Snowfall Observations and Products in the 21st Century: Meeting the needs of FEMA and the climate community

YMCA of the Rockies, Estes Park, Colorado

May 25-27, 2011

Workshop Objective: To facilitate collaboration among federal and non-federal partners to improve the quality, quantity, and accessibility of historical and current snowfall observations and derivable products from NOAA and non-NOAA networks in support of FEMA and the wider user community.

The workshop will consist of a series of presentations in plenary followed by discussions within three co-convening breakout groups. One-page summaries of the issues associated with the primary objective for each breakout group have been developed by a designated lead and are included with this agenda. Although each breakout group has a primary issue to discuss and report on, there will also be the opportunity to provide input on the issues associated with the primary objective of the other two co-convening breakout groups.

Wednesday, May 25, 2011

7:00-8:00 Dining Room open

8:00 Welcome and Logistics

8:05-8:15 Workshop challenge (Lawrimore)

DEFINING USER REQUIREMENTS

8:15-8:45 FEMA's Snow Disaster Declaration Process (Yandle)

8:45-9:30 Evaluating snowfall events; Perspectives from FEMA Regions 1, 3, and 7 (Barnett, Brand, Hillman)

9:30-10:15 State Government Perspective and Requirements (Gally, CO; Crumpler, VA; Green, NY; Schulz, AZ)

10:15-10:30 Break

10:30-10:50 NWS Perspectives on Snowfall Observations and the Disaster Declaration Process (Maier)

SNOWFALL OBSERVING PRACTICES

10:50-11:10 NOAA's Observer Training Program (J. Jones, NWS Training Center)

11:10-11:30 COOP Network snowfall observing practices, present and future (Zdrojewski)

11:30-11:50 NOAA/NWS Current Standard Observing Practices; ASOS, Snow Paid, NWS Spotters (Townsend)

11:50-12:10 Snowfall observing practices within FAA's Contract Observing Program (Chaney, Calamita)

12:15-1:15 – Lunch

1:15-2:30 Snow data Panel
Presenters will each have 5 minutes to provide perspectives on snow quality issues associated with data measurement practices and local quality control practices that help ensure data quality. A moderator will preside over a period of questions and answers.

NCDC (Heim)
Global Snow Climate Lab, Rutgers Univ. (Robinson)
Midwest Regional Climate Center (Hilberg)
NOHRSC (Olheiser)
CoCoRaHS (Doesken)

2:30-3:00 BREAK

3:00-3:15 Perspectives on historical observing practices and homogeneity of the snowfall record; Part 1 (Kunkel)

3:15-3:30 Perspectives on historical observing practices and homogeneity of the snowfall record; Part 2 (Hubbard)

3:30-3:45 Quantifying Errors and Bias in snowfall records: Perspectives from the WMO Solid Precipitation Intercomparison (D. Yang)

3:45-3:55 Breakout Objectives (Lawrimore)

4:00-5:00 Breakout Session #1: Improving the Quality of Snowfall Measurements at the Point of Observation

Objective: *Develop recommendations for standardizing snowfall measurement practices across networks, with special focus on:*

(1.1) Observing Procedures
(1.2) Training Tools and Methods
(1.3) NWS Spotter and other unofficial data sources

5:10-6:00 Return to Plenary, Summaries and Recommendations from Breakouts

Thursday, May 26, 2011

7:00-8:00 Dining Room open

8:00-8:10 Review of Day 1 and Objectives for Day 2 (Lawrimore)

Emerging Measurement Technologies

8:10-8:40 The Delaware automated snow observing network (Brinson)

8:40-9:00 Automated snowfall observations at the national and regional level; Environment Canada (D. Yang)

9:00-9:20 The Snotel Automated Snow Network (Gillespie)

9:20-9:40 Auto measurement R&D, Leveraging activities within NOAA's RCRN Program; Marshall Test Bed, CO (Gutman)

9:40-9:45 Breakout Objectives (Lawrimore)

9:45-10:45 Breakout Session #2: Expanding the Quantity and Enhancing the Quality of Current and Historical Snowfall Observations

Objective: Identify ways to expand the network of high quality snowfall observations, with special focus on:

(2.1) Establishing methods for incorporating additional data sources (manual or automated) that meet established quality standards

(2.2) Refining the work plan for 2011-2012 NOAA/RCRN automated snow measurement study

(2.3) How FEMA and States can best fill gaps by using existing sources of data.

10:45-11:00 Break

11:00-11:30 Summaries and Recommendations from Breakout #2

Improving NOAA's Historical Snow Climatologies and Products

11:30-11:50 NOAA's Snow Climatology Dataset and User Perspectives (Heim)

11:50-12:10 New Gridding Methodologies; NCDC's 5X5 km gridding methodology (Vose [Dial-in]/Squires)

12:10-12:30 Development and Applications of a 1X1 Degree snowfall dataset (Mote)

12:30-1:30 Lunch

1:30-1:50 Snow product development and delivery at NOHRSC (Halquist)

1:50-2:10 Web-based data delivery at NCDC (Squires)

2:10-2:40 NWS Central Region Snowfall Analysis (Walawender)

2:40-3:00 BREAK

3:00-3:10 Breakout Objectives (Lawrimore)

3:15-4:15 Breakout Session #3: Improving Analysis and Assessment Capabilities through an improved historical record

Objective: *Identify methods for resolving inadequacies in existing snow climatologies and data accessibility within NOAA, with special focus on:*

(3.1) Quality control of historical data

(3.2) Methods for resolving data density limitations

(3.3) Improved solutions to web-based delivery of snow data and products

4:15-5:00 Summaries and Recommendations from Breakout #3

6:30 Group Event

Friday, May 27, 2011

7:00-8:00 Dining Room open

8:00-8:15 Separating Hail and Snow reporting practices (Zdrojewski)

8:15-9:15 Breakout Session #4: Hail reporting practices within NOAA networks

Objective: (4.1) *Develop recommendations for changes to NWS Directives that will clarify and standardize hail reporting practices across COOP and ASOS networks to preserve the snow record.*

Breakout #4 provides the opportunity to reconvene two breakouts from previous sessions to address issues not completed during the earlier discussions. Decisions regarding these breakouts and participants will be made at the close of Day 2.

9:15-10:00 Summaries and Recommendations from Breakout #4

10:00-10:15 Break

10:15-10:30 Setting the stage for Breakout #5 (Lawrimore)

10:30-11:30 Breakout Session #5: Charting a way forward

Objective: *With consideration given to FEMA's snow disaster assessment process, prioritize recommendations from each breakout session and create a list of short and longer-term action items.*

At the close of Day 2, the set of highest priority issues and recommendations will be brought forth and revisited during the final set of breakout discussions. Consider recommendations regarding how FEMA could better tailor the snow disaster assessment process to existing and evolving data products and changes NOAA can make to improve its collection and delivery of high quality observations.

11:30-1:00 Open discussion of Recommendations from Breakouts and Agreement on the way forward

1:00 Workshop Ends (Dining Room remains open until 1:30)

Breakout Sessions

1-page background summaries of the objective and issues for each breakout group are included on pages 13-23.

Breakout Session #1: Improving the Quality of Snowfall Measurements at the Point of Observation.

1.1 Observing Procedures (**Doesken**): Improve the quality and comparability of snowfall measurements regardless of its source.

Allen, Jotham	FEMA/OCC
Brand, Gary	FEMA Region 3/Philadelphia
Brinson, Kevin	U. Delaware
Calamita, Joe	FAA Contract Weather Program, Operations Team Lead
Doesken, Nolan	Colorado State
Gillespie, Mike	Snotel Program, USDA-NRCS, CO/NM, Snow Survey Supv.
Heim, Richard	NOAA NCDC
Helfrich, Sean	National Ice Center
Hubbard, Ken	RCC, HPRCC
Johnson, Sally	NOAA FEMA Liaison
Korzeniewski, Bryant	NOAA NCDC
Kunkel, Ken	NOAA NCDC/CICS
Maier, Chris	NOAA NWS/OCWWS/RAD/AB
Mote, Tom	U. GA
Scharfenberg, Kevin	NOAA NWS OCWWS/COOP Program
Yang, Daqing	Environment Canada

1.2 Training Tools and Methods (**Marsh**): Identify inadequacies and methods for standardizing snow observer training across networks including COOP, ASOS, snow paid, snow spotter, and CoCoRaHS.

Asmus, Mike	NOAA NWS Southern Region
Barnett, Tim	FEMA Region 1/Boston
Chaney, Deb	FAA Terminal Safety and Operations Support
Couch, Mike	NOAA NWS OPL, Topeka, KS
Crumpler, Brian	State, Virginia Dept of E.M. Preparedness Division
Halquist, John	NOAA NOHRSC
Hilberg, Steve	RCC, Midwest RCC

Jones, Jim	NOAA NWS KC Training Center
Kelsch, Matt	UCAR/COMET
Marsh, Sergio	NOAA NWS OSD
Miller, Donald	NOAA NWS
Ryan, Wendy	Colorado State
Schulz, Will	State, Arizona
Smith, Victoria	State, Colorado Office of E.M.
Squires, Mike	NOAA NCDC

1.3 NWS Spotter data sources (**Townsend**): Considering the importance of snow spotter observations to the snow disaster declaration process, consider adequacy of the program regarding recruiting, observing practices, potential need for classification and segregation of snow spotter observations based on training and quality, and the need to archive snow spotter observations.

Juskie, John	FEMA
Eise, John	NOAA NWS SSD
Gally Marilyn	State, Colorado Office of E.M.
Gimmestad, Chad	NOAA NWS WFO Boulder
Green, Shannon	State, NYS Office of Emergency Management
Guttman, Ethan	NCAR/Marshall Testbed-ATDD
Hillman, Joe	FEMA Region 7/Kansas City
Lawrimore, Jay	NOAA NCDC
Olheiser, Carrie	NOAA NOHRSC
Reges, Henry	Colorado State CoCoRaHS
Robinson, Dave	Rutgers University
Rovito, Dino	FAA/NEXTGEN/Avn Wx
Townsend, Tom	NOAA NWS Central Region
Yandle, Denise	FEMA, Kirkland, WA, Acting PA Policy Branch Chief
Zdrojewski, Jim	NOAA NWS OCWWS CSD

Breakout Session #2: Expanding the quantity and enhancing the quality of current and historical snowfall observations.

2.1 New data sources (**Robinson**): Establish methods for incorporating additional data sources (manual or automated) that meet established quality standards.

Brand, Gary	FEMA Region 3/Philadelphia
Chaney, Deb	FAA Terminal Safety and Operations Support
Couch, Mike	NOAA NWS OPL, Topeka, KS
Eise, John	NOAA NWS SSD
Gally Marilyn	State, Colorado Office of E.M.
Gillespie, Mike	Snotel Program, USDA-NRCS, CO/NM, Snow Survey Supv.
Gimmestad, Chad	NOAA NWS WFO Boulder
Halquist, John	NOAA NOHRSC
Helfrich, Sean	National Ice Center
Hillman, Joe	FEMA Region 7/Kansas City
Hubbard, Ken	RCC, HPRCC
Jones, Jim	NOAA NWS KC Training Center
Kunkel, Ken	NOAA NCDC/CICS
Reges, Henry	Colorado State CoCoRaHS
Robinson, Dave	Rutgers University
Yang, Daqing	Environment Canada

2.2 NOAA/RCRN automated snow measurement study (**Lawrimore**): Refine and establish a work plan for the 2011-2012 NOAA/RCRN automated snow measurement study.

Asmus, Mike	NOAA NWS Southern Region
Baker, Bruce	ATDD (Calling in)
Brinson, Kevin	U. Delaware
Doesken, Nolan	Colorado State
Guttman, Ethan	NCAR/Marshall Testbed-ATDD
Hilberg, Steve	RCC, Midwest RCC
Johnson, Sally	NOAA FEMA Liaison
Korzeniewski, Bryant	NOAA NCDC
Lawrimore, Jay	NOAA NCDC
Marsh, Sergio	NOAA NWS OSD

Miller, Donald	NOAA NWS
Ryan, Wendy	Colorado State
Townsend, Tom	NOAA NWS Central Region
Zdrojewski, Jim	NOAA NWS OCWWS CSD

2.3 Short-term solutions to data gaps (**Heim**): Address problems associated with insufficient current and historical data availability, develop recommendations for changes that will improve the snowstorm analysis process for FEMA and States and that can be implemented in the near term (before the 2011-2012 snow season).

Allen, Jotham	FEMA/OCC
Barnett, Tim	FEMA Region 1/Boston
Calamita, Joe	FAA Contract Weather Program, Operations Team Lead
Crumpler, Brian	State, Virginia Dept of E.M. Preparedness Division
Green, Shannon	State, NYS Office of Emergency Management
Heim, Richard	NOAA NCDC
Juskie, John	FEMA
Kelsch, Matt	UCAR/COMET
Maier, Chris	NOAA NWS/OCWWS/RAD/AB
Mote, Tom	U. GA
Olheiser, Carrie	NOAA NOHRSC
Rovito, Dino	FAA/NEXTGEN/Avn Wx
Scharfenberg, Kevin	NOAA NWS OCWWS/COOP Program
Schulz, Will	State, Arizona
Smith, Victoria	State, Colorado Office of E.M.
Squires, Mike	NOAA NCDC
Yandle, Denise	FEMA, Kirkland, WA, Acting PA Policy Branch Chief

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Breakout Session #3: Improving Analysis and Assessment Capabilities through an improved historical record.

3.1 Quality control (**Kunkel**): Identify steps that can be taken to improve the quality control process and ensure homogeneity of the historical and near real-time data record.

Allen, Jotham	FEMA/OCC
Barnett, Tim	FEMA Region 1/Boston
Calamita, Joe	FAA Contract Weather Program, Operations Team Lead
Couch, Mike	NOAA NWS OPL, Topeka, KS
Doesken, Nolan	Colorado State
Eise, John	NOAA NWS SSD
Guttman, Ethan	NCAR/Marshall Testbed-ATDD
Hilberg, Steve	RCC, Midwest RCC
Hubbard, Ken	RCC, HPRCC
Kunkel, Ken	NOAA NCDC/CICS
Lawrimore, Jay	NOAA NCDC
Maier, Chris	NOAA NWS/OCWWS/RAD/AB
Robinson, Dave	Rutgers University
Scharfenberg, Kevin	NOAA NWS OCWWS/COOP Program
Schulz, Will	State, Arizona
Yang, Daqing	Environment Canada

3.2 Resolving data density limitations (**Heim**): Taking into account FEMA's observational requirements, identify station density requirements and methods (e.g., data rescue, gridding and interpolation, modeling) that can be used to improve data density in the snow climatology record to provide needed statistical perspective.

Asmus, Mike	NOAA NWS Southern Region
Brand, Gary	FEMA Region 3/Philadelphia
Brinson, Kevin	U. Delaware
Gally Marilyn	State, Colorado Office of E.M.
Gimmestad, Chad	NOAA NWS WFO Boulder
Green, Shannon	State, NYS Office of Emergency Management
Halquist, John	NOAA NOHRSC
Heim, Richard	NOAA NCDC

Helfrich, Sean	National Ice Center
Johnson, Sally	NOAA FEMA Liaison
Marsh, Sergio	NOAA NWS OSD
Mote, Tom	U. GA
Rovito, Dino	FAA/NEXTGEN/Avn Wx
Ryan, Wendy	Colorado State
Zdrojewski, Jim	NOAA NWS OCWWS CSD

3.3 Web-based data access (**Squires**): Taking into account existing and future web-based data delivery tools, identify new web-based solutions that can be implemented in the near term and longer term to address FEMA's data access needs.

Chaney, Deb	FAA Terminal Safety and Operations Support
Crumpler, Brian	State, Virginia Dept of E.M. Preparedness Division
Gillespie, Mike	Snotel Program, USDA-NRCS, CO/NM, Snow Survey Supv.
Hillman, Joe	FEMA Region 7/Kansas City
Jones, Jim	NOAA NWS KC Training Center
Juskie, John	FEMA
Kelsch, Matt	UCAR/COMET
Korzeniewski, Bryant	NOAA NCDC
Miller, Donald	NOAA NWS
Olheiser, Carrie	NOAA NOHRSC
Reges, Henry	Colorado State CoCoRaHS
Smith, Victoria	State, Colorado Office of E.M.
Squires, Mike	NOAA NCDC
Townsend, Tom	NOAA NWS Central Region
Yandle, Denise	FEMA, Kirkland, WA, Acting PA Policy Branch Chief

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Breakout Session #4: Hail reporting practices within NOAA networks

4.1 Distinguishing hail from snow (**Zdrojewski**): Develop recommendations for changes to NWS Directives that will clarify and standardize hail reporting practices across COOP and ASOS networks to preserve the snow record.

Breakout #4 provides the opportunity to reconvene two breakouts from previous sessions to address issues not completed during the earlier discussions. Decisions regarding these breakouts and participants will be made at the close of Day 2.

Breakout Session #5: Charting a way forward

Objective: With consideration given to FEMA's snow disaster assessment process, prioritize recommendations from each breakout session and create a list of short and longer-term action items.

At the close of Day 2, the set of highest priority issues and recommendations will be brought forth and revisited during the final set of breakout discussions. Consider recommendations regarding how FEMA could better tailor the snow disaster assessment process to existing and evolving data products and changes NOAA can make to improve its collection and delivery of high quality observations.

Breakout Session #1.1: Improving the Quality of Snowfall Measurements at the Point of Observation.

Lead: Nolan Doesken, Colorado State Climate Office, Colorado State University

Objective: Improve the quality and comparability of snowfall measurements regardless of its source.

Background: Historically, most snow data gathered and used in the U.S. have come from manual observations with many of these observations coming from volunteers. Inconsistencies in observation have sometimes been evident resulting in questions about the reliability and historic continuity of snowfall data. Measuring snow involves three separate measurements: 1) The water content captured in a rain gauge, 2) the maximum accumulation of fresh snowfall since the previous observation and 3) the total depth of snow on the ground at the time of observation including both fresh and previously existing snow. Each element of the measurement is important, but it is the combination of all three that best defines the impact of a storm. Inches of fresh snowfall is significant, but the water content and total depth on the ground helps tell the complete story. The illusive challenge for achieving high quality and consistent snow observations relates to the fact that snow may melt, compact (settle), switch to rain, freezing rain or sleet, and/or be drifted and redistributed by the wind all within a few hours of time. Measuring something that is hard to catch and constantly changing requires training, effort, skill and experience or very sophisticated observing systems. The most extreme storms are often accompanied by high winds making it difficult to find representative measurement locations but also adding uncertainty to the measurement of gauge precipitation (water content) since gauges tend to catch only a fraction of the snow when it falls horizontally.

Issues:

(1) Historically there has not always been total agreement on the definition of "snowfall". How can we overcome this and will a concise definition help improve training and data quality across networks?
(2) What constitutes a representative location and measurement surface for taking snow measurements, and how well can this be standardized and enforced?
(3) Much of the U.S. snowfall data is gathered by volunteers. Can data from volunteers be relied on?
(4) The interval between observation of snowfall (once a day, once every 6 hours, once every hour, etc) affects the resulting snow reports. Can the most appropriate time interval and time(s) of day for snow observations be determined, and can this measurement interval be standardized? Should data from different observational intervals be combined and compared?
(5) Is the single element -- the accumulation of fresh snowfall – sufficient to describe the severity of a storm or do other measurements (water content, total depth, wind, etc) also need to be factored in?
(6) The most intense storms are often the most difficult to measure. Observational uncertainty is inevitable, but is this uncertainty understood and acceptable to data users?

Breakout Session #1.2: Improving the Quality of Snowfall Measurements at the Point of Observation.

Lead: Sergio Marsh, National Weather Service, NOAA

Objective: Identify inadequacies and methods for standardizing snow observer training across networks including COOP, Surface Observations, snow paid, snow spotter, and CoCoRaHS.

Background: Most snow data recorded and used in the U.S. come from manual observations. Inconsistencies in observational methods result in questions about the reliability and historic continuity of snowfall data measurements, and by inference the training of the observers. Not only are there different measurements (water content, accumulation of fresh snowfall, total depth of snow on the ground), but traditionally different programs have used snow measurements towards different aims, either operational or climatologically. Not only can this be confusing for the user of the data, but for the observer as well, as there are different ways of measuring the data. Can there be a single method to train all observers measuring snow data (regardless of the program) to obtain high quality data. Measuring something that is hard to catch and constantly changing requires training, effort, skill and experience or very sophisticated observing systems. The most extreme storms are often accompanied by high winds making it difficult to find representative measurement locations but also adding uncertainty to the measurement of gauge precipitation (water content) since gauges tend to catch only a fraction of the snow when it falls horizontally.

Issues:

(7) Standardizing observer training within NOAA and non-NOAA networks.
(8) Are there inadequacies in current training programs across COOP, Surface Observations, snow paid, snow spotter, CoCoRaHS and other programs, that need to be addressed.
(9) Can one method of training from a program (snow measurement for Surface program) be applied to other programs (COOP, snow spotters, etc)
(10) Measurements apply to snow depth and snowfall. The differences are in the details:
    - Representative locations
    - Interval between observation of snowfall (once a day, once every 6 hours, once every hour, etc)
    - Intense storms are often the most difficult to measure

Breakout Session #1.3: Improving the Quality of Snowfall Measurements at the Point of Observation

Lead: Tom Townsend, NOAA NWS

Objective: Considering the importance of storm spotter observations to the snow disaster declaration process, consider adequacy of the program regarding recruiting, observing practices, potential need for classification and segregation of spotter observations for snow based on training and quality, and the need to archive spotter observations for snow.

Background: FEMA's snow assistance policy directs that the need for disaster assistance will be based on a comparison of historical snowfall observations ("snowfall climatology") with observations from the current event provided by the NWS Cooperative Observers Network (COOP) as well as other observations verified by NCDC or NWS as being representative of snowfall in the affected county. Although traditionally the acceptance of "other" observations had been restricted to those taken within formal networks by trained observers (e.g., FAA, snow paid observers, CoCoRaHS), before the conclusion of the 2010-2011 winter season the sources of observations verified by NCDC or NWS were expanded to include observations from NWS spotter resources*. Spotter observations were designed to serve an important role in increasing the density of weather observations and providing the NWS with information essential to the forecast and verification process. Now that its role has been expanded to include the FEMA snow assessment process, which involves comparison with climatological observations from NOAA observing networks, ensuring the quality of the observations for this purpose is a high priority. Obtaining observations with the accuracy required for this purpose is complicated by the level of training given to spotters, less experienced observers with no established observation location, and by observers who may be biased toward inflated reporting.

*In a memorandum dated January 6, 2011, FEMA clarified these other sources to include "...NWS spotter resources, verified by NCDC or NWS as representative of snowfall in a county, as a primary source of data even when Cooperative Network Stations exist and report."

Issues: Given the unique nature of NWS spotter resources and their growing importance to the snow assessment process, this breakout will focus on methods for ensuring the quality and consistency of this resource with other observing networks. Topics for discussion include the following:

1. Does the climate community have confidence in the overall quality of spotter observations for comparison with historical snowfall extremes.
2. How can NOAA ensure that spotter observers are sufficiently experienced and trained to provide accurate observations.
3. Do there need to be classes of spotter observations for snowfall – some higher quality than others and clearly marked as reliable enough for FEMA's use?
4. Is there a better way to designate and disseminate spotter observations for snowfall that better meets FEMA's needs.
5. Should there be a requirement for formally archiving spotter observations for snowfall and how technically difficult would it be to label, track, and disseminate from the WFOs to NCDC's archive.

Breakout Session #2.1: Expanding the quantity and enhancing the quality of current and historical snowfall observations.

Lead: Dave Robinson, Rutgers University

Objective: Establish methods for incorporating additional data sources (manual or automated) that meet established quality standards.

Background: Variations in snowfall, snow cover and snow water equivalent are common over short distances, often at a sub-county scale, due to storm tracks, changing elevation, and proximity to water bodies (to name a few). Remote sensing techniques can discern some of these variations, but alone they do not provide the detailed information necessary for disaster declarations, hydrological forecasting and engineering-related issues (e.g. snow loads), and other purposes. Therefore it is essential to have a spatially dense network of in situ observations for these purposes (as well as for ground truthing satellite products), making sure that these observations adhere to NWS observing standards. Fortunately, there is greater potential than ever to enhance the spatial coverage of snow observations beyond that heretofore available from NWS Cooperative and First-order stations. Sources for additional observations include NWS Spotters, CoCoRaHS observers and an expanding number of automated stations. So too is it recognized that not all Cooperative observers are contributing snow observations, yet could if provided training and encouragement. However efforts to increase the number of acceptable reports cannot be achieved without adequate observer training (including refresher training) and quality control. So too must attention be paid to improving the quality of historical data from Cooperative stations in order to provide accurate perspective to current observations, whatever their source.

Questions to be addressed in this breakout session:

(1) Can additional active Cooperative stations be encouraged to report snow? Is current snow reporting adequate at those reporting snow?
(2) Can timely and accurate observations of snow be secured from non-official NWS networks, be they manual or automated (e.g. CoCoRaHS, NWS Spotter, DEOS automated)?
(3) Are historical snow observations available from these ancillary networks?
(4) Should ancillary observations pass the quality controlling being done on Cooperative data and subsequently archived at NCDC in order to qualify as part of an expanded network?
(5) Is it possible to adequately quality control historical Cooperative observations?

Breakout Session #2.2: Expanding the quantity and enhancing the quality of current and historical snowfall observations.

Lead: Jay Lawrimore, NOAA NCDC

Objective: Refine and establish a work plan for the 2011-2012 NOAA/RCRN automated snow measurement study.

Background: Today most snowfall observations continue to be provided by volunteer observers, some operating within and others outside official NOAA observing programs. The quality of these observations is dependent on the expertise of the individual observer and the observer's willingness to brave harsh conditions to make consistent and accurate reports. Automated snow measurements were widely established in the 1980s as part of networks such as SNOTEL. But measurements have largely been confined to snow depth and snow water equivalent and primarily in remote mountainous areas of the West. Efforts to combine automated snow sensor technology with other information to produce observations of snowfall as a replacement for manual snowfall measurements have met with mixed success. But recent advances give hope that large-scale networks of fully automated sensors can provide high quality objective and reproducible measurements of snowfall without manual oversight. NOAA NWS sponsored a study which was conducted from 2006 to 2008 at several sites around the U.S. in an effort to establish methods for making automated snowfall measurements. This project ended without a fully established algorithm and methodology. Today as part of a program to develop new observing capabilities, NOAA's Regional Climate Reference Network program is sponsoring a pilot study which will involve the collection of automated snow sensor measurements at four or five NWS Weather Forecast Offices for the purpose of furthering the effort to establish algorithms for snowfall measurements.

Issues:

(1) Several NWS Weather Forecast Offices continued to maintain ultrasonic snow depth sensors following the conclusion of the 2006-2008 study.
(2) NOAA's Atmospheric Turbulence and Diffusion Division (ATDD) has gained recent experience in automated snowfall and snow depth measurements as part of the RCRN program operating from NCAR's Marshall Test Site.
(3) Lessons learned from NOAA's 2006-2008 study as well as experiences from the Marshall testbed can be applied to establishing automated snow sensor measurements at up to five Weather Forecast Offices (WFO) around the U.S. during the 2011-2012 winter season.
(4) Climatologists at the Colorado State Climate Office in Fort Collins, Colorado operate an automated snow sensor package on site and are willing to contribute to oversight of the operation and collection of automated snow sensor measurements at the WFO locations.
(5) This breakout discussion will focus on requirements associated with the necessary automated snow sensor equipment, automated precipitation gages, best approaches for conducting the study, and necessary steps for establishing this study in advance of the 2011-2012 winter season.

Breakout Session #2.3: Expanding the quantity and enhancing the quality of current and historical snowfall observations.

Lead: Richard Heim, NOAA NCDC

Objective: To address problems associated with insufficient current and historical data availability, identify solutions than can be implemented in the near term (before the 2011-2012 snow season) for dealing with less than optimum coverage and better leveraging existing resources to improve the snowstorm analysis process for FEMA and States.

Background: FEMA's snow assistance policy directs that the need for disaster assistance will be based on a comparison of snowfall totals from the current event compared to observations from the historical record. NOAA NCDC's historical snowfall climatology consists of data that include maximum historical 1-day, 2-day, and 3-day snowfall totals from observations taken by NWS Cooperative Observers. This dataset, which was developed in the mid-1990s, suffers from problems that include in many cases short periods of record, missing observations, and a lack of station data in many counties. In addition, observations from the current snow event are often unavailable in affected counties or with sufficient density to properly characterize all parts of a county. While other discussions are focused on lengthy development efforts for new products that will address gaps in spatial coverage, this breakout is focused on near-term changes (less than 6 months) that can be implemented in advance of the 2011-2012 snow season to address problems associated with data coverage deficiencies and improve the snowstorm analysis process.

Issues: Developing new snowfall climatologies using new gridding methodologies, modeling, and other dataset building practices will require one or more years of development. Other actions that can be taken within the next several months to address historical and current observational deficiencies need to be considered to improve the snowstorm analysis process. This breakout will focus on identifying changes in the data analysis process that can be implemented in advance of the 2011-2012 winter season. Topics for discussion include:

(1) Historical data are provided from NCDC's snowfall climatology, with a goal of annual updates, and data provided via the snow climatology website (http://www.ncdc.noaa.gov/ussc/).
(2) Current observations provided by NCDC (http://www.ncdc.noaa.gov/snow-and-ice/dly-data.php) include COOP, CoCoRaHS, and ASOS manually augmented observations.
(3) States rely on other observations which are collected from a patchwork of other locations which are often not widely known and inconsistent from one Weather Forecast Office to the next.
(4) Many counties have no historical 1, 2, or 3-day snowfall extreme data, and in other cases, no available observations for the event in question. Current policy allows snowfall observations in adjacent counties to be used for snowstorm assessment.
(5) States are forced into creative and time consuming detective work to identify the data needed for the snowstorm assessment.

(6) What processes and/or data can be utilized or implemented in the next 6 months to improve snow observation coverage and climatologies for data-sparse counties and streamline the process for federal and State partners?

Breakout Session #3.1 Improving Analysis and Assessment Capabilities through an improved historical record and better access tools and products.

Objective: Taking into account FEMA's observational requirements, what steps can be taken to improve the quality control process and ensure homogeneity of the historical and near real-time data record.

Lead: Ken Kunkel, NOAA NCDC and Cooperative Institute for Climate and Satellites

Background: The U.S. snowfall record is affected by data quality issues associated with random errors (e.g., errors of transcription, digitization, or observation) as well as systematic biases ("inhomgeneities") that are due to factors that change through time such as station moves, changes in observer, modification of the site, and changes in observational practices. Automated quality control processes are used to identify and remove random errors, and in some cases manual quality control processes are used to identify errors in the historical record as well as errors in current observations as part of near real-time operational quality control programs. Identifying inhomogeneities is an even more complex program, but is of particular interest to ensuring the consistent comparison of current with historical observations.

Issues: Quality control procedures have been put in place to identify and remove random invalid observations from the historical record. There is concern that quality control algorithms used in constructing NCDC's snow climatology have a high false positive rate (valid observations identified as invalid) that have created excessively large data gaps. In addition, the homogeneity of the historical record is often compromised by station moves, changes in observer, modification of the site, changes in observational practices, etc. This often limits the length and density of suitable records to evaluate the climatology of extreme events and seasons. Topics for discussion related to these issues include:

(1) To what extent should quality control procedures be modified to reduce the false detection of invalid snowfall observations. Should NCDC's snow climatology be reprocessed using other less stringent quality control procedures already available (e.g., those used in GHCN-Daily operational processing).
(2) Are the procedures that have been applied to identify homogeneous records appropriate, or too stringent.
(3) Are there steps that can be taken to "rescue" a greater portion of the historical record through appropriate adjustments.
(4) Are there current practices that may compromise the long-term homogeneity of data records from existing sites.
(5) Are there recommendations for observing practices or quality control procedure to ensure the future quality and homogeneity of long-term data records.

Breakout Session #3.2: Improving Analysis and Assessment Capabilities through an improved historical record and better access tools and products.

Lead: Richard Heim, NOAA NCDC

Objective: Taking into account FEMA's observational requirements, identify station density requirements and methods (e.g., data rescue, gridding and interpolation, modeling) that can be used to improve data density in the snow climatology record to provide needed statistical perspective.

Background: Snowstorm assessments rely on both accurate and complete measurements of snowfall amounts taken during the snow event in question as well an accurate and complete historical record from which to compare the current event. Existing historical snowfall climatologies suffer from spatial and temporal gaps that complicate the assessment process. There are many counties with no historical observations, and in other cases counties for which historical measurements don't always fully reflect the sharp gradients that may exist due to topographical and climatological differences across the full expanse of the county.

Issues: Advances in gridding methodologies, modeling, and dataset development practices over the past 15 to 20 years provide new opportunities for addressing deficiencies in the historical snow record. This breakout discussion will focus on answering questions related to data density requirements and potential solutions.

(1) factors to consider for station records: length and completeness of record for each station; comparable records for station-to-station comparisons; data rescue to key more data for existing stations, key new stations
(2) minimum number of stations per county: 1? 2? more?
(3) topographical/geographical factors (mountains, coasts) affect number of stations/station density in a region or county
(4) Should missing values in a station's record be estimated via an interpolation method to improve the historical record? What method should be used?
(5) Should an interpolation method be used to increase the number of stations (current & historical values)?
(6) Should a gridded data base (strict interpolation of station data) be used (in addition to? or in place of station data?) for current and/or historical snowfall values? What methodology should be used? What grid resolution? Length of interpolated record? Can a gridded approach truly reflect local topographical/climatological features?
(7) Should modeled snow data be used (in addition to? or in place of station data?) for current and/or historical snowfall values? Which type (numerical weather forecast models? climate models? reanalysis models? ex.: NOHRSC)? Output variables (just snowfall, or many others such as snow water content?)? Length of model record? Operational issues (available near-real time)? How realistic are the results?

Breakout Session #3.3: Improving Analysis and Assessment Capabilities through an improved historical record and better access tools and products.

Lead: Mike Squires, NOAA NCDC

Objective: Taking into account existing and future web-based data delivery tools, identify new web-based solutions that can be implemented in the near term and longer term to address FEMA's data access needs.

Background: Criteria used for a disaster declaration are based on historical snowfall data maintained at NCDC as well as current snowfall observations provided by NCDC and an assortment of NOAA NWS sites. In particular, record or near-record one-day, two-day, or three-day snowfall within a county is required for a disaster declaration recommendation. FEMA and State representatives rely on access to current and historical observations as a key part of the application and assessment process. Although sufficient data may be available to complete an assessment, the process is complicated by web-based tools and products that are not easily accessible nor optimally designed to support the assessment process.

Examples of web sites providing snowfall information within NOAA include:

1. NWS Eastern Region Hydrometeorological Event Display: http://www.erh.noaa.gov/hydromet/erEventDisplay.php
2. NWS Southern Region Experimental Snowfall Analysis: http://www.srh.noaa.gov/ridge2/snow/
3. NCDC's Snow Climatology Database: http://www.ncdc.noaa.gov/ussc/
4. NCDC U.S. Snow Monitoring maps: http://gis.ncdc.noaa.gov/maps/snowfall.map?view=resis
5. NOHRSC Interactive Snow Information: http://www.nohrsc.nws.gov/interactive/html/map.html

There are many other web sites within NOAA, state governments, and universities that also provide snowfall data.

Issues: Issues to be discussed include the following:

(1) Do the current NCDC web sites meet FEMA's needs? Can they be improved?
(2) Should NCDC create on-line tools that would facilitate the analysis FEMA needs to perform in determining a declaration?
(3) What type of technologies would be useful to FEMA or other stakeholders? For example; kml files, OGC map services, data extraction methods …
(4) Is there other snowfall information that FEMA or stakeholders could use for analysis. For example; one-day or multiple-day snowfall return periods, percentiles, rankings, …
(5) Are other types of winter storm observations useful? For example; blizzards, freezing rain, …
(6) Many users of these web sites may not have a technical background in weather, climate, or statistics. Is there a need for more on-line documentation to put all this information into perspective? Some examples include explaining the spatial variability of snowfall, the importance of the period of record when looking at record snowfall information, and the differences between observing networks.

Breakout Session #4.1: Hail reporting practices within NOAA networks.

Objective: Develop recommendations for changes to NWS Directives that will clarify and standardize hail reporting practices across COOP and ASOS networks to preserve the snow record.

Lead: Jim Zdrojewski, NOAA NWS

Background: Hail measurements have always been confusing for the observer. Depending on the program for which observations are being conducted (Climate, Aviation, etc.), there are differing ways of recording the observation. These differences often create confusion among the observers and the data user and often lead to difficulties in distinguishing hail from snowfall in the observational record.

Issues: The NWS has different documented ways to record hail measurements. Add other agencies who take measurements such as the FAA into the mix and it just adds to the confusion. Depending on how the measurements are recorded they may or may not be added to the snowfall measurement totals. This has the potential to contaminant the snow climatology of a location. This breakout session will discuss the various ways that hail is being recorded and discuss possible solutions for standardizing and clarifying hail reporting procedures. Issues for discussion include:

(1) What is hail and what other forms of precipitation should be included with hail?
(2) Should each type of program record hail measurements the same?
(3) Should hail amounts be totaled separately from snow?
(4) How do we implement the recommendations and who needs to be involved?
(5) How would changing the recording method affect the climate record?