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Combined high-resolution rain/wind measurements over extreme wind events using Synthetic Aperture Radar

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Spaceborne observations over extreme atmospheric events at global scale such as Tropical Cyclones, Extra-Tropical Cyclones, Polar Lows and Medicanes are a key component in extreme events monitoring and in anticipating appropriate risk mitigation and emergency response at landfall. In particular, meteorological forecasters and numerical modelers need to access various sources of conventional and specialized data/products including remote sensing observations to refine their analysis or adjust their models.

Recent progresses in SAR processing have shown the potential of C-band SAR data acquired in dual-polarization for estimating at high-resolution (1 km) an ocean surface wind field [1, 2], including extreme events such as major hurricanes (category -3 to -5) [3]. Comparison with SFMR for yield to high correlation (R > 0.90), small bias (< 0.5 m.s-1) and RMSE (< 5 m.s-1) [4], including at highest wind speeds (80 m.s-1).

C-band SAR signal can also be impact by non-wind related signatures. This is particularly true over Mediterranean Sea where strong convective events, associated with heavy precipitations are often met. These deep convections lead to SAR signatures through several processes, either surface and/or volume scattering and can significantly bias the wind estimates if not well delineated. A combined estimation of the wind vector and rain signature is therefore mandatory.

The present work shows the ability of SAR measurements to provide accurate wind vector estimation, by providing independent wind speed and wind direction estimates [6] as well as a complementary rain rate regression based on Deep Neural Network architecture [5]. This is illustrated over several medicanes or extra-tropical storm use cases and described statistically.

The provision of these measurements is made possible through CYMS project (Cyclone and Storm Monitoring Service based on Sentinel-1), an ESA funded project since 2020, aiming at monitoring ocean extremes with SAR, in view of its potential integration as part of a Copernicus Service.

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