



# Improving Forecaster and User Decisions for Extreme Events

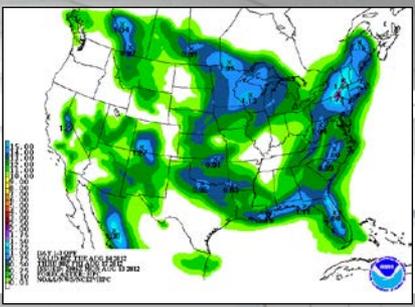
David Novak  
Acting Deputy Director  
NWS/Weather Prediction Center

With major contributions from Tony Fracasso (WPC) and  
Wallace Hogsett (WPC)

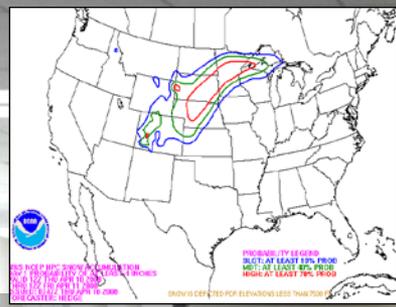
5-27-2014



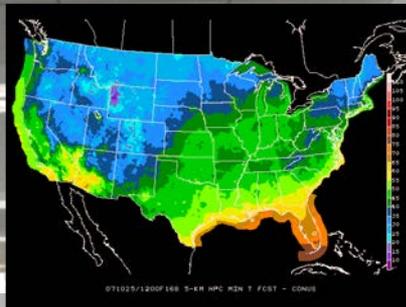
# WPC Operational Desks



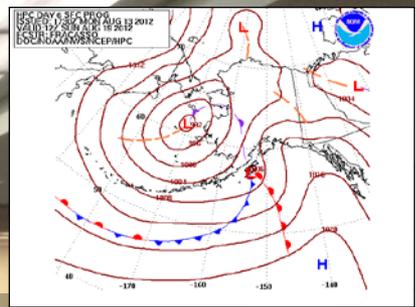
QPF



Winter Weather



Medium Range



Alaska Med. Range



Met Watch

MODEL DIAGNOSTIC DISCUSSION  
 NWS HYDROMETEOROLOGICAL PREDICTION CENTER CAMP SPRINGS MD  
 136 AM EDT MON AUG 13 2012

VALID AUG 13 0000 UTC THRU AUG 16 1200 UTC

...TROF AMPLIFYING INTO THE NRN TIER BY WED-THU...

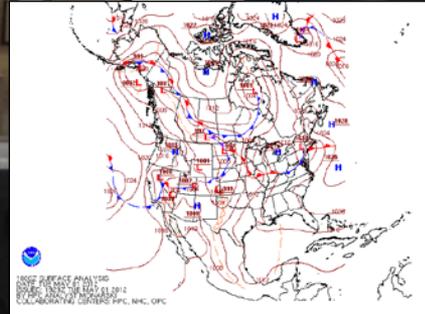
PREFERENCE: NAMGFS/12Z ECMWF BLEND  
 CONFIDENCE: AVERAGE TO ABOVE AVERAGE

OPERATIONAL MODELS AND ENSEMBLE MEANS NOW DISPLAY ONLY RELATIVELY MINOR DETAIL DIFFS SFC/ALOFT THRU THE PERIOD... AFTER EXHIBITING SOMEWHAT GREATER SPREAD AND CONTINUITY CHANGES OVER THE LAST FEW DAYS. A GENERAL CONSENSUS SOLN INCORPORATING A BLEND OF THE NAMGFS/12Z ECMWF APPEARS REASONABLE. THE UKMET/CANADIAN GLEB ADD TO OTHER SOLNS THAT SHOW LESS SWVD AMPLITUDE WITH THE TROF ALOFT VERSUS THE 12Z ECMWF ON WED... SO THERE IS GREATER SUPPORT FOR GOING SOMEWHAT MORE TOWARD THE 06Z MODELS THAT ARE A LITTLE FASTER THAN THE 12Z ECMWF WITH PORTIONS OF THE SFC SYSTEM OVER THE PLAINS AND VICINITY.

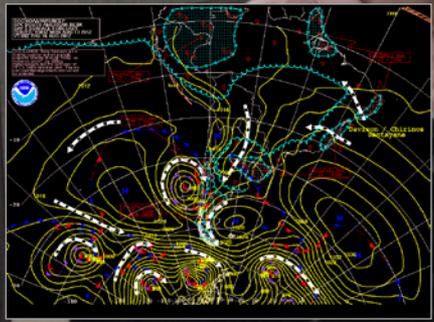
Model Diagnostics



Short Range



Surface Analysis



International



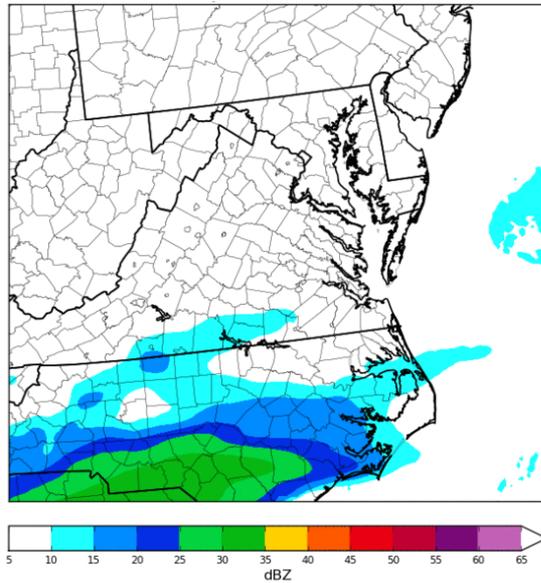
Tropical

# Incredible Predication Advances

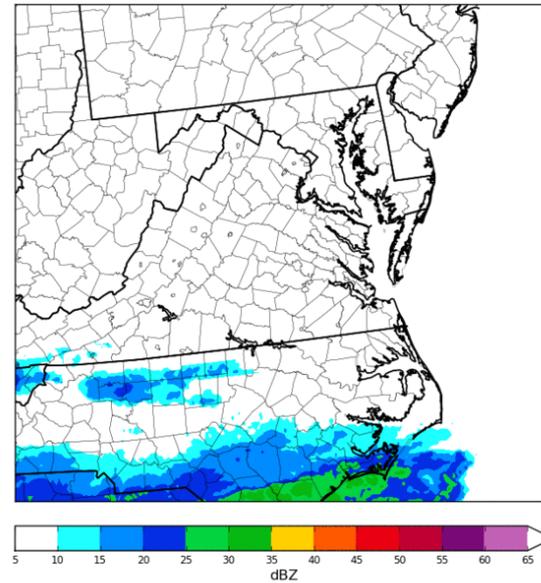
## 13 Feb 2014 DC Snowstorm

Overnight snowfall rates of 2-3 inches per hour

NAM CONUS Nest



Observed



Courtesy Eric Rogers

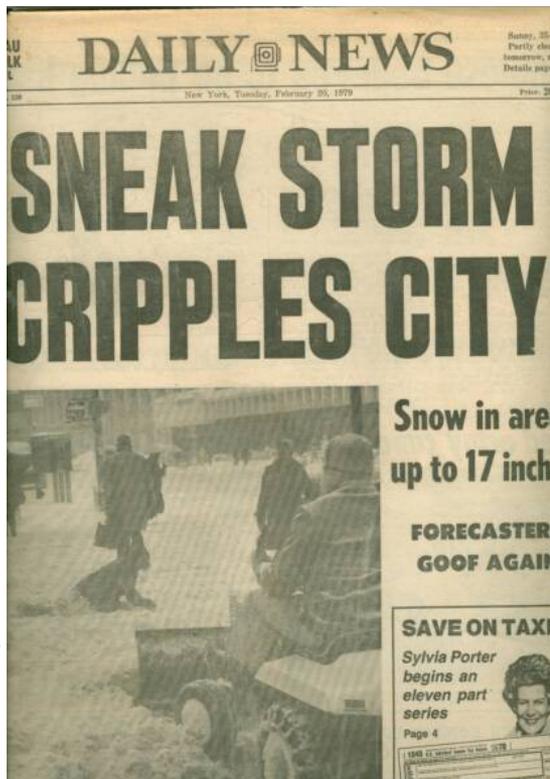


# Improved Forecasts but Changing Users



## 1979 President's Day Blizzard

<http://www.hurricanes-blizzards-noreasters.com/>



City gridlock with little warning

## 2010 Blizzard



City gridlock despite blizzard warning 18 hours in advance

Decisions being made at longer lead times demand more accurate and consistent predictions



# Improving Forecaster's Decisions





# Data Overload

## **At the Weather Prediction Center:**

- Over 250 ensemble members per day
- Over 15 unique model systems available in workstation menu
- Isobaric, PV, isentropic perspectives

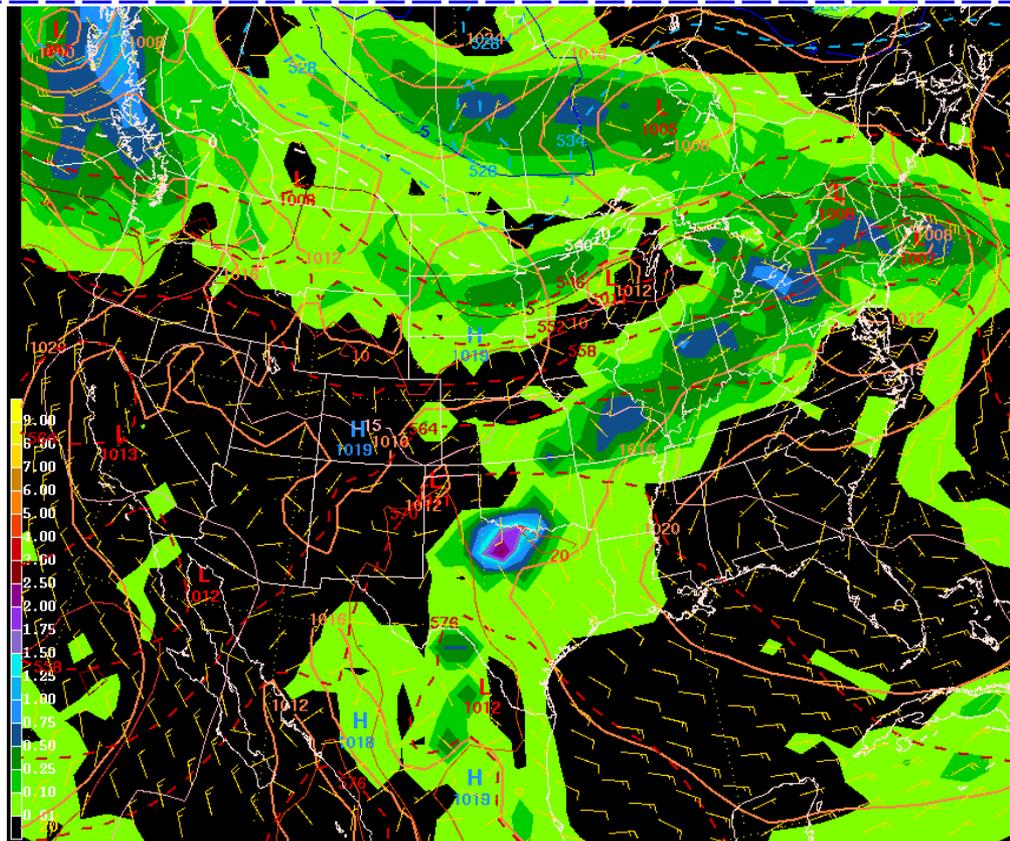
**Can we use this data more effectively to raise situational awareness of extreme events?**



# Synthesizing Information (50 members in 10 seconds)

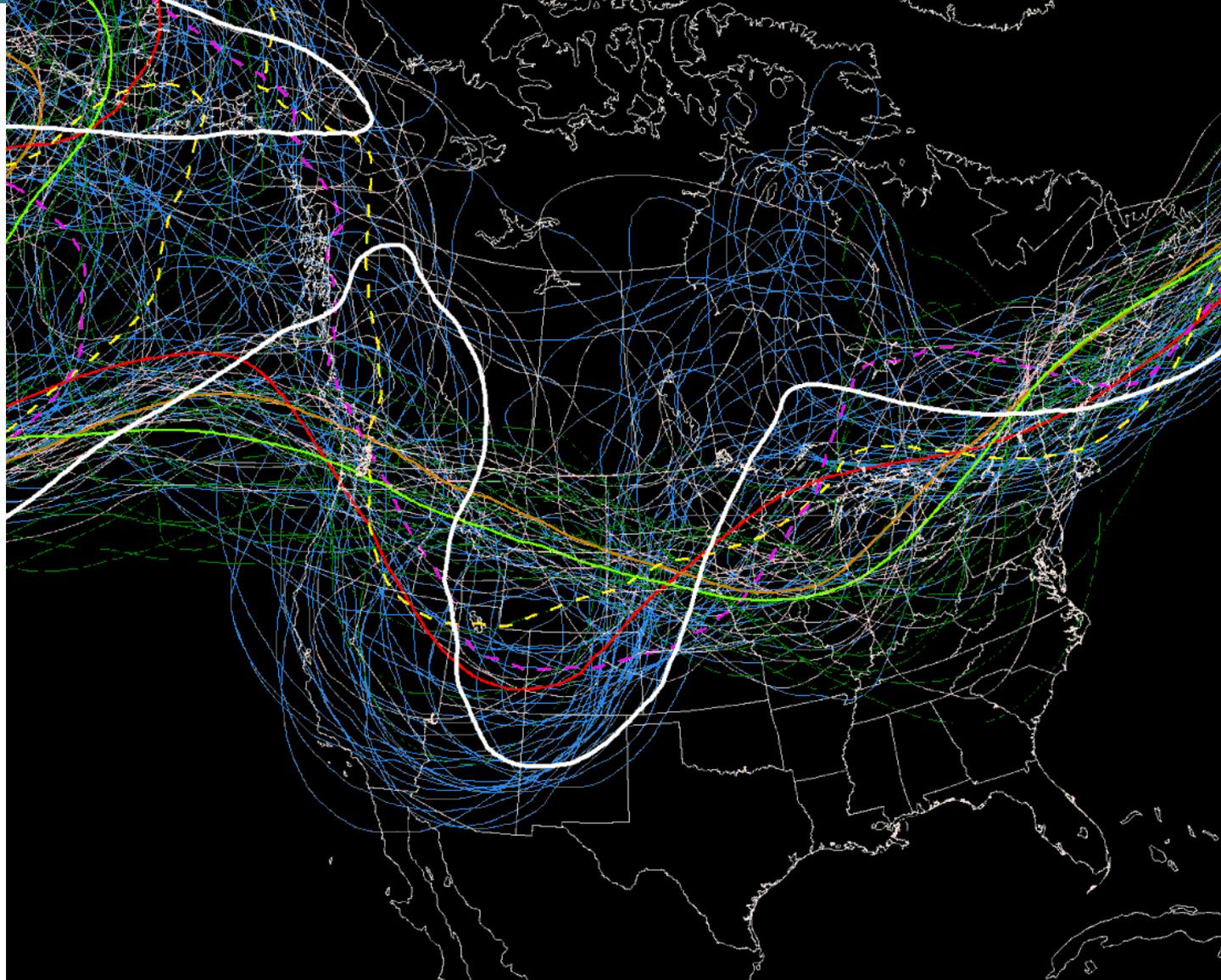


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# Synthesizing Information (Ensemble Spaghetti)



562 dm line  
verification (white)  
vs ensemble  
member forecast

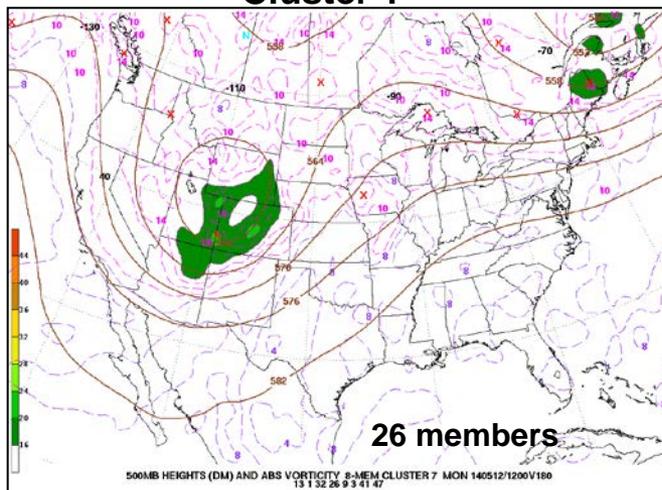


# Synthesizing Information (Ensemble Clusters)

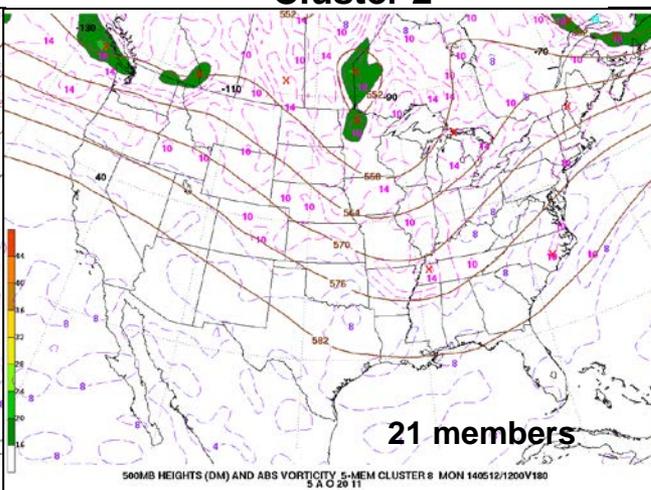


## Day 7 Forecast Clusters

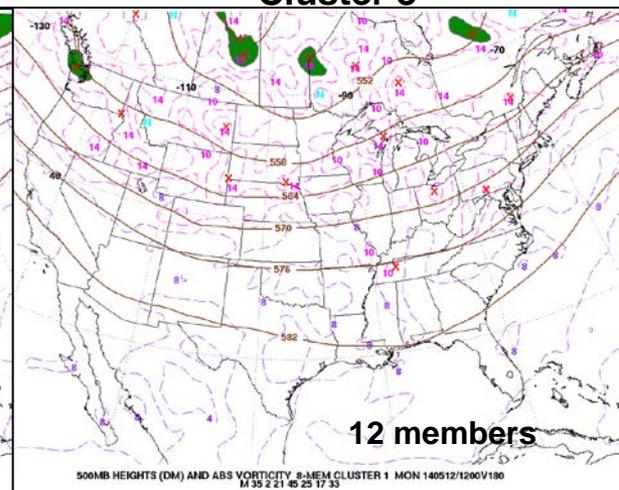
Cluster 1



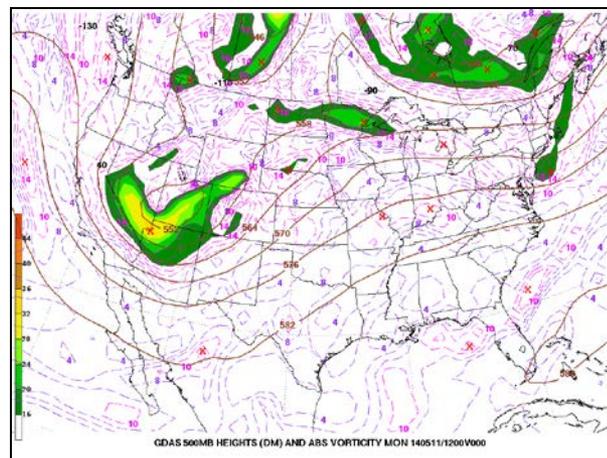
Cluster 2



Cluster 3



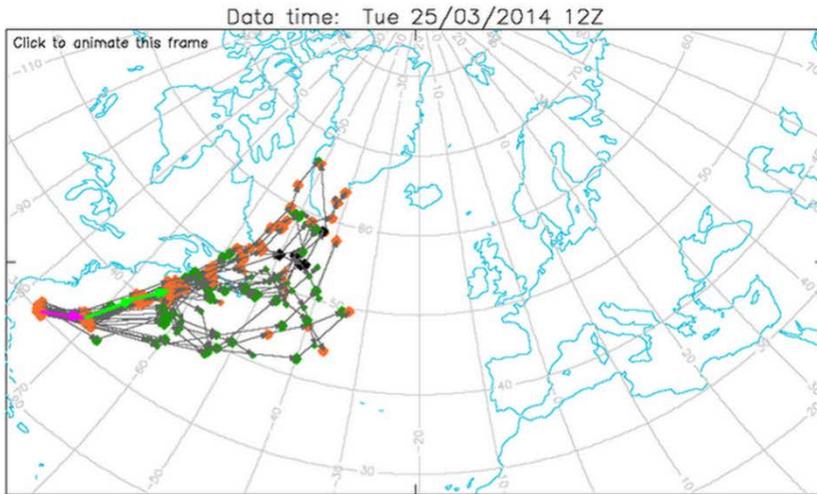
Observed



Clusters provide a quick summary of the range of scenarios.

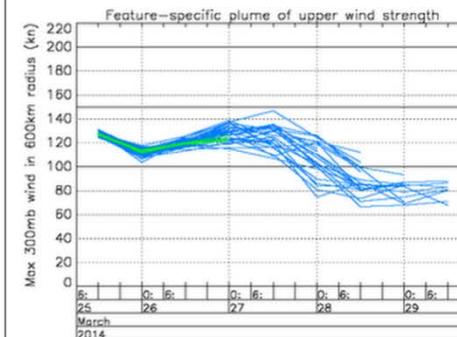
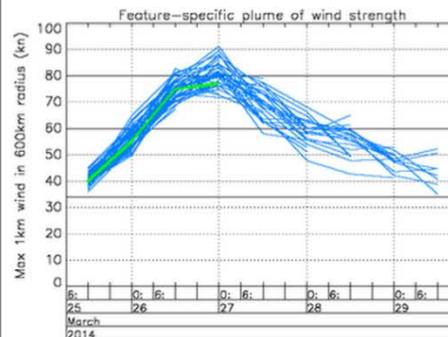
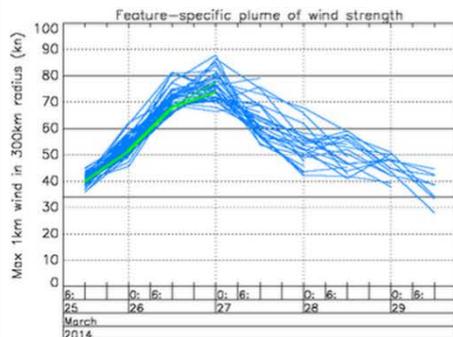
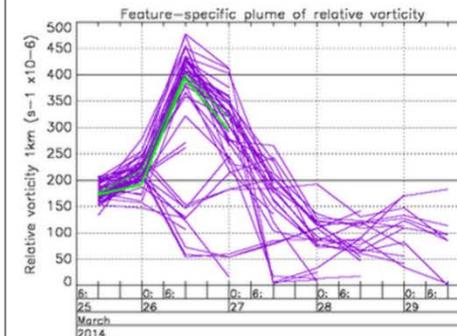
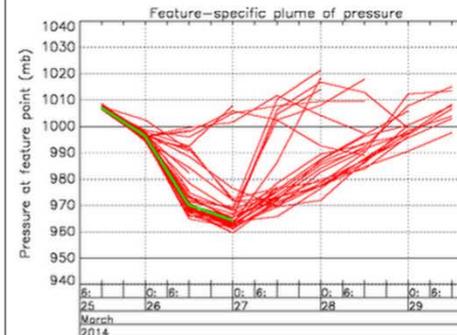


# Synthesizing Information (Low Tracks)



Percentage of members in track, and a list of the member numbers:

T+ 0: 100%	Del: 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100%	Del: 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 90%	Del: 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,27,28,29,30,31,32,34,35,36,37,38,39,40,41,42,44,45,46,47,48,50
T+ 36: 80%	Del: 0,1,2,3,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,27,28,29,30,31,32,34,36,38,40,41,42,44,45,47,48,50
T+ 48: 57%	1,2,3,6,7,9,10,11,12,16,17,18,20,21,22,23,24,25,27,28,29,31,32,36,38,40,41,42,47
T+ 60: 45%	1,2,3,6,7,9,10,12,16,17,18,20,23,25,27,28,29,31,32,36,40,41,42
T+ 72: 39%	1,2,3,6,7,9,10,12,16,18,23,25,27,28,29,31,32,40,41,42
T+ 84: 27%	1,6,9,10,12,16,18,23,25,27,29,31,40,41
T+ 96: 18%	8,9,12,18,23,27,29,31





# Synthesizing Information (Situational Awareness Display)



- Compare today's multi-model ensemble mean forecast to a 30 year climatology to determine:
  - **How unusual** (members must show an unusual feature relative to climatology)
  - **How confident** (many members must show this feature at the same time & location)
- Display as situational awareness dashboard



# 7 Day NAEFS Forecast

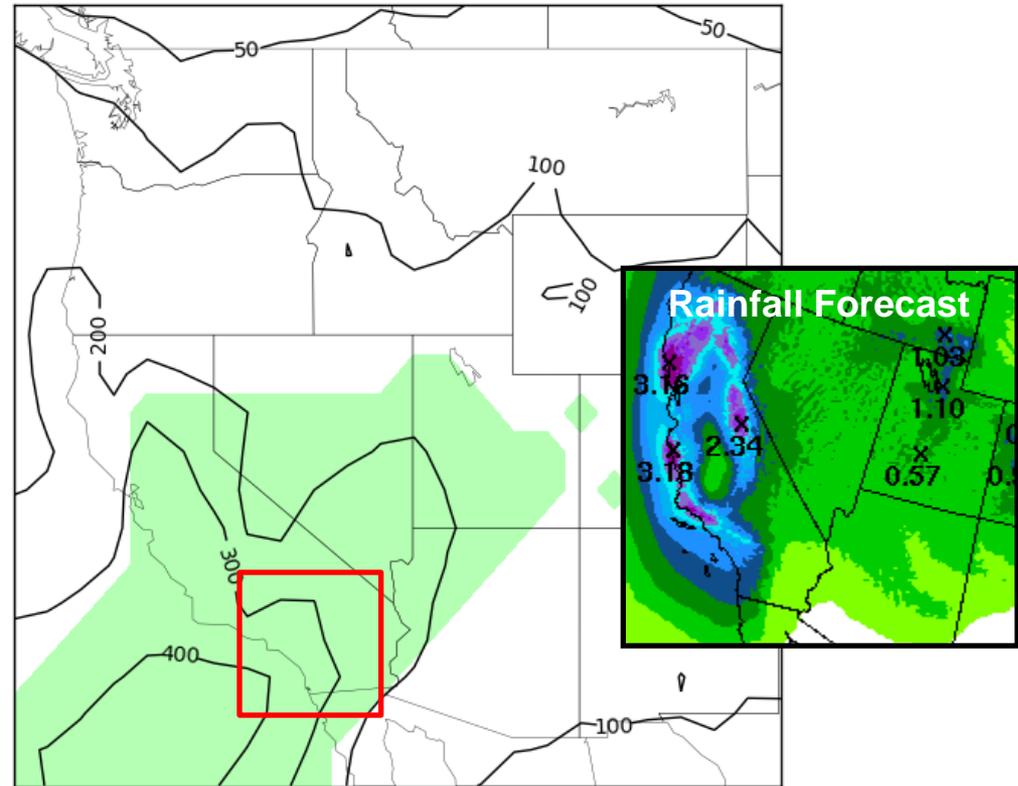


Forecast Hour

CWA SGX Table Feb 22, 2014 00Z Run									
	Z	I	U	V	WSP	SLP	Q	PW	IVT
6	06Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG
12	12Z	AVG	90	AVG	AVG	AVG	10	10	AVG
18	18Z	10	AVG	AVG	AVG	AVG	10	10	AVG
24	00Z	10	AVG	AVG	AVG	AVG	10	90	AVG
30	06Z	10	AVG	AVG	AVG	AVG	10	90	AVG
36	12Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG
42	18Z	AVG	90	AVG	AVG	AVG	AVG	90	AVG
48	00Z	AVG	90	AVG	AVG	AVG	AVG	90	AVG
54	06Z	AVG	90	AVG	AVG	AVG	AVG	90	AVG
60	12Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG
66	18Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG
72	00Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG
78	06Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG
84	12Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG
90	18Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG
96	00Z	AVG	90	AVG	AVG	AVG	AVG	90	AVG
102	06Z	AVG	90	AVG	AVG	AVG	AVG	90	AVG
108	12Z	AVG	90	AVG	AVG	AVG	AVG	90	AVG
114	18Z	AVG	90	90	AVG	AVG	AVG	90	AVG
120	00Z	90	90	90	AVG	90	AVG	90	90
126	06Z	90	90	90	AVG	90	AVG	90	90
132	12Z	90	90	90	AVG	90	AVG	90	90
138	18Z	90	AVG	90	AVG	90	AVG	90	AVG
144	00Z	90	AVG	97.5	AVG	90	AVG	90	AVG
150	06Z	90	AVG	90	AVG	90	AVG	90	AVG
156	12Z	AVG	AVG	90	90	AVG	90	AVG	90
162	18Z	AVG	AVG	90	97.5	90	10	90	90
168	00Z	10	AVG	90	97.5	90	10	90	90
174	06Z	10	AVG	90	97.5	90	10	90	90
180	12Z	10	AVG	90	90	90	10	90	90
186	18Z	AVG	AVG	90	AVG	AVG	AVG	AVG	90
192	00Z	AVG	AVG	90	AVG	AVG	AVG	AVG	AVG
198	06Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG
204	12Z	AVG	10	AVG	10	AVG	AVG	90	AVG
210	18Z	AVG	AVG	AVG	10	AVG	AVG	AVG	AVG
216	00Z	AVG	AVG	AVG	10	AVG	AVG	90	AVG
222	06Z	AVG	90	AVG	10	AVG	90	90	AVG
228	12Z	90	AVG	AVG	10	AVG	90	90	AVG
234	18Z	90	90	AVG	AVG	AVG	90	AVG	AVG
240	00Z	90	AVG	AVG	AVG	AVG	AVG	AVG	AVG

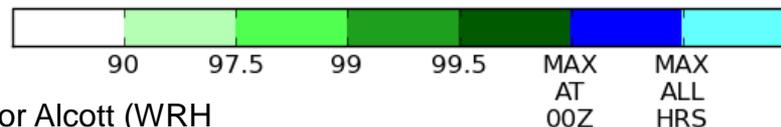
NAEFS Mean Integrated WV Transport ( $\text{kgm}^{-1} \text{s}^{-1}$ ) and Climatological Percentile  
 HOUR 168 - VALID 00:00 UTC Sat Mar 01 2014

Variables



Relative to the 18-Feb to 11-Mar 1979-2009 CFSR climatology

Color coded to how unusual



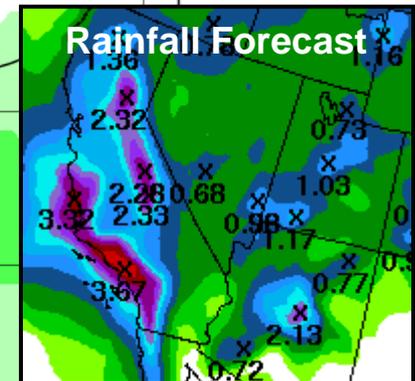
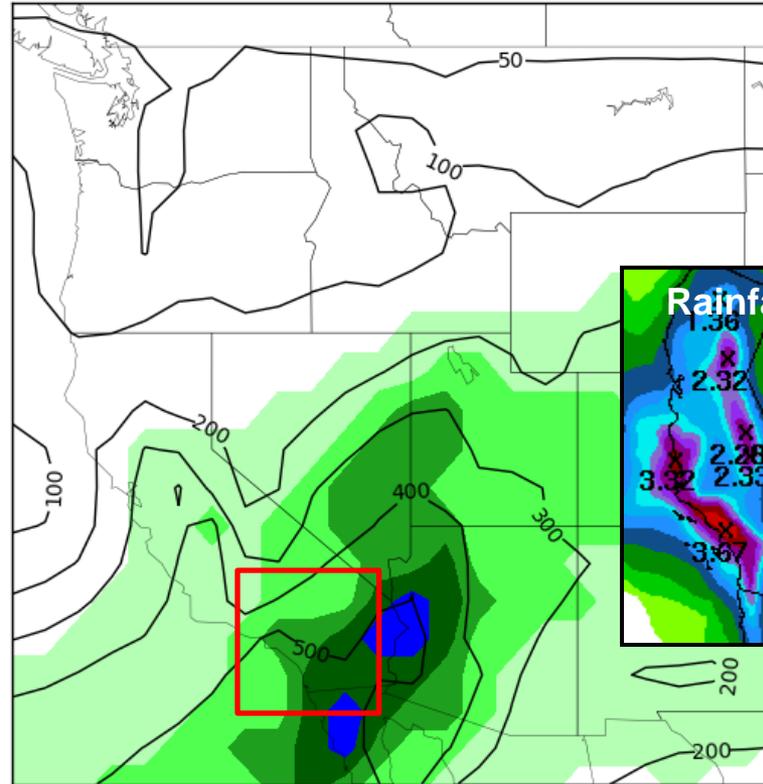
Courtesy Trevor Alcott (WRH)



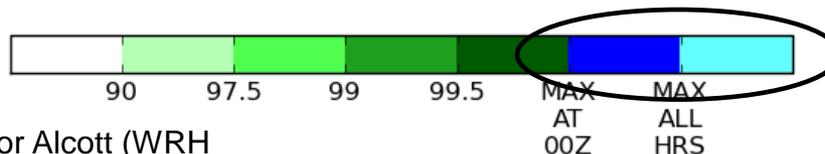
# 3 Day NAEFS Forecast



NAEFS Mean Integrated WV Transport ( $\text{kgm}^{-1} \text{s}^{-1}$ ) and Climatological Percentile  
 HOUR 072 - VALID 00:00 UTC Sat Mar 01 2014



Relative to the 18-Feb to 11-Mar 1979-2009 CFSR climatology



Never seen over past 30 years near this time of season

Courtesy Trevor Alcott (WRH)

Forecast Hour

CWA SGX Table Feb 26, 2014 00Z Run										
	Z	I	U	V	WSP	SLP	Q	PW	MT	
6	06Z	AVG	97.5	AVG	90	AVG	AVG	97.5	90	AVG
12	12Z	AVG	97.5	AVG	AVG	AVG	AVG	90	90	AVG
18	18Z	AVG	90	90	AVG	AVG	AVG	90	90	90
24	00Z	AVG	90	90	AVG	90	AVG	90	90	90
30	06Z	90	90	97.5	90	90	AVG	99	97.5	90
36	12Z	90	90	97.5	AVG	90	AVG	99	97.5	90
42	18Z	90	97.5	97.5	AVG	90	AVG	99	97.5	90
48	00Z	90	90	99	AVG	97.5	AVG	97.5	90	90
54	06Z	10	AVG	97.5	90	97.5	10	99	97.5	97.5
60	12Z	2.5	90	90	99.5	99	2.5	99.5	99	99.5
66	18Z	2.5	90	97.5	99.5	99.5	2.5	99	99.5	MAX
72	00Z	2.5	AVG	97.5	99.5	99.5	1	99.5	99	MAX
78	06Z	2.5	90	90	99	99	1	99.5	97.5	99
84	12Z	2.5	90	90	97.5	97.5	2.5	99	90	97.5
90	18Z	10	90	90	97.5	90	10	97.5	90	90
96	00Z	10	90	90	90	AVG	10	97.5	90	90
102	06Z	AVG	AVG	AVG	AVG	AVG	AVG	97.5	90	AVG
108	12Z	AVG	AVG	AVG	AVG	AVG	AVG	90	90	AVG
114	18Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG	AVG
120	00Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG	AVG
126	06Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG	AVG
132	12Z	AVG	AVG	AVG	10	AVG	AVG	90	AVG	AVG
138	18Z	AVG	AVG	AVG	10	AVG	AVG	90	AVG	AVG
144	00Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG	AVG
150	06Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG	AVG
156	12Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG	AVG
162	18Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG	AVG
168	00Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG	AVG
174	06Z	AVG	AVG	AVG	AVG	AVG	AVG	90	AVG	AVG
180	12Z	AVG	AVG	AVG	10	AVG	AVG	AVG	AVG	AVG
186	18Z	AVG	AVG	AVG	10	AVG	AVG	AVG	AVG	AVG
192	00Z	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG
198	06Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG	AVG
204	12Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG	AVG
210	18Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG	AVG
216	00Z	AVG	90	AVG	AVG	AVG	AVG	90	AVG	AVG
222	06Z	AVG	90	AVG	AVG	AVG	AVG	90	AVG	AVG
228	12Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG	AVG
234	18Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG	AVG
240	00Z	AVG	90	AVG	AVG	AVG	AVG	AVG	AVG	AVG



# California Atmospheric River

Feb 27-March 2, 2014



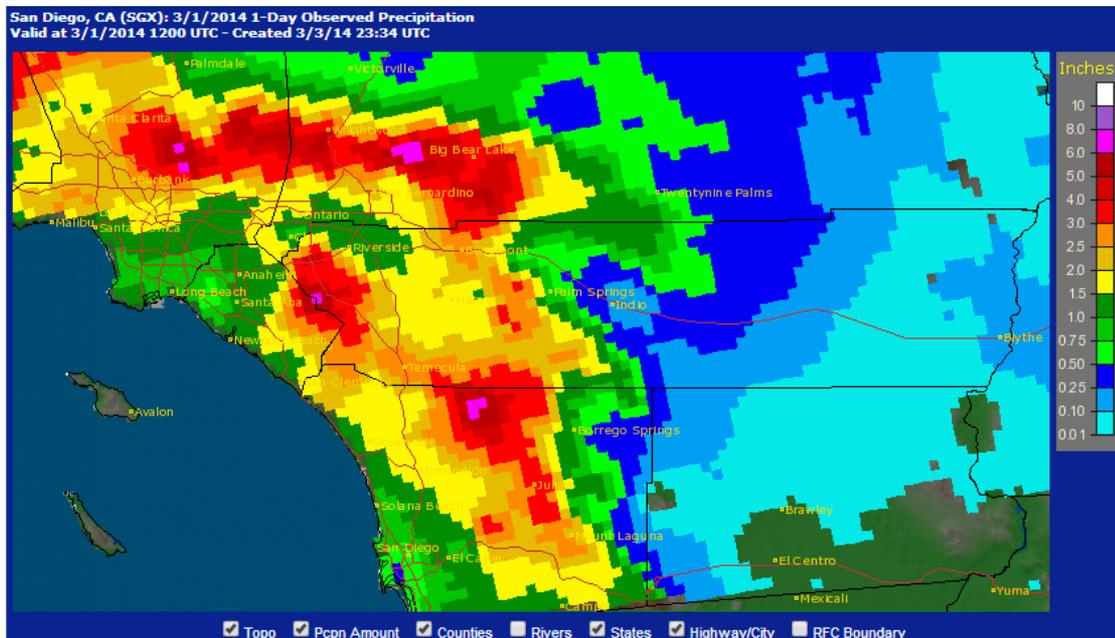
Country Club Drive dip at Harmony Grove NBC7



Cathedral Canyon KESQ



Lake Elsinore PE



Images courtesy Alex Tardy (SGX)



# Improving User's Decisions



*Connecting with decision makers to improve national preparedness for weather events*

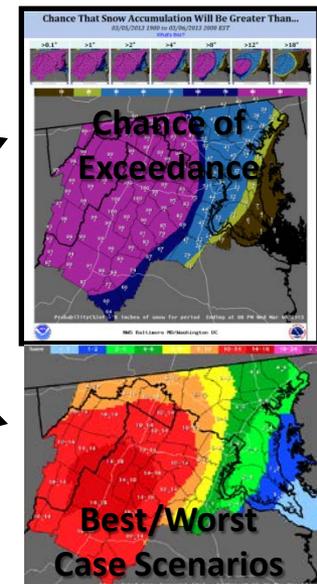
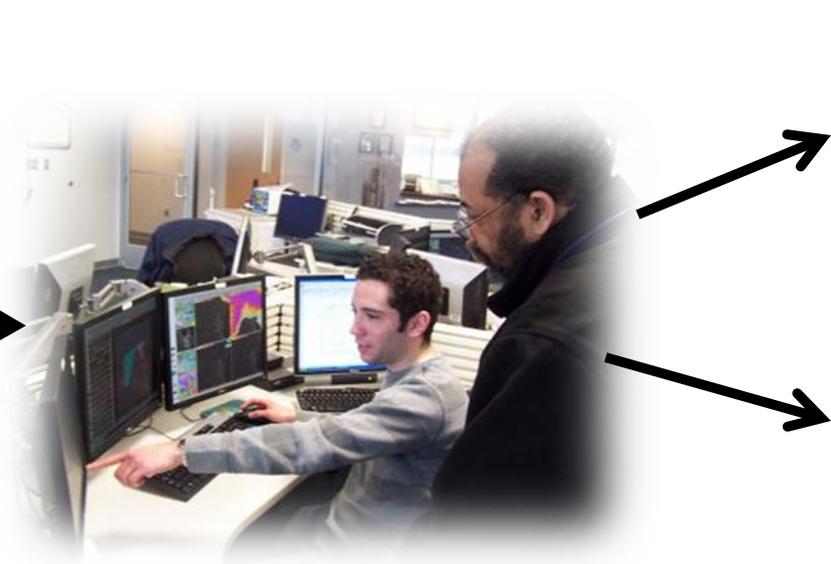
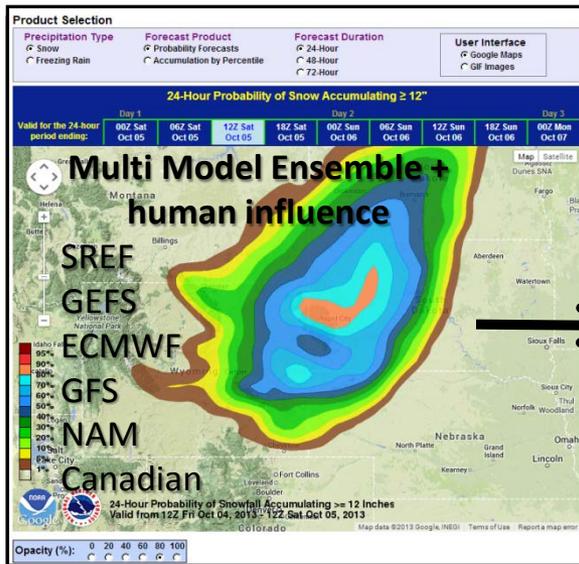


# Communicating Impact (Snowfall)



## WFO Baltimore-Washington Pilot Project IDSS in an Urban Environment

Create and communicate snowfall probability information for decision makers

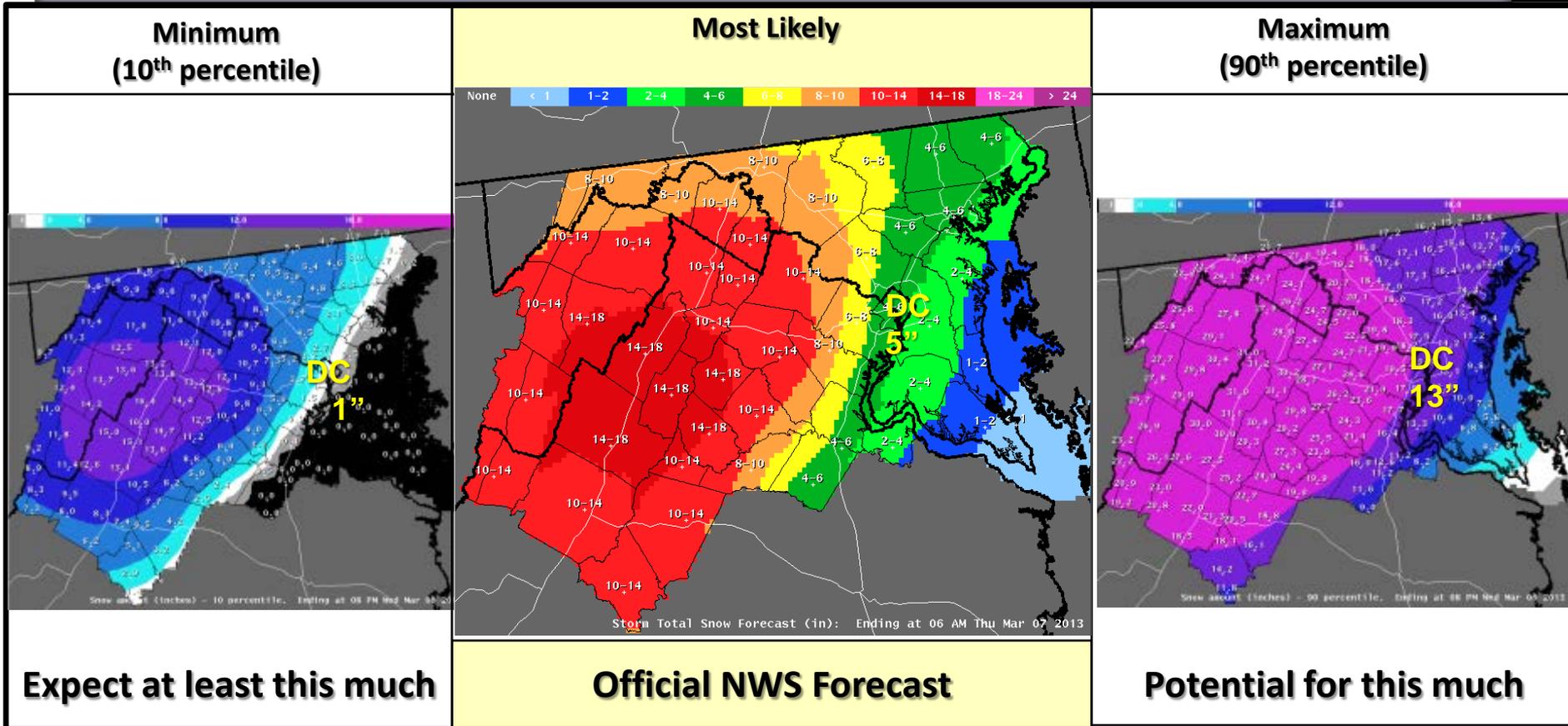




# Communicating Impact (Snowfall)



Provide a reasonable best / worst-case scenario



Local Emergency Manager: "This is one of the most important new initiatives from NWS we have seen for Emergency Managers in years."



# Communicating Impact (Aviation)



$$\text{Risk of Event} > \text{Risk Tolerance} = \text{Take Action}$$

## NWS worked with FAA and Industry to define risk tolerance thresholds

Chance of Heavy Snow  
**45%**

Risk Tolerance  
**40%**

Action  
**Cancel Flights**

Criteria for DCA

Event	Slight Prob >40%	Modt Prob >40%	High Prob > 40%
3-h Snow	> 0.2"	> 0.75"	> 1.5"
24-h Snow	> 1"	> 2"	>6"
3-h Fz Rain		> 0.01"	> 0.05"
Visibility	< 3 mi	< 1 mi	< ½ mi





# Communicating Impact (Aviation)



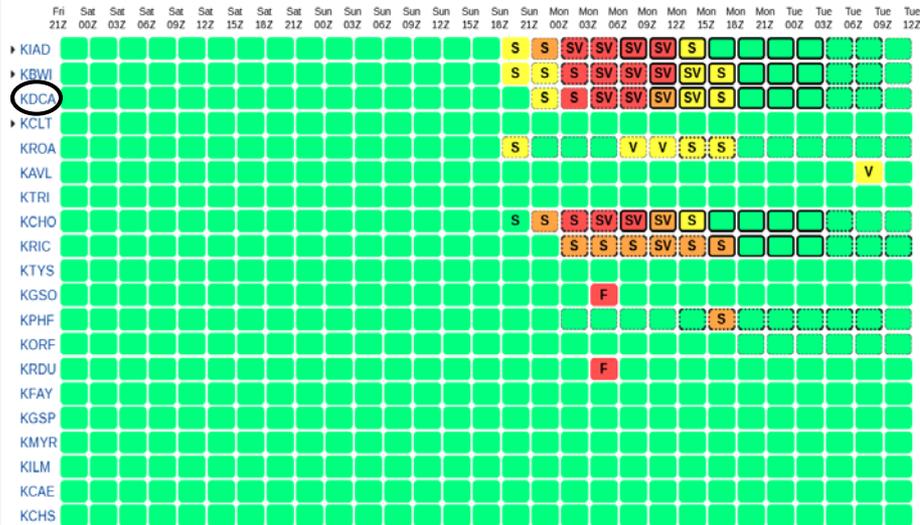
## 3 Days Before

### Aviation Winter Weather Dashboard

INFO

[<< Previous SREF Run](#)      Viewing Old SREF Run ( [View Latest](#) )      [Next SREF Run >>](#)  
 1500 UTC Fri 14 Mar 2014      2100 UTC Fri 14 Mar 2014      0300 UTC Sat 15 Mar 2014  
 Updated : 1921 UTC Fri 14 Mar 2014      Updated : 0117 UTC Sat 15 Mar 2014      Updated : 0715 UTC Sat 15 Mar 2014  
 Current Time: 15:07:26 UTC Mon 17 Mar 2014

Auto Update:  ARTCC:  Region:  Sort:  Impacts First:  Hide Nominal:  24h Snow:



### Criteria for DCA

Event	Slight Prob >40%	Modt Prob >40%	High Prob > 40%
3-h Snow	> 0.2"	> 0.75"	> 1.5"
24-h Snow	> 1"	> 2"	>6"
3-h Fz Rain		> 0.01"	> 0.05"
Visibility	< 3 mi	< 1 mi	< ½ mi

Mouseover dashboard boxes above to display detailed impact information for the selected airport and time period.  
 Click on the Airport Identifier to view SREF plume diagrams.

Impact Type: S : Snowfall      F : Freezing Rain      V : Visibility<sup>[1]</sup>  
 Impact Category: Nominal Slight Moderate High  
 24h Snowfall: Nominal Slight Moderate High

[1] Impacts due to visibility are only displayed when 2m temperature ≤ 28°F.

This dashboard provides a decision support tool to alert operational meteorologists and air traffic managers to potential winter weather impacts at major airports.  
 It was developed at the [Aviation Weather Testbed](#), located at the [NOAA Aviation Weather Center](#).

View Archived SREF Run:



# Communicating Impact (Aviation)



## 1 Day Before

### Aviation Winter Weather Dashboard

INFO

<< Previous SREF Run

Viewing Old SREF Run ( View Latest )

Next SREF Run >>

1500 UTC Sun 16 Mar 2014

2100 UTC Sun 16 Mar 2014

0300 UTC Mon 17 Mar 2014

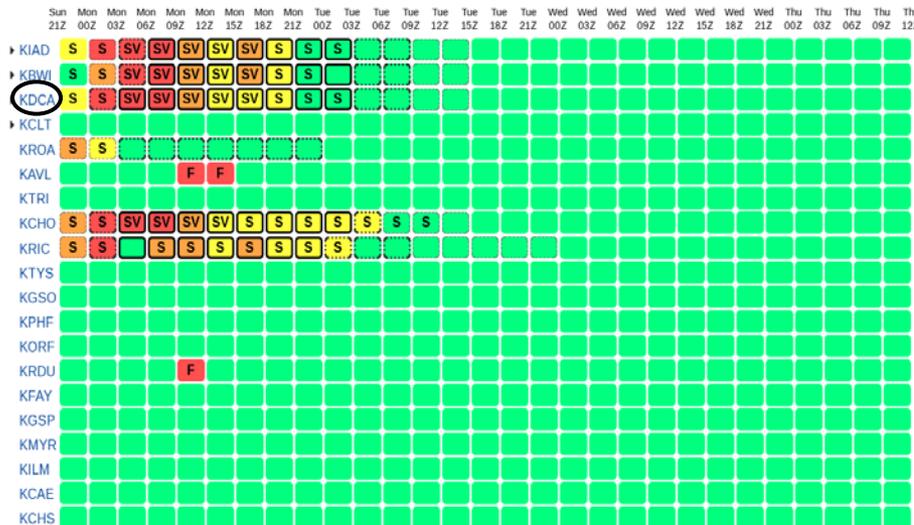
Updated : 2151 UTC Sun 16 Mar 2014

Updated : 0115 UTC Mon 17 Mar 2014

Updated : 0712 UTC Mon 17 Mar 2014

Current Time: 15:05:08 UTC Mon 17 Mar 2014

Auto Update:  ARTCC: ALL Region: Mid Atlantic Sort: Climate Impacts First:  Hide Nominal:  24h Snow:  Reset



### Criteria for DCA

Event	Slight Prob >40%	Modt Prob >40%	High Prob > 40%
3-h Snow	> 0.2"	> 0.75"	> 1.5"
24-h Snow	> 1"	> 2"	>6"
3-h Fz Rain		> 0.01"	> 0.05"
Visibility	< 3 mi	< 1 mi	< 1/2 mi

Mouseover dashboard boxes above to display detailed impact information for the selected airport and time period. Click on the Airport Identifier to view SREF plume diagrams.

Impact Type: S : Snowfall F : Freezing Rain V : Visibility<sup>[1]</sup>

Impact Category: Nominal Slight Moderate High

24h Snowfall: Nominal Slight Moderate High

[1] Impacts due to visibility are only displayed when 2m temperature ≤ 28°F.

This dashboard provides a decision support tool to alert operational meteorologists and air traffic managers to potential winter weather impacts at major airports. It was developed at the Aviation Weather Testbed, located at the NOAA Aviation Weather Center.

View Archived SREF Run: 2100 UTC Sun 16 Mar 2014

**1/3 of flights  
canceled at DCA**



# Summary

**Incredible prediction advances, but:**

**-Incredible user needs continue to expand**

**-Risk of data overload for forecasters and users**

**Combat these challenges with novel visualization methods to raise situational awareness of extreme events**

**-Based on multi-model ensemble information**



# BACK UP

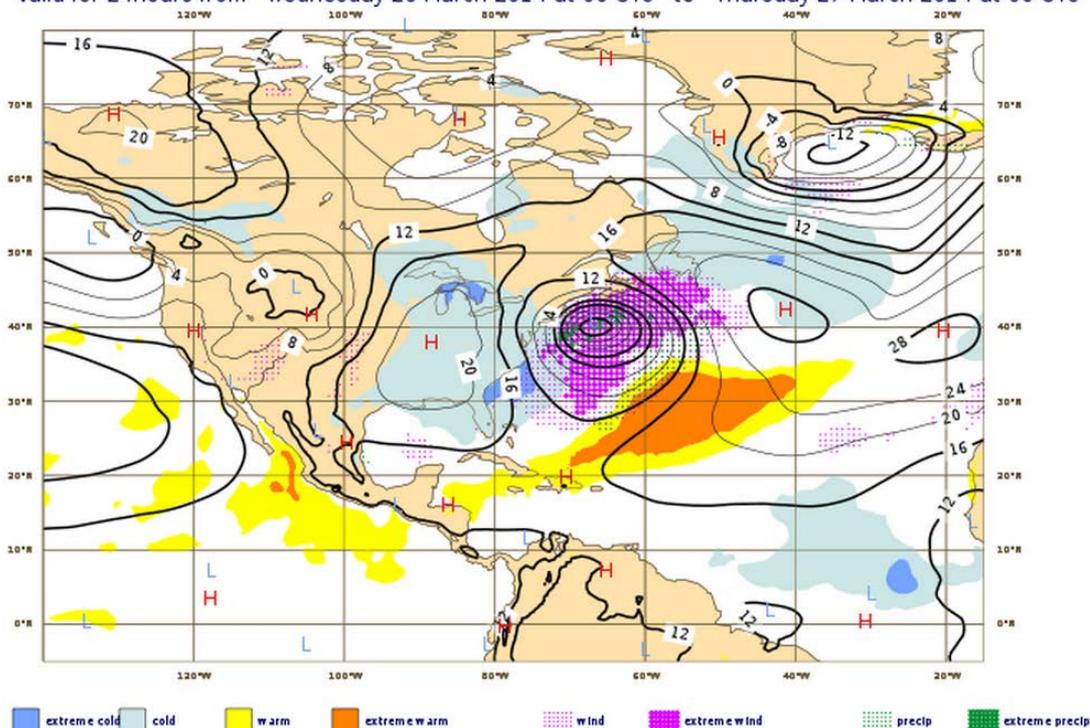




# Synthesizing Information (Extreme Forecast Index)



Anomalous weather predicted by EPS: Saturday 22 March 2014 at 00 UTC  
 1000 hPa Z ensemble mean ( Wednesday 26 March 2014 at 12 UTC )  
 and EFI values for Total precipitation, maximum 10m wind gust and mean 2m temperature (all 24h)  
 valid for 24hours from Wednesday 26 March 2014 at 00 UTC to Thursday 27 March 2014 at 00 UTC



- Identify “extreme” events relative to model climatology.
- Requires robust reforecast dataset.

