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ESTIMATING ARCTIC SNOWFALL WITH A LAND SURFACE HYDROLOGY MODEL

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Much of the uncertainty in land-based Arctic freshwater estimates relates to the difficulty of measuring solid precipitation (Goodison et al. 1998). Precipitation gauges that work well for liquid precipitation perform poorly for mixed and solid precipitation because the gauge itself disrupts the boundary layer wind flow and causes snow to preferentially fall downwind from the gauge (Sevruk 1998). Another problem in the Arctic is the paucity of gauges (compared to mid-latitudes) which is compounded by creating gridded products for use in climate studies when there are only a few points of observation (Bowling et al. 2000). Such products are even more misleading when different countries and regions use different kinds of gauges, each kind with a unique bias toward undercatch.

The goal of this work is to reconstruct a century-long record of solid precipitation in the Arctic by running the NASA Seasonal to Interannual Prediction Project (NSIPP) land surface hydrology model in an inverse mode (Ducharne et al. 2000, Koster et al. 2000). To this end, the model is run using observations of snow depth and surface air temperature to reconstruct the precipitation that must have fallen to produce the observed snow depth. Transport of snow by wind on the Arctic prairies may be as much as 75% (Pomeroy and Gray 1995) and sublimation induced by strong winds may account for losses to the atmosphere of nearly 30% (Pomeroy et al. 1997). For these reasons, the model includes compaction, surface sublimation, and blowing snow. This reconstruction is based on simple snow depth measurements using a ruler, with minimal instrumental error and little or no destructive influence on the snowpack. The snow depth record is quite long (back to 1890 in some stations) and adds thousands of stations to the small number of precipitation gauges in the Arctic (over 400 new stations in the Mackenzie catchment alone). By estimating the historical land-based solid precipitation in the Arctic, uncertainty in the Arctic freshwater budget associated with precipitation gauges is significantly reduced.

The Reynolds Mountain station at Reynolds Creek Experimental Watershed (RCEW) in southwestern Idaho was chosen to calibrate and evaluate the method. Hourly measurements of all the relevant climate and hydrological variables for this study have been taken at RCEW since 1984 (Marks et al. 2001). Snow depth and snow water equivalent (SWE) are measured on several permanent snowcourses, twice monthly, and SWE is measured on an automatic snowpillow (pressure-based measurement of the weight of overlying snow) once hourly. RCEW was one site of the World Meteorological Organization's Solid Precipitation Intercomparison Project from 1987-1994, a time during which instrumental biases associated with several solid precipitation gauges were carefully evaluated against the double fenced intercomparison reference (DFIR), considered the least biased snow gauge available. Transfer functions were then developed to adjust the gauge data for known biases. These adjustments are applied to the precipitation observations for the present study.

First, the model is forced with corrected observed precipitation, surface temperature, surface pressure, vapor pressure, wind, incoming shortwave and longwave radiation. The simulated snow depth is then compared to observed snow depth (from cumulative corrected gauges, pillows, and courses) to demonstrate the ability of the model to reproduce the observed snowpack. Then the model is run in an inverse mode to reconstruct precipitation. In this way, snowdepth observations and modeled snowpack physics are used to calculate how much precipitation must have occurred to produce the observed snow depth. Results from a pilot run show excellent agreement (< 3% yearly SWE) between NSIPP reconstructed precipitation and adjusted observed precipitation.

For further detail, please regard the authors' forthcoming paper on this subject.

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