Variability of snow cover over Southern Siberia during 1982-2019

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Introduction

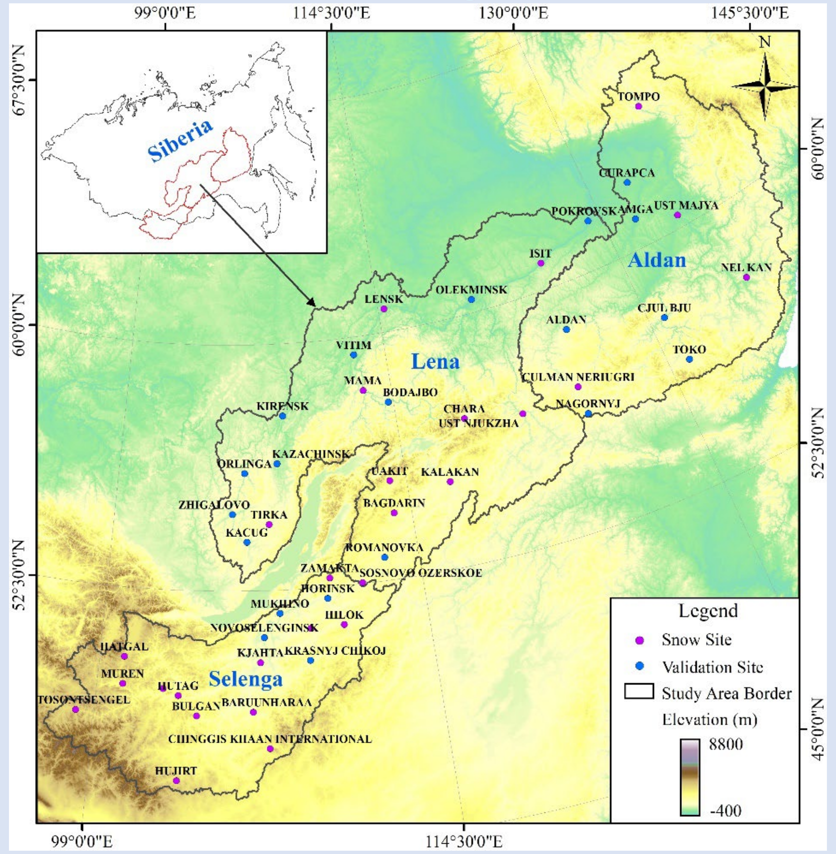
Motivation

- In recent decades, Southern Siberia has shown some drastic hydro-climatic changes, manifested, for example, in an increased number of wildfires and widespread permafrost degradation. River discharges have also changed considerably in some cases (Han & Menzel, 2021);
- Snow cover has a critical impact on permafrost stability, for example through changes in surface albedo, soil temperature, energy balance and ecosystem carbon exchange;
- A major part of Siberia is covered by snow in winter, with snow cover sometimes lasting for more than half a year.

Objectives

- To investigate and to quantity the variability of snow cover characteristics across Southern Siberia;
- To analyze the effect of climate change on snow cover;
- To explore the applicability of the TRAIN model and Globsnow reanalysis data to estimate snowpack characteristics and its spatio-temporal variability.

Study area



The figure shows the three investigated basins Selenga, Lena and Aldan

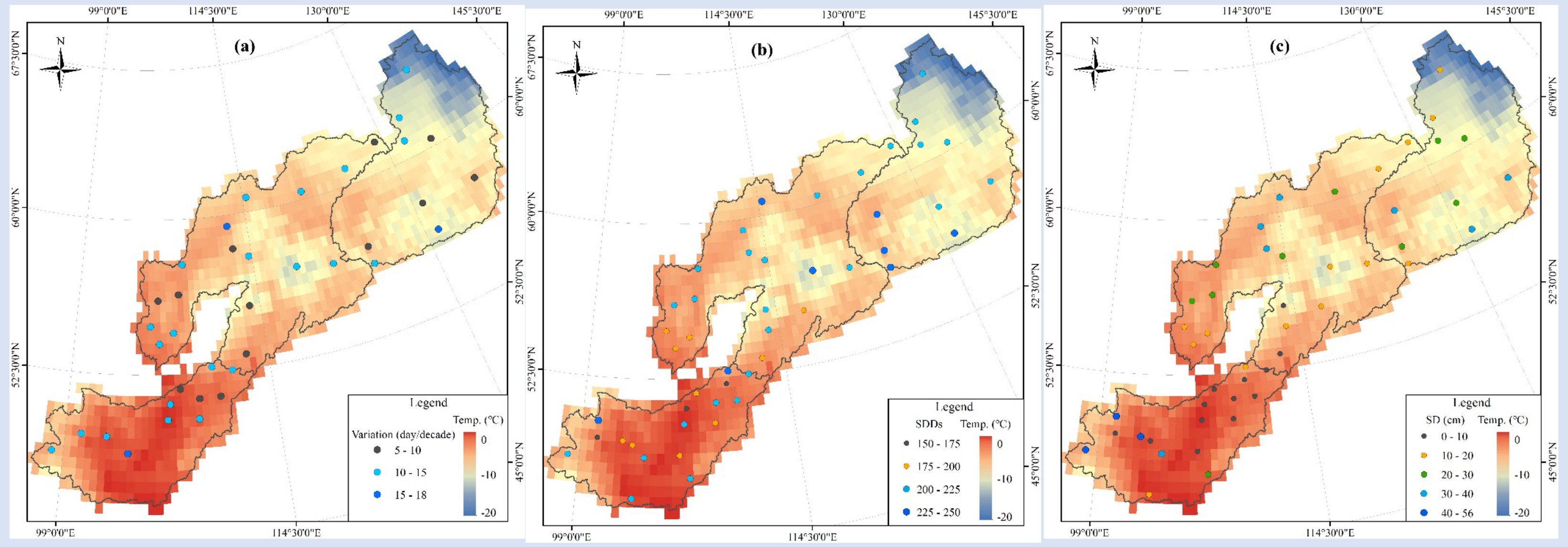
Data used in this study

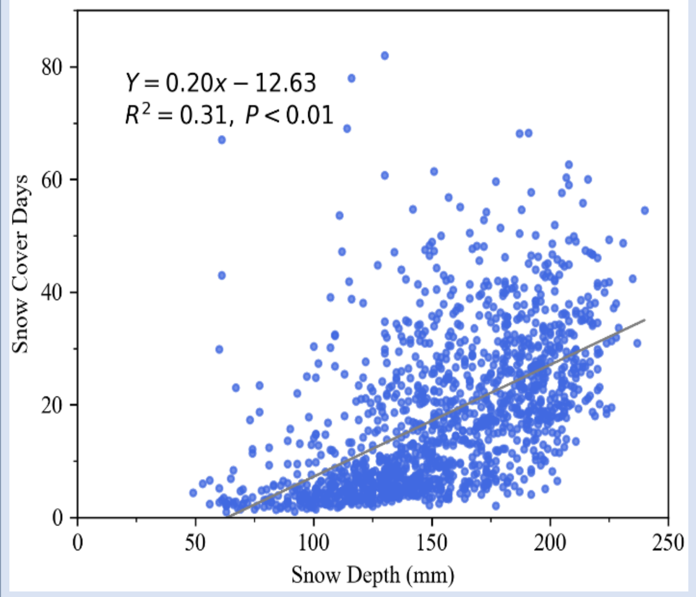
Data Type	Parameters	Spatial Resolution	Temporal Resolution	Period	Source
GSOD	Snow Depth, Precipitation, Air Temperature, Dew Point, Wind Speed	Station	Daily	1982-2019	https://www.ncei.noaa.gov/data/global-summary-of-the-day/access/
ERA5	Solar Radiation	0.1° ×0.1°	Hourly	1982-2019	https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land?tab=form
RIHMI-WDC	SWE	Station	Daily	1982-2019	http://www.wdcb.ru/
GlobSnow-3	SWE	25 km×25 km	Daily	1982-2017	https://www.globsnow.info/swe/archive_v3.0/L3A_daily_SWE/NetCDF4/

Selected snow indices

Indices	Description
SOD	the date when snow is first recorded in a snow year
SED	the date when snow is last recorded in a snow year
SDDs	Snow duration days (SDDs): the cumulative number of days between SOD and SED in a snow year
SCDs	Snow cover days (SCDs): the cumulative number of days that snow is recorded during SDDs in a snow year

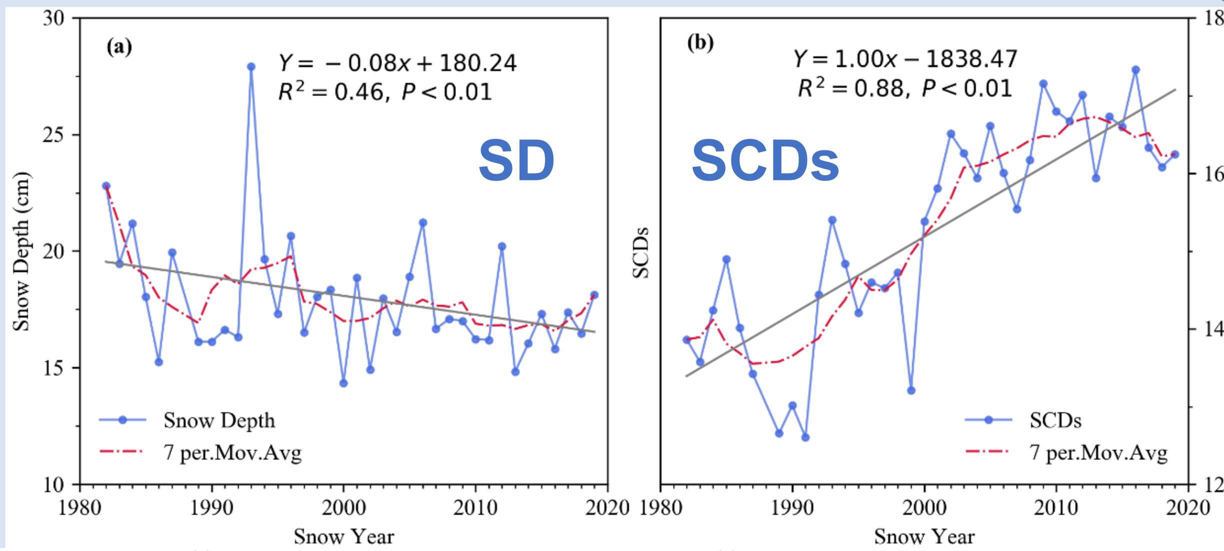
Snow cover variation

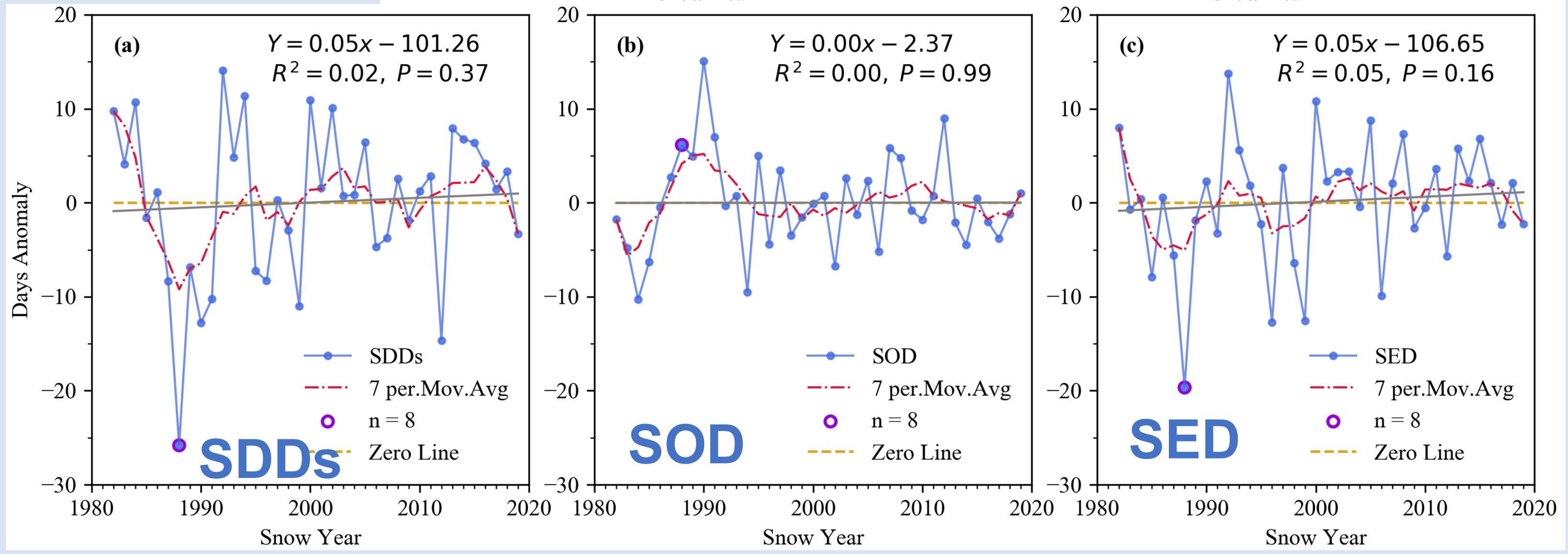




- All investigated sub-regions showed increasing trends in SCDs, with the vast majority being from 10 to 15 days / decade.
- The most pronounced spatial differences in SDDs and snow depth were found in Selenga, with complex topography and higher gradients in air temperature.
- In general, SCDs increased with snow depth.

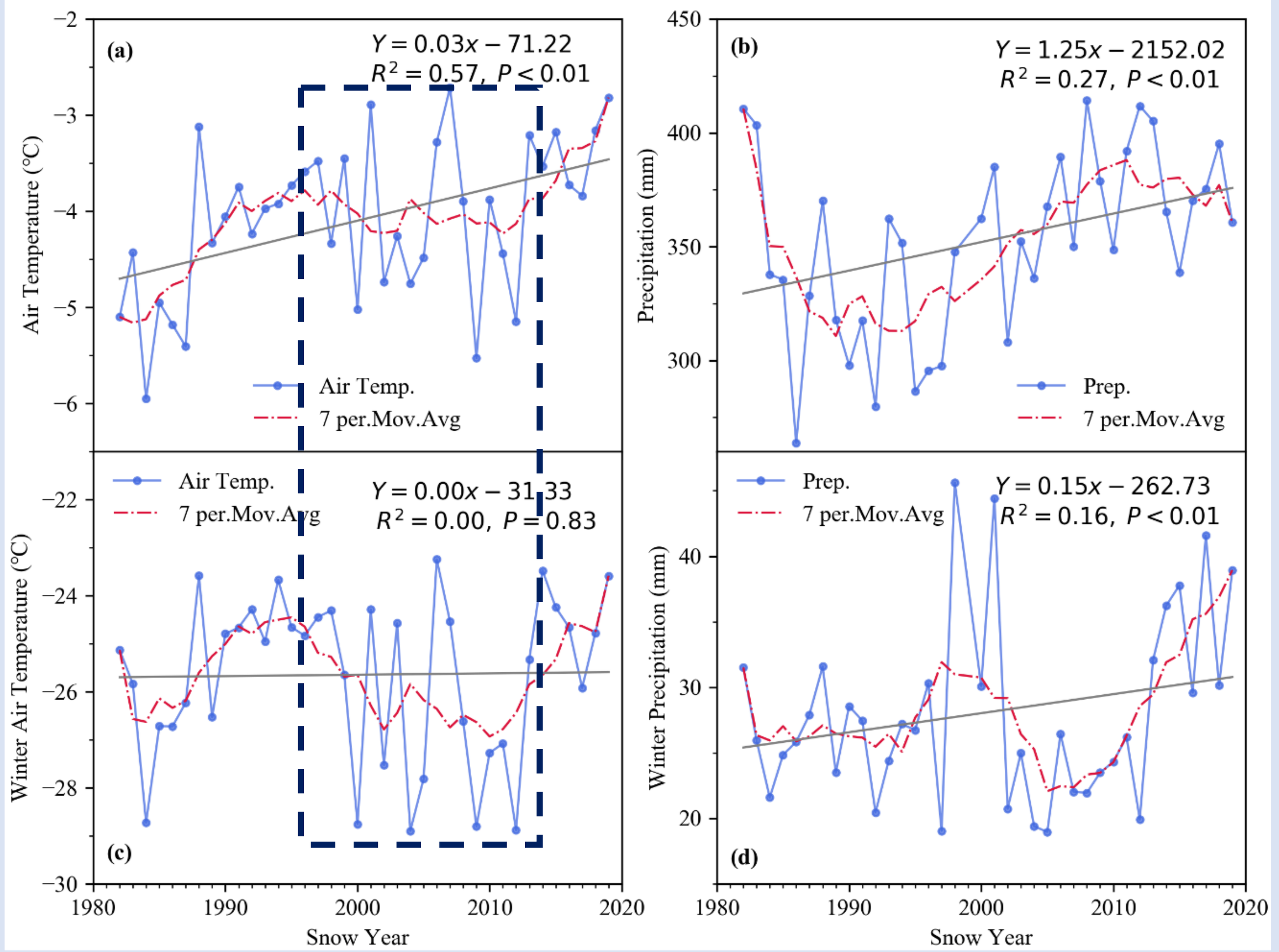
Variation of snow indices





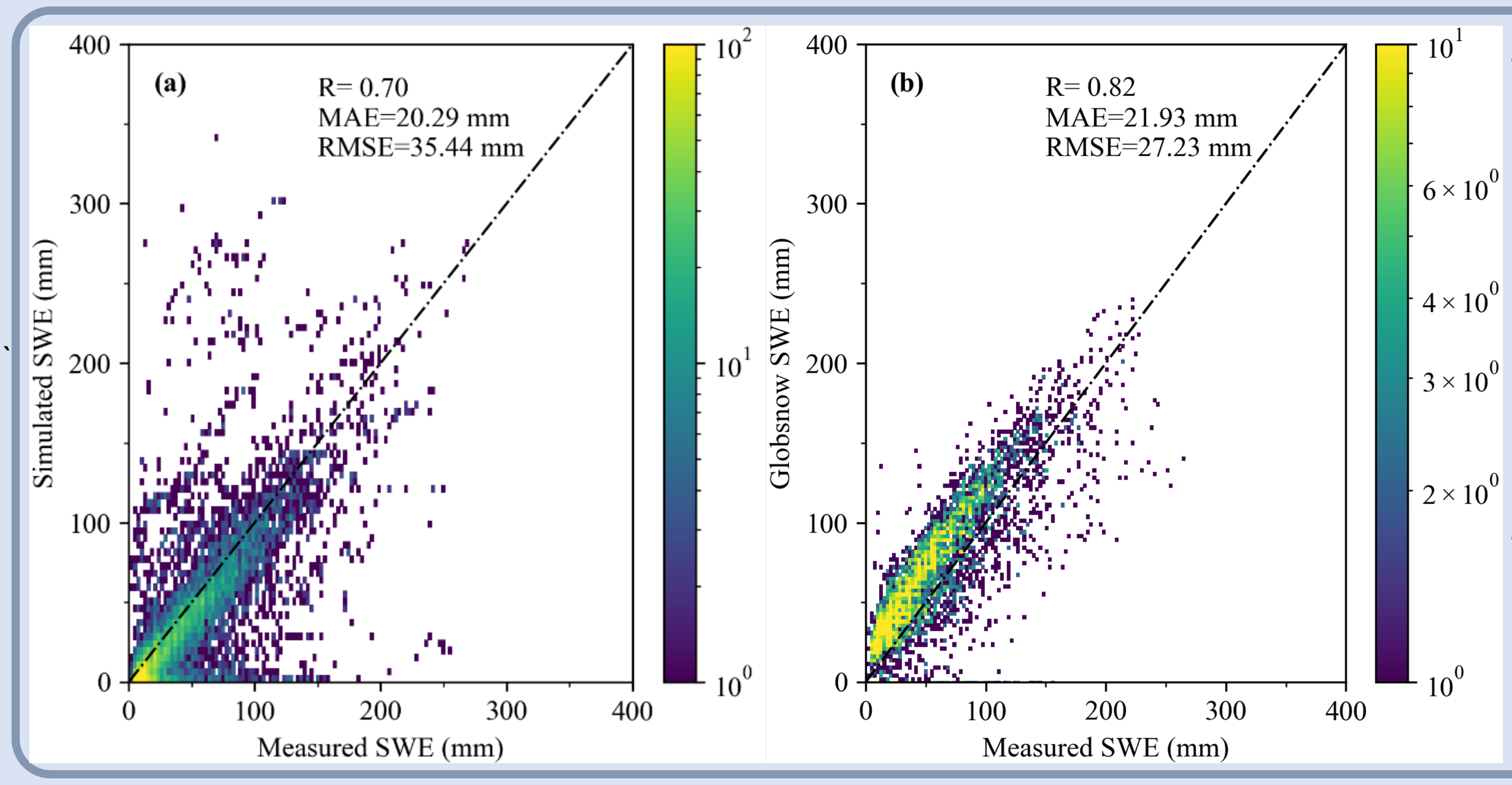
- A significant decreasing trend was observed in snow depth SD.
- During 1982-2019, the SCDs have increased by more than 35 days.
- SDDs, SOD, and SED did not show significant long-term trends.

Effect of climatic conditions on snow cover



- Long-term increasing trends have been observed in annual air temperature and precipitation (left figure, upper panel); however, no such patterns were found in winter (lower panel).
- Between the mid-1990s and about 2010, observed winter air temperature showed a remarkable decrease, which might have induced the significant increase in SCDs.

Snow simulations with TRAIN and GlobSnow data



- SWE from the Globsnow product as well as simulated SWE based on the hydro-logical model TRAIN show an acceptable performance in southern Siberia.
- In general, the TRAIN simulation is closer to the observations than the Globsnow data.

Summary

- SCDs and snow depth showed significant increasing resp. decreasing trends during 1982-2019.
- The pronounced increase in SCDs might be induced by the decreased winter air temperature since the mid-1990s.
- A recent increase in winter temperatures might reverse the development in SCD.
- Compared with the remotely sensed Globsnow data, simulated SWE based on the TRAIN model showed a better performance in southern Siberia.

Reference: Han, L. & Menzel, L. (2021): Hydrological variability in southern Siberia and the role of permafrost degradation. *J Hydrol* 604, https://doi.org/10.1016/j.jhydrol.2021.127203