Correcting Dew Point Measurements for Pressure

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RAF Algorithm Review

10/12/2011

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- Chilled mirror inside
- Note small hole
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- Temperature at which ambient vapor pressure is in equilibrium w/ water

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Dew Point Definition:

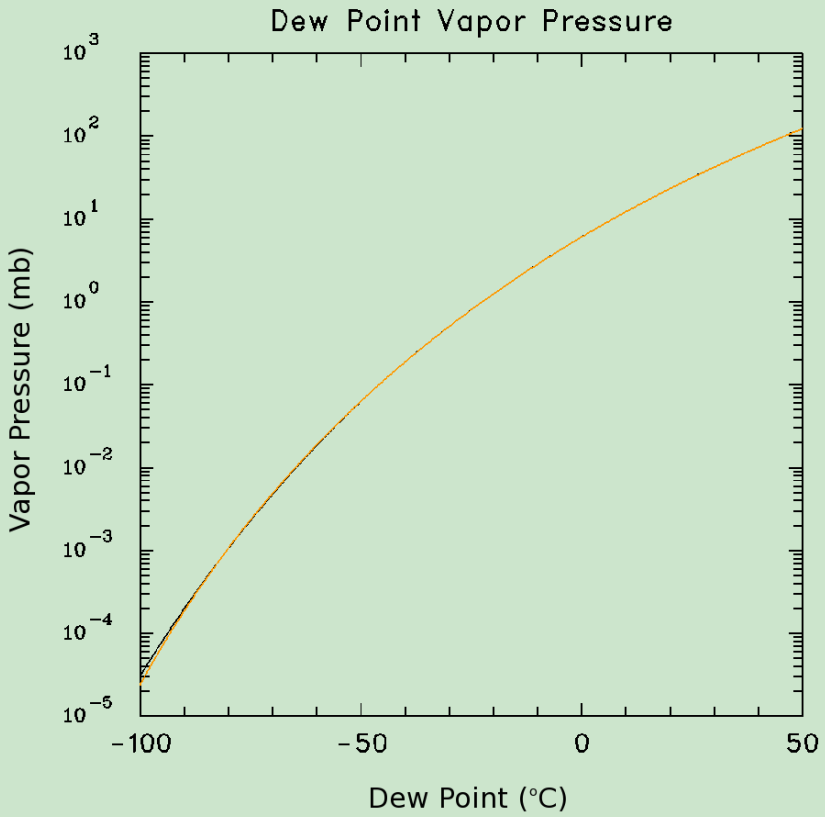
- Temperature at which ambient vapor pressure is in equilibrium w/ water
- Vapor pressure change: proportional to total pressure

SENSITIVITY TO PRESSURE

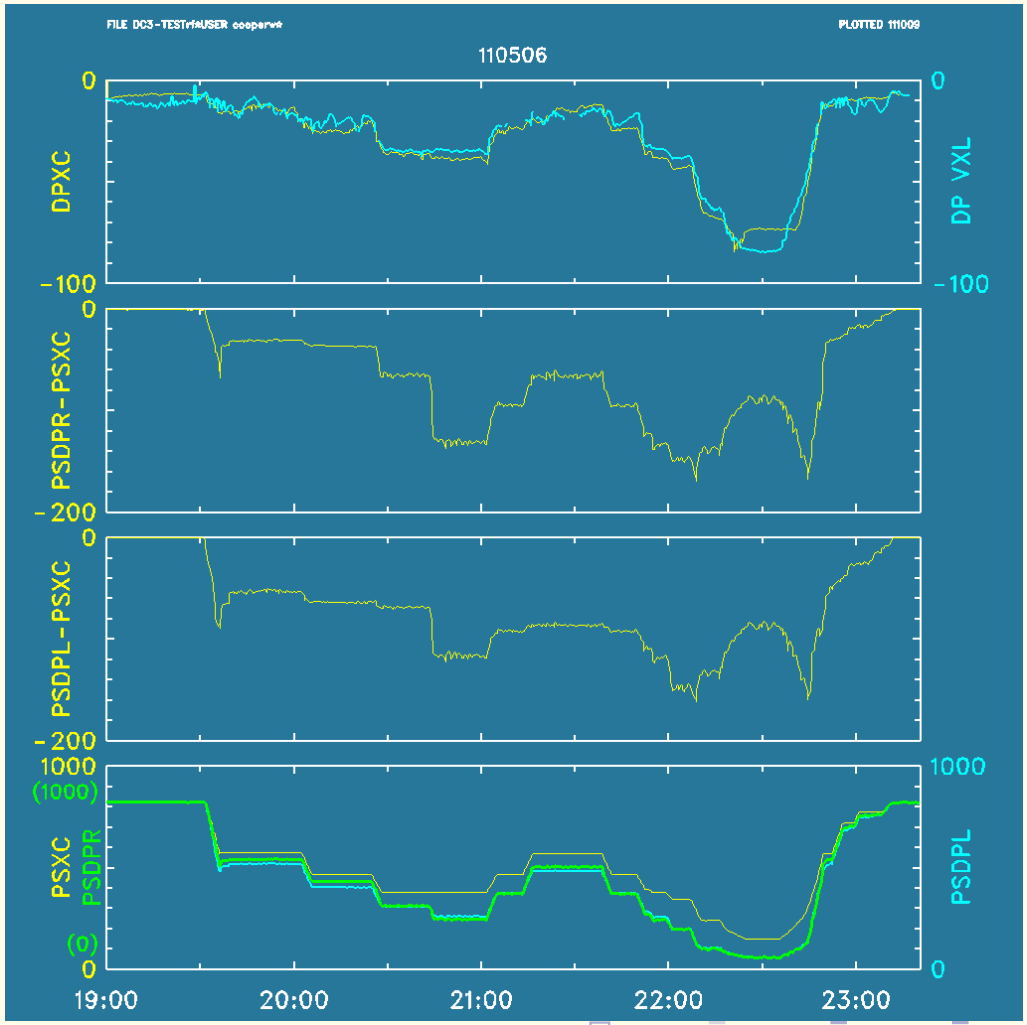
Vapor Pressure at Equilibrium

- Change in vapor pressure of -50% or +100%:
  - near 0°C, dew point changes by approx. 10°C
  - near -50°C, dew point changes by approx. 6°C

1°C error in dewpoint for 8% change in vapor pressure @ $T_{DP} = 0°C$;
for 12% change @ $T_{DP} = -50°C$.
$\pm 10\%$ errors are significant

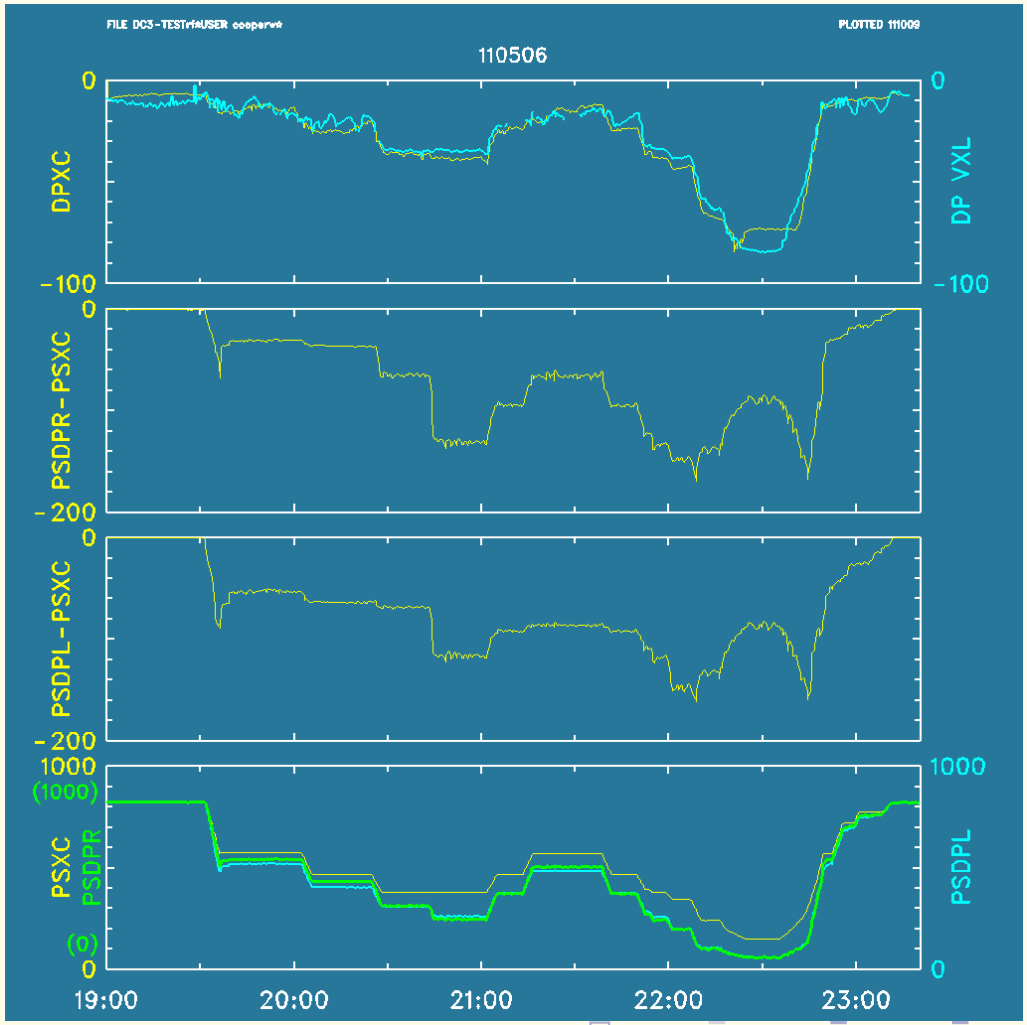


HOW LARGE IS THE PRESSURE DEVIATION?



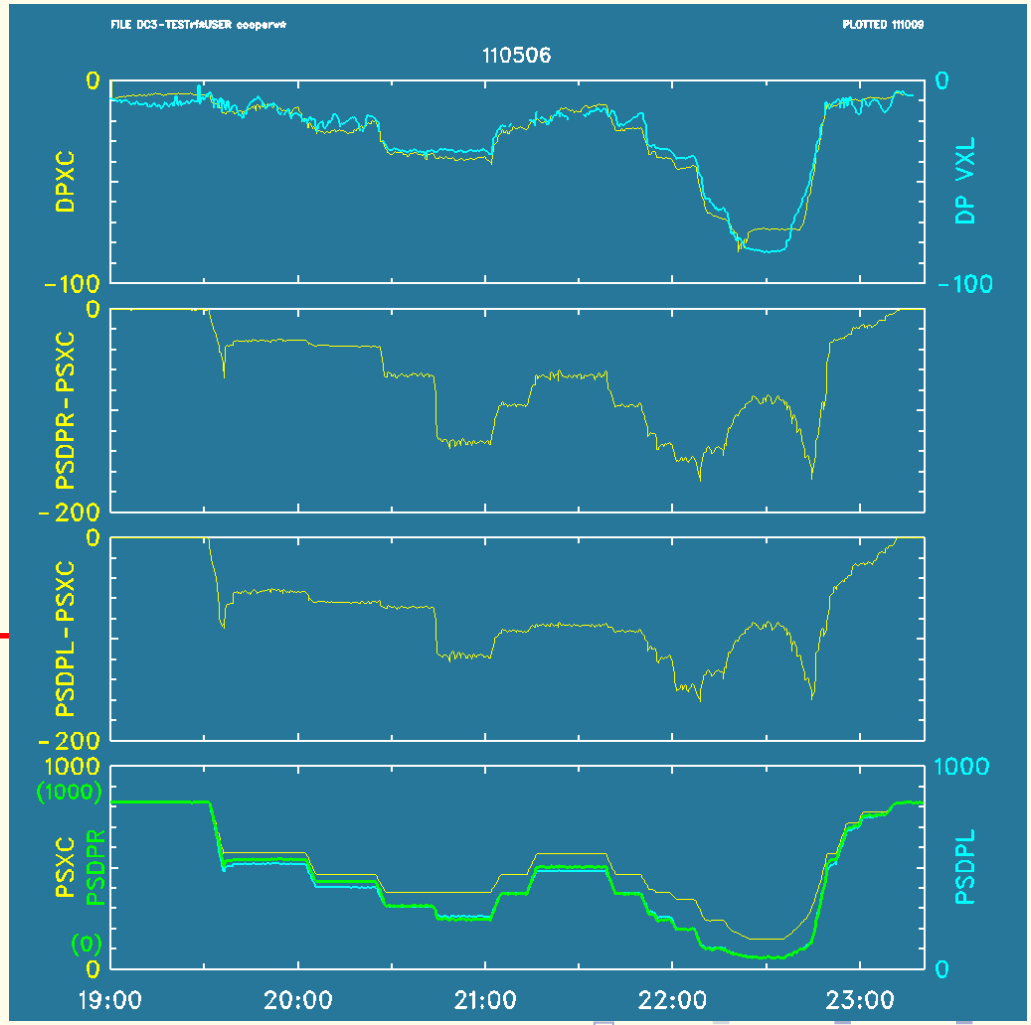
HOW LARGE IS THE PRESSURE DEVIATION?

PSXC (yellow) compared to PSDP{R,L} (cyan, green) - Note ca. 100 mb difference at max altitude



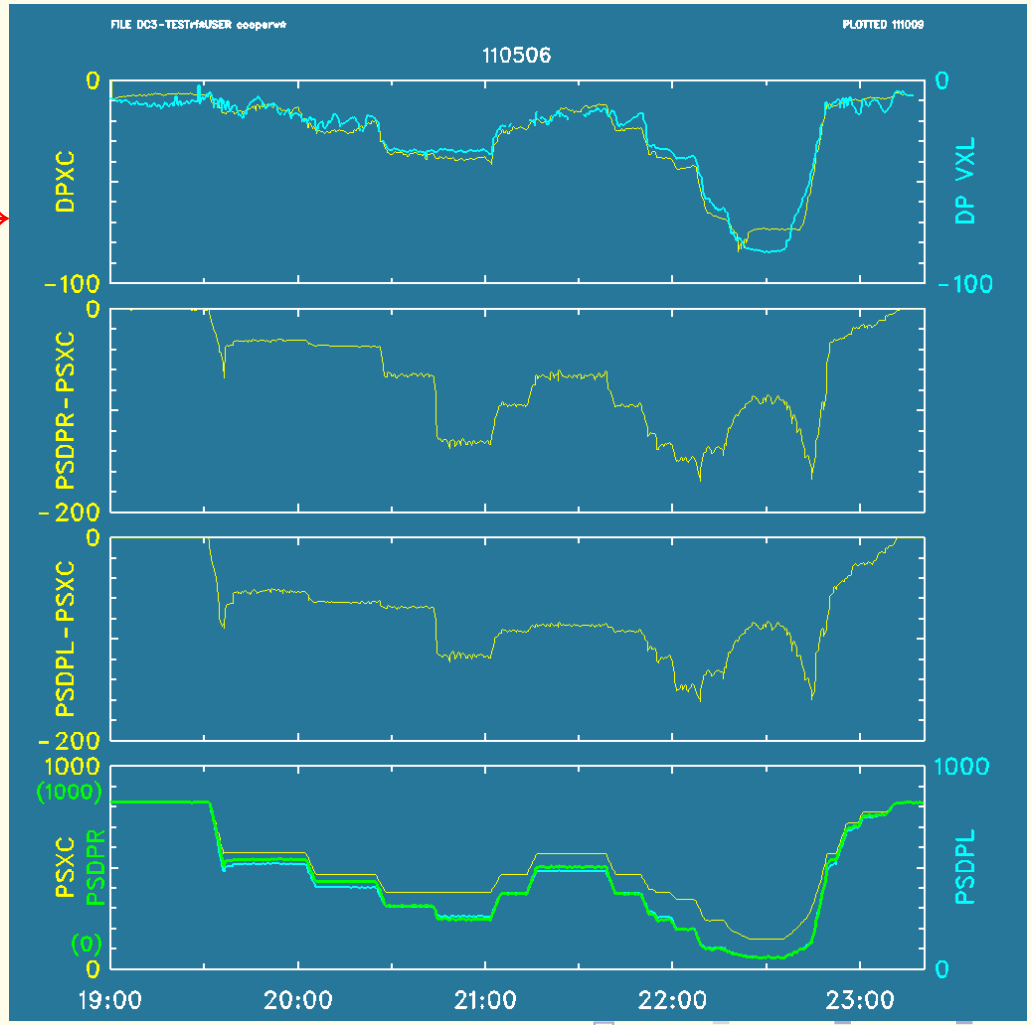
HOW LARGE IS THE PRESSURE DEVIATION?

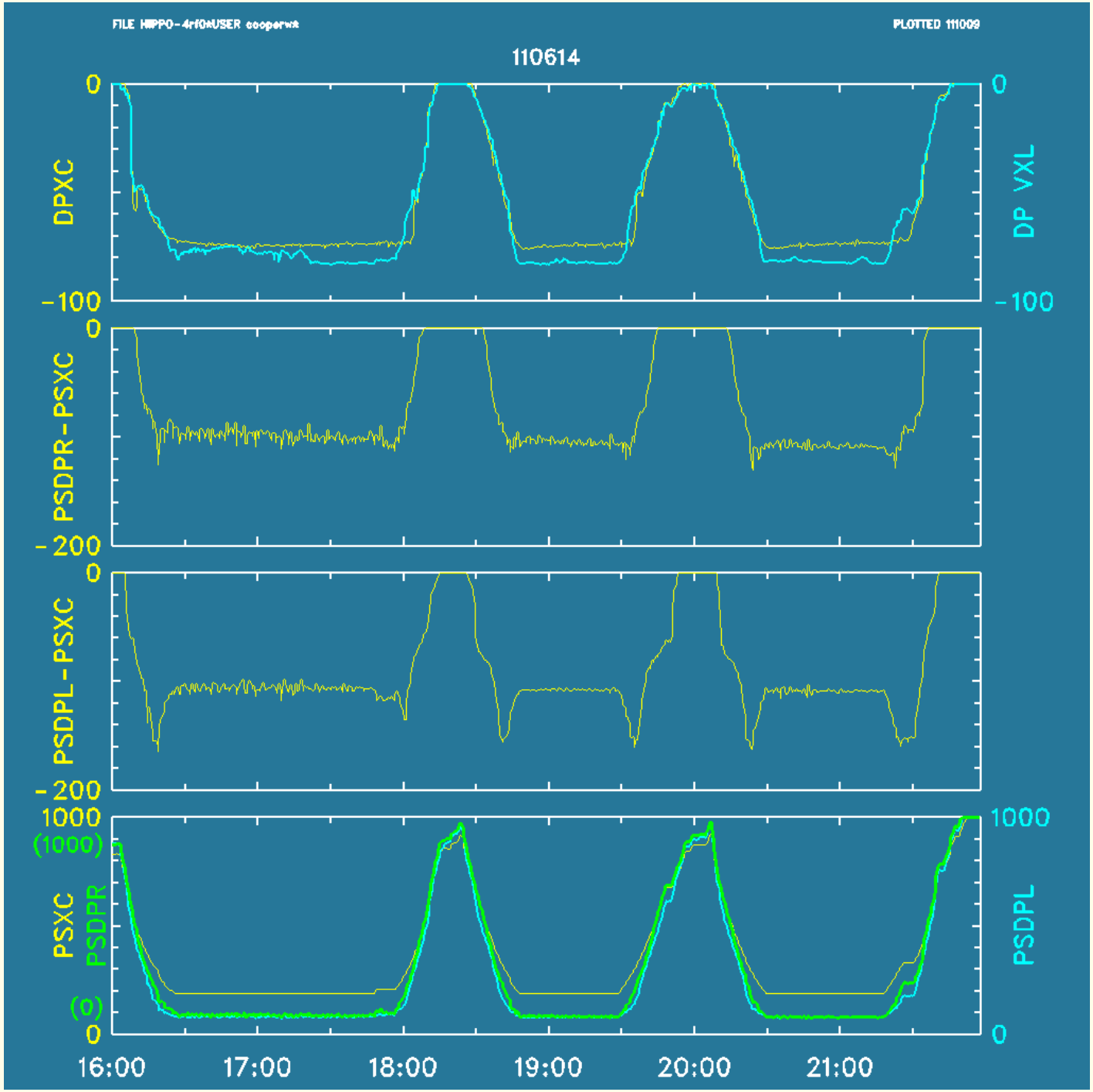
Extreme deviations run up to 180 mb, with a pressure *deficit* at high altitude.



HOW LARGE IS THE PRESSURE DEVIATION?

Pressure correction will *increase* the dew point. Comparison with VCSEL (cyan trace) is already fairly good, may get worse?

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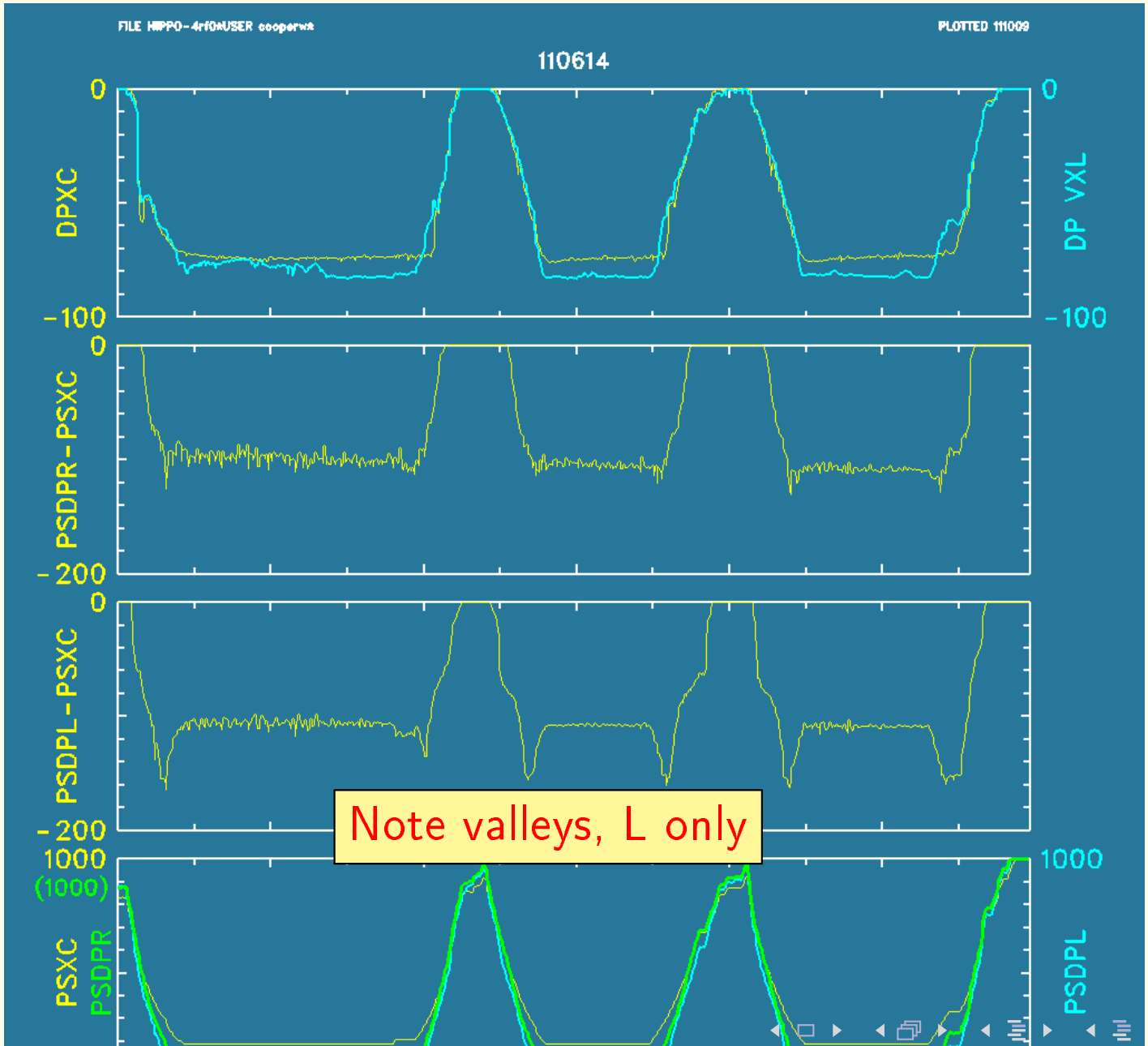
PLOTTED 111009
110614
DPXC
DP VXL
PSDPR-PSXC
PSDPL-PSXC
PSXC
PSDPR
PSDPL
0
-100
-200
1000
(1000)
(0)
16:00
17:00
18:00
19:00
20:00
21:00


FILE HIPPO-4rf0nUSER cooperwk
PLOTTED 111009
110614
DPXC
0
-100
DP VXL
PSDPR-PSXC
-200
PSDPL-PSXC
Note valleys, L only
PSXC
PSDPR
(1000)
1000
PSDPL

ALGORITHM WHEN PSDPx IS AVAILABLE

Modified DPXC

1. Obtain vapor pressure from measured DPx
2. Correct for "enhancement factor"
3. Scale vapor pressure by F={PSXC}/{PSDPx}
4. Get DPXC via interpolation table, e to DPXC

Available since DC3-TEST, May 2011

Includes HIPPO-4, HIPPO-5, ICEBRIDGE

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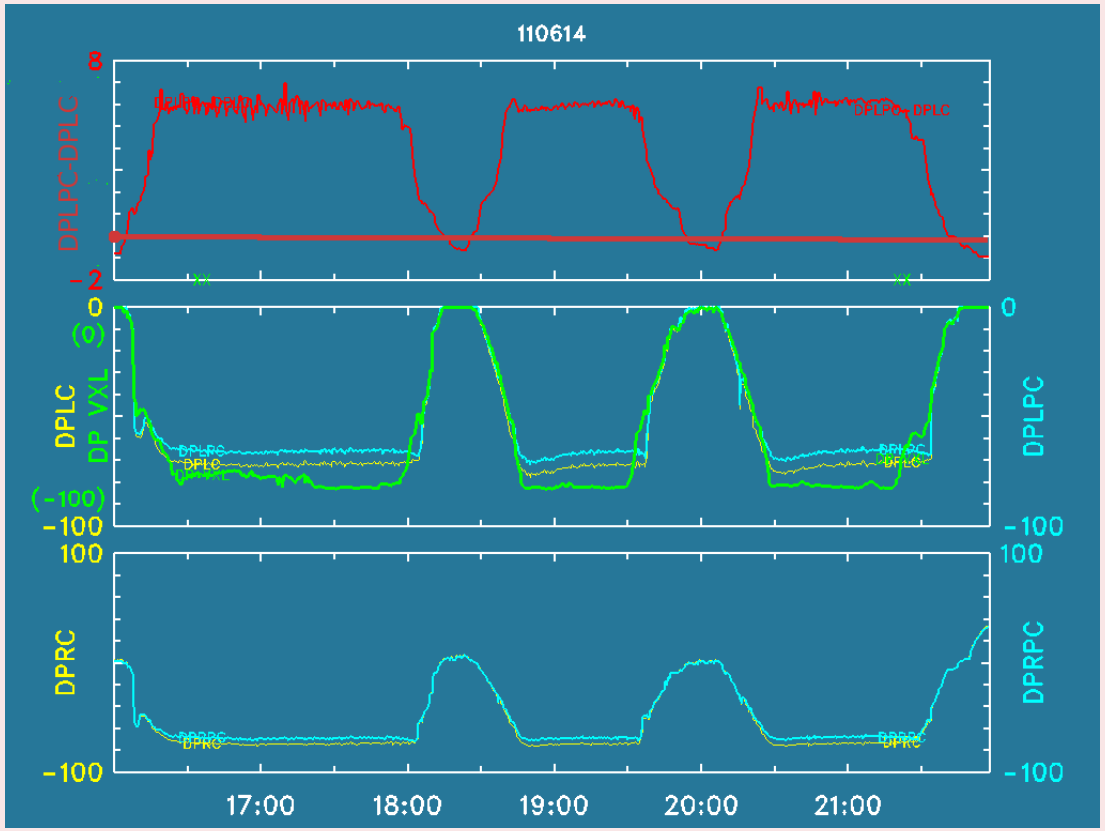
Errors

- Errors range from slightly high to 6C too low

Are Errors Important?



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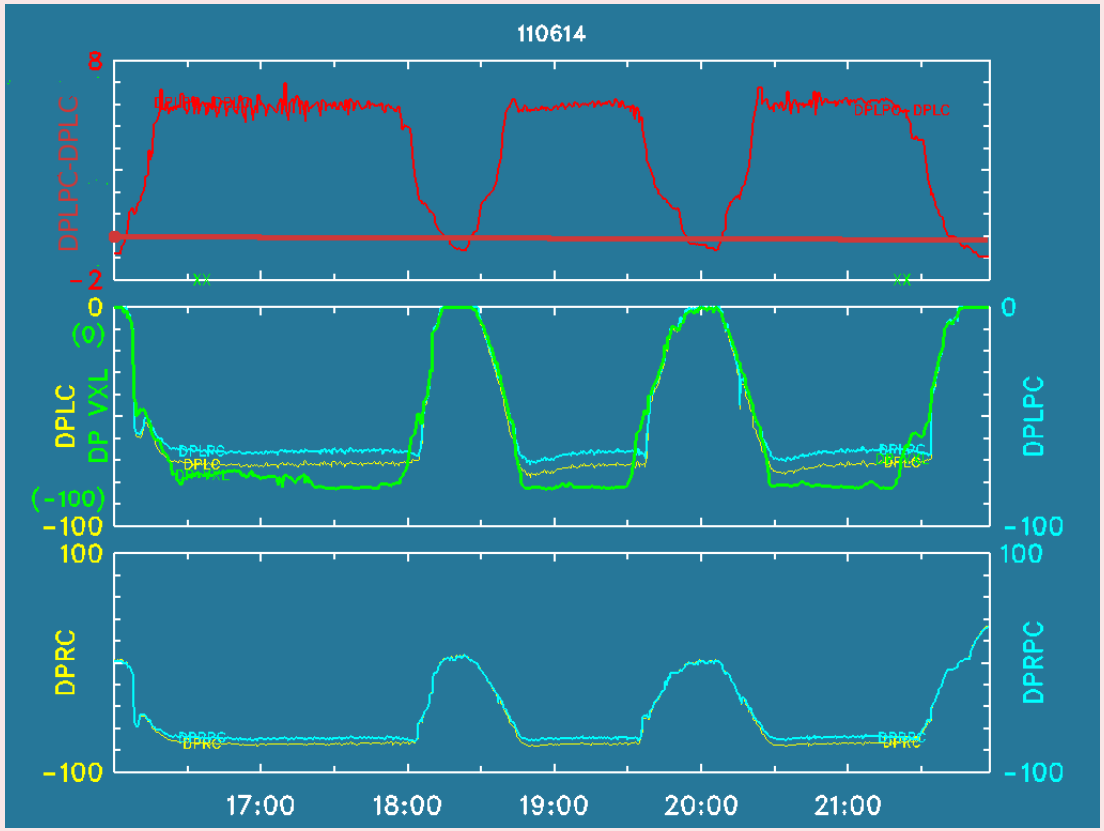

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- Where VCSEL measures about -80C, DP now is between -60C and -65C

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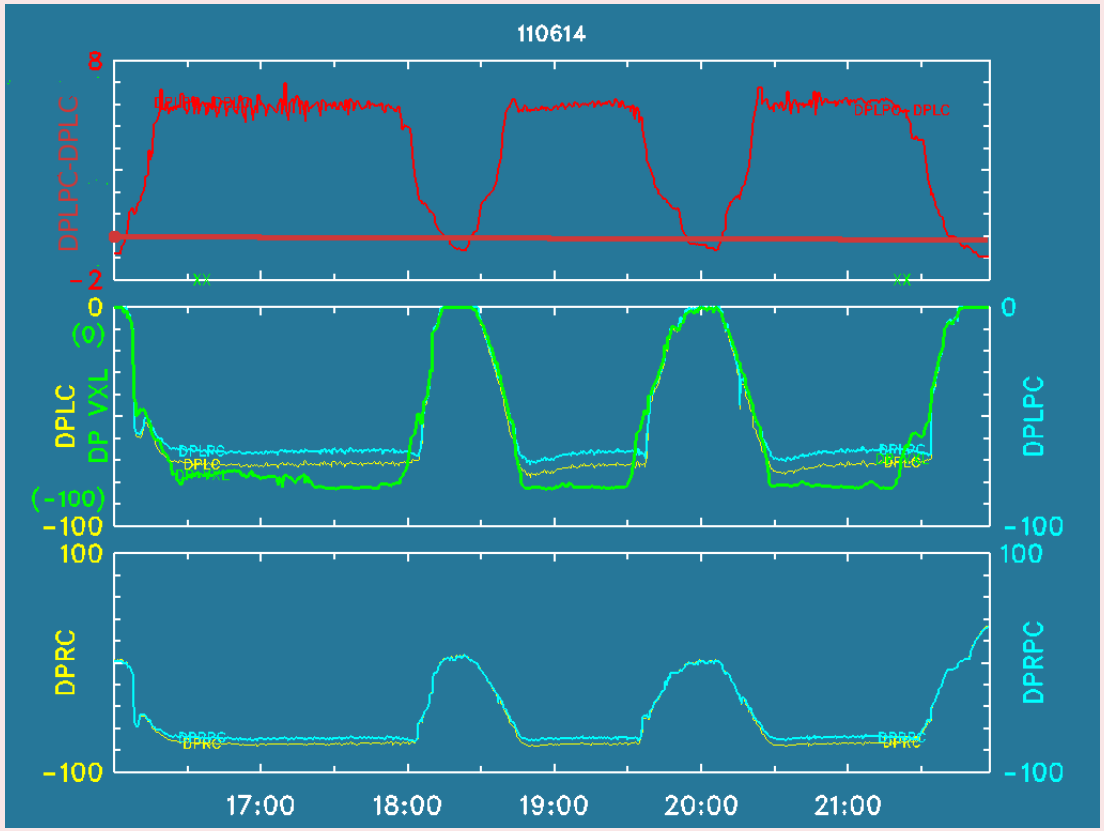

POSSIBLE CORRECTION PROCEDURE

- Find which aspects of flight conditions determine the pressure deficit
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POSSIBLE CORRECTION PROCEDURE

- Find which aspects of flight conditions determine the pressure deficit
- From exploring these possibilities, found PSXC, XMACH2, QCRC seem to be best
- Fit determined for HIPPO-4 RF01. (Coefficients in memo)
- Possible dependence on PSXC, Mach No, TAS, QCRC, ATTACK, SSLIP.
- Best fit, for PSDPL:

$$P_{DP} = P_a a(a_0 + a_1 \Delta \mathrm{p} + a_2 M^2)$$

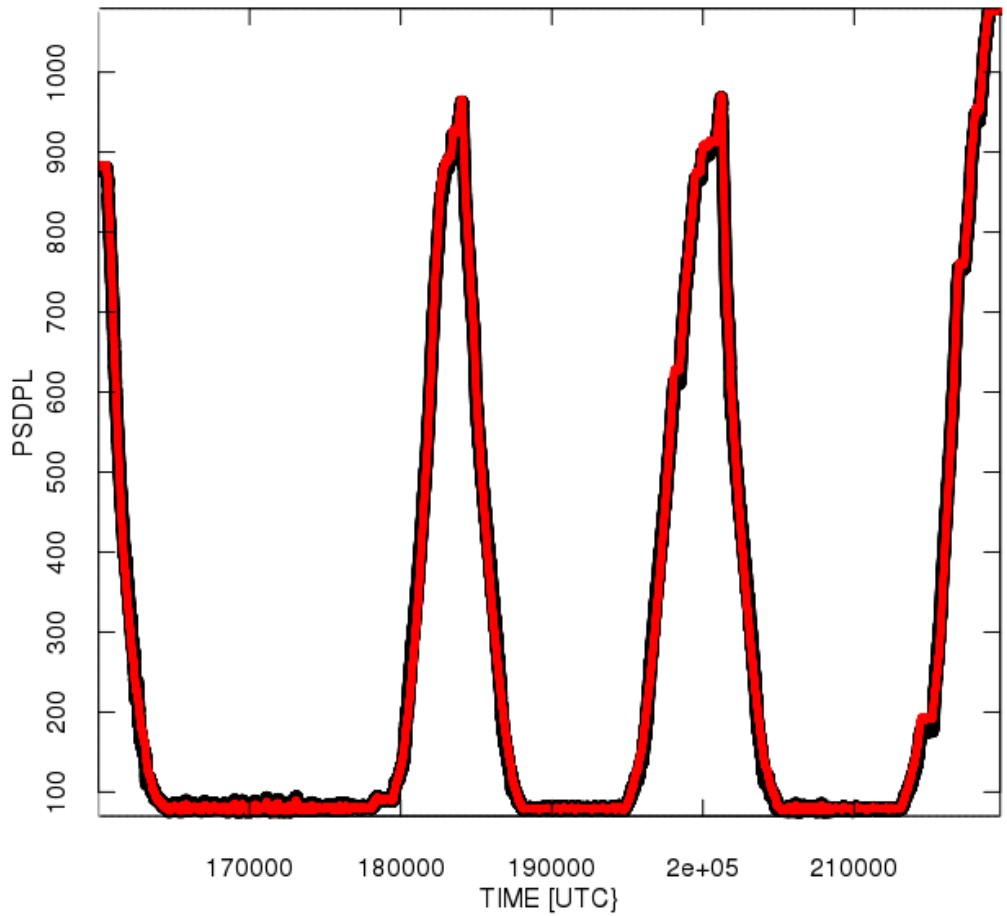
- Test: apply to DC3-TEST (RF03), different project and different flight profile

FIT RESULTS

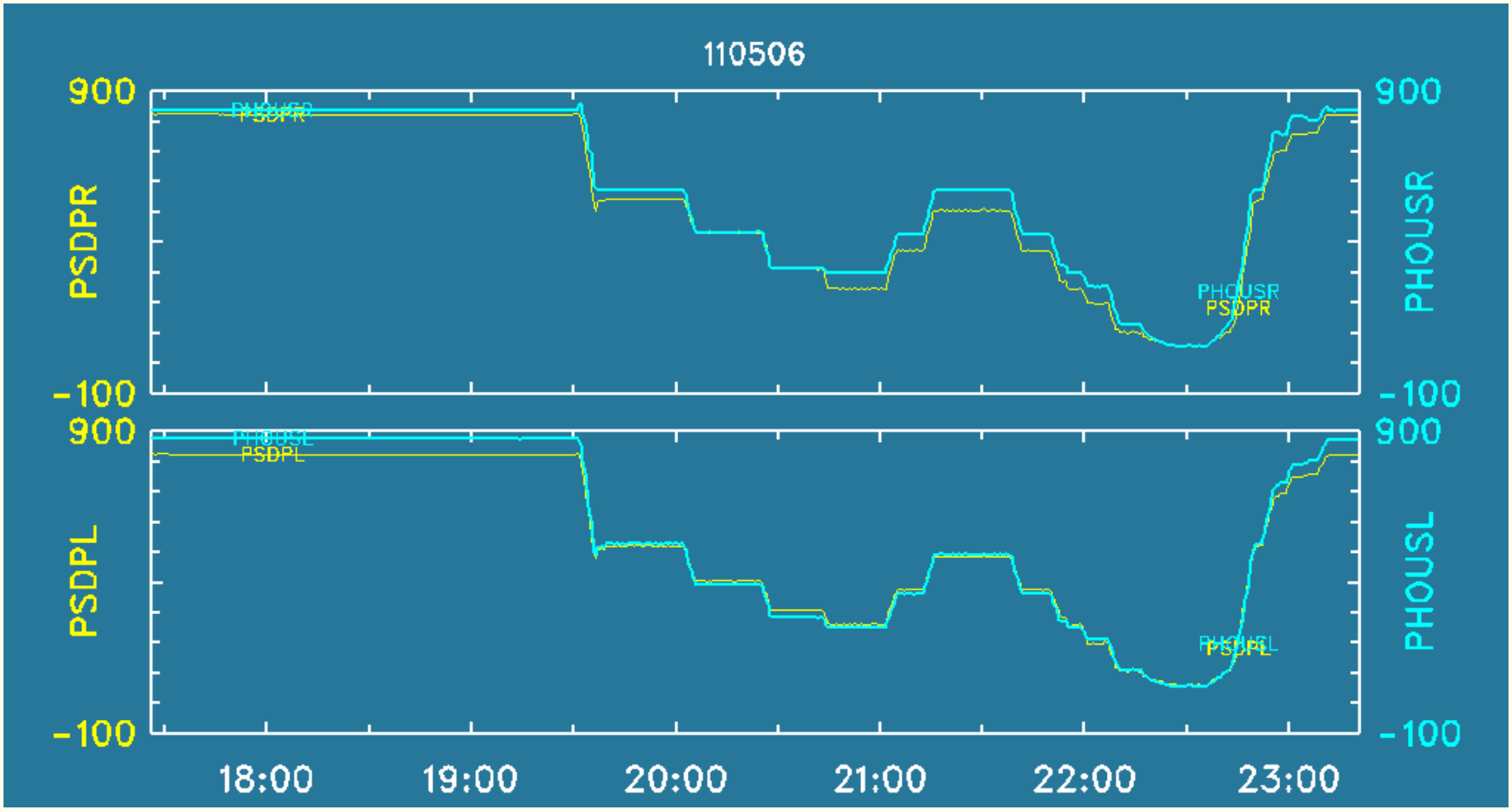
Black Line:
Measured PSDPL

Thin red line:
Results of fit

Fit RMS: 7.9 mb



APPLICATION TO A DIFFERENT FLIGHT



CONCLUSIONS

Recommendations:

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    1. Calculate the pressure ratio PSXC/PSDPx =Rx
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2. For old GV data, consider reprocessing with the pressure determined from (1) to correct for rather large errors in the dew point measurements, which can be 5-10°C.
3. Change the "long_name" of DPLC and DPRC to distinguish them from DPLS/DPRS.