

# Numerical Study of the Propagation of Electromagnetic Waves to Detect Putative Water-ice in Complex Permittivity Structures of the Lunar Regolith

\*Shunya Takekura<sup>1</sup>, Hideaki Miyamoto<sup>1</sup>, Makito Kobayashi<sup>1</sup>

1. University of Tokyo

The existence and the state of water-ice on the Moon is an active topic of discussion for both scientific and engineering interests. Ground penetrating radar (GPR) is an effective method for addressing this question because it can rapidly map the subsurface structure of the permittivity without contacting the ground. The relative permittivity of regolith is known to be controlled by several factors, including density, mineralogy, and porosity. A recent study shows that the strong temperature dependence on the permittivity may play a significant role (Kobayashi et al., 2023). The top of the lunar regolith is expected to have a complicated temperature structure, which would lead to complex permittivity structures in the shallow subsurface. However, the responses of such structures to GPR measurements has not been studied. Therefore, in this study, we perform the numerical analysis by taking into account the effects of porosity and temperature on the relative permittivity of the regolith.

We use the FDTD method by assuming that the water-ice containing layer exists in the lunar polar region. We simplify that the regolith is composed exclusively of anorthosite only. The profile of the relative permittivity of the regolith is modeled considering the subsurface structures of both porosity and temperature as proposed by previous works (Feng & Siegler, 2021; Hayne et al., 2017). We find that detection of the water-ice containing layer by UHF-band GPR is possible even assuming a low water-ice content, if the depth of the layer is deep enough than the characteristic depths determined by the frequency band. More detailed results and applications on measurement system will be discussed in the presentation.

## References:

Kobayashi et al., *Earth, Planets and Space*, **75**, 8 (2023).

Feng & Siegler, *Journal of Geophysical Research-Planets*, **126**, (2021).

Hayne et al., *Journal of Geophysical Research-Planets*, **122**, 2371-2400 (2017).

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