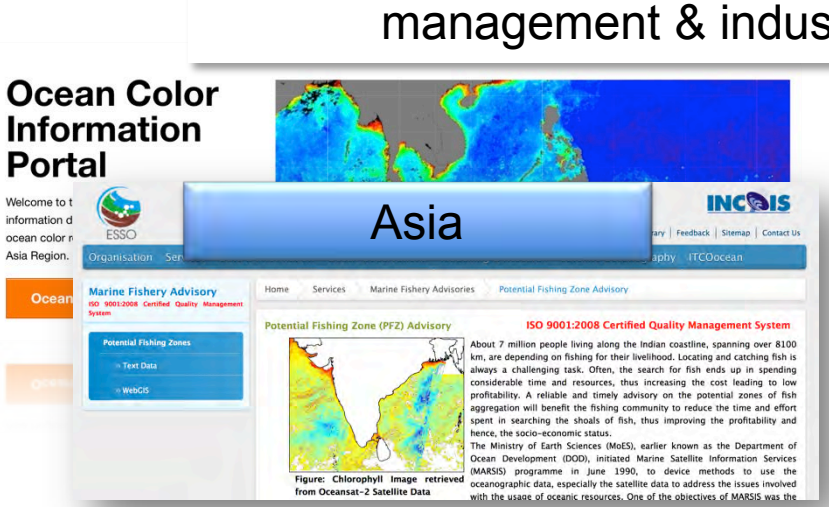
Water Quality & Eutrophication Monitoring: as abov;, regional & national regulatory authorities; municipal & water facility managers; private sector e.g. agriculture, tourism, public…

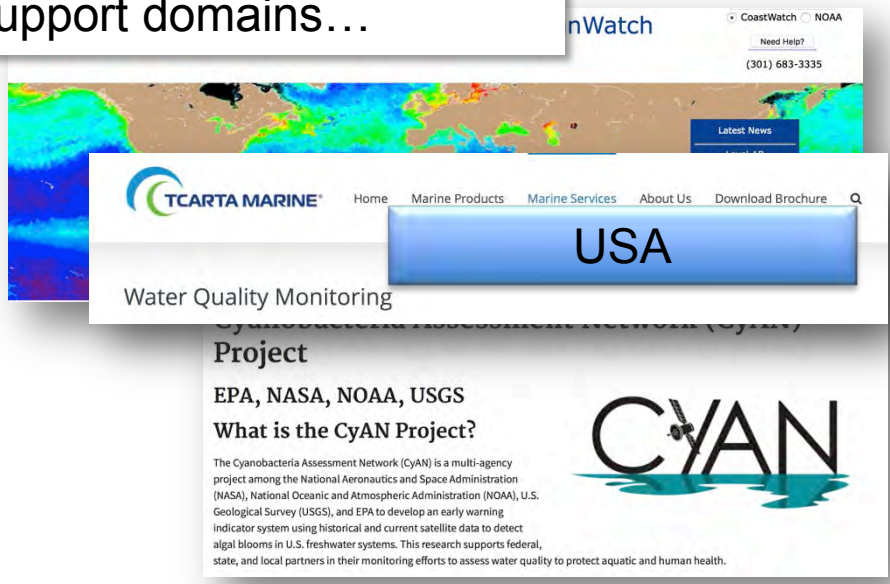
Spatial Planning, Conservation & Biodiversity : regional & municipal environmental & urban management; wastewater & urban planning, conservation managers…

Operational Services using Ocean Colour

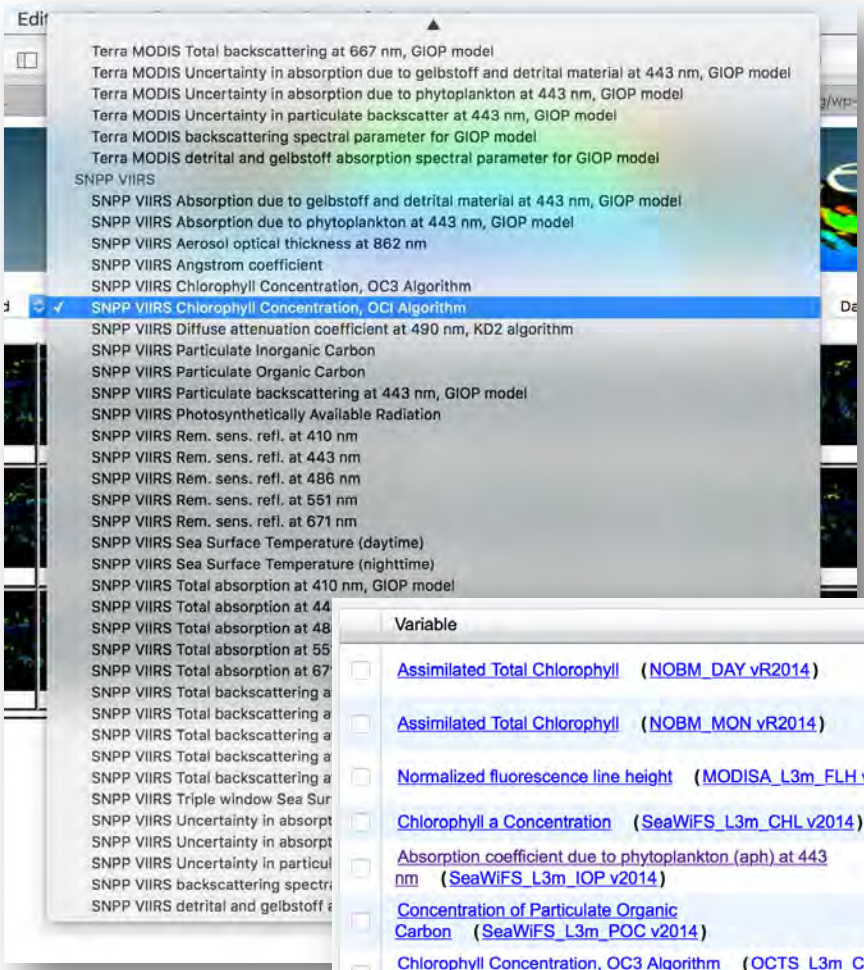


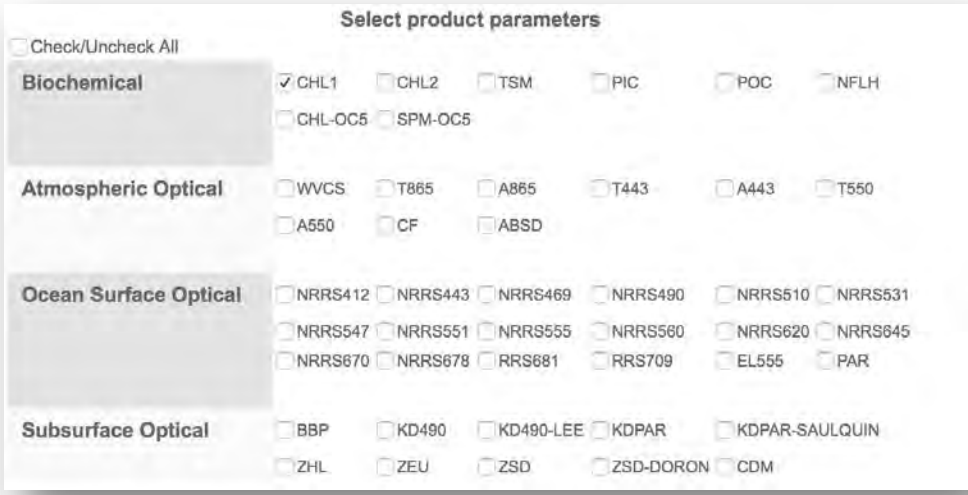
Increasingly wide array of public service & commercial platforms providing variety of ocean colour-based products across fisheries, aquaculture, water quality resource management & industrial support domains…





Admirably wide range of products across sensors for scientists is difficult and complex for non-specialists…





Variable	Source	Temp.Res.	Spat.Res.	Begin Date	End Date	Units
Assimilated Total Chlorophyll (NOBM_DAY vR2014)	NOBM Model	Daily	0.667 x 1.25 °	1998-01-01	2012-12-31	mg chlorophyll/m^3
Assimilated Total Chlorophyll (NOBM_MON vR2014)	NOBM Model	Monthly	0.667 x 1.25 °	1998-01-01	2012-12-31	mg chlorophyll/m^3
Normalized fluorescence line height (MODISA_L3m_FLH v2014)	MODIS-Aqua	Monthly	4 km	2002-07-04	2016-12-31	mW cm^-2 um^-1 sr^-1
Chlorophyll a Concentration (SeaWiFS_L3m_CHL v2014)	SeaWiFS	Monthly	9 km	1997-09-04	2010-12-11	mg m^-3
Absorption coefficient due to phytoplankton (aph) at 443 nm (SeaWiFS_L3m_IOP v2014)	SeaWiFS	Monthly	9 km	1997-09-04	2010-12-11	m^-1
Concentration of Particulate Organic Carbon (SeaWiFS_L3m_POC v2014)	SeaWiFS	Monthly	9 km	1997-09-04	2010-12-11	mg m^-3
Chlorophyll Concentration, OC3 Algorithm (OCTS_L3m_CHL v2014)	OCTS	Monthly	9 km	1996-11-01	1997-06-30	mg m^-3
Chlorophyll a Concentration (OCTS_L3m_CHL v2014)	OCTS	Monthly	9 km	1996-11-01	1997-06-30	mg/m^2
Concentration of Particulate Organic Carbon (OCTS_L3m_POC v2014)	OCTS	Monthly	9 km	1996-11-01	1997-06-30	mg m^-3
Chlorophyll a concentration (MODISA_L3m_CHL v2014)	MODIS-Aqua	Monthly	4 km	2002-07-04	2016-12-31	mg m-3
Concentration of Particulate Organic Carbon (MODISA_L3m_POC v2014)	MODIS-Aqua	Monthly	4 km	2002-07-04	2016-12-31	mg m^-3

What are the constraints on user uptake? A fisheries perspective….

Table 1. Number of publications citing the different ocean-colour sensors, the number of publications per year the satellite was in orbit, and the number of papers with a subject classification of "oceanography" or "fisheries", or with "fish" included in the search string.

			Oceanography		Fisheries		"Fish" in search	
Sensora	Number of papers	Papers per orbit year	Number	%	Number	%	Number	%
CZCS	428	56	208	49	7	2	8	2
GLI	34	49	11	32	0	0	0	0
SeaWiFS	1 175	92	478	41	24	2	32	3
MERIS[a]	140	17	14	10	0	0	2	1
MODIS[a]	361	45	74	20	4	1	3	1
OCM[a]	65	6	19	29	0	0	8	12
OCTS[a]	64	80	17	27	0	0	1	2
Total	2 267	46	821	36	35	2	54	2

[a]Search string included the term "colour" ("color") or "chlorophyll".
As of 19 May 2010. *Source*: ISI Web of Science.

Table 1 supports the assertion that ocean- colour data are largely underutilized in fisheries science. There may be several reasons for this.

(i) **Dissemination**. Satellite data availability and their potential use in fisheries are not always effectively communicated outside the satellite community.

(ii) **Unfamiliarity**. Satellite data can be difficult to access, manipulate, and process, particularly when the skills and compu tational resources needed for manipulating large datasets are lacking.

(iii) **Unavailability of desired products**. For many fisheries appli- cations, the parameter of interest may not be readily available or easily calculated. Examples of these include primary production, front locations, and climatologies.

(iv) **Data inadequacy**. The 12-year time-series of ocean-colour data is relatively short compared with fisheries datasets that often span many decades. Additionally, many fisheries operate in coastal (case II) waters, where interpretation of satellite ocean colour is complicated by the lack of site- specific algorithms—the standard algorithms are defined for open-ocean (case I) waters (Gordon and Morel, 1983).

(v) **Resistance to change**. Stock assessment/management tends to avoid the use of environmental data, because of the complexities involved, especially when simpler population models often suffice for short-term (1 year) predictions. For assessment biologists, it can also be difficult or impossible to undertake new and innovative analyses in addition to preparing routine assessments built on traditional frameworks.

ICES Journal of Marine Science (2011), 68(4), 677–686. doi:10.1093/icesjms/fsq168
The rocky road from research to operations for satellite ocean-colour data in fishery management
Cara Wilson

These user communities need simple, easily understood products that provide optimal, (highest confidence & validity) data seamlessly across all water types, regardless of phytoplankton biomass, sediment content etc….don’t laugh....

Much variability in “equivalent” products between sensors and algorithms

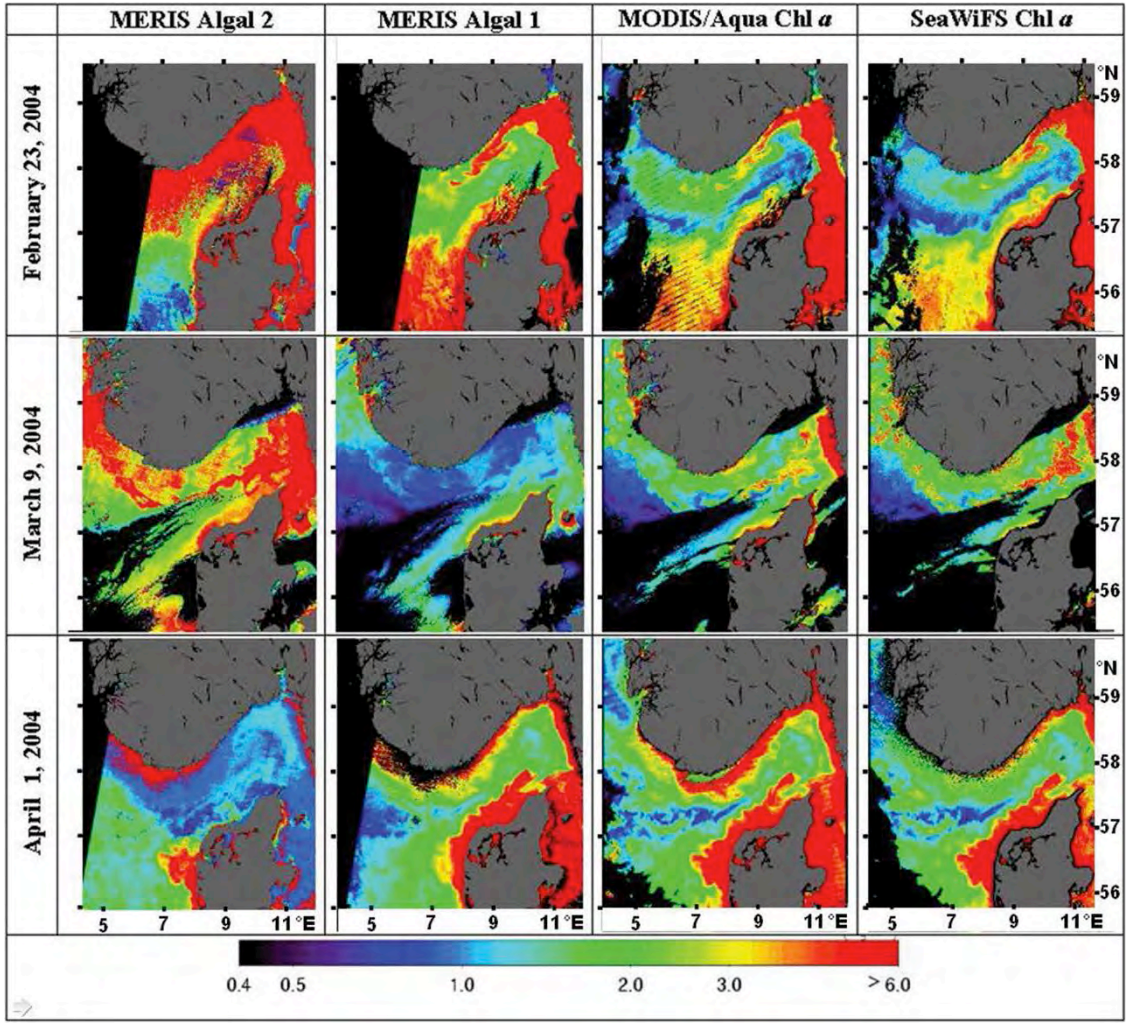


Figure 3 Chlorophyll distribution in North Sea and Skagerrak region as retrieved by the MERIS Algal 2, MERIS Algal 1, MODIS/Aqua Chl a, and SeaWiFS Chl a products (from left to right) for 23 February, 9 March and 1 April 2004 (from top to bottom). Black areas indicate unprocessed pixels (clouds, corrupt atmospheric correction, or out of swath areas). Data are plotted with the same logarithmic colour scale, as indicated by the colour bar. The unit is mg m−3. Copyright: ESA/NASA/Orbimage.

Inter-comparison of ocean colour data products during algal blooms in the Skagerrak

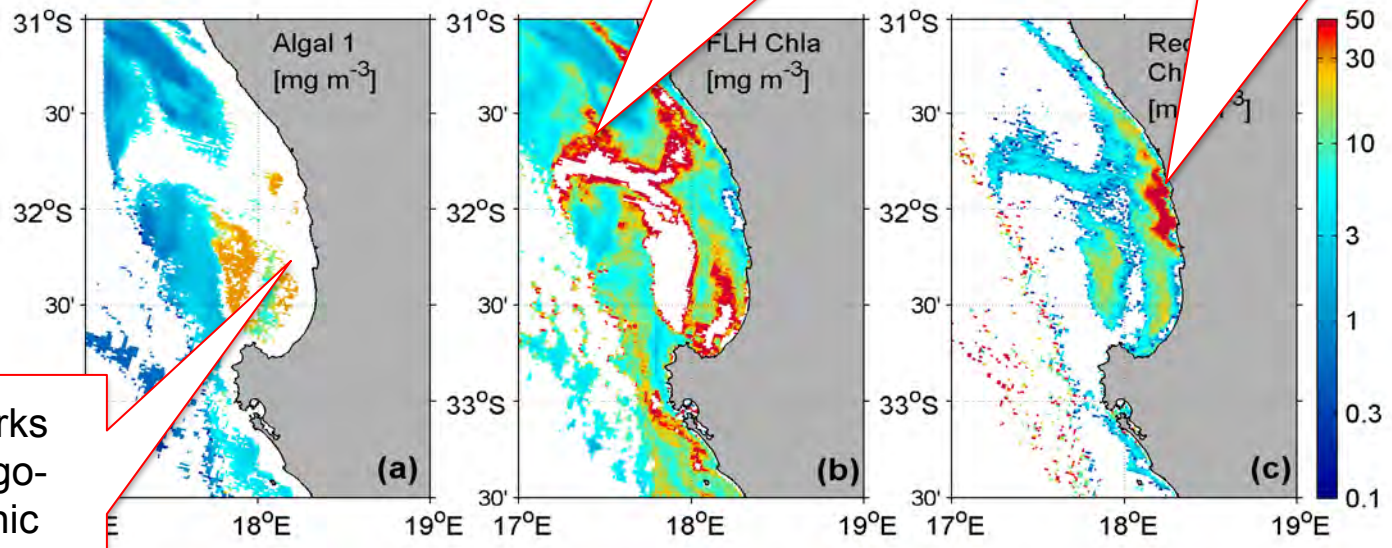
A. Folkestad ✉, L. H. Pettersson & D. D. Durand

Pages 569-592 | Published online: 04 Dec 2010

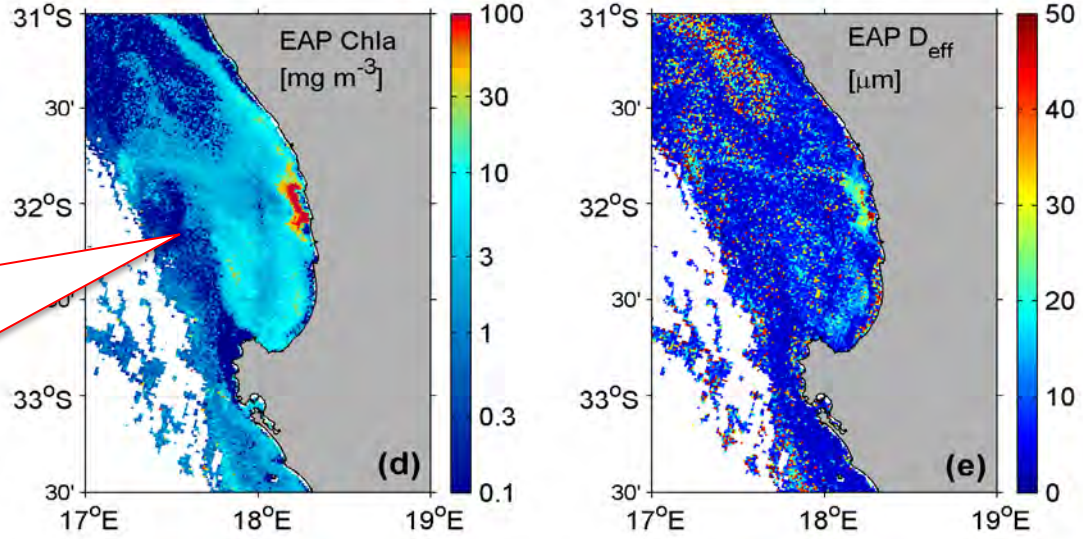
Different algorithms are needed for different water types….

FLH based algorithms work well - but only at moderate biomass

2 band red edge algorithm work well – but only at high biomass



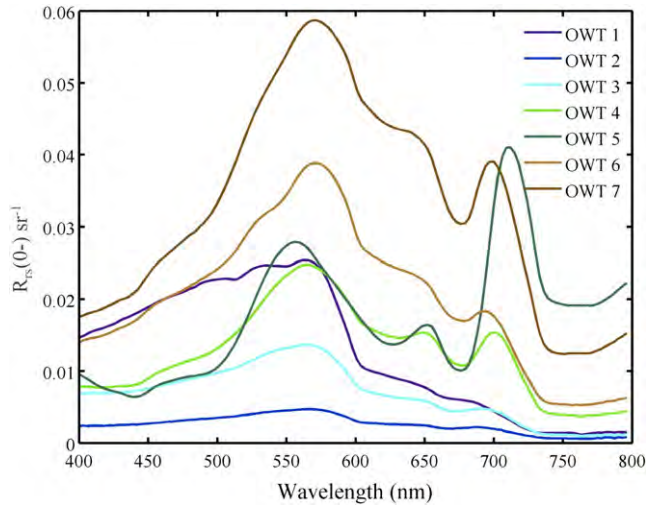
Algal 1 works well for oligo-mesotrophic waters, doesn't work at high biomass



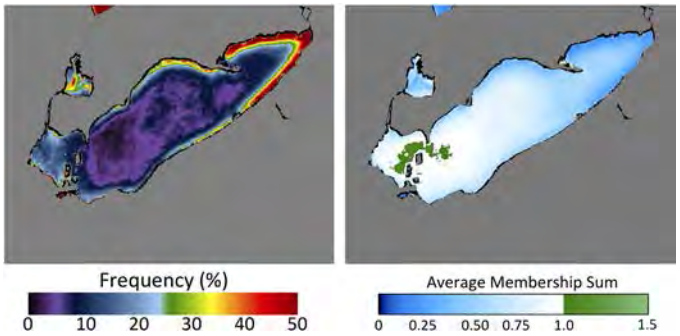
Analytical algorithm works well at moderate to high biomass, poorly at low biomass

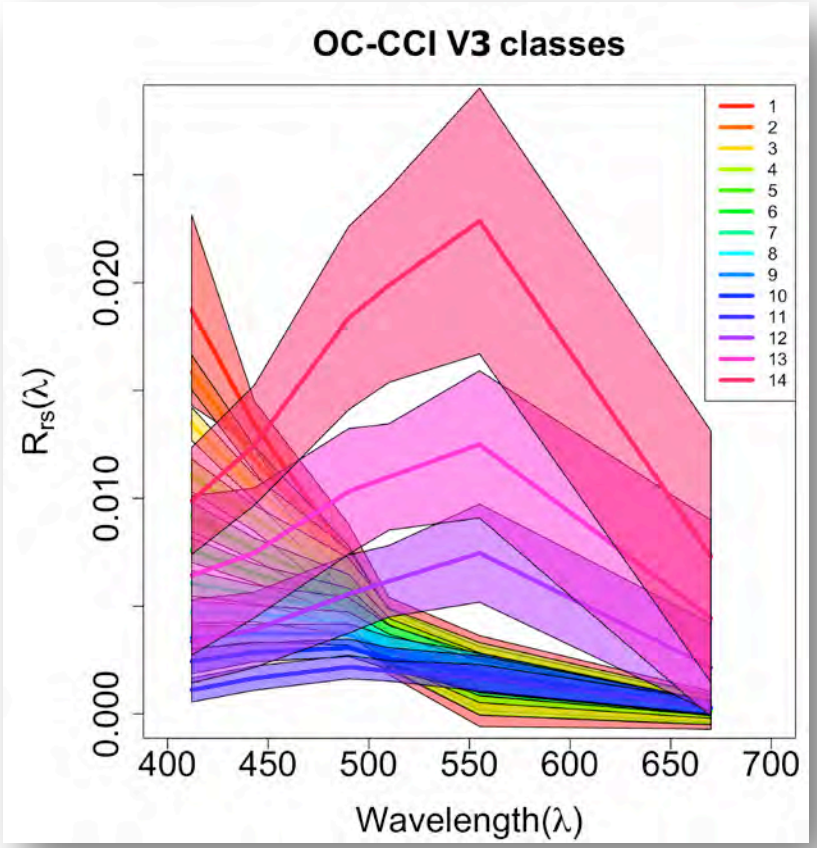
The Optical Water Type approach offers a very powerful algorithm framework to dynamically classify water types, apply a range of water type specific and optimal algorithms, and seamlessly blend algorithm output (including uncertainties) in a single product…

OC-CCI, Algorithm Theoretical Baseline Document (Ocean Colour Algorithm Blending) 2016.
Jackson and colleagues, PML.

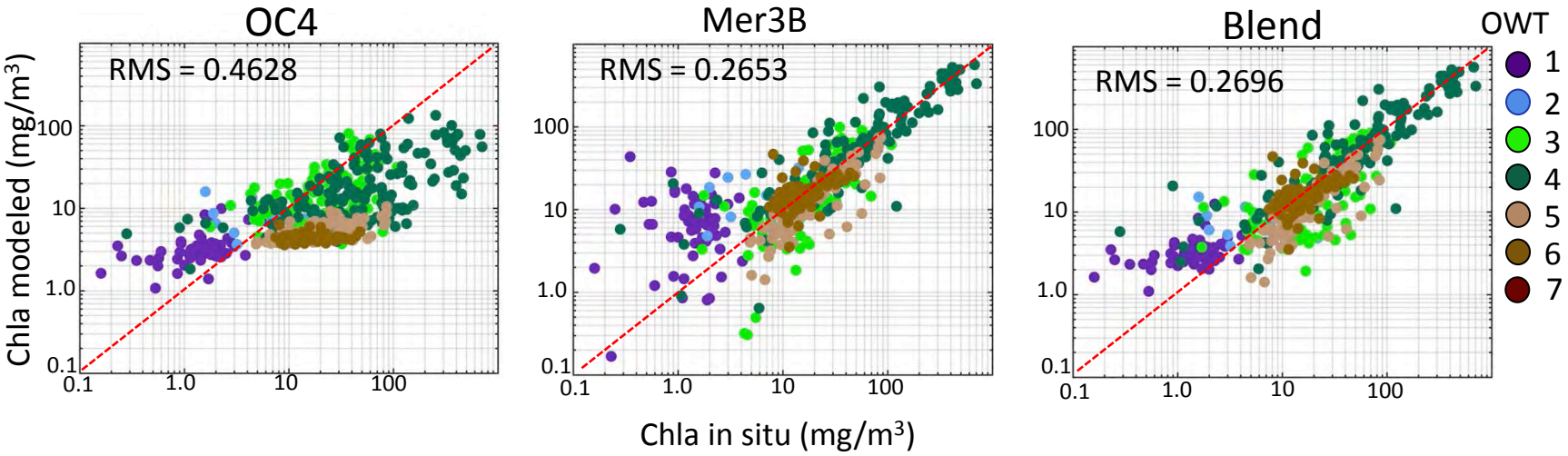


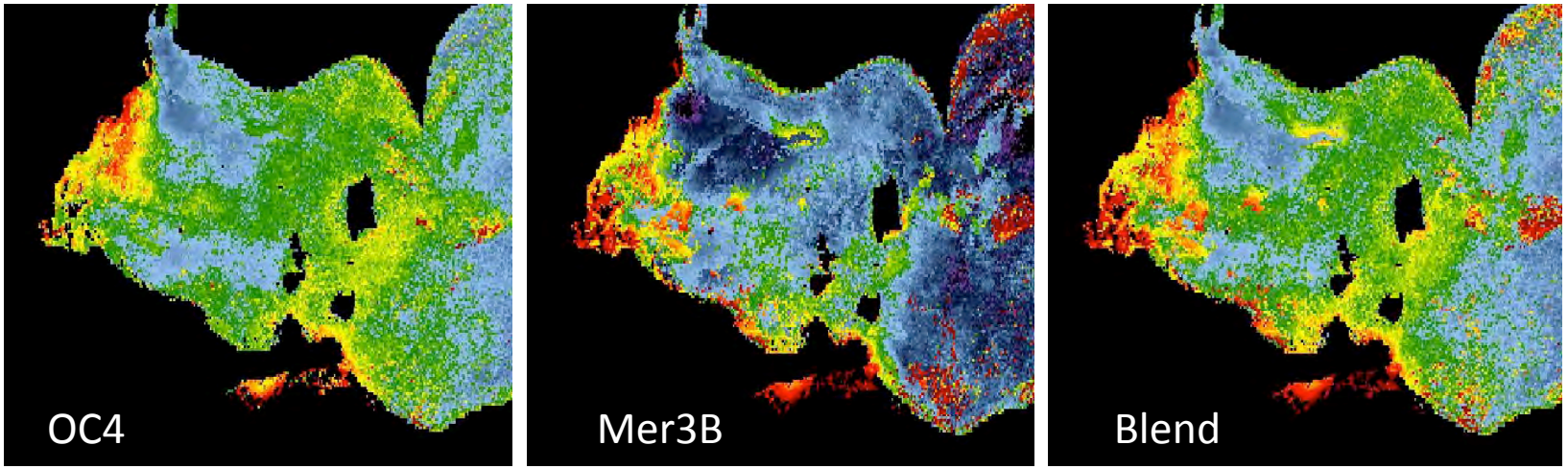
membership function.





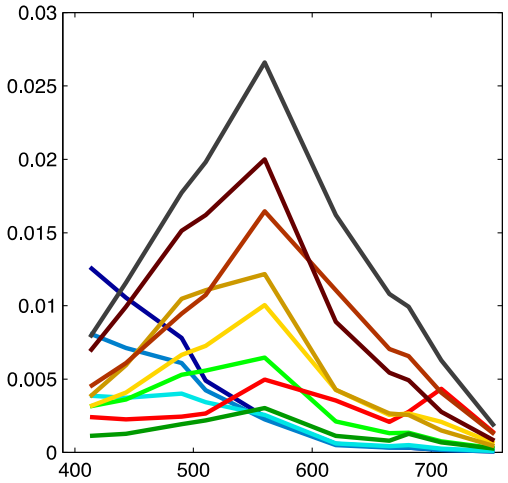
Algorithm Blending





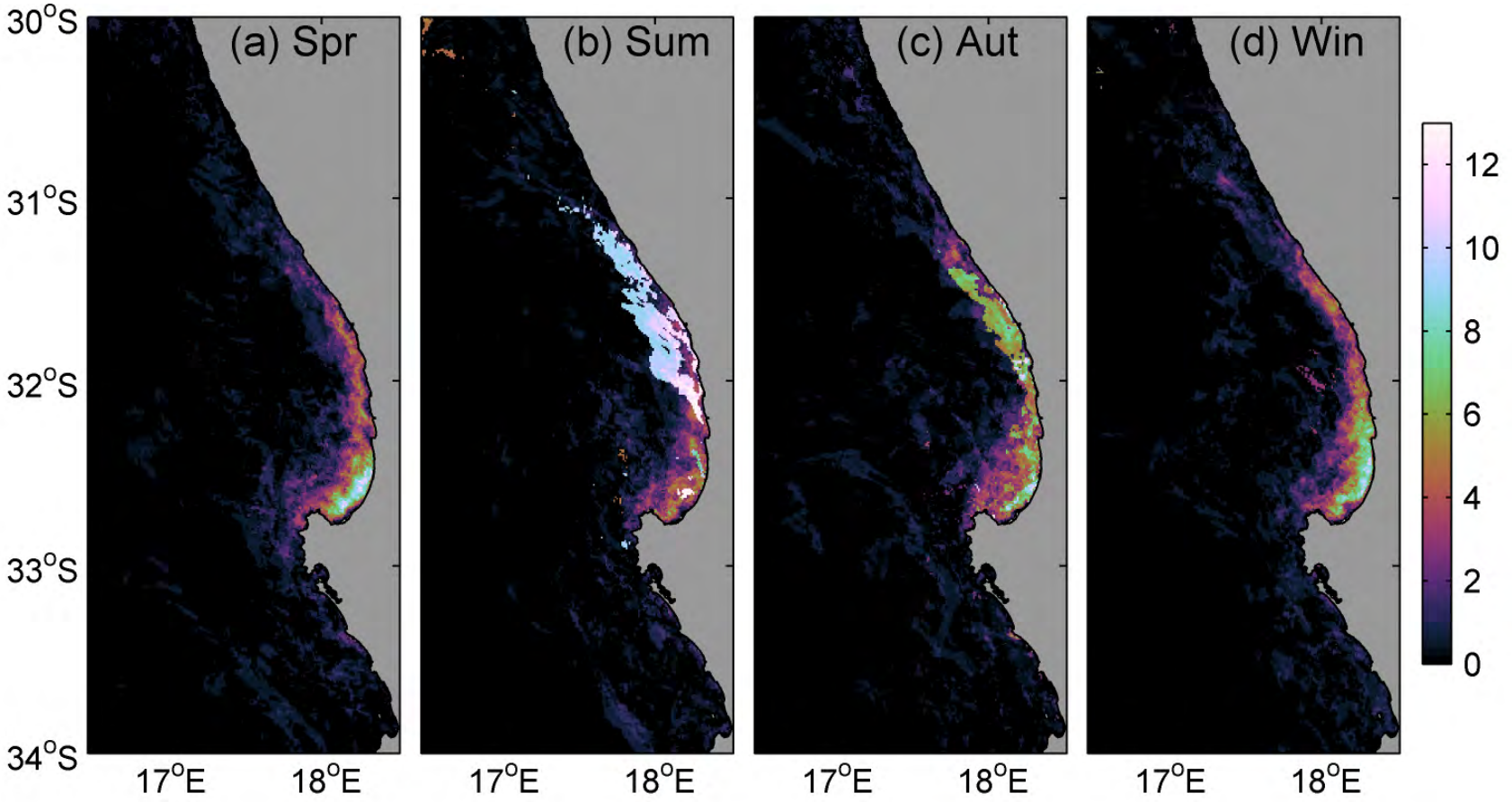
MERIS August averages

Optical Water Types that have ecological significance have considerable value in their own right….



The mean R_{rs} spectra of the eleven optical water type classes that were used to classify MERIS reflectance data of South African coastal waters, as well as the corresponding [Chl a] ranges and frequency of occurrence. Also included are the class means (dark grey) and medians (light grey), as well as the mean $b_{bs}(560)$ for the elevated reflectance classes.
M. Smith, PhD, submission to RSE July 2017

Optical Water Types that have ecological significance have considerable value in their own right….



The percentage dominance of OWT6 for each annual upwelling season (October through May) along the west coast of South Africa for MERIS data. Note that the notation in the labels are the abbreviations of the years used per panel.
M. Smith, PhD, submission to RSE July 2017

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