Assessing the impact of assimilating OSTIA SST and AVISO SLA on the performance of HYCOM on the Agulhas Bank

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Marine Earth Observation, NRE

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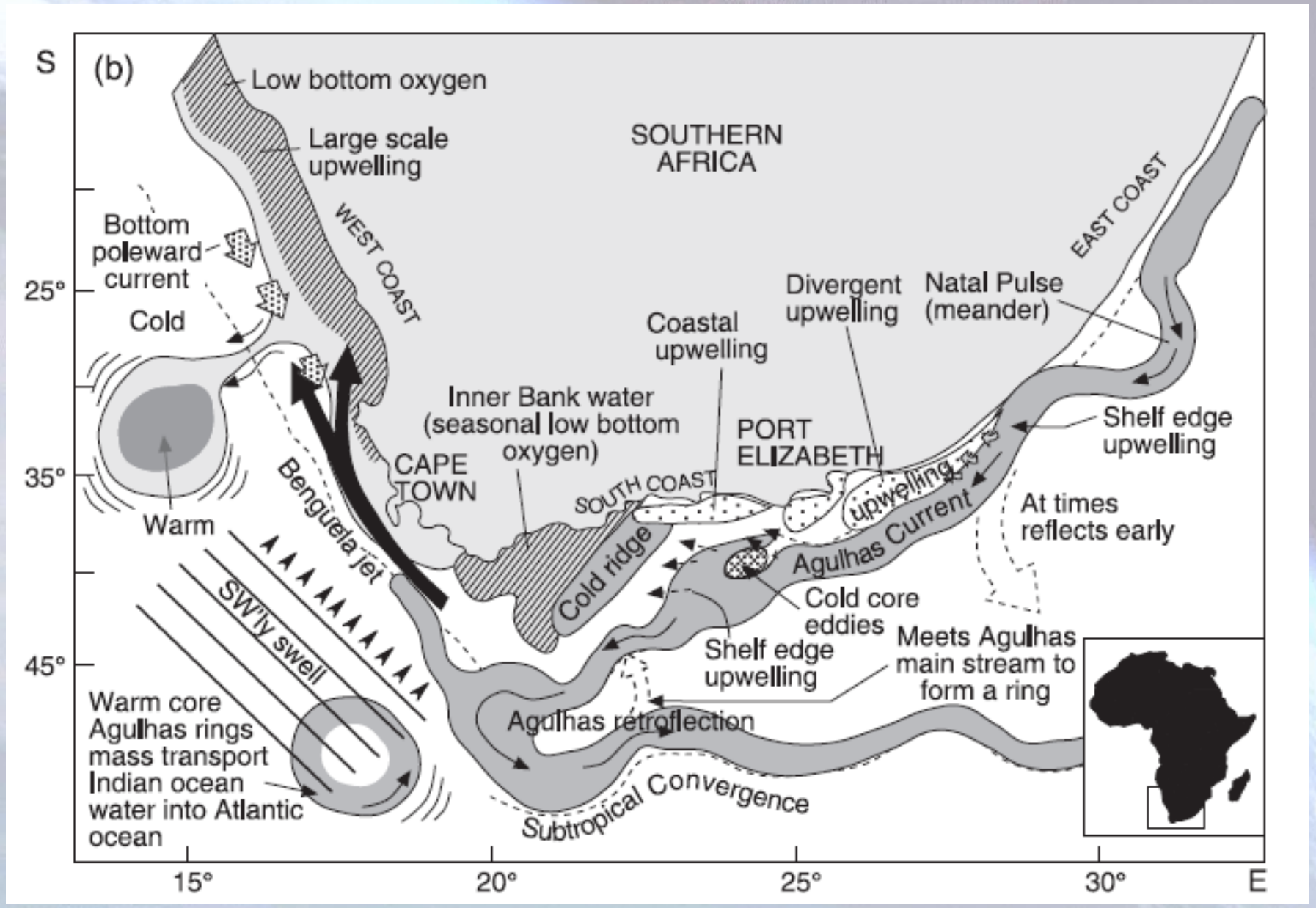
CSIR

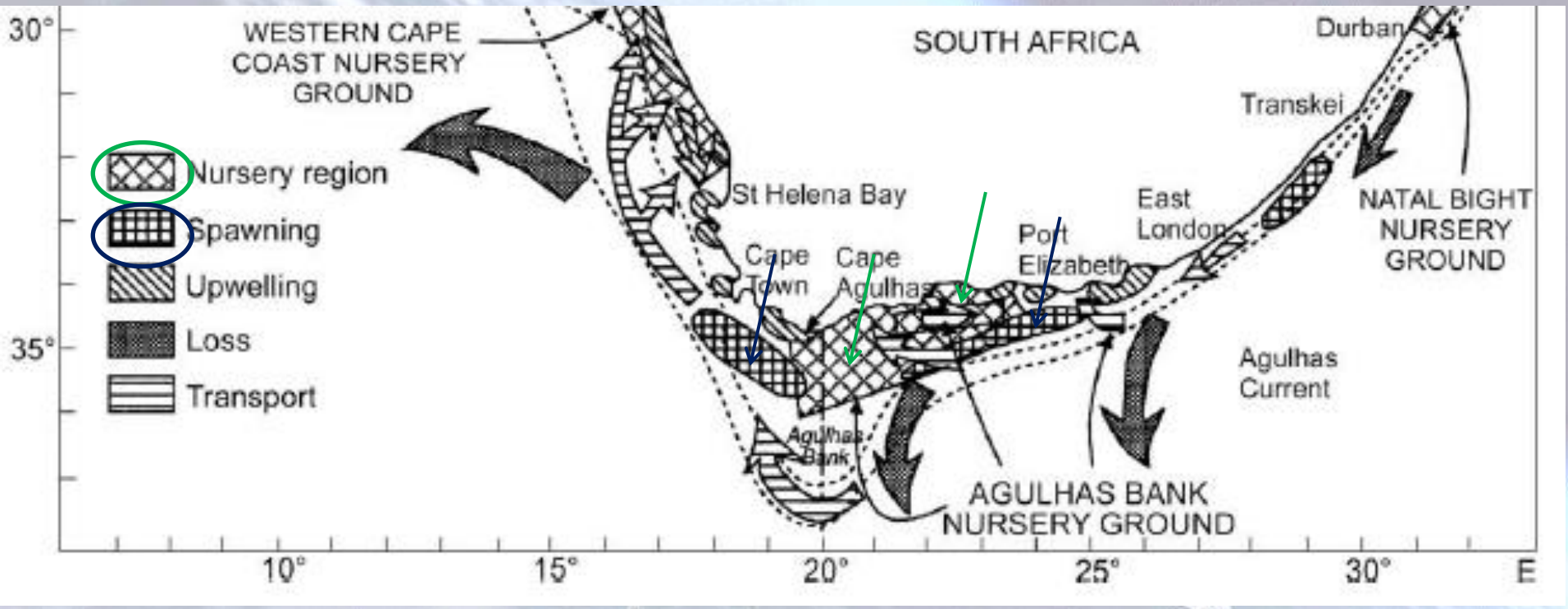
our future through science

Complex physical dynamics

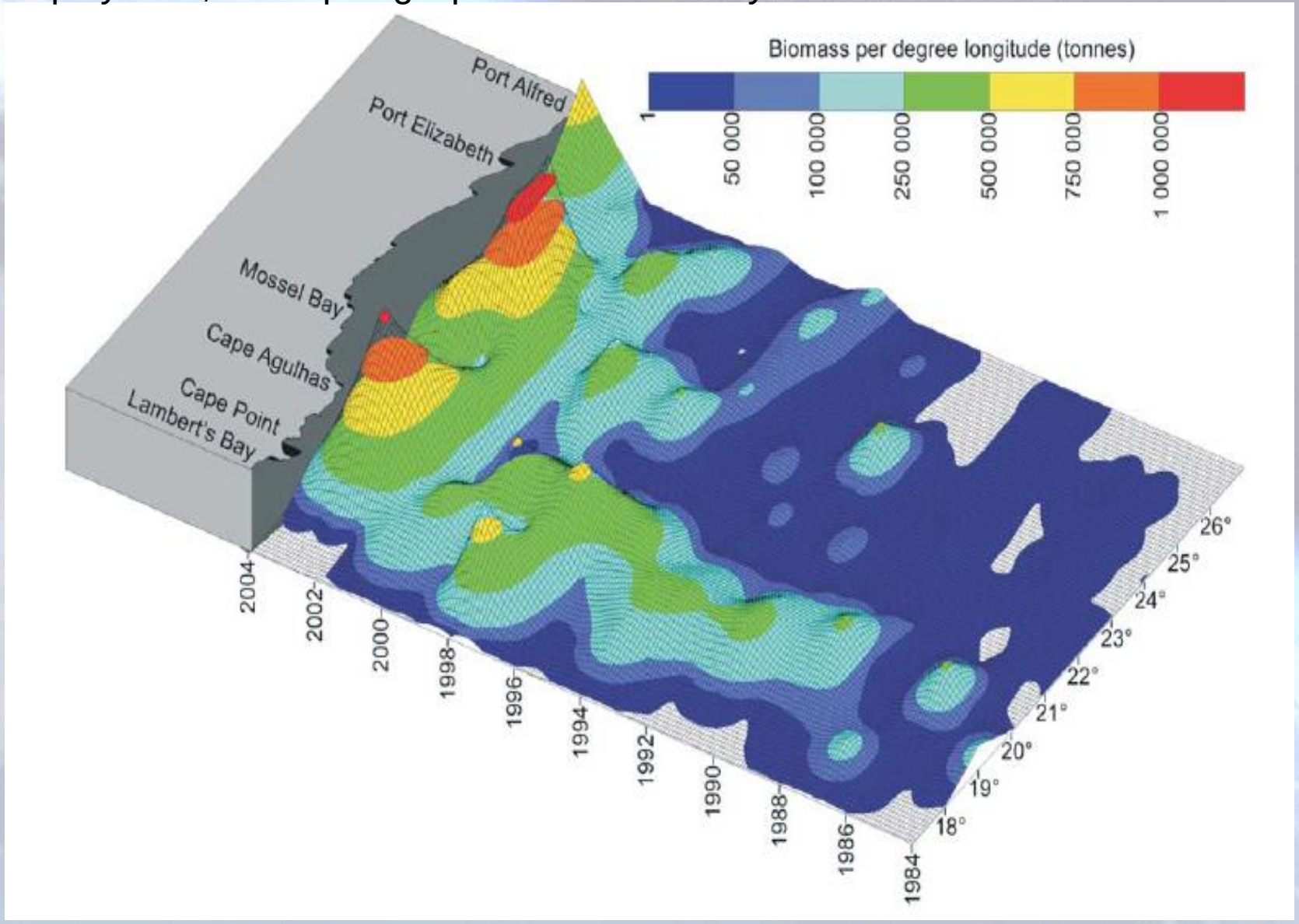


From Roberts 2005

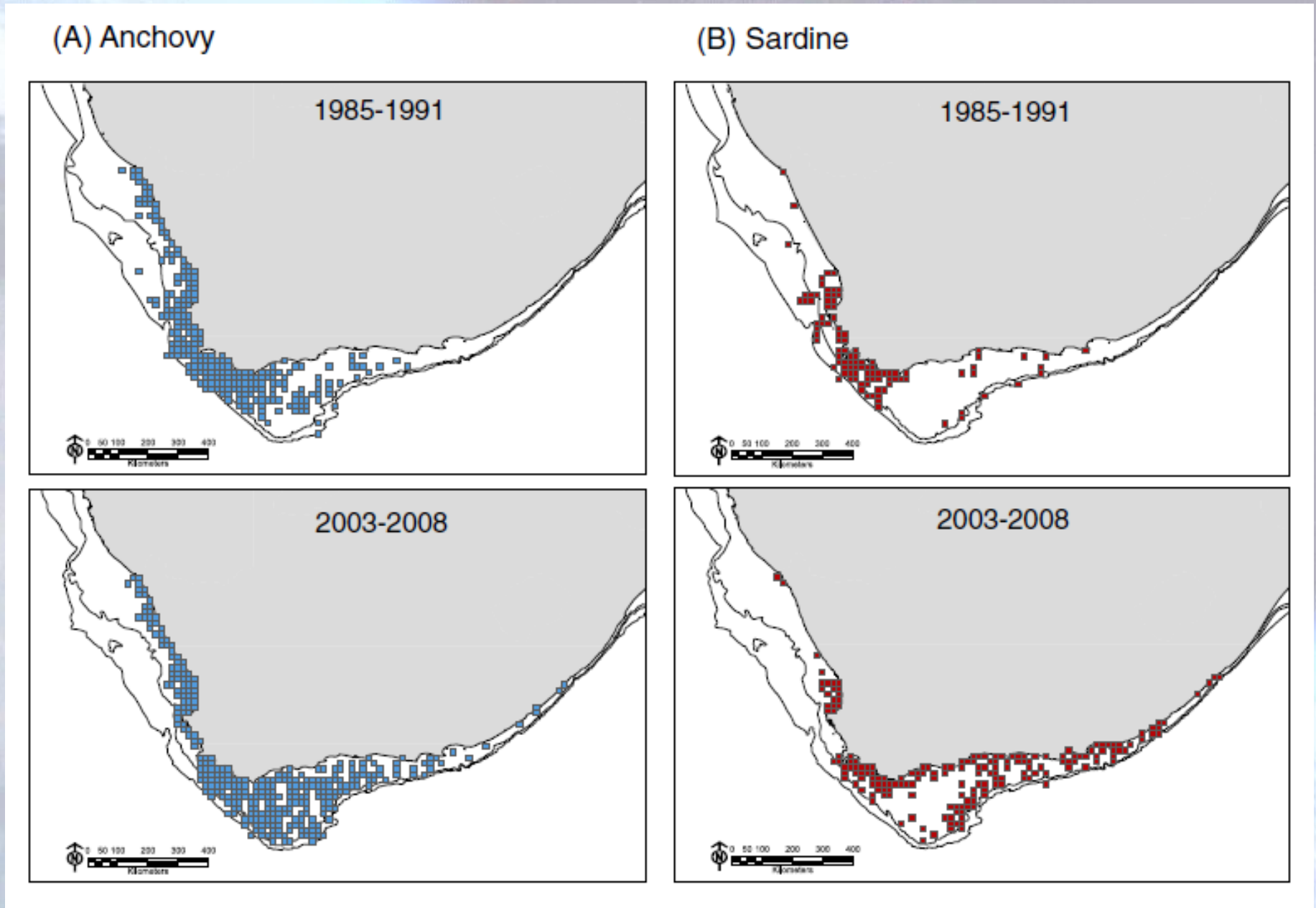
Important Spawning and Nursery Grounds



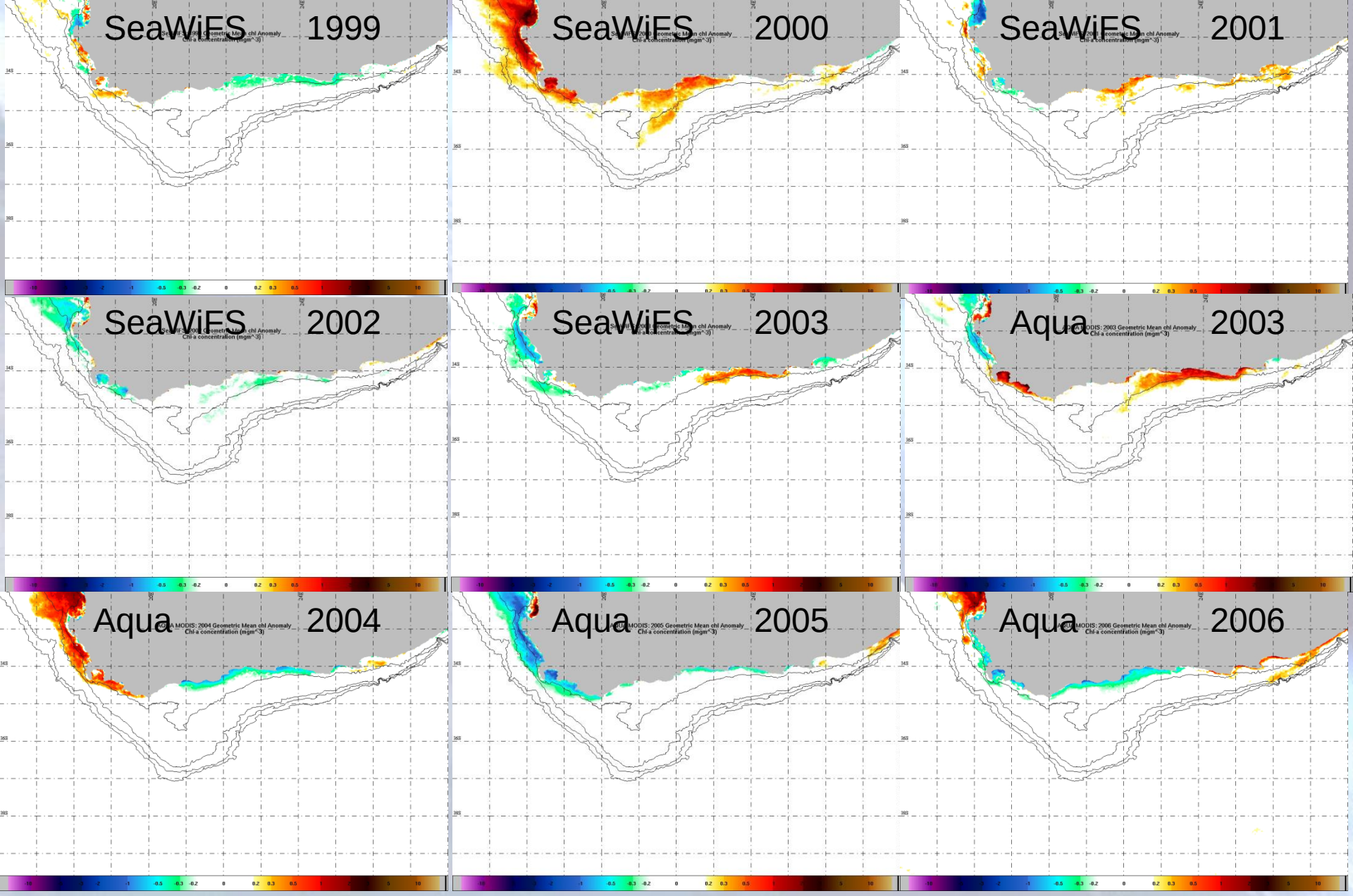
South Africa's largest fishery in terms of volume landed, as well as direct and indirect employment, is the pelagic purse-seine fishery on the West and South Coasts.



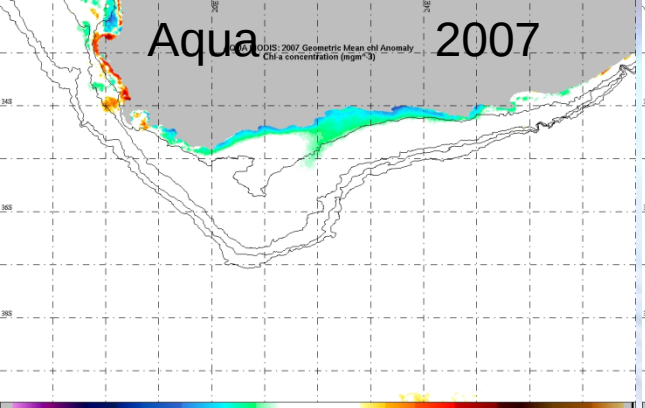
Changes in the distribution of sardine biomass as seen during pelagic spawner biomass surveys, 1984-2004. The coast has been linearized (Hutchings et al., 2009).

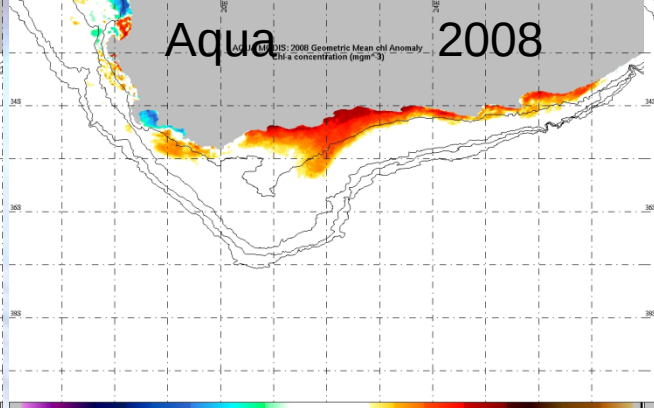


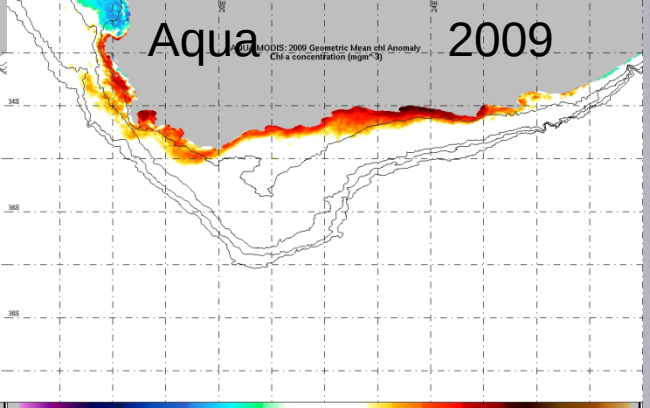
Distribution of anchovy and sardine before and after the eastward shift that occurred in the mid to late 1990s based on May and November survey data. (Blamey et al 2015)

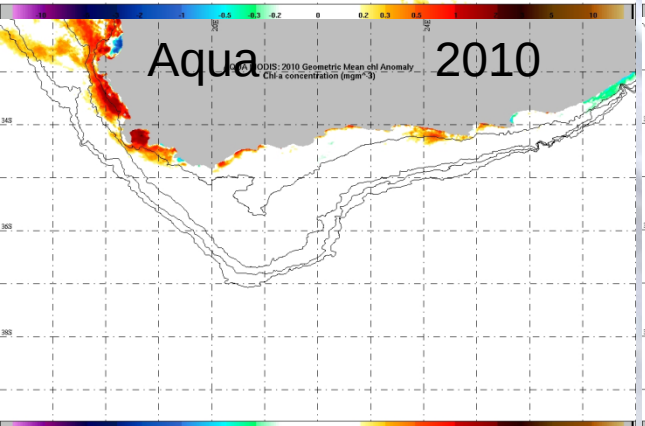


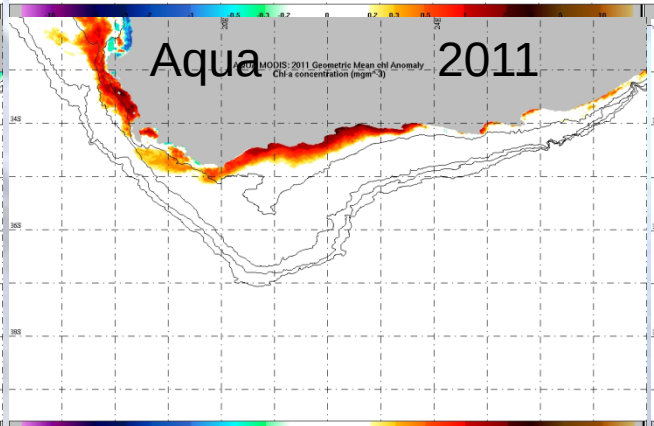
Chlorophyll-a Yearly anomalies

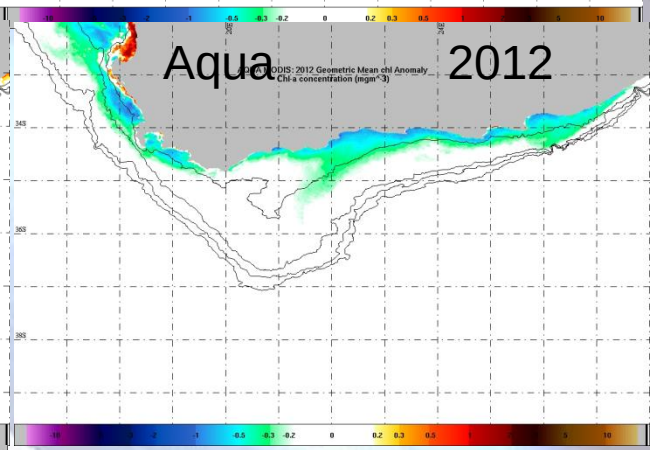


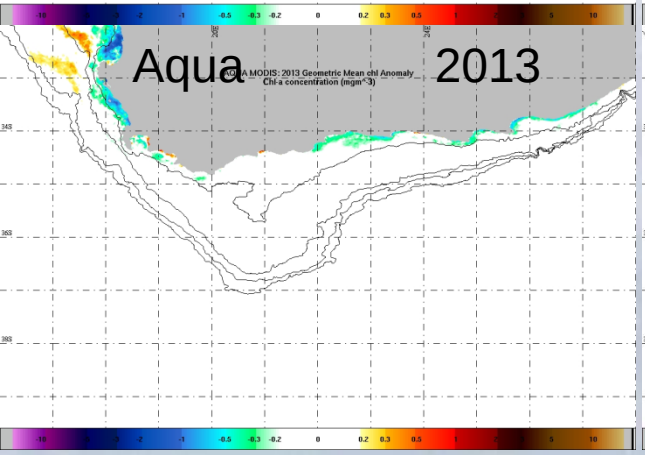


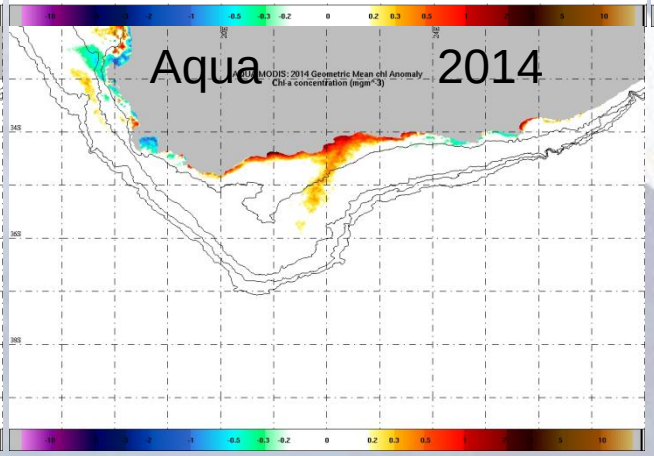




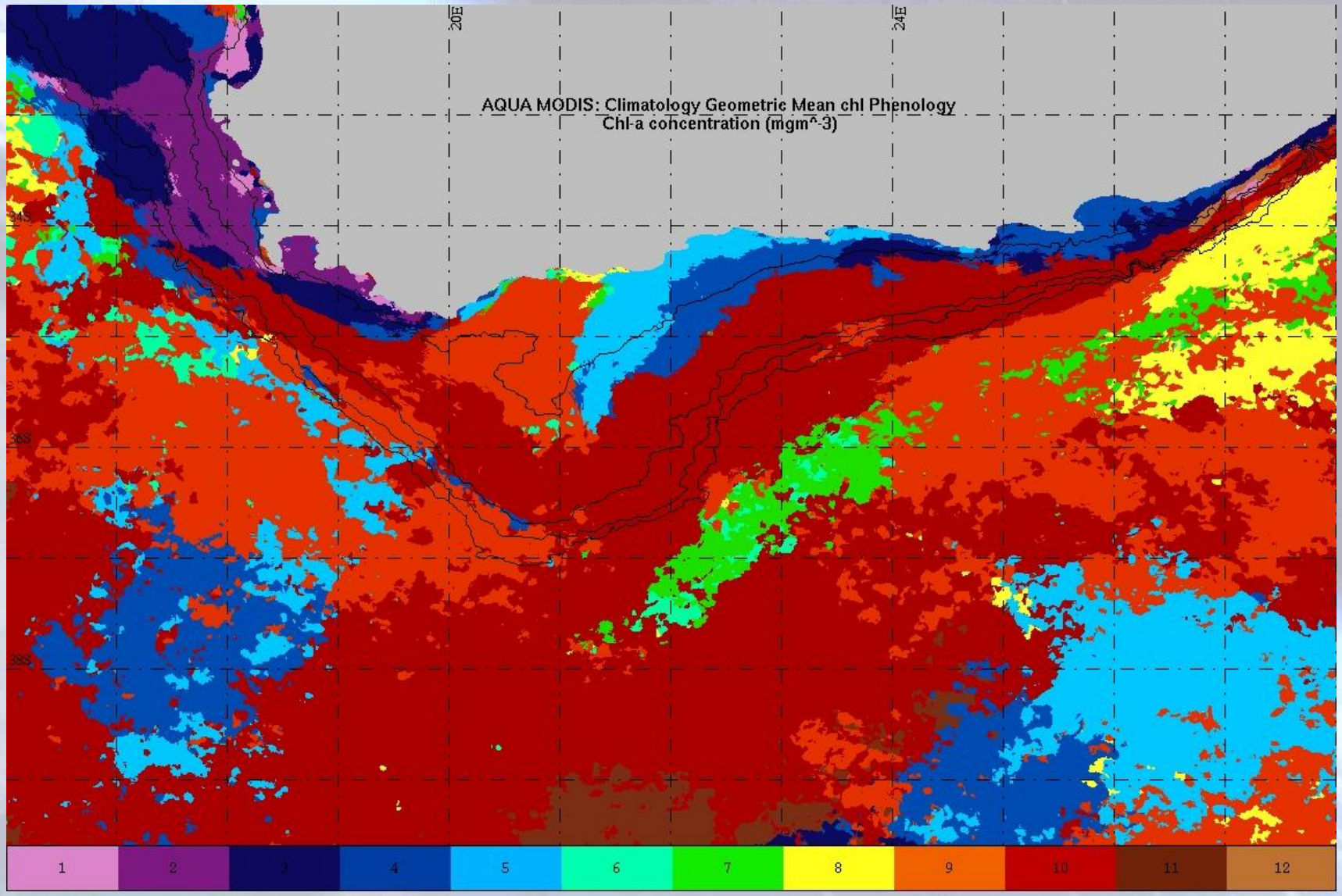




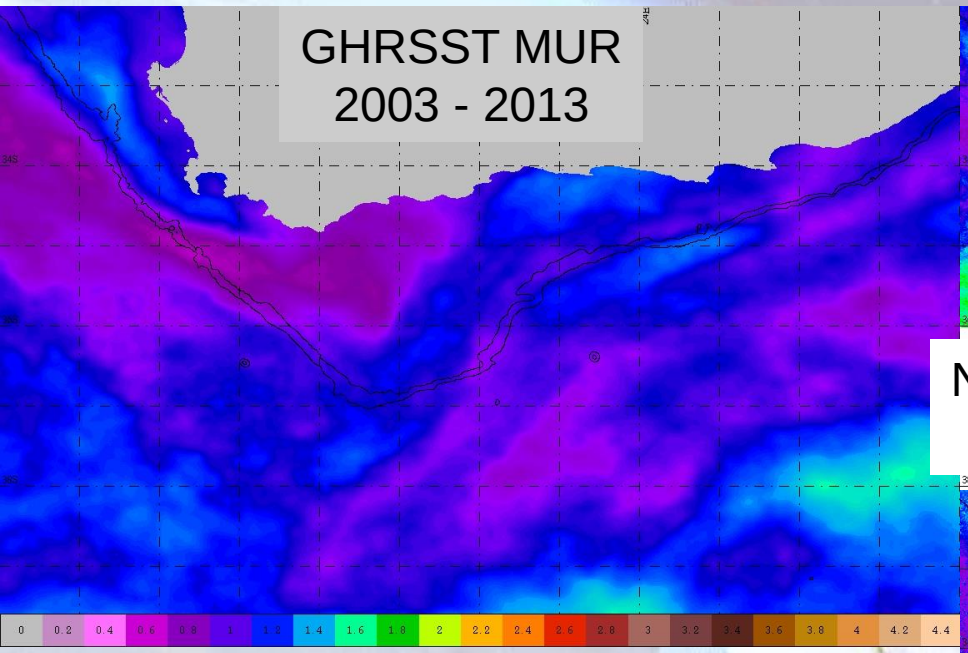


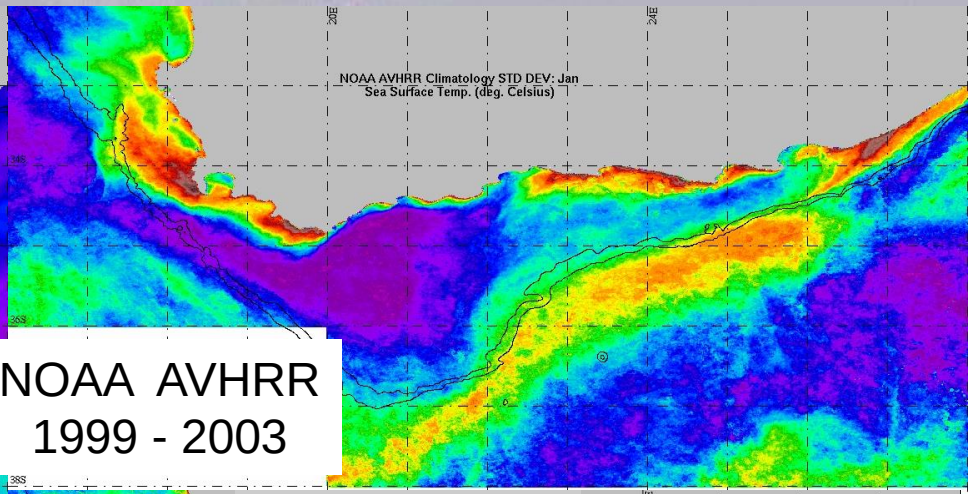


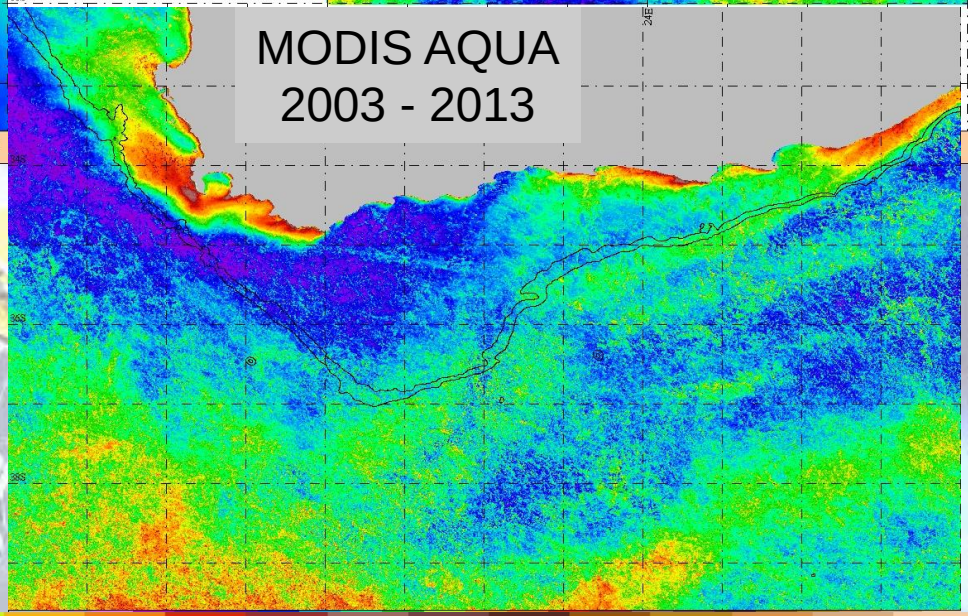
Chlorophyll-a Yearly anomalies



MODIS AQUA Chl-a Median Peak 2003 - 2014

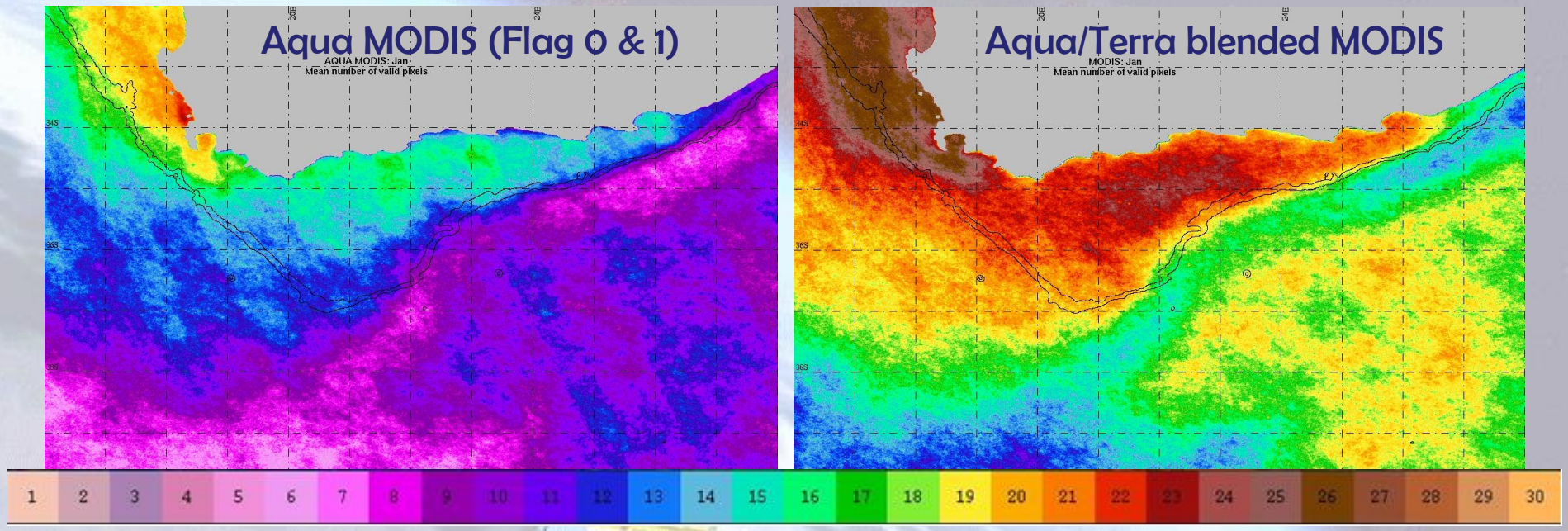




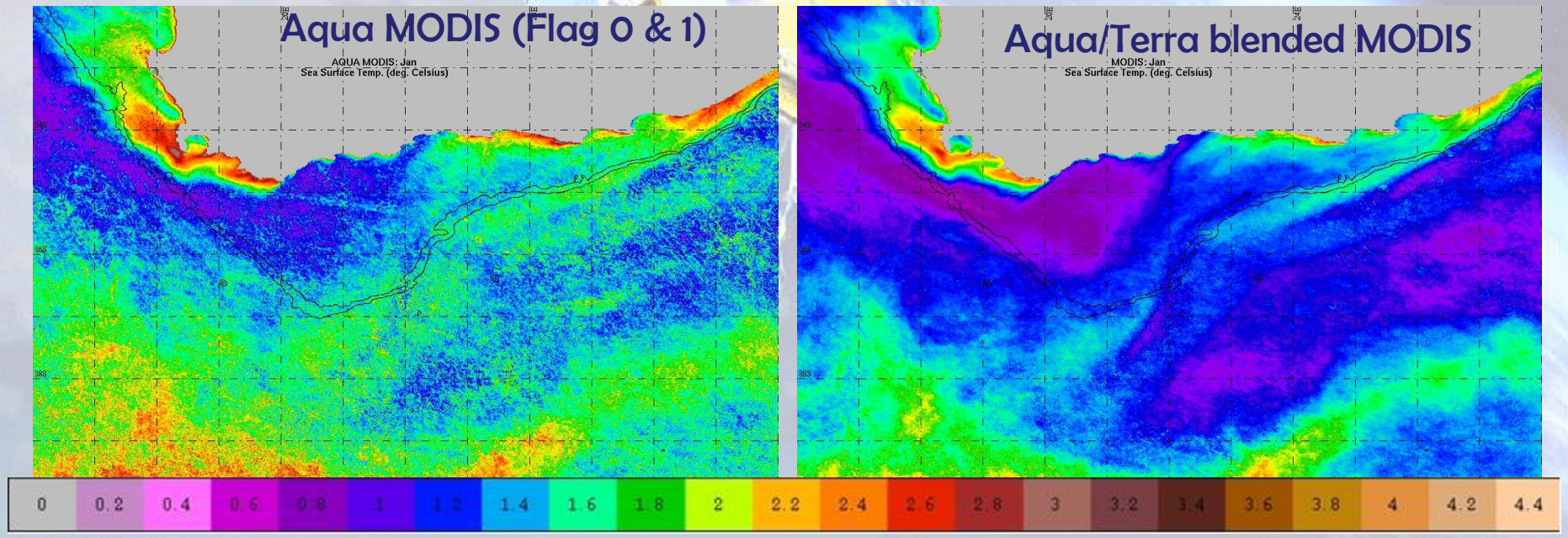


SST STD DEV for January Climatology

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4



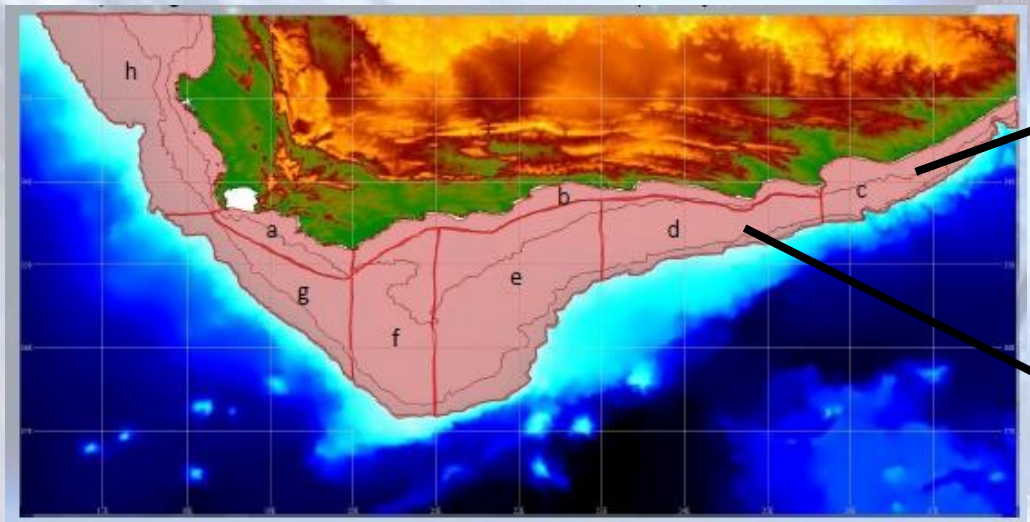
Mean cloud free days for January Climatology 2003-2014

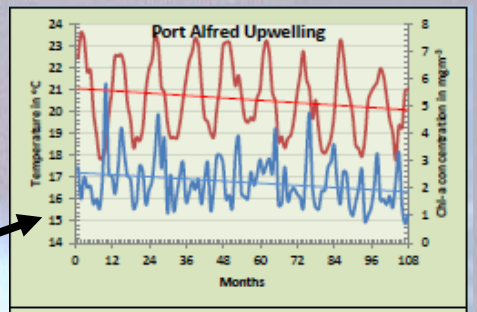


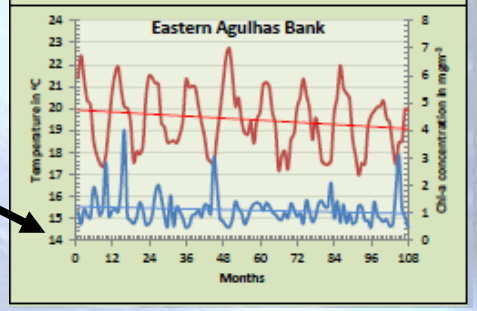
Std Dev of SST for January Climatology 2003-2014

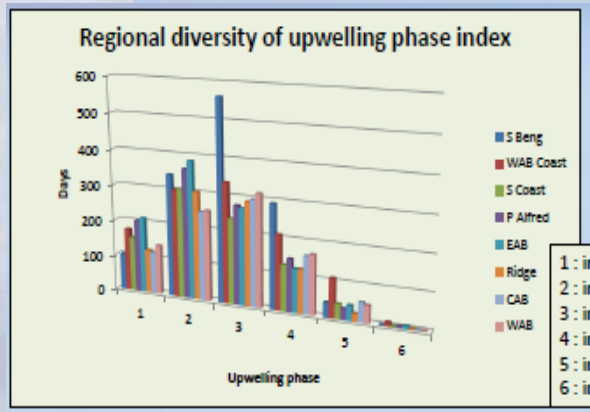
Decadal analysis of coastal ecosystems with SST and ocean color

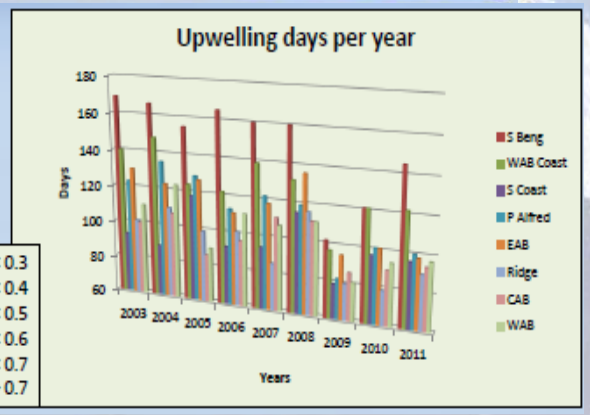
Chlorophyll Phenology and SST standard deviation suggest that the Agulhas Bank has several bio-physical provinces







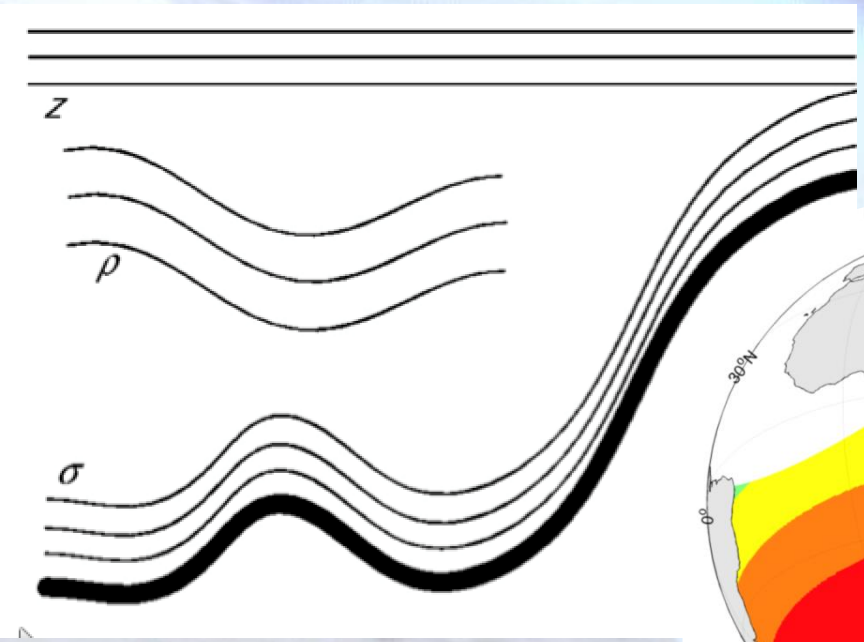




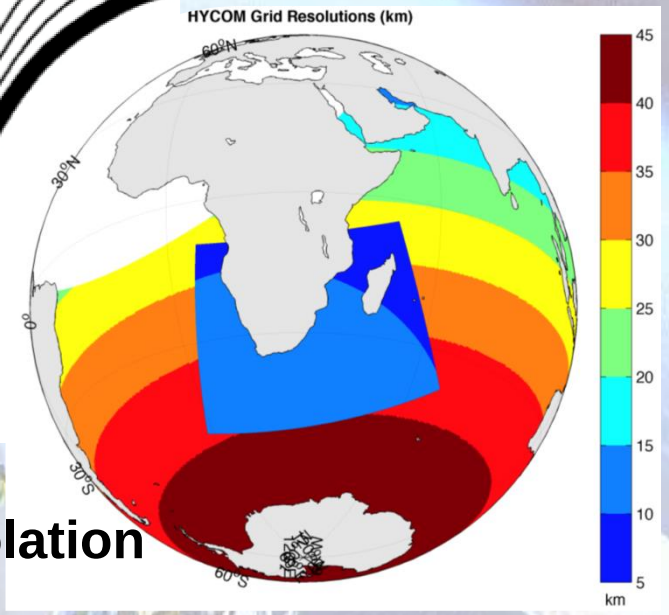
Only data with a mean upwelling index >0.2 and regional cloud cover <40% were considered when examining the spatial and temporal variability of upwelling within the ecosystem provinces

[Chl-a] variability shows no seasonal preference at Port Alfred and the Eastern Agulhas Bank indicating that the high upwelling variability is not dominated by the seasonal wind field, but by instabilities in the Agulhas Current at the shelf edge.

Regional modelling and data assim. system



Hybrid Coordinate Ocean Model



- Combines optimal features of isopycnic coordinate and fixed-grid ocean models in one framework.
- The hybrid vertical grid conveniently resolves regions of vertical density gradients – e.g. thermocline and surface fronts.

Ensemble Optimal Interpolation

- Ensemble methods are generally more dynamically consistent.
- Computationally relatively inexpensive
  - Run 1 forecast member and use a historical (static) ensemble as the forecast error.
- Shown to produce good results in dynamically similar regions

Currently: Assimilate satellite AVISO SLA and OSTIA SSTs

From Backeberg et al 2014

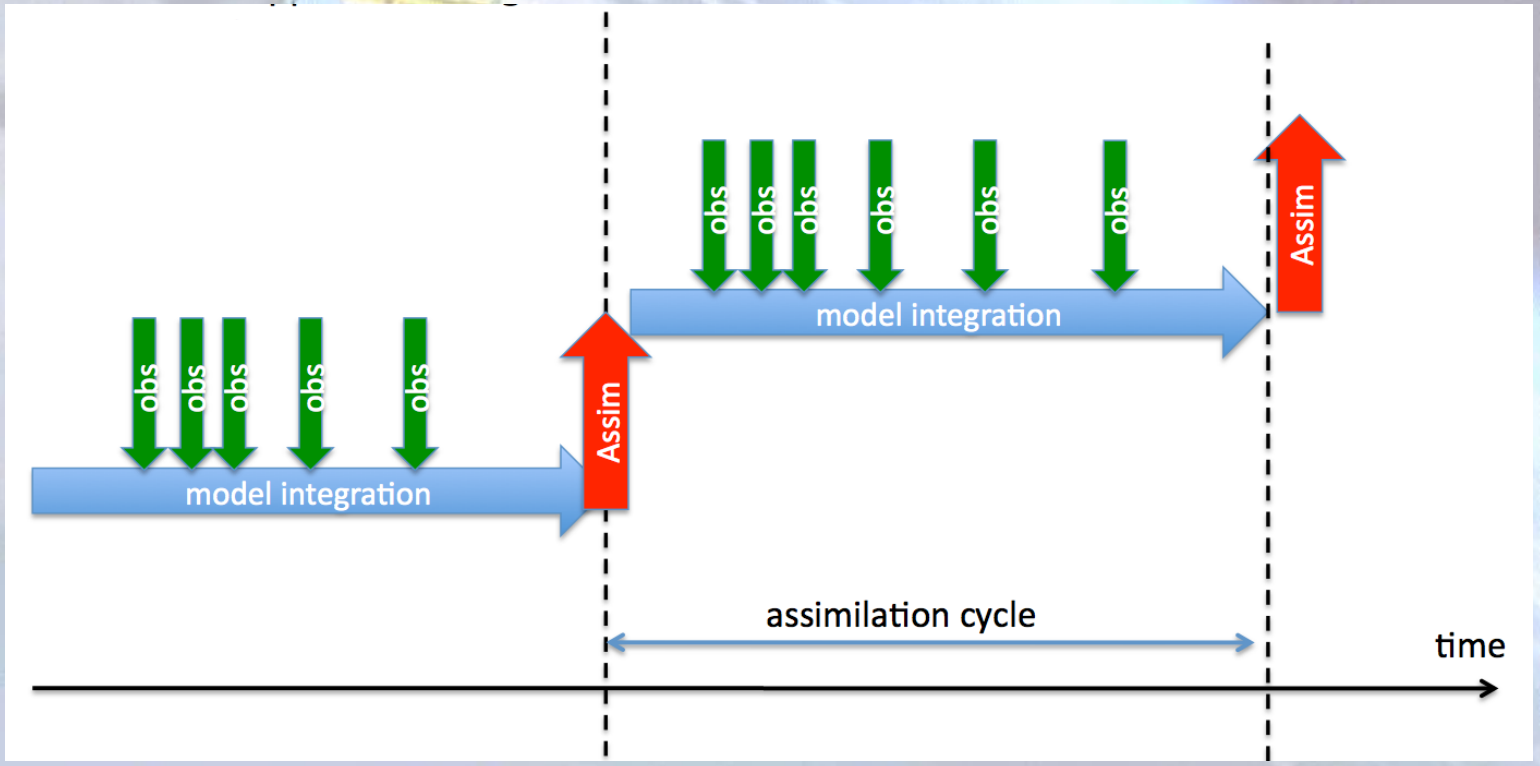
Constraining model errors using observations…

Data Assimilation

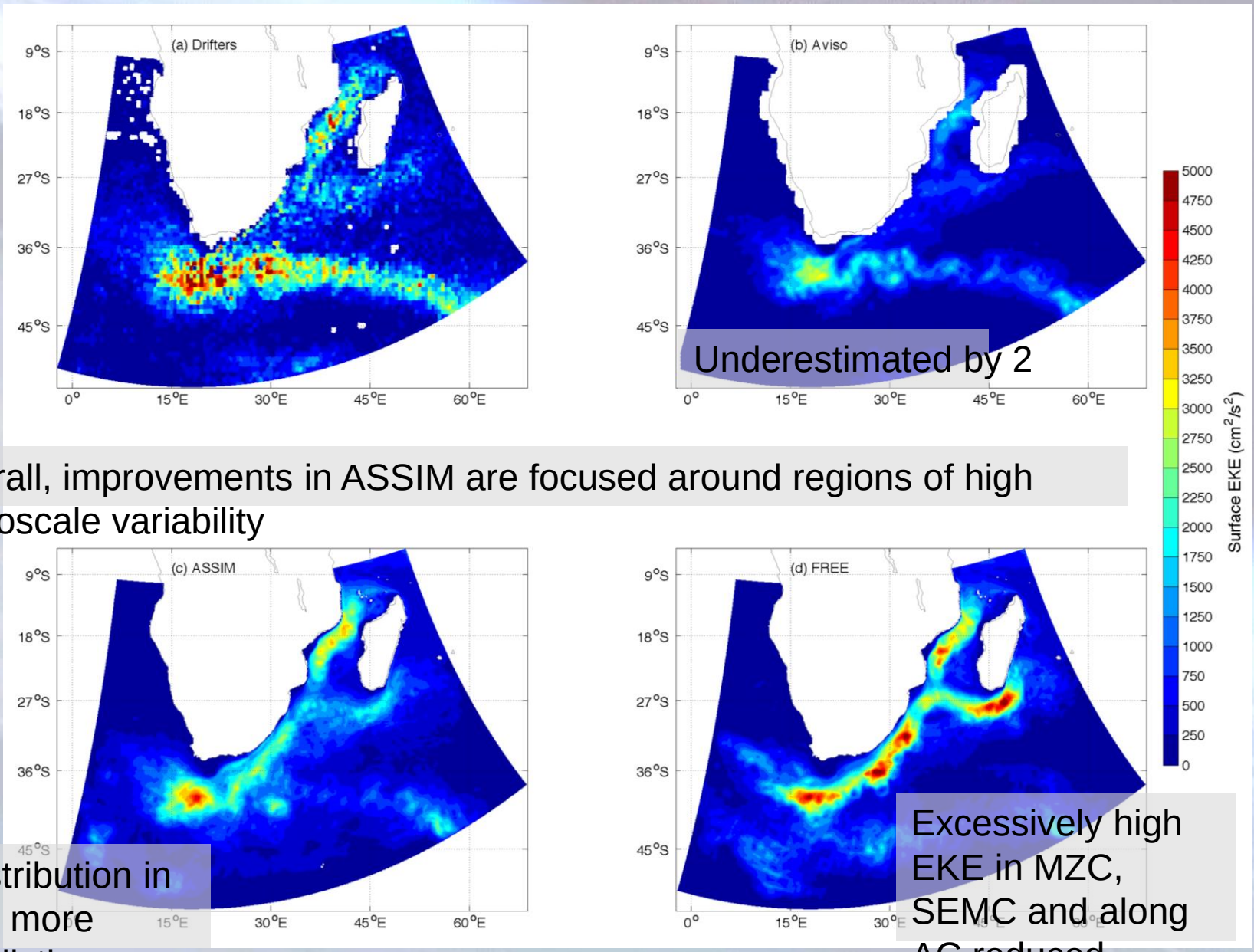
- Process through which observations and models are merged providing an optimal estimate of the “truth”.
- Assume that neither model nor observation represent the complete “truth”.
- Estimates of the ocean state are determined by:
  - Observational field, which are **sparse** in space and time (**<1% of the model domain is observed**)
  - Model field, which has **inaccuracies**
- Challenge: constrain model errors with few observations (need to calculate **multivariate covariance** of one observation with the model grid)
- Data assimilation uses observations to **improve the nowcast**

Assimilation cycle

- Observations are sparse in time.
- It is therefore impractical to stop the model each time a new observation becomes available.
- A common approach is to gather observations in batches and assimilate these at given intervals.
- We assimilate **along-track SLA** at 7-day intervals
- Compare model and observations at same time



Drifter derived EKE comparison



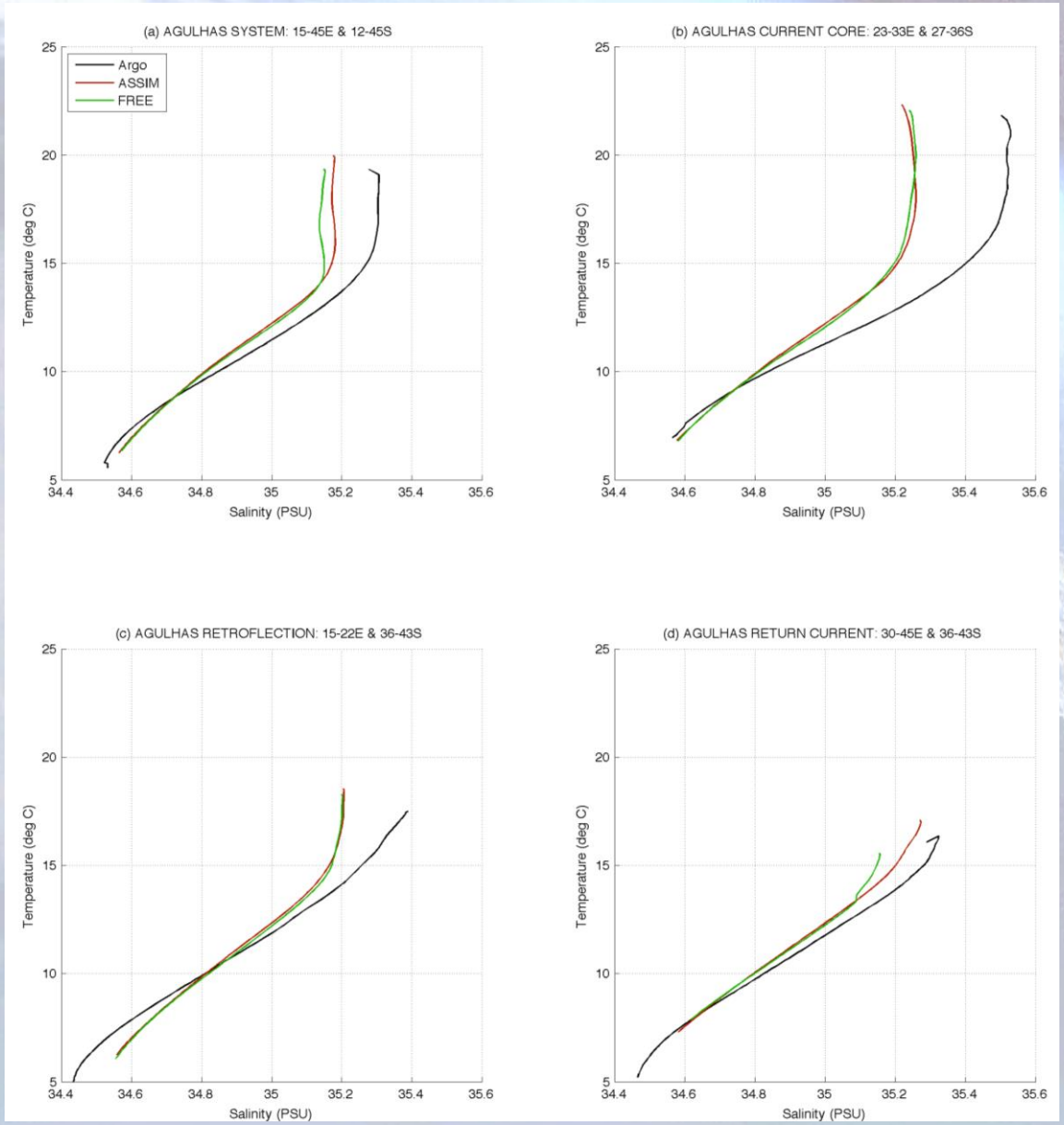
Underestimated by 2

Overall, improvements in ASSIM are focused around regions of high mesoscale variability

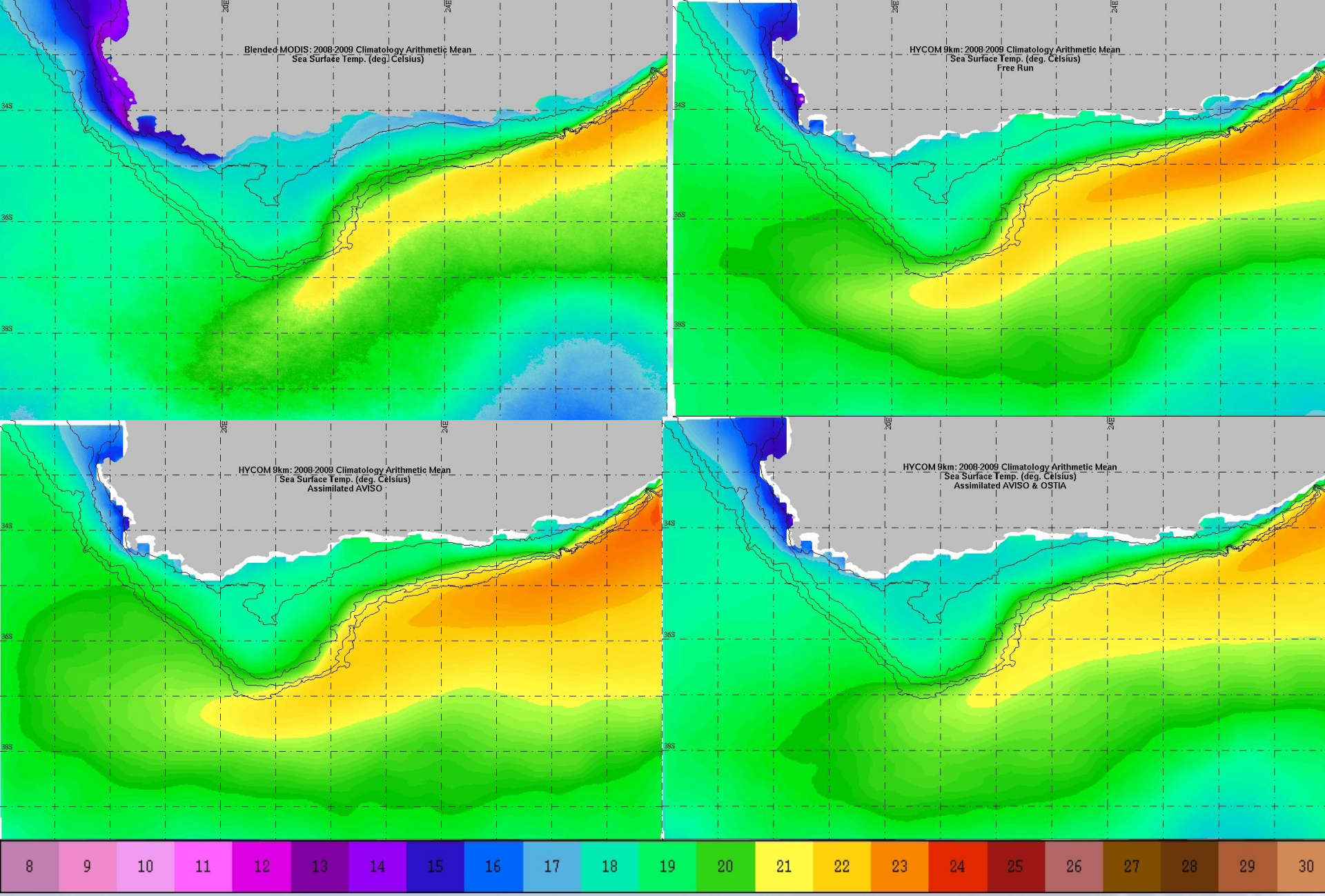
Distribution in AR more realistic

Excessively high EKE in MZC, SEMC and along AC reduced

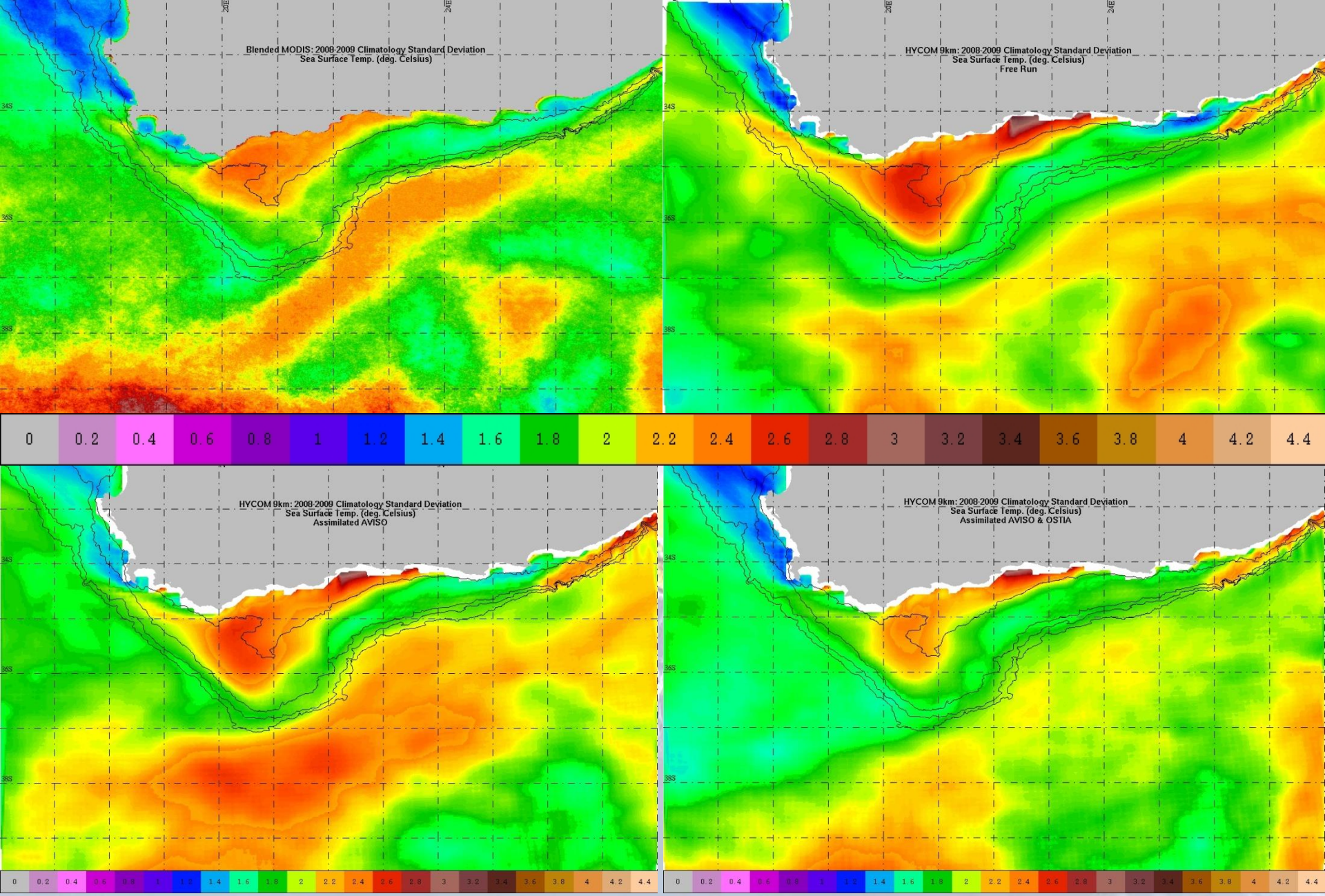
Comparison to Argo



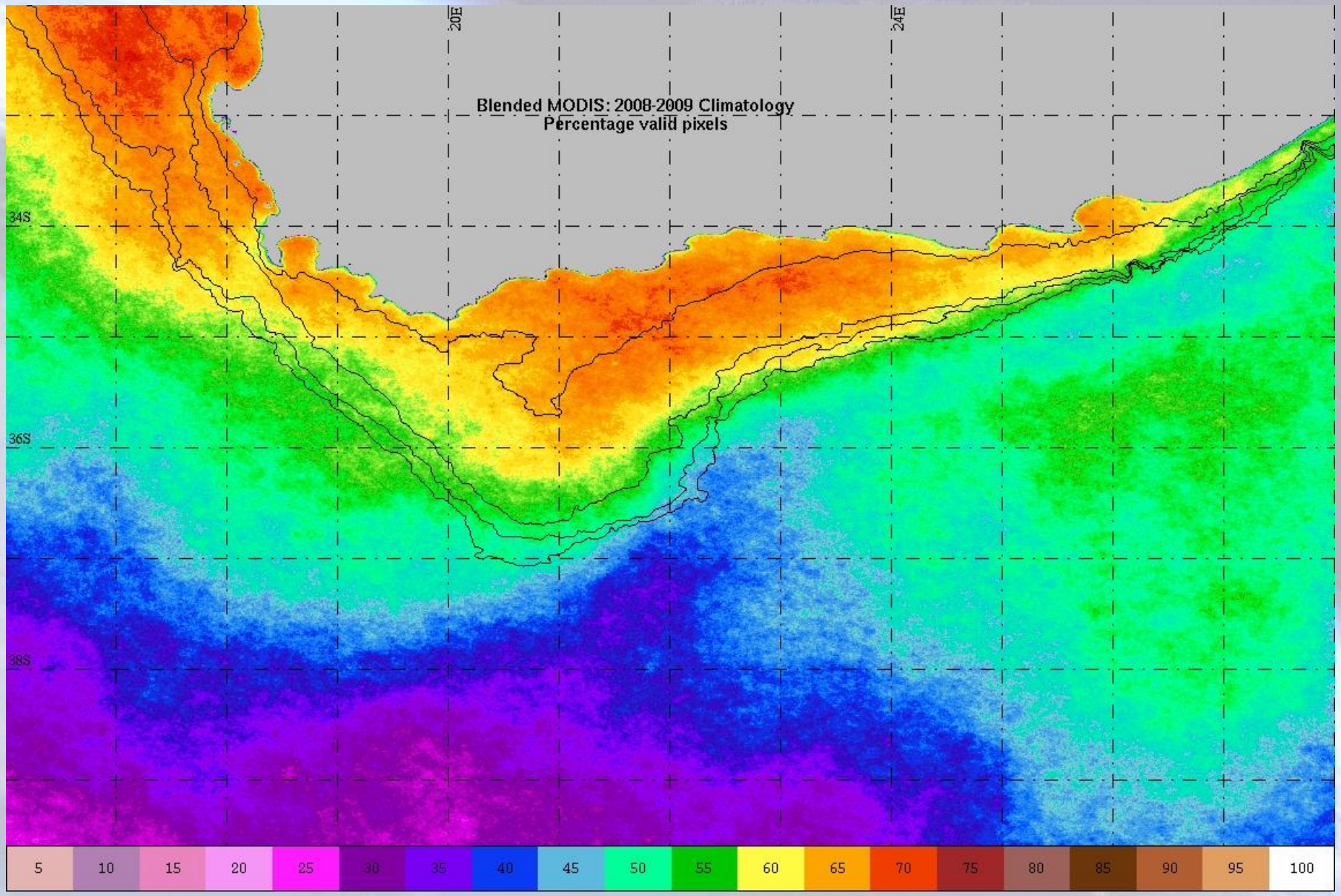
Assimilating along- track SLA data has a positive impact on water masses in the range of T>15ºC and S>35.1 PSU, aligning these more closely with the observed Argo profiles. These temperature ranges are associated with Indian Central Water (IWC), a subtropical water mass that typically resides in the upper 500m.



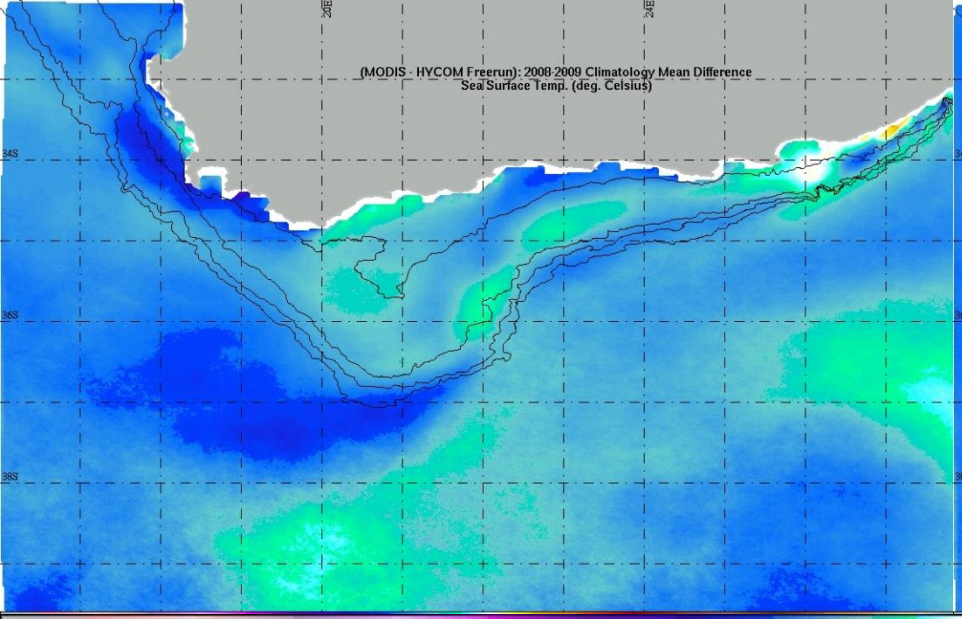
Blended MODIS SST vs HYCOM Model Runs: 2008-2009 Mean

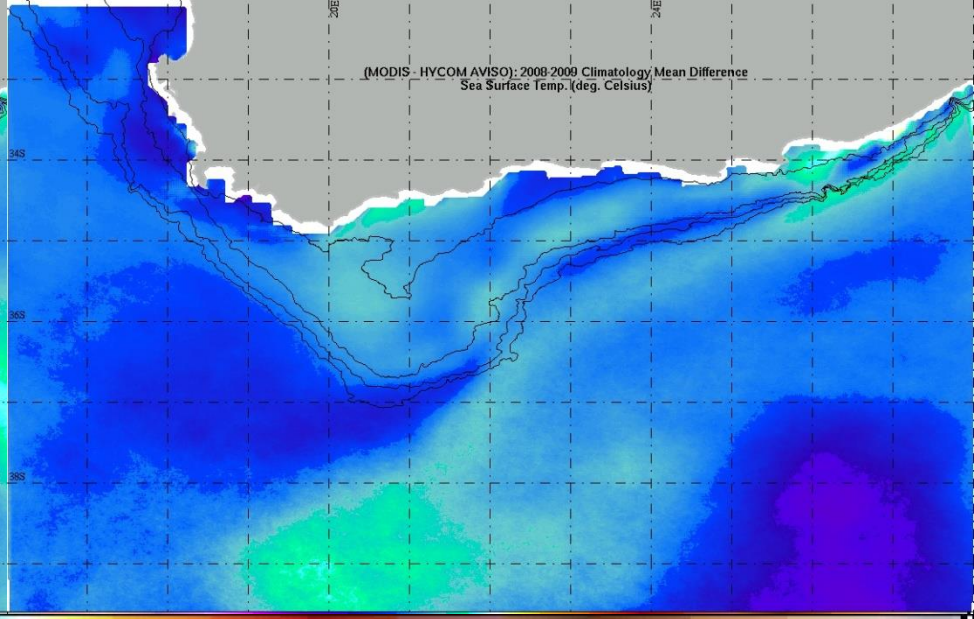


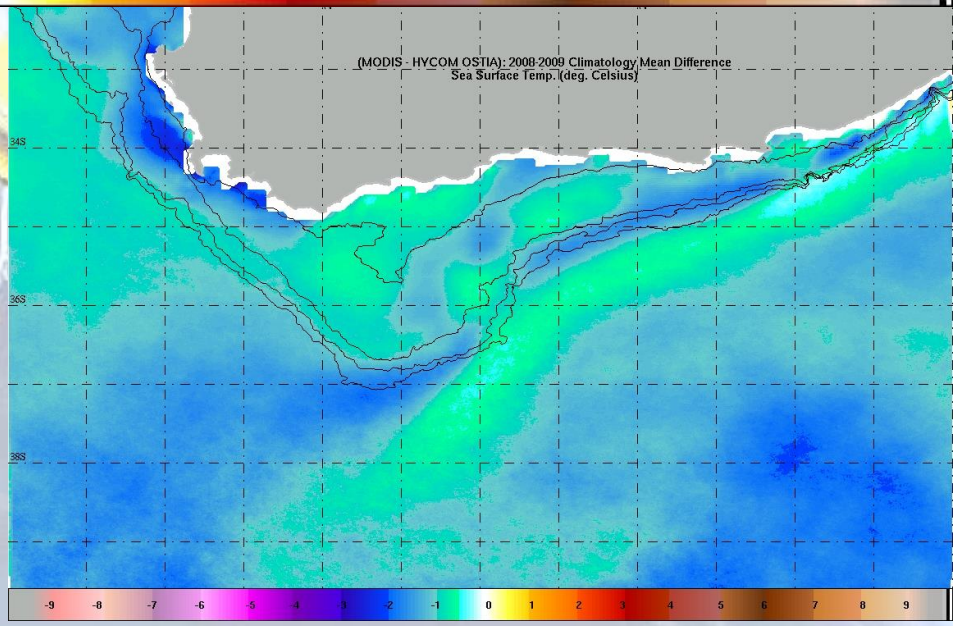
Blended MODIS SST vs HYCOM Model Runs: 2008-2009 Std Dev



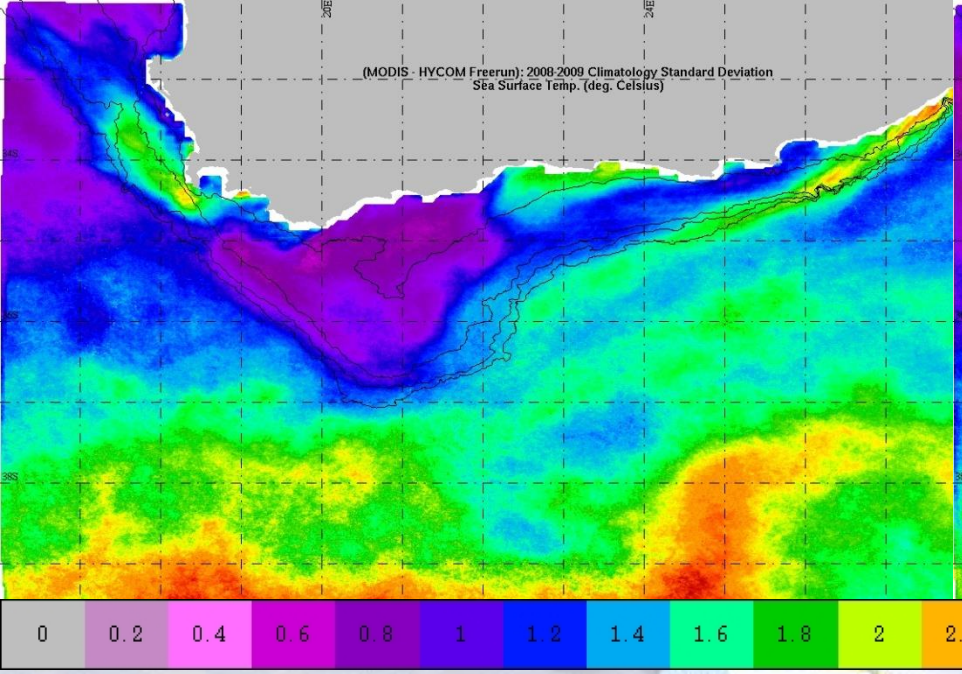
Blended MODIS SST percentage pixels retained for 2008-2009

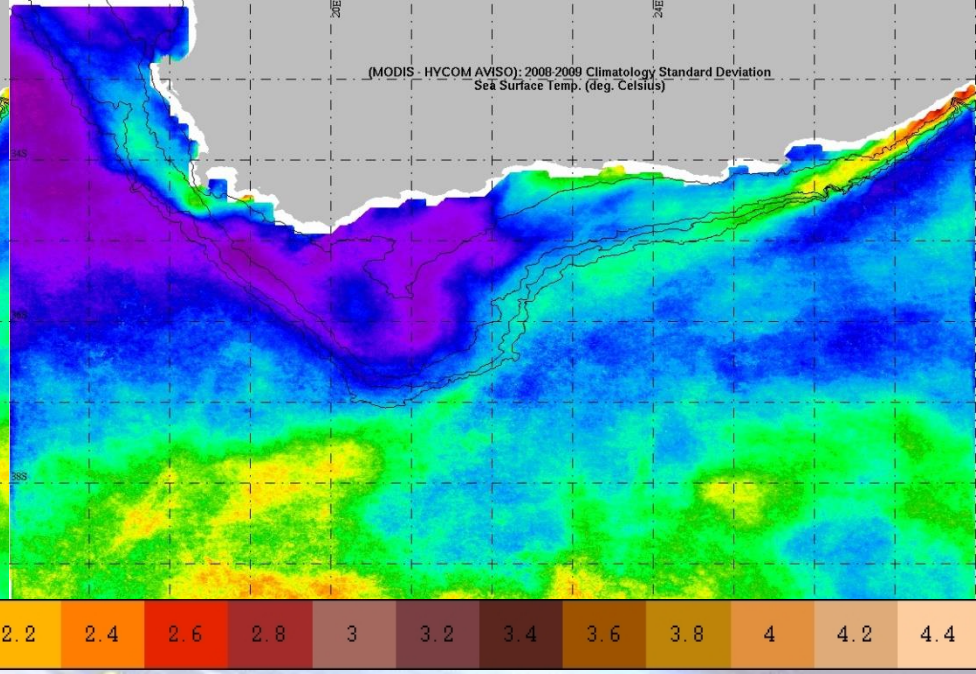


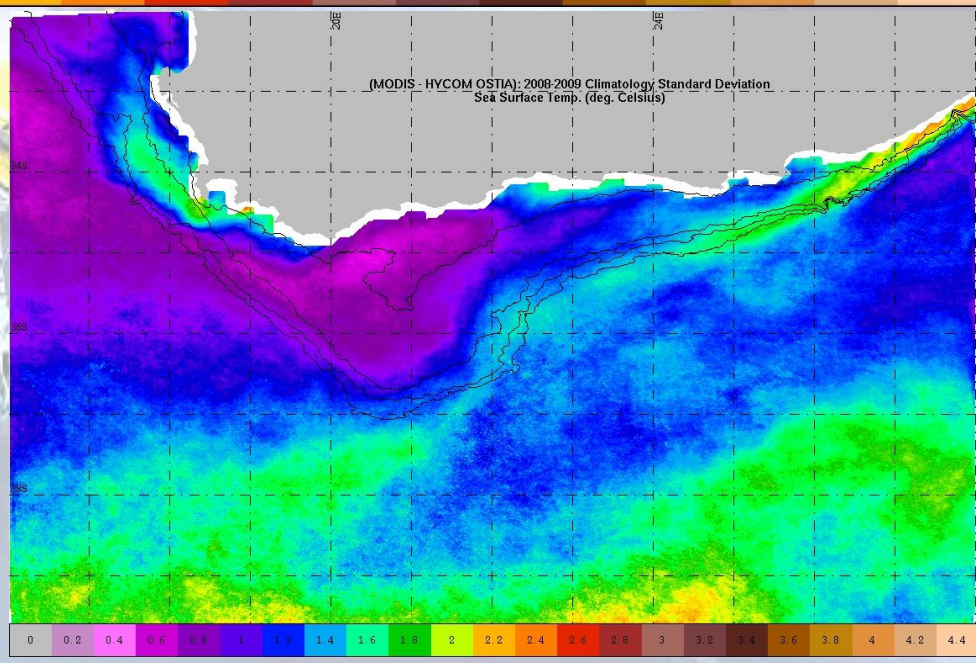




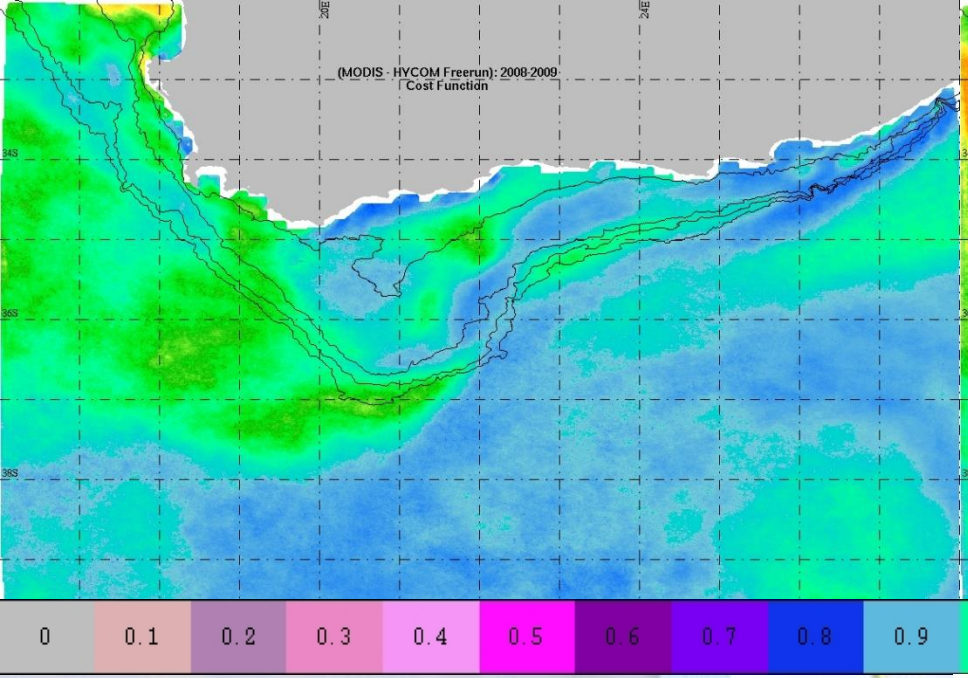
Blended MODIS SST vs HYCOM Model Runs: Climatology Mean Difference

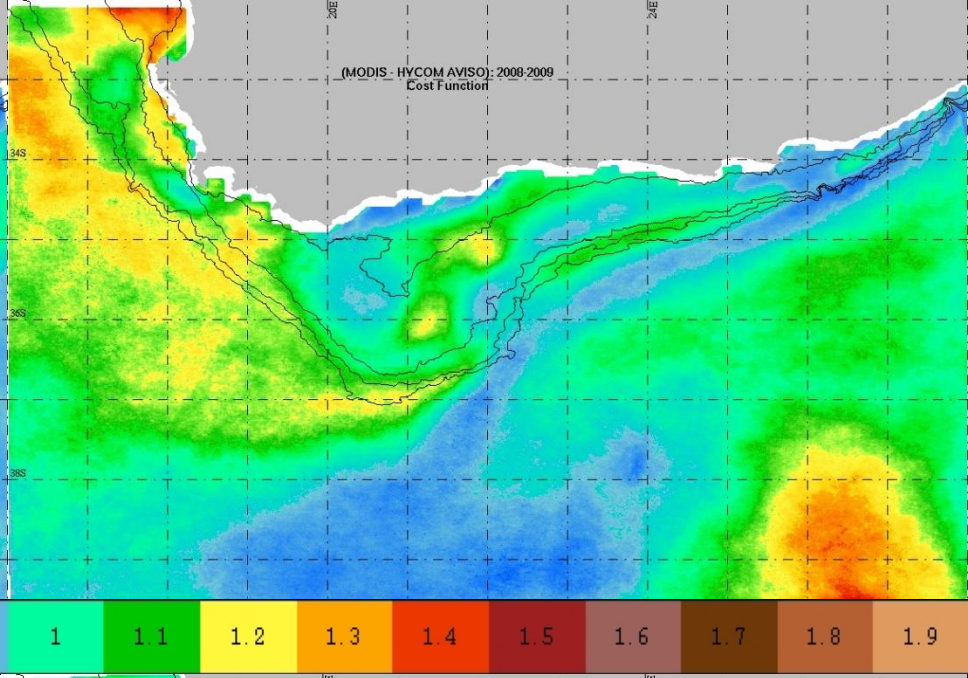






Blended MODIS SST vs HYCOM Model Runs: 2008-2009 Std Dev of Mean Difference

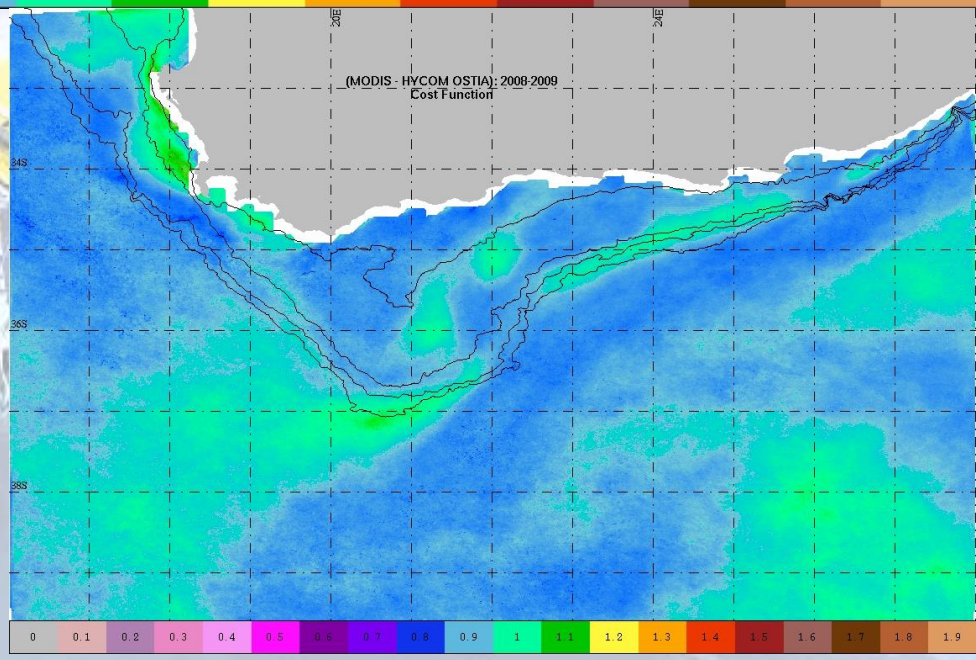




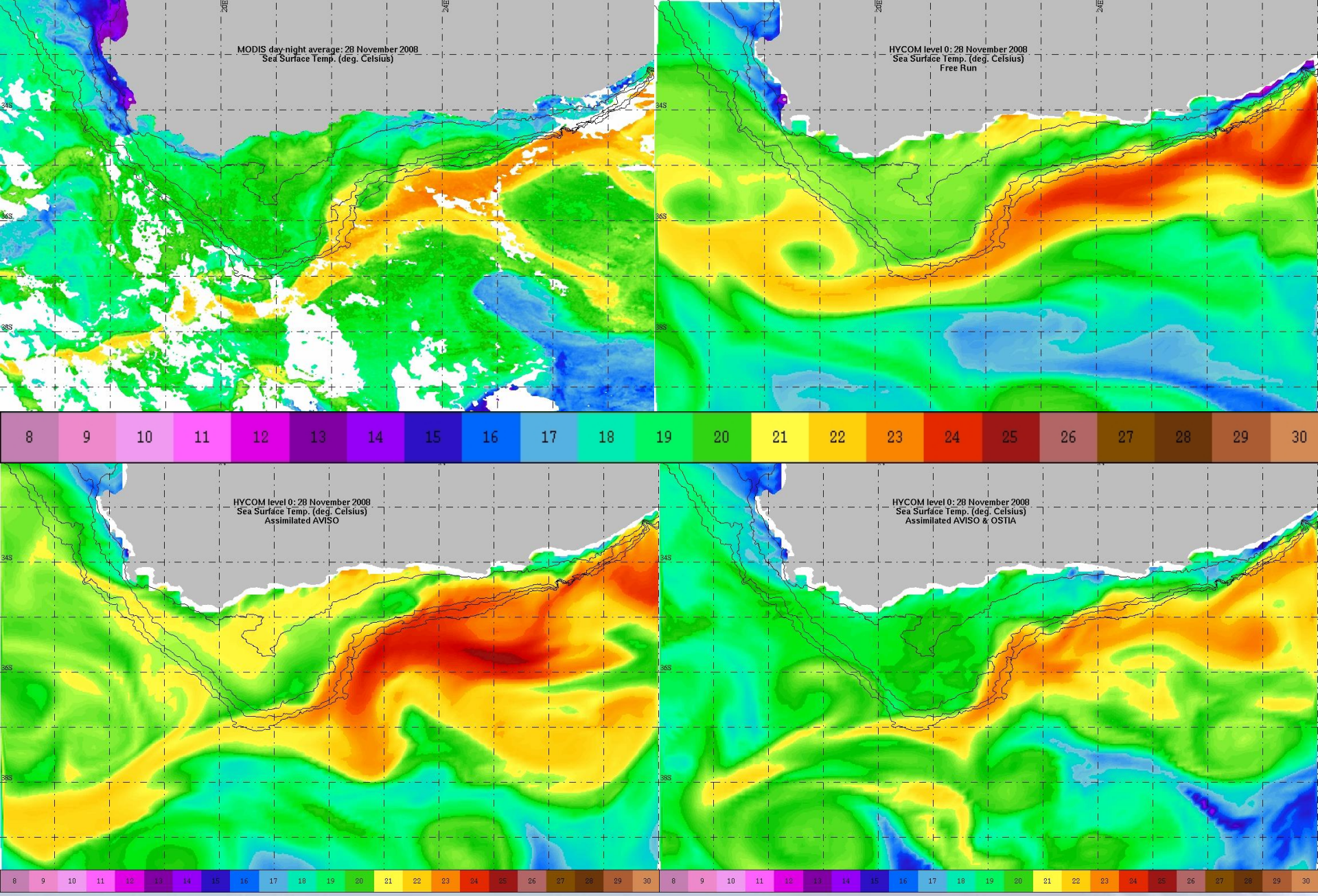
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9

$$CF = \frac{1}{N}\sum_{n=1}^{N}\frac{\left|D_n - M_n\right|}{\sigma_D}$$

$$\sigma_D = \sqrt{\frac{1}{N}\sum_{n=1}^{N}\left(D_n - \overline{D}\right)^2}$$

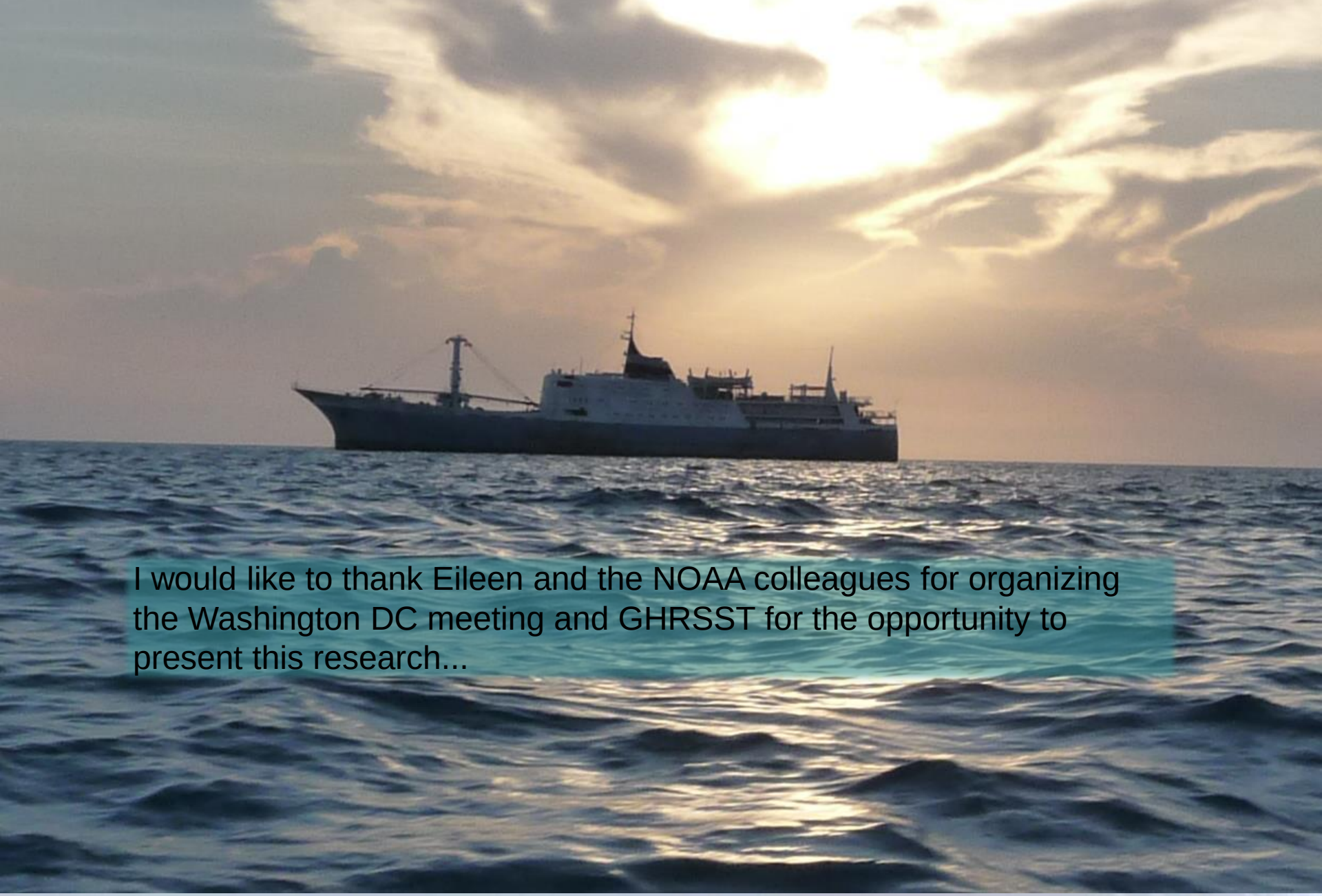


From George et al 2010


MODIS day-night average: 28 November 2008
Sea Surface Temp. (deg. Celsius)
HYCOM level 0: 28 November 2008
Sea Surface Temp. (deg. Celsius)
Free Run
HYCOM level 0: 28 November 2008
Sea Surface Temp. (deg. Celsius)
Assimilated AVISO
HYCOM level 0: 28 November 2008
Sea Surface Temp. (deg. Celsius)
Assimilated AVISO & OSTIA
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Summary

- Small Pelagic fish abundance and distribution are closely linked to the variability of the upwelling systems in which they exist,
- The Agulhas Bank provides both a spawning ground and nursery area , and is the centre of abundance for numerous commercially exploitable species,
- Distribution shifts observed in several exploitable species within South African EEZ during mid 1990s, persisting into 2000's
- Variability in production on the west and south coasts resonate with observed migration in pelagics,
- Variability within several bio-physical oceanographic provinces may impact marine resource migration,
- Agulhas Current and shelf representation of HYCOM model enhanced with the assimilation of satellite products,
- Further investigations should include an examination of the deviation of assimilated runs from MODIS observations between assimilation intervals,
- A comparison of model hydrography on the shelf will also be compared to complimentary cruise results.



I would like to thank Eileen and the NOAA colleagues for organizing the Washington DC meeting and GHRSST for the opportunity to present this research...

Thank You!