Detailed simulations of spatial snow accumulation patterns and near surface snow properties

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Accumulation is determined by wind

Snow accumulation on the Antarctic Ice Sheet is governed by snow transport by wind.

This complex process is challenging to include in models and makes the interpretation of measurements, remote sensing products and simulation results difficult.

Here we present model simulations of near surface (uppermost 10 cm) snow density under the influence of drifting and blowing snow.

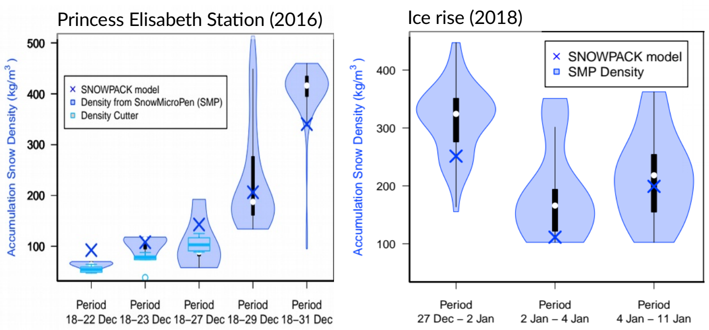
One-dimensional simulations

SNOWPACK is a detailed, physics based, multi-layer snow model.

The model calculates drifting snow based on near surface, centimeter scale, snow microstructure.

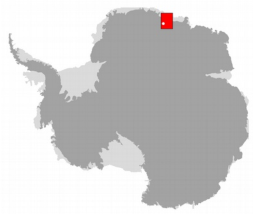
Drifting snow conditions impact simulated new snow density during accumulation events.

The SNOWPACK model, driven by locally measured weather data, correctly simulates the temporal evolution of snow density in accumulation events:

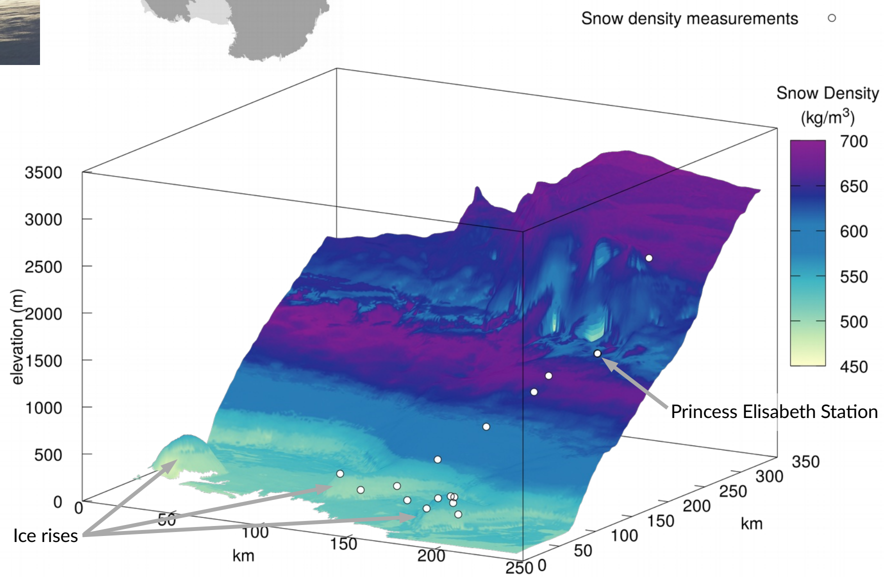


Simulated snow density in accumulation events, compared to observed density in accumulation events. By combining accumulation depths from repeat terrestrial laser scanning with snow density measurements from SnowMicroPen (SMP) and density cutters, the distribution of new snow density of fresh accumulations could be precisely determined. The violin plots illustrate the spread in density found by the SMP or density cutter measurements.

Study domain



The study domain is in east Dronning Maud Land, from the Princess Elisabeth Station to the coast, where measurements were collected at ice rises.



Preliminary simulated near surface (uppermost 10 cm) snow density in the distributed simulations in the domain over east Dronning Maud Land, driven by MERRA-2 forcing.

Spatially distributed simulations

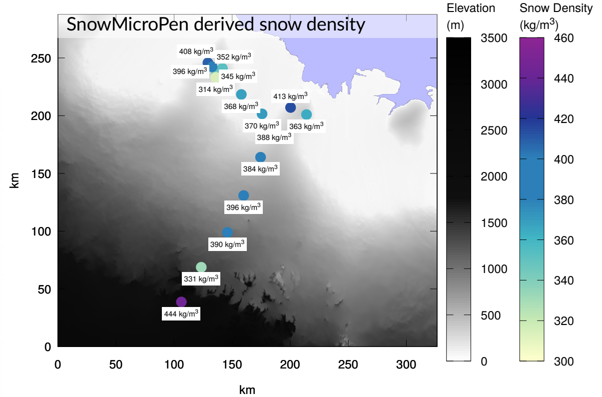
SNOWPACK is also run in a distributed mode for spatially distributed simulations of snow processes.

MERRA-2 is used for meteorological forcing conditions.

Statistical downscaling of wind based on the terrain model is applied to determine wind-exposed and wind-sheltered areas, and adjust wind speed accordingly.

Areas with higher downscaled wind speeds exhibit higher near surface snow density and vice versa.

Spatial variability in snow density



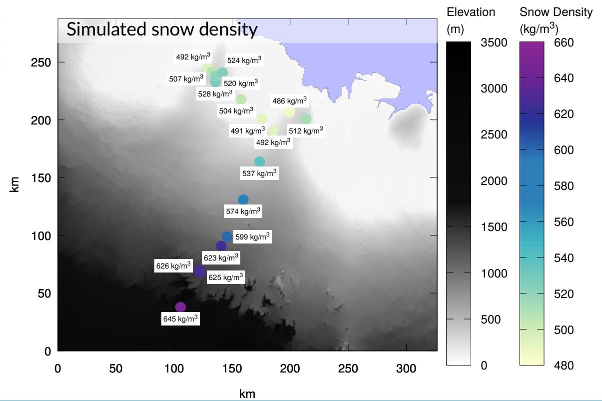
Observed (above) and simulated (below) near surface (uppermost 10 cm) density.

Spatial variability in near surface snow density is found, both on 100 km and 10 km scales, with density varying between 314 and 444 kg/m³.

Higher density is found near the plateau, and at the lee side of ice rises. Lower density is found in the sheltered areas of the mountain range, and at the windward side of ice rises.

The large scale variability is reproduced by the simulations forced by MERRA-2, albeit with a significant bias. The small scale variability is reproduced in the opposite way as observed.

Statistical downscaling of wind was found to not correspond to dynamic effects on the local scale near the ice rises, causing a bias in density.



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