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综述与评述

冻土遥感研究进展——可见光、红外及主动微波卫星遥感方法

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摘要：

多年冻土和季节冻土分别占北半球裸露地表的24% 和55%。近地表土壤冻融的范围、冻结起始日期、持续时间及冻融深度对寒季/寒区的植被生长、大气与土壤间能量、水分及温室气体交换都具有极其重要的影响。卫星遥感结合地面观测资料研究局地到区域尺度的季节冻土和多年冻土已取得诸多成果。综述了近几十年来卫星遥感技术在冻土研究中的应用。监测多年冻土和地表冻融循环通常需要综合利用可见光、红外、被动微波及主动微波（包括合成孔径雷达SAR和散射计）遥感数据，任何单一波段的传感器都无法满足研究需求。SAR图像能提供空间分辨率较高的寒季/寒区近地表土壤冻融状态的起始日期、持续时间和区域演变等信息，但目前在轨SAR的重访周期相对于春秋季的土壤冻融循环变化过长;星载被动微波传感器具有多通道观测且重访周期较高，但空间分辨率很低的特点;光学和热红外传感器的时空分辨率介于SAR和被动微波遥感之间，但应用于冻土研究时需要具备多年冻土分布和冻融深度与环境因子相关关系的先验信息。总体而言，微波遥感是探测无雪覆盖近地表土壤冻融循环的有效技术手段，而利用热红外传感器反演的地表温度研究土壤冻融过程具有极大潜力。应用卫星遥感反演的积雪范围、雪深、融雪、地表类型、归一化差值植被指数、地表反照率和土壤水分等参数对研究局地、区域乃至全球尺度的冻土都大有裨益。

关键词： 多年冻土;季节冻土;冻融循环;遥感

Overview of the Satellite Remote Sensing of Frozen Ground: Visible thermal Infrared and Radar Sensor

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Abstract:

Permafrost and seasonally frozen ground regions occupy approximately 24% and 55%, respectively, of the exposed land surface in the Northern Hemisphere. The areal extent, timing, duration, and depth of the near surface freeze/thaw soil have a significant impact on the plant growth, energy, water and trace gas exchanges between the atmosphere and the soils in cold seasons and cold regions. Satellite remote sensing combined with ground “truth” measurements have been used to investigate seasonally frozen ground and permafrost at local to regional scales with some successes. The objective of this paper is to provide an overview of satellite remote sensing techniques applied to study seasonally frozen ground and permafrost over the last few decades. Remote sensing of permafrost terrain and surface freeze/thaw cycles typically uses a combination of data in optical thermal wavelengths, passive microwave sensing, and active microwave remote sensing (including the scatterometer and Synthetic Aperture Radar). Any single sensor is not capable of providing the range of observations needed. SAR imaging provides information on the timing, duration, and regional progression of the near surface soil freeze/thaw status in cold seasons/regions with a relatively high spatial resolution, but the revisiting period of existing satellites are relatively longer compared to the soil freeze/thaw cycle in fall and spring. Spaceborne passive microwave sensors offer more frequent coverage at several wavelengths, but with substantially lower spatial resolution. The optical thermal sensors provide a compromise in spatial resolution and temporal sampling between SAR and passive microwave satellites, but a prior relationship between permafrost (and freeze/thaw depth) and corresponding environmental factors needs to be provided. Overall, microwave remote sensing is a promising technique to detect the near surface soil freeze/thaw cycles over snow free land. The potential of using land surface temperature derived from

the thermal infrared sensors to study soil freezing and thawing processes is marked. Satellite remote sensing data products, such as snow cover extent, snow depth, snowmelt, land surface type, Normalized Difference Vegetation Index (NDVI), surface albedo and soil moisture, can be very helpful for the frozen ground researches at local, regional, and global scales.

Keywords: Permafrost Seasonally frozen ground Frozen/thawed cycle Remote sensing

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