L-Band Microwave Emission of Soil Freeze-Thaw State in a Tibetan Meadow Ecosystem

Introduction

Soil freeze-thaw (FT) transition monitoring is essential for quantifying hydrologic dynamics over cold regions, e.g. the Tibetan Plateau (TP). We investigate the L-band (1.4 GHz) microwave emission characteristics of soil FT cycle via analysis of tower-based brightness temperature ($T_B{}^p$) measurements using the ELBARA-III radiometer in combination with simulations performed by a model of soil emission considering vertical variations of soil permittivity and soil temperature.

Field Site and Measurements

As part of SMOS/SMAP cal/val activities, the ESA funded ELBARA-III radiometer is deployed within a well instrumented soil moisture and soil temperature (SMST) monitoring network (Maqu, Fig.1).

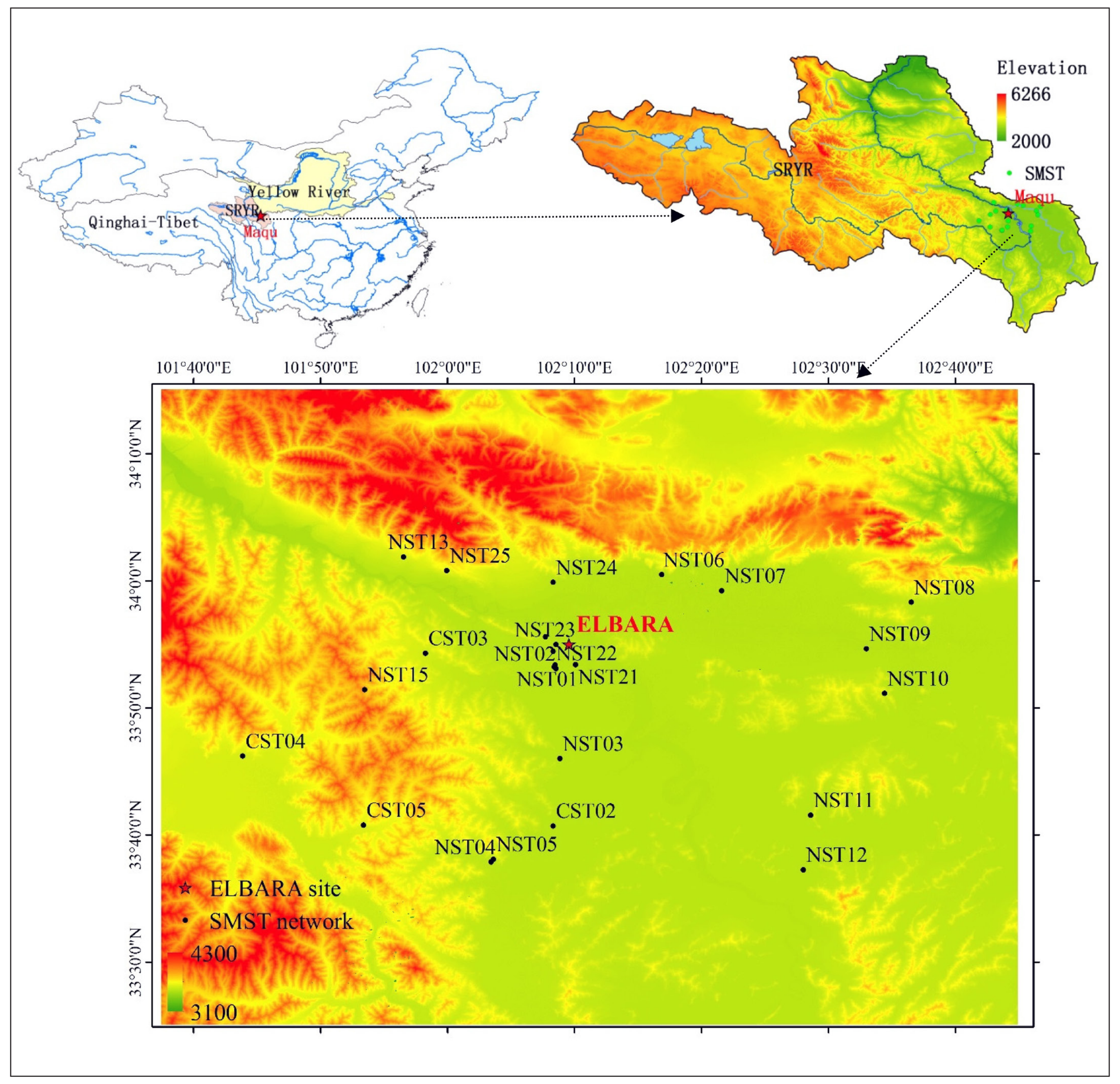

Figure 1. Location of the Maqu SMST monitoring network and the ELBARA-III filed site.

The ELBARA-III radiometer is mounted on a 4.8 m high tower (Fig. 2a). The daily measurements include elevation scanning sequences toward the ground and zenith (sky) measurements. The angular range considered for the elevation scans is performed every 30 min between 40°-70° in steps of 5°.

Sky measurement is performed at 23:55 every day at 155°. Supporting micro-meteorological (Fig. 2c) as well as SMST profile measurements (Fig. 2b) are also conducted. Long term analysis of these in situ measurements is shown in Fig. 3.

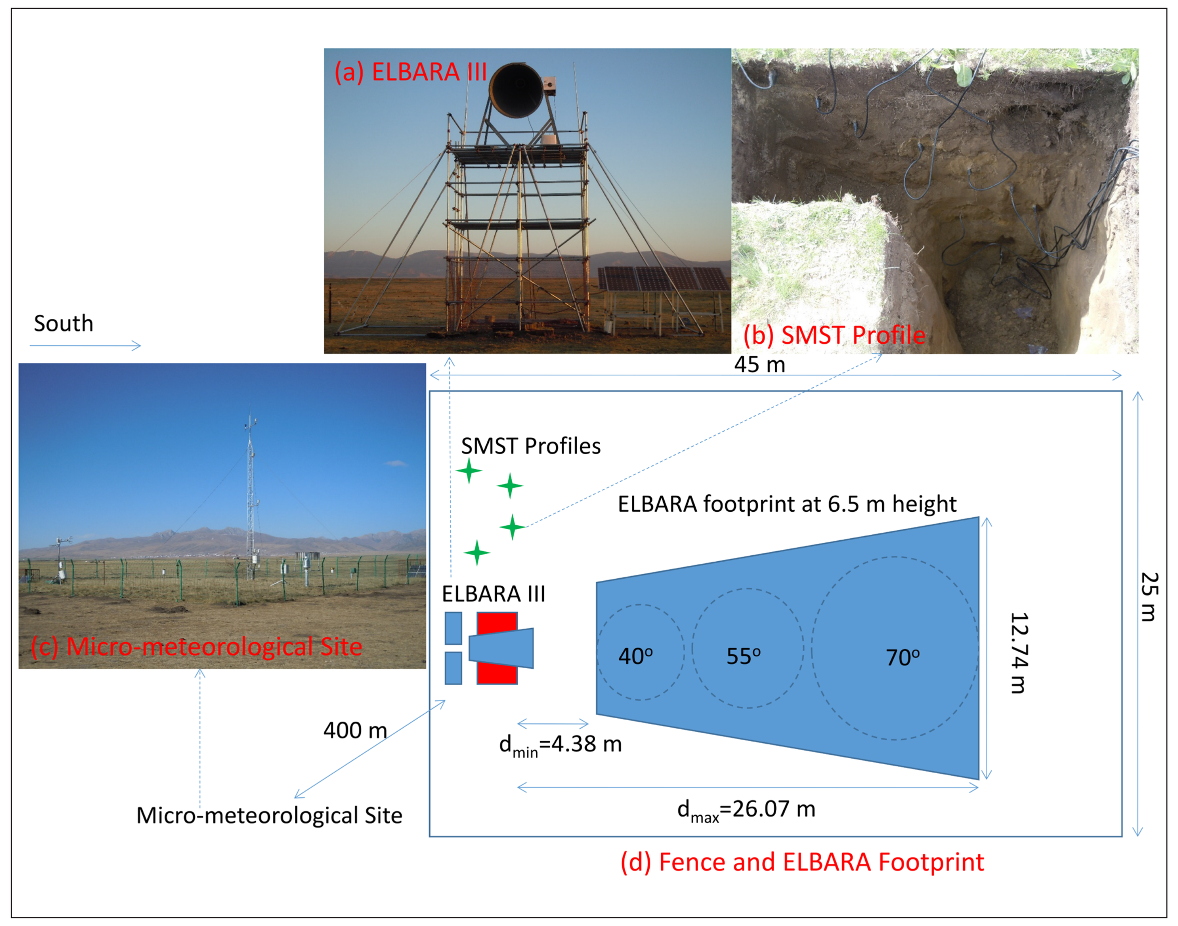

Figure 2. Fence and footprint of the ELBARA-III field site as well as the deployed measurements.

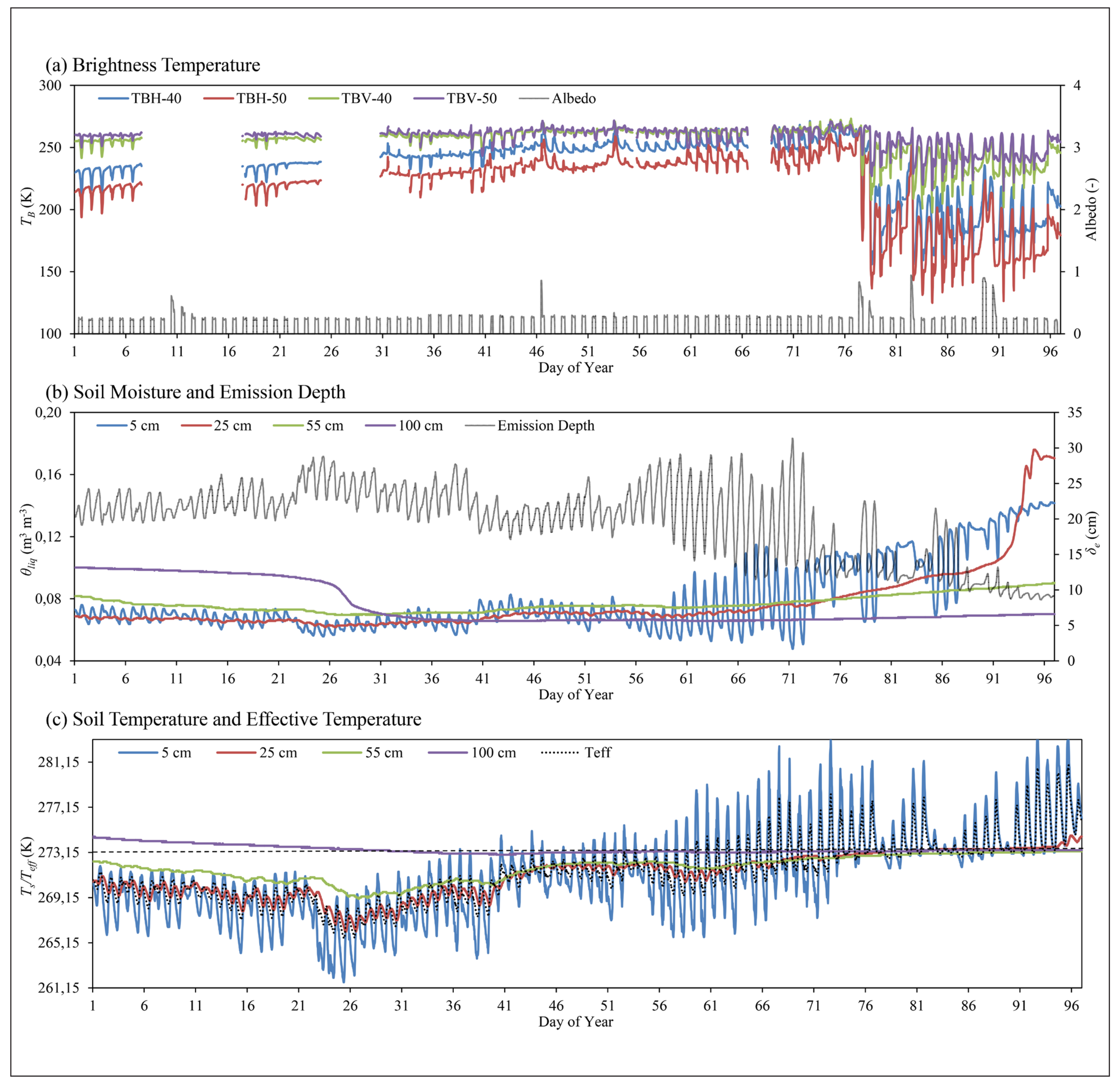

Figure 3. Measurements with a 30-min interval from 1 January (DOY 1) to 5 April (DOY 96) 2016.

Integrated Tor Vergata Emission Model and Noah Land Surface Model

The Tor Vergata model assumes the soil as a homogeneous infinite half space with a rough interface, while the overlying vegetation is represented as an ensemble of discrete dielectric scatterers. For the Maqu site, the vegetation contribution is small due to sparse areal-coverage (LAI=0.2-0.3) in winter.

The soil emission is estimated by the IEM. The soil permittivity is computed by the four-phase dielectric mixing model, with SMST derived either from the in situ measurements or simulations by an augmented Noah land surface model (Zheng et al. 2015a,b, 2016).

Three numerical experiments are conducted to obtain the SMST of the top soil layer as input to the Tor Vergata model to simulate $T_B{}^p$ (Fig. 4): (i) in situ measurements at 5 cm (EXP1), Noah simulations configured with (ii) four (0.1, 0.4, 1.0 and 2.0 m, midpoint of top layer at 5 cm) or (iii) five (0.05, 0.1, 0.4, 1.0 and 2.0 m, midpoint of top layer at 2.5 cm) soil layers.

Key Findings

1. The impact on $T_B{}^p$ (Fig. 4d) caused by diurnal changes of ground permittivity (Figs. 4a&4c) is dominating the impact of changing ground temperature (Fig. 4b)
2. The $T_B{}^p$ signatures of diurnal soil FT cycle is more sensitive to the liquid water content of the soil surface layer than the in situ measurements taken at 5 cm (Fig. 4d)

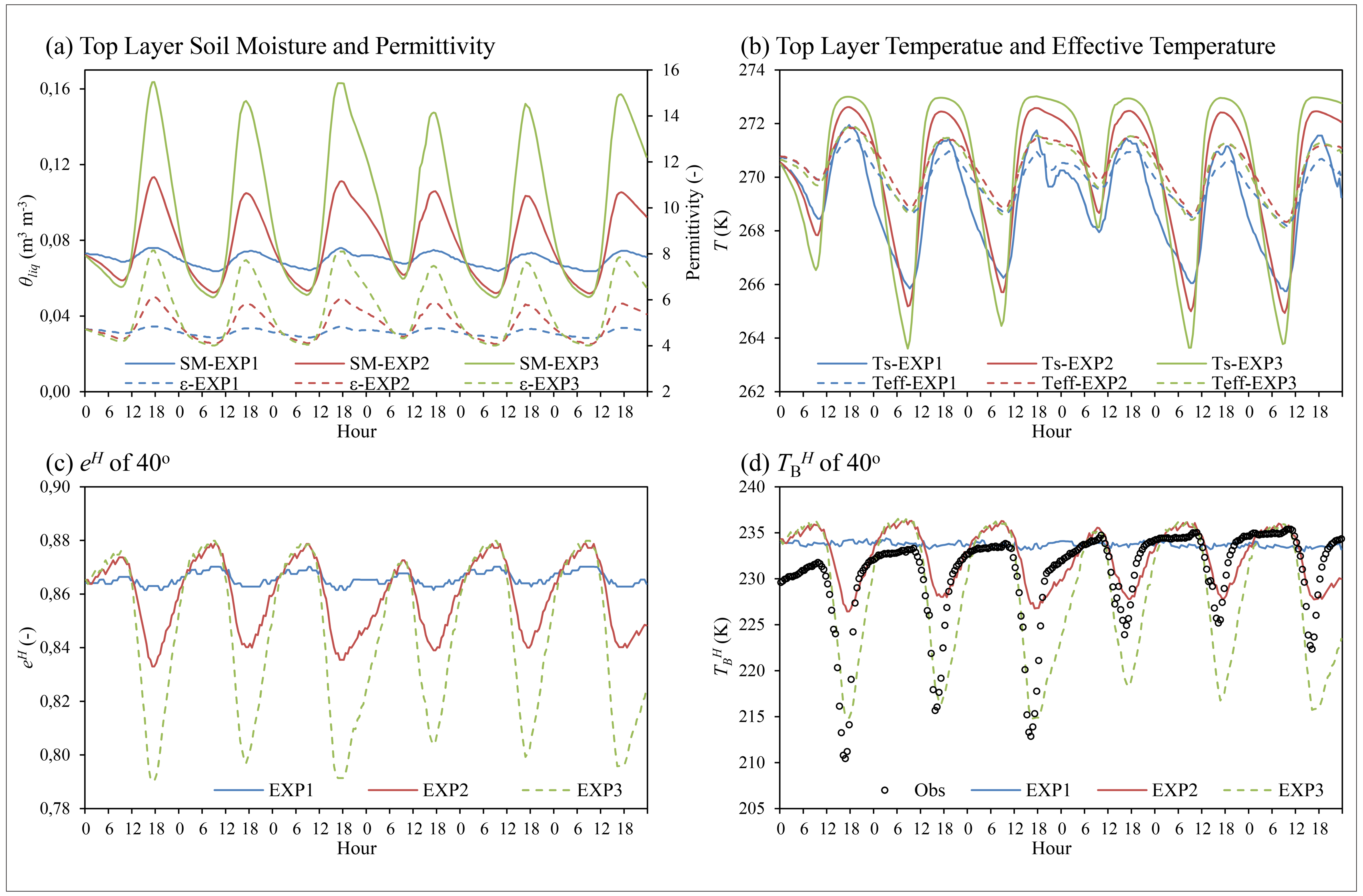

Figure 4. Diurnal variations of surface layer (a) liquid soil water and permittivity and (b) soil temperature and effective temperature, as well as (c) emissivity and (d) $T_B{}^p$ of horizontal polarization at angle 40° produced by three numerical experiments for 1 to 6 January.

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Reference

Zheng, D., et al. (2016), Impacts of Noah model physics on catchment-scale runoff simulations, JGR-Atmospheres, 121(2), 2015JD023695.
Zheng, D., et al. (2015a), Augmentations to the Noah Model Physics for Application to the Yellow River Source Area. Part I: Soil Water Flow, JHM, 16(6), 2659-2676.
Zheng, D., et al. (2015b), Augmentations to the Noah Model Physics for Application to the Yellow River Source Area. Part II: Turbulent Heat Fluxes and Soil Heat Transport, JHM, 16(6), 2677-2694.

For more information

D. Zheng[1], X. Wang[2], R. van der Velde[1], Z. Su[1], Y. Zeng[1], J. Wen[2], Z. Wang[2], M. Schwank[3], P. Ferrazzoli[4]

Email: d.zheng@utwente.nl

[1] Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, the Netherlands [2] Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, China [3] Swiss Federal Research Institute WSL, Switzerland [4] Dipartimento di Ingegneria Civile e Ingegneria Informatica, Tor Vergata University, Italy