Ocean Dynamics from Space

New understanding of intense current dynamics from high resolution satellite sensor synergy

J.A.Johannessen, B. Chapron, F. Collard, V. Kudryavtsev, J. Tournadre

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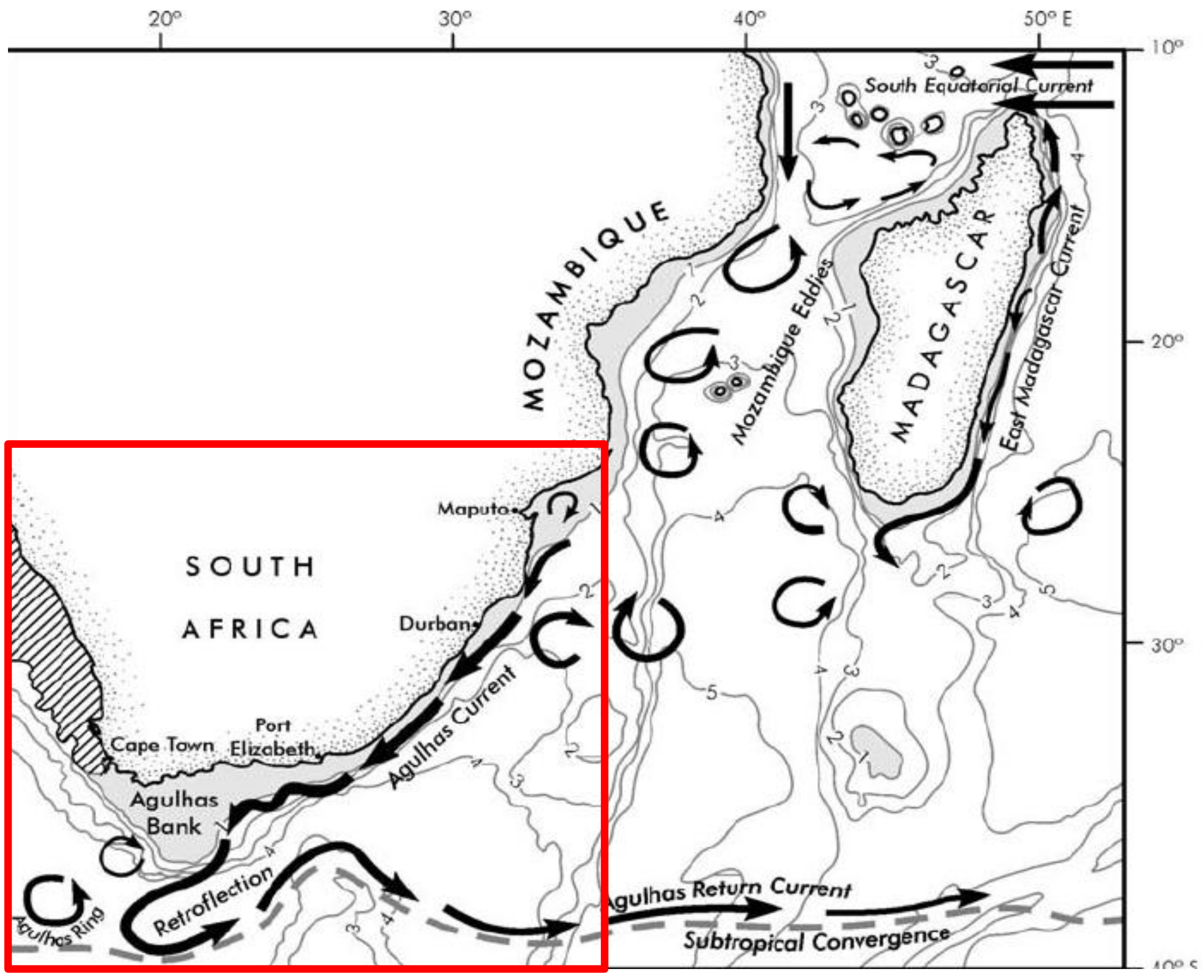
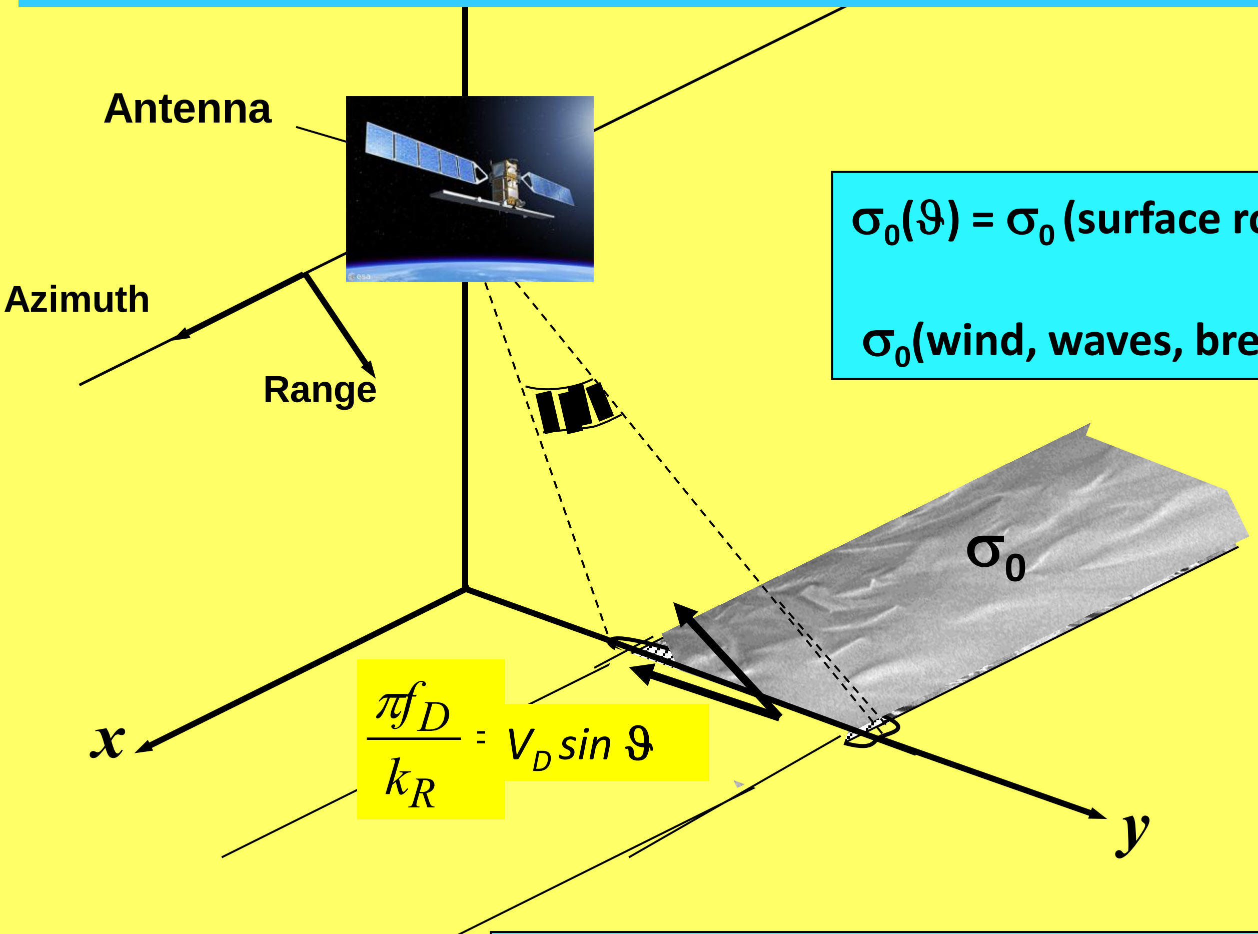
Ocean Dynamics from Space

The greater Agulhas Current regime

- **An excellent natural laboratory** to explore the Doppler anomaly measurements as well as satellite synergy (SAR, RA, IR and OC) and develop new methods for quantitative estimates of current information and surface dynamics.
- Surface current velocities up to 2-3 m/s measured from in-situ platforms
- Rio09 provides the latest MDT based on integrated use of altimetry, surface drifters, Argo floats and GRACE based geoid
- **More than 1200 SAR acquisitions since spring 2007**



APPROACH: SAR Imaging of Roughness and Doppler Shift



$\sigma_0(\vartheta) = \sigma_0$ (surface roughness) =

σ_0(wind, waves, breaking, current

$V_D = V_D$ (wind driven scatterer, waves, breaking, current)

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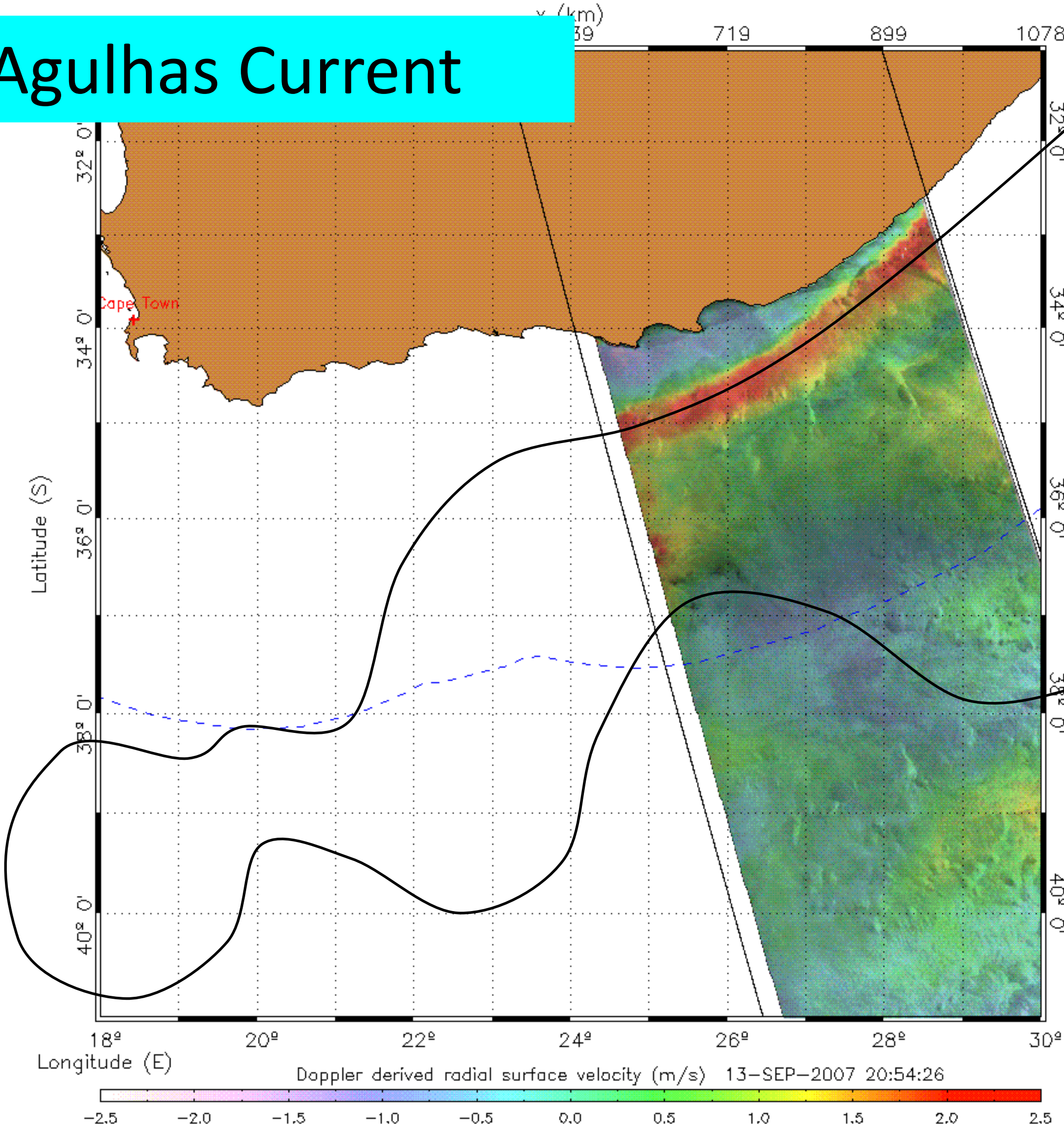
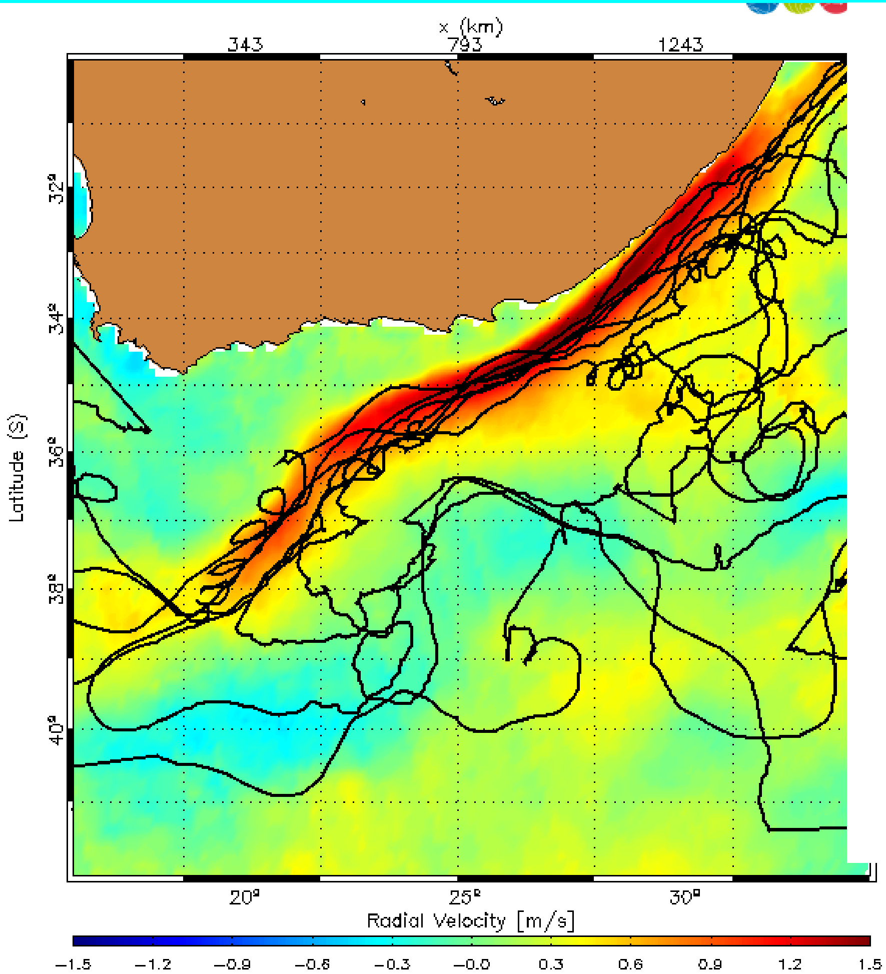
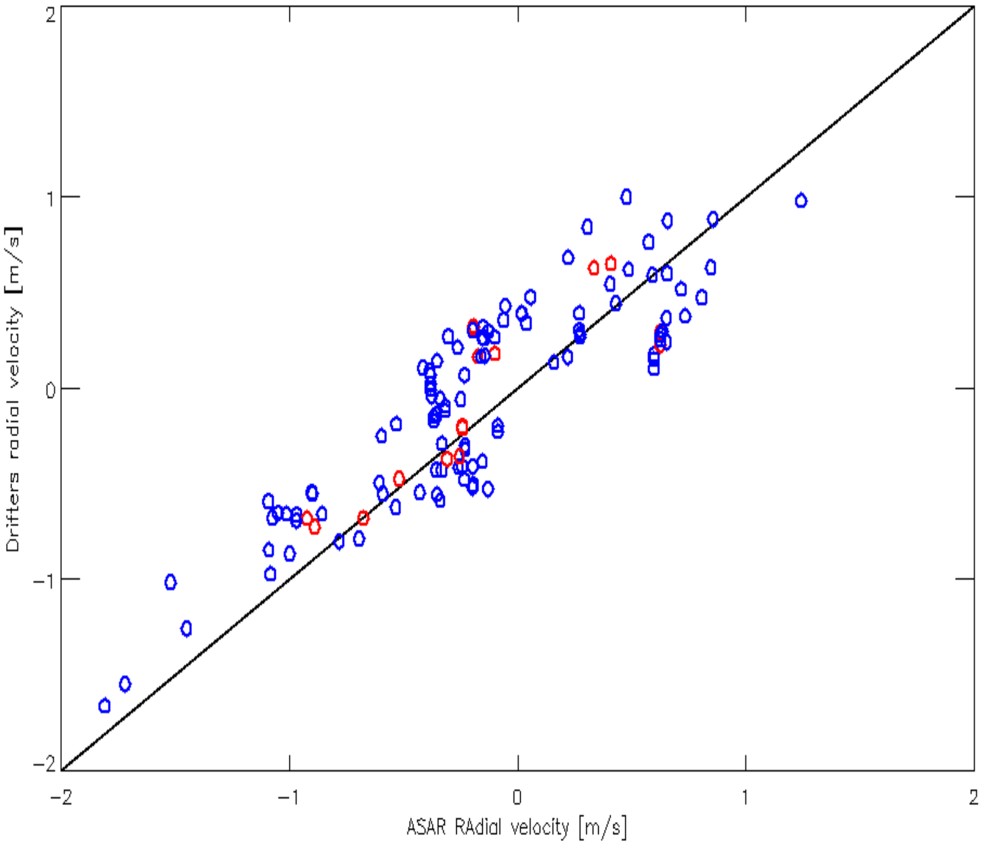
The greater Agulhas Current

Direct measurements of surface flow of the Greater Agulhas Current as obtained from ASAR Wide Swath Mode on 13, 16, 19 and 22 September 2007. The radial surface velocity is marked in the colour bar in metres per second.



Surface drifter trajectory and ASAR range Doppler velocity





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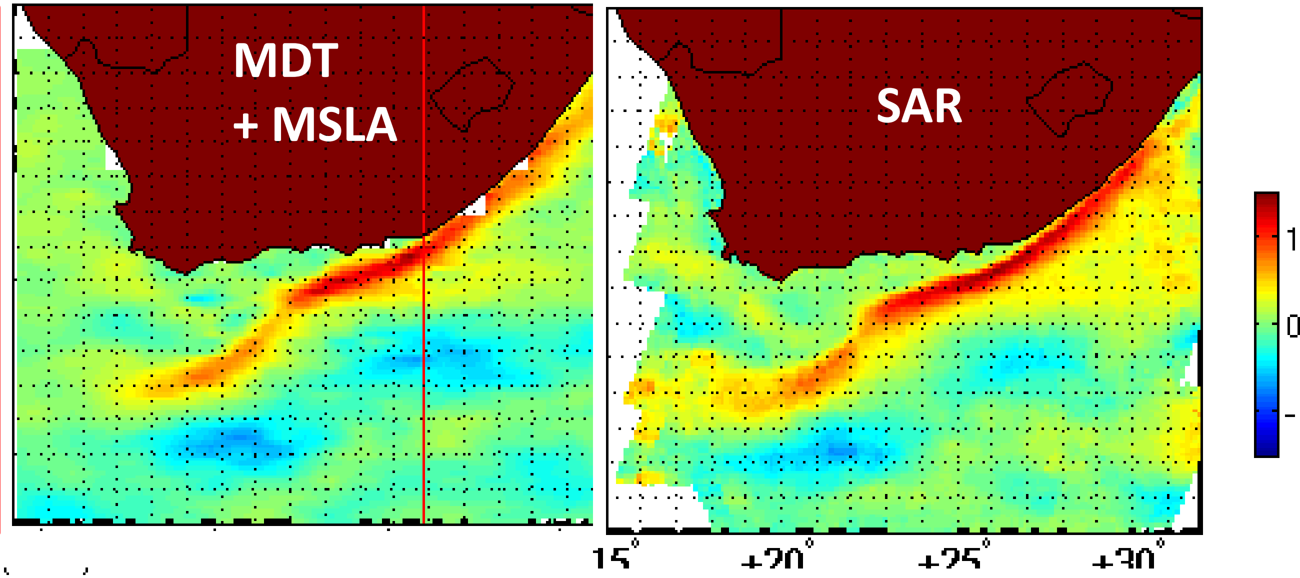
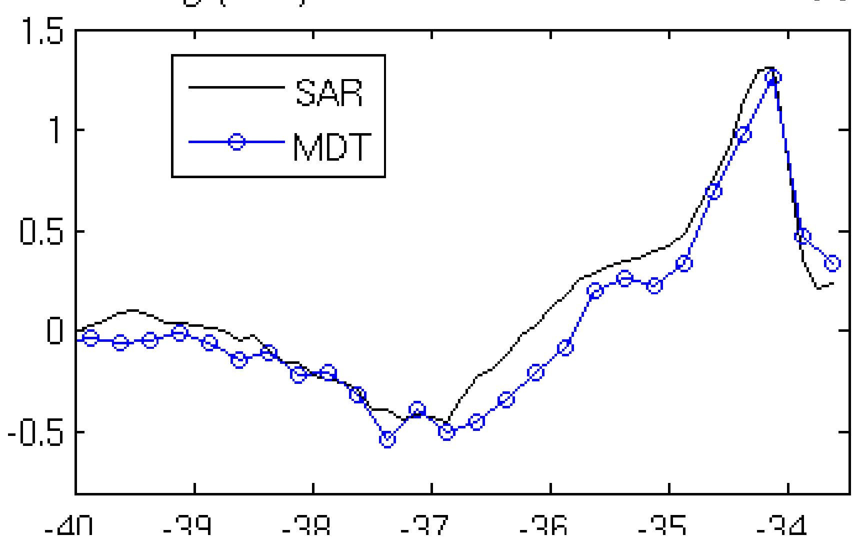
2008-2010: New retrievals of surface velocities from Envisat ASAR

500 km

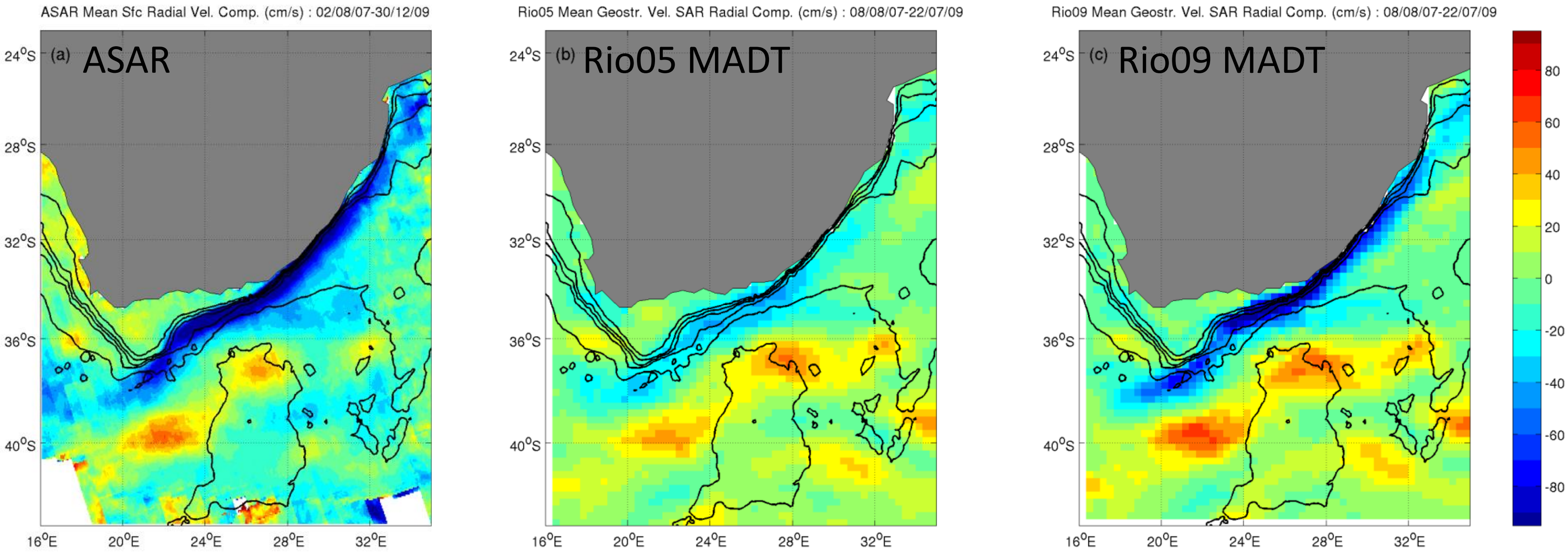




Chapron, Collard, Johannessen
In preparation

Rio05 / Rio09 MADT and SAR velocity comparison

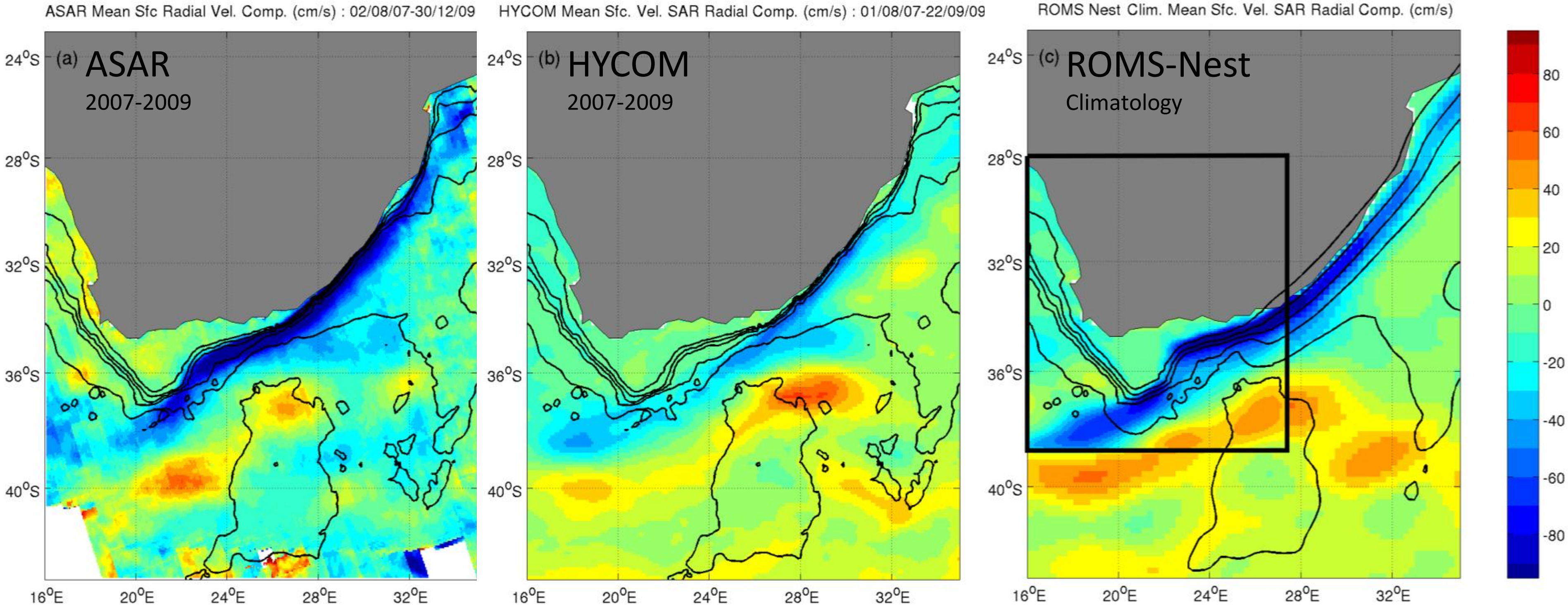
Mean Radial Velocity Component for 2007-2009



Note: 200, 500, 1000, 2000 and 4000 m isobaths plotted

- Agulhas Current radial velocities in Rio05 MADT siginificantly weaker than ASAR observations.
- Rio09 MADT better qualitative comparison to ASAR observations – stronger Agulhas Current core.

Model-SAR surface radial velocity comparison



Note: 200, 500, 1000, 2000 and 4000 m isobaths plotted

- High resolution nest (~9 km) of ROMS over Agulhas Bank has more realistic bathymetry.
- Demostrates superior topographic stearing of sigma-coordinate regime in Agulhas region (?)

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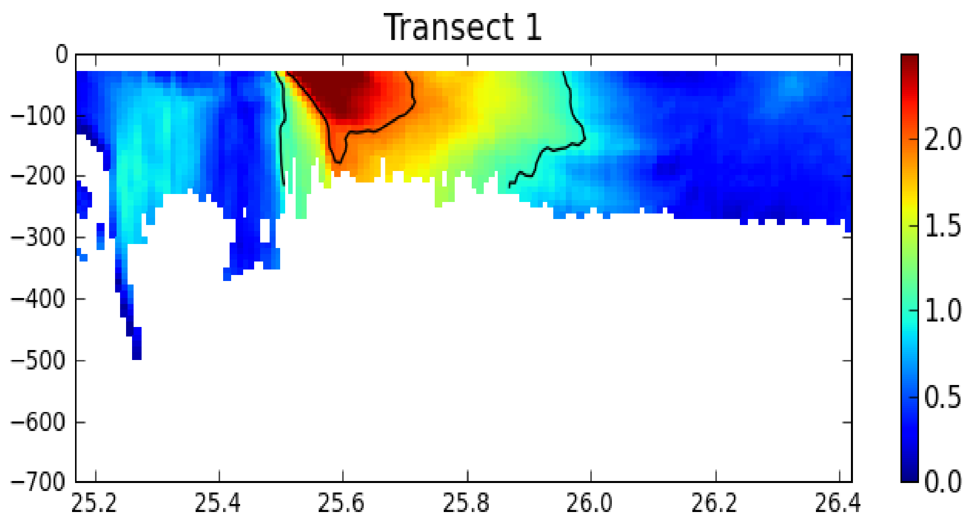
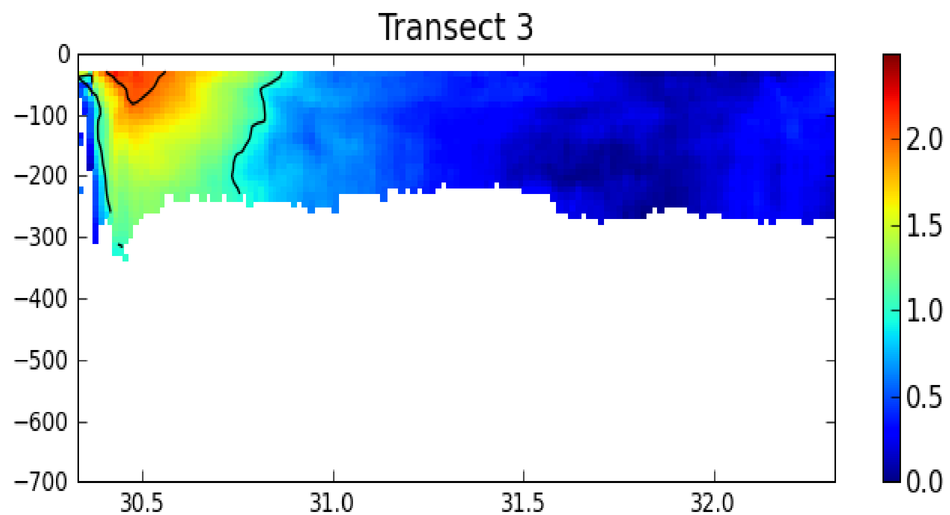
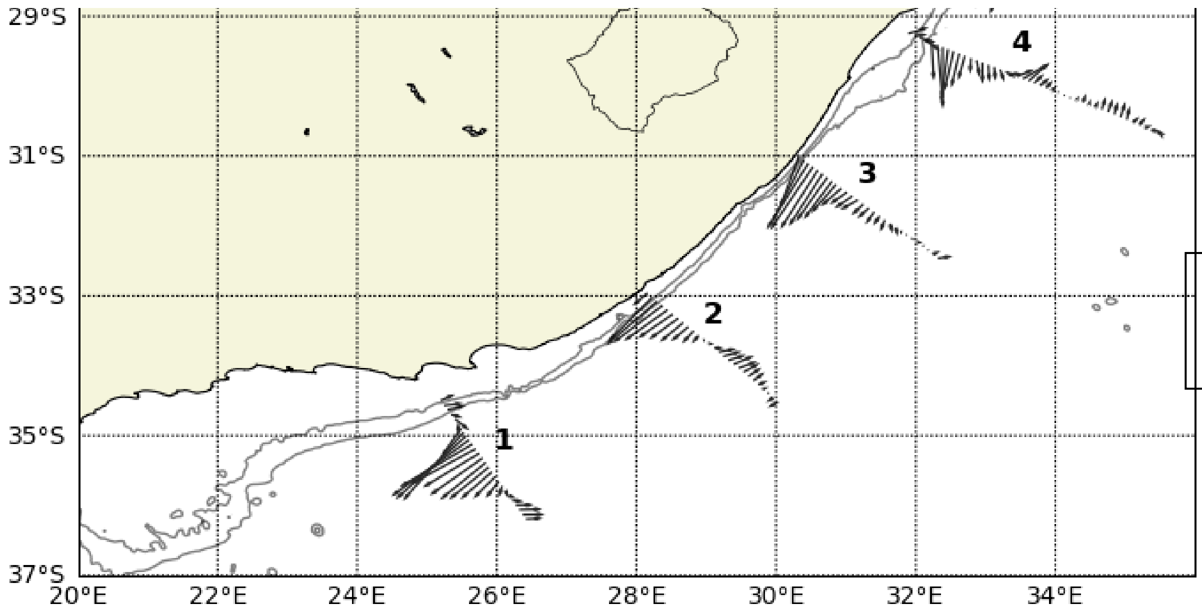


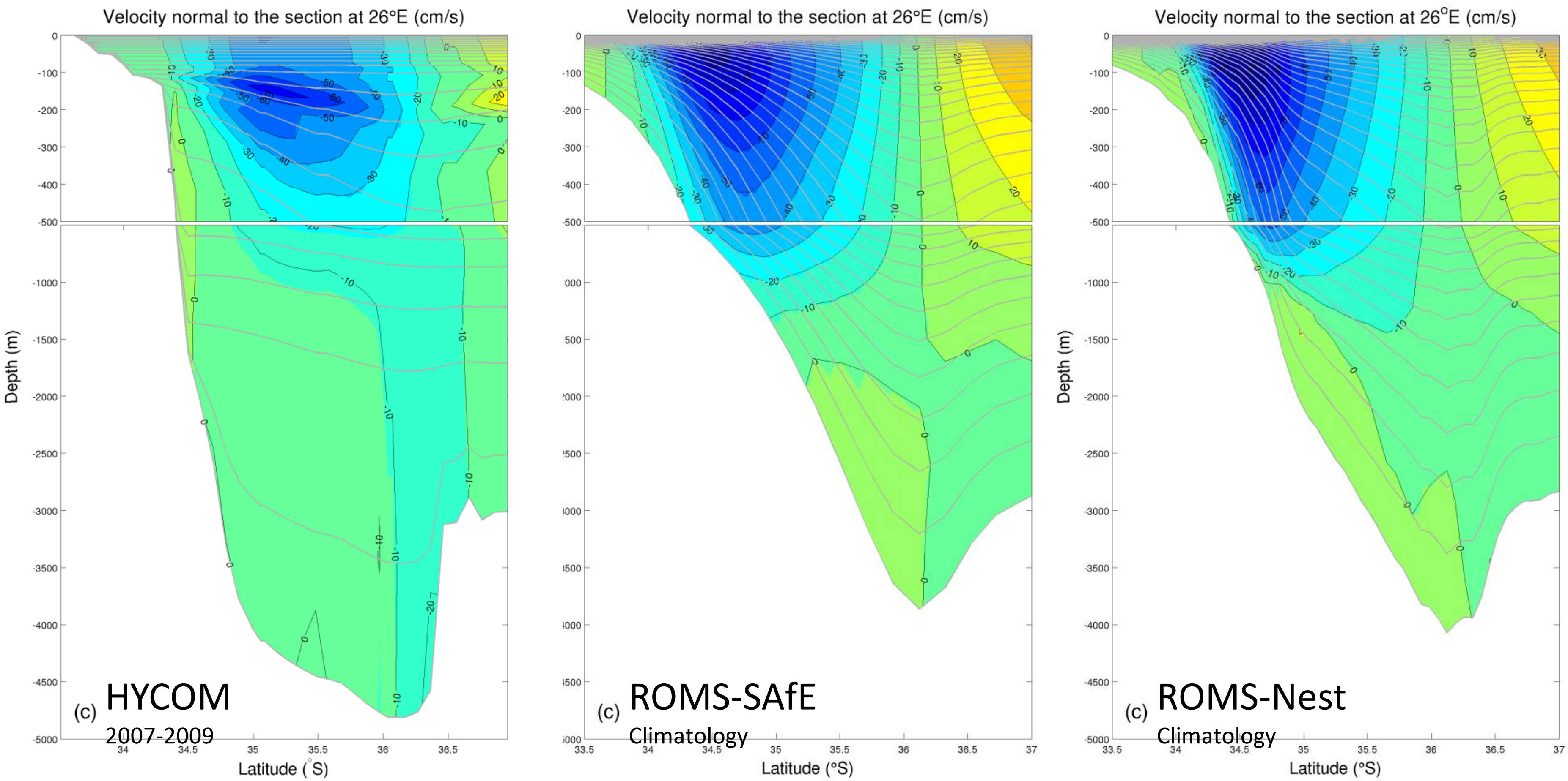




Courtesy Beal from AUCE campaign

Model comparison of the Agulhas vertical structure

North-South section at 26°E



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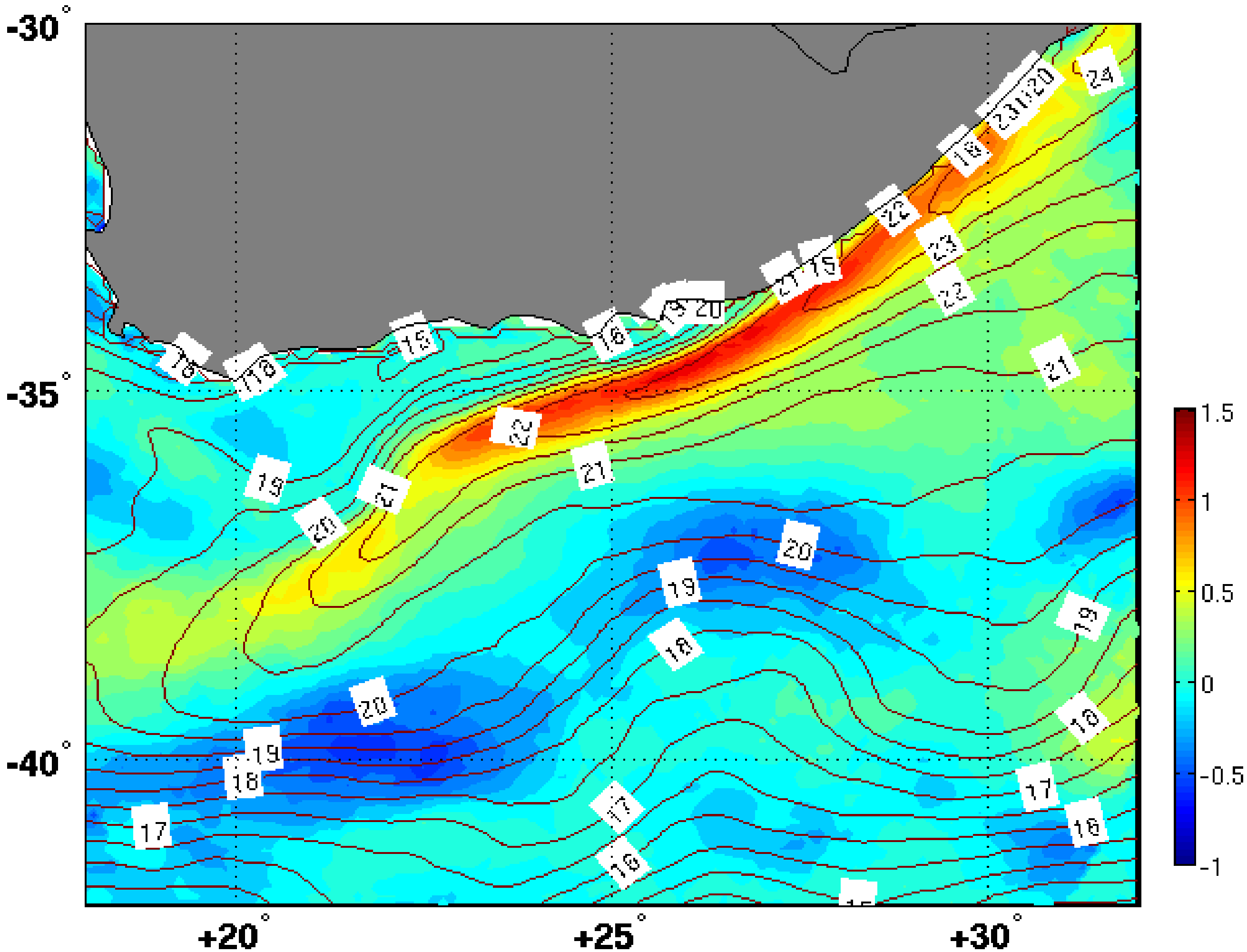
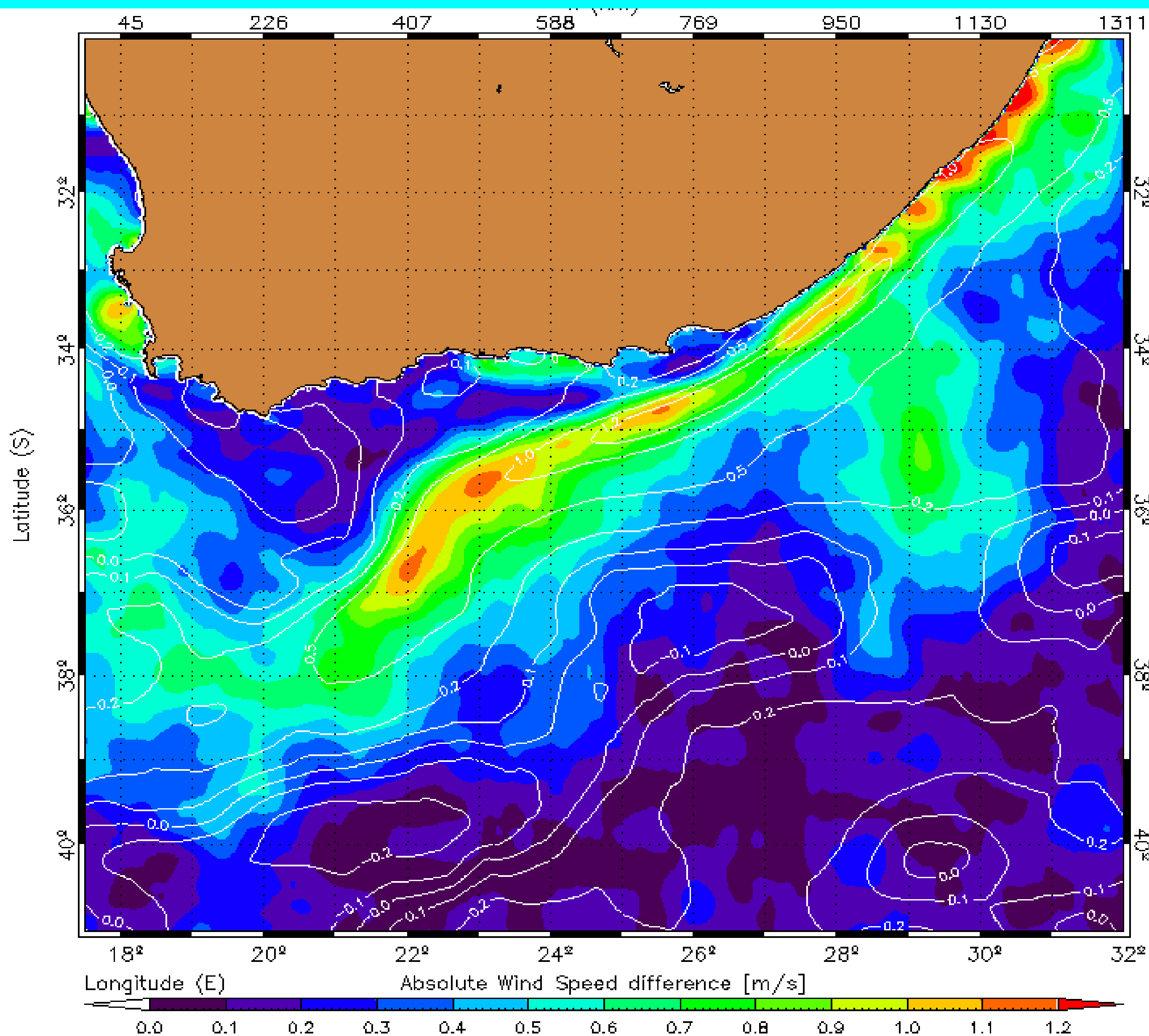
Climatology: Range Doppler velocity & Sea Surface Temperature



Climatology: Annual wind speed difference ASCAT - ECMWF



Reconstruction of Surface Currents from SST

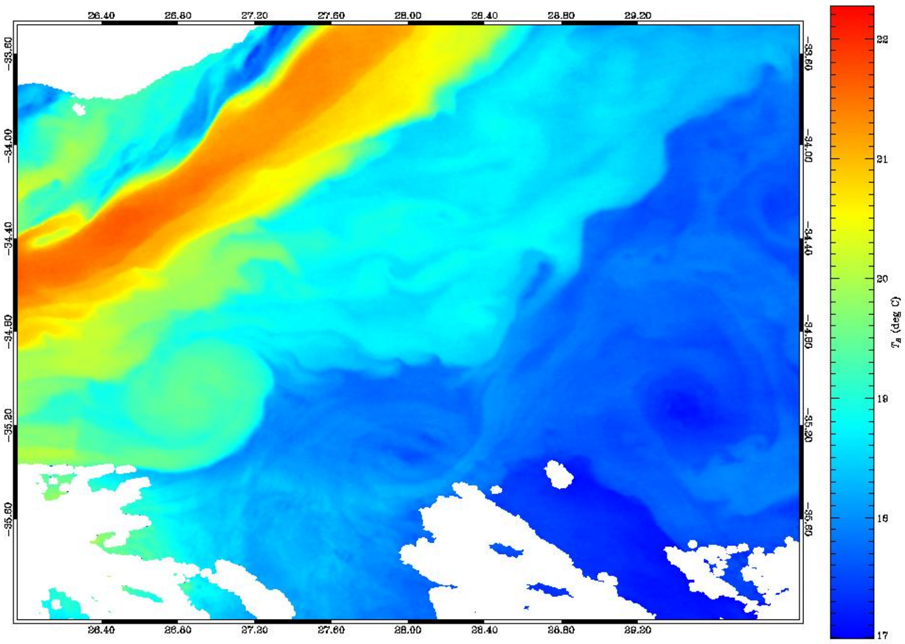
1. Surface Quasi – Geostrophy fields

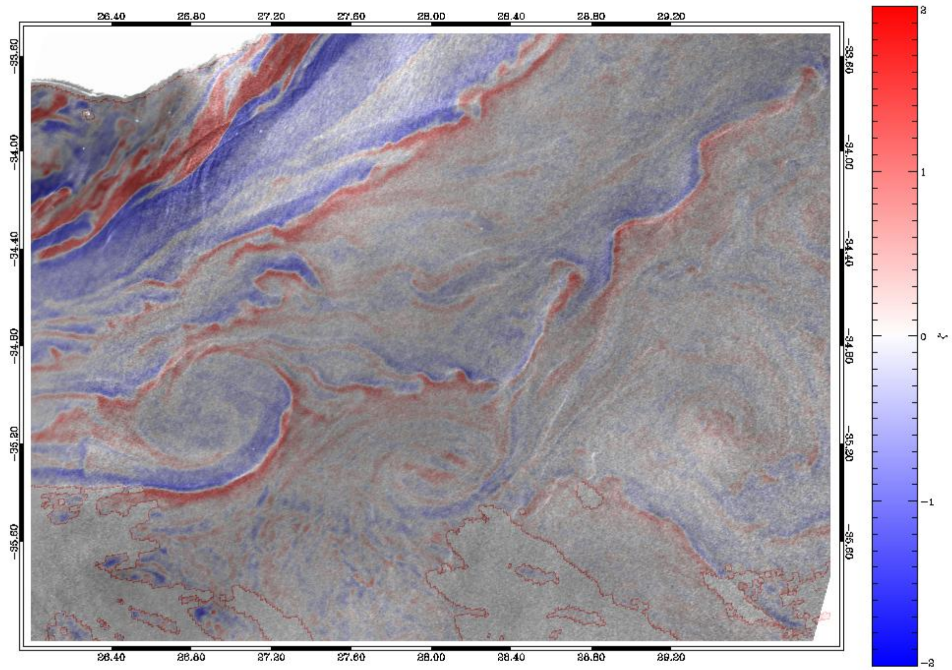
QG Stream-function

$$\mathbf{SST}\,(T_s)\ \rightarrow\ \psi(\mathbf{k},z)=\frac{g\alpha T_s(\mathbf{k})}{fn_b k}\exp(n_0 kz)$$

Vorticity of the surface QG current

$$\Omega_z(\mathbf{k})=k^2\psi(\mathbf{k})=\frac{g\alpha}{fn_b k}k^2 T_s(\mathbf{k})$$





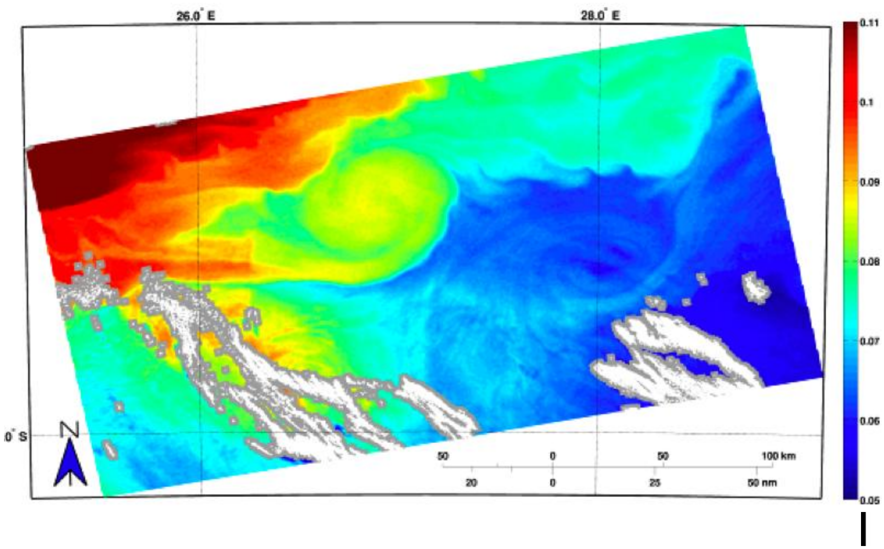
Reconstruction of Surface Currents from SST

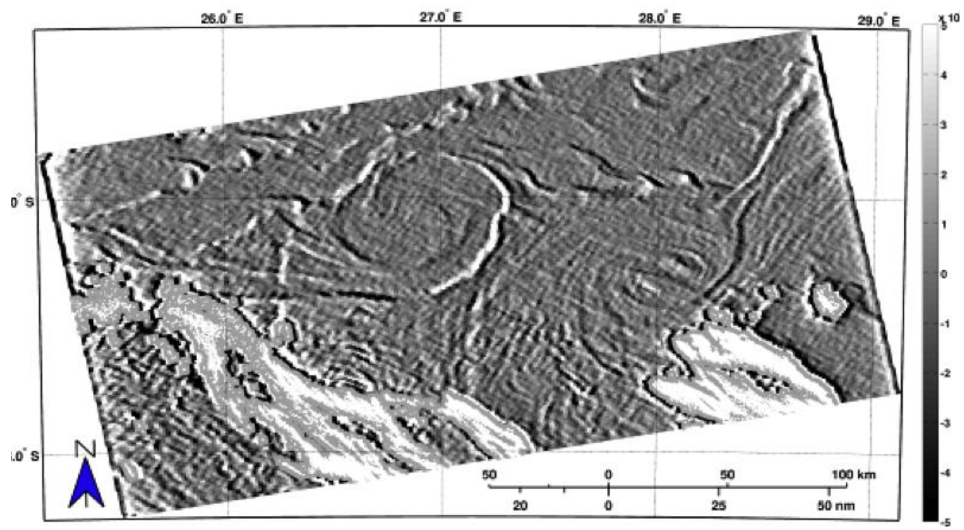
2. Interactions Ekman and SQG currents (after Klein and Hua, 1990)

$$\tilde{u}_1 = -f^{-1}\bar{u}_j \frac{\partial U_2}{\partial x_j}, \quad \tilde{u}_2 = f^{-1}\bar{u}_j \frac{\partial U_1}{\partial x_j}$$

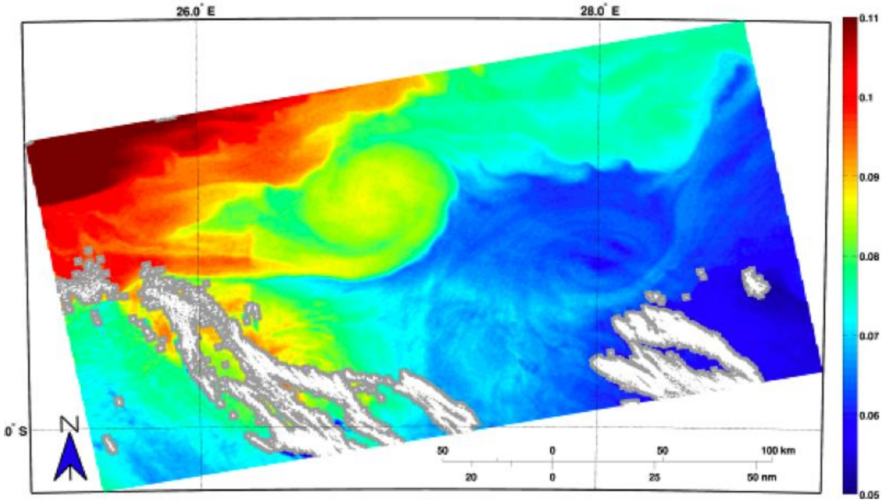
3. Generation of vertical pumping (convergence/divergence)

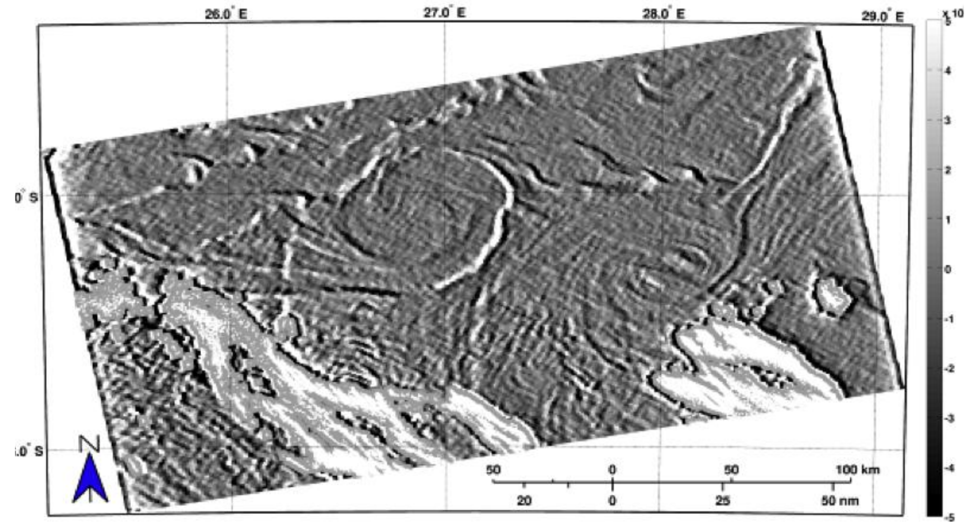
$$\nabla \cdot \boldsymbol{V} = -f^{-1}\bar{u}_j \frac{\partial}{\partial x_j}\Omega_z$$

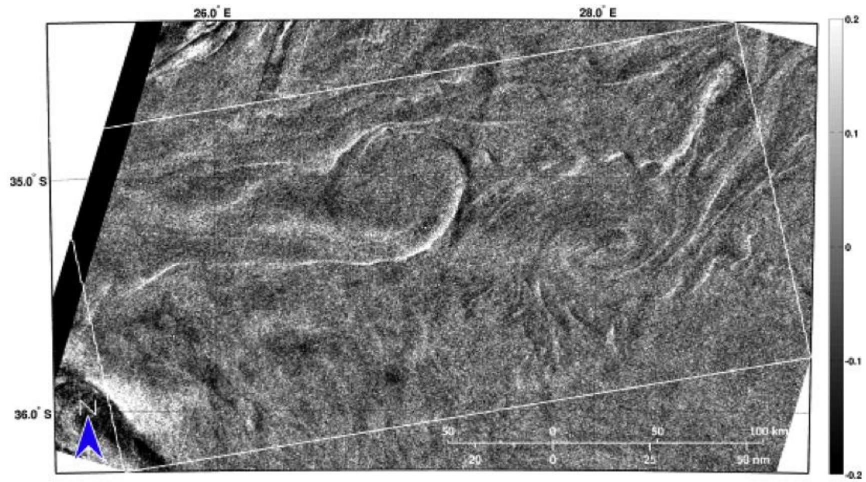




Reconstruction of Surface Currents from SST

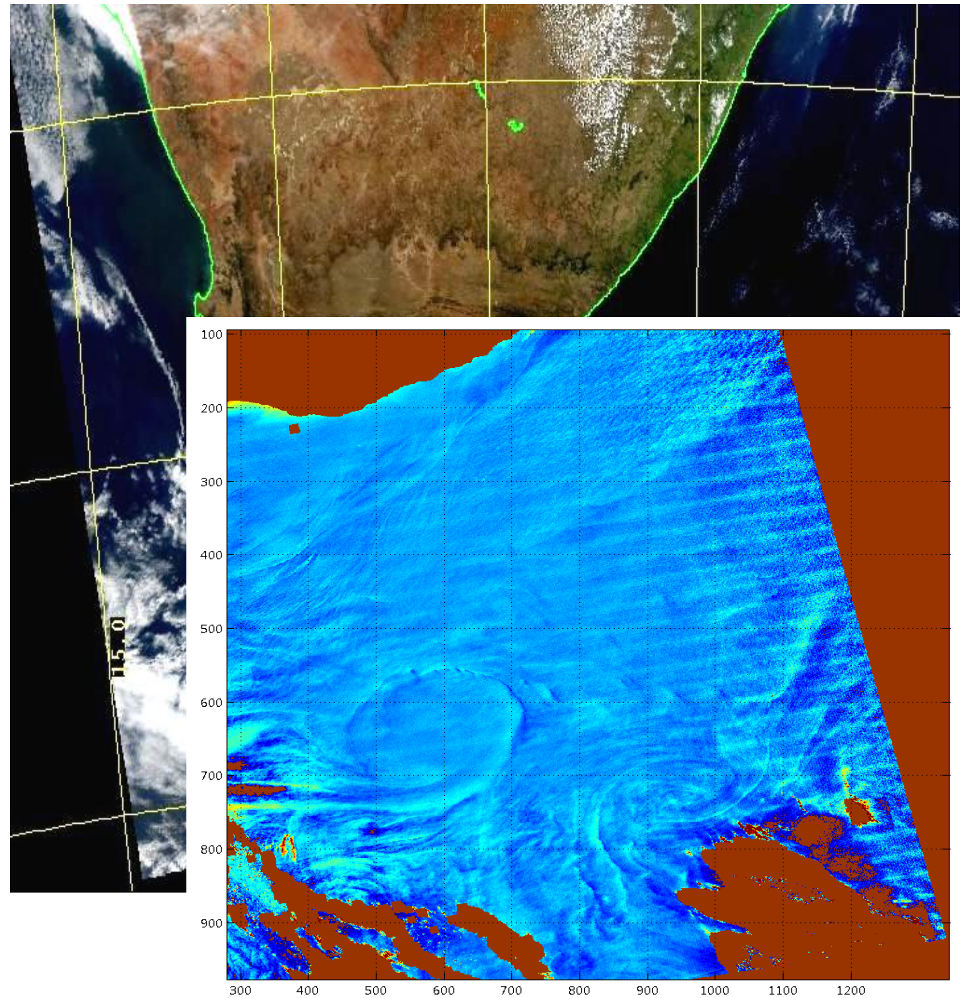




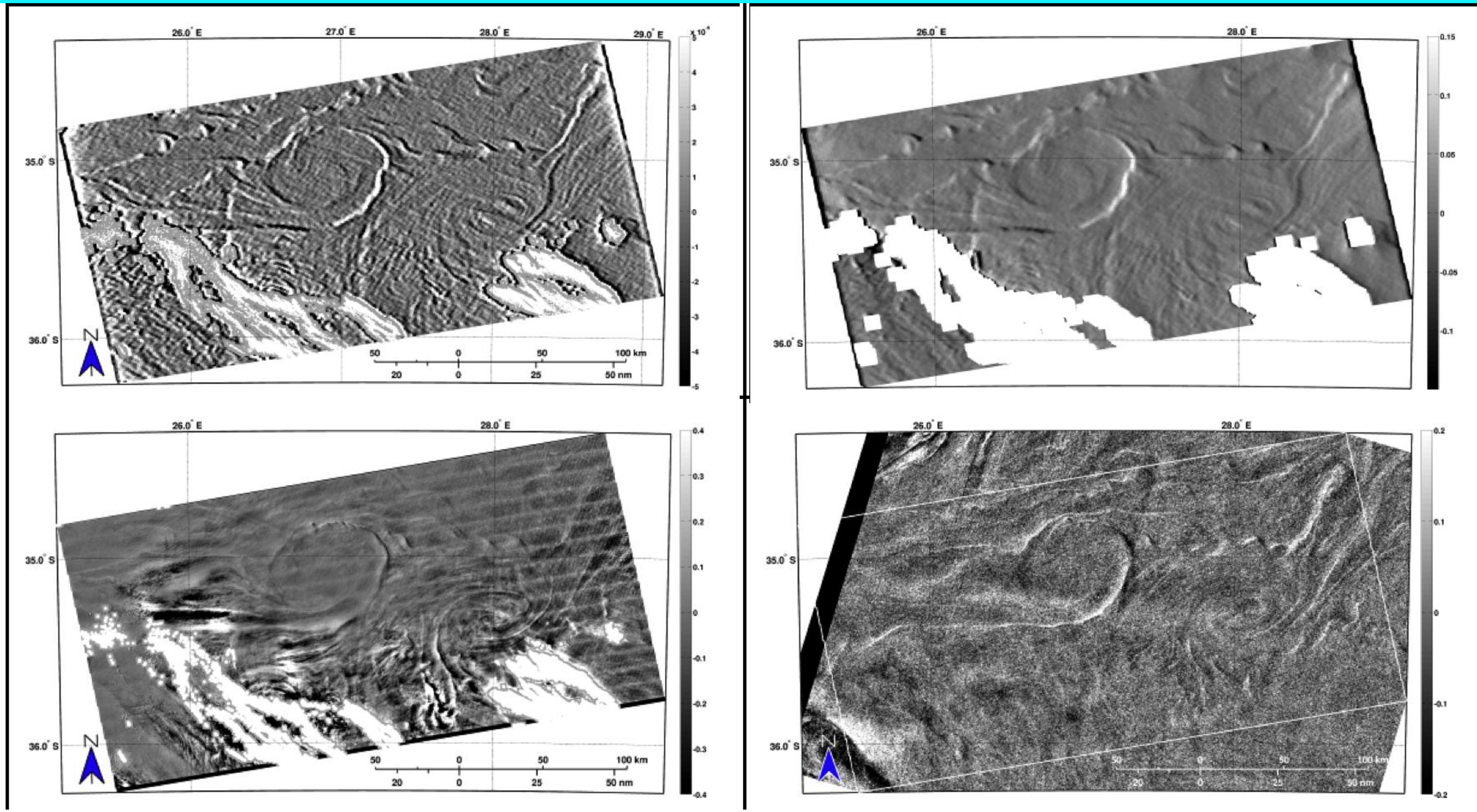


The SAR roughness

Taking advantage of the sunglint!

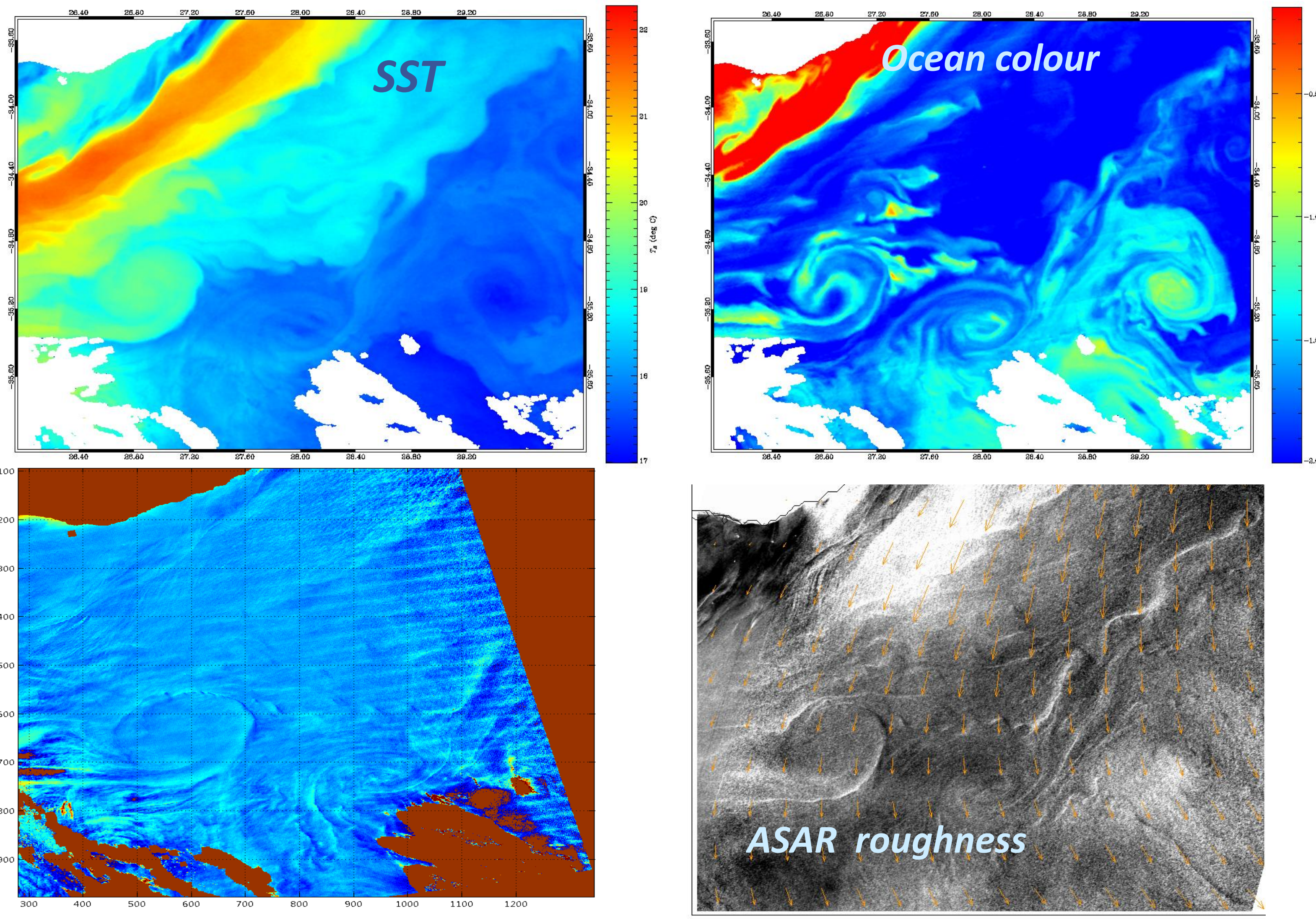


(Upper left) Divergence of the surface current derived from the SST field. Bright (dark) banded areas correspond to the current convergence (divergence). RIM simulations of contrasts in the MSS (upper right), reflected shortwave signal (lower left) and observed SAR image(lower right)



Courtesy - V. Kudryavtsev, A. Myasoedov, B. Chapron, J.A. Johannessen, F. Collard

Synergy: Mesoscale Processes



Challenges and Future work

- Motions at small scales are key ingredients of the ocean dynamics. A new innovative approach combining remote sensing synergy (altimetry, SST, colour, surface wind), realistic high-resolution modeling and theoretical idealized models is needed. This would stimulate and increase research.

- Power increase of supercomputers with numerical simulations at very high resolution (500 m-1 km) over regional scales are now possible. As such, a stronger complementarity can now be foreseen between observations and numerical results with similar resolution.

- **Build a dynamically-constrained mapping capability to reconstruct the full 3D motion in the upper oceanic layers from very high resolution satellite data (optical and radar imagery, sea surface temperature) combined with lower resolution data such as sea surface height from altimetry**.

- Major advances in ocean modeling via increased use of high resolution satellite observations. Higher resolution and improved physics are two major ingredients to improve the global and regional ocean monitoring and forecasting systems.

- More work on this concept is highly needed by a larger international team sharing expertise and capacity and the importance of dedicated upper ocean in-situ experiments is not forgotten.