THP Snow OSSE Activities

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Objective

**Overall**: How can we use a Snow Observing System Simulation Experiment (OSSE) to support SnowEx?

**Phase 1**: Snow Ensemble Uncertainty Project (SEUP): Modeling exercise to characterize SWE uncertainty across North America to identify regions and temporal periods of high variability.

**Phase 2**: Higher resolution Snow OSSE to evaluate impact of assimilated SWE observations to improve snow characterization

**Phase 3**: Snow OSSE to test forward modeling approach assimilating raw observations
Phase 1: SEUP

Science Questions:
- Where are the areas of high and low uncertainty in SWE at different times of the year, and for different years?
- What factors govern spatial variability in SWE uncertainty? How do those change throughout the season, and for different years? Specifically, what is the role of mountains, forests, albedo, high precipitation / deep snow, etc., along with the associated uncertainty, in determining spatiotemporal SWE uncertainty patterns?

Plan: Use the Land Information System (LIS) framework to run an ensemble of models and forcing datasets and compare results. Assess the results to help select field campaign sites for further investigation.
Snow Ensemble Uncertainty Project (SEUP)

- MODELS: LIS models – Noah-MP (3 layer snow), JULES (1-layer snow), Catchment (3-layer snow), Noah (1-layer snow), Liston model: SnowModel (multiple layers, run independently)
- FORCING: Realistic forcing uncertainty – MERRA2-corrected, GDAS, ECMWF
- ROUTING: HyMAP
- RESOLUTION: 5km
- TIME STEP: 3 Hours

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<th>MERRA2</th>
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<td>Noah-MP</td>
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<td>JULES</td>
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Results

Mean SWE over entire time period for each ensemble member.
Point comparisons

Point comparison of Noah-MP results with ECMWF forcing compared to ground observation in the Olympic Mountains in 2016 (Justin Pflug, UW).

Point comparison of JULES results compared to ground observation in the Sierra Mountains over three years. (Nicoleta Cristea, UW)
Time during which NoahMP results showed that there was no snow cover at the simulation point but MODIS snow cover data (normalized difference snow index) demonstrate there was indeed snow cover at that point during the period (Yueqian Cao, Duke University).
Spatial Comparison

RMSE (kg/m²)

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Spatial comparison of ensemble results to ASO in Tuolumne Basin (Rhae Sung Kim, NASA).
Comparison of MODIS-derived snow extent and Noah-MP* modeled snow extent for the western United States - February 2017

Mean Maximum Snow Cover for February 2017

Daily Maximum Snow Cover from MODIS and Noah-MP* for February 2017

*with MERRA2 forcing

MODIS
Noah-MP with MERRA2 forcing

(Dorothy Hall and Nick Digirolamo, NASA)
Agreement between the MODIS CGF- and the Noah-MP* model-derived snow extent for the month of February 2017

*with MERRA2 forcing

(Dorothy Hall and Nick Digirolamo, NASA)
Uncertainty Analysis

Analysis of spatial and temporal uncertainty in the ensemble results (Rhae Sung Kim, NASA)
Uncertainty Analysis

Characterize spatial and temporal variability, and identify specific regional and seasonal factors that drive uncertainty in SWE estimation (Lawrence Mudryk, EC).
SnowEx 2019

February 2017 – Example Wet Month (Jeremy Johnston, GMU)

Mean Ensemble SWE

Coefficient of Variation

Range

Idaho

Colorado

Produced by Jeremy Johnston, GMU
Next Steps

- Continue analysis of SEUP results
- Analyze Alaska region for 2020 campaign
- Begin design of Phase 2 & 3