(None) = RL-2003

RADIOBRIGHTNESS OF PERIODICALLY HEATED, TWO-PHASE MEDIA

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December 19, 1988

Abstract

Soils that contain liguids or gases that freeze during diurnal insolation will appear radiometrically distinctive. That is, they will appear to have anomalously high thermal inertias caused by the latent heats of fusion or sublimation. The effect should be observable in the diurnal variation of the radiobrightness of freezing moist soils, or in the radiobrightness of Mars soils that are saturated with CO_2 ice.

The 1-dimensional, heat flow equation for moist soils,

$$\frac{\partial E(T)}{\partial t} = \frac{\partial}{\partial z} K(T) \frac{\partial T}{\partial z}$$

is non-linear because both the enthalpy, E(T), and the thermal conductivity, K(T), are non-linear functions of T at freeze/thaw phase boundaries. Furthermore, diurnal insolation may cause phase boundaries at more than one depth, z. The problem is particularly difficult because these phase boundaries propagate and, occasionally, cancel themselves, and because soils that contain clay freeze over a range of temperatures rather than at 0^{o} C--that is, they possess diffuse phase boundaries.

The problem of periodic heating of two-phase media has come to be known as Stefan's problem. There are several numerical techniques for its solution. The Chernous'ko method was most readily modified for diffuse phase boundaries, and was developed as a modeling tool for examining the radiobrightness of diurnally heated soils. These models exhibit diurnal radiobrightness spectral gradients similar to those computed from the 10.7, 18, and 37 GHz radiobrightness temperatures from the Scanning Multichannel Microwave Radiometer (SMMR) on Nimbus-7 (reported in a separate abstract, England, et al), and may explain the anomalously flat radiobrightness spectrum of Mars.