Snowdrifts in ground mounted PV power plants

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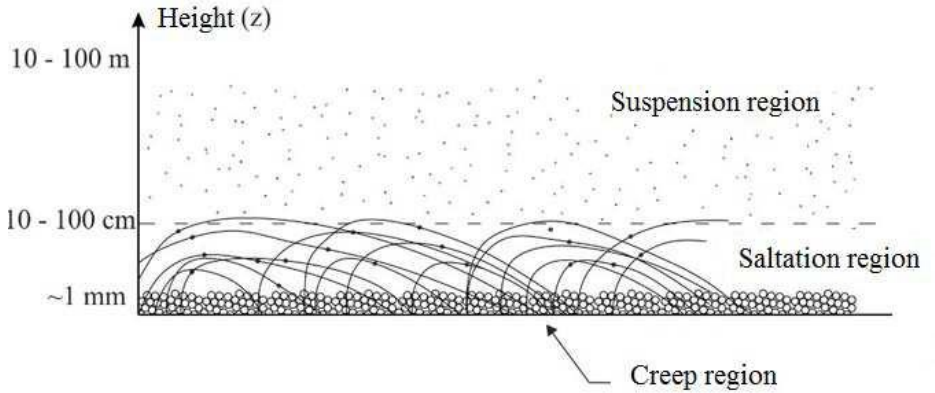
High Latitude Photovoltaics Workshop, Piteå

Occurrence of snowdrifts

- Transport of wind-blown snow
- Accumulates in low-wind speed areas
- The «aerodynamic shade»



Horizontal snow transport mechanisms (Sundsbø, 1988)

Aerodynamic shade of an object (Ronald Tabler, 2003)

Snowdrifts from a snow fence (Ronald Tabler, 2003)

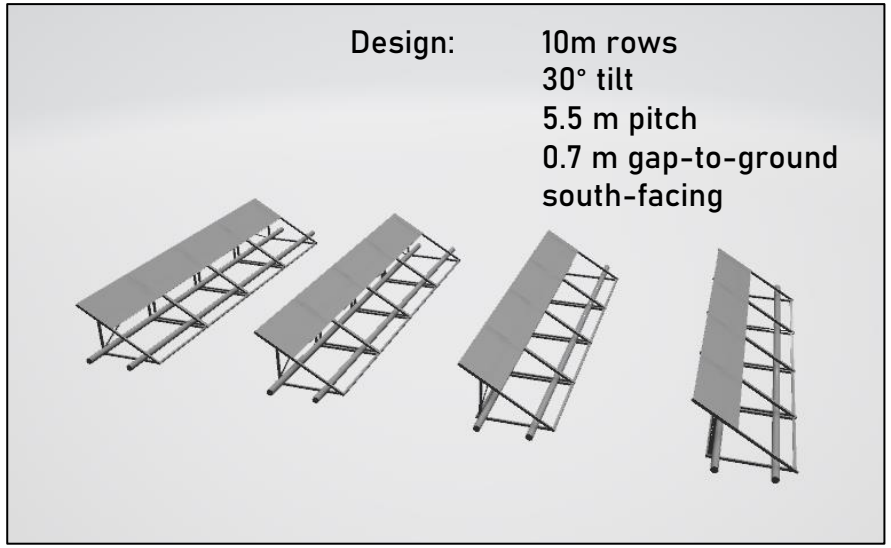
Consequence of snowdrifts in PV plants

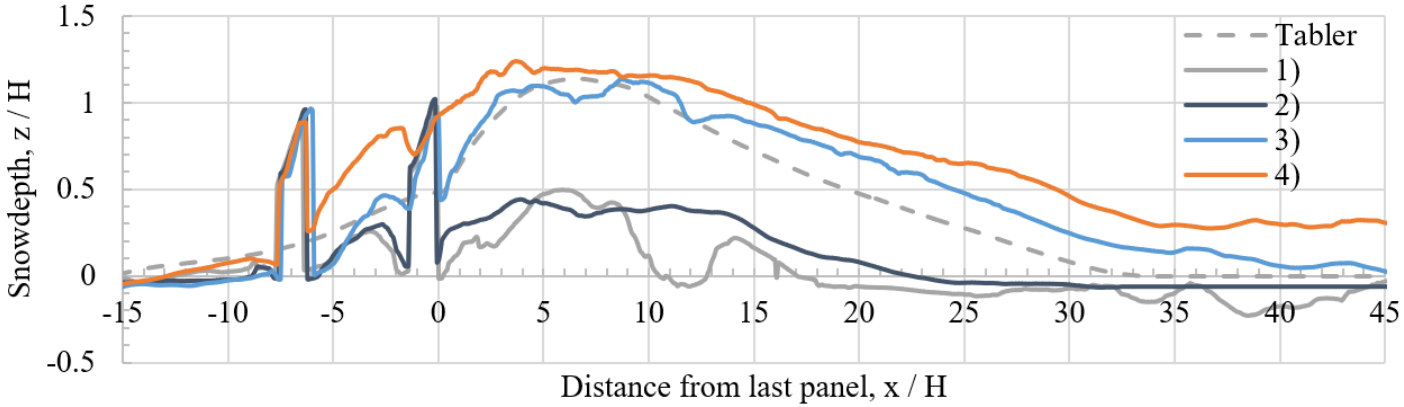
- Non-uniform mechanical load

- Yield losses

Field measurements in Svalbard

- Traditional PV plant design
- Snowdrifts size (h = 1.3 m):
  - height = 1.4 h = 1.8 m
  - length = 50 h = 65 m
- Similarity with snow fences – efficient in trapping snow

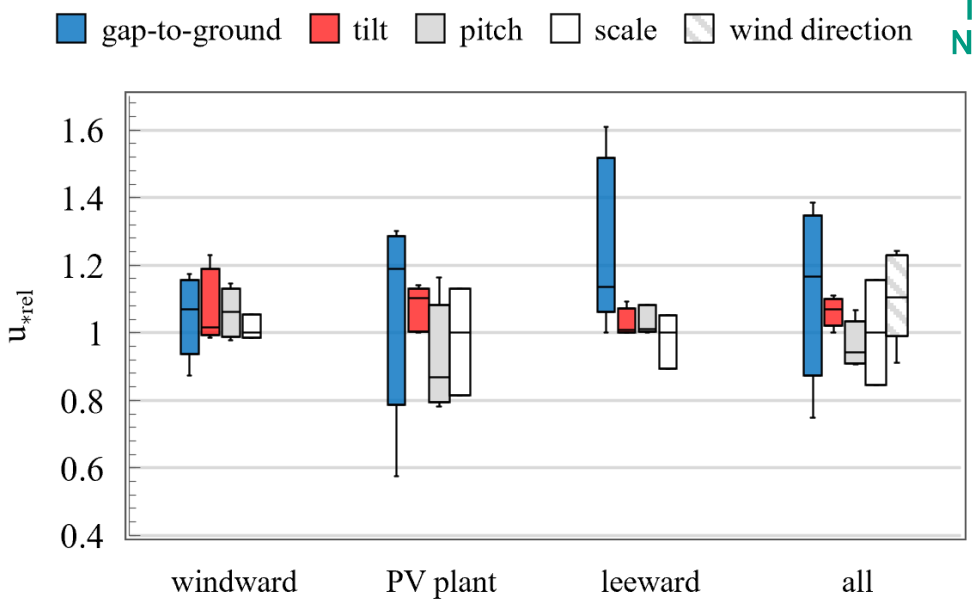




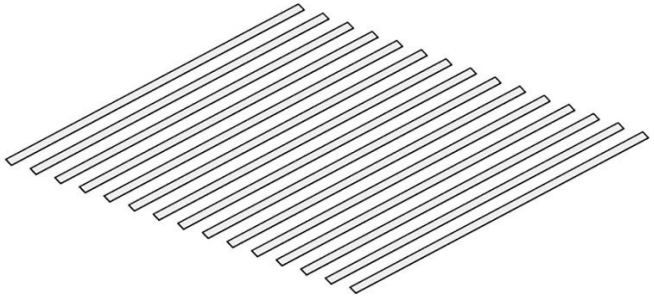
Polar Solar power plants – Investigating the potential and the design challenges, Solar Energy, Frimannslund et al. 2021

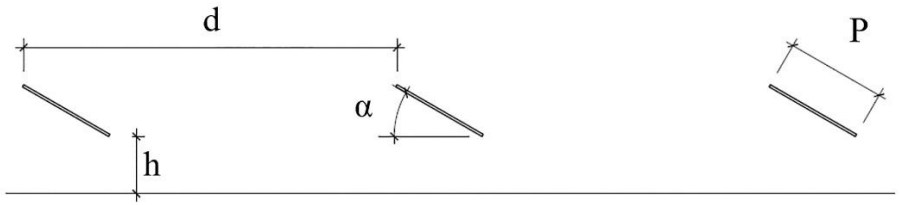
Impact of PV configuration

- Numerical study:
  - CFD and energy yield simulations
- Quantified sensitivity of snowdrift accumulation conditions to the parameters
- Adaption should depend on the PV plant size and climate conditions



Sensitivity of snowdrift accumulation to PV plant parameters



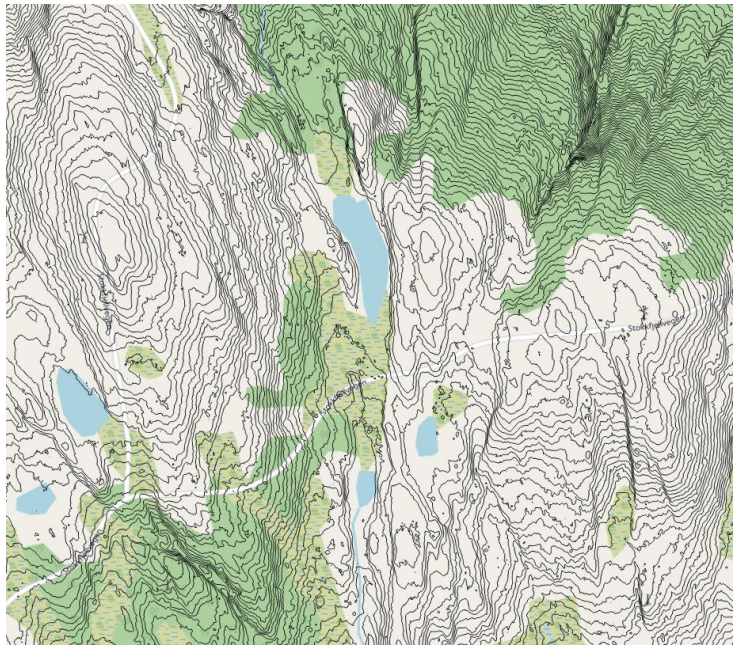


Investigated PV plant configuration

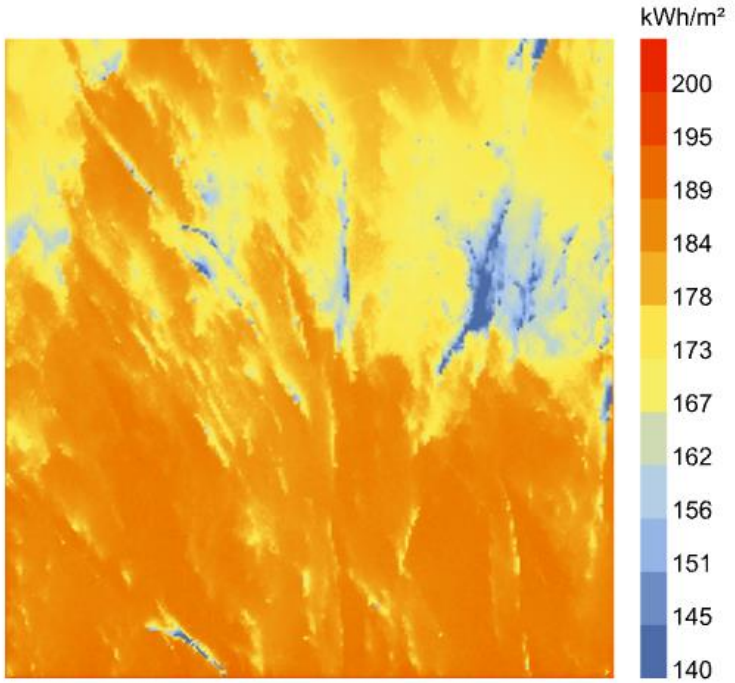
Impact of solar power plant design parameters on snowdrift accumulation and energy yield, Cold Regions Science and Technology, Frimannslund et al. 2022

Impact of terrain

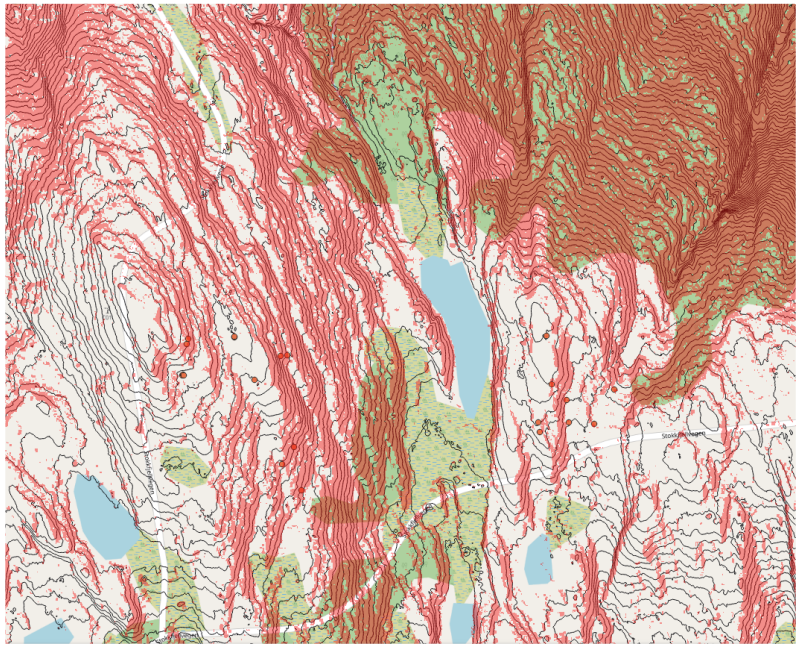
- Local topography can be susceptible to snowdrift accumulation
  - Large differences over small distances: terrain depressions, leeward side of ridges
  - PV plant should not be placed in where snowdrifts commonly form



Terrain topography



Terrain radiation analysis



Terrain snowdrift analysis

Princess Elizabeth Station, Antarctica

- Terrain ridge and buildings susceptible to snowdrifts
- PV plants configuration prone to accumulation, but snowdrifts likely arise from terrain / buildings

"*In Utsteinen, we are never done with clearing the snow that accumulates in front of the garages*."

Snow accumulation at Princess Elizabeth Station - © International Polar Foundation

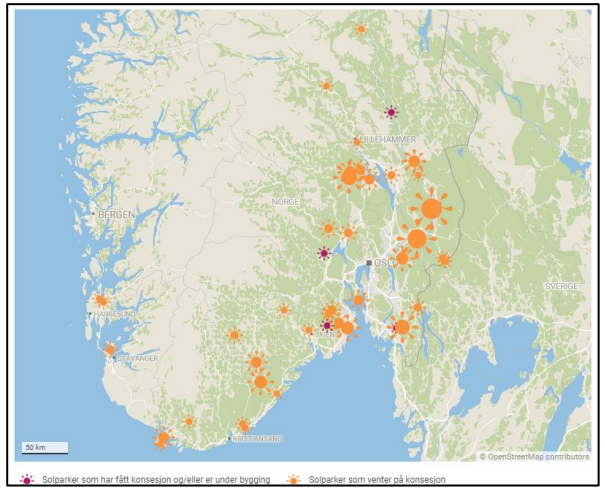
Experience from Isfjord Radio, Svalbard

- Increased gap-to-ground to reduce snowdrifts + favourable wind direction
- Only experience from one winter (ongoing)
- No terrain effects, but system produce windward and leeward drifts

Photo: M. O. Sellevold, Store Norske Energi

Planned ground mounted PV plants in snowdrift terrain

- PV deployment in snowdrift climates in Norway
  - PV plants in existing wind farms
- Lack of guidelines for PV plant design in snowdrift climates and resulting load/yield consequence



Location of PV plant consession applications in Norway (Teknisk Ukeblad, tu.no)

Wind farm, Kjøllefjord, northern Norway (Statkraft)

Snowdrift design strategies

- A snowdrift design strategy can be employed for PV plants in severe snowdrift climates
  - **Deposition strategies**:
    - Snowdrifts can form in designated areas
  - **Non-deposition strategies:**
    - Snowdrifts should not develop
- Choice of strategy depend on PV plant size and snowdrift climate
- Work in progress