Satellite-based inferences of turbulence

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Satellite products with high skill for nowcasting/forecasting turbulence:

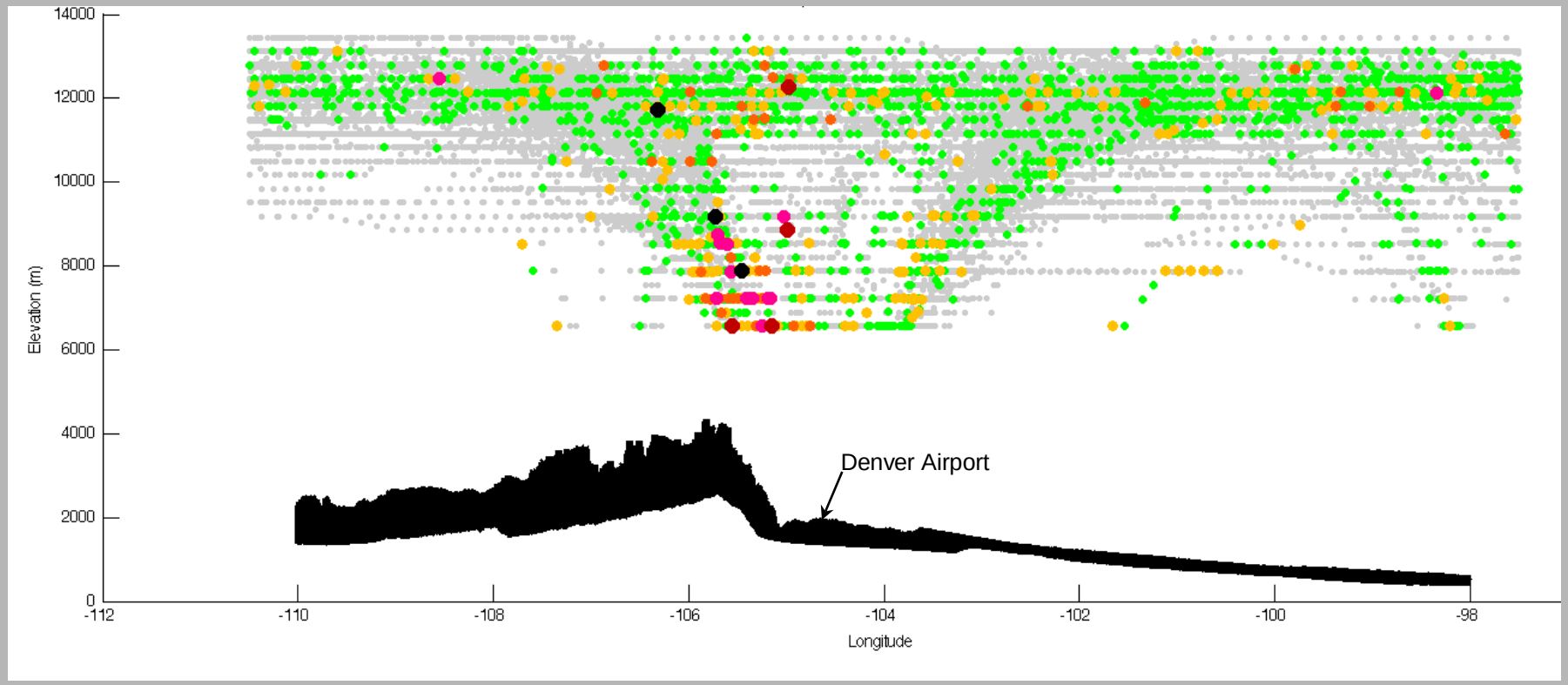
- **Downslope Mountain Wave Turbulence product**
- **Tropopause Folding Turbulence Product**
- **Overshooting convective cloud top detection**

In research mode:

- **Enhanced-V signature**
- **Transverse banding**
- **Rapid anvil cloud expansion**

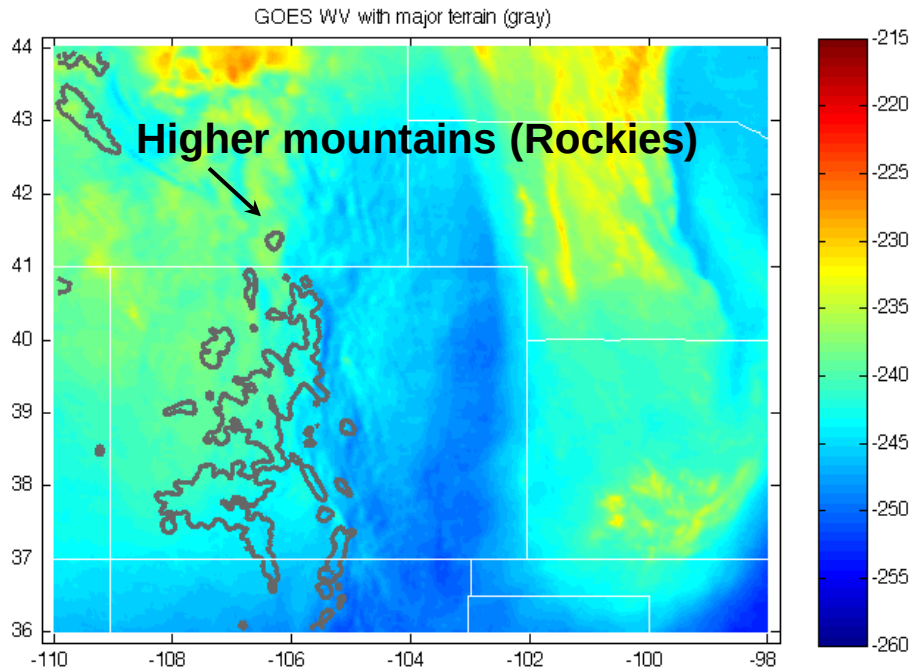
Mountain Wave Turbulence (MWT) detection

EDR Climatology: West -> East transect in central Colorado (March 2006)

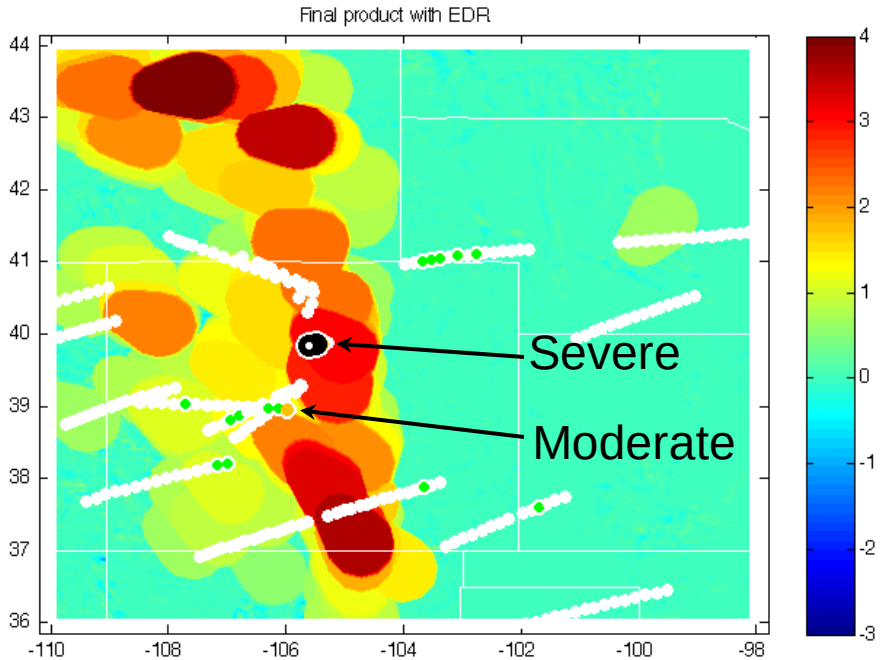


- **According to the EDR record, MWT is concentrated <u>predominantly</u> around area of the the strongest downslope winds**

Mountain Wave Turbulence (MWT) detection



GOES-12 WV for 12 Nov 2005 1745 UTC



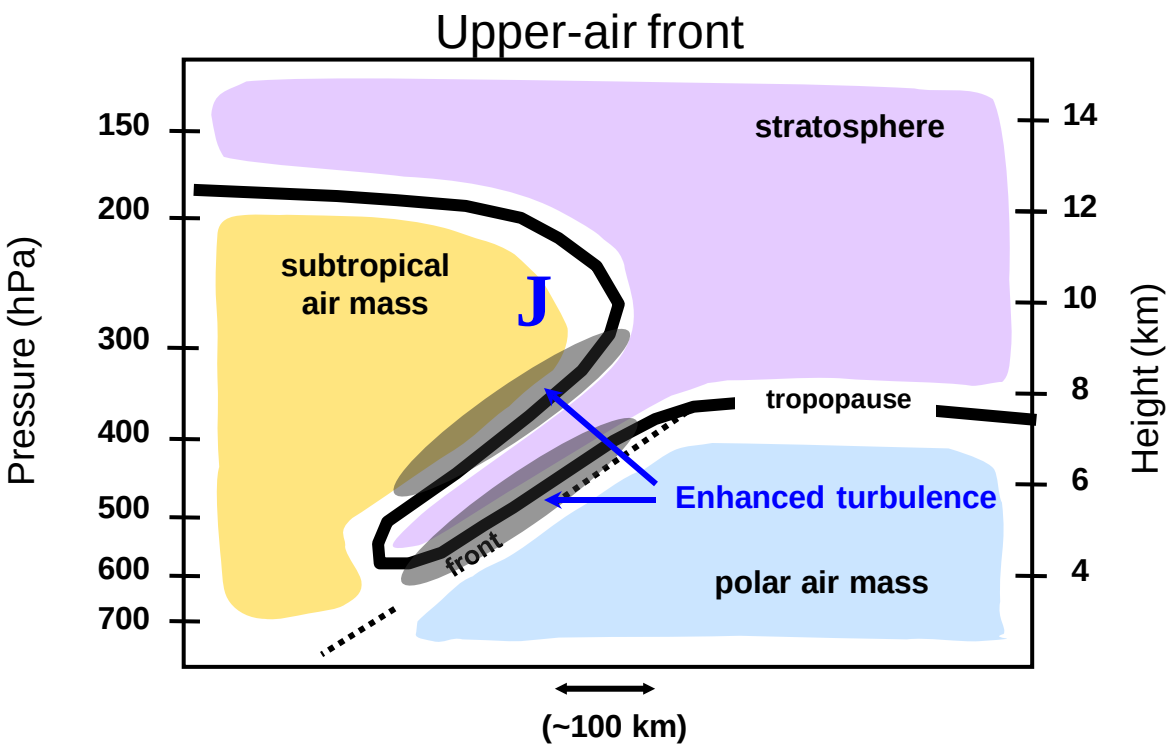
Corresponding downslope MWT product

- **The downslope MWT product identifies the regions in the mid-to-upper troposphere influenced directly by downslope vertical winds evident in the WV imagery**
- **Optimum: POD of 70% / FAR of 20%**
- **Forecast capability of 0-3 hrs**
- **Downslope MWT product is being integrated into the GTG end product with global geostationary coverage**

Tropopause Folding Turbulence Prediction (TFTP)

- Tropopause folding describes an event at the tropopause break in which the tropopause folds into the troposphere due to ageostrophic flow around the jet stream.

- This frequently leads to dynamical instability (enhanced turbulence) because of high levels of vertical shear across the boundary of the tropopause fold, which contains elevated potential vorticity.



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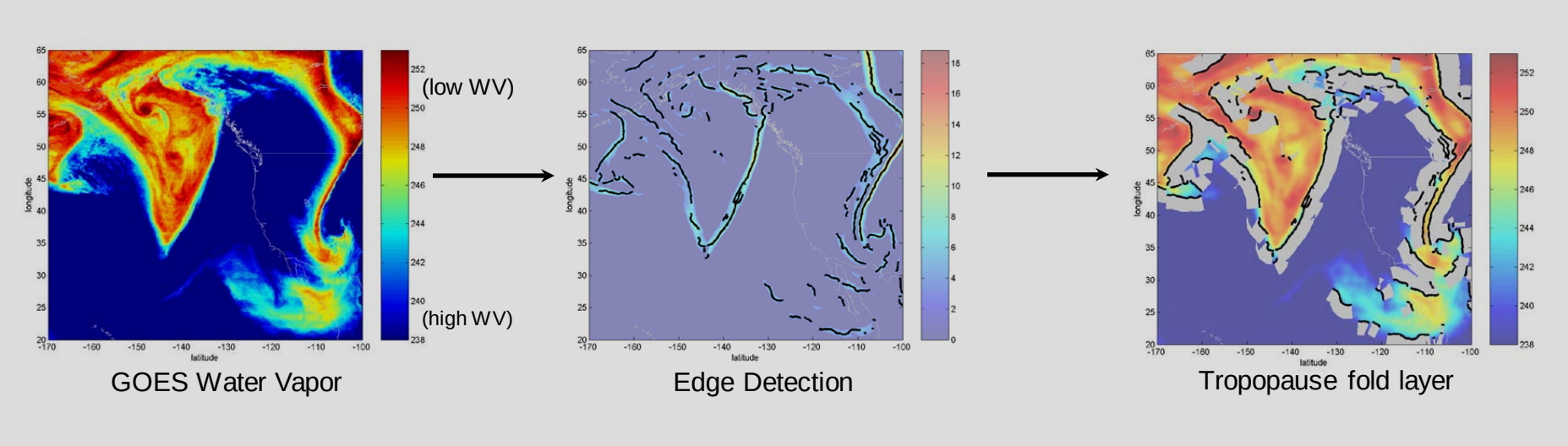
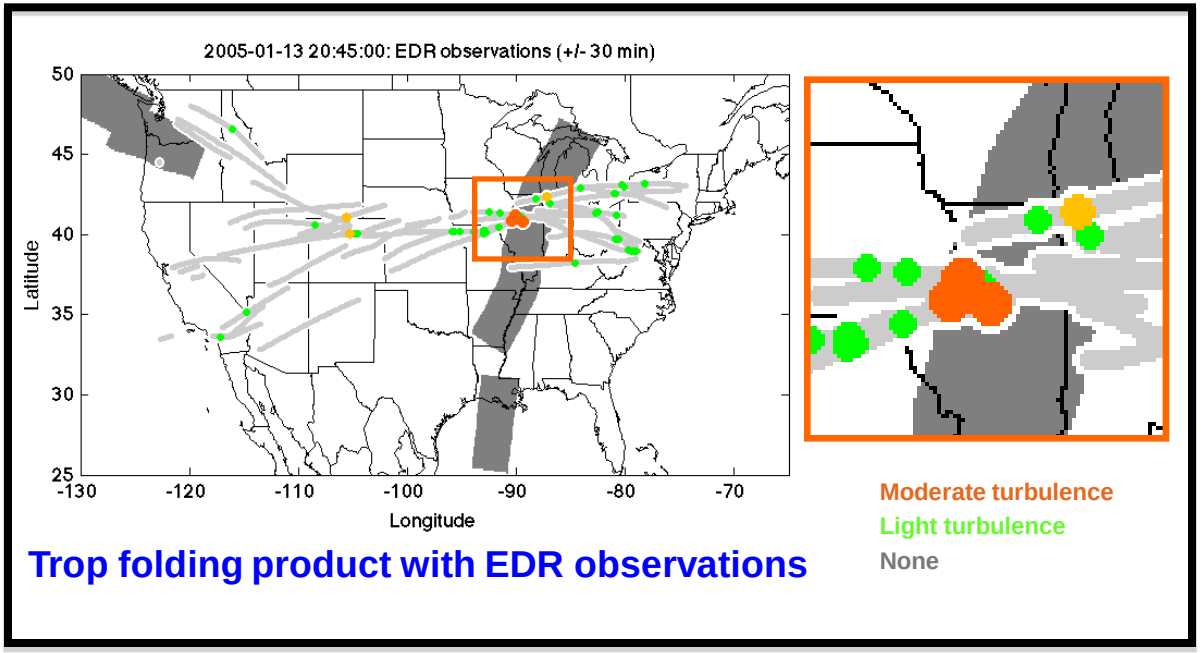


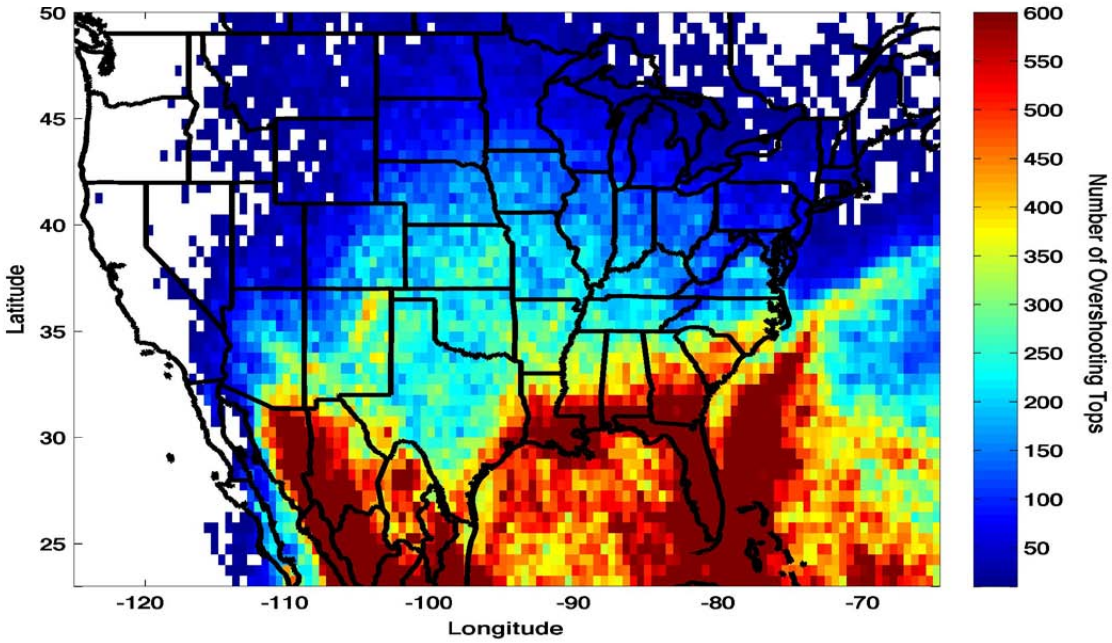


Trop folding product with EDR observations

- Can be produced from any satellite water vapor channel.
- Meets the accuracy standard of the GOES-R program office requirements
- TFTP is being integrated into the GTG end product with global geostationary coverage.
- TFTP will also be available as a GOES-R product in 2016

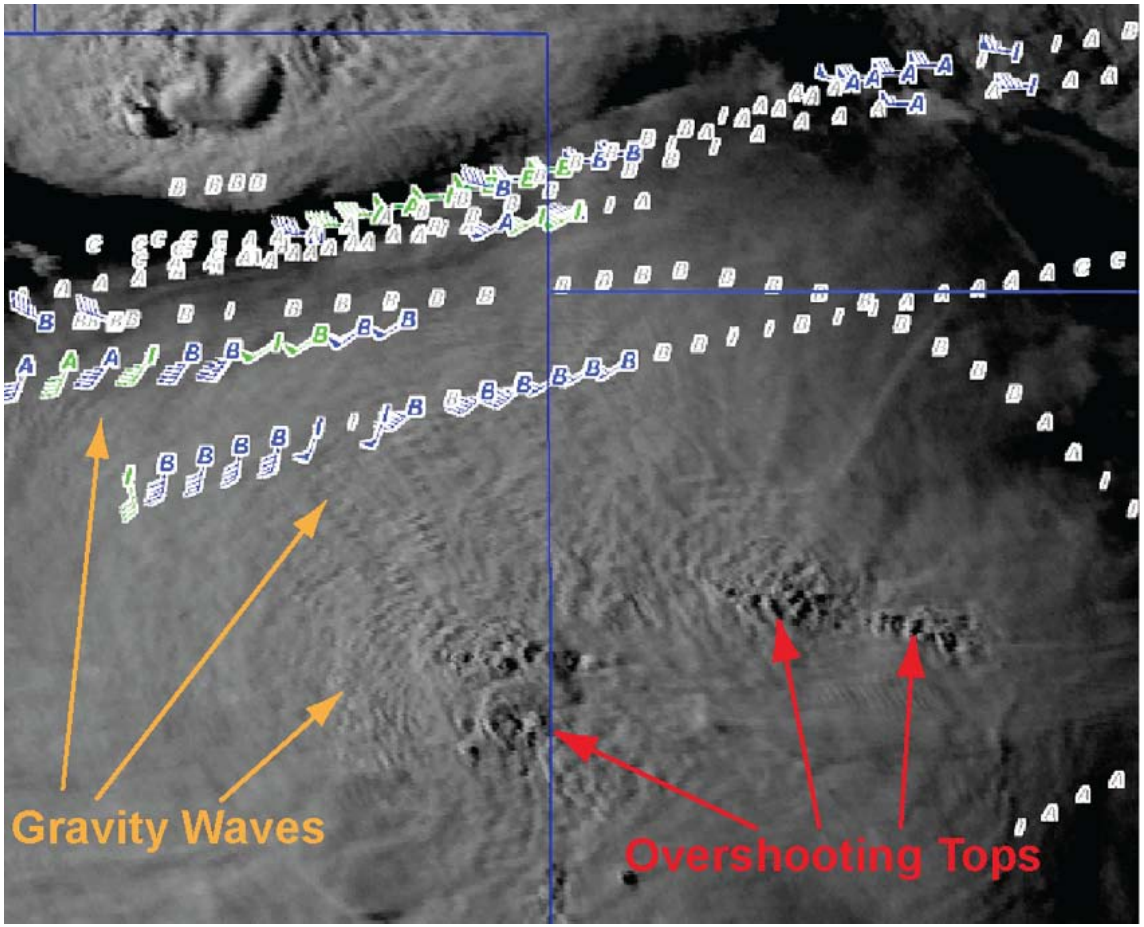
Overshooting Convective Cloud Top ("OT") Detection

Frequency of Overshooting Tops

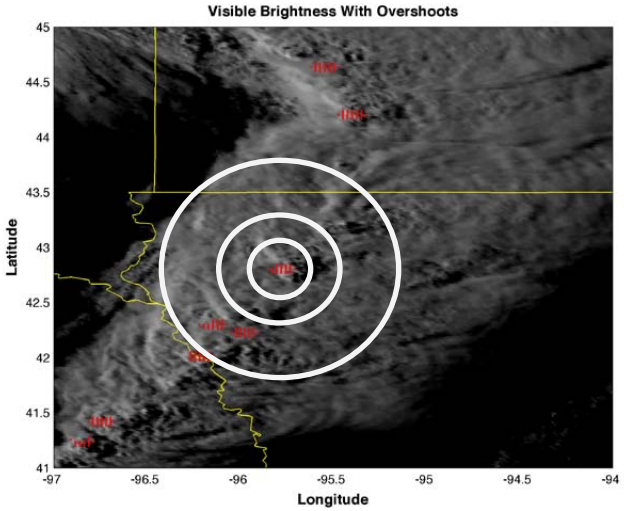


- **Caused by uplifting that penetrates the tropopause**
- **Specific, quantifiable indication of intense convection**

Overshooting Convective Cloud Top ("OT") Detection



Where does the hazard end?



- **Aircraft turbulence is common within a radius of 15km**

- **Product is being integrated into GTG with global geostationary coverage**

In development

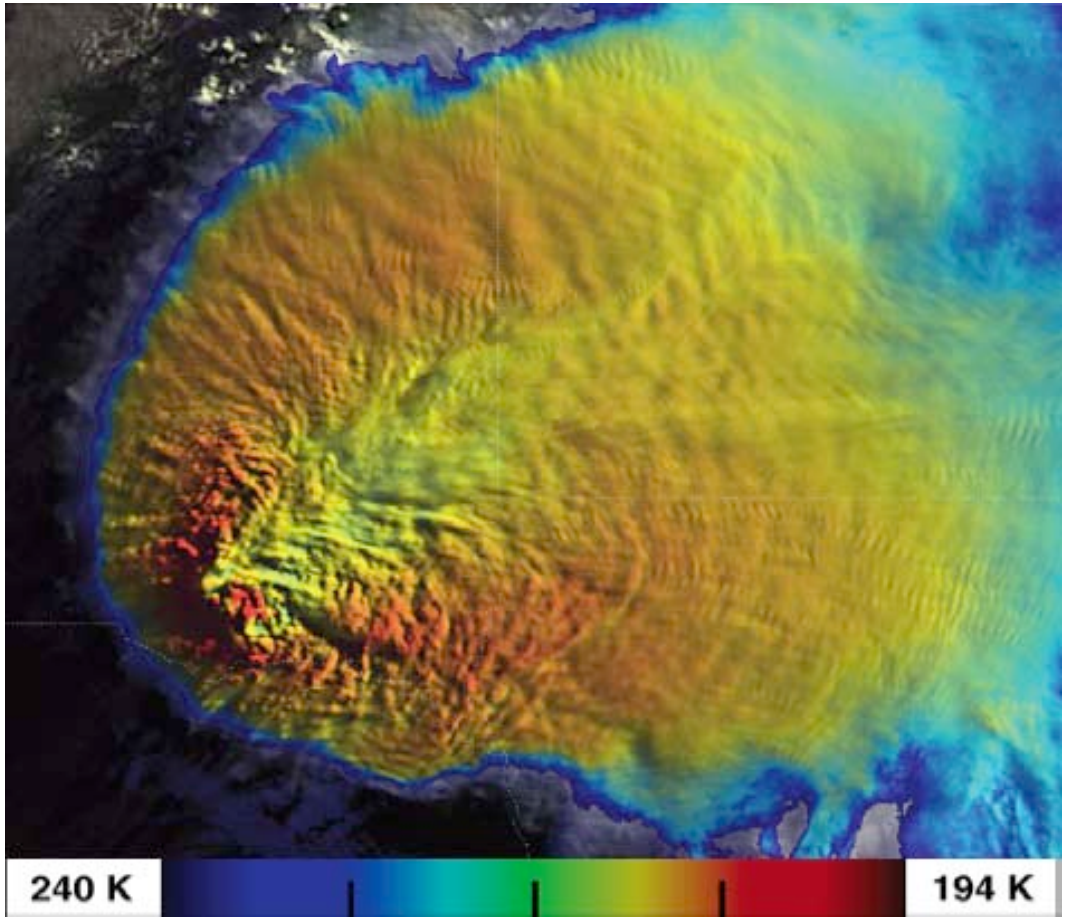


Image Courtesy of Martin Setvak (CHMI)

Enhanced-V Signature

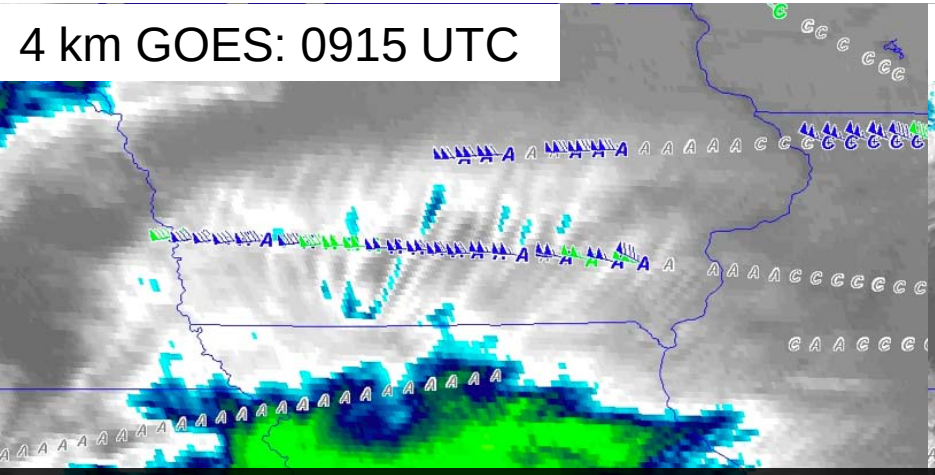
- The most intense variety of overshooting tops create a visibly evident obstruction in the upper-air flow in a V-pattern.

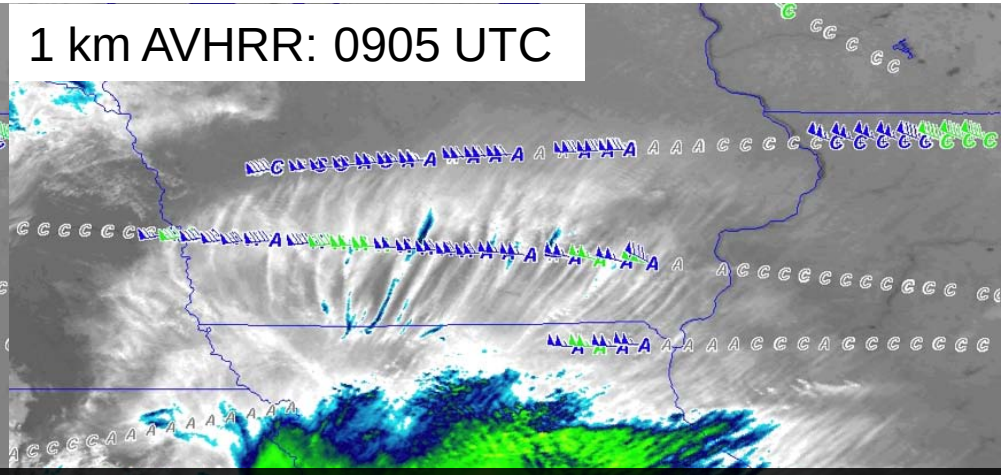
- The relationship to turbulence is still being explored. We expect it to be an amplified version of the overshooting top relationship.

- Objective enhanced-V signature detection will be available as a GOES-R derived product in 2016 and is currently in beta-testing with proxy platforms.

In development

Transverse banding





- Turbulence was associated with decaying convection up to hundreds of miles from the lowest IR temperatures in 93% of events studied in 2006.

- Targeted by CIMSS/UCAR as a key area of future investigation - prototype in 2011? (proposed)

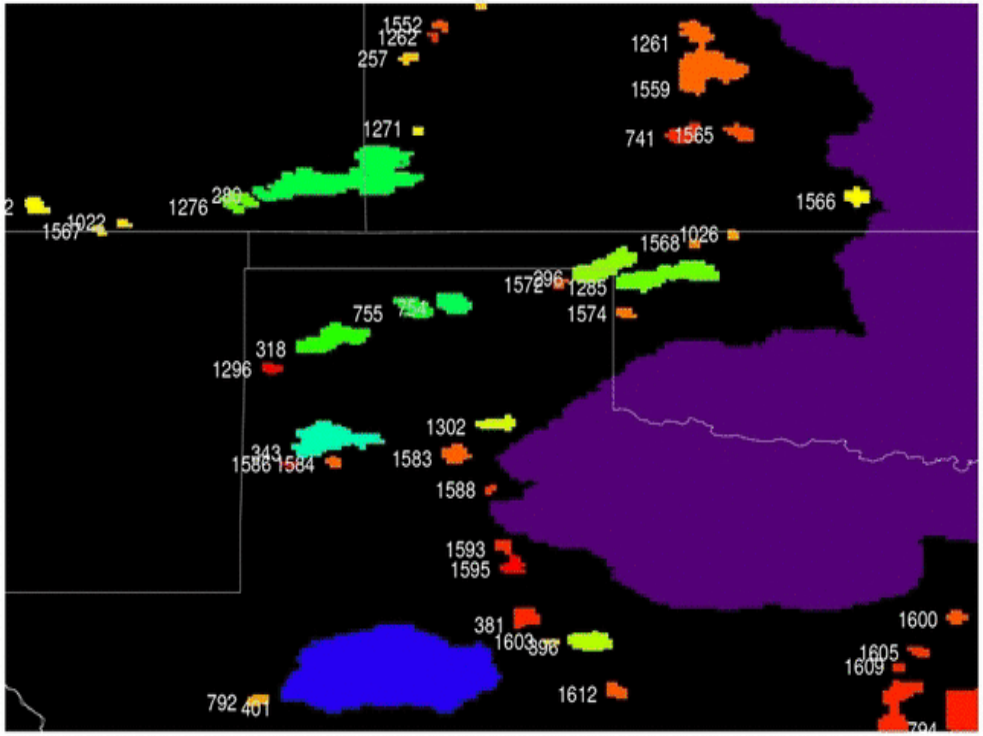
- Tools for application already developed in Mountain Wave detection projects.

- Best performance at 1 km resolution: Most effective with polar orbiters and future GOES-R.

- Computationally expensive: pattern matching for position, wavelength, direction at 1 km or finer scales.

In development

Rapid Anvil Cloud Expansion



Rapid anvil expansion is part of the cloud tracking and identification system being developed by UW/CIMSS and OU-CIMMS/NSSL

- Rapid expansion is often associated with the development of transverse cirrus bands (early warning opportunity).

Accuracy/Gaps

Latency: Polar orbiters: 3hr, GEO: ~15min

Horizontal resolution: 4km with GEO (2km with GOES-R)

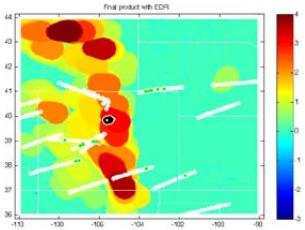
Vertical resolution: Low (b/c wave activity is deep!)

Coverage: Global with GEO

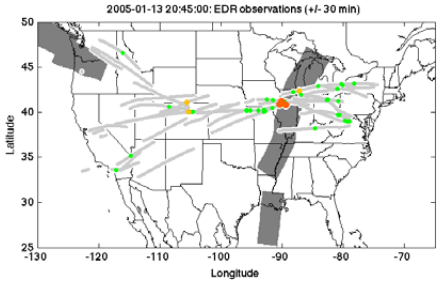
- 48 states: 15 minutes
- Select sectors: 30 minutes
- Global: 3 hours

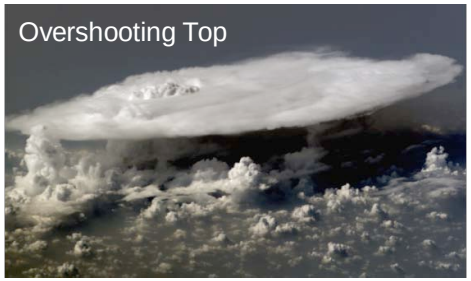
Pathways for satellite nowcasting/ forecasting products in NextGen system

Mountain wave



Tropopause folding





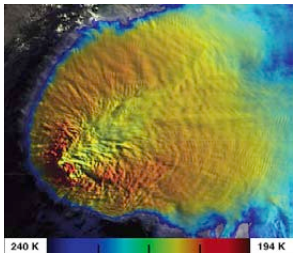
GTG-N,

Global GTG

NextGen 4D cube

Future, in development

Enhanced-V



Rapid Anvil, Transverse banding