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AN OPTIMIZED APPROACH TO MAPPING FREEZING TERRAIN WITH SMMR DATA

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Abstract

Soil moisture contributes to the energy exchange between the air and the ground through latent heats of fusion and vaporization. Consequently, the processes of thawing frozen ground or of evaporating soil moisture cause soil thermal inertias to appear anomalously high. There is a large body of literature about deriving soil moisture from radiobrightness. Moisture state can also be inferred from radiobrightness [1]. Frozen soil classification is based upon a combination of 37 GHz radiobrightness and spectral gradient, $\partial T_b(f)/\partial f$, where $T_b(f)$ is the radiobrightness at frequency f. Frozen soils appear cold at 37 GHz, and exhibit a negative spectral gradient that is largely caused by volume scatter darkening at the shorter wavelengths.

This two parameter "freeze indicator" has been applied to data from the Scanning Multichannel Microwave Radiometer (SMMR) on Nimbus-7. For these data, the spectral gradient is a linear, least-square fit to the 10.7, 18, and 37 GHz radiobrightnesses. Conceptually, a surface is classified as frozen only if both the 37 GHz radiobrightness and the spectral gradient are sufficiently low. A freeze map is generated by displaying the freeze indicator for each pixel location. However, data processing is complicated by the very different spatial resolutions of the different SMMR frequency channels. Resolution compensation (equalization) must be performed prior to classification so that spatial averaging is similar at all frequencies. Assuming that no a priori surface information is available, common practice for resolution compensation is to degrade the high frequency (fine resolution) data to the resolution of the low frequency (coarse resolution) data. As a result, fine resolution information is lost.

Under certain constraints, fine resolution information can be recovered in the location estimate of the freeze/thaw boundaries [2]. If the constraints are met, the coarse resolution freeze/thaw boundaries can be registered to fine resolution, 37 GHz boundaries (i.e., to 37 GHz radiobrightness threshold crossings). These 37 GHz boundaries become better estimates of freeze/thaw boundary locations than those at coarse resolution.

In this paper, we show that boundary registration can be optimized through clustering. Specifically, 37 GHz radiobrightnesses and spectral gradients from SMMR measurements are grouped into frozen and thawed clusters for an area that includes North Dakota, about half of each neighboring state, and part of Canada for the Fall of 1984. From the intersection of the clusters, fine resolution 37 GHz radiobrightness boundaries are defined that register with the freeze map boundaries. In addition, fine resolution, 37 GHz radiobrightness boundary widths (regions of boundary uncertainty) are also defined.

[1] Zuerndorfer, B. W., England, A. W., Dobson, C. M., and Ulaby, F. T. (1989). "Mapping freeze/thaw boundaries with SMMR data," *J. Agriculture and Forest Meteorology*, under review.

[2] Zuerndorfer, B. W., England, A. W., and Wakefield, G. H. (1989). "The radiobrightness of freezing terrain," *1989 IEEE Int. Geosci. and Remote Sensing Symp.*, Vancouver, Canada.