GOES-R Proving Ground Demonstration at the Hazardous Weather Testbed 2014 Spring Experiment Final Evaluation

Project Title: GOES-R Proving Ground Demonstration at the 2014 Spring Experiment - Experimental Warning Program (EWP) and Experimental Forecast Program (EFP)

Organization: NOAA Hazardous Weather Testbed (HWT)

Evaluator(s): National Weather Service (NWS) Forecasters, Broadcast Meteorologists, Storm Prediction Center (SPC), National Severe Storms Laboratory (NSSL)

Duration of Evaluation: 05 May 2014 – 06 June 2014

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1. Executive Summary

This report summarizes the activities and results from the GOES-R Proving Ground demonstration at the 2014 Spring Experiment, which took place at the NOAA Hazardous Weather Testbed (HWT) in Norman, OK from May 5 to June 6. The Proving Ground activities were focused in the EWP (4 weeks), with informal demonstrations taking place in the EFP (5 weeks). A total of twelve National Weather Service (NWS) forecasters representing four NWS regions and an additional four broadcast meteorologists evaluated up to nine experimental GOES-R products, capabilities and algorithms (Table 1) in the real-time simulated short-term forecast and warning environment of the EWP using the second generation Advanced Weather Interactive Processing System (AWIPS-II). This included NSSL-WRF GOES-R Advanced Baseline Imagery (ABI) Synthetic Imagery, NearCast model forecasts and analyses of atmospheric moisture and instability, GOES-R Convective Initiation (CI) algorithm, ProbSevere statistical model, Overshooting Top (OT) Detection (OTD) algorithm, Pseudo Geostationary Lightning Mapper (PGLM) total lightning, Lightning Jump algorithm (LJA), and the Total Lightning Tracking Tool (TLTT). Additionally, GOES-14 Super Rapid Scan Operations for GOES-R (SRSOR) 1-minute imagery was available from May 8-24 for participants to view in AWIPS-II (EWP) and NAWIPS (EFP). Many visiting scientists also attended the EWP over the four weeks to provide additional product expertise. Projects evaluated in the EWP alongside GOES-R were the WFO-OUN WRF NWP model and the GSD ensemble LAPS. The SPC/HWT Satellite Liaison, William Line (OU-CIMMS and NOAA/SPC), provided overall project management and subject matter expertise for the GOES-R Proving Ground efforts in the HWT with support from Kristin Calhoun (OU-CIMMS and NOAA/NSSL).

Product feedback from the evaluation was abundant and came in several forms, including daily surveys, daily debriefs, weekly debriefs, 358 blog posts, informal conversations in the HWT and the weekly "Tales from the Testbed" webinars. Common feedback included: suggestions for improving the algorithms, ideas for making the displays more effective for information transfer to forecasters, best practices for product use, and situations in which the tools worked well and not so well. Participants agreed the synthetic satellite imagery comparisons with actual imagery is a valuable means of evaluating the latest model forecast in real-time, requesting it be produced with additional NWP models. The total lightning products (PGLM and LJA) and ProbSevere model were also found to have significant use, providing lead time and confidence to experimental warning issuance. Many forecasters expressed a desire to see the NearCast analyses and forecasts in their home offices, finding the observation-based instability and moisture fields to be unique and successful in highlighting regions of increased (decreased) convective potential. Participants found that the OTD algorithm was helpful when monitoring mature convective evolution and decay as it makes obvious where particularly strong updrafts and potential hazardous weather is occurring. They acknowledged that the OTD algorithm would likely have increased utility at night and in areas where radar coverage is lacking. The CI algorithm at times provided lead-time to initial convective development, but was often too erratic and inconsistent for forecasters to use confidently. The TLTT software needs substantial improvements as the tool was often slow and performed erratically, with users agreeing its greatest impact would be in post-event, research settings. Finally, participants experienced many situations in which the 1-minute satellite imagery provided operationally-significant information not captured in current 5-15 minute imagery.

2. Introduction

GOES-R Proving Ground demonstrations in the HWT provide users with a glimpse into the capabilities, products and algorithms that will be available with the future geostationary satellite series, beginning with GOES-R which is scheduled to launch in early 2016. The education and training received by participants in the HWT fosters excitement for satellite data and helps to ensure day-1 readiness for the receipt of GOES-R data. The HWT provides a unique opportunity for product developers to interact directly with various forecasters and to observe the baseline and enhanced capability GOES-R algorithms being used alongside standard observational and forecast products in a simulated operational forecast environment (research transition to operations, or R2O/O2R). This interaction helps the developer to understand how forecasters use their product, and what improvements might increase the product usability in an operational environment. Feedback received from participants in the HWT has proven invaluable to the continued development of GOES-R algorithms. Finally, the EWP allows for the testing of satellite-based products in the AWIPS-II data visualization system.

This year, the EWP was conducted during the weeks of May 5, May 12, May 19, and June 2, with three NWS forecasters and one broadcast meteorologist participating each week. One of the twelve NWS participants was a Center Weather Service Unit (CWSU) forecaster. In an effort to extend the Proving Ground knowledge and participation to the broader meteorological community, and recognizing the critical role played by the private sector in communicating warnings to the public, broadcast meteorologists participated in the Spring Experiment for the first time this year, working alongside NWS forecasters. Training modules for each demonstration product were sent to and completed by participants prior to their arrival in Norman, and were in the form of an Articulate Power Point presentation. Each week participants arrived in Norman on a Sunday, worked 8 hour forecast shifts Monday-Thursday and a half-day on Friday before traveling home Friday afternoon.

Much of Monday was a spin-up day that included a one hour orientation, familiarization with the AWIPS-II system where forecasters learned how to load each product, and one-on-one hands-on training between participants, product developers, and the HWT Satellite Liaison. The shifts on Tuesday, Wednesday and Thursday were “flex shifts”, meaning the start time was anywhere between 9 am and 3 pm, depending on when the most active convective weather was expected to occur. The Friday half-day involved a weekly debrief and preparation and delivery of the “Tales from the Testbed” webinar. Each week, a different weekly coordinator was tasked with: choosing the start time for the Tuesday, Wednesday and Thursday “flex shifts”, selecting the two County Warning Areas (CWA’s) for the day’s operations, providing operations status updates, and overseeing EWP activities. The decision on when and where to operate each day was partially based off of input from the daily EFP weather briefing and EFP 1- and 3-hour probabilistic severe forecasts.

Shifts typically began a couple of hours before convective initiation was expected to occur as many of the products demonstrated this year have their greatest utility in the pre-convective environment. Forecasters, working in pairs, provided experimental forecasts for their chosen CWA. Early in the shift, these were primarily mesoscale forecasts discussing the environment, where convection was expected to occur, and what the applicable demonstration products were showing. Once convection began to grow upscale, one forecaster in the pair would switch to issuing experimental warnings for their CWA while the other forecaster would continue to monitor the mesoscale environment. Blog posts regarding the use of demonstration products in the warning decision-making process were composed during this period along with continued posts about the mesoscale environment. If severe convective activity in a CWA ceased or was no longer expected to occur, the weekly coordinator would move the pair of forecasters to a more convectively active CWA.

At the end of each week, the four forecasters participated in the "Tales from the Testbed" webinar, broadcast by the Warning Decision Training Branch (WDTB) via GoToMeeting. These 22 minute presentations gave participants an opportunity to share their experience in the HWT with over 30 offices each week, including NWS Headquarters, NWS WFOs and product developer's nationwide, providing widespread exposure for the GOES-R Proving Ground products. Topics for each of the four webinars were chosen based off the particular week's weather. Sixteen minutes were allowed afterward for questions and comments from anyone on the call.

Feedback from participants came in several forms. During the short-term experimental forecast and warning shifts, participants were encouraged to blog their decisions along with any thoughts and feedback they had regarding the products under evaluation. A total of 358 GOES-R related blog posts were written during the four weeks of the Spring Experiment by forecasters, developers, weekly coordinators and the HWT Satellite Liaison. At the end of each shift (Monday-Thursday), participants filled out a survey of questions for each product under evaluation. The Tuesday-Thursday shifts began with a "daily debrief" in which participants discussed their use of the demonstration products during the previous day's activities. Friday morning, a "weekly debrief" allowed product developers an opportunity to ask the forecasters any final questions, and for the forecasters to share their final thoughts and suggestions for product improvement. Feedback from the 2014 Spring Experiment is summarized in this document.

3. Products Evaluated

Table 1. List of products demonstrated within the 2014 HWT Spring Experiment

Demonstrated Product	Category
NSSL-WRF GOES-R ABI Synthetic Imagery	Baseline
NearCast Model	GOES-R Risk Reduction
GOES-R Convective Initiation	Future Capabilities
Probability of Severe Model	GOES-R Risk Reduction
Overshooting Top Detection	Future Capabilities
PGLM Total Lightning Detection	Baseline
Lightning Jump Algorithm	GOES-R Risk Reduction
Total Lightning Tracking Tool	Decision Aid
GOES-14 SRSOR 1-minute imagery	Baseline
Category Definitions: **Baseline Products -** GOES-R products that are funded for operational implementation	

Future Capabilities Products - New capability made possible by ABI
GOES-R Risk Reduction – New or enhanced GOES-R applications that explore possibilities for improving AWG products. These products may use the individual GOES-R sensors alone, or combine data from other in-situ and satellite observing systems or models with GOES-R

3.1 NSSL-WRF GOES-R ABI Synthetic Imagery

Colorado State University/Cooperative Institute of Research in the Atmosphere (CIRA)

The synthetic satellite imagery demonstrated in this year's experiment is generated from the 4 km NSSL-WRF convection allowing Numerical Weather Prediction (NWP) model. After the NSSL-WRF cycle is complete, model output is fed into the Community Radiative Transfer Model (CRTM) to produce the synthetic imagery. The imagery is generated daily from the 0000 UTC model run as a 13-36 hour forecast valid from 1300 UTC the current day to 1200 UTC the next day. Available to forecasters were the GOES-R ABI 10.35 µm longwave IR window channel and the 6.95 µm IR midlevel water vapor channel. The purpose of this demonstration was to expose forecasters to some of the channels that will be available with the GOES-R ABI, evaluate synthetic imagery as an additional means of viewing model data, and test a NWP model forecast evaluation technique.

The demonstration of synthetic satellite imagery in the HWT exposed forecasters to a relatively new model forecast evaluation technique. It was recommended that participants use side-by-side comparisons of the forecast imagery with observed imagery as a method of evaluating the current model forecast cycle. A 4-panel procedure was set up for the experiment so forecasters could easily make the comparisons. For example, the timing and location of convective activity later in a forecast cycle might be in error due to effects of earlier model misplacements that were apparent in the synthetic imagery. Furthermore, a forecaster might lose or gain confidence in forecast parameters output by the model (CAPE/CIN, temperature, etc.) based off how the synthetic imagery compares to actual imagery. It is acknowledged that since the atmosphere and models are highly non-linear, a particular model forecast might have errors initially but recover several hours later, and vice versa.

In general, forecasters found the synthetic satellite imagery to be a useful and unique tool for evaluating a particular model forecast cycle. More specifically, participants speculated the effects that displacements early in the forecast cycle might have on subsequent hours. Forecasters understood that even if feature placement or timing was off, constructive information could still to be gained from the synthetic imagery such as storm character and evolution.

> "So far, the simulated imagery seems to have a decent handle on storm initiation near the WY/NB border in particular, which allows for increased confidence in its forecast, even if the spatial placement isn't necessarily exactly spot-on."
> *Forecaster,* "A Quick Comparison", *HWT GOES-R Blog*

> "Synthetic imagery was too fast with eroding low clouds across the Mid-Atlantic which gave me lower confidence in using the forecast of that model (NSSL-WRF)"
> *Forecaster, Post-Event Surveys*

> "Overall – they provided a good starting point over CO. It showed the stratus burning off in eastern CO in about the right time. Plus – CI initiates around 18-19 UTC which is evident in the actual satellite obs. Thus – the NSSL WRF should provide an accurate depiction of overall convective evolution."
> *Forecaster*, "Simulated Satellite – Thursday", *HWT GOES-R Blog*

> "We also spotted errors in convective development in the NSSL WRF because of a cirrus shield it developed that slowed the model heating. In reality the area in question had good heating and storms developed much sooner than the model forecasted. A good example of using synthetic imagery to evaluate model performance and adjust a model forecast."
> *Forecaster, Post-Event Surveys*

One such example in which multiple forecasters used the synthetic imagery to evaluate the 00 UTC NSSL-WRF model forecast cycle occurred on May 22 in western Virginia (Fig. 1). Forecasters noticed that the NSSL-WRF forecast had developed convection by 19 UTC that was not occurring in the actual imagery. They believed the discrepancy was due to the fact that the model had not produced the thick cirrus shield that was present in reality over the region which had likely prevented the heating necessary for convection to occur at that time. Convection developed in the area two hours later.

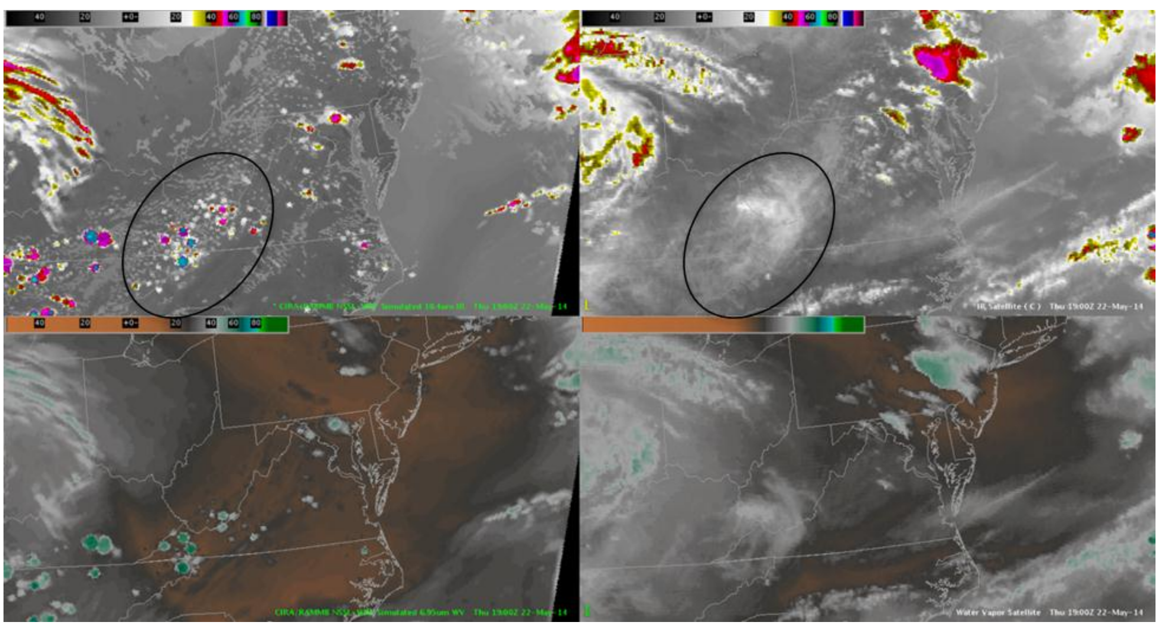

Figure 1: On left, May 22, 2014 00 UTC NSSL-WRF 19 hour forecast valid at 19 UTC for 10.35 μm IR (top) and 6.95 μm IR (bottom). On right, May 22, 2014 19 UTC observed GOES-East 11 μm IR (top) and 6.7 μm IR bottom. From blog post "Simulated Satellite WRF. Cirrus/Insolation issues leading to convection".

The synthetic imagery demonstration exhibited an alternative method for forecasters to visualize model output in 4-dimensions. By viewing model data in a single integrated image and using their experience interpreting satellite imagery, forecasters could more quickly comprehend the model information. In particular, the imagery helped to increase situational awareness to the timing and location of features such as shortwaves, convective initiation and dissipation, low fog/stratus clouds, high cirrus clouds and general cloud cover trends. Several forecasters noted that current sky cover forecast guidance is lacking, and that this tool could certainly help to fill that void. The synthetic imagery provided participants with more detailed insight into how the day's weather might unfold.

> "This gave me a heads up on where clouds would move. There isn't great guidance for sky grids, so I would look at this to see where stratus is moving, etc. if it was verifying well."
> *Forecaster,* "Week 2 Debrief", *HWT GOES-R Blog*
>
> "[The synthetic imagery] was helpful in anticipating areas where stronger convection would be likely, and the mode of the convection expected."
> *Forecaster, Post-Event Surveys*
>
> "The long-lived supercell that moved from the DEN area into northeast CO appears to be weakening as of 2330 UTC and the forecast simulated satellite data did well in forecasting not only the initiation of the convection, but also in the early demise in northeast CO."
> *Forecaster,* "Simulated Satellite Demise of Storms", *HWT GOES-R Blog*

Overall, participants from all weeks agreed that the synthetic imagery would be useful to have in their forecast offices, and would like to see it produced with other high resolution convection-allowing models. It provides them with an alternative method for visualizing model output and a relatively easy way to spot errors in the model forecast.

3.2 NearCast Model

University of Wisconsin/Cooperative Institute for Meteorological Satellite Studies (CIMSS)

The GOES NearCast model was designed to increase the utility of GOES moisture and temperature retrievals for forecasters. Multi-layer products from the model are used to help determine where and when convective development is more (or less) likely to occur in the near future (1-9 hour forecast range), helping to fill the information gap that exists between observation-based nowcasts and longer-range (beyond 12 hours) numerical forecasts. The model uses a Lagrangian approach to dynamically project GOES soundings forward in space and time at multiple layers of the atmosphere that are consistent with the observing capabilities of the GOES instruments. The technique preserves fine details present in the full-resolution (10-12 km) observations such as gradients, maxima, and minima, which often provide the focus for convective development. Finally, the Lagrangian approach allows for the use of ten minute time steps, enabling forecast products to be available minutes after the hourly GOES sounder observations are processed. In the GOES-R era, the NearCast model will utilize the Legacy Vertical Temperature and Moisture Profiles, which are GOES-R baseline products that will provide comparable quality to the current sounder.

Available to forecasters in the HWT for the 2014 Spring Experiment were analyses and 1-9 hour forecasts of: low- (centered around ~780 mb) and mid- (centered around ~500 mb) layer theta-e, vertical theta-e difference (mid-low), low (~900-700 mb) and mid (~700-300 mb) layer precipitable water (PW), and vertical PW difference (low-mid). The vertical theta-e difference field provides an objective means of identifying where mid-level cooling/drying is occurring over low-level warming/moistening, corresponding to where convective instability may be developing. Based on past feedback from the HWT, a "CONUS" version of the NearCast model that combines data from the sounders on both GOES-East and West was developed and implemented for evaluation in this year's experiment. The main purpose of the NearCast demonstration was to determine whether the guidance provided by the NearCast system using GOES moisture and temperature profiles provides forecasters with useful and unique analysis and short-term forecast information about the thermodynamic structure of the atmosphere.

Part of this year's NearCast demonstration included the evaluation of NearCast analysis animations to determine whether they might help a forecaster gain a better understanding of how the atmosphere has evolved to its current thermodynamic state. Forecasters were encouraged to load a 4-panel NearCast procedure which included low and mid-layer theta-e, theta-e difference, and low layer PW. This enabled the forecaster to view the past several hours of NearCast analyses leading up to the present, followed by the latest Nearcast forecast. Additionally, by overlaying transparent IR or visible satellite imagery, forecasters could see how convective activity has evolved with respect to the NearCast fields. 87% of survey respondents found that analysis loops of NearCast fields helped to improve their situational awareness at the beginning of the shift to some extent (greater than or equal to 3 on a scale of 1-5).

> "Looking at the analyses and seeing the trends, especially in the theta-e difference field, was very helpful, especially when analyzed in conjunction with the forecast."
> *Forecaster, Post-Event Surveys*

> "I can see [the analysis loops] being useful as I come in in the morning. It fills the gap that exists in sounding data, and gives you an idea of the scope of convective instability."
> *Forecaster,* "Week 3 Debrief", *HWT GOES-R Blog*

Evaluating the degree to which the 1-9 hour NearCast forecasts helped to increase confidence in near future atmospheric moisture and stability evolution, 88% of forecasters responded at least "somewhat". In particular, the forecasts helped increase situational awareness to where on-going convection was more likely to continue to progress, and where new convection was more likely or less likely to develop.

> "Used the Forecast NearCast to determine the future of storm movement through the CWA and raised confidence in them passing through the CWA during the next couple hours."
> *Forecaster, Post-Event Surveys*

> "The past few days have shown that the NearCast tool has worked very well for giving us the ability to pick out where convection would be more likely."
> *Forecaster, Post-Event Surveys*

> "There were a few cases where you saw decreasing moisture moving in, which was not picked up on in the models, which did have a big effect on storm development."
> *Forecaster,* "Week 2 Debrief", *HWT GOES-R Blog*

> "This was the most consistent product throughout the week. It gave me confidence in where the moisture boundaries would be in the near future, and convection consistently developed along those boundaries."
> *Forecaster,* "Week 1 Debrief", *HWT GOES-R Blog*

As an example, the NearCast instability forecasts provided to forecasters increased confidence about the development and evolution of convection across Maryland on May 22, 2014. At 1935 UTC, the forecaster mentioned in a blog post that, according to the NearCast forecast, "the unstable environment would start over western MD and move across the state into the Delmarva Peninsula. Behind it some more stable air will move in. It will be interesting to see if storms follow this track and move from NW to SE along the area and at the same time." The forecaster wrote a follow-up blog post at 2141 UTC, explaining that "storms initiated on the boundary and as they moved into the unstable air, they became stronger." Figure 2 shows this thunderstorm development along the gradients in the NearCast theta-e difference field. The forecaster went on to explain that storms further to the west "began to weaken as more stable air moved in."

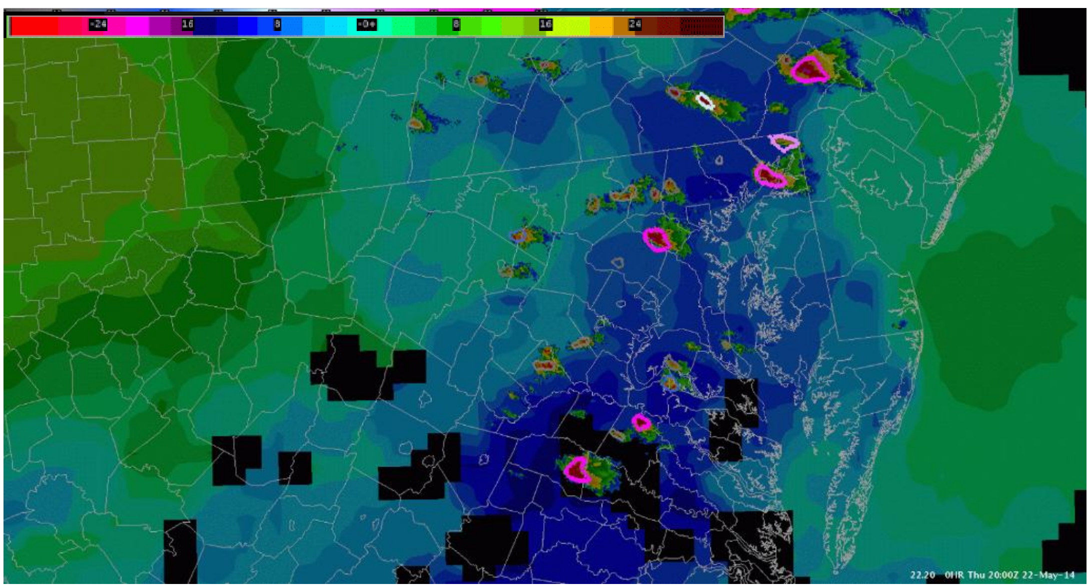

Figure 2: May 22, 2014 2000 UTC NearCast model theta-e difference analysis with Multi-Radar Multi-Sensor (MRMS) composite reflectivity and ProbSevere model contours overlaid. From blog post "NearCast Verifies with Radar".

It was stressed in the training that instability and moisture gradients and maxima depicted in the NearCast fields are often the focus for convective development, given the proper forcing. This proved to be the case throughout the experiment, leading to increased forecaster confidence to where convective activity was more likely to occur.

> "In Charleston it showed a distinct boundary, that is where convection fired. Operationally it would have given me more confidence in the pulsey environment."
> *Forecaster,* "5/13/14 Daily Debrief", *HWT GOES-R Blog*

> "This added value to my forecast process. For example, in West Virginia no boundary was evident at the surface, but there was a boundary in NearCast, and that is where convection fired. That sold me."
> *Forecaster,* "Week 2 Debrief", *HWT GOES-R Blog*

> "I really liked seeing the gradients, most of the storms developed in theta-e difference minima or moisture maxima or along gradients"
> *Forecaster,* "Week 2 Debrief", *HWT GOES-R Blog*

An example of convection developing along a theta-e difference gradient in the NearCast model occurred on May 20 in eastern Wyoming (Fig. 3). Convection initiated within a narrow north-to-south oriented plume of convective instability. The forecaster mentioned that "storms have developed and moved east across this convective instability gradient producing marginally severe hail." The NearCast field continued to be useful after initiation, as the forecaster went on to explain "the lead supercell is currently weakening and also moving out of the instability axis."

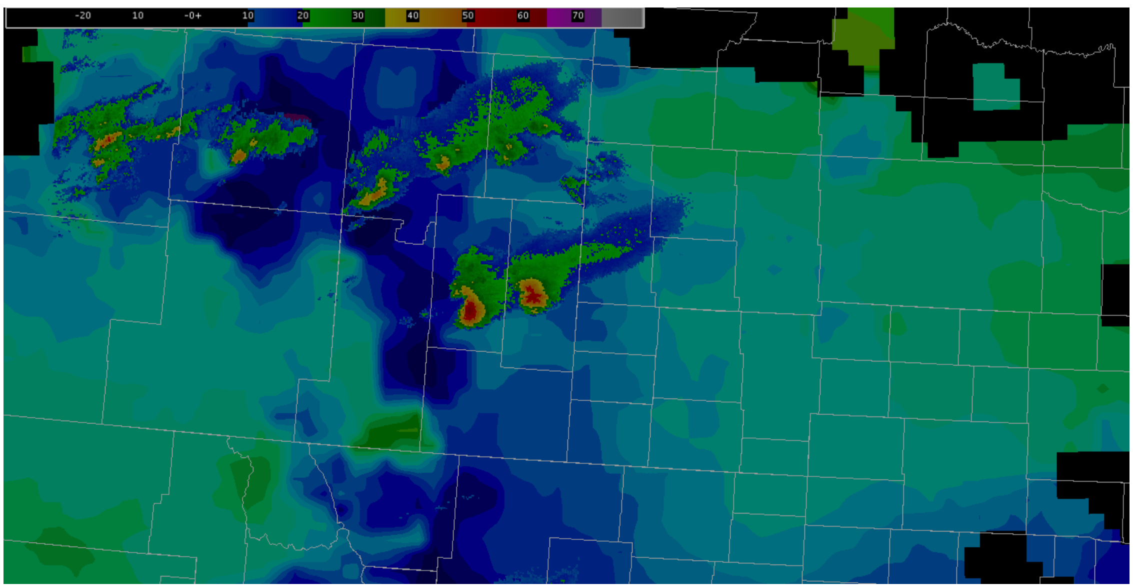

Figure 3: May 20, 2014 2200 UTC NearCast model theta-e difference analysis with MRMS composite reflectivity overlaid. From blog post "NearCast Supports Weakening".

Since the NearCast system uses GOES Sounder retrievals, data gaps exist due to cloud cover. However, by merging ten hours of previous observations in its analysis and forecast products, the NearCast model is able to provide stability and moisture information in areas even after the IR satellite observations are no longer available, further increasing the utility of earlier GOES profiles. On days where cloud cover was persistent over broad areas, the NearCast system could no longer alleviate the gaps in GOES IR retrievals. Some forecasters indicated they would like to see the fields interpolated, while others recommended filling in data gaps with model data and including an on/off switch. Finally, one participant simply overlaid NWP fields similar to those from the NearCast to fill in gaps. However, the majority of forecasters understood why the data gaps exist and were not bothered by them, appreciating the added value that the observation-based GOES NearCast system provides.

> “I liked and used it because it is observed thermodynamic data, of which there is very little.”
> *Forecaster,* “Week 2 Debrief”, *HWT GOES-R Blog*
>
> “I do not like to rely [only] on NWP data, so this was nice.”
> *Forecaster,* “Week 2 Debrief”, *HWT GOES-R Blog*
>
> “I actually like the gaps, it tells the forecaster where we don't have data, instead of interpolating, a forecaster can interpolate in his head.”
> *Forecaster,* “Week 1 Debrief”, *HWT GOES-R Blog*

Forecasters across all weeks integrated NearCast products effectively into their forecast decision-making process, primarily in assessing the thermodynamic environment. They appreciated having high-resolution (horizontally and temporally), observation-based information about the near-future atmospheric moisture and stability changes that is not otherwise available, but is highly desired.

The enhanced NearCast analyses and short-range forecasts were the primary ways that forecasters used the GOES Moisture and Temperature soundings in their forecasting process. Without the NearCasts, forecasters would have been unlikely to use the GOES retrievals as stand-alone observations. The NearCast products were especially effective in increasing situational awareness to where convection was more and less likely to initiate in the 0-6 hour range and how on-going convection was likely to evolve. The training was certainly an important part of this success, as it focused on what features to look for in the NearCast fields via multiple examples. The theta-e difference instability field was very well-received by the forecasters, garnering an average rating of 4.41 out of 5 from participants when asked how useful its addition would be to their forecast office. Finally, although the data gaps were undesirable, participants understood why they occurred and didn’t let that deter them from using the NearCast products due to the valuable and unique information they provide in areas where GOES data have recently been available.

3.3 GOES-R Convective Initiation

University of Alabama in Huntsville (UAH) and
NASA Short-term Prediction Research and Transition Center (SPoRT)

The GOES-R Convective Initiation (CI) algorithm has gone through several iterations of the HWT Spring Experiment, incorporating forecaster feedback into its continued development. This fused product combines various GOES convective cloud properties and Rapid Refresh model environmental fields in a logistic regression framework to produce probabilities of convective initiation. The output is a 0-100% probability that a given cloud object will achieve a 35 dBz reflectivity echo at the -10C level in the 0-2 hour forecast range. Some modifications to the algorithm since last year’s experiment include improved detection of cumulus clouds at night and a significant increase to the GOES-West validation database. For product display in AWIPS-II, default procedures overlaying the CI algorithm on visible and IR imagery were set up for and utilized by the participants. The main goals of this demonstration were to gauge the real-time performance of the GOES-R CI algorithm and to assess its impact on operational nowcasts and forecasts.

At the start of each week, participants were excited about the potential of a product to provide lead time to initial convective development. While there were situations where the CI algorithm had a positive impact on the forecast, participants generally developed mixed feelings regarding the product's reliability, and it became apparent that improvements would need to continue to be made. The probabilities were often inconsistent, sometimes giving <10% probabilities where clear-sky convection developed, or high probabilities where nothing occurred. The lead-time to CI was also quite inconsistent, spanning anywhere from negative lead-time to two hours. These inconsistencies made it difficult to identify specific thresholds to look for in the situation at hand. The lack of confidence in the probabilities was evident in the survey, where 36% of participants answered there was "no discernible minimum threshold for CI to occur", while the other respondents were split between the thresholds of 50-60%, 60-70%, and 70-80%.

> "CI never identified, even low values, linear cu field that eventually developed into a line of storms in EC Kansas"
> *Forecaster, Post-Event Surveys*

> "Some areas that were indicated to develop were in a region that subjective analysis would indicate a very low probability of CI (i.e., behind the cold front in a region of little mesoscale forcing)."
> *Forecaster, Post-Event Surveys*

> "Mixed results in Chicago area. Highlighted boundary where we had towering cu. Wide variety of values, from 10 to 80, but whole boundary went."
> *Forecaster,* "5/20/14 Daily Debrief", *HWT GOES-R Blog*

Forecasters noted specific situations where the product's performance was exceptionally poor. The probabilities changed drastically and became much less useful at night, when the spatial resolution is purely IR-based (4 km vs. 1 km) and a much more simplified cloud mask is used. Also, discrepancies between GOES-East and West probabilities (where they overlapped) confused forecasters and decreased their confidence in the product in those areas. It was made clear to participants that these variances are due to the different East/West training datasets. Finally, the product was unable to be processed under cirrus during periods of Rapid Scan Operations due to the unavailability of necessary data.

> "I thought this product was really great during the daytime, but I do not see it being at all useful at night as it was very inaccurate."
> *Forecaster,* "Week 2 Debrief", *HWT GOES-R Blog*

> "It was particularly erratic around the Appalachian mountains."
> *Forecaster,* "Week 2 Debrief", *HWT GOES-R Blog*

> “There were differences between GOES-East and west in Colorado in terms of probabilities (pretty big difference). This did not increase confidence; in fact it confused me a bit not knowing what to rely on.”
> *Forecaster, Post-Event Surveys*

Additionally, participants mentioned that the product display was often very noisy with probability values exhibiting considerable variability from image to image. In an effort to alleviate the noisiness, many participants removed the lower probabilities from the display, while others displayed the probability values in larger bins (as opposed to the default 10%). These simple AWIPS-II modifications made it easier to identify areas of interest out of the noisy field. Forecasters did like viewing the product as an overlay on visible or IR satellite imagery.

> “It was sometimes hard to get a sense of what the probs meant. If I used it, I would get rid of everything under 50%. I just don’t like that much clutter.”
> *Forecaster,* “Week 2 Debrief”, *HWT GOES-R Blog*

> “I changed the color scale to 3 colors to lessen the clutter and flashiness: 1-30, 30-70, 70-100. This made it a little easier to use.”
> *Forecaster,* “5/13/14 Daily Debrief”, *HWT GOES-R Blog*

> “Neighborhood approach, larger spatial probabilities might be a good idea. Instead of showing probabilities for each individual object”
> *Forecaster,* “Week 3 Debrief”, *HWT GOES-R Blog*

As with other GOES-R demonstration products, forecasters understand that this algorithm will greatly benefit from the increased temporal, spatial and spectral resolution of the GOES-R ABI. Participants noted the improved performance/utility on days when the satellite was in rapid scan mode.

> “I noticed today that with the satellite out of rapid scan mode, the CI tool has not been nearly as effective. It does not give the type of lead times that we had seen in rapid scan mode.”
> *Forecaster,* “CI Tool Shortcomings – Thursday 1945 UTC”, *HWT GOES-R Blog*

> “Overall this is a nice product that is in great need of the higher res that GOES-R will provide. This should be a product available with GOES-R data from the beginning and made available to broadcast mets as well. It will greatly help in our situational awareness.”
> *Forecaster, Post-Event Surveys*

A May 20, 2014 Midwest severe weather event showed how the CI algorithm suffers from the current GOES routine scan schedule. At 2045 UTC, the algorithm indicated probabilities ranging from 27 to 70% along a cu field from east-central Iowa into southwest Wisconsin (Fig. 4). By 2100 UTC, the first 35 dBz radar echoes appeared in the areas that had the highest probabilities 15 minutes prior. Due to the 2045 UTC full disk scan, the next CI update was not until 2115 UTC, when convection had already initiated further along the boundary. The half-hour gap caused much of the initial development to be missed by the algorithm, making it difficult to effectively utilize the product in this situation.

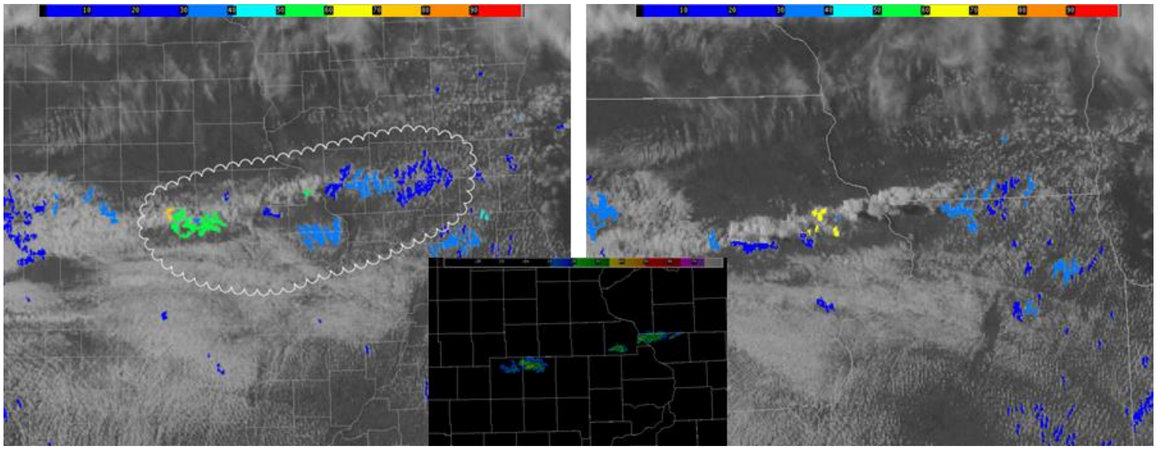

Figure 4: May 20, 2014 2045 UTC GOES-R CI, visible satellite imagery (left), 2100 UTC MRMS reflectivity at -10C isothermal level (middle), 2115 UTC GOES-R CI, visible satellite imagery (right). From blog post "Convective Development in Iowa".

Despite its deficiencies, 54% of respondents still felt that the CI algorithm had "some" impact in the operational nowcast/forecast process, while 19% believed it had a large or very large impact. There were situations where the product helped to increase situational awareness to where convection was more likely to develop in the very near future, sometimes confirming what was already expected. The probabilities helped to focus attention to particular areas of interest and away from less favorable ones. Furthermore, forecasters found that trends in the probabilities as well as relative probabilities were often just as valuable (if not more) to the forecaster as the exact probability values.

> "Sets/reinforces situational awareness to where storms will be developing soon… and areas one may need to watch in the future."
> *Forecaster, Post-Event Surveys*

> "There were a few really good examples of this algorithm giving 15 minutes to 1 hour of lead time to storm initiation."
> *Forecaster, Post-Event Surveys*

> It was very interesting in that it helped to tell you which areas not to focus on. Then I would go in and focus on areas with higher probs."
> *Forecaster,* "5/19/14 Daily Survey", *HWT GOES-R Blog*

> "A line of clouds formed in Nebraska. CI showed some higher probs on the northern end of the line, where storms would first initiate several scans later. Probs increased down the line before convection continued its development."
> *Forecaster,* "Week 1 Debrief", *HWT GOES-R Blog*

One situation in which the GOES-R CI algorithm provided a forecaster with substantial lead time to initiation occurred on May 14, 2014 in West Virginia. By 2015 UTC, an area of 51-85%

probabilities with no radar returns was evident in the region (Fig. 5). 45 minutes later at 2100 UTC, scattered to isolated storms had developed within the areas of higher probabilities. The forecaster noted that CI values over 50% would typically increase his confidence to the development of convection.

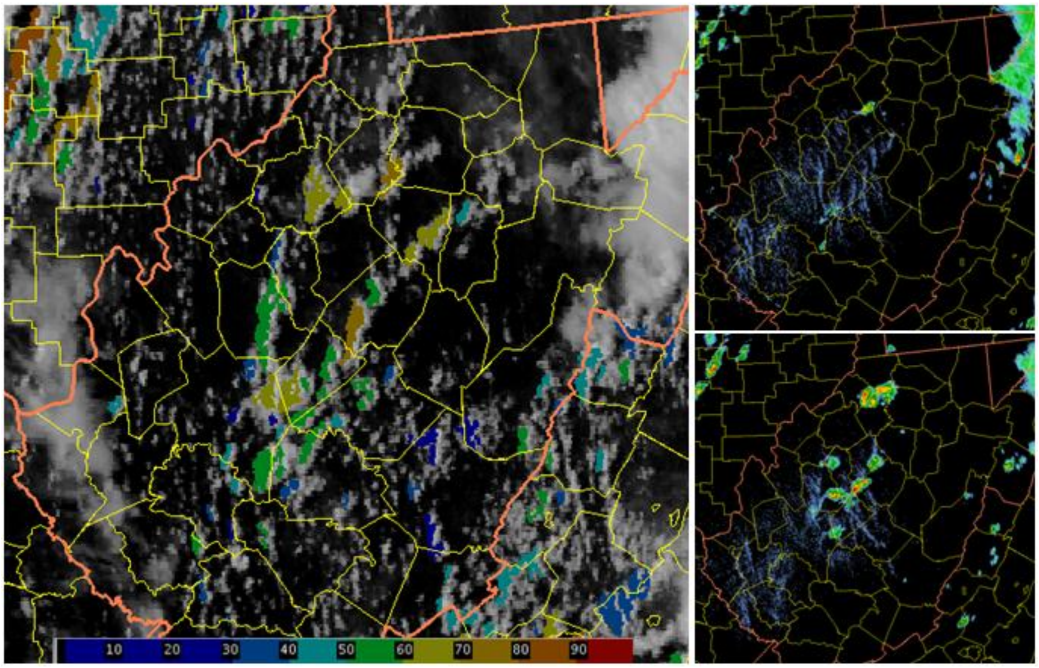

Figure 5: May 14, 2014 2100 UTC GOES-R CI, visible satellite imagery (left), 2100 UTC radar reflectivity (top right), 2145 UTC radar reflectivity (bottom right). From blog post "GOES-R Convection Initiation Nails Developing Storms in Wonderful West Virginia".

Participants speculated situations in which and users for whom the GOES-R CI algorithm might hold exceptional value. Broadly speaking, this included forecasters responsible for large forecast domains and broadcast meteorologists since the product helps to focus attention on areas of interest, especially during busy forecast situations.

> "I can see real use of this product in the area I work where sea breeze storms and convection firing west of DC and Baltimore is a concern."
> *Forecaster, Post-Event Surveys*

> "The best place for this product may be for a forecaster called on shift that needs to orient themselves to where convection will fire in a quick and dirty method with no pre-analysis time."
> *Forecaster, Post-Event Surveys*

> "Broadcaster world would very much use this – something that tells you where to pay attention is valuable. Every broadcaster would like to have the ci."
> *Forecaster,* "6/03/14 Daily Debrief", *HWT GOES-R Blog*

With the progression of each week as the forecasters gained experience with the product, they were able to calibrate themselves to the probabilities somewhat in the region of focus, allowing them to use the product more effectively. One week has proven to be enough time to collect general feedback on potential product utility in operations and suggestions for display. As is the case with most products under evaluations, however, more time with the product in their home forecast environment would allow the forecasters to make better/more informed assessment of the products accuracy/performance in a variety of weather situations.

> "One of those tools you have to use a lot to learn what regimes it's useful for, and not"
> *Forecaster,* "Week 1 Debrief", *HWT GOES-R Blog*
>
> "In WV I noticed persistent areas anywhere between 50 and 70 not convecting, 70 and above it did, that is the threshold I keyed on."
> *Forecaster,* "5/13/14 Daily Debrief", *HWT GOES-R Blog*

As in previous years, although many forecasters had positive thoughts regarding the CI algorithm, it just isn't quite yet ready for operations. The probability values were often inconsistent and noisy, especially at night, making it difficult for a forecaster to use the product with confidence. Much of the negative feedback may be due to the lack of time each participant has to calibrate themselves to the product and forecast domain. Additionally, participants didn't like seeing major differences between the GOES-East and West versions. There were certainly instances when the product did help to increase forecaster situational awareness and lead-time to convective initiation, typically up to one hour. Participants made a variety of suggestions for product visualization, often implementing changes themselves. Finally, broadcast meteorologists and forecasters responsible for large domains noted the particular value this product could provide to their offices.

3.4 Probability of Severe Model

University of Wisconsin/Cooperative Institute for Meteorological Satellite Studies (CIMSS)

New to the HWT this year was the NOAA/CIMSS ProbSevere model. This observation-driven statistical model produces a probability that a developing storm will first produce any severe weather in the next 60 minutes. The data fusion product merges NWP-based instability and shear parameters, satellite vertical growth and glaciation rates, and radar derived maximum expected size of hail (MESH). A developing storm is tracked in both satellite and radar imagery using an object-oriented approach. As the storm matures, the NWP information and satellite growth trends are passed to the overlapping radar objects. The product updates approximately every two minutes (with MRMS) and is displayed as contours colored by probability overlaid on radar imagery. Data readout is available by mousing over the probability contour, revealing the probability of severe along with the model predictor values. The main purpose of this demonstration was to determine if the ProbSevere model output could be used to increase confidence and/or lead-time for severe thunderstorm and/or tornado warning issuance. Additionally, feedback regarding the product display and readout was desired.

As convection began development each day, forecasters were quick to load the ProbSevere model, most often as an overlay on radar reflectivity. The vast majority of participants agreed that the model did indeed have a positive impact on their warning decision-making. It often pushed the forecaster in a particular direction when on the fence between issuing a warning or not. In fact, when asked if the ProbSevere model helped to increase their confidence in issuing severe thunderstorm (tornado) warnings, 78% of respondents answered “yes”. This was true for decisions to issue a warning and for the decisions to not issue a warning. Additionally, almost half of the respondents (47%) answered that the model increased lead-time to warning issuance.

> “It did help with confidence and prompted us to issue several warnings well ahead of the real WFO.”
> *Forecaster, Post-Event Surveys*

> “When [the probability] goes over 80% [I] had more confidence to issue a warning.”
> *Forecaster, Post-Event Surveys*

> “Low probabilities did help here and ultimately no warning was given.”
> *Forecaster, Post-Event Surveys*

> “This may be a very useful tool in more effectively separating marginal events from those that have a greater impact and giving us better confidence to warn on the higher impacts.”
> *Forecaster, Post-Event Surveys*

One example of the ProbSevere model providing increased lead time before the first occurrence of severe weather came in southeast South Dakota during the afternoon of May 8 (Fig. 6). In an environment characterized by ~1500 J/kg MUCAPE and ~50 kts EBShear, a cell had experienced strong satellite growth rates. The model first generated probabilities over 50% at 2006 UTC, when the storm reached 60%. Forecasters were advised to pay attention to the 50% threshold as cells that go beyond that value are more likely than not to become severe according to the model. The local WFO issued a severe thunderstorm warning at 2025 UTC when the ProbSevere value was 91%. One inch hail was reported with this storm at 2038 UTC, 32 minutes after the ProbSevere probability first exceeded 50%.

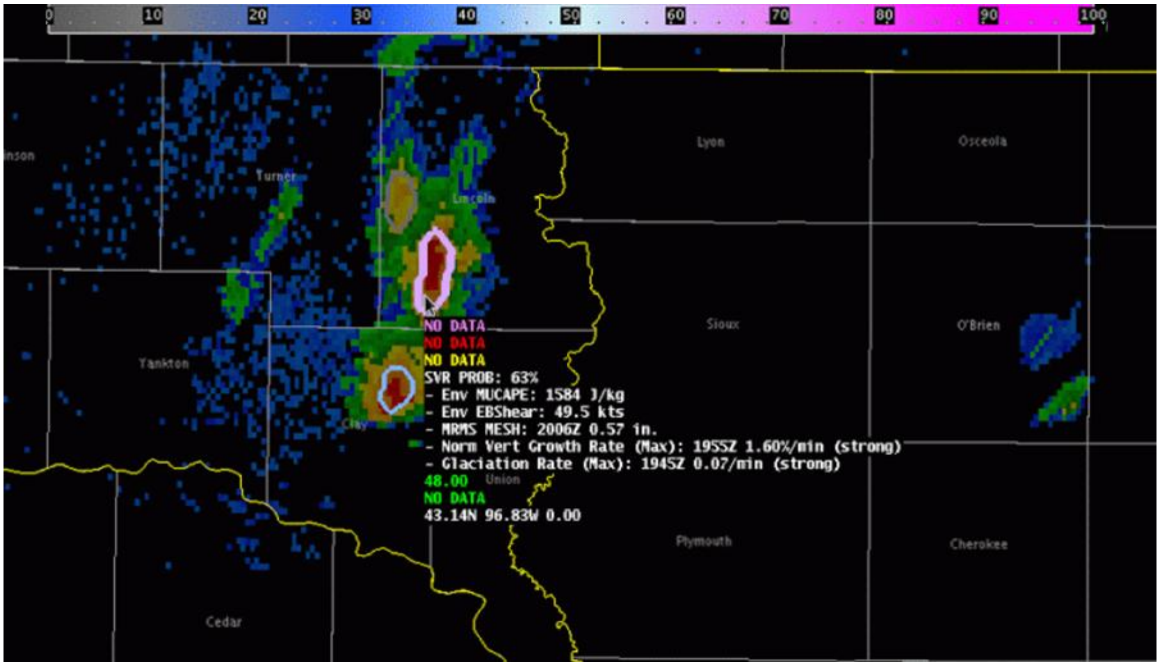

Figure 6: May 8, 2014 2006 UTC MRMS composite reflectivity and NOAA/CIMSS ProbSevere model probability contour and readout. From blog post "Storms develop further southwest along dryline".

At the very least, participants found the ProbSevere model to be a nice confirmation tool, and liked that it draws attention to storms that should be monitored more closely. This point was especially valuable in busy situations with multiple storms developing.

> "For situational awareness, if I'm on air, prob severe would be very helpful for me, especially if I am the only one in at the time. I can quick see prob severe on another cell, leading me to look at it."
> *Forecaster,* "6/03/14 Daily Debrief", *HWT GOES-R Blog*

> "It was useful in flagging areas where I should be looking. I would take a closer look at those storms with higher probs."
> *Forecaster,* "Week 2 Debrief", *HWT GOES-R Blog*

> "It is nice to be able to quickly show you what is happening with a storm or group of storms, especially when I was previously paying attention to some other, already active storms."
> *Forecaster,* "5/07/14 Daily Debrief", *HWT GOES-R Blog*

Forecasters found value in monitoring trends in the probabilities. For example, many noted that significant upward trends in probabilities would lead them to take a closer look at that storm, and possibly issue a warning. Several emphasized, however, the importance of seeing sustained high probabilities before issuing a more confident warning. Similarly, although the product provides probabilities that the storm will first produce severe weather in the next 60 minutes, forecasters did at times find it useful for monitoring convective maintenance and weakening (beyond 60 minutes). There were several cases when the decreasing trends in probabilities provided confidence in letting warnings expire.

> “When the probabilities trend higher more quickly, I’m more likely to jump the gun on a warning if on the fence about a decision.”
> *Forecaster, Post-Event Surveys*

> “The storm had a decreasing trend in the prob severe category. Its trend went from 35% to 11% in less than 20 min while storms just a county to the north had prob severe numbers over 90%. Based on this, we kept the newly issued SVR a county to the north.”
> *Forecaster,* “No warn – prob severe”, *HWT GOES-R Blog*

> “Watching trends in the probability of severe over northeast CO indicates a significant downward trend in prob severe with the long-lived storm that went through DEN. Provided confidence in letting the warnings expire.”
> *Forecaster,* “Prob Severe and Demise of Storms”, *HWT GOES-R Blog*

By the end of each week, participants had a good understanding of situations in which the product performed best, and when it was not as reliable. The probabilities seemed to be most accurate with discrete cells, when hail was the primary threat. The product performed comparatively poorly after storms became more organized (i.e., linear modes), and when the primary severe threat was wind (as was covered in the ProbSevere training material). Similarly, participants expressed concern about multicellular systems, as the probability with one cell would often “take over” or merge with that from a nearby cell. Finally, users found the model to be less valuable with very rapidly developing convection due to the 1-2 MRMS scan lag (2-4 min) in product availability.

> “It generally is most reliable on discrete cells, even after maturation.”
> *Forecaster, Post-Event Surveys*

> “Perhaps the prob severe tool is best utilized for severe hail and possibly tornados, but it definitely did a poor job with winds.”
> *Forecaster,* “Prob severe tool fail”, *HWT GOES-R Blog*

> “With rapidly developing convection, storms went severe within a few scans, prob severe lag kind of hurt it.”
> *Forecaster,* “6/04/14 Daily Debrief”, *HWT GOES-R Blog*

Throughout the experiment, participants provided their thoughts on how the algorithm might be improved. For one, 100% of survey respondents answered that probabilistic output by specific threat (e.g., tornado, hail, wind) would be useful. Many envisioned themselves using a 4 panel display showing probability of any severe, hail, wind, and tornado, each overlaid on a different radar field. Forecasters suggested potential input variables for each of the individual threats. For wind: downdraft CAPE, temperature-dewpoint depressions, storm motion, column velocity, low level relative humidity, and 0-3 km shear. For hail: areal extent of negative ZDR cores on 0.5 degrees, 700-500 mb lapse rates, CAPE in hail growth zone, and 500 mb temperatures. For tornadoes: 0-1 km storm relative helicity and bulk shear, mixed-layer lifting condensation level, and updraft helicity.

The display was one of the favorite aspects about the ProbSevere model, as 93% of respondents found the probability contours and readout to be unobtrusive and intuitive. The contour color scheme worked well for most participants, and the gradual increase in contour size with probability generally was also a positive. Many felt that this display was successful in drawing the user's attention to a particular cell, and most liked having the lower probabilities plotted because it was useful to see the progression. Participants really valued the ability to sample the contour for the exact probability as well as the predictor values. It provided a quick and easy way to get information about the storm and its surrounding environment, increasing situational awareness while informing the user of what is impacting the probability.

> "I think the display of the product is good in that it allows me to focus on a storm of interest without getting overloaded or bombarded with too much information."
> *Forecaster, Post-Event Surveys*

> "The best part for me was the mouseover sampling and being able to look at the predictors. It really enhances your situational awareness."
> *Forecaster,* "Week 2 Debrief", *HWT GOES-R Blog*

Forecasters provided many suggestions for how the ProbSevere display could be improved. Some tinkered with the color scheme, commenting that the gradients didn't stick out enough and the ~10% and ~40% probability colors appeared too similar. Several forecasters preferred the change in contour thickness (contours become thicker with increasing probability) to be more dramatic, while others felt the thickness change was not necessary.

> "It might be a good idea for the overlay to have a pixel or two worth of a black border on either side of the line. This would allow the overlay, particularly at medium or lower values, to stick out more."
> *Forecaster, Post-Event Surveys*

> "Display is fine, but individual elements [in the readout] could change color to highlight magnitude changes."
> *Forecaster, Post-Event Surveys*

> "Once it is mature or producing severe, maybe make it a different color or something."
> *Forecaster,* "06/03/14 Daily Debrief", *HWT GOES-R Blog*

Participants valued the inclusion of satellite growth rates as a predictor as there were many cases when the product highlighted storms before robust radar signatures were detected, especially in rapidly growing storms. One such case occurred on May 21, 2014 in central Illinois (Fig. 7). With favorable CAPE and shear present, strong satellite growth rates were observed by 1845 UTC leading to a probability of 45% at 1928 UTC that the storm would first produce severe in the next 60 minutes. At this time, however, radar signatures were still weak with only .06" MESH. The MESH jumped to .5" and the probability exceeded 90% at 1936 UTC, roughly 12 minutes before the first NWS warning was issued. One inch hail was first reported with this cell at 2020 UTC. The satellite growth rates signaled the development of strong convection prior to significant radar signatures, exhibiting the value of satellite information to this algorithm.

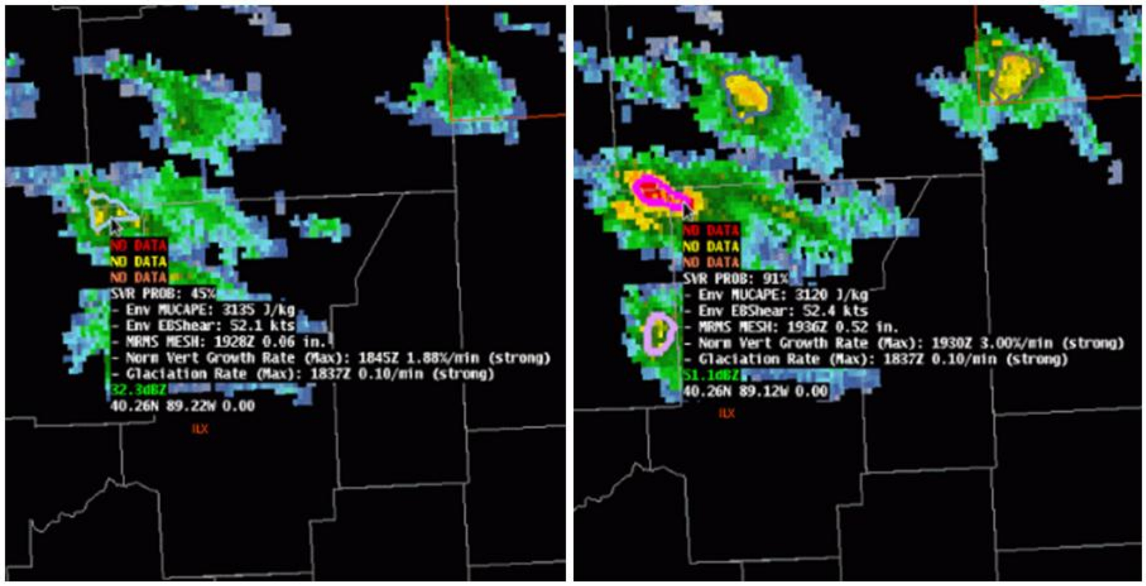

Figure 7: May 21, 2014 1928 UTC (left) and 1936 UTC (right) radar reflectivity and NOAA/CIMSS ProbSevere model. From blog post "ProbSevere in the Land of Lincoln".

In summary, participants really enjoyed evaluating the ProbSevere model, offering many suggestions for algorithm improvement and display enhancement. The product increased confidence and sometimes lead-time to warning issuance, and also identified which storms should be monitored or interrogated further. When asked if they would use the product during warning operations at their home WFO if available, 98% of respondents answered yes. Additionally, the broadcast meteorologists really appreciated that the product highlights the most threatening storms, as the busy broadcast environment often limits their ability to fully investigate the necessary meteorological data. It was apparent from this experiment that the ProbSevere model can have a positive impact on the forecast and warning decision-making of a variety of forecasters, and its continued development and improvement will certainly be appreciated.

3.5 Overshooting Top Detection

University of Wisconsin/Cooperative Institute for Meteorological Satellite Studies (CIMSS)

The OTD algorithm uses satellite-observed spatial gradients in the infrared window channel, GFS tropopause temperature, and satellite brightness temperature thresholds to identify and determine the magnitude of OTs. The product offers continuous day/night detection capability and can be produced where sufficient satellite coverage is available. OTs signifiy the presence of deep convection with an updraft strong enough to vertically penetrate the tropopause into the lower stratosphere. Convection with OT signatures is often associated with nearby hazardous weather conditions such as frequent lightning, heavy rainfall, and severe weather. The product provides a means for users to quickly identify OTs in animations of satellite imagery, which is especially important during busy nowcast situations. In response to Proving Ground feedback, the algorithm is currently being improved via GOES-R Risk Reduction, namely to incorporate more NWP and to eliminate fixed thresholds.

One of the main foci of this year's OTD demonstration was to evaluate the usefulness of trends in OTDs and their relationship to overall storm evolution. Feedback from SPC demonstrations has revealed that the presence of a persistent OT feature can signify an especially long-lived and potential hazardous weather-producing storm. Similarly, decreasing trends in previously persistent and abundant OTs may indicate the thunderstorm or convective system is weakening. Unfortunately, during the experiment's operation hours there were few instances of a mature convective system traversing its way near one of the CWA's, so the product was fairly difficult to evaluate in that manner.

> "We were unable to use it at night when it is harder to see OT's, and when many more OT's are often detected as storms have matured."
> *Forecaster,* "Week 2 Debrief", *HWT GOES-R Blog*

> "I didn't get to see if monitoring trends in OT's would be useful (we didn't work late enough shifts), but I think it could have utility in the weakening stages of convection."
> *Forecaster,* "Week 1 Debrief", *HWT GOES-R Blog*

Despite these limitations, there were still a few excellent examples of forecasters successfully using the product to monitor mature convective evolution. They used it to help identify where the strongest updrafts were moving, and to help identify cells that were experiencing weakening trends.

> "I liked looking at it for the overall trends. Cold pool developed that overran front, OT's went away, then storm weakened."
> *Forecaster,* "5/12/14 Daily Debrief", *HWT GOES-R Blog*

> "OT detection was associated with the strongest storm at the time."
> *Forecaster, Post-Event Surveys*

> "Decreasing trends did correspond to storm weakening."
> *Forecaster, Post-Event Surveys*

> "I think the most useful aspect of this is when the OT is no longer occurring, as that can be a little harder to detect than the initiation of an OT for an observer looking at satellite imagery."
> *Forecaster, Post-Event Surveys*

As expected, instances occurred where OTs suspected in the visible imagery (owing to visual identification of storm tops) were not detected by the algorithm. When missed detections were suspected, the HWT Satellite Liaison would sit down with the forecaster and interrogate the feature, revealing why it was not detected by the algorithm. The feature was either an OT that did not meet the brightness temperature thresholds of the algorithm, or was misclassified as an

OT by the forecaster. It became clear to forecasters how the higher spatial resolution of the GOES-R ABI will improve the OT algorithm's detection accuracy.

> "Missed a few that could be seen in 1km VIS but upon inspecting 4km IR we could see why."
> *Forecaster, Post-Event Surveys*

> "A must have for nighttime in GOES-R era with higher satellite resolution."
> *Forecaster, Post-Event Surveys*

Forecasters felt that this product in particular suffers from the current 15 minute scan intervals, and will have increased value with the more rapid imagery updates in the GOES-R era. With increased temporal resolution, trends in the OTs will become more valuable as misses between updates will decrease.

> "I think with 5 and 1 minute data, this would be more useful, especially at night."
> *Forecaster,* "6/3/14 Daily Debrief", *HWT GOES-R Blog*

> "One of the limitations was the 15-30 minute updates. It wasn't terribly useful in the hot seat."
> *Forecaster,* "Week 3 Debrief", *HWT GOES-R Blog*

As mentioned, in addition to severe weather, OTs are often associated with heavy rainfall, especially in areas of persistent OTDs. One example noted by a forecaster came during the day on May 21 in the northeast quarter of Colorado (Fig. 9). OTs were consistently detected in an area of almost stationary convection between 2100 and 2330 UTC. The forecaster mentioned that although the severe weather threat had diminished, OTs were still being detected with the storms, and "they could be significant rain producers and should continue to be monitored." Areas in the vicinity of the persistent OTs received in excess of 1.5 inches of rainfall.

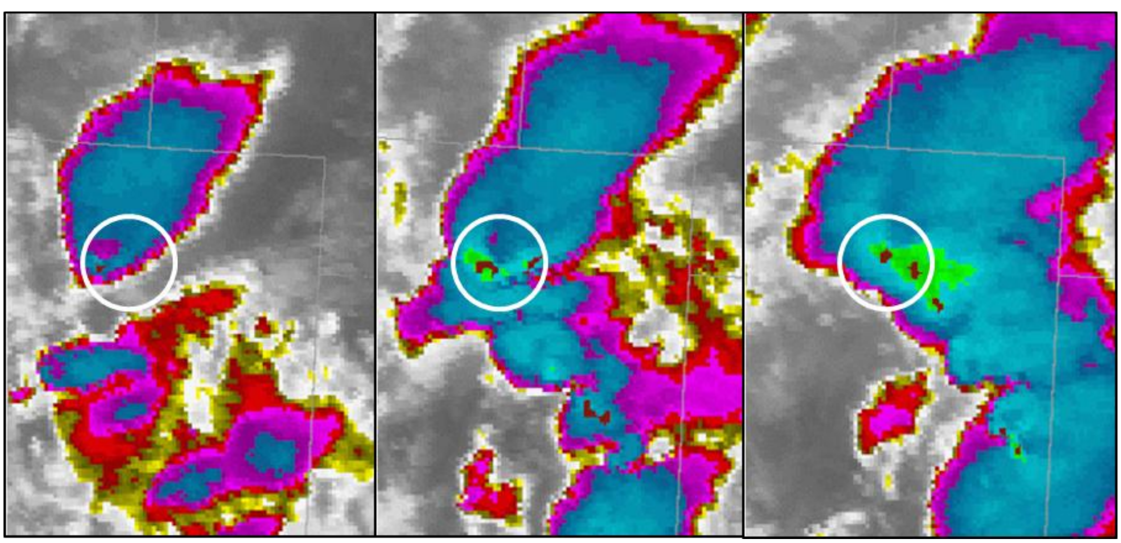

Figure 9: May 21, 2014 2130 UTC (left), 2230 UTC (middle), 2330 UTC (right) Overshooting Top Detection's (red fill) and GOES-East IR brightness temperature. Locations within white circle received over one inch of rainfall from these storms. From blog post "Over-Shooting Top and Heavy Rain".

Most participants agreed that the OTD product had utility in increasing situational awareness and confidence to where hazardous weather was likely occurring or would soon occur, sometimes confirming what they already knew. The display was non-obtrusive, and helped to draw the user's attention to noteworthy storms.

> "In WFO operations – it might be handy as a situational awareness product – such as monitoring storms that move into the area."
> *Forecaster, Post-Event Surveys*

> "I can see, with MCS's, this information being useful. You can see where stronger storms are in a complex, keying you in on those areas."
> *Forecaster,* "6/04/14 Daily Debrief", *HWT GOES-R Blog*

Finally, participants mentioned that the OTD product would likely have enhanced utility for agencies responsible for larger geographic forecast areas, such as NCEP National Centers and CWSU's, especially in regions where radar coverage is lacking. In the WFO, it would be most useful for a mesoscale analyst, and not so much the radar operator. Additionally, since broadcast meteorologists don't have as much time to interrogate meteorological data as an NWS forecaster, they agreed that this product would be especially useful to them for monitoring trends in potential hazardous weather occurrence.

> "Trends in overshooting top detection would be helpful for building and more specifically decaying storms so I could help my customers determine when they could safely fly in a certain area again after avoidance."
> *Forecaster, Post-Event Surveys*

> "Use will be primarily for the ocean areas. Aviation Weather Center convective SIGMETS may get help from this."
> *Forecaster, Post-Event Surveys*

> "In areas where radar coverage is a little more sparse or when a radar is down, I see more utility in helping to identify where the strongest updrafts are."
> *Forecaster,* "Week 1 Debrief", *HWT GOES-R Blog*

> "Really useful for me in busy environment. I can speak for every broadcaster, we'd all love to have this product."
> *Forecaster,* "Week 4 Debrief", *HWT GOES-R Blog*

To summarize, most of the negative feedback regarding this product stemmed from perceived OT missed detections. Training covered the concept behind the algorithm, and much time was spent during the experiment interrogating the IR imagery to understand why particular misses occurred. Forecasters understood that the accuracy and utility of this product will be enhanced with the higher spatial and temporal resolution of the GOES-R ABI. In future demonstrations of GOES-R algorithms, it should continue to be made clear that these are proxy products that will be enhanced by the increased capabilities of the GOES-R instruments. Forecasters felt that the OTD algorithm had its greatest utility in increasing situational awareness and confidence to where hazardous weather likely was or would be occurring. This is especially true at night when the absence of 1km visible imagery makes it difficult to quickly and correctly identify an OT feature. Additionally, they found that looking for trends in OTDs was a useful method for monitoring mature convective evolution and decay, even when visible imagery is available. This is an aspect that should be interrogated further, and highlighted in future demonstrations and training. Finally, many participants remarked that this tool would likely be most valuable to forecasters responsible for large geographic areas and who have less time to interrogate meteorological data. Feedback from the use of the OTD algorithm in SPC operations will be included in a future SPC-specific report.

3.6 GOES-14 Super Rapid Scan Operations for GOES-R 1-minute imagery

For the first time during a HWT Spring Experiment, GOES-14 was out of storage mode and able to provide SRSOR 1-min imagery. The daily-changing approximately 1500x2000 km sector of 1-minute imagery was available in AWIPS-II for EWP participants to view from May 8-24. Additionally, the EFP side of the HWT utilized the imagery in NAWIPS during daily operations. Feedback from the use of 1-minute imagery in SPC operations will be included in a future SPC-specific report.

GOES-14 SRSOR demonstrates a capability of the GOES-R ABI when in Mode 3 “flex mode” scan strategy, which will include 30 second imagery over one 1000x1000 km sector, or two 1000x1000 km sectors of 1-minute imagery. The 1000x1000 km refers to the size at the satellite sub-point. In addition to familiarizing users with a future ABI capability with respect to its temporal resolution, this evaluation sought to understand how 1-minute imagery might benefit users in operations. Acknowledging that 1-minute satellite data will likely play an important role as part of future data-fused products, this demonstration focused on the potential utility of the imagery itself in operational environments.

Similar to what has been experienced in previous demonstrations, forecasters quickly appreciated the benefit of 1-minute satellite imagery over current 5-30 minute imagery. After the initial excitement, participants consistently realized situations in which the 1-minute imagery itself has a positive impact on the forecaster decision-making process. When asked if 1-minute imagery provided additional value compared to 5- or 15- minute imagery, all respondents answered “Yes”. Some of the most commonly experienced improvements to forecaster situational awareness and nowcasting included: quicker and more confident identification of boundaries, improved lead time to confidence that convective initiation is occurring, more value in identifying overshooting tops and other cloud top features and their trends, and enhanced ability to differentiate between stronger and weaker updrafts.

> “It allowed you to see so much more structure/trends. You could easily see areas of subsidence as cu were squashed or boundaries where things were being enhanced.”
> *Forecaster, Post-Event Surveys*

"The 1-minute imagery showed quicker storm scale and cumulus evolution which increased lead time for convective initiation. Also, you could see boundaries on which storms developed much better."
Forecaster, Post-Event Surveys

"The addition of 1-min data is amazingly useful to warning operations. Being able to see convection develop and dissipate in near real-time is a great tool, especially as convective initiation is taking place."
Forecaster, Post-Event Surveys

"It is amazing to see how much is missed when only analyzing 15-minute data. If 1-min data was available all the time, I would definitely use satellite data more when diagnosing storms in normal operations back in my WFO.
Forecaster, Post-Event Surveys

"Around great lakes looking at advection fog, I wish we had 1 minute updates so we could see how much fog is spreading inland."
Forecaster, "5/12/14 Daily Debrief", *HWT GOES-R Blog*

"I was looking at a differential heating boundary. North had cirrus, south had a lot of bubbly. As soon as the cu moved into the cirrus, it died off. It is something that in 15 minute scans you just couldn't see."
Forecaster, "5/12/14 Daily Debrief", *HWT GOES-R Blog*

"I will prefer to view the raw data, but I do see it being useful as input into other products as well"
Forecaster, "Week 2 Debrief", *HWT GOES-R Blog*

"Being able to see individual convective attempts and failures is very useful. On radar I was not able to tell that the convective tower had failed, but with the [1-minute] visible imagery I was able to see that the tower had failed to mature and soon the radar echo dissipated."
Forecaster, "Watching Towers Grow", *HWT GOES-R Blog*

No major AWIPS-II performance issues were experienced when loading and viewing the 1-minute imagery. The only related concern was the 64 frame limit currently in AWIPS-II, as forecasters often wanted to view more than just one hour of imagery. It didn't take long for forecasters to appreciate the value that 1-minute satellite imagery adds to a variety of forecast situations, acknowledging the complete benefit would be discovered through longer-term use.

3.7 PGLM Total Lightning

NASA Short-term Prediction Research and Transition Center (SPoRT)

To help prepare users for the total lightning (in-cloud and the cloud-to-ground lightning) detection capability of the GOES-R Geostationary Lightning Mapper (GLM) instrument, a pseudo-GLM product has been developed which utilizes total lightning data from various Lightning Mapping Array (LMA) regional research networks around the US. Lightning channel VHF radiation sources detected by an LMA network are recombined into a flash extent density gridded field and remapped to the nominal 8 km x 8 km spatial resolution of the GLM. When an individual flash enters a grid box for the first time, the flash count of that box is increased by one. Subsequent channels of the same flash propagating through the same grid box are not counted so as not to overweight the grid by flashes having more sources detected and located (which varies with distance from the network center). The PGLM updates every 1-2 minutes, depending on the LMA. The products available to forecasters included the Flash Extent Density (FED), Flash Initiation Density (FID) and Maximum Flash Extent Density (MFED). The regional LMA's utilized in this year's experiment included: Oklahoma, Northern Alabama, Washington D.C., Colorado, and West Texas. With the PGLM being restricted to LMA regional domains, opportunities to evaluate it were limited, though participants across all weeks had at least some exposure to the data. In addition to familiarizing users with total lightning data, the all-important trends in total lightning and their relationship to storm evolution were evaluated.

In a testament to the training, almost 60% of respondents had "High" or "Very High" confidence in using the total lightning data throughout the experiment. This led to participants using the total lightning data effectively in experimental operations, as over 50% responded that it had a "High" or "Very High" impact for an event. Much of the positive impact was due to the high refresh rate of the product, often providing lead time over radar data to the initiation, strengthening, and dissipation of storms. Additionally, the total lightning magnitudes and trends were helpful in highlighting the most noteworthy storms in particularly complex radar situations. Finally, when comparing the PGLM to cloud-to-ground (CG) lightning data, forecasters appreciated that the total lightning data provides a significantly more complete picture of the lightning activity within a storm (Fig. 10).

> "Total Lightning was one of the first indications that these storms were really developing in North AL."
> *Forecaster, Post-Event Surveys*

> "Having the 1-minute total lightning data was very helpful in being able to see the response of a cell merger in [Lubbock] and gave a couple minutes more lead time to anticipate what was to come."
> *Forecaster, Post-Event Surveys*

> "Flash extent density displayed an increase in its value while the cell of interest still had relatively low reflectivities (<= 30 dBz). In the successive image of 0.5 km MSL composite merged reflectivity, a large increase in reflectivity was observed."
> *Forecaster,* "Flash Extent Density vs. Reflectivity", *HWT GOES-R Blog*

> "Total lightning towards the end of the day seemed to emphasize where the electrification in the storm was (something CG data sources do not show)."
> *Forecaster,* "5/19/14 Daily Debrief", *HWT GOES-R Blog*

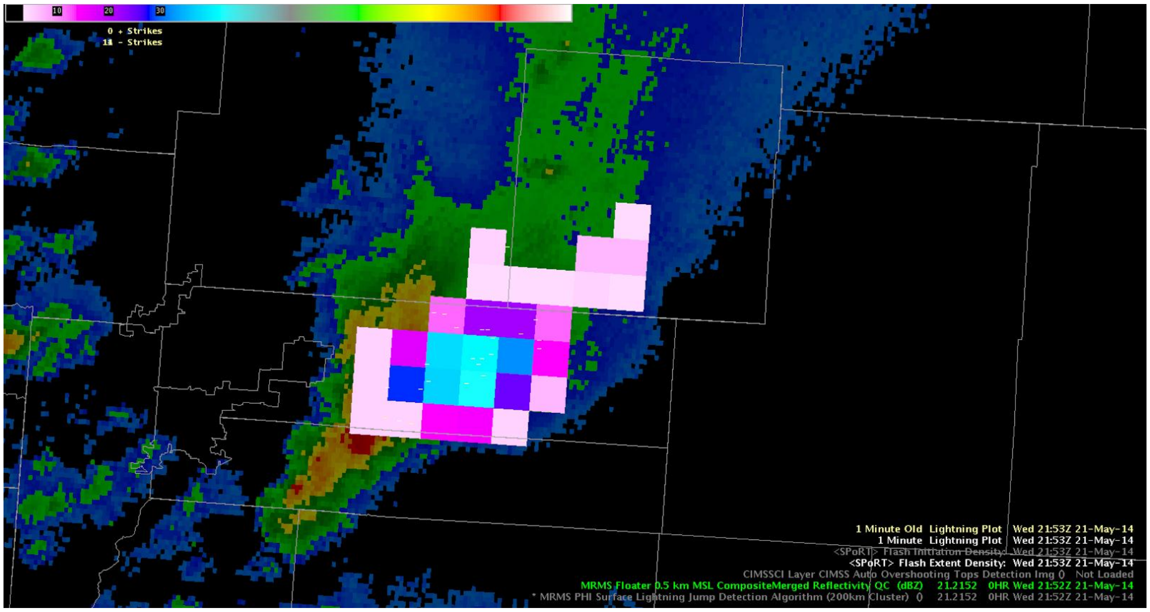

Figure 10: May 21, 2014 2152 MRMS composite reflectivity (underlay), PGLM total lightning FED (overlay), and National Lightning Detection Network (NLDN) CG strikes (minus signs). Note that the total lighting extends into the storm anvil, while CG strikes are concentrated within the highest reflectivity areas. From blog post "Anvil Flashes in PGLM".

The total lightning data, especially trends, often impacted the forecaster's warning decision-making process. This included increased lead time to and confidence in warning issuance. Broadcasters also expressed the benefits total lightning data will provide in their forecast environments, one noting "the chopper folks are constantly asking me where there is lightning to decide whether it is safe for them or not."

> "The lightning tools were helpful to identify storms that were likely to go severe and based on the trends in lightning, warning confidence was increased."
> *Forecaster, Post-Event Surveys*

> "I used the lightning tools as my main warning tool as they were extremely helpful in picking up on storms that went severe."
> *Forecaster, Post-Event Surveys*

> "I could see myself using it in warning operations, monitoring updraft health."
> *Forecaster*, "Week 3 Debrief", *HWT GOES-R Blog*

After using the PGLM total lightning products, participants often had recommendations for improvement to the display. While some users liked being able to interpolate the data in AWIPS-II, most preferred the standard gridded look. Many recommended a colormap different than the default AWIPS-II one, explaining that a broader color range would allow for quicker identification of significant trends/features in the fields. Forecasters requested the ability to color contour the lightning data, which would allow for a non-obtrusive overlay on other products such as radar and satellite imagery. Overall, forecasters appreciate the unique information total lightning data added to the forecast process, and look forward to its availability with GOES-R.

3.8 Lightning Jump Algorithm

University of Alabama at Huntsville and
University of Oklahoma/Cooperative Institute for Mesoscale Meteorological Studies and
NOAA/National Severe Storms Laboratory

In severe storms, rapid increases in lightning flash rate, or "lightning jumps", are coincident with pulses in the storm updraft. Earlier studies suggested the jumps typically precede severe weather, such as tornadoes, hail and straight line winds, at the surface by tens of minutes. The GOES-R GLM provides a general path to operations for the use of continuous total lightning observations and the lightning jump concept over a hemispheric domain. The operational implementation of the LJA pre-GLM in the 2014 HWT experiment was produced using LMA data and a merged radar data set over five locations: Washington D.C., central and northeastern Colorado, northern Alabama, Oklahoma and west Texas. The LJA used fully automated methods for storm cell identification, tracking, and lightning jump detection. Initial testing was completed in the HWT during the 2014 Spring Experiment to assess if the LJA had impact on situational awareness, diagnosing convective trends, and the short-term prediction of severe weather.

The initial visual implementation of the LJA was produced as a gridded storm object, colored by sigma (standard-deviation) level (Fig. 11). The colorization of the jump was based on a stoplight-scale: no jump was indicated by gray and moved from green for a 1-sigma jump through yellow to orange and red with increasing sigma levels. Initial feedback on the color scale was positive as the increasing intensity (i.e., higher sigma levels) corresponded with brighter colors commonly used to indicate severity of a storm. The LJA was provided to forecasters at two different scales to see if there was any utilization of the product for lines in addition to smaller storm objects. Scale 1 required storms were at least 200 km^2 in size, while the larger Scale 2 was 600 km^2. The smaller scale was more heavily utilized in operations, although forecasters did find utility in having access to both scales, particularly for comparative purposes.

On days of operations within one of the LMA domains, the LJA was heavily utilized in warning operations, usually in conjunction with local radar products. A couple of factors influenced the heavy use:

(1) Rapid Update – the 1-min update filled in gaps in both time and distance from the radar.
(2) Simplicity – the LJA display provided a view of rapid intensification in a way that was easy to integrate into the storm interrogation process and easy differentiate between storms.
(3) Correspondence with other metrics – multiple forecasters noted extra confidence in warning decisions with the LJA matching or preceding corresponding increases in radar intensity.

Almost all of the forecaster feedback regarding the LJA during the 2014 Spring Experiment was exceedingly positive. Forecasters that used the data found it useful for both situational awareness and warning decisions. However, there was limited frustration with cases that were on the boundaries of an LMA domain where detection efficiency was low or when working within environments that were not conducive for lightning. The other issue that caused some difficulty was time-matching the product within AWIPS-II as the LJA was most commonly used with radar data, which updated at approximately 4-5 min intervals compared to the 1-min LJA updates. Most commonly, the forecasters used the LJA in a four panel configuration combined with the pseudo-Geostationary Lightning Mapper flash extent density (1-min) product, and radar data, similar to Fig. 11.

> "When I saw the jump and maybe a couple scans in a row, I was confident to issue a severe t'storm warning. It also drew my eye to the storm in general!"
> *Forecaster, Post-Event Surveys*

> "The jumps were very helpful in identifying quickly intensifying storms. … it provided valuable information that, to my knowledge, is not displayed elsewhere."
> *Forecaster, Post-Event Surveys*

> "Effectively, looking at the sigma increase 3 to 4 was a reason for the warning decision along with the fact that the environment is favourable."
> *Forecaster,* "First warning of the day. Using lightning products", *HWT GOES-R Blog*

> "I really think this could be one of the most valuable tools in WFO operations. Once a jump - or more precisely a series of jumps occurred - there seem to be excellent correlation to an increase in storm intensity."
> *Forecaster, Post-Event Surveys*

Forecaster feedback through the blogs and surveys also provided some details regarding how the LJA may be improved before it is operational. Though it is likely the updates below will not all be completed prior to the second planned demonstration in 2015, work has already begun to address the following points:

(1) Inclusion of metadata similar to the mouse-over ability of the ProbSevere product. The ProbSevere product was also displayed to forecasters during the 2014 experiment (Fig. 11, bottom right panel) and featured sampling ability that provided details regarding the individual elements that comprised the algorithm-derived probabilities. The mouse over for the lightning jump should contain the current flash rate as well as the degree of jump in sigma.

(2) Combination with the ProbSevere product or similar. This type of product provides a vehicle to provide the forecaster information from satellite, lightning and radar as an all-in-one product. The advantage this provides is that it approaches a forecaster-over-the-loop product without becoming a "black box" as all the information that is part of the product is also provided as metadata. Initial discussions between scientists at OU/CIMMS and UW/CIMSS leading development of these algorithms began during the 2014 experiment after frequently noting these products in use next to each other by forecasters. However, it is unlikely that this will be ready for the 2015 experiment, since this element requires additional research and validation.

(3) CONUS-scale LJA detection utilizing Earth Networks (ENI) total lightning data. One of the repeated complaints during the 2014 experiment was the limited range of use of the algorithm. Initial investigation of substituting ENI is currently ongoing to determine if this could be a valid substitute within the LJA in the pre-GLM era.

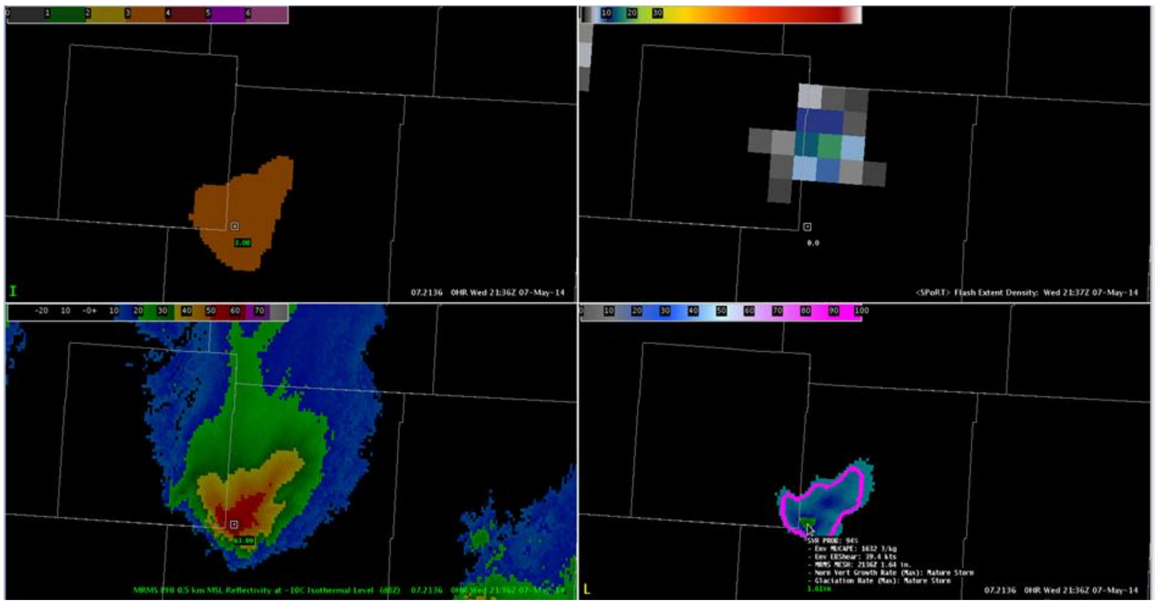

Figure 11: AWIPS-II screenshot from the 2014 Spring Experiment real time operations in the HWT on 7 May 2014 at 2136 UTC. Top Left: Representation of LJA, colored by sigma level – 3-sigma level shown. Top right: pseudo-GLM flash extent density. Bottom left: Reflectivity at -10 C. Bottom right: MESH and ProbSevere model (94%).

3.9 Total Lightning Tracking Tool

NASA Short-term Prediction Research and Transition Center (SPoRT) and Meteorological Development Lab (MDL)

The TLTT allows forecasters to manually generate an object oriented time series of PGLM total lightning products in real-time (akin to a phenomenon-based tracking meteogram). The product has received many updates since the 2013 experiment, including the capability to track fields other than total lightning such as satellite products, radar products, and NWP data. Under evaluation this year was the: timeliness for implementing the tool, effectiveness of the generated time series, ease of use, and the effectiveness of the tool on observations beyond the PGLM.

Forecasters generally appreciated the ability to visualize trends in various fields, and found the TLTT to be fairly intuitive when working correctly. They liked being able to track numerous storms at once, with the graphical interface allowing for simple comparisons of fields between storms. Participants also took advantage of the ability to track fields other than total lightning, often examining and comparing several fields with one storm. Particular fields tracked by forecasters in the HWT included PGLM total lightning products, LJA, radar reflectivity and velocity, dual pol products, and MRMS products. In fact, 86% of respondents who evaluated the tracking tool used it with radar fields. Over 60% of respondents found the tool to be "somewhat" or “very easy” to implement, while over 70% agreed the tracking tool had an effective (unobtrusive) AWIPS-II display.

Although most participants saw great potential in this tool, there were far too many technical issues holding it back from operational readiness. Using the product as they would in a normal operational environment, participants were easily frustrated as it constantly slowed or froze/crashed AWIPS-II (the tool used a lot of system memory), had meteograms multiply or disappear, and generally exhibited odd behavior. There were instances when data would not plot, even though it was available, causing gaps to appear in the graph. The TLTT was consistently poor with its first guess track, and at times users experienced temporal mismatches when tracking multiple fields. Many of the problems experienced were most apparent or enhanced when multiple fields and/or objects were being tracked at the same time, something participants wanted to do. The abundance of issues led many to believe the TLTT would not be useful in an operational environment in its current state, especially during critical warning operations.

> “There were some major issues with the meteogram including the meteogram going missing altogether, the timing not lining up on the two products analyzed, and constant internal errors that popped up.”
> *Forecaster, Post-Event Surveys*
>
> “Too clunky to use in a warning environment.”
> *Forecaster, Post-Event Surveys*
>
> “The tool kept popping up, even after it was closed. It got quite annoying after a while so I eventually just killed CAVE and restarted.”
> *Forecaster, Post-Event Surveys*
>
> “I loaded the base velocity product and then the meteogram program and it seemed to work well initially, but as the radar product updated the meteorgram split into two boxes, one for 8 bit and one that just indicated velocity. It later added a 3rd box that included 4-bit after the screen updated again.”
> *Forecaster,* “Three Meteogram Boxes One Product”, *HWT GOES-R Blog*

Even when the tool was working properly, participants generally did not believe they would use it during busy warning operations. This was in large part due to the manual nature of the tool and resulting length of time it takes to create a meteogram of significance. Rather, this tool might be more appropriate for a warning coordinator or mesoscale analyst, alerting radar operators to significant trends. Many more participants agreed that the product would have its greatest benefit after the event, for research purposes.

> “I don’t see much utility of this tool in WFO operations. It takes too long to place the “circle” where you want it. There just isn’t time during critical ops.”
> *Forecaster, Post-Event Surveys*
>
> “I can see this being used after the fact, looking at a storm, but not in real-time. It is too labor intensive.”

Forecaster, “Week 2 Debrief”, *HWT GOES-R Blog*

Throughout each week, participants suggested improvements to enhance the value of the tool. For example, additional products/fields they would like to have the ability to track include storm top convergence, gate-to-gate, max reflectivity in the column, and all tilts. The users much preferred having one tracking circle displayed as opposed to the “slinky” of circles for each time, which cluttered up the screen and were difficult to maneuver. They did not like that, for example, increasing the size of one circle would cause some to grow even larger and some to shrink, suggesting they all just change at the same rate. Other ideas to improve the tool itself include tracking a storm based on its cell ID number, hiding products on the meteogram that are hidden in the main display, and having the ability to bring back a graph that had been closed.

> “I would really like to be able to put in a freezing level height (or one derived from a model) and be able to track reflectivity above that level. This would be a good way to monitor hail cores, better than the current method of just tracking a storm at a particular slice.”
> *Forecaster,* “Tracking Tool Idea”, *HWT GOES-R Blog*

> “I think this tool would be much more effective if you could track things at certain elevations versus particular radar slices.”
> *Forecaster, Post-Event Surveys*

> “The meteogram takes up a lot of real-estate. It would be nice to have the option of bringing up the meteogram in a separate window.”
> *Forecaster,* “Week 1 Debrief”, *HWT GOES-R Blog*

Participants found the TLTT to have some operational value, mainly in non-busy forecast situations and in research environments for post-storm interrogation. A majority of participants found the visualization to be effective, and agreed that the tool was easy to implement when working correctly. Despite the general acceptance of the concept, the product’s true potential was held back by many bugs which made it very difficult to use consistently, almost impossible at times. Many suggestions were offered which could make the product more user-friendly and help to enhance its operational value. Feedback and information from a concurrent evaluation of the TLTT at NOAA’s Operation’s Proving Ground (OPG) in Kansas City, Missouri can be found in a separate write-up.

4. Summary and Conclusions

The GOES-R Proving Ground was a major component to the 2014 HWT-EWP Spring Experiment. Twelve NWS forecasters and four broadcast meteorologists evaluated up to nine GOES-R products and capabilities and interacted directly with algorithm developers during the four week experiment. With only two other projects under evaluation alongside GOES-R, participants had ample opportunity to evaluate, identify strengths and weaknesses, and suggest potential improvements for all of the tools. Participants provided copious amounts of product feedback in a multitude of ways, including daily surveys, daily debriefs, weekly debriefs, 358 blog posts, informal conversations in the HWT and the "Tales from the Testbed" webinars. This feedback included suggestions for improving the algorithms, ideas for making the displays more pleasing, best practices for product use, and situations in which the tools worked well and not so well.

Training, in the form of Articulate PowerPoint presentations for each product, was well received by participants. They were able to complete it before arriving in Norman, and felt prepared to use all of the products by the start of each week. The first half of each Monday was mostly spin-up, consisting of an overview of how the week would go, a brief tutorial of AWIPS-II, and informal one-on-one training between the developers/satellite liaison and participants. By the second half of each Monday, forecasters were comfortable with loading and using the demonstration products in AWIPS-II. At the suggestion of the week one participants, an information sheet highlighting each demonstration product, its location in AWIPS-II, and notable procedures was created for reference during experimental operations. This was well-received by the week 2-4 participants, and is recommended for future experiments.

For the first time, broadcast meteorologists participated in the EWP Spring Experiment alongside and to the same degree as the NWS forecasters. It was recommended they visit their local WFO for AWIPS familiarization before their arrival in Norman, with those doing so finding it to be quite beneficial. All broadcasters noted the most difficult part about the experiment was learning AWIPS-II on the fly, and recommended a longer "walkthrough" on Monday. The broadcasters were quick to develop needed AWIPS-II skills, however, and by mid-week were participating just as effectively as the NWS forecasters, providing an alternative perspective not heard in years past. The broadcast and NWS participants enjoyed working together during experimental operations, agreeing it was truly educational for both sides as they don't often get the opportunity to interact. The broadcasters expressed the desire to have most-to-all of the demonstration products in their station offices as they help to highlight areas and storms where hazardous weather is more likely to occur or already occurring.

As part of this year's Spring Experiment, we sought methods to more efficiently and effectively integrate new satellite-based products into the decision-making process of forecasters already saturated with an array of analysis and forecast tools. In particular, a fused convective product display was tested and evaluated by participants. The default 4-panel procedure developed for the experiment included the NearCast model theta-e difference field, GOES-R CI algorithm, OTD algorithm, and PGLM Total Lightning (Fig. 12). Additionally, visible and IR satellite imagery, surface observations, and CG lightning data were included in the display. Not only did this routine provide a rapid means of viewing multiple satellite products and other observational data simultaneously, but it also revealed to participants the enhanced value of the individual products when used together. During warning situations, participants loaded and viewed the 4-panel display on one workstation, while their other workstation was dedicated to radar-based products and warning issuance.

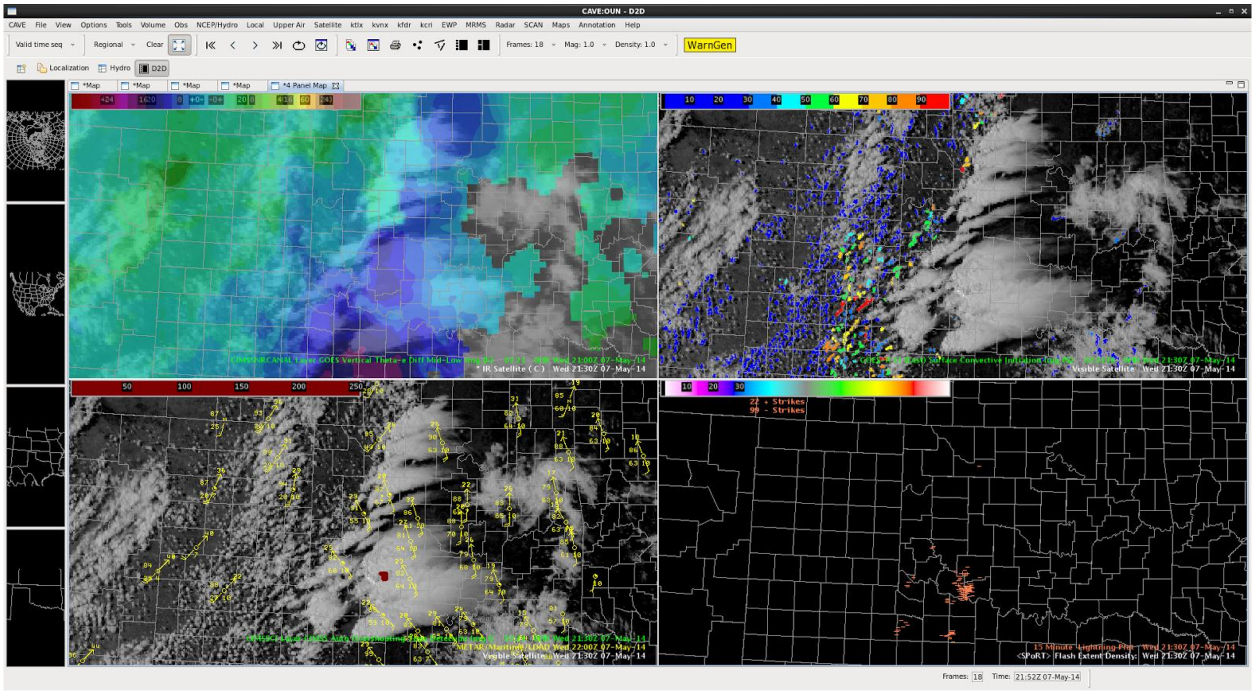

Figure 12: An example of the fused convective product display from May 07, 2014. Upper left: NearCast model theta-e difference analysis and GOES-East IR imagery. Upper right: GOES-R CI algorithm and GOES-East visible satellite imagery. Lower left: Overshooting Top Detection algorithm and GOES-East visible satellite imagery. Lower right: PGLM Total Lightning FED and NLDN CG lightning.

Introduced to the fused convective product display at the beginning of each week, the majority of forecasters quickly understood the value of viewing the products in unison, consistently using the 4-panel display during experimental operations throughout the week. Since each forecaster has a personal decision-making process, it came as no surprise that many modified versions of the display were developed and used. For example, the ProbSevere model (most often overlaid on MRMS products) and Lightning Jump algorithm were included in several versions. An abundance of blog entries were composed by participants interrogating the weather situation utilizing some variation of a combined product display.

> "Overall, I think this procedure will be of operational use, especially once GOES-R is actually launched and these products increase in overall utility."
> *Forecaster*, "On the Usefulness of the GOES-R Convective 4-Panel Procedure", *HWT GOES-R Blog*

There were many situations where forecasters experienced the value of using multiple demonstration and other observational products in tandem:

> "Overlaying the vertical theta-e difference [NearCast] with sfc obs really helps to identify and highlight boundaries and possible convective development. This in conjunction with a satellite image is a real good procedure for [situational awareness]. Adding the CI product further enhances the areas within the CU filed that may develop further."
> *Forecaster*, "More NearCast", *HWT GOES-R Blog*

> "As the storms began to break out, I used the prob severe tool in combination with the total lightning initiation and total lightning extent and lightning jump and based on how they all came together, I felt comfortable issuing the warning. About 15 minutes later, golf ball size hail was reported so with this particular t'storm these products did well together."
> *Forecaster*, "When I decided to issue a warning", *HWT GOES-R Blog*

Across all four weeks, participants found at least some operational utility in all of the GOES-R products demonstrated. They would like to see synthetic satellite imagery produced with other NWP models as it provides an alternative for visualizing model data and a method for quick model forecast evaluation. Participants had many suggestions for enhancing/improving the ProbSevere Model and LJA, including using the latter as a predictor in the former. Both the ProbSevere Model and total lightning data often provided increased lead time and confidence to warning issuance. Forecasters felt that the NearCast thermodynamic fields effectively filled a temporal and special gap that exists in observation-based vertical moisture information. While forecasters liked the idea of the CI algorithm and its performance at times, too often were the probabilities erratic and noisy to be used confidently in its current form. The present version of the TLTT had many limitations including apparent software bugs, and participants agreed it was too labor intensive to use in warning operations. Forecasters felt that the OTD algorithm would be most valuable to forecasters responsible for large forecast domains and ocean areas, but look forward to using it with the increased resolutions of the GOES-R ABI. Finally, participants experienced many examples where the 1-minute satellite imagery had a positive impact on their forecast decision-making process, and very much look forward to its future routine availability.

Overall, participants enjoyed their experience in the HWT, and felt that the experiment was very well organized. They found at least some utility in all of the products demonstrated, and look forward to seeing improvements in the future.

More detailed feedback and case examples from the 2014 EWP Spring Experiment in the HWT can be found on the GOES-R Proving Ground HWT blog at:
www.goesrhwt.blogspot.com

Archived weekly "Tales from the Testbed" webinars can be found at:
http://hwt.nssl.noaa.gov/ewp/

More information on SRSOR can be found at:
http://cimss.ssec.wisc.edu/goes/srsor2014/GOES-14_SRSOR.html