ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Snow drift modelling in complex terrain

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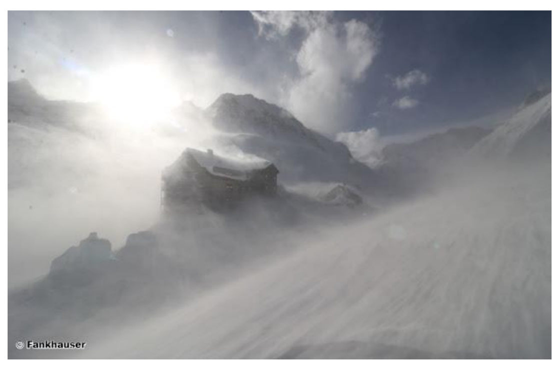
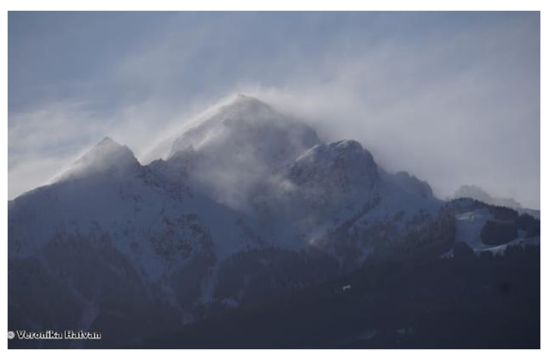
- 2-layer-scheme, little input data, high temporal and spatial resolution, low computational effort
- Based on a semi-empirical statistical snow drift point model, lateral distribution via a topographic parameter

1. Snow drift

The **snow transport due to wind** plays a crucial role for the snowpacks structure and its temporal and spatial development, especially in complex terrain.



Snow drift mainly **adds a load of snow** to some areas and **erodes** it elsewhere, thereby increasing shear stress. Therefore it's an **important factor** regarding **snow distribution** and thus also **avalanche danger**.



Snow drift is a **complex process**, depending on several meteorological parameters (e.g. precipitation or wind), the topography and the properties of the existing snowpack, all of which may **vary substantially over short distances and times**.

2. Goal

Development of a **snow drift model**

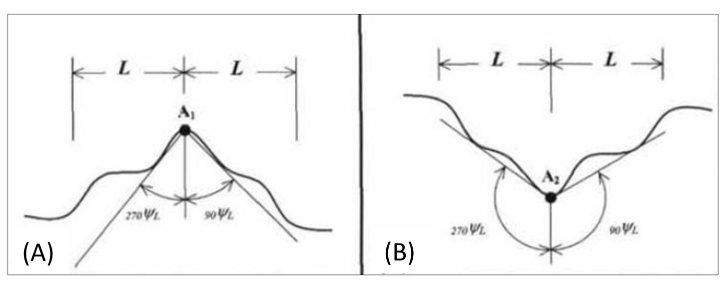
- … for **modelling** snow drift for selected cases (analysis mode).
- … to **estimate** extreme **additional snow loads due to snow drift** and take it into account for avalanche risk management and planning.
- … for **use in the operational snow cover model SNOWGRID** (Olefs et al.,2013): large model domain, simplified internal snow physics, **high temporal** (15 min) and **spatial** (100 m) **resolution.**

3. Snow drift model

- **Simple 2-layer-scheme** (old snow, new snow)
- Required **input**:
  Wind speed, height and density of old and new snow, topographic parameters
- Captures **initial and main process** of local and measureable snow drift → **saltation**
- **Includes settling** and **snow density increase due to wind**
- **Computes available snow drift amount for each grid cell:**
  - Independent of wind direction and therefore unsigned
  - Friction velocity u^* from logarithmic wind profile
  - if $u^* > u^*_{th}$: available snow drift amount = $c * u^*$

  u^*_{th} … friction velocity threshold, depending on snow density (according to Liston et al., 2007)
  c … coefficient (based on in-house development of semi-empirical statistical snow drift point model)

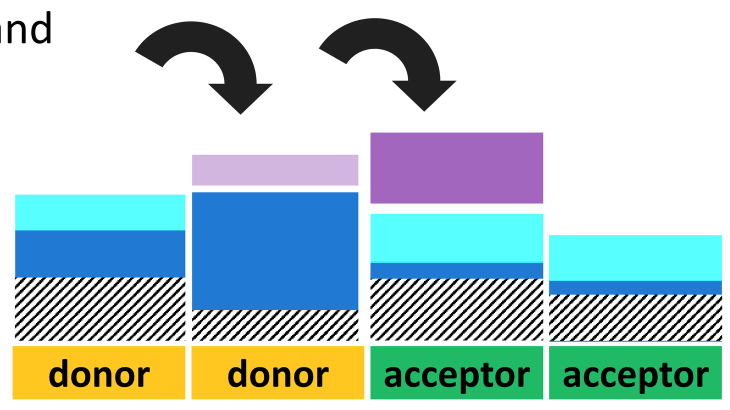
- **Lateral distribution of available snow drift amount:**
  - Based on the terrain parameter **negative openness** (idea: Hanzer et al., 2016)
  - Threshold determines donor and acceptor cells of snow drift amount



© Yokoyama et al., 2002; φ = mean nadir angle of compass direction(s), L=radial limit of calculation
(A) Low score of negative openness → wind exposed
(B) High score of negative openness → wind protected

Concept: lateral snow distribution

- snow holding capacity based on different land cover types (Corine2012)
- old snow layer
- new snow layer
- snow drift amount
- additional snow drift amount for donor cell; is not accumulated but redistributed in the next timestep

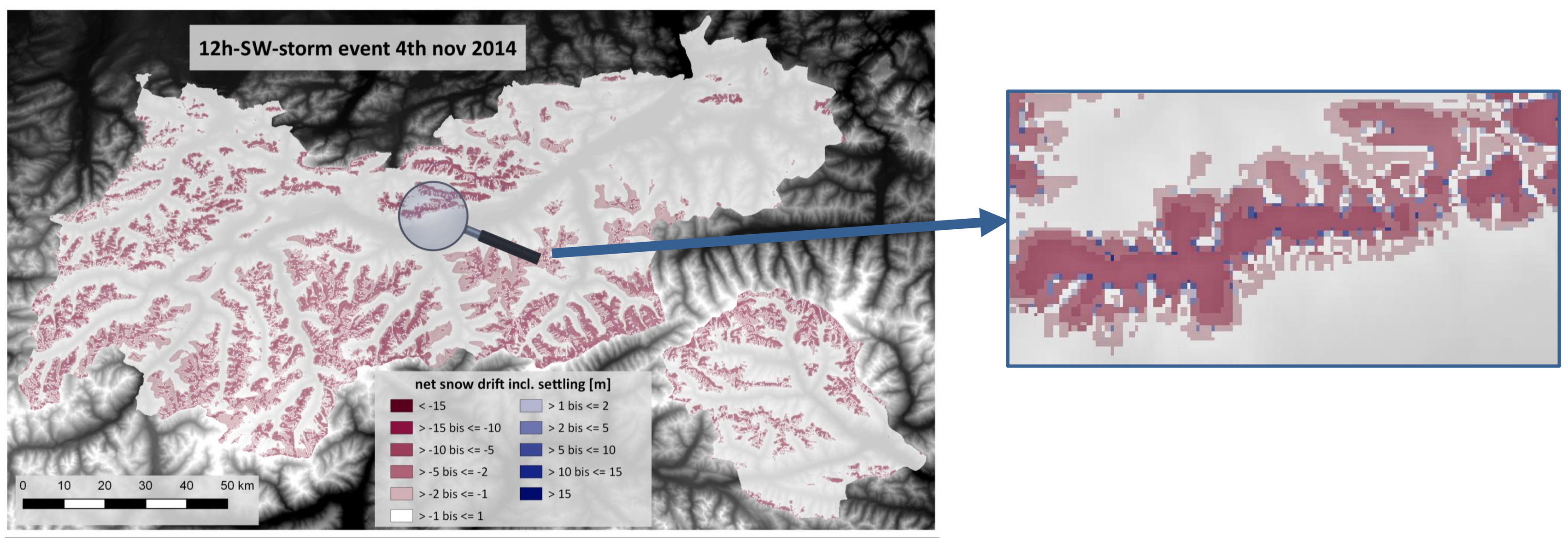


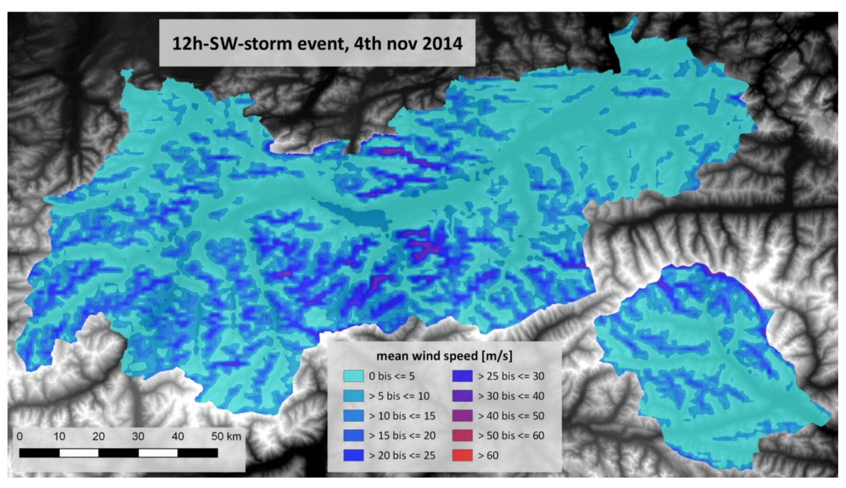
1D-lateral snow distribution scheme

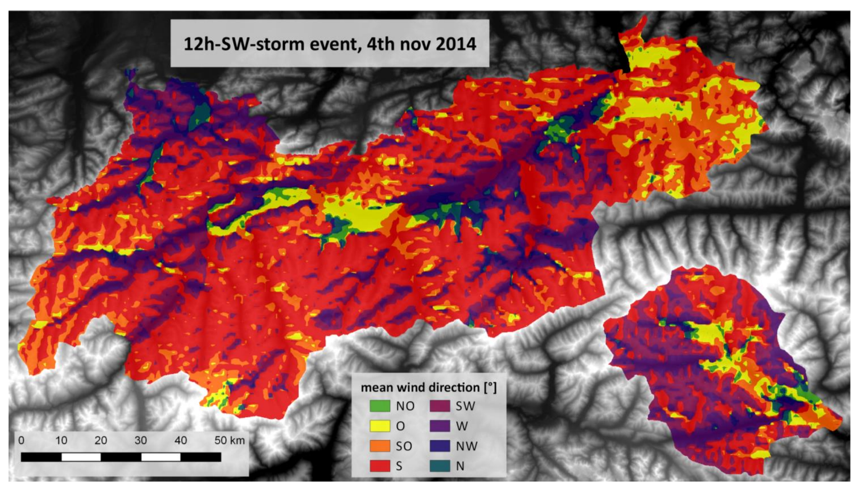
4. Results

CURRENT APPLICATION: Modelling maximum potential of snow drift

- Extreme wind conditions:
  Historical **storm events** in Tyrol, Austria: INCA-model wind @10m, (Haiden et al.,2011)
- **High quantities of erodible snow** as initial condition:
  Great amount of old snow; 72h new snow sum for a return period of 150 yrs
- **Incl. settling** of the snowpack , **without** additional **precipitation**

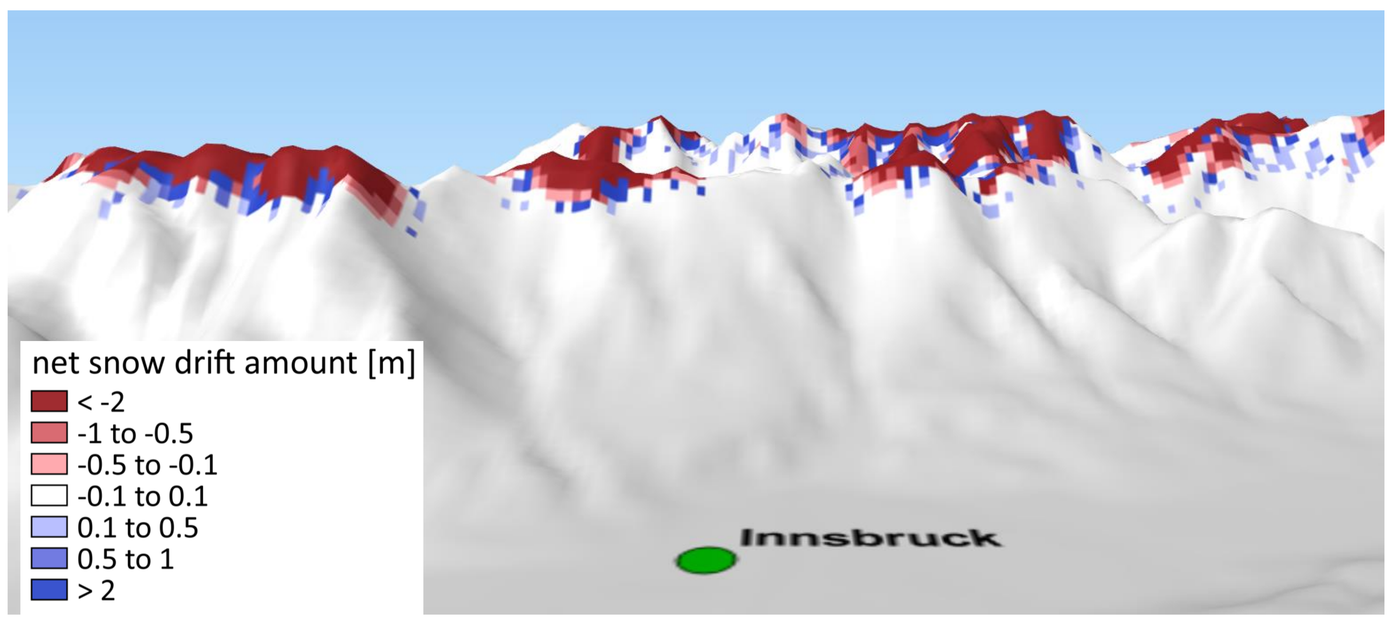




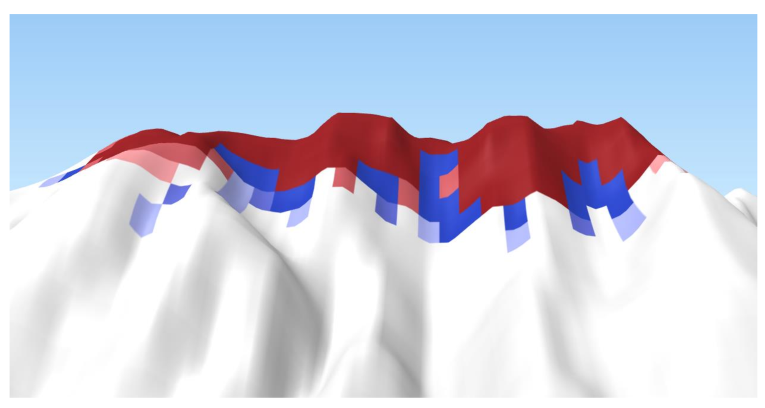


FUTURE APPLICATION: Implementation in operational snow cover model SNOWGRID

- First results of **net snow drift forecast with SNOWGRID**:
  Temporal resolution: 15 min, spatial resolution: 100 m
- **Incl. settling** of the snowpack and **precipitation**



3D-maps of 24h-net snow drift amount from 4th January 12.00 noon to 5th January 12.00 noon for the mountain range in the North of Innsbruck, Austria.
red pixels: net snow erosion,
blue pixels: net snow accumulation



5. Outlook

- Consideration of sublimation and decrease of snow drift amount as a function of the distance
- Implementation of donor and acceptor cells based on sectors of wind direction
- …

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MINISTERIUM FÜR EIN LEBENSWERTES ÖSTERREICH
WILDBACH- UND LAWINENVERBAUUNG

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