

Evaluation of Reported Snowfall at Local Climatological Data Stations during the East Coast Blizzard of January 22-23, 2016

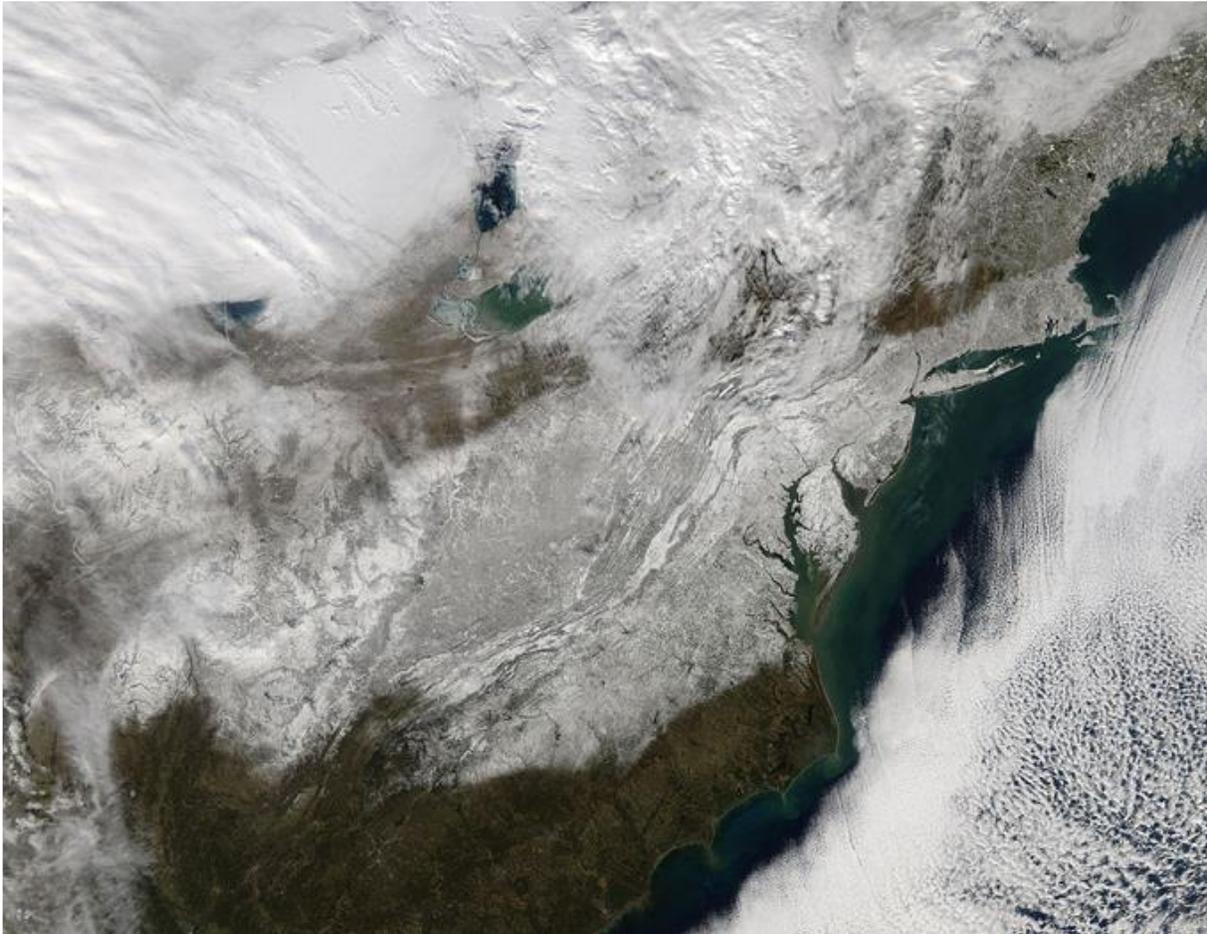


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Section A: Acronyms

Snow Measuring Board (SMB): A white board that is at least 24 inches x 24 inches used to measure snowfall.

Snow Measuring Stick: A ruler with measurement increments to the nearest tenth of an inch used to measure snowfall and/or snow depth. Length of the ruler will vary based on location and average snowfall.

Snowfall: Maximum amount of new snow that has fallen since the previous observation.

Snow Depth: The total depth of snow (including any ice) on the ground at the normal observation time. The snow depth includes new snow that has fallen combined with snow already on the ground.

Snowfall Water Content (also known as Water Equivalent): The water content of new snowfall since the previous day's observation.

Snow Depth Water Content: The water content of new and old snow on the ground measured by taking a core sample.

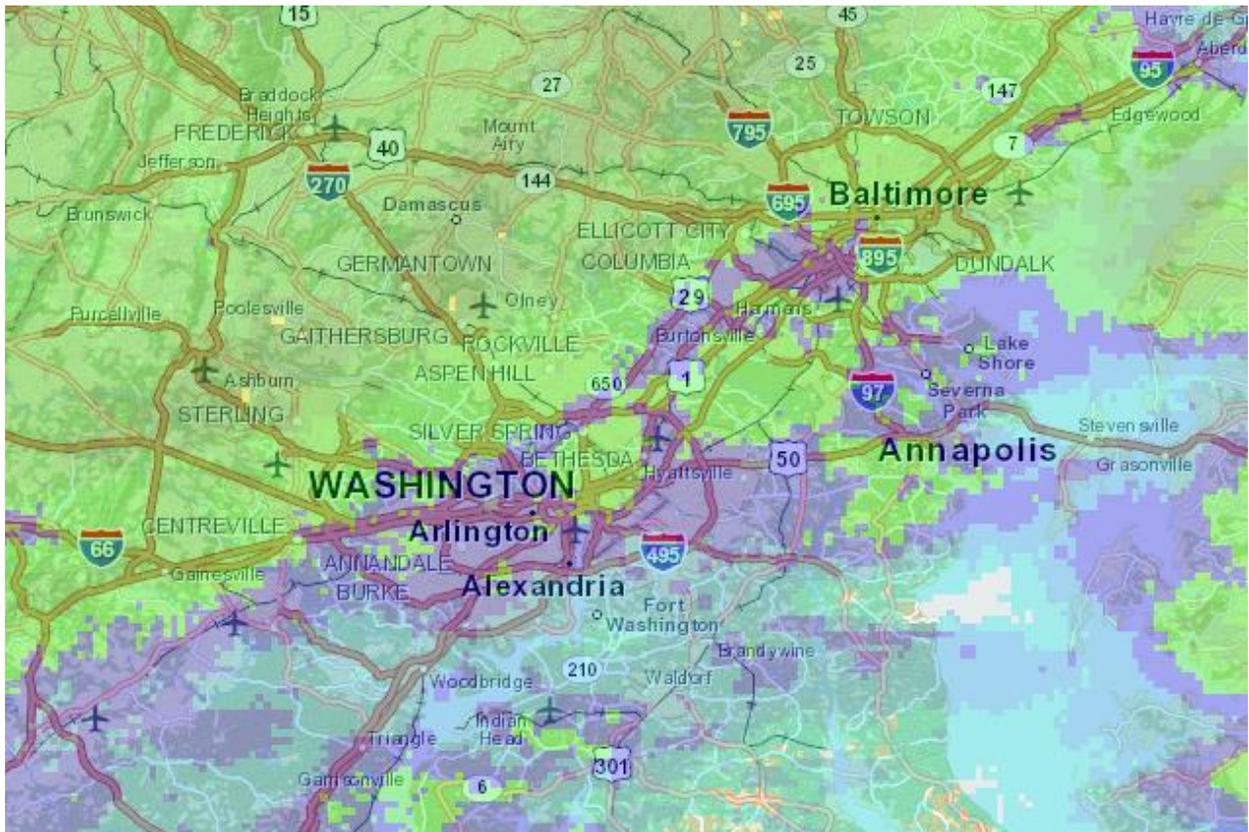
Station Information System (SIS): The metadata database used for Cooperative Observer Stations. ASOS sites can also be listed in the SIS for the purpose of metadata transfer to NCEI.

Section B: Background

After major winter storms in recent years, post-storm analysis found that some observers were not consistently adhering to observing standards established by NWS. As a result, on several occasions, some observing procedures resulted in inflated or underestimated values.

Given the magnitude of the East Coast Blizzard of January 22-23, 2016, a snow team was established to evaluate snowfall amounts, observing procedures, and observing sites.

Precipitation is inherently variable. This is very apparent when looking at radar returns and seeing the varied intensities of the precipitation. Precipitation amounts, and therefore snowfall, can vary greatly over a very short distance. For example, across the DC metro area, total liquid precipitation amounts for the blizzard showed a significant contrast among observation sites; Franconia 1.3SSE (2.60"), McLean 2.4SSE (1.94"), Falls Church 1.6W (2.86"), and The White House (1.82").



Radar Image Valid at 01/23/2016, 0930 Local Time

Another aspect of snowfall totals is the actual measurement. This evaluation examined the policies, procedures and practices of observing snow depth at eight Local Climatological Data (LCD) locations from Washington, D.C. to New York City to determine if the reported snowfall was accurate.

Section C: Team Membership

Name	Affiliation	Role
Andy Horvitz	NWS Analyze, Forecast and Support Office, Silver Spring, MD	Co-Lead, National Public Program Lead
Jim Zdrojewski	NWS Office of Observations, Silver Spring, MD	Co-Lead, Acting National Cooperative Observer Program Manager
Peter Gabrielsen	NWS Eastern Region Headquarters, Bohemia, NY	Systems Operations Division Chief
Chris Stachelski	NWS Eastern Region Headquarters, Bohemia, NY	Observing and Climate Lead
Nikki Becker	NWS Forecast Office, Gray, ME	Observing Program Leader
Steve Zubrick	NWS Forecast Office, Baltimore/Washington D.C.	Science and Operations Officer
Tim Morrin	NWS Forecast Office, New York City, NY	Observation Program Leader
Kim Curry	Federal Aviation Administration, Washington D.C.	Air Traffic Services, Manager, Contract Operations Group
Jay Lawrimore	NOAA National Centers for Environmental Information (NCEI), Asheville, NC	Dataset Section Chief
Dave Robinson	Rutgers University, Piscataway, NJ	New Jersey State Climatologist

Section D: Findings and Recommendations

A historic winter storm, with a rating of category 4 on NOAA's Northeast Snowfall Impact Scale (NESIS), resulted in record to near record snowfall on January 22-23, 2016, from the Washington, D.C., area to New York City.. Reports of over 30 inches of snow were prevalent in portions of Maryland and West Virginia, with localized totals exceeding 40 inches. The blizzard caused major transportation disruptions from North Carolina to portions of Southern New England.

In general, taking snowfall and snow depth measurements are difficult because snow amounts can have a large variability. The meteorology factors, such as snow bands, thundersnow, snow/sleet/rain boundaries can cause large variability in snowfall, even over small distances, as was evident in this blizzard. Other factors to consider during measurements include wind, intensity of the snowfall and location of the observing site.

A Snow Measurement Team was established to assess snowfall measurements at eight Local Climatological Data (LCD) locations from Washington, D.C. to New York City. The team was also responsible for determining if the siting at the LCD locations were representative of the surrounding areas and if the current snow measurement practices were accurate and following established procedures.

This report summarizes and validates observation siting and snow measurement procedures during the East Coast Blizzard of 2016. With the exception of Newark, NJ, all sites evaluated in this report followed snow measuring guidelines. This is addressed in Finding 2. The team also recognized that there are siting issues at John F. Kennedy International Airport, NY (JFK). Of significant interest, the observer at Ronald Reagan Washington National Airport, VA (DCA) took particular care to measure the snow and ensure accuracy of the snowfall totals. Several key findings and recommendations were reached by the team and are as follows:

Finding 1: Ronald Reagan Washington National Airport, VA (DCA) - The reported storm total snowfall amount of 17.8 inches was determined to be accurate. Surrounding area snowfall totals were also representative of this report. Storm totals in Virginia included 18.0 inches near Cherrydale, VA, and 18.5 inches near Rivercrest, VA (both in Arlington County), as well as 19.4 inches from a trained spotter one mile WNW of DCA. National Harbor in Maryland, across the Potomac River from the City of Alexandria, reported 17.0 inches of snow. The DCA Contract Weather Observer (CWO) was experienced and followed FAA Order 7900.5C for all snow measurements. While the observer could not locate the snow measurement board (SMB) for several hours during the afternoon of January 23rd, proper measuring procedures were followed as per the FAA Order, and the 17.8 inch total (tied for 4th greatest on record at DCA) was a representative amount for this location. The SMB was buried under the snow, and this is reasonable given the six-hour period between official snow depth measurements. The observer measured total snow depth, which was consistent with the depth on the SMB, once the board was located.

Recommendation 1: Add flags to more easily locate the SMBs in deep snowfall.

Finding 2: Newark Liberty International Airport, NJ (EWR) - Snowfall measurement procedures did not follow FAA Order 7900.5C. The CWO measured and summed hourly snowfall totals instead of taking a single measurement of snowfall every six hours. This resulted in inflated 6-hourly and daily snowfall amounts and a preliminary all-time record snowfall of 28.1 inches. Based on interviews with the CWO at EWR, the practice of summing hourly snowfall totals may have been occurring since 1996.

Recommendation 2: Since the blizzard, the CWO observers at EWR have been re-trained on proper procedures for measuring snowfall and snow depth. A separate team will investigate the best course of action to determine the accurate snowfall total and, as appropriate, amounts may be changed. This team will also access the historical record of snowfall reports at EWR and determine whether the EWR practice of taking hourly snowfall measurements justifies any annotations or modifications to the long term historical record.

Finding 3: A miscommunication between New York NWS Weather Forecast Office (WFO) and the Central Park Conservancy resulted in a different snow total being reported by the WFO for the storm (26.8 inches), versus the Conservancy's total (27.5 inches). The Conservancy total would set a new all-time record for Central Park, versus the initial total reported which would rank as the second greatest snowstorm at this location.

Recommendation 3: The Central Park storm total should be changed to 27.5 inches to reflect the Conservancy's numbers on their own worksheet, which were deemed accurate. The correct daily totals should be: 0.2 inch of snow on January 22nd, 27.3 inches on January 23rd, and a trace of snow on January 24th.

Finding 4: As a result of past issues with measuring snow at the Philadelphia International Airport, PA (PHL) in the 1990s, the NWS WFO in Mount Holly, NJ, opted to move the snow observation site from the airport to a nearby private residence, in order to obtain official snowfall measurements more relative of the entire area. This was done as part of the Snow Paid program.

Recommendation 4: WFOs with poorly located snow measuring sites at airports should look at alternative sites off, but near airport property, as sources for representative snow measurements.

Finding 5: CWO observers follow FAA Order 7900.5C, which is equivalent to the previous version (1997) of the NWS Snow Measurement Guidelines. The one difference from the current 2013 NWS Snow Measurement Guidelines is related to measurements taken when there is melting between observations. This situation was not applicable to measurement procedures during the East Coast Blizzard of 2016.

Recommendation 5: The current NWS Snow Measurement Guidelines will be provided to the FAA for inclusion into FAA Order 7900.5C. Also, a correction will be made to the current guidelines to include the placement of the SMB on top of the snow after clearing.

All procedures, whether the site is NWS or FAA, should be the same. Procedures should be provided by the NWS and these should be reflected in the FAA Order 7900.5C. When changes are made to the procedures, these changes should be communicated to the FAA for inclusion into their documentation.

Currently the NWS allows measurements to be taken at either 24-hour increments, or 6-hourly increments. It is recommended that an overall assessment of practices at airport, and other sites that measure at 6-hourly increments, be conducted to ensure consistency in observing practices are established.

Finding 6: There remains some confusion among WFOs regarding relationships and providing NWS government furnished equipment to the CWOs. Some WFOs are under the impression that, since routine inspections of the CWOs have ceased, all contact should have stopped. However, it is stated in FAA Order 7900.5C that training will be provided for snow measuring. It is also stated that the NWS will provide snow measuring equipment to the CWO.

Recommendation 6: WFOs with CWO airports within their County Warning Area should ensure annual training of CWO observers and check that the snow measurement equipment is in good working order before commencement of the snow season. This information is documented in FAA Order 7900.5C. This requirement should be documented in the NWS Directive NWSI 10-1301.

Finding 7: During the blizzard, all Weather Precipitation Accumulation Gauges (AWPAGs) under-measured precipitation at airports, and in the case of Newark, failed during the event, resulting in CWOs using measurements from snow melted by hand and measured with an eight inch standard rain gauge, a voluntary service performed by the CWOs. One exception was Central Park, NY, where the location near a grove of trees shelters the equipment and allows for a better catch of precipitation.

Recommendation 7: Since the AWPAG gauges are located with the ASOS instrument cluster on the airfield, wind greatly impacts the catch. The WFOs should provide a Standard Rain Gauge, which would be included in other snow measuring equipment (see Recommendation 4), and train the observers in its use during particularly windy events which could cause an under catch at the AWPAG.

Finding 8: Messaging of record and near record events are not always consistent. There is no NWS guidance (or directive) on using social media for this as well.

Recommendation 8a: All communication of snowfall amounts should be marked as preliminary until the process is verified through quality assurance/quality control (QA/QC) at NCEI.

Recommendation 8b: NWS Headquarters (NWSHQ) and each of the Regions should develop a consistent policy to provide WFOs with a standardized method to communicate record events.

Recommendation 8c: To support the role of Impact-based Decision Support Services, NWSHQ should develop policy so the WFOs have a standardized means to communicate impacts of the event through social media and to promote social media platforms to describe record reporting information. Additionally, a policy directive should be created to provide guidelines to assist field offices to understand NWS social media policy.

Recommendation 8d: Create a national standard for inclusion into policy on criteria for when a data record is defined as preliminary and when the record becomes official. Collaborate with NCEI and the NWS Office of Communications on formulation.

Hourly Precipitation Amounts For Newark Liberty Int'l Airport (EWR)
 Date: 1/23/2016 Station: KEWR
 CALL PR (800) Desk @ (800) and 3 inches Phoned snow desk at 0057 L

TIME	8-INCH RAIN GAUGE	ASOS LIQUID EQUIVALENT	HOURLY SNOWFALL	CUMULATIVE SNOWFALL	SNOW DEPTH	TEMPERATURE USED	REMARKS SECTION
LOCAL STANDARD TIME	Hundredth of an Inch (0.00)	Hundredth of an Inch (0.00)	Tenth of an Inch (0.0)	Tenth of an Inch (0.0)	Whole Inch (0)	Liquid to Frozen	Precip Type, Edited Groups, Etc.
0051		.03	1.5	1.9	1		931001 931001 SNINCR 1/1 1.0" at 0057 L
0151		.03	1.6	1.5	2		DRIFT SNOW
0251	.05	.01	1.4	1.9	2	15-1	T=24 DRIFT SNOW
0351	.03	.01	1.3	2.2	2	15-1	T=24 DRIFT SNOW
0451	.03	.02	1.7	3.9	4	15-1	T=24 DRIFT SNOW
0551	.08	.02	1.1	5.0	5	15-1	T=24 DRIFT SNOW
0651	.05	.02	1.5	6.5	7	T=25 15-1	931741 921051 4/007 SNINCR 2/13
0751	.13	.07	2.0	8.5	9	T=26 15-1	SNINCR 2/19
0851	.17	.07	2.5	11.0	11.0	T=26 15-1	SNINCR 3/11
0951	.10	N/A	1.5	12.5	13	T=27 15-1	SNINCR 2/13
1051	.07	N/A	.9	13.4	13	T=26 15-1	SNINCR 2/13
1151	.09	N/A	1.6	15.0	15	T=27 15-1	SNINCR 2/13
1251	.11	N/A	1.5	16.5	17	T=27 15-1	931741 931100 4/017 1330 12
1351	.09	N/A	1.1	17.6	18	T=27 15-1	comparing to DRIFTING
1451	.11	N/A	1.7	19.3	18	T=27 15-1	comparing to DRIFTING
1551	.13	N/A	2.1	21.4	18	T=27 15-1	comparing to DRIFTING
1651	.14	N/A	2.1	23.5	20	T=24 15-1	DRIFTING
1751	.09	N/A	1.4	24.9	21	T=25 15-1	DRIFTING
1851	.05	N/A	.8	25.7	22	T=25 15-1	DRIFTING
1951	.04	N/A	1.0	26.7	23	T=25 15-1	SNINCR 1/23
2051	.04	N/A	.6	27.3	24	T=25 15-1	SNINCR 1/24
2151	.01	N/A	.3	27.6	24	T=25 15-1	DRIFTING
2251	T	T	.1	27.7	23	T=26 15-1	DRIFTING
2351	.01	N/A	.2	27.9	21	T=25 15-1	DRIFTING
Daily Totals	1.81						

Green highlighted sections indicate 6-hourly synoptic observations (06z, 12z, 18z, and 00z).
 Yellow highlighted sections indicate 3-hourly observations (09z, 15z, 21z, and 03z).

933RRR (Water Equivalent on Ground) Required at 18z if snow depth equals 2 inches or greater.
 4/sss (Snow Depth on Ground) Required at all synoptic times (00Z, 06Z, 12Z, 18Z) whenever there is at least .5 inches (half inch) or greater on the ground.
 931nnn (Newly Fallen Snow) Required at all synoptic times (00Z, 06Z, 12Z, 18Z) whenever newly fallen snow occurs during the past 6hrs, including trace amounts (931000). This includes ice pellets (sleet).
 SNINCR (Snow Increasing Rapidly) Required if snow fall increases by 1 inch or more during the past hour AND the snow depth increases by 1 inch or more during the past hour. Reported as inches per hour/ inches on ground, for example, SNINCR 1/2.

27.5 INCH

Snow observing form filled out by observers at Newark Liberty International Airport (EWR). Note the observations are all hourly measurements.

Section E: General Evaluation of the Blizzard

1. Synoptic Overview

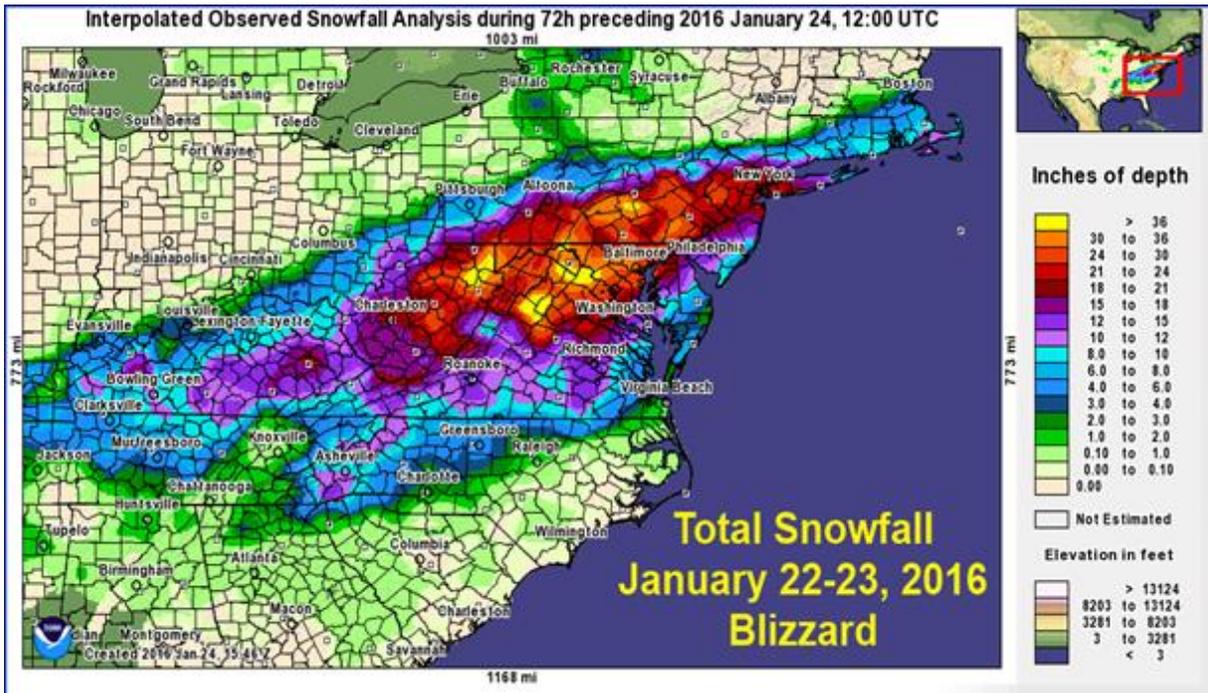
A historic winter storm, rated a category 4 on NOAA's Northeast Snowfall Impact Scale (NESIS), resulted in record to near record snowfall from the Washington, DC area to New York City on January 22-23, 2016. Reports of over 30 inches of snow were prevalent in portions of Maryland and West Virginia with localized totals exceeding 40 inches. The blizzard caused major transportation impacts from North Carolina to portions of Southern New England.

The storm developed from a disturbance that moved across the United States and impacted the East Coast on January 22-23, 2016. A relatively strong 500 millibar (i.e. mid-level) short-wave trough moved into the Southern Plains on January 22nd, deepening as it moved eastward and then northward, and finally northeastward along the East Coast. There was relatively strong confluence ahead of the shortwave and in the implied jet entrance region over the northeastern United States. The surface low also tracked from the Southern Plains to the Coastal Carolinas and then northeastward along the East Coast. Most of the snow and heavy snow fell in the gradient between the surface anticyclone to the north and the developing surface cyclone along the coast. This event was characterized by strong easterly flow at 850 millibars. As with most significant snowstorms, the heaviest snow fell in close proximity to a strong low-level jet (LLJ). The strong LLJ likely resulted in heavy snowfall, strong winds, blizzard conditions, and severe coastal flooding in Delaware and New Jersey.

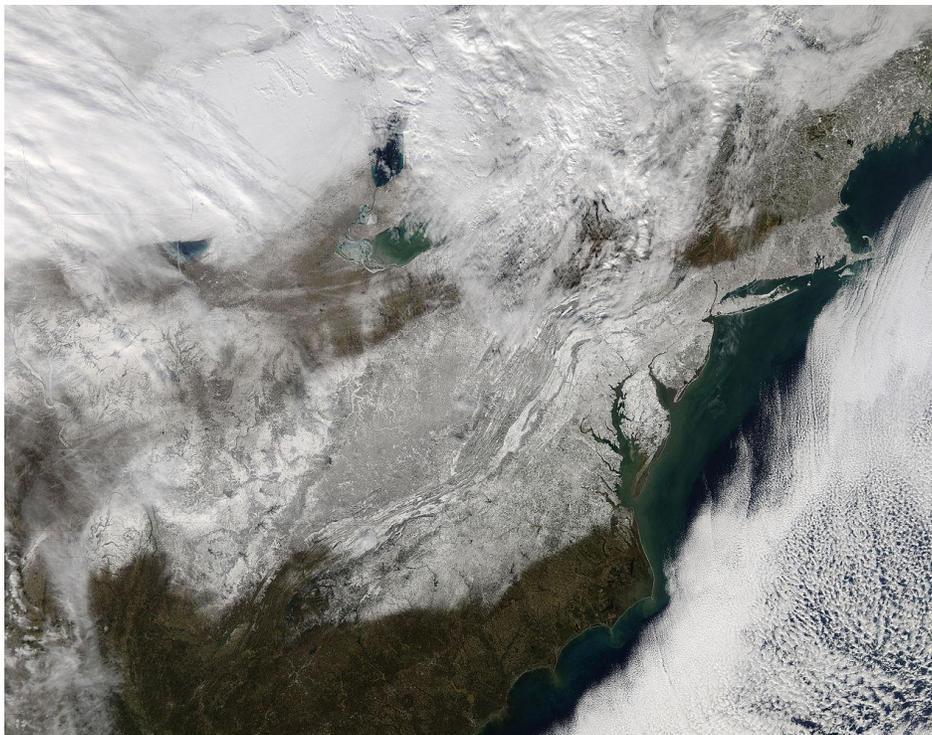
There was a sharp northern cut-off to the snowfall with this system. The storm produced a broad swath of 18 to 30 inches of snow from West Virginia into southeastern New York, including New York City and western/central Long Island while portions of southern New England reported a moderate snowfall of 4-8 inches with over a foot reported on portions of Cape Cod. South of Washington, D.C., amounts were significant across central Virginia, with 11.4 inches measured in Richmond, while snowfall of 1-2 inches occurred across central North Carolina before changing to sleet and freezing rain which caused dangerous driving conditions across the Piedmont. The highest snow amount reported from the blizzard was 42 inches at Glengary, WV. Widespread wind gusts of 45-55 mph were observed from Virginia to Massachusetts. Portions of coastal Virginia, Maryland, Delaware, New Jersey and Massachusetts reported wind gusts of 60-75 mph. The peak gust reported was 85 mph in Assateague, VA. Blizzard conditions (at least three consecutive hours with visibility less than $\frac{1}{4}$ mile along with wind gusts to 35 mph or greater) were verified at a number of the LCD locations from Washington to New York City.

The blizzard covered about 434 thousand square miles and impacted around 102.8 million people. Of this total, approximately 1.5 million people experienced snowfall

accumulations of over 30 inches, and nearly 24 million experienced accumulations of over 20 inches as a result of the blizzard.



Total snowfall for the January 22-23, 2016 blizzard.



NASA MODIS Imagery at 1:30 PM EST on January 24, 2016 showing the extent of the snowfall from North Carolina to Massachusetts. Note the sharp northern edge to the snowfall.

2. Storm Total Precipitation Amounts at LCD Sites

- a. The following chart represents the storm total precipitation amounts from the blizzard, and was gathered from the Regional Climate Center's Applied Climate Information System (ACIS) database using xmACIS. Assumptions made with this data include;

1. Daily amounts were taken from NWS Daily Climate products
2. Amounts were quality checked before being issued

Site	Liquid Total	Snowfall Total	Greatest Daily Depth	Water Content Ratio
DCA	1.48	17.8	18 ¹	12.0:1
IAD	2.63	29.3	28	11.1:1
BWI	2.13	29.2	26	13.7:1
NYC	2.32	26.8	22	11.6:1
JFK	2.91	30.6	28	10.5:1
LGA	2.43	28.2	27	11.6:1
EWR	1.85	28.1	20	15.2:1
PHL	1.60	22.4	18	14.0:1

Table Key:

DCA: Ronald Reagan Washington National Airport, VA

IAD: Washington Dulles International Airport, VA

BWI: Thurgood Marshall Baltimore Washington International Airport, MD

NYC: Central Park, NYC

JFK: John F. Kennedy International Airport, NY

LGA: LaGuardia International Airport, NY

EWR: Newark Liberty International Airport, NJ

PHL: Philadelphia International Airport, PA

¹Daily Snow Depth greater than snowfall total due to rounding of snow depth per snow measuring guidelines

3. Individual LCD Site Parameter Overview

NWS Responsible Office	Who Measures The Snow?	How Often Are Measurements Required to be Taken?	Is Snowfall Measured?	Is Snow Depth Measured?	Is Snowfall Water Content Measured?	Is Snow Depth Water Content Measured?	What Equipment Is Available?	What Guidance Is Used For Measuring Snow?	Was Guidance Followed During This Storm?
Ronald Reagan Washington National Airport (DCA)									
WFO Sterling, VA	Contract Weather Observers	6-hourly	Yes	Yes	Yes	Yes	AWPAG, SRG, SMB, Snow Sticks	FAA 7900.5C	Yes
Washington Dulles International Airport (IAD)									
WFO Sterling, VA	WFO Sterling	6-hourly	Yes	Yes	Yes	Yes	SRG, SMB, Snow Sticks	NWS Snow Guidelines	Yes
Thurgood Marshall Baltimore-Washington International Airport (BWI)									
WFO Sterling, VA	Snow-Paid	6-hourly	Yes	Yes	Yes	Yes	SRG, SMB, Snow Sticks	NWS Snow Guidelines	Yes
New York City Central Park (NYC)									
WFO New York City	Central Park Conservancy	6-hourly	Yes	Yes	No	No	SMB, Snow Sticks	NWS Snow Measuring Guidelines	Yes
John F. Kennedy International Airport (JFK)									
WFO New York City	Contract Weather Observers	6-hourly	Yes	Yes	Yes	No	AWPAG, SRG, SMB, Snow Sticks	FAA 7900.5C	Yes
LaGuardia International Airport (LGA)									
WFO New York City	Contract Weather Observers	6-hourly	Yes	Yes	Yes	No	AWPAG, SRG, SMB, Snow Sticks	FAA 7900.5C	Yes
Newark Liberty International Airport (EWR)									
WFO New York City	Contract Weather Observers	6-hourly	Yes	Yes	Yes	No	AWPAG, SRG, SMB, Snow Sticks	FAA 7900.5C	No
Philadelphia International Airport (PHL)									
WFO Mount Holly, NJ	Snow-Paid	6-hourly	Yes	Yes	Yes	Yes	SRG, SMB, Snow Sticks	NWS Snow Measuring Guidelines	Yes

Preliminary Records at LCD Sites Based on Initial Values Reported

Single Storm Snowfall Record

Station	New Record	Previous Record	Records Started
Baltimore-Washington International Airport, MD	29.2" (January 22-24, 2016)	28.2" (February 15-18, 2003)	1883
Newark International Airport, NJ	28.1" (January 22-24, 2016)	27.8" (January 7-8, 1996)	1929 for Airport (EWR) *1843 if counting Co-Op Records
NYC/LaGuardia Airport, NY	28.2" (January 22-24, 2016)	25.4" (February 11-12, 2006)	1944
NYC/Kennedy International Airport, NY	30.6" (January 22-24, 2016)	26.0" (February 16-18, 2003)	1948

Greatest Snow Depth Record

Station	New Record	Previous Record	Records Started
Washington Dulles Airport, VA	28" (January 24, 2016)	26" (February 10, 2010)	1962
NYC/LaGuardia Airport, NY	27" (January 24, 2016)	26" (February 5, 1961)	1944
NYC/Kennedy International Airport, NY	28" (January 24, 2016)	Tied 28" (February 18, 2003)	1948

Greatest Calendar Day Snowfall

Station	New Record	Previous Record	Records Started
Baltimore-Washington International Airport, MD	25.5" (January 23, 2016)	23.3" (January 28, 1922)	1883
Newark International Airport, NJ	27.5" (January 23, 2016)	25.9" (December 26, 1947)	1929
NYC/LaGuardia Airport, NY	27.9" (January 23, 2016)	23.3" (February 12, 2006)	1944
NYC/Kennedy International Airport, NY	30.3" (January 23, 2016)	21.6" (February 17, 2003)	1948
NYC/Central Park, NY	26.6" (January 23, 2016)	24.1" (February 12, 2006)	1869

4. Messaging of Snow Totals and Records

Messaging of snow totals and records varied between the various WFOs impacted by the January 2016 Blizzard, based on a review by NWS WFOs in New York City, Mount Holly, NJ, and Sterling, VA. All WFOs did issue text-based Public Information Statements (PNS) once the event was underway, which included total storm snowfall amounts, although the initial report times varied from office to office. WFO New York City (OKX) was the last of the four offices to issue an initial PNS, not doing so until 7:44 AM on Saturday, January 23rd, which was over 8 hours after snow had started falling in their County Warning and Forecast Area (CWFA) and over 5 hours after accumulations started to occur. NWS Eastern Region Headquarters has developed a Directives supplement (02-2003 to the NWS Directive NWSI 10-513) with Section 4.6 providing guidance on issuing PNSs for snowfall totals. The supplement states that PNSs should be issued every three hours during an event, however the initial issuance is at the WFO's discretion with respect to criteria outside of what is felt as just user interest. It should be noted that issuing a PNS falls in-line with other workload duties at a WFO. The use of the PNS as a standard for reporting snow totals within Eastern Region, however, is inconsistent with what all other NWS regions practice, which is to typically send these out as a Local Storm Report (LSR) text-based product. To remedy this, in October of 2015, Section 4.6 of the Eastern Region Directive supplement was updated to require WFOs to issue LSRs for winter weather events meeting thresholds established with local partners. This was done to support national vendors plotting of weather information and to be consistent with how other NWS regions report on winter events. It should be noted the PNS is also the only product that always states that snow totals are unofficial values.

While the PNS and LSR products do provide an update during an unfolding event as to how much snow fell at various locations with the latest report time noted, they do not typically provide any information as to how an amount relates to climatology. Instead, other products are used to convey this information to users. In the past, this was exclusively done through legacy based text products. In more recent years, some offices have also developed special event summary web pages and more recently have gravitated toward a combination of text-based and graphical products issued through social media channels approved by NWS Headquarters, such as Facebook and Twitter. This has resulted in a wider variation of how offices are passing on information. The positive aspect to this is that WFOs are able to reach a wider base of users. On the flip side, this has created vast differences in how WFOs relay information.

A closer look at how three of the impacted WFOs conveyed information on records follows:

WFO New York City (OKX)

WFO New York City has the largest responsibility of primary climate stations that are Local Climatological Sites (LCD sites) in the NWS Eastern Region with six LCD locations. Four of these sites - Central Park, LaGuardia Airport and Kennedy International Airport in New York City and Newark Airport, New Jersey - were used for this report. WFO New York City maintains on their website, climatology for each of these locations, however records listed are much more extensive for Central Park than for the other three sites. The only station with a list of top snowstorms that can be found is for Central Park. As a result, messaging from WFO New York City was very heavily geared toward the total at Central Park. The WFO provided text-based products and social media products on the Central Park snow total, including a mix of graphical and text in the latter. Many of these social media posts were shared by large scale media within their own stories in their original form. The top tweet alone from the WFO was on the storm total at Central Park and where it ranked in the records. There were 1,450 retweets on this tweet. Text-based products included a climate section in the Area Forecast Discussion (AFD) as well as the Record Event Report (RER) product.

Messaging on records for the other LCD sites, however, was not as extensive. Some of this was likely the result of the overall workload at the WFO during the event. The WFO did issue RERs for records reached on January 23rd the following morning and relayed those via social media, however, the report content was generic and only stated the value broke the previous daily record. No reports could be found stating that the greatest snowstorm on record was set at LaGuardia, Kennedy or Newark airports from this event. Media interest in this record at Newark was evident looking at an article on nj.com². However, it is clear that the media was not able to quickly find an official answer.

There was also a vast difference in how the confidence in the totals was messaged between various sites from WFO New York City. While a tweet was issued by the WFO that stated the Central Park snow total was the second largest storm total on record for New York City which made it sound clear-cut, correspondence with a reporter for the above mentioned article on nj.com indicated that a total for Newark was unofficial and the verification process on the amount could take anywhere from 3 to 6 days.

² http://www.nj.com/weather/index.ssf/2016/01/its_unofficially_official_newark_breaks_its_snowfa.html

WFO Mount Holly (PHI)

WFO Mount Holly has responsibility for five LCD sites - Philadelphia International Airport and Allentown in Pennsylvania, Wilmington, Delaware and the International Airport and State Marina for Atlantic City, New Jersey. The later of these sites is a historic site and does not report snow or snow depth. Only Philadelphia is included in this evaluation.

WFO Mount Holly relied heavily on text-based products as a communicative tool for this event for totals during the storm as well as placing the event in climatological perspective before and after the storm. The WFO used a mixture of the RER product as well as added a Climate section in the Area Forecast Discussion (AFD). The products issued were timely and focused on several of the LCD sites that measure snow that would be more heavily impacted by the storm. As a result, the WFO did a good job in not just being “Philadelphia-centric” with record products issued.

Social media content though, on the records reached and the historic context of the storm, was very light on both Facebook and Twitter by WFO Mount Holly. A graphic was composed before the storm stating that the total snowfall from it could exceed the normal winter snowfall. However, content on the records reached after the storm was non-existent for Allentown, despite the location reaching three impressive records. In addition, little information was also available on the total at Philadelphia despite the snowfall being ranked among the top storms on record for the city.

The WFO’s website also relies heavily on using current text-based products and other links such as to xmACIS for information, but has little other detailed information available outside of graphs of seasonal snowfall totals.

Confidence in the record values or any mention of a value being preliminary was not stated on any text-based or social media products. However, the WFO did conduct an interview with the Philadelphia Inquirer for an article³ published on January 25th that described the process of how snow is measured and snowfall measurements were quality controlled by their office including some of the challenges in measuring snow at airports.

³ http://www.philly.com/philly/news/20160126_Snow_measurements__More_art_than_science.html

WFO Sterling (LWX)

WFO Sterling has a total of three LCD sites in their area - Baltimore, Maryland and Reagan National and Dulles International Airports, both in Virginia. The values measured at BWI and IAD ranked among the greatest on record for the period of record.

The WFO relied exclusively on text products to communicate information on records set. Some information was sent through RERs with calendar day records while others such as storm records were located in the AFD. The WFO did list values for all three of their LCD sites in the AFD. The WFO was the only one of the three storm-impacted WFOs to relay information about an all-time record snow depth being reached through a RER.

The WFO webpage contains local climate information for the three LCD sites, as well as a list of greatest snowstorms for the area⁴. The WFO also maintains a list of monthly snowfall for each of their LCD sites as well as daily records, all of which are kept updated.

There were no social media posts issued by the WFO on the record snow reached at Baltimore-Washington International Airport for the Baltimore climate station despite stating so in formal text products. Confidence in the record values or any mention of a value being preliminary was not stated on any text-based or social media products for any of the three LCD sites.

⁴ http://www.weather.gov/lwx/winter_storm-pr

Section F: Siting and Measurement Procedures

1. Siting and Procedures

A visit was made to each of the snowfall observing sites. Snow measuring areas were assessed for usability. The observers or site supervisors were interviewed. All locations used the procedures appropriate for each location with the following exceptions. Airport locations are some of the most difficult areas to find a suitable area for measuring snow that is accessible, secure from public contamination and protected from excessive wind. WFOs with poorly located snow measuring sites at airports should look at alternative sites off or near airport property as suitable locations for snow measurements. Flags should also be used to more easily locate SMB in deep snowfall.

CWO observers follow FAA Order 7900.5C which is equivalent to the previous version (1997) NWS Snow Measurement Guidelines. The one difference from the current 2013 NWS Snow Measurement Guidelines is related to measurements taken when there is melting between observations. This situation was not applicable to measurement procedures during the East Coast Blizzard of 2016. It was also noted that the current NWS Snow Measuring Guideline left out a step in the process of clearing the SMB. While it was assumed, it was never stated that the SMB should be placed on top of the snow after clearing.

The current NWS Snow Measurement Guidelines will be provided to the FAA for inclusion into FAA Order 7900.5C. Also, a correction will be made to the current guidelines to include the placement of the SMB on top of the snow after clearing.

There remains some confusion among WFOs regarding relationships and providing NWS government furnished equipment to the CWOs. Some WFOs are under the impression that since routine inspections of the CWOs has stopped, all contact should have stopped. However, it is stated in FAA Order 7900.5C that training will be provided for snow measuring. It is also stated that the NWS will provide snow measuring equipment to the CWO.

WFOs with CWO airports within their County Warning Area should ensure annual training of CWO observers and check that the snow measurement equipment is in good working order before commencement of the snow season. This information is documented in FAA Order 7900.5C. This requirement should be documented in the NWS Directive NWSI 10-1301.

All Weather Precipitation Accumulation Gauges (AWPAGs) during the event under measured precipitation at airports. In in the case of Newark, the AWPAG failed during the event, resulting in CWOs using measurements from snow melted by hand and measured with an eight inch standard rain gauge, a voluntary service performed by the CWOs. One exception was Central Park, NY, where the location near a grove of trees sheltered the equipment and allowed for a better catch of precipitation.

Since the AWPAG gauges are located with the ASOS instrument cluster on the airfield, wind greatly impacts the catch. The WFOs should provide a Standard Rain Gauge, which would be included in other snow measuring equipment (see Recommendation 4), and train the observers in its use during particularly windy events which would cause an under catch at the AWPAG.

2. Site Specific Measurement Areas and Procedures

a. DCA



Measurement Area - Located on the side of the old terminal in a semi-enclosed area with trees and bushes surrounding the location offering some protection from the wind.

Procedure - Followed FAA Order 7900.5C. The SMB was lost during the afternoon of January 23. Measurement procedures, however, were followed.

Snowfall Total - The reported storm-total snowfall amount of 17.8 inches was determined to be accurate. The observation measurement area is located on the side of the old terminal building in a grass-covered semi-enclosed area with trees and bushes surrounding the location offering some protection from the wind. The DCA Contract Weather Observer (CWO) followed FAA Order 7900.5C for all snow measurements. While the observer could not find the SMB for several hours during the afternoon on January 23rd, proper measuring procedures were followed and the 17.8 inch total (tied for 4th greatest on record at DCA) was a representative amount for this location. Surrounding area snowfall totals were also representative of this report in Virginia and included 17.0 inches near National Harbor, MD; 18.0 inches near Cherrydale and 18.5 inches near Rivercrest (both in Arlington County, VA), as well as 19.4 inches from a trained spotter one mile WNW of DCA.

b. IAD



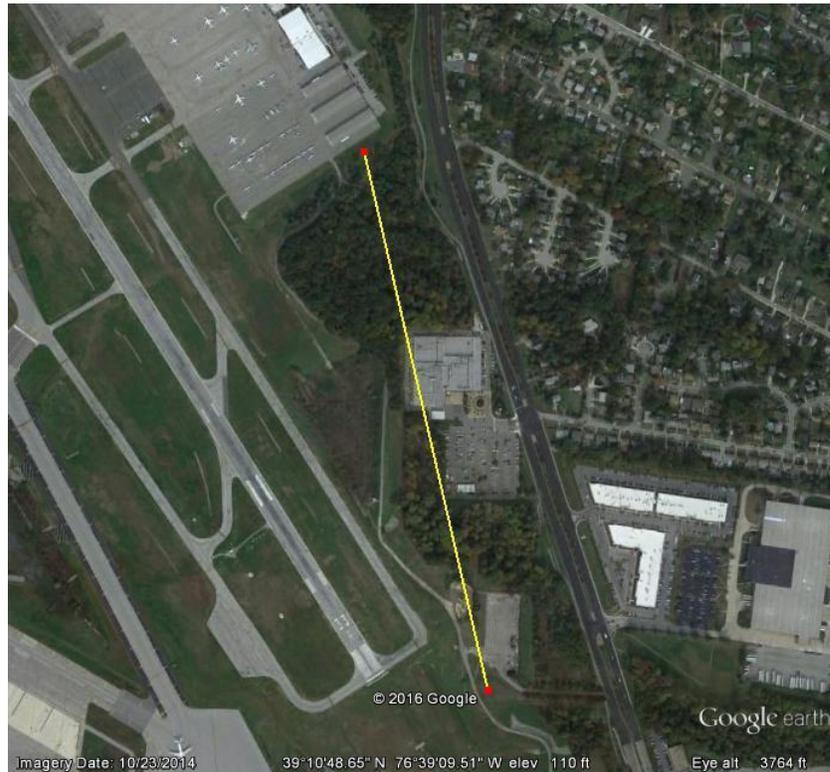
Measurement Area - Located at WFO Sterling, VA, approximately 40 feet from the west side of the WFO building.

Procedure - Followed 2013 NWS Snow Measurement Guidelines

c. BWI



Measurement Area - During the blizzard, the site was located on a relatively flat grassy area, subtly higher in terrain than the surrounding area. Aside from a 7 foot tall chain link fence located about 130 feet to the northeast, the nearest wind obstruction was a 30-40 foot tall tree located approximately 170 feet to the east. Other wind breaks (trees) to the north were about 500 feet away. Exposures in other directions were virtually unlimited. The site was located about 600 feet



east-southeast from the end of active runway 33R, but was not within range of the massive snow-blowing trucks used to clear runways.

Due to safety issues with access to the existing BWI site, effective Feb 1, 2016, a new snow measuring site was identified. It is located approximately one half mile N-NW of the former site. This site is in a much safer location closer to the Snow Paid observer office. It meets National Weather Service reporting site criteria, is sheltered from wind but far enough from nearby obstructions so as not to be contaminated, has suitable wind breaks, and is adjacent to an area of the airport that is regularly plowed (not blown).

Procedure - Followed 2013 NWS Snow Measurement Guidelines

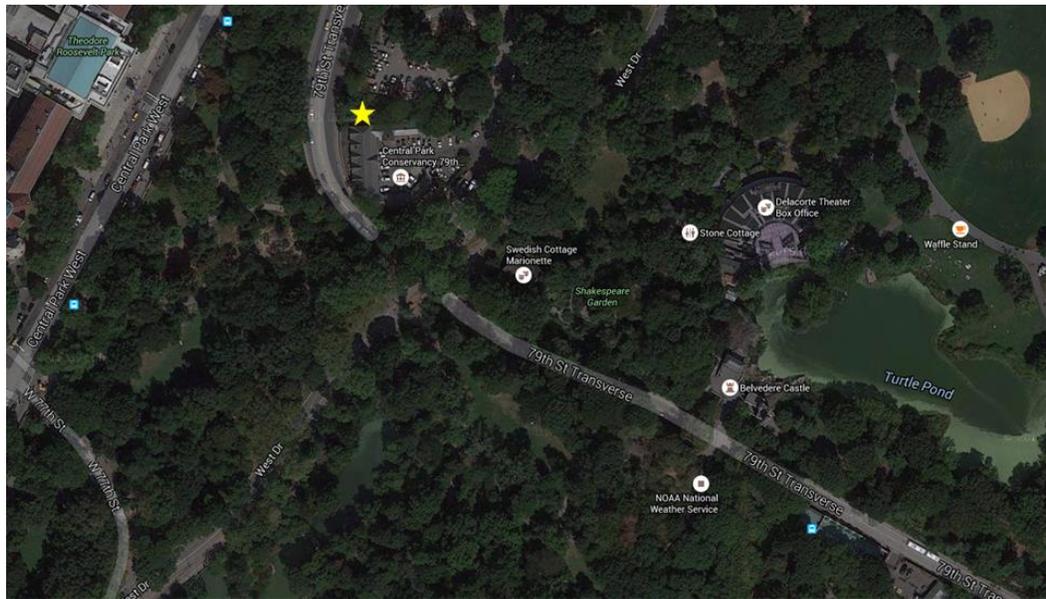
d. NYC (Central Park)



Location of the present snow measuring site at Central Park, NY, looking north.



Location of the present snow measuring site at Central Park, NY, looking east.



Yellow star denotes snow measuring area.

Measuring Area - The Conservancy measures snow at a maintenance yard office located at the 79th Street Transverse. This site is located about 650 feet west of the longstanding weather equipment at Belvedere Castle. Snow is measured in a secured area on the north side of the maintenance facility on a leveled area of a cliff. There are some small trees west and east of the snow measuring site. The site is located just out a rear door entrance allowing for a staging area to be in close proximity to the clipboards and snow sabers. A total of three staff members took the snow measurements for this storm. Observations were all taken on two SMBs that are marked by reflectors. One observer did some spot checks of snow on the ground during the event in a grassy area just across and to the east of the conservancy around 1 AM on Sunday, January 24th. However, the observer stated safety concerns at venturing further out at night into the park.

A recommendation was made to the Conservancy staff to consider using some of these grassy areas, if possible, during daytime hours as well as for the 1200 UTC snow depth as a buddy check. However, many grass areas have large trees that tower overhead which could block snowfall. In addition, the Conservancy staff has no way to rope off or secure any of these grass areas from the public to protect the snow in order for it to be measured in pristine condition.

Precipitation during the event was exclusively measured by the AWPAG that is a part of the Central Park ASOS located in a fenced enclosure just south of Belvedere Castle. There is an 8 inch standard rain gauge in this enclosure but no

one was able to read this during or just after the event given the enclosure is locked. However, this site did report a much higher total in its AWPAG compared to that measured at the nearby airports. This is likely due to the site being sheltered in an area with trees nearby, which helped to block the wind versus the open field of an airport.

Procedure - Followed 2013 NWS Snow Measurement Guidelines

Snowfall total - A miscommunication between NWS WFO New York City and the Central Park Conservancy resulted in a different snow total being reported by the WFO for the storm (26.8 inches) versus the Conservancy's total (27.5 inches). The Conservancy keeps a spreadsheet which is then entered and shared with the WFO. This sheet was shared with the team. Reports of snowfall at the site are phoned into the NWS New York City office by the Conservancy staff during the event every six hours as well as at Midnight in order to collect the calendar day snowfall total. The WFO staff then logs them onto a form. The WFO remains the only source for directly distributing this information. The Conservancy total would set a new all-time record for Central Park, versus the initial total reported, which would rank as the second greatest snowstorm at this location.

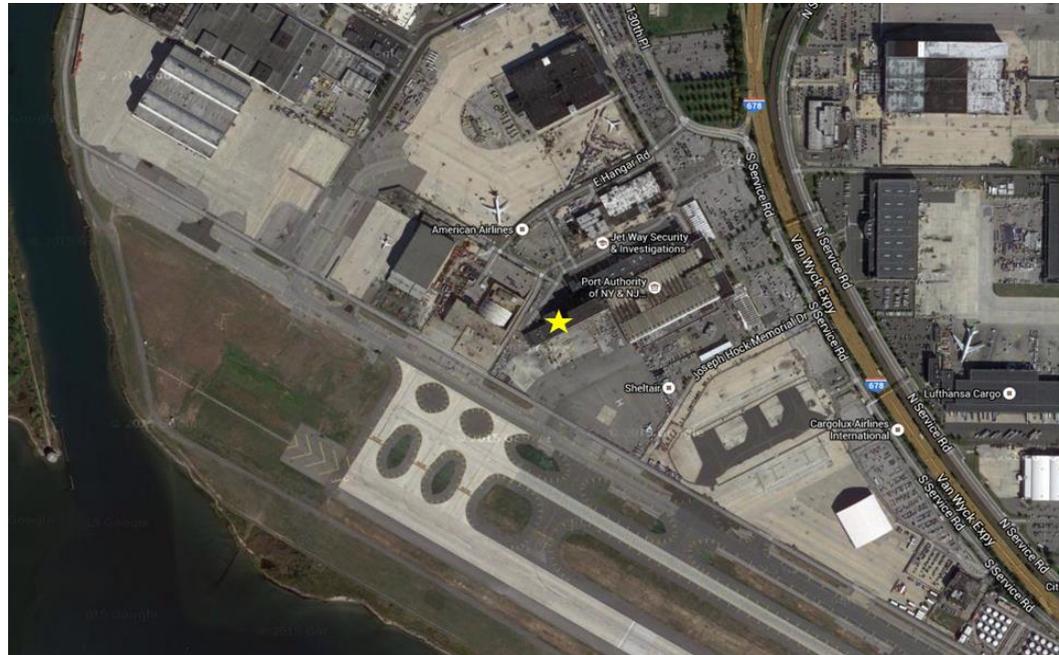
The Central Park storm total should be changed to 27.5 inches to reflect the Conservancy's numbers on their own worksheet which were accurate. The correct daily totals should be: 0.2 inch of snow on January 22nd, 27.3 inches on January 23rd and a trace of snow on January 24th.

e. JFK



The primary area used for official snow measurements at JFK International Airport denoted by the white SMB in the photo. This is a view looking southeast. An 8-inch standard rain gauge is also located on the roof as a back-up to the ASOS at JFK.

View northeast from the top of the building housing the CWO office at JFK International Airport. Some of the grassy areas around the parking lot are used at times as a supplemental location for measuring snow at this site in conjunction with the primary site on the roof of the contract office.



The location of the CWO office and snow measurement site at JFK International Airport is noted by the yellow star. Map courtesy Google Earth.

Measurement Area - This is the only site that takes measurements from a rooftop location. Official snowfall, snow depth and back-up liquid precipitation measurements for John F. Kennedy International Airport (JFK), NY are taken by Contract Weather Observers at a non-descript building located off East Hangar Road on the western end of the JFK airport complex. The area itself is heavily developed with little in the way of vegetation and sits very close to the waters of Jamaica Bay and the Bergen Basin to the west.



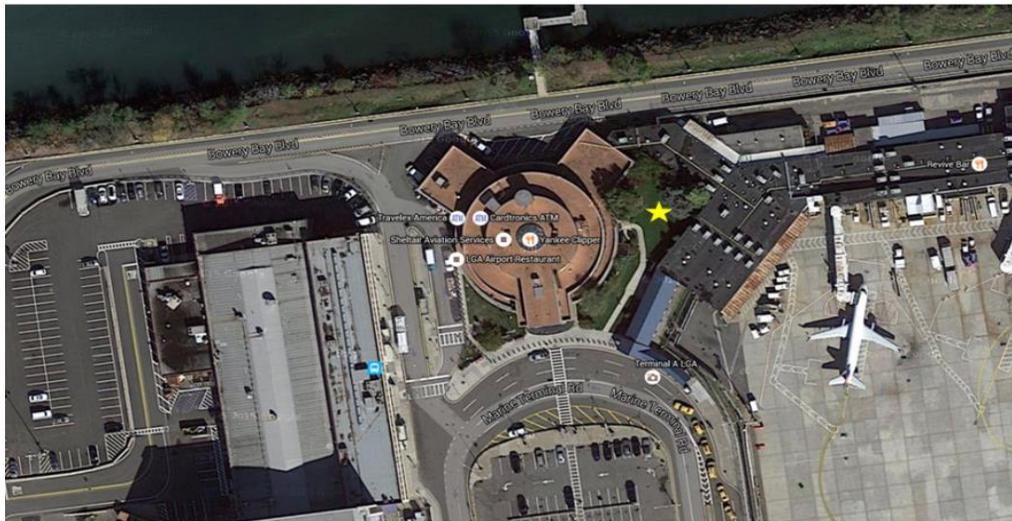
A site for measuring snow at this location remains a challenge due to the heavy urbanization of the area. As a result, snow and snow depth are measured on the roof of the CWO building with a secondary site existing in a nearby parking lot with limited grass. Snow boards are deployed on the roof of the building when needed from a nearby staging area by the observers and are placed just north of the 8 inch standard rain gauge. The major concern about this area is drifting. There was no mention if snow melt from heat generated by the building is a concern at this location.

Procedure - Followed FAA Order 7900.5C

f. LGA



Looking east from the roof of the Marine Air Terminal toward the primary snow measuring area at LaGuardia Airport. The orange cone is the location used for measuring snow.



The location of the primary snow measurement site at LaGuardia Airport is noted by the yellow star. Map courtesy Google Earth.

Measurement Area - The U.S. Weather Bureau Office moved to this location on the third floor of the Marine Air Terminal on June 30, 1961. This site remained in

use by the National Weather Service through April 30, 1996 before being turned over to CWOs on May 1, 1996 with the commissioning of the ASOS at this location. The contract observers still use the same room as the NWS and United States Weather Bureau. The snowboards are placed in a grassy courtyard just east of the Marine Air Terminal with the observing area marked with a cone.

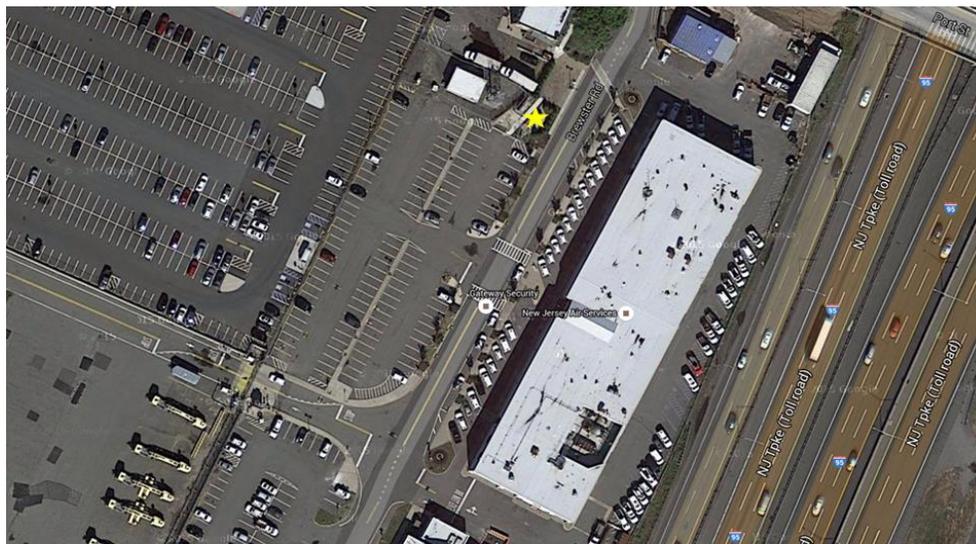
Procedure - Followed FAA Order 7900.5C

g. EWR



Location of the snow observing site at Newark, facing southeast.

The location of the primary snow measurement site at Newark Liberty International Airport is noted by the yellow star. Map courtesy Google Earth.



Measurement Area - The contract weather observer office at Newark is presently located in Building 80 on the far northeast side of the Newark Liberty International Airport complex near the New Jersey Turnpike. The official snow measuring site at Newark sits in a small area across Brewster Road from Building 80 just north of a large parking lot. There are a total of 4 SMB placed in a fenced-off area that the observers coordinate with the Port Authority of New York and New Jersey. This same area was used since the office moved to this location, but within the last year, a sidewalk was installed. A conversation with the senior observer who has been at Newark since August 1996 says that they have not had any issues with snow removal from the sidewalk impacting the site. The boards are placed in a large wooden box that contains dirt and placed on top of the dirt. The general area had white landscaping rock and was surrounded by small, bendable pine trees to the east. A large green utility box was located just north of the snowboards.

Procedure - Procedure/Snowfall Total: Newark, NJ (EWR) - Snowfall measurement procedures did not follow FAA Order 7900.5C. The CWO measured and summed hourly snowfall totals instead of taking a single measurement of snowfall every six hours. This resulted in inflated 6-hourly and daily snowfall amounts and a preliminary all-time record snowfall of 28.1 inches. Surrounding locations in Essex County, NJ measured lower totals including 24.0 inches in West Orange and 23.5 inches in Millburn. The storm-total snowfall of 28.1 inches at EWR is further brought into question by the reported snow depths of 20 and 19 inches on the 24th and 25th, respectively. Snowfall totals were more similar to respective snow depth reports at other area LCD sites; at JFK, a

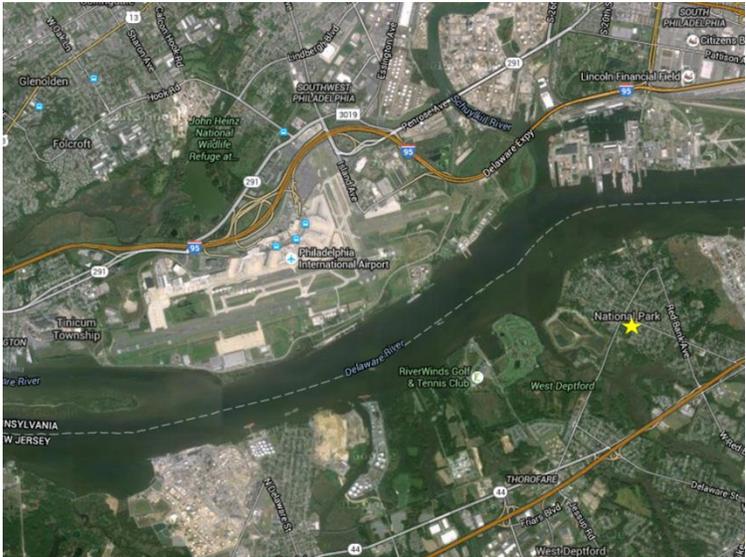
storm-total snowfall of 30.6 inches and a 28 inch snow depth on the 24th; at LGA, a storm-total snowfall of 28.2 inches and a 27 inch snow depth on the 24th; at Central Park, a 26.8 inch storm-total snowfall and a 22 inch snow depth on the 24th. Based on interviews with the CWO at EWR, the practice of summing hourly snowfall totals may have taken place. This has been occurring, possibly since 1996.



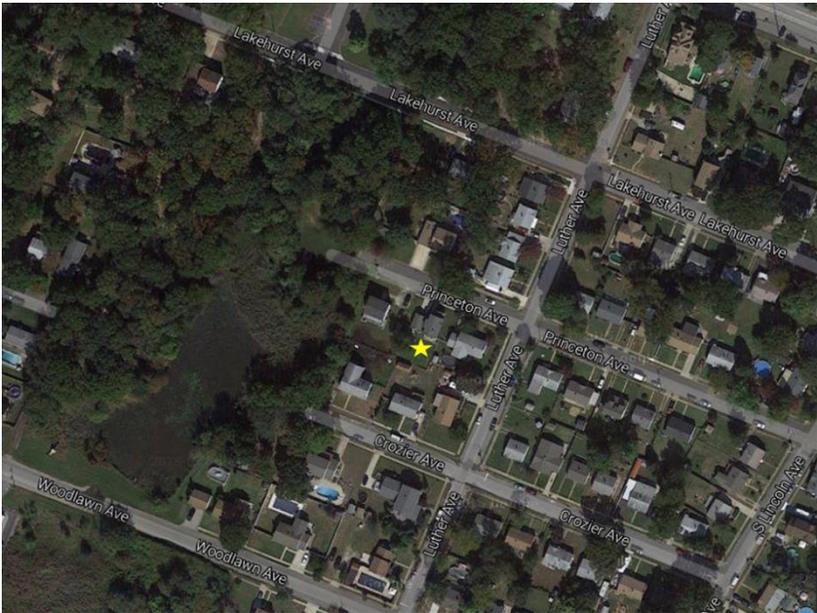
h. PHL

Broad overview of the yard of the off-airport residence that hosts the snow observing site (Snow Paid) for Philadelphia International Airport in National Park, NJ looking southwest. The white board in the middle is the snowboard and general area the observer uses.

Map showing the location of the observer's residence in National Park, NJ relative to Philadelphia International Airport. Map courtesy of Google Earth.



Location of the residence that serves as a Snow Paid observer for Philadelphia International Airport in National Park, NJ.



Measurement Area - This site's measurements are taken by one individual at a private residence in National Park, NJ in a relatively open yard with minor

obstructions being a chain link fence on one side and a small tree on another side. There is sufficient grass and a lack of paved surfaces in the immediate area where snow is measured.

Procedure - Followed 2013 NWS Snow Measurement Guidelines

As a result of past issues in the 1990s with measuring snow at Philadelphia International Airport (PHL), the NWS WFO in Mount Holly, NJ, opted to obtain snow measurements off the airport site for Philadelphia when the Snow Paid Program was introduced in the fall of 2004 by the National Weather Service.

Snow measurements at PHL had issues due to difficulty in finding a suitable location to measure snow and the exposure of the airport measuring locations due to wind. An article published in the *Philadelphia Inquirer* on March 6, 1994 describes that although the observers had a snowboard, the observers poured antifreeze into a rain gauge and estimated snow totals from the liquid total because there was a lack of safe places to measure snow during snow events during the winter of 1993-1994. During the Blizzard of 1996, the observers at PHL had to estimate the 'measured' snow total for the event off of hourly liquid precipitation totals due to the considerable blowing and drifting of snow. This event's total caused considerable controversy, especially considering it set an all-time storm record for this site. The Snow Paid program, once established, allowed the WFO to move the site to a better location to support climatology.

WFOs with poorly located snow measuring sites at airports should look at alternative sites off, but near airport property as sources for snow measurements.

Section G: References

[NWS Snow Measurement Guidelines](#)
[FAA Order JO 7900.5C](#)