

# Combined use of glider, radar and altimetry data to study a coastal current in the western Mediterranean Sea

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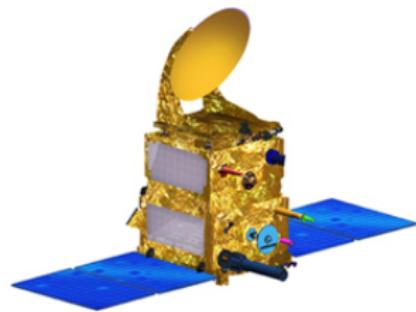
**CSIC**  
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Universitat de les Illes Balears



**SOCIB**  
Balearic Islands Coastal Observing and Forecasting System

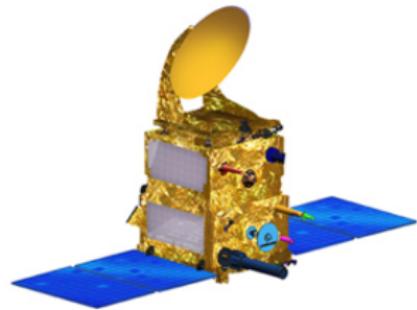


Objective: combine satellite altimetry and in situ measurements



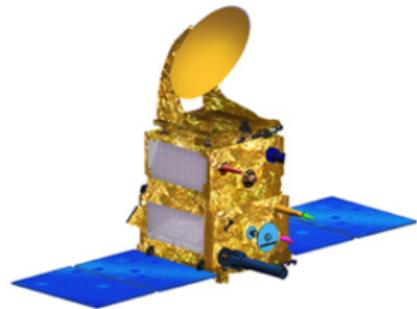
- Satellite altimetry: observation of mesoscale processes

## Objective: combine satellite altimetry and in situ measurements



- **Satellite altimetry:** observation of mesoscale processes
- **Glider:** high-resolution, sub-surface measurements

## Objective: combine satellite altimetry and in situ measurements

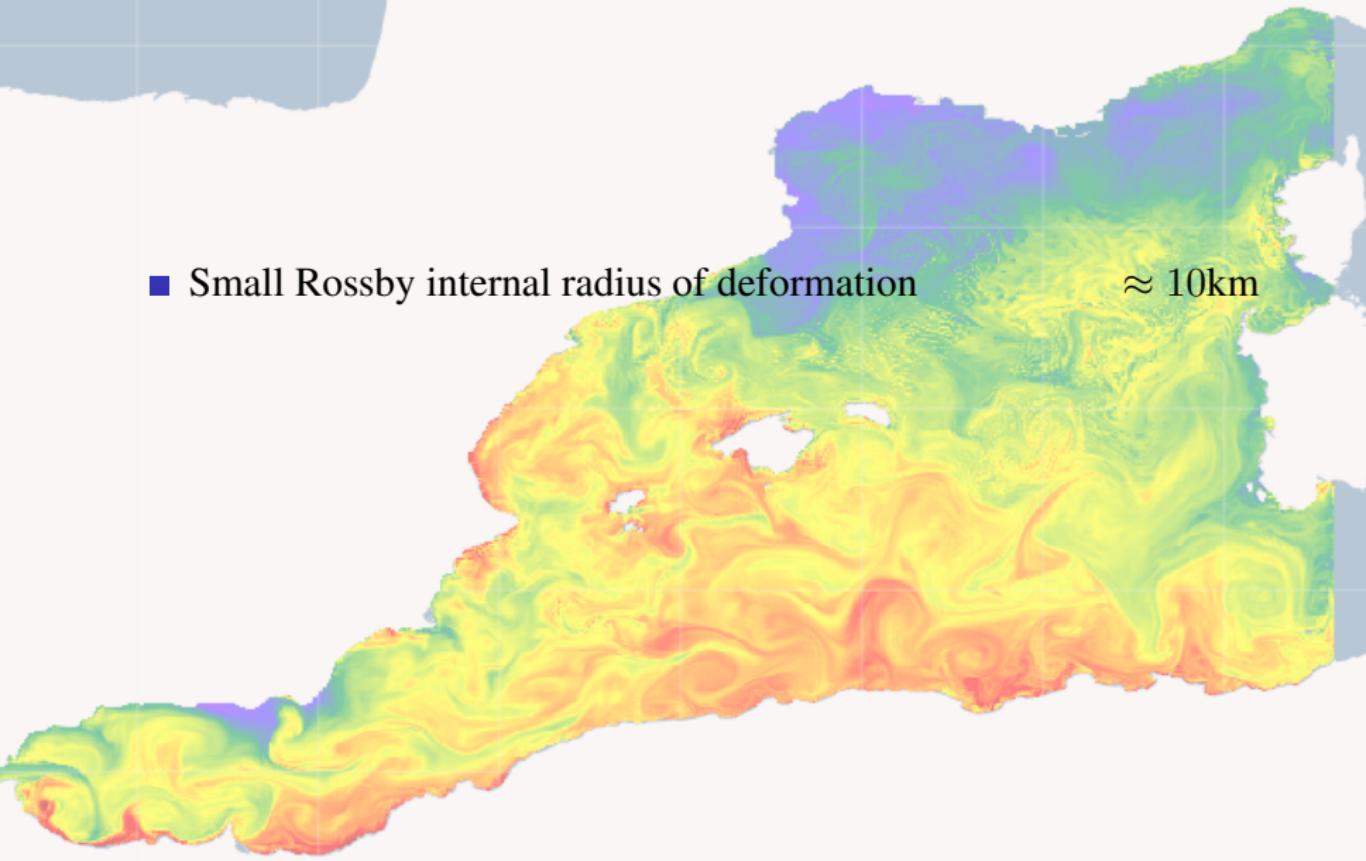


- **Satellite altimetry:** observation of mesoscale processes
- **Glider:** high-resolution, sub-surface measurements
- **Altimeter + glider:** improved description of the dynamics

## Context: the Mediterranean Sea, a complex region

- Small Rossby internal radius of deformation

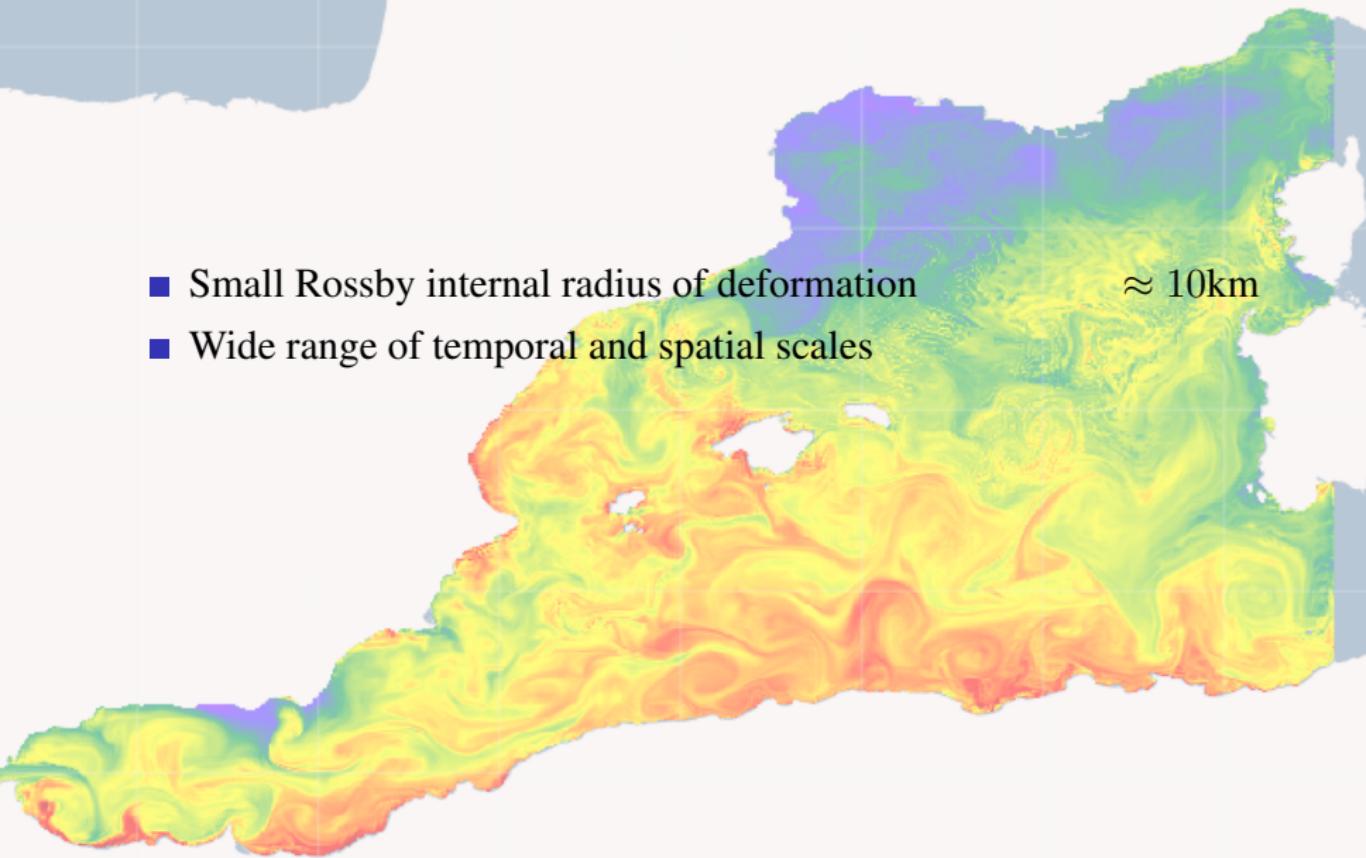
$\approx 10\text{km}$



## Context: the Mediterranean Sea, a complex region

- Small Rossby internal radius of deformation
- Wide range of temporal and spatial scales

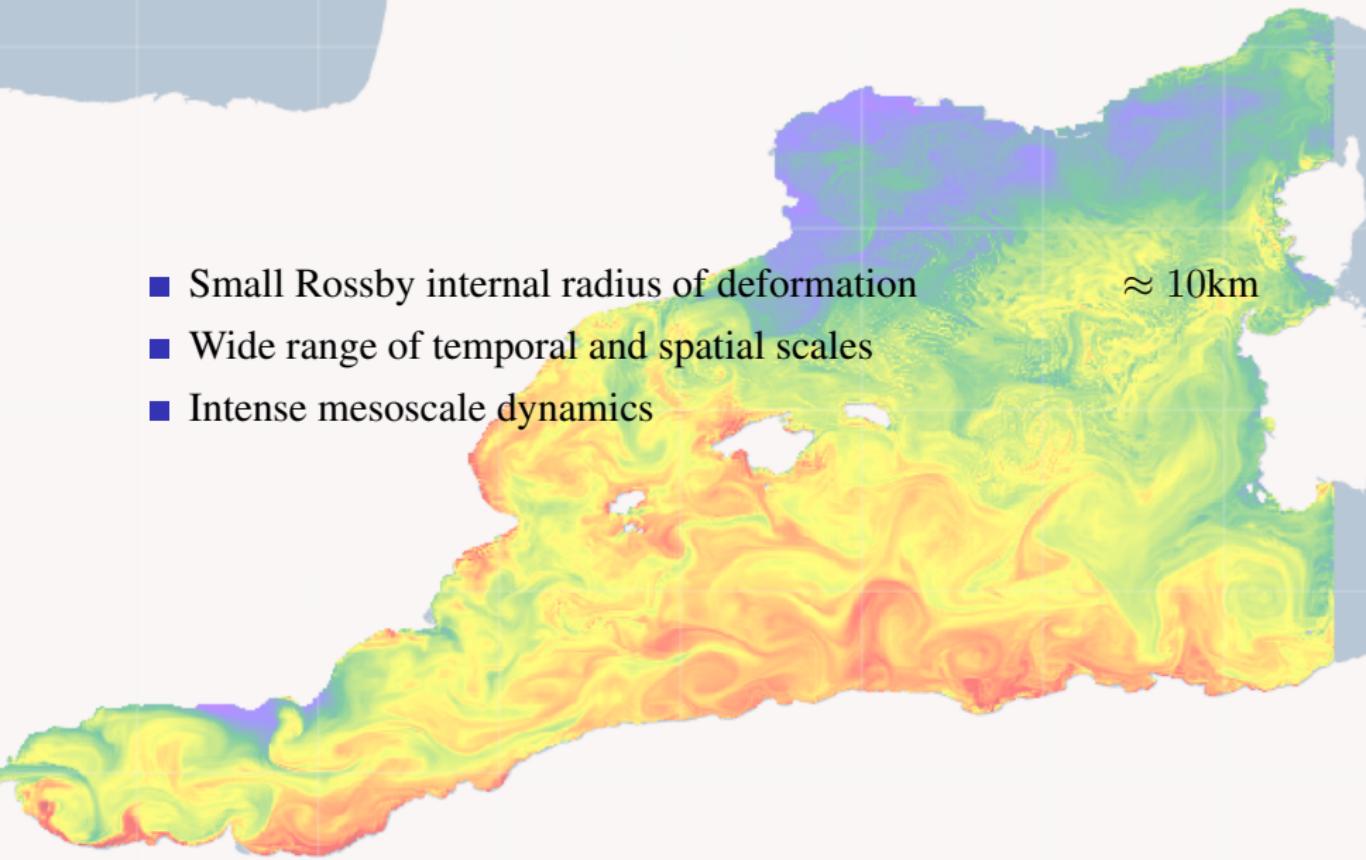
$\approx 10\text{km}$



## Context: the Mediterranean Sea, a complex region

- Small Rossby internal radius of deformation
- Wide range of temporal and spatial scales
- Intense mesoscale dynamics

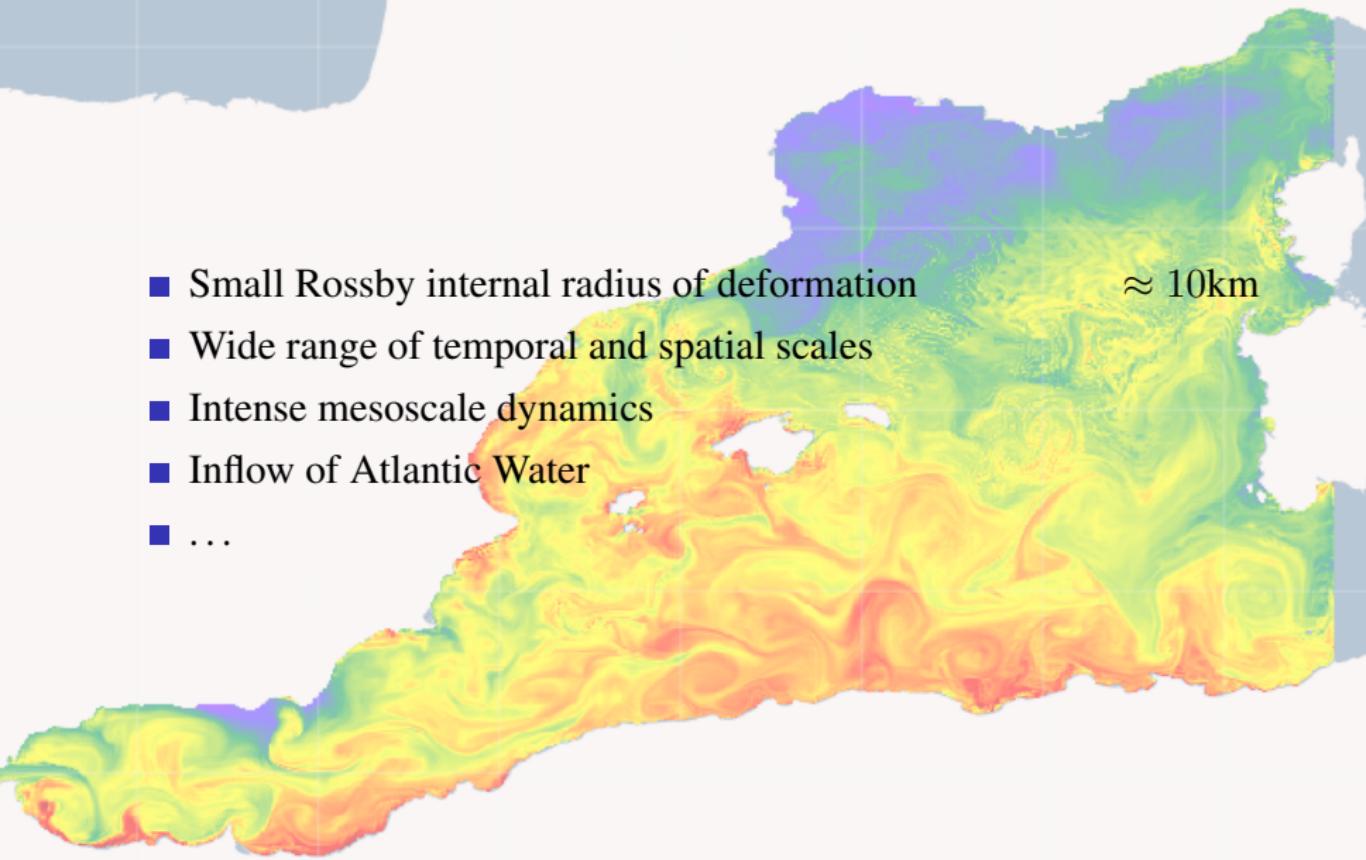
$\approx 10\text{km}$



## Context: the Mediterranean Sea, a complex region

- Small Rossby internal radius of deformation
- Wide range of temporal and spatial scales
- Intense mesoscale dynamics
- Inflow of Atlantic Water
- ...

$\approx 10\text{km}$



# The challenge: combine platforms and approach the coast

## G-Altika mission

When? August 1–5, 2013

Where? Ibiza Channel, Western Mediterranean Sea

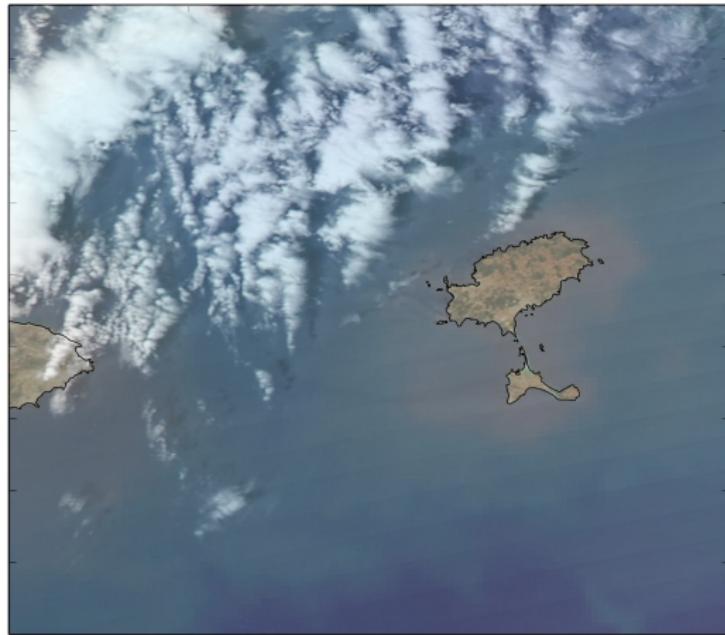
→ Poster B983 by E. Heslop *Sub-seasonal and mesoscale variability of oceanic circulation at key 'choke' points: an example from the Western Mediterranean*

How? Glider, drifters, HF radar, satellite altimetry, ...

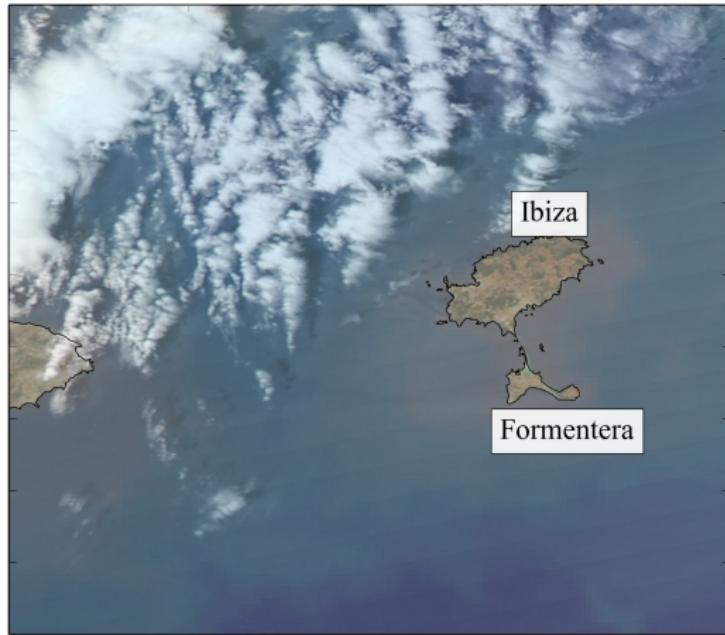
→ Poster B982 by A. Lana

Surface current patterns in the Ibiza Channel with the use of High Frequency (HF) Radar system

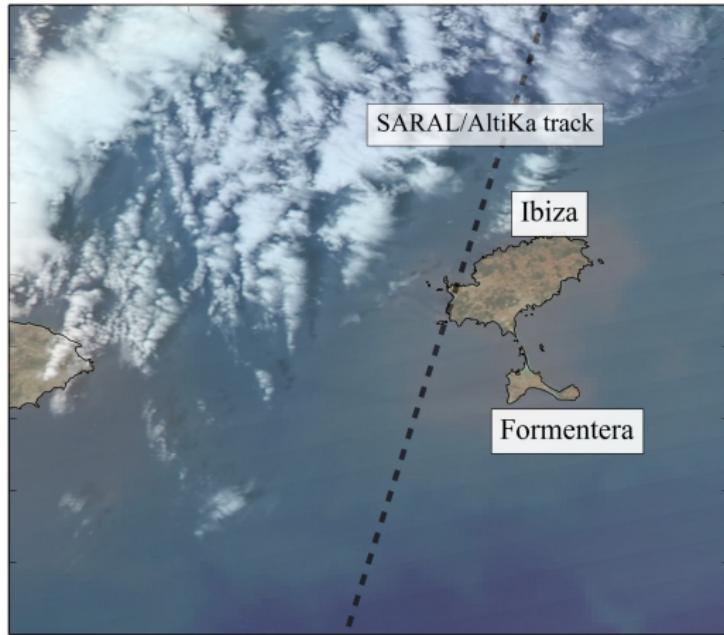
# G-AltiKa data



# G-AltiKa data

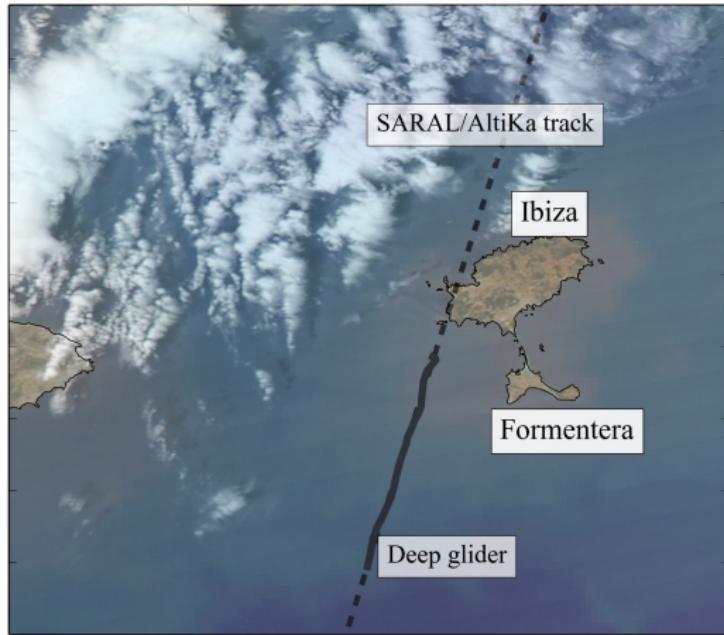


# G-AltiKa data



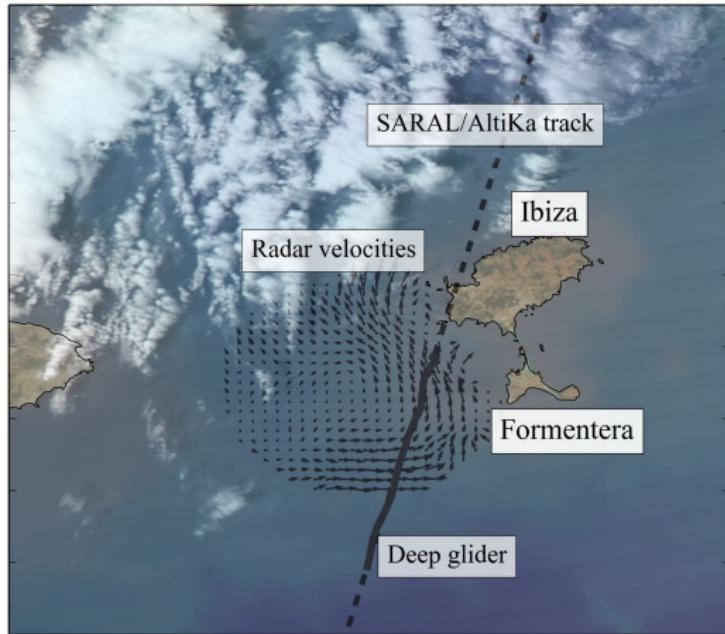
- 1 Hz (AVISO) and 40 Hz SLA (PEACHI)

# G-AltiKa data



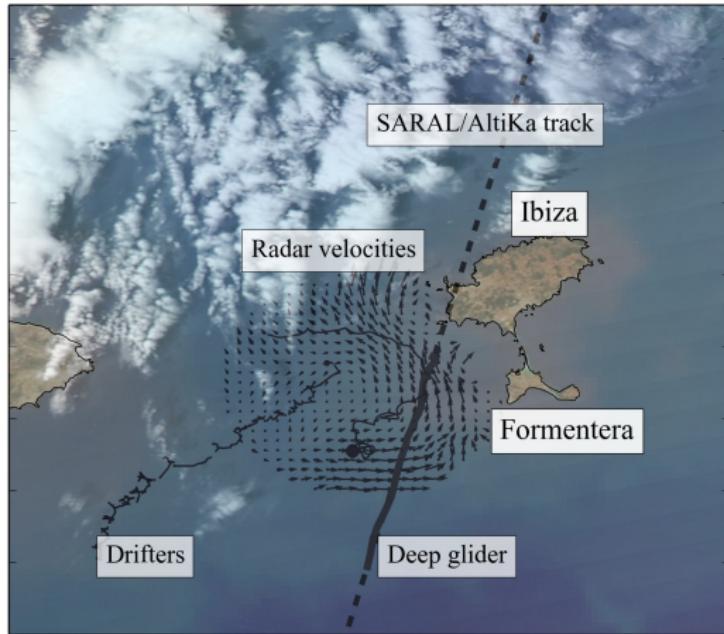
- 1 Hz (AVISO) and 40 Hz SLA (PEACHI)
- Slocum glider

# G-AltiKa data



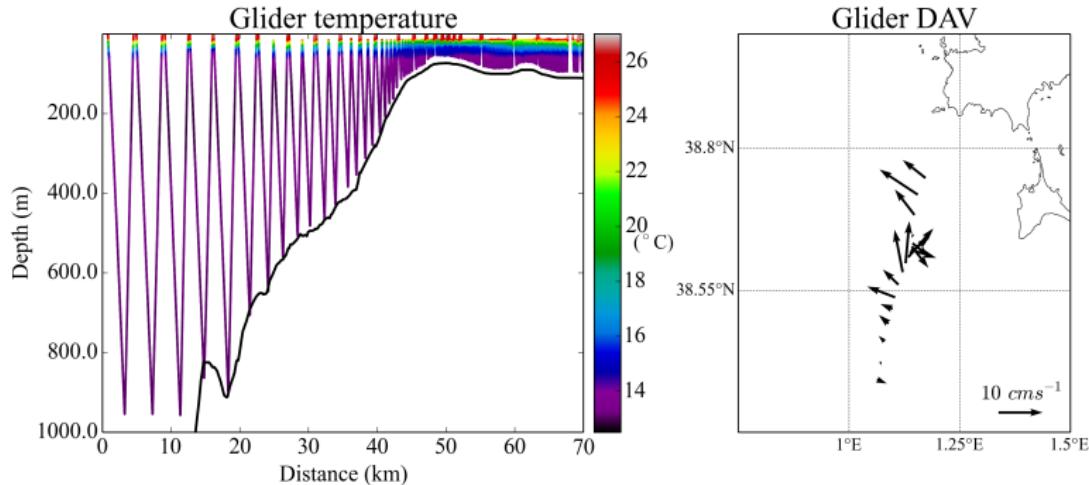
- 1 Hz (AVISO) and 40 Hz SLA (PEACHI)
- Slocum glider
- HF radar (CODAR)

# G-AltiKa data



- 1 Hz (AVISO) and 40 Hz SLA (PEACHI)
- Slocum glider
- HF radar (CODAR)
- Drifters

# Glider: provides $T$ , $S$ and depth-averaged velocity



Resolution:  $< 1$  km in coastal area

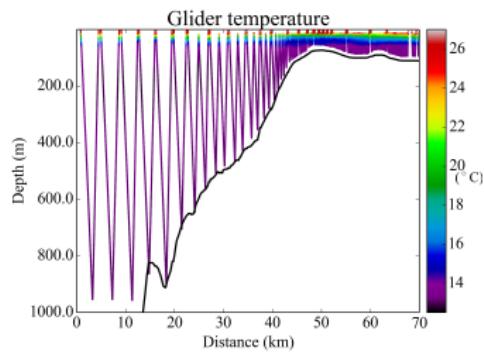
Depth-averaged velocity: difference between expected and real surfacing locations

# Processing: interpolation, filtering, ...

## 1 Computation of dynamic height

How?

- Integration of density computed from glider  $T$  and  $S$
- Reference levels: between 300 and 900 m



# Processing: interpolation, filtering, ...

- 1 Computation of dynamic height
- 2 Computation of Absolute Dynamic Topography (ADT)

How?

Sum of Sea Level Anomaly and Mean  
Dynamic Topography  
[Rio et al. (2014) Ocean Sci. Discuss.]

$$ADT = MDT + SLA$$

## Processing: interpolation, filtering, ...

- 1 Computation of dynamic height
- 2 Computation of Absolute Dynamic Topography (ADT)
- 3 Spatial interpolation on the 40 Hz satellite track

How?

Bilinear interpolation of MDT, SLA,  
glider DH, HF radar velocities

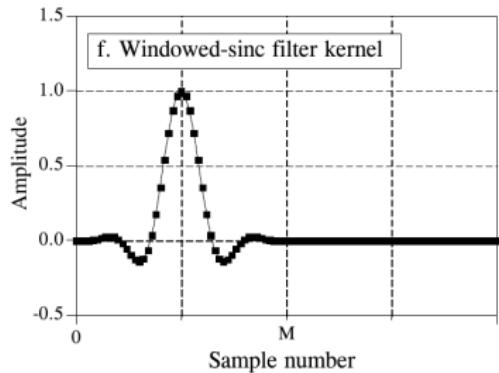
# Processing: interpolation, filtering, ...

- 1 Computation of dynamic height
- 2 Computation of Absolute Dynamic Topography (ADT)
- 3 Spatial interpolation on the 40 Hz satellite track
- 4 Signal filtering

How?

- Sinc filter with Blackman window
- Cut-off: 30 hours for HF radar,  
14 km for altimetry and glider data

From Smith (2002),  
<http://www.dspguide.com/>



## Processing: interpolation, filtering, ...

- 1 Computation of dynamic height
- 2 Computation of Absolute Dynamic Topography (ADT)
- 3 Spatial interpolation on the 40 Hz satellite track
- 4 Signal filtering
- 5 Geostrophic velocity computation

How?

Spatial derivative along-track

No additional filtering

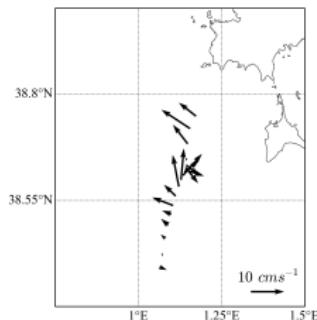
# Processing: interpolation, filtering, ...

- 1 Computation of dynamic height
- 2 Computation of Absolute Dynamic Topography (ADT)
- 3 Spatial interpolation on the 40 Hz satellite track
- 4 Signal filtering
- 5 Geostrophic velocity computation
- 6 Correction to glider velocities

How?

Use the difference between:

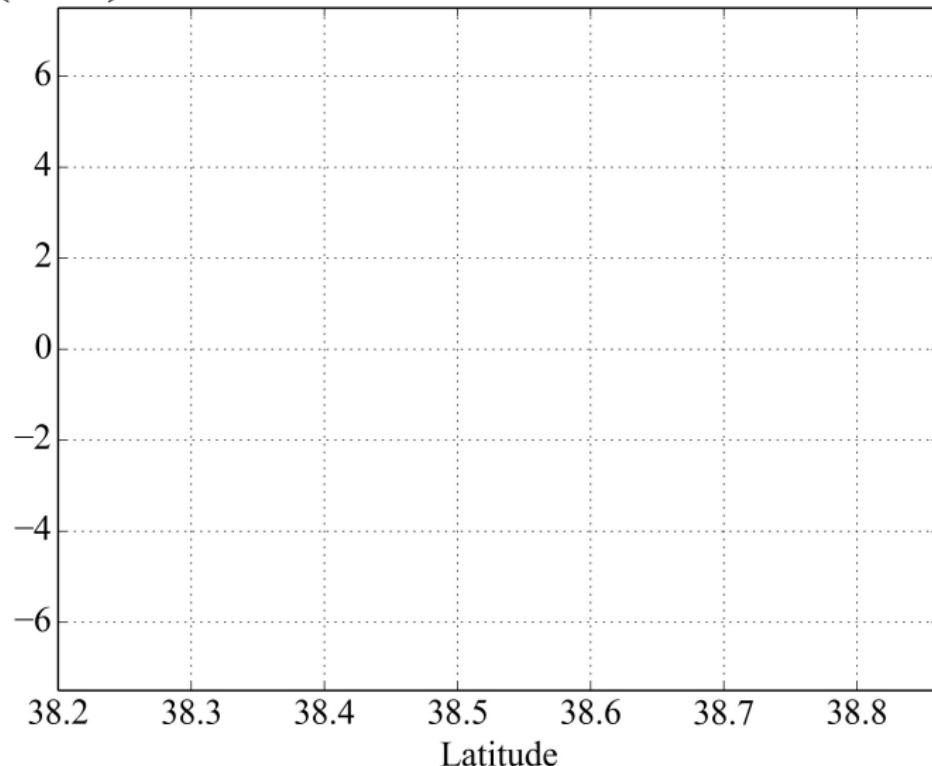
- the relative depth-average geostrophic currents (computed from DH)
- the absolute DAV (computed from glider GPS)



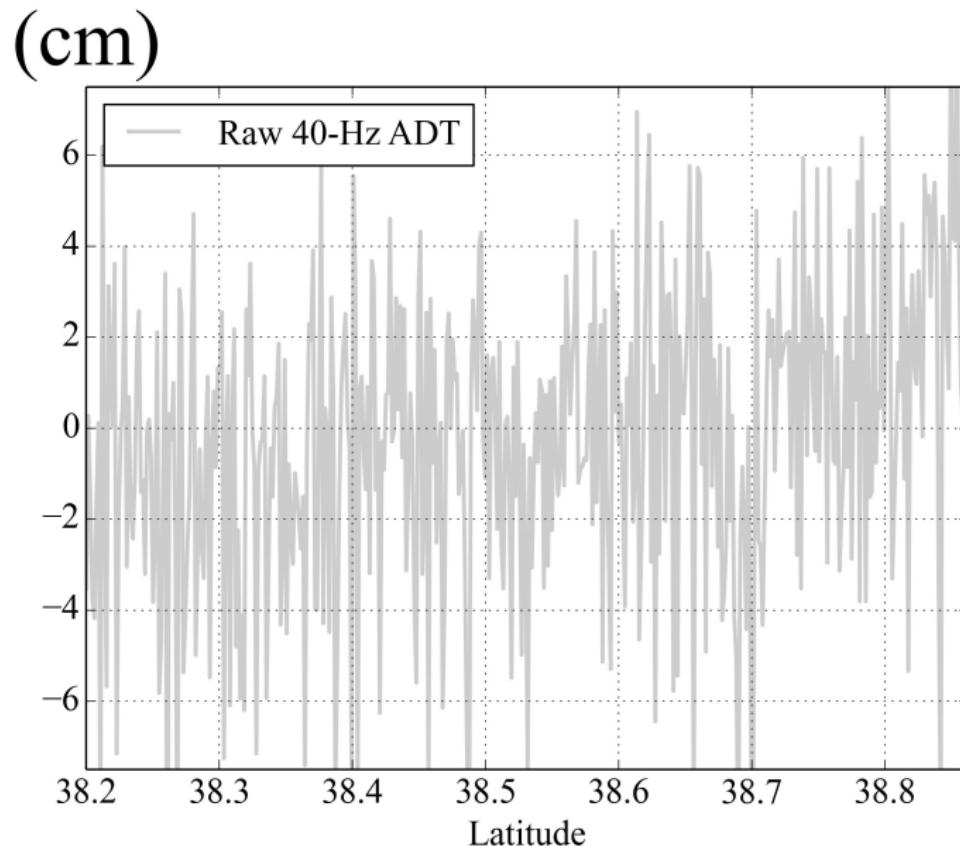
[Bouffard et al. (2012) Prog. Ocean.]

## Results: Along-track ADT and DH

(cm)

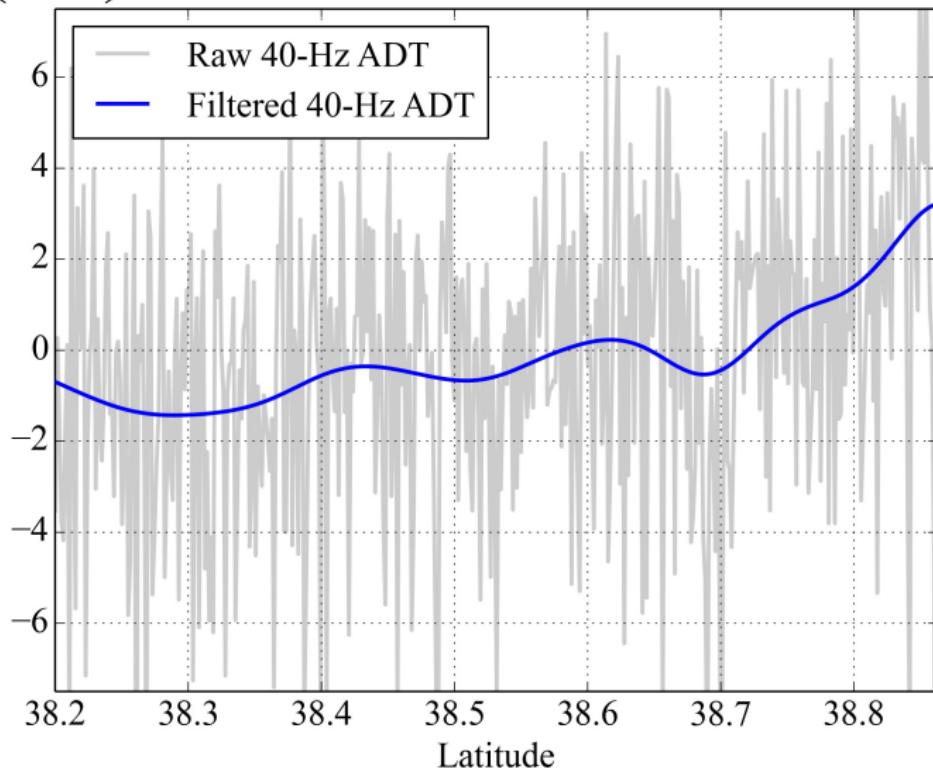


## Results: Along-track ADT and DH



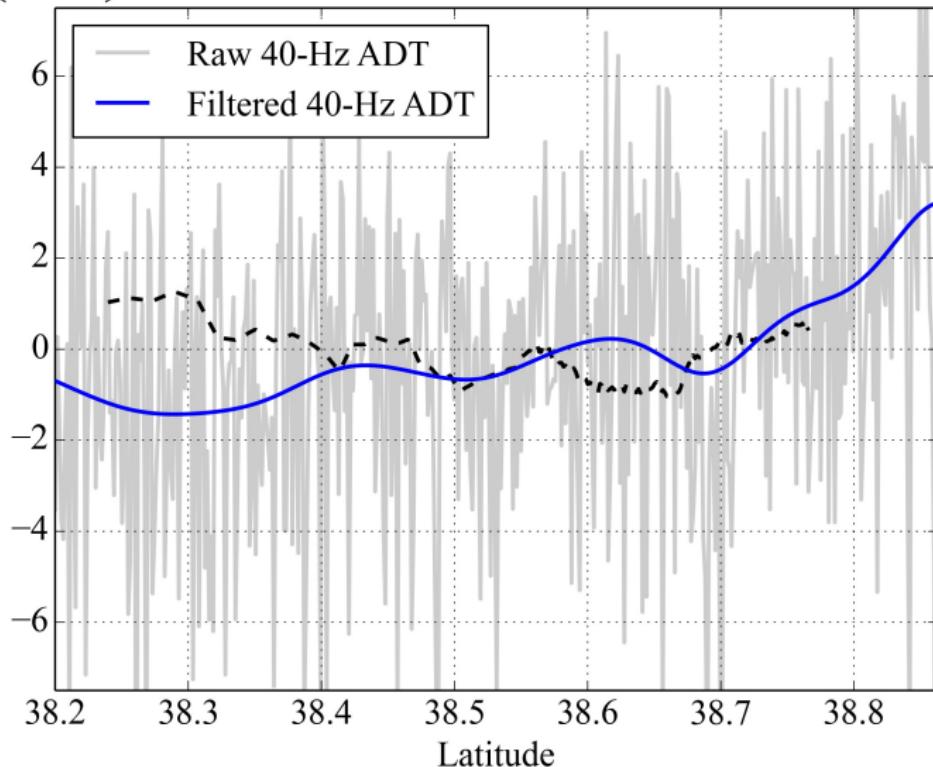
## Results: Along-track ADT and DH

(cm)



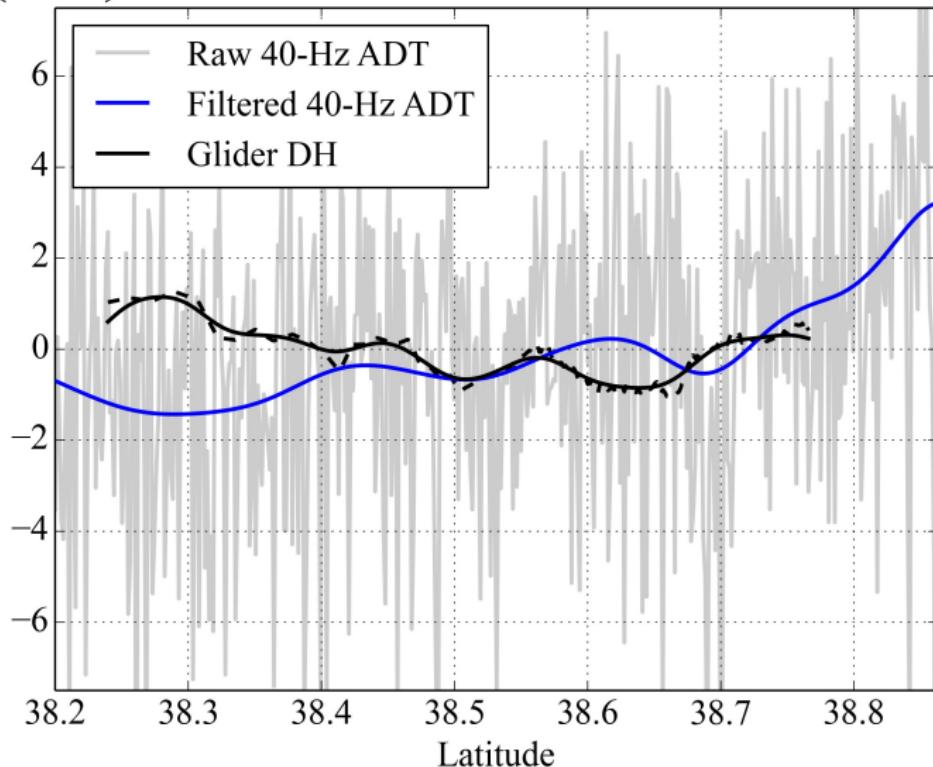
## Results: Along-track ADT and DH

(cm)



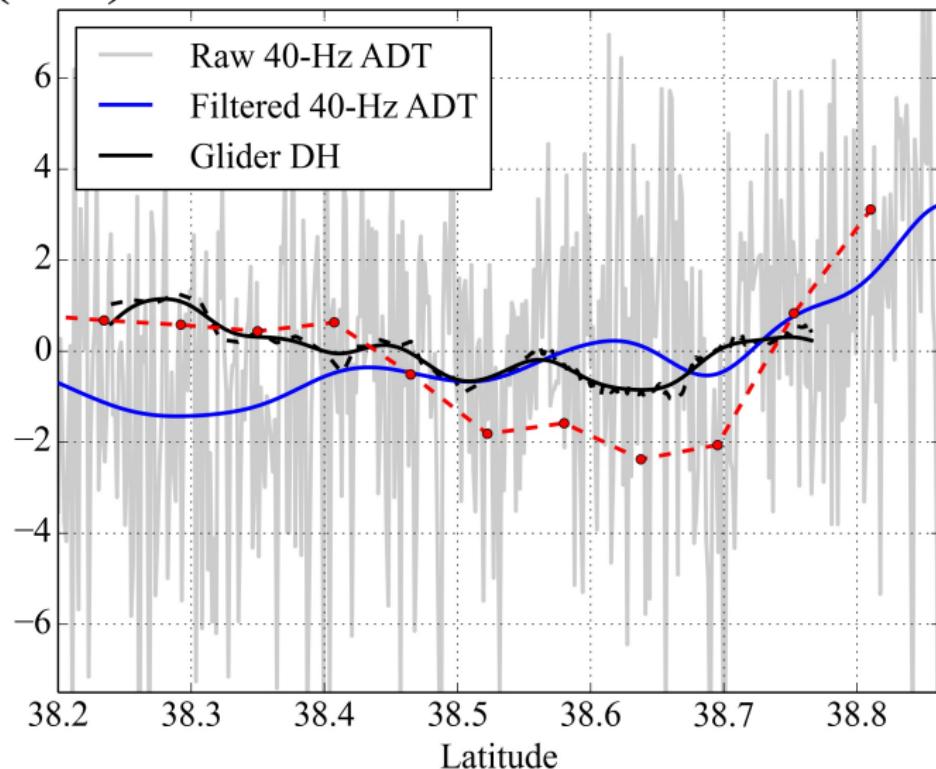
## Results: Along-track ADT and DH

(cm)

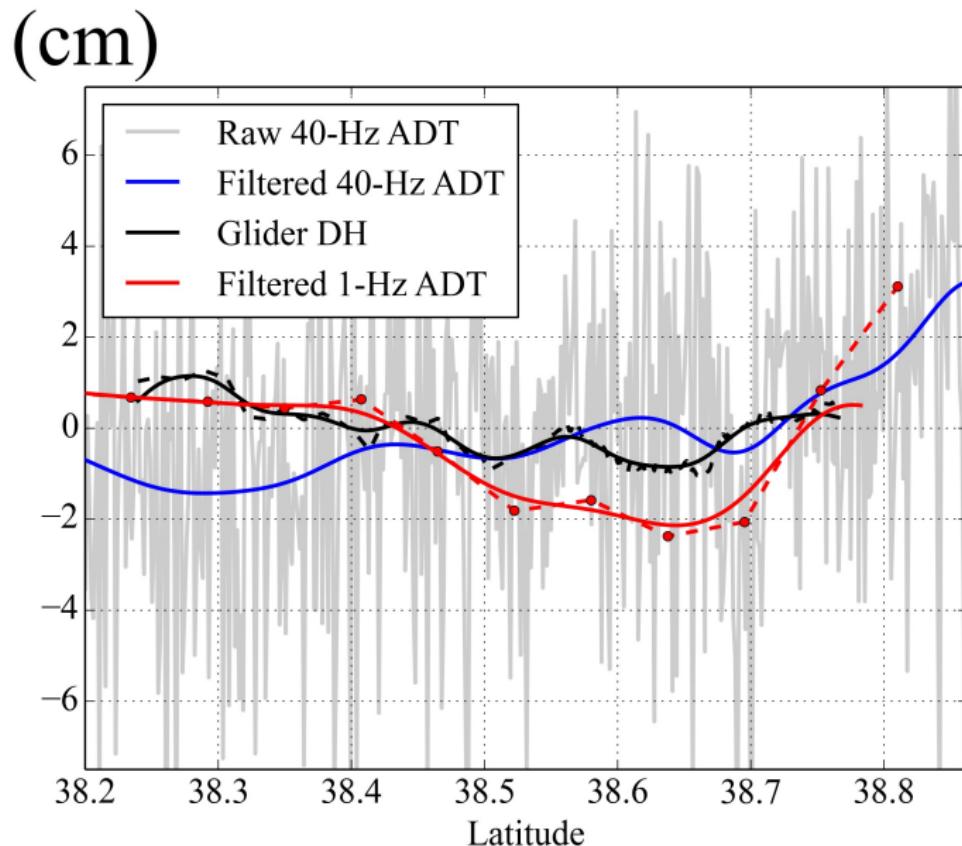


## Results: Along-track ADT and DH

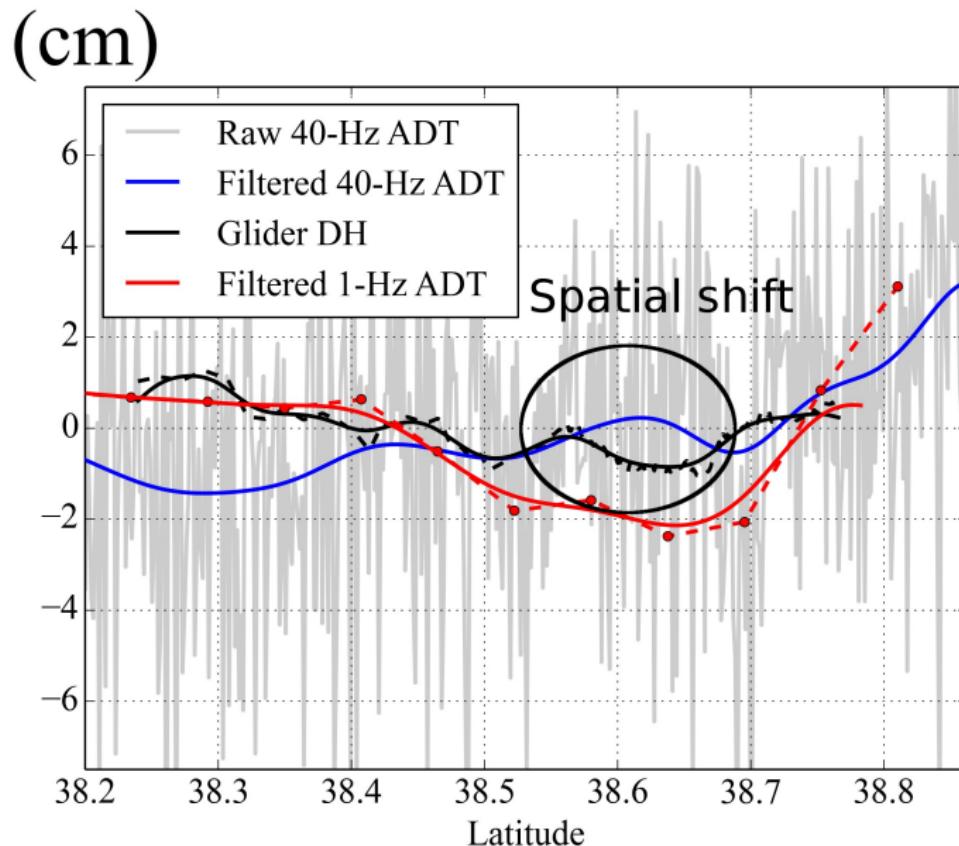
(cm)



## Results: Along-track ADT and DH



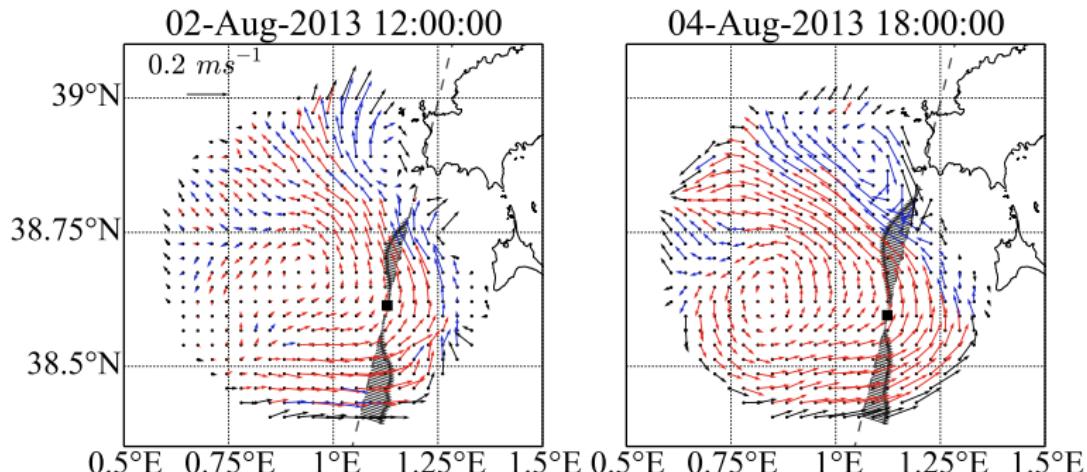
## Results: Along-track ADT and DH



# Radar velocities show time variability

5-km shift: different times of measurement

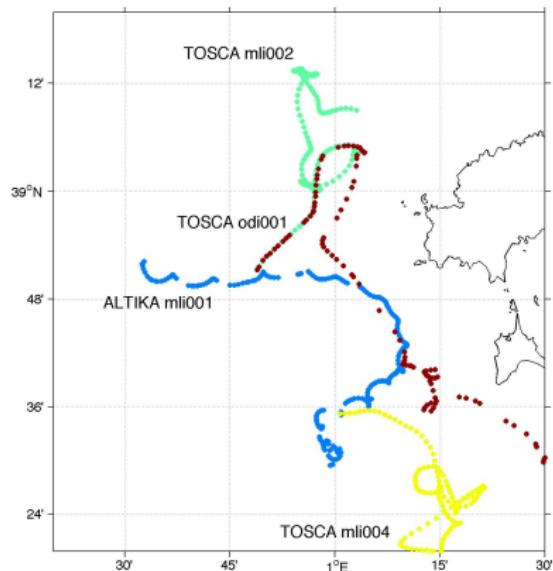
Plausible assumption considering HF radar



Positive vorticity

Negative vorticity

# Radar validation: drifters vs. radial velocities

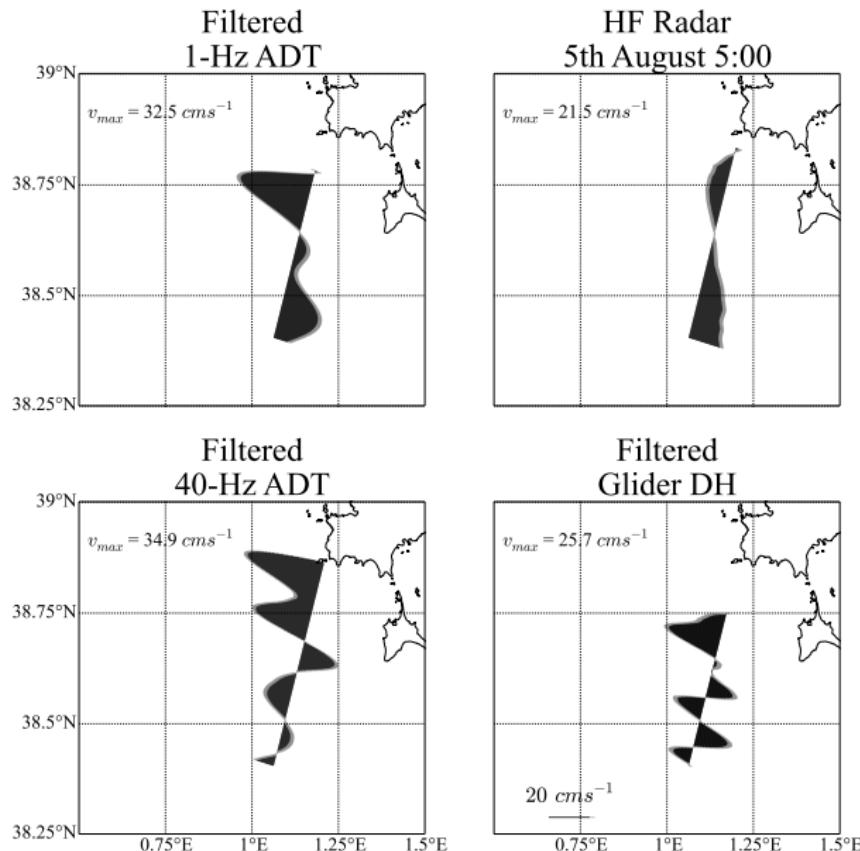


## Correlations:

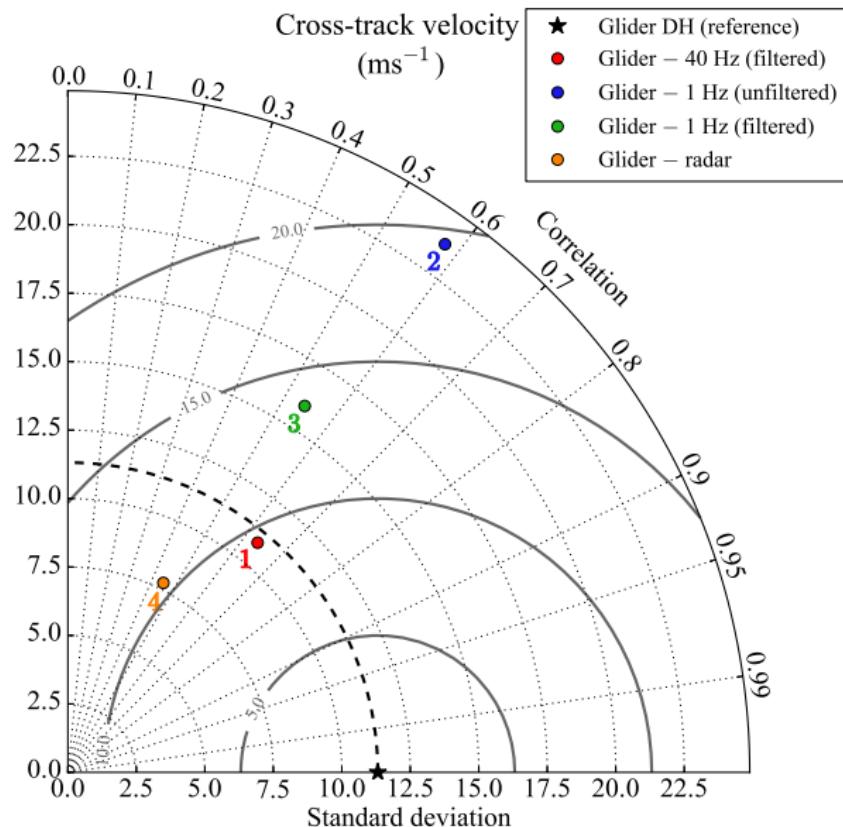
- TOSCA: 0.88 and 0.83
- AltiKa: 0.80 and 0.70

→ Poster B982 by A. Lana

# Cross-track velocities



# Comparison of the fields: Taylor diagram



## Correlations

- Glider–HF radar:  
45%
- Glider–40 Hz  
SLA: 63%

# Summary & conclusions

## 1. Weak observed gradients

(expected accuracy of the AltiKa instrument)

- Coastal area: NW-ward coastal current  
(width  $\approx 20$  km,  $v \approx 20 \text{ cm s}^{-1}$ )
- Offshore: divergence of results  
(data processing, ...)

## Summary & conclusions

### 2. Agreement between filtered 40 Hz ADT and the glider DH

- Similar circulation pattern
- 5 km spatial shift
- Correlation 63%, RMS  $< 10 \text{ cm s}^{-1}$

## Summary & conclusions

### 3. Complementary approach + robustness

- Altimetry → velocity closer to the coast ( $\lesssim 10$  km)
- Glider → horizontal resolution  $< 1$  km
- Radar → spatial coverage + 1-hour temporal resolution

# Summary & conclusions

## 4. Future work

- Need for additional sources of validation (drifters)
- In situ measurements closer to the coast
- Description of the dynamics

# Thanks for your attention

# Thanks to the contributors!



M. Torner, S. Cusí, C. Castilla, J.-P. Beltrán,  
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