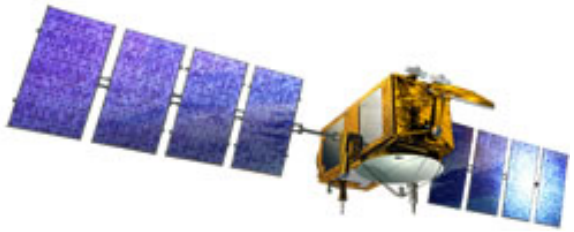
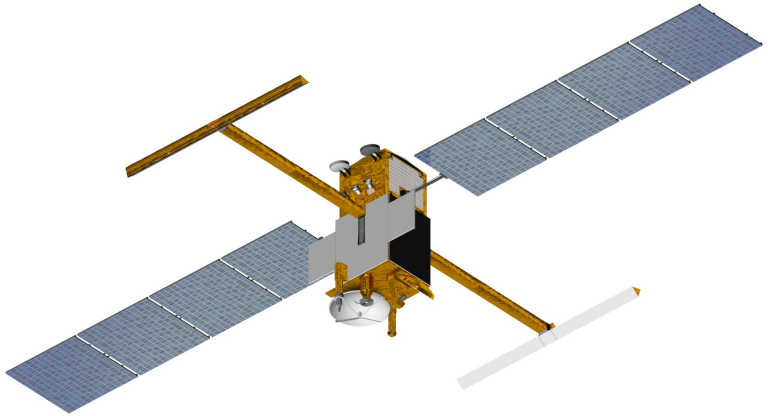
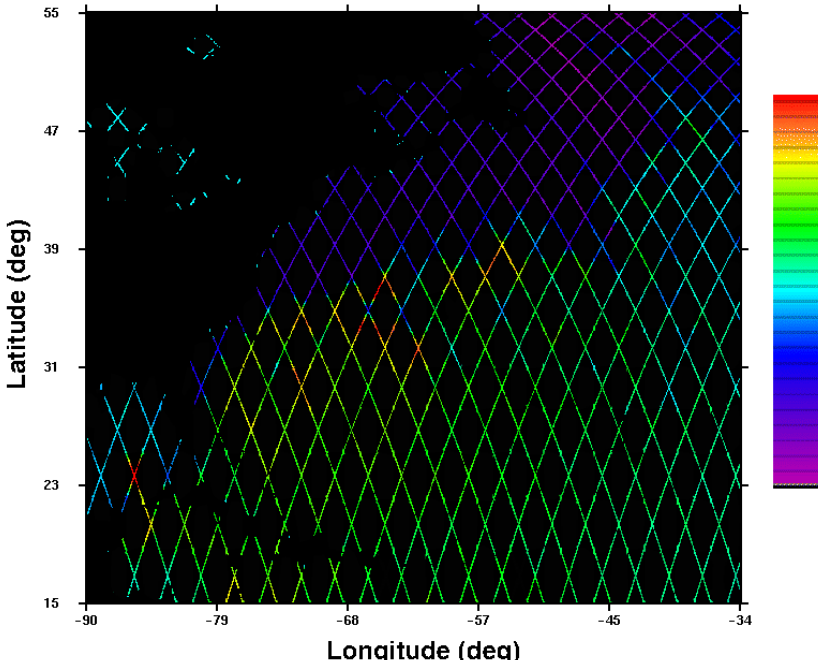
SWOT MISSION (Surface Water Ocean Topography) : A revolutionary step for Earth Water Monitoring

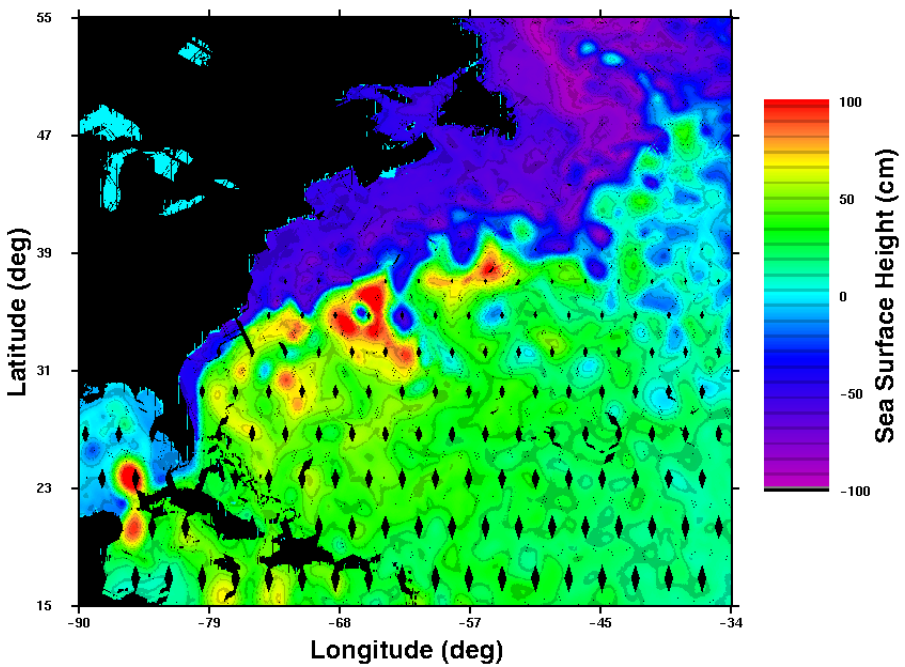




Classical Nadir Altimetry



Swath Altimetry



20 years of nadir altimetry – understanding global, basin-scale & large mesoscale signals

Satellite observations over the last decades have provided a revolution in our understanding of ocean dynamics

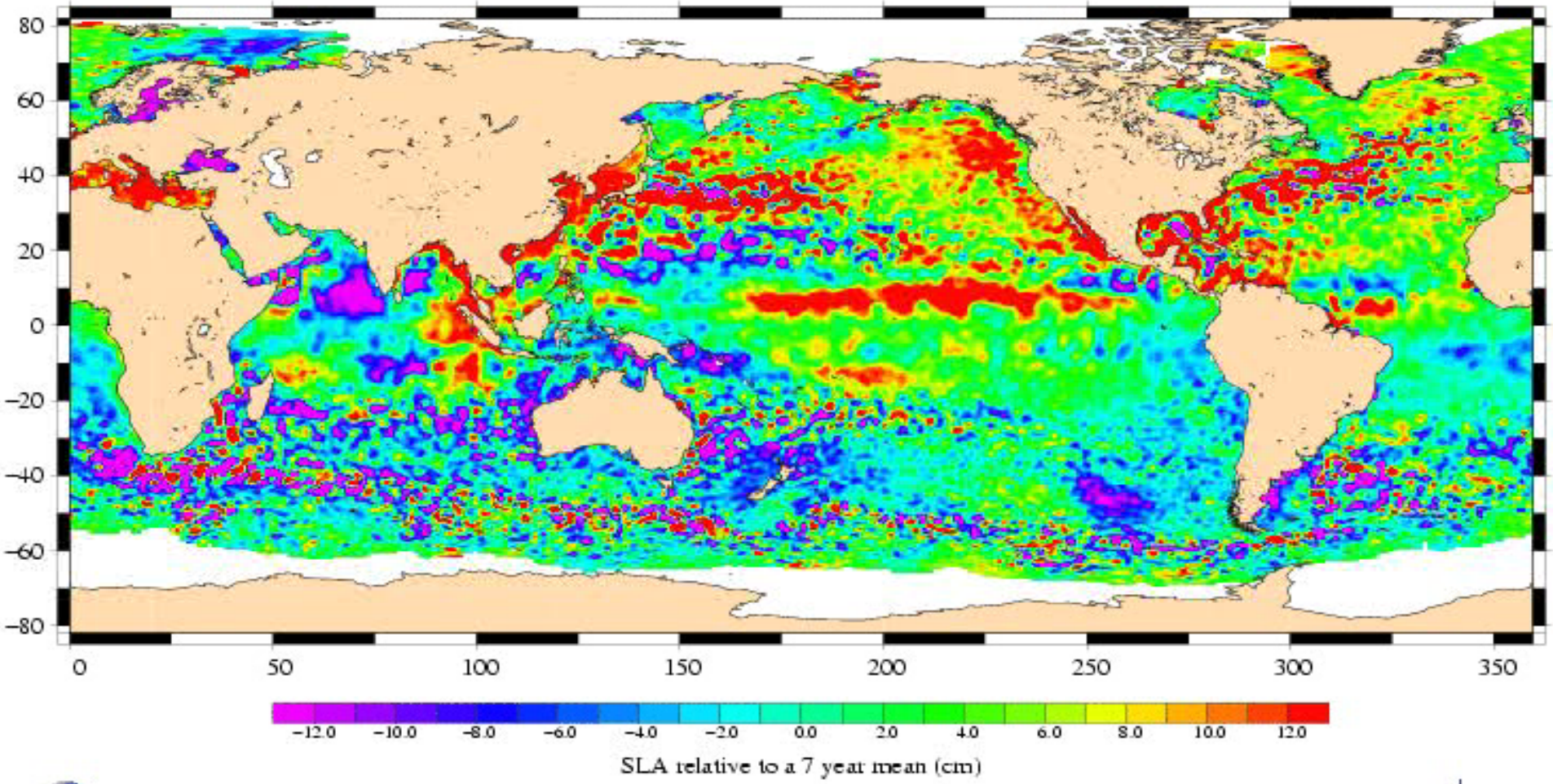
All satellites measure surface parameters, but most satellites measure mixed layer processes (SST, SSS, surface ocean colour).

Satellite altimetry is different, since sea level responds to depth-integrated ocean motions.

Satellite altimetry is a powerful tool for oceanographers since it observes the signature of surface and sub-surface processes

Satellite nadir altimetry has been particularly important for understanding ocean processes at different scales, from global, to basin-scales, to the larger mesoscales.

20 years of nadir altimetry – understanding global, basin-scale & large mesoscale signals



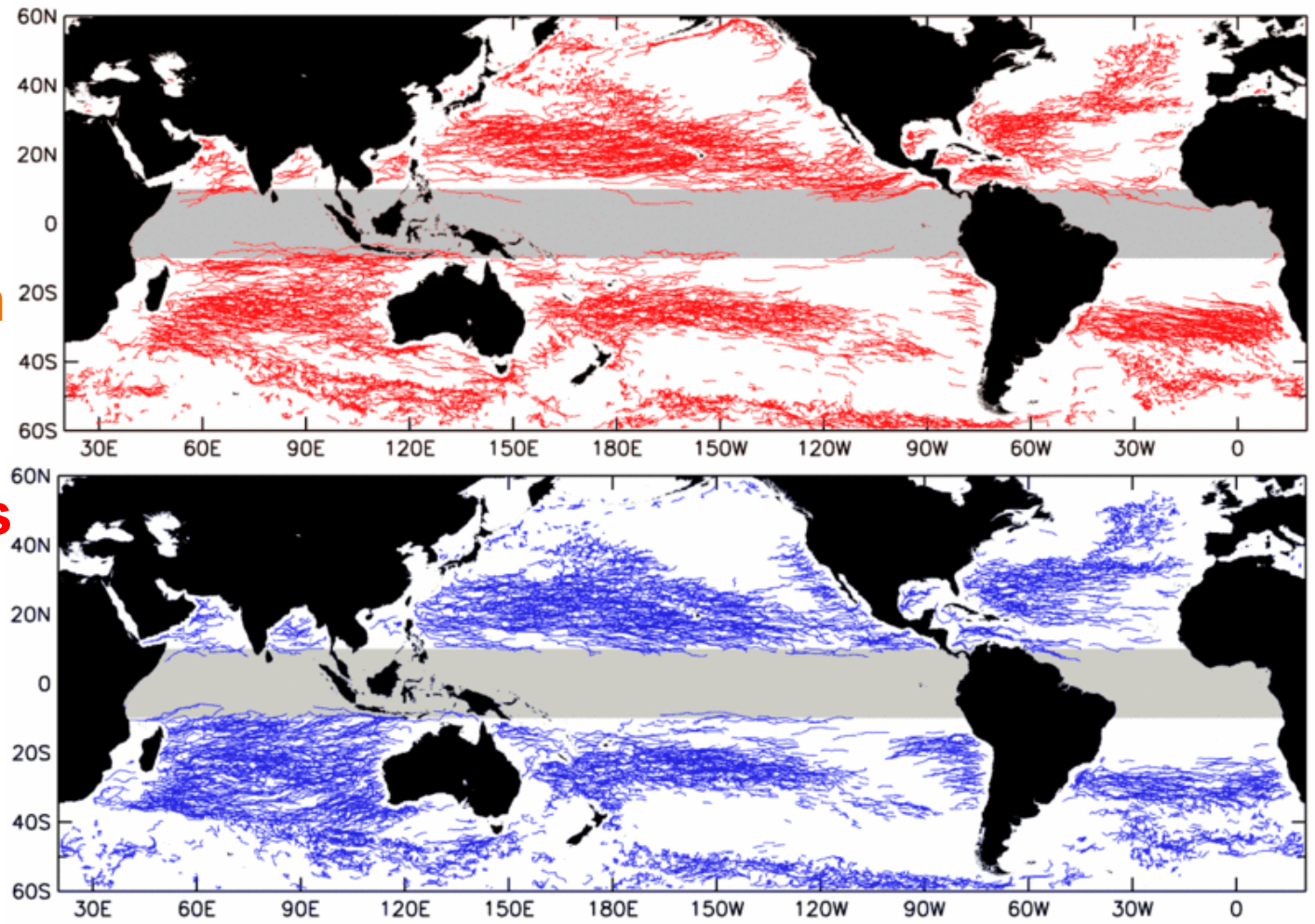
CLS

cnes

Climate time series for mesoscale studies

dual mission : T/P-ERS then J1-ENV

Tracking eddies from 16 years of dual mission altimetry



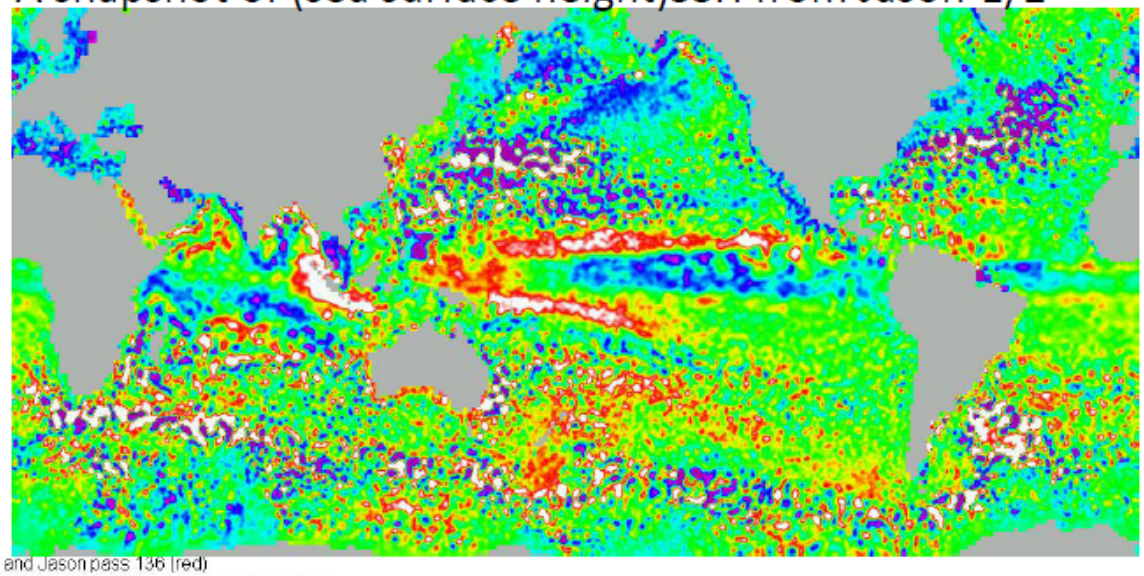
Anticyclones (warm)

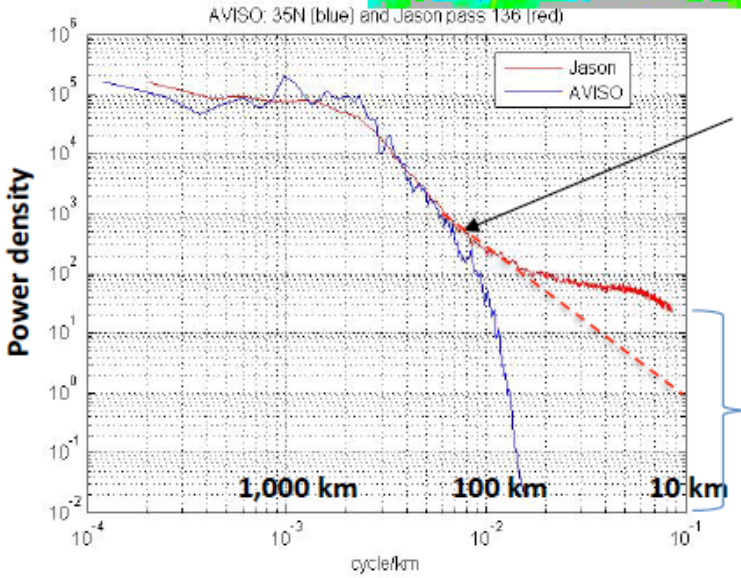
Cyclones (cold)

Chelton et al., 2012

The limit of resolution of Jason-1/2

A snapshot of (sea surface height)SSH from Jason-1/2





Drop in energy of 2-D gridded SSH spectrum (blue) vs alongtrack spectrum (red) at 200 km Indicates the mapping resolution with nadir altimeter constellations.

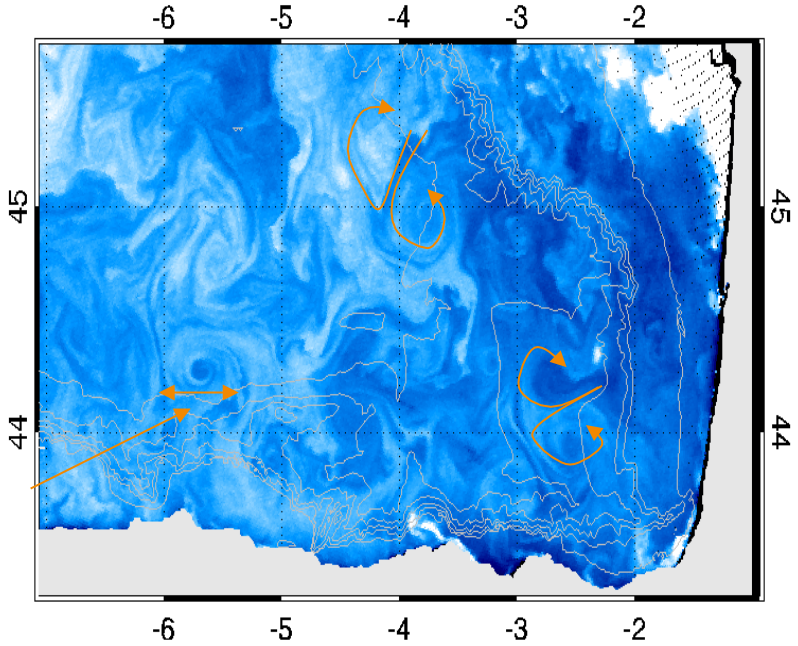
SWOT will extend the measurement down to 15 km

STRUCTURES 10-200 KM : LATERAL & VERTICAL TRANSPORT

Mesoscale eddies:

- Horizontal transport & mixing (heat, carbon, nutrients)

MODIS SST image – Bay of Biscay



50 km

Eddies ~50 km, Filaments ~10 km

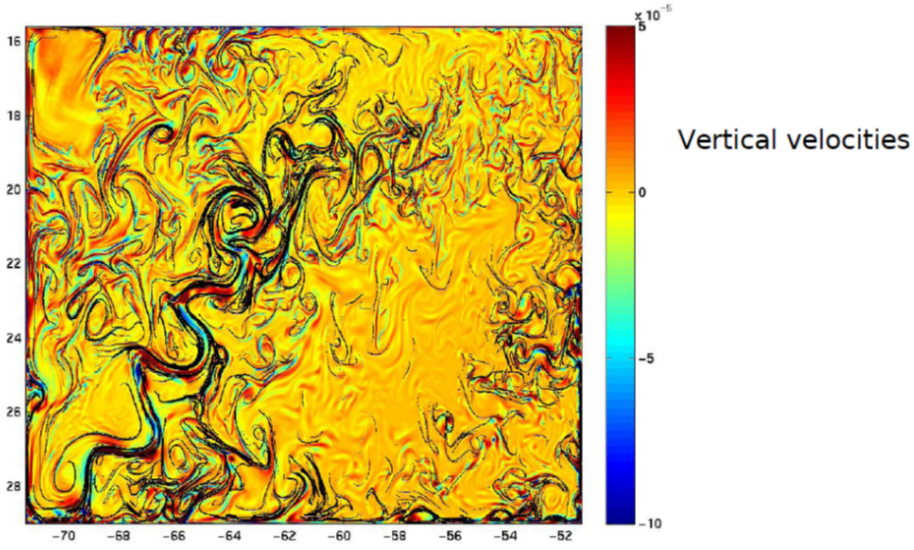
Dussurget et al, LEGOS

Submesoscale Fronts & Filaments

- 50 % of vertical velocities !

Model (2 km resolution) – N Atlantic

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



Vertical cells and Lyapunov lines are colocalized

Lévy et al, LOCEAN

Workshop :
Towards High-Resolution of Ocean Dynamics and Terrestrial Surface Waters from Space

21 – 22 October 2010, Lisbon, Portugal

Carl Wunsch :

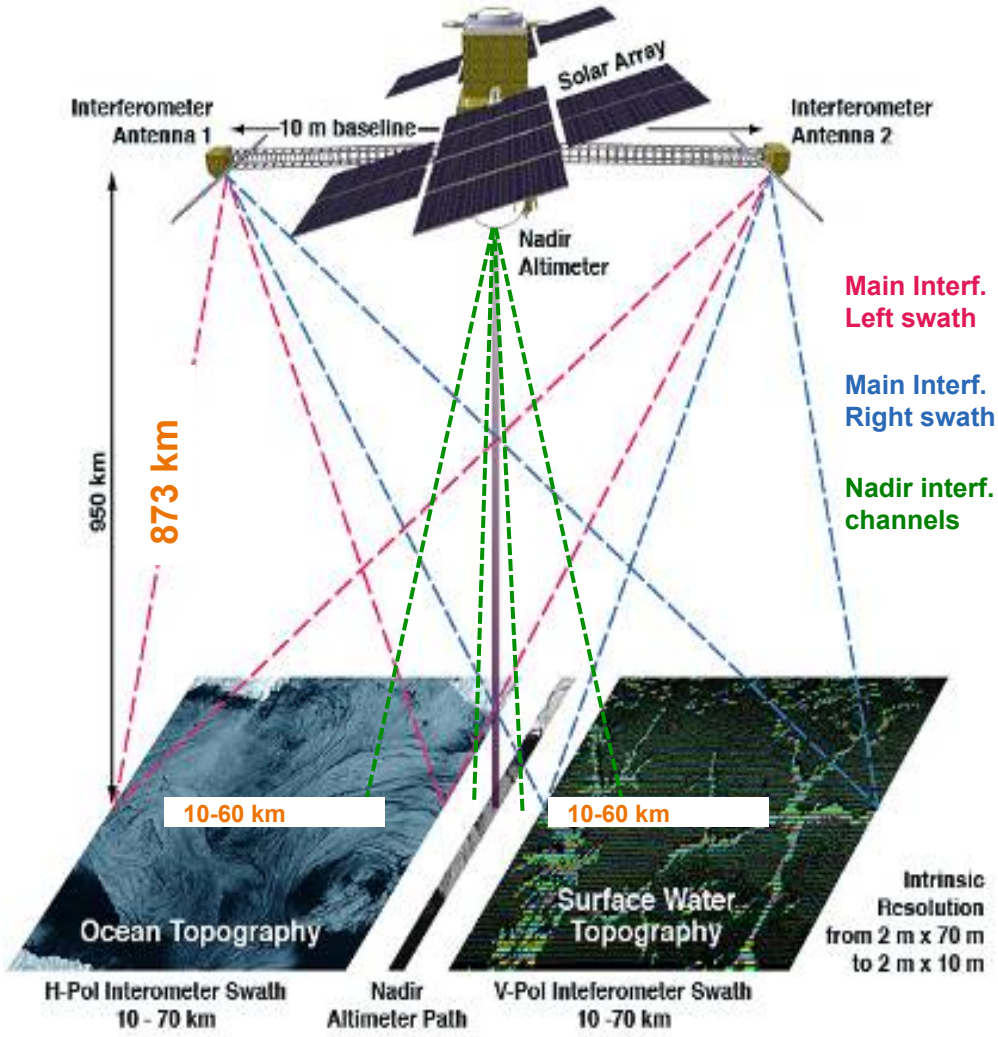
Key point 1 : new oceanographic instruments working on previously unmeasured time or spatial scales, have led to surprising, sometimes **startling, discoveries that were not predicted**.

Key point 2 : experience strongly suggests that **models must be tested against observations on all time and space scales**. One of the major issues facing oceanography is that high resolution models become fundamentally untestable, so we need more repeated observations at finer space and time scales.

SWOT Mission description

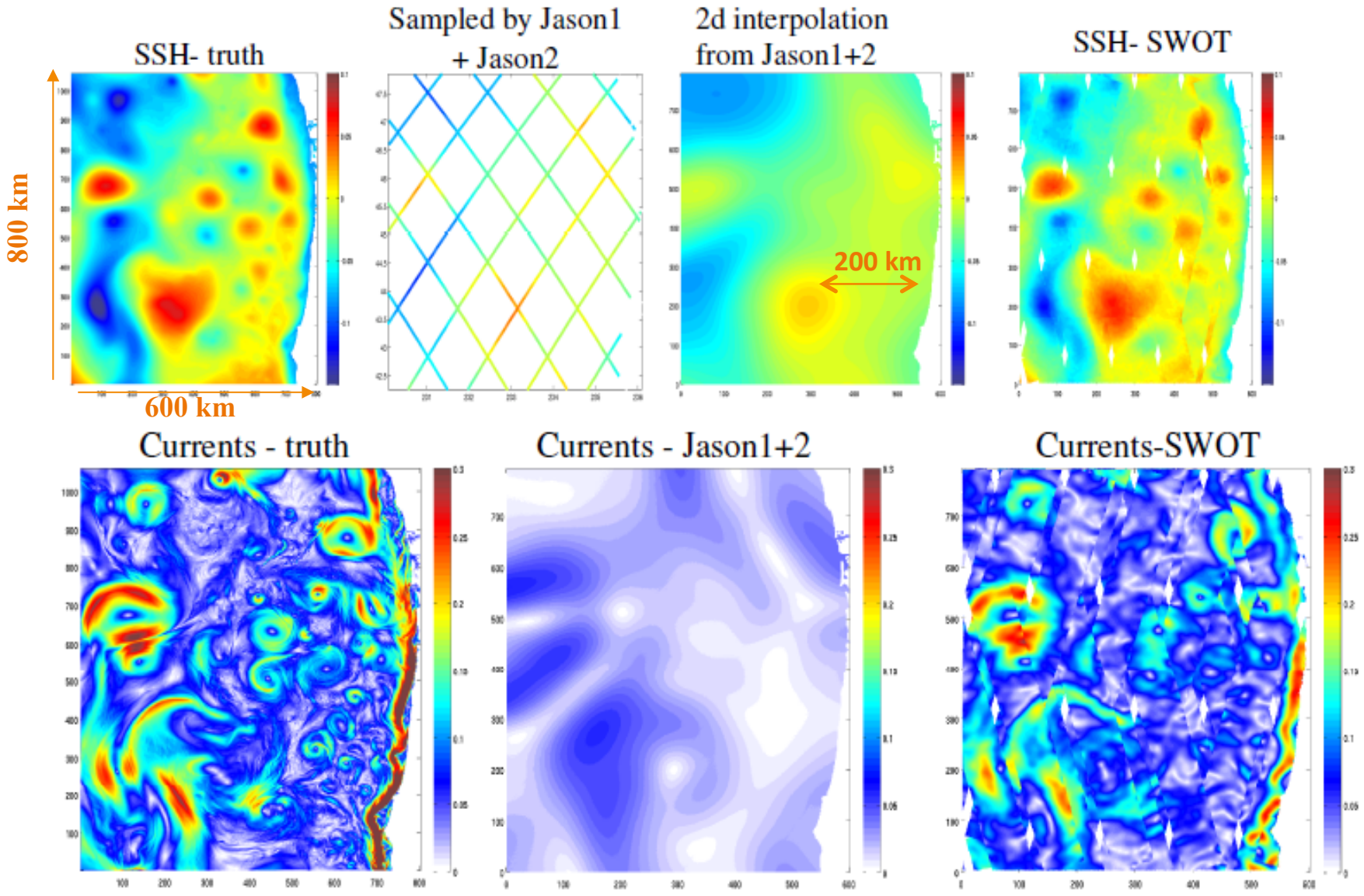
Mission Architecture

- Ka-band SAR interferometric (KaRIn) system with 2 swaths, 60 km wide
- Produces heights and co-registered all-weather SAR imagery
- Intrinsic resolution 2 m x 10-70 m grid
- Averaged to detect 100 m wide rivers, 250 m^2 lakes and onboard processor gives 1 km^2 grid over oceans
- Interferometry will reduce noise by 1 order of magnitude : 1.5 cm^2/cycle/km^2
- Use conventional Jason-class altimeter for nadir coverage, radiometer for wet-tropospheric delay, and GPS/Doris/LRA for POD.



- Partnered mission NASA, CNES & CSA
- Mission life of 3.5 years
- 890 km Orbit, 78° Inclination, 21 day repeat
- Launch: 2020

SIMULATION OF OCEAN DYNAMICS BY SWOT

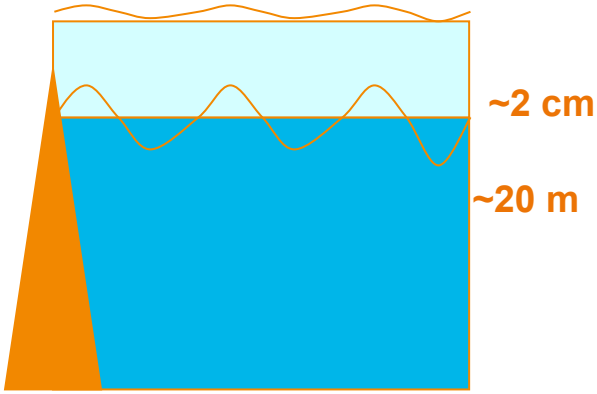


C. Ubelmann

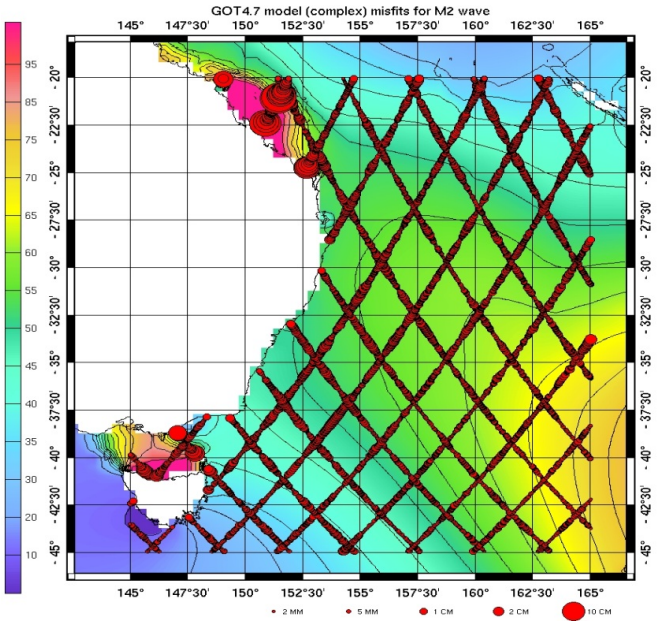
Orbit chosen to better observe coastal and internal tides

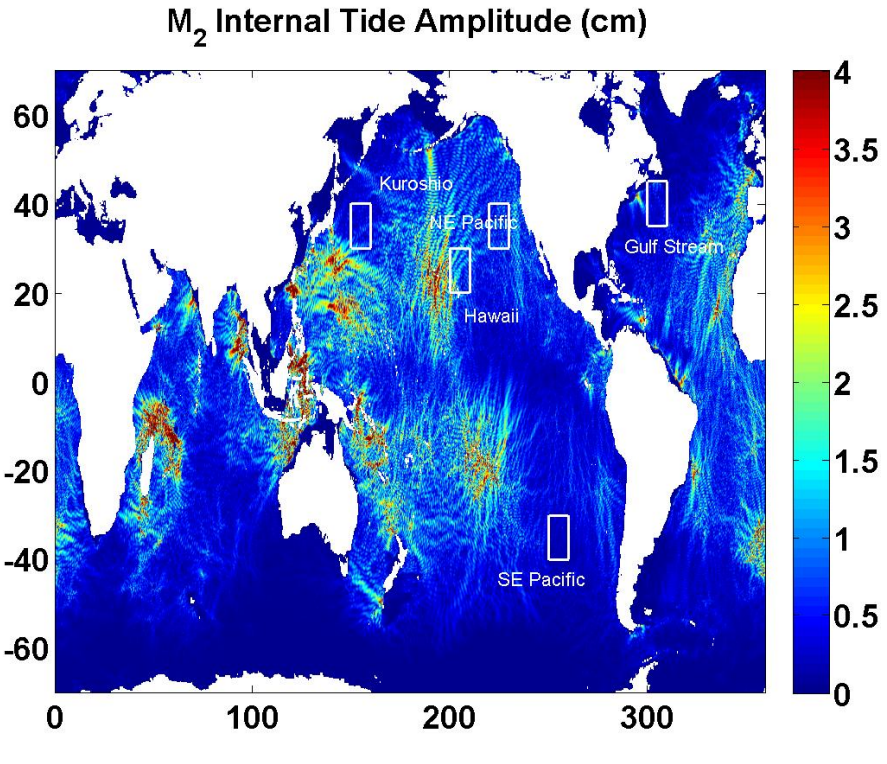
Coastal tides are observed today by tide gauges or alongtrack data – 3 years of SWOT data will provide finer-scale 2D data

2D propagation of Internal tides observed by SWOT – important for ocean mixing & energy dissipation



Coastal & internal tides



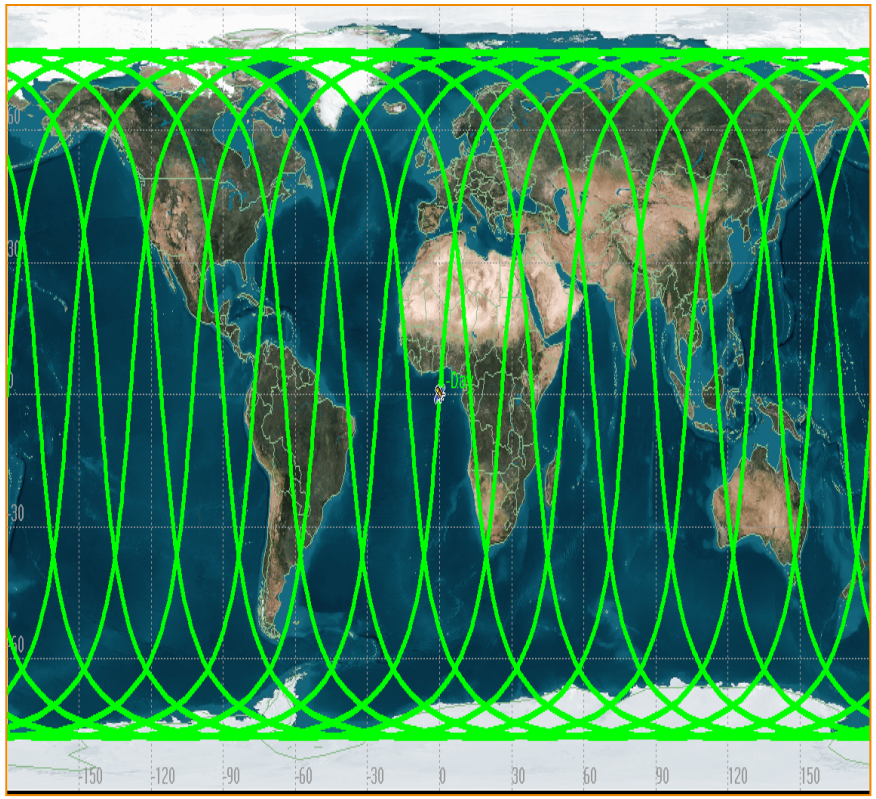


Model : HYCOM 1/12° ***Arbic et al., 2012***

SWOT orbits

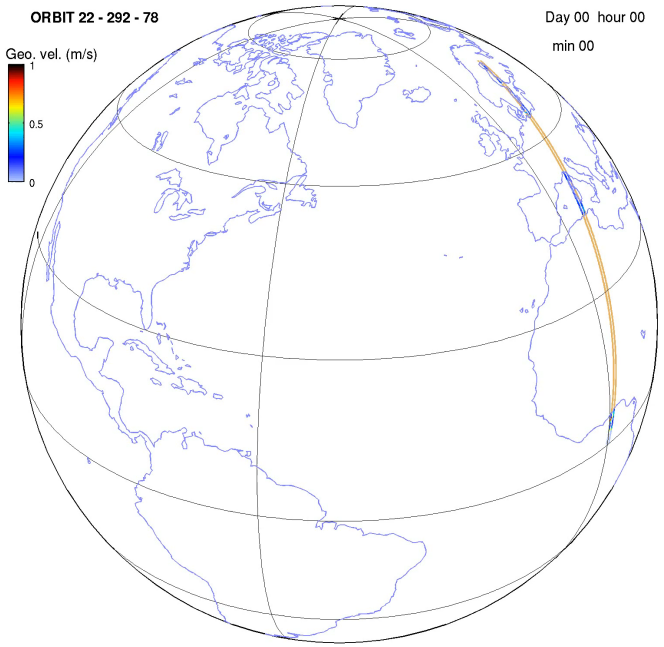
1-day fast sampling orbit

Duration 60 days. Limited coverage
CalVal & fast ocean processes

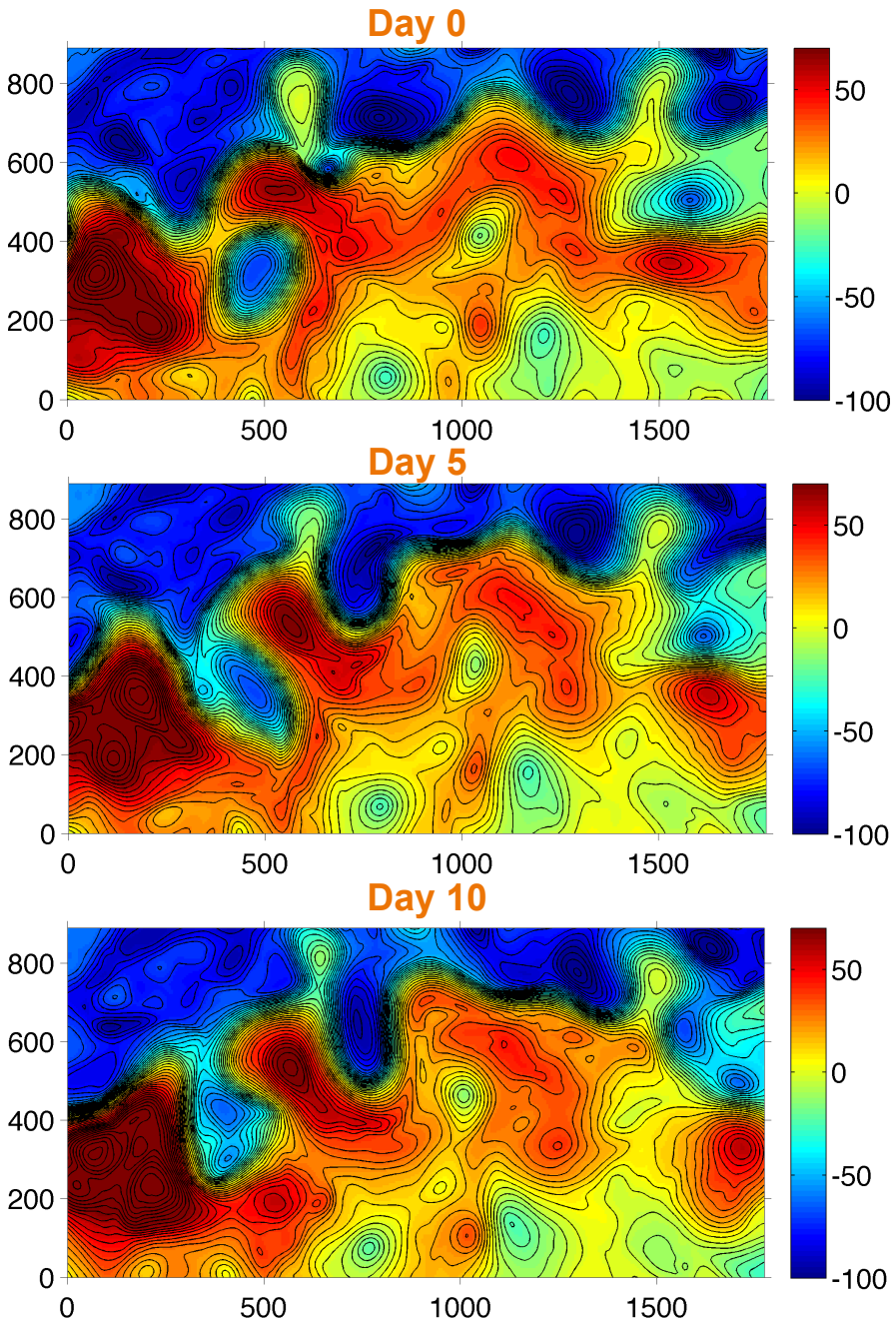


Nominal orbit : 21-day sampling

Duration : 3-years. Global coverage

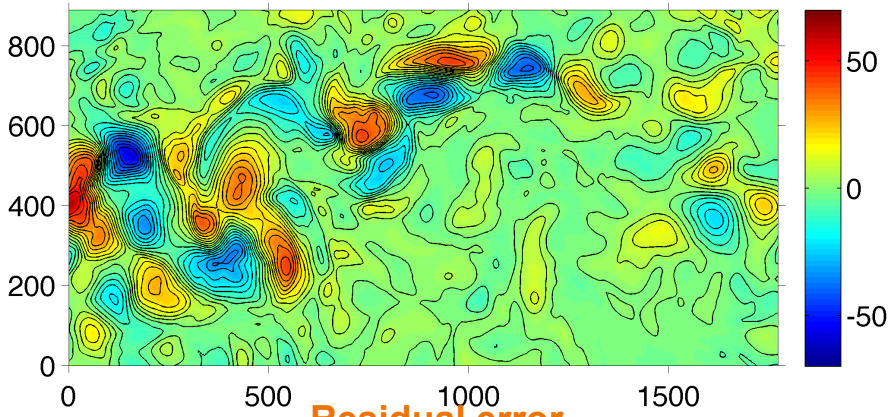


SWOT will provide excellent spatial coverage but not enough temporal coverage



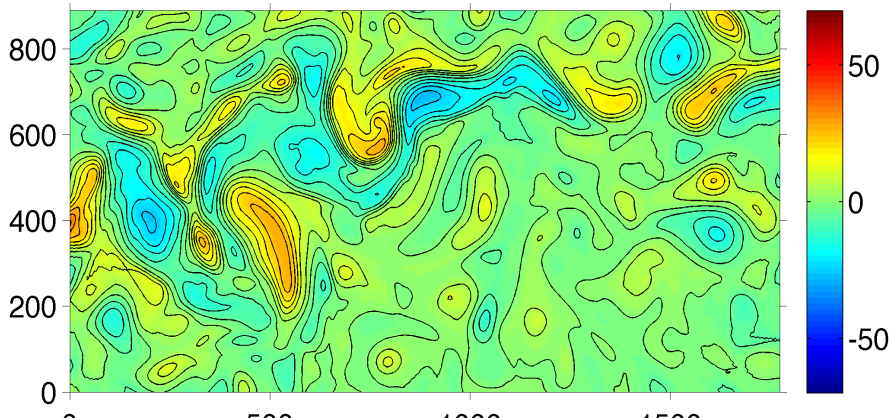
New techniques needed to extrapolate/interpolate fine-scales horizontally

Linear estimation of Day 5 from Days 0 and 10



Residual error

Dynamic estimation of Day 5 from Days 0 and 10



Residual error

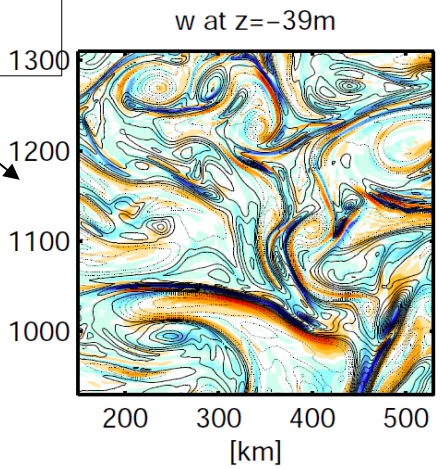
C. Ubelmann

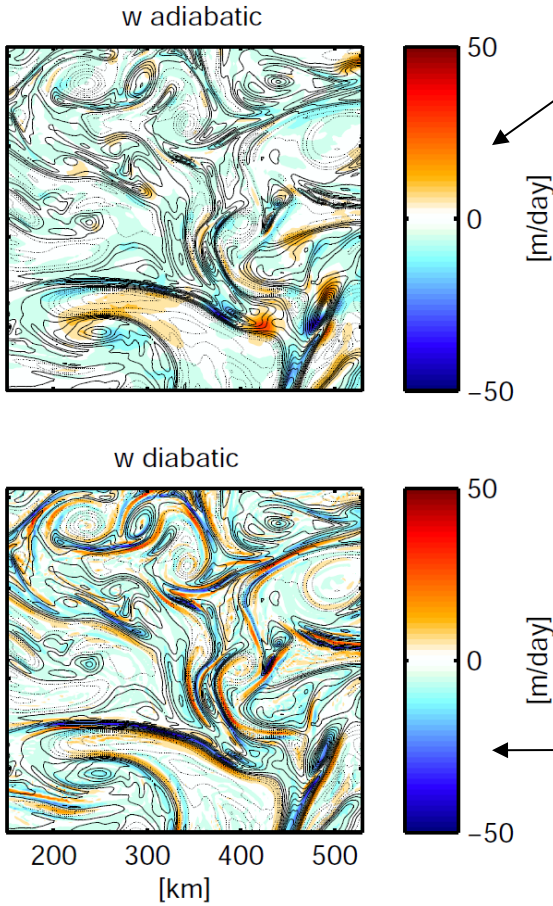
RECONSTRUCTION OF VERTICAL VELOCITIES : LAYERS 0-500M

3D dynamics in the upper ocean can be diagnosed using HR SSH & sQG theory (to take into account the mesoscale and submesoscale eddy turbulence) including diabatic processes in the mixed layer with SST and Scatterometer data (to take into account the vertical mixing driven by the air sea Fluxes)

(Klein et al. 2012))

Observed W field within the ML (in color)





Diagnosed W field without mixing

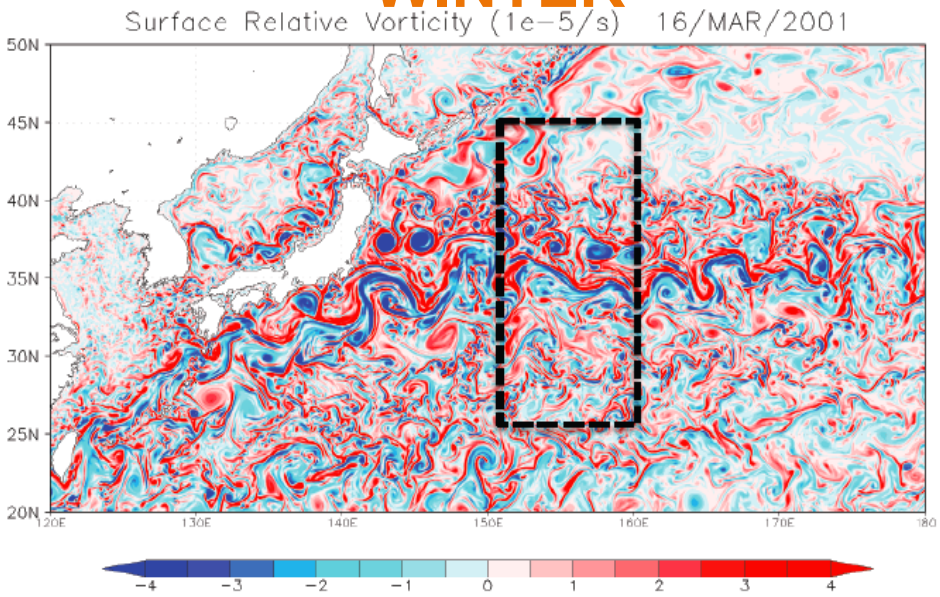
Diagnosed W field with mixing

Klein et al., LPO

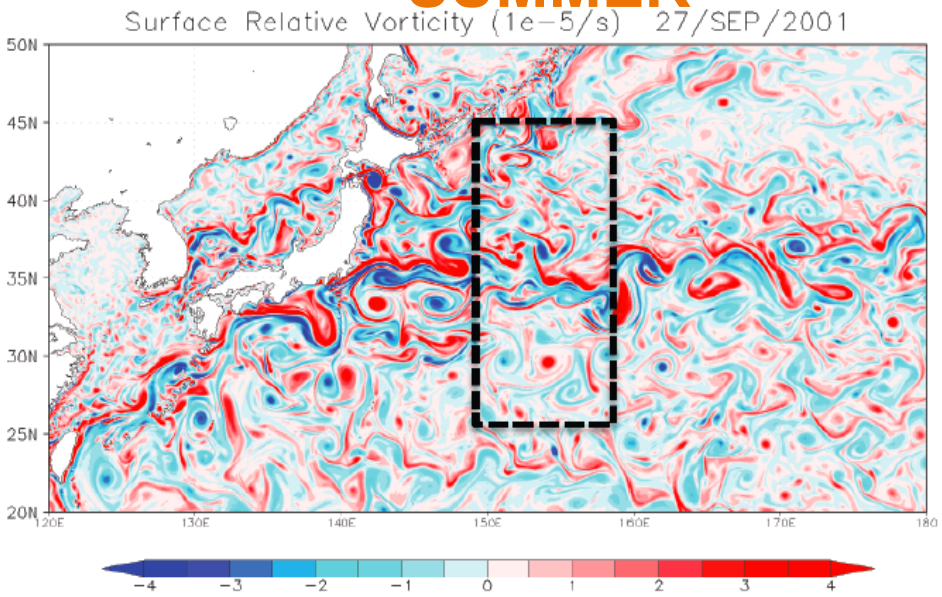
North Pacific simulation (1/36th 100 vertical levels) (Sasaki et al.,'13.) :

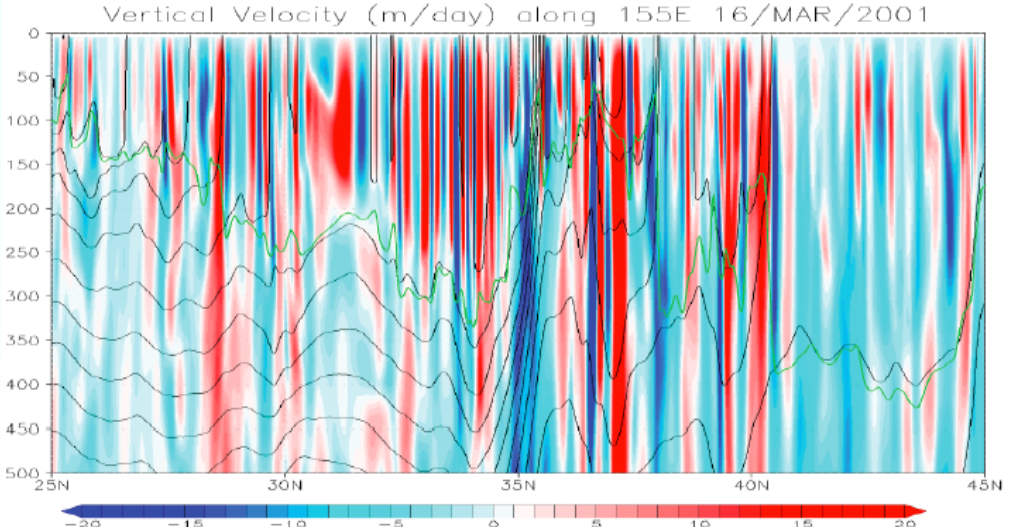
Impact of submesoscale mixed-layer instabilities on larger scales

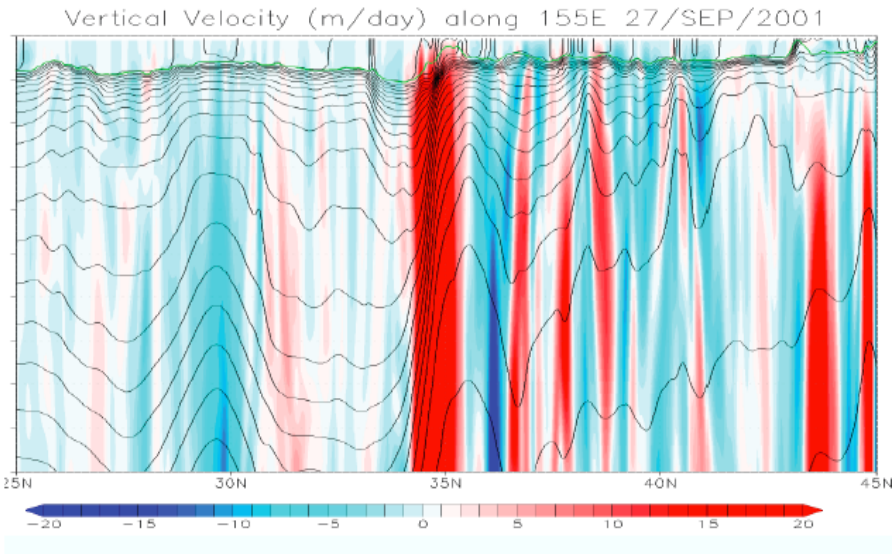
WINTER



SUMMER

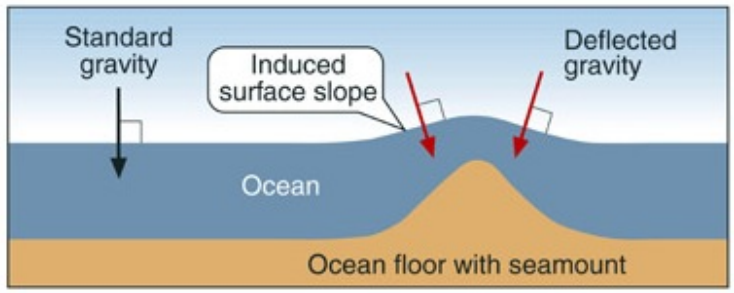




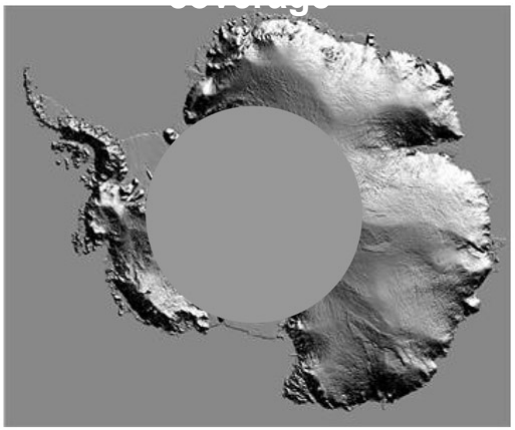


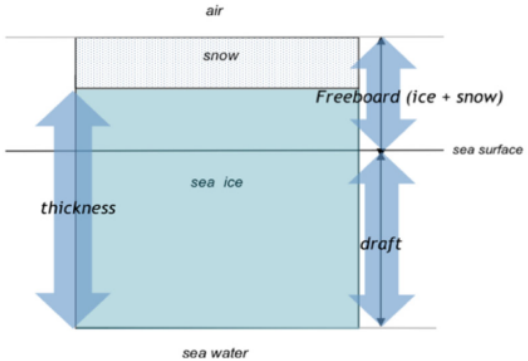
SYNERGISTIC SCIENCE

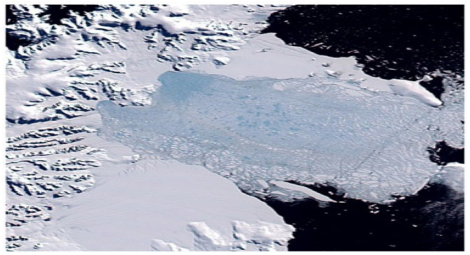
Ocean Bathymetry



Polar Ice Cap topography and sea-ice thickness







Estuaries

The AirSWOT experiment

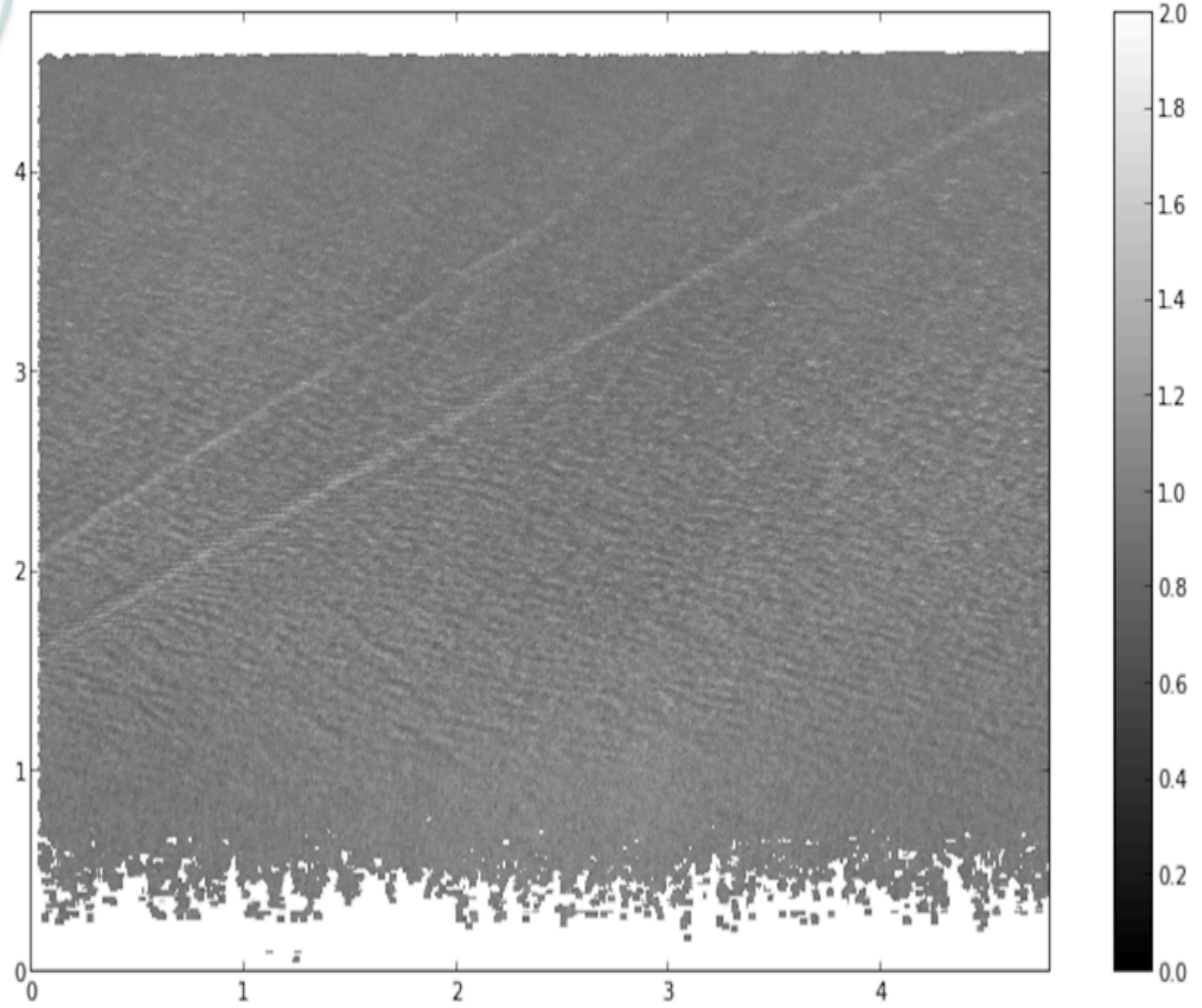
- AirSWOT is a Ka-band radar interferometric airborne sensor developed by NASA, that will be the **calibration & validation platform** for the SWOT mission.

- AirSWOT will be able to:
  - ✦Demonstrate the measurement physics and accuracy
  - ✦Calibrate and validate the SWOT instrument
  - ✦Provide SWOT-like science products to aid SWOT science in the pre-launch phase

- Test the sampling strategy of AirSWOT 2D SSH, fine-scale in-situ data, satellite data & models

- AirSWOT ocean validation :
  in the US off Monterey in Fall 2014
  in France, Bay of Biscay in 2016-2017

Ship Wakes and Waves in Radar Brighness



SWOT Conclusions

For ocean studies, SWOT will provide a revolution in global, 2-D observations of sea surface height with an order of magnitude less noise than traditional nadir altimetry

SWOT will allow us to improve our observations & understanding of mesoscale & sub-mesoscale dynamics in all weather conditions – 2D energy fluxes, generation & dissipation mechanisms, etc

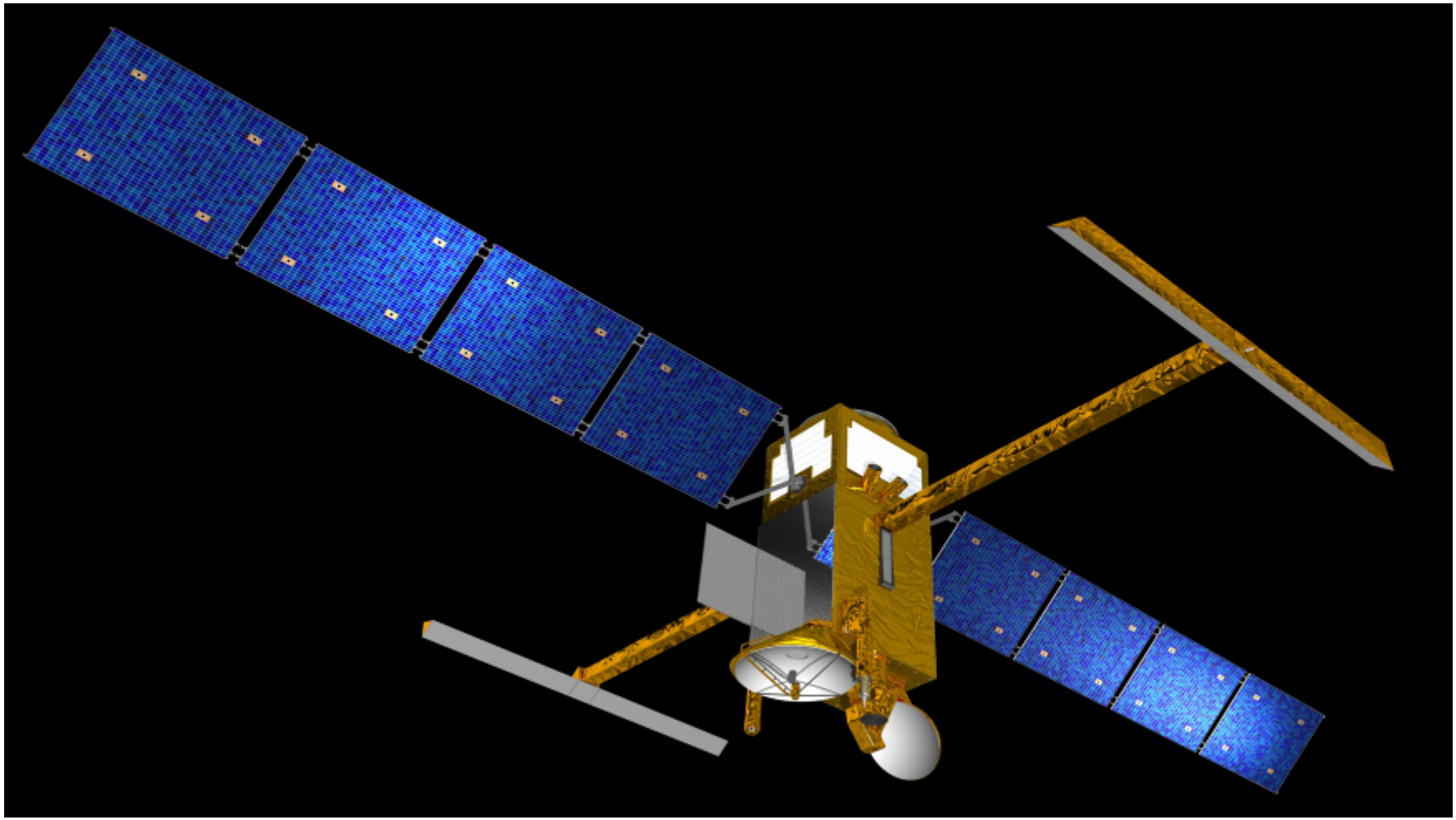
Vertical velocities can be obtained from sQG theory or models, improving our knowledge of heat, carbon & nutrient exchange between the surface mixed layer & deeper layers

In preparation for SWOT : we have established a Science Definition Team of 40 scientists for 2013-2015 – observationalists, modellers, assimilators in ocean physics and biogeochemistry.

A new team will be established by NASA-ROSES and CNES-TOSCA with a call for propositions next year

For more information – see http://swot.jpl.nasa.gov

THANKYOU



THE SWOT SPACECRAFT