Terrestrial Freeze-Thaw Monitoring in the Northern Hemisphere using Satellite Active and Passive Microwave Remote Sensing

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Terrestrial Freeze-Thaw Monitoring in the Northern Hemisphere using Satellite Active
and Passive Microwave Remote Sensing

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Introduction:
Approximately 50 million km² of the terrestrial Northern Hemisphere undergoes seasonal freeze-thaw (F/T) transitions each year. The timing and duration of landscape F/T processes are closely linked to surface energy budget and hydrological activity, vegetation phenology, terrestrial carbon budgets and land-atmosphere trace gas exchange. Satellite microwave remote sensing is relatively insensitive to signal degradation by atmospheric contamination and solar illumination effects and is uniquely capable of detecting and monitoring a range of biophysical processes associated with the F/T signal, especially at high latitudes.

Datasets:
- Sensor: SSM/I, AMSR-E, SeaWinds
- Platform: DMSP, Aqua, QuikSCAT
- Frequency: 3 GHz, 36 GHz, 13.4 GHz
- Polarization: H-pol, H-pol, H-pol
- Resolution: 25x25km, 25x25km, 15x25km

Accuracy assessment of Terrestrial F/T products:
(1) Pixel-to-point comparison with NCDC air temperatures
(2) Pixel-to-pixel comparison with NNR air temperatures
(3) Comparison between SSM/I F/T and AVHRR/MODIS NPP onset/offset
(4) Multi-sensor F/T classification comparison

Conclusions:
- Satellite F/T classification accuracy ranges from ~40-60% and is higher and lower during respective thaw and freeze transitions; classification accuracy is similar for different sensors and from year-to-year;
- Thaw transition generally coincide with growing season timing and length defined by independent satellite (MOD17) derived NPP time series;
- Annual mean F/T dates from SSM/I and AMSR-E shows similar F/T patterns, while those from SeaWinds displays earlier thaw timing in STA (later in CNV) and earlier freeze timing in both algorithms;
- The STA and CNV algorithms produce similar F/T patterns and time series, through STA shows earlier thaw timing than CNV;
- F/T classification accuracy is generally improved over regions with medium cold temperature constraints, while F/T accuracy is mostly consistent with respect to LC and terrain heterogeneity.

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- Microwave sensors are able to observe freezing and thawing of landscape has its origin in the distinct changes in landscape dielectric properties that occur during transitions between solid and liquid phases of water.