Aviation Weather Testbed – Final Evaluation

Project Title: 2013 Summer Experiment

Organization: NOAA's Aviation Weather Testbed (AWT)

Evaluator(s): Aviation Weather Center (AWC) forecasters, Central Weather Service Unit (CWSU) forecasters, Federal Aviation Administration (FAA) personnel, and general aviation personnel

Duration of Evaluation: 12 August 2013 – 23 August 2013

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

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1. Summary

The 3rd annual Summer Experiment at the Aviation Weather Testbed (AWT) in Kansas City, MO, took place from August 12-23, 2013, its purpose two-fold: (1) it provided a pre-operational environment in which to test and evaluate new GOES-R proxy products, and (2) it also aided in familiarizing forecasters with the capabilities of our next generation GOES satellite series. Participation throughout the two-week period included fourteen Aviation Weather Center (AWC) operational forecasters as well as forty-four external visitors representing organizations throughout the aviation community. The participants camefrom the Federal Aviation Administration (FAA) and other flight services companies including Lockheed Martin and the United Parcel Service (UPS), and research scientists from the Air Force Weather Agency (AFWA), the GOES-R program, Earth Networks, National Oceanic and Atmospheric Administration (NOAA) laboratories, and a number of universities. The following report details the activities and results of this demonstration.

2. Introduction

Similar to the 2013 Winter Experiment, the structure of this year's summer demonstration was focused around the forecast desks dealing with convective activity. These include World Area Forecast (WAF) desks on the international operations branch (IOB), the Convective SIGMET (CSIG) desk and the Collaborative Convective Forecast Product (CCFP) desks, as well as our National Aviation Meteorologist (NAM) desk on the domestic operations branch (DOB).

As the AWC is a global forecast center, the World Area Forecast desks are responsible for every corner of the globe and output a 24-hour forecast of convection, icing, and turbulence, as well as jets and tropopause heights. Flight planners, particularly those mapping flight routes over the oceans, use this information to find the safest and most cost efficient path for international flights. On the other hand, CSIG and CCFP are domestic products, with CSIG outlooks and SIGMETs for convection issued and/or updated every hour and 4, 6, and 8-hr CCFP forecasts of convective probability issued every 2 hours (Fig. 1).

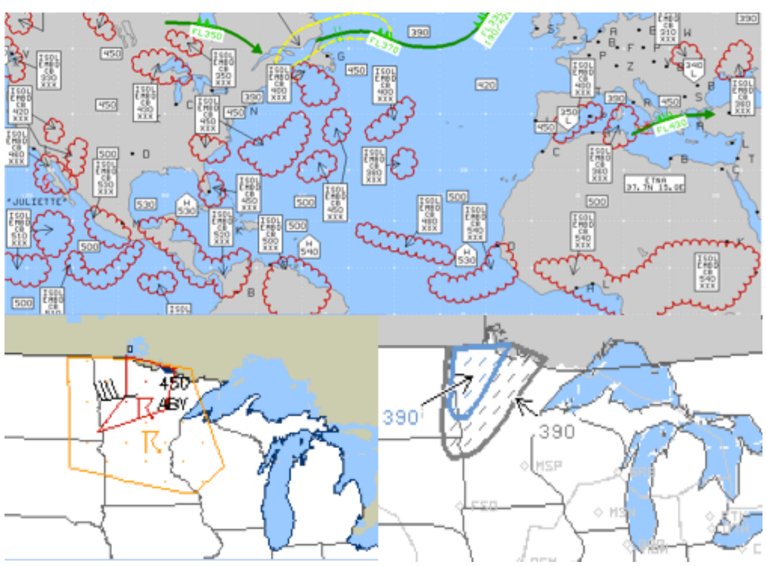


Figure 1. Global Graphics 12-hr forecast (top), CSIG outlook and SIGMETs (bottom left), and CCFP 6-hr forecast (bottom right). Red 'cotton balls' denote forecasted convection in the global graphics image. Yellow outlined boxes contain the CSIG outlook, with red boxes indicating active SIGMETs. Boxes in the CCFP forecast give convective coverage and probability as well as flight levels at which it is likely to occur.

The forecasters at the NAM desk, located in Warrenton, VA, within the Air Traffic Control Systems Command Center (ATCSCC, issue Aviation Weather Statements (AWS, Fig2) to update traffic flow managers on weather hazards expected to impact aviation operations in the short term. Convection, both scattered and widespread, is the primary cause of disruptions to centers and routes. Additionally, their focus remains on the busiest airspace and centers, typically found in the Golden Triangle region from New York to Chicago to Atlanta (Also Fig. 2).

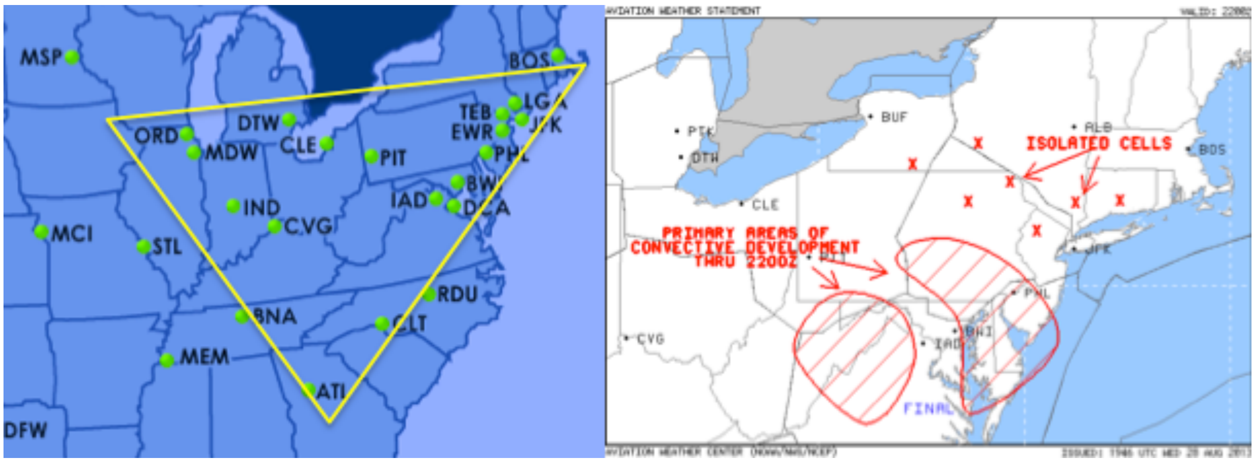


Figure 2. The 'Golden Triangle' region (left) and an experimental AWS issued August 28th for convection in the Northeast corridor (right).

Unlike the 2012 Summer Experiment, which consisted of four desks constructed around various new forecasting tools (i.e. high-resolution verification, GOES-R, etc.), the 2013 demonstration consisted of four ‘mock’ operational desks including a WAF Global Graphics (GG) desk, a CSIG desk, a CCFP desk, and a NAM desk. Additionally, a Situational Awareness desk was employed as a means for a more detailed evaluation of various products, both model and real-time (i.e. GOES-R and lightning datasets, etc.), that can be used to provide additional operational situational awareness. This desk was highly mobile, collaborating frequently with the other four desks while monitoring the onset, evolution, and cessation of convection.

Each day of the experiment began with a teleconference at 1315Z (815 CDT) with the ATCSCC in Warrenton, VA. These briefings with traffic flow managers at the command center, controllers from larger airports, and airline dispatchers fostered collaboration in communicating the current and expected weather and air traffic planning concerns (both near centers and enroute) for the day. Using these potential areas of interest as a focus point, participants at each desk went through their typical forecast procedures, issuing products utilizing both commonly used tools as well as the new datasets provided. Later in the afternoon, after the lunch period ‘brown bag’ seminars (given by experiment participants from GOES-R, NextGen, Earth Networks, etc.), participants returned to their desks, completing or updating their forecasts. The day concluded with an in depth summary and discussion of events from each desk including focus areas, ;, new datasets used, and how the datasets performed.

3. GOES-R Products Evaluated

A number of products were evaluated at the Summer Experiment and are listed below in Table 1. These products were chosen based on AWC needs and applicability for the time of year. Providers were the University of Wisconsin’s Cooperative Institute for Meteorological Satellite Studies (CIMSS), the Cooperative Institute for Research in the Atmosphere (CIRA), and NASA’s Short-term Prediction

Research and Transition Center (SPoRT). Baseline products, those products that are implemented as part of the GOES-R initial continuity operational product set, and Future Capabilities products, those that offer new capabilities made possible by ABI, were utilized in the experiment.

Synthetic model-derived decision aids used to show the capabilities of baseline cloud and moisture imagery included the NSSL-WRF and NAM Nest Simulated Satellite Forecasts. Other baseline products included the Pseudo Geostationary Lightning Mapper (PGLM) and the GLD360 Decision Aid used to demonstrate the baseline Lightning Detection capabilities, and the ACHA Cloud Height Algorithms. Future Capabilities products mainly encompassed those within the 'Convective Toolkit'; i.e. Cloud-top Cooling and Overshooting Top Detection, and the GOES-R Convective Initiation. Experimental Super Rapid Scan 1-minute imagery from GOES-14 was used to showcast the ABI 1-min rapid refresh mesoscale capability. Additionally, a 1-9 hour Nearcasting model was included as the only Risk Reduction product.

Table 1. GOES-R products demonstrated within the 2013 Summer Experiment

Demonstrated Product	Category
Simulated Cloud and Moisture imagery	Baseline
Nearcasting Model	Risk Reduction
Convective Initiation	Future Capability
Cloud Top Cooling/Overshooting Top Detection	Future Capability
Pseudo Geostationary Lightning Mapper	Baseline
GLD360 Lightning Stroke/Density	Baseline
GOES-14 Super Rapid Scan imagery	Baseline
ACHA Cloud Height Algorithms	Baseline
Category Definitions: **Baseline Products** - GOES-R products providing the initial operational implementation **Future Capabilities Products** - New capability made possible by ABI **Risk Reduction** – Research initiatives to develop new or enhanced GOES-R applications and explore possibilities for improving current products	

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

Various forecast fields are collected from the 00 UTC run of both the NSSL-WRF and the NAM Nest, including pressure, temperature, water vapor, heights, canopy temperature, cloud water, cloud ice, snow, graupel, and rain, all of which are processed as inputs for a radiative transfer model. Synthetic radiances and brightness temperatures are generated through this model and displayed as simulated satellite imagery meant to represent the capabilities of the Advanced Baseline Imagery (ABI) on GOES-R. Participants were provided with the NSSL-WRF simulated imagery of ABI bands 8-16, which a focus on the low through mid/high-level water vapor levels (bands 8 – 10; 6.19, 6.95, and 7.34 μm) and the clean infrared channel (band 14; 10.35 μm). Additionally, the mid-level water vapor (6.95) and clean infrared channels (10.35 μm) were provided from the NAM Nest.

Though the original intent of the simulated satellite imagery was to provide forecasters a first glimpse into the capabilities of the GOES-R ABI, it continues to also be a popular forecast tool. This can be attributed to its aesthetically pleasing appearance and the ease of use, as satellite imagery is something forecasters are accustomed to looking at on a daily basis. It was widely used during the Winter Experiment and was once again utilized at the Summer Experiment, though due to the unpredictable nature of convection, perhaps not relied upon as much. Additionally, the use of the product varied based on which product was being issued.

Given the global domain of the Global Graphics desk and the comparatively small domestic domain of the NSSL-WRF and NAM Nest models, participants at this desk did not use the Simulated Imagery, instead conveying their wish for a broader domain consisting of more oceanic regions. On the other hand, participants at both the CSIG and CCFP desk used the imagery frequently, most commonly at the beginning of each day, to gauge not only a possible time for convective initiation, but also convective behavior in the post-initiation stage (see Fig. 3 below).

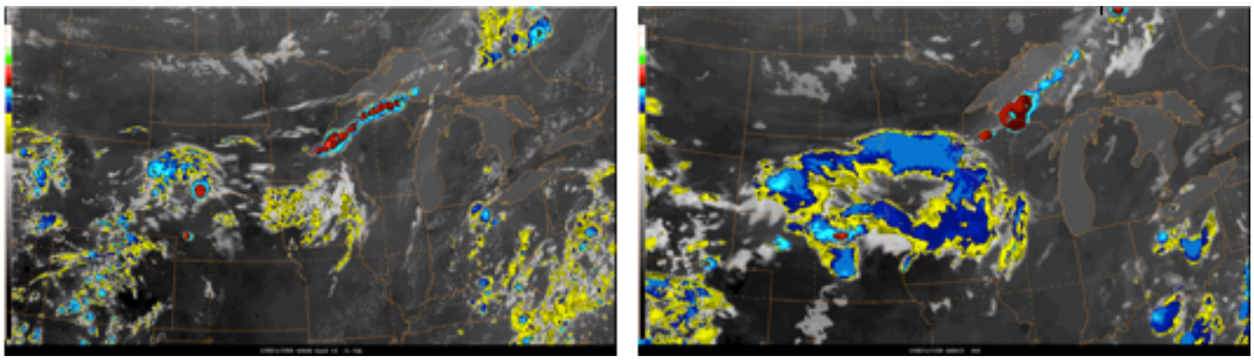


Figure 3. 20130821 2000 UTC WRF Simulated IR (left) and 2100 UTC NAM Nest Simulated IR (right). At the beginning of the day participants from both CSIG and CCFP used this imagery to increase their situational awareness, identifying potential areas of convective initiation near Minneapolis Center later in the afternoon and where they should consider issuing outlooks.

As each afternoon wore on, participants at these desks found themselves using the simulated imagery less and less, because as the convective activity increased, their focus shifted more to ongoing convection. In particular, CSIG is responsible for issuing and/or amending SIGMETs for ongoing convection over the entire CONUS, and for the demonstration also issued an experimental 2-hour outlook. Issuing these products each hour, especially on a busy weather day, leaves little time for looking at future potential convection. However, it was still very important at the beginning of the day as a situational awareness tool. Participants used this to familiarize themselves with the current ongoing weather and anticipated weather later in the day.

This imagery was also used at the NAM desk. As the NAMs are responsible for issuing an AWS for any impending weather that will impact major hubs or jet routes, it is important that they know when these weather issues will occur. For this reason, participants often consulted the Situational Awareness desk, sharing their areas of concern and using the simulated imagery to narrow down the time and coverage of the convection. In the case shown above in Figure 1, it was used to estimate the time of initiation near Minneapolis Center and subsequently when an AWS may need to be issued.

The simulated imagery is currently being provided via the LDM by UW CIMSS. Additionally, two bands are also being provided via ftp by CIRA. This imagery is received in AREA file format and made available for display in N-AWIPS. As of July 2013, this imagery is available in the AWT and also in AWC operations.

3.2 Nearcasting Model – University of Wisconsin's Cooperative Institute for Meteorological Satellite Studies

The NearCasting Model, provided by UW-CIMSS, integrates the hourly full-resolution (10-12 km) information from the 18-channel GOES sounder. Using a Lagrangian approach in which multi-layer moisture information is advected forward in time via RAP modeled wind, this 'model' generates 1-9 hour ‘nearcasts’ of atmospheric stability indices. These nearcasts were designed to fill the 1-9 hour information gap between long-range numerical forecasts and short-term radar forecasts, and enhance current NWP forecasts by successfully capturing characteristics (gradients, maxima, and minima) that will define the development of convective instability (or stability). The Lagrangian approach allows for this information to be provided several hours in advance, even after subsequent IR satellite observations have become cloud contaminated.

Within the NearCast suite are a number of products, each based on a particular parameter typically used in forecasting atmospheric instability (or stability). This year individual layers and layer differences of theta-e and precipitable water were demonstrated (Figure 4). Additionally, a number of improvements were made to the color enhancements, allowing for easier interpretation of the given values. These Nearcasting products generated via GOES-E were delivered to the AWT for last year’s Summer Experiment via the University of Wisconsin’s LDM and display via N-AWIPS

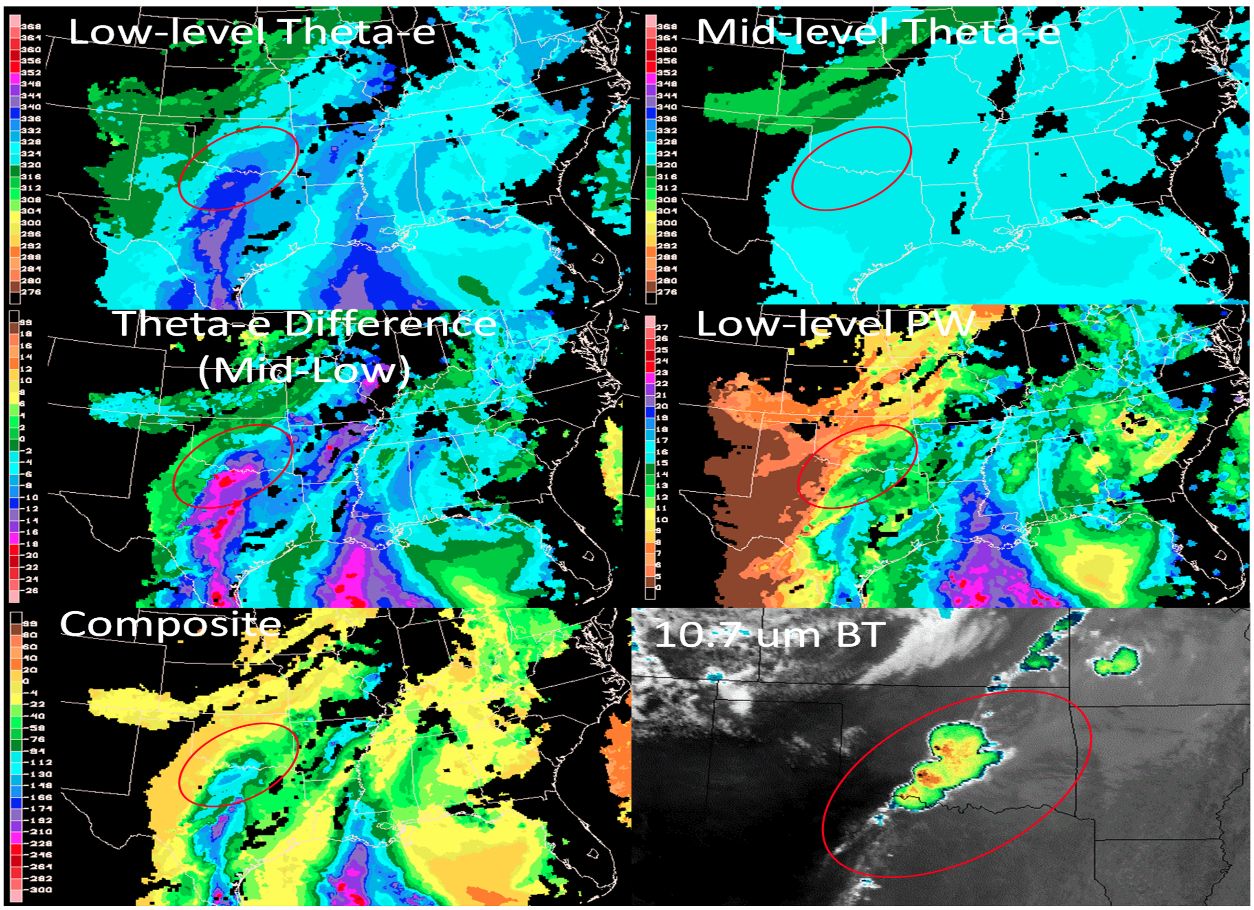


Figure 4. Sample of Nearcast Model parameters available for demonstration at the 2013 Summer Experiment

As with the simulated imagery, those at the Global Graphics desk chose not to utilize this imagery due to the limited CONUS domain. However, at the remaining three desks it was used to provide situational awareness for convective initiation and behavior later in the afternoon. This was of particular use over off shore regions where flight routes exist, but observations are much more sparse (Fig. 5).

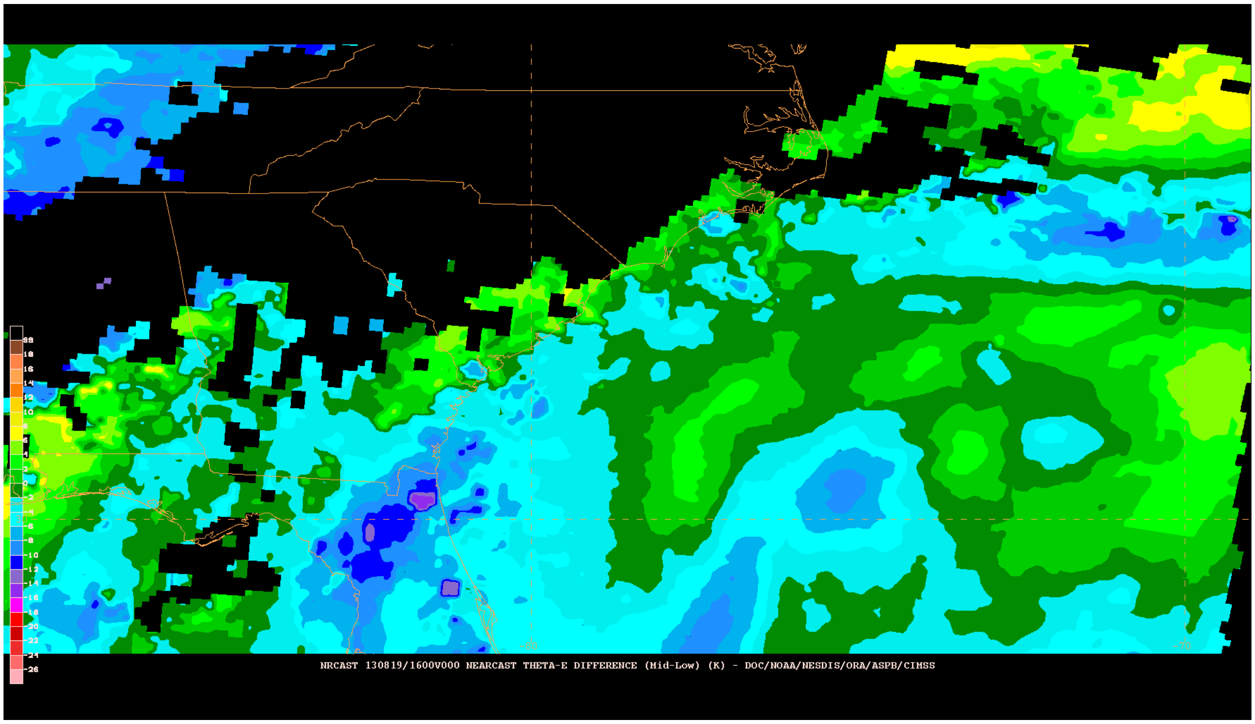


Figure 5. 20130819 1600 UTC Nearcast theta-e difference along the East Coast. Atlantic flight routes (AR routes) extended roughly from Wilmington, NC south to Miami, FL. Convection in these areas can result in flight diverts further off shore or back on shore. In this case, participants noted the stability over SC and instability over GA, inferring that convection along the existing outflow boundary would have less of a chance of firing north, but would likely occur and extend south through GA and into northern FL.

Most participants were attracted to the theta-e difference product as this variable is something familiar and often referred to in regular forecasting operations. They used this parameter not only to diagnose where convection initiation may be more likely to occur, given the presence of dry air overrunning lower level moisture (negative theta-e values), but also behavior of ongoing convection. In the case noted in Figure 5, there was ongoing convection present in Georgia, extending east through the Carolinas. An outflow boundary was generated by this activity, but given the mid-level stability (green and yellow colors), they were able to infer that there was a good chance any convective growth here would be inhibited. Given the lack of growth in the morning hours and subsequent clear skies, participants also chose to monitor that area for a higher likelihood of initiation along the sea breeze front later in the afternoon.

Like the simulated imagery, the Nearcast was generally used as a situational awareness tool at the beginning of the day. However, more often than not, it was also monitored throughout the remainder of the day for the potential effects on convective behavior. Additionally, it is important to note that it was not used as a standalone product. While the Nearcast provides valuable information on convective stability and/or instability, there will always be other environmental factors contributing to the initiation and evolution of convective initiation (Fig. 6).

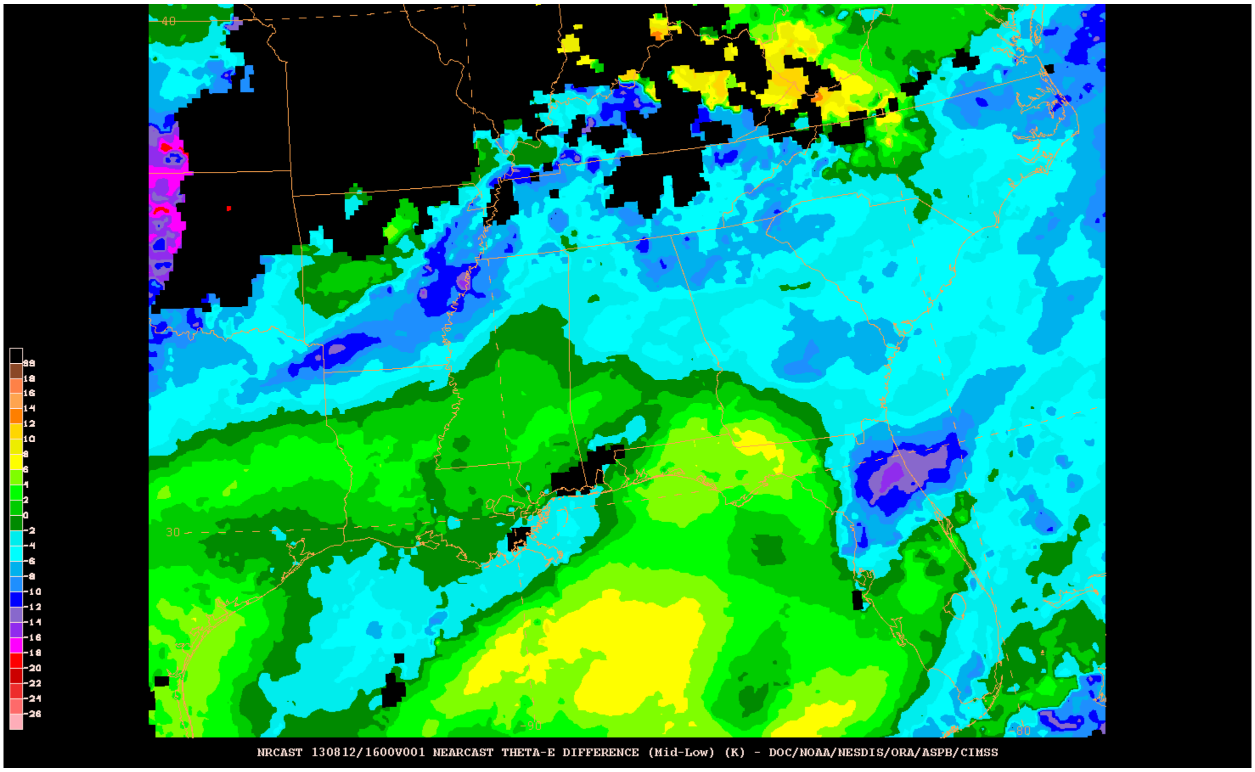


Figure 6. 20130812 1600 UTC theta-E difference. Note the area of instability in northern FL over Jacksonville Center. In this case convection did not initiation given a strong cap that held throughout the entire day.

In the case shown above in Figure 5, participants were monitoring an area in northern FL for potential impacts not only to the AR routes, but also to Jacksonville Center. However, while there was an area of fairly significant instability indicating a higher likelihood of initiation, the pre-existing cap was strong enough to inhibit any initiation and subsequently any products from being issued.

The Nearcasting model products are currently available within the AWT. However, while participants found these to be useful tools, plans for transitioning the products into operations have yet to be developed.

3.3 Convective Toolkit

3.3.1 GOES-R Convective Initiation – University of Alabama in Huntsville and NASA's Short-term Prediction Research and Transition Center

Last year's summer demonstration featured the University of Alabama's (UAH) SATellite Convection and Analysis Tracking (SATCAST) algorithm, which was based strictly on IR satellite interested fields (Walker et al. 2012). However, given the proving ground feedback to move away from satellite-only products and integrate model data, UAH, in a collaborative effort with NOAA's Earth System Research Laboratory (ESRL) and CIMSS, provided a fused approach in which 10 satellite interest fields defined by Mecikalski and Bedka (2006) and Walker et al. (2012) and Mecikalski et al. (2013) were combined with the Rapid Refresh (RAP) model. This newly developed GOES-R CI nowcasting algorithm in development, based on the heritage of the SATCAST approach, was provided for the AWT Summer Experiment. This product provides a probability of a cloud object achieving a 35 dBZ echo top height based on both satellite observations and 15 model fields (e.g. capping inversion strength, CAPE, precipitable water). Additionally, while last year's product was provided as a grid, the significantly slow loading time within N-AWIPS resulted in a switch to McIDAS AREA format, overlaying the product with visible and IR satellite imagery for both GOES-E and GOES-W (Fig. 7).

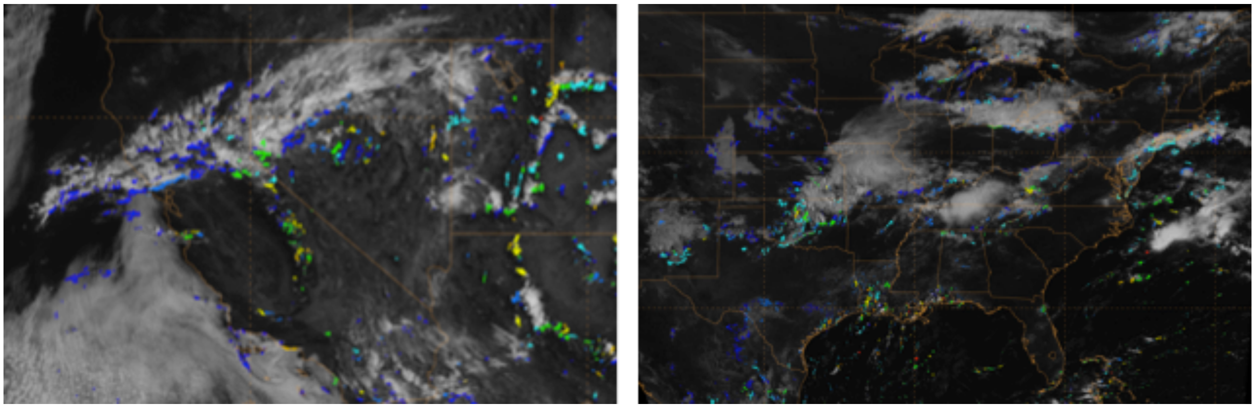
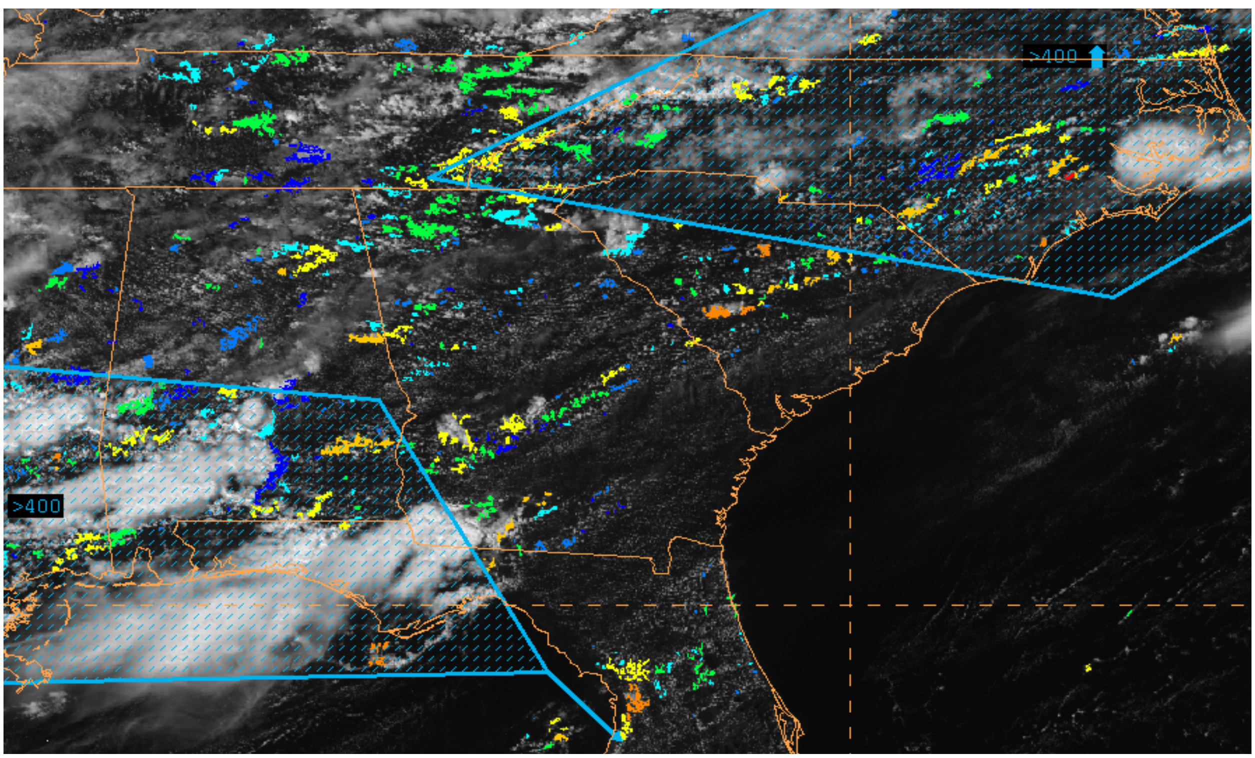


Figure 7. Samples of the GOES-W (left) and GOES-E (right) domains of the GOES-R Convective Initiation product

Given the difficulty with loading the product in N-AWIPS in the past, this product was not widely used amongst participants last year. However, with the new image format and much improved loading latency, as well as the new GOES-W domain (see Fig. 7), it was found to be of much more use and was widely used at this year's Summer Experiment.

The GOES-R CI nowcast product was utilized with particular interest at the CSIG desk. On the AWC operations floor this desk is responsible for issuing/amending Convective SIGMETs every hour, while also issuing an outlook. Participants within the summer demonstration issued these SIGMETs, while also constructing an experimental 2-hour outlook of convection. One example of its use in amending a CSIG is shown below in Figure 8.



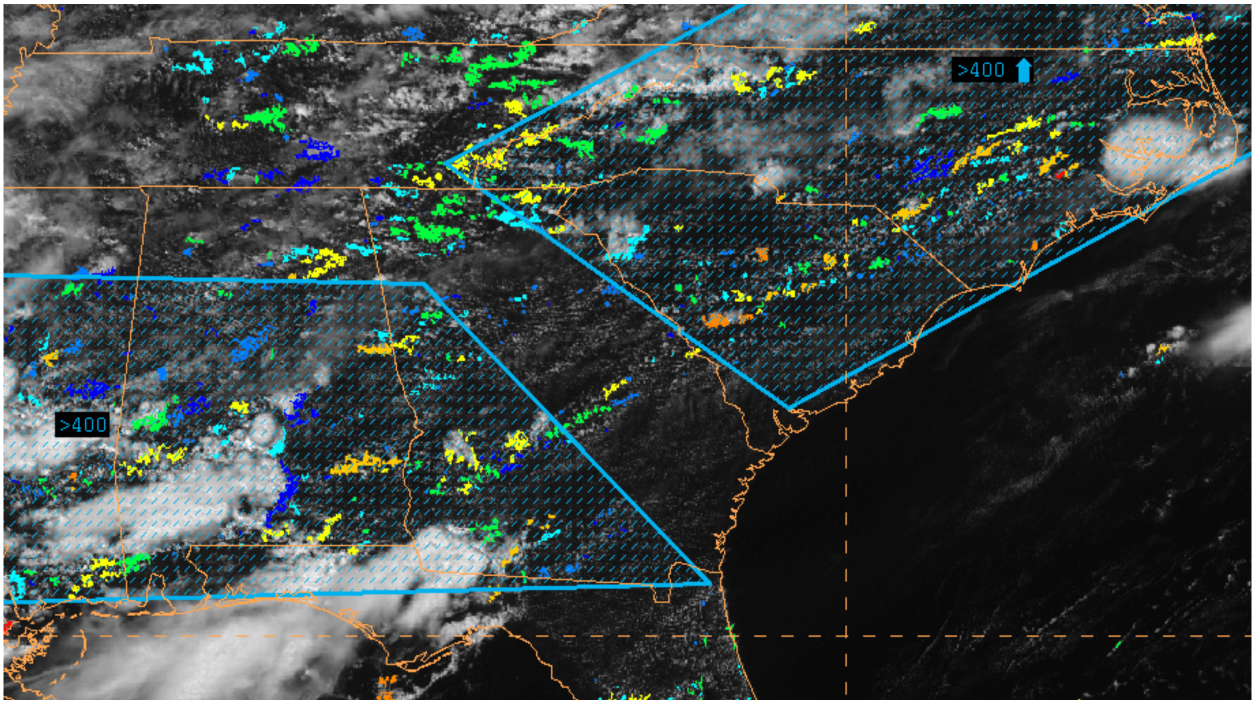


Figure 8. 20130813 1732 UTC CI with 1755 UTC (top) 2-hr outlooks and 1855 UTC (bottom) 2-hr outlooks. The 2-hr CSIG outlooks were amended based on consistently increasing probabilities seen the GOES-R CI in central SC and southwestern GA

In this case, the GOES-R CI was showing high probabilities (≥; shown in yellow and orange) in both central SC and southwestern GA. However, confidence was also increased as these probabilities consistently increased over consecutive satellite scans, leading participants to amend the next hour's outlook. Participants subsequently began using the CI differently, noting trends across a region instead of focusing on individual objects, was very important when utilizing the product from a National Center's perspective. The product has most often been used at the Hazardous Weather Testbed (HWT), where participants consist of NWS forecasters who are accustomed to working with the small domains of the County Warning Areas. However, at the AWC, and particularly for those at the CSIG desk, the forecast encompasses the entire CONUS area. Because of the increased workload inherent with issuing products for the entire CONUS domain, especially on convectively active days, forecasters are not afforded substantial time for an in depth analysis of what can be a very 'busy' product. As a result, they found their focus drawn to analyzing trends of signals over a broad area, as seeing signals rise from 50% (green) to 60% and higher (yellow, orange, and red) increased forecaster confidence in the growth, and subsequently the likelihood of thunderstorm initiation of particular areas of cloud objects. As shown below in Figure 9, this is especially useful when these areas are near major hubs and/or jet routes

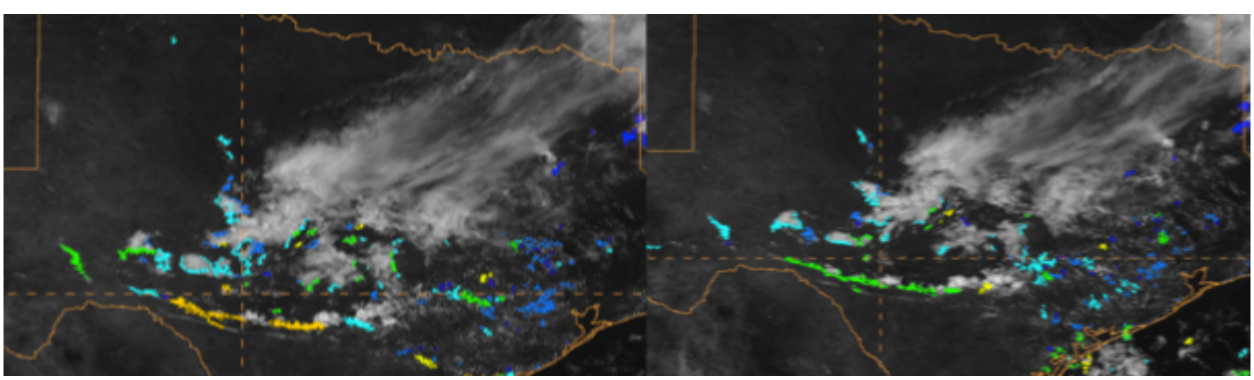


Figure 9. 20130816 1732 UTC (left) and 1745 (right) GOES-R CI. Note the decrease in probability over south central TX.

While this area was being monitored for potential activity over Fort Worth and Houston Centers associated with the outflow boundary of the existing convection, an outlook was not issued due in part to the decreasing trend in the GOES-R CI probabilities (note the decrease from orange to green in south central TX).

The trend of GOES-R CI was also used at the NAM desk in the issuance of the AWS, particularly in the construction of the product (i.e. how big the box should be). In Figure 10 below an example of a wider scale AWS over the southwestern Gulf state area is shown.

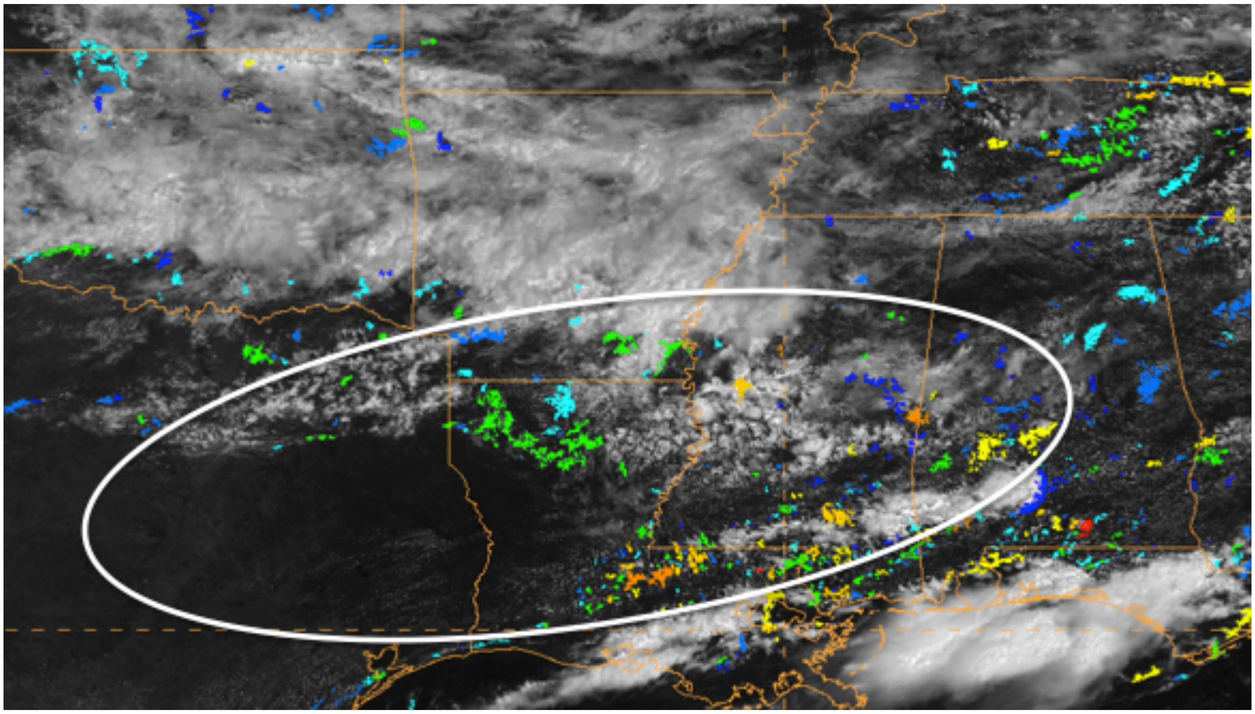


Figure 10. 20130813 1702 UTC GOES-R CI. Circled in white is the rough area over which an AWS was issued given the trend of increasing probabilities within the GOES-R CI.

The location and size of the AWS was of particular importance here as ongoing convection resulted in flight routes between Fort Worth and Houston Centers and the Atlanta Center being diverted into a corridor over northern LA and central MS. As the outflow boundary from the northern convection sagged south, GOES-R CI probabilities within this corridor began to increase, indicating a higher likelihood of initiation in this area. Because of this, an AWS was issued over the entire region, providing a heads up to traffic flow managers for potential traffic complications should initiation occur and the corridor fill in.

Overall participants responded very positively to the product. As with any satellite derived product it is not one to be used as a standalone, but as another tool within a forecaster's toolbox. Additionally, given the 'busy' display often associated with the product, particularly in a broad cloud field, participants noted that familiarizing themselves with the display, and subsequently knowing where it could be used within their forecast procedures was a bit more challenging. However, with proper training and a gradual transition into operations, this is a hurdle that can easily be overcome.

The GOES-R CI is currently available in the AWT and will be transitioned into AWC operations later this fall, accompanied by forecaster training.

3.3.2 Cloud-Top Cooling – University of Wisconsin's Cooperative Institute for Meteorological Satellite Studies

The University of Wisconsin's Cloud-Top Cooling (CTC) Algorithm was designed to provide a satellite-based tool for diagnosing convective cloud growth. Using IR brightness temperatures and AWG cloud phase information, the algorithm (Sieglaff et al. 2011) identifies immature convective clouds that are growing vertically, and hence cooling (K/15 minutes). Additionally, the UW-CTC utilizes GOES visible optical depth retrievals, which enables detection of growing convection beneath areas of thin cirrus clouds during daytime and allows for better detection of the strongest cooling rates with developing convection. This algorithm was developed as a future capability of GOES-R and is meant to take advantage of the 5-minute latency the ABI will provide. However, at the moment it utilizes the current GOES imager, which can impede the overall value of the product given the 15-minute (and longer during full disk mode) latency.

A GOES-W for the domain was added in the past calendar year, however a GOES-W domain for the product was added. This provided participants additional information over the western CONUS, particularly in the southwest where monsoon season was in full swing during the duration of the Summer Experiment. Additionally, it was of use in those areas, not only the west, but over the entire CONUS and offshore where radar data and observations are relatively sparse. Figure 11 shows a west coast example.

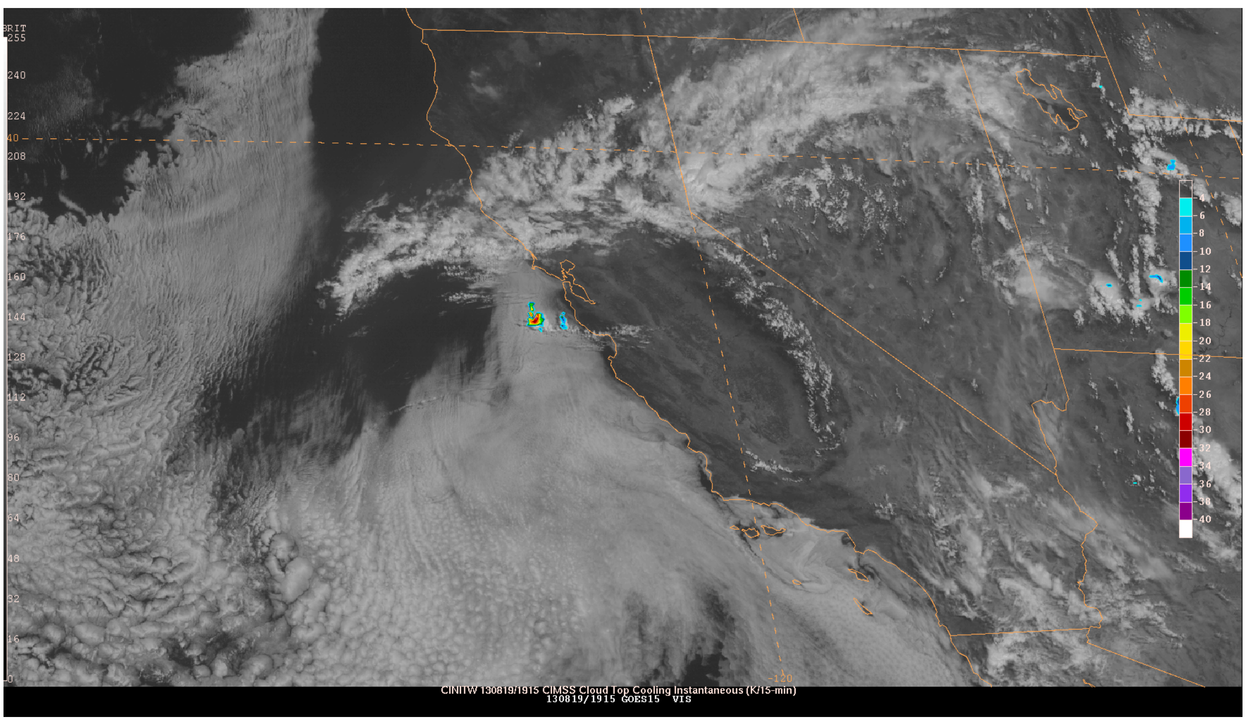


Figure 11. 20130819 1915 UTC Cloud Top Cooling. Note the strong cooling rate just southwest of San Francisco Center.

Convection is relatively rare off the West Coast, however in this particular instance an upper level low resulted in the initiation of convection just southwest of San Francisco Center. While there aren't many flight routes in the area and no CSIG was issued given the very limited coverage, several minor diverts were required both into and out of the center and the CTC was able to provide some lead-time to this initiation.

This lead-time is where participants at the CSIG desk, and especially the NAM desk, were able to utilize the CTC the most. As traffic flow management is an exercise in efficiency, getting aircraft into and out of centers as safely and as cost-effectively as possible, knowing exactly when a center will be affected by convection and how significant that effect may be is vitally important. For this reason, participants at the NAM desk found the CTC, and its ability to provide lead-time, extremely useful. This was noted one afternoon over Minneapolis Center (Fig. 12).

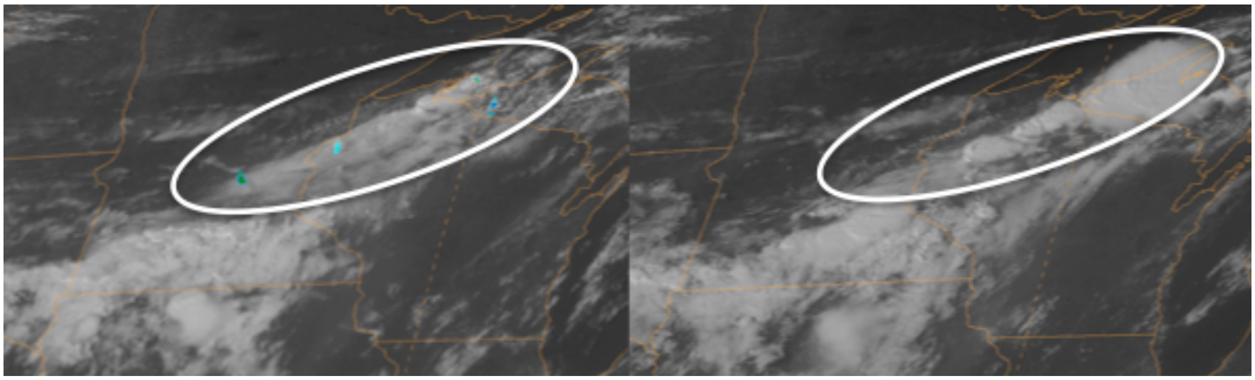


Figure 12. 20130821 1855 (left) and 2032 (right) UTC Cloud-Top Cooling and visible imagery over Minneapolis Center. Cooling signals were noted beginning at 1855 UTC but were generally north of the airport. Cells fired roughly 20 minutes later, remaining far enough away for traffic rates to remain near normal until after 2000 UTC.

The CTC was also found to be useful in distinguishing between weakly and rapidly developing convective cloud objects. By using the intensity of the cooling signals, whether strong (>-25K/15 min) or weak (<-10K/15min), or even absent all together, participants were able to gauge which cloud objects in particular may cause an issue. During one particular afternoon, participants at the NAM desk were monitoring an ongoing area of convection southeast of Houston Center as well as the potential for additional sea breeze convection. An AWS was issued, however, given the weak CTC signals, all of which were confined to southern LA, the statement suggested that no major convective activity should be anticipated (Fig. 13).

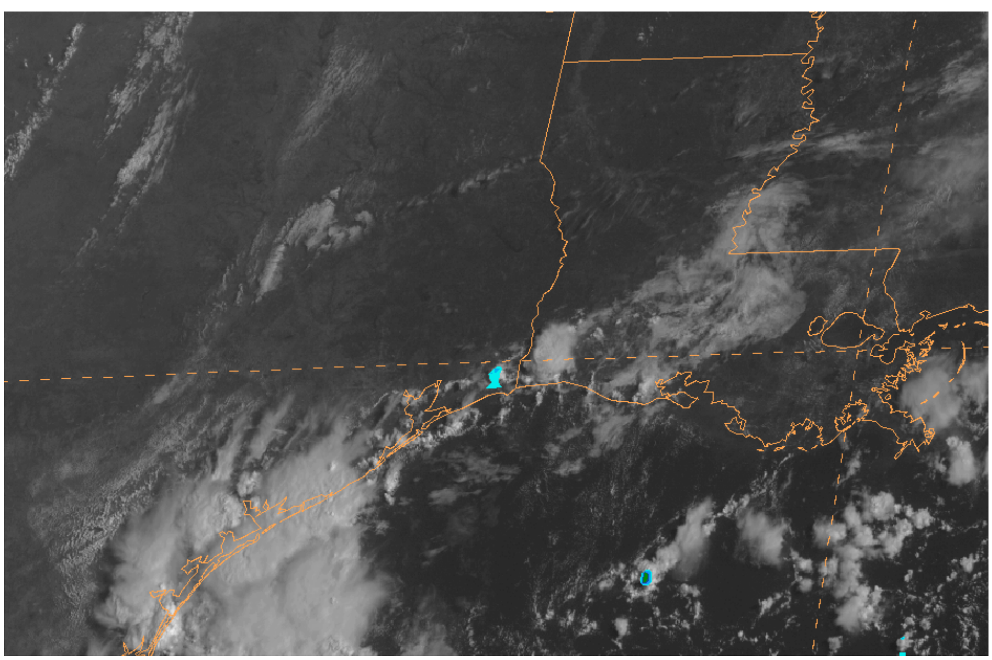


Figure 13. 20130820 1432 UTC Cloud-Top Cooling and visible imagery near Houston Center. Note the weak CTC signal in southeast LA, and the absence of any cooling signals along the coast of TX.

The CTC, as is quite often the case, was used in tandem with the GOES-R CI. As mentioned in the previous section, the CI provides a 0-2 hour nowcast of cloud objects that are or are not likely to initiate. Participants were able to use this information to pinpoint particular areas of interest and subsequently monitor those areas for the first CTC signals. Shown below in Figure 14 is the CI an hour before the first CTC signals occurred.

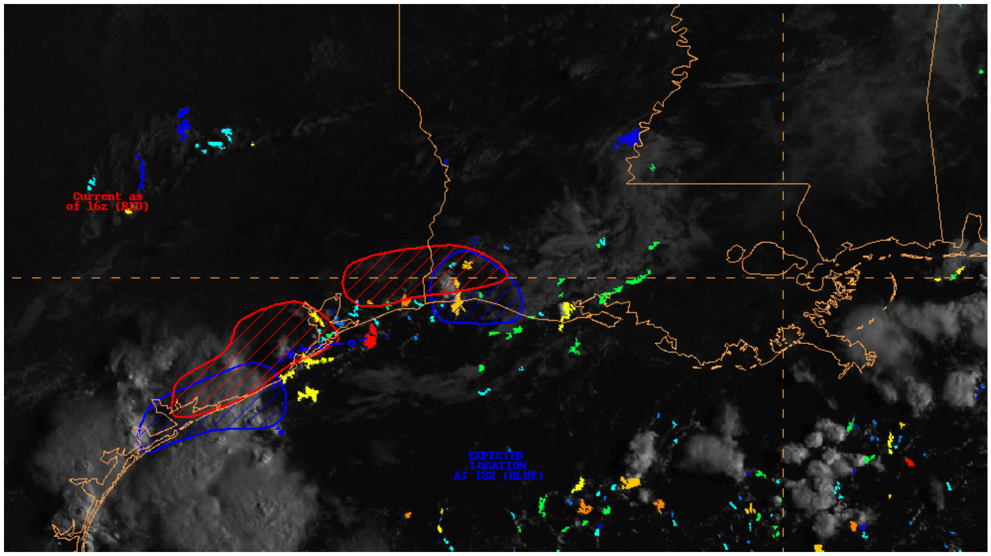


Figure 14. 20130820 1332 UTC GOES-R CI and the 1545 UTC AWS. An increasing trend in probabilities was noted along the TX and LA coast, and the first CTC signals further narrowed down particular issue areas, one in TX associated with the ongoing convection, and the other on the border of TX and LA associated with both higher CI probabilities and moderate CTC cooling signals.

Though the product did occasionally struggle with thick cirrus decks, participants were overall pleased with its performance. Again, the most utility was found in the lead-time and also over data sparse areas such as the mountainous areas in the Western CONUS domain and also off shore areas beyond radar range.

The CTC was transitioned into AWC operations in the fall of 2012 and the use of the product has continued to gradually increase within the past year.

3.3.3 Overshooting Top Detection – NASA Langley Research Center

The Overshooting Top Detection (OTD) algorithm (Bedka et al. 2010) was designed as a means to identify anomalously cold groups of cloud pixels within an anvil cloud that are associated with overshooting tops, and subsequently, very strong updrafts. It contains not only a simple binary yes/no detection but also a magnitude of the overshooting tops (Fig. 15). In the 2012 summer demonstration the focus was on the binary version and how it could be utilized in aviation operations. However, this year both versions were featured, with particular focus on the magnitude product, especially in data sparse areas.

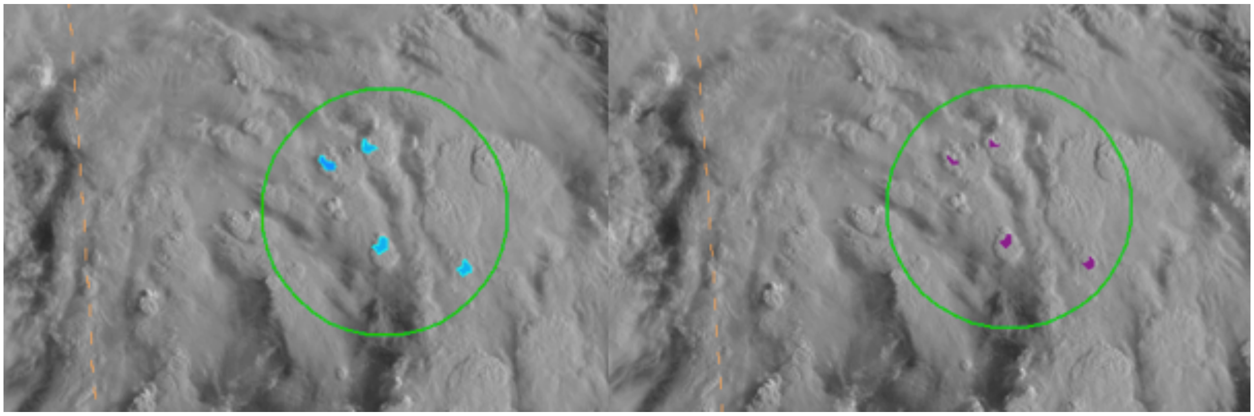


Figure 15. 20130829 1145 UTC OT magnitude (left) and binary detection (right)

There has been much debate over the utility of the OTD as traffic flow managers and aviation forecasters are generally very adept at identifying overshooting tops via visible satellite imagery and subsequently diverting airplanes accordingly. For this reason, it has been found to be of more use in broader areas of convection where there are many embedded cells and cloud cover may impede a visual assessment. In the above example the area of convection was out of radar range but many cells were noted. In the simple binary detection, no further details can be inferred; however the OT magnitude display indicated the northernmost cells to be the most intense. It is this information that could be of use to traffic flow managers, particularly if divert routes are limited and pilots must shoot the gap between convective cores. Knowing which is the most intense would allow for the safest rerouting possible.

Another use of the Overshooting Top detection was found in the Tropical Overshooting Top (TOT) product (Monette and Velden, 2012). A sister algorithm to the OTD, the TOT also provides an overshooting top magnitude, though identifies only the stronger of the features flagged by the Bedka et al. version. This algorithm was available not only for GOES-E and GOES-W, but also for Meteosat, as the expanded domain allowed for those at the Global Graphics desk to utilize this data (Fig. 16).

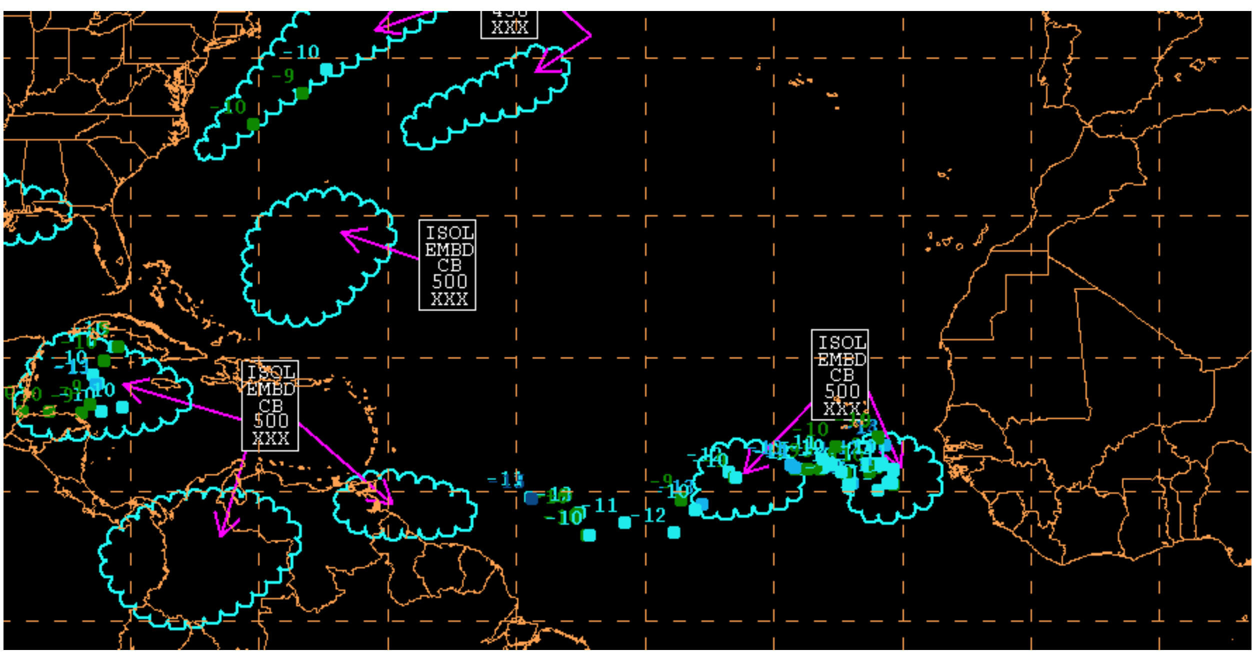


Figure 16. 20130814 12Z Global Graphic convection forecast and validation using 12Z Tropcial Overshooting Tops. Greens indicated weaker OTs while light and dark blues indicate stronger OTs.

At the Global Graphics desk participants issue a 12-hour forecast of, among other things, convection. However, validating these forecasts a day later is nearly impossible given the lack of observations over the oceanic areas. The ground-based global lightning datasets can be used to some extent, but with lower detection efficiencies over water, the reliability can be questionable. For this reason participants utilized the TOTs as an additional means to validate their convection forecasts, many mentioning their wish for TOT detection across the entire globe.

The OTD and TOT detection products are available in the AWT for display in N-AWIPS. Additionally, the OT detection version of the algorithm was transitioned onto the operations floor last fall along with the CTC. It is anticipated that this will be updated to include the magnitude of both the OTD and TOT in the near future.

3.4 Lightning Detection

3.4.1 Pseudo Geostationary Lightning Mapper - NASA's Short Term Prediction Research and Transition Center

In an effort to create a proxy dataset to represent total lightning data from the Geostationary Lightning Mapper (GLM; Goodman et al. 2013), the Lightning Mapper Array (LMA) networks were utilized as a pseudo-GLM (PGLM) product. The PGLM is generated from seven LMA networks: Northern Colorado, New Mexico Tech, West Texas, Oklahoma (central and southwest), Houston, TX, Northern Alabama, and Washington DC. Before being translated into an AREA file and ingested into N-AWIPS, VHF data from these networks is sorted into flashes and an estimated lightning density within a 8x8-km grid box is given to match the expected GOES-R GLM resolution. For the AWT Summer Experiment, a 2-minute flash density was utilized.

The unveiling of the PGLM in the 2012 summer demonstration was slightly impeded by its late arrival and various processing issues in the remaining days during which it was available; however, since then much improvement has been made. It has undergone several successions of color bars, now featuring one that provides more in depth detail of lower flash values as well as more obvious transitions or increases in flash density. Also, a status bar has been added for each network. This came about from the 2013 Spring Experiment at the HWT, where it was noted that there are times during which all the sensors in a network may not be active, resulting in lower flash values and possibly an erroneous representation of a lightning jump. The status bars will change from green to yellow to red if the number of sensors drops below an ideal value (which varies based on network) or if the data from a network is old (Fig. 17).

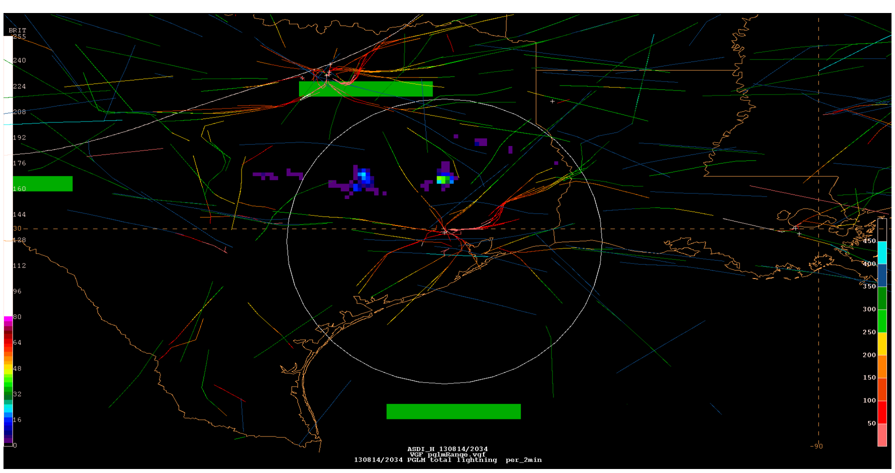


Figure 17. A sample of the improved PGLM flash density display and new status bar feature over Houston Center, overlaid with the Aircraft Situation to Display (ASDI) flight tracking data.

Forecasters are very eager for the arrival of the GLM, not only for forecasting convection over the CONUS, but also, and perhaps more so, for the forecasting and validation of convection within broader, global GLM domain. Seeing this experimental product within the summer demonstration allowed them a pre-launch glimpse into GLM-like data. However, the challenge inherent with evaluated a product limited to an LMA network were quite notable.

Participants at the CSIG and NAM desks utilized this data, particularly its total lightning capability, in identifying areas of convection that, while not appearing that impressive on radar, contained high or rapidly increasing lightning densities. This was of particular use to the NAMs, who can advise traffic flow managers on potential issues with divert routes, especially when a pilot must shoot the gap between storms and may need to stray closer to one cell in an area of embedded convection. However, as mentioned, the use was limited given the LMA domains. The NAMs main focus is on major flight routes and hubs, which generally encompasses the DC network, to a lesser extent, the Houston network, and perhaps northern Colorado as it contains Denver. However, during the few cases in which convection occurred within the networks, participants were pleased with the result, particularly when viewing the total lightning data in conjunction with radar imagery. This allowed them to conceptualize the future use of GLM observations in regions where radars may not be available.

Those at the global graphics desk would have loved to test a GLM proxy product for their forecasts, as lightning is one of the main ways in which they product and validate their products. However, again, the limited domain of the LMA networks, constrained to the CONUS domain, had them focusing on other global lightning datasets (GLD and Earth Networks).

Again, overall forecasters are very much looking forward to the arrival of the GLM data and are pleased with the PGLM. The only drawback in an evaluation from a National Center's perspective is the limited domain associated with the LMA networks.

The PGLM is currently available in the AWT and a transition into operations is expected by the end of September 2013.

3.4.2 GLD360 Lightning Stroke Density – NOAA's Aviation Weather Center

Gridded Lightning Density (GLD) data, provided courtesy of Vaisala, was made available to the Aviation Weather Center earlier this summer in a point data format. In an effort to create a dataset that provided more information than simply stroke data, the AWRP meteorologist at the AWC designed a gridded lightning density display, providing a 10-minute average of lightning stroke density every 5 minutes. Shown below in Figure 18 is the GLD stroke display as well as the GLD stroke density.

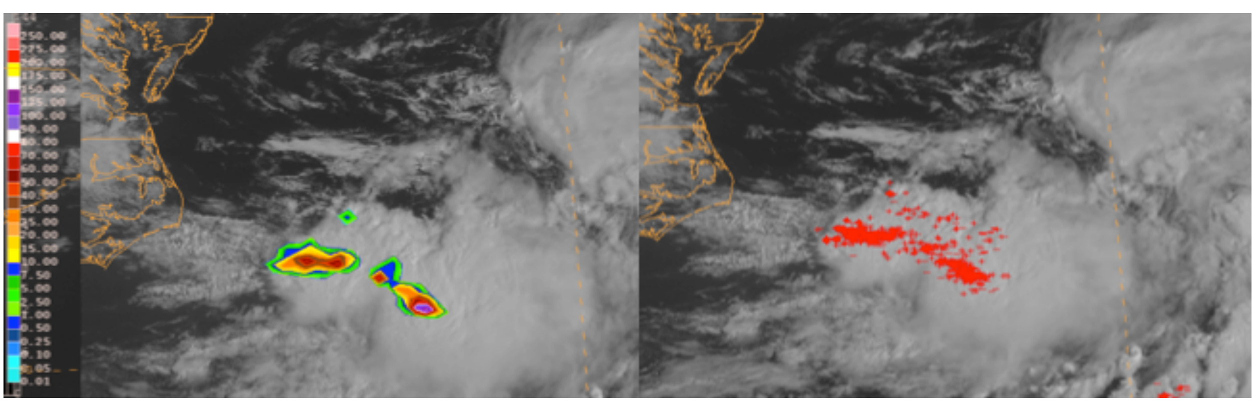


Figure 18. GLD density (left) and GLD strikes (right).

Participants were very much in favor of the density product as it provided much more information than a simple stroke plot. Not only could they determine which cells within a complex or line contained the most intense lightning activity, but they could also monitor the trend of the lightning activity. Seeing the increase or decrease within the density, particularly at the NAM desk, was very helpful when attempting to identify which cells may or may not cause traffic constraints.

However the drawback to the GLD data comes in what is actually detected. While it can detect some very strong in-cloud (IC) strokes, by in large the density is made up entirely of cloud-to-ground (CG) strokes. As such it can miss lightning activity associated with IC lightning, which is still very dangerous to aircraft. For this reason, most participants tended to rate the Earth Networks (ENI) lightning higher, as it does detect IC as well as CG. The difference in flash densities was noted on many occasions, one of which is shown here in Figure 19.

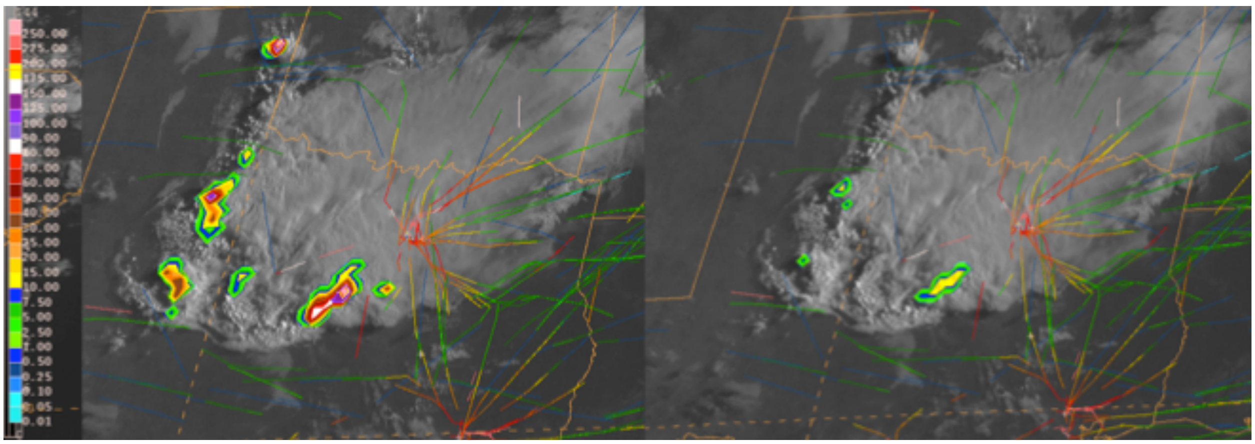


Figure 19. 20130816 1332 UTC Earth Networks (left) and GLD (right) lightning densities and ASDI flight routes over Texas. Note the higher flash densities in the ENI, which is to be expected as ENI detects total lightning while the GLD does not.

Earth Networks provided the ENI to the AWC in early summer and as with the GLD, the AWRP meteorologist created the 10-minute averaged lightning stroke density. Additionally, an ENI global lightning density product was also generated. However, because the GLD data the AWC receives is not global (only encompassing a domain from the western Pacific, across the U.S. and to the western coast of Africa), it could not be done for that dataset. Because of this, the global graphics participants tended to gravitate towards the ENI, using it not only for their forecasts but also for validation.

As the ENI displays total lightning, some attempt was made to compare this data with the PGLM. However, given the 10-minute average display of the ENI versus the 2-min density of the PGLM and the stroke versus strike nature of the displays, respectively, it would be, as the saying goes, comparing apples to oranges. However, in an effort to create a unified total lightning display, and take advantage of the PGLM data in a display beyond the limited domains of the LMA, there was some in depth discussion regarding combining the two datasets in a more apples to apples approach for future demonstrations.

The GLD and ENI lightning datasets are currently available in AWC Operations.

3.5 GOES-14 Super Rapid Scan 1-minute Imagery – University of Wisconsin's Cooperative Institute for Meteorological Satellite Studies

The decision was made early in the year to activate GOES-14 for a short period of time during the late summer and early fall to provide 1-minute Super Rapid Scan imagery (SRSOR). The goal of the GOES-14 rapid scan experiments is to familiarize forecasters with the rapid temporal refresh expected with

GOES-R ABI and how it benefit operations. Coincidentally, the first two weeks of these operations were slated to occur during the Summer Experiment. Sectors varied each day depending on request and did take into account and accommodate the needs of the summer demonstration on several occasions.

Both the CSIG and NAM desks, those with more real-time, nowcasting responsibilities, consistently used the 1-minute imagery as a situational awareness tool, identifying details missed in the typical 15-minute latency of GOES-E and GOES-W. An excellent example of this was noted in association with convective development around Minneapolis Center (Fig. 20).

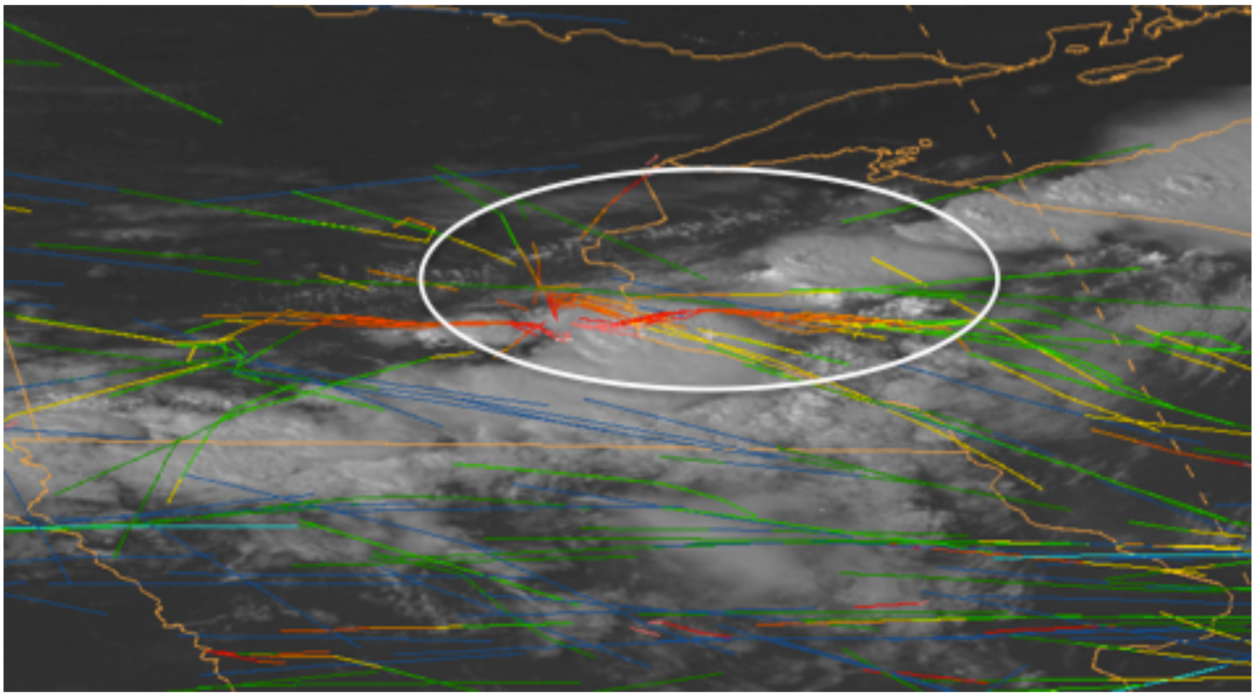


Figure 20. 20130821 2100 UTC 1-min visible imagery and ASDI flight routes over Minneapolis Center.

While it is not notable in the above still image, participants used the 1-minute imagery to monitor the convective development just to the northeast of the center. In particular, the growth of southwestern most cell closet to Minneapolis was very obvious in the SRSOR, especially the rapid expansion of the anvil as it began to impede the airspace above the center. Having this additional detail will provide air traffic managers and aviation forecasters a more accurate picture of the growth rate or dissipation of convection, and thus allow for more efficient and safer divert routes.

Overall forecasters were very pleased with the SRSOR imagery and look forward to seeing it in operations on a permanent basis come the launch of GOES-R. This imagery, whenever GOES-14 is activated, is made available to AWC operations for display in N-AWIPS.

3.6 ACHA Cloud Algorithms - University of Wisconsin's Cooperative Institute for Meteorological Satellite Studies

The Algorithm Working Group's Cloud Height Algorithms (ACHA) consist of the Cloud Top Height, Could Top Phase, Cloud Top Temperature, and Cloud Emissivity products (Fig. 21). While these have not specifically been designed for use in convection forecasting, many are used in some form for the derived convection algorithms. As such, it is important for forecasters to have some understanding of these building blocks and for that reason, these algorithms, while not a main foci, were shown at the Summer Experiment.

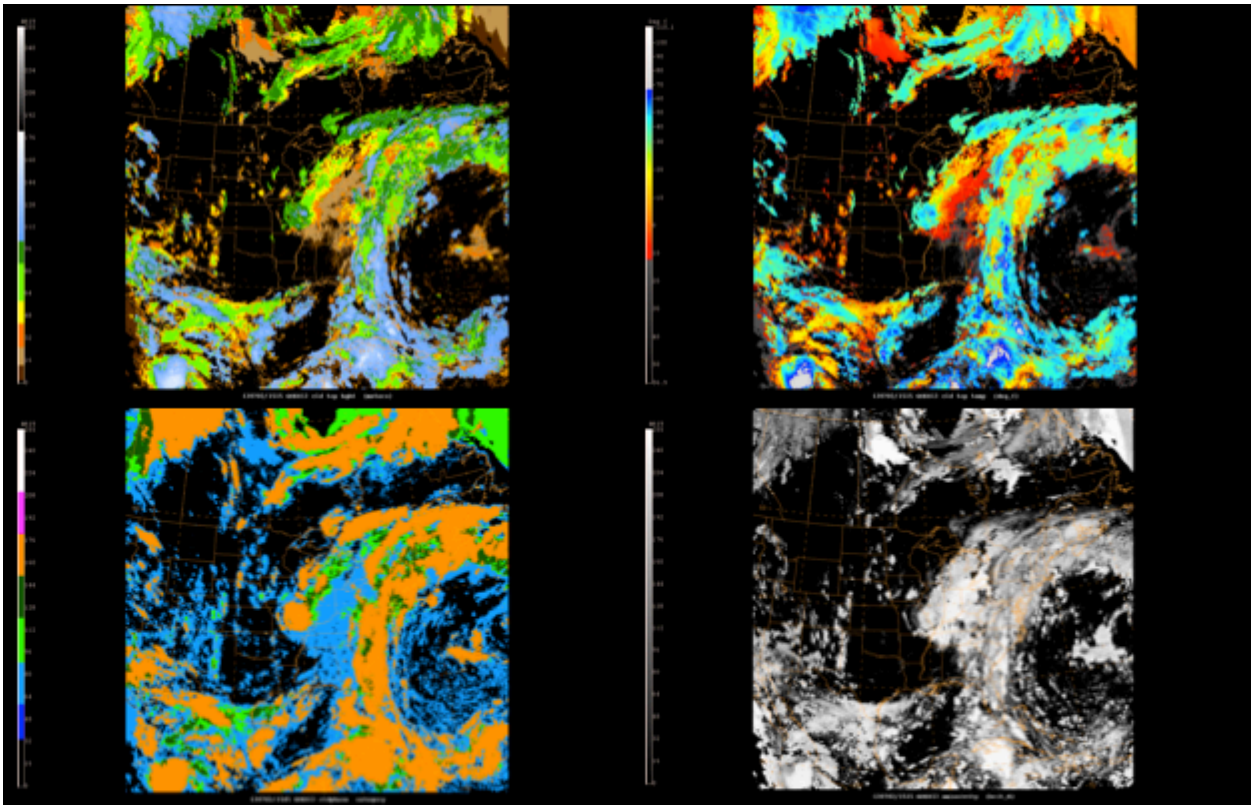


Figure 21. ACHA algoriths; cloud top height (top left), cloud top temperature (top right), cloud top phase (bottom left), and cloud emissivity (bottom right).

Participants at the global graphics desk showed a particular interest in these products. As mentioned in sections above, there is an inherent challenge in forecasting over oceanic and international domains given the lack of observations. With satellite data as one of very few observation datasets available, it is highly relied upon, both for forecasting and especially for validation. As such, having these products available in a global domain would be very beneficial. In particular, the cloud top height was noted as one that would be especially useful for forecasting convection.

However, the one issue is in the units. Currently the AWC receives this data in hundreds of meters (i.e. 32 = 320 meters or ~1000 feet). As aviation meteorologists are accustomed to using viewing all datasets in flight levels (feet), using meters makes it somewhat difficult and time consuming to mentally convert, particularly on a busy day. In future demonstrations it would be far more beneficial to obtain these datasets not only on the global scale, but also in feet.

The ACHA algorithms are currently available in the AWT. Additionally, as part of the Fog and Low Stratus suite, the Cloud Top Phase is available in AWC operations.

4. Summary and Conclusions

The 3rd annual Summer Experiment, though similar in purpose as the previous two, was unique in its own right. Using the success of the 2013 Winter Experiment structure as a basis, it was redesigned to account for desks currently found out on the AWC operations floor. This, as well as the inclusion of a Situational

Awareness desk, provided participants a chance to explore and evaluate the products in an operational-like setting and proved to be very beneficial to the GOES-R Research to Operations (R to O) effort at the Aviation Weather Center. Additionally, given the lack of science shifts on a regular basis due to being short-staffed, and the limited time to view new datasets during a regular operational shift, forecasters were eager to spend more time with each product, and subsequently provide a more in-depth evaluation. The feedback received via blog posts, surveys, and in-depth discussions, will play an important part in determining the direction for the next step in the R to O process for the products evaluated in this year's demonstration.

The Simulated Cloud and Moisture imagery continues to be a very popular forecast tool, particularly now that it has been transitioned into AWC operations and forecasters have been using it more frequently in there day to day procedures. However, the Nearcasting model has also drawn the interest of forecasters, its fields providing valuable information on both the likelihood of convection initiation and the behavior of ongoing convection in the 1-9 hour period. Currently there is no clear path to operations for this product, though given the use noted in this year's demonstration, it may be beneficial to consider further discussion on this matter.

Both the GOES-R Convective Initiation and the Cloud Top Cooling algorithms within the Convective Toolkit were widely used within the summer demonstration. The improvements made to the GOES-R CI over the past year, including the generation of the new fused version and the change of formats to increase the loading speed, showed a great amount of potential as a forecast tool in the 0-2 hour period, but also was often used in tandem with the CTC to increase confidence in convective behavior, from growth to maturity and cessation. This was particularly important at the CSIG and NAM desks, as both are responsibility for convection forecasting during this time period. While previous training and transition to operations of the CTC resulted in a better understanding of the display and use of the algorithm, the GOES-R CI was found to be more of challenge. It was noted that given the often 'busy' display inherent with broad scale cloud fields, the learning curve in integrating the product into typical forecast procedures would be perhaps more difficult than most. However with the gradual transition to operations of this product in the near future and the associated training, the comfort level of the forecasters should improve.

The utility of the Overshooting Top Detection algorithm continues to be explored, this year's focus on the OT magnitude (as supposed to the binary detection). The additional information proved useful in broad areas of embedded convection, particularly over data sparse regions. Using the magnitude as a gauge for intensity, participants were able to better identify the safest divert routes through these areas. Additionally, the OTD and it sister algorithm, the Tropical Overshooting Top, provided valuable information to participants at the Global Graphic desk in the validation of the 12-hour convection forecasts. Their only request was that this information be provided on a global domain, as opposed to just the GOES-E, GOES-W, and Meteosat regions currently available.

Given the global forecasting responsibilities at the AWC, lightning datasets are widely utilized. The summer demonstration featured several new datasets including the PGLM, the GLD360, and Earth Networks. The PGLM saw perhaps the most improvement of any product, featuring a new color bar as well network status bars and the addition of data from a number of new LMA networks. Forecasters were very pleased to see this new display, especially when monitoring the rapid development and intensification of convection, however the limited domains of the LMAs inhibited frequent use of the product. Subsequently, the GLD and ENI datasets were more commonly used, particularly the gridded stroke densities (as opposed to the simply stoke plots). Of the two, participants tended to gravitate towards the ENI as it displays total lightning (where the GLD is generally only displaying CG strokes). To this end, much discussion took place regarding the creation of a total lightning product which will combine stroke data from the ENI with stroke data collected in the LMA networks, as not only will this reduce the number of lightning datasets forecasters must sift through and understand, but it will also allow for the PGLM data to be used in conjunction with a wider domain.

Also widely utilized was the SRSOR 1-minute imagery GOES-14. The spare satellite was reactivated for the latter part of the month of August, allowing for forecaster evaluation during the summer demonstration. This imagery was meant to emulate the expected temporal resolution of GOES-R and was popular among forecasters, particularly for the excellent situational awareness it provides via the additional detail in areas of rapid convective development.

Lastly, the ACHA Cloud Height algorithms were demonstrated, not as a main focus, but as a means to strengthen the background knowledge of forecasters, as many of these algorithms are used in the derived convection products. Of the four algorithms evaluated, the Cloud Top Height was noted to be of the most use as knowing where thunderstorm tops are located is vitally important to traffic flow managers. Additionally, it was requested that this data be available on a global scale to aid in the global forecasts of convection generated at the Global Graphics desk. Stemming from this, participants also requested that this data be provided in feet, as the current unit (meters) is not one they are accustomed to using in aviation forecasting.

Overall, the feedback from participants was very constructive and by in large positive. The success of this demonstration can be attributed not only to work of the product developers, but also to those involved in the training process. Following the discussion at the Winter Experiment, one-page fact sheets were made available to participants, providing a brief summary and example of the various GOES-R datasets. Having a strong base knowledge of these tools allowed for a higher degree of confidence in interpretation of each product and subsequently a more in-depth evaluation.

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

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

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

5. References

Baum, B. A., P. Yang, A. Heymsfield, S. Platnick, M. King, Y-X. Hu, S. Bedka, 2005: Bulk Scattering Properties for the Remote Sensing of Ice Clouds. Part II: Narrowband Models. J. Appl. Meteor., **44**, 1896–1911.

Bedka, K., J. Brunner, R. Dworak, W. Feltz, J. Otkin, T. Greenwald, 2010: Objective Satellite-Based Detection of Overshooting Tops Using Infrared Window Channel Brightness Temperature Gradients. J. Appl. Meteor. Climatol., **49**, 181–202.

Bedka, K., R. Dworak, J. Brunner ,and W. Feltz, 2012: Validation of Satellite-Based Objective, Overshooting Cloud Top Detection Methods Using Cloudsat Cloud Profiling Radar Observations. J. Appl. Meteor. and Climatol., In Press.

Han, Q., R. Welch, J. Chou, W. Rossow, A. White, 1995: Validation of Satellite Retrievals of Cloud Microphysics and Liquid Water Path Using Observations from FIRE. J. Atmos. Sci., **52**, 4183–4195.

Hartung, D. C., J. M. Sieglaff, L. M. Cronce, and W. F. Feltz, 2012: An Inter-Comparison of UWCI-CTC Algorithm Cloud-Top Cooling Rates with WSR-88D Radar Data. *Submitted to Wea. Forecasting.*

Heymsfield, A. J., S. Matrosov, B. Baum, 2003: Ice Water Path–Optical Depth Relationships for Cirrus and Deep Stratiform Ice Cloud Layers. J. Appl. Meteor., **42**, 1369–1390.

Mecikalski, J. R. and K. M. Bedka, 2006: Forecasting Convective Initiation by Monitoring the Evolution of Moving Cumulus in Daytime GOES Imagery. Mon. Wea. Rev., 134, 49-78.

Mecikalski, J. R., J. K. Williams, D. Ahijevych, A. LeRoy, J. R. Walker, and C. P. Jewett, 2013: Optimizing the use of geostationary satellite data for nowcasting convective initiation. *J. Appl. Meteorol. Climatol.*, In preparation.

Monette, S. A. and Velden, C. S. 2012: Examining Trends in Satellite-Detected Tropical Overshooting Tops as a Potential Predictor of Tropical Cyclone Rapid Intensification. *J. Appl. Meteor. Climatol.*, **51**, 1917-1930

Seemann, S. W., E. Borbas, R. Knuteson, G. Stephenson, H. Huang, 2008: Development of a Global Infrared Land Surface Emissivity Database for Application to Clear Sky Sounding Retrievals from Multispectral Satellite Radiance Measurements. J. Appl. Meteor. Climatol., **47**, 108–123.

Schmit, T. J., and co-authors, 2013: GOES-14 Super Rapid Operations to Prepare for GOES-R, Conditionally accepted *J. Applied Remote Sensing*.

Sieglaff, J. M., L. M. Cronce, W. F. Feltz, K. M. Bedka, M. J. Pavolonis, and A. K. Heidinger, 2011: Nowcasting convective storm initiation using satellite-based box-averaged cloud-top cooling and cloud-type trends. *J. Appl. Meteor. Climatol*., **50**, 110–126.

Walker, J.R., W.M. MacKenzie, Jr., J.R. Mecikalski, and C.P. Jewett, 2012:An Enhanced Geostationary Satellite-based Convective Initiation Algorithm for 0-2 Hour Nowcasting with Object Tracking. *J.Appl.Meteor.Climatol*. **51**. 1931-1949