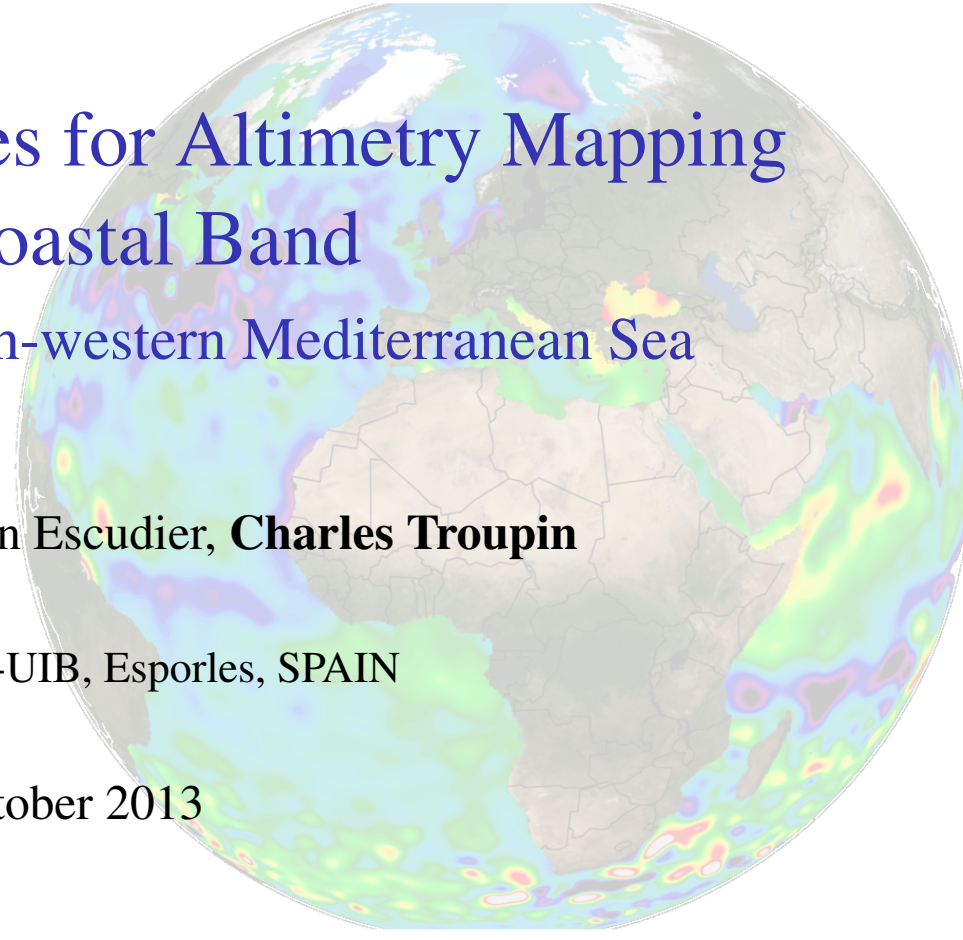
Innovative Approaches for Altimetry Mapping in the Coastal Band

Applications to the North-western Mediterranean Sea



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8 October 2013

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IMEDEA CSIC Universitat de les Illes Balears myOcean SOCIB Balearic Islands Coastal Observing and Forecasting System Govern de les Illes Balears SeaDataNet

Scientific motivation and objectives

Satellite altimetry: unique contribution to the global observation of eddy variability

(Le Traon and Morrow, 2001; Ducet et al., 2000; Fu et al., 2003; Pascual et al., 2006)

but . . .

Scientific motivation and objectives

Small scales ($\sim$40 km) and coastal zone not well resolved

(Nencioli al., 2011; Pascual et al., 2010)

Scientific motivation and objectives

Two objectives:

1. Improvement of 2D mapping of the currents in the coastal zone
2. Integrated approach for better monitoring/understanding dynamical processes in the North Western Mediterranean Sea

1.
High-resolution maps
with influence of the bathymetry

Method 1: optimal interpolation

SLA = large-scale + small-scale

- Large-scale: AVISO product $L = 100$ km, $T = 10$ days
- Small-scale: [High-Resolution product] $L = 30$ km, $T = 5$ days

$$C(r,t) = \exp\left(-\frac{r^2}{2L^2}\right)\exp\left(-\frac{t}{T}\right)^2$$

Method 2: increased covariance along isobaths

[High-Resolution+BATHY product]

$$C(r = a - b, t) = \exp\left(-\mathbf{R}^2\right) \exp\left(-\frac{t}{T}\right)^2$$

Method 2: increased covariance along isobaths

$$\mathbf{R}^2 = \frac{|a-b|^2}{2L^2} + \frac{1}{\phi}\frac{|PV(a)-PV(b)|^2}{PV^2(a)+PV^2(b)}$$

[Davis et al. 1998]

[Dussurget et al. 2011]

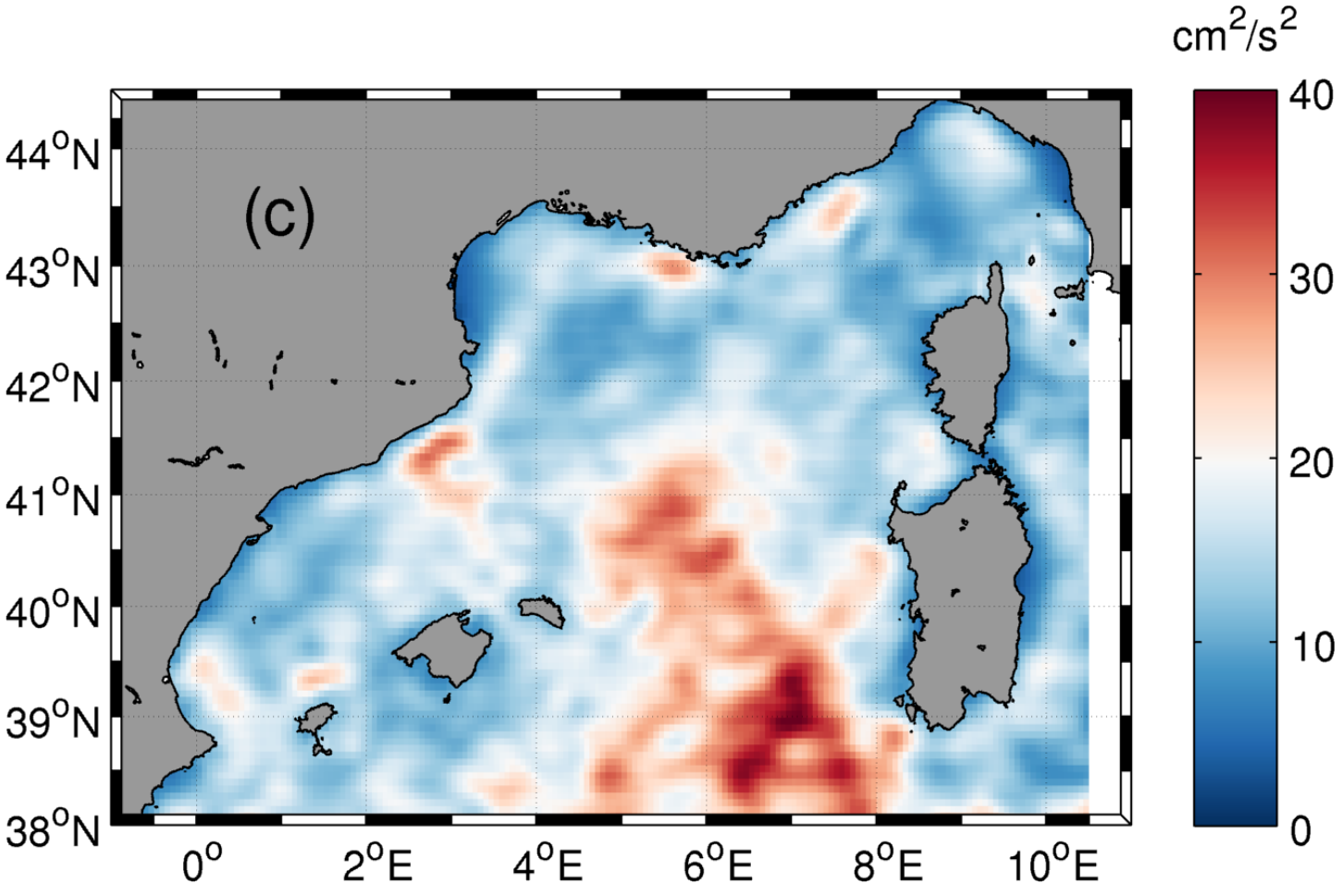
$$PV = \frac{f}{H} = \frac{\mathrm{C}oriolis}{\mathrm{B}athymetry}$$

Optimal values: $L = 30$ km, $T = 3$ days, $\Phi = 0.7$

Eddy Kinetic Energy (2003–2010)

larger mean value & stronger near coast

[High-Resolution] *minus* AVISO



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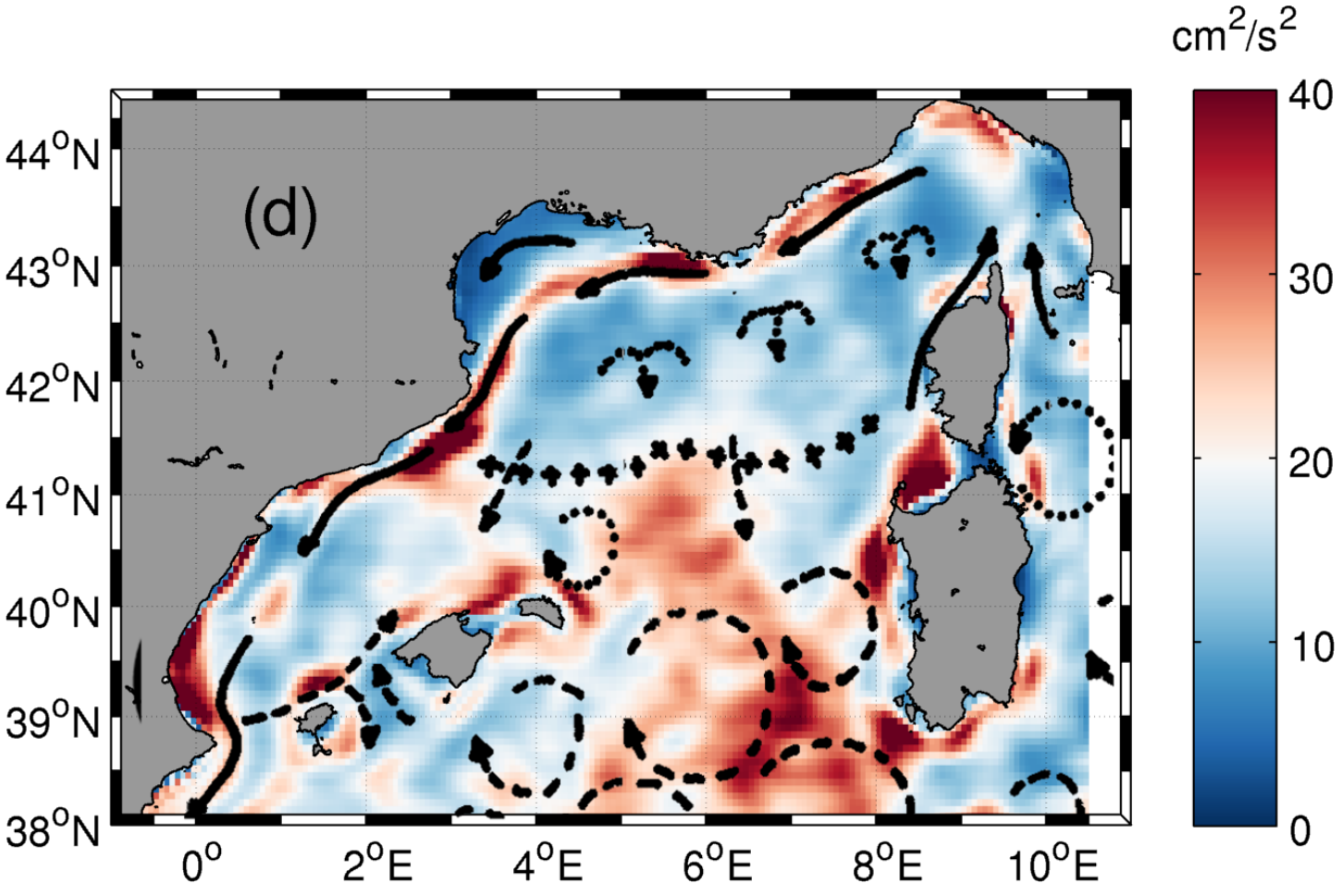

More details...

GEOPHYSICAL RESEARCH LETTERS, VOL. 40, 1–6, doi:10.1002/grl.50324, 2013

Improvement of coastal and mesoscale observation from space: Application to the northwestern Mediterranean Sea

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2.
Data-interpolating variational analysis

Data-interpolating variational analysis

Method: minimize a cost function including:

- an *observation* constraint — proximity to data
- a *smoothness* constraint — not too strong irregularities
- a *behaviour* constraint — physics (advection, diffusion)

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Solver: finite-element method

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Parameters: determined from data

- Correlation length scale
- Signal-to-noise ratio

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Formulation: $d_i =$ data, $\mu_i =$ data weight,
$\varphi =$ analyzed field, $\Omega =$ domain

$$J[\varphi] = \sum_{i=1}^{N} \mu_i \left[d_i - \varphi(x_i, y_i)\right]^2 + \int_\Omega \left(\boldsymbol{\nabla}\boldsymbol{\nabla}\varphi : \boldsymbol{\nabla}\boldsymbol{\nabla}\varphi + \alpha_1 \boldsymbol{\nabla}\varphi \cdot \boldsymbol{\nabla}\varphi + \alpha_0 \varphi^2\right) \mathrm{d}\Omega$$

Data-interpolating variational analysis

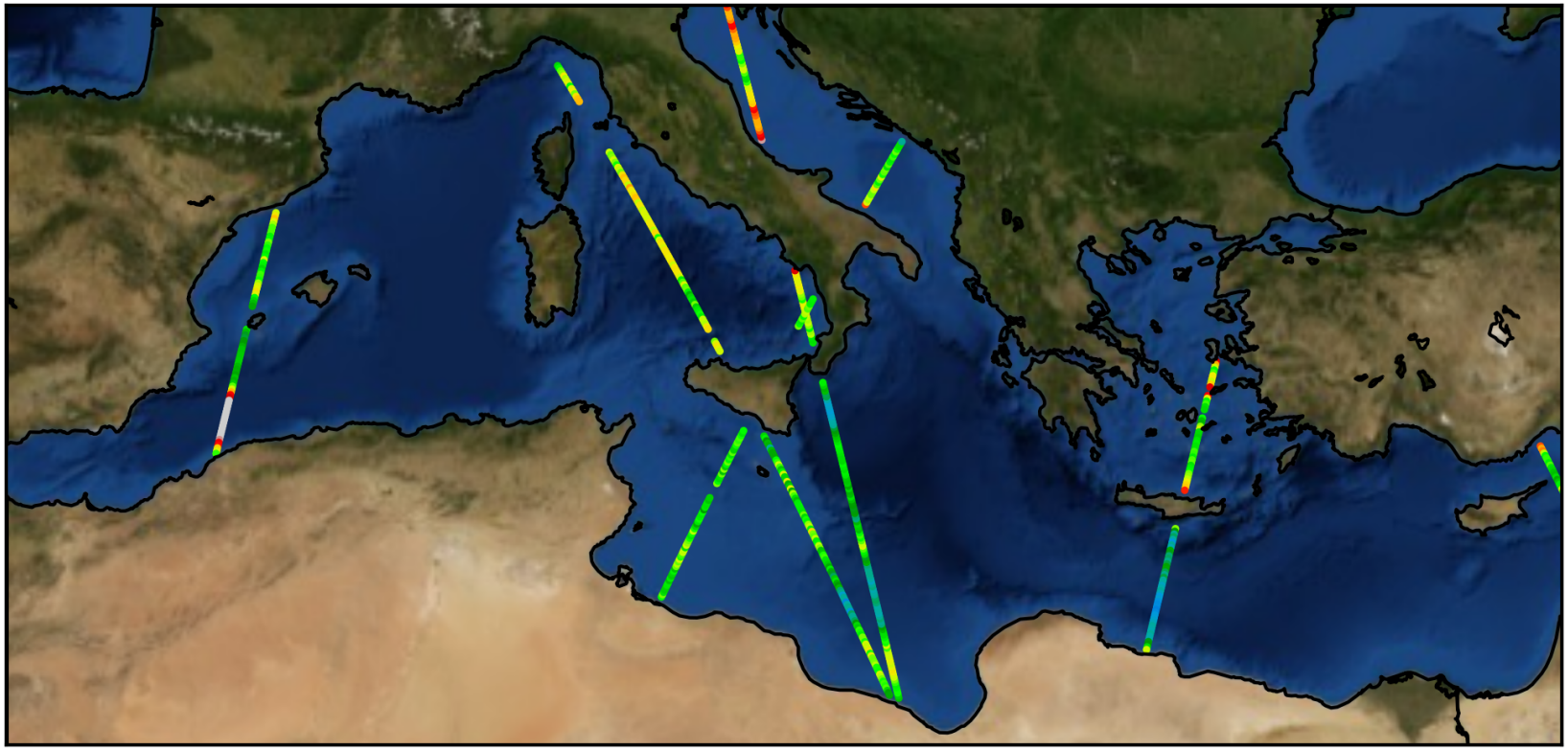
Create contour (from topography)

Data-interpolating variational analysis

Create contour (from topography)

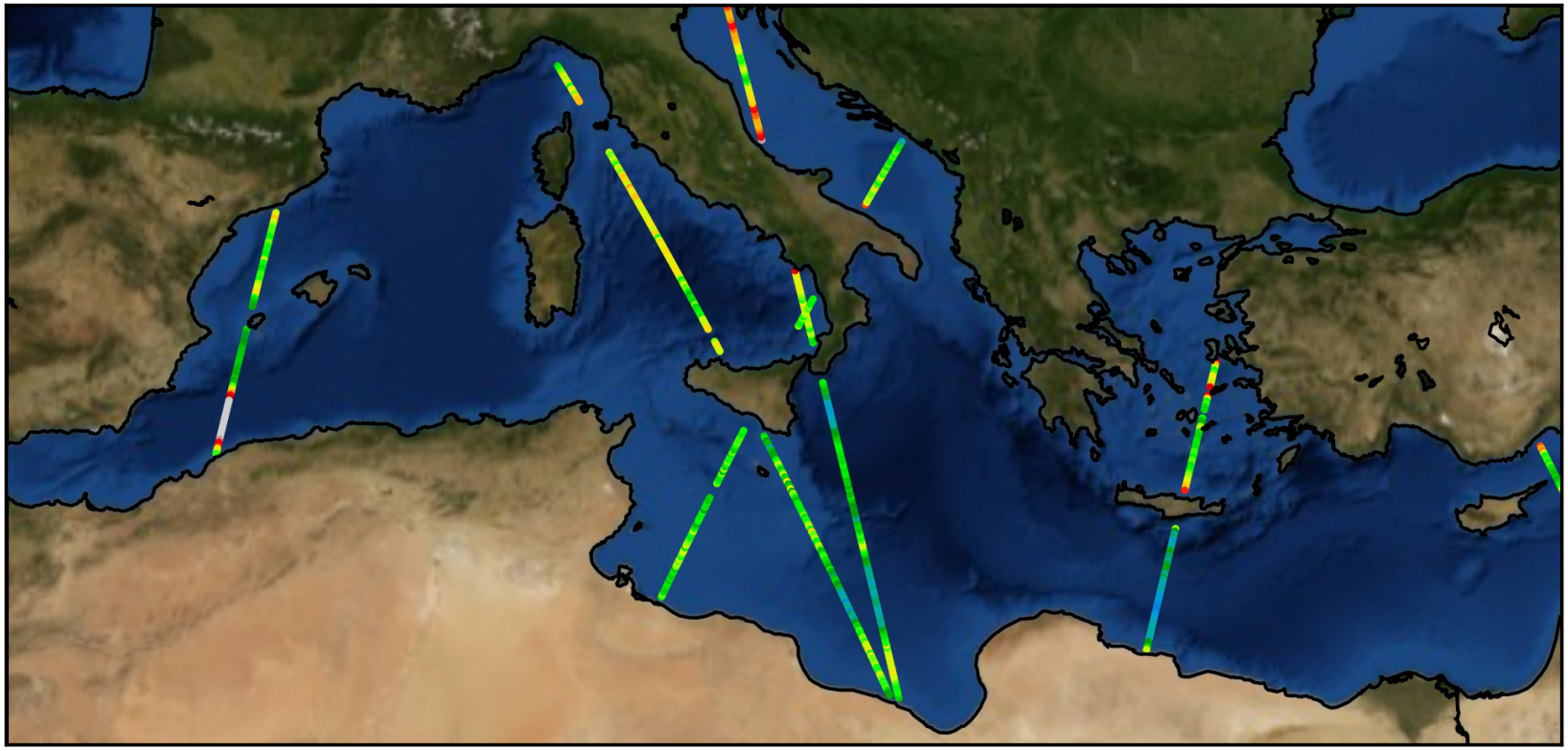
Data-interpolating variational analysis

Extract data



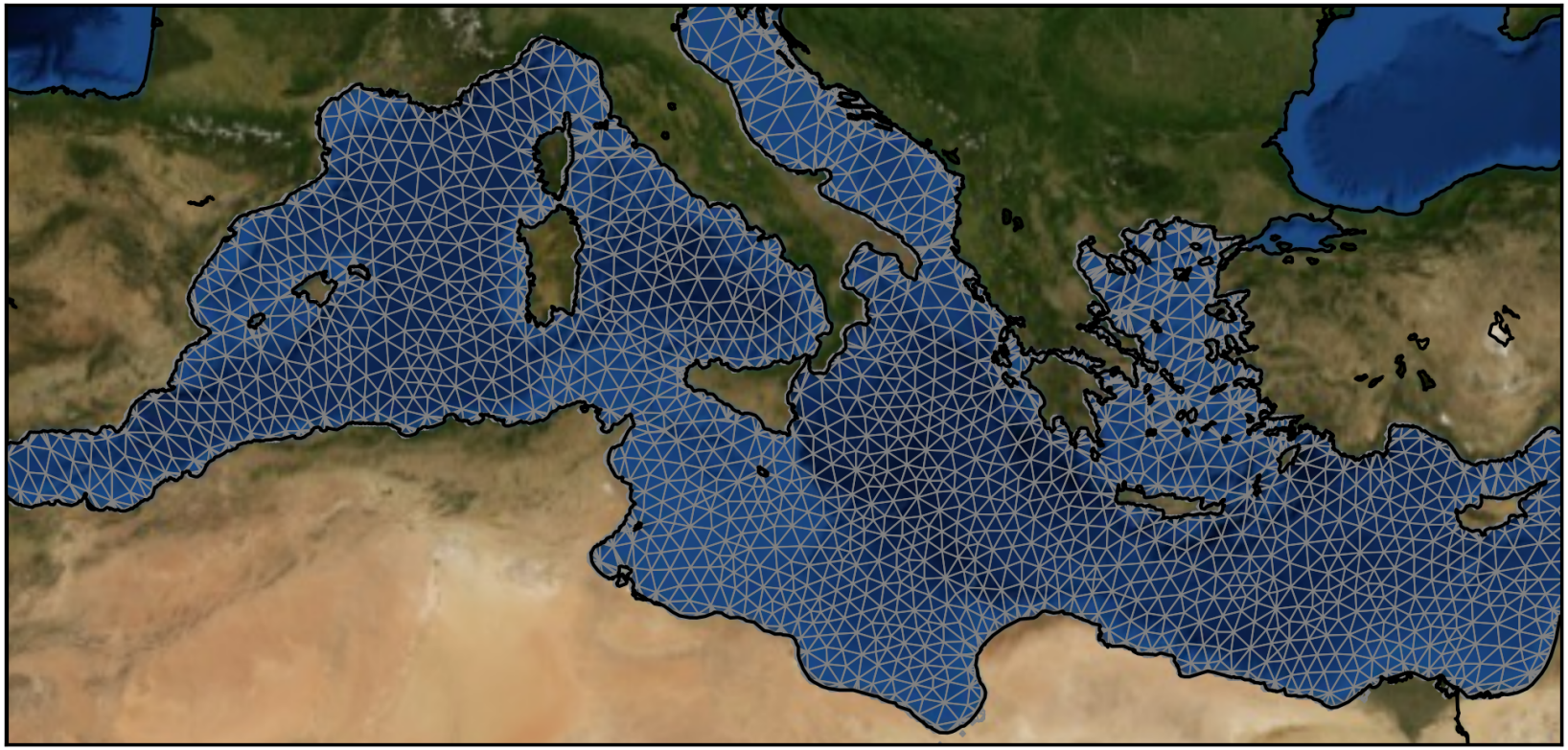
Data-interpolating variational analysis

Evaluate analysis parameters



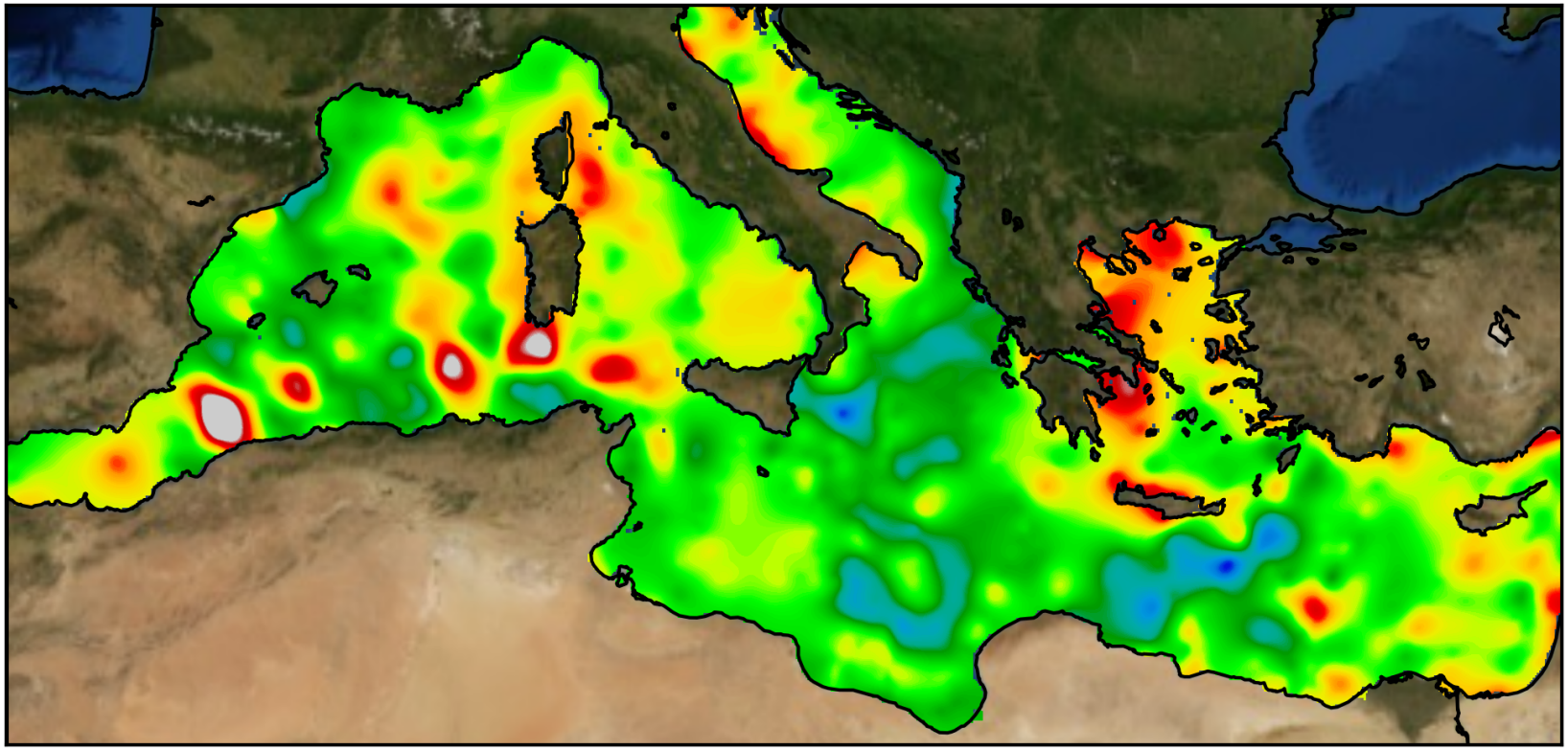
Data-interpolating variational analysis

Create finite-element mesh



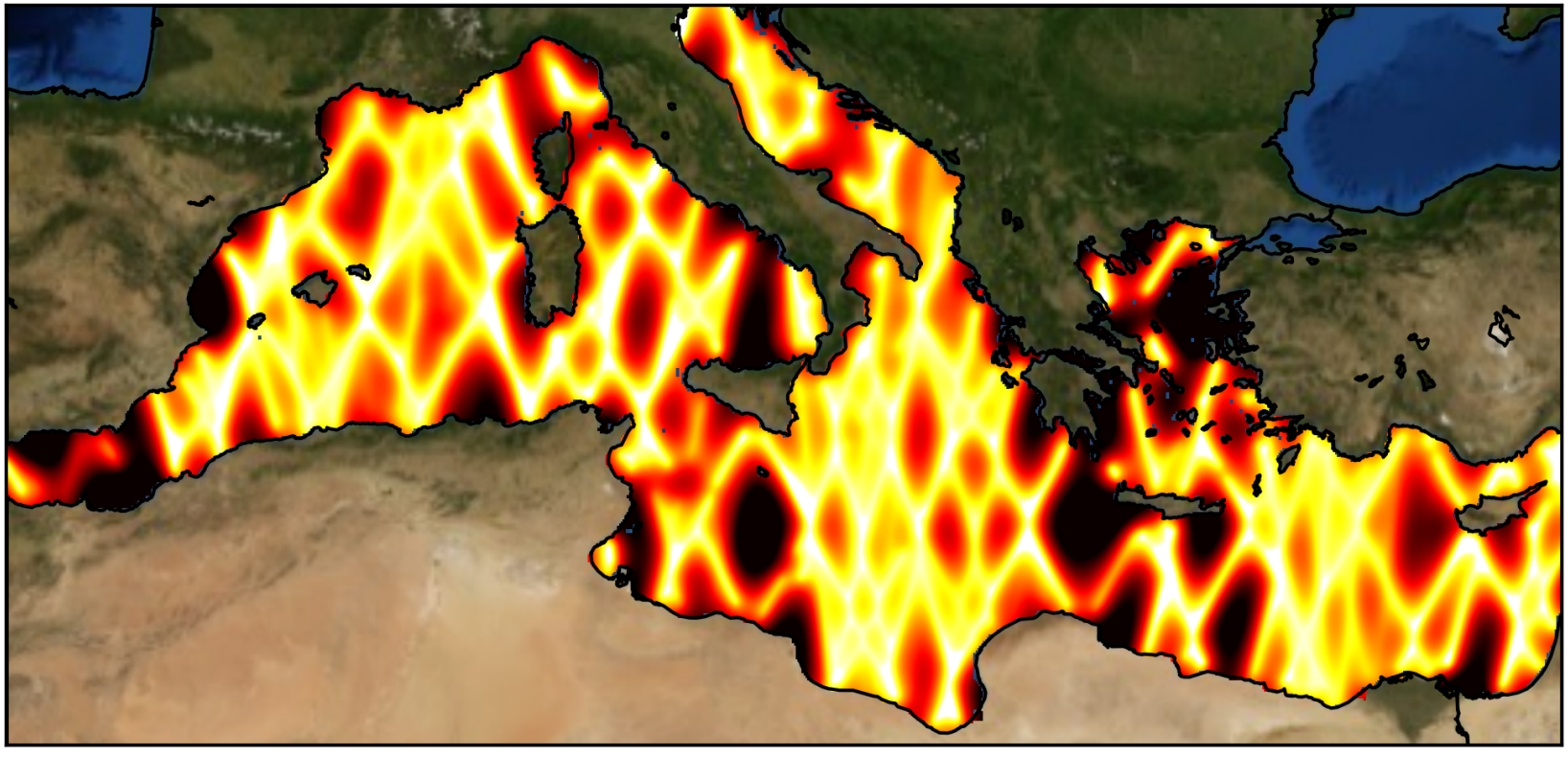
Data-interpolating variational analysis

Generate analysis



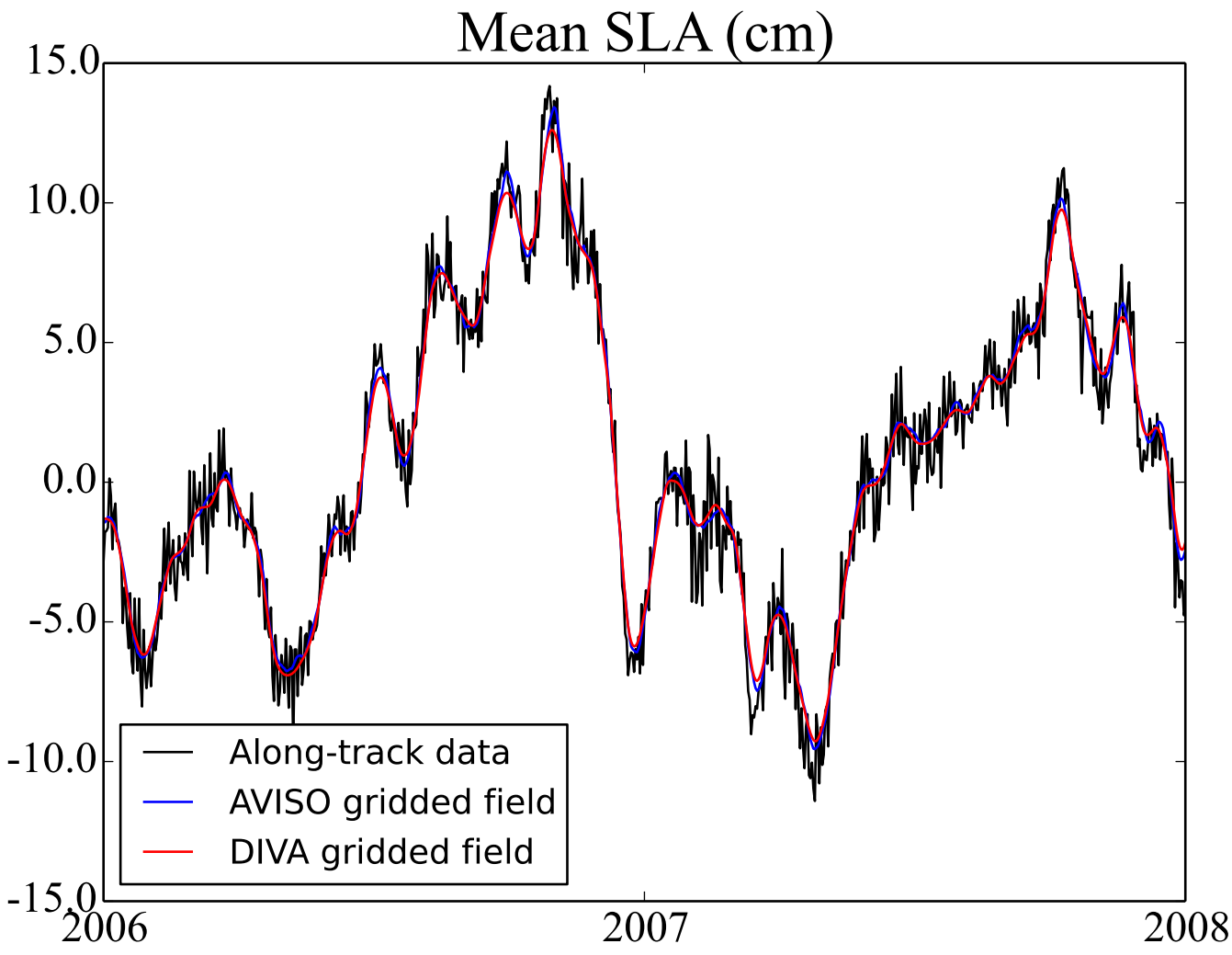
Data-interpolating variational analysis

Generate error field



Comparison with AVISO products

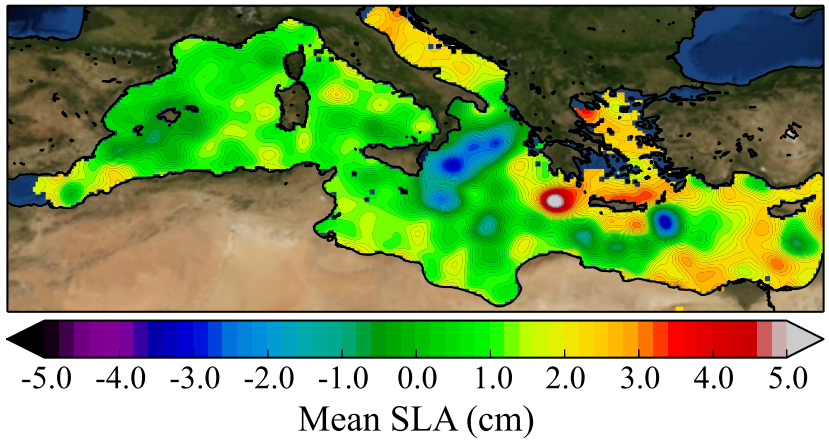
Spatial averaged SLA (2006-2008)



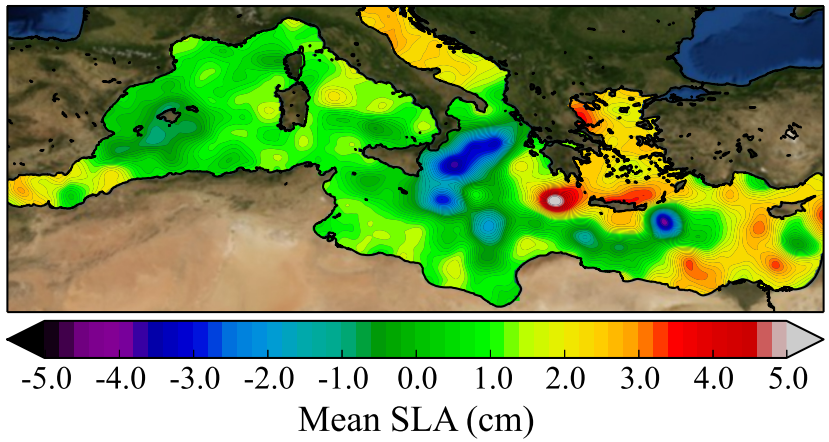
Comparison with AVISO products

Time-averaged SLA

AVISO (14 October 1992 – 19 January 2011)

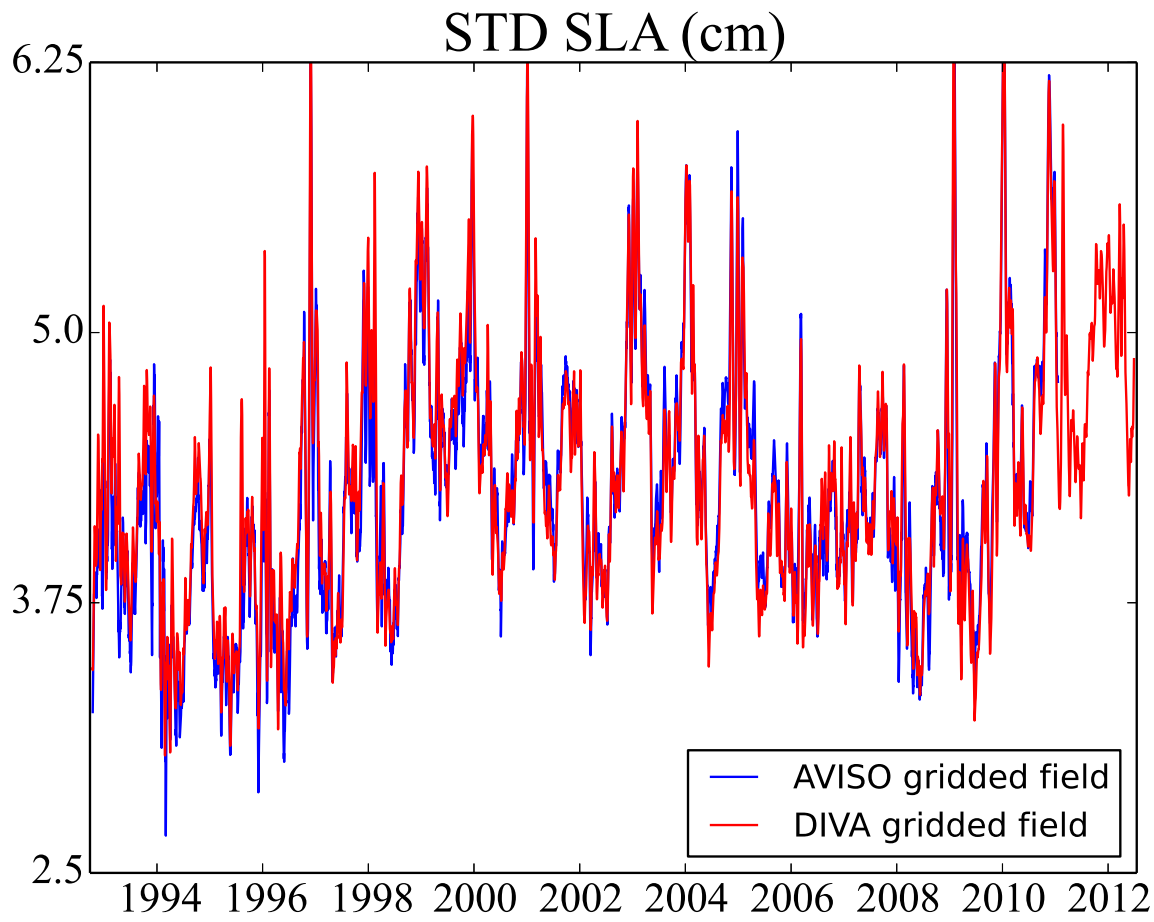


Diva (24 September 1992 – 9 July 2012)



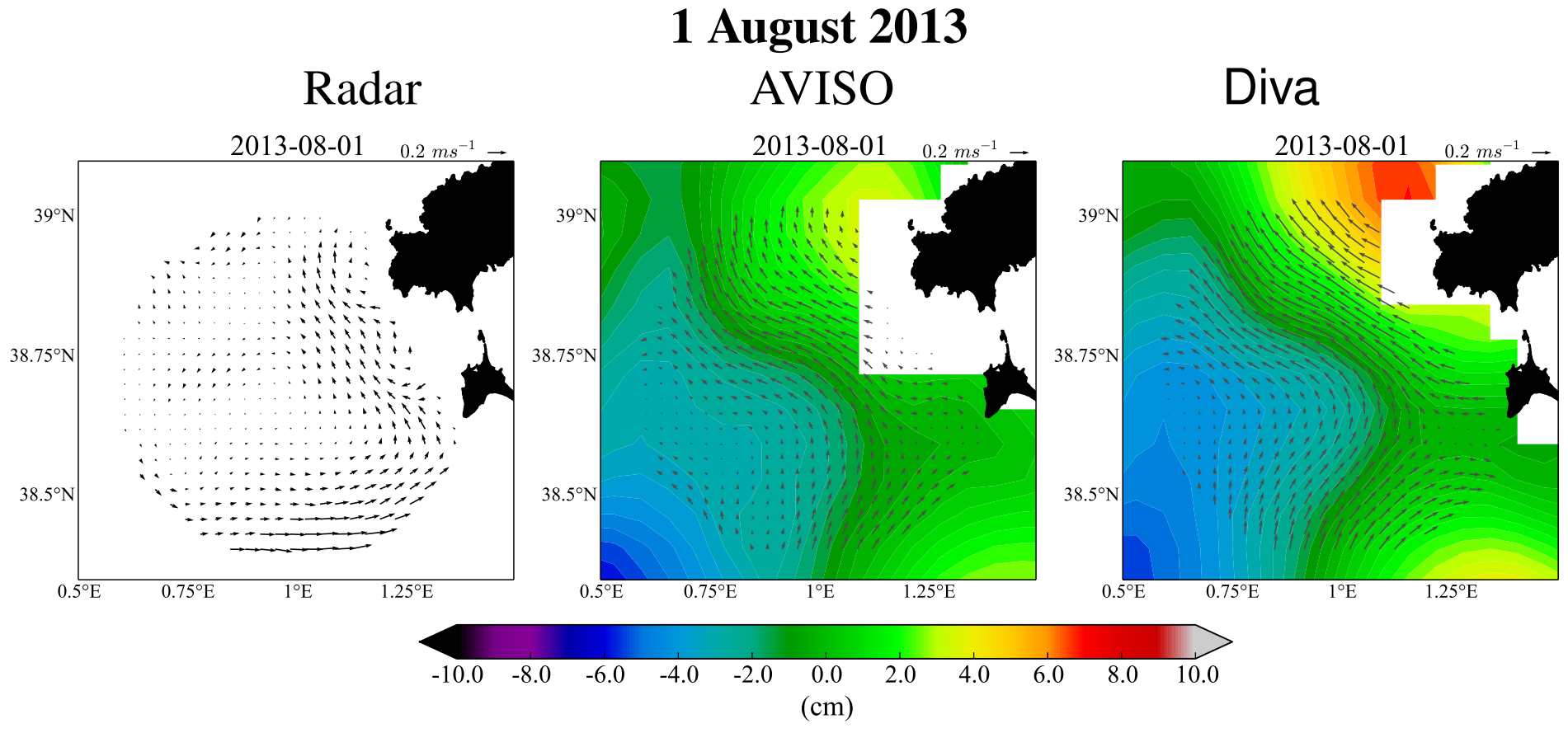
Comparison with AVISO products

Standard Deviation SLA (1992-2012)



Comparison with radar data

- Surface currents in the Ibiza Channel: SOCIB HF-radar facility.
- Altimetry-derived velocities re-interpolated onto radar grid.



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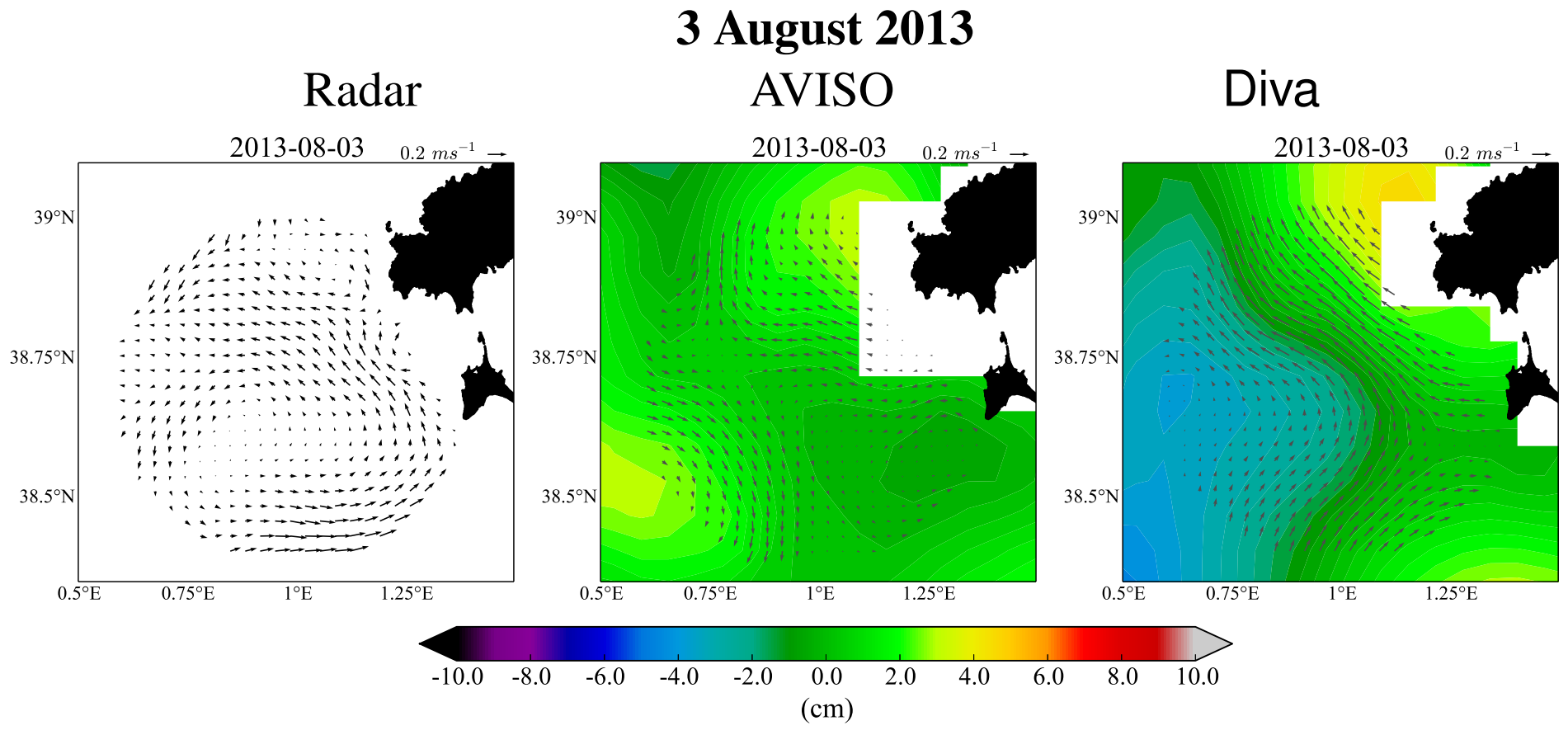

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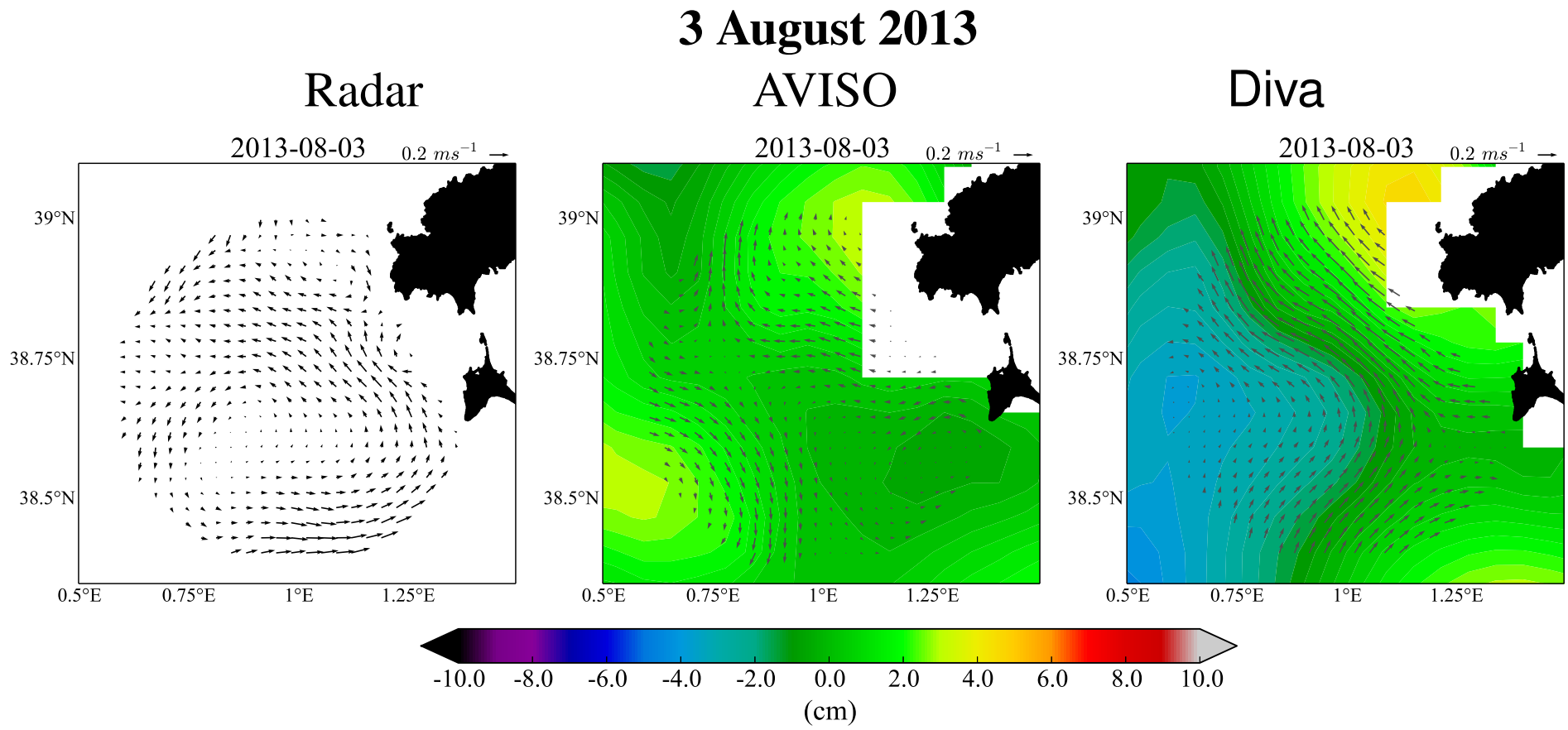
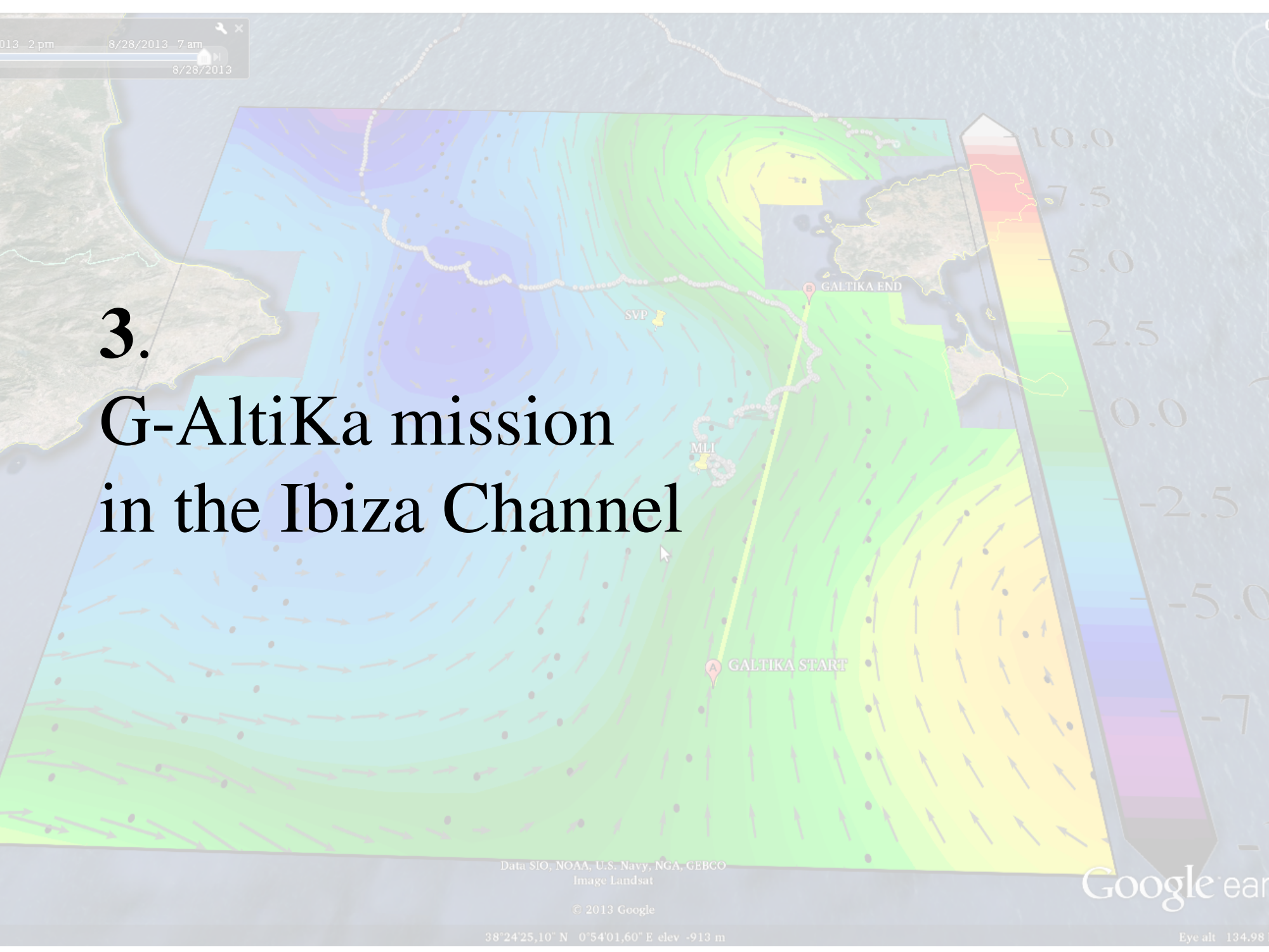
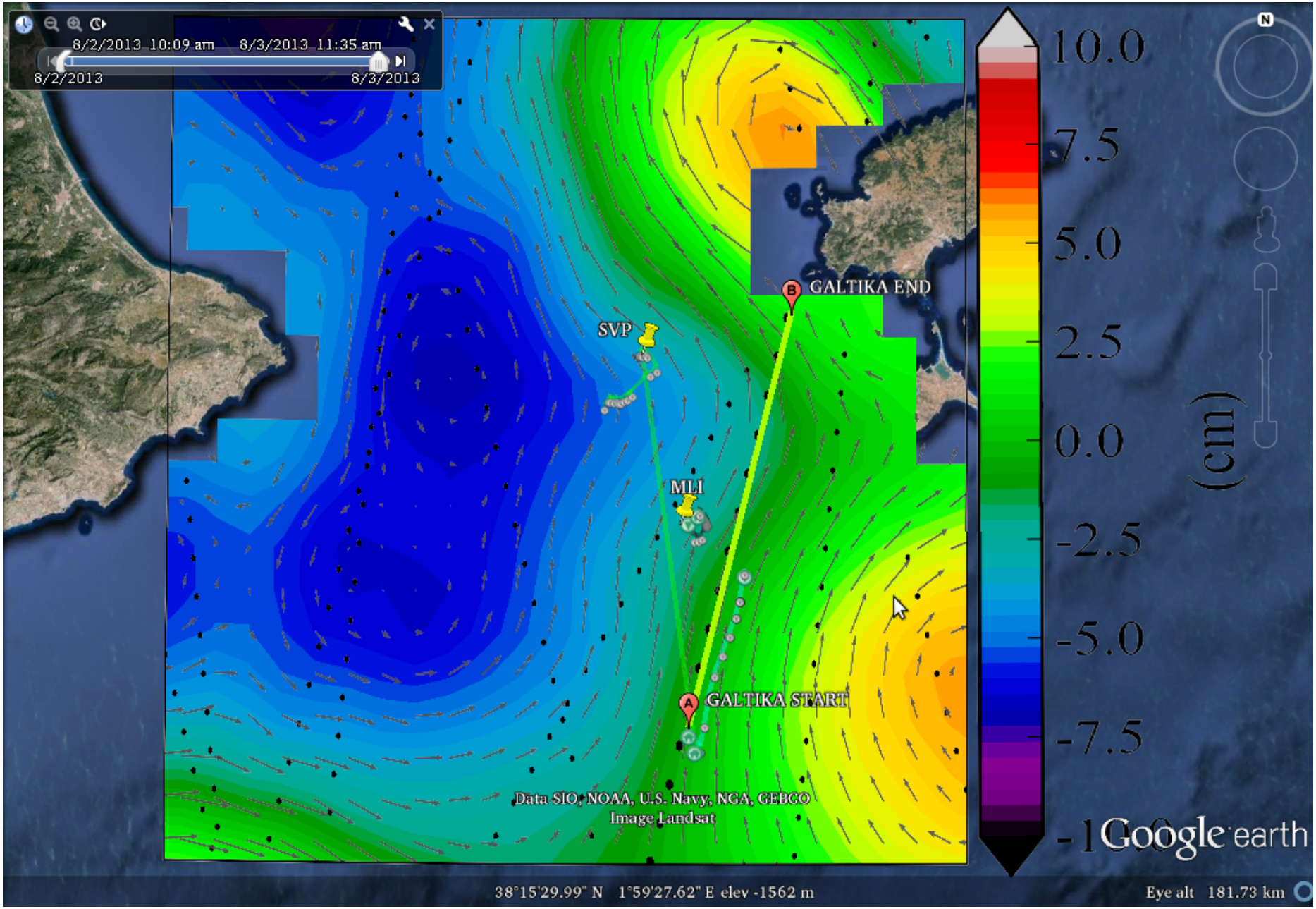


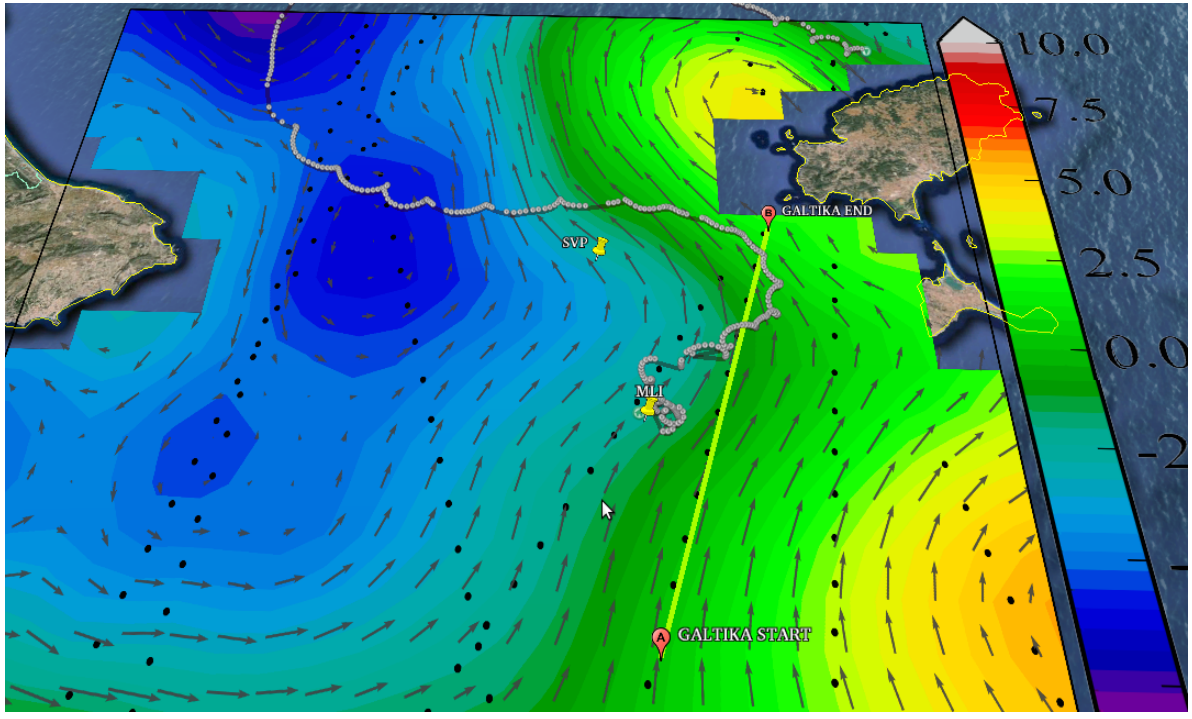
See Poster OSTST no. 20 for details and statistics



3.
G-AltiKa mission in the Ibiza Channel


8/2/2013 10:09 am
8/3/2013 11:35 am
8/2/2013
8/3/2013
GALTIKA END
SVP
MLI
GALTIKA START
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
10.0
7.5
5.0
2.5
0.0
-2.5
-5.0
-7.5
-10.0
(cm)
Google earth
38°15'29.99" N 1°59'27.62" E elev -1562 m
Eye alt 181.73 km

G-AltiKa: multi-sensor experiment in the Ibiza Channel



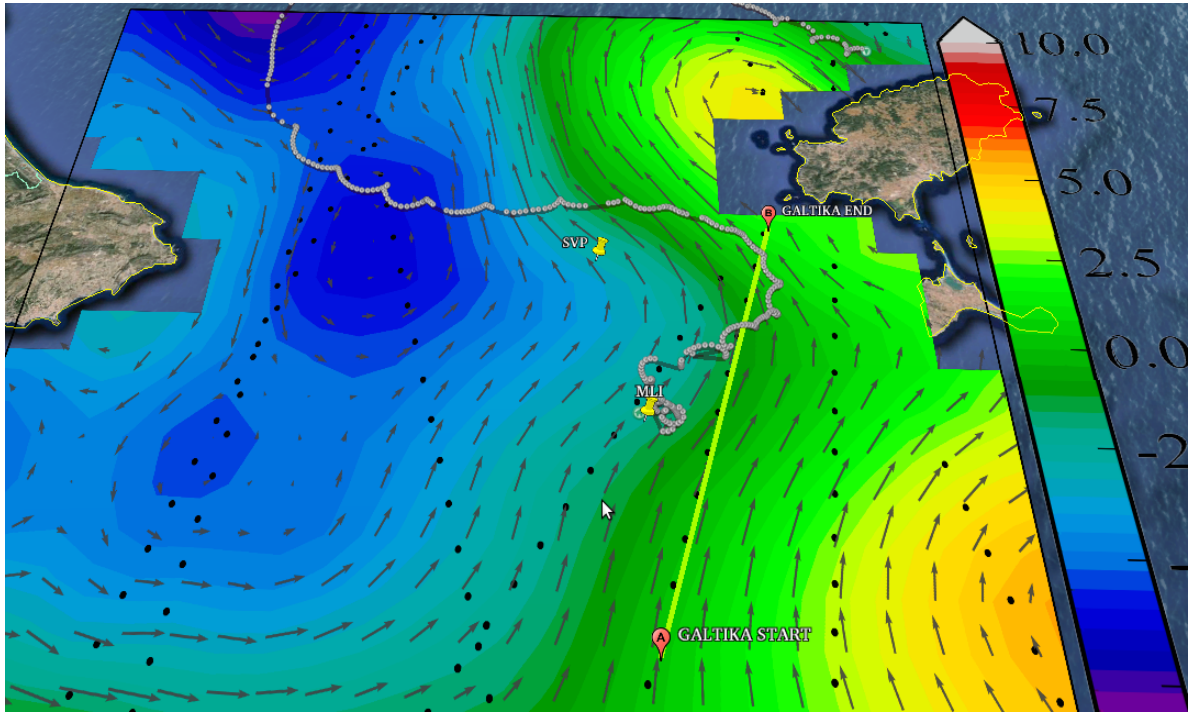
Location: Ibiza Channel, NW Mediterranean Sea

Period: August 2013

Sensors:

- deep Slocum glider along SARAL-AltiKa track no. 16
- HF-radar (SOCIB)
- 2 surface drifters (SVP and MLI)

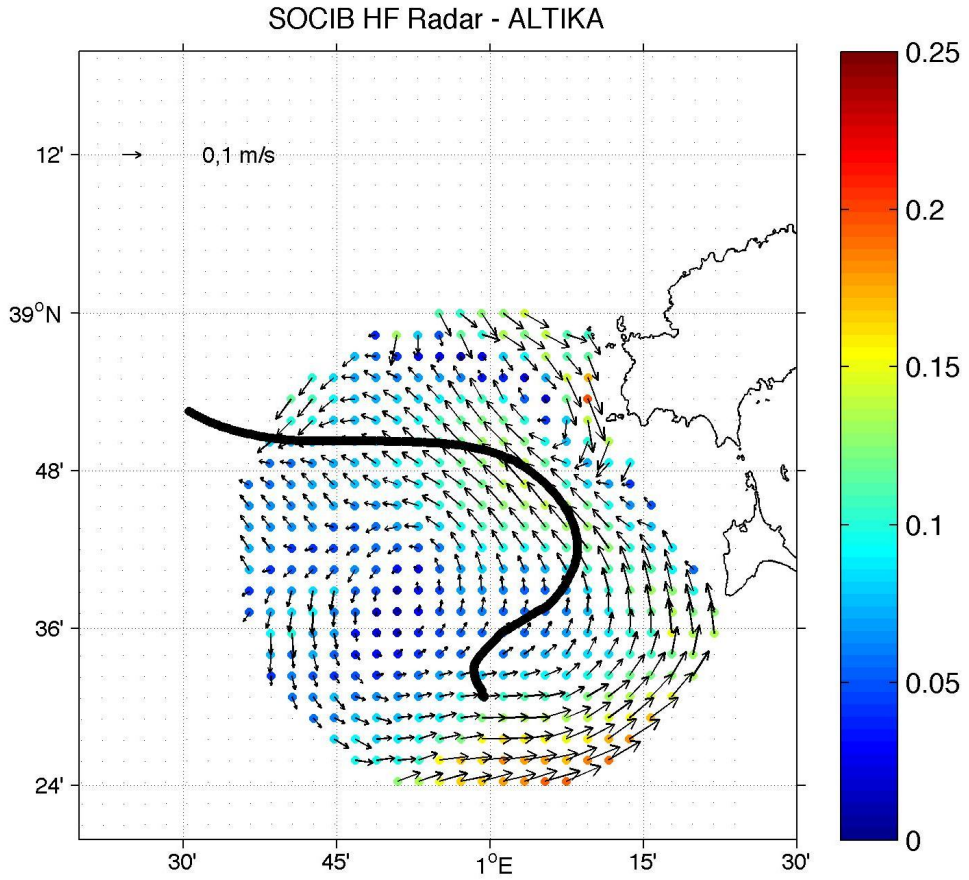
G-AltiKa: multi-sensor experiment in the Ibiza Channel



Objectives:

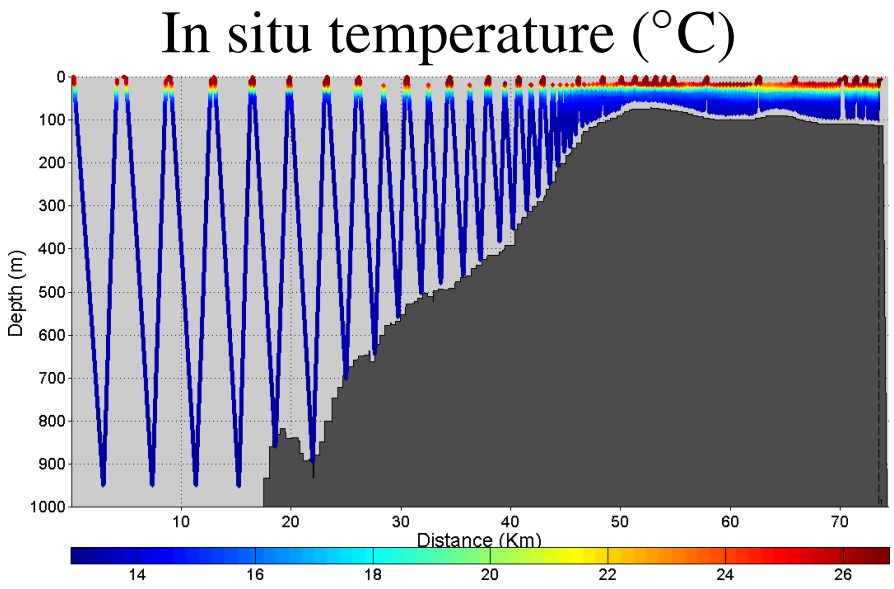
1. Processing, validation, inter-calibration of multi-platform datasets in coastal ocean (focus on SARAL/AltiKa)
2. Integrated approach to improve the monitoring and understanding of dynamical processes in the Western Mediterranean Sea

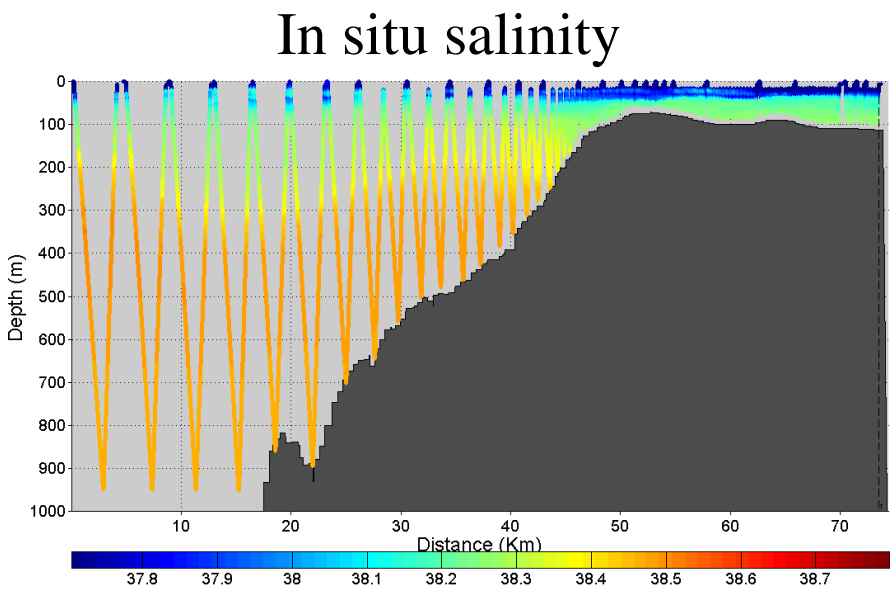
G-AltiKa experiment: radar and drifter velocities



- Ekman component not removed
- Meander and current close to the coast (< 10km)

Glider profiles: increasing resolution towards coast





Resolution:

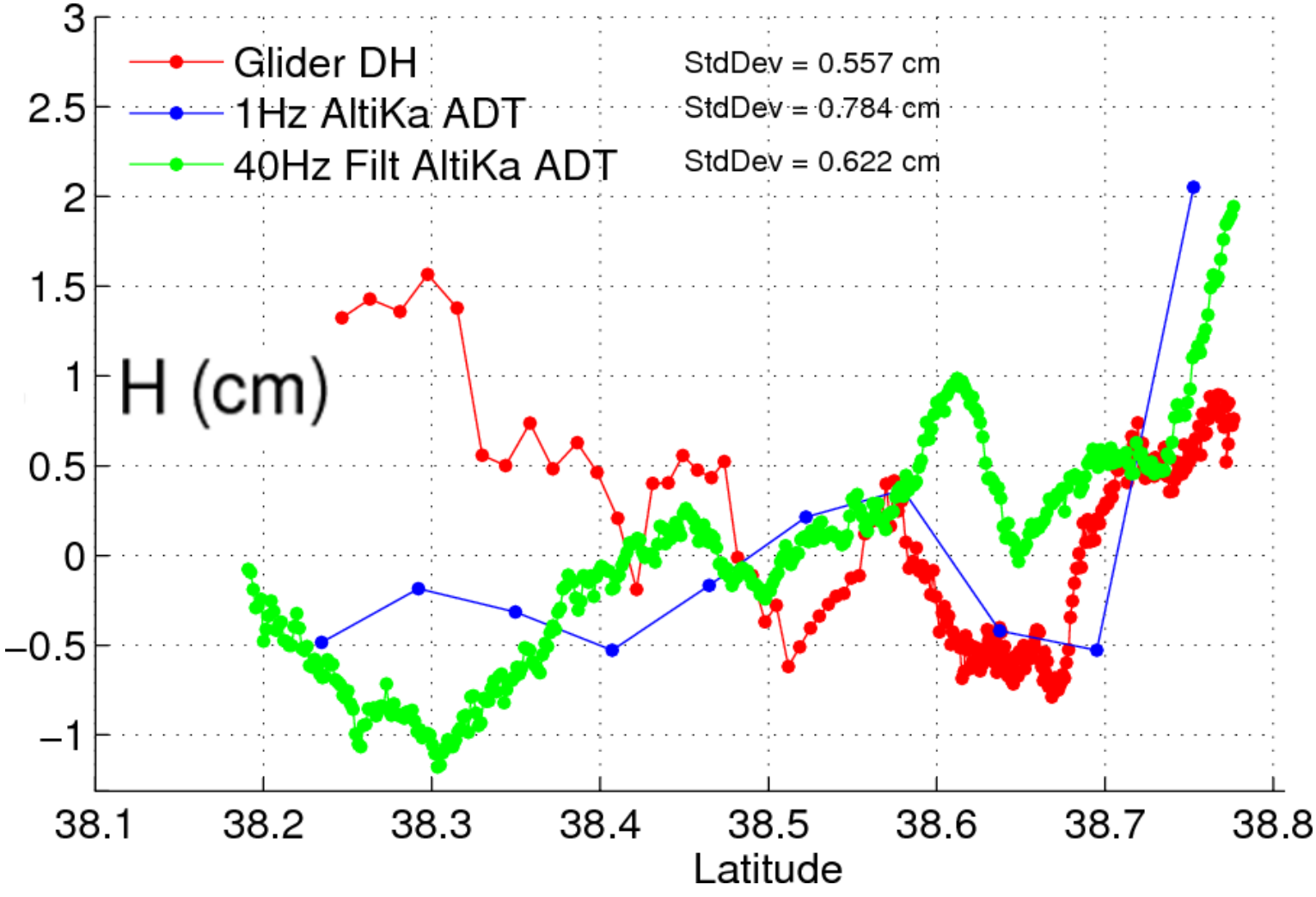
≈5 km offshore,

≈1 km in coastal area

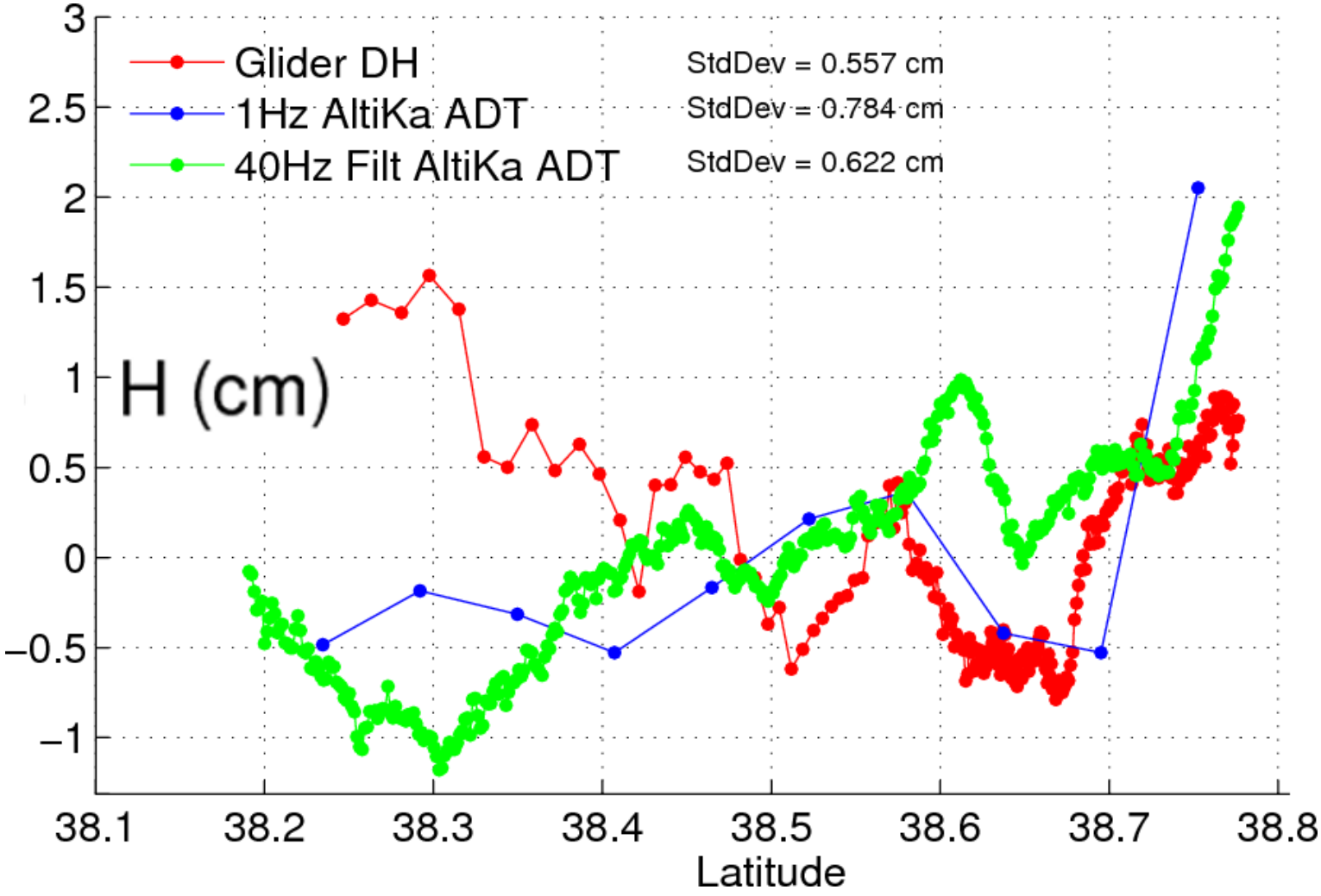
Dynamic height:

not sensitive to level of reference

Glider vs SARAL/AltiKa along track velocity



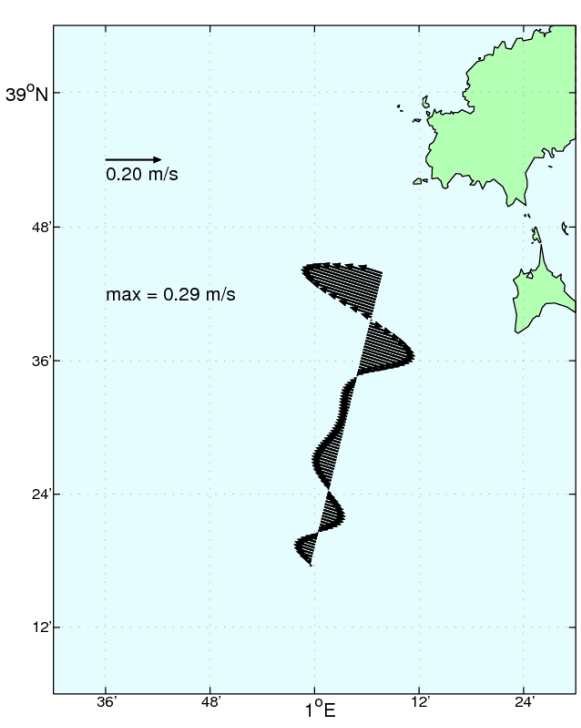
Glider vs SARAL/AltiKa along track velocity



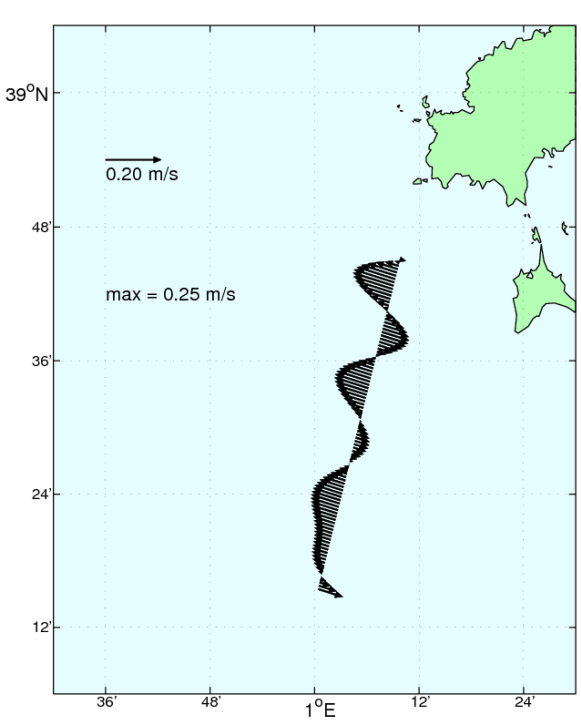
Open-sea: differences Coastal zone: good agreement → coast current

Difference structures in 1 Hz and 40 Hz Very small gradients ($\sim$ 2 cm)

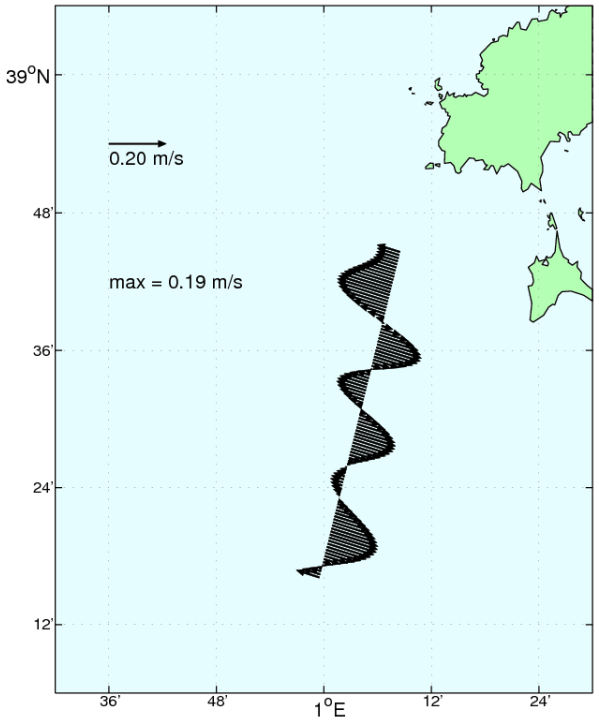
Glider vs SARAL/AltiKa along track velocity



(a) 1 Hz



(b) 40 Hz

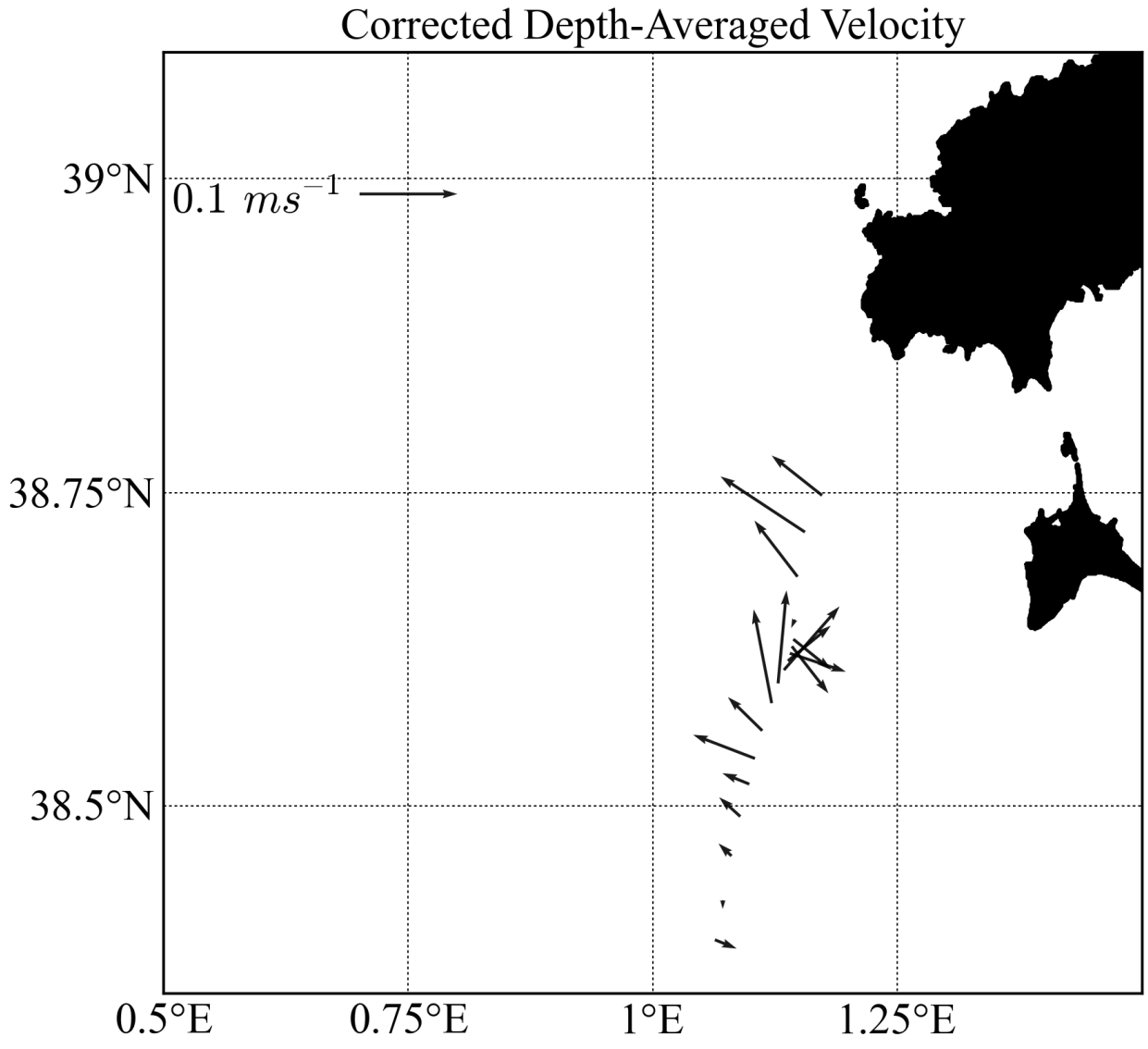


(c) Glider

- Lanczos filter (14 km window)
- Agreement with depth-averaged velocity from glider (next slide)

Glider vs SARAL/AltiKa along track velocity

Depth averaged velocity: estimated by glider



Conclusions & perspectives

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5. Promising results by SARAL/AltiKa in the coastal band (also see Ananda's poster no. 91)
6. Looking forward to Sentinel-3 and SWOT!

Thanks for your attention
Thanks to the contributions!

M. Torner, S. Cusí, C. Castilla, J.-P. Beltrán, K. Sebastián, S. Lora, I. Lizarán, M. Juza, J. Tintoré

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G. Valladeau, M.-I. Pujol, C. Pelloquin, Y. Faugère

A. Guillot, N. Picot