MONITORING LAND SURFACE SEASONAL FREEZE/THAW STATE FOR QUANTIFYING CONTROLS ON BOREAL ECOSYSTEM PRODUCTIVITY: LINKING TERRESTRIAL WATER AND CARBON CYCLES WITH NASA'S SOIL MOISTURE ACTIVE/PASSIVE (SMAP) MISSION

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Abstract:

Satellite active and passive microwave remote sensing can be applied to characterize soil moisture and the transitioning of water between frozen and non-frozen conditions. NASA's Soil Moisture Active/Passive (SMAP) mission, currently under development, will use a combined radiometer and high-resolution radar to measure surface soil moisture and freeze-thaw state providing new opportunities for scientific advances and societal benefits. Major science objectives of SMAP support the understanding of processes linking terrestrial water, energy and carbon cycles, the quantification of net carbon flux and the extension of capabilities for weather and climate prediction models. Soil moisture is a key control on evaporation and transpiration at the land-atmosphere boundary. The landscape transition between seasonally frozen and non-frozen conditions occurs each year over more than 50 million km^2 of the global biosphere, affecting hydrologic and ecological processes and associated trace gas dynamics profoundly. Combined, soil moisture and its freeze/thaw state define a surface hydrospheric state that is key to linking terrestrial water and carbon cycles and a key determinant of the terrestrial carbon cycle.

The SMAP suite of data products will include maps of landscape freeze/thaw state derived from L-band radar at 1-3 km spatial resolution with a 2-day refresh rate for the high northern latitudes (i.e. latitudes above 50 degrees north). Satellite active and passive microwave remote sensing can be applied to detect large changes in landscape dielectric properties associated with water transitioning between frozen and non-frozen conditions. In the northern high latitudes, seasonal freeze/thaw transitions associated with this process dominate time-series microwave remote sensing signatures. The SMAP freeze/thaw algorithm employs a temporal change detection scheme to delineate freeze/thaw state changes associated with temporal variations in landscape dielectric properties. Development of the baseline SMAP algorithm follows from application of legacy data sets provided by satellite radars, both scatterometers and Synthetic Aperture Radars (SARs), and radiometers. These legacy data sets are also currently being applied in assembly of

an Earth System Data Record (ESDR) quantifying freeze/thaw dynamics for the global vegetated land surface.

This presentation reviews algorithm development and associated SMAP science objectives addressed through the baseline SMAP data products and applications. The legacy data sets applied include data spanning a 25 year record, and thus also allow construction of a consistent multi-year data record of land surface freeze-thaw state spanning multiple satellite missions and sensors, including some overlap between missions. Baseline and optional algorithm implementations are explored, utilizing temporal change detection schemes to analyze daily radar backscatter and radiometric brightness temperatures to map freeze/thaw changes. Empirical methods and radar backscatter and microwave emissions models are used for merging overlapping sensor time series into calibrated F/T time series. The F/T state variable provides a surrogate measure of landscape water mobility and associated cold temperature constraints to biological processes, including vegetation productivity and carbon exchange. Potential applications of the F/T products are presented, including hydrologic and carbon cycle applicatsion, as well as ecological forecasting. We introduce a framework for using SMAP data products in an integrated scheme with other satellite data sources to support assessment of global terrestrial carbon cycling.

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