

Analysis of TTL wave properties and relationships to cirrus

M. Joan Alexander¹

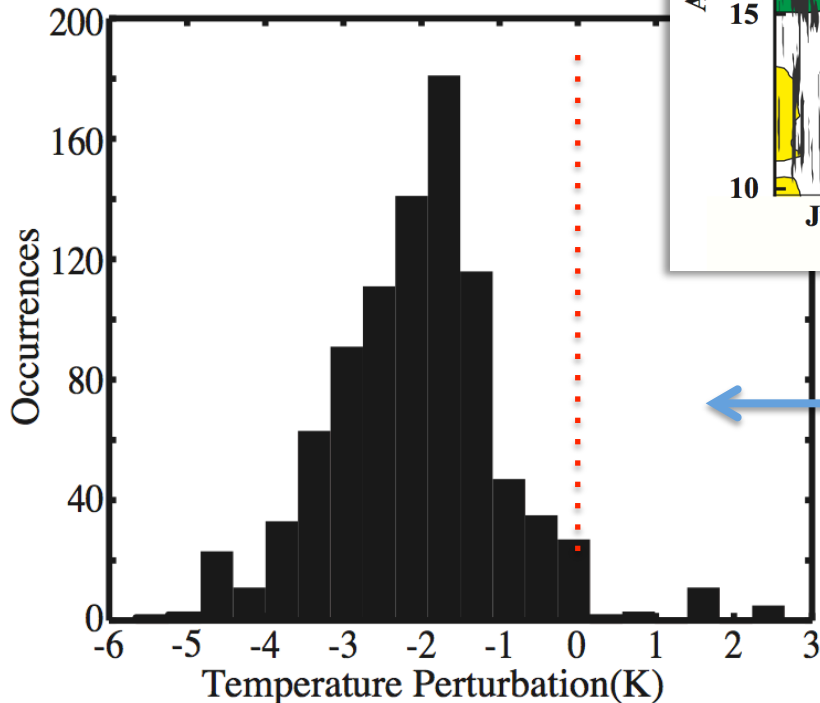
Ji-Eun Kim²

*Thanks to the ATTREX Team for the
beautiful measurements and we are
looking forward to collaborations on
this work.*

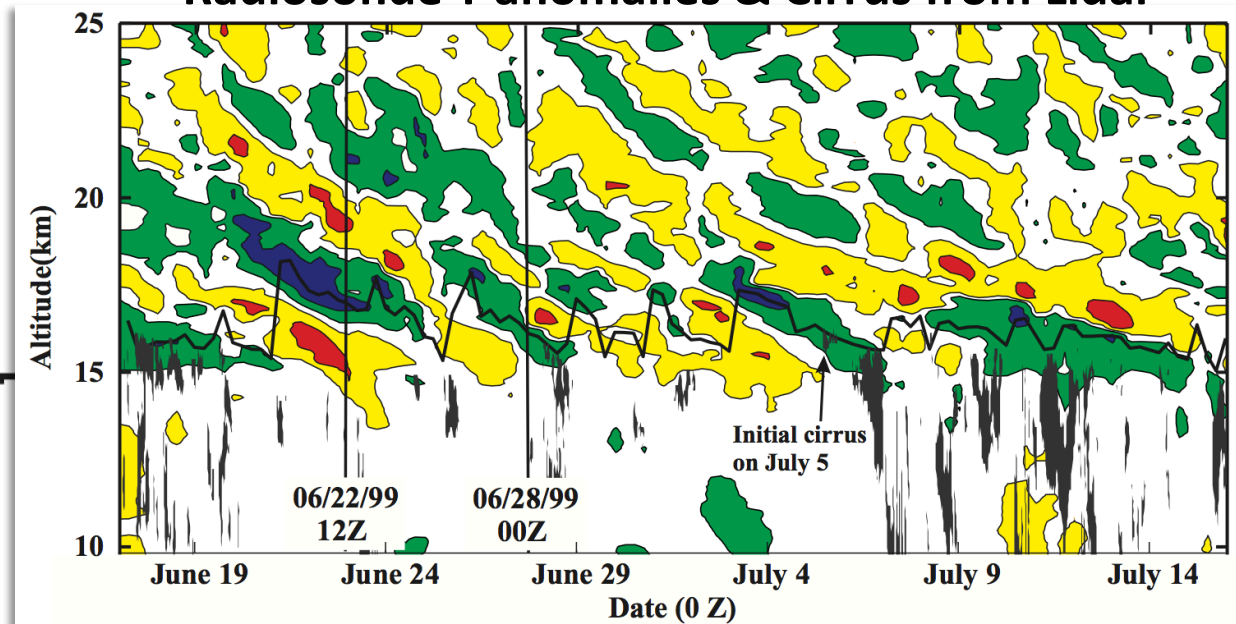
TTL Wave Effects on Cirrus

Boehm & Verlinde [2000]

- Observations at Nauru in equatorial Pacific showed Kelvin wave modulation of cirrus.
- Implied a role for waves in dehydration of the stratosphere.



30-day Intensive Observation Period Radiosonde T anomalies & Cirrus from Lidar



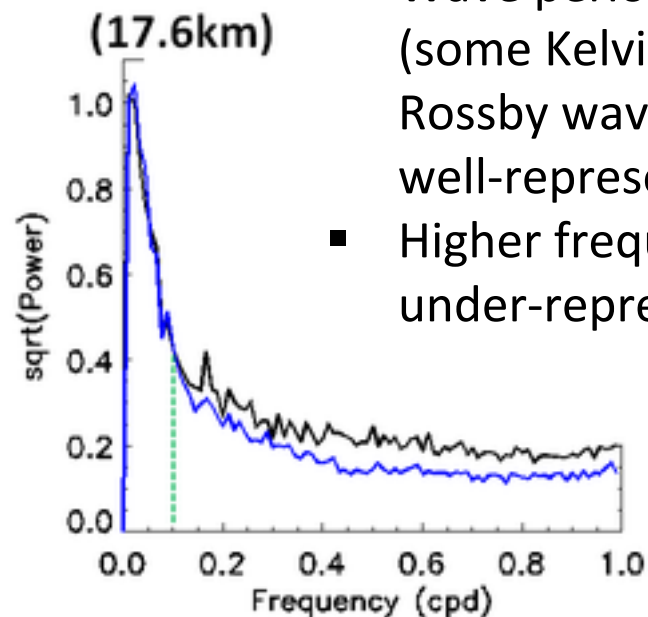
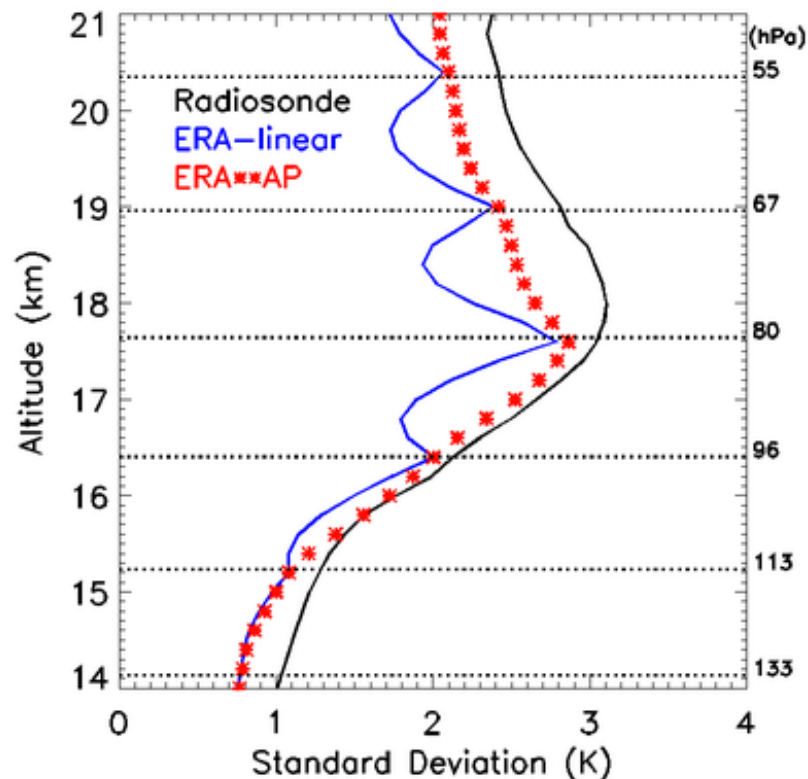
Cirrus occurrence above 15 km... almost exclusively in cold phases of tropical waves

TTL Wave Effects on Cirrus

Wave variance near the cold point is under-represented in ERA-Interim

Kim & Alexander [2013]

Western Pacific Radiosonde Sites

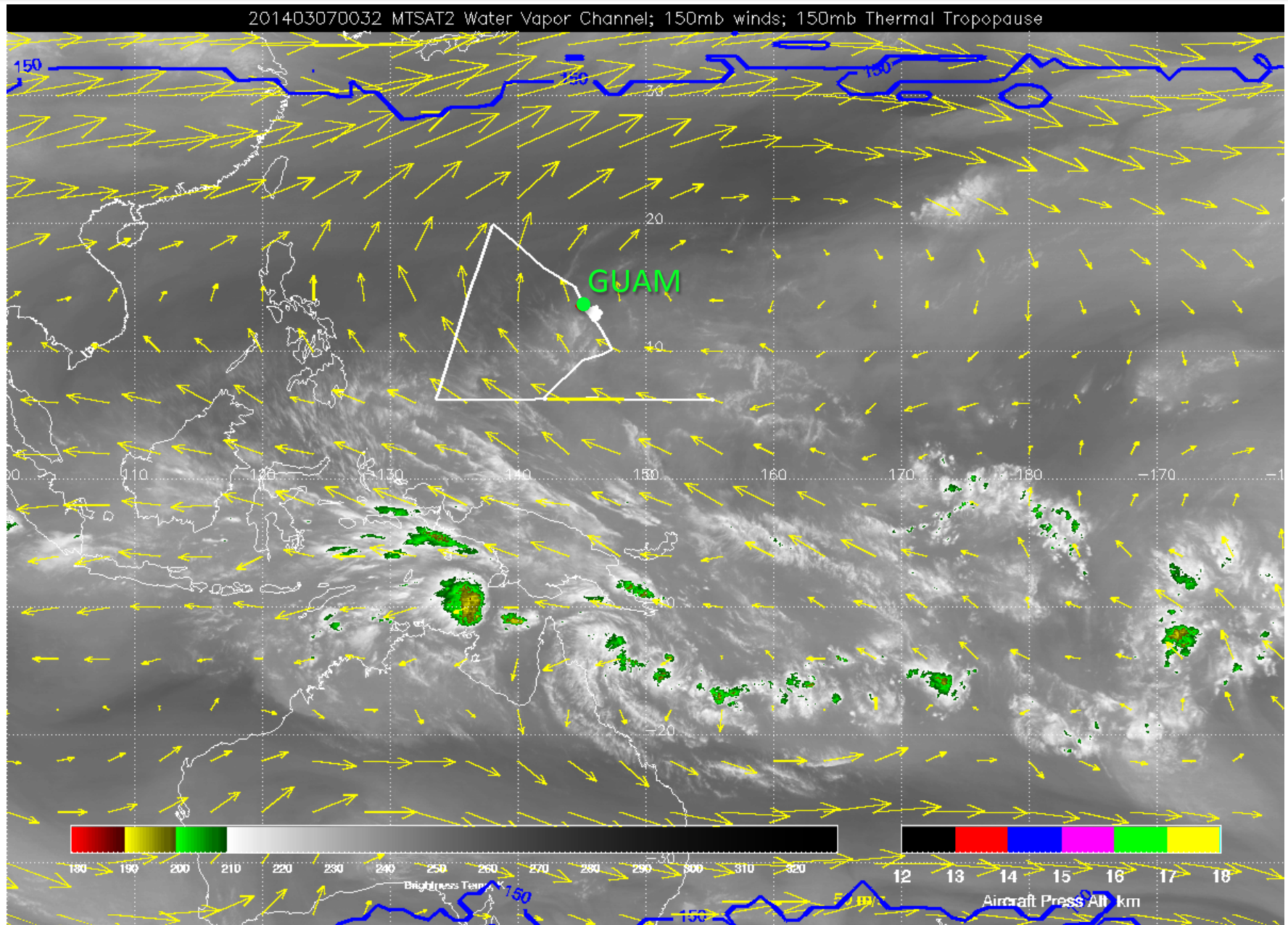


- Wave periods > 10 days (some Kelvin and Rossby waves) are fairly well-represented.
- Higher frequencies are under-represented.

How important are these higher frequency waves to cirrus formation?

- Regional patterns?
- Seasonal and interannual variations?

ATTREX Flight 6-7 March 2014

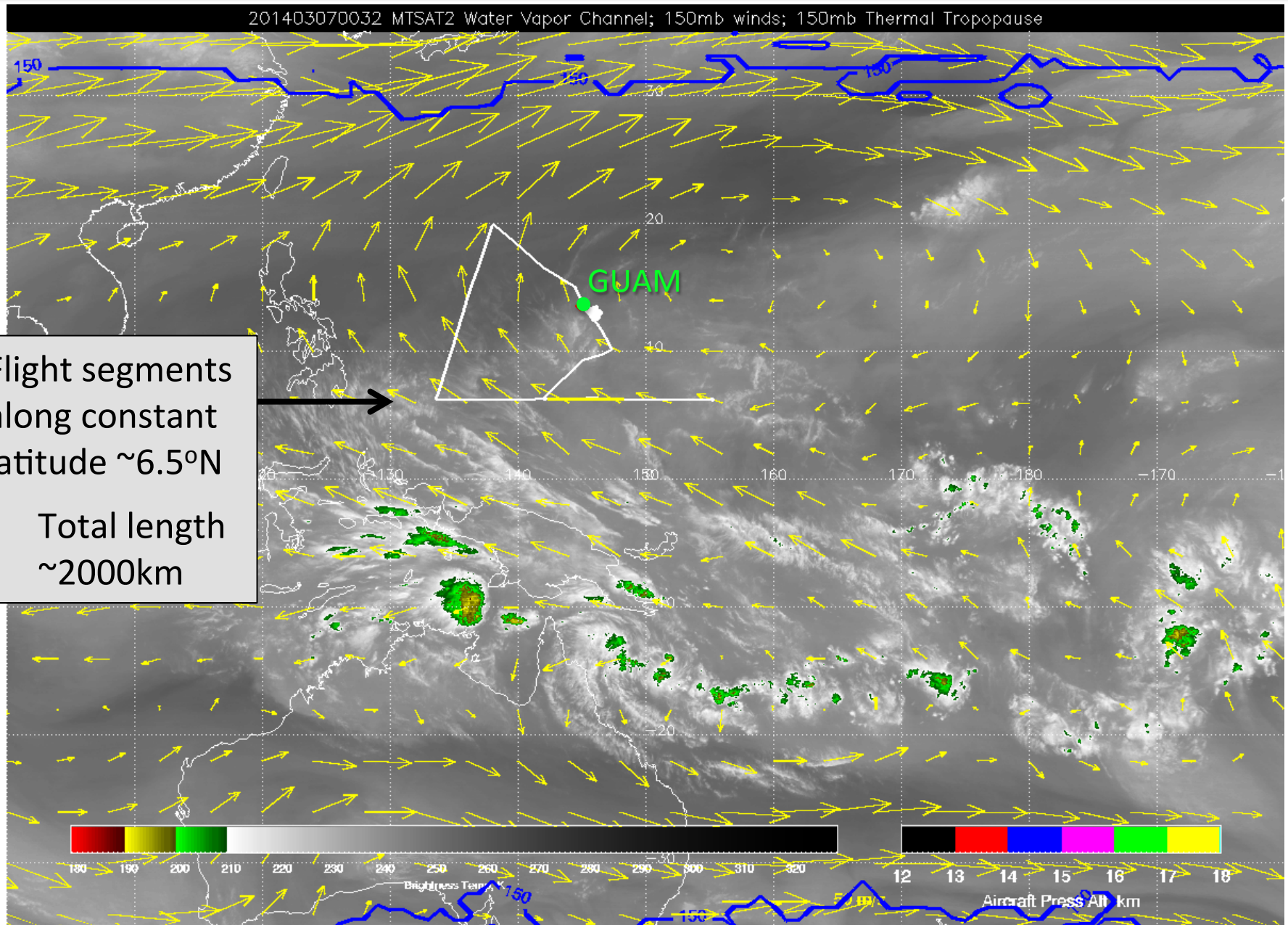


ATTREX Flight 6-7 March 2014

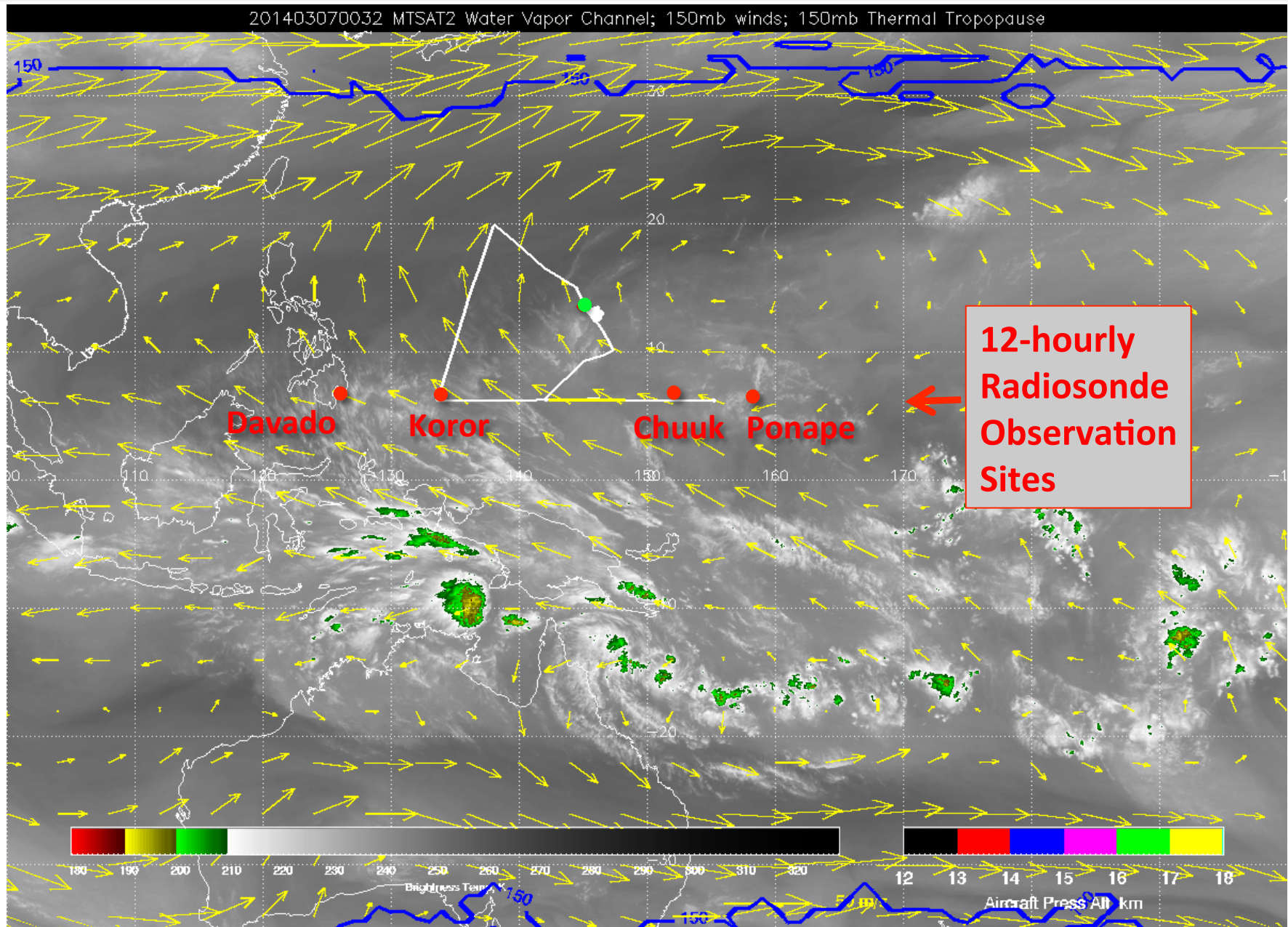
201403070032 MTSAT2 Water Vapor Channel; 150mb winds; 150mb Thermal Tropopause

Flight segments along constant latitude $\sim 6.5^\circ\text{N}$

- Total length $\sim 2000\text{km}$



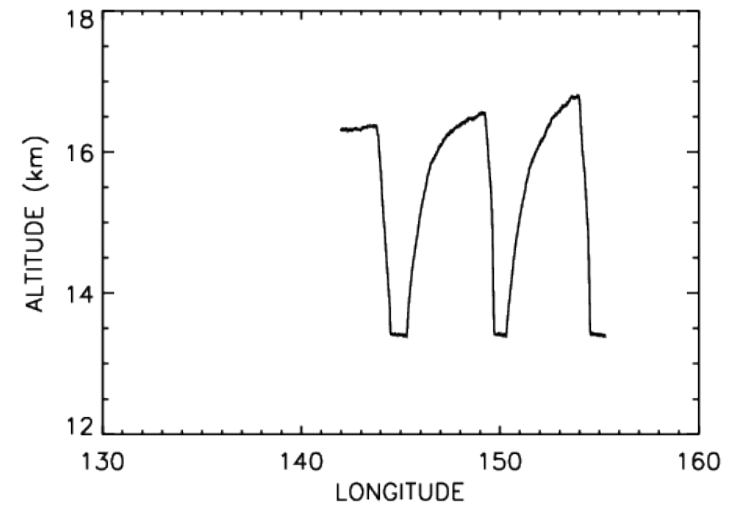
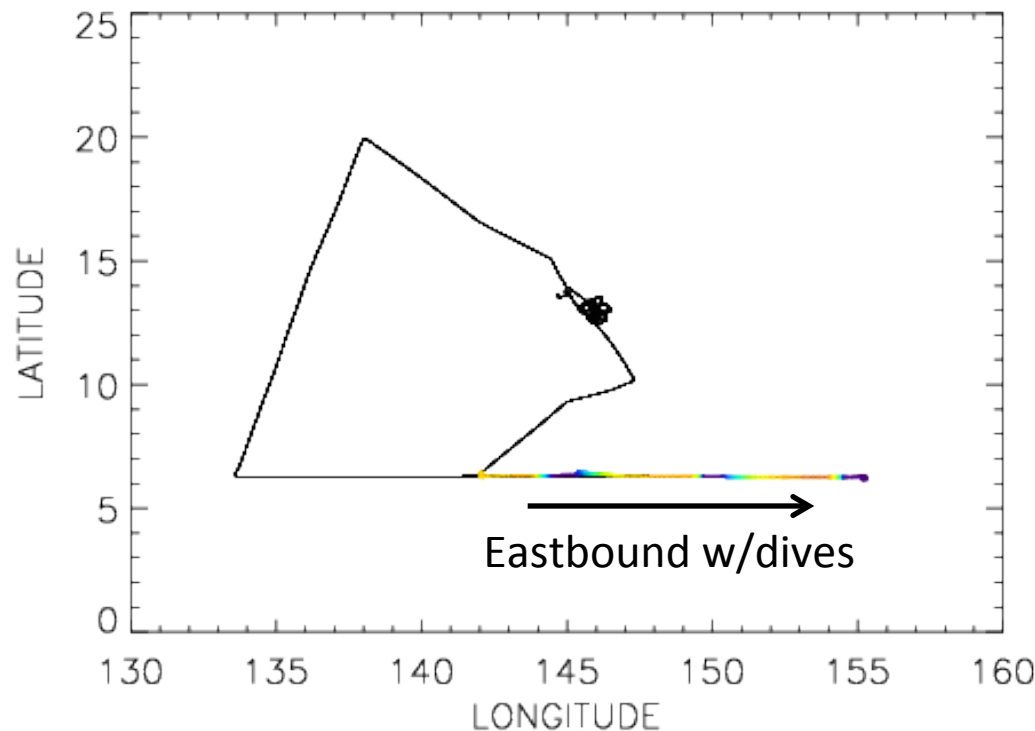
ATTREX Flight 6-7 March 2014



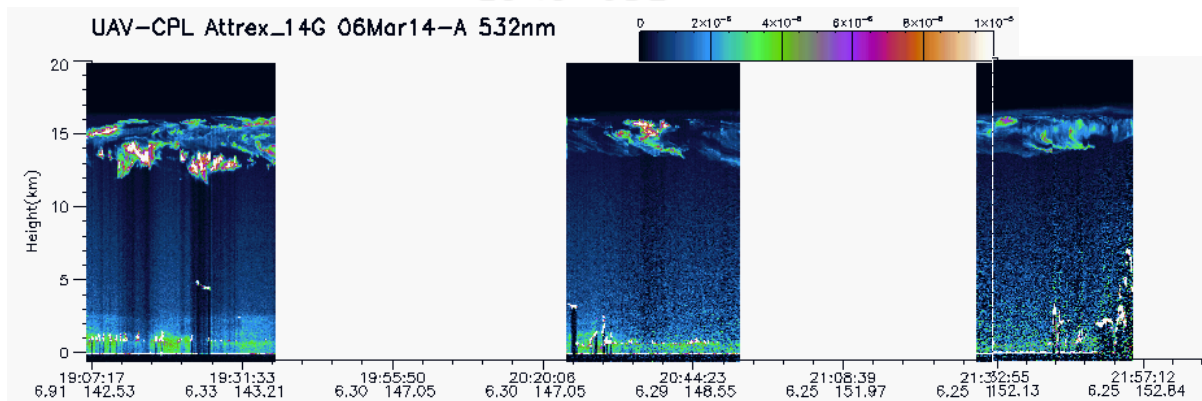
ATTREX Flight 6-7 March 2014

“Wave Flight”

06–07 March 2014



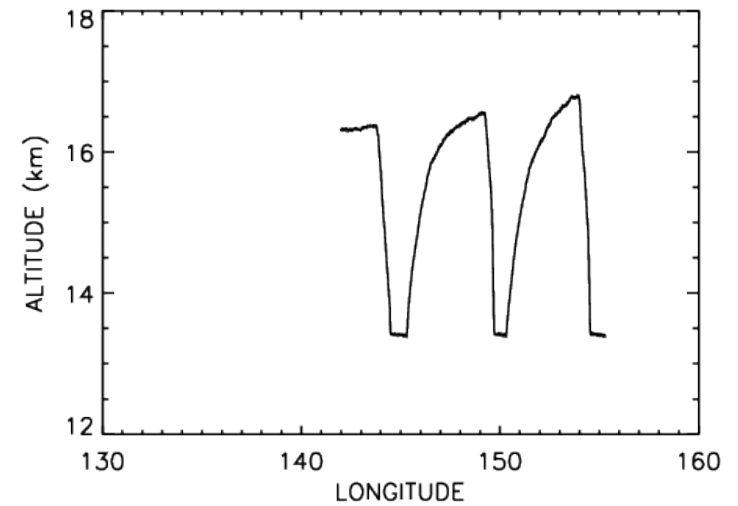
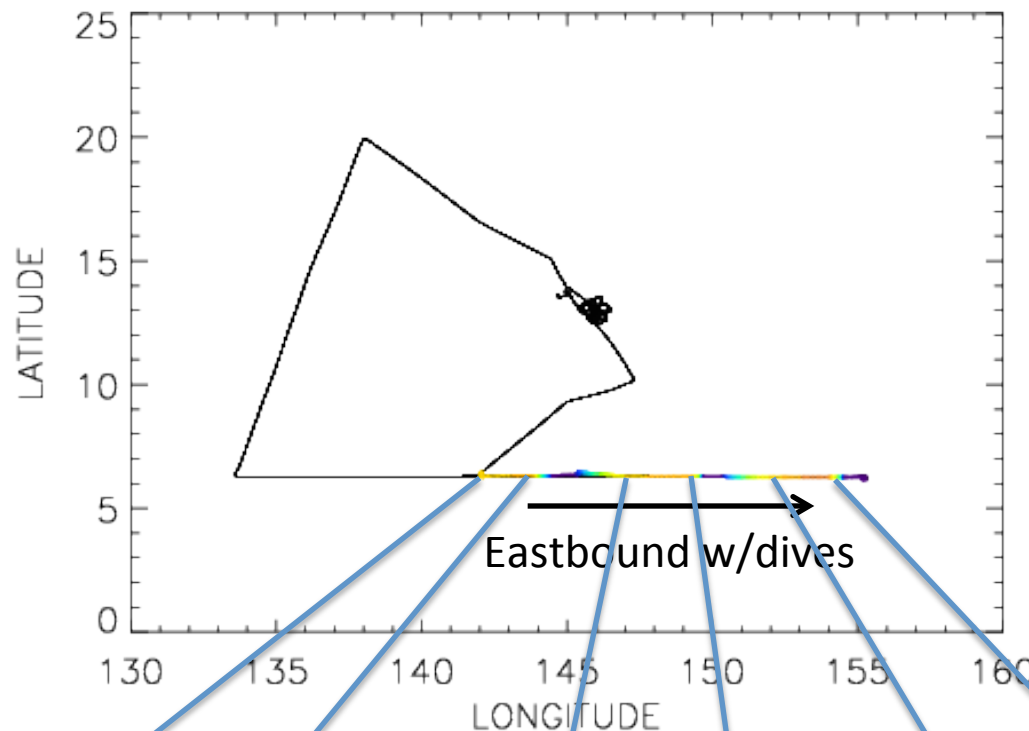
- Dives $z = 13.4 - 16.8$ km
- CPL shows cirrus layers $\sim 12 - 16$ km



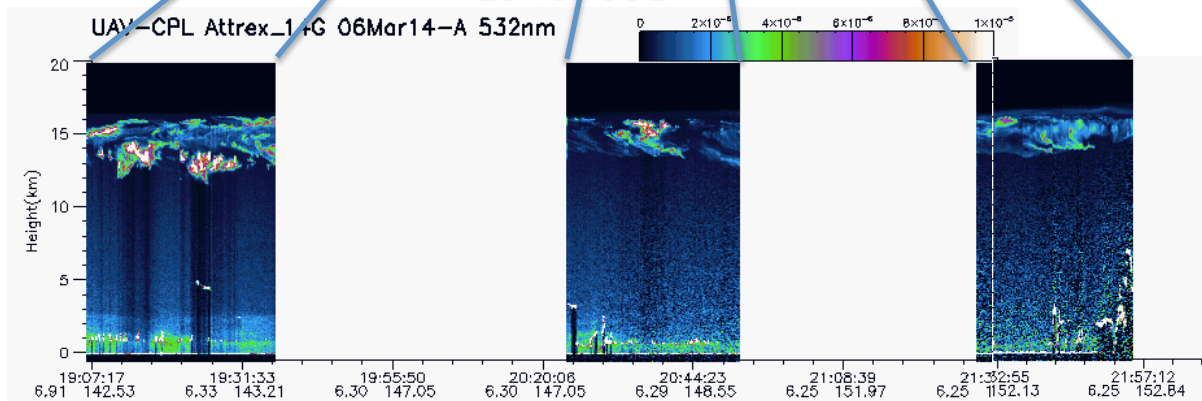
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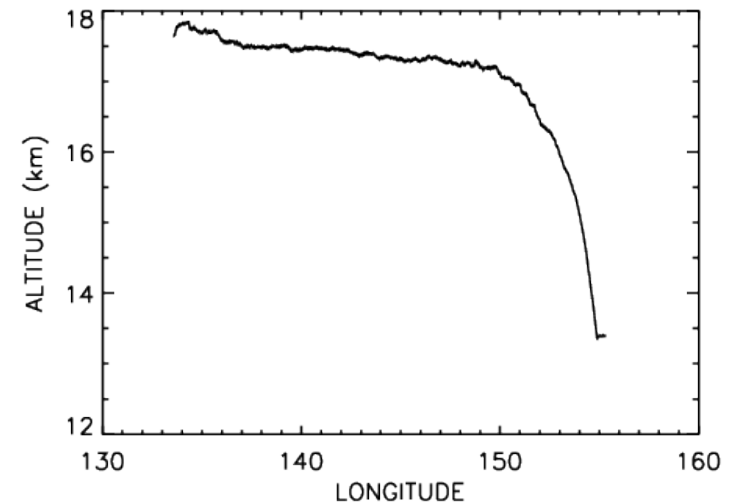
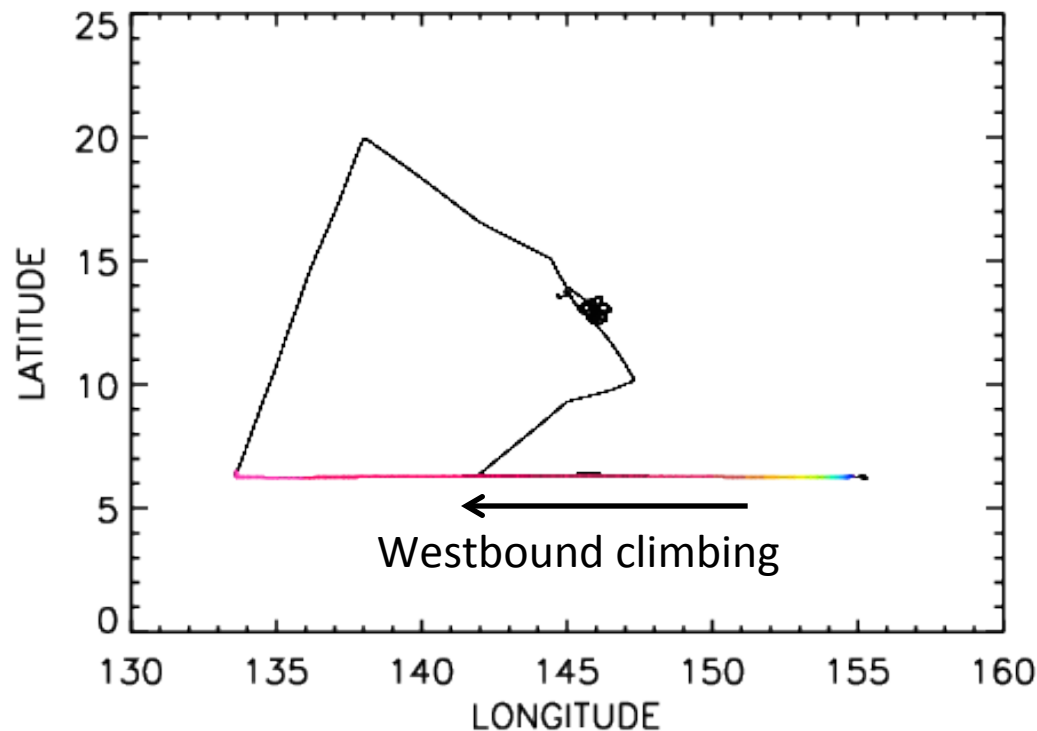
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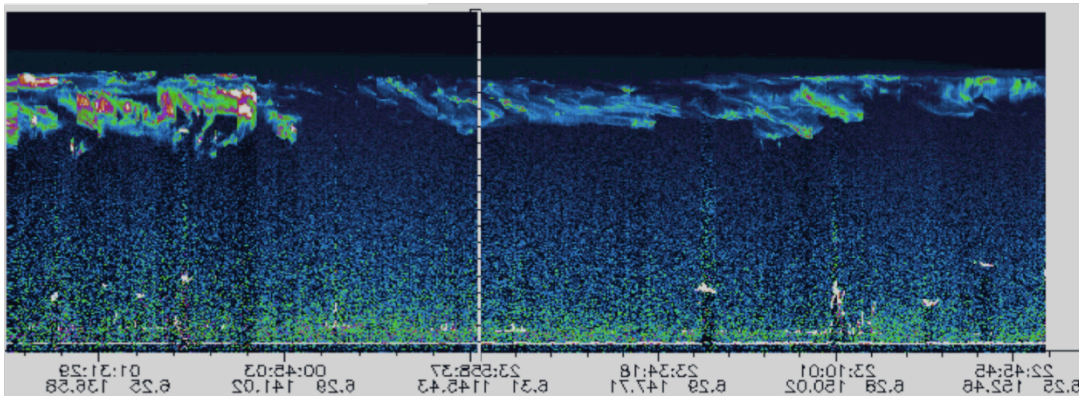
ATTREX Flight 6-7 March 2014

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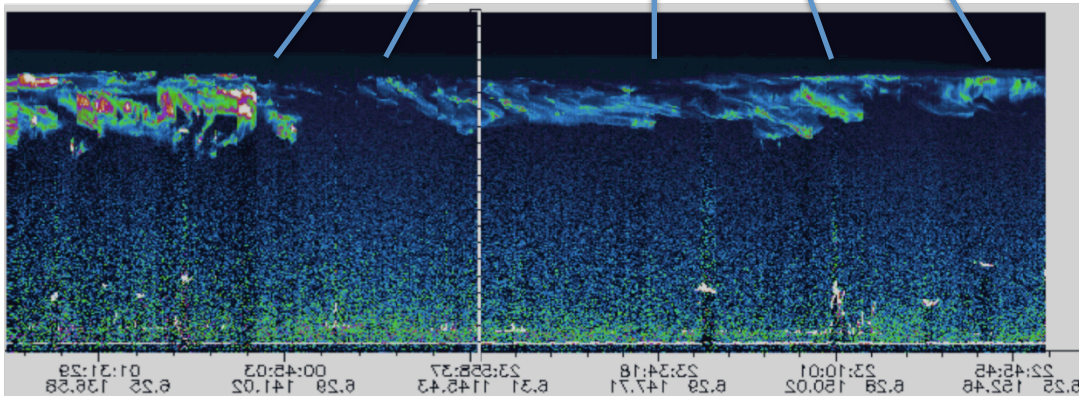
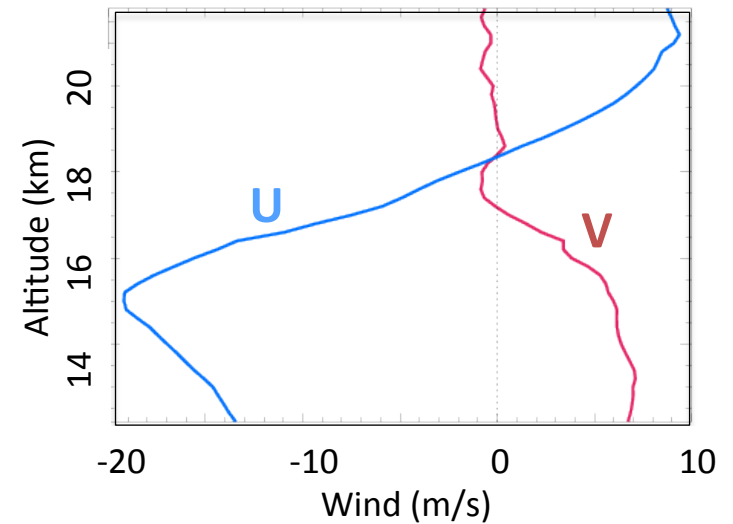
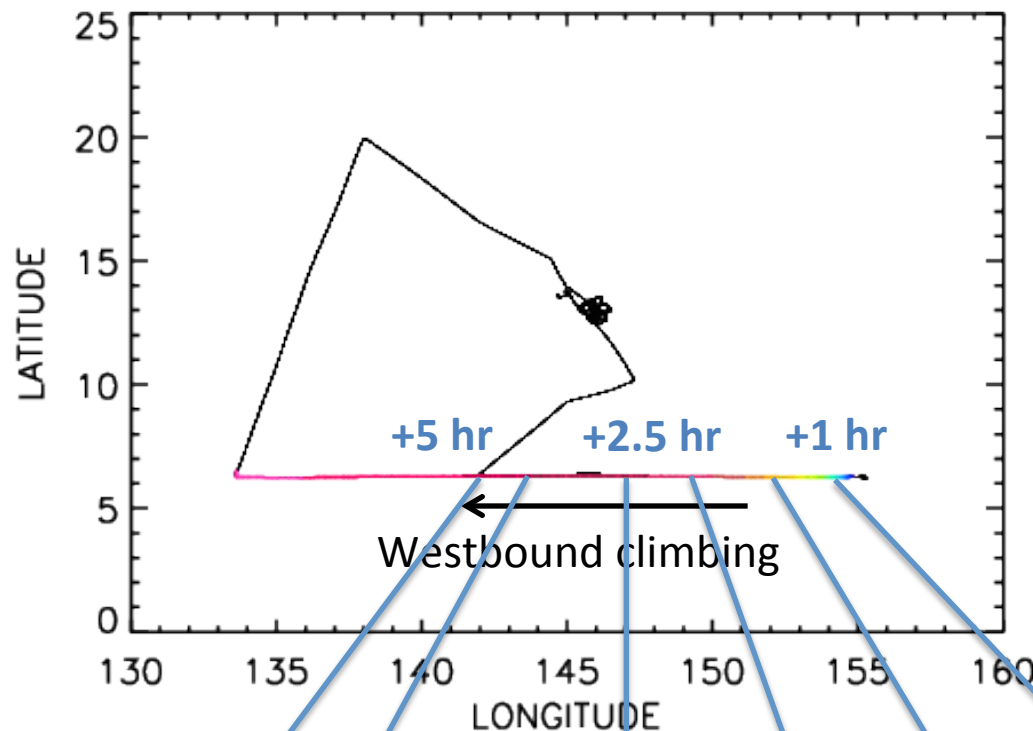
- CPL shows cirrus sloping east-to-west with altitude
- Slope is consistent with westward wind shear or westward wave propagation.



ATTREX Flight 6-7 March 2014

“Wave Flight”

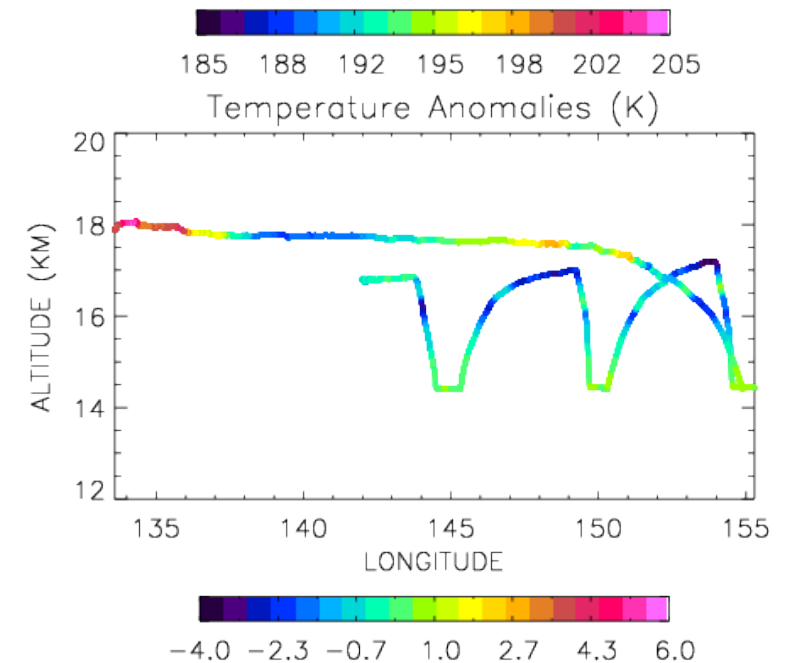
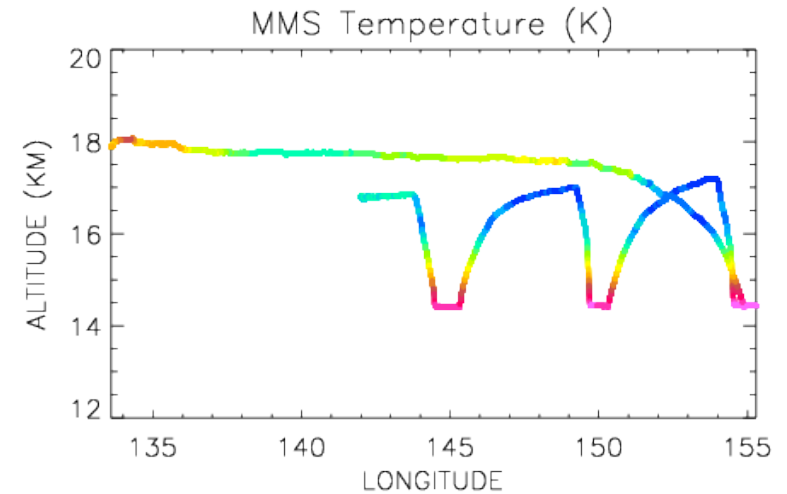
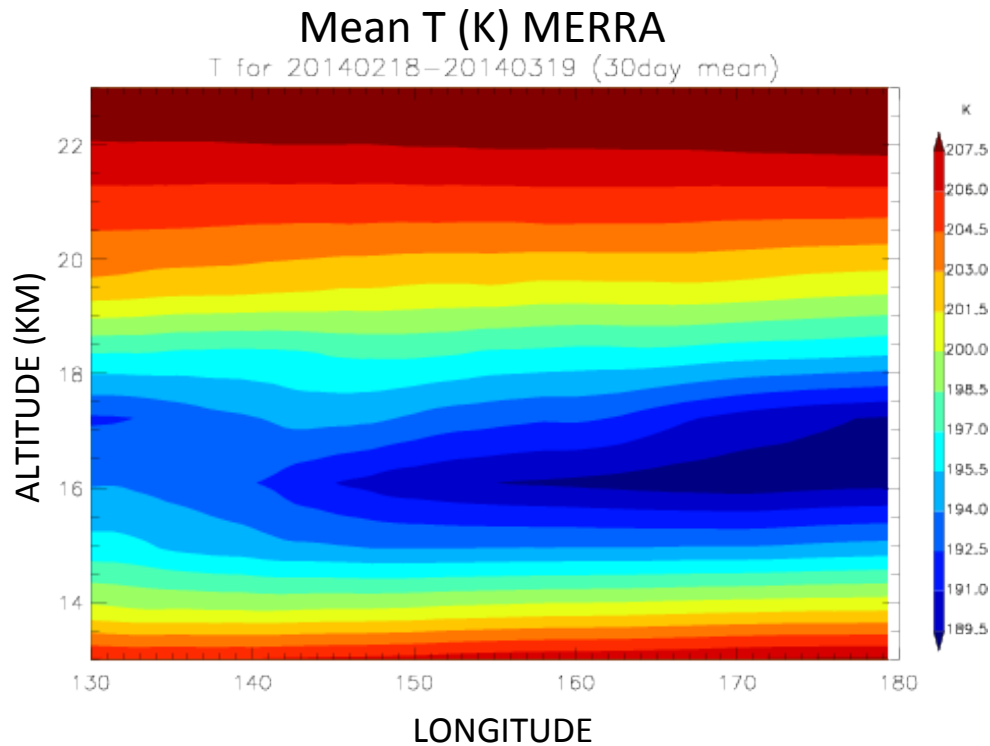
06–07 March 2014



- CPL shows cirrus sloping east-to-west with altitude
- Slope is consistent with vertical wind shear or westward wave T'
- Dramatic changes on timescales > 2 hr

ATTREX Flight 6-7 March 2014

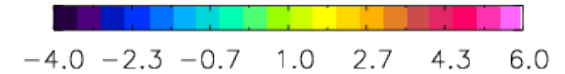
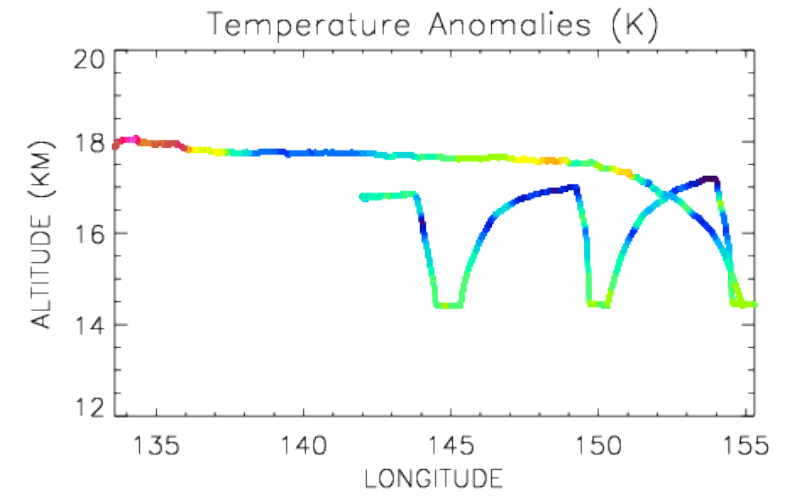
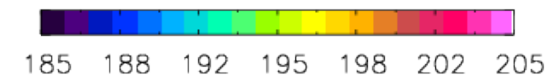
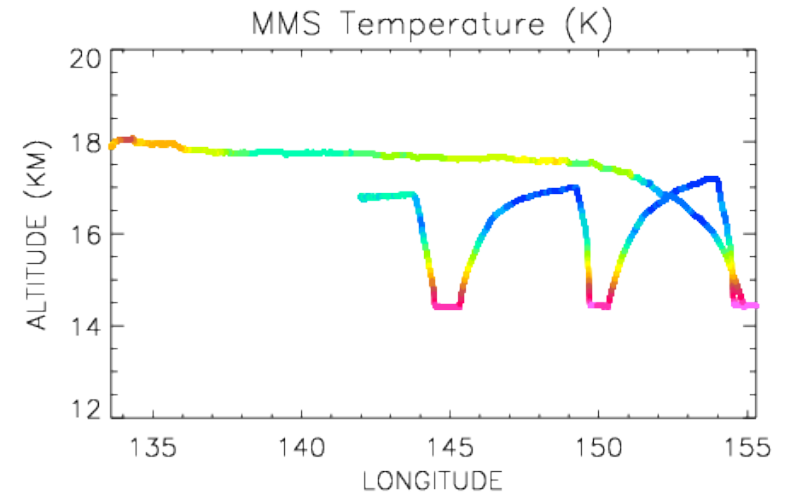
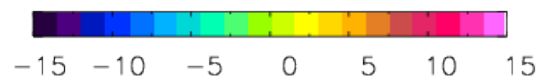
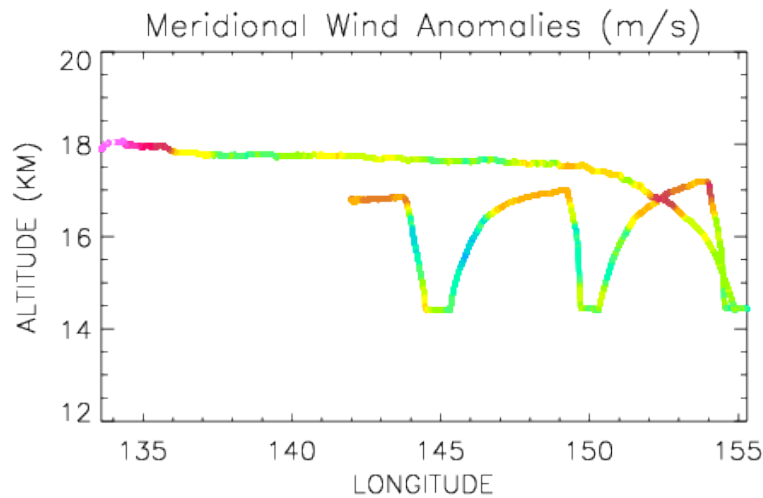
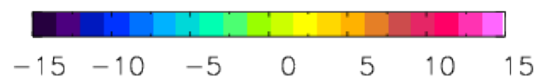
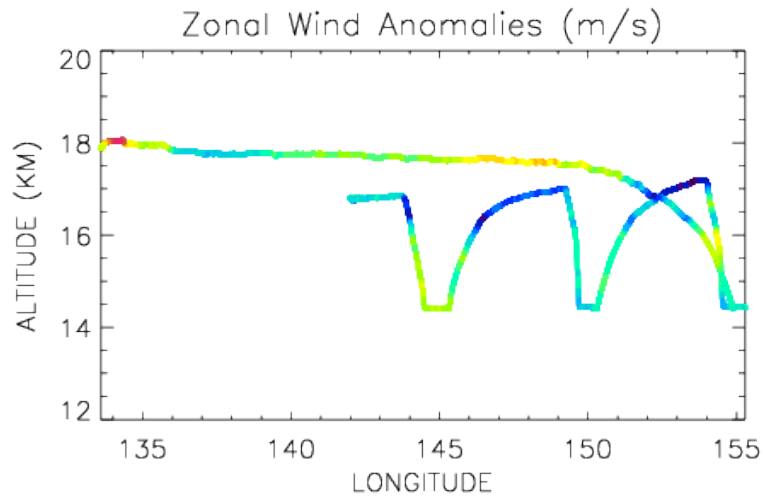
Compute Temperature Anomalies from 30-day time-mean T profile



Temperature anomalies reveal fine-scale vertical structure ~1-2 km observed by MMS. Horizontal structure > 1000km.

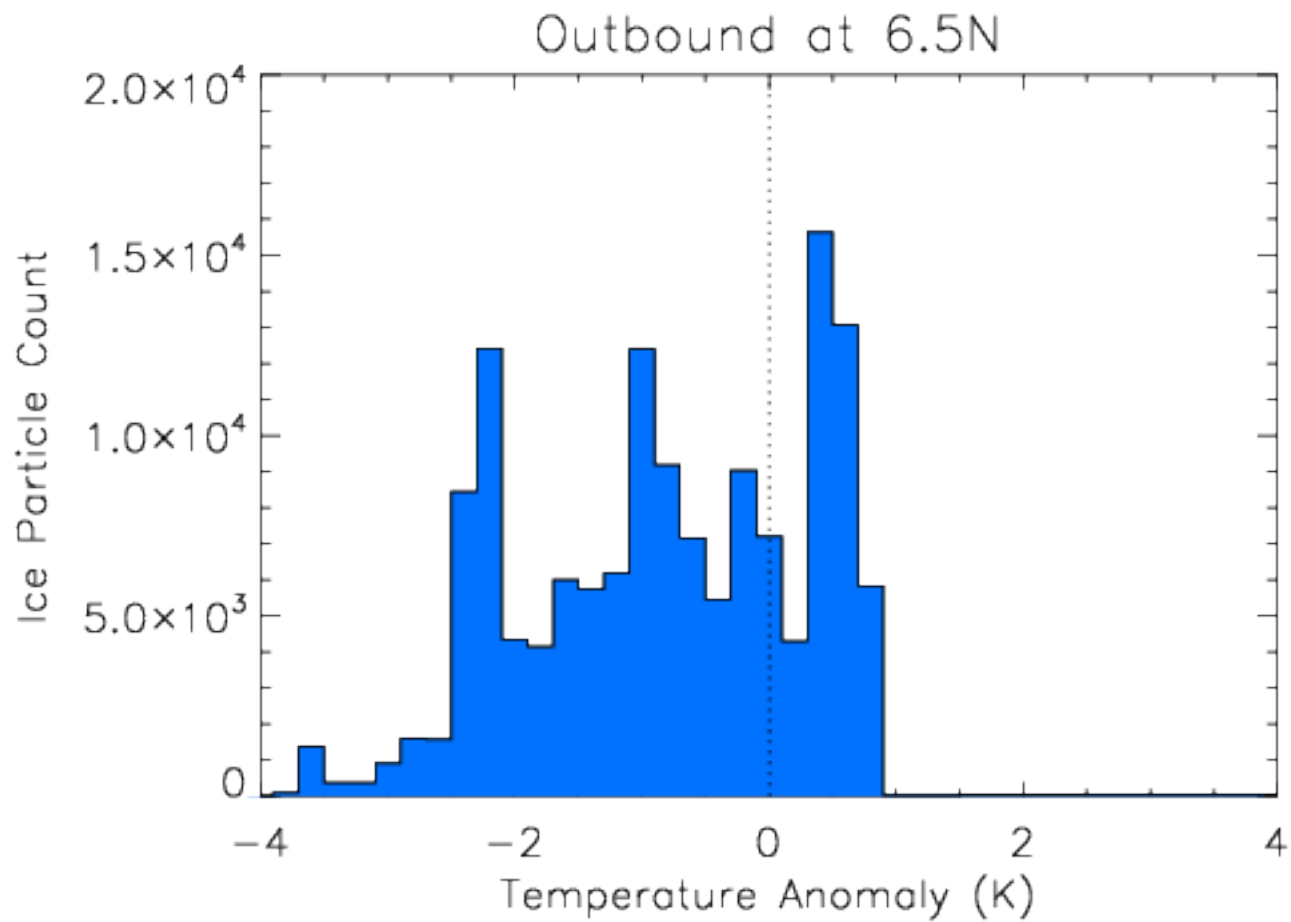
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Similar anomalies also seen in Zonal and Meridional Wind



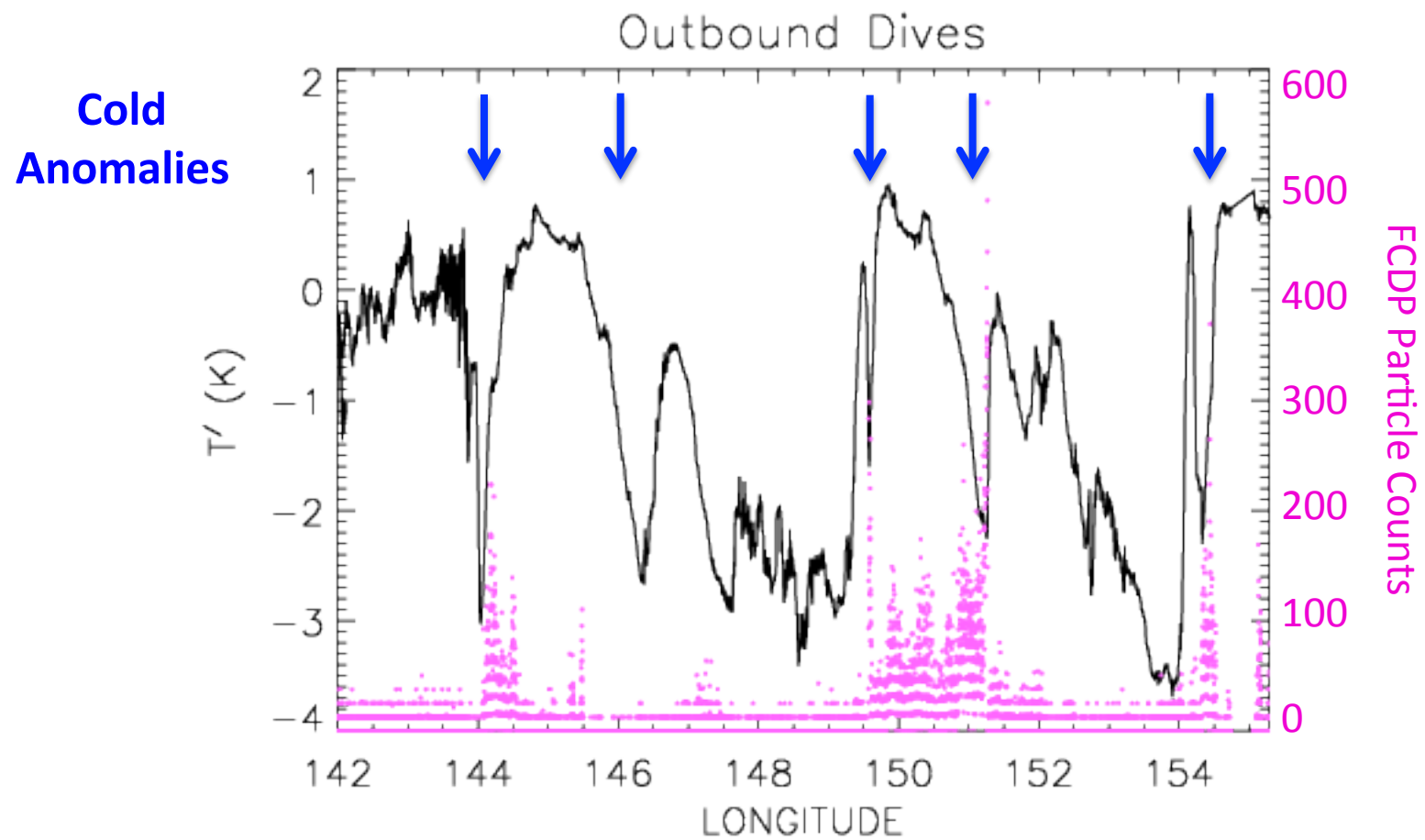
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Relationships between FCDP Particle Counts and Temperature Anomalies



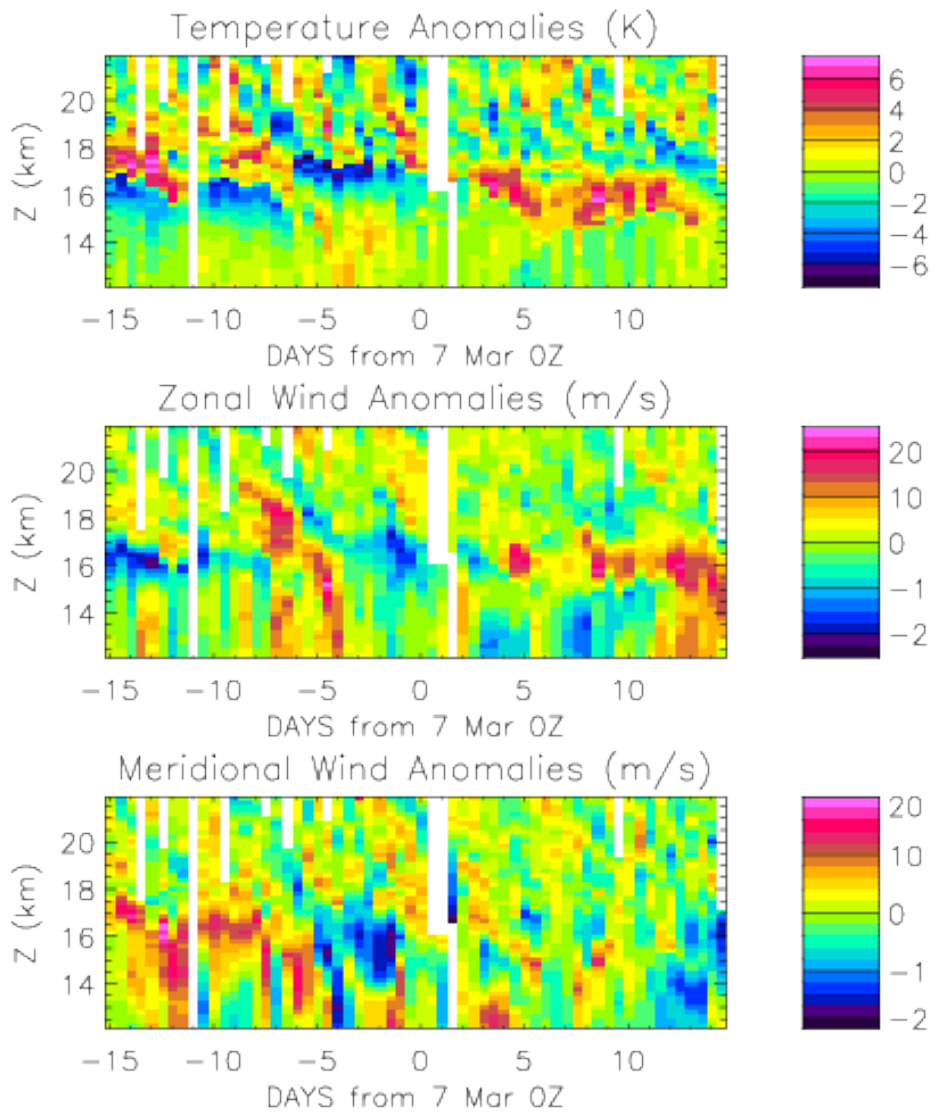
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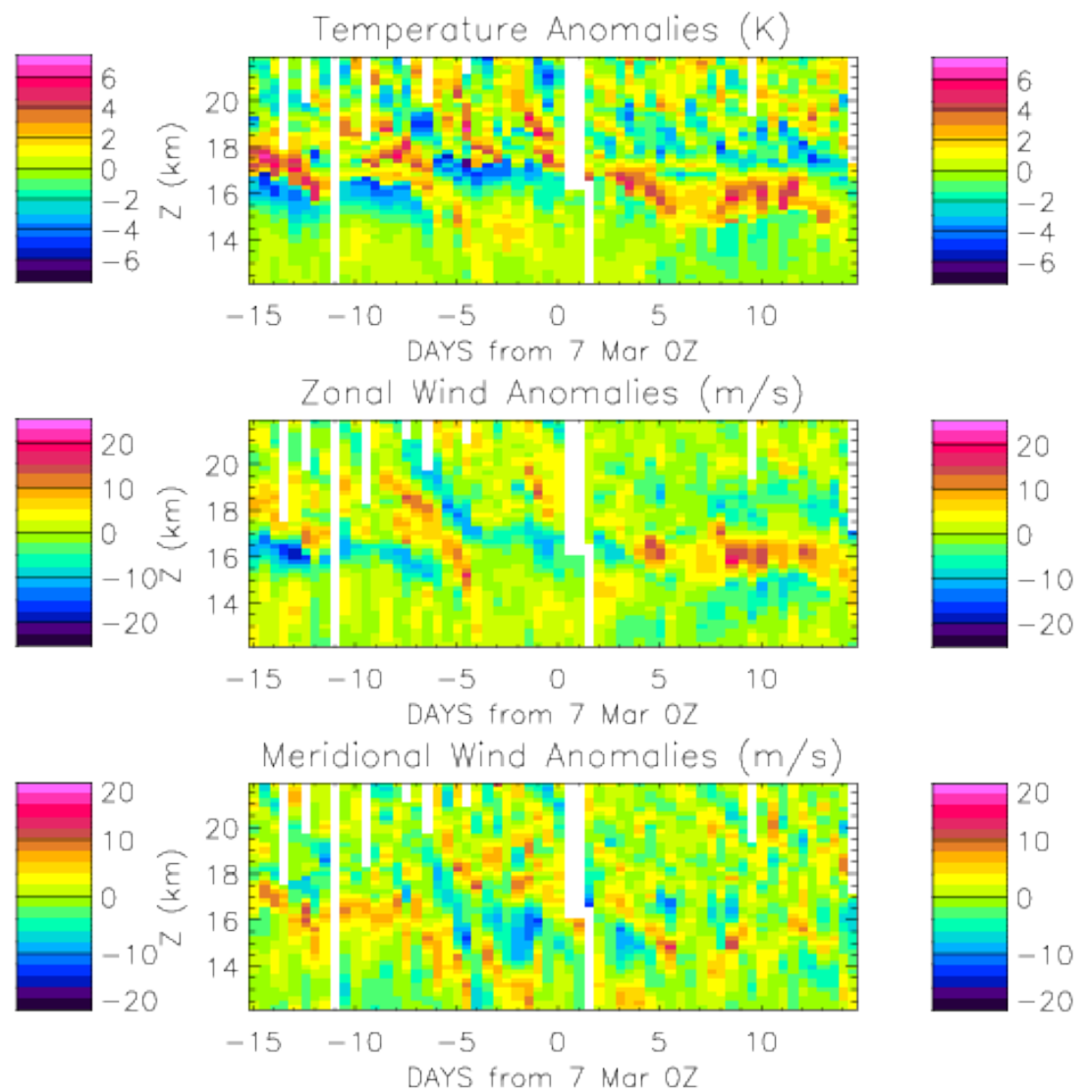


Radiosonde Profiles at Chuuk

Anomalies from 30-day Means

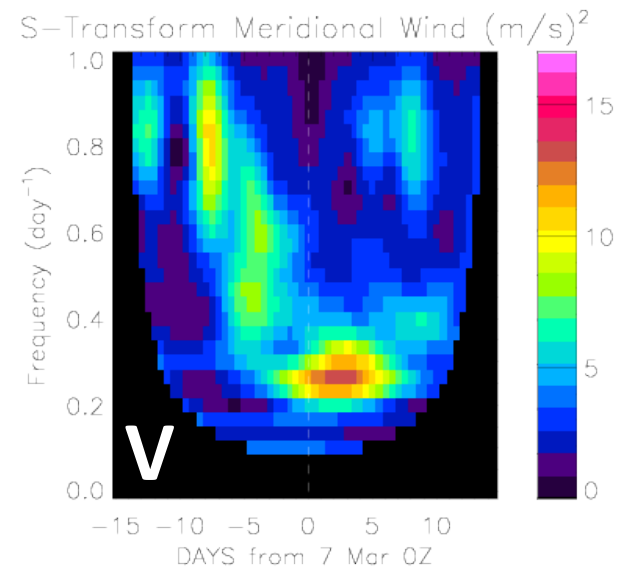
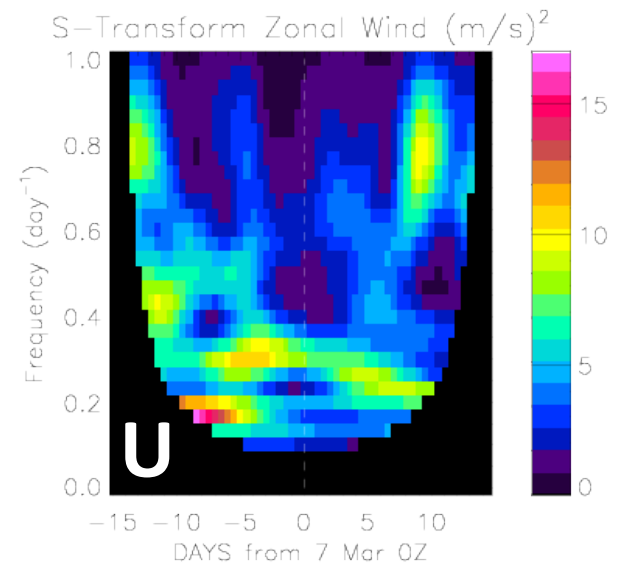
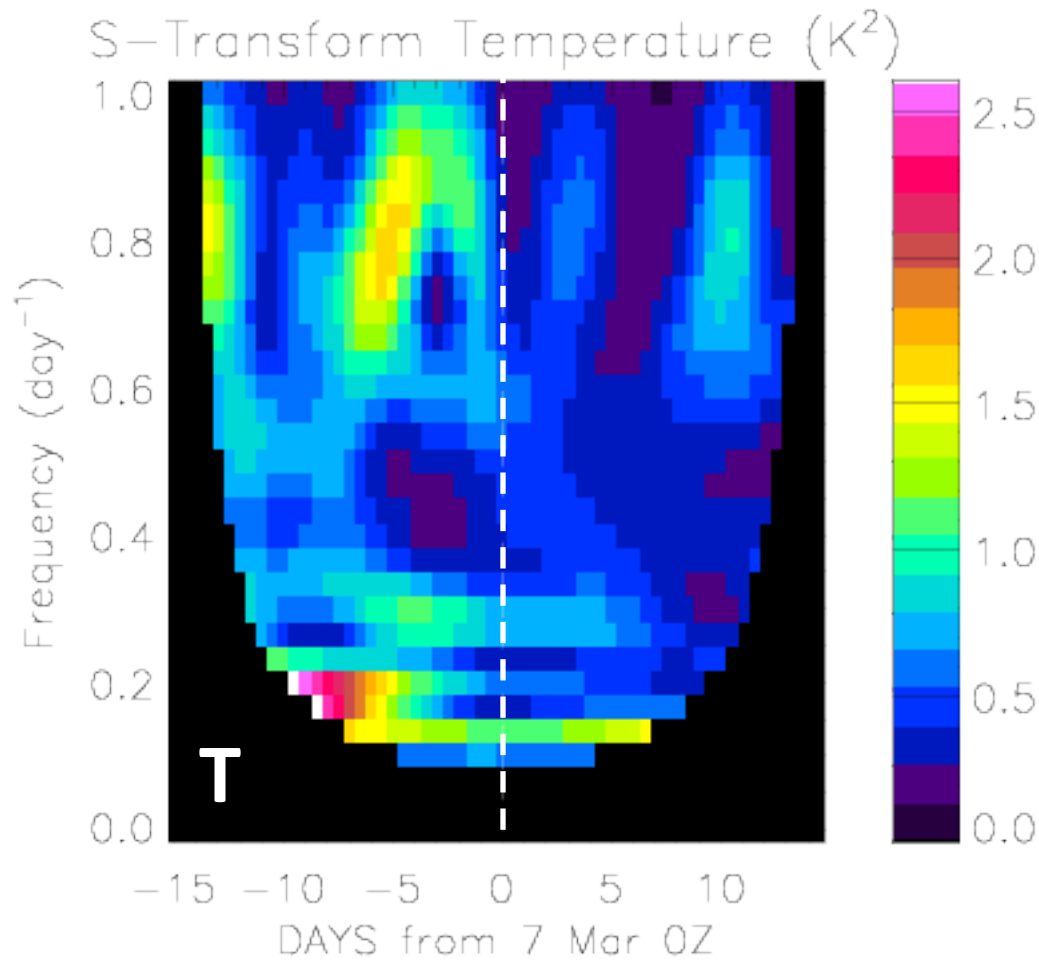


Filtered to retain short $\lambda_z < 4$ km



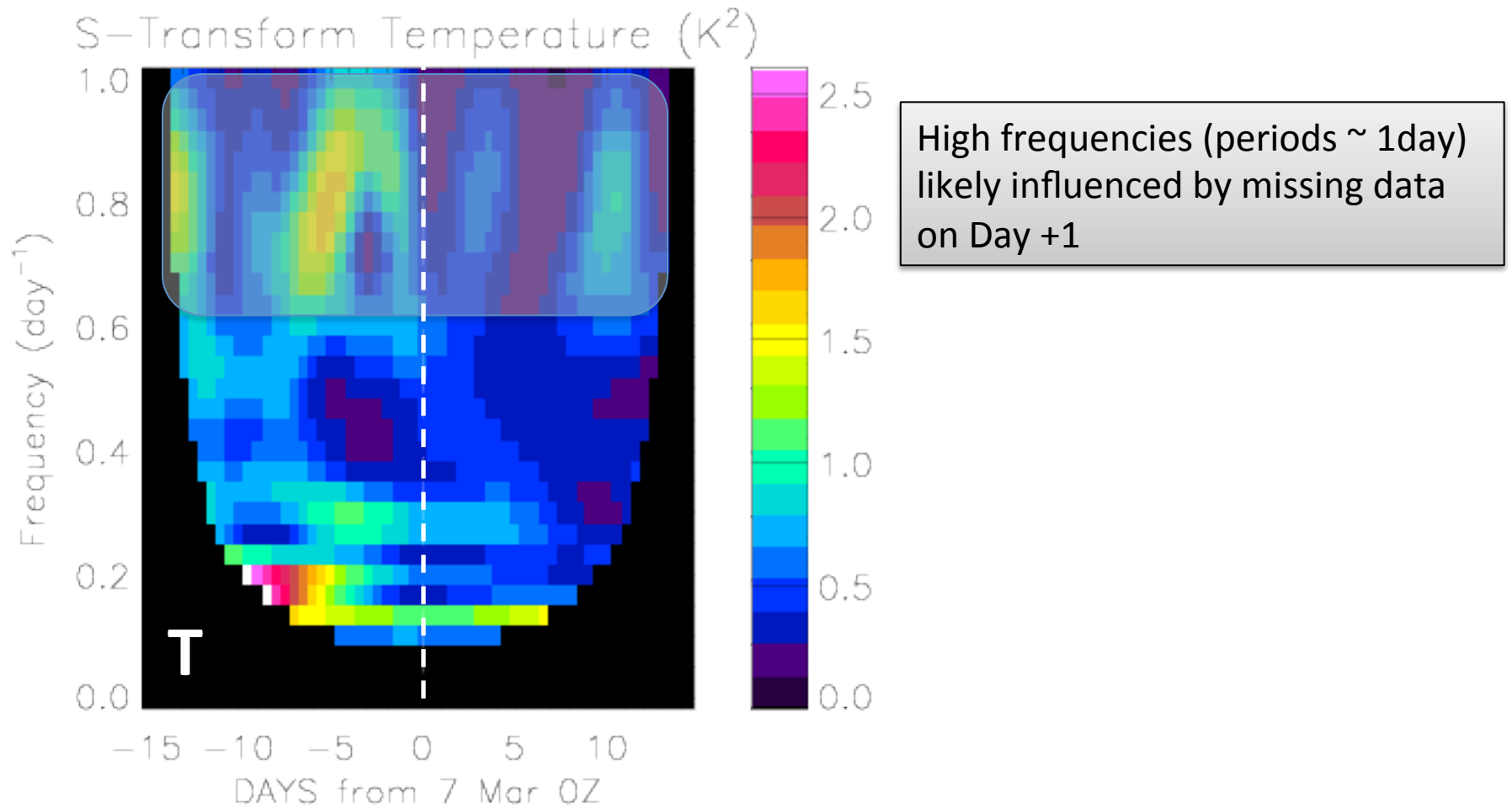
Radiosonde Profiles at Chuuk

S-Transform: Time History of Frequencies of Variability



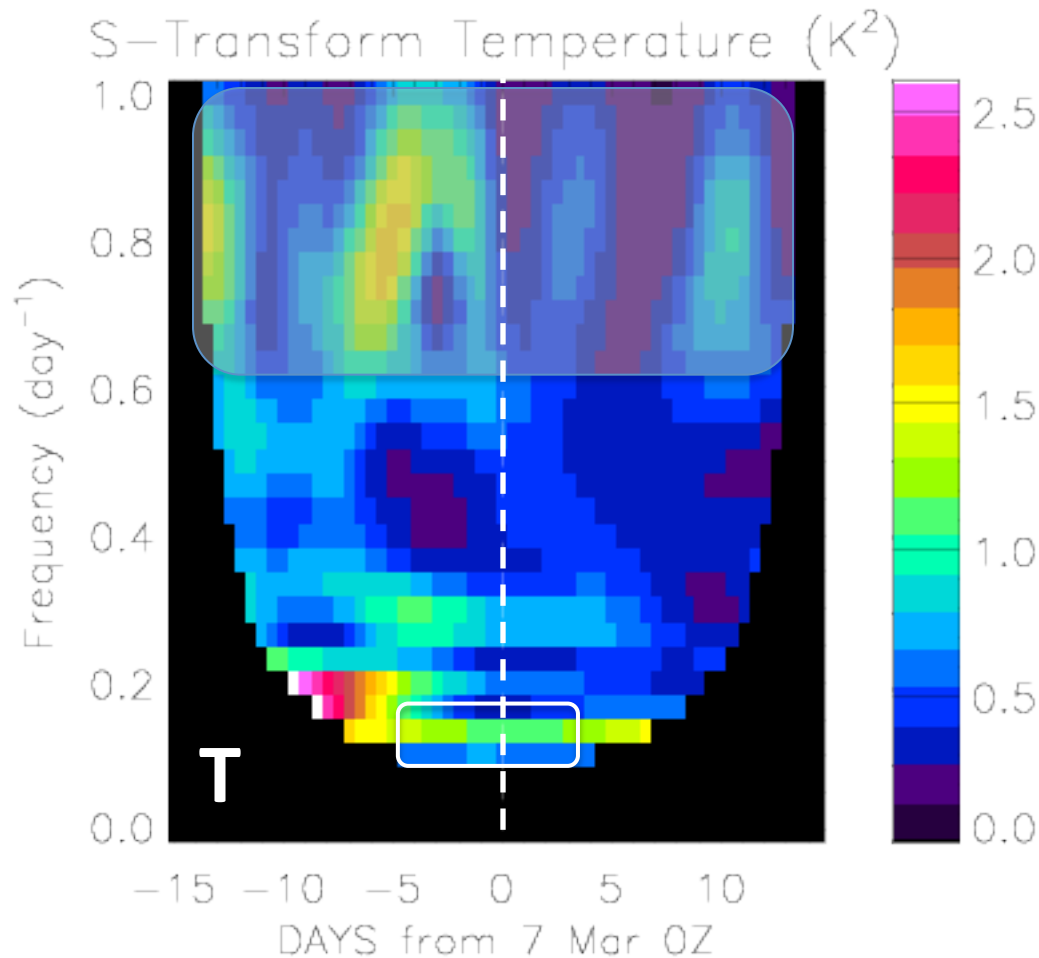
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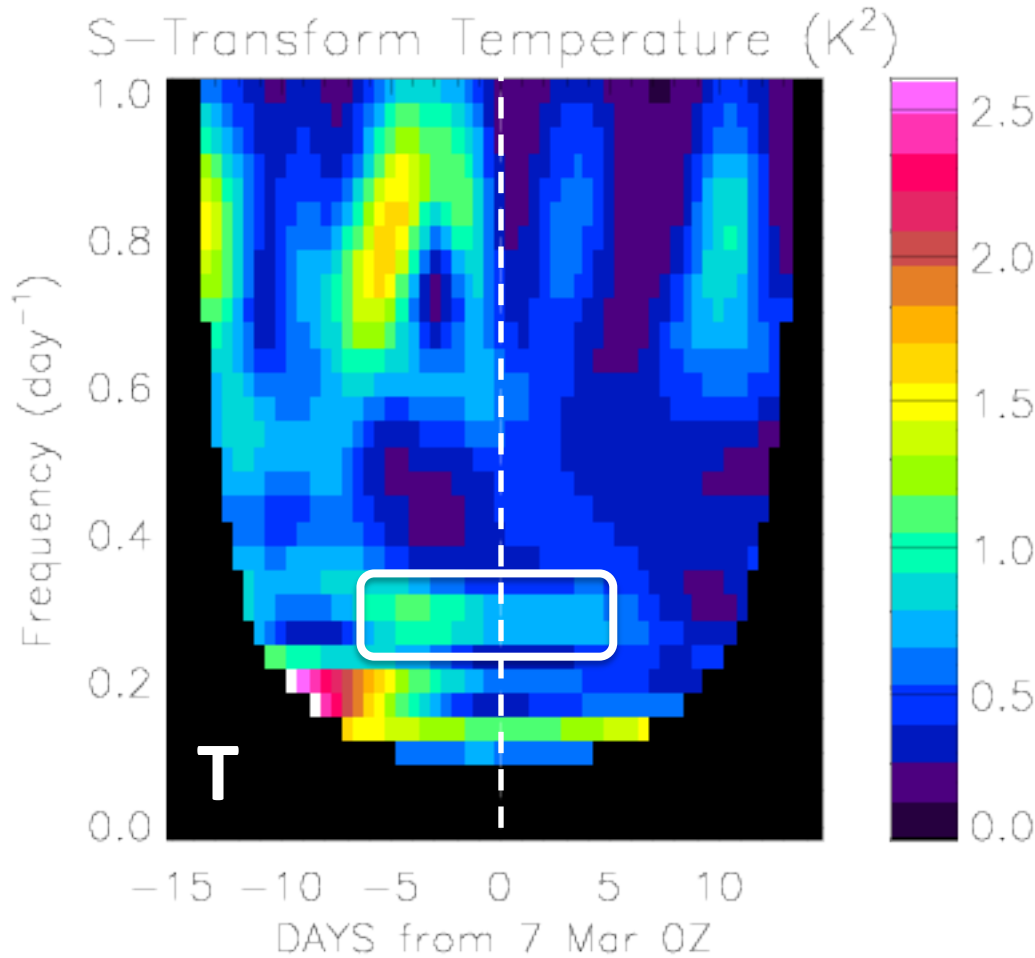
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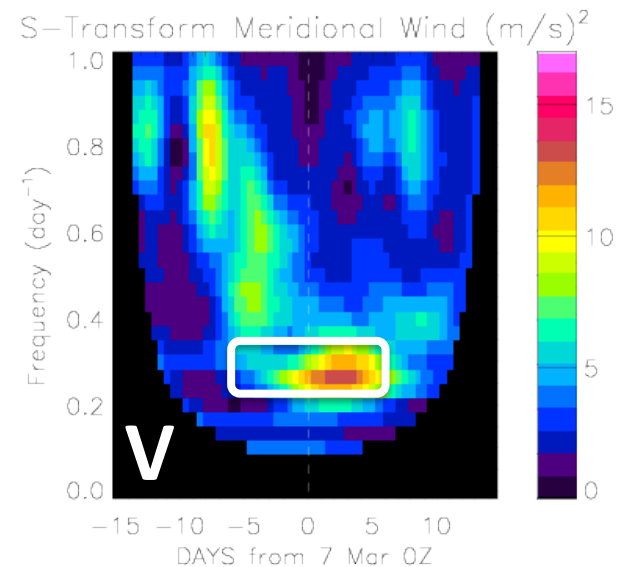
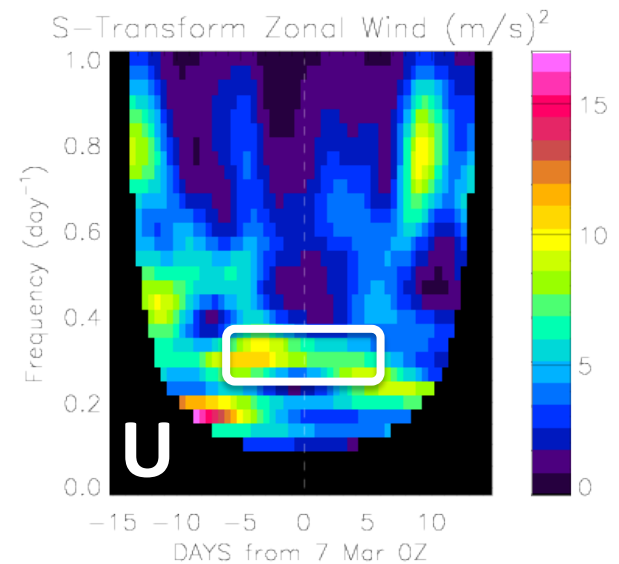
- Low frequency wave (period ~ 10 days) is Kelvin wave.
- Temperature anomaly is weak on flight day.

Radiosonde Profiles at Chuuk

S-Transform: Time History of Frequencies of Variability in the TTL

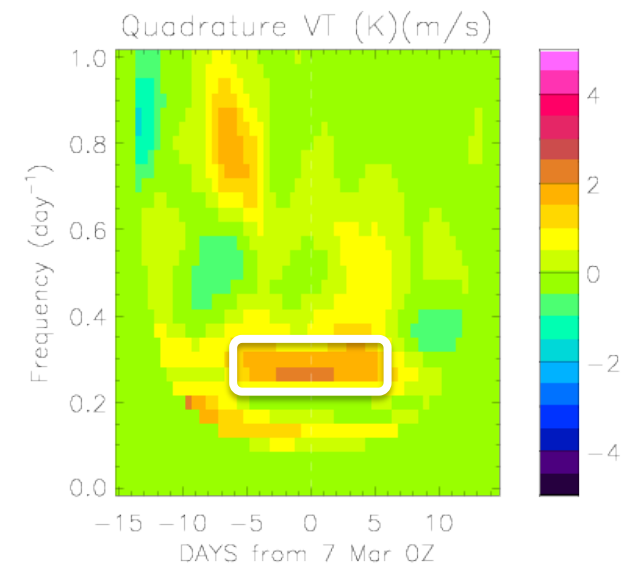
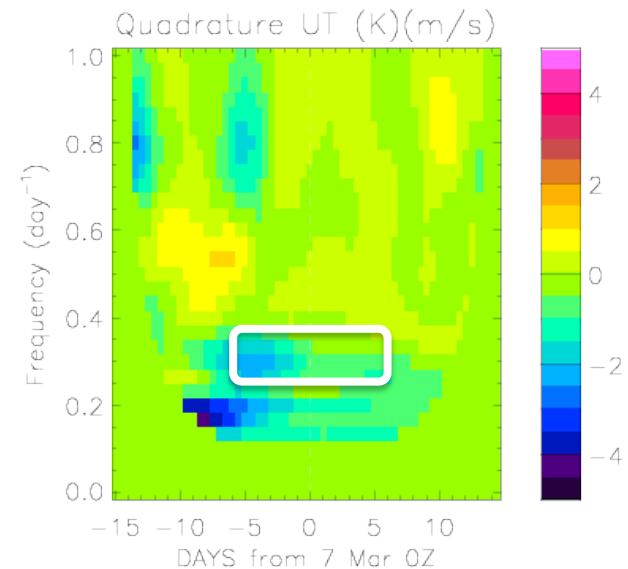
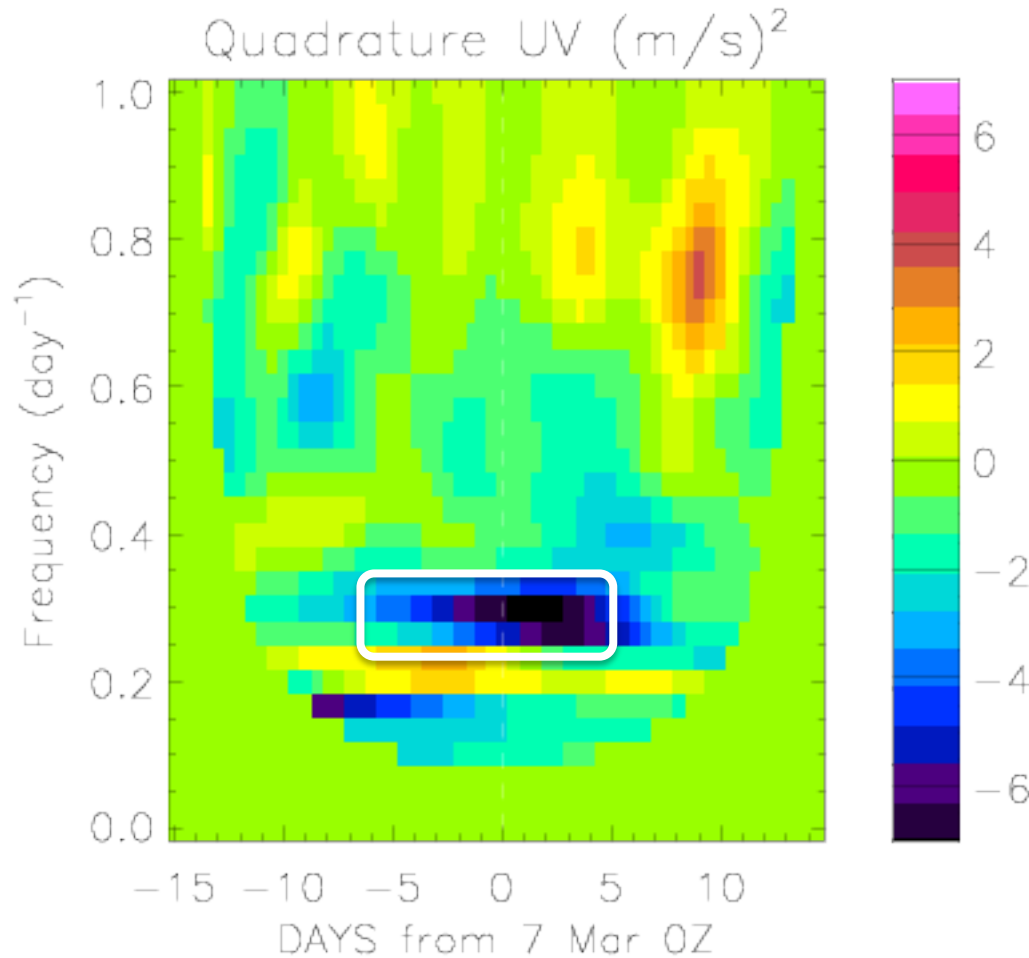


Wave with period ~ 3 days present on the flight day and several days prior.



Radiosonde Profiles at Chuuk

S-Transform: Cospectra reveal additional wave properties



Quadrature in (U,V), (U,T), and (V,T) reveal the 3-day inertia-gravity wave is propagating northwestward relative to the wind.

Conclusions

Analysis of the “Wave Flight” at 7°N on 6-7 March 2014.

- Evidence that cold layers ~1-2 km deep due to waves are influencing cirrus formation.
- Both 10-day Kelvin wave and 3-day inertia-gravity wave signals with vertical wavelengths < 4km are observed at Chuuk in days leading up to the flight.
- Waves of such fine vertical scale are not resolved in reanalyses.
- The 3-day wave appears to be the dominant signal on flight day... an observational first for inertia-gravity waves influencing tropical cirrus formation?

Further work planned to compute the wave horizontal structure utilizing additional radiosondes and MTP observations and hope to evaluate wave effects on dehydration.