Observation of swell pattern and energetic surface currents with synthetic aperture radar

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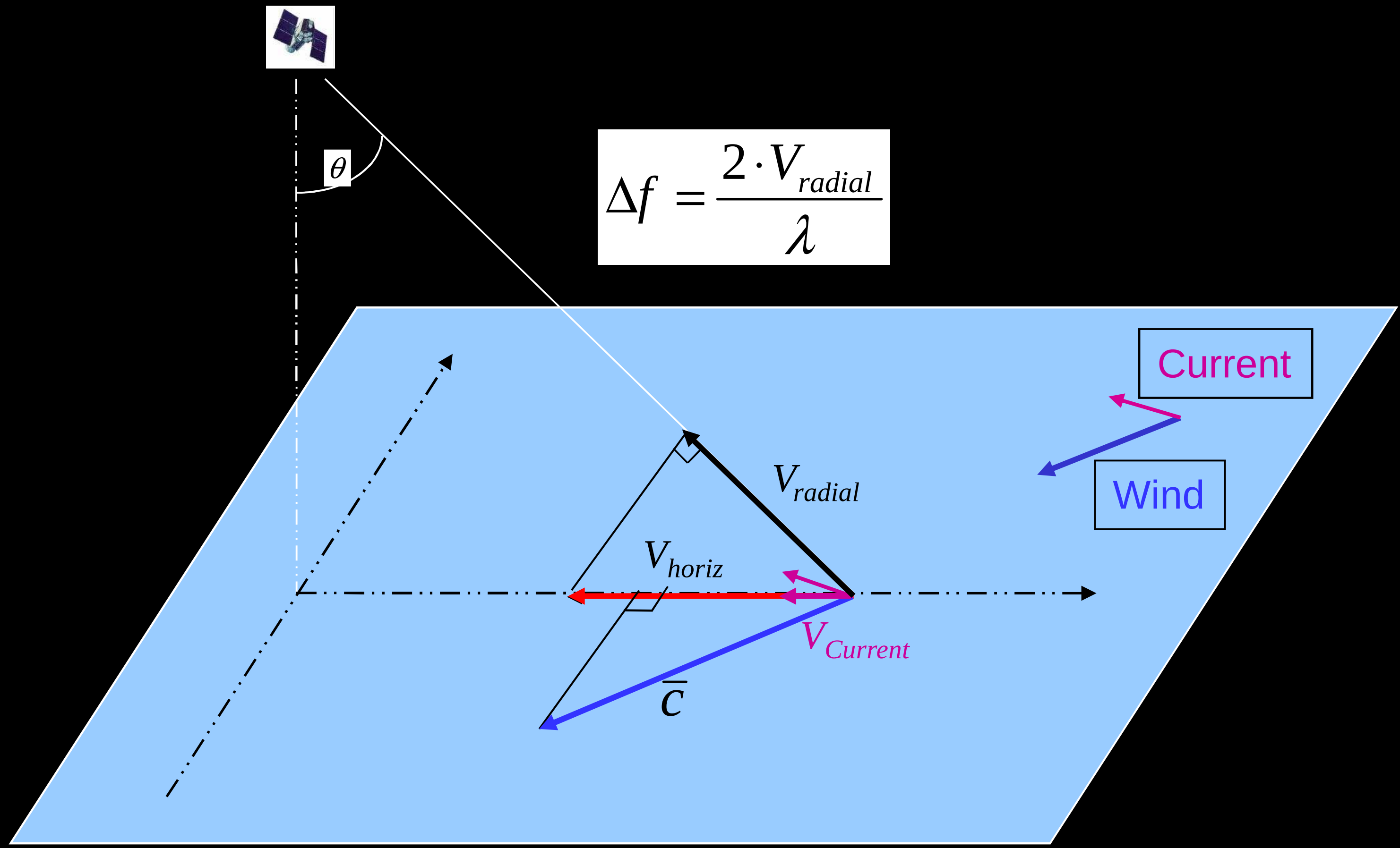
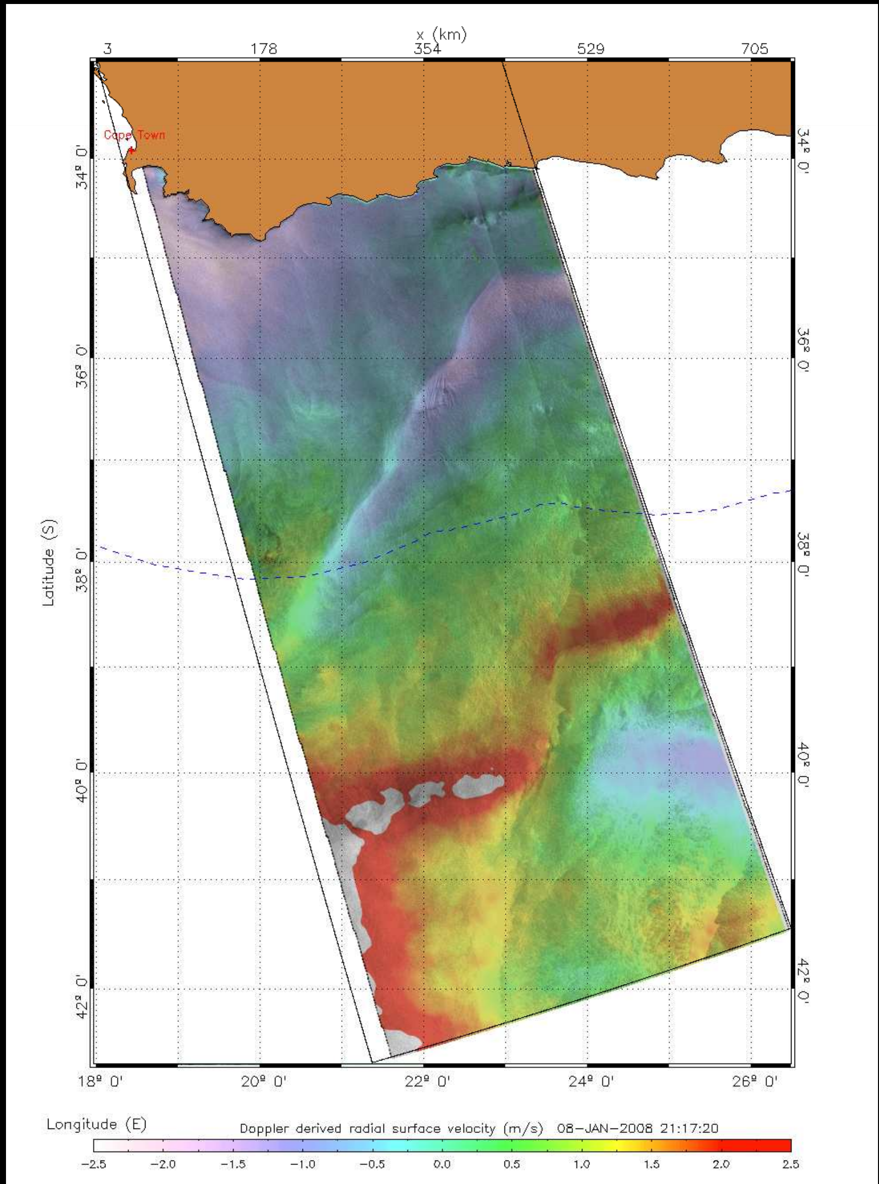
From Doppler shift to surface current velocities

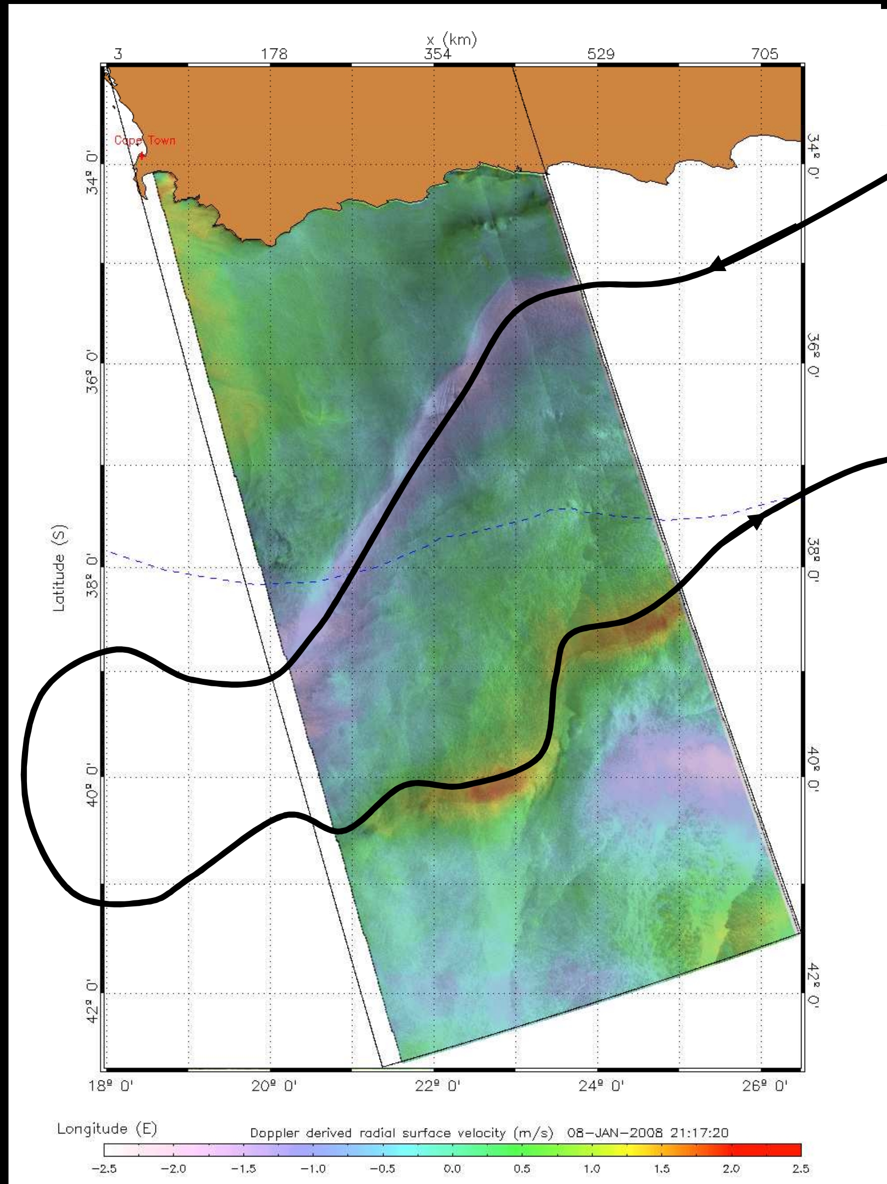


retrieval of Surface Currents from Doppler shift

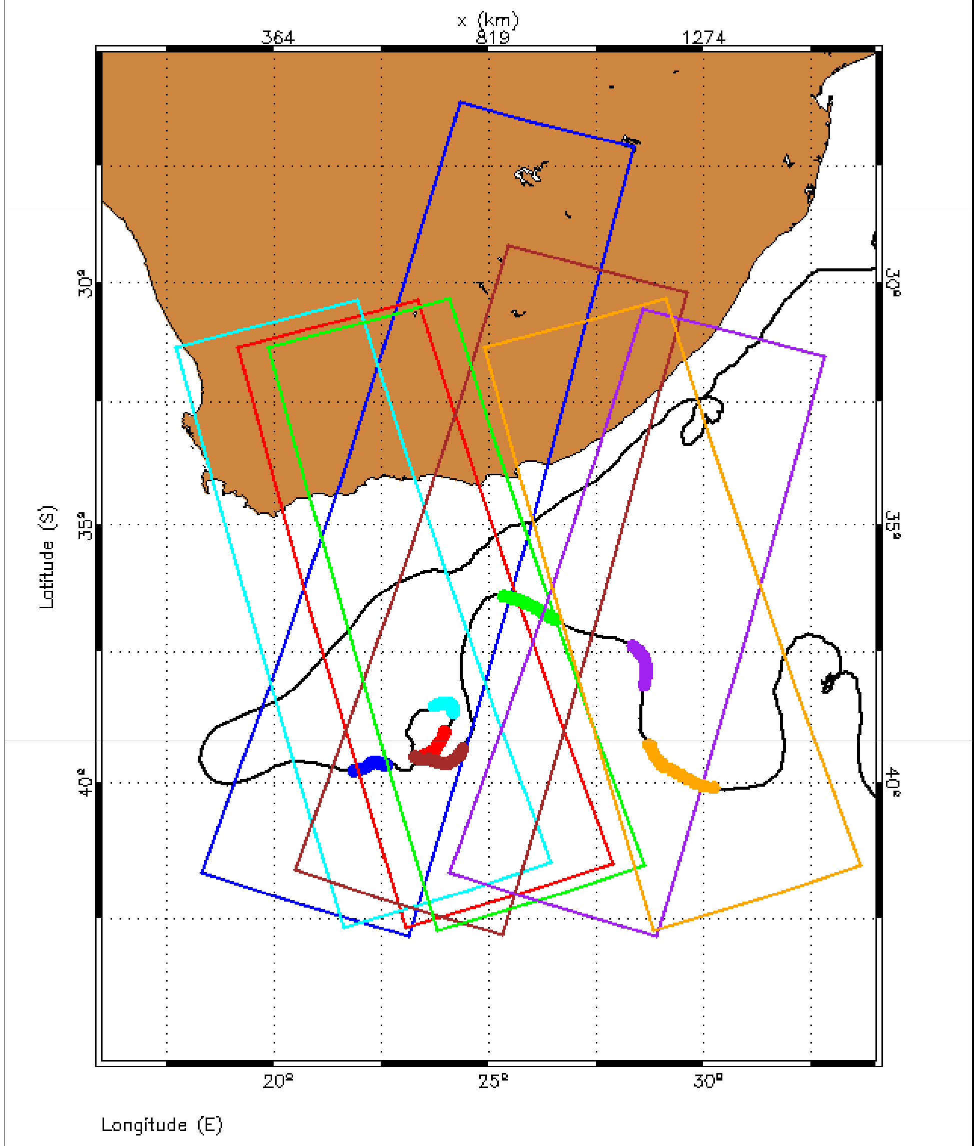
- Doppler velocities

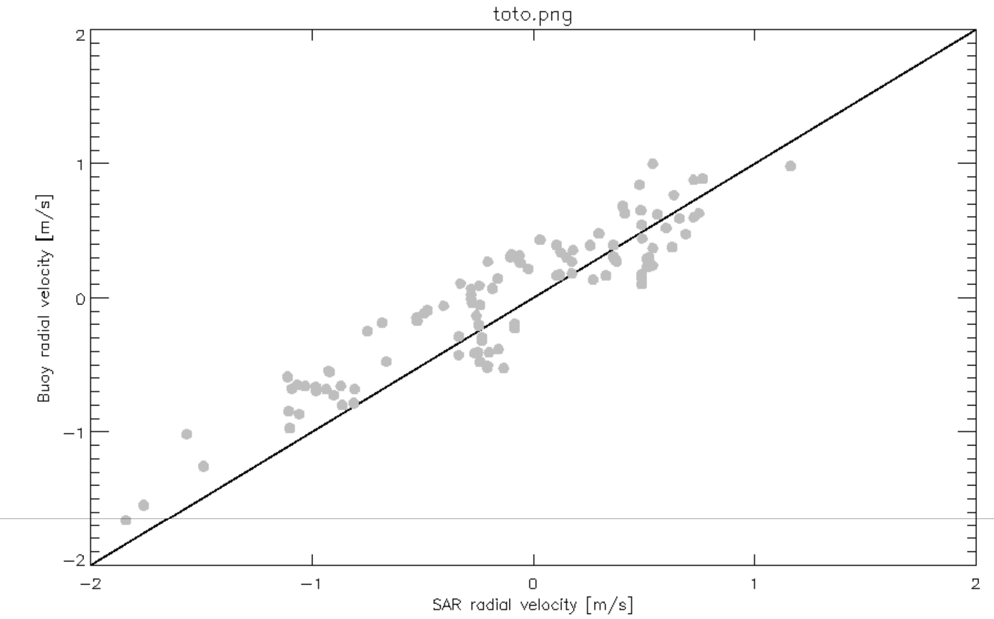


- Residual velocities

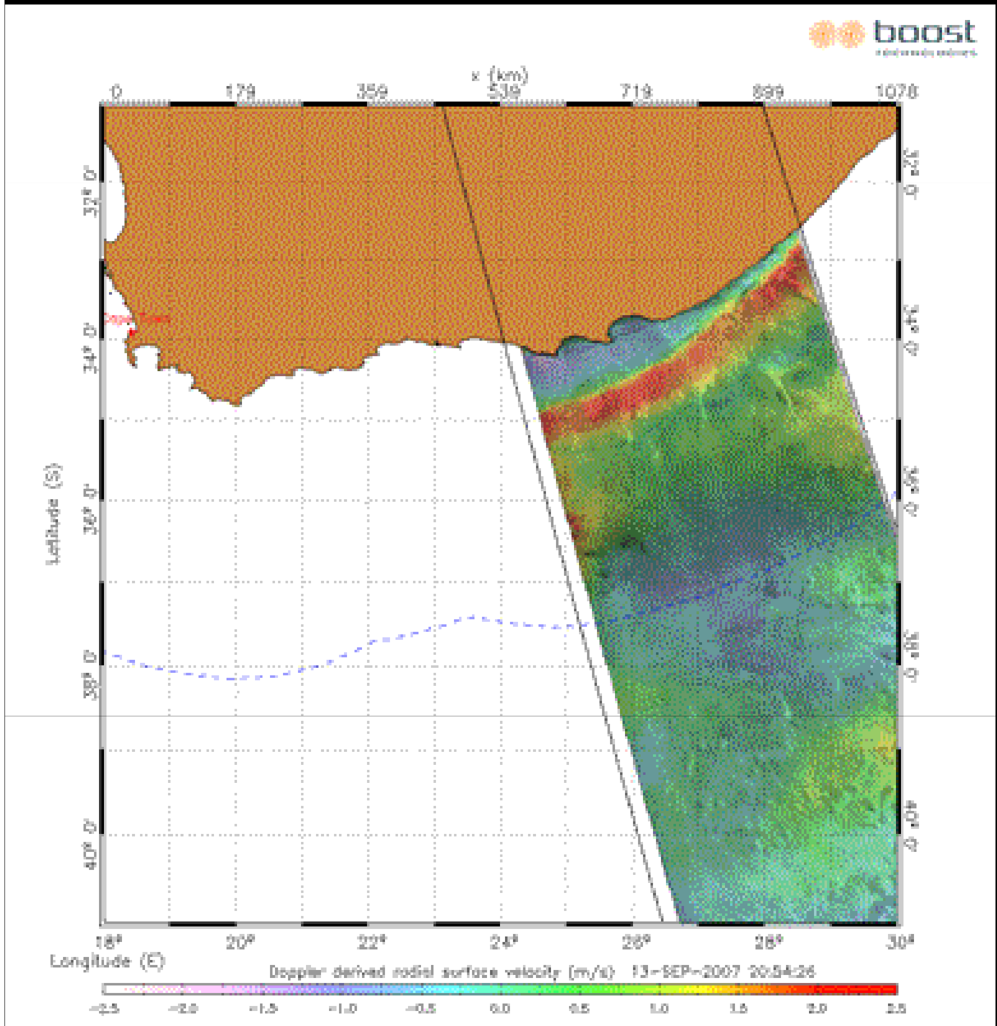


Comparison with a lagrangian drifter (15m depth)

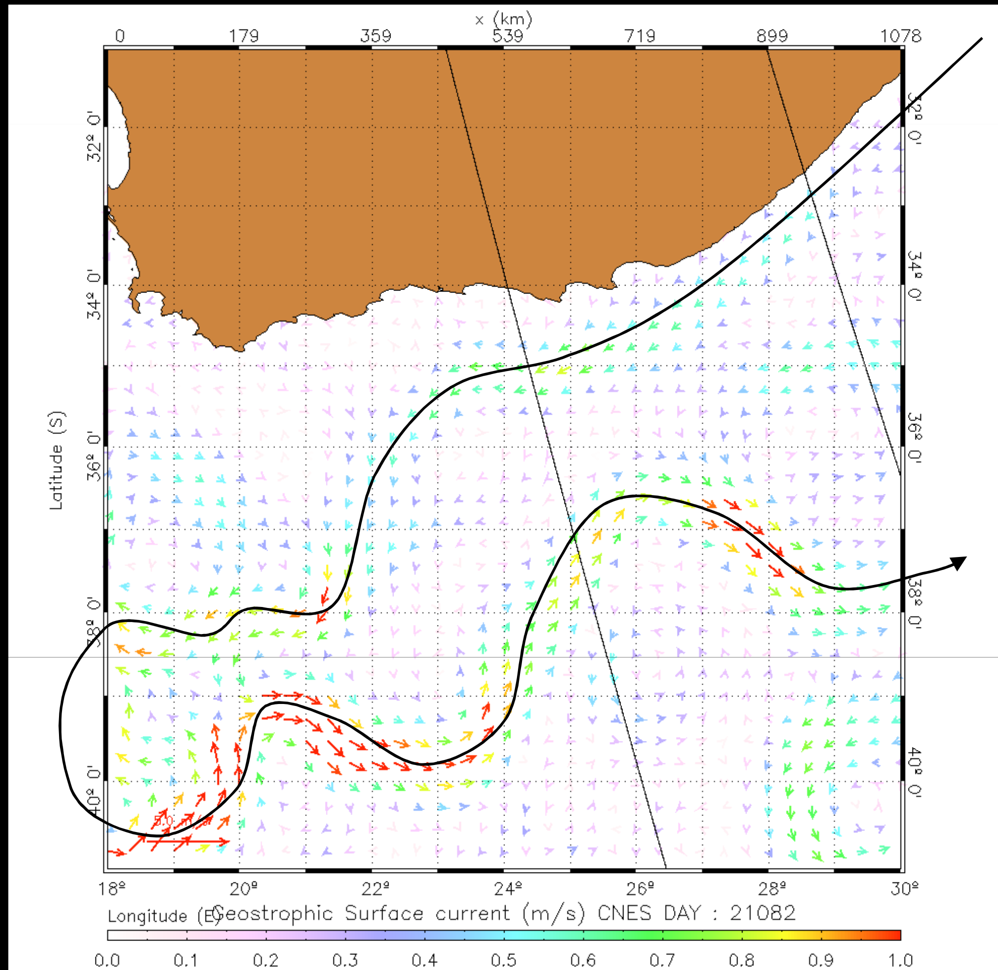




SAR observation of strong surface currents



Map of surface velocity of the Agulhas Current using SAR Doppler information

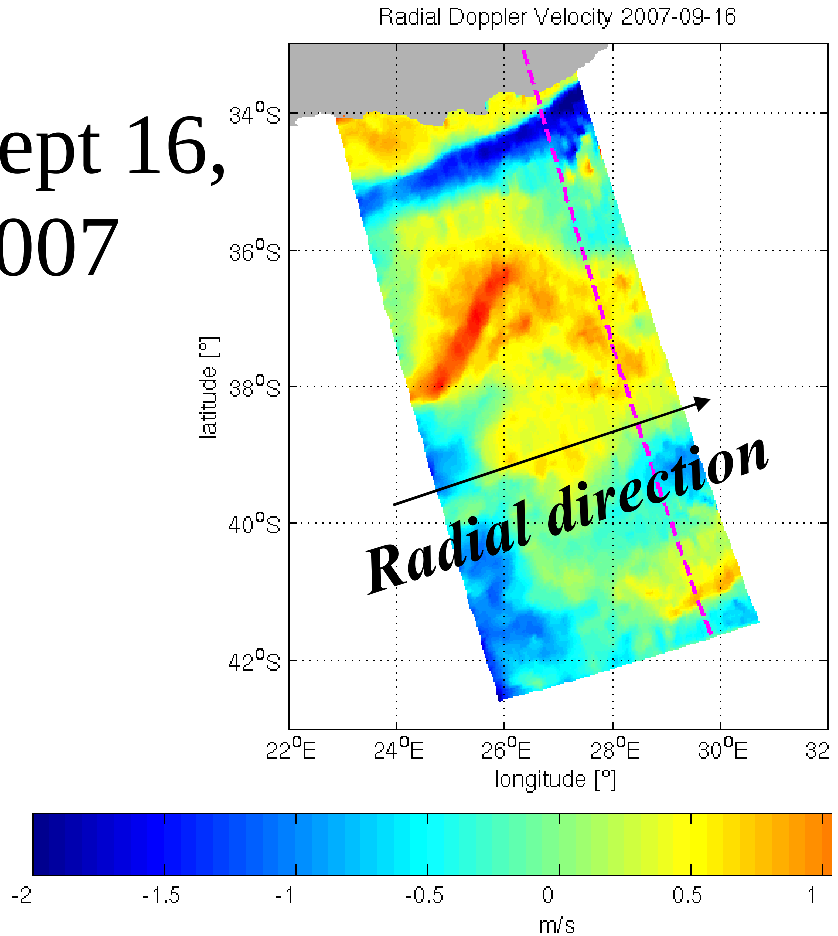


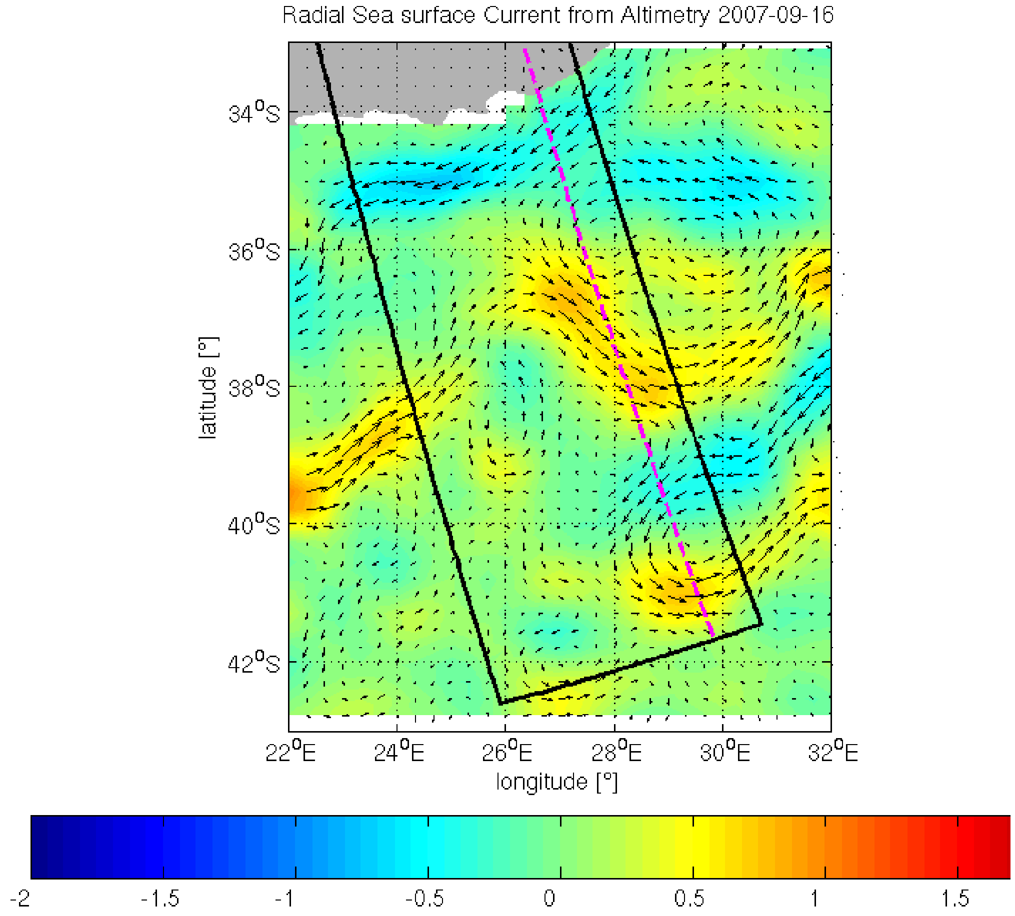
Altimetry derived geostrophic surface current : 3 days mean

SAR vs. conventional altimetric surface currents

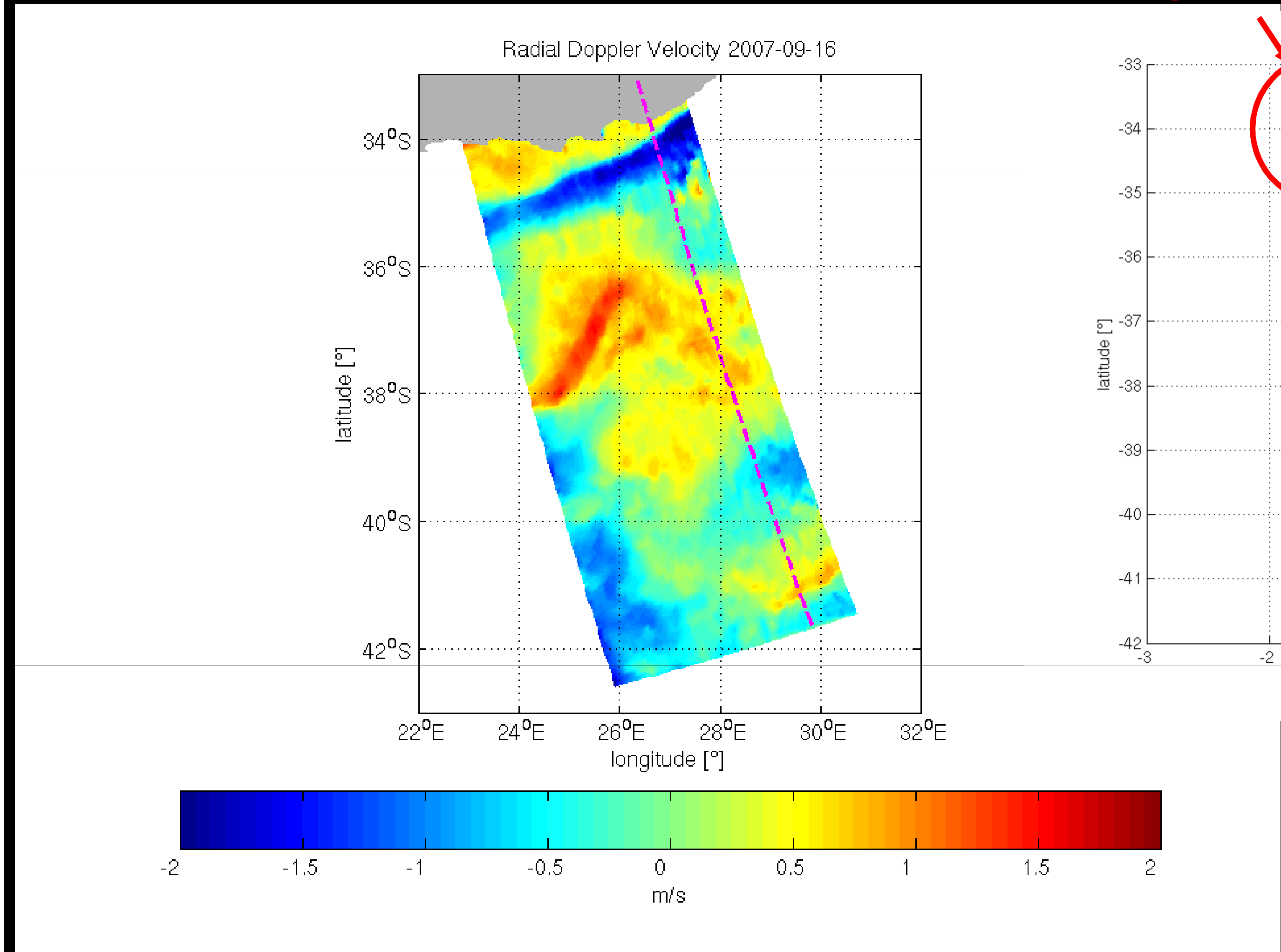
Projection on SAR radial direction

- Sept 16, 2007

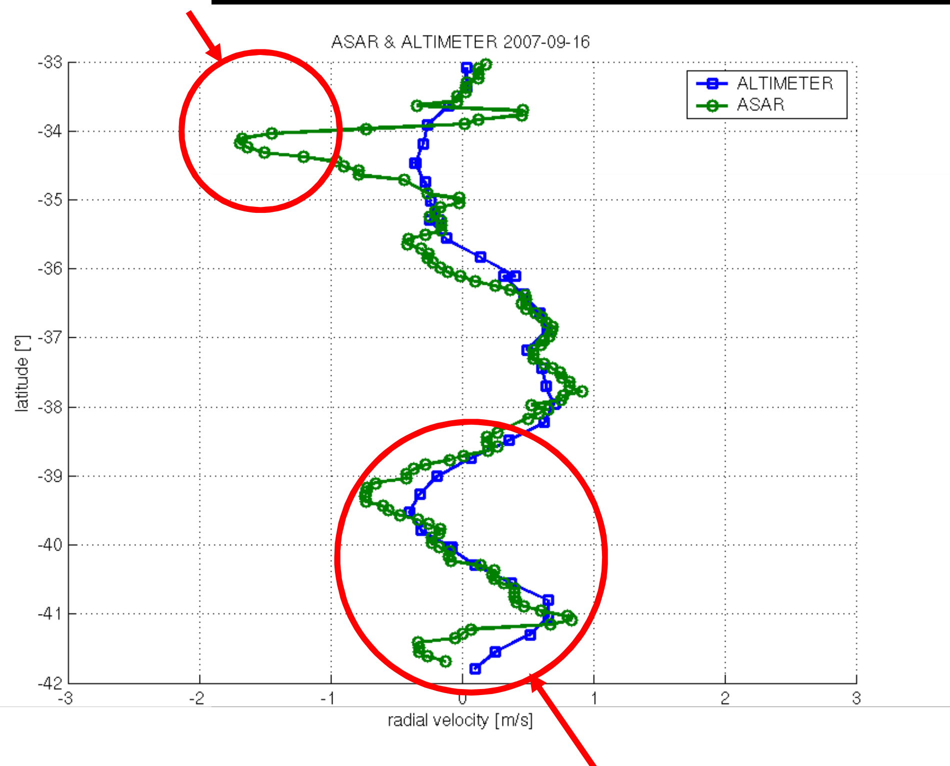




SAR vs. conventional altimetric surface currents



Agulhas main stream

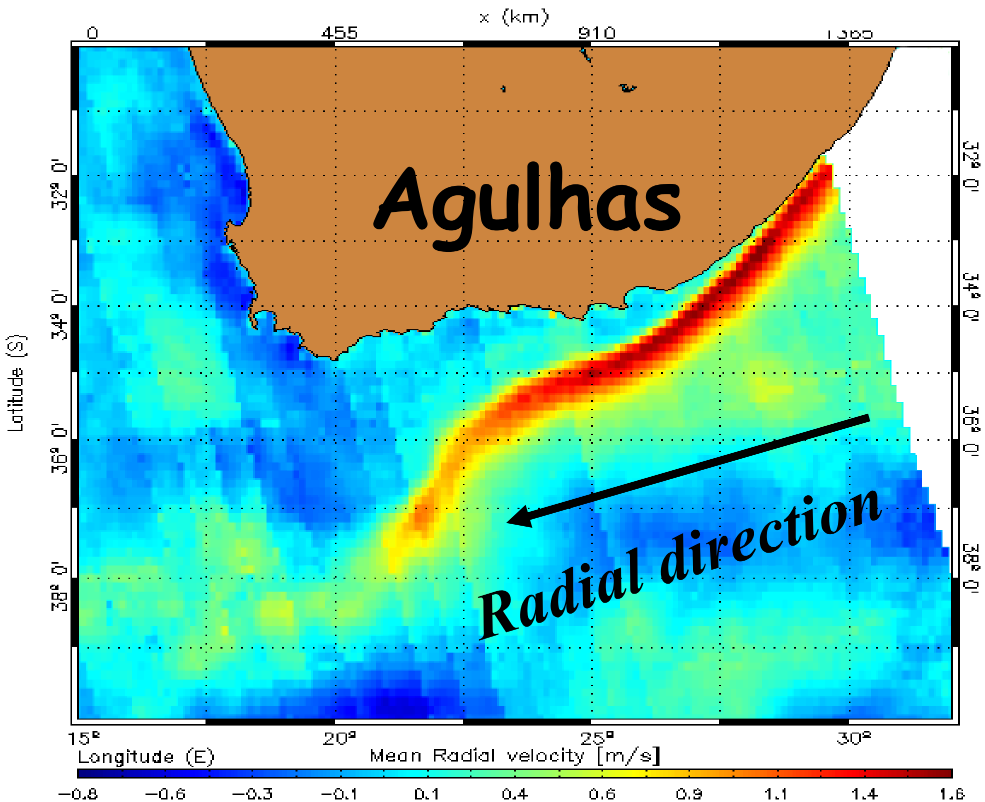


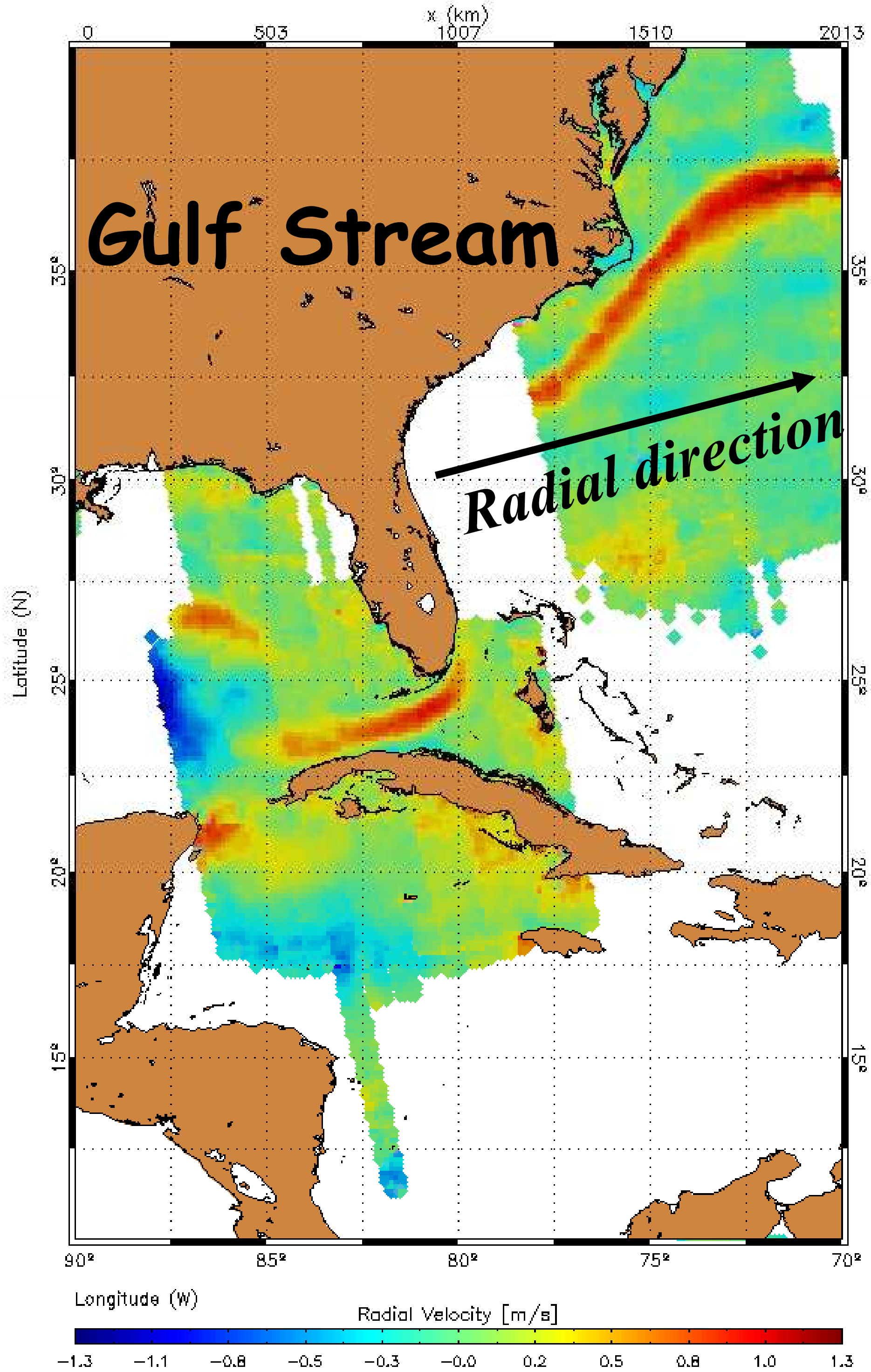
Mesoscale eddie

Challenge in coastal altimetry : what percentage of surface current magnitude signs in ocean topography

Mean current

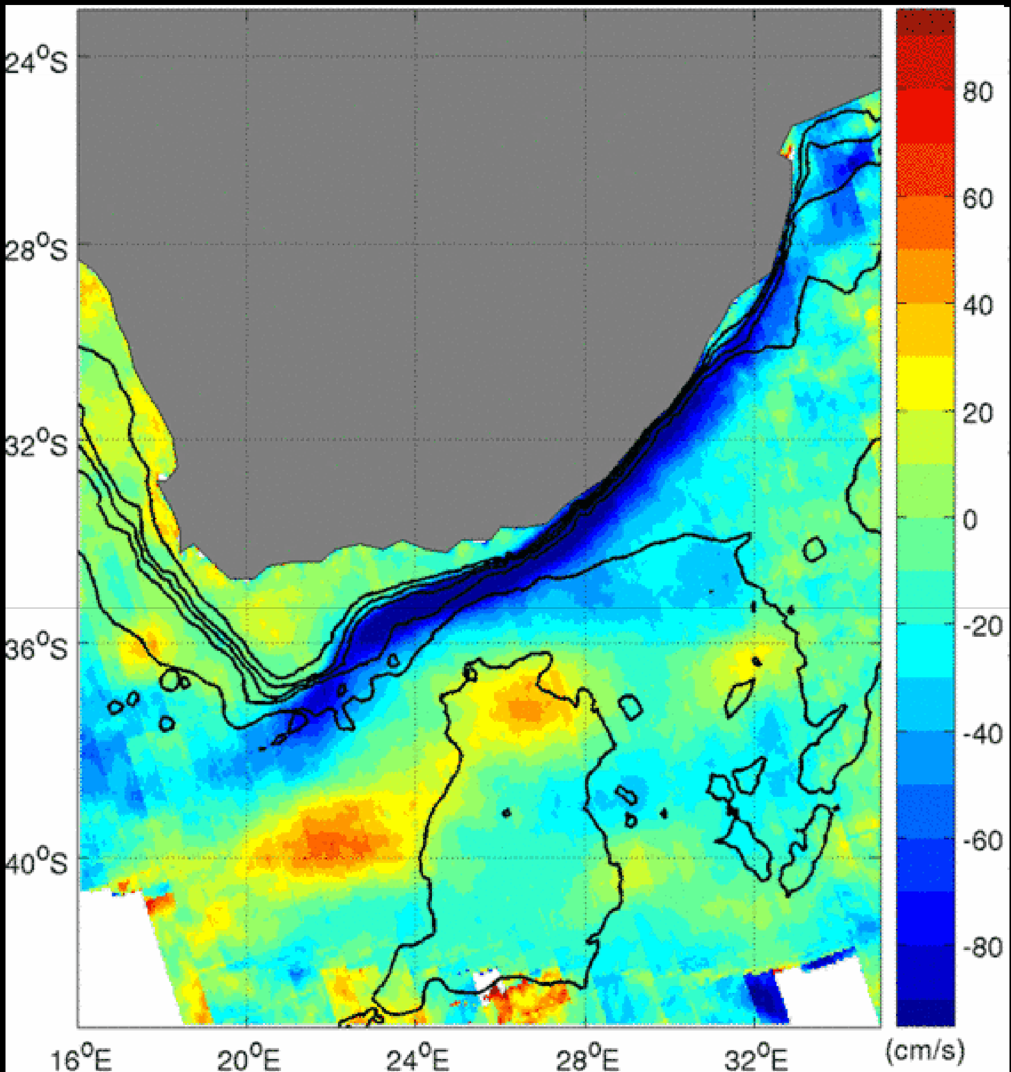
Annual mean ascending radial component of surface current over Agulhas
and Gulf stream

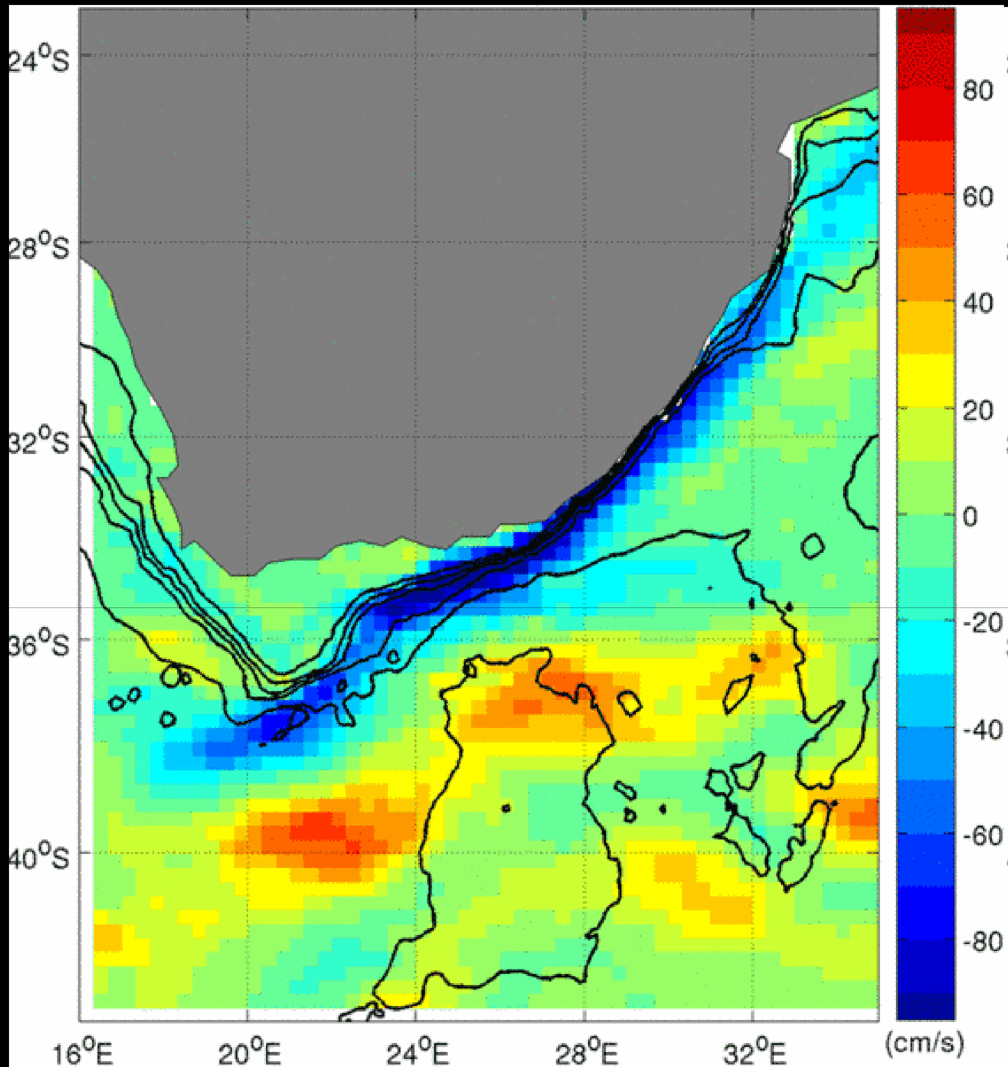




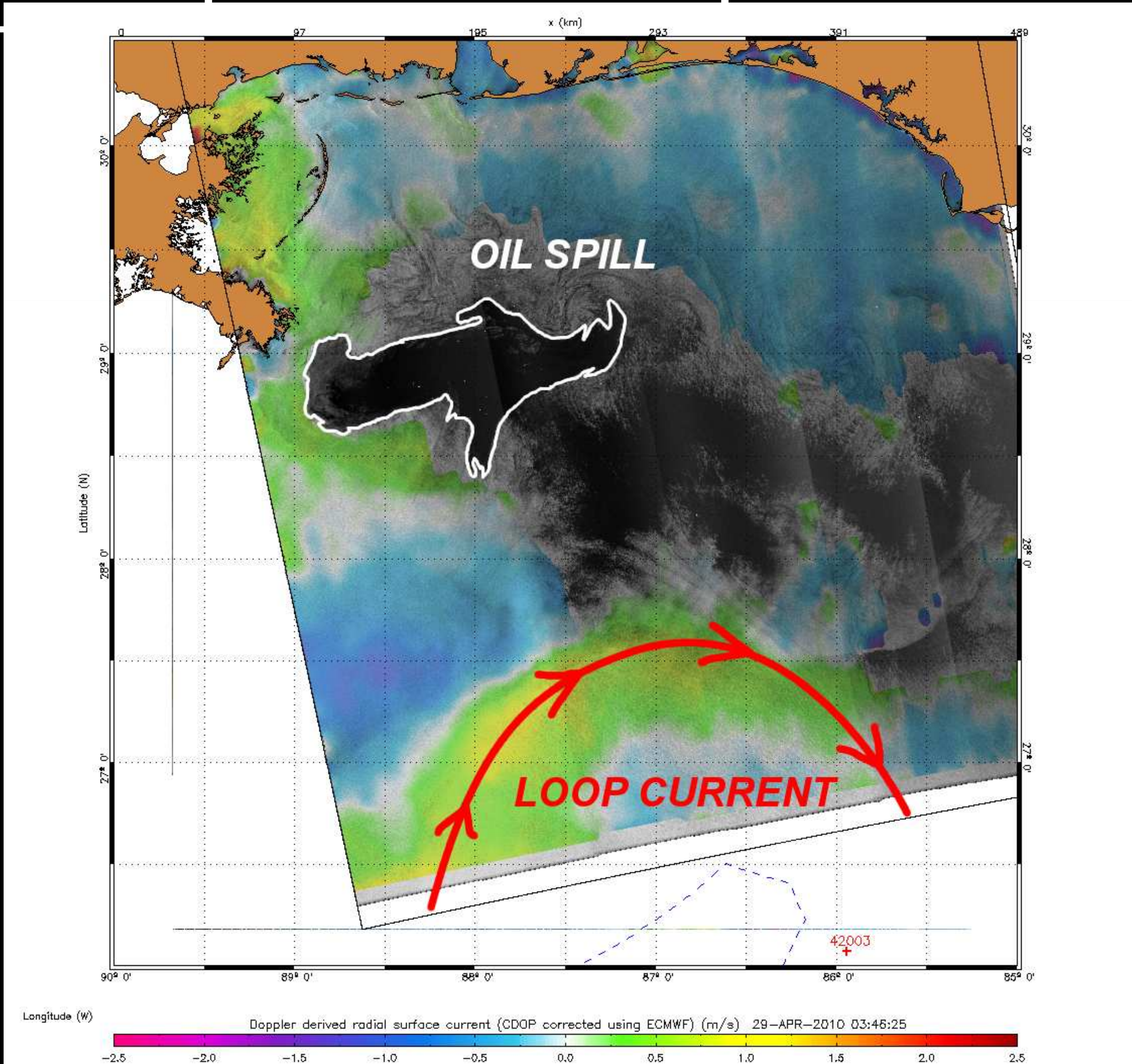
Meridional mean surface current

SAR vs. MDT Rio09





Oil spill drift in loop current



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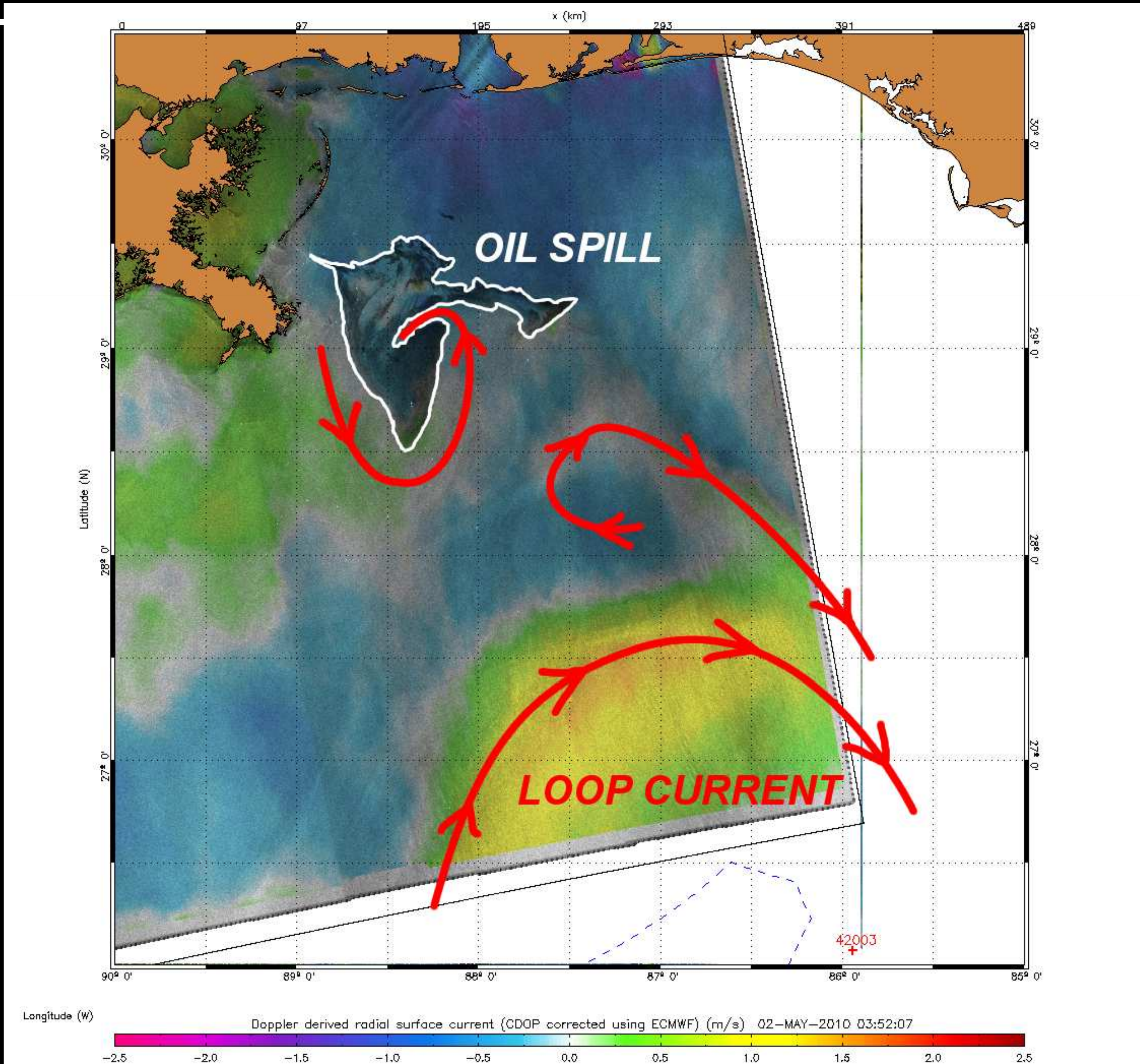

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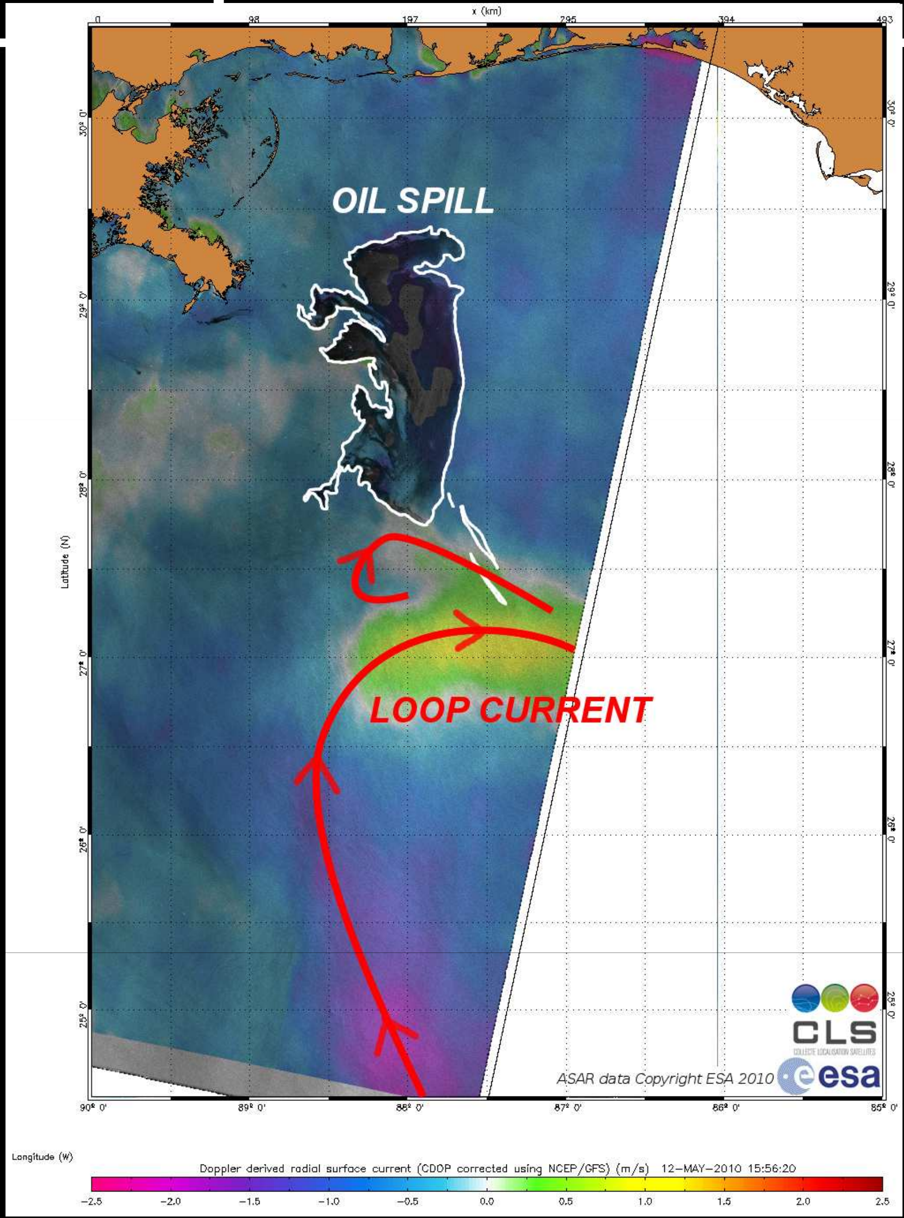

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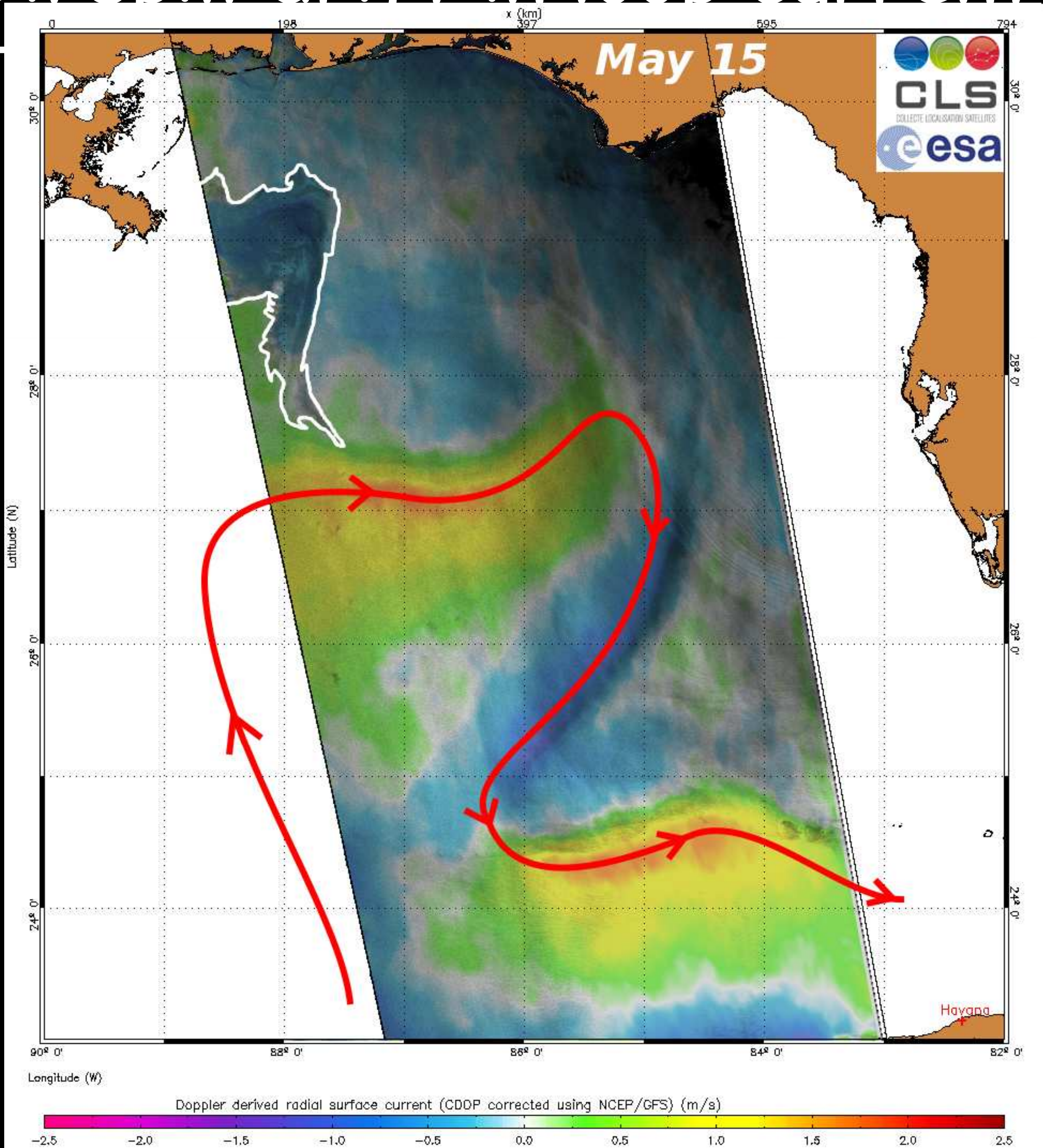

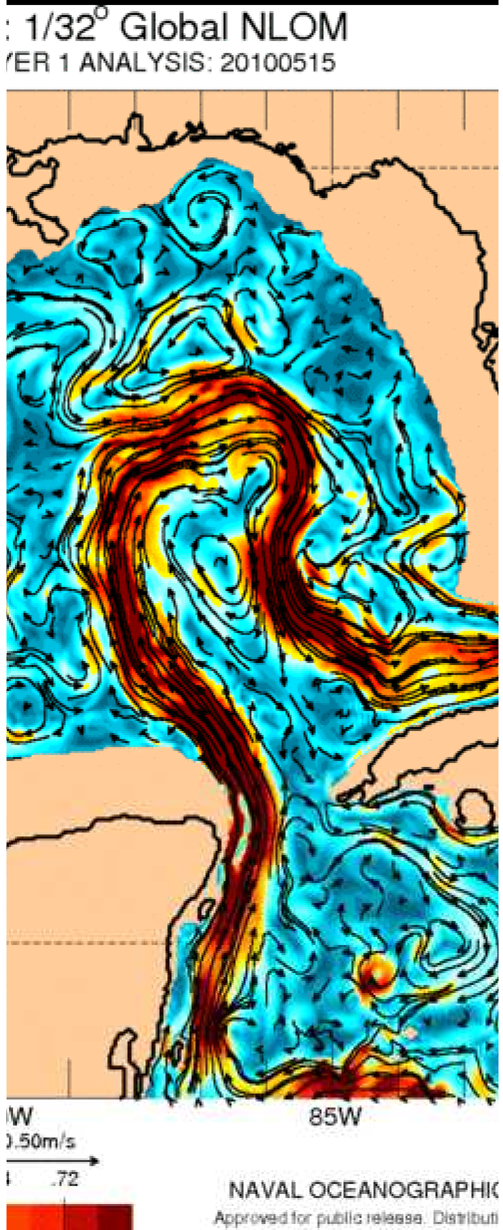

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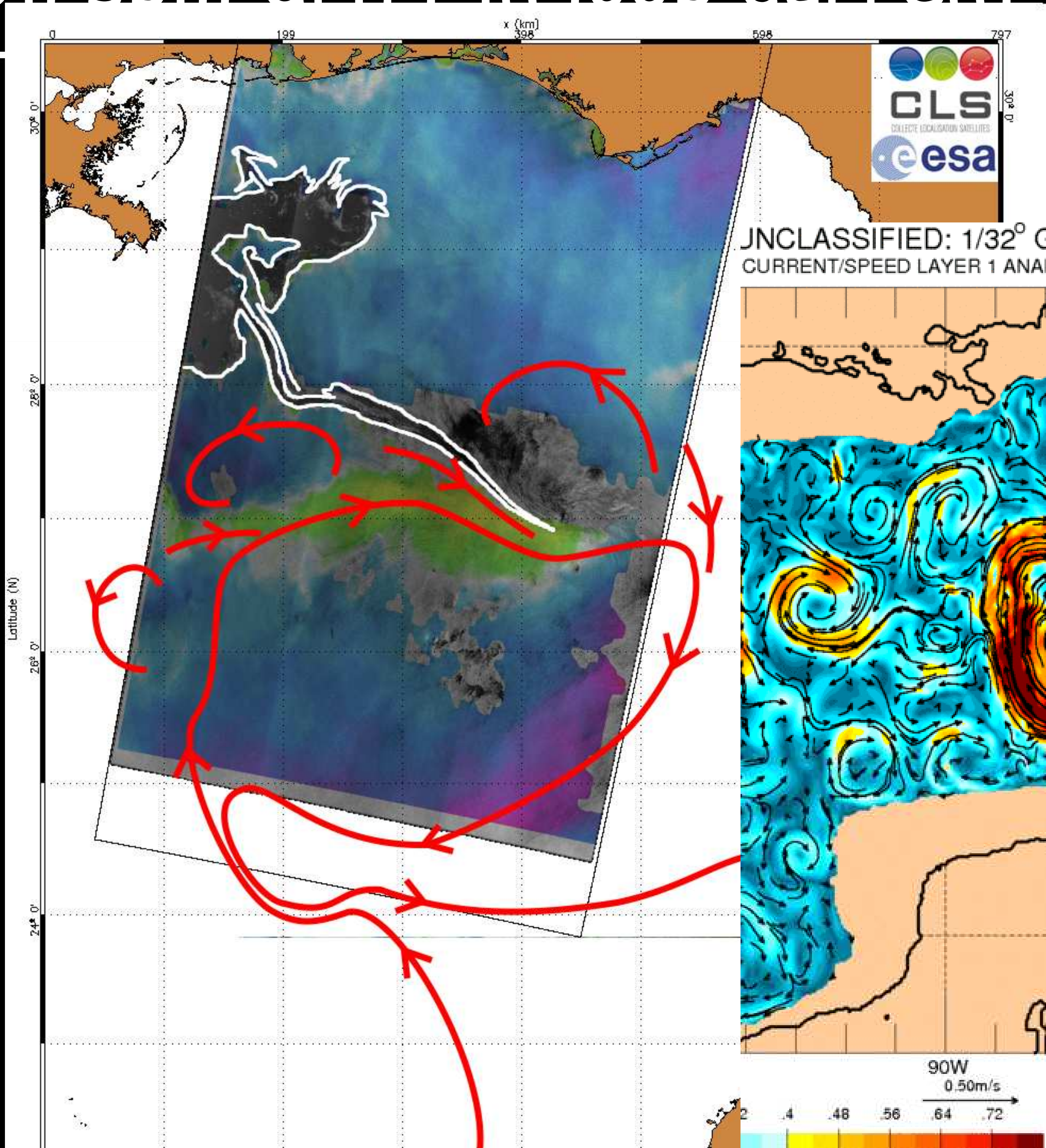

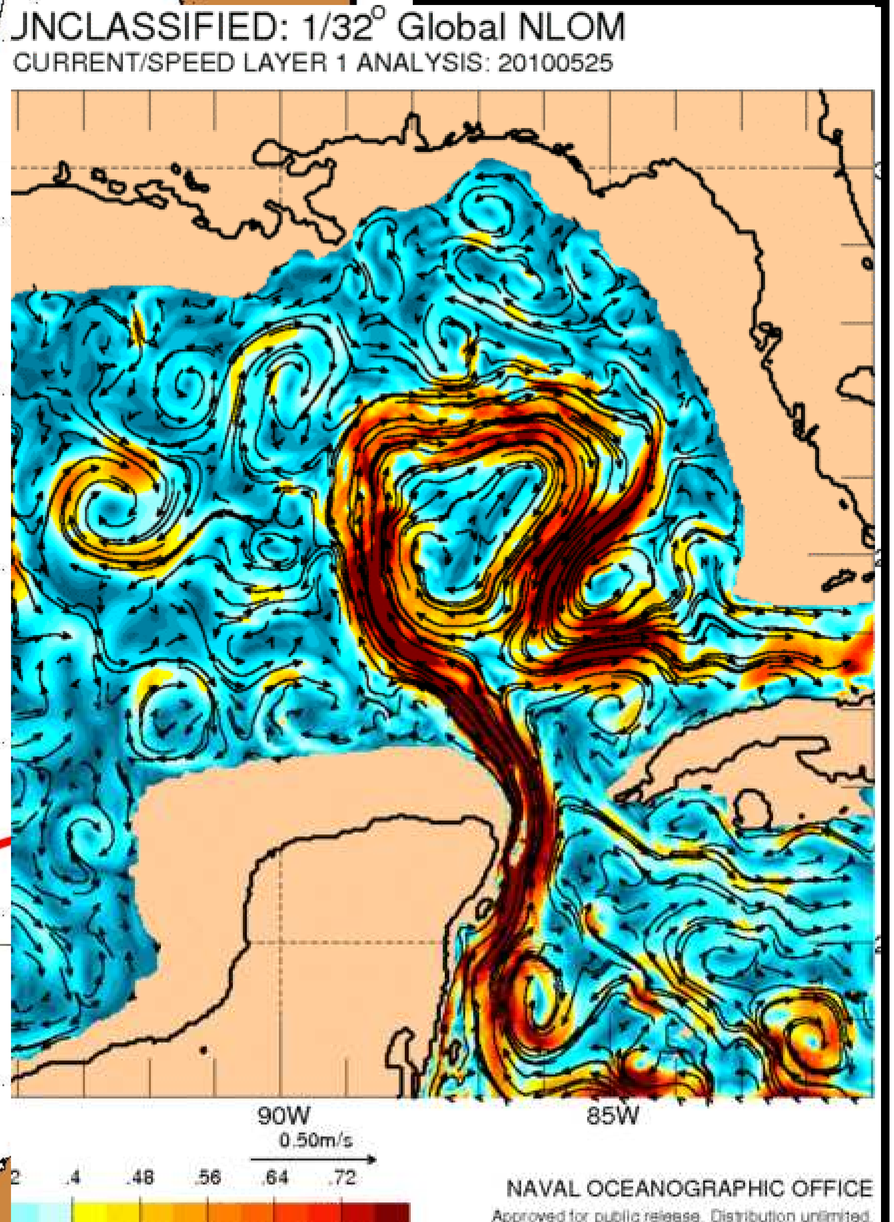

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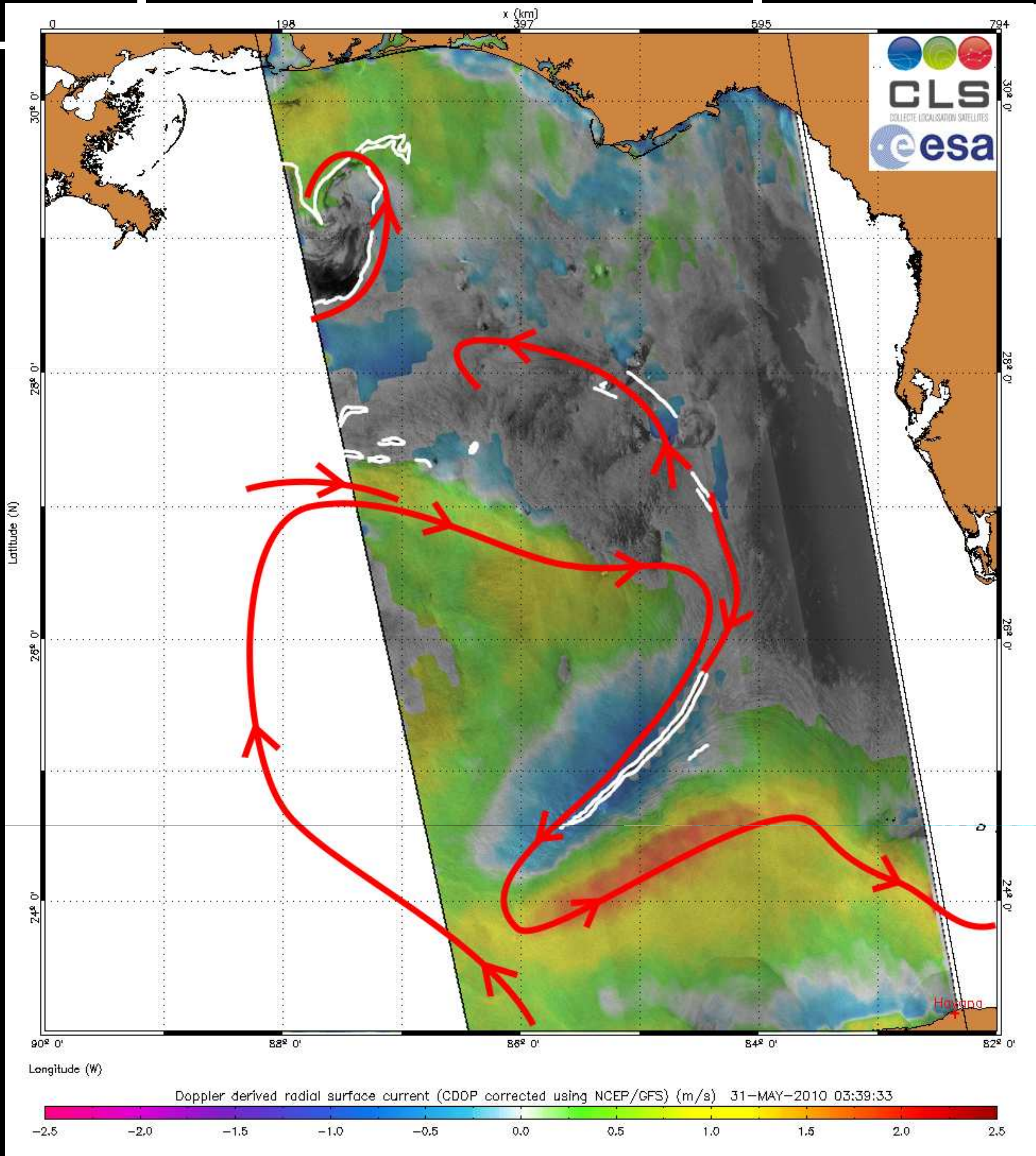

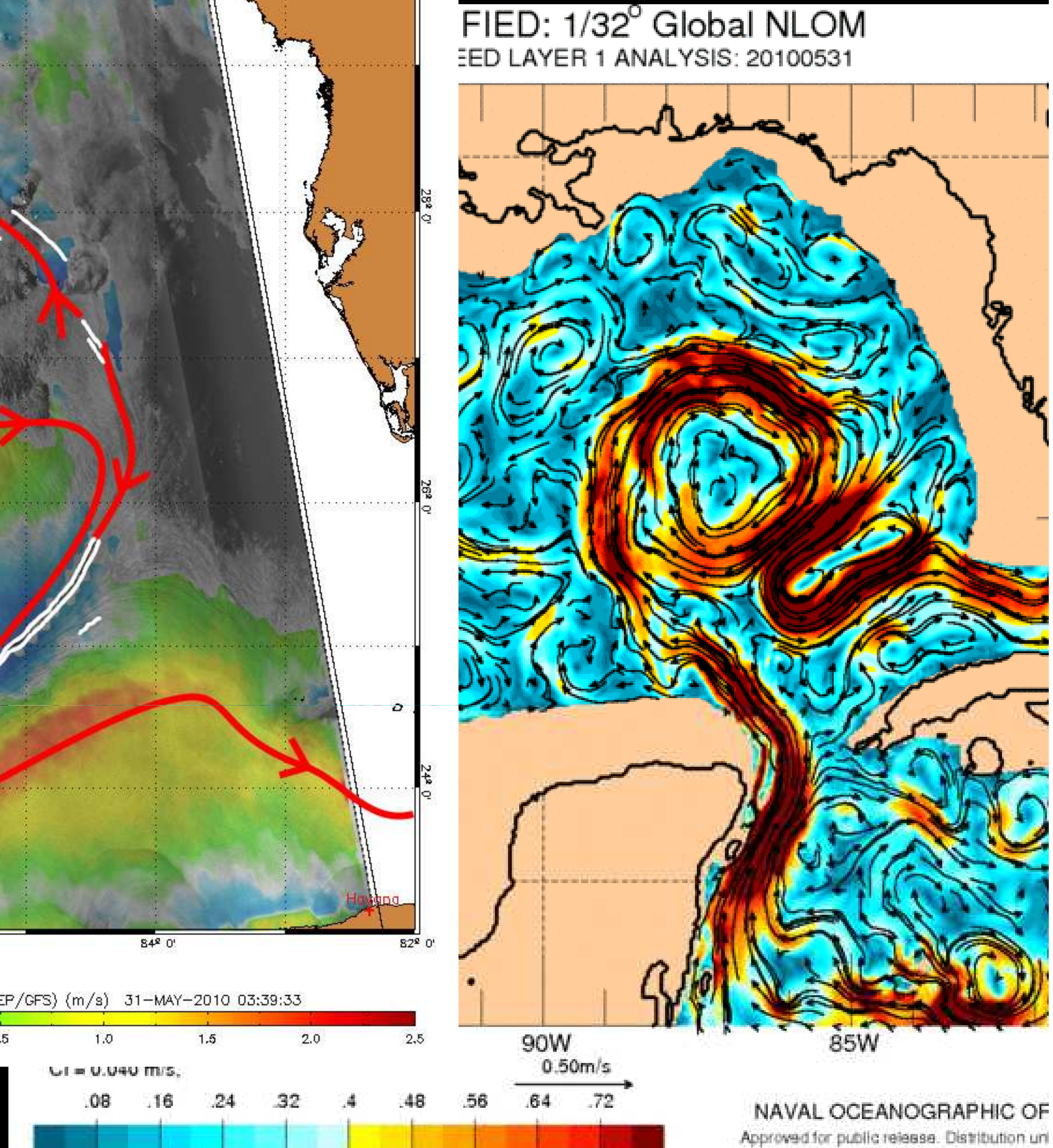

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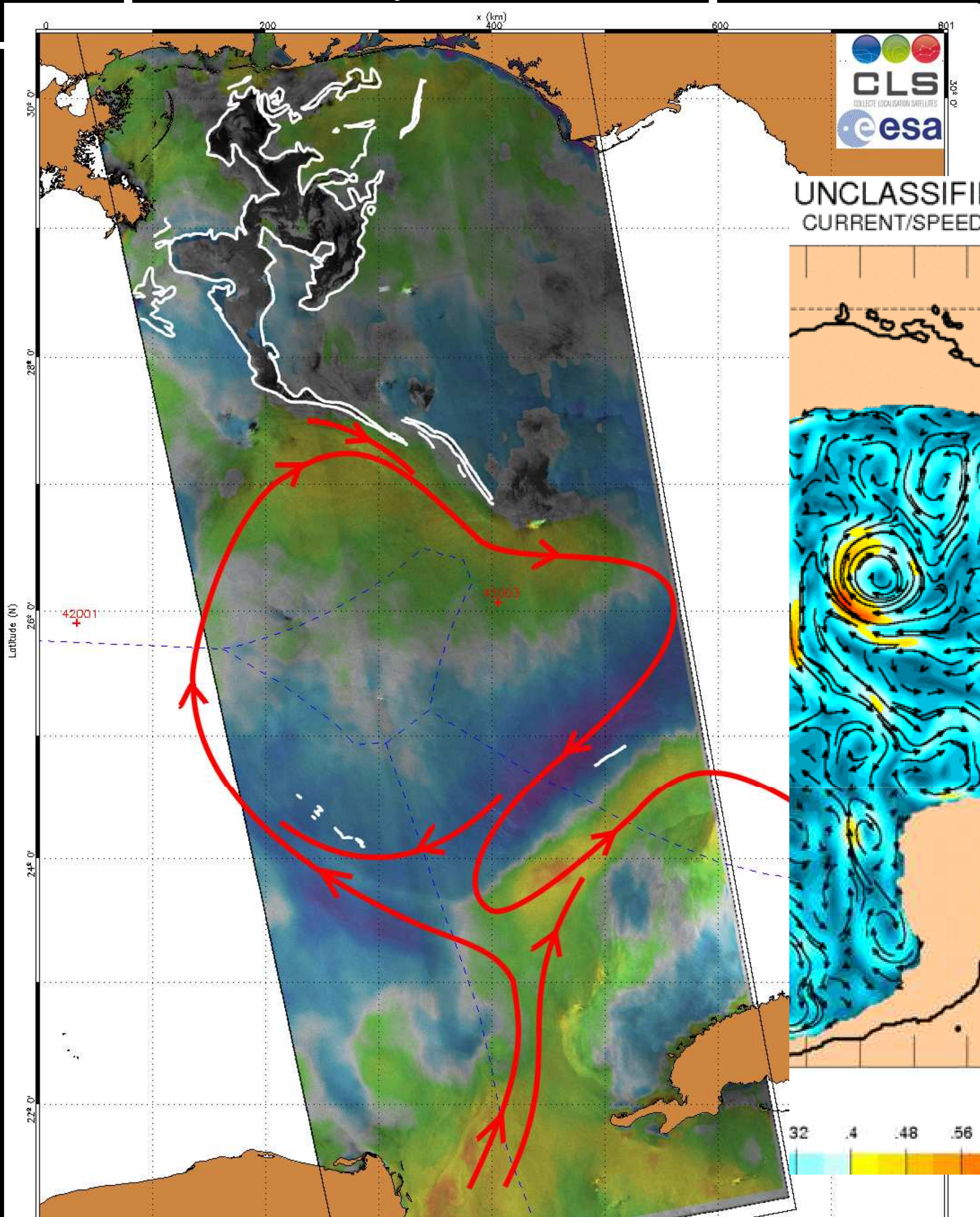
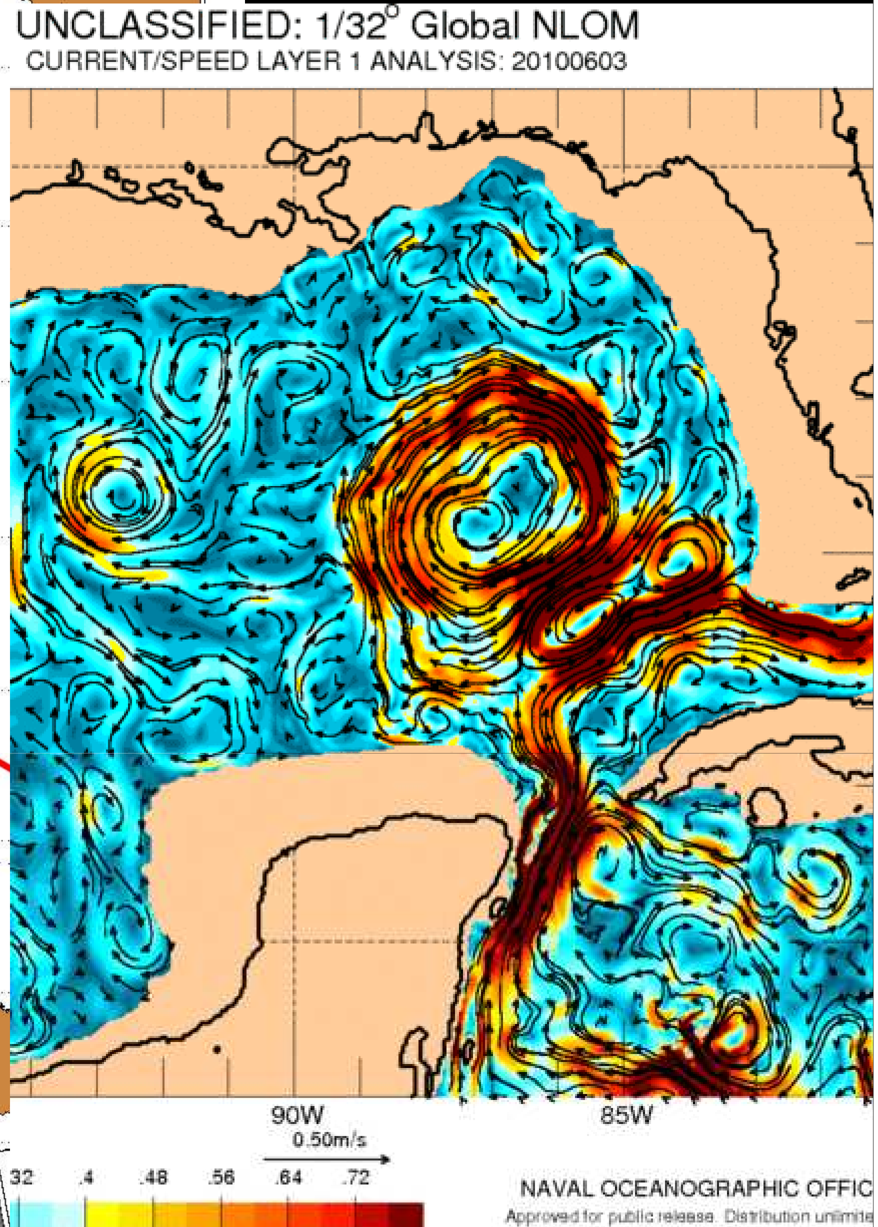
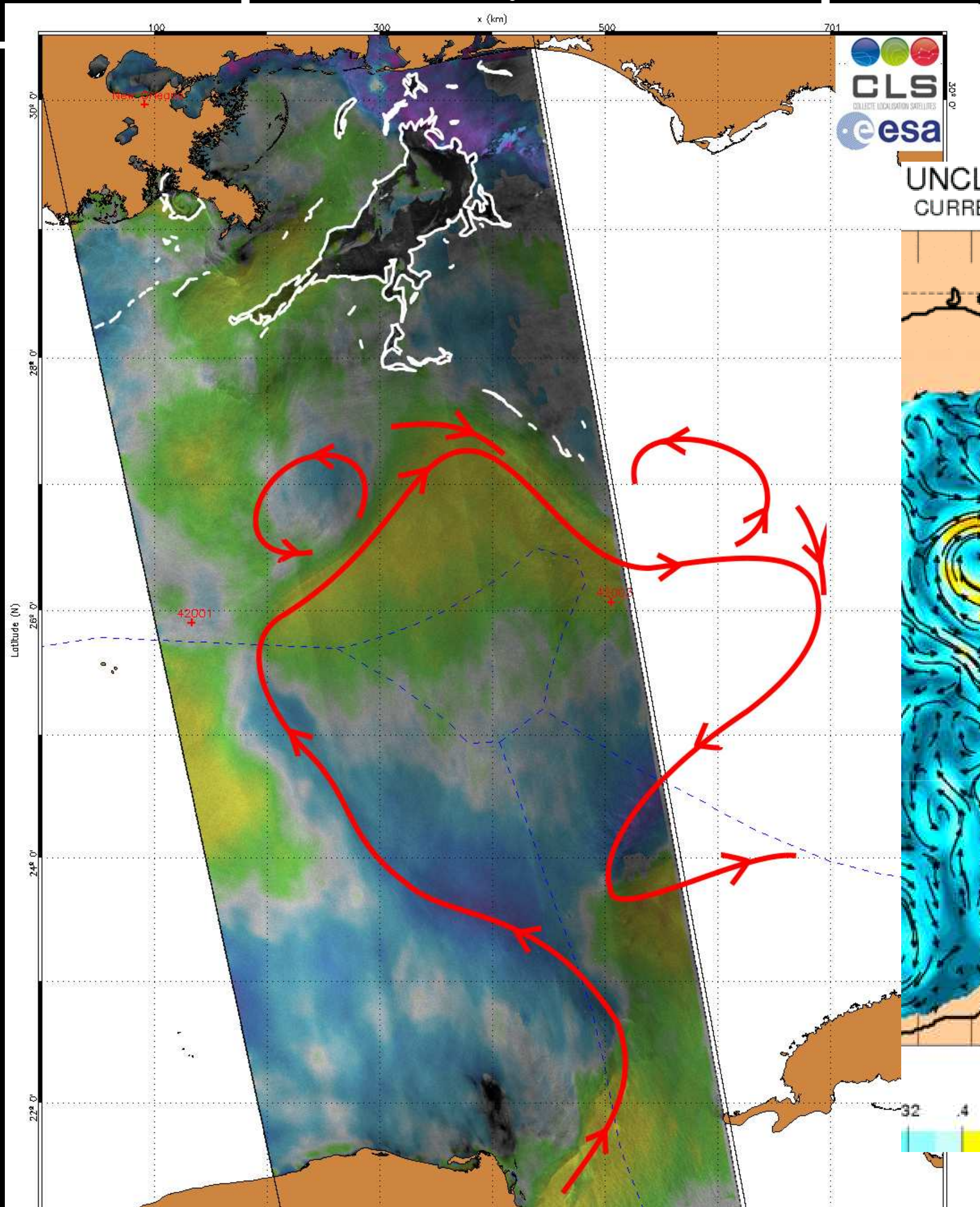
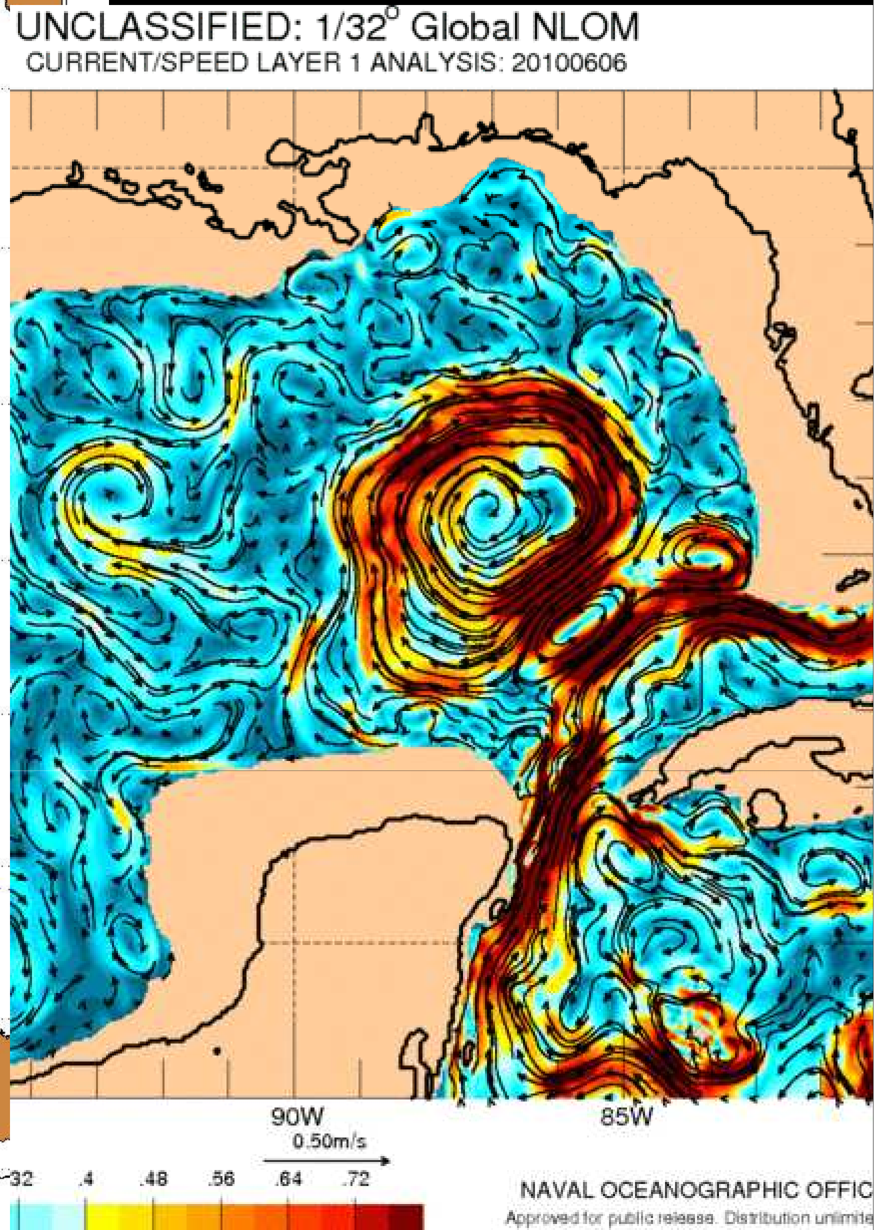


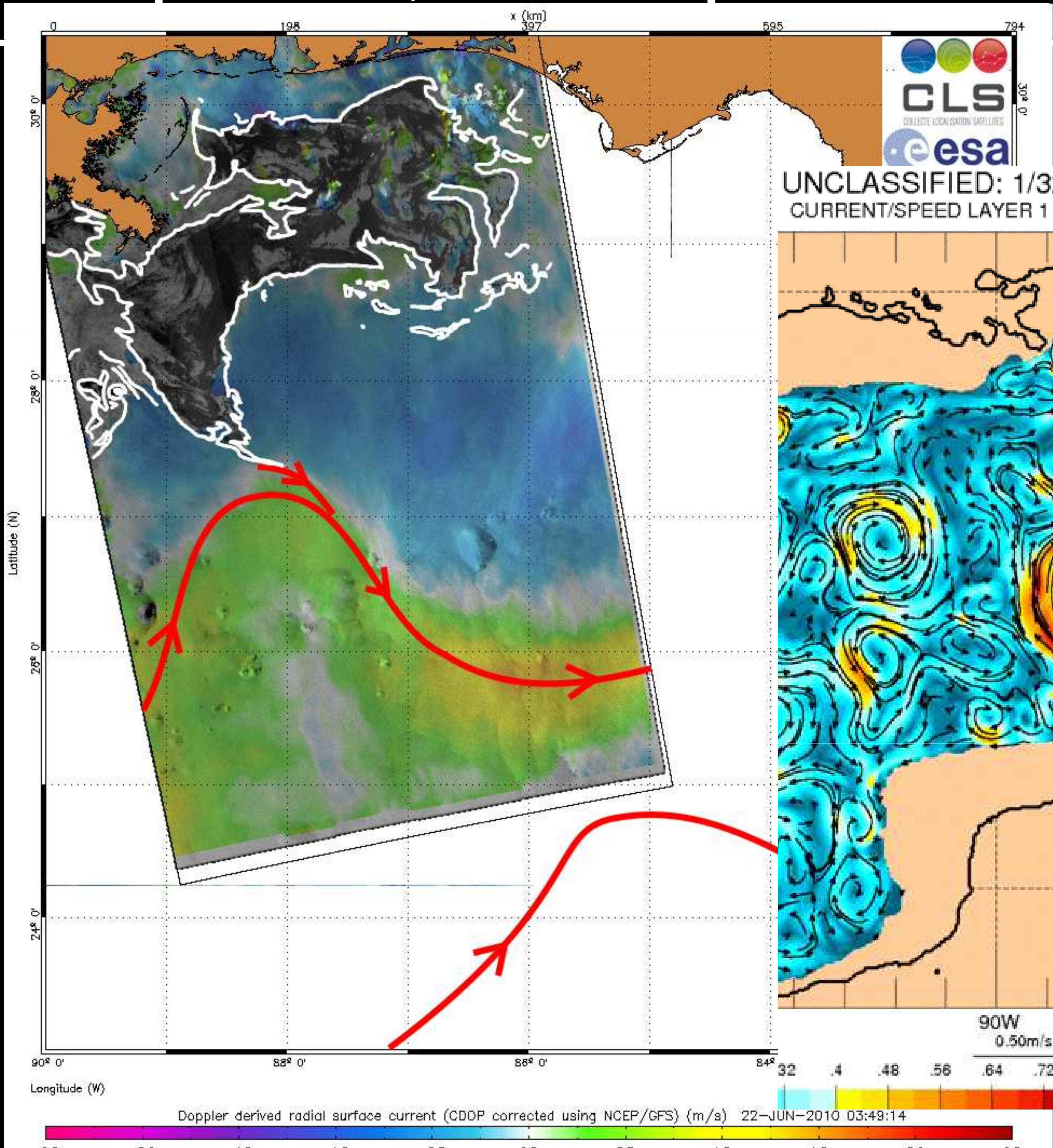


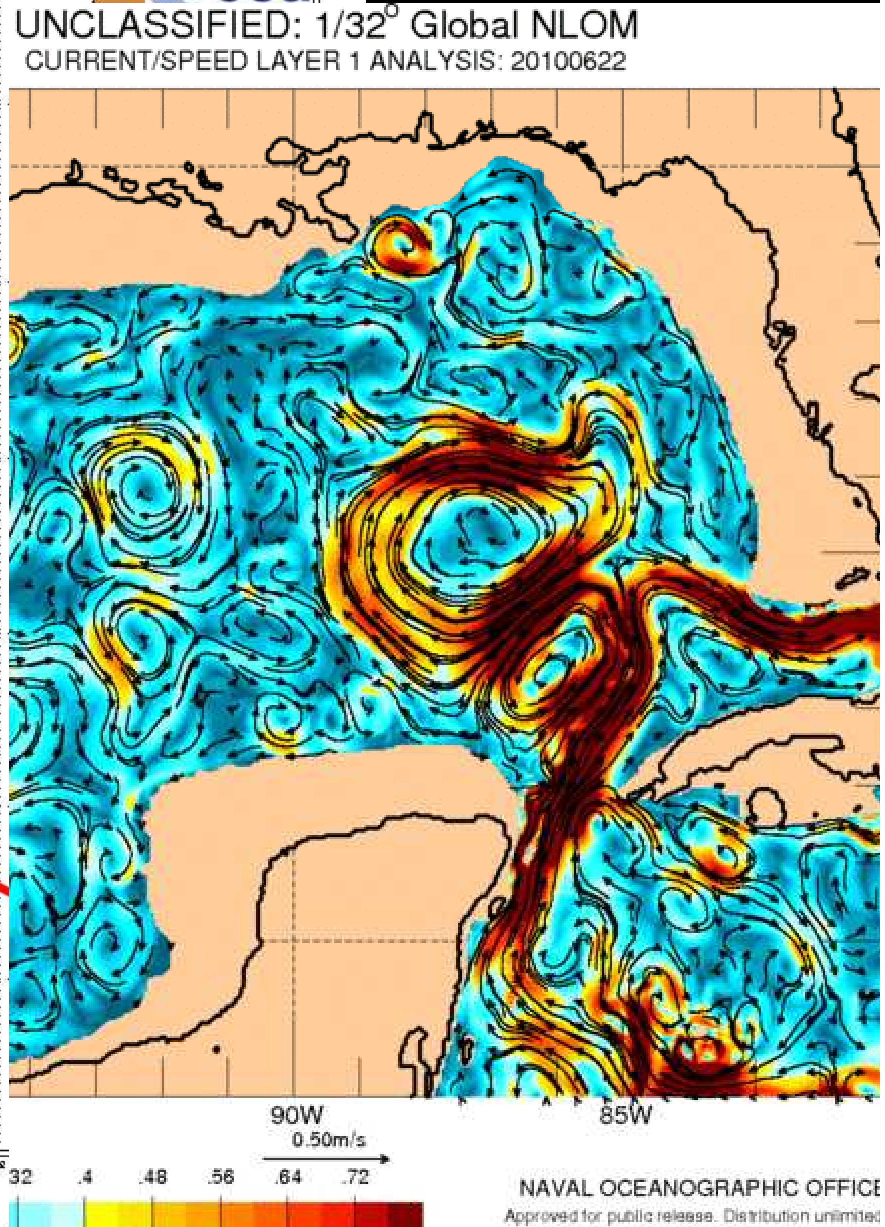
Oil spill drift in loop current





Oil spill drift in loop current





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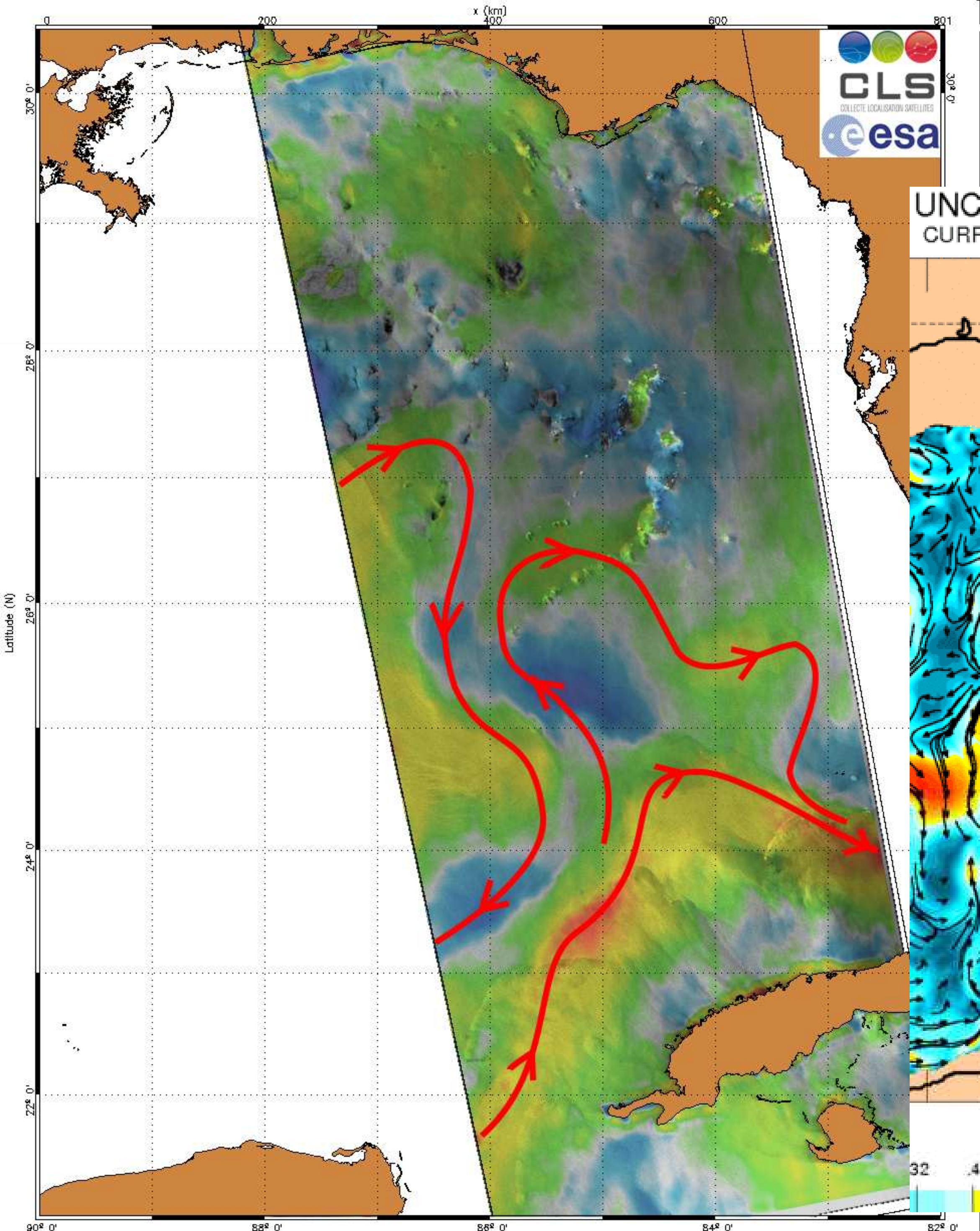

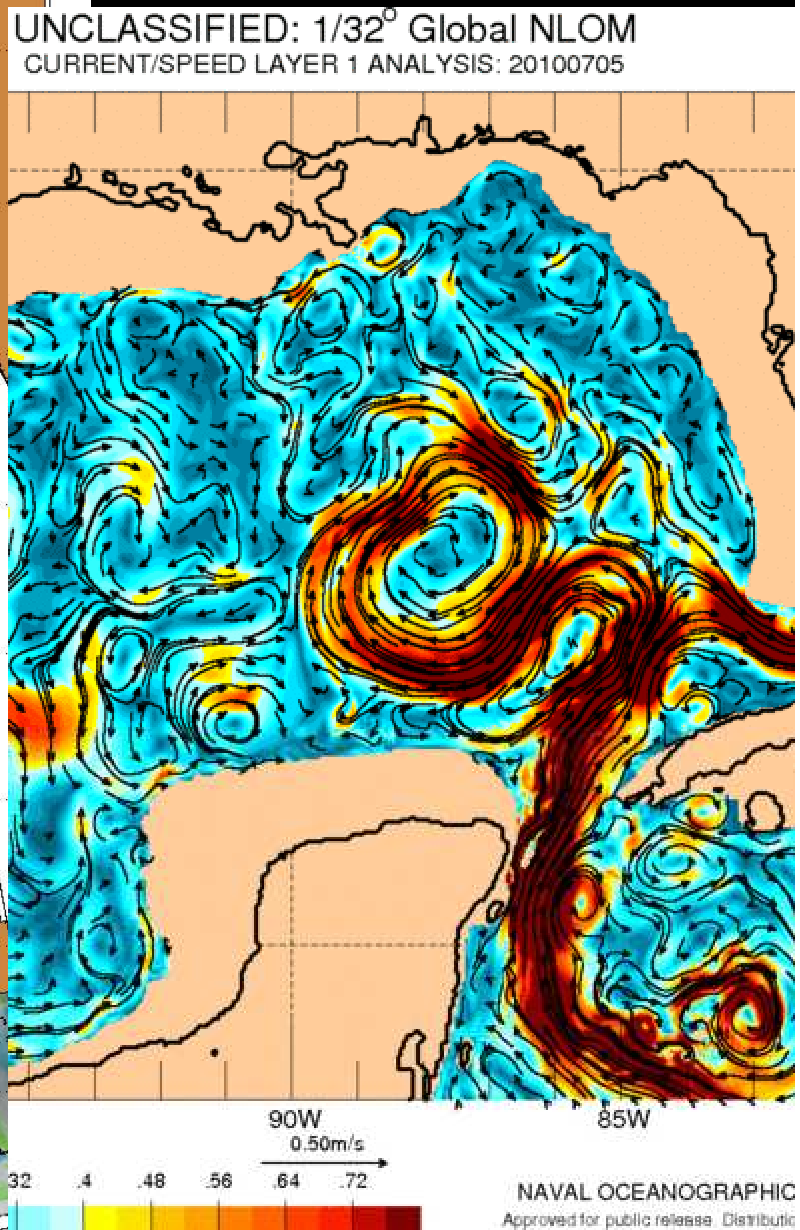

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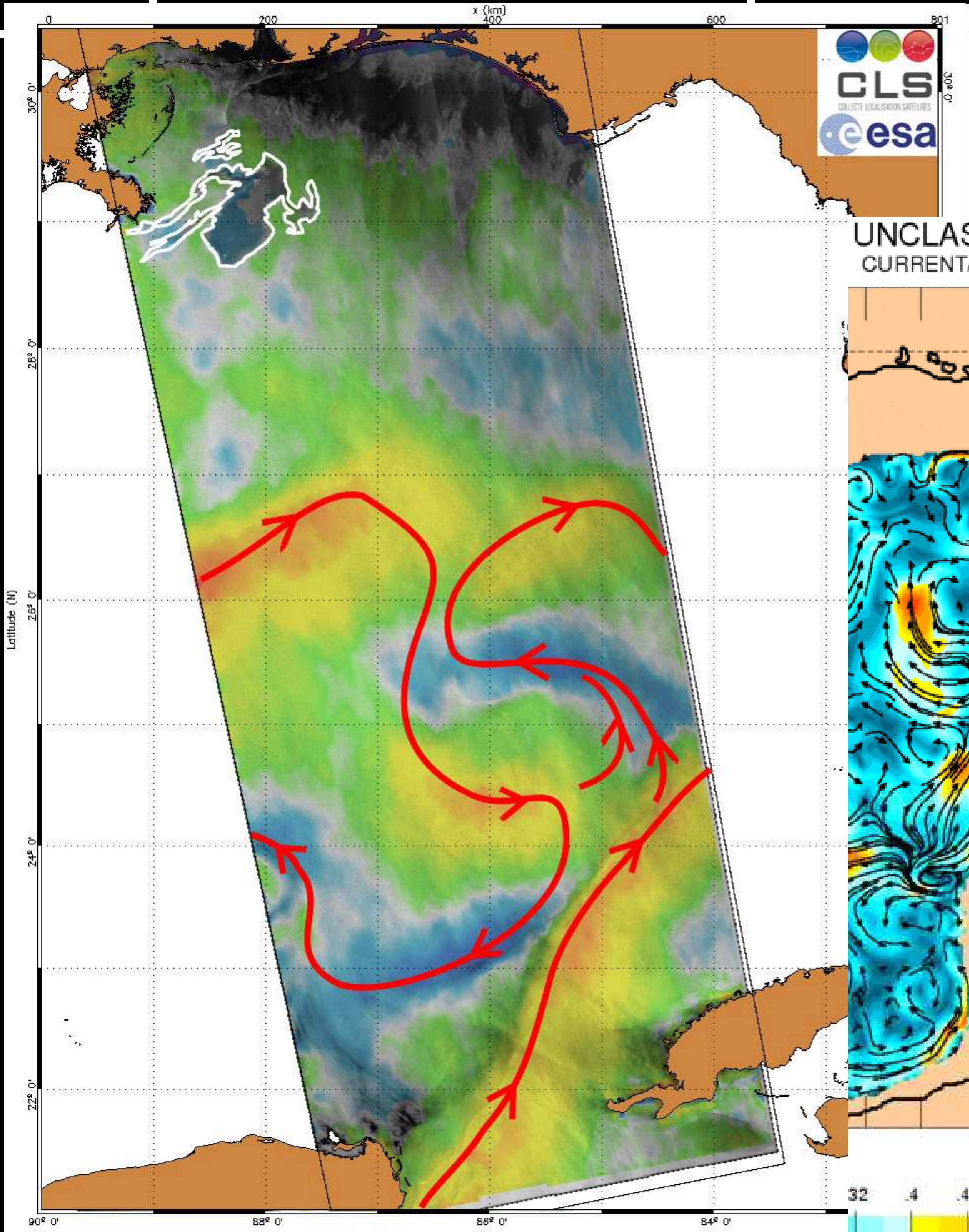
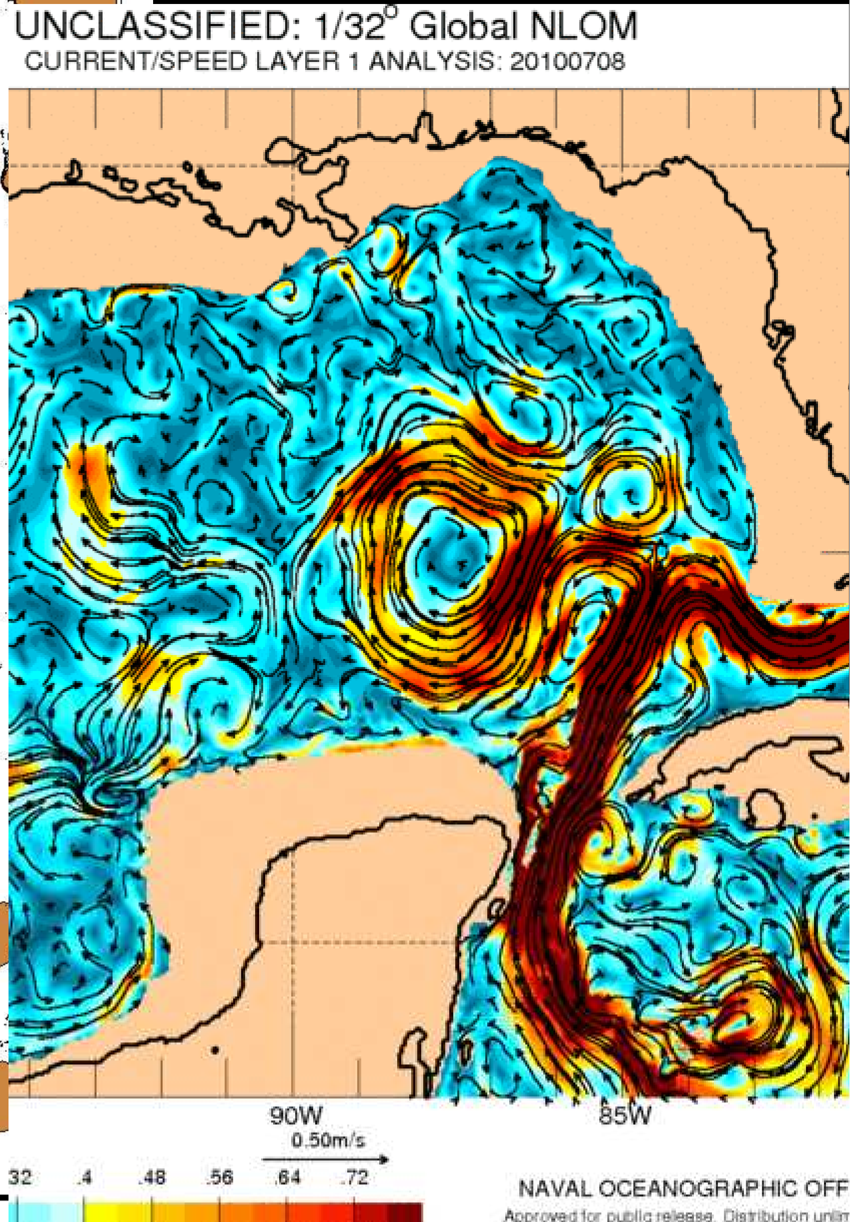
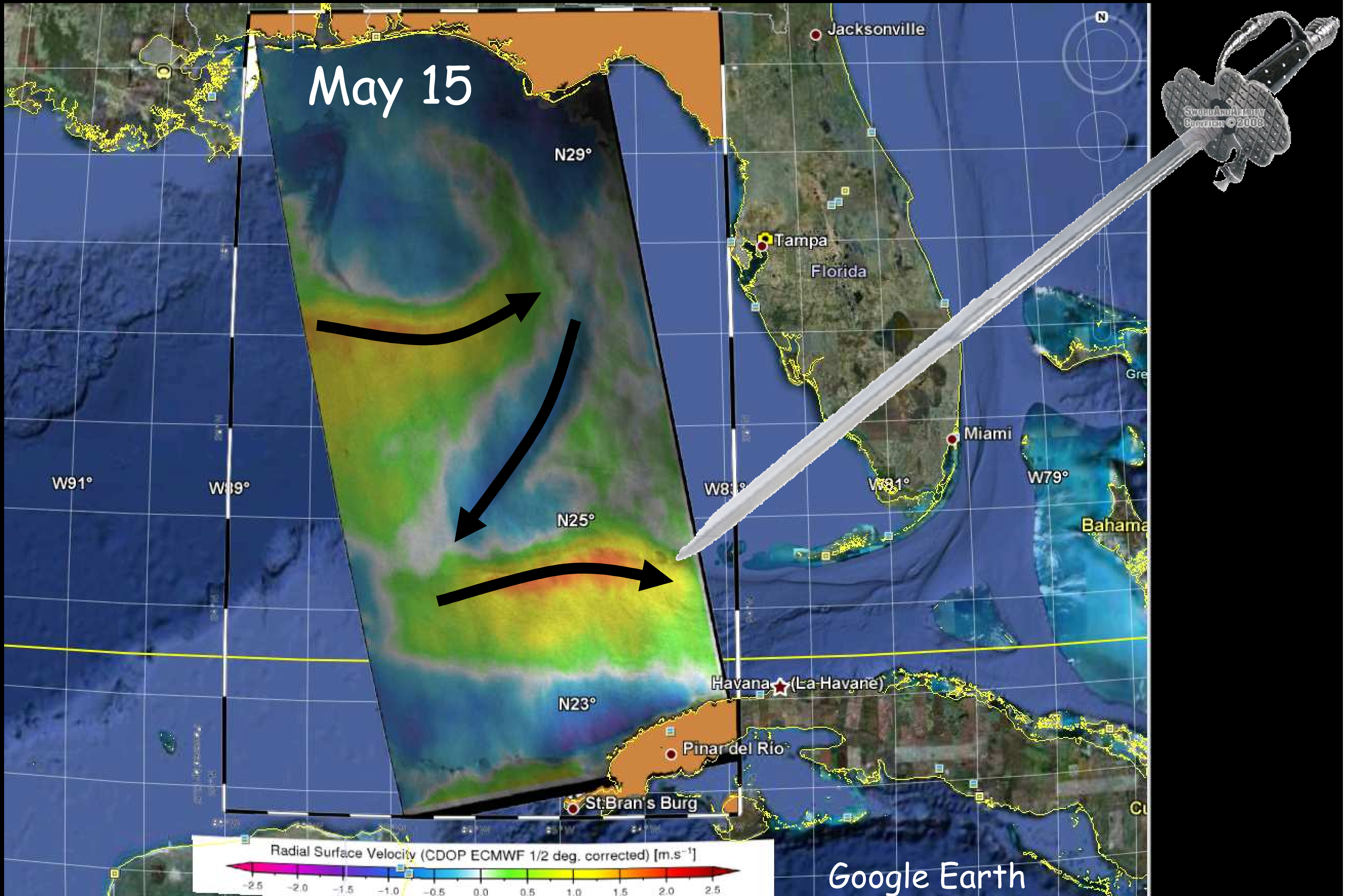




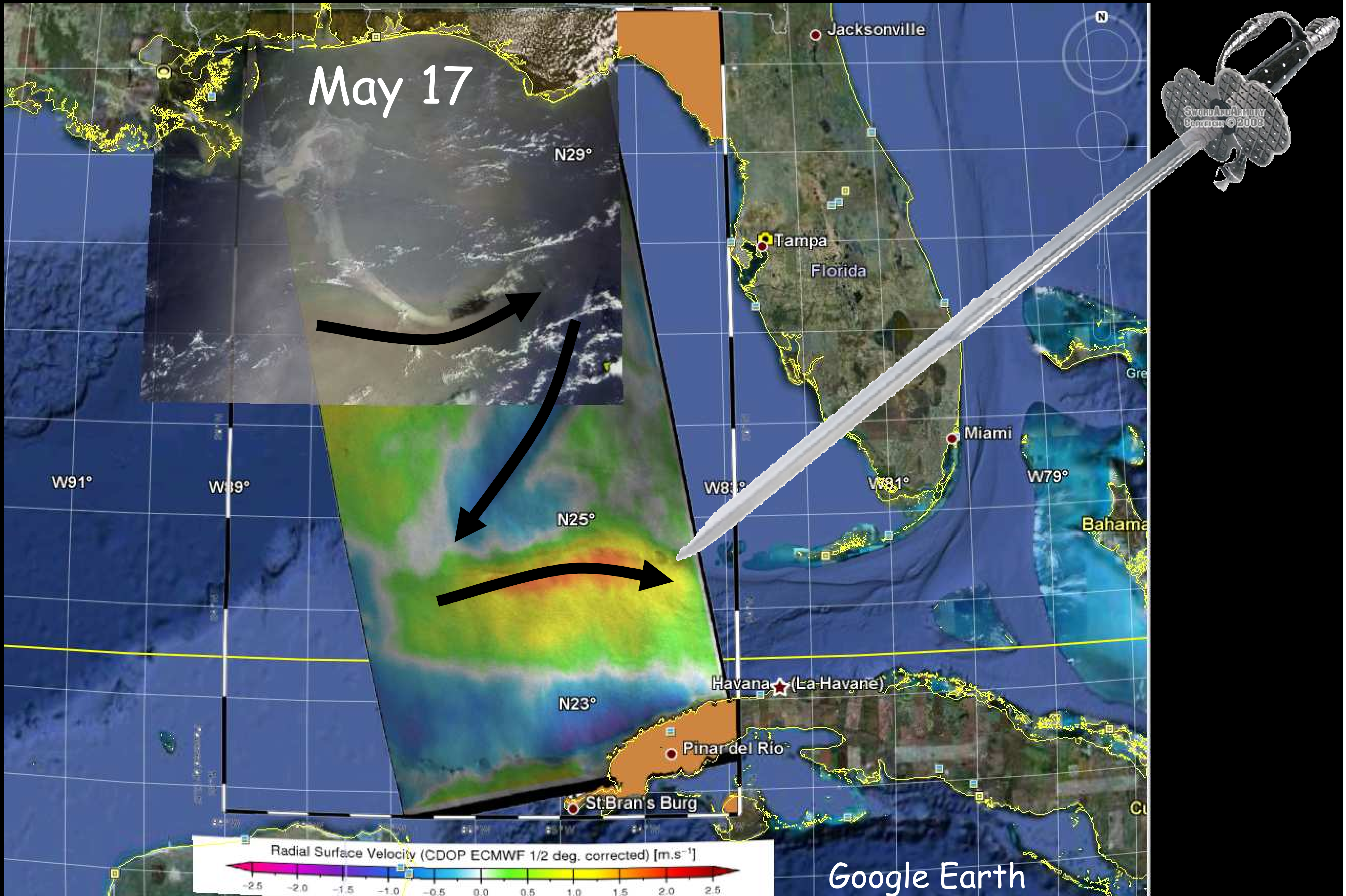
S W O R D

SWath Ocean Radar Doppler



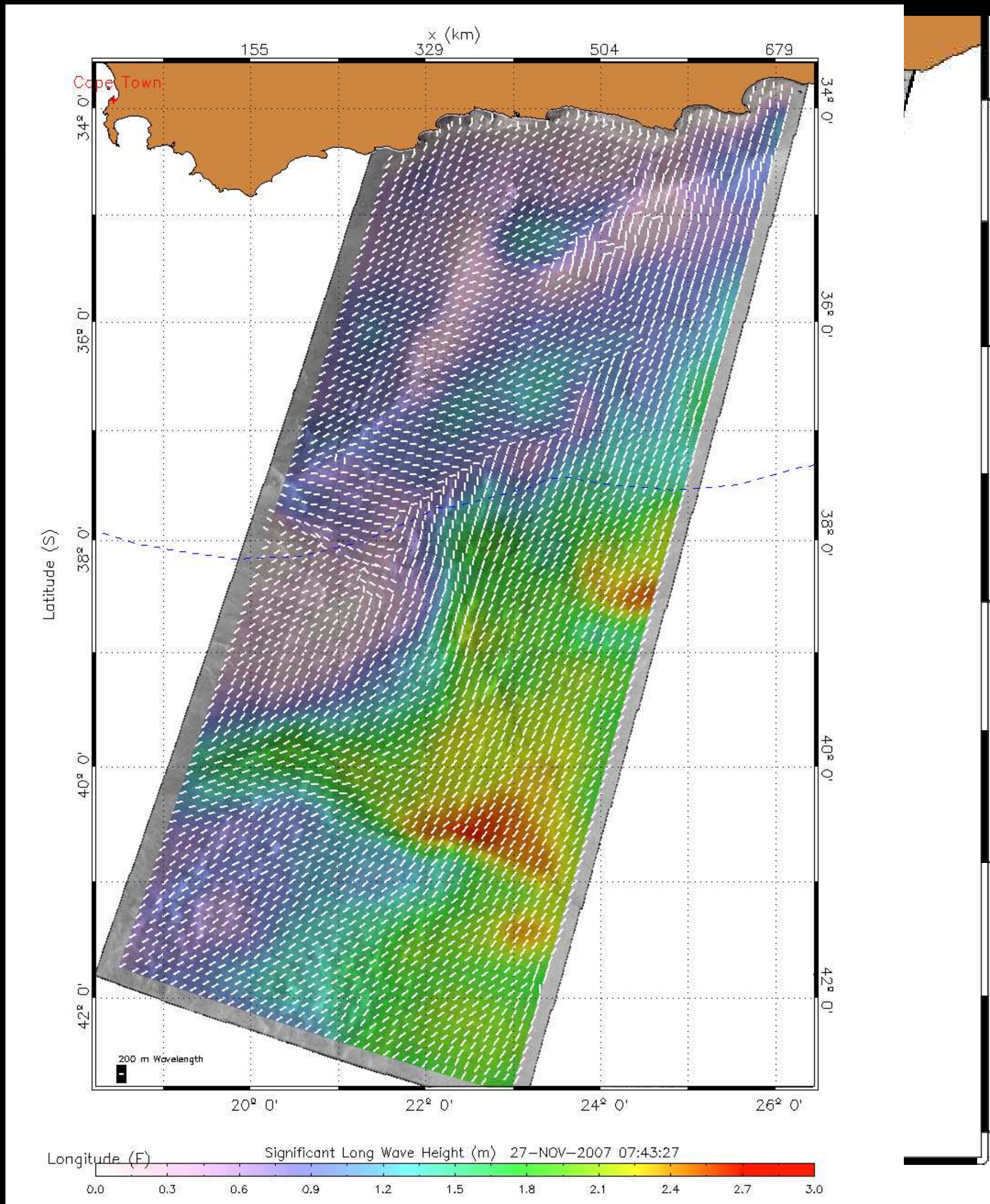
S W O R D

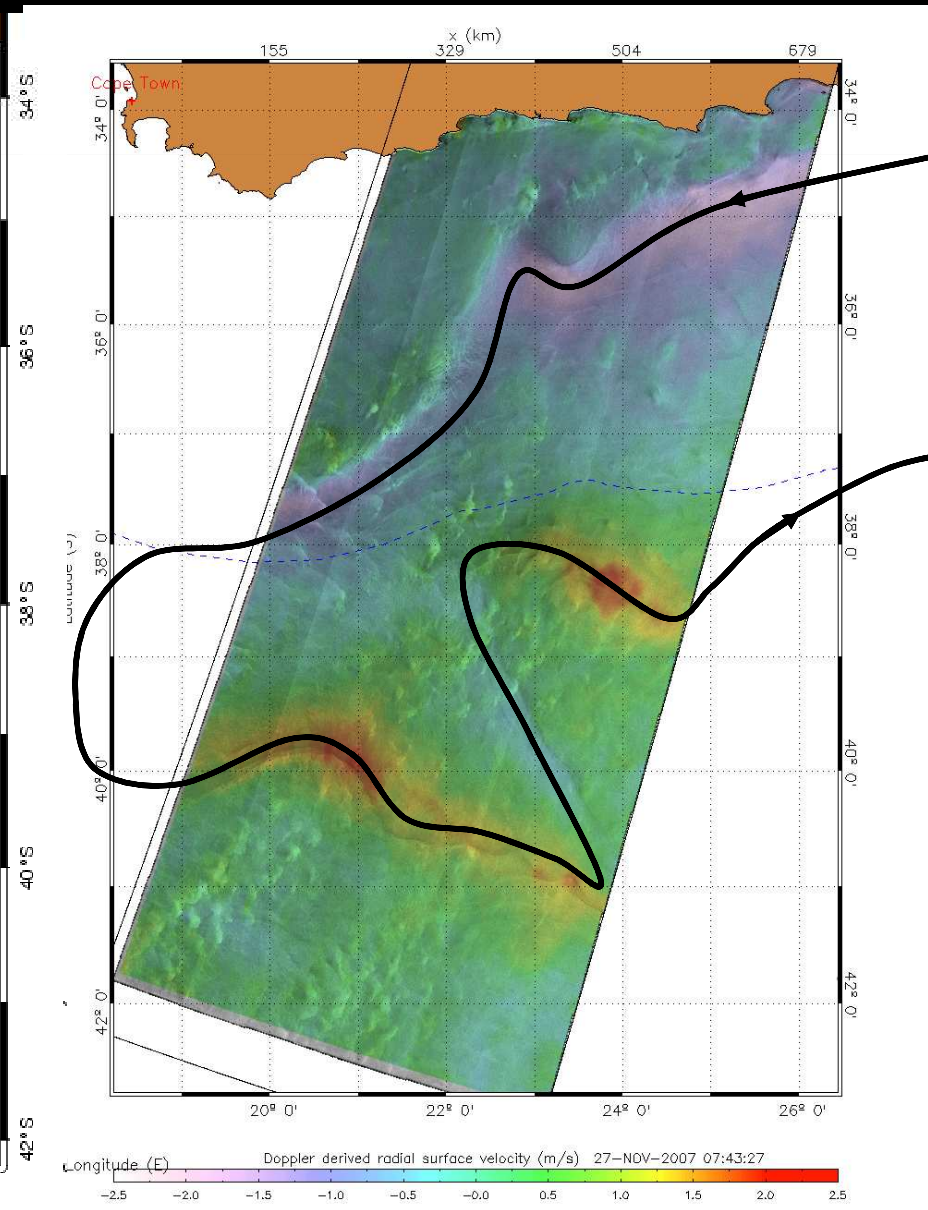
SWath Ocean Radar Doppler



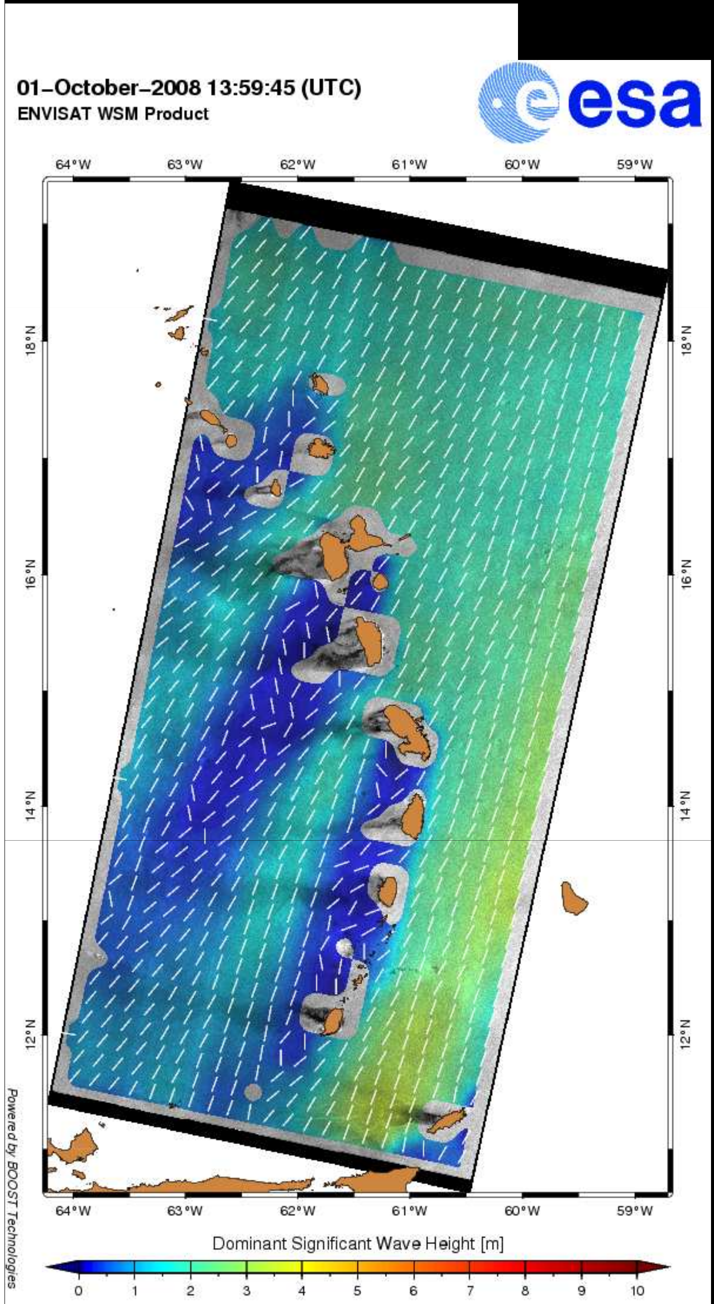
Wave transformation in current

- Significant swell height and dominant direction



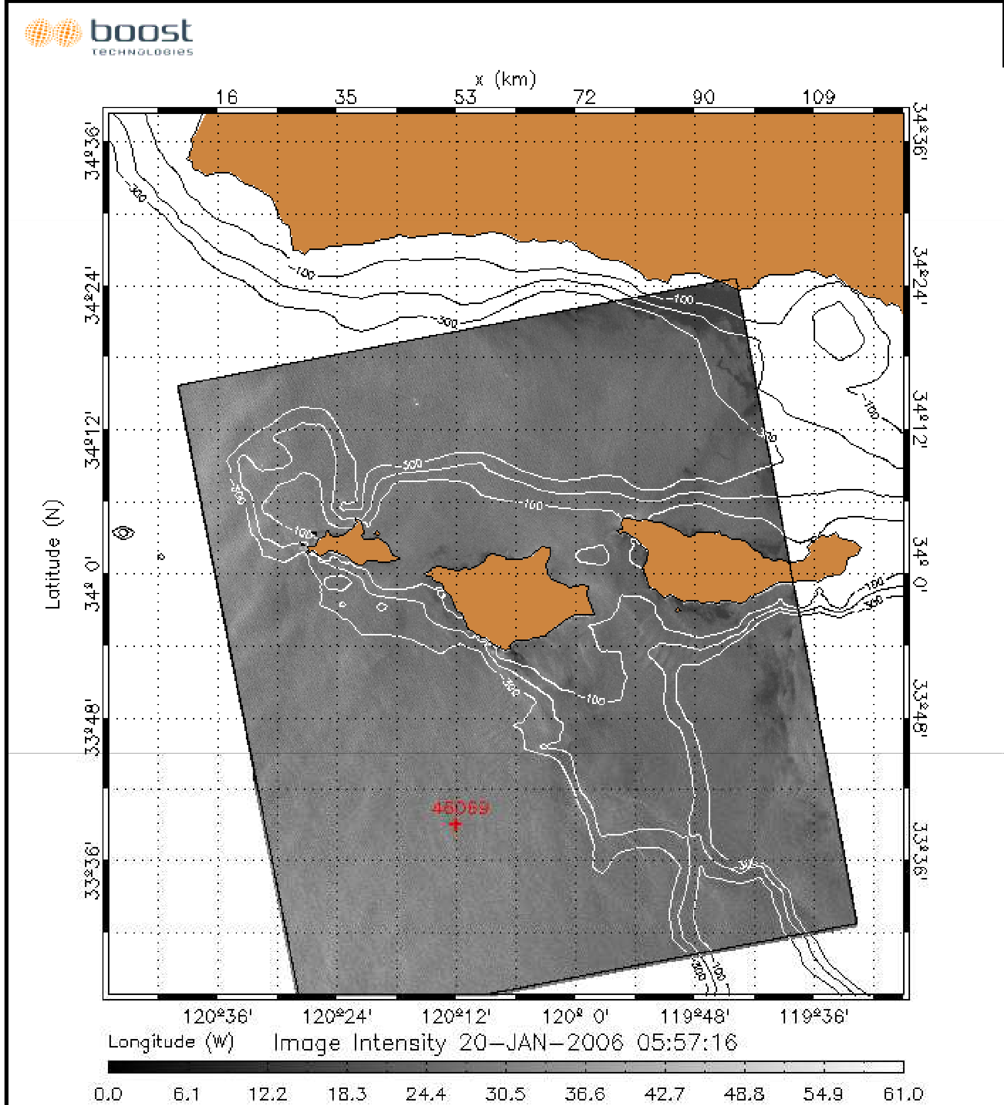


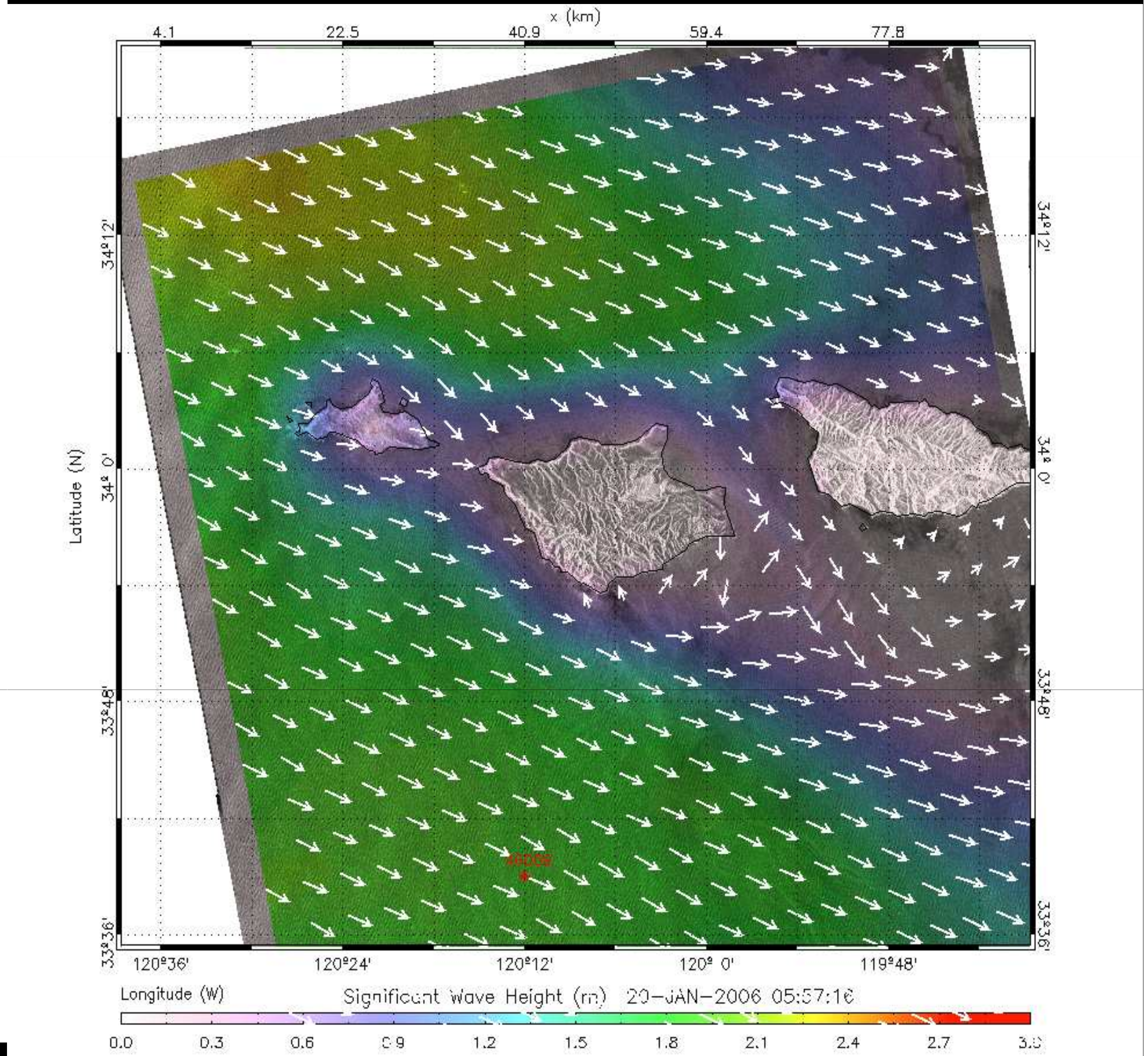
SAR swell products



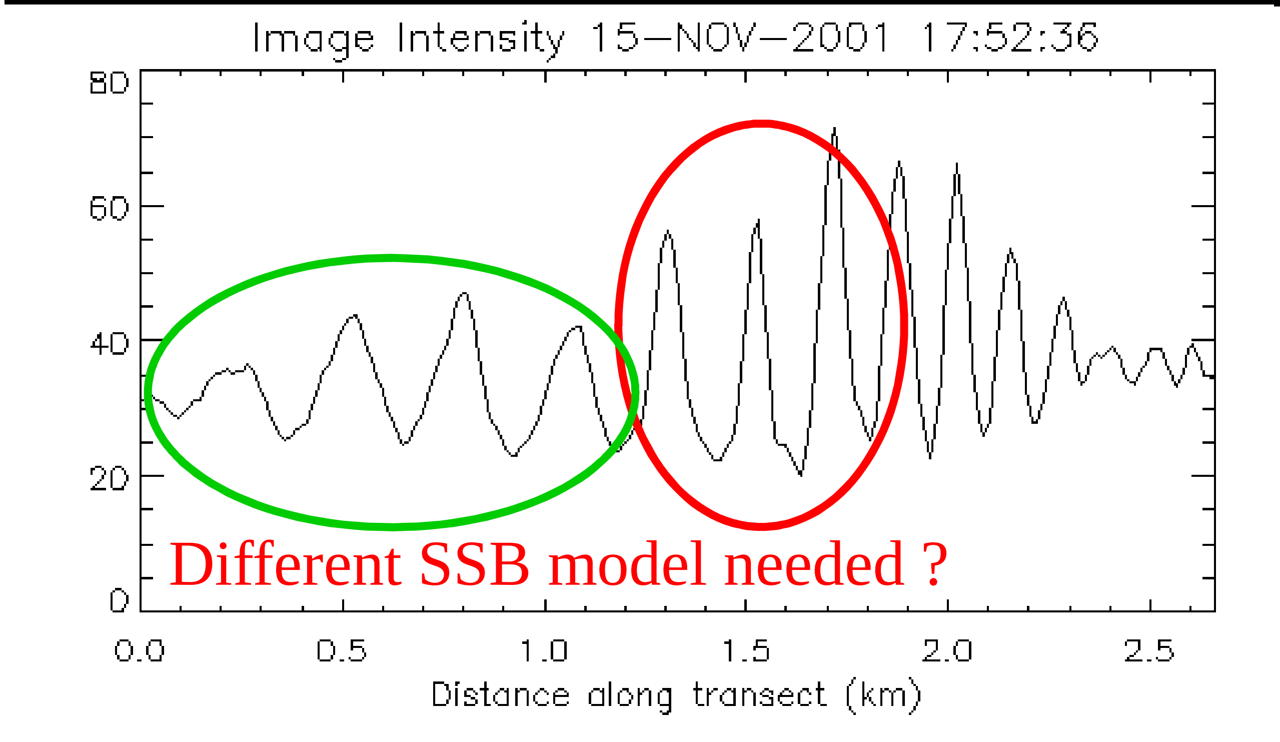
- Only SAR enables observation of spatial variations of 2D swell spectrum measurement
  - http://soprano.cls.fr/waveProducts/
- Available information of the swell component
  - Significant wave height
  - Wavelength (size of arrow)
  - Dominant direction
- General breakthrough
  - First high resolution wave field observation at 5km resolution
  - Wave inversion in shallow water

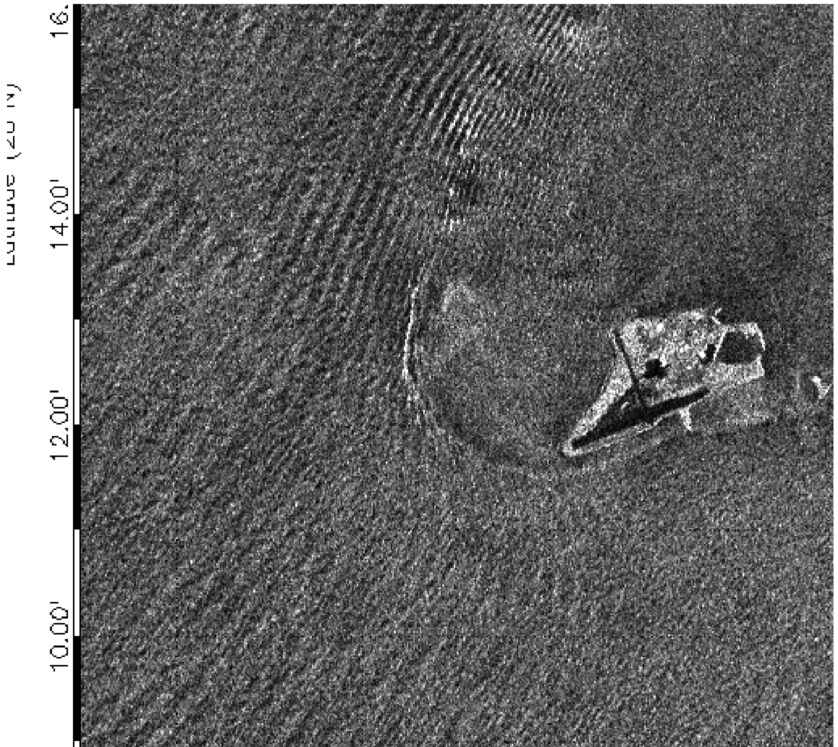
Observation of Swell variation in coastal area

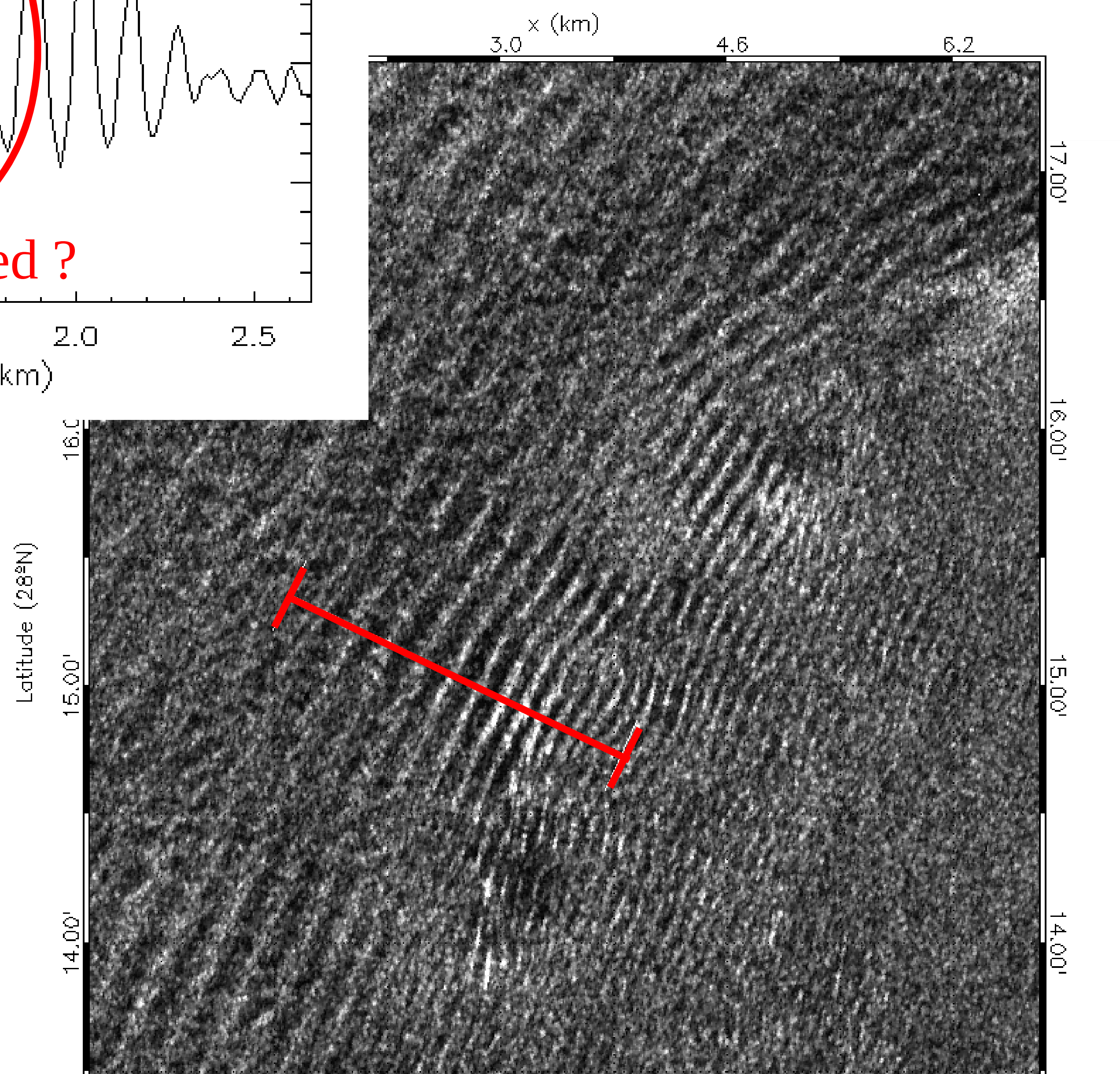




Swell nonlinearities in shallow water







Infragravity waves and Sea level remote sensing

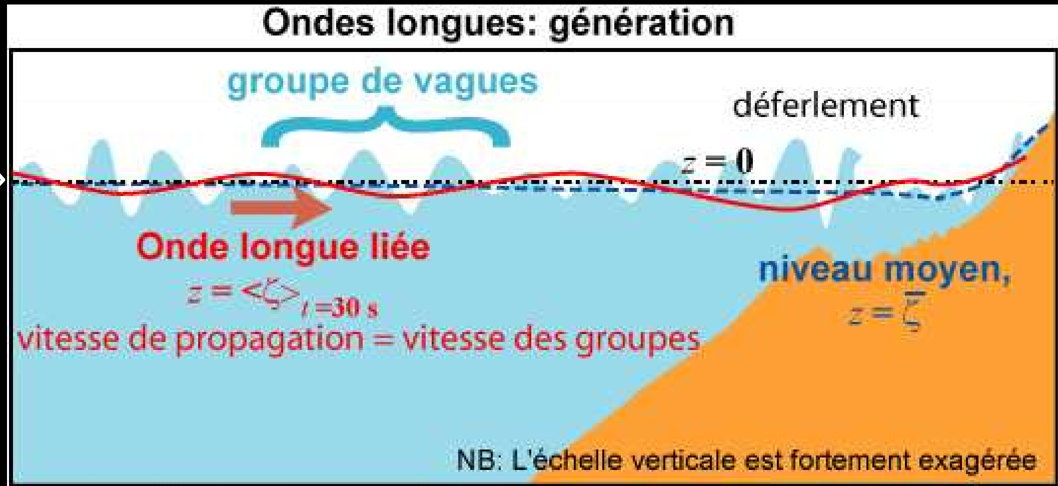
Generalities on infragravity (IG) waves

1. Unlike gravity waves, free IG waves are typically longer than altimeter footprints

2. Infragravity (IG) waves are generated as « bound waves » by the nonlinear difference interaction of « normal waves » of frequencies f1 and f2 and wavenumbers k1 and k2:

f_IG = f1 – f2 (0.001 to 0.05 Hz)

and k_IG = k1 -k2



At this stage the wavelength of IG waves is the lenght of wave groups (0 (1 km)).
Forced IGs are strongly amplified at the coast (amplitude can reach 1 m on the beach face).
As the forcing wave groups are dissipated, the IG waves are realeased as free modes. This energy is mostly trapped in the coastal zone, but a fraction of that energy leaks into the deep ocean. Free waves have the same frequency (0.001 to 0.05 Hz) … but the wavelength is given by the linear surface gravity wave dispersion:
assuming shallow water: L_IG = sqrt(g*D)/f_IG [more generally, f^2 = g k tanh(kD)/(2*pi)^2]
For D= 4000 m and a typical f_IG=0.02 Hz, this gives L_IG = 9 km

Conclusion

- 1cm at 10km resolution shall necessitate validation with improved MDT and instantaneous surface current field at finer resolution
- Strong heterogeneity of wave field in dynamical area. Needs to estimate the impact on altimeter interferometric measurement precision
- Wave bends as function of vorticity (and the wave group velocity) : wave impact and high resolution topography anomalies like SSB are not independant of surface currents.
- SAR can provide an independant high resolution NRCS and Doppler shift map : when defining the orbit, having SWOT swath inside an existing SAR swath would bring interesting comparisons opportunities.