Visualization of liquid distribution in wet snow using X-ray CT and MRI

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X-ray computed tomography (CT) is a nondestructive technique to obtain detailed images and has been used to investigate dry snow physics with high resolution, However, it cannot be applied to the investigation of wet snow because the X-ray absorption coefficient of snow particles is similar to that of water, and therefore, distinction between snow particles and water in X-ray images is difficult. Magnetic resonance imaging (MRI) is also nondestructive tool for obtaining detailed images. Because MRI acquires nuclear magnetic resonance (NMR) signals of protons in liquid water and images the NMR signal intensity, distinguishing water signals from those of snow particles in the MR image of a wet snow sample is possible. However the MR image cannot distinguish between snow particles and air gap because no NMR signal is obtained from those. Recently, NIED has introduced " cryospheric micro X-ray CT" and "cryospheric MRI"; therefore, we attempted to combine an X-ray CT image and MR image to compensate for the disadvantages associated with each of the techniques.

To measure a sample using X-ray CT and MRI, the sample holder used in both devices was made of acrylic. The sample holder was filled with dry snow particles and was imaged using X-ray CT. The X-ray CT image provided information of snow particles. Then, a small amount of dodecane ($C_{12}H_{26}$) was placed in the sample holder at -5 ℃ to avoid sample melting and an MR image was acquired, which provided liquid ($C_{12}H_{26}$) distribution information. Finally, the MR image was superimposed on the X-ray CT image using ImageJ (free image analysis software). The superimposed image contains three-dimensional information of the wet snow sample, namely the distribution of snow particles, liquid, and air gap. This result indicates that combined X-ray CT image and MR image analysis will be a useful method for understanding wet snow physics; however, there is still room for improvement, such as strict temperature control to avoid melting when pure water is used.