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VALIDATION OF SATELLITE SNOW MONITORING BY TIME-LAPSE PHOTOGRAPHY IN THE VICINITY OF THE SKALNATÉ PLESO OBSERVATORY DURING THE 2021-2025 SEASONS

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AIMS

1.) To validate the satellite observations of snow cover by in situ observations via a trail camera in the vicinity of Skalnaté Pleso Observatory (Fig. 1) using the data from four winter seasons.

2.) Figure out whether satellite monitoring provided by Copernicus is usable for further research in our region of interest.

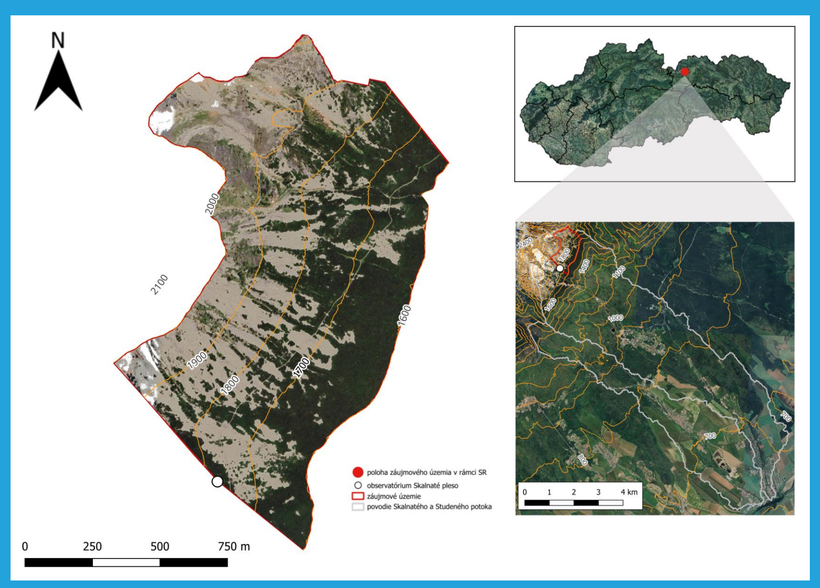

Fig. 1: Study area

TRAIL CAMERA DATA

- Camera is located on the roof of Skalnate Pleso Observatory, capturing the area between cca 1600 – 2000 masl.
- Conducted by the Tetrao Spromise S328 trail camera by its time lapse function.
- Data retrieved by a 3-step procedure, including the method by Salvatori et al., 2011 and Portenier et al., 2020.

Fig. 2: Trail camera

SATELITTE DATA

- Program Copernicus -> WEkEO service -> portfolio HR & SI a HR-WSI.
- **GFSC** = gap-filled fractional snow cover product (Sentinel-1 - radar and Sentinel-2 - optic) was used
- Product represents snow cover maps with 60x60 m resolution.
- It consists of FSCOG and SWS products.

PROCESSING OF SATELLITE IMAGES

- Satellite images were predominantly in daily steps, but sometimes there were bigger time gaps.
- **Average percentage of snow cover** was computed from pixels covering the study area in every GFSC image (Fig. 3).
- Images with more than 30% cloud cover were excluded from analyses.
- Missing satellite-based values for days when we disposed of a value from the time-lapse camera were complemented using linear interpolation.
- Images was validated for 4 winter seasons – from 2021/2022 to 2024/2025 – always from November to May (inclusive).

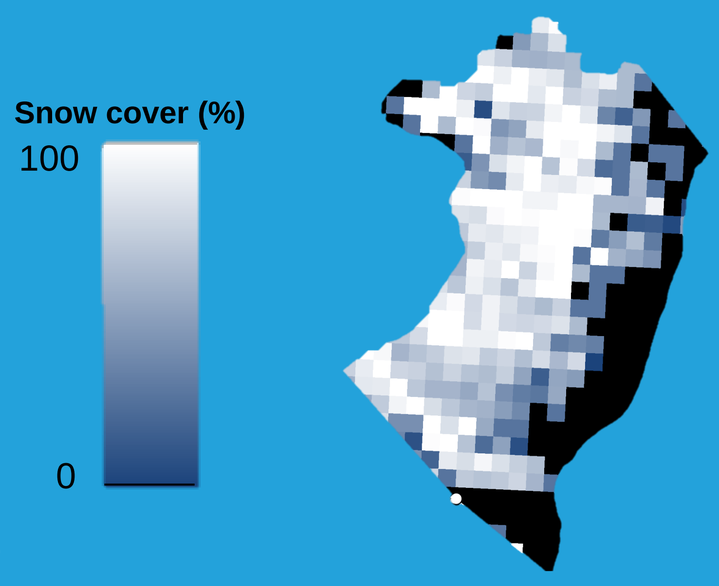

Fig. 3: GFSC Raster Image

RESULTS

- The comparison of ground observations and satellite monitoring shows that the product GFSC of the Copernicus program was **reliable only partially** in our region of interest.
- Satellite data shows a good match with the trail camera **in the periods of stable snow cover**, when the difference between the two observation techniques was within a **few percent (mostly January and February).**
- Considerably bigger differences were recorded **in the periods of rapid changes** – in case of suddenly accumulation or melting snow.
- The most significant discrepancy between the trail camera and satellite data was observed during the last season of 2024/2025, which was poor in terms of snowfall and did not reach 100% coverage even once.

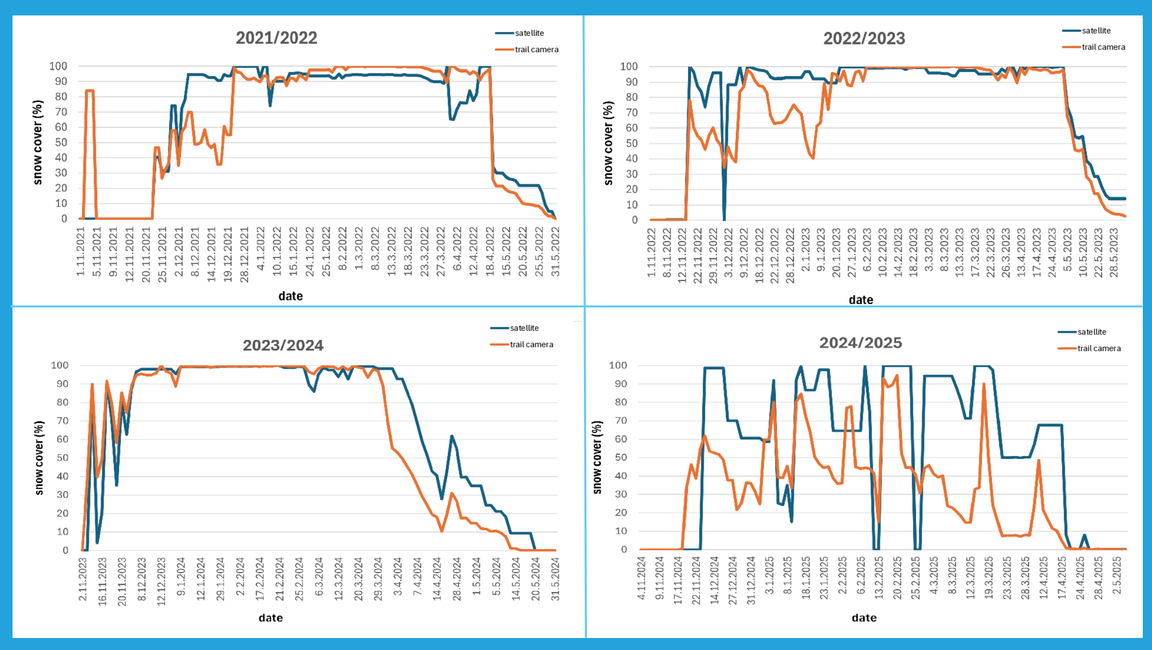

Fig. 4: Development of snow cover monitored by satellite comparing to trail camera during season 2021/2022 – 2024/2025

LIMITS AND RECOMMENDATIONS

- Of the total number of approximately 800 images, about a quarter had to be interpolated due to invalidity -> this could have distorted the results.
- The radar product SWS (SAR Wet Snow processing from Sentinel-1) isn't included in the GFSC product for our region of interest. This product would help reduce the impact of cloud cover.
- Skalnate pleso observatory 1475,5 hours vs. Hurbanovo (SHMI) 2100 hours of sunshine proves the need for cloud-penetrating sensing.
- **Recommendations for further research:** processing of raw data from Sentinel-1 (or another satellites with SAR sensors), combination of unnamed aerial imaging and terrestrial laser scanning or extending validation to other mountainous locations in Slovakia.
- **The main disadvantage**: in case of the presence of cloud cover, the last available image repeats (up to a 7-day time window).

REFERENCES

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