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Innovative observations of Sea State by Sentinel-1 satellite radar imagery: Storm Tracking for Maritime Situation Awareness

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In order to investigate geophysical processes, a new algorithm and processor for meteo-marine parameter estimation from satellite borne Sentinel-1 (S1) Synthetic Aperture Radar (SAR) images was developed and used for storm observations. The sea state and wind fields estimated simultaneously from twice daily SAR acquisitions are combined with numerical forecast model results and in-situ measurements during storm evolution and propagation. The focus of investigations is the storm peak/center propagation, front movement, and arrival of swell.

The S1 Interferometric Wide Swath Mode (IW) covers area-strips of thousand kilometres of earth and ocean surface with a resolution of $\sim$10m by sequences of multiple individual IW images with an approximate size of 200km$\times$250km. The worldwide acquisitions at a high repetition rate are free for common use and nowadays provide unprecedented observation of ocean processes and natural phenomena. Due to the independence of sunlight and cloud coverage, SAR data are an indispensable source of 2D information of the ocean surface at open sea and irreplaceable for coastal applications.

The rapid development of satellite techniques, SAR sensors, SAR processors, information extraction algorithms and ground infrastructures during the last years enabled a series of oceanographic applications with near real-time (NRT) capabilities. Several minutes after acquisition, the produced data with geo-coded information on wind speed and wave height can be transferred to the weather services for validation of the forecasting models. The different kind of data like wave height, surface wind speed, ice coverage, oil spills etc. can be processed in parallel for the same image and combined for supporting Maritime Situation Awareness (MSA). The algorithms currently developed for this purpose are integrated into a prototype processor for Sentinel-1 imagery. The DLR Ground Station Neustrelitz applies this prototype as part of a near real-time demonstrator MSA service. The presented scientific service involves daily provision of surface wind and sea state parameters estimated fully automatically from S1 IW images of North and Baltic Sea.

An example of efficient storm tracking in the Black Sea over three days is presented. The HZG forecast spectral wave model running for the Black Sea reproduces the storm peak propagation near to the S1 observations. In detail, the storm peak observed by S1 is shifted $\sim$80km towards the south in comparison to the model simulations. During this storm, the ship “Geroi Arsenala” of river-sea class licensed for inland waterways with access to the coastal seas was capsized about 40 kilometres to the south of the Kerch Strait in the open Black Sea, according to the associated press. Obviously, the course was taken too far from the coast to shorten the way across the sea with unexpected high sea state. With the Sentinel satellites and the processing framework demonstrated in this work, we have appropriate tools to rise MSA to unprecedented levels, which helps avoiding such accidents.

Also, the tracking of hurricane Irma with storm waves reaching up to 14m significant wave height and moving towards Golf of Mexico will be shown.