Detection and Monitoring of Fire Disturbance in the Alaskan Tundra Using a Two-decade Long Record of Synthetic Aperture Radar Satellite Images

Using the extensive archive of historical ERS-1 and -2 synthetic aperture radar (SAR) images, this analysis demonstrates that fire disturbance can be effectively detected and monitored in high northern latitudes using radar technology. A total of 392 SAR images from May to August spanning 1992-2010 were analyzed from three study fires in the Alaskan tundra. The investigated fires included the 2007 Anaktuvuk River Fire and the 1993 DCKN178 Fire on the North Slope of Alaska and the 1999 Uvgoon Creek Fire in the Noatak National Preserve (below).

Seasonal Analysis
The best time for burned area detection is as late in the growing season as possible before frozen ground conditions develop. This corresponds to mid-August for the study fires. Intra-annual plots of backscatter one year post fire (right) within the entire burn perimeter (grey square) and polygon pairs (red corresponds to burn and blue to unburned) shows the difference between burned and unburned is smaller (0.1 to 0.6 dB) in early May, with the difference increasing over the growing season. Generally, the May data for all three fires showed variable response year-to-year but May images consistently showed less differentiation between burned and unburned signatures.

Inter-annual Analysis
Plots of the radiometric response over the entire ERS data record (above) clearly show the fire event (dashed line) and the lasting impact on the record. Fire scars are brightest one year post fire (below) with the brightness gradually decreasing each subsequent year post-fire. The fires evaluated are approximately 3.0 to 3.3 dB brighter than adjacent unburned areas during the end of the growing season one year post fire. The regions used in the analysis and defined by the homogeneous burned and unburned polygon pairs for Anaktuvuk River Fire (a), DCKN178 Fire (b), and Uvgoon Creek Fire (c) are shown on ERS images one year post fire (below).

Landscape Recovery
In contrast to electro-optical studies from the same region, measures of landscape recovery as detected by the SAR were on the order of four to five years instead of one. Analysis of variance (ANOVA) was used to conduct a longitudinal analysis of landscape recovery post-fire. A three-way additive effects ANOVA was implemented for each fire that estimates $\sigma$ as a function of the year in which burn occurred (the year effect), the polygon regions (the region effect), and burn status (the burn effect). Plots of the effect of burn derived from the ANOVA model (below) show landscape recovery (a return to zero burn effect) four years post-fire for DCKN178 (b) and five years post-fire for Uvgoon (c). Not enough data are available to document the return for the Anaktuvuk River Fire (a), but three years post fire is above the zero-effects line. The 95% confidence intervals are represented by the dashed blue lines.