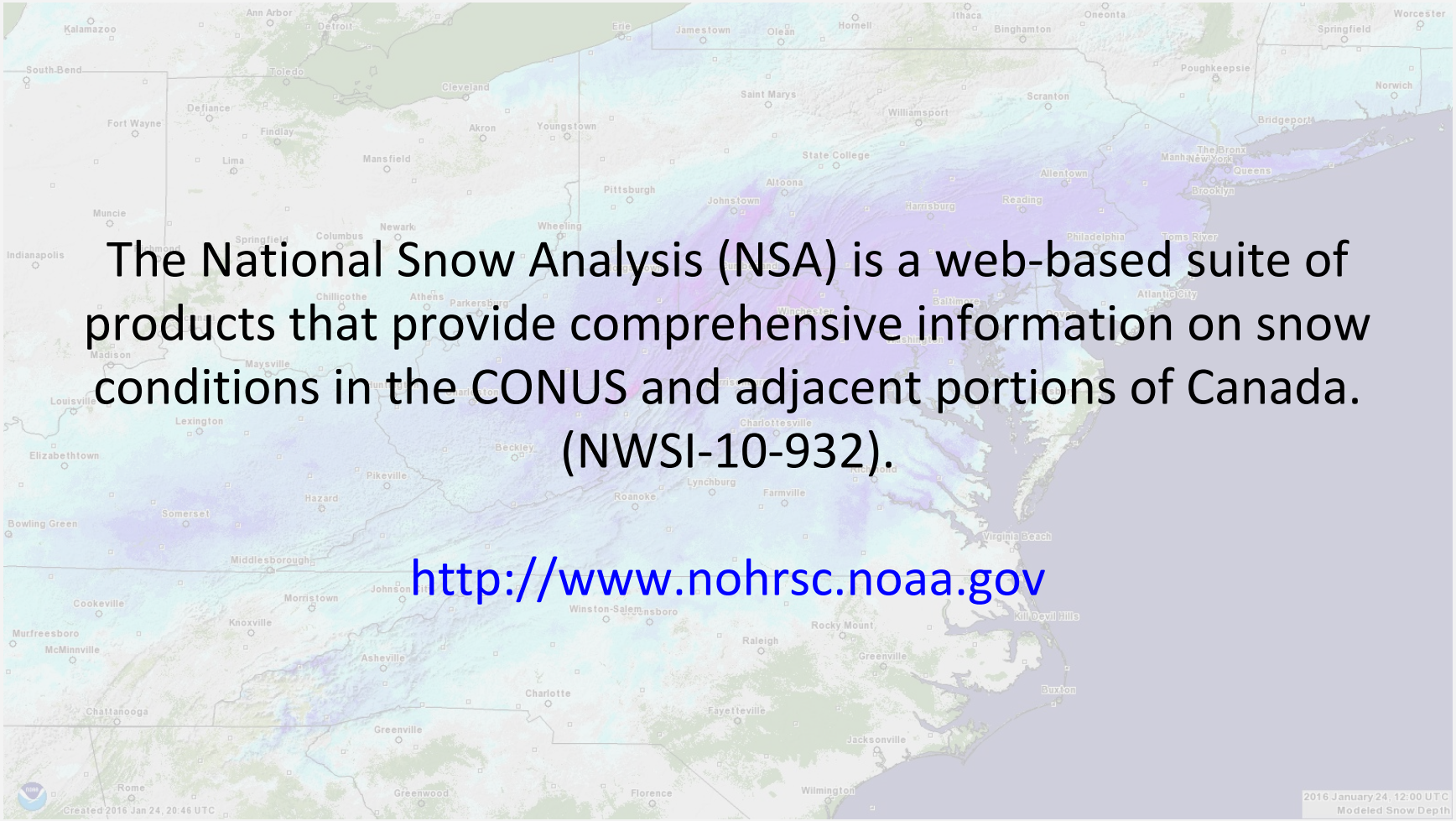
National Snow Analysis: 13 Years of Operations

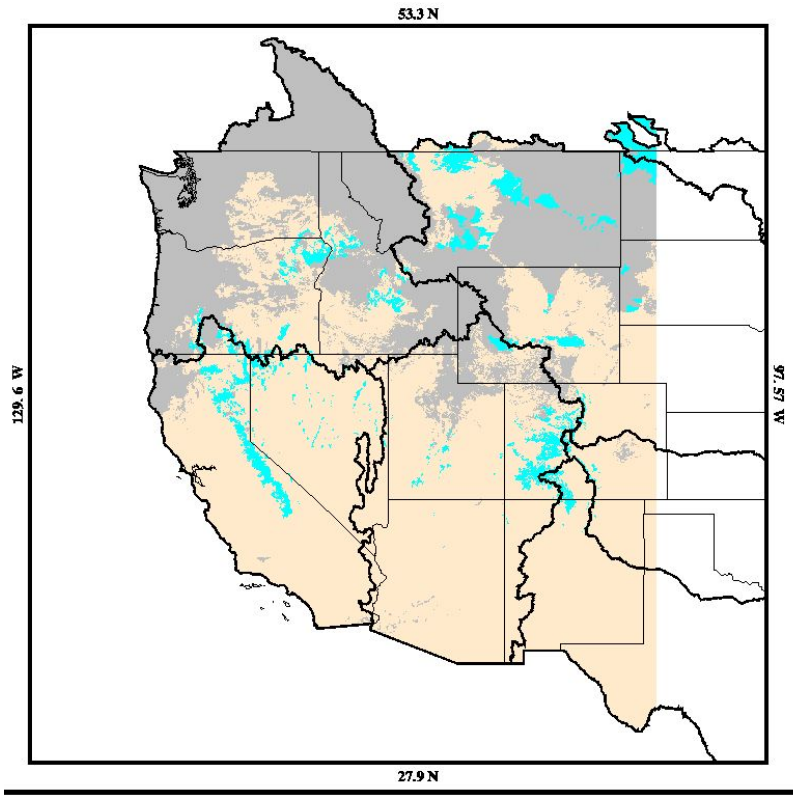
Greg Fall, NSA Operations Lead
Office of Water Prediction—Chanhassen, MN (NOHRSC)

NSA Operations Team:
Shawn Carter, Sanian Gaffar, Anders Nilsson, Carrie Olheiser, Kent Sparrow, Tim Szeliga



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

http://www.nohrsc.noaa.gov



SATELLITE SNOW COVER

19-22 Nov 1998

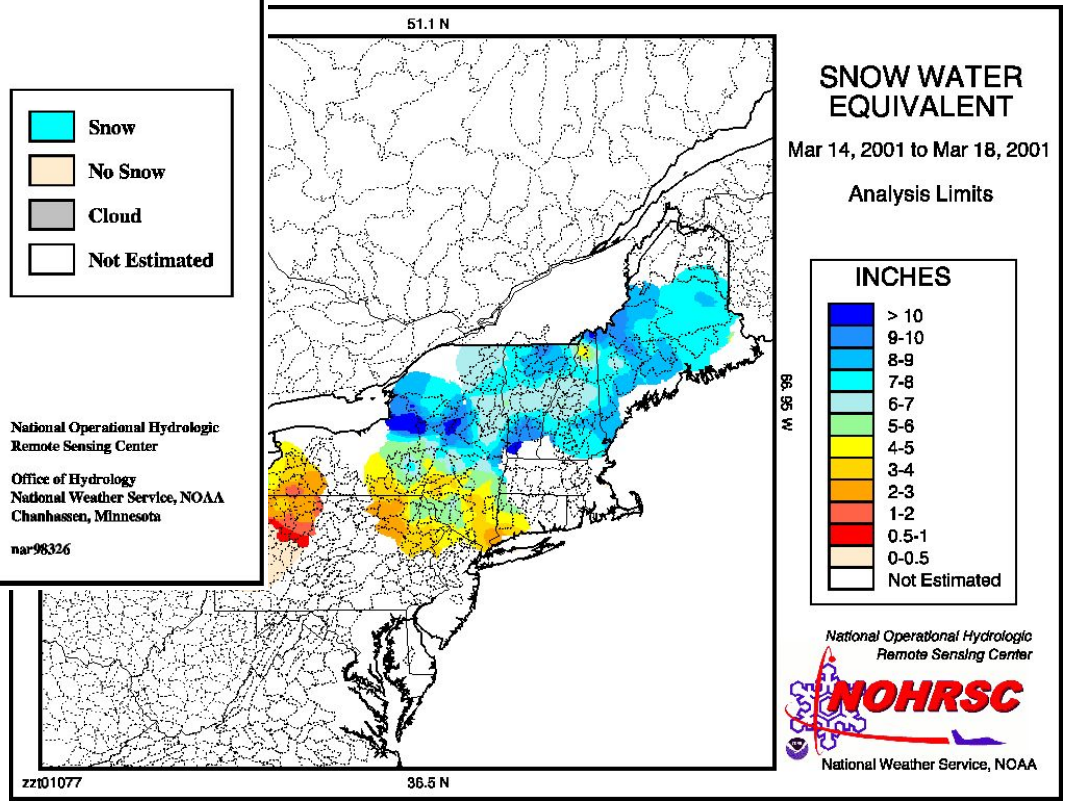
North America

- Snow
- No Snow
- Cloud
- Not Estimated

National Operational Hydrologic
Remote Sensing Center

Office of Hydrology
National Weather Service, NOAA
Chanhassen, Minnesota

nar98326



SNOW WATER EQUIVALENT

Mar 14, 2001 to Mar 18, 2001

Analysis Limits

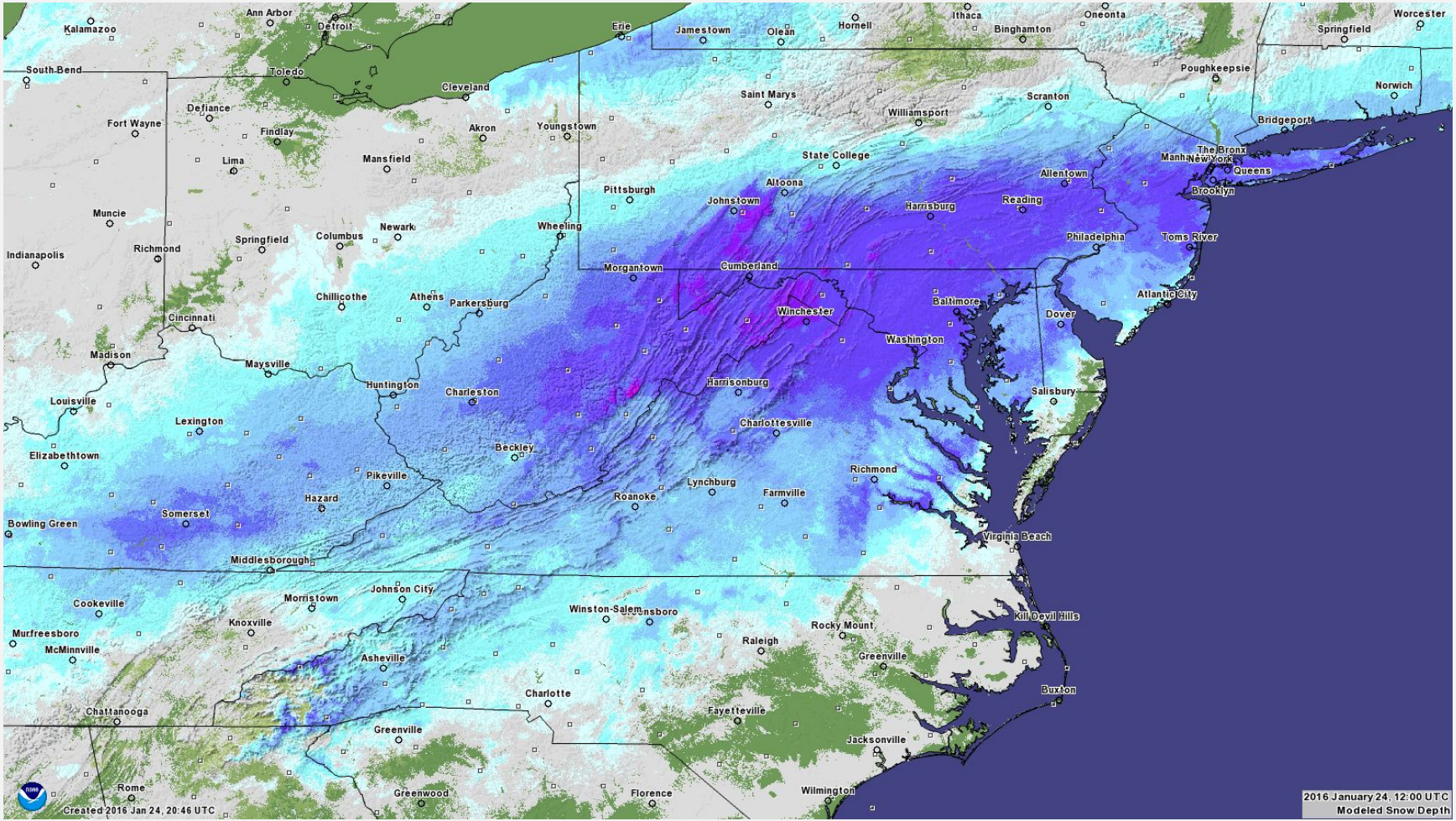
INCHES

- > 10
- 9-10
- 8-9
- 7-8
- 6-7
- 5-6
- 4-5
- 3-4
- 2-3
- 1-2
- 0.5-1
- 0-0.5
- Not Estimated

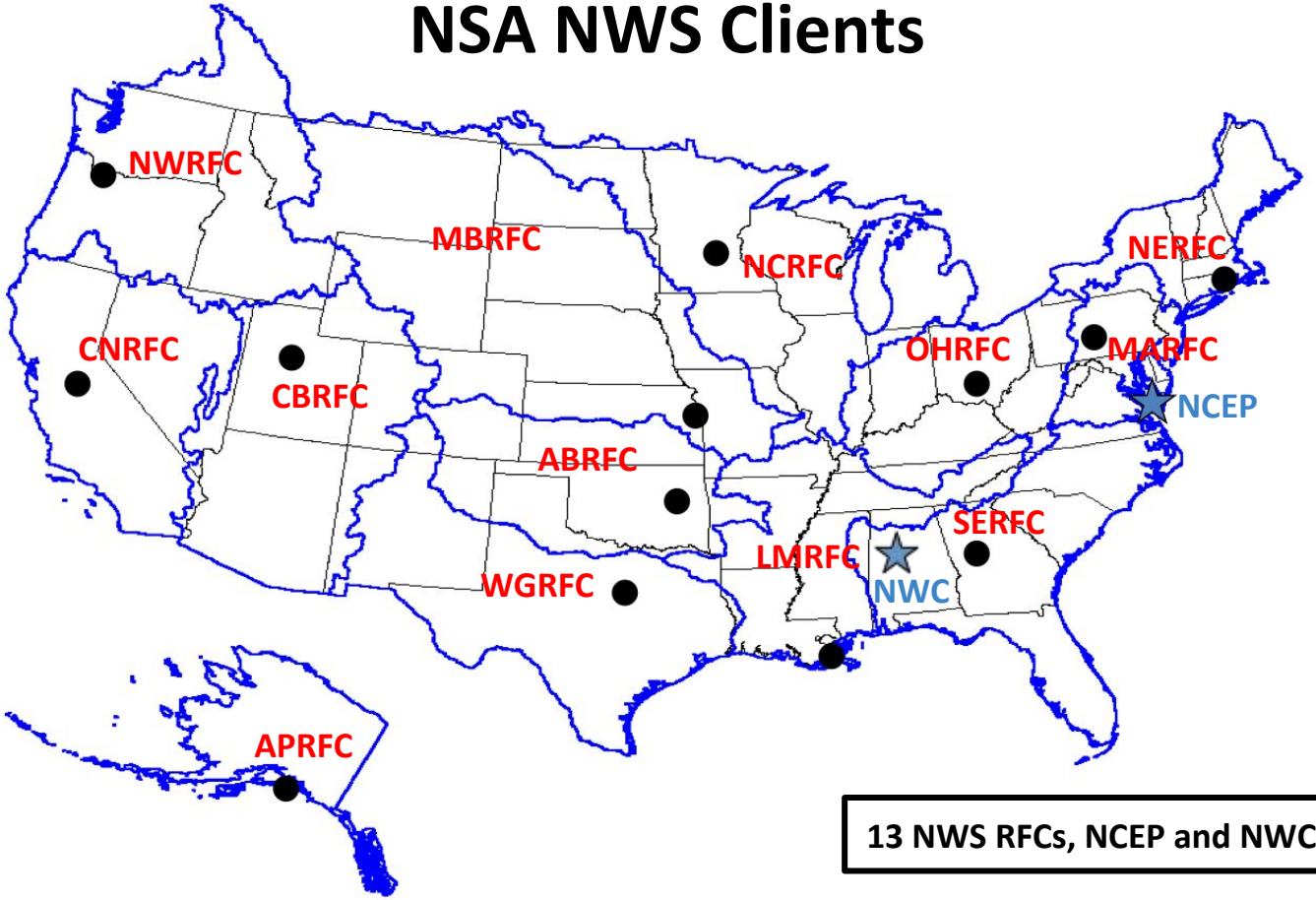
National Operational Hydrologic
Remote Sensing Center

NOHRSC

National Weather Service, NOAA


Kalamazoo
Ann Arbor
Detroit
Erie
Jamestown
Olean
Hornell
Ithaca
Binghamton
Oneonta
Springfield
Worcester
South Bend
Toledo
Cleveland
Saint Marys
Poughkeepsie
Norwich
Defiance
Scranton
Williamsport
Fort Wayne
Findlay
Akron
Youngstown
Bridgeport
Lima
Mansfield
State College
The Bronx
Manhattan
New York
Queens
Allentown
Brooklyn
Pittsburgh
Altoona
Johnstown
Harrisburg
Reading
Muncie
Newark
Wheeling
Springfield
Columbus
Philadelphia
Toms River
Indianapolis
Richmond
Morgantown
Cumberland
Chillicothe
Athens
Parkersburg
Baltimore
Atlantic City
Winchester
Dover
Cincinnati
Washington
Madison
Maysville
Harrisonburg
Huntington
Charleston
Salisbury
Louisville
Lexington
Charlottesville
Elizabethtown
Beckley
Richmond
Pikeville
Lynchburg
Farmville
Hazard
Roanoke
Somerset
Bowling Green
Virginia Beach
Middlesborough
Johnson City
Morristown
Cookeville
Winston-Salem
Kill Devil Hills
Knoxville
Rocky Mount
Murfreesboro
Raleigh
McMinnville
Greenville
Asheville
Buxton
Charlotte
Chattanooga
Fayetteville
Greenville
Jacksonville
Rome
Greenwood
Florence
Wilmington
Created 2016 Jan 24, 20:46 UTC
2016 January 24, 12:00 UTC
Modeled Snow Depth

NSA NWS Clients



13 NWS RFCs, NCEP and NWC

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

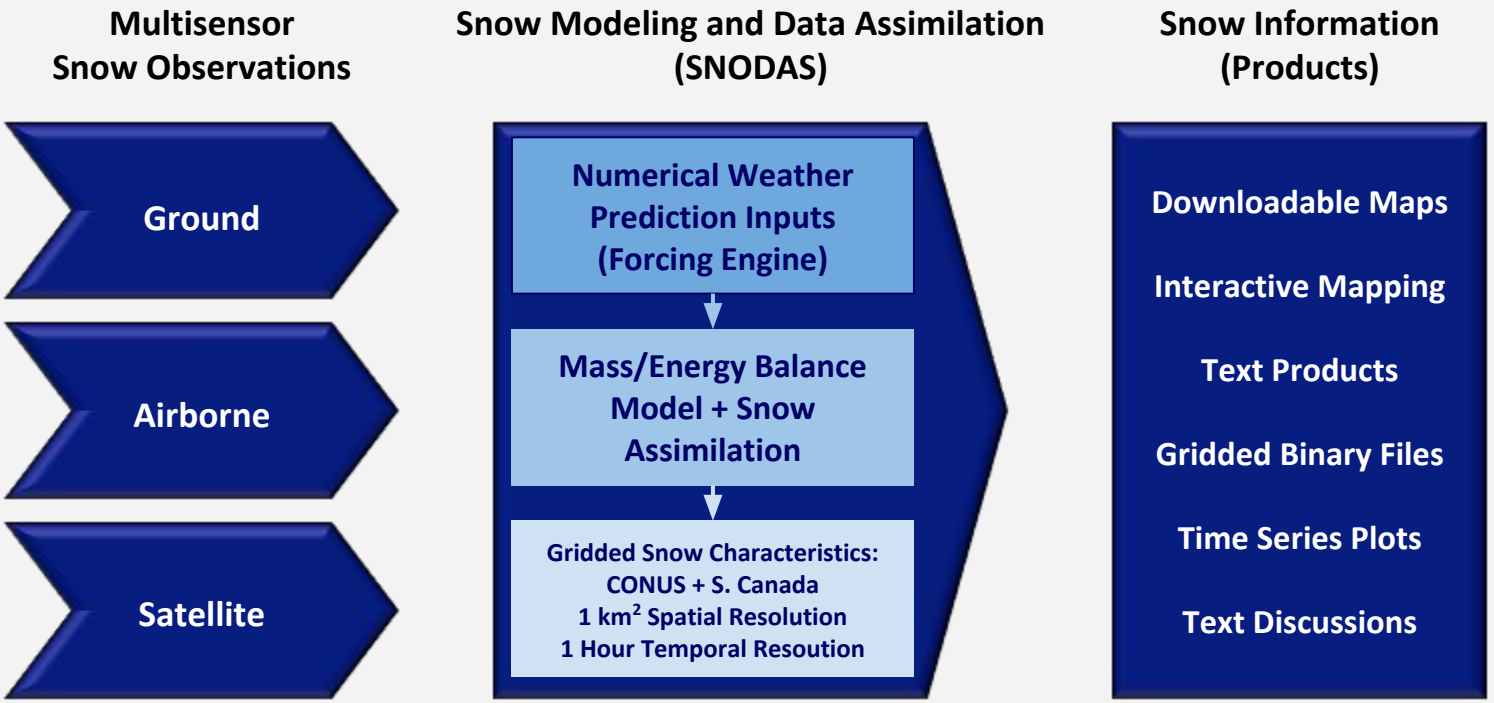
Private Sector

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

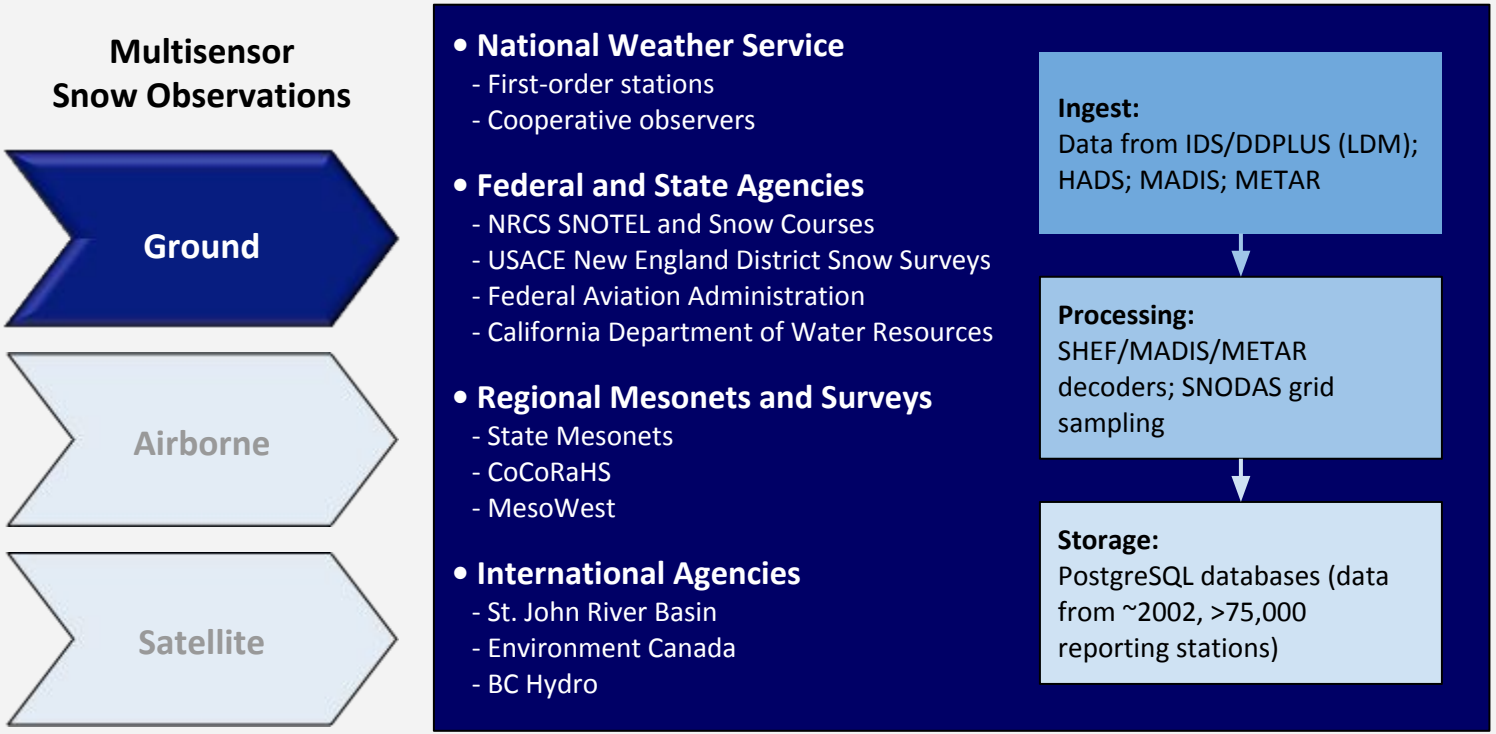
International (Canada)

- 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

National Snow Analysis

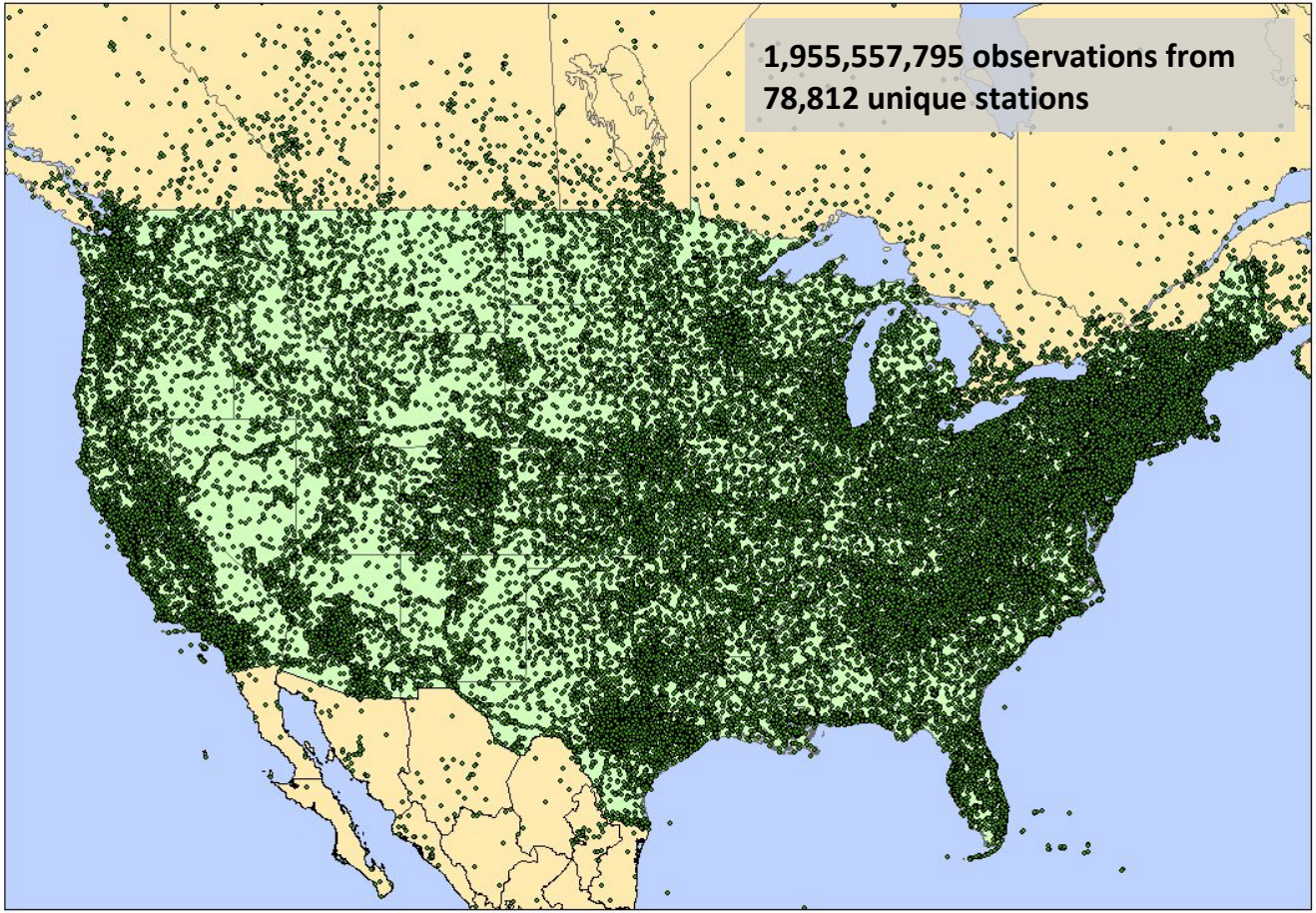


National Snow Analysis



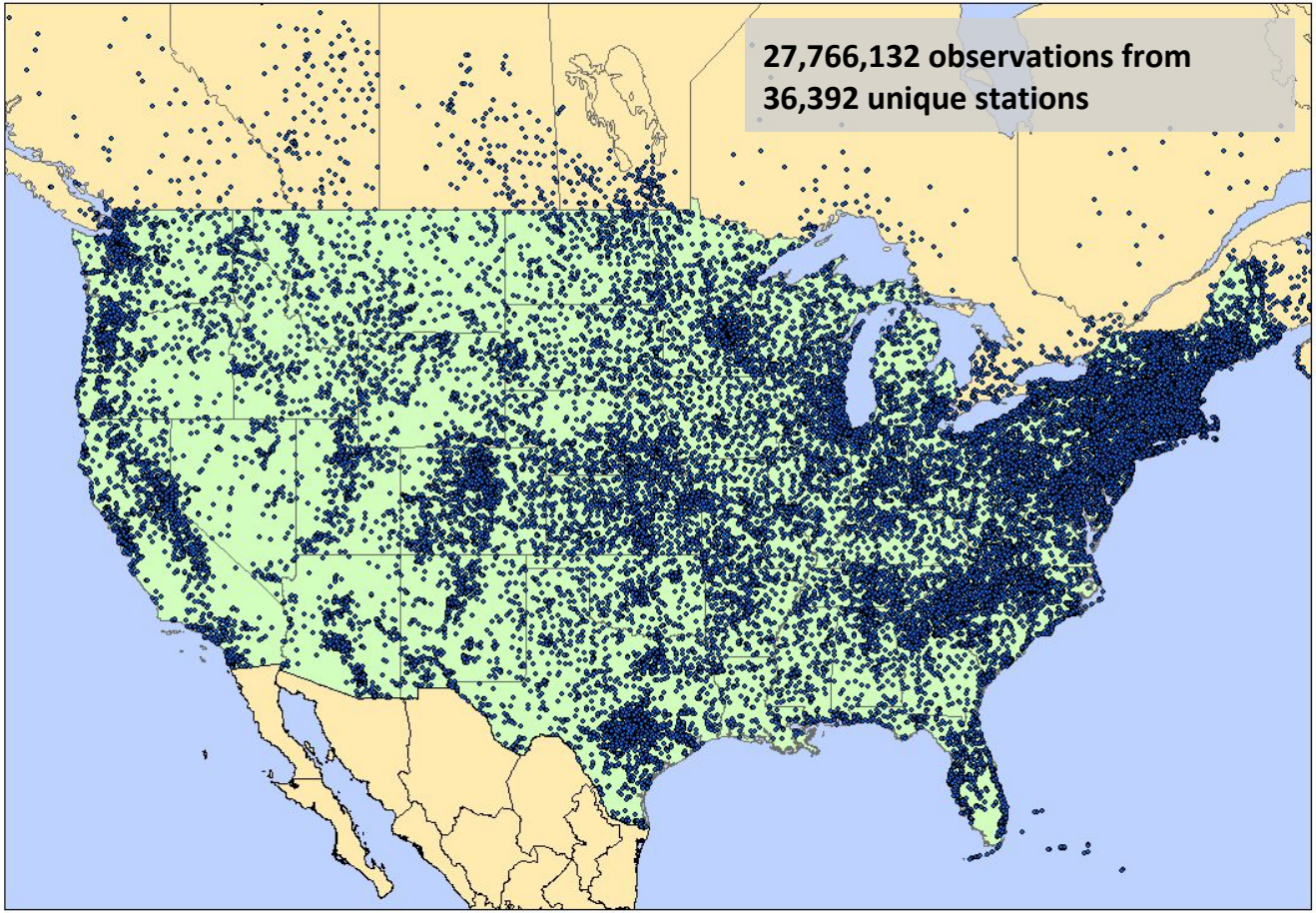
Reporting Stations: All Fields

Oct 1, 2016 - Sept 20, 2017



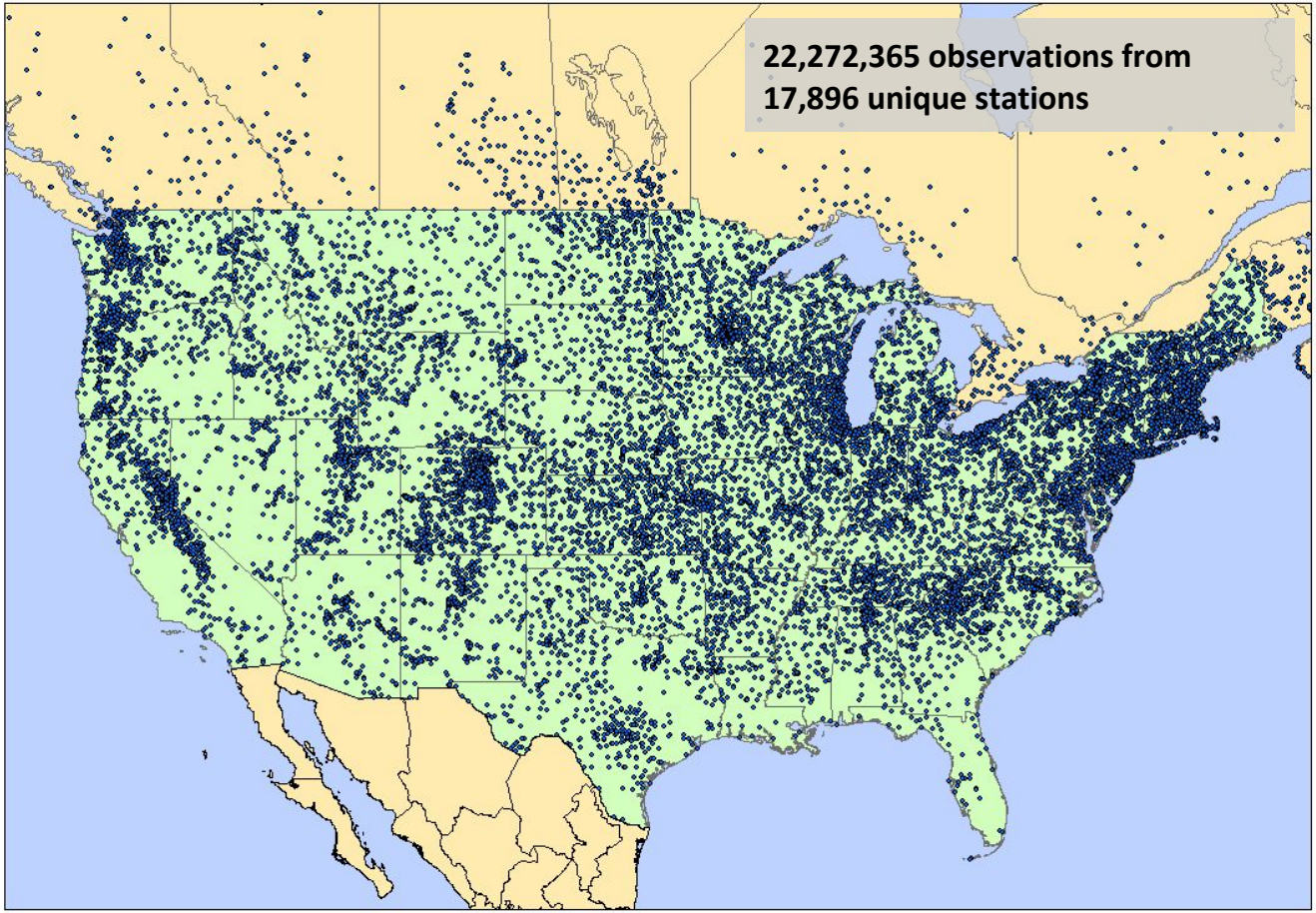
Reporting Stations: SWE, Snow Depth, and Snowfall

Oct 1, 2016 - Sept 20, 2017



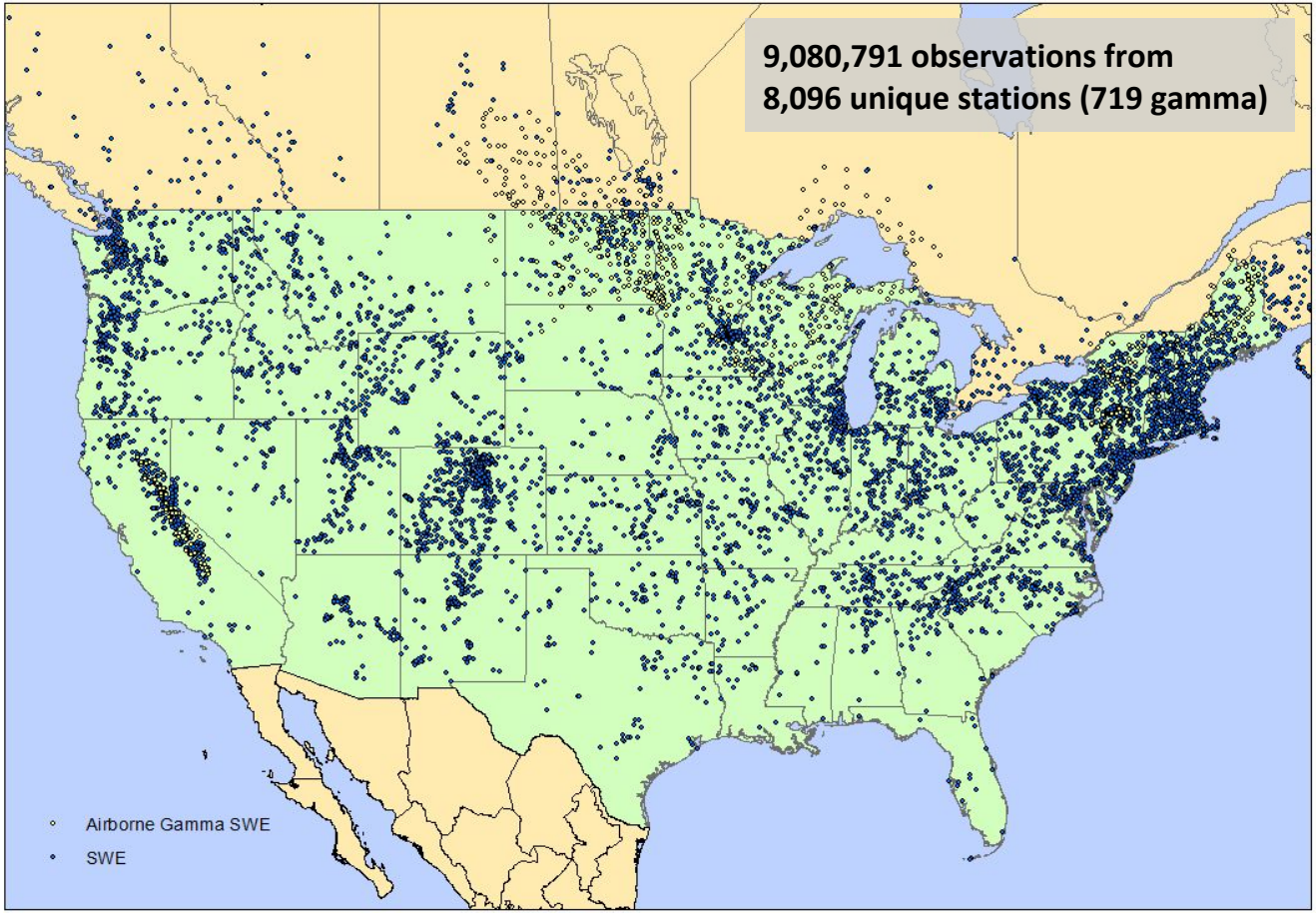
Reporting Stations: SWE and Snow Depth

Oct 1, 2016 - Sept 20, 2017



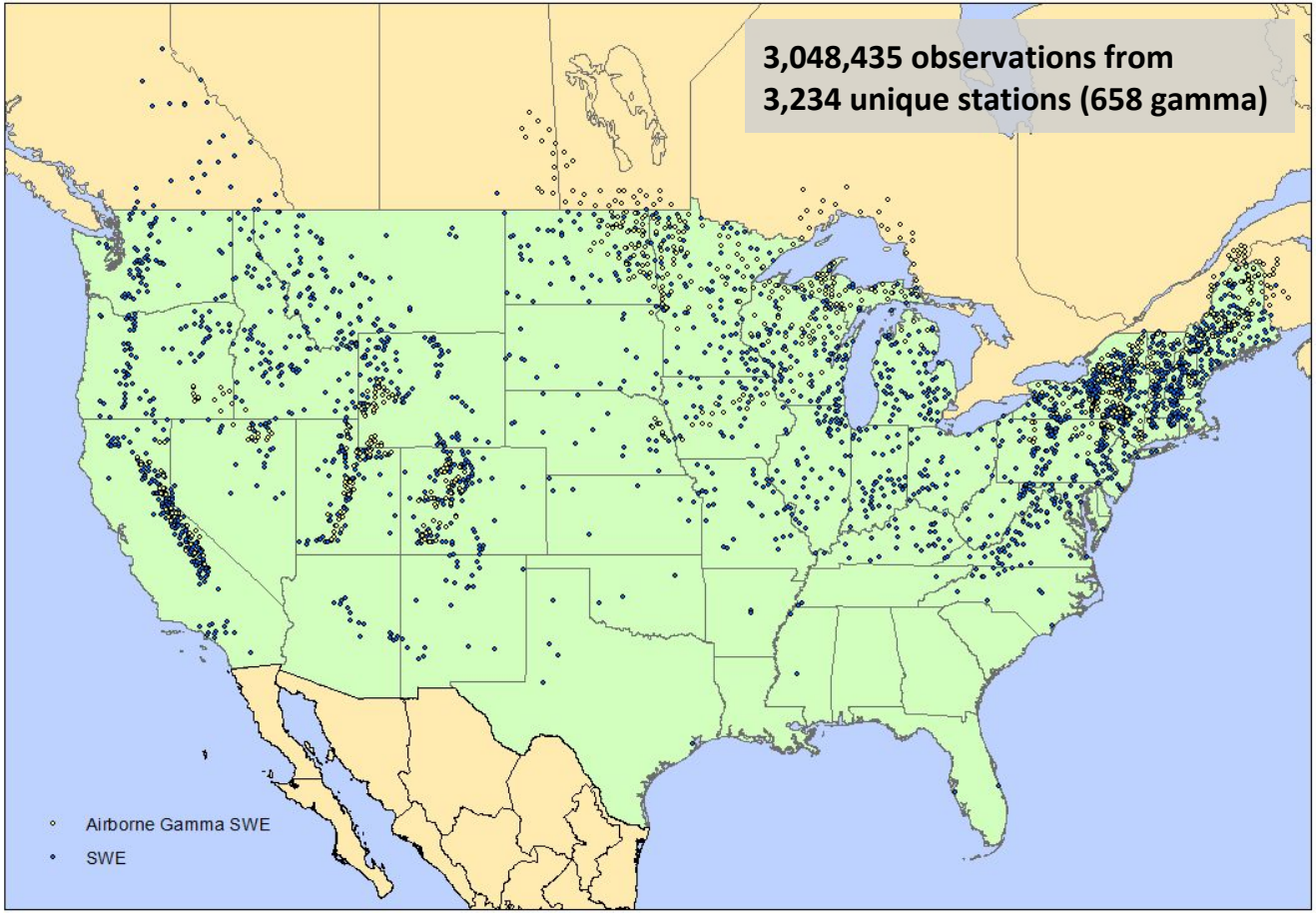
Reporting Stations: SWE

Oct 1, 2016 - Sept 20, 2017



Reporting Stations: SWE

Oct 1, 2014 - Sept 20, 2005



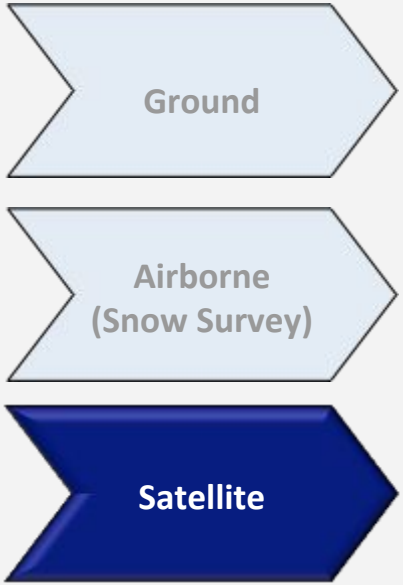
National Snow Analysis

Multisensor Snow Observations

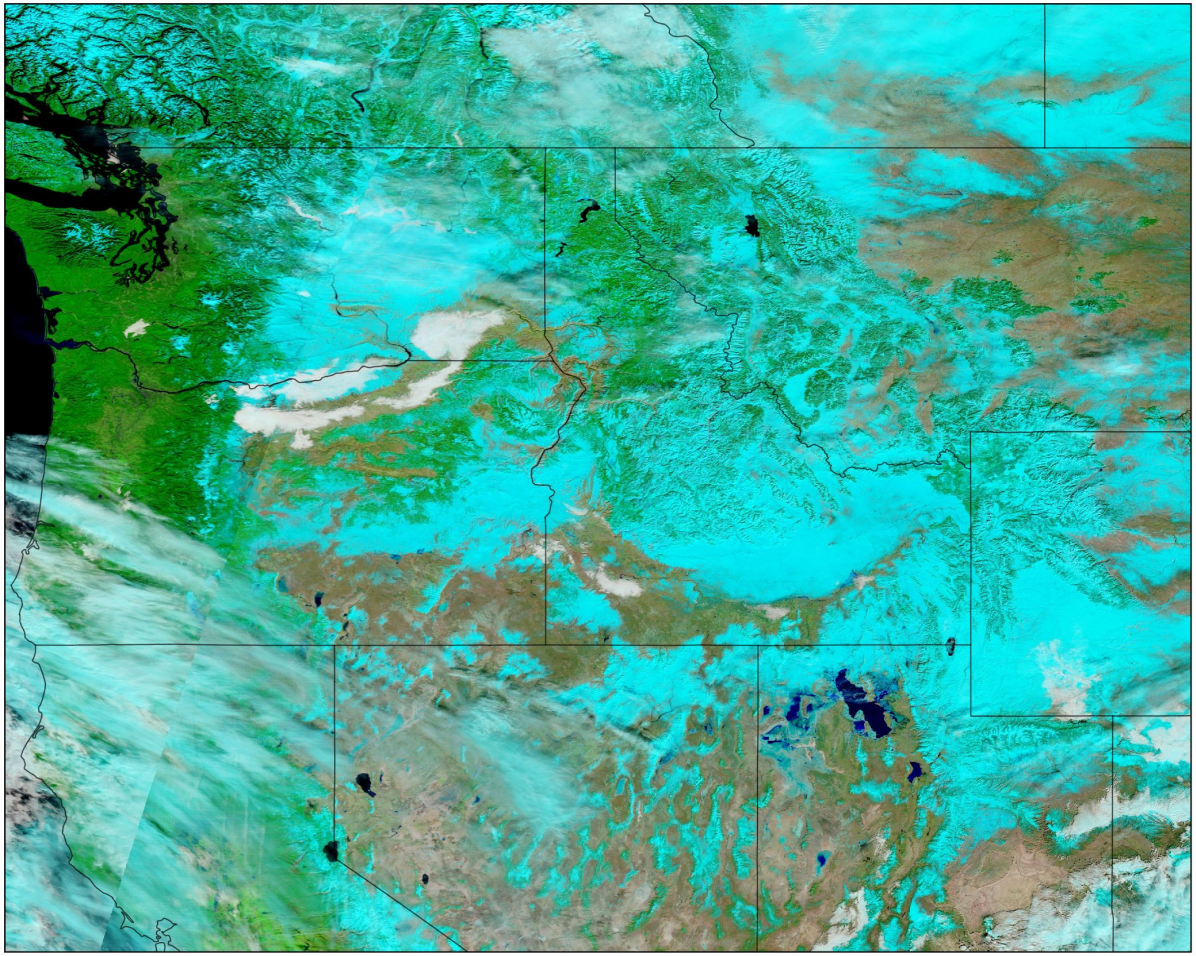
- **The Airborne Snow and Soil Moisture program estimates snow water equivalent (SWE) and soil moisture by measuring the attenuation by water of naturally occurring terrestrial gamma radiation (K, U, Th isotopes).**
- **Uses 3 gamma detection systems deployed in NOAA aircraft.**
- **Primary motivations for Airborne surveys:**
  - **Augmenting gaps in surface networks and surveys;**
  - **Measuring snow where no surface observations exist.**
- **Uses of Airborne SWE observations:**
  - **Assimilated directly into SNODAS;**
  - **Guidance for RFC flood forecast models;**
  - **Key users include USACE, NYC DEP, APRFC**
- **Coverage includes 2,568 flight lines in 37 states and 9 provinces.**
- **Typically 1,500 lines are flown each year.**

National Snow Analysis

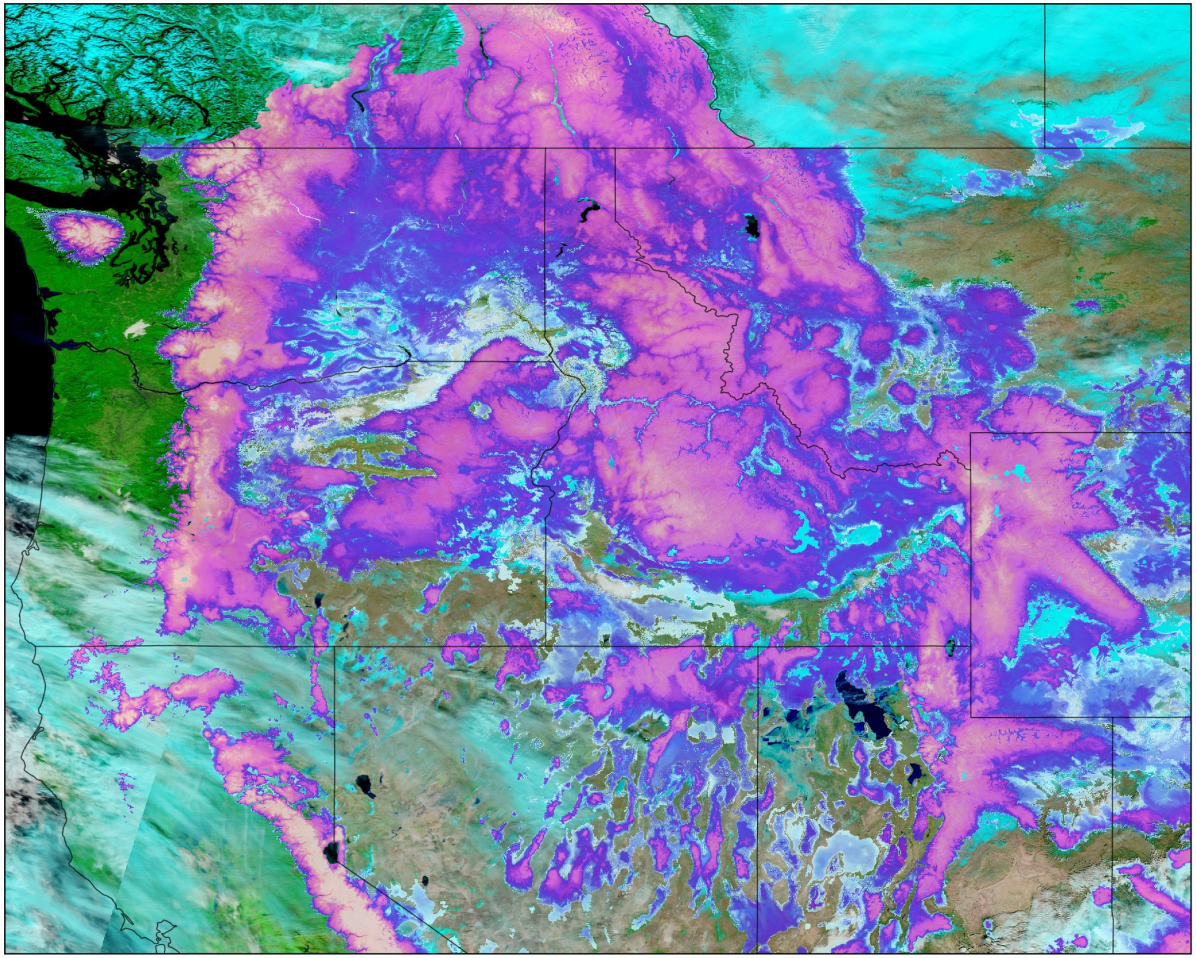
Multisensor Snow Observations

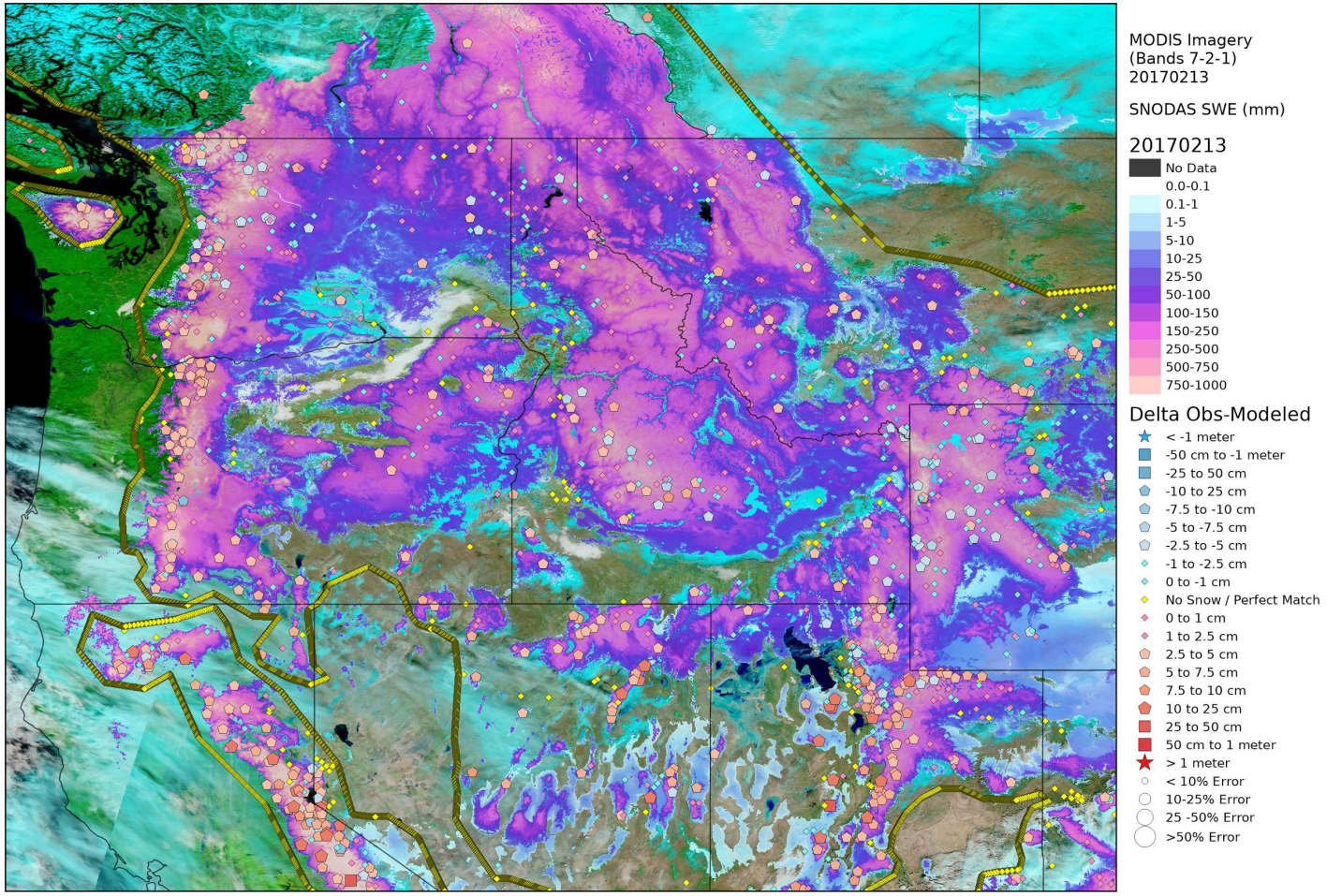


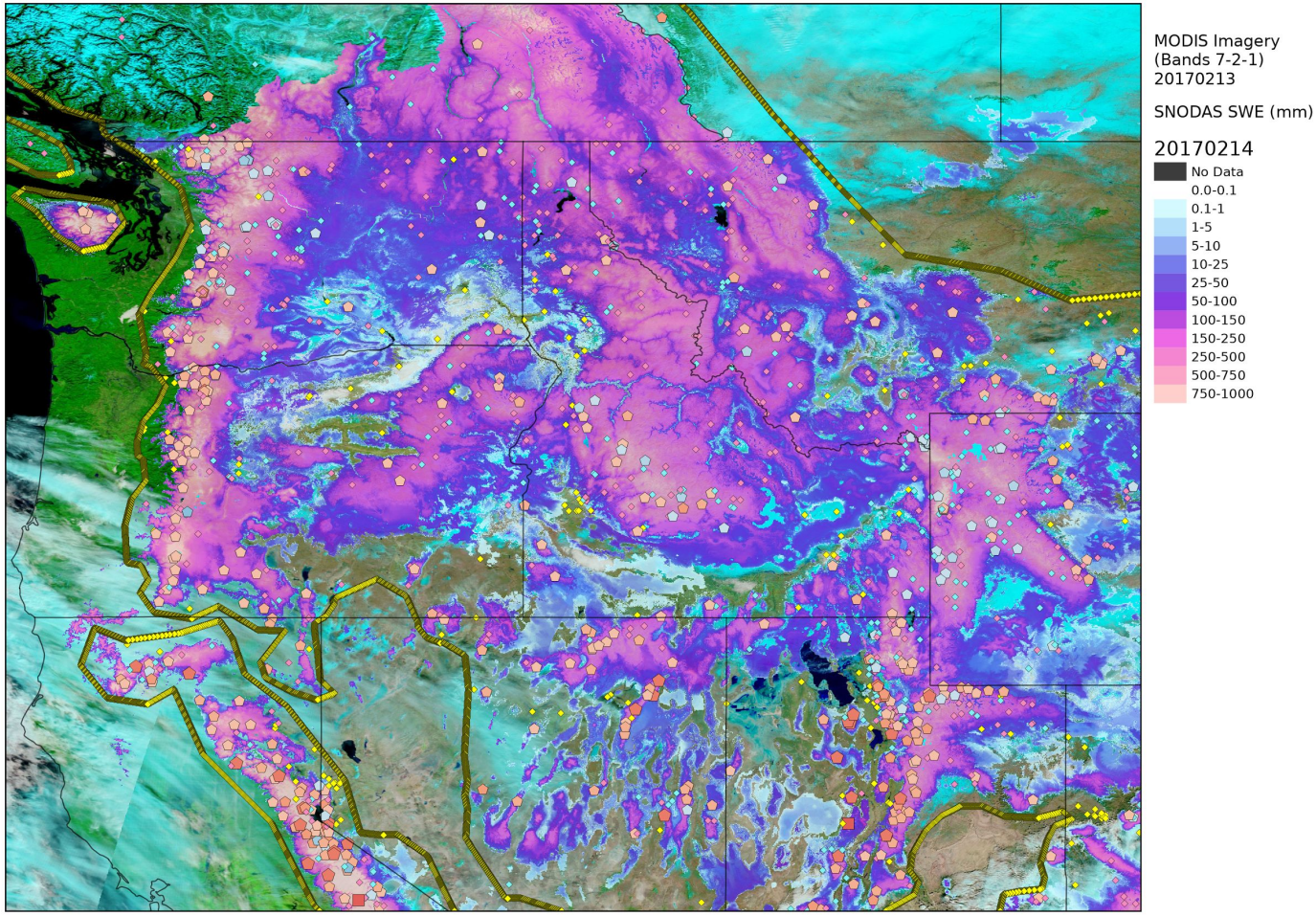
- MODIS snow cover (bands 7-2-1) provides binary snow cover guidance in SNODAS assimilation.
  - Satellite snow cover may be used to directly delineate the snow/no-snow boundary.
  - Provides qualitative guidance (a sanity check) on assim.
- GOES-16 and GOES-S will provide
  - More timely snow cover data
  - Fractional snow cover products

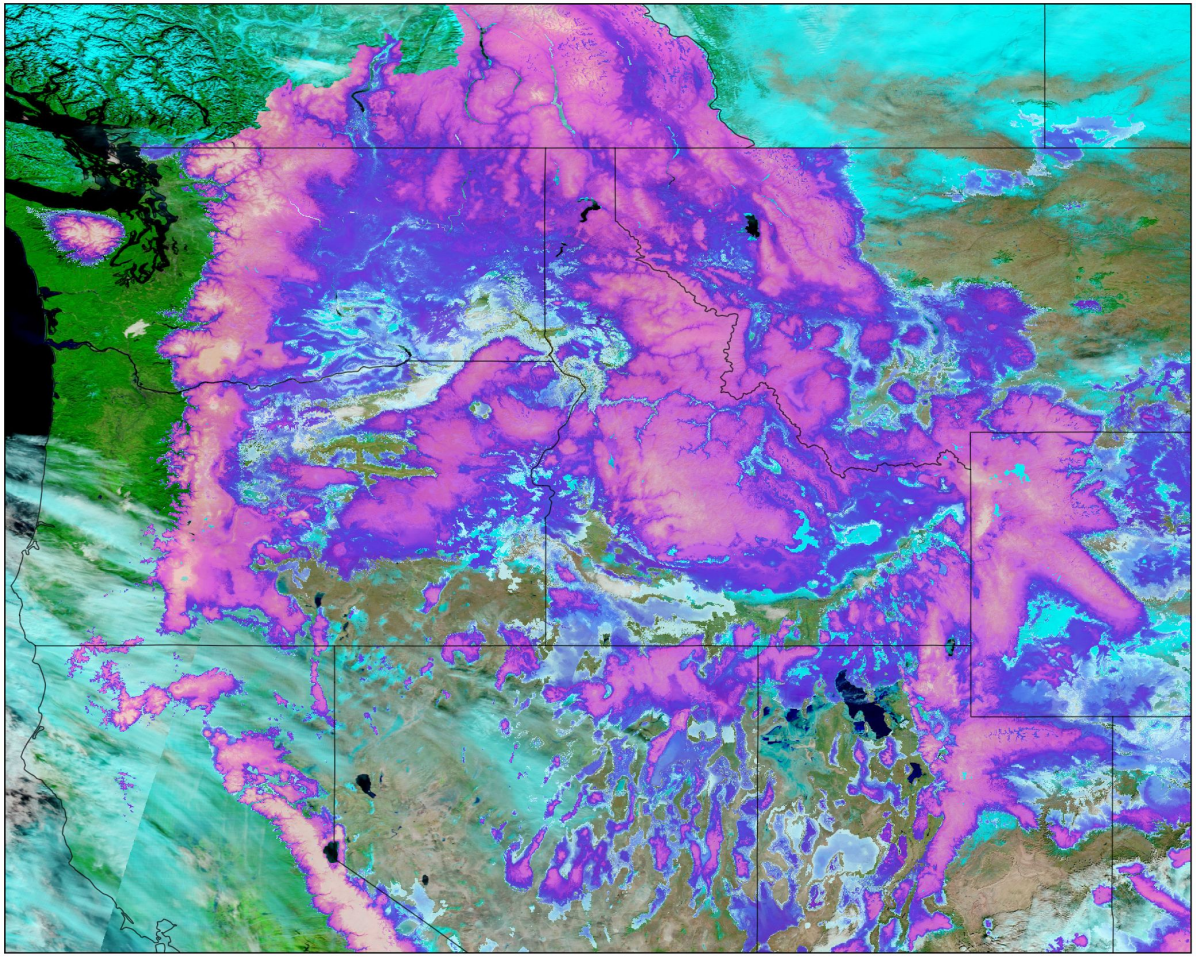


MODIS Imagery
(Bands 7-2-1)
20170213

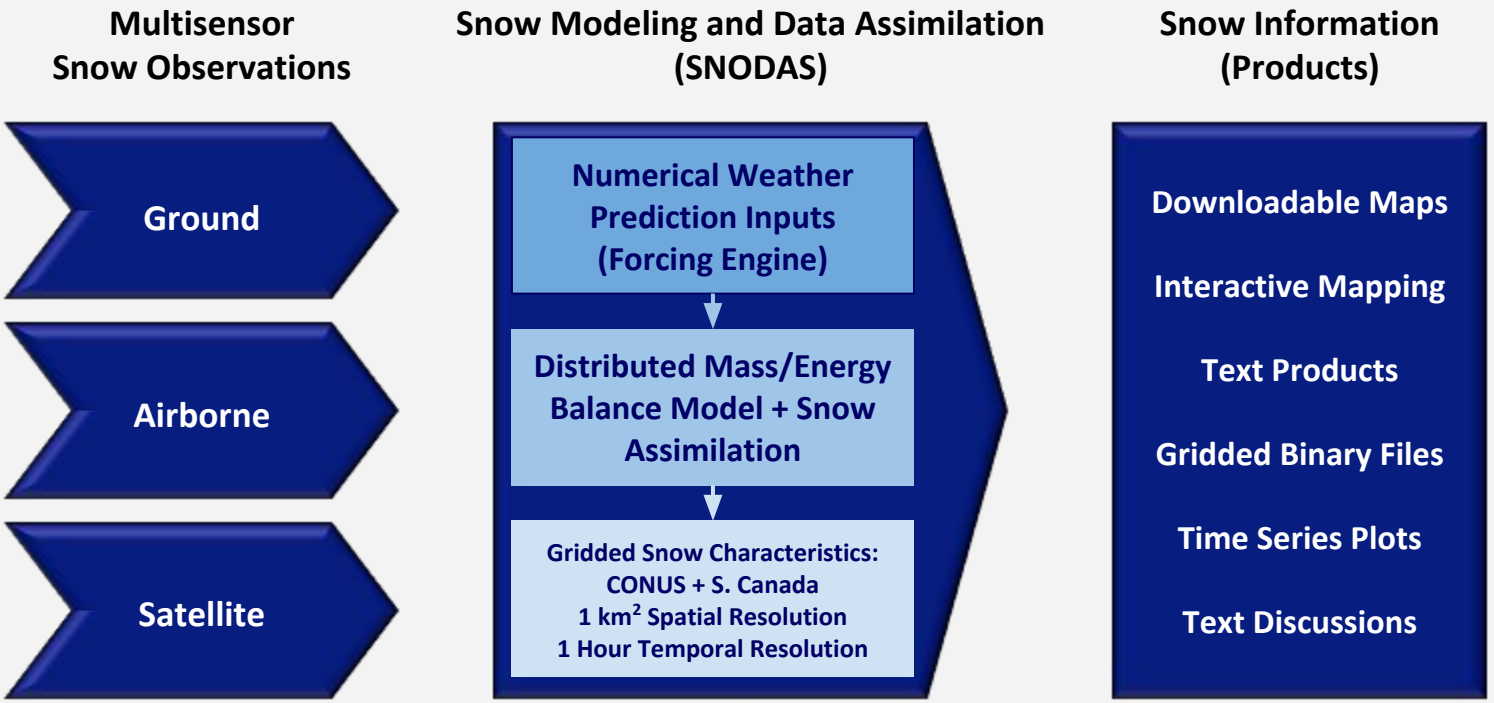

MODIS Imagery
(Bands 7-2-1)
20170213
SNODAS SWE (mm)
20170213
No Data
0.0-0.1
0.1-1
1-5
5-10
10-25
25-50
50-100
100-150
150-250
250-500
500-750
750-1000

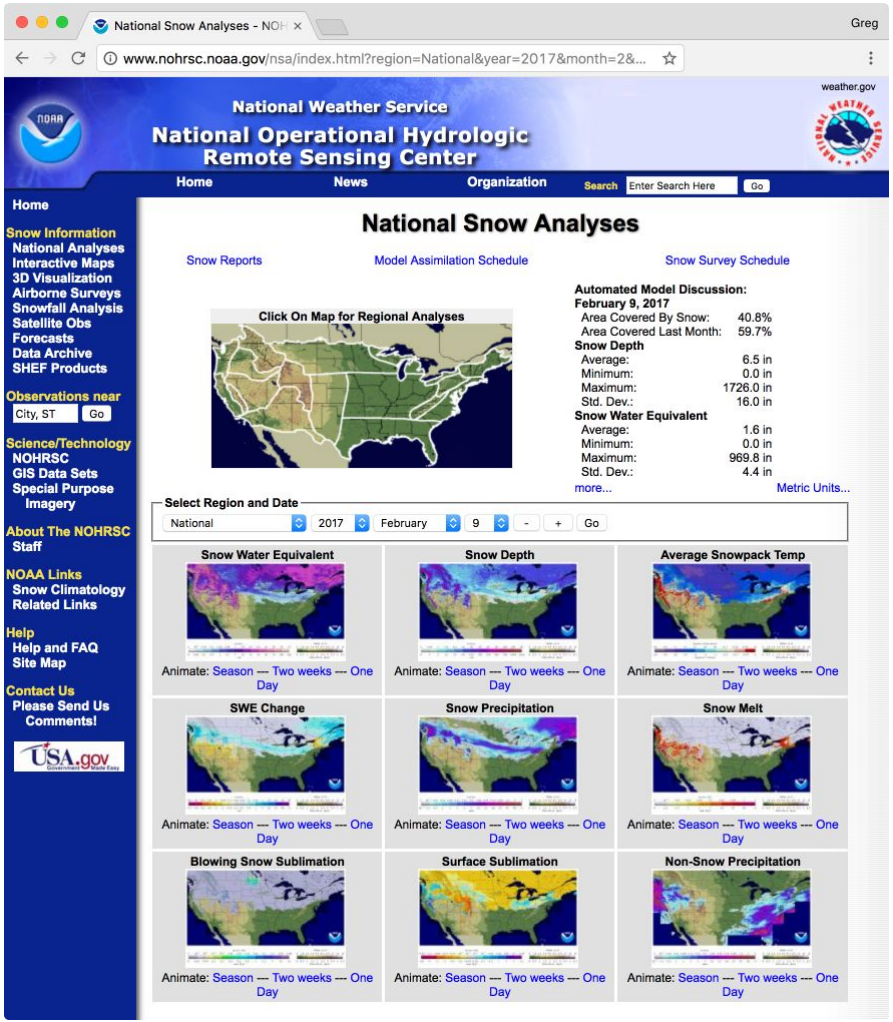

MODIS Imagery
(Bands 7-2-1)
20170213
SNODAS SWE (mm)
20170213
No Data
0.0-0.1
0.1-1
1-5
5-10
10-25
25-50
50-100
100-150
150-250
250-500
500-750
750-1000
Delta Obs-Modeled
< -1 meter
-50 cm to -1 meter
-25 to 50 cm
-10 to 25 cm
-7.5 to -10 cm
-5 to -7.5 cm
-2.5 to -5 cm
-1 to -2.5 cm
0 to -1 cm
No Snow / Perfect Match
0 to 1 cm
1 to 2.5 cm
2.5 to 5 cm
5 to 7.5 cm
7.5 to 10 cm
10 to 25 cm
25 to 50 cm
50 cm to 1 meter
> 1 meter
< 10% Error
10-25% Error
25 -50% Error
>50% Error


MODIS Imagery
(Bands 7-2-1)
20170213
SNODAS SWE (mm)
20170214
No Data
0.0-0.1
0.1-1
1-5
5-10
10-25
25-50
50-100
100-150
150-250
250-500
500-750
750-1000


MODIS Imagery
(Bands 7-2-1)
20170213
SNODAS SWE (mm)
20170214
No Data
0.0-0.1
0.1-1
1-5
5-10
10-25
25-50
50-100
100-150
150-250
250-500
500-750
750-1000

National Snow Analysis




National Snow Analyses - NOH
Greg
www.nohrsc.noaa.gov/nsa/index.html?region=National&year=2017&month=2&...
National Weather Service
National Operational Hydrologic Remote Sensing Center
weather.gov
Home
News
Organization
Search
Enter Search Here
Go
Home
Snow Information
National Analyses
Interactive Maps
3D Visualization
Airborne Surveys
Snowfall Analysis
Satellite Obs
Forecasts
Data Archive
SHEF Products
Observations near
City, ST
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Science/Technology
NOHRSC
GIS Data Sets
Special Purpose Imagery
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Snow Climatology
Related Links
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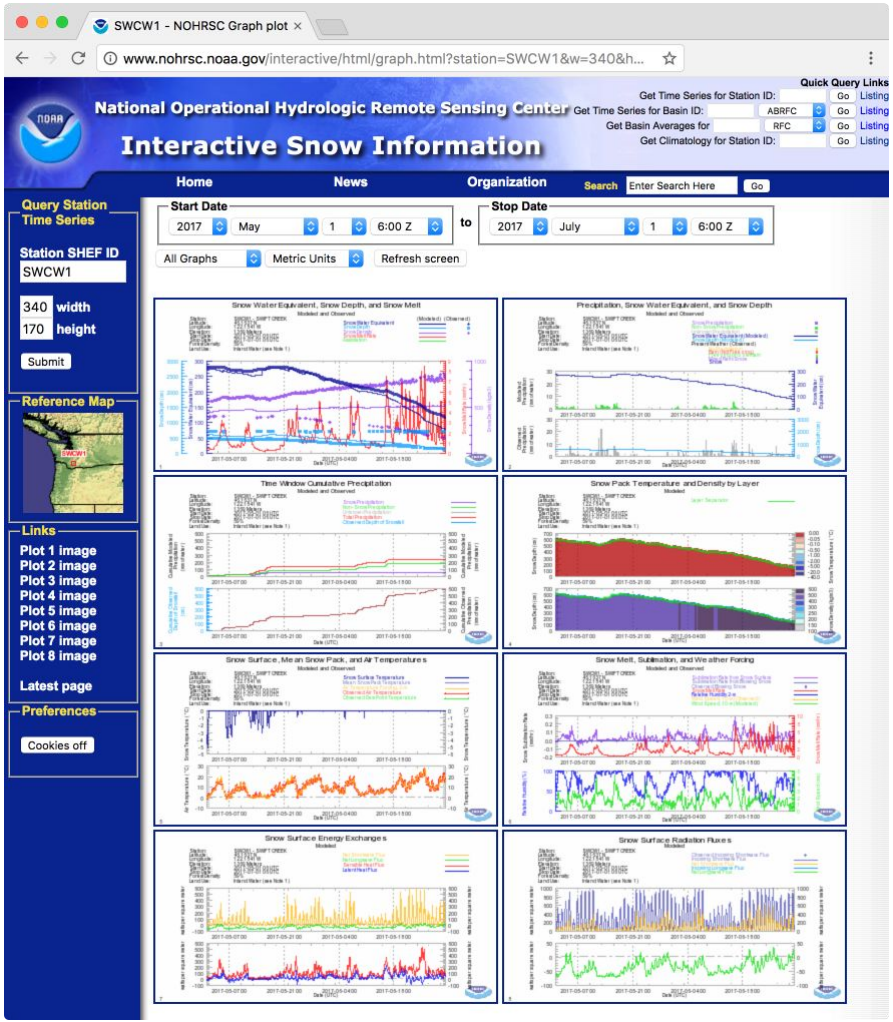
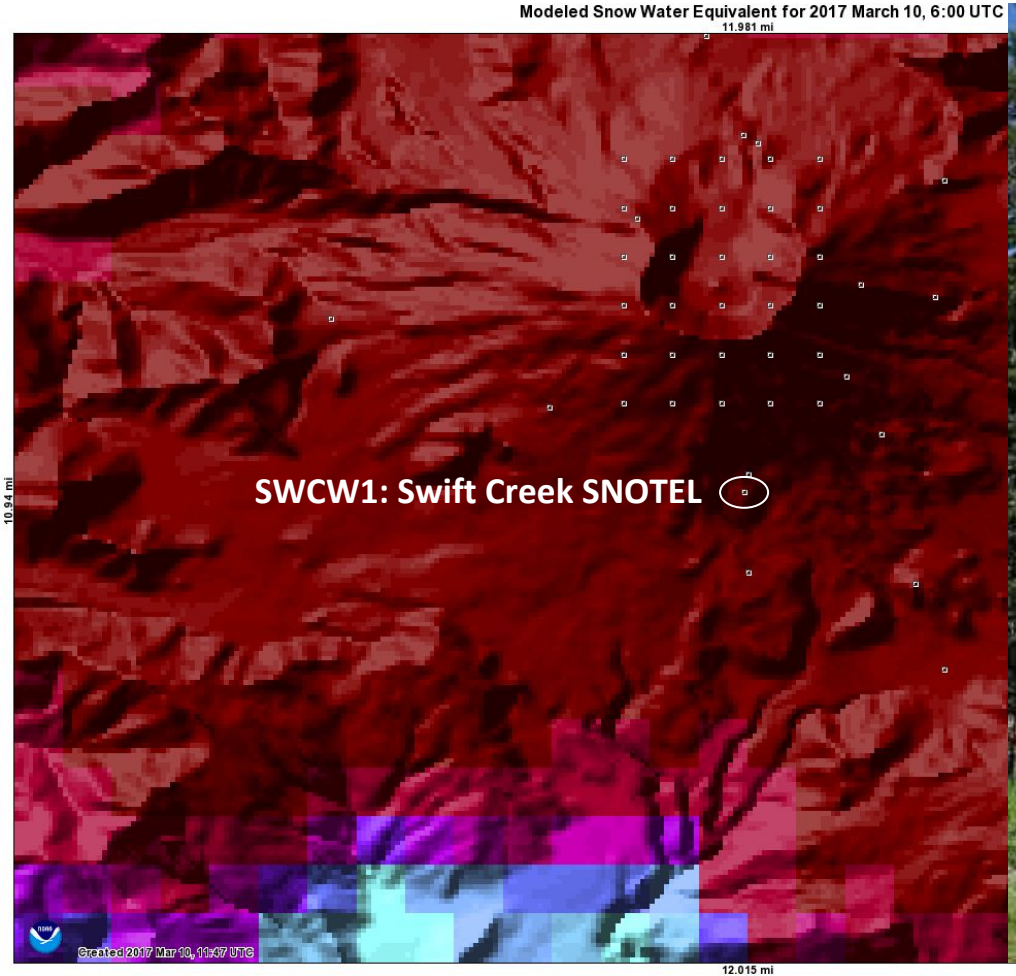
Help and FAQ
Site Map
Contact Us
Please Send Us Comments!
USA.gov
National Snow Analyses
Snow Reports
Model Assimilation Schedule
Snow Survey Schedule
Click On Map for Regional Analyses
Automated Model Discussion:
February 9, 2017
Area Covered By Snow: 40.8%
Area Covered Last Month: 59.7%
Snow Depth
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
Snow Depth
Average Snowpack Temp
SWE Change
Snow Precipitation
Snow Melt
Blowing Snow Sublimation
Surface Sublimation
Non-Snow Precipitation
Animate: Season --- Two weeks --- One Day

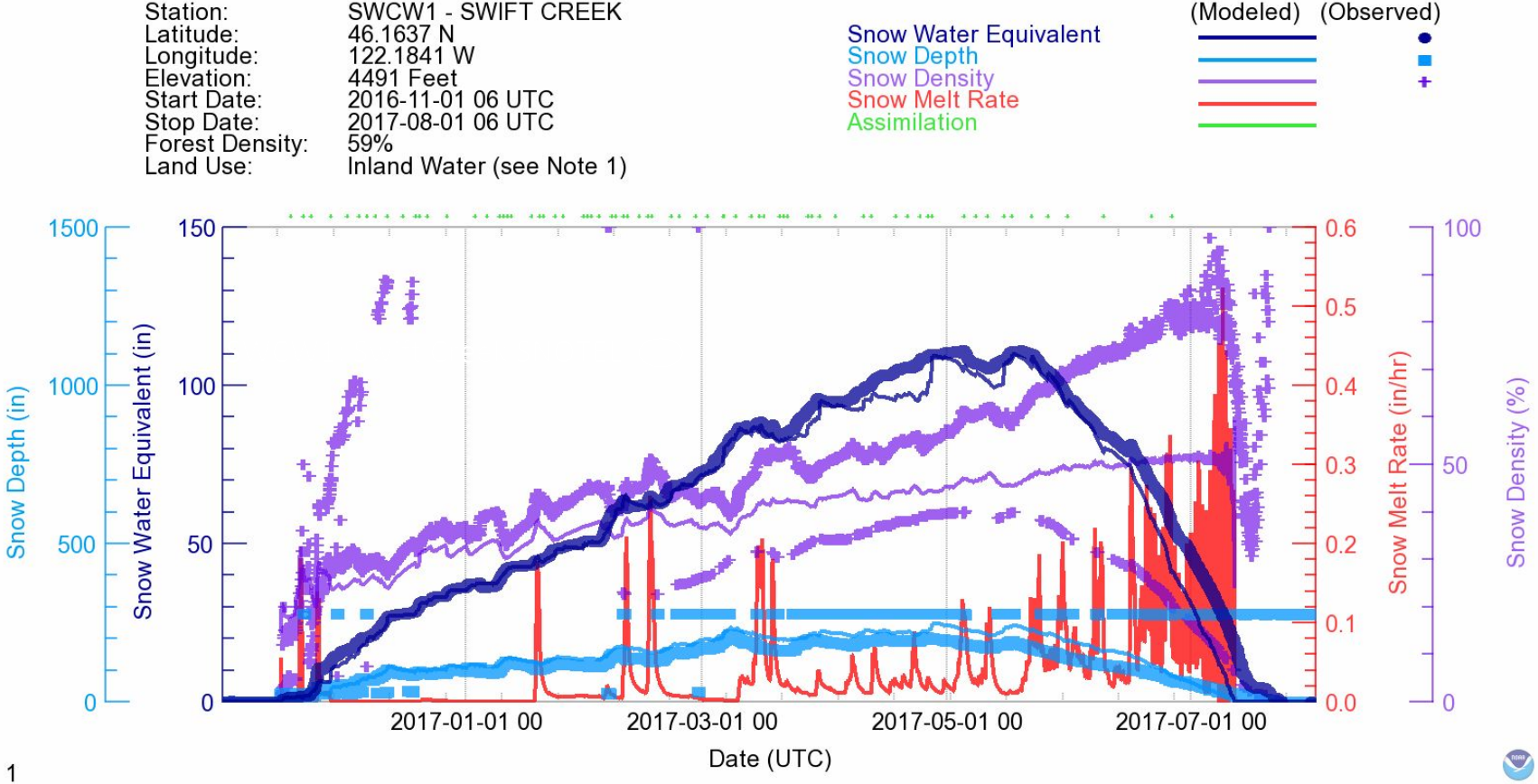

SWCW1 - NOHRSC Graph plot
www.nohrsc.noaa.gov/interactive/html/graph.html?station=SWCW1&w=340&h...
Quick Query Links
Get Time Series for Station ID:
Get Time Series for Basin ID:
ABRFC
Get Basin Averages for
RFC
Get Climatology for Station ID:
Go
Listing
National Operational Hydrologic Remote Sensing Center
Interactive Snow Information
Home
News
Organization
Search
Enter Search Here
Go
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 6 image
Plot 7 image
Plot 8 image
Latest page
Preferences
Cookies off
Start Date
2017
May
1
6:00 Z
to
Stop Date
2017
July
1
6:00 Z
All Graphs
Metric Units
Refresh screen
Snow Water Equivalent, Snow Depth, and Snow Melt
Precipitation, Snow Water Equivalent, and Snow Depth
Time Window Cumulative Precipitation
Snow Pack Temperature and Density by Layer
Snow Surface, Mean Snow Pack, and Air Temperatures
Snow Melt, Sublimation, and Weather Forcing
Snow Surface Energy Exchanges
Snow Surface Radiation Fluxes


Modeled Snow Water Equivalent for 2017 March 10, 6:00 UTC
11.981 mi
10.94 mi
SWCW1: Swift Creek SNOTEL
Created 2017 Mar 10, 11:47 UTC
12.015 mi

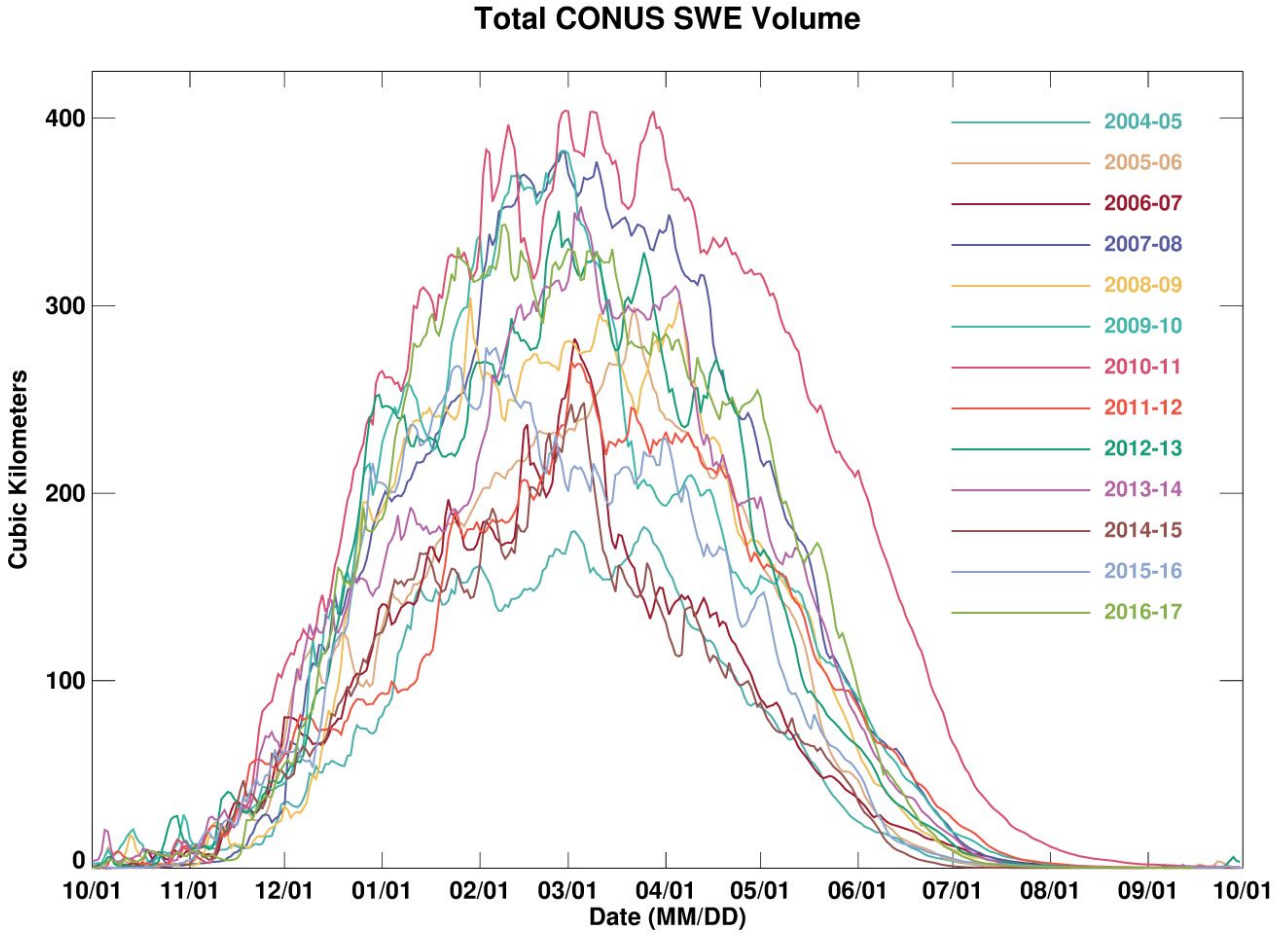
Snow Water Equivalent, Snow Depth, and Snow Melt

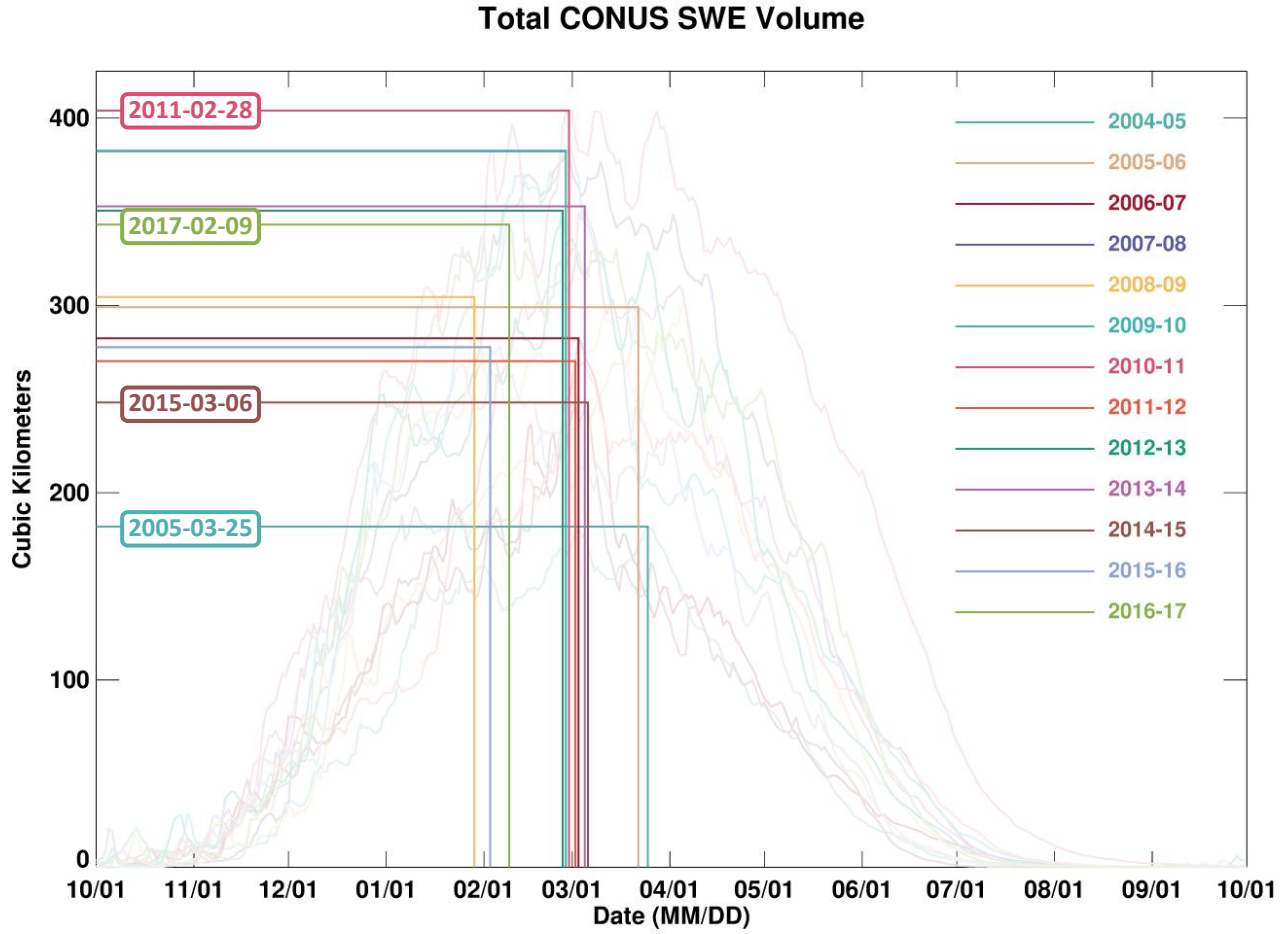
Modeled and Observed

Station:	SWCW1 - SWIFT CREEK
Latitude:	46.1637 N
Longitude:	122.1841 W
Elevation:	4491 Feet
Start Date:	2016-11-01 06 UTC
Stop Date:	2017-08-01 06 UTC
Forest Density:	59%
Land Use:	Inland Water (see Note 1)

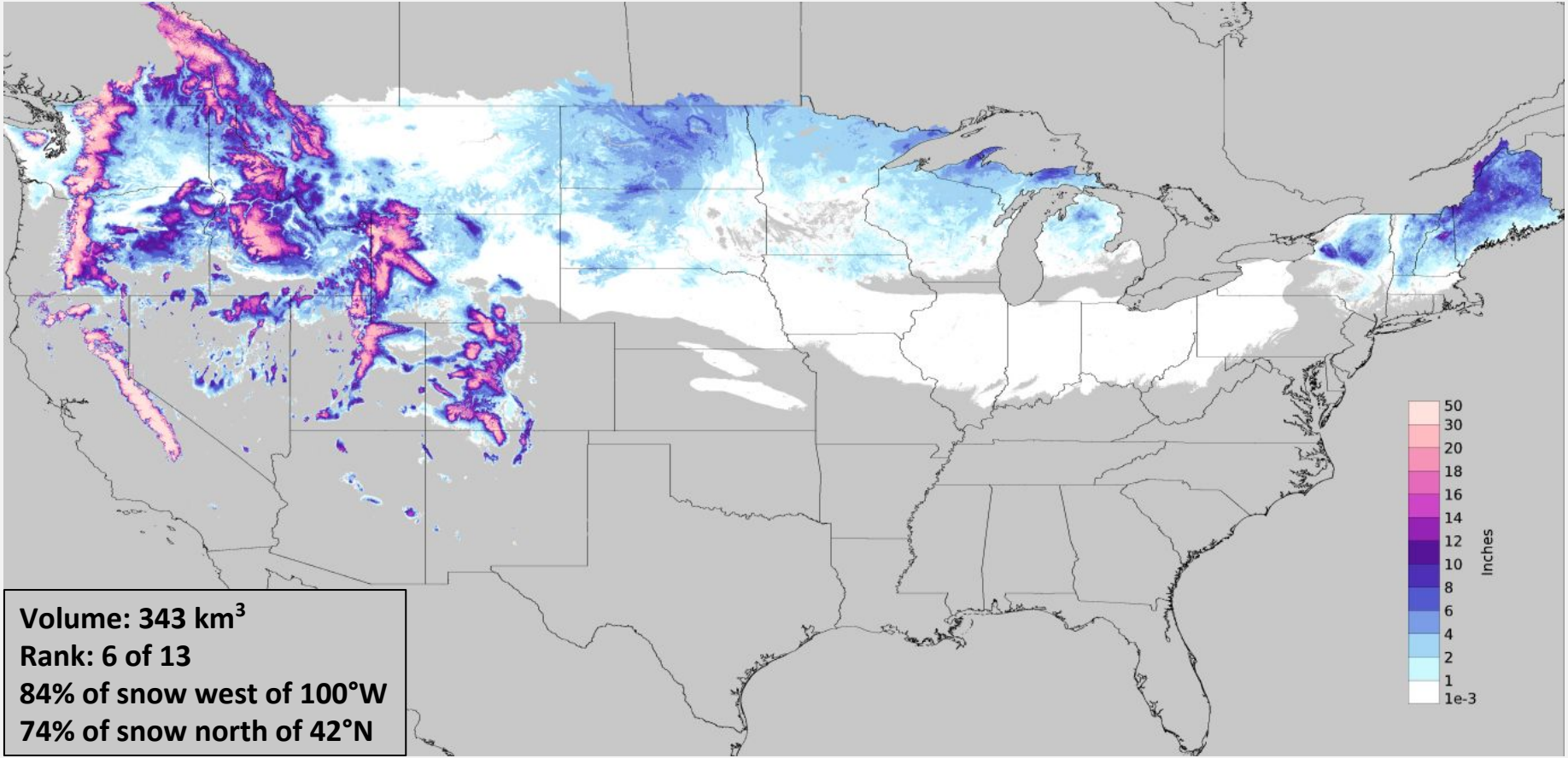


National Snow Analysis Period of Record: 2004-2017


Total CONUS SWE Volume
Cubic Kilometers
400
300
200
100
0
10/01
11/01
12/01
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01
Date (MM/DD)
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17

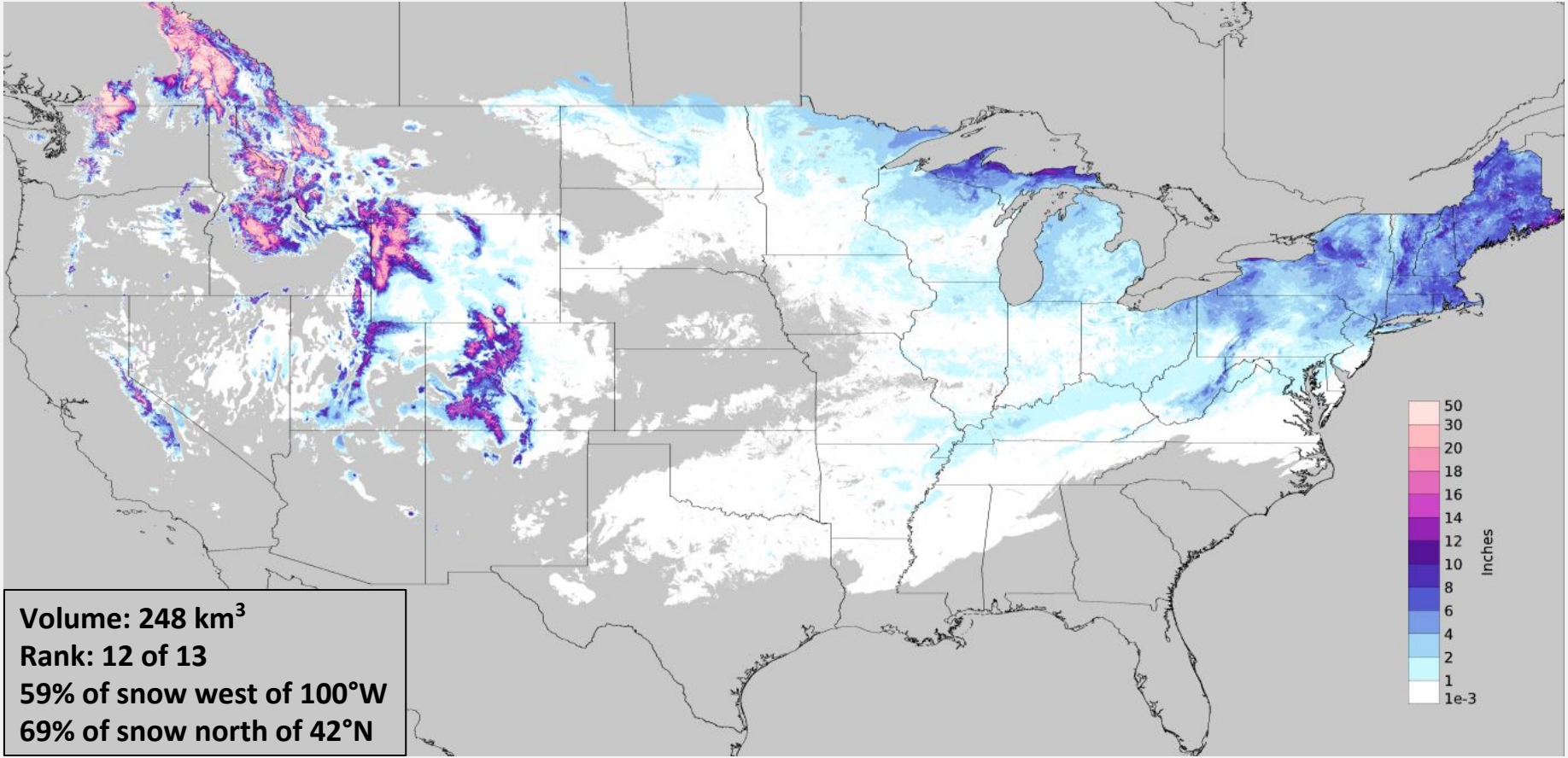

Total CONUS SWE Volume
Cubic Kilometers
400
300
200
100
0
10/01
11/01
12/01
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01
Date (MM/DD)
2011-02-28
2017-02-09
2015-03-06
2005-03-25
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17

Modeled SWE, 2017-02-09



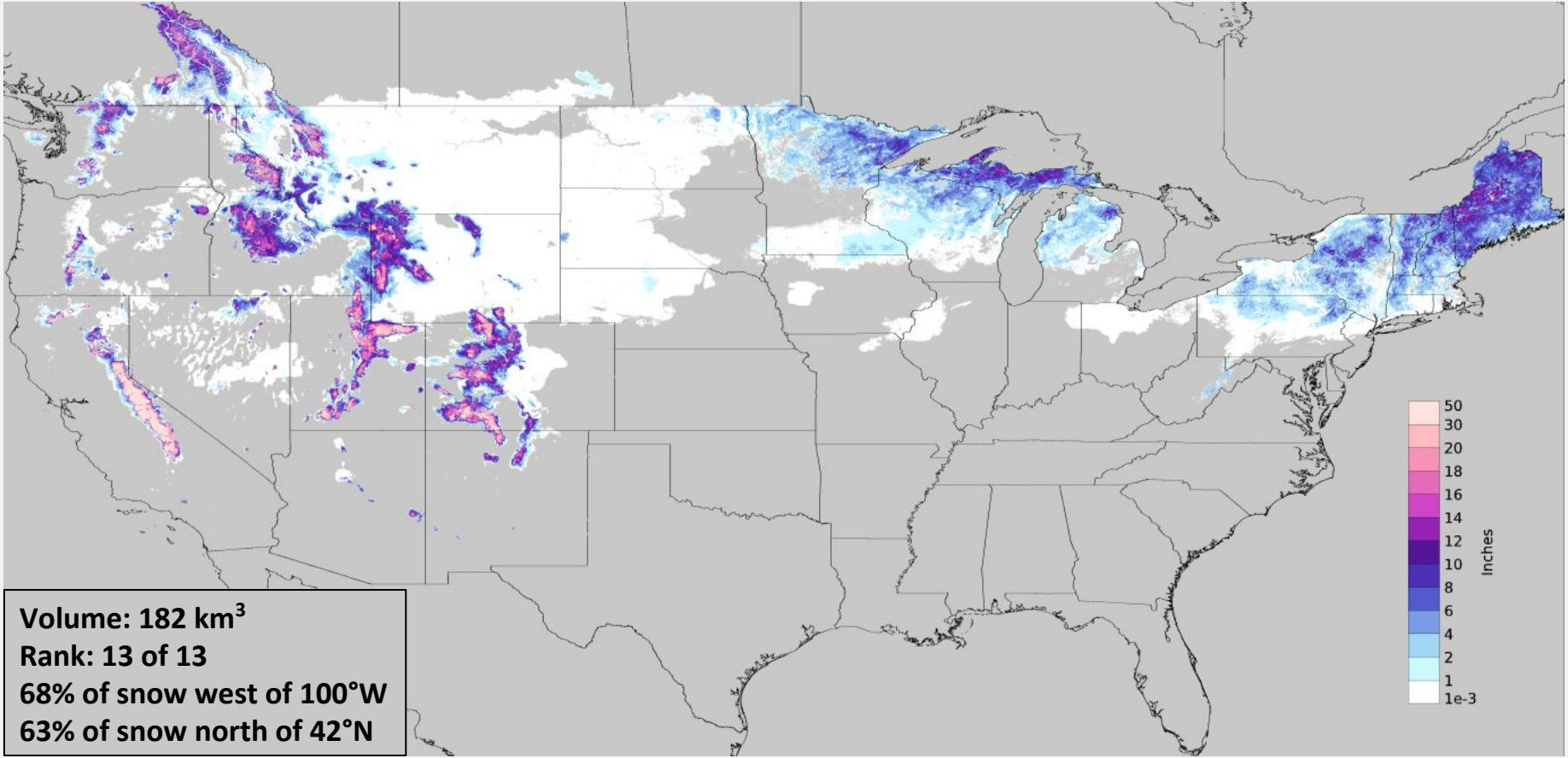
Volume: 343 km^3
Rank: 6 of 13
84% of snow west of 100°W
74% of snow north of 42°N

Modeled SWE, 2015-03-06



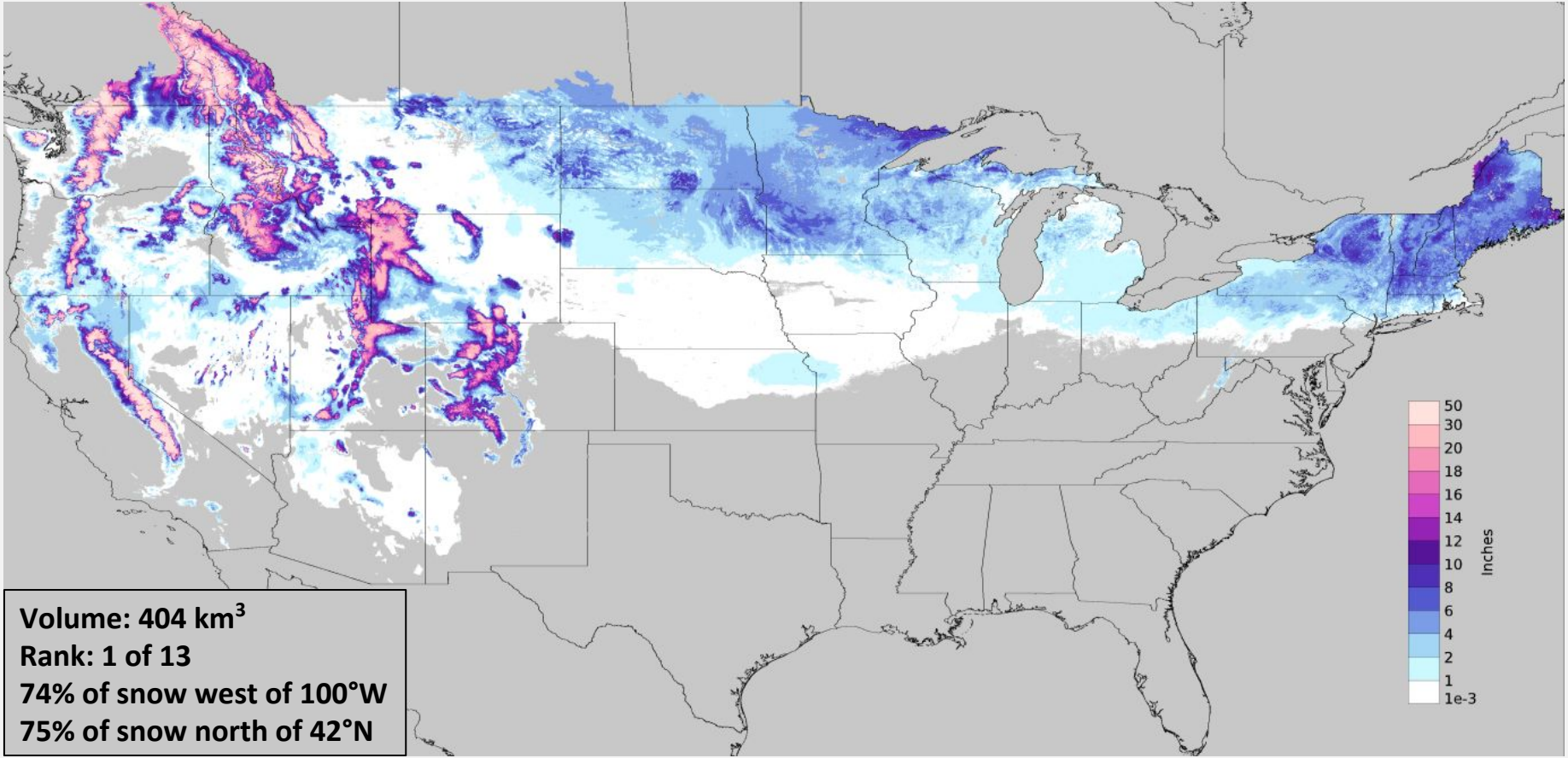
Volume: 248 km^3
Rank: 12 of 13
59% of snow west of 100°W
69% of snow north of 42°N

Modeled SWE, 2005-03-25



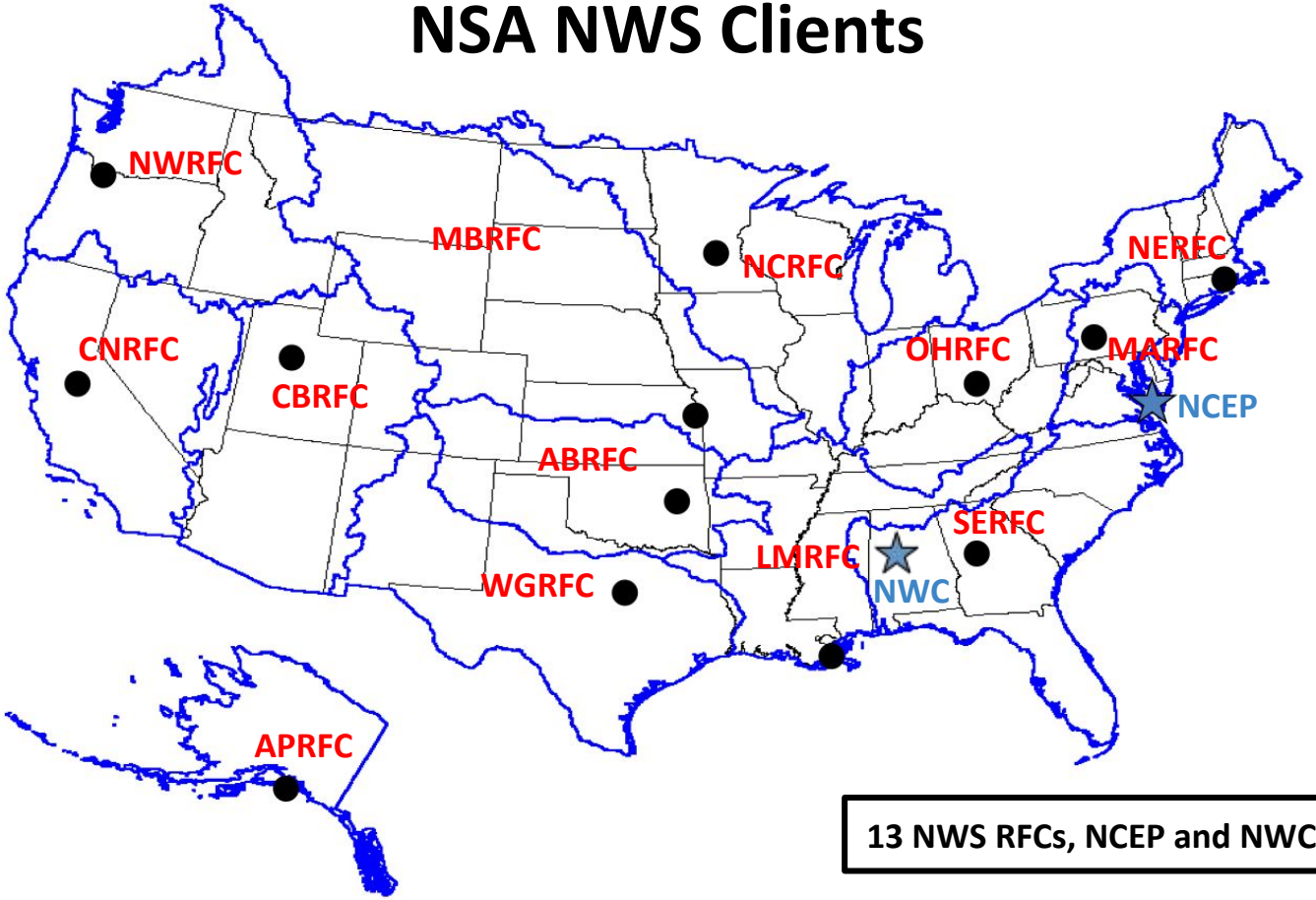
Volume: 182 km^3
Rank: 13 of 13
68% of snow west of 100°W
63% of snow north of 42°N

Modeled SWE, 2011-02-28



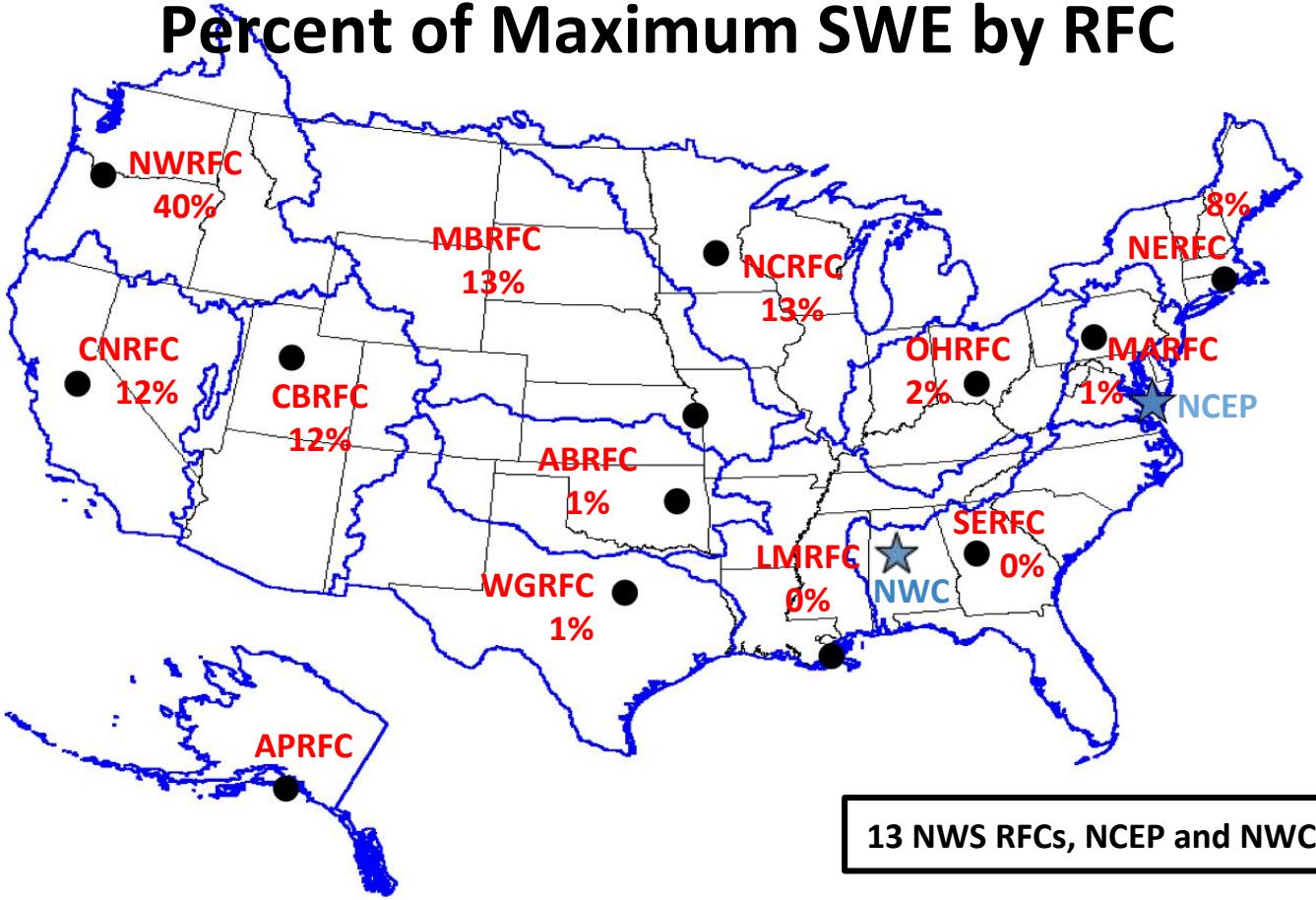
Volume: 404 km^3
Rank: 1 of 13
74% of snow west of 100°W
75% of snow north of 42°N

NSA NWS Clients



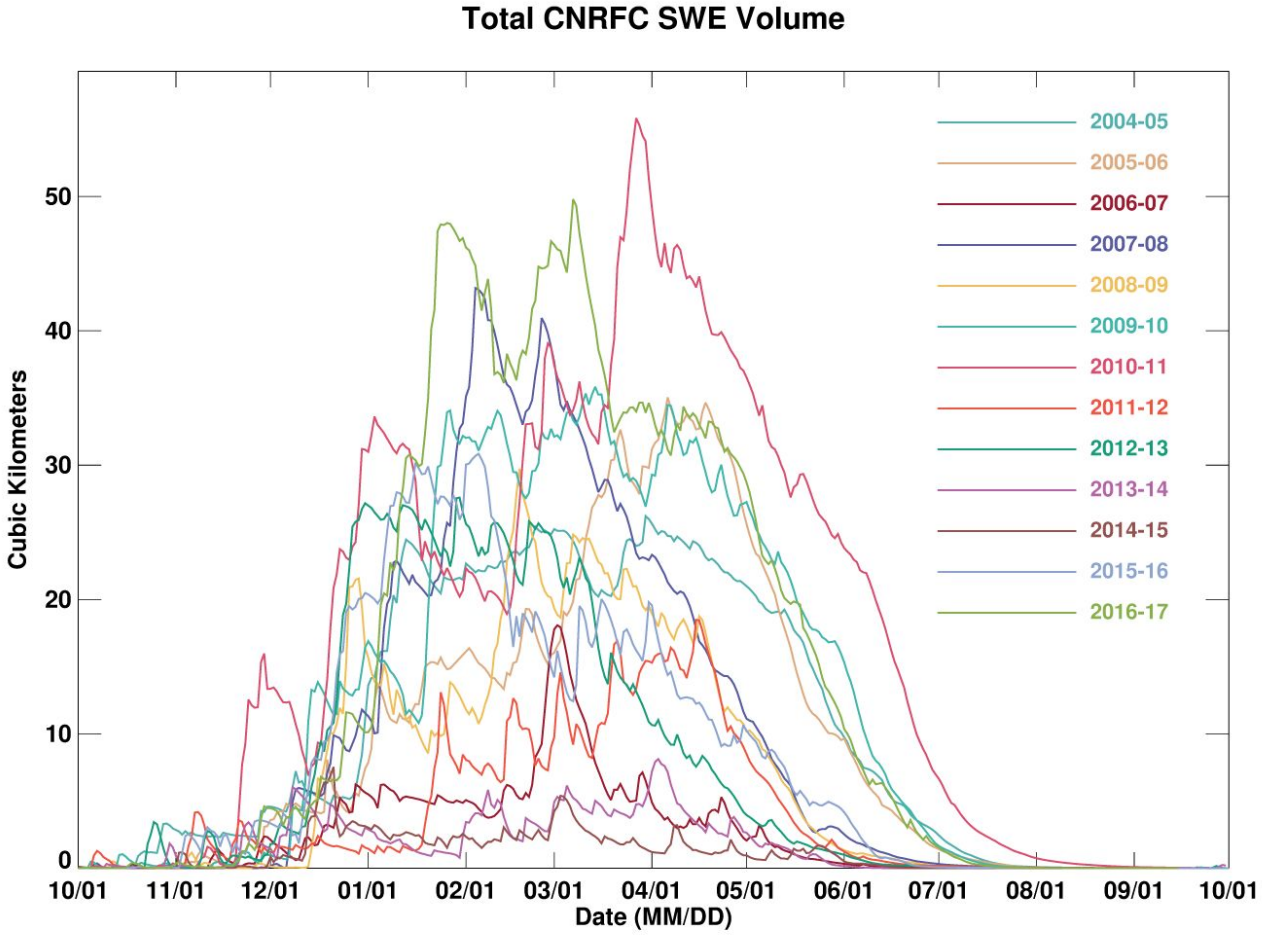
13 NWS RFCs, NCEP and NWC

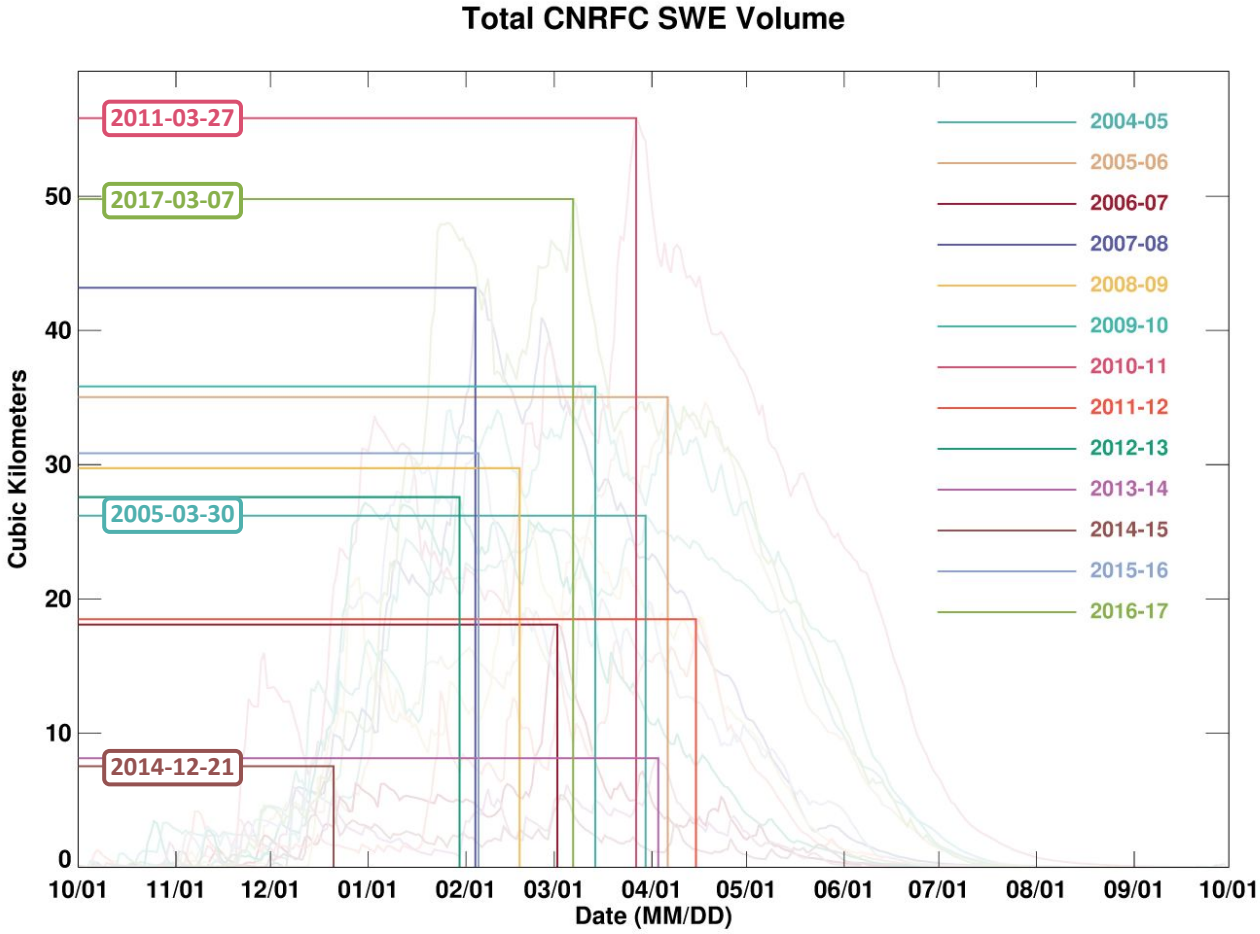
Percent of Maximum SWE by RFC



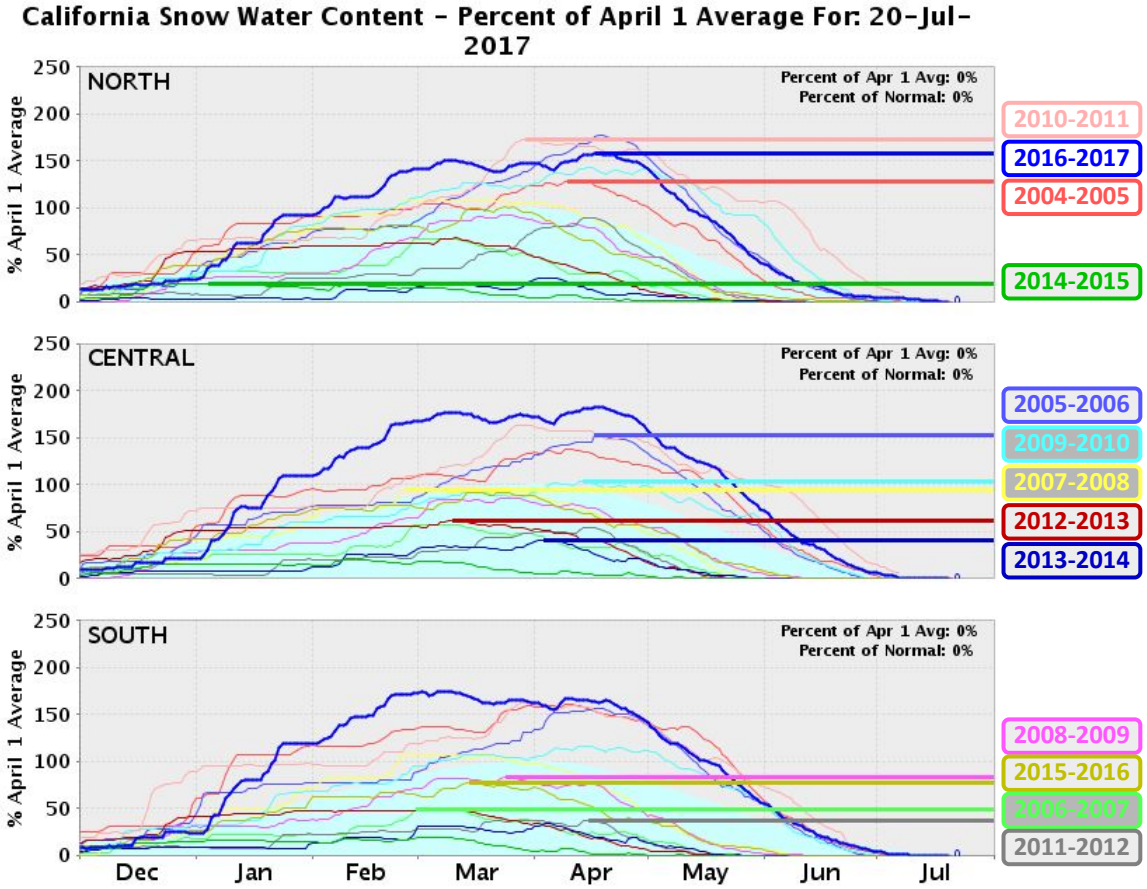
13 NWS RFCs, NCEP and NWC

Rank	National			CNRFC			NWRFC		
	Year	Max. SWE (km^3)	Date	Year	Max SWE (km^3)	Date	Year	Max SWE (km^3)	Date
1	2010-11	404	02/28	2010-11	56	03/27	2010-11	198	04/22
2	2009-10	383	02/27	2016-17	50	03/07	2016-17	181	03/10
3	2007-08	382	02/27	2007-08	43	02/04	2011-12	179	04/07
4	2013-14	353	03/05	2009-10	36	03/14	2007-08	173	04/01
5	2012-13	351	02/26	2005-06	35	04/06	2013-14	156	04/02
6	2016-17	343	02/09	2015-16	31	02/05	2008-09	155	04/04
7	2008-09	305	01/29	2008-09	30	02/18	2005-06	152	03/20
8	2005-06	299	03/22	2012-13	28	01/30	2012-13	149	03/24
9	2006-07	282	03/03	2004-05	26	03/30	2015-16	143	03/30
10	2015-16	278	02/03	2011-12	18	04/14	2006-07	128	03/03
11	2011-12	270	03/01	2006-07	18	03/02	2009-10	117	04/14
12	2014-15	248	03/06	2013-14	8	04/03	2014-15	86	03/03
13	2004-05	182	03/25	2014-15	8	12/21	2004-05	51	03/31


Total CNRFC SWE Volume
Cubic Kilometers
0
10
20
30
40
50
10/01
11/01
12/01
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01
Date (MM/DD)
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17


Total CNRFC SWE Volume
Cubic Kilometers
0
10
20
30
40
50
10/01
11/01
12/01
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01
Date (MM/DD)
2011-03-27
2017-03-07
2005-03-30
2014-12-21
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17

Rank	CNRFC		
	Year	Max SWE (km^3)	Date
1	2010-11	56	03/27
2	2016-17	50	03/07
3	2007-08	43	02/04
4	2009-10	36	03/14
5	2005-06	35	04/06
6	2015-16	31	02/05
7	2008-09	30	02/18
8	2012-13	28	01/30
9	2004-05	26	03/30
10	2011-12	18	04/14
11	2006-07	18	03/02
12	2013-14	8	04/03
13	2014-15	8	12/21

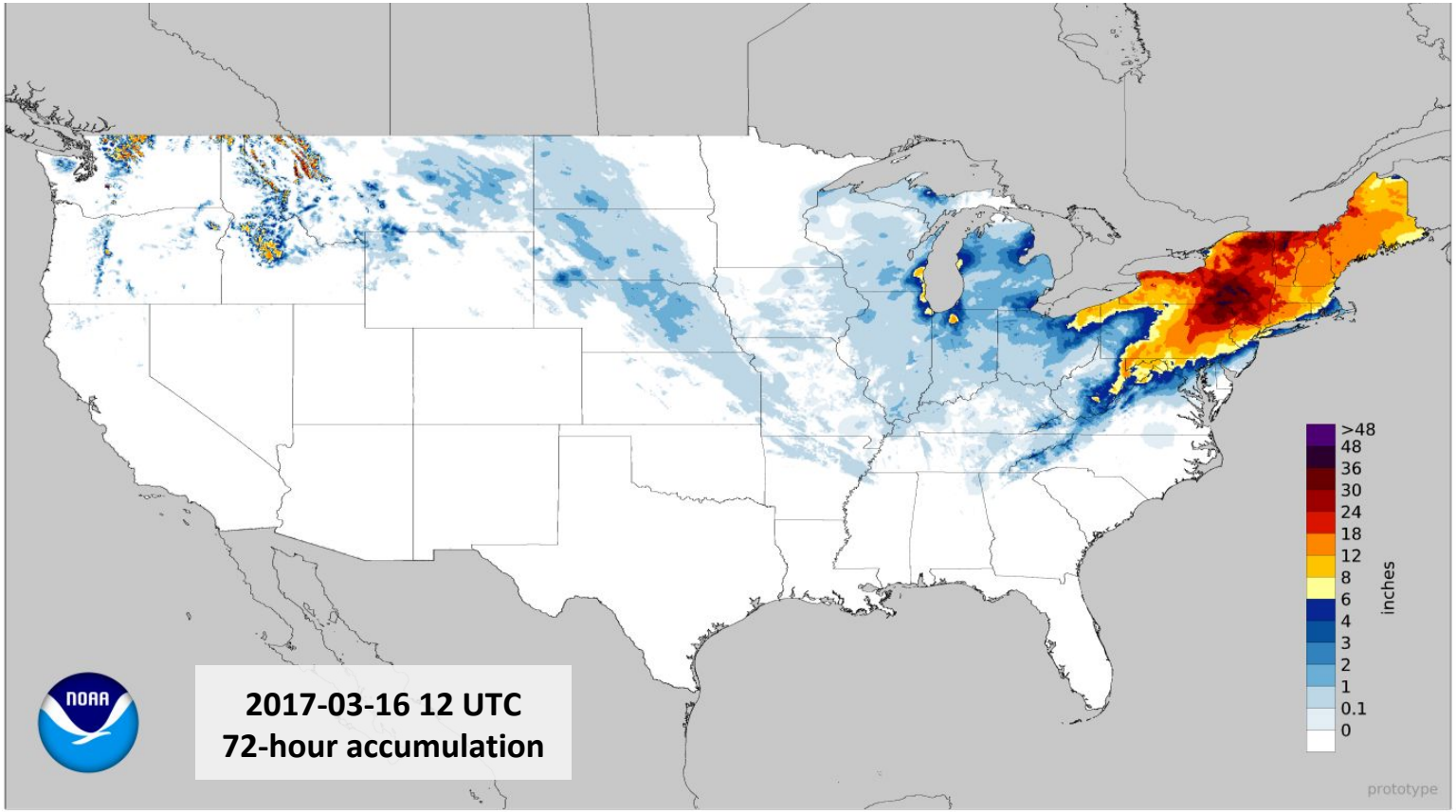


http://cdec.water.ca.gov/snowapp/swcchart.action

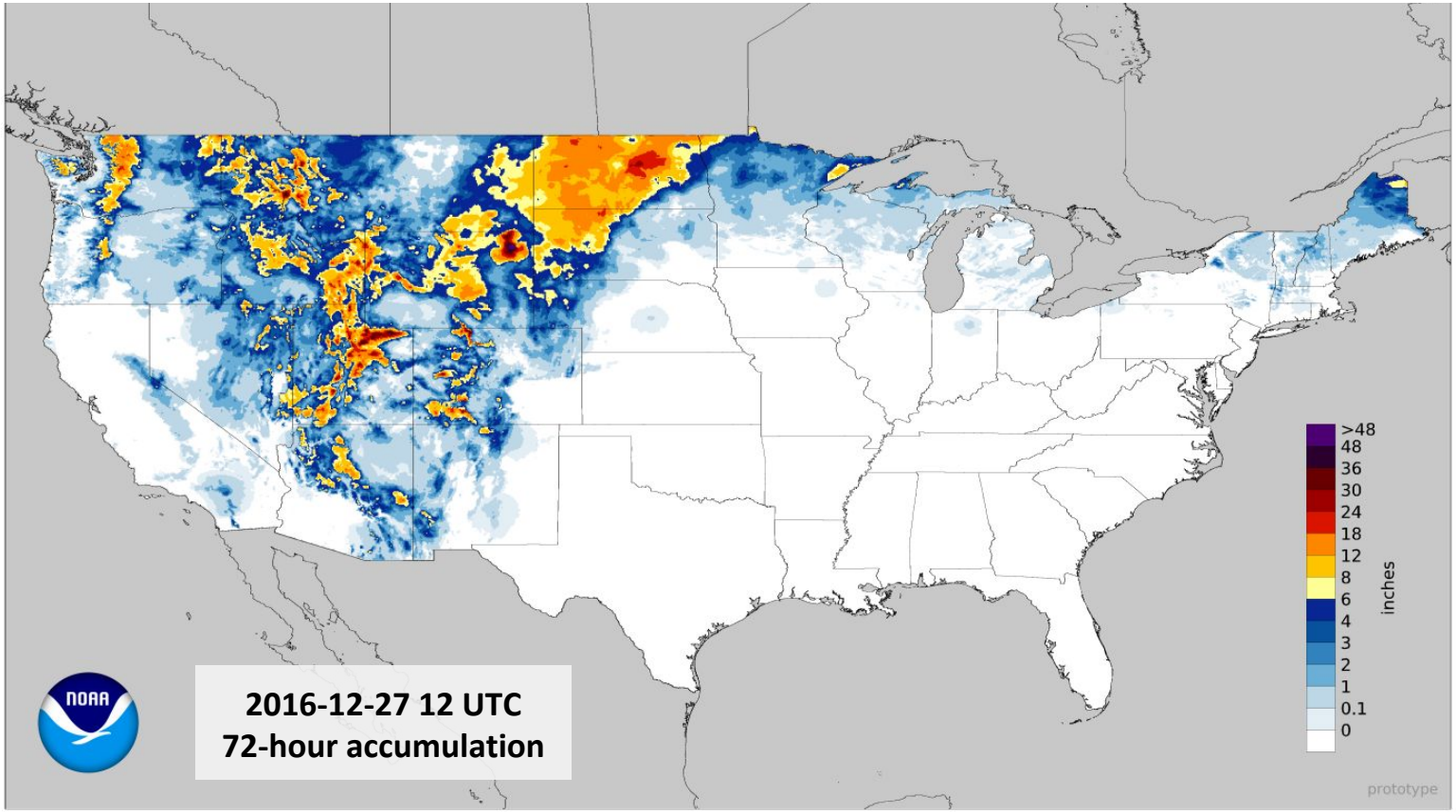
National Snowfall Analysis

- Unsupported; “pre-experimental;” currently leverages NSA operations.
- 2x-daily (00 and 12 UTC), 4 km gridded variational analysis of observed 24-hour snowfall accumulation.
- Background analysis:
  - HRRR f03 snow:precipitation (WEASD:APCP) ratio;
  - Stage IV QPE;
  - Climatological Snowfall to liquid ratio (SLR) based on GHCN-D 1986-2015.
- Gauge QC module and subdivision module enable analyses outside of 12Z.
- Two ordinary kriging passes assimilate observed snowfall.
- First issuance appears about 45 minutes after the analysis time (00:45 or 12:45 UTC); repeated hourly for 96 following hours.
- 48-hour, 72-hour, and seasonal aggregations are performed in post-processing.
- Formats: PNG, GeoTIFF, NetCDF, GRIB2.
- Did I mention the analysis is unsupported?

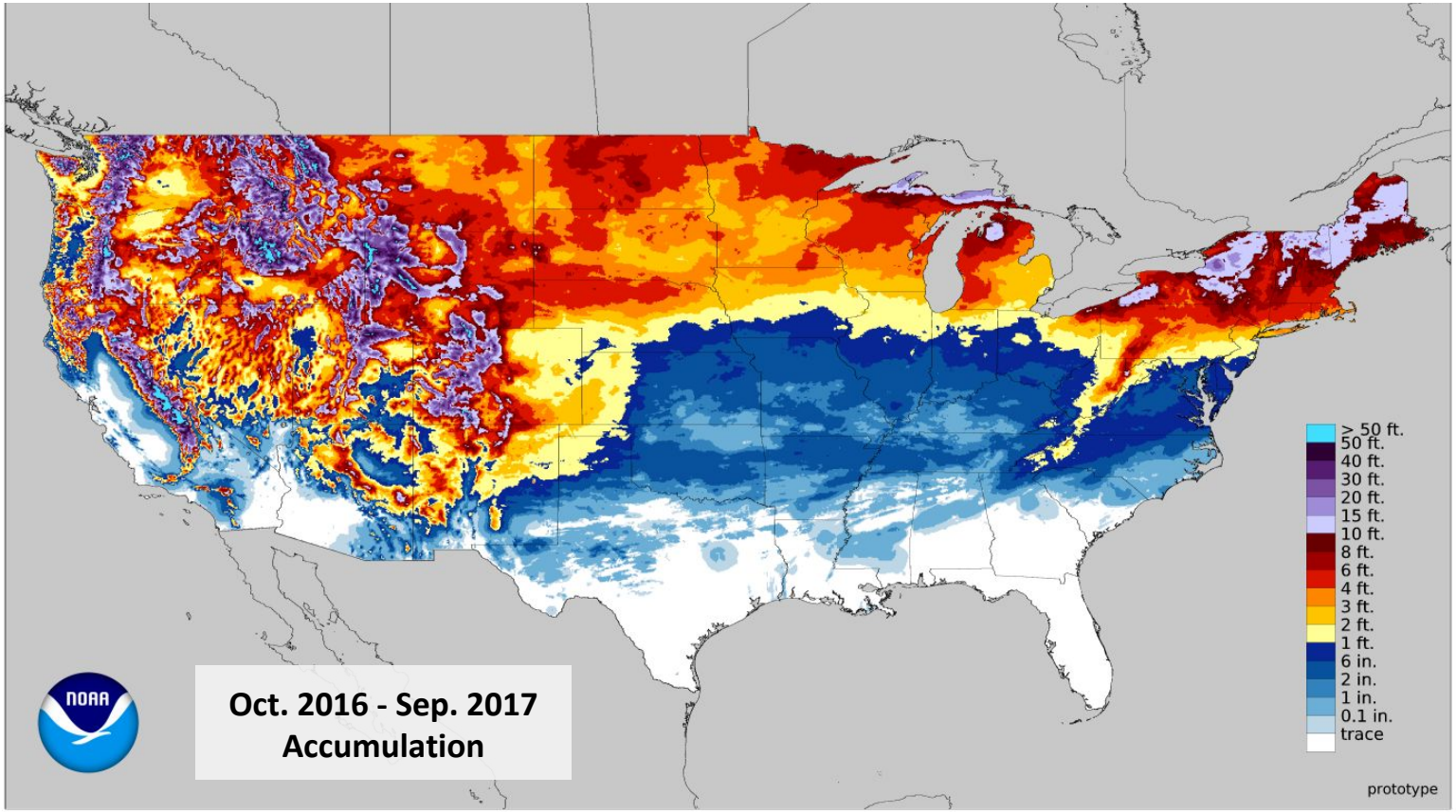
National Snowfall Analysis



National Snowfall Analysis

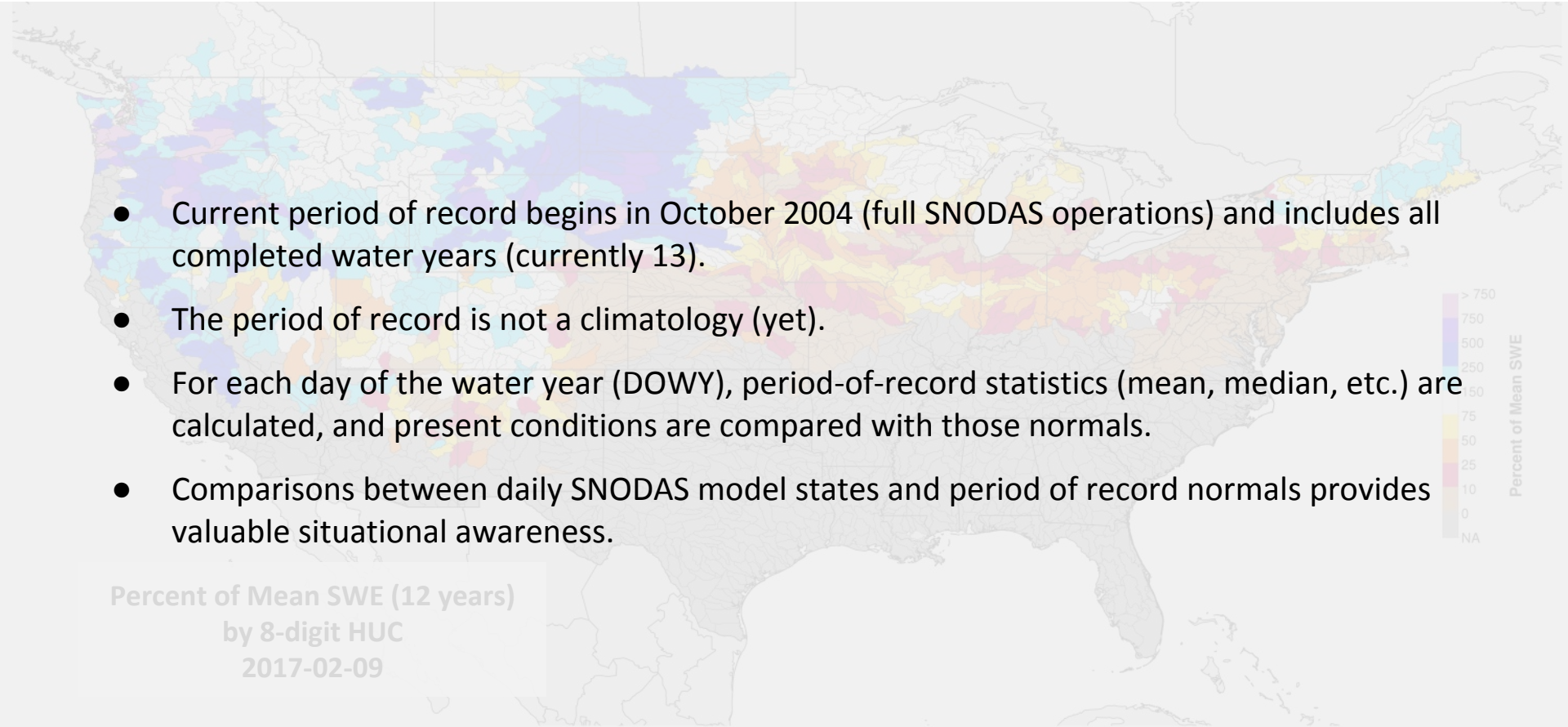


National Snowfall Analysis

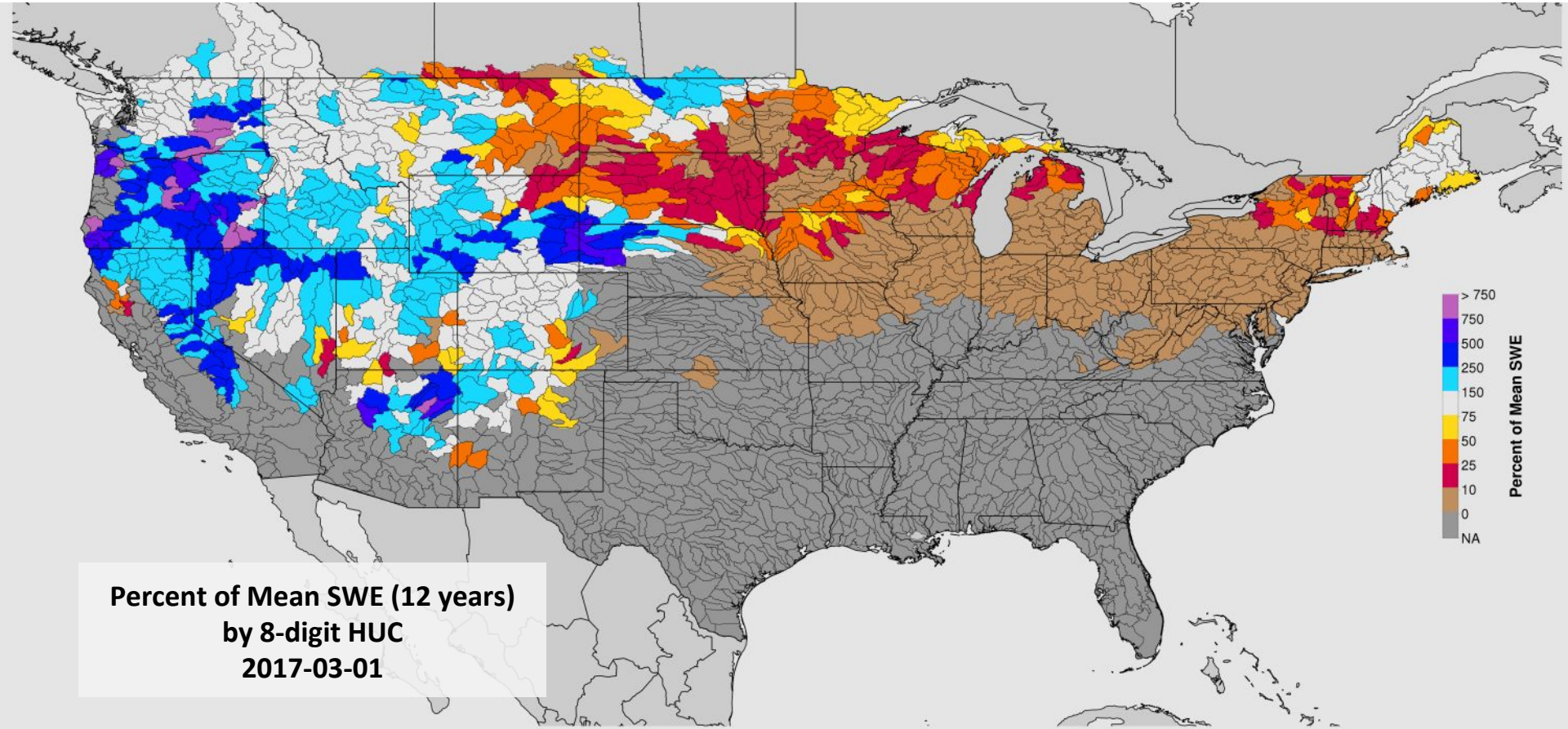


NSA Period of Record Normals

- Current period of record begins in October 2004 (full SNODAS operations) and includes all completed water years (currently 13).
- The period of record is not a climatology (yet).
- For each day of the water year (DOWY), period-of-record statistics (mean, median, etc.) are calculated, and present conditions are compared with those normals.
- Comparisons between daily SNODAS model states and period of record normals provides valuable situational awareness.



NSA Period of Record Normals



THANKS