Cryogenic Hygrometer
and
Filter Radiometers

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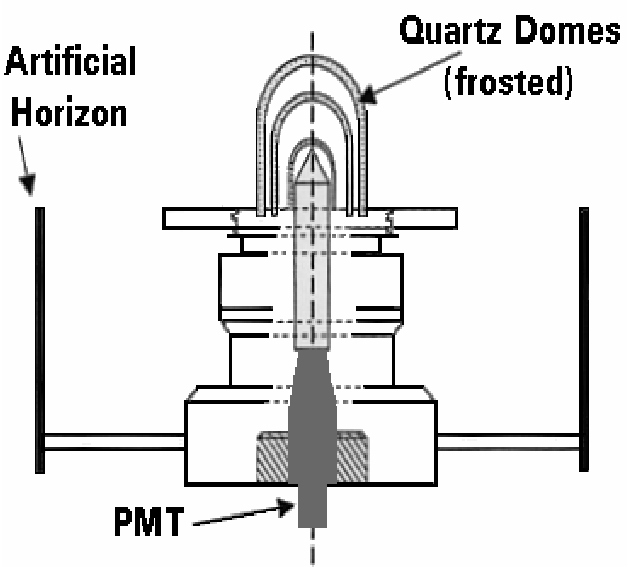
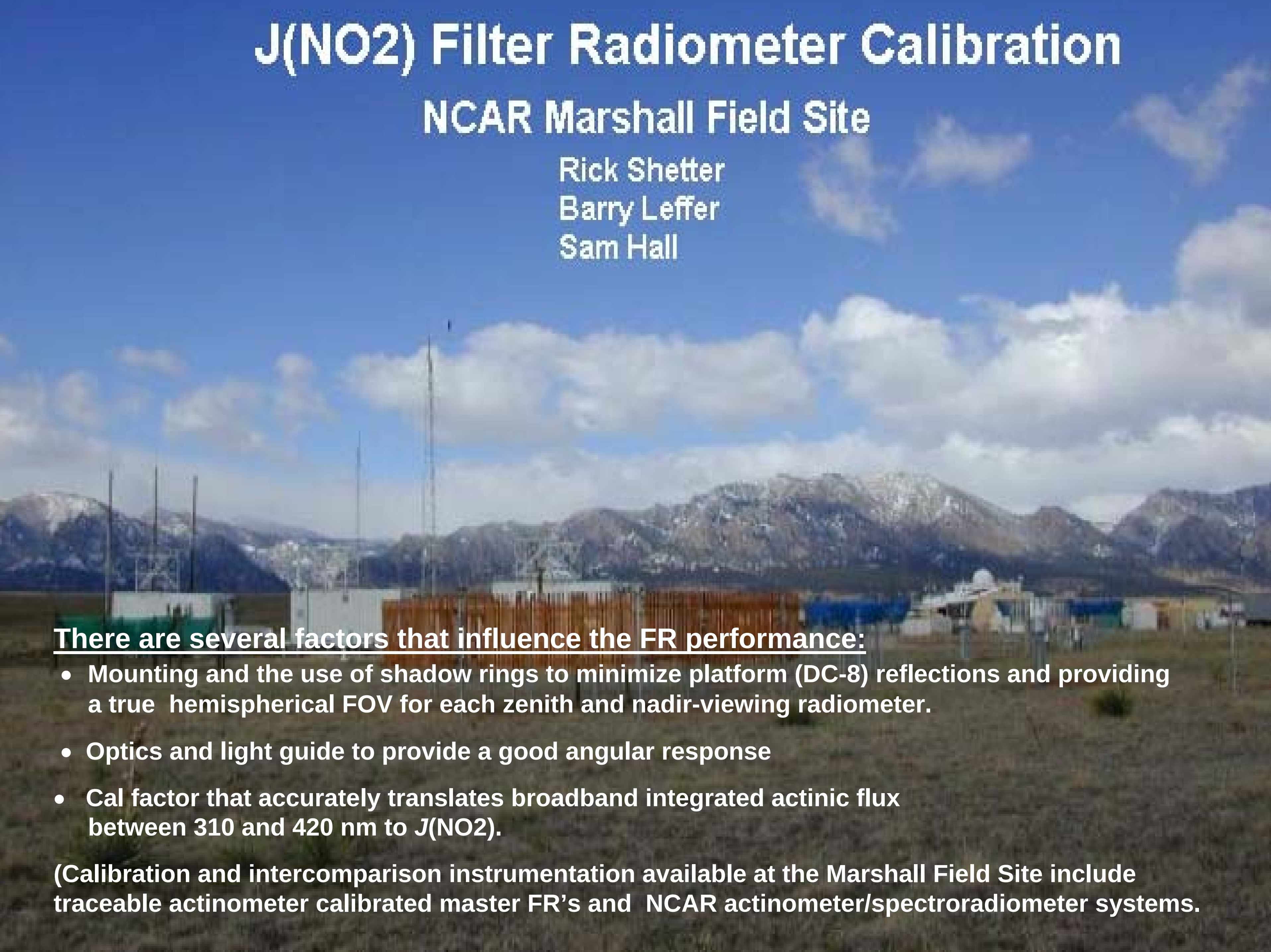
Filter Radiometer - Photolysis Rate of NO_2

$J(NO_2)$ - FILTER RADIOMETER
Commercially Available - METCON

TECHNIQUE	Solar radiative flux measured with photodiode tube via frosted quartz hemispherical dome and rod for a light guide and optimum glass filters.
BAND-PASS FILTERS	310 → 420 nm (2*UG3 + 1*UG5) Restricts output signal to broadband integrated actinic flux - proportional to photolysis rate of NO_2.
CALIBRATION	Calibrated with reference $j(NO_2)$ radiometer traceable to a chemical actinometer.
UNCERTAINTY	10 %
UNITS	J(NO2)- sec^{-1}





J(NO2) Filter Radiometer Calibration

NCAR Marshall Field Site

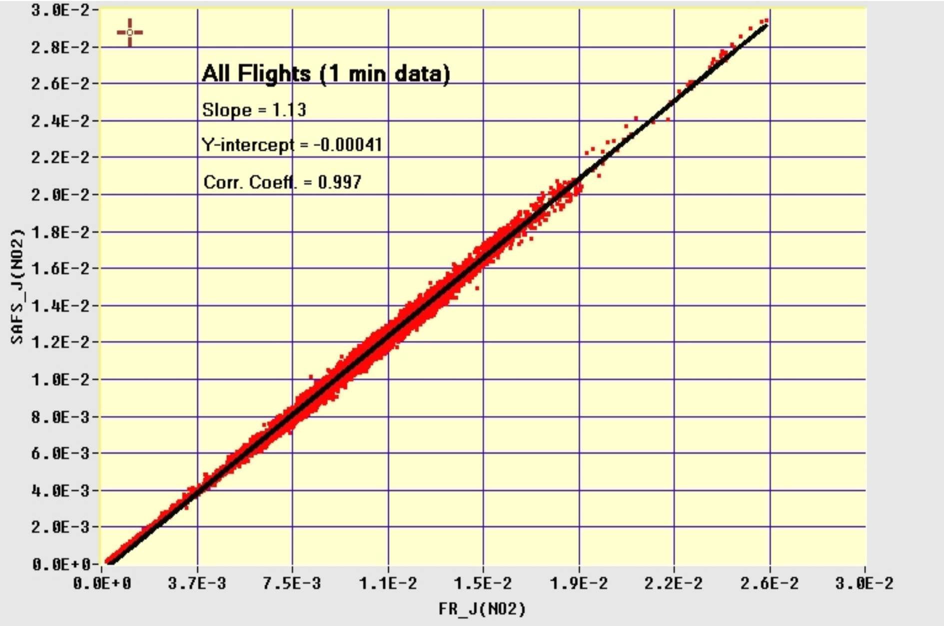
Rick Shetter
Barry Leffer
Sam Hall

<u>There are several factors that influence the FR performance:</u>

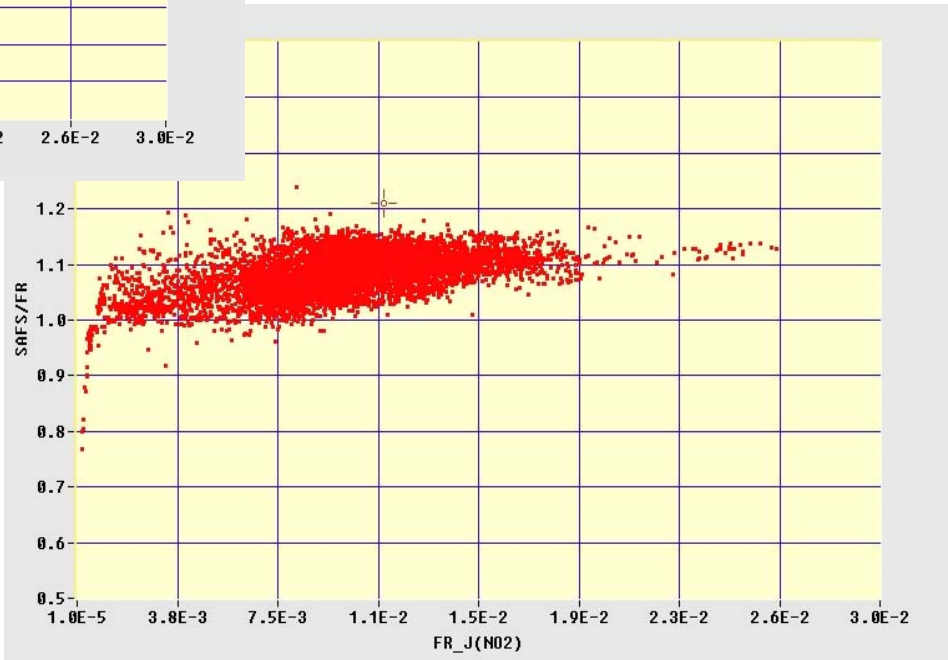
- **Mounting and the use of shadow rings to minimize platform (DC-8) reflections and providing a true hemispherical FOV for each zenith and nadir-viewing radiometer.**
- **Optics and light guide to provide a good angular response**
- **Cal factor that accurately translates broadband integrated actinic flux between 310 and 420 nm to *J*(NO2).**

(Calibration and intercomparison instrumentation available at the Marshall Field Site include traceable actinometer calibrated master FR's and NCAR actinometer/spectroradiometer systems.

DC-8 Filter Radiometer/SAFS Correlation



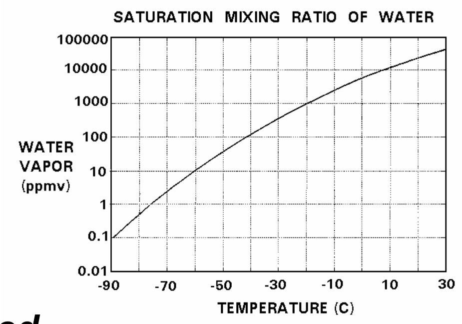
Correlation Plot



Ratio of Total J(NO2),
<u>SAFS</u>
FR

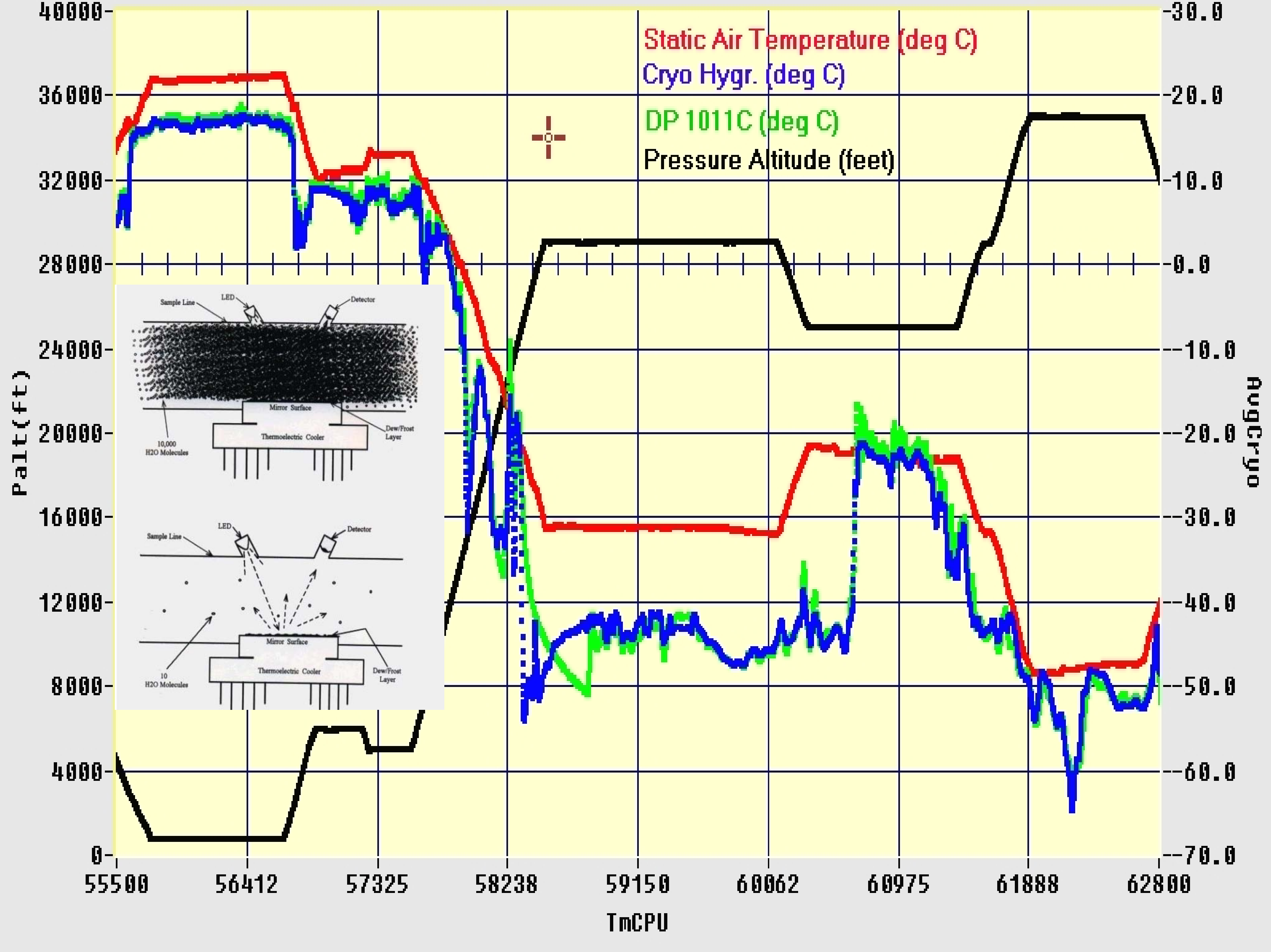
IN SITU H_2O VAPOR MEASUREMENTS
Cryo Hygrometer

Principal H_2O Vapor Measurement Technique - Chilled Mirror Hygrometry
Chilled mirror technique is capable of fundamental accuracy – measures a primary humidity parameter.



Tropospheric H_2O vapor concentrations vary dynamically over 5-6 orders of magnitude.

Enhance application of H_2O vapor data sets via an understanding of the measurement technique.
" ***…theoretical calculations and <u>published specs are limited in their descriptions of complex measurement conditions</u>.…
no one can anticipate all uses or combinations of environmental conditions to which an instrument will be subjected.
It is <u>important for the user to be aware of the sensors' limitations</u>.***"
<u>Sensors</u>, Oct, 1991

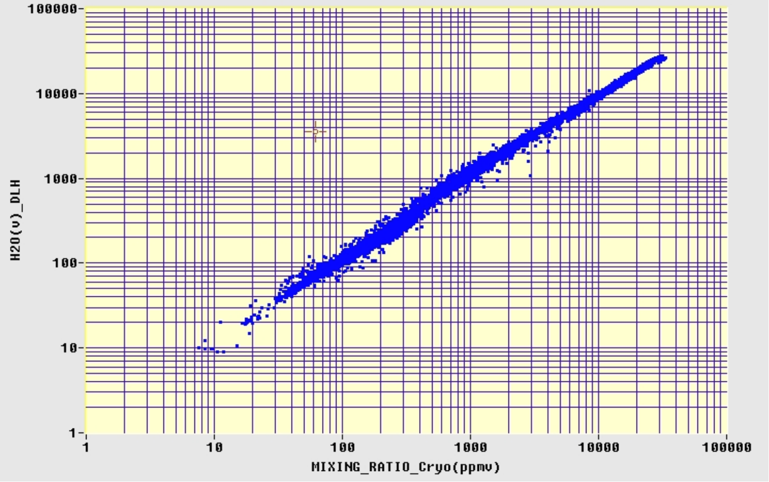


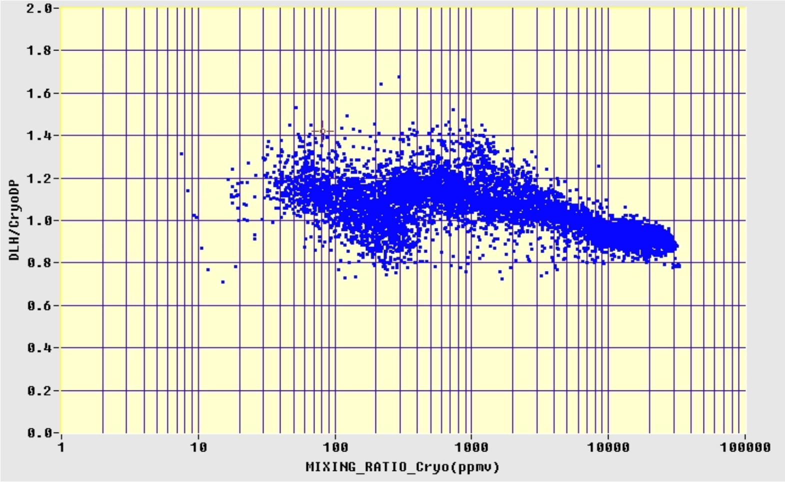
Static Air Temperature (deg C)
Cryo Hygr. (deg C)
DP 1011C (deg C)
Pressure Altitude (feet)
Palt(ft)
AvgCryo
TmCPU
40000
36000
32000
28000
24000
20000
16000
12000
8000
4000
0
-30.0
-20.0
-10.0
-0.0
--10.0
--20.0
--30.0
--40.0
--50.0
--60.0
--70.0
55500
56412
57325
58238
59150
60062
60975
61888
62800
Sample Line
LED
Detector
Mirror Surface
Thermoelectric Cooler
Dew/Frost Layer
10,000 H2O Molecules
10 H2O Molecules

DC-8 Water Vapor Measurement Comparisons

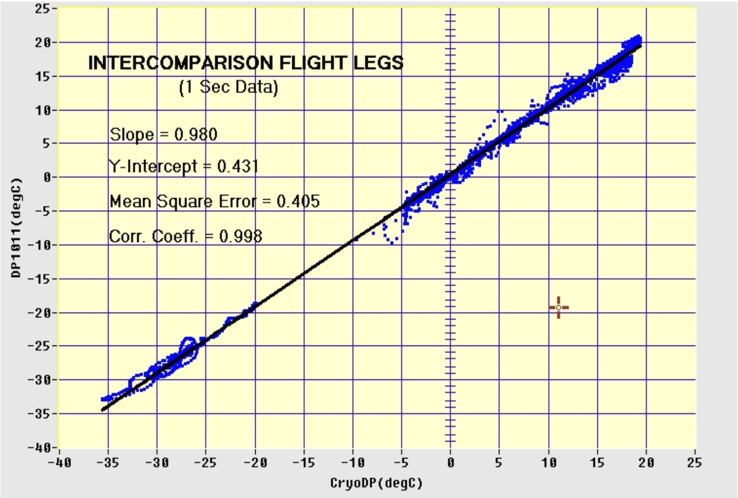
All DC-8 Flights (1 min data)

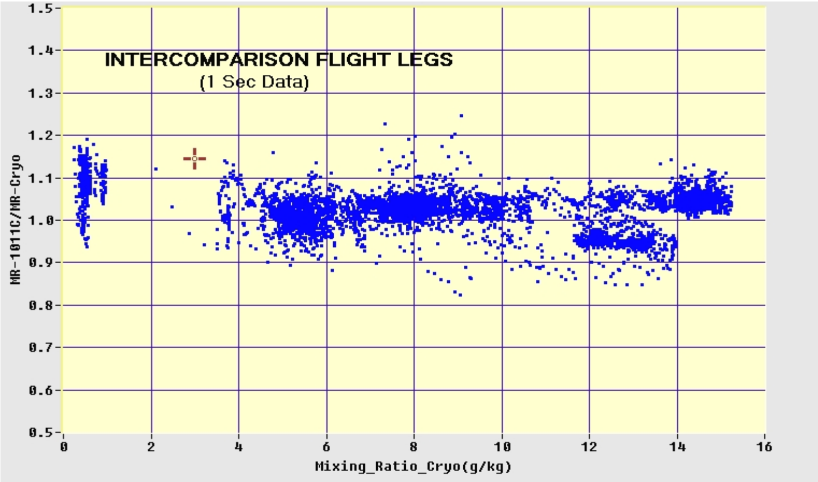
DLH vs. Cryo Mixing Ratio (ppmV)





Intercomparison Flight Legs Chilled Mirror Hygrometers (Cryo vs. 1011C)





Archived Data

File Name:

cryo_dc8_2004mmdd_ra.ict → nav_dc8_2004mmdd_r0.ict

- INSTRUMENT_INFO: Merged data set compiled by combining ICATS Navigation Data + Cryogenic Hygrometer + J(NO2) Filter Radiometer (Zenith and Nadir Viewing)
- R0: J(NO2) corrected for altitude, temperature, and SZA
- R0: Parameters Associated With Water Vapor Are Calculated Using DP_Proj (deg C)
- Source of Proj_DP identified by value identified as FLAG_DP_PROJ (0 - Null Data; 1 - Cryo; 2 - 1011C)

Parameters (**Measured** & *Calculated*):

- **DP_PROJ (degC)**
- FLAG_DP_PROJ
- *REL_HUMIDITY_ICE (%)*
- *REL_HUMIDITY_H2O (%)*
- *SAT_VAPOR_PRESSURE_H2O (mb)*
- *SAT_VAPOR_PRESSURE_ICE (mb)*
- *VAPOR_PRESSURE_H2O (mb)*
- *VAPOR_PRESSURE_ICE (mb)*
- *MIXING_RATIO (g/kg)*

- ***j*(NO2)Nadir (1/s)**
- ***j*(NO2)Zenith (1/s)**

Applied Dew/Frost Point - 101

Measured Primary Humidity Parameter = Dew/Frost Point (Deg C)

Calculated Parameters:

VAPOR_PRESSURE_H2O (mb) = 6.1121 EXP[17.502 x T/(240.97 +T)]

VAPOR_PRESSURE_ICE (mb) = 6.1115 EXP[22.452 x T/(272.55 +T)]

SAT_VAPOR_PRESSURE_H2O (mb) = 6.1121 EXP[17.502 x T/(240.97 +T)]

SAT_VAPOR_PRESSURE_ICE (mb) = 6.1115 EXP[22.452 x T/(272.55 +T)]

Where,

T = Dew/frost point for VAPOR_ PRESSURE calculations and Static Air Temp. for SAT_ VAPOR_PRESSURE

$$\text{REL\_HUMIDITY\_H2O (\%)} = \frac{\text{VAPOR\_PRESSURE\_H2O (mb)}}{\text{SAT\_VAPOR\_PRESSURE\_H2O (mb)}} \times 100$$

$$\text{REL\_HUMIDITY\_ICE (\%)} = \frac{\text{VAPOR\_PRESSURE\_ICE (mb)}}{\text{SAT\_VAPOR\_PRESSURE\_ICE (mb)}} \times 100$$

$$\textit{MIXING\_RATIO (g/kg)} = \frac{0.622 \times 10^3 \text{ (VAPOR\_PRESSURE)}}{\text{(STATIC PRESSURE)} - \text{(VAPOR\_PRESSURE)}}$$

Where,

VAPOR_PRESSURE_H2O is used for Dew/Frost Points equal or greater than 0 degC and
VAPOR_PRESSURE_ICE for Dew/Frost Points less than 0 degC.

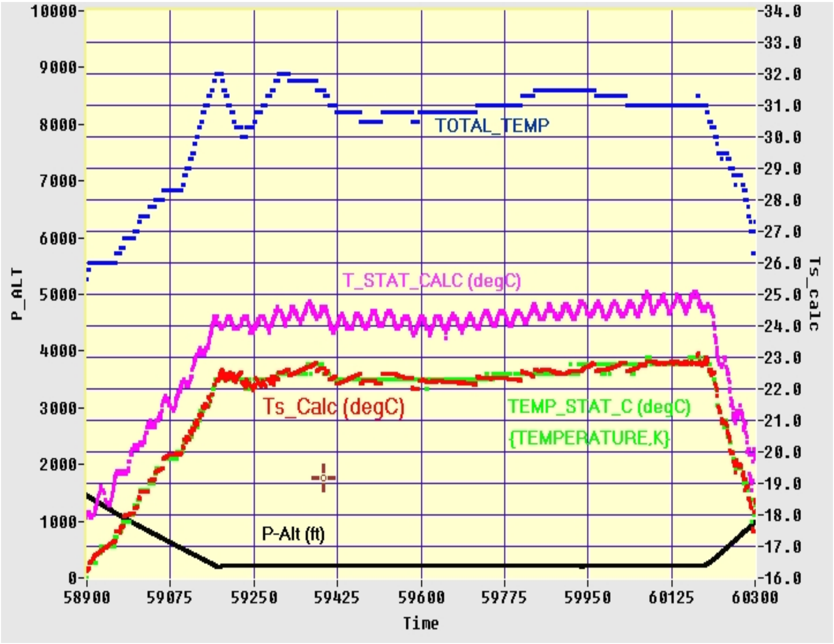
Static Air Temperature

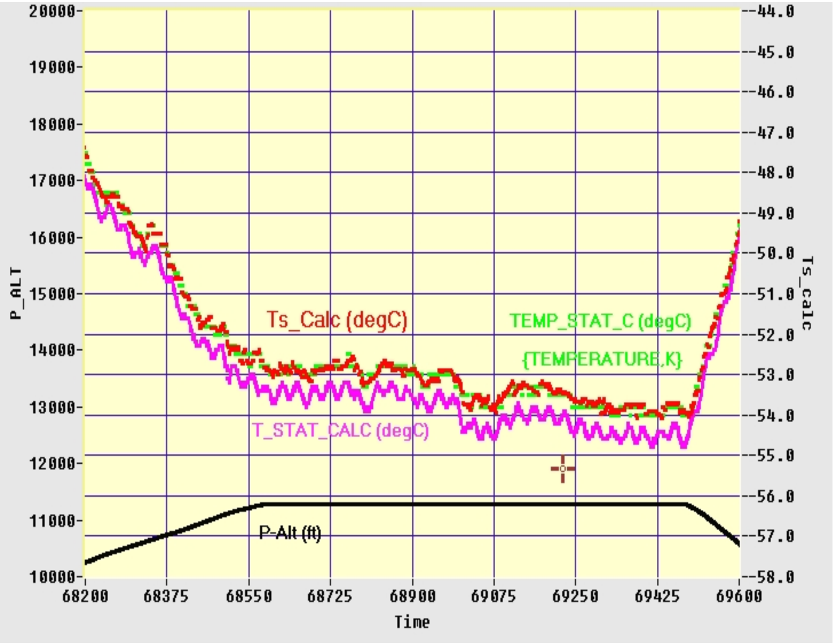
<u>File Name:</u>

nav_dc8_2004mmdd_ra.ict → nav_dc8_2004mmdd_r0.ict → mrgxx_dc8_2004mmdd_r0.ict

<u>Temperature Parameters:</u>

TEMP_TOTAL (degC) → TEMP_TOTAL (degC) → TOTAL_TEMP, K
TEMP_STAT_C (degC) → TEMP_STAT_C (degC) → TEMPERATURE, K
TEMP_STAT_CALC (degC) →





Comments

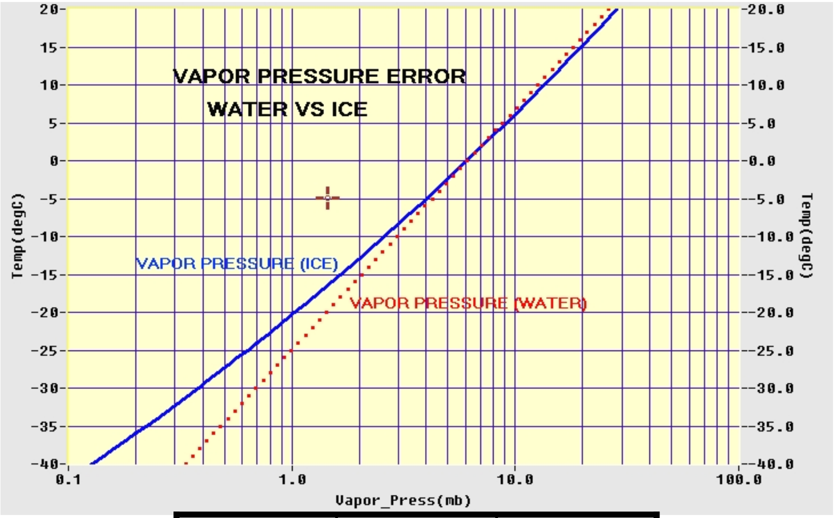
- Filter Radiometer and Cryogenic Hygrometer exhibited good correlation with other DC-8 instrument techniques - take a another look at differences.

- Good intercomparison with NOAA WP-3D measurements.

- Consider dynamic response of instrumentation and spatial separation for intercomparison purposes.

- Dew/Frost Ambiguity → →
  - Super-cooled water
  - Utilize descent soundings

- Static Air Temperature
  - Resolution (0.25 deg)
  - Marginal performance



Frost Pt.	Equiv. Dew Pt.	% Vapor Press Err.
-2	-2.3	2
-5	-5.6	5
-10	-11.2	10
-20	-22.2	22