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NASA-SPoRT Methodology for JPSS and GOES-R Proving Ground Assessments

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1. INTRODUCTION

The purpose of a SPoRT assessment is to evaluate experimental products in operations, by leveraging collaborations with knowledgeable and enthusiastic partners in operational offices such as National Centers, National Weather Services offices, River Forecast Centers, Center Weather Service Units, and others. Based on feedback from participants from short (4-8 week) evaluation periods on a specific product or group of products targeting a specific weather forecast purpose, products can evolve over the course of seasons or years to accommodate decision support systems, address forecaster suggestions, incorporate new technology, and improve unexpected flaws. Generally, the operational weather product life cycle takes one of two paths: either a product evolves and improves over time, including mostly incremental changes; or the product or type of products available for a given forecast problem radically changes to a different product or type of products over time. Examples of each life cycle will be described herein, within the context of NASA-SPoRT product assessments with specific forecast users.

2. SPoRT PARADIGM FOR TRANSITIONING DATA TO OPERATIONS

Herein we will broadly and briefly discuss the NASA-SPoRT paradigm for transitioning products to the operational environment, particularly as it pertains to product assessments.

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This paradigm generally starts with the identification of a forecast issue or problem that needs to be solved (see Figure 1 throughout this description). A product is developed or found that appears to meet the forecast need in question, and SPoRT personnel and forecasters at specific SPoRT partner WFOs (along with product developers if they are not from NASA-SPoRT) will collaborate on determining whether this cursory solution is ready for a full assessment, and if so, to develop appropriate training for forecasters, including relevant applications.

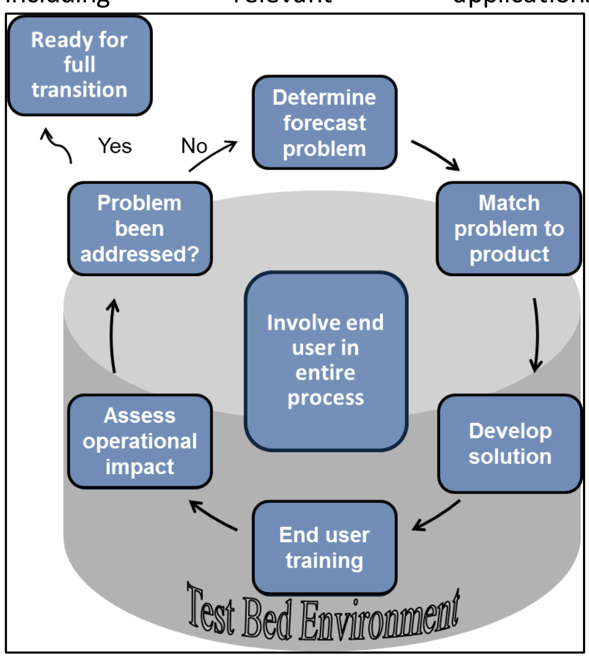

Figure 1 A schematic of the NASA-SPoRT paradigm for transitioning products and data to operations.

The assessment process determines whether the product has an impact on forecast operations and whether the forecast problem is being addressed by the product. If the answer to these questions is “no”, the product will often return to a product development stage. If the answer is “yes”, the product may be ready for full transition to the larger forecast community. The purpose of establishing a specific process like this is to help bridge the so-called “Valley of Death” between research and operations, because researchers and forecasters often are unable to come together and work on products in a test bed environment in a way that is mutually beneficial and where communications between parties is clear and straight-forward.

NASA-SPoRT assessments are generally short (on the order of 4 to 8 weeks long) and intensive, with a stated goal of one survey per day from the group of offices participating. An assessment will usually include a few offices evaluating one or several products that meet a specific forecast challenge. Prior to the formal evaluation period, those participating offices are given one-page front and back training guides on the product(s), called Quick Guides, to keep in the operations area, and product developers help SPoRT personnel give live teletraining sessions on the product(s) and answer questions. Also, training modules for some products are produced by SPoRT personnel and sent out to WFOs and placed on the SPoRT training page for forecasters to reference throughout their use of the product(s). In addition to filling out the short survey, offices can share insights learned during partner collaboration calls, via emails with product developers and SPoRT personnel, and on the SPoRT blog (http://nasasport.wordpress.com/).

3. INCREMENTAL CHANGES WITHIN A PRODUCT: GOES-R CI

UAH GOES-R CI is an example of a product that has undergone a number of incremental changes over several years, largely in order to address end-user feedback. UAH GOES-R CI is developed at UAHuntsville by John Mecikalski and transitioned to forecasters for assessment with the assistance of NASA-SPoRT as part of the GOES-R Proving Ground. This product nowcasts convective initiation in the 0-2h range for tracked cloud objects across successive GOES satellite scans (Walker et al. 2012 describes the current version of the algorithm).

The product that was evaluated by forecasters in 2010 was a binary version of GOES-R CI (see Figure 2), in which products were colored as either convective-likely or not. It was derived from 6 satellite IR fields that indicate cloud properties like height and glaciation and time changes in those cloud properties. During evaluations of the product in 2010, forecasters indicated that the binary feedback was not very detailed and at times confusing; e.g., a tracked object might change between being convective-likely and non-convective and back again in successive GOES scans.

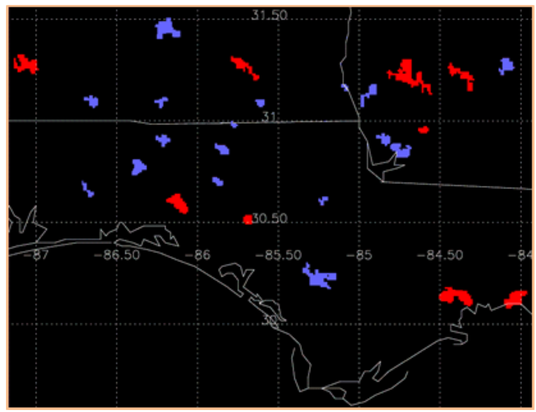

Figure 2 The binary version of UAH GOES-R CI evaluated in the 2010 assessments.

In response to this feedback, the product development team at UAHuntsville altered the product display and underlying algorithms, revealing a “Strength of Satellite Signal” version of GOES-R CI in 2011 (see Figure 3). The Strength of Signal version contained the same satellite fields, but it used a large database of past convective events and a logistic regression technique to produce resultant data that labelled tracked objects with a probability of convection, on a scale that looks similar to radar reflectivity. In 2011 and 2012 assessments, forecasters viewed the change very favorably; however they now suggested that the product could be enhanced with environmental data.

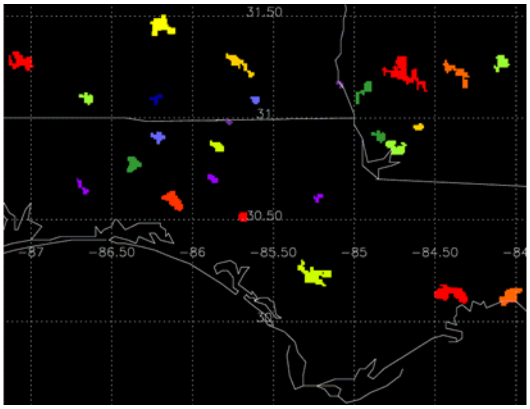

Figure 3 The "Strength of Signal version of UAH GOES-R CI evaluated in the 2011-2012 assessments.

The 2013 version of the product incorporated this change (see Figure 4). The underlying algorithm now included, in addition to the GOES IR fields, several fields from the RAP model to indicate things like lifted index and CAPE. During the evaluations in 2013, forecasters again favorably noted the change, noted a possible glitch in the GOES-West data, and suggested some improvements to the way the product handles sea breeze, which product developers are working on for the 2014 season.

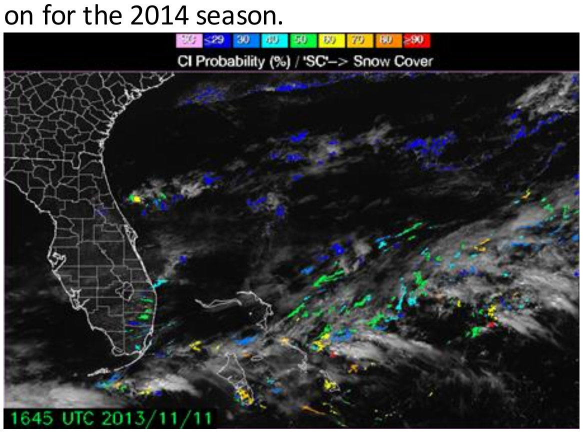

Figure 4 The "probabilistic" version of UAH GOES-R CI evaluated in 2013 and currently in operations.

4. INCREMENTAL CHANGES WITHIN A PRODUCT: GOES-R QPE

NESDIS GOES-R QPE can be examined more in depth as an example of a product early in its developmental lifecycle, having undergone its first year of operational assessments in 2013. This product is a satellite based precipitation estimate product which uses both IR from GOES and microwave from a number of different satellites to provide a 15-minute rain rate product and a number of accumulation products ranging from 1 hour to 7 days (Kuligowski 2010). This product is developed at NESDIS by Bob Kuligowski and transitioned to operations and evaluated with the assistance of NASA-SPoRT through the GOES-R Proving Ground (see Figure 5).

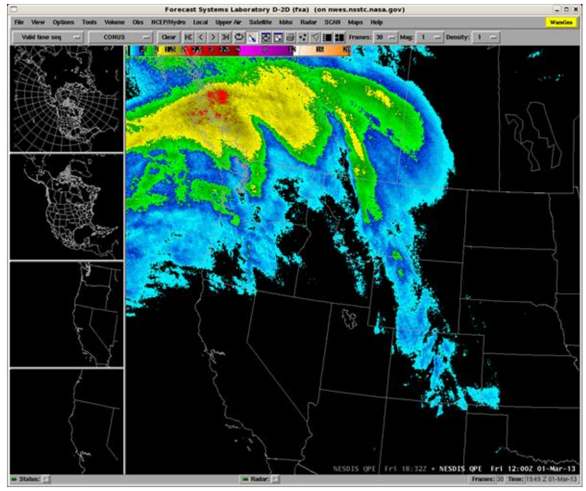

Figure 5 6-hr Accumulation of NESDIS GOES-R QPE in AWIPS.

GOES-R QPE has transitioned to 7 WFOs and an RFC on the West Coast, in Alaska, and in San Juan, PR, amassing over 90 surveys from these disparate environments during formal evaluations. Recall that the goal of assessments is to bring together the product development team with the forecast community, who is the ultimate end-user, in order to allow the two sides to communicate about specific product applications and uses, expectations, perceptions, transition issues, etc., while the product is in rigorous use. Both the stipulation operational perspective and the stipulation of frequent use/many cases over varied conditions are vital to receiving useful feedback for product developers to make improvements.

Specifically during this product's 2013 assessment seasons, forecasters provided a number of suggestions and insights that resulted beneficial changes to this product or possible changes for the future of this product in the years to come. Before one set of assessments had even started, the RFC forecasters had requested accumulation products in longer durations than the WFOs, which was easily provided by the product development team. Even the WFOs themselves requested and relied on different accumulation products.

Forecasters also noted some cases in which GOES-R QPE exhibited inaccuracies related to cloud identification and other processes. GOES-R QPE would sometimes assign rain rates to cirrus clouds, for example, leading forecasters to suggest that cirrus be masked out of processing if possible (see Figures 6 and 7 for a representative example). Also, the product might assign rain rates in the wrong locations when strong upper level winds would displace cloud tops from the surface. Dr. Kuligowski is experimenting on solutions to the wind shear problem, and having additional cases and feedback will provide assistance. A solution to one problem could be provided right away during an assessment. Early in the West Coast WFOs' assessment period, an innocuous cumulous cloud was assigned a high rain rate. The GOES-R QPE algorithm had a fail-safe that, when GOES-West imagery was missing or not useable, replaced it with parallax-corrected GOES-East imagery. For that exact circumstance, the fix still resulted in substantial limb-cooling, and when alerted to the problem, Dr. Kuligowski could make a change to the operational product to prevent future occurrences.

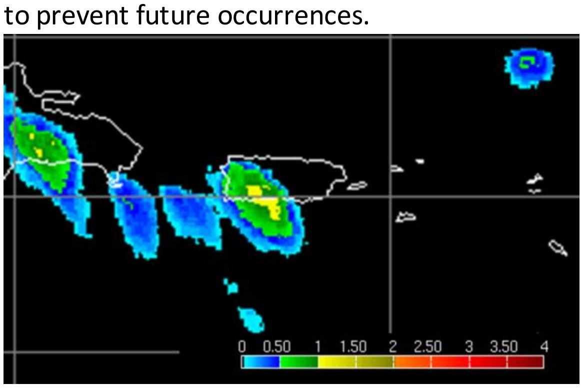

Figure 6 NESDIS GOES-R QPE is associating rain with cirrus clouds in this 12-hr accumulation.

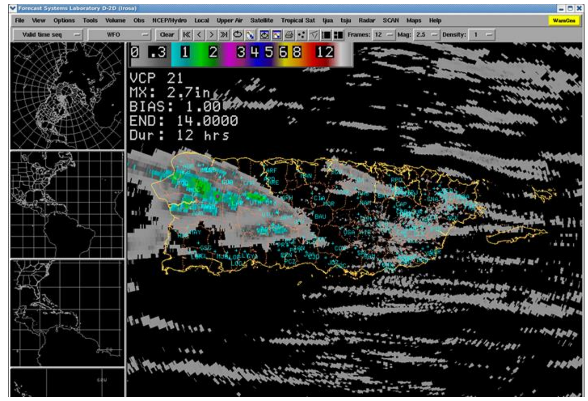

Figure 7 Compare this 12-hr radar-derived rainrate to Figure 6.

A few other challenges noted by forecasters will perhaps be rectified by the additional channels and scan frequency provided by the GOES-R era of the instrument. Forecasters observed that GOES-R QPE underestimated rainfall associated with very intense thunderstorms exhibiting very cold IR brightness temperatures and overshooting tops. The algorithm sometimes also underestimated or at times failed to estimate rain rates in which the depth of the warm layer was very deep (i.e., greater than 4 km), or when cloud tops were relatively warm (-20 to -40C). Forecasters provided a list of cases from their WFOs encompassing these different types of events, from the warm rain process events to the very intense heavy rain events, so that Dr. Kuligowski can examine them in depth and continue to make changes as necessary.

5. RADICAL CHANGES ACROSS PRODUCTS: FOG PRODUCTS

In contrast to GOES-R CI, in which one product addresses the forecast challenge of convective initiation and that product evolves based on forecaster feedback, this section will describe how a multitude of diverse products addressed the issue of forecasting and nowcasting fog. Several of these products were relevant based on the capabilities of the satellites available at the time, but were made obsolete by advances in technology rather than by forecaster demands.

A NASA-SPoRT assessment of fog and low cloud products occurred in the fall and winter 2008-2009 season and included Southern Region WFOs from coastal and inland locations in two separate assessments (more information about those assessments can be found in the JFM 2009 NASA-SPoRT Quarterly Report on the NASA-SPoRT webpage: http://weather.msfc.nasa.gov/sport/library/sportReports.html). At that time, the products being assessed were NESDIS GOES Low Cloud Base, NESDIS GOES Fog Depth, and the 11-3.9 um spectral difference product from both GOES and MODIS. The Low Cloud Base and GOES Fog Depth products helped differentiate between fog and low clouds (see Figure 8). The new product for forecasters to become acquainted with at that time was the higher resolution MODIS imagery in the spectral difference product (see Figure 9).

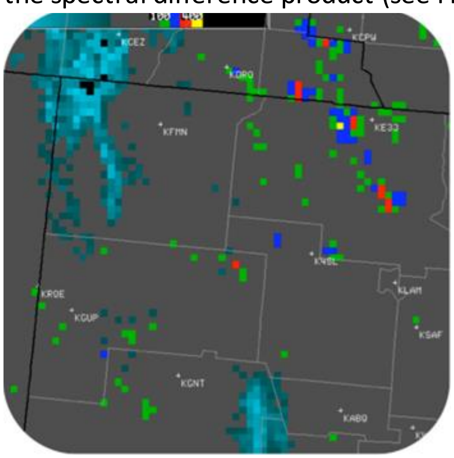

Figure 8 GOES Low Cloud Base identified the approximate height of low clouds to help identify fog.

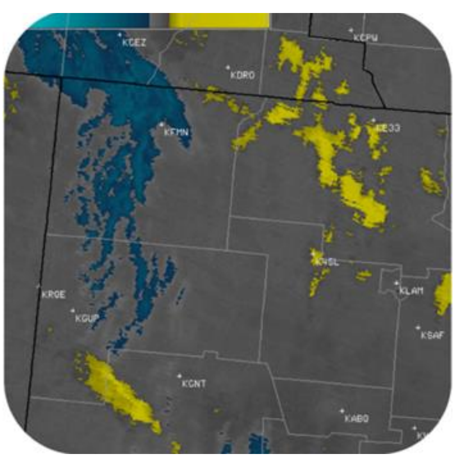

Figure 9 The MODIS version of the 11-3.9 um spectral difference product was, in 2009, a startling change due to its increased resolution over GOES.

In the 2013-2014 fog season, the Southern Region coastal and inland offices again assessed a series of products for their utility in identifying low clouds and fog. This time, however, that series of products included the 11-3.9 um MODIS/GOES hybrid product, the VIIRS and MODIS Nighttime Microphysics RGB (Figure 10), and the VIIRS Day/Night Band RGB. Some underlying goals of these assessments were to provide training and exposure to these offices in using RGBs and new instruments prior to the GOES-R era, to assess our training materials, and to transition RGBs to these offices, rather than to simply assess and possibly change the way an RGB product is produced.

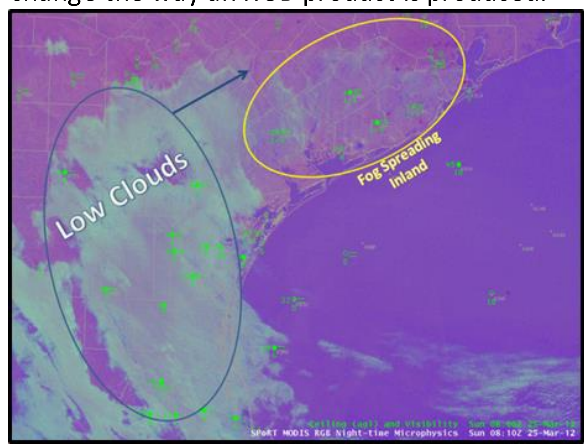

Figure 10 The Nighttime Microphysics RGB differentiates between fog and low clouds in this example provided by the Corpus Christi WFO.

6. CONCLUSIONS

Overall, the transition and assessment process is interactive, involving the product developers and the forecasters from start to finish in order to achieve successful results. Regarding assessments, NASA-SPoRT hosts short, intensive evaluation periods dedicated to a product or products that address a specific forecast problem. Again, the product developers and forecasters are encouraged to be in communication throughout the assessment process. Throughout a series of assessments, products often evolve either iteratively, based on forecaster feedback, or more drastically, based on changes in the available technology. These more radical changes to new products, such as the emergence of RGBs, often result in the need for additional training and exposure for forecasters to become comfortable with these products in operations, and assessments can serve a dual purpose to help meet that need.

7. REFERENCES

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Kuligowski, R. J. (2010). **Rainfall Rate (QPE)** *Algorithm Theoretical Basis Document*, NOAA NESDIS STAR.