Mass Balance and Hydrological Modeling of the Hardangerjøkulen Ice Cap in South-Central Norway

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Motivation



- Improve prediction of streamflow from Glaciers in WRF-Hydro The WRF-Hydro is a physics-based, distributed hydrological modeling system.
- Issues with Glaciers in WRF-Hydro (i.e. Noah-MP land surface model)
 - Glaciers are represented as a land surface category. Snow can accumulate. Represented by a 3 level snow model.
 - Glacier cannot melt beyond the accumulated snow (i.e. glacier cannot decrease).
 - Ablation zone not well represented. Streamflow from decreasing glacier is not well accounted for.
 - Glacier land surface category having a surface albedo of old snow. Does not represent areas with surface ice.
 - Ice albedo ~0.3
 - Snow albedo of glacier surface category: ~0.67
- Melting of glacier (thus streamflow) dependent on surface albedo



Glacier treatment



Adding a detailed physical based snow scheme to Noah-MP land surface model to simulate the glacier mass balance and stream flow



Glacier treatment



Adding a detailed physical based snow scheme to Noah-MP land surface model to simulate the glacier mass balance and stream flow





Hardangerjøkulen in Norway





Hardangerjøkulen in Norway



Rembedalskåka

Hardangerjøkulen

Midtdalsbreen

Middalselvi

Finseelvi

Finse research station

Photo: Sven Dahlgren







Legend



Ran WRF with 3 km grid spacing domain driven by ERA-Interim reanalysis. Second inner WRF domain nested at 1 km. Time period: August 2014-December 2018.

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



Glacier Mass balance





Mass Balance 2015

Model Crocus Model Noah-MP Observation







Total Mass balance over Rembesdalskåka



Albedo top part of glacier

- Modis (Terra and Aqua)
- Crocus
- --- Noah-MP





Albedo northern part of glacier

- Modis (Terra and Aqua)
- Crocus
- --- Noah-MP





Streamflow Middalselvi

0

05/01

07/01

08/01

09/01

Date

10/01

06/01

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



0

12/01

11/01

05/01

06/01

07/01

08/01

Date

09/01

10/01

11/01

12/01

Streamflow Middalselvi

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





Sensitivity study. Assume ice surface albedo equal to snow albedo





Summary

- Investigating impacts on melting glacier in Norway and its streamflows
- 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.
- Future testing/use of the WRF-Hydro/Glacier system
 - Alaska
 - Iceland
 - Chile (Patagonia)

Questions?