# THE COHERENT MICROWAVE EMISSION OF FREEZING SOIL: EXPERIMENTAL RESEARCH AND MODEL SIMULATION

*Zhao Shaojie[1, 2], Zhang Lixin[1, 2], Zhang Yongpan[1, 2], Xing Weipo[1, 2]*

*1. State Key Laboratory of Remote Sensing Science, Beijing Normal University, Beijing, 100875, China.*
*2. School of Geography and Remote Sensing Science, Beijing Normal University, Beijing, 100875, China.*
*Email: shaojie.zhao@gmail.com*

## 1. INTRODUCTION

The microwave radiation characteristics of frozen soil have been investigated at different frequencies [1][2][3]. In the Winter Ground Microwave Radiometric Experiment (WIGMIRE), the coherency effect from a wet smooth bare soil surface was observed by a four-frequency dual polarized Microwave Radiometer. This phenomenon could be explained by a simple two layer radiative transfer model in which the coherence of microwave emission from different soil layers was considered. However, the thickness of the frozen layer in the footprint is not uniform.

## 2. EXPERIMENT METHOD

A Truck Mounted four-frequency dual polarized Microwave Radiometer (TMMR) was set up to monitor the microwave emission of frozen soil in National Experiment Station for Accurate Agriculture, 30km north of Beijing, China. The frequencies of TMMR are 6.925GHz, 10.65GHz, 18.7GHz and 36.5GHz. Each frequency module was well calibrated before measurement.

A bare ground of 10m*15m was smoothed before measurement as the viewing area of the radiometer. In12-06- 2008, this area was fully irrigated so that the water content of the surface soil is relatively homogeneous; the volumetric water content was around 70%. After the irrigation, the surface started to freeze because the ambient temperature was below 0℃. The microwave emission measurement began at 16:23 when the freezing of soil had just began, and ended at 12:00 the next day. The surface physical temperature was measured by two platinum thermometers. The thickness of the surface frozen layer was directly measured by ruler.

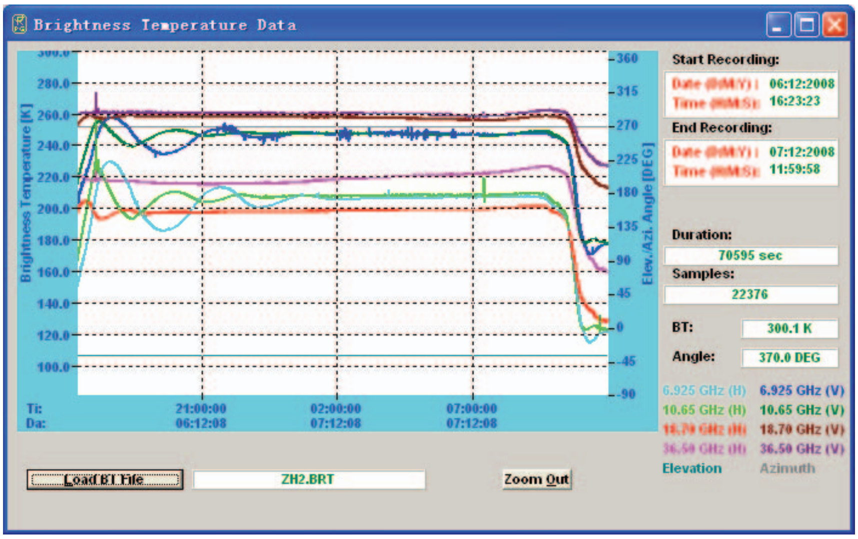


Fig. 1 Brightness temperatures change with time as the soil freeze.

The physical temperature of soil surface was around -1℃ in the surface frozen layer and didn’t change much during the freezing process. This could be explained by the release of latten heat during the phase change of water. But the brightness temperature oscillated strongly during the freezing process. (Fig. 1) The oscillation amplitude, period and lasting time show strong dependence on frequency and polarization.

## 3. TWO LAYERS COHERENT MODEL

For freezing soil, the dielectric difference between frozen layer and the unfrozen layer is sharp especially when the water content is high. When the thickness of the frozen layer is smaller than the microwave penetration depth, the effective emissivity could be calculated by two approaches: coherent and non coherent [4]. The coherent emission model could explain the oscillation period very well but the measured oscillation amplitudes of microwave brightness temperatures are smaller than the output of coherent model. This may because the thickness of the frozen layer in the footprint is not uniform. If we consider the effective emissivity to be the weighted sum of coherent emissivity and noncoherent emissivity, the modeled brightness temperature oscillation amplitude become comparable with the measured data.

## 4. CONCLUTION

In ground microwave radiation measurement of freezing soil, the brightness temperature shows evident coherent effect, especially for low frequencies. This effect could be explained by considering the radiation coherence between the frozen and unfrozen soil layer in a two layers coherent model. This indicate that it’s important to consider the coherent effect in modeling freezing soil with a frozen layer thinner than microwave penetration depth.

## 5. REFERENCES


[1] Wegmüller, “The effect of freezing and thawing on the microwave signatures of bare soil”, *Remote Sens. Environ*, vol. 33, pp. 123-135, 1990.

[2] M. Schwank, M. Stähli, and H. Wydler et al., “Microwave L-band emission of freezing soil,” *IEEE Trans. Geosi. Remote Sensing*, vol. 42, pp. 1252—1261, 2004.

[3] Y. -A Liou, and A. W. England, “A land surface process/radiobrightness model with coupled heat and moisture transport for freezing soil,” *IEEE Trans. Geosi. Remote Sensing*, vol. 36, pp. 669−677, 1998.

[4] Ulaby, F. T., Moore, R. K., and Fung, A. K., Microwave remote sensing: active and passive, vol. 1-3. Dedham, MA: Artech House, 1986.