Atmospheric Gravity Waves signature on the sea surface: insights from SWOT and OSCAR observations

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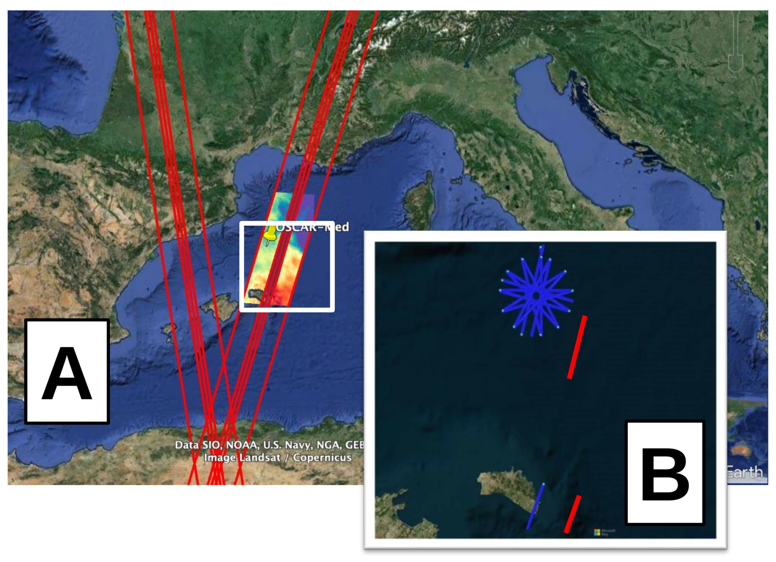
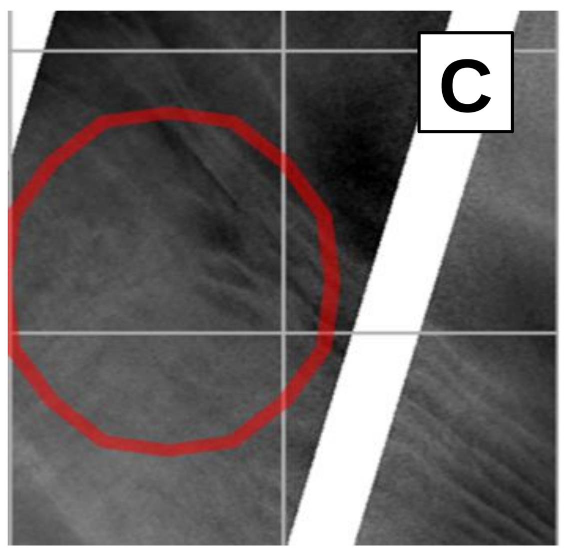
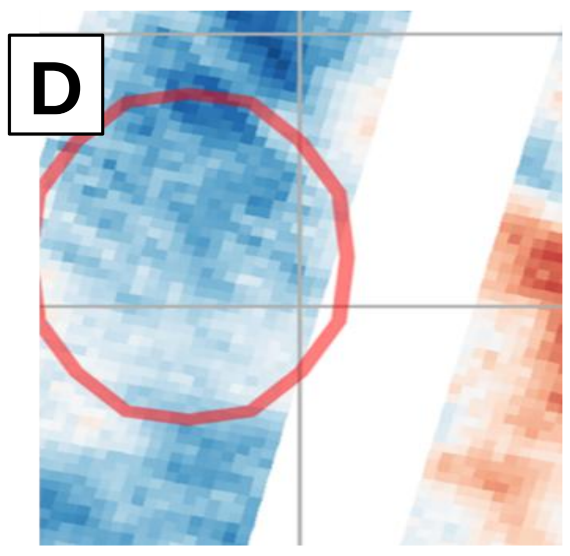
Introduction & Context



Atmospheric Gravity Waves (AGW) are typically generated over topographical features (lee waves) or in the presence of fronts (e.g. coastal frontal waves). AGW contribute to the spatial fluctuations of lower atmospheric wind and temperature fields over the ocean. Under good conditions (humidity and clear sky), AGW cause the cloud structure to change and can be visibly observed. At the surface, wind speed variation modulates the sea surface roughness, allowing these features to be observed by SAR imaging systems. AGW wavelengths range from a few to several tens of kilometres [e.g. Li 2004 NOAA SAR Manual].

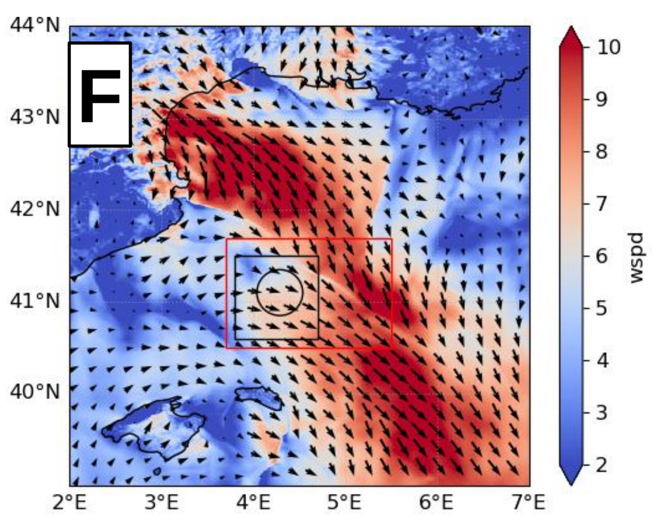
During the BioSWOT Med & OSCAR campaigns conducted in May 2023 in the Western Mediterranean, North of Minorca, during the **1-day "fast-sampling" SWOT orbit (A)**, AGW were observed in SWOT **(C)** NRCS and **(D)** Sea Level Anomaly - SLA and OSCAR data **(G)**. It is the first time, AGW are observed in SLA. In this poster we describe the main characteristics of the observed AGW and discuss if the signal in SLA is real (inverse barometric effect) or an instrumental artefact.





OSCAR (E), Ocean Surface Current Airborne Radar, is a new Doppler SAR scatterometer, providing 2D images of the surface at 8m resolution over a 5km swath. OSCAR provides unique 2D synoptic views of ocean and atmosphere dynamics (**currents**, waves, **winds**). This campaign proceeded with **three roses patterns** with **14 tracks (B)** below SWOT left sub-swath on **May 5, 7 and 8, 2023**.

AROME (F) mean wind conditions.



Conclusions

Atmospheric Gravity Waves generated by atmospheric front

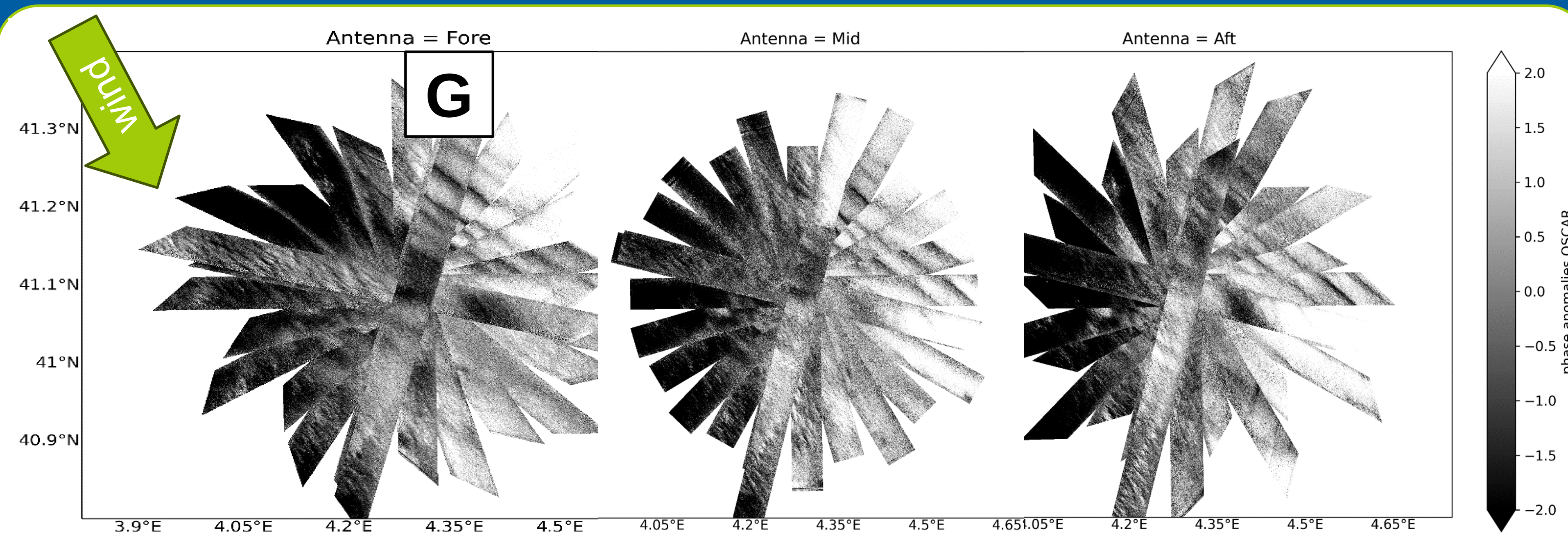
Observed in SWOT & OSCAR data with a wavelength down to 2 km

- OSCAR wind speed amplitude variations > 1m/s
- SWOT KaRIn Sea Level Anomaly amplitude up to 2cm (eq. 2hPa if inverse barometric effect)

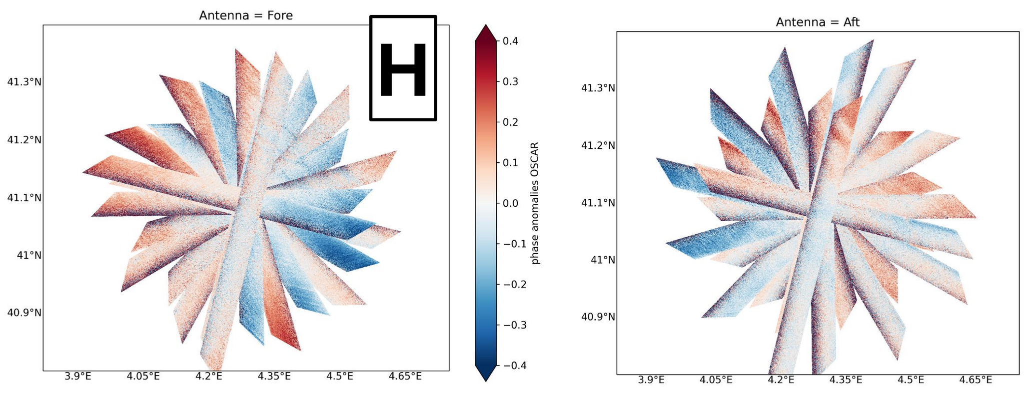
AROME 0.01° (1.5km) confirms AGW presence:

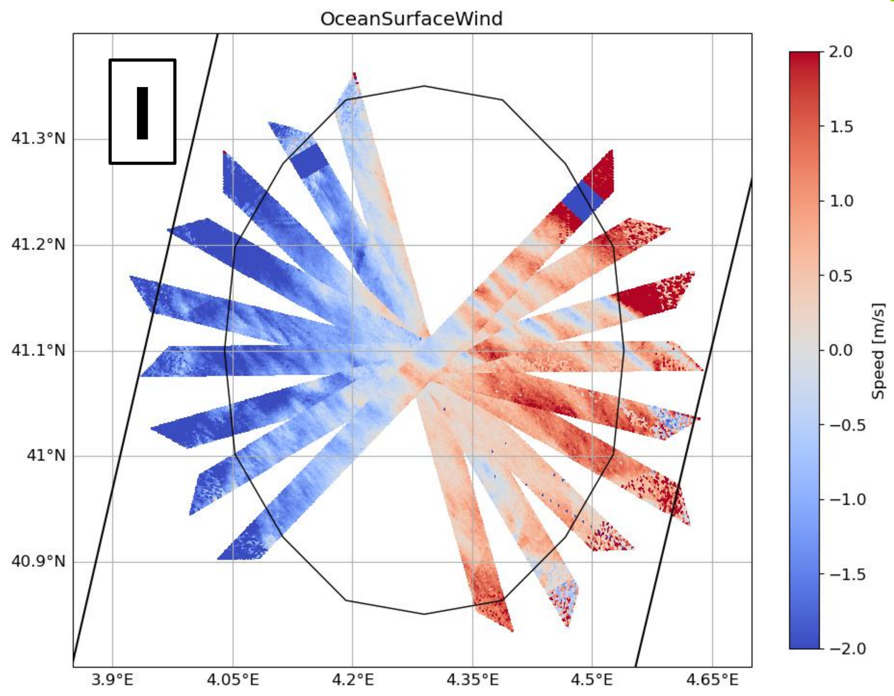
- Resolved AGW wavelength of ~10km due to a too coarse model resolution, with an amplitude of 0.2hPa (i.e. 10% of what is observed)
- This suggests that the model is not sufficiently resolved to reproduce the observed processes.
- The hypothesis of an instrumental effect affecting KaRIn SLA measurements cannot be ruled out.

The temporal evolution of AGW observed by OSCAR, and consistent with AROME, suggests that the amplitude was strongest between 15:00 and 16:30 UTC, i.e., before SWOT overflight.



(G) OSCAR rose pattern on the 8th of May 2023 with **NRCS** anomalies in Fore, Mid and Aft look directions; and **(H) interferograms** anomalies in Fore and Aft directions.

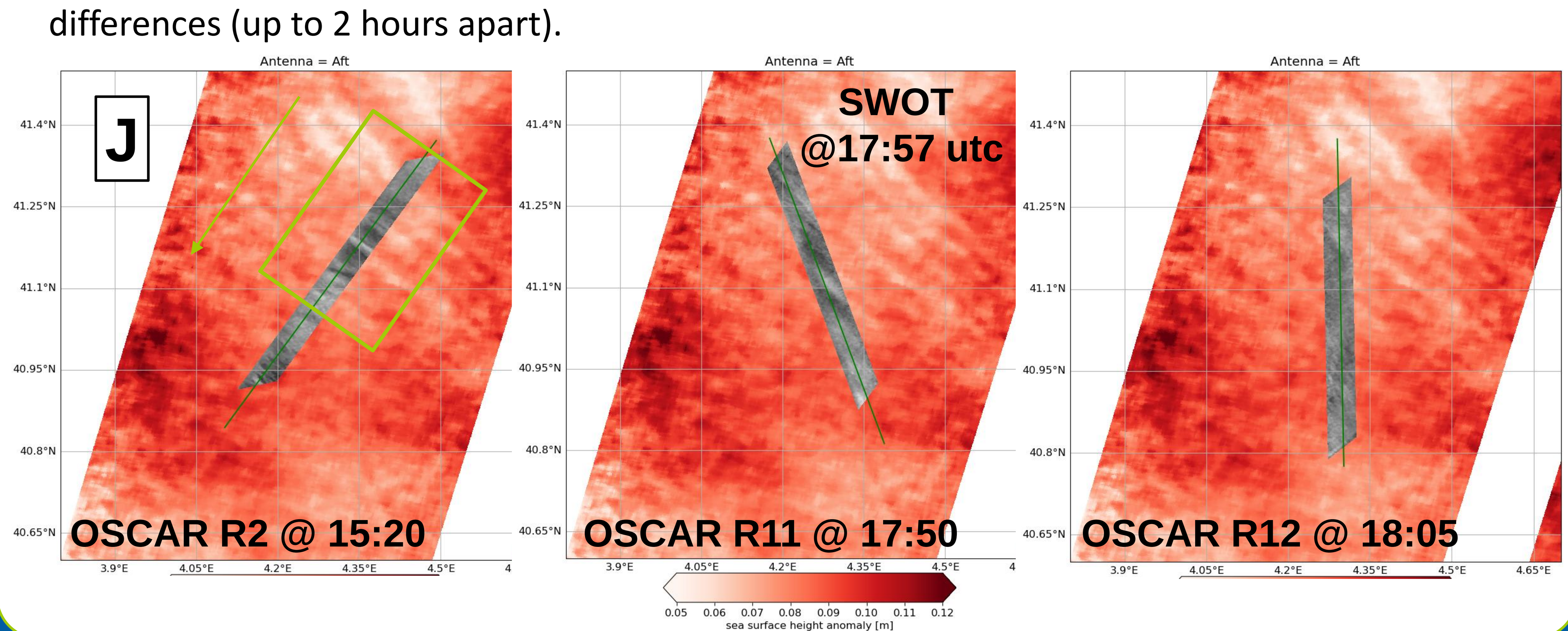


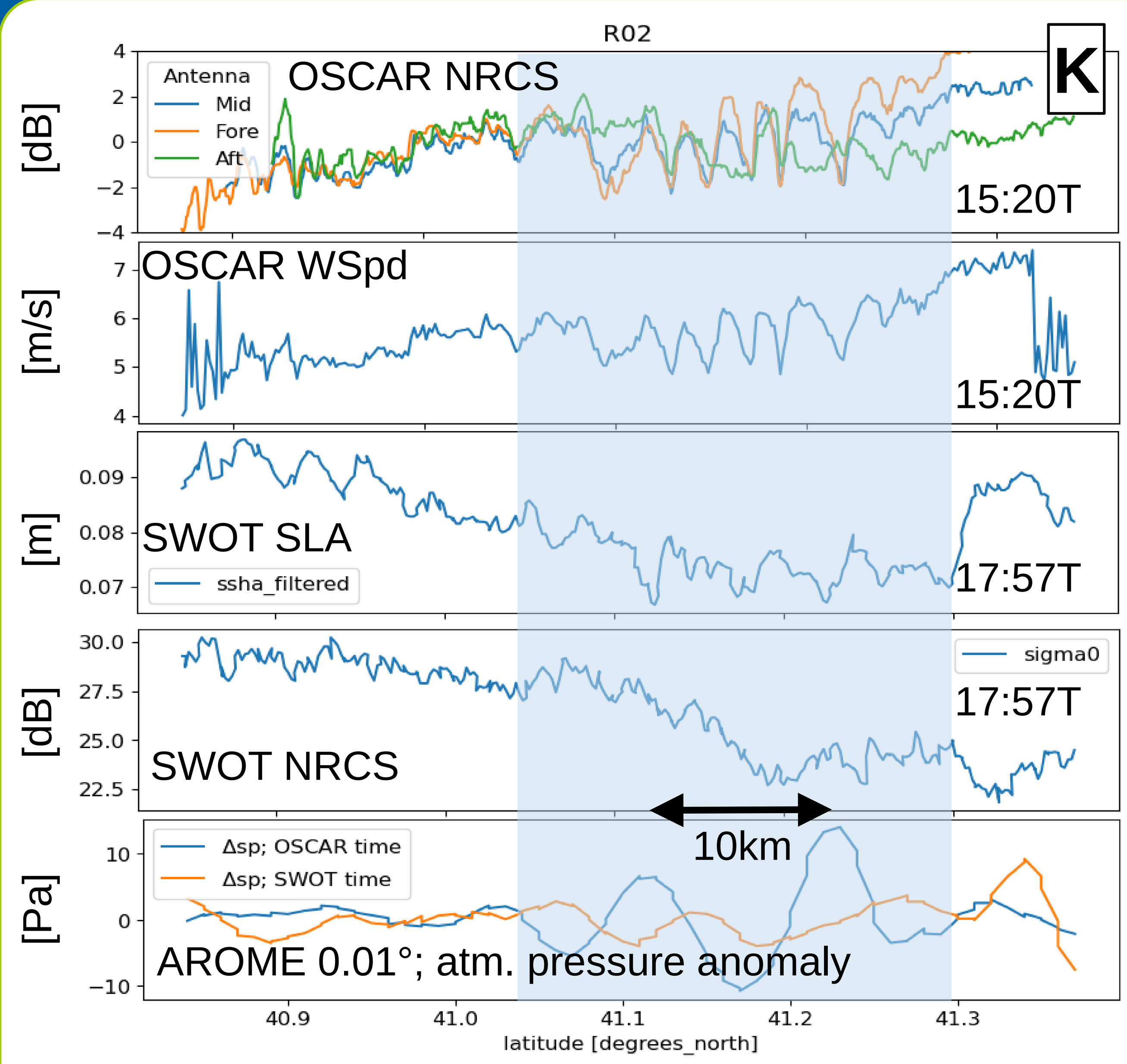


8m resolution **OSCAR** Level 1 data **(H, G)** of **NRCS** anomaly and **Interferogram** respectively measures the **sea surface roughness** and **ocean surface motion** in different azimuths. Data are acquired during 4 hours and centered on SWOT pass; they observed the same AGW in NRCS for some tracks in the three azimuth directions (Fore, Mid, Aft).

OSCAR azimuthal diversity allows the retrieval of **Ocean Surface Vector Wind (OSVW)** and **Total Surface Current Vector (TSCV)**. Wind anomaly **(I)**, derived from OSVW (mean of ~6m/s), highlights wind speed oscillation > 1m/s with wavelength down to 2km. The current is rather homogeneous with a magnitude of ~0.2m/s, certainly dominated by inertial oscillation generated by strong wind the night before.

Superposition of SWOT KaRIn Sea Level Anomaly and OSCAR NRCS Anomaly from the Fore antenna **(J)** highlights the good consistency between the observations despite the time differences (up to 2 hours apart).

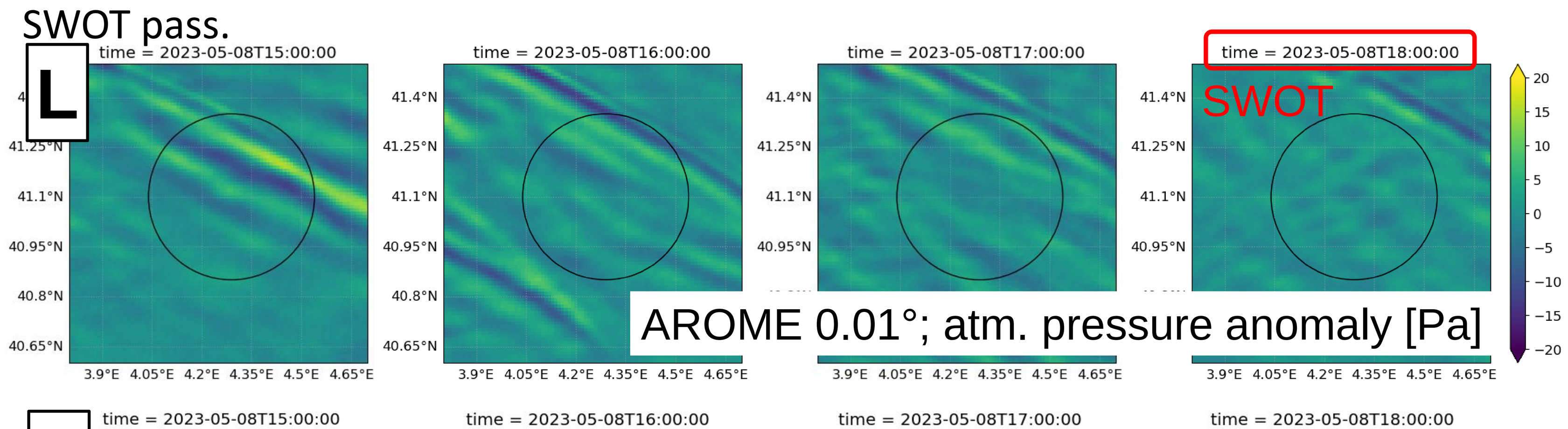


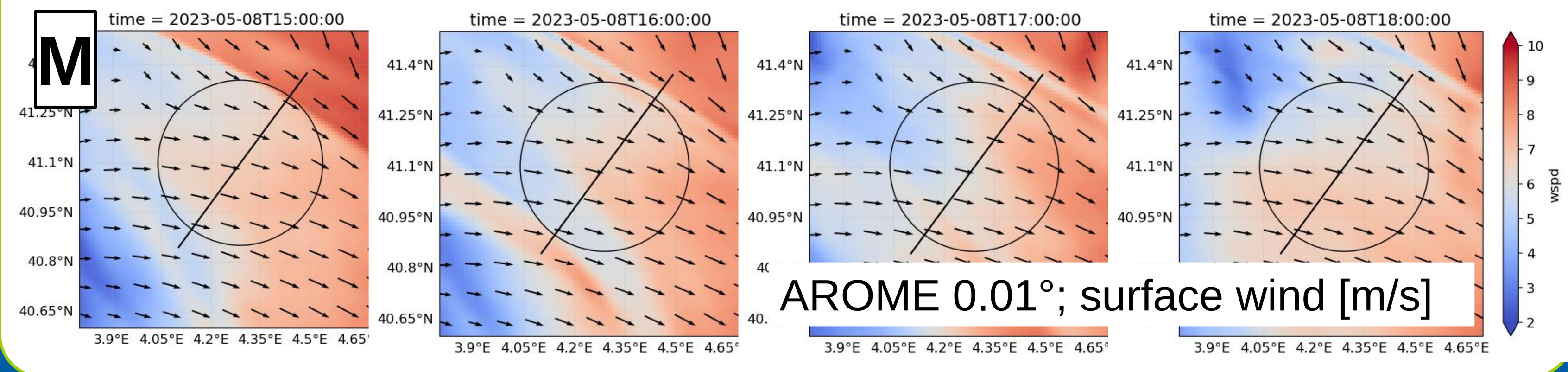


(K) Transects along the line represented in **(J-R2)** from top to bottom: OSCAR NRCS anomaly against the mean across track for the three antennas (Fore, Mid, Aft) for track R2 taken at 15:20; OSCAR derived wind speed for track R2; SWOT KaRIn Sea Level Anomaly (SLA); SWOT KaRIn NRCS and AROME atmospheric pressure anomaly for the time of OSCAR track R2 (15:00) and SWOT (18:00).

Transect along OSCAR track R2, which is the most perpendicular to the AGW crest, reveals high variability (2km wavelength) of the sea surface roughness as sensed by OSCAR NRCS **(K top)**, corresponding to retrieved wind speed variations higher than 1m/s **(K, 2nd panel)**. SWOT KaRIn SLA **(K, 3rd panel)** and NRCS **(K, 4th panel)** are anticorrelated and show variations at similar wavelength to OSCAR. SWOT SLA variations are 1-2cm, corresponding to a direct inverse barometric effect of 1-2hPa. AROME 0.01° (1.5km resolution) outputs **(K, bottom; L, M)** confirm the presence of Atmospheric Gravity Waves (AGW) generated at the atmospheric front. AROME AGW wavelengths are above 10km, suggesting that the model is too coarse to represent adequately their processes.

The temporal evolution, observed by OSCAR and modeled by AROME, suggests that AGW amplitude was strongest at 15UTC and decreased over time, at the time of SWOT pass.





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