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An enhanced distributed temperature-index melt model including radiosonde data and solar radiation

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Most temperature-index models rely on temperatures measured at one weather station on, or close to, the glacier, and a constant lapse rate is assumed as an estimate of the temperature distribution across the glacier surface. However, since the lapse rates are highly variable in time, this simple approach is not optimal for Arctic glaciers where inversion layers are common in the lower atmosphere. Therefore, the focus of this work is to investigate the possibility of using radiosonde data to improve the spatial distribution of air temperature and solar radiation in a grid-based temperature-index model.

A mass balance field program including operation of automatic weather stations (AWS) on Sørbreen, a 15 km^2 glacier on Jan Mayen (N 71˚02', W 8˚12', 80-2200 m a.s.l.), was initiated in 2007. The main AWS at 330 m a.s.l. collects hourly data of air temperature, air humidity, wind speed and direction, barometric pressure, short- and longwave radiation fluxes, and melt rates using a sonic ranger. One less equipped weather station is installed at 880 m a.s.l. to investigate gradients in meteorological variables. The Norwegian Meteorological Institute operates a meteorological station since 1921, at 10 m a.s.l., 20 km southwest of Sørbreen. Radiosondes are deployed twice a day, since 1949. Air temperature, humidity, air pressure and wind speed and direction are recorded at 10 meters intervals, to a height of 25000-30000 meters.

Radiosonde data are analyzed and compared with the meteorological data from the two AWSs on the glacier, during the melt season of 2008. An enhanced distributed temperature-index model is developed, driven by hourly temperature data from the main AWS on the glacier and potential clear-sky direct solar radiation. The radiosonde temperature observations are used to estimate the temperature lapse rate across the glacier surface. The radiosonde humidity profiles are used to calculate a radiation transmissivity index to compensate for elevation differences in the cloud cover. Both lapse rates and transmissivity indexes are calculated twice a day and interpolated to hourly time steps. Preliminary results show that better spatial estimates of temperature lapse rate and solar radiation improve the accuracy of the melt modeling of this glacier since the ablation is highly affected by temperature inversion and the low-atmosphere cloud cover.