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Towards an advanced Pan-European Snow Cover Product from Sentinel-1 SAR and Sentinel-3 SLSTR

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The Sentinel satellite series of the European Copernicus programme operates microwave and optical sensors, providing unique and comprehensive data for long-term monitoring of the global environment. A key parameter for climate monitoring, hydrology and water management is the seasonal snow cover. In the frame of the ESA project SEOM S1-4-SCI Snow, led by ENVEO, we developed, implemented and tested a novel approach for monitoring melt extent of the seasonal snow cover and apply this for the Pan-European domain by synergistically exploiting Sentinel-1 SAR and Sentinel-3 SLSTR data.
Sentinel-3 SLSTR is a multispectral medium resolution optical sensor providing daily coverage over mid- and high latitudes. For generating a fractional snow extent product we apply multi-spectral algorithms for cloud screening, the discrimination of snow free and snow covered regions and the retrieval of fractional snow extent. A drawback of snow extent from optical data is the susceptibility to cloud cover. In order to fill gaps in the time sequence we apply a data assimilation procedure using a snow pack model driven by numerical meteorological data of ECMWF in order to simulate daily changes in the snow extent in cloudy areas. Complementary to the total fractional snow extent, derived from SLSTR, we utilize Sentinel-1 SAR data to map the extent of melting snow areas. The Copernicus Sentinel-1 mission, comprising two identical satellites (S1A and S1B), is equipped with a C-Band SAR sensor operating over land surfaces in Interferometric Wide Swath (IW) Mode at co- and cross-polarizations, covering a swath width of 250 km. In order to select an optimum algorithm for retrieval of snowmelt area, we conducted round-robin experiments for various SAR algorithms over different snow environments, including high mountain areas in the Alps and in Scandinavia and various lowland areas of Central Europe covered by grassland, agricultural plots, and forests. The tests show good agreement between snow extent from SAR and from Sentinel-2 and Landsat-8 data in mountain areas outside of forests. In lowlands ambiguities may arise from temporal changes in backscatter related to soil moisture, agricultural activities and possibly also some other processes. Dense forest cover is a major obstacle for snow detection by SAR. Therefore, areas with dense forest cover are masked out. Based on the results of the round-robin tests, we selected for retrieval of snowmelt area extent a change-detection algorithm using VV- and VH-polarized backscatter data. The algorithm applies multi-channel speckle filtering and a data fusion procedure to combine the VV and VH ratio images of snow-covered versus snow-free images for snow segmentation. The binary SAR snowmelt extent product, provided at 100 m grid size, is combined with the snow product of Sentinel-SLSTR to obtain maps of total snow area and melting snow. We present the results of round robin experiments of SAR wet snow algorithms and their performance in different environments and show prototype products of the synergistic snow product for the Pan-European domain.