January 2010

GOES-R Aviation Products

Enhanced-V and Overshooting Top Detection

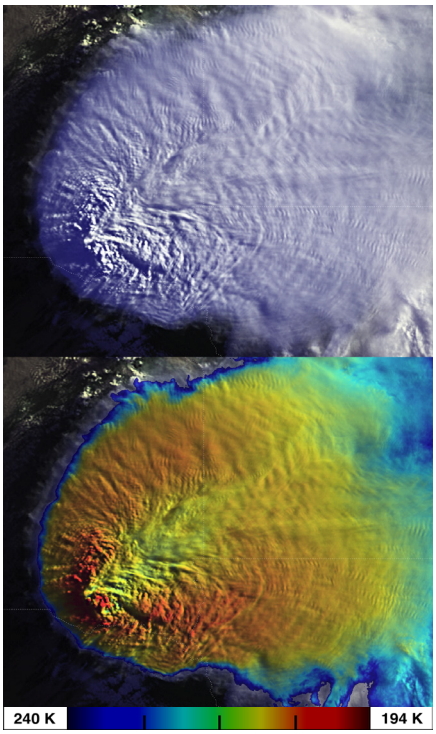
What Is GOES-R?

The Geostationary Operational Environmental Satellite - R Series (GOES-R) is the next generation of National Oceanic and Atmospheric Administration (NOAA) geostationary Earth-observing systems. Superior spacecraft and instrument technology will support expanded detection of environmental phenomena, resulting in more timely and accurate forecasts and warnings. The Advanced Baseline Imager (ABI), a sixteen channel imager with two visible channels, four near-infrared channels, and ten infrared channels, will provide three times more spectral information, four times the spatial resolution, and more than five times faster temporal coverage than the current system. Other advancements over current GOES capabilities include total lightning detection (in-cloud and cloud-to-ground flashes) and mapping from the Geostationary Lightning Mapper (GLM), and increased dynamic range, resolution, and sensitivity in monitoring solar X-ray flux with the Solar UV Imager (SUVI). GOES-R is scheduled for launch in 2015.

Why Are Overshooting Tops and Enhanced-V Signatures Important?

An overshooting convective cloud top is a domelike bulge atop an anvil cloud indicating a strong updraft within a convective storm system. Despite their relatively small size and short duration, storms with prominent overshooting tops (OTs) often produce hazardous weather conditions such as en-route turbulence, frequent lightning, heavy rainfall, and damaging winds at the ground.

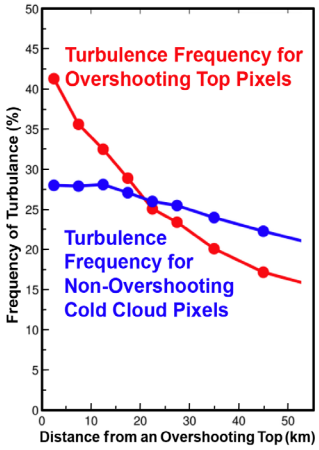
The enhanced-V signature resembles a V- or U-shaped area of cold infrared brightness temperatures (BT) that enclose an area of warm BT downwind. Theory suggests that when the jet stream wind flow approaches an intense OT, it is diverted around the OT as if it were a solid obstacle, like water flowing around a boulder in a stream. Downwind of the OT, the air subsides and warms, producing the warm wake frequently observed in tandem with the enhanced-V. Storms with an enhanced-V are often indicative of an especially severe thunderstorm with large hail, damaging wind, and/or tornadoes. The **Enhanced-V and Overshooting Top (OT) Detection** products will increase the warning accuracy and lead time for severe thunderstorm hazards, and also reduce the injuries resulting from aircraft encounters with turbulence. From 1992 to 2001, the Federal Aviation Administration (FAA) reported 509 weather accidents related to turbulence, with nearly 23% resulting in fatal injuries.



Upper: A 1 km Advanced Very High Resolution Radiometer (AVHRR) visible channel false color composite of a tornadic thunderstorm along the South Dakota/Nebraska border on 9 July 2009. The textured area on the western side of the storm is an overshooting top. Lower: 11 µm infrared window channel BT superimposed onto the above false color composite, showing the presence of an enhanced-V signature and anvil thermal couplet downstream of the overshooting top.

How Will GOES-R Detect These Hazards?

Current thunderstorm forecasts are based on a combination of numerical weather prediction model output, upper-air observations from weather balloons, ground-based radar and wind profiling instrumentation, and satellite imagery. Satellite imagery provides critical, real-time, detailed observations

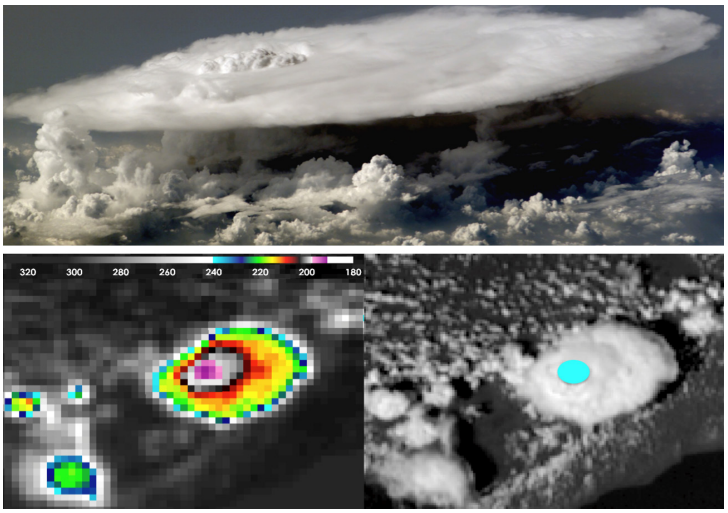


The frequency of turbulence observed when aircraft fly within varying distance from detected overshooting tops and cold pixels (IR temperature < 215 K) that do not meet the overshooting top detection criteria. Turbulence is observed significantly more often when aircraft fly very close to overshooting tops.

of rapidly changing conditions that may not be predicted by computer models or directly observed by weather radar. For example, studies have shown that the enhanced-V signature can appear 30 minutes before the onset of severe weather on the ground. GOES-R will have capabilities that make a critical difference in hazard detection: more OTs and enhanced-V's can be identified with higher spatial resolution imagery, and the improved temporal resolution will allow for earlier detection and timelier updates. In addition, increased warning lead-time of severe storms will likely occur with the improved spatial and temporal resolution of GOES-R data used in the **Enhanced-V Detection** product.

How Do These Products Work?

The OT and enhanced-V signature are inter-related as an OT must be present to obstruct the upper-level wind flow and produce the V-shaped temperature pattern. An OT often appears as a small cluster of very cold 11 μm infrared BTs surrounded by a warmer anvil cloud. Spatial gradients in an infrared BT image are computed to identify these cold pixel clusters. Clusters that are colder than a numerical weather prediction model tropopause temperature forecast are classified as OTs. After an OT is identified, the algorithm then searches for an enhanced-V signature. One near-constant feature of the enhanced-V signature is the presence of a focused area of warm IR BT downwind of the OT. The OT and downwind warm area form an "anvil thermal couplet" which can be objectively detected with much higher accuracy than the actual V- signature. In general, as the magnitude of the anvil thermal couplet associated with the enhanced-V increases, the probability of severe weather also increases. The **OT** and **Enhanced-V Detection** products operate seamlessly during both day and night using 2 km infrared (IR) window channel imagery.



Upper: An anvil cloud with overshooting top, photographed from the International Space Station, February 5, 2008. Lower: 3 km Meteosat Second Generation (MSG) Spinning Enhanced Visible and Infrared Imager (SEVIRI) 10.8 μm brightness temperature (Lower Left) and 1 km SEVIRI high-resolution visible imagery (Lower Right) at the same time as the photograph above. The cyan circle in the lower right image shows an ***Overshooting Top Detection*** *by the GOES-R ABI algorithm.*

What Are the Benefits?

Atmospheric turbulence is a major aviation hazard and prompt detection and avoidance is essential for aviation safety. The GOES-R objective **OT Detection** product will better identify locations of convectively induced turbulence at a higher accuracy and frequency than would be available through the use of current GOES imagery. This information will allow flight planners to provide warning or reroute aircraft that may be affected by turbulence. More timely and accurate identification of overshooting tops can lead to a reduction in aircraft accidents. **OT Detection** can also indicate the location of a severe storm, and **Enhanced-V Detection** will provide forecasters with more confidence in issuing severe weather warnings. The **Enhanced-V Detection** product will complement radar-based warnings and will provide significant benefit when and where radar is not available or the coverage is sparse.

Contributors: Kristopher Bedka – SSAI, Jason Brunner – CIMSS, Wayne Feltz – CIMSS, and Martin Setvak – Czech Hydrometeorological Institute

Research and Development Partners for Enhanced-V and Overshooting Top Detection

- Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin
- NOAA National Environmental Satellite, Data, and Information Service, Center for Satellite Applications and Research (NESDIS/STAR)
- Science Systems and Applications, Inc. (SSAI)
- Noblis, Inc.

On the Web

http://convection.satreponline.org/doc_bedka.php

For More Information, Contact:

GOES-R Program Office
Code 417
NASA Goddard Space Flight Center
Greenbelt, MD 20771
301-286-1355

Jim Gurka, james.gurka@noaa.gov

Steve Goodman, steve.goodman@noaa.gov