Observing Coastal dynamics with SAR Altimetry

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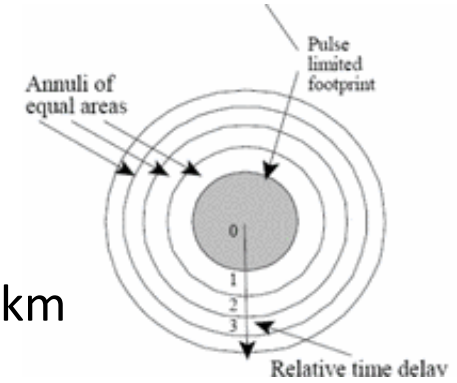
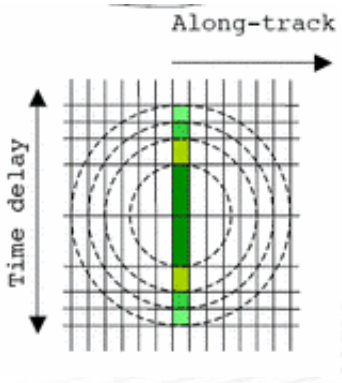
Interest of SAR altimetry for observing coastal dynamics?

- **Increase the data coverage near the coastline**

  its footprint decreases the land contamination and allows getting good data closer to the shoreline

Circular 10 km





Rectangular 10 km * 300 m

- **Accessing smaller spatial scales**

  Lower noise level than LRM Ku altimetry

SAR data level-2 products

- SAR Level-2 products generated by **CNES Cryosat2 Prototype Processor** (CPP) SAR retracking [May 2012 -March 2013]
- Can be downloaded here : **ftp.cy2_sar_l2.oceanobs.com**
- All scientists are welcome to use them and provide feedbacks on the CPP SAR retracking on all the possible topics (ocean, coastal, sea ice, hydrology, sea floor mapping…)

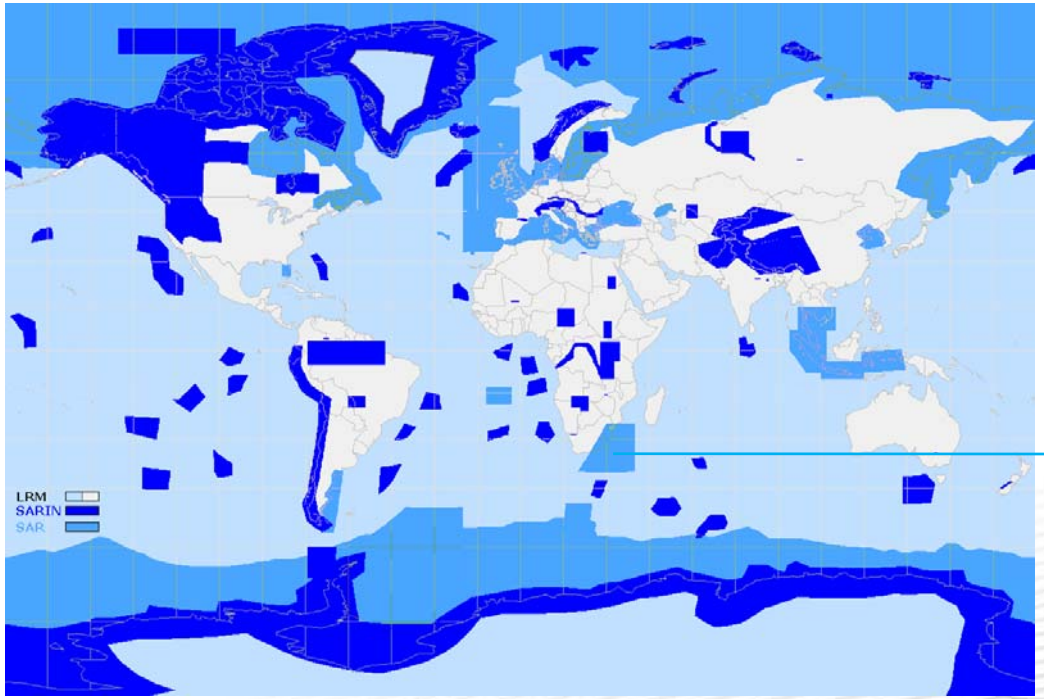
- **Quality** of the CPP SAR data :

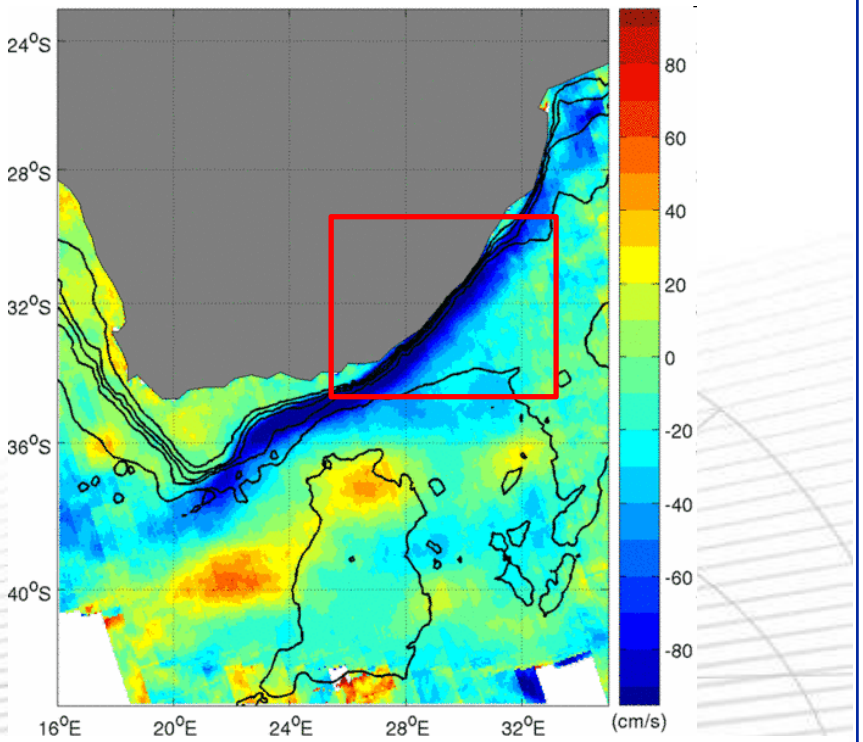
-Addressed at large scales this morning by comparison with RDSAR

-Already **evidenced** at scales below 100 km in open ocean (Equatorial Pacific) : Boy et al OSTST 2012; Dibarboure et al., under review

Coastal dynamics with Cryosat-2 SAR mode data

This analysis demonstrates the interest of SAR mode altimetry for coastal end user. It focuses on the coastal part of the Agulhas Current.

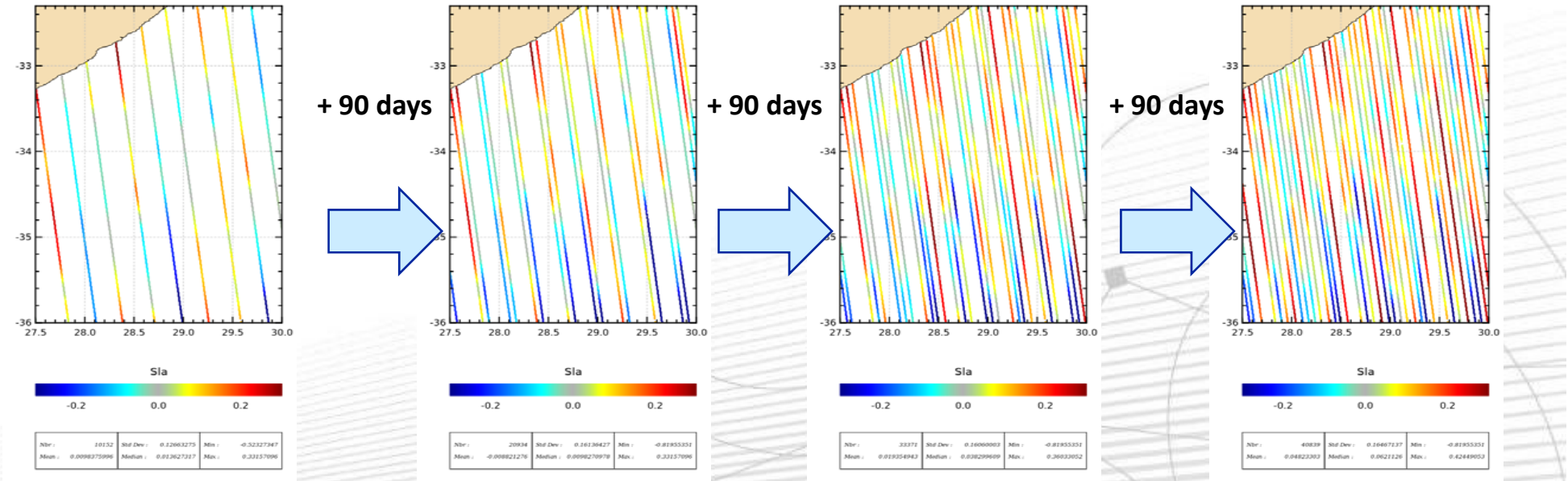




Map of mean surface current derived from Envisat ASAR, Rouault et al 2010

Just some words on Cryosat-2 time sampling

- Cryosat-2 orbit is not optimized for observing time-evolution of oceanic mesoscale processes.
- The orbit shifts by 80 km westward every 30 days=> tracks are moving both in space and time which makes difficult to follow oceanic structures especially in the coastal areas.



Coastal dynamics with Cryosat-2 SAR mode data

In order to

- Explore the capability of SAR data to provide more accurate measurements in the coastal strip 0-15 km
- Assess the advantages of SAR data in term of high resolution altimetry in between coastal and open ocean

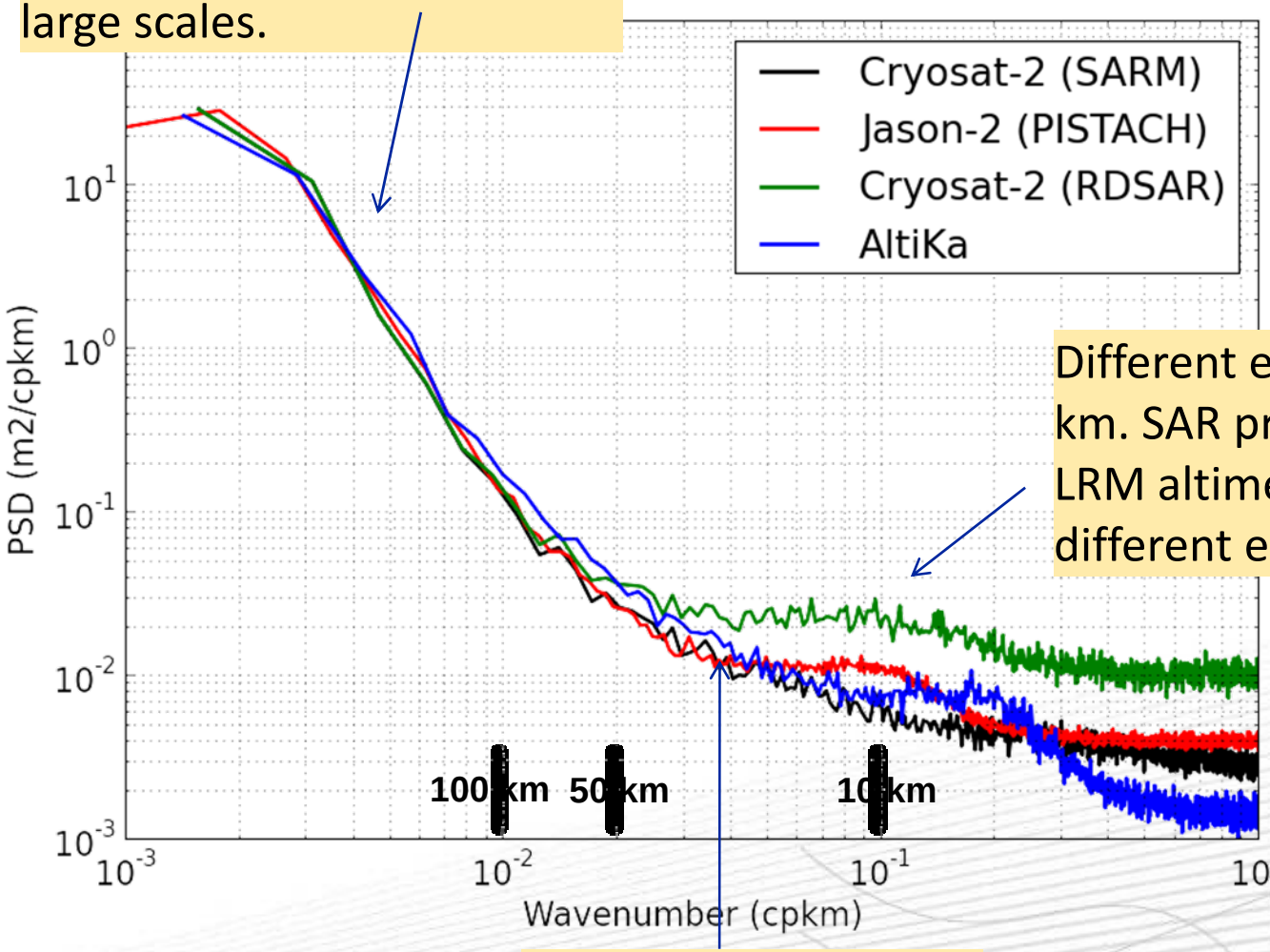
We use

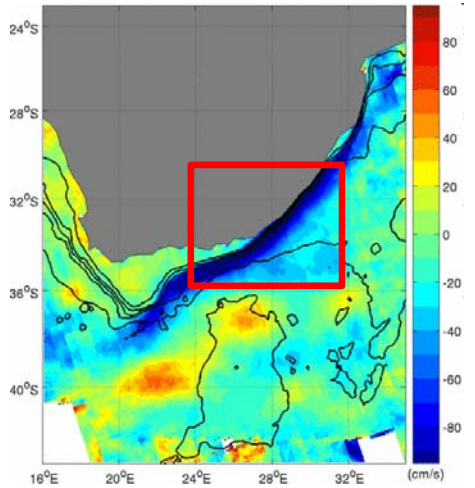
❶ Spectral analysis of SLA

❷ Geostrophic velocities

❶ Spectral Analysis of SLA

Very good agreement between the 4 data sets at large scales.



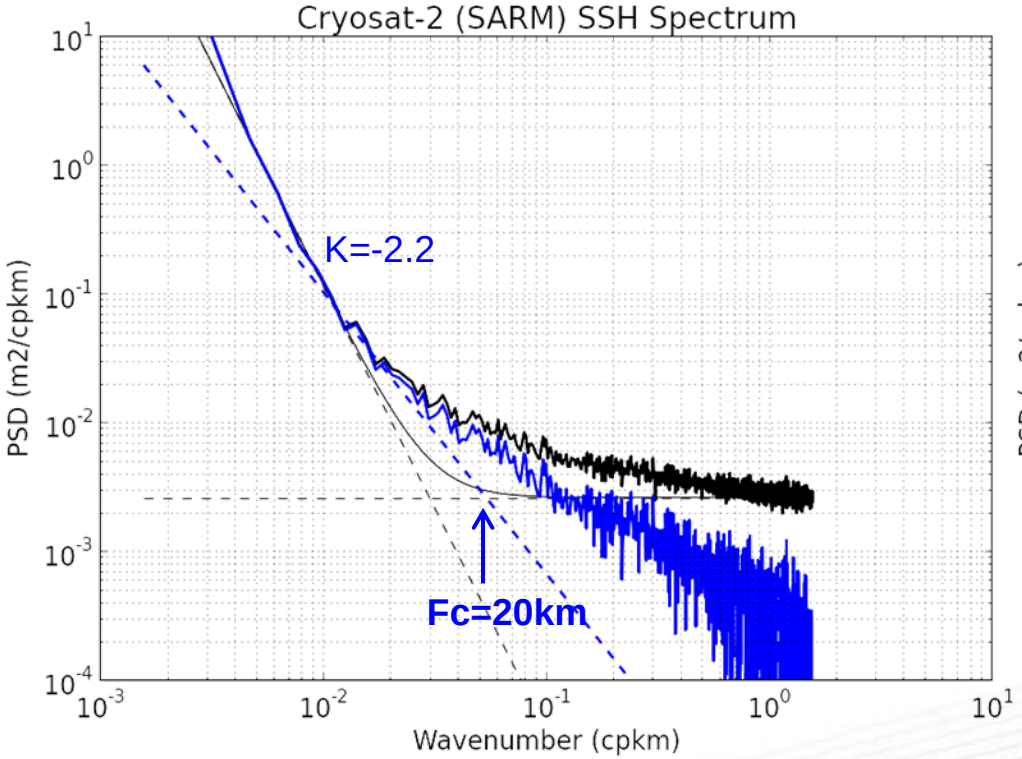


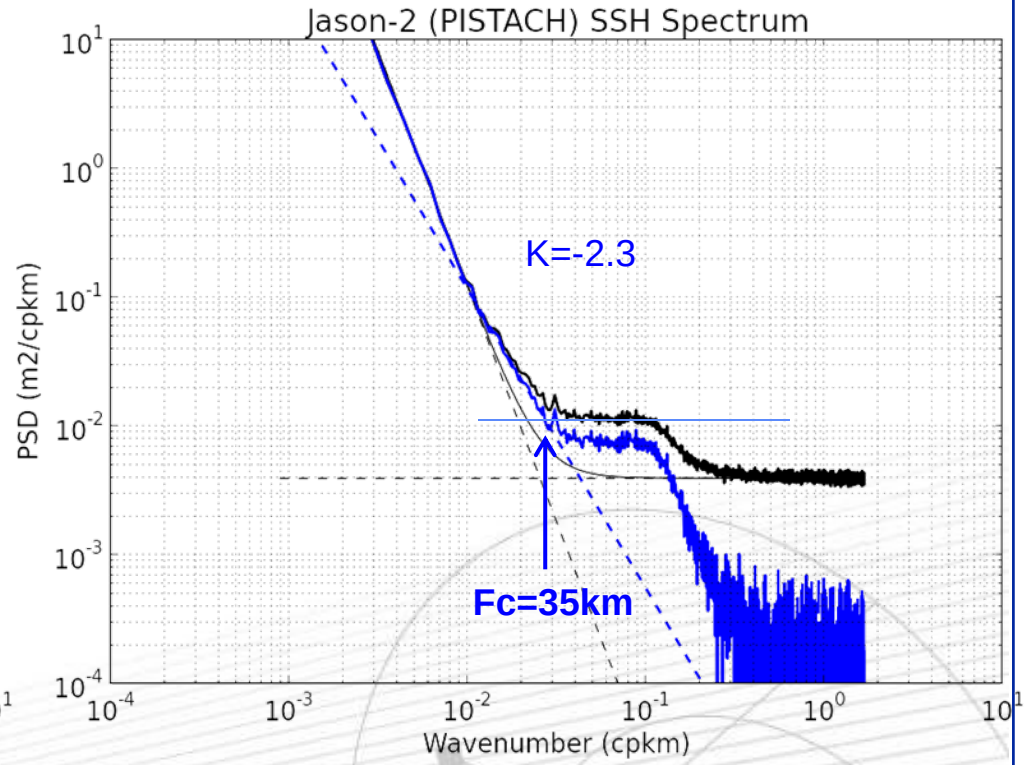
Different energy level between 10 and 30 km. SAR presents less error whereas all LRM altimeters exhibit an error but with different energy level.

Different instrumental noise, as expected

SAR perfectly follows J2 spectrum for scales > 25 km.

A clearer picture of this spectral hump between 10 and 30 km is reached when removing the instrumental noise of each altimeter (blue curves)



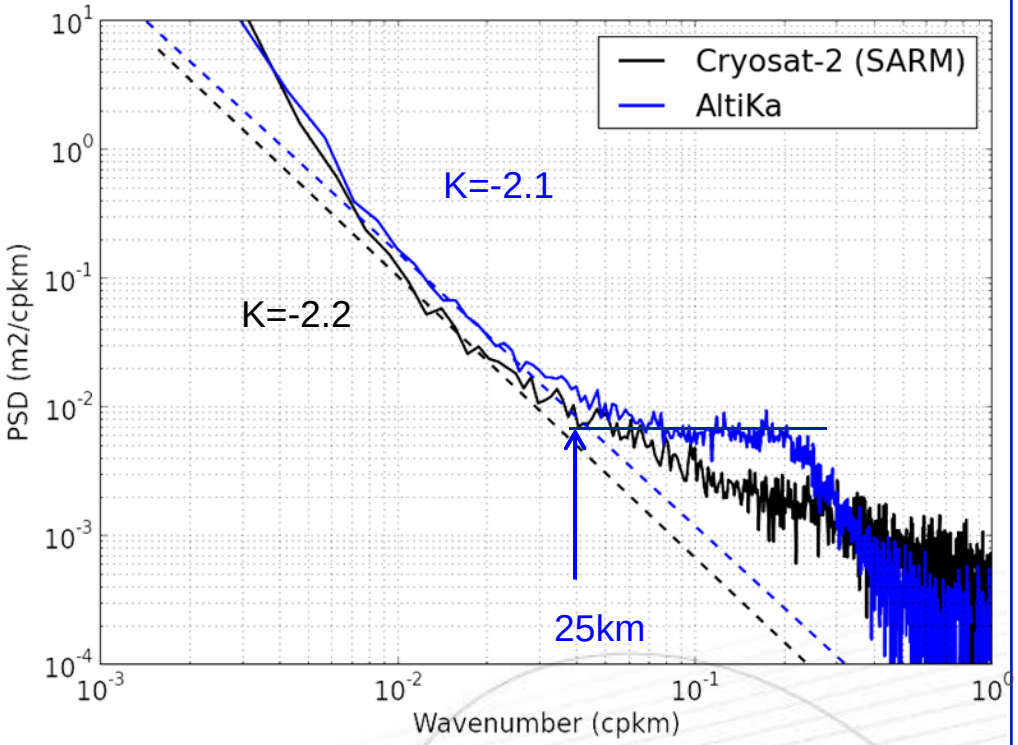


The **spectral slope** can be estimated between 50km and 100km. Similar value in k-2.2 are obtained. The **length scale** where we observe half signal/half noise is the crossing point of this slope with the noise. **SAR altimetry would enable reaching smaller scales than JA2 LRM** , limited by its errors between 10-30km .

Using only some months of data, **Altika spectrum** is compared to SAR after instrumental noise removal.

Similarly to other LRM altimeter, Altika data are limited by its noise plateau but at smaller scales.

Altika spectum follows the slope observed with the SARM down to 25 km (best performance ever seen for a LRM altimeter)



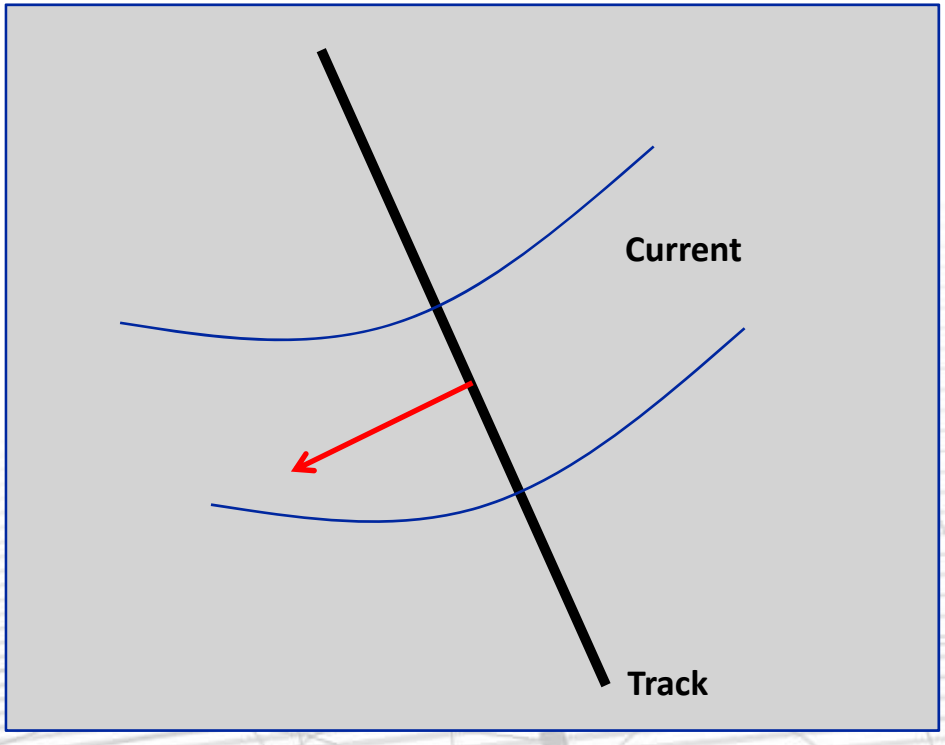
→ Gives confidence in SAR SLA spectral content until 25 km

❷ Geostrophic Currents

- 20 Hz SAR SLA are used to compute across track geostrophic current anomalies
- The SLA are spatially filtered with a cut off of 25 km for SAR and 50 km for estimating SAR small-scale contents.

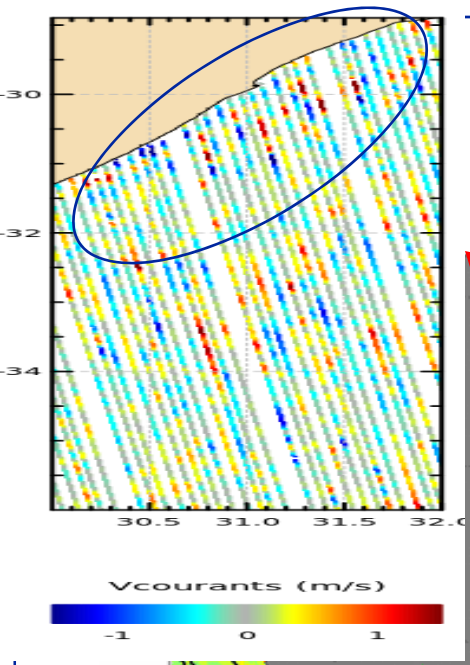
$$V = \frac{g}{2.\Omega.\sin(latitude)} . \frac{dSLA}{dx} = \frac{g}{f} . \frac{dSLA}{dx}$$

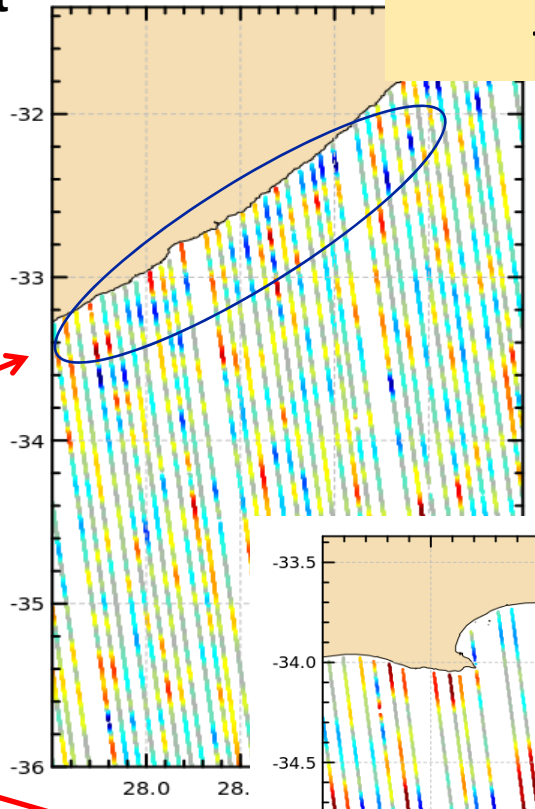
Focus on the **Cryosat ascending tracks** rather than descending because they **better intersect the Agulhas current** capturing nearly all the current velocity (perpendicular to the current direction)

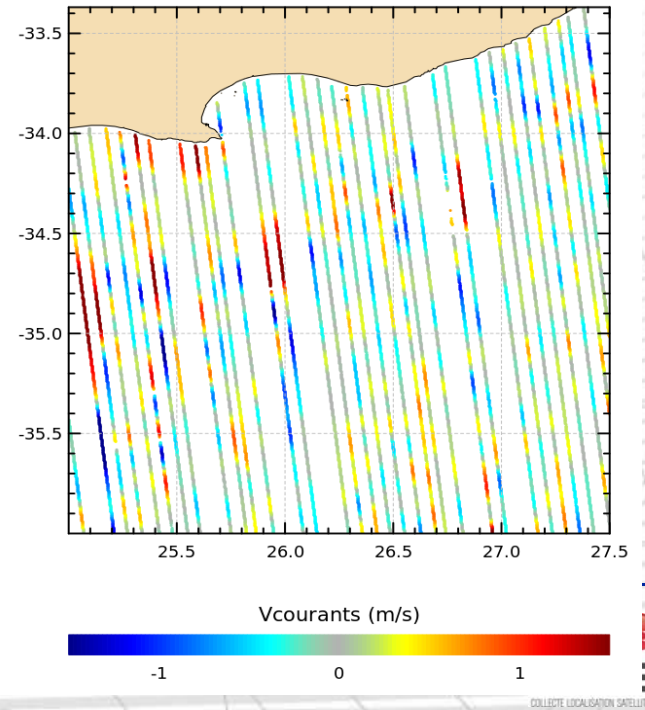


11months of C2 SAR velocities where the Agulhas Current is very close to the coast

Coherent structures are observed near the coast.



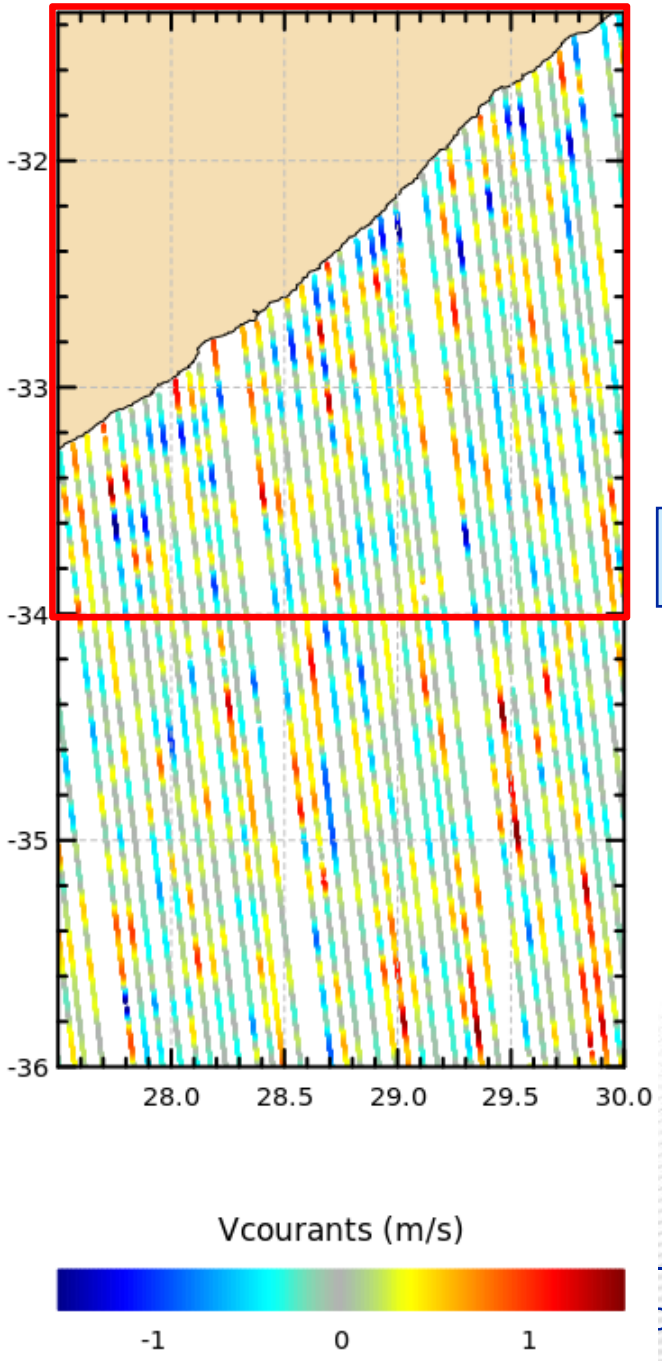


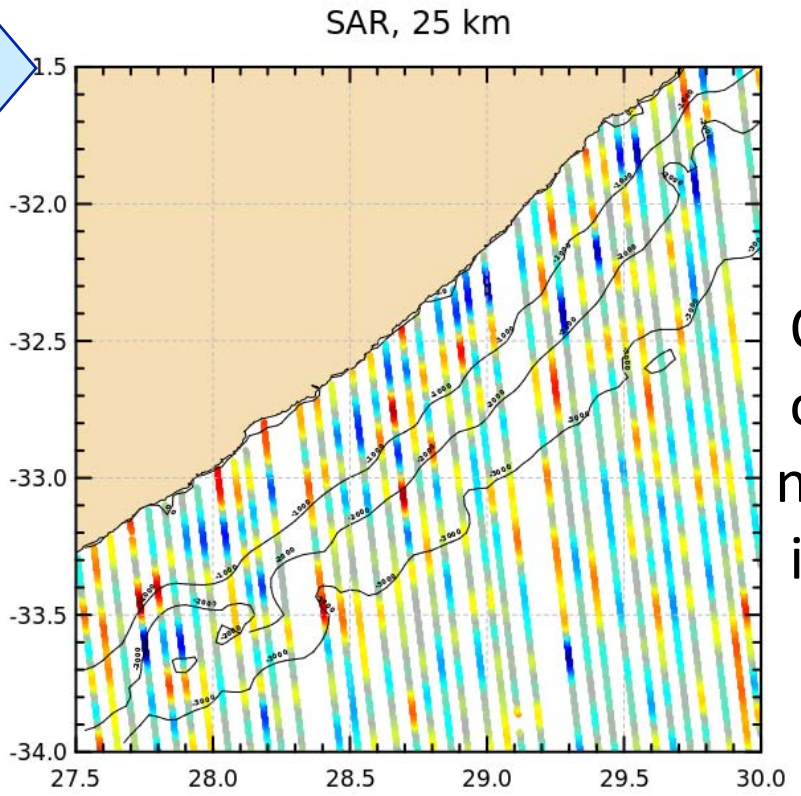


Map of mean surface current derived from Envisat ASAR, Rouault et 2010

Negative anomaly located on the inshore edge of the current, with a strong magnitude close to the mean current intensity.

A lot of small structures of the current match also very well the bathymetry contours.





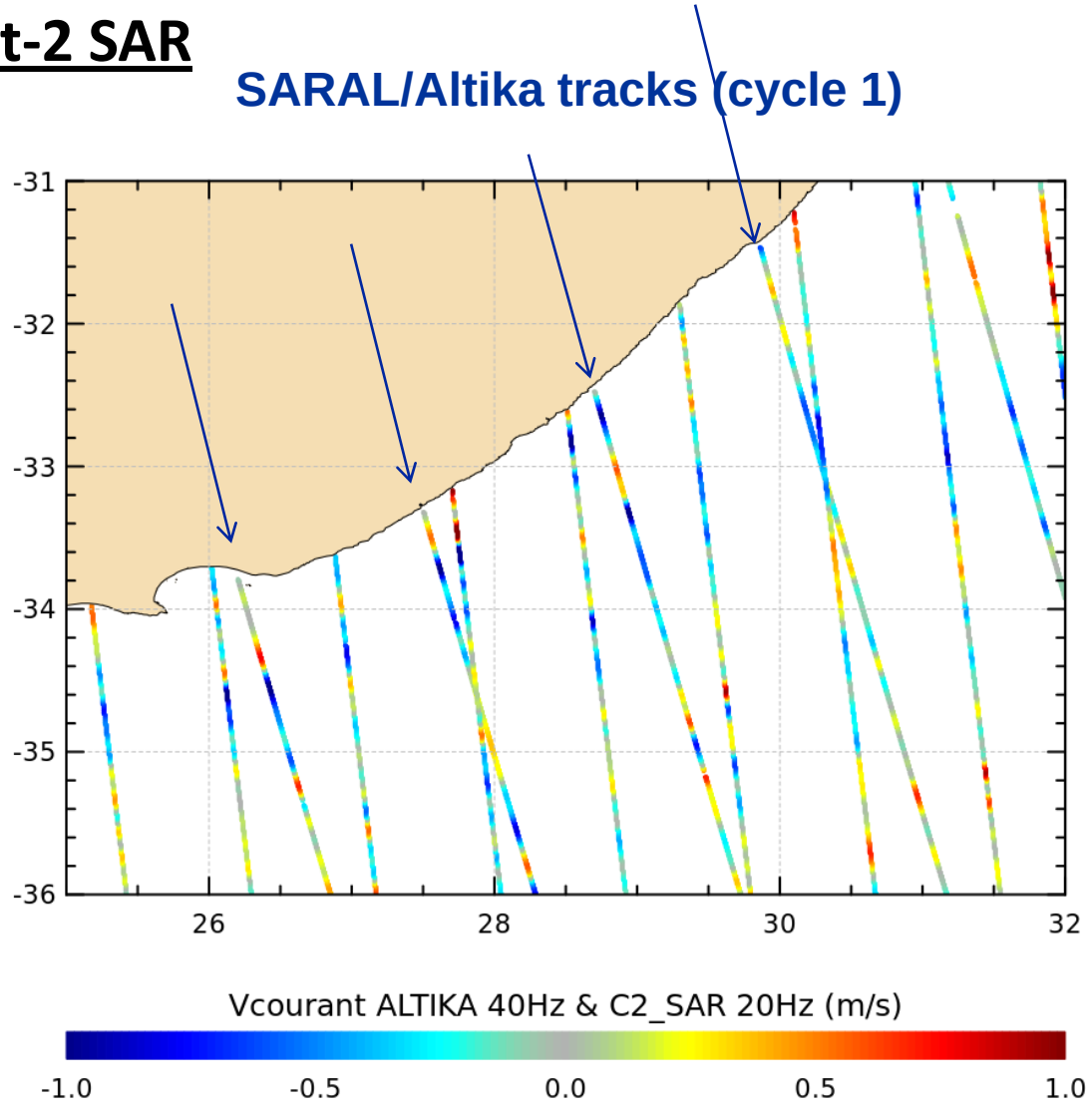
Oceanic signal or geoid signal not resolved in MSS ?

Zoom on a 20 days period (11Mars – 31Mars 2013) with SARAL/Altika and Cryosat-2 SAR

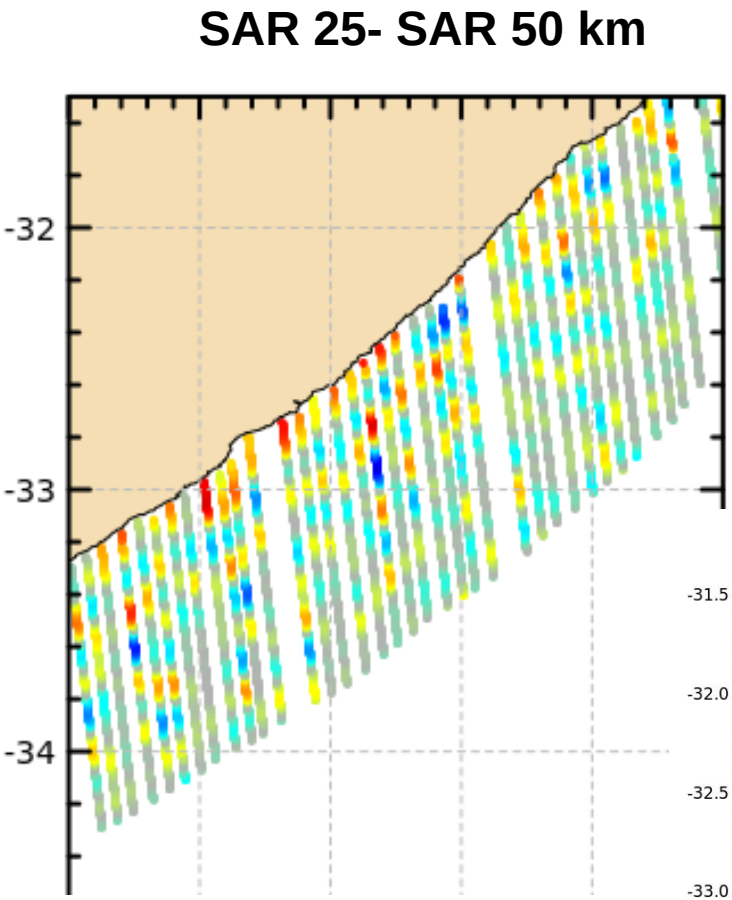
Most of the HR features seen by C2-SAR (in part. coastal band trip of negative anomalies of velocity) are **confirmed by Altika HR data**.

⇒Cryosat-2 SAR has monitored a particular coastal pathway of the Algulhas current, 20 km closer to the coast than usually

HR capabilities of SAR mode and of Ka-LRM are very convincing



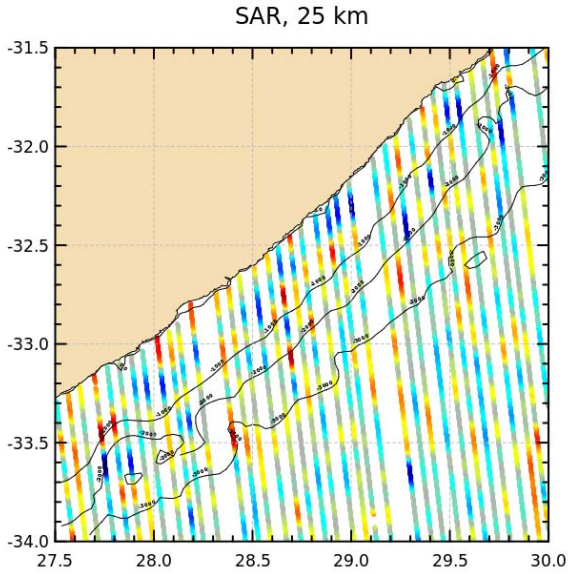
SAR altimetry: High-resolution in the coastal ocean !!



Comparing velocity anomalies obtained from SAR SLA filtered at 50 km and at 25 km,

25km filtered SAR altimetry data

- better localize the current inshore close to the coast
- Increase its speed (+/- 50%)



Conclusions (1/2)

- Spectral analysis of SAR SLA shows **a continous decay in the oceanic slope until small scales** while LRM altimeters are saturated by a noise plateau at wavelengths between 10 and 30 km (reduced for Ka Band)

- Over the Agulhas region, SAR altimetry enables observing **signal at smaller spatial scales** than LRM altimetry (down to 25 km here).

- Geostrophic currents computed from SLA with 25 km resolution reveals **HR dynamics of the Agulhas Current** over the analysed period, confirmed by Altika data

Conclusions (2/2)

- The **repetitive tracks of Sentinel-3** associated to SAR mode should allow to further improve the observability of short wavelength signals.

- SAR altimetry shows great potential for small scale observability which is important for coastal dynamics but **some errors are surely remaining** (we are still discovering errors in LRM after 20 years of extensive use….).

  => intensive calibration of the Sentinel-3 products is needed over ocean during the commissioning phase, focusing on all different scales (climate, mesoscale, submeso)