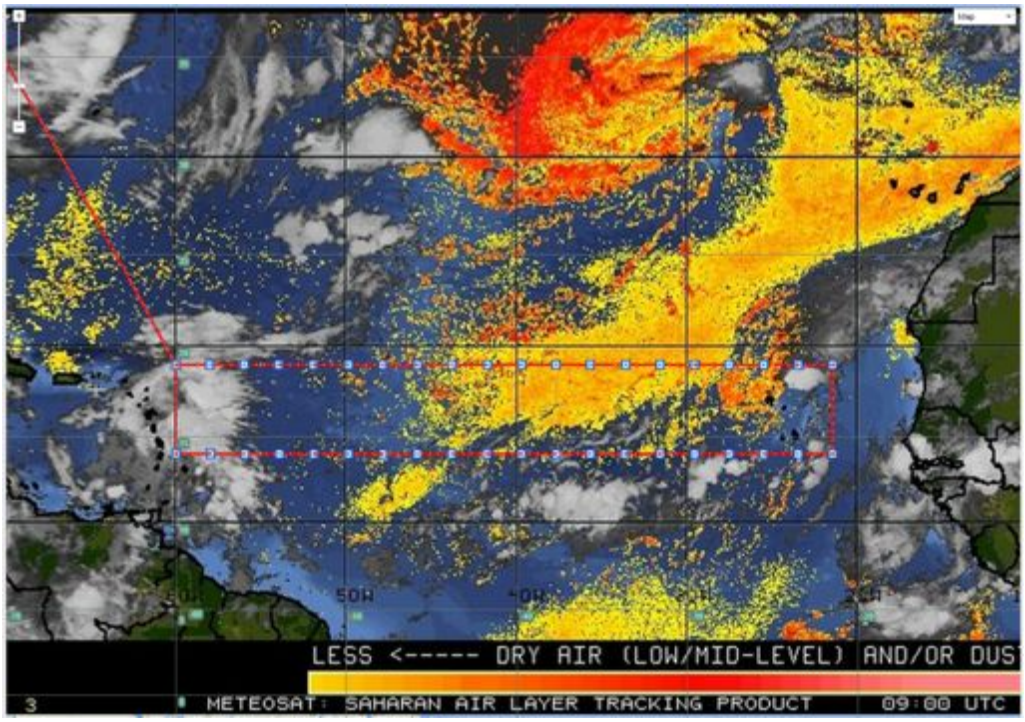
Hurricane and Severe Storm Sentinel (HS3) Mission

HS3 2014-09-22 Flight Report: GLOBALHAWK AV-6 Main Development Region Survey

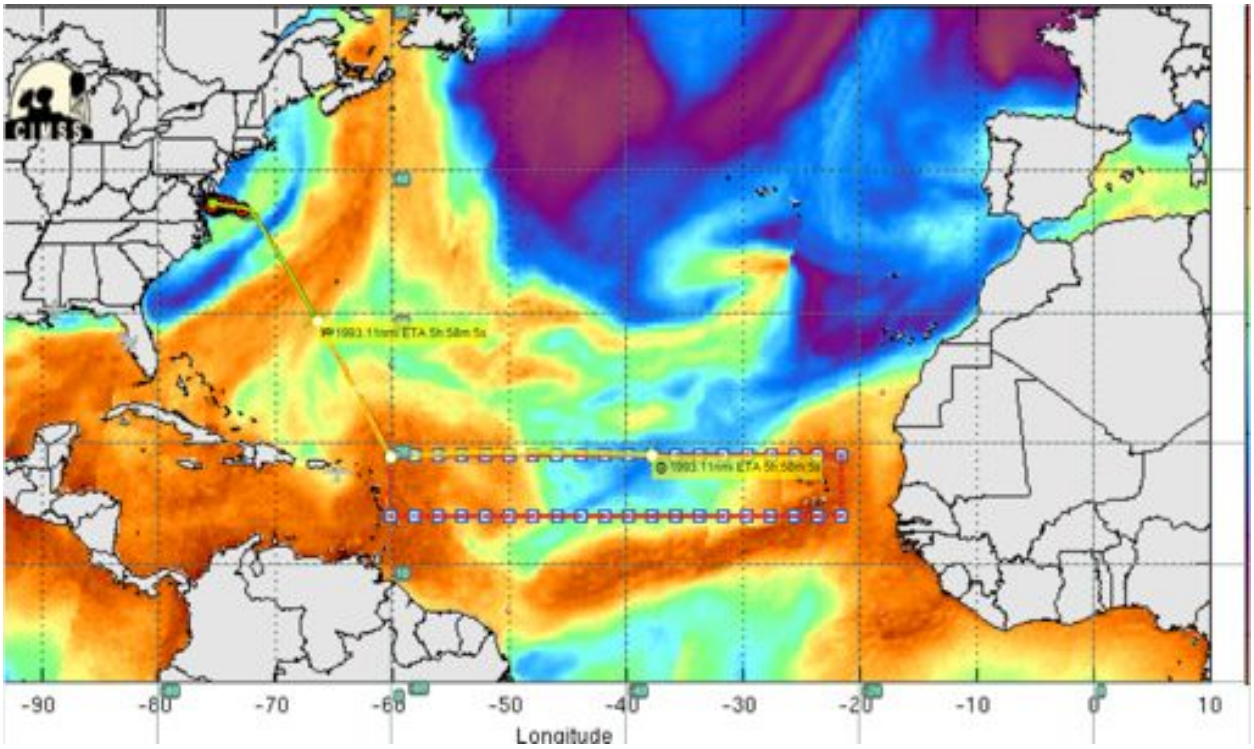
Flight Scientist shifts:

Name	Time
Braun	0930-1400 UTC
Didlake	1300-1700
Newman	1600-2000
Thorncroft	1800-2200
Zawislak	2100-0100
Hendricks	2300-0300
Sippel	0200-0600
Montgomery	0500-0900
Colarco	0800-1200

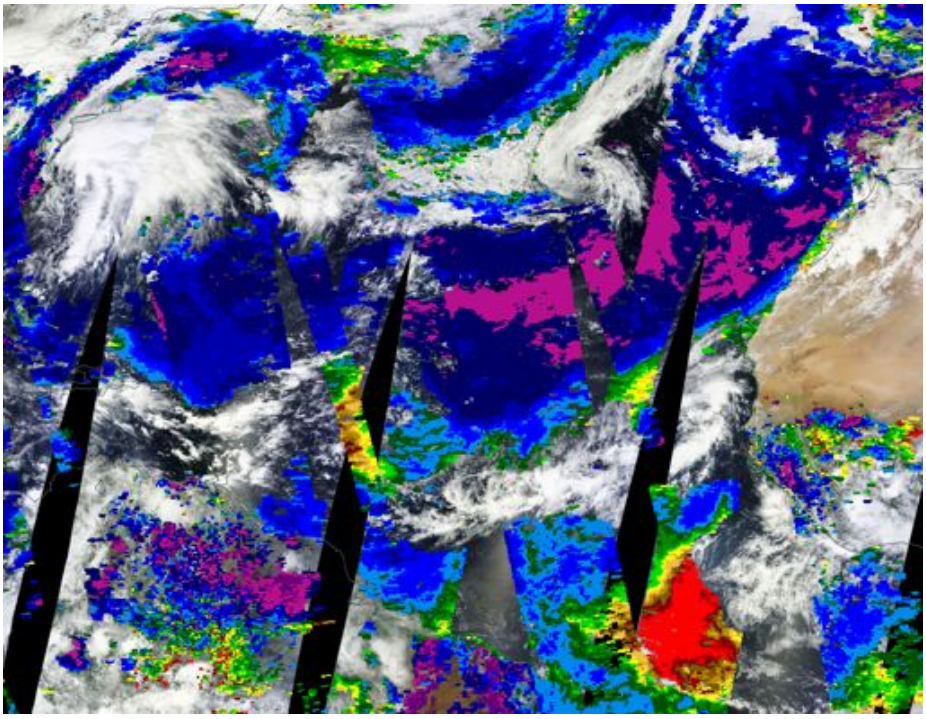
Mission goal: Broad survey of the main development region. Flight pattern consists of two long east-west legs at 19 and 14 deg N from 60 to 21W. See image below. A total of 40 dropsondes, 20for each leg.



0900 GOES SAL product shows a broad region of dry air along the planned route.

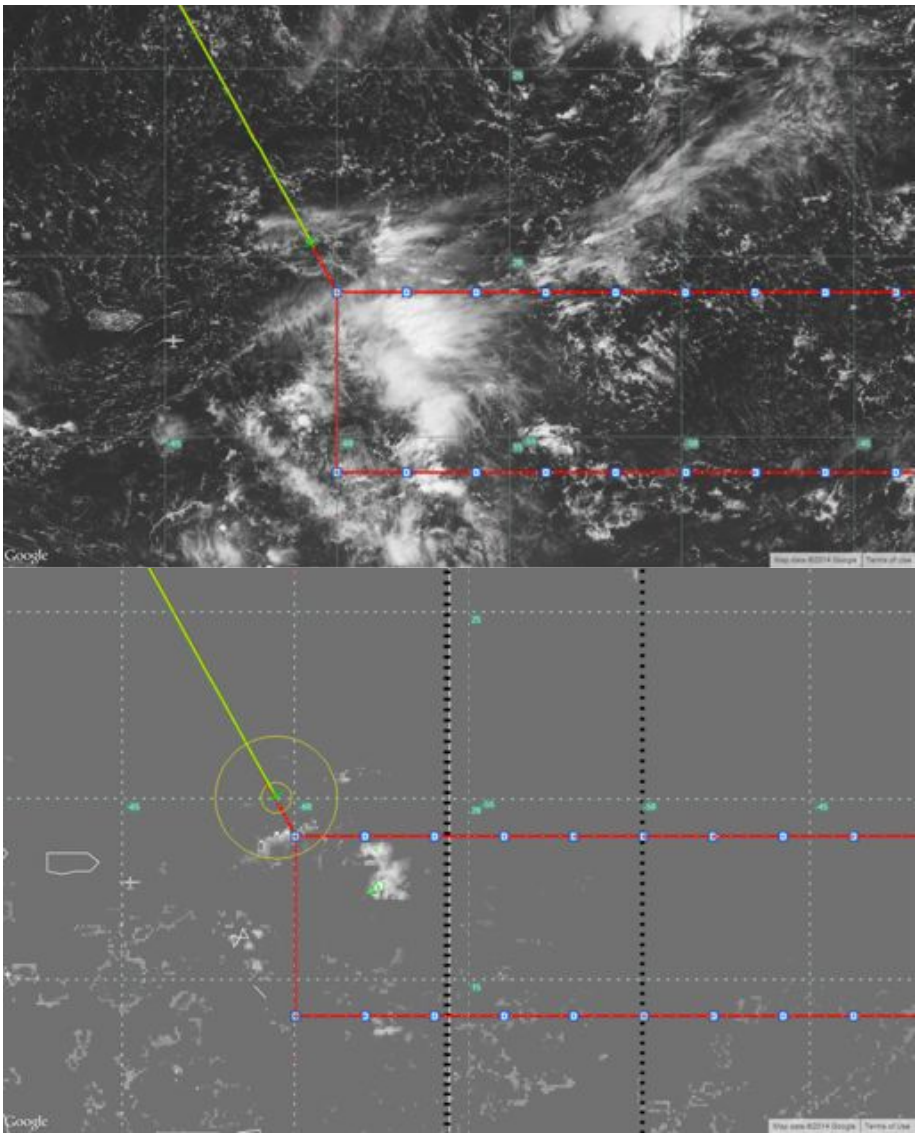


1000 MIMIC-TPW analysis of TPW. East end of flight pattern takes us through the wave over the Cape Verdes.

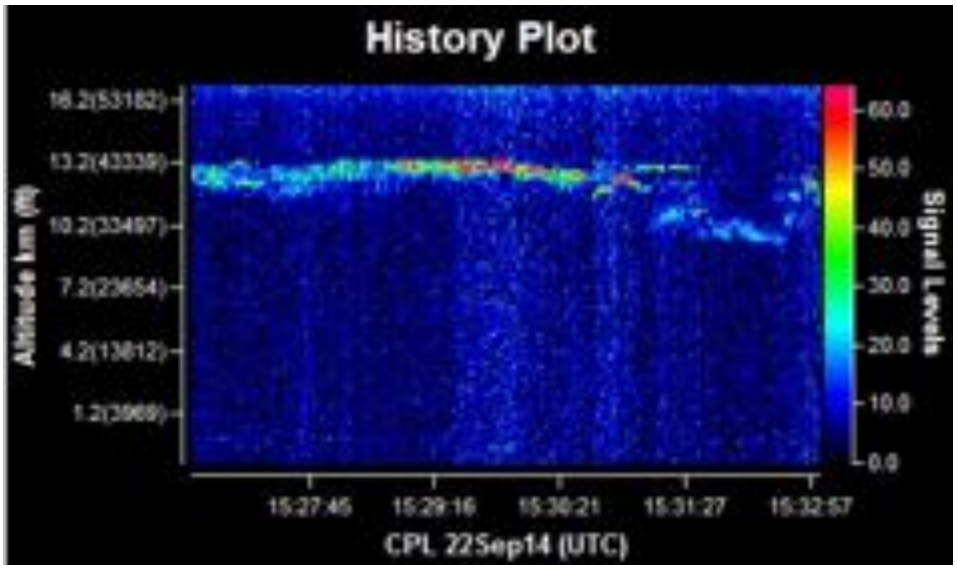


MODIS AOD product from Sunday afternoon, 9/21, shows little dust, suggesting that dry air is primarily of non-Saharan origin.

1101 Takeoff



1531 Visible satellite showing our approach to the cloud mass associated with former P34L. A few specks of cloud tops above 46 kft.



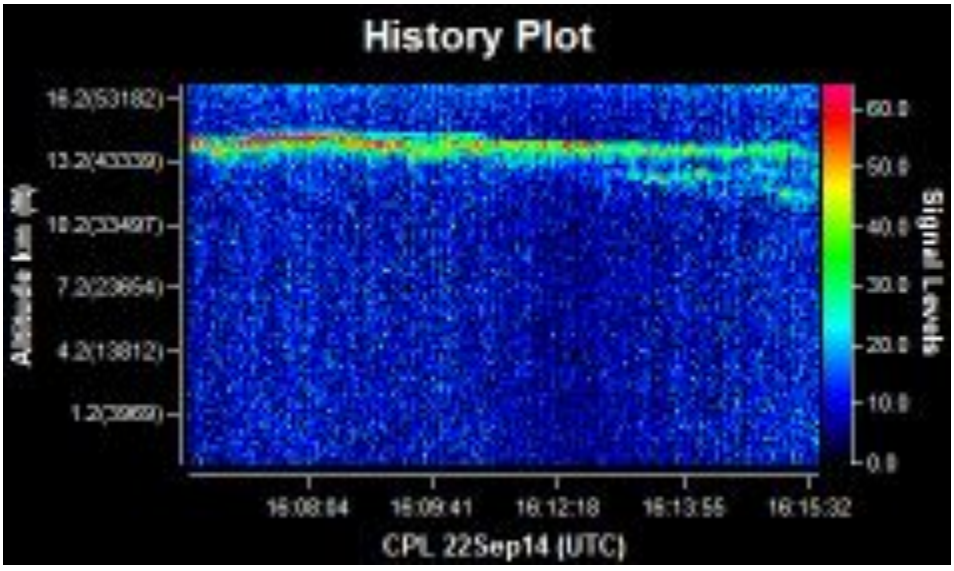
1531 CPL shows high cirrus ahead of the P34L remnants.

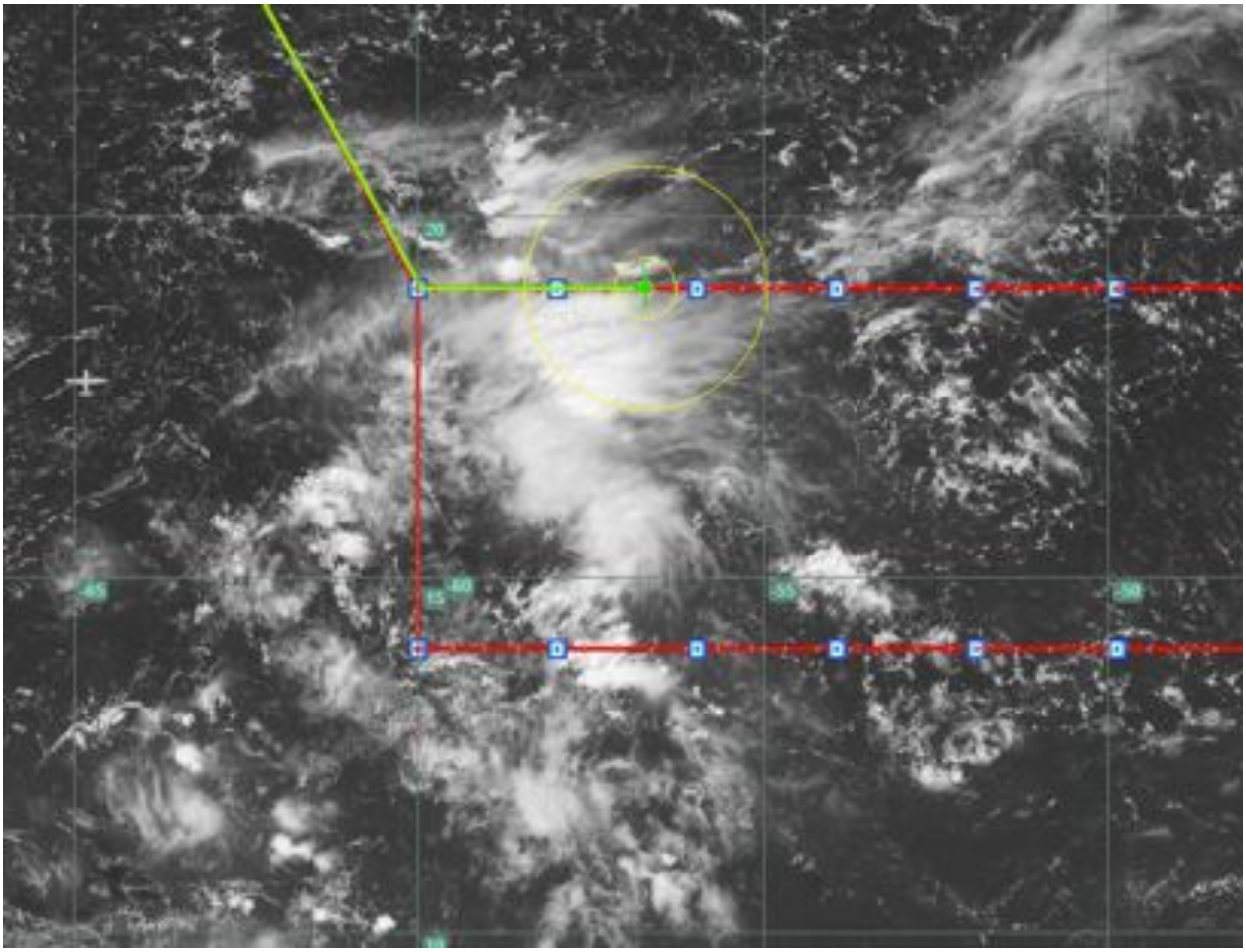
1531 SHIS is not cooling as quickly as needed. Doing another recycle as we approach remnants of P34L. SHIS data wiill not be available for first pass by P34L.

1554 D01 sonde released

1613 D02 sonde released

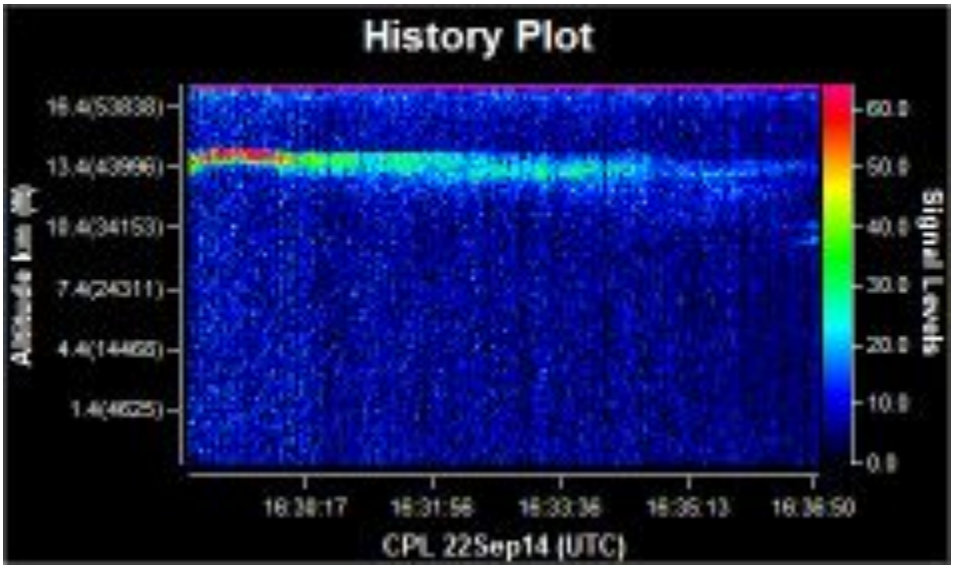
1620 CPL image. Just flying past some cirrus blow-off from convection associated with P34. See CPL below and GOES visible.



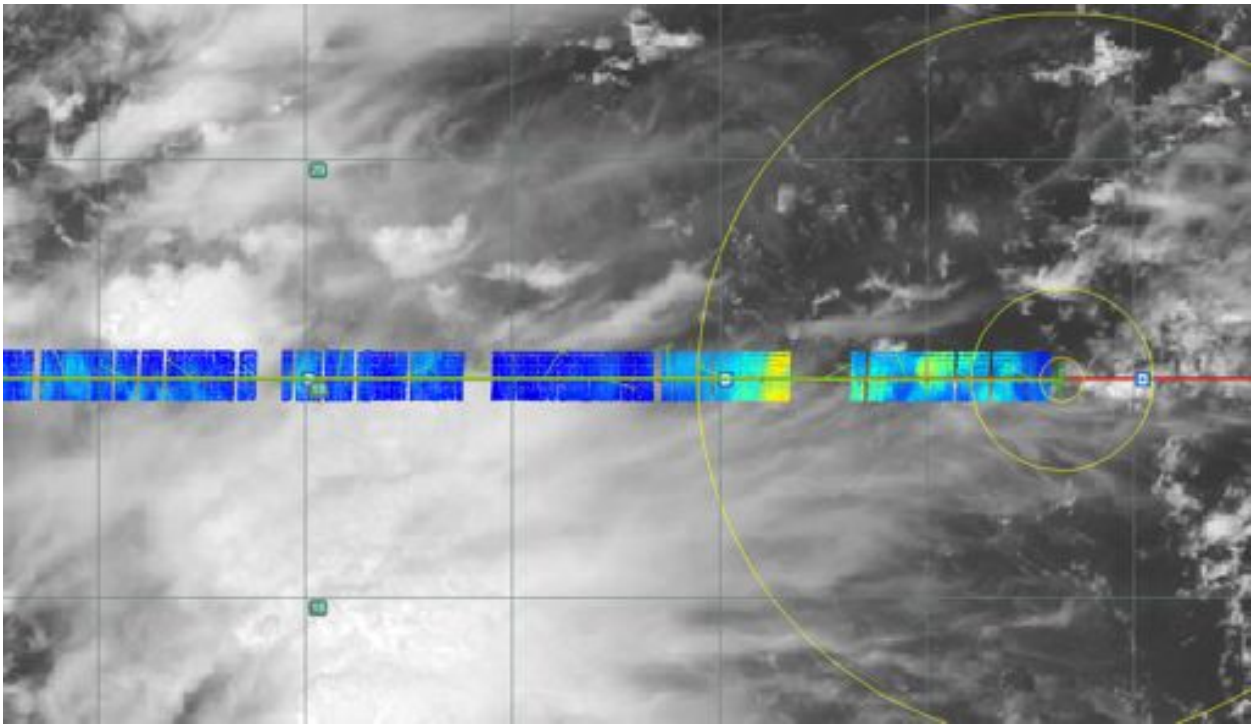


1634 Sonde #3 ~56W

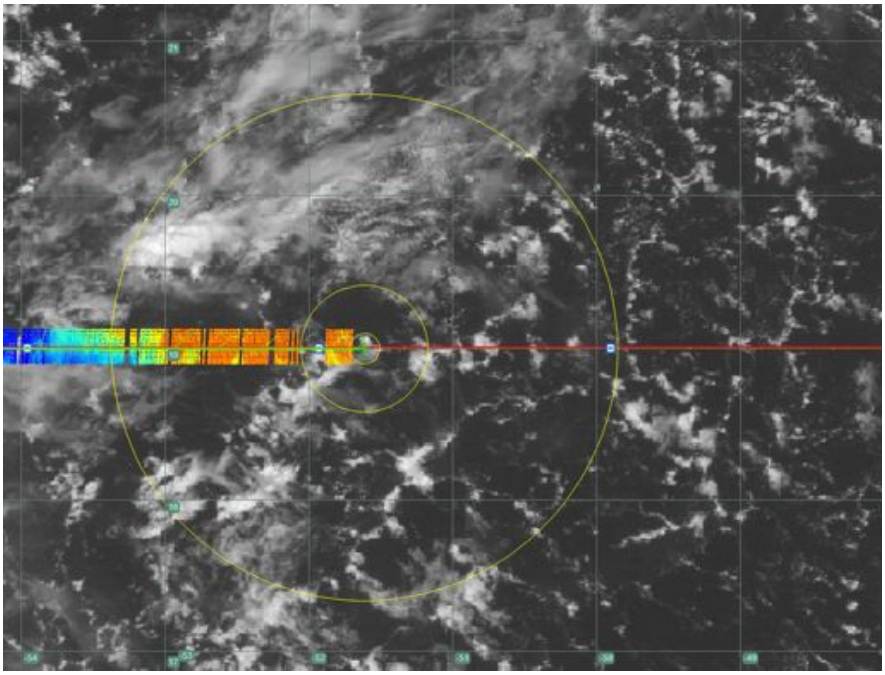
1643 Starting to move east of cirrus blowoff. See CPL below.

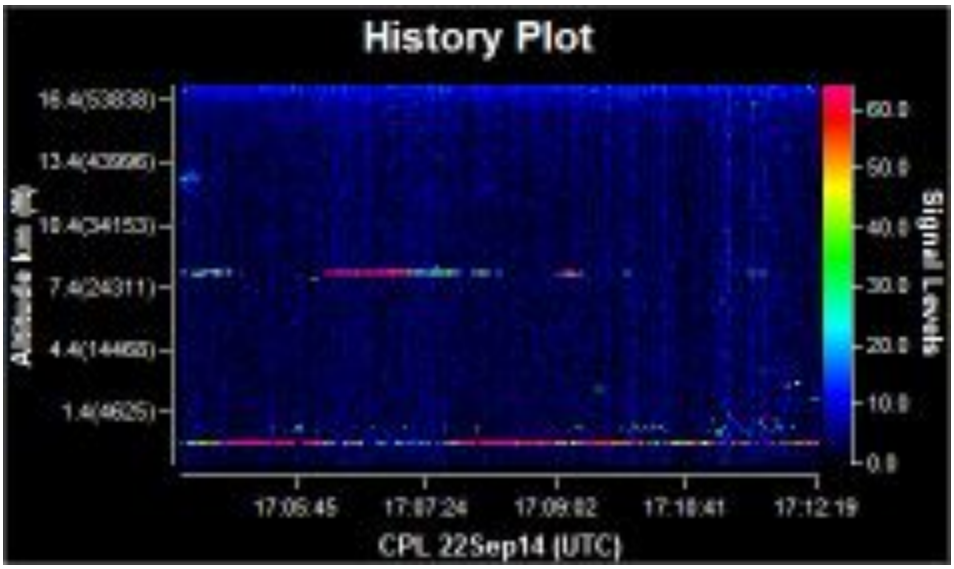


1650 Note that we are coming off the cirrus from SHIS.

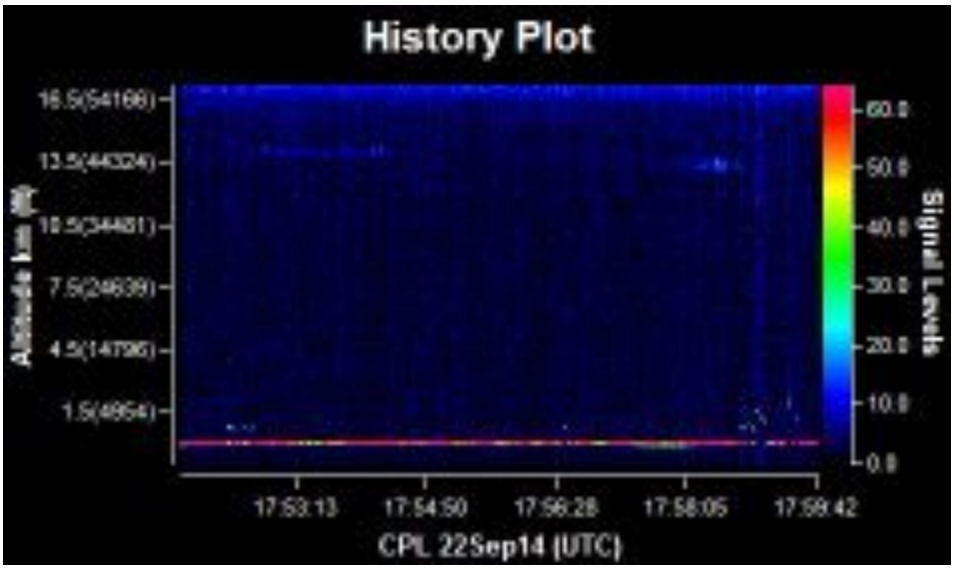


1717 Clear of the cirrus now and over fairly clear skies.





1807 Should be into relatively dry air now. 7 sondes now out.



1818 Sonde 8 pitched out.

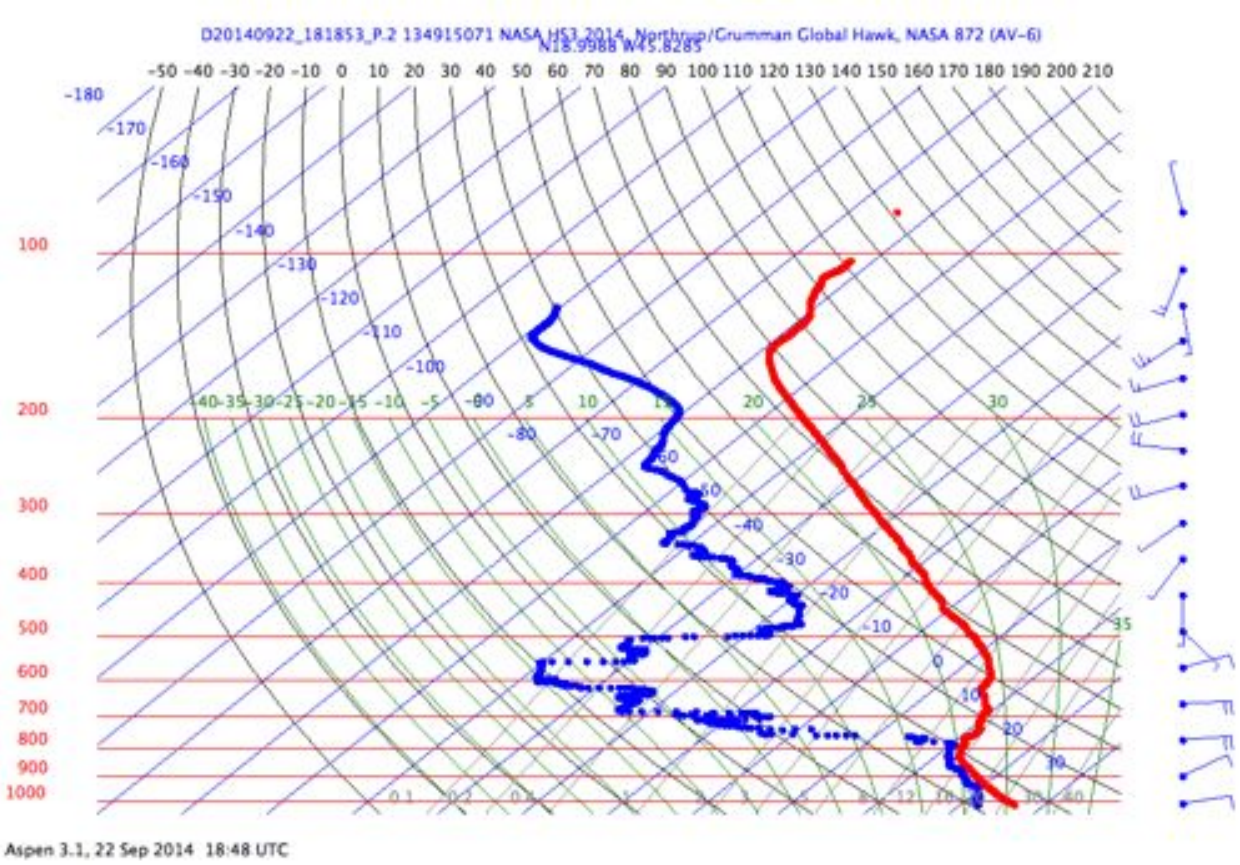
Chris Thorncroft Mission Scientist

18.40 Sonde 9 Pitched out

19.01 Sonde 10 Pitched Out

19.03 Just shallow clouds out ahead

Sonde 8 image below: Getting drier!



19.13: Some linear organisation in the low-level clouds

19.22: Sonde 11 Pitched Out

19.43: Sonde 12 Pitched Out

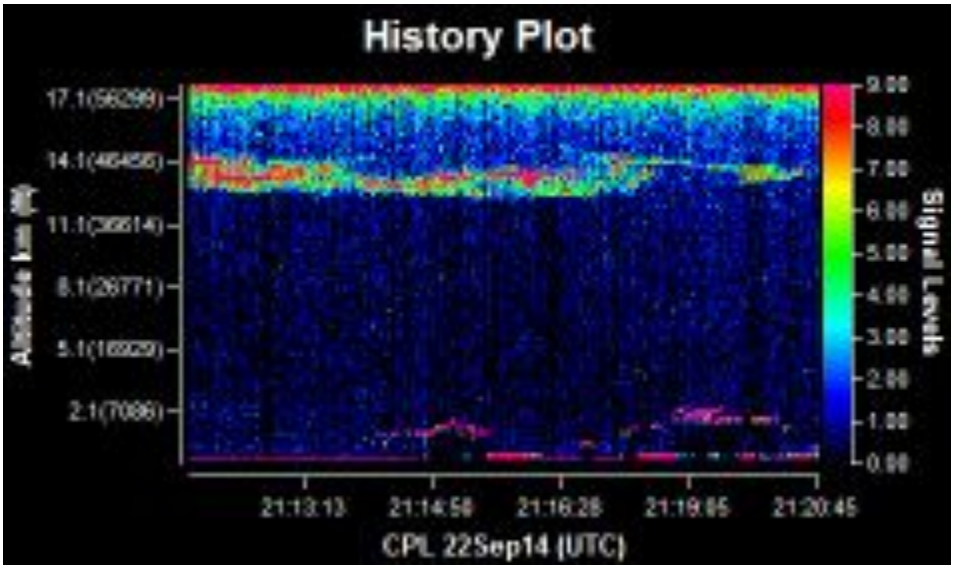
20.04: Sonde 13 Pitched Out

20.24: Sonde 14 Pitched Out

20.45: Sonde 15 Pitched Out

21.06: Sonde 16 Pitched Out

21.23 – finally something interesting in CPL:

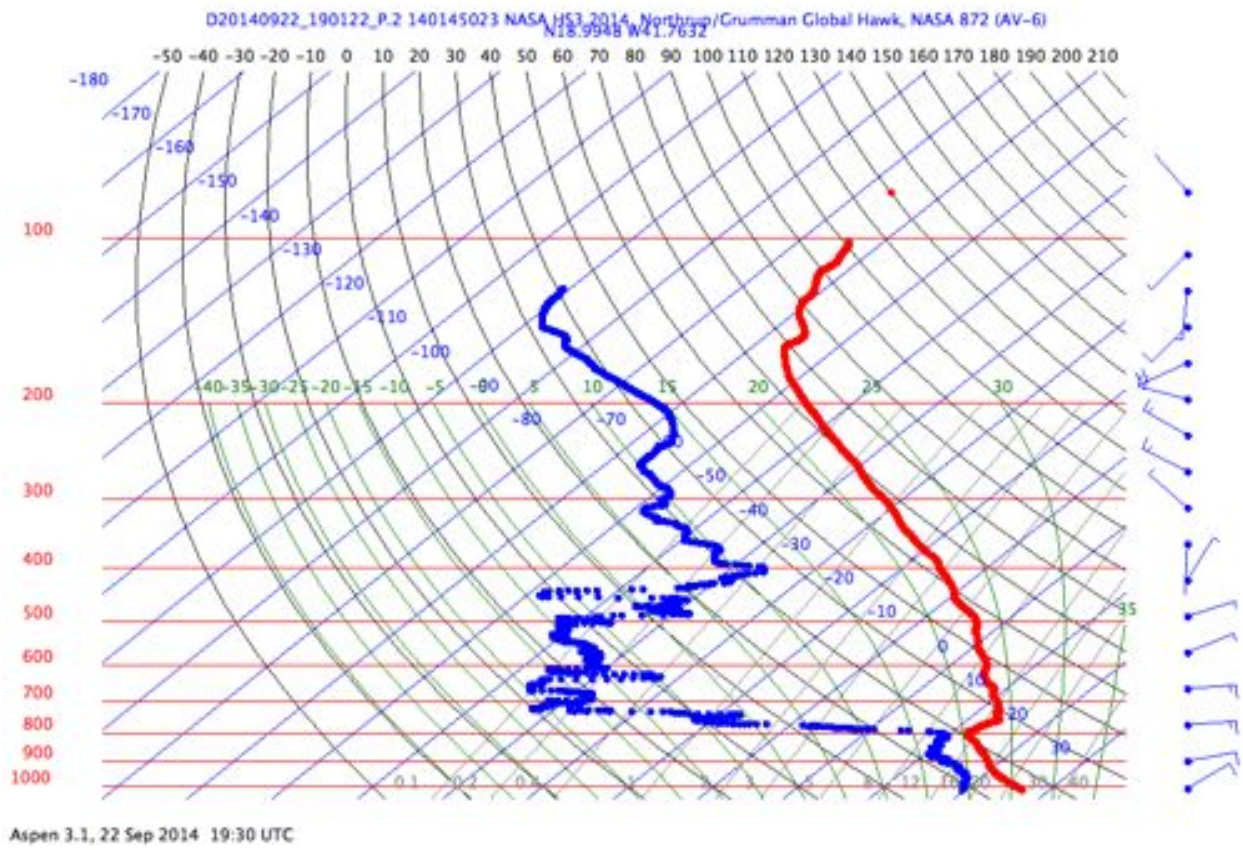


Upper-level clouds, consistent with expected moistening as we start to see the weak trough in the east.

21.27 Sonde 17 Pitched Out

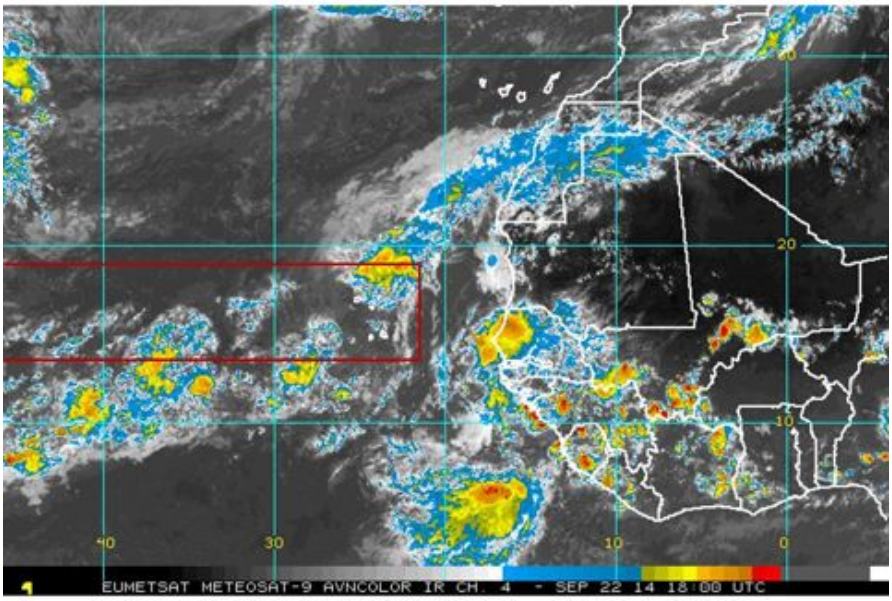
21.48 Sonde 18 Pitched Out

22.09 Sonde 19 Pitched Out

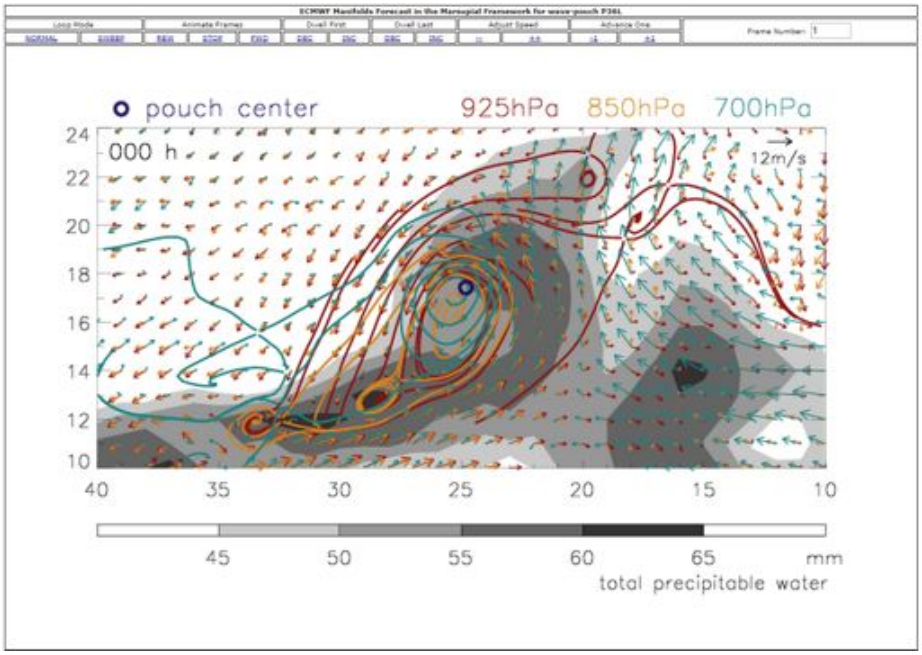


Sonde 10 above – highlighting dryness of profile

Below is the 1800Z METEOSAT image of the East Atlantic, which demonstrates the organization of P36 around the Cape Verde islands.



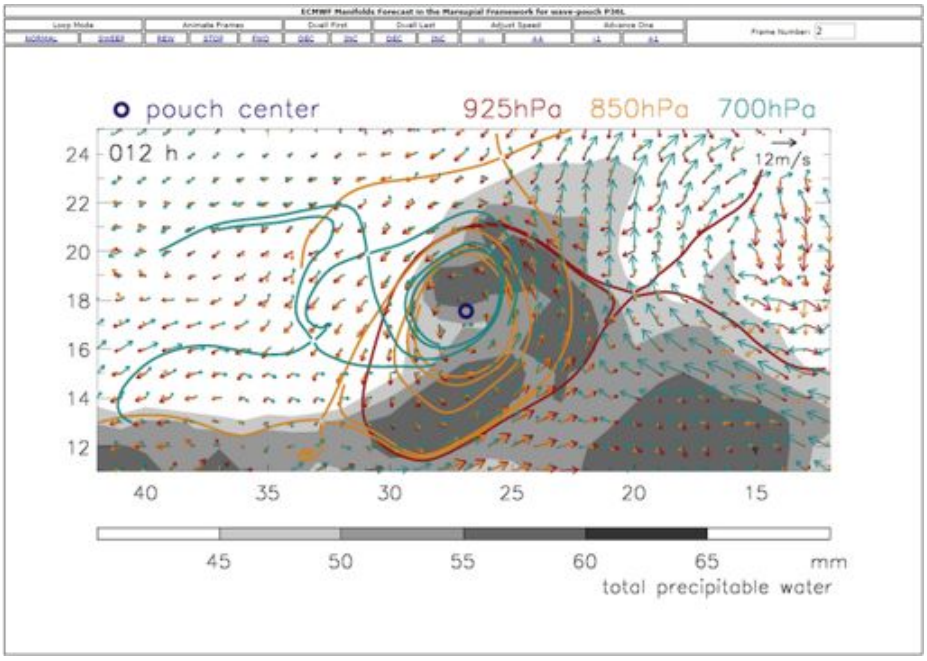
The Dividing Streamline analysis using ECMWF model data on Sep 22 1200 UTC gives estimate of moist envelope and its boundaries - assuming flow is strictly steady in frame co-moving with the eastely wave.



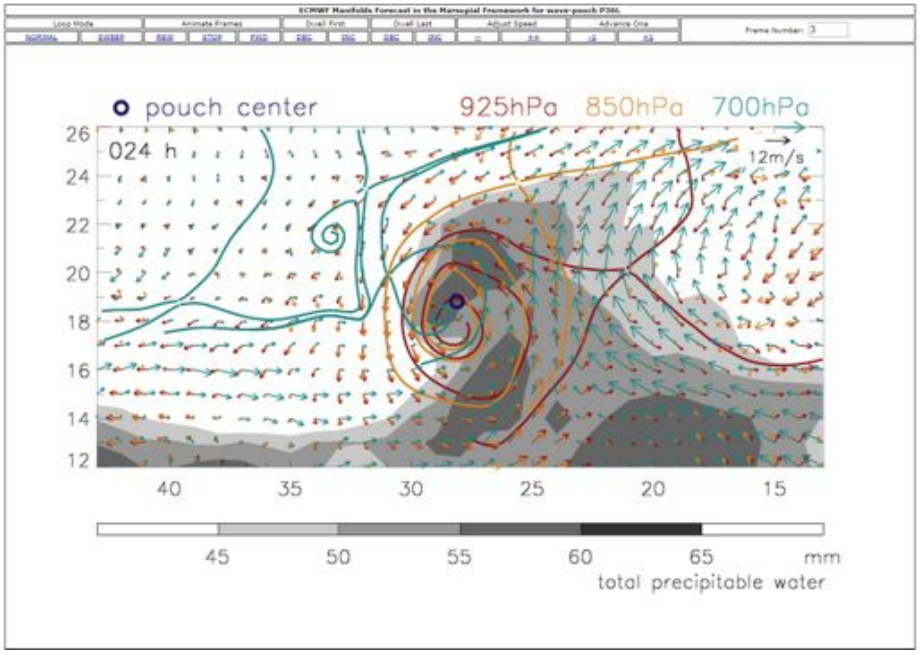
(http://met.nps.edu/~mtmontgo/storms2014/P36L/2014092212/ecmwf/P36L_manifolds_ECMWF_2014092212_loop.html) [By 24 hours (see below), the dividing streamline at 700 hPa has diminished in size, and exhibits an opening to the west. The co-moving winds near the opening at this level (green) are

directed eastwards and thus the pouch is susceptible to dry air intrusions from the very dry air to the west.]

Dividing Streamline analysis using ECMWF forecast data at 23 Sep 00 UTC (12 h forecast from 12 Z). This time corresponds approximately with the time that the AV-6 was flying around P29L.

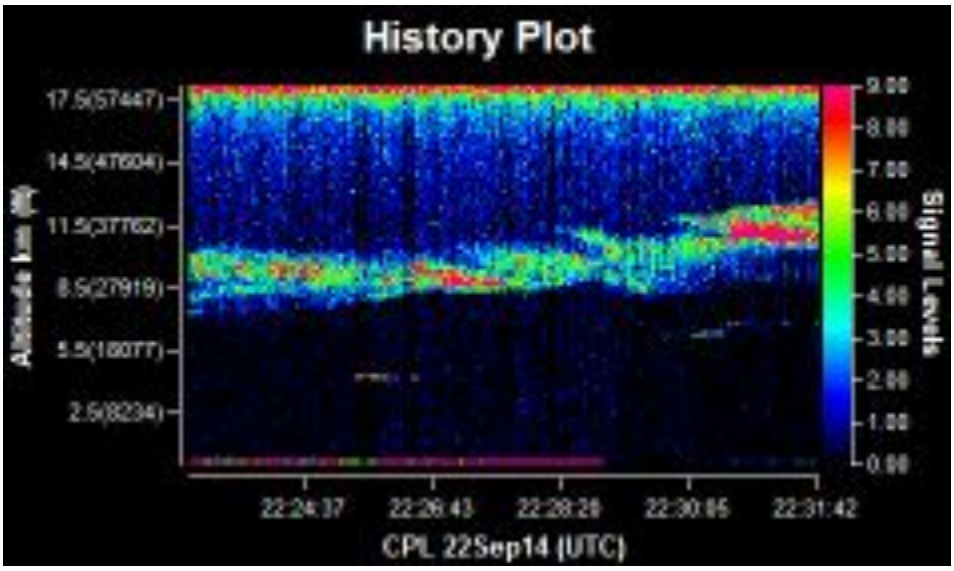


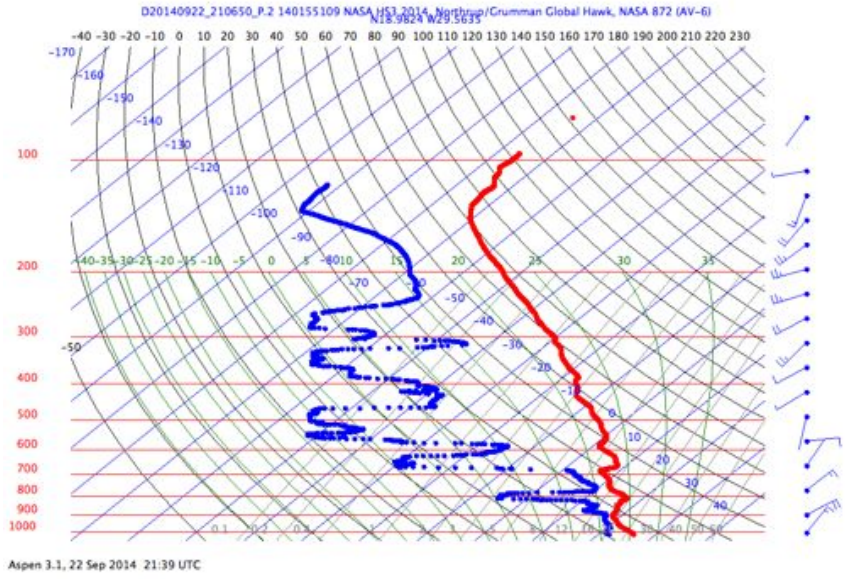
Ditto using ECMWF forecast data at 23 Sep 12 UTC (24 h forecast from 12 Z).



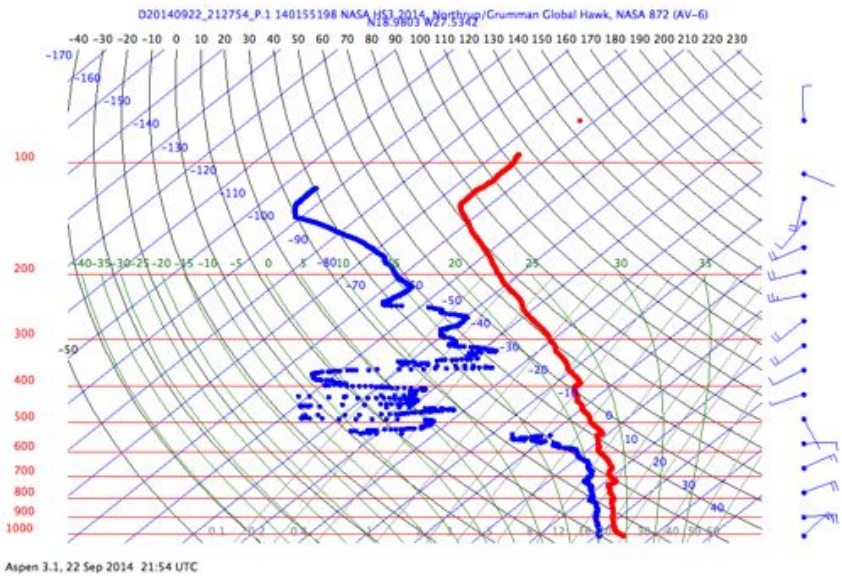
2230Z: AVAPS is manually loading a sonde, believes there may be a sonde rolling around? If so, may be reduced to 39 sondes.

22.31 Sonde 20 Pitched Out - should be east of the P36 wave trough axis. CPL indicates clouds up to 11.5 km; generally no high convective cloud tops seem to be apparent.

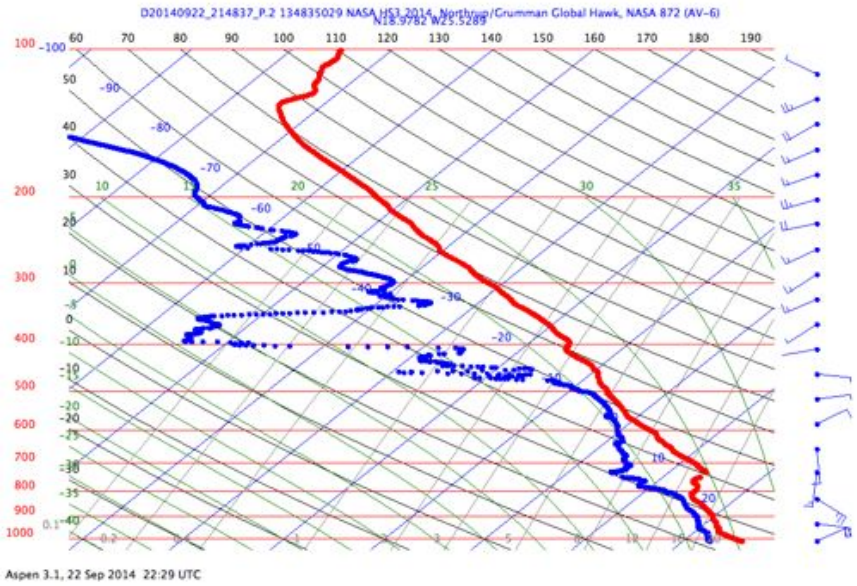




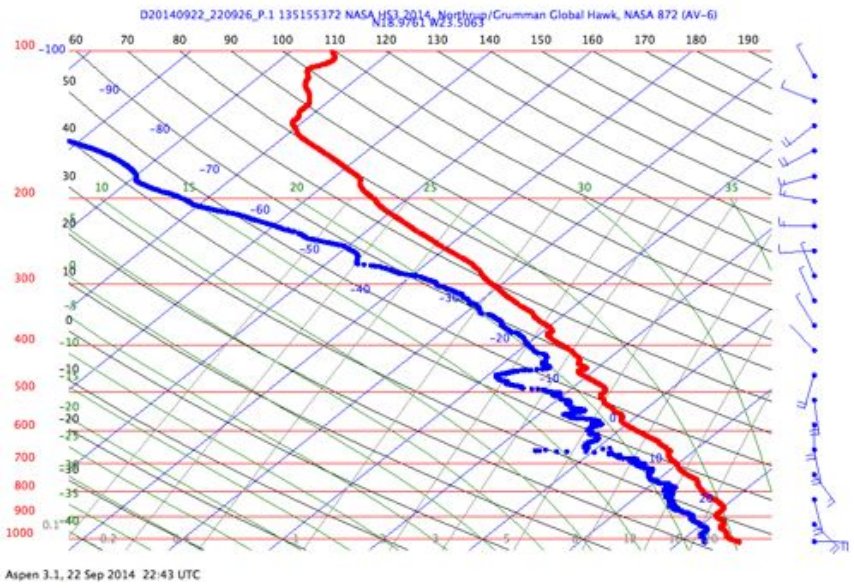
Sonde (#16) above is from 2106Z and is located near 19N/29.7W. Based on the winds, this sounding is likely west of the trough axis associated with P36L. Confined to 600 hPa and below. Humiditiy is improving at low levels.



Next sonde (#17) at 2127Z near 19N/27.5W indicates that the humidity is improving at midlevels now. Distinct directional change in wind still apparent near 500 mb. The winds would indicate that this sonde is closer to the trough axis.



Sonde #18 near 19N/25.6W seems to indicate that we have passed the trough axis just to the east as winds near 700 hPa have turned southerly. Perhaps a downdraft signature between 800 and 700 hPa, as well.



Sonde #19 near 19N/23.5W certainly indicates the eastern side of the wave trough associated with P36L. As expected, the humidity has now increased over the troposphere.

(For lower tropospheric flow kinematics context, see Dividing Streamline product and discussion above for P29L. MTM)

2250Z: Report from AVAPS is that a sonde is probably loose. This sonde was the last in bin 5. They shifted the carriage and did not experience any resistance, which means the renegade sonde should not be issued for the continued pattern, except that only 39 sondes would be released. We are deciding about which drop to potentially skip – perhaps one in drier air. Probably drop #35.

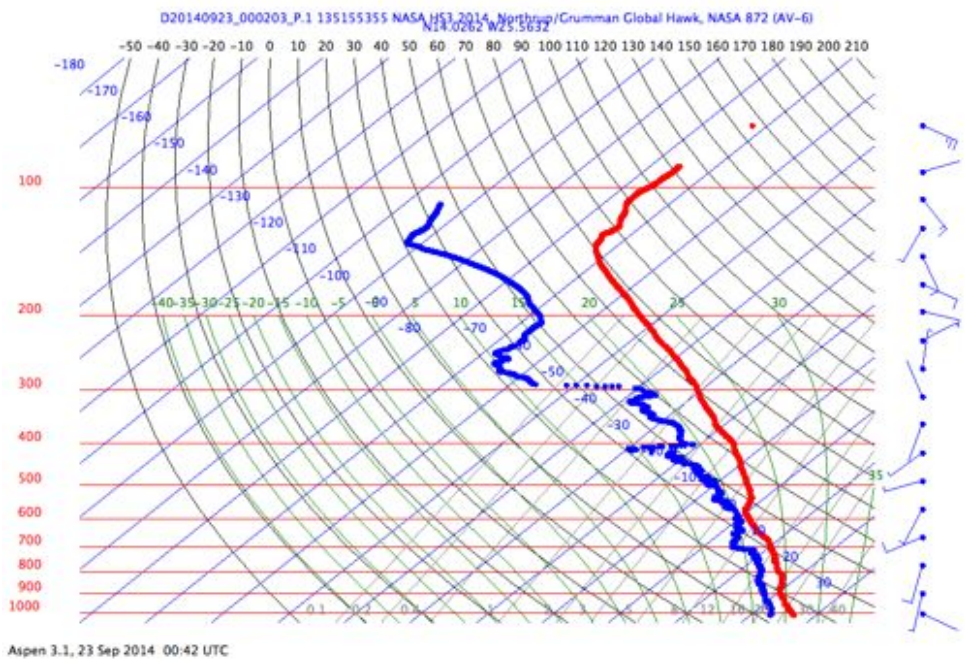
23.21 Sonde 21 Pitched Out - in the turn. Launch command sent early.

23.41 Sonde 22 Pitched Out – Launch command sent early. South of Cape Verde, still in moist plume east of trough axis.

00.02 Sonde 23 Pitched Out . AVAPS reports that bin #6 has not been cleared, which was expected after this drop. Unsure of where this sonde came from – is it the rogue sonde or did one come in from another bin? We will proceed under the assumption that we still only have 39 available.

00.21 Sonde 24 Pitched Out. Over cirrus, presumably in the wave trough.

00.41 Sonde 25 Pitched Out.



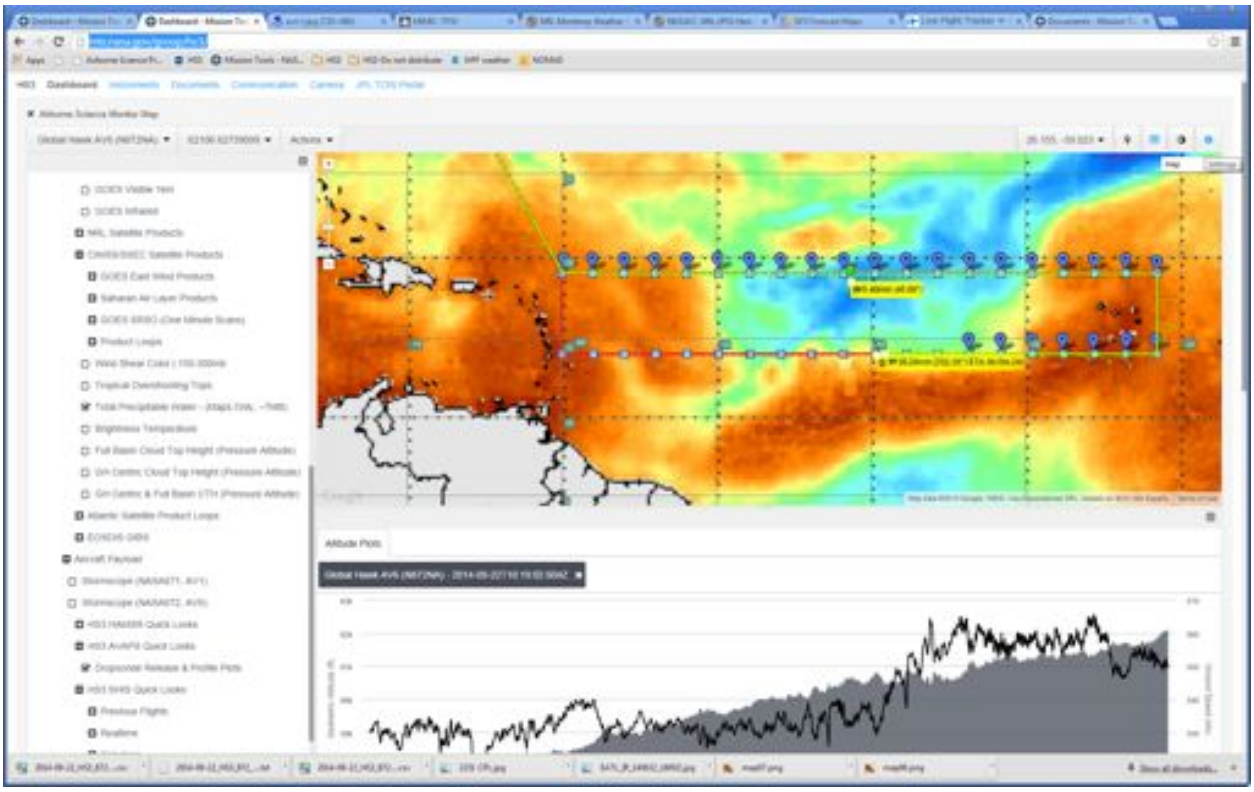
Sonde #23 (14.2N, 25.56W) indicates moist troposphere on western edge of P36.

01.01 Sonde 26 Pitched Out.

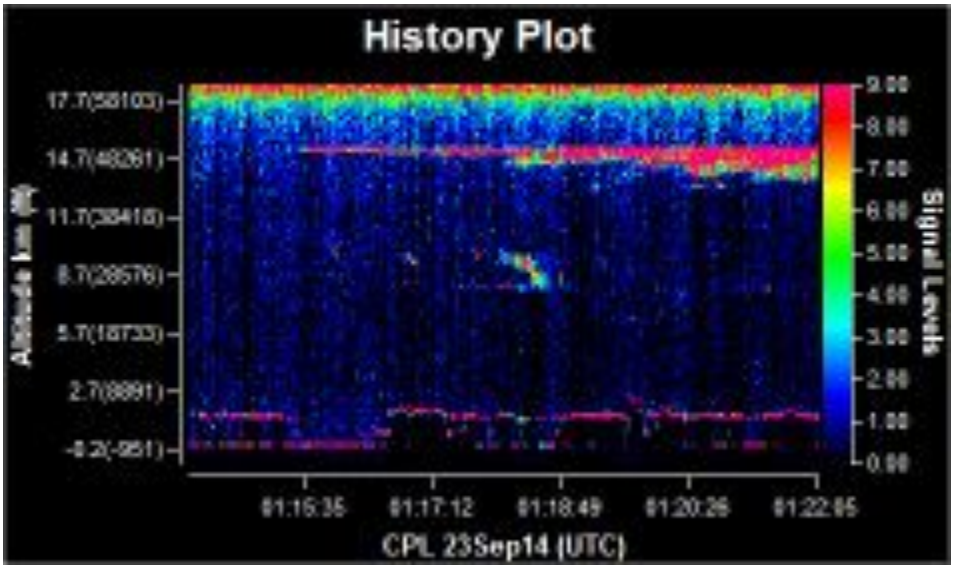
01.21 Sonde 27 Pitched Out.

01.23 GH has been traversing directly on a north-south oriented gradient in TPW for past hour or so at 14N, with moist air to the south and dry air to the north. It will be interesting to examine these sondes to see which air mass the drops were made in.

TPW near 01.30.

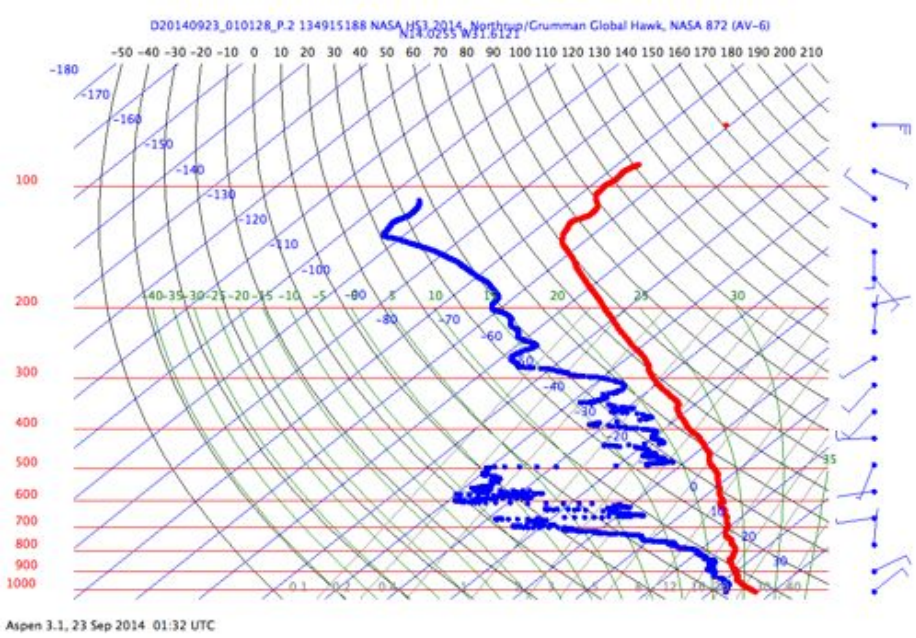


CPL at 01.15-01.22

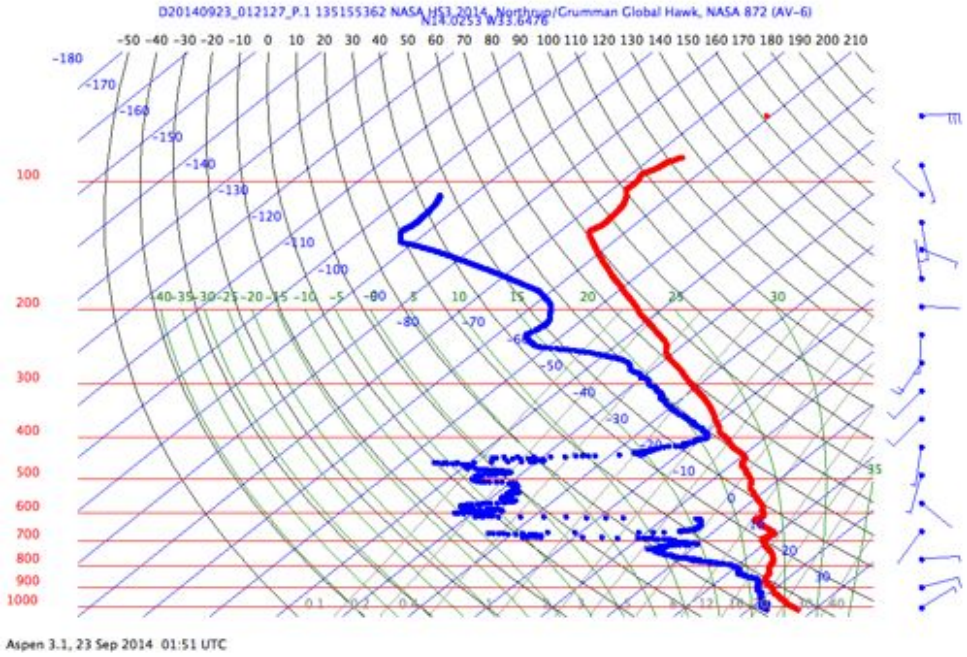


01.42 Sonde 28 Pitched Out.

02.01 Sonde 29 Pitched Out.



Sonde #26 (14.02N, 31.61W) shows dry mid level air, as GH is exiting moist envelope associated with P36. Moister air at upper levels- possibly due to being near cirrus layer.



Sonde #27 (14.02N, 33.64W) shows a similar pattern.

02.22 Sonde 30 Pitched Out.

02.42 Sonde 31 Pitched Out.

02.50 Based on discussion with AVAPS, there is not enough certainty that we are missing a sonde to warrant changing the science pattern. They feel there is quite possibly 40 good sondes. D35 will thus proceed as planned, and we will finish the grid. If it turns out we are missing a sonde, the last drop will be skipped. Additionally, the environment near D35 is showing more interesting spatial variability, so it is better to keep this drop. EAH.

03.02 Sonde 32 Pitched Out.

03.21 Sonde 33 Pitched

03.41 Sonde 34 pitched

04.01 Sonde 35 pitched

04.21 Sonde 36 pitched

04.41 Sonde 37 pitched

05.03 Sonde 38 pitched

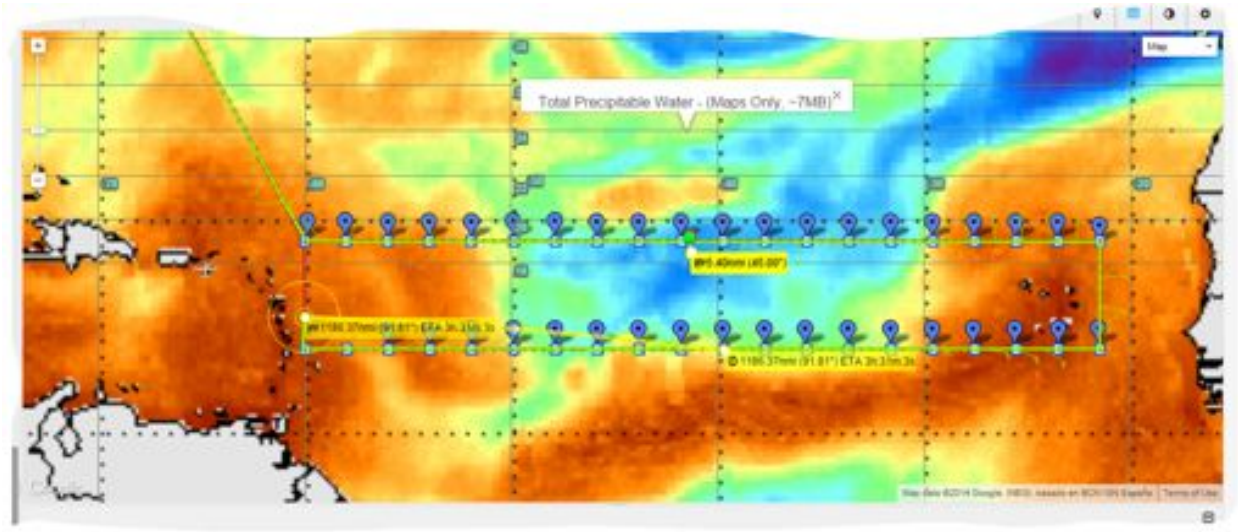
M. Montgomery Mission Scientist.

05.23 Sonde 39 pitched (Anticipated KU problem, but KU is back.)

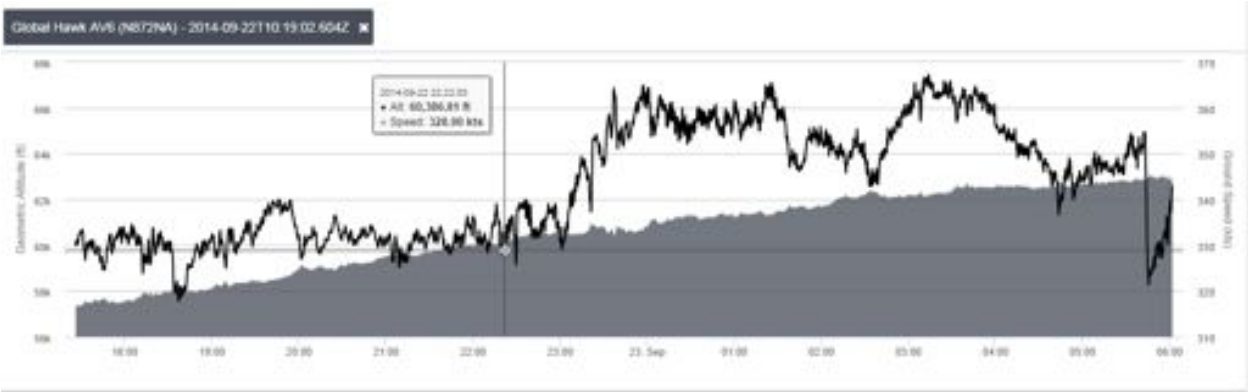
05.45 Sonde 40 pitched

Dropped last sonde and KU connection is successful. Plane headed due north now.

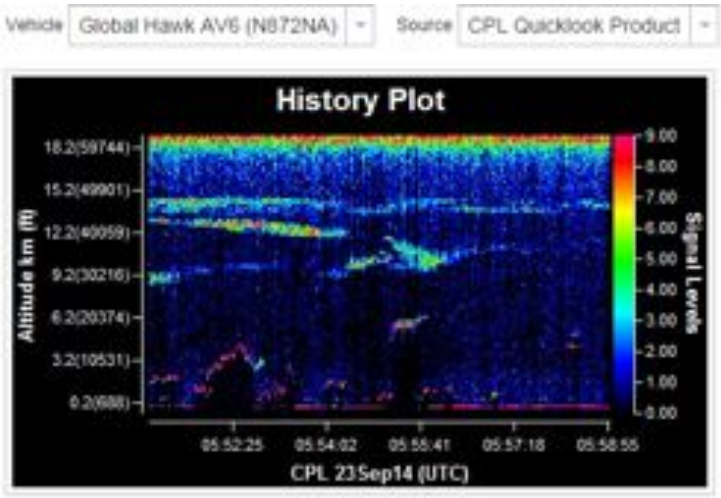
TPW near 06.00 Z



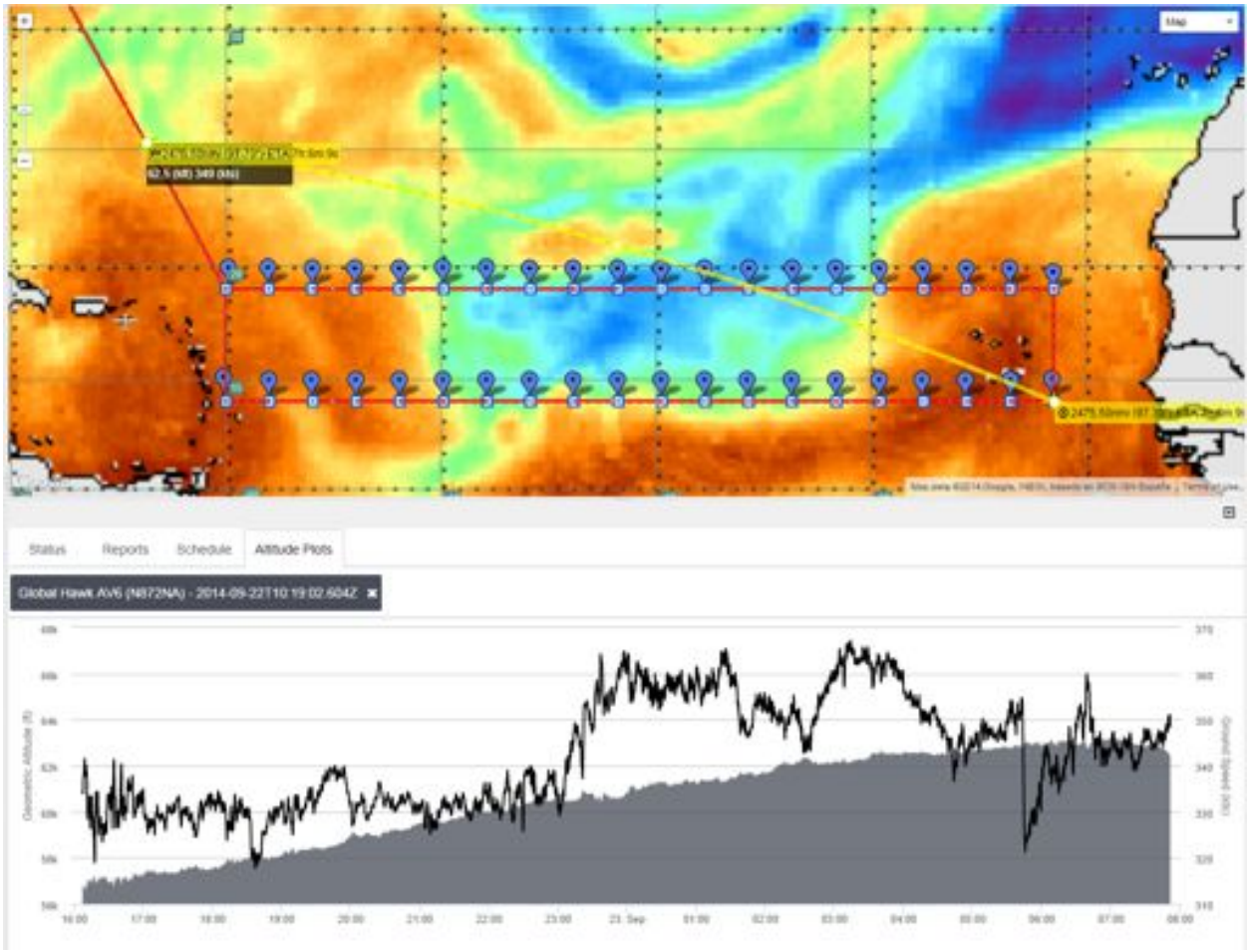
Flight-time record of AV-6 up to 0600 Z.



CPL Quicklook product at 05.58 Z



Ditto above at 07.43 Z



08.09 Z

During tonight's MDR flight, I have been wondering what is going wrong with P36L?

Is the strong vertical shear between 200 hPA and 850 hPA (greater than 30 knots observed along the 19 N transect) the main "reason" for the predicted weakening of P36?

Tonight, the forecaster group suggested that, yes, the vertical shear was the primary reason for the demise of P36L.

However, how does this vertical shear contribute to the demise of P36L?

For example, does the vertical shear act to vertically tear apart the pouch and thereby diminish the mesoscale reservoir of vorticity that can be amplified by convection within?

Alternatively, does the tearing apart of the pouch expose the pouch to hostile intrusions of dry air?

[Of course, the tearing of the pouch and intrusions of dry air may occur effectively simultaneously.]

Perhaps the primary effect of vertical shear is to to ventilate dry air into the pouch (from the west relative to the pouch).

(The conventional view on the role of lower and middle tropospheric dry air in tropical cyclogenesis is that the dry air leads to strong precipitation-driven downdrafts and low-level divergence and vortex weakening. However, dry air has been shown not to increase the strength of precipitation-driven downdrafts for non-supercell environments (Kilroy and Smith 2012; James and Markowski 2011). In fact,

the primary effect of dry air intrusion has been suggested to reduce the strength of convective-scale updrafts, thereby reducing the ability of convection to amplify low- and middle- level vertical vorticity.)

Can the current observations be used to help answer the foregoing questions?

0930z Colarco is MS (was here on time, but MM wanted to continue on… ☺

1120z Coming in a little early, Chase got up earlier than expected. Here's an HDVis picture:

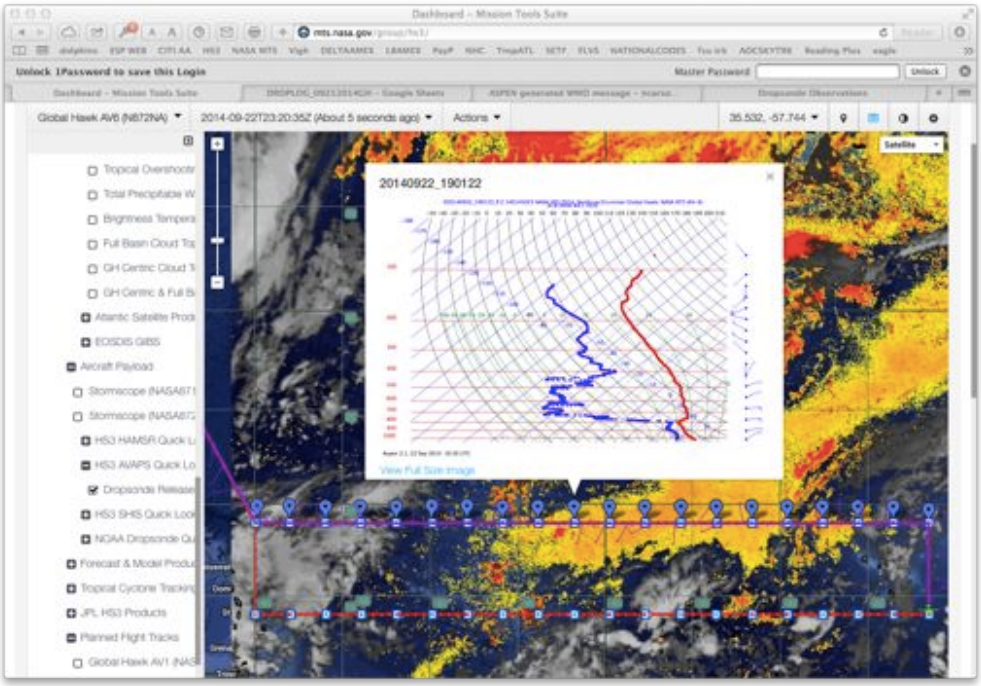
1128z Landing

Instrnument Reports

AVAPS

AVAPS loaded and deployed 40 sondes during RF09 through the MDL. Mechanically, AVAPS experienced just a single issue where one load command did not successfully execute and returned a system fault. The launcher carriage was exercised to ensure there were no blockages and the fault was cleared, but there was still some concern that a sonde had fallen below the dispenser (but still securely within the aircraft) and was not available for launching. Later operations revealed, however, that all sondes were still available for deployment. Speculation is that the sonde initially failed to drop completely from the dispenser, but the event is being investigated further to try and obtain a definitive answer. Data return from the sondes was very good with just one significant data gap in one sounding. The raw binary data files also showed these data to be missing. All 40 soundings were processed in real-time by the HRD team and made available to the GTS and MTS. Soundings revealed large areas with very dry air and significant vertical wind shear. Post flight system testing revealed no issues and the system is ready for the next flight.

Two sondes were accidentally deployed a minute or so before there intended location. This may have been related to operator fatigue toward the end of a shift and when a new operator was being trained. Because of the slow pace in deploying sondes during this mission and delays in getting replacement staff in place due to family illnesses, we had staffed AVAPS with just a single operator throughout the bulk of the flight for the first time. To avoid potential fatigue issues on future missions we will return to staffing with two operators during periods of sonde deployments.



Sondes Allocated		**750**	
Remaining		**174**	**23.2%**
Released		**576**	**76.8%**
Flight	**Take off Date**	**Sonde Usage**	**Sondes Left**
RF01	8/26/2014	75	675
RF02	8/28/2014	70	605
RF03	9/3/2014	50	555
RF04	9/5/2014	59	496
RF05	9/11/2014	64	432
RF06	9/14/2014	80	352
RF07	9/16/2014	88	264
RF08	9/18/2014	50	214
RF09	9/22/2014	40	174

S-HIS Summary

W. Sessions, J. Taylor; SSEC, University of Wisconsin-Madison

This flight took AV-6 eastward at 18 N, returning along 8 N with sondes evenly spaced during these portions of the flight path. Tropical wave activity was weak, but the transits did intersect with the Saharan Air Layer (SAL). Relatively cloud free conditions dominated, allowing for deeper profile comparisons than the Edouard flights permitted with many of the sondes.

Figure 1. AV-6 flight path shown by S-HIS 900 cm^{-1} brightness temperatures.

Surface moisture layers were limited to below 850 hPa for a long section of the first long track at 18 N. Layers extending to 500 hPa can be found associated with the coastal currents in the far eastern and western segments. This decrease can be seen in Figure 2 as AV-6 exits a cloudy region moving east.

SAL interaction was forecast to begin around 2130 UTC. This coincided with an increase in cloud cover and surface moisture. CPL quick look observations in Figure 3 show what are likely high cloud layers. Potential dust retrievals appeared quite low in comparison. Figure 4 shows the S-HIS cloud top pressure retrieval and humidity fields surrounding the period shown in Figure 3.

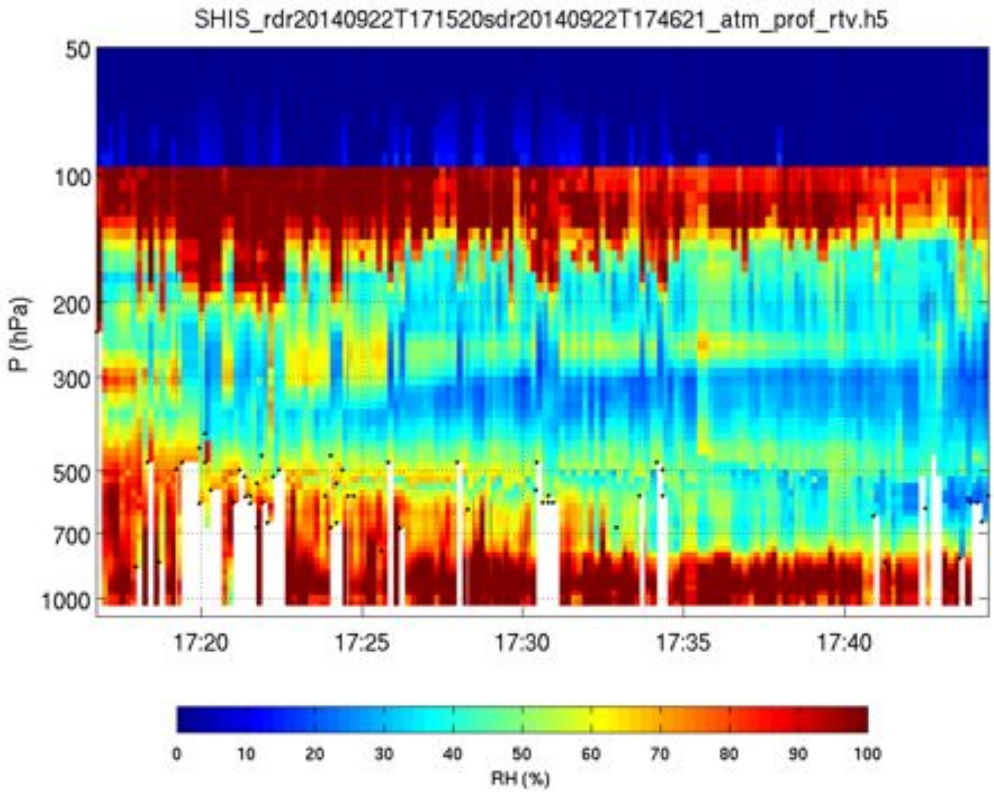


Figure 2. Relative humidity profile during the easterly transit along 18 N.

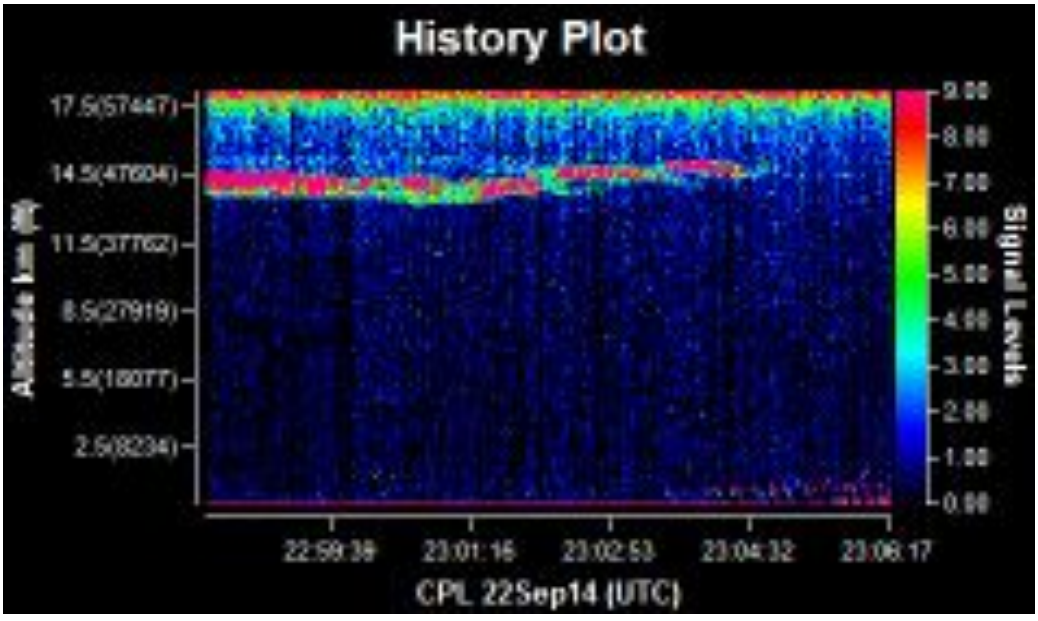


Figure 3. CPL backscatter retrieval east of Cape Verde

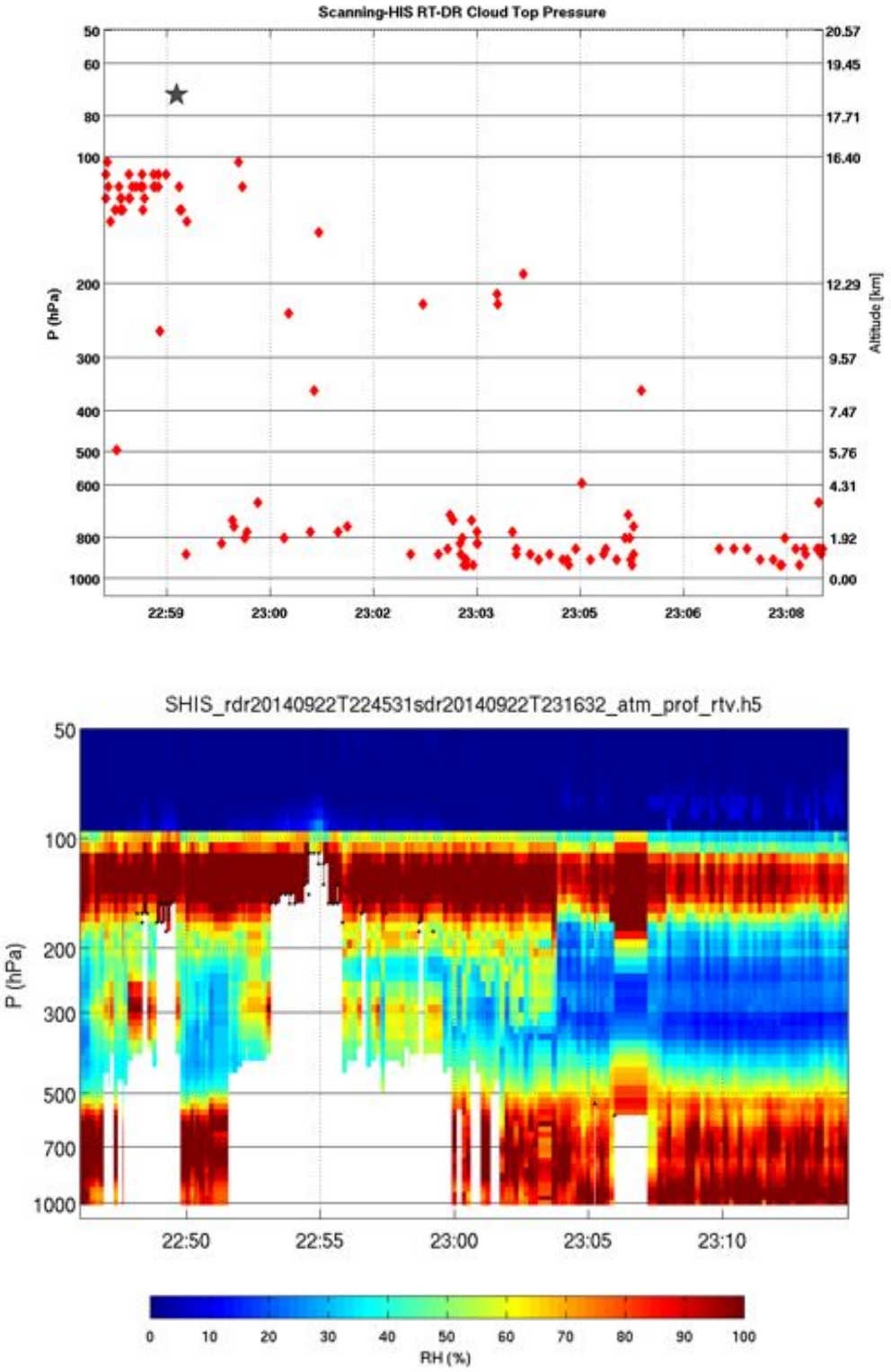


Figure 4. RT-DR cloud top pressure (top) and relative humidity profile (bottom) surrounding the layer depicted in Figure 3.

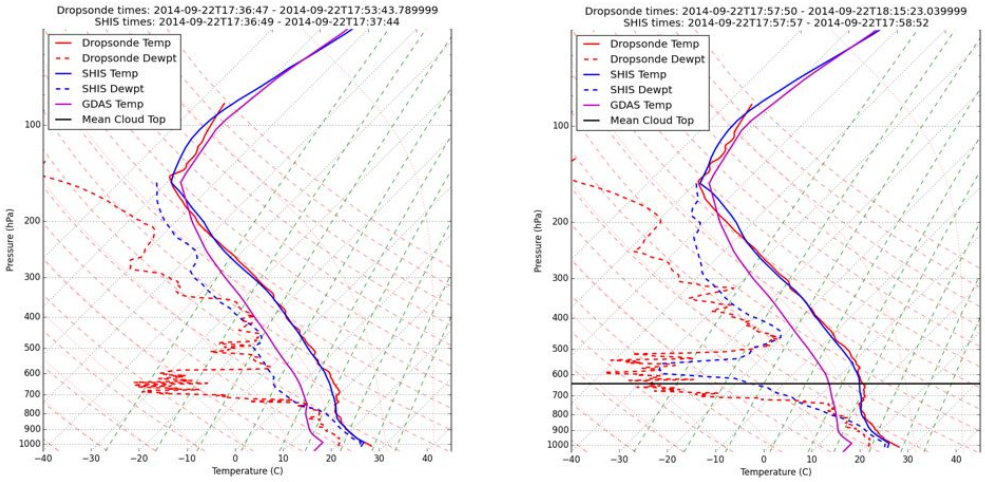


Figure 5. Profile comparison between AVAPS and averaged S-HIS profile.

A new field of view averaging and selection algorithm applied to the S-HIS retrievals used in the AVAPS comparisons improved the temperature and dewpoint agreement (fig. 5). The two profiles shown were taken east of a convective complex during the eastward track, with the later one more fully capturing the mid-level dry slot. Several full profile comparisons exist along the track, with a comparison generated and displayed in MTS for all sondes.

Instrument Summary

The Scanning-HIS operated well throughout the flight. Two instrument power cycles were performed during the outbound transit. The detector temperature did not drop sufficiently after the first power cycle and a second cycle at 1532 UTC was performed. Detector temperature dropped to and remained at approximately 80 K for the duration of flight science.

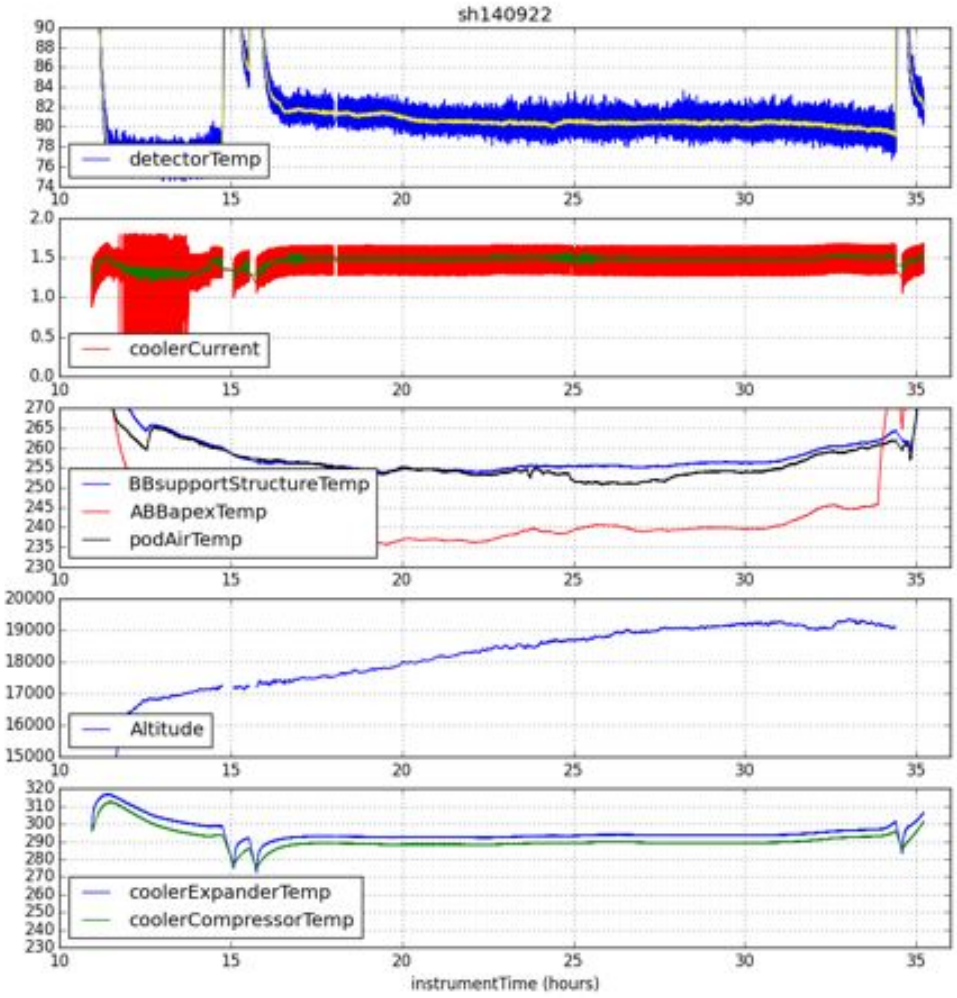


Figure 6. Scanning-HIS instrument temperature display.

Timeline (All times UTC)

- 1010 GH engine start
- 1023 DC41 ON (BusA)
- 1023 DC42 ON (BusB)
- 1035 Ku ON and transmitting
- 1056 Taxi
- 1056 IL41 ON (SHIS Power)
- 1101 Takeoff
- ABB cooled 273K, status = all green
- 1445 Deep power cycle for S-HIS
- 1504 DC41, DC42, IL41 on

- 1532 IL41 off for another 10 minute power cycle
- 1544 DC41, DC42, IL41 on
- 0954 IL42 ON (Descent heaters)
- 1024 Instrument power OFF before descent (IL42, IL41, DC42, DC41)
- 1035 Instrument power ON (DC41, DC42, IL41, IL42)
- 1114 Instrument power OFF (DC41, DC42, IL41, IL42) est L-0:20
- 1128 Landing

Misc notes

- 1550 Start straightaway #1
- 2250 End straightaway #1
- 2320 Start straightaway #2
- 0532 End straightaway #2

CPL

No additional laser energy adjustment was made for this flight. CPL performed as well as the previous flight and all data were captured to the disk. Some dust was seen in this survey flight, but not much. This can be seen in the attached image from the 532 channel. An interesting 1064 depol image from 21:57 UTC can be viewed on the cpl website. All data have been processed and are posted on this site. Data Spans 12:12 9/22 to 10:07 9/23 UTC.