GOES-R Product Training Document

for the
GOES-R Proving Ground
Aviation Weather Testbed 2012 Summer Experiment

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GOES-R Product: *NSSL/WRF Advanced Baseline Imager Bands*

Product Overview: Several variables (i.e., temperature, water vapor, and other physical and microphysical parameters) from the 0000 UTC NSSL 4-km WRF-ARW runs are sent to CIMSS and CIRA where the synthetic imagery is generated and available daily starting at 1200 UTC. The best use of the product is to compare the morning simulated imagery (1200-1500 UTC) with that of the observed to determine if the model has similar timing and location of meteorological features (e.g., shortwaves, jet streaks, etc.). If they are similar, then confidence should increase that the remaining model forecast output is a viable solution. The 10.35 minus 3.9 μm fog product discriminates low-level clouds from high clouds and the 10.35 minus 12.3 μm band difference can indicate areas of moisture convergence and/or pooling.

Product Strengths:
• Satellite imagery can be viewed before the simulated time actually occurs.
• Multiple water vapor bands allow different atmospheric levels to be viewed.
• Realistic depictions of GOES-R ABI imagery.

Product Weaknesses:
• Synthetic imagery is only as accurate as the model forecast.

Products to be displayed within N-AWIPS:
• Band 8 (6.19 μm): Upper-level Tropospheric Water Vapor
• Band 9 (6.95 μm): Upper/Mid-level Tropospheric Water Vapor
• Band 10 (7.34 μm): Lower/Mid-level Tropospheric Water Vapor
• Band 11 (8.5 μm): Cloud-top Phase
• Band 12 (9.61 μm): Ozone
• Band 13 (10.35 μm): Clean Infrared Longwave
• Band 14 (11.2 μm): Infrared Longwave
• Band 15 (12.3 μm): Dirty Infrared Longwave
• Band 16 (13.3 μm): CO2 Infrared Longwave
• 10.35 minus 3.9 μm (low-level cloud and fog detection)
• 10.35 minus 12.3 μm (low-level water vapor convergence detection)

Training Resources:
• http://rammb.cira.colostate.edu/visit/video/goesr101/player.html

•http://rammb.cira.colostate.edu/training/visit/training_sessions/synthetic_imagery_in_forecasfore_severe_weather/video/

Real-Time Web Access:
• http://cimss.ssec.wisc.edu/goes_r/proving-ground/nssl_abi/nssl_abi_rt.html

GOES-R Product: *University of Wisconsin CIMSS NearCasting Model*

Product Overview: Hourly initializations of the NearCasting Model use information from the GOES-13 sounder water vapor channels to help define regions most susceptible to convection for the following 9 hours. This technique initializes a trajectory model with Rapid Update Cycle (RUC) winds and GOES-13 sounder precipitable water observations at different levels. The retrieval uses the three water vapor channels: 10 (7.4 μm), 11 (7.0 μm), and 12 (6.5 μm). Although the exact level is a function of the air mass and satellite-viewing angle, the weighting function from channel 10 typically peaks around 600 or 700 mb and channel 12 peaks closer to 400 mb. Using the three channels, the distribution of water vapor in the low to middle portion of the atmosphere can be defined. The model can predict areas of destabilization (convective potential) if "low" level moisture is below "upper" level drying. Difference fields are represented as a moisture change with height. If a region has moisture decreasing with height (negative values), then that region is convectively unstable.

Product Strengths:
- Available within minutes of observation times and frequently updated (hourly).
- Uses GOES sounder observations that are not included over land in traditional NWP models.
- Valuable tool to validate and diagnose the accuracy of NWP output fields.
- Fills the data gap between short-range observations and long-range NWP guidance.
- Although initial observations are limited to clear-air regions, the NearCasting technique moves data into areas that can later become obscured by clouds.

Product Weaknesses:
- Initial observations are limited to clear-air regions.
- RUC model winds used for initializations can include significant initial adjustment noise and must be smoothed.

Products to be displayed within N-AWIPS:
- Vertical theta-e difference
- 500-mb mean-layer theta-e
- 780-mb mean-layer theta-e
- Vertical precipitable water difference
- 500-mb mean-layer precipitable water
- 780-mb mean-layer precipitable water
- Vertical precipitable water gradient difference
- Long-lived Convection Index

Training Resources:
- http://hwt.nssl.noaa.gov/Spring_2011/EUMETSAT_2010_Petersen_NearCasting_Text.pdf

Real-Time Web Access:
- http://cimss.ssec.wisc.edu/model/nrc/

GOES-R Product: *WRF / HRRR Lightning Threat Forecast*

Product Overview: The WRF and HRRR Lightning Threat Forecast is a model-based method for making quantitative forecast fields of lightning threat. The algorithm uses microphysical and dynamical output from high-resolution, explicit convection runs of the WRF and HRRR Models. Two separate proxy fields are used to assess lightning flash rate density and areal coverage, based on storms simulated by the models. One lighting threat field is based on the flux of large precipitating ice (graupel) in the mixed phase layer near -15C and has been found to be proportional to lightning flash peak rate densities while accurately representing the temporal variability of flash rates during updraft pulses. The second lightning threat field, based on vertically integrated ice hydrometeor content in the simulated storms, has been found to be proportional to peak flash rate densities while also providing information on the spatial coverage of the lightning threat, including lightning in storm anvils. Finally, a composite threat is created by blending the two aforementioned lightning threat fields after adjustments are made to account for the differing sensitivities of the two basic threats to the specific configuration of the WRF and HRRR models.

Product Strengths:
- Based on observations of lightning physics which should be robust and regime-independent.
- Provides quantitative estimates of flash rate fields.
- Fast and simple diagnostic tool.
- Designed to use gridded proxy fields.

Product Weaknesses:
- Method is only as good as the model output.
- 4-km WRF has a tendency to under-represent updrafts

Products to be displayed within N-AWIPS:
- Hourly Max Lightning Threat 1 (Graupel Flux at -15C)
- Hourly Max Lightning Threat 2 (Vertically Integrated Ice)
- Hourly Max Lightning Threat 3 (Combination of Lightning Threat 1 & 2)

Training Resources:
- http://weather.msfc.nasa.gov/sport/training/lfa/LFAtraining_20111025.pdf

Real-Time Web Access:
- http://rapidrefresh.noaa.gov/hrrrconus/

GOES-R Product: *University of Wisconsin CIMSS Cloud-Top Cooling (CTC)*

Product Overview: The UWCI-CTC experimental satellite-based products are used to diagnose and nowcast convective initiation and convective cloud-top cooling rate. The UWCI-CTC algorithm uses GOES imager data to determine immature convective clouds that are growing vertically and hence cooling in infrared satellite imagery. Additionally, cloud phase information is also utilized to deduce whether the cooling clouds are immature water clouds, mixed phase clouds, or ice-topped (glaciating) clouds.

Product Strengths:
- Diagnoses developing convective clouds in clear, partly cloudy, or cirrus (day only) scenes.
- Algorithm is day/night independent because it only uses infrared channels.
- Small time latency, product is available approximately 2 minutes after initial code execution.
- Operates on both rapid (7.5 min) and operational (15 to 30 min) scanning patterns.
- Large spatial coverage (eastern 2/3 of CONUS).
- As much as 60 minute lead-time before significant radar echoes/cloud to ground lightning.
- Validation of algorithm shows low false alarm rate within SPC risk areas (26%).

Product Weaknesses:
- Fast moving clouds can occasionally induce false alarms.
- False alarms may increase with GOES 30 min resolution full-disk scans.
- Radar echo/cloud to ground lightning lead time may be small with rapidly developing thunderstorms

Products to be displayed within N-AWIPS:
- Instantaneous box-averaged cloud-top cooling rate (K $(15\ \text{min})^{-1}$)

Training Resources:
- http://www.goes-r.gov/products/opt2-convective-initiation.html

Real-Time Web Access:
- http://cimss.ssec.wisc.edu/snaap/convinit/quicklooks/?products=vis,irw,instctc&datetime=LATEST&action=view_fader&region=east&autorefresh=yes

GOES-R Product: *UAH Convective Initiation SATCAST*

Product Overview: The University of Alabama in Huntsville (UAH) is developing a proxy product similar to the one they produced for the GOES-R Algorithm Working Group (AWG) official algorithm called SATellite Convection Analysis and Tracking (SATCAST). Beginning in late 2008 through 2009, UAH developed an object tracking methodology that will exploit the high temporal resolution data from GOES-R. Since the current GOES does not have the temporal resolution of GOES-R, the GOES-R CI algorithm cannot operate optimally with the current GOES instrument's 15-min refresh rate. In order to provide more accurate object tracking, a combination of overlap and mesoscale atmospheric motion vectors methodologies have been employed with great success. This addition allows for accurate object tracking with up to a 15-minute and, sometimes, 30-minute temporal resolution. The advantages of the object based SATCAST is that it can monitor object sizes down to 1 pixel, and easily track cloud objects between consecutive satellite scans for validation purposes. The algorithm has recently undergone an enhancement that will provide forecasters with a "Strength of Signal" (SS) output. This method applies a linear regression approach to combine information from all available GOES IR channels into a single numerical value on a scale from 0 to 100, giving a sense for how strong the satellite-retrieved signal is for the development of cloud objects between the previous two GOES satellite scans.

Product Strengths:
- Can monitor object sizes down to 1 pixel.
- Easily track cloud objects between consecutive satellite scans for validation purposes.
- Strong strength of signal can be used as situational awareness for convective development.

Product Weaknesses:
- The algorithm will not operate in areas of cirrus clouds.
- False signals of vertical development may occur from newly forming clouds.
- Night time processing is still hindered by a decreased quality cloud mask.

Products to be displayed within N-AWIPS:
- Strength of Signal (0-100)

Training Resources:
- not available

Real-Time Web Access:
- http://www.nsstc.uah.edu/~jwalker/UAH_SATCASTv2_CI_VIS.png

GOES-R Product: *Enhanced-V / Overshooting Tops*

Product Overview: Overshooting tops (OTs) are the product of deep convective storm updraft cores of sufficient strength to rise above the storms' equilibrium level near the tropopause region and penetrate into the lower stratosphere. Thunderstorms with OTs frequently produce hazardous weather at the Earth's surface such as heavy rainfall, damaging winds, large hail, and tornadoes. The GOES-R OT product identifies clusters of pixels significantly colder than the surrounding anvil cloud with a diameter consistent with commonly observed OTs. Turbulence and cloud-to-ground lightning are found to occur most frequently near the OT region, indicating that OTs represent significant hazards to ground-based and in-flight aviation operations. Thunderstorms with an enhanced-V and strong anvil thermal couplet signature in infrared satellite imagery have been shown to be especially severe. The enhanced-V signature can appear 30 minutes before the onset of severe weather on the ground, thus providing a forecaster with crucial warning lead-time.

Product Strengths:
- More consistent day/night OT detection capability with greater accuracy than existing algorithms.
- Small time latency.
- Algorithm is flexible and can be operate in rapid scan and operational scanning patterns.
- Product shows strong relationships with cloud-ground lightning, aircraft turbulence, maximum in-storm radar reflectivity, and surface severe weather reports.

Product Weaknesses:
- OTs are not well detected in storms with limited (< 8 km) anvil extent.
- Marginal OT events with little to no horizontal IR BT gradient will not be detected.
- Very cold, non-convective cirrus plumes with significant texture in the IR BT field may be misclassified as an OT.

Products to be displayed within N-AWIPS:
- Enhanced-V (thermal couplet) detection
- Overshooting top detection
- Probability of turbulence
- Probability of cloud-to-ground lightning
- Probability of severe weather at surface

Training Resources:
- http://rammb.cira.colostate.edu/training/visit/training_sessions/objective_overshooting_top_and_thermal_couplet_detection/video/
- http://cimss.ssec.wisc.edu/snaap/overshootingtop/
- http://www.goes-r.gov/products/opt2-enhanced-V.html

Real-Time Web Access:
- http://cimss.ssec.wisc.edu/snaap/convinit/quicklooks/?products=vis,irw,overtop&datetime=LATEST&action=view_fader&region=east&autorefresh=yes

GOES-R Product: *NASA SPoRT Pseudo-Geostationary Lightning Mapper*

Product Overview: A GOES-R Pseudo-Geostationary Lightning Mapper (PGLM) demonstration product takes the raw total lightning observations, or sources, from any of the ground-based Lightning Mapping Array (LMA) networks available and recombines them into a flash extent gridded field. These data are mapped to a GLM resolution of 8 km and will be available at 1 or 2 min refresh rate, depending on the ground-based network being used. With the flash data, when a flash enters a grid box, the flash count will be increased by one. Also, no flash is counted more than once for a given grid box. The pseudo GLM is not a true proxy data set for the GLM as it does not attempt to create a correlation between the VHF ground-based networks and the eventual optical-based GLM (individual events, groups, flashes at 20 second latency). However, the pseudo GLM product will give forecasters the opportunity to use and critique a demonstration of GLM type data to help improve future visualizations of these data. Additionally, experience gained using LMA-based 8-km products will serve as an idea farm and reference for comparison with full GLM proxies and derived products.

Product Strengths:
- Can be used as lightning situational awareness tool.
- Thunderstorms can be electrically active without the presence of cloud-to-ground strikes.
- Total lightning increases as the thunderstorm updraft strengthens.
- Pseudo GLM product will give forecasters the opportunity to use and critique a demonstration of GLM type data to help improve future visualizations of these data.

Product Weaknesses:
- Only 5 ground-based networks are available to create the PGLM: Washington D.C., West Texas, Oklahoma, North Alabama, and Central Florida.
- The pseudo GLM is not a true proxy data set for the GLM as it does not attempt to create a correlation between the VHF ground-based networks and the eventual optical-based GLM.

Products to be displayed within N-AWIPS:
- Total lightning flash extent density

Training Resources:
- http://weather.msfc.nasa.gov/sport/training/pseudo_GLM/launcher.html

Real-Time Web Access:
- not available

GOES-R Product: *Low Cloud and Fog*

Product Overview: The GOES-R fog/low cloud detection products are designed to quantitatively (expressed as a probability) identify clouds that produce Instrument Flight Rules (IFR) conditions (ceiling < 1000 ft and/or surface visibility < 1 mile). Both satellite and NWP model data are used as predictors and ceilometer-based surface observations of cloud ceiling are used to train the classifier. During the day, the 0.65, 3.9, and 11 μm channels (in various ways) along with boundary-layer relative humidity information from the NWP model are used as predictors. A similar approach is utilized at night without the 0.65 μm channel. Either global or regional NWP models can be used, depending on the availability (the Rapid Refresh model is used over CONUS).

Product Strengths:
- Replaces the commonly-used qualitative 3.9-11 μm brightness temperature difference method for detecting fog/low stratus that can only be used during the night.
- Comparisons to surface observations indicate that the GOES-R IFR probability product greatly outperforms the traditional 3.9 – 11 µm brightness temperature difference.
- Provides a quantitative probability that each non-ice pixel contains fog/low stratus clouds (MVFR criteria of cloud ceiling < 3000 ft).
- The GOES-R low cloud / fog algorithm is available during both day and night (except in the small terminator region where the day/night transition occurs).
- Products are generated within minutes of receiving satellite data.

Product Weaknesses:
- There is usually a recognizable "boundary" around the U.S. where the GOES-R products significantly change between neighboring pixels due to the spatial limit of the RUC/RAP model.
- At certain times of the year around 4 - 7 UTC, a 3.9 μm stray-light correction will cause the GOES IFR probabilities to artificially increase in some locations for a short period of time.
- The primary limitation of the GOES-R approach is that some discontinuity will be associated with the transition from sunlit to non-sunlit conditions and vice-versa.

Products to be displayed within N-AWIPS:
- Probability of IFR conditions
- Cloud thickness
- Cloud-top phase

Training Resources:
- http://cimss.ssec.wisc.edu/~mpav/GOES-R_FLS_training_05232012.pptx

Real-Time Web Access:
•http://cimss.ssec.wisc.edu/geocat/index.php?view=animation&region=goes_east_2_conus&products[]=goesr_IFR_fog_prob