Operations Plan

for the
GOES-R Proving Ground
portion of the
National Hurricane Center 2010 Hurricane Season PG Experiment

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Product developers contributed the material regarding their respective products.

Revision Date: June 17, 2010

Table of Contents

1 Introduction

1.1 Plan Purpose and Scope

The purpose of this plan is to identify the goals of the National Hurricane Center (NHC) Hurricane Season Proving Ground (PG) Experiment, provide an overview of the GOES-R products being demonstrated, describe the activities necessary to conduct the experiment, identify the participants and their responsibilities, establish a project timeline/schedule with milestones and deliverables, and identify related activities at the NHC. This plan will only describe the activities associated with the 2010 GOES-R PG activities at the NHC.

1.2 Overview

The NHC will receive early exposure to GOES-R PG products during the 2010 Hurricane Season Experiment running from August through the end of November. Pre-operational demonstrations of these GOES-R PG data will provide NHC operational forecasters an opportunity to critique and improve the products relatively early in their development.

2 Goals of Proving Ground Project

The goals of the NHC Hurricane Season PG Experiment are to demonstrate identified GOES-R surrogate products real-time at the NHC during the 2010 hurricane season so the NHC forecasters can use, get familiar with, and evaluate the products and provide valuable feedback to the GOES-R Program Office (GPO).

3 GOES-R products to be demonstrated

The GOES-R products to be demonstrated include those that use proxy Advanced Baseline Imager (ABI) data from the Spinning Enhanced Visible and Infrared Imager (SEVIRI) instrument on Meteosat-9 and current GOES, and proxy Geostationary Lightning Mapper (GLM) data from global ground-based lightning networks. The initial products for 2010 were chosen in consultation with NHC based on feasibility, the similarity to planned GOES-R products, and forecaster availability for evaluation. These products include GOES-R Baseline products as well as GOES-R Decision Aids and are listed in Table 1 and described further in the following subsections.

Table 1. Products to be demonstrated during Experiment

Demonstrated Product	Category
Hurricane Intensity Estimate (HIE)	Baseline
Super Rapid Scan imagery	Baseline
Red-Blue-Green (RGB) air mass product	Decision Aid
RGB dust product	Decision Aid
Saharan Air Layer (SAL) product	Decision Aid
Rapid Intensity Index (RII)	Decision Aid
Category Definitions: **Baseline** - GOES-R products that are funded for operational implementation as part of the ground segment base contract. **Decision Aid** - Products or tools that aid the forecaster's decision process and/or automatically analyze the data and determine when the forecaster needs to react.	

3.1 GOES-R Baseline

3.1.1 Hurricane Intensity Estimate

The HIE is the only hurricane-specific product that is part of the official GOES-R Baseline set. The HIE will be a GOES-R algorithm designed to estimate hurricane intensity (mean sea level pressure (MSLP) and max surface wind) from ABI IR-window channel imagery. The code will be derived from the current Advanced Dvorak Technique (ADT), which is an objective and fully-automated algorithm that is operational now in National Environmental Satellite, Data, and Information Service (NESDIS). Cooperative Institute for Meteorological Satellite Studies (CIMSS) will adapt the current ADT code to operate exclusively on Meteosat-9 imagery, as a proxy to an ABI product demonstration. The HIE will be provided to NHC via a web page, which is the same method used to provide the ADT.

3.1.2 Super Rapid Scan Imagery

NHC indicated an interest in super rapid scan operations (SRSO) data during a strong hurricane landfall to gain experience with the utility of the high time resolution observations from GOES-R. This will only be possible if the GOES-15 science test is coincident with the Atlantic hurricane season because hurricane landfalls automatically trigger rapid scan operations (RSO), which preclude SRSO. However, given the successful launch of GOES-15, the science test is tentatively planned for August and September, so this possibility looks promising. Part of the science test includes the collection of 30-second data. These data will be collected over a tropical cyclone if possible. If GOES-15 is not available, SRSO and RSO data from GOES-east will be collected during periods of interest prior to landfall. The NASA Genesis and Rapid Intensification Processes (GRIP) and National Science Foundation (NSF) RE-Depression Investigation of Cloud-systems in the Tropics (PREDICT) programs will occur during the upcoming GOES-R PG period. Chris Velden will serve as the focal point for those experiments, and in consultation with CIRA, SRSO or RSO data will be collected during intensive observation periods of those experiments.

3.2 GOES-R Decision Aids

3.2.1 Red-Blue-Green (RGB) air mass product

The air mass product is an RGB composite based upon data from infrared and water vapor channels from Meteosat Second Generation (MSG). Originally designed and tuned to monitor the evolution of cyclones, in particular rapid cyclogenesis, jet streaks and PV (potential vorticity) anomalies by scientists at European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), it is also useful for tropical/subtropical applications. The product highlights differences between dry, tropical and cold air masses. This is accomplished by differencing the two water vapor channels (i.e., ch. 5 at 6.2 μm and ch. 6 at 7.3 μm) as depicted in the red colors, where red is associated with dryer air mass conditions locally, by Ozone differences by differencing ch. 8 at 9.7 μm and ch. 9 at 10.8 μm, where Green indicates low Ozone & typically thus tropical air masses, and by using ch. 5 at 6.2 μm to indicate gross air mass temperature differences. The air mass product helps discriminate tropical air masses (i.e., moist and lower ozone) that are predominantly green, from subtropical air masses (i.e., dryer) that are depicted greenish red, and mid-latitude air masses, typically having more blue colors. For tropical applications it should be helpful in determining and tracking the origin of air parcels as they interact with tropical systems, and improved identification of shallow upper level features (cold lows and jets streaks). For more information on the interpretation of this product see (Kirkman,

cited 2010). The use of this product in the GOES-R proving ground will provide important feedback concerning how similar products may be tuned for improved use in tropical applications.

The optimal method for display of RGB products would be on an AWIPS-II system at NHC. However, after consultation with NHC, their AWIPS-II systems will not be ready for use in 2010. AWIPS-II development for the National Centers lags that for the WFOs, and there is no working system in the NHC operations area. They do have operational AWIPS and N-AWIPS systems, but neither of these has the capability to properly display RGB images. As a stop-gap for 2010, NHC staff recommended using Google Earth format (KML files) for the RGB product display. PCs to display the Google earth format are available in the hurricane forecaster and TAFB operations area. A special "tiling" capability is being developed to reduce the bandwidth requirements.

3.2.2 RGB dust product

The dust product is an RGB composite based upon infrared channel data from the Meteosat Second Generation satellite. It is designed to monitor the evolution of dust storms during both day and night. The Dust RGB makes use of channel differences that are close to IR windows near 8.7 μm and 11 μm. The resulting product depicts dust in magenta and purple colors over land depending on the whether it is day or night, respectively. A dusty atmosphere can also be tracked the over water as magenta coloring. For more information on interpretation see (Kirkman et al., cited 2010). The product will allow for the monitoring of dust storms over the African Continent and tracking of that plume into the tropical Atlantic waters where easterly waves move and sometimes develop into tropical cyclones. The dust serves as a tracer for a dry mid-level airmass, and has radiative influences on the atmosphere and affects the microphysics of cloud development. Dust plumes in the tropical Atlantic have been hypothesized to slow tropical storm development (Dunion and Velden 2004) and directly affect sea surface temperatures (SSTs) where tropical cyclones form (Evan et al. 2008). The RGB dust product will be delivered in the same Google Earth format described in 3.2.1.

3.2.3 Saharan Air Layer Product

The SAL product is another example of an enhanced image product potentially related to tropical cyclone evolution. The SAL product uses a split window (11 and 12 μm) algorithm to identify and track dry, dusty air (e.g., Saharan dust outbreaks) in the lower to middle levels of the atmosphere. These dust outbreaks traverse the Atlantic Ocean from east to west and can reach as far west as the western Caribbean, Florida, and Gulf of Mexico during the summer. There is evidence that they can negatively impact tropical cyclone activity in the North Atlantic. Similar to the air mass product, the SAL product is not directly related to the mandatory baseline or option 2 products, but will be possible from GOES-R, and will provide experience with image visualization techniques. The SAL product will be delivered in the same Google Earth format described in 3.2.1.

3.2.4 Rapid Intensity Index

A prototype rapid intensity index will be run in near-real time to demonstrate a decision aid using proxy GLM data from various sources. These data are combined in a discriminant analysis algorithm that provides optimal weights of the independent variables to provide a classification of whether or not a tropical cyclone will rapidly intensify in the next 24 hours. This RII algorithm is very similar to an operational guidance product available to NHC. However, the operational algorithm does not include lightning data. The comparison of operational and experimental RII

products will provide an estimate of the utility of lightning data for rapid intensity prediction. This product represents an application of one of the GOES-R baseline products.

4 Proving Ground Participants

The Proving Ground participants are broken into two categories, Providers and Consumers. Providers are those organizations that develop and deliver the demonstration product(s) and training materials to the consuming organization. The Consumers are those who work with the providers to integrate the product(s) for demonstration into an operational setting for forecaster interaction. For the Summer/Fall Experiment at the NHC, there are two providers, CIRA and CIMSS, and there is one consumer, the NHC.

4.1 CIRA

CIRA will be providing three of the six products demonstrated in the NHC PG Experiment and coordination on a fourth product.

4.1.1 RGB Air Mass Product

The RGB Air Mass product is generated from MSG channels 5 (WV6.2), 6 (WV7.3), 8 (IR9.7), and 9 (IR10.8). The raw imagery is ingested from NESDIS operational servers and generated using Man computer Interactive Data Access System (MCIDAS) and the following recipe.

Beam	Channel	Range	Gamma
Red	WV6.2 – WV7.3	-25 ... 0 K	1
Green	IR9.7 – IR10.8	-40 ... +5K	1
Blue	WV6.2	+243 ... +208 K	1

The channel differences are scaled over the ranges provided above and the individual color composites are created in satellite projection. These components are then remapped into a 3 km rectilinear grid. These remapped components are then combined to create a composite RGB. The RGB images are then converted to JPEGs. Special image processing has been developed to subdivide the large single JPGs into smaller 256 x 256 images (i.e., tiles) and create KML files that can be displayed and looped in Google Earth. These files are then served to NHC in the Google Earth format described in section 3.2.1. Feedback then will be collected from NHC users at the end of the demonstration period.

4.1.2 RGB Dust Product

The RGB Dust product is generated from MSG channels 7 (IR8.7), 9 (IR10.8), and 10 (IR12.0). The raw imagery is ingested from NESDIS operational servers and generated using MCIDAS and the following recipe.

Beam	Channel	Range	Gamma
Red	**IR12.0 – IR10.8**	**-4 .... +2 K**	**1**
Green	**IR10.8 – IR8.7**	**0 .... +15 K**	**2.5**
Blue	**IR10.8**	**+261 ... +289 K**	**1**

The use of a gamma factor other than one means that the scaled difference is stretched using a power of $1/\gamma$ [e.g., in this case $\delta^{1/\gamma}$, where δ is scaled brightness temperature difference (i.e., 0 to 1 over a range of 0 to 15 K)]. The same process as described in Section 3.2.1 will be used to serve

KML files via the internet for use in Google Earth at NHC. Feedback then will again be collected from NHC users at the end of the demonstration period.

4.1.3 Rapid Intensity Index

A prototype rapid intensity index will be run in near real time to demonstrate a decision aid using proxy GLM data. The lightning data will be from the Vaisala GLD360 feed that is scheduled to be established at CIRA through a special interagency agreement. The product will also use input from other sources, including GOES imagery and NCEP model fields. This product represents an application of one of the GOES-R baseline products. The operational RII is provided to NHC in a text format via an ftp process from the NCEP IBM computer system located in Maryland. The experimental RII will be provided in a similar format via ftp from CIRA.

4.1.4 Super Rapid Scan Imagery

CIRA will be involved in arranging the schedules for the super rapid scan operations (SRSO) data, in coordination with NHC, CIMSS, and the NESDIS Office of Satellite Operations (OSO). CIRA will also archive the SRSO data for later use in research and training activities.

4.2 CIMSS

CIMSS will be providing two of the six products demonstrated in the NHC PG Experiment and they are described below. CIMSS will also be involved with the collection of the SRSO data.

4.2.1 Hurricane Intensity Estimate

The HIE will be run in real-time at UW/CIMSS in Madison, WI, during East Atlantic tropical cyclone events. It will be automatically activated upon NHC declaring any such system a Tropical Depression or greater strength. Estimates will be provided at 15-minute intervals, simulating what will be possible with GOES-R. The HIE will run until target storms reach 60W, at which time the viewing angle from Meteosat becomes suspect.

Forecasters at the NOAA National Hurricane Center (NHC) will be able to access the real-time Meteosat ADT/HIE output via a dedicated web site at CIMSS. The product format will follow the convention of the current ADT output and displays; a format that NHC is already familiar with.

Forecasters participating in the GOES-R Proving Ground demo at NHC will provide a brief evaluation of the proxy HIE performance at the end of the 2010 Atlantic hurricane season.

4.2.2 Saharan Air Layer Product

The SAL product will be generated in real-time at UW/CIMSS in Madison, WI. The imagery will be derived from Meteosat SEVIRI channels (simulating GOES-R ABI), and will be produced every 15 minutes, include a capability for looping (2-3 hr loops). The images can be made available in Google Earth format to conform with the other PG products to be demonstrated to NHC.

Forecasters at the NOAA National Hurricane Center (NHC) will be able to access the real-time Meteosat SAL product and view images/loops of this product in real-time using Google Earth by accessing web servers at UW-CIMSS.

Forecasters participating in the GOES-R Proving Ground demo at NHC will provide a brief evaluation of the proxy SAL product at the end of the 2010 Atlantic hurricane season.

4.2.3 Super Rapid Scan Imagery

CIMSS will be involved in arranging the schedules for the super rapid scan operations (SRSO) data, with an emphasis on the NSF PREDICT and NASA GRIP experiment periods. When an intensive data collection period is planned, C. Velden will coordinate with CIRA so that they can arrange the SRSO period with NESDIS/OSO.

4.3 NHC

The NHC will be providing one of the six products demonstrated in the NHC PG Experiment and it is described below.

4.3.1 Super Rapid Scan imagery

The SRSO and RSO data can be made available through the existing NHC GOES ingest and display systems. The collection and display of this data will provide forecasters with experience with the higher time resolution imagery that will be available from GOES-R. The SRSO and RSO data archived at CIRA will also be provided to NHC for training.

5 Responsibilities and Coordination

5.1 Project Authorization

- Jack Beven; Hurricane Specialist, NHC
- Steve Goodman; GOES-R Chief Scientist and PG Program Manager

5.2 Project Management

- Mark DeMaria; NOAA/NESDIS/STAR/RAMMB
- Renate Brummer; CIRA/CSU

5.3 Technical Support at NHC

- Jiann-Gwo Jiing; Technical Support Branch Chief, NHC
    - Implementation of all product delivery mechanisms at NHC will be coordinated with the TSB Chief

5.4 Product Evaluation

- Jack Beven; Hurricane Specialist, NHC
- Michael Brennan; Hurricane Specialist, NHC
- Mark DeMaria; NOAA/NESDIS/STAR/RAMMB
- John Knaff; NOAA/NESDIS/STAR/RAMMB
- Chris Velden; U. Wisconsin, CIMSS
- Jason Dunion; NOAA/Hurricane Research Division

5.5 Product Training

5.5.1 Hurricane Intensity Estimate

Training on this product will be available on the CIMSS product page of the Proving Ground web page http://cimss.ssec.wisc.edu/goes_r/proving-ground/products_list.html. This training will include links to documentation on the ADT, which is very similar to the HIE. Training on the HIE will also be part of the PowerPoint presentation that will be provided to the Forecasters before the start of the experiment period.

5.5.2 Super Rapid Scan Imagery

NHC is already very familiar with rapid scan imagery from GOES, so little training will be needed. A brief description and links to examples from previous science tests will be provided on the CIRA Proving Ground web page.

5.5.3 RGB Air Mass

Training on this product will be available on the CIRA Proving Ground products web page http://rammb.cira.colostate.edu/research/goes-r/proving_ground/cira_product_list. This training will include links to EuMetSat Training from which the product was derived and general RGB training at COMET. Information on this product will also be part of the PowerPoint presentation that will be provided to the Forecasters before the start of the experiment period.

5.5.4 RGB Dust

Training on this product will be the same as described above for the RGB Air Mass product.

5.5.5 Saharan Air Layer

Training on this product will be similar to that described above for the RGB Air Mass product, except that the product description will appear on the CIMSS Proving Ground products page instead of the CIRA page.

5.5.6 Rapid Intensity Index

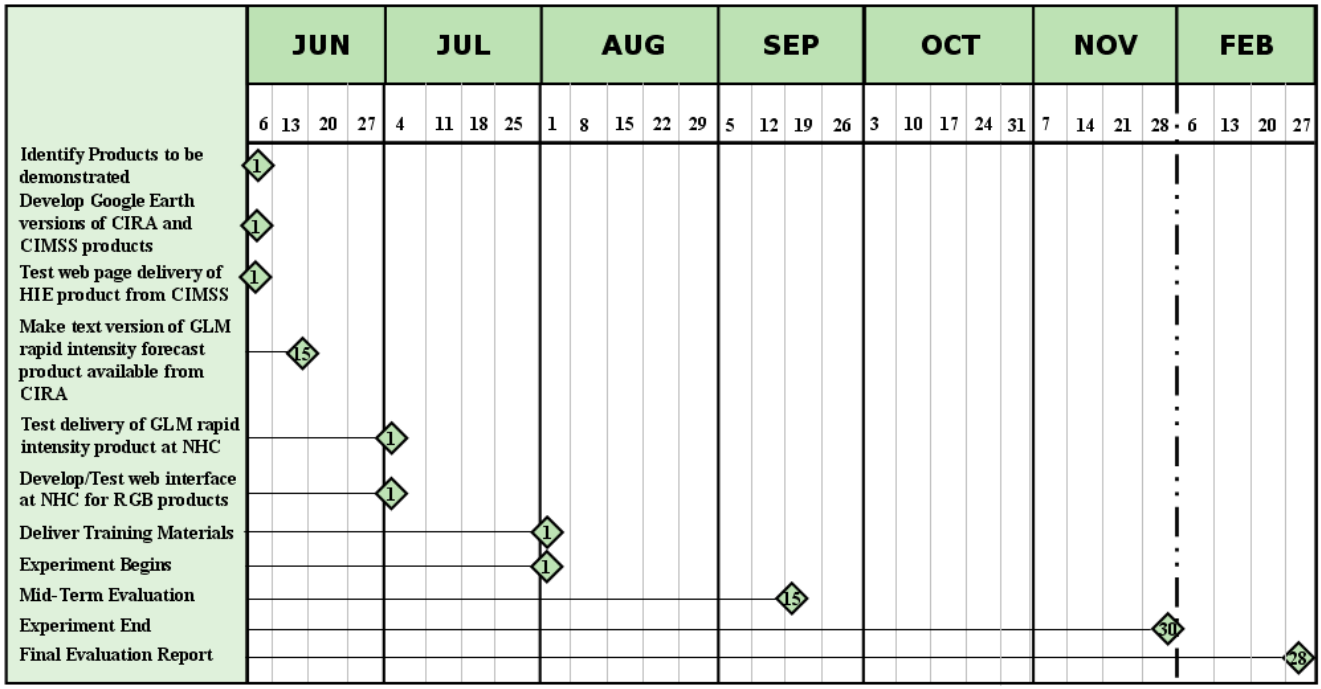
Training on this product will be available on the CIRA product page. Links to training on the operational version of the rapid intensity index will also be provided. Information on this product will also be included in the PowerPoint presentation for NHC described above.

5.5.7 General Sources

- Training on individual products will be posted on the GOES-R Proving Ground web page using the template for the other PG products
- Links will be provided in the PG training pages to more in-depth material
- Links will be provided to COMET training on RGB products
- Links will be provided to EUMETSAT training on related Meteosat products
- Links to journal articles on the rapid intensity index

6 Project Schedule

There are many activities that lead up to the successful execution of the NHC 2010 Hurricane Season PG Experiment such as identifying participants, coordinating schedules, delivering and integrating algorithms and products, and developing and delivering training materials. These specific activities are identified in the chart below.



Following the conclusion of the experiment, a report on NHC GOES-R PG will be provided at the 2011 Interdepartmental Hurricane Conference (March 2011).

7 Milestones and Deliverables

7.1 Products from Providers

Products to be demonstrated within this year's Experiment should be delivered to NHC no later than August 1st.

7.2 Training materials from Providers

Each product delivered to the GOES-R PG Experiment will be accompanied by related training material. NHC forecasters and scientists participating in the Experiment may not be familiar with the products; therefore, it is important that they receive training in order to properly evaluate product performance during real-time forecasting exercises. Training on each of the products being demonstrated will occur in July, in coordination with Jack Beven and Michael Brennan. This will consist of a PowerPoint presentation of no longer than 30 minutes in length and will be presented by a participating product expert. In addition, a short write-up explaining how the product works and its uses, including example images, will be provided for distribution amongst the NHC forecasters for reference.

7.3 Mid-term evaluation report

A mid-term evaluation report shall be provided to the project authorization team at the date specified within the operations plan timeline. This report shall detail the current status and progress of the GOES-R PG Experiment activities and suggest changes if needed.

7.4 Final report

A final report detailing the GOES-R PG NHC 2010 Hurricane Season Experiment activities during the entirety of the experiment shall be provided to the GOES-R Program Office at the date specified within the operations plan timeline. This report will discuss how each product was demonstrated within the various experiments. The report will also present feedback provided by participants of the Experiment as well as suggestions for improvements upon the GOES-R PG Experiment activities for years to come. This feedback will be captured by Jack Beven and Michael Brennan during their interactions with the participants throughout the Experiment timeframe, in coordination with Mark DeMaria and the product developers. The developers will assist with quantitative evaluations where possible. In particular, the HIE and GLM rapid intensity forecast product provide quantitative information that can be evaluated statistically following the experiment.

8 Related activities and methods for collaboration

The NHC is also involved in a number of other demonstration projects including the Joint Hurricane Testbed (JHT) and the Hurricane Forecast Improvement Project (HFIP). Efforts will be made to coordinate those activities with the PG to make sure the forecasters are not overwhelmed with the evaluation of experimental product evaluations. The mid-project review planned for mid-September will be used to determine if adjustments to the PG are needed.

9 Summary

This year's GOES-R PG Experiment activities at the NHC will support the PG effort to demonstrate the defined GOES-R products within an operational framework through various experimental programs. Feedback gathered from these activities will aid in successful product training for forecasters as well as improvements in product performance by product developers.

10 References

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