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Frozen soil observation - Frequency domain reflection method

冻土观测 频域反射法

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Table of Contents

Foreword

This document is in accordance with the provisions of GB/T 1.1-2020 "Guidelines for standardization work Part

1.Structure and drafting rules for standardization documents" Drafting. Please note that some of the contents of this document may involve patents. The issuing organization of this document does not assume the responsibility for identifying patents. This document was proposed by the China Meteorological Administration. This document is under the jurisdiction of the National Technical Committee for Standardization of Meteorological Instruments and Observation Methods (SAC/TC507). This document was drafted by: Henan Meteorological Science Institute, Henan Zhongyuan Optoelectronic Measurement and Control Technology Co., Ltd., China Meteorological Administration Meteorological Observation Center, Beijing Huayun Oriental Detection Technology Co., Ltd. The main drafters of this document are. Chen Haibo, Yu Guohe, Li Peng, Wu Dongli, Cheng Lin, Wu Su, Li Shuyan, Liu Yinfeng, Li Cuina, Niu Na, Zhao Guoqiang, Shi Likui, Wang Yanbin, Zhang Guangzhou, Tian Hongwei, Zhang Xihe, Chen Tao, Hu Chengda. Frequency Domain Reflectometry for Frozen Soil Observation

1 Scope

China's national method for observing frozen soil by frequency domain reflectometry. The technique measures the dielectric permittivity of soil from the response of a probe to a radio frequency signal, and it works for frozen ground because liquid water and ice have permittivities that differ by a factor of forty - so the measurement distinguishes unfrozen water from ice directly and continuously. That is exactly what permafrost monitoring needs.

The property that matters is not whether the ground is below zero but how much of its water is still liquid, since it is the unfrozen fraction that governs the soil's strength and its response to warming, and a substantial fraction remains liquid well below zero in fine-grained soils. China has more infrastructure on permafrost than any other country outside Russia - the Qinghai-Tibet railway and highway above all - and monitoring its thermal state is a continuing engineering obligation.

This document describes the principles, observation conditions, observation instruments, observation procedures, quality control and observation of frozen soil using frequency domain reflectometry. Report. This document applies to observations of frozen soil using the frequency domain reflectometry method.

2 Normative references

The contents of the following documents constitute essential clauses of this document through normative references in this document. For referenced documents without a date, only the version corresponding to that date applies to this document; for referenced documents without a date, the latest version (including all amendments) applies to This document.

GB/T 31162 Technical specification for lightning protection of ground meteorological observation sites (rooms)

GB/T 35221 General rules for surface meteorological observations

3 Terms and definitions

The terms and definitions defined in GB/T 35221 and the following apply to this document.

3.1 frozen soil Soil that contains moisture and is frozen when the temperature drops to 0°C or below. [Source: GB/T 35234-2017, 3.1, modified]

3.2 Observe and record the freezing level of frozen soil and its upper and lower depth limits.

3.3 A technique for measuring the dielectric constant of a medium by determining the frequency of the reflection peak of the medium to a swept frequency signal in a specific frequency band.

3.4 The dielectric constant of soil is measured based on the principle of frequency domain reflection, and the significant difference in dielectric constant between frozen and unfrozen soil is observed. Permafrost observations.

4 Principle

During the freezing and thawing process of soil, the water-ice phase change in the soil causes the soil dielectric constant to change, resulting in a change in soil capacitance.

Based on the LC oscillation circuit Frequency response principle, the instrument using frequency domain reflection technology automatically measures the reflection frequency of the soil, and then judges according to the change of soil reflection frequency Soil freezing state, observe the soil freezing layer and its upper and lower limit depths. The soil dielectric constant is shown in formula (1), the relationship between soil capacitance and soil dielectric constant is shown in formula (2), and the soil reflection frequency and the oscillation voltage are shown in formula (3).