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Observation of small-scale structures and Vortex Rossby Waves in Tropical Cyclones: insights from SAR imagery

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The estimation of Tropical Cyclone (TC) intensity has become a major challenge for meteorologists and climate scientists over years, as it is still poorly predicted and leads to consequent human and material damages on coastal cities and islands every year. Intensity changes can be caused by large scale exterior events such as tropospheric troughs or vertical wind shear interacting with the TC, but recent studies suggested that small-scale processes and eyewall dynamics have a leading role acting as a trigger, or a response, to external events and intensity changes. In particular, Vortex Rossby Waves and rainbands interactions, which are inherent to the TC structure, play a key role in propagating energy and vorticity between the TC core and its periphery. The lack of observation of these small-scale processes occurring in very high winds and extreme sea conditions in the eyewall and its surroundings is one of the main limitations to our understanding of intensity fluctuations. Here, we present a unique dataset composed of more than 150 Synthetic Aperture Radar (SAR) images acquired onboard SENTINEL-1 and RADARSAT-2 satellites. Using a wide swath acquisition mode, and a dedicated algorithm, this dataset provides kilometer resolution wind speed and direction data at the sea surface over more than 70 storms and TCs. It allows a description of small to large scale structures in a wide range of life cycle steps. We develop a method to automatically estimate the TC structure, eye shape, and Vortex Rossby Waves distribution from the SAR images. Then, conducting a statistical analysis over the 150 images, we highlight the relations between TC size, intensification rate, asymmetry degree, and small-scale structures.