

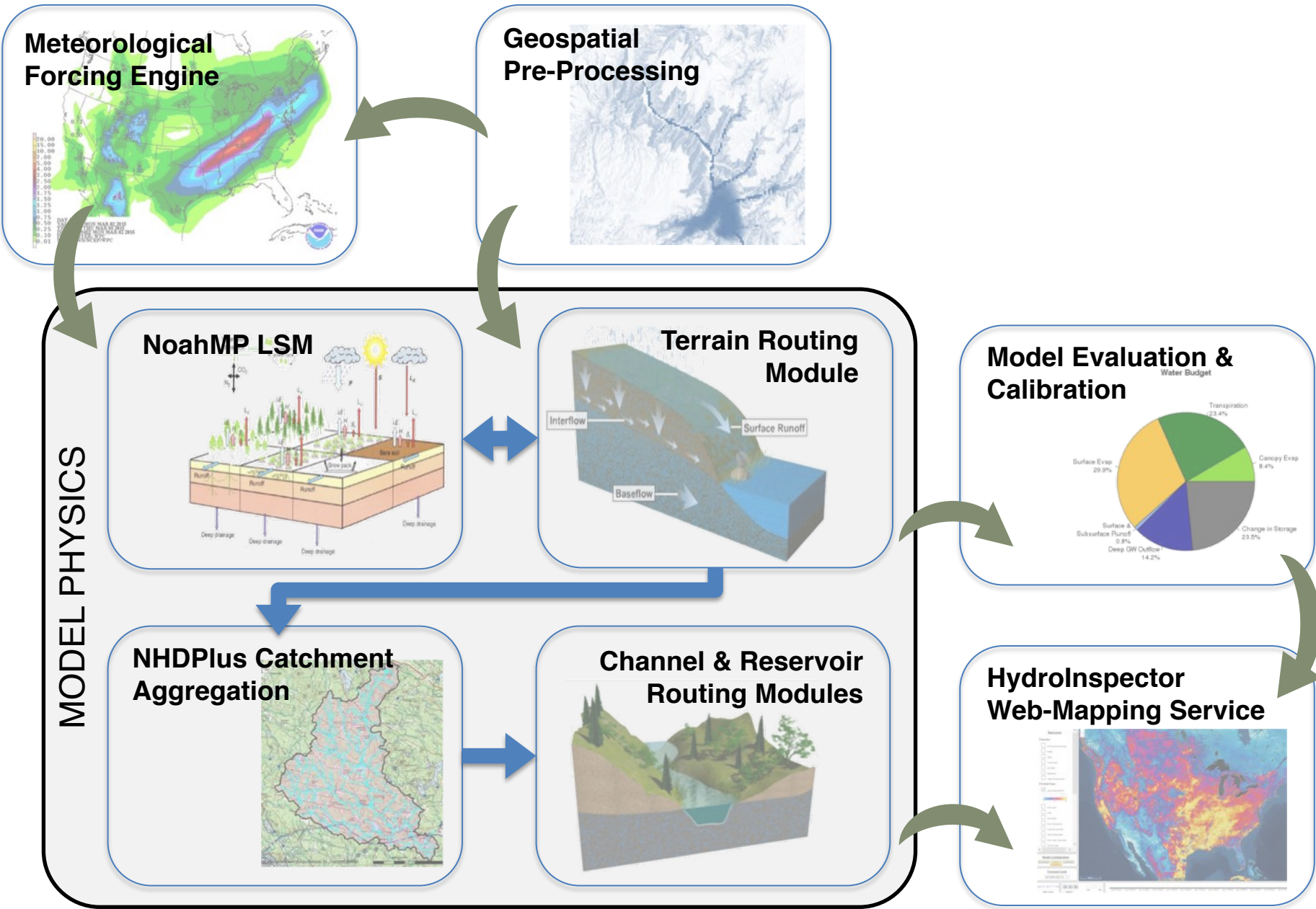
Retrospective and Realtime Snow Analysis of the National Water Model Using In-Situ and Remotely Sensed Observations

Logan Karsten - NCAR

*D. Gochis, A. Dugger, J. McCreight, M. Barlage,
G. Fall, C. Olheser*



National Water Model Description: WRF-Hydro Modeling System



National Water Model (NWM)

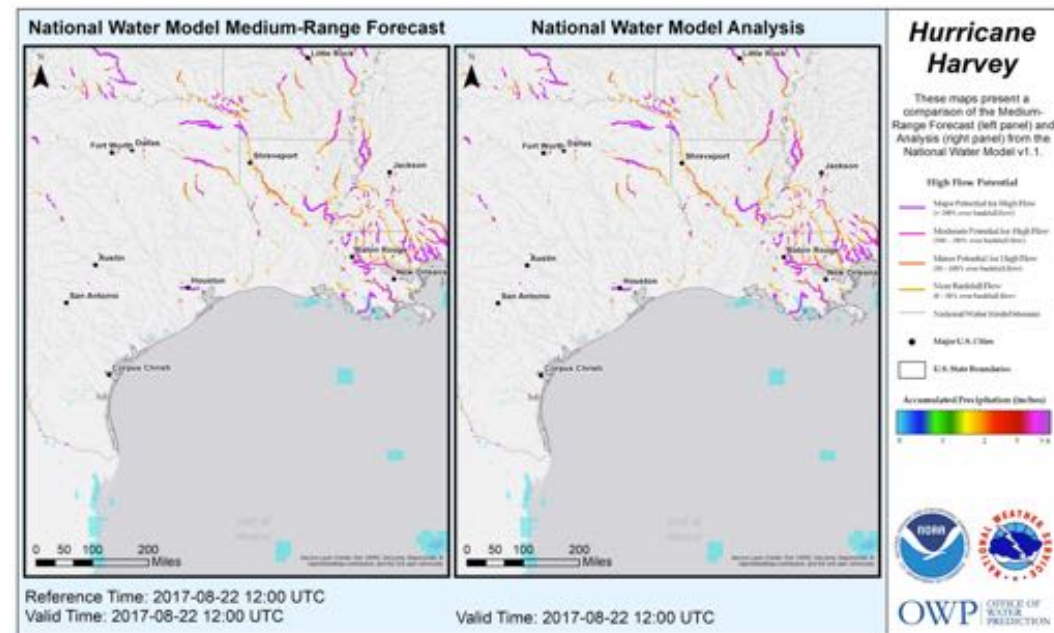
- NWM implemented in August 2016 and upgraded in May 2017 by OWP, NCEP and NCAR
- Hydrologic core is WRF-Hydro, a community-based hydrologic modeling *framework* supported by NCAR
- Chief Goal: Provide foundation for sustained growth in nationally consistent operational hydro forecasting
- Full spectrum hydrologic model, providing guidance for underserved locations
- Hourly analyses and short-range forecasts along with 4 x day medium-range and daily long-range forecasts

• Hydrologic Output

- River channel discharge and velocity at 2.7 million river reaches
- Reservoir inflow, outflow, elevation
- Ponded water depth and depth to soil saturation on 250 m CONUS+ grid

• Land Surface Output

- 1km CONUS+ grid
- Soil and snow pack states
- Energy and water fluxes

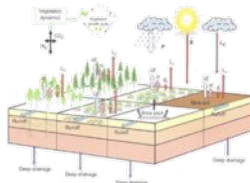


WRF-Hydro Physics Permutations

WRF-Hydro Options

Current NWM Configuration

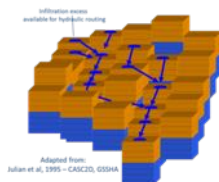
Column Land
Surface Model



3 up-to-date column land models: Noah, NoahMP (w/ built-in multi-physics options), Sac-HTET

NoahMP:
4-layer soils
3-layer snowpack

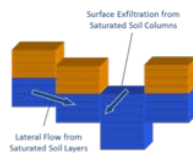
Overland
Flow Module



3 surface routing schemes:
diffusive wave, kinematic wave, direct basin aggregation

Diffusive wave

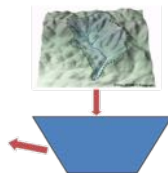
Lateral
Subsurface Flow
Module



2 subsurface routing schemes: Boussinesq shallow saturated flow, 2d aquifer model

Boussinesq shallow saturated flow

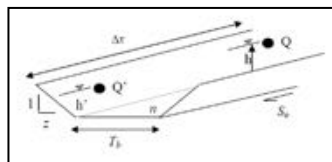
Conceptual
Baseflow
Parameterizations



2 conceptual baseflow schemes:
direct aggregation storage-release with pass-through or exponential model

Exponential model

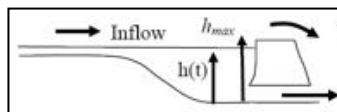
Channel
Routing/
Hydraulics



5 channel flow schemes: diffusive wave, kinematic wave, RAPID, custom-network Muskingum or Muskingum-Cunge

Custom-network (NHDPlus) Muskingum-Cunge model

Lake/Reservoir
Management



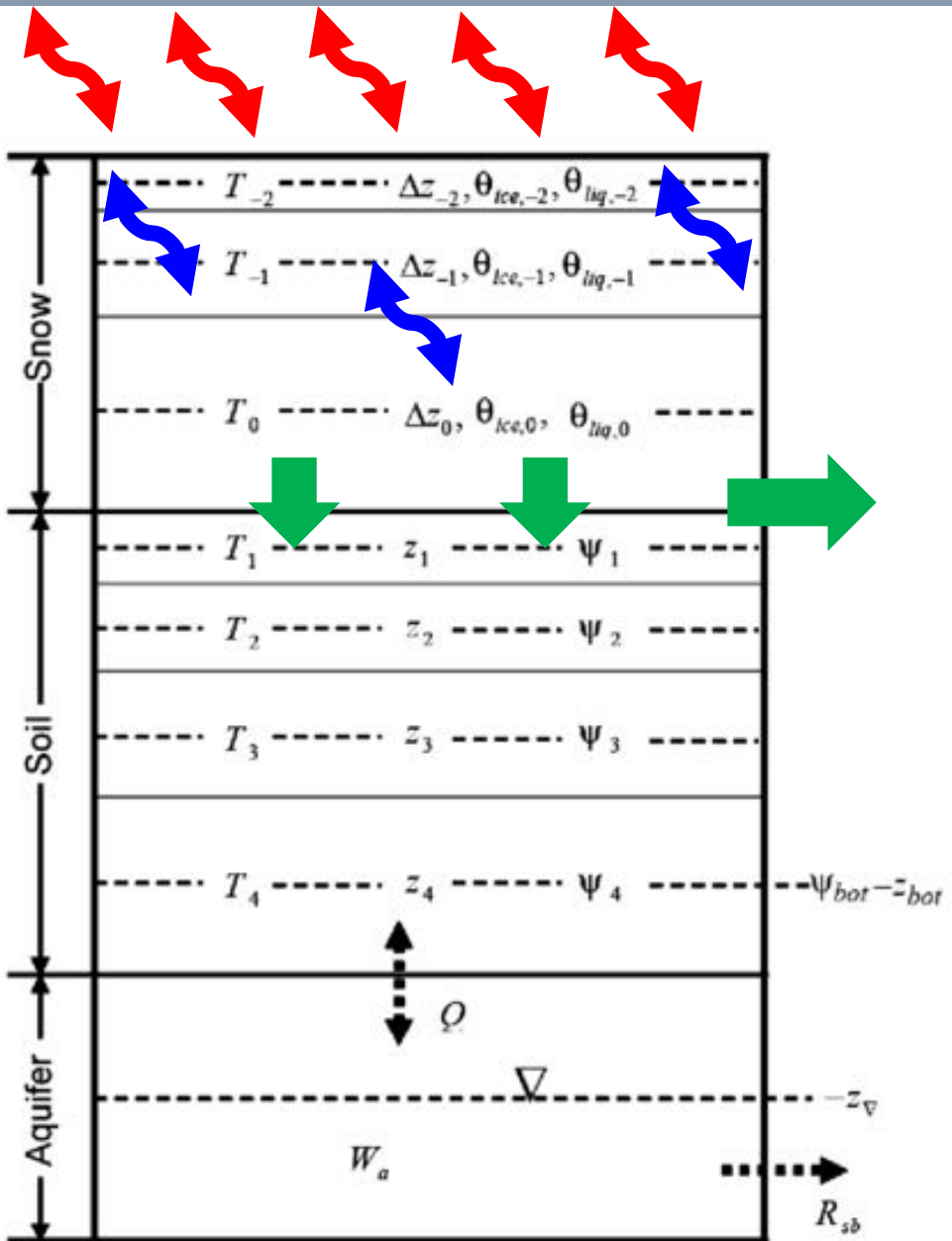
1 lake routing scheme: level-pool management

Level-pool management

NoahMP Snow Physics in the National Water Model

- For snow depth < 45 mm, snow is combined with top soil layer.
- Once snow depth is equal to or above 45 mm, snow layers are created depending on thresholds.
- Snow depth derived from SWE and density.
- Snow cover fraction impacted by MFSNO parameter in NoahMP

$$f_{sno} = \tanh\left(\frac{h_{sno}}{2.5z_{0g}(\rho_{sno}/\rho_{new})^m}\right)$$



NoahMP Snow Physics in the National Water Model

- NWM Versions 1.0-1.2 use the CLASS snow albedo scheme within the NoahMP model.
 - Simple decay of snow albedo based on age from fresh snowfall.
 - Albedo resets after fresh snowfall.
 - 0.84 for fresh snow
 - Exponential decay based on age.

$$\alpha_{s,VIS} = 0.79[\alpha_{s,T} - 0.70] + 0.84$$
$$\alpha_{s,NIR} = 1.21[\alpha_{s,T} - 0.70] + 0.56$$

$$\alpha_{s,VIS} = 0.97[\alpha_{s,T} - 0.50] + 0.62$$
$$\alpha_{s,NIR} = 1.03[\alpha_{s,T} - 0.50] + 0.38$$

Dry Snow

Melting Snow

Verseghy, D. L. (1991), CLASS-A Canadian land surface scheme for GCMS:
I. Soil model, *Int. J. Climatol.*, 11, 111-133, doi:10.1002/joc.3370110202.

- NWM Version 2.0 will use the BATS snow albedo option within the NoahMP model
 - Changes in snow albedo decay
 - Impacts from impurities and dust

$$\alpha_V = \alpha_{VD} + 0.4f(ZEN)[1 - \alpha_{VD}],$$

$$\alpha_{IR} = \alpha_{IRD} + 0.4f(ZEN)[1 - \alpha_{IRD}],$$

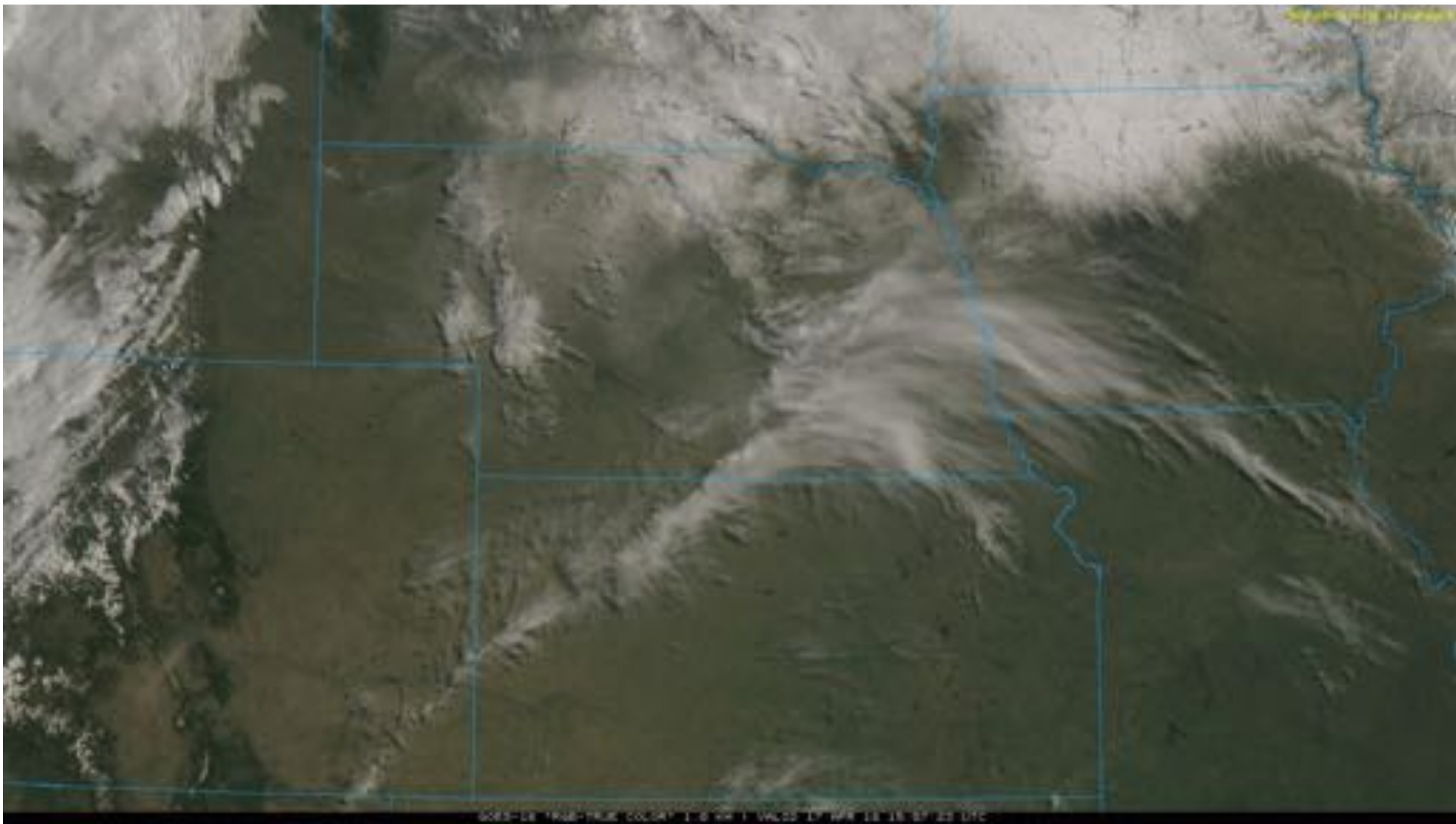
$$\alpha_{VD} = [1 - C_S F_{AGE}] \alpha_{VO},$$

$$\alpha_{IRD} = [1 - C_N F_{AGE}] \alpha_{IRO},$$

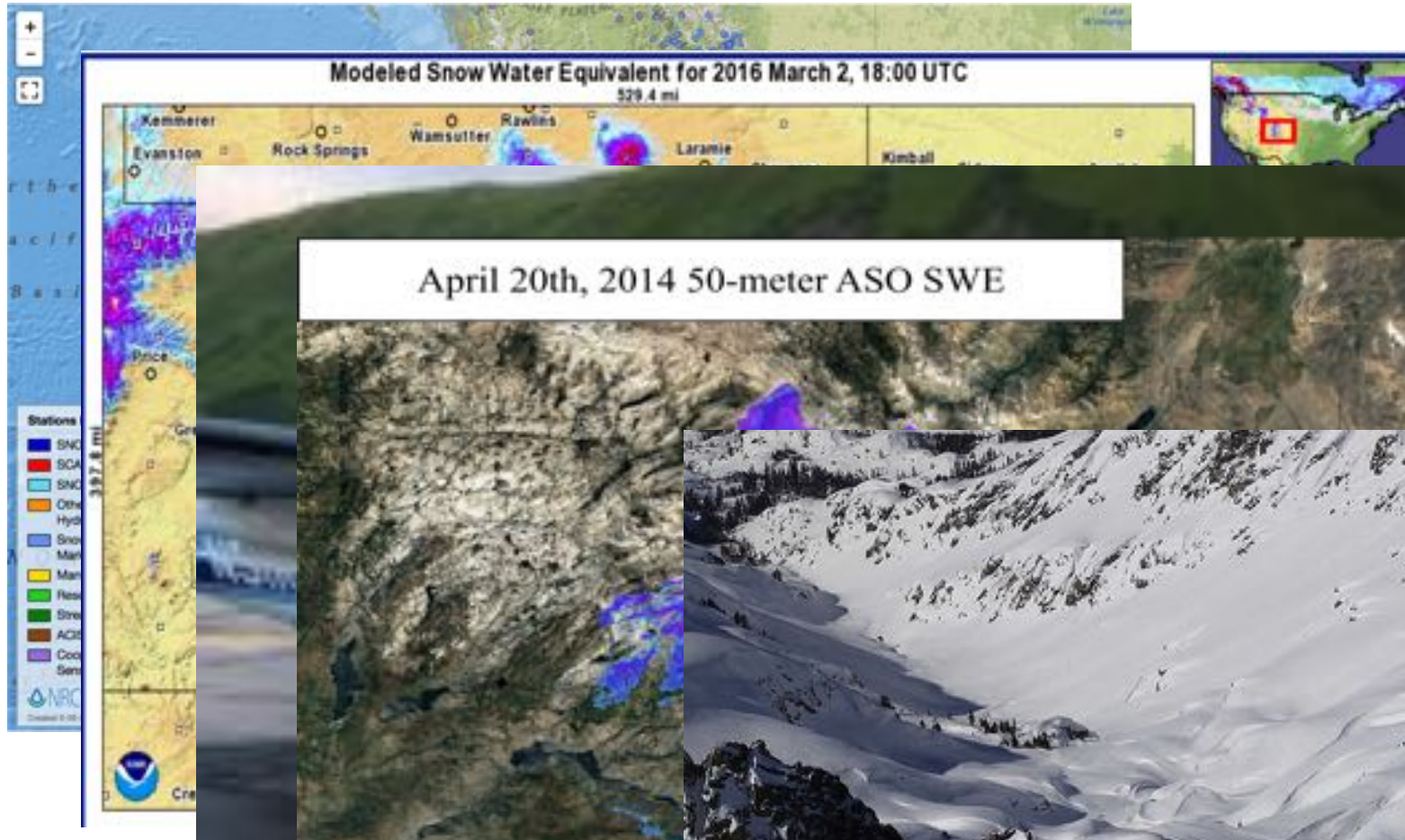
$$C_S = 0.2, C_N = 0.5,$$

Dickinson, R. E., A. Henderson-Sellers, and P. J. Kennedy (1993), Biosphere-Atmosphere Transfer Scheme (BATS) version 1e as coupled to the NCAR Community Climate Model, *NCAR Tech. Note NCAR/TN-387+STR*, 80 pp., Natl. Cent. for Atmos. Res., Boulder, Colo.

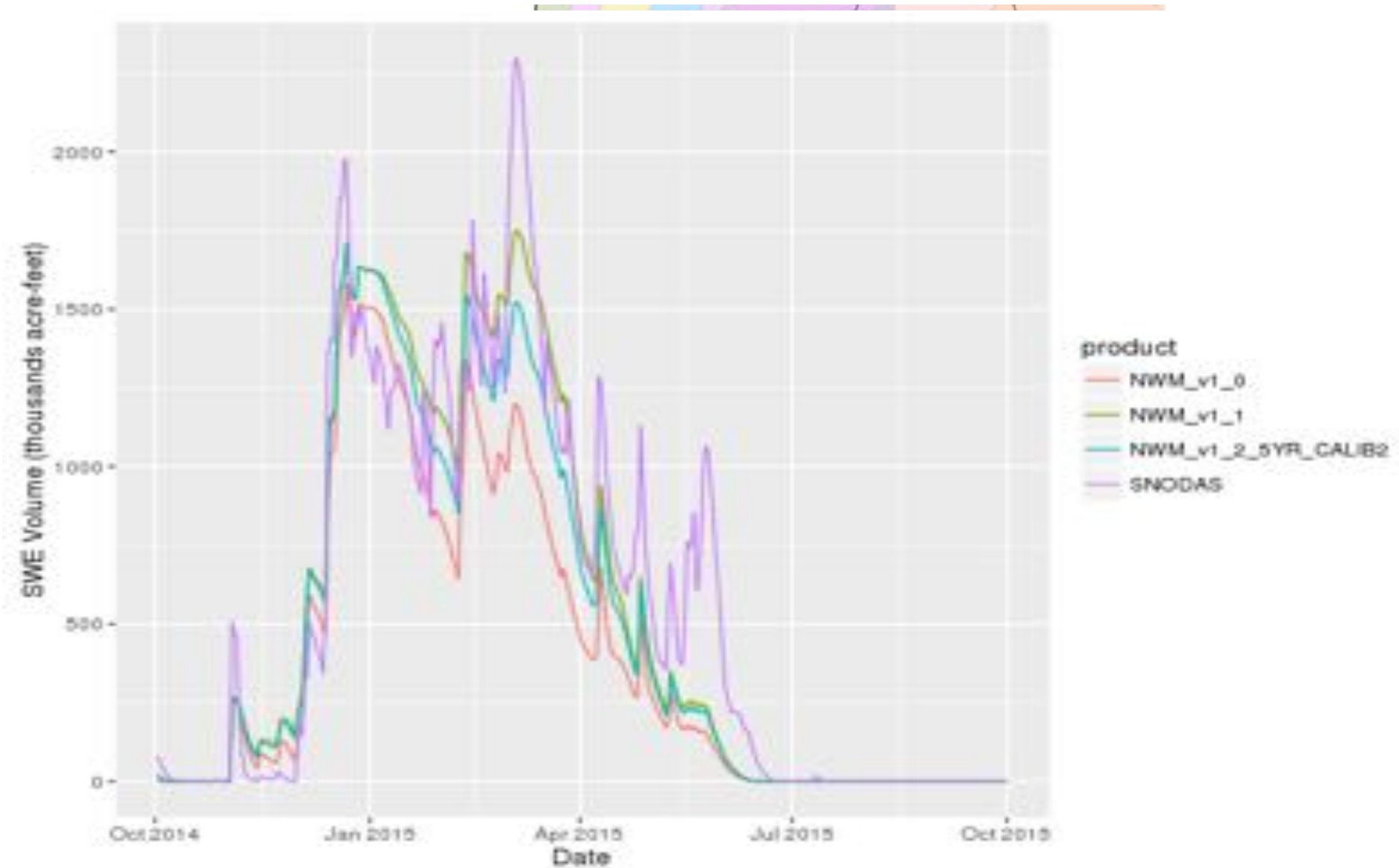
Snow Albedo....



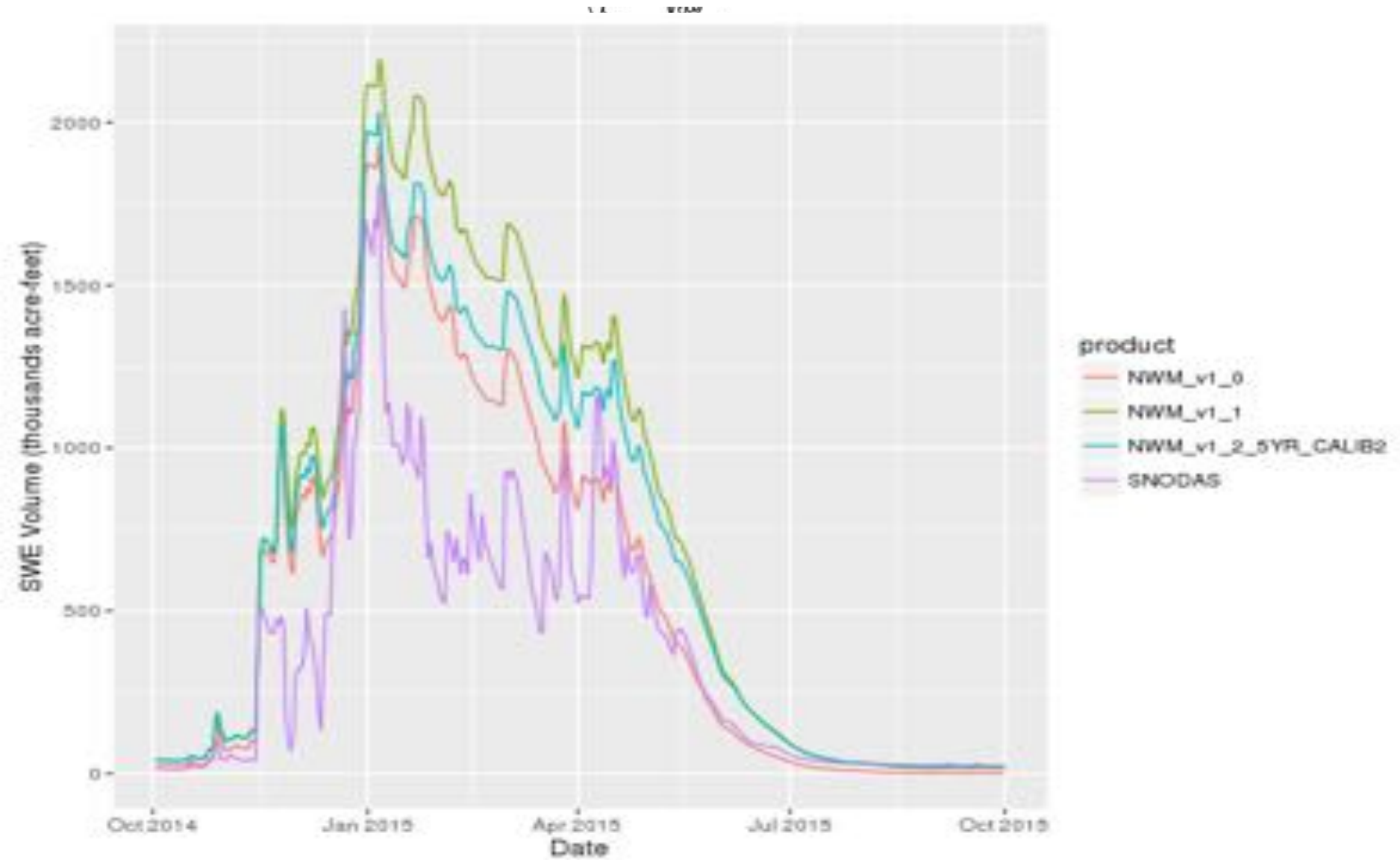
National Water Model Snow Analysis



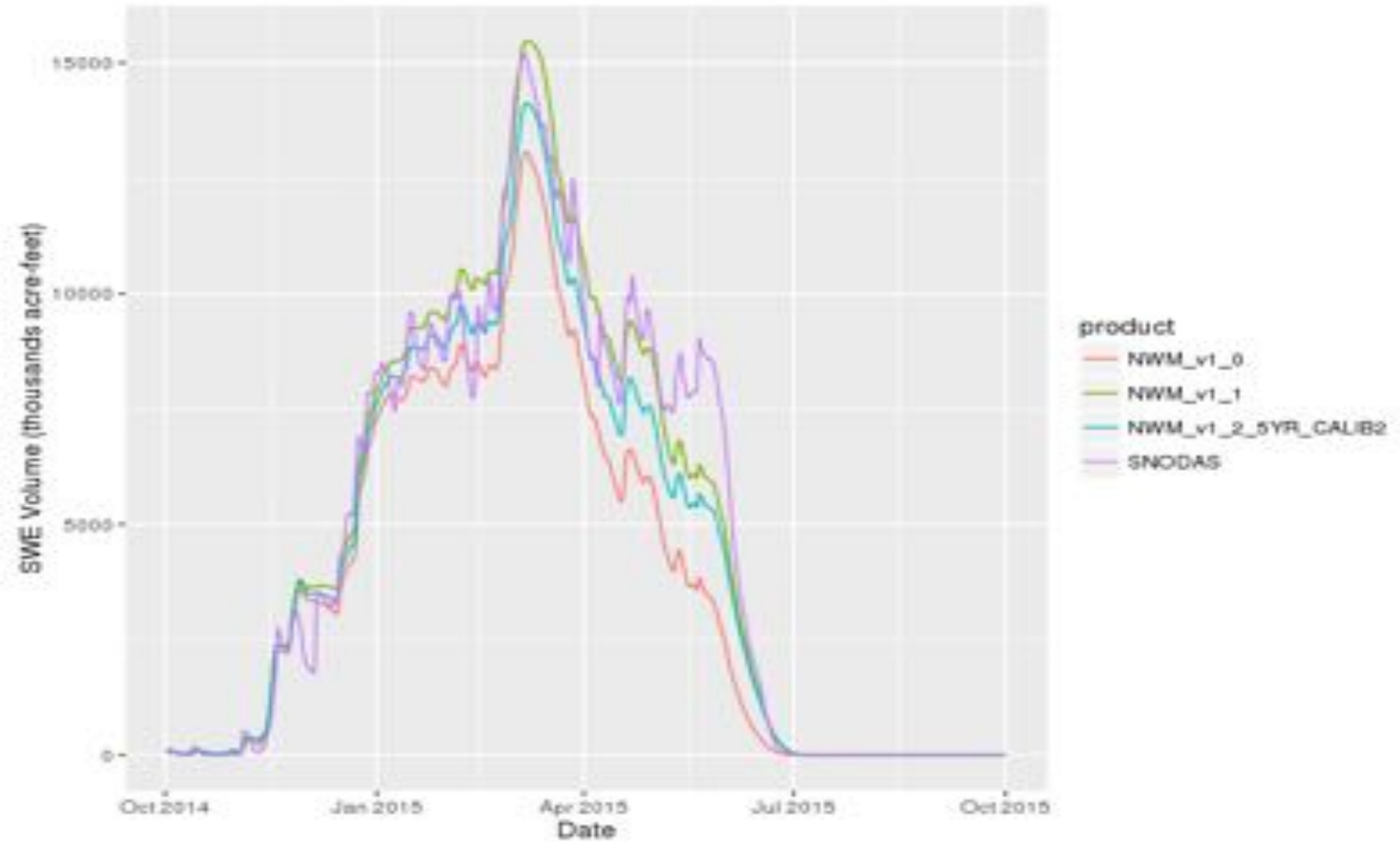
5-Year Retrospective Study



5-Year Retrospective Study

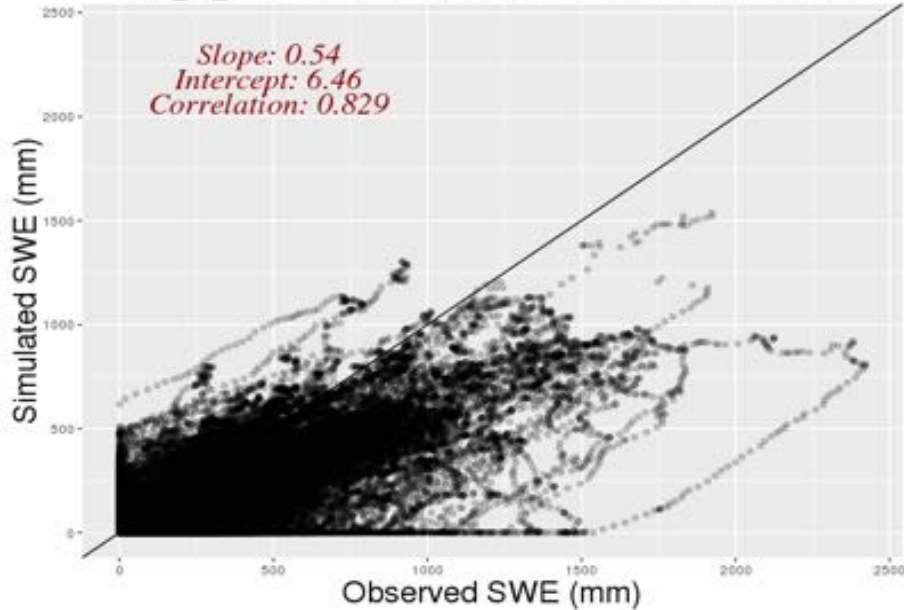


5-Year Retrospective Study

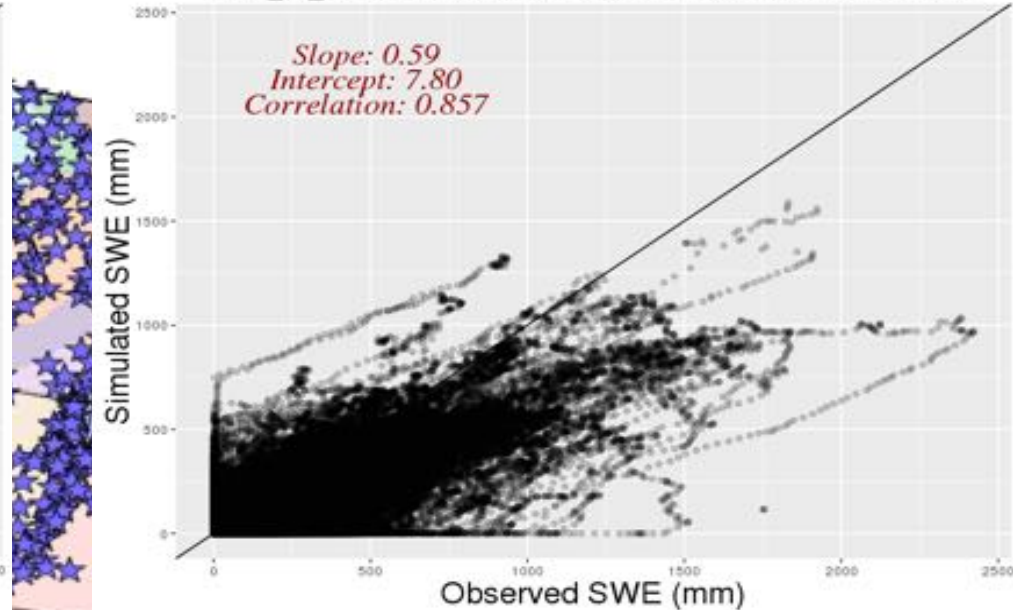


5-Year Retrospective Study

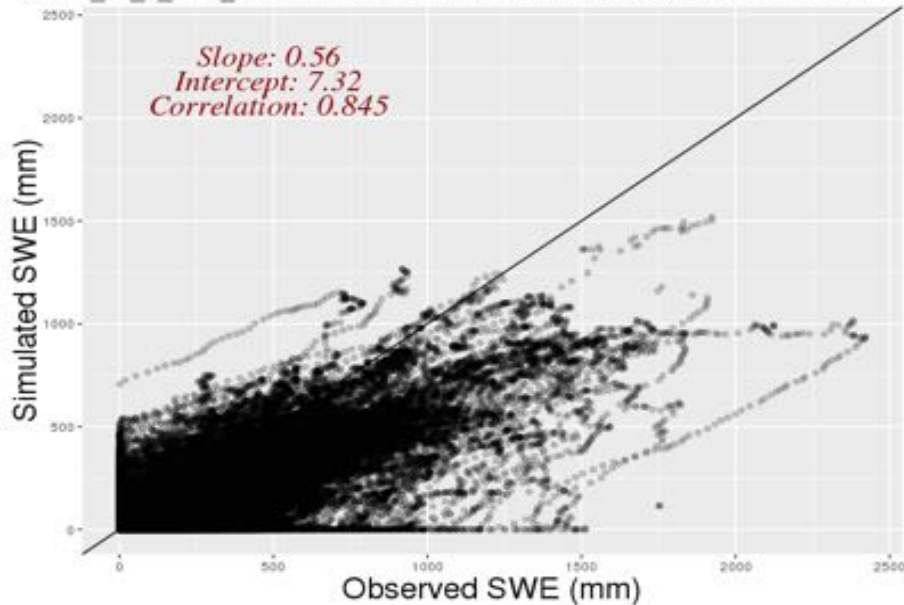
NWM_v1_0 In-Situ SWE Observations for: 2013-10-01 to: 2014-10-01



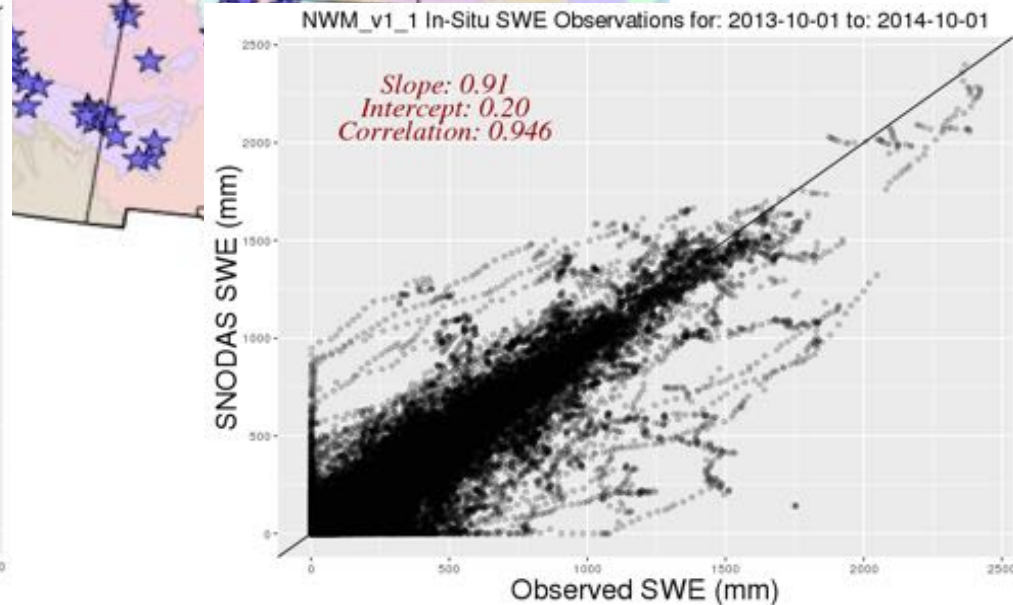
NWM_v1_1 In-Situ SWE Observations for: 2013-10-01 to: 2014-10-01



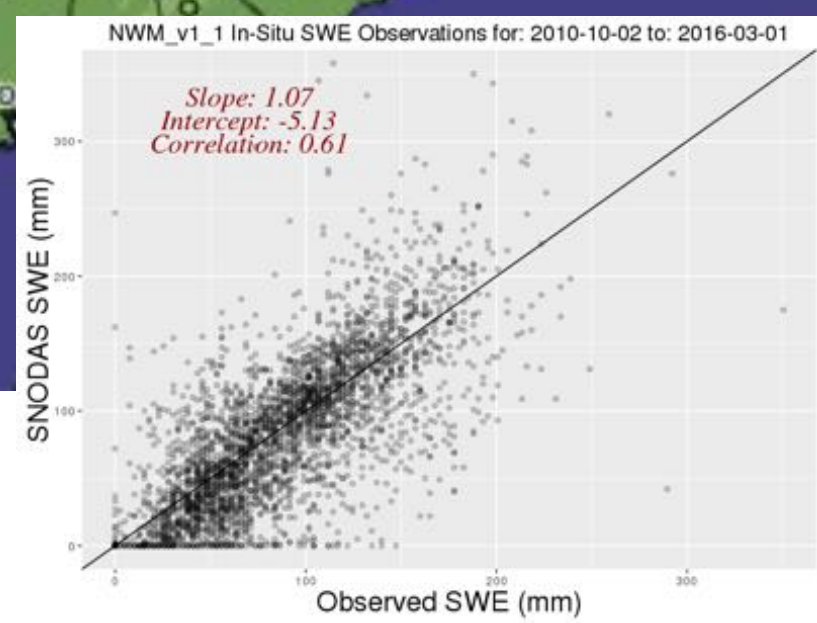
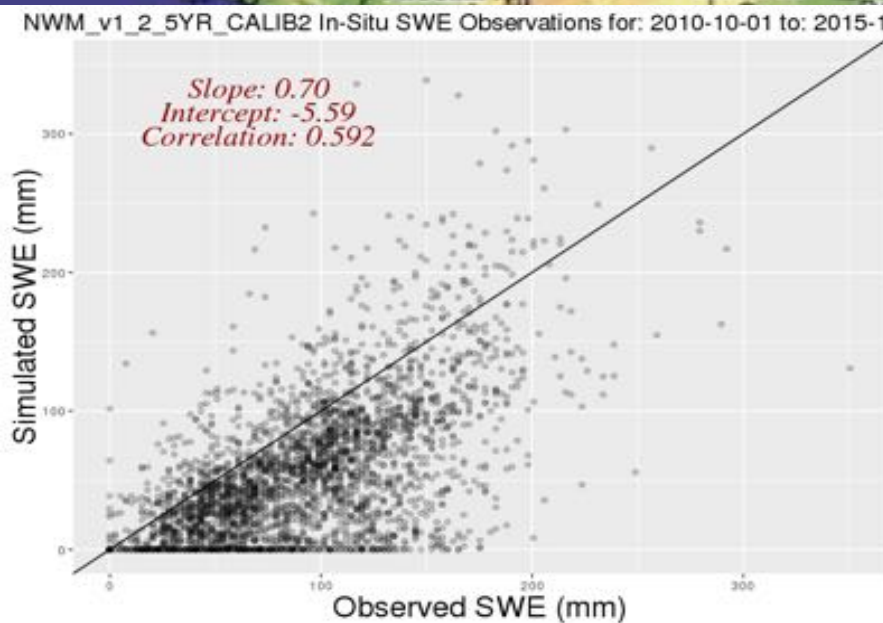
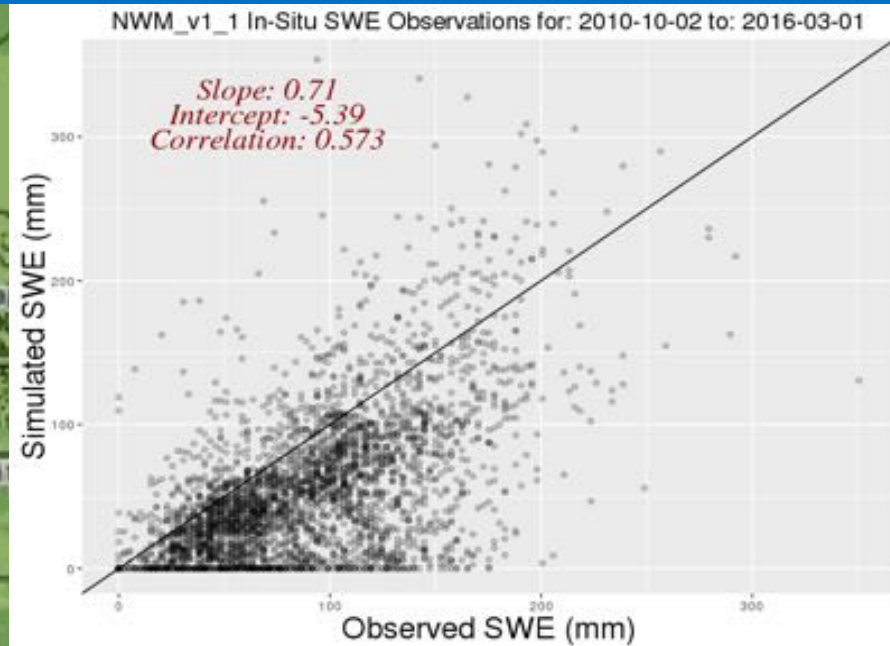
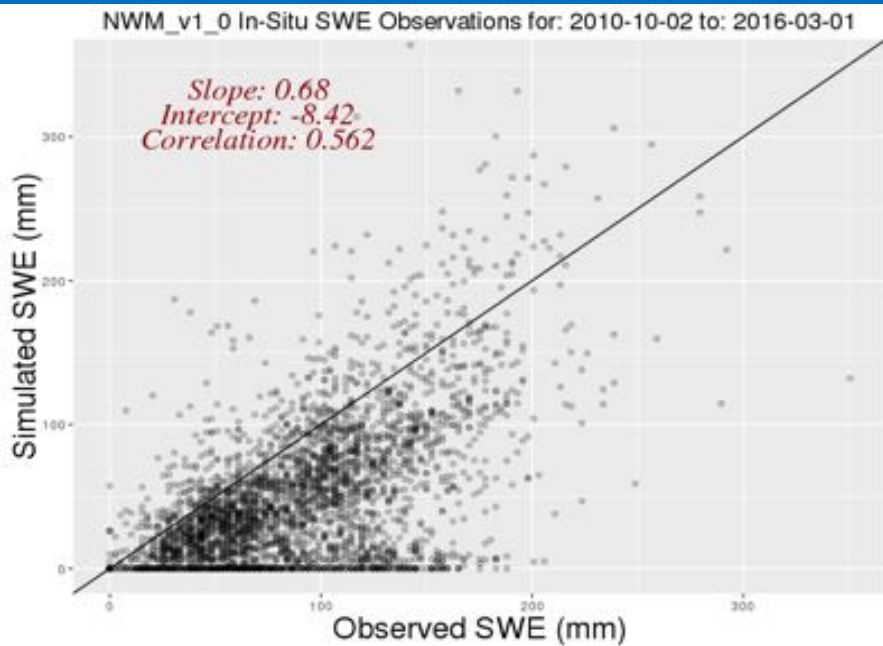
NWM_v1_2_5YR_CALIB2 In-Situ SWE Observations for: 2013-10-01 to: 2014-11-01



NWM_v1_1 In-Situ SWE Observations for: 2013-10-01 to: 2014-10-01

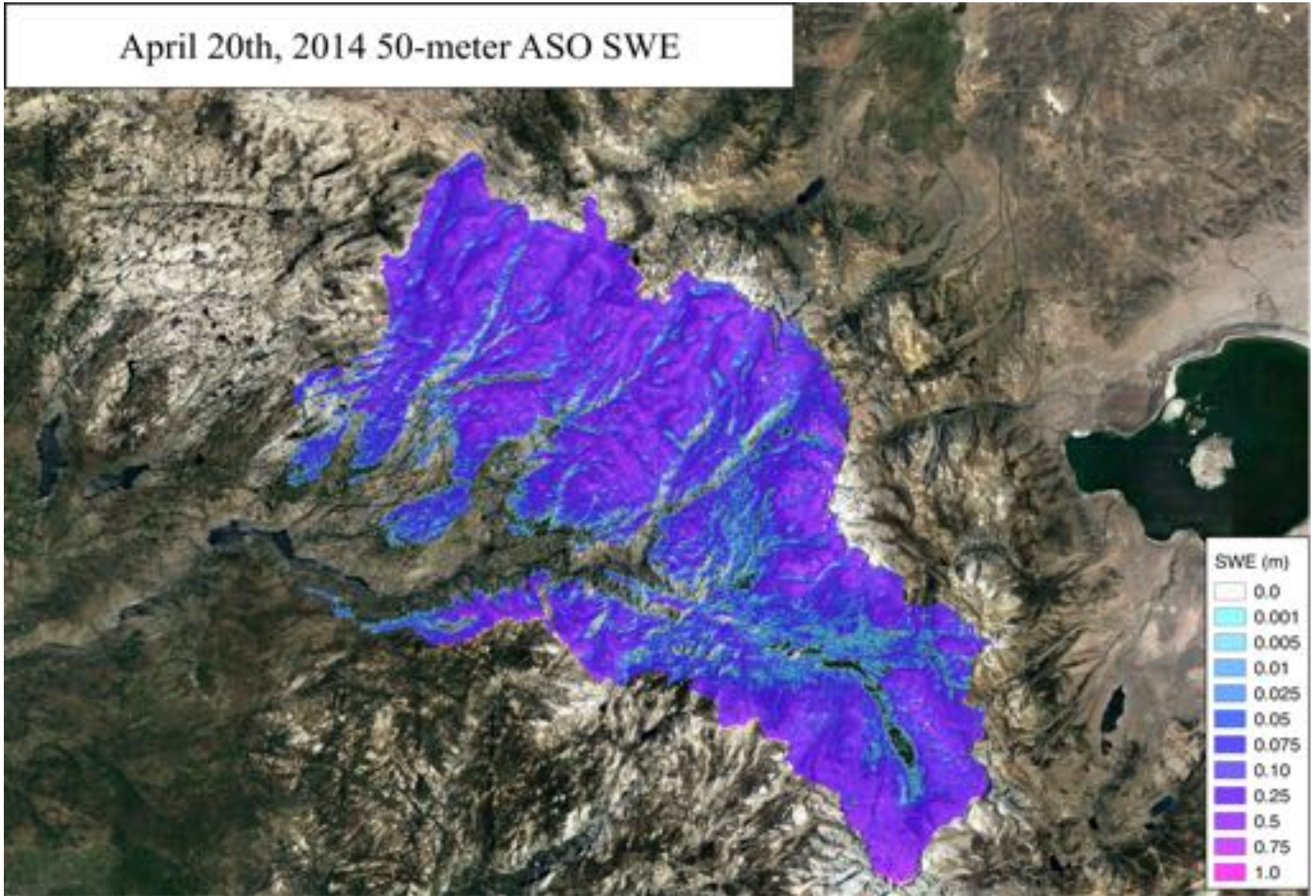


5-Year Retrospective Study



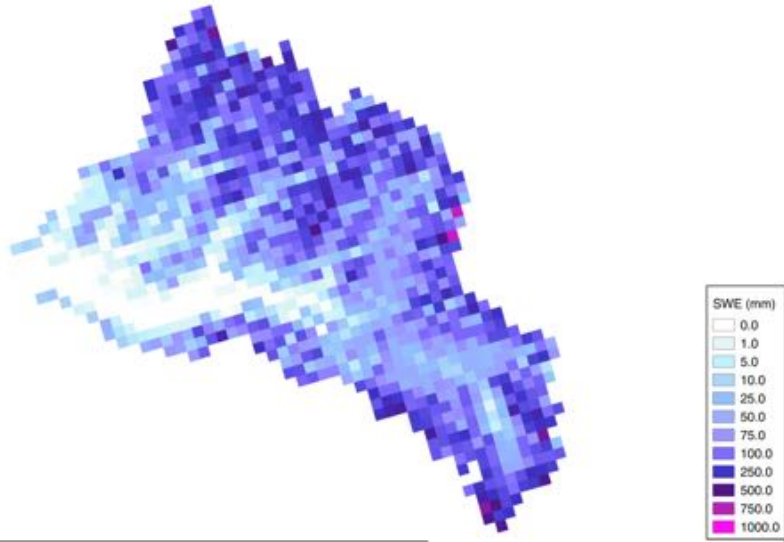
5-Year Retrospective Study

April 20th, 2014 50-meter ASO SWE

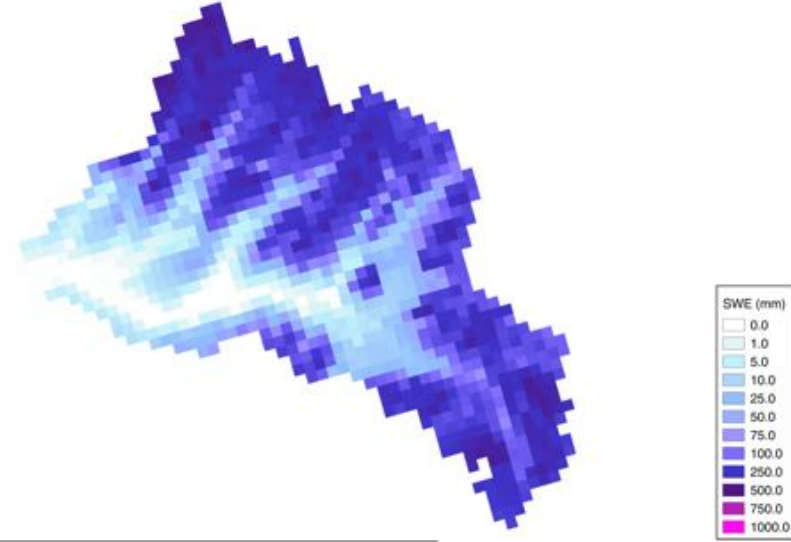


5-Year Retrospective Study

2014-2015 Water Year Mean ASO SWE



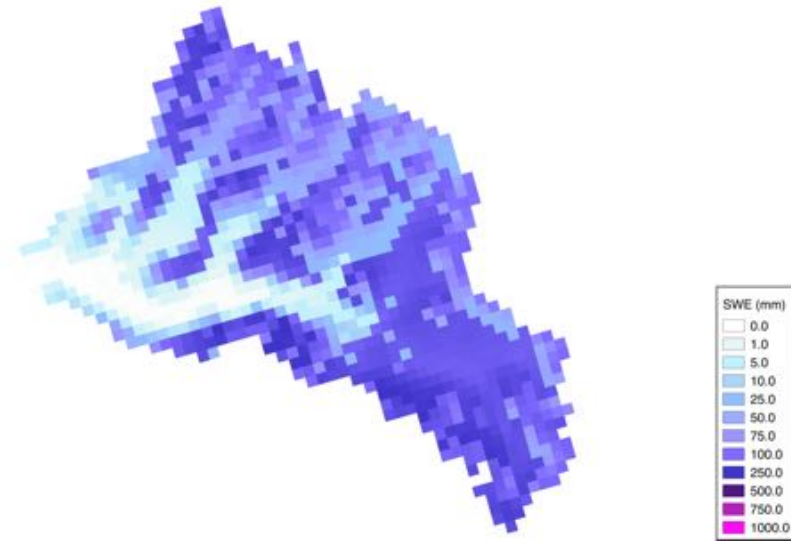
2014-2015 Water Year Mean SNODAS SWE



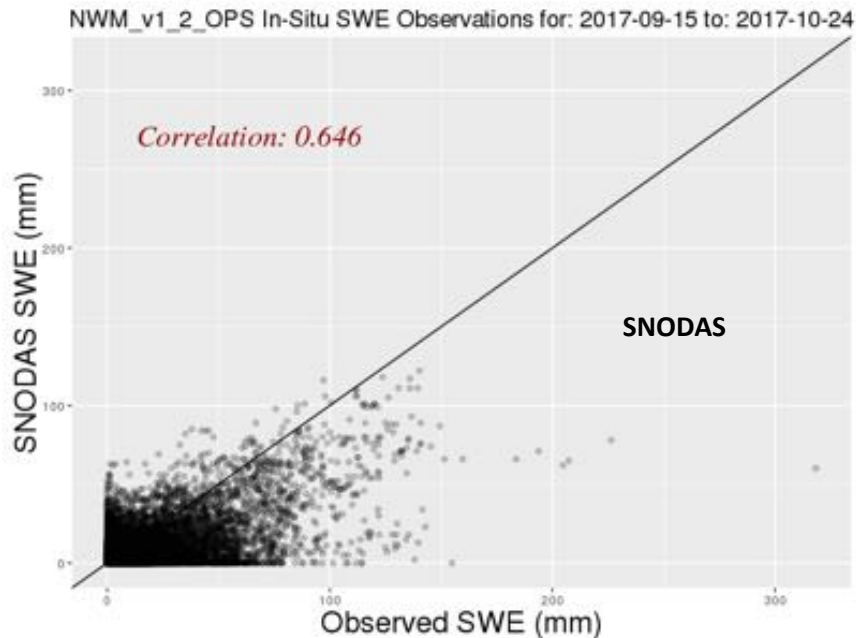
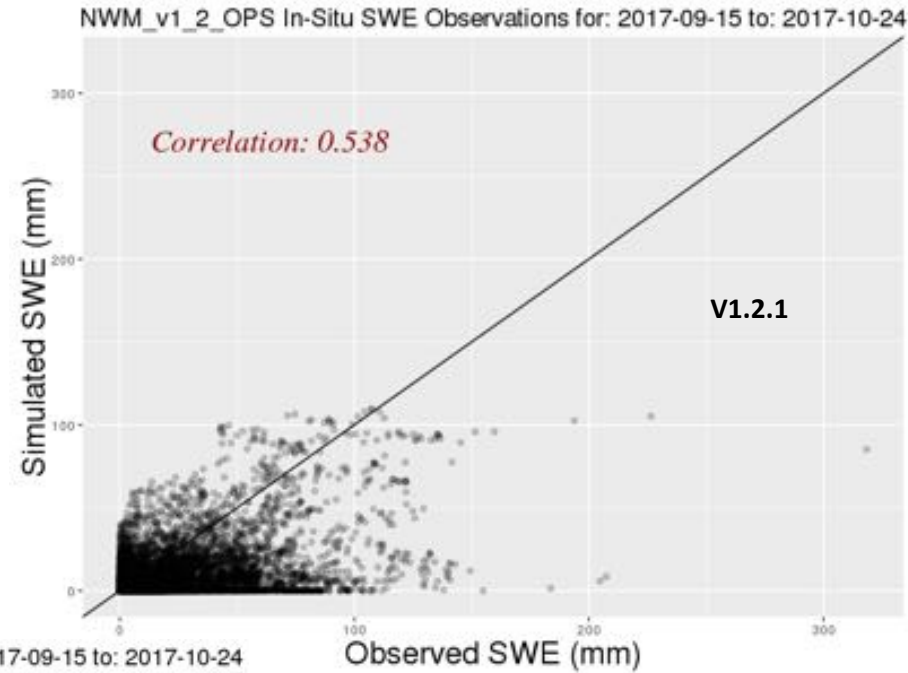
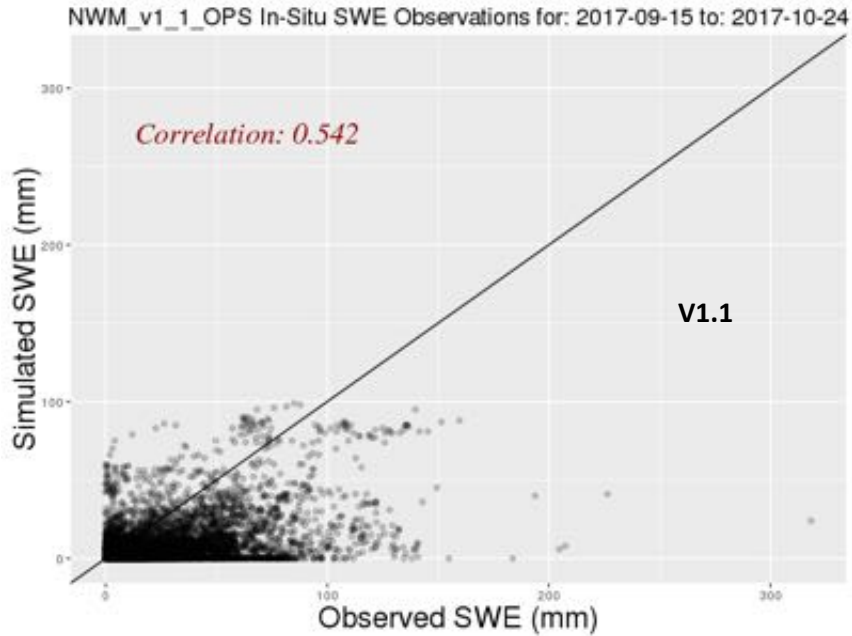
2014-2015 Water Year Mean v1.0 NWM SWE



2014-2015 Water Year Mean v1.1 NWM SWE

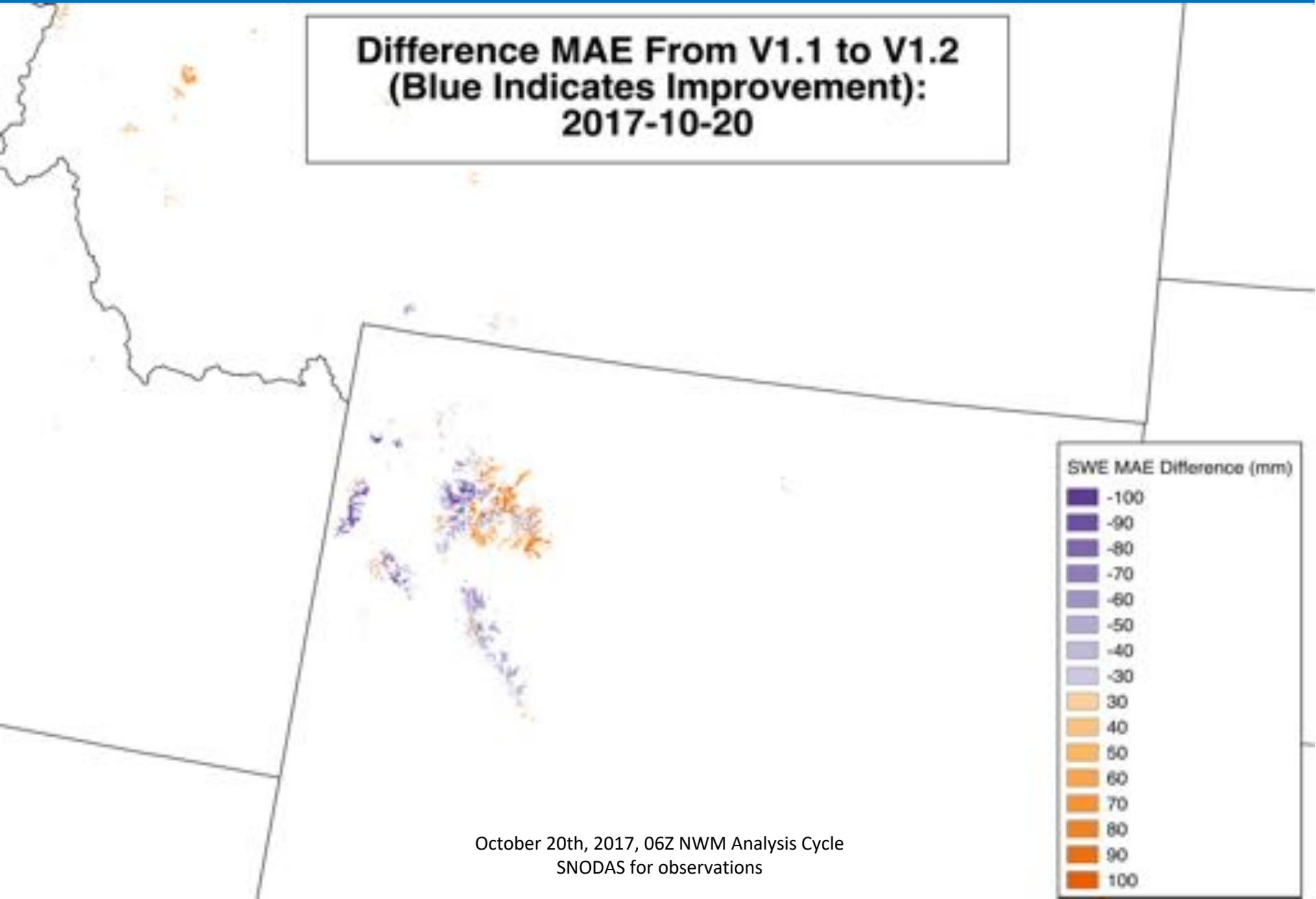


NWM V1.2 National Snowpack Improvement



NWM V1.2 National Snowpack Improvement

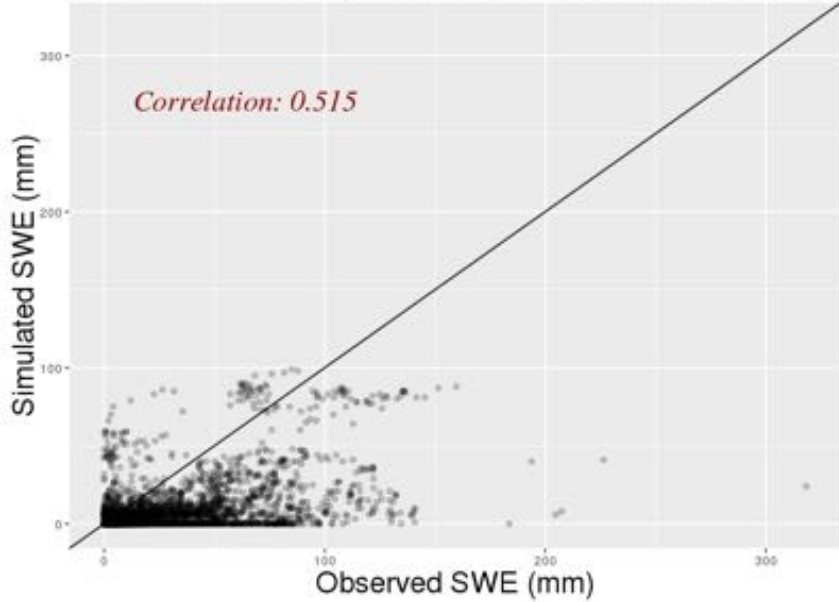
**Difference MAE From V1.1 to V1.2
(Blue Indicates Improvement):
2017-10-20**



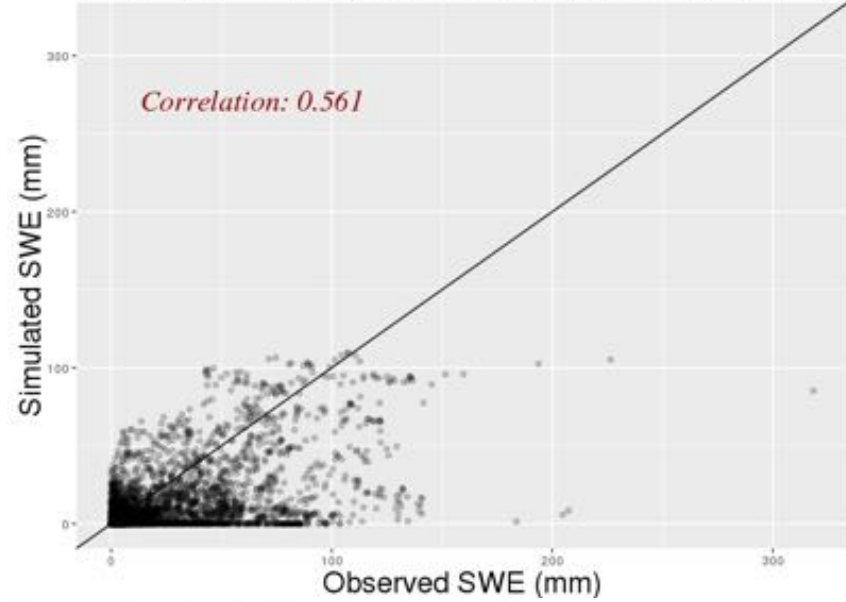
October 20th, 2017, 06Z NWM Analysis Cycle
SNODAS for observations

NWM V1.2 National Snowpack Improvement

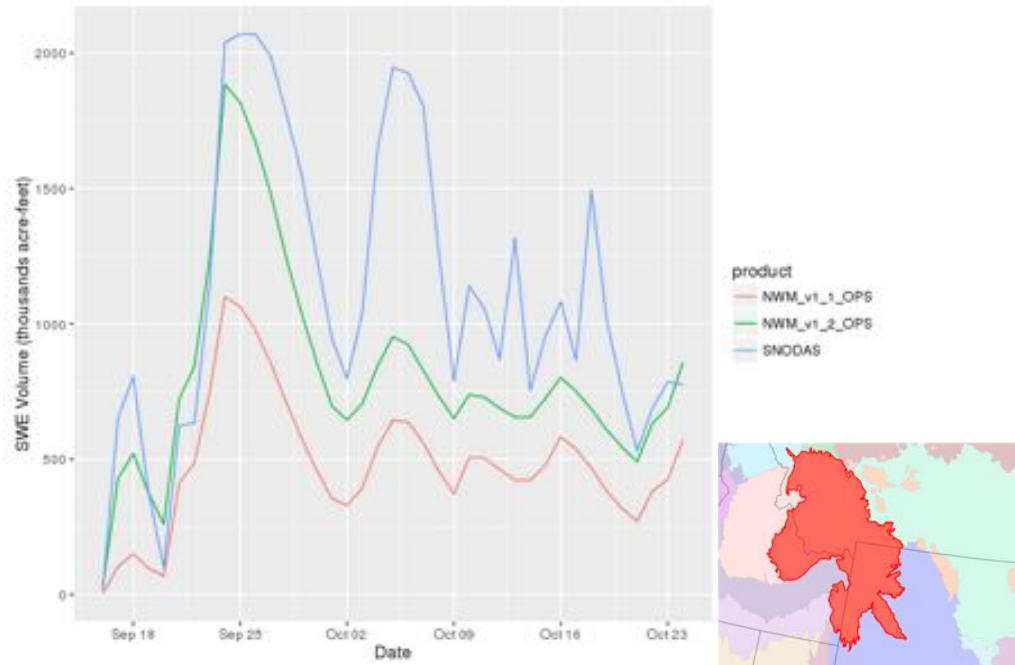
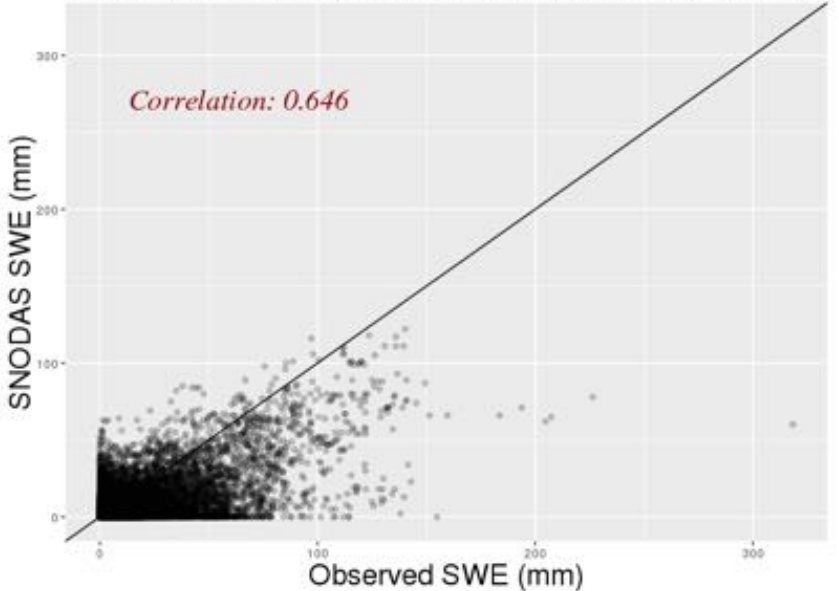
NWM_v1_1_OPS In-Situ SWE Observations for: 2017-09-15 to: 2017-10-24



NWM_v1_2_OPS In-Situ SWE Observations for: 2017-09-15 to: 2017-10-24

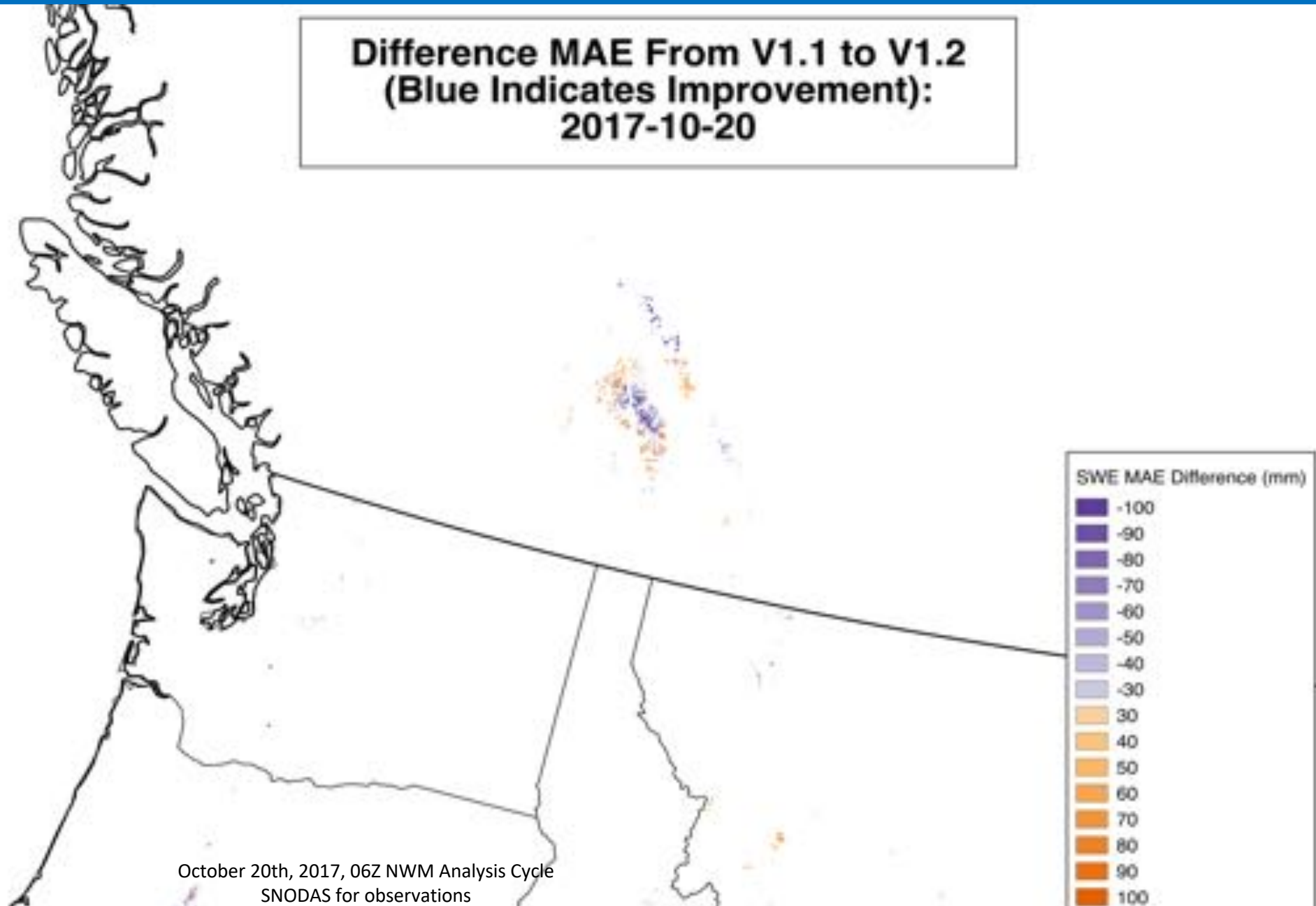


NWM_v1_2_OPS In-Situ SWE Observations for: 2017-09-15 to: 2017-10-24



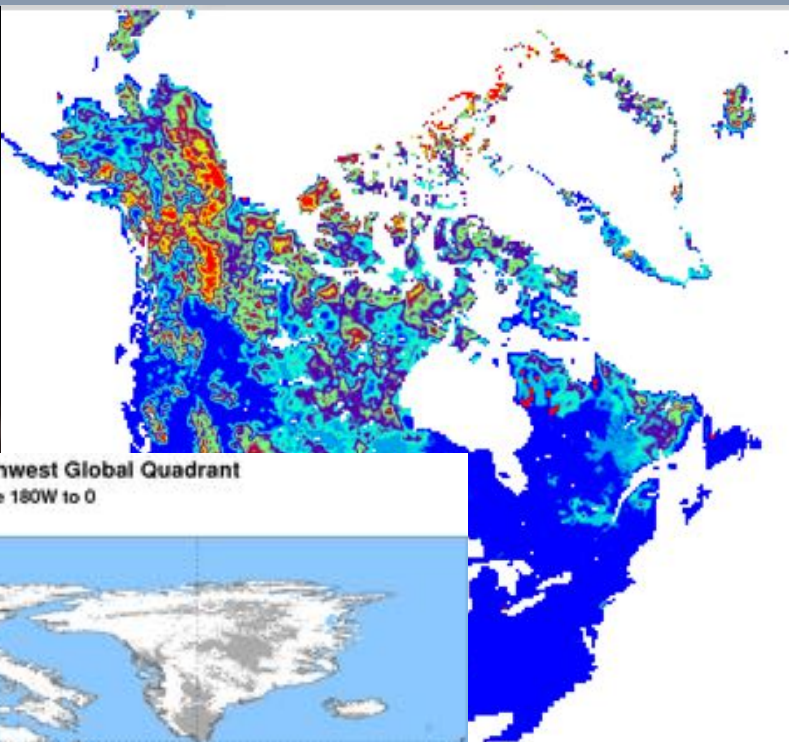
NWM V1.2 National Snowpack Improvement

**Difference MAE From V1.1 to V1.2
(Blue Indicates Improvement):
2017-10-20**

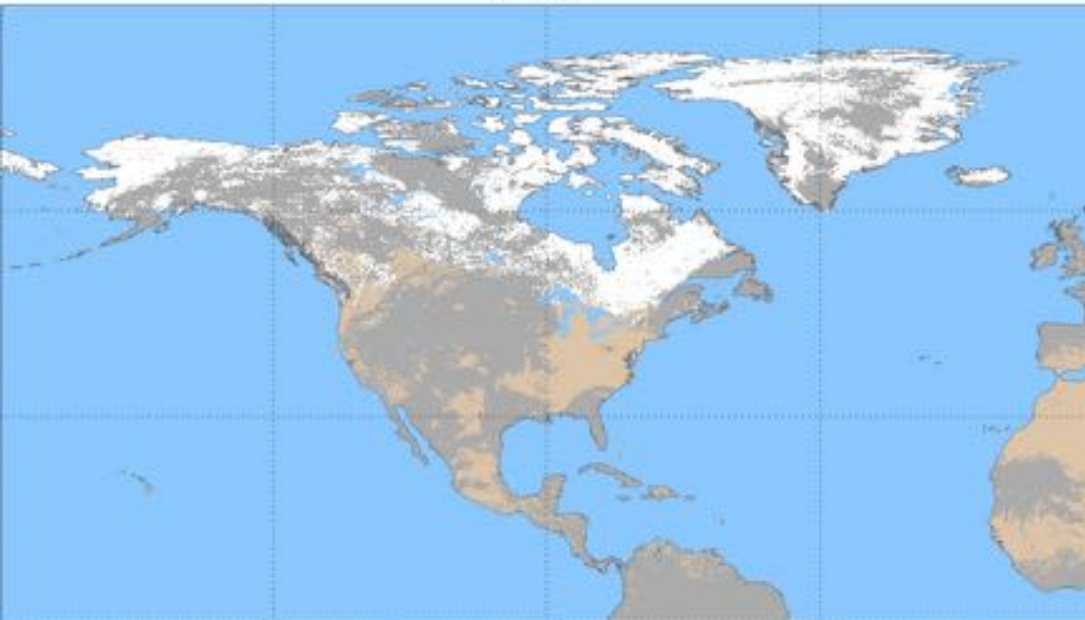


October 20th, 2017, 06Z NWM Analysis Cycle
SNODAS for observations

Expansion of Remotely Sensed Snow Observations



Suomi NPP VIIRS Snow Cover - Northwest Global Quadrant
Latitude 0 to 90N - Longitude 180W to 0
29 Mar 2016



Undetermined or No Data Clear Land Cloudy Water Snow

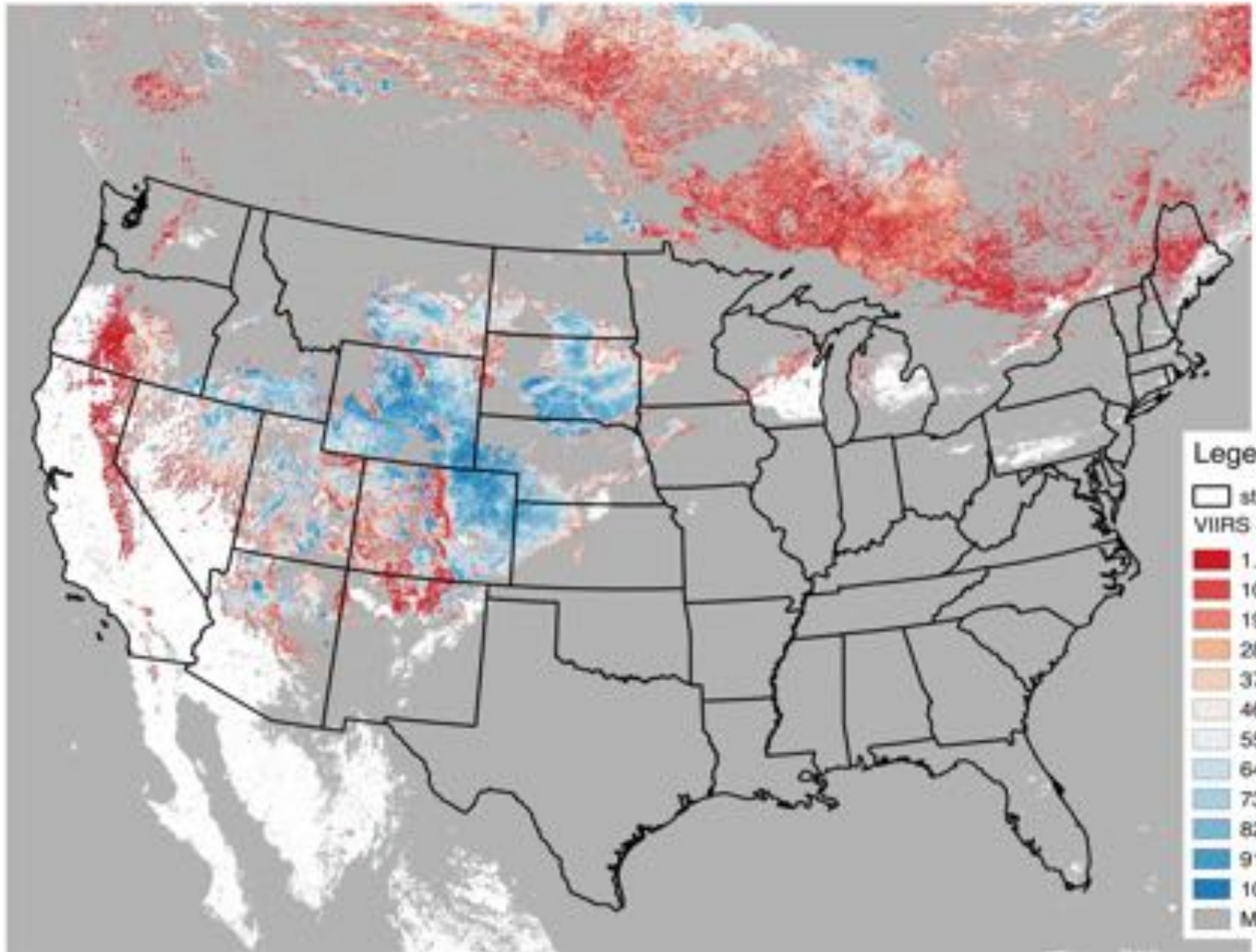


Expansion of Remotely Sensed Snow Observations



VIIRS Fractional Snow Cover

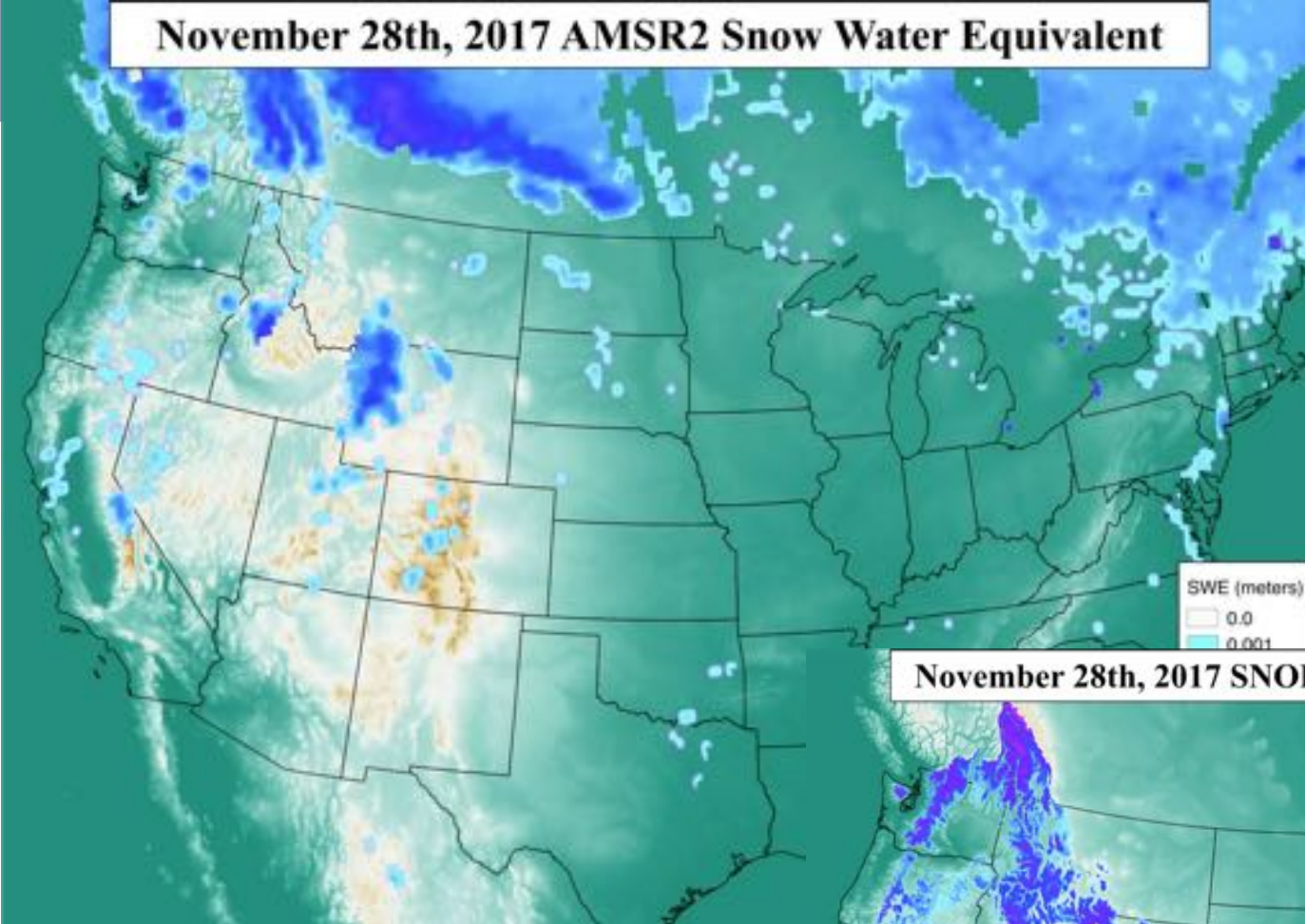
2015-01-02 Analysis



Legend

	states
VIIRS Snow Cover	
	1.000000
	10.000000
	19.000000
	28.000000
	37.000000
	46.000000
	55.000000
	64.000000
	73.000000
	82.000000
	91.000000
	100.000000
	Missing

November 28th, 2017 AMSR2 Snow Water Equivalent



November 28th, 2017 SNODAS Snow Water Equivalent



Next Steps

- Release of public WRF-Hydro calibration workflow
 - See public announcements for code and documentation
- Incorporation of snow observations and error metrics into calibration workflow
 - Calibration of snow-related parameters
- Exposure of additional snow-related parameters
 - Snow albedo
 - Rain/Snow partitioning
- Open to collaboration!

NCAR UCAR RAL Research Applications Laboratory science • serving • society

RAL HOME WHO WE ARE WHAT WE DO SOLUTIONS WORK WITH US

WRF-Hydro Modeling System

WRF-Hydro

OVERVIEW

WELCOME

The Weather Research and Forecasting Model Hydrological modeling system (WRF-Hydro) is a community-based model coupling framework designed to link multi-scale process models of the atmosphere and terrestrial hydrology.

The underlying goal of WRF-Hydro development is to improve prediction skill of hydrometeorological forecasts using science-based numerical prediction tools.

The WRF-Hydro modeling system was originally designed as a model coupling framework designed to facilitate easier coupling between the Weather Research and Forecasting model and components of terrestrial hydrological models. WRF-Hydro is both a stand-alone hydrological modeling architecture as well as a coupling architecture for coupling of hydrological models with atmospheric models. WRF-Hydro is fully-parallelized to enable its usage on clusters and high performance computing systems alike.

Like the WRF model it does not attempt to prescribe a particular or singular suite of physics but, instead, is designed to be extensible to new hydrological parameterizations. Although it was originally designed to be used within the WRF model, it has evolved over time to possess many

WRF-HYDRO MODELING SYSTEM OVERVIEW

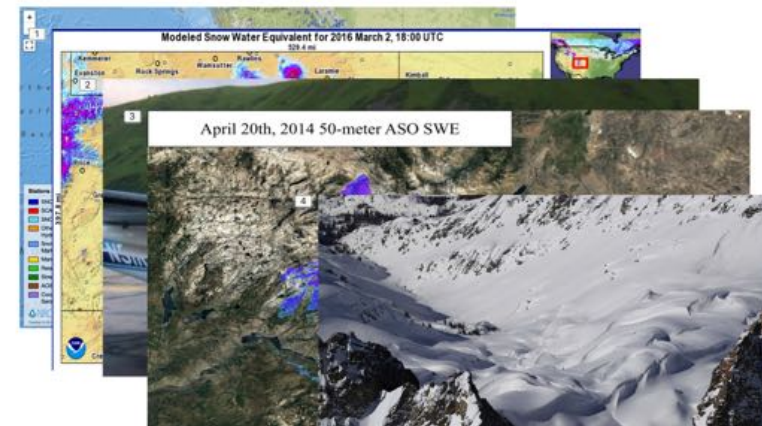
- > Model Code
- > Technical Description & User Guide
- > Input & Output Variables
- > Terms of Use
- > Pre-Processing Tools
- > Regrid Scripts
- > Meteorological & Terrain Data
- > Test Cases
- > Rerhydro
- > HydroInspector
- > Resources
 - > Talks & Webinars
 - > Training & Materials
 - > Publications
 - > Events

WRF-HYDRO SUPPORT

- > CONTACT wfhdro@ucar.edu for support
- > Subscribe for updates and announcements
- > Events

PRINCIPAL INVESTIGATOR

Dave Gochis
Scientist III



Questions?

karsten@ucar.edu

gochis@ucar.edu