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Evaluation and development of techniques for the retrieval of snow properties from microwave remotely sensed data

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Snow has the largest area extent of any component of the cryosphere, influencing the hydrological, meteorological and climatological aspects of the Earth. Microwave remote sensing is a crucial tool for monitoring the state of the cryosphere providing estimates of parameters of hydrological interest and improving our understanding of the global water energy cycle.

The ENVISNOW project of the European Commission was designed for the launch of the ENVISAT satellite to develop and validate new multi-sensor algorithms for retrieving snow and soil parameters from remote sensing data for use in global climate and hydrology. Within the framework of the ENVISNOW project, we investigated existing techniques and proposed new techniques for the retrieval of snow parameters from both active and passive microwave measurements. Data at different spatial and temporal scales were collected from both active and passive instruments. In particular, ground-based multi-frequency radiometric data at C-, Ku- and Ka-band were collected 24 hours per day during the Microwave Alpine Snow Melting Experiment (MASMEX) in 2002 at the Mount Cherz plateau, Eastern Italian Alps, together with nivological and meteorological parameters. A temporal sequence of five ERS-2 SLCI SAR satellite images covering the period from December 2001 to May 2002 was also acquired for the same test area. At a larger scale, a set of brightness temperatures covering all of Finland from the beginning of 1997 through the end of 1999 was selected to test algorithms for the retrieval of snow water equivalent and snow depth.

The retrieval of the temporal behavior of snow wetness is performed by inverting the ground-based radiometric data through a multi-layer model based on Strong Fluctuation Theory. The results are validated by using the output of a hydrological model

driven by the collected meteorological data. The mean particle radius, fractional volume and snow depth are derived from local scale brightness temperature measurements by inverting an electromagnetic model based on the Dense Medium Theory (DMRT) using numerical techniques based on genetic algorithms. The values of the retrieved snow parameters are compared with the averaged values of snow properties collected on field at the same time of the microwave measurements. At medium-scale resolution, the snow wetness and the snow covered area are obtained from backscattering coefficients by inverting the DMRT electromagnetic model through an iterative technique. In this case the validation set is made of measurements of snow properties performed close in time to the passage time of the satellite. Finally, the retrieval of snow water equivalent and snow depth from space-borne data is performed using techniques both from the literature (such as the Chang's algorithm or the HUT iterative inversion algorithm) and a new technique based on the inversion of the HUT electromagnetic model through an Artificial Neural Network. Results obtained with the different techniques are compared with the temporal behaviors of snow water equivalent and snow depth over twelve different selected locations.