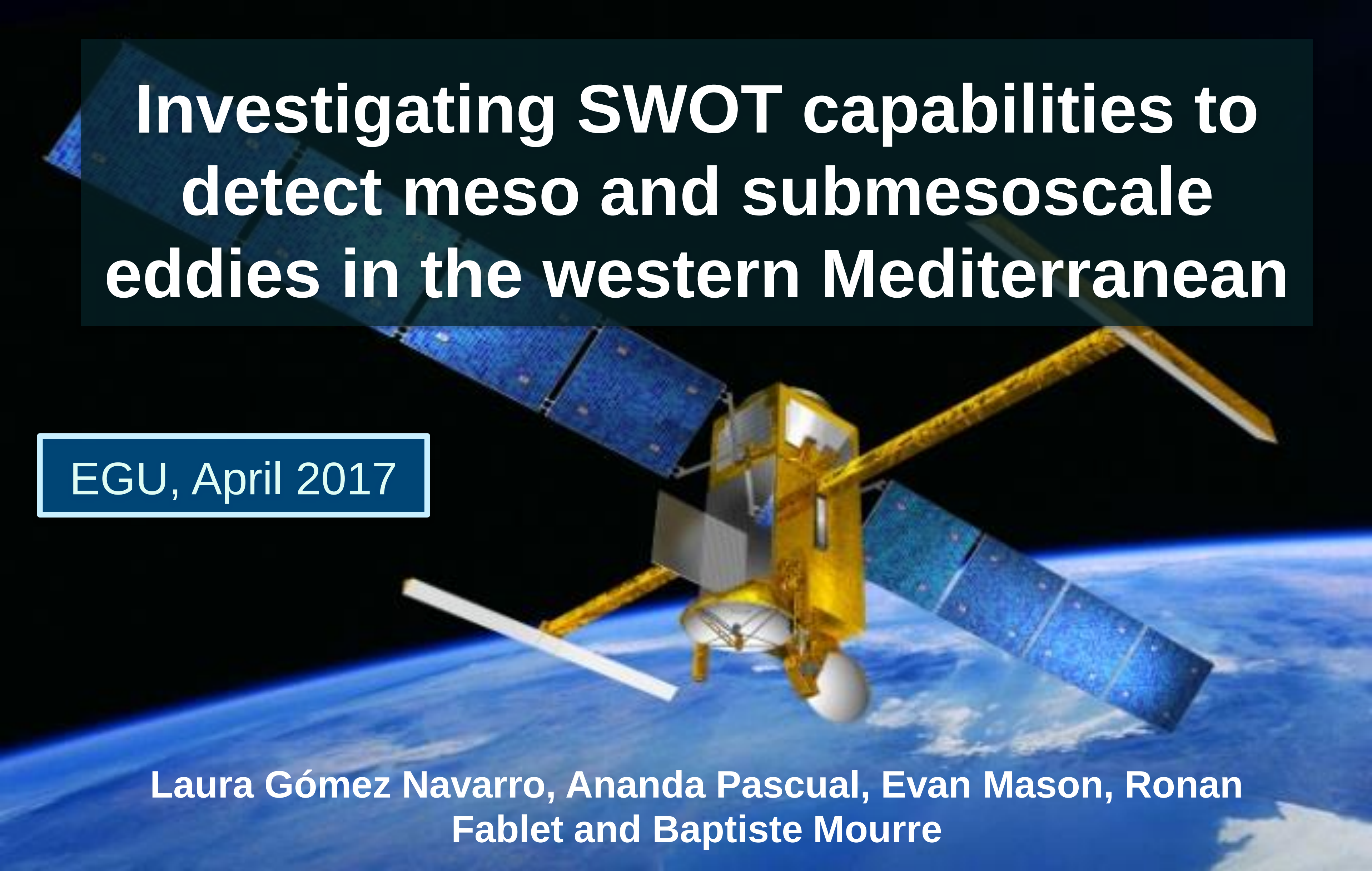

Investigating SWOT capabilities to detect meso and submesoscale eddies in the western Mediterranean

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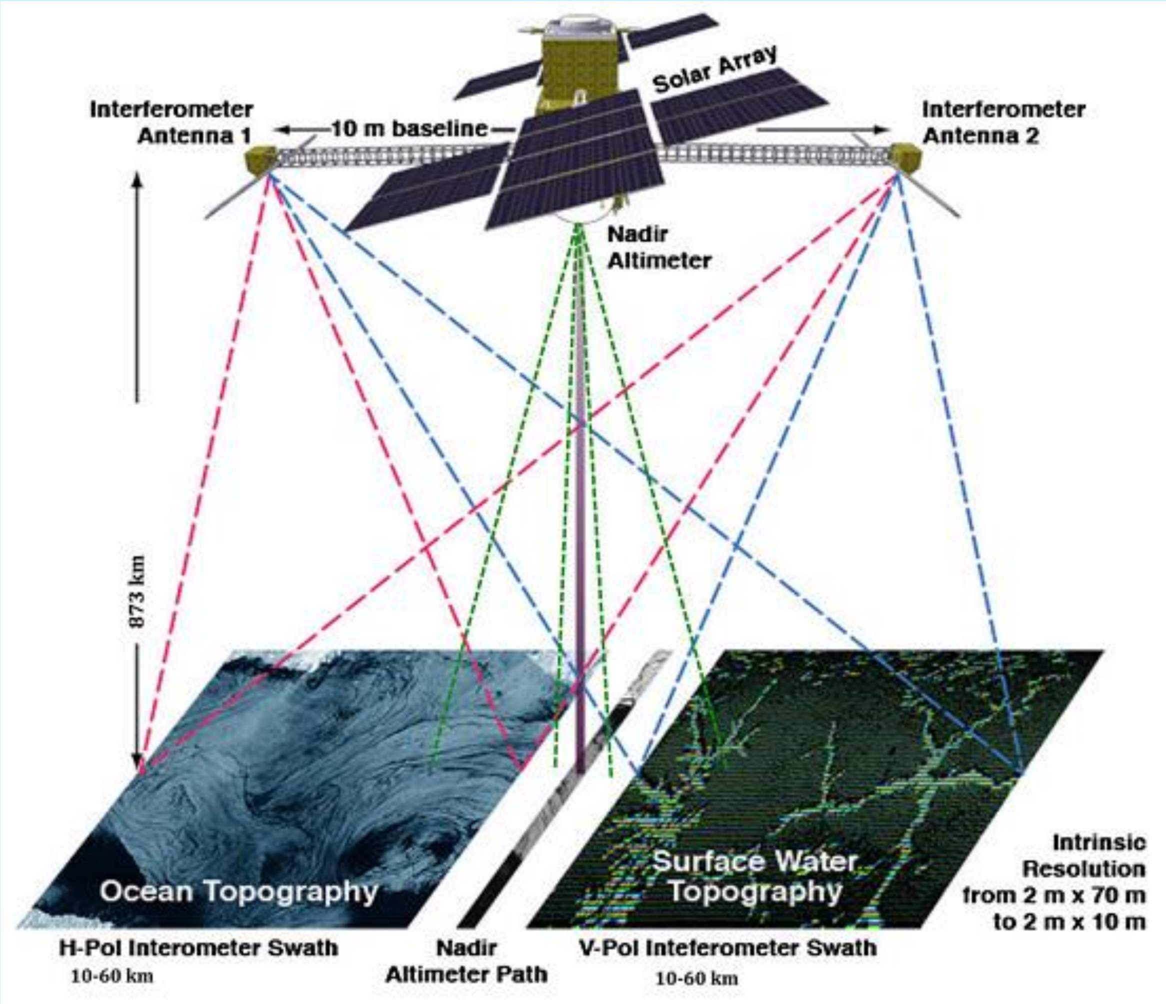
IMEDEA
CSIC
Consejo Superior de Investigaciones Científicas
UIB Universitat de les Illes Balears
IGE Institut des géosciences de l'environnement
Lab-STICC
SOCIB Balearic Islands Coastal Observing and Forecasting System

Surface Water Ocean Topography mission

- **Wide-swath** altimeter
- Launch: 2021
- Provide **water elevation** maps
  - – Oceanography
  - – Hydrology

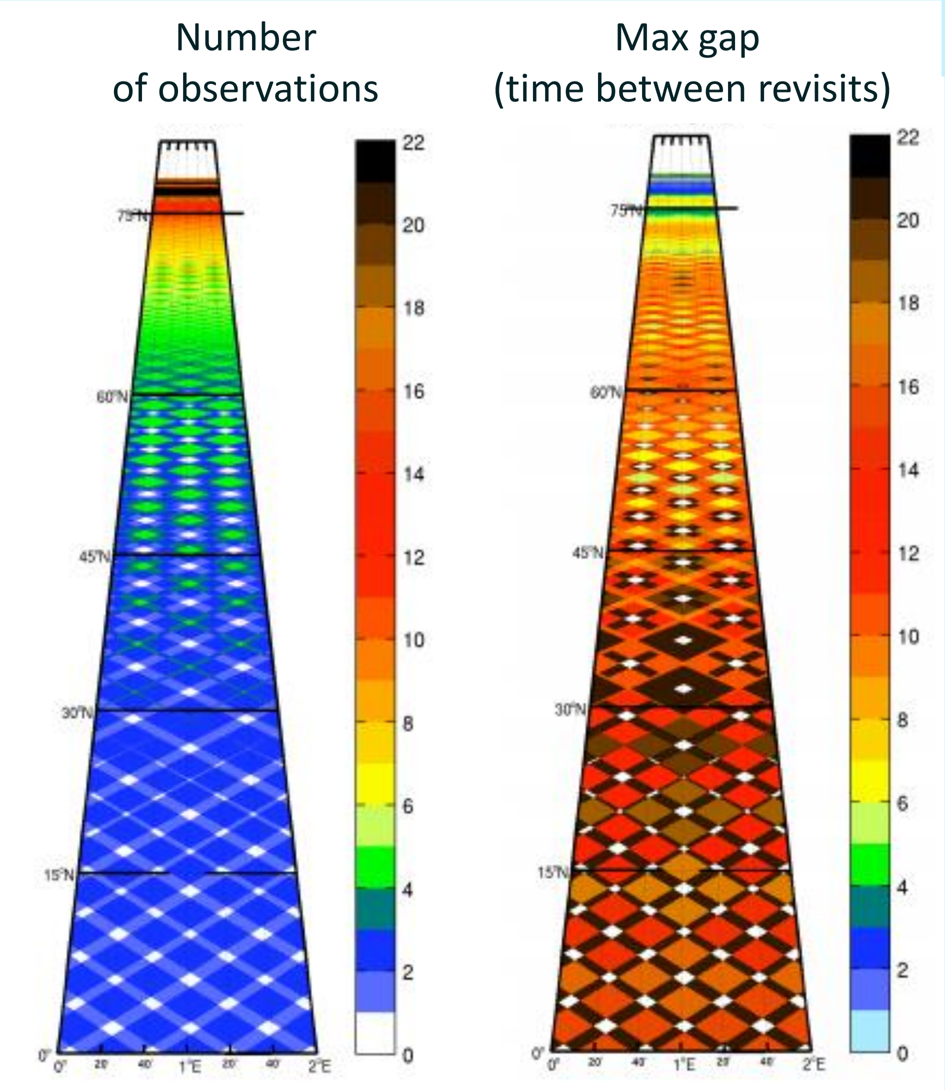
(Lee *et al*., 2010; Rodríguez, 2010)



(Fu and Ubelmann, 2013)

Satellite characteristics

- Higher spatial resolution than present day satellites:
  - Possible **15km wavelength** in most of the Ocean
- Not very good temporal resolution
  - Time between revisits **~10 days**, given its 21 day repeat cycle and swath overlap



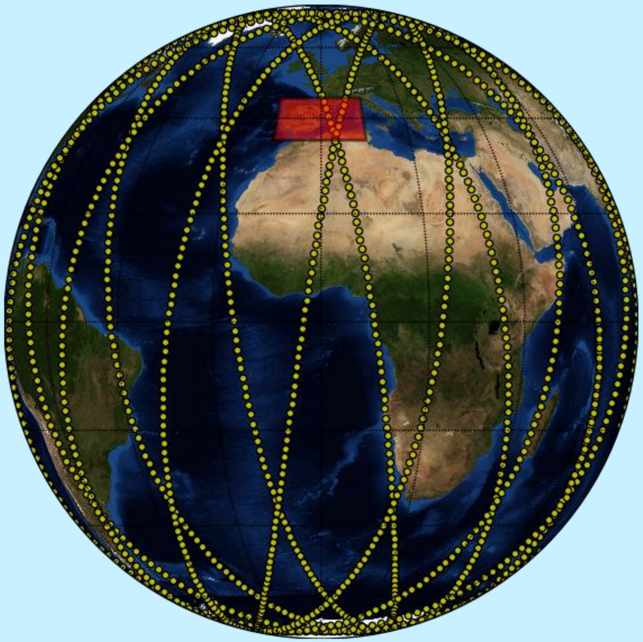
(Ubelmann *et al*, 2015)

(Fu and Morrow, 2016)

Satellite characteristics

- 2 orbits:
  - Fast-sampling phase: 60 days

    → SWOT **cal/val** tracks in the western Mediterranean:

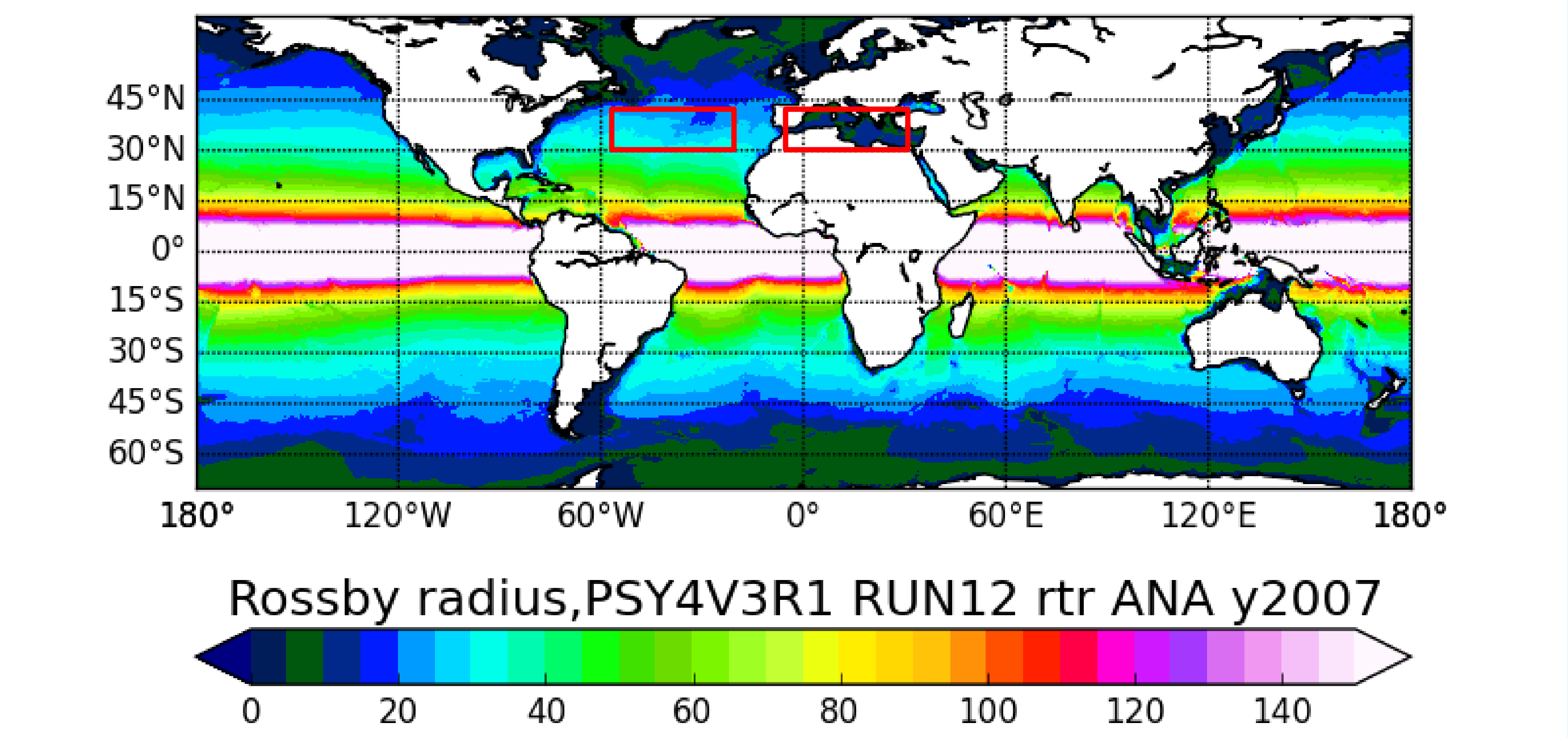


  - **Nominal phase:** 21-day repeat-cycle

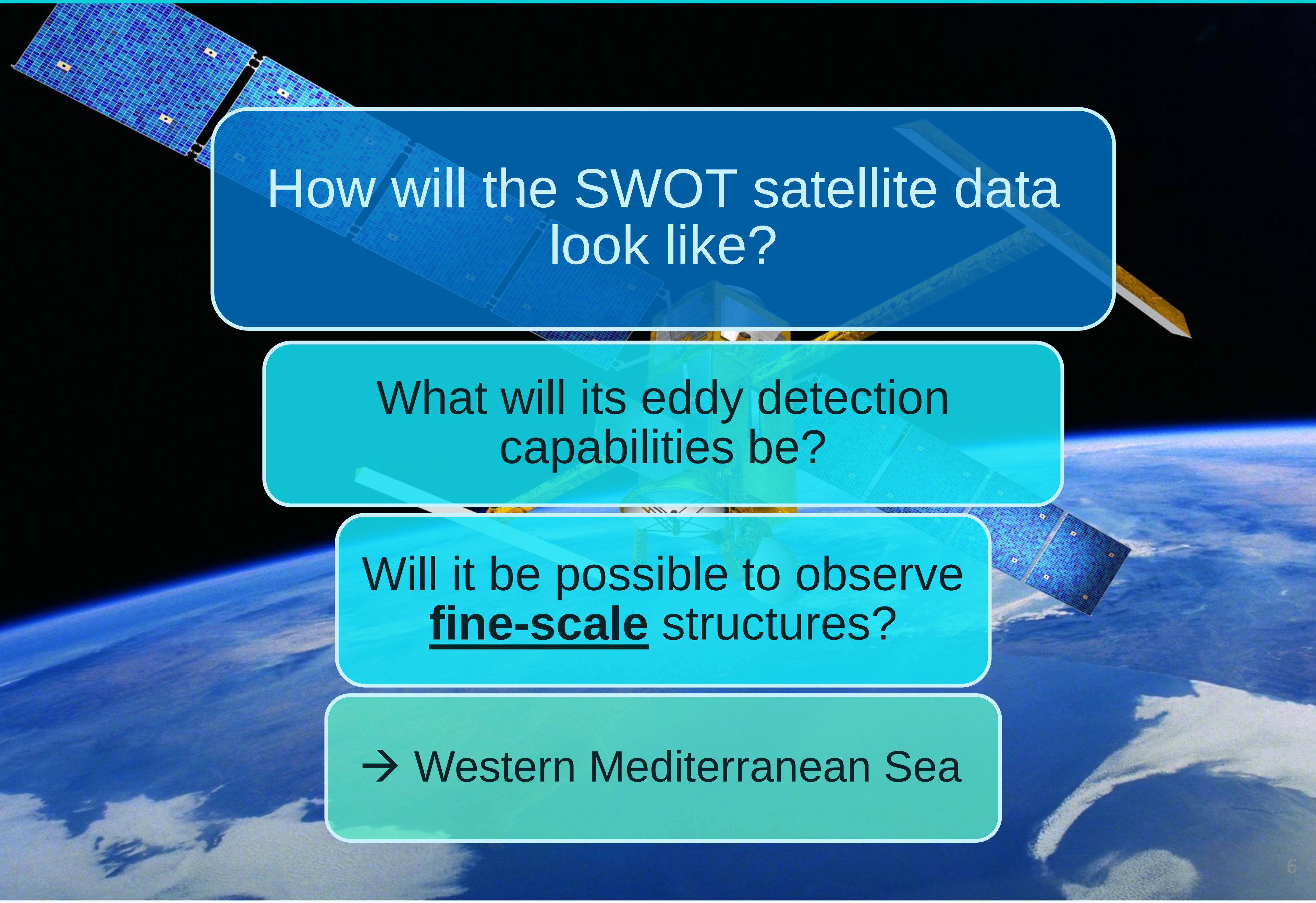
(Ubelmann *et al*, 2015)

Motivations

- Smaller structures in Med.:



First baroclinic deformation radius (km) from a numerical simulation (Copernicus Marine Service). Courtesy Angélique Melet (Mercator-Ocean)



How will the SWOT satellite data look like?

What will its eddy detection capabilities be?

Will it be possible to observe **fine-scale** structures?

→ Western Mediterranean Sea

The SWOT simulator

- Developed to simulate synthetic observations of SSH from SWOT

Caltech

Generates the domain and orbit specified grid files

OGCM input data linearly interpolated in space into the SWOT grid

Simulates SSH for each possible path in time + space domains → **Model interp.**

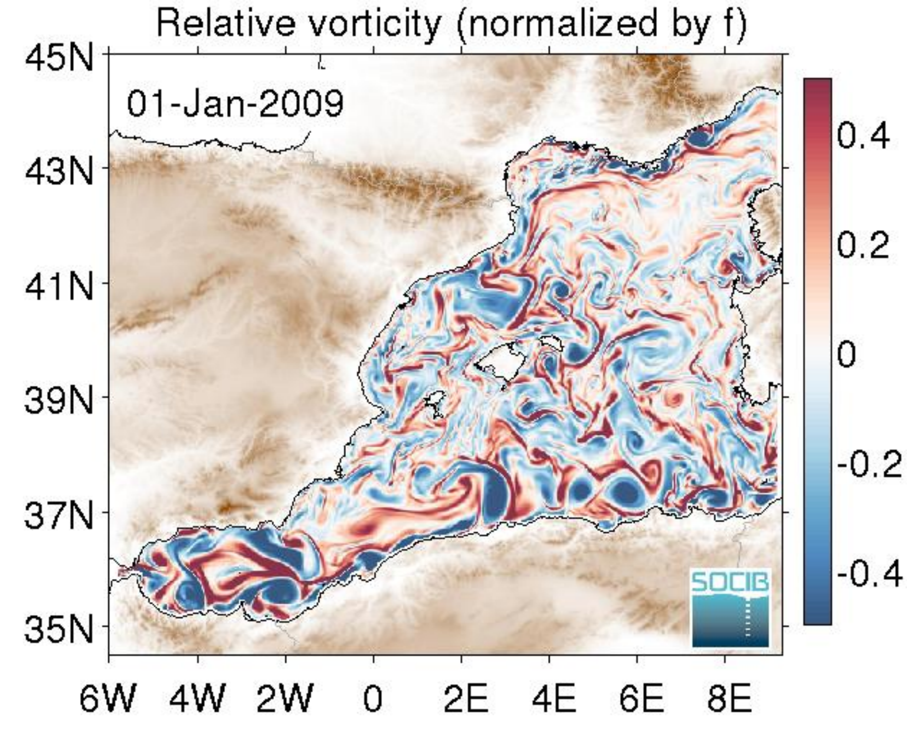
Adds measurement error + noise → **Pseudo-SWOT data**

(Gaultier, L., & Ubelmann, C., 2015)

Simulator input data: WMOP

- Western Mediterranean OPerational forecasting system (WMOP)
- Spatial resolution of ~**2 km** (Juza *et al.*, 2016)
- **2009 – 2015** hindcast
- High resolution weather forecast forcing:
  - Temporal: 3 hrs
  - Spatial: 5 km

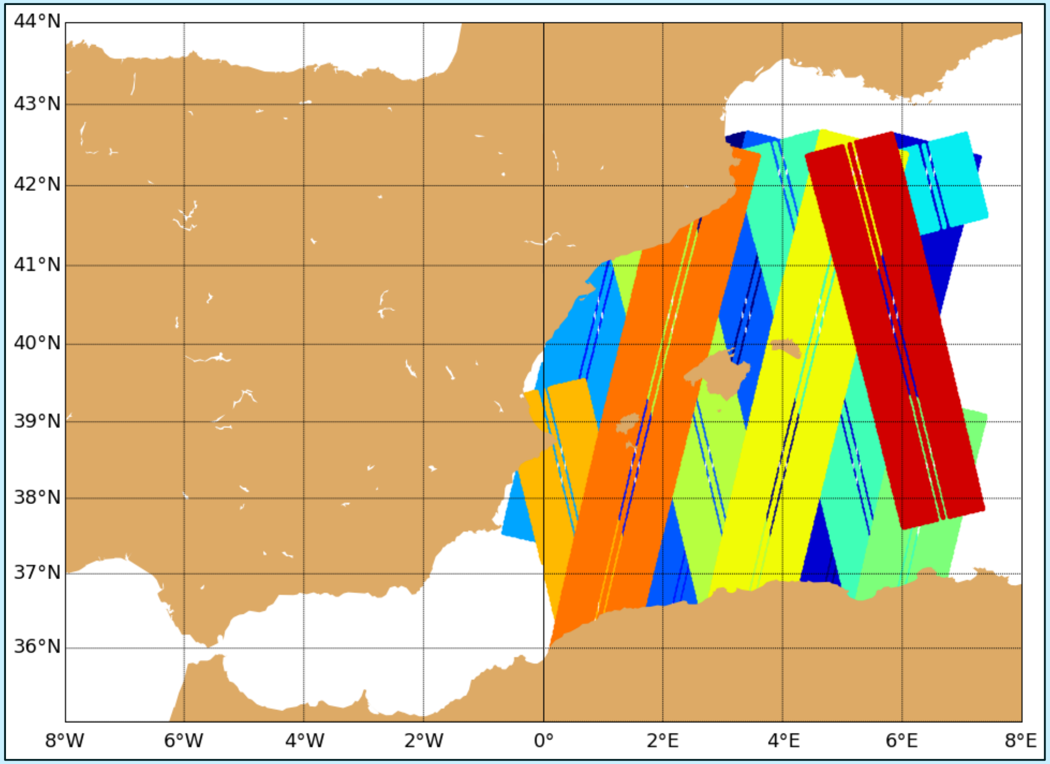
→ More energy: **Allows to resolve mesoscale and permit submesoscale**



(B. Mourre)

Simulator outputs

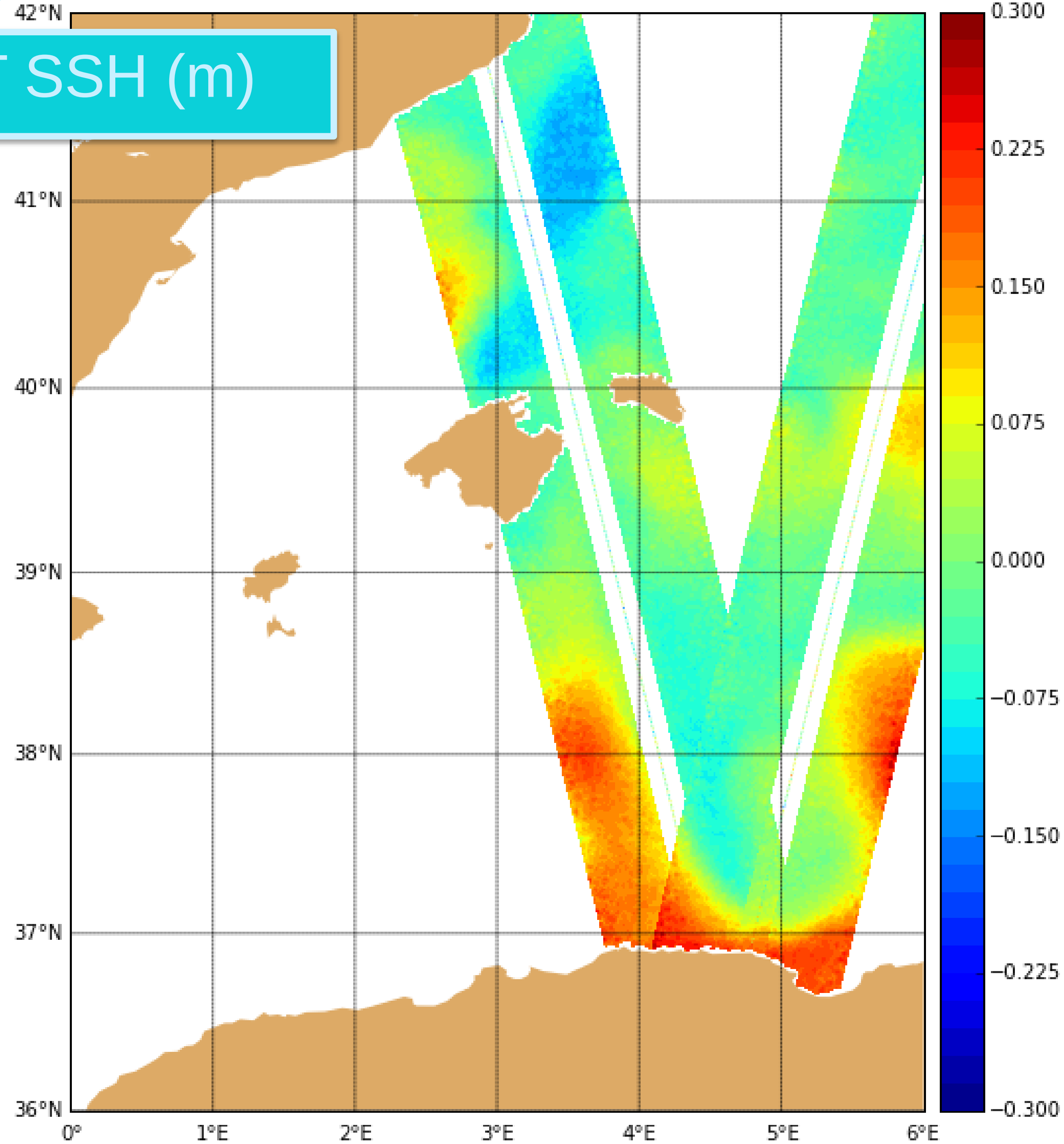
- Input files: daily WMOP hindcast → for whole period (2009-2015)
- Orbit: nominal (292 passes in total) → 14 in this region



(pass number)

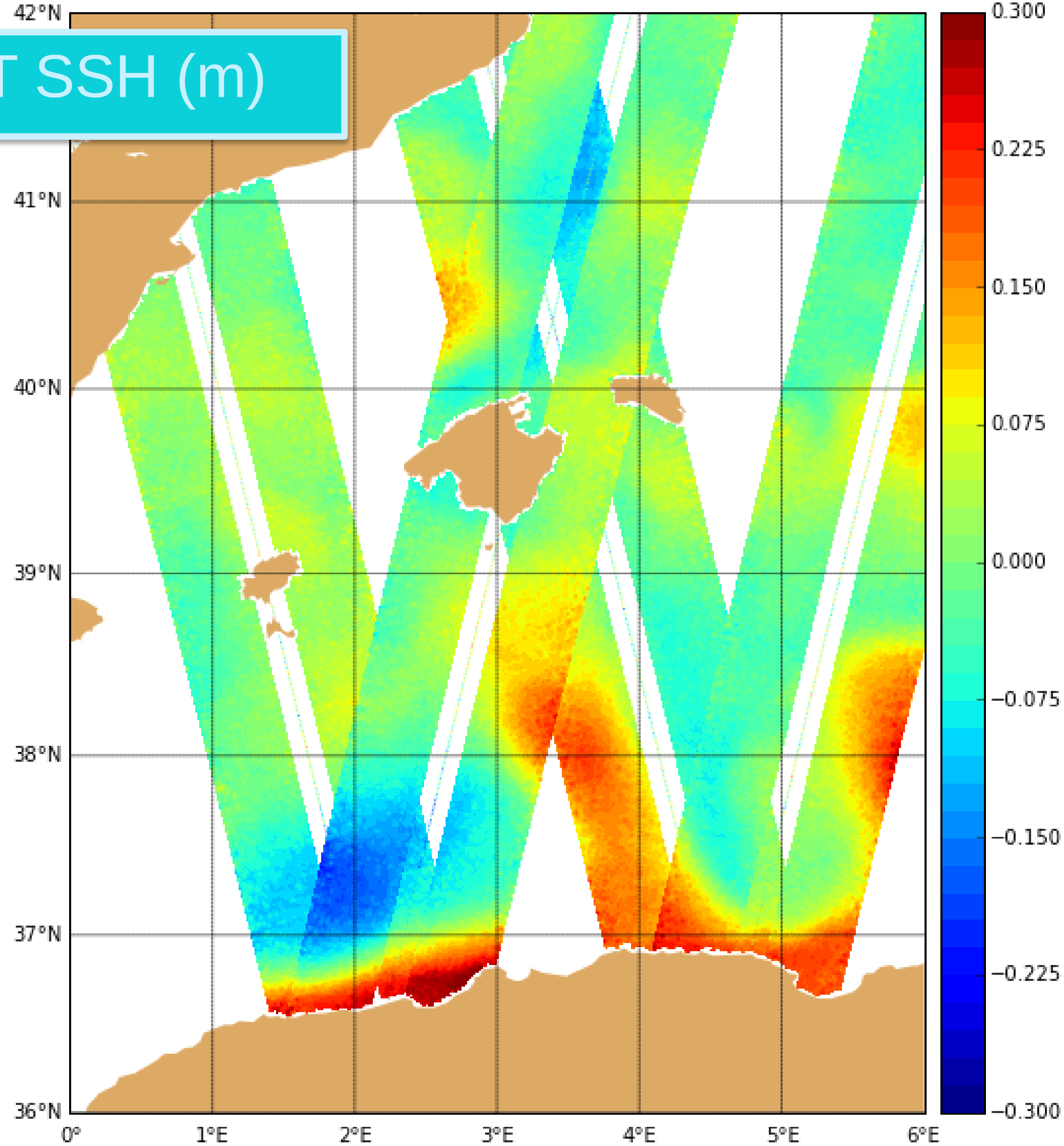
Pseudo-SWOT SSH (m)

Cycle 2: Day 1



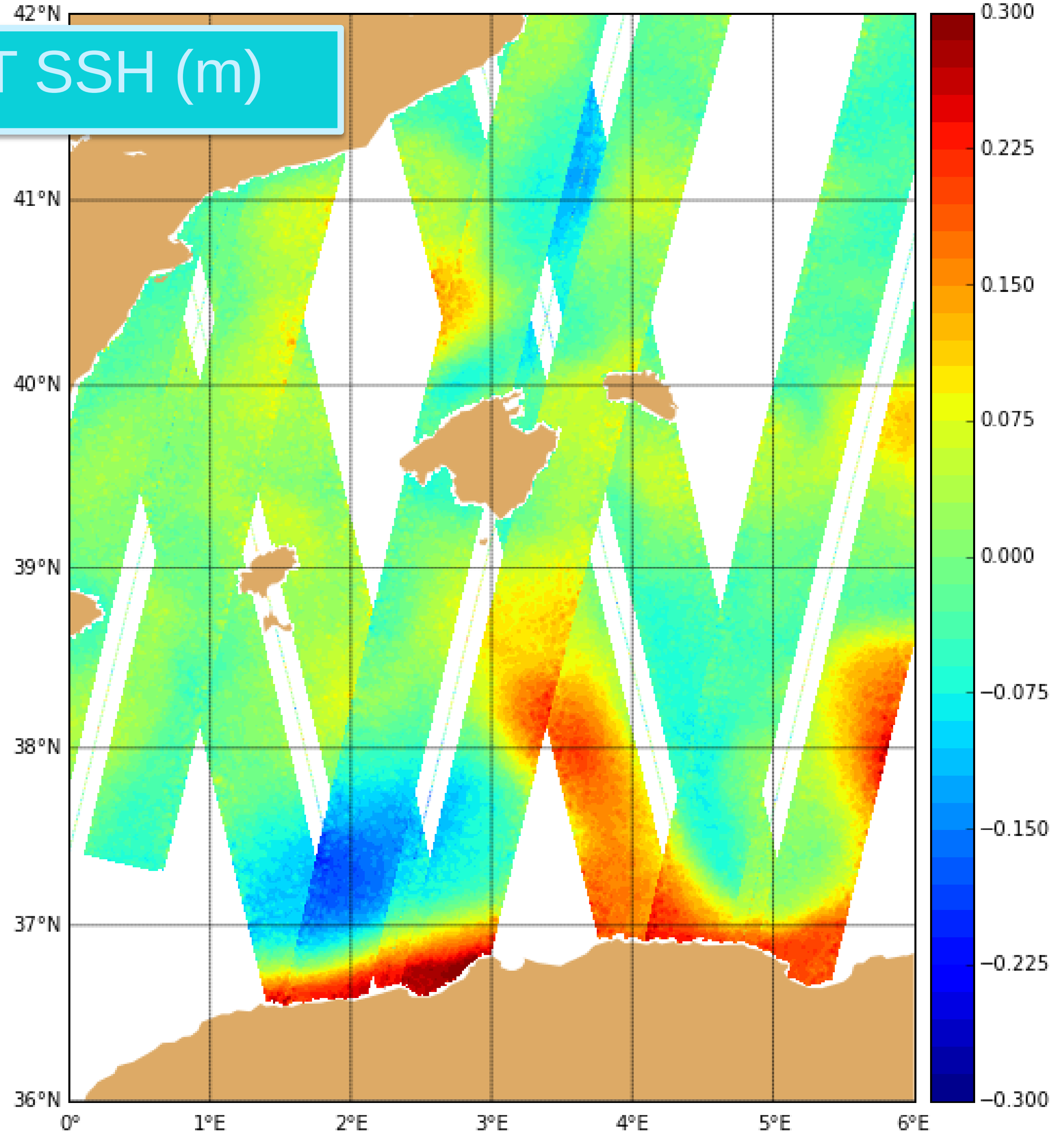
Pseudo-SWOT SSH (m)

Cycle 2:
Day 2



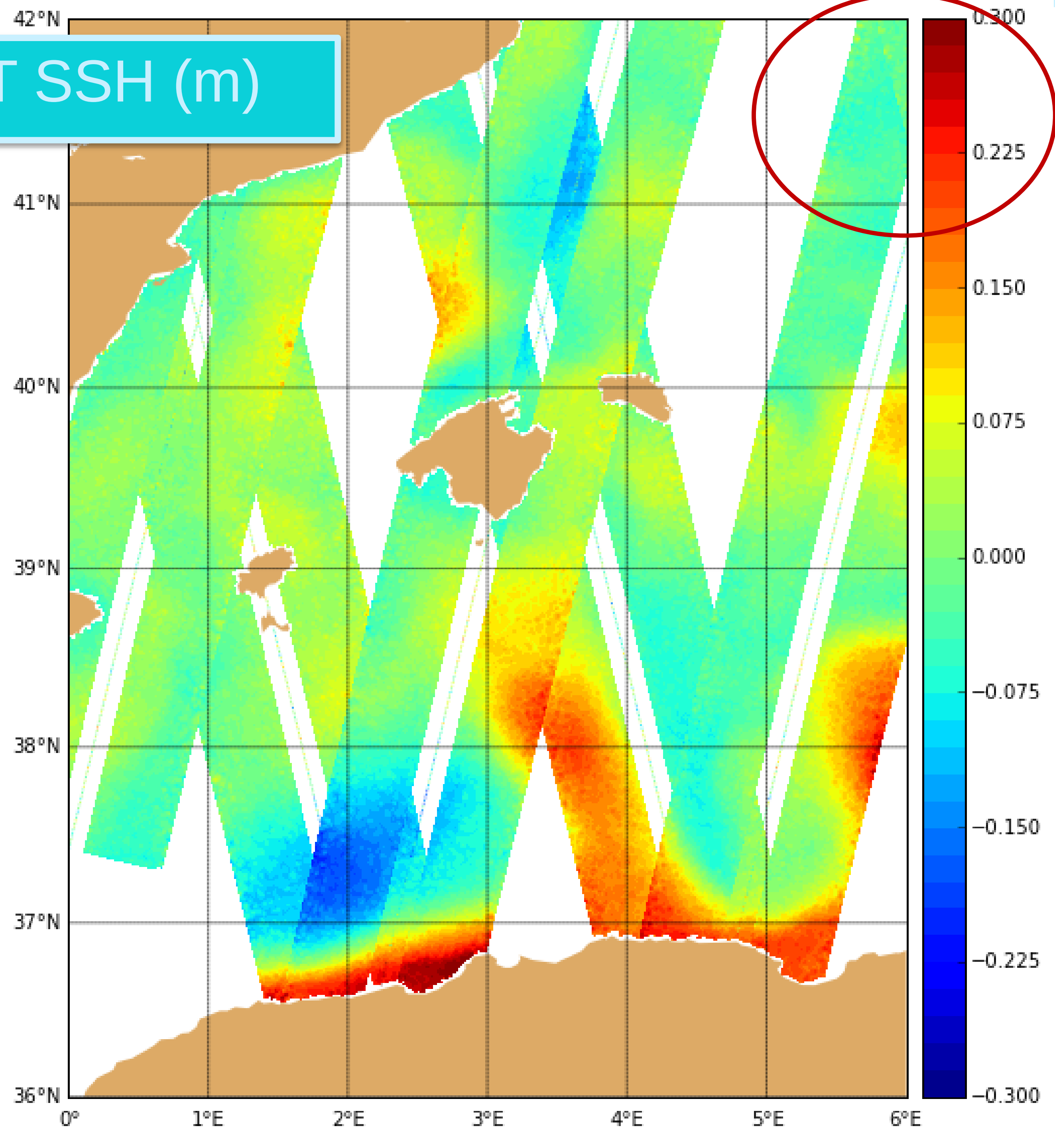
Pseudo-SWOT SSH (m)

Cycle 2:
Day 3



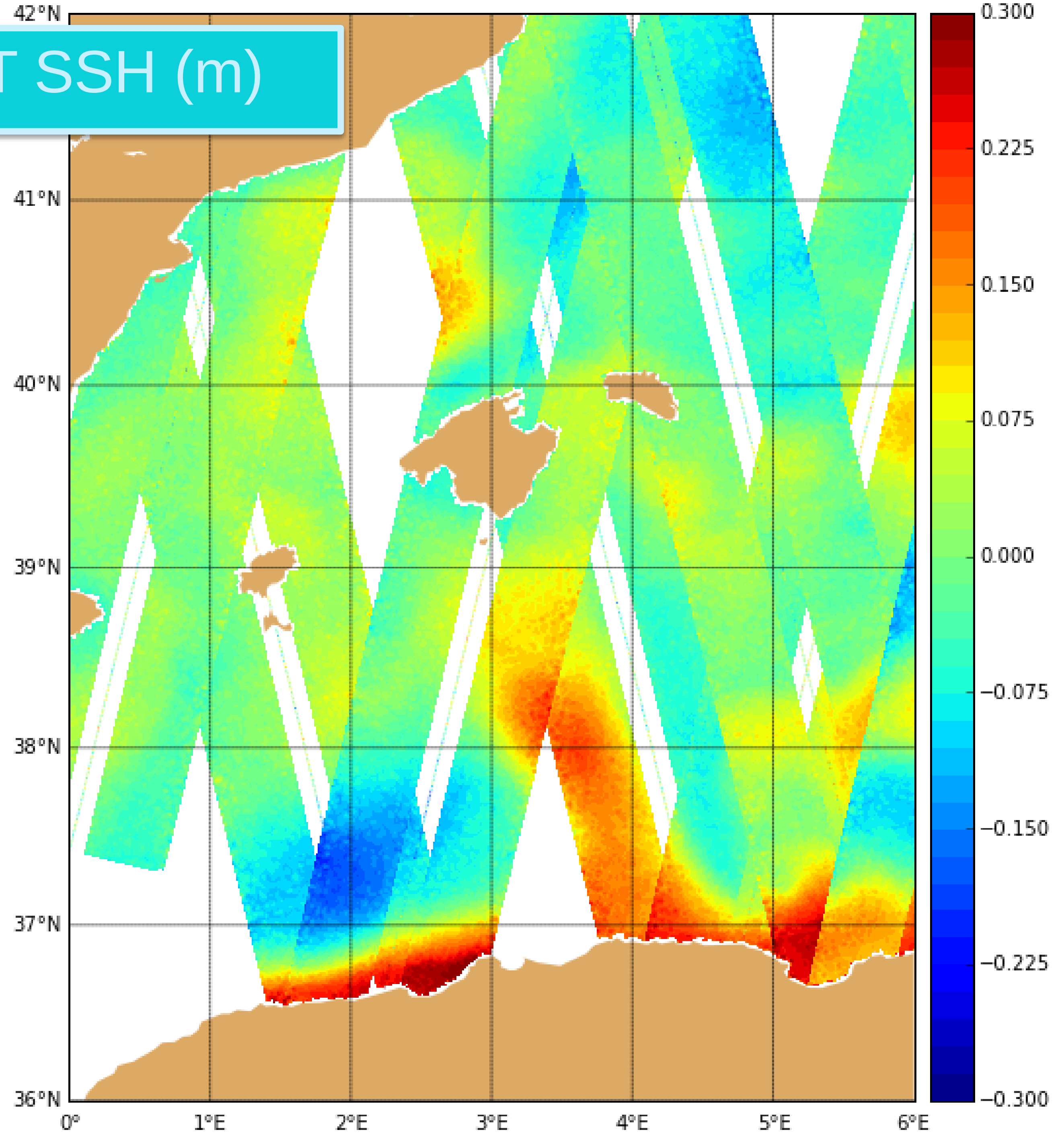
Pseudo-SWOT SSH (m)

Cycle 2: Day 10



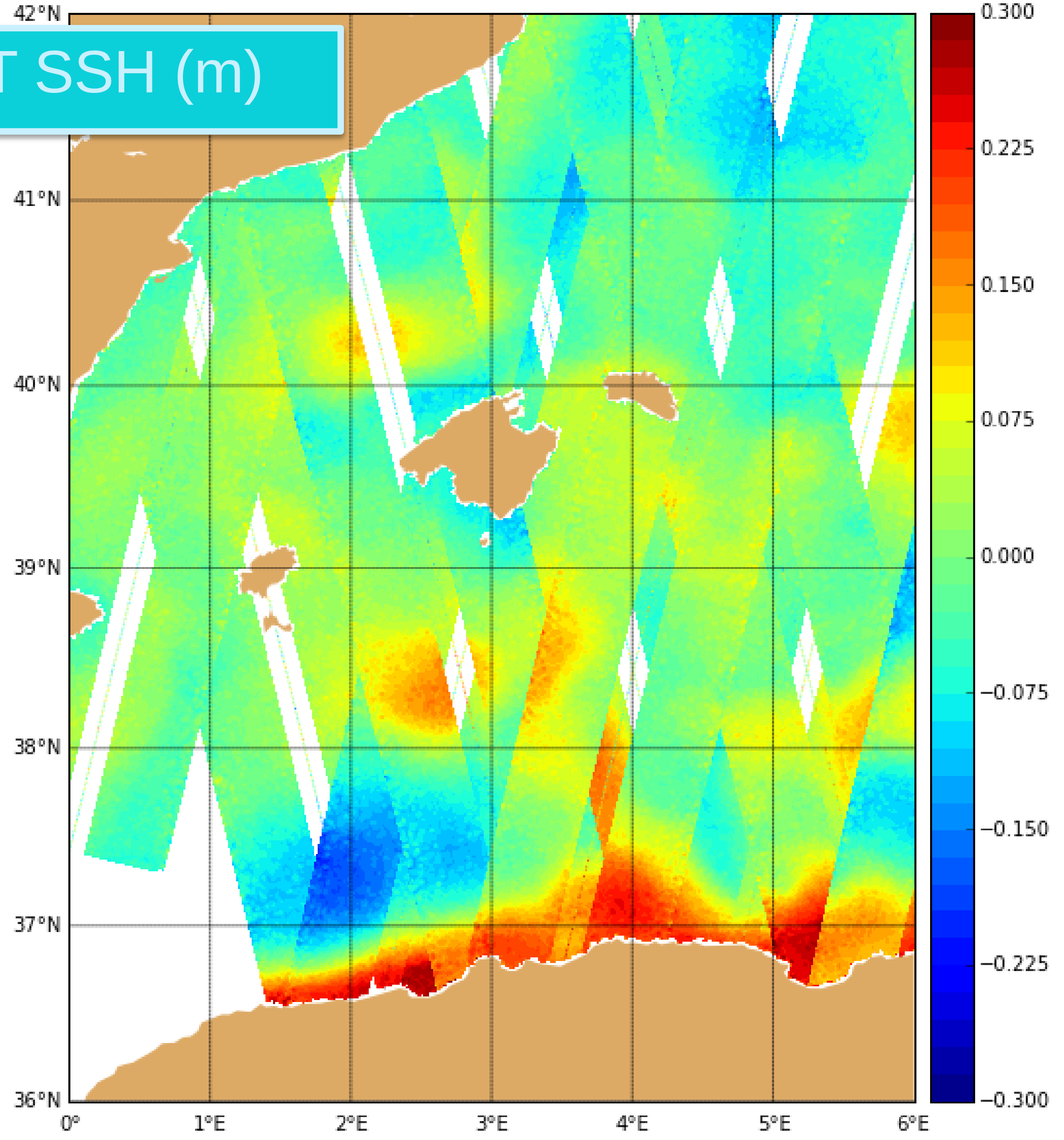
Pseudo-SWOT SSH (m)

Cycle 2: Day 11



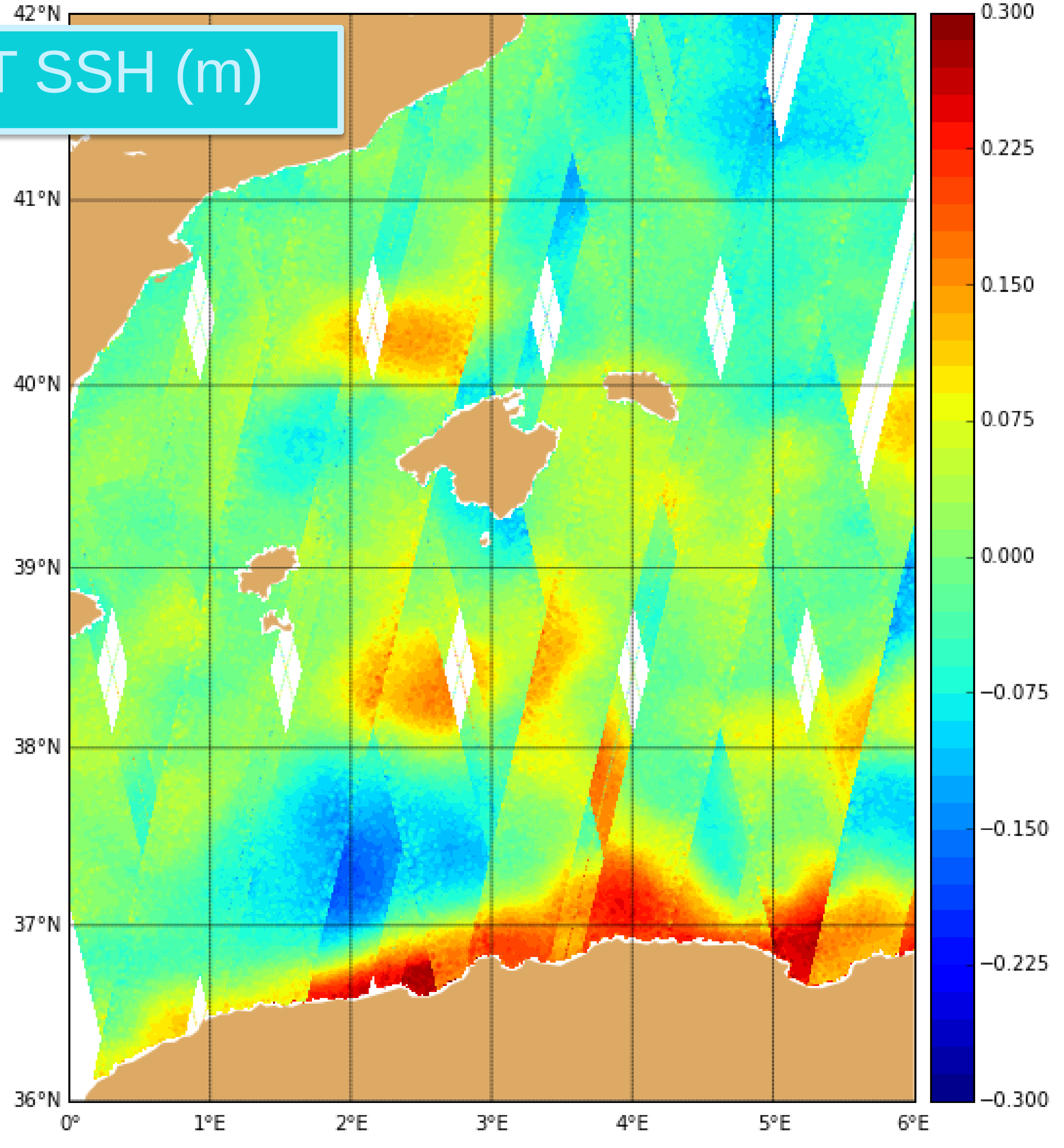
Pseudo-SWOT SSH (m)

Cycle 2:
Day 12



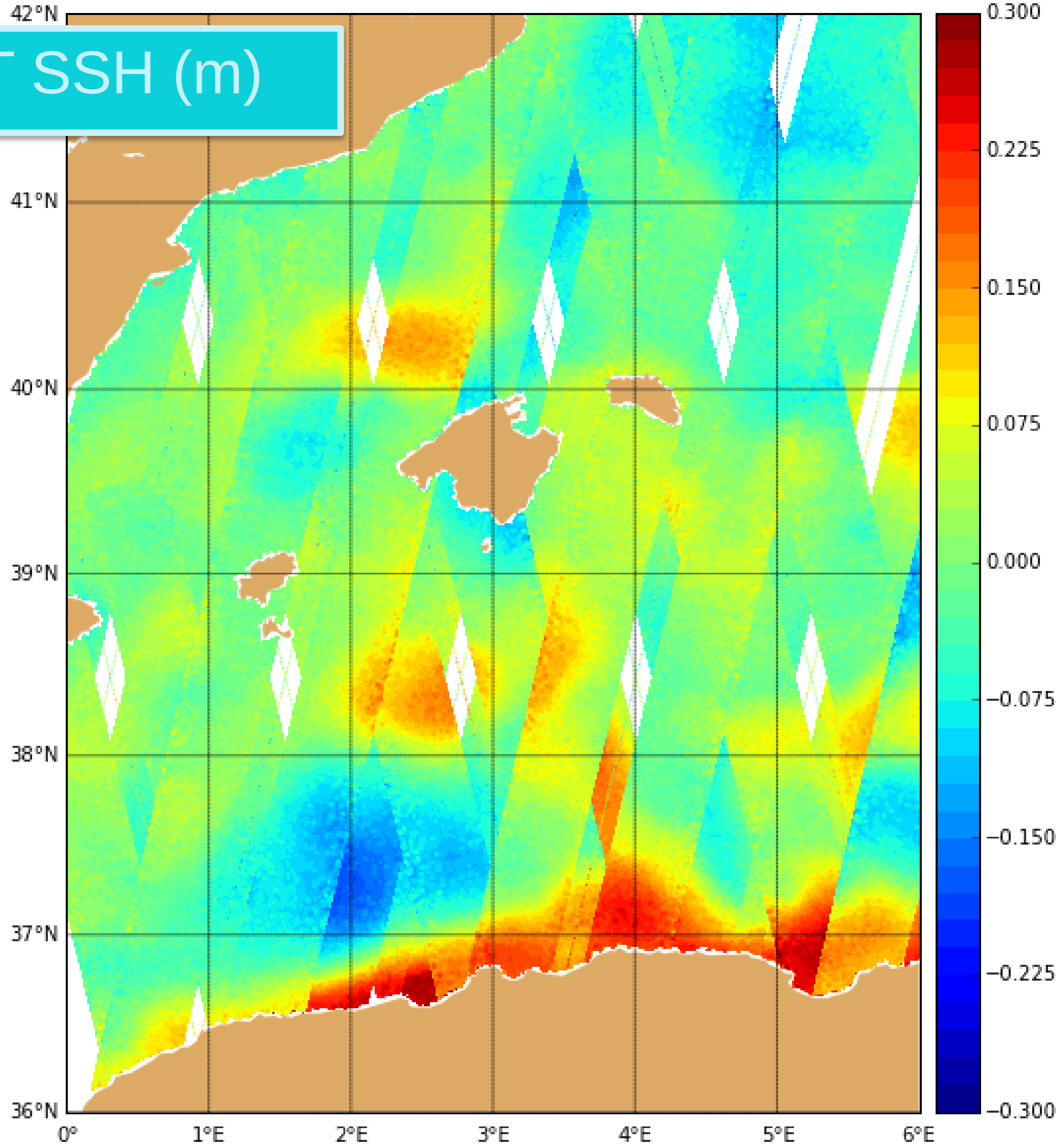
Pseudo-SWOT SSH (m)

Cycle 2:
Day 13



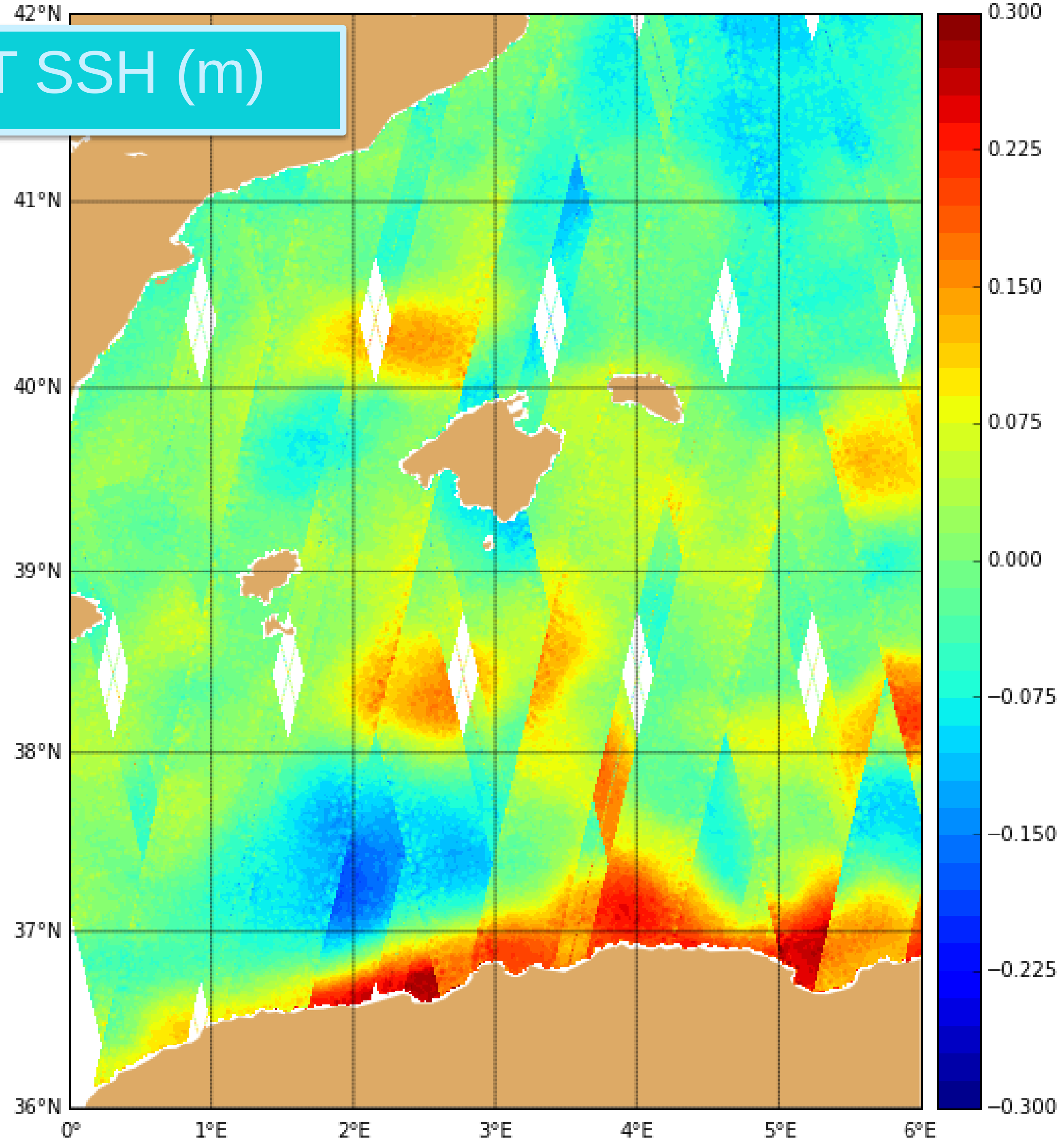
Pseudo-SWOT SSH (m)

Cycle 2:
Day 14



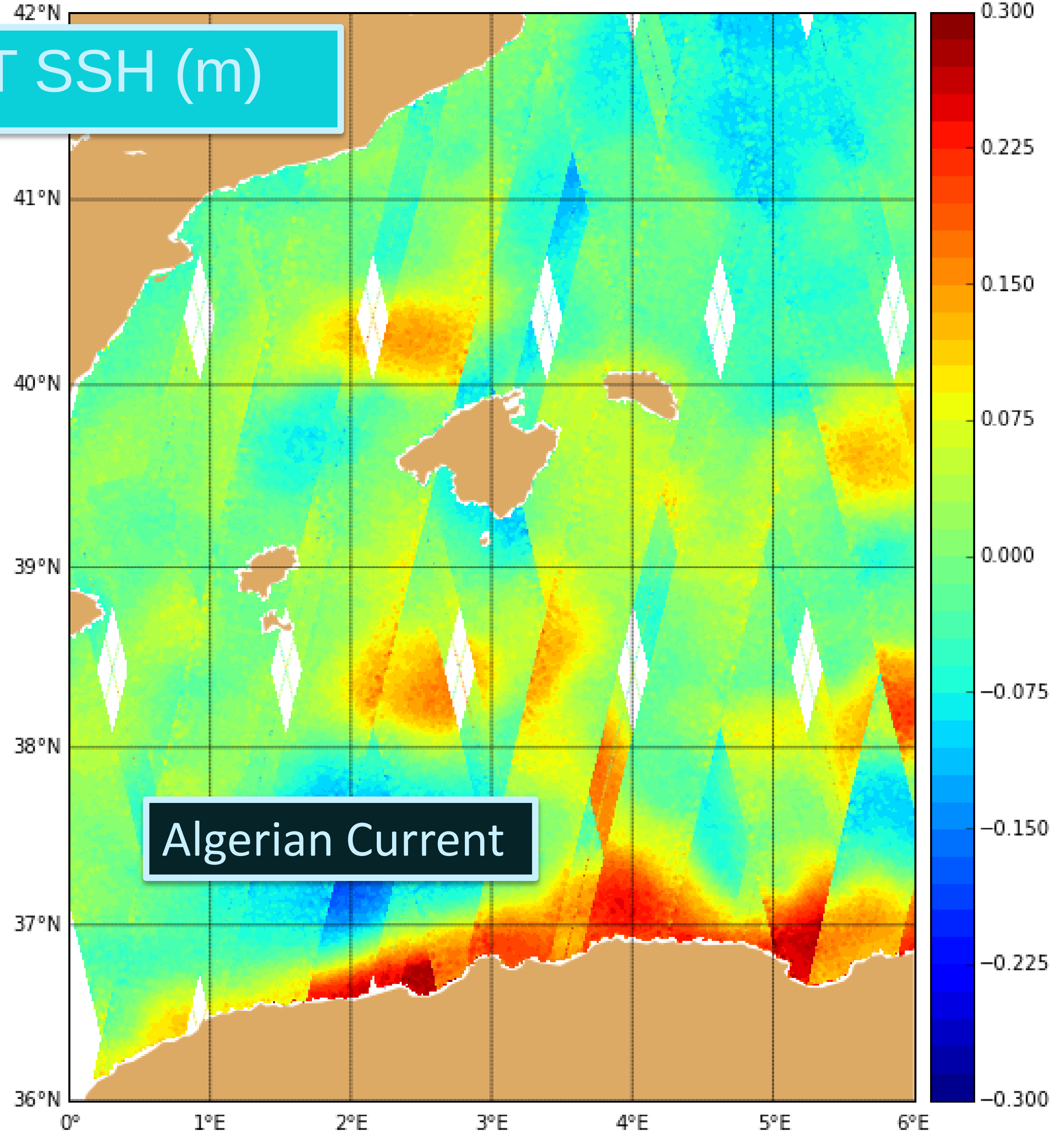
Pseudo-SWOT SSH (m)

Cycle 2:
Day 21



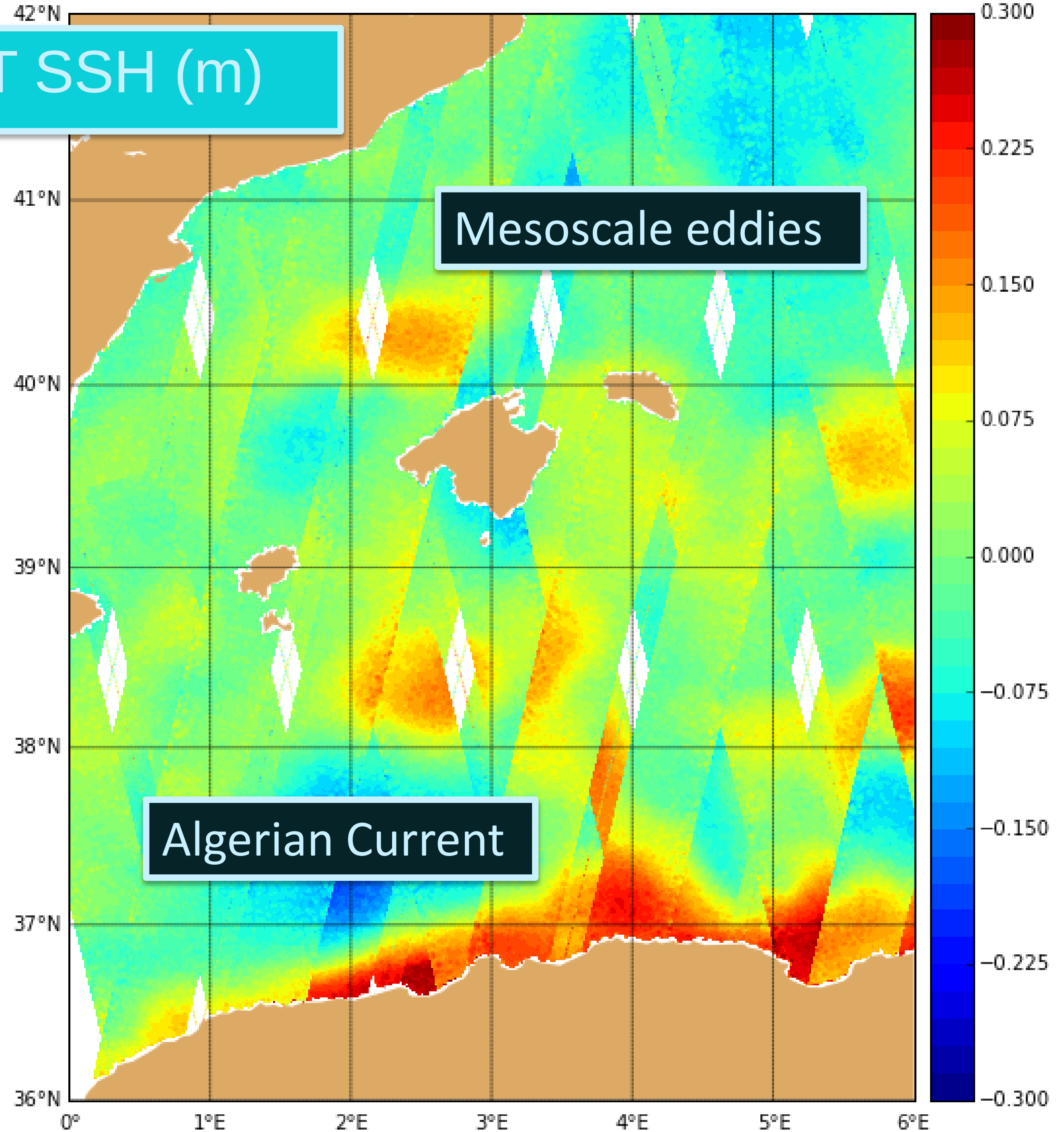
Pseudo-SWOT SSH (m)

Cycle 2: Day 21



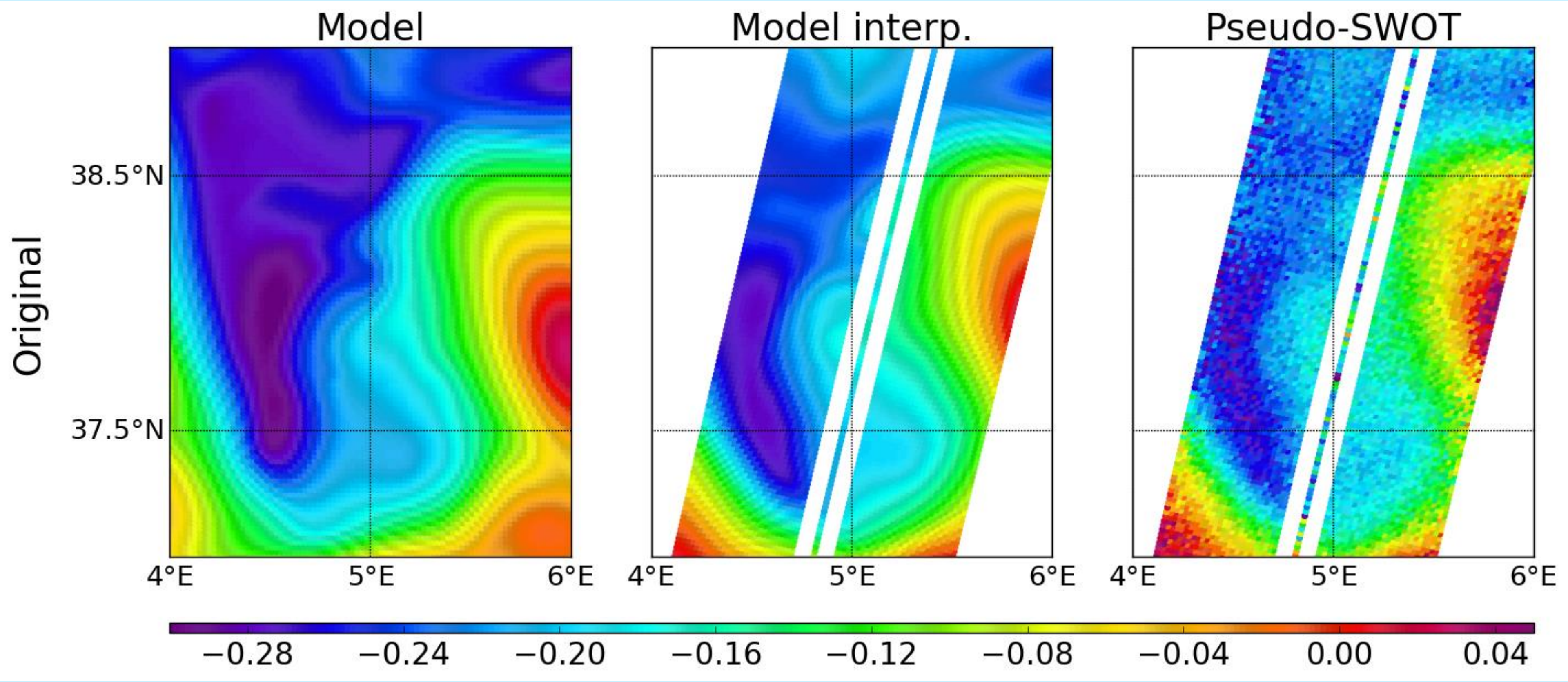
Pseudo-SWOT SSH (m)

Cycle 2: Day 21



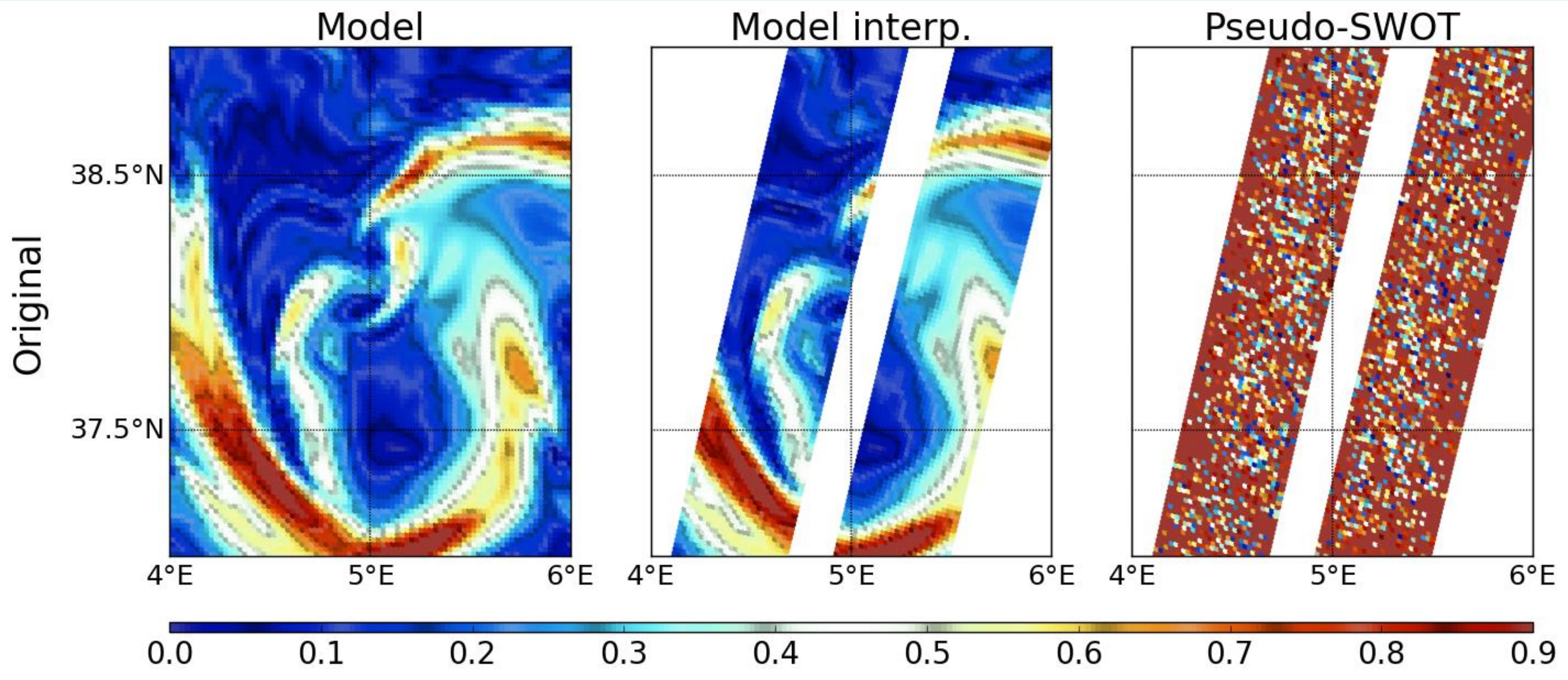
Simulator outputs

- Day 2. Cycle 2 pass 15:
  - ADT (m)



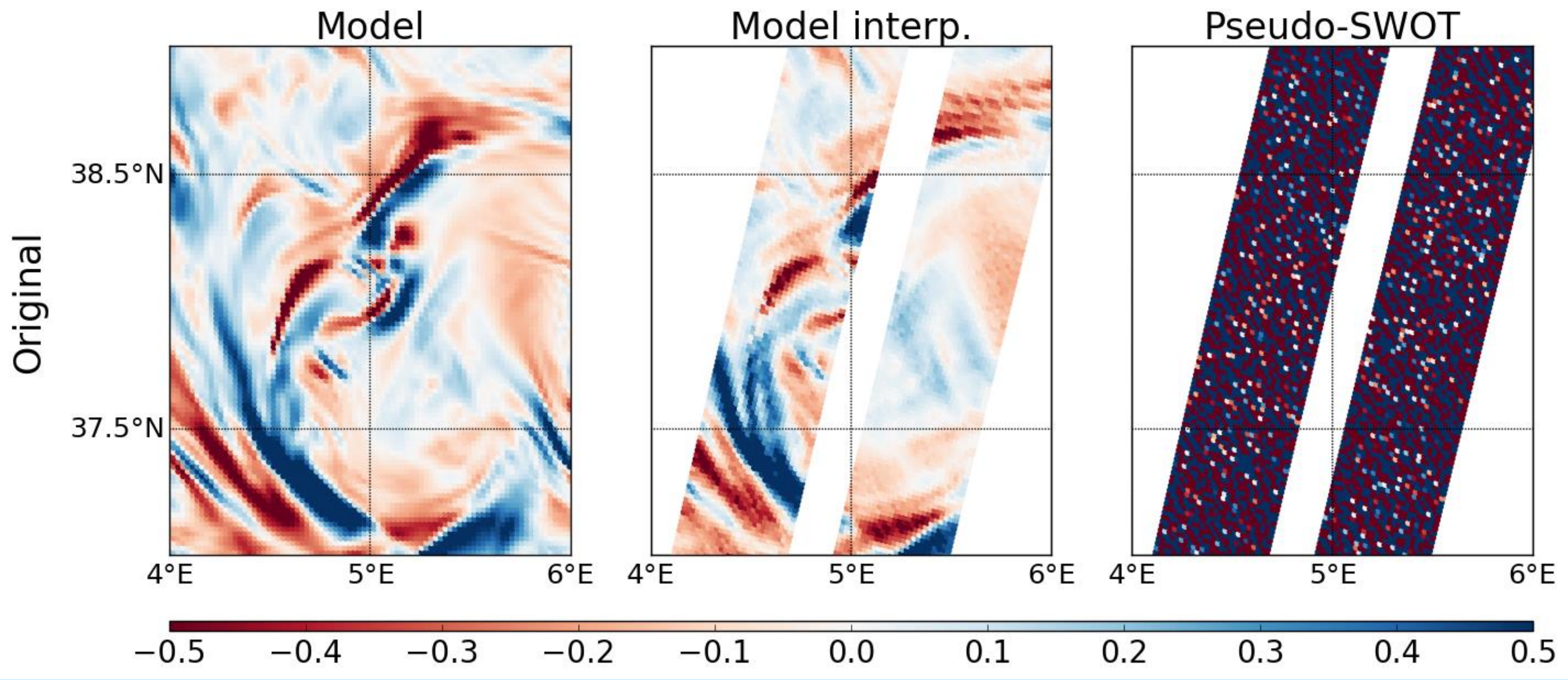
Simulator outputs

- Day 2. Cycle 2 pass 15:
  - Absolute geostrophic velocity (m/s)



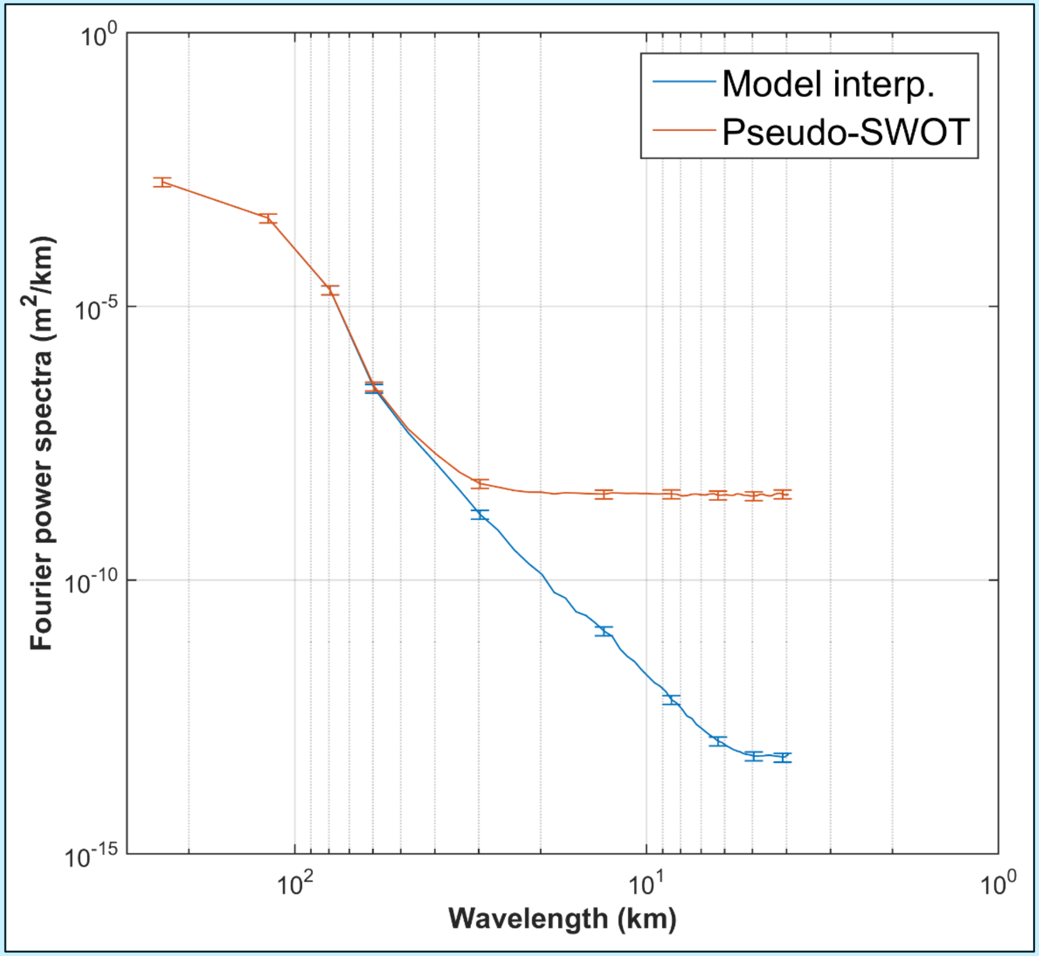
Simulator outputs

- Day 2. Cycle 2 pass 15:
  - Relative vorticity (normalized by f)



Simulator outputs

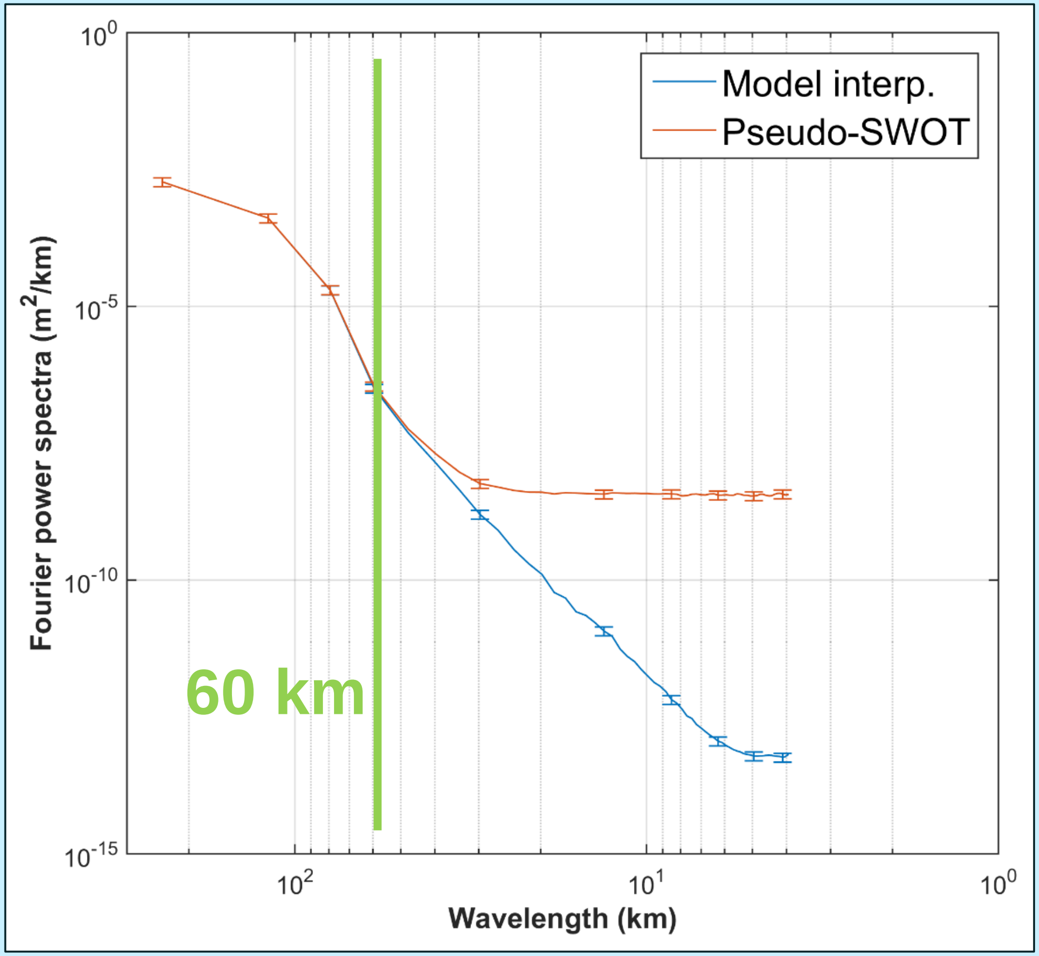
- Pass 15 ADT spectra: (117 cycles temporal mean)



* Errorbars denote 95% confidence interval

Simulator outputs

- Pass 15 ADT spectra: (117 cycles temporal mean)



* Errorbars denote 95% confidence interval

Simulator outputs

- Filtering: Laplacian diffusion
  - Low-pass filtering method which as a smoothing PDE uses the heat equation:

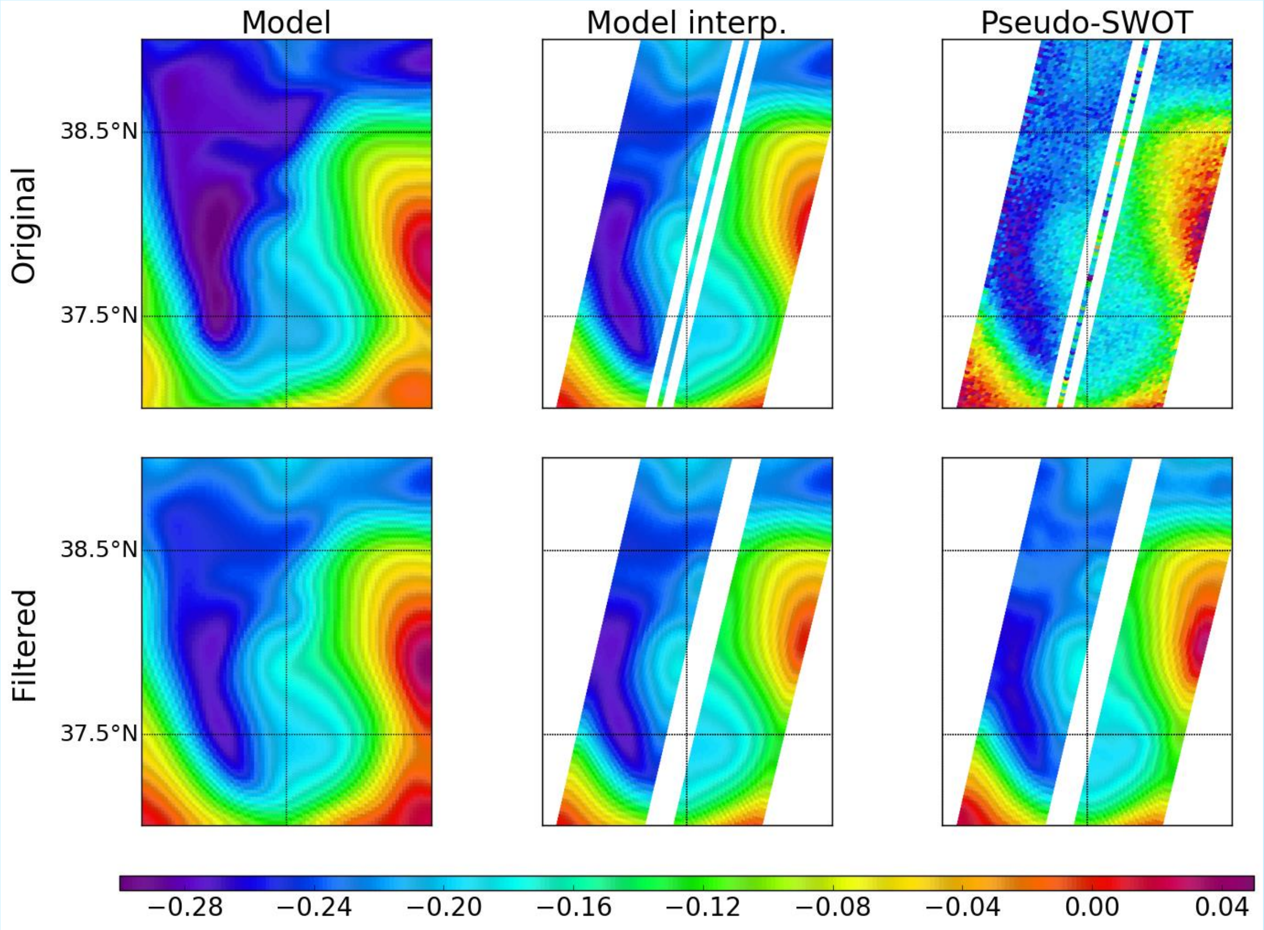
$$\partial_t u(t,x) - \Delta u(t,x) = 0 \iff \partial_t u = \frac{\partial^2 u}{\partial t^2} + \frac{\partial^2 u}{\partial x^2}$$

  - Isotropic method (acts equally in all directions)
  - 2 cut-off wavelengths:
    - 30 km
    - 60 km

Simulator outputs

- Filtering
  - Cut-off wavelength of about 30 km:

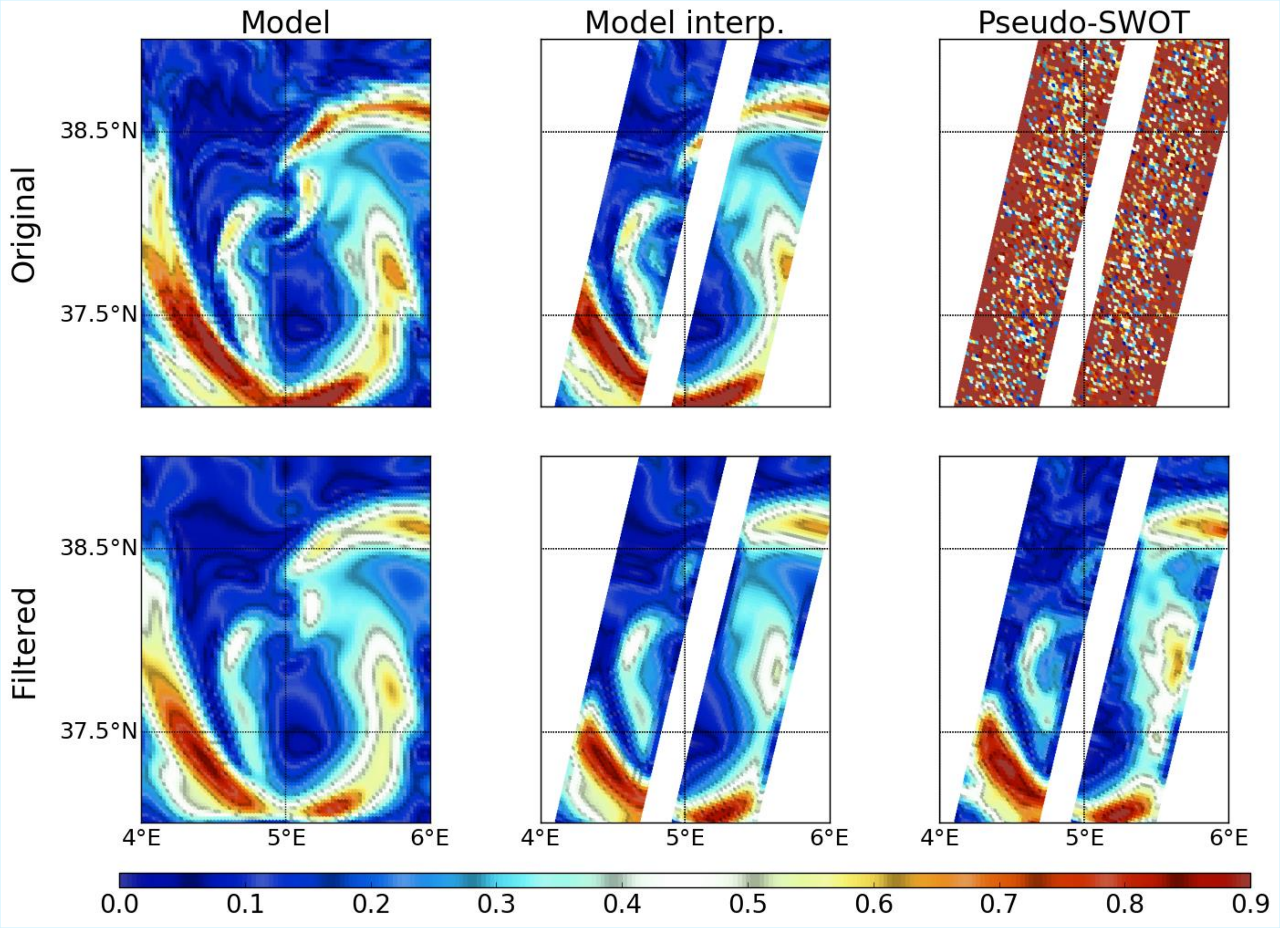
ADT (m)



Simulator outputs

- Filtering
  - Cut-off wavelength of about 30 km:

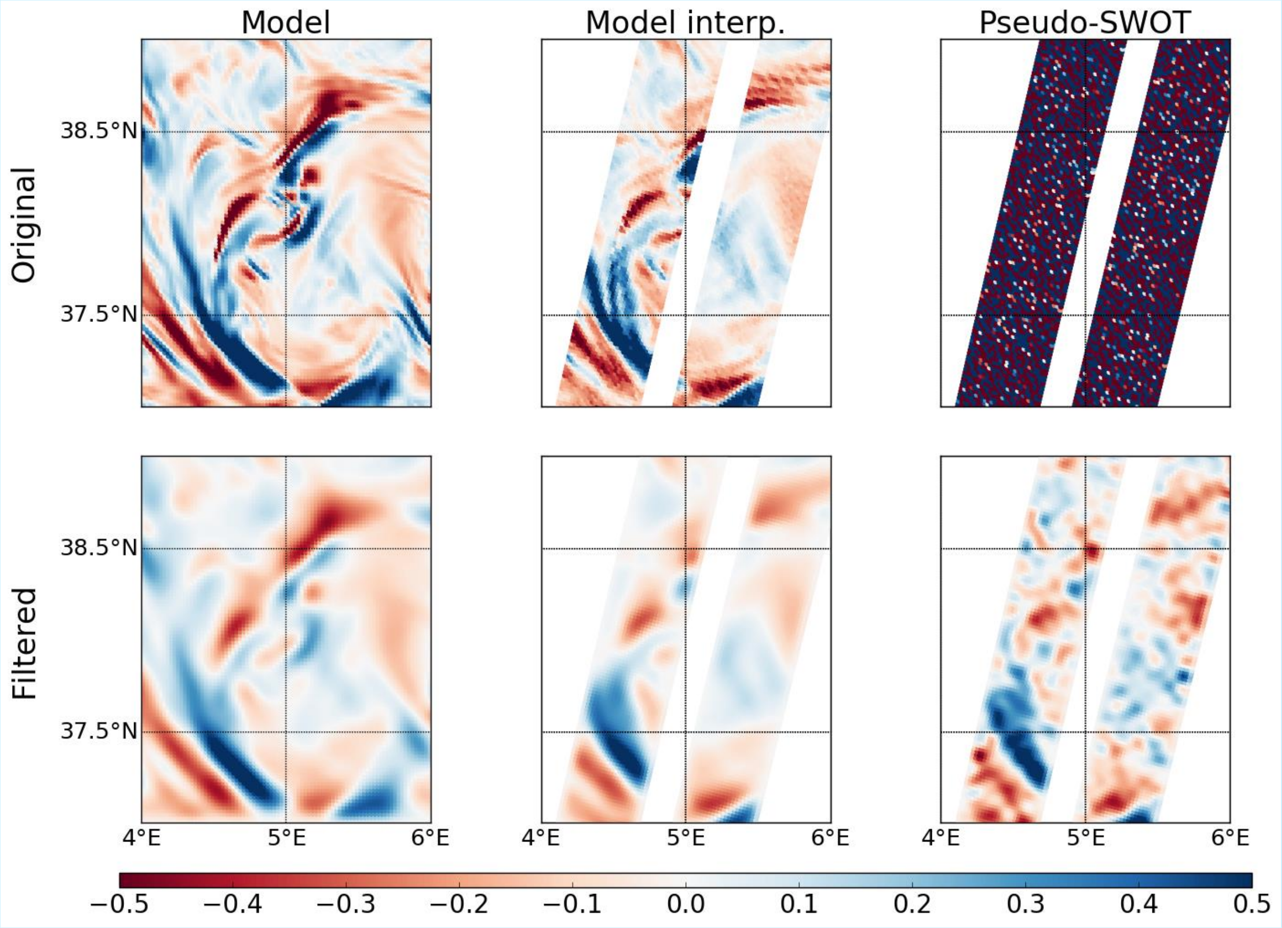
Absolute geostrophic velocity (m/s)



Simulator outputs

- Filtering
  - Cut-off wavelength of about 30 km:

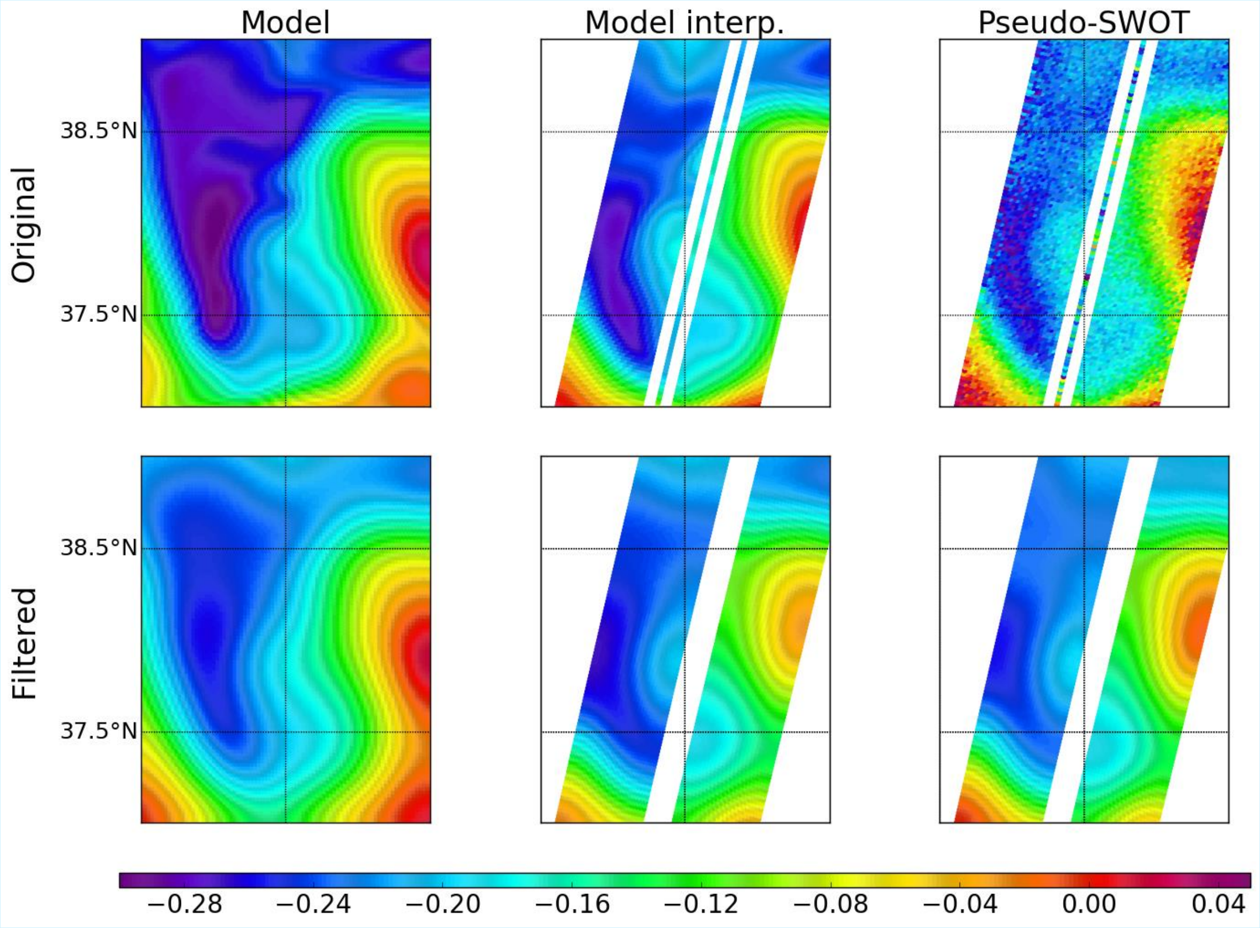
Relative vorticity (normalized by f)



Simulator outputs

- Filtering
  - Cut-off wavelength of about 60 km:

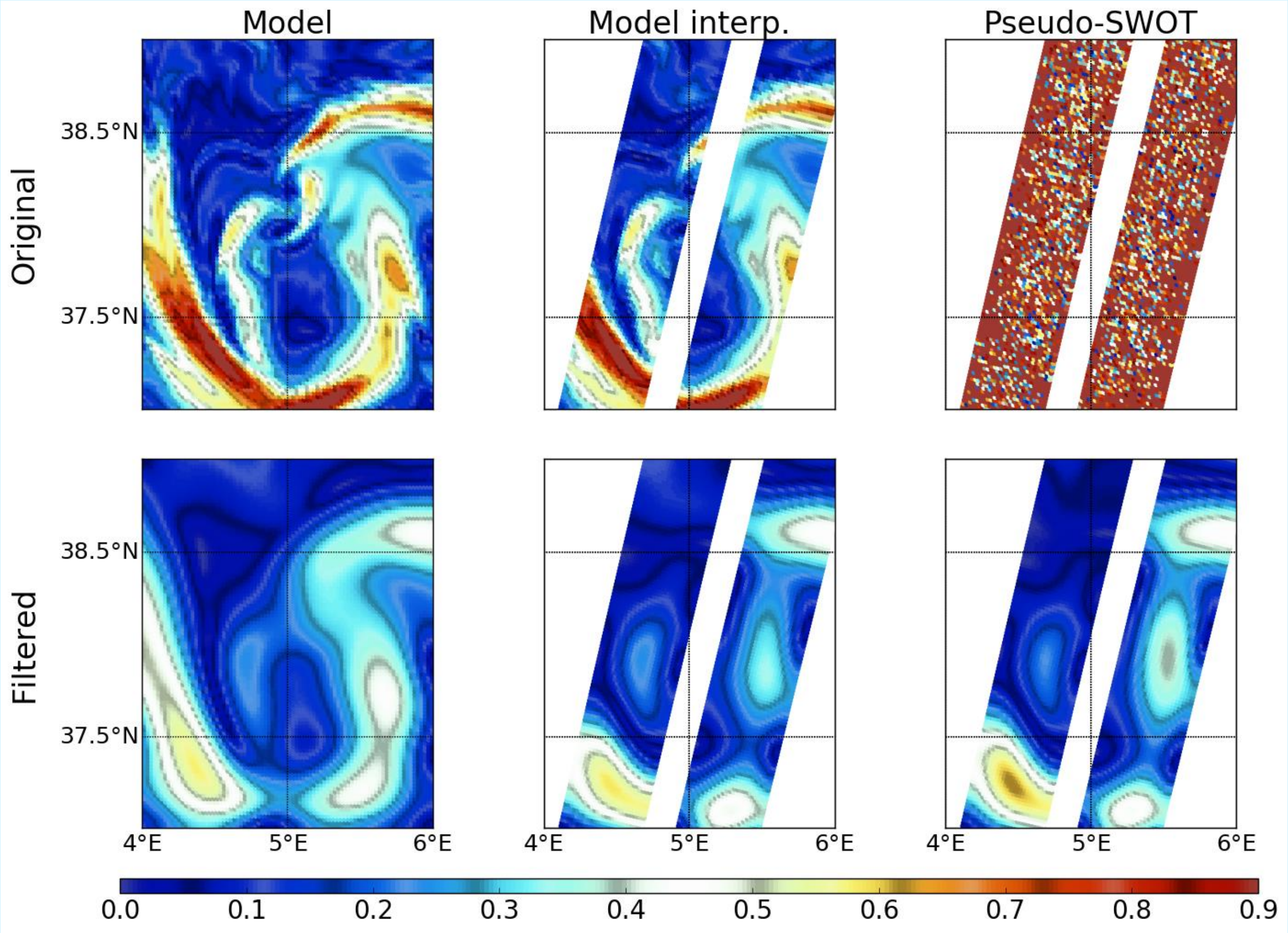
ADT (m)



Simulator outputs

- Filtering
  - Cut-off wavelength of about 60 km:

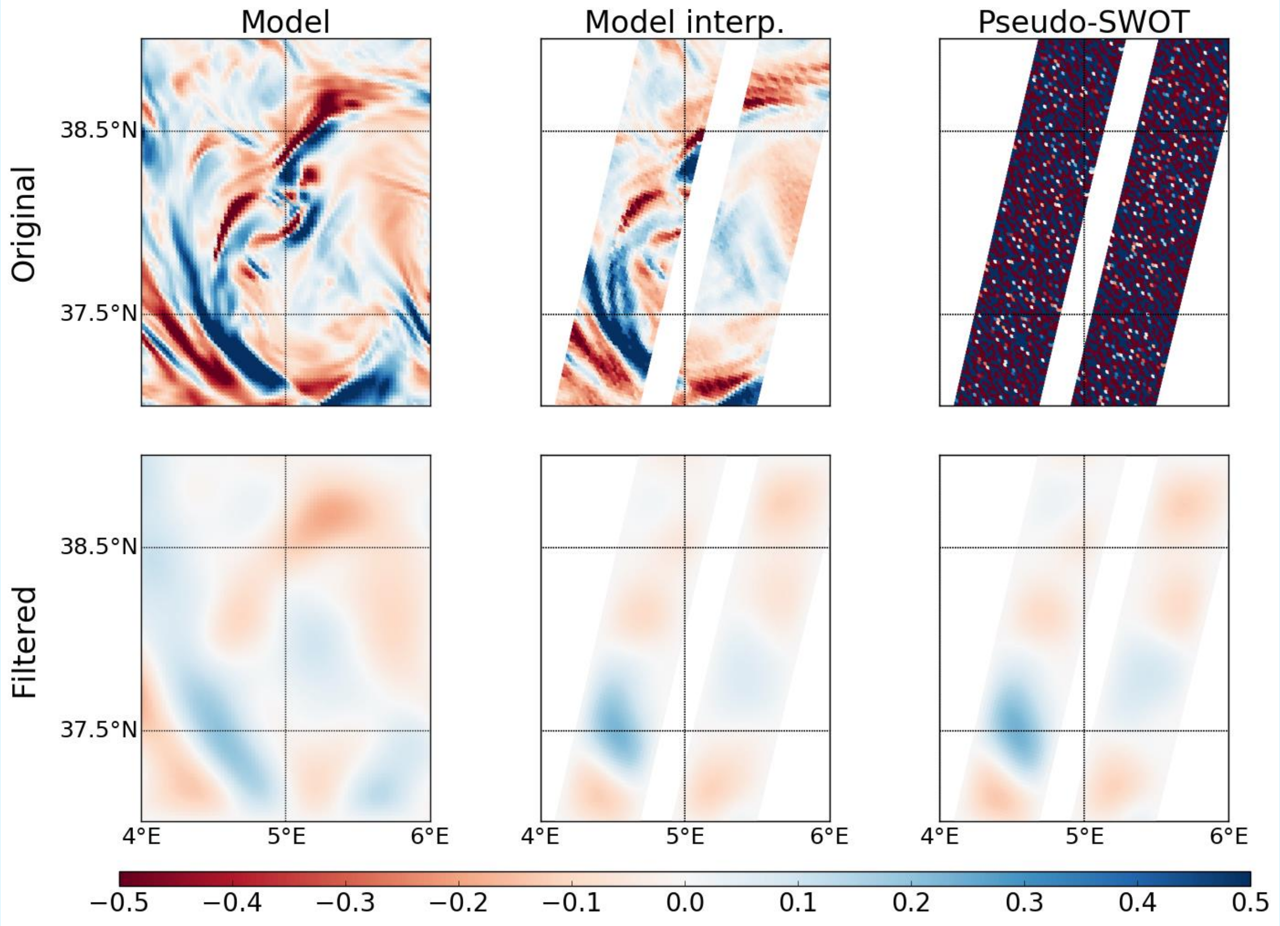
Absolute geostrophic velocity (m/s)



Simulator outputs

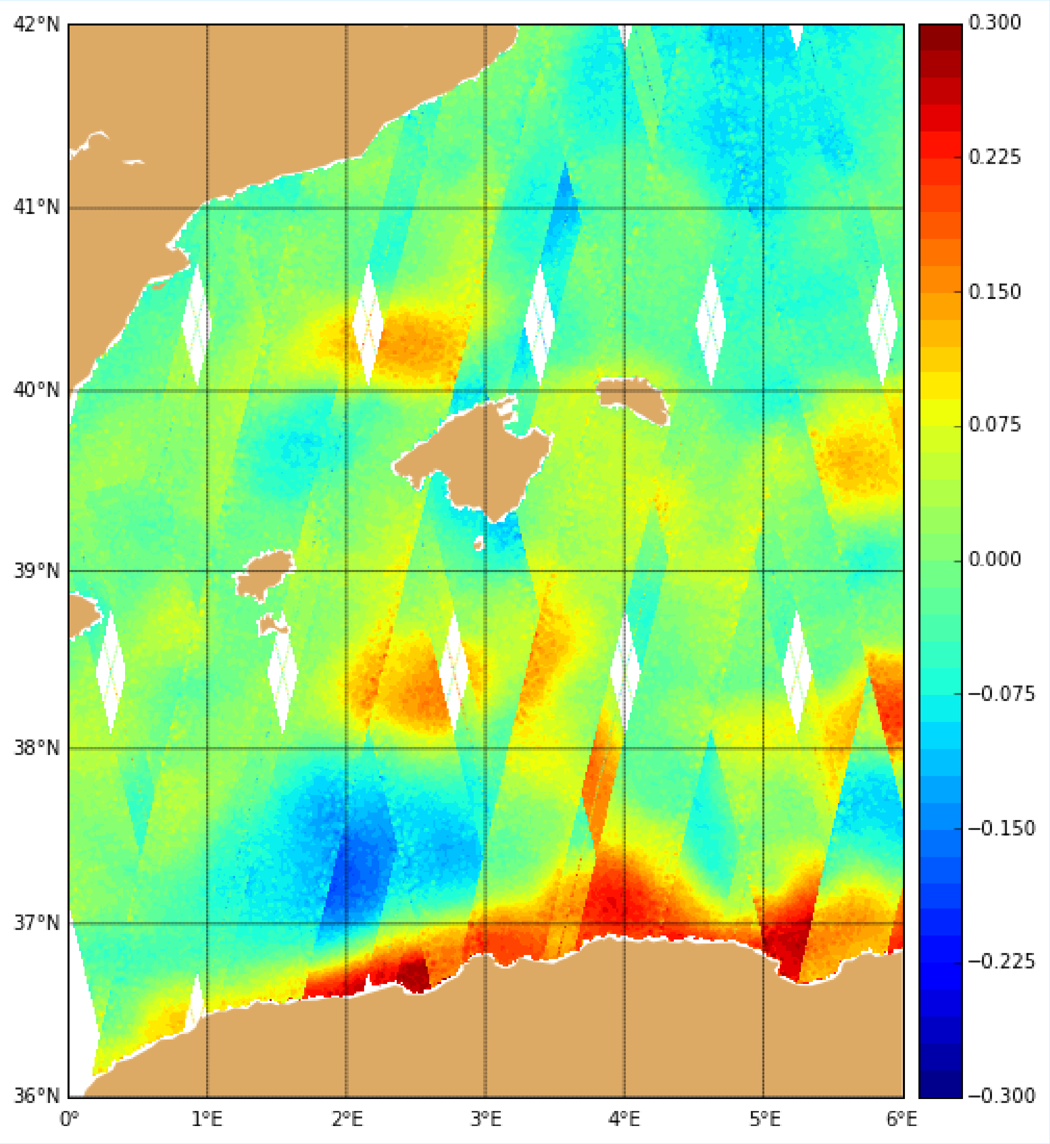
- Filtering
  - Cut-off wavelength of about 60 km:

Relative vorticity (normalized by f)



- Higher **spatial coverage**

→ Pseudo-SWOT data allows the observation of **mesoscale** structures.



- Noise → **too high** for deriving variables (vel., vorticity)

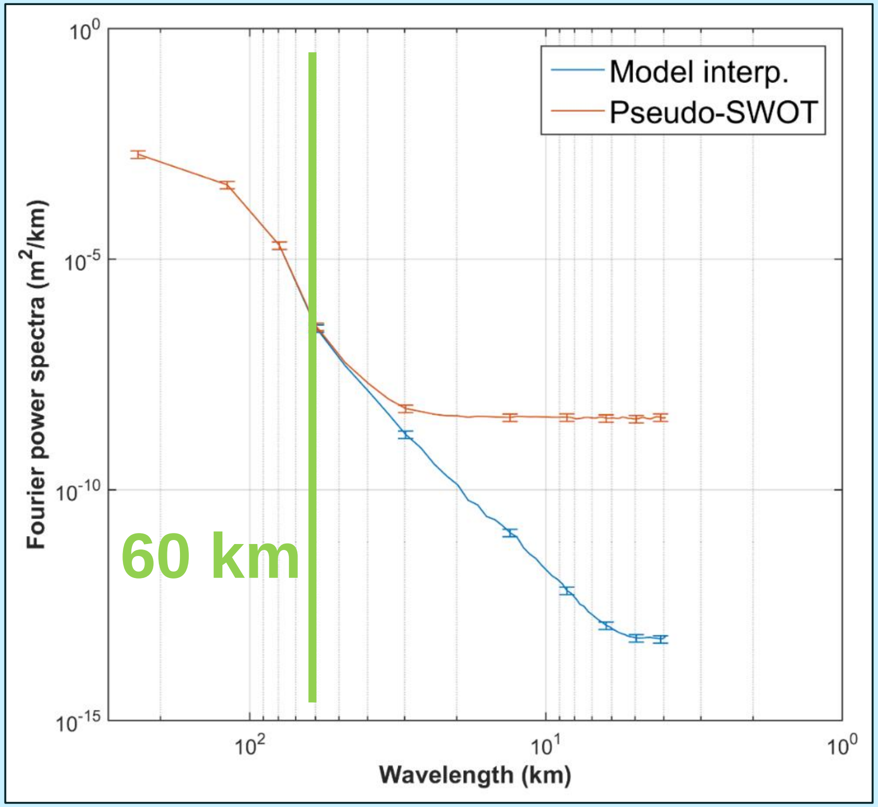
, but **big improvement after filtering**

- SWOT simulated data:

Resolves λs > 60 km.

→ Significant improvement compared to standard altimeter gridded fields:

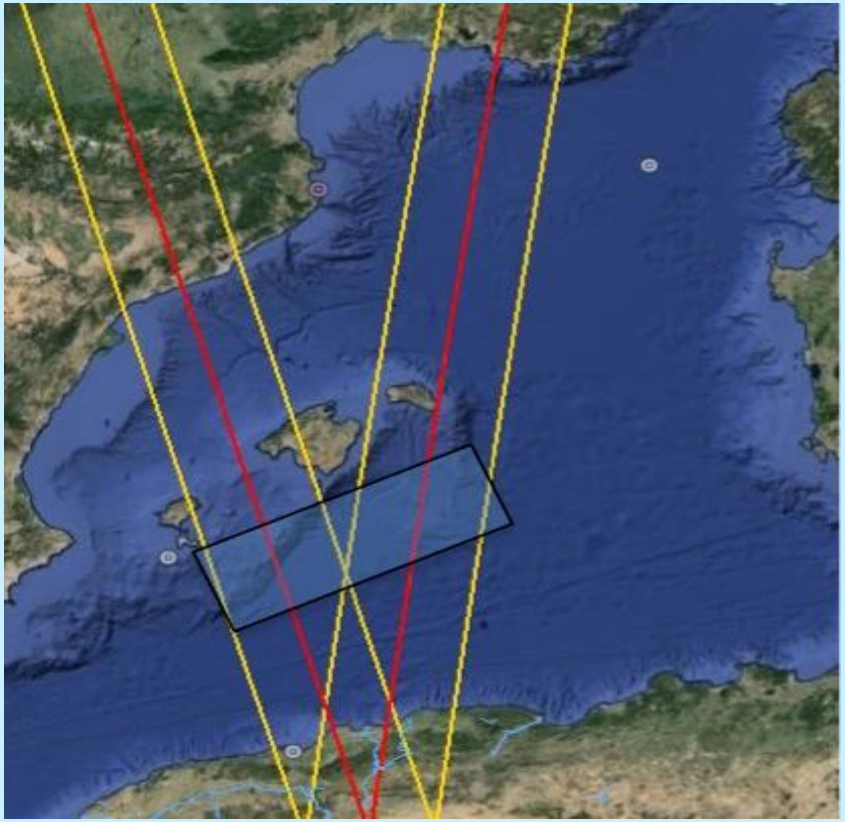
Resolve λs > 150-200 km.



- **New simulations:**
  - New version of simulator

→**Fast-sampling phase:**

Cal/val region where experiments will be done under the PRE-SWOT project (P.I. Ananda Pascual)



  - **OGCM 1/60º**

- Other filtering methods

Acknowledgements

- Ananda Pascual, my supervisor at IMEDEA
- Evan Mason for all his help during this internship
- Ronan Fablet for his help with the Seabird data and the filtering of the SWOT data
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- Lucile Gaultier for her help with the simulator
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