

ATTREX/CONTRAST/CAST Science Team Meeting, Oct, 2014

A fine vertical wave structure & its relation with trace gas transport

Ji-Eun Kim

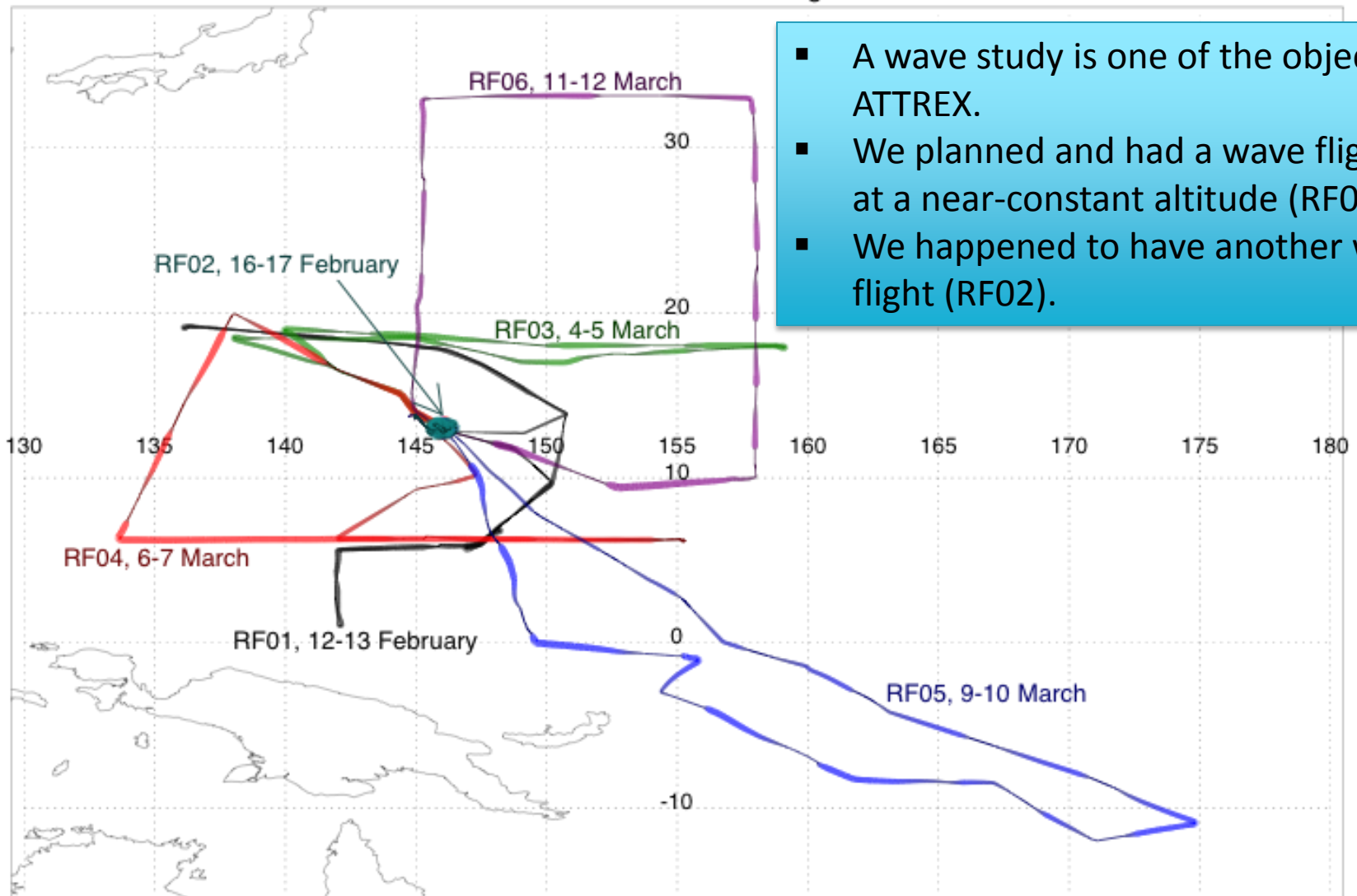
University of Colorado, Boulder, CO

M. Joan Alexander

NWRA/Colorado Research Associates, Boulder, CO

Thanks to the ATTREX team!

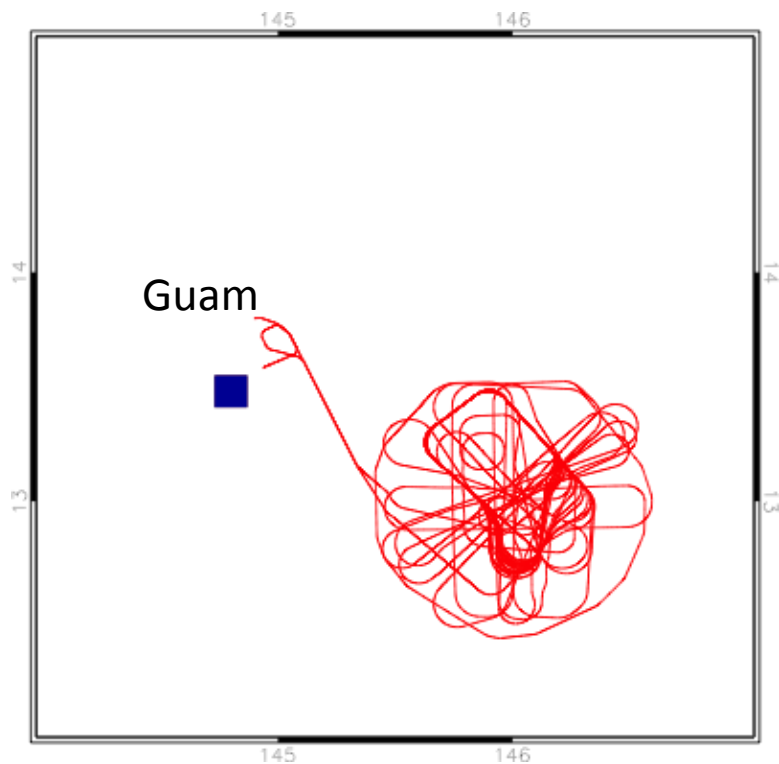
2014 ATTREX science flights



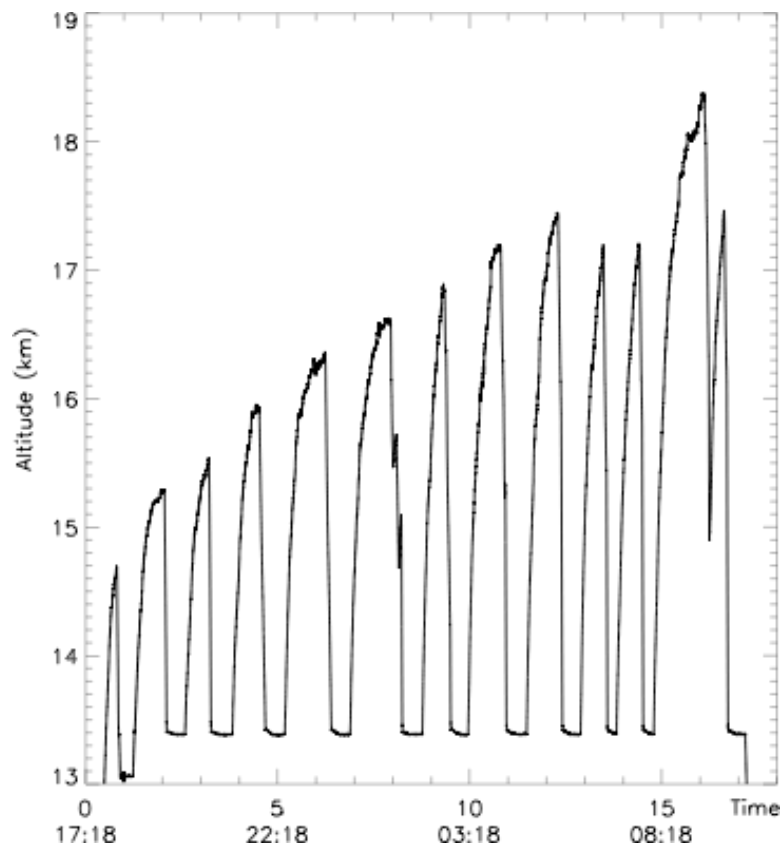
- A wave study is one of the objectives of ATTREX.
- We planned and had a wave flight (7deg) at a near-constant altitude (RF04).
- We happened to have another wave flight (RF02).

Stuck in the UA zone? → Unprecedented wave measurements!

GH path on Feb 16-17



~0.5-1 hourly ~24 vertical profiles
like continuous radio-/dropsonde



Datasets: Large scale to small scale

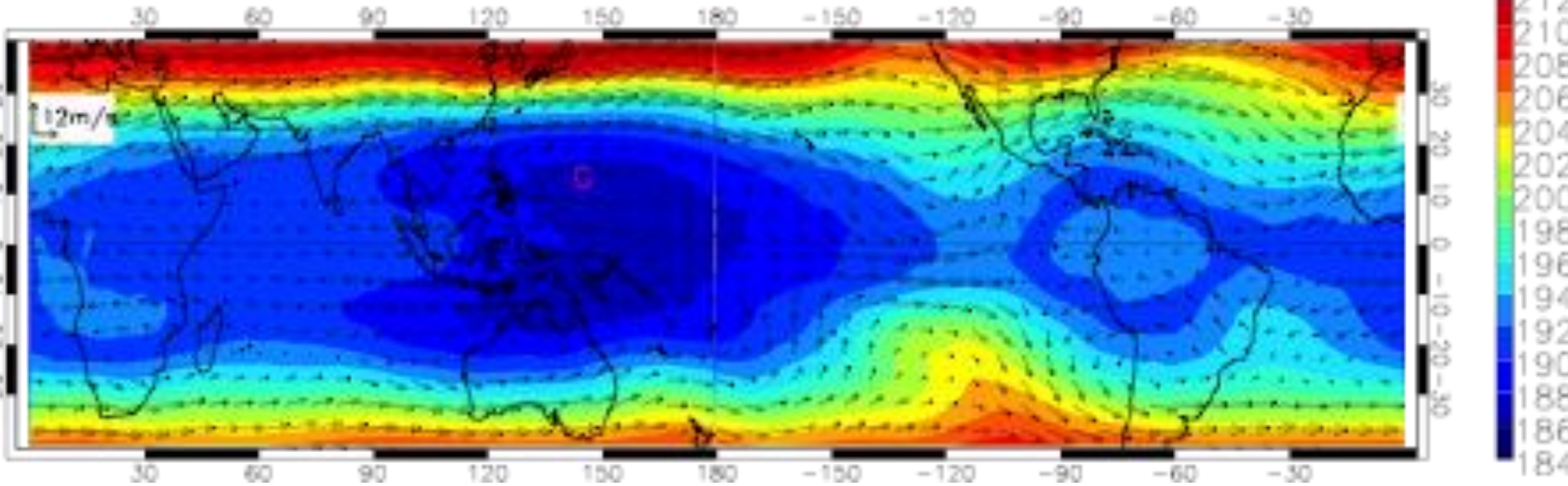
- MERRA
 - well represents slow, large scales
- MLS CO
 - Large scale tracer distribution in the TTL
- Guam radiosonde
 - 2/day meteorological measurements
 - Good vertical and frequency wave structure
- GlobalHawk
 - Meteorological fields with tracers
 - Very high vertical, time resolution (0.5-1 hourly)
 - CPL clouds

* Everything in log-pressure altitude for comparison, except for CPL

Mean fields show typical Gill-type DJF TTL.

Mean temperature and winds

MERRA mean 20131201-20140228

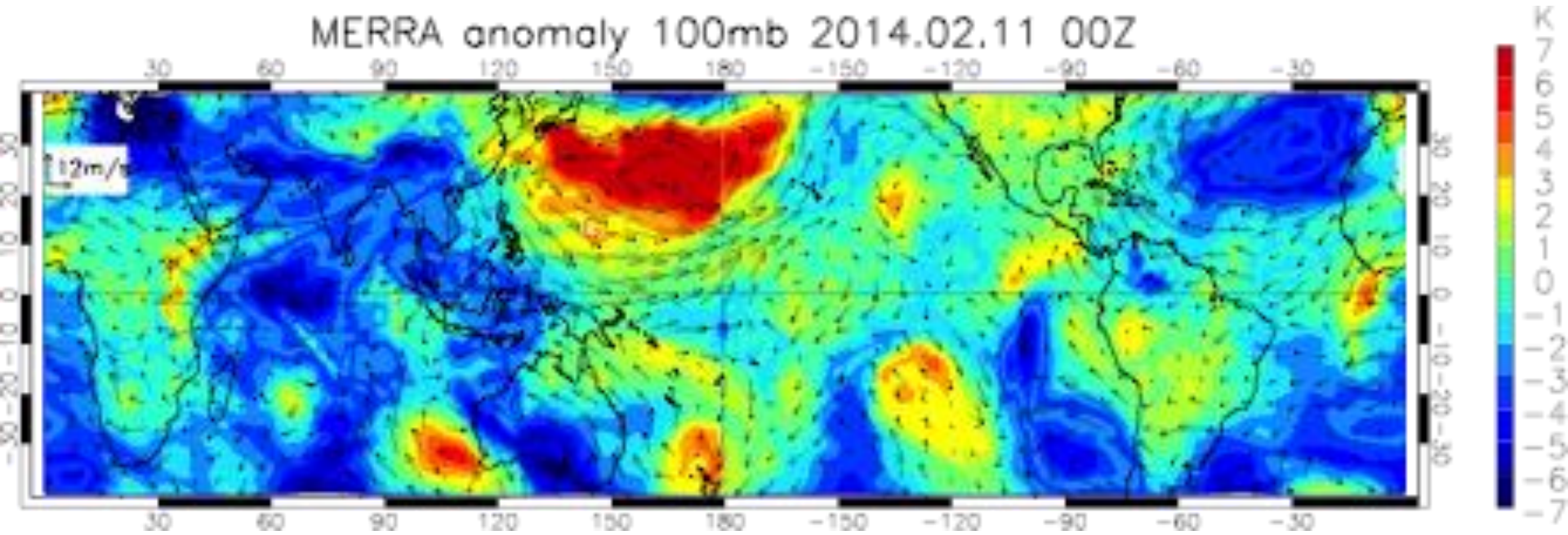


No strong wind near Guam

MERRA evolution (Day -6)

Temperature and wind anomaly

MERRA anomaly 100mb 2014.02.11 00Z

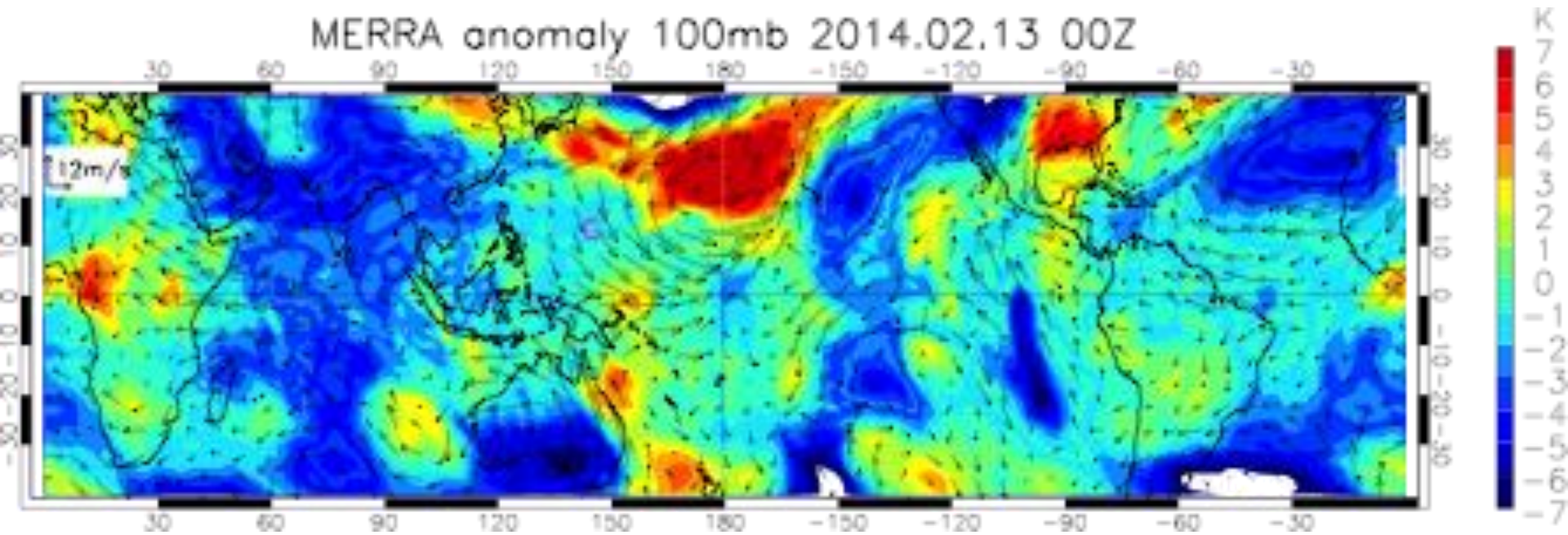


Strong cyclonic circulation in TTL near Guam

MERRA evolution (Day -4)

Temperature and wind anomaly

MERRA anomaly 100mb 2014.02.13 00Z

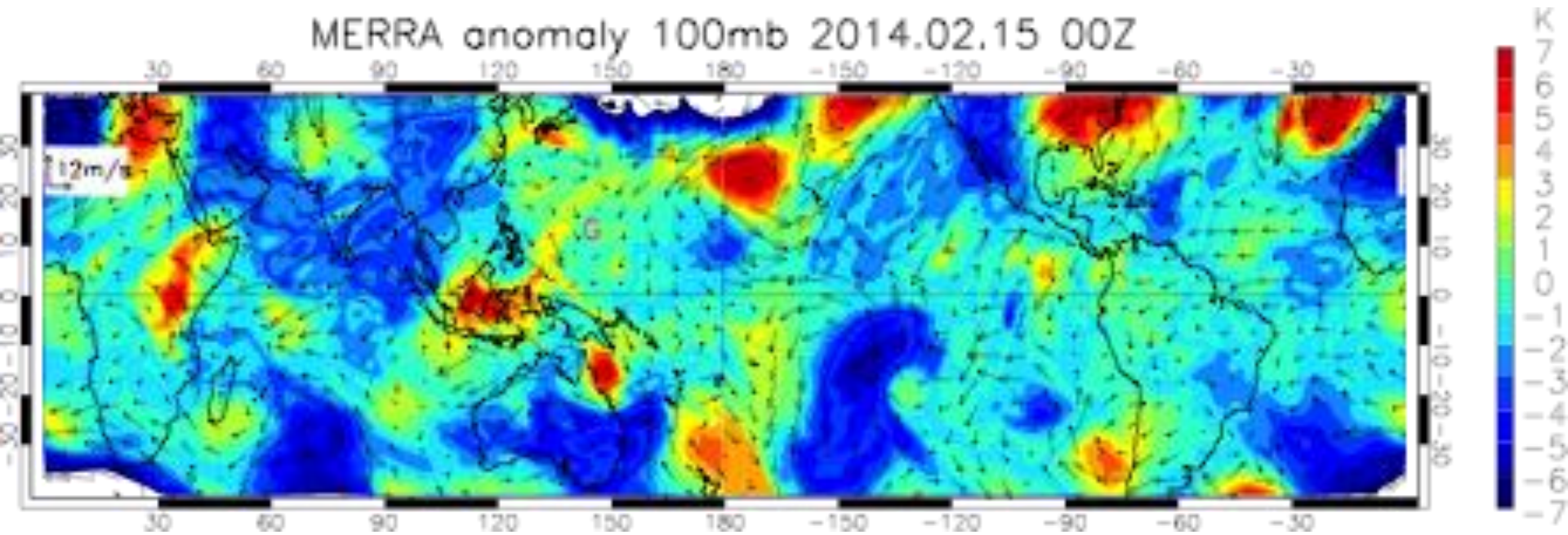


Cyclonic Rossby wave circulation propagating eastward

MERRA evolution (Day -2)

Temperature and wind anomaly

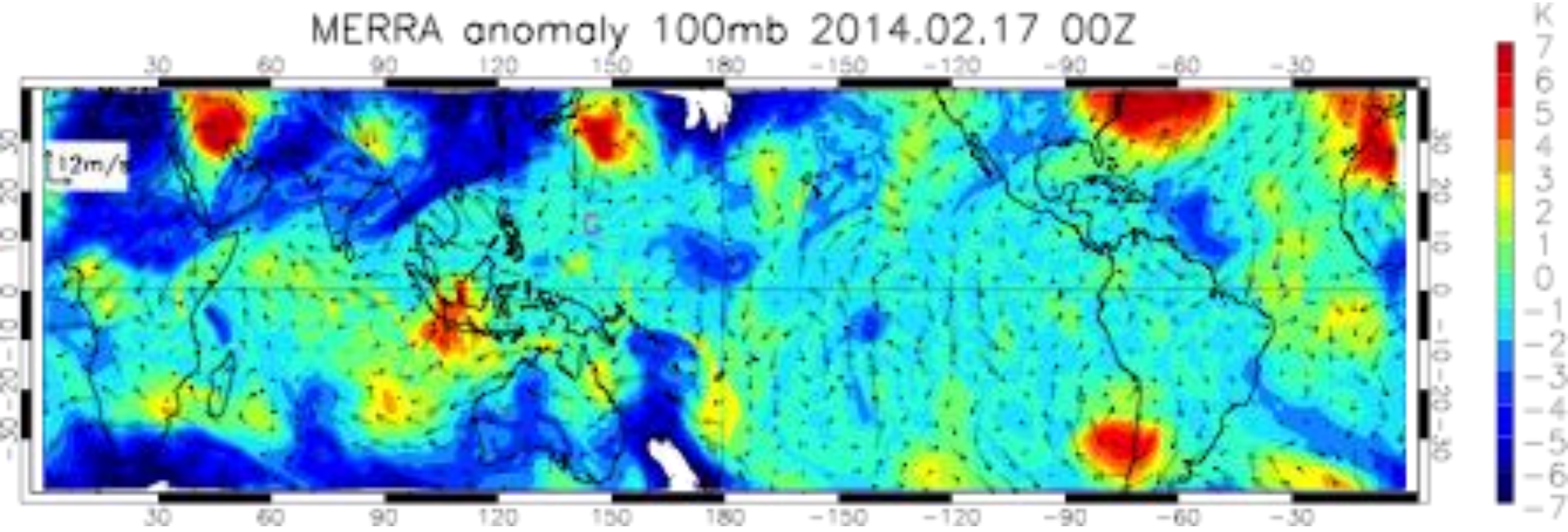
MERRA anomaly 100mb 2014.02.15 00Z



Cyclonic Rossby wave circulation propagating eastward

MERRA evolution (Day 0)

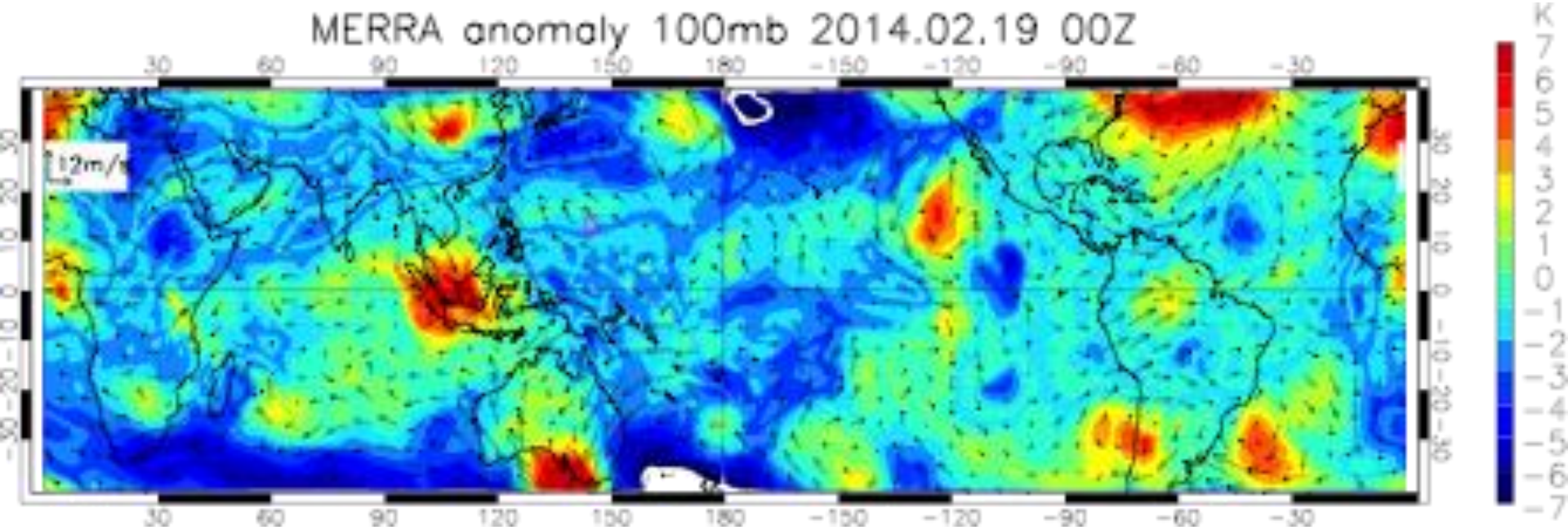
Temperature and wind anomaly



No strong large-scale disturbances in Guam

MERRA evolution (Day +2)

Temperature and wind anomaly

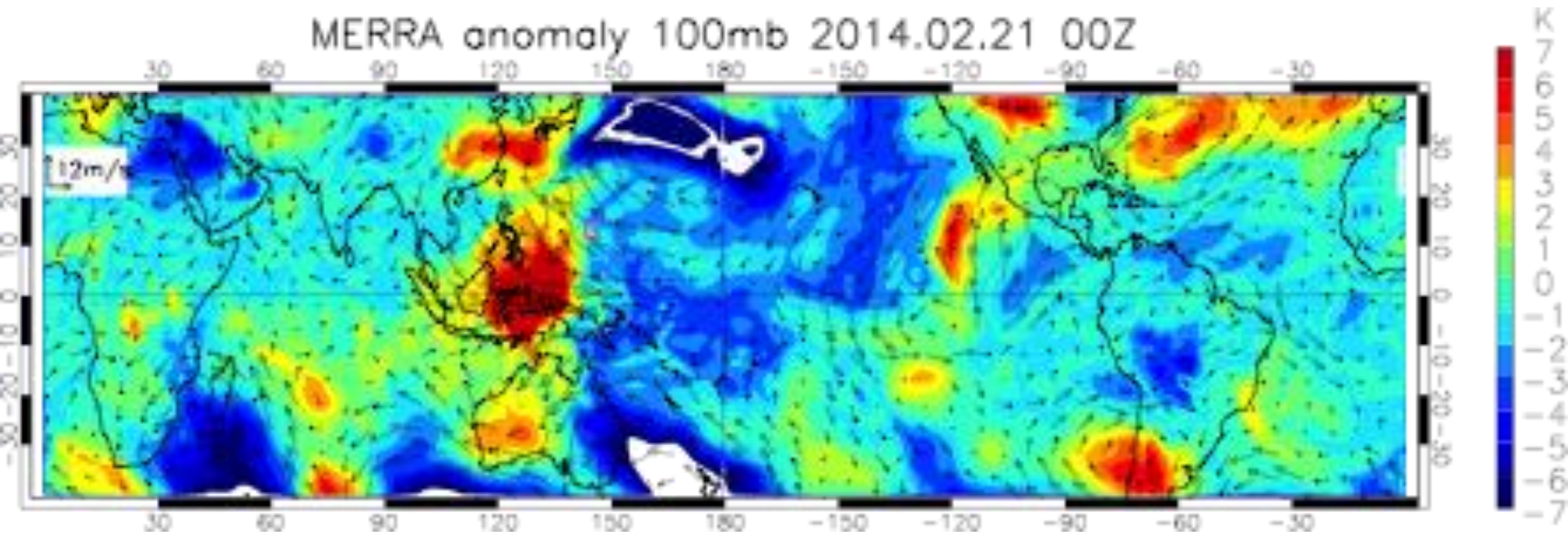


A Rossby wave anti-cyclonic motion developed

MERRA evolution (Day +4)

Temperature and wind anomaly

MERRA anomaly 100mb 2014.02.21 00Z

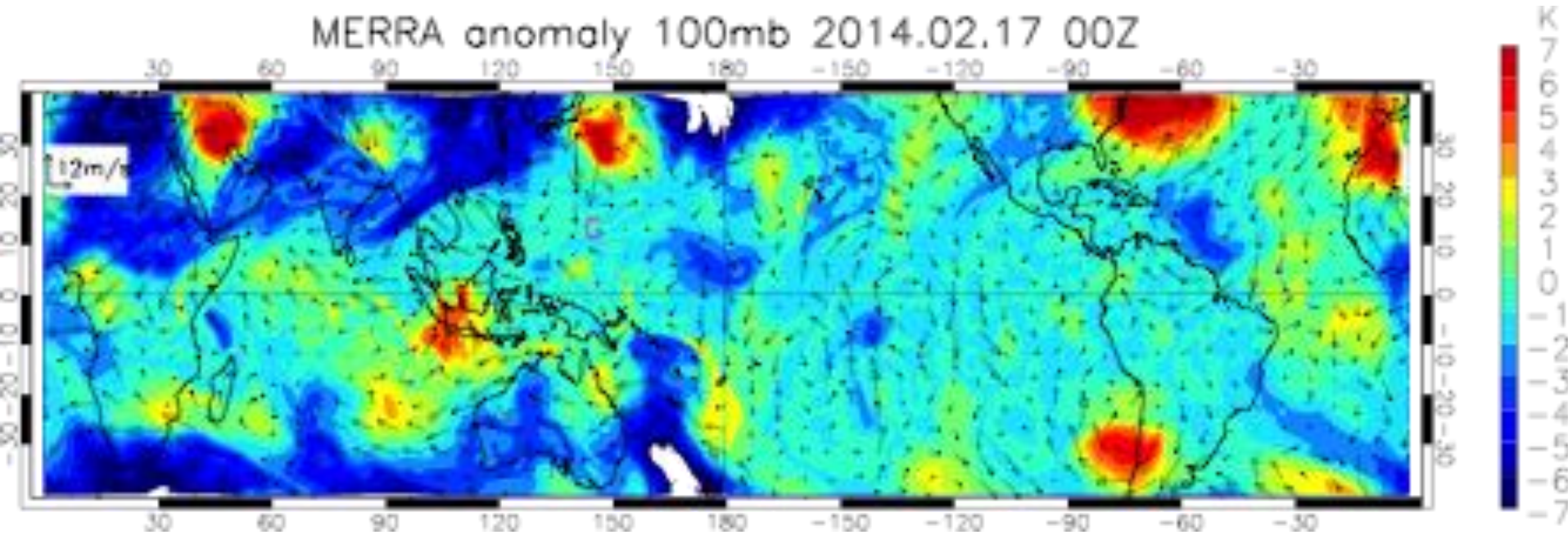


Rossby wave anti-cyclonic circulation propagating eastward

Measurement Day (Day 0)

Temperature and wind anomaly

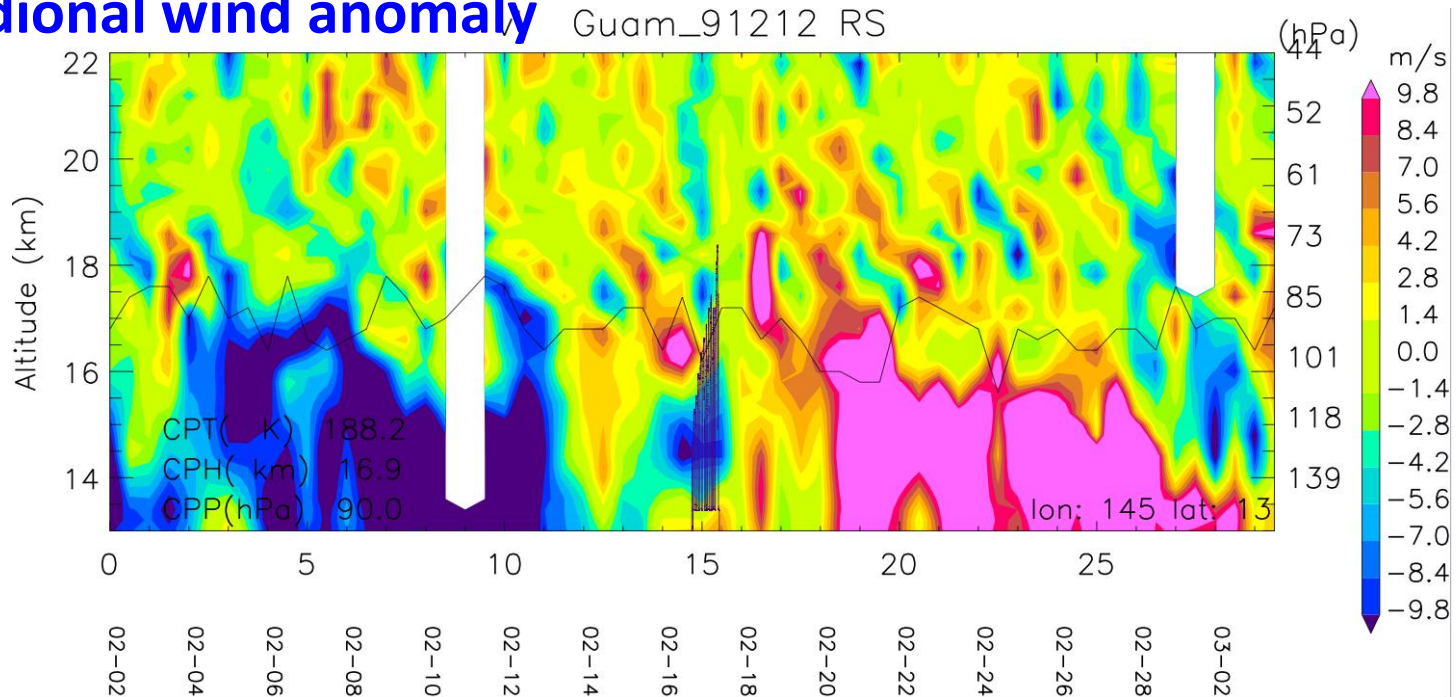
MERRA anomaly 100mb 2014.02.17 00Z



- The day was right in the middle of strong cyclonic and anti-cyclonic motions.
- This is consistent with radiosonde observations.
- It looks nothing is going on near Guam.

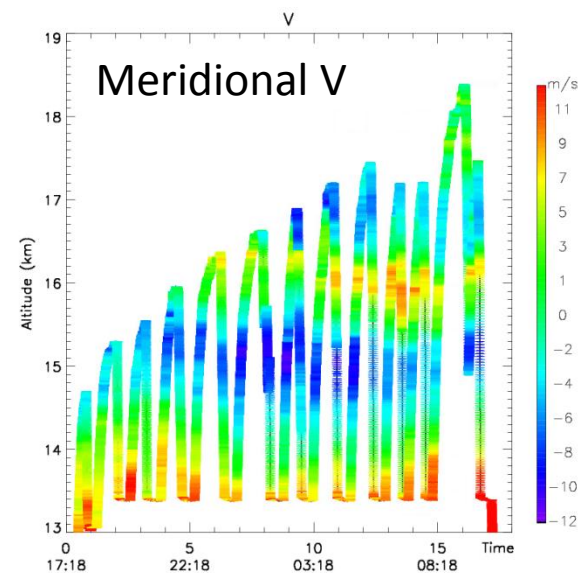
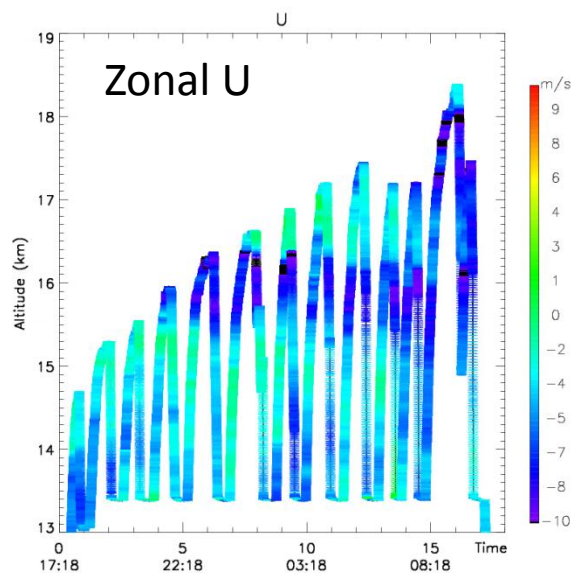
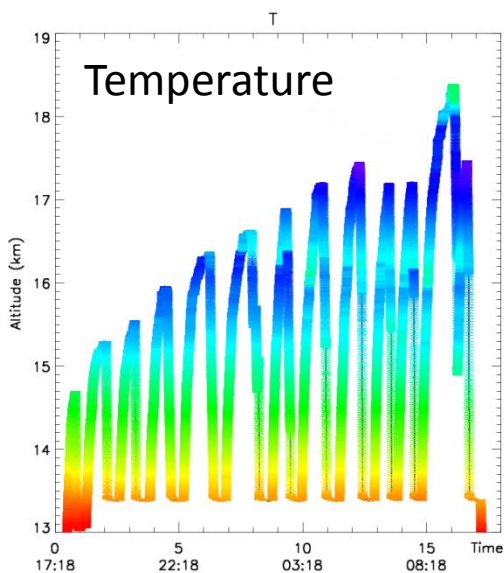
30-day Guam radiosonde shows the same feature

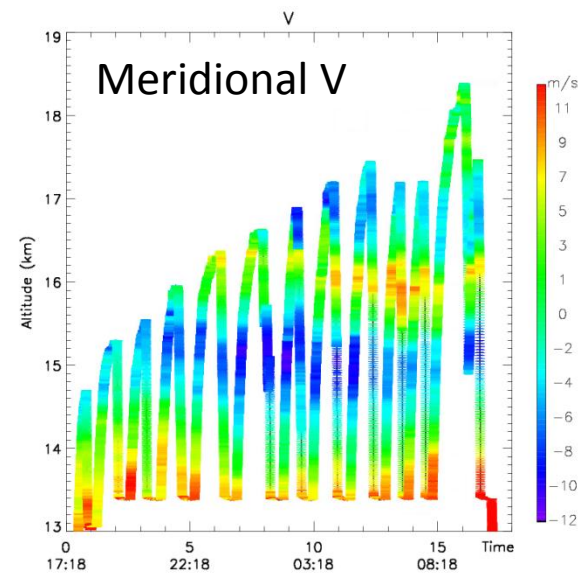
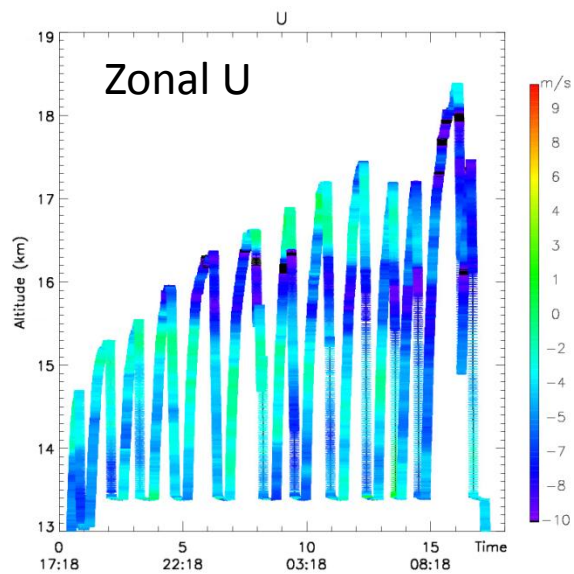
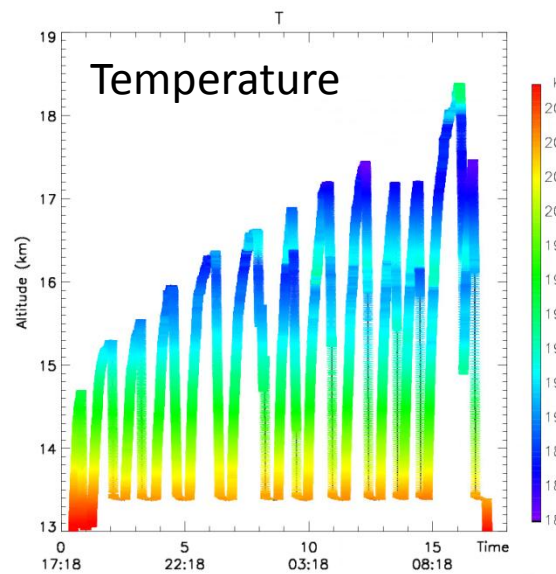
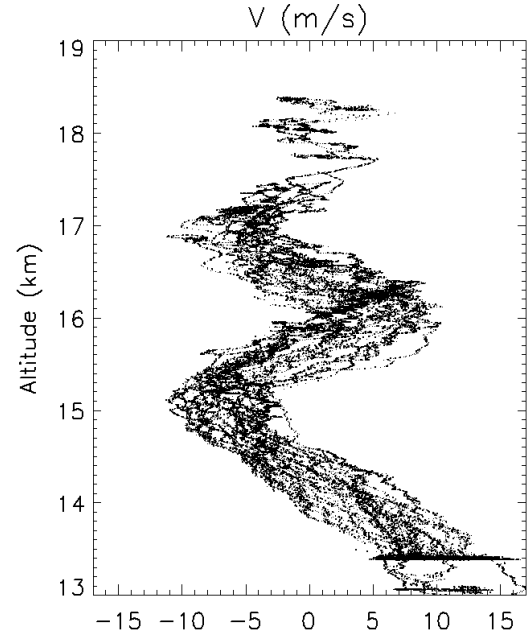
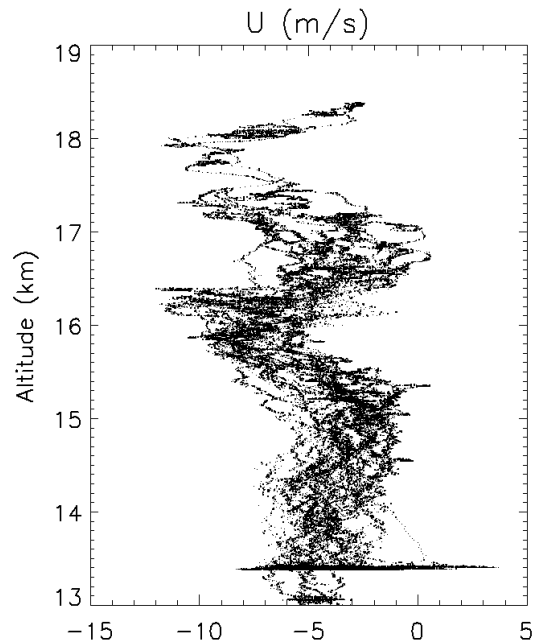
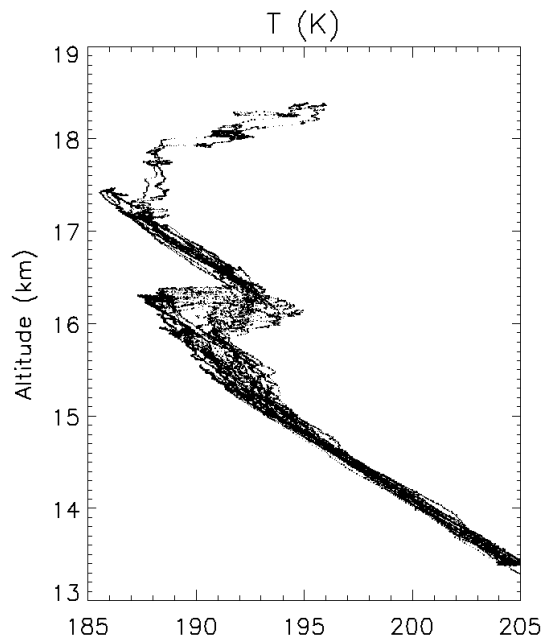
Meridional wind anomaly

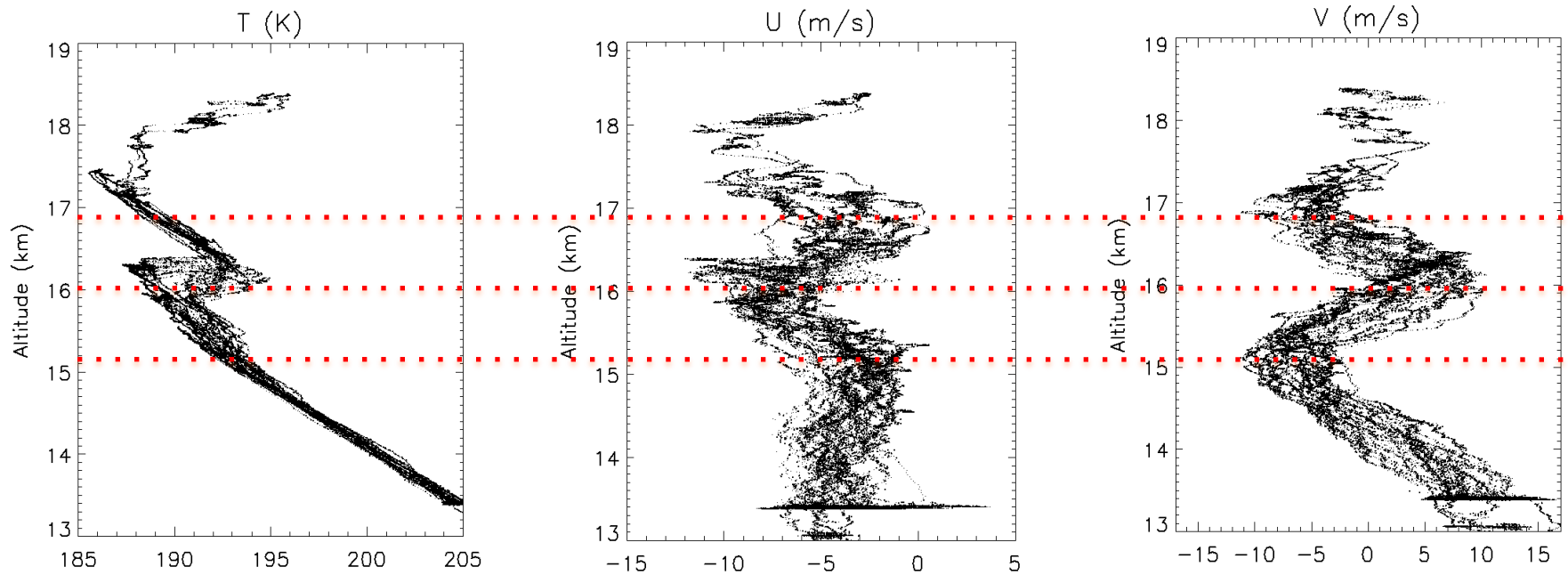


- The day was right in the middle of strong cyclonic and anti-cyclonic motions.
- This is consistent with radiosonde observations.

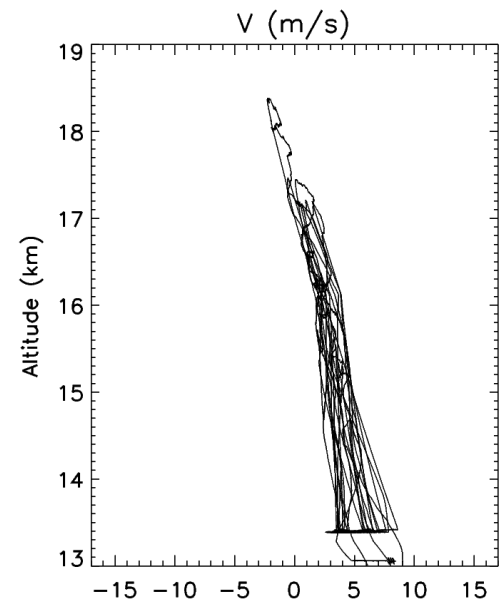
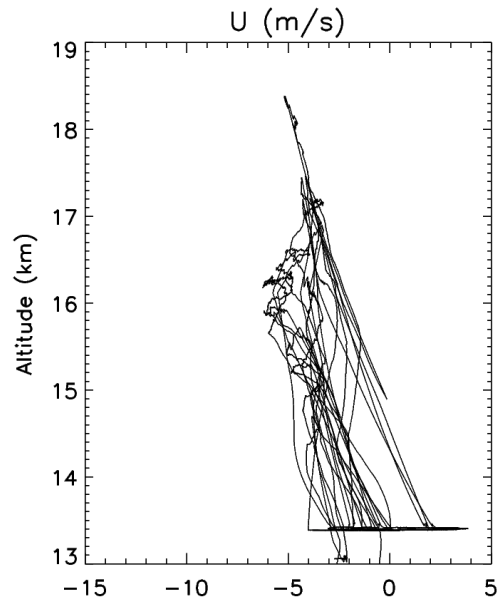
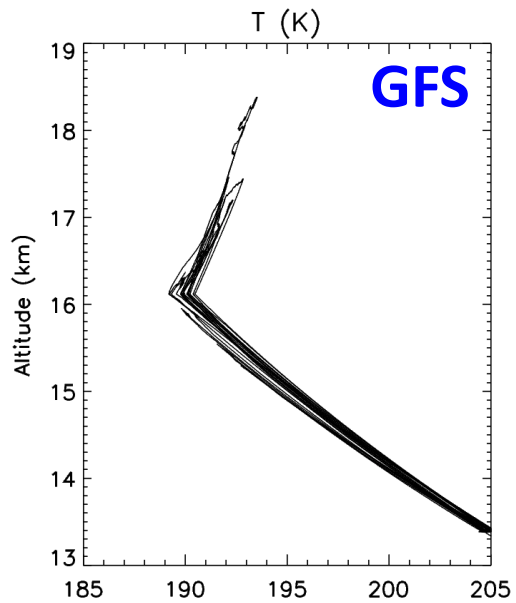
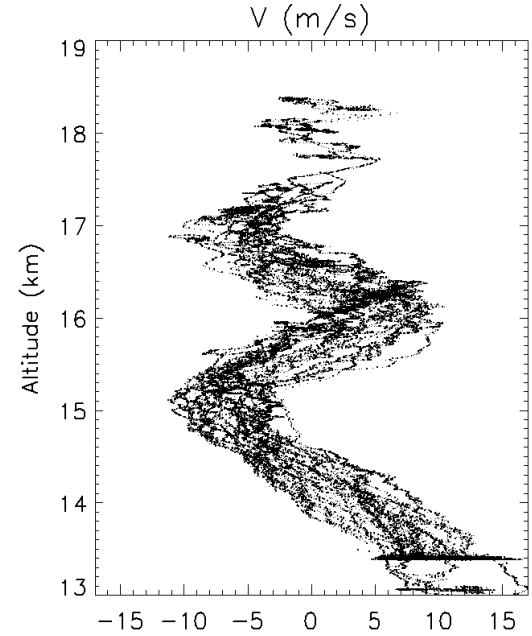
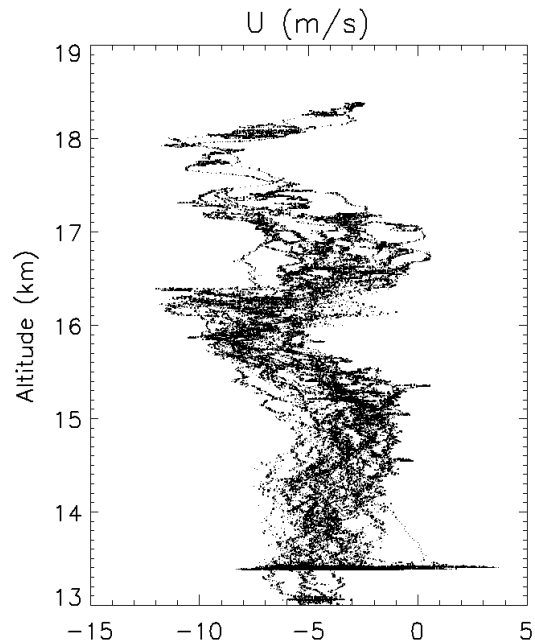
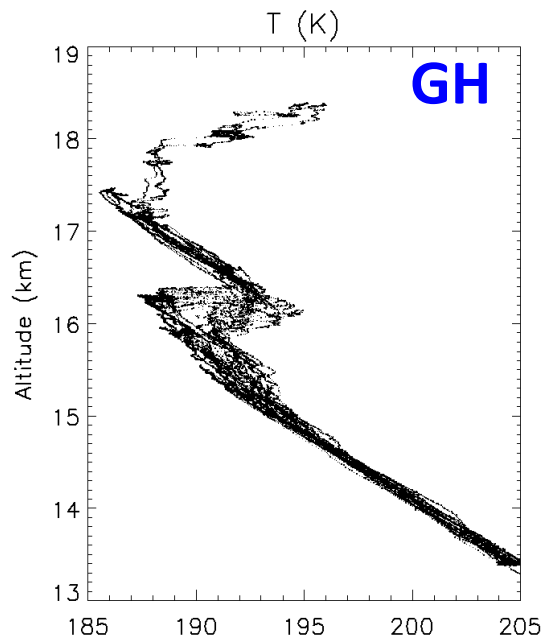
Actual atmosphere was not boring!



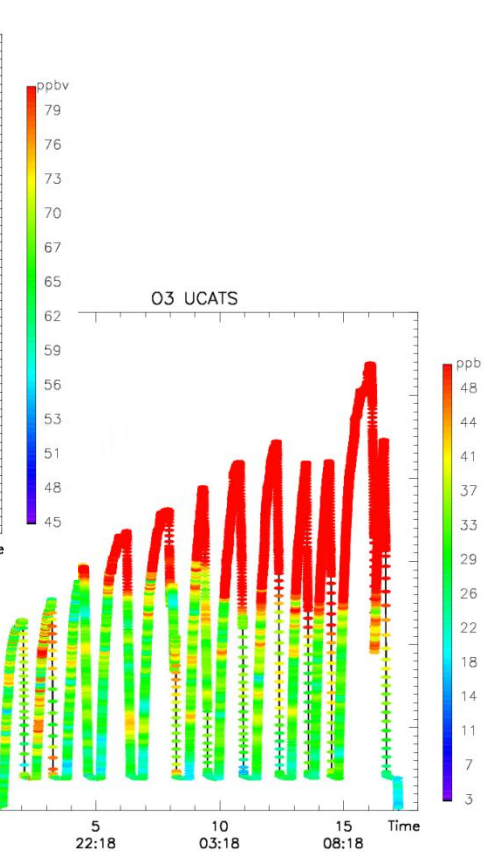
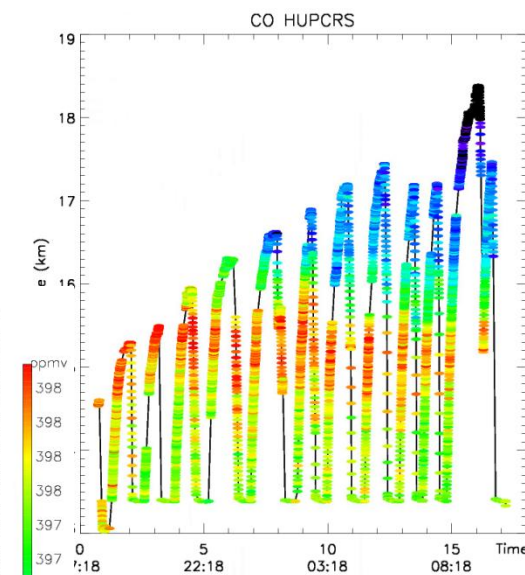
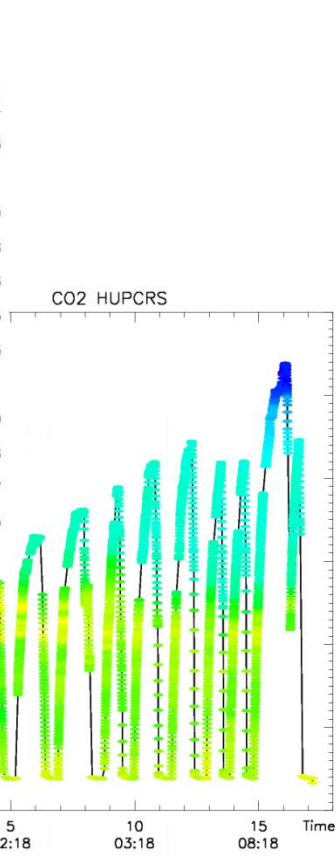
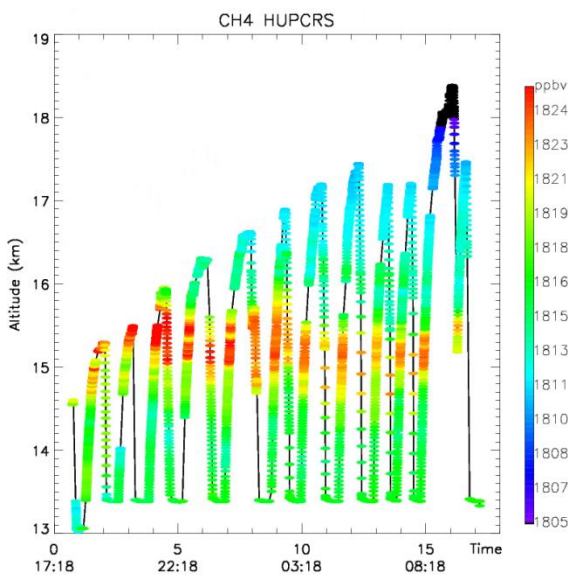
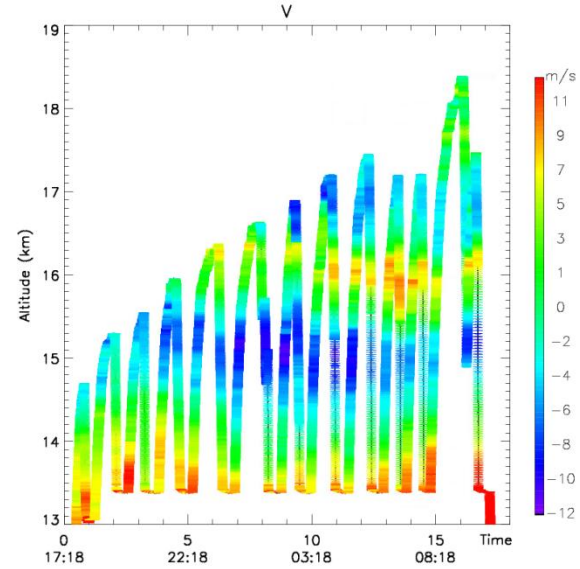
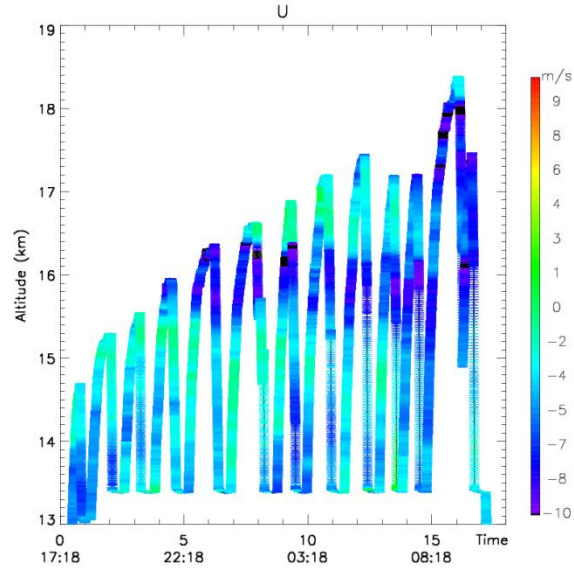
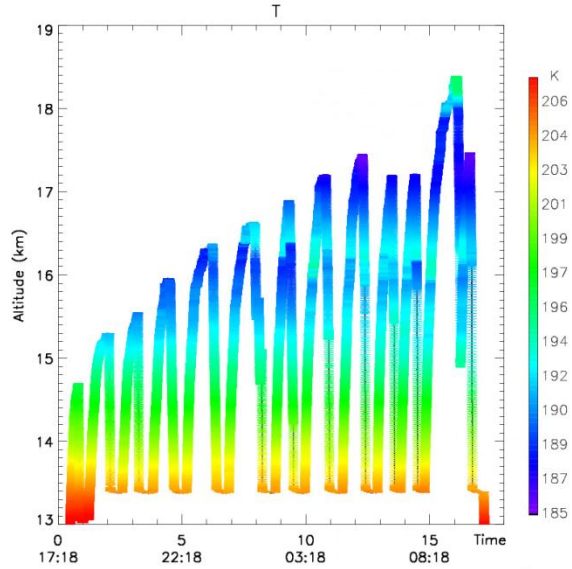




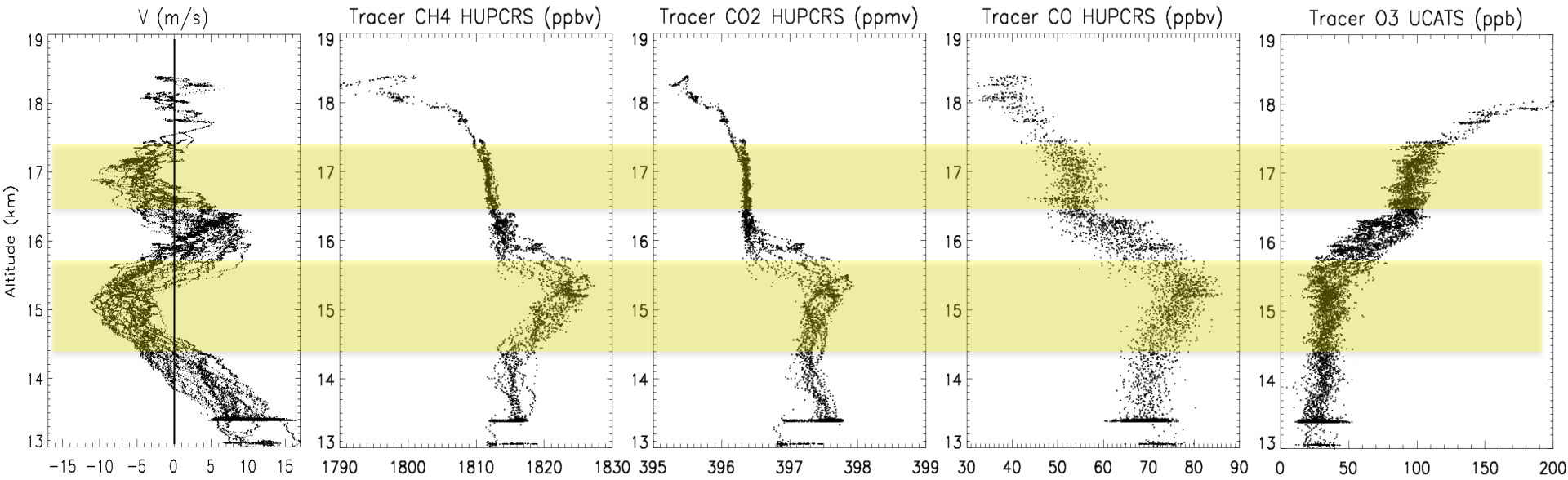
- Opposite phase of U and V
- Gravity waves with vertical wavelength ~ 1.7 km
- Analysis model vertical resolution near TTL ~ 1.2 km
→ can resolve ~ 2.4 km scales at most



■ Current models cannot resolve the scale.

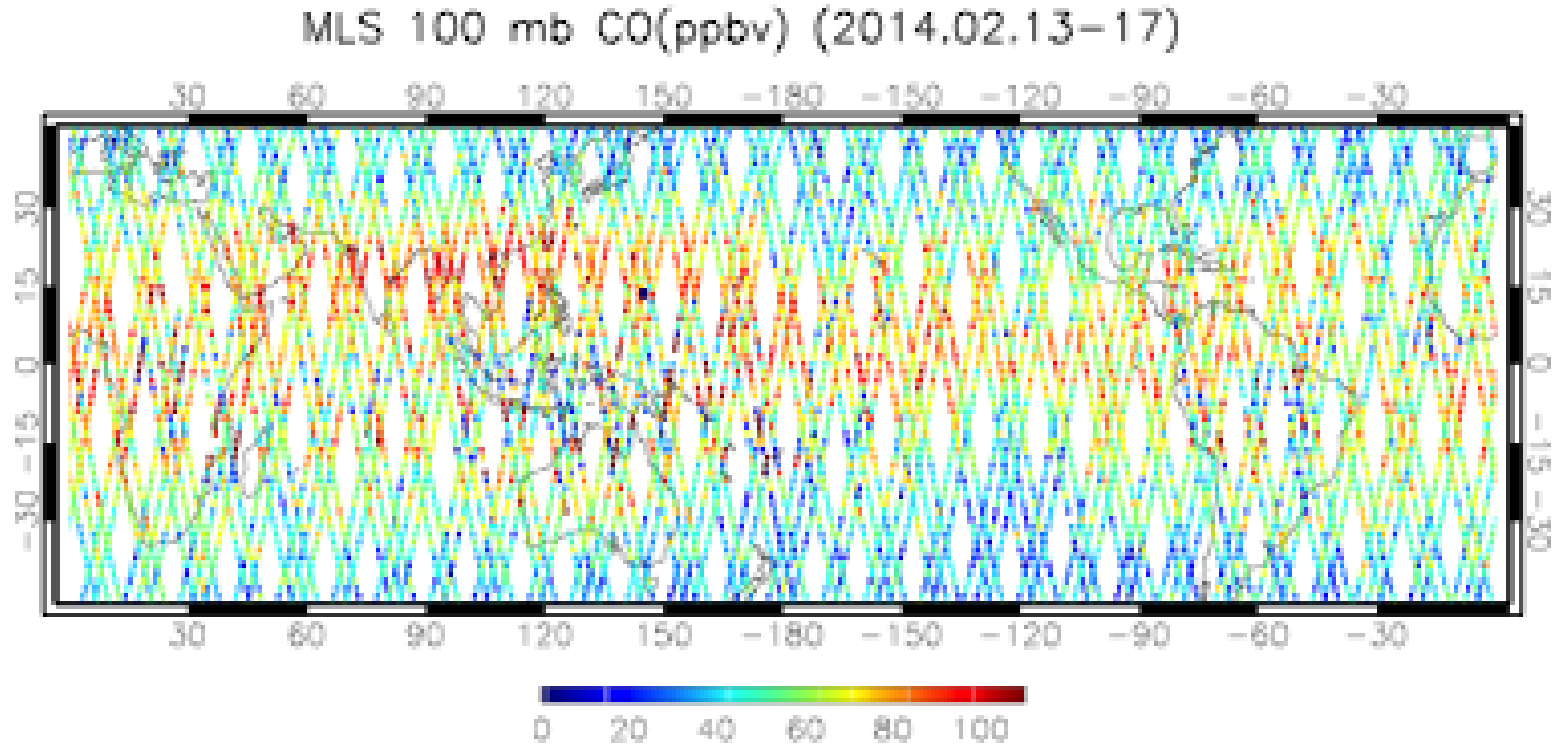


Vertical mixing? Horizontal transport?



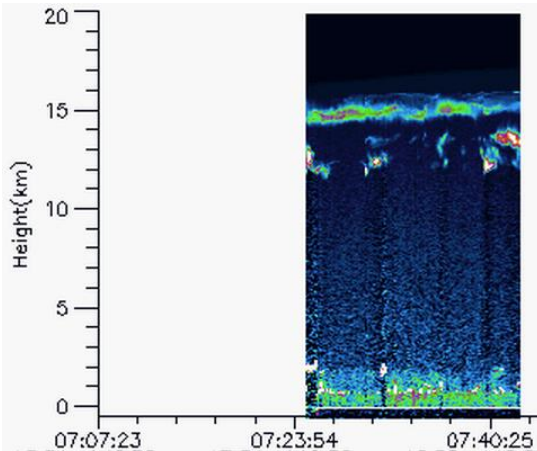
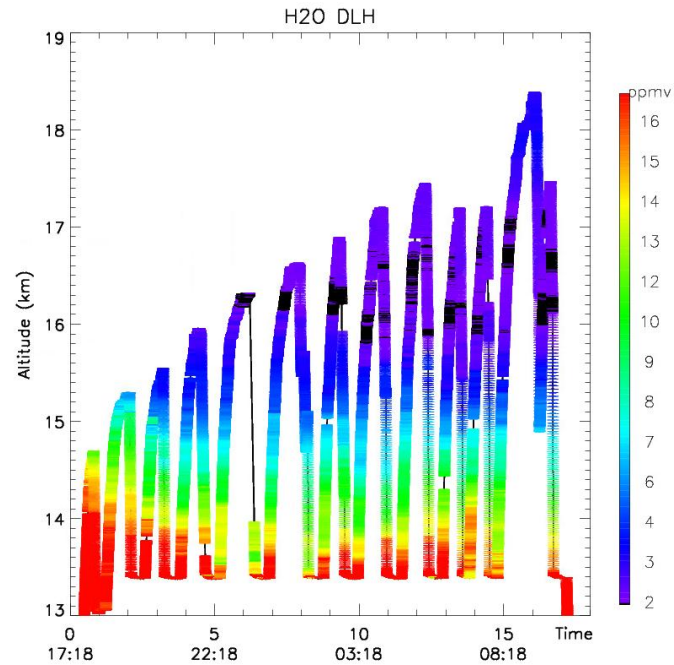
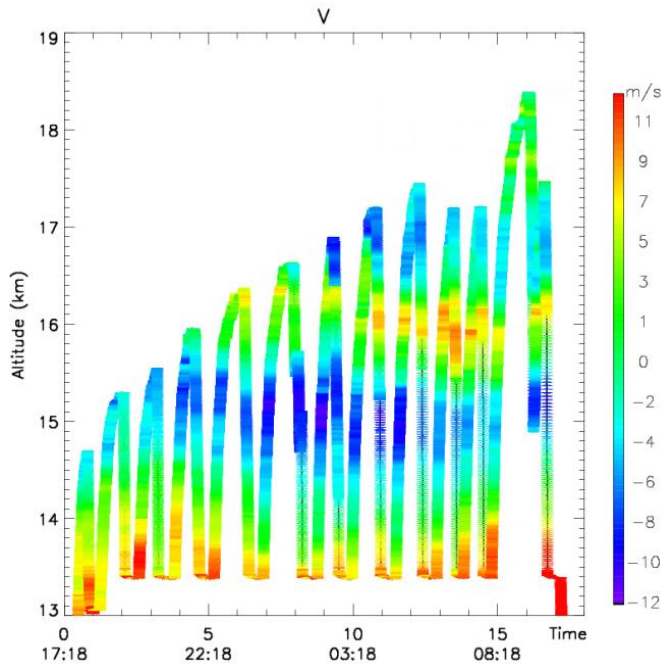
- Waves induce vertical and horizontal motions.
- 17 km layer is vertically well mixed.
- 15 km layer has enhanced tropospheric air with northerly wind.

More tropospheric air is distributed north of Guam

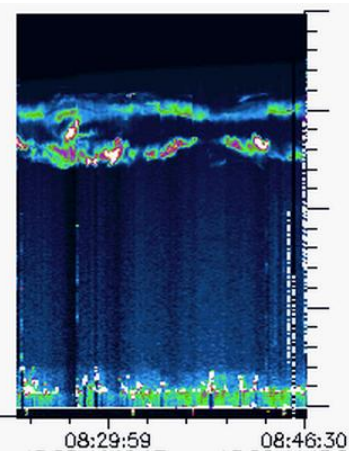


→ Northerly wind (-v) would transport higher CO into Guam.

Evidence of dehydration

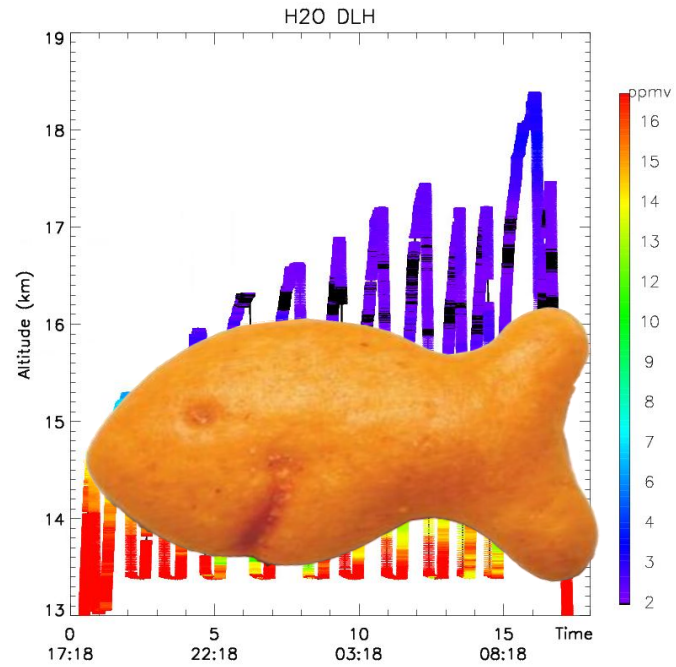
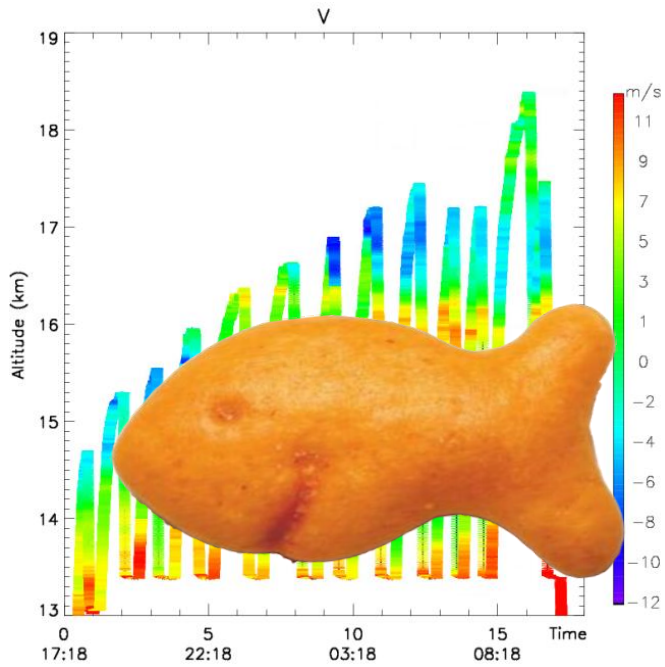


CPL 532 nm

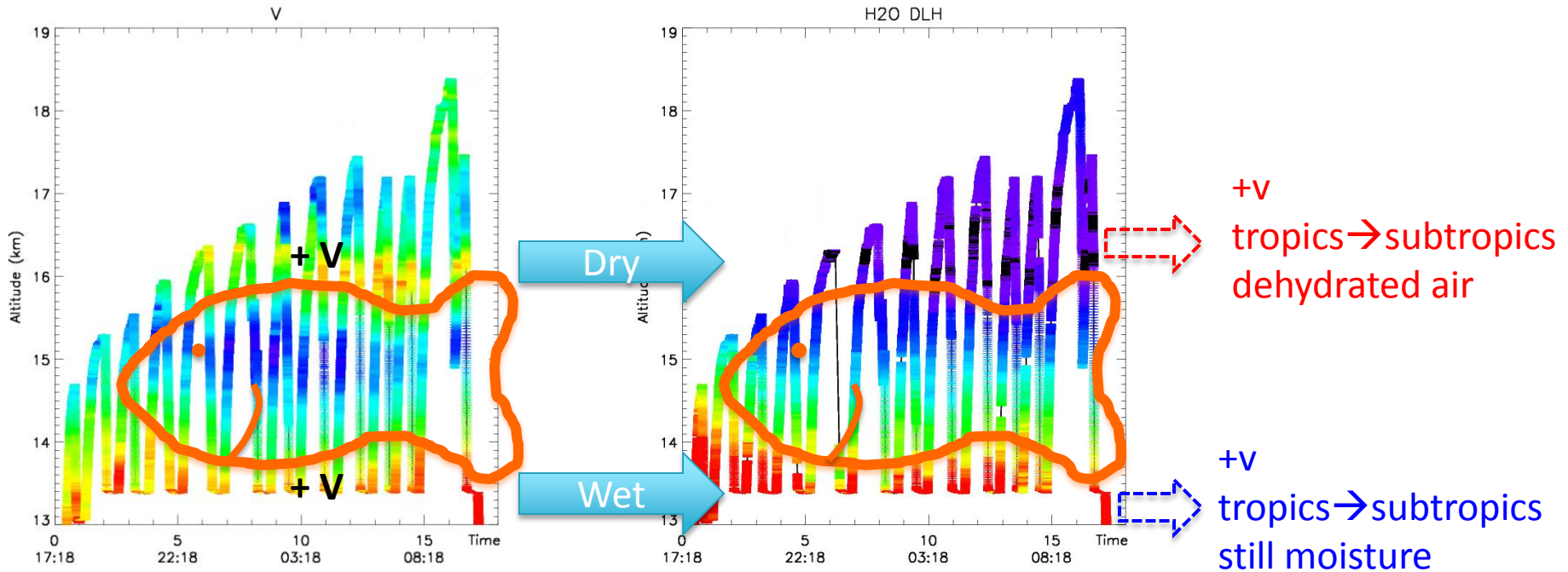


Highest
dehydration
level ~ 15 km

Evidence of dehydration

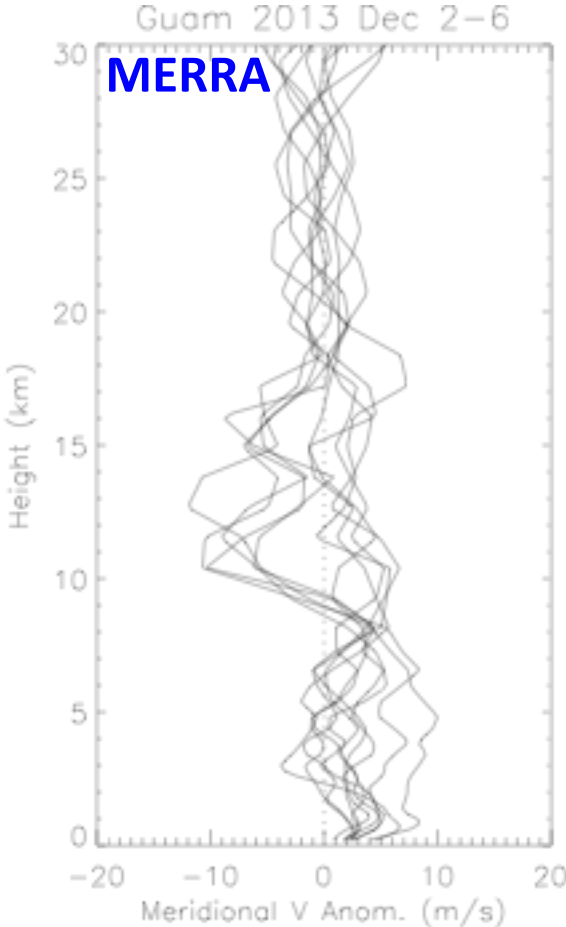
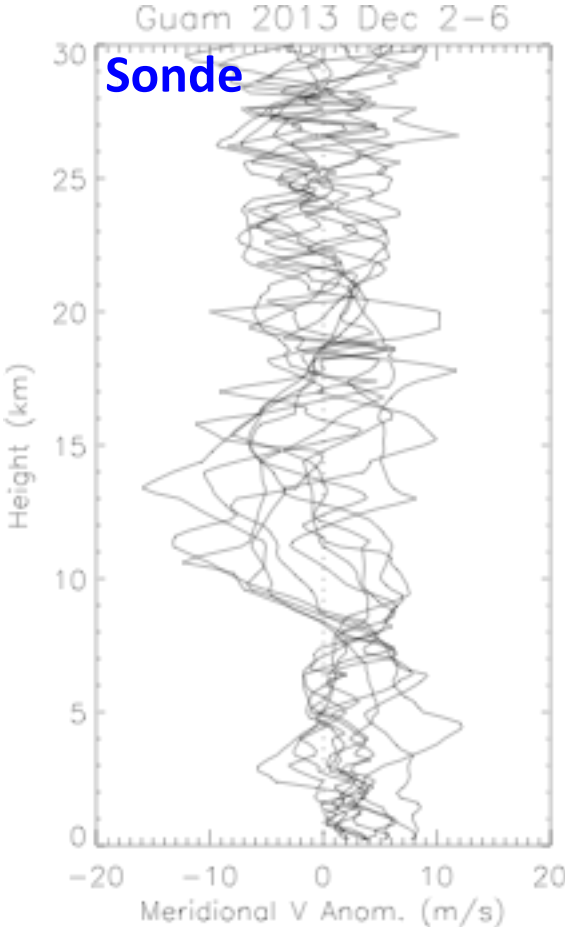


Evidence of dehydration and meridional transport

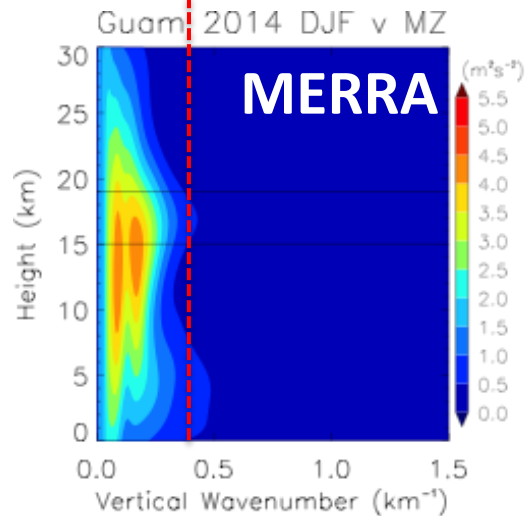
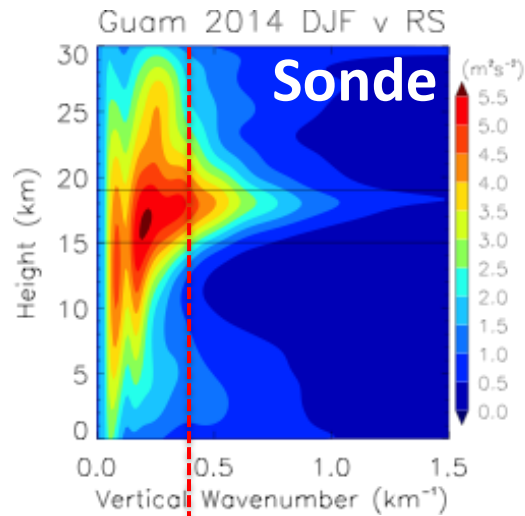


- Water vapor is also transported by wave motions.

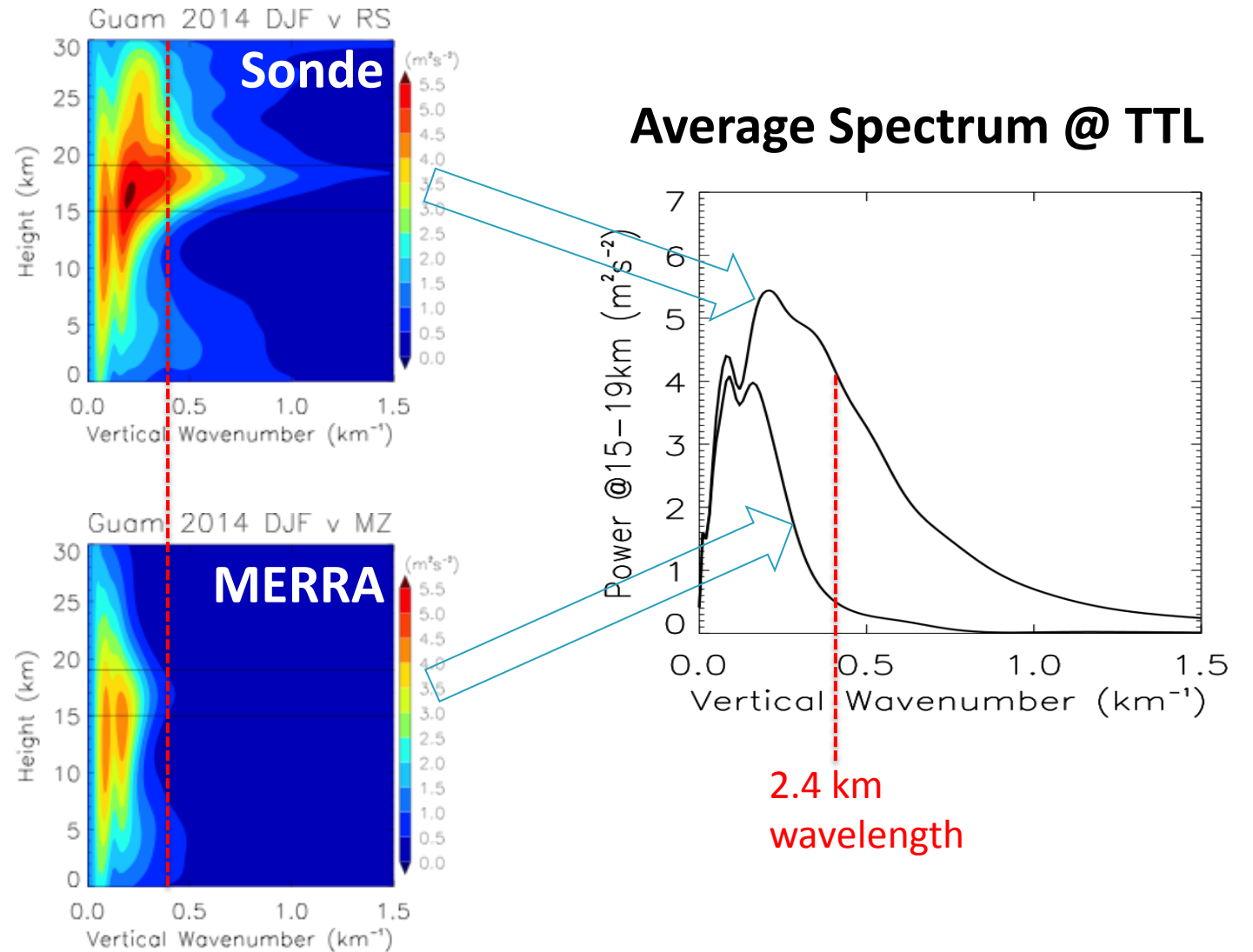
How often do these waves exist?



Vertical wavelet (S-transform) analysis



Short vertical wavelength spectrum is significant



Conclusion

- A fine scale wave is observed.
- There is a strong correlation between meridional wind and tracers.
- A significant portion of TTL disturbances is attributed to short vertical wavelength waves.
- This is lacking in models, implying weaker vertical mixing and horizontal transport at these scales in models.

