Spatial validation of an operational snow cover model over the eastern Alps using remote sensing data

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1. Background & Methods

In Austria, correct estimates of the current spatial distribution of the snow cover are strongly needed in very high resolution for a large variety of authorities (avalanche warning and hydrological services) and for specific users (hydropower and road maintenance companies, winter tourism) as a supporting tool. The operational snow cover model SNOWGRID [c] operated at ZAMG provides this information in near real-time with a temporal and spatial resolution of 15 minutes and 100 m, respectively (model domain of 28 m points). In the nowcasting mode, SNOWGRID is driven by gridded meteorological input data from the INCA model [a]. Besides the validation with in-situ point measurements (e.g. snow depth, snow water equivalent), an area-wide validation using remote-sensing data is necessary to detect possible weak points in the model or the input data, especially in regions were point measurements are unfeasible (e.g. tilted slopes), questionable (e.g. precipitation in high elevations) or very sparse. Thus, we use fractional snow cover (FSC) data from the Moderate Resolution Imaging Spectroradiometer (MODIS) to perform a spatial validation of the SNOWGRID results, following these steps:

- Retrieving FSC maps from MODIS raw data applying a spectral linear unmixing approach with local end-member selection developed by ENVEO for alpine non-forested terrain. In forested areas a binary snow classification is applied using the Normalized Difference Snow Index [b].
- Nearest-neighbour interpolation of the 250 m MODIS data to the 100 m model grid
- Conversion of FSC and SNOWGRID snow depth (SD) into binary snow cover (BSC) by applying 2 thresholds on each of the products (15, 50 % FSC; 1 and 15 cm SD)
- Calculation of statistical parameters using contingency tables: Probability of detection (POD), False alarm rate (FAR (snow/no snow)), Hit rate (HR), Kupers Skill Score (KSS) for days with > 50 % valid MODIS data in the model domain (no clouds no missing data,).

2. Spatial model performance

![Binary Map of Snow Cover: Comparison of MODIS FSC & SNOWGRID](image)

21-APR-2015, 10:30 UTC

![Regional performance in Tyrol](image)

3. Improvement of model processes

3.1 Implementing a snowline depression effect by precipitation cooling (PC) in SNOWGRID:
- Improvement of calculated total snow depth at station Dellach (Carinthia) [1]
- Area-wide positive effect is still visible in BSC in mid march [2]

![SNOWGRID SD without PC](image)

Oberved MODIS

![SNOWGRID SD with PC](image)

Calculated MODIS BSC without PC

Calculated MODIS BSC with PC

3.2 Comparison of 2 different energy-balance parameterizations in SNOWGRID:
- Simple degree-day scheme (TI) (air temp. Ta as single proxy) vs. extended degree-day scheme (ETI) (Ta, global radiation on real surface, albedo [d]) after a melting period on 9-Nov-2014 following a heavy early snowfall (20-24 Oct 2014). KSS increases from 0.28 (TI) to 0.44 (ETI) for Tyrol.

MODIS (observed) Snowgrid calc. simple degree-day scheme

SNOWGRID calc. extended degree-day scheme

4. SNOWGRID: Examples of use
