The satellite mission COld REgions Hydrology High-resolution Observatory (CoReH2O) is one of the six missions which has been selected for scientific and technical feasibility studies within the Earth Explorer Programme of the European Space Agency. The mission aims at closing major gaps in present snow and ice observations. The focus of the mission is on spatially detailed repeat measurements of snow and ice properties in order to advance the understanding of the role of the cryosphere in the climate system and to improve the knowledge and prediction of water cycle variability and changes. CoReH2O will provide spatially detailed observations of extent, water equivalent and melting state of the seasonal snow cover, of snow accumulation and diagenetic facies on glaciers, of permafrost features, and of sea ice properties with emphasis on new ice formation and snow burden. A dual frequency SAR is proposed, operating at X-band (9.6 GHz) and Ku-band (17.2 GHz), VV and VH polarizations, with a swath width of about 100 km. Ku-band is more sensitive to shallow snow, whereas X-band provides greater penetration for sensing deeper snow.

In preparation of this mission experimental and theoretical studies started in order to investigate on several aspects and improve the methods for retrieval of snow physical properties from SAR data.

The aim of this paper is to investigate on the impact of vegetation in the retrieval of snow parameters from backscattering measurements at the X- and Ku-bands.

In the first part of the paper key vegetation types found in snow covered regions where identified on the basis of available global scale data base. The analysis was conducted at global scale using an open-source data base (ECOCLIMAP) with a resolution of 10x 10 Km. Maps of different types of vegetation were produced and analyzed. Computations were then performed on an area between latitude of 40° and 88° which is the area containing the largest parts of the cryosphere of the globe and is therefore most interesting for the CoReH2O mission. From the analysis we could conclude that, for about 40 % of the interested area, the effect of vegetation in the retrieval of snow parameters can be ignored. Furthermore, herbaceous vegetation, which covers a large part of the remaining area (around 54%), and coniferous forests are the most interesting vegetation types and their effect on $\sigma^0$ will have to be considered in the definition of the retrieval algorithms of snow parameters.

In the second part of the paper a model able to simulating scattering from a vegetated snow-covered terrain was developed and implemented. Among the possible models a model similar to MIMICS, which was originally developed at IFAC for the simulation of agricultural crops and then modified for forest vegetation, was selected. The main advantages of this model are that it can be combined with the snow model that was developed and tested within the CoReH2O activities and which was used to investigate on sensitivities to snow parameters at X and Ku band. The model was developed for the simulation of both agricultural and forest vegetation and inputs are related to measurable vegetation parameters.

The scattering from snow was computed by a single layer DMRT models, which considers snow parameters (grain size and shape, snow depth and density) as inputs. The total backscatter is composed of the individual scattering contributions at the air/snow interface, snow/ground interface (attenuated by the snow pack), snow volume, and snow/ground and ground/snow
interactions. For the medium below the homogeneous half space (e.g. frozen or unfrozen soil) is assumed, whose backscattering contribution can be modelled by surface scattering. The snow volume is modelled as a dense medium of ellipsoidal or cylindrical ice particles characterized by an effective grain size. The surface soil scattering was computed by the AIEM model.

In the vegetation model, the canopy is divided into a certain number of horizontal layers over a snow-covered terrain. Each layer contains different groups of scatterers, and each group is assumed to be composed of identical scatterers that are uniformly distributed in the azimuth direction and with a certain density (number of elements m3). Moreover, the scatterers are randomly oriented in elevation, with a distribution described by their probability density function. The number of layers, as well as the thickness of each layer, depends on the vegetation type. For example, agricultural vegetation can be represented as a single layer, while two or three layers are used for forest. The scatterers are then characterized, as extinction and scattering properties, as a function of shape and size using different approaches.

Moreover the scattering was computed for both close and sparse canopies. In this last case (e.g. the case of boreal forest) the cover fraction factor was introduced and total contribution was represented as a sum of forested area, snow area and the interaction between the forest-free area and the forested area.

Due to the lack of contemporaneous acquisitions of SAR and ground data (of both snow and vegetation) the validation at Ku and X band of the complete model (snow+vegetation) so far has been unfeasible. Nevertheless the model was validated at C-band by using the data set presented in recent papers. Further validation is planned with coincident Ku and X band backscatter data sets that have been acquired during field experiments in the Alps and in Alaska in winter 2007/08.

The sensitivity analysis to vegetation parameters was conducted on both sparse vegetation (shrubs or natural herbaceous) and coniferous forest. For these crop types the backscattering coefficient was simulated at the CoReH2O configuration: frequencies 9.6 and 17.2 GHz, polarization VV and HV, incidence angle between 30 and 40 degrees. The ground under the vegetation was assumed to be covered with dry snow having a SWE value between 20 and 200 mm. The simulations were conducted for two to three different grain sizes and two different soil roughness.

The analysis conducted on herbaceous vegetation confirmed that the presence of sparse vegetation attenuates the $\sigma^0$ of snow but does not affect the sensitivity to SWE. Nevertheless, since the influence of vegetation on the $\sigma^0$ of snow signature can be very high, the knowledge of vegetation type is fundamental in order to correctly retrieve snow properties from SAR data. As expected the attenuation is higher at 17.2 GHz than 9.6 GHz and at an incidence angle of 40° than at 30°.

The results obtained for coniferous forest demonstrated that for relative low woody volume value (<= 110 m$^3$/ha) $\sigma^0$ of vegetated snow-covered areas was influenced by the snow and soil properties (grain size, SWE, soil roughness, etc.). Among the snow parameters, grain size had the strongest impact on $\sigma^0$ signature. The cover fraction (CF) is another important parameter that influenced the $\sigma^0$ signature. In fact, also at low woody volume value, the sensitivity to SWE was strongly reduced if CF was higher than 0.5. Furthermore, when the woody volume was higher than 200 m$^3$/ha, and CF was higher than 0.25, the sensitivity to snow properties disappeared at all frequencies and polarizations. In this case the $\sigma^0$ trend (as a function of SWE) was quite flat and the retrieval of snow properties was not feasible.

On the basis of these results proposals to take into account these effects in the development of the algorithm for the retrieval of snow properties on vegetated area are illustrated.

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