TCI Dropsonde Analysis of TC Warm Core Structure Compared to Satellite Observations

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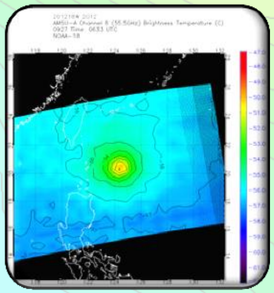
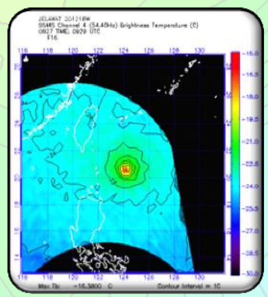
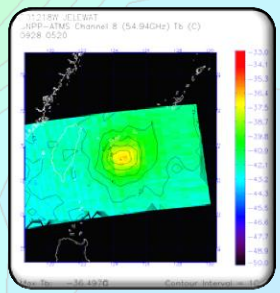
AMSU



SSMIS



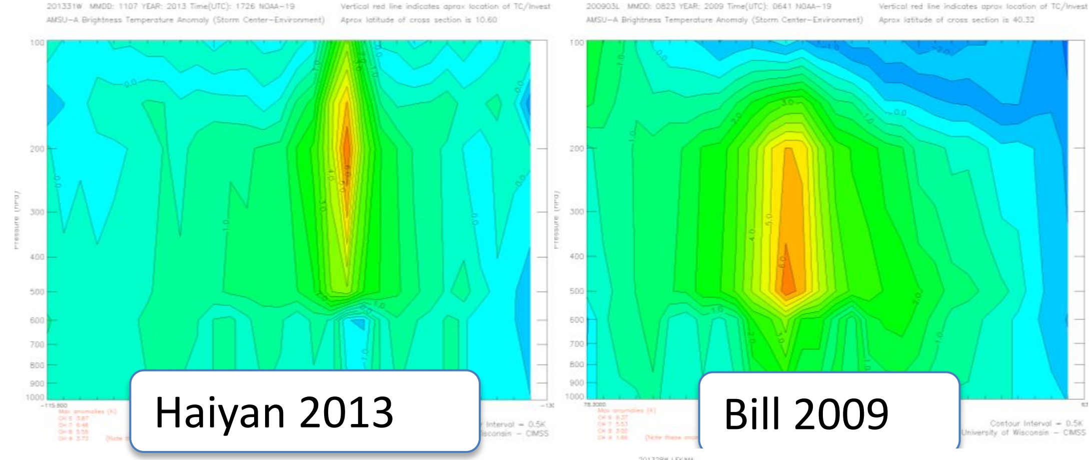
ATMS

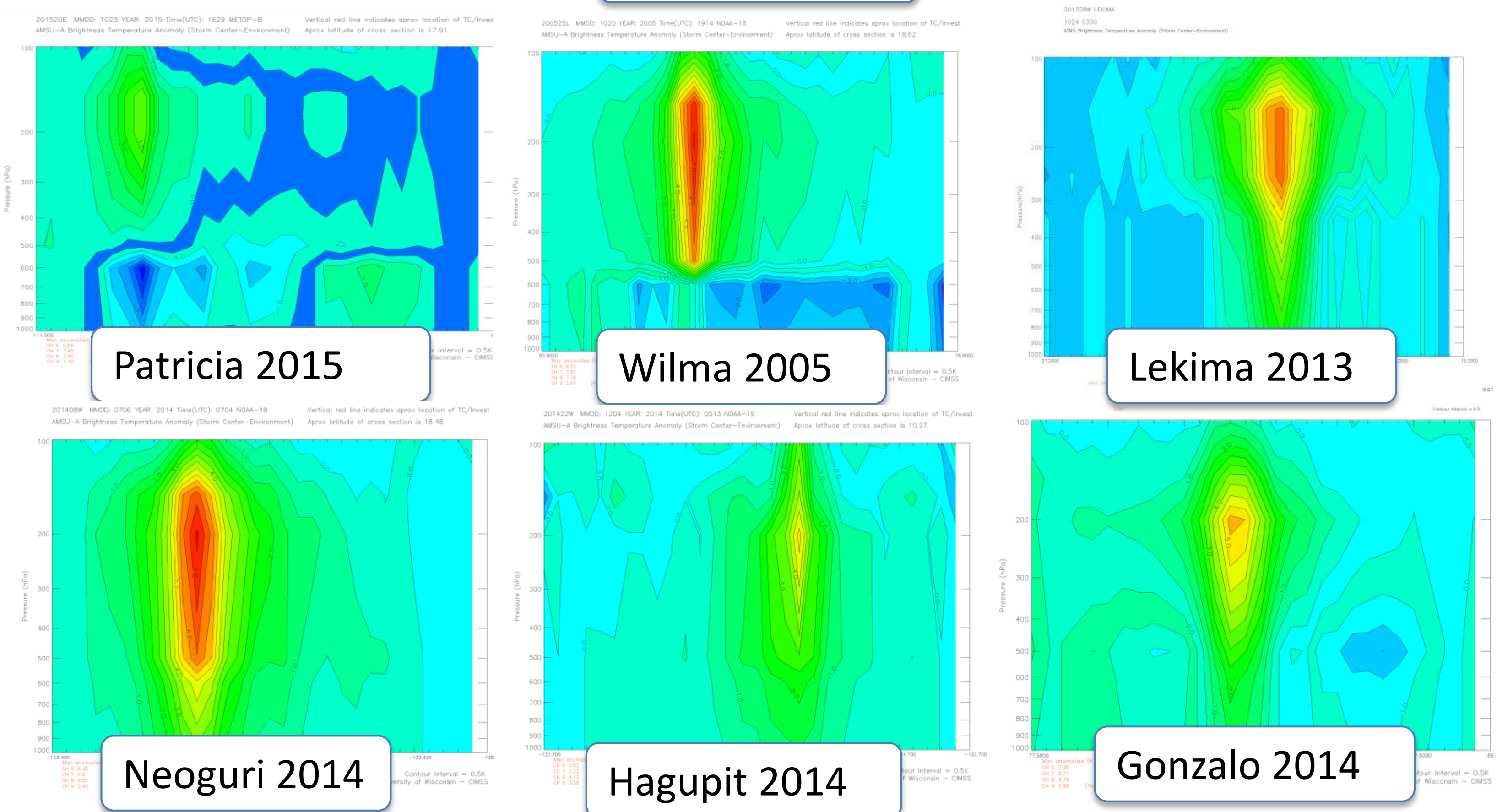


Warm Core Observations from Sounders

Microwave sounder observations since 1998

A few recent examples from AMSU and ATMS





Objective: Employ the unique observations of TC warm core structures from TCI campaigns to improve our characterization of remotely-sensed warm cores from satellite microwave sounders.

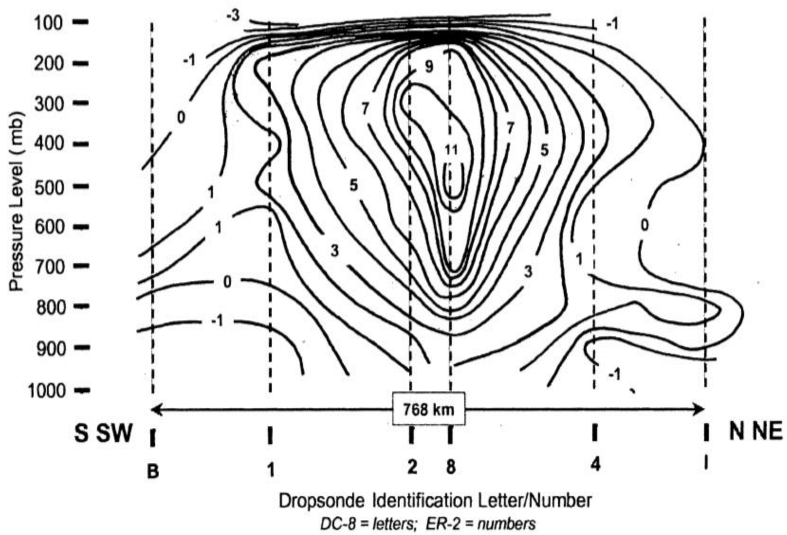


FIG. 6. Cross section through Erin's core showing temperature perturbation. Analysis was made by compositing dropsondes along/nearby the dashed line shown in Fig. 1. The vertical slide is oriented from southwest to northeast. Maximum perturbation temperature of +11°C and distance scale are shown. Initial release times of dropsondes are 1629, 1648, 1704, 1750, 1928, and 1936 UTC for B, 1, 2, 4, 8, and I, respectively.

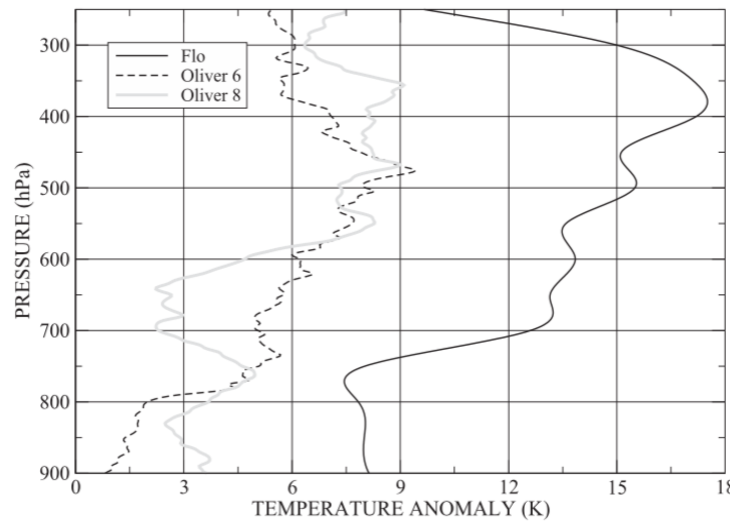


FIG. 10. Temperature anomalies computed using environmental soundings for Flo and for Oliver on both days.

Halverson 2006
CAMEX 4 Hurricane Erin 2001

Durden, 2013
Individual soundings
Also Stern et el (Earl 2010)

Recent field campaigns with high-altitude aircraft allow for a detailed look at thermodynamic core structure of intense TCs

Hurricane Edouard 2014 (HS3 Global Hawk)

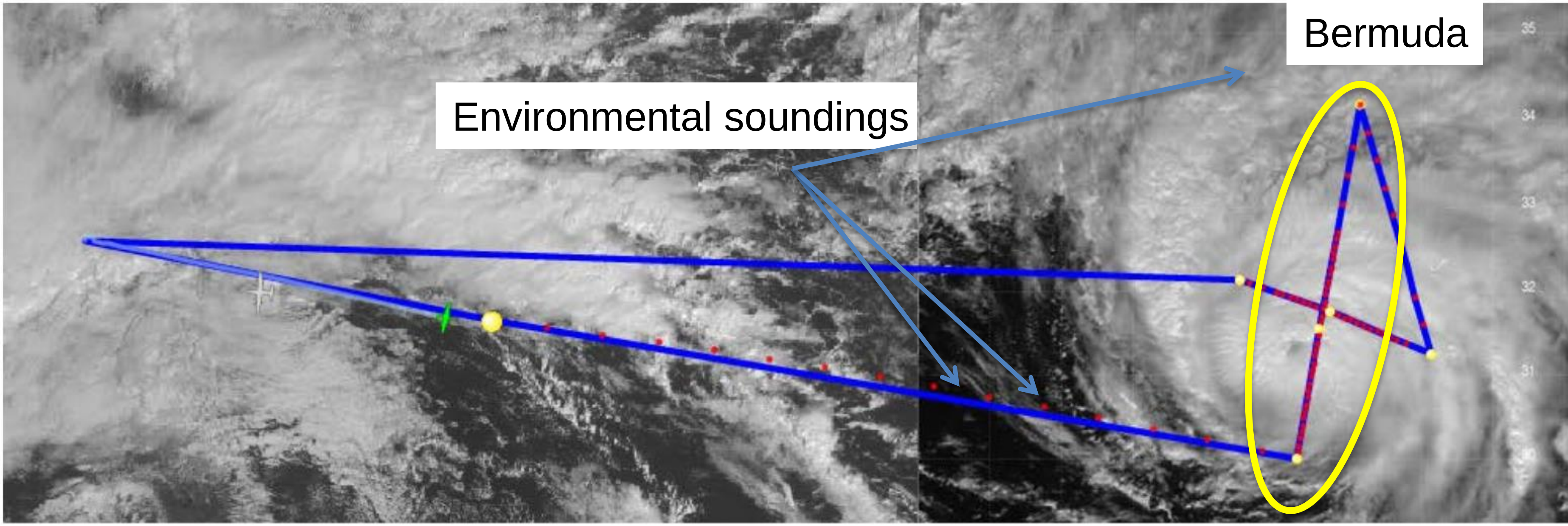
Hurricane Joaquin 2015 (TCI WB-57)

Hurricane Patricia 2015 (TCI WB-57)

Hurricanes Gaston, Hermine, Matthew 2016 (SHOUT GHawk)

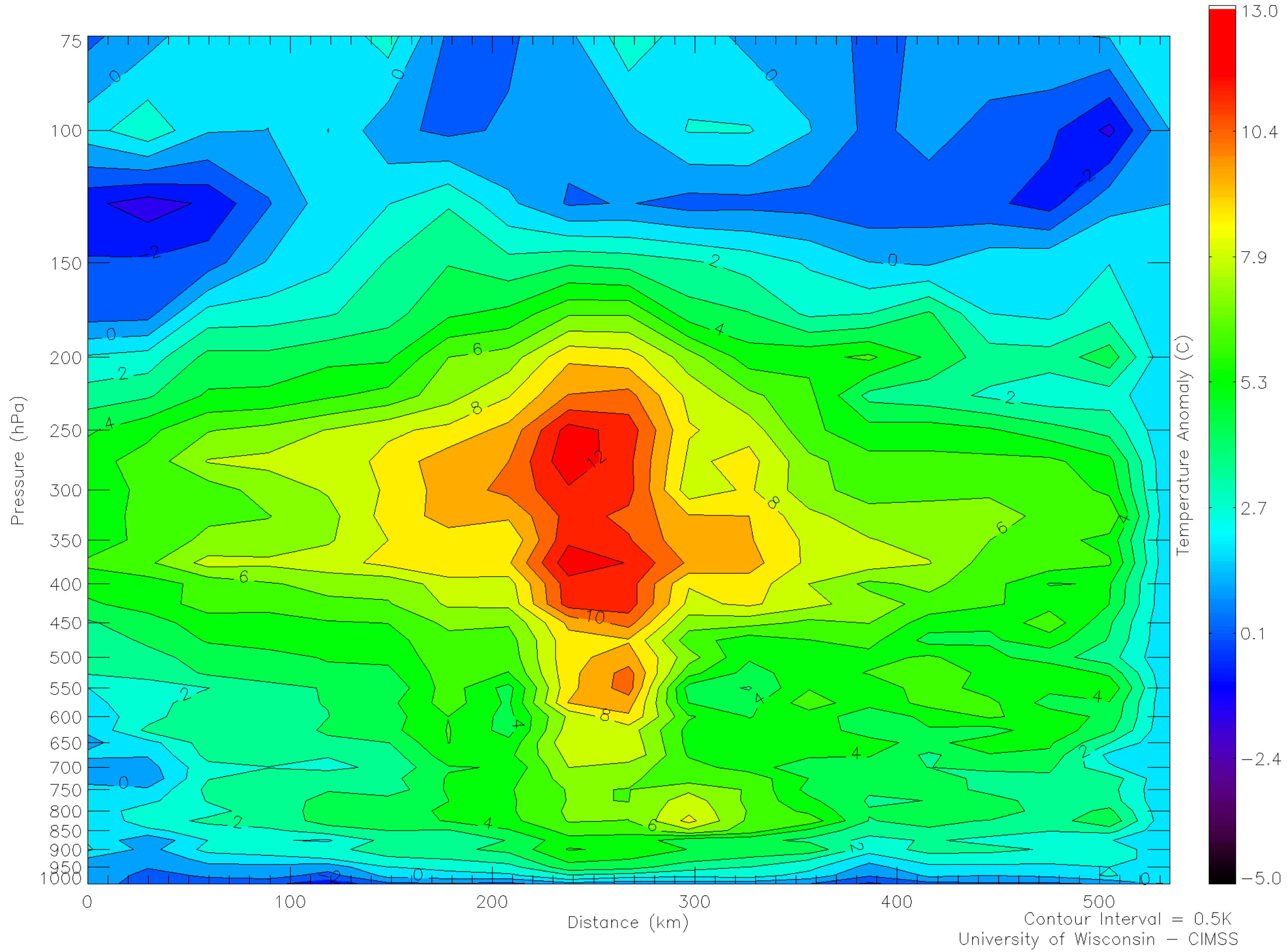
Methodology: Use dropsonde temperature profiles in the TC eye. Derive a mean environmental temperature profile around the TC from an average of dropsondes, nearby upper air soundings if available, and model soundings. Take the difference to compute the thermal anomaly in the TC core region.

Hurricane Joaquin October 4, 2015
WB-57 Dropsondes

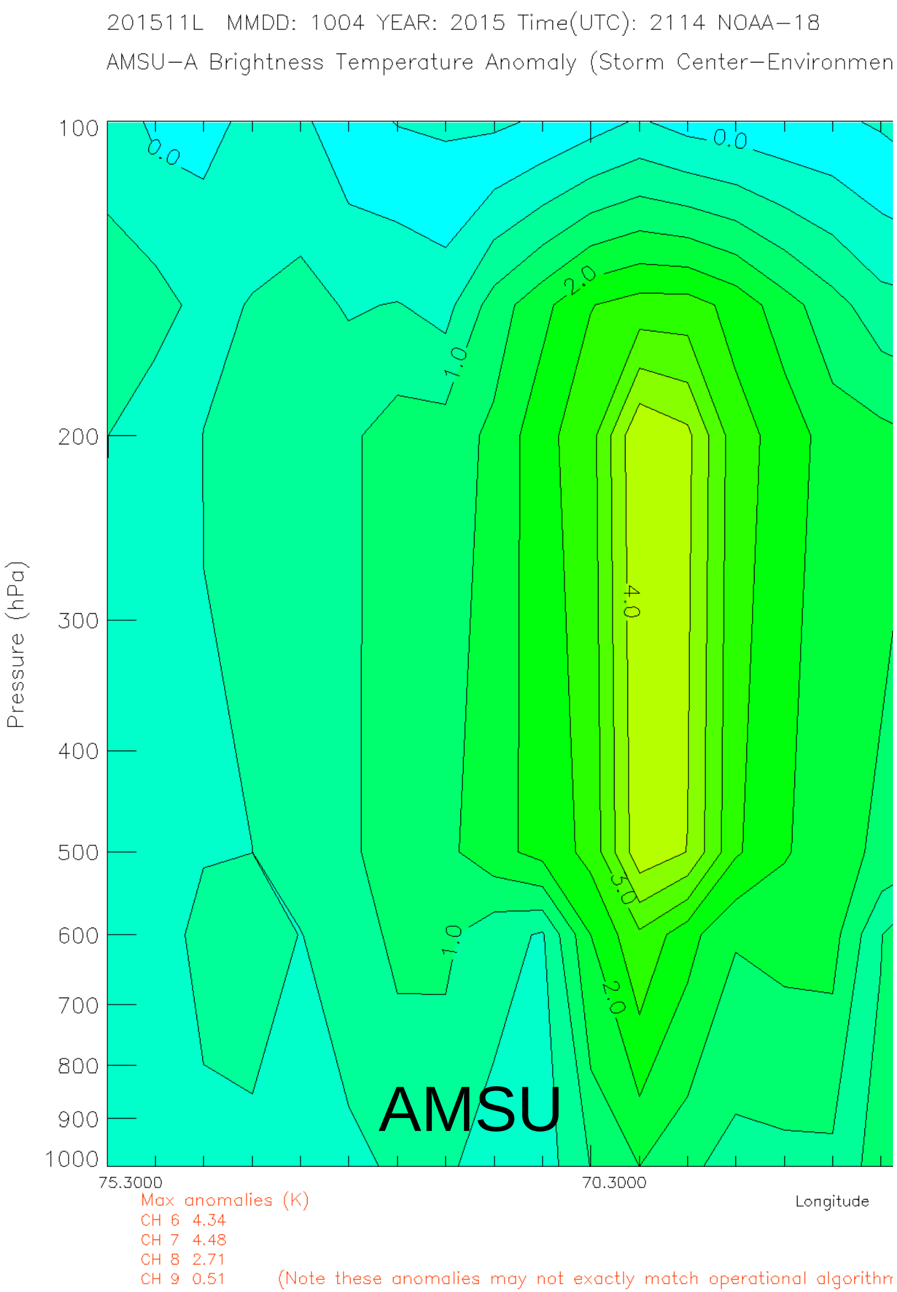


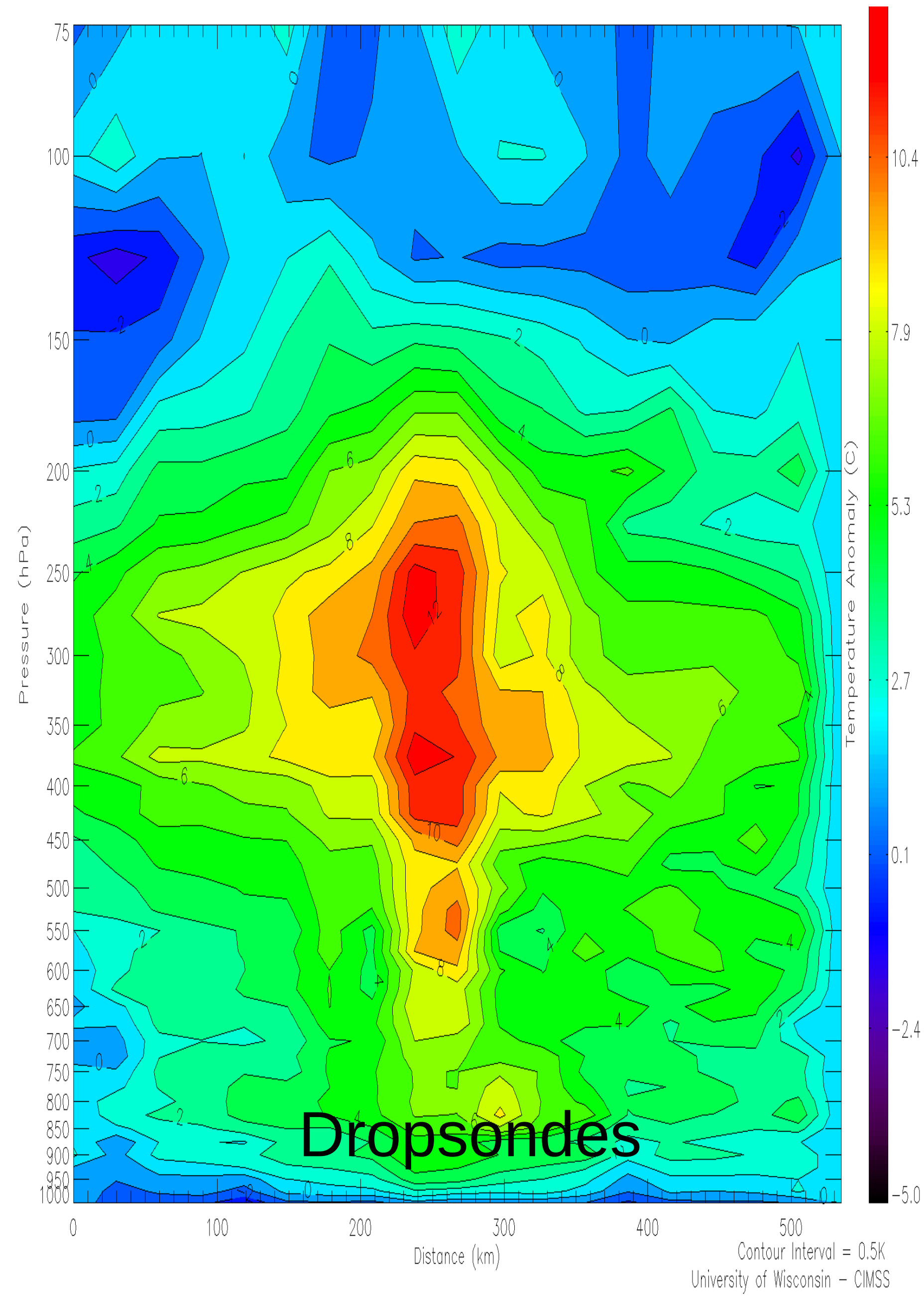
Use dropsondes from inbound leg along with the 03/12Z and 04/00Z sounding from Bermuda to compute environmental temperature.

Hurricane Joaquin October 04, 2015 1800 UTC

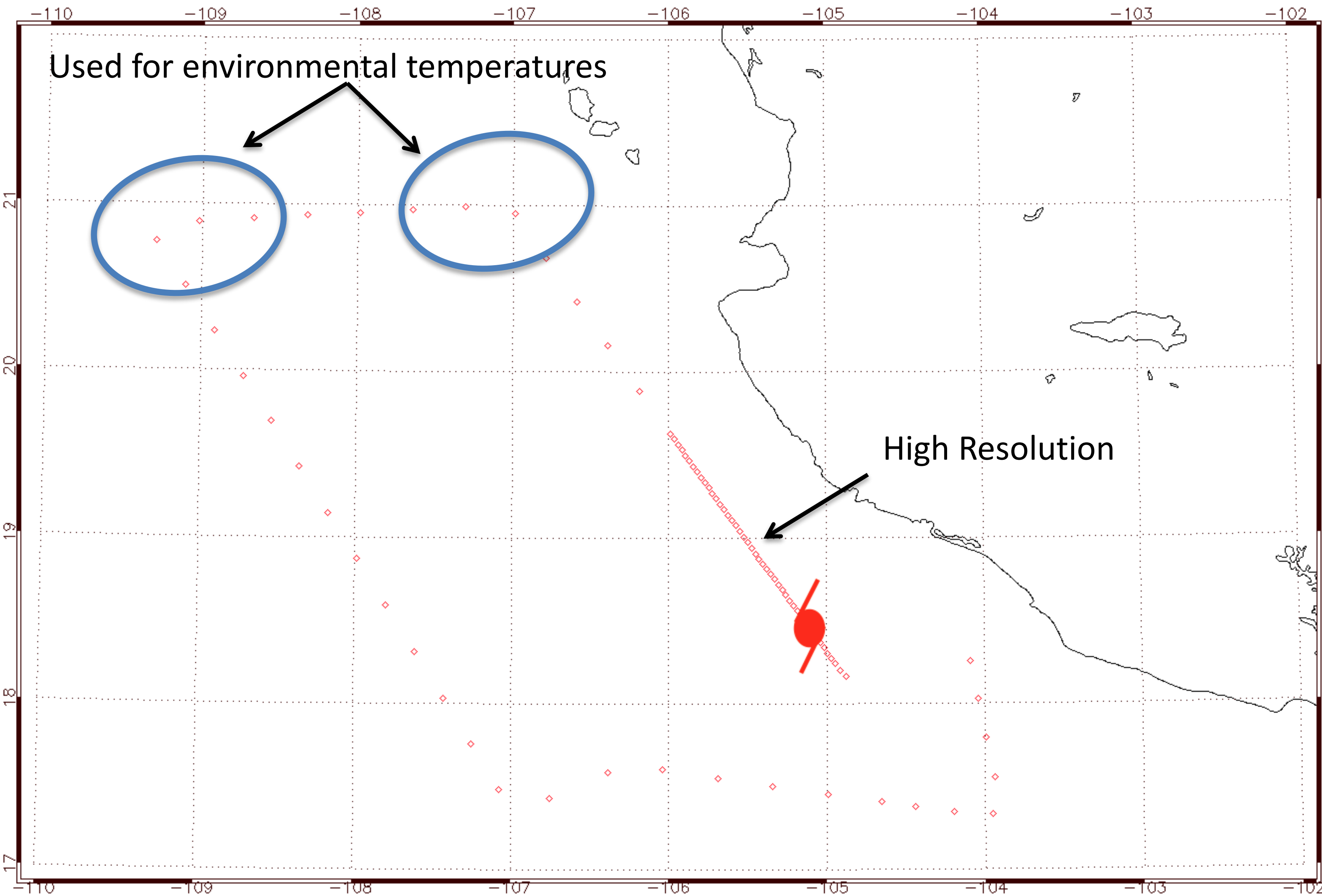


Hurricane Joaquin October 04, 2015

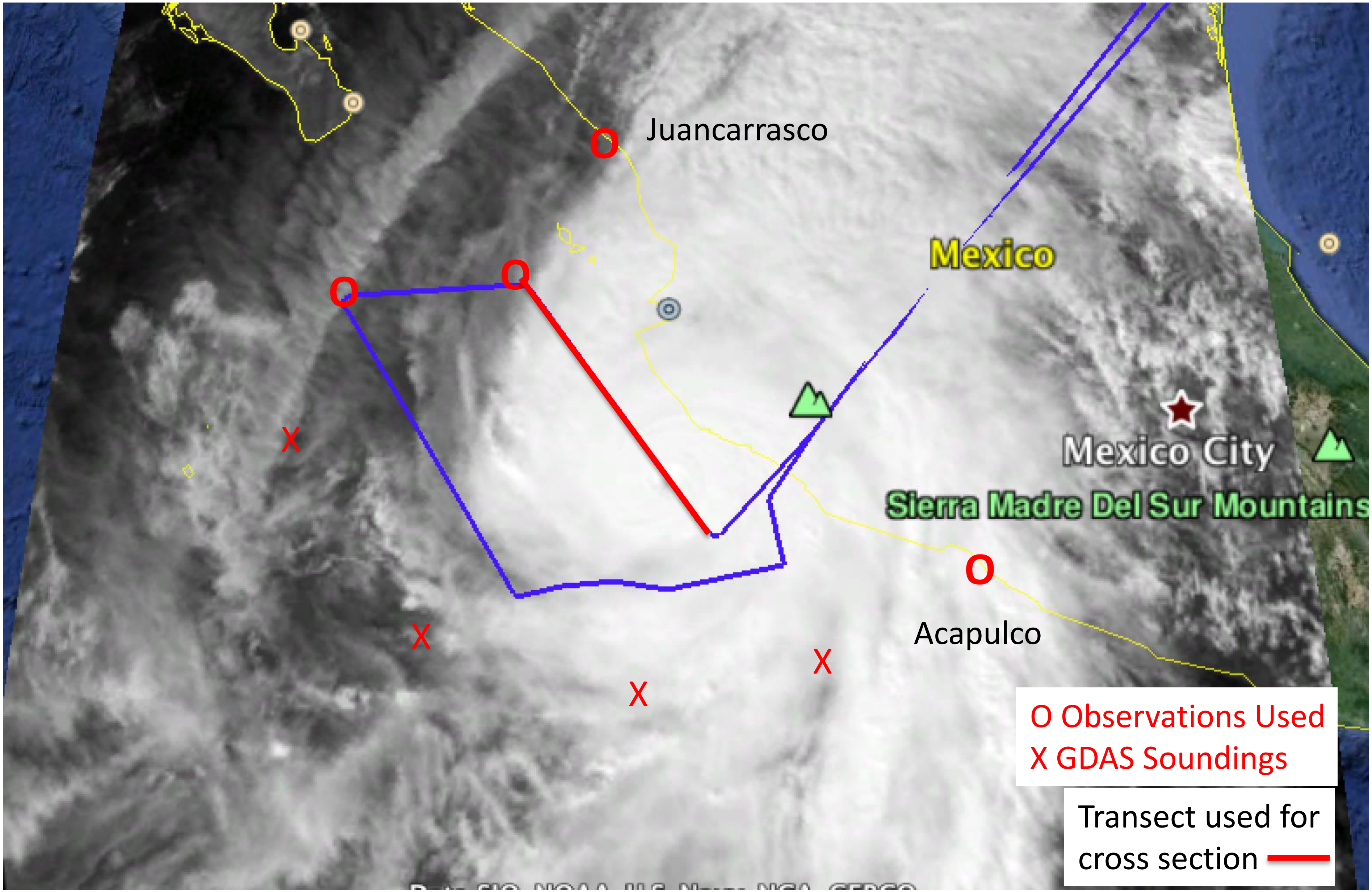




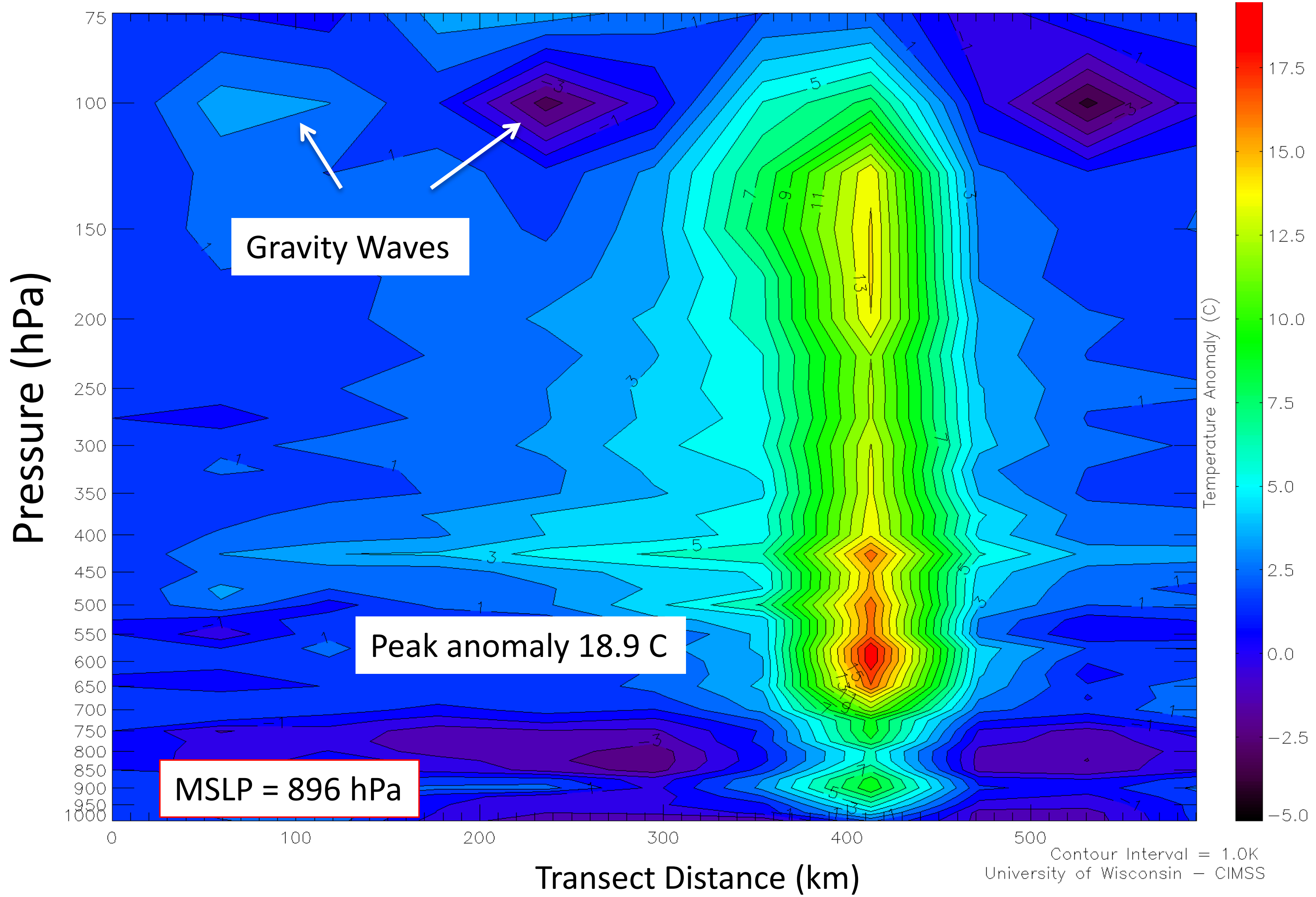
Hurricane Patricia October 23, 2015
WB-57 Dropsondes



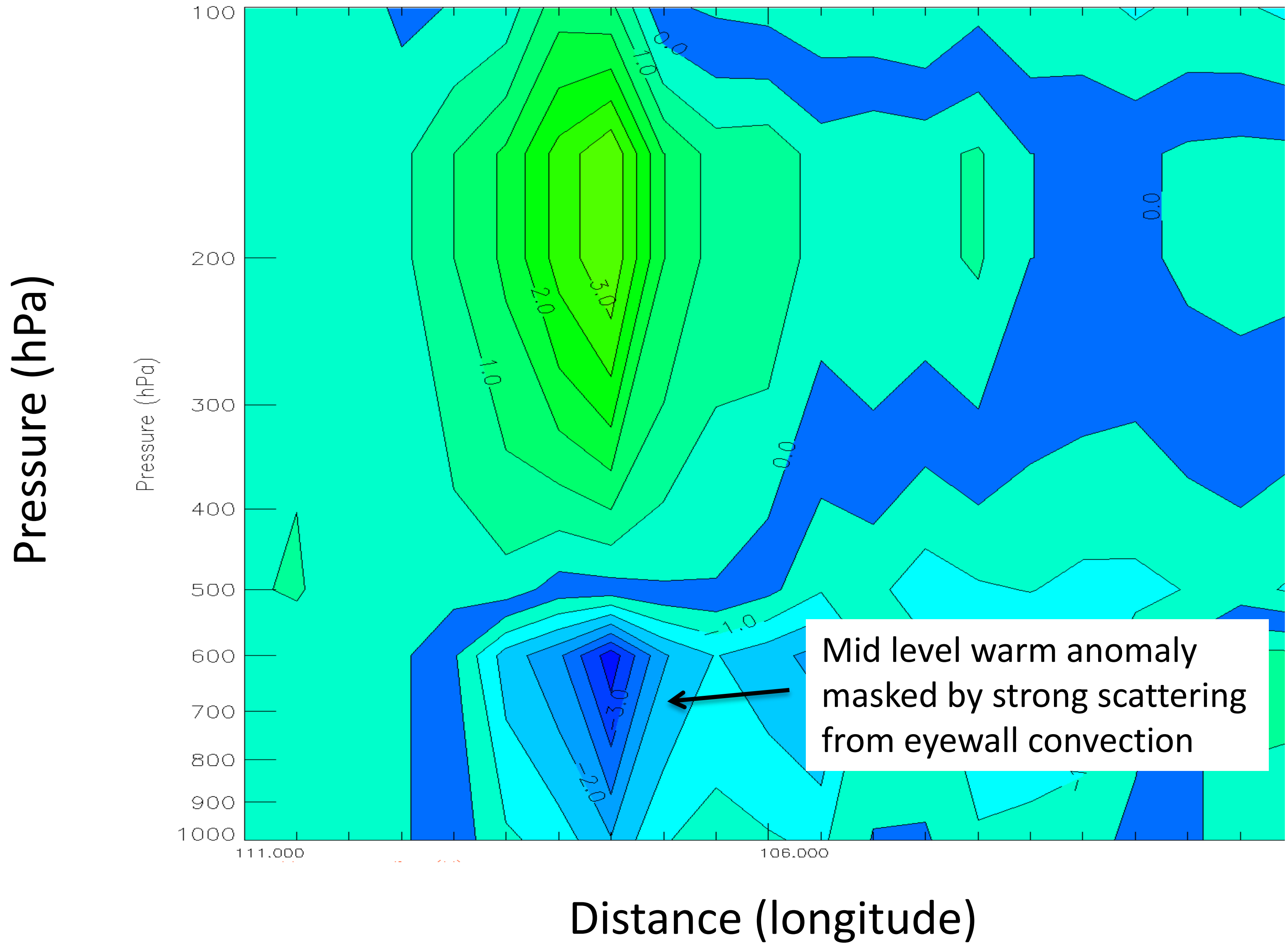
Hurricane Patricia October 23, 2015
Environmental Temperatures



Hurricane Patricia October 23, 2015
Temperature Anomaly from WB-57 Dropsondes ~20UTC



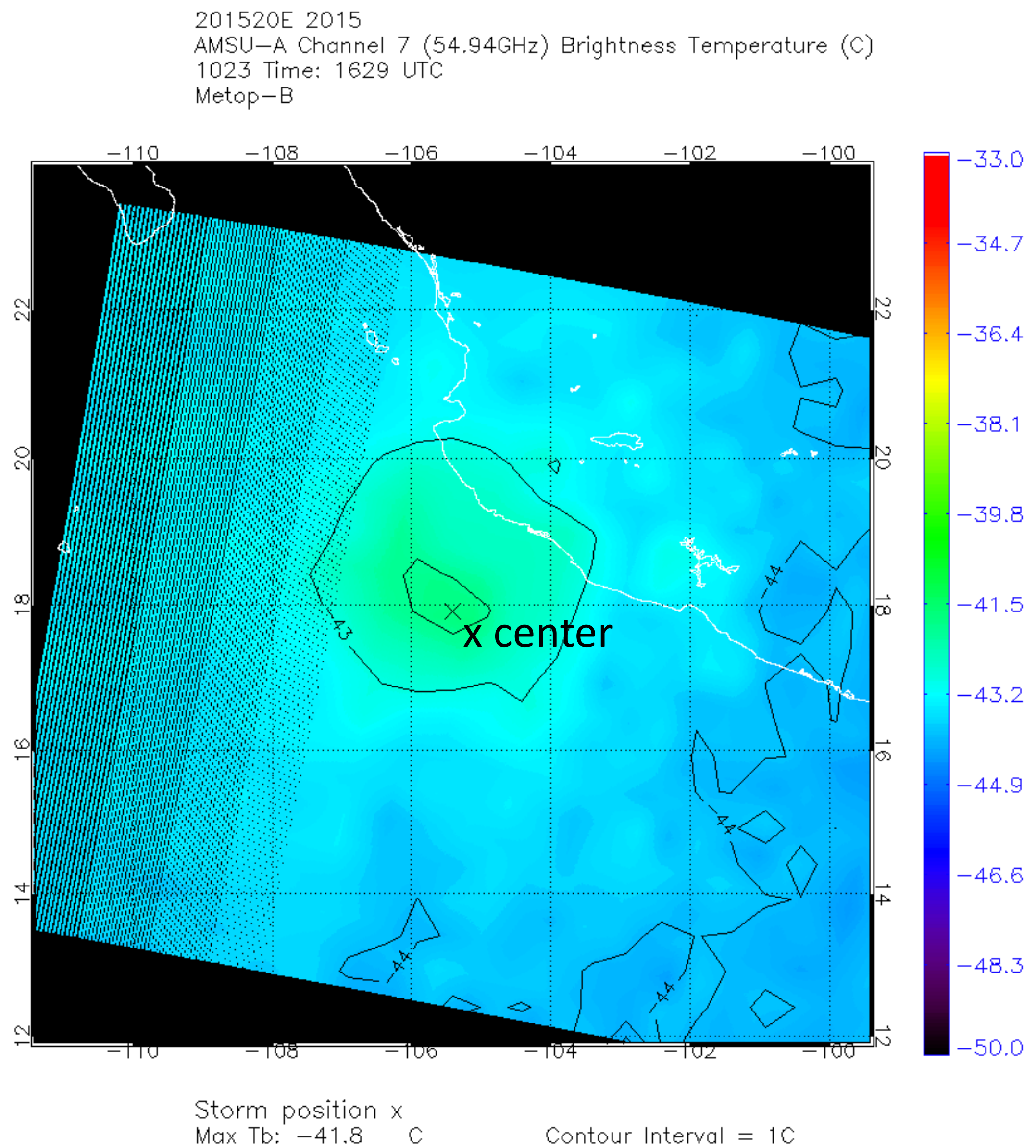
Hurricane Patricia October 23, 2015 1629Z
METOP-B Temperature Sounder Cross Section



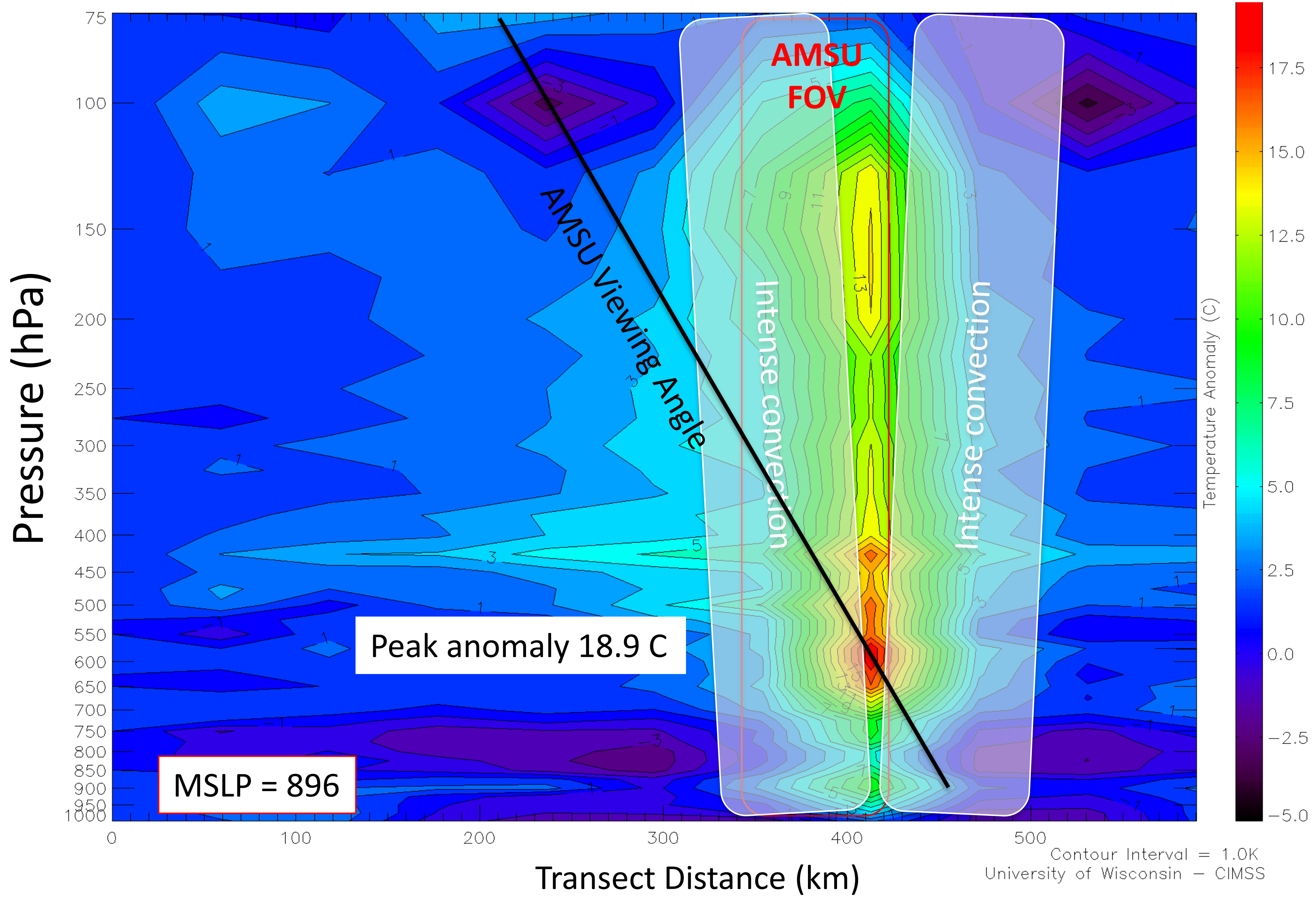
Hurricane Patricia Oct 23: AMSU pass 1629 UTC

Center of Patricia is near the edge of the scan where AMSU FOVs become large, resulting in volumetric smoothing (reduction) of the warm core signal.

FOV center is also offset from true TC position, resulting in additional under-sampling and increased influence from eyewall scattering, and a further reduction in the warm core signal.



Hurricane Patricia October 23, 2015
Temperature Anomaly from WB-57 Dropsondes ~20UTC



Conclusions

Satellite-borne microwave sounders can detect and characterize warm thermal anomalies in tropical cyclones, however:

Resolving the vertical extent of the peak warming (especially the important aspect of mid-level maxima in the eye) can be problematic due to FOV resolution, vertical resolution, scan angle, and precip attenuation.

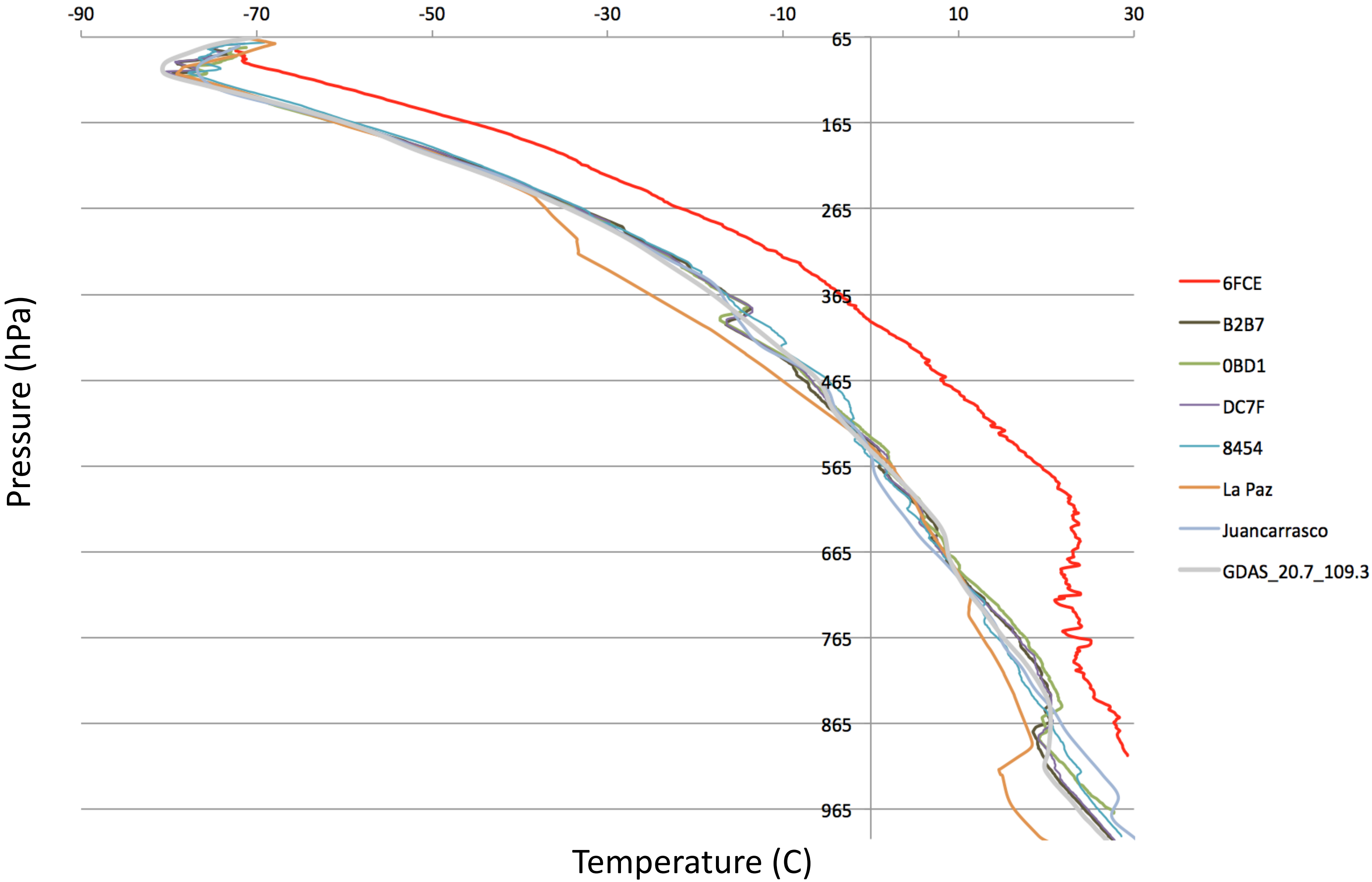
- Nadir passes over storms with eyes > 30 km diameter are more likely to resolve a mid-level warm core if it exists
- TCs with very small eyes result in significant attenuation thus masking the mid-level warm core.

Dropsonde observations show that dual warm core maxima appear to be common but may be difficult to resolve by satellite microwave sounders. Instead, these maxima are often depicted as weaker, near-continuous warm anomalies extending from ~550-150 hPa.

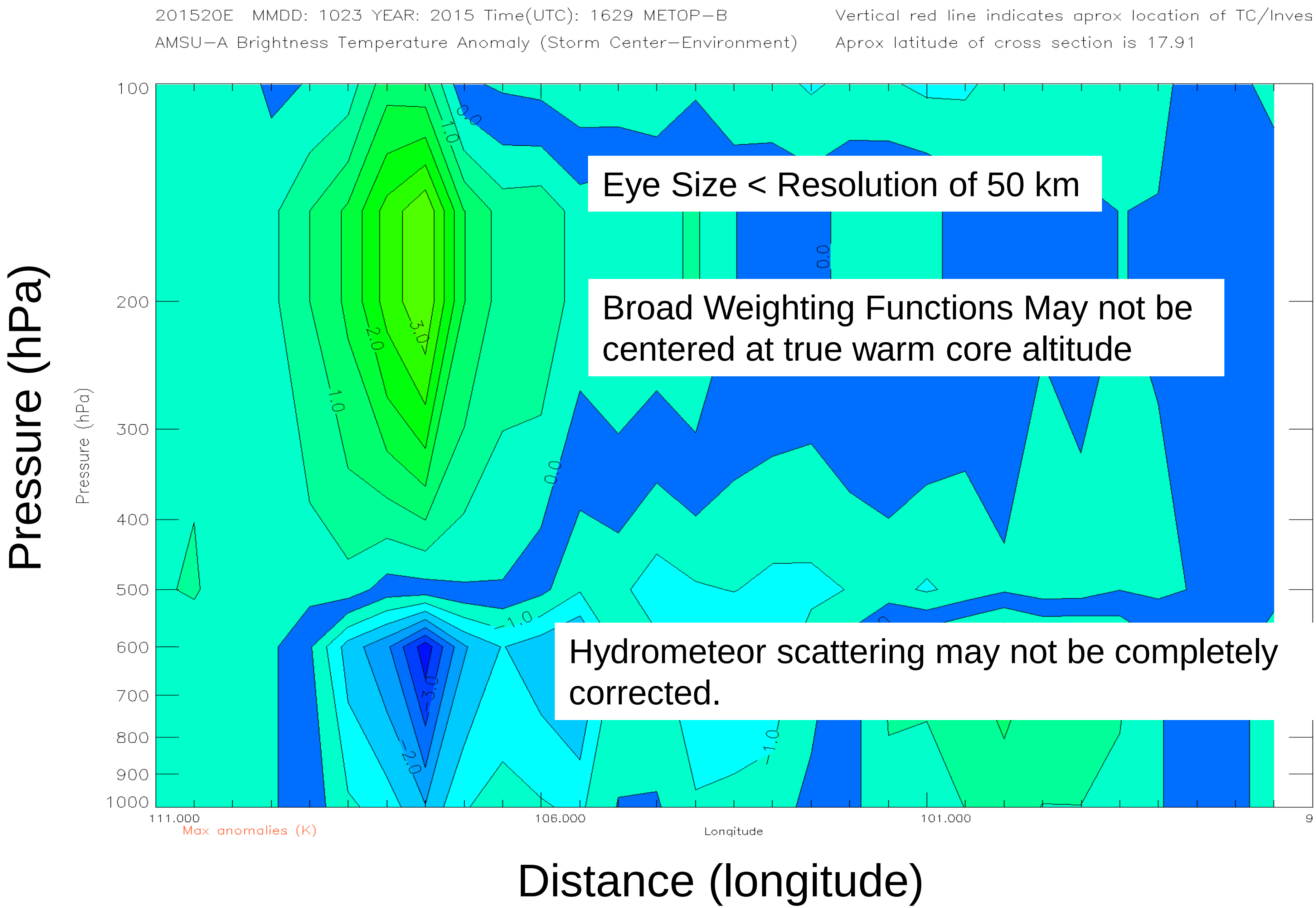
We can use this information to calibrate and correct for the inherent limitations in the satellite signal to provide more realistic depictions of the warm core structures and ultimately intensity estimation.

Extra Slides

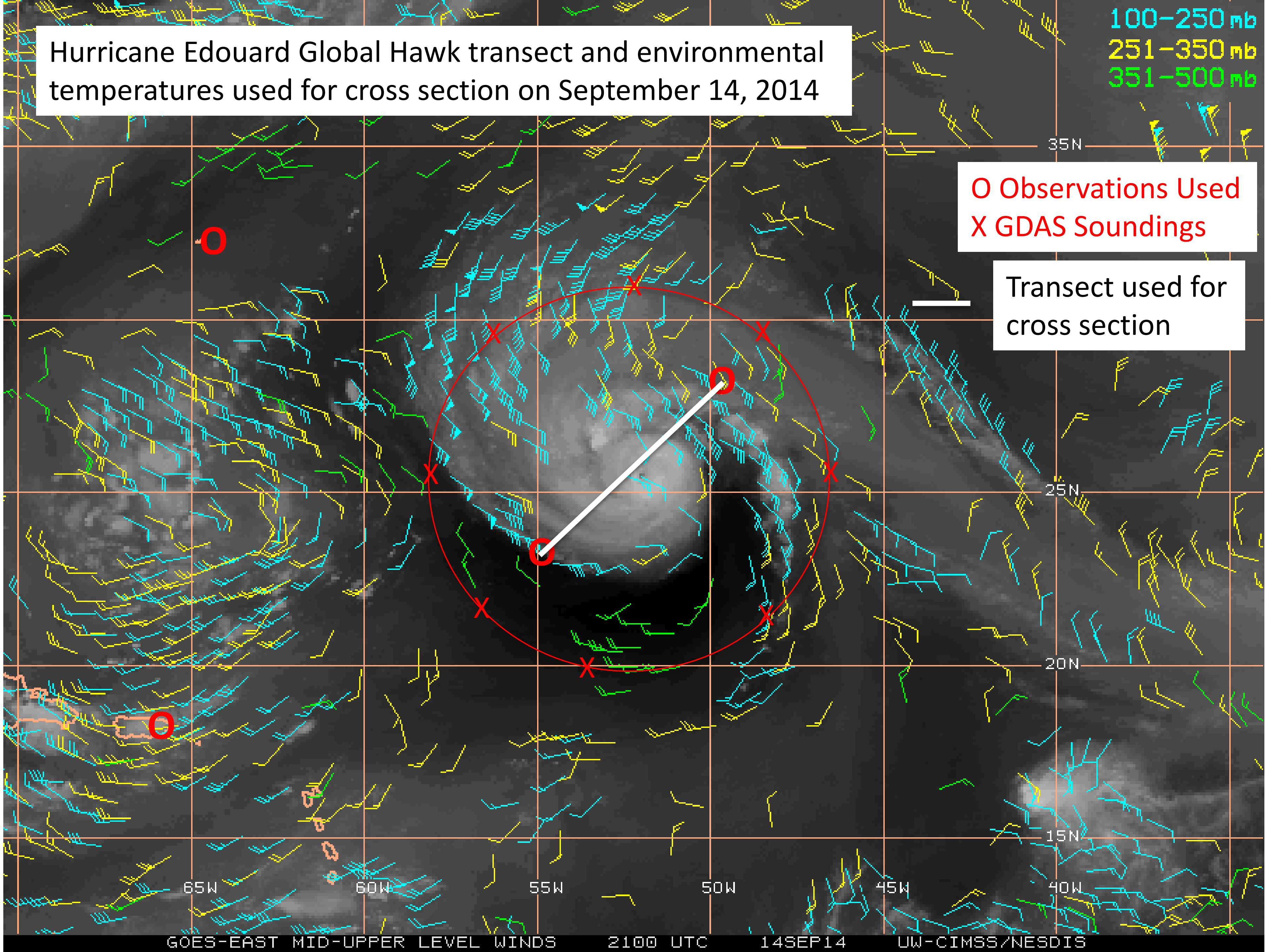
Sounding Comparison for Hurricane Patricia October 23, 2015
Eye Sounding (6FCE) with several environment soundings



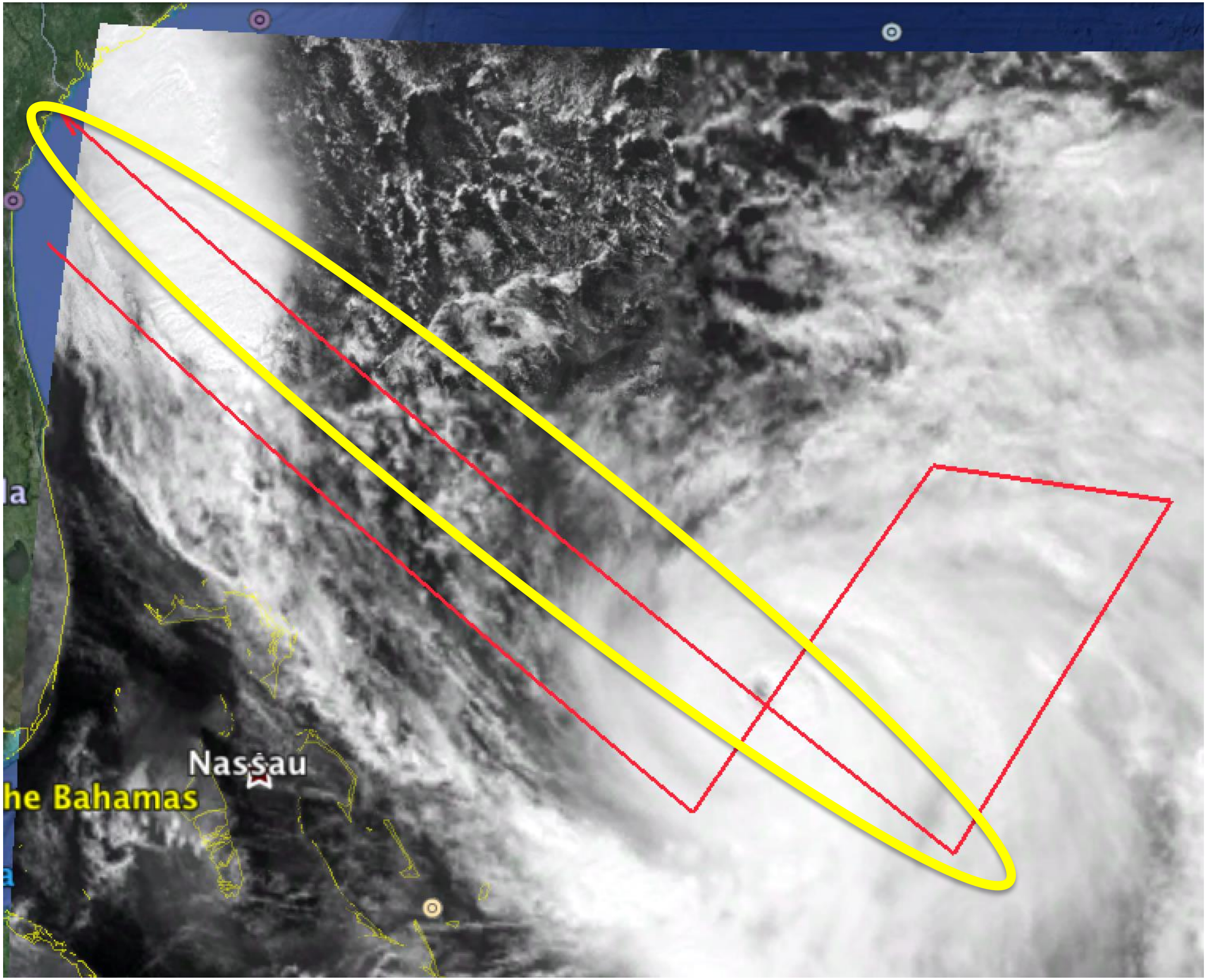
Error Sources for Microwave Sounders



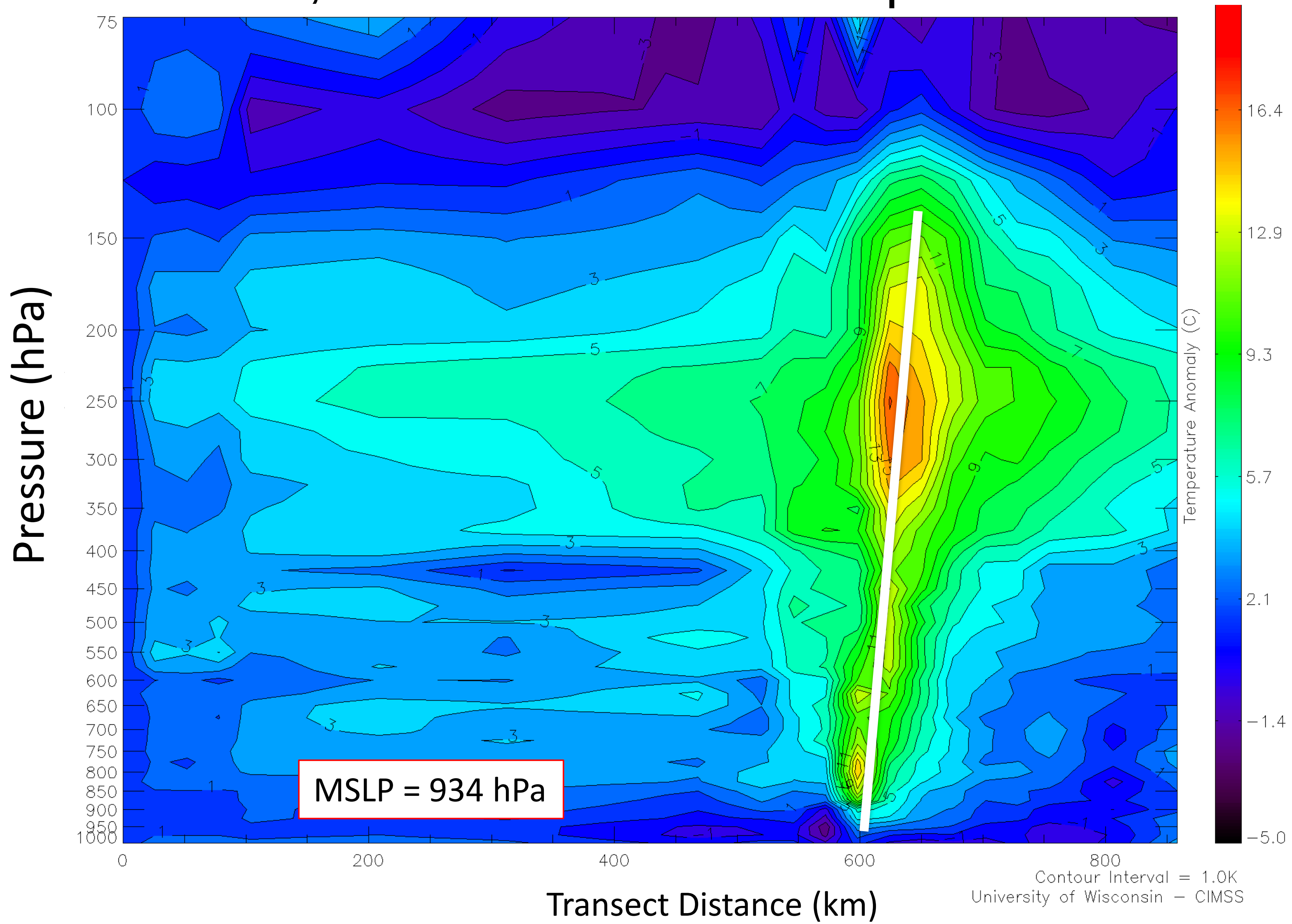
Hurricane Edouard Global Hawk transect and environmental temperatures used for cross section on September 14, 2014



Hurricane Joaquin WB-57 track on October 3, 2015

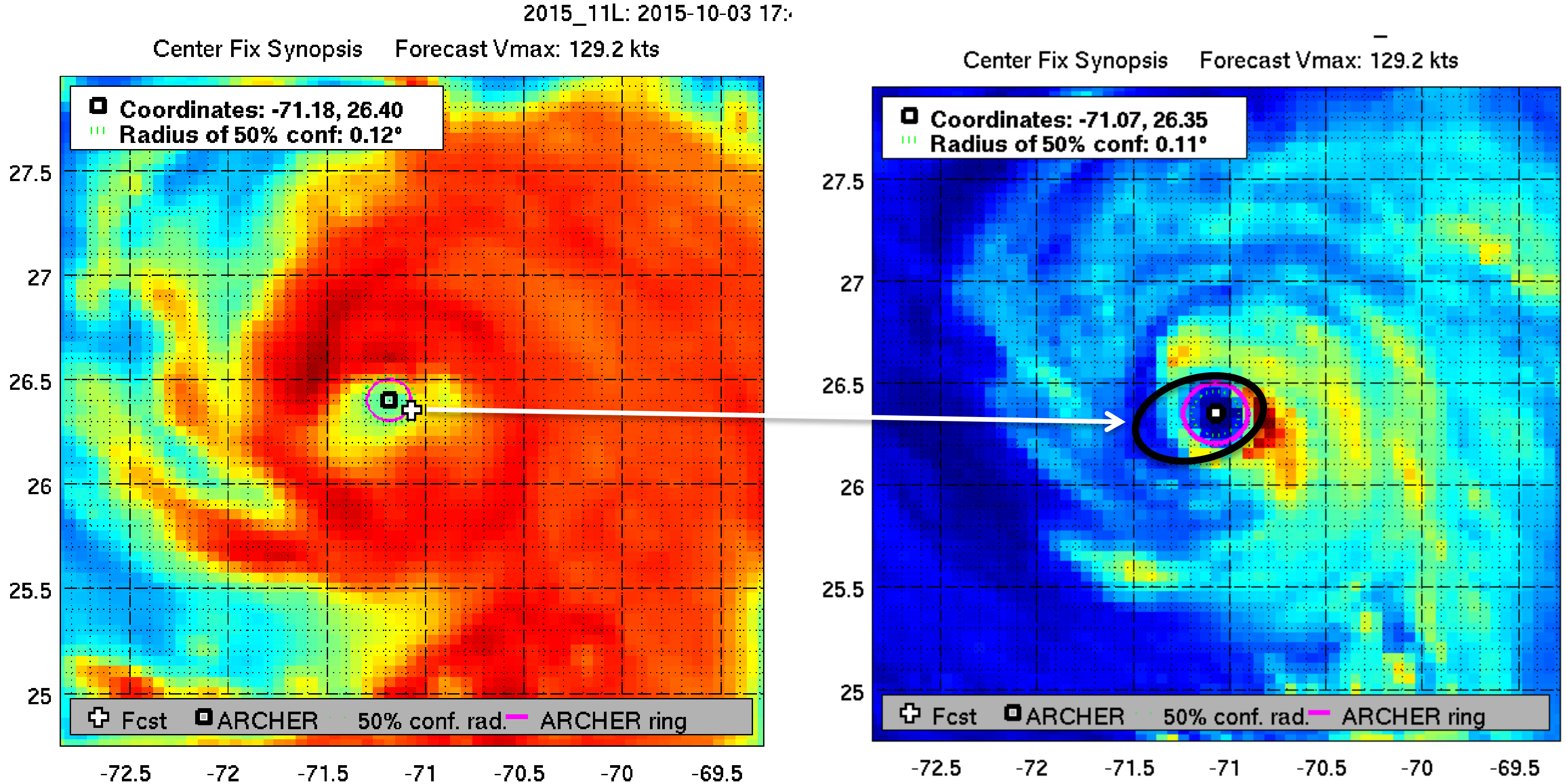


Hurricane Joaquin Temperature Anomaly October 3, 2015 from WB-57 Dropsondes ~17UTC



Hurricane Joaquin October 3, 2015

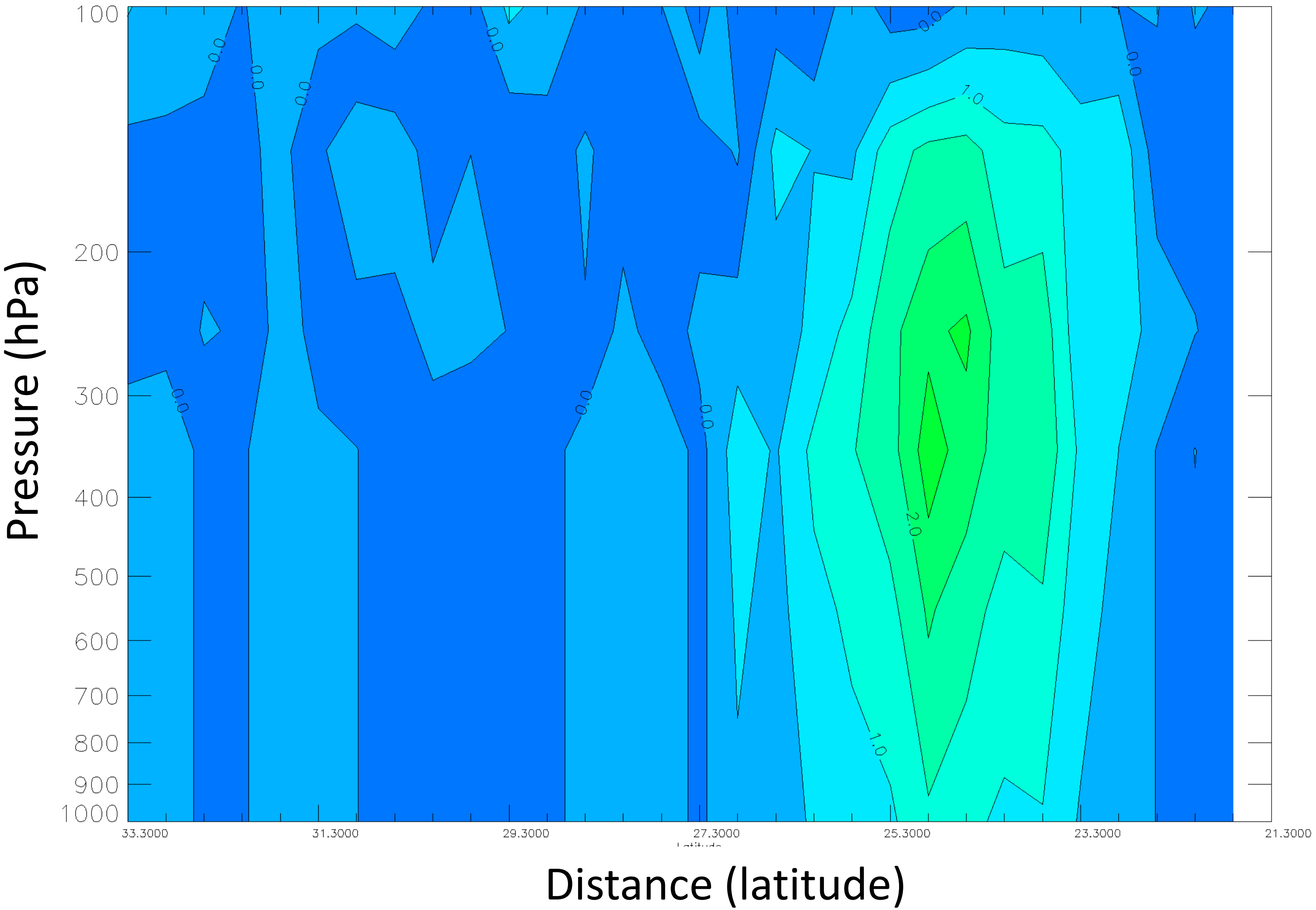
Elongation of Joaquin's low level center and vortex:
A result of warm core tilt?



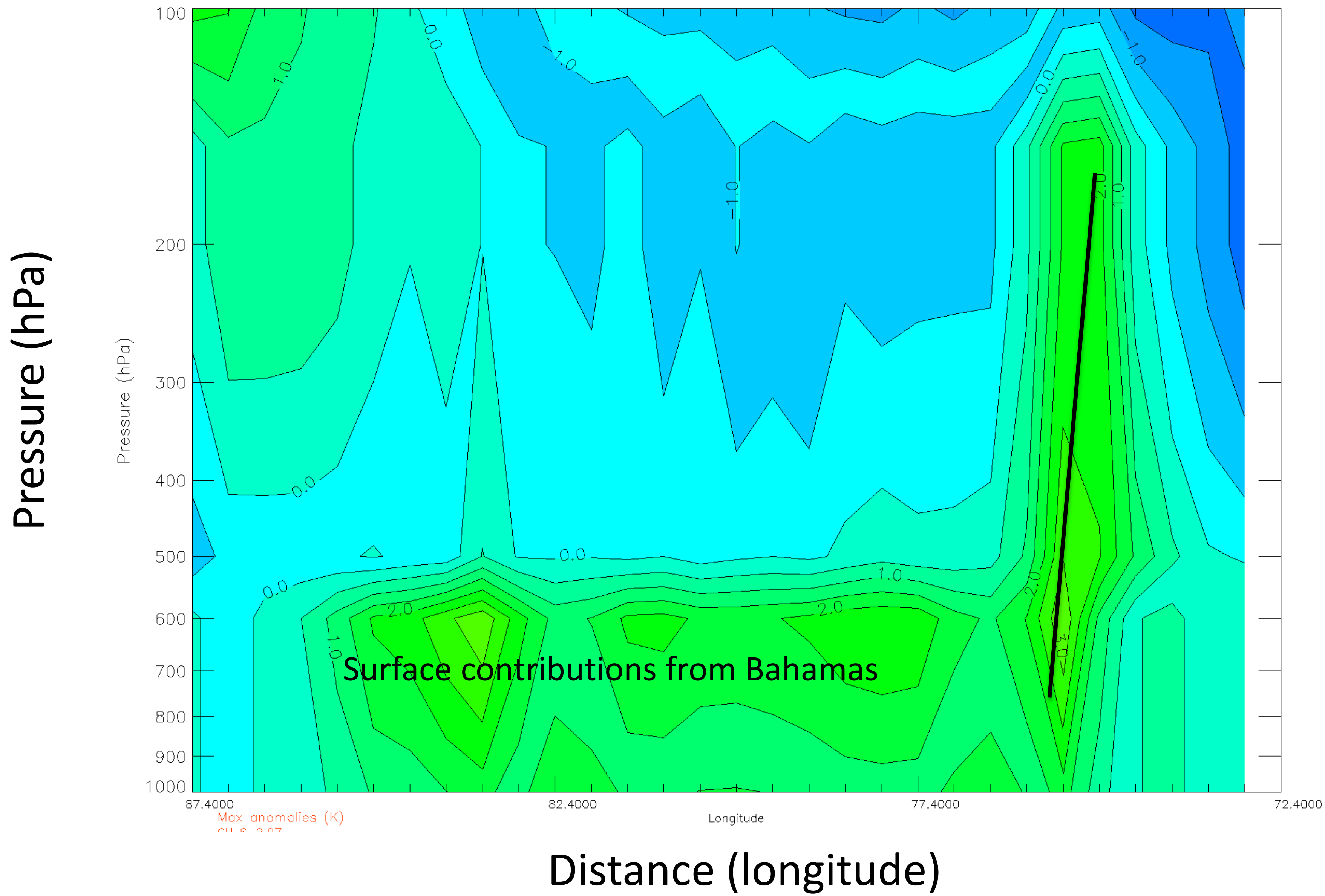
CIMSS ARCHER 37 GHz
AMSR2 image from 1731Z

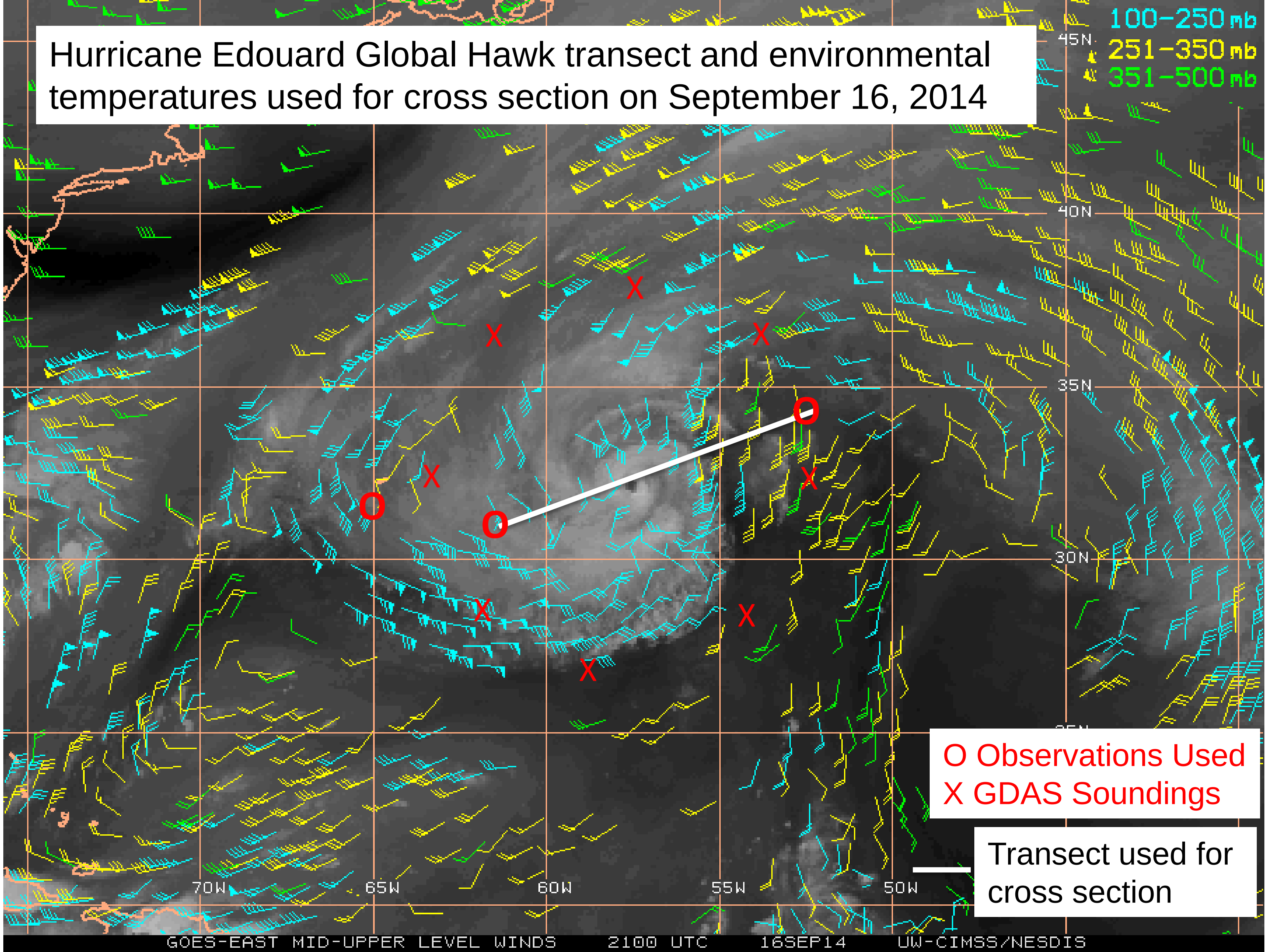
CIMSS ARCHER 89 GHz
AMSR2 image from 1731Z

Hurricane Joaquin October 3, 2015
1832Z ATMS Temperature Sounder Cross Section

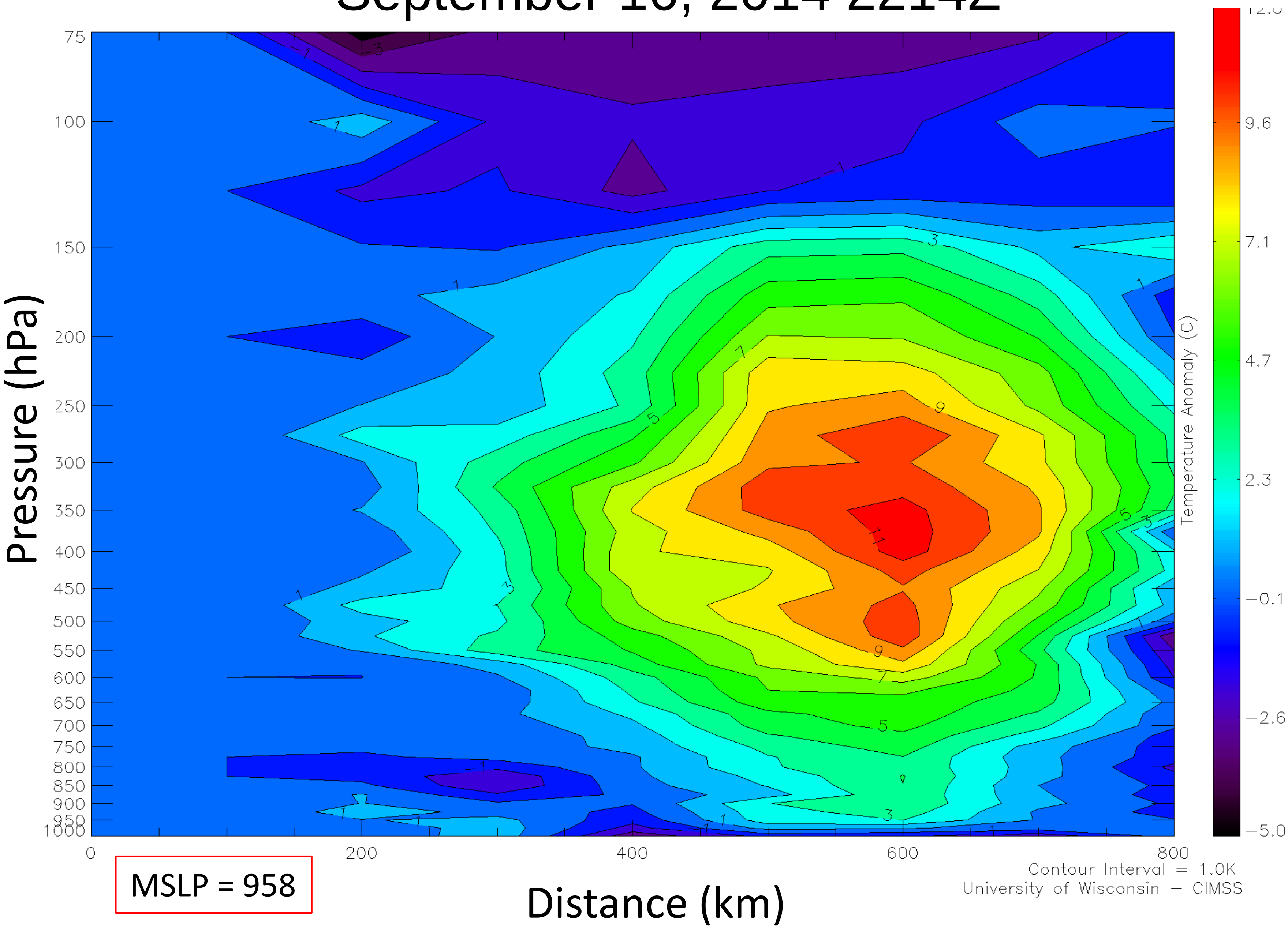


Hurricane Joaquin October 3, 2015 1459Z METOP-B Temperature Sounder Cross Section




Hurricane Edouard Global Hawk transect and environmental temperatures used for cross section on September 16, 2014
100-250 mb
251-350 mb
351-500 mb
45N
40N
35N
30N
70W
65W
60W
55W
50W
O Observations Used
X GDAS Soundings
Transect used for cross section
GOES-EAST MID-UPPER LEVEL WINDS 2100 UTC 16SEP14 UW-CIMSS/NESDIS

Hurricane Edouard Temperature Anomaly
September 16, 2014 2214Z



Hurricane Edouard Temperature Anomaly September 16, 2014 2025Z from AMSU