Aviation Weather Testbed – Final Evaluation

Project Title: 2013 Winter Experiment

Organization: NOAA's Aviation Weather Testbed (AWT)

Evaluator(s): Aviation Weather Center (AWC) forecasters

Duration of Evaluation: 11 February 2013 – 22 February 2013

Prepared By: Amanda Terborg (UW/CIMSS and NOAA/AWC)

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1. Summary

On the 11th – 22nd of February 2013, the first annual Winter Weather Experiment (hereafter referred to as the WWE) took place at the Aviation Weather Testbed in Kansas City, MO. Though smaller than its sister demonstration in the summer, the goals of the WWE were the same: (1) it provided a pre-operational environment in which to test and evaluate new GOES-R products with proxy data, and (2) it also aided in familiarizing forecasters with the capabilities of our next generation GOES satellite series. Participation was mainly in-house, with 18 Aviation Weather Center operational forecasters, but also included 3 WFO forecasters, visitors from Lockheed Martin, the National Transportation Safety Board (NTSB), the National Center for Atmospheric Research (NCAR), NASA Langley Research Center (LaRC), and the Air Force Weather Agency (AFWA). The following report details the activities and results of this demonstration.

2. Introduction

The structure of the experiment was built around the operational set-up within Aviation Weather Center (AWC), with a focus on those desks at which winter weather hazards are forecast; these include World Area Forecast (WAF) desks on the international operations branch (IOB), and Area Forecast (FA) desks and our National Aviation Meteorologist (NAM) desk on the domestic operations branch (DOB).

As the AWC is a global forecast center, the World Area Forecast desks are responsible for covering every corner of the globe and output a 24 hour forecast of icing and turbulence, as well as jets and tropopause heights. Mainly flight planners, particularly those mapping flight routes over the oceans, use this information to find the safest and most cost efficient path for international flights. On the other hand, the FA desks forecast for the East, Central, and West portions of the CONUS, issuing 3, 6, 9, and 12 hour graphical AIRMETs for icing, turbulence, low-level wind shear, freezing level, and ceiling and visibility.

The NAM desk is more unique. Located in Warrenton, VA, within the Air Traffic Control Systems Command Center (ATCSCC), these forecasters are responsible for updating traffic flow managers on weather hazards expected to impact aviation operations in the short term. In the winter that includes turbulence and icing, but mainly ceiling and visibility as low ceilings cause the most disruption to centers. Additionally, their focus remains on the busiest airspace and centers, typically found in the Golden Triangle region from New York to Chicago to Atlanta.

In order to cover all aspects of forecasting at the AWC, the WWE consisted of five ‘mock’ operational desks including one WAF Global Graphics North (GGN) desk, three FA desks (icing, turbulence, and ceiling and visibility), and one NAM desk. The GGN and FA desks were pre-loaded to included the typical N-AWIPS forecasting packages used in operations, and the NAM desk included one N-AWIPS terminal and one AWIPS-2 terminal.

Each day of the experiment began with a weather briefing, identifying potential areas of interest, and a forecast verification from the previous day. From there participants at each desk went through their typical forecast procedures, issuing products utilizing both commonly used tools as well as the new datasets provided. Later in the afternoon, typically after a lunchtime seminar given by various attendees (Lockheed Martin, NTSB, NCAR, and others), participants returned to their desks, updating or completing their forecasts. The day was concluded with an in depth summary and discussion of events from each desk; which areas were focused upon, which new datasets were used and how those datasets performed.

3. GOES-R Products Evaluated

The GOES-R products demonstrated within the WWE are listed in Table 1. These products were chosen based on AWC needs and applicability for time of year, and were provided by the University of Wisconsin's Cooperative Institute for Meteorological Satellite Studies (CIMSS), the Cooperative Institute for Research in the Atmosphere (CIRA), and the NASA LaRC. Both Baseline products, those products that are funded for operational implementation as part of the GOES-R base contract, and Future Capabilities products, those that are new capabilities made possible by ABI as options but require more funding for further exploration, were utilized in the experiment. Synthetic model-derived decision aids used to show the capabilities of baseline cloud and moisture imagery included the NSSL-WRF and NAM Nest Simulated Satellite Forecasts, and the Future Capabilities products included the Fog and Low Stratus (FLS) and the Flight Icing Threat (FIT).

Table 1. GOES-R Baseline and Future Capabilities products demonstrated during the 2013 Winter Weather Experiment at the AWT.

Demonstrated Product	Category
Simulated Cloud and Moisture imagery	Baseline
Fog and Low Stratus	Future Capability
Aircraft Icing Threat	Future Capability
Category Definitions: **Baseline Products -** GOES-R products that are funded for operational implementation **Future Capabilities Products -** New capability made possible by ABI	

3.1 Simulated Cloud and Moisture Imagery – University of Wisconsin Cooperative Institute of Meteorological Satellite Studies (UW-CIMSS) and Cooperative Institute for Research in the Atmosphere (CIRA)

Various forecast fields are collected from the 00 UTC run of both the NSSL-WRF and the NAM Nest, including pressure, temperature, water vapor, heights, canopy temperature, cloud water, cloud ice, snow, graupel, and rain, and are processed as inputs for a radiative transfer model. Synthetic radiances and brightness temperatures are generated through this model and displayed as simulated satellite imagery representing the Advanced Baseline Imager (ABI) on GOES-R.

Participants at the WWE were provided with NSSL-WRF simulated imagery of ABI bands 9-16, with a focus on the mid-level tropospheric water vapor (band 9 - 3.9 μm) and clean infrared (10.35 μm) as well the synthetic band difference (10.35 – 3.9 μm). In addition, the clean infrared channel (10.35 μm) was provided from the NAM Nest. This imagery was found to be of particular use at both the FA turbulence and FA icing desks. Cases from each and forecaster feedback are outlined below.

On 2013 February 13, a very strong jet (with a core in excess of 150 knots in places) was stretched across the Southeast U.S. extending from Texas up through the Appalachians, with a building ridge over West Virginia and Virginia. Shown below in Figures 2 and 3 is the 1515 UTC

GOES-13 water vapor imagery and the 1500 UTC NSSL-WRF simulated water vapor channel (band 9), both with the 1500 UTC PIREPs overlaid. In this case the simulated imagery was praised for picking up not only the intense shear zone over the southern Mississippi Valley, but also the 'notches and bumpiness' in the building ridge over the Mid-Atlantic, both of which are features typically associated with moderate or great turbulence events.

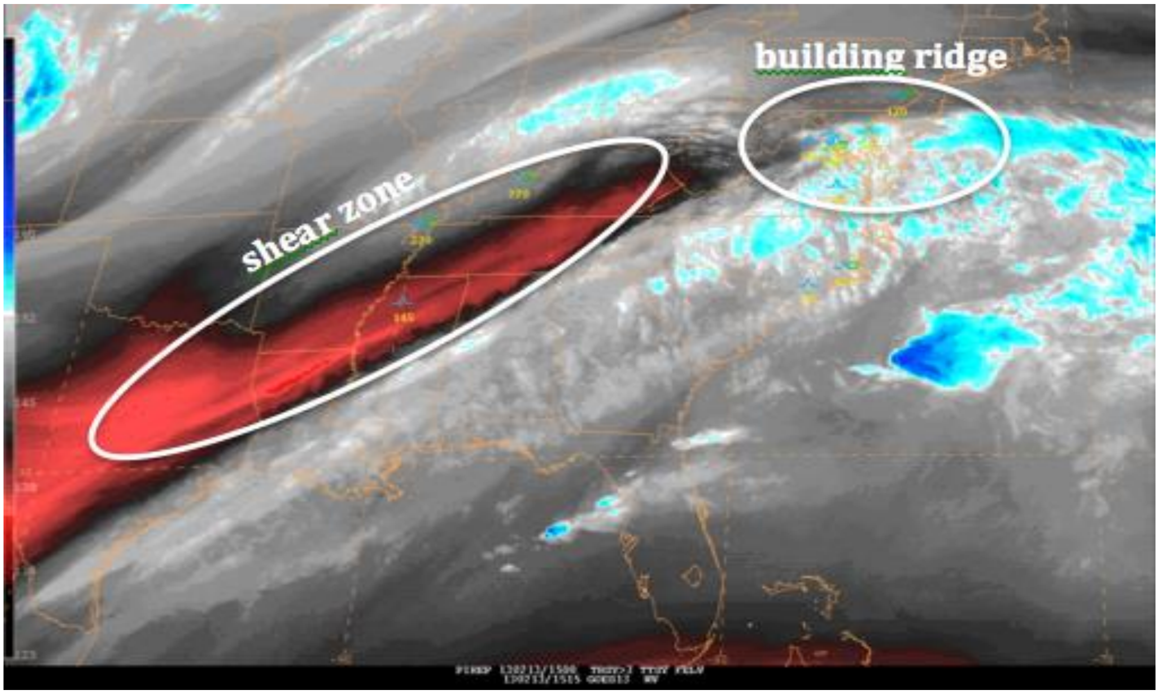

Figure 1. 20130213 1515 UTC GOES-13 water vapor and 1500 UTC MOG turbulence PIREPs

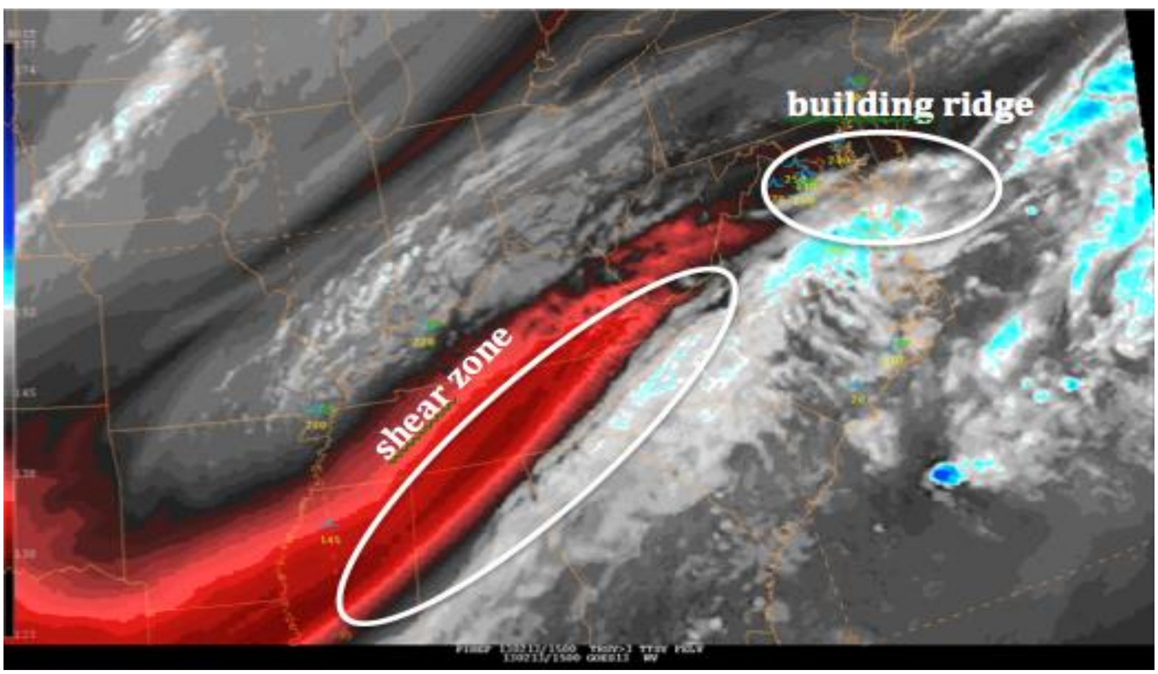

Figure 2. 20130213 1500 UTC NSSL-WRF simulated water vapor and 1500 UTC MOG turbulence PIREPs

The feedback from the forecasters on the turbulence desk was consistently positive throughout both weeks of the demonstration. Additionally there were multiple requests for its transition to operations. Below are just a few of many comments…

> "It was very helpful in determining the signatures associated with moderate or greater turbulence events."
>
> "The simulated imagery had a lot of success in turbulence forecasting and ran very, very well."
>
> "This stuff is awesome! I was very impressed with how well it performed."
>
> "Overall I'm very happy with the turbulence features that the simulated imagery keyed in on."

There were also many comments on the appealing appearance of the display itself. Forecasters, particularly veteran forecasters, put a lot of stock in how a dataset looks; it needs to be simplistic in that they can quickly and easily interpret what they are looking at and be able to apply it to their forecasts. If they find themselves unable to do this, the dataset, regardless of how it performs, won't be given a second glance. The simulated imagery was found to be very aesthetically pleasing, mimicking the imagery typically used in AWC operations and subsequently allowing the forecasters to work with a display they are already familiar with. As one forecaster stated, "It's so real!"

While the simulated imagery was consistently used for turbulence forecasting, it was also found to be useful tool in forecasting for icing. On the AWC operations floor it is common to see FA forecasters looking at IR imagery as they work to issue their AIRMETs for icing, a special enhancement table added to better identify areas of concern. This table utilizes a specific range of colors to pinpoint and enhance cloud tops between 0 and -25°C, the temperature range in which icing typically forms.

A number of forecasters at the WWE found that this enhancement could be used with the simulated IR imagery from both the NSSL-WRF and NAM Nest to identify potential areas of icing. Shown below in Figures 3 and 4 is the 1500 UTC NAM Nest and NSSL-WRF simulated IR imagery with the icing enhancement, both of which are overlaid with the icing AIRMET and light-moderate or greater icing PIREPs. Note both models identified the areas of icing over southern Florida associated with a slow moving cold front and region of precipitation. Forecasters were able to utilize this imagery to better pinpoint the area in which to issue an AIRMET for the remainder of the forecast periods.

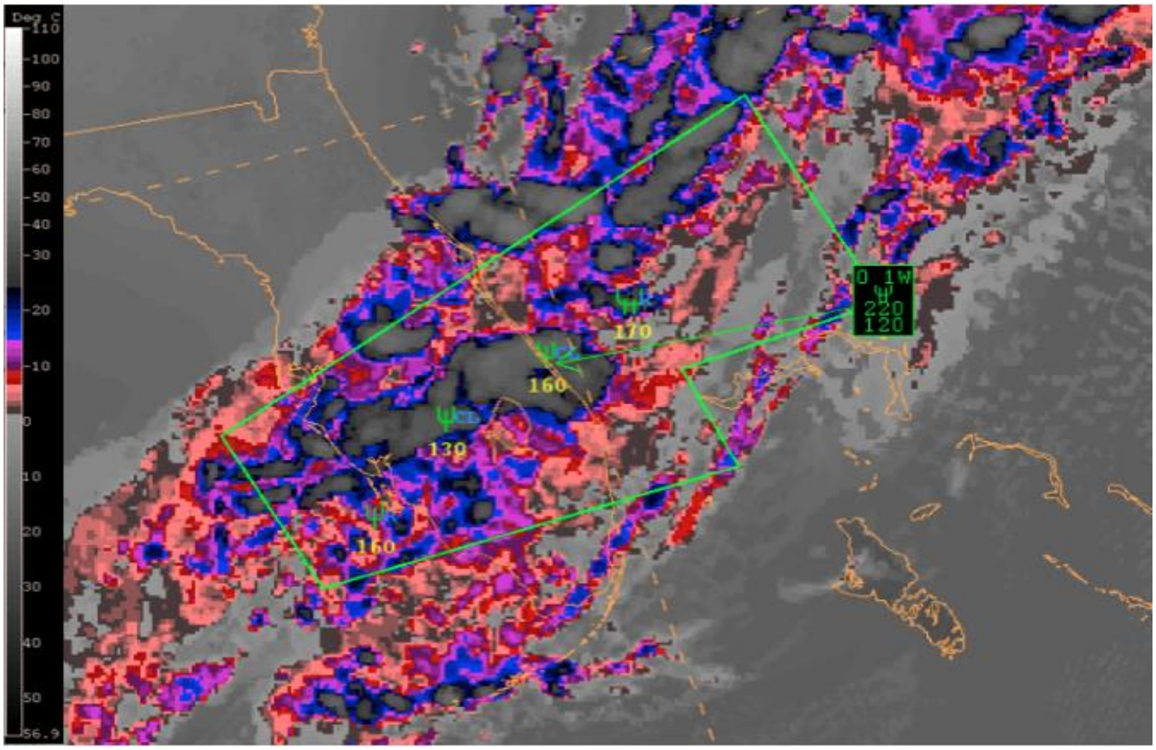

Figure 3. 20130215 1500 UTC NSSL-WRF simulated IR with icing enhancement; overlaid with icing AIRMETs and 1500 UTC icing PIREPs

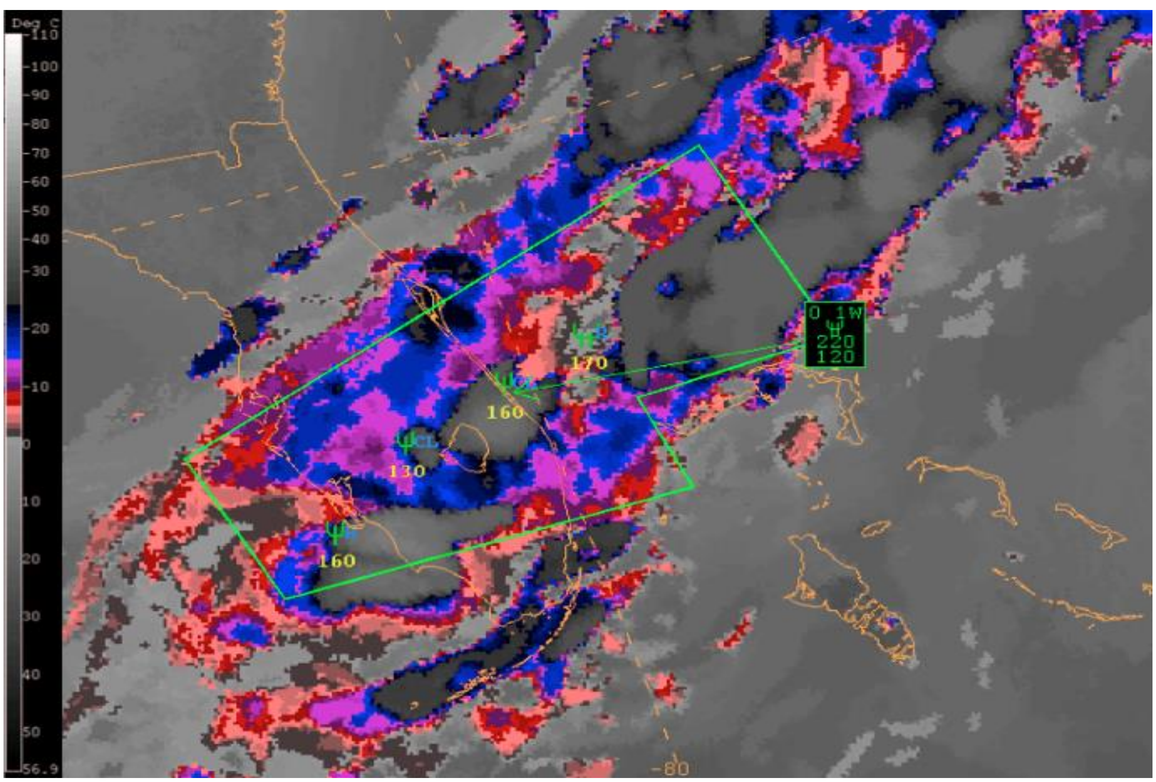

Figure 4. 20130215 1500 UTC NAM Nest simulated IR with icing enhancement; overlaid with icing AIRMETs and 1500 UTC icing PIREPs

However, it was also noted that while the enhancement picks up clouds from 0 to -25°C, once you get beyond -20°C clouds often become partly or completely glaciated, conditions which would inhibit icing from occurring, limiting the threat. To identify only liquid clouds in which temperatures are below freezing, forecasters used the simulated band difference. This difference (10.35 – 3.9 μm), typically used to aid in forecasting fog and low ceilings, identifies and highlights liquid water clouds. Comparing this image with the with simulated imagery and icing enhancement allowed for forecasters to better narrow down regions of potential icing conditions. The 1500 UTC forecast on 15 February 2013 is shown below in Figure 5.

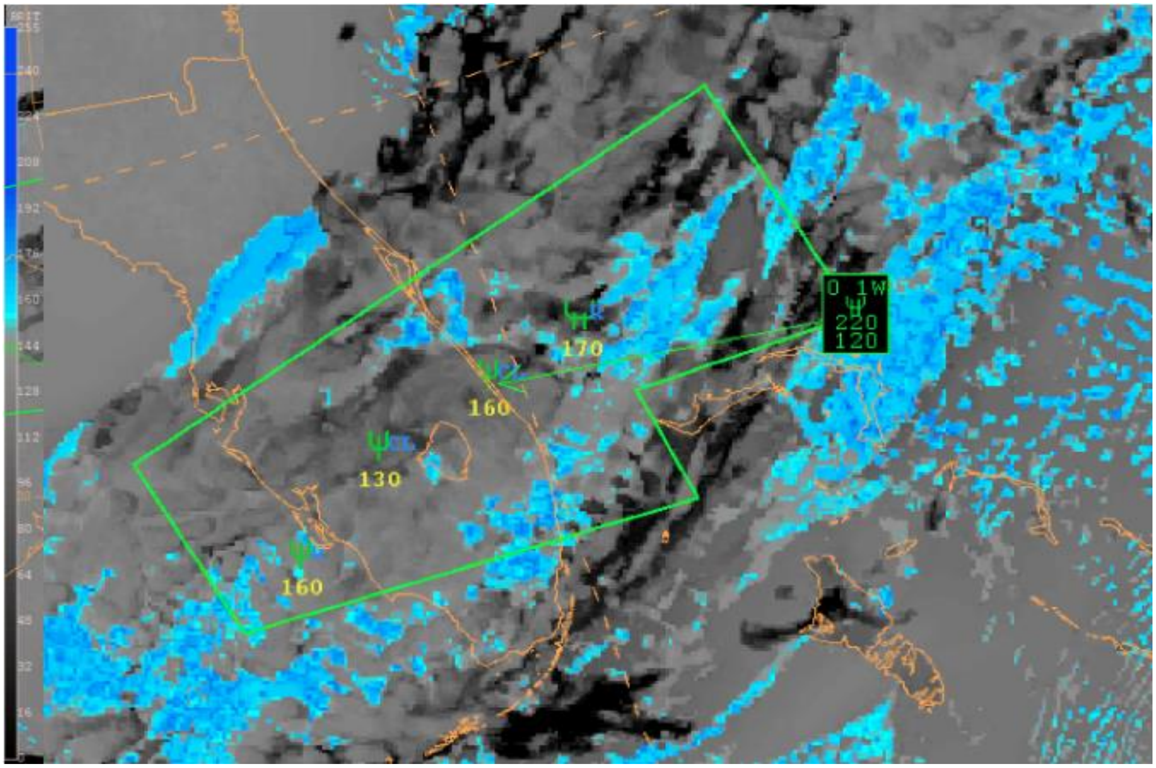

Figure 5. 20130215 1500 UTC NSSL-WRF simulated band difference; overlaid with icing AIRMETs and icing PIREPs. Note the area of low clouds (blue) within the icing AIRMET area

3.2 Flight Icing Threat – NASA Langley Research Center (NASA LaRC) and UW CIMSS

The Flight Icing Threat integrates various GOES-R cloud properties to generate a display in which forecasters are provided with information on icing conditions. It is composed of three components including (1) an icing mask available day and night which discriminates regions of possible icing, (2) an icing probability, estimated during the daytime only, and (3) a two-category intensity index which is also derived during the daytime only. While it is difficult to validate a product such as this given the lack of icing PIREPs and other methods of ice measurement, it has been shown to have skill in identifying areas of more significant icing conditions.

The vast majority of forecasters found this product to be a very useful diagnostic tool. As one forecaster stated:

If you don’t understand what’s going on with the current weather, how can you make a forecast?’

Situational awareness is key for whichever products a forecaster is responsible for issuing and in this regard the FIT was able to provide valuable information. Below in Figure 6 is one such case in which the FIT was used in this manner. The 2115 UTC FIT image is shown with the 2100 UTC icing AIRMETs and icing PIREPs. A broad area of precipitation associated with a slow moving cold front was draped over the Southeast U.S. In this region, the FIT indicated several areas, shown in the reds and yellows, of higher probabilities of light to moderate icing conditions. Specifically, it pinpointed two areas, one along northern portion of the Appalachians in the Virginia, and the other off the Mid-Atlantic coast (both captured by the northern most AIRMET regions). Both regions contained multiple moderate icing PIREPs at 2100 UTC.

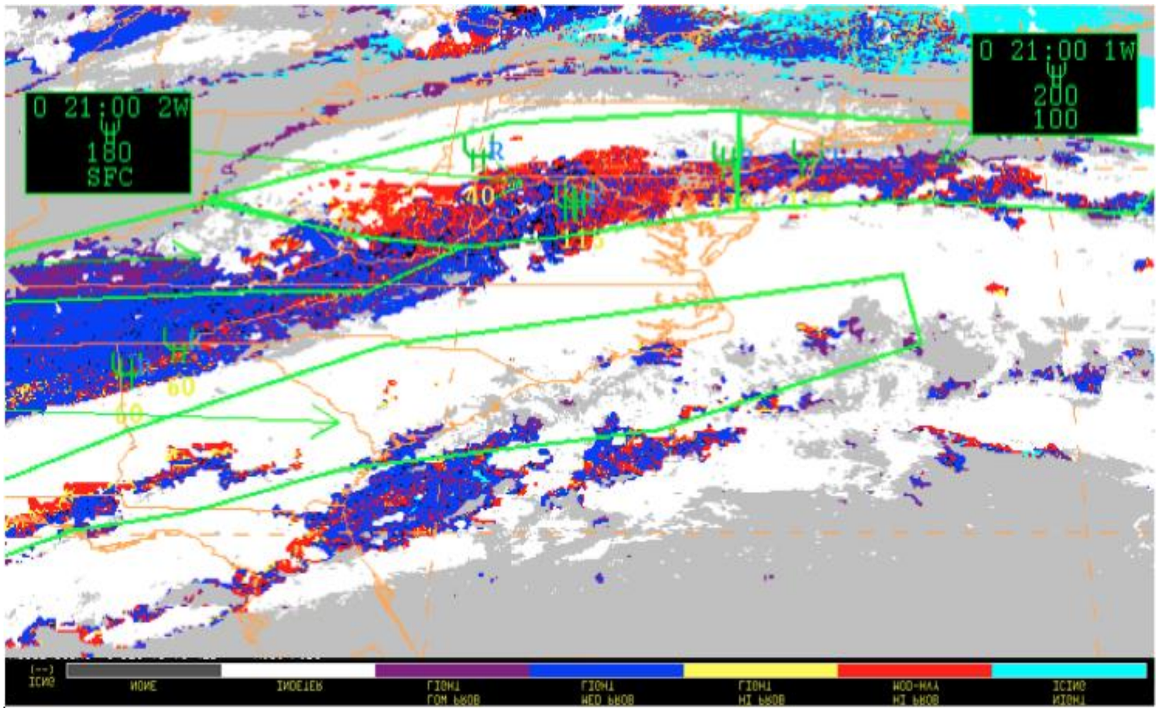

Figure 6. 20130215 2115 UTC FIT; overlaid with the 2100 UTC icing AIRMETs and icing. The color scale of the FIT is as follows: light gray = no icing, white = indeterminate, purple = low prob light icing, blue = medium prob light icing, yellow = high prob light icing, red = high prob moderate to heavy icing, cyan = night icing, and dark gray = no retrieval/bad data. PIREPs.

As mentioned, many forecasters were able to use this as a situational awareness tool, but focused mainly on the areas of red, or higher probabilities of heavier icing. While they did appreciate the detail in the display itself, they commented that it wasn’t necessarily needed. FA forecasters are responsible for issuing AIRMETs for icing, turbulence, ceiling and visibility, freezing level, and low-level wind shear, all in a very short period of time. Because of this, they need to keep their focus broader and only on the most significant hazards, i.e. moderate or greater icing.

Given the somewhat noisy display presented in the FIT, the areas of interest were often further identified by also using the GOES-R Cloud Phase. The cloud phase uses IR brightness temperatures to identify the phase of cloud; i.e. liquid, mixed phase, supercooled, or glaciated. Below in Figure 7 is the 2115 UTC Cloud Phase for February 15, overlaid with the 2100 UTC icing AIRMETs and icing PIREPs. Note the areas of interest picked out in the FIT image above correspond to areas of supercooled droplets (greens), further supporting the likelihood of icing conditions.

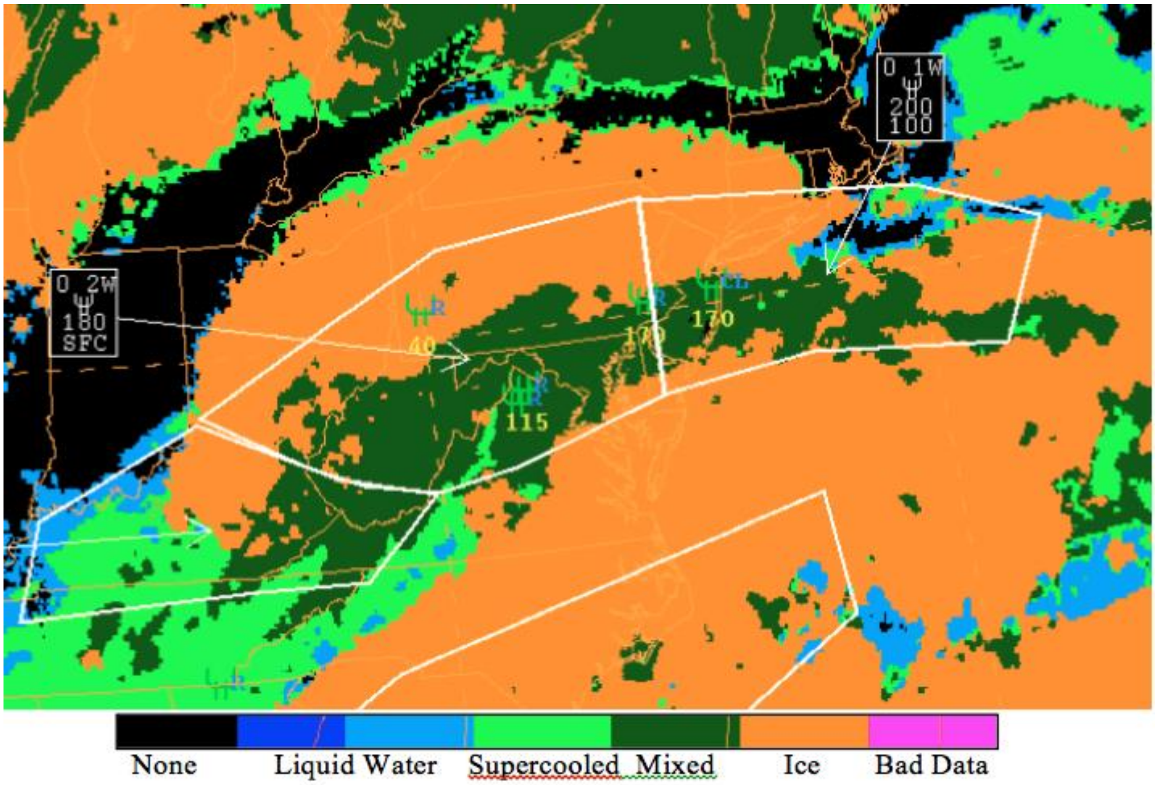

Figure 7. 20130215 2115 UTC Cloud Phase; overlaid with icing AIRMETs and icing PIREPs.

3.3 Fog and Low Stratus – UW CIMSS

The Fog and Low Stratus algorithm is a fused product, using both model and satellite data to output a probability of IFR and LIFR conditions. Previously tested at the Summer Experiment in 2012, forecasters commented on its use as a diagnostic and situational awareness tool. The feedback from the Winter Experiment was similar and it was once again utilized to diagnose current low ceiling conditions.

This was found to be of most use at the NAM desk. As mentioned in an earlier section, the NAMs provide information on more near term, nowcasting aviation concerns. While they do look at 9 and 12 hours forecasts, their main focus typically doesn't stray beyond 6 hours. For this reason, the FLS was particularly useful. Below in Figure 8 is the FLS image from February 11, overlaid with the NAM ceiling forecast for the afternoon and evening.

In this case, the FLS was used to get an idea of the dissipation rate of the fog over Philadelphia (PHL) and Reagan National (DCA). With this information they could give the traffic flow managers an estimation of when the ceilings would lift enough for operations to resume and also when they could safely release inbound flights. For example, if the fog was estimated to dissipate within the hour at PHL, flights inbound from Chicago O'Hare (ORD) could be released despite the fact that ceilings may not yet have lifted.

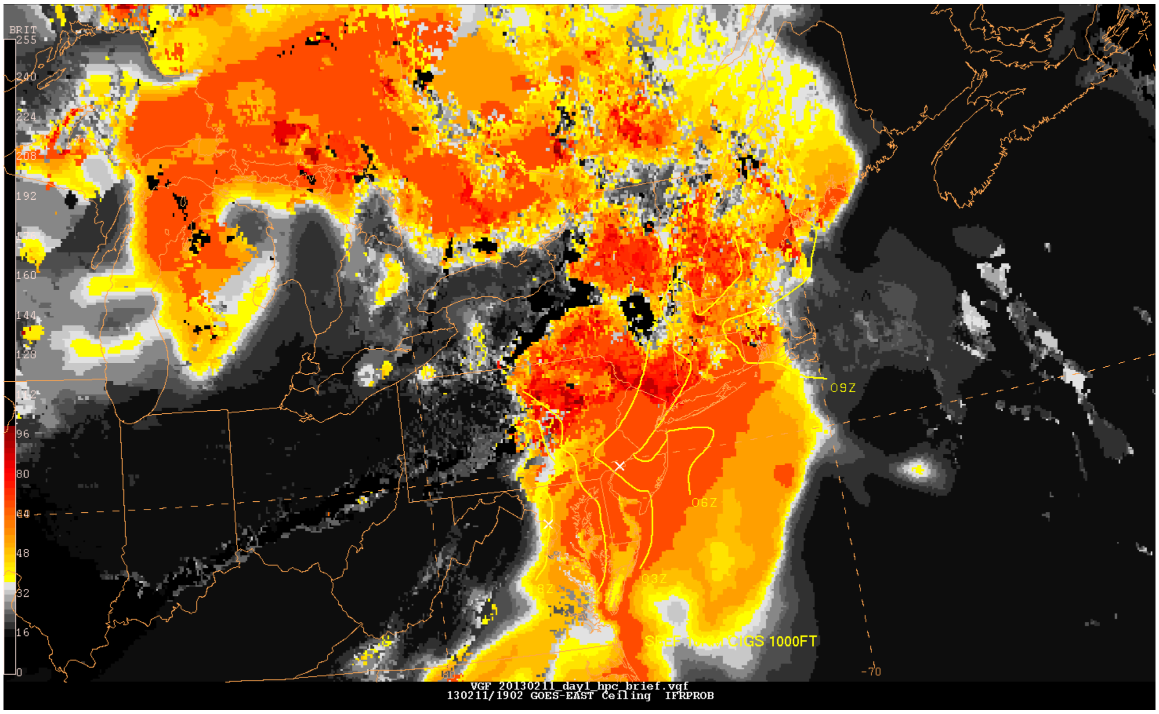

Figure 8. 20130211 1902 UTC FLS and NAM forecast for ceilings

4 Results

The first annual Winter Weather Experiment, though designed as a smaller scale demonstration, proved to be just as beneficial to the GOES-R Research to Operation (R to O) effort at the Aviation Weather Center. Forecasters very much appreciated the chance to explore new satellite tools and also those previously evaluated within the Summer Experiment, from a winter season perspective. Given the limited time to view new datasets during a regular shift, they were also eager to provide a more in-depth evaluation. The feedback received via in depth discussions, blog posts, and surveys, will play a vital part in determining the direction for the next step in the R to O process for the above-mentioned products.

While all of the products were well received, the Simulated Cloud and Moisture Imagery was by far the most popular amongst participants and consistently was praised with very positive feedback. In fact, many forecasters requested use of this data during their shifts and it is anticipated that these Baseline products will be at the top of the list for implementation. Construction of training materials has begun in a collaborative effort between the satellite liaisons at the AWC and WPC to transition these products into operations at both centers.

The Flight Icing Threat was new addition to the AWT, but by in large its debut was a positive one. Forecasters were very pleased with its skill in identifying areas of moderate or greater icing. However, as mentioned above, the level of detail caused a lot of noise within the display, noise that wasn't necessarily needed. Again, given the time constraints of FA forecasters, the scope of the AIRMETs are relatively broad, covering only the more significant hazard areas. As such, the pixel-by-pixel detail, while appreciated, makes the product less intuitive and more likely not to be used. Additionally, forecasters found the nighttime limitation to be significant, as a binary yes/no icing identification over a broad area doesn't provide much useful information for forecasting the most intense areas of icing. Though despite this, the forecasts found it to be a useful diagnostic tool with a great deal of potential. With further development the product could be an asset to AWC operations.

Overall, feedback from the participants was very good, and the success of the demonstration can be attributed not only to the work of the product developers, but also to those involved in the training process. There was much discussion on the Research to Operations effort within the AWC, and the GOES-R Proving Ground was praised for its very well written training materials. The one-page fact sheets distributed to each desk were said to have just right level of detail and allowed for forecasters to interpret each product with a higher degree of confidence. Having a stronger base knowledge of these tools provided a much more in-depth evaluation and subsequently a very positive experience.

More detailed feedback and case examples from the 2013 Winter Weather Experiment can be found on the GOES-R Proving Ground AWT blog at:
http://goesrawt.blogspot.com/

General information about the experiment, all included datasets, the testbed blog, training material, etc., can be found at the AWT testbed home page:
http://testbed.aviationweather.gov/page/public?name=2013_Winter_Experiment

Details on the baseline algorithms and optional future capabilities can be found at:
http://www.goes-r.gov/resources/docs.html

5 References

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