GOES-R Nowcasting Initiatives

Dr. Steven Goodman
GOES-R Program Chief Scientist
NOAA/NESDIS

WGNR Meeting
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14-15 August, 2014
Mission Objectives - Why GOES-R?

The GOES-R Series will provide significant improvements in the detection and observations of meteorological phenomena that directly impact public safety, protection of property, and our Nation’s economic health and prosperity.

- Improves hurricane track & intensity forecasts
- Increases thunderstorm & tornado warning lead time
- Improves aviation flight route planning
- Data for long-term climate variability studies

- Improves solar flare warnings for communications and navigation disruptions
- More accurate monitoring of energetic particles responsible for radiation hazards to humans and spacecraft
- Better monitoring of Coronal Mass Ejections to improve geomagnetic storm forecasting
GOES-R Science Program

http://www.goes-r.gov/users/risk-reduce/index.html

GOES-R Risk Reduction - Fiscal Year 2014 New Starts

Towards providing forecasters with better identification and analysis of severe pyroConvection events using GOES-R ABI and GLM Data
Principal Investigators: Bryan Baum (CIMMS), Scott Bechmeier (CIMMS)
Proposal Abstract | Proposal Summary

Towards an operational use of stroke level lightning data in severe weather forecasting
Principal Investigators: Phillip Bitzer and Lawrence Caray (Univ. of Alabama-Huntsville)
Proposal Abstract | Proposal Summary

Satellite Product Analysis and Distribution Enterprise System (SPADES)
Principal Investigator: William Denig (NESDIS-NGDC)
Proposal Abstract | Proposal Summary

Using total lightning data from GLM/GOES-R to improve real-time tropical cyclone genesis and intensity forecasts
Principal Investigators: Alexander Fierro (CIMMS) and Mark DeMaria (NWS-NHC)
Proposal Abstract | Proposal Summary

Development of GOES-R ABI Hot Validation and Assessment Products
Principal Investigators: Kevin Galle (NESDIS-STAR), Phil Schumacher (NWS-Sioux Falls WFO), Josh Boustead (NWS -Omaha WFO)
## GOES-R 2014 Risk Reduction Awards

### High Impact Weather Projects

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### High Impact Weather Projects

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$Pending Available Funds
Introducing NWS Forecasters to Prototype GOES-R Products

- Synthetic GOES-R products ABI products are being demonstrated at NOAA testbeds and GOES-R Proving Ground
- Synthetic GOES-R ABI products help forecaster readiness on day one
- Facilitates user training

CAPE- an example of Derived Stability Indices indicates a strong instability axis extending into the high plains east of the Rockies.
Tool to Generate GOES-R ABI Synthetic Aerosol Products

WRF-CMAQ simulated aerosol fields were provided as input to CRTM (Community Radiative Transfer Model) to generate top of the atmosphere radiances at 6 ABI bands.

High AOD due to smoke from fires in Colorado

Haze in the southeast US

Simulated radiances at 6 ABI bands are provided as input to aerosol retrieval algorithm to generate aerosol optical depth (AOD) and aerosol detection products.
GOES-R ABI Aerosol Detection Algorithm Testing on VIIRS Data for a Multi-day Fire Event in Alaska
Volcanic Ash Prediction

2010 Eyjafjallajokull volcanic eruption

Ash Detection product (left) and Ash Loading (right) using the GOES-R Volcanic Ash Algorithm applied to Meteosat-9/SEVIRI data¹ (From Mike Pavolonis, NESDIS/STAR, and Justin Sieglaff, CIMSS)

¹http://www.goes-r.gov/products/baseline-volcanic-ash.html
M. Pavolonis gave the NOAA perspective; the VAACs in Washington and Anchorage have responsibility for large areas. NOAA also operates Met Watch Offices. Algorithm development at NOAA aims at exploiting all sensors in orbit, that is, for volcanic ash detection, both LEO and GEO-based instrumentation is being used based on an optimal estimation approach, including Bayesian classifiers and general cost function. In addition, a near-real time volcanic eruption alert system is in place, exploiting the presence of rapidly changing gradients in satellite imagery during an eruption.

M. Pavolonis indicated that, internationally, the biggest single weakness with VAACs was that major eruptions could occur and remain undetected for hours, especially in unexpected places.
Aviation Baseline Product: Volcanic Ash Product Suite

- Chile's Puyehue-Cordón Caulle Volcano erupted on June 4, 2011, forming a tall ash plume above the Andes Mountains.

- The GOES-R Proving Ground provides near real-time volcanic ash retrieval products (using Meteosat SEVIRI data as a proxy for the GOES-R Advanced Baseline Imager) to identify a significant volcanic ash plume emerging over the Atlantic Ocean impacting aviation operations with many cancelled flights.

- Similar data was provided to the London Volcanic Ash Advisory Center (VAAC) during the eruption of Eyjafjallajökull in Iceland in May 2010.

Reliance on manual analysis of satellite images from a single sensor means that volcanic ash advisories and volcanic SIGMETS are not always timely and accurate!

Nabro volcano in Eritrea erupted for the first time in recorded history on June 12, 2011 at ~20:30 UTC, injecting volcanic ash and dangerous concentrations of SO₂ high into the atmosphere.

The first VAA was issued at 04:00 UTC on June 13 (~7.5 hours after the start of the eruption!)

VA ADVISORY
DTG: 20110613T0000Z
VAAC: TOULOUSE
VOLCANO: DUBBI 0201-10
PSN: N1335 E4148
AREA: ETHIOPIA
SUMMIT ELEV: 1025M
ADVISORY NR: 2011/01
INFO SOURCE: METEDSAT IMAGERY
AVIATION COLOUR CODE: UNKNOWN
ERUPTION DETAILS: ERUPTION STARTED AROUND 23UTC
OBS VA CLD: FL150/300 N1335 E4145 - N1440 E0345 - N1625 E0345 - N1330 E4145
FCST VA CLD = 06: 13/0900Z
FCST VA CLD = 12H: 13/1500Z
FCST VA CLD = 18H: 13/2100Z
RMK: PLEASE CHECK SIGMET FOR CURRENT WARNINGS.

The height estimate for this cloud was also severely underestimated.
Automated alert would have been issued after 20:45 UTC image on June 12, 2011

**VOLCANIC ALERTS**

**STARTING DATE/TIME OF IMAGE:** 2011-06-12 20:45:00 [UTC]
**PRIMARY INSTRUMENT:** Meteosat-9 SEVIRI
**WMO SPACECRAFT ID:** 999
**LOCATION/ORBIT:** GEO
**L1 FILE:** met9_1_2011_163_2045.area.gzi
**VOLCANO DATABASE:** /data/common/VOLCAT_DATA/alerts/Volcat Alerts
**NUMBER OF ASH CLOUD ALERTS:** 0
**NUMBER OF VOLCANIC Cb ALERTS:** 1
**NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS:** 0
**NUMBER OF SO2 CLOUD ALERTS:** 0

**REPORT WITH IMAGES:**
http://volcano.ess.wisc.edu/alert/report/10621

**POSSIBLE VOLCANIC ERUPTION DETECTED**

**Alert Status:** New Alert Object
**Latitude of Radiative Center:** 13.371 [degrees]
**Longitude of Radiative Center:** 41.508 [degrees]
**Mean Viewing Angle:** 50.49 [degrees]
**Mean Solar Zenith Angle:** 142.87 [degrees]
**Nearby Volcanoes (meeting alert criteria):**
- Maelalhe (19.32 km)
- Nabro (20.02 km)
**Maximum Height (AMSL):** 16.5 [km] (54106.97 [ft])
**90th Percentile Height (AMSL):** 15.5 [km] (50710.42 [ft])
**Mean Tropopause Height (AMSL):** 16.5 [km] (54099.02 [ft])
**Trend in IR Brightness Temperature:** -45.26 [K]
**Vertical Growth Rate Time Interval:** 15 [minutes]
**Vertical Growth Rate Anomaly:** 7.45 [number of stddev above mean]
**Total Area:** 720.09 [km²]

**Geographic Regions of Nearby Volcanoes:** Ethiopia
**VAAC Regions of Nearby Volcanoes:** Toulouse
**FIIR Regions of Nearby Volcanoes:** Unknown

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**Annotation Key**

(Annotation colors are not related to colors in underlying image)

- Ash/Dust Cloud
- Volcanic Cb
- SO2
- Thermal Anomaly
Subscriptions to the experimental NOAA volcanic cloud alerting system will be more broadly available in 2014.
Ash probability determined from satellite observations alone

MET-9 SEVIRI (04/16/2010 - 18:00 UTC)
Ash probability determined from PUFF simulations alone (Bursik et al., 2012)
Ash probability determined from satellite + PUFF simulations alone

MET-5 SEVIRI (04/16/2010 - 18:00 UTC)
New RGB Recipe for Discriminating Blowing Dust
Photo from Eastern Colorado midday on 29 April
GOES-14 SRSOR 1-min Super Rapid Scan Experiment
GOES-R Demonstrations at NOAA Testbeds and Proving Grounds
(http://cimss.ssec.wisc.edu/goes/srsor2014/GOES-14_SRSOR.html)

• Dates:
  • May 8-22, 2014
  • August 14-28, 2014

• Target Locations:
  • Norman, OK- NEXRAD, MPAR, OKLMA (primary site)
  • Huntsville, AL- NEXRAD, UAH dual-pol radars, NALMA
  • Sterling, VA- NEXRAD, TDWR, DCLMA
  • Fort Collins, Colorado- NEXRAD, CSU-CHILL, NCLMA
  • Melbourne/KSC, FL- NEXRAD, LDAR II
  • IPHEX/Hydrometeorology Testbed - GPM validation campaign
  • Atlantic Ocean/GulfMex Basin- NASA EV-1 Hurricane and Severe Storm Sentinel-HS3 science flights
GOES-14 1-min Imagery

Click to animate hyperlink
GOES-R Rapid Refresh - 1-min Imagery and Lightning

Derecho/Lightning/Tornado (June 13, 2013)

Courtesy of Scott Rudlosky, CICS-MD
- “This helped me to determine the flow of a boundary that was feeding directly into the main boulder storm which lead to the idea that extra baroclinic spin could have added to a decision for TOR warning when the cell had matured.”
- “… we could clearly see the convergence zone forming east of a convective cell.”
- “If 1-min data was available all the time, I would definitely use satellite data more when diagnosing storms in normal operations back in my WFO.”
- “This has provided extra confidence and lead time for the issuance of two mesoscale discussions compared to the normal satellite update frequency, latency.”
- “In the pre-storm environment, these data were especially helpful in monitoring the vertical growth of cumulus convection and in the identification of boundaries.”
- “With weakly forced, nebulous low-level boundaries over the Northeast today, the ability to see where boundary layer cumulus is deepening and clumping in this manner is quite striking.”

“Satellite imagery at 1-min temporal resolution needs to become the new standard for severe weather operations.”
GOES-14 SRSOR Intensive Observation Period

GOES-R Proving Ground Demonstrations at Aviation Weather Center and Hazardous Weather Testbed

- Dates: 11 August - 8 September, 2014
- Objectives: Optimal use of ABI scan modes, rapid refresh imagery and products, blended ABI-GLM, satellite, radar, NWP
- Target Locations:
  - Norman, OK- NEXRAD, MPAR, OKLMA (primary site)
  - Huntsville, AL- NEXRAD, UAH dual-pol radars, NALMA
  - Sterling, VA- NEXRAD, TDWR, DCLMA
  - Fort Collins, Colorado- NEXRAD, CSU-CHILL, NCLMA
  - Melbourne/KSC, FL- NEXRAD, LDAR II
  - Atlantic Ocean/GulfMex Basin- NASA EV-1 Hurricane and Severe Storm Sentinel-HS3 science flights
AMVs in High Impact Weather

• Adapt the GOES-R AMV tracking algorithm to focus on the smaller (meso) scales for AMV derivation, quality control, and applications and coincident with periods of GOES rapid-scan operations.

• Optimize the algorithm settings, tuning, and AMV derivation path to increase the data density and improve the ultimate quality.

• Run the refined GOES-R AMV algorithm using proxy datasets, such as available from routine GOES RSO/SRSO periods, and from recent special GOES-14 1-min scanning periods (i.e., Hurricane Sandy). Prepare the AMV datasets for trial assimilation into operational regional models.

• Collaborate with national centers of expertise in regional data assimilation and NWP (NCEP-EMC, JCSDA, ESRL) to conduct AMV impact experiments on jointly-selected cases of interest (high-impact weather events, model forecast busts, tropical cyclones, etc.).

• Post-launch real-time demonstrations in Year 3

C. Velden (CIMSS)
GOES-13 Winds Using GOES-R Clear-Sky Mask, Cloud and Derived Motion Winds (DMW) Algorithms

Significance: Early demonstration of GOES-R algorithms using current operational GOES imagers. Plans and work in place to replace existing operational GOES cloud and DMW algorithms with GOES-R algorithms.

Cloud-drift winds derived from 15-min GOES-13 11um imagery 1000 UTC 22 April 2012 – 0800 UTC 23 April 2012

Cloud-drift winds derived from 15-minute GOES-13 LWIR (11um) imagery over Hurricane Sandy (4-day loop)

Courtesy of Chris Velden, CIMSS
AMVs in High Impact Weather

Atmospheric Motion Vectors from GOES-R
Proxy: AMVs from special GOES-14 super-rapid-scan ops during Hurricane Sandy

Low-Level (700-950 hPa) Vectors from VIS

AMVs from 15-min images (routine GOES sampling)
1800 UTC 26 Oct, 2012
C. Velden (CIMSS)

AMVs from 1-min images (meso GOES-R sampling)
1800 UTC 26 Oct, 2012
C. Velden (CIMSS)

VIS/IR cloud-tracked winds from 5-min image intervals derived using the current NESDIS operational AMV algorithm. Tests using the new GOES-R tracking algorithm are underway. Data assimilation and model forecast impact experiments are planned.
C. Velden (CIMSS)
Nowcasting Demonstrations at the NOAA Hazardous Weather Test Bed

Using Probability of Severe to help issue Warnings

It has been a very active day with storms over our warning area. The Prob. of Severe tool really helped me focus in on the storms that were more intense and then I was able to use Dual-Pol info to help verify and issue the warnings. I was able to observe that the Prob of Severe as it followed the strengthening and thus weakening of the individual storms. As you can see from above...when they turned the hot pink color..is normally when I was issuing the warning and actually allowed the warnings to expire when they started to drop down to the gray color. This also verified with storm spotter data so I find this tool very useful and I really like it. ~Vollmar

1 Minute Satellite Feed

Today the GOES-14 BRDGR is updating at one minute intervals. This provides an excellent opportunity to see how quickly cloud tops develop, even well before the radar updates. In the first image you can see the vort in the circled area. The general area is the same area in which clouds have already developed and are beginning to see upper level winds.

Updated: Showers and thunderstorms have initiated in the same area that satellite feed was showing the high tops. The one minute feed gave great lead time in this instance.

Jared Maples
1-min Imagery

- Integrated 1-minute imagery (when available), CTC, OTD and NearCast into SPC operations (at least 11 MD’s).
  - Forecasters have used these products in their decision-making, and have provided me with operational examples.

“DISCUSSION...TRENDS IN REGIONAL RADAR IMAGERY...LIGHTNING DATA...AND CIMSS GOES-R CLOUD TOP COOLING AND OVERSHOOTING TOP PRODUCTS INDICATED CONVECTION AND EMBEDDED TSTMS CONTINUING TO INCREASE IN COVERAGE AND INTENSITY SINCE 1930Z ACROSS NORTHEAST TX TO SWRN AR.”
1-minute Imagery in SPC

- Feedback from SPC forecasters and HWT participants has been helpful in starting to identify the operational significance of raw 1-minute imagery.

“Using cloud character and trends to diagnose boundary locations and motion…”

“… allowed for careful analysis of overshooting and collapsing thunderstorm tops, the character of storm anvils (ie. the health of the storm) and the identification of convectively generated outflows.”

“Satellite imagery at 1-minute resolution needs to become the new standard for severe weather operations.”
Nowcast Challenges

- Water cannon of data
  - Not just satellite (radar, NWP, etc)
  - Must display data in an understandable manner so forecasters can more easily assimilate it into their decision-making process
- Must identify satellite products that add information not already available to the forecaster

- Plans to incorporate JPSS and other polar data into SPC operations- and blend with geostationary satellite data offers additional application opportunities
Future Capability Products...

...Fog and Low Stratus
Future Capability Products...

...Fog and Low Stratus
Future Capability Products...

...Probability of Convective Initiation (i.e., 35 dBZ)
Future Capability Products...

...Probability of Convective Initiation (i.e., 35 dBZ)
Use of GOES–R Data to Improve Convective Initiation Forecasting

Assimilation of GOES-R cloud-top cooling rates provides more realistic short-range forecast of convective initiation and development.

Courtesy of John Mecikalski, UAH
Future Capability Products...

...Probability of Severe Convection
Future Capability Products...

...Probability of Severe Convection

0.0015 SVS Valid 22:08Z Tue 27 May 14 Thru 22:45Z Tue
SVR PROB: 95%
- Env MUCAPE: 2712 J/kg
- Env EBShear: 25.6 kts
- MRMS MESH: 2210Z 3.26 in.
- Norm Vert Growth Rate (Max): 1725Z 1.60%/min (strong)
- Glaciation Rate (Max): 1815Z 0.03/min (moderate)
52.5dBZ

...Probability of Severe Convection
ProbSevere, Test Warnings, & Dual-Pol Variables
(20 May 2138 UTC)
ProbSevere, Test Warnings, & MRMS Composite Z (20 May 2142 UTC)
ProbSevere, Test Warnings, & Z
(20 May 2225 UTC)
Future Capability Products...

...Overshooting Top Detection
2014 HWT Takeaways

http://hwt.nssl.noaa.gov/ewp/

• Products with limitations this week
  – GOES-R Convective Initiation
    • Had to “calibrate to” each day
    • Many false alarms amidst cumulus field
  – vLAPS
    • Tended to overestimate Composite Z
    • CAPE fields were generally accurate predictors over land
2014 HWT Takeaways

• New products almost ready for operations
  – ProbSevere
    • Trends on target
    • Struggles with mature cells
  – NearCast
    • Predicted area of convective instability well
    • Possibly add an interpolation toggle ability to fill gaps in with NWP
2014 HWT Takeaways

- Get this to my office “yesterday”!
  - Lightning Flashes & Lightning Jump Algorithm
    - Increases confidence in severity of storms
    - Provided information about updraft health
  - Super-Rapid Scan Operations (SRSOR) Imagery
    - Used to observe key storm-scale features; 1-min temporal resolution made this possible
  - Simulated Satellite Imagery
    - Comparison to reality raised or lowered confidence in using model
    - When on-track, predicted areas of storm development
Summary

http://cimss.ssec.wisc.edu/goes/srsor2013/GOES-14_SRSOR.html

- Launch Readiness Date- 1st Quarter 2016
- User Readiness Components-
  - User System
  - Risk Reduction
  - Proving Ground
  - Training
- Products available for testing 40 days after launch, available to users for science assessment/validation
- Program studying request for GOES-R operations following PLT
- JARS and BAMS describe SRSOR 2012, 2013 experiments
- 1-min Super Rapid Scan 2014 Experiment- May 14-25, August 14-28
Thank you!

For more information visit www.goes-r.gov