Assessing SWOT-Derived Surface Velocities Against High Frequency Radar Observations: Insights from the Ibiza Channel and Ebro Delta

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High Frequency Radars (HFRs) measure surface currents at a similar spatial resolution to SWOT, offering the unique possibility to evaluate KaRin-derived geostrophic velocities in coastal areas and gain insight into:

- The effect of unbalanced wave motions and performance of filtering applied when inferring velocities
- Scales resolved and validity of geostrophic approximation

Satellite

Multi-mission DUACS

European Seas Gridded L 4 Sea Surface Heights And Derived Variables [1]

SWOT

L3_LR_SSH_Expert_v2.0.1[2] filtered[3] SSHA and velocities

Cyclo- and geostrophic velocities derived from filtered SSHA with a fitting kernel [4]

Ebro Delta
Fast-sampling phase (Apr – Jul '23)
SWOT pass 016
13-point fitting kernel

Ibiza
Science phase (26 Jan '25)
SWOT pass 348
9-point fitting kernel

High Frequency Radars

- Hourly surface currents at 3 km resolution from HFR-DeltaEbro & HFR-Ibiza [5]
- Gap-filled with DIVAnd [6]
- Low-pass filtered and corrected for Ekman current [7]

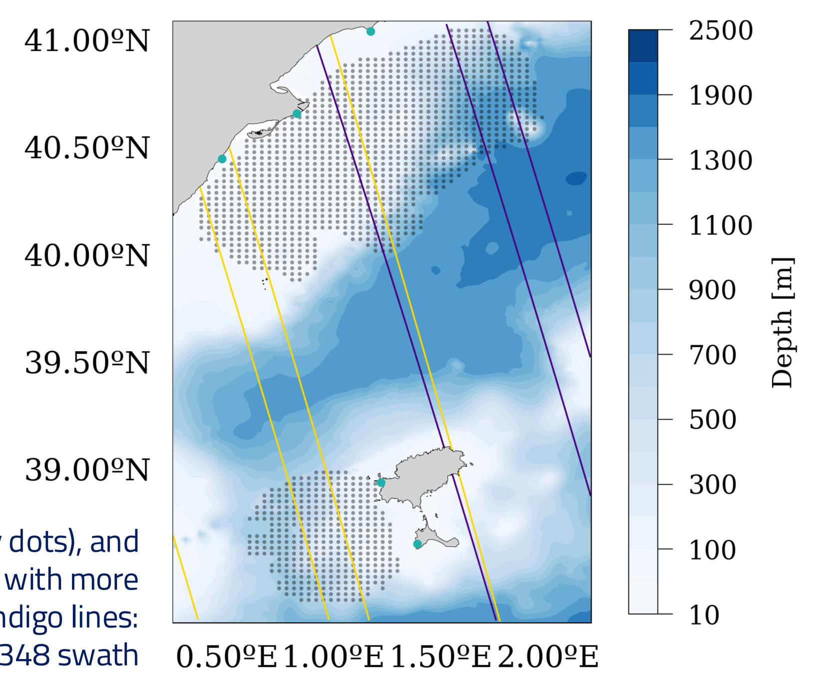
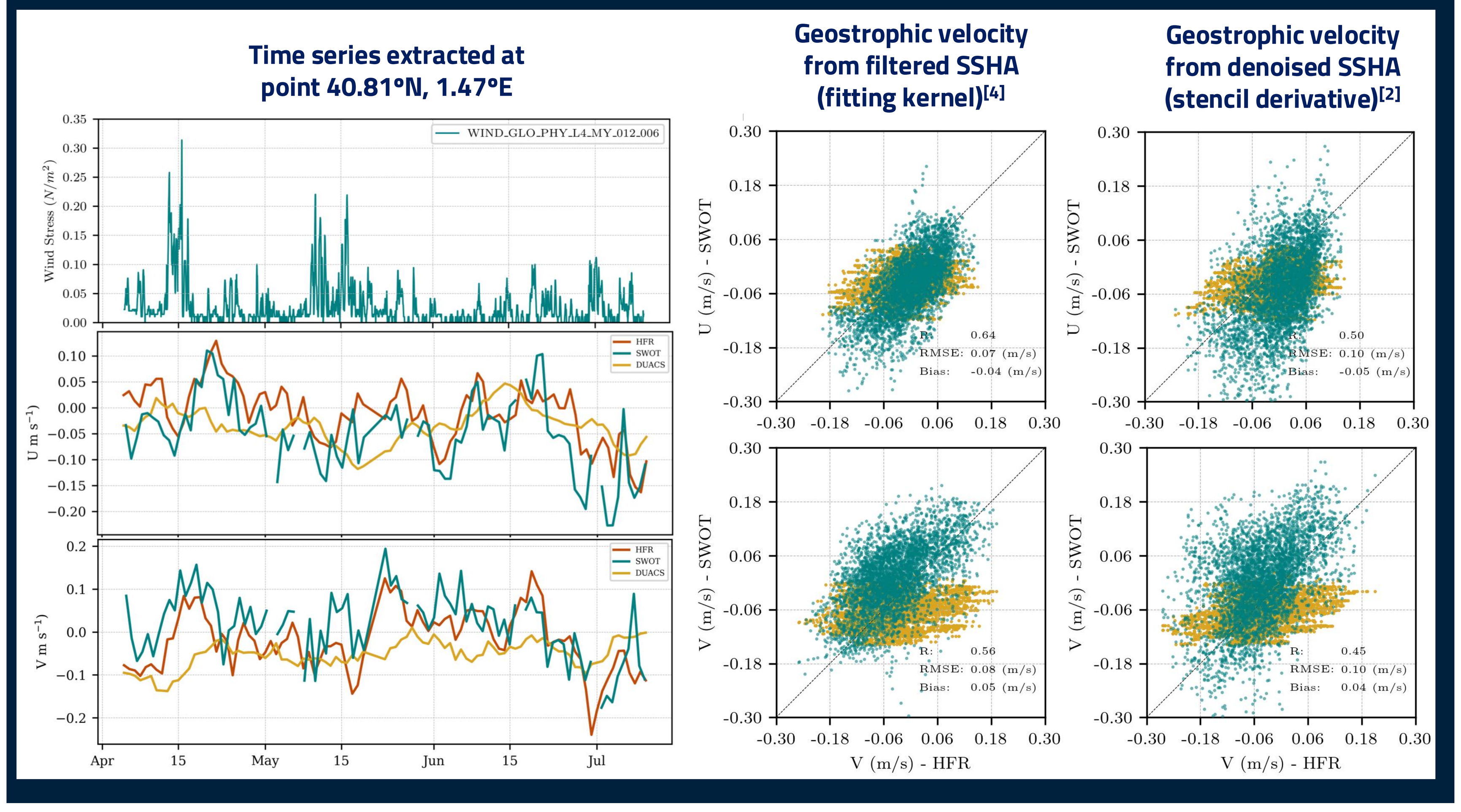
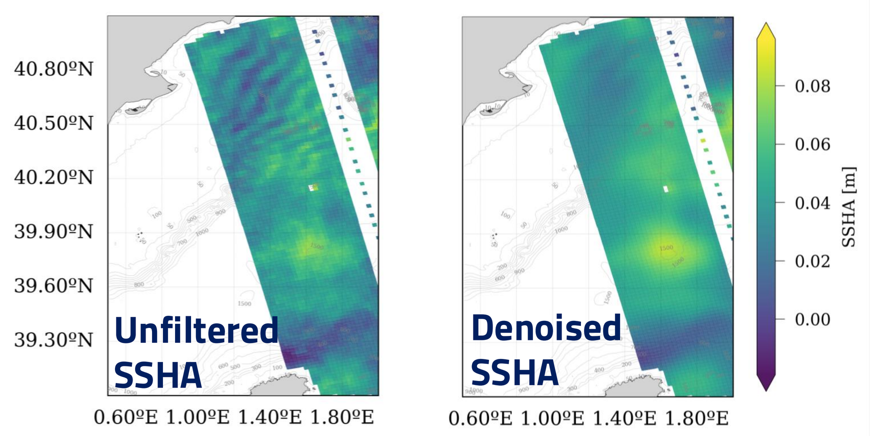


Fig.1 HFR sites (green dots) and coverage (grey dots), and SWOT passes. Grey dots show the HFR grid points with more than 50% data availability during the study period. Indigo lines: pass 016 swath. Yellow lines: pass 348 swath

DUACS- and SWOT-derived velocities vs HFR-DeltaEbro



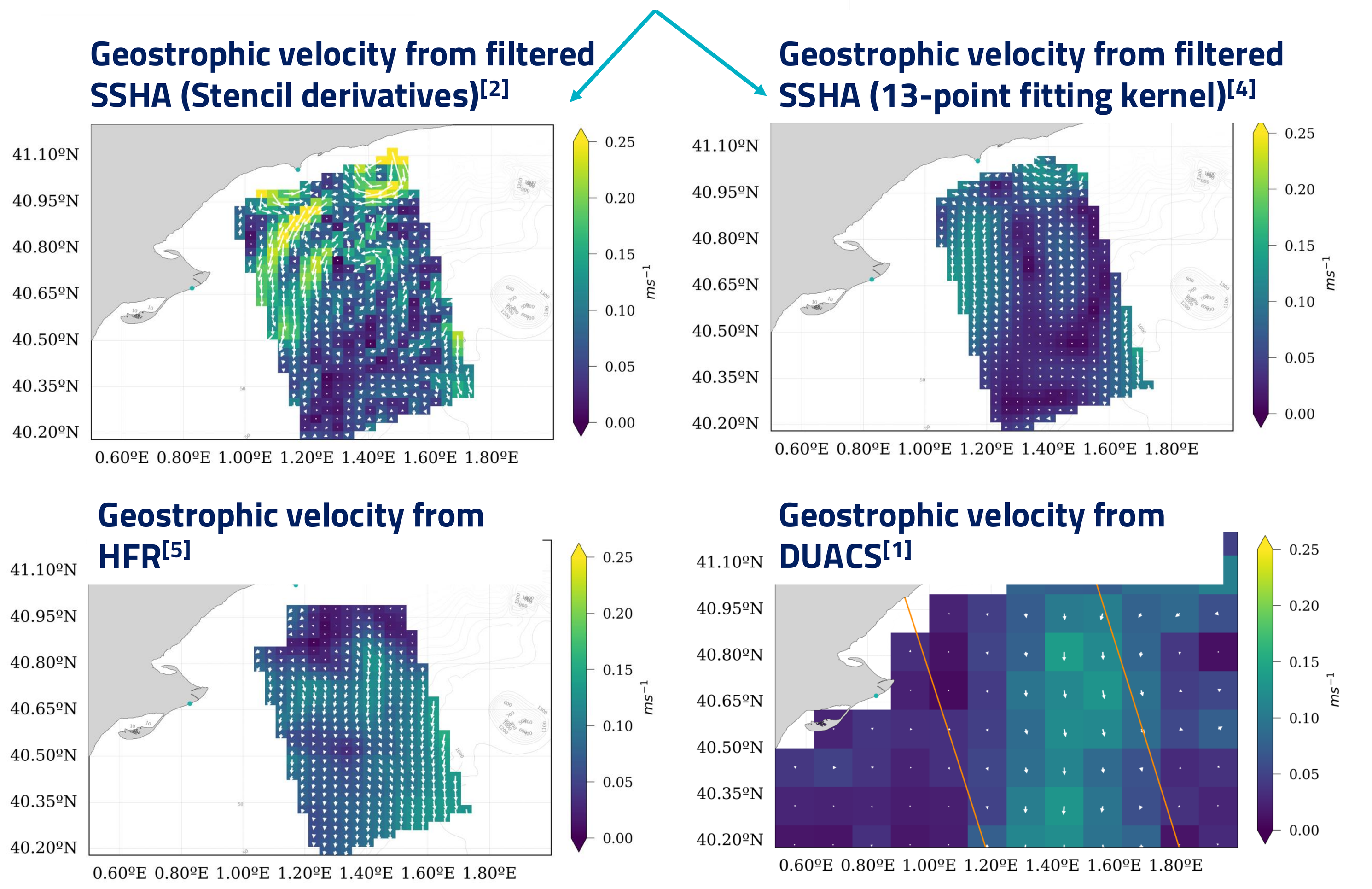
Impact of unfiltered wave-like signature on velocity derivation



Wave signature visible over the continental shelf during a strong Mistral wind event on the 13th April 2023

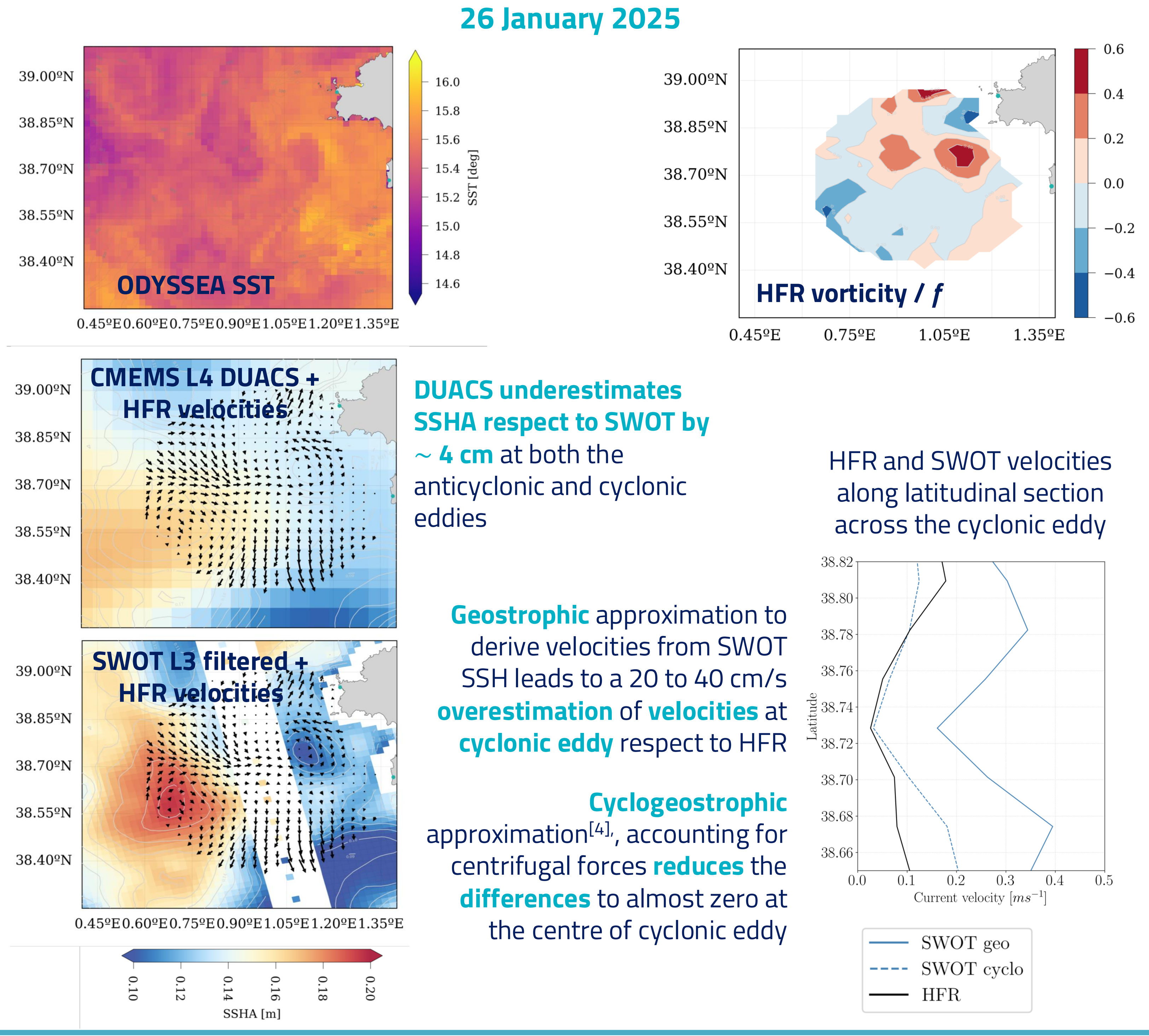
Denoising does not remove the wave-like motions

SWOT-derived velocities calculated either with stencil derivatives or a fitting kernel strongly differ from DUACS and HFR



Submesoscale eddies detected by SWOT and the derivation of velocities when the geostrophic approximation breaks down

26 January 2025



DUACS underestimates SSHA respect to SWOT by ~ 4 cm at both the anticyclonic and cyclonic eddies

Geostrophic approximation to derive velocities from SWOT SSH leads to a 20 to 40 cm/s **overestimation** of **velocities** at **cyclonic eddy** respect to HFR

Cyclogeostrophic approximation[4], accounting for centrifugal forces **reduces** the **differences** to almost zero at the centre of cyclonic eddy

HFR and SWOT velocities along latitudinal section across the cyclonic eddy

- Validation of SWOT-derived velocities against HFR measurements in the Ebro Delta region shows that the fitting kernel method from [4] yields superior results compared to stencil derivatives.
- Neither methodology provides reliable results in the presence of unbalanced wave motions.
- In the Ibiza Channel, accounting for centrifugal forces when deriving velocities resulted in better agreement between SWOT and HFR in the presence of strong gradients.

References:

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