Top-of-atmosphere radiance simulations over snow-covered surfaces for satellite-based carbon dioxide remote sensing

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Detailed modeling of snow surface reflectivity could improve the satellite-based remote sensing of CO2 in the high-latitude regions especially during the shoulder seasons.

We created a measurement-based BRDF for a snow surface and simulated atmospheric radiative transfer.

Findings so far
● The reflectivity of snow surfaces in weak CO2 band is about 2 to 4 times stronger than in strong CO2 band.
● The strongest spectral signal is visible in the near-glint geometry.
● Polarization effects of the surface reflection are pronounced in the CO2 bands.
Motivation

- To better constrain the carbon fluxes in the Arctic and boreal regions, an increased seasonal coverage of satellite observations is necessary.
- One of the challenges in high latitudes is the snow cover in Spring as snow is extremely dark in SWIR wavelengths.
Snow surface BRF models

- Spherical harmonic functions were fitted onto reflectivity data measured by J. Peltoniemi et al., FGI.

- The reflectivity depends on the snow's grain size, temperature and age, but in general snow surfaces are highly forward scattering.
Example snow reflectance spectra, measured

Snow1 – Light zenith 69.2°

Figure based on measurements by J. Peltoniemi, FGI
Novel atmospheric radiative transfer model RaySca

- Deterministic ray-tracing model
- Only first-order scattering considered
- Fully 3D atmosphere
- HITRAN API used for gas absorption spectra computation
- Full Stokes vector of radiation (i.e. polarization) considered
- Arbitrary (polarizing) BRDF model on the planetary surface
- First mention: Mikkonen et al. (2021, in preparation)
This research is being conducted as part of ESA funded project *Study on Improved Glint Retrieval for CO2M* (SNOWITE: SNOw, Water and Ice Treatments Explored for CO2M).

First study of the feasibility of retrievals over snow with the aim of improving CO2M observations at high latitudes.

The 18-month project includes simulated radiances and retrievals, assessment of existing missions at high latitudes, and new AirCore measurements.

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