# Status of IKP data

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# Status of Data

- IKP data made available at the Paris meeting, September 2014
- Comma-delimited ASCII files
- No new release of the data since Paris
- Probably no new releases in future unless users point out errors

# Long Term Archive

- Personal copies have been distributed to the various science team groups
- Official long-term archive copy on the NCAR field catalog
  - Password protected
  - Please see me for details if required

# Reminder

- Functionality of IKP-2 was excellent in Darwin. A few glitches related to loss of isokinetic flow have been set to -999 in IKP-2 data set
- Background humidity removal limits the use of the data, especially at warm temperatures
  - Wetting of inlet lines by rain before takeoff (usually dry by cruise altitude
  - Ingestion of ice crystals in background humidity lines requires use of ice-saturation assumption in cloud
  - Between clouds, switch to background humidity if lines not wet
    - Offsets in background humidity from IKP-2 in non-cloudy air requires manual adjustment
    - Occasionally, out-of-cloud intervals are very short, and not practical to switch to background humidity -→ occasional negative IKP TWCs

# Reminder

- Noise level in IKP-2 increases in tropical boundary layer due to large background humidity variations and lack of full synchronization between IKP-2 and background humidity measurement
  - Saturation background humidity at -10 C and 0 C of the order of 2 and 5 gm-3 respectively (subtracting a large number from IKP-2 to get TWC).
  - At 0 C, noise in (IKP-2 – background) in non-cloudy air can be a few tenths of a gm-3 due to imperfect synchronization
  - Decision to blank out IKP TWC for temperature > 0 C.
- Improvements in IKP-2 baseline in Cayenne expected due to new inlet system
  - Reverse flow inlet line, on belly protected from rain (wheel spray ?)
  - Dry air purge on ground
  - ‘zero’ calibration at altitude

# End of presentation

Thank you, merci

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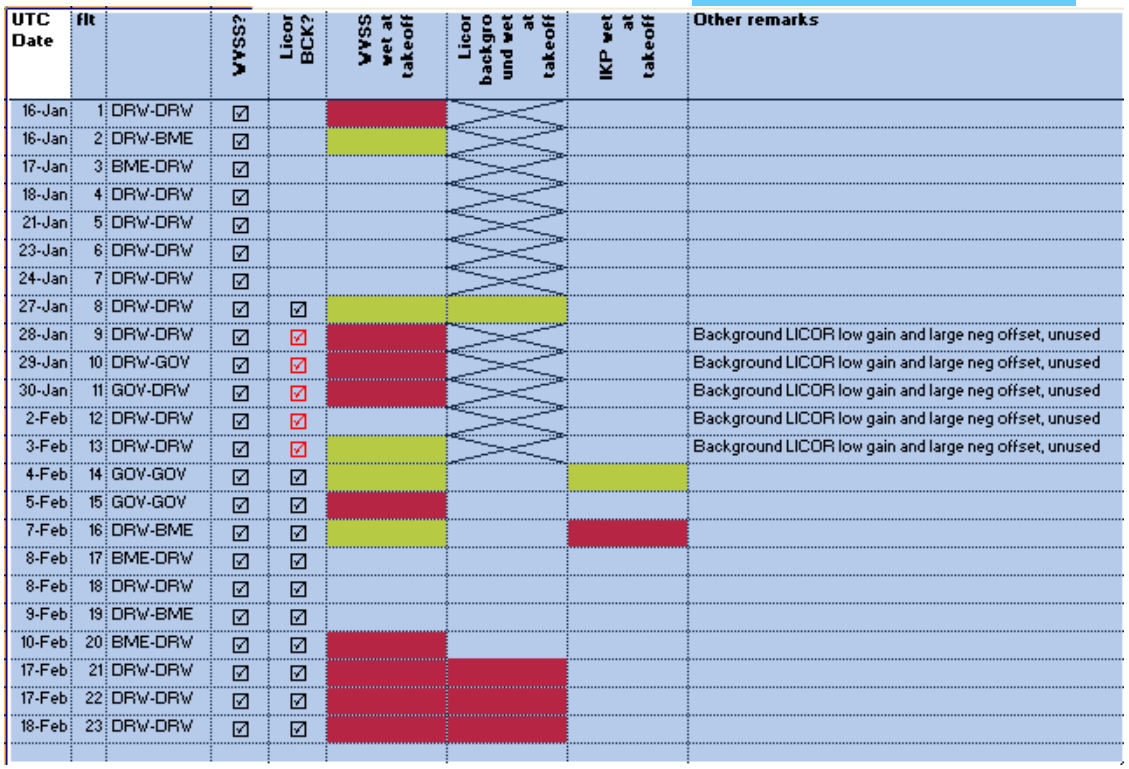
# Background humidity problems
# Magnitude of background subtraction

| T-C | Pres-mb | Palt-Kft | esgm3 | eigm3 |
|---|---|---|---|---|
| 20 | 851 | 4.74 | 17.53 | 21.37 |
| 10 | 677 | 10.74 | 9.48 | 10.47 |
| 0 | 532 | 16.80 | 4.87 | 4.88 |
| **-10** | **417** | **22.61** | **2.36** | **2.15** |
| -20 | 334 | 27.70 | 1.07 | 0.88 |
| **-30** | **273** | **32.14** | **0.45** | **0.34** |
| -40 | 226 | 36.15 | 0.18 | 0.12 |
| **-50** | **187** | **39.97** | | **0.04** |

# Background humidity problems: General Problem of Moisture in Lines Before Takeoff

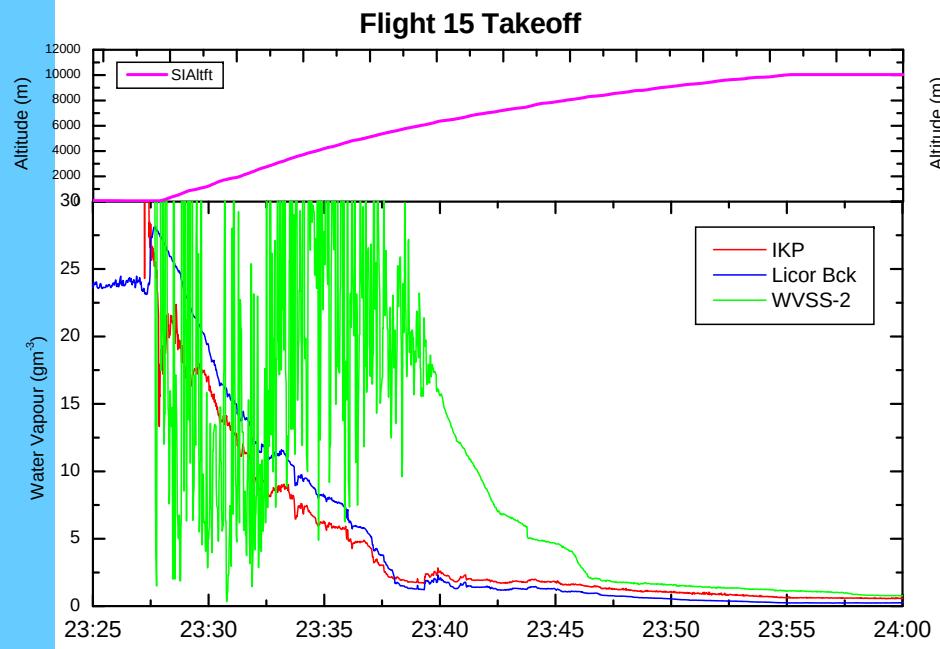
- WVSS-2 and LICOR availability shown at right
- Water in lines sometimes contaminates background humidity at beginning of flight
- Almost always cleared up by landing
- May be related to rain before takeoff
- Even IKP wet on takeoff a couple of flights

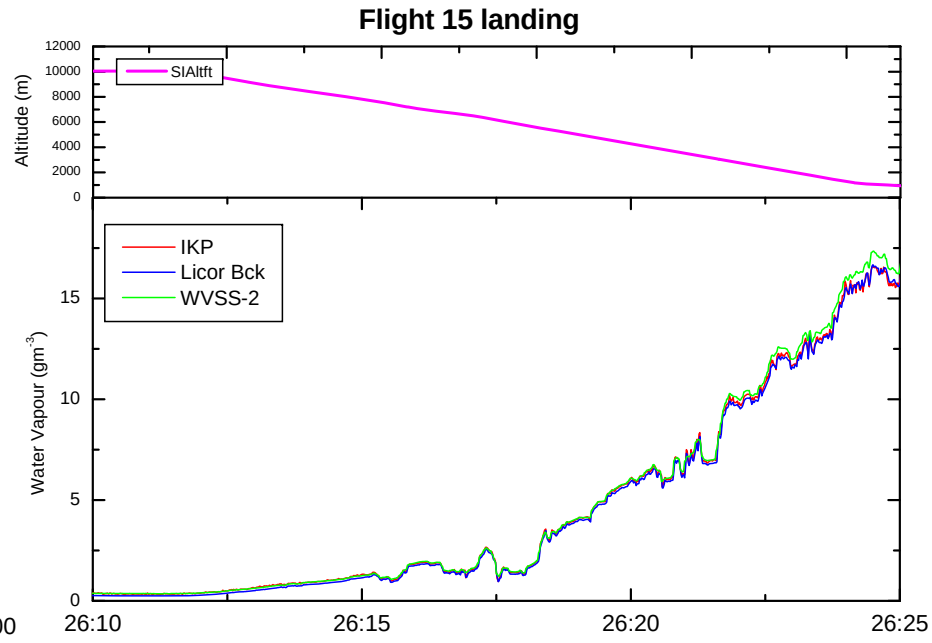


| UTC Date | flt | | WVSS? | Licor BCK? | WVSS wet at takeoff | Licor background wet at takeoff | IKP wet at takeoff | Other remarks |
|---|---|---|---|---|---|---|---|---|
| 16-Jan | 1 | DRW-DRW | ☑ | | | | | |
| 16-Jan | 2 | DRW-BME | ☑ | | | | | |
| 17-Jan | 3 | BME-DRW | ☑ | | | | | |
| 18-Jan | 4 | DRW-DRW | ☑ | | | | | |
| 21-Jan | 5 | DRW-DRW | ☑ | | | | | |
| 23-Jan | 6 | DRW-DRW | ☑ | | | | | |
| 24-Jan | 7 | DRW-DRW | ☑ | | | | | |
| 27-Jan | 8 | DRW-DRW | ☑ | ☑ | | | | |
| 28-Jan | 9 | DRW-DRW | ☑ | ☑ | | | | Background LICOR low gain and large neg offset, unused |
| 29-Jan | 10 | DRW-GOV | ☑ | ☑ | | | | Background LICOR low gain and large neg offset, unused |
| 30-Jan | 11 | GOV-DRW | ☑ | ☑ | | | | Background LICOR low gain and large neg offset, unused |
| 2-Feb | 12 | DRW-DRW | ☑ | ☑ | | | | Background LICOR low gain and large neg offset, unused |
| 3-Feb | 13 | DRW-DRW | ☑ | ☑ | | | | Background LICOR low gain and large neg offset, unused |
| 4-Feb | 14 | GOV-GOV | ☑ | ☑ | | | | |
| 5-Feb | 15 | GOV-GOV | ☑ | ☑ | | | | |
| 7-Feb | 16 | DRW-BME | ☑ | ☑ | | | | |
| 8-Feb | 17 | BME-DRW | ☑ | ☑ | | | | |
| 8-Feb | 18 | DRW-DRW | ☑ | ☑ | | | | |
| 9-Feb | 19 | DRW-BME | ☑ | ☑ | | | | |
| 10-Feb | 20 | BME-DRW | ☑ | ☑ | | | | |
| 17-Feb | 21 | DRW-DRW | ☑ | ☑ | | | | |
| 17-Feb | 22 | DRW-DRW | ☑ | ☑ | | | | |
| 18-Feb | 23 | DRW-DRW | ☑ | ☑ | | | | |

# Background humidity problems

## Example of Moisture in Lines Before Takeoff



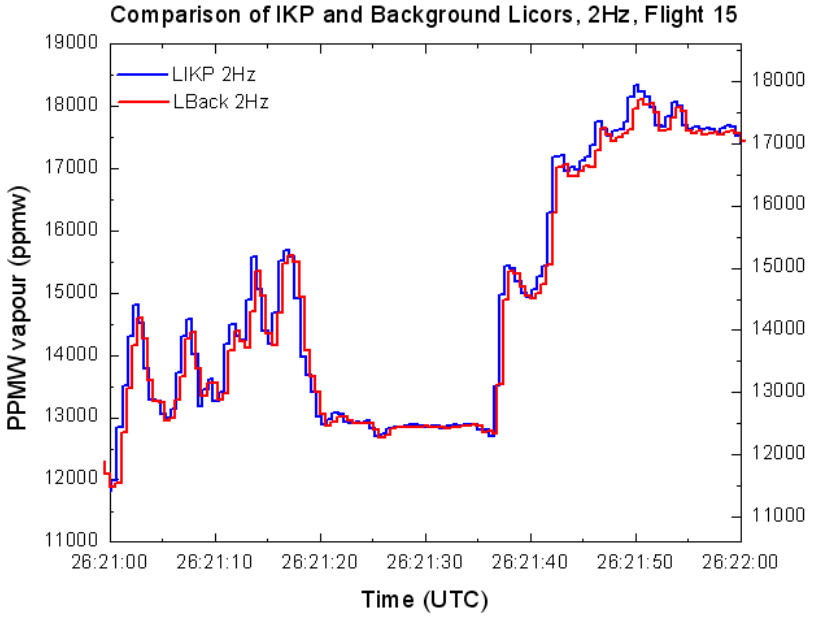
# Background humidity problems
# Time Synchronization

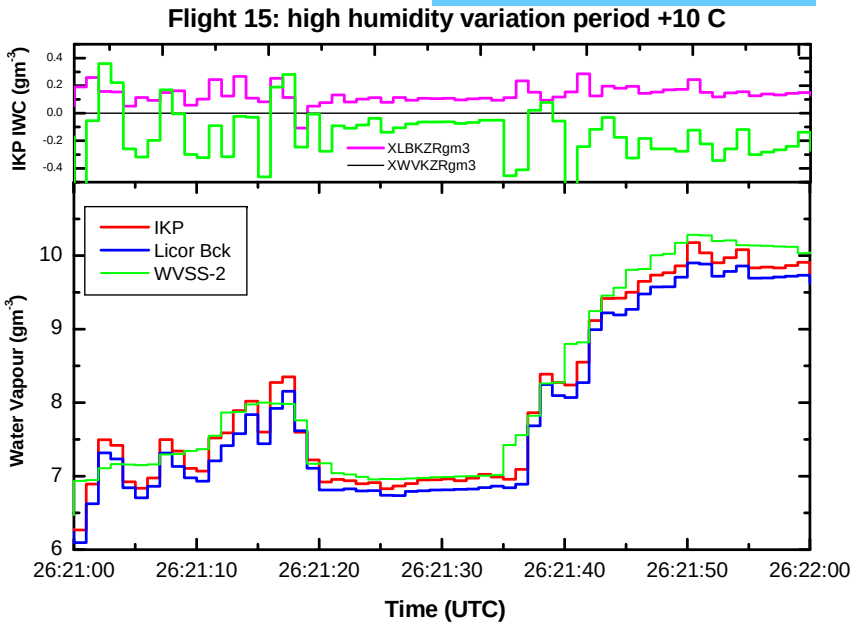
- Basic data rates of humidity measurements:
  - IKP Licor:  2 per second
  - Background Licor:  2 per second
  - WVSS-2: one per 2.2 seconds

- Noticed that variations in humidity from second to second could be quite large in clear air, especially at warmer temperatures
- Also noticed that although there was very good coherence between the IKP, WVSS, and background LICOR measurements, small time phase differences could lead to relatively large background subtraction errors (baseline noise in IKP IWC):
  - Due to natural variability in humidity field
  - Due to differences in sampling methodologies between instruments
  - Due to different sample line lengths

  - Decided to go back to highest frequency sampling available from the instruments, and align them to sample as best as possible from the data available
    - Produced 1 second interval data with frame start times aligned to within about 50 ms.
    - Small improvement

# Background humidity problems
# Time Synchronization

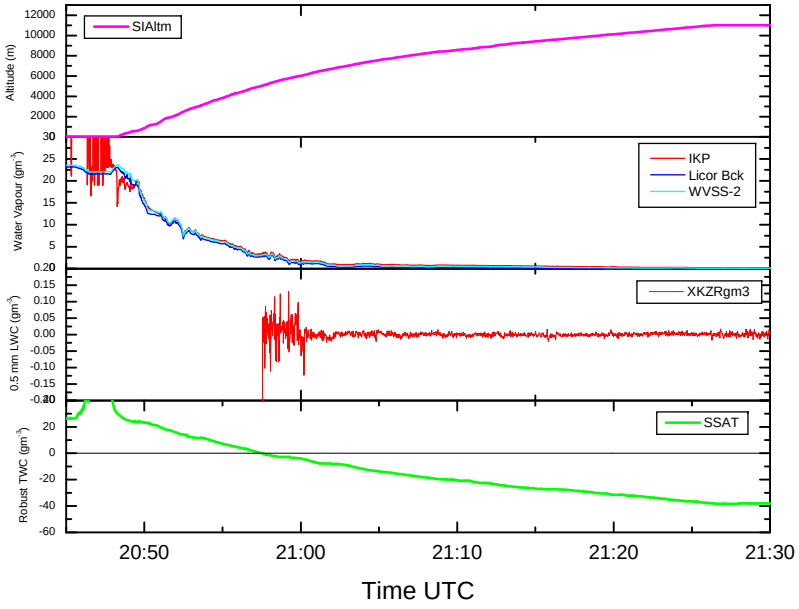


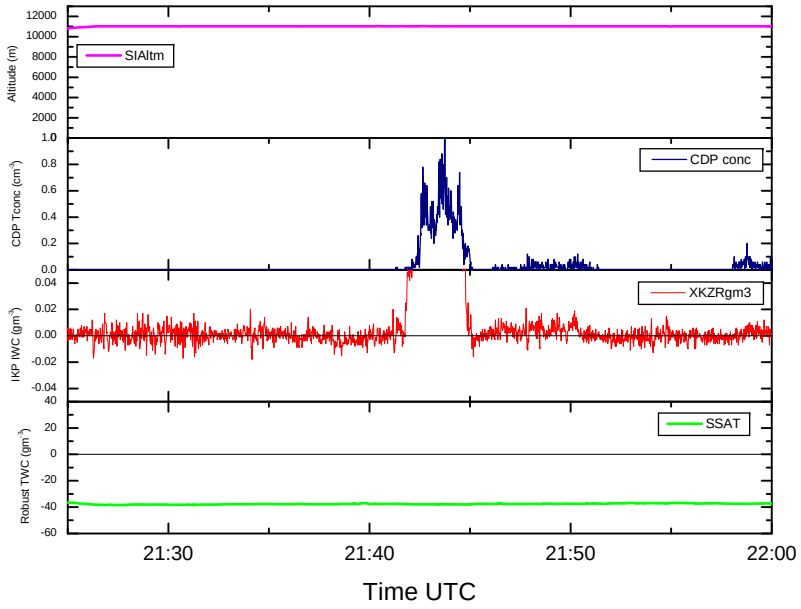

- left slide shows response of IKP Licor and Background Licor in cloud-free air at around +10 C (this is typical agreement)
- Agreement appears to be excellent although there is a small bias (~400 ppmw) and minor differences appear in high-variation periods
- Right slide shows the results of these minor variations on IKP $gm^{-3}$ calculation, even after improving the time synchronization
- At this temperature, noise in IKP $gm^{-3}$ baseline is about ± 0.15 $gm^{-3}$ using LICOR background humidity, ± 0.5 $gm^{-3}$ using WVSS-2 background humidity,

# IKP baseline noise after background removal

Flight 19 - takeoff

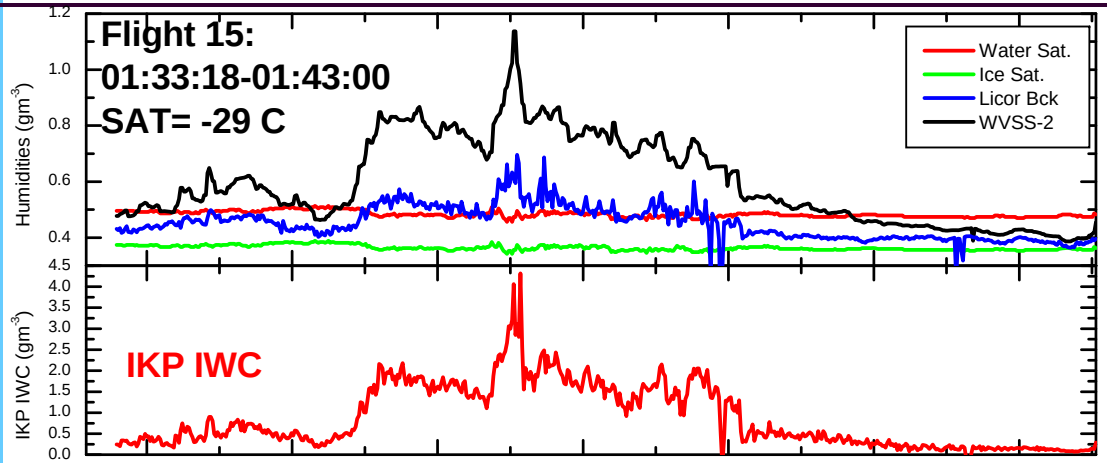


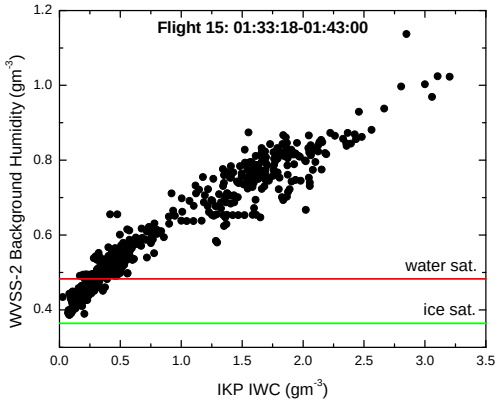

Flight 19 - Straight and Level at 11000m

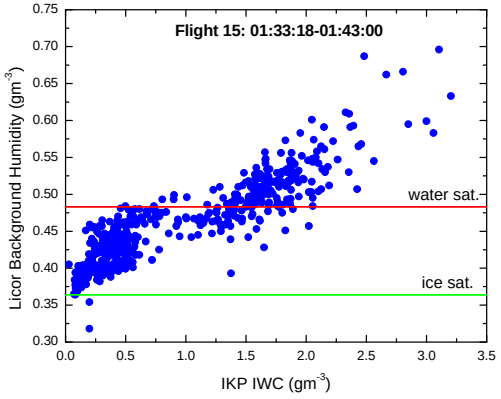



- these are typical clear-air IKP baseline results for Flight 19 after synchronization and bias removal – Licor background was used
- Left is takeoff climb. Data are blanked out below freezing level, initially noise in baseline around ± 0.1 $gm^{-3}$, then becoming more stable
- On right is typical straight and level high-altitude. Baseline noise ~ ± 0.02 $gm^{-3}$. Seems to be the fundamental minimum noise level.

# IKP baseline removal in cloud




- Example of background humidity measurements during traverse through cloud to > 4 $gm^{-3}$
- WVSS clearly appears to ingest IWC, and is not suitable for background humidity removal in cloud
  - WVSS response proportional to IWC, rising ~0.7 $gm^{-3}$
  - Water-Ice saturation difference is ~ 0.12 $gm^{-3}$
- Licor Background is not so clear: appears to sometimes climb above water saturation in IWC, but not by a large amount.
  - Licor background proportional to IWC, rising ~0.35 $gm^{-3}$

# IKP baseline removal in cloud: Decision

- Use Ice Saturation in cloud, because:
  - WVSS-2 cannot be used in cloud due to ice crystal ingestion
  - There is good Licor background humidity data for only 6 of the 17 data flights
  - The LICOR data usually goes up in high-IWC cloud, correlated to IWC.
    - Could be real, although some cases rises seem to exceed difference between water and ice saturation
    - Could also be ice ingestion
  - One consistent method though entire data set instead of mixture of methods.
- Needed to apply small offsets to measured ice saturation values to account for small offsets between IKP LICOR and SAT-derived ice saturation values
  - Search for low-IWC areas at edges of cloud and assume ice saturation. Use this as offset . Tended to be relatively slow variation in offset with time
- Accuracy of IKP background humidity does not affect IKP statistics (Appendix D) by a large amount. More important for scientific studies.

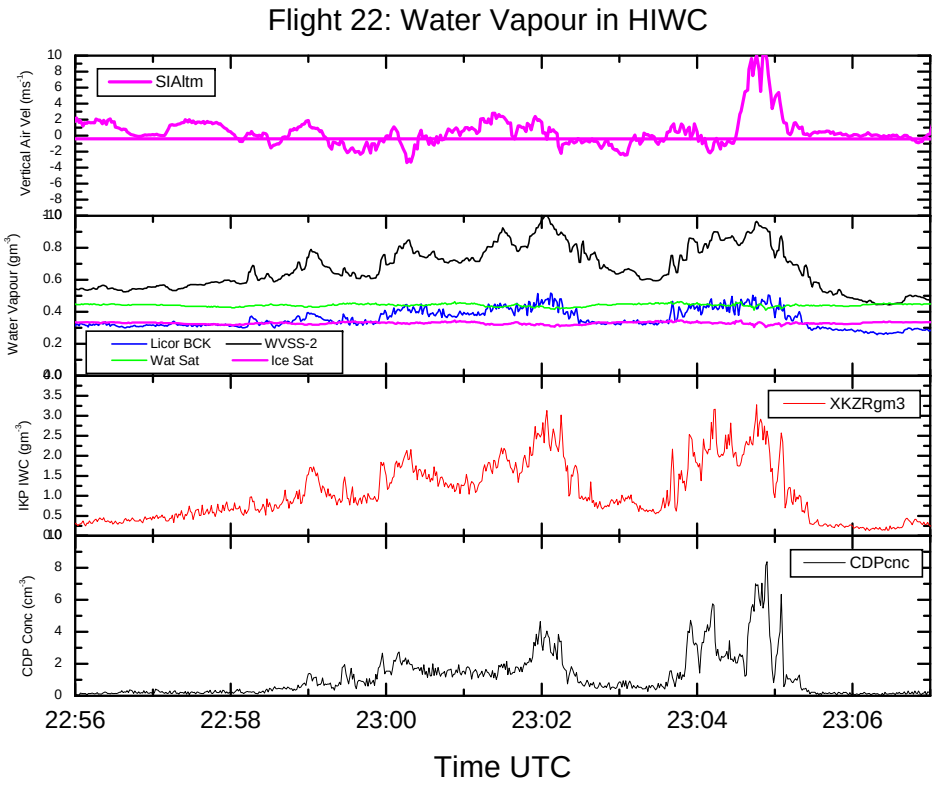
# IKP baseline removal between clouds: Decision

- Cannot use ice saturation between clouds, even for short clear-air periods, due to sub-saturation in these regions
  - results in a large negative offset in IKP IWC in these regions (subtracting too large a background humidity), even to several tenths of a $gm^{-3}$. Gives the appearance of an offset to all of the data.
- Technique used: Switch from ice saturation in cloud, to one of the background humidity measurements (WVSS or background LICOR), whichever is better, outside of cloud.
  - Apply time-dependent offsets to account for drift between background instruments and IKP LICOR in clear air.

# Overall results in background-removed IKP TWC:

- Due to low background humidity measurements at our prime altitudes, IKP IWC time histories appear quite acceptable. Background-removed IKP TWC baseline noise at in the -30 to -50 C range appears to be of the order of ± 0.02 $gm^{-3}$.
- Must be more careful at -10 C. Noise in baseline probably more like 0.1 - 0.2 $gm^{-3}$.
- In the boundary layer, noise levels go up, increasing with temperature and inhomogeneity of the vapour field. Second-to-second noise levels at +10 C can easily exceed ± 0.5 $gm^{-3}$.
- With the present background humidity measurement set-up, we cannot expect good measurements at temperatures warmer than zero due to the highly variable background humidity measurements outside of cloud, and the very high background levels. Consequently, IKP data at SATs warmer than 0 C has been blanked out.
- Very good IKP performance otherwise
  - Only a few hang-ups of the probe. Overall reliability of probe and data system very good.
  - Isokinetic performance quite good (IKP factor typically between 0.9 and 1.1 is straight and level flight).
  - No signs of saturation. IKP time histories correlated very well with Robust probe in terms of rises and falls, and even quite well in terms of relative magnitude of changes.
- Background humidity removal is very manual and time intensive. Took ~400 hours to do the DRW-14 data, ~6 times longer than I had first guessed.
  - Hope to make some improvements fin the F20 set-up or next flight program, at least in terms of reducing ice crystal ingestion and wetting of the lines before takeoff for the background LICOR.

# IKP baseline removal in cloud




- Example shows background humidity traces for traverse through cloud reaching ~2.5 $gm^{-3}$.
- WVSS clearly ingests and reacts to IWC, and is not suitable for background humidity removal in cloud
  - WVSS response proportional to IWC, rising ~0.6 $gm^{-3}$
  - Water-Ice saturation difference is ~ 0.1 $gm^{-3}$
- Licor Background is not so clear: appears to sometimes climb above water saturation in IWC, but not by a large amount.
  - Licor background proportional to IWC, rising ~0.2 $gm^{-3}$