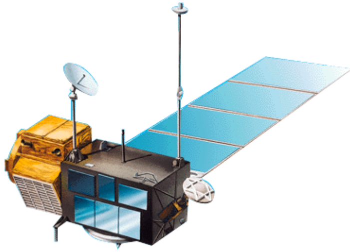

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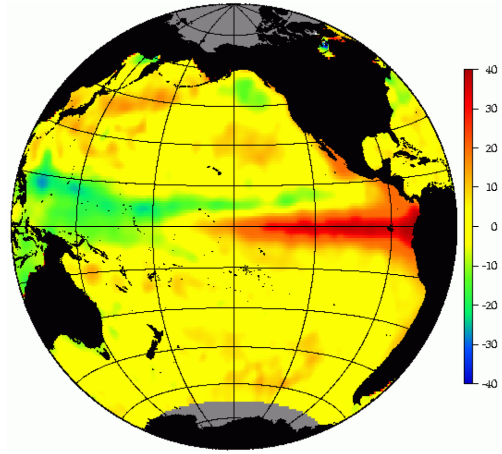
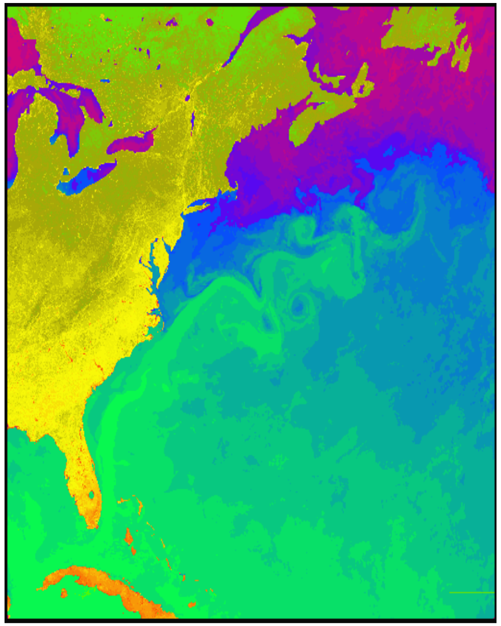
LEGOS



Ocean Dynamics observed by altimetry – today & the future



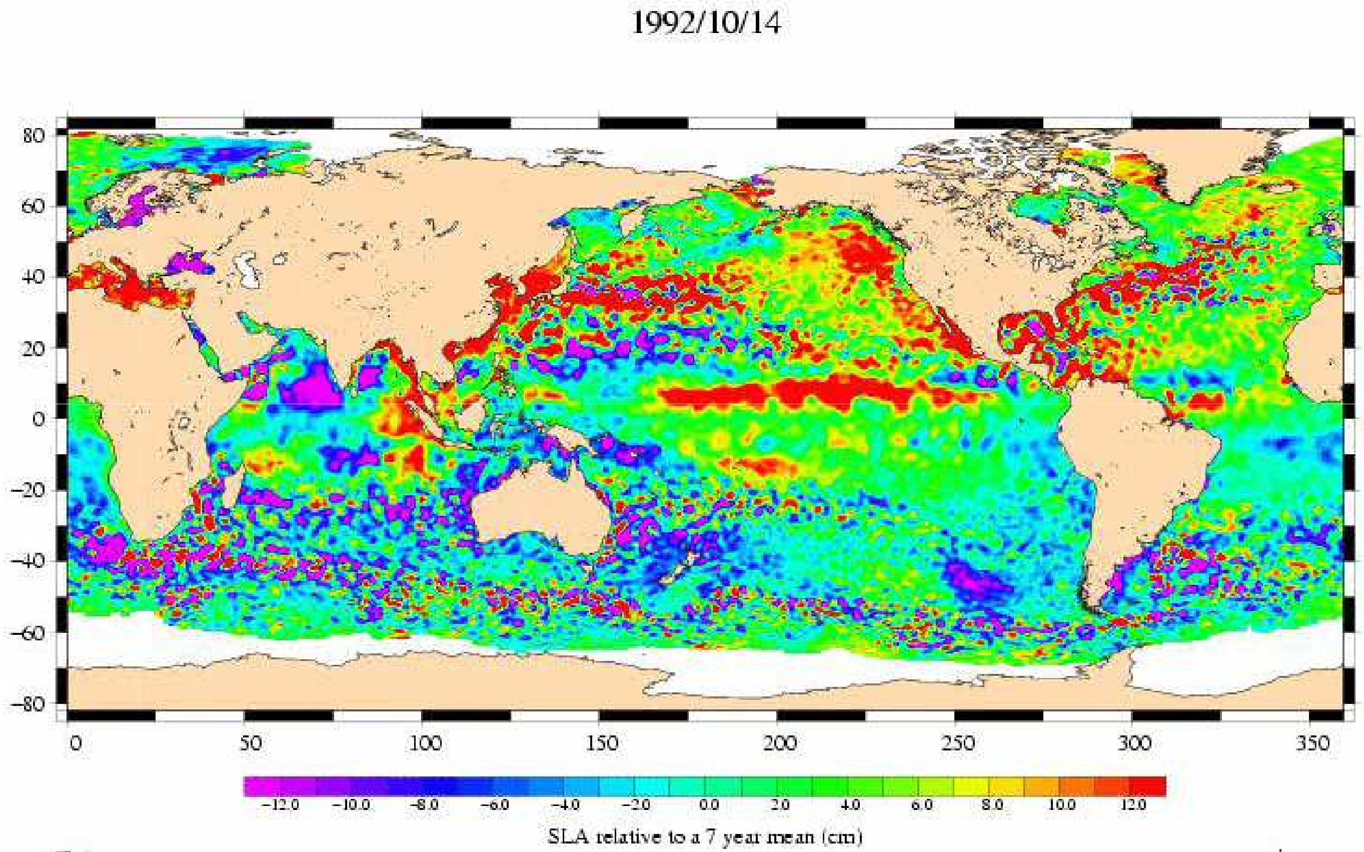
Rosemary Morrow

LEGOS, Toulouse

Lee-Lueng Fu

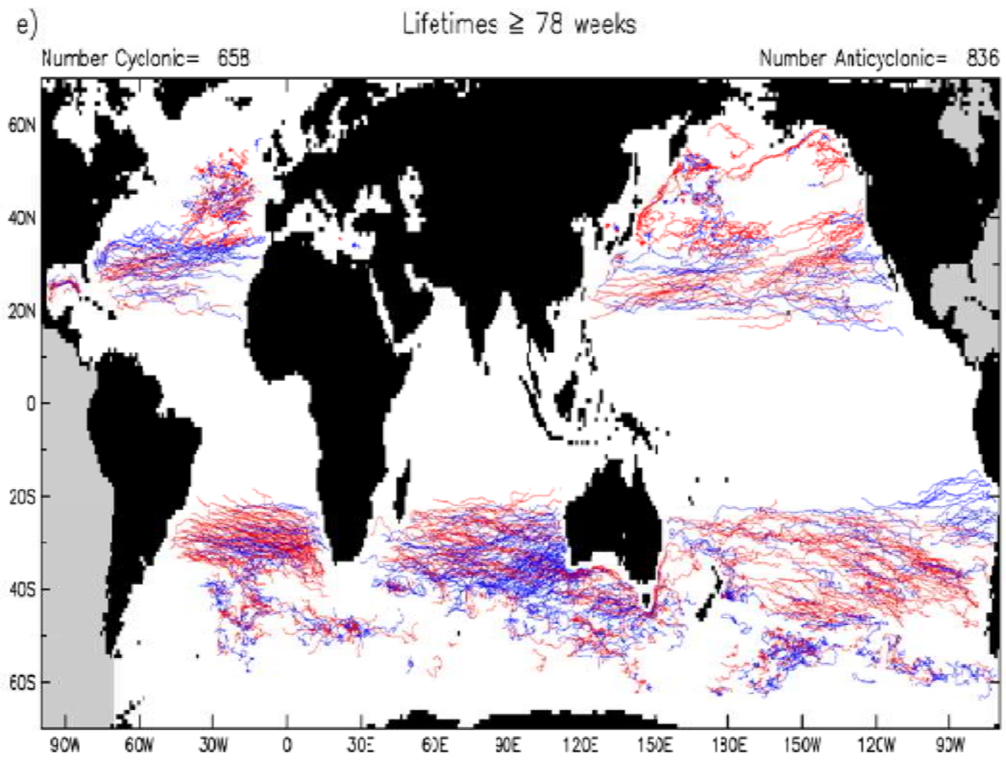
JPL - NASA

« Our current knowledge of mesoscale eddy activity in the ocean derived from altimetry is largely based on gridded AVISO data sets »

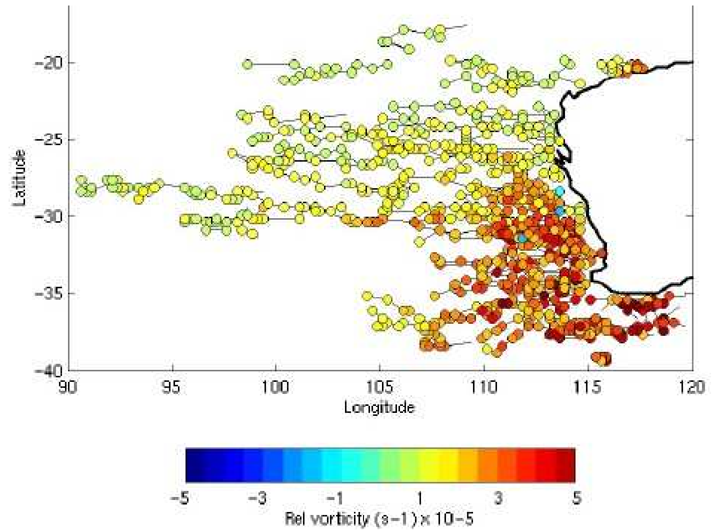


18 year time series (w. minimum 2 altimeters) => monitoring the impact of mesoscale eddies on the large-scale climate system

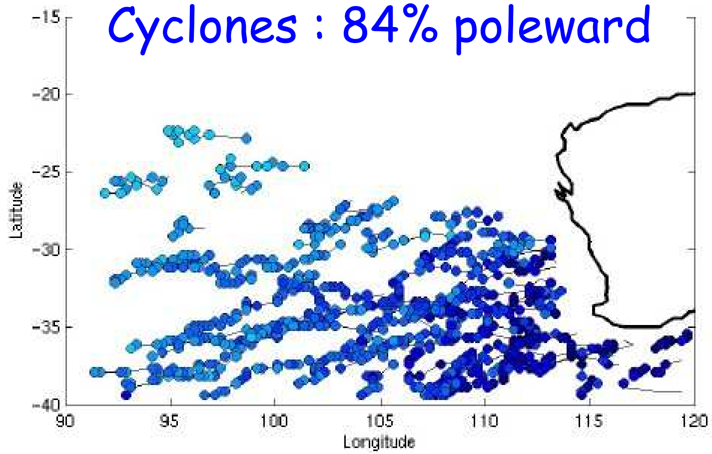
Tracking large-scale non-linear eddies over years



Anti-cyclones : 74% equatorward



Cyclones : 84% poleward



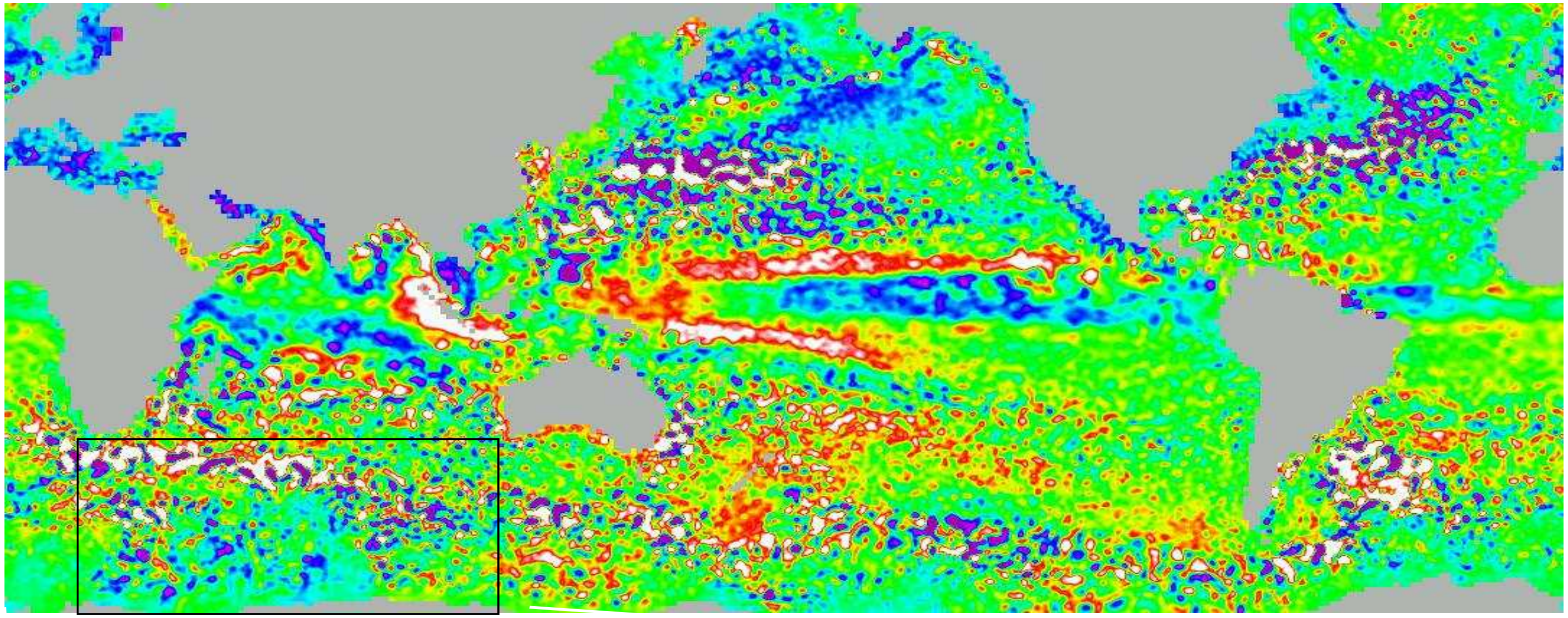
Eddies mainly generated near E boundaries & bathymetry

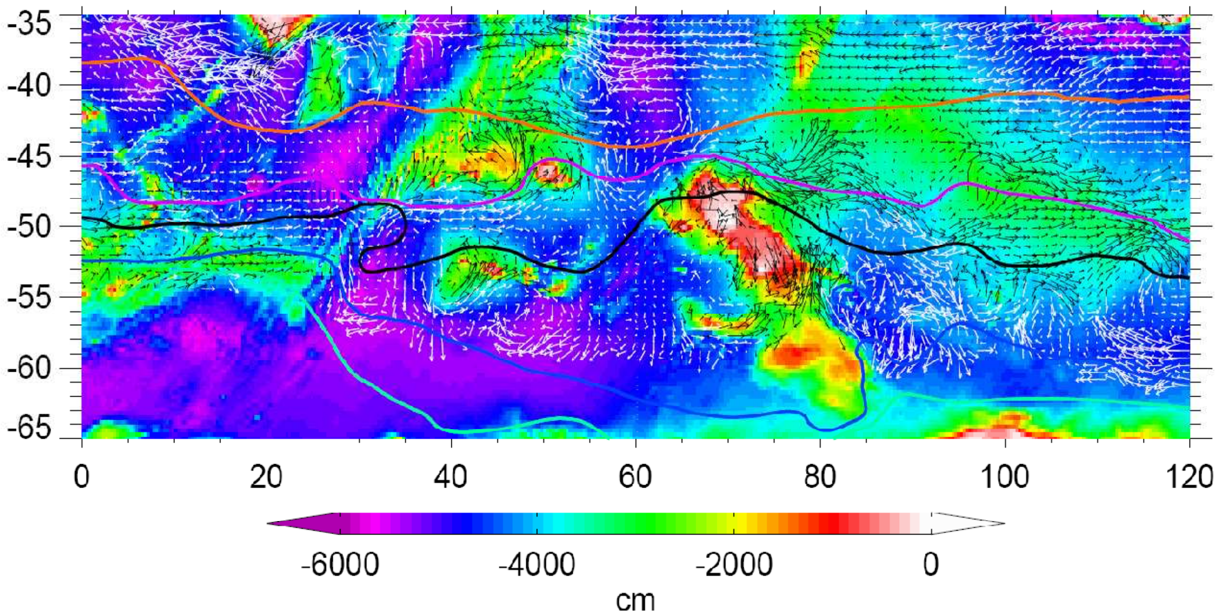
Cyclones tend to the poles, anticyclones to the equator

Morrow et al., 2004

Chelton et al., 2010

Mapping mesoscale eddies with present altimeter data (AVISO)

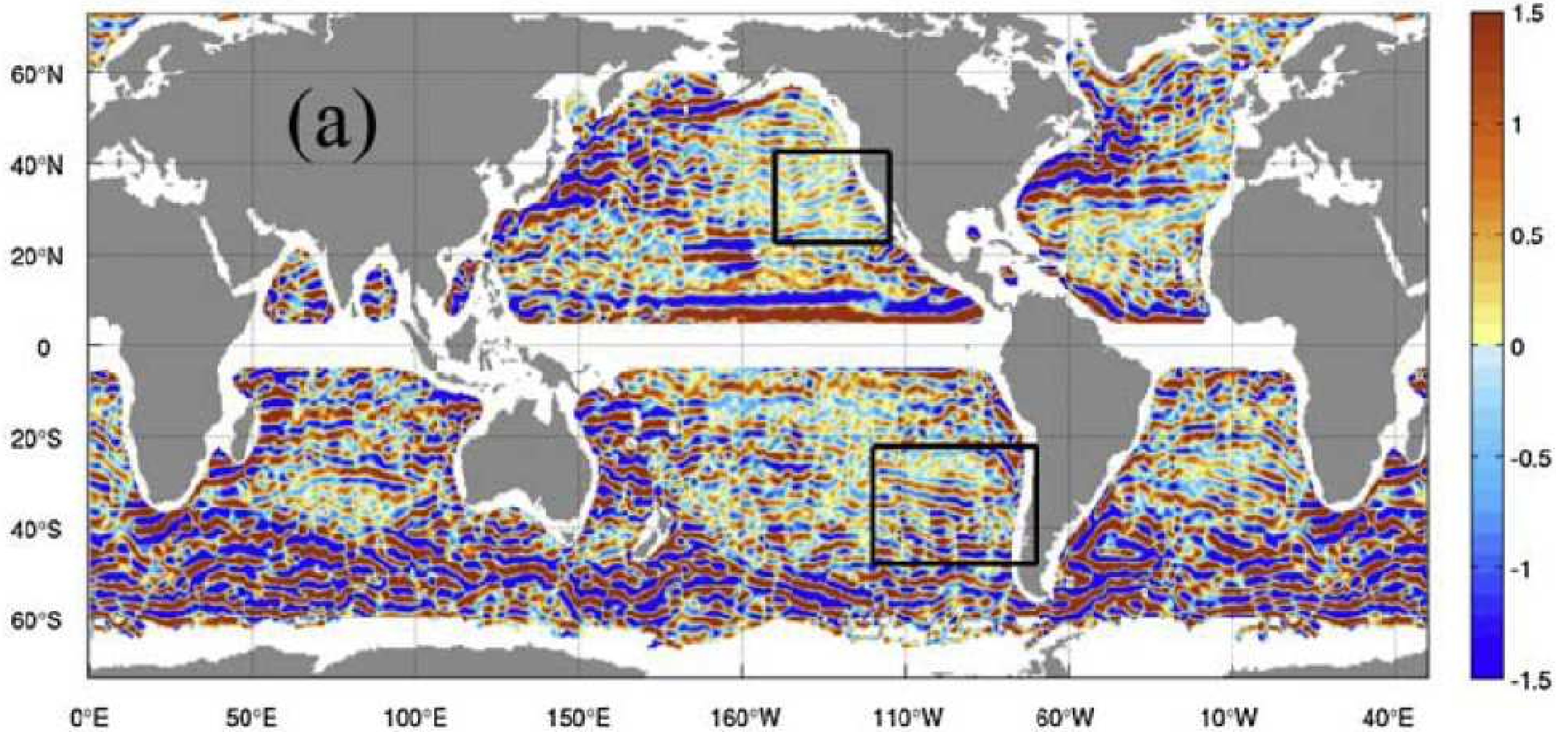




The pattern of eddy propagation is revealed by the altimetry data.

Fu, 2009

Strong zonal mean ocean jets – impact on atmospheric circulation



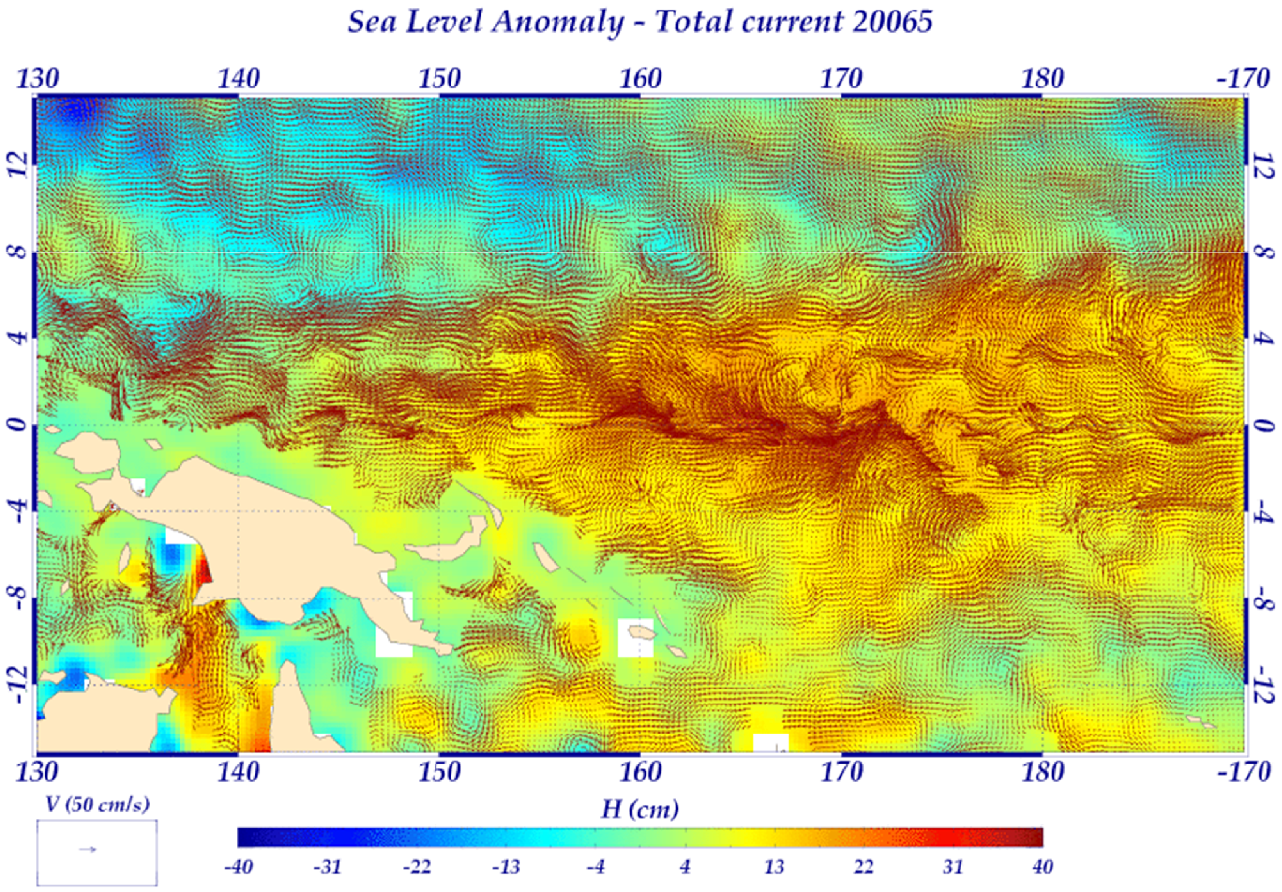
10 year mean zonal surface geostrophic velocity

after Maximenko et al., 2008

Surface circulation

High-resolution (1/4°), nearly synoptic (7 day period) mapping of surface currents using mapped altimetric surface height and scatterometry winds:

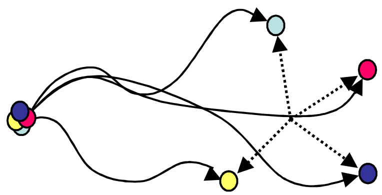
Example : western tropical Pacific, showing velocity vectors overlaid on sea level anomaly (cm)



Sudre & Morrow , 2008

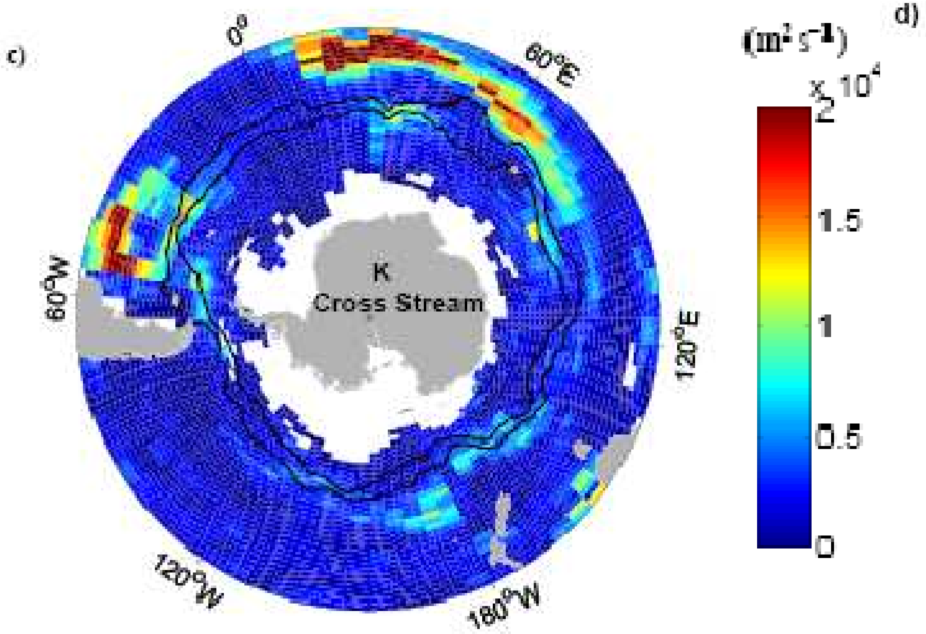
Eddy diffusion and mixing from altimetric surface currents

Higher order eddy statistics can be calculated from altimetric geostrophic surface currents.

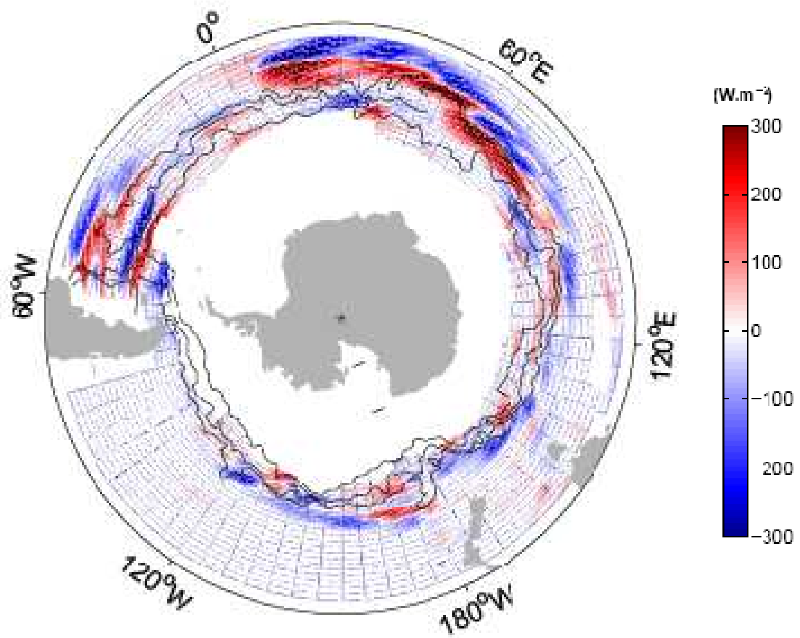


Lagrangian particles or tracers are advected with the 2D flow => eddy diffusion statistics *(Sallée et al., 2008, Shuckberg et al., 2008)*

Cross-stream eddy diffusion coefficient



Eddy heat diffusion



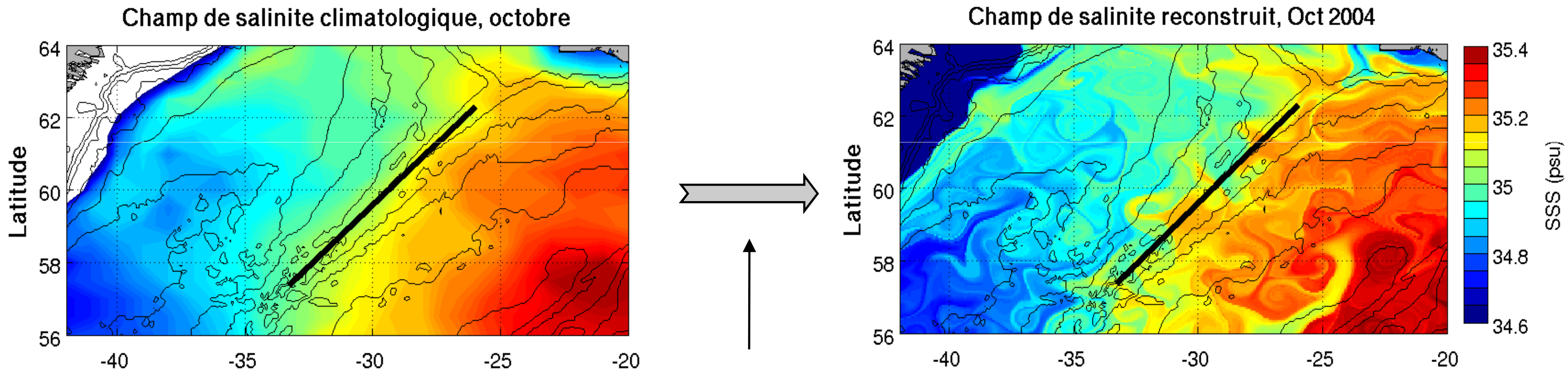
Frontogenesis : Irminger Sea

Frontogenesis Mecanisms

Statistical model

Monthly mean SSS climatology

SSS Field after deformation



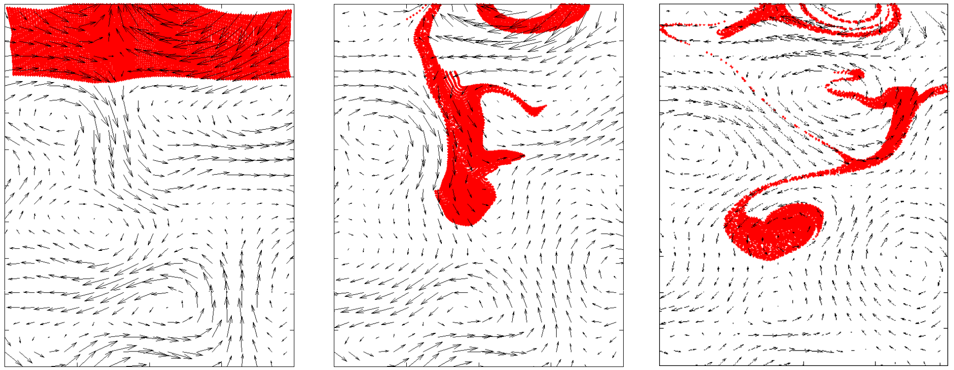
Advection of fluid particles during 30 days
(adjustment time based on local gradient values)

- Stirring of tracer field by mesoscale structures
- Comparison with in-situ SSS observations - frontogenesis linked to horizontal advection

Despres et al., 2010

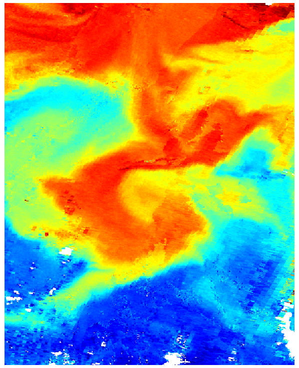
Evolving turbulent field drives strong filamentation

Tracer released into an evolving 2D altimetric current field develops filamentation patterns



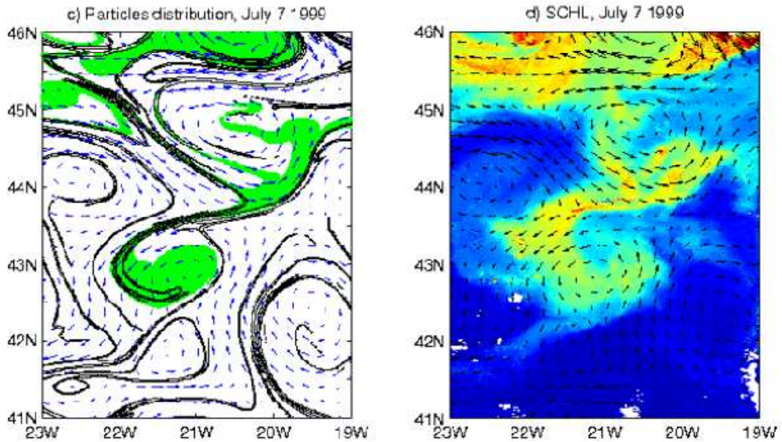
Jour 0 Jour 10 Jour 15

F. D'Ovidio,
LOCEAN, Paris



Traceur observed

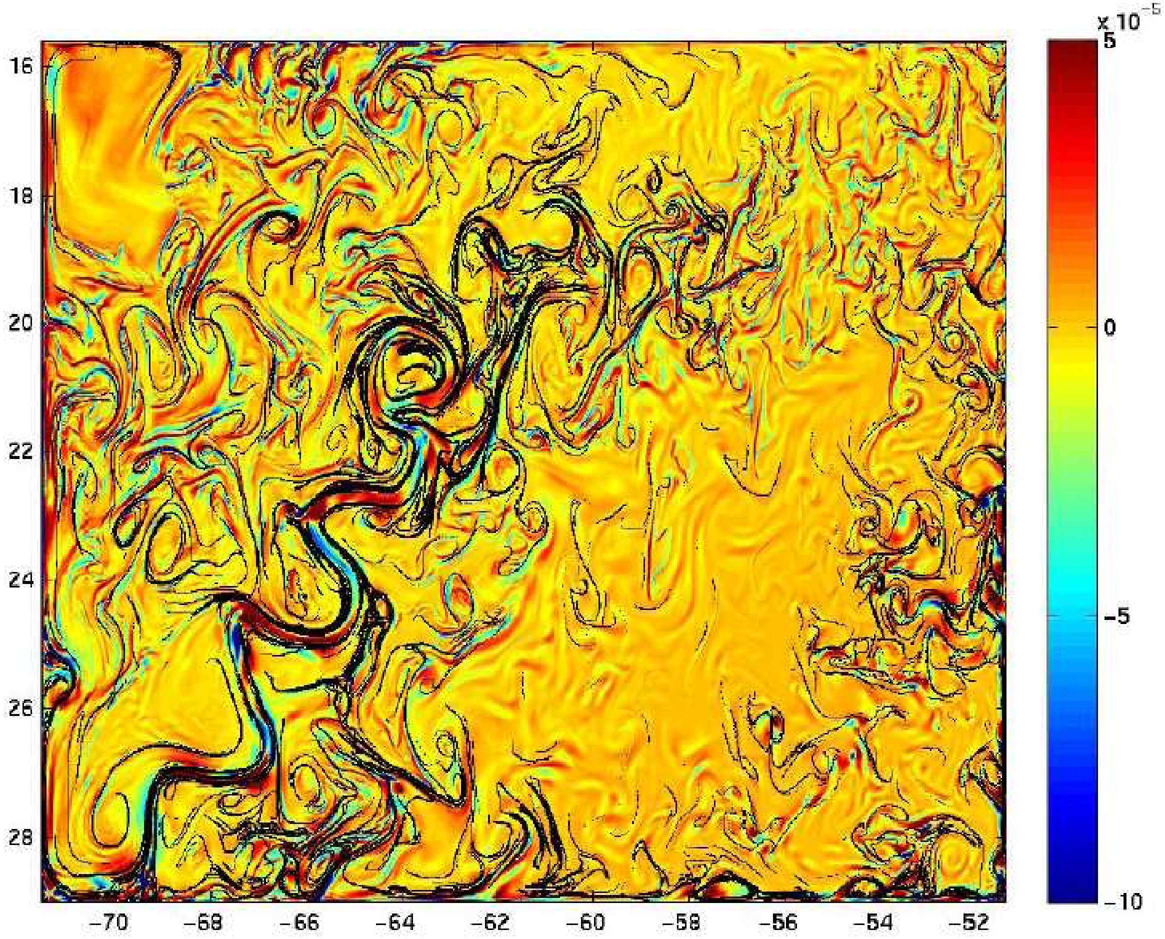
Filament positions derived from Lyapanuv exponants



Tracer filaments patterns can be observed from satellite SST or ocean color (Chlorophyll)

=> Statistical techniques based on evolving altimetric currents now used to derive filament zones

OPA 1/54 resolution (with M. Lévy and M. Jouini) N Atlantic



Vertical velocities

Vertical cells and Lyapunov lines are colocalized

Today's Challenges in Altimetry

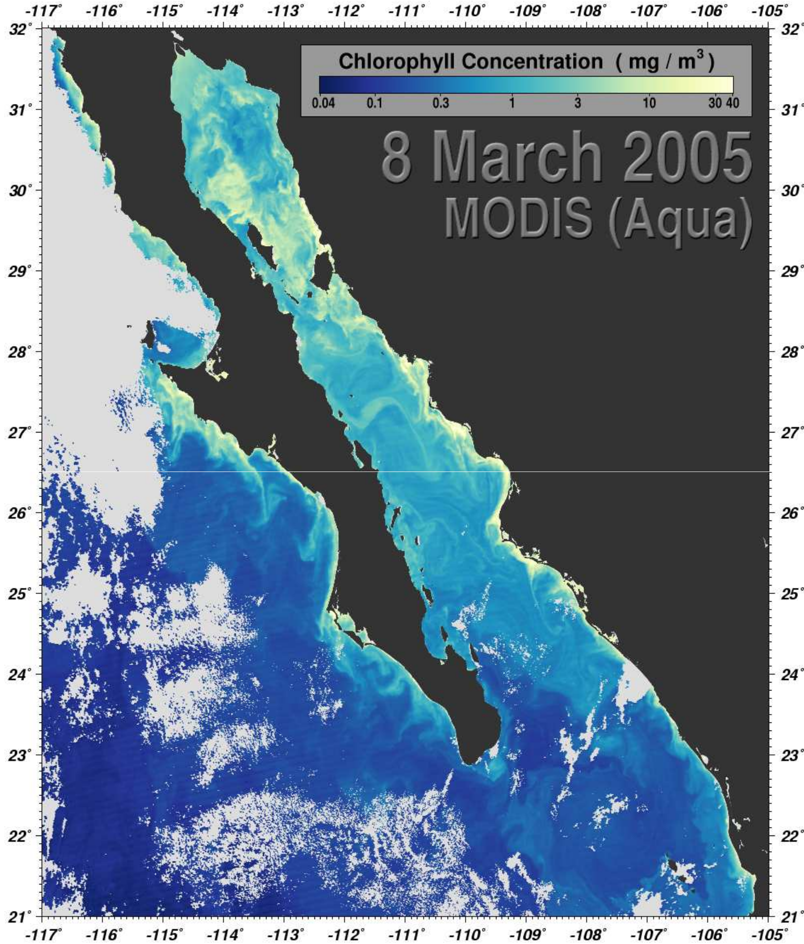
« Our current knowledge of mesoscale eddy activity in the ocean derived from altimetry is largely based on gridded AVISO data sets »

1) High-latitude, coastal & near-shore processes missed

2) Mesoscale processes (driving the horizontal dynamics) **only partially observed** with present generation altimeters (scales > 200 km)

Ocean fronts and filaments can be studied with **cloud-free** SST and ocean colour

- Scales 1-50 km, 2-30 days



Need high resolution sea level observations 1-100 km!

Spectra - alongtrack data

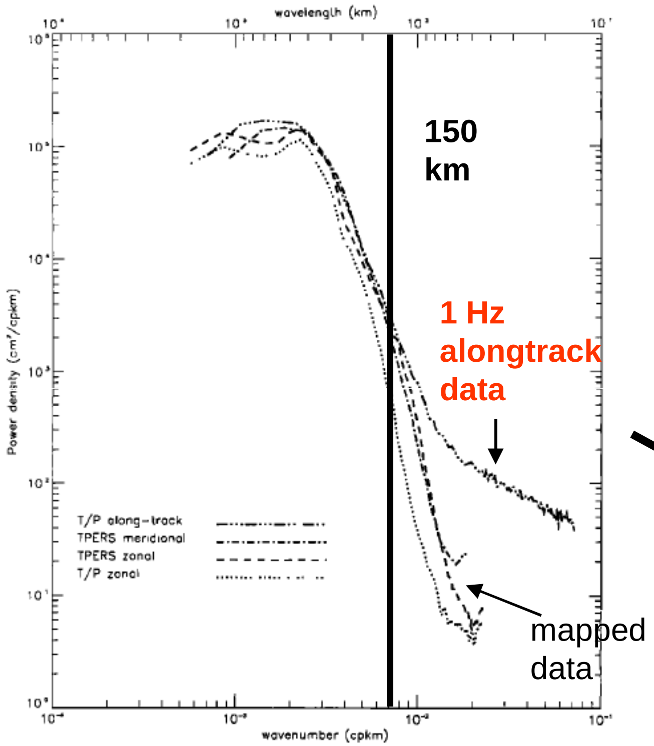
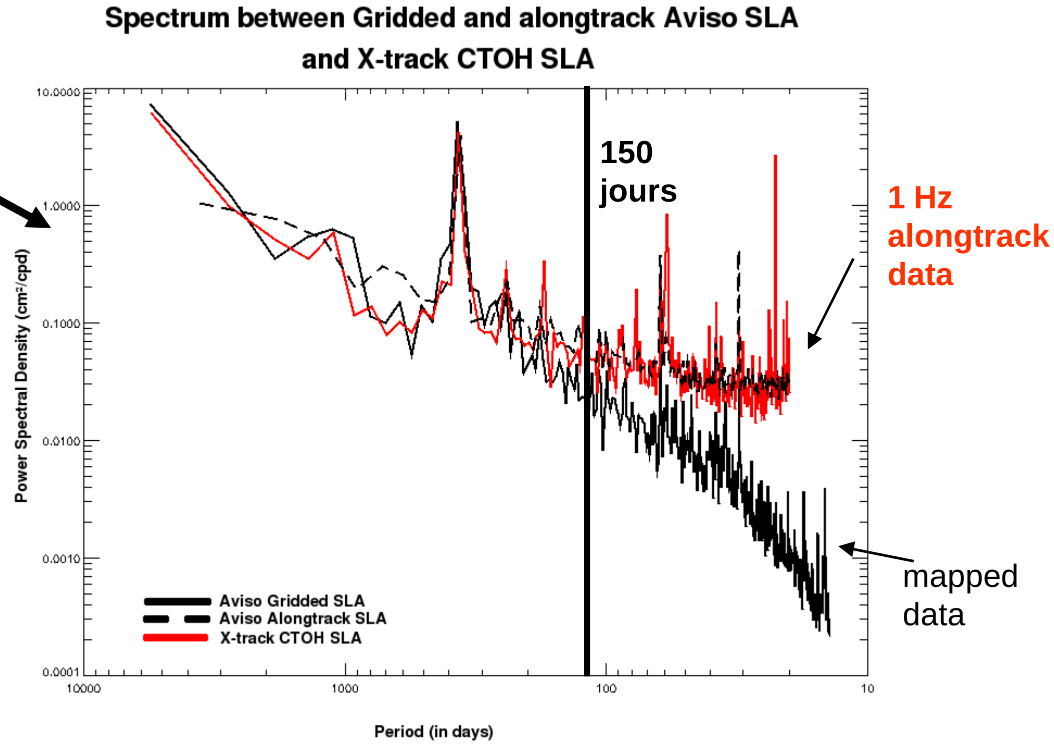


Figure 1. The 1993 mean wavenumber spectra in the Gulf Stream region (33°–43°N; 70°–50°W) of the along-track SLA data (dash-dot-dot-dot) compared with the zonal component of the T/P maps (dotted) and the zonal (dashed) and meridional (dash-dot) components of the combined maps.

Ducet et al., 2000. JGR

Temporal spectra

-17 yr time series

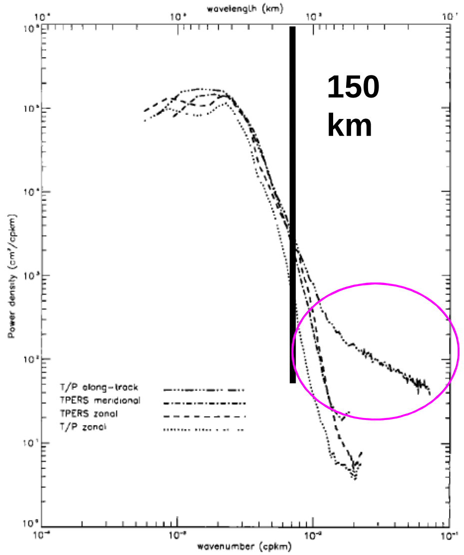


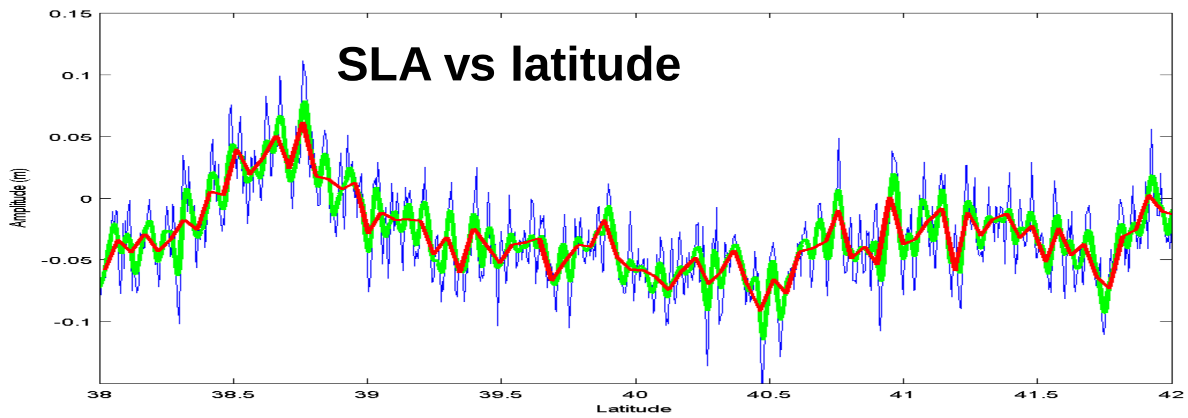
Solutions ?

- Specific reprocessing of altimetric data to recover data in coastal & high-latitude regions

- Development of new missions or altimetric constellations to provide better coverage of smaller mesoscale & submesoscale processes

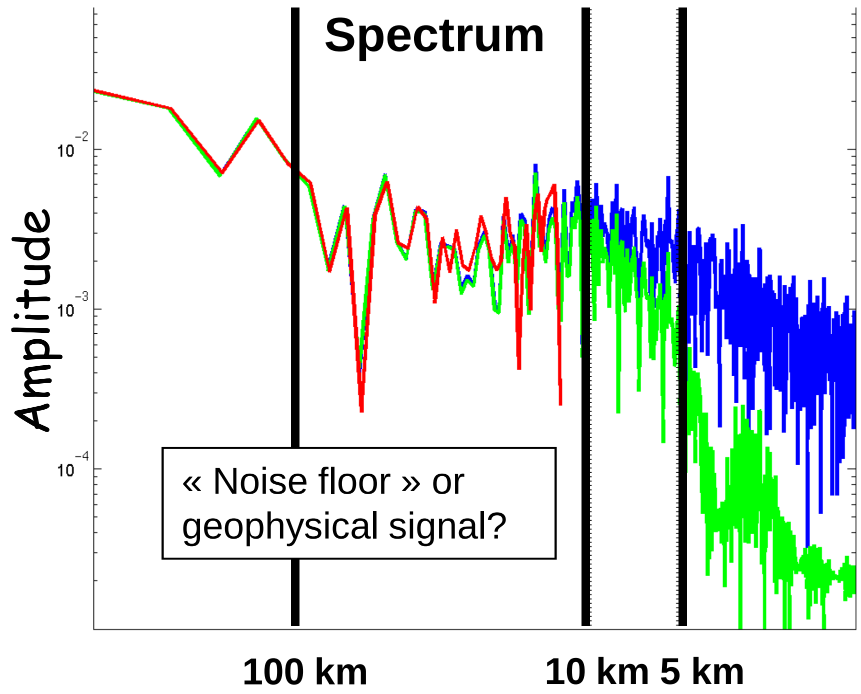
Reprocessing alongtrack data – recovering small-scale signals





Statistics from one T/P track SLA – track 146 – cycle 146

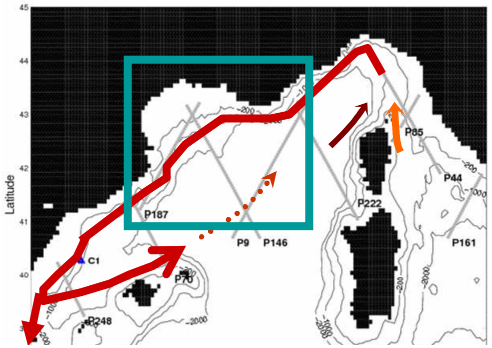
- 10 Hz unfiltered
- 10 Hz filtered using a 1hz cutoff frequency
- 1Hz (mean)

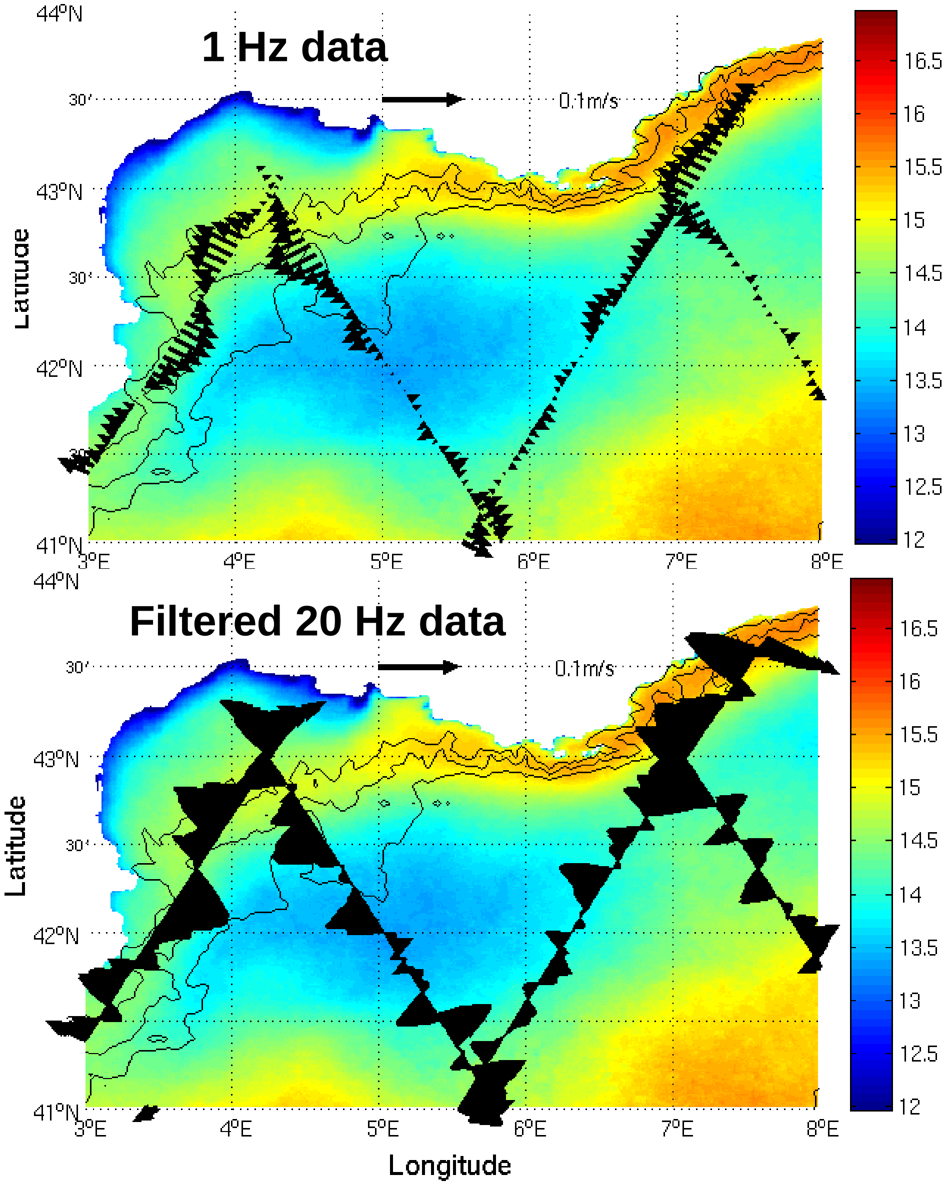


Many different groups working on this problem (PISTACH, COASTALT, CTOH, RADS, …)

Extending altimetry into the coastal zone

LPC Current circulation





Monthly climatology of:

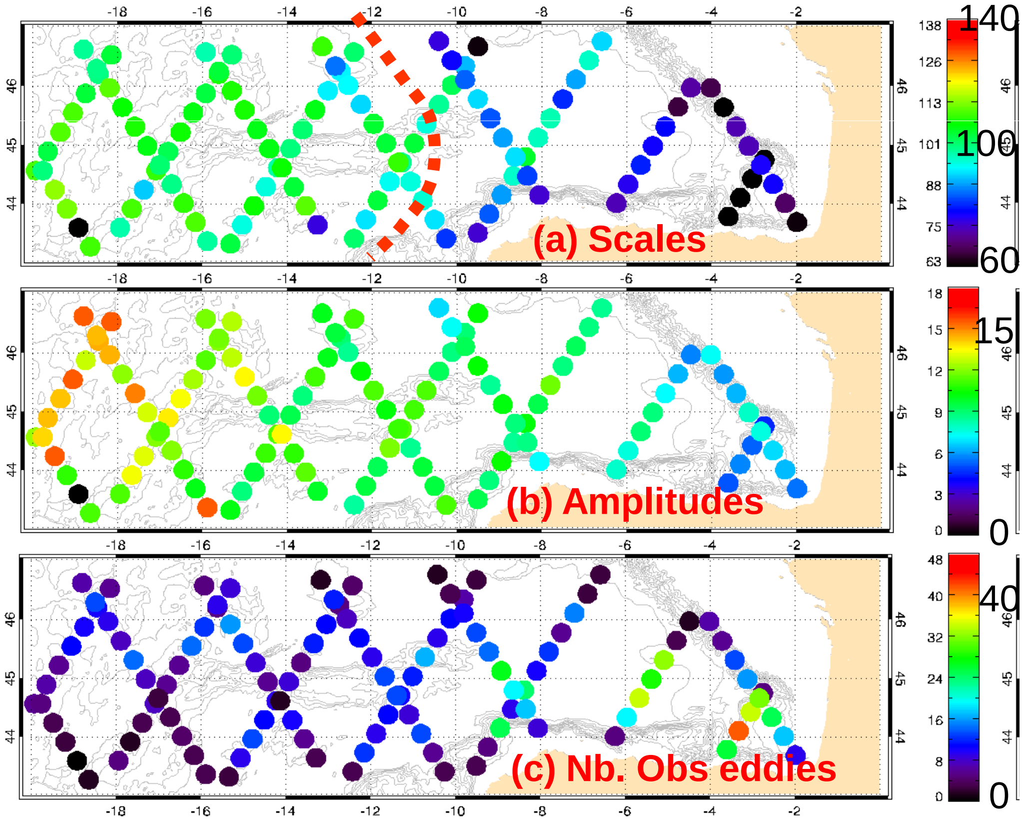
- SST (AVHRR over the period 1998-2007)
- Cross-track geostrophic current anomalies (altimetry – T/P & Jason-1 over the period 1993-2007)

http://ctoh.legos.obs-mip.fr/products/coastal-products

Observability of mesoscale dynamics

- Spatial evolution visible from alongtrack data and maps.
- Scales and amplitude discrepancies (mainly in BoB)

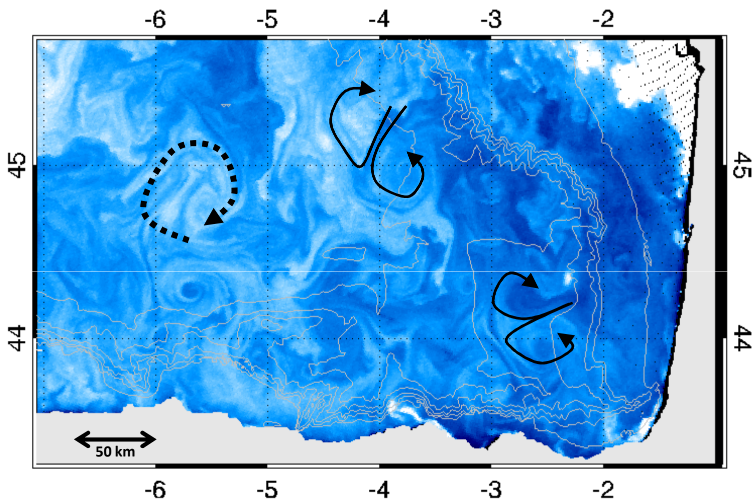
CTOH - XTRACK



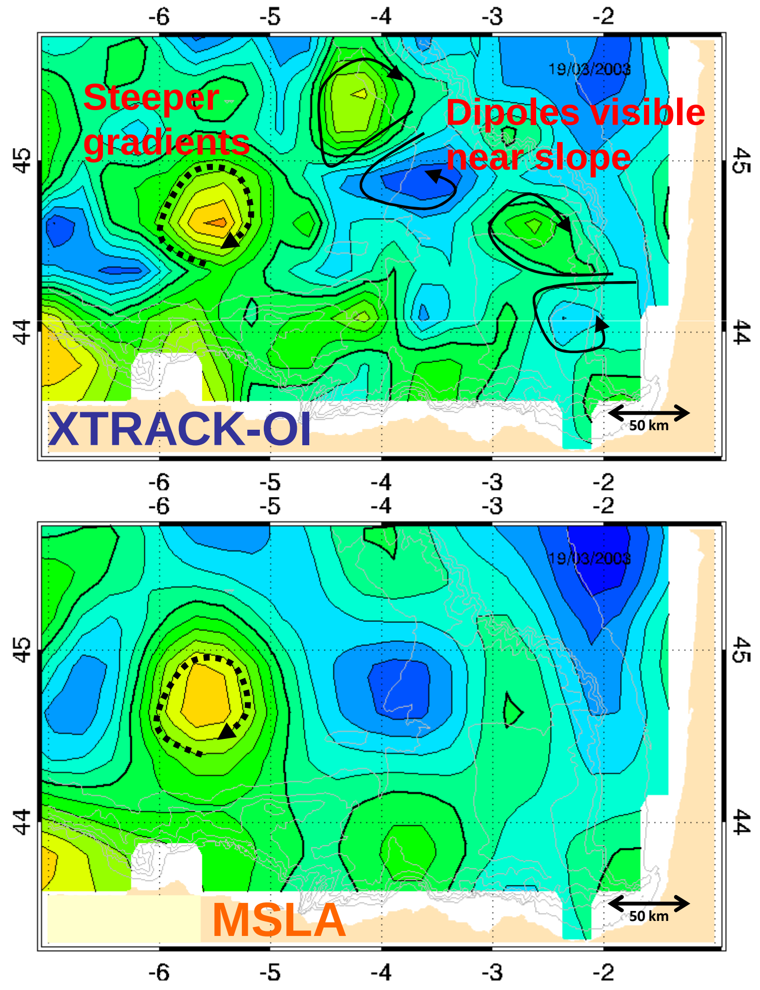
Improving mapping in regional seas

Maintaining smaller scales close to generation sites

Using 4 missions : J1, T/P, GFO, ENV

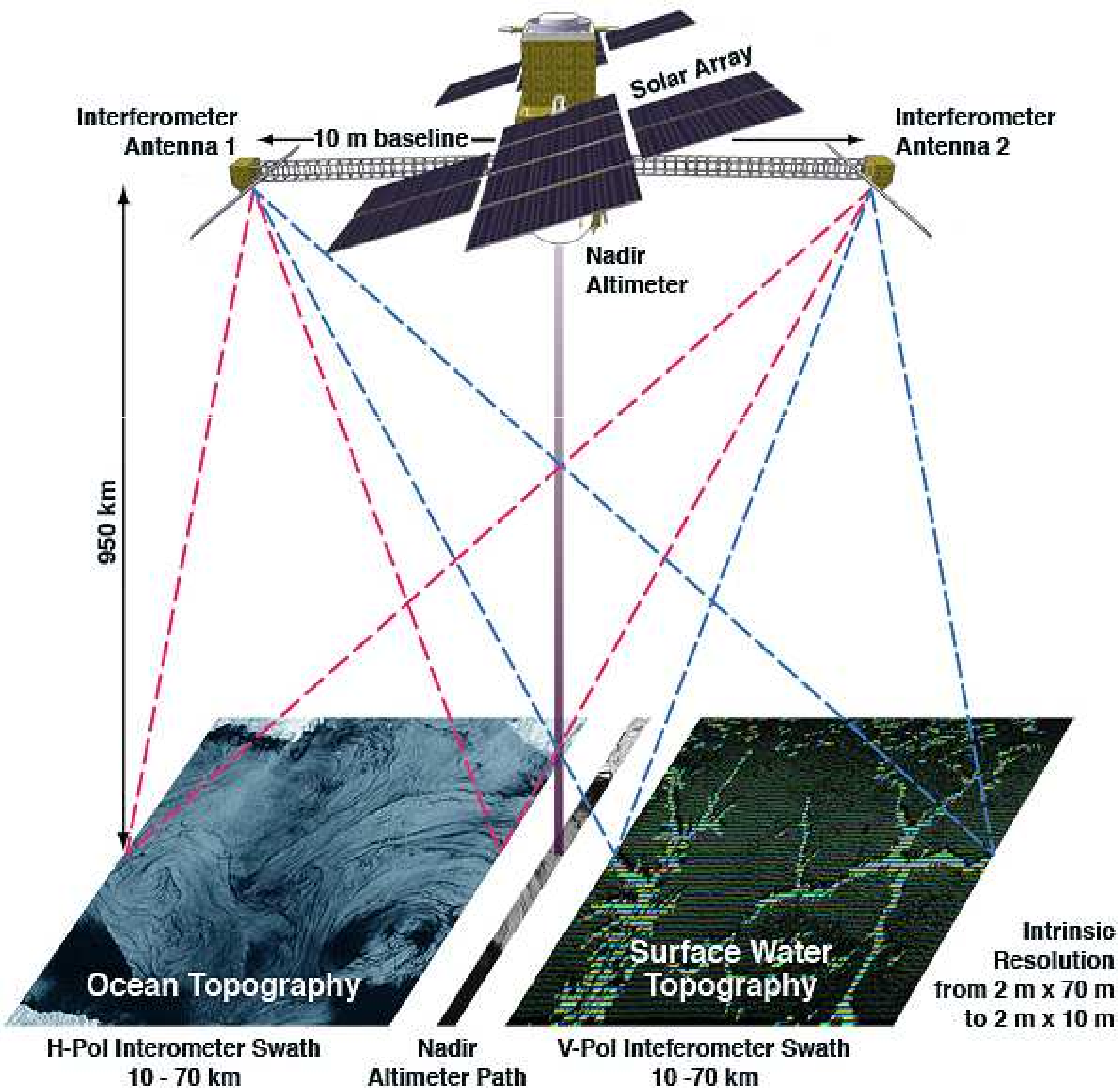


- Satellite imagery may provide punctual information on fine scale dynamics

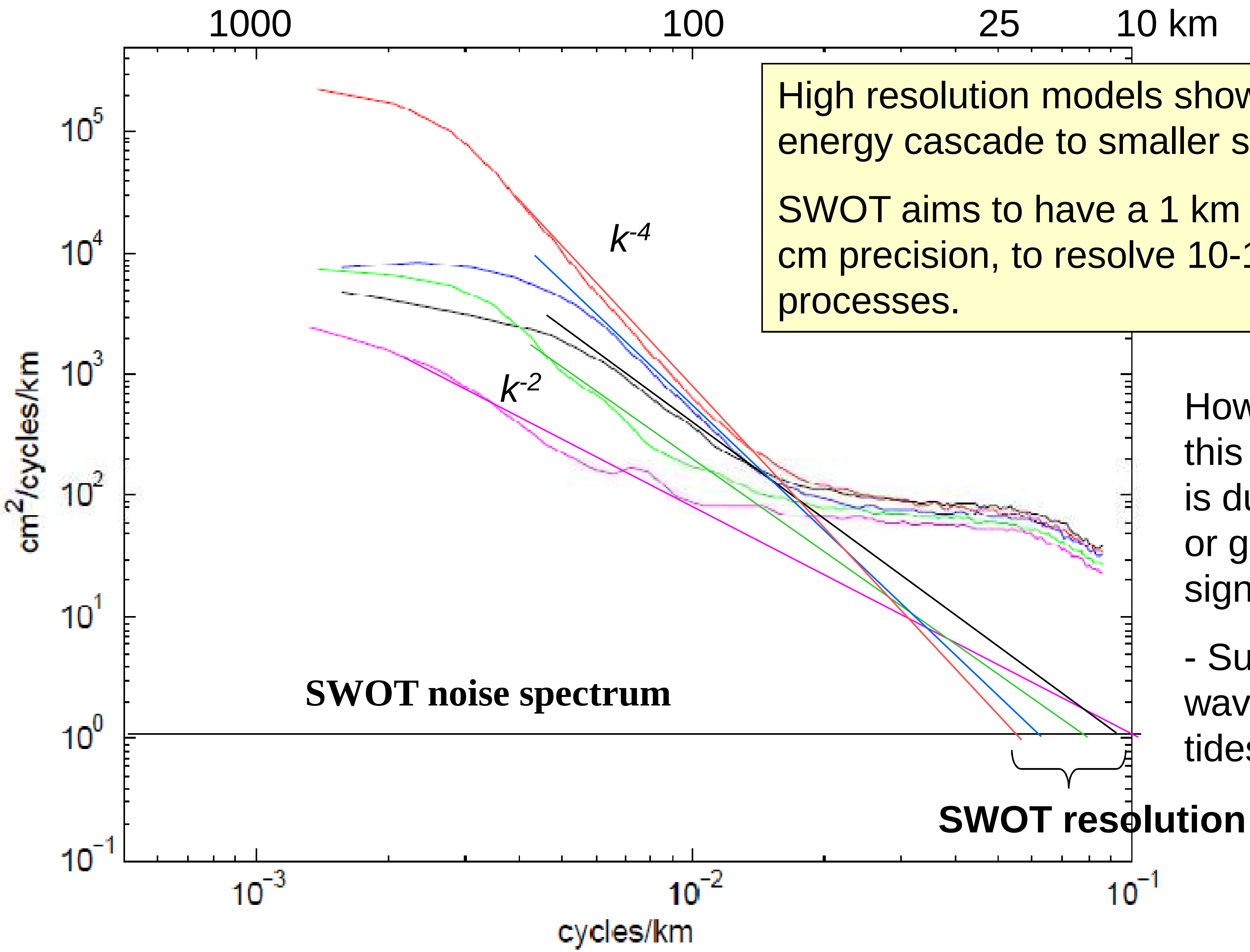


Nadir altimetry : resolves 30-50 km alongtrack, 200 km between tracks

SWOT : goal : resolve ~10 km in 2D (BC Rossby radius)



SSH wavenumber spectrum



High resolution models show an energy cascade to smaller scales

SWOT aims to have a 1 km grid at 1 cm precision, to resolve 10-15 km processes.

How much of this difference is due to noise, or geophysical signals ?

- Surface waves, internal tides, etc

Ongoing work – next decade

1) Continue global monitoring with satellite data – **extending the constellation to higher latitudes & coastal zones** (SARAL/Altika, Cryosat2, Sentinel-3, SWOT, …)

2) Reprocessing alongtrack data – **working with 10-20 Hz data**

3) **Investigating geophysical signals in the 10-200 km band** : impact of small mesoscale & sub-mesoscale signals, internal tides, waves & wave-current interactions on sea surface height

4) Combining **different satellite data** (altimetry, SST (IR & MW), colour, SSS)

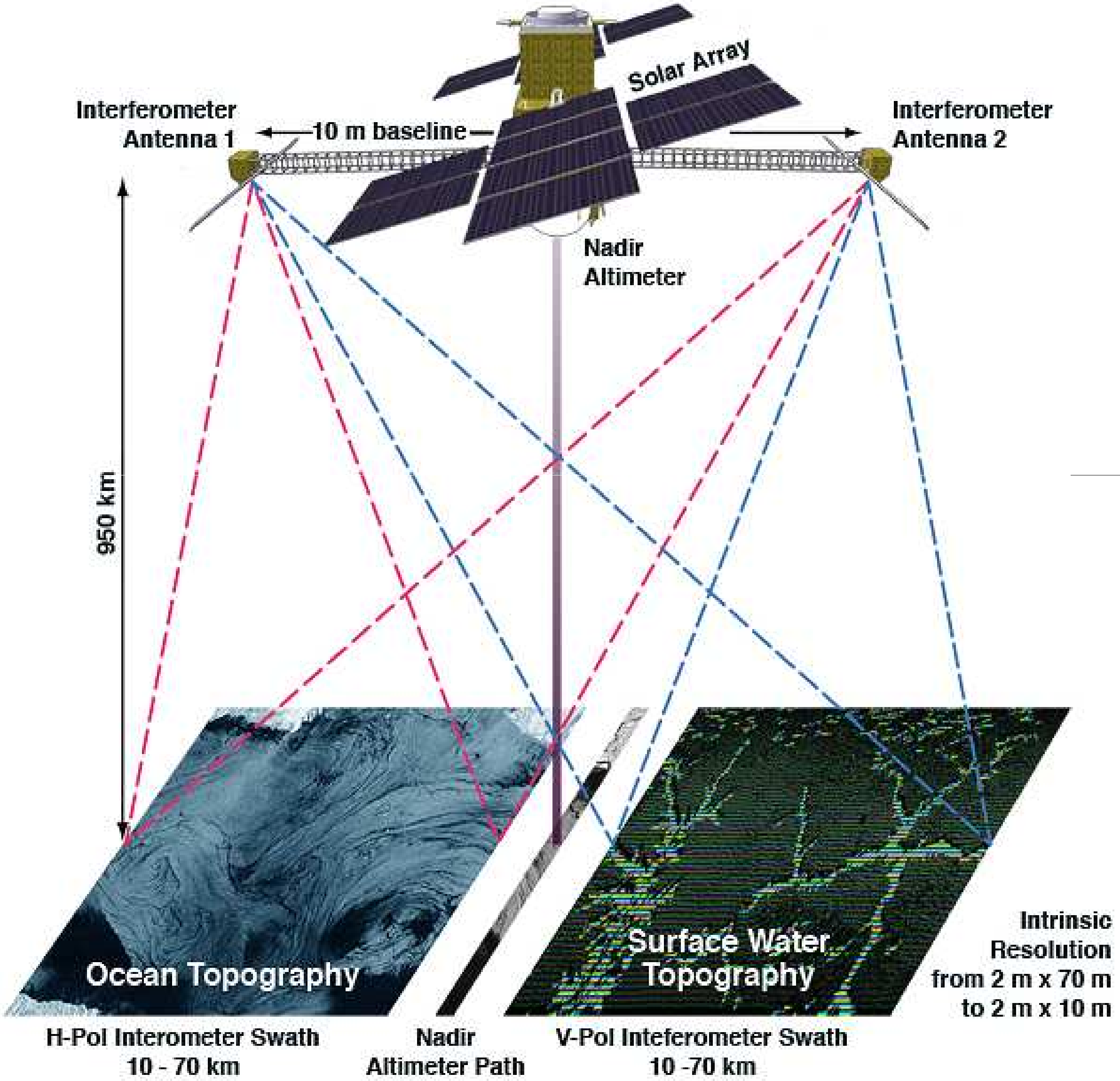
5) Combining satellite & in-situ observations with **statistical models & OGCMs**

Thank you!

extras

Improving the spatial sampling at high precision : SWOT

The Surface Water and Ocean Topography Satellite Mission



Science Objectives

For Hydrology : mesure variations in water storage in lakes, dams, & flood plains larger than 250m^2 & estimate the discharge of rivers larger than 100 m at monthly, seasonal and annual timescales.

For Oceanography: mesure the global ocean circulation at **1 cm precision** down to scales of 2-10 km, to better understand the **dissipation of kinetic energy** and processes that drive the **ocean uptake of heat and carbon**

CNES/NASA program

Included in NASA's Decadal Survey

Launch date 2020

22-day repeat to 78°N &°S

Improving the spatial-temporal sampling at today's precision : Iridium NEXT

Proposal to fly up to 24 light altimeters onboard Iridium NEXT constellation

Data transmitted via Iridium to ground in true real time

Latitudes up to 86°N &°S

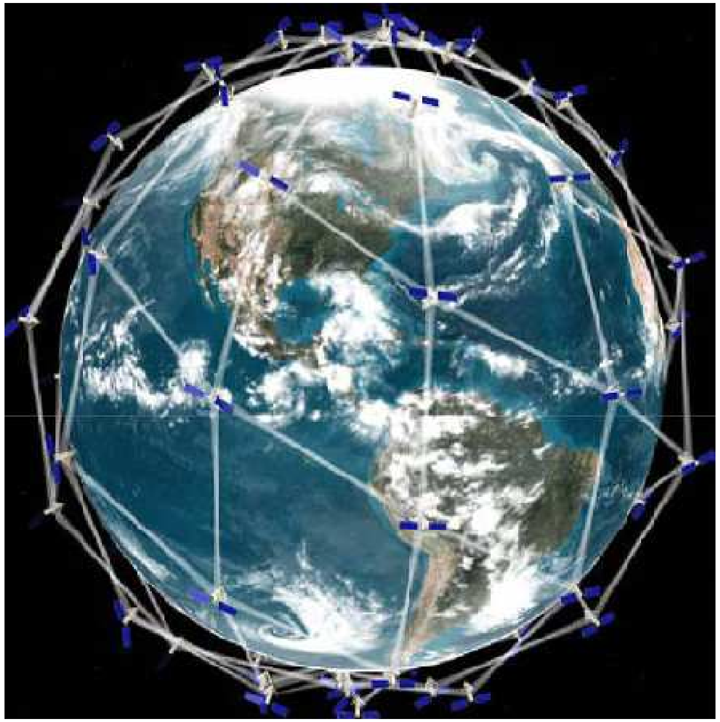
RT altimeter precision : 6 cm

3-day product : 3 cm

Applications :

Coastal phenomena could be close-to-correctly sampled at 45-50 latitude after 3 days and everywhere after 7 days

Observability of **extreme weather events** (storms, cyclones, very high wave events) at least once a day everywhere



Proposal only – possible funding from operational agencies (eg NOAA) – start > 2015