BAMS
Meeting Summary

Six Priorities for Investment in Snow Research and Product Development

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NOAA Snow Workshop

What: Snow observations and research communities within NOAA's National Weather Service (NWS), Oceanic and Atmospheric Research (OAR), and National Environmental Satellite, Data, and Information Service (NESDIS), and other organizations came together to assess snow research goals and necessary improvements.

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In March 2020, the NOAA Snow Workshop brought together the snow observation and research communities from offices across NOAA's National Weather Service (NWS), Oceanic and Atmospheric Research (OAR), and National Environmental Satellite, Data, and Information Service (NESDIS), along with subject matter experts from other agencies and organizations. While the organizing committee had planned for a 2-day workshop in College Park, Maryland, the workshop was adapted to a virtual format due to COVID-19 health and travel concerns.

A keynote address by NWS Director Dr. Louis Uccellini reviewed historic events that shaped our understanding of snow forecasting and operations. Workshop presentations surveyed existing observational capabilities and resources; priorities for new snow measurement capabilities and new products; and mature research and new technologies that might readily transition to operations and meet observational needs. The workshop considered the needs of two types of snow data users: those in the data assimilation and modeling community, using snow data to improve snow analyses and predictions, and operational stakeholders who use snow data to enhance decision support for hydrology, transportation, and other sectors, from near–real time to seasonal time scales.

Workshop participants articulated the need to sustain connections within the snow community, by establishing channels for communication and collaboration, and hosting additional snow-specific workshops. Workshop participants recommended that announcements of opportunity include operations-driven research leading to snow products and advocated for the establishment of a dedicated test bed for snow products.

Guided discussions sessions with subject matter experts identified six priorities for snow research and product development:

1) Snow datasets are disparate and involve multiple observation types, including human observers, automated ground stations, airborne campaigns, and satellite-based observations.

Product needs

- A unified snow dataset that ingests many types of snow observations and includes several snow parameters. This dataset would provide consistency across NOAA and the broader snow community, and would serve various applications, including NOAA's National Centers, National Centers for Environmental Information (NCEI), NWS field offices, and Regional Climate Centers, as well as decision-support tools such as NWS's Local Climate Analysis Tool (LCAT). Organizations concerned with climate time scales, including NWS's Climate Prediction Center (CPC) and state climatologists, requested a

30–60-yr record to provide historical context to current and projected conditions in a gridded format at daily temporal resolution. A global dataset would be most beneficial to snow data assimilation and for Earth system model initialization. The Snow Data Assimilation System (SNODAS), in operation for 16 years, might provide the foundation for this unified dataset.
- Enhanced metadata for snow observational networks, including instrumentation, methods (i.e., for human observers), quality control flags, and measurement uncertainty.
- Inclusion of U.S. National Network snow data in the Global Telecommunications System (GTS).

Research questions
- Which snow datasets are most reliable? This may vary by region and/or parameter.
- What are the measurement standards for each type of observation and for each snow parameter?
- How can uncertainty be quantified within the unified dataset? Formal data assimilation requires good estimates of observational uncertainty.
- How can in situ and remotely sensed observations be unified? Collocated datasets could be used for validation/unification.
- How can linear interpolation be improved, particularly in areas of poor observational coverage?
- How can a unified dataset for use in operational settings be tested?
- How can end users' spatial resolution and latency requirements be met?

2) Inconsistencies in the spatial coverage and frequency of snow observations limit snow data assimilation and model performance.

Product needs
- Identify and prioritize gaps in the spatial observational record ("data deserts").
- Maintain support for human observer programs, including the Cooperative Observer Program (COOP) and SnowPaid, to provide snow measurements at least daily in data sparse regions.
- Enhance observation density in western states and Alaska.
- Reduce data latency, for improved operational, near-real-time model initialization and cross validation with other datasets.

Research questions
- How can model adjoints be advanced, i.e., how to improve understanding of relationships in time and in space in the model, in order to infer what has happened before and at neighboring grid cells?
- How to minimize the impacts of irregular spatial representation of snow observations and temporal asynchronicity (i.e., no observations taken during summer) on model performance?
- How do mismatches between model grids and snow observation stations, especially in areas with complex terrain, affect land–atmosphere feedbacks?

3) Snow projections are not available at subseasonal to seasonal (S2S) time scales. S2S products would help stakeholders in many sectors (e.g., transportation and recreation) prepare for winter. Additionally, these products would improve water supply and flood risk management in the late winter and spring.

Product needs

- Enhanced CPC Winter Outlook with expected number of minor snow events and major winter storms, with thresholds for these events to be determined by working with regional stakeholders.
- Seasonal snowfall and snowpack [snow water equivalent (SWE)] outlooks (with above, below, equal chance for seasonal snowfall totals relative to climatology) similar to CPC's seasonal temperature and precipitation outlooks. A gridded product would be needed to verify snow probabilities.

Research questions

- How can coupling between atmospheric, hydrologic, and ocean models be strengthened?
- What are the sources of predictability for snow at S2S time scales? Is the predictability of snow similar to that of temperature and precipitation?
- Would improved spring snowmelt modeling lead to better near-surface temperature forecasts (e.g., for mild days that start with a small amount of snow on the ground)?
- At what scale must snow processes be represented in order to enhance snow predictability? How can sub-grid-scale processes be represented?

4) Snowfall rate is an important snow parameter for operational users, especially those making decisions in near–real time, e.g., the road transportation and aviation sectors. Snowfall totals, currently used in snow forecast messaging, are less useful in making short-term decisions. Snowfall rate could be an additional forecast parameter issued by NWS Weather Forecast Offices (WFOs).

Product need

Climatology of snowfall rates by month and location that should include at least 30 years of data, providing historical context for weather forecasts and messaging. SNODAS, with an existing 15-yr, daily, gridded dataset, might provide the foundation for such a climatology.

Research questions

- How can snowfall rate be measured in near-real time?
- Can observational networks (e.g., SNOTEL, METAR sites) be modified for more frequent reporting, thus providing estimates of snowfall rate? Additionally, enhanced surface-based instrumentation may prove valuable for capturing the characteristics (e.g., snow-to-liquid ratio) of different types of snowfall events (synoptic scale versus lake effect)
- Are webcams (and other nontraditional technologies) suitable for measuring snowfall rate?

5) Snow parameters are codependent, but the relationships between some snow parameters are poorly understood. Snow parameters may be measured with different methods, frequency, accuracy, and ease. For example, snowfall (as measured on the ground) is easier to measure than falling snow. Further, model studies tend to optimize for snow parameters independently, leading to inconsistencies in model output.

Product need

Algorithms defining the relationships between (and/or conversion between) snow parameters.

Research questions

- How can snow parameters be jointly and consistently adjusted in models?

- How can model ensembles be used to optimize snow parameters?
- How can SWE be converted to snow depth?
- What is the relationship between falling snow and snowfall accumulation?
- How does snow affect air temperature?
- How can snow metamorphosis be better represented in models? Snow metamorphosis, and its impacts on snowpack, affects hydrologic modeling and S2S forecasts.

6) Models have difficulty distinguishing liquid from solid precipitation. Models, such as those contributing to the National Blend of Models, may disagree on the location of the rain–snow line, and use different methods to diagnose this parameter. Improved analysis of precipitation type and density on the ground would benefit real-time operations, retrospective evaluation (i.e., to assess snowfall accumulation for a specific area over a 10-day period) and model initialization.

Product needs

- High-accuracy analysis of hydrometeor type.
- Density estimates of accumulating precipitation on the ground when precipitation is partially frozen.

Research question

Which datasets and/or models are best used or combined to locate the rain–snow line, particularly in complex terrain? These could include ground-based radar, profiling research radars, satellite datasets, and existing snow analyses [e.g., National Operational Hydrologic Remote Sensing Center (NOHRSC)].

The NOAA Snow Workshop strengthened connections within the snow community and identified the above six priorities for investment in snow research and product development. These priorities are already informing NOAA's funding solicitations for snow-related research. The workshop planning committee has begun to discuss efforts to sustain engagement among the snow community and develop the high-priority products mentioned above.

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