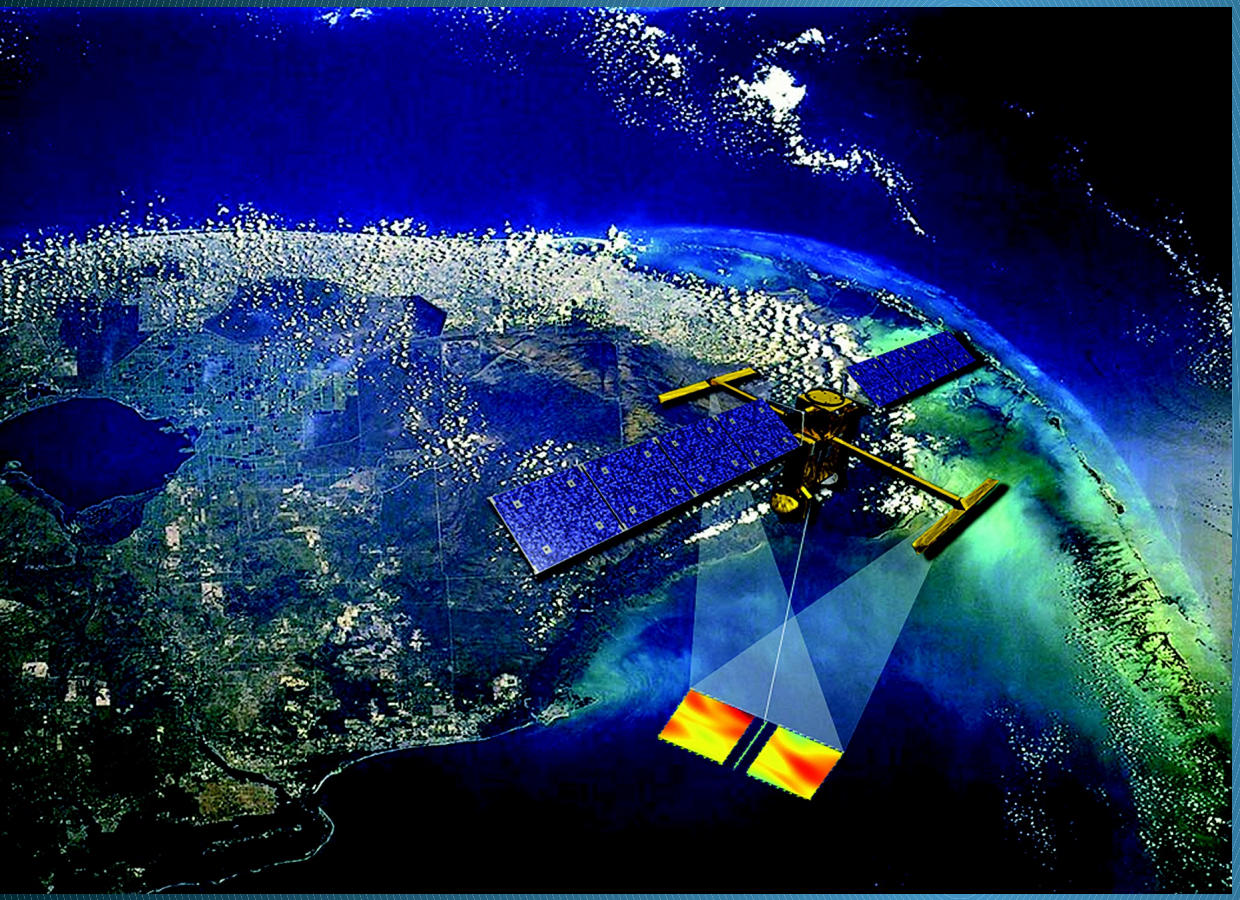
SWOT – Surface Water Ocean Topography
2D fine-resolution sea surface height : links to surface currents



Rosemary Morrow

LEGOS, Toulouse, France

Acknowledge :

Ernesto Rodriguez

SWOT Science and Pr… team…

SWOT (Surface Water & Ocean Topography)

NASA/CNES/CSA/UKSA – launch in Sep 2021

Hydrologic science objectives :

- Provide a **global inventory of all terrestrial surface water bodies** whose surface area exceeds **$(250m)^2$ (lakes, reservoirs, wetlands)** and **>10km long river reaches whose width exceeds 100m (requirement)**.
- Measure global patterns of storage change in terrestrial surface water bodies and river discharge at **sub-monthly, seasonal, and annual time scales**.

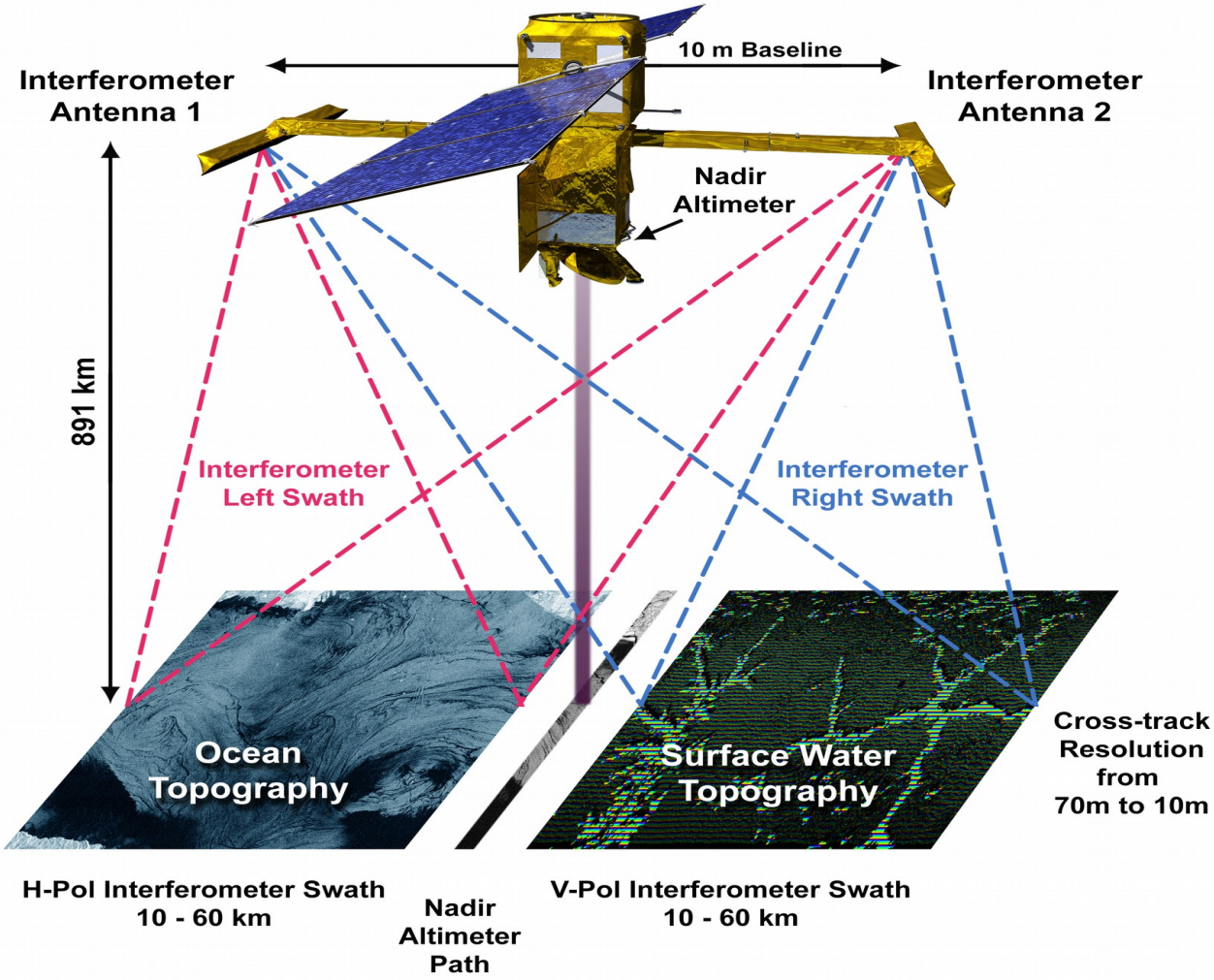
Ocean Scientific objectives

• Observe the **ocean mesoscale and submesoscale** circulation at spatial resolutions of 15 km and larger, providing the missing link between 15 and 200 km for ocean climate studies.

• Observe **coastal and high-latitude tides and internal tides**, important in the ocean's energy budget, and for ocean mixing & dissipation

Technological objective - a new standard for future

SWOT -2D measurement of surface water topography



Ocean Data Products : (after onboard processing)

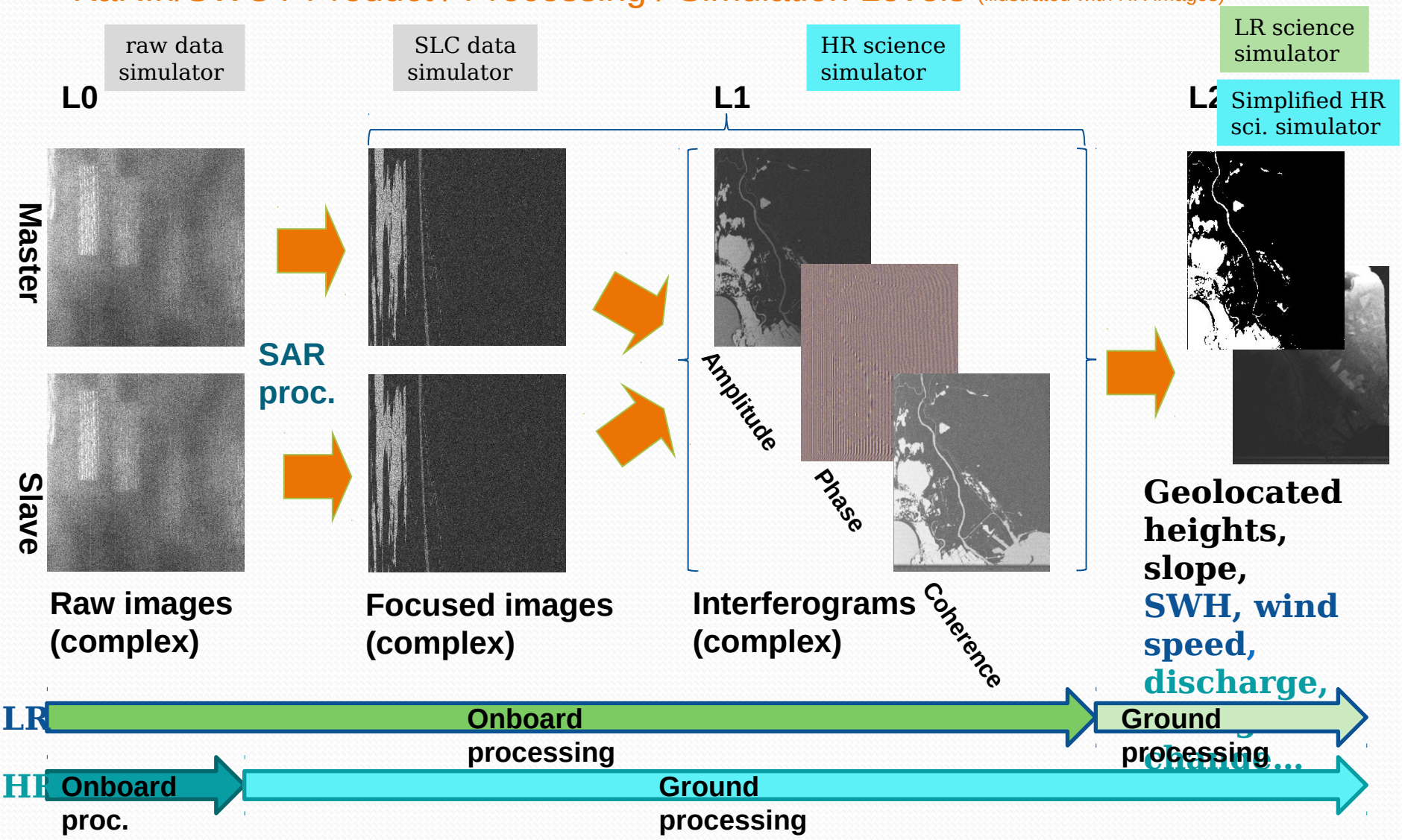
- Basic oceanographic SSH product (2 km resolution/posting)
- Expanded products – full corrections, wind/waves (2 km)
- Expert high resolution product: SSH (500m resolution/ 250m posting) & SAR images (power, power variance, Doppler Centroid at 250 m)

2D SSH observations – very low noise (2.5 cm km²/cyc)

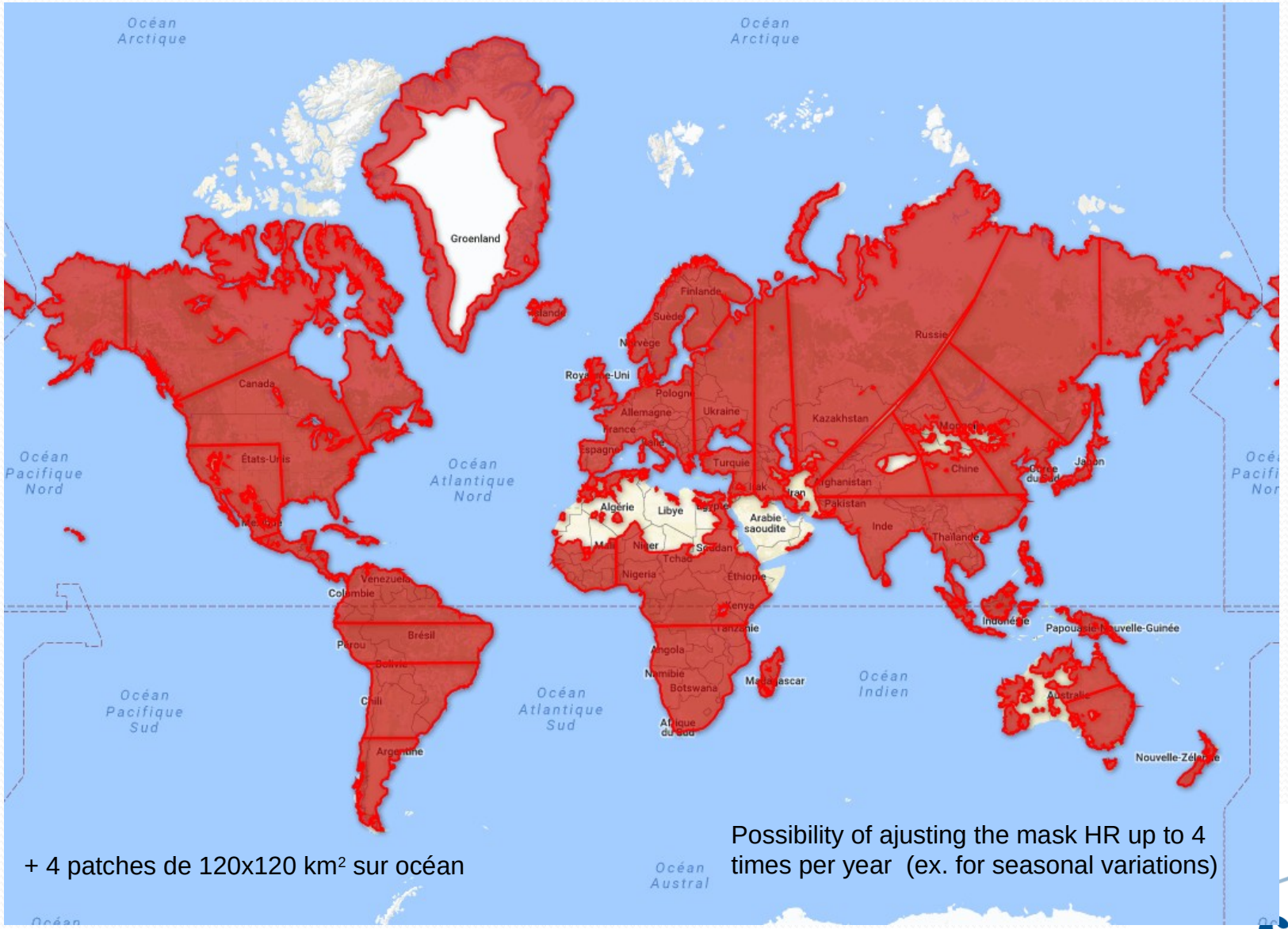
Image : K. Wiedman

KaRIn LR and HR Modes: Onboard vs. Ground Processing

KaRIn/SWOT Product / Processing / Simulation Levels (illustrated with HR images)



LR data available globally ; HR on Mask



SWOT orbits

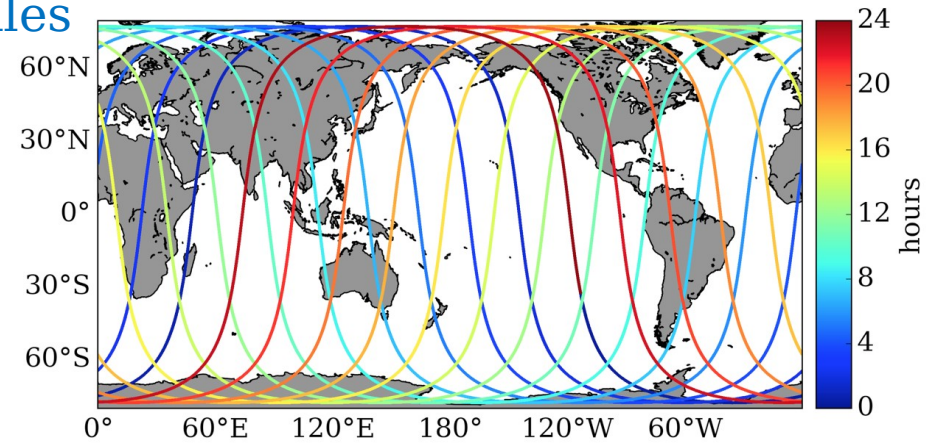
Nominal Launch date : Sept 2021

First 6 months : 1-day orbit :

1st 3 months – instrument checkout

2nd 3 months - Dec-Feb 2022 – Science orbit

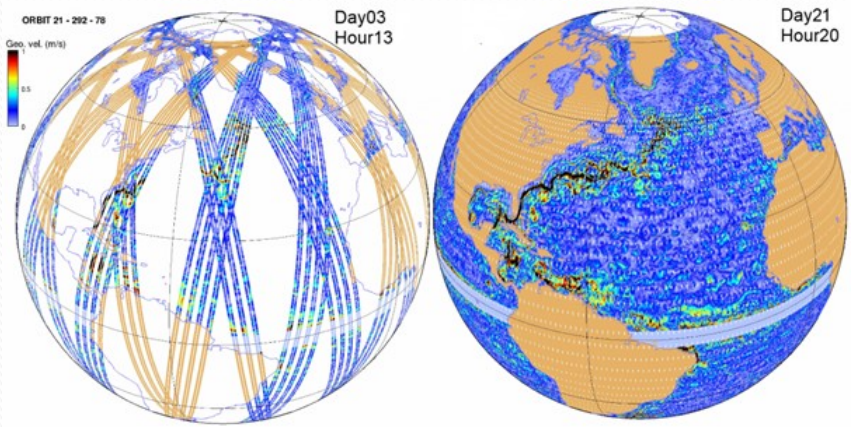
- Ideal for ocean studies of rapidly evolving small mesoscales and submesoscales



3-year 21-day repeat orbit
Nominally : Mar 2022 to Mar 2025

Full global coverage

1-day and 10-day sub-cycles for better mesoscale coverage

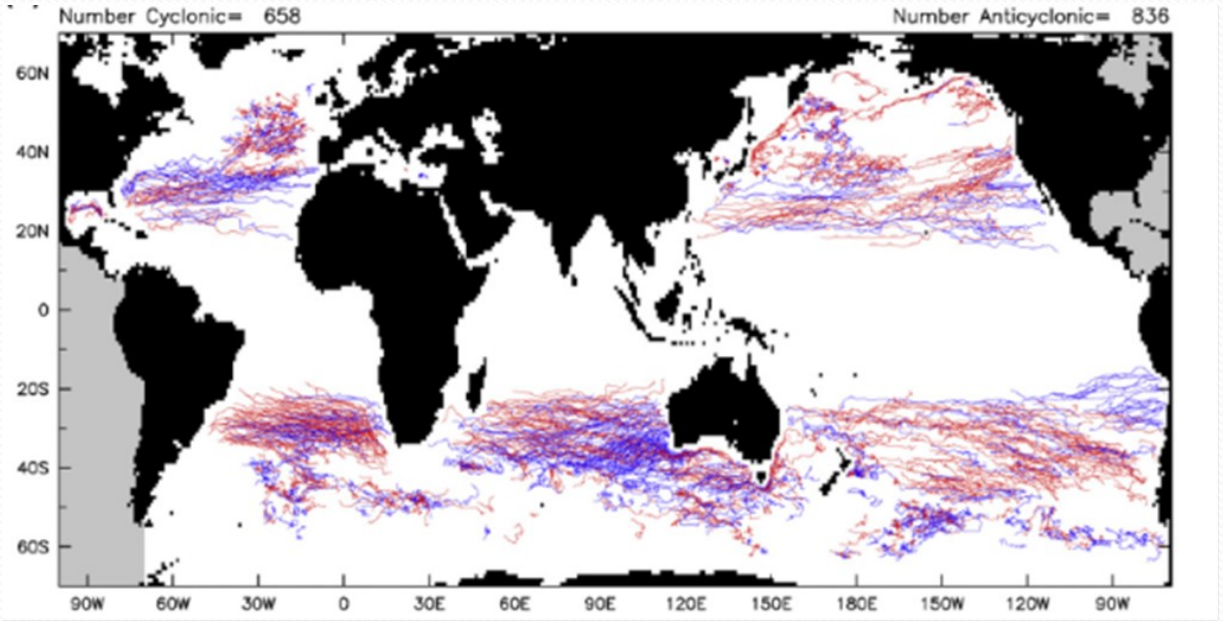


1st Ocean science objective : small mesoscales and submesoscales (> 15 km

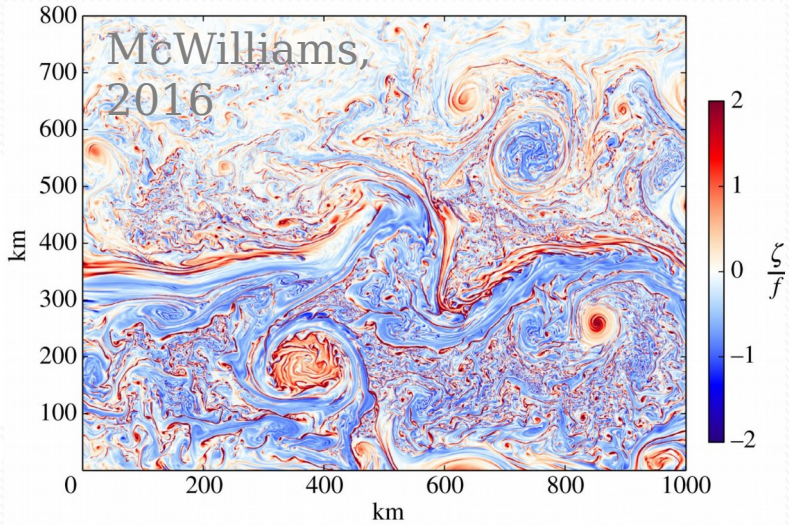
Seen in tracer images …

Sun-glint ‘spirals of the sea’

Vortex radii are 5 km, spectral wavelength 20 km



Tracking large mesoscale eddies – small ones not observed



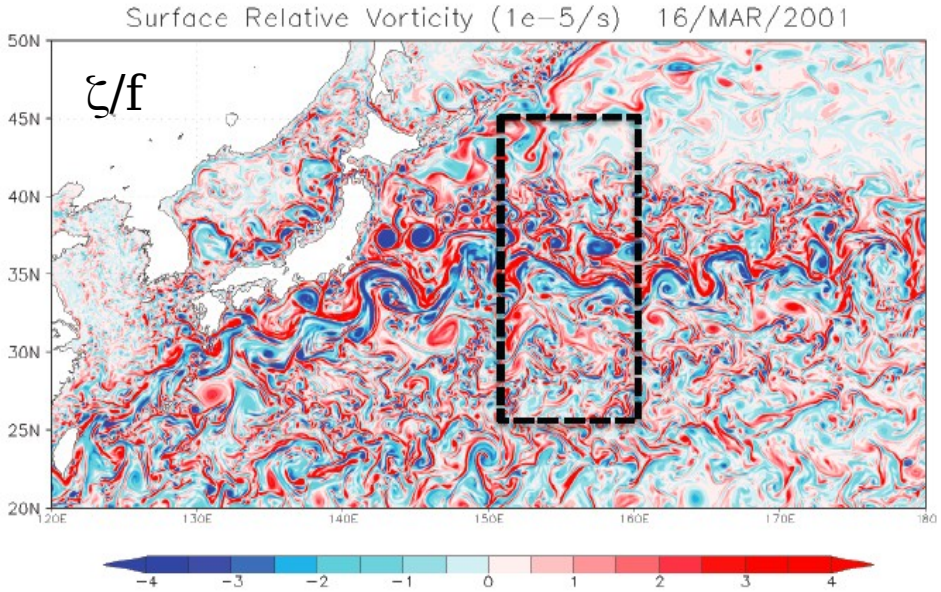
Submesoscales now simulated with high resolution models –>

need high-resolution observations to validate them

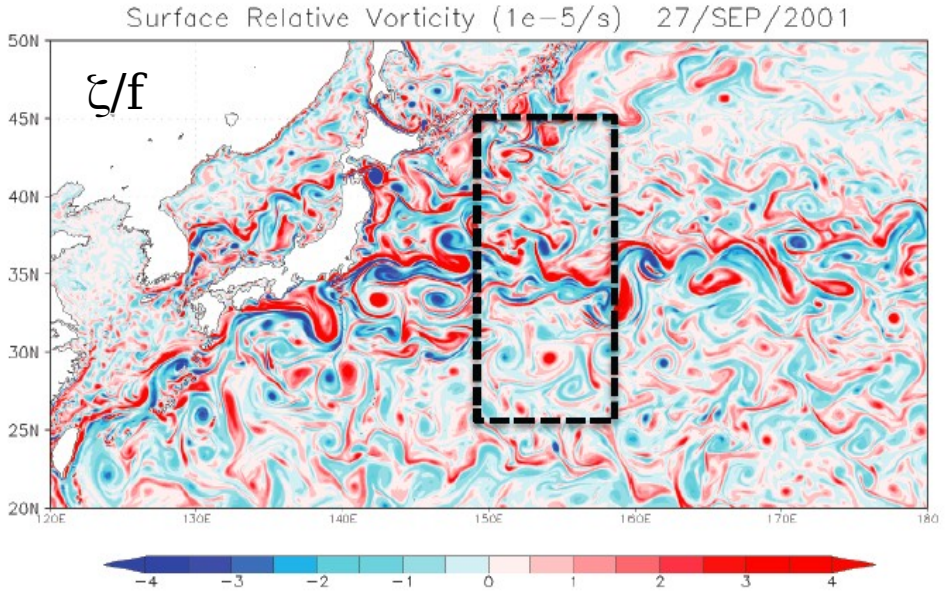
North Pacific simulation (1/36th 100 vertical levels) (Sasaki et al.,'13.) :

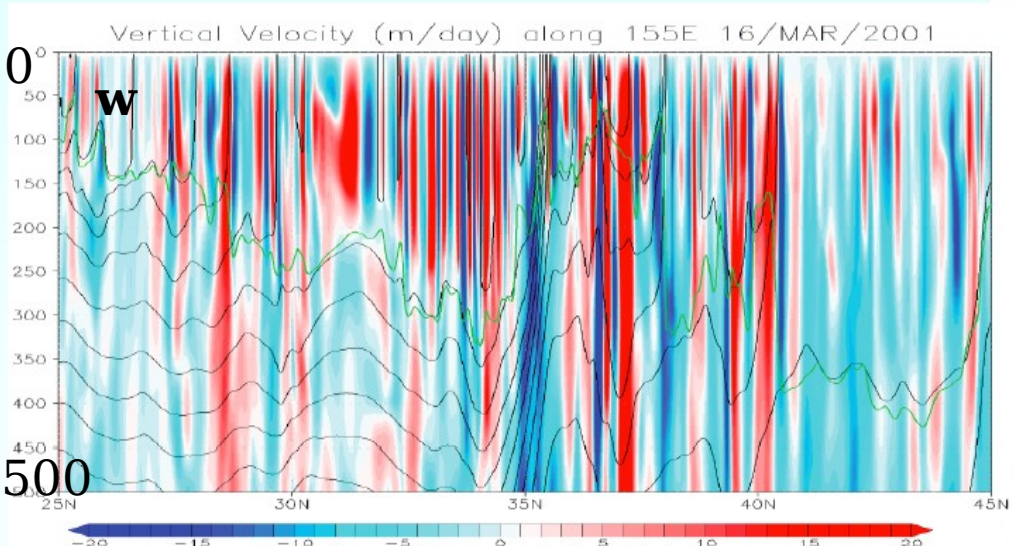
Winter submesoscales have energetic vertical velocities

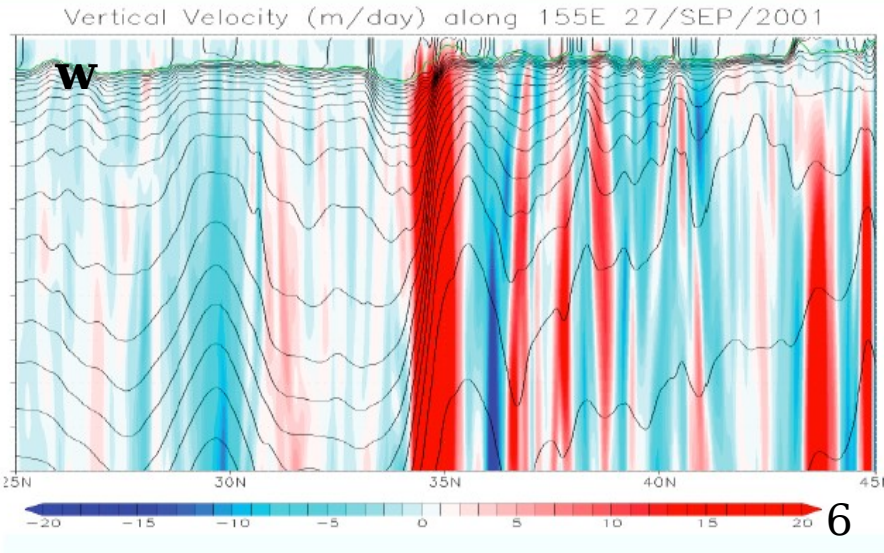
WINTER



SUMMER







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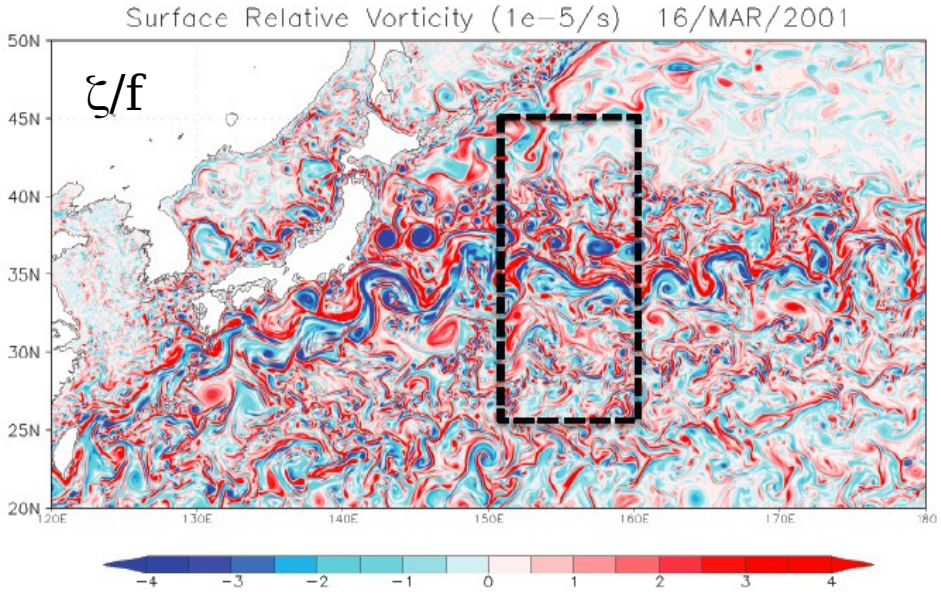
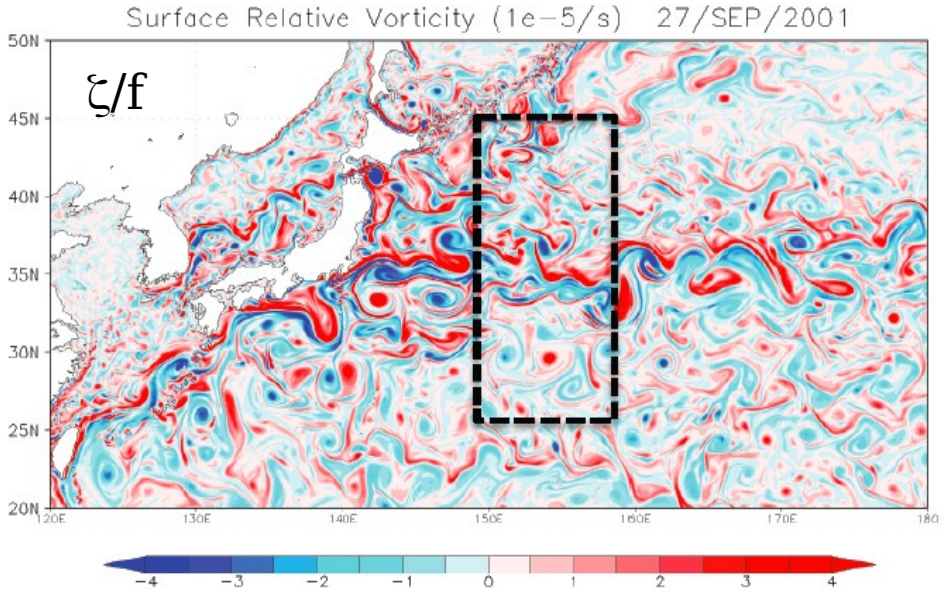
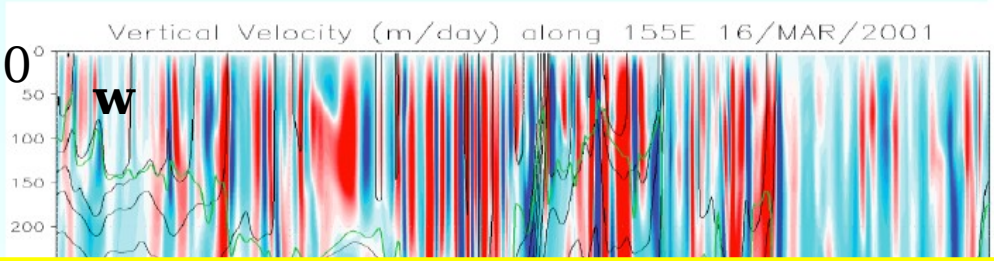
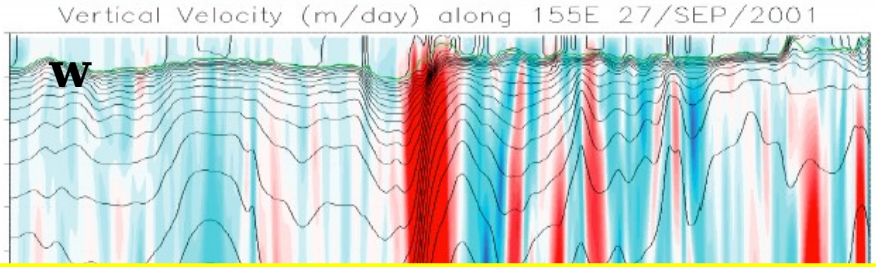


SUMMER







SWOT's SSH will reflect the **vertical integral** of the density/pressure anomalies at depth

In winter, => deep ML instabilities have a distinct signature in SSH

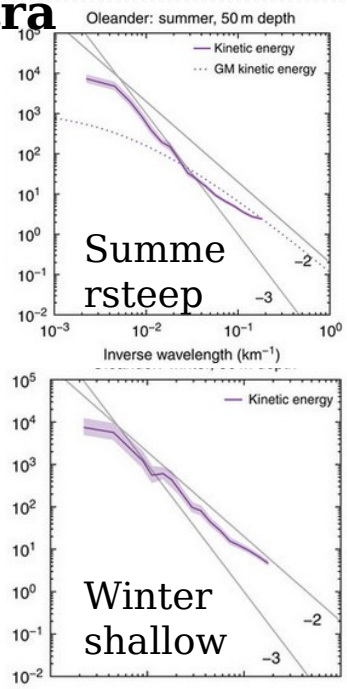
In summer, => shallow mixed layer processes are weak - little imprint on SSH

Alongtrack altimetry can already detect high small-scale energy in winter

Models, in-situ and alongtrack altimetric SSH wavenumber spectra show steeper slopes in summer, shallower in winter

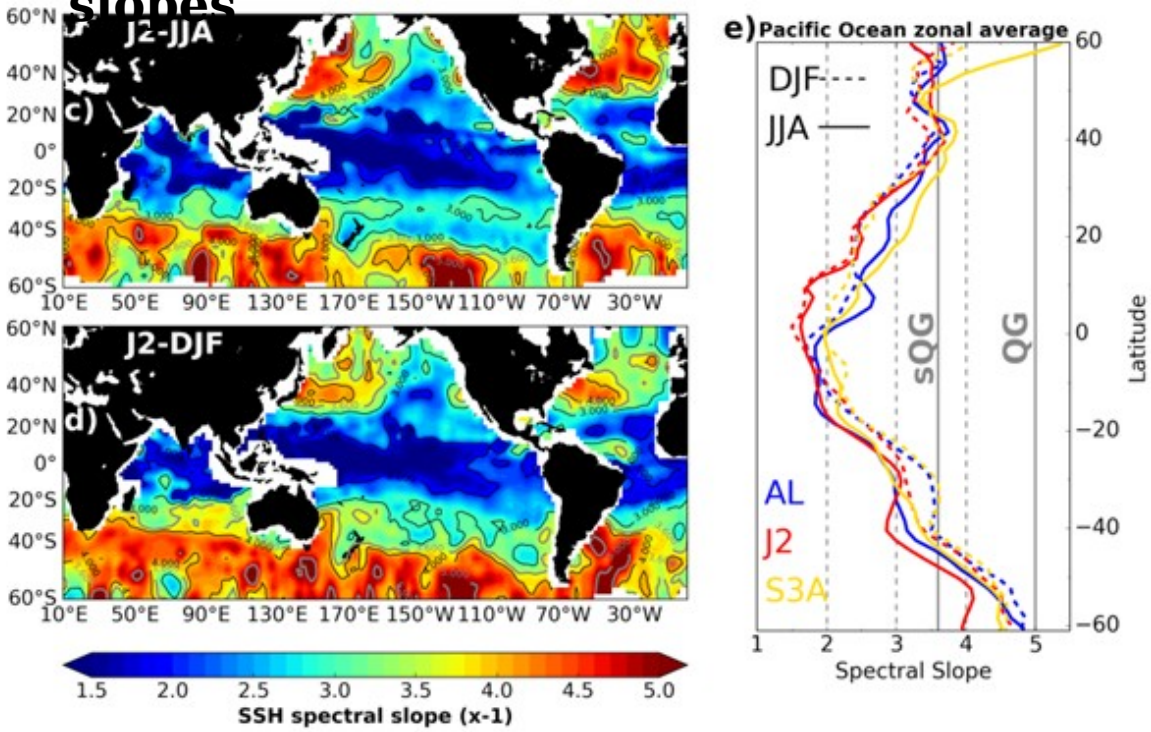
SWOT (lower noise) should also observe the 2D anisotropic structure and strain

Oleander In-situ KE spectra



Callies et al., 2017

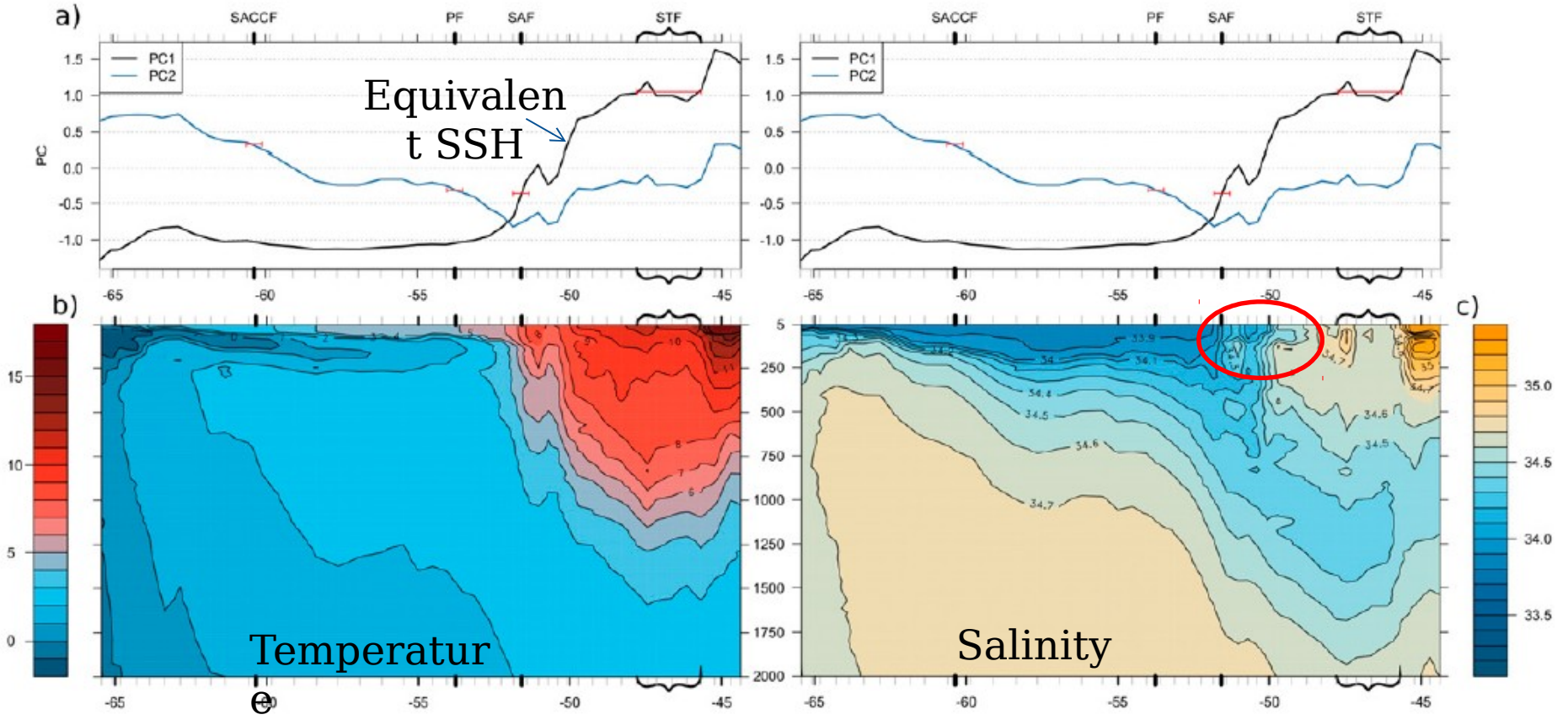
Alongtrack altimetric SSH spectral slopes



Vergara et al., 2018 in prep

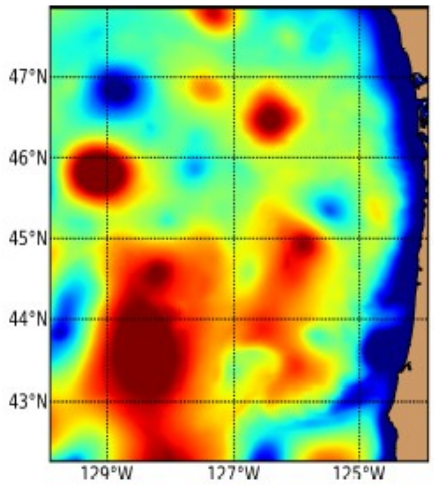
subsurface fronts and currents is complex

- Altimetric SSH gradients respond to depth-integrated Panom
- Surface fronts in T, S, currents can be shifted northward by Ekman transport
- SKIM will detect the different surface jets, combined with

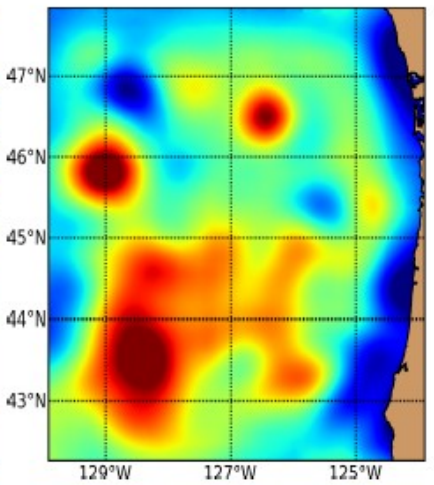


Sections WOCE SR3 S of Tasmania, Pauthenet et al.,

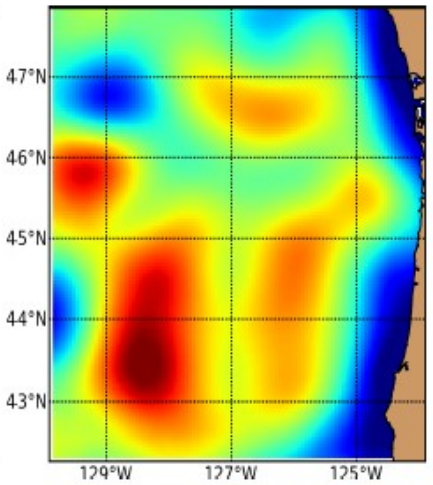
2D Reconstruction from Mapping



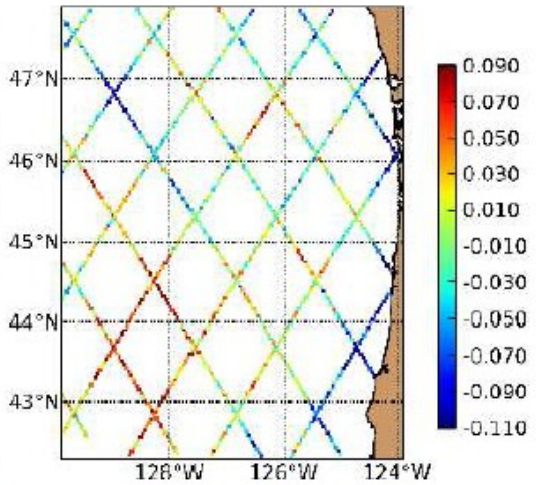
(a) Truth



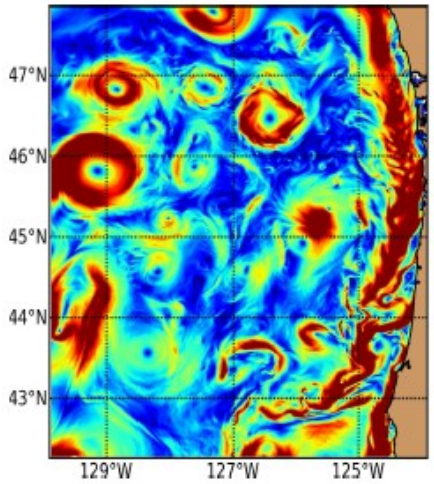
(b) Mapped SWOT



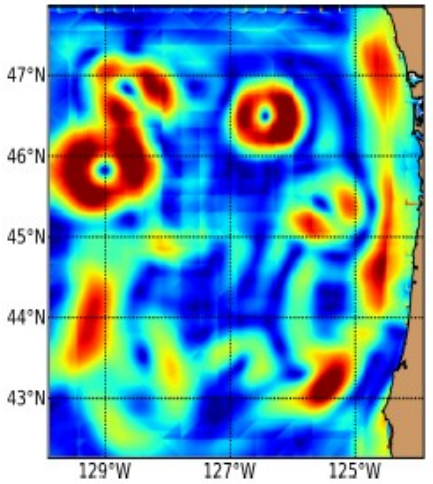
(c) Mapped nadir



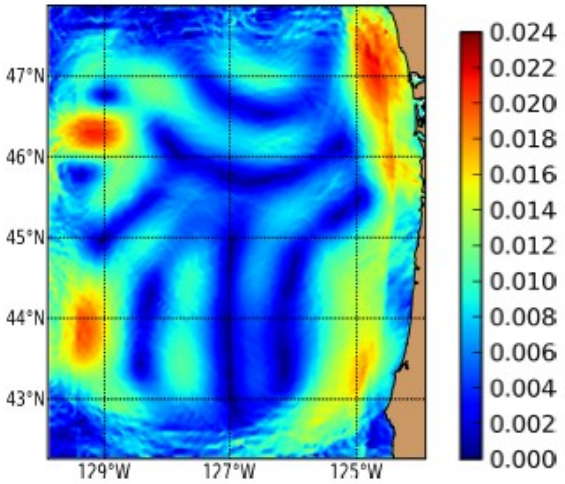
(d) Along track



(e) True Velocity



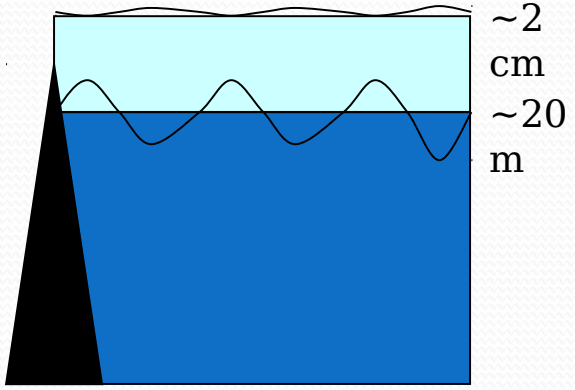
(f) From SWOT-like mapped observations



(g) From Nadir-like mapped observations

(Gaultier et al

tides
- a Challenge and Opportunity

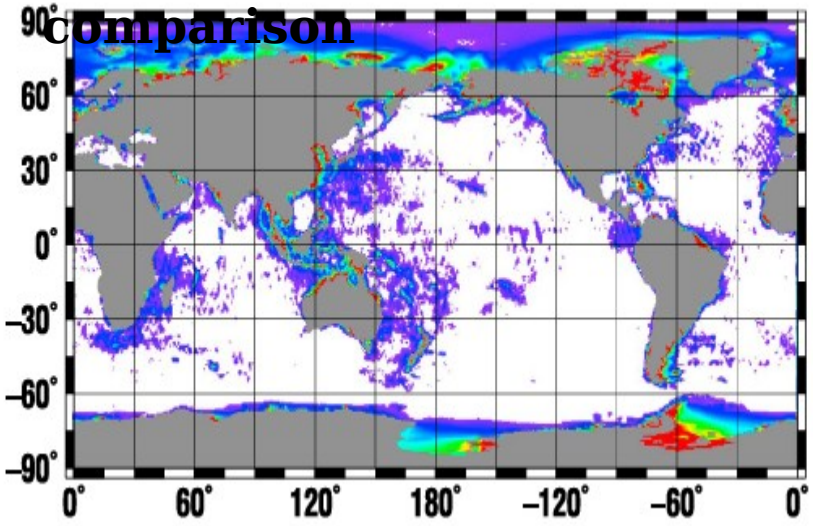


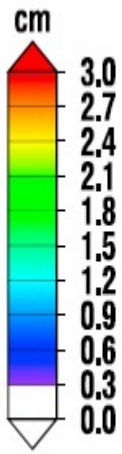
SWOT **orbit chosen to resolve tides** – 3 years of SWOT data will provide finer-scale 2D tides

–> first and maybe LAST mission designed for 2D tides

2D signature of **Internal tides** observed by SWOT provide unprecedented ocean mixing & energy

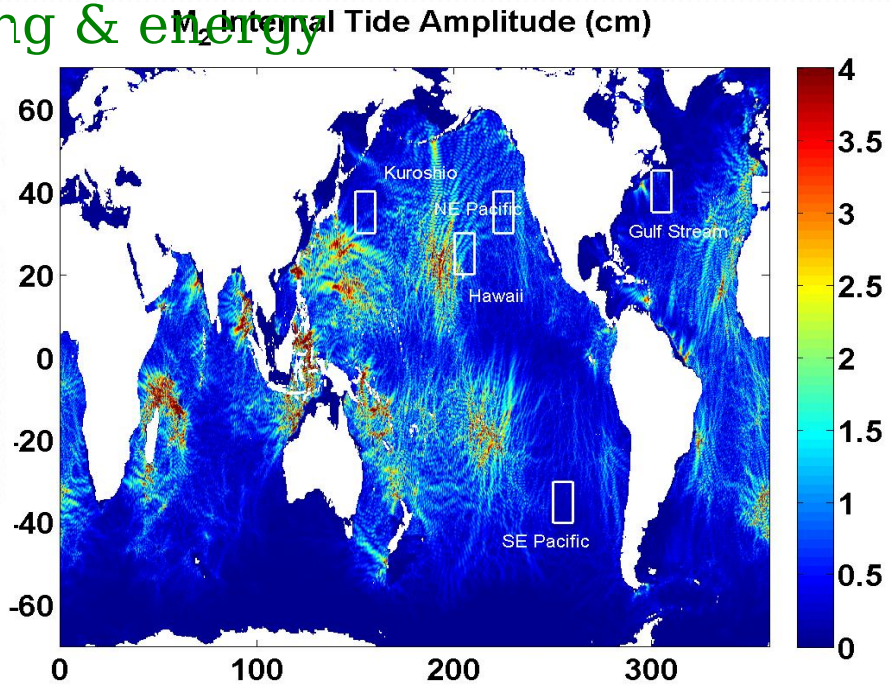
Barotropic Tide model comparison





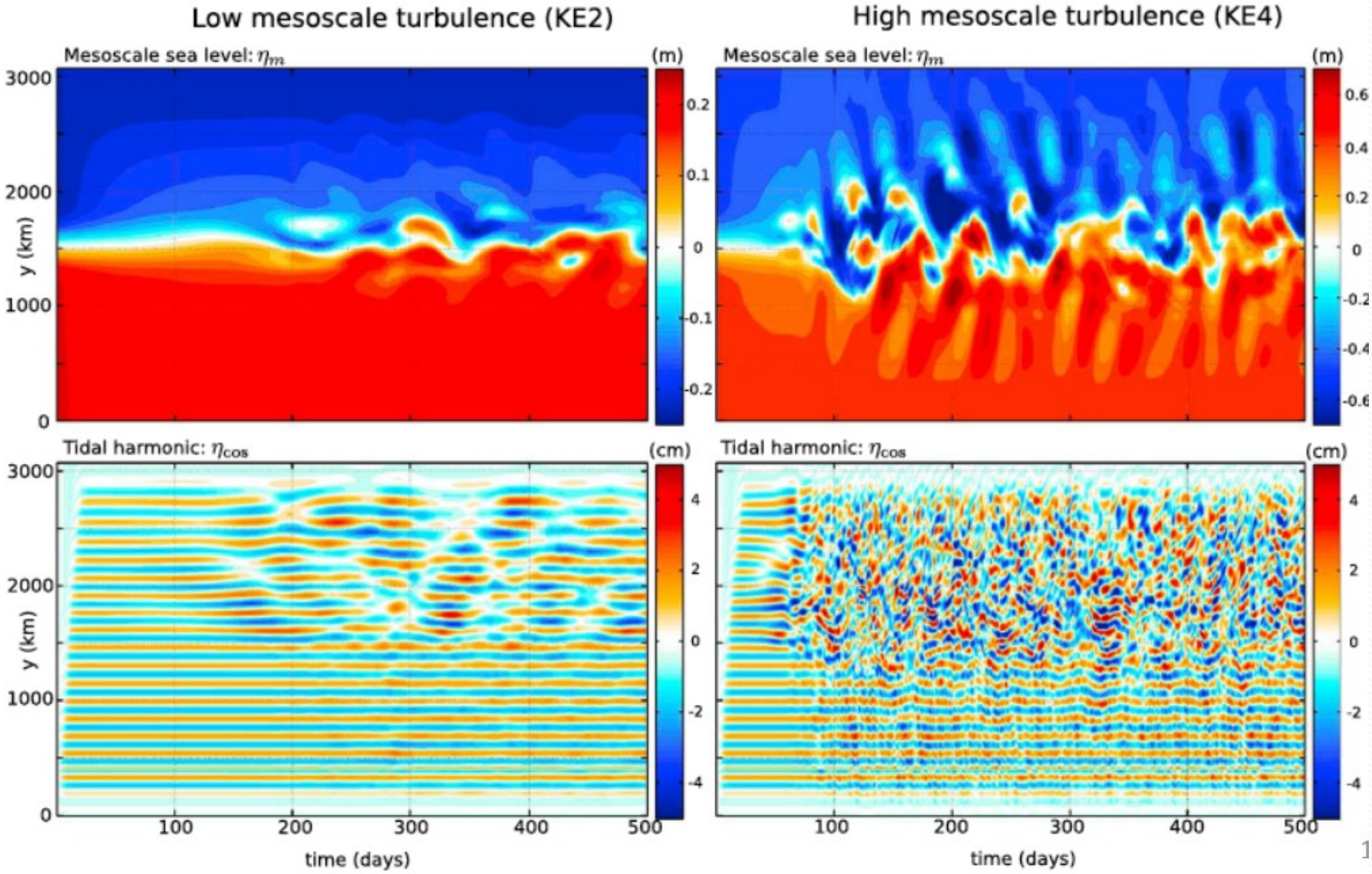
St. Dev of 7 global tide models, M2

Stammer et al., 2014



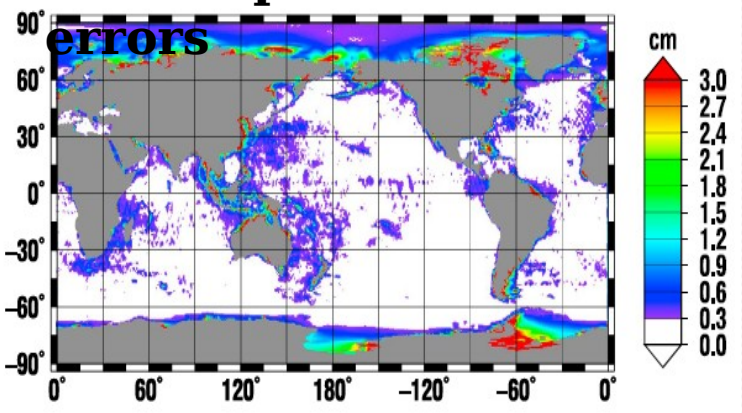
Model : HYCOM 1/12° *Arbic et al.,*

Ponte and Klein (2015) idealized experiments on internal tide incoherence



SWOT's 250m resolution tidal currents

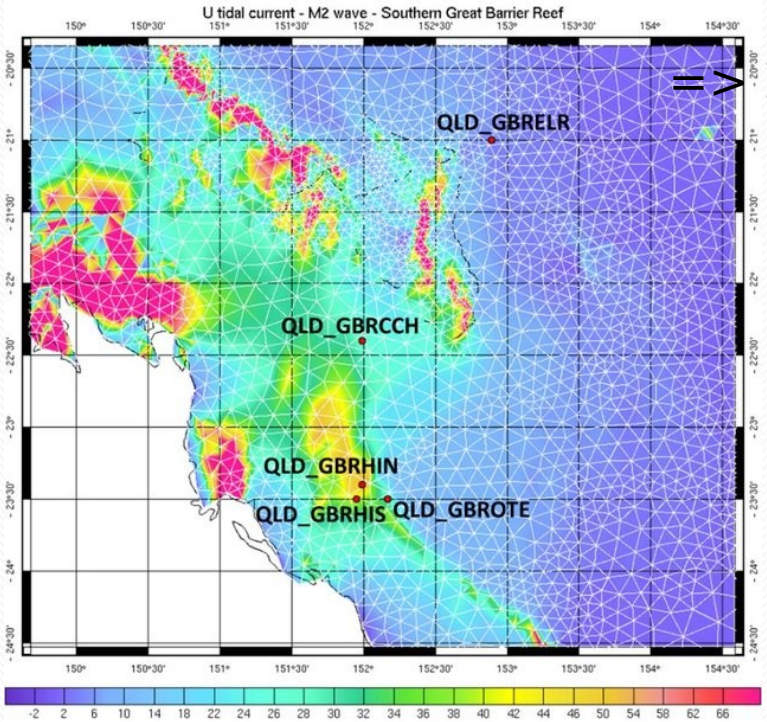
Barotropic Tide model errors

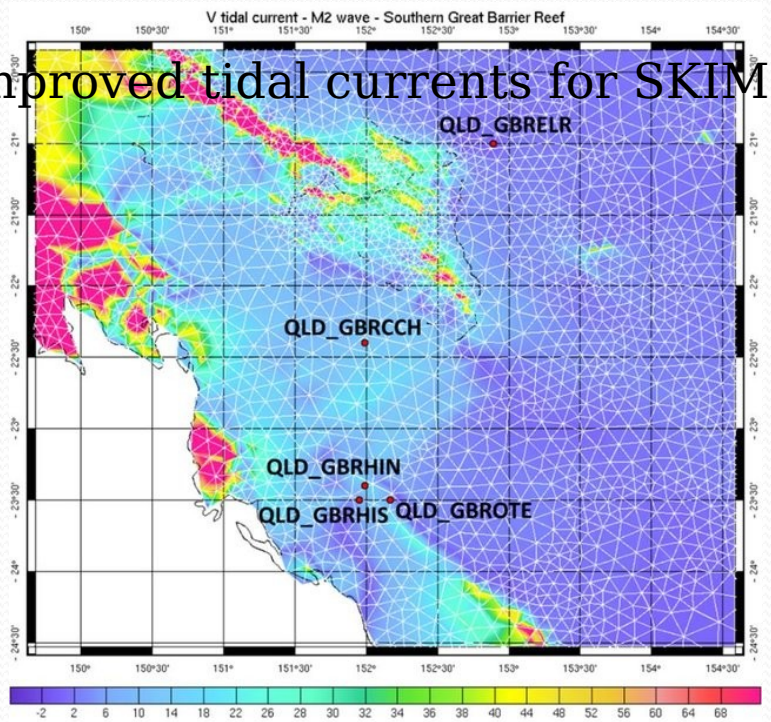


Swot will provide improved SSH and tidal currents – like tide gauges at 250 m resolution
Validation of tidal models, eg FES2014

Coastal tidal currents
High-latitude tidal currents (ice-free zones to 78°)

=> Improved tidal currents for SKIM





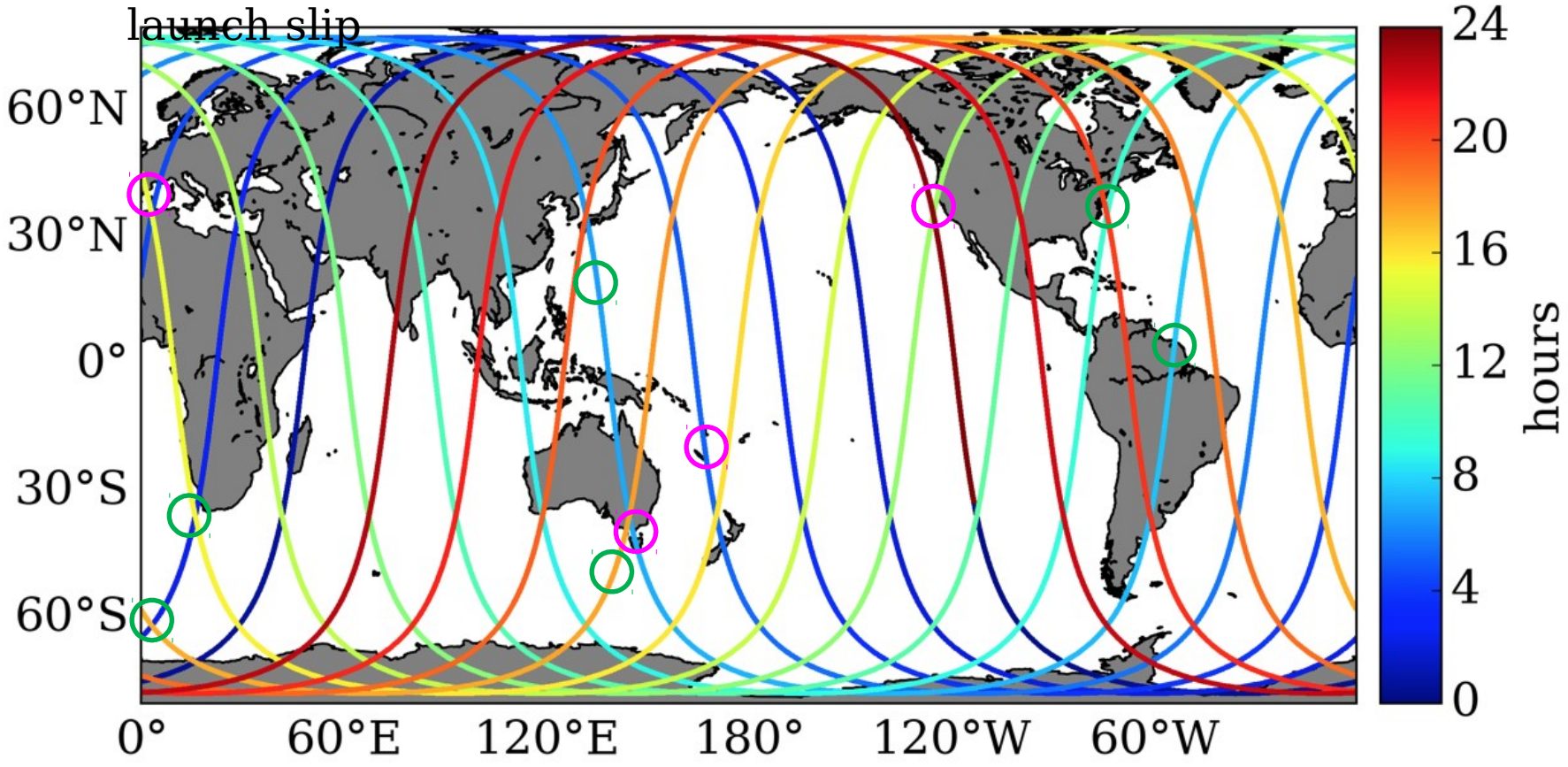
Assessment of the FES2014 Tidal Currents on the shelves around Australia, Cancet et al., 2017

SWOT CalVal - “Adopt-a-crossover” plan

- Resolving 4D ocean Pressure (-> SSH) and velocity variability 15-150 km : incl IWs
- Frontal/submesoscale processes campaigns

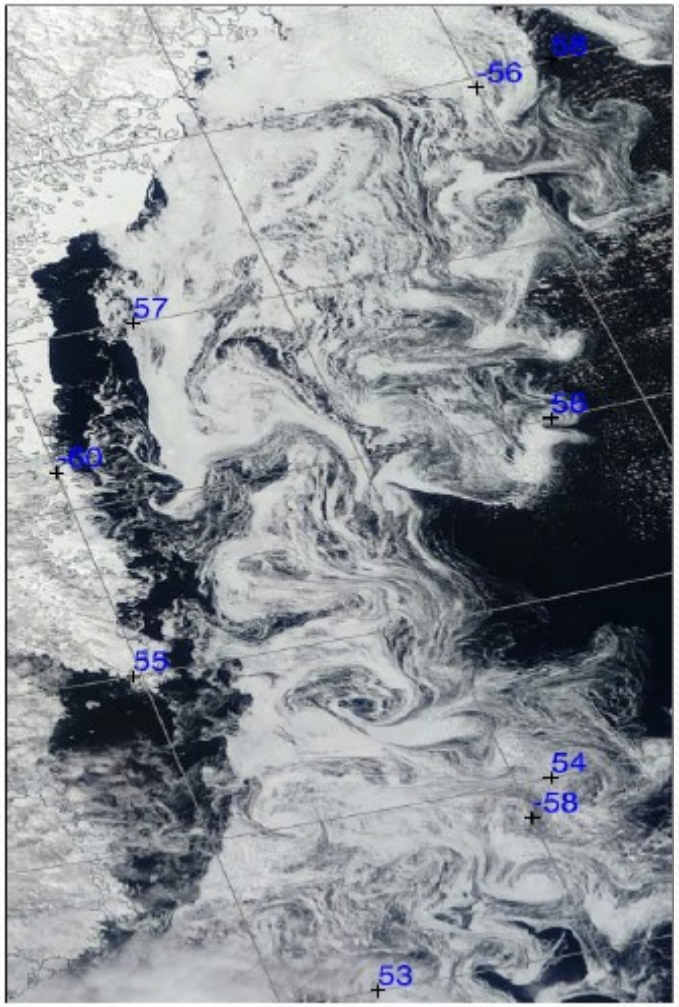
International « **Adopt-a-crossover** » plan – simultaneous in-situ studies in 1-day phase

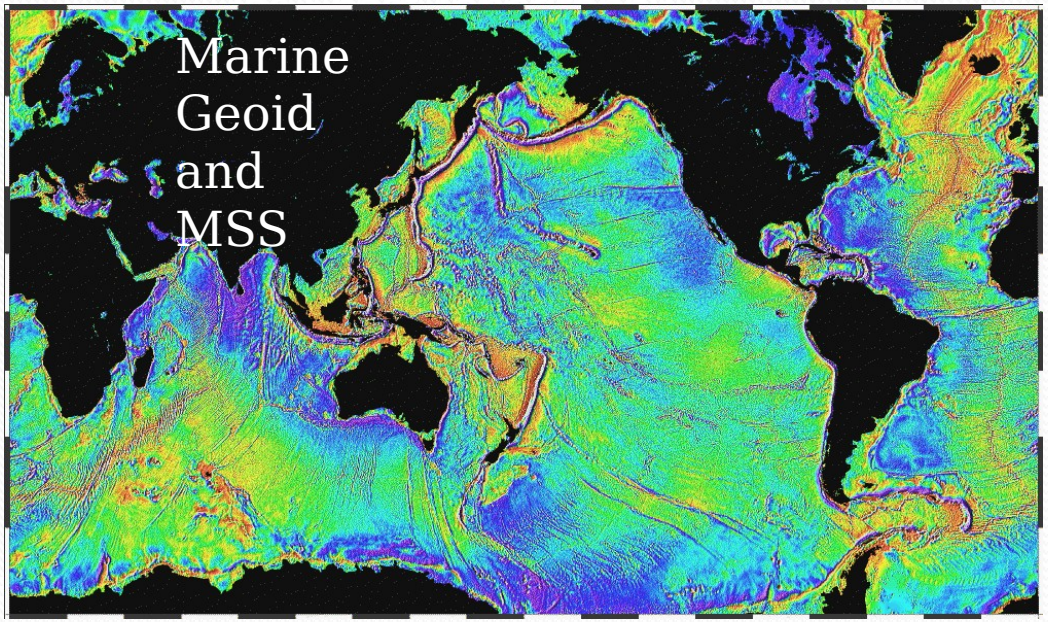
Dec-Feb 2022 – light or long-term deploments in case of launch slip



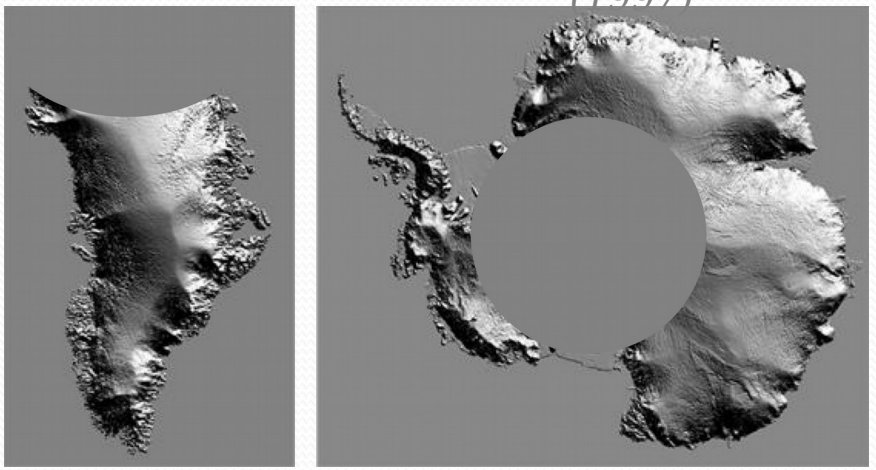
Mission Design)

Small mesoscale sea-ice monitoring and freeboard





Sandwell and Smith (1997)



Polar Ice caps

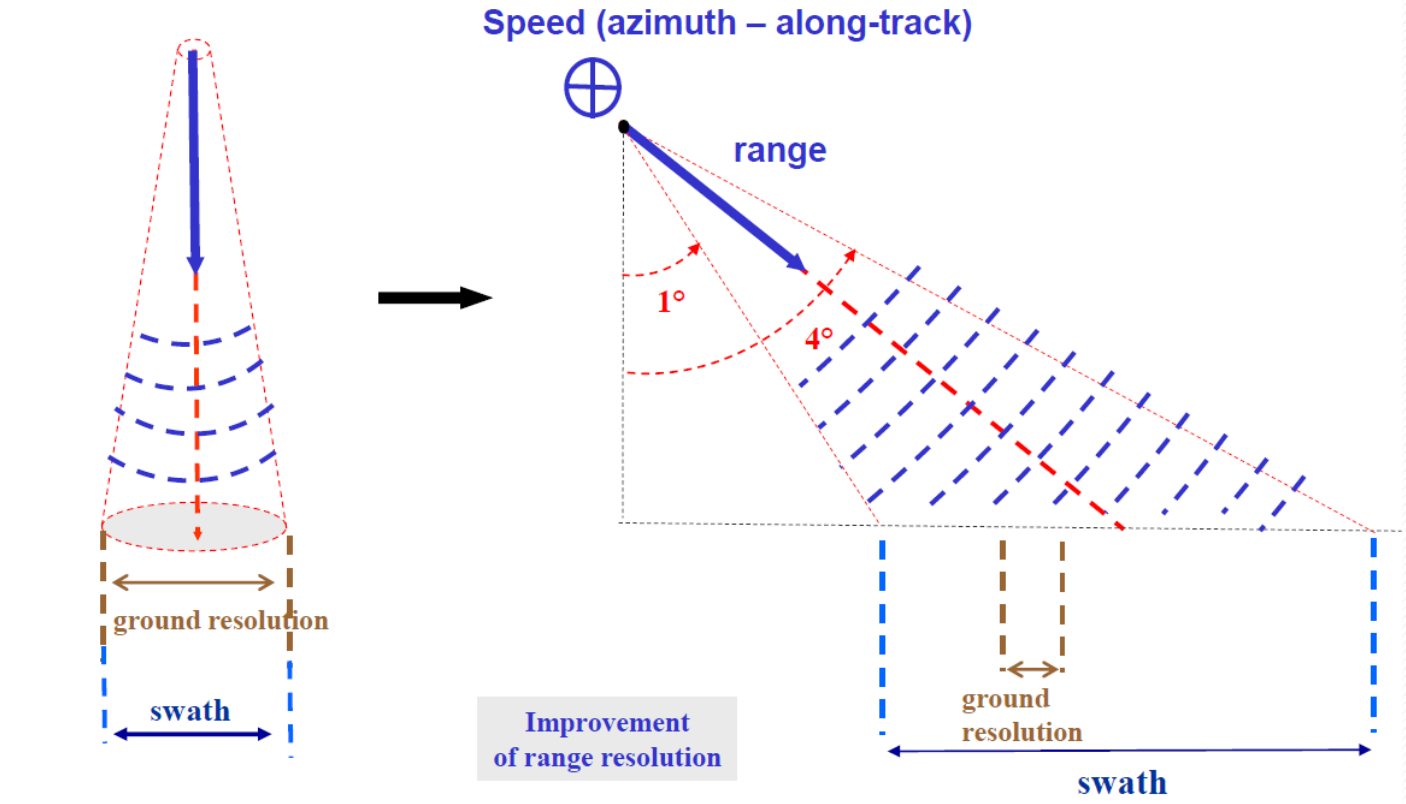
SWOT and surface currents and SKIM

- SWOT observes SSH and SSH images … need careful processing to remove noise, and separate coherent internal tides
- Expecting good observations of anisotropic 2D structure of small mesoscales, and derived balanced velocities and strain
- Balanced flow currents can be derived from SSH gradients down to 15-40 km wavelength, depending on SWH conditions, reflect depth-integrated gradients. Complementary to SKIM surface currents
- SWOT will provide greatly improved tides and tidal currents after 3 years … useful for all past and future missions & model validation
- SWOT will provide unique observations of the interactions between balanced flow and internal gravity waves (incl internal tides)

SWOT Measurement

From nadir to wide swath altimetry

→ Off-Nadir illumination



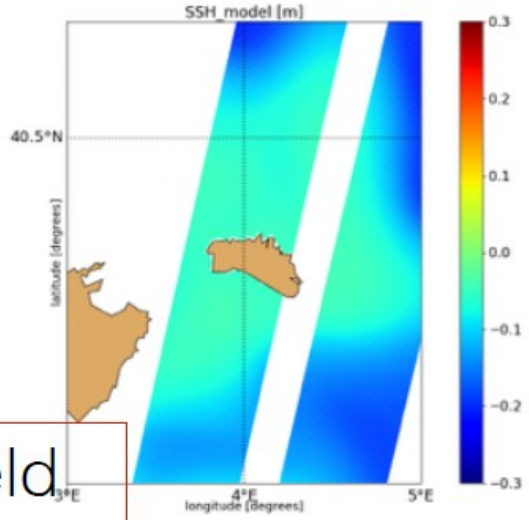
Ocean Data Products :

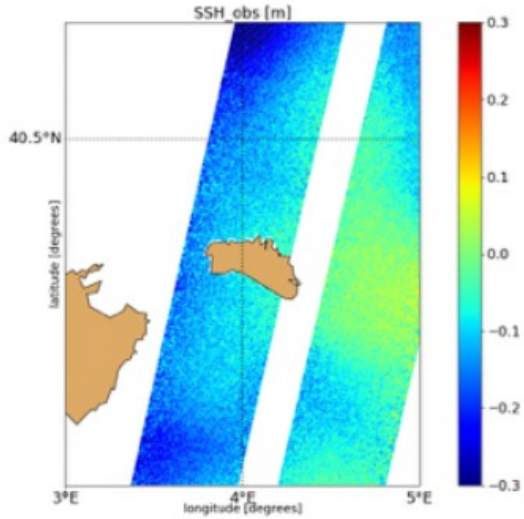
- basic oceanographic SSH product (2 km resolution/posting)
- Expanded low resolution product – full corrections, wind/waves (2 km)
- expert high resolution product: SSH & SAR images (500m resolution/ 250m posting)

SWOT Noise reduction and 2D reconstruction

Different SWOT-ST groups exploring techniques to reduce noise in 2D SSH images, and for fine-scale 2D reconstruction

Without noise



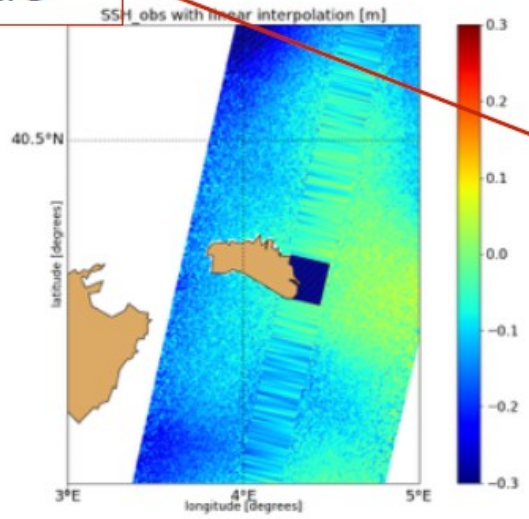


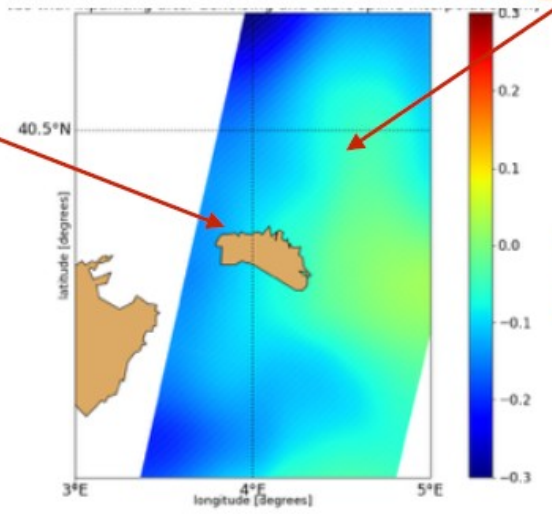
With noise

Smooth field near islands

Fill the gap

With noise, linear interpolation in the gap





With noise, after denoising and inpainting

E. Cosme

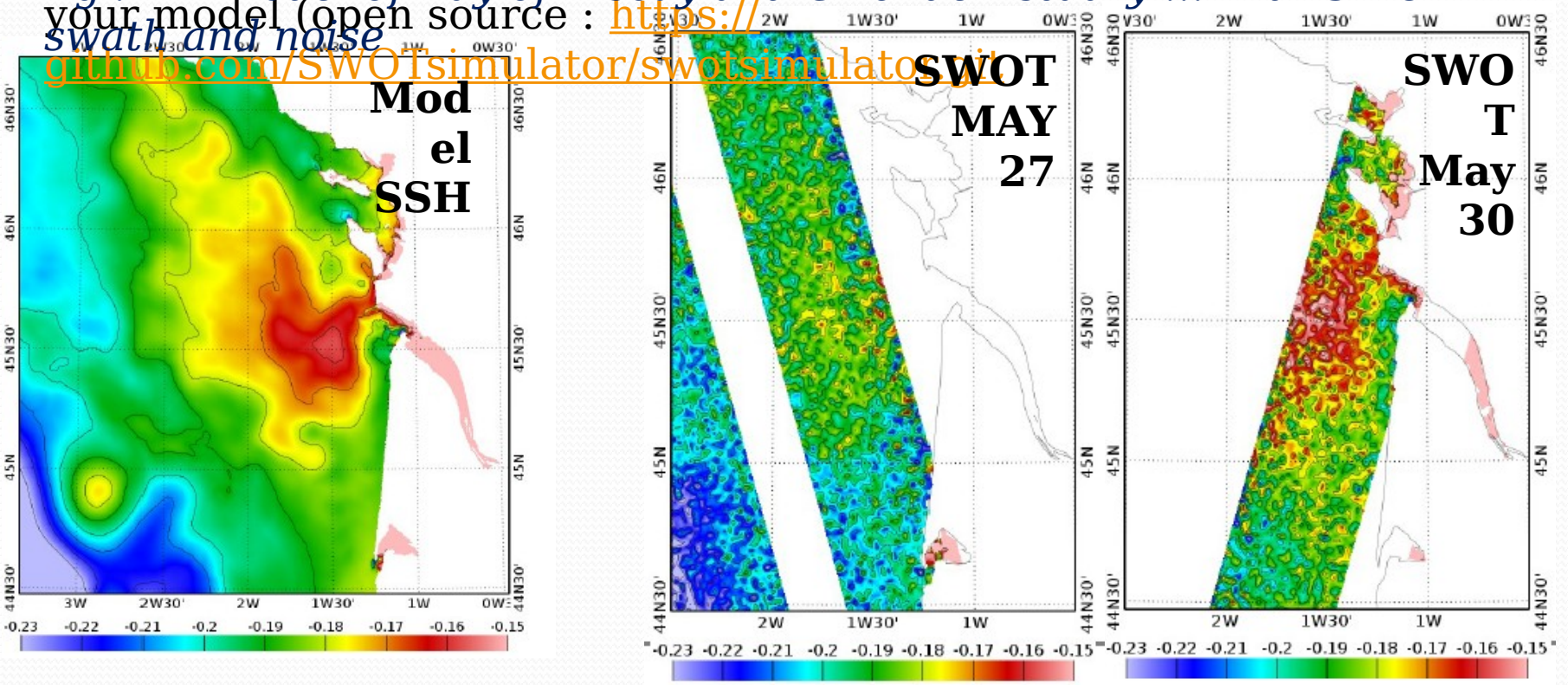
Preparing for SWOT - ocean simulator

SWOT 2D high-resolution SSH – capturing the eddy anisotropy and strain

Precise 2D horizontal SSH gradients needed for velocity and vorticity

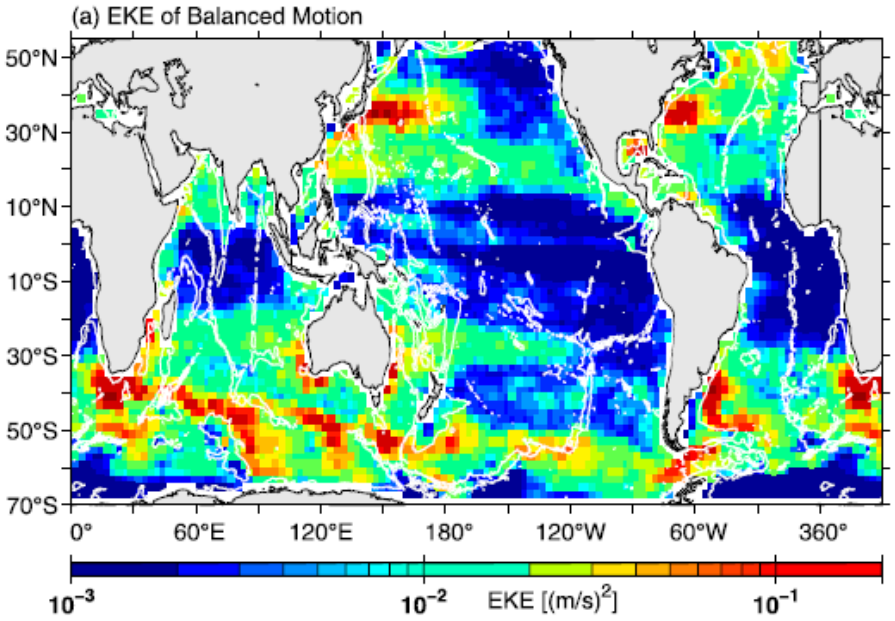
SWOT simulator to study successive passes over a region using your model (open source : https://github.com/SWOTsimulator/swotsimulator)

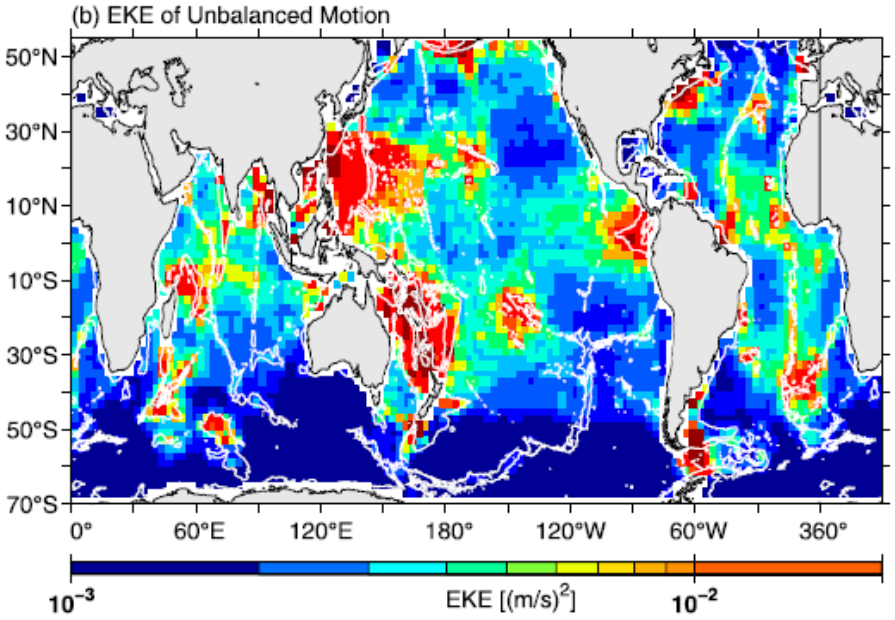
Eg : HR model of Bay of Biscay and Gironde Estuary … with SWOT swath and noise



Toublanc et al. (in prep)

balanced motions or internal gravity waves?

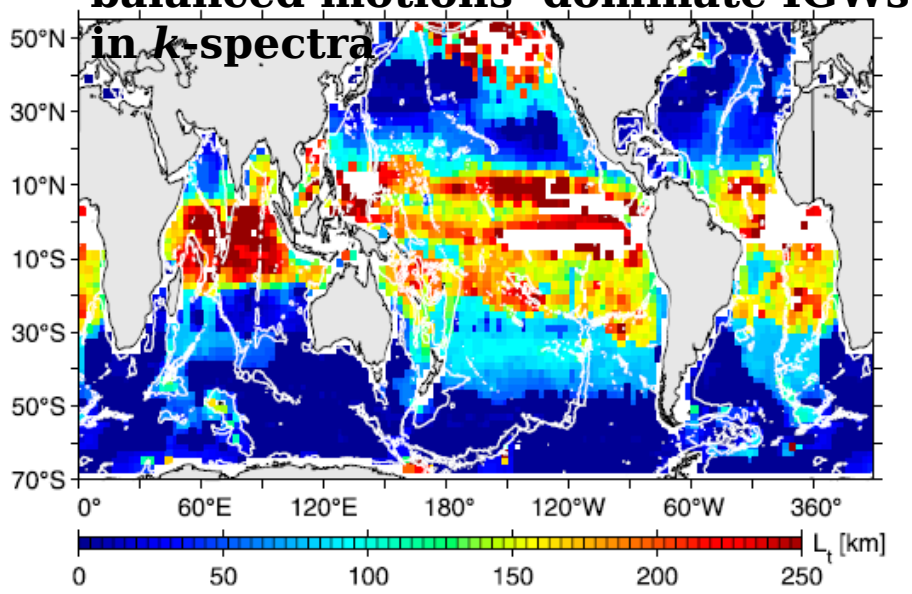




- In mid to high EKE regions => balanced motions dominate scales > 50 km
- Tropics & low energy regions => internal waves dominate

=> Coherent internal tide corrections being developed

Transition scale (km) : where balanced motions dominate IGWs in *k*-spectra



Qiu et al., 2018,