Status of MTP Data Analysis for TCSP

MJ Mahoney
JPL/Caltech

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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 (Tnav) is compared to radiosondes (Traob) near the ER-2 flight track, we find: \( T_{\text{nav}} - T_{\text{raob}} = -1.00 \pm 0.36 \text{ K} \) (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, Tnav is \(~7\text{ K}\) too warm during the early part of the flight.
  - On 2005.07.24, Tnav is \(~6\text{ K}\) too warm for the entire flight.
The Two TCSP Flights Which Have 7 K Tnav Errors

Legend: Zp (blue), Tnav (black), Tmtp = 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.
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

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

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

Humberto - ideal flight track

Emily - non-ideal flight track
• MTP temperature calibration and data analysis
• Background for interpreting MTP data
• **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.
Are there GWs? There appears to be wave activity from 50-54 ks, but flight legs are too short to be certain.
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
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• MTP temperature calibration and data analysis
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• 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 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.
Five cycles with wavelength of ~75 km and amplitude ~300 m
Red and blue traces are when wave activity was seen during flight; mostly in NW quadrant like Hurricane Gordon.
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).
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Subsidence over Hurricane Gert

Red dots identify ER-2 location when GOES-10 images were taken
Region north or red lines is where isentropes subside.
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 north of red line (44-60 ks)
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
ER-2 transects of TS Dennis eye at ~75 and 80 ks
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
ER-2 nearest the eye of Humberto at ~78 ks and ~81.5 ks
Calibration appears to be stable with range.

Poorer statistics increases standard deviation as range decreases.
ER-2 transects of TS Dennis eye at ~75 and 80 ks
ER-2 near TS Dennis eye from 79 to 92 ks
Dennis North of Cuba. Near eye from 48-56 ks