# Soil Moisture Experiment in the Luan River


# Multi-frequency and multi-angular ground-based microwave radiometer and radar cooperative experimental data for grassland in 2018

## Document, Version 1

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# 1. Abstract

This data set was collected in 2018 during the ground-based microwave radiometry and radar cooperative experiment, which is part of the Soil Moisture Experiment in the Luan River (SMELR). The experiment site is located in Zhenglan Banner, Inner Mongolia (115.93 ° E, 42.04 ° N, at 1362 m in altitude). The data set contains four parts, namely brightness temperature data, radar backscatter coefficient, soil data and vegetation data. The microwave brightness temperature data was observed by a vehicle-mounted dual-polarized multi-frequency radiometer (RPG-6CH-DP), including the horizontal (H) and vertical (V) polarization brightness temperatures at L-, C- and X-bands. The brightness temperature data was acquired every 30 minutes from 30 ° to 65 ° with an interval of 2.5 °. The active microwave data is obtained by ground-based synthetic aperture radar (GBSAR), including the L- and C-band backscattering coefficients under four polarization modes (VV, VH, HH, HV), and the incidence varies from 30 ° to 65 ° (2.5 ° interval). The soil data contains the surface roughness, soil moisture and temperature at six depths of layer (1 cm, 3 cm, 5 cm, 10 cm, 20 cm, 50 cm). The vegetation data is mainly the vegetation water content of the grassland.

The experimental period lasted from August 18 to September 25, 2018, and it provided important data for the land surface microwave radiation modeling and validation, as well as the development of soil moisture retrieval algorithms.

**Fig.1.** Overview of the ground-based experiment in grassland

# 2. Instruments

2.1. Vehicle-mounted dual-polarized multi-frequency radiometer (RPG-6CH-DP)

The vehicle-mounted dual-polarized multi-frequency radiometer (RPG-6CH-DP) contains three frequencies: L-band (1.41 GHz), C-band (6.925 GHz) and X-band (10.65 GHz). The L-band works with a planar patch array, and the C- and X-bands share a parabolic antenna (configurations shown in Table 1). All three bands (six channels) can work simultaneously to obtain dual-polarized multi-frequency brightness temperatures.

Table 1. The configuration of the RPG-6CH-DP radiometer


| Parameter | L-band | C-band | X-band |
|---|---|---|---|
| Frequency | 1.41 GHz | 6.925 GHz | 10.65 GHz |
| Bandwidth | 20 MHz | 400 MHz | 400 MHz |
| Geometry | Planar 64 square patch array | Parabolic antenna | |
| Half power beam width | 11° | 6.85° | 6.11° |
| Side lobe level | < -30 dB | < -30 dB | < -35 dB |
| Radiometric resolution | < 0.2 K @ 1 second integration time | | |

The calibration of the radiometer was conducted regularly when the sky was cloudless. The C- and X-bands were calibrated by using the sky-tipping method, which takes a set of angular sky observations to correct the nonlinearity of the radiometer. The L-band was calibrated using a two-point calibration method, which utilizes a unique constant value of 6.6 K with the direction towards the north celestial pole (elevation angle of 42 °in this experimental area) as the cold point. For details of radiometer calibration, please refer to Zhao et al. (2021).

## 2.2. Ground-based Synthetic Aperture Radar

GBSAR is mainly composed of three parts: control platform, vector network analyzer, control case and computer. The control platform consists of a hydraulic lifting platform and a synthetic aperture orbit (length: 3.5 m). In the experiment, the backscatter coefficients of the grassland at L-band (center frequency: 1.26 GHz) and C-band (center frequency: 5 GHz) are mainly collected, including four polarization modes, namely VV, VH, HH, HV, and the original incident angle varies from 20 °to 70 °. In order to coordinate with the radiometer, the data within the range of 30-65 °

(2.5 ° interval) was extracted through data smoothing. GBSAR was calibrated before each observation. The L-band was calibrated with a large metal disk, and the C-band was calibrated with a metal corner reflector.

Fig. 2. The overview of GBSAR

2.3. Soil temperature and moisture sensor

The grassland is equipped with Decagon EM50 instrument and 5TM sensors during the experiment. The 5TM uses capacitance/frequency domain technology to determine volumetric water content by measuring the dielectric constant of the soil. Besides, the 5TM sensor is equipped with an onboard thermistor to accurately measure soil temperature. For more detailed technical specifications of 5TM sensor, readers are referred to: https://metos.at/portfolio/decagon-5tm-soil-moisture-sensor/.

## 3. Data details

The data file is saved in *xlsx* format and is named as: ZhenglanqiExp+ '_ParaName'. 'ParaName' represents the abbreviation of the observed parameter. For example, the brightness temperature is named as 'ZhenglanqiExp_TB.xlsx', the backscatter data is named as ‘ZhenglanqiExp_Sigma0’, the soil data set is named as 'ZhenglanqiExp_Soil.xlsx' and the vegetation water content data is named as 'ZhenglanqiExp_VWC.xlsx'. The data set can be directly opened with Excel. Details of each parameter are as followed.

Details of each parameter are described as followed.

3.1. Brightness temperature

The experimental area is an open natural pasture, covering an area of about 4 square kilometers. The radiometer was raised to a maximum height of 6.35 meters above the ground to meet the observation requirements of far-field conditions. The main observation mode of the radiometer is shown in Figure 3, in which the incident

angle of the observation surface varies from 30 ° to 65 °, and repeated observations are set in four directions.

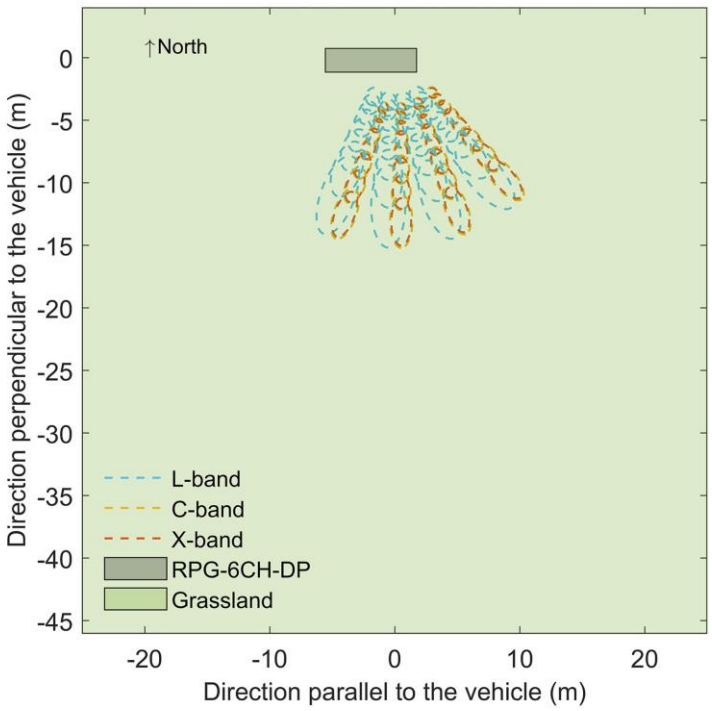


Fig. 3. The scanning mode of radiometer in the experiment

3.2. Radar backscatter coefficient

The original observation angle range of ground-based radar is about 20-70 °. In order to match the observations of the vehicle-mounted microwave radiometer, the backscatter coefficients in the range of 30-65 ° (2.5 ° interval) were extracted. Each observation corresponds to four polarization modes, namely VV, VH, HH, HV.

3.3. Soil moisture and temperature

Soil moisture and temperature were measured by the Decagon EM50 instrument (5TM probes), and the nominal resolution and accuracy of 5TM probe are 0.0008 $cm^3/cm^3$ (± 0.03 cm3/cm3) for SM and 0.1 K (± 1 K) for soil temperature. The soil probes were installed horizontally at six different depths, which were 1 cm, 3 cm, 5 cm, 10 cm, 20 cm and 50 cm. It should be noted that the measurement at 1 cm may be affected by the air.

3.4. Surface roughness

The surface roughness was measured nearly every week by taking pictures of a 1-m needle board, and root mean squared height *s* and correlation length *l* were calculated after digitalizing the surface height profile. The measurements were conducted three times in the north-south and east-west directions to obtain a soil surface profile of 3 m respectively. The average value of the surface roughness

parameters (root mean square height and autocorrelation length) are provided in the data file.

3.5. Vegetation properties

The vegetation water content of the grass was randomly sampled three times according to an area of 1m × 1m and measured by the Owen drying method. The average value of each measurement and its standard deviation are provided in the data file.

## 4. Data Citations

Zhao, T., Hu, L., Geng, D., Shi, J. (2021). Multi-frequency and multi-angular ground-based microwave radiometer and radar cooperative experimental data for grassland in 2018. National Tibetan Plateau Data Center.

## 5. Reference


[1] Zhao, T.J., Shi, J.C., Lv, L.Q., Xu, H.X., Chen, D.Q., Cui, Q., Jackson, T.J., Yan, G.J., Jia, L., Chen, L.F., Zhao, K., Zheng, X.M., Zhao, L.M., Zheng, C.L., Ji, D.B., Xiong, C., Wang, T.X., Li, R., Pan, J.M., Wen, J.G., Yu, C., Zheng, Y.M., Jiang, L.M., Chai, L.N., Lu, H., Yao, P.P., Ma, J.W., Lv, H.S., Wu, J.J., Zhao, W., Yang, N., Guo, P., Li, Y.X., Hu, L., Geng, D.Y., & Zhang, Z.Q. (2020). Soil moisture experiment in the Luan River supporting new satellite mission opportunities. Remote Sensing of Environment, 240, 111680

[2] Zhao, T.J., Shi, J.C., Entekhabi, D., Jackson, T.J., Hu, L., Peng, Z.Q., Yao, P.P., Li, S.N., & Kang, C.S. (2021). Retrievals of soil moisture and vegetation optical depth using a multi-channel collaborative algorithm. Remote Sensing of Environment, 257, 112321.


## 6. Disclaimer

(1) This data is generated by the “Soil Moisture Experiment in the Luan River” under the framework of the "Integrated Remote Sensing Experiment of Carbon, Water Cycle and Energy Balance". When users use the data, please clearly state the source of the data in the text, and quote the citation method provided by this data in the reference section.

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