Modeling streamflow from melting glaciers

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Motivation

 Improve prediction of streamflow from glaciers in the streamflow model WRF-Hydro

- Glaciers are represented as a land surface category in the land surface model Noah-MP
- Snow can accumulate. Represented by a 3 level snow model.
- Glacier cannot melt beyond the accumulated snow (i.e. glacier cannot decrease and cannot produce streamflow from melting ice).
- Albedo in Noah-MP is time dependent, and not physical based.
- Use the physical based snowpack model Crocus to represent glaciers

The WRF-Hydro System

WRF-Hydro Physics Components – Output Variables

Noah-MP



Recently added a Glacier Component (Crocus) in the Noah-MP Land Surface Model Crocus called from module_sf_noahmpdrv.F



New glacier treatment within the land surface model in Noah-MP



No energy fluxes between bottom of glacier and the ground below



Evaluation

Hardangerjøkulen, Norway



Astore Catchment, Pakistan



South Central Alaska





WRF-Hydro/Glacier simulation over Hardangerjøkulen

Downscaled ERA-Interim reanalysis to 1km with WRF.

WRF-Hydro/Glacier run at 100m, forced with the 1km WRF simulation.

Middalselvi: 60% glacierized Finseelvi: 15% glacierized





Mass Balance Hardangerjøkulen 2015







NCAR UCAR

Streamflow Middalselvi (60 % glacierized)

NCAR UCAR NOTE: WRF-Hydro has not been calibrated for this watershed



NOTE: WRF-Hydro has not been calibrated for this watershed



NCAR

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South Sentral Alaska



Mass Balance Anomaly Wolken et al., 2020



Mean modeled SWE over glacier cells: Anomaly





Change in Glacier thickness 2000-2019

Change in Glacier thickness 2004-2016 WRF-Hydro/Glacier











Change in Glacier thickness 2000-2019

Change in Glacier thickness 2004-2016 WRF-Hydro/Glacier





Hugonnet, 2021, Nature





Astore Catchment, Pakistan

500



400 Streamflow [m³s⁻¹] 00 00 100 0 Dec Sep Nov Jan Feb Aug Jan Mar May Jun ١٦ Oct Apr

Mehboob et al (2022), Journal of Hydrology



Antarctica

By Tamara Pletzer

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- Glaciers very different from warmer Alpine Glaciers
 - Updated water percolation in Crocus
 - Use different assumptions for snow and ice albedo





Summary

- Investigating streamflow impacts from melting glacier
- Implemented a detailed physical based snow module (Crocus) into Noah-MP land model in the WRF-Hydro system to model glacier mass balance and subsequent streamflow
- Model results with new glacier snow module (Crocus) compares well with observations.
- Correct use of surface albedo improves streamflow modeling.
- Disclaimer:
 - No dynamical movement of glaciers.
 - All melt from glacier is assumed to go into surface runoff.
- <u>https://github.com/NCAR/wrf hydro nwm public</u>
 - Can use WRF-Hydro/Glacier with a namelist option

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Eidhammer et al: Mass balance and hydrological modeling of the Hardangerjøkulen ice cap in south-central Norway, Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-119, in review, 2020.

