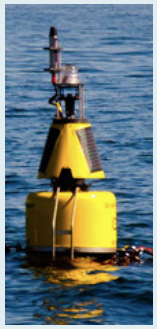
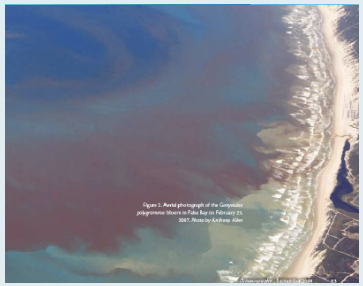
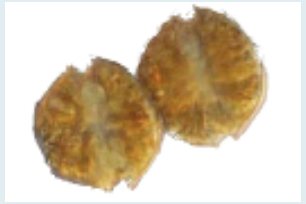
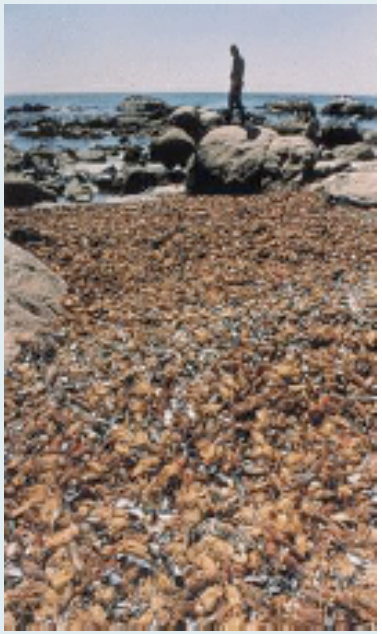
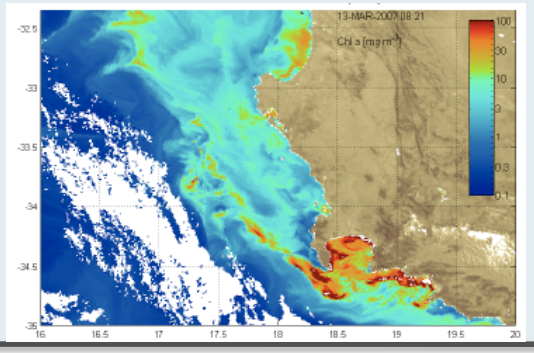


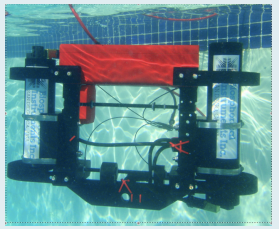
Harmful Algal Bloom Events in the Southern Benguela: Comparison of Coast Colour & Regional Algorithms











Hayley Evers-King

University of Cape Town

Including work from:

Stewart Bernard, Council for Scientific and Industrial Research, South Africa
Mark Matthews, University of Cape Town, South Africa
Grant Pitcher, Department of Agriculture, Forestry and Fisheries, South Africa
Trevor Probyn, Department of Agriculture, Forestry and Fisheries, South Africa
Lisl Robertson-Lain, University of Cape Town, South Africa
Marie Smith, University of Cape Town, South Africa

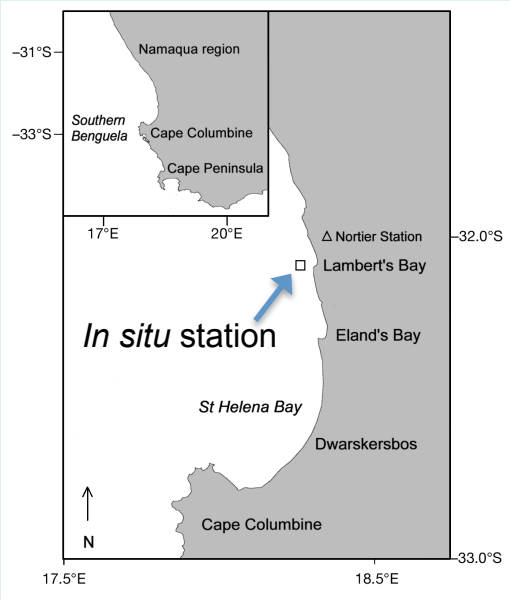
Coast Colour User Consultation Meeting - Lisbon, Portugal 19th-20th October 2011

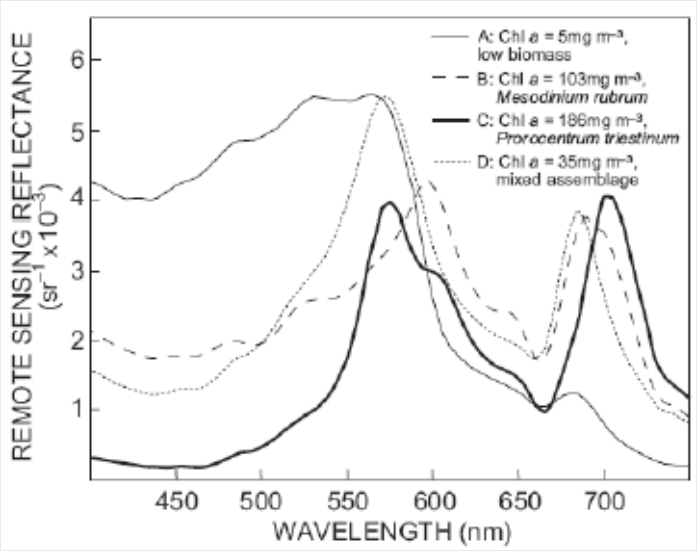
Overview

- Why the Benguela?
- Harmful Algal Blooms (HABs)
- Requirements for observation/forecasting
- Regional approaches to determine chlorophyll and community structure in the Benguela.
- Algorithm performance using Coast Colour products.
- A note on FR coverage.
- Summary

Why the Benguela?

- Dynamic, upwelling region, optically dominated by high phytoplankton biomass (up to 2000 mg m^{-3} recorded!).
- Many examples of mono-specific blooms.
- High signal:noise ratio.
- Important for national fishing and aquaculture industries.
- Suffers from Harmful algal blooms (HABs).
- Great opportunity and need for understanding of the ecosystem and development of observational techniques.





Harmful Algal Blooms (HABs)…

Harmful Algal Blooms (HABs)

- Impacts associated either with high levels of biomass or toxicity of specific species.
- Toxicity is a problem for aquaculture in the region.
- High biomass blooms have caused low oxygen events resulting in fish mortality and lobster “walk outs”.

See Pitcher *et al*., 2010.

Requirements for forecasting…

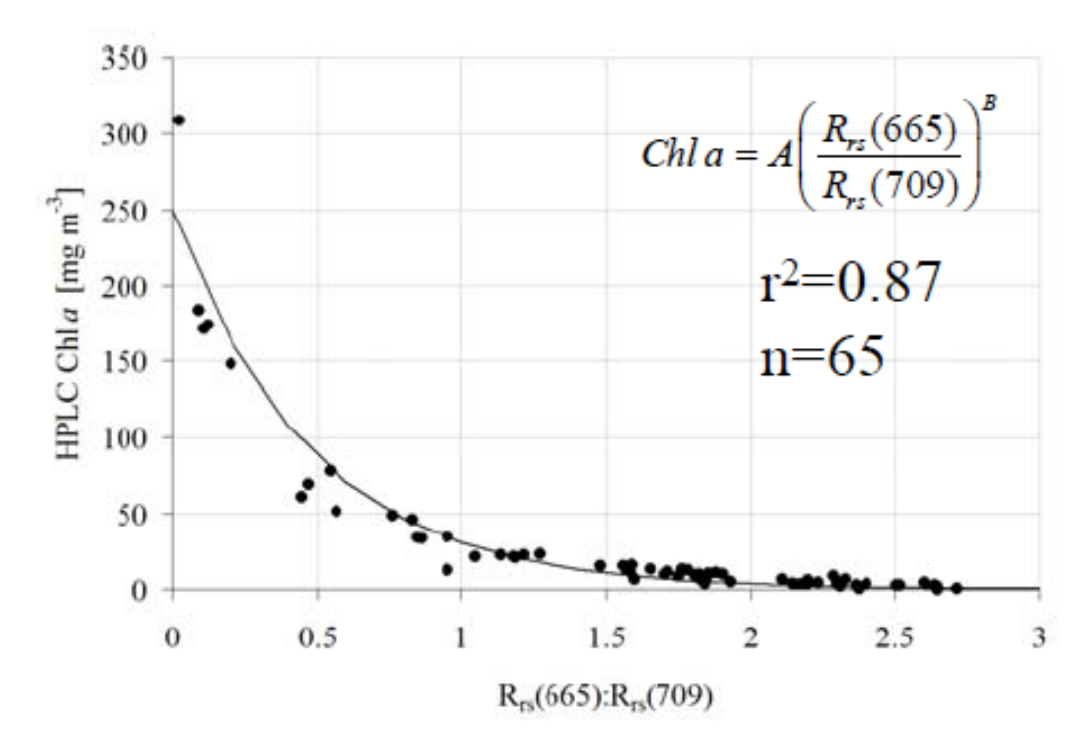
Requirements for continued observation and forecasting

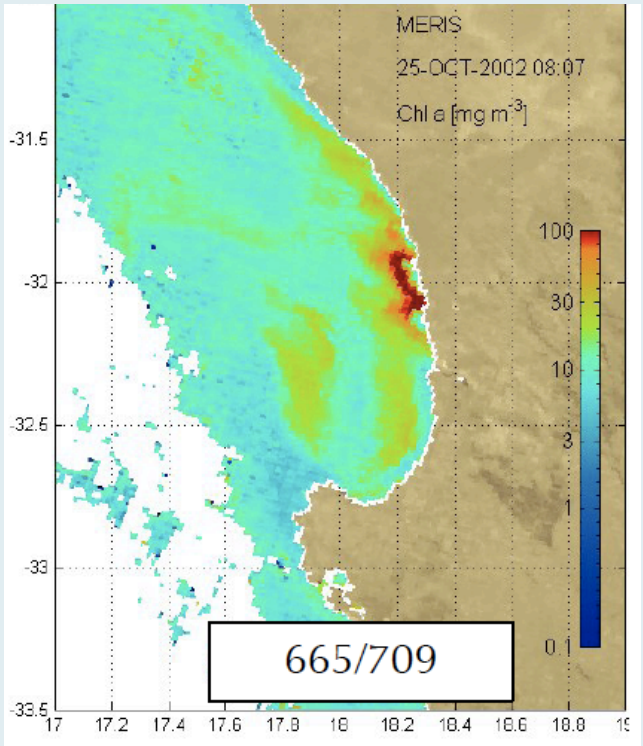
- Species succession/HAB development is complex.
- Best potential method is to calculate statistical likelihood of "ecological windows" for HAB species.
- Requires real-time physical/chemical/ biological data.
- Ideally coupled bio-physical models.
- Buoy deployment and sampling continues.
- Use of this data in a predictive capacity requires high resolution, species level identification using remote sensing methods…

See Bernard *et al*., 2006

Regional approaches…

Regional approaches: '709' empirical algorithm

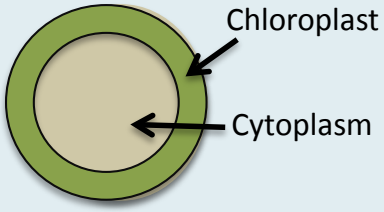




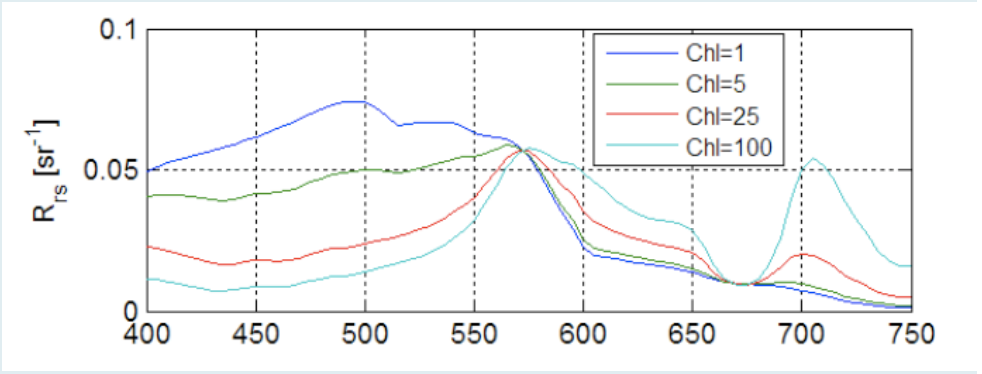
- An empirical algorithm which determines chlorophyll concentration using a 665nm:709nm reflectance ratio.
- Takes advantage of the relationship observed between reflectance and backscattering at red wavelengths in high biomass waters.
- Used in switching algorithm with algal 1, for chlorophyll > 10mg m^{-3}.

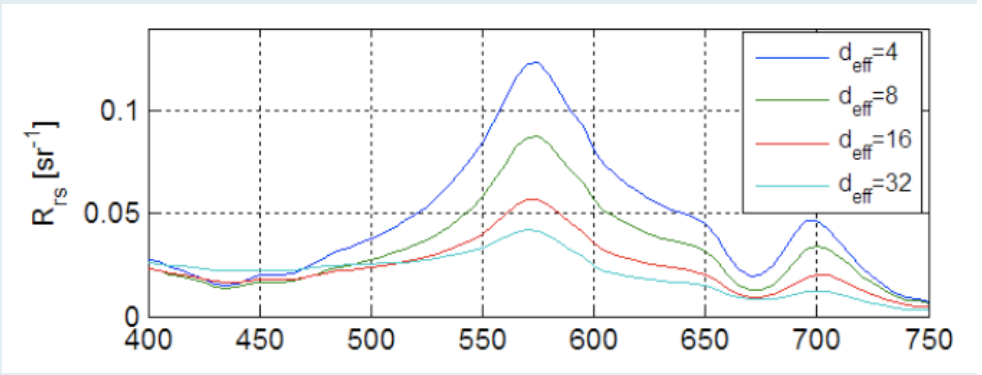
Regional approaches : A semi-analytical size algorithm…

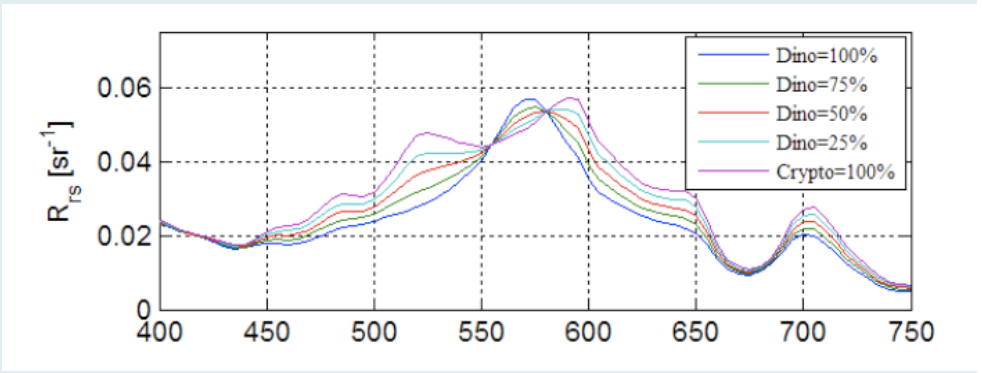
Regional approaches: A semi-analytical size algorithm



- A semi-analytical algorithm to investigate community structure in the Benguela (Bernard *et al*., in prep).
- Similar to GIOP approach.
- Uses absorption and backscattering basis vectors pre-computed from two layered sphere model using equivalent size distributions of upwelling species (Bernard *et al*., 2009).
- Inversion determines chlorophyll, fluorescence quantum yield, effective diameter of assemblage (amongst other variables).



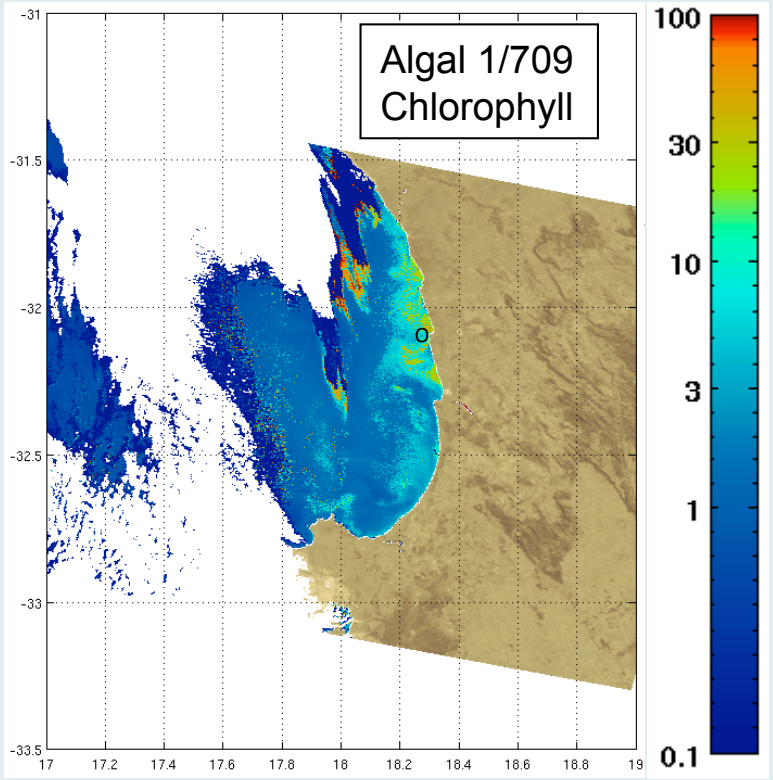




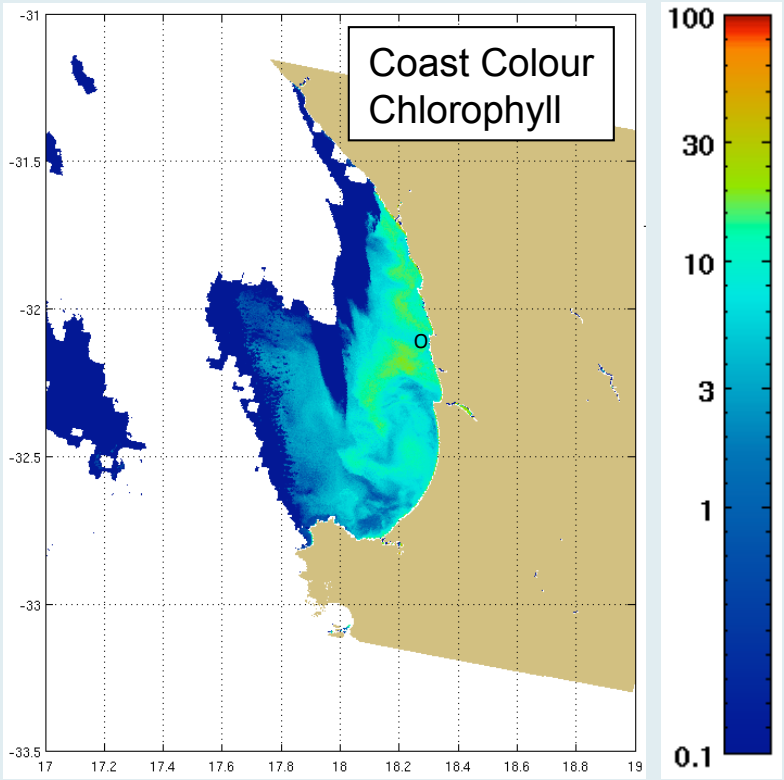
'Low' biomass case study…

'Low' biomass case study: 15th March 2006

- In situ data from moored buoy, TSRB, fluorometry, coulter counter and microscopy.
  - *Pseudo-nitzschia* spp. (± 20 µm eq.sph.diameter) dominated assemblage.
  - In situ chlorophyll ≈ 8 mg m^{-3}.
- **Aim: Compare algorithm performance using standard and Coast Colour processed L2 MERIS FR products.**



Algal 1/709 Chlorophyll switching algorithm used as standard Chl product for Africa by Marine Remote Sensing Unit – Cape Town. Switches at Chl >10 mg m^{-3}



Chlorophyll results:15th March 2006…

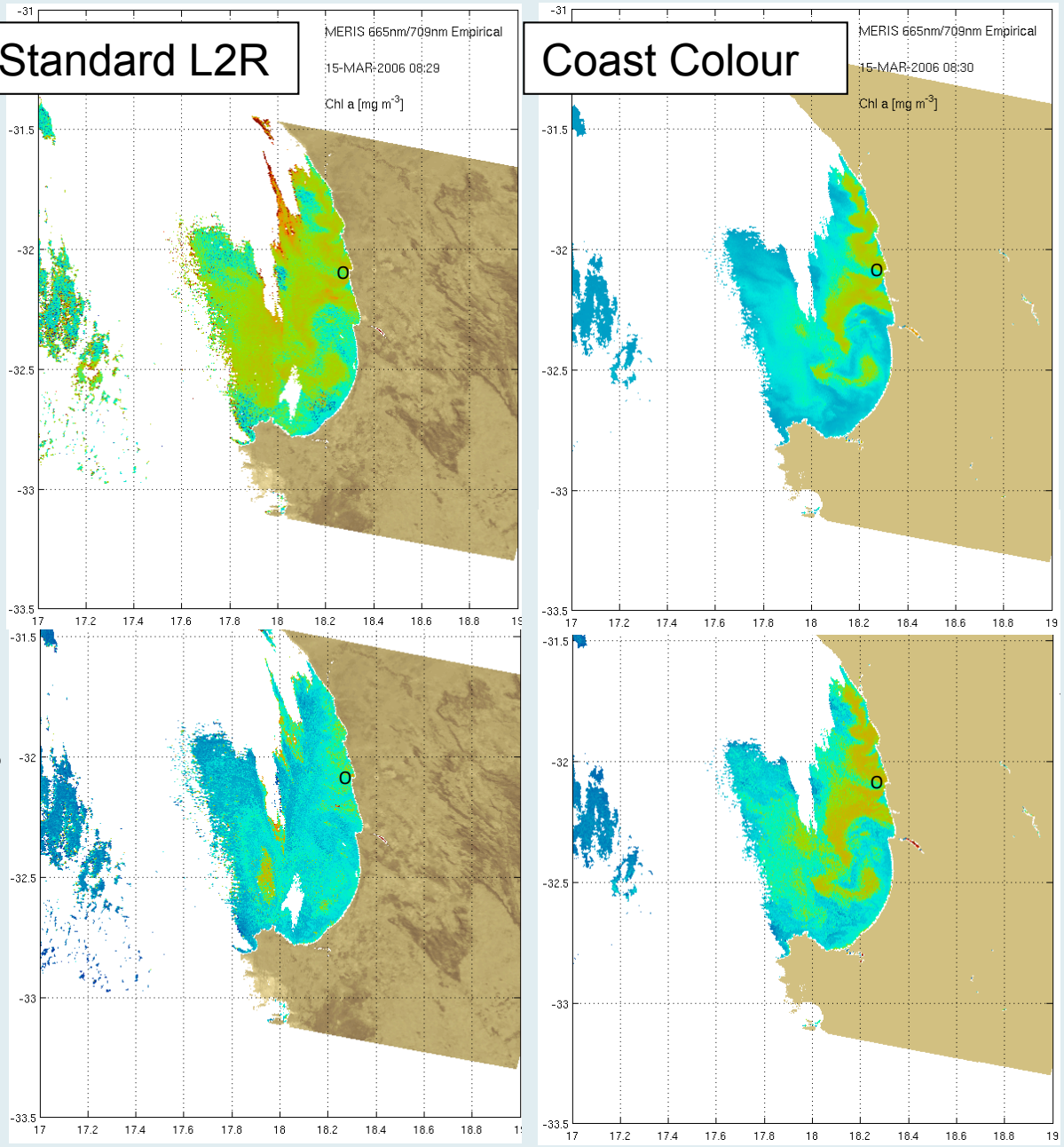
Chlorophyll results: 15th March 2006

Standard L2R

Coast Colour

709 empirical

Semi-analytical



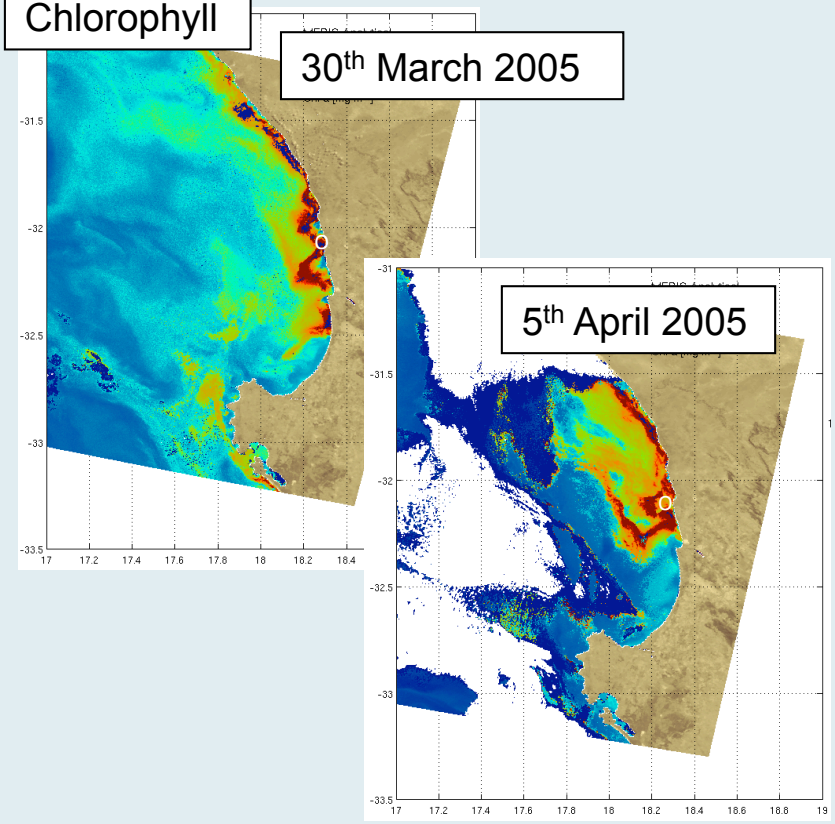
- Anticipated overestimation from 709 algorithm in relatively low biomass waters using standard product.
- Use of Coast Colour product results in less severe overestimation.

….but this is unusually low chlorophyll for the Benguela, what happens when algorithms applied to high biomass, mono-specific blooms?

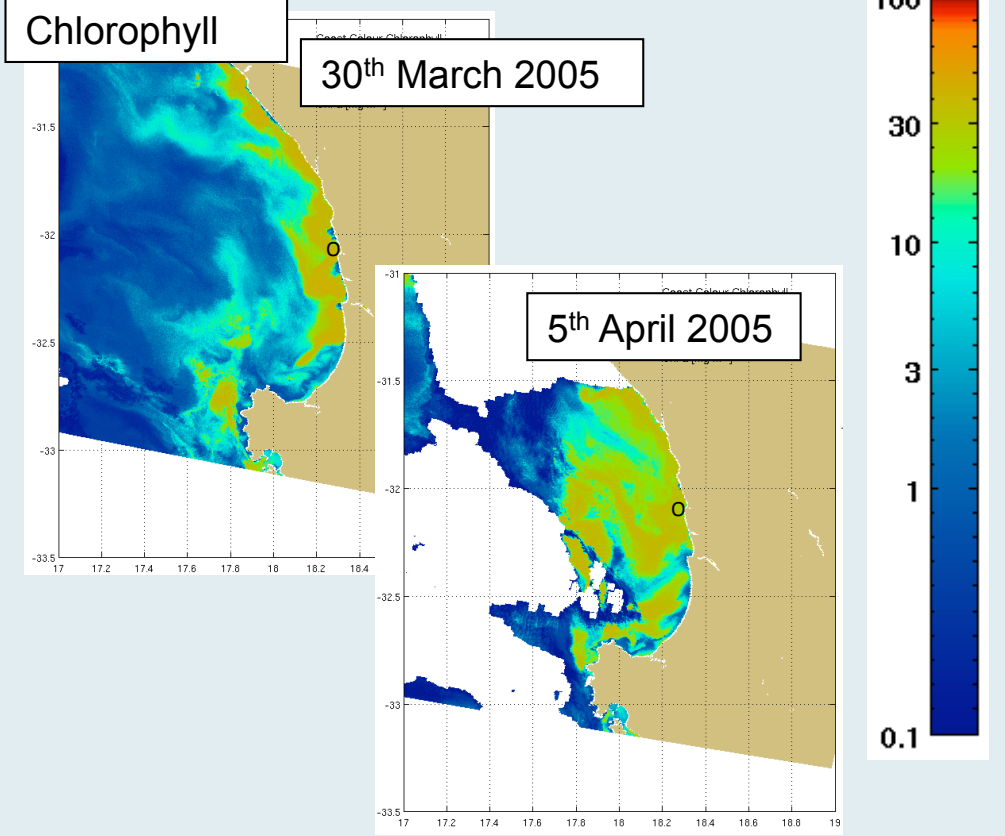
High biomass case study: 30th March 2005 – 5th April 2005

- Data as before
  - Progression from *Prorocentrum triestinum* (± 10 µm) to *Ceratium furca* (± 30 µm).
  - In situ chlorophyll ≈ 184 mg m^{-3} – 38 mg m^{-3} .
- **Aim: Compare algorithm performance for higher biomass waters.**

Algal 1/709 Chlorophyll



Coast Colour Chlorophyll

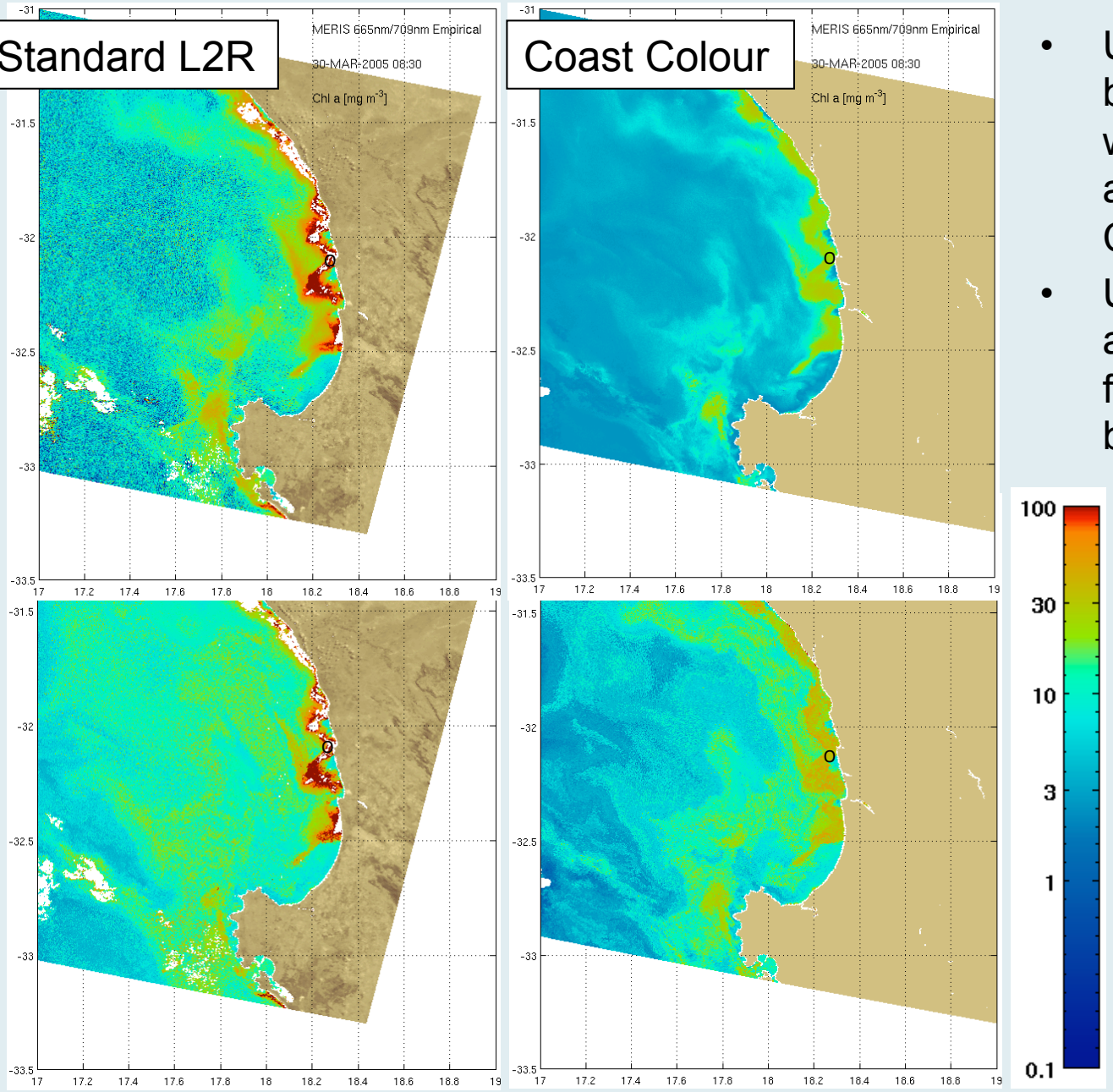


Results: 30th March 2005…

Chlorophyll results: 30th March 2005

709 empirical

Semi-analytical



- Underestimation of high biomass bloom values when using both algorithms with Coast Colour data.
- Using Coast Colour data achieves better retrieval for lower biomass, non-bloom waters.

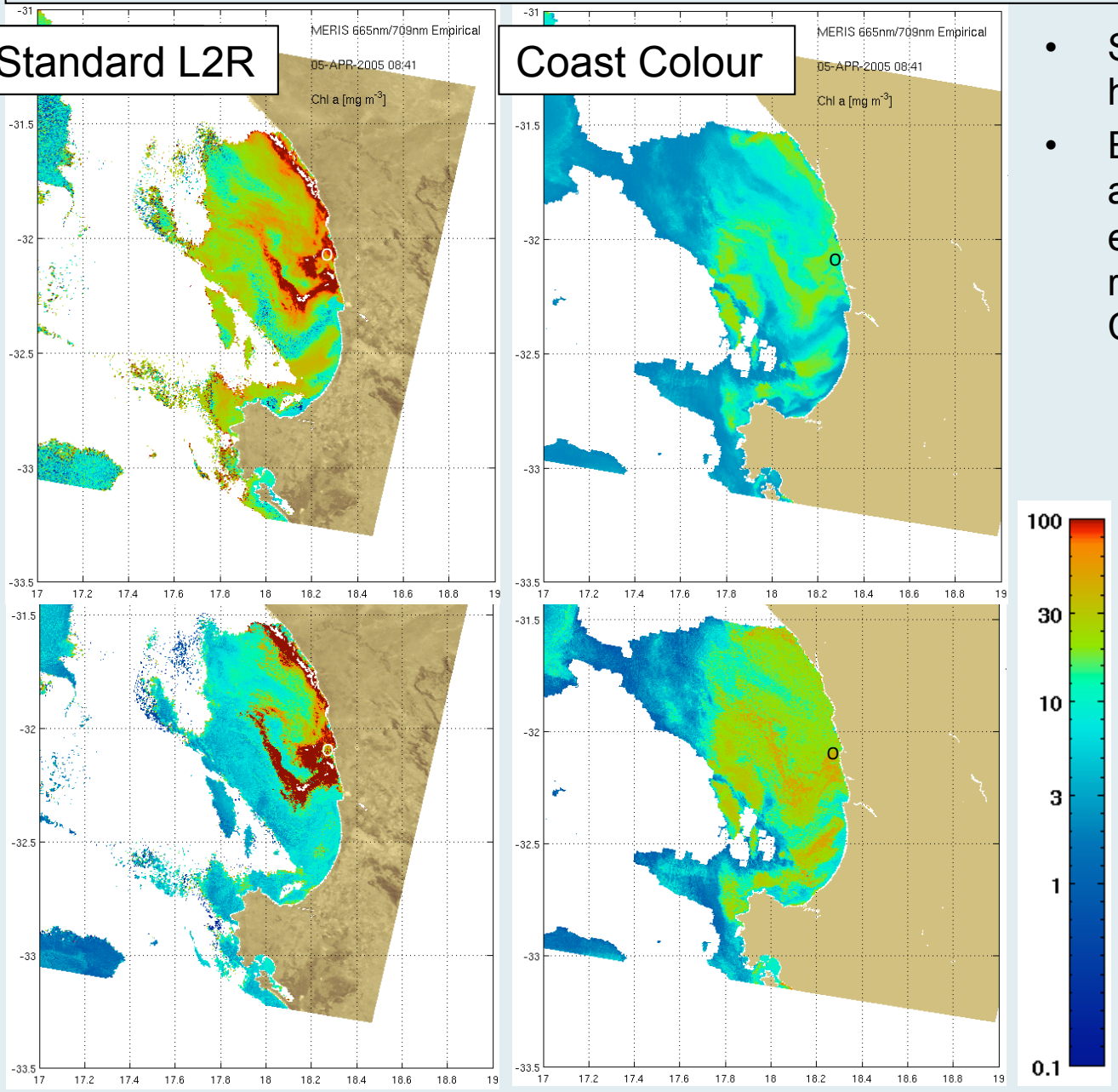
Chlorophyll results: 5th April 2005

Standard L2R

Coast Colour

709 empirical

Semi-analytical



- Similar results for second half of bloom event.
- Except using semi-analytical size algorithm – extent of higher biomass region appears larger using Coast Colour data.

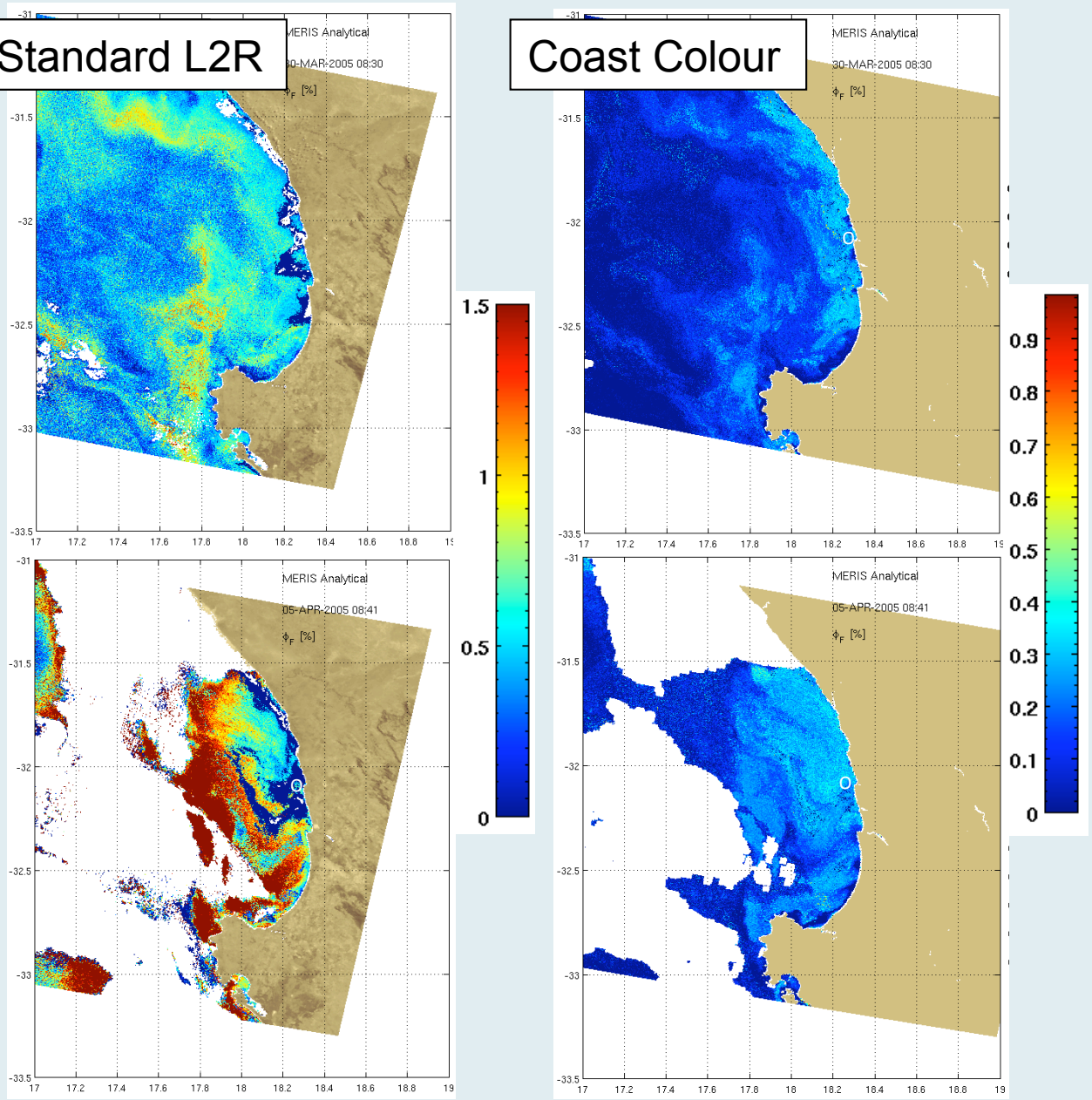
Fluorescence quantum yield results

Standard L2R

Coast Colour

30th March 2005

5th April 2005



- Fluorescence quantum yield products are potential indicators of PFT and physiology...
- In the Benguela:
  - large FQY = diatom blooms
  - small FQY = high biomass dinoflagellate blooms

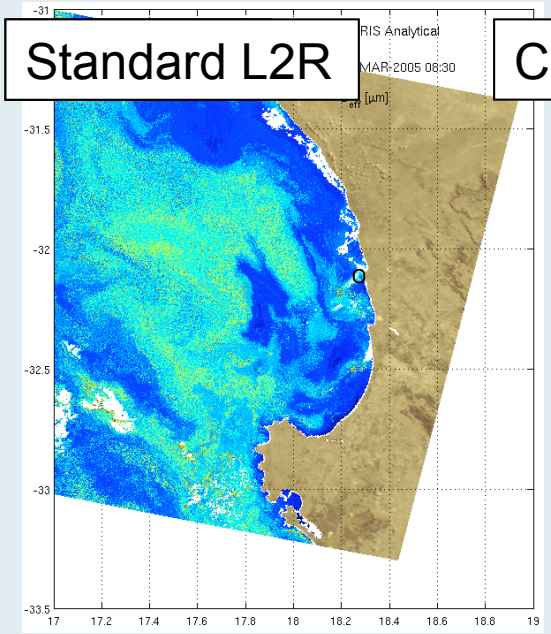
  (Ongoing research)
- This variability does not seem to be expressed when the CC data is used.

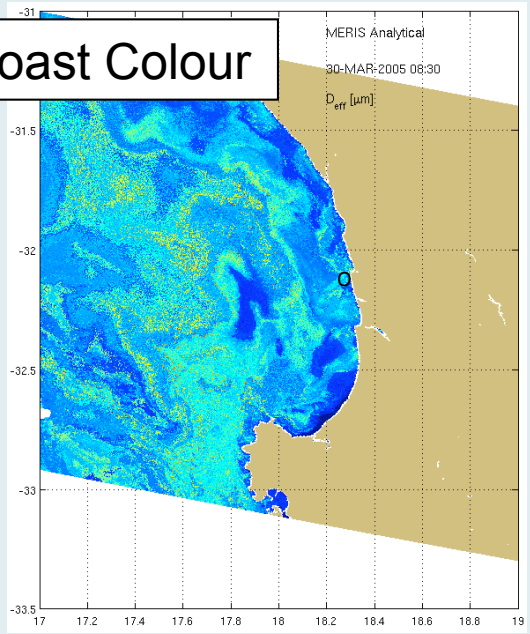
Size results

Standard L2R

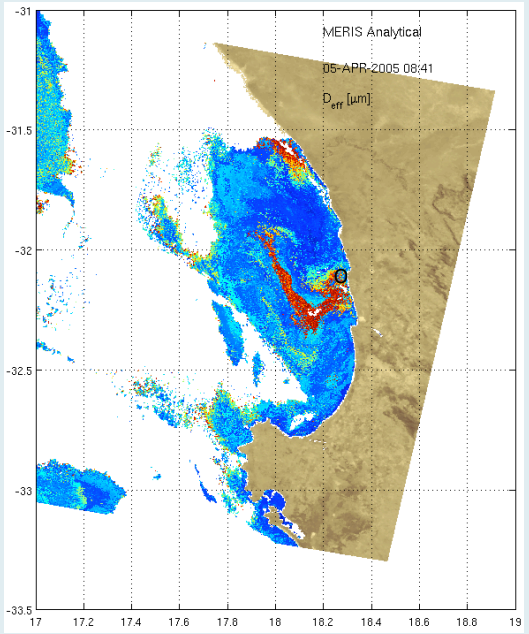
Coast Colour

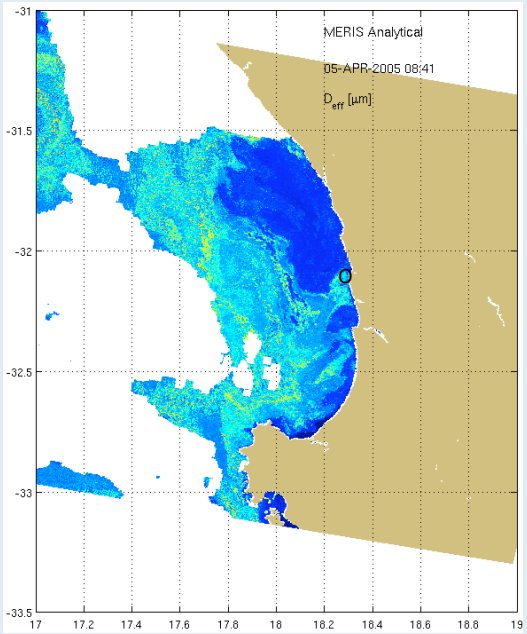
30th March 2005

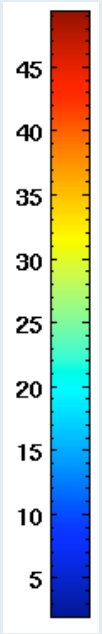




5th April 2005



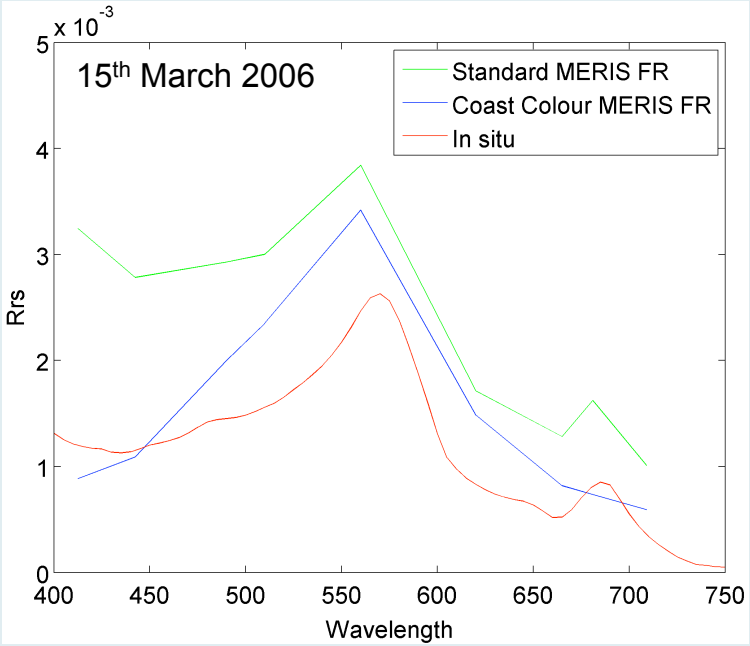


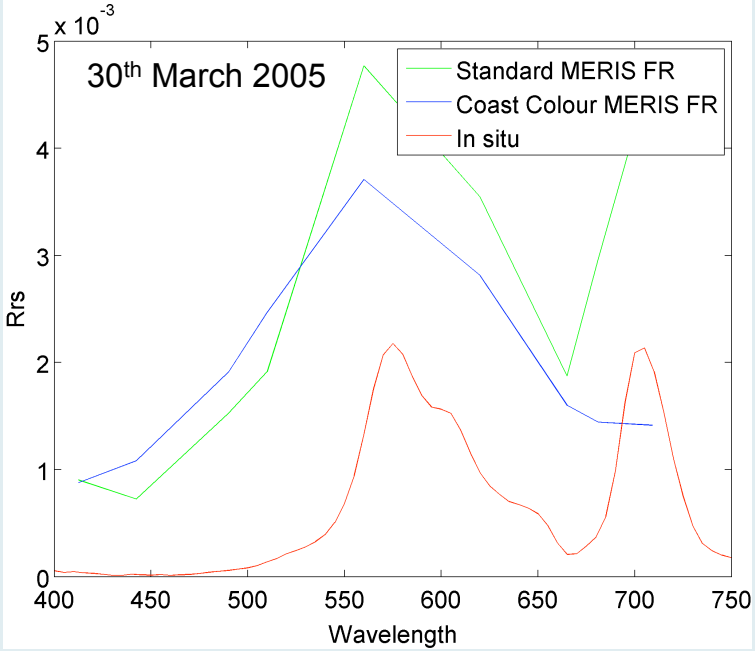


- Using the semi-analytical size algorithm with standard FR product we can see the transition from smaller to larger cells dominating the coastal bloom.
- Using Coast Colour data does not yield the same results.

- Why differences in behaviour using 709 algorithm?
- Why no high chlorophyll values despite using regionally designed algorithms?
- Why no recognition of significant changes on size structure?

Examining algorithm performance: reflectance spectra



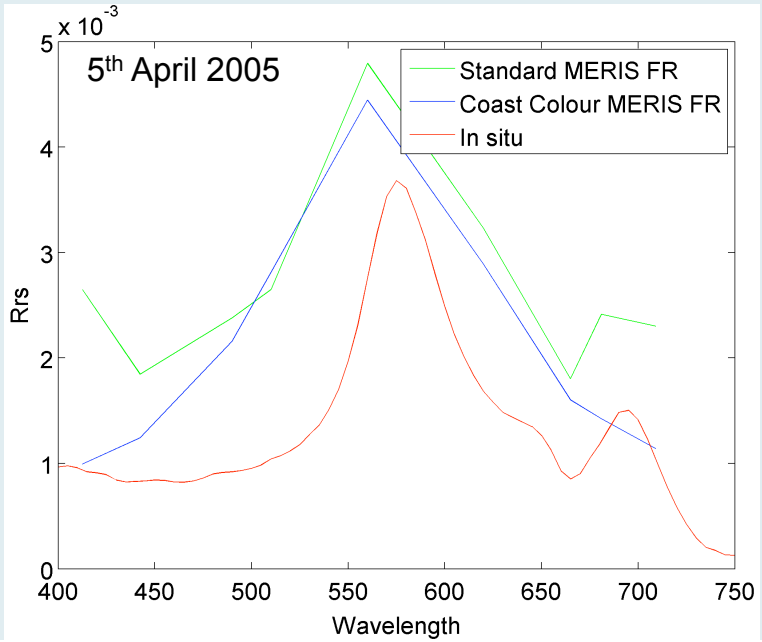


- Coast Colour reflectance generally closer to *in situ* data in blue and green region of spectrum.

- However reflectance in the red is poorly represented – could explain difference in algorithm performance.

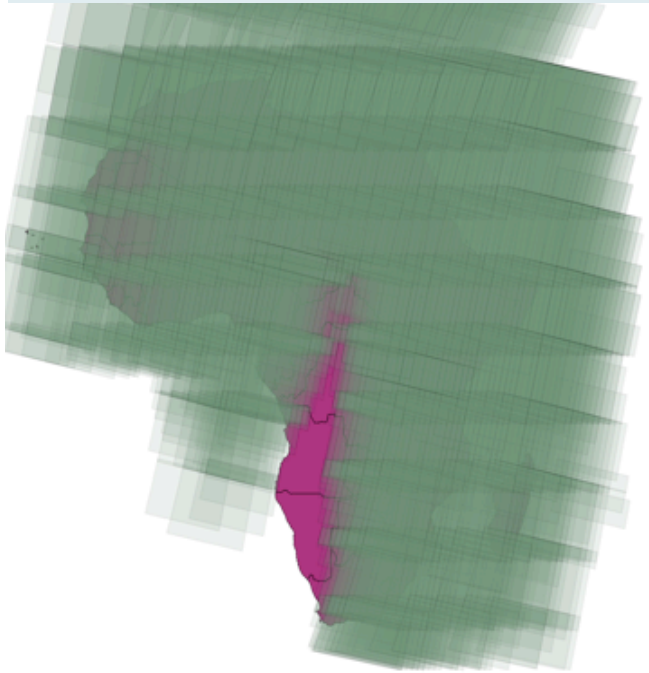
  - "709" algorithm uses these bands specifically.

  - Size algorithm based on species with spectral characteristics in red.

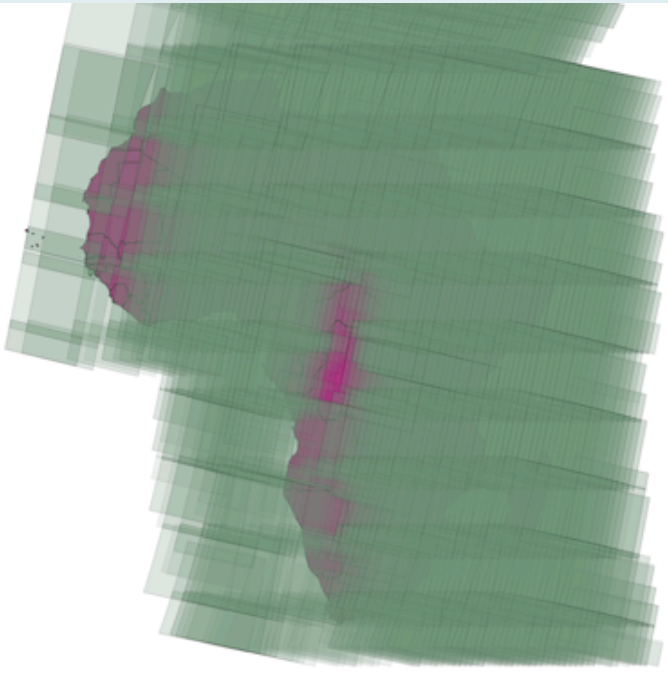


FR coverage

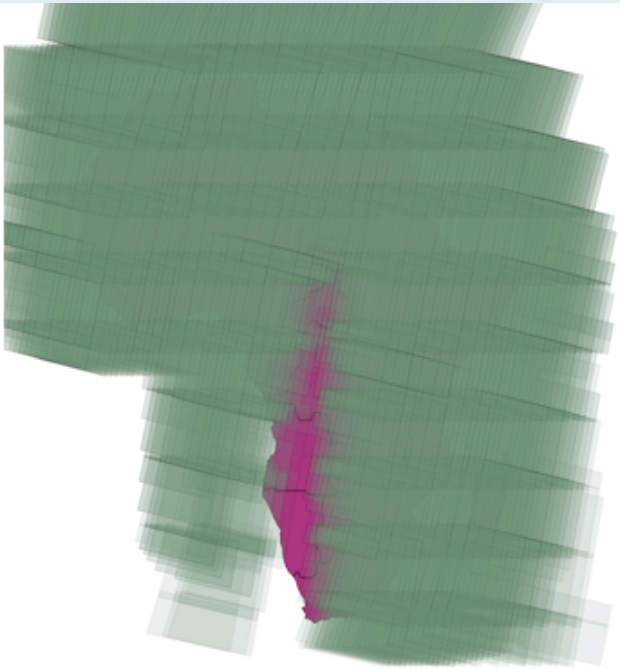
October – December 2010



January – March 2011



April – June 2011



Low coverage in some months but not others?

Summary and conclusions…

Summary and conclusions

- Coast Colour data could help achieve more accurate results for “low” chlorophyll waters in the Benguela.
- Initial investigations show better representation of reflectance signal in blue-green area of spectrum when compared to *in situ* data.
- However, lack of signal in the red means regionally developed algorithms, which take advantage of this signal, tend to under report high biomass and cell size.
- Further investigation across range of bloom scenarios is required in parallel with algorithm sensitivity testing.
- Regionally specific Coast Colour algorithms may be beneficial and we would be keen to be part of this development process.

References and thanks

- Pitcher *et al*., (2010) Harmful algal blooms of the southern Benguela Current: a review and appraisal of monitoring from 1989 to 1997, 22, p. 225-271.
- Bernard *et al*., (2006) The requirements for forecasting harmful algal blooms in the Benguela. Large marine ecosystems, 14, p.281-302.
- Bernard *et al*., (2009) Simulating the optical properties of phytoplankton cells using a two-layered spherical geometry. Biogeosciences Discussion, 6, p. 1-67.

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