

# Status of MTP Data Analysis for TCSP

MJ Mahoney

JPL/Caltech

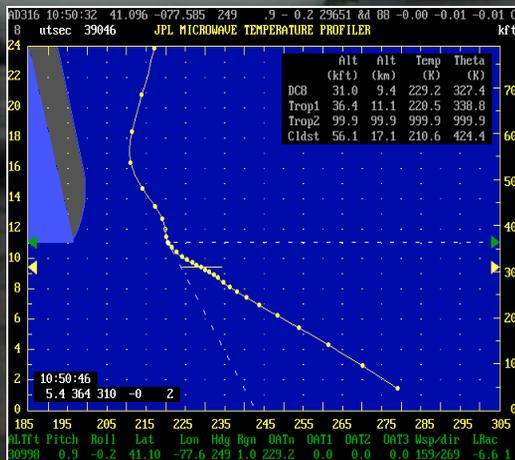
TCSP Science Team Workshop

Huntsville, AL

April 4-5, 2006

# The Microwave Temperature Profiler (MTP)

Captain, I see an MTP on that little spy plane!



MTP Flight History:  
 Field Campaigns: 46  
 Flights: 739  
 Flight Hours: 4176

## Outline

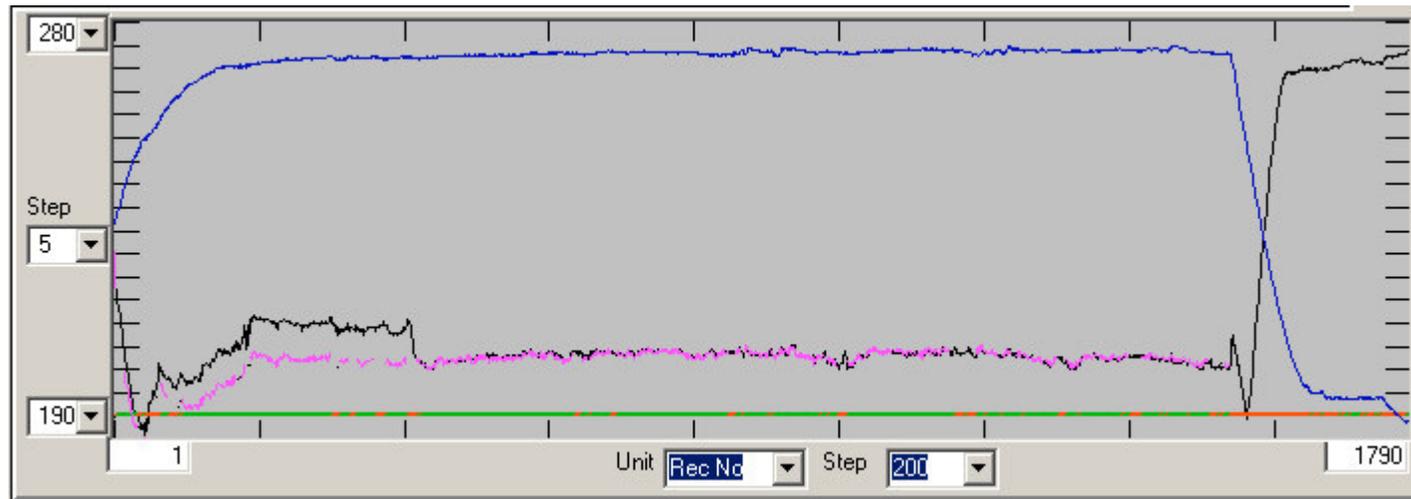
- **MTP temperature calibration and data analysis**
- Background for interpreting MTP data
- Large amplitude temperature structure
- Gravity waves (GWs) in MTP data
- Subsidence over hurricanes

# MTP Temperature Calibration for TCSP

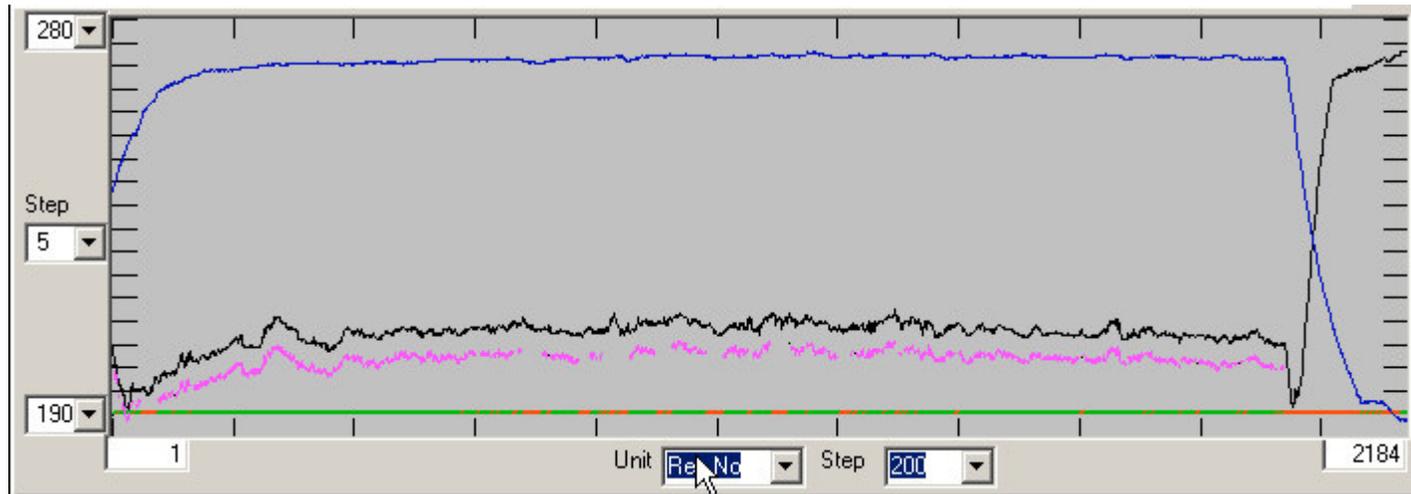
- The MTP temperature is calibrated to agree with radiosondes near the ER-2 flight track.
- When the ER-2 navigation data recorder (NDR) outside air temperature ( $T_{nav}$ ) is compared to radiosondes ( $T_{raob}$ ) near the ER-2 flight track, we find:  $T_{nav} - T_{raob} = -1.00 \pm 0.36 \text{ K}$  ( $N=25$ ) That is, the NDR temperature is 1 K too cold. The result is statistically significant and very robust.
- Two flights have much larger errors of opposite bias:
  - On 2005.07.20,  $T_{nav}$  is  $\sim 7 \text{ K}$  too warm during the early part of the flight.
  - On 2005.07.24,  $T_{nav}$  is  $\sim 6 \text{ K}$  too warm for the entire flight.

## The Two TCSP Flights Which Have 7 K Tnav Errors

2005.07.20

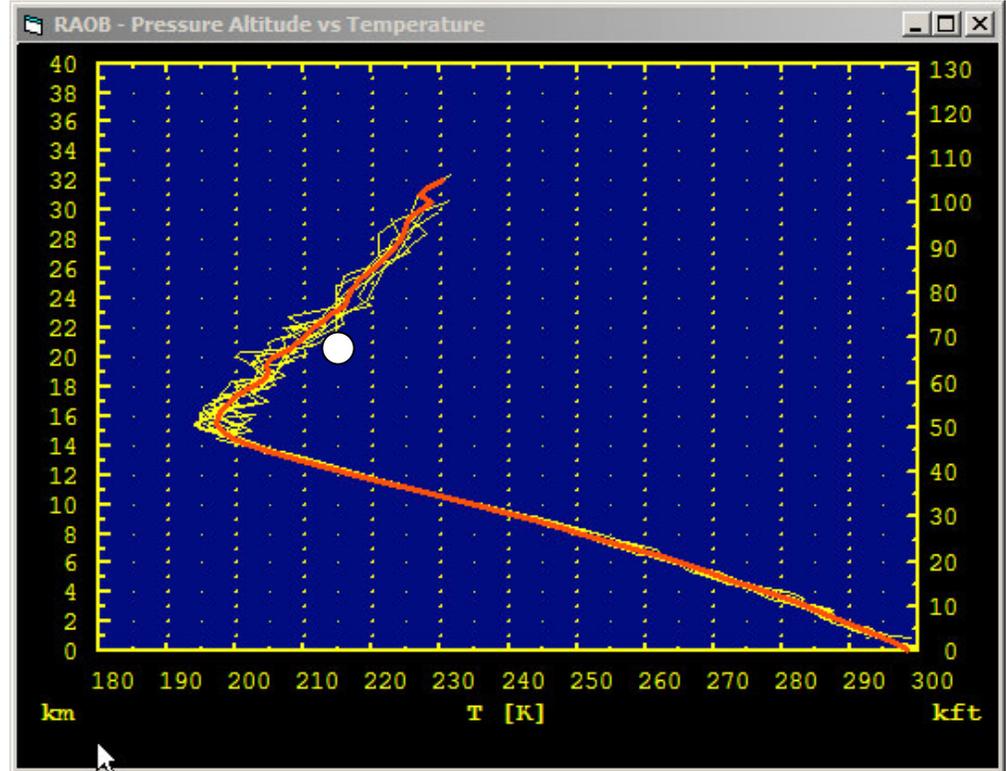
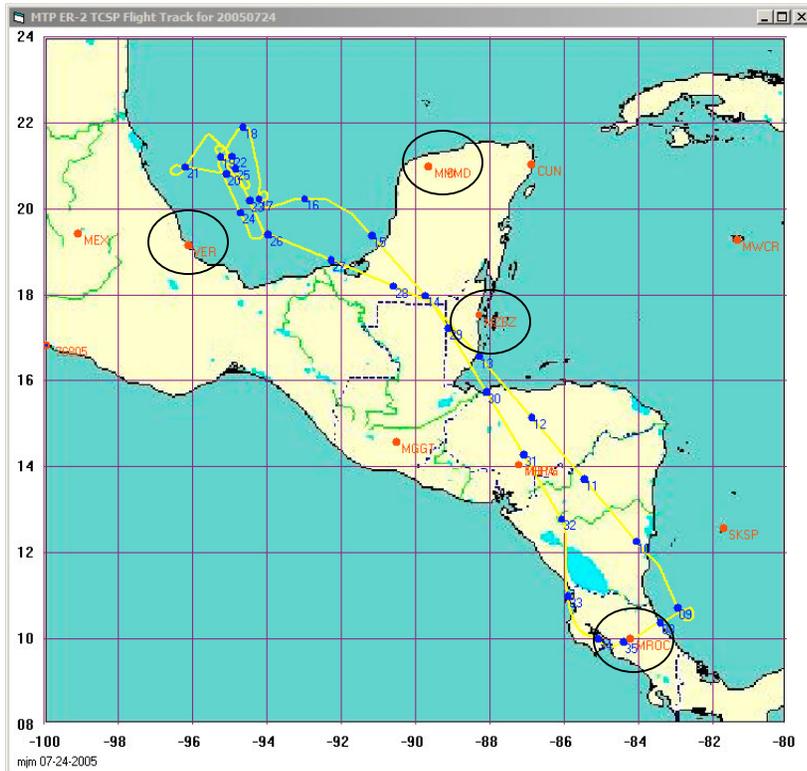


2005.07.24



Legend: Zp (blue), Tnav (black), Ttmp = Traob (pink)

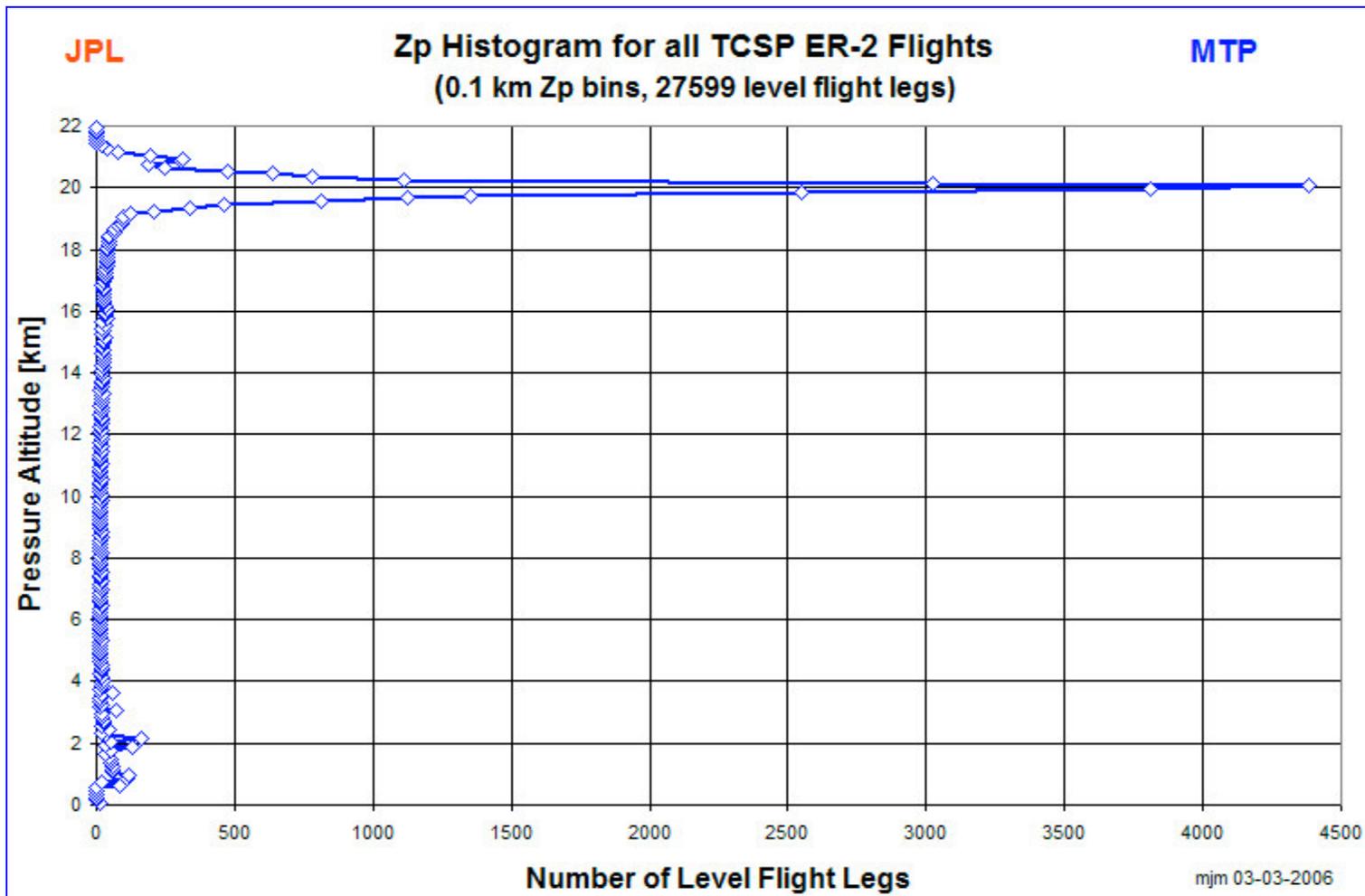
## Comparison of Tnav to RAOBs on 2005.07.24



ER-2 Flight Track on 2006.07.24  
Location of RAOB sites circled

Soundings from MROC, MZBZ, MMMD, and VER (yellow) over 24 hour period, and their average (red). Tnav temperatures at 20 km are represented by the white dot.

# MTP Data Analysis for TCSP

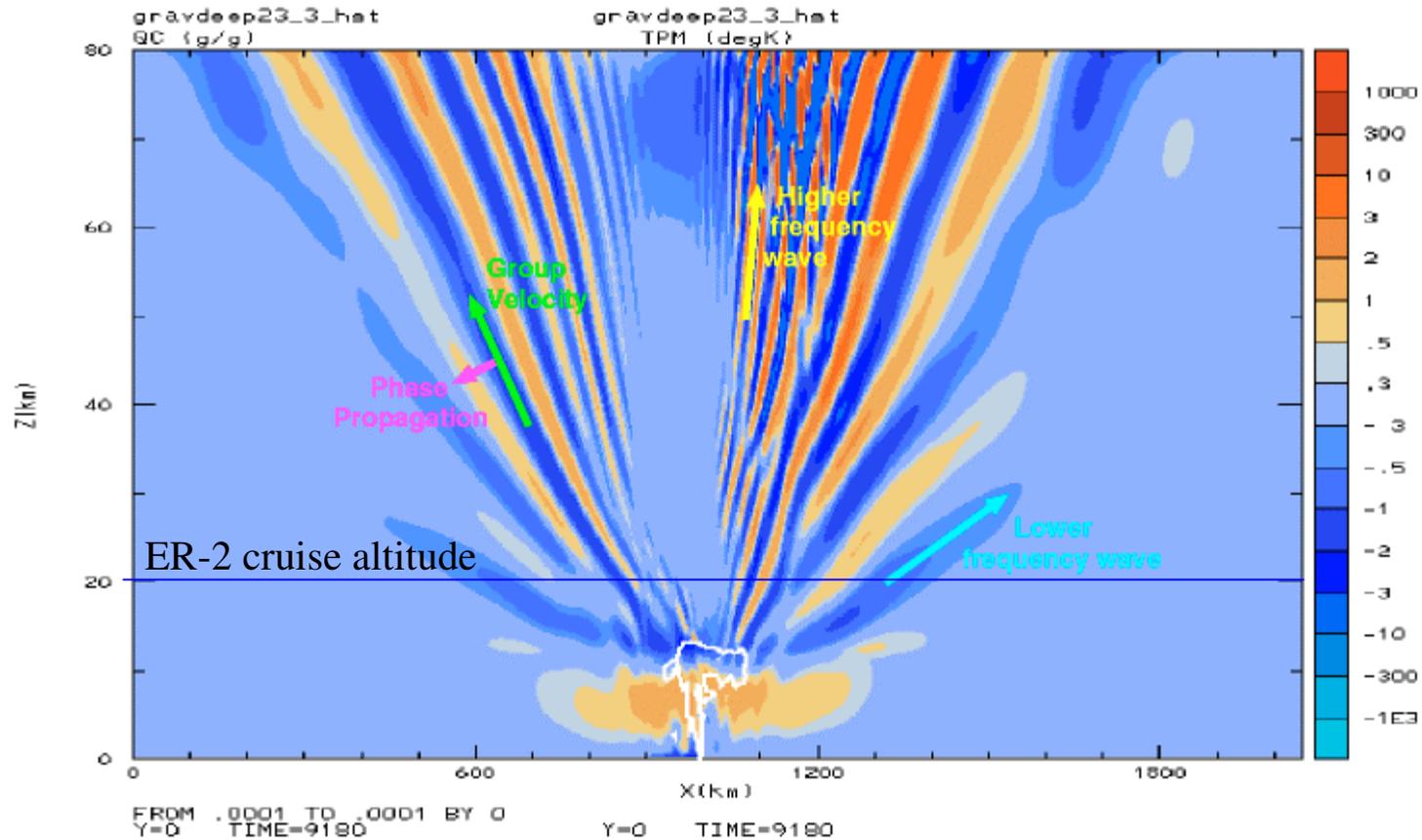


The limited number of flight levels allowed retrieval coefficients (RCs) to be calculated at more closely spaced levels. This minimizes RC interpolation errors. These are the best ER-2 retrievals ever. [Final data is on the NSSTC archive.](#)

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# Gravity Waves Associated with Convection

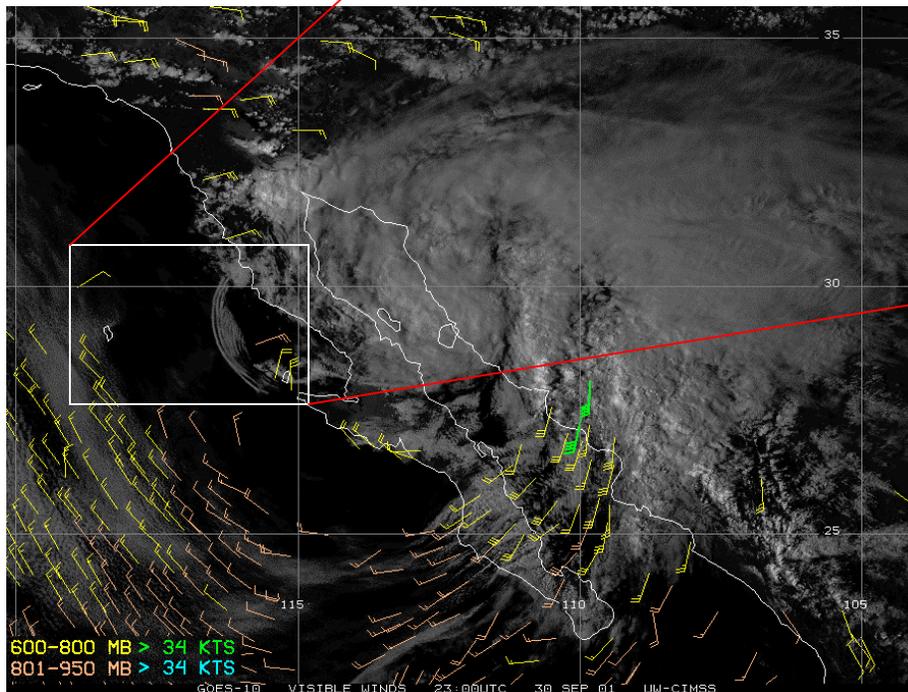
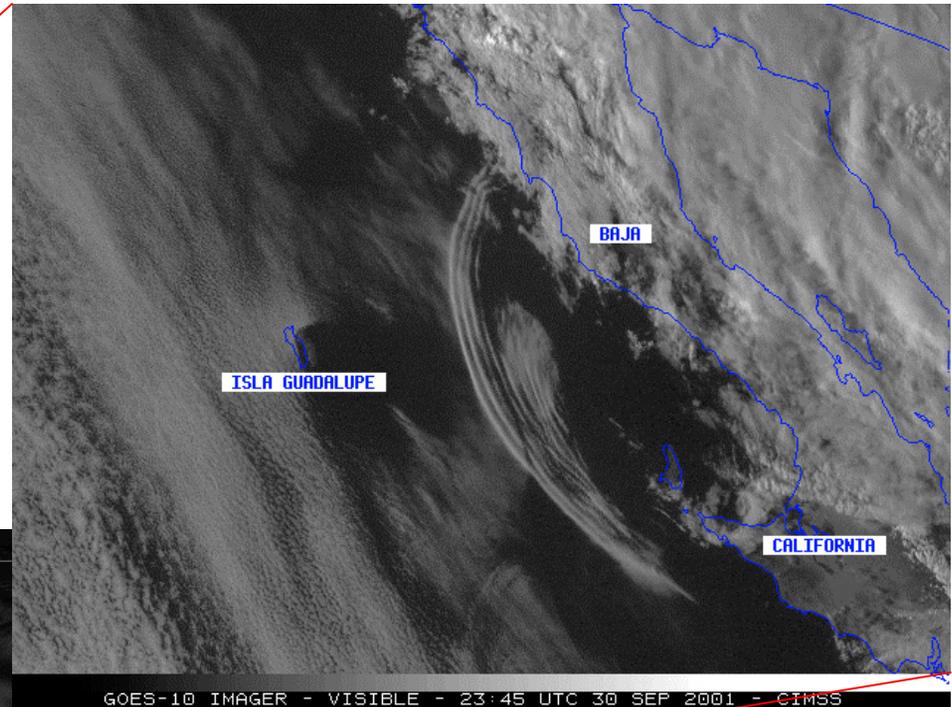


M. Joan Alexander - CEDAR Tutorial Lecture 06/21/02  
[See Holton and Alexander (1999) for model description.]

Models predict that GWs should be associated with strong convection. During CRYSTAL-FACE we found that >70% of GWs could be traced back to convection (Wang et al., 2006).

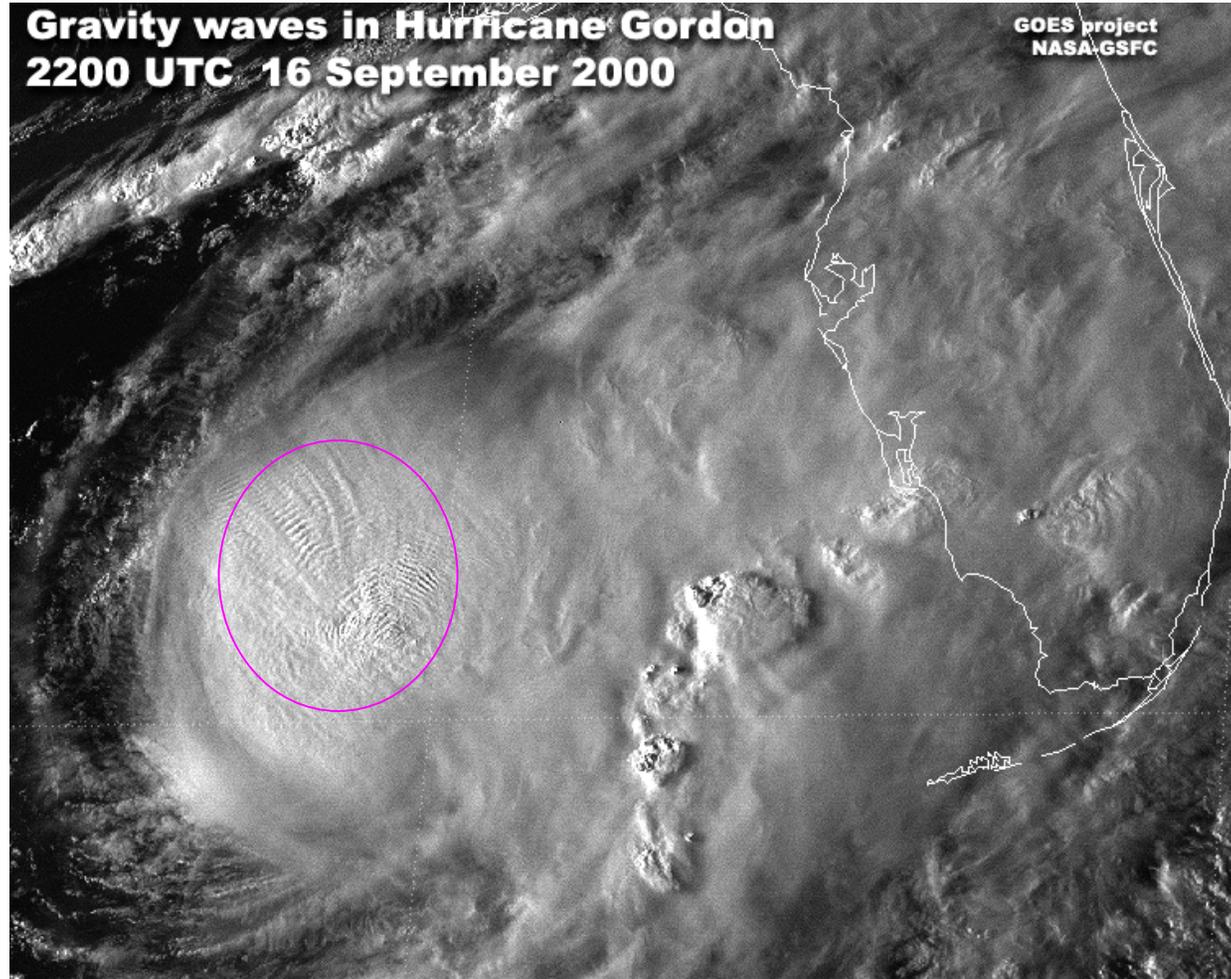
# Gravity Waves from Tropical Depressions

If GWs can radiate from strong convection, they should also be expected from TDs, TSs, and Hurricanes. Other wave mechanisms involved as well.



GOES-10 image of gravity waves radiating from a tropical depression off Baja California

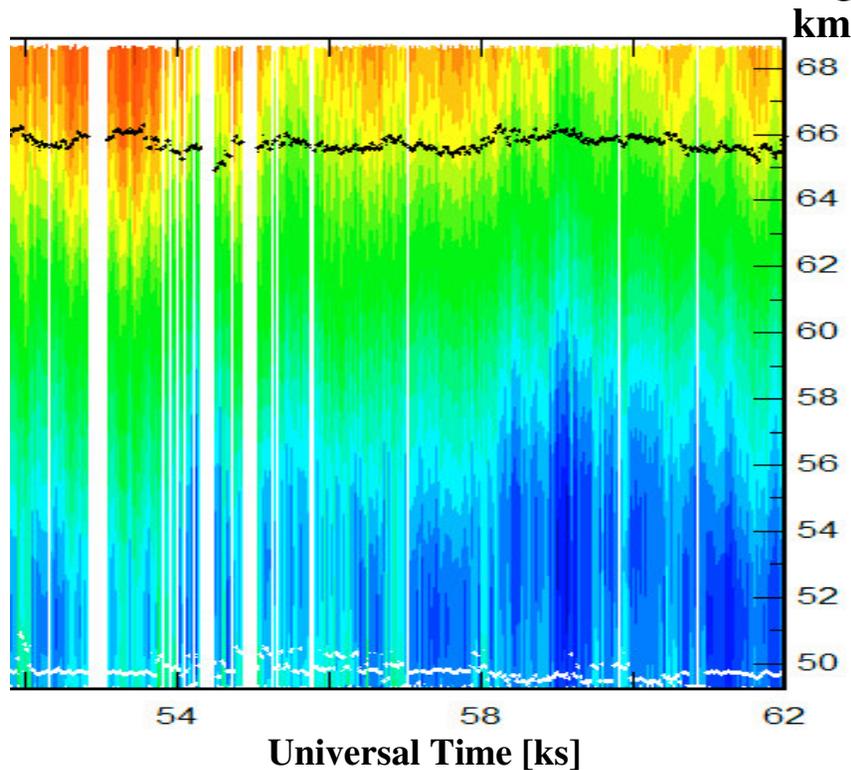
## GWs Associated with Hurricanes



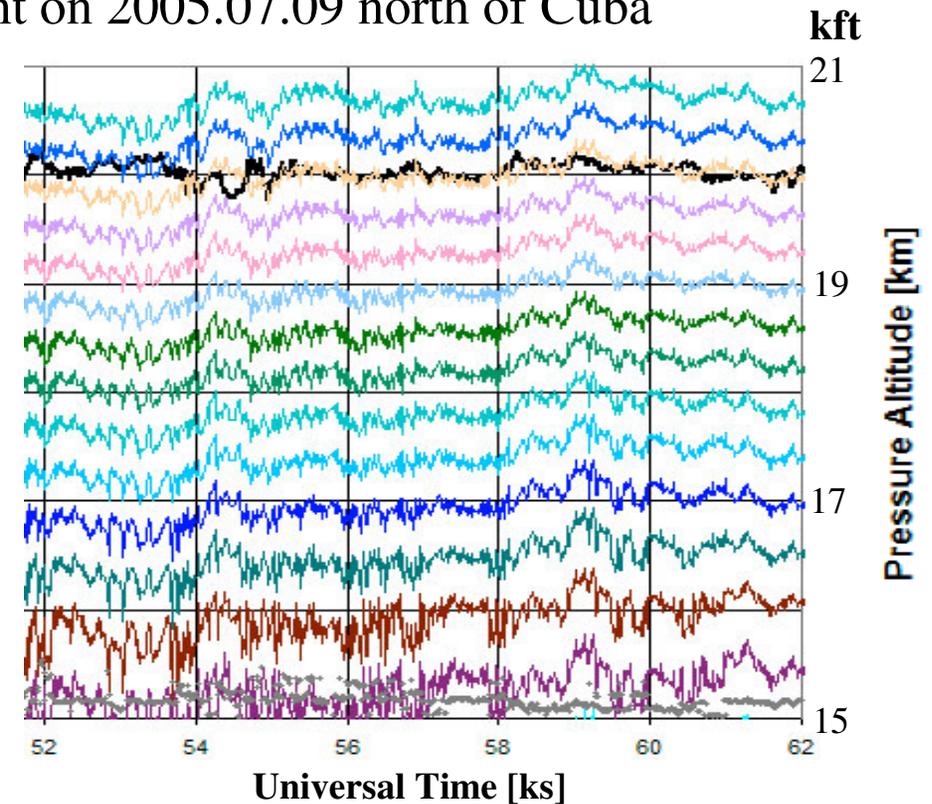
Pink circle (diameter  $\sim 160$  km) hi-lites gravity waves initiated by strong convection several hours earlier in Hurricane Gordon. Their wavelength is  $\sim 7$  km.

## To “See” GWs MTP Data Are Converted to Isentropic Surfaces

Last half of Hurricane Dennis flight on 2005.07.09 north of Cuba



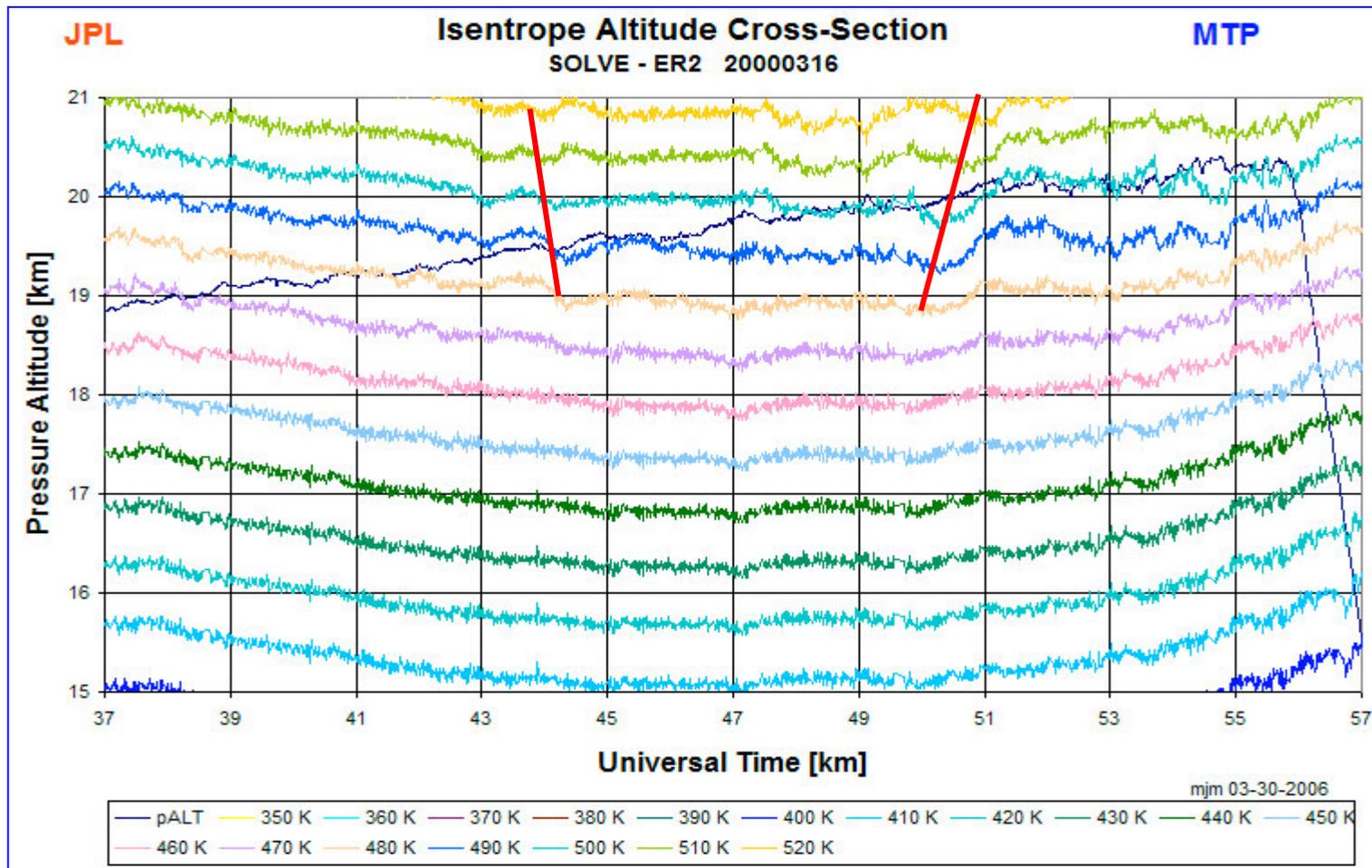
Color-coded Temperature Curtain (CTC)



Isentropes Altitude Cross-section (IAC)

While CTCs (left panel) are useful for identifying many atmospheric phenomena, they are poor at identifying atmospheric waves. By converting temperature profiles to potential temperature (or theta) profiles, the altitude of a fixed theta can be identified as a function of time. A cross-section of these theta surfaces, or isentropes, we call an IAC (right panel). Air parcels move along isentropes, or constant theta surfaces.

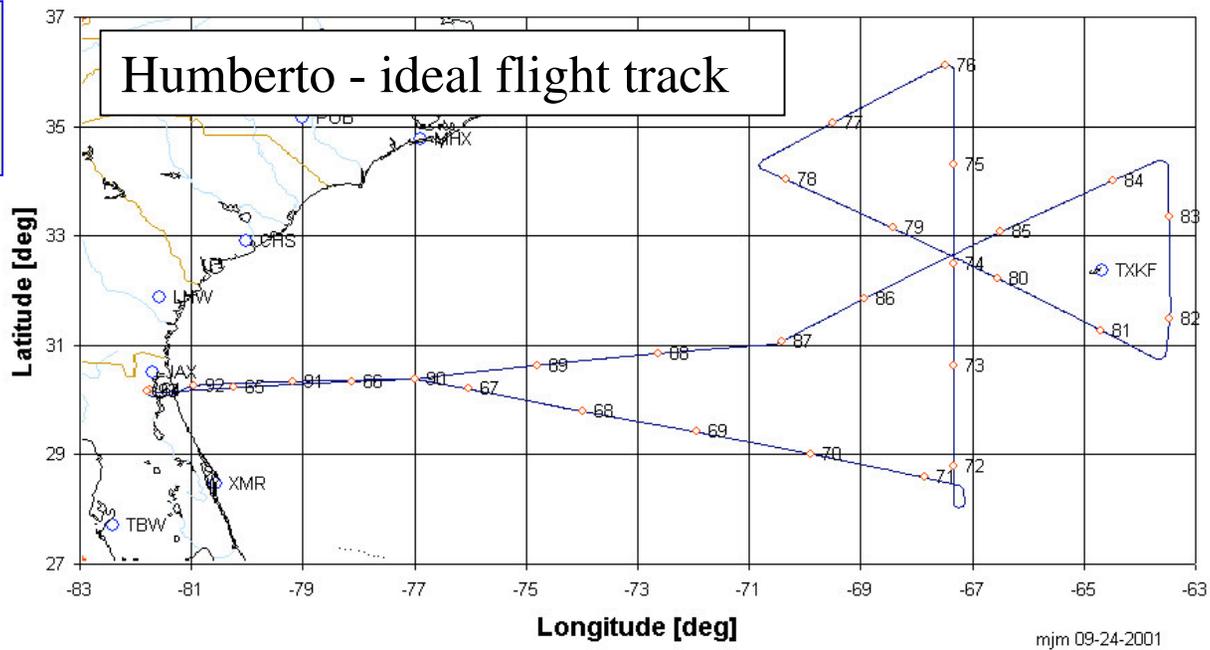
## An Example of ER-2 MTP Data “Almost Without” GWs



This IAC is a portion of a SOLVE transit flight from Kiruna, Sweden, to Westover AFB, MA, between Iceland and Westover AFB. The red lines show phase fronts of GWs SE of Greenland and north of Nova Scotia. Otherwise, the isentropes are free of GWs. They show more “fuzz” than TCSP isentropes due to hardware improvements in the past six years.

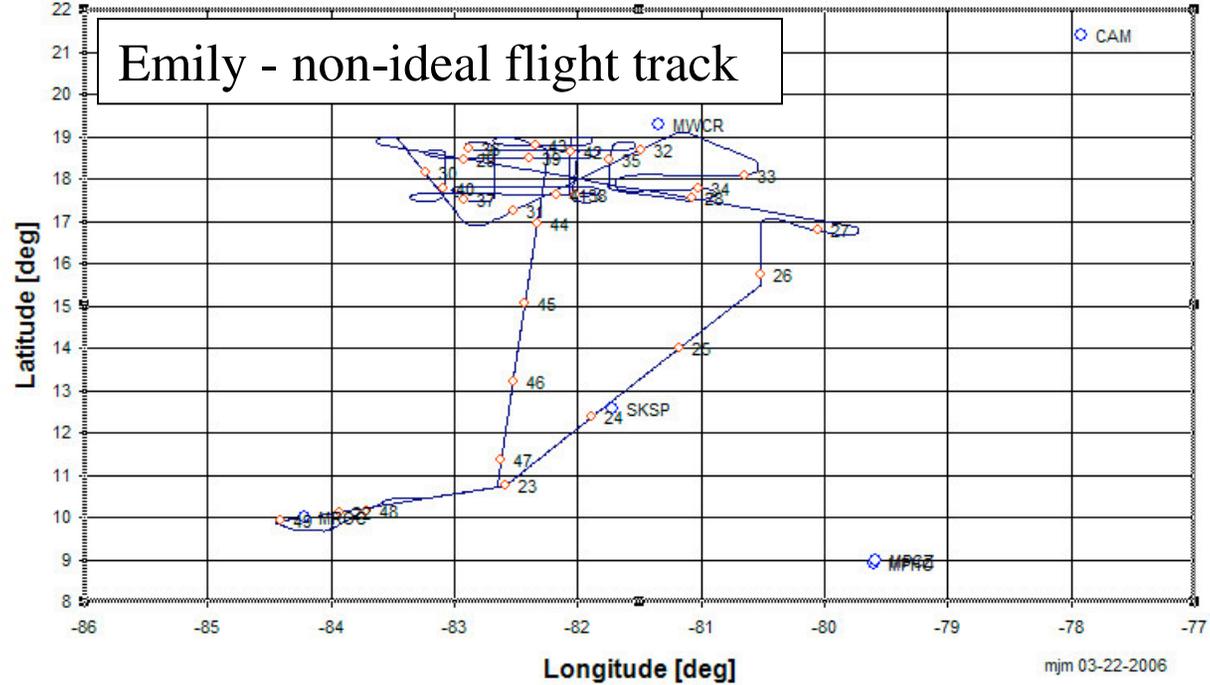
**Optimum Strategy for MTP to Observe GWs**

CAMEX4 - ER2 20010923



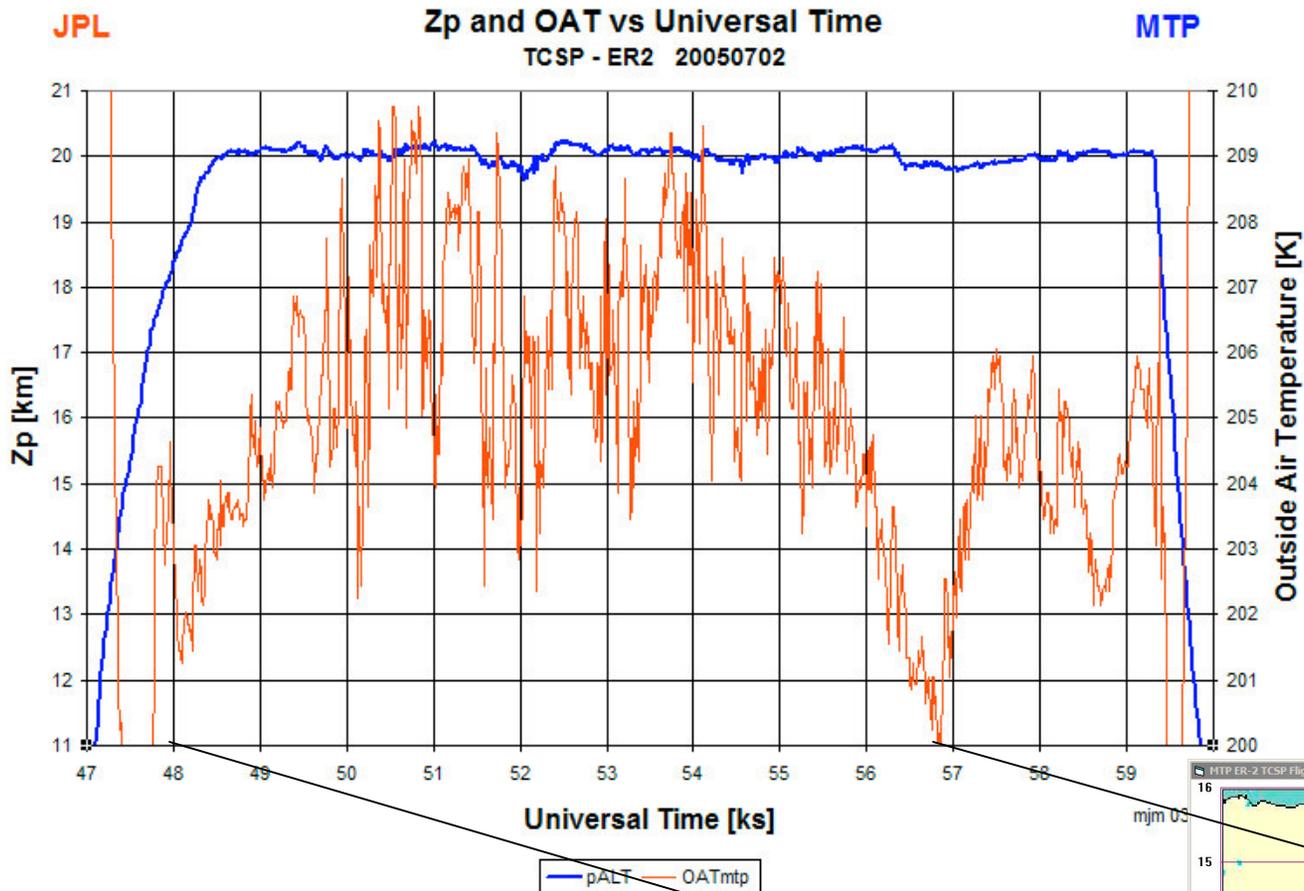
CAMEX-4 flight tracks were more suitable for studying gravity waves because of longer flight legs, which make the GW data easier to interpret.

TCSP - ER2 20050717



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- **Large amplitude temperature structure**
- Gravity waves (GWs) in MTP data
- Subsidence over hurricanes

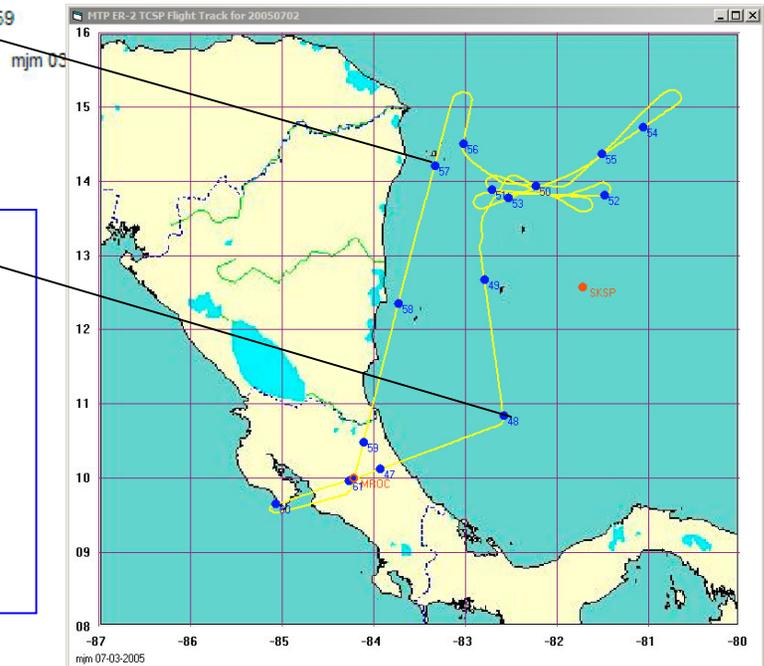


Large Mesoscale  
 Temperature  
 Variability  
 Over  
 Convection:  
 GW?

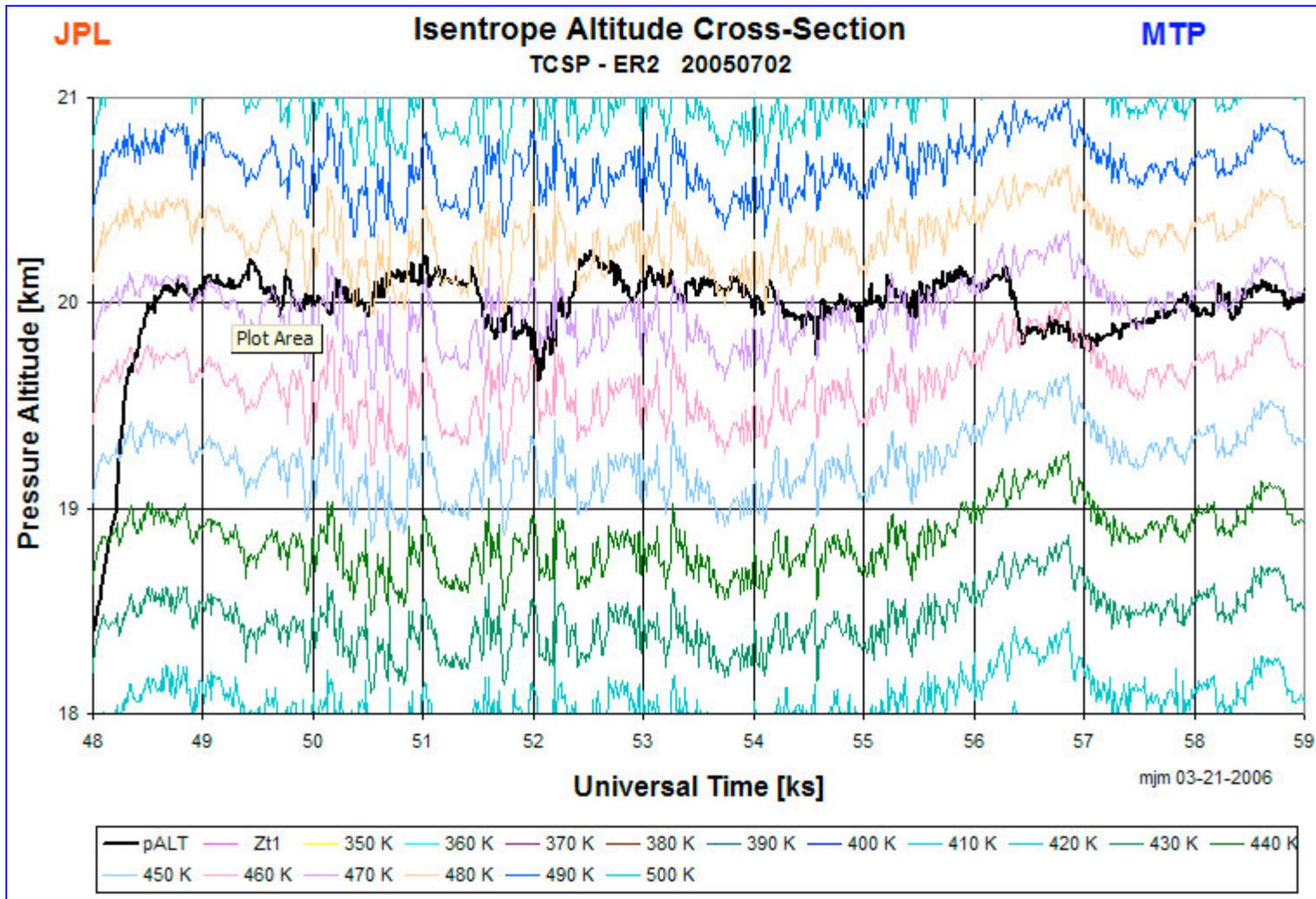
Rapid drop in T on edge of convection

Peak-to-peak T variability of ~8 K at 20 km more than 4 km above the tropopause!

These might be GWs, but the restricted orientation of flight lwga does not allow firm conclusions.

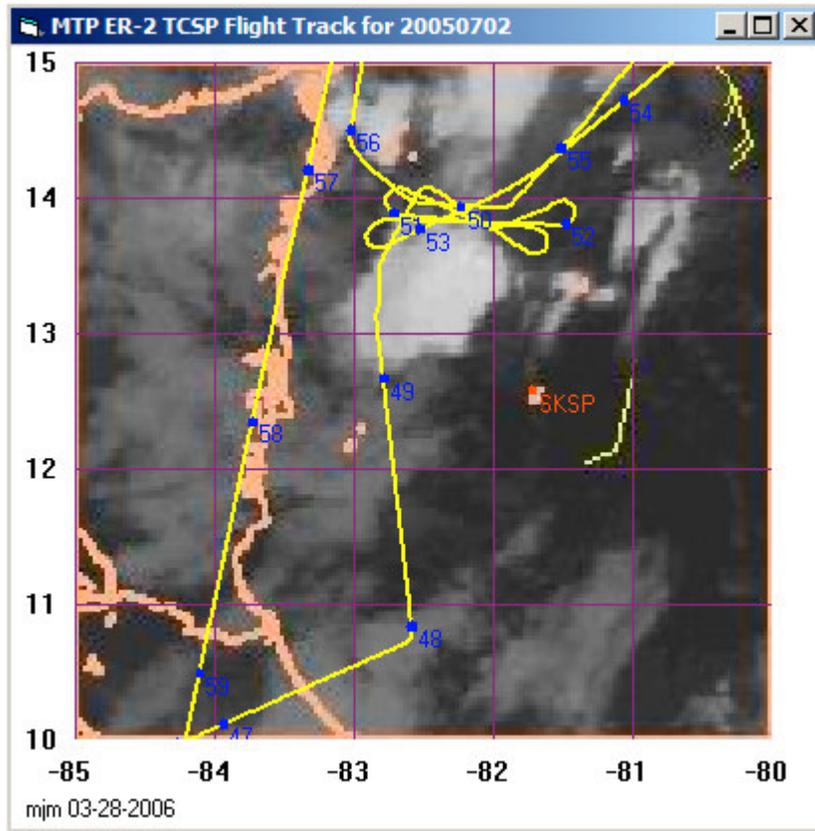


## 2005.07.02 Convection Flight (continued)



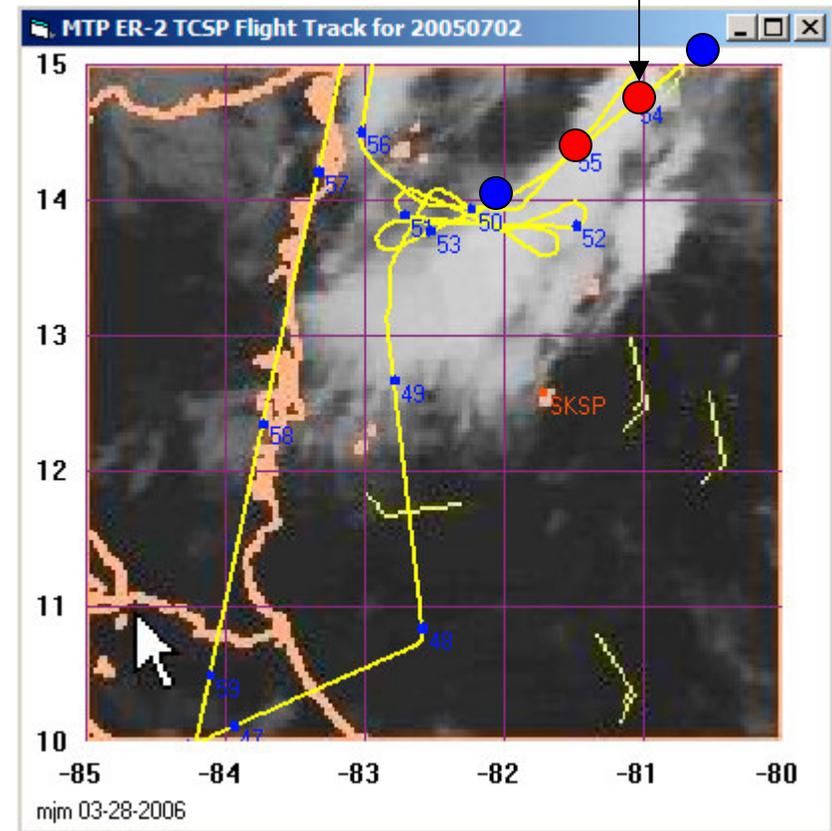
Are there GWs? There appears to be wave activity from 50-54 ks, but flight legs are too short to be certain.

## 2005.07.02 Convection Flight (continued)



GOES-10 at 12UT (43.2ks)

Large change in convection over 3 hrs



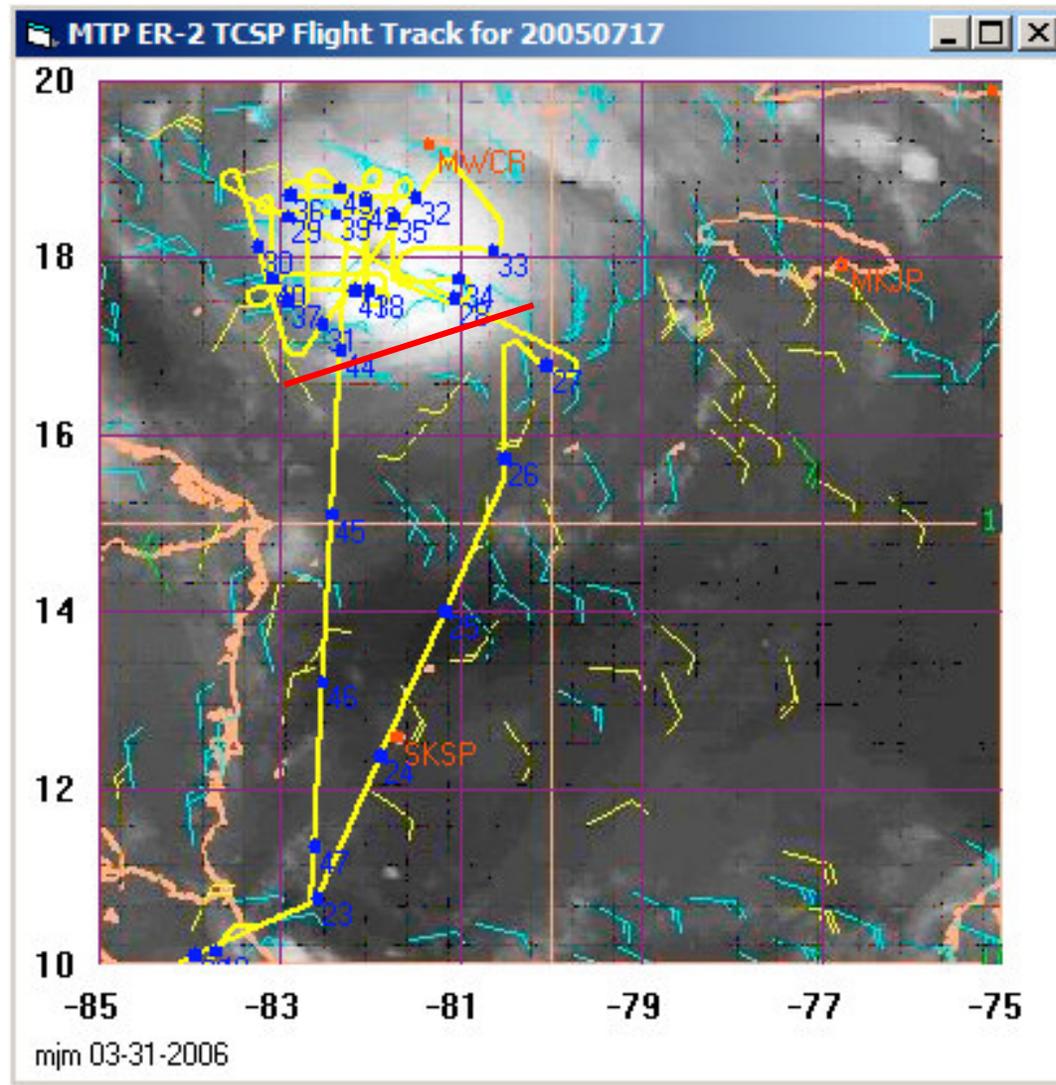
GOES-10 at 15UT (54.0ks)

Red dots ~4.5 K warmer than Blue dots

## Outline

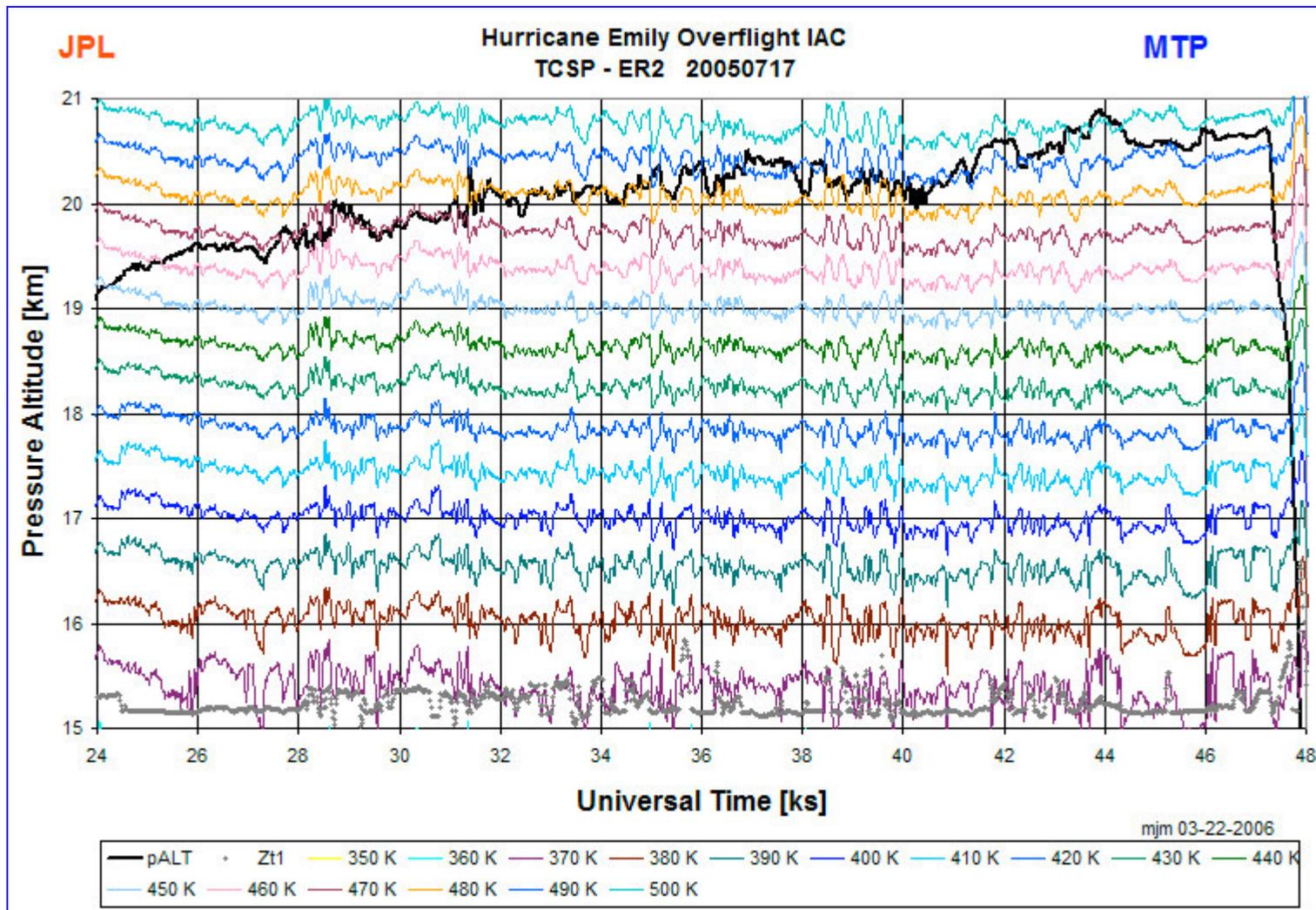
- MTP temperature calibration and data analysis
- Background for interpreting MTP data
- Large amplitude temperature structure
- **Gravity waves (GWs) in MTP data** - Low amplitude gravity waves appear on nearly all TCSP and CAMEX-4 hurricane flights
- Subsidence over hurricanes

## GWs Seen During Hurricane Emily Overflight



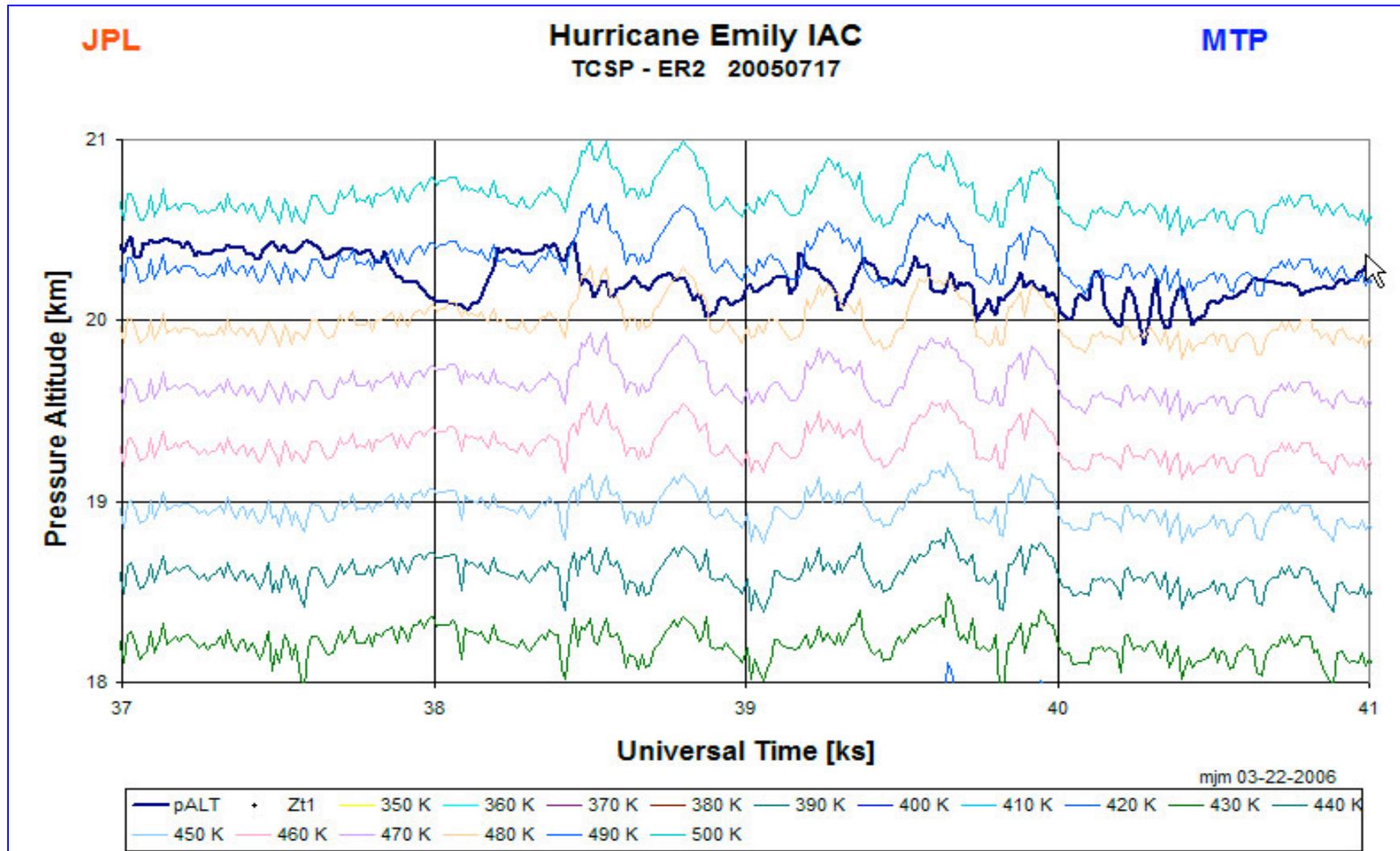
GWs are seen by MTP north of the red line in this GOES-10 image

# GWs Seen During Hurricane Emily Overflight



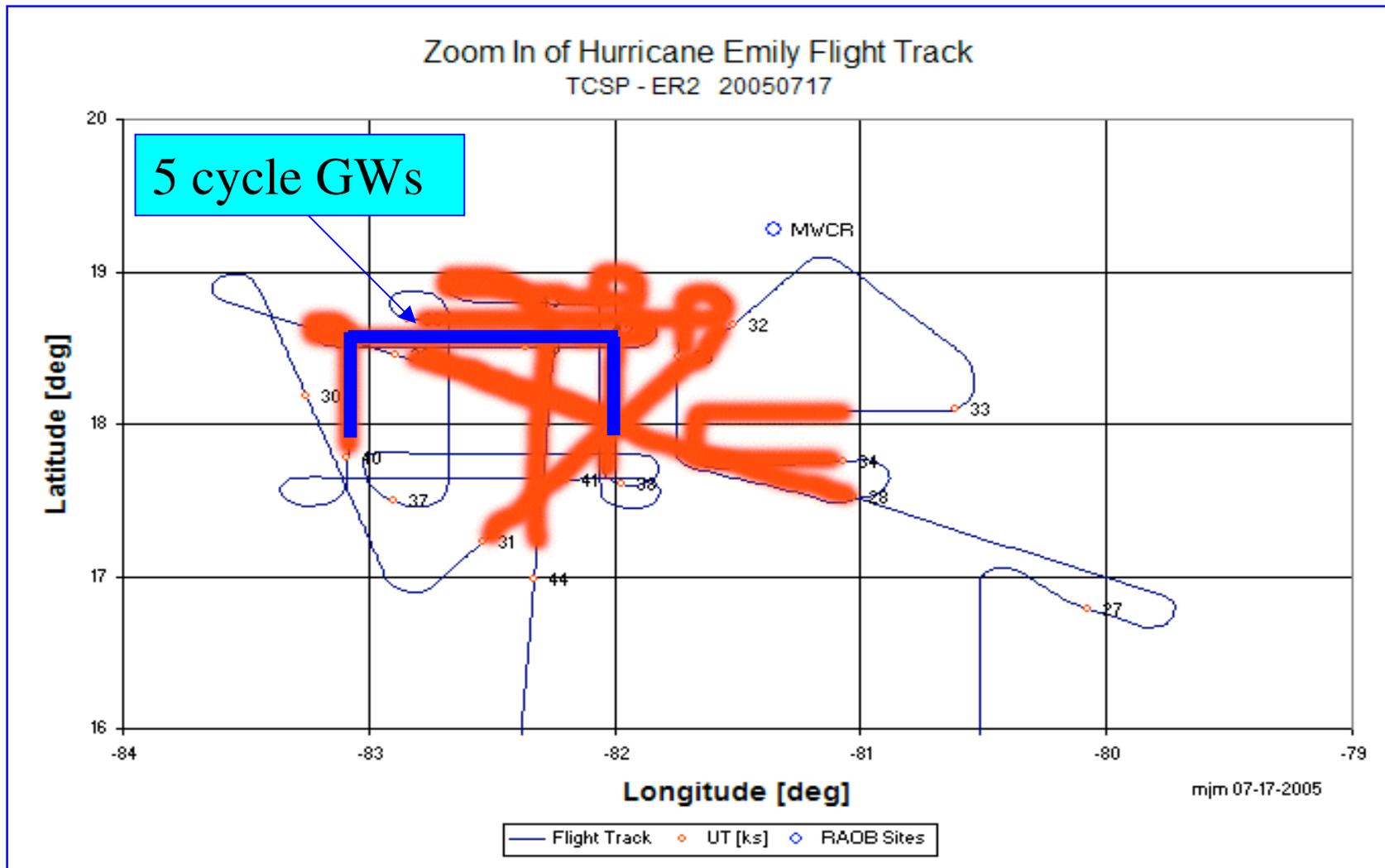
Note smooth isentropes until 27 ks and after 44 ks, and the ER-2 altitude excursions. The next slide focuses on the GWs between 38-40 ks.

## GWs Seen During Hurricane Emily Overflight (cont.)



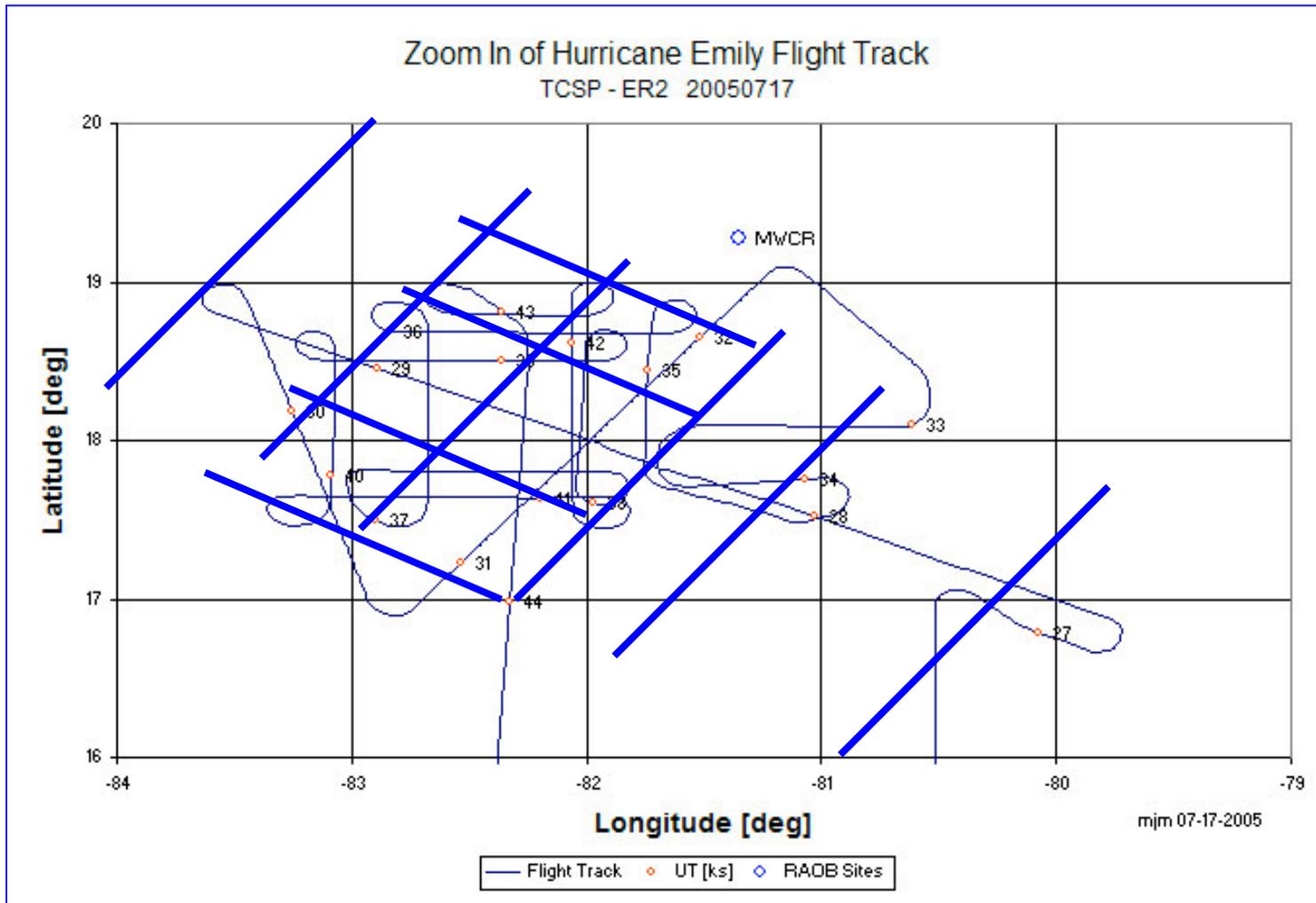
Five cycles with wavelength of  $\sim 75$  km and amplitude  $\sim 300$  m

## GWs Seen During Hurricane Emily Overflight (cont.)



Red and blue traces are when wave activity was seen during flight; mostly in NW quadrant like Hurricane Gordon.

## GWs Seen During Hurricane Emily Overflight (cont.)



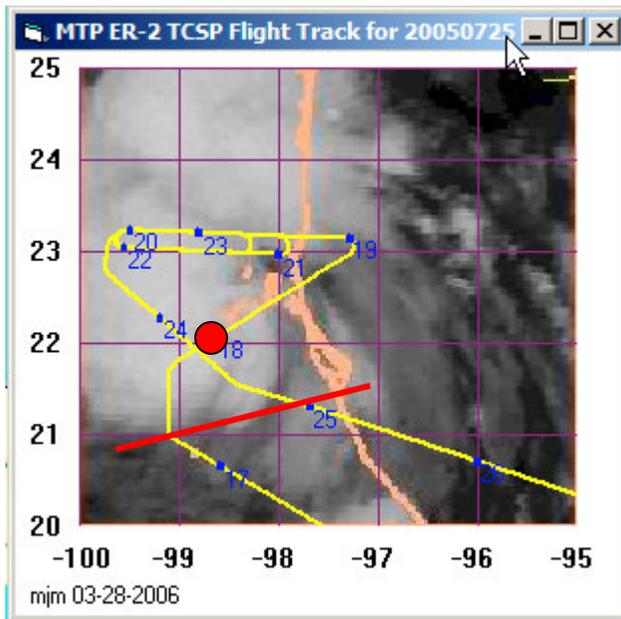
If peaks of isentropes are plotted along the flight track, it appears that there may be waves propagating oriented NW and NE with a wavelength of 40-60 km (blue lines)

## Outline

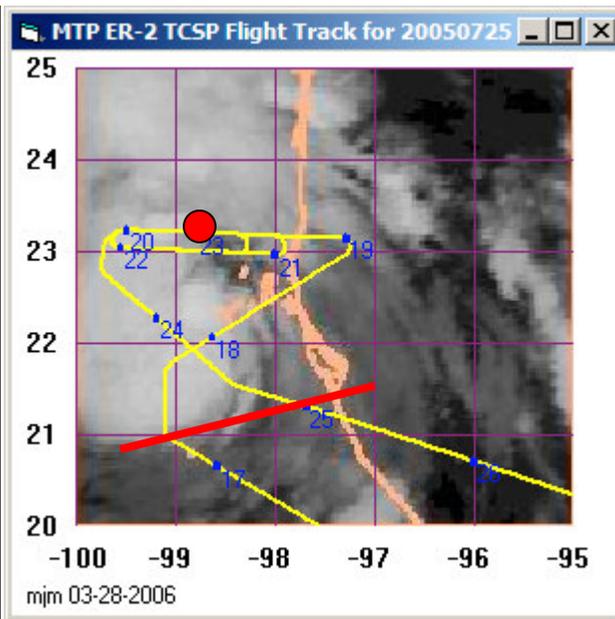
- MTP temperature calibration and data analysis
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- **Subsidence over hurricanes**

## Subsidence over Hurricane Gert

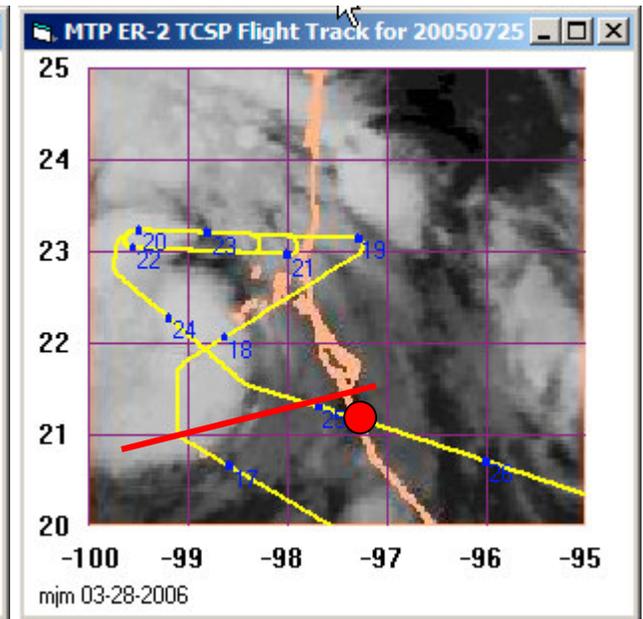
Gert - 5 UT (18 ks)



Gert - 6 UT (21.6 ks)



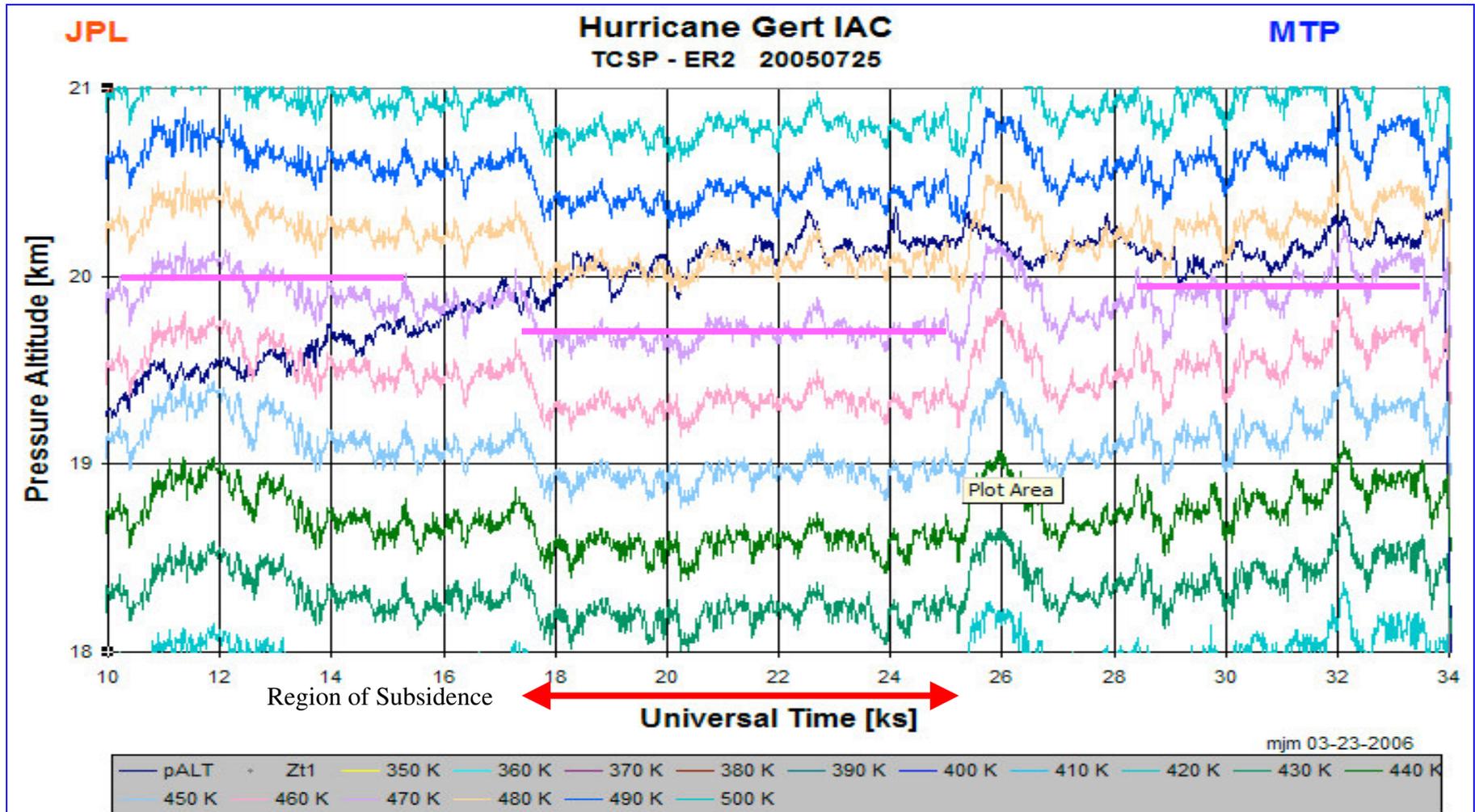
Gert - 7 UT (25.2 ks)



Red dots identify ER-2 location when GOES-10 images were taken

Region north or red lines is where isentropes subside.

## Subsidence over Hurricane Gert (continued)



Notice that isentropes drop ~250 m from 17.4-25.0 ks (see pink lines), implying subsidence over Hurricane Gert. Rising isentropes at 17 & 26 ks, suggest something is happening near the edge of the hurricane at 20 km! What?

## What's Available on the MTP Web Site

### JPL MTP on the TCSP Campaign June-July 2005

[Policy on Use of Data](#)

[Flight Summary](#)

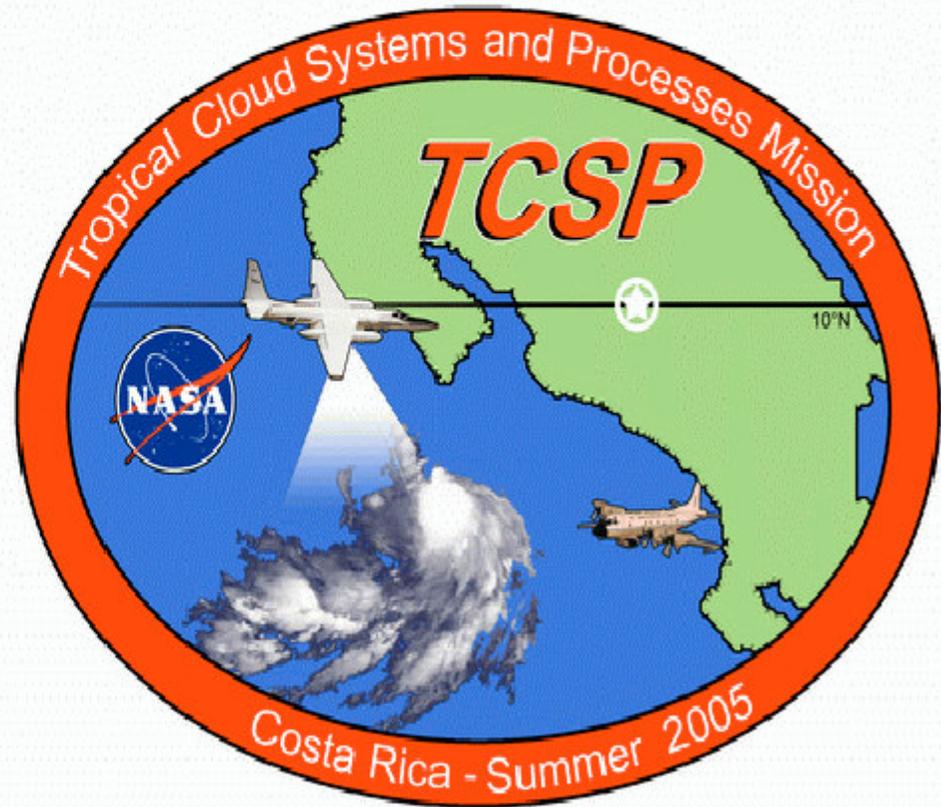
[CTC Image Calendar](#)

[Science Results](#)

[Photo Gallery](#)

[MTP Instrument Description](#)

[TCSP Mission Home Page](#)

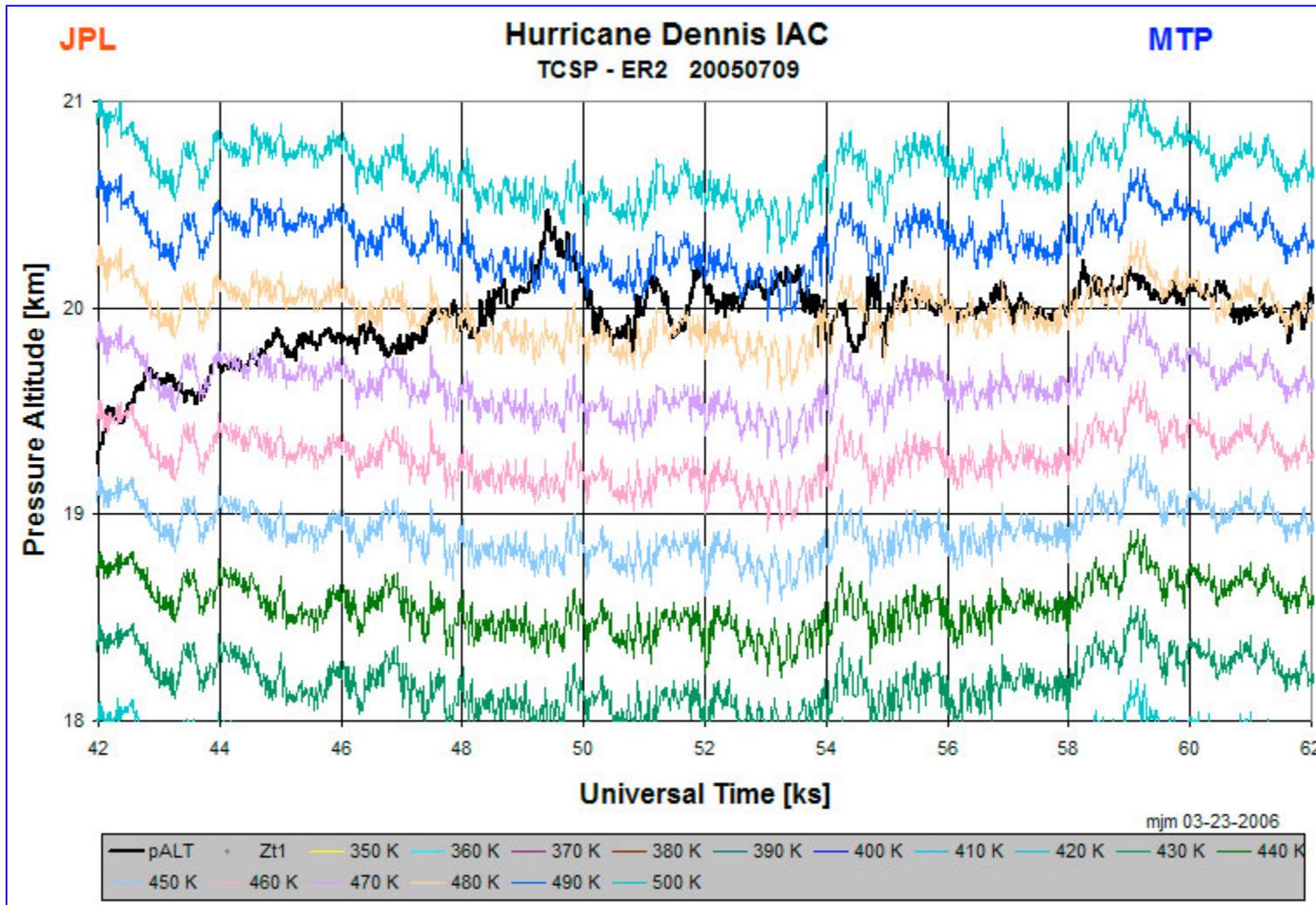


<http://mtp.jpl.nasa.gov/missions/tcsp/tcsp.html>

Backup

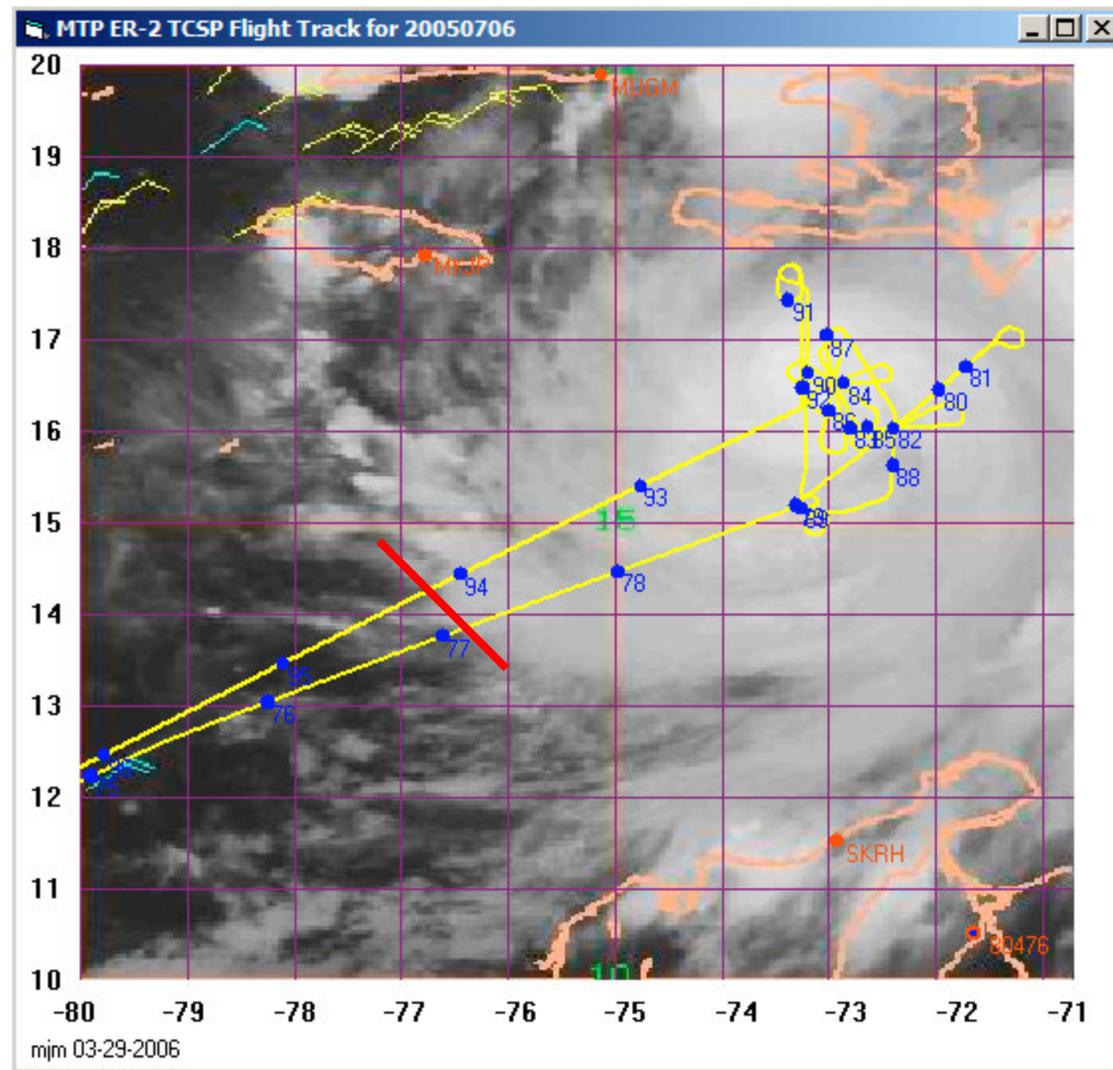


## GWs Seen During Hurricane Dennis Overflight (cont.)



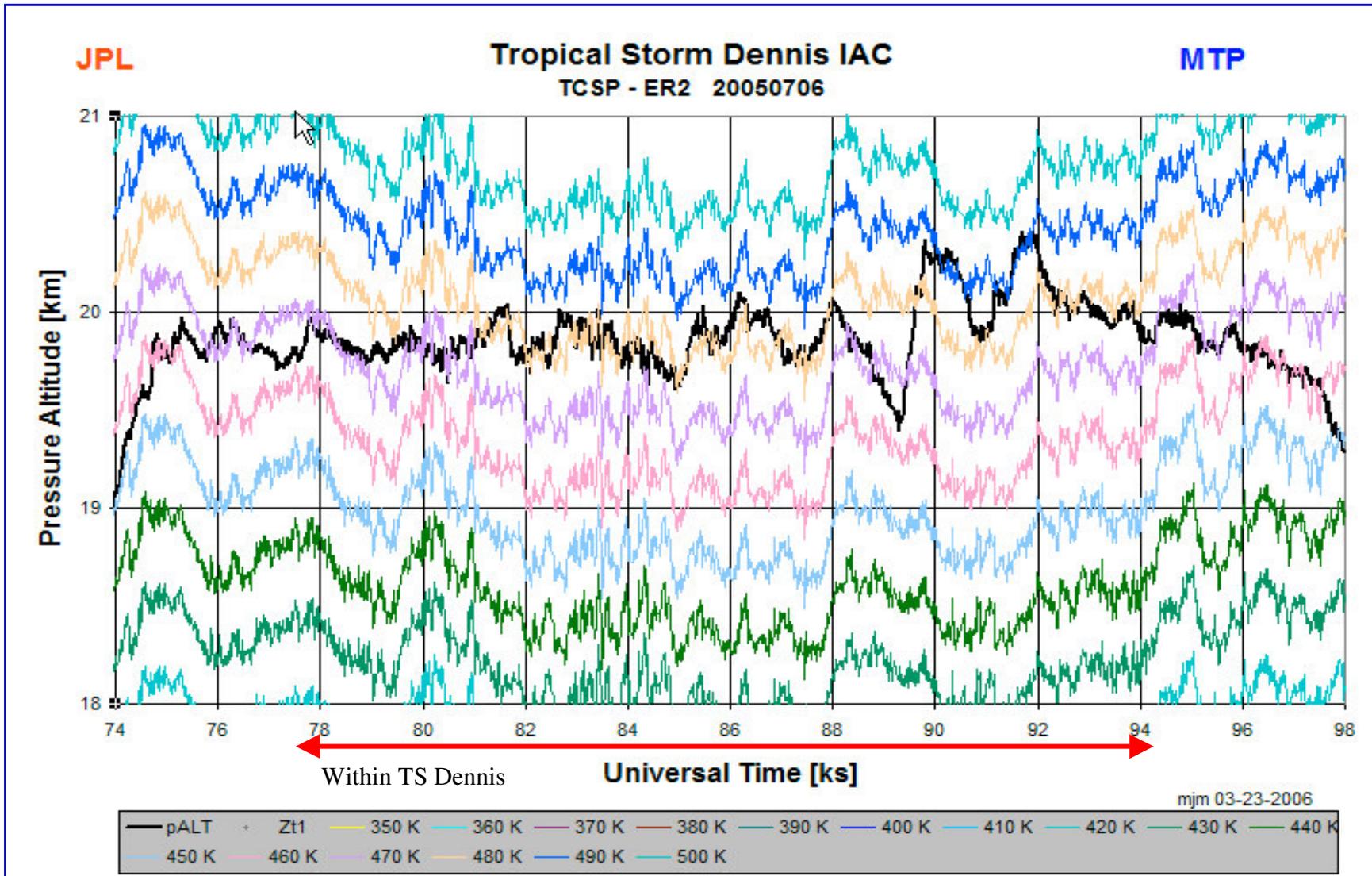
Hurricane Dennis North of Cuba. GW activity from 44-60 ks

# Subsidence over Hurricane Dennis



Region beyond red line shows subsidence.

# Subsidence over Hurricane Dennis (cont.)



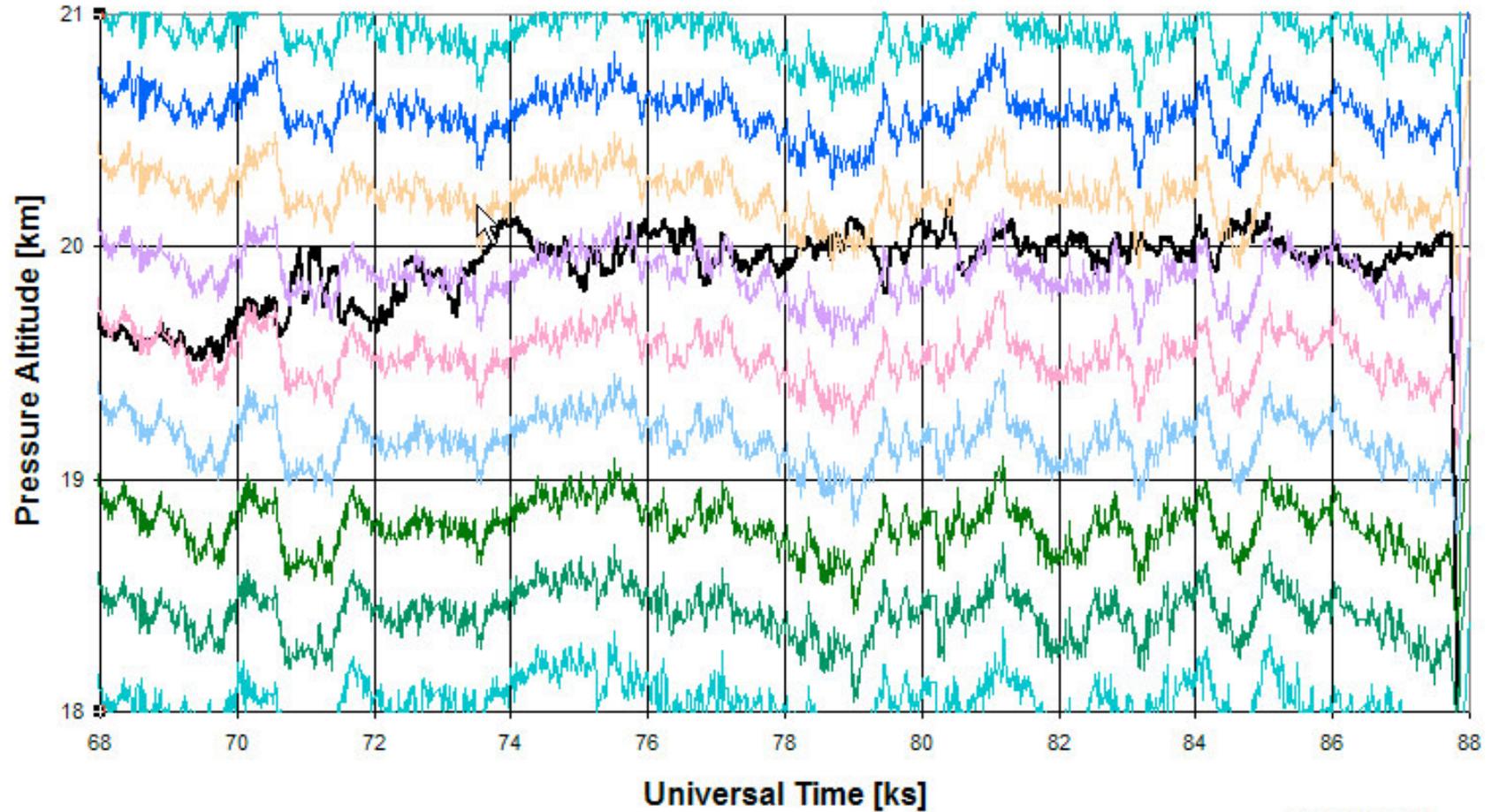
ER-2 near TS Dennis eye from 77 to 94 ks

JPL

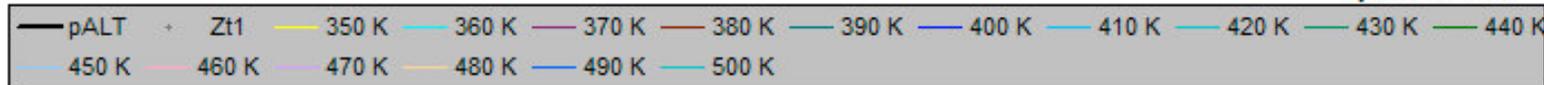
### Tropical Storm Dennis IAC

MTP

TCSP - ER2 20050705



mjm 03-23-2006

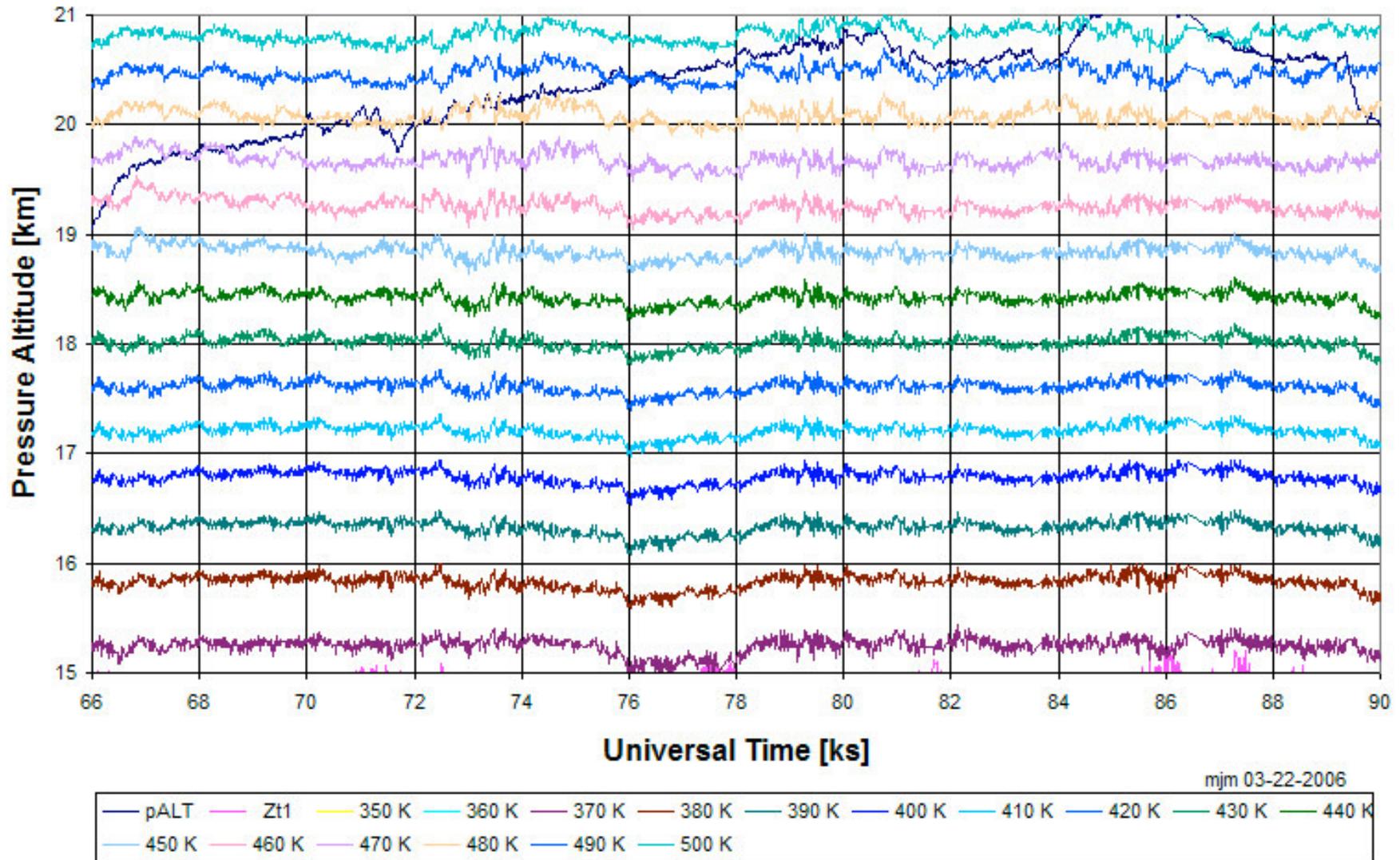


ER-2 transects of TS Dennis eye at ~75 and 80 ks

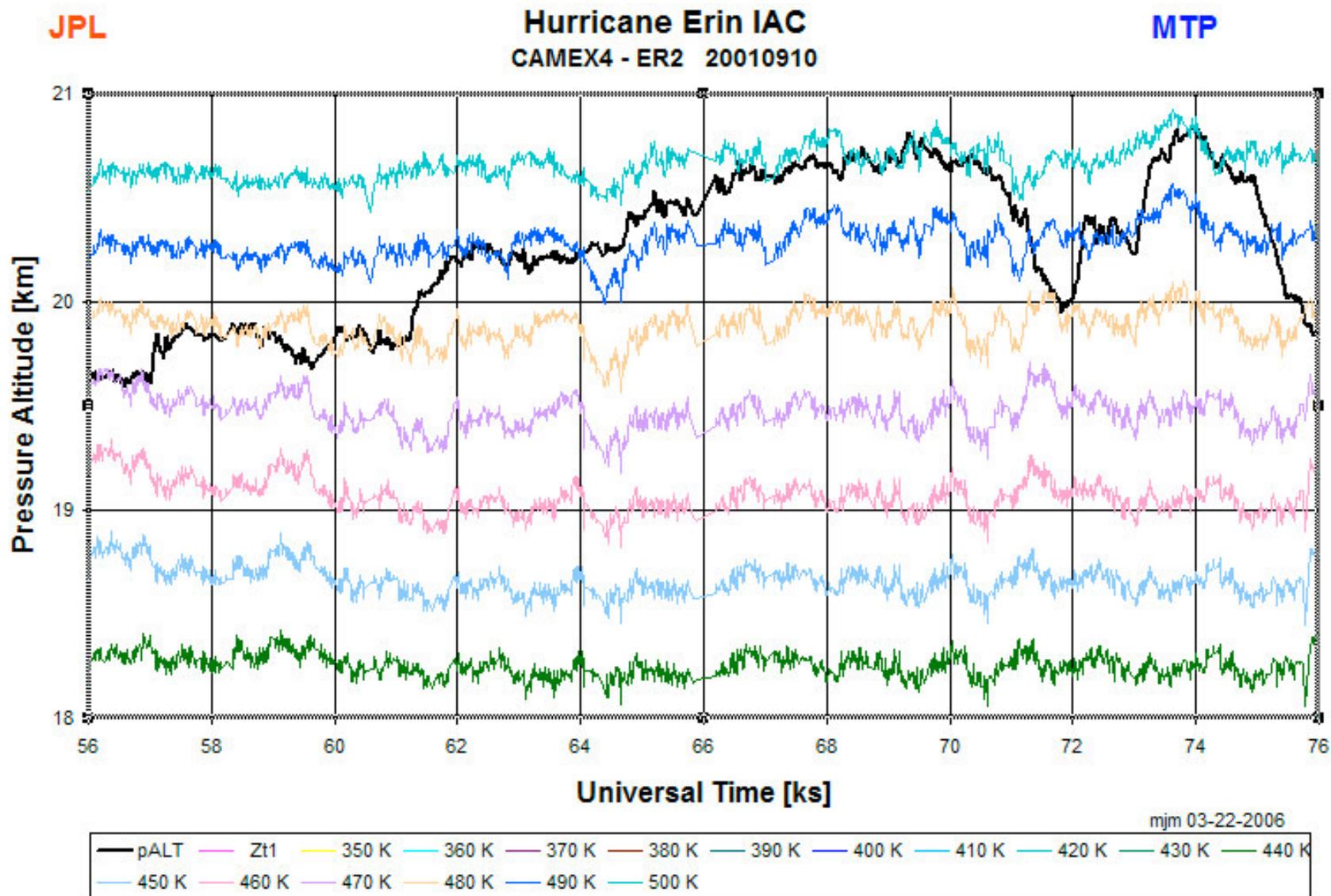
JPL

### Hurricane Humberto IAC CAMEX4 - ER2 20010923

MTP



ER-2 made three transects of the eye at ~74.0, 79.5 and 85.5 ks

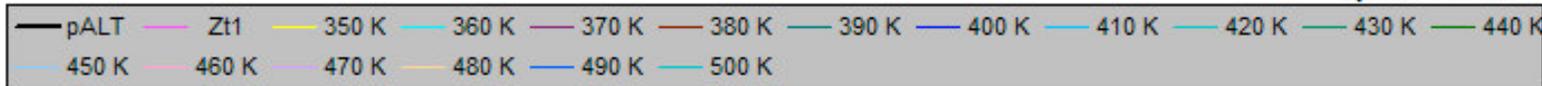
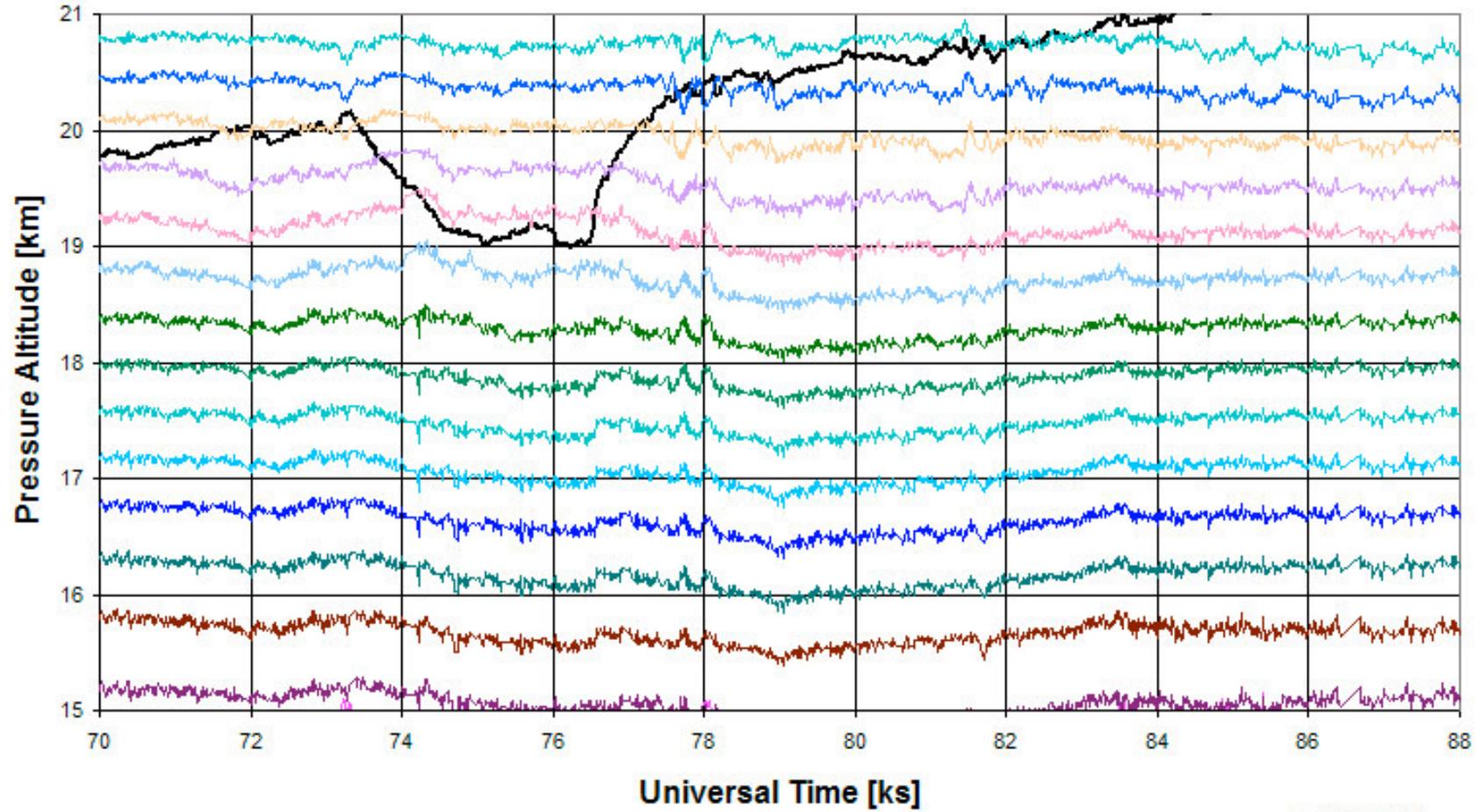


During CAMEX-4 ER-2 transects of Erin at 61.5, 64.5 and 70.0 ks

JPL

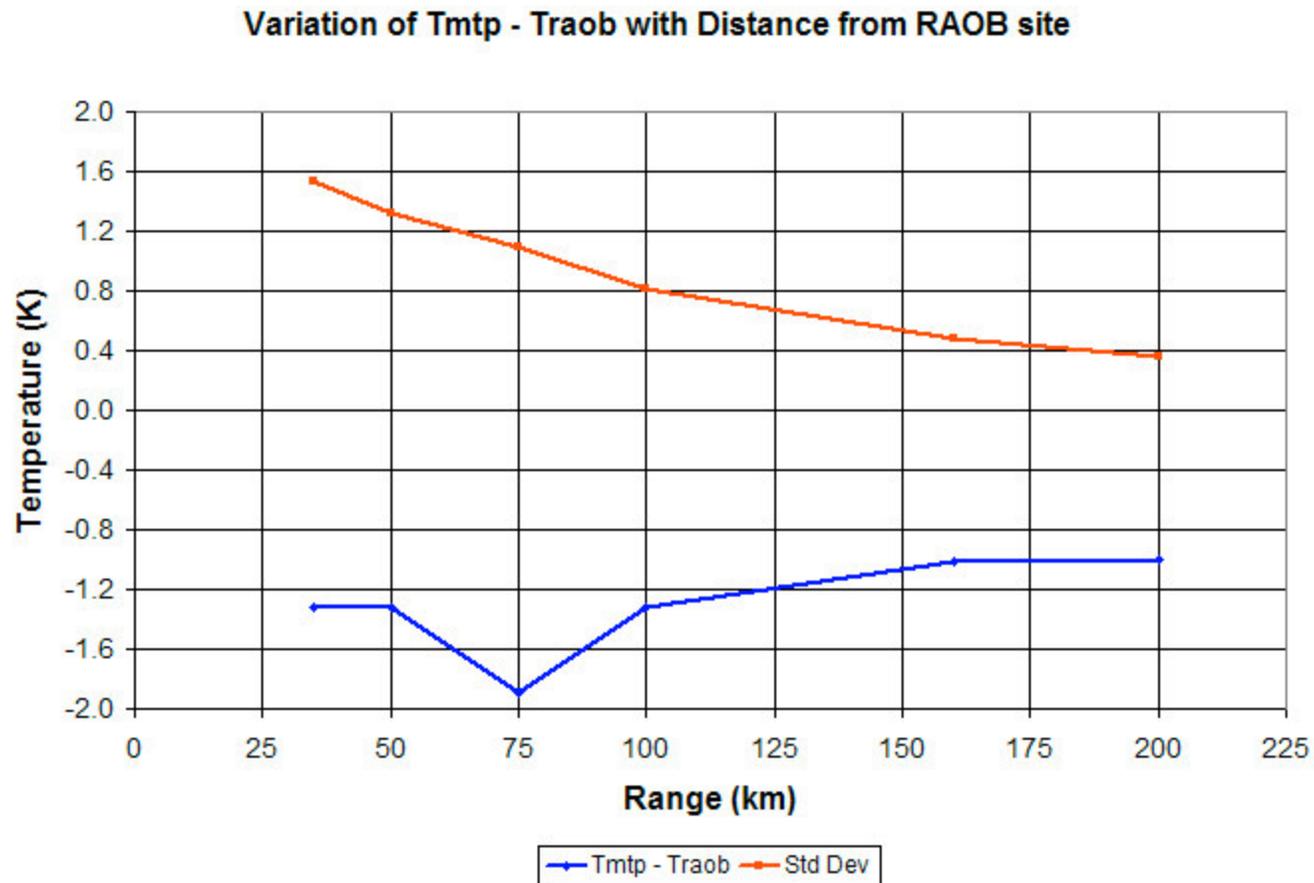
### Hurricane Humberto IAC CAMEX4 - ER2 20010924

MTP



ER-2 nearest the eye of Humberto at ~78 ks and ~81.5 ks

# Behaviour of Temperature Calibration with Range to RAOB Site



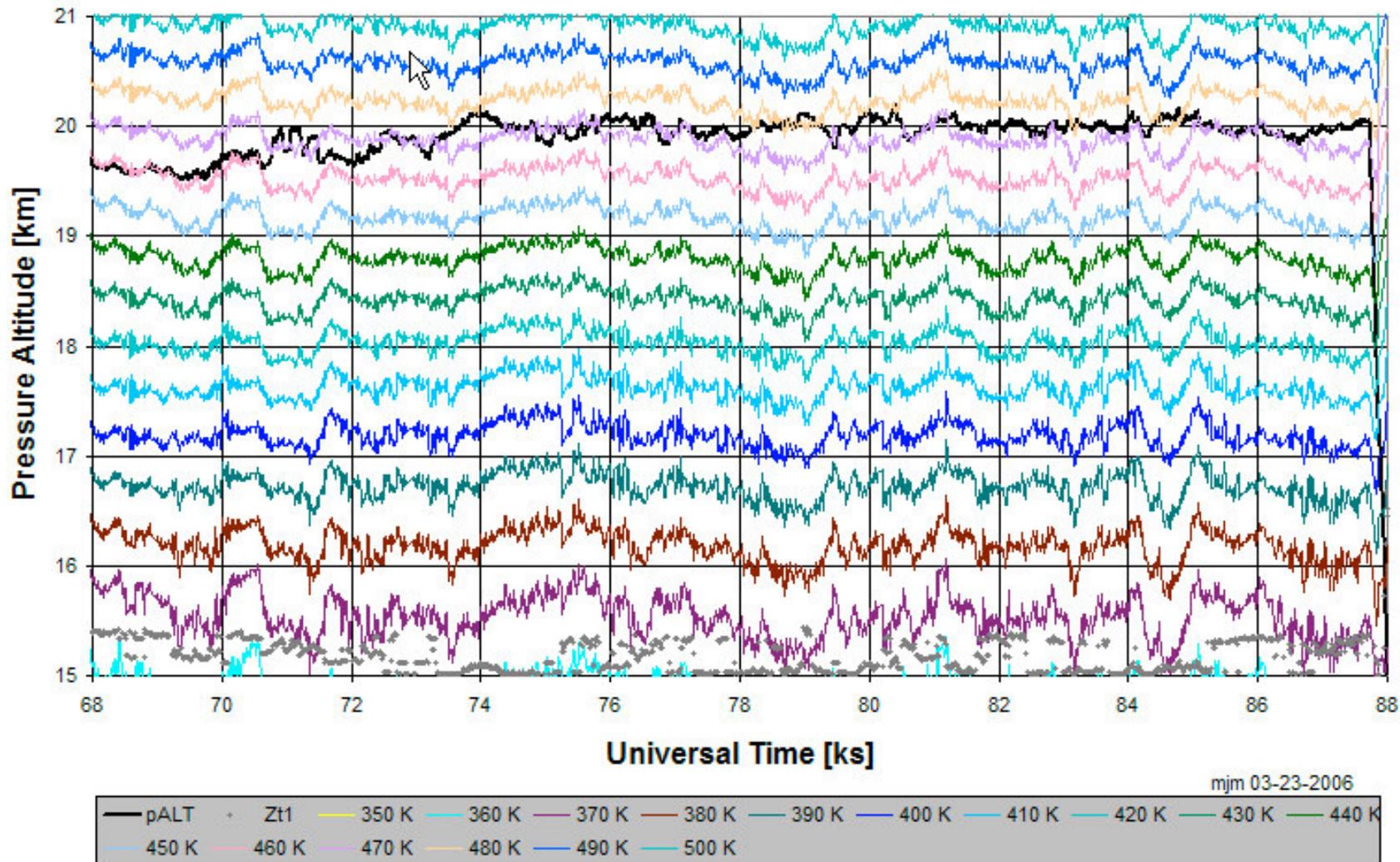
Calibration appears to be stable with range.

Poorer statistics increases standard deviation as range decreases.

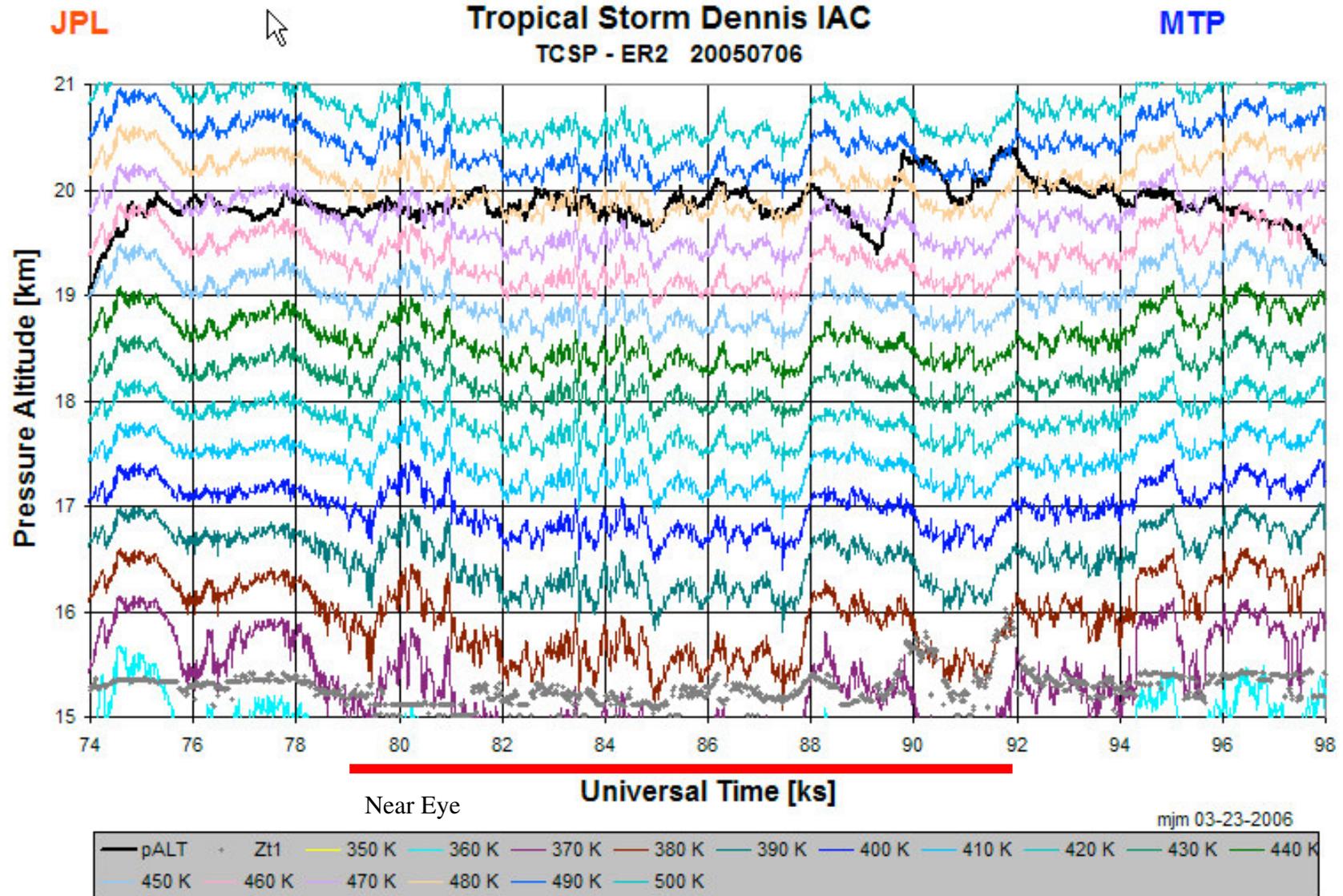
JPL

### Tropical Storm Dennis IAC TCSP - ER2 20050705

MTP



ER-2 transects of TS Dennis eye at ~75 and 80 ks



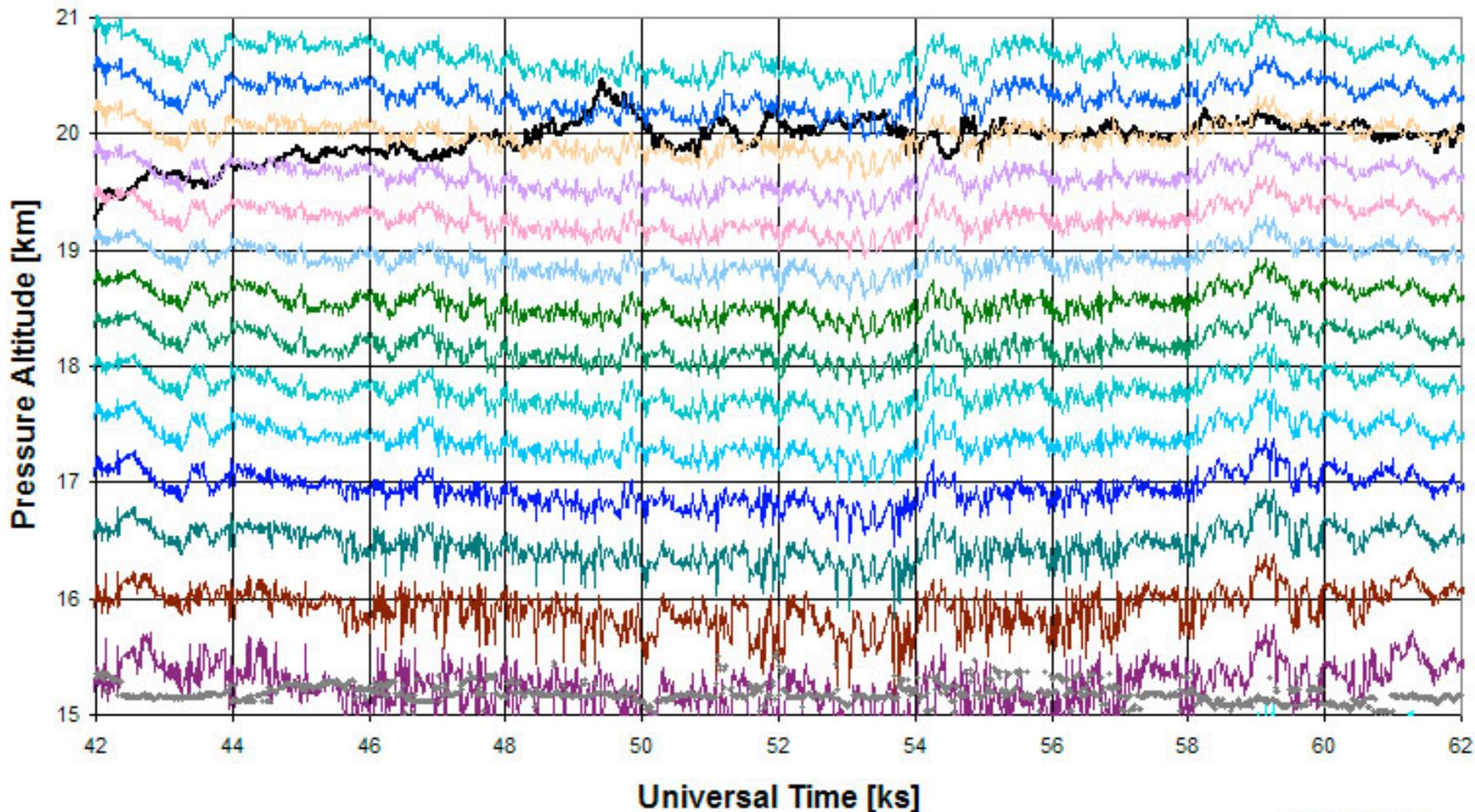
ER-2 near TS Dennis eye from 79 to 92 ks

JPL

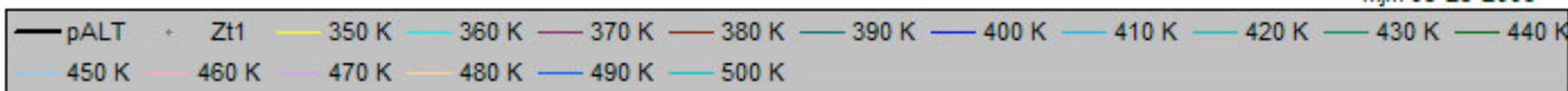
# Hurricane Dennis IAC

MTP

TCSP - ER2 20050709



mjm 03-23-2006



Dennis North of Cuba. Near eye from 48-56 ks