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The 4th International Workshop on Advances in SAR Oceanography

From 2D to 3D upper layer dynamics: The way forward

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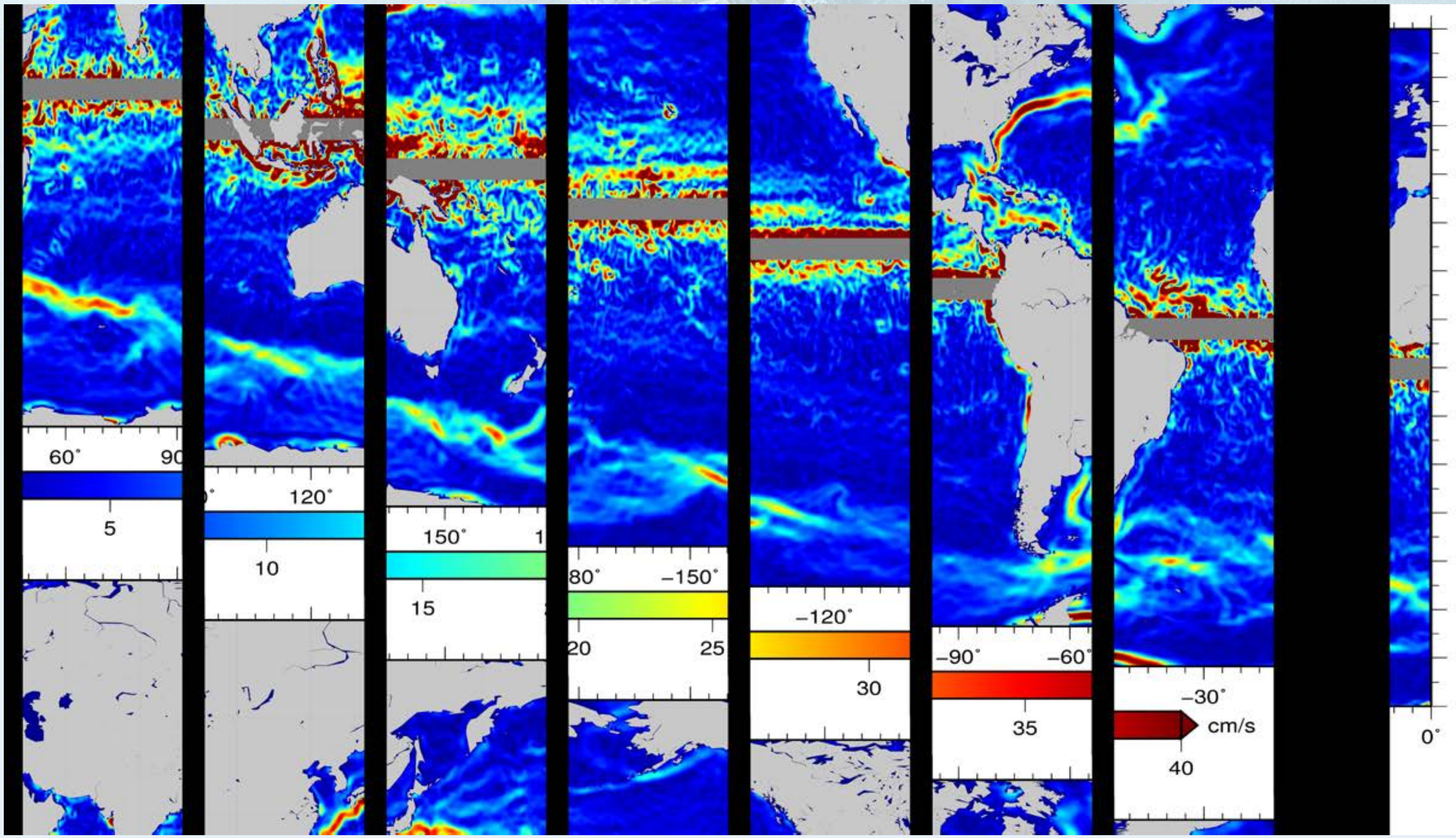
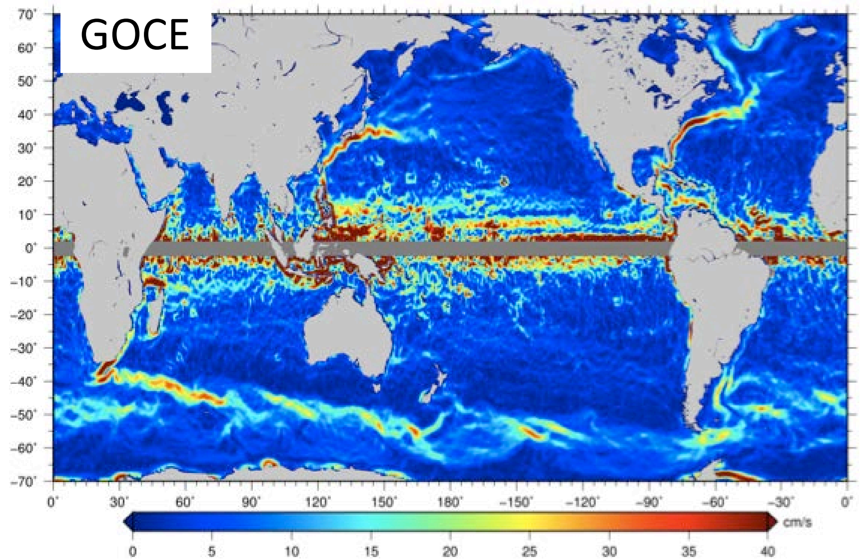
Upper ocean energy, scales and transfer

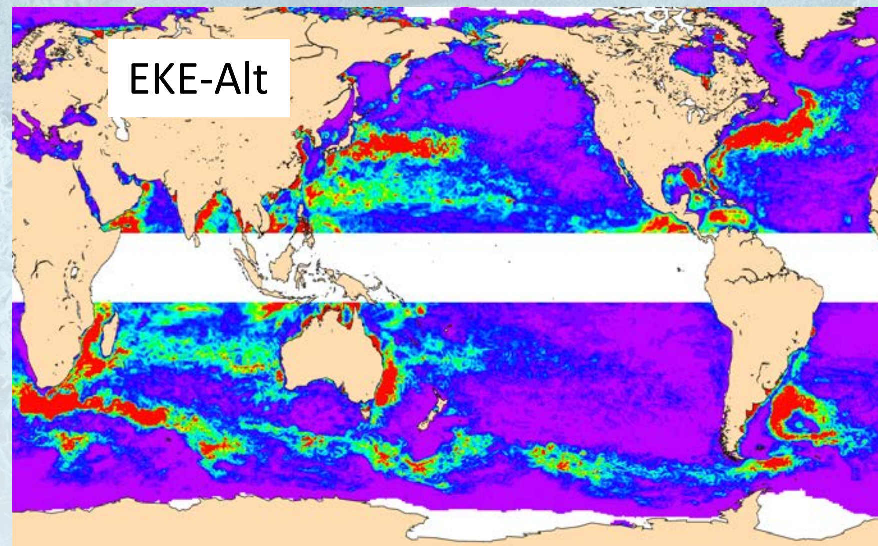
- At mesoscale (order 100 km) the energy is contained along meandering currents and eddies. Typical temporal scale is about 10 – 30 days (but seasonal is not unusual).
- At sub-mesoscale (1-10 km) the energy is found along boundaries and filaments often with strong vertical motion. Time scales from hours-to-days .
- The energy spectrum follows a K^{-2} structure from order 100 km to order 1-10 km. PE is transferred to finer scales. KE is moved from finer to longer scales

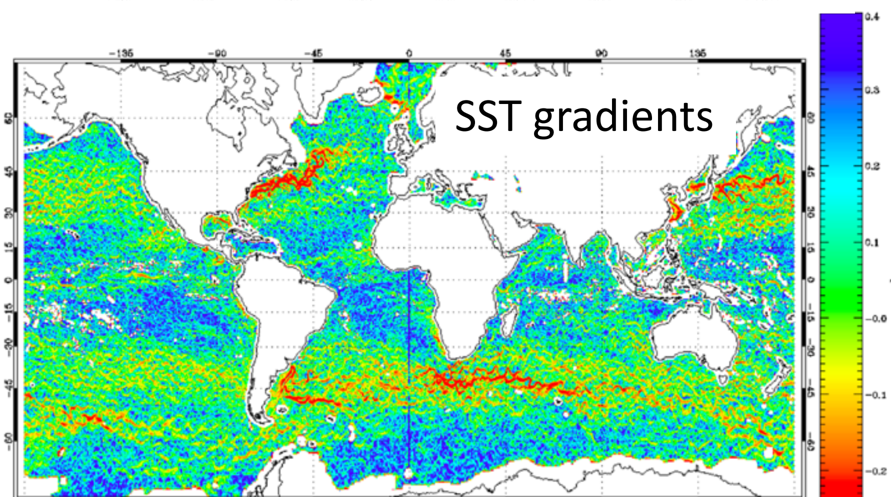
Geostrophic currents from GOCE (order 100 km)



Geostrophic surface current speeds derived from the **filtered** GOCE_TIM3-CLS11 MDT

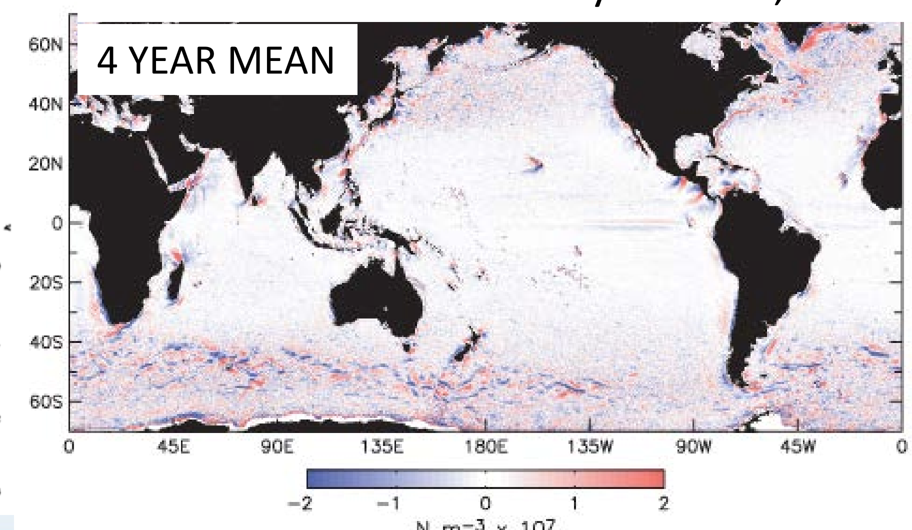






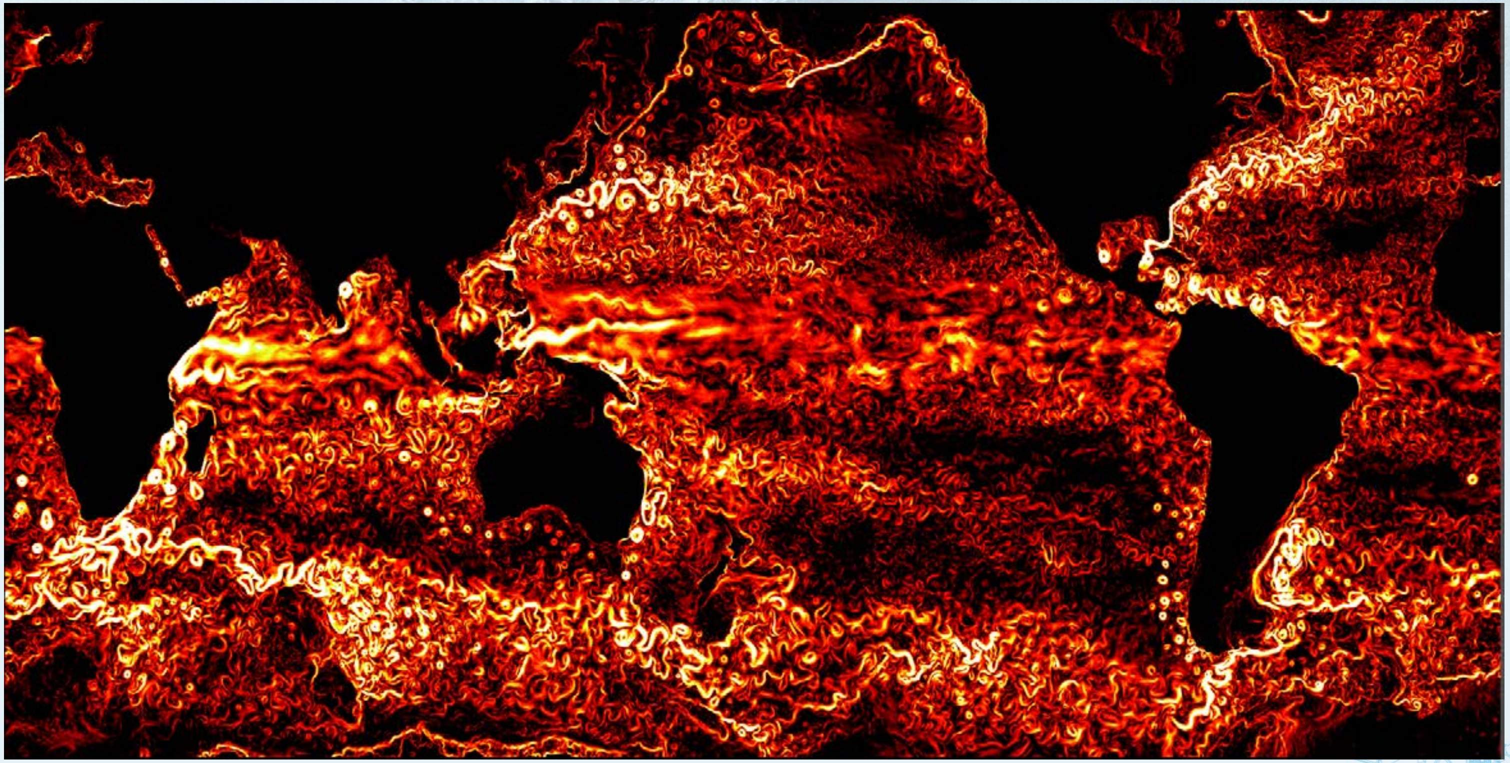
Courtesy Antonio Turiell

Wind stress curl - courtesy Chelton, 2007



A fully turbulent ocean !

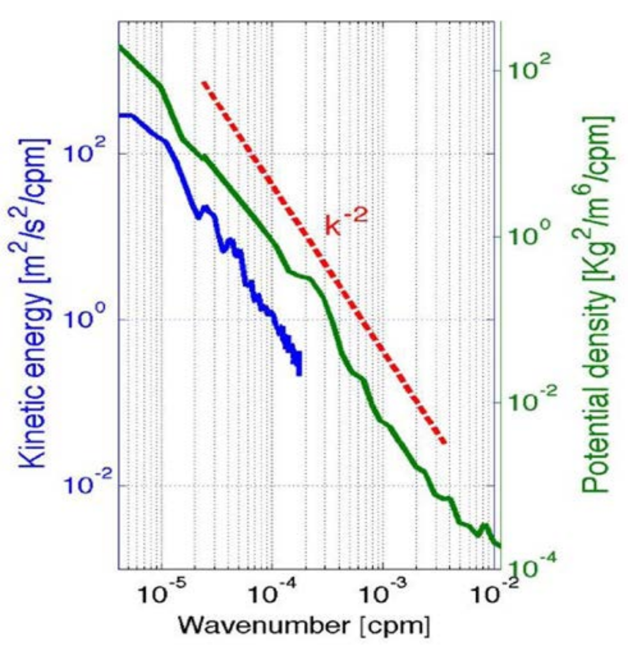
with a large number of mesoscale eddies (with 100km scales)

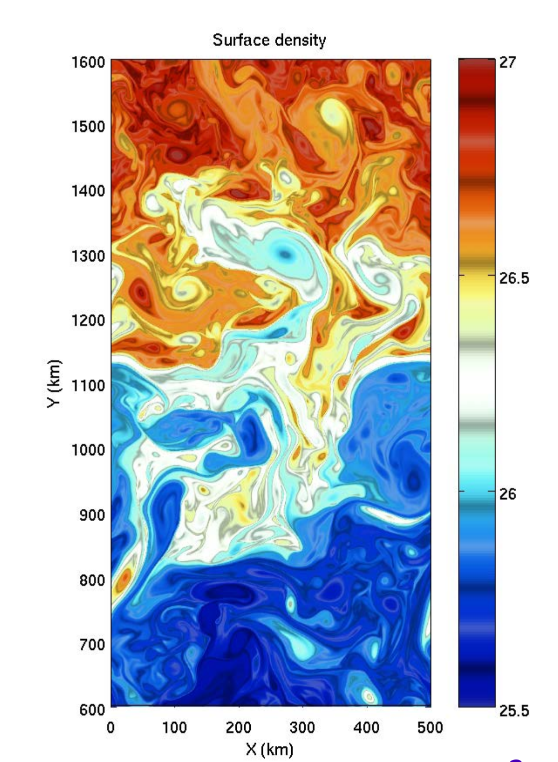


Ocean surface currents from an OGCM [Courtesy Raf Ferrari , MIT,USA]

SST gradients are affected by FRONTOGENESIS !

Observations: Ferrari & Rudnick, 2000
Wang et al., 2010

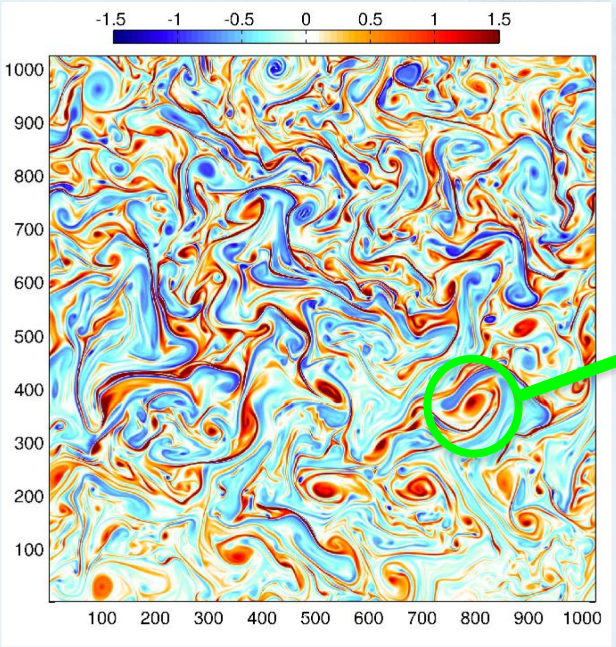


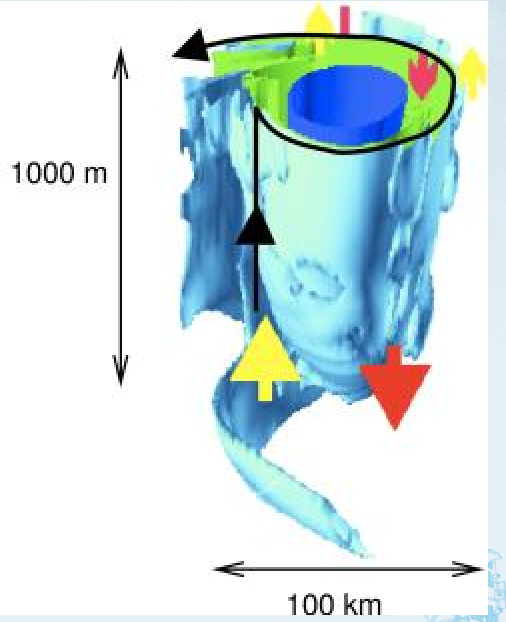


SST spectrum slope in k^{-2}
(as for the velocity spectrum)

Courtesy Klein

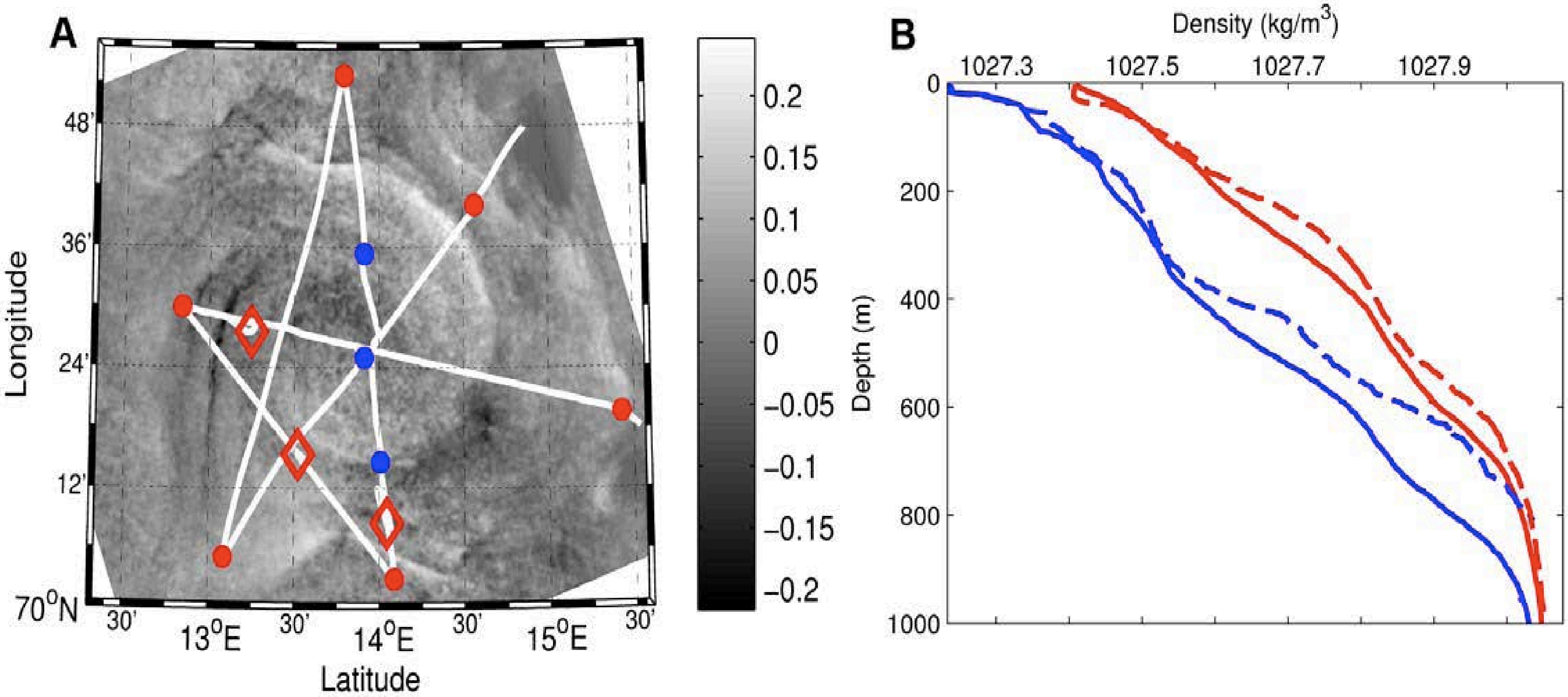
Models (10 km) suggest that fine-scale dynamics is very active vertically and act relatively deep





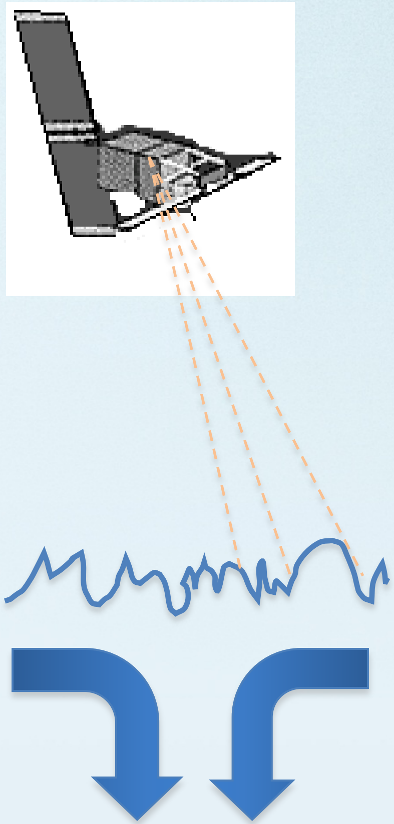
Figures courtesy of P. Klein, Hua and G. Lapeyre

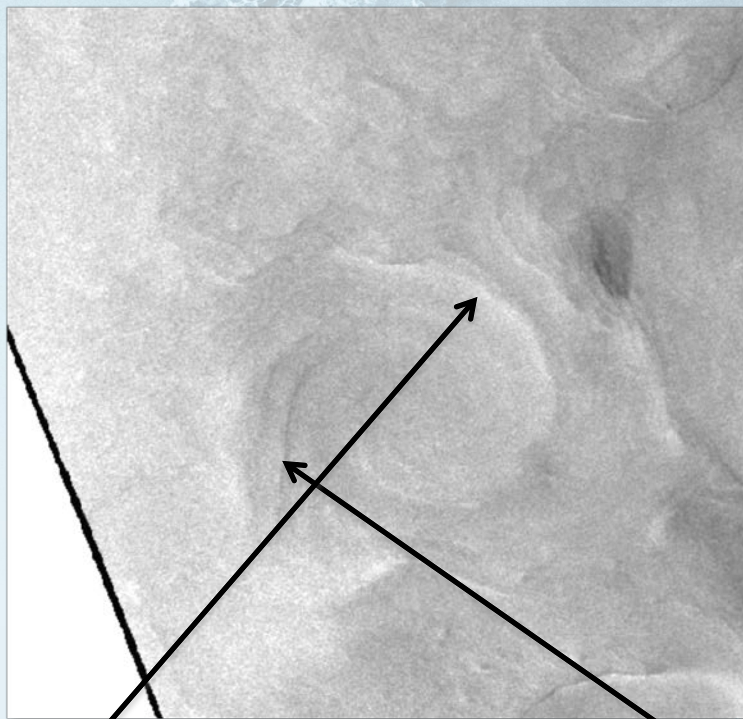
Anticyclonic Eddy in the Norwegian Sea

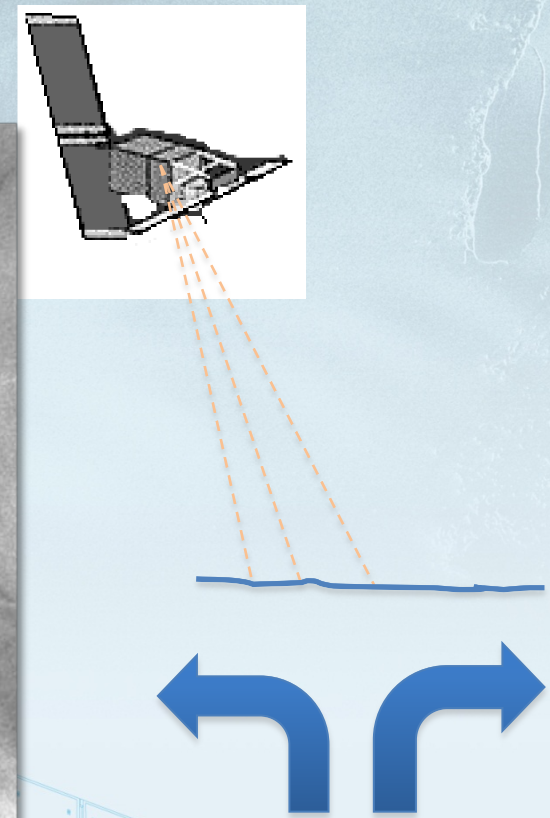


Godø et al., 2011

SAR detection



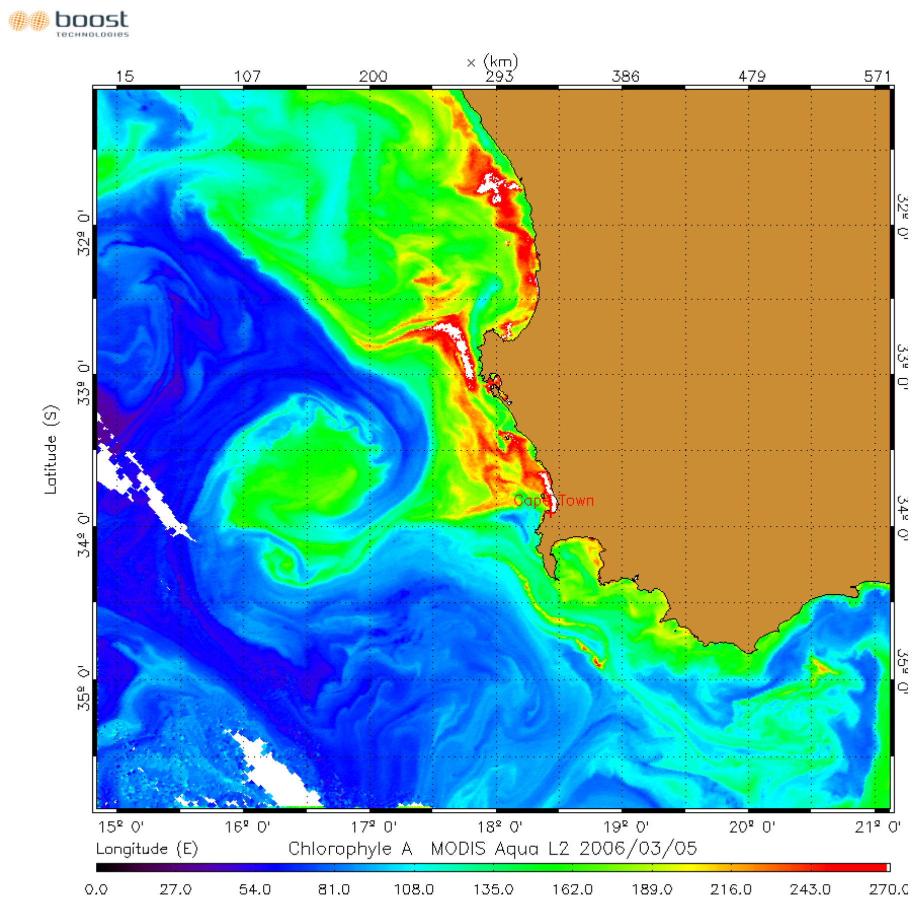


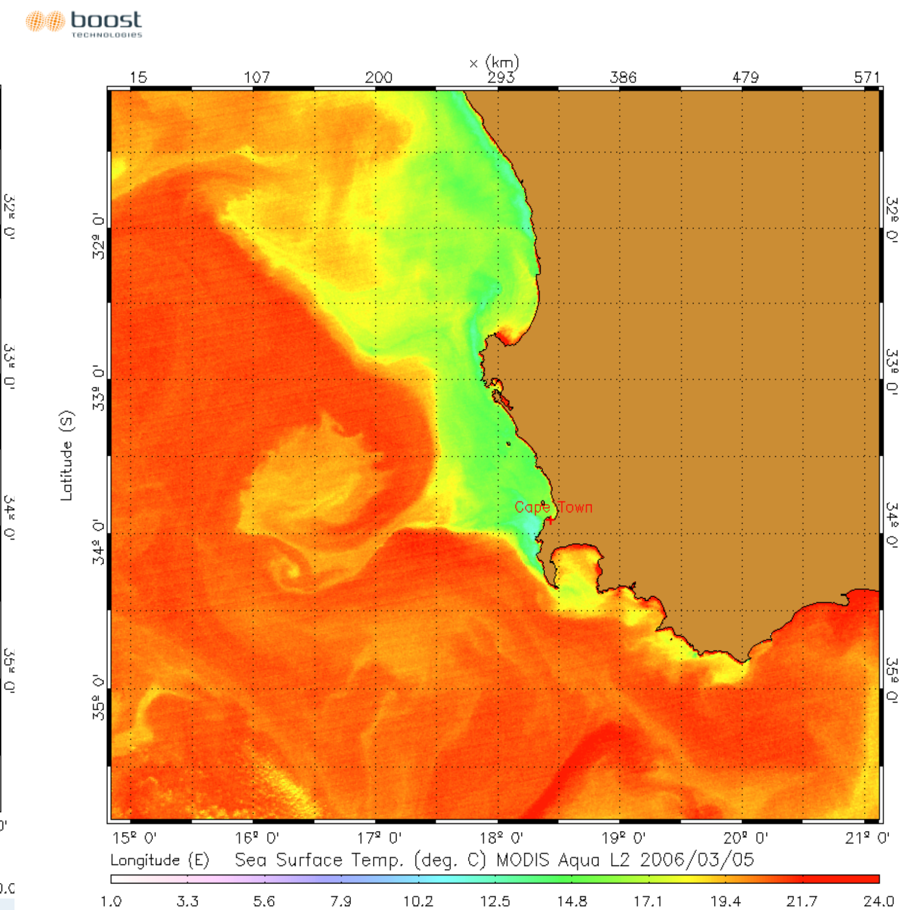


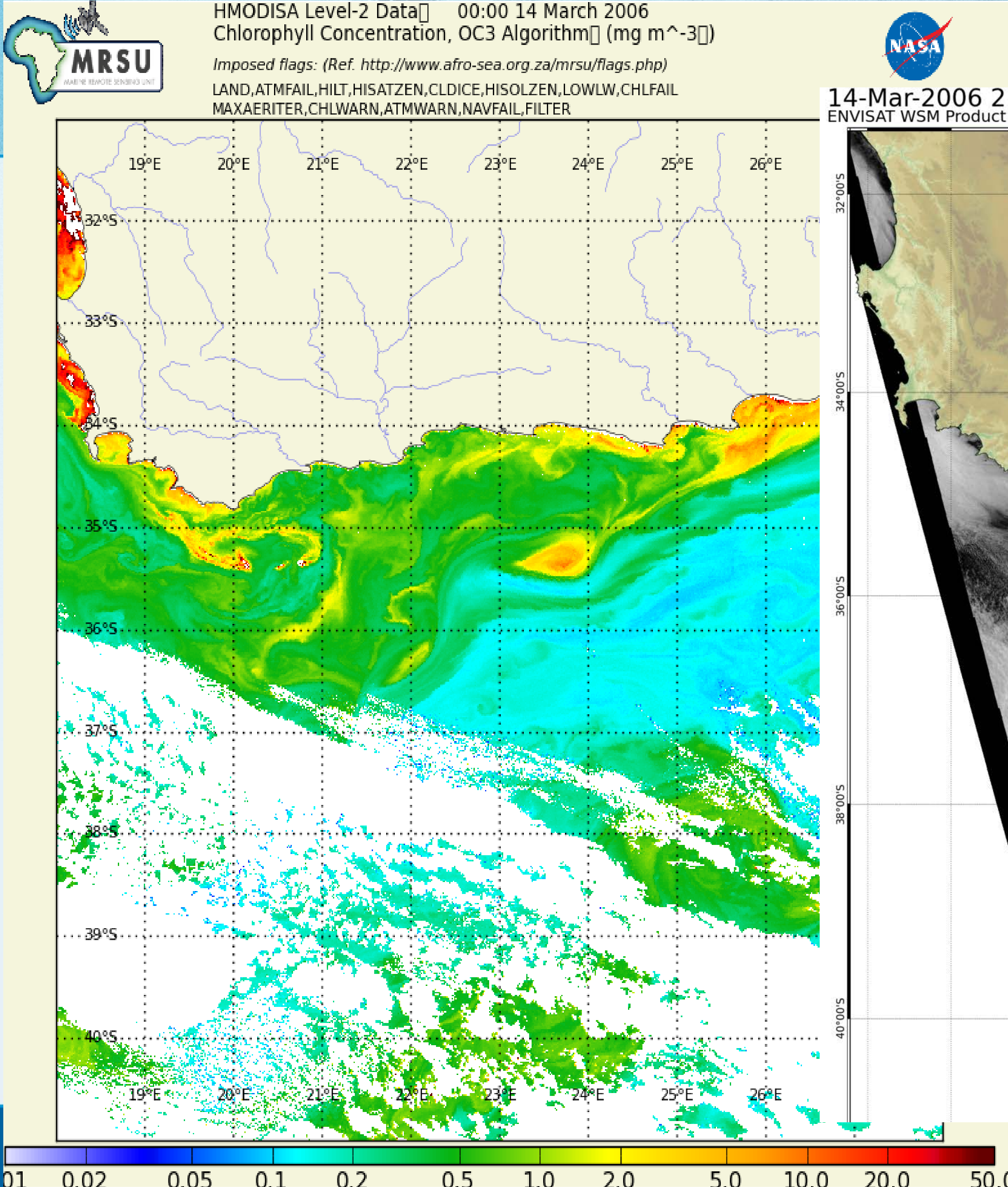
Convergence
Rough ocean surface
Light areas in the SAR image

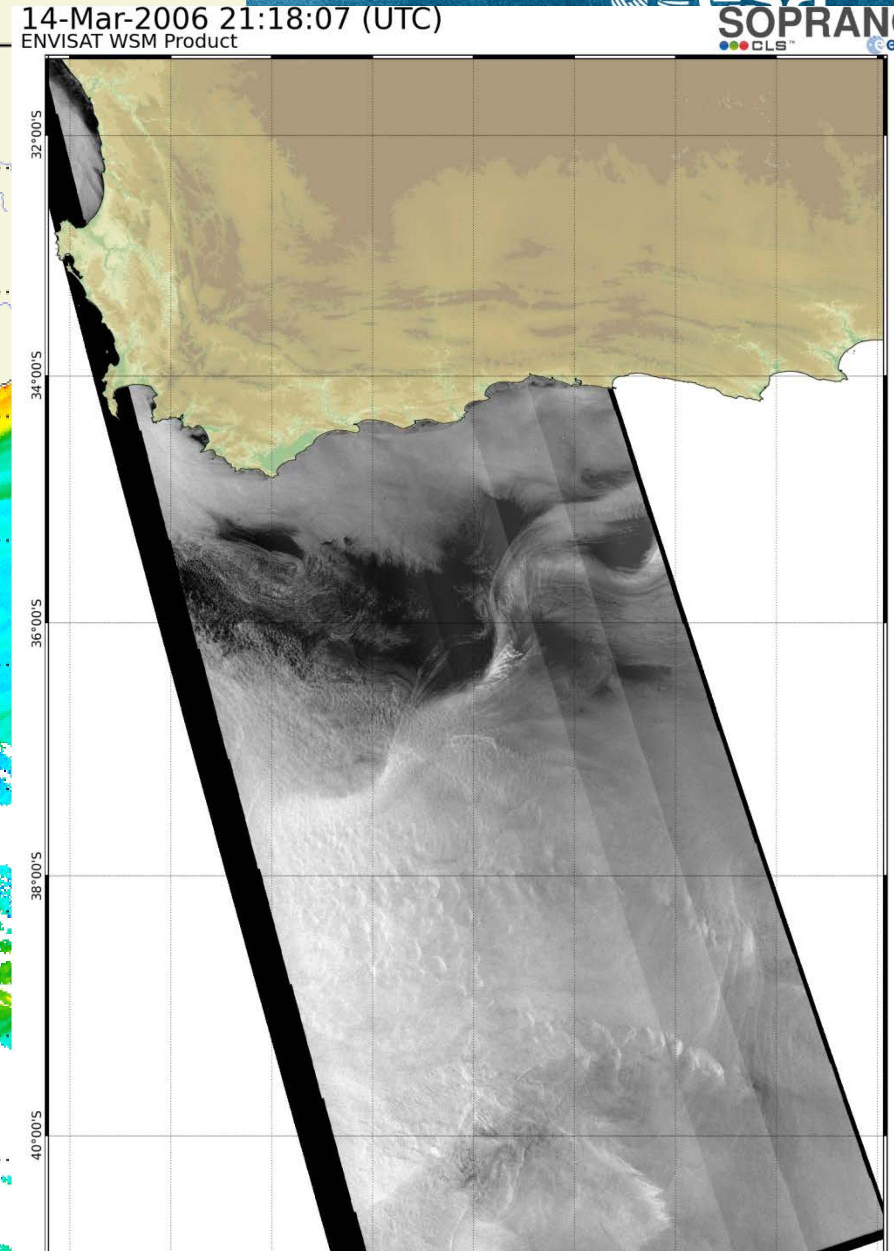
Divergence
Smooth ocean surface
Dark areas in the SAR image

Challenge: 2D expression to 2D/3D dynamics






MRSU
HMODISA Level-2 Data 00:00 14 March 2006
Chlorophyll Concentration, OC3 Algorithm (mg m^-3)
Imposed flags: (Ref. http://www.afro-sea.org.za/mrsu/flags.php)
LAND,ATMFAIL,HILT,HISATZEN,CLDICE,HISOLZEN,LOWLW,CHLFAIL
MAXAERITER,CHLWARN,ATMWARN,NAVFAIL,FILTER
NASA
19°E 20°E 21°E 22°E 23°E 24°E 25°E 26°E
32°S
33°S
34°S
35°S
36°S
37°S
38°S
39°S
40°S
0.02 0.05 0.1 0.2 0.5 1.0 2.0 5.0 10.0 20.0


14-Mar-2006 21:18:07 (UTC)
ENVISAT WSM Product
SOPRANO
CLS
32°00'S
34°00'S
36°00'S
38°00'S
40°00'S
Powered by C.L.S

SYNERGETIC APPROACH to OCEAN DYNAMICS

Quantity	Sensors	Satellite
MDT+SLA	Gradiometry and altimetry	GOCE, Jason 2 +S1 + S3
SST, ΔSS	Radiometry	Metop, Aqua, S3
OC, ΔOC	Spectrometry	Aqua, S3
σ, $\Delta\sigma$	SAR	Radarsat 2, S1
Doppler anomali (= velocity)	SAR	Radarsat 2, S1
ΔMSS (~ $\Delta\sigma$)	Spectrometry	Metop, Aqua, S3
τ, $\Delta\tau$ (impact on ABL)	SAR, Saccetrometry	Metop, Radarsat, S1

Synergetic Approach to Ocean Dynamics: Scales ~ 100 km to ~ 1 km

MDT
MDT+SLA

SST, ΔSST
OC, ΔOC

σ, Δσ, Doppler
ΔMSS (~ Δσ)

SSS, ΔSSS

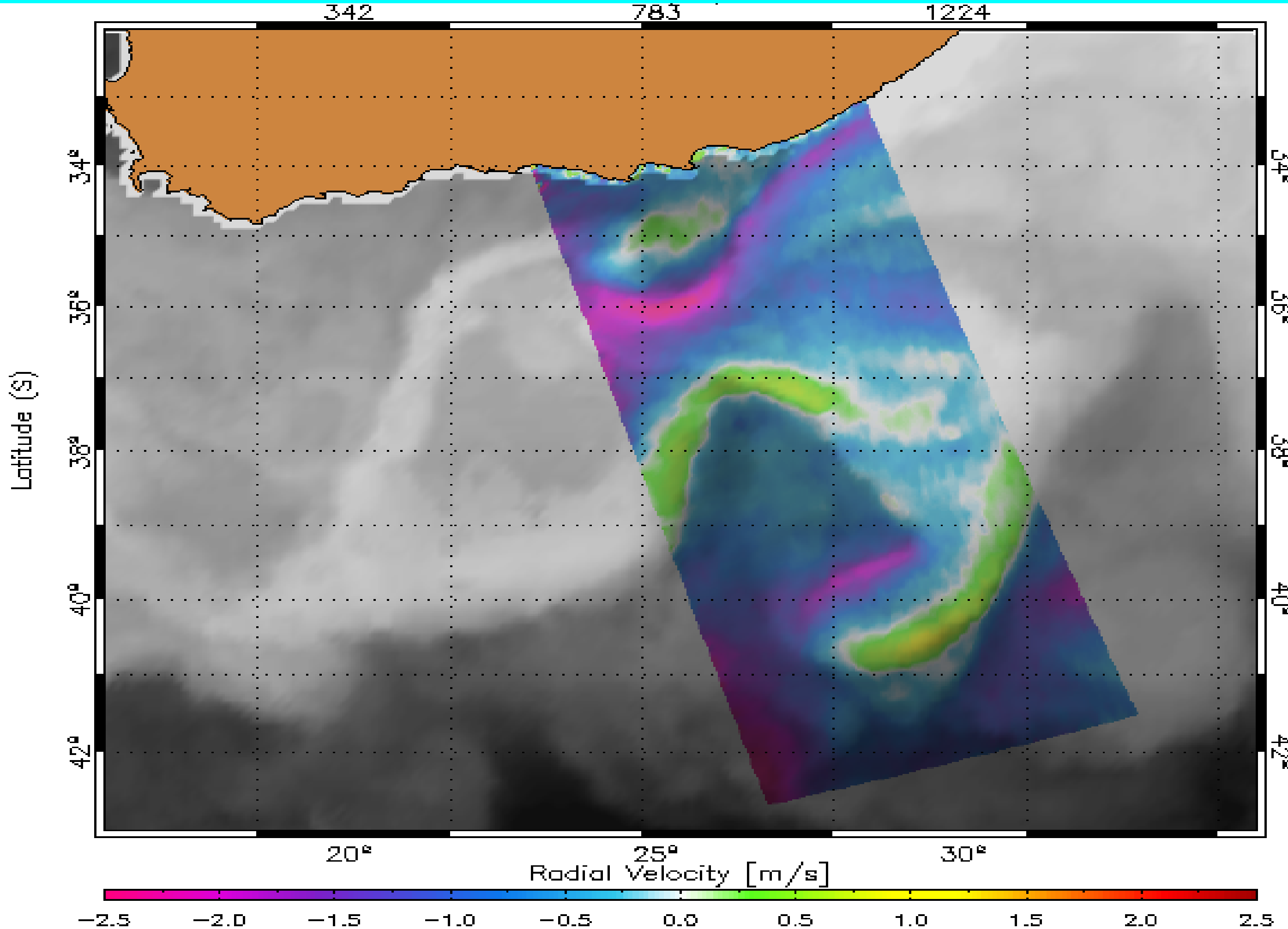
τ, Δτ (impact on ABL)

- $\underline{U} = \underline{U}_{mean} + \underline{U}'_{pert}$
- Divergence of $\underline{U}$
- Curl of $\underline{U}$
- Ekman Current

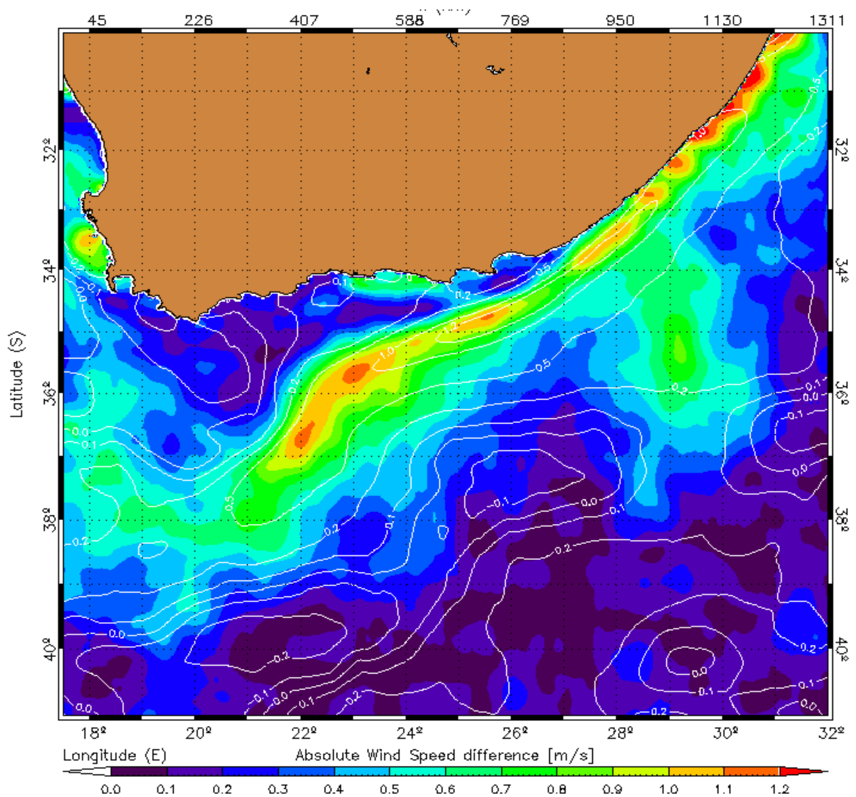
Develop and apply common tools and methods (gradient detectors, Lyaponov, MCC, SQG, DOPRIM, et)

Make a consistent transfer of these fields to 2D surface dynamics and next to 3D upper (500m) ocean dynamics combined with models

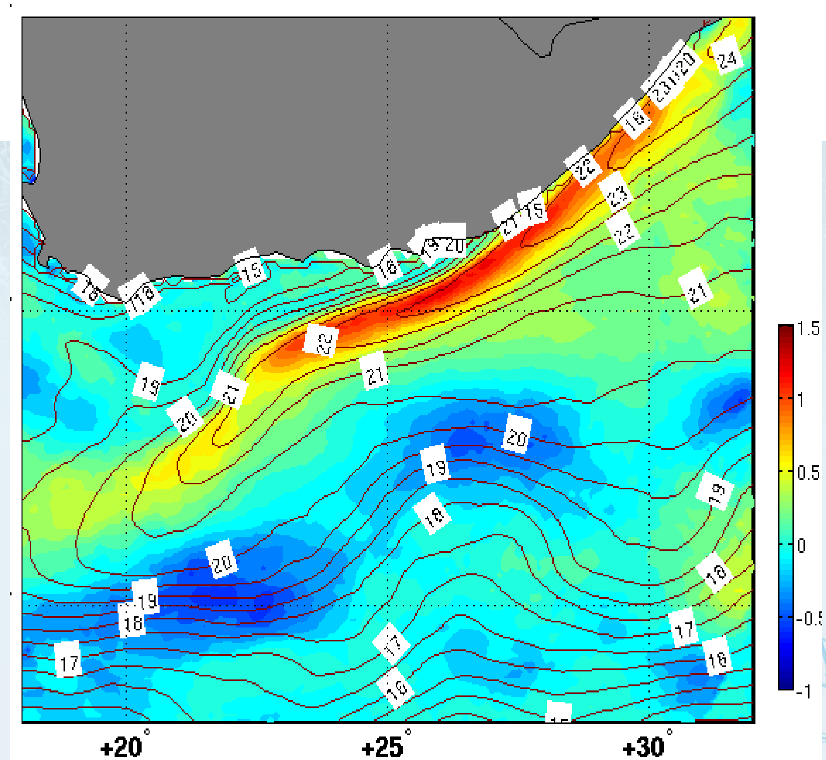
SST and range Doppler velocity overlay – 14 April 2009



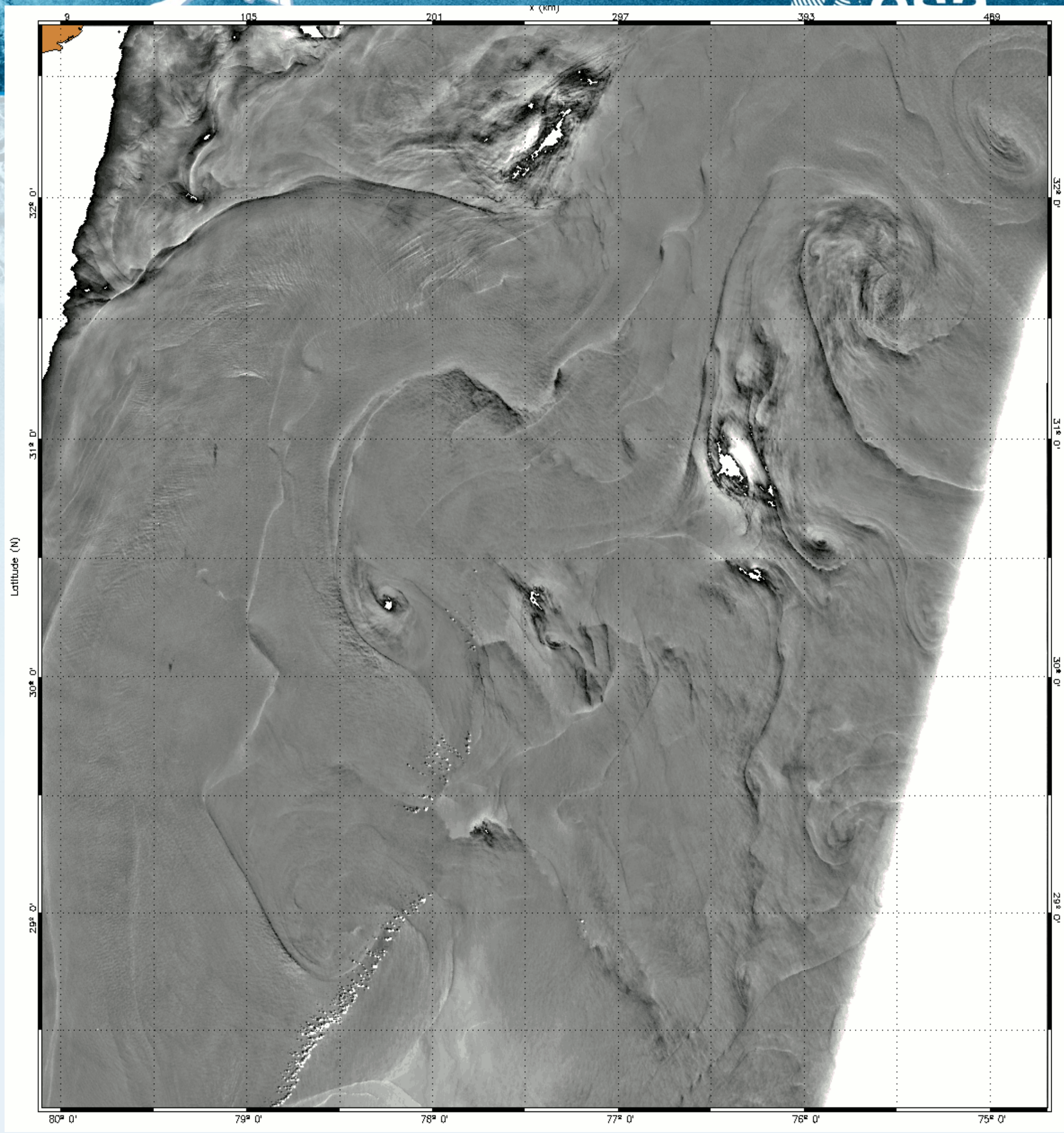
Annual wind speed anomaly from ASAR



SST and range Doppler velocity

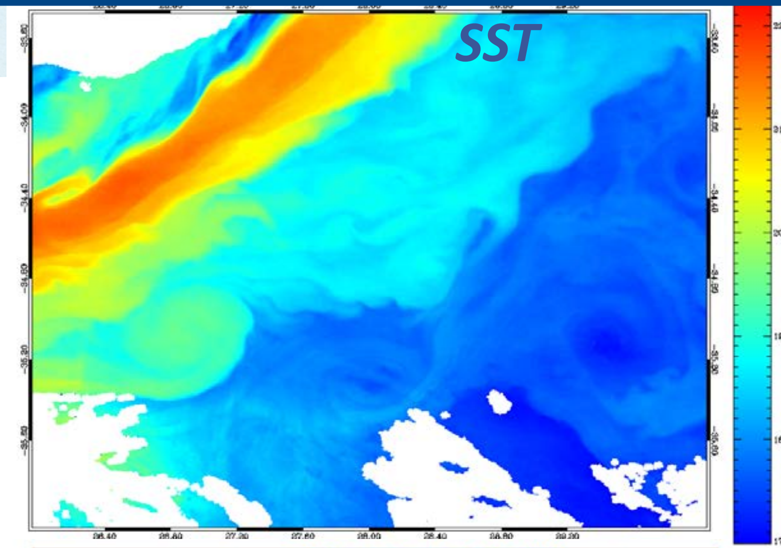


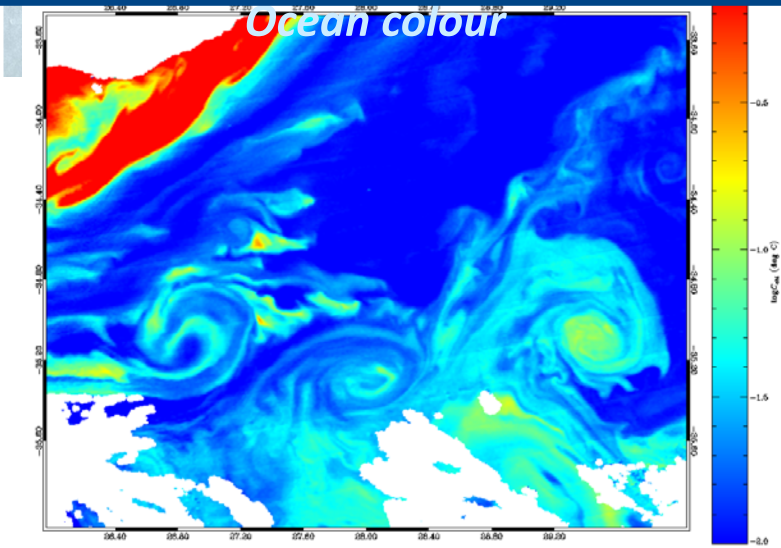
Advantage of Sunglint!

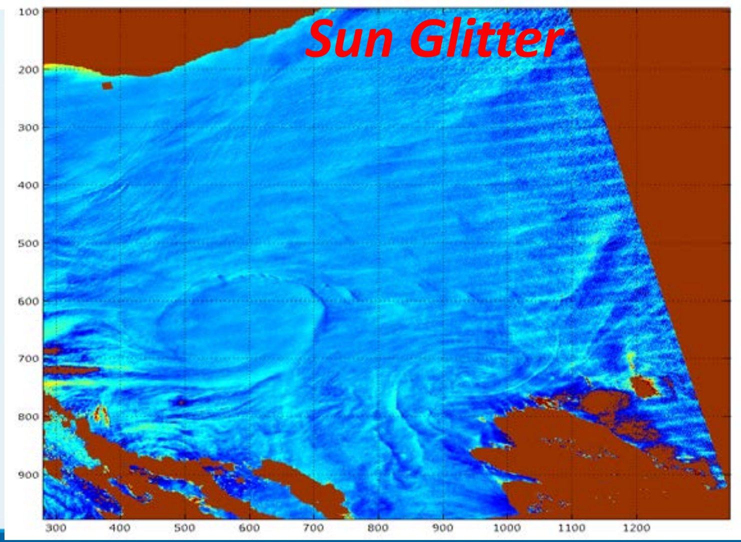


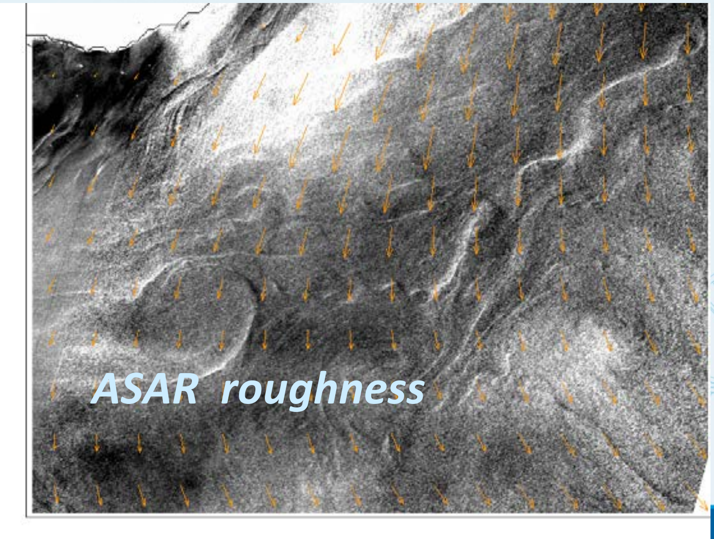
AVHRR SST AND SUNGLINT

Challenges at the mesoscale (Synergy)

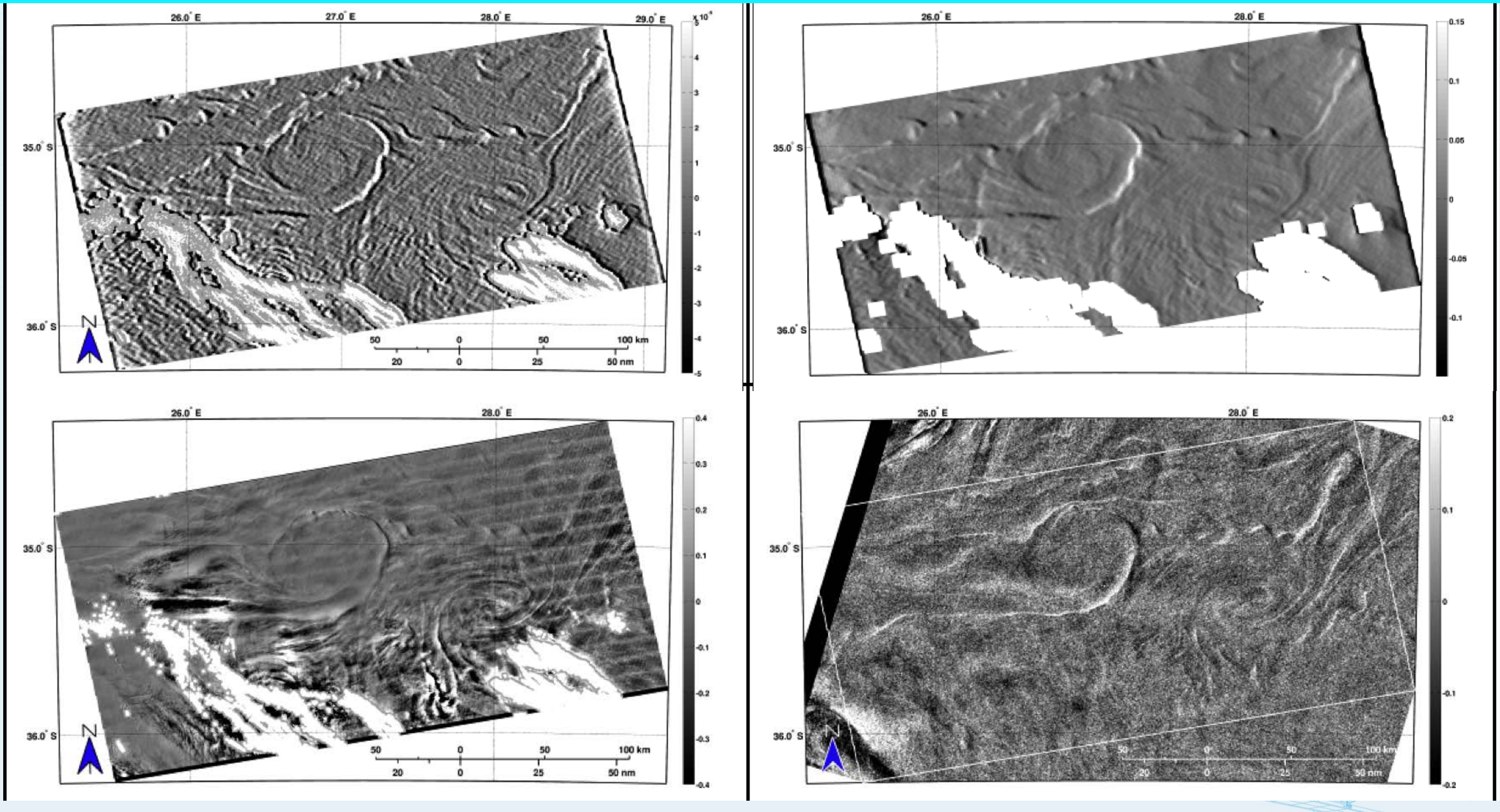








MODIS SST map (upper left) , RIM simulations of contrasts in the MSS (upper right). The Mean square slope derived from the MODIS reflected shortwave signal (lower-left) and Envisat ASAR backscatter image (lower-right) of the mushroom like eddy



Kudryavtsev, A. Myasoedov, B. Chapron, J.A. Johannessen, F. Collard, 2012 (in press)

From 2D to 3D Dynamics : SUMMARY

- Consistent synergetic studies of altimetry (with new geoid from GOCE), radiometry, spectrometry, scatterometry and SAR are necessary to advance our knowledge and ability to connect 2D surface expressions with upper layer 3D mesoscale (~ 100 km) to submesoscale (~ 1-10 km) ocean dynamics. In turn, new understanding will be gained regarding:
  - The two-way coupling to upper layer biology (phyto- and zooplankton).
  - Gas exchange across the air-sea interface
- High resolution (~ 10 km) model simulations of upper ocean dynamics will be much better assessed and validated.
- International team sharing expertise and capacities should be stimulated to do this. Take advantage of supersites!!!! The first preliminary plans are now being cooked.