

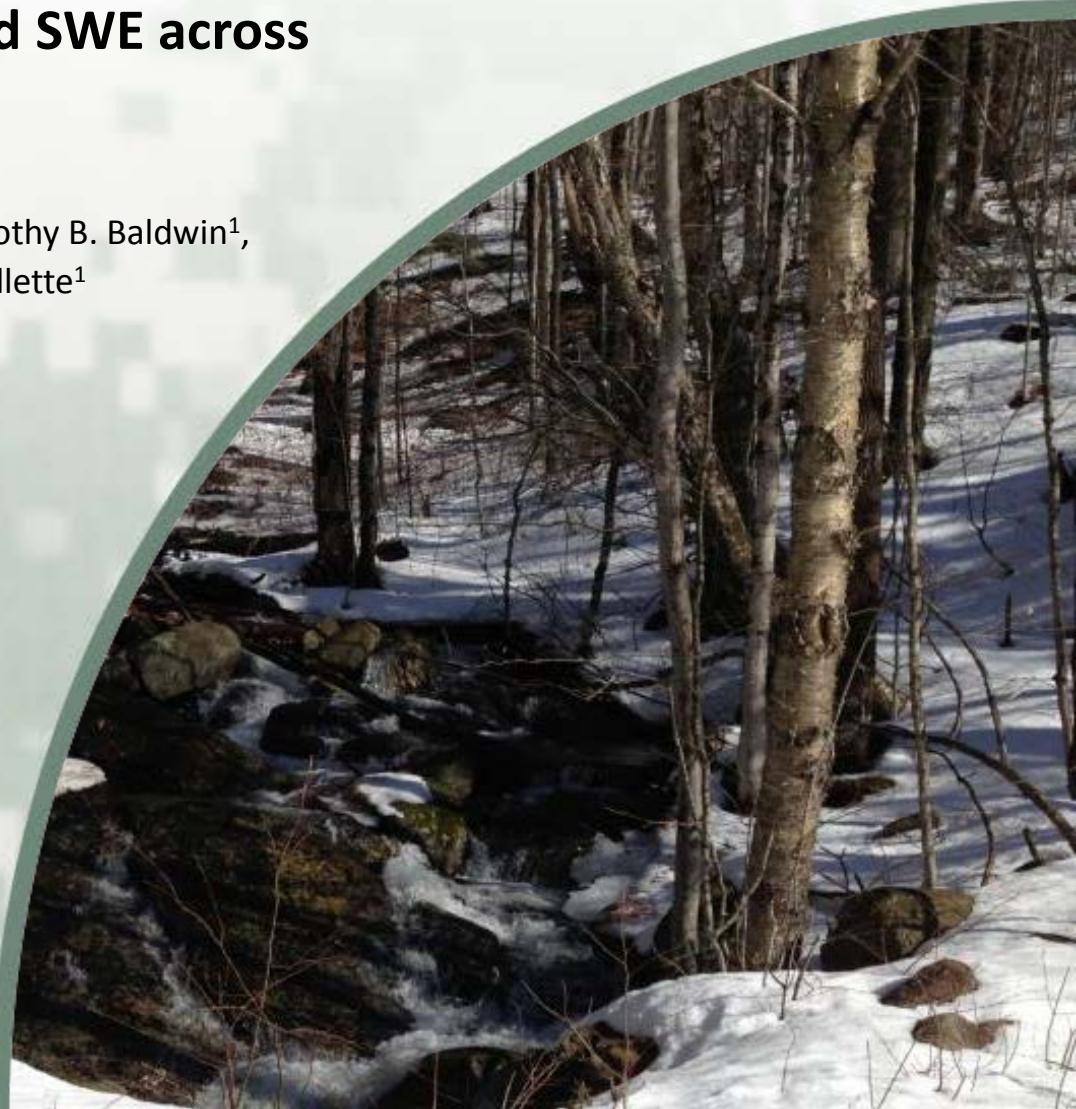
Watershed-based comparison of global SWE algorithms to SNODAS modeled SWE across the United States

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² University of New Hampshire

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Boulder, CO



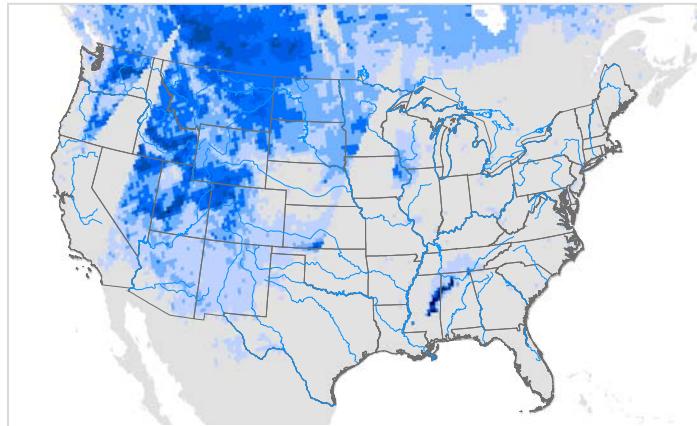
Overview

- Comparison of passive microwave SWE estimates from 4 global satellite-based products to NOAA daily gridded SWE products in the U.S. on a watershed scale.
- Analysis specifically focused on:
 - ▶ Regional differences
 - ▶ Effects of vegetation, deep snow
 - ▶ Ability to capture relative magnitude, accumulation and ablation timing

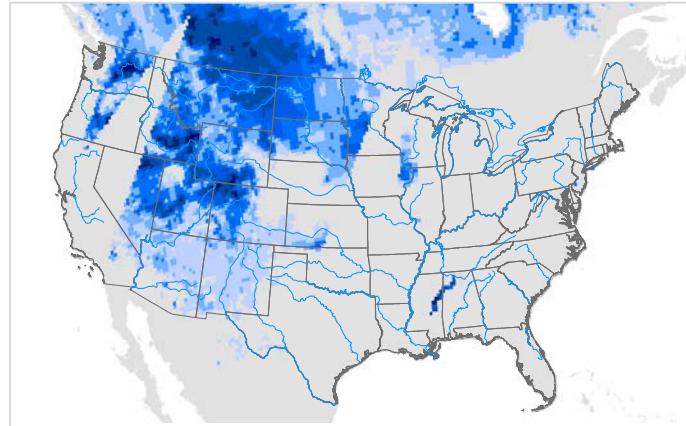
DATA

Passive microwave-based products used in comparison:

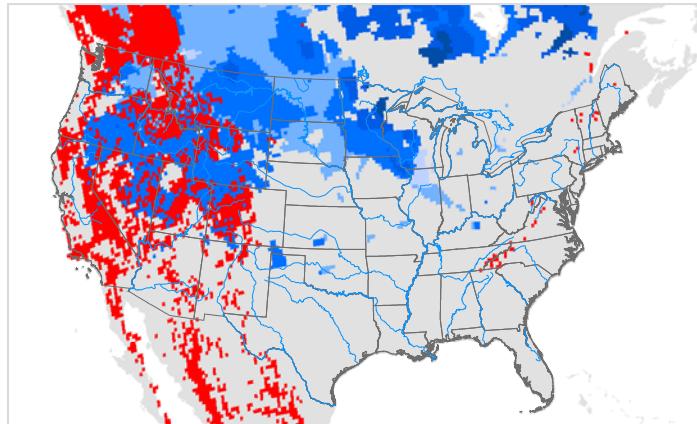
AMSR-E STANDARD



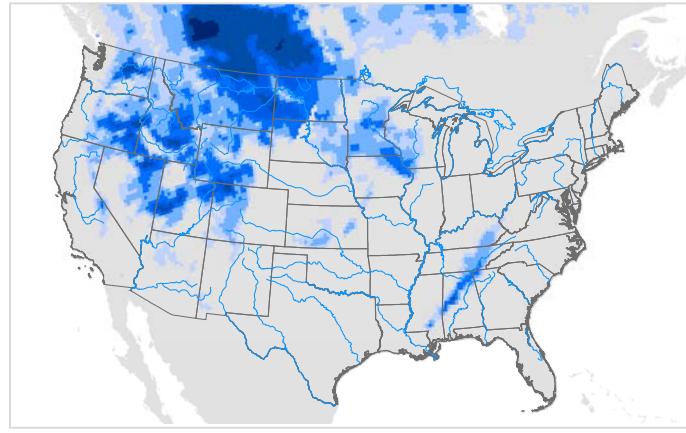
AMSR-E PROTOTYPE



GLOBSNOW



SSM/I



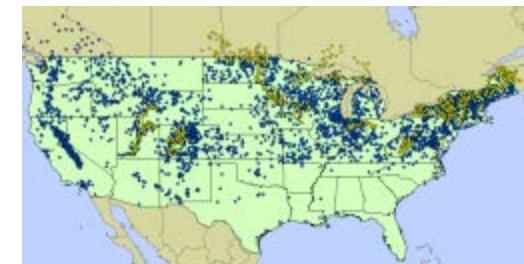
01 JAN 2011 SWE (mm)

0
0 - 25
26 - 50
51 - 75
76 - 100
101 - 150
151 - 200
> 200

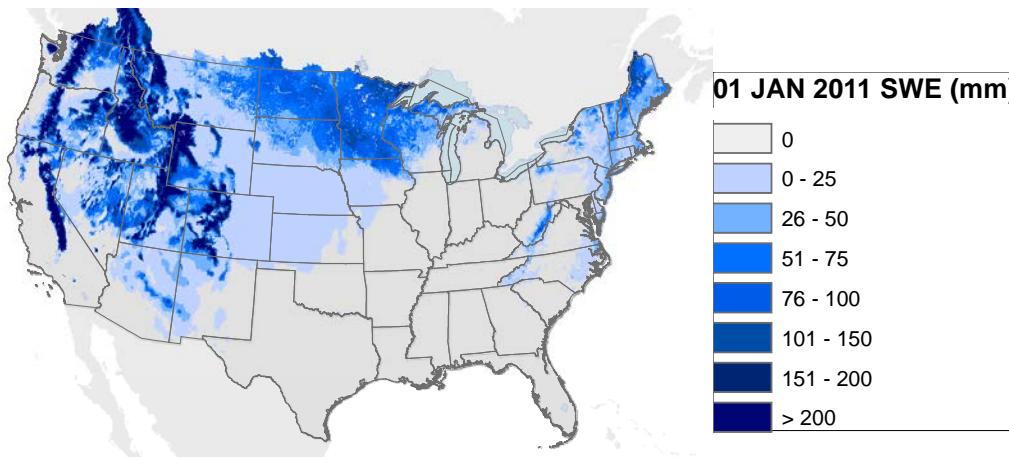
NOAA National Snow Analyses (SNODAS)

National Operational Hydrologic Remote Sensing Center (NOHRSC)

- SWE estimates based on multisensor snow observations combined with energy balance snow model
- Hourly/Daily gridded SWE product for conterminous U.S.
- 1 km² resolution
- POR: October 2003 – Present
- Sources of Error:
 - Uncertainty in forcing data and model results
 - Gaps in available observation data



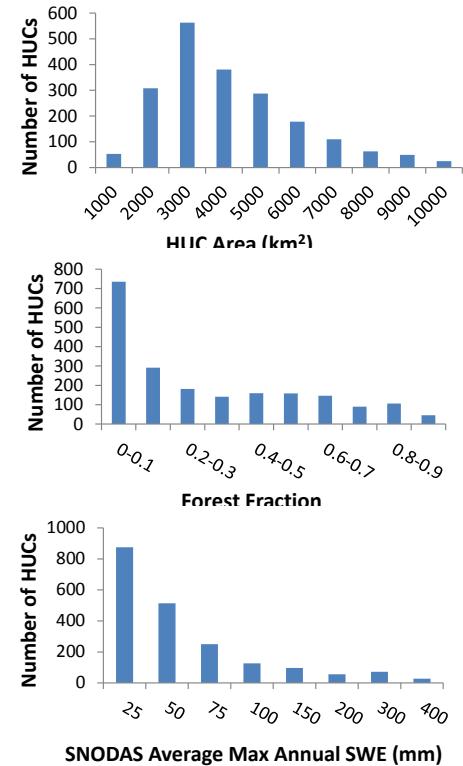
2006-07 Ground Observations (Cline 2008)



NOHRSC Flight Lines (<http://www.nohrsc.noaa.gov/>)

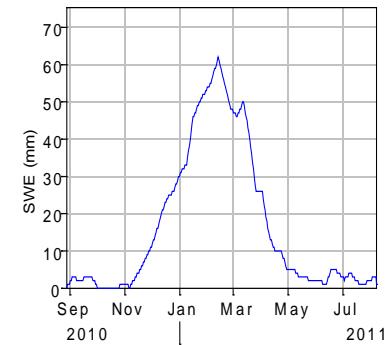
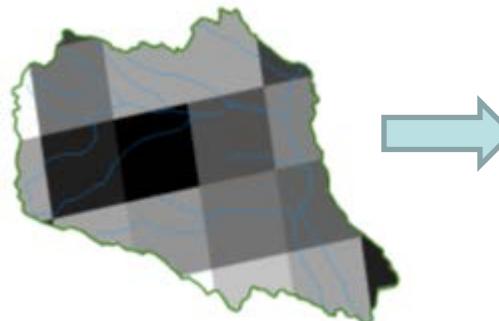
Method

- SWE Comparison (2004-2011):
 - ▶ Evaluation done on watershed scale
 - Weekly maximum average basin SWE
 - Only computed for basins with no missing pixels
 - ▶ Compared magnitude, correlation and timing of SWE estimates.
 - ▶ Analyzed by max annual SWE and forest cover



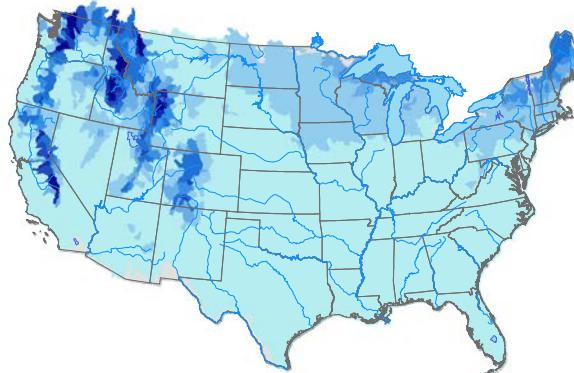
Method

- Weekly basin SWE values were calculated between October and May each winter, 2004 – 2011.
- For each HUC,
 - ▶ Calculated the weekly basin-average SWE depth for each data source
 - ▶ Used maximum weekly pixel values to filter missing data and scatter in passive microwave
 - ▶ Annual maximum SWE were taken from weekly time series
- Statistics:
 - ▶ Average, Maximum, Minimum
 - ▶ Difference in average annual maximum
 - ▶ Correlation, with forest cover and max swe
 - ▶ Spearman's rank-order
 - ▶ Nash-Sutcliffe efficiency

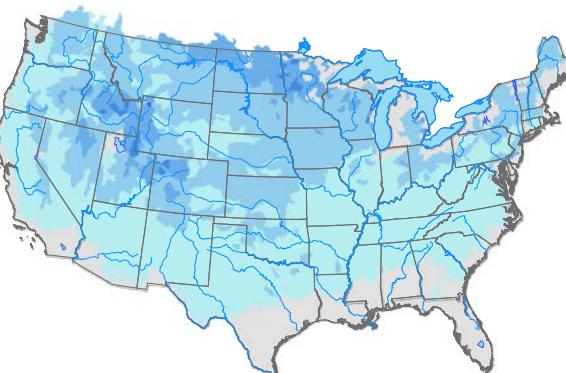


Average Maximum Annual SWE, 2004 - 2011

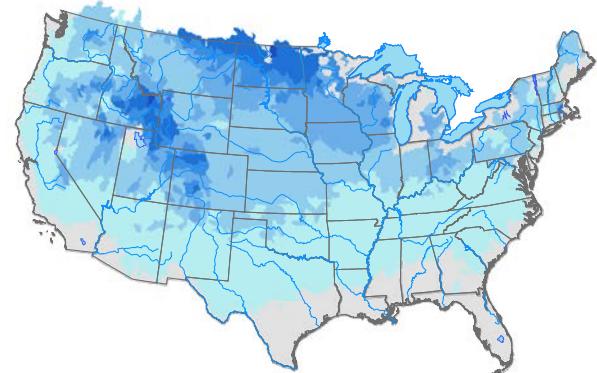
SNODAS



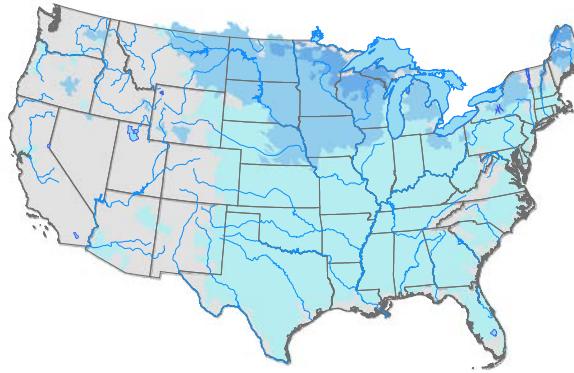
AMSR-E STANDARD



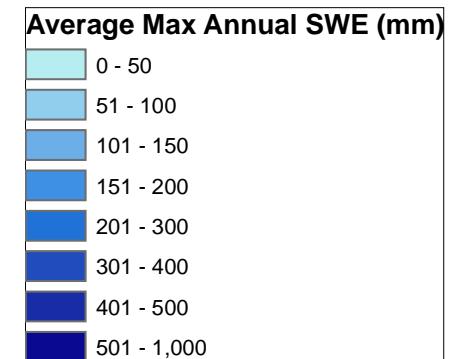
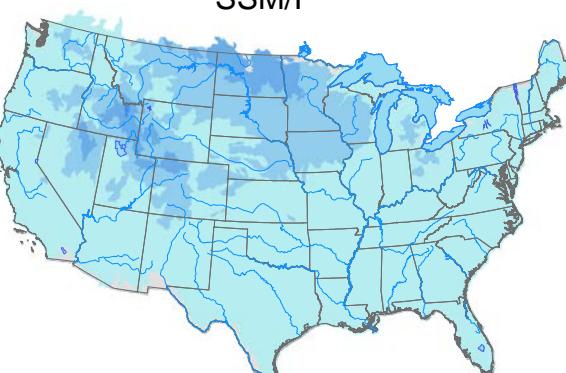
AMSR-E PROTOTYPE



GLOBSNOW

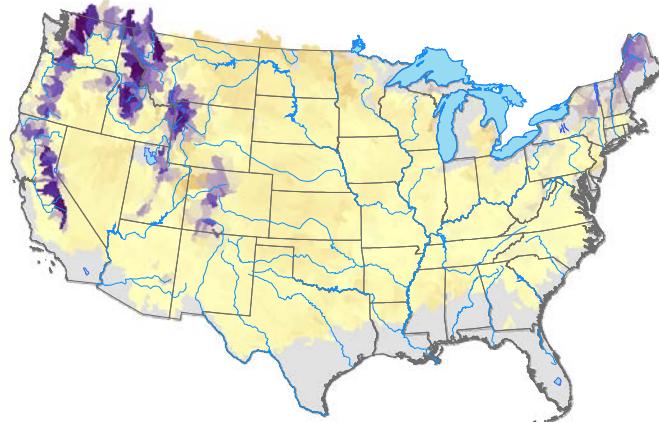


SSM/I

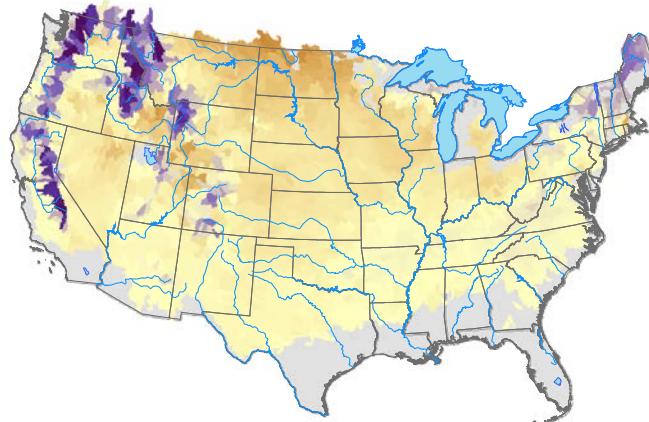


Difference in Average Annual Maximum SWE

SNODAS - AMSR-E STANDARD



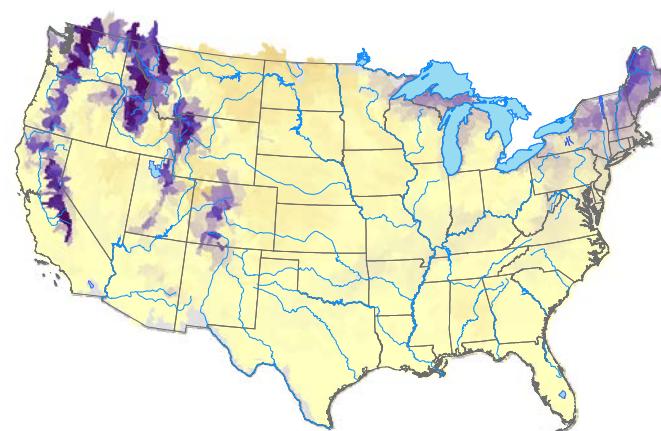
SNODAS - AMSR-E PROTOTYPE



SNODAS - GLOBSNOW



SNODAS - SSMI

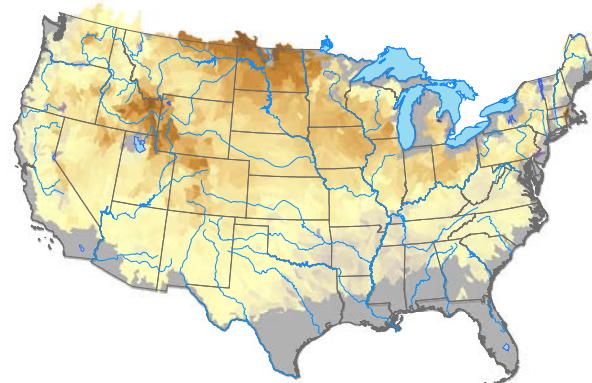


Difference in Average
Annual Max SWE (mm)

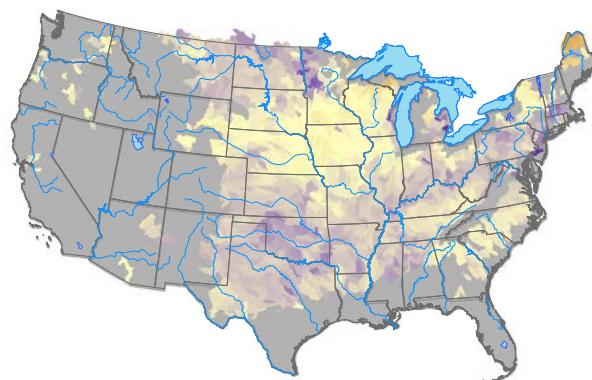


Difference in Average Annual Maximum SWE

AMSR-E STANDARD -
PROTOTYPE



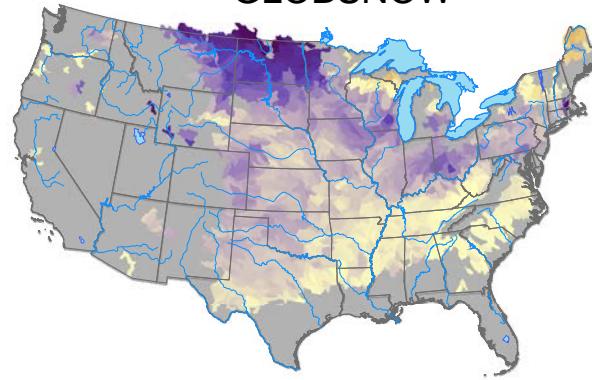
AMSR-E STANDARD -
GLOBSNOW



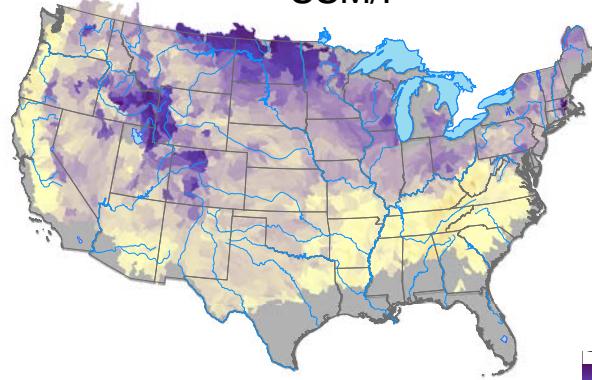
AMSR-E STANDARD –
SSM/I



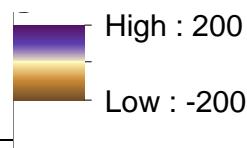
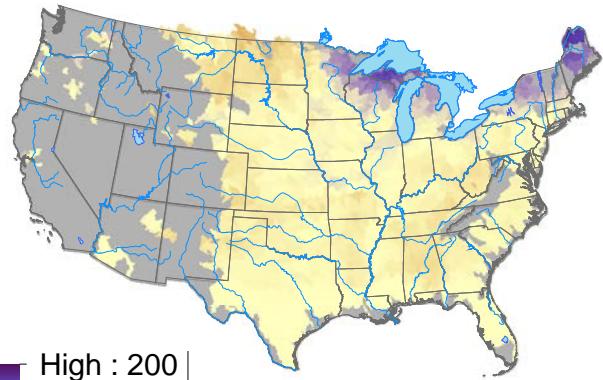
AMSR-E PROTOTYPE -
GLOBSNOW



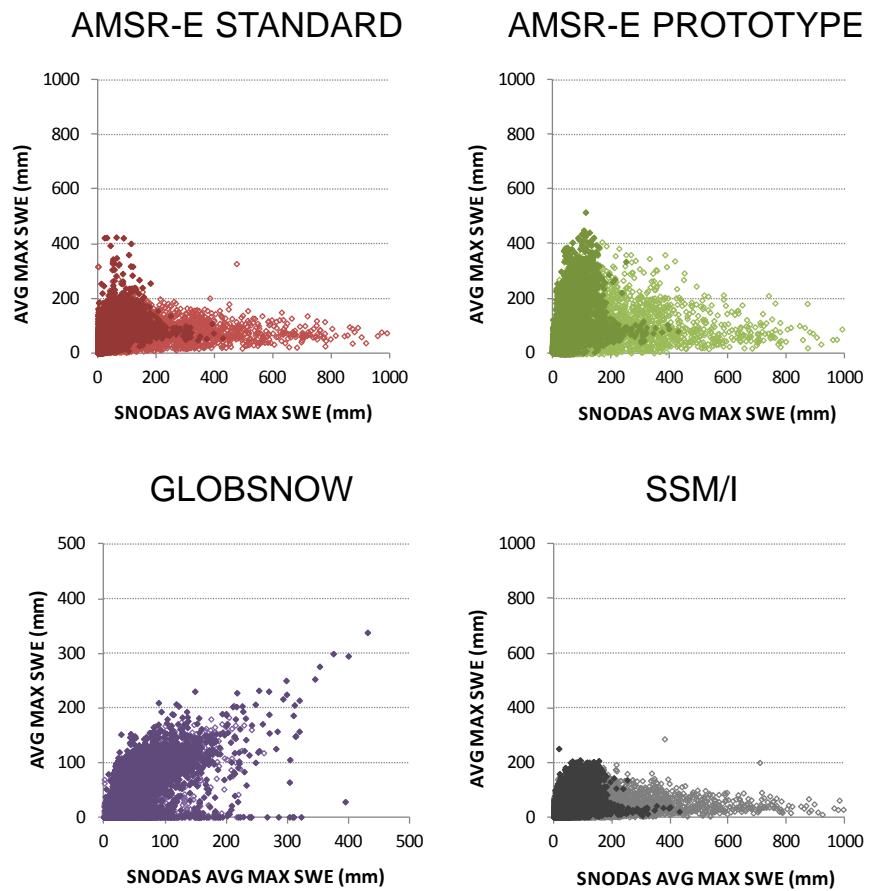
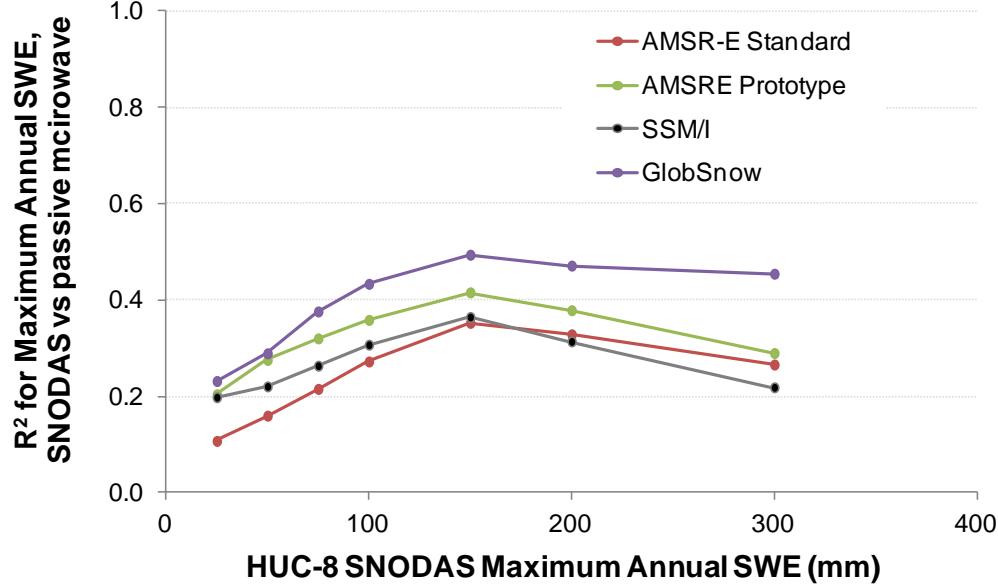
AMSR-E PROTOTYPE –
SSM/I



GLOBSNOW – SSM/I



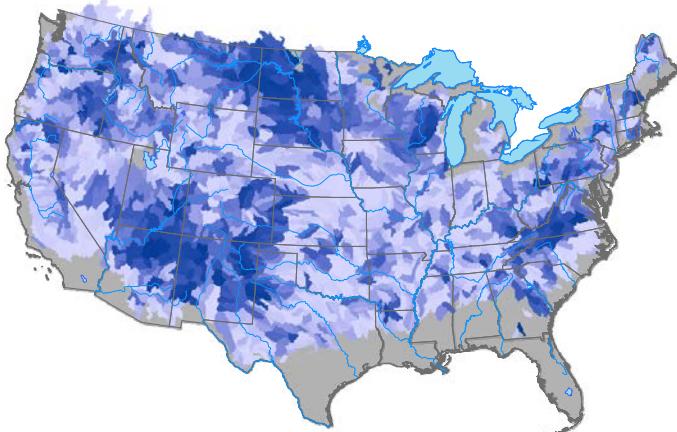
Average Maximum Annual SWE, 2004 - 2011



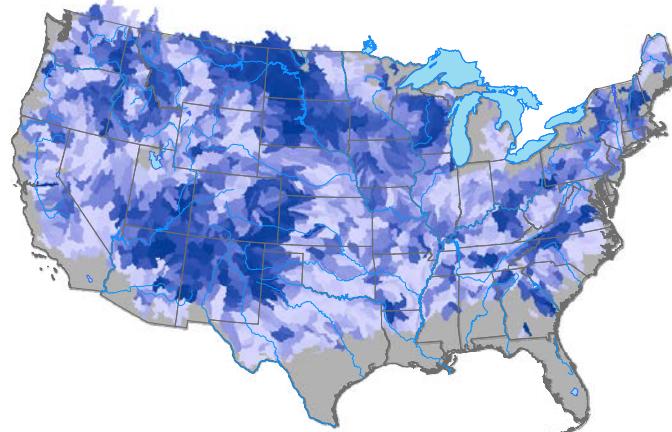
HUCs with data available from all sources (shown in dark), and all HUCs (shown in light)

Correlation Annual Maximum SWE, 2004 - 2011

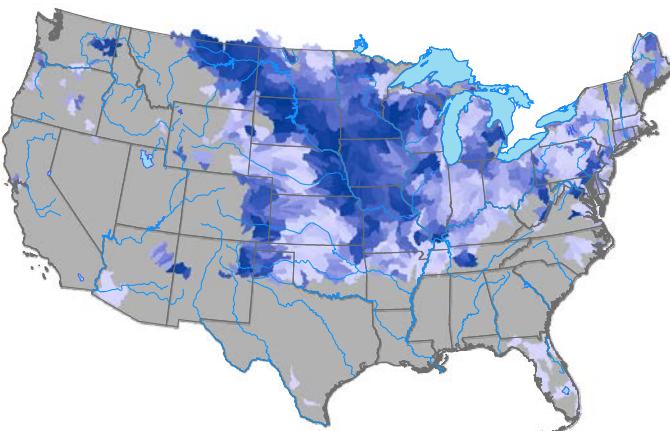
SNODAS / AMSR-E STANDARD



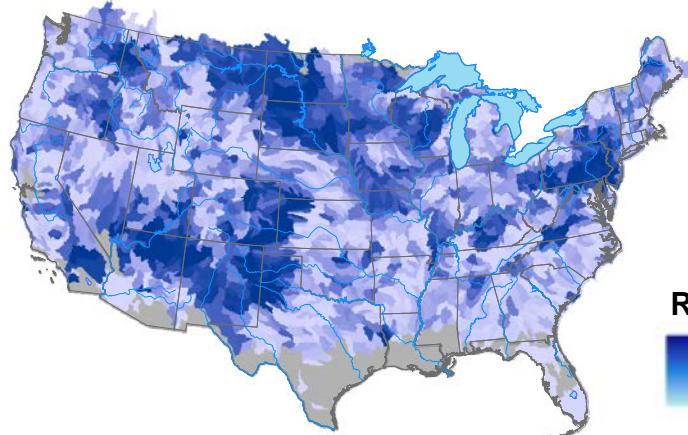
SNODAS / AMSR-E PROTOTYPE



SNODAS / GLOBSNOW

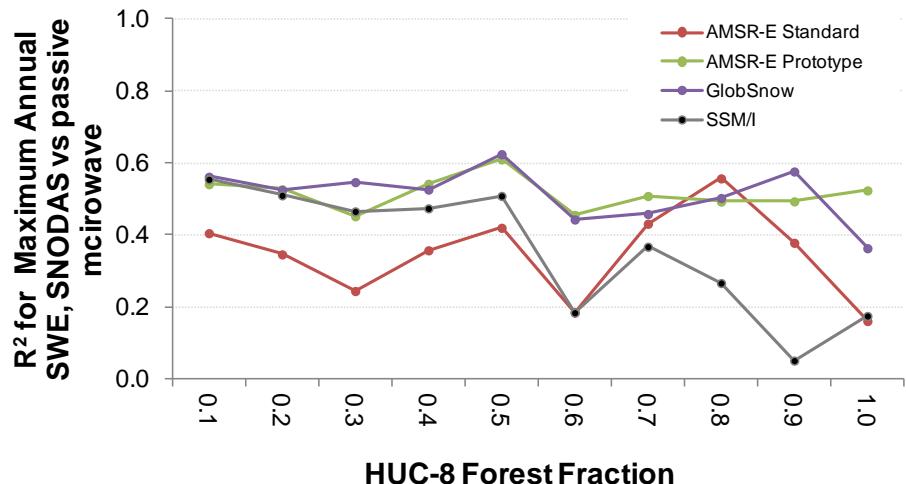
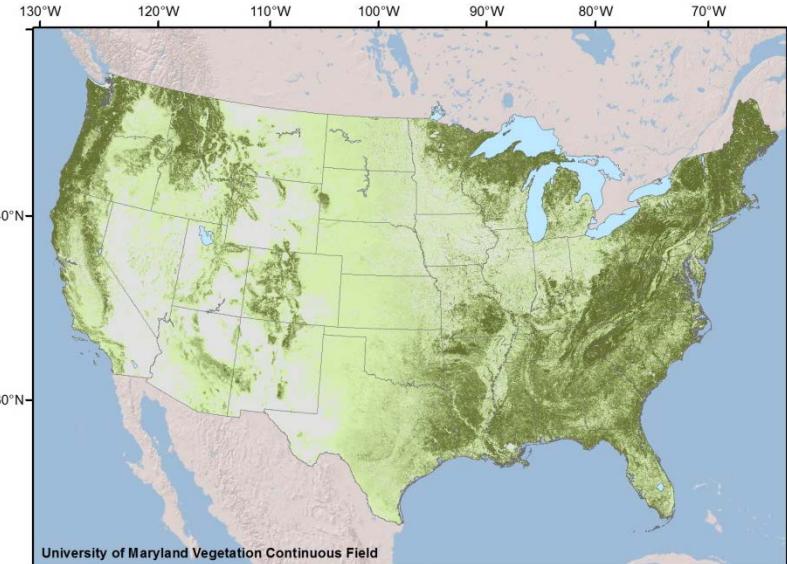


SNODAS / SSMI

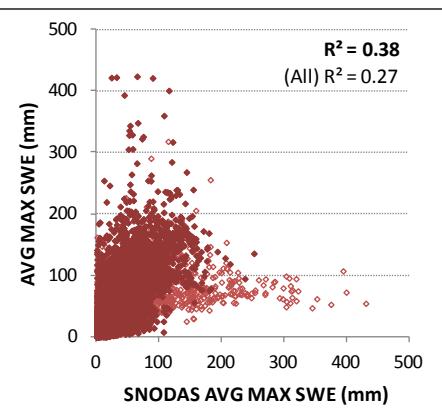


R^2
High : 1
Low : 0

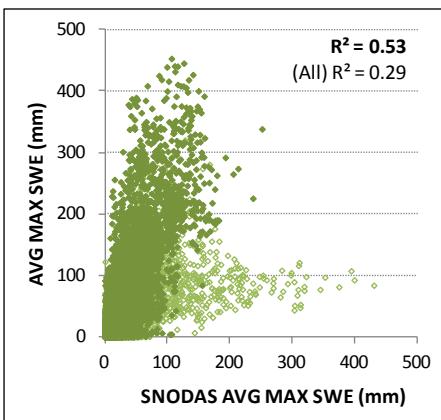
Annual Max SWE Correlation by Forest Cover



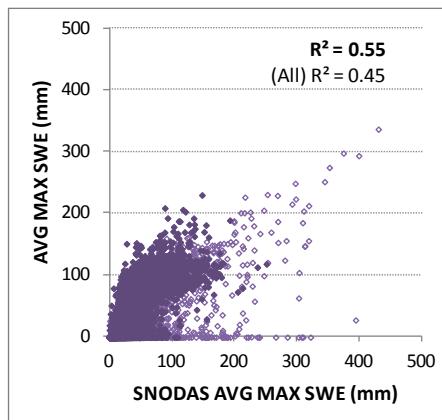
AMSR-E STANDARD



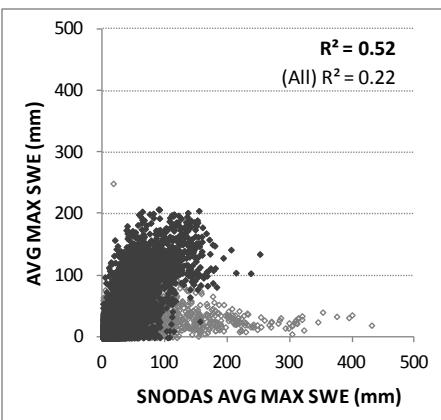
AMSR-E PROTOTYPE



GLOBSNOW



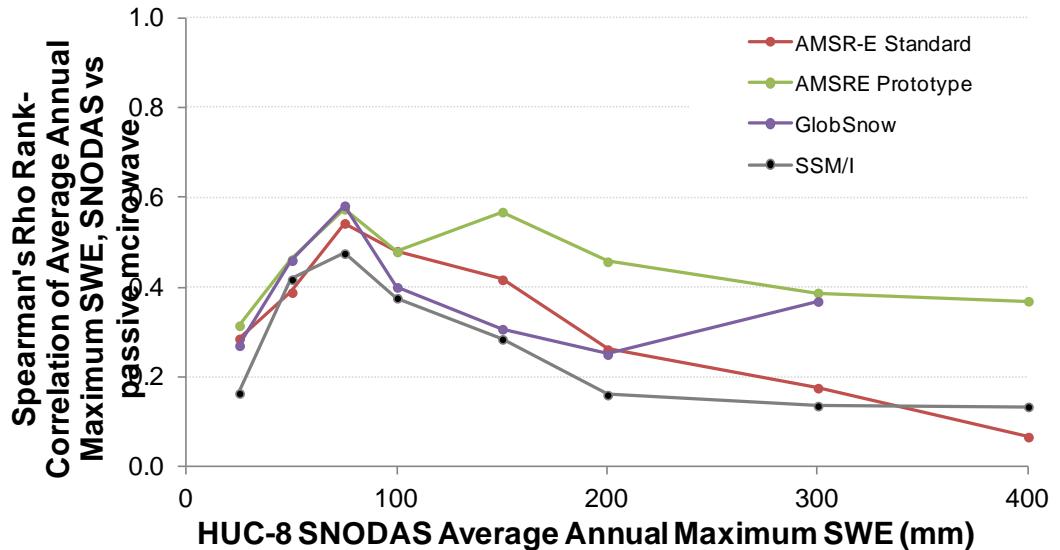
SSM/I



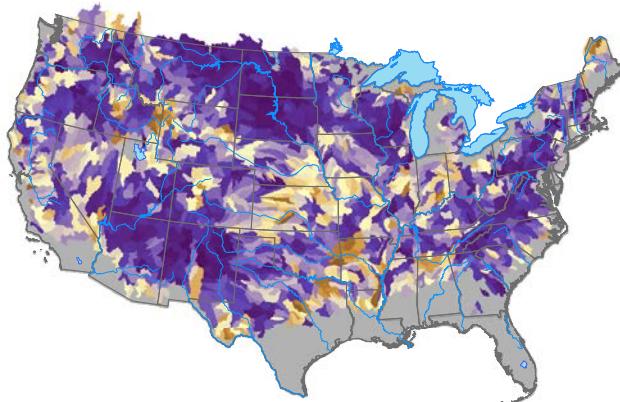
HUCs with < 50% Forest Cover (shown in dark), and all HUCs in region (shown in light)

Spearman's Rank Correlation

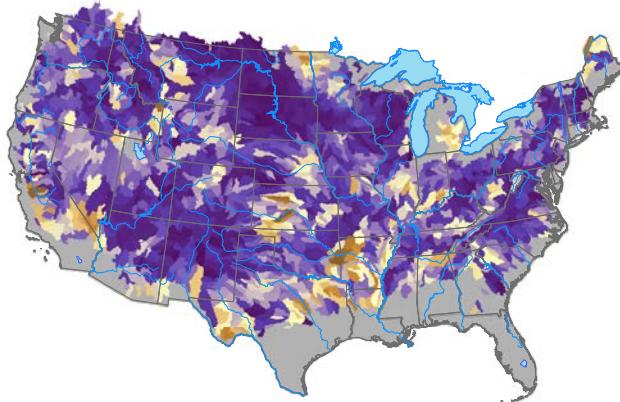
Annual Maximum SWE, 2004 - 2011



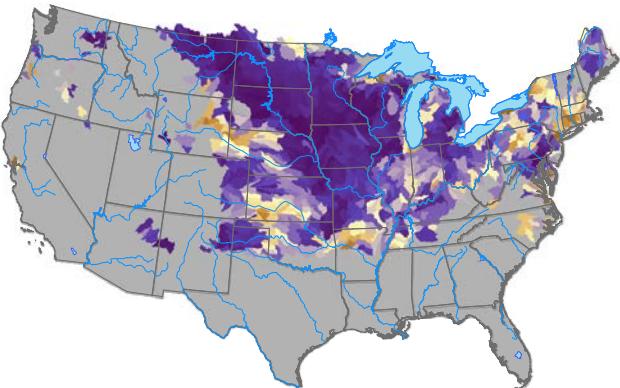
SNODAS – AMSR-E STANDARD



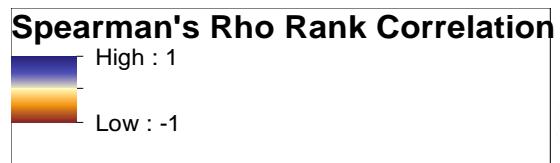
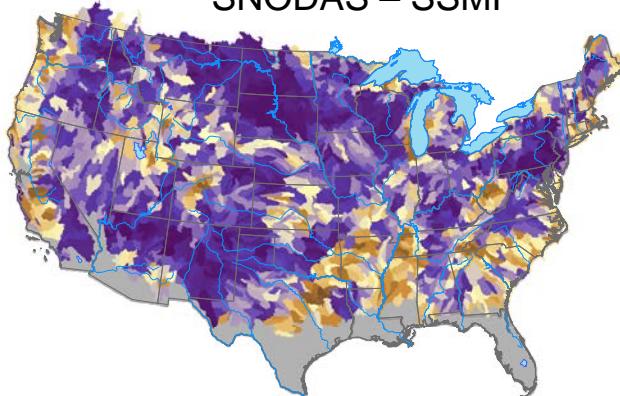
SNODAS – AMSR-E PROTOTYPE



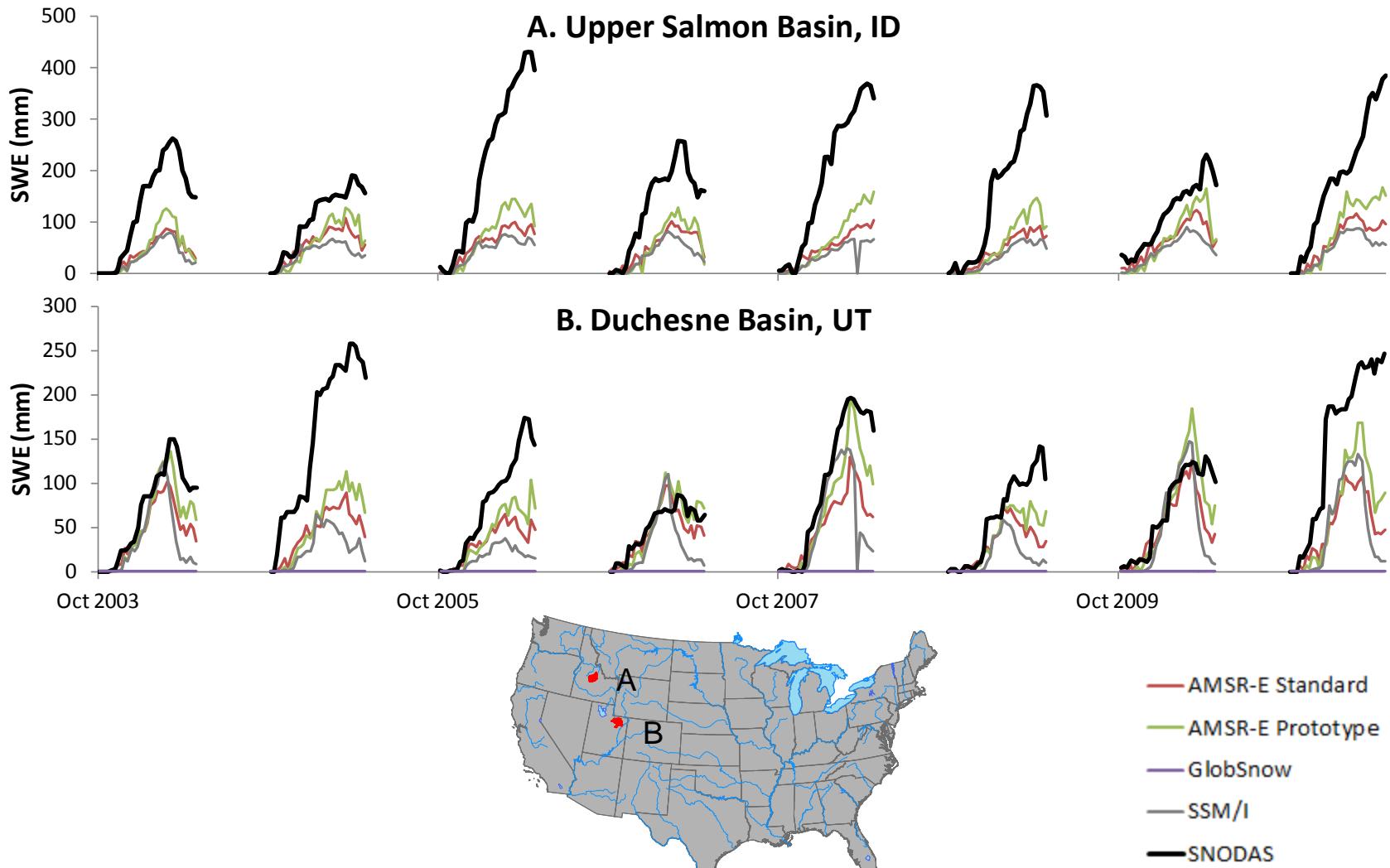
SNODAS – GLOBSNOW



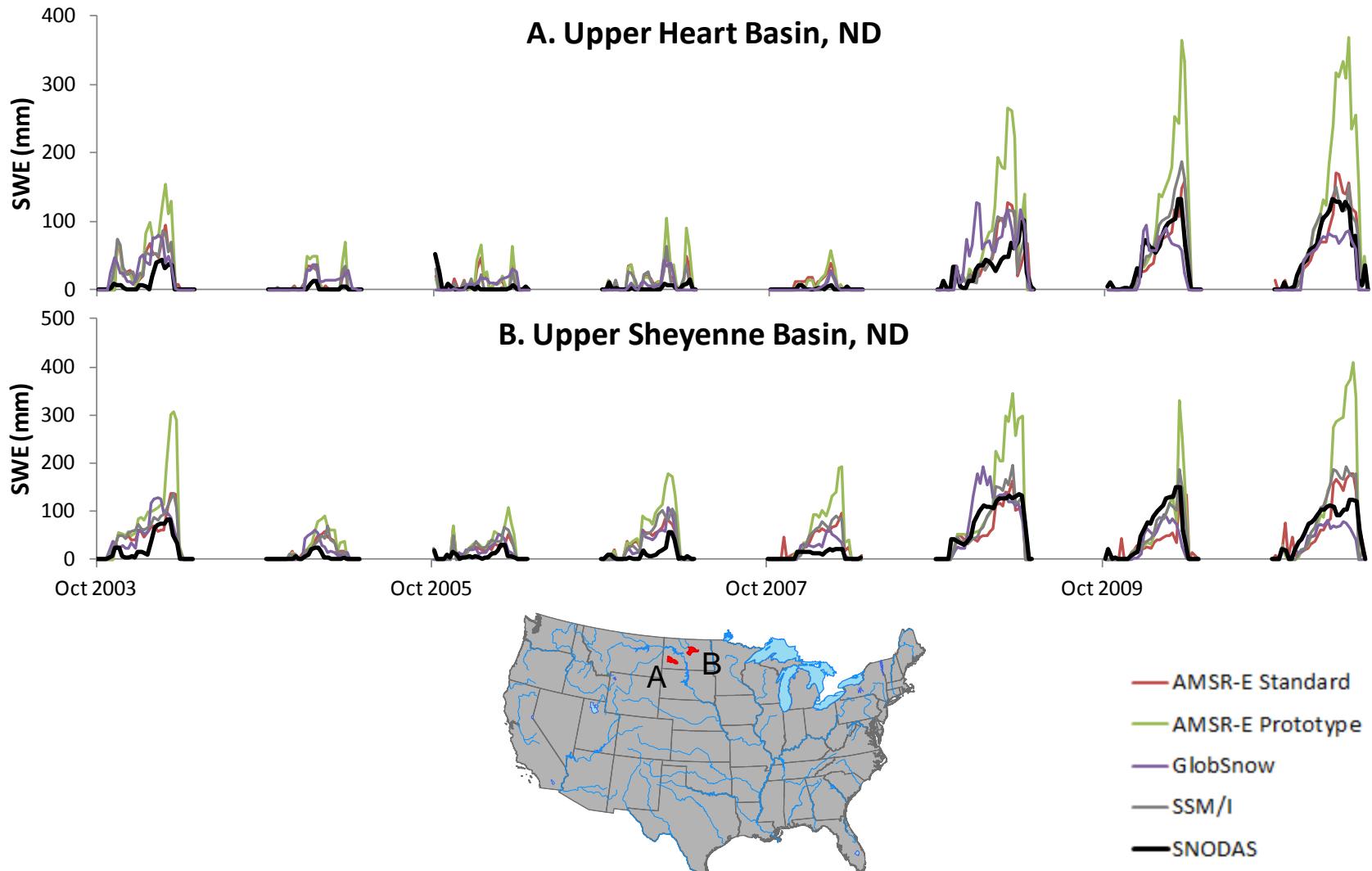
SNODAS – SSMI



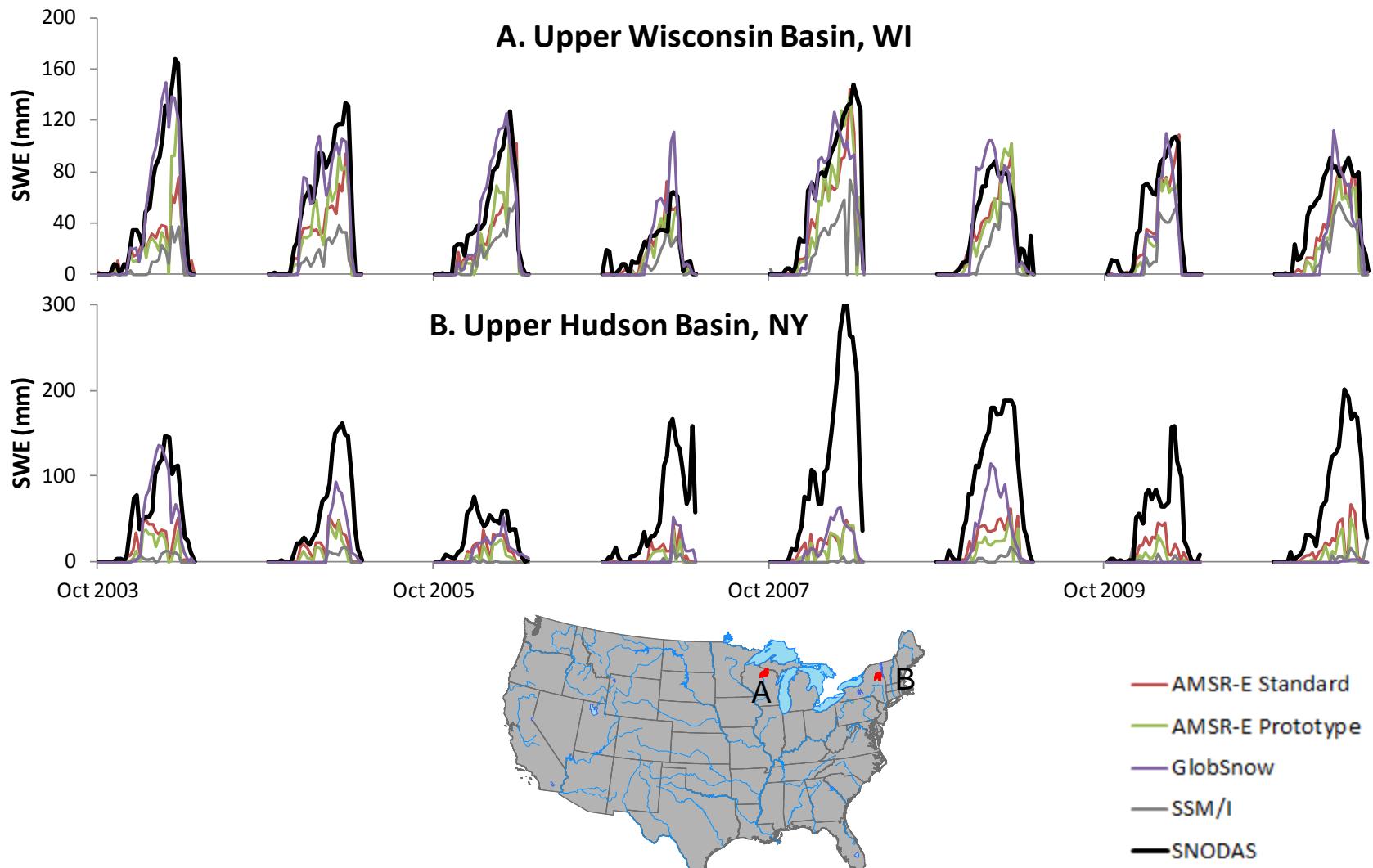
Example weekly SWE time series



Example weekly SWE time series



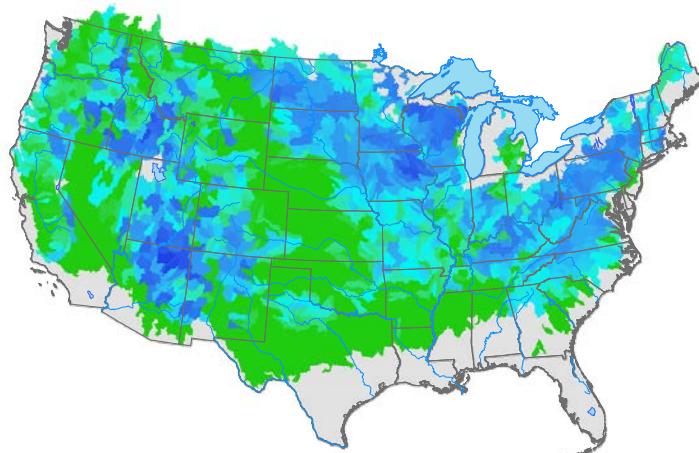
Example weekly SWE time series



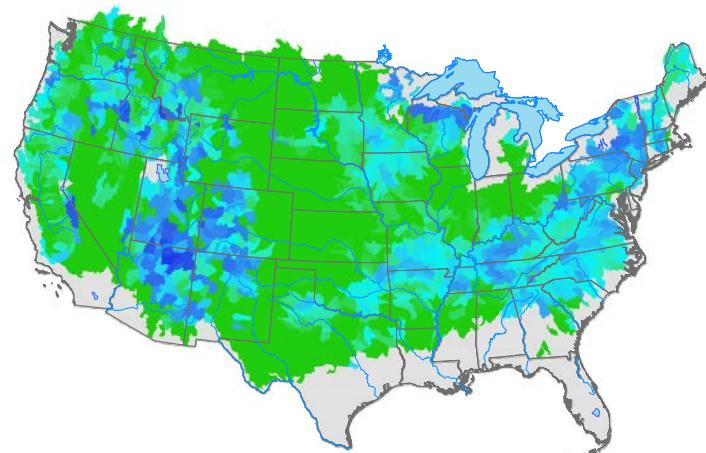
Nash-Sutcliffe Efficiency Measure

Oct – May Weekly SWE, 2004 - 2011

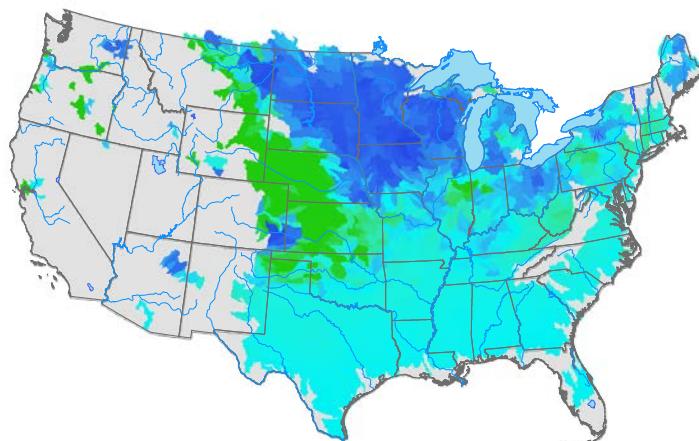
SNODAS – AMSR-E STANDARD



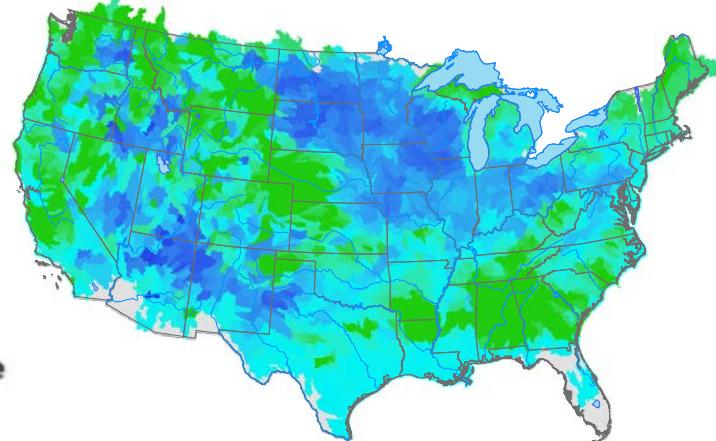
SNODAS – AMSR-E PROTOTYPE



SNODAS – GLOBSNOW



SNODAS – SSMI



Nash-Sutcliffe
High : 1
Low : -1

Conclusions and next steps

Conclusions:

- Agreement
 - ▶ Northern Plains region: GlobSnow, AMSR-E Standard, SSM/I
 - ▶ Mountainous southwest: AMSR-E Standard and Prototype, SSM/I
 - ▶ Great Lakes: GlobSnow
- Disagreement
 - ▶ Northern Plains region: AMSR-E Prototype
 - ▶ Deep snow: Rocky and Sierra Nevada Mtns: AMSR-E Standard and Prototype, SSM/I
 - ▶ East Coast: All underestimate

Next Steps:

- Evaluate unmasked GlobSnow in mountain basins
- Include discharge in analysis of reference basins

Acknowledgements:

- NASA ESPCoR Grant: NNX11AQ34A, *Passive Microwave Detection of Snowmelt and Runoff*
- Army funded applied research program (PI John Eylander)