ORACLES P3 Flight Scientist Post-Flight Status

Date: ___17 August 2017_____

Flight number: ____PRF04Y17_____

Routine flight or target of opportunity? ____Target_____

If target of opportunity, what is the goal? __Resample airmasses from 4 horizontal legs in flight PRF03Y17_____

Flight scientist: _____Jens Redemann_____

Assistant flight scientist: _____n/a_____

Ground scientist: _____Sarah Doherty_____

Asst. Ground scientist: _____Michael Diamond_____

Take-off: _____07:58UT (TMS)_____

Landing: _____16:51UT (ASI)_____

Quick summary:

Representative ACAOD or ACAOD range for flight: ____0.2; 0.37 max full column_____

Do the models predict crossing a gradient in aerosol age? YES (older in boundary layer, younger above)
Yes/No/Unclear
Notes: not a target at the time of planning. Given E-W extent of overall flight track, it is expected that we will cross a large gradient in aerosol age in HSRL2 curtain.

Did the flight cross a gradient in macroscopic cloud properties, like cloud fraction?
Yes/No/Unclear YES
Notes: More clouds expected (and encountered) near spiral descent at WP6

Did the flight cross a gradient in aerosol loading? YES
Yes/No/Unclear
Notes: More AOD near resampled trajectory endpoints than near Ascension

At any point during the flight, was there a clear separation between the smoke plume(s) and cloud tops? YES
Yes/No/Unclear

How many of the following maneuvers took place?

Ramps _0_____ Square spirals ___1_____

MBL legs __~2.5hrs of MBL sampling from WP12 to WP14 to ASI_____

Cloud legs _mostly sawtooth_____

Above cloud legs __ most legs on track between WP8 and WP11_____

Sawtooth legs __3_____

Plume legs __>6_____

Above plume legs __outbound to WP6 all above plume____

Instrument status:

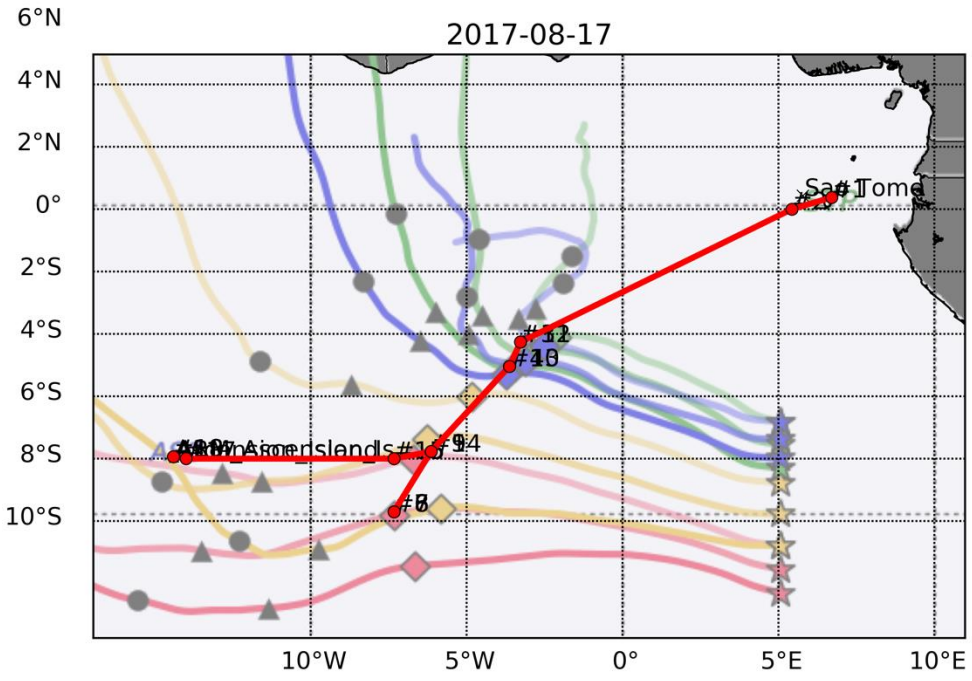
Instrument	Comments
P3	No issues; very accommodating; last lidar run over ARM site should have been extended beyond site; FS failed to reiterate that.
4STAR	Good flight, no problems.
HiGEAR	Leak problem at high altitude; CN counters odd.
HiGEAR-AMS	Instrument worked well. Exercised new sampling mode. Results look “exciting"
HSRL-2	Rough start with seed laser; recovered quickly; got good data rest of the flight.
RSP	Fine.
APR3	Good day.
Cloud probes	Worked well overall; issues with CIP images fixed (check – notes unclear)
CCN	Issues with orifice on inlet; measured at ambient
PDI	Worked well
Vertical winds	
WISPR/CVI	Great day of science, saw precipitating cloud.
COMA	Worked well
SSFR	Good flight
data	No issues

PRF04Y17 date 08/17/2017 day-of-week Mission Report
flight scientist: Jens Redemann
ground scientist: Sarah Doherty

flight plan and objective:

Suitcase flight São Tomé to Ascension Island.

- **Resample plume-level parcels that were sampled on routine flight on Aug 15, 2017**
- **Flight path connects midpoints of legs sampled on Aug 15 on their 48hr trajectories**
- **Overflight of parcels for lidar sampling, then re-trace of track at projected parcel height after transport**
- **Then forward run along same track near cloud top**



Map showing flight track as flown (red line), underlayed with forward-trajectories of points sampled on Aug 15 flight. Colored diamonds indicate airmass locations after 2 days, i.e. on 17 August. On Aug 15 these air masses were sampled at 2-2.5km altitude; on 17 Aug they are at 1800m-2100m altitude.

Also of interest is observing mixing of aerosol into the BL and (hopefully) into clouds to the west of the study region. Flight plan was to transit high to 9.7S, 7.33W on track shown above; spiral descent; then go back NE along the same line, but at altitude of forward trajectory end-points. At 4.26S, 3.27W turn and had back SW along flight track, nominally sampling clouds and maybe the boundary layer, back to 9.7S, 7.33W, then head west towards Ascension.

Flight Summary:

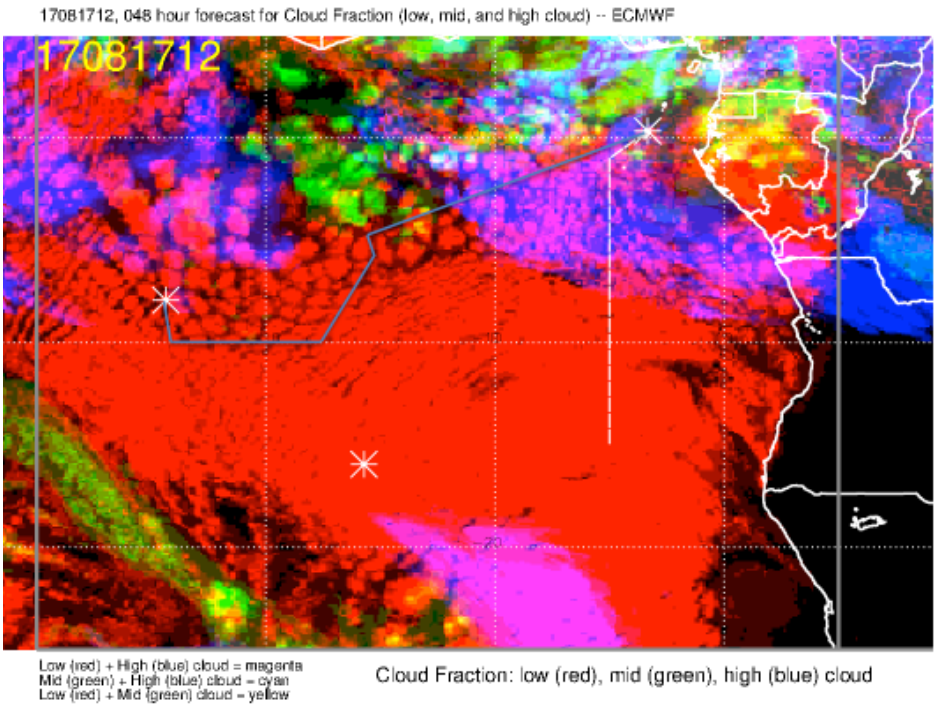
The planned mission was flown in a manner close to the way it was planned through the sampling of the plume legs at the forward-trajectory semi-Lagrangian points. However, the low clouds had largely cleared in the region between WPs 3 and 5, precluding cloud sampling on the NE to SW leg. Instead, we re-sampled at plume height. Also, due to significant interest in the BL pop-Cu near ASI, the P3 headed west at 8S (rather than planned 9.7S). The hope was to

sample scattered cumulus clouds along 8S between ~8W and Ascension. The P3 sampled the plume to 7.5W, then descended into the MBL briefly, then back up to above the plume, then back down to min altitude. Sawtooths through the boundary layer were then flown in the hope of intersecting cumulus clouds. Clouds were seen but time in cloud was insufficient for sampling. On approach to Ascension Island we overpassed the ARM site at high altitude; however, the pilots turned as soon as they hit the ARM site lat/lon. HSRL can not get retrievals while in a turn, so goal is to re-do overpass on tomorrow's coordination flight.

Highlights of the flight:
1) Observing (APR3 &HSRL; see images below) decoupled boundary layer along transit from TMS to 9.7S, 7.3E, with cumulus embedded in drizzling stratocu. Then, on west-bound leg at 8S heading west from ~7W later in the flight (~14:45-16:30 UTC) observed well-mixed, coupled boundary layer with broken cumulus.
2) Observing (HSRL; see image below) the tapering of the pollution layer at the northern-most edge of the (only) low cloud deck crossed. This cloud deck was dissipating as the day progressed.
3) Doing the square spiral through the edge of the low cloud deck, with portion of the square spirals over drizzle cells. Then ascending to do a cloud leg where aerosol had mixed down into cloud/boundary layer.
4) Sampling of the lower FT aerosol layer just north/northeast of where it becomes fully mixed into the BL.
5) Extensive sampling of the "semi-lagrangian" points predicted by the forward trajectories, **covering approx. 6 degrees of latitude and several altitudes. Peak in aerosol layer was where expected from the trajectories.**
6) Extensive boundary layer sampling east of Ascension, where the aerosol was almost fully in the boundary layer. AOD ~ 0.3 with only ~0.08 above the boundary layer. Boundary layer was extremely well-mixed.

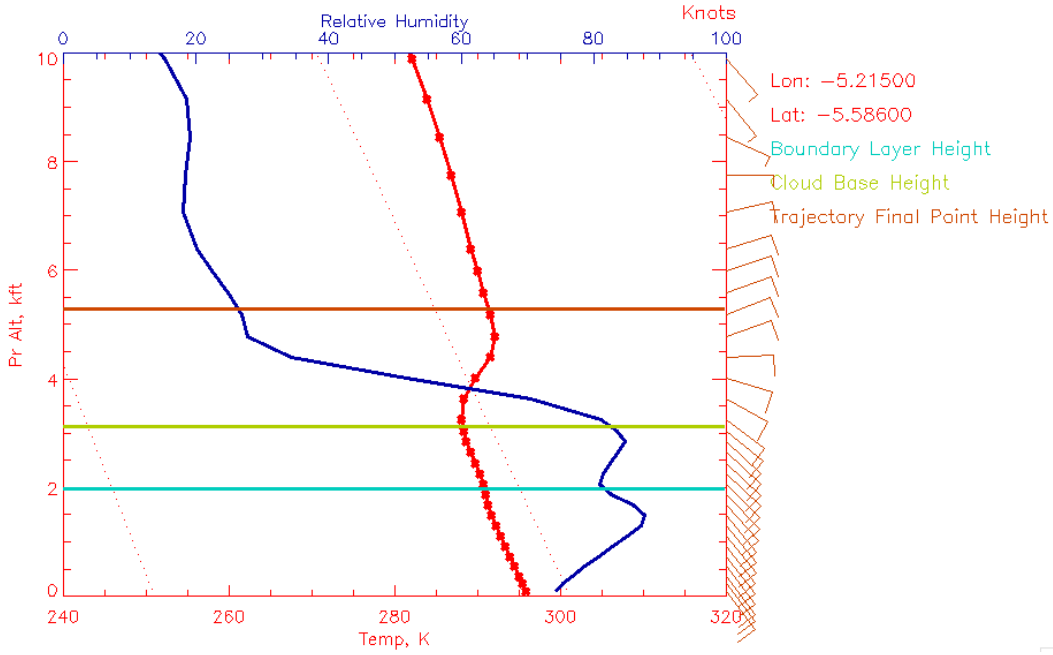
A-Priori Forecast: 4-5 line synopsis with selection of images taken from the forecast briefings, Available at http://bocachica.arc.nasa.gov/ORACLES/oracles_2017.html, bottom of page

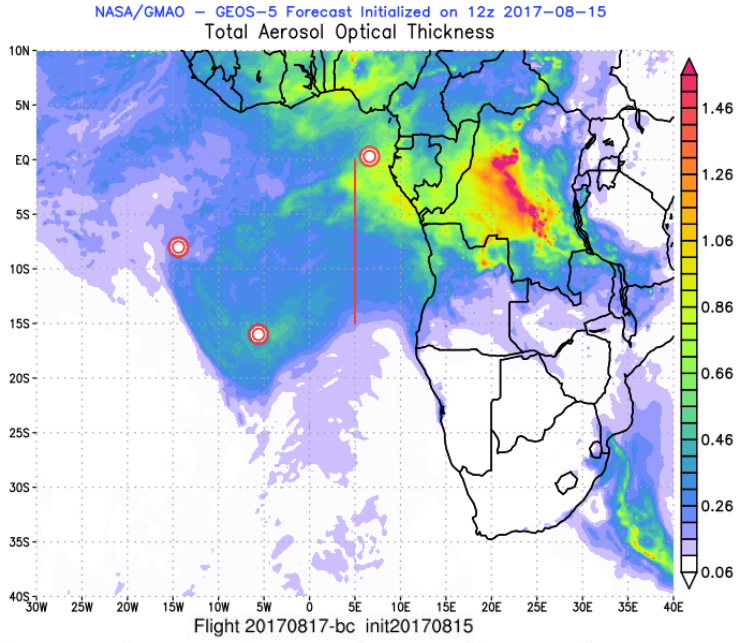
- **Surge of moisture is being surveyed on this day. 800mb surge is slightly slower (in its westward progression) than previous forecast.**
- **Lagrangian end members (of Aug 15 routine flight) chosen for survey are clearly above the BL on this day.**
- **Based on two cases, UKMO model is underpredicting high clouds in this region. So, expect high clouds (thin) to be on the first third of flight track**
- **600mb (4 km) is also not very organized. Situation dominated by moisture intrusion from the north. This northern 600mb moisture surge appears to be moving faster to the west than previous forecasts.**
- **Unclear was whether the boundary layer heights in this study region would be so high that the aerosol layer sampled on 15 August might have descended and then been fully mixed into the boundary layer (and low clouds). If this was the case, this would make the robustness of our semi-lagrangian sampling strategy questionable.**



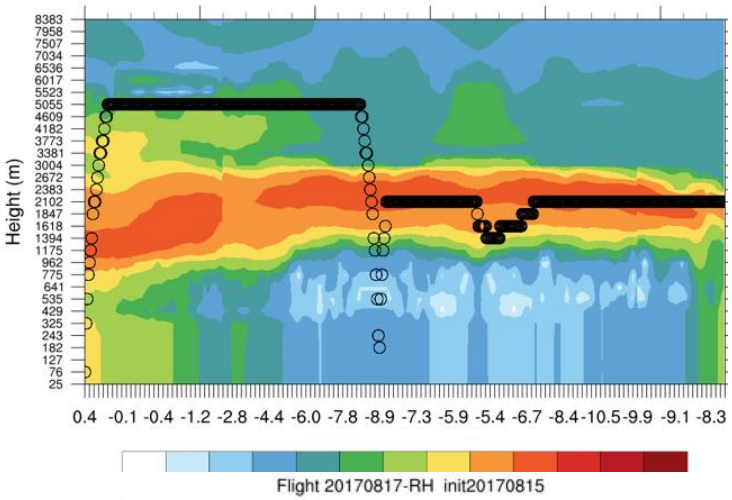
Most recent forecast. This indicates high cloud cover on first part of track. We are at the northern edge of the forecast SC deck. Middle clouds are enhanced relative to old fcst.

Below: Sounding from model valid at 12Z, Aug 17. Trajectory final point height is above BL and RH gradient. This is at approx. 5S, 5W. Other points in the region have the same behavior.

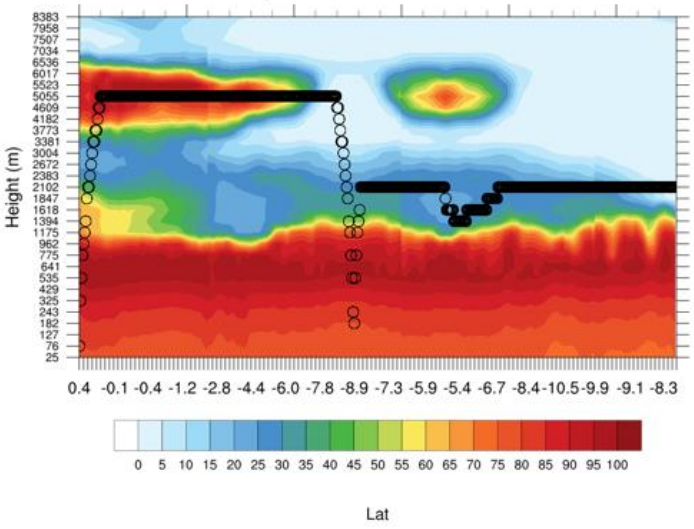




GMAO AOD forecast for 17 August, showing higher AOD in a NE to SW area coinciding with our study area.



Forecast "curtain" **of BC mass mixing ratio along the planned flight track.**



Forecast "curtain" **of RH along the planned flight track, showing cloud top heights increasing somewhat, from ~1.1km at the NE end of the track to ~1.4km at the SW end of the track.**

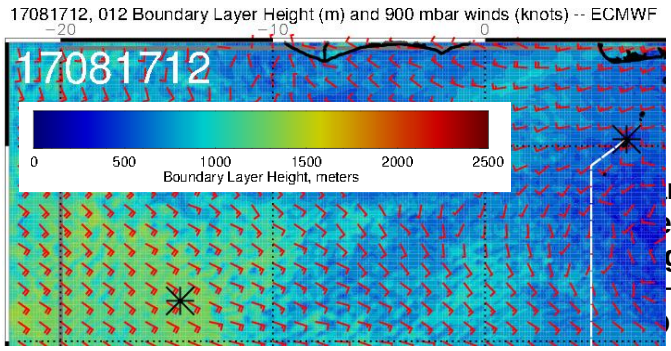
Forecast Verification:

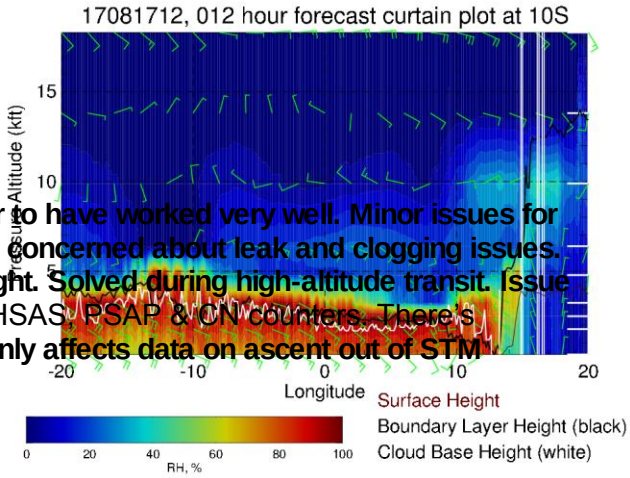
The low cloud deck dissipated to the south more rapidly (and extensively) than expected from the forecast. See images from 10:00UTC, 12:00UTC, 14:00UTC and 16:00UTC below. Thus, the only cloud sampling during the flight was of the very northern edge of the main low cloud deck, at ~9.5S.

The heart of the aerosol layer topped out at ~2.2km, somewhat lower than give in the aerosol forecast curtain above.

Cloud top heights (HSRL-2) ~500 m higher than modeled RH had suggested

- **HSRL shows clouds south of 5 S at 1500 m and rising to > 2 km, whereas ECMWF shows boundary layer height (and RH-based definition) below 1500 m all east of 10 W**





r to have worked very well. Minor issues for
e concerned about leak and clogging issues.
ght. Solved during high-altitude transit. Issue
HSAS, PSAP & CN counters. There's
nly affects data on ascent out of STM.

Flight Instrument/logistics notes: 4-5 lines on anything of note

HiGEAR front rack inlet problems at beginning of flight. Solved during high-altitude transit. Issue affected their front rack, which contains the SP2, UHSAS, PSAP & CN counters. There's redundancy for all but the SP2 in their other rack. Only affects data on ascent out of STM.

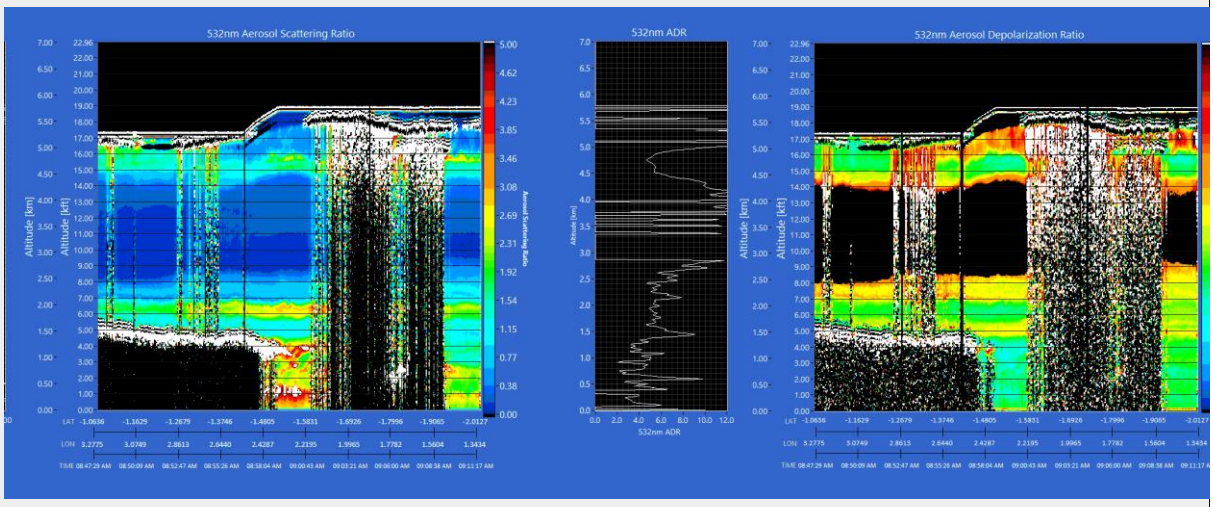
Selection of cloud for sampling: The only clouds present to sample when the P3 was at lower altitudes were at the very south end of the flight track, which were sampled immediately after spiraling down at 9.7S. There was also very scattered cumulus clouds west of 8W to Ascension Island which we tried to sample, but they were too scattered.

Run Table [UTC]

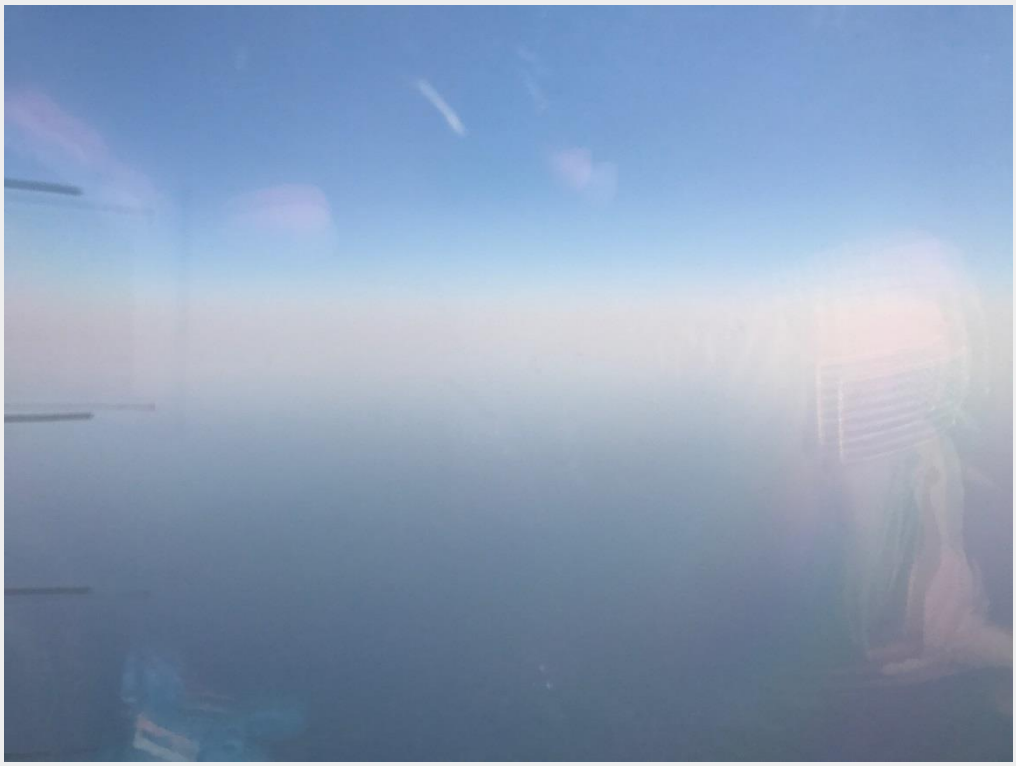
In table below, text color corresponds to color of coordination points in forward trajectory map above.

description	beginning time	end time	altitude	notes
Takeoff	**07:58 UTC**	**X**	**To max alt**	**take-off, overcast conditions some mid-levels clouds, smoke layer above ~10.6Kft HiGEAR front rack inlet problems at beginning of flight.**
				
	08:37			**APR sees drizzle, flat cloud top**
	08:41			**climbing to 16kft**
	08:46			**climbing to 16.5kft to get above mid-level cloud**
	08:49			**visually it appears that the 16kft cloud deck is embedded in some smoke**

description	beginning time	end time	altitude	notes
				
Ferry leg	**08:59**	**11:25**		**Cirrus observed in the morning along the northern end of the track, first as fairly substantial cirrus then as thin streamers. The streamers were hard to see, but possible to make out, in the IR imagery. Cirrus ended around 5 S.** **See APR3 and HSRL curtains in images section below, showing decoupled boundary layer along transit and transition from plume above BL to plume mixed fully into BL.**
	09:14			**Large clear slot between 8 and 14kft**

description	beginning time	end time	altitude	notes
				
	09:19			smoke looks thicker towards North of flight track
	09:48			AOD is 0.04 but there are still plenty of Ci visible from the cockpit
	10:06			pix – Ci streaks near WP 3
				

description	beginning time	end time	altitude	notes
	10:13			lidar curtain shows two layers with tops at 16.5 and 9kft at WP3
	11:10			upper layer in lidar curtain starting to disappear
Square spiral descent	11:25	11:48	To min alt	Beautifully aligned spirals!
	11:36			Fairly thick cloud at 6.5kft
Square spiral ascent	11:48	11:55	To 1300m	Much more polluted in the BL than above the cloud; in BL: • 550nm scattering: ~50-70Mm^{-1} • CO ~120 ppb • SP2 rBC ~125/cc
Cloud leg	11:58	12:15	~1700m	A bit of changing altitude to stay in-cloud (~1500-1700m) with slow descent overall as cloud altitude descended to the NE Terra image: 6.5-11 S, 8-3 W, we sampled right along blind spot Definitely wave activity at northern edge, not just diurnal breakup
Plume leg for semi-lagrangian sampling	12:15	12:34	1800m	(8.5 S, 7 W) to (7.5 S, 6 W) between WP8 and 9 Aerosol concentrations decrease from SW to NE • 550 nm scattering decreases from ~120 to 90 Mm^{-1} over leg. [On Aug 15 Routine flight scat in this air parcel was 165-180 Mm^{-1}] • CO ~300-200 ppb • SP2 rBC range from 150-254/cc, average around 200/cc. [On Aug 15 Routine flight this was ~400/cc]
	12:20			Pix in plume

description	beginning time	end time	altitude	notes
				
Min-alt leg for 4STAR sky scan	12:39	12:42	Min alt	• 550 nm scattering ~ 60-70 Mm^{-1} • CO ~110ppb • SP2 rBC ~120/cc
	12:40			full column AOD of 0.37 plus 4STAR sky scans near 7.5S; slightly bumpy ride, some white caps
	12:47			found bottom of smoke layer near 4,400ft during ascent back to 5,900 ft
Plume leg for semi-lagrangian sampling	12:48	13:08	1800m	(7 S, 5.5 S) to (6 S, 4.5 W) • 550 nm scattering increases from ~60 to 70 Mm^{-1} over leg. [On Aug 15 Routine track, was 170 Mm^{-1}] • CO ~200ppb • SP2 rBC increases from 95 to 215/cc over leg. [On Aug 15 Routine track, was 300-400/cc]

description	beginning time	end time	altitude	notes
	12:58			heart of plume seems to be below 5,900
Plume leg for semi-lagrangian sampling	13:08	13:18	1250m	(6.5 S, 4 W) Descended to get more into heart of the plume • 550 nm scattering ~75-80 Mm^{-1} • CO ~200ppb • SP2 rBC 90 to 120/cc over leg
	13:15			en route descent/ascent finding higher plume loading, 5,900ft
Plume leg for semi-lagrangian sampling	13:20	13:24	1800m	(5 S, 3.5 W) • 550 nm scattering ~80-110 Mm^{-1}. [On Aug 15 Routine track, was 160-170 Mm^{-1}] • SP2 rBC ~180-210/cc. [On Aug 15 Routine track, was 350-430/cc]
	13:25			ascending to hit WP 10 at 6,700ft GPS, WP10 to 11 at 6.7kft, course reversal at WP11 and descend to 5.7kft; at 5.7kft we are below the heart of the plume, running short distance, pilots talking to ATC, ascending 300ft
Plume leg for semi-lagrangian sampling	13:26	13:41	2100m	• 550 nm scattering increases from 70 to 90 over leg. [On Aug 15 Routine track, was ~60 to 90 Mm^{-1}] • SP2 rBC increases from 140 to 200/cc over leg. [On Aug 15 Routine track, was 100-190/cc]
TURN	13:41	13:43	~2000m	At WP 11 (4.26S, 3.27W), turn from heading NE to heading SW along same track.

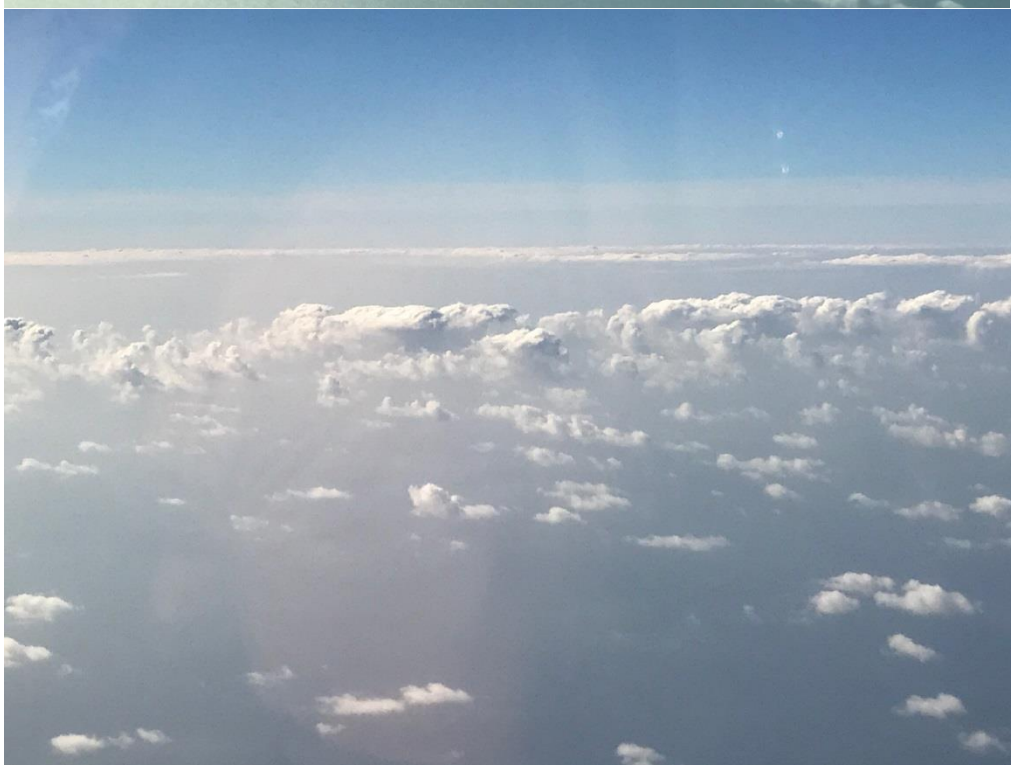
description	beginning time	end time	altitude	notes
Plume leg for semi-lagrangian sampling	13:43	13:48	1750m	(4.5 S, 3.5 W) • 550 nm scattering increases from ~80 to 140 Mm^{-1} over leg. [On Aug 15 Routine track, was 160-170 Mm^{-1}] • CO 190-210ppb • SP2 rBC increases ~190 to 250/cc. [On Aug 15 Routine track, was 350-430/cc]
Plume leg for semi-lagrangian sampling	13:49	14:10	1800m	(5 S, 3.5 W to 6S, 4.5W) • 550 nm scattering decreases from ~120 to 80 Mm^{-1} over leg. [On Aug 15 Routine track, was 160-170 Mm^{-1}] • SP2 rBC ~200/cc. [On Aug 15 Routine track, was 350-430/cc]
Plume leg for semi-lagrangian sampling	14:10	14:20	1800m	(6 S, 4.5 W) to (6.5S, 5W) • 550 nm scattering ~80 Mm^{-1}. [On Aug 15 Routine track, was 170 Mm^{-1}.] • CO ~200ppb SP2 rBC 180-210/cc. [On Aug 15 Routine track, was 300-400/cc]
	14:18			no significant difference in plume legs between WP13 and 15 at 5,400 and 5,900ft altitudes
Plume leg for semi-lagrangian sampling	14:21	14:45	1800m	(6 S, 4.5 W) to (6.5S, 5W) • 550 nm scattering ~80 Mm^{-1}. [On Aug 15 Routine track, was 170 Mm^{-1}.] • CO ~200ppb SP2 rBC 180-210/cc. [On Aug 15 Routine track, was 300-400/cc]
	14:25			changed plan for remainder of flight to eliminate WP15. Instead head along 8S towards ASI and do BL profiling in shallow Cu regime

description	beginning time	end time	altitude	notes
TURN	14:45	--	1650m	Turn westbound at 8S • Head towards Ascension due to time running out • Hold altitude at ~1700m for plume sampling. • AOD ~0.14
Plume leg	14:45	15:00	1650m	(8.0S, 6.5W) to (8.0S, 7.5W)
En-route descent to 200ft	15:00	15:04	To min alt	For 4STAR AOD & scans AOD ~0.3
Low MBL leg	15:06	15:10	75m	• 550 nm scattering ~60-75 Mm^{-1} • CO ~100ppb • SP2 rBC 125-140/cc
Ascent	15:10	15:18	To 2200m	
Above-plume leg	15:18	15:28	2200m	AOD ~0.08 at 2200m
	15:25			pix of increasing shallow Cu
				

description	beginning time	end time	altitude	notes
Descent	**15:28**	**15:36**	**To 75m**	**Almost at 10W, descending to min. altitude**
	15:35			**pop-Cu disappearing, cloud tops near 2,800ft**
Low(er) MBL leg	**15:36**	**15:38**	**75m**	• **550 nm scattering ~ 70-75 Mm^{-1}** • **CO 120-130ppb** • **SP2 rBC 170-180/cc**
Ascent	**15:38**	**15:39**	**To 850m**	
High(er) MBL leg	**15:39**	**15:54**	**850m**	**Saw cloud tops at** 2800' **but very scattered, so not clear there was any real cloud sampling. But are capturing what is where clouds would** be… **BL well-mixed; scattering, CO and SP2 counts very constant:** • **550 nm scattering ~ 40-50 Mm^{-1}** • **CO ~100ppb** • **SP2 rBC ~170/cc**
	15:53			**pop-Cu increasing – pix**

description	beginning time	end time	altitude	notes
				
Descent to min alt	**15:54**	**15:57**	**To 75m**	
Lower(er) MBL leg	**15:57**	**15:59**	**75m**	**Scattering, CO and SP2 counts essentially unchanged from that at 850m** **AOD ~0.33**
Ascent	**16:00**			
Sawtooths in BL	**16:06**	**16:24**	**Variable through BL**	**Sawtooths through vertical extent of boundary layer. (8S, 12-13W)** **16:15 at ~1600m** (5,250') **altitude, scattering and CO drop off; top of layer.** **BL conc. steady; well-mixed** • **550 nm scattering ~ 45-55 Mm^{-1}** • **CO ~100ppb** • **SP2 rBC ~100-125?/cc (more variable)**
	16:16			**much thicker clouds near 13W – pix**

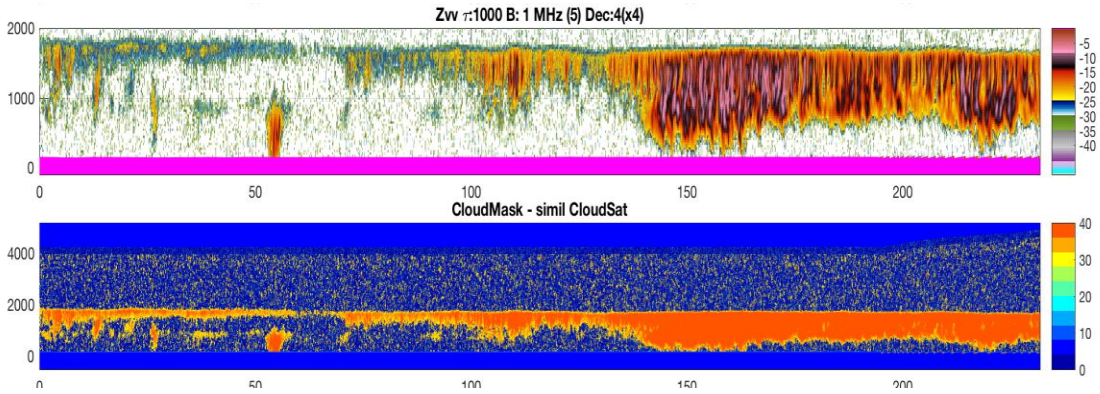
description	beginning time	end time	altitude	notes
				
Ascent	**16:25**		**To max alt**	**Ascend to high altitude, heading for Ascension.** **At 16:32 UTC at 4800m, 15,**700’ **at 7.97S, 14.2W**
	16:29			**Textbook? Pop-Cu pix**

description	beginning time	end time	altitude	notes
	 			

description	beginning time	end time	altitude	notes
ASI ARM site overpass	**16:33**	**?**	15,000’	**Overpass of ARM site, but P3 turned right at the ARM site location. HSRL2 data not usable while in turn (but okay just before overpass of ARM site). APR3 turned off to avoid damaging ground radar.**
				
Start descent in to ASI	**16:35**			
LANDING	**16:51:35**			

APR-3 curtain from transit at high altitude

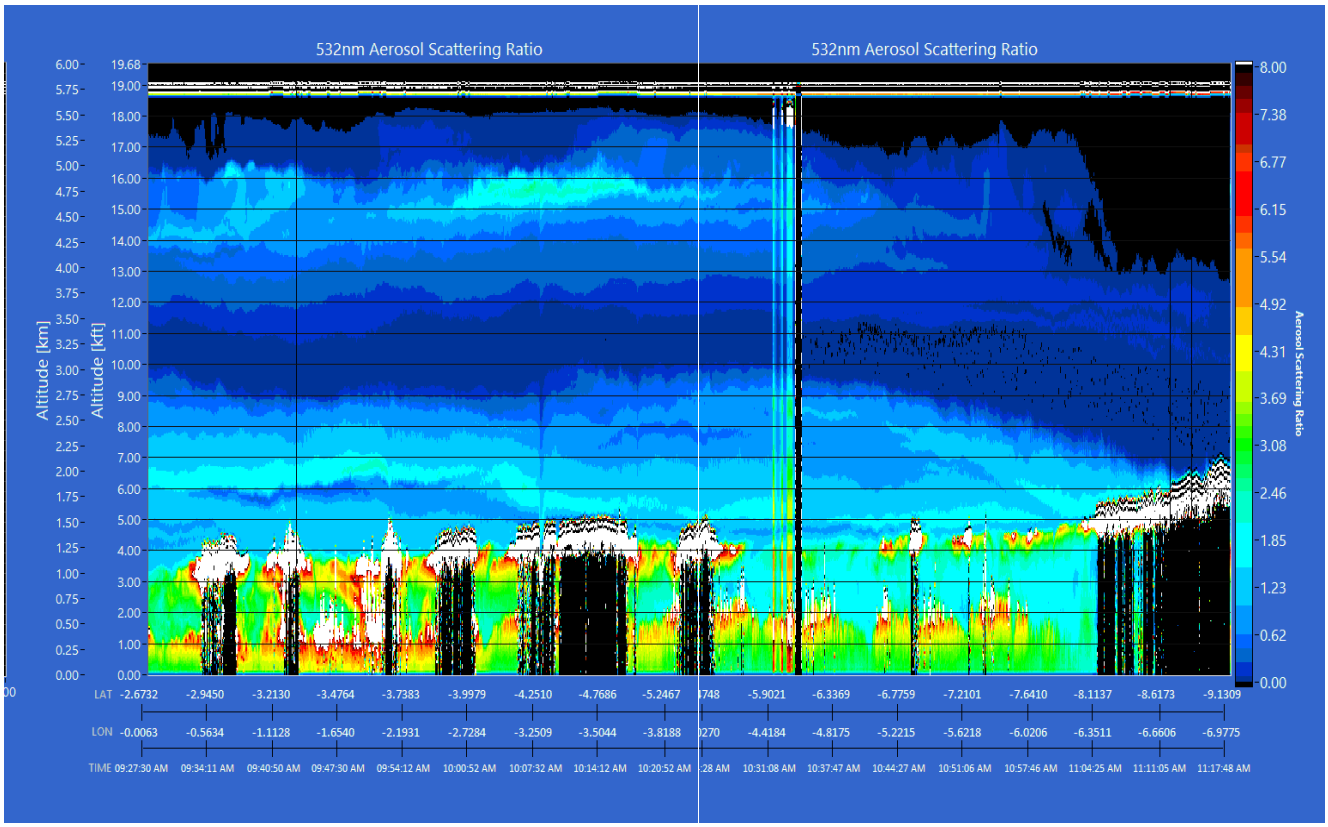
- **Decoupled boundary layer with LCL/scud clouds prevalent, broken Sc**
- **Some Cu rising into Sc**



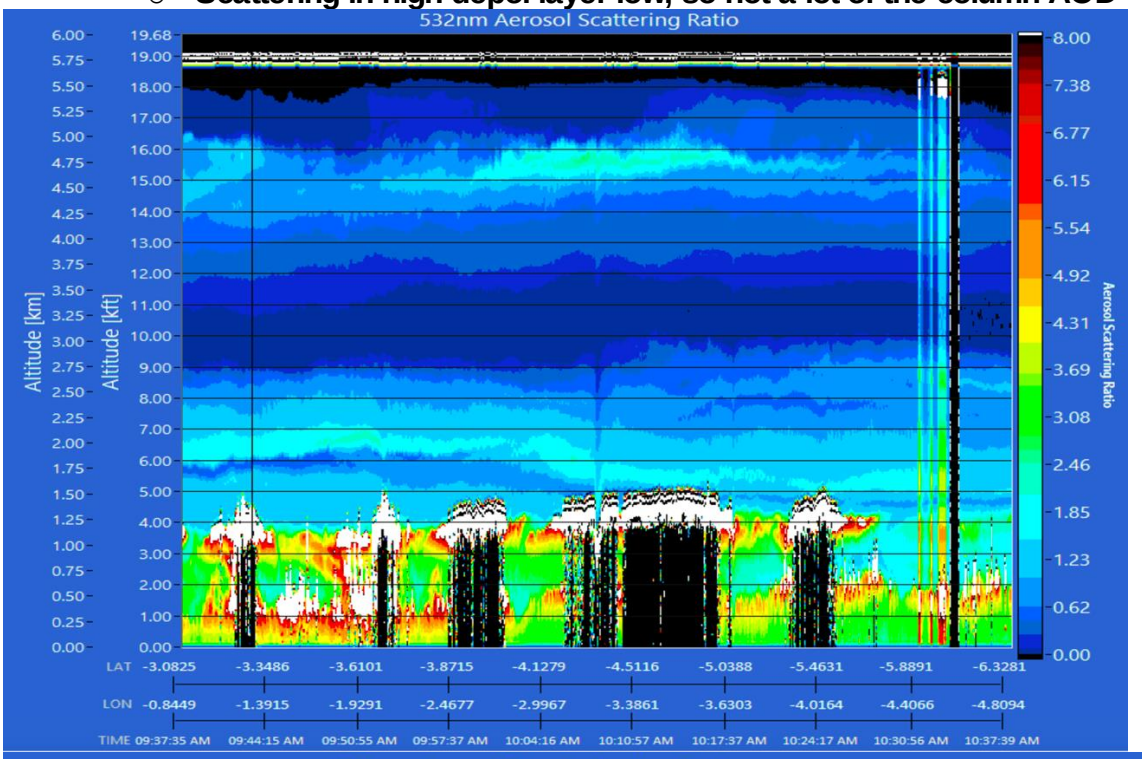
- **HSRL2 curtain on high-altitude transit leg from STM to 9.7S, 7.3W.**
- **Two plumes on HSRL image**
  - **Lower layer at ~2km altitude**
  - **Uppler layer ~4.75km altitude**
  - **Higher plume disappears at around 6.5 S**
  - **Lower plume disappears into cloud layer at 9 S**

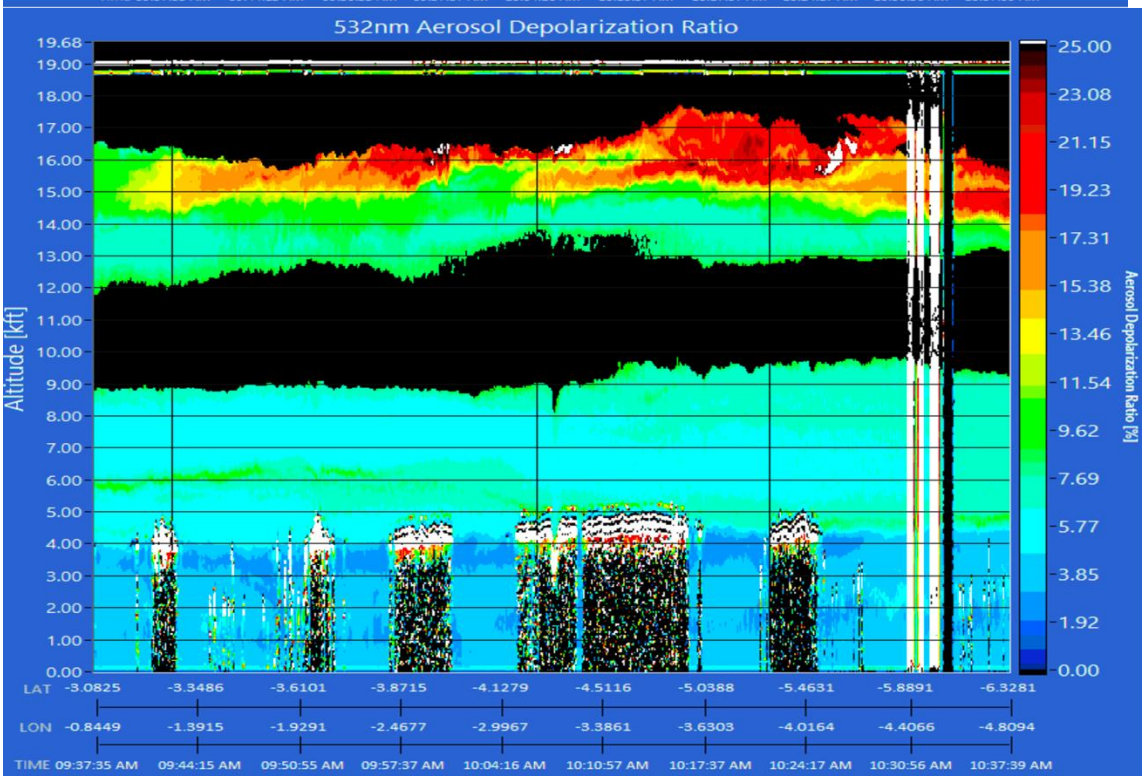
At ~3S, 0.8E the upper layer (now at ~14-16,000’ altitude) depolarization increased from ~**4-5% to ~20%, increasing as we went SW**

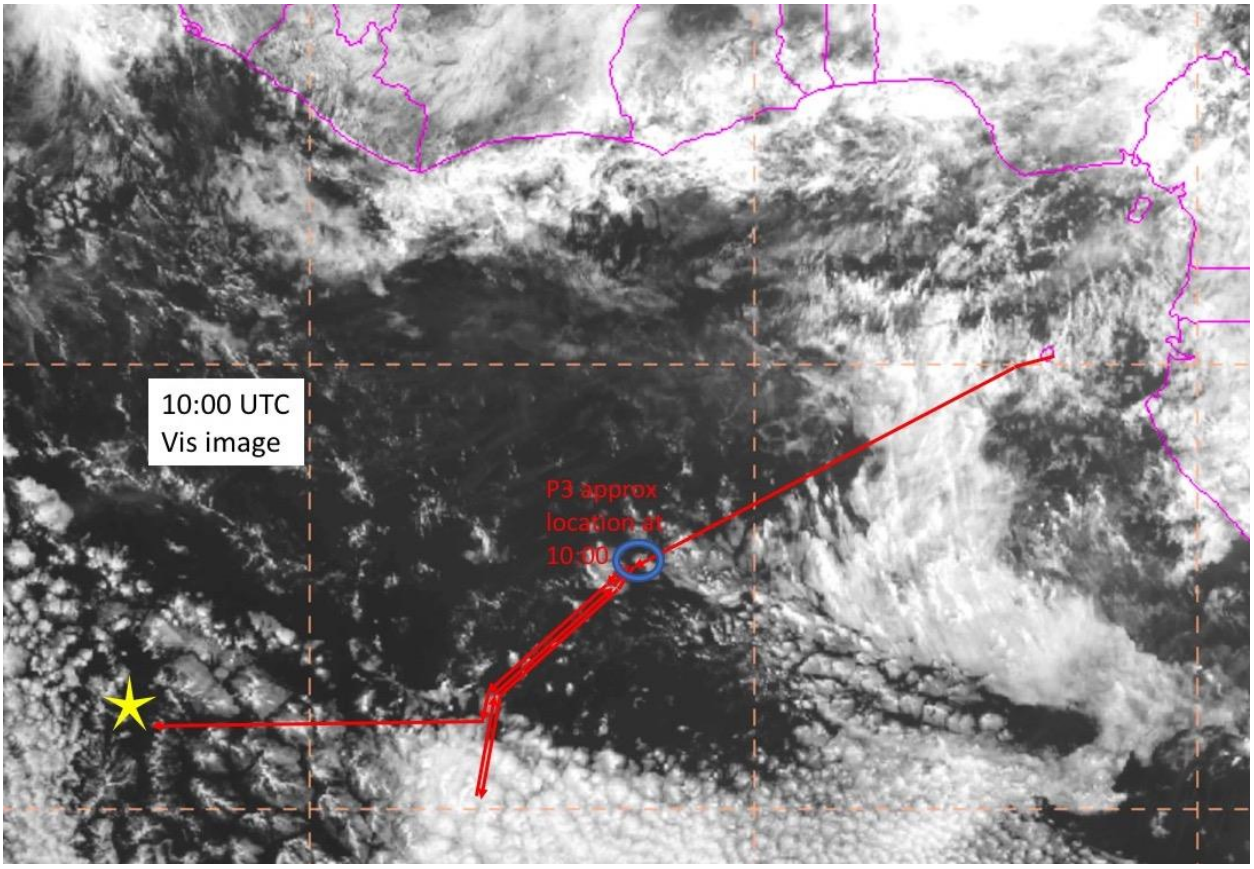
  - **Most likely explanation is a mix of BB and dust (pure dust depol ~ 35%)**



- **Scattering in high depol layer low, so not a lot of the column AOD**



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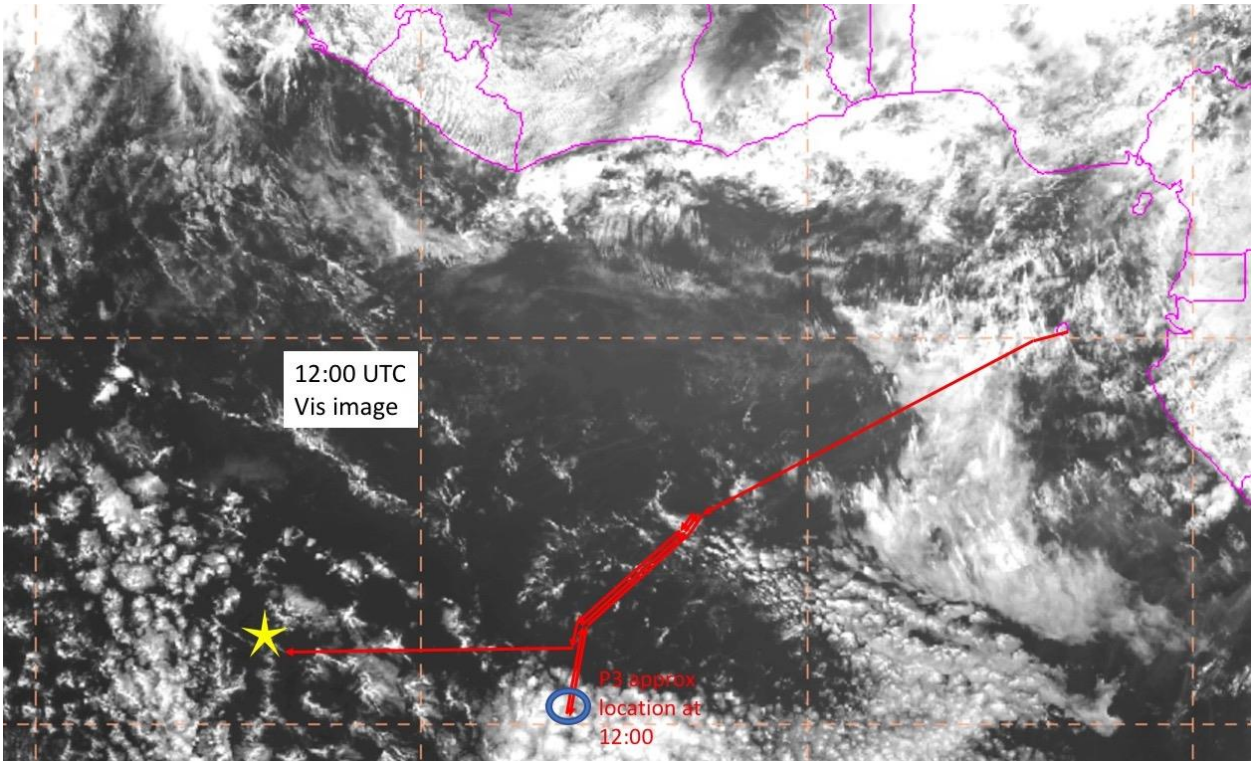
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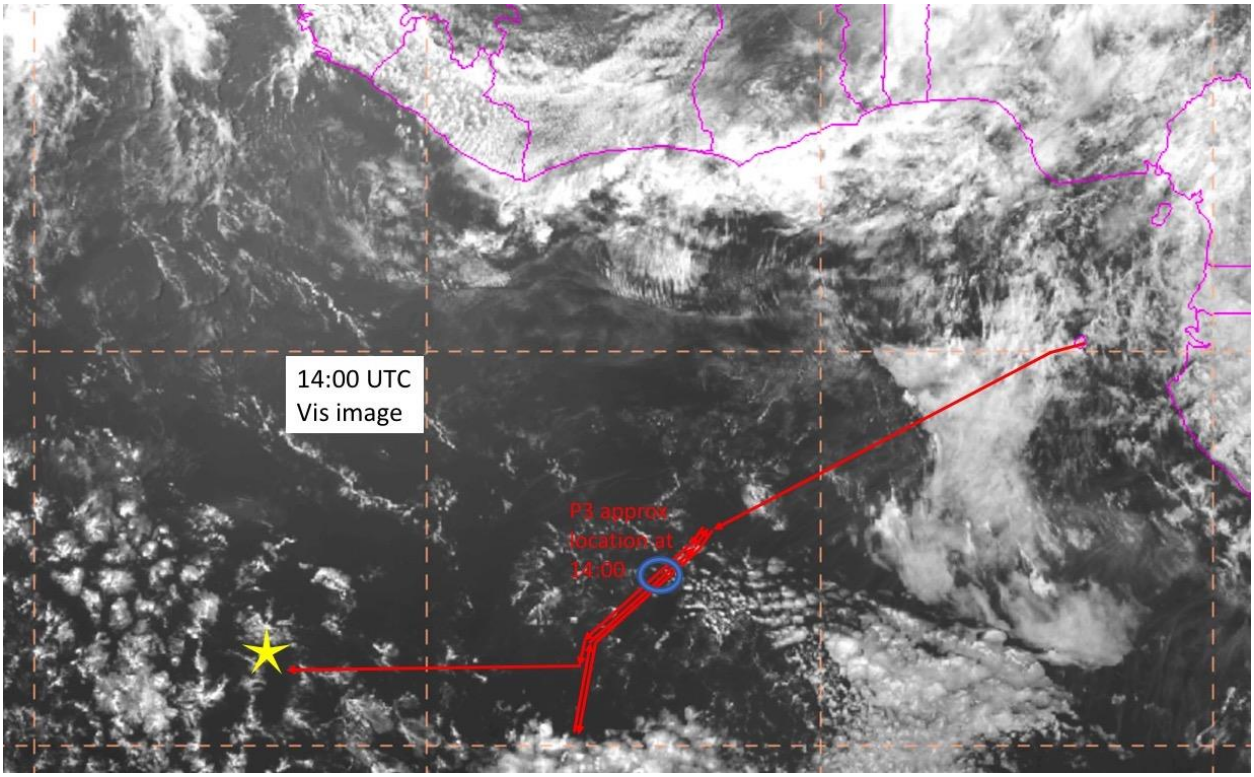
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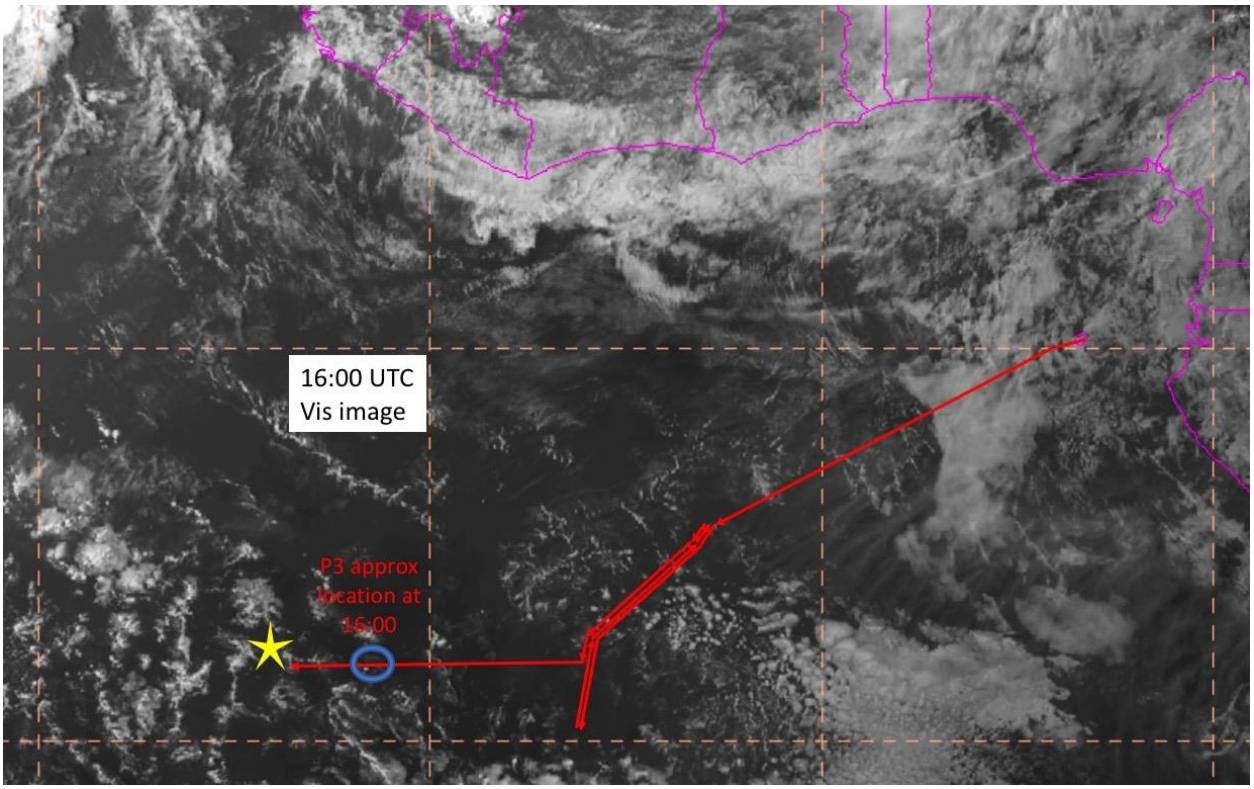
location at
14:00


16:00 UTC
Vis image
P3 approx
location at
16:00