

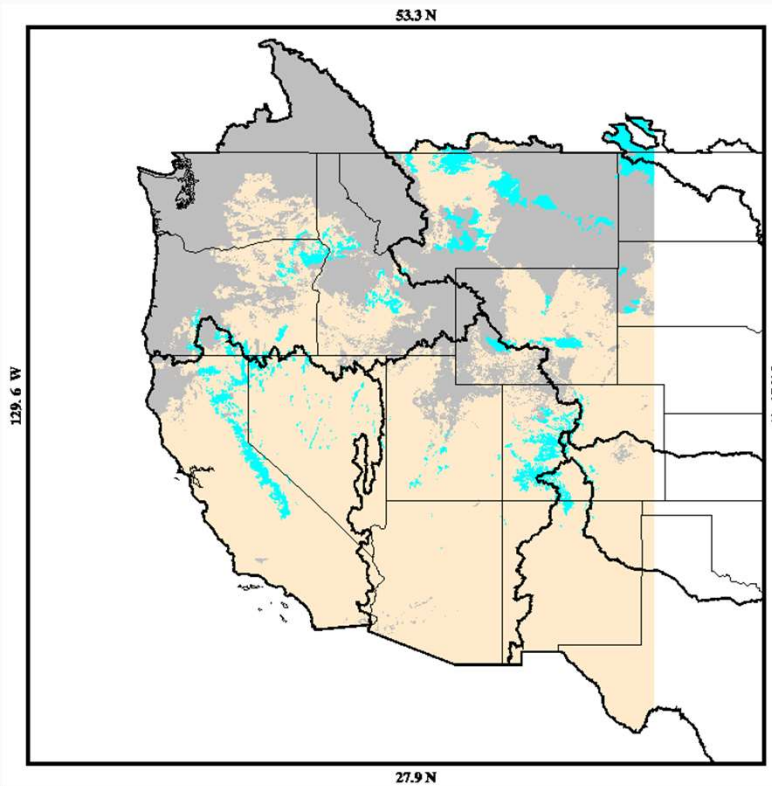
The National Snow Analysis: Past, Present, and Future

Greg Fall

Office of Water Prediction—Chanhassen, MN (a.k.a. NOHRSC)

AWRA 2019, November 6

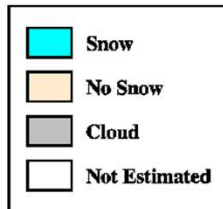




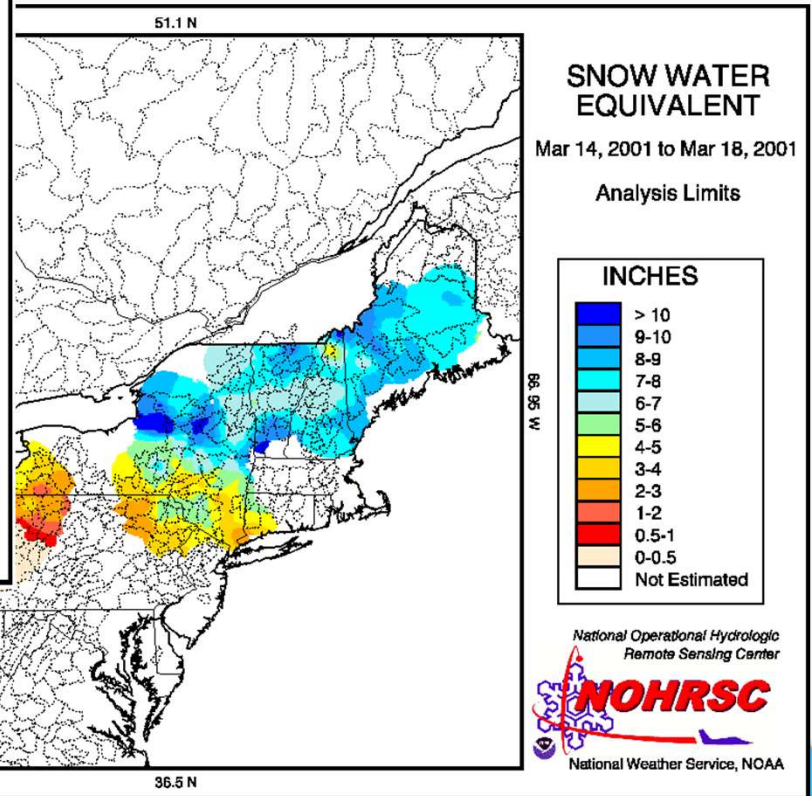
SATELLITE SNOW COVER

19-22 Nov 1998

North America



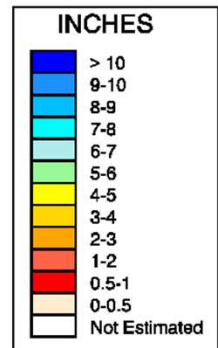
National Operational Hydrologic Remote Sensing Center
 Office of Hydrology
 National Weather Service, NOAA
 Chanhassen, Minnesota
 nar96326



SNOW WATER EQUIVALENT

Mar 14, 2001 to Mar 18, 2001

Analysis Limits



National Operational Hydrologic Remote Sensing Center



National Weather Service, NOAA

NOHRSC products, late 90s/early 00s.

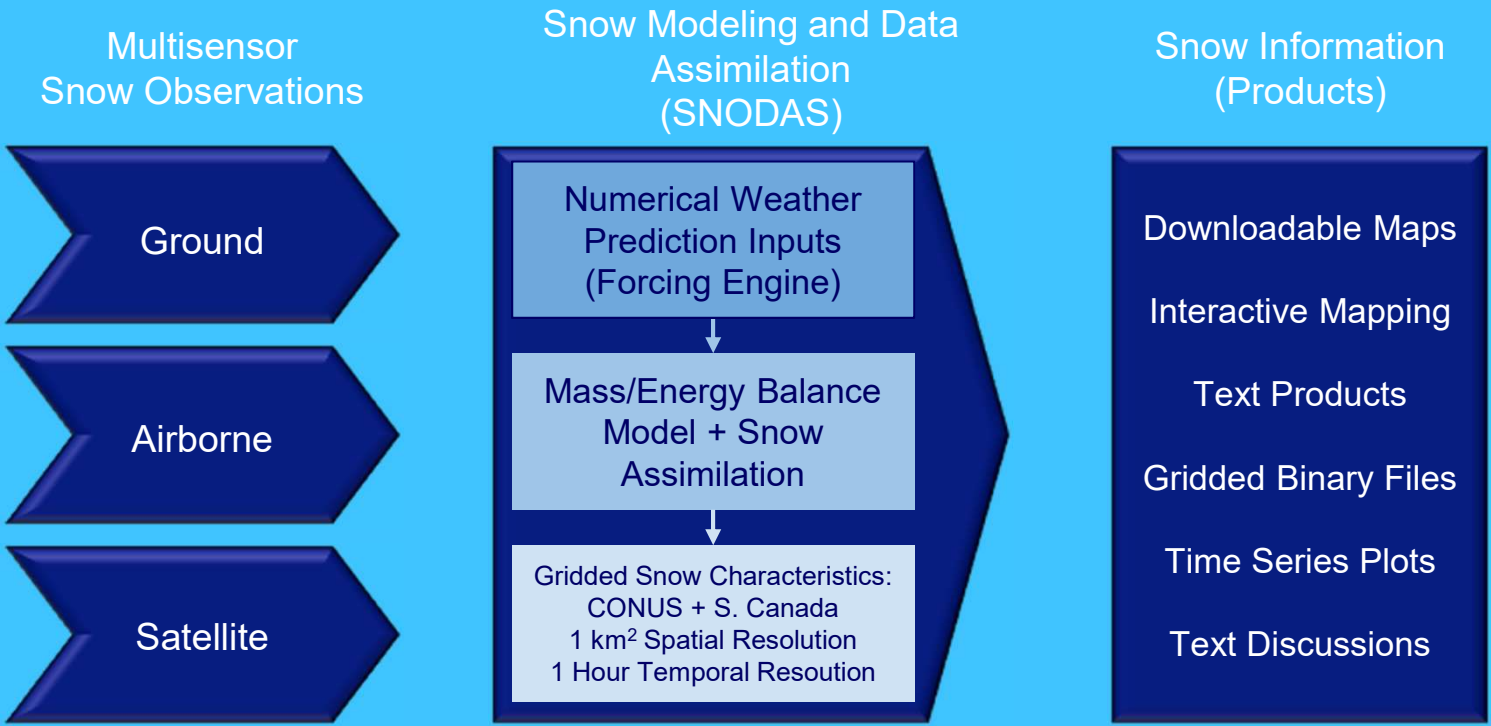
The National Snow Analysis (NSA) is a web-based suite of products from the Office of Water Prediction (OWP) that provide comprehensive information on snow conditions in the CONUS and adjacent portions of Canada.
(NWSI-10-932).

<http://www.nohrsc.noaa.gov>

To support the National Weather Service's mission by producing the best estimate of snow water equivalent, using all available data, including satellite, airborne, and in-situ observations, to protect life, property, and the enhancement of the national economy.

<http://www.nohrsc.noaa.gov>

National Snow Analysis



NSA Stakeholders

National Weather Service

- River Forecast Centers
- Weather Forecast Offices
- Weather Prediction Center
- National Water Center

Federal and State Agencies

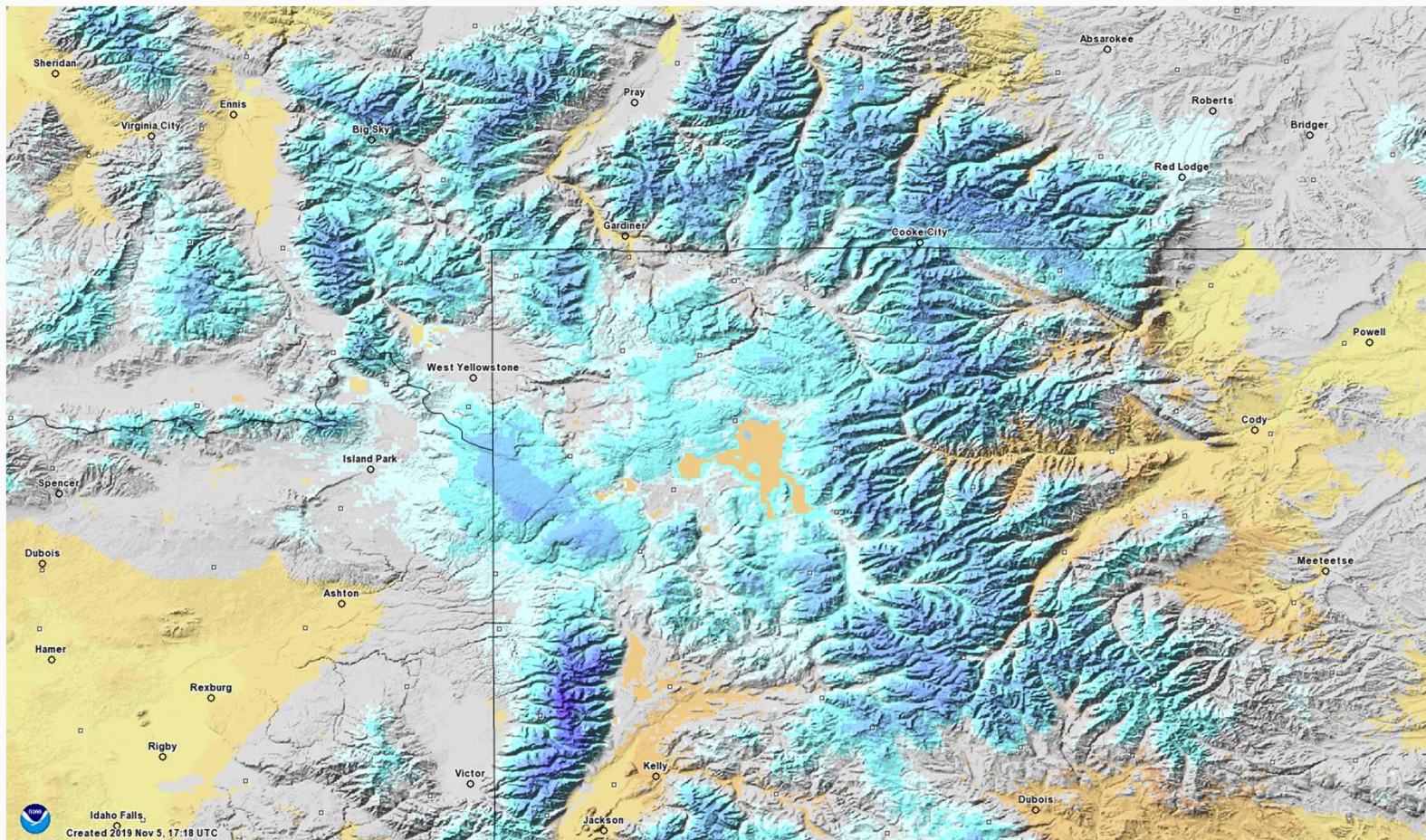
- U.S. Army Corps of Engineers
- Bureau of Reclamation
- New York Department of Environmental Protection
- Natural Resources Conservation Service
- Department of Transportation
- Montana Department of Emergency Services
- San Francisco Public Utilities Commission
- University of Albany ASRC/CESTM
- University of Wisconsin Sea Grant Institute
- National Snow and Ice Data Center
- Federal Emergency Management Administration

Private Sector

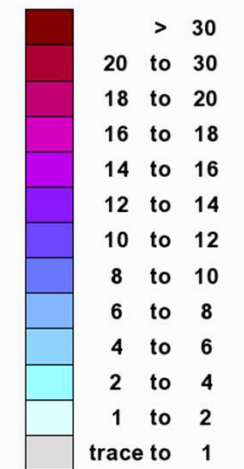
- Baron Advanced Meteorological Systems, LLC
- The Weather Channel
- Meteorlogix, Inc.
- WeatherBell
- Merrill Lynch
- Weather Decision Technologies, Inc.
- SnowStreet
- AccuWeather
- Snow Plot Operators
- Oppenheimer
- Campbell Soup Company
- Snowmobile outfitters
- Mountaineers
- Skiers
- General Public

International (Canada)

- Manitoba Department of Natural Resources
- New Brunswick Department of Natural Resources
- Alberta Environment
- BC Hydro
- British Columbia Ministry of Environment
- Environment Canada
- Saint John River Basin Commission

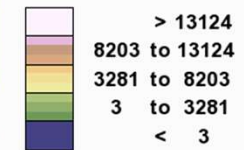


Inches of water equivalent



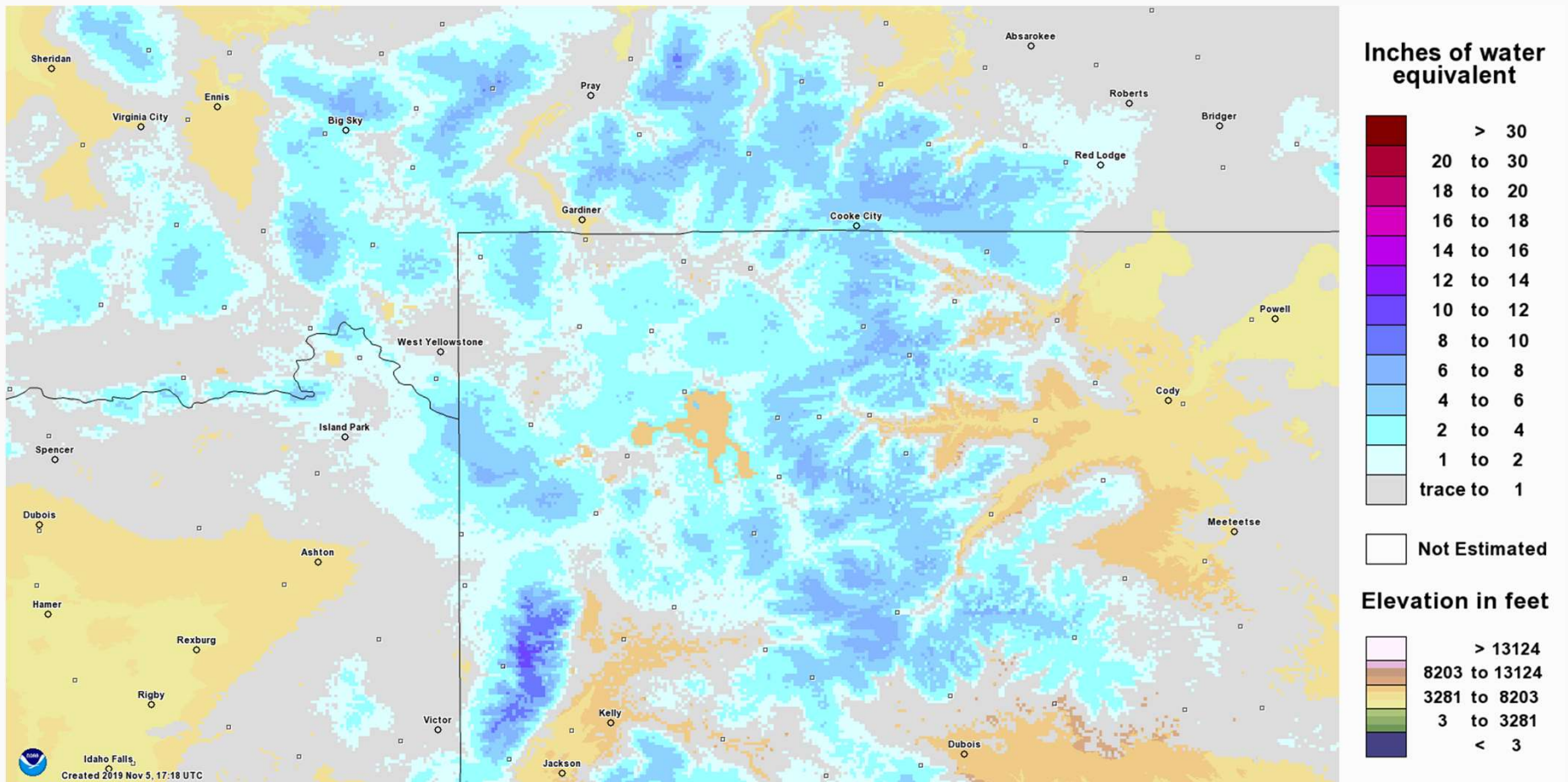
Not Estimated

Elevation in feet



SNODAS SWE, 2019-11-05

Idaho Falls
Created 2019 Nov 5, 17:18 UTC

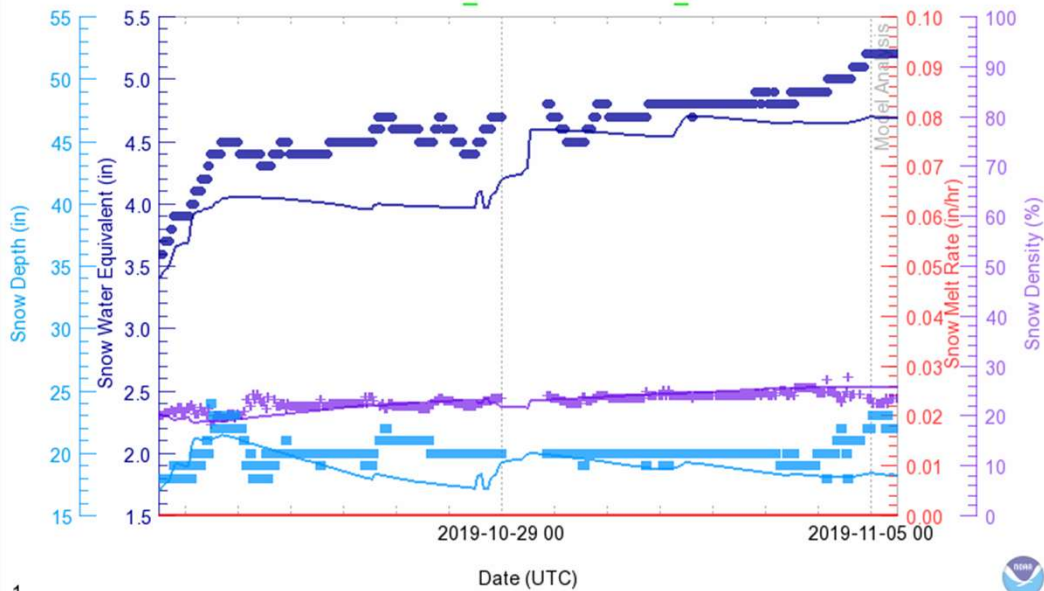


SNODAS SWE, 2019-11-05

Snow Water Equivalent, Snow Depth, and Snow Melt

Modeled and Observed

Station:	WHTM8 - WHITE MILL	(Modeled)	(Observed)
Latitude:	45.0458 N	Snow Water Equivalent	●
Longitude:	109.9099 W	Snow Depth	■
Elevation:	8747 Feet	Snow Density	+
Start Date:	2019-10-22 12 UTC	Snow Melt Rate	
Stop Date:	2019-11-05 12 UTC	Assimilation	
Forest Density:	82%		
Land Use:	Cool Conifer Forest		



1



Sample time series for WHTM8 (White Mill) SNOTEL near Cooke City, MT.

National Snow Analyses - NOAA

www.nohrsc.noaa.gov/nsa/index.html?region=National&year=2017&month=2&...


National Weather Service
National Operational Hydrologic Remote Sensing Center

Home News Organization Search Enter Search Here Go

National Snow Analyses

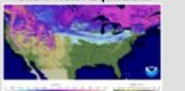
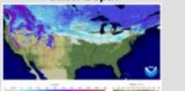







Snow Reports Model Assimilation Schedule Snow Survey Schedule

Click On Map for Regional Analyses



Automated Model Discussion:
February 9, 2017
Area Covered By Snow: 40.8%
Area Covered Last Month: 59.7%
Snow Depth
Average: 6.5 in
Minimum: 0.0 in
Maximum: 1726.0 in
Std. Dev.: 16.0 in
Snow Water Equivalent
Average: 1.6 in
Minimum: 0.0 in
Maximum: 969.8 in
Std. Dev.: 4.4 in
more... Metric Units...

Select Region and Date
National 2017 February 9 Go

Snow Water Equivalent  Animate: Season — Two weeks — One Day	Snow Depth  Animate: Season — Two weeks — One Day	Average Snowpack Temp  Animate: Season — Two weeks — One Day
SWE Change  Animate: Season — Two weeks — One Day	Snow Precipitation  Animate: Season — Two weeks — One Day	Snow Melt  Animate: Season — Two weeks — One Day
Blowing Snow Sublimation  Animate: Season — Two weeks — One Day	Surface Sublimation  Animate: Season — Two weeks — One Day	Non-Snow Precipitation  Animate: Season — Two weeks — One Day

USA.gov

SWCW1 - NOHRSC Graph plot

www.nohrsc.noaa.gov/interactive/html/graph.html?station=SWCW1&w=340&h=170

National Operational Hydrologic Remote Sensing Center
Interactive Snow Information

Home News Organization Search Enter Search Here Go

Start Date: 2017 May 1 6:00 Z to Stop Date: 2017 July 1 6:00 Z

All Graphs Metric Units Refresh screen

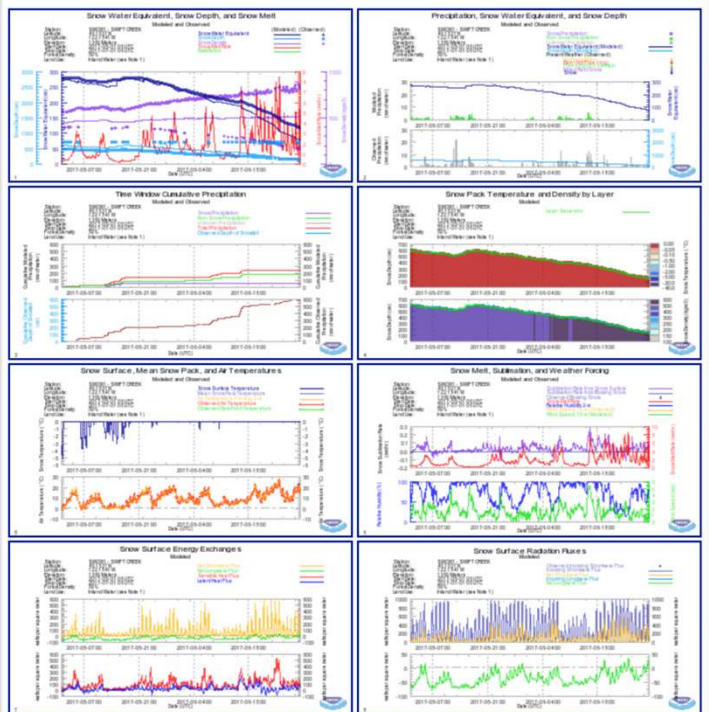
Query Station Time Series
Station SHEF ID: SWCW1
340 width
170 height
Submit

Reference Map

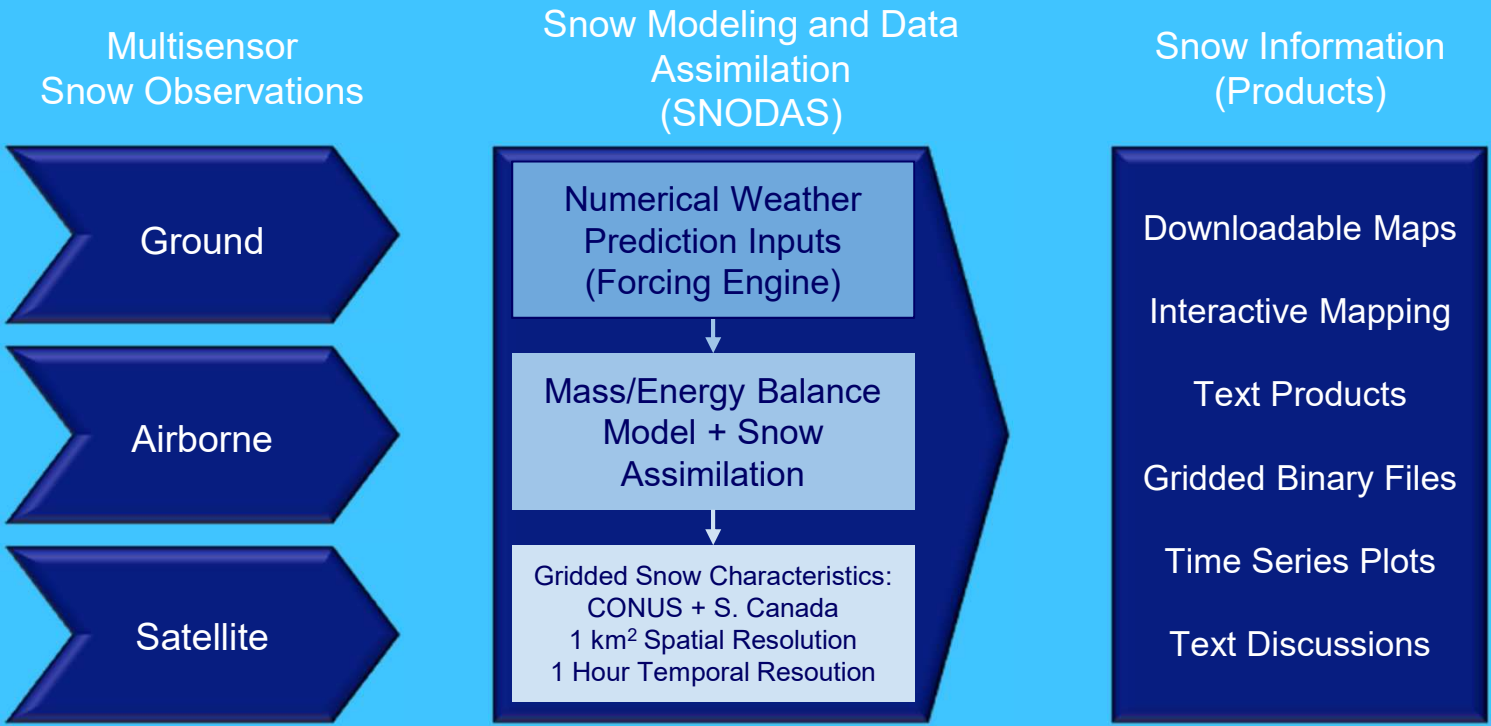
Links
Plot 1 image
Plot 2 image
Plot 3 image
Plot 4 image
Plot 5 image
Plot 7 image
Plot 8 image

Latest page
Preferences
Cookies off

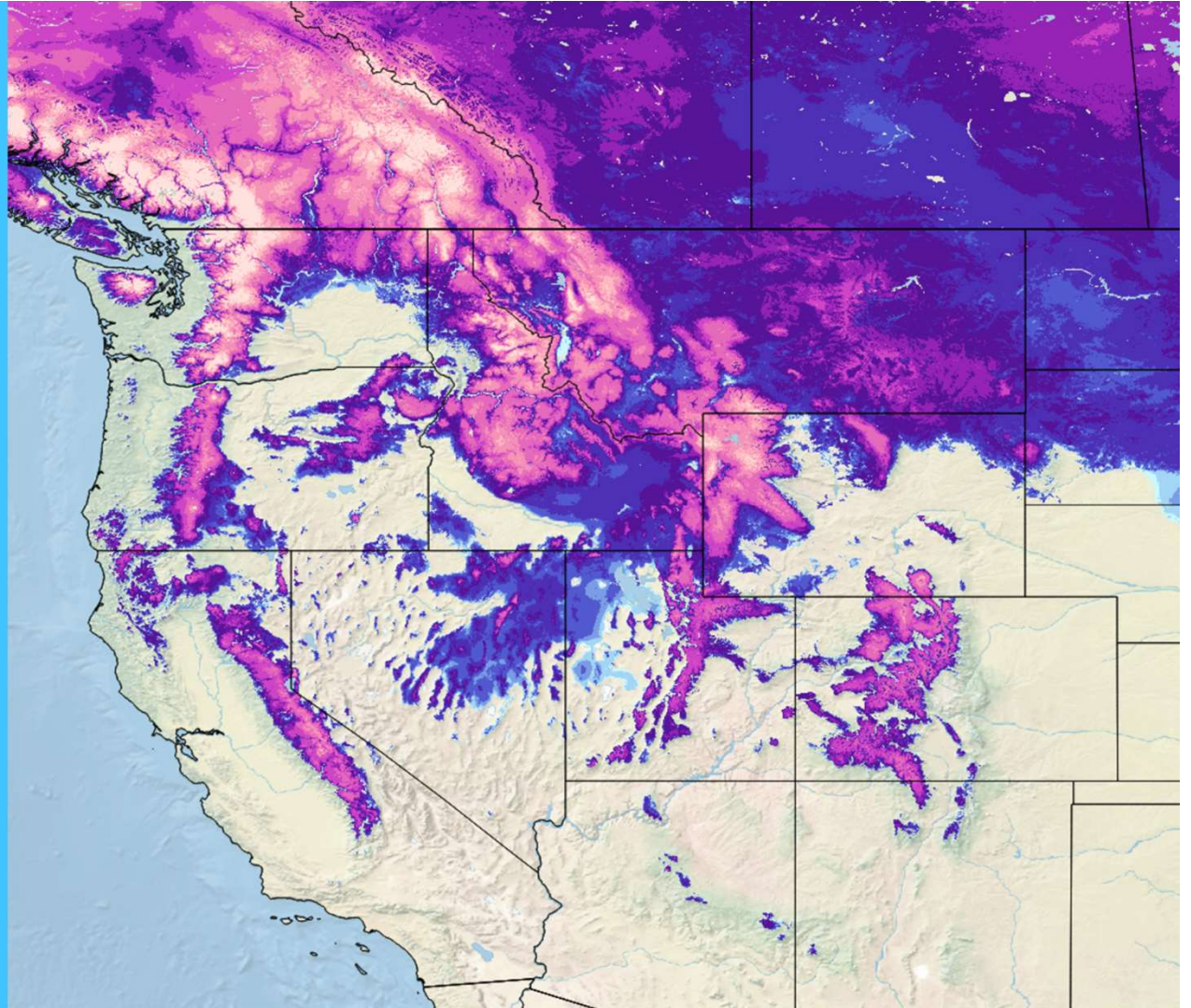
Quick Query Links
Get Time Series for Station ID: Go Listing
Get Time Series for Basin ID: ABRFC Go Listing
Get Basin Averages for: RFC Go Listing
Get Climatology for Station ID: Go Listing



National Snow Analysis

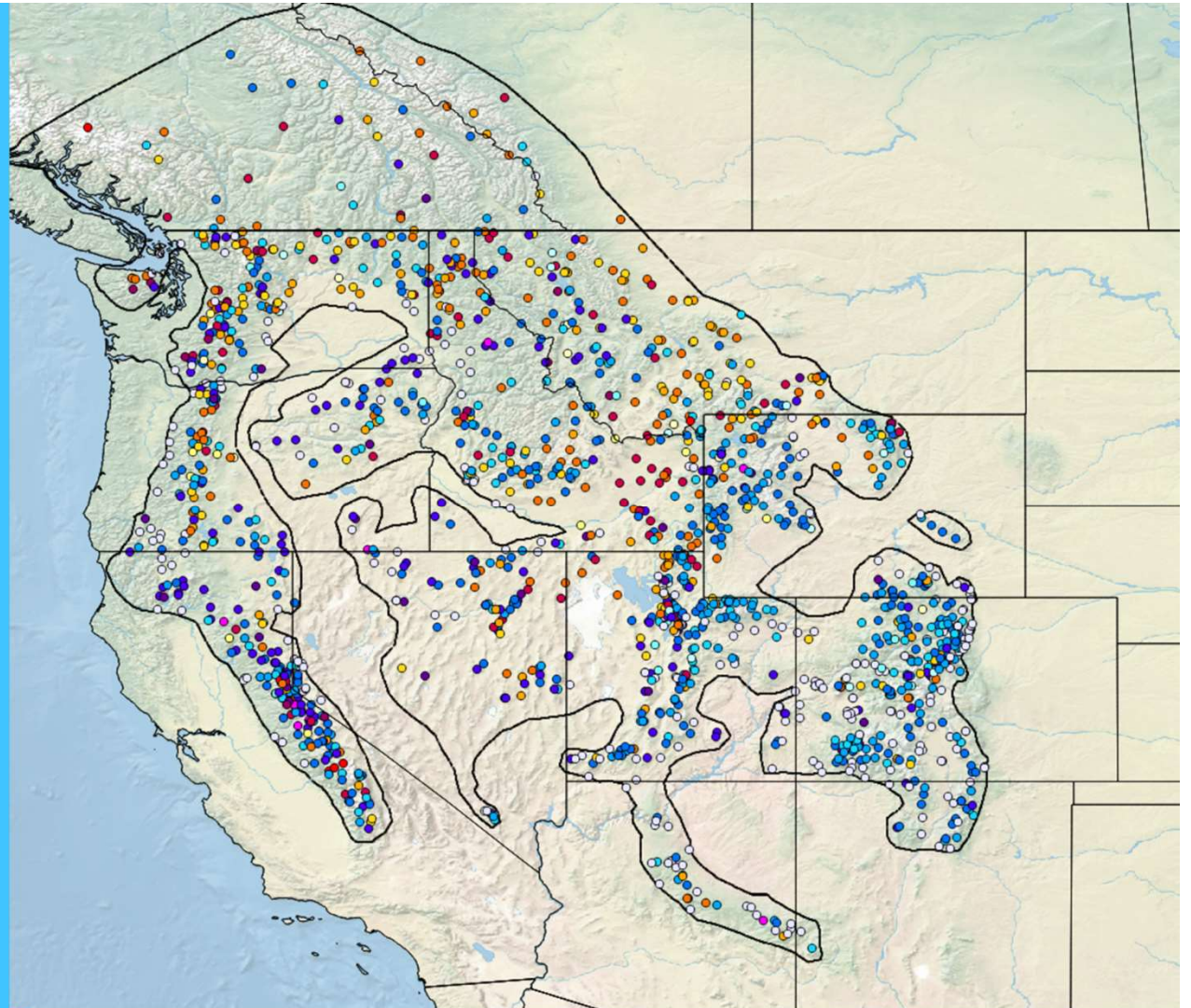


SNODAS SWE,
2018-03-09



Observed - Modeled SWE, 2018-03-09

1,658 observations



SWE Observing Stations, 2018-03-09

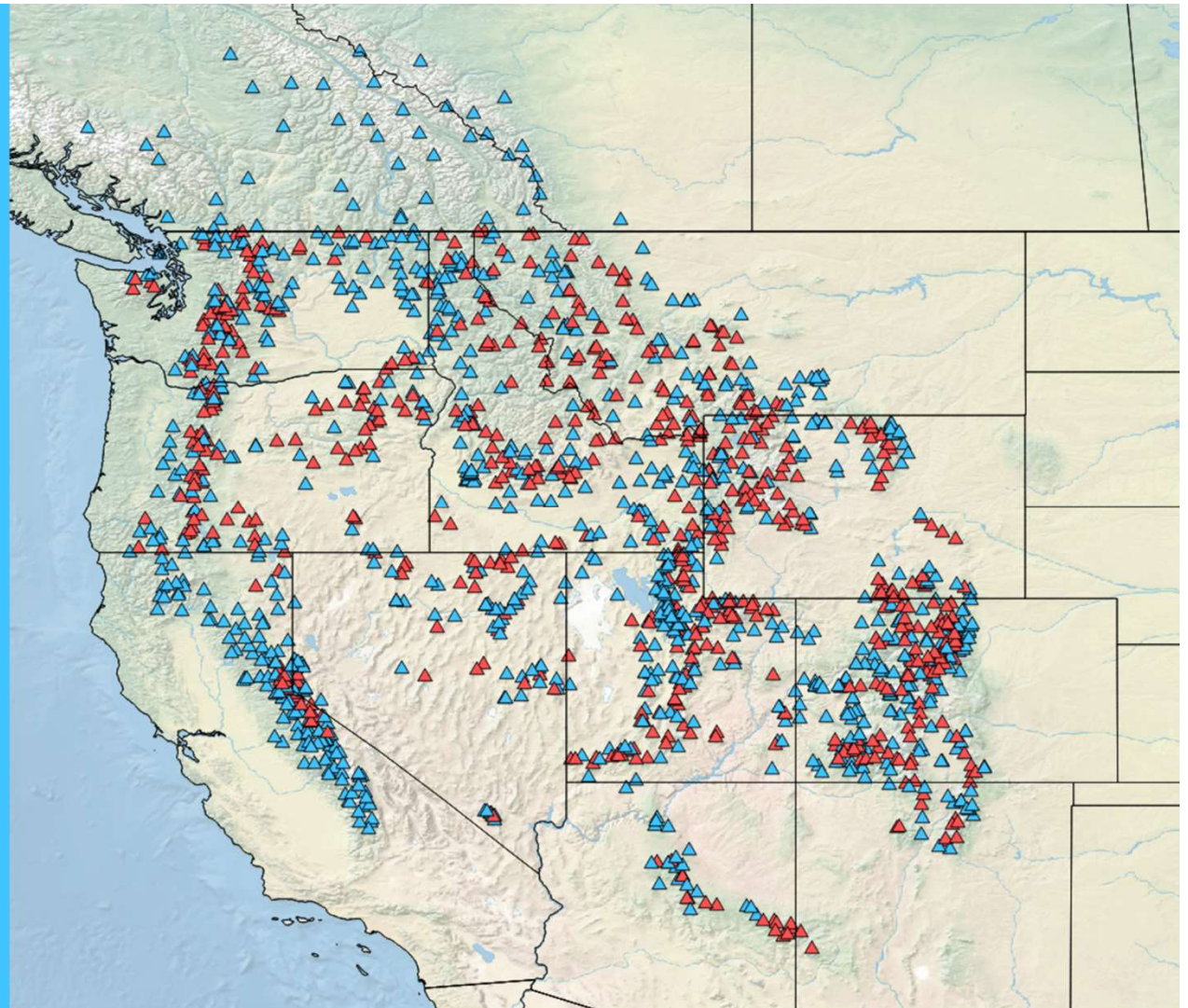
- 1,658 observations
- 684 SNOTEL
- 974 non-SNOTEL (ASOS, COOP, CoCoRaHS, HADS, and others)



SNOTEL (41%)

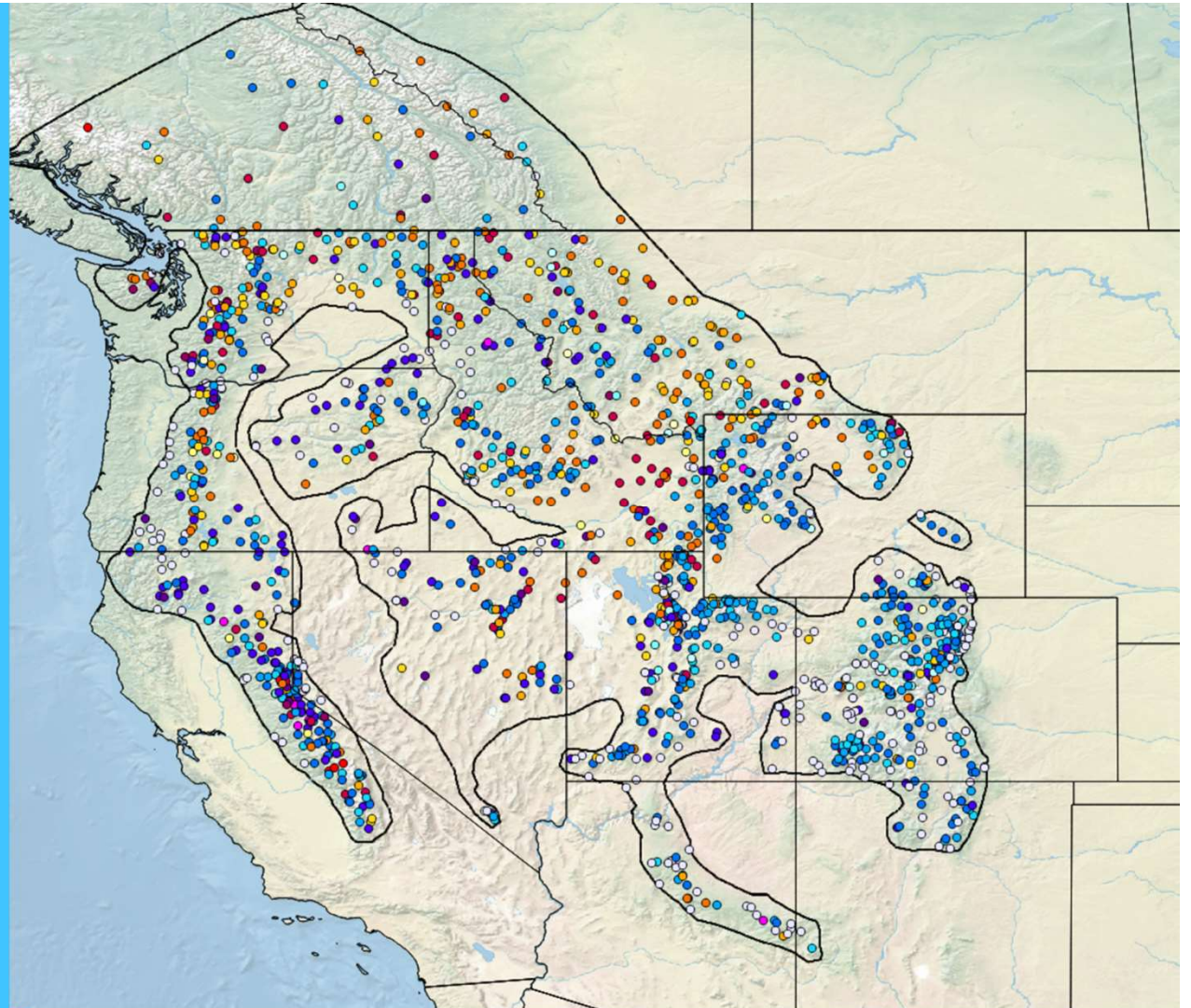


non-SNOTEL (59%)

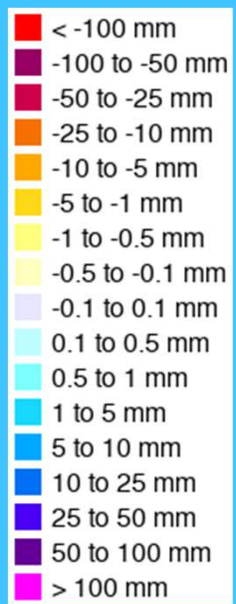


Observed - Modeled SWE, 2018-03-09

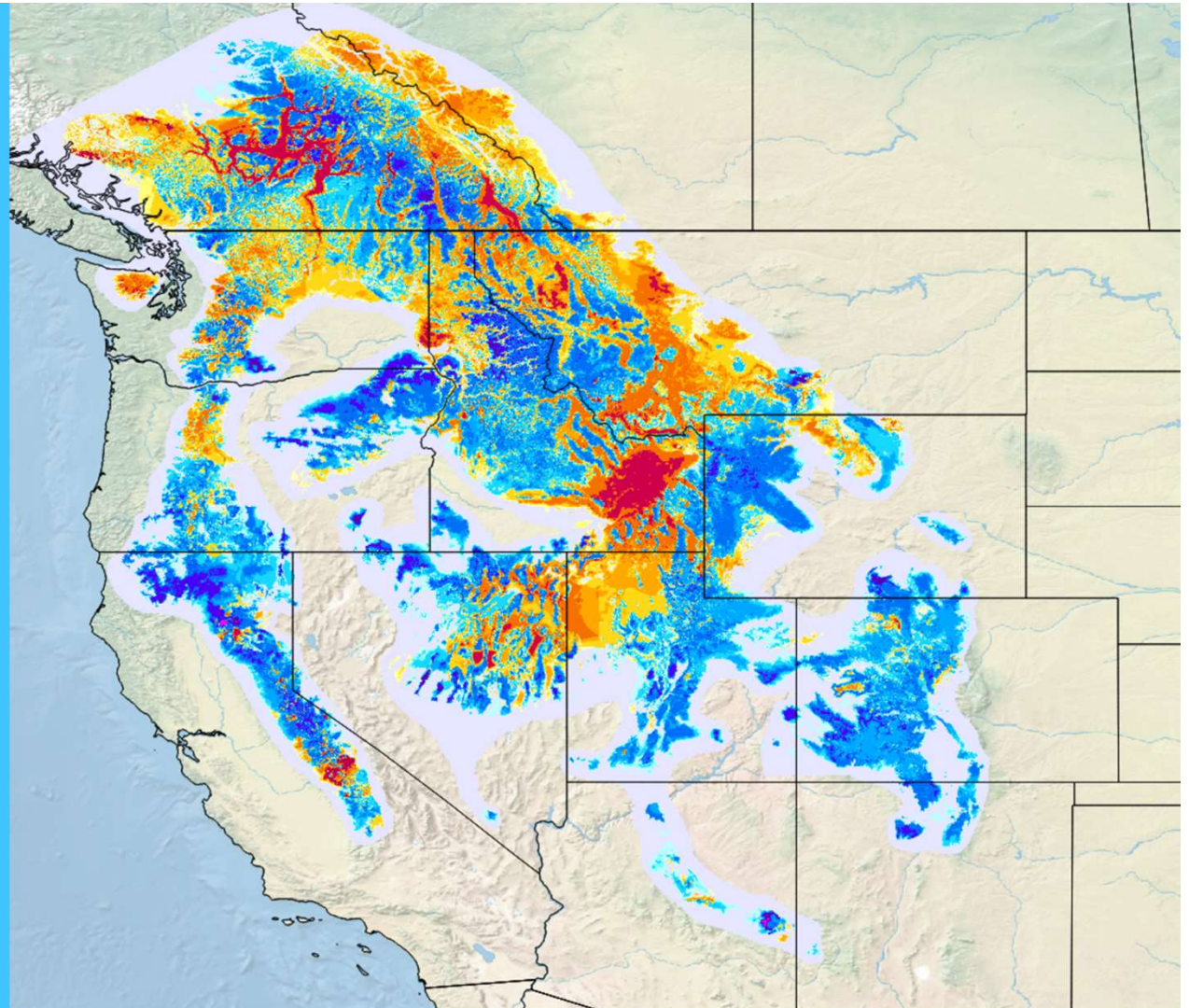
1,658 observations



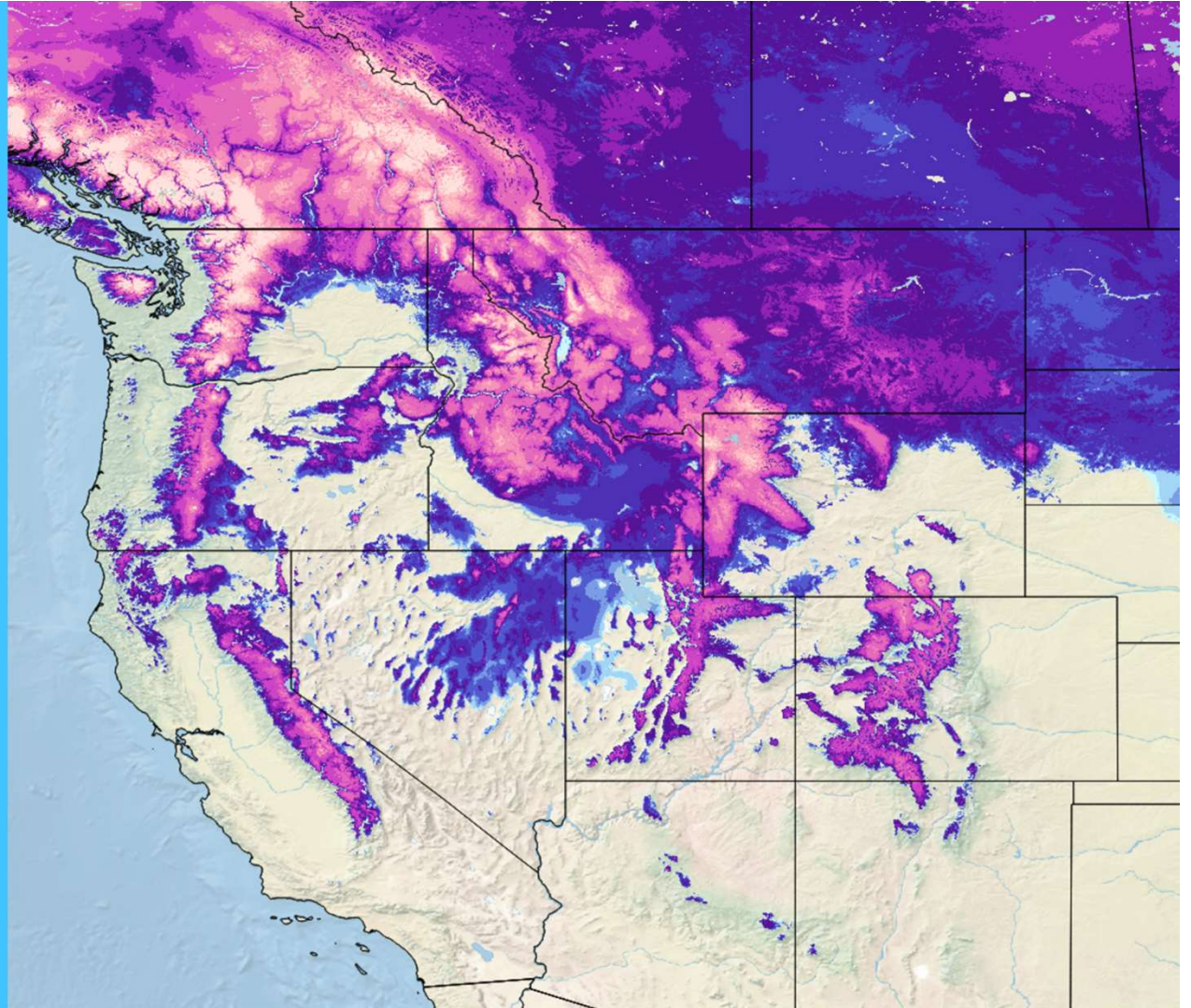
SWE Nudging, 2018-03-09



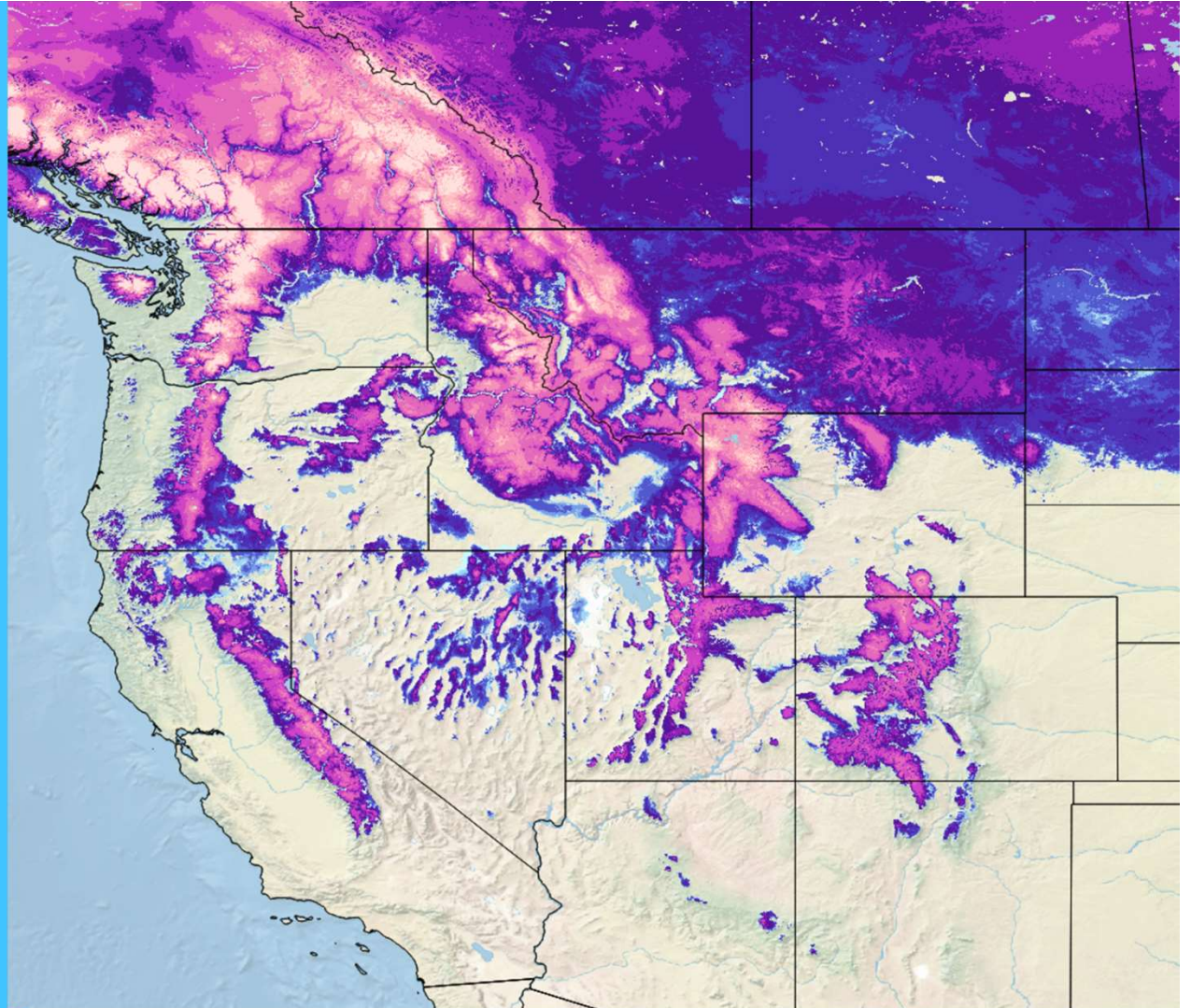
Observed - Modeled SWE



SNODAS SWE,
2018-03-09



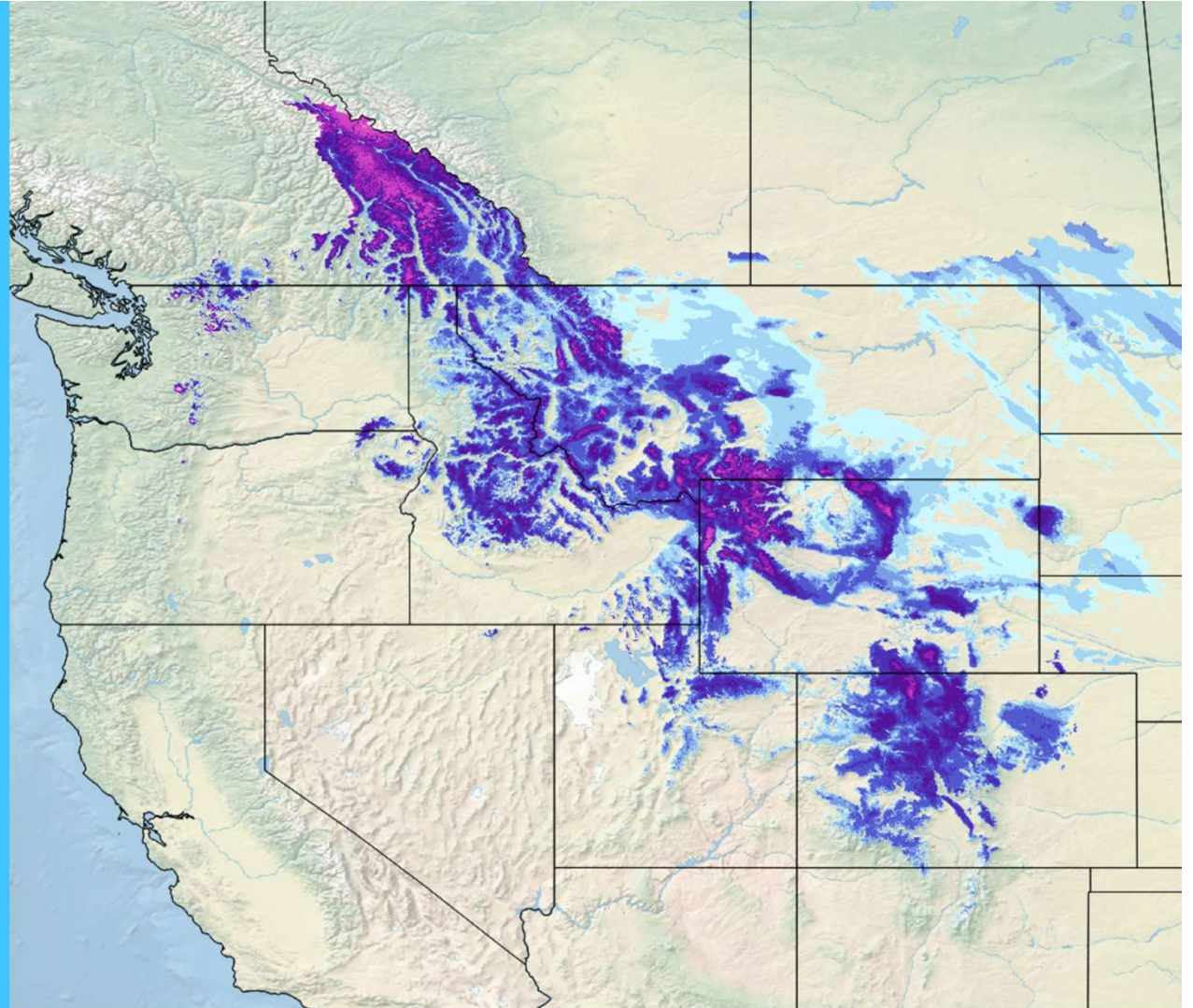
SNODAS SWE,
2018-03-10



SNODAS Period of Record Normals

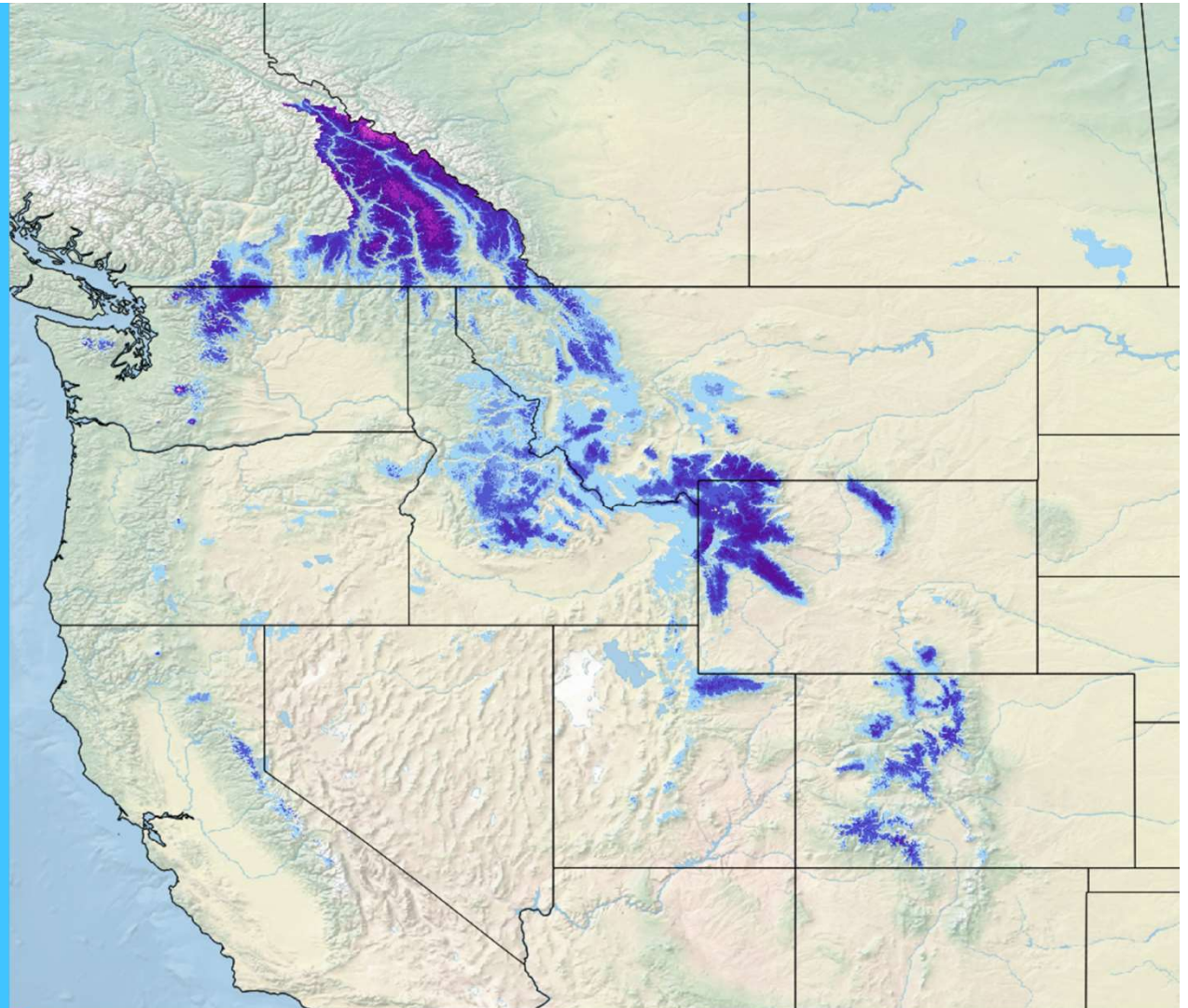
- Period of record begins in October 2004 and includes all 15 completed water years.
- For each day of the water year, period-of-record statistics are calculated and present conditions are compared with those normals.
- Comparisons between daily SNODAS model states and period-of-record normals provides valuable context for evaluating present conditions.

SNODAS SWE,
2019-11-05



SNODAS Median SWE, 11- 05

Period of Record:
October 2004-September 2019
(15 years)

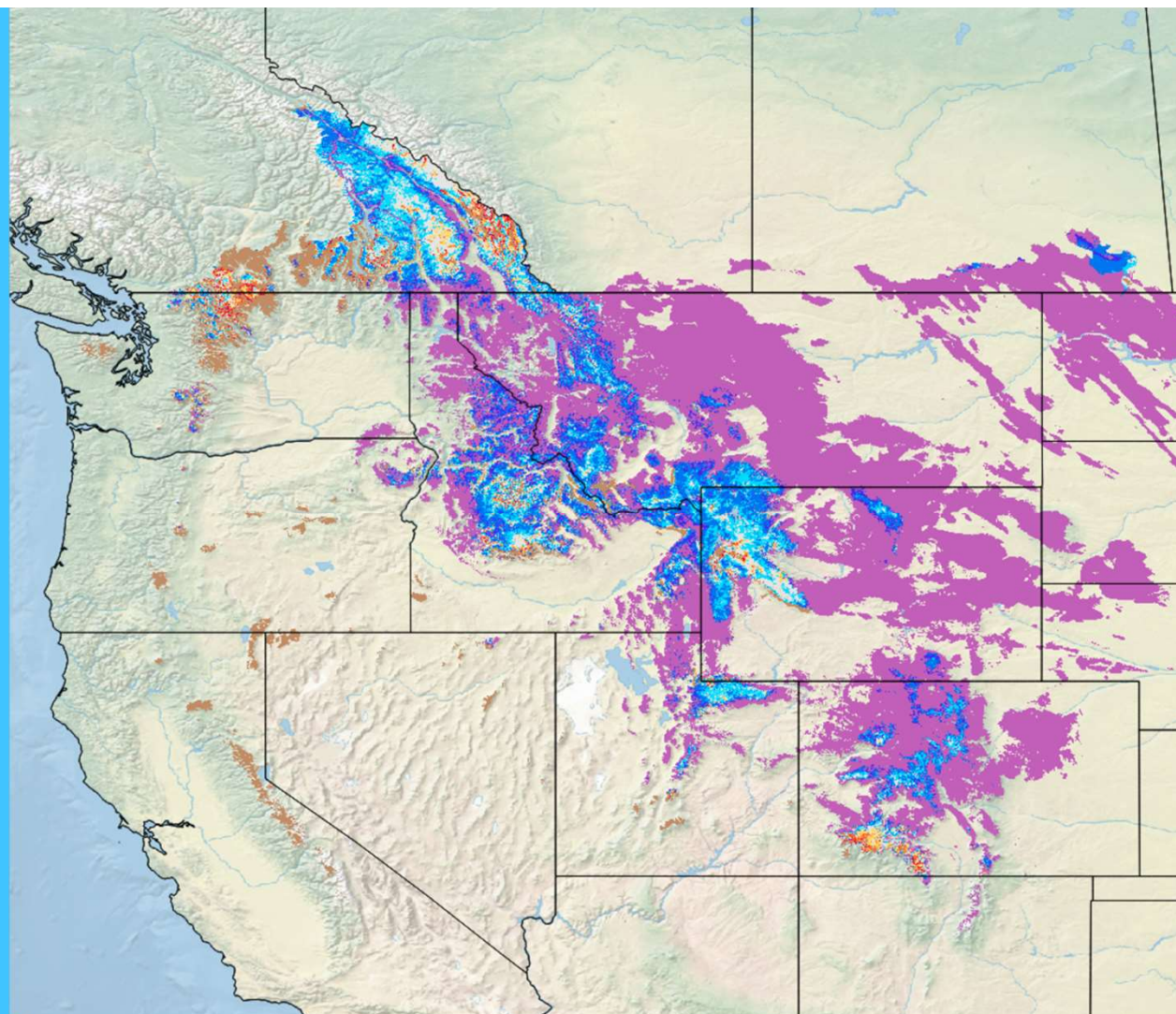


SNODAS % Median SWE, 2019-11-05

Period of Record:
October 2004-September 2019

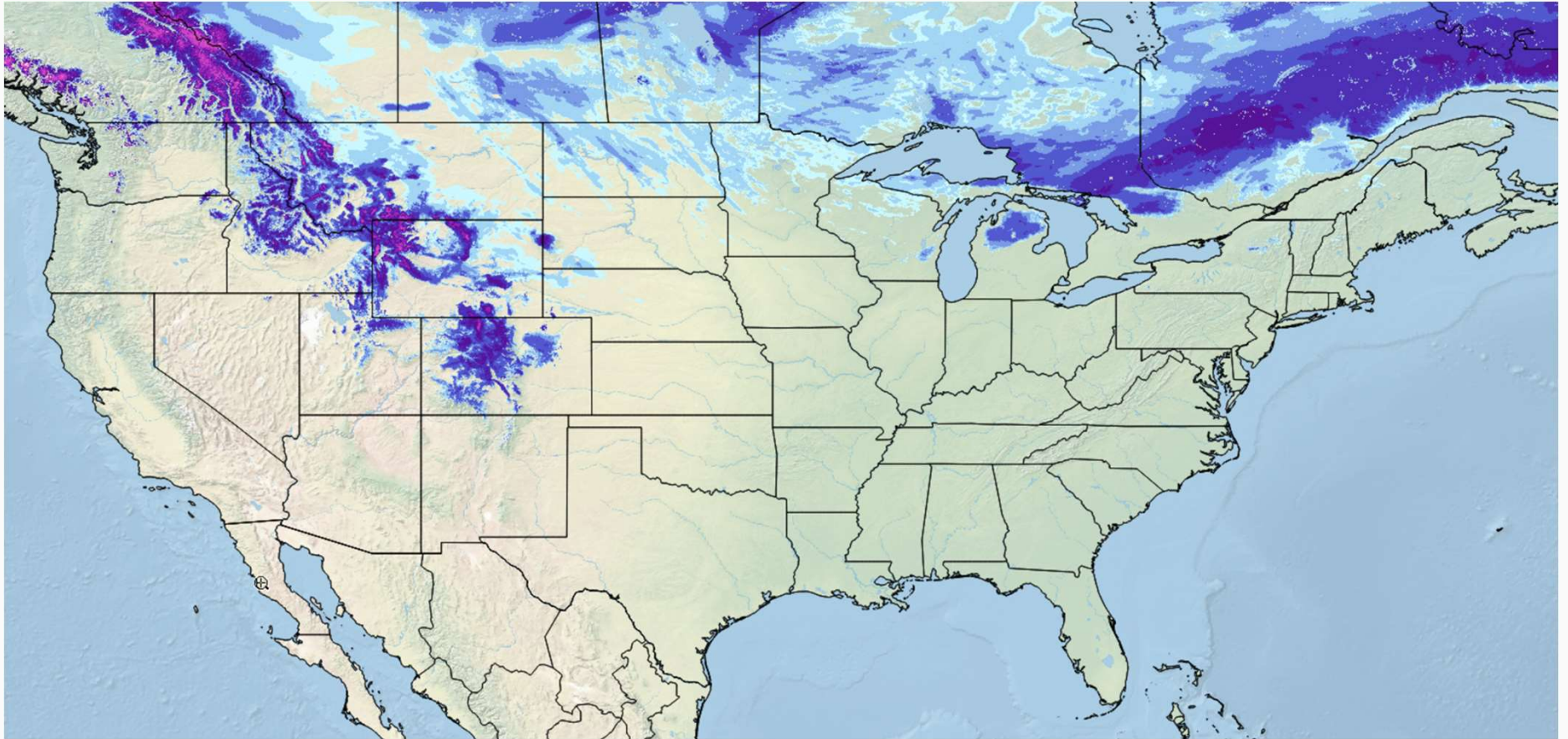


Percent of
15-Year Median

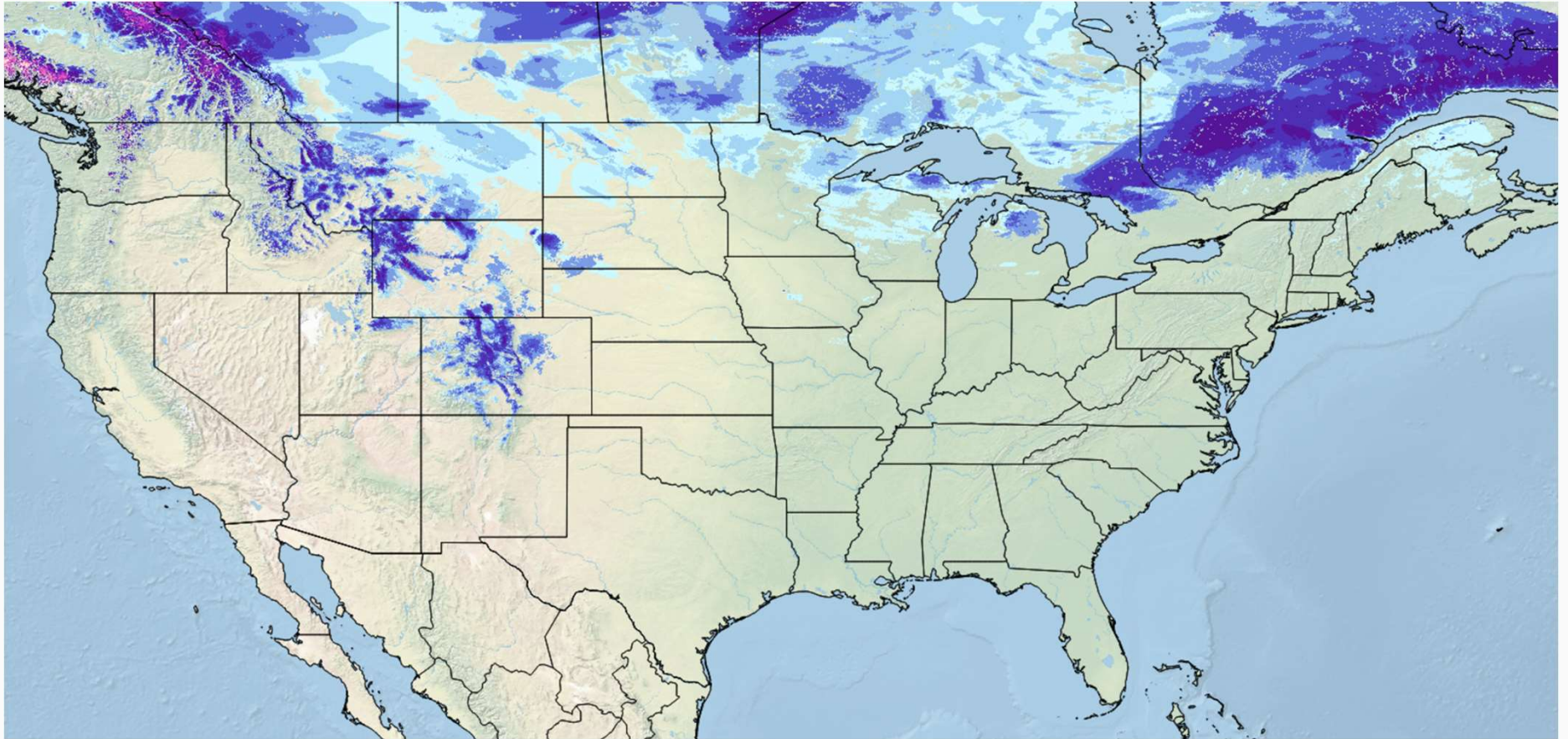


The National Water Model (NWM) is a hydrologic modelling framework that simulates observed and forecast streamflow over the entire continental United States (CONUS).

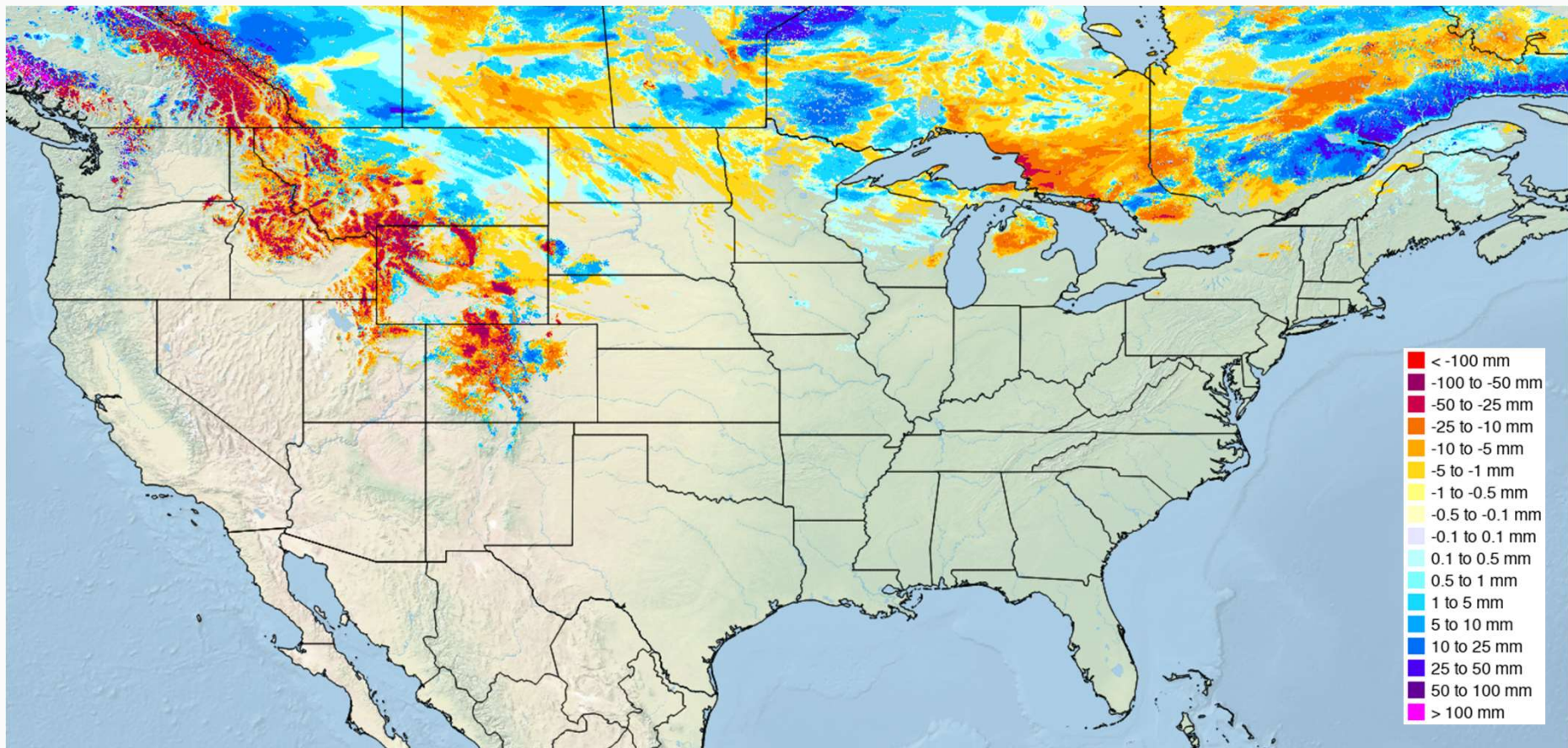
<https://water.noaa.gov/about/nwm>



SNODAS SWE, 2019-11-05 12Z



National Water Model SWE, 2019-11-05 12Z



NWM - SNODAS SWE Difference, 2019-11-05 12Z

SNODAS and the National Water Model

- The Office of Water Prediction (OWP) seeks to improve its land surface analysis and water prediction.
- From the NWM perspective, land surface analysis states are also initial states for predicting streamflow.
- Programatically, SNODAS and NWM snow estimation represent a duplicity of capabilities. OWP seeks in the long term to unify these, and in doing so to improve our snow analysis and water prediction capabilities.

SNODAS and the National Water Model

- Merging the snowpack analysis capabilities of SNODAS and the NWM means:
 - Implementing snow data assimilation capabilities into the NWM;
 - Developing an assimilation process whereby *both* snowpack analysis and streamflow forecasting in snowmelt dominated areas are improved in the NWM.
- There will exist tensions between the NWM emphasis on streamflow prediction and the SNODAS emphasis on land surface analysis.

SNODAS and the National Water Model

- Potential benefits to SNODAS:
 - Improved automated QC of gauge observations;
 - Improved objectivity in snow DA preprocessing (selection of regions and observations to include in assimilations);
 - Increased sophistication in snow DA methodology.
- We also intend to operationalize new remote sensing observations for snow data assimilation—particularly those collected by the next generation of operational airborne sensors.

Transparency

- The lack of citable literature on the SNODAS model and assimilation system is a longstanding problem.
- We are initiating a SNODAS Documentation Project, which will:
 - Document the SNODAS model physics, forcing engine, parameter data, and assimilation processes;
 - Evaluate model forcings and estimate uncertainty in nudging grids;
 - Distribute detailed information on assimilation activities *since day one*, including observations used in each assimilation, region delineations, and nudging grids.

Gregory.Fall@noaa.gov

Abstract

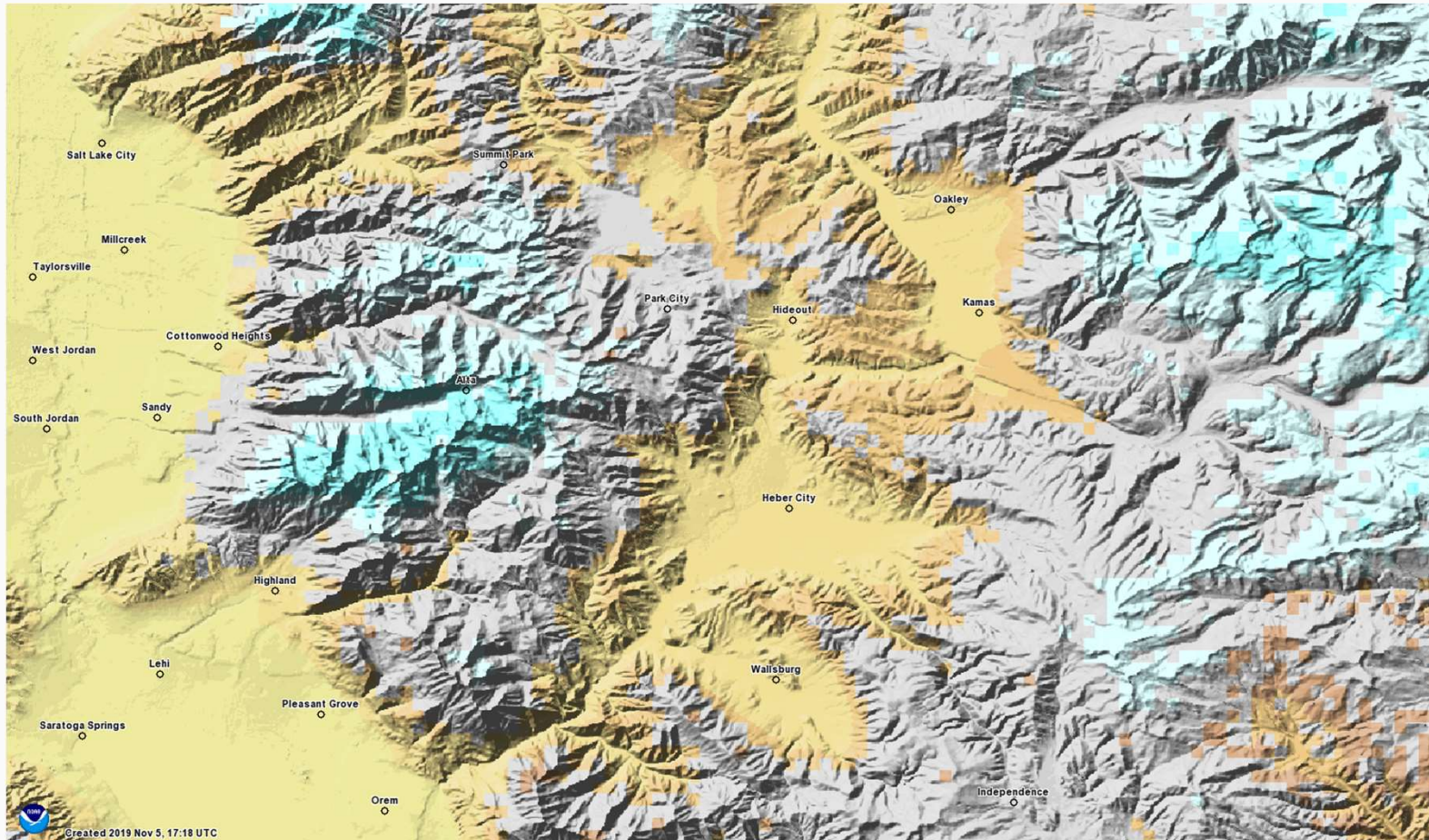
The National Weather Service (NWS) Office of Water Prediction (OWP)—Chanhassen, MN (formerly the National Operational Hydrologic Remote Sensing Center, or NOHRSC) operates the National Snow Analysis (NSA), which, via the Snow Data Assimilation System (SNODAS) system, combines a snowpack mass and energy balance model with routine assimilation of surface and airborne observations of snow depth and snow water equivalent over the Conterminous United States and southern Canada. The NSA has produced operational snow analysis at 1 km spatial resolution and 1-hour temporal resolution for 15 seasons since operations began in October 2004. Data from SNODAS and the NSA is used by a wide variety of clients and stakeholders for situational awareness, resource management, and disaster prediction and preparation.

Since 2016, OWP has operated the National Water Model (NWM), which includes a land surface snowpack model not unlike that used by the SNODAS system. Development of an operational snow assimilation capability for the NWM has begun, and in time the capabilities of SNODAS and the NWM will become merged, providing a continually improving resource for snow information and water prediction.

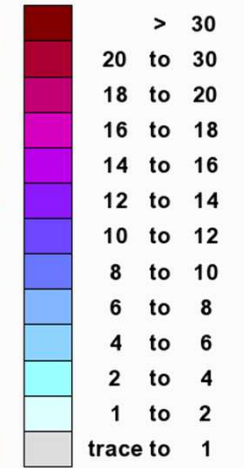
Our presentation for this session will summarize 15 years of SNODAS operations and will describe the ways in which operational snow analysis and prediction in the NWS will improve in the near future via the incorporation of new information sources and the implementation of more advanced assimilation techniques.

SNODAS Documentation Project

- Model physics
- Parameter Data
 - Evolution
- Forcings
 - Evolution RUC->RAP->HRRR
 - Downscaling
 - Correction
- Assimilation
 - Points
 - Candidates
 - Used
 - Nudging layer generation
- Transparency
 - Data
 - Contacts

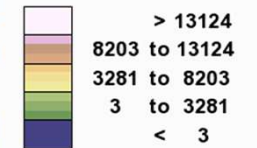


Inches of water equivalent



Not Estimated

Elevation in feet

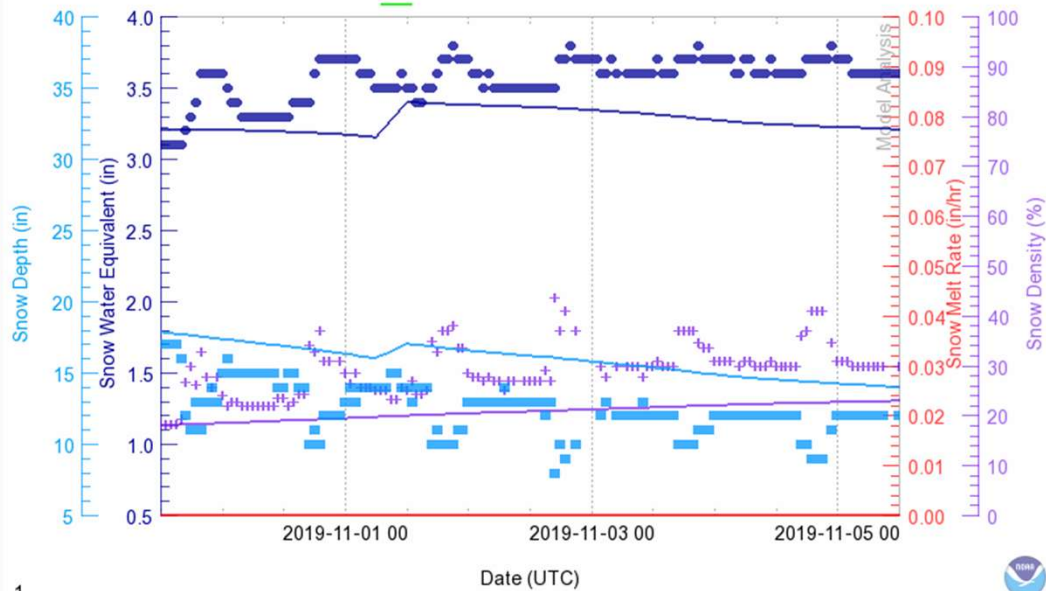


SNODAS SWE, 2019-11-05

Snow Water Equivalent, Snow Depth, and Snow Melt

Modeled and Observed

Station:	SBDU1 - SNOWBIRD	(Modeled)	(Observed)
Latitude:	40.564 N	Snow Water Equivalent	●
Longitude:	111.655 W	Snow Depth	■
Elevation:	9652 Feet	Snow Density	+
Start Date:	2019-10-30 12 UTC	Snow Melt Rate	
Stop Date:	2019-11-05 12 UTC	Assimilation	
Forest Density:	36%		
Land Use:	Deciduous Broadleaf Forest (5)		



1



Sample time series for SBDU1 (Snowbird) SNOTEL.