QUIKSCAT BACKSCATTER SENSITIVITY ON LANDSCAPE FREEZE/THAW STATE OVER ALECTRA SITES IN ALASKA FROM 2000 TO 2008: APPLICATION TO SMAP VALIDATION PLANNING

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The NASA Soil Moisture Active and Passive (SMAP) mission is dedicated to measurement of global soil moisture and boreal land surface freeze/thaw state [1]. The satellite will carry radar (active) and radiometer (passive) L-band instruments that will perform simultaneous and coincident measurements of the Earth's surface. The combination of data from the two instruments will allow unprecedented spatial accuracy and temporal frequency for global mapping of soil moisture and freeze/thaw state. The freeze/thaw state will be determined in boreal region (>45°N) at spatial classification accuracy of 80 % at 3 km geometrical resolution.

The objective of the SMAP Science Cal/Val Program is to calibrate and validate the science algorithms and products relative to the mission requirements. The overall strategy to meet this objective in terms of Level 2 products (soil moisture and freeze/thaw state) includes (1) ground-based efforts: in situ monitoring using ground based observation networks and intensive field campaigns using airborne sensors and ground-data acquisition; (2) alternative satellite based soil moisture products, and (3) application of land surface modeling. This study contributes to the efforts establishing the ground-based validation strategy for the freeze/thaw state product.

In order to study the freeze/thaw state of the landscape and its relationship to radar backscatter the thermal conditions of each component of the landscape needs to be known. This requires sophisticated data set. The Alaska Ecological Transect (ALECTRA) experiment sites provide a unique data set that satisfies this requirement. These sites encompass several measurements of the physical temperatures of the landscape from subsurface soil to vegetation stem and branches. Additionally, the sites observe the plant growth activity through xylem flow measurements. Furthermore, many of the sites are situated in the vicinity of other experimental research sites including flux towers and other biophysical sampling stations. The sites investigated here distribute themselves from north to south over the state of Alaska, so that the northernmost sites are located on the border of the arctic region and the southernmost site is located near the coast on Kenai Peninsula. These sites cover a wide range of both land cover and meteorological conditions.

Numerous studies have investigated and established the application of radar backscatter signal for detecting freeze/thaw state of the landscape (e.g. [2]-[5]). The studies encompass analyses utilizing L-, C-, and Ku-band data. Since the objective of this study is to analyze the validation issues of SMAP measurements, the optimal frequency of choice would naturally be L-band. However, there is no long time series of adequately high temporal fidelity (daily) radar measurements at L-band available over freezing and thawing areas. Therefore, the daily (applies over Alaska) Ku-band data of NASA's QuikSCAT satellite scatterometer obtained between years 2000 to 2008 is utilized. The effect of the vegetation is very different for Ku-band than for L-band; this is accounted for when interpreting the results. Furthermore, the analysis needs to account for the fact that QuikSCAT data has 25 km spatial resolution (as opposed to 3 km of SMAP), which amounts as higher heterogeneity within the footprint. Both ascending (6 am) and descending (6 pm) overpasses of QuikSCAT are investigated for understanding the diurnal cycle of freeze/thaw and backscatter evolution The backscattering signal of horizontal and vertical polarization, and their ratio, is included.

Each site shows remarkable similarity for backscatter signature over the annual cycle. The maximum deviation from the mean of each day is only about 1 dB on average. On the other hand, the signatures are different from site to site and also the mean yearly freezing and thawing dates are notably different. This is due to both different terrain and land cover type and meteorological conditions. Hence, for example, the effect of snow cover and snow wetness at these extremes are very different which affects especially the detection of thaw events.

For evaluating which temperature sensors are most important for the changes in the radar backscatter the binary state for each sensor were retrieved: the output of each sensor was reduced to give indication whether it was above or below 0°C. The match between the backscatter and the binary state of different temperature was then investigated by determining how much the backscatter obtained under frozen conditions overlap with the backscatter obtained under thawed conditions. The reason why the analysis is done in this way is that in this way the backscatter freeze/thaw algorithm of choice does not affect the result. Furthermore, using only the binary state of the temperature does not overemphasize the magnitude of the temperature.

The results give the optimal combination of the thermal sensors in the landscape to predict the radar response to freezing and thawing event. Very importantly the optimal combination varies with the type of terrain type and landcover, which indicate different validation strategy for different type of landscape. The understanding obtained in this study using Ku-band at 25 km resolution level over long time series with high temporal fidelity can then be combined with L-band observations, which have higher resolution but not long time series with high temporal fidelity, to formulate the correct in situ sampling strategy for SMAP validation.

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