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GROUND MOVEMENT ESTIMATION IN YAKUTIA USING DUAL-POL INSAR TERRASAR-X DATA

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Introduction

Thawing permafrost and the resulting microbial decomposition of previously frozen organic carbon is one of the most significant potential feedbacks from terrestrial ecosystems to the atmosphere in a changing climate [Zimov et al., 2006]. Permafrost has a profound influence on the hydrology, landscape and ecology of northern environments. The thawing is restricted to some meters below the top layer of soil and a permafrost layer remains frozen below the surface. In such areas, the top layer of soil that thaws during the summer and freezes in winter -known as the active layer- warms up enough to enable plants to grow during the spring and summer. For an accurate assessment of the carbon transfers, the active layer thickness over different soils and surface types needs to be known, as well as the dynamics of soil moisture during the annual freeze/thaw cycle. In this initiating work, time series of X-Band SAR data are investigated for surface change detection. Polarimetric and interferometric estimators are evaluated as a function of the ground measurements for characterization of the processes occurring in the active layer and on the surface.

SAR data

TerraSAR-X data have been acquired over two sites located around 50 km at east of Yakutsk (Central Siberia) every 11 days during one year to cover a whole freeze/thaw cycle. The selected polarimetric channels were HH and HV ensuring sensitivity to vegetation dynamics and enabling polarimetric optimization of the coherence.

Ground measurements

Ground measurements were performed over the two sites two months before the SAR acquisition. Active layer depth, soil moisture gradient, vegetation height and type were collected. We also have used temperature vertical profiles measured over instrumented sites during height years. These profiles were established over 5 typical East-Siberian environments: two alas (thermokarstic depressions) composed by grass and other herbaceous vegetation and lakes, and three other sites covered respectively by birch, larch and pine forests.

Results

First, using our SAR time series, dynamics of estimators derived from polarimetric decomposition techniques [Lee et al., 2009; Cloude et al., 2009] is investigated over the different surface types to determine how relevant is SAR polarimetry at Dual-Pol to follow the surface changes due to variations of vegetation state, soil moisture and snow cover, in such an environment.

Secondly, vertical ground movements due to change of the water state and its migration in porous soils during the freeze/thaw cycle are detected using differential interferometry [Wang et al., 1999; Ferretti et al., 2001; Bernardino et al., 2002] at different polarizations. The amount of subsidence is then linked to the soil physical properties and its relation with the active layer thickness is investigated.

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