Microwave Temperature Profiler (MTP) Measurements During EUPLEX

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Talk Outline

- Calibration and Retrieval Issues
- Comparisons of MTP Retrievals with Radiosondes
- Examples of Retrievals after Calibration/Retrieval Improvements
- Some Examples of Isentrope Surface Behaviour
  - 2003.01.30: Start within vortex at edge of cold pool
  - 2003.02.06: Start deep in both vortex and cold pool
  - 2003.02.09: Start near vortex edge and within cold pool

Complete details at URL:

http:\\mtp.jpl.nasa.gov\missions\euplex\euplex.html

MTP Calibration and Retrieval Issues

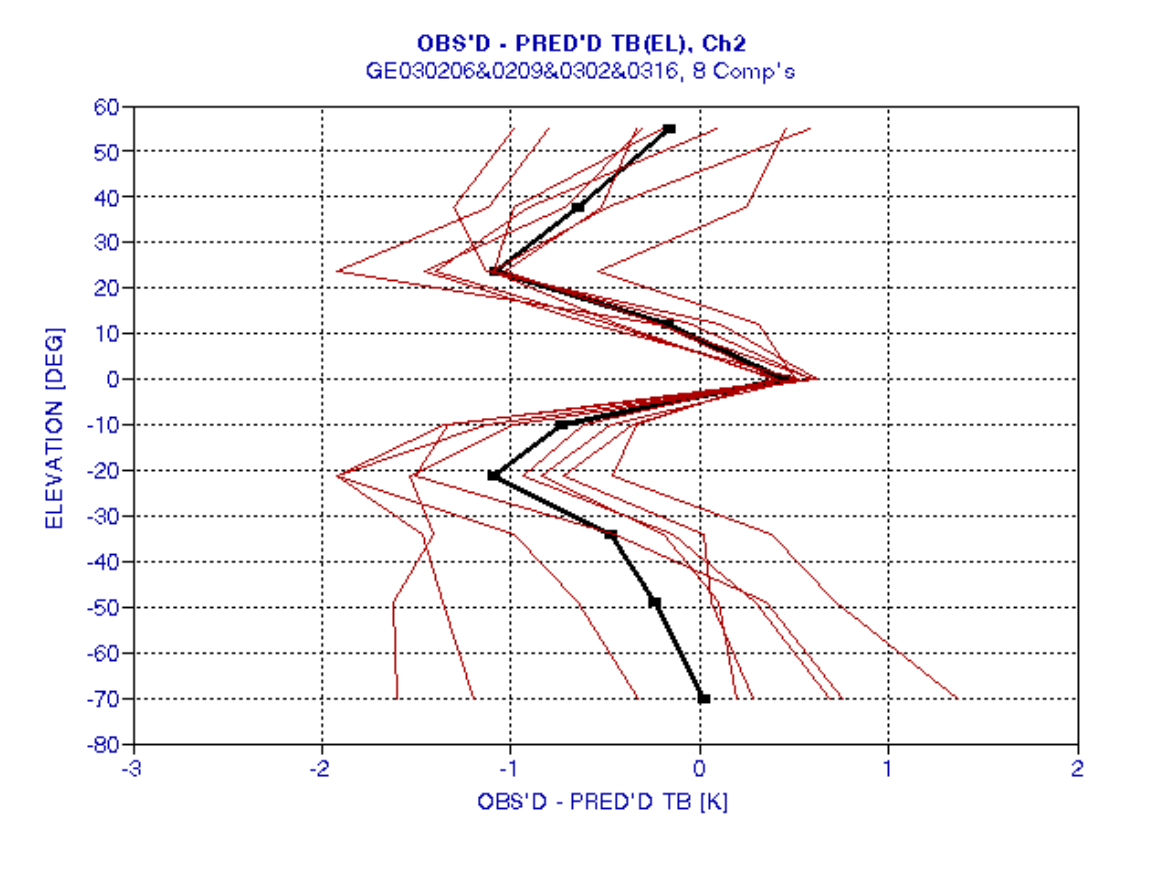
Calibration Issues:

- Window Correction Table (WCT)
- Outside Air Temperature (OAT)
- Instrument Gain
- T-profile interpolation routine

Retrieval Issues:

- The Variation in Radiosonde Temperature Profiles
- Selecting Radiosondes for Calculating RCs

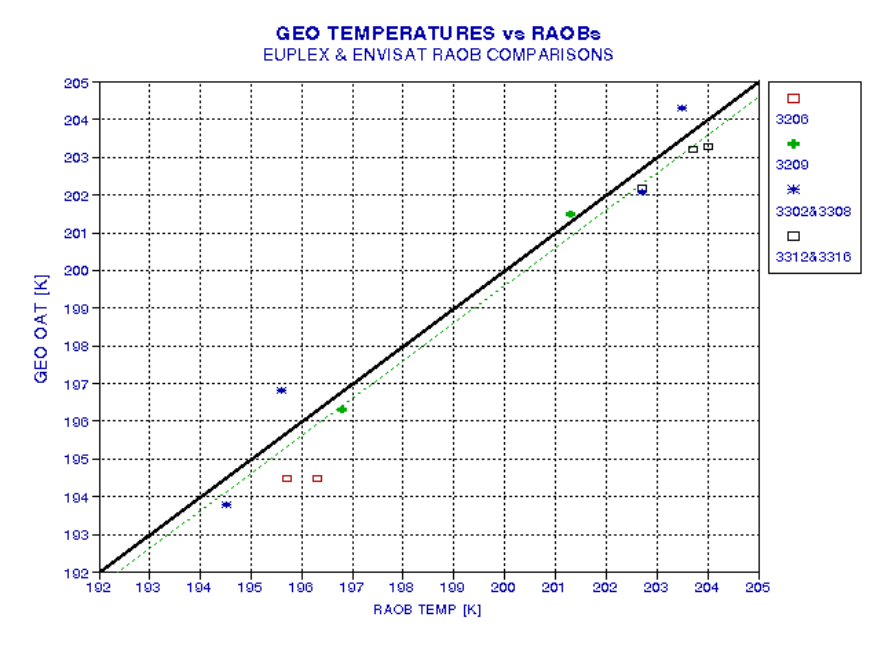
MTP Calibration Issues: Window Correction Table (WCT)

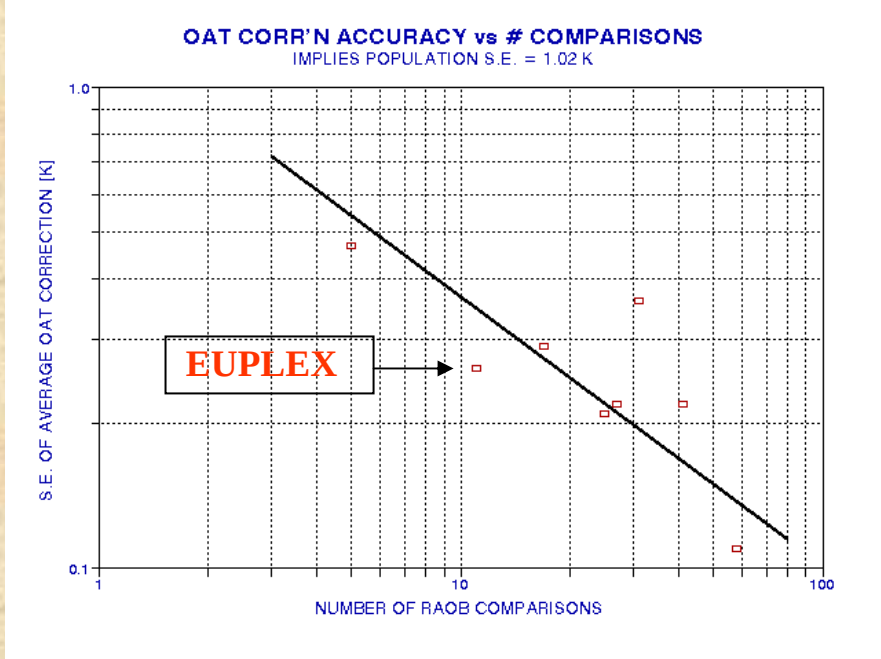


Brightness temperature corrections -- "Window Corrections" -- for one of the 3 MTP frequency channels used during EUPLEX

- MTP beam sidelobe levels change as it observes 10 different elevation angles during a scan
- Radiosondes close to the aircraft flight track are used to calculate what brightness temperatures should have been observed, and these are compared to the measured brightness temperatures to determine what corrections are needed

MTP Calibration Issues: Outside Air Temperature (OAT)



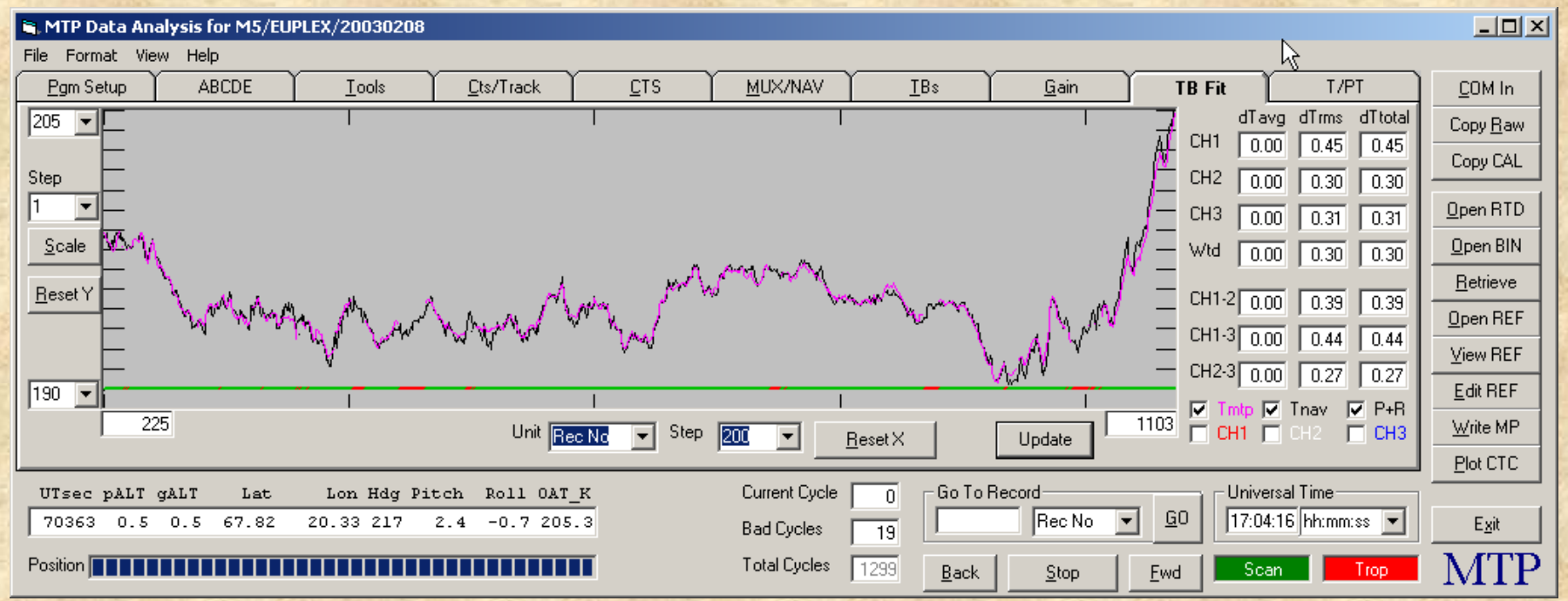


Radiosondes close to the Geophysica flight track are compared to measured temperatures to determine their accuracy. Atmospheric variability is carefully taken into account in this process, as it is very important.

Bias corrections for 8 recent campaigns show that a single comparison has a standard error of ~1 K, and that the error in the bias correctly decreases with $1/\sqrt{N}$, where N is the number of comparsions made during a campaign

$$T_{TDC} = T_{RAOB} + (0.39 \pm 0.26)\ K \quad \text{for} \quad N=11$$

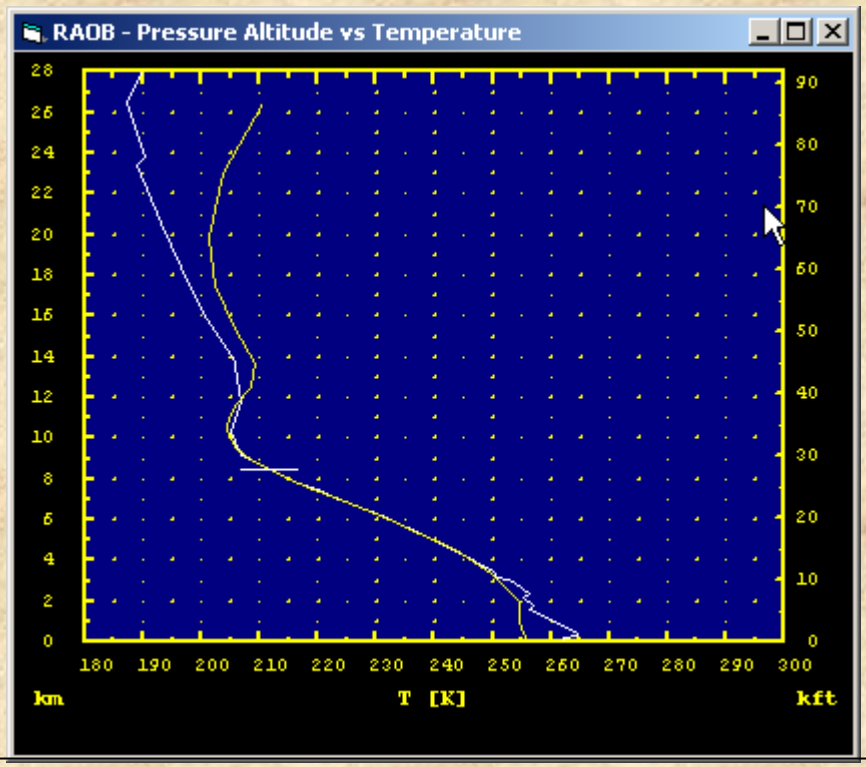
MTP Calibration Issues: Instrument Gain



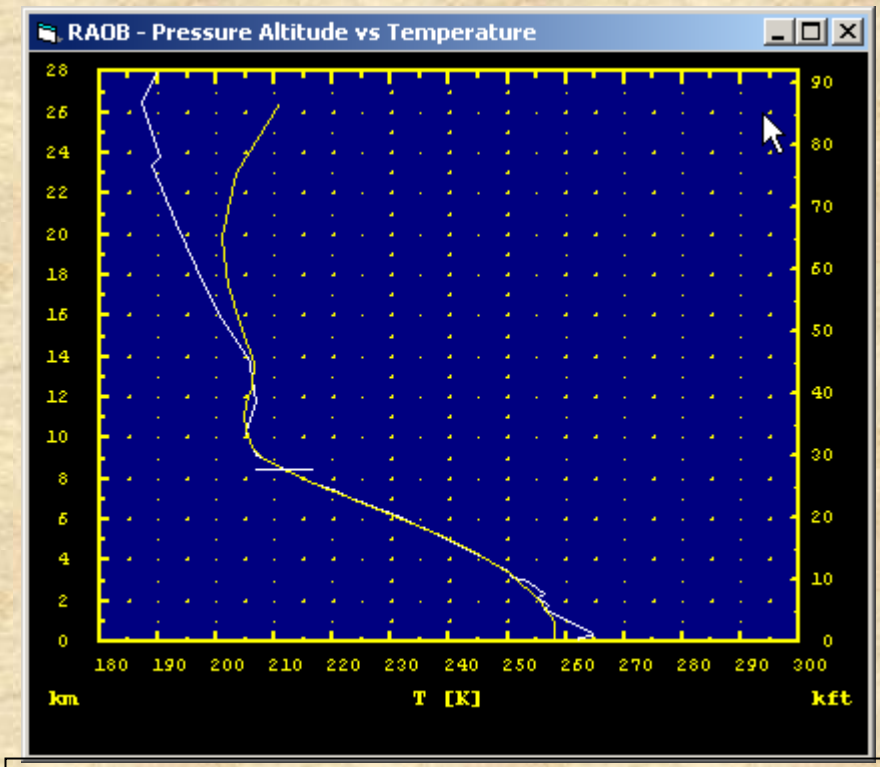
- MTP and TDC outside air temperatures agree to ±0.30 K when a +0.39 K correction is applied to TDC

- Using corrected TDC OATs as a reference temperature -- instead of the MTP target temperature -- minimizes the impact of gain changes, since the off-horizon temperature differences with respect to the reference are smaller.

MTP Calibration Issues: T-profile interpolation routine



Retrieval at 8.5 km obtained by interpolating retrievals at 7.0 and 10.0 km

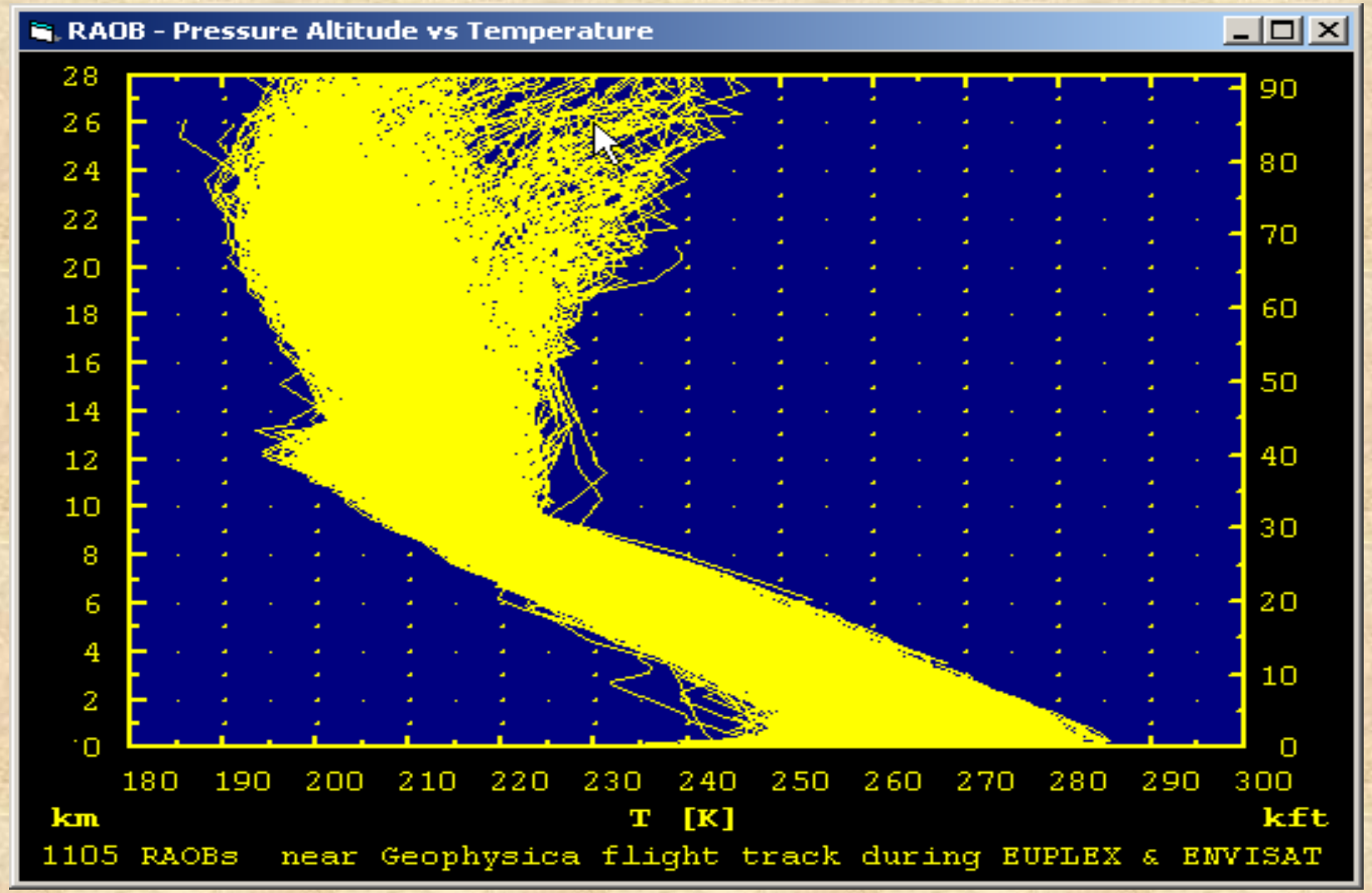


Retrieval at 8.5 km obtained by interpolating RCs at 7.0 and 10.0 km, then doing retrieval

- The simulated retrievals shown above show that when retrieval coefficients (RCs) are not available at flight level, interpolating them to flight level produces better retrievals (when structure is present) than interpolating the two separate retrievals to flight level. Note that we only expect to improve the retrieval within ±6 km of the aircraft where useful information is being measured by the MTP. The retrievals should not improve further away. Optimum RCs were not used for this simulated example

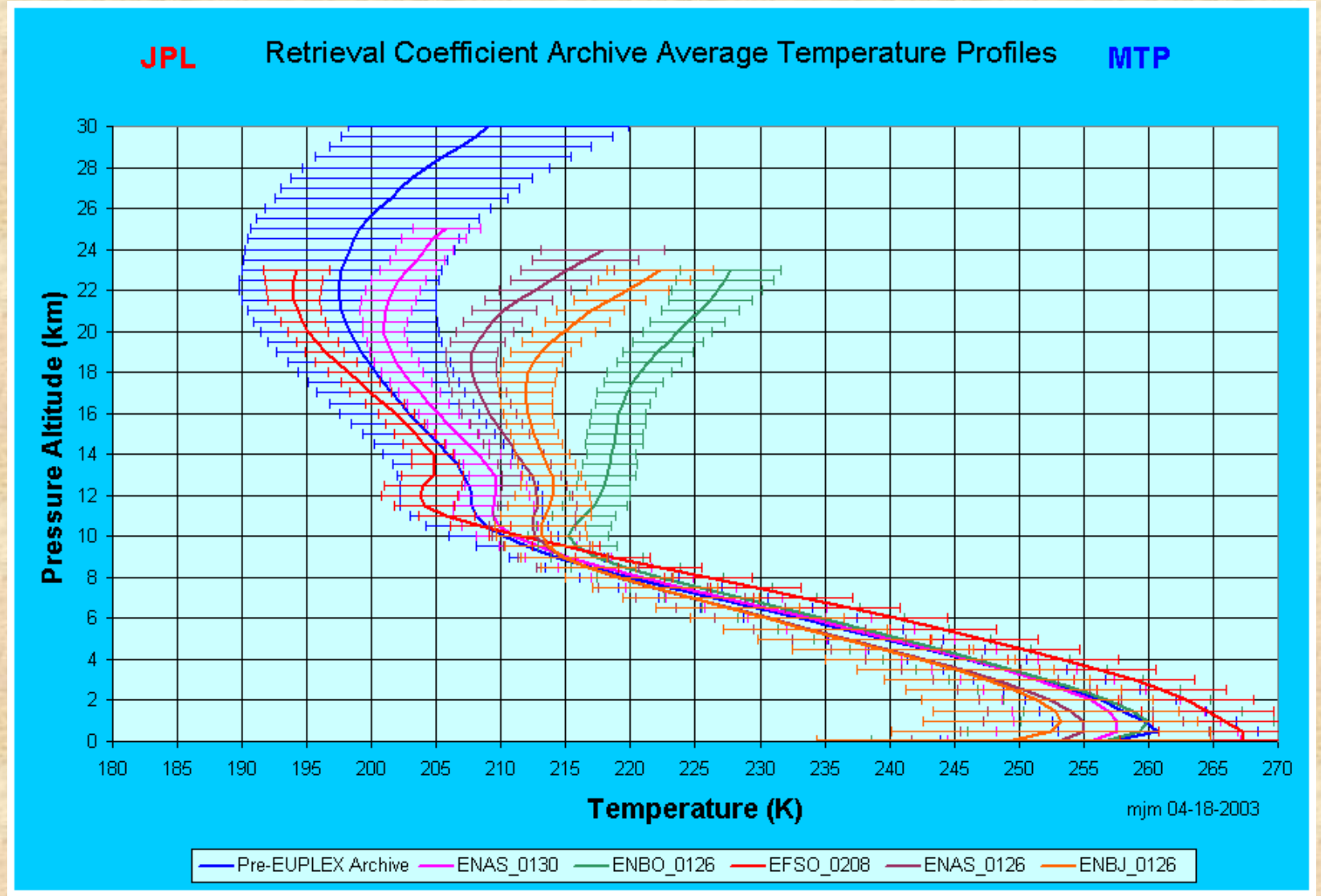
- The simulated retrievals will be used to determine the retrieval errors as a function of distance from the aircraft

MTP Retrieval Issues: The Variation in Radiosonde Temperature Profiles



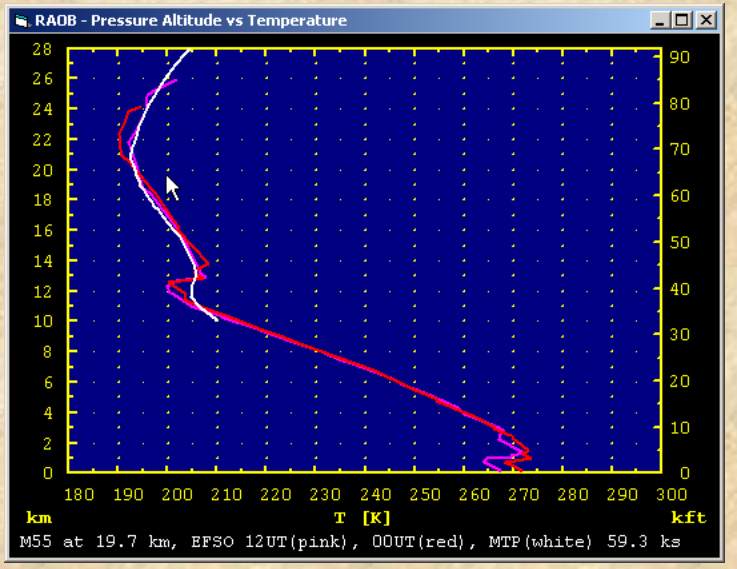
- The variation of 1105 radiosondes launched near the Geophysica's flight track
- The temperature variation in the stratosphere is enormous (>40 K)
- This requires special consideration when calculating retrieval coefficients

MTP Retrieval Issues: Selecting Radiosondes for Calculating RCs

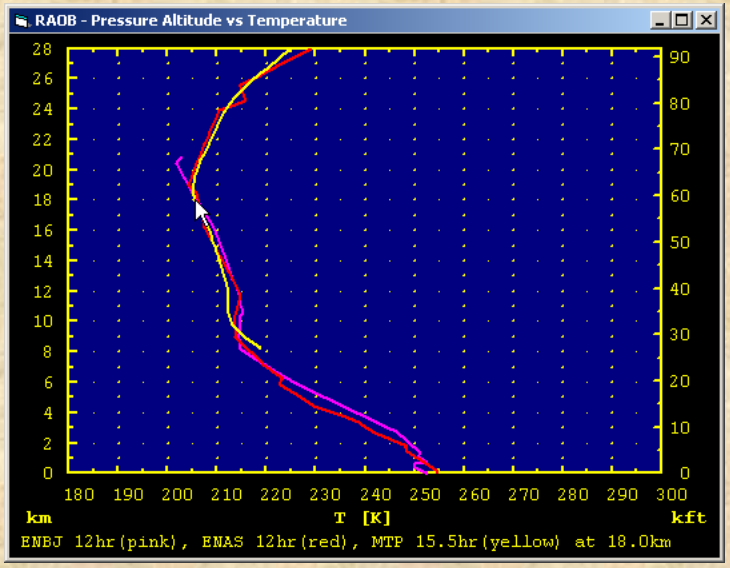


To minimize retrieval errors, many sets of retrieval coefficients must be calculated in order to capture the wide range of variability that is seen in the winter Arctic vortex

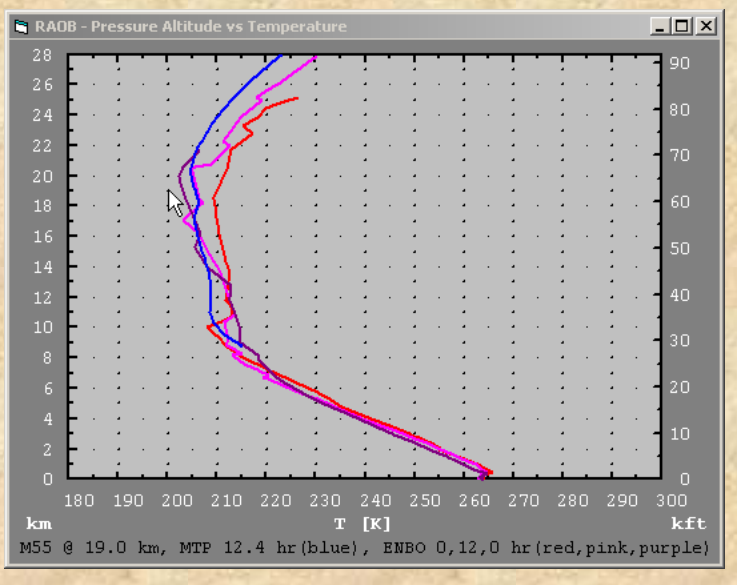
Comparison of MTP Retrievals to Nearby Radiosondes



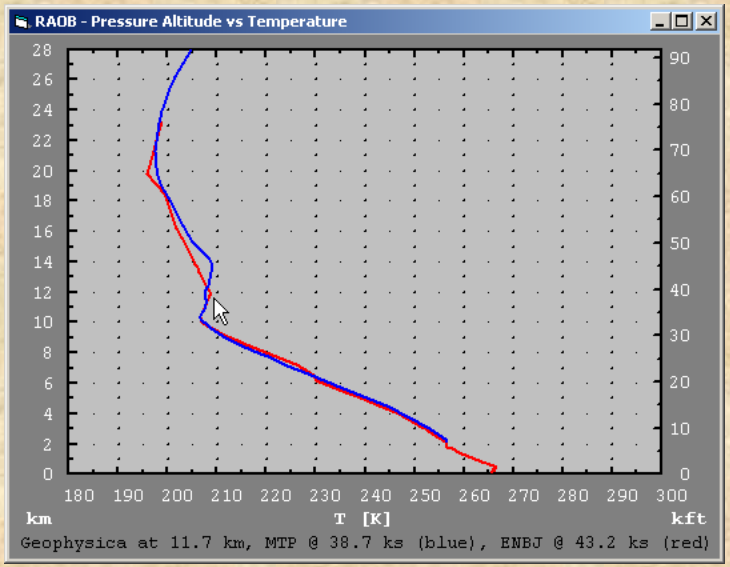
EFSO 2003.02.08 12 & 00 UT, MTP at 13.4UT -- inversion



ENBJ & ENAS 2003.01.19 12 UT, MTP at 15.5 UT -- normal

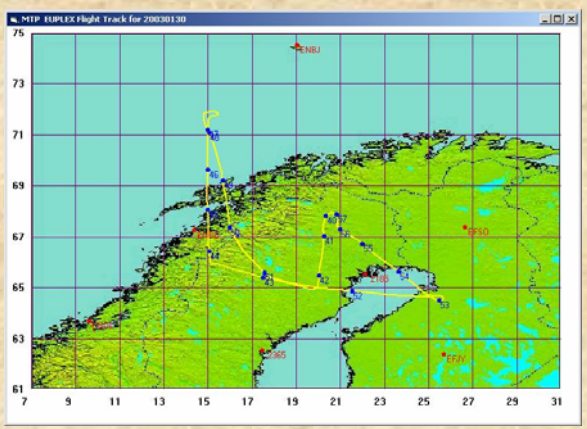


ENBO 2003.01.30 00 & 12 & 00 UT, MTP at 13.4 UT -- T variable

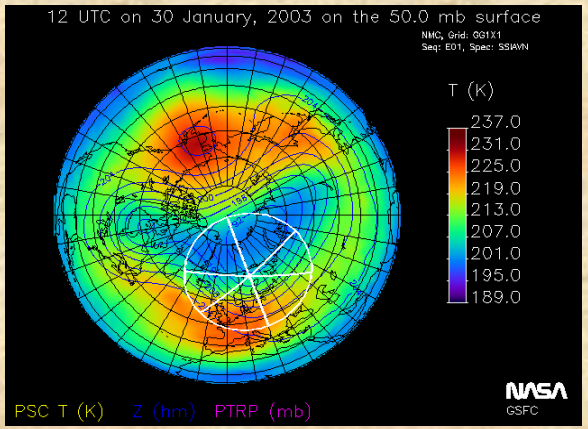


ENBJ 2003.02.02 12 UT, MTP at 10.8 UT -- real structure

Note: In the above plots, the white arrow represent the Geophysica altitude at the time of the comparison



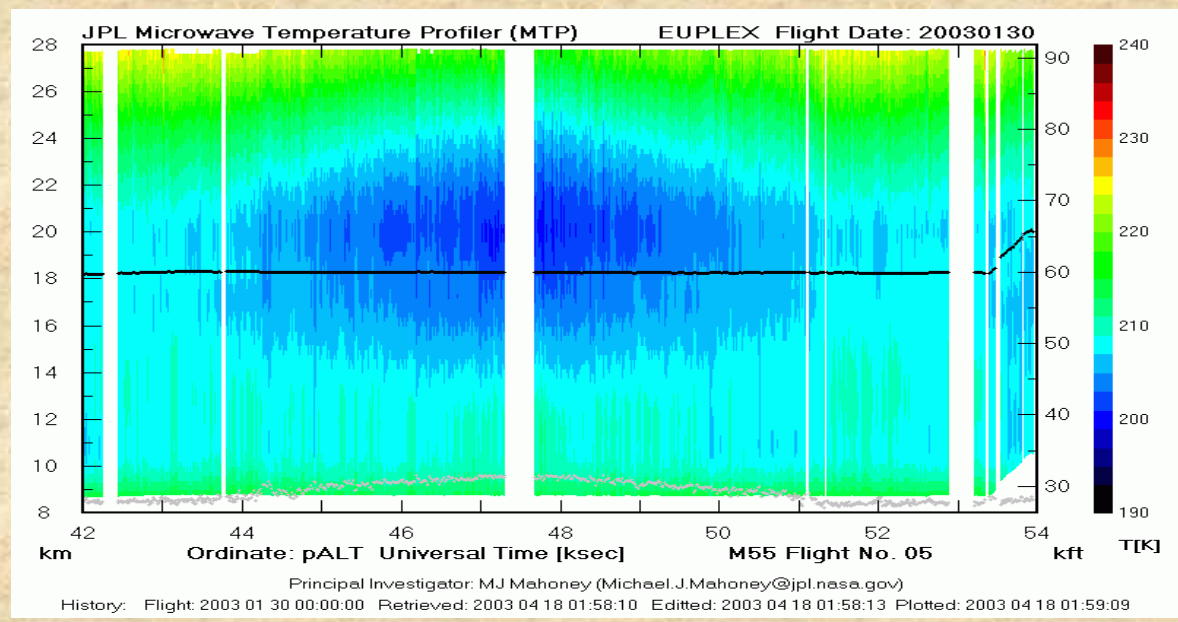
Geophysica Flight Track on 2003.01.30



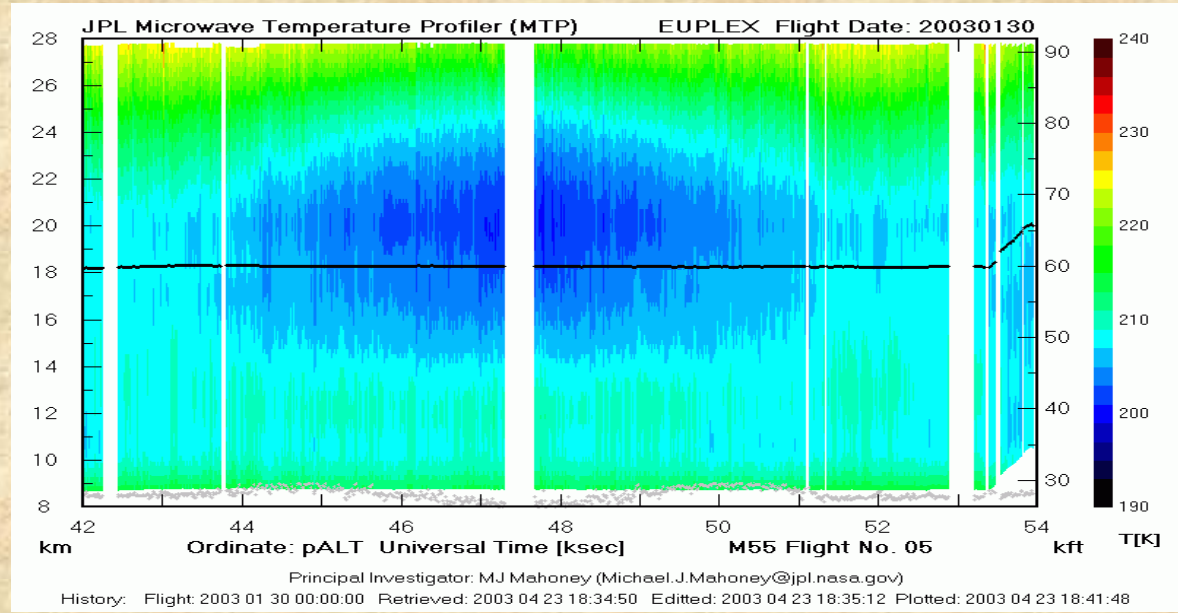
NASA GSFC Temperature Field

Calculating RCs using RAOBs on flight day as a template significantly improves the quality of MTP retrievals as indicated by the quality metric

Improvement in the MTP temperature profiles is masked because each color step is ~2 K (i.e., too coarse)

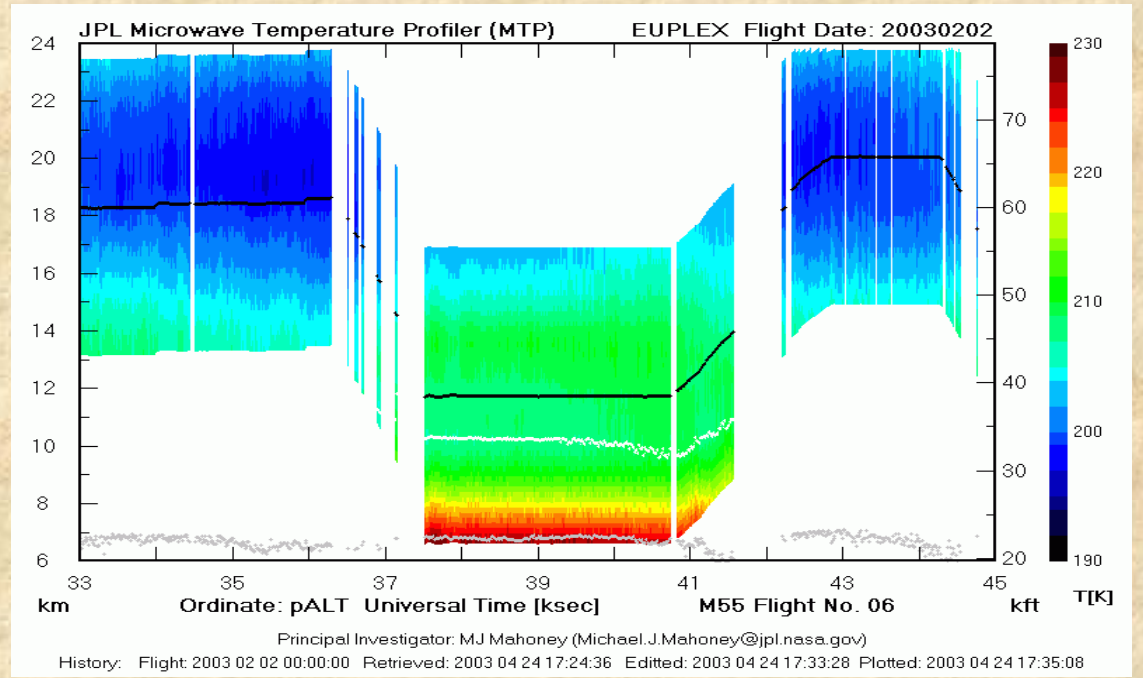


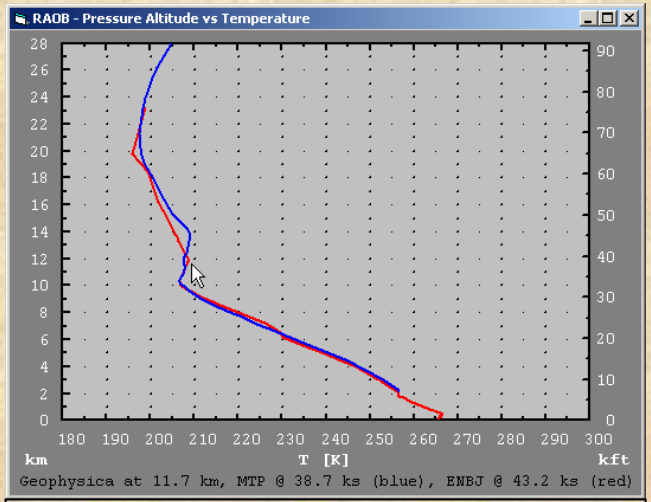
RCs calculated prior to campaign have degraded performance mid-flight



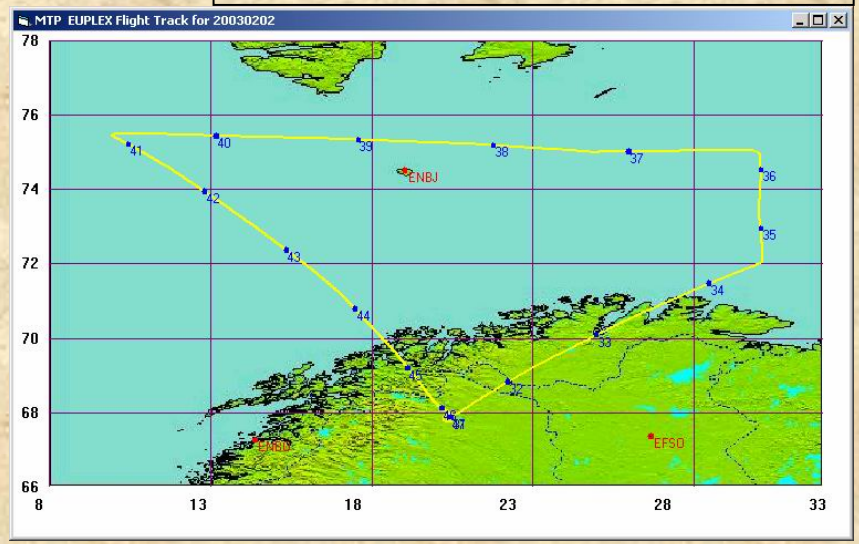
RCs calculated after campaign have excellent performance mid-flight

The EUPLEX Flight of 2002.02.02





Comparison of MTP (blue) with ENBJ 1200UT radiosonde (red), M55 flight track is shown below



- Using a new altitude interpolation routine significantly improved the retrieval quality during the dip
- There is excellent agreement between the ENBJ temperature and tropopause, and those measured by the MTP. We believe the MTP structure above the tropopause is real
- There is a significant tropopause dip at 41 ks as the Geophysica gets furthest west

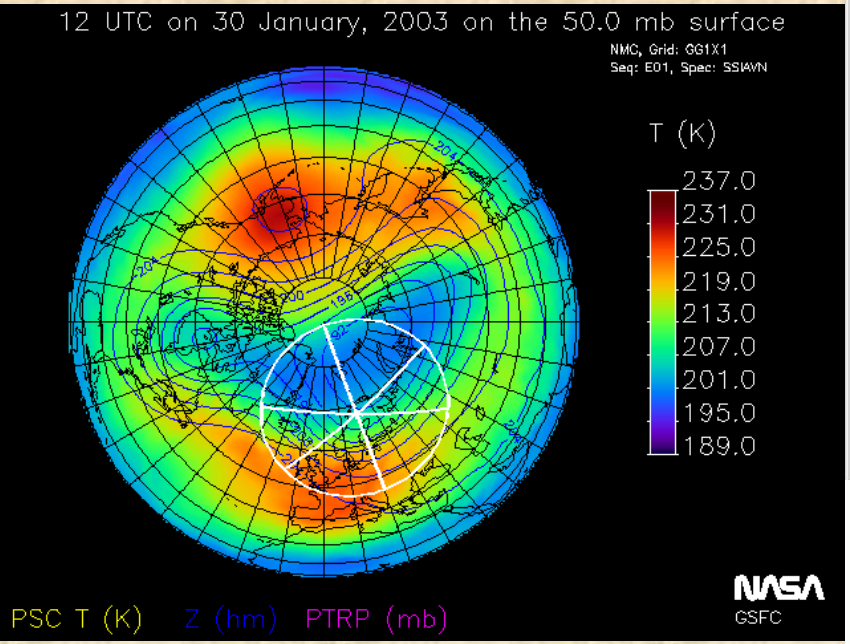
Three Examples of Isentrope Surface Behaviour

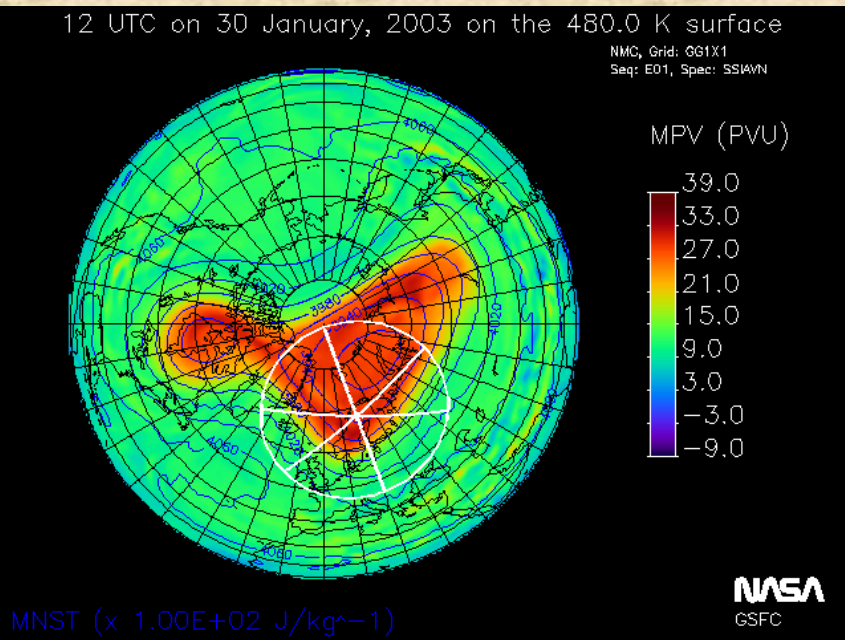
Why? Identify vortex structure and whether there is wave activity

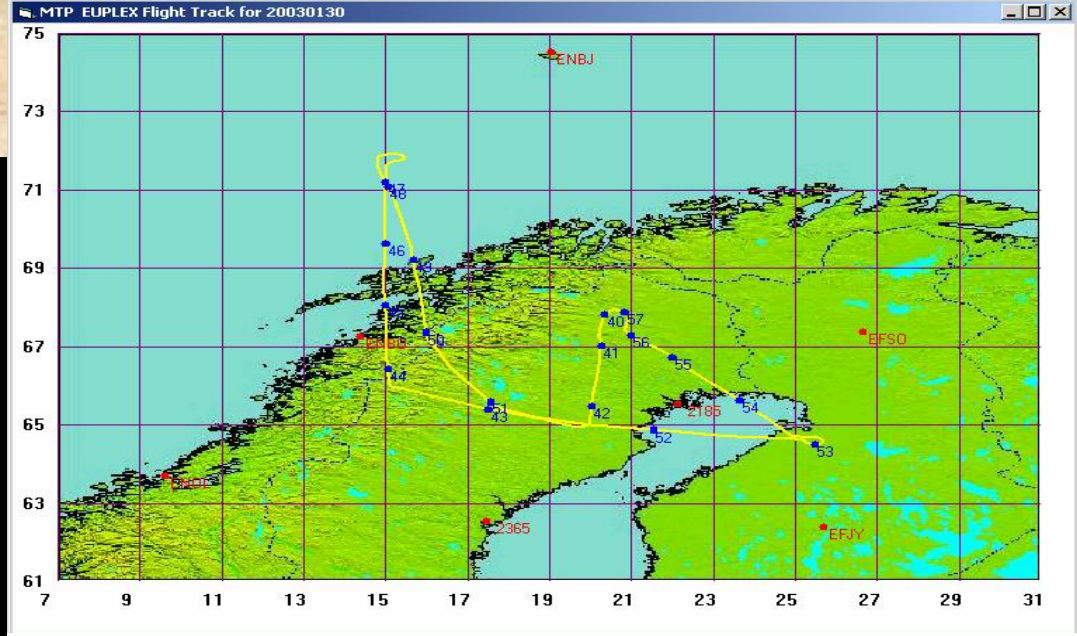
- 2003.01.30:
  - Start within a weak vortex near the edge of the cold pool
  - See isentropes rise as expected; wave activity is weak as forecast
- 2003.02.06:
  - Start deep within both the vortex and the cold pool
  - Isentropes are 1 km higher, and there is no wave activity as forecast
- 2003.02.09:
  - Start near the vortex edge, but within the cold pool
  - Moderate wave activity near the vortex edge dies out deeper into the vortex

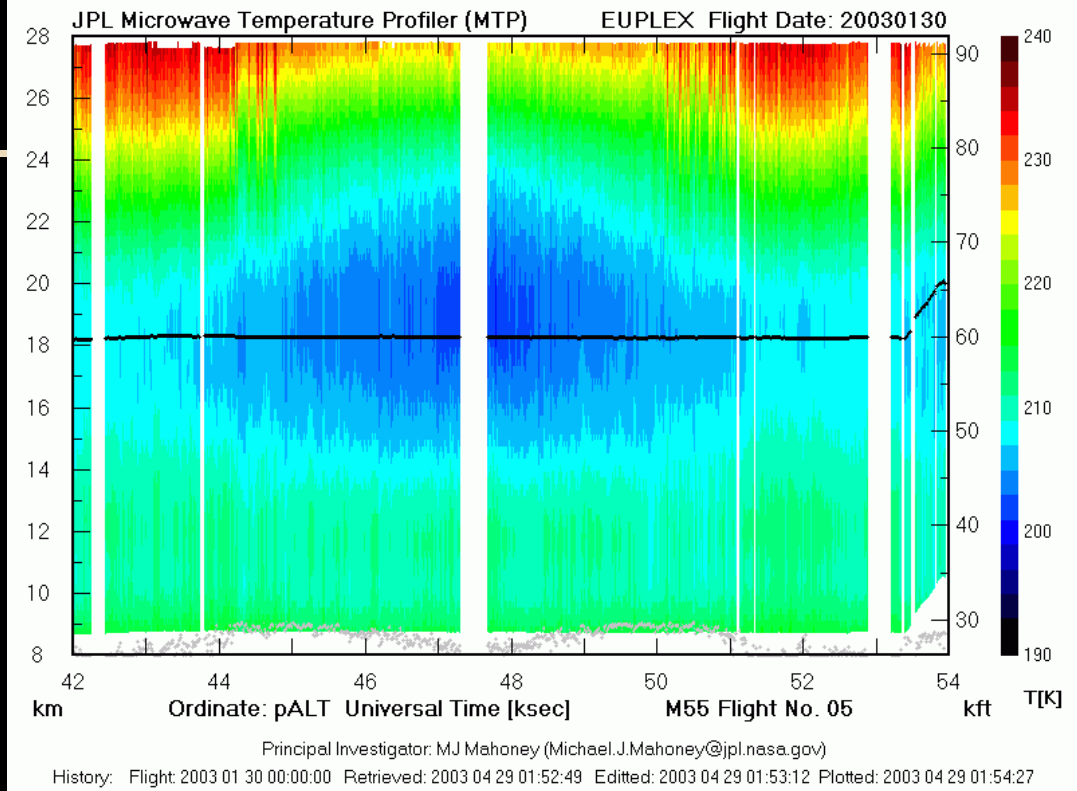
2003.01.30

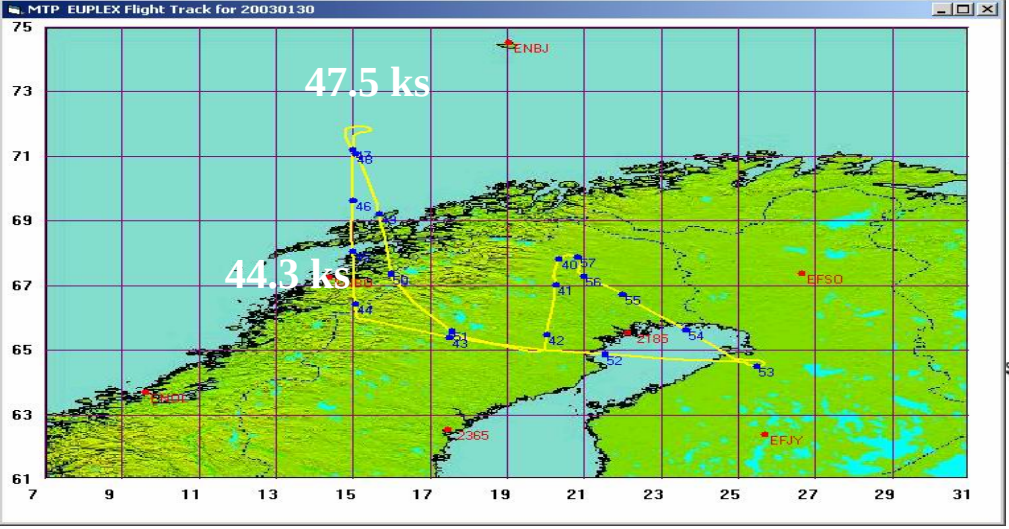
Inside Vortex at Edge of Cold Pool

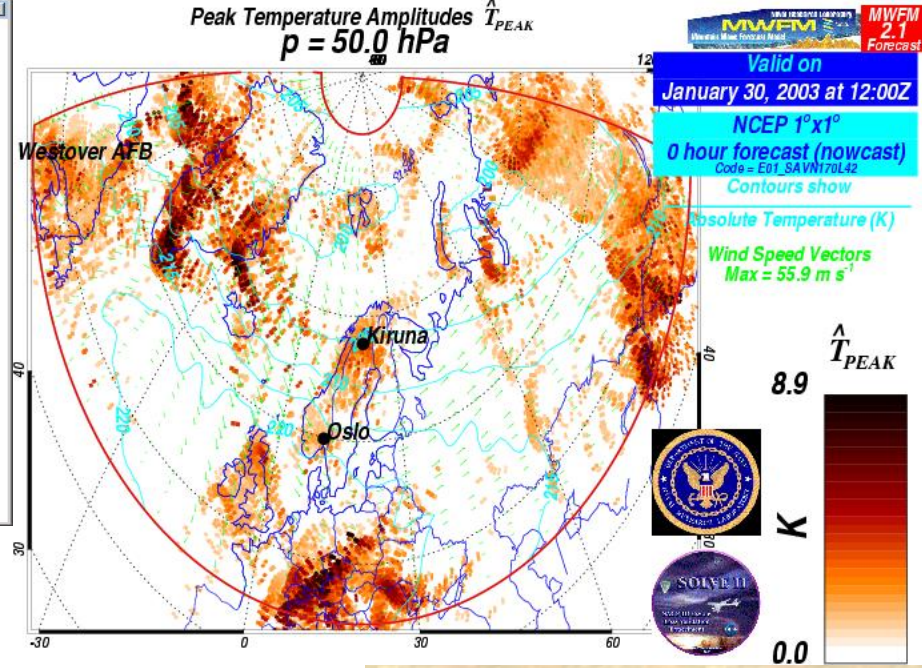












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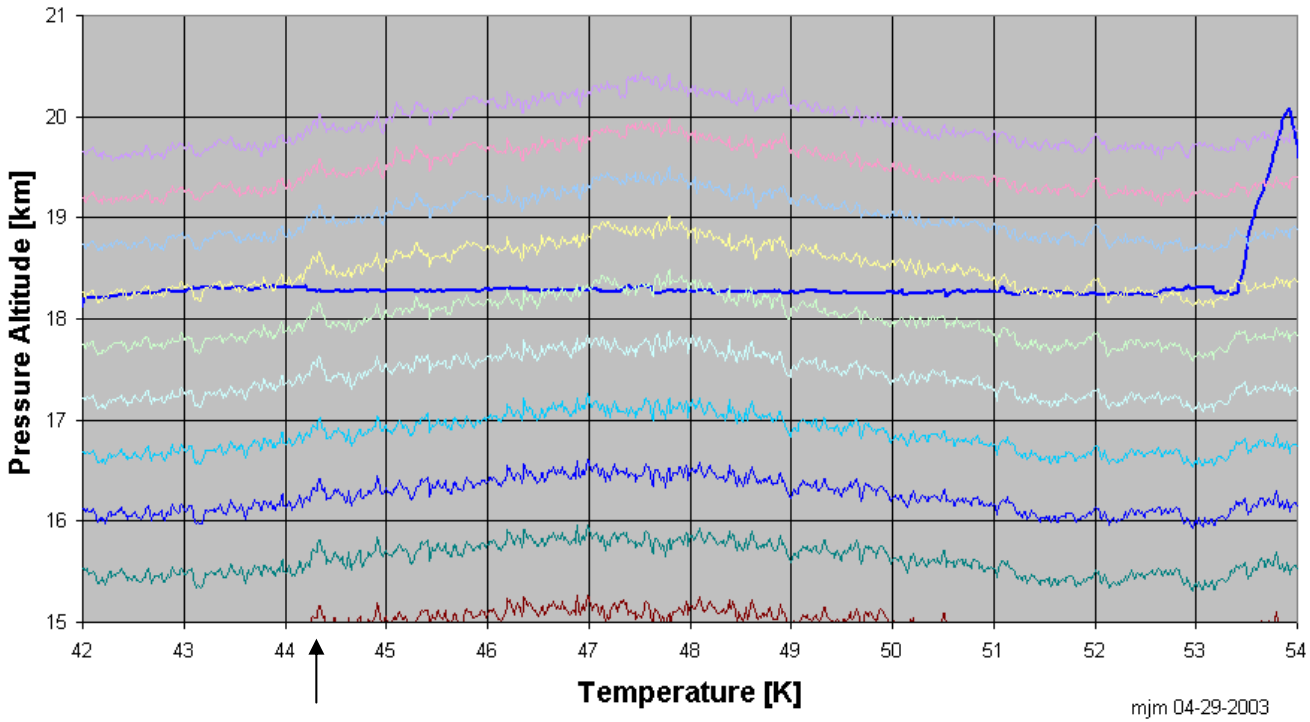
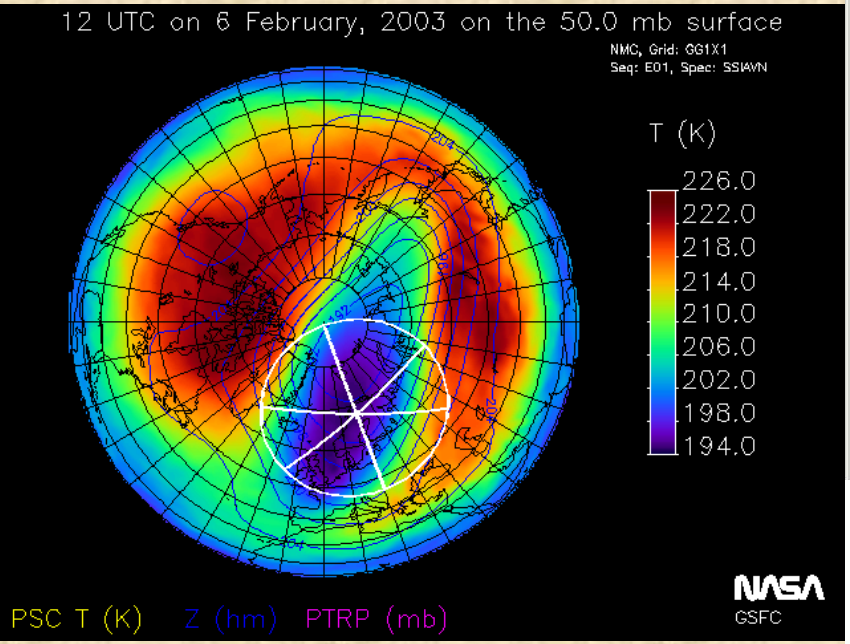
Isentrope Altitude Cross-Section

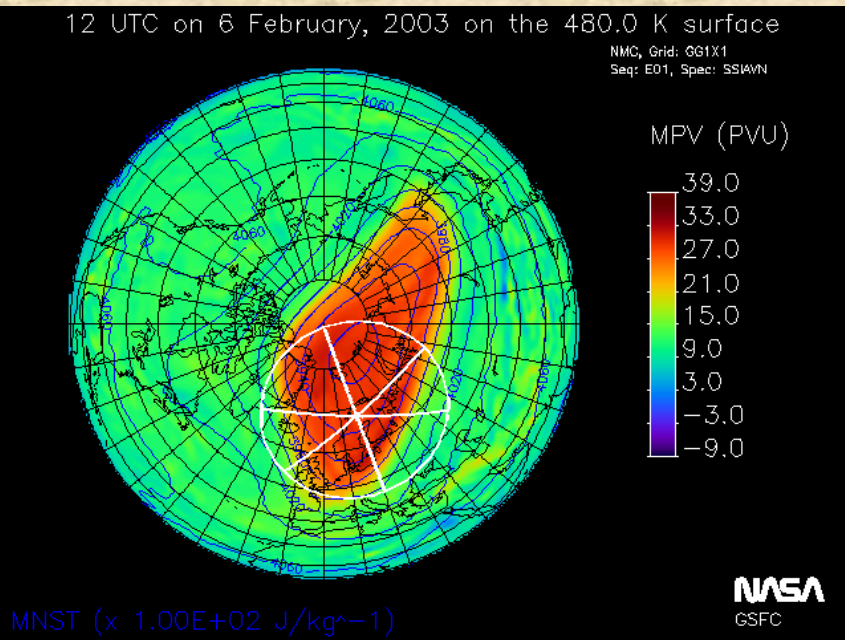
EUPLEX - M55 20030130

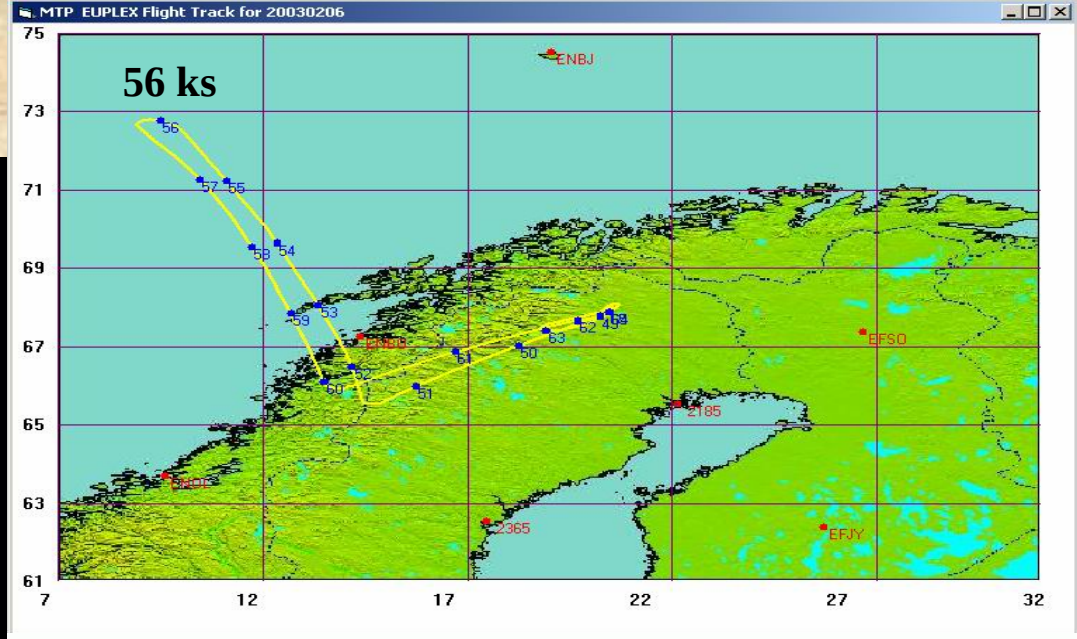


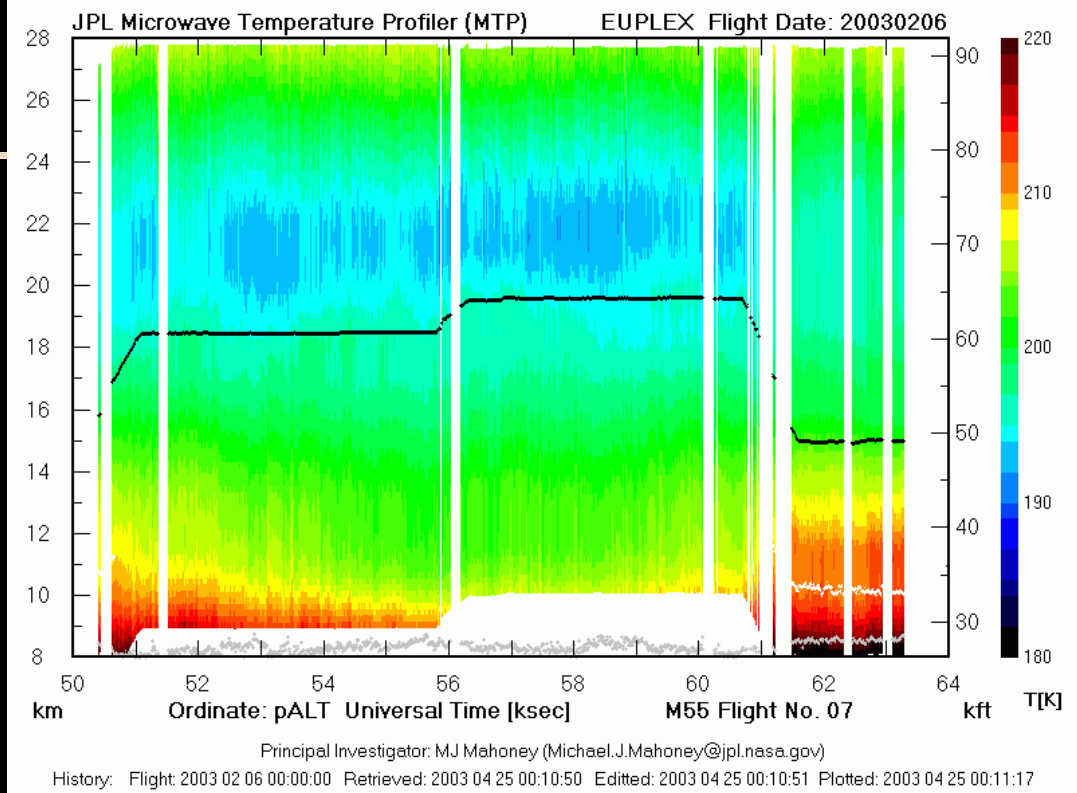
- Wind Speed: 16 kts
- Wind Direction: NW
- Lee Waves? Weak
- Wave at 44.3 ks near west coast of Norway
- Isentropes rise (as expected) as M55 flies deeper into the vortex

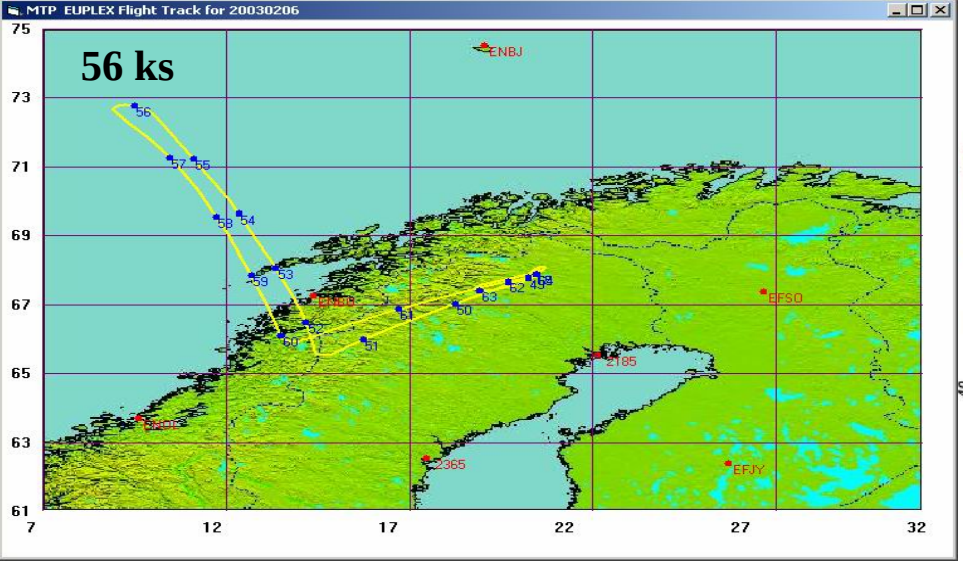
2003.02.06
Deep Inside Vortex & Cold Pool

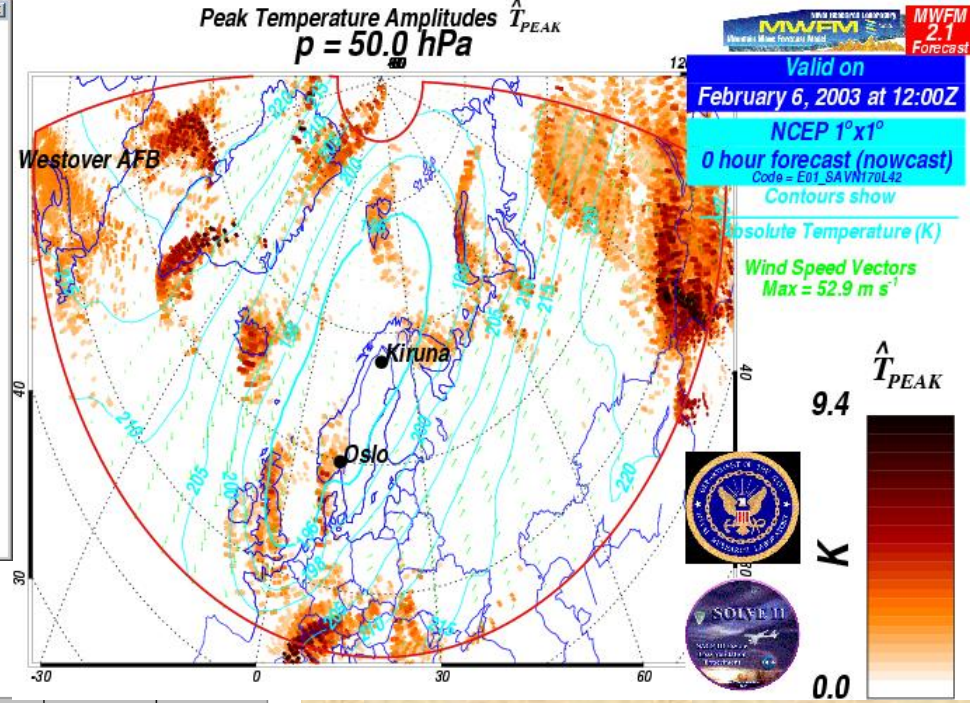


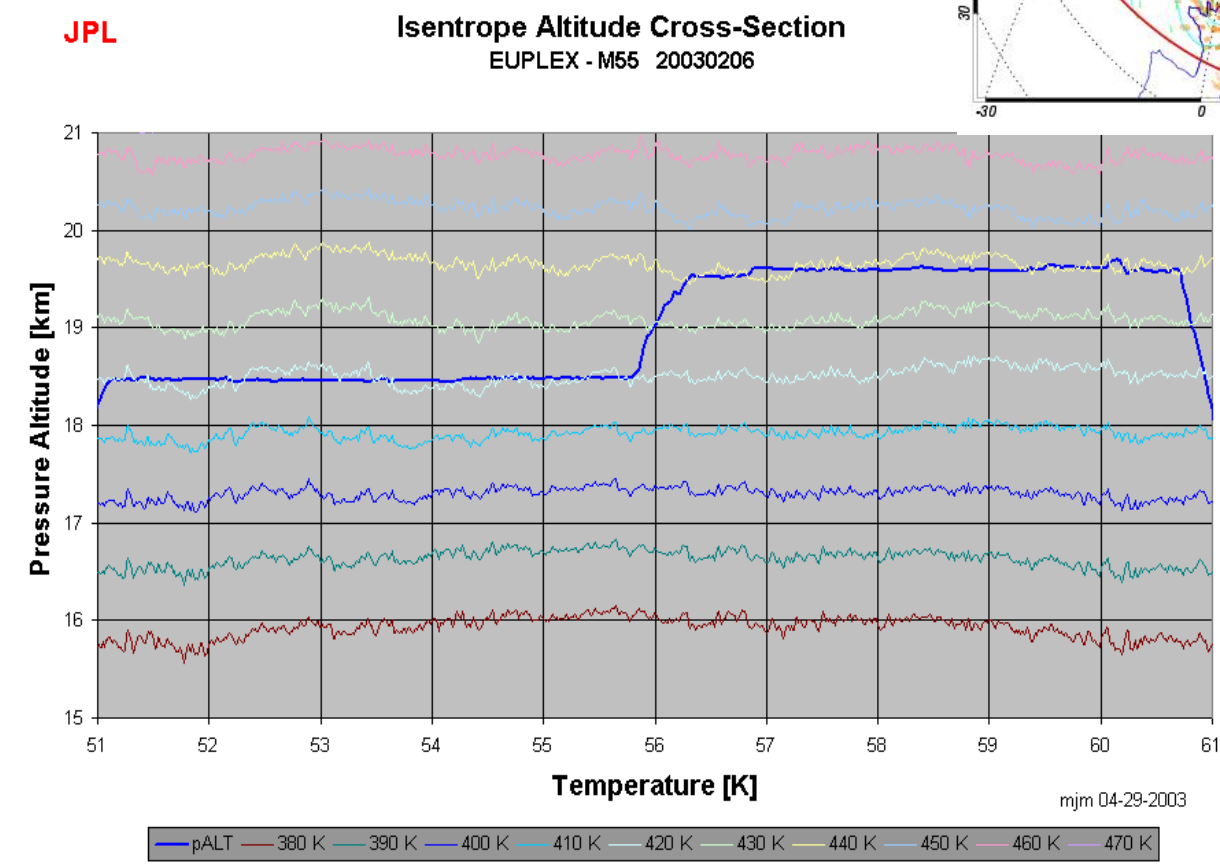






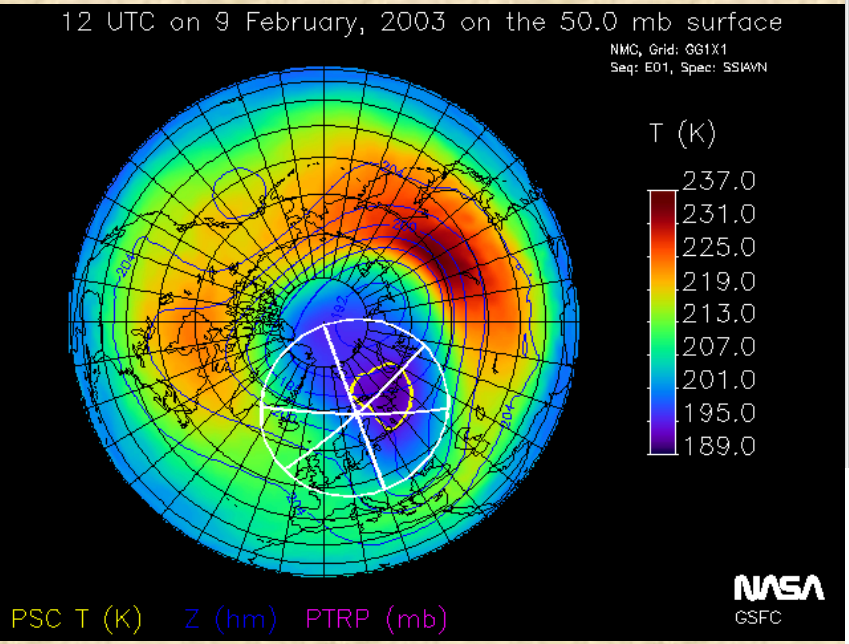


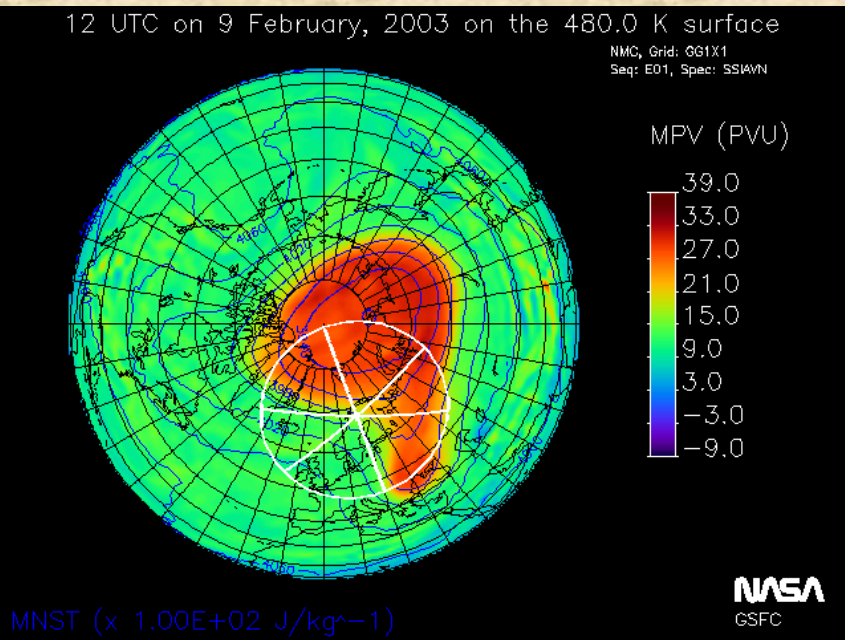


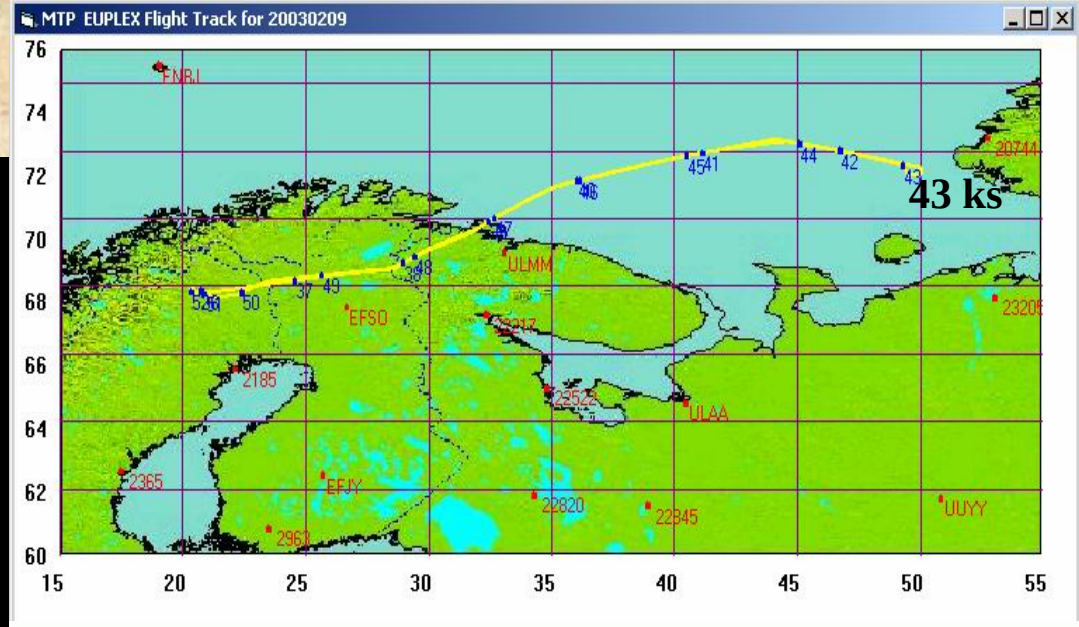


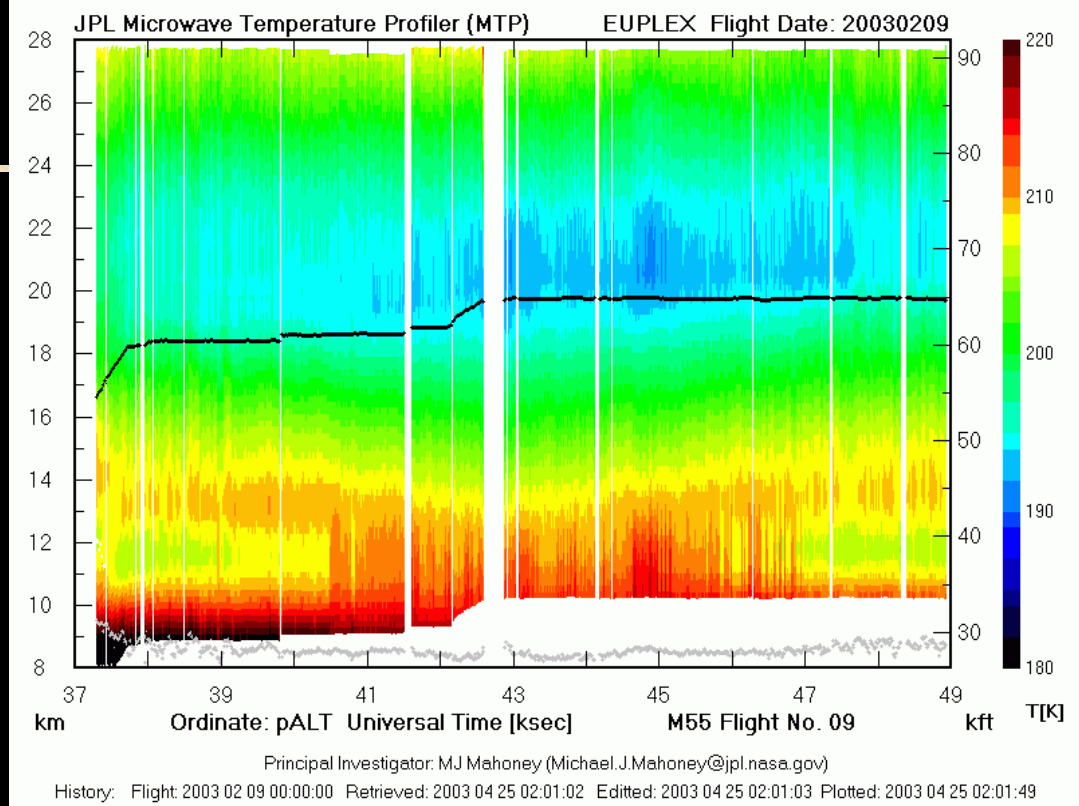
- Wind Speed: 10 kts
- Wind Direction: NW
- Lee Waves? None
- This is as expected deep in the vortex
- Isentropes are 1km higher
- May be low amplitude, $\lambda \sim$ 200 km inertia-gravity waves present over the ocean

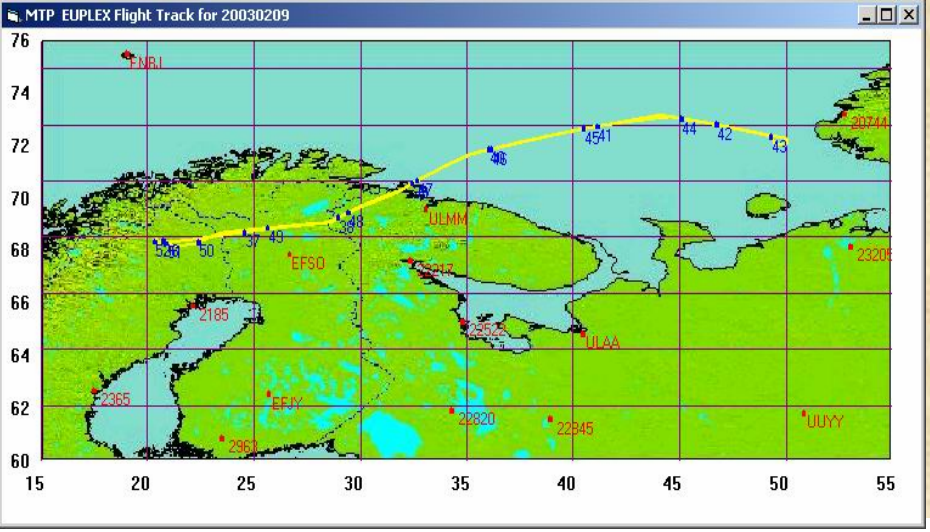
2003.02.09
Vortex Edge: Into Vortex,Cold Pool

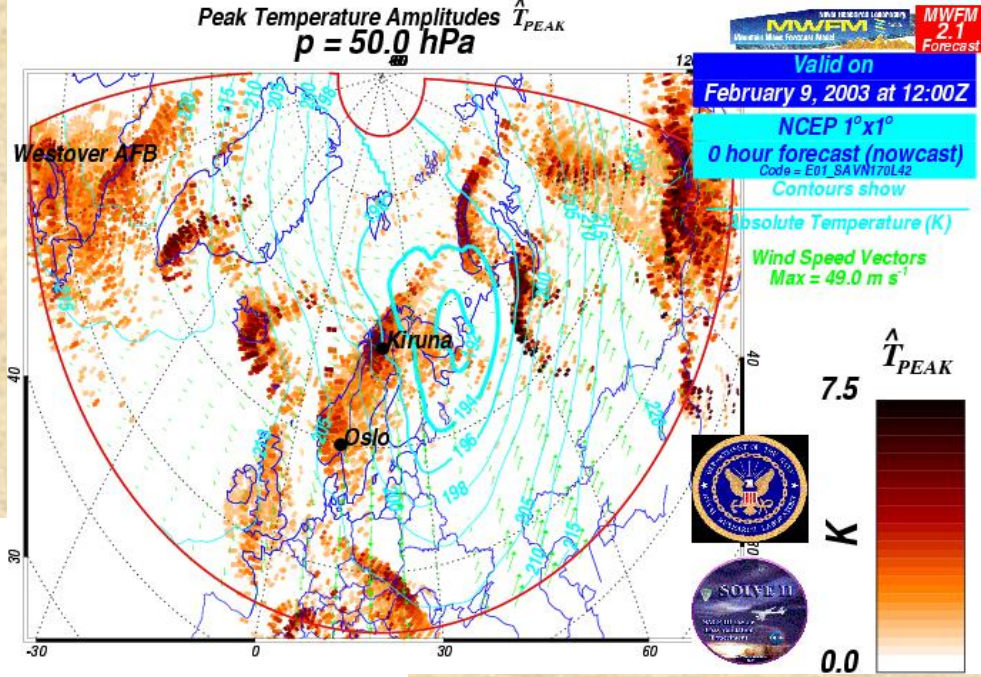












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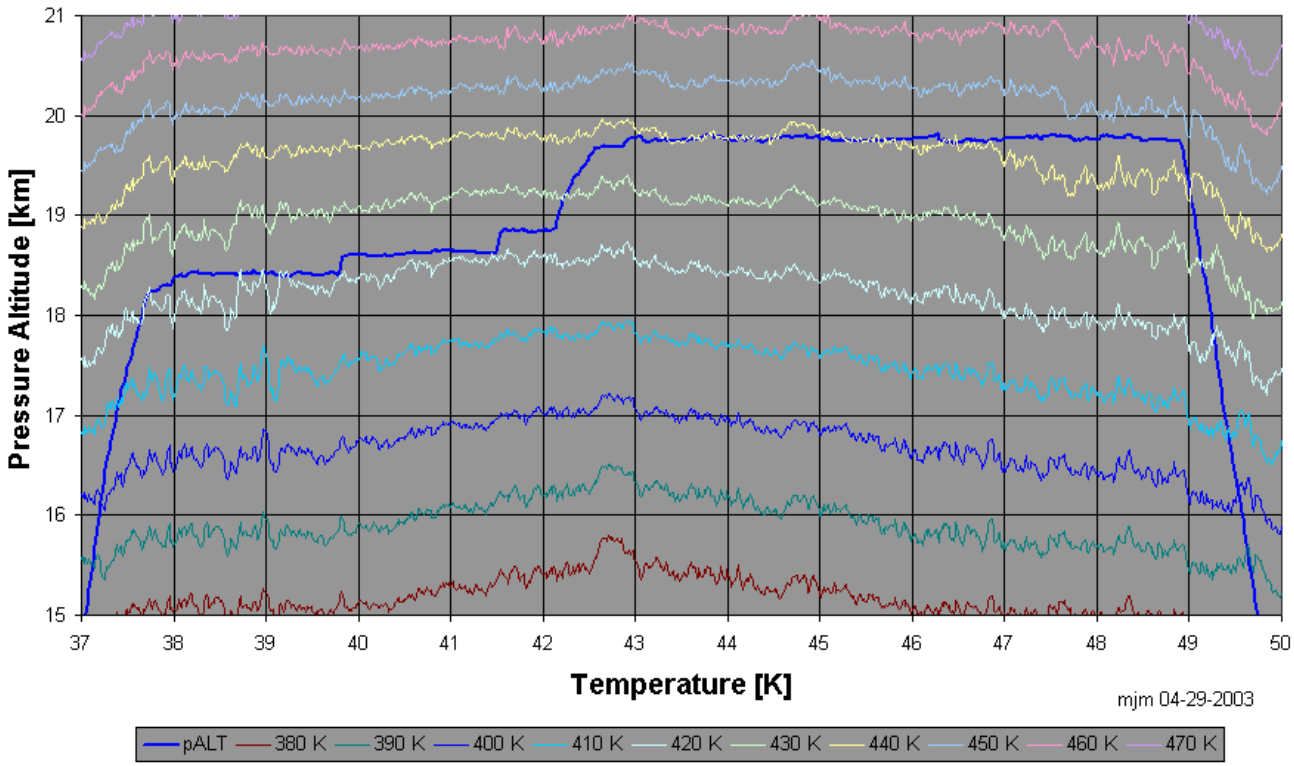
Isentrope Altitude Cross-Section
EUPLEX - M55 20030209



- Wind Speed: 27 kts
- Wind Direction: WNW
- Lee Waves? Moderate
- 500 meter mesoscale fluctuations present near edge of vortex; these die as the M55 goes deeper
- Tropopause inversion vanishes deep in vortex

Summary Remarks

- MTP temperature calibration is in excellent agreement with radiosondes near the Geophysica flight track. This should be expected since the MTP is calibrated against radiosondes.
- Post-mission retrieval coefficients capture the wide range of temperatures seen in the stratosphere during EUPLEX
- MTP measurements are important for understanding the mesoscale structure between the sparsely located radiosonde launch sites, especially the temperature structure entering and leaving the vortex, as well as the temperature structure above the M-55 flight altitudes.
- MTP-derived isentropes indicate that wave activity was weak during EUPLEX. This was in agreement with the MWFM.

Acknowledgements

• This work was supported by Dr. Mike Kurylo of the NASA Upper Atmosphere Research Program.

• We thank NASA GSFC Code 916 for the use of the potential vorticity and temperature fields.

• We thank NRL for the MWFM 2.1 lee wave activity forecasts.