GOES-R Aviation Products

October 2009

Turbulence

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.

How Does Turbulence Affect Aviation Safety?

Atmospheric turbulence comes in many forms, from waves that occur downwind of a mountain range to convection within thunderstorms. Because of the short, episodic nature of turbulence and the difficulty in observing it directly, turbulence remains a major aviation hazard. In a recent study, the National Aviation Safety Data Analysis Center reported 548 aircraft accidents due to turbulence in the United States over a ten-year period, 115 of which involved fatalities. By providing better warnings of turbulence, we can reduce fatalities and injuries in our airspace.

How Will GOES-R Detect Turbulence?

The aviation community receives some forecasts of turbulence from numerical weather prediction models and from detecting patterns in recent pilot reports. However, satellite observations provide critical, real-time, detailed observations of rapidly changing conditions that are not predicted by computer models. Using these satellite observations, it

An anvil cloud with overshooting top, photographed from the International Space Station, February 5, 2008.

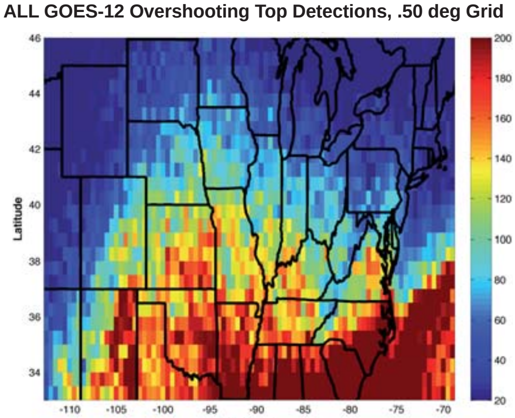
is possible to track the events that trigger severe turbulence so that flight planners can localize the area of disturbance and either provide adequate warning or reroute any vulnerable aircraft. GOES-R will have capabilities that make a critical difference in hazard detection: more turbulence-causing events can be identified with higher spatial resolution imagery, and the improved temporal resolution will allow for earlier detection and timelier updates.

There are currently two turbulence products being developed for the GOES-R Proving Ground: **The Overshooting Top Detection** product and the **Tropopause Folding Turbulence Prediction** product.

How Do These Products Work?

An overshooting convective cloud top is a domelike bulge atop an anvil cloud representing a strong updraft within the convective system. Storms with overshooting tops often produce hazardous weather conditions such as aviation tur-

April-Sept. 2004-2008 ALL GOES-12 Overshooting Top Detections, .50 deg Grid



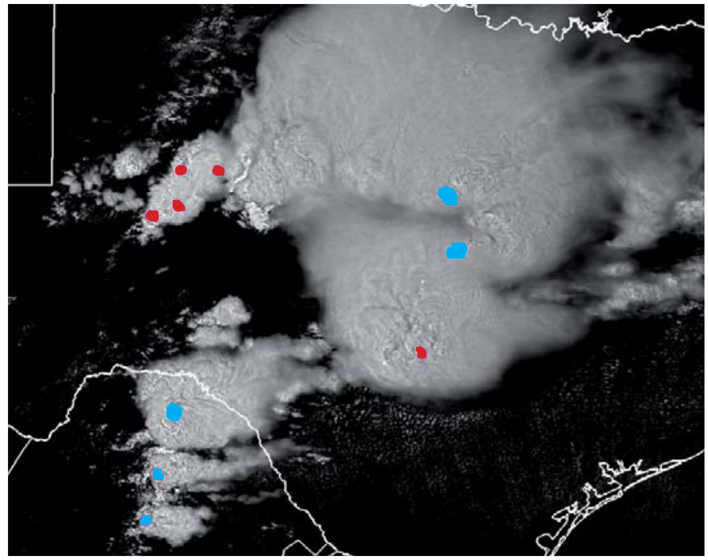
A five-year climatology of overshooting tops detected within GOES-12 infrared imagery. Warm colors indicate frequent overshooting top activity.

bulence, frequent lightning, heavy rainfall, large hail, wind shear, damaging wind (e.g., microbursts), and tornadoes.

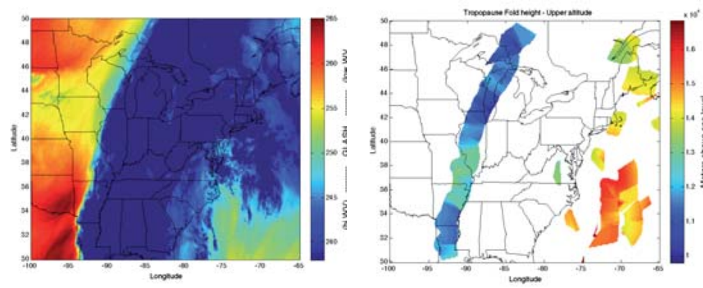
There is no real-time **Overshooting Top Detection (OTD)** product for the current GOES Imager. The **OTD** algorithm has been shown to perform with an accuracy of up to 96% and operates seamlessly during both day and night using 2 km infrared (IR) window channel imagery. The **OTD** product will provide forecasters with a new way to identify turbulent regions in the vicinity of thunderstorms.

The **Tropopause Folding Turbulence Prediction (TFTP)** product is focused on a particular type of clear-air turbulence that is generally undetectable from the aircraft cockpit or from radar, yet can cause in-flight injuries aboard commercial aircraft and even more serious hazards for smaller aircraft. Tropopause folding occurs when a layer of stratospheric air is drawn into the lower atmosphere under the path of the jet stream or an area of robust convection. The vertical stability of this air, combined with the effects of the high wind speed, causes strong turbulent eddies to develop. The location of these eddies is often associated with observations of significant in-flight turbulence.

The **TFTP** product detects the boundaries in the atmosphere where clear-air turbulence is likely to occur. While an experimental version of the **TFTP** has been in operation for several years using the GOES-12 water vapor channel, the improved spatial and temporal resolution of GOES-R will allow regions of interest to be detected earlier and with greater accuracy than with current satellites.



Overshooting top detections overlaid upon a 0.25-km resolution Moderate Resolution Imaging Spectroradiometer (MODIS) image for part of Texas on 13 July 2003; the blue dots indicate overshooting tops detected using both a current 4-km GOES-12 image and the synthetic ABI image, and the red dots indicate additional overshooting tops detected only with the high resolution 2-km synthetic ABI imagery.



Left: Water vapor concentrations retrieved from simulated GOES-R ABI water vapor image. Right: Height of areas prone to turbulence from tropopause folding, indicated by water vapor boundaries.

Research and Development Partners for Turbulence Products

- 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://cimss.ssec.wisc.edu/snaap/turbulence
http://convection.satreponline.org/doc_bedka.php

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What Are the Benefits?

Atmospheric turbulence is a major aviation hazard and prompt detection is essential for airspace safety. The advanced spatial resolution of the GOES-R ABI will provide identification of more turbulence-causing events, while the improved temporal resolution will offer earlier detection of turbulence and timelier updates. This information will allow flight planners to provide warning or reroute aircraft that may be affected by turbulence. More timely and accurate identification of turbulence can lead to a reduction in aircraft accidents resulting in injury or death.

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