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

Logan Karsten - NCAR

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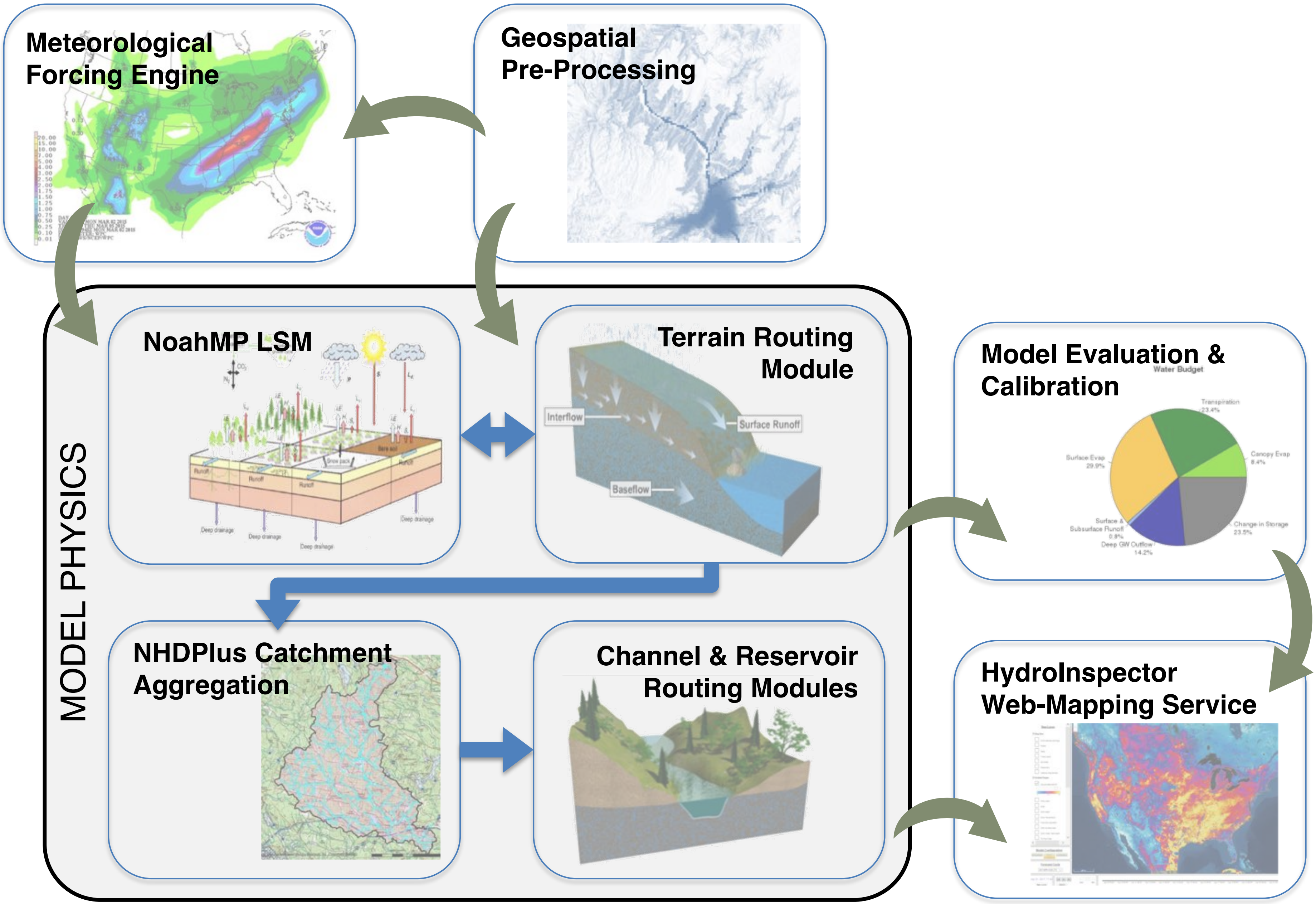
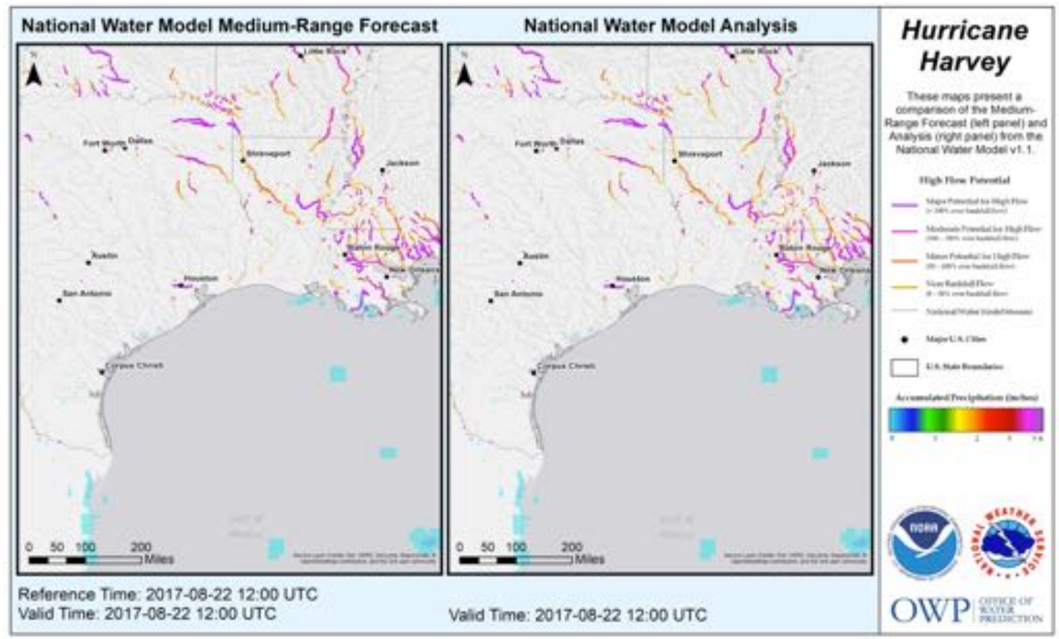
National Water Model Description: WRF-Hydro Modeling System



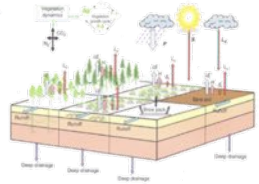
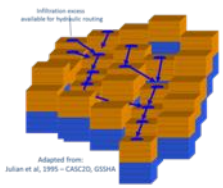
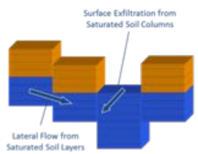
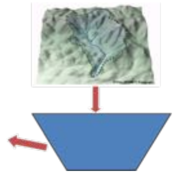
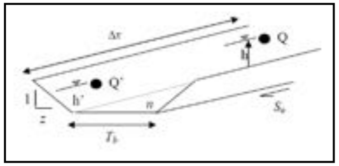
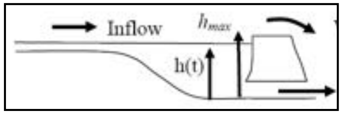
National Water Model (NWM)

- 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



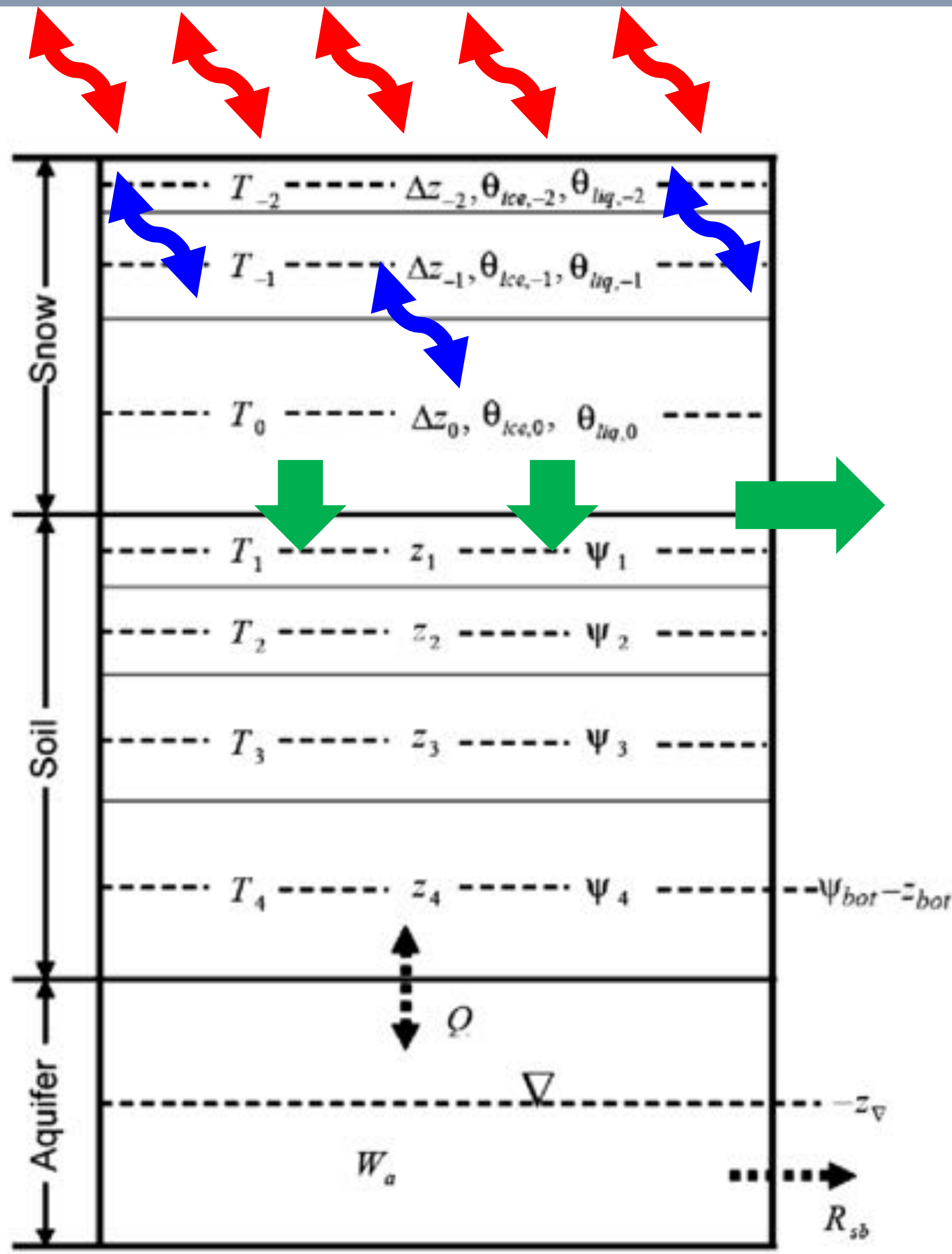
WRF-Hydro Physics Permutations

		WRF-Hydro Options	Current NWM Configuration
Column Land Surface Model		**<u>3 up-to-date column land models</u>:** Noah, NoahMP (w/ built-in multi-physics options), Sac-HTET	NoahMP: 4-layer soils 3-layer snowpack
Overland Flow Module		**<u>3 surface routing schemes</u>:** diffusive wave, kinematic wave, direct basin aggregation	Diffusive wave
Lateral Subsurface Flow Module		**<u>2 subsurface routing schemes</u>:** Boussinesq shallow saturated flow, 2d aquifer model	Boussinesq shallow saturated flow
Conceptual Baseflow Parameterizations		**<u>2 conceptual baseflow schemes</u>:** direct aggregation storage-release with pass-through or exponential model	Exponential model
Channel Routing/ Hydraulics		**<u>5 channel flow schemes</u>:** diffusive wave, kinematic wave, RAPID, custom-network Muskingum or Muskingum-Cunge	Custom-network (NHDPlus) Muskingum-Cunge model
Lake/Reservoir Management		**<u>1 lake routing scheme</u>:** 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

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



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.

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

Dry Snow

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

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

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

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

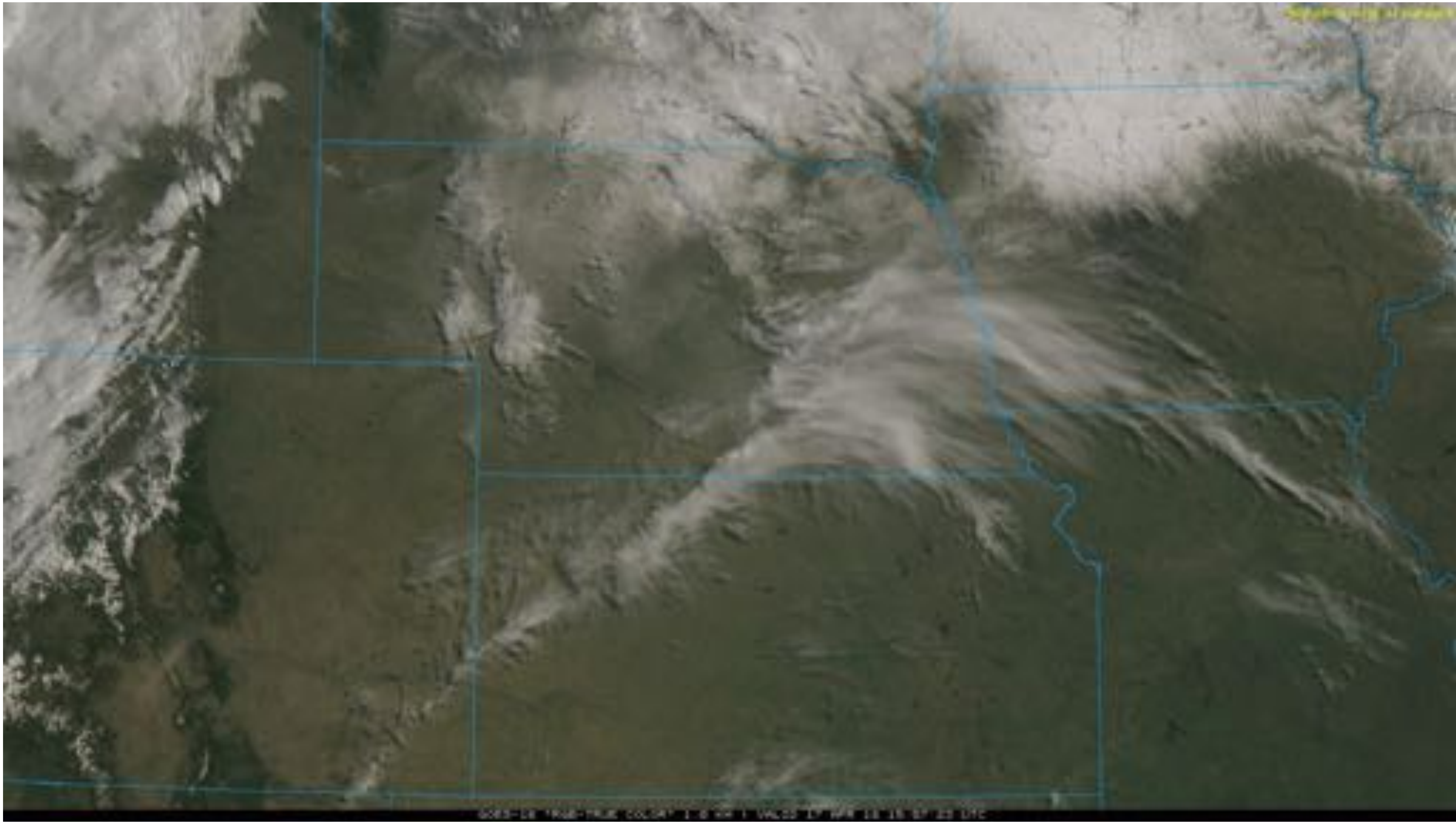
$$C_S = 0.2,\ C_N = 0.5,$$

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

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

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....



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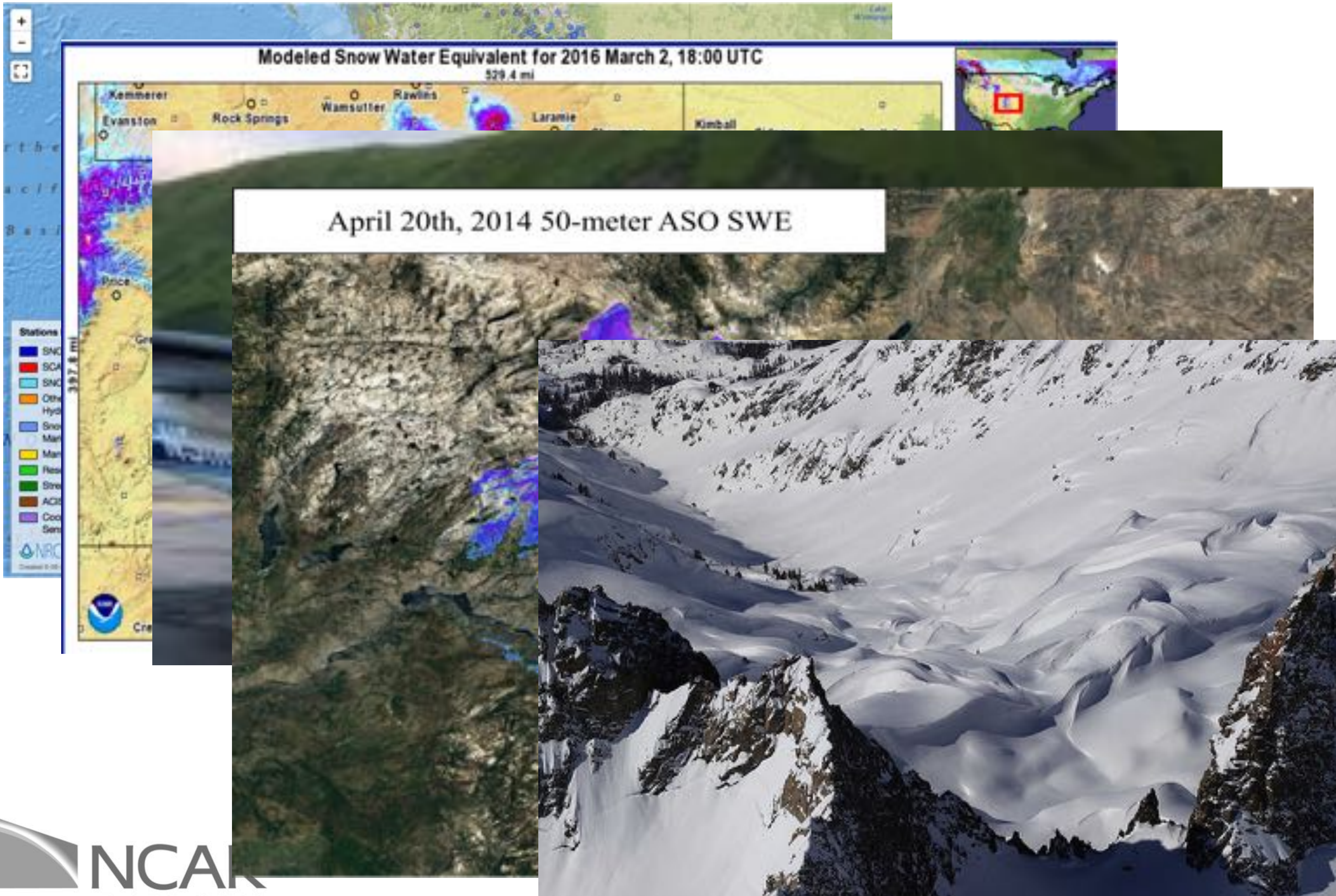
National Water Model Snow Analysis



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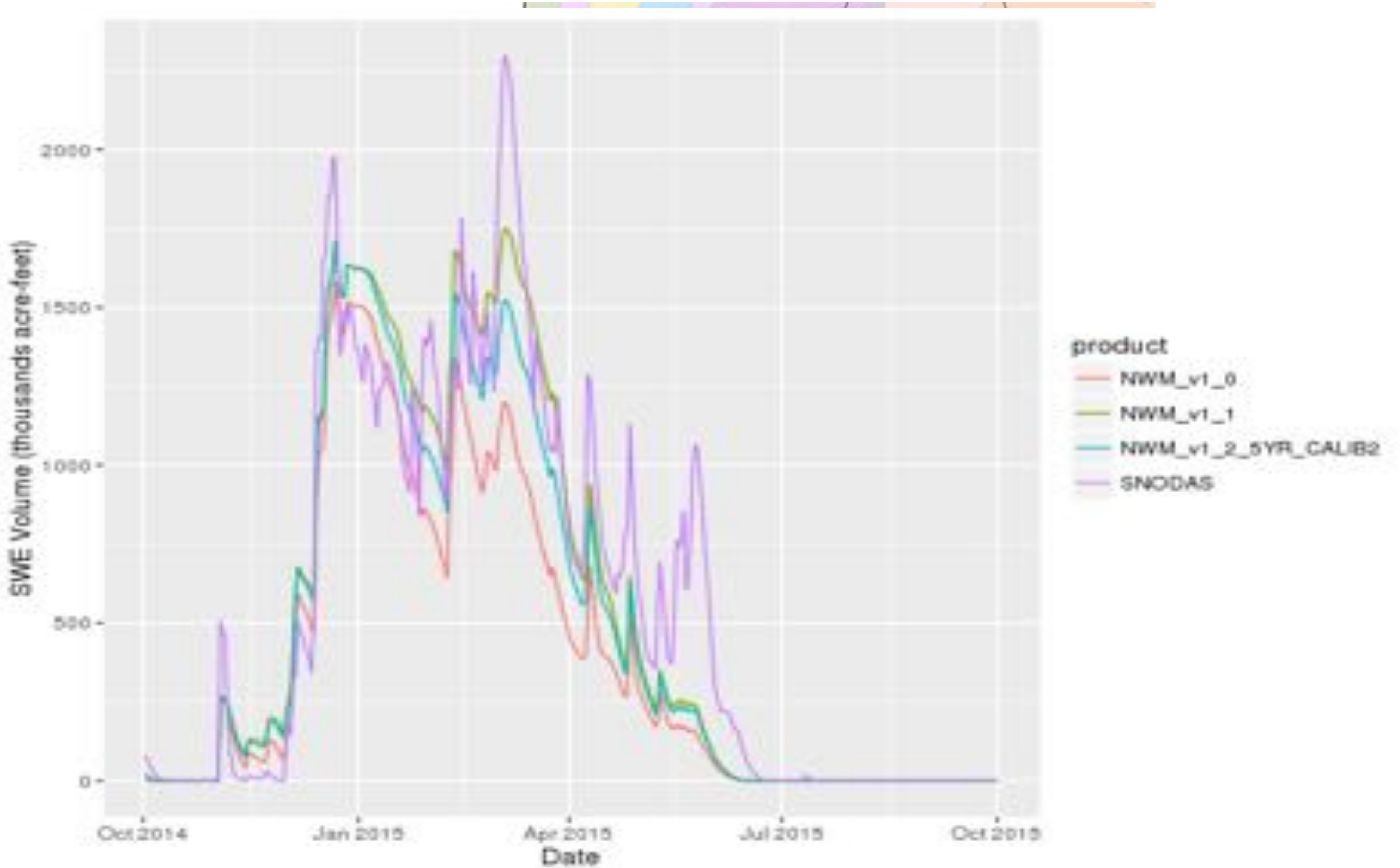
5-Year Retrospective Study



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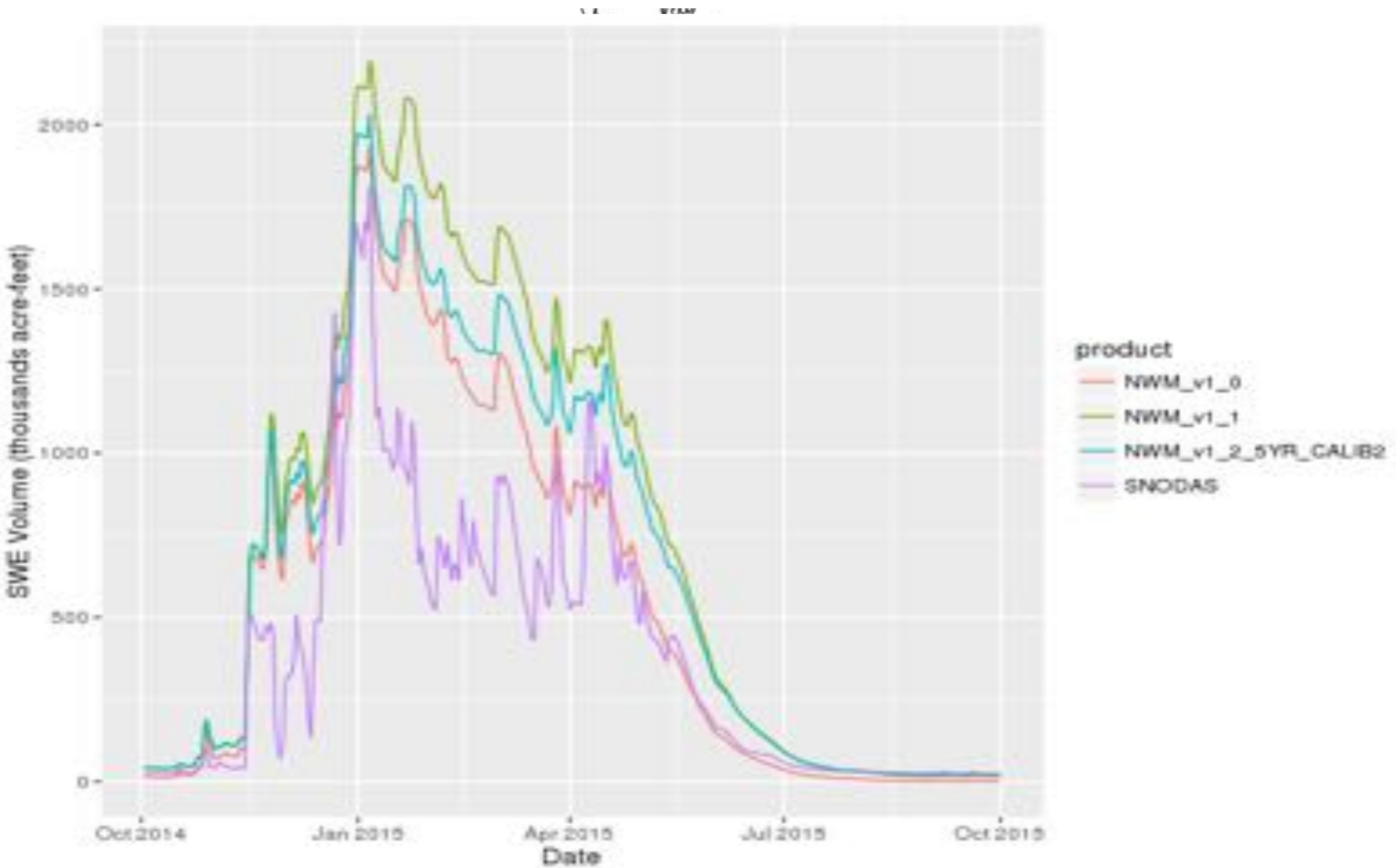

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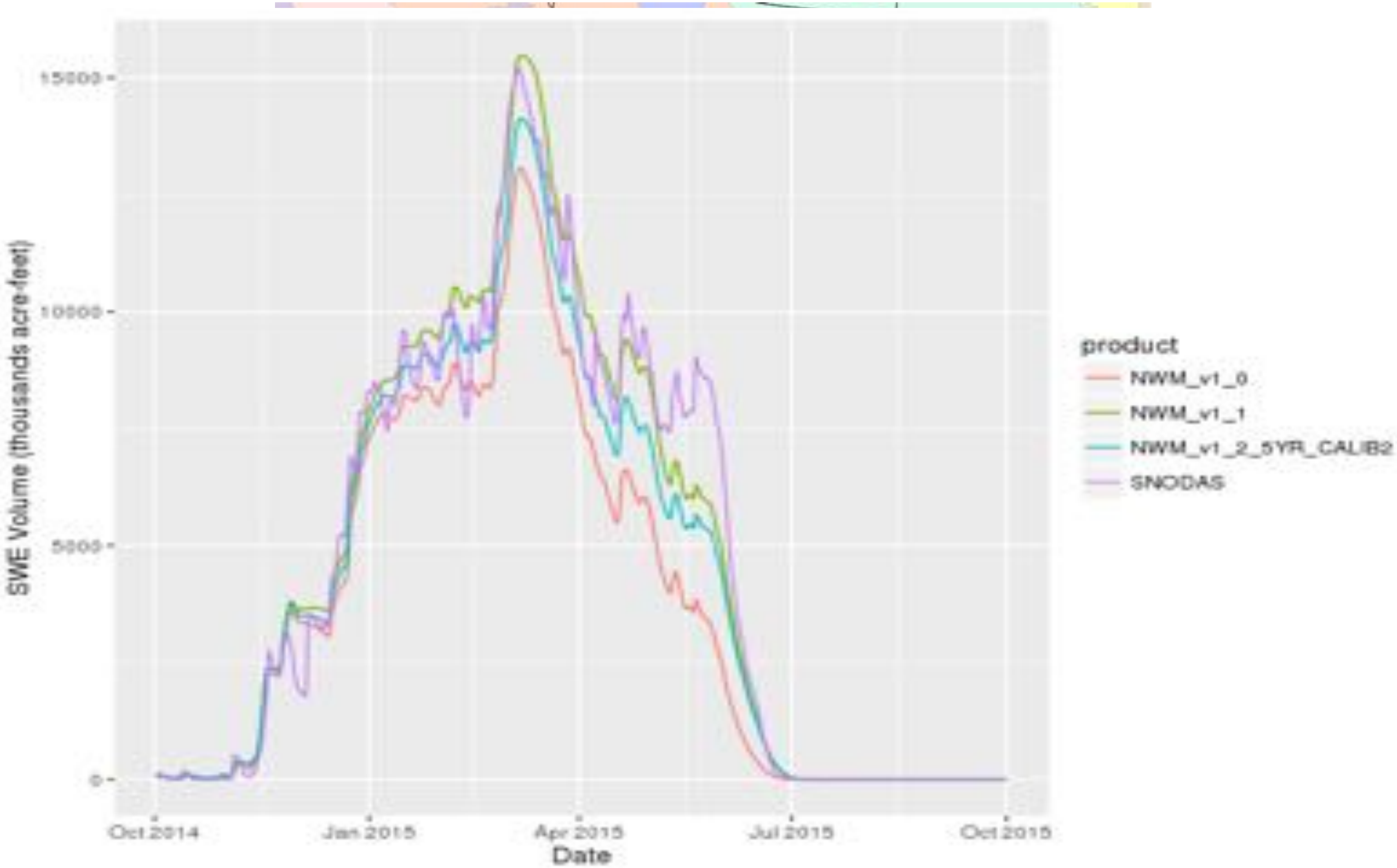

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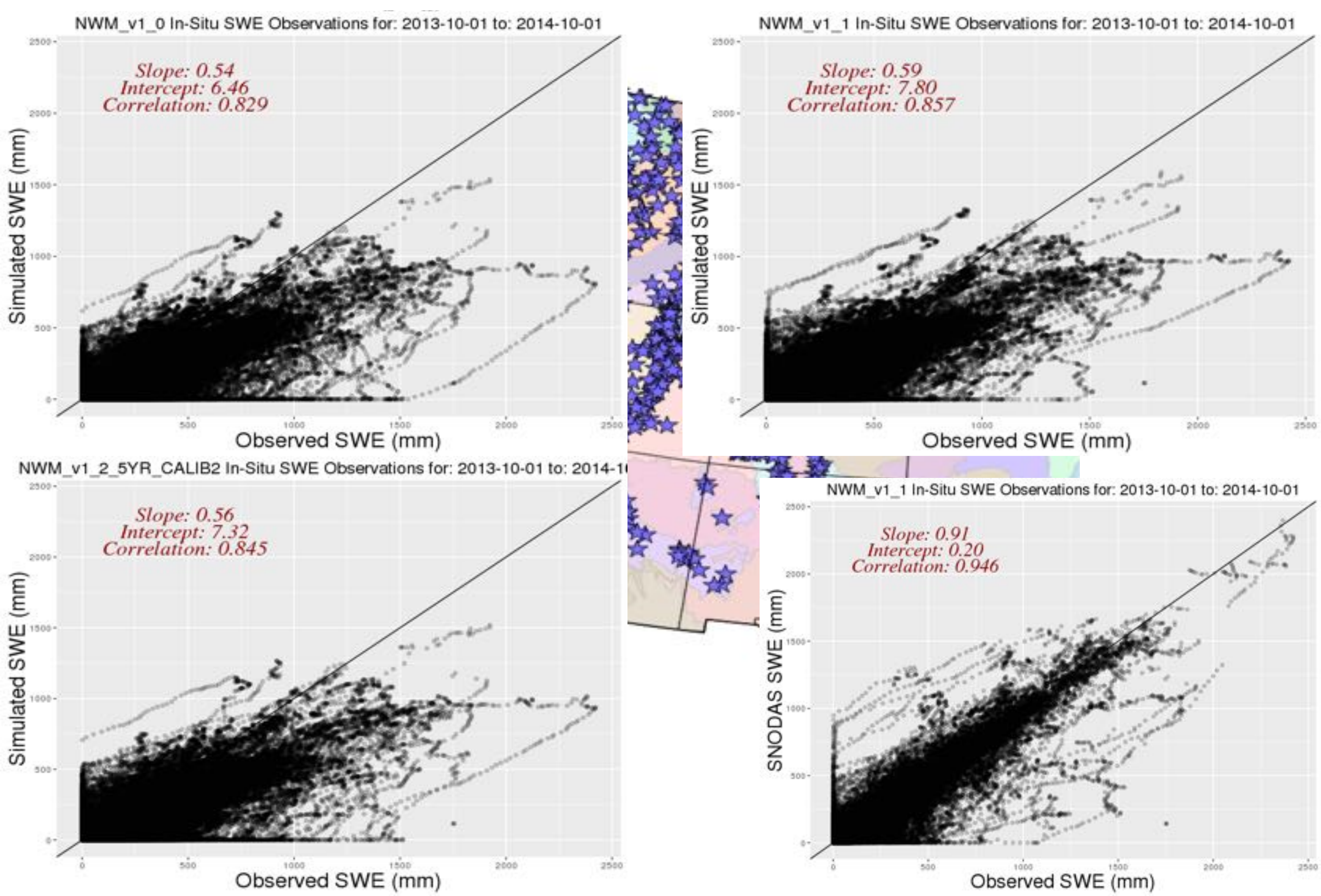

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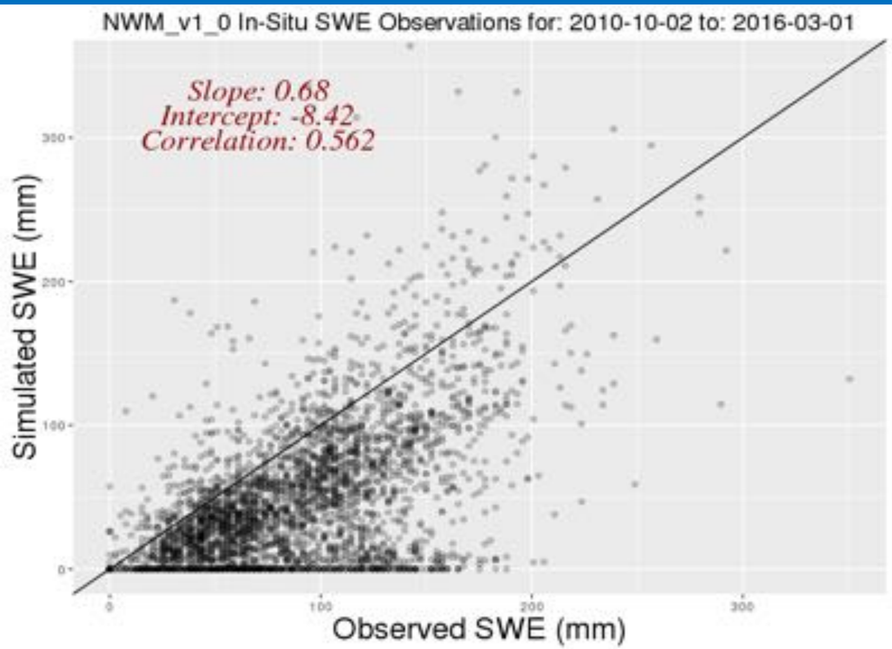

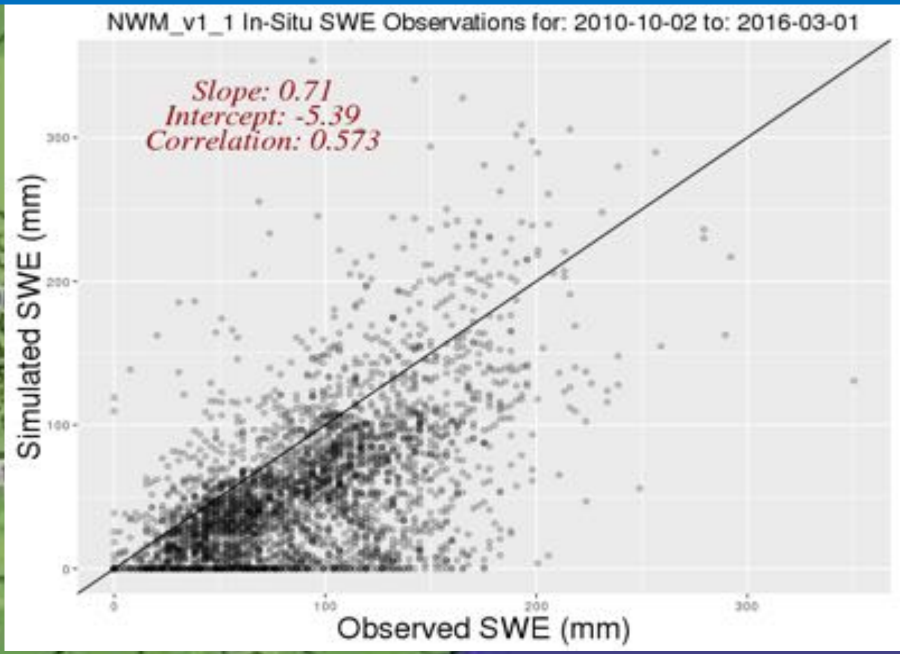

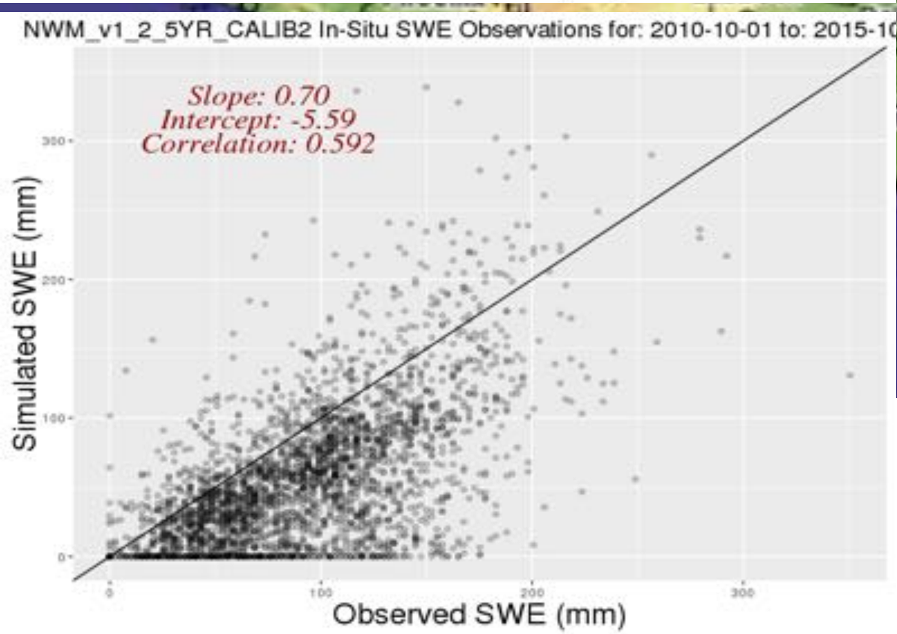

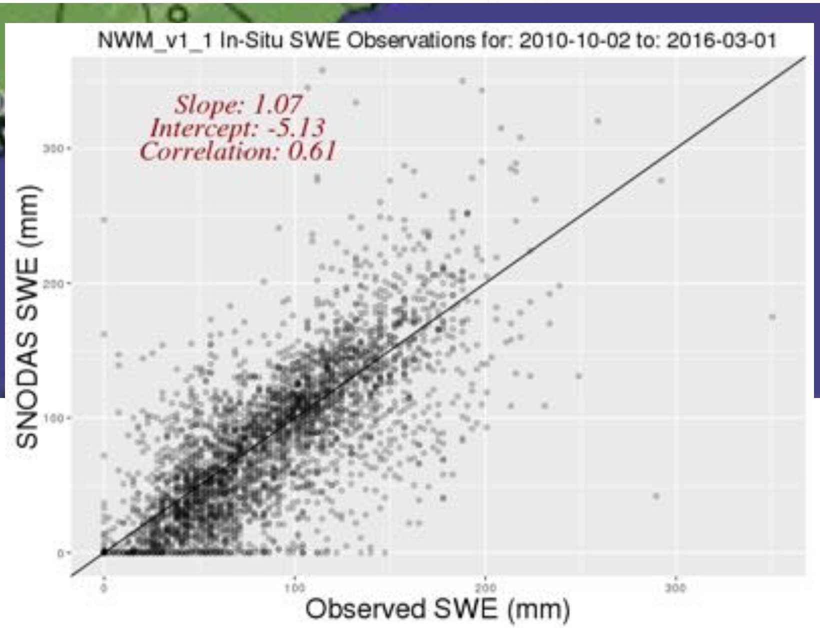

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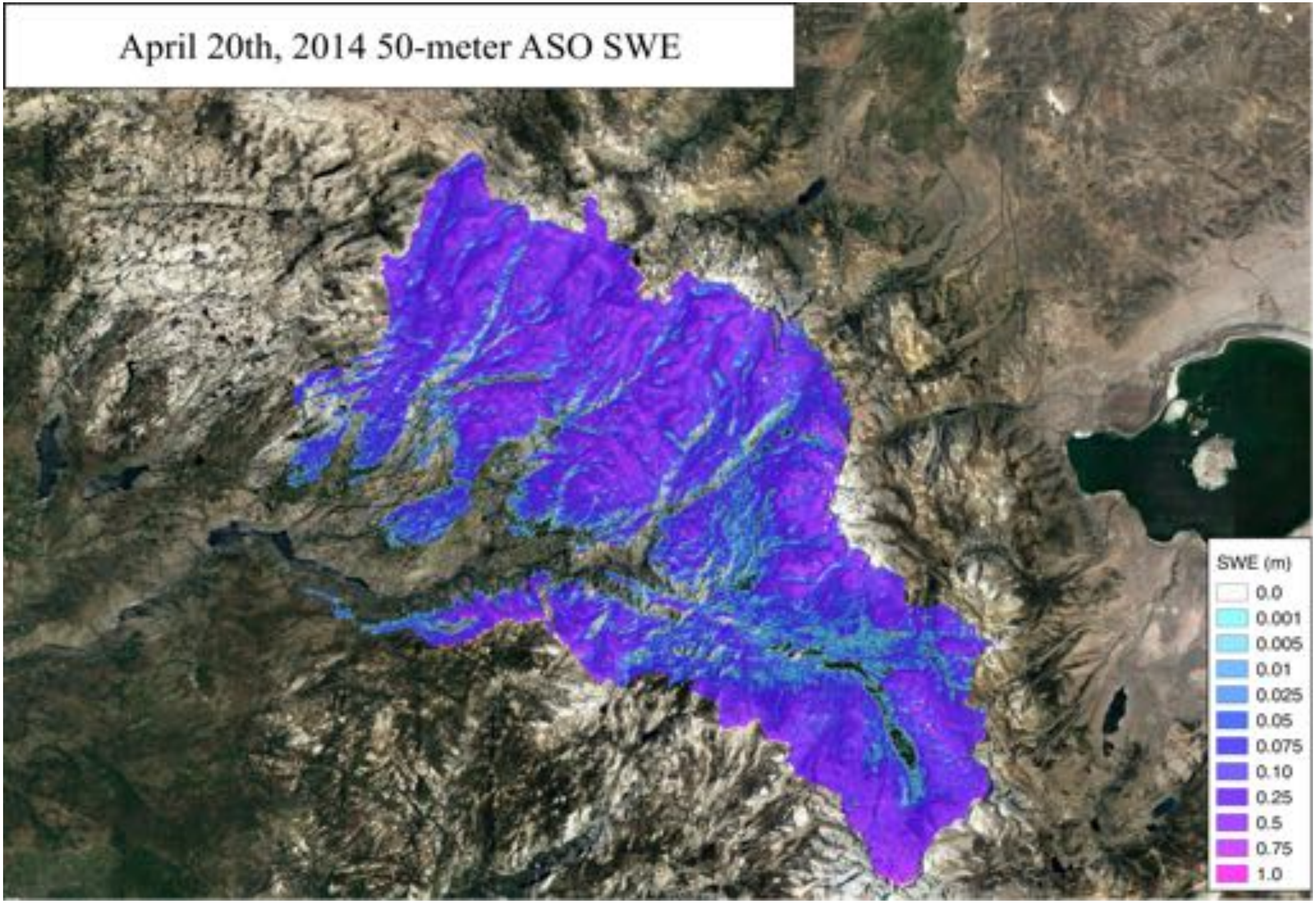
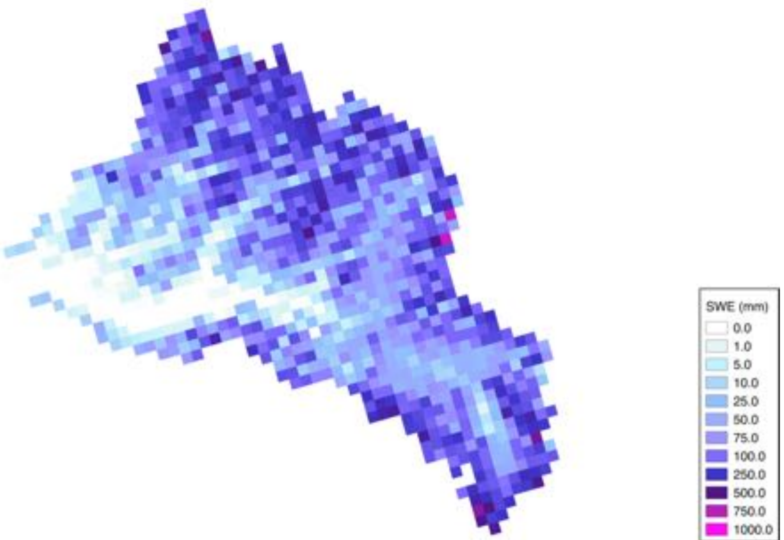
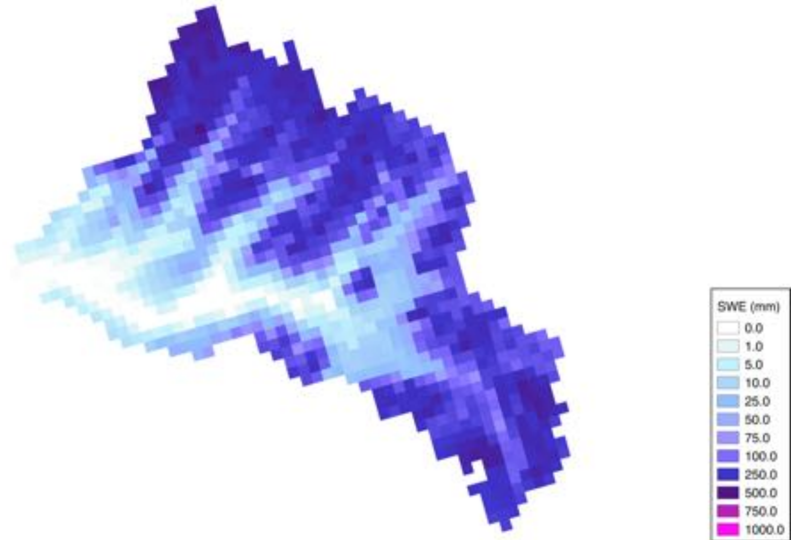


5-Year Retrospective Study

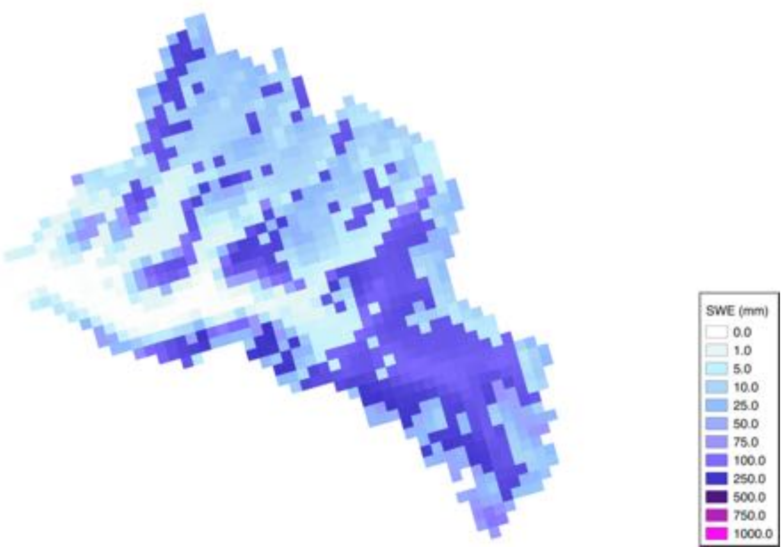
2014-2015 Water Year Mean ASO SWE



2014-2015 Water Year Mean SNODAS SWE

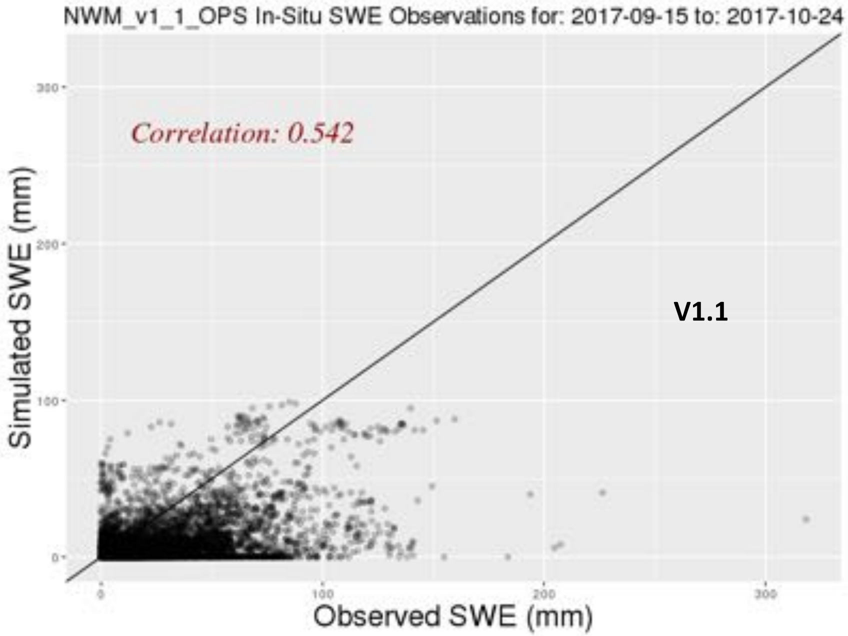


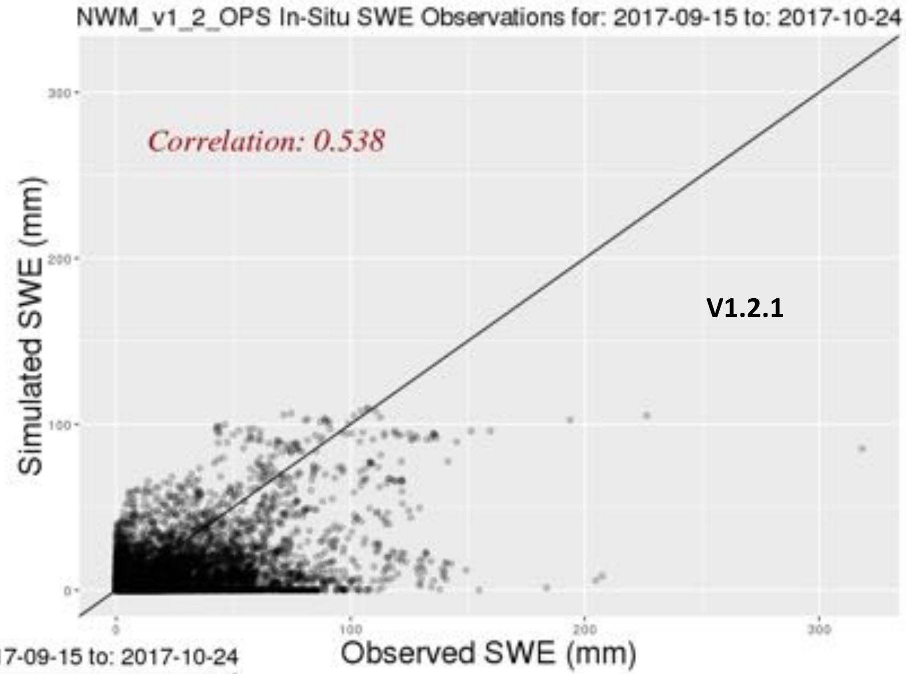
2014-2015 Water Year Mean v1.0 NWM SWE

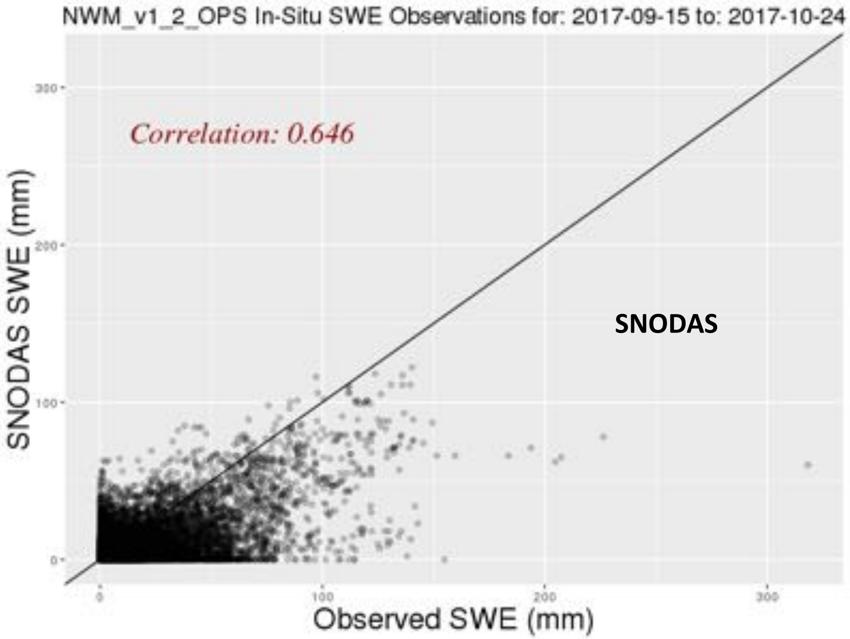


2014-2015 Water Year Mean v1.1 NWM SWE

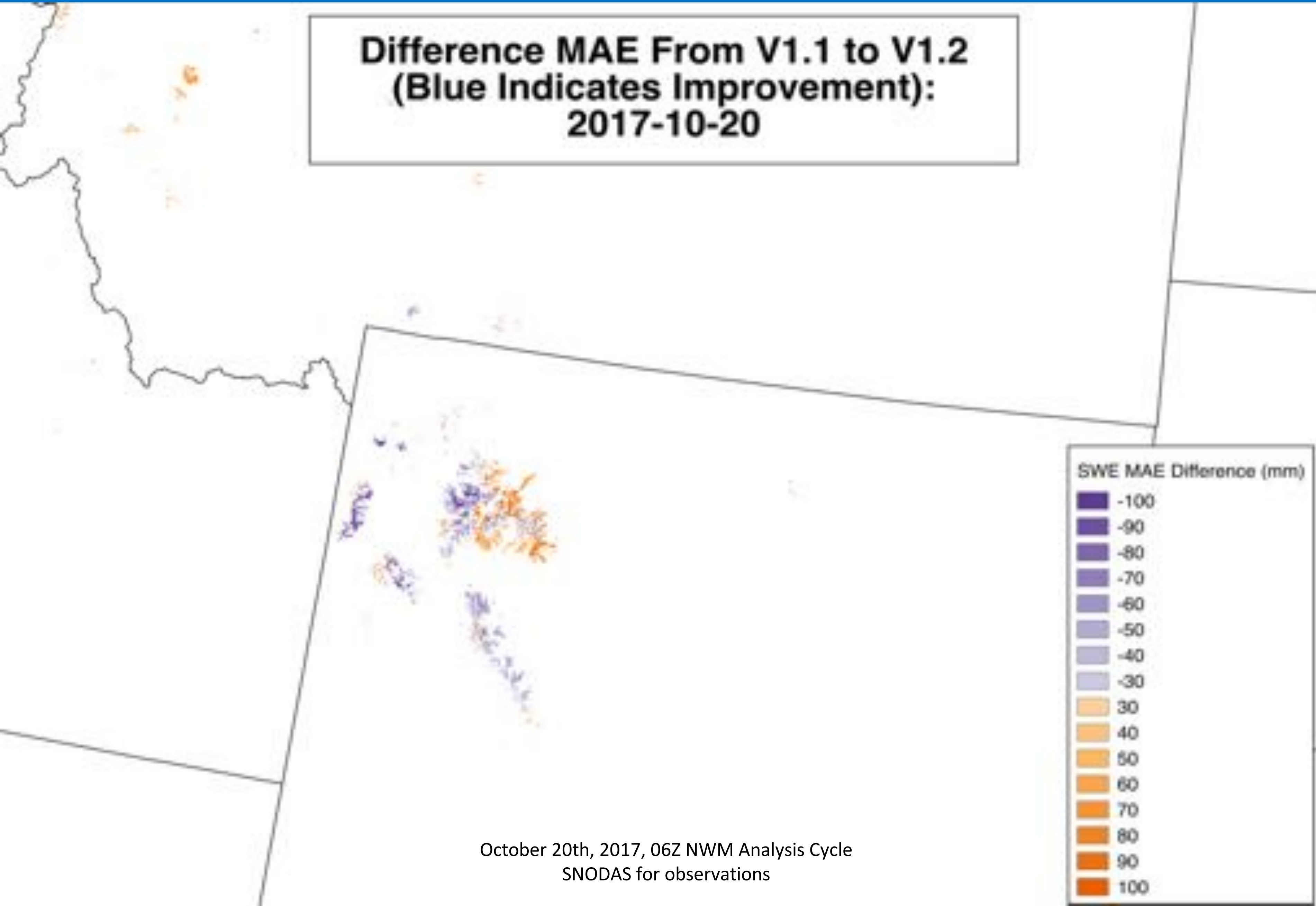
NWM V1.2 National Snowpack Improvement





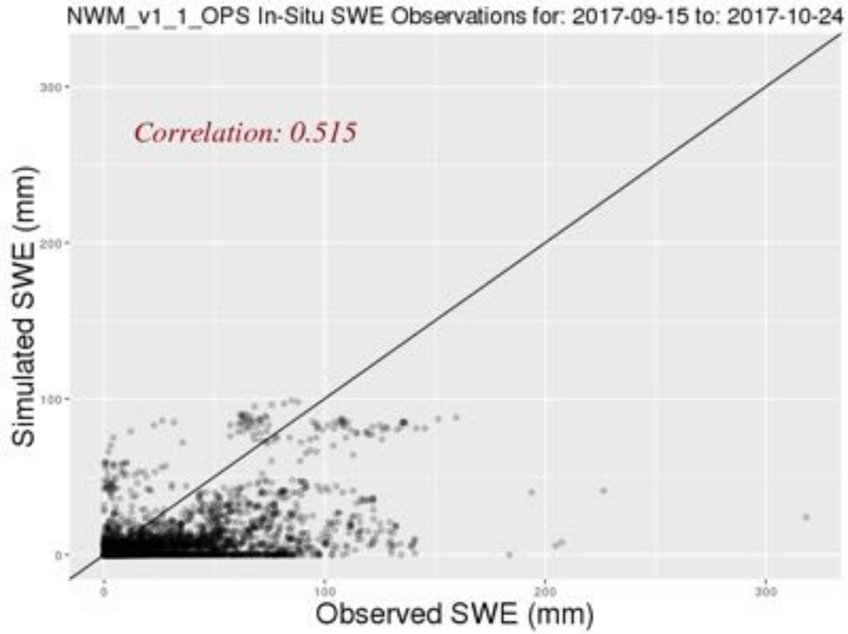


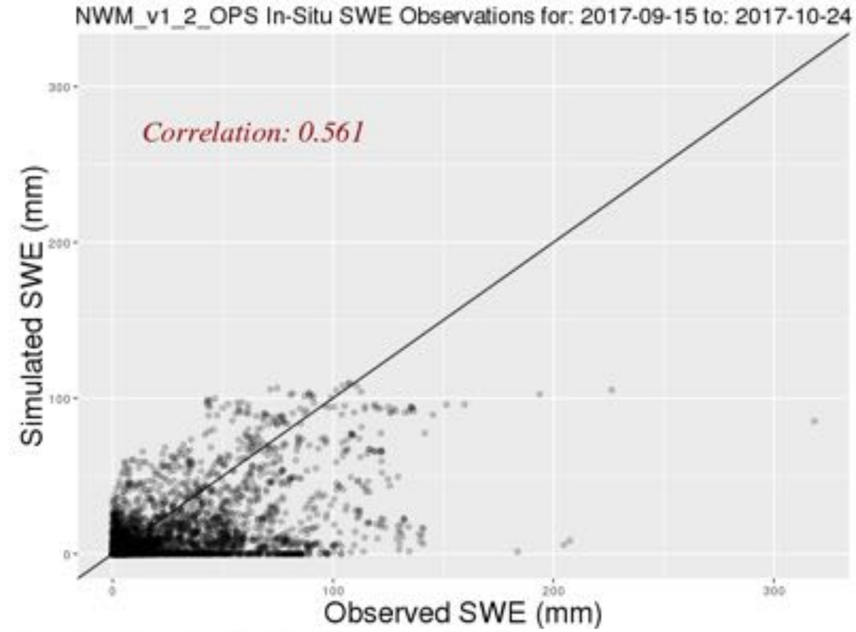
NWM V1.2 National Snowpack Improvement

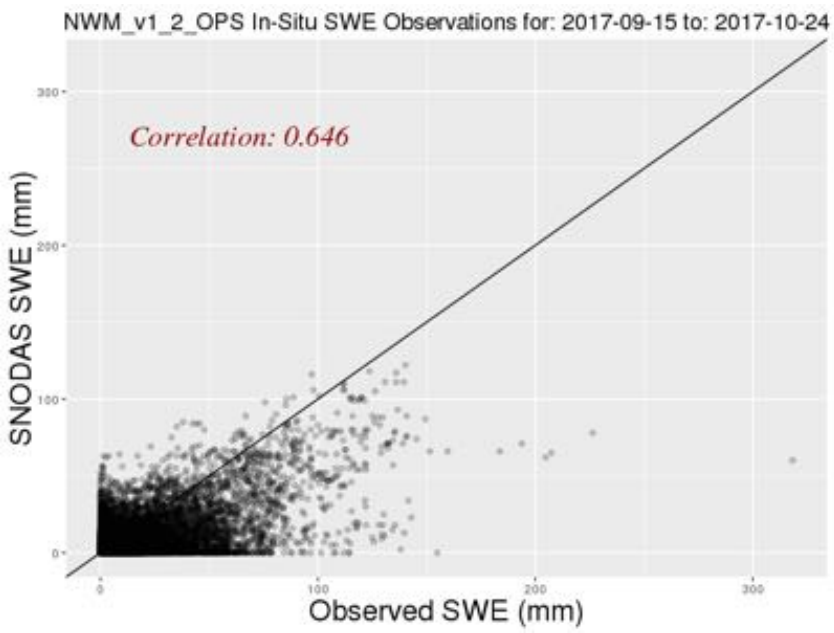


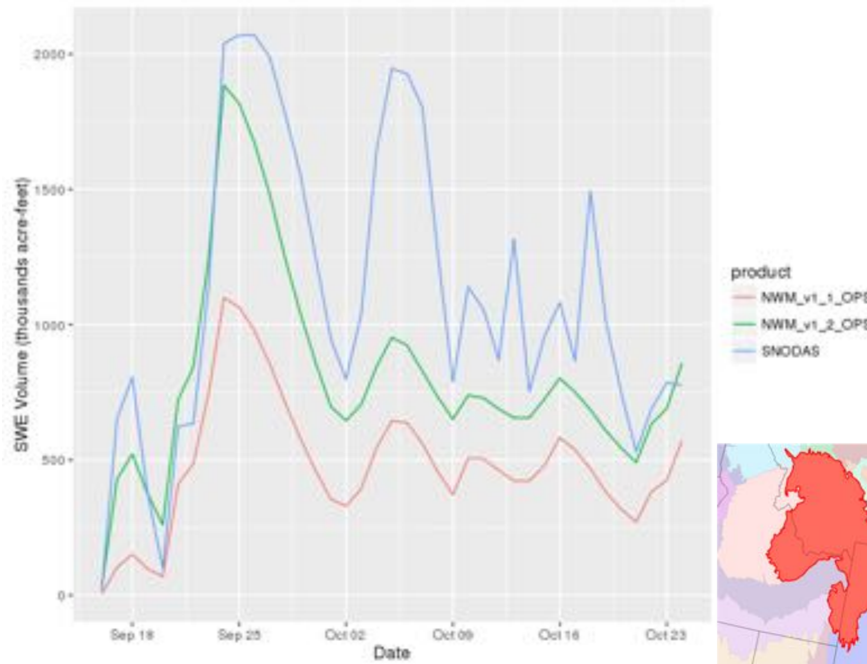
October 20th, 2017, 06Z NWM Analysis Cycle
SNODAS for observations

NWM V1.2 National Snowpack Improvement

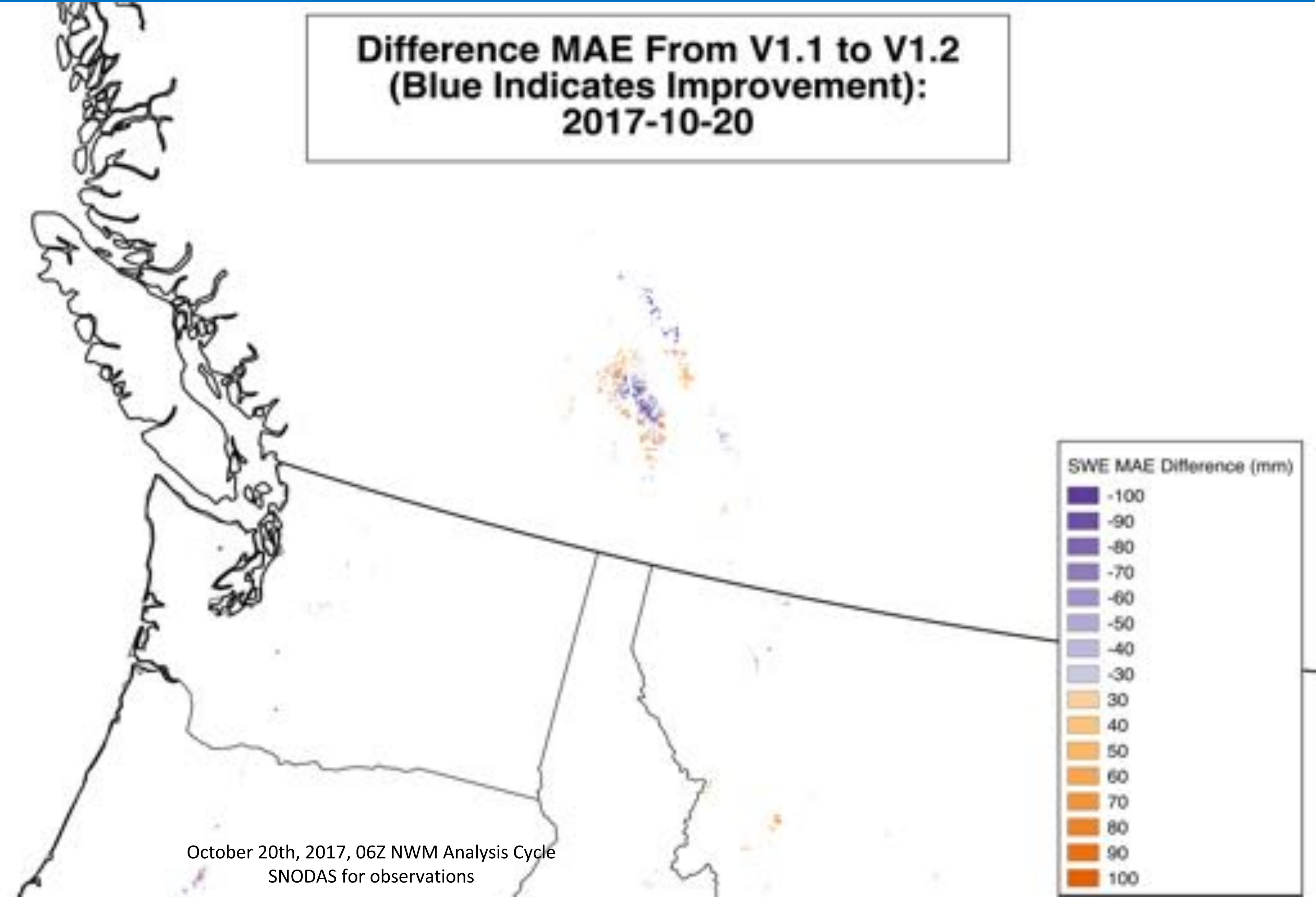






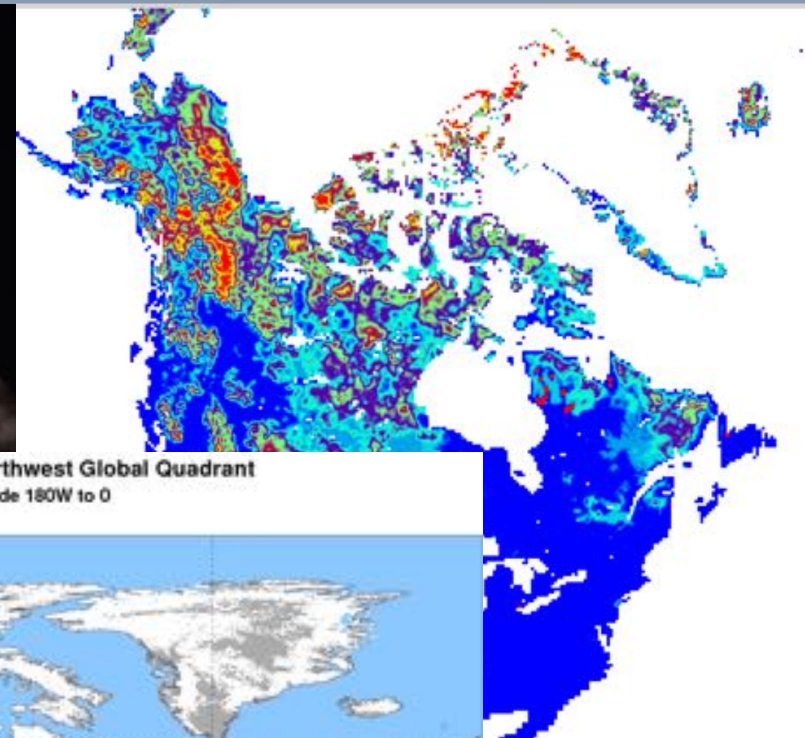


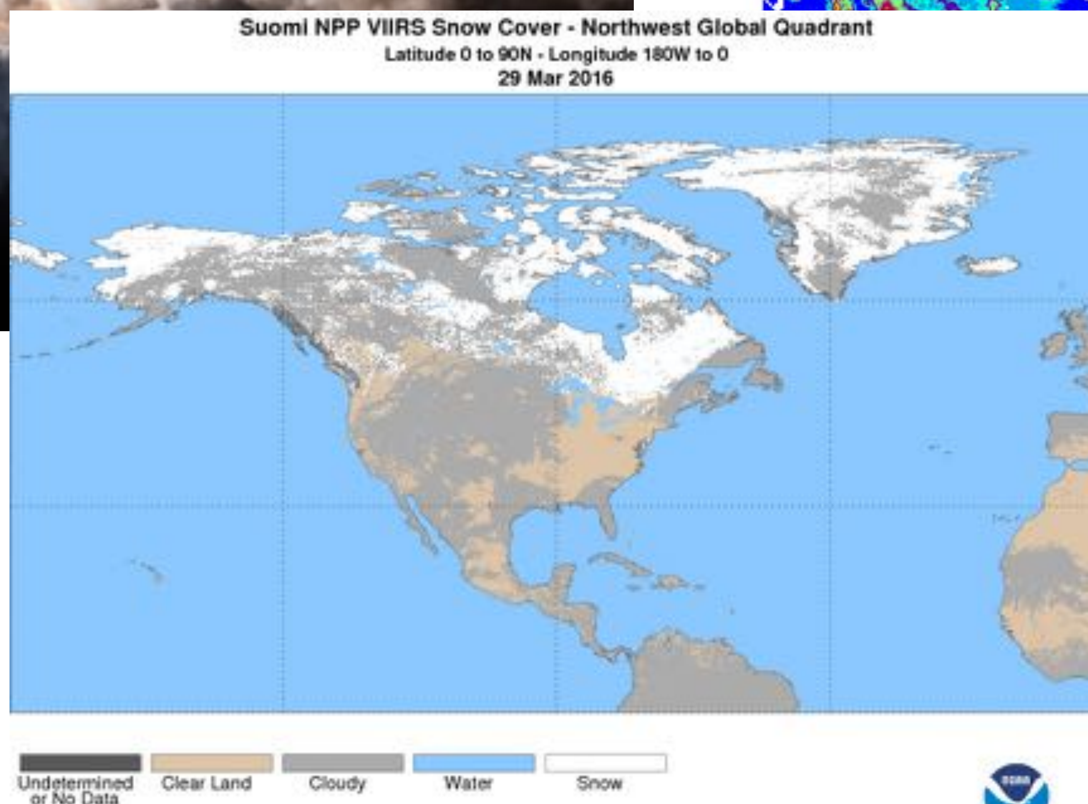
NWM V1.2 National Snowpack Improvement



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

Expansion of Remotely Sensed Snow Observations





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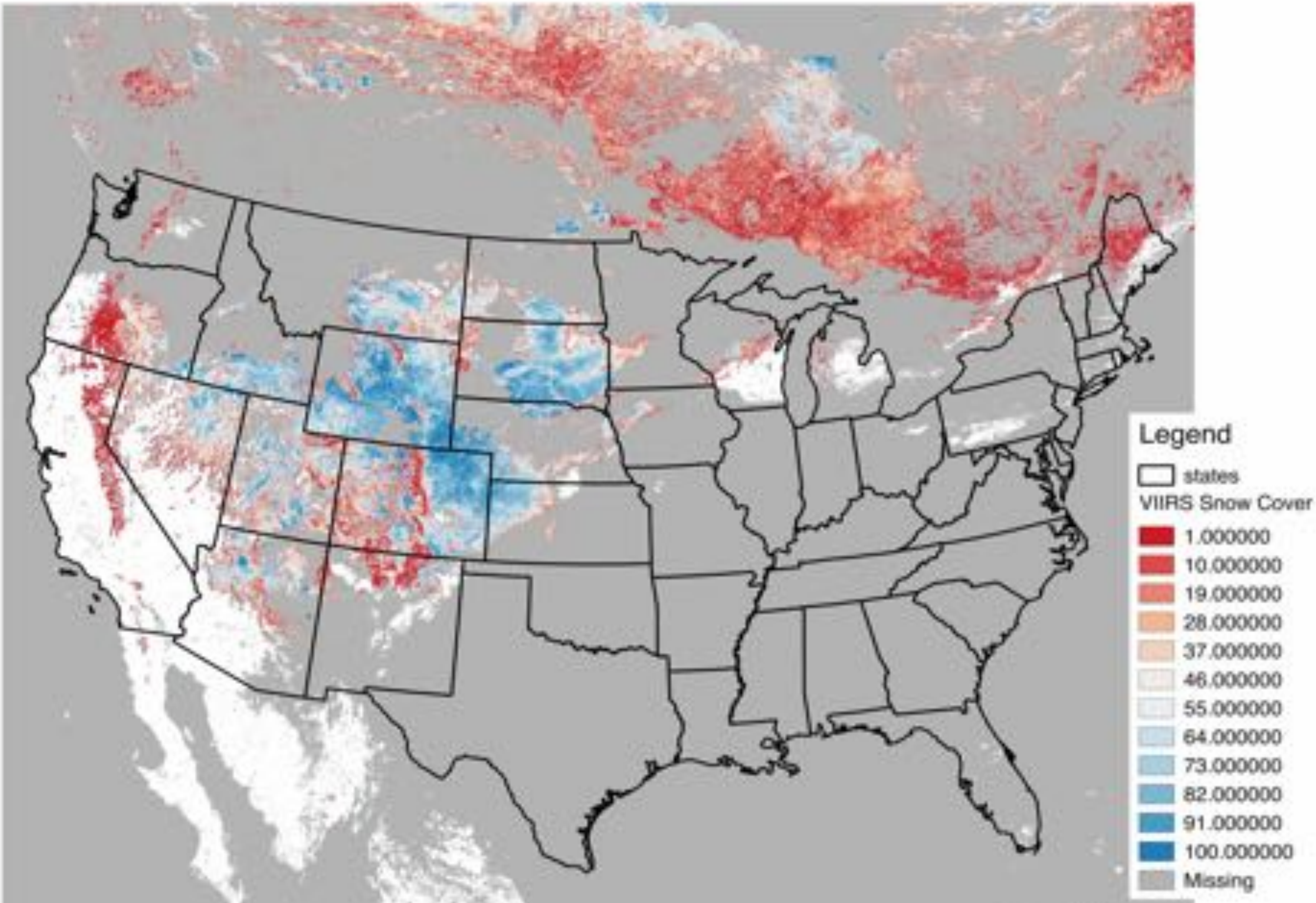
NOAA/NESDIS/STAR

Expansion of Remotely Sensed Snow Observations

VIIRS Fractional Snow Cover

2015-01-02 Analysis



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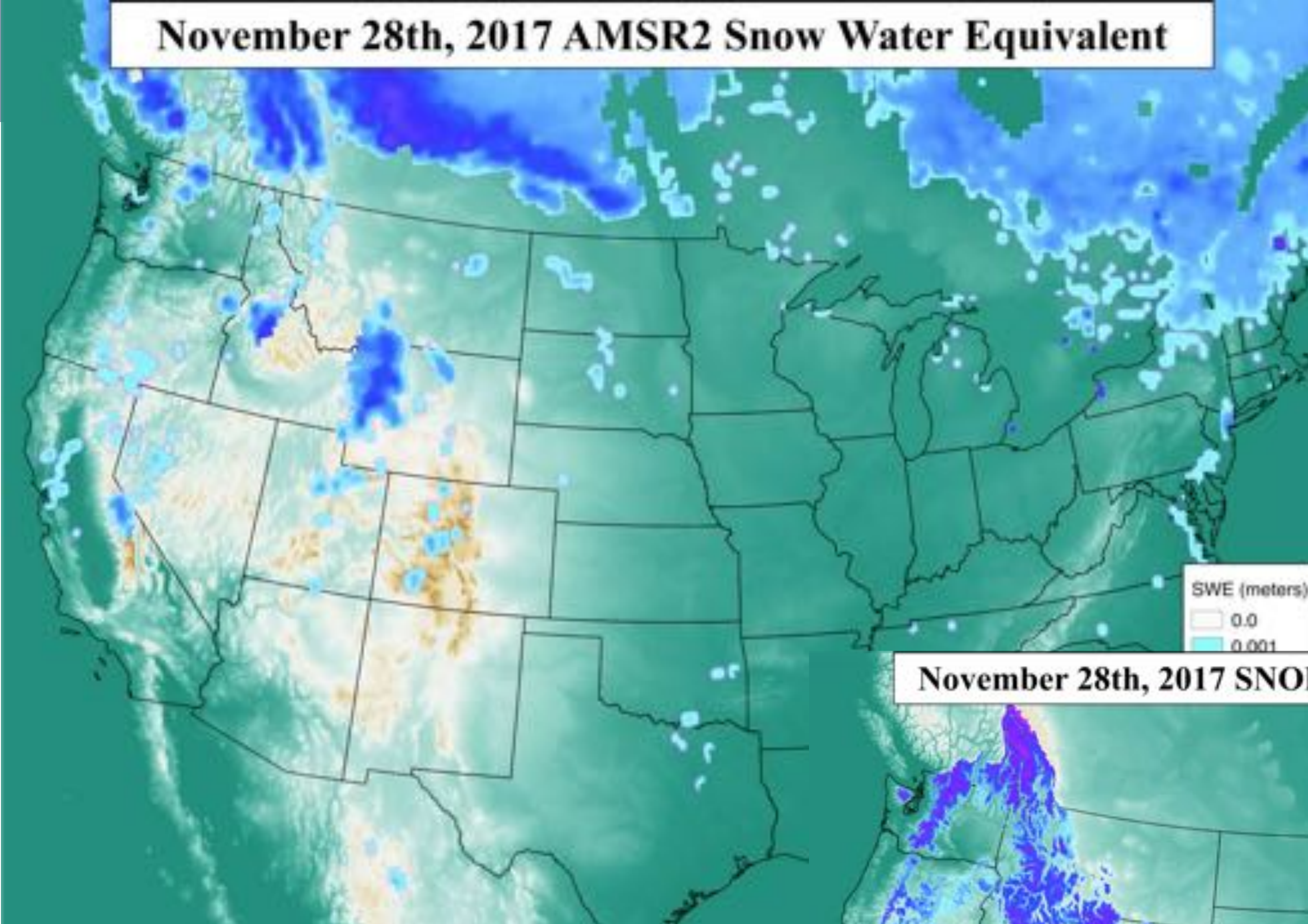

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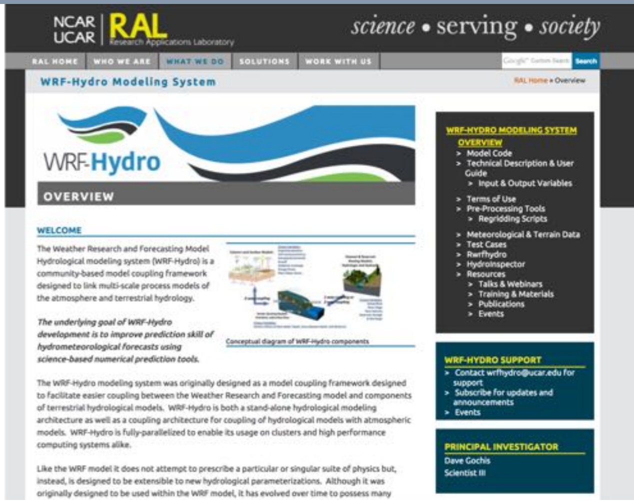
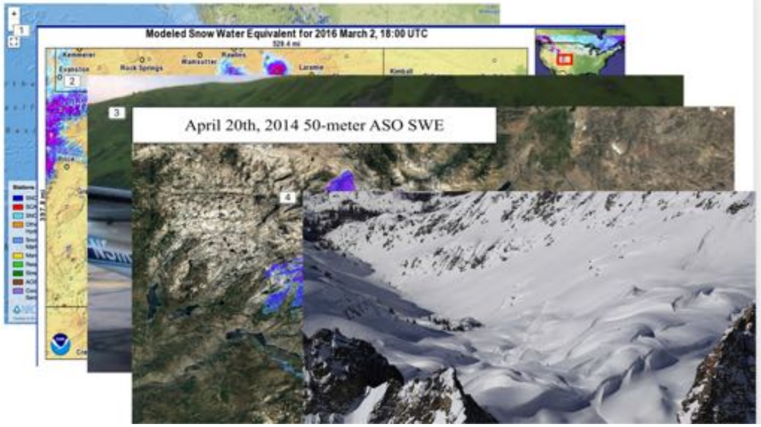
Next Steps



- 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!



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Questions?

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