EGU21-10721
https://doi.org/10.5194/egusphere-egu21-10721
EGU General Assembly 2021

Spatial estimation of snow water equivalent by modeling of the melting of seasonal snow and glacier in Iceland

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Runoff from seasonal snow- and glacier melt is critical for hydropower production and reservoir storage in Iceland as the energy system is strongly dependent on summer inflow. The isolation and high natural climate variability can pose a risk to the energy security of the power system as drought conditions and low-flow periods are usually not foreseen in great advance. Forecasting the timing, spatial distribution and magnitude of seasonal melt is a challenge and influences the operational control of energy infrastructure and long-term resource planning. As hydropower generation provides over 72% of the total average energy produced in Iceland, accurate forecasting of seasonal melt is essential for the operation of the national power system.

In this study, we present results from a spatially-distributed energy-balance model combined with gap-filled satellite-based time series of fractional snow cover and surface albedo from MODIS. The model reconstructs seasonal snow and glacier melt for the Icelandic highlands providing insight into the spatio-temporal distribution of snow water equivalent over the study period. The reconstruction method uses daily, satellite-derived estimates of fractional snow cover and albedo to scale the melt flux at every pixel. Modeled snow melt was integrated over time, reconstructing the maximum snowpack/glacier melt for each year. The model runs at a 500 m spatial resolution, with a daily timestep from 1 March to 30 September during 2000 to 2019 spanning the general seasonal snow and glacier melt period.

Energy-balance components were validated with in-situ observations from the Icelandic highlands and a network of stations operated annually at various Icelandic glaciers. Ground-based measurements of snow water equivalent (snow pits, surface mass balance) were used to validate the model performance as well as discharge observations. Simulations indicate a good performance compared with summer glacier mass balance records from Vatnajökull, Hofsjökull, Langjökull and Mýrdalsjökull. Sparse and discontinuous measurements of seasonal snow water equivalent from snow pillows or transects from snow courses were available from a few location, providing limited capabilities for direct validation for seasonal snow. Discharge observations in highland catchments indicate acceptable performance.

The results allow for quantification of the spatial distribution of snow water equivalent,

relationships to elevation and other topographical parameters as well as between basins and years. Discrimination between seasonal snow and glacier melt on a catchment scale is valuable to analyze the annual variability in these two critical hydrological water sources and how they are related.