MUSICAL
Multi-Sensors Information: ocean Color and ALtimetry

Marie-Hélène Radenac (marie-helene.radenac@cnes.fr), Véronique Garçon (veronique.garcon@cnes.fr), Monique Messié, Jérôme Llido, Joël Sudre

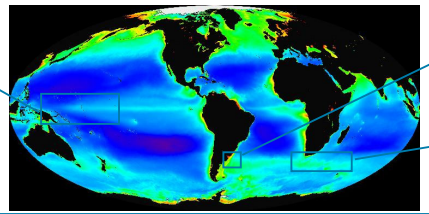
Christine Provost (christine.provost@lodyc.jussieu.fr), Martin Saraceno, Nicolas Barré

LEGOS-IRD-CNRS, Toulouse, France

LODYC-CNRS, Paris, France

Our **MUSICAL** (MUlti-Sensors Information: ocean Color and ALtimetry) proposal intends to combine eclectic satellite and *in situ* data to provide a comprehensive three-dimensional picture of the highly climate sensitive regions we study.
We use the combined altimetry T/P-JASON data in conjunction with other remotely sensed data (ocean colour, sea surface temperature, surface winds), with *in situ* data (TAO/TRITON mooring array, ARGO floats), and with model outputs over a wide range of temporal scales.

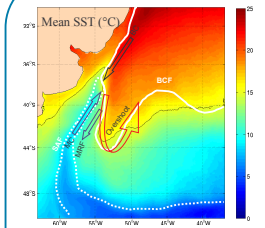
3. at the intra-seasonal to interannual range, we study the impact of westerly wind bursts (WWB) on biology in the western tropical Pacific and its potential modulation during El Niño and non-El Niño years

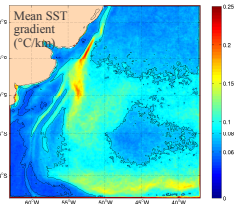


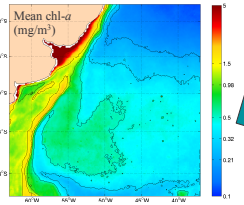
1. with high frequency data, we observe mesoscale and sub-mesoscale structures and their interactions with biology in the Brazil-Malvinas Confluence zone

2. at the seasonal to interannual range, we investigate the possibility of detecting planetary wavelike features all along the South Atlantic Subtropical Convergence zone

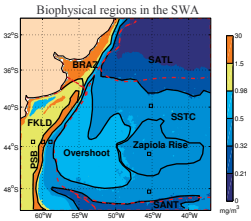
1. Brazil-Malvinas Confluence region





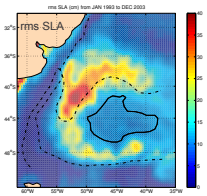


• The variability of thermal fronts is discussed with nine years of AVHRR data (1987-1995) using a gradient based edge detector (Saraceno et al., 2004a).
• The time-space distribution of chlorophyll-*a* is examined using 6 years (1998-2003) of sea surface color images from SeaWiFS (Saraceno et al., 2004b).
• Simultaneous high resolution (1.1 km) MODIS SST and color images document structures in physics and biology at the meso- and sub-meso-scales (Barré et al., 2004).



Background colors represent the six ranges of chl-*a* magnitudes identified with an histogram method. Regions obtained (solid black lines) retrieves Longhurst (1998) Provinces (dash-dot red lines)

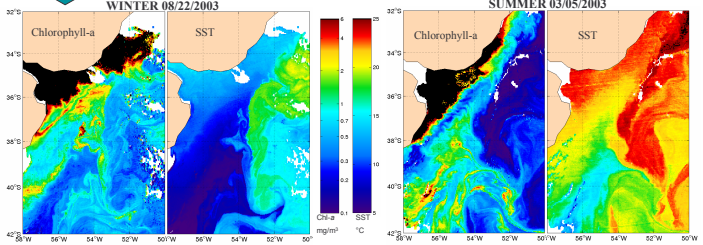
Three new regions are identified: the Overshoot, the Patagonian Shelf Break (PSB) and the Zapiola Rise regions.



Root mean square of Sea Level Anomaly obtained from 11 years of Sea Surface Height from ERS + TOPEX/POSEIDON + JASON merged data set in a 1/3° mercator grid. Dash-dot lines are mean position of BCF and SAF.1

The Zapiola Rise shows up as a region of low SST gradients, low kinetic energy and a late bloom in chlorophyll-*a*.

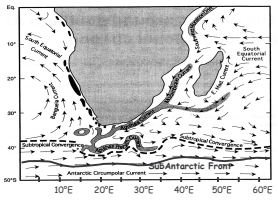
• The Brazil-Malvinas collision front changes to a NW-SE orientation in summer
• Chlorophyll-*a* appears are as a good tool to study dynamics in the region



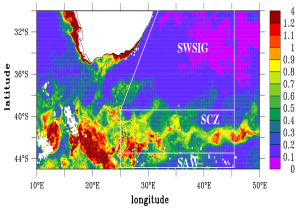
Saraceno, M., C. Provost, A. R. Piola, J. Bava, and A. Gagliardini, Brazil Malvinas Frontal System as seen from 9 years of advanced very high resolution radiometer data, J. Geophys. Res., 109, C05027, doi:10.1029/2003JC002127, 2004a.
Saraceno, M., C. Provost, A. R. Piola, On the relationship of satellite retrieved surface temperature fronts and chlorophyll-*a* in the Western South Atlantic, submitted, 2004b.
Barré, N., C. Provost and M. Saraceno, Spatial and temporal scales in the Brazil-Malvinas confluence region as observed by MODIS high resolution simultaneous SST and color images, submitted to Advances in Space Research, 2004.

2. the South Atlantic Subtropical Convergence zone

South of Africa, using simultaneously T/P-ERS-2, AVHRR and SeaWiFS data, we have deduced, with wavelets transforms, the dominant wavelengths associated to the Rossby wave of the Agulhas Return Current (Machu and Garçon, 2001; Llido et al., 2004).



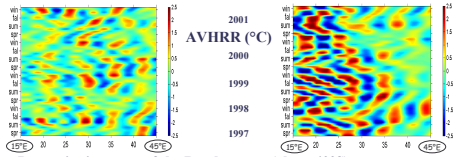
The Agulhas Current system (Lutjeharms et al., 2001)



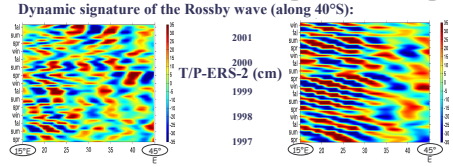
SWSIG : South Western Indian Subtropical Gyre
SCZ : Subtropical Convergence Zone
SAW: Subantarctic Waters

Rossby waves signature could be easily detected, along the Subtropical Convergence, in altimetric sea level, SST and ocean color anomalies as well as in outputs of dynamical heights, SST and chlorophyll anomalies from a three dimensional coupled physical-biological model of the Agulhas Current System (Llido, 2004).

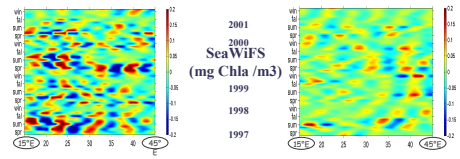
Thermal signature of the Rossby wave (along 40°S) :



Dynamic signature of the Rossby wave (along 40°S):



Ocean color signature of the Rossby wave (along 40°S):



The Agulhas Plateau delimits the region in two zones :

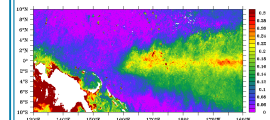
▪ **west of AP:** westward propagation of anomalies with characteristic speeds between 3.6-5.4 cm s^{-1}, 4.5-7.6 cm s^{-1}, 2.3-3.6 cm s^{-1} for SST, SLA and Chla, respectively.

east of AP: either stationary features (mostly for Chla) or slower eastward propagation with typical speeds between 1.1-4.4 cm s^{-1}, 1-3.4 cm s^{-1} for SST and SLA, respectively.

Machu and Garçon, 2001, J. Mar. Res., 59, 795-812.
Llido, Machu, Sudre, Dadou and Garçon, 2004, J. Mar. Res., 62, 595-609.
Lutjeharms, Monteiro, Tyson, and Obura, 2001, S. Afr. J. Sci., 97, 119-130.
Llido J., 2004, Variabilité spatiale et temporelle du système biologique dans la Convergence Subtropicale au sud de l'Afrique. PhD University Paul Sabatier, Toulouse, France, 303 pp.

3. the western tropical Pacific

- Introduction - The influence of two main ecosystems is observed in the western tropical Pacific region :

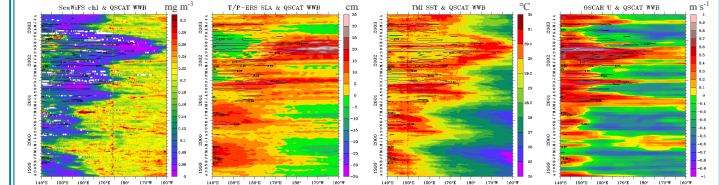


Sep. 1999 SeaWiFS chlorophyll (mg m^{-3})

▪ in the east: cold and salty waters of the equatorial upwelling with High Nutrient-Low Chlorophyll (HNLC) characteristics (chl>0.1 mg m^{-3}). Biological activity at intraseasonal (tropical instability waves, equatorial Kelvin waves) and ENSO scales.
▪ in the west, warm (T>28°C) and cold warm pool waters with oligotrophic characteristics (chl<0.1 mg m^{-3}). Biological variability at intraseasonal scale associated with intraseasonal westerlies and interannual scale related to ENSO disruption.

- Data - In a first step, we gathered satellite-derived products: SeaWiFS chlorophyll (McClain et al., 1998), T/P-ERS2 sea level anomaly (SLA) (Le Traon et al., 1998), QuickScat winds (Pegion et al., 2000), TMI SST (Chelton et al., 2000), and the OSCAR satellite-derived near-surface currents (Bonjean and Lagerloef, 2002).

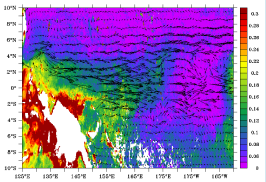
- Evolution of westerly winds, surface chlorophyll, SLA, SST, and surface zonal current along the equator -



Longitude-time diagrams of chlorophyll, SLA, SST, and zonal current from Aug. 1999 to Aug. 2003. The 2 m s^{-1} (black) and 5 m s^{-1} (purple) zonal wind speed are superimposed on each diagram.

La Niña: mid-1998 - mid-2001 low westerly wind activity, strong South Equatorial Current (SEC), high SLA in the west, poor and warm water pool west of 170°E
Intensification of westerly wind activity: mid-2001 - mid-2002 eastward migration of the warm pool, pulses of eastward surface current. In the west: SLA decrease, SST decrease, and chl increase
Peak of El Niño: end of 2002 strong westerly wind activity, eastward surface current, poor and warm water at 180°W-160°W. In the west: low SLA, SST < 29.5°C, chl > 0.1 mg m^{-3}
Waning of the event: early 2003 low westerly wind activity, strong SEC. In the west: SLA increase, SST increase, and chl decrease

- Discussion - During El Niño event, in the western Pacific:
SLA decrease ⇒ uplift of the deep nutrient pool
▪ ⇒ higher biological production ⇒ higher background chl level
▪ ⇒ WWB are more efficient to entrain nutrient into the euphotic layer (Siegel et al., 1995) ⇒ higher phytoplankton biomass
▪ Zonal advection of chl rich water from the west by the eastward surface flow is a very likely process as suggested by the October 2002 situation. Chl poor waters are located in the region of current convergence
▪ An insight into the thermo-haline and circulation vertical structures will be given by *in situ* temperature, salinity, and current derived from the TAO/TRITON moorings



Oct. 2002 SeaWiFS chlorophyll (color scale) and OSCAR near-surface current (vectors)

Bonjean and Lagerloef (2002) Diagnostic model and analysis of the surface currents in the tropical Pacific ocean. J. Phys. Oceanogr., 32, 10, 2938-2954
Chelton et al. (2000) Satellite microwave SST observations of transequatorial tropical instability waves. Geophys. Res. Let., 27, 1239-1242
Le Traon et al. (1998) An improved mapping method of multisatellite data. J. Atmos. Oc. Tech., 13, 522-534
McClain et al. (1998) Science quality SeaWiFS data for global biosphere research. Sea Tech., 39, 10-16
Pegion et al. (2000) Objectively derived daily "winds" from satellite scatterometer data. Mon. Wea. Rev., 128, 3150-3168
Siegel et al. (1995) Solar radiation, phytoplankton pigments and the radiant heating of the equatorial Pacific warm pool. J. Geophys. Res., 100, 4885-4891