

# **Requirement for Snow Data, Products, and Information in the Hydrologic Services Program National Weather Service, NOAA**

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## **Overview**

This Requirement for Snow Data, Products, and Information in the Hydrologic Services Program National Weather Service, NOAA has been collated from findings, requirements, and information documented in the 1993, 1996, and 1997 NOAA Disaster Survey Reports and the NWS Assessment of Hydrologic and Hydrometeorological Operations and Services by the National Research Council. The 1996 and 1997 floods were severe snowmelt floods; consequently, the survey reports clearly document much of the RFC and WFO snow data, products, and information requirement. Additionally, this document includes requirements articulated by NWS regional, RFC, and WFO personnel who attended the Eastern Region snow workshop held at the MARFC on December 1-4, 1998; the Western/Alaska Regions snow workshop held at the NWRFC on July 26-30, 1999; and the Eastern Region snow workshop held at Ithaca, NY, on July 18-19, 2000. Lastly, this document includes input and requirements documented at the 4<sup>th</sup> Cold Region Hydrology Workshop held at the NWS Training Center in Kansas City on November 14-17, 2000. This document includes those relevant requirements that are identified in the workshop white paper titled Recommendations and Requirements for Improving National Weather Service Hydrologic Services in Cold Regions, drafted by Gregg Rishel (workshop chairman). Similarly, the workshop white paper has been edited slightly to ensure internal consistency with this requirements document.

Because the snow data, products, and information requirement is similar (but certainly not identical) for all RFCs and WFOs (where snow is a significant hydrometeorological variable), this document has been written to address the national requirement for snow data, products, and information for the NWS Hydrologic Services Program. On January 3, 2001, version 2.2 of this document was distributed to the HSD Chiefs for review and comment. This version incorporates the comments and suggestions received from the HSD Chiefs.

## **A. Requirements for Areal Extent of Snow Cover Data and Information**

1. Digital maps depicting the areal extent of snow cover for the continental U.S., those portions of Canada draining into the U.S., and Alaska, are required on a daily basis.
  - a. Maps are required to depict the areal extent of snow cover at a nominal resolution of 1 km x 1 km.
  - b. Maps are required to depict categories of observed snow cover and snow-free land where clouds are not present.
  - c. Maps are required to depict categories of estimated snow cover and estimated snow-free land where clouds are present.
  - d. Maps are required to depict the relationship between snow cover and elevation with a precision of 328' (100 m) elevation.
2. Alphanumeric summaries of the percentage of areal extent of snow cover by NWS forecast basin are required on a daily basis.
  - a. Summaries are required to include a breakdown of percent areal extent of snow cover by RFC-defined elevation zones within forecast basins where these zones are defined.
3. Digital maps depicting the 24-hour, 48-hour, 72-hour, 96-hour, and 120-hour changes in the areal extent of snow cover for the continental U.S., those portions of Canada draining into the U.S., and Alaska are required on a daily basis.
4. The aforementioned digital maps and alphanumeric summaries depicting and describing the areal extent of snow cover are required to be available on AWIPS and on the Internet within 12 hours of satellite data acquisition.

## **B. Requirements for Snow Water Equivalent (SWE) Data and Information**

1. Digital maps depicting the spatial distribution of SWE for the continental U.S., those portions of Canada draining into the U.S., and Alaska, based on all available satellite-, airborne-, and ground-based data, are required on a daily basis.
  - a. Maps are required to depict SWE at a nominal resolution of 1 km x 1 km, with a precision of 1/10 inches of water.
2. Alphanumeric summaries of the mean SWE averaged over each NWS forecast basin are required on a daily basis where snow is a significant hydrometeorological variable.
  - a. Summaries are required to include a breakdown of mean SWE by RFC-defined elevation zones within forecast basins where these zones are defined.
3. Digital maps depicting the deviation from normal (1970 - 2000) SWE for the continental U.S., those portions of Canada draining into the U.S., and Alaska are required on a daily basis.

4. Digital maps depicting the 24-hour, 48-hour, 72-hour, 96-hour, and 120-hour changes in SWE for the continental U.S., those portions of Canada draining into the U.S., and Alaska are required on a daily basis.
5. The aforementioned digital maps and alphanumeric summaries depicting and describing SWE are required to be available on AWIPS and on the Internet by 0000 UTC each day.

**C. Requirements for Updating Operational River Forecast Models with Snow Data and Information.**

1. An operational method is required to update the snow water equivalent, areal extent of snow cover, heat deficit, liquid water equivalent, and mean snow temperature state variables in the NWSRFS SNOW-17 model with the best available estimates of the actual magnitudes of these state variables occurring in the forecast basin.
  - a. The estimation and updating method is required in all modeling domains of the continental U.S., those portions of Canada draining into the U.S., and Alaska.
2. An operational method is required to update the snow water equivalent, areal extent of snow cover, heat deficit, liquid water equivalent, and mean snow temperature state variables in the NWSRFS SNOW-43 model with the best available estimates of the actual magnitudes of these state variables occurring in the forecast basin and their associated uncertainty.
  - a. The estimation and updating method is required in all modeling domains of the continental U.S., those portions of Canada draining into the U.S., and Alaska.

**D. Requirements for New Snow Modeling Procedures**

1. New snow modeling procedures are required for mountainous areas that account for the effect of terrain on precipitation and temperature.
2. New snow modeling procedures are required that use meteorological variables in addition to air temperature to estimate the amount of snowmelt, either to directly calculate snowmelt, or to determine and apply regional corrections to SNOW-17 and SNOW-43.
3. New snow modeling procedures are required to use observed streamflow information as feedback in an automatic updating technique for snow water equivalent estimates and other state variables of the Snow-17 model. Techniques should be developed to use computed snowmelt runoff volume from streamflow (or river stage) observations or simulations to adjust the appropriate snow model variables.

## **E. Requirements for New Snow Modeling Guidance Products and Information**

1. New products are required that will provide guidance for adjusting relevant major and minor parameters in the NWSRFS SNOW-17 and SNOW-43 models to reduce discrepancies between NWSRFS snow model states and observed snow cover states or the best available estimate of snow cover states occurring in the forecast basin.
2. New products are required from the NOHRSC Snow Data Assimilation System (SNODAS) that depict “red flag” areas alerting forecasters of potentially high snow melt rates and other snow cover conditions relevant to river and flood forecasting operations at RFCs and WFOs.
  - a. Graphical snow melt alert products are required for relevant areas.
  - b. Daily text discussion products are required that i) briefly describe major features of SNODAS-estimated snow characteristics, and ii) include a thorough description of conditions throughout all snow melt alert areas.
3. New products are required from the NOHRSC SNODAS that provide forecasts of future snow cover conditions out to 48 hours.

## **F. Requirements for Enhanced Snow Data Displays and Snow Model Visualization**

1. Improved digital displays are required that will allow RFC and WFO forecasters to visualize what is taking place inside snowmelt and rainfall-runoff models.
  - a. Displays are required to depict maps of modeled snow states.
  - b. Displays are required to depict time series graphs of modeled snow states.
2. Improved digital displays are required that will depict the interaction between precipitation and terrain for the current event and compare this to isohyetal analysis of historical data.

## **G. Requirements for Snow Data**

1. All snow-related observations (snow water equivalent, snow depth, and snow fall) by RFC and WFO personnel and by cooperative observers are required to be encoded in SHEF and made available on AWIPS within 24 hours of the observations.
  - a. The station metadata must be provided to the NOHRSC by the RFCs and contain for each station a valid and unique station ID, station name, latitude and longitude, and station type (e.g., SNOTEL, snow course, snow spotter, etc).
  - b. A national web-based snow observation data entry tool is required to facilitate the ingest and distribution of snow data from various cooperating snow observers.
    - i. The tool must be applicable across regions, and supported at a national level.
    - ii. The tool must contain sufficient password protections or other devices to ensure that data entry is limited to qualified individuals.
    - iii. The tool must provide a mechanism to encode snow observations in SHEF

automatically and distribute these data over AWIPS within 24 hours using standard AWIPS products such as RR1, RR2, or RR3.

2. The Eastern, Central, Western, Southern and Alaska Regions require airborne snow water equivalent data to be collected over significant portions of their respective regions each year. In heavy snow years, airborne snow water equivalent data collection is required almost continuously from early December through June. The airborne snow water equivalent data are required to be transmitted to the RFCs, WFOs, and NOHRSC in near real-time each day after each snow survey mission is complete. The airborne program should have sufficient resources to respond to "emergency requests" for special survey missions after heavy snow storms immediately before spring flood outlooks issued by the RFCs.
3. New observations of snow water equivalent, snow depth, and snowfall are required in areas where such observations are sparse or altogether lacking. (e.g., high elevation areas of the eastern U.S. above 2000 feet). RFCs and WFOs need to define both the minimum and the optimum networks for snow data required to support the RFC's conceptual hydrologic modeling function and the WFOs snow data requirements. Both the spatial and temporal distribution of required snow observations should be defined by the RFCs and WFOs.

#### **H. Requirements for Training**

1. Training is required to be provided every other year to RFCs and WFOs on the physics of snow accumulation and ablation.
2. A web-based training module for snow hydrology is required.
3. Training is required to be provided every other year to RFCs and WFOs on the product generation practices and interpretation of National Operational Hydrologic Remote Sensing Center snow cover and snow water equivalent data products and information services.
4. A snow measurement training video for cooperative observers is required.

#### **I. Observation Equipment**

1. Funding is required for Adirondack snow samplers and other measurement instruments to augment and improve snow data collection by cooperating observers.
2. Funding is required for implementation and maintenance of a dense network of highly reliable, hourly reporting, automated all weather precipitation gages.

## **J. Improved Snow Information in Operational NWP Models**

1. Improved snow information from the NOHRSC SNODAS is required to be integrated into operational numerical weather prediction (NWP) models (Eta and RUC2) to improve meteorological forecasts in cold regions.

## **K. Radar Snowfall Algorithms and Products**

1. Implementation of operational Z-S or other suitable WSR-88D radar snowfall algorithms is required to estimate snowfall water equivalent and resulting snow depth from NEXRAD data. The OSF Snow Accumulation Algorithm needs to be tested, verified, and implemented.
  - a. Algorithms must be capable of generating reliable, real-time snowfall water equivalent and snow depth products.
2. Development of an operational WSR-88D precipitation algorithm that uses climate, terrain, and elevation information to adjust precipitation estimates for all precipitation types (e.g., use PRISM information to adjust estimates).

## **L. Improved Station Location Information**

1. Accurate and precise station location information and unique NWSLI or regional station IDs are required for all permanent or long-term NWS or cooperating snow observation stations.
  - a. Latitude and longitude position is required to the nearest second.
  - b. Elevation position is required to the nearest 30 m, using the WGS84 datum.
  - c. Location information should be collected using the Global Positioning System (GPS) rather than topographic maps.

## **M. NOHRSC SNODAS Data Products and Information**

1. Daily gridded SNODAS data sets depicting key national snow cover state variables and processes are required to be permanently archived for future NWSRFS snow model calibration activities.
2. Verification of SNODAS data products and information is required to be performed.
  - a. Required verification must include the collection of new ground- and airborne-based snow data in specified regions to be used as independent “ground-truth” verification data.
  - b. Required verification must include evaluations of comparisons between SNODAS-estimated snow characteristics and RFC-estimated snow characteristics (e.g. NWSRFS or other mechanisms).

3. A SNODAS spin-up time of 72 hours is required to ensure that most snow observations from cooperating observers have a sufficient amount of time to be reported, distributed, and included in the SNODAS assimilation cycle.
4. To be assimilated into the daily 1200 UTC SNODAS analysis, all snow-related observations (snow water equivalent, snow depth, and snow fall) made by RFC and WFO personnel and by cooperative observers for the previous 24-hour period (1200 UTC to 1200 UTC) must be encoded in SHEF, using valid and unique station identifiers, and made available on AWIPS no later than 1400 UTC.

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