

# Updated summary of MERIS global MCI observations 2002 to 2012

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CoastColour

Darmstadt, Germany, May 2013



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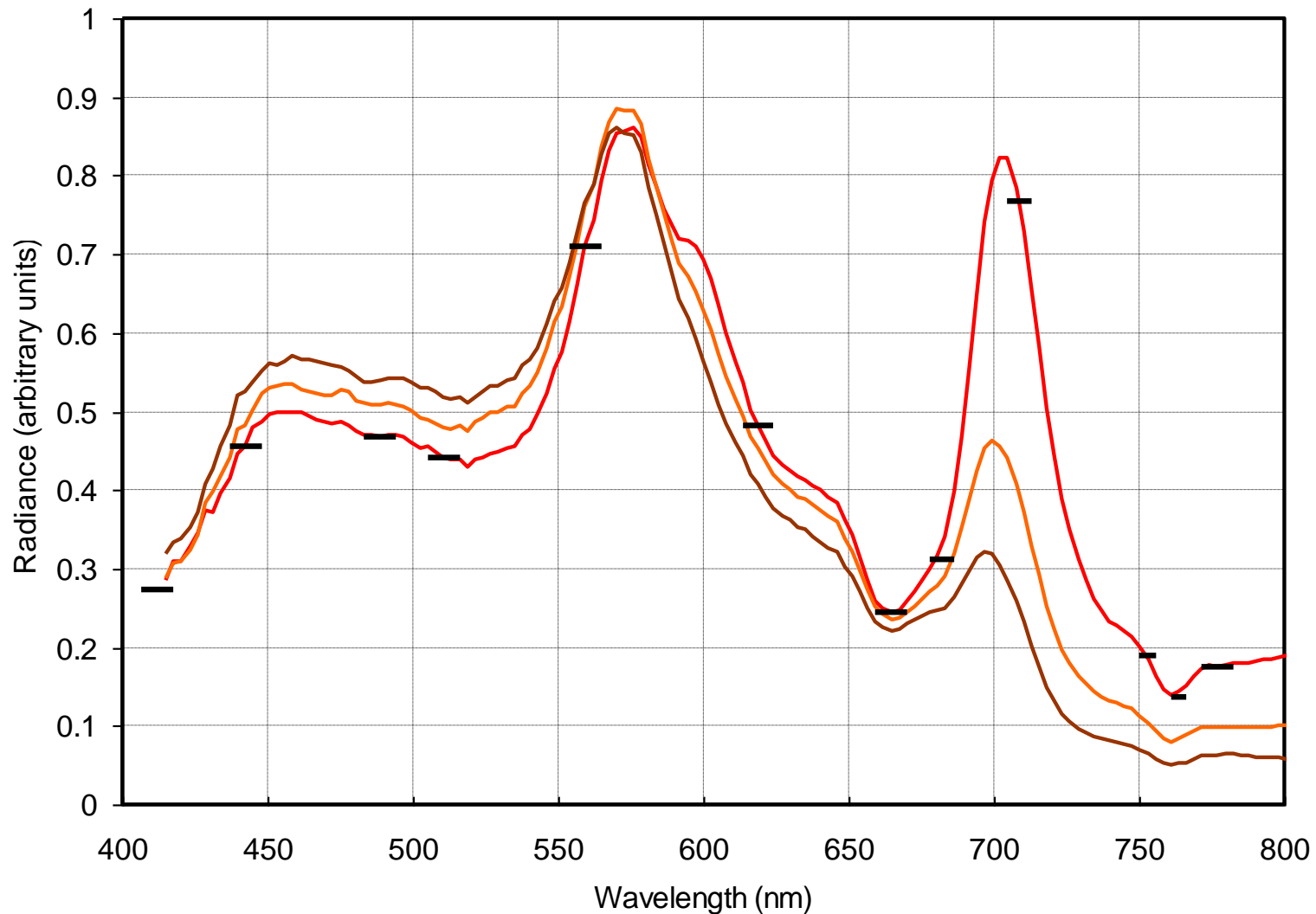
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# Maximum Chlorophyll Index (MCI)

- A peak near 705 nm occurs in spectra of surface blooms with high chlorophyll
- The red edge in the reflectance spectrum of marine vegetation also gives a peak here





Radiance spectra observed in coastal waters of BC in “red tide” conditions, showing the peak near 705 nm and positions of MERIS bands. Spectra are from low-flying aircraft using CASI imaging spectrometer



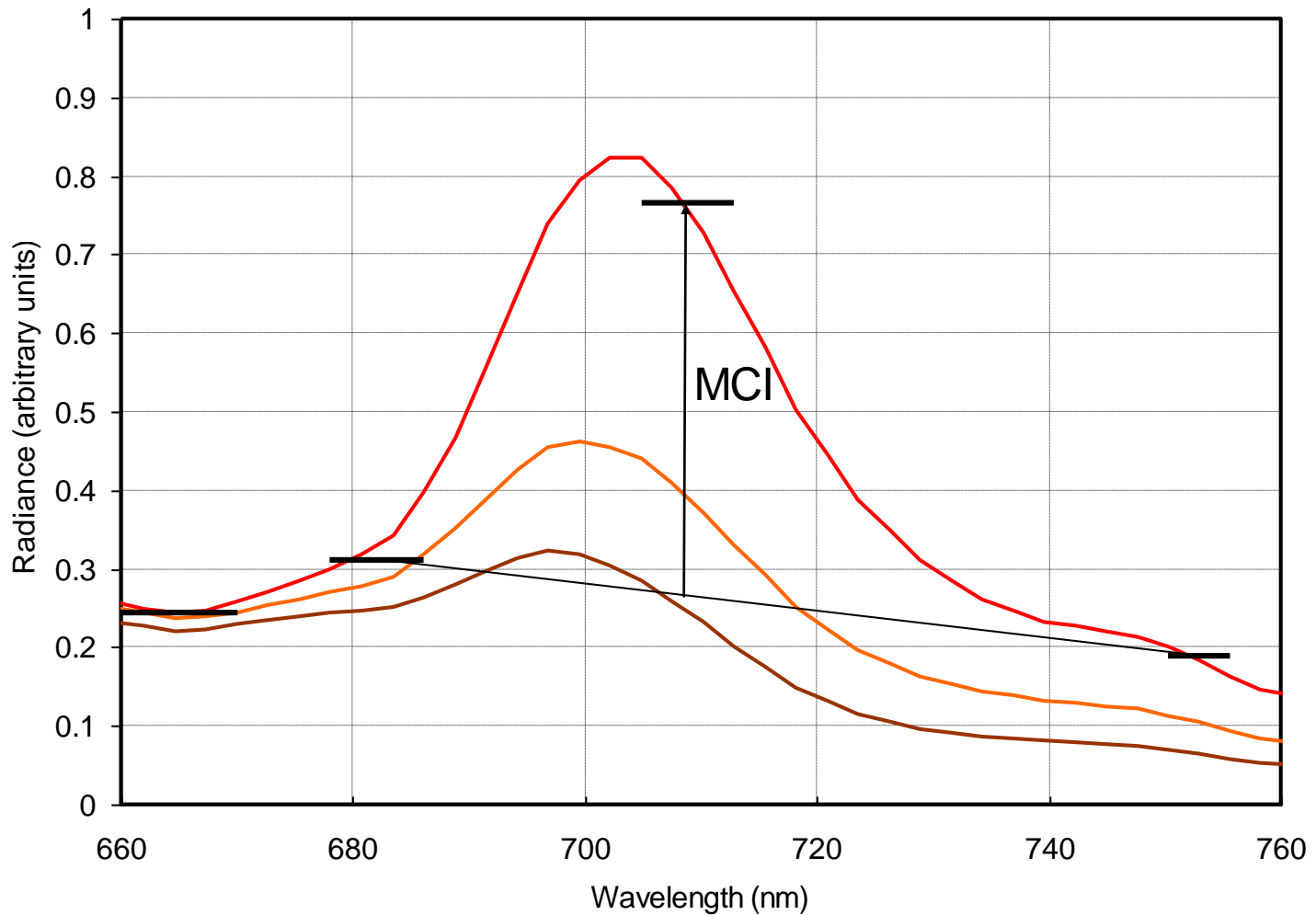
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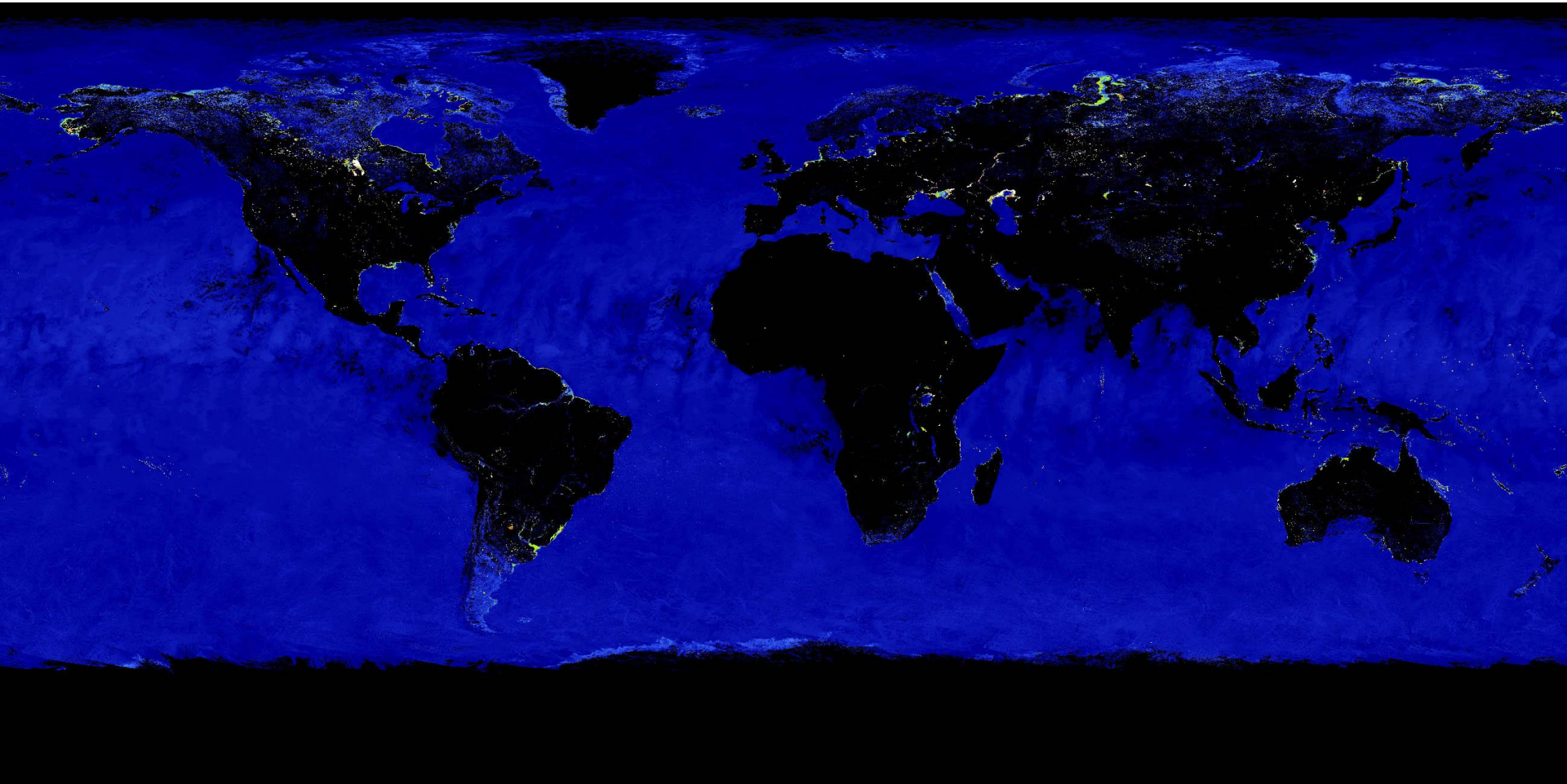
Computation of MCI (Maximum Chlorophyll Index) from MERIS data, using the band at 709 nm and a linear baseline between bands at 681 and 754 nm



# Use of MCI for detecting surface blooms, floating vegetation

- High MCI indicates dense phytoplankton blooms (*Heterosigma*, *Trichodesmium*) or floating vegetation (e.g. *Sargassum*).
- Spectrum may show either a peak at 709 nm (bloom in near-surface water) or a red edge (surface slick).
- Time series of bloom events in many parts of the world show a regular seasonal cycle with strong inter-annual variability.
- *Sargassum* shows annual circulation pattern in the Gulf of Mexico and North Atlantic, with “*Sargassum* eddies” in the Gulf Stream. Anomalous distribution in 2011.





Global MCI (max-value) composite computed by ESA's G-POD  
for all days of August 2008

Ocean data missing only in high-cloud-cover areas and near poles



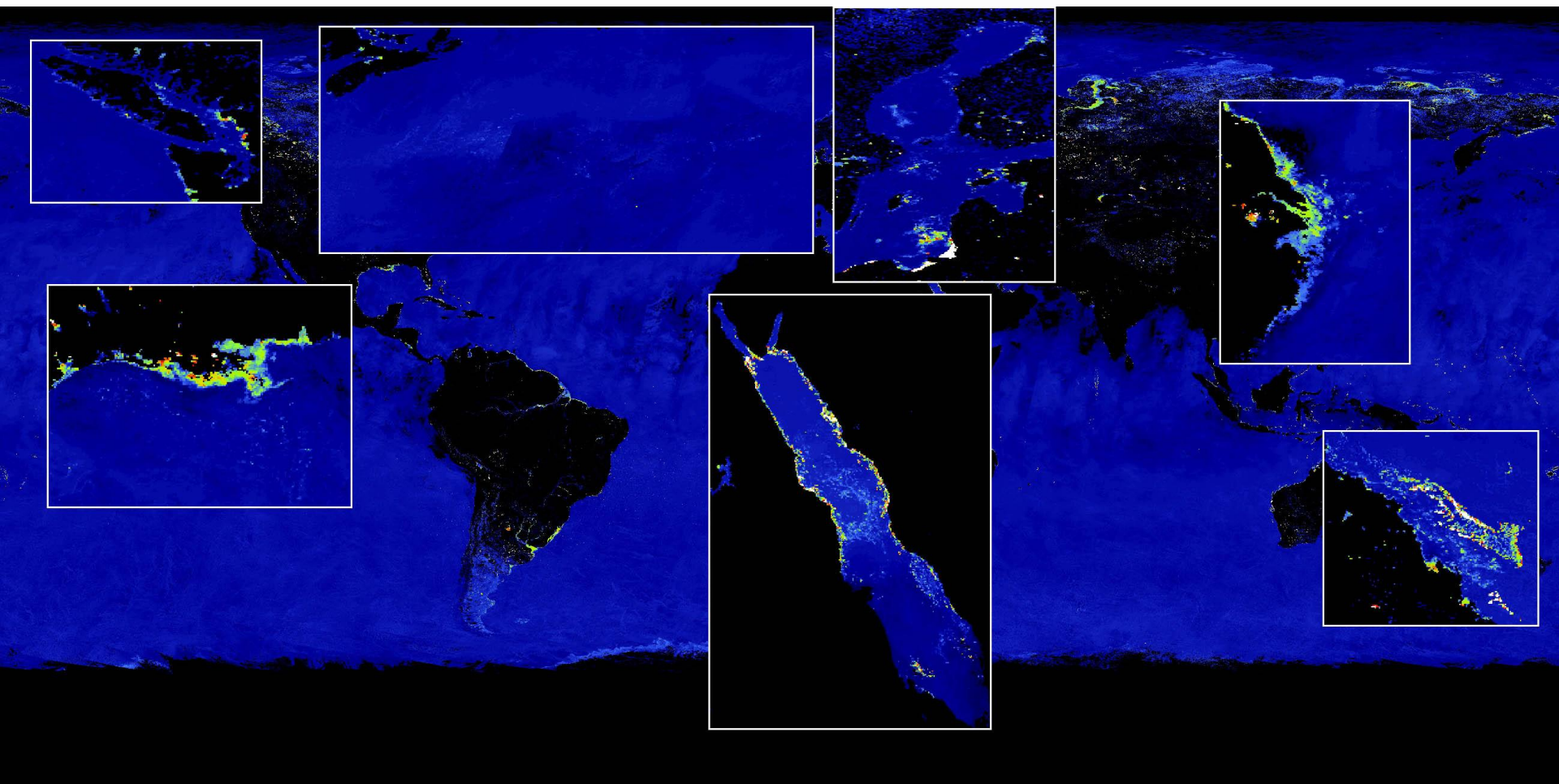
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Global MCI composite computed by G-POD for August 2008, with blow-ups showing floating vegetation and bloom events. Clockwise from top left: bloom in Strait of Georgia, *Sargassum* in North Atlantic, bloom in Baltic, bloom off Chang Jiang river, *Sargassum* off Mississippi, bloom in Red Sea, coral and bloom on Great Barrier Reef.



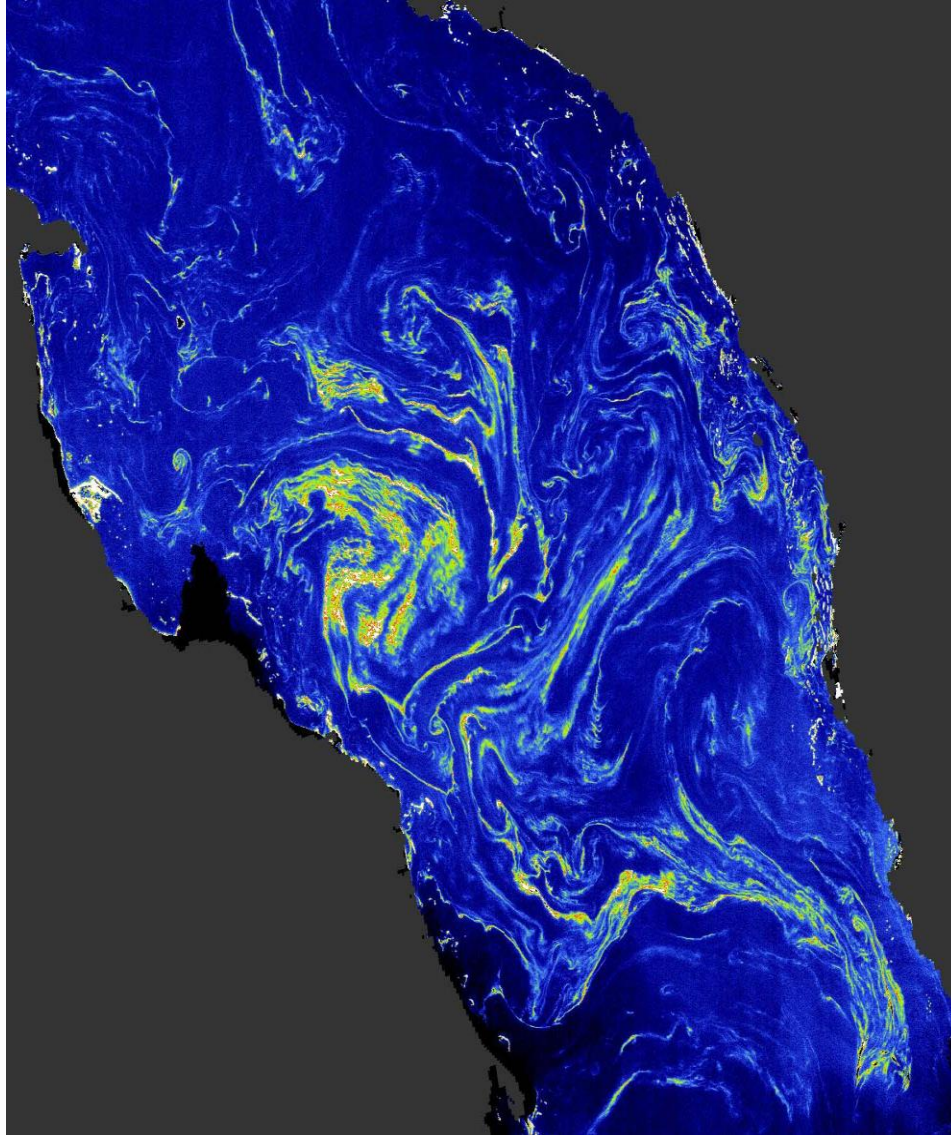
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Intense surface *Trichodesmium?* bloom in the Red Sea, 30 July 2005. MCI image, about 300 km across.



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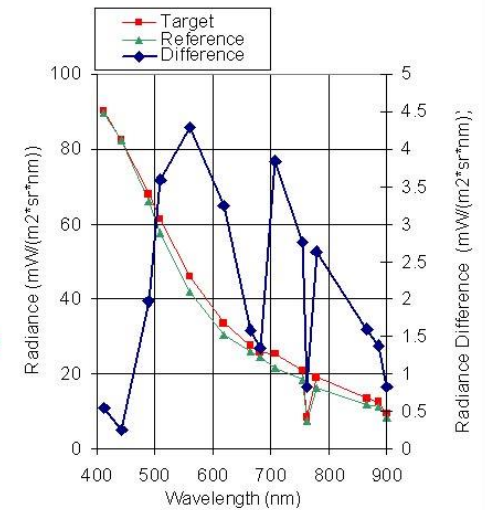
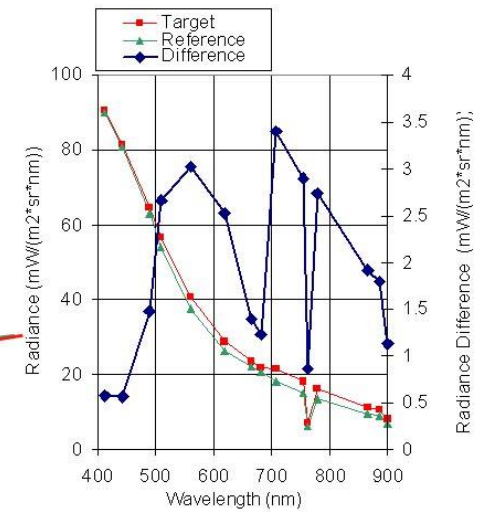
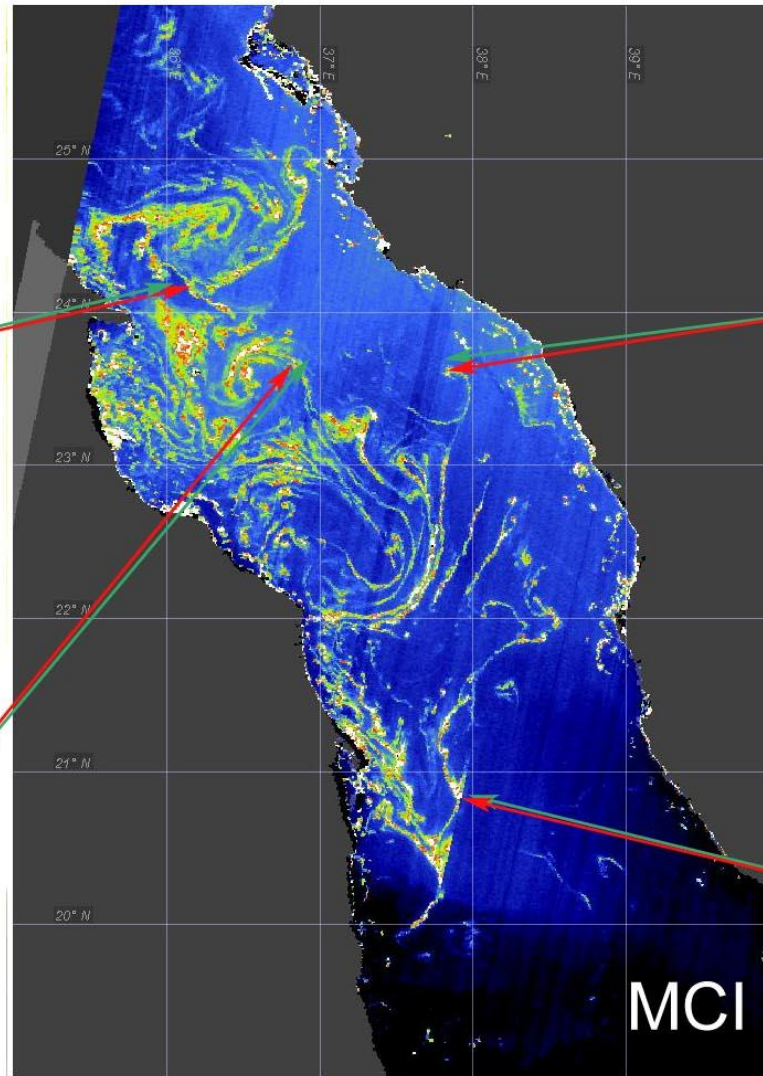
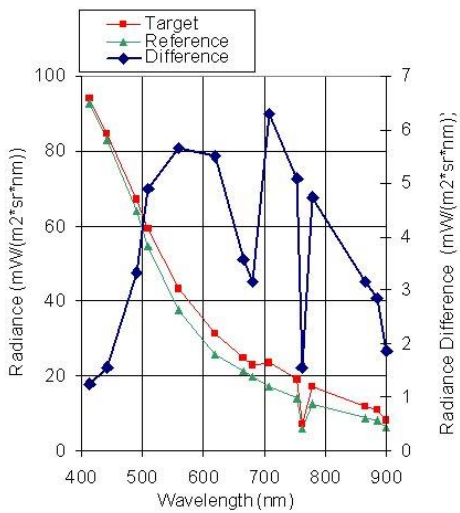
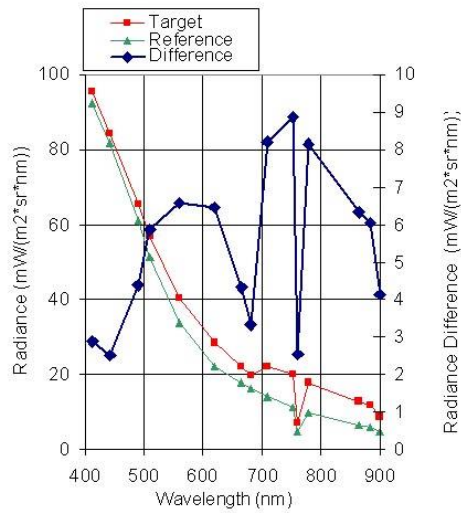
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MCI image and spectra of a bloom believed to be *Trichodesmium* in the Red Sea on June 23, 2006



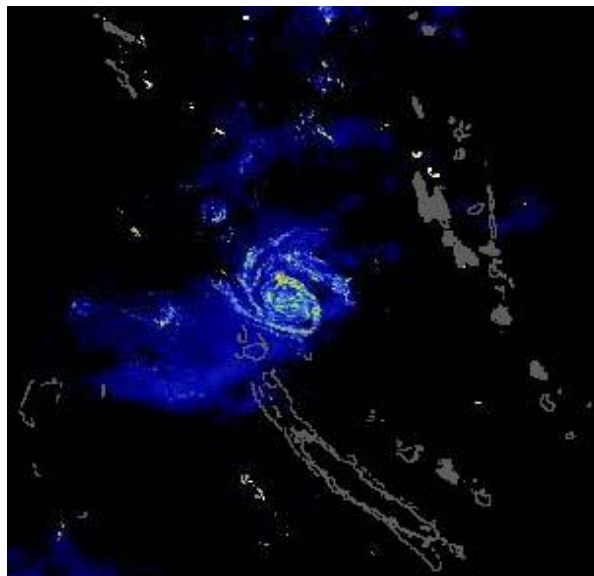
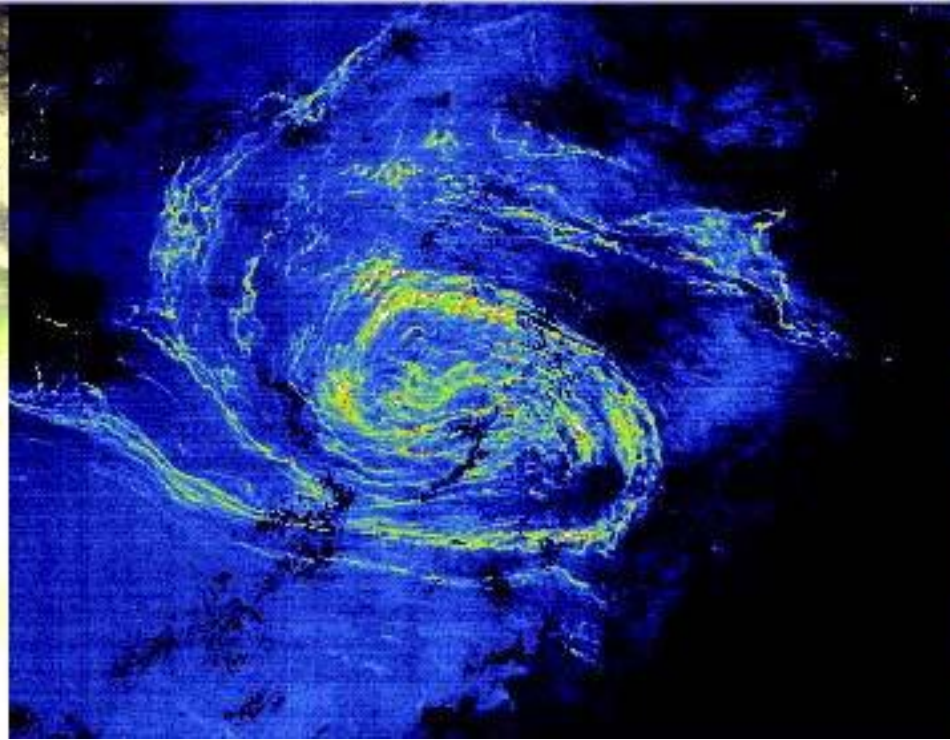
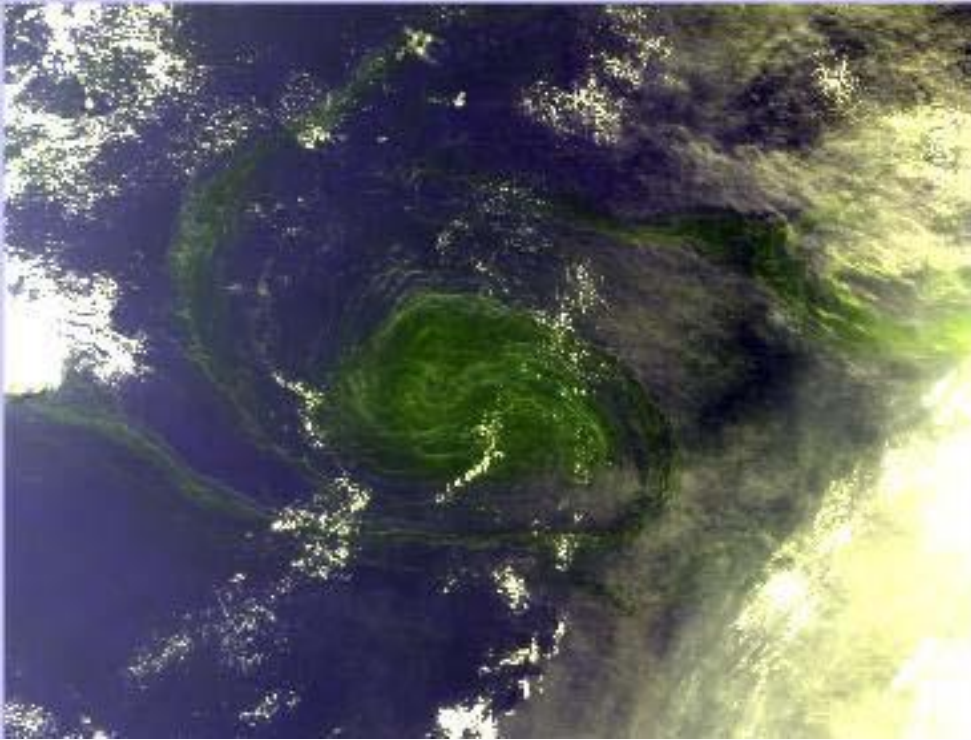
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Intense surface *Trichodesmium*?  
bloom in the Coral Sea near  
Noumea, 17 March 2007

True colour, top left. MCI top right.  
Location map with Noumea, bottom  
left.



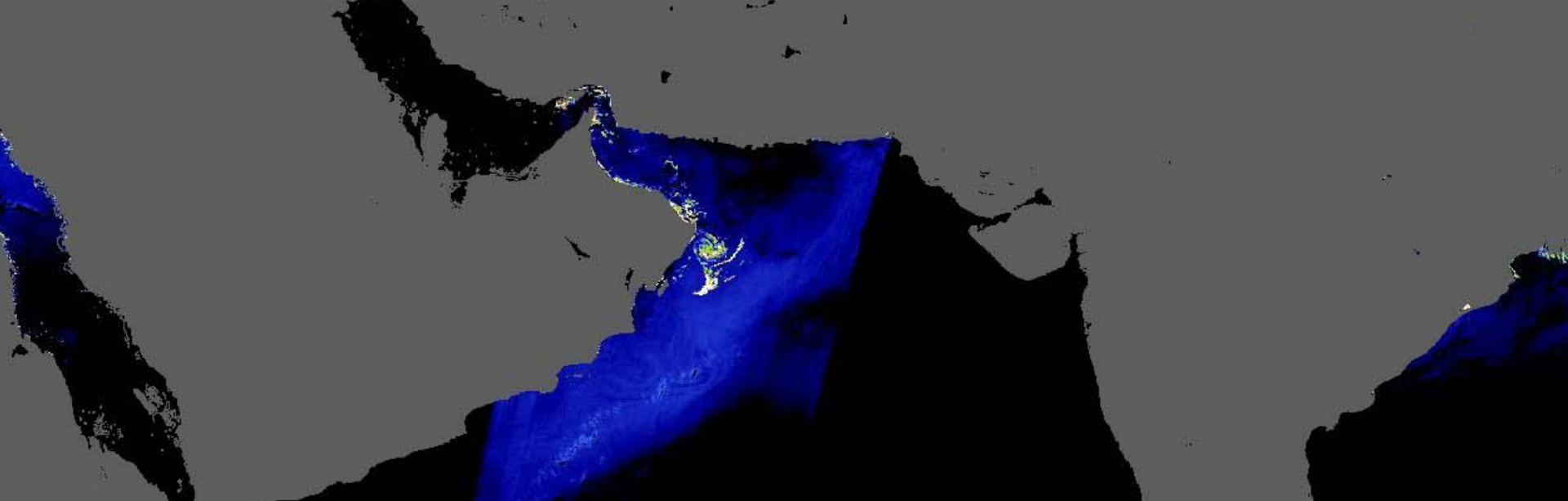
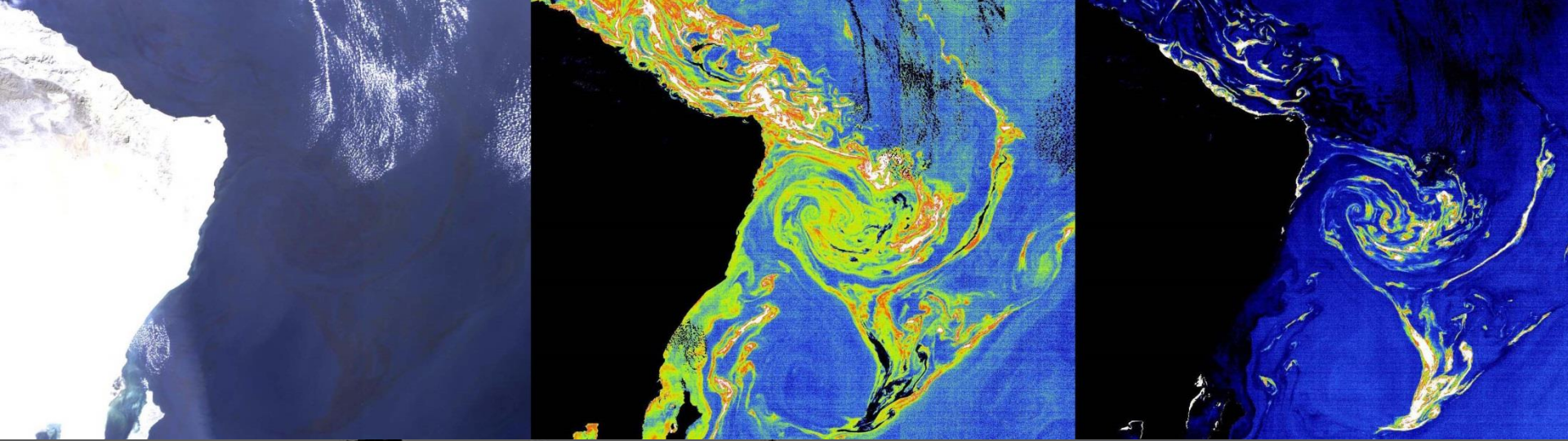
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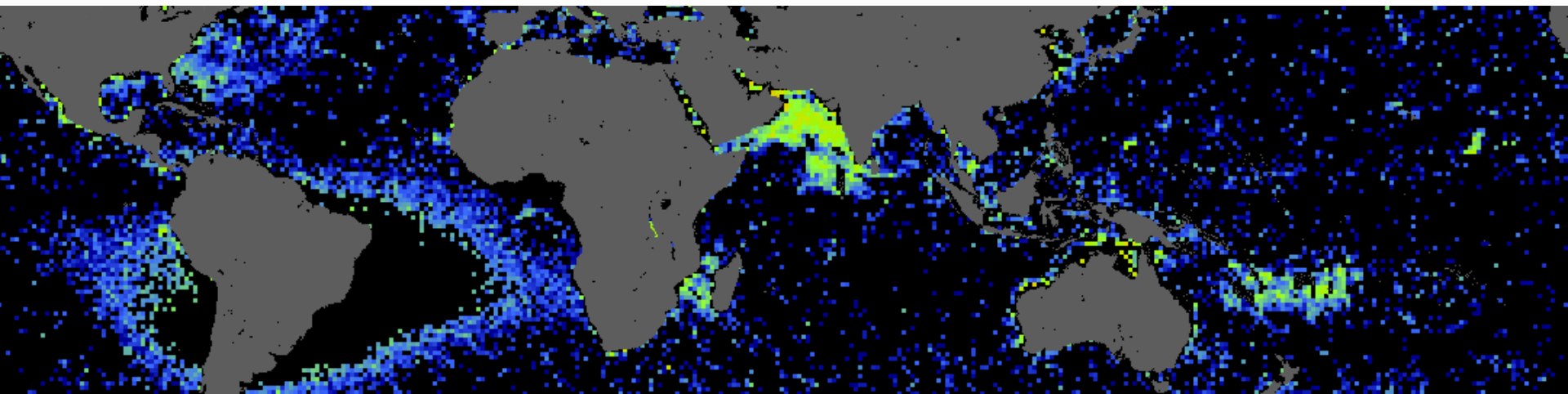


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Intense surface *Trichodesmium?* bloom from MERIS global search. Off Oman, Arabian Sea, 26 Nov 2008.  
True colour, top left. FLH top centre. MCI top right.  
Location map with full MERIS swath, bottom.



Global distribution of MERIS MCI signal for 2008 with persistent targets masked (coral reefs and peak SAA cosmic rays), derived from daily global composites of MCI provided by ESA's GPOD

North Atlantic: Sargassum

South America: SAA cosmic rays

Arabian Sea, Madagascar, Australia coasts, South Pacific: Trichodesmium



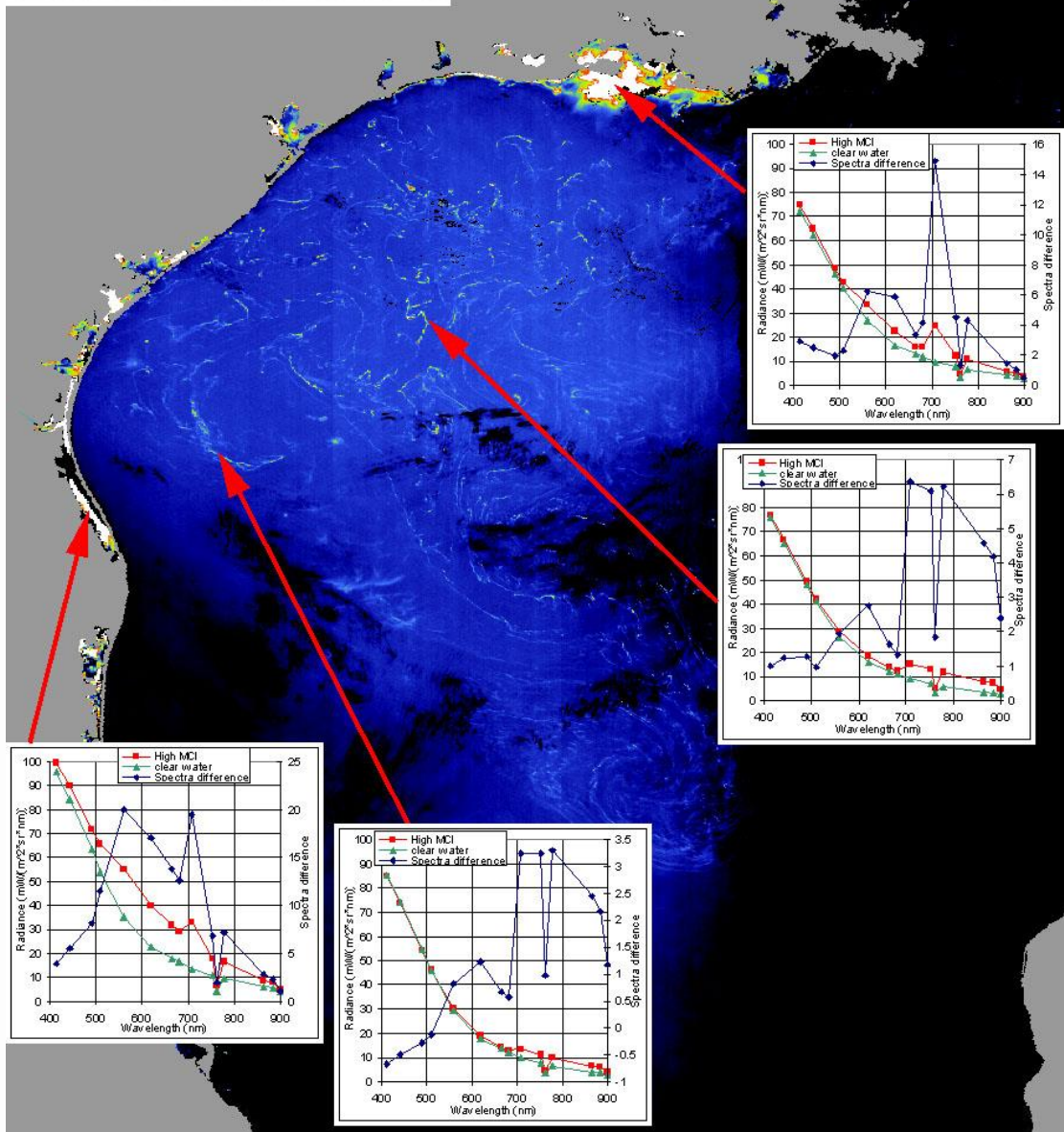
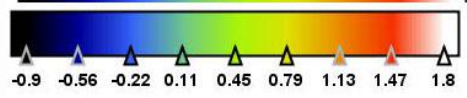
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MERIS bloom hunt:  
2 June 2005  
Western Gulf of Mexico

This was the first satellite image of floating, pelagic *Sargassum*, known to be spatially widespread since the time of Columbus, but not previously detected in satellite images.

Note the difference between “red-edge” spectra of *Sargassum* in the Gulf, and “709-peak” spectra of blooms in coastal lagoons



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Sargassum slick observed in the western Gulf of Mexico on 2 June 2005 off Corpus Christi Texas (Tracy Villareal, University of Texas)



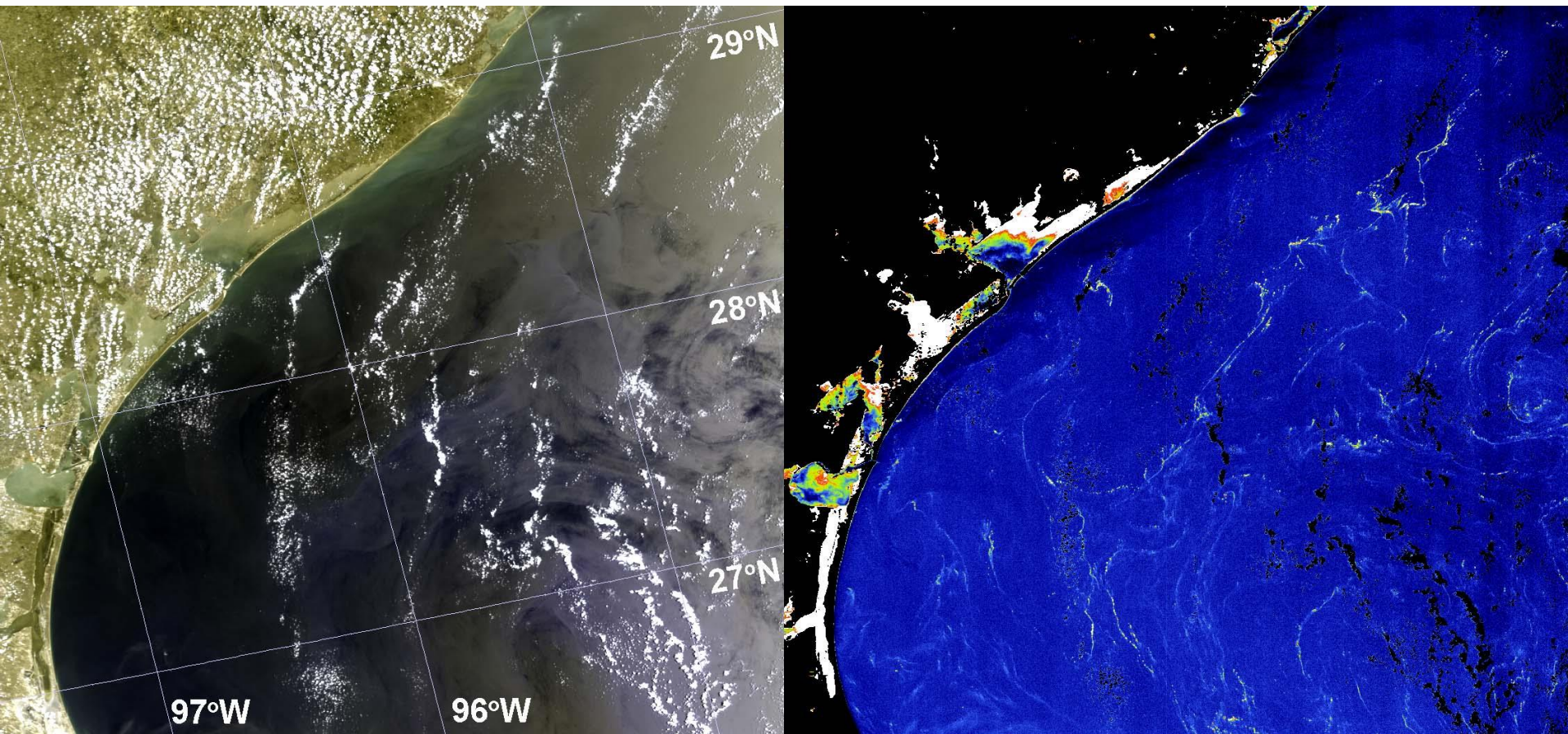
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Patterns of floating *Sargassum* in the north-west Gulf of Mexico imaged by MERIS (FR imagery, 300 m resolution) on May 23, 2005. Images show true colour (RGB, left) and MCI (radiance peak at 709 nm, right). Dark patterns in the sun glint on the left image show where *Sargassum* smooths the water



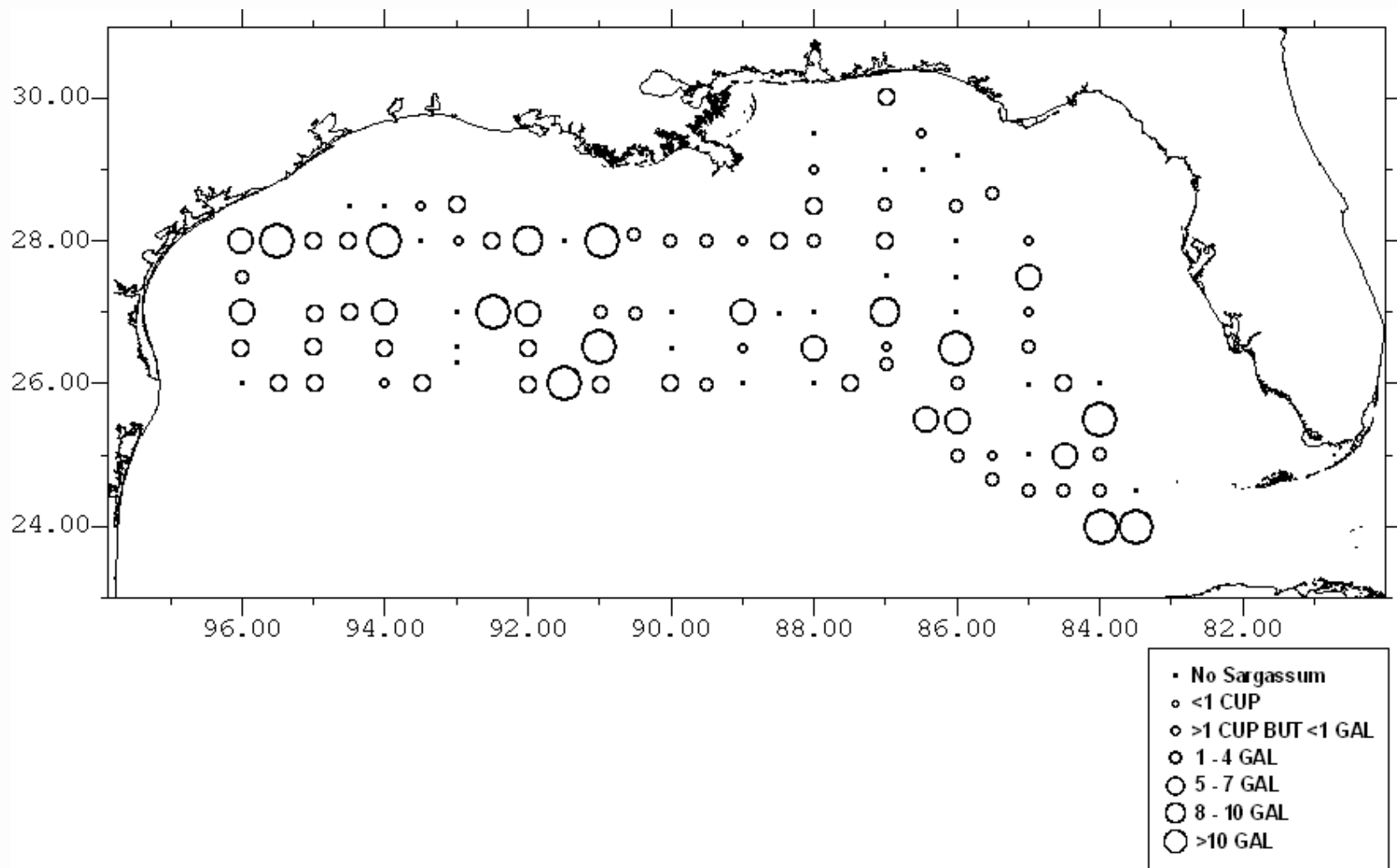
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Amounts of *Sargassum* collected in 10-minute Neuston net tows at surface with 2 m wide, 1 m deep net opening, 0.5 m submerged, for cruise #2 in 2005, May 14 to May 30 (Zapfe, NOAA, Pascagoula, Miss.)



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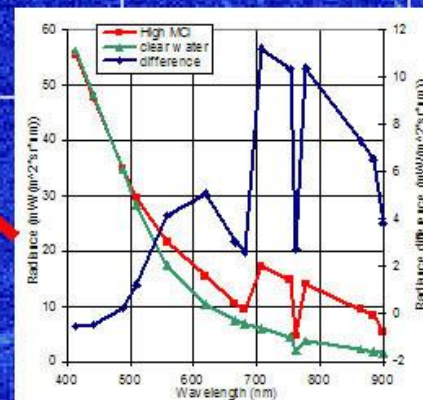
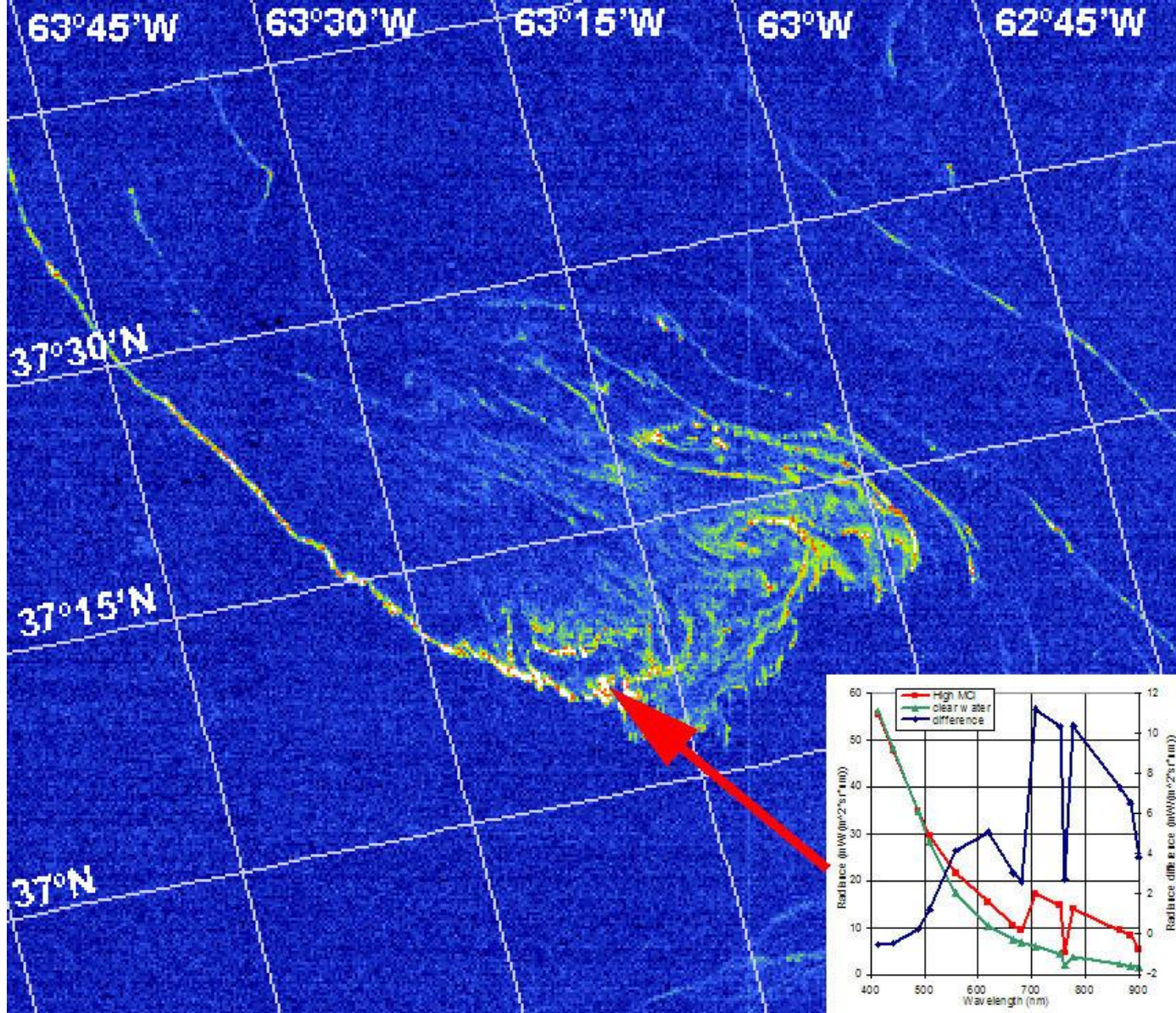
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MERIS FR MCI image of floating Sargassum on 22 Oct 2007. The spectrum shows the “red-edge” and a local maximum at 620 nm



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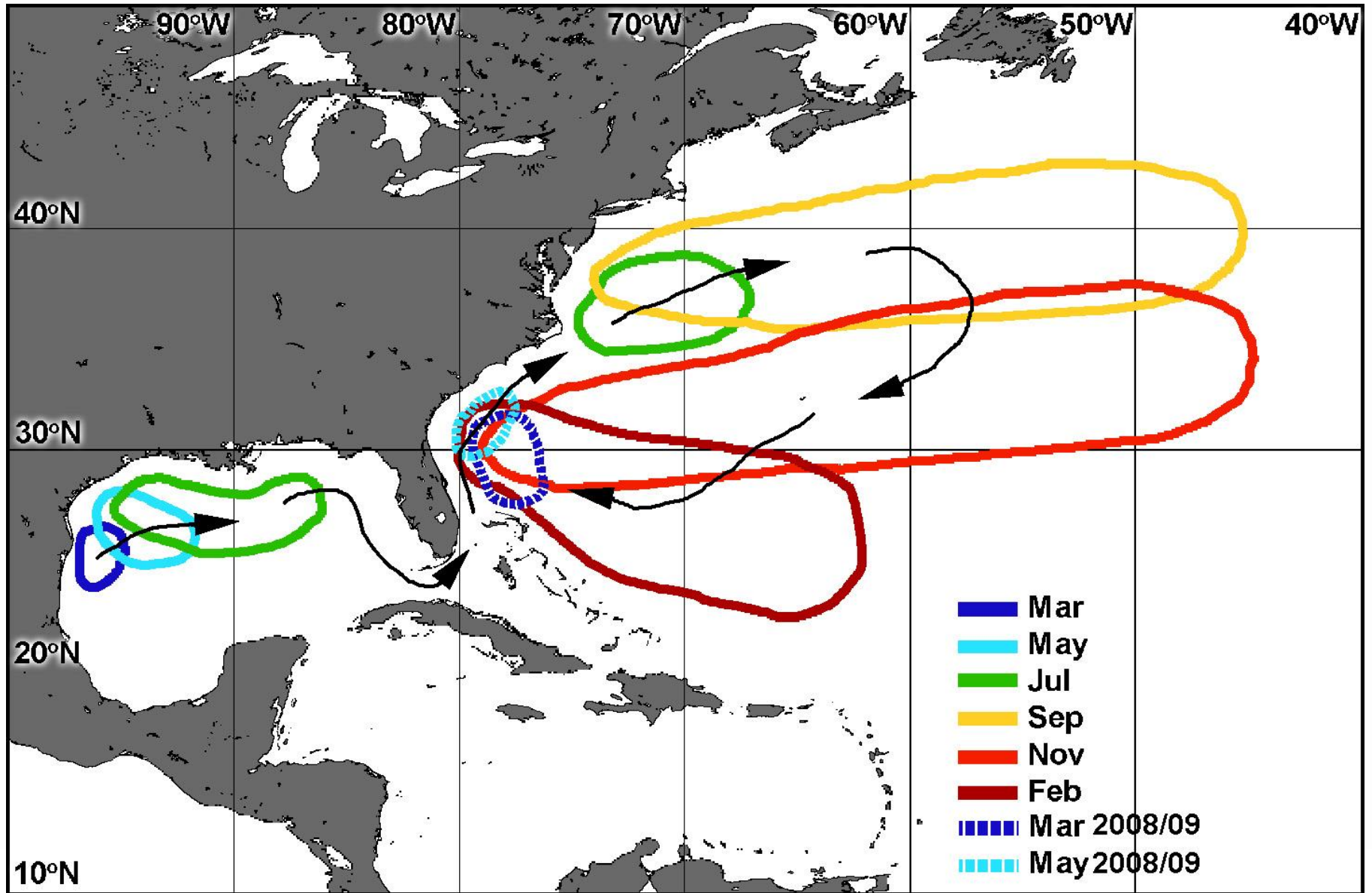
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# Sargassum distribution summary 2002 to 2010





# Port Aransas Texas, April 2011



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# Barbados 2 Aug 2011



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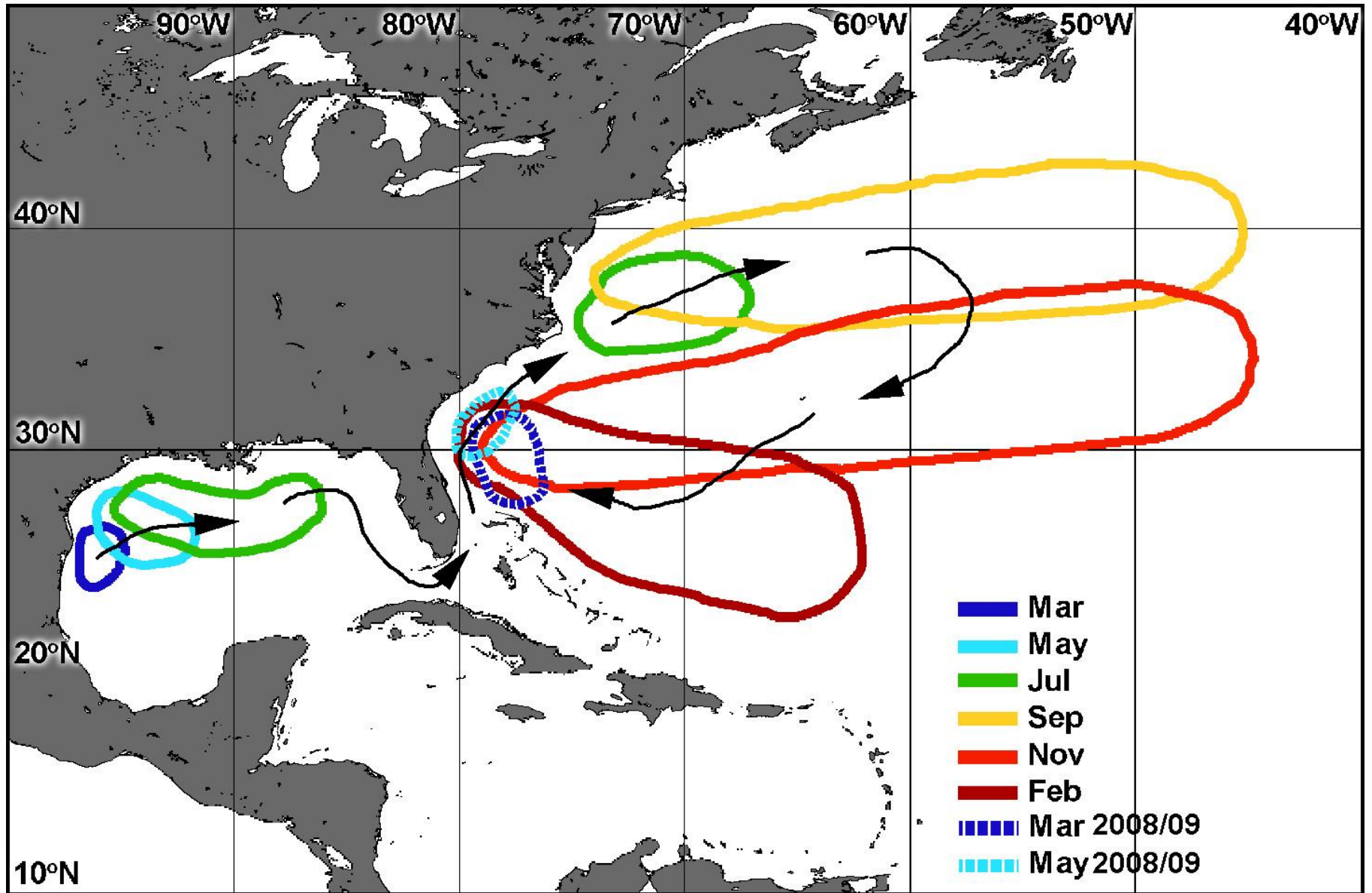
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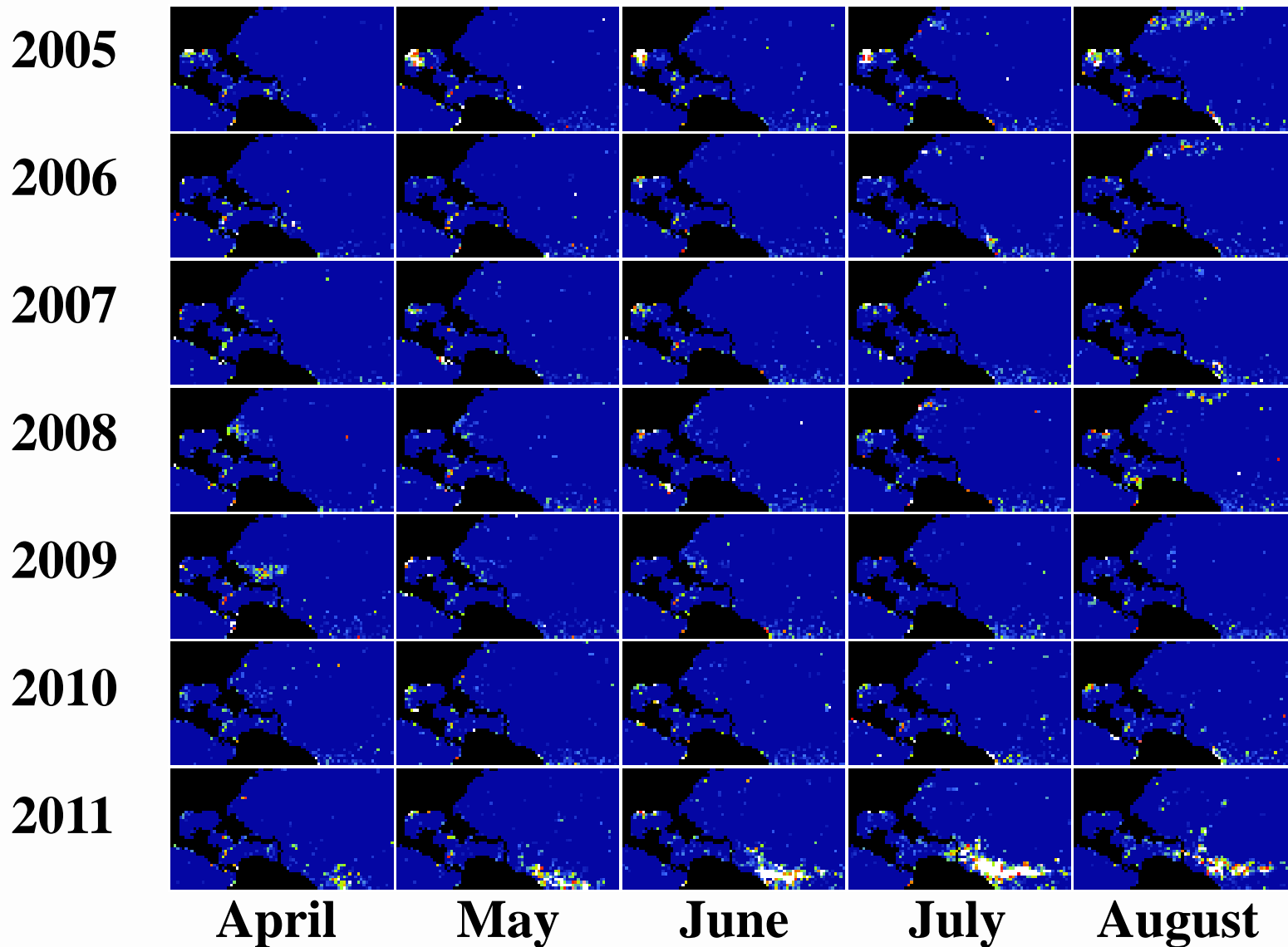


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# Sargassum distribution summary 2002 to 2010





Sargassum distribution computed for 1-degree squares, showing the high growth in the north equatorial Atlantic in 2011



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## Sierra Leone, Africa, 24 August 2011



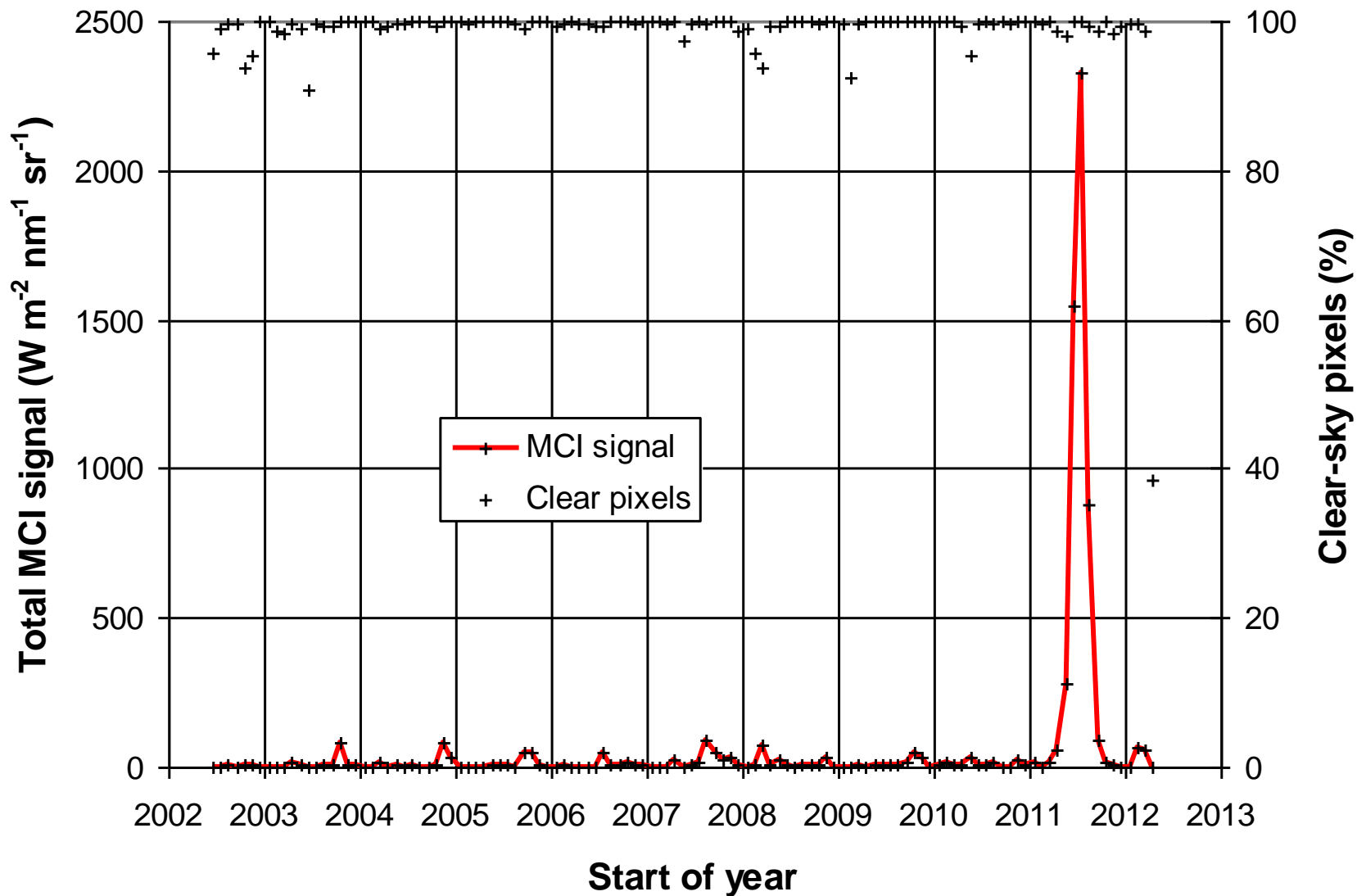
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Time series of total MCI signal in area 38 to 51W, 5 to 9N, showing the “*Sargassum* event” in May to August 2011 (peak in July)



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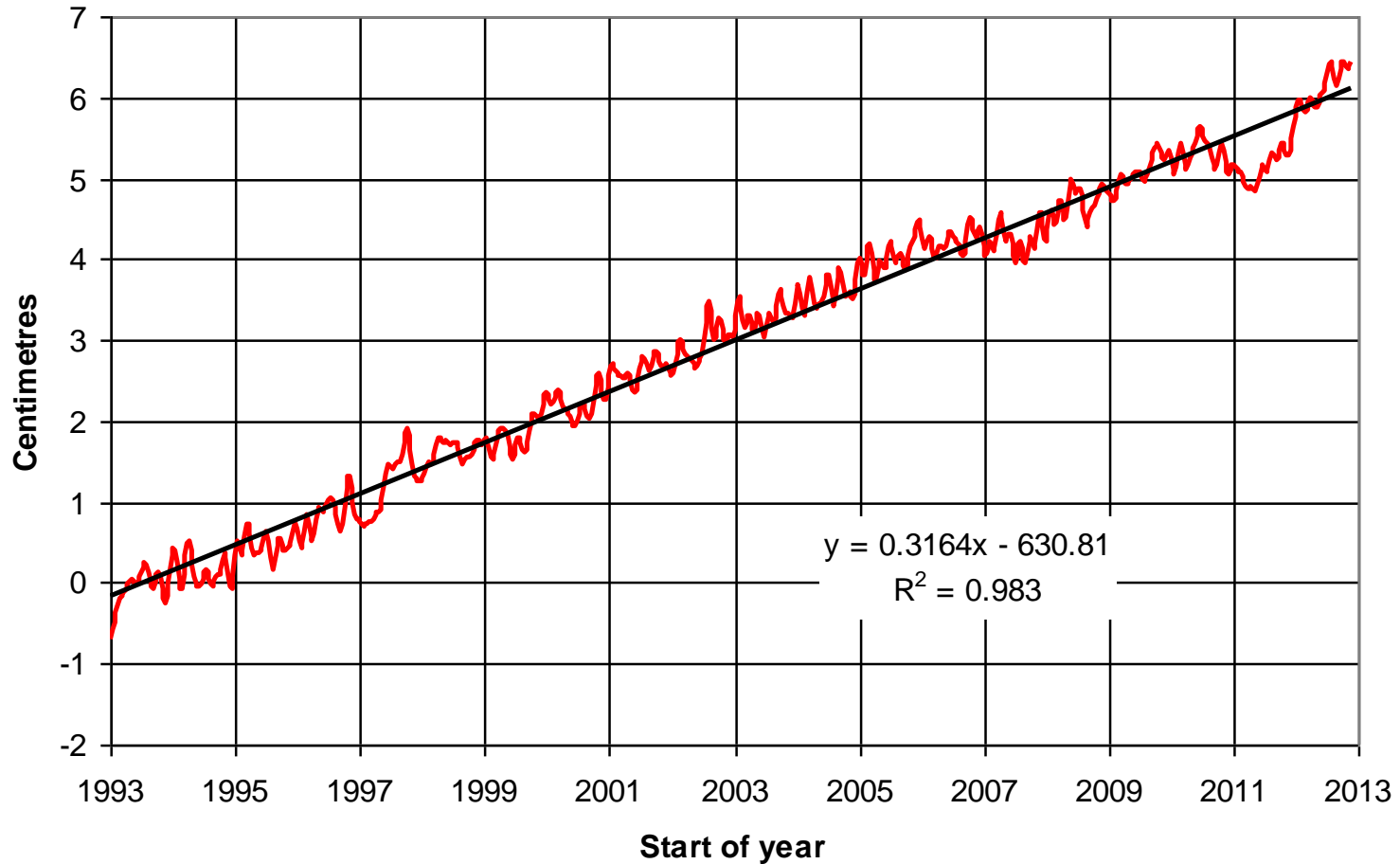


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# AVISO Global Sea Level



Global average sea surface height as measured by altimetry, showing rise rate of 3.2 mm/year



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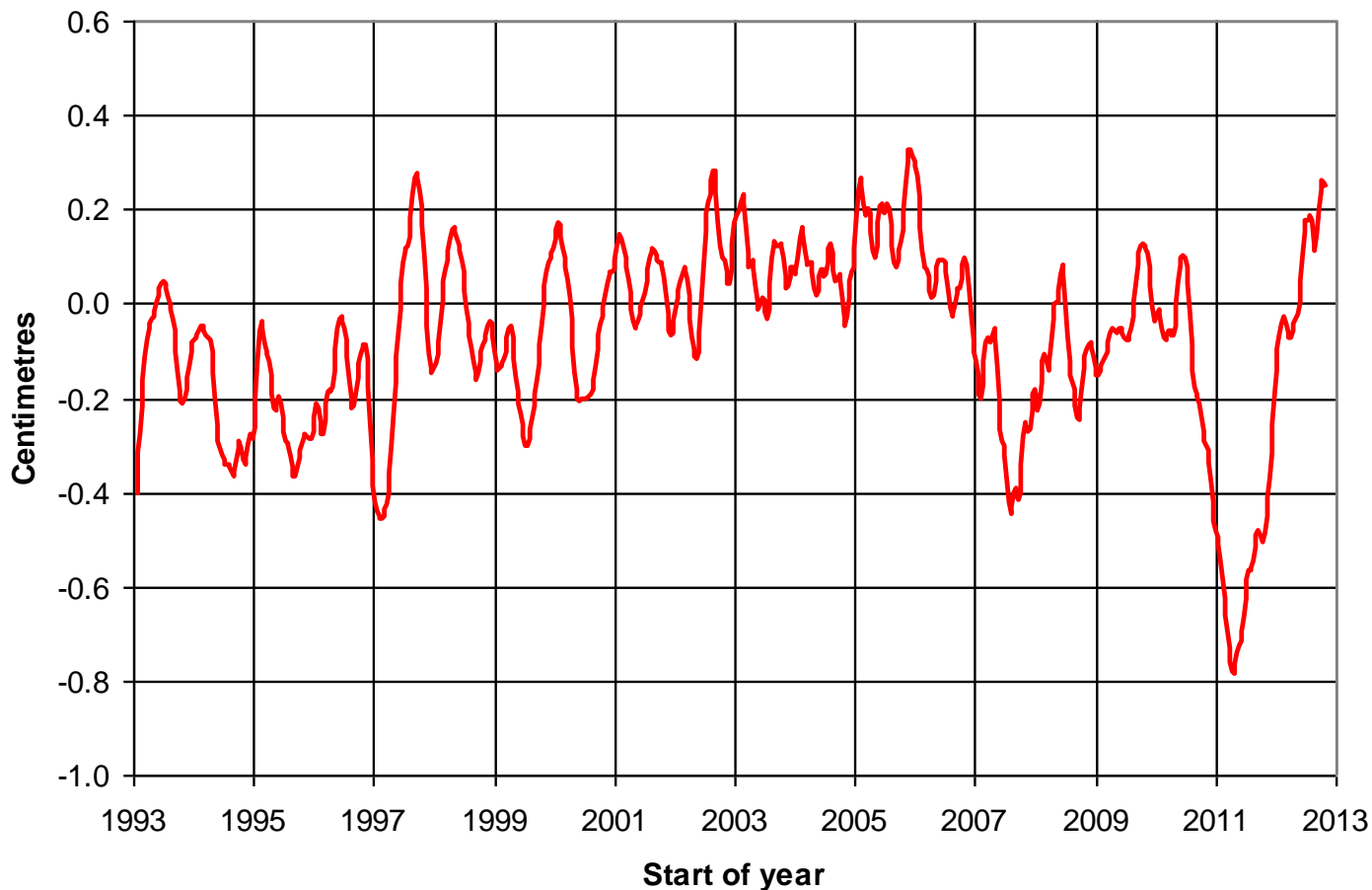
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## AVISO Global Sea Level (trend removed)



Global average sea surface height as measured by altimetry with trend removed, showing the minimum due to temporary water storage on land, peaking in early 2011



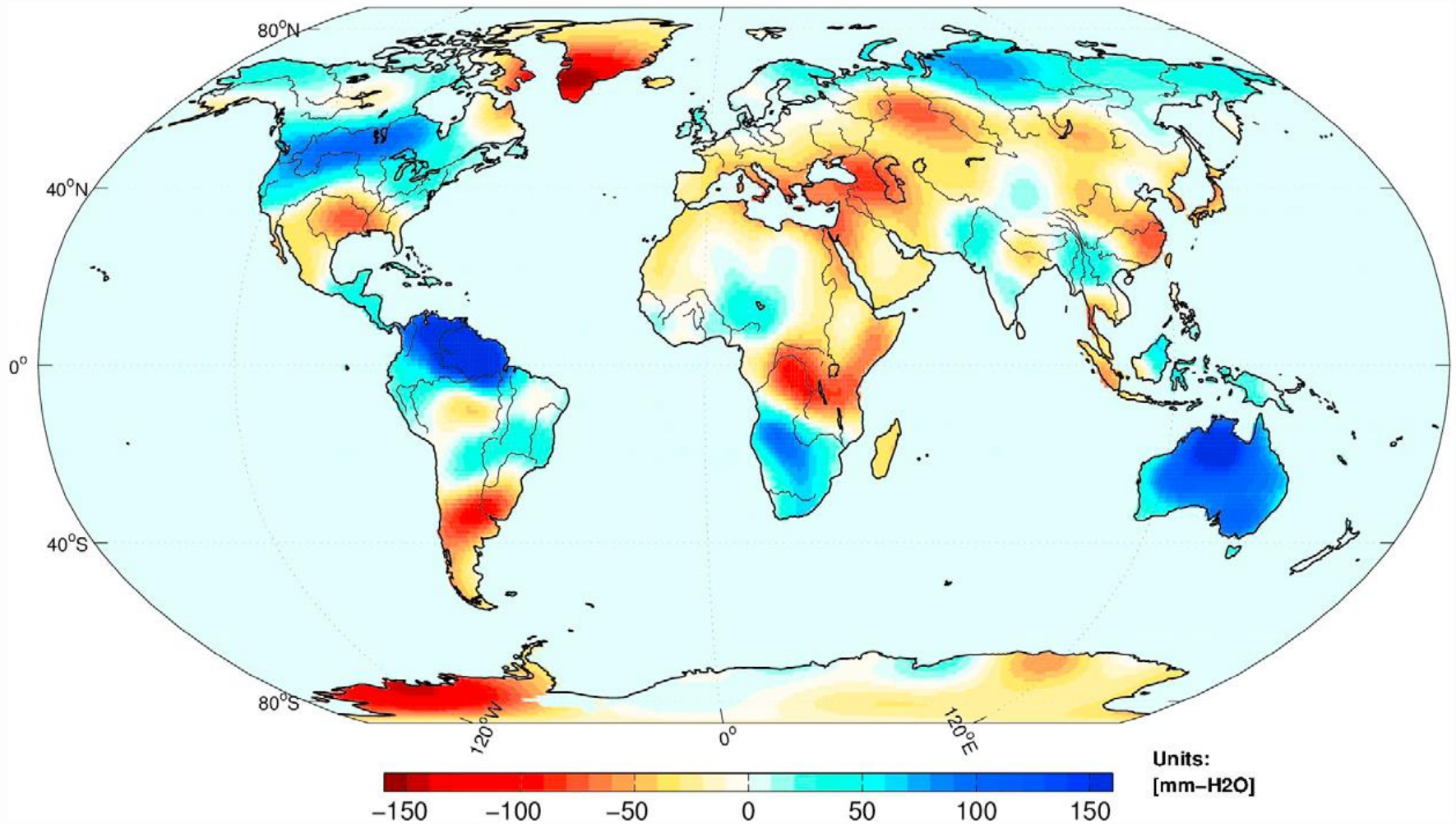
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The spatial distribution of this stored water as shown by the GRACE satellite.

C. Boening et al.: GRL 2012, “La Niña 2011 — so strong, the oceans fell.”

Figure 3. Change in water mass from beginning of 2010 (JFM average) to mid 2011 (MAM average). Blue colors indicate an increase in water mass over the continents.



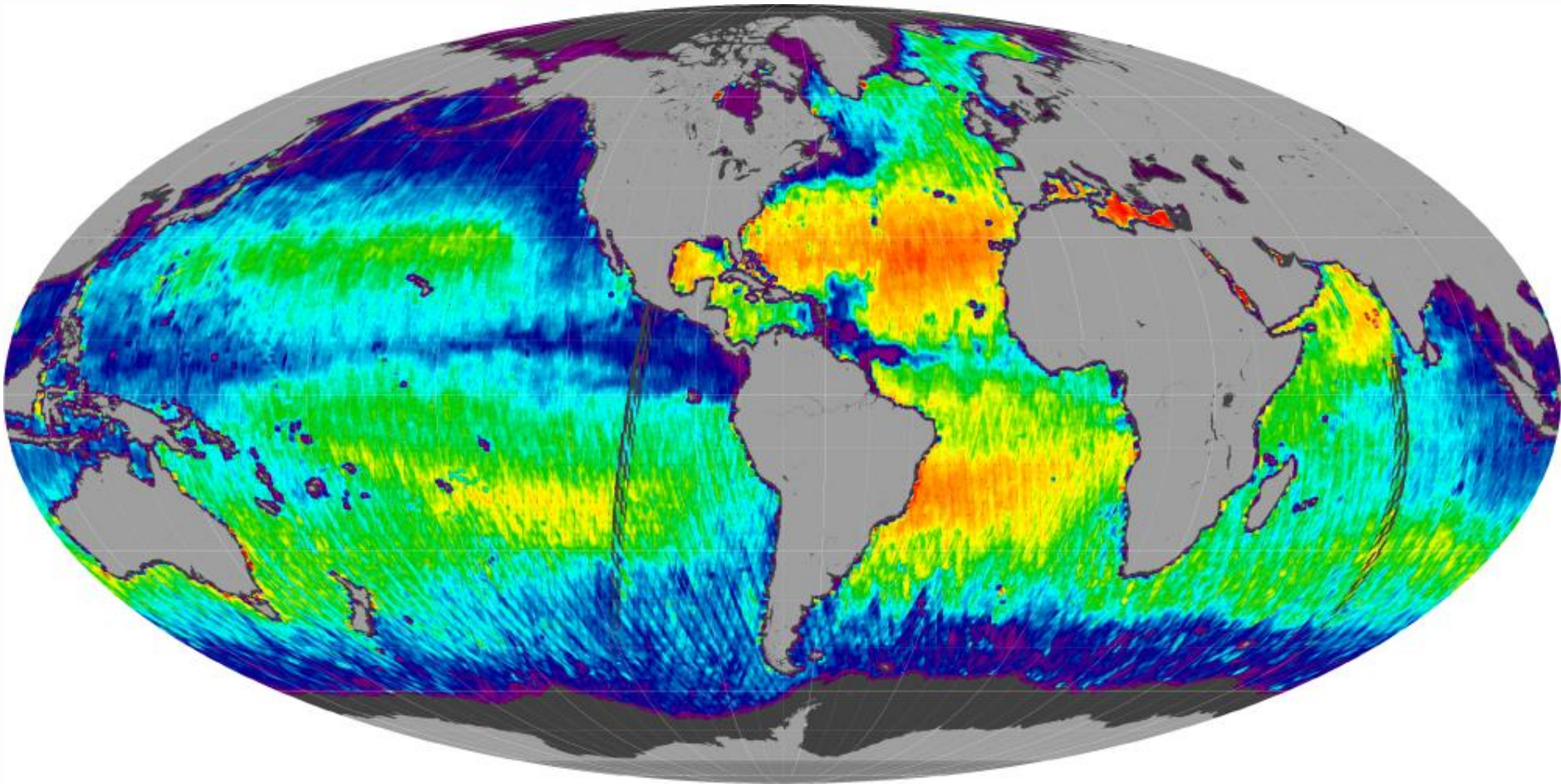
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Aquarius global ocean surface salinity image: August 2011



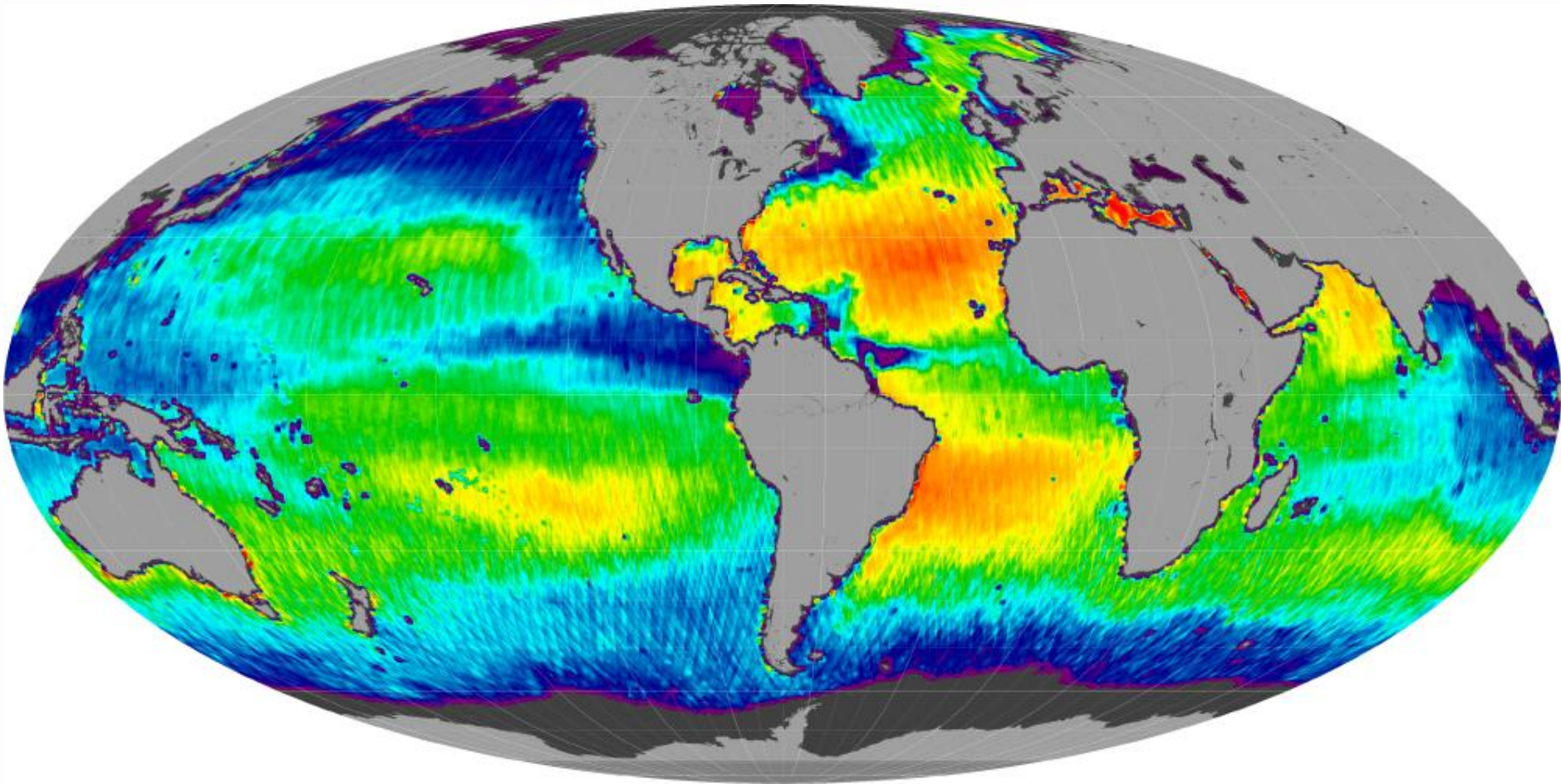
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Aquarius global ocean surface salinity image: August 2012



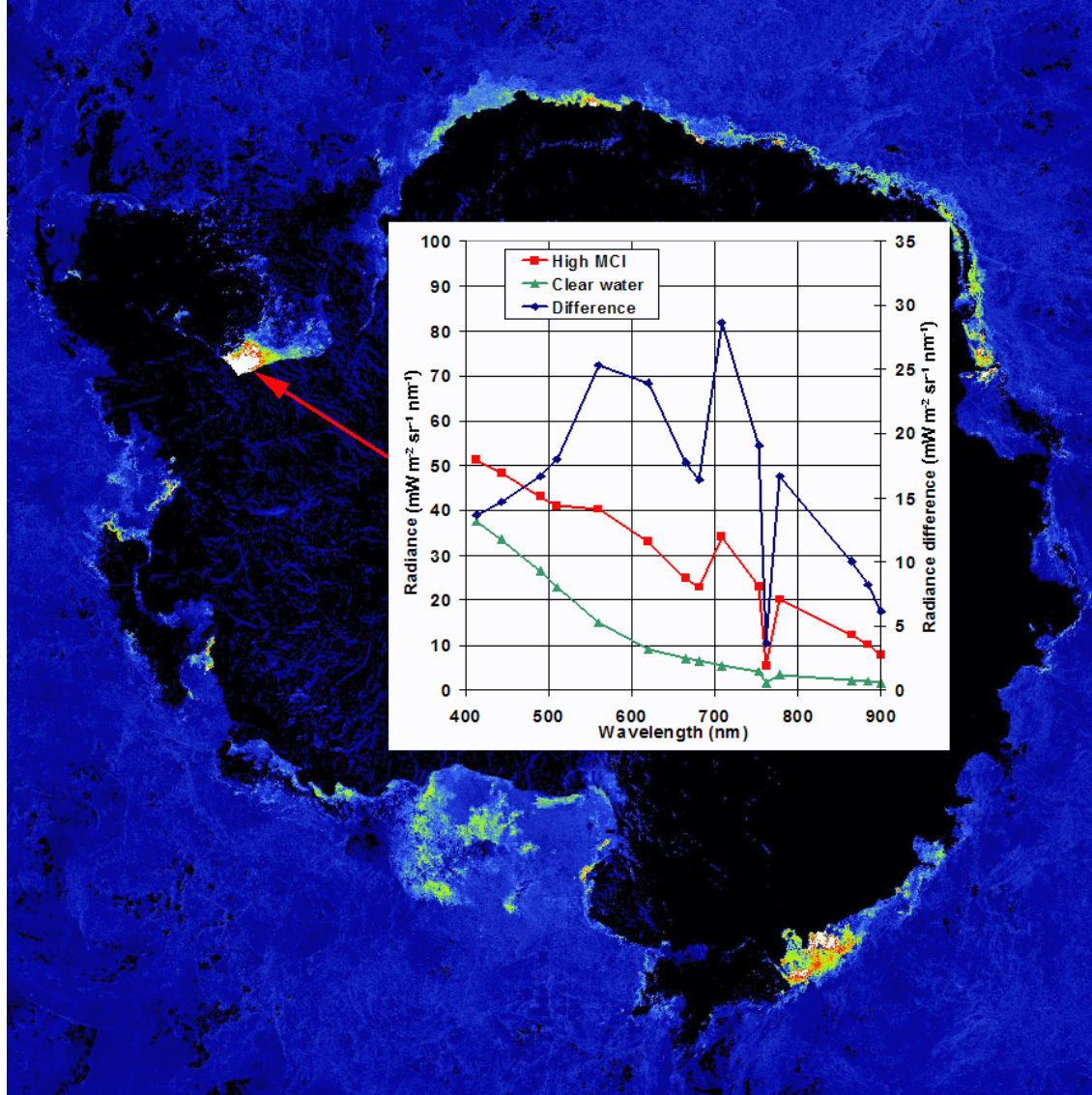
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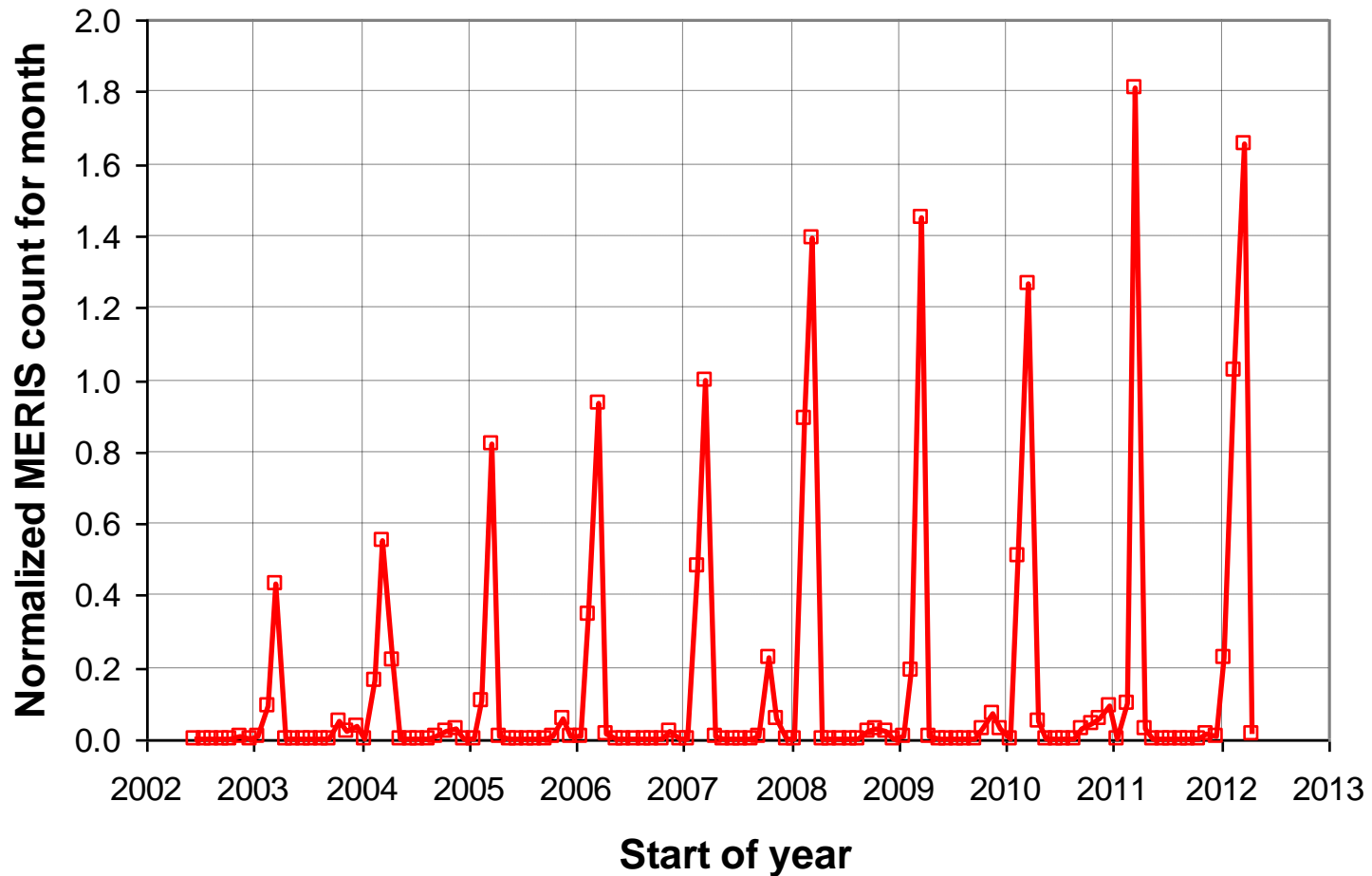


A composite MCI image for February 2007 showing the Antarctic (polar stereographic projection) with areas of high MCI close to the summer ice edge. High signals in the south west Weddell Sea (upper left) are where Smetacek et al., (Deep Sea Res., 39, 153, 1992) reported “superblooms” among ice. Black areas are land, ice or persistent cloud.



# Antarctic bloom count statistics

Total MCI signal in 60S to 80S (all longitudes)



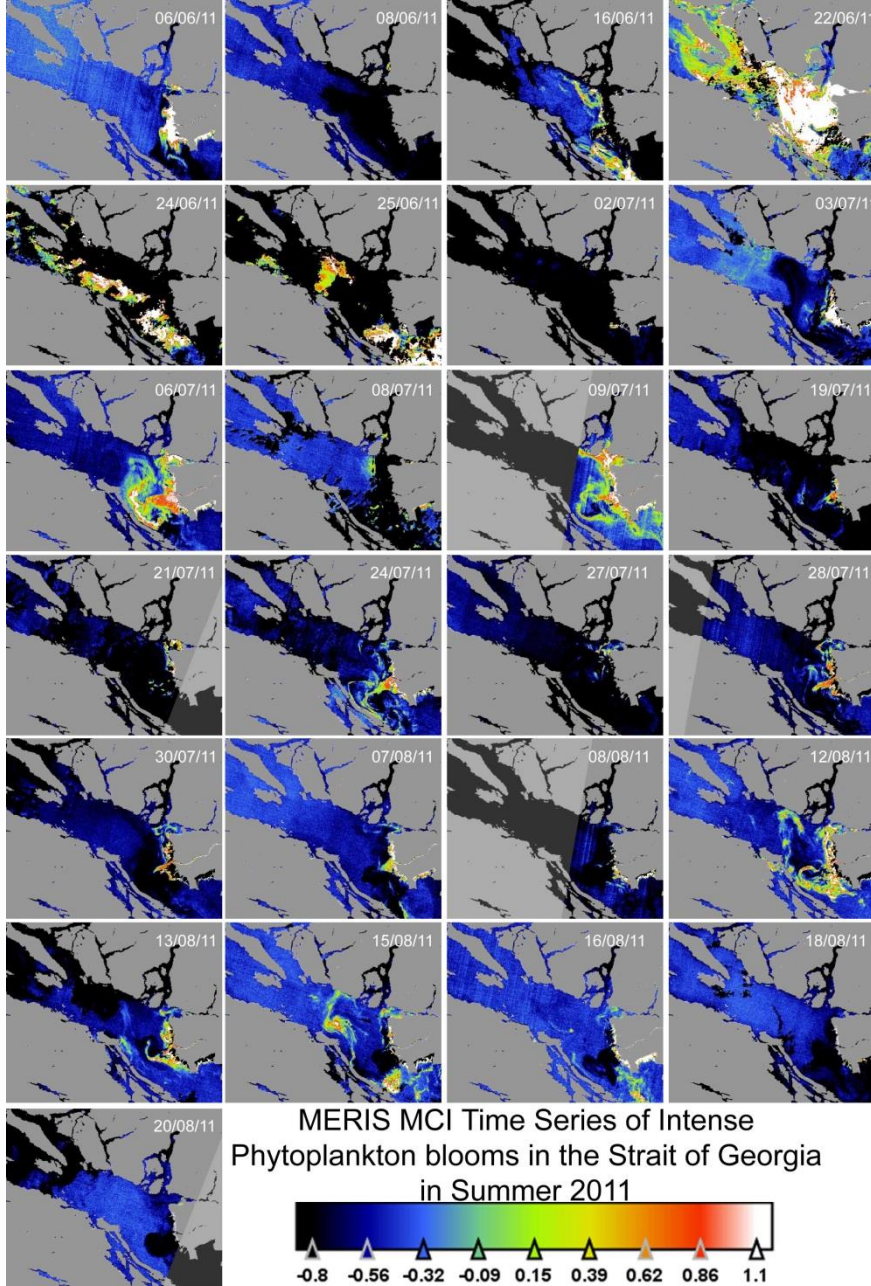
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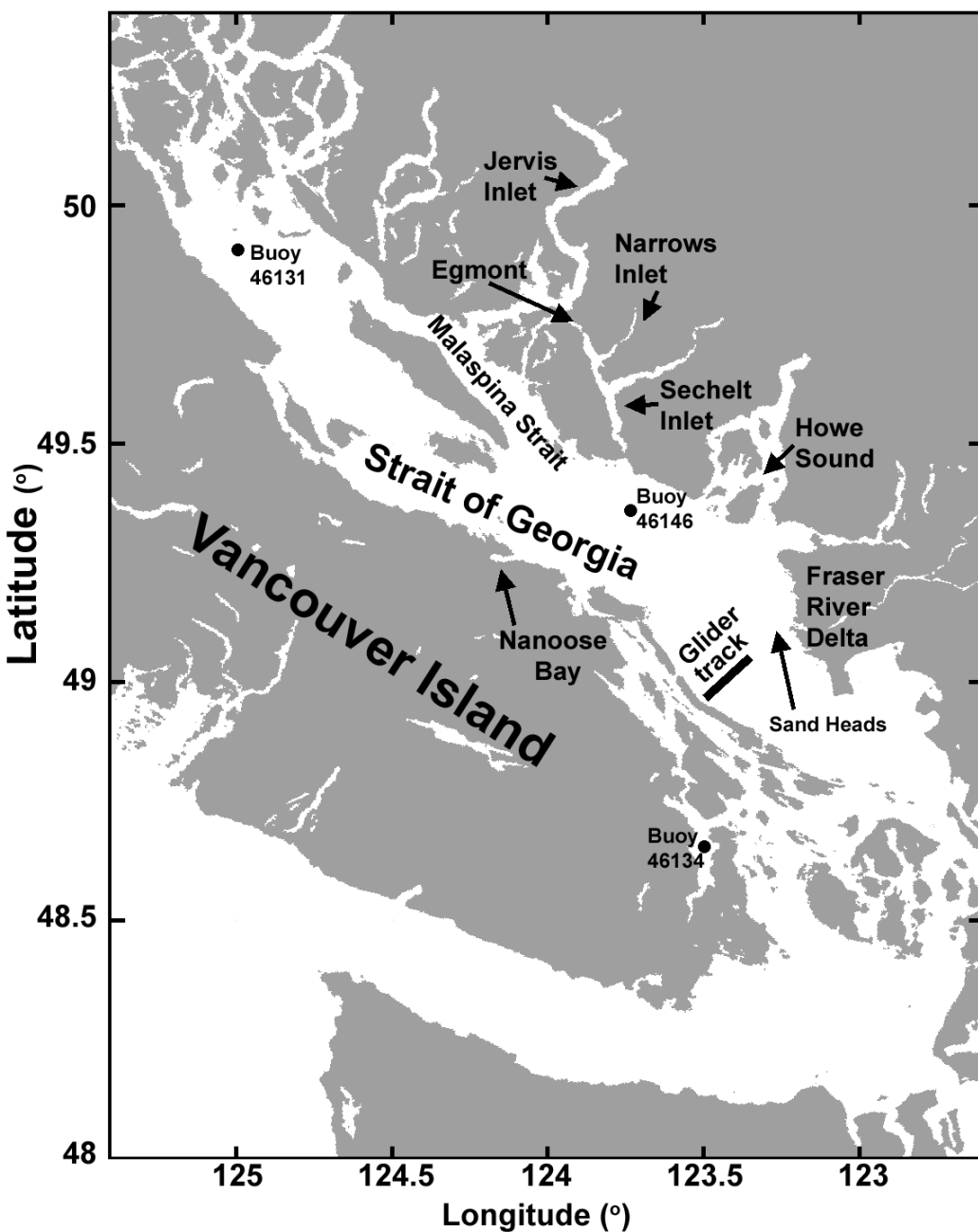
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# Strait of Georgia, BC, Canada



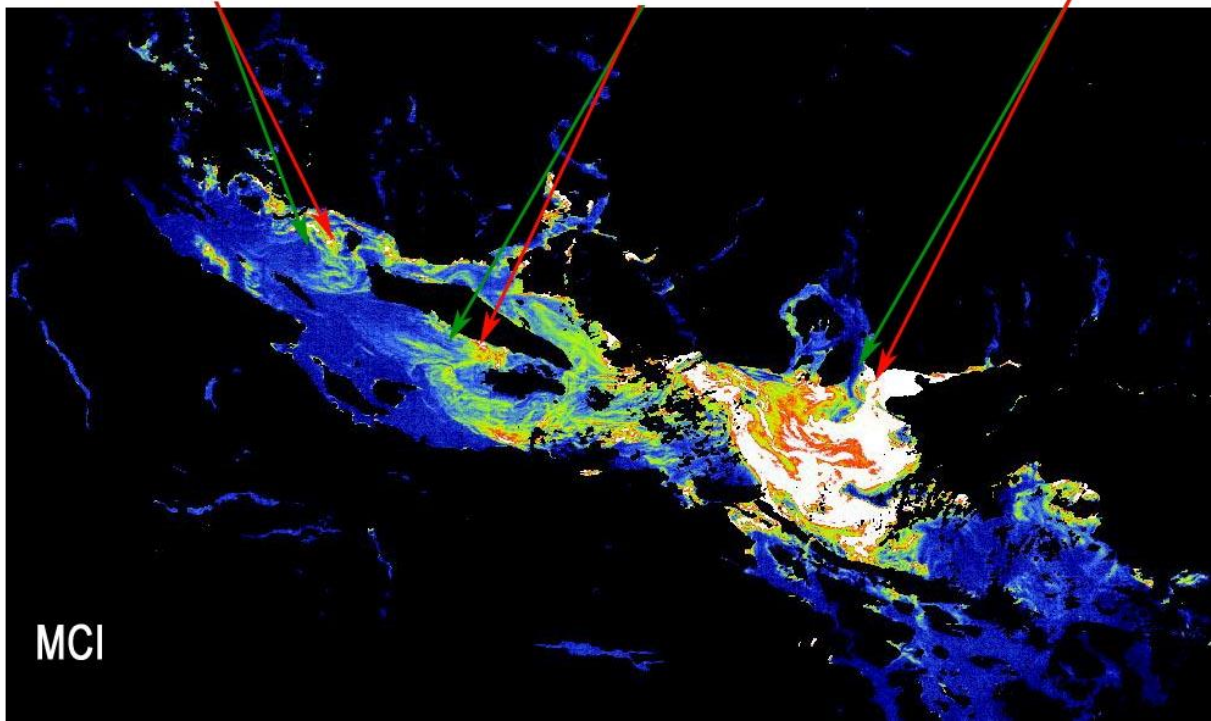
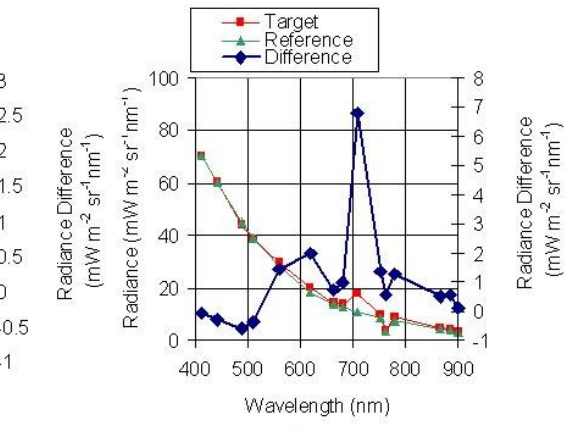
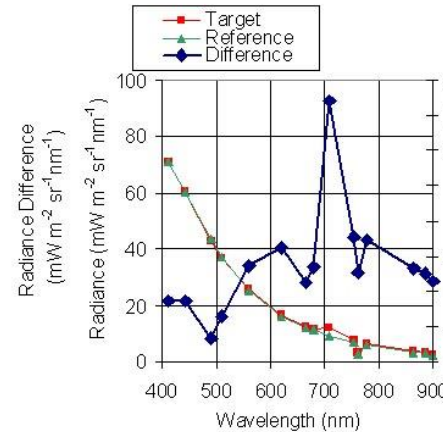
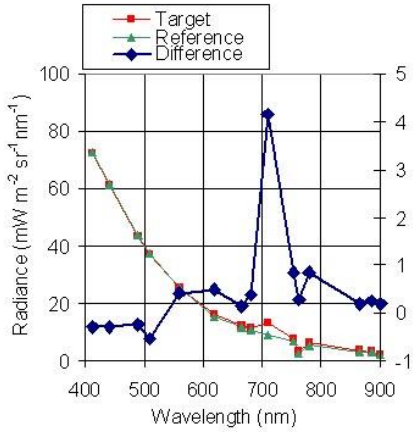
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# Heterosigma blooms in the Strait of Georgia, 22 June 2011



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# Conclusions

- There are strange spectra still to be discovered in the world's oceans (and lakes)
- Bands at 681 and 709 nm in addition to standard bands are valuable for detecting fluorescence and quantifying blooms and floating vegetation.
- They give quantitative data essential for monitoring global and local change
- Neither of these bands are present on US sensors SeaWiFS, VIIRS, 709 nm not present on MODIS
- Now that MERIS has died with Envisat, we wait for OLCI on Sentinel 3a to continue providing MCI



April 9 2013

Dear Dr. Gower,

We have learned of your published research on mild cognitive impairment. We would like to invite you to participate in our publishing program. In particular, we have in mind a new research or review article for a hardcover edited collection (by selected invitation only) tentatively entitled:

## **Mild Cognitive Impairment (MCI): Symptoms, Causes & Risk Factors and Clinical Outcomes**

**Senility from Space?**



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