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Neural-network parametric modeling of ocean surface brightness temperature polarimetric observations for Sentinel Copernicus Imaging Microwave Radiometer

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The Copernicus Space Component Expansion program includes new missions that have been identified by the European Commission as priorities for implementation in the coming years by providing additional capabilities in support of current emerging user needs. The passive microwave imaging mission, such as the Copernicus Imaging Microwave Radiometer (CIMR) is uniquely able to observe a wide range of parameters, in particular sea ice concentration, and serve operational systems at almost all-weather conditions, day, and night. This mission shall provide improved continuity of sea ice concentration monitoring missions, in terms of spatial resolution (about 15 km), temporal resolution (sub-daily) and accuracy (in particular, near the ice edges). Additional measurement of sea surface temperature in the polar regions may also be included.

CIMR mission, to be launched in 2025, is designed to host spectral channels at 1.413 (L band), 6.925 (C band), 10.65 GHz (X band), 18.70 (K band), and 36.5 GHz (Ka band) with a radiometric sensitivity less than 0.4 K (except at Ka band where 0.7 K is goal) and a spatial resolution less than 60, 15, 15, 5, and 4 km, respectively. Such resolutions are obtained with a large deployable reflector mesh antenna of about 7-m diameter. CIMR shall be capable of measuring the full brightness temperature (BT) Stokes vector for all bands in the same way WindSat and SMAP (Soil Moisture Active Passive) spaceborne radiometers accomplished (even though not for all bands and not necessarily fully polarimetric). Most of the sea-surface retrieval techniques, developed so far, have been based on maximum likelihood approaches exploiting the sea-surface geophysical model function (SSGMF). Even though previous missions span over most CIMR channels, there is not a systematic development and synthesis of CIMR SSGMF with a polarimetric capability.

In this work we aim at modeling CIMR sea emissivity GMF Stoke vector parameters, coupled with a microwave atmosphere radiative transfer (MART) model in clear/cloudy conditions and ECMWF ReAnalyses (ERA5) input data, to simulate CIMR brightness temperatures (BT) in different sea climatic regions, i.e., Northern and Southern Atlantic Ocean and Mediterranean Sea. MART simulations are statistically validated with AMSR2 (Advanced Microwave Scanning Radiometer 2) at C, X, K and Ka band and SMAP data at L band. A feed-forward neural network (NN) is developed to simulate polarimetric CIMR BT Stokes vector directly from ERA5 inputs as well as an inverse NN to retrieve the surface wind velocity and direction, sea surface salinity and temperature from CIMR polarimetric BT data. The designed NN is built with 1 hidden layer and sigmoidal functions, 151

inputs (from ERA5 profiles) and 20 outputs (BT Stokes vector for 5 frequency channels) trained and tested on the 3 selected areas of interest. The results show a correlation coefficient between the predicted and actual values larger than 0.9, meaning that the forward and inverse NNs successfully capture the relationship between the ERA5 inputs and the simulated CIMR BT Stokes vector. Results will be illustrated and discussed, pointing out potential developments and critical issues.