



Analysis of Trace Gas Measurements Made Near Outflow of Active & Aged Convection during CONTRAST

Johnny Luo¹, Sonya Pyo¹, Laura Pan², Eric Apel² and Becky Hornbrook²

¹ City College of New York, CUNY

² National Center for Atmospheric Research

Jan 30 2014





Analysis of Convective Flights during CONTRAST: Hunt for Fresh Outflow

Johnny Luo¹, Sonya Pyo¹, Laura Pan², Eric Apel² and Becky Hornbrook²

¹ City College of New York, CUNY

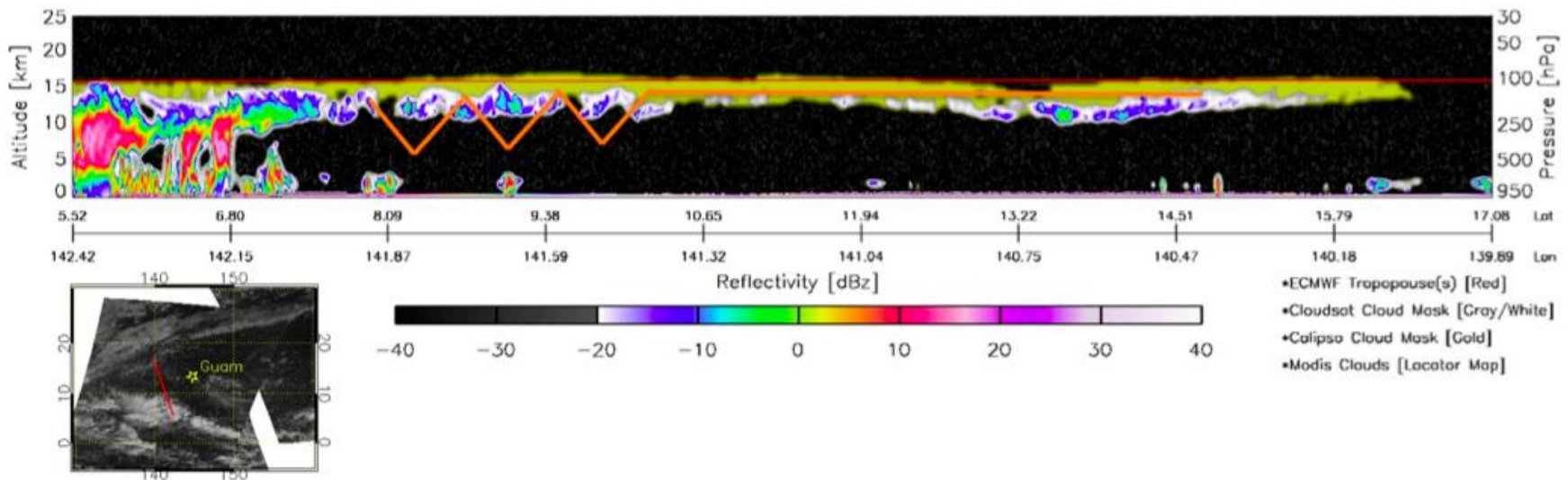
² National Center for Atmospheric Research

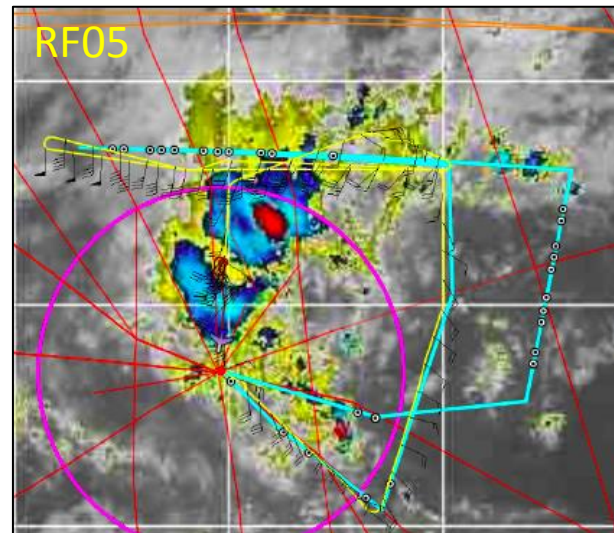
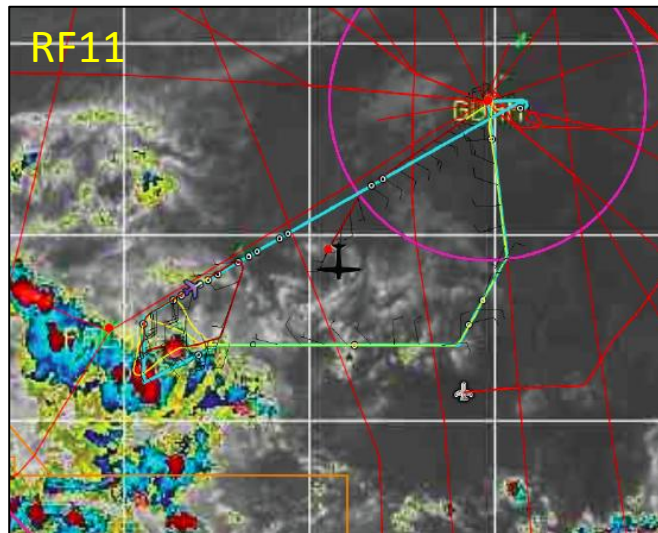
Jan 30 2014



Five scenarios from **CONTRAST Operations Plan** (Draft Nov 11, 2013):

1. Domain survey
2. **Fresh convective outflow**
3. Lagrangian downwind flight
4. Photochemistry evolution flight
5. Extra-tropical lower stratospheric flight

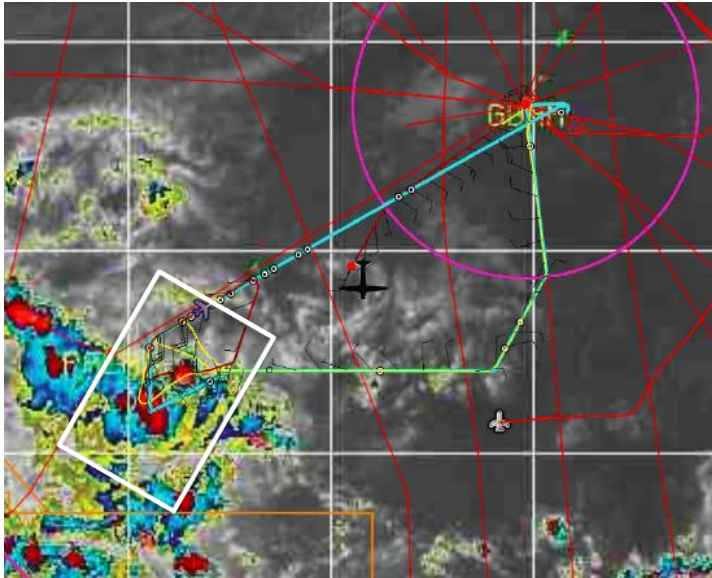




Outline

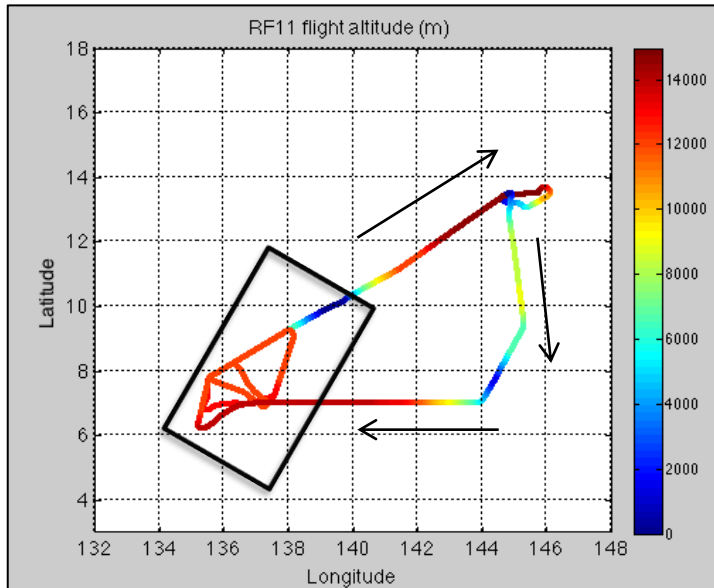
1. RF11: Fresh convection
2. RF05: Aged convection
1. Discussions and Summary

RF 11 (Feb 13 2014)

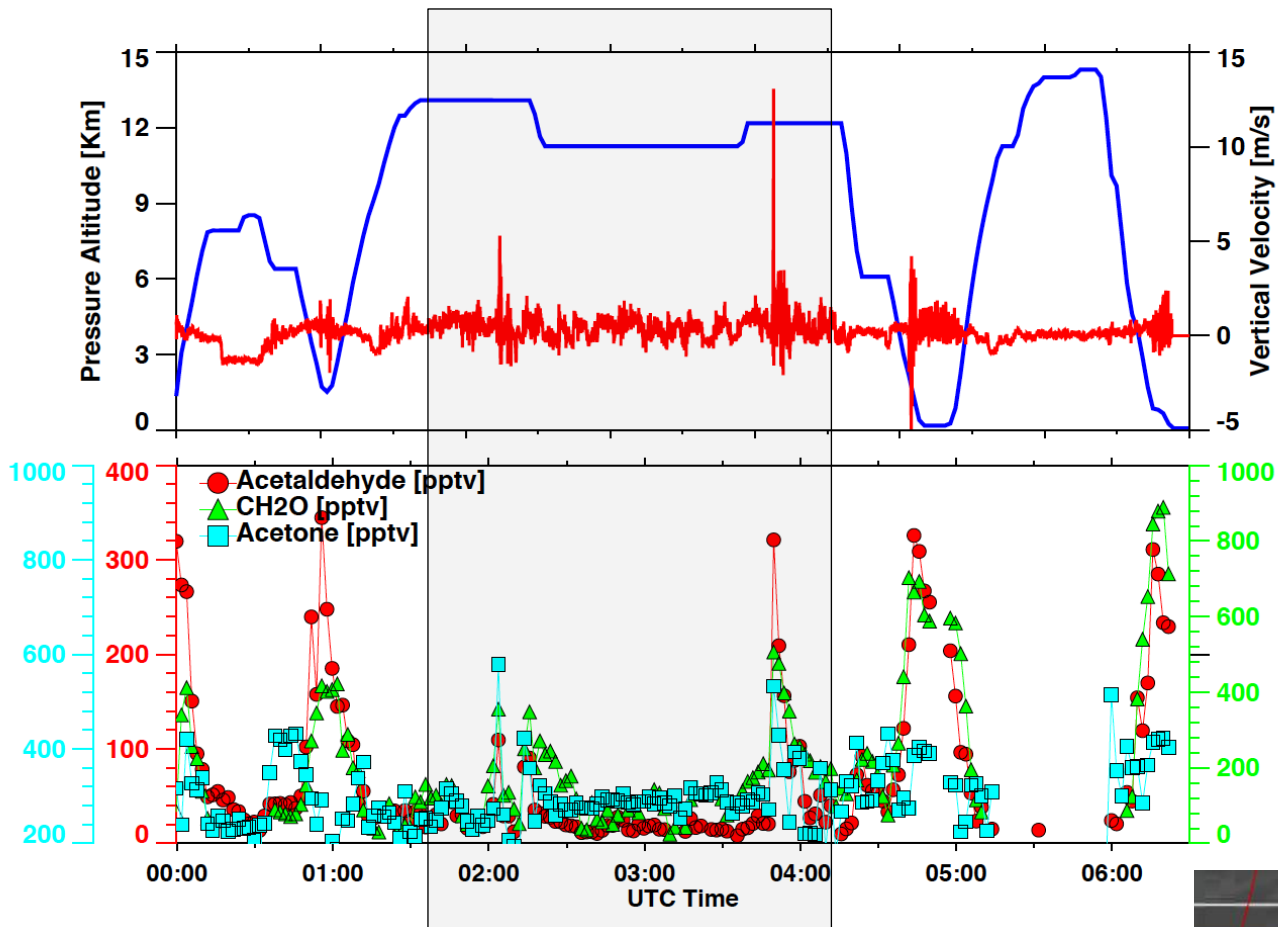


RF11 is a golden day for convection

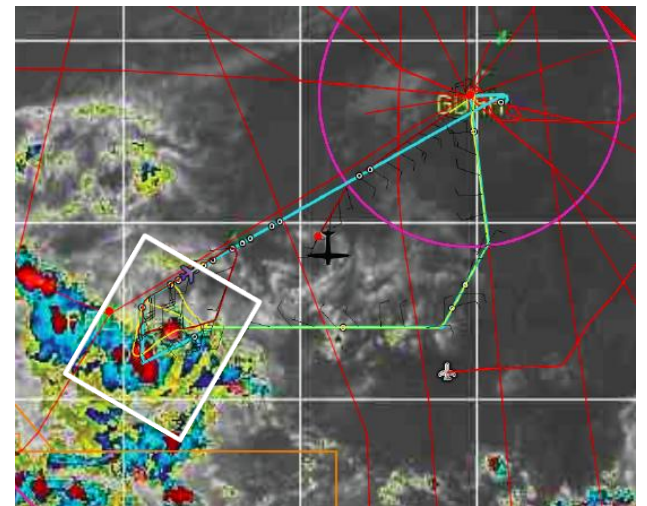
- GV spent 3+ hrs near and inside the same convective system, sampling various parts and different life stages of the convection
- (By accident) GV went into an actively developing convective cell, where trace gases show very interesting features



- Deep profile in the nearby environment (0-14 km)
- Global Hawk and BAe146 were also flying nearby

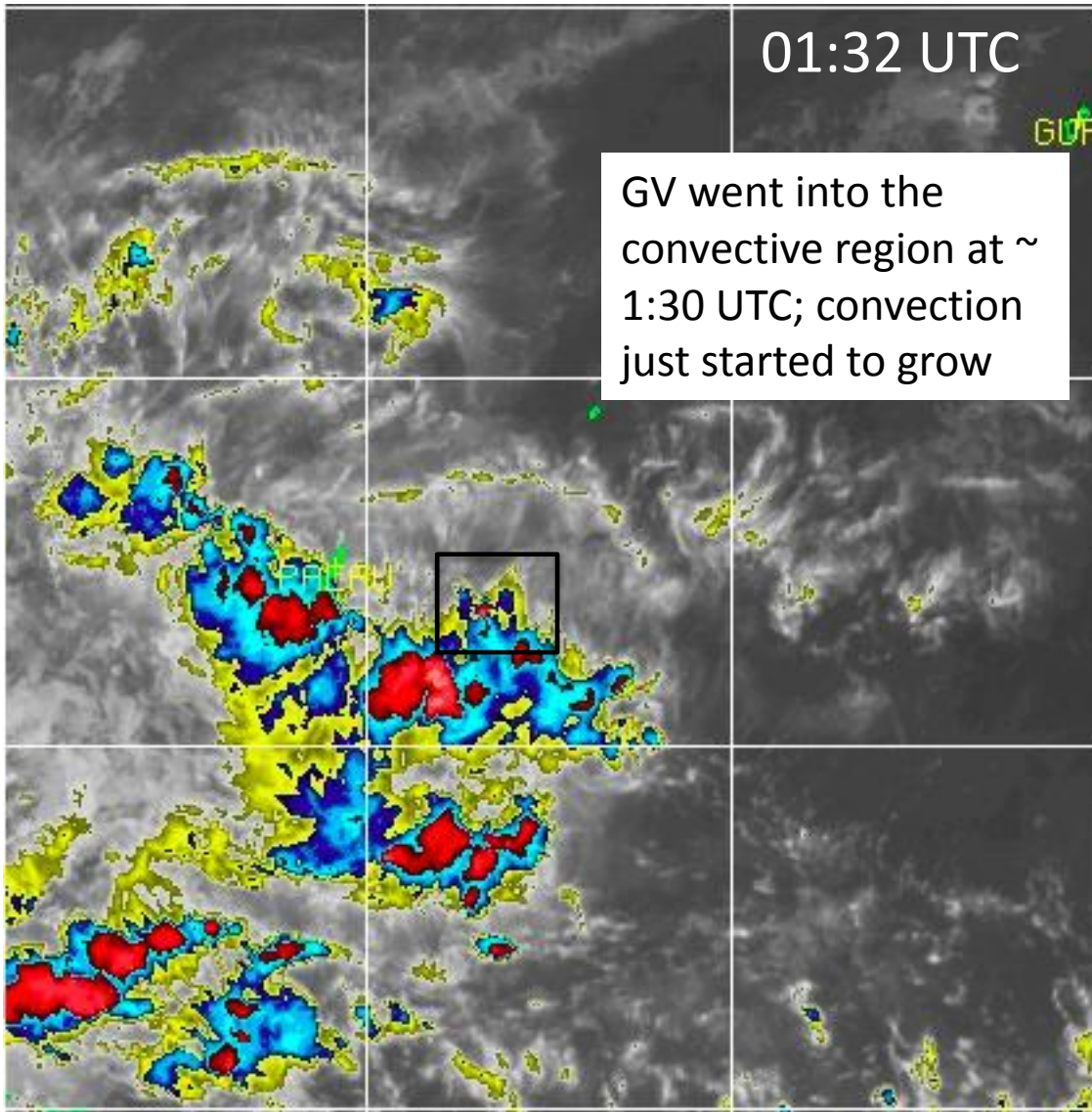


Courtesy: Eric Apel, Becky Hornbrook, and Laura Pan



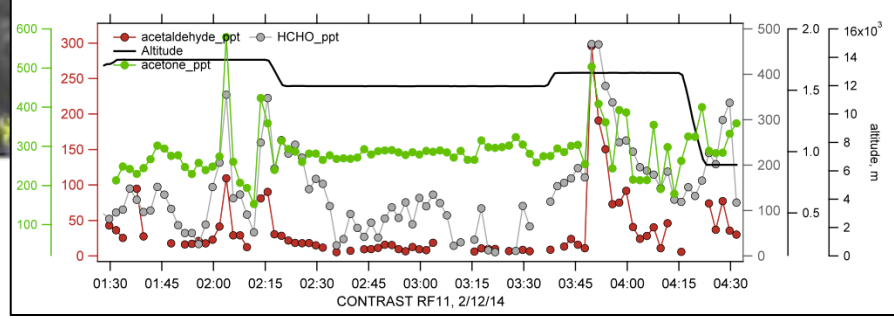
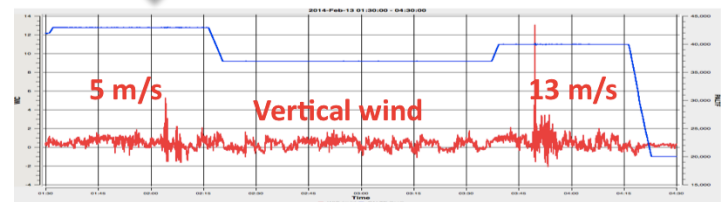
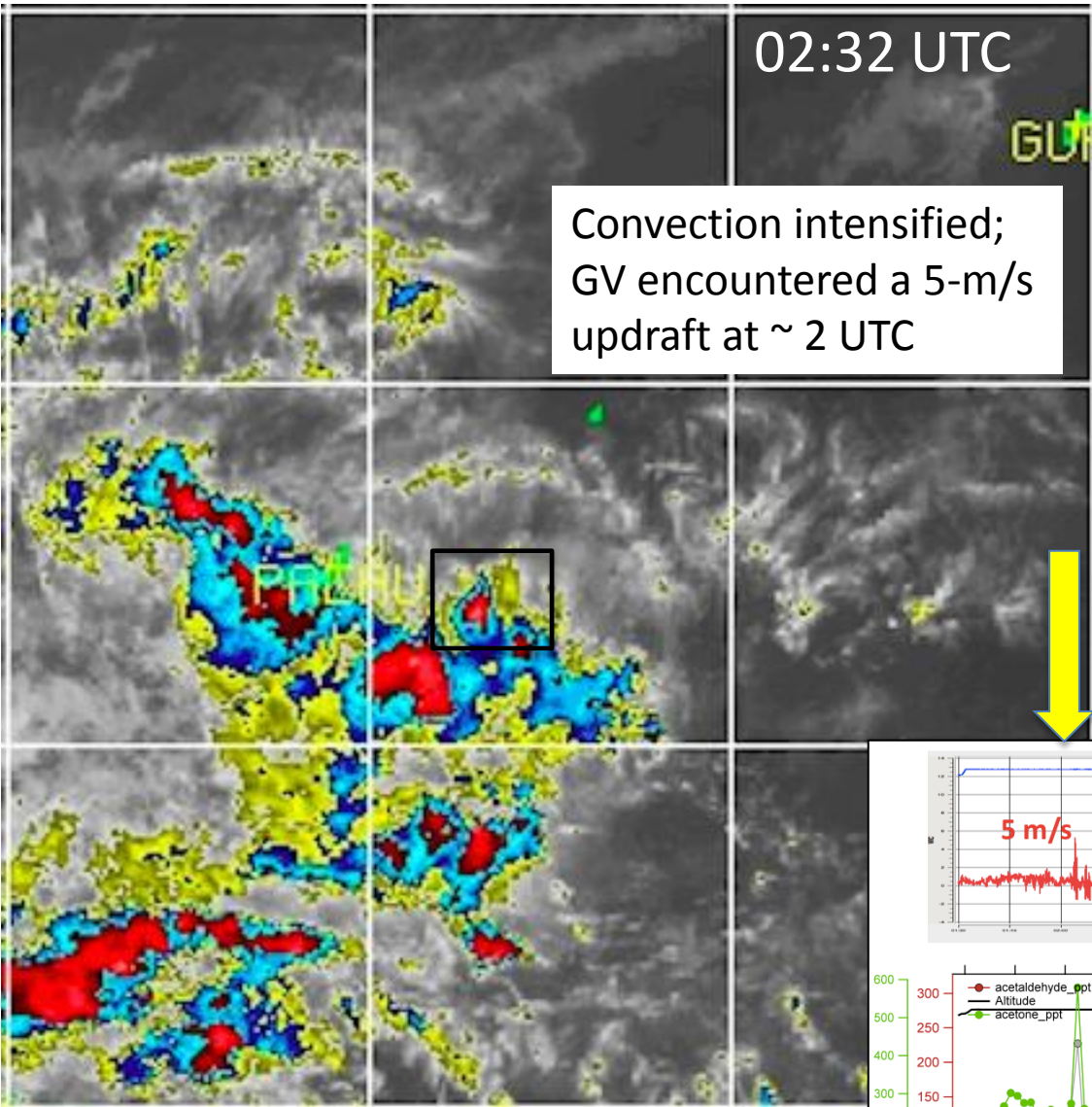
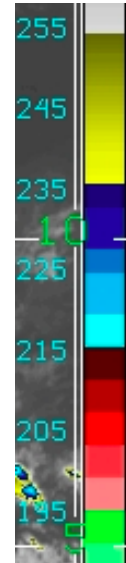
01:32 UTC

GV went into the convective region at ~ 1:30 UTC; convection just started to grow



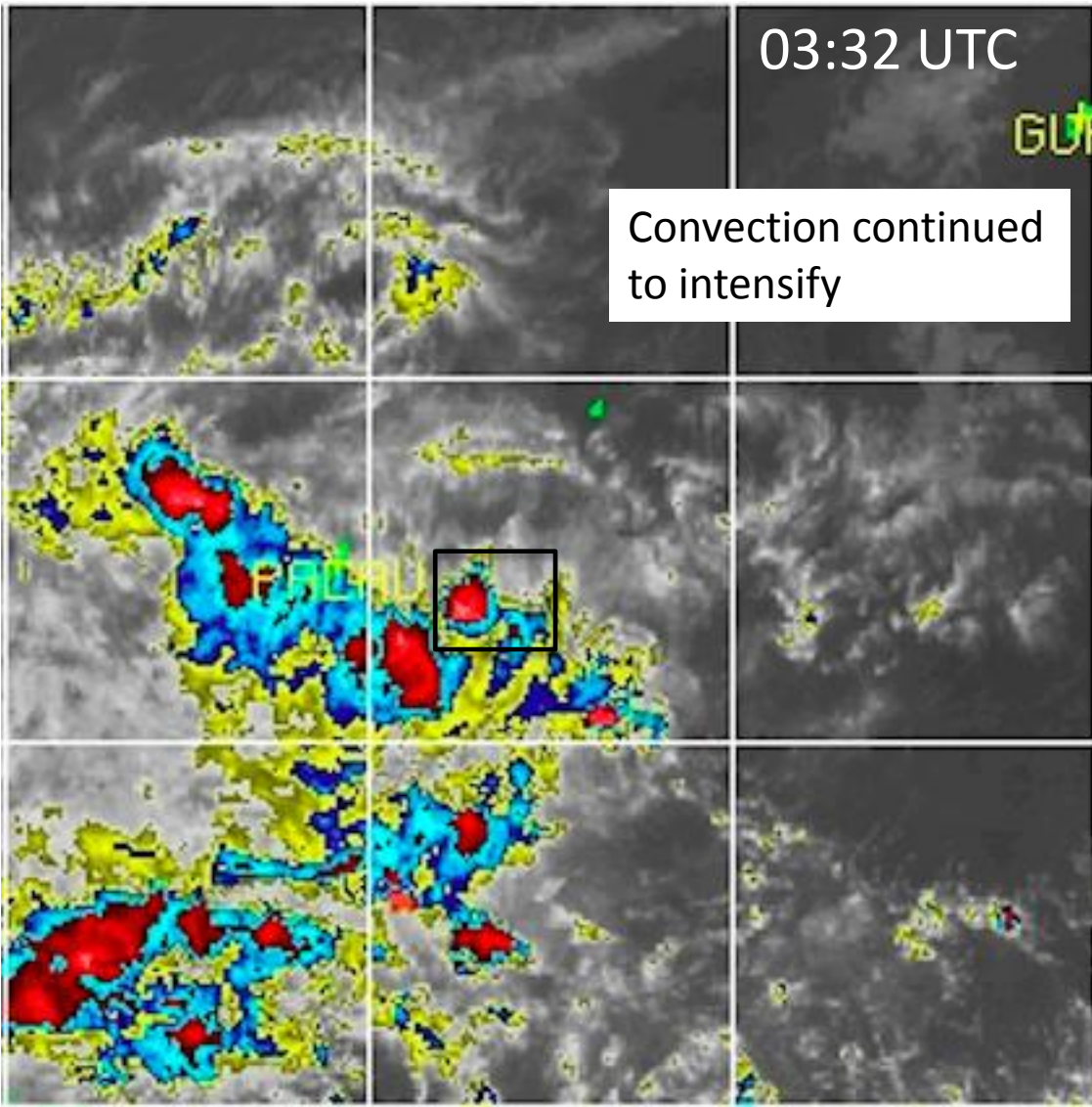
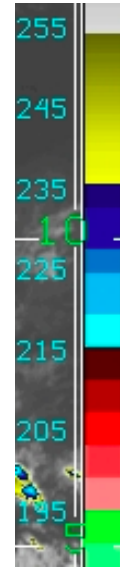
02:32 UTC

Convection intensified;
GV encountered a 5-m/s
updraft at ~ 2 UTC



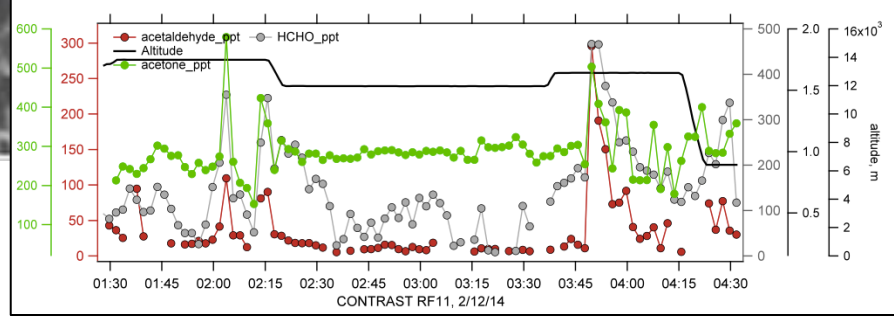
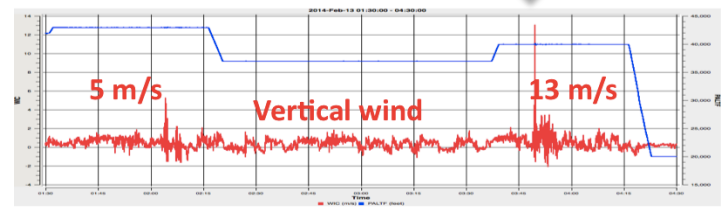
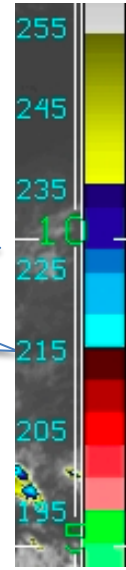
03:32 UTC

Convection continued
to intensify



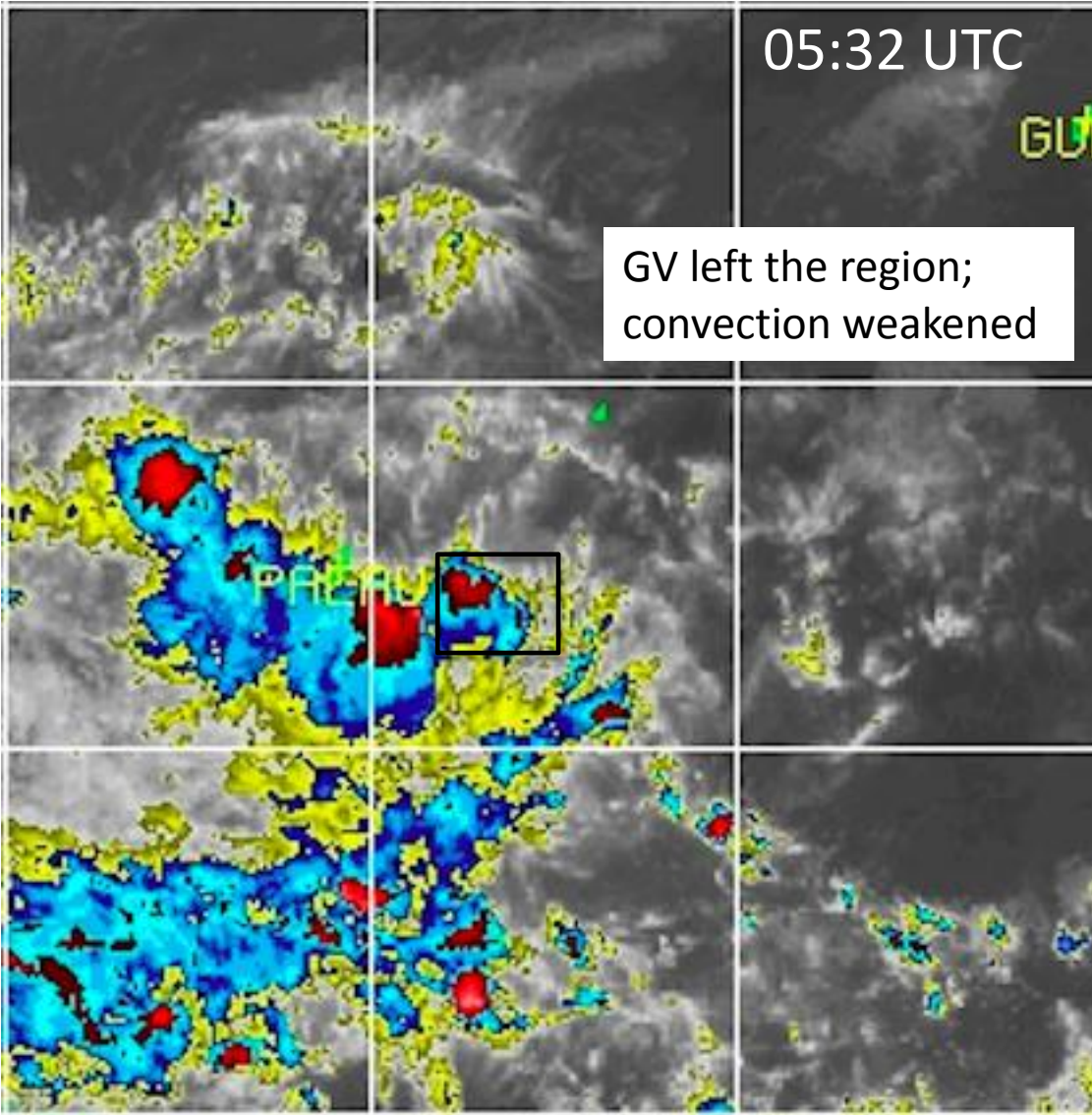
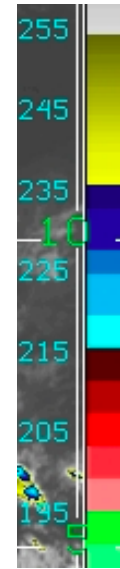
04:32 UTC

GV went into a 13-m/s updraft at ~ 4 UTC



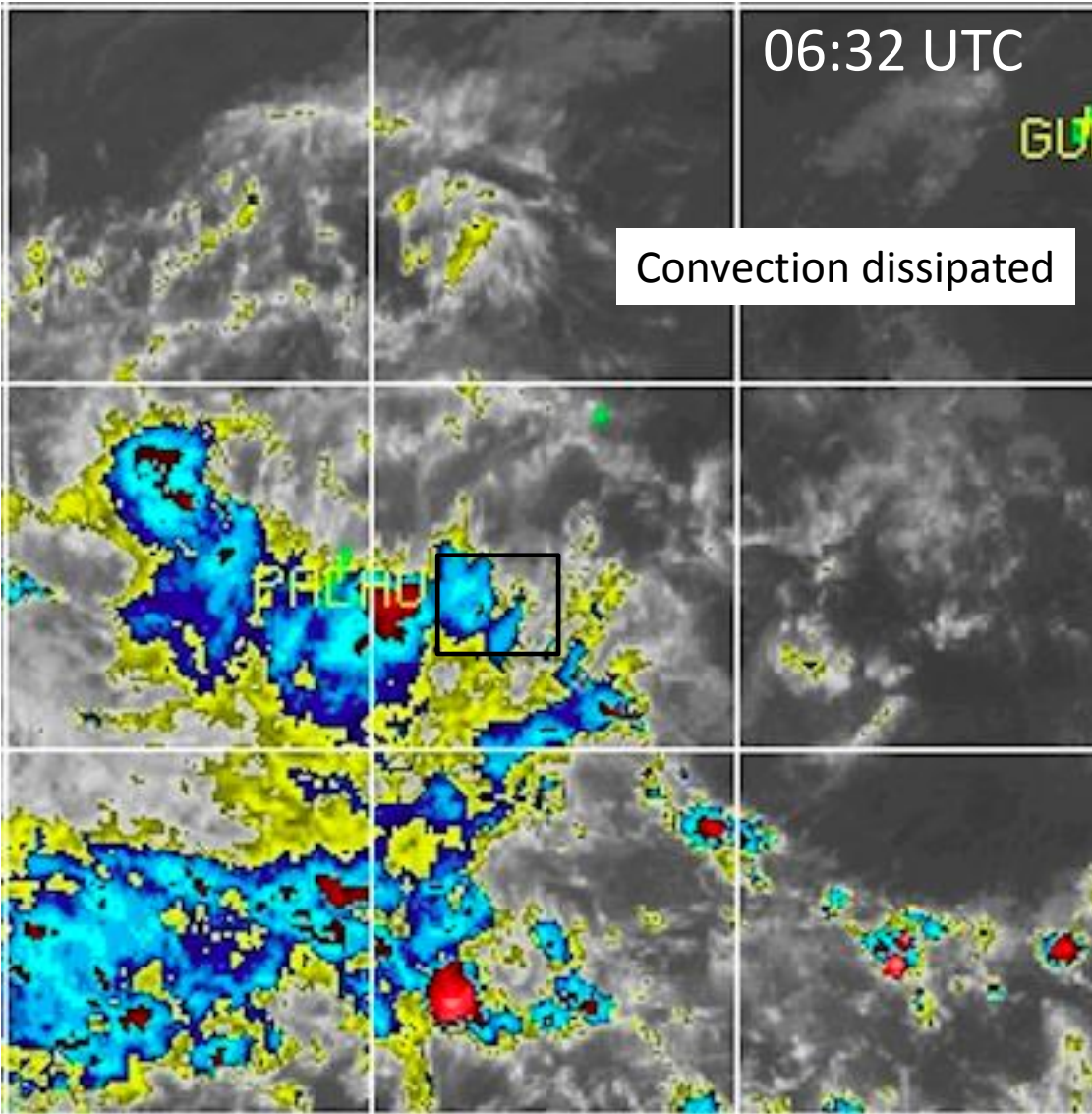
05:32 UTC

GV left the region;
convection weakened

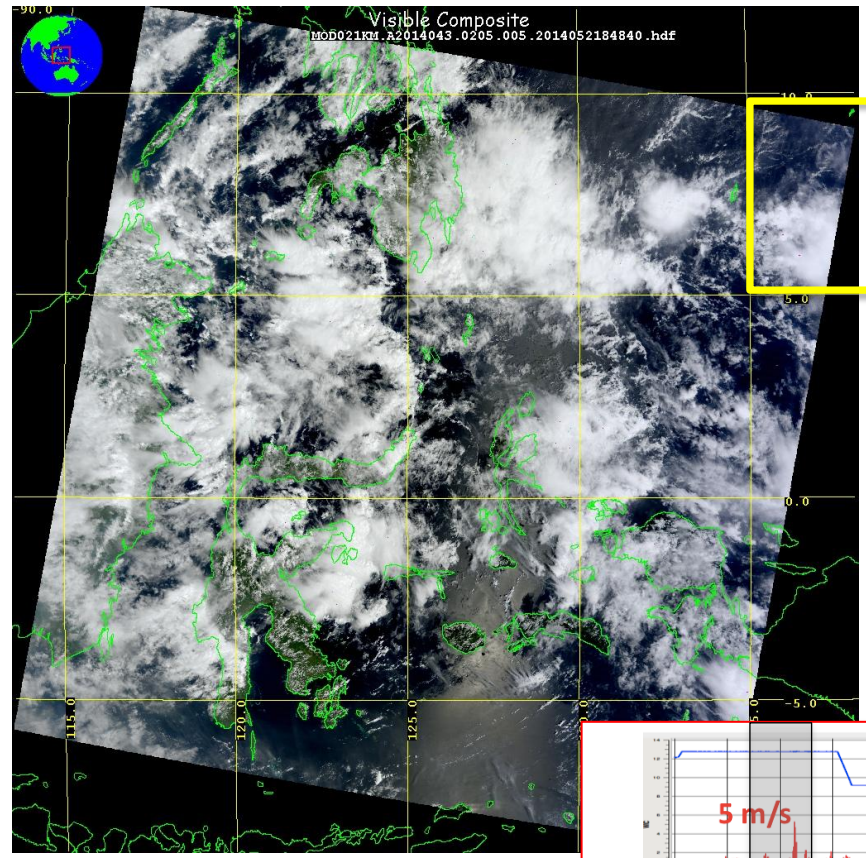


06:32 UTC

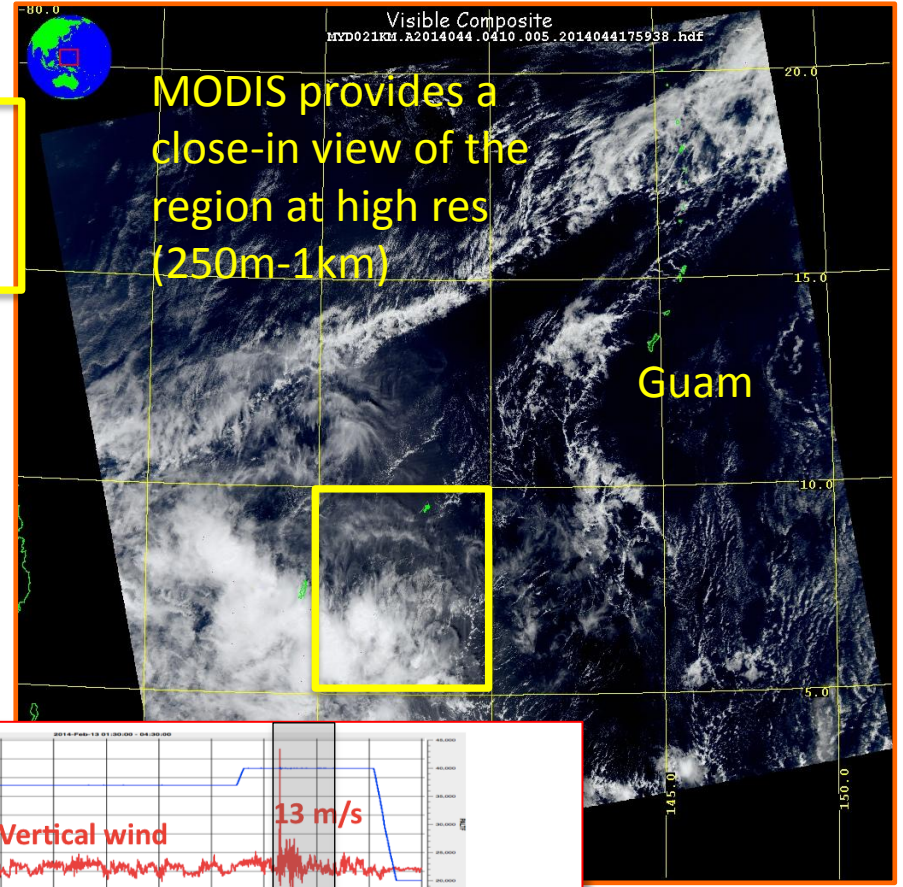
Convection dissipated



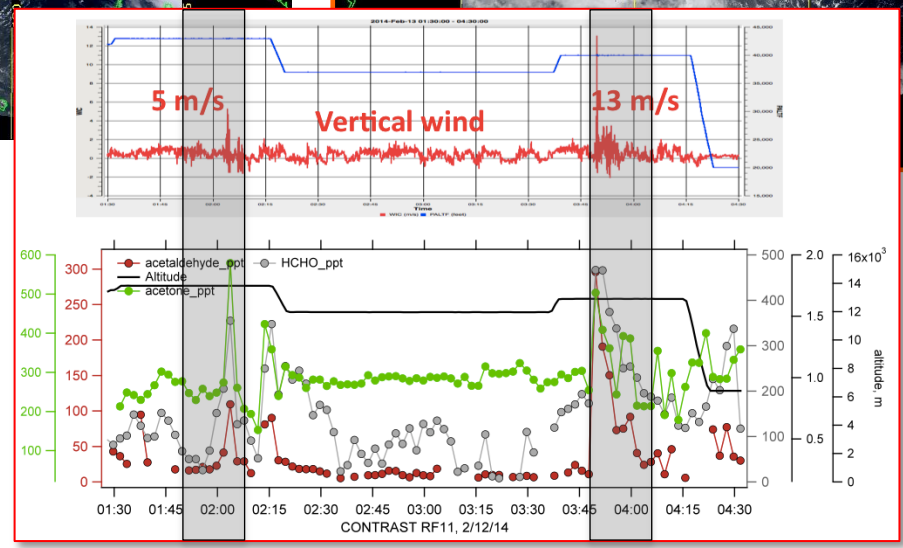
Terra 2:05 UTC



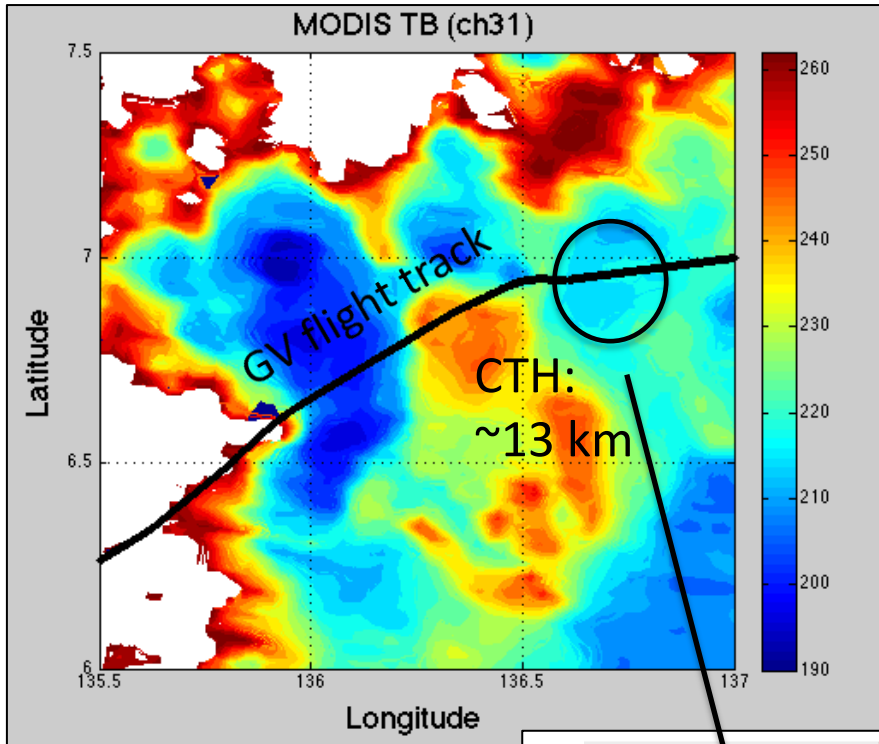
Aqua 4:10 UTC



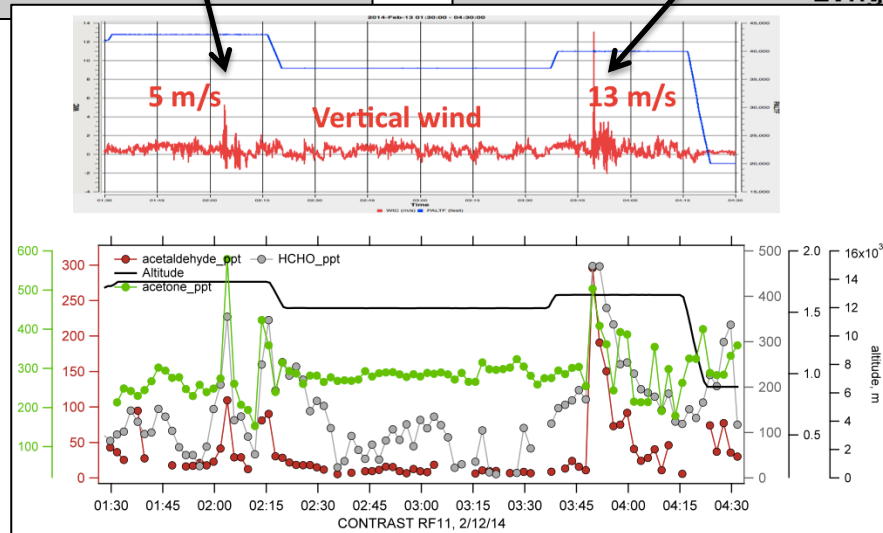
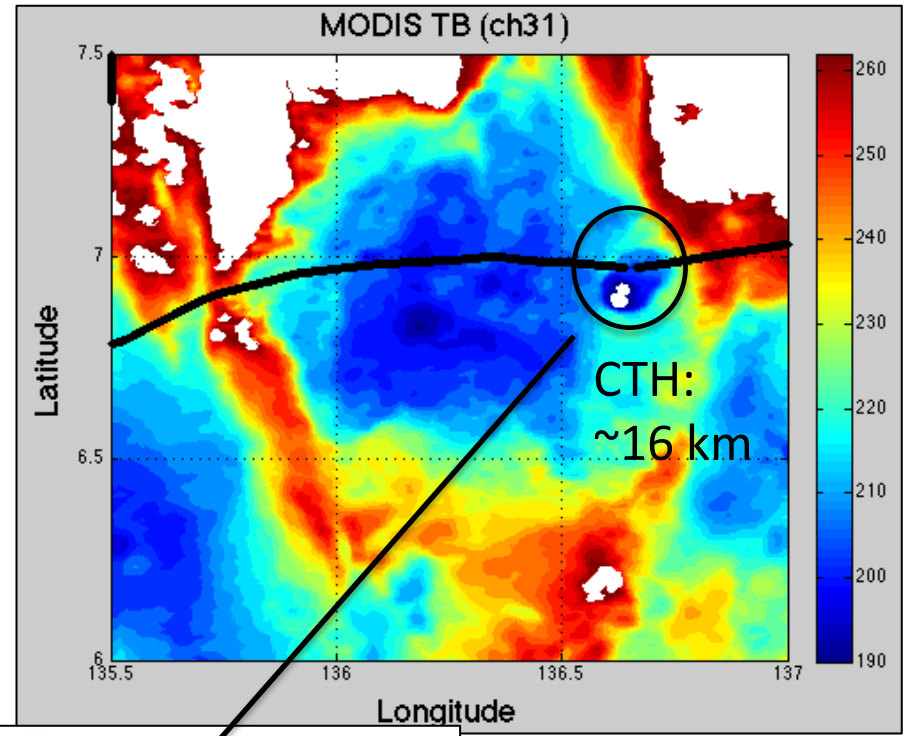
MODIS provides a close-in view of the region at high res (250m-1km)



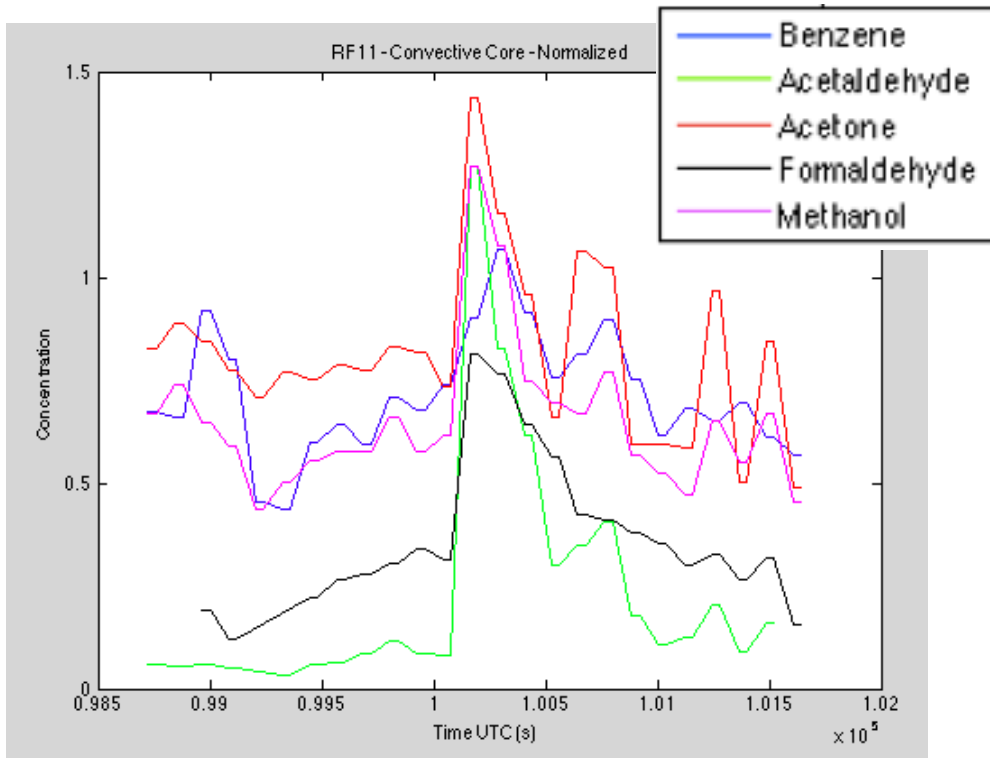
MODIS Terra 2:05 UTC



MODIS Aqua 4:10 UTC



Normalize each species by their corresponding MBL values.



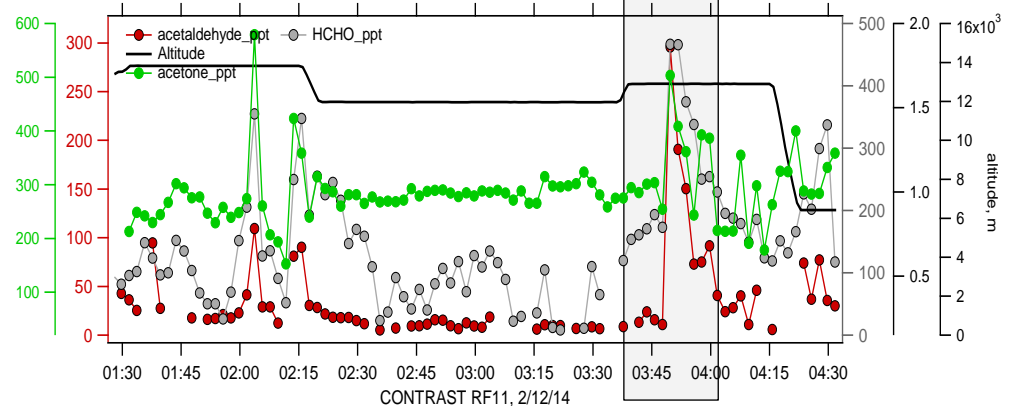
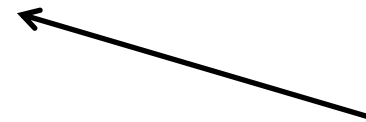
➤ VSL species (HCHO, CH₃CHO) show large spikes inside the fresh convection and decay quickly as GV moved away.

➤ Longer-lived species also show spikes but maintain fairly high background values away from convection.

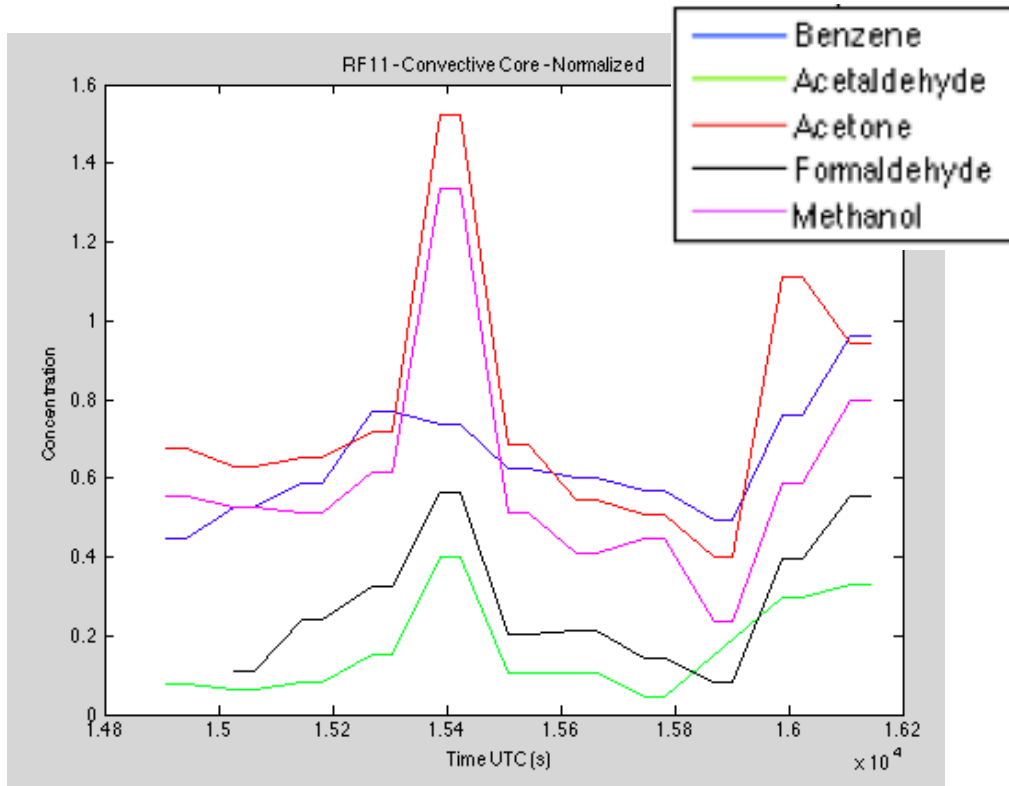
5 tracers:

Very short lived: acetaldehyde, formaldehyde (hours)

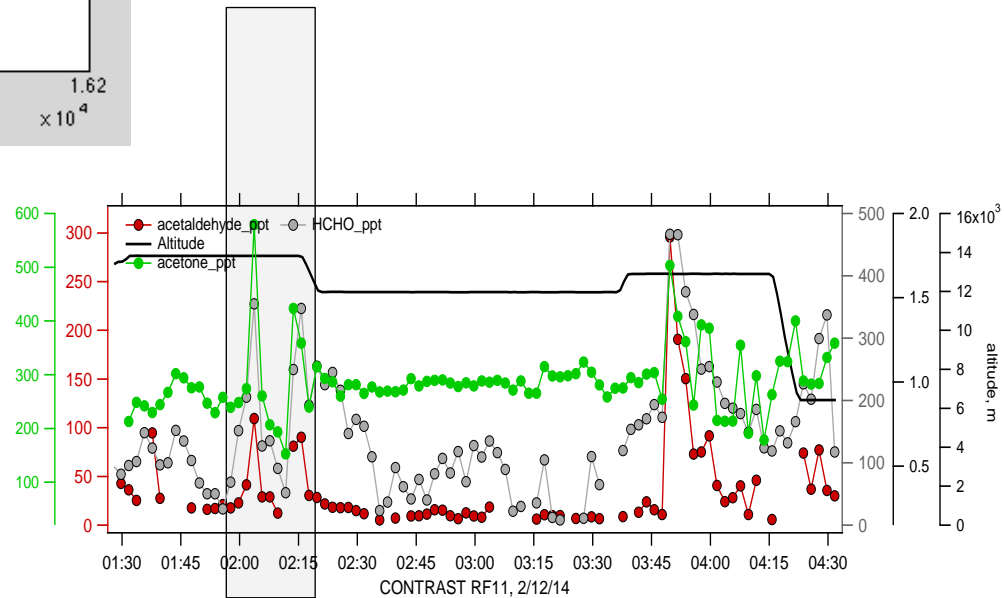
Long-lived: methanol (7 days), benzene (5 days), acetone (weeks)



Normalize each species by their corresponding MBL values.



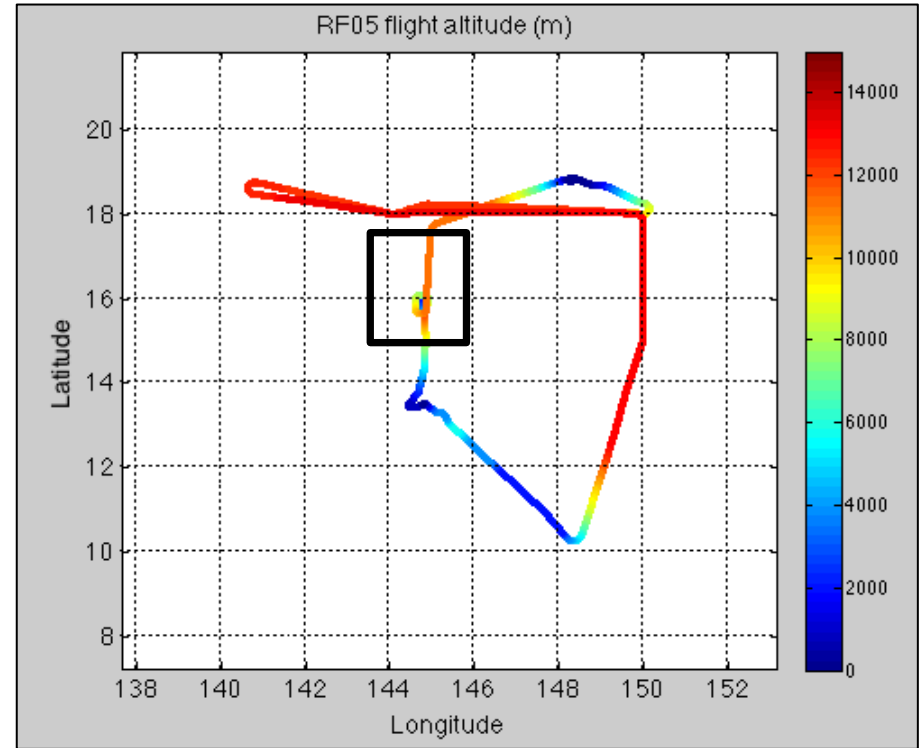
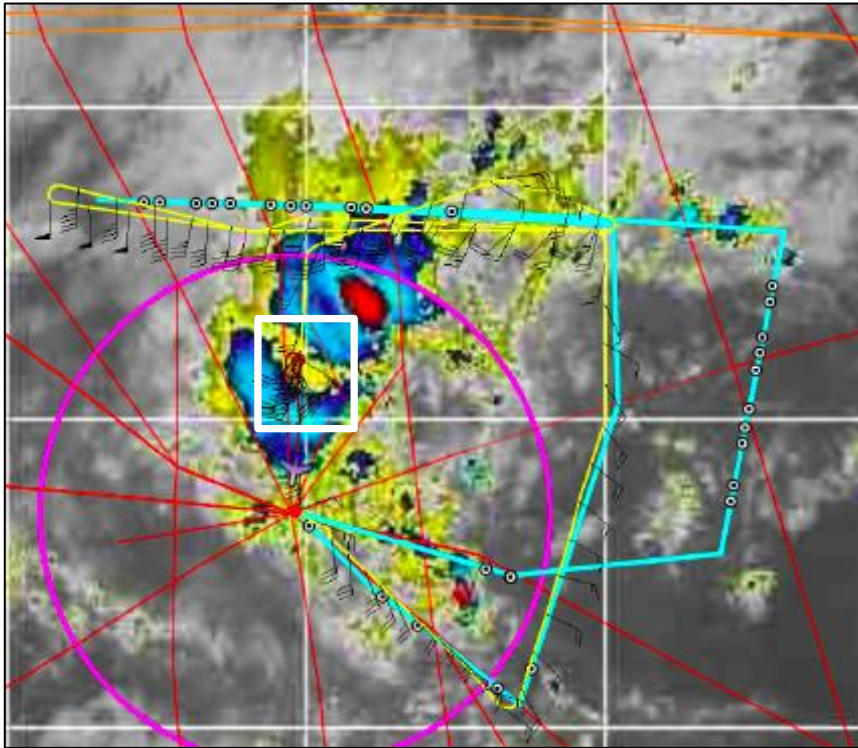
➤ Similar pattern to the previous case, except that VSL species do not show as much enhancement.



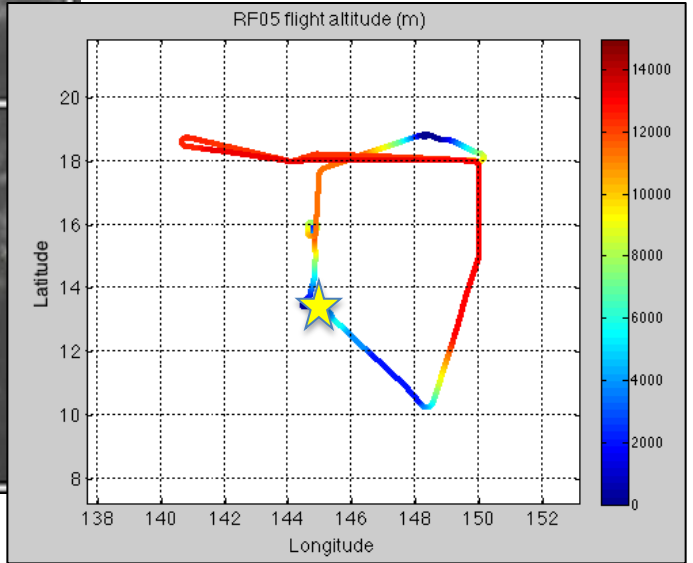
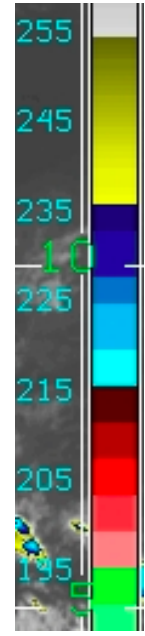
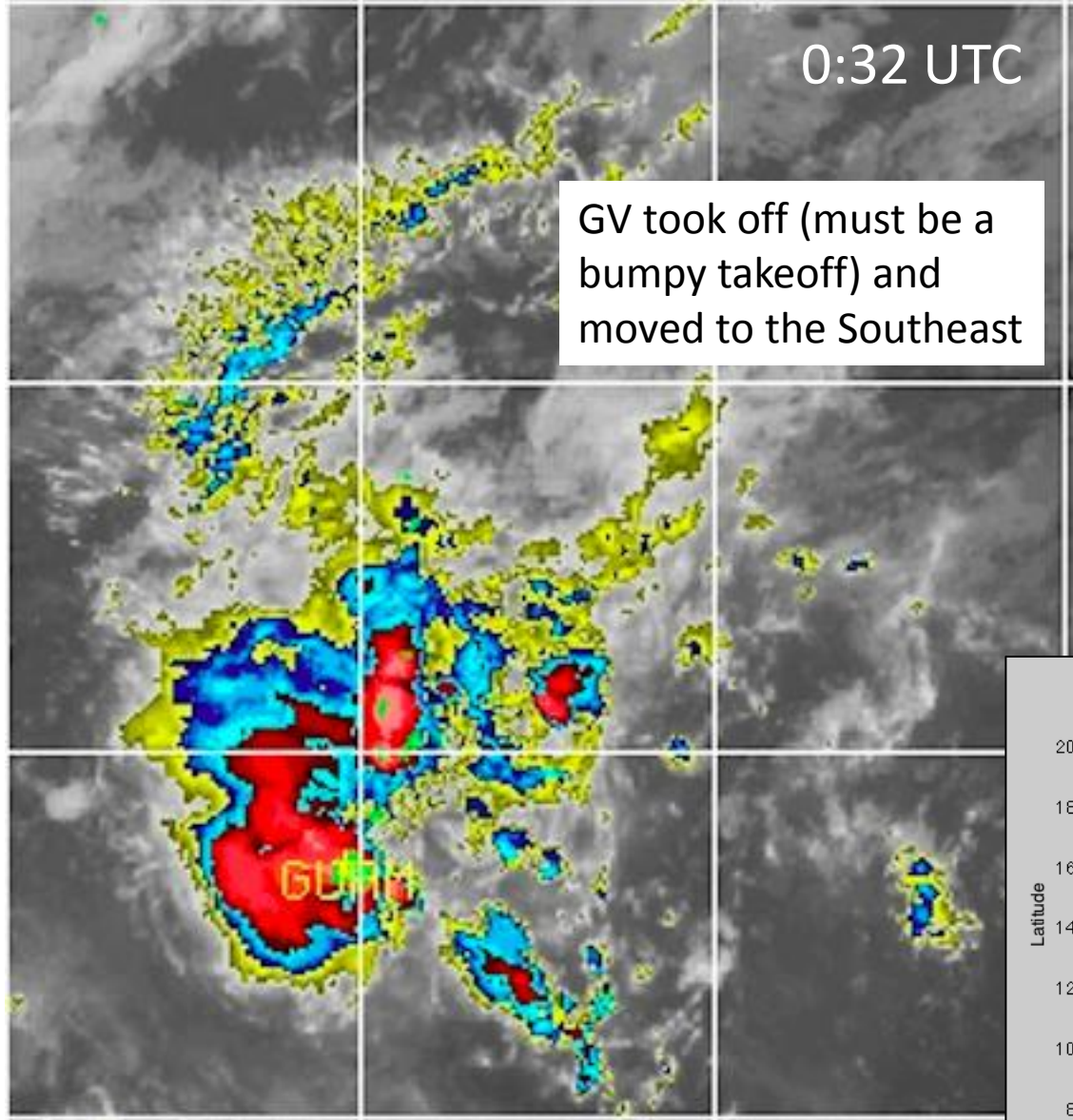
Outline

1. RF11: Fresh convection
- 2. RF05: Aged convection**
3. Outflow and overshooting statistics from a cloud radar (CloudSat) perspective for the TWP
4. Summary

RF 05

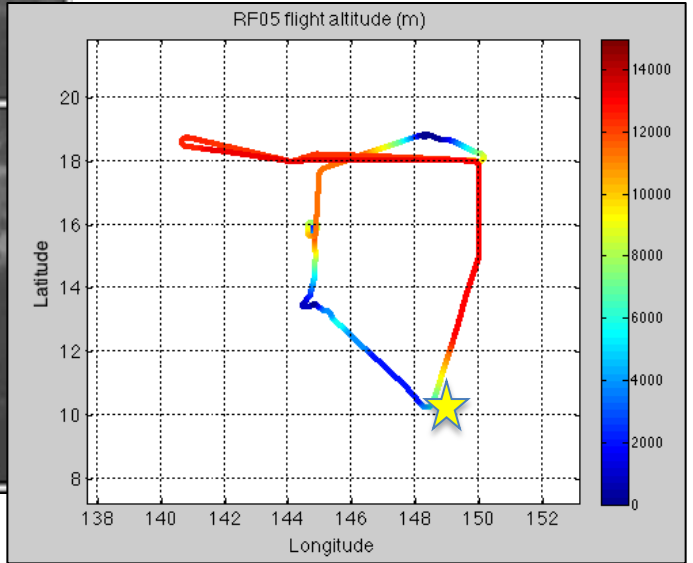
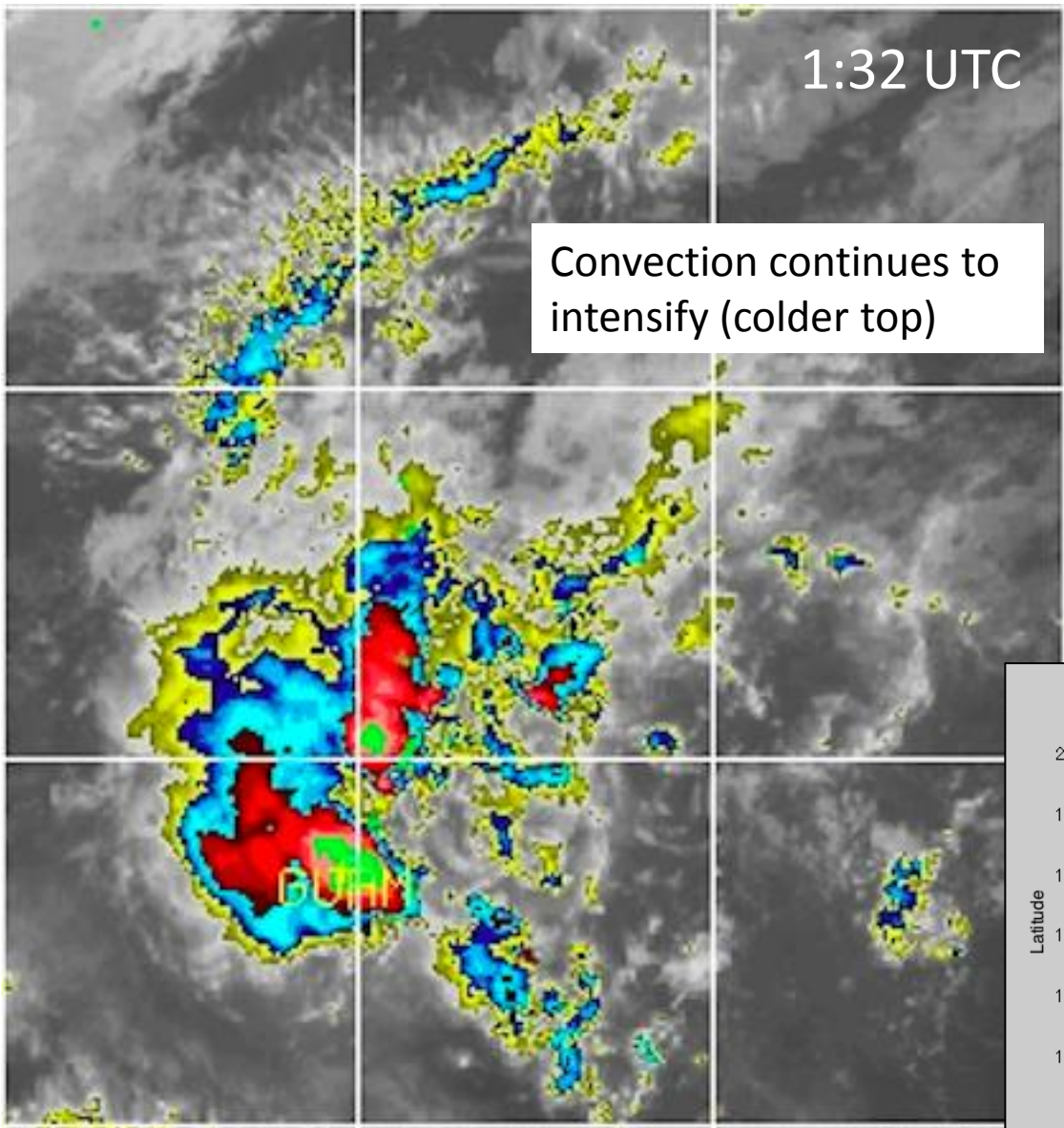
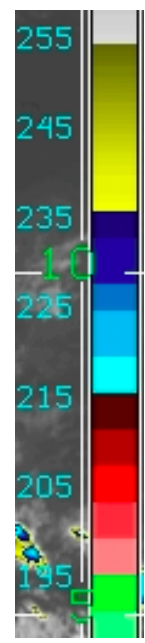


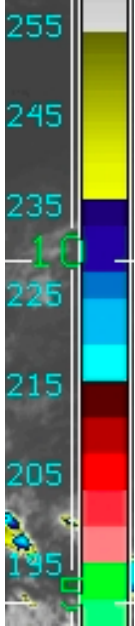
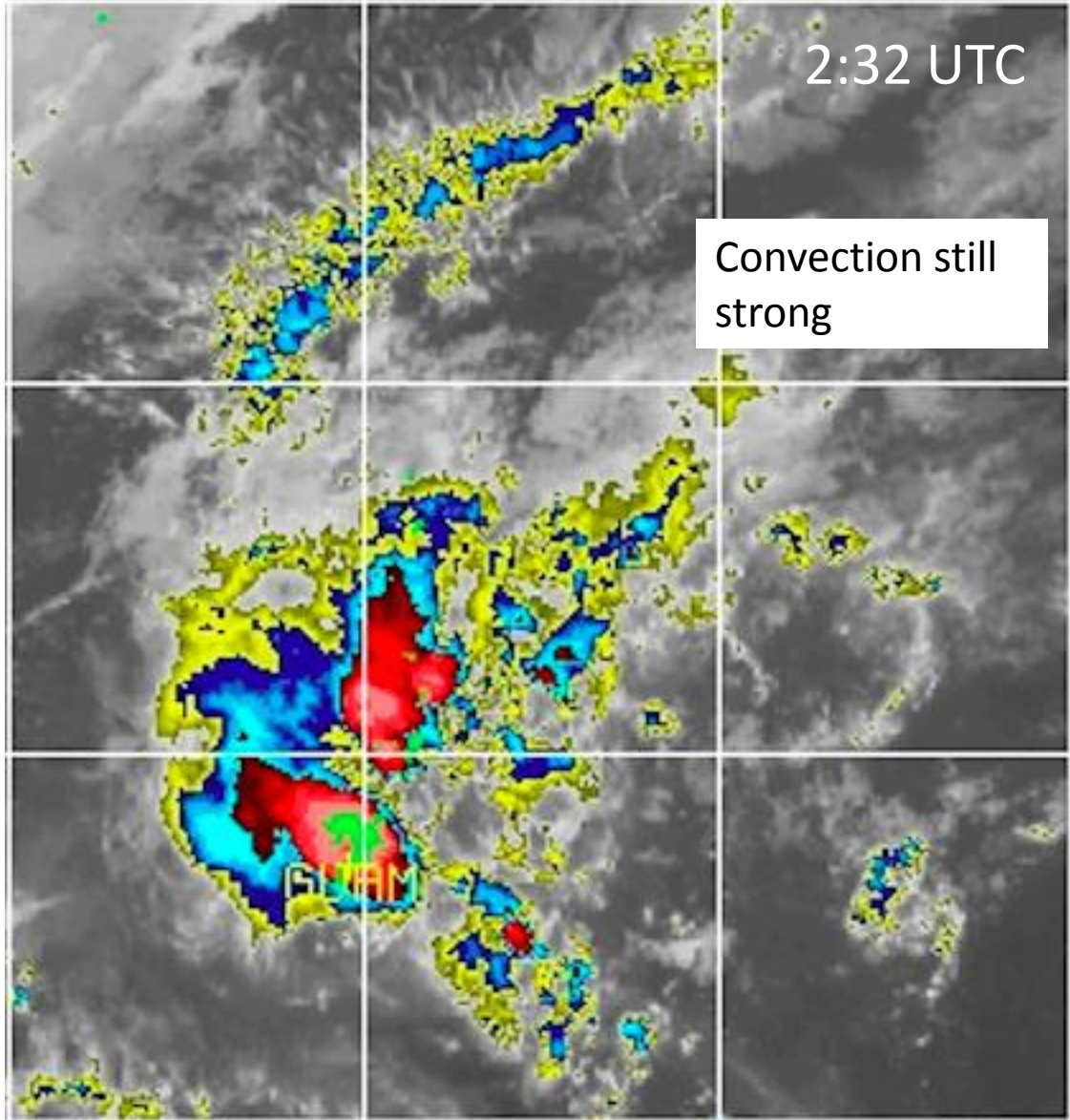
- GV spent ~ 1hr inside the convective region.
- Convection is at dissipating stage (aged).
- Spiraled down inside the convective region (to 1900m).

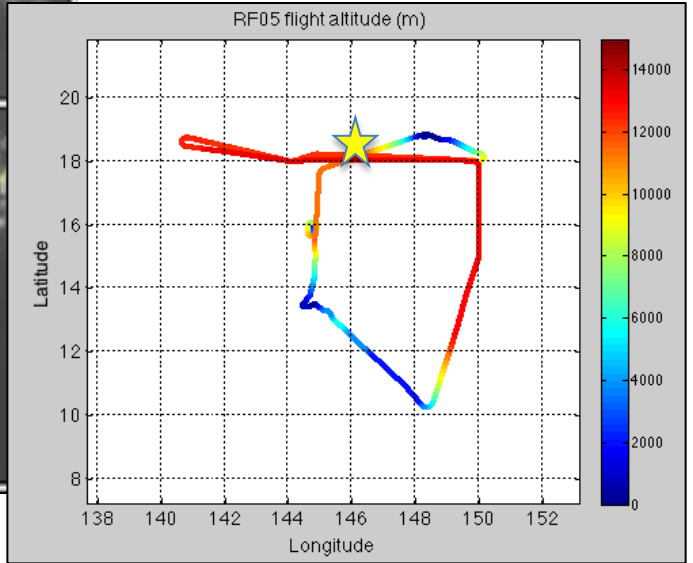
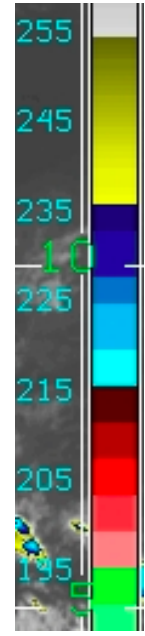
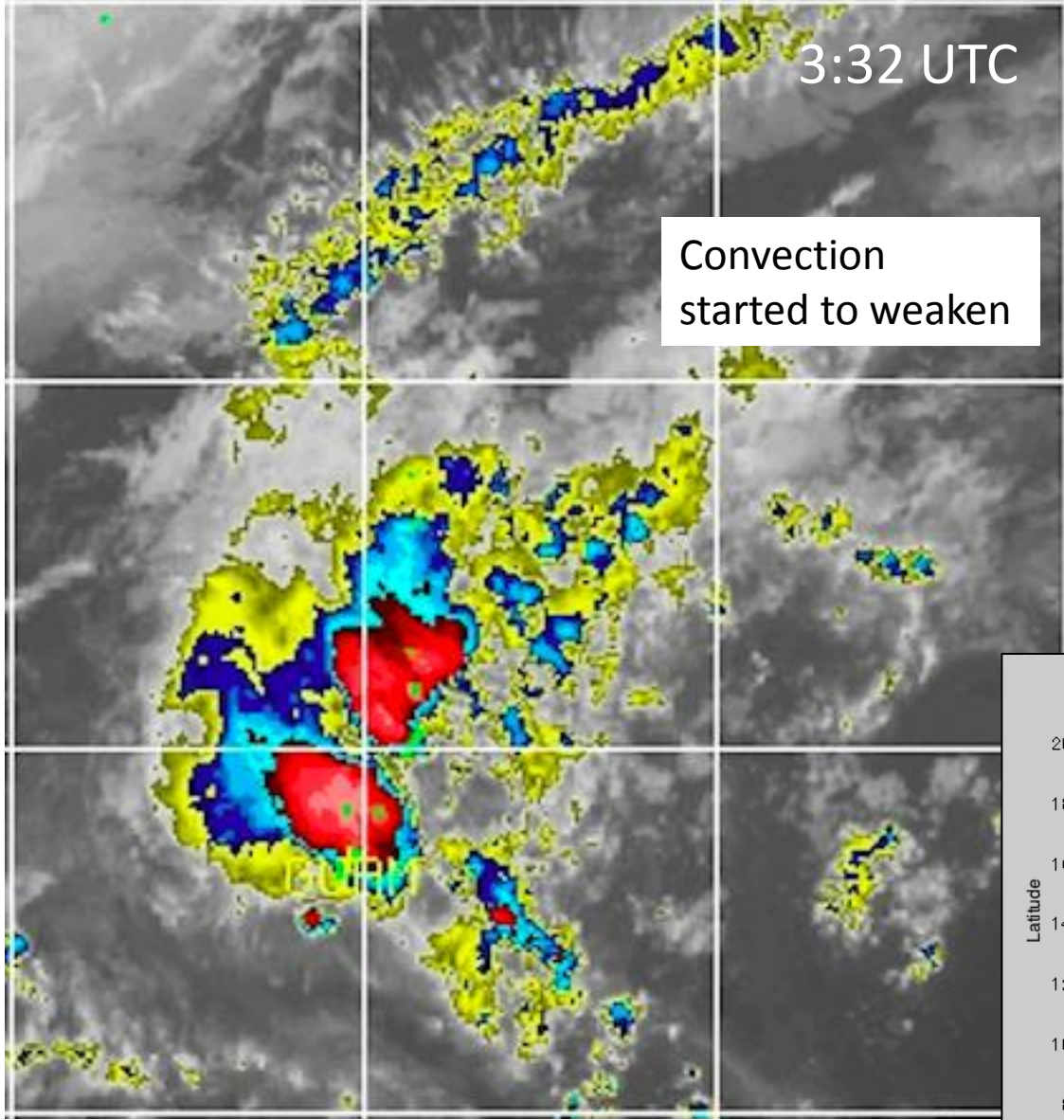


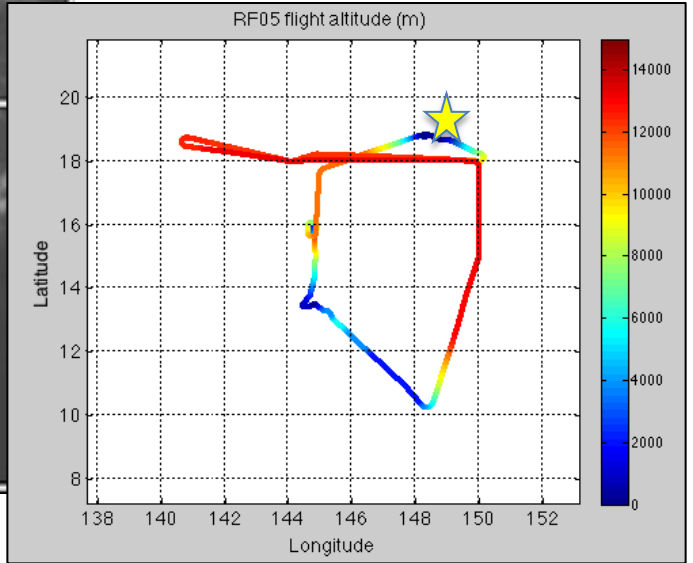
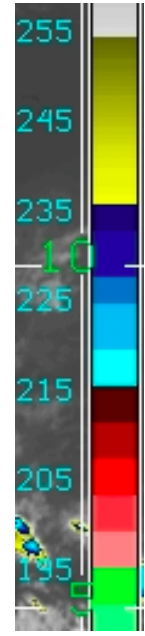
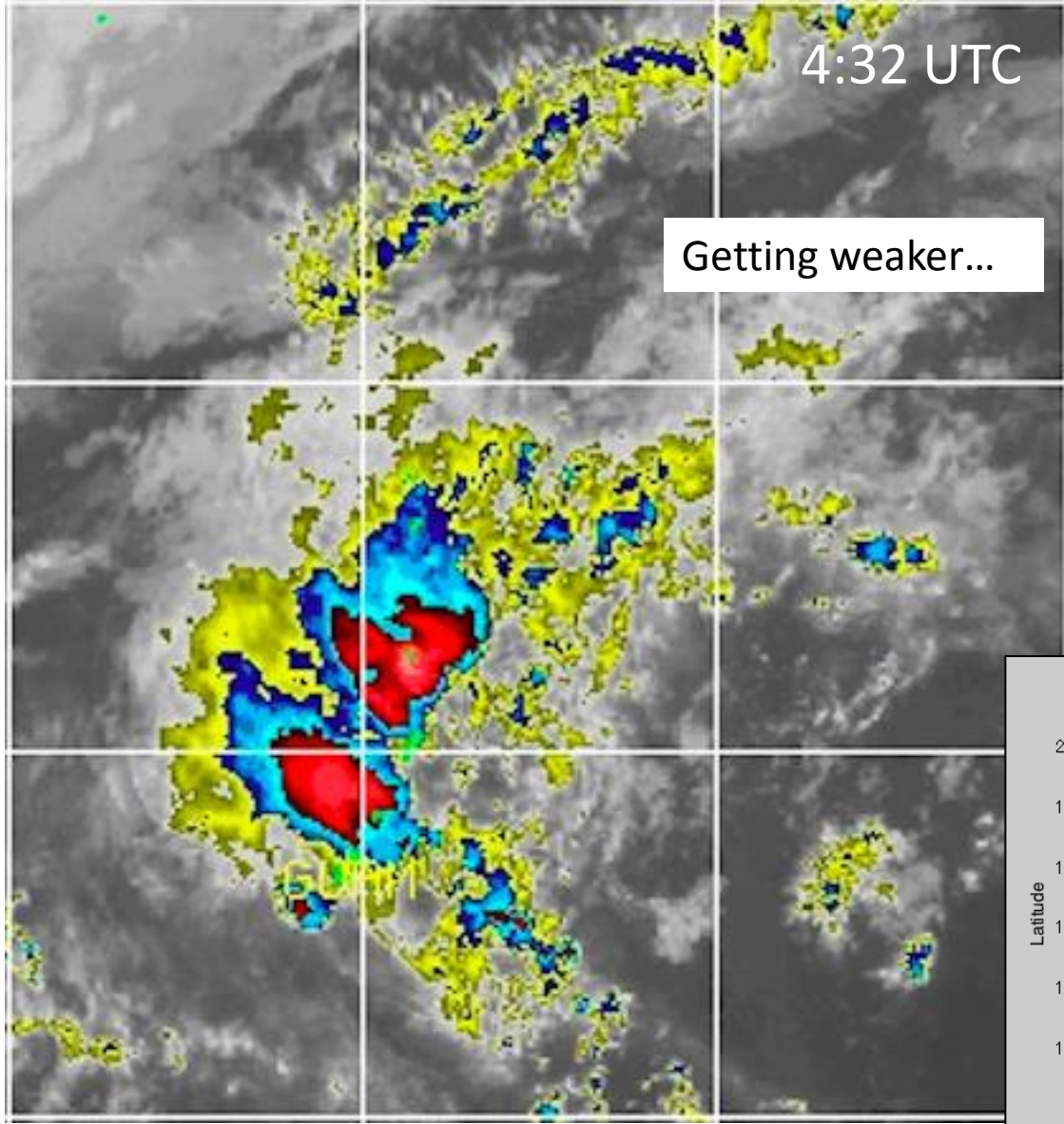
1:32 UTC

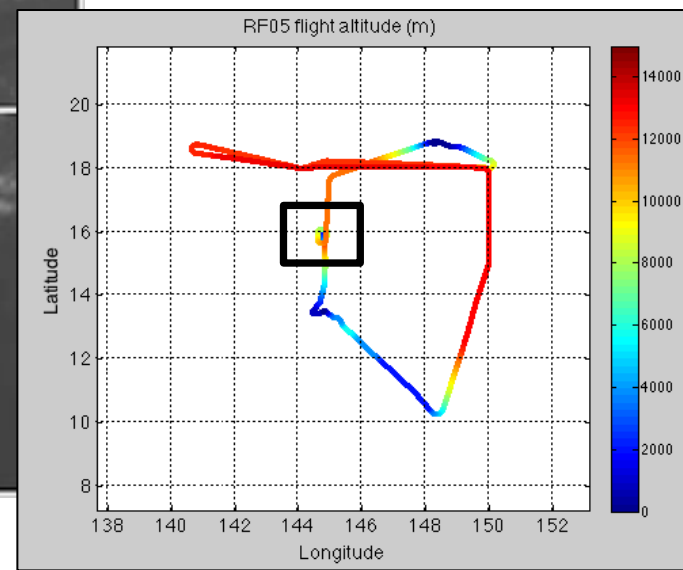
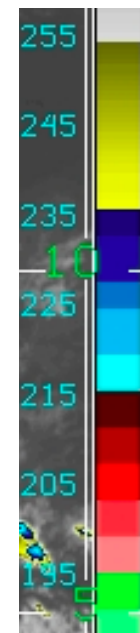
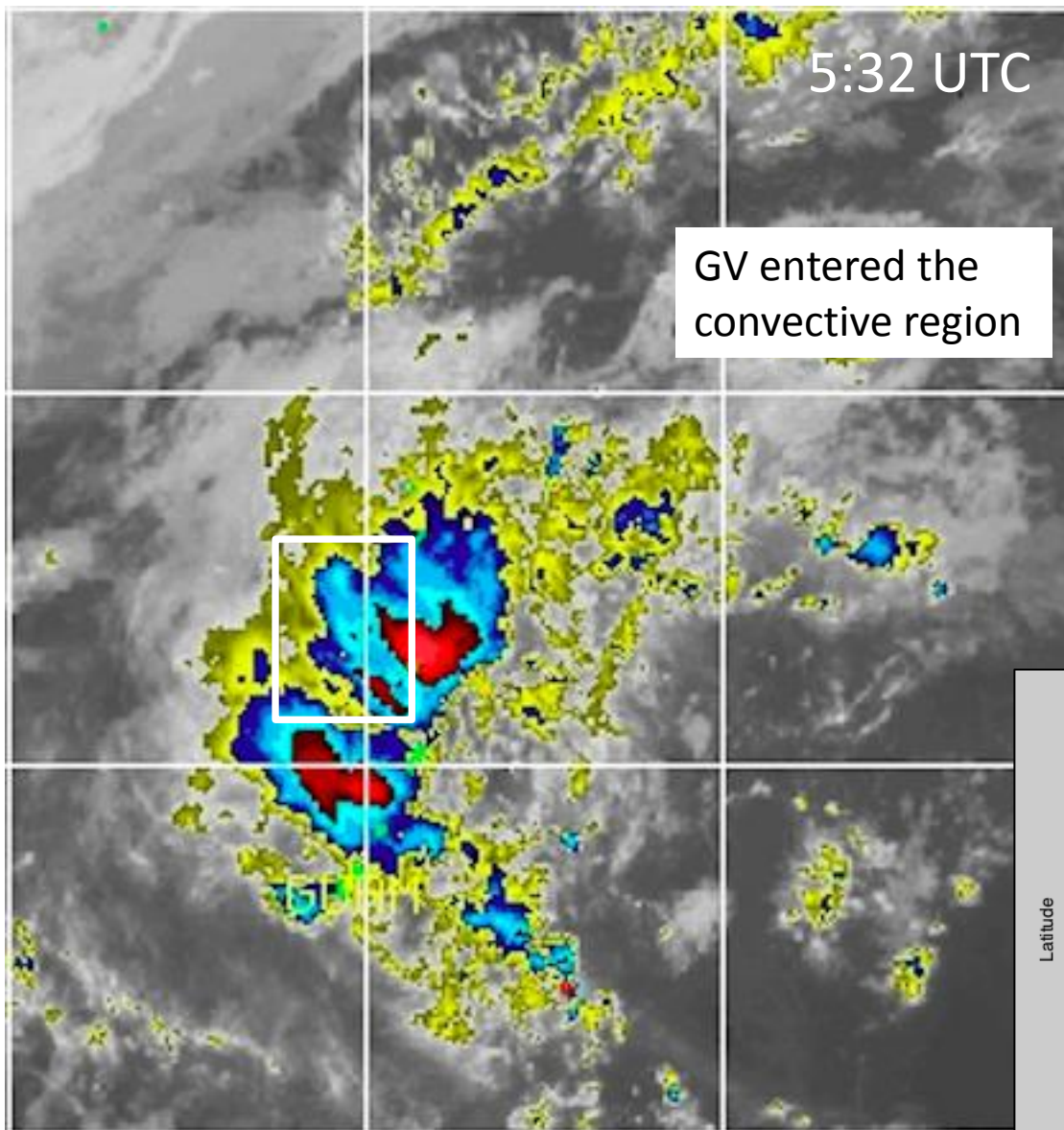
Convection continues to intensify (colder top)

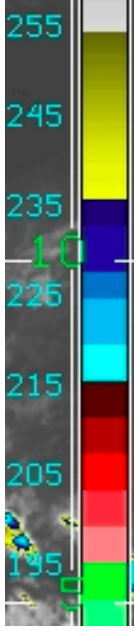
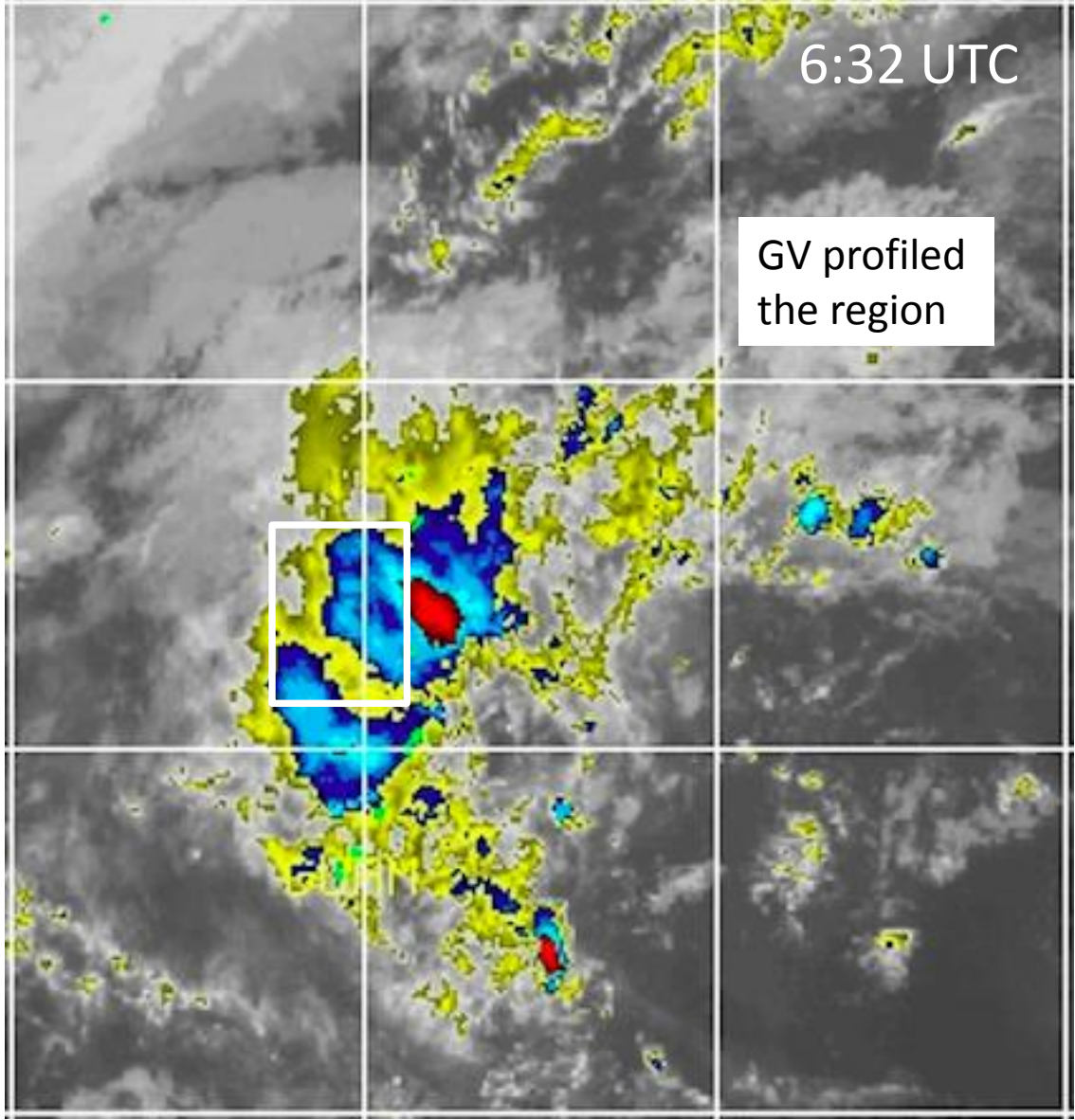


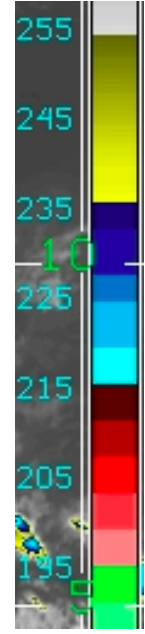
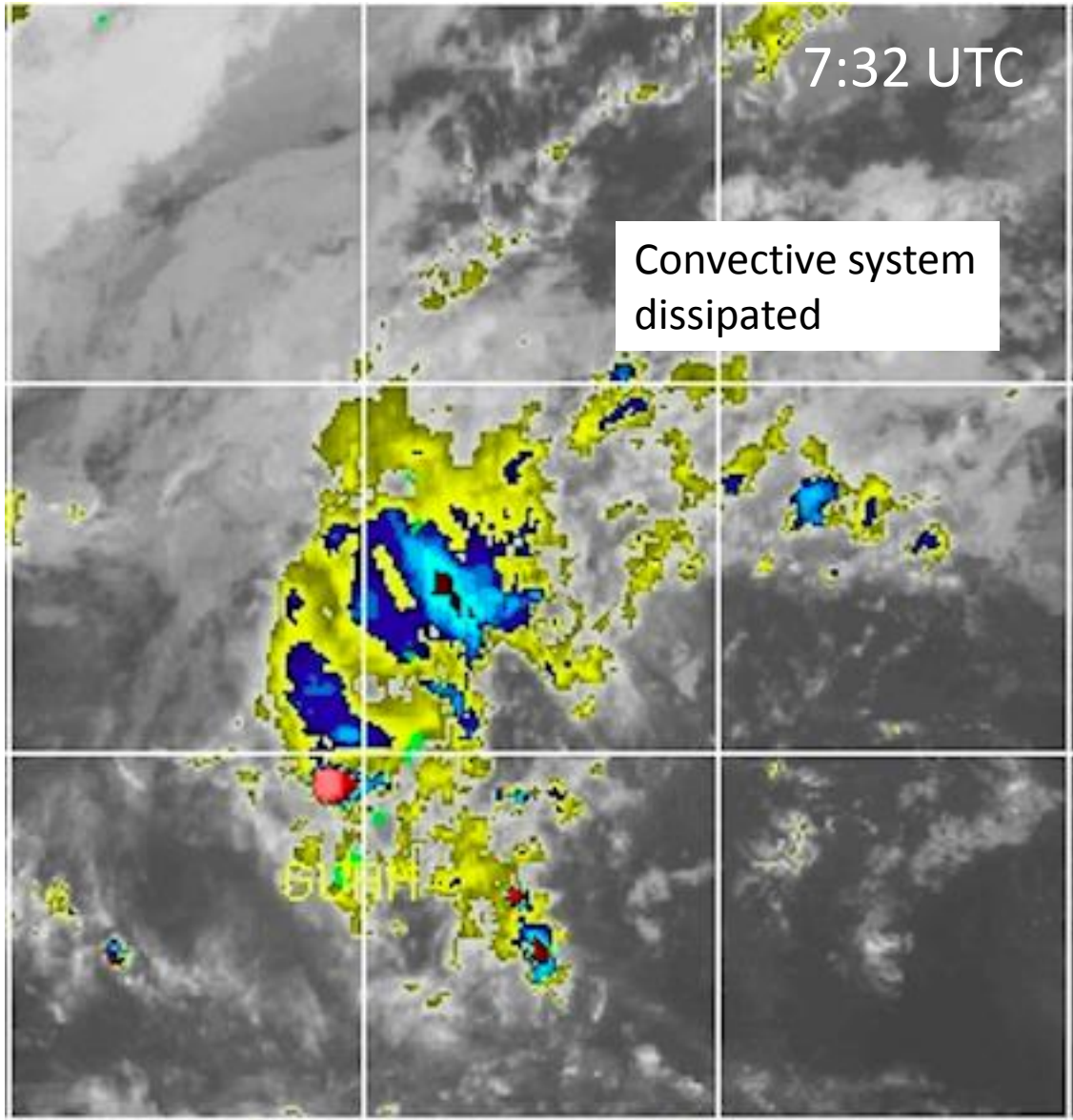


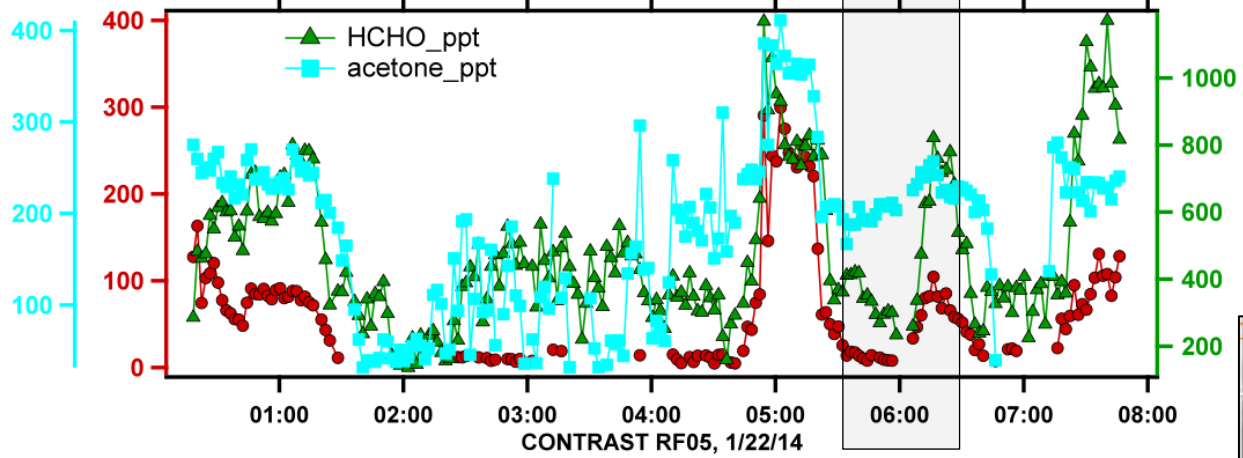
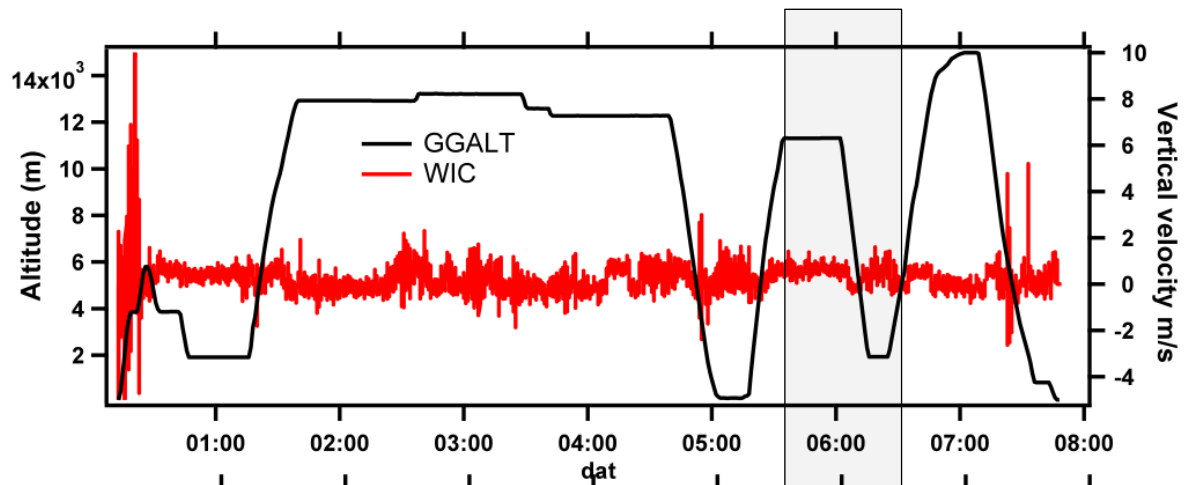




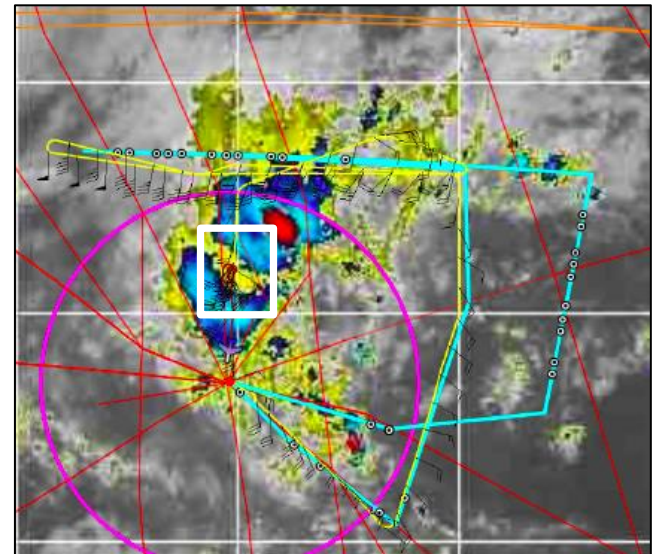




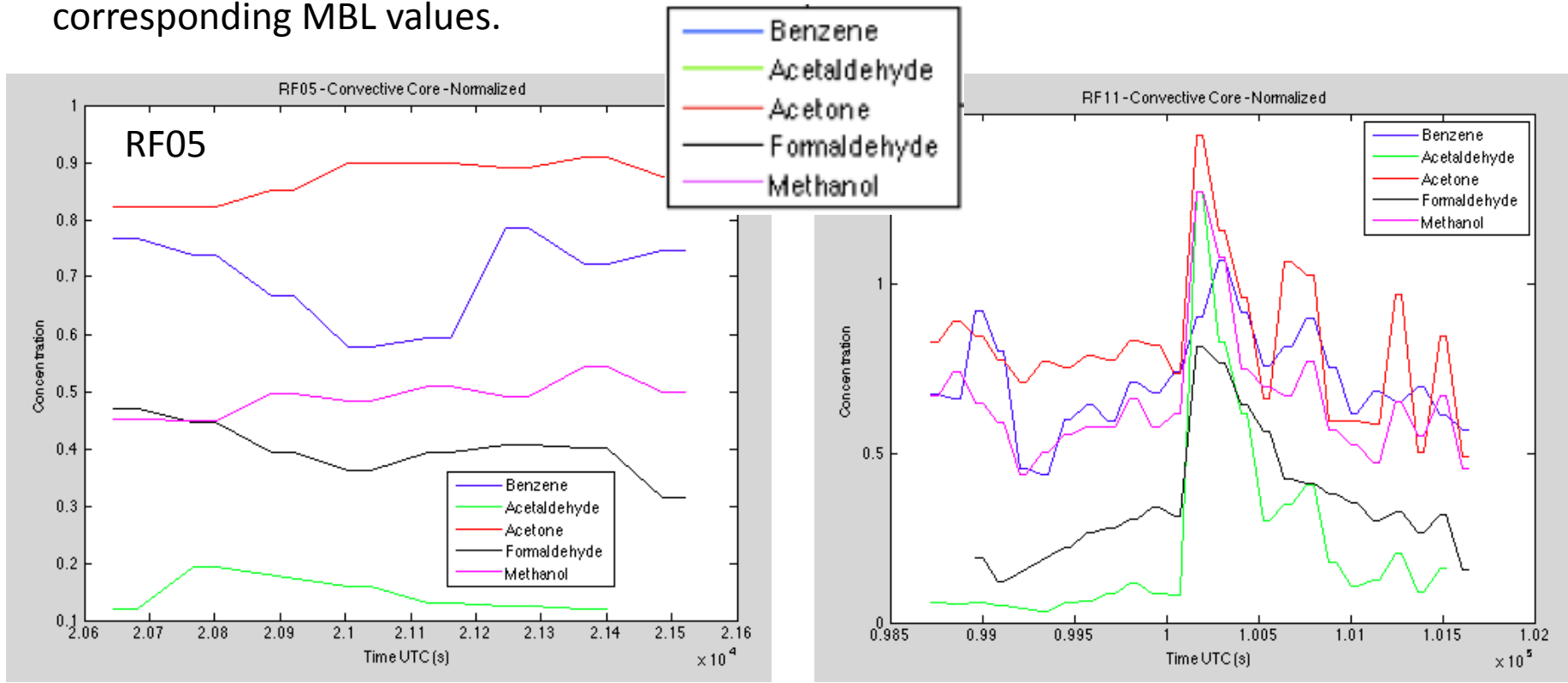




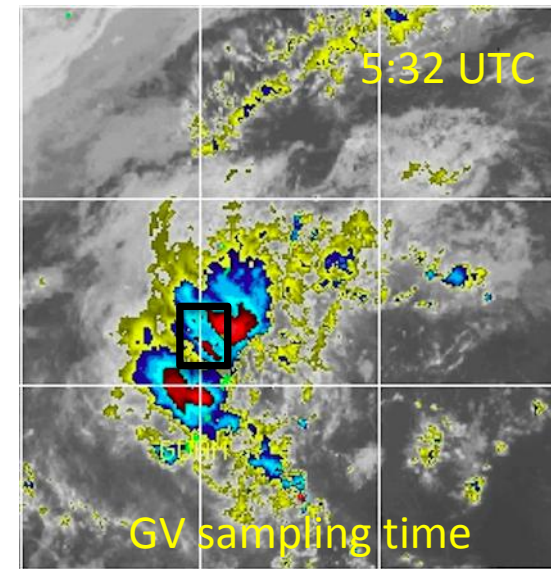
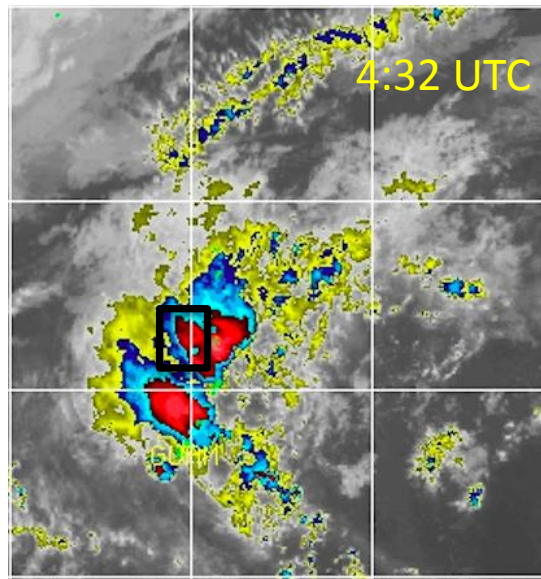
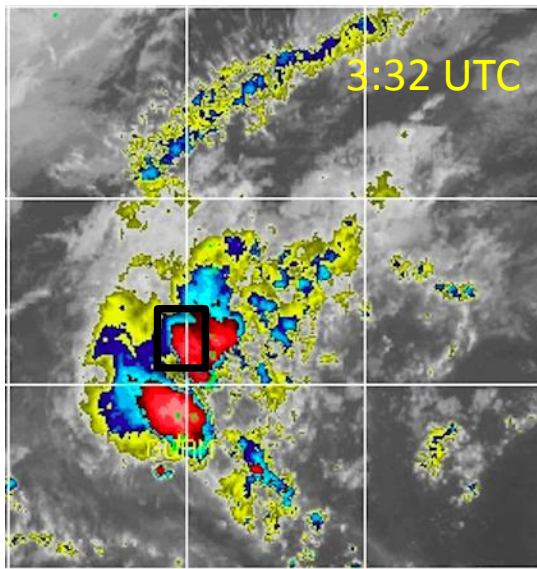
Courtesy: Eric Apel



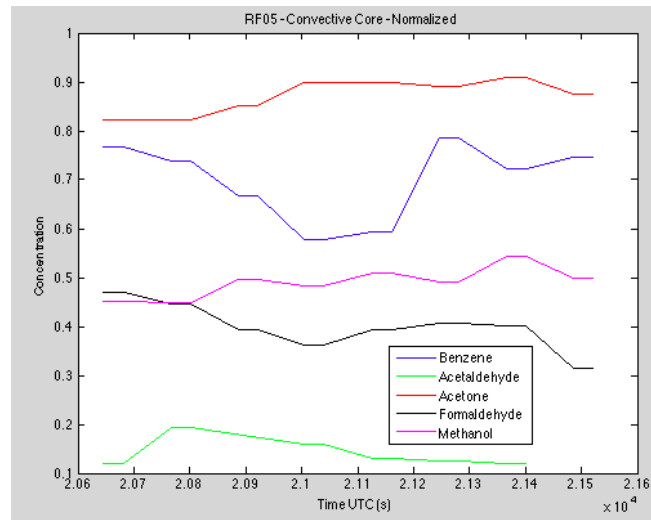
Normalize each species by their corresponding MBL values.



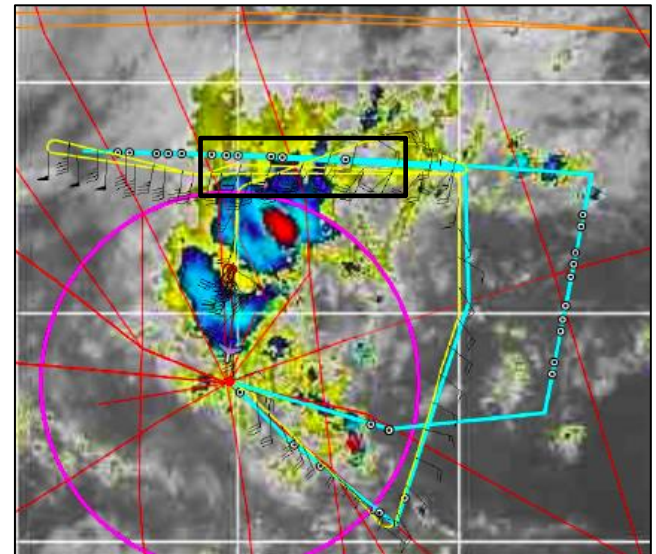
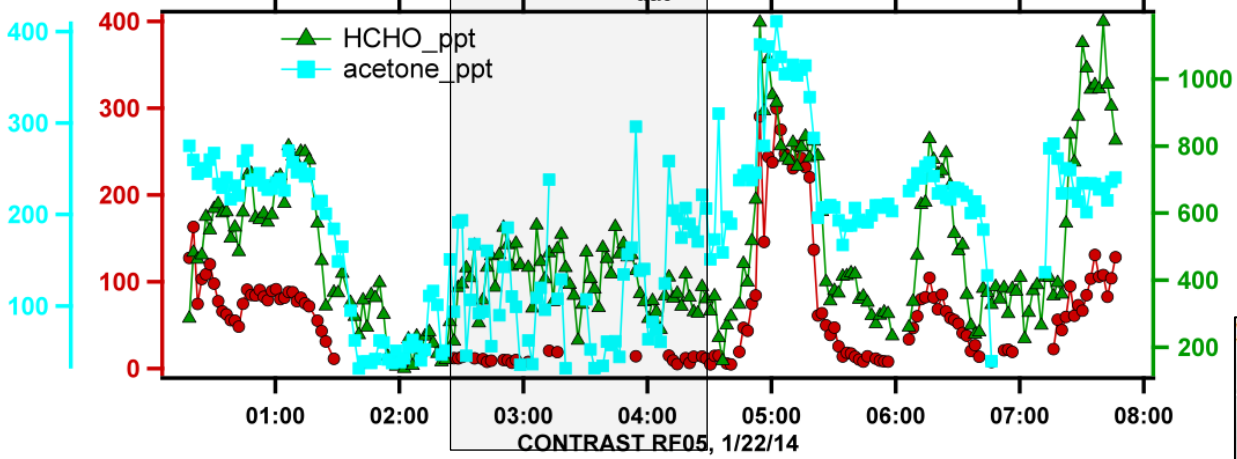
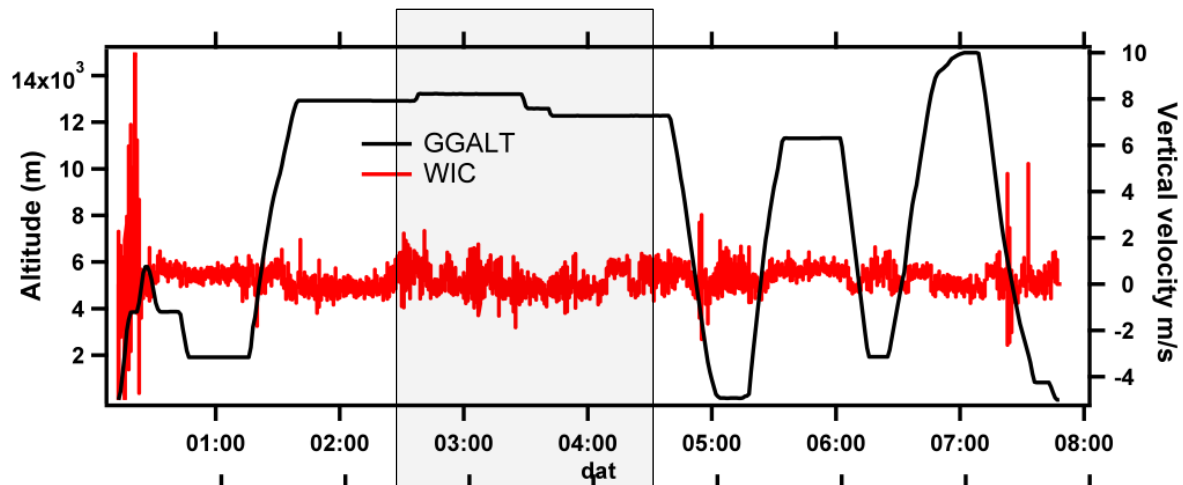
- RF05: no spikes in trace gases (no very fresh updrafts)
- RF05: VSL species (e.g., HCHO) still maintain reasonably high value in relation to the MBL.



This region was under the influence of fresh convection about 2 hours ago.



RF05 : sampled dissipating convection, but still *fresh enough*, most likely only a few hours from leaving the MBL.



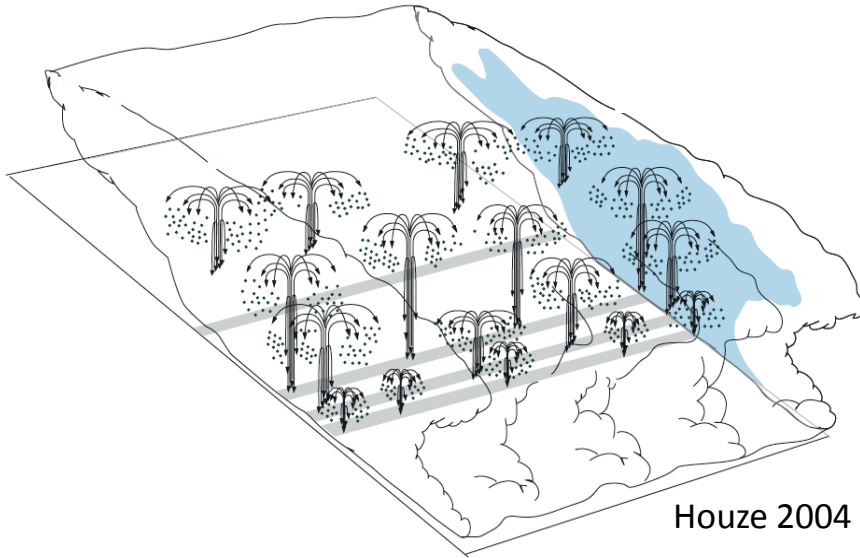
Courtesy: Eric Apel

Outline

1. RF11: Fresh convection
2. RF05: Aged convection

1. Discussions and Summary

Time scales for different pathways



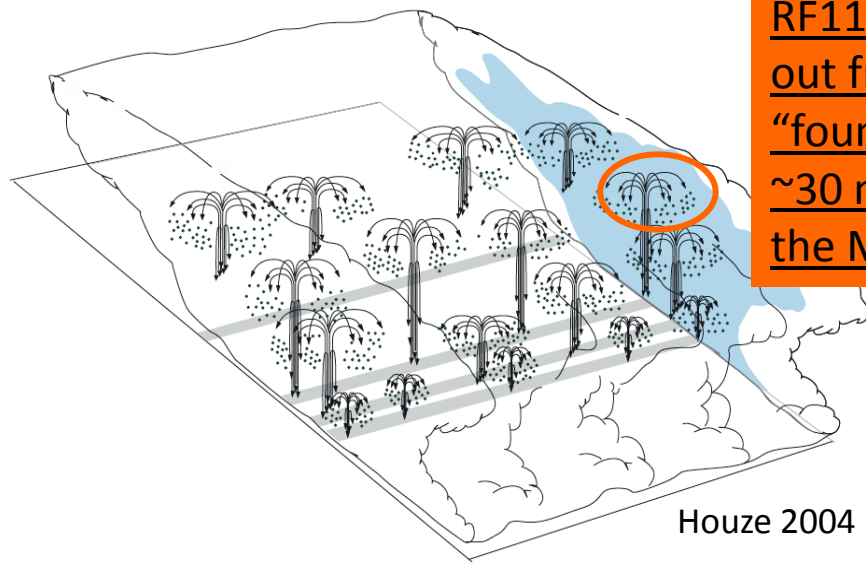
Convective core or updraft (10 m/s):

$15 \text{ (km)}/10 \text{ (m/s)} \approx 25 \text{ min}$

Outside of the cores (1 cm/s):

$15 \text{ (km)}/1 \text{ (cm/s)} \approx 17 \text{ days}$

Time scales for different pathways



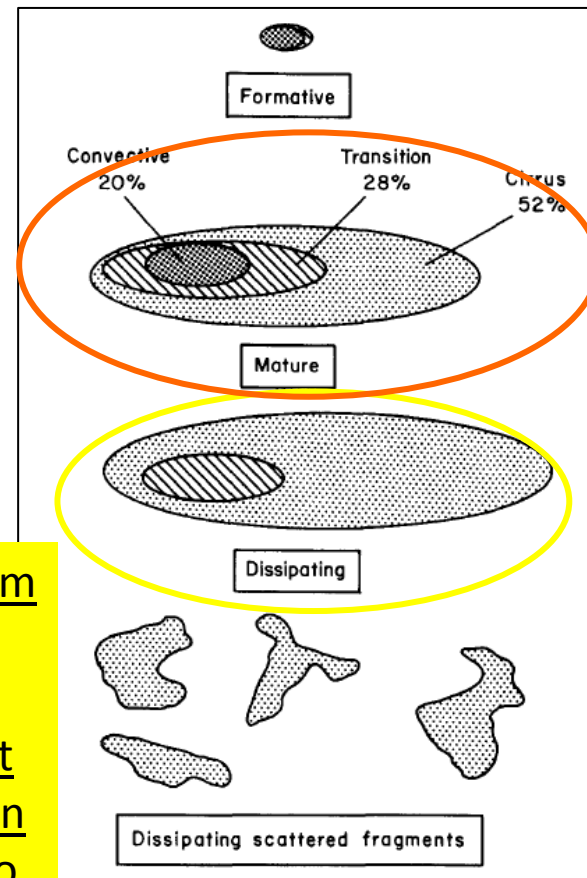
RF11: air fresh out from "fountains"; ~30 min from the MBL

Convective core or updraft (10 m/s):
 $15 \text{ (km)}/10 \text{ (m/s)} \approx 25 \text{ min}$

Outside of the cores (1 cm/s):
 $15 \text{ (km)}/1 \text{ (cm/s)} \approx 17 \text{ days}$

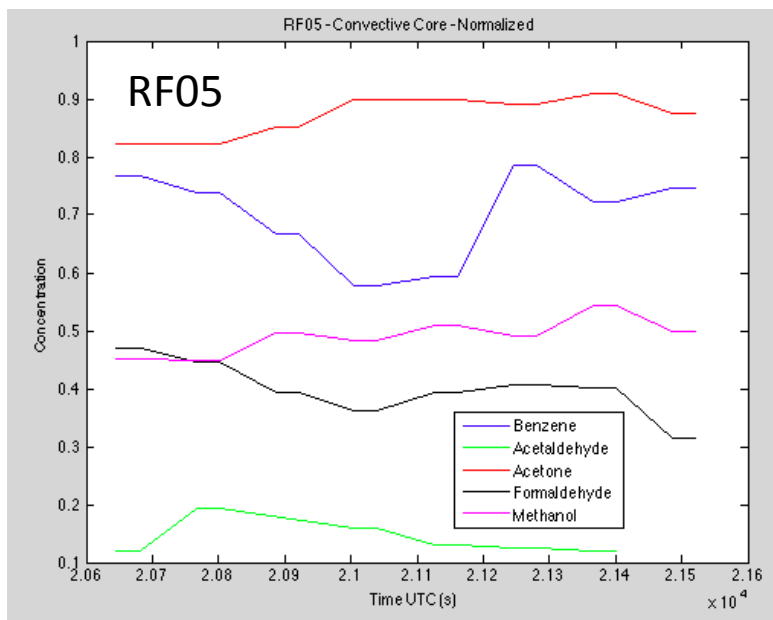
RF05: air from earlier "fountains" that died out no more than a few hrs ago.

Convective life cycle

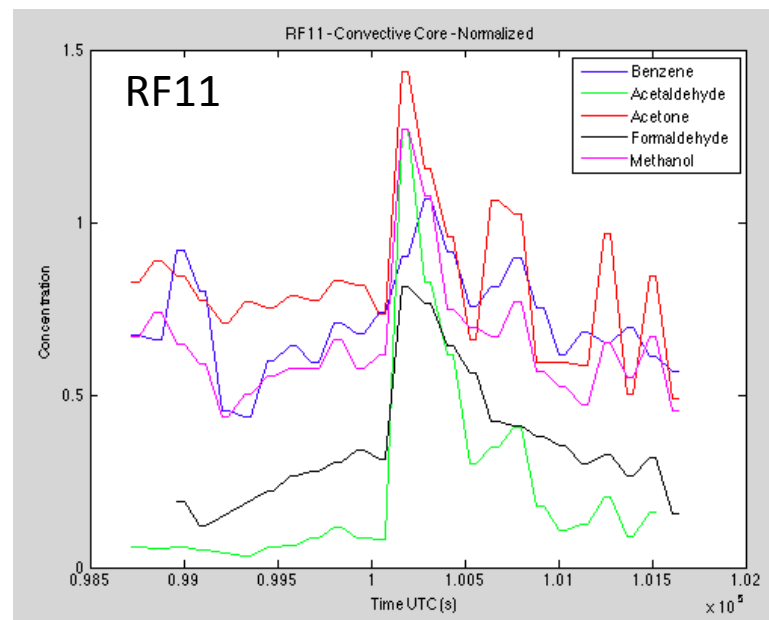


Machado and Rossow 1993

Age from the MBL: A few hours



Age from the MBL: ~ 30 min

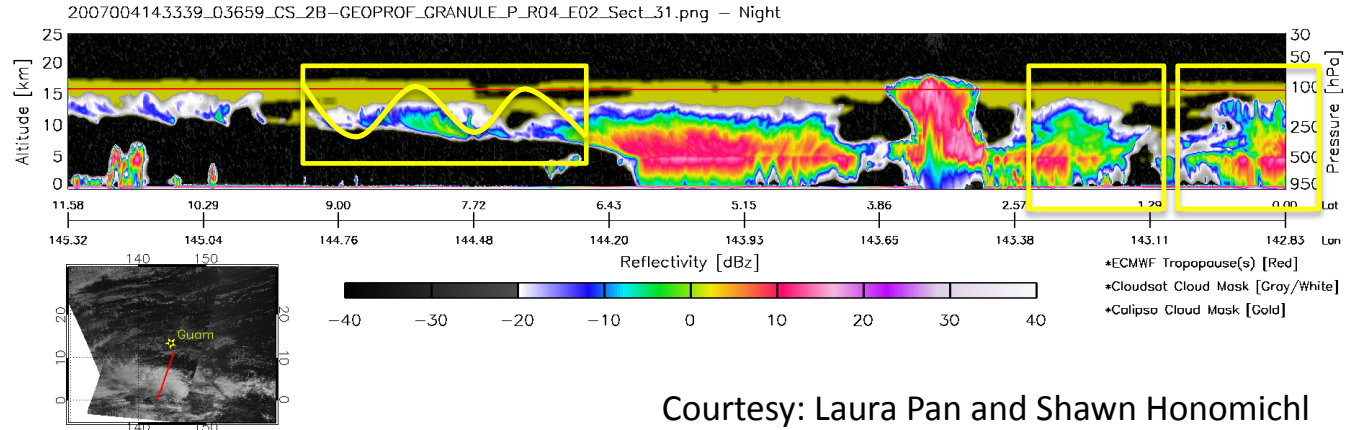


Some chemical modeling should be helpful in quantitatively relating these tracer distribution patterns (e.g., spikes and elevated levels) to air mass life time.

My daydreaming (en route from NYC to Denver): perhaps a satellite analysis of the distribution of the “fountains” (convective cores) and their lifecycle will provide a global estimate of the capability by which VSL species are transported by deep convection to the UT/LS.

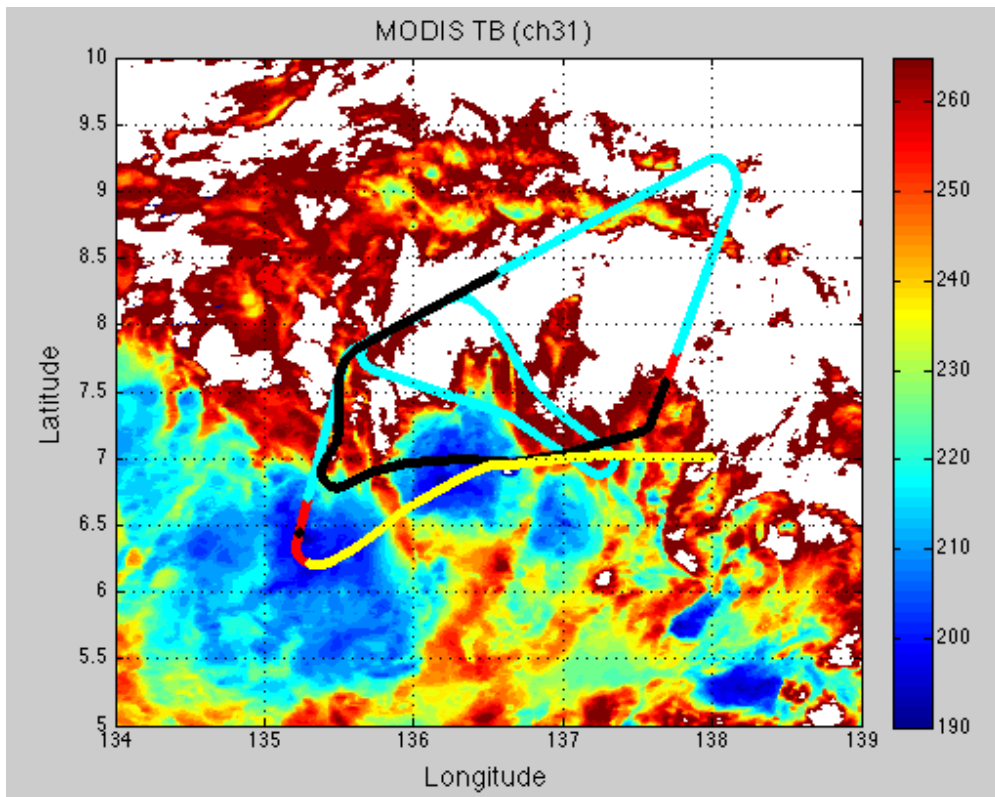
Summary

“Fresh convective outflow” scenario was very successfully sampled.



- RF11: 3.5 hrs inside and near the same convective system; sampled *very fresh* (~ 30 min from the MBL) outflow from convective updrafts.
- RF05: sampled convection at dissipating stage; outflow is still fresh enough (no more than a few hours)
- Joint analysis of cloud imageries and trace gas distribution (VSL and long-lived species) is very helpful in determining the freshness or the age of convective outflow. We plan to conduct the same analysis on other flights and flight segments.

Backup slides



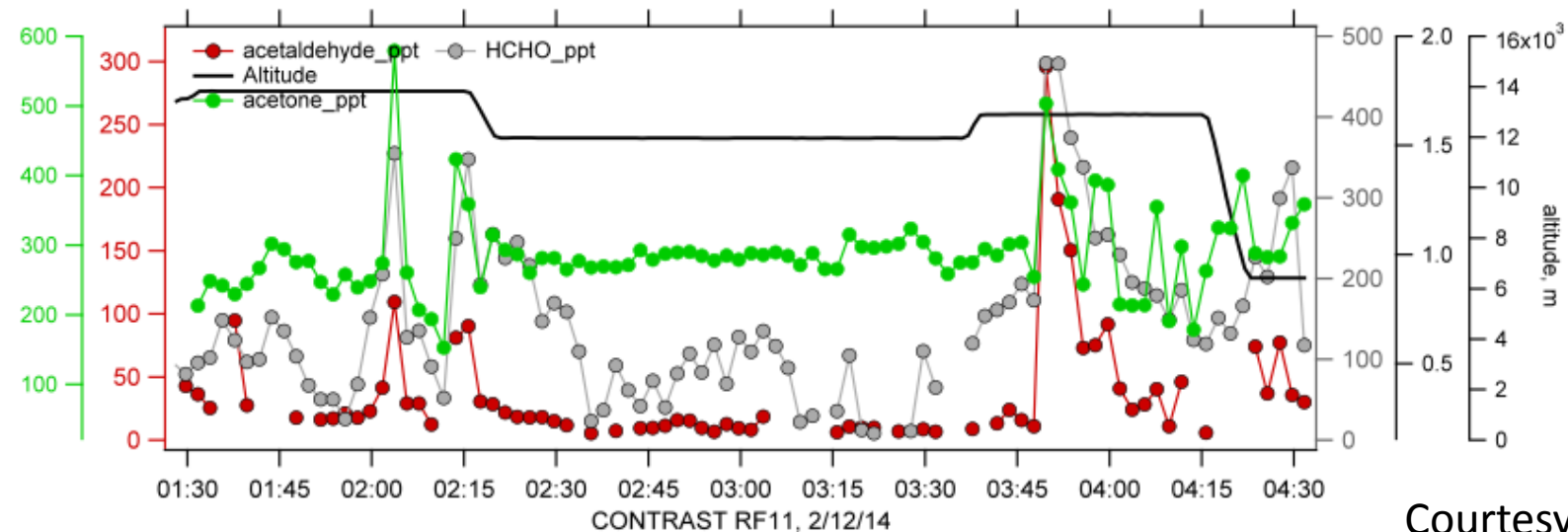
MODIS Aqua 4:10 UTC

- 14 km
- 13 km
- 12 km

Toward the end of the 14-km leg, GV is deepest into the convective cloud (but the system was not as developed back at 2 UTC)

The 13-km leg went into a vigorously developing convection ~ 70 km in diameter.

The 12-km leg is mostly outside the convection.



Courtesy: Eric Apel

