Measurement of Surface Reflectivity Using Signals of Opportunity

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ABSTRACT

The Signals of Opportunity (SoOp) concept, using only passive receivers across the available microwave spectrum from P to Ka band, may complement or become a cost effective alternate to active technologies. In this paper, we develop methods for estimating reflectance from bistatic scattering of digital communication Signals of Opportunity (SoOp) across the available microwave spectrum from P to Ka band and conduct proof-of-concept experiments at the Fraser Experimental Forest, Colorado to acquire measurements to relate the SoOp reflectivity to a snow-covered soil surface. The forward modeling of this scenario is presented and multiple sensitivities are conducted. Available SoOp receiver data along with in situ snow and air temperature measurements collected since January 2015 will be used to validate theoretical modeling results.

The algorithm we developed for this work is based on wave theory. The exact solution of the Maxwell's equation is solved for a layered structure to account for the multiple reflections. For the SoOp concept, the phase and amplitude of the reflected field are detected. The phase and amplitude of the detected SoOp signal contains information on the volume of the snowpack and reflectivity of ground surface. For demonstration, we use a two-layer model. Multi-layer structures can be solved recursively and used to simulate ice layers in snow, different soil moisture levels in different depths of the root zone area, or layered structures of vegetation. In the snow case, the wavenumber is related to the snow density, eventually, the snow-water equivalent (SWE) will be reflected into the phase change.

In the winter season of 2014-2015, we conducted a field experiment using S-band illuminating sources to detect surface reflectivity. The direct and reflected S-band signals was recorded and cross-correlated to generate reflected waveforms and the direct signal was auto-correlated to generate direct waveforms. The ratio of the peak of reflected waveform over the peak of direct waveform is used to compute the complex reflectivity. The amplitude of the reflectivity was found to be related to the wetness of snow pack and ground reflectivity.