ORACLES P3 Flight Scientist Post-Flight Status

Date: 08/21/2017

Flight number: PRF07Y17

Routine flight or target of opportunity?: Suitcase flight Ascension Island to São Tomé. Focus on west-east gradient in plume altitude & concentration.

Flight scientist: Jens Redemann

Ground scientist: Rob Wood

Asst. Ground scientist: Sarah Doherty

Take-off: 11:13:03 UTC

Landing: 19:21:38 UTC

Quick summary:

Representative ACAOD or ACAOD range for flight: low at Ascension (##?) to ~0.7-.75 at 8S, 2.5E

Do the models predict crossing a gradient in aerosol age?
Yes/No/Unclear

Did the flight cross a gradient in macroscopic cloud properties, like cloud fraction?
Yes/No/Unclear – (more variability in cloud properties than a gradient)

Did the flight cross a gradient in aerosol loading?
Yes/No/Unclear -- Almost clean at Ascension; highest loadings yet (?) (AOD ~0.7) to the east.

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

How many of the following maneuvers took place?

Ramps 2

Square spirals 2(@8S,7.5@ & 8S, 2.5E)

MBL legs 3

Cloud legs 2-3 (partly sawtooth)

Above cloud legs 3

Sawtooth legs 1(ish) (part sawtooth, part level)

Plume legs 3

Above plume legs 2

Instrument status:

Instrument	Comments
P3	bleed air leak needed to be fixed, delayed take-off by ~1:15hrs
4STAR	NIR spectrometer (1020-1559nm) not working; good AOD up to 0.74
HiGEAR	Performed well, issues with TDMA, saturation
HiGEAR-AMS	Great flights – highest loadings of campaign to date
HSRL-2	Minor glitch in image generation
RSP	Performed well
APR3	Excellent day; some minor electronics issues for ~5mins;
Cloud probes	Really good flight; measured drizzle;
CCN	Highest CCN concentrations of campaign to date
PDI	Worked well; still issues with small sizes
Vertical winds	
WISPR/CVI	Instrument worked well; excited by in plume structure
COMA	High level of CO (500ppm); among top 5 loadings of campaign
SSFR	Good day; no anomalies
data	Worked well; got APR quick-looks working

PRF07Y17 date 08/21/2017 Mission Report
flight scientist: Jens Redemann
ground scientist: Rob Wood / Sarah Doherty
flight plan and objective: 1-2 line synopsis, image of proposed flight plan

- Suitcase flight Ascension Island to São Tomé.
- Measure west-to-east transition from aerosol mostly in the boundary layer, clean above (except maybe a low-concentration dust layer); to heavier free troposphere pollution above (and mixing into?) low cloud to the east.
- Also, sampling on Routine flight track, to build statistics.

Flight Summary: 7-8 line synopsis, include actual flight path (aircraft altitude-time from IWG and/or visible satellite image from NASA worldview with flight path superimposed)

This was the return suitcase flight from ASI to TMS, originally scheduled for 19 Aug 2017. It was scheduled for 9hrs, but aircraft maintenance issue (unrelated to fire warning) reduced possible flight time to 8hrs (8.3 hrs logged). Science focus was on three different plume and cloud regimes along 8S and the routine track (along 5East). Flight featured profiles in very different conditions with ACAOD of 0.73 near 8S and 0E.

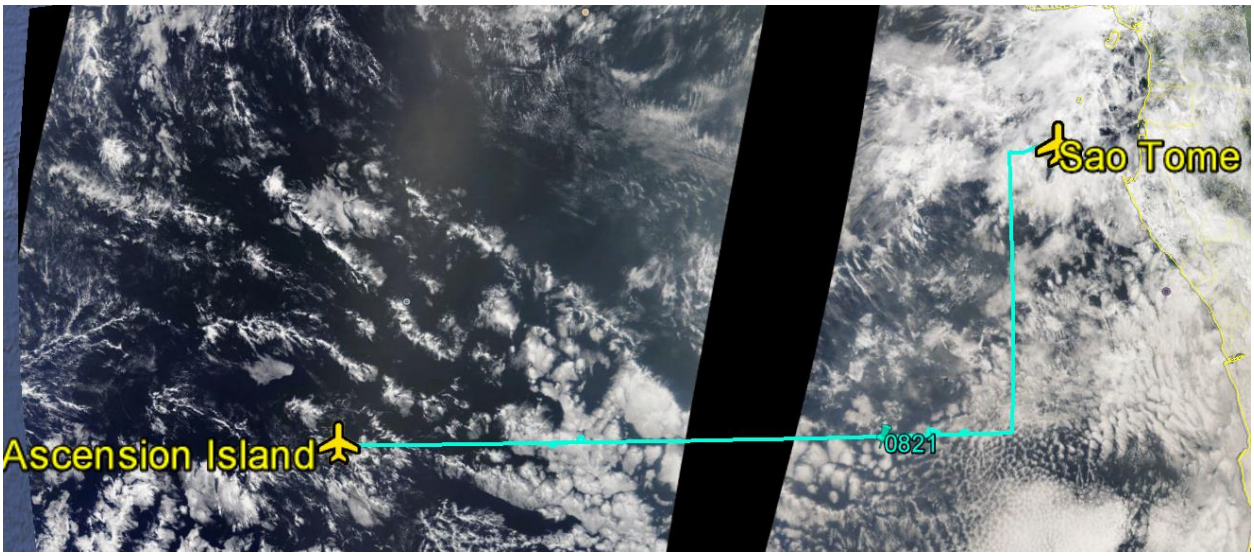


Figure 1: Flight track on top of MODIS-Terra RGB

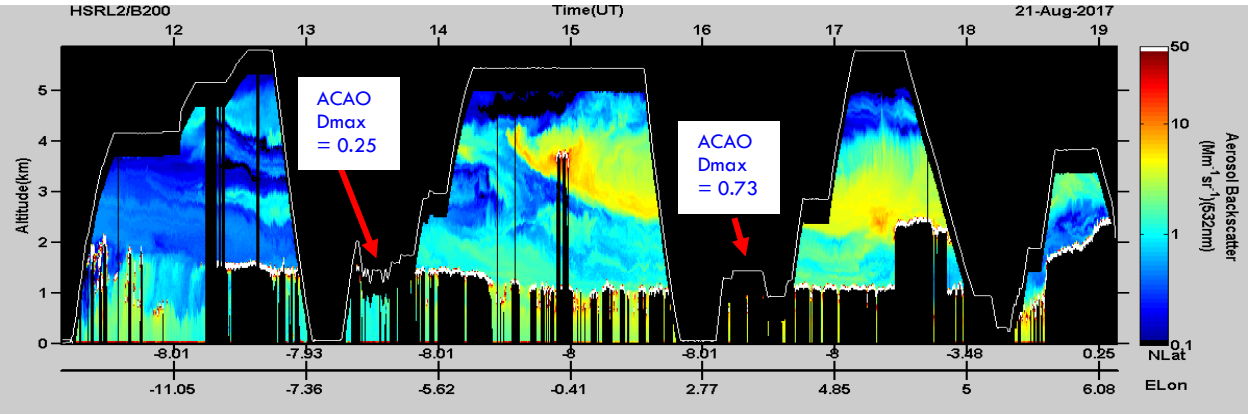
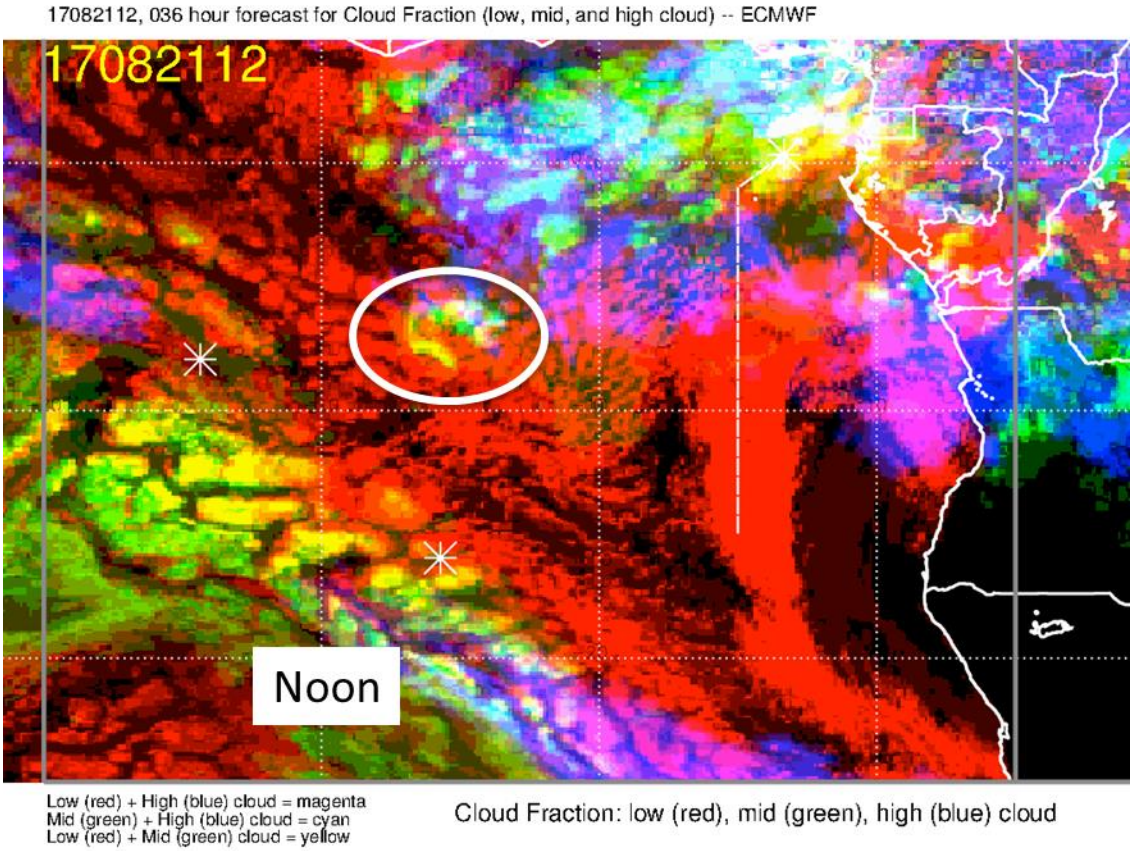


Figure 2: Lidar backscat. Curtain with 4STAR ACAOD indicated.

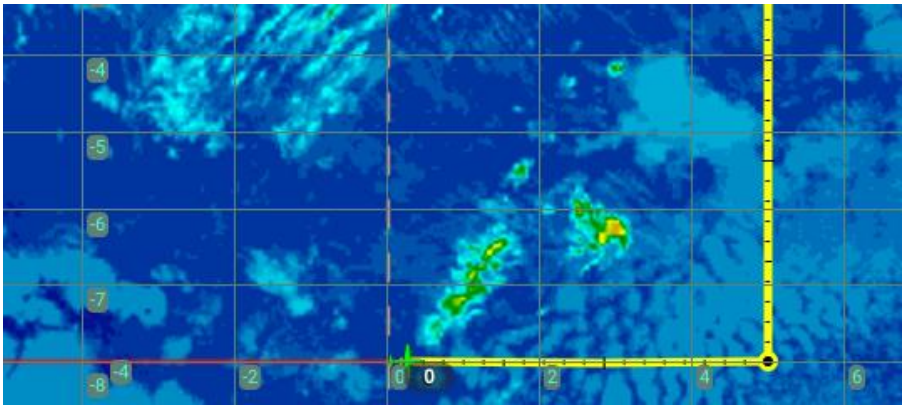
A-Priori Forecast: 4-5 line synopsis with selection of images taken from the forecast briefings, Available at http://bocachica.arc.nasa.gov/ORACLES/oracles_2017.html, bottom of page
e.g.,

- EC high and middle cloud fcst is verifying for current time, so is believable.
- Middle cloud (white circle, yellow/green) near track is possible with all the moisture coming off the continent
- High cloud (orange, circle, magenta/blue) along routine track also believable.
- Significant moisture at mid-level along last two thirds of planned flight track



Clouds forecast: Expected broken low clouds along almost the entire track. Mid-level clouds over TMS and streaks of high cloud at TMS and south. High clouds also possible, but spotty, in the central part of the 8S west-to-east track.

Observed:
Low clouds were more broken than expected from forecast.
High clouds (cirrus) were encountered on the 8S track (near 1E). A blob of mid-level clouds were encountered at ~8S, 0E (see image below).
A distinct layer of clouds at 2.25km, embedded in aerosol layer, were also encountered north of 5.8S on 5E north-south track.


-4
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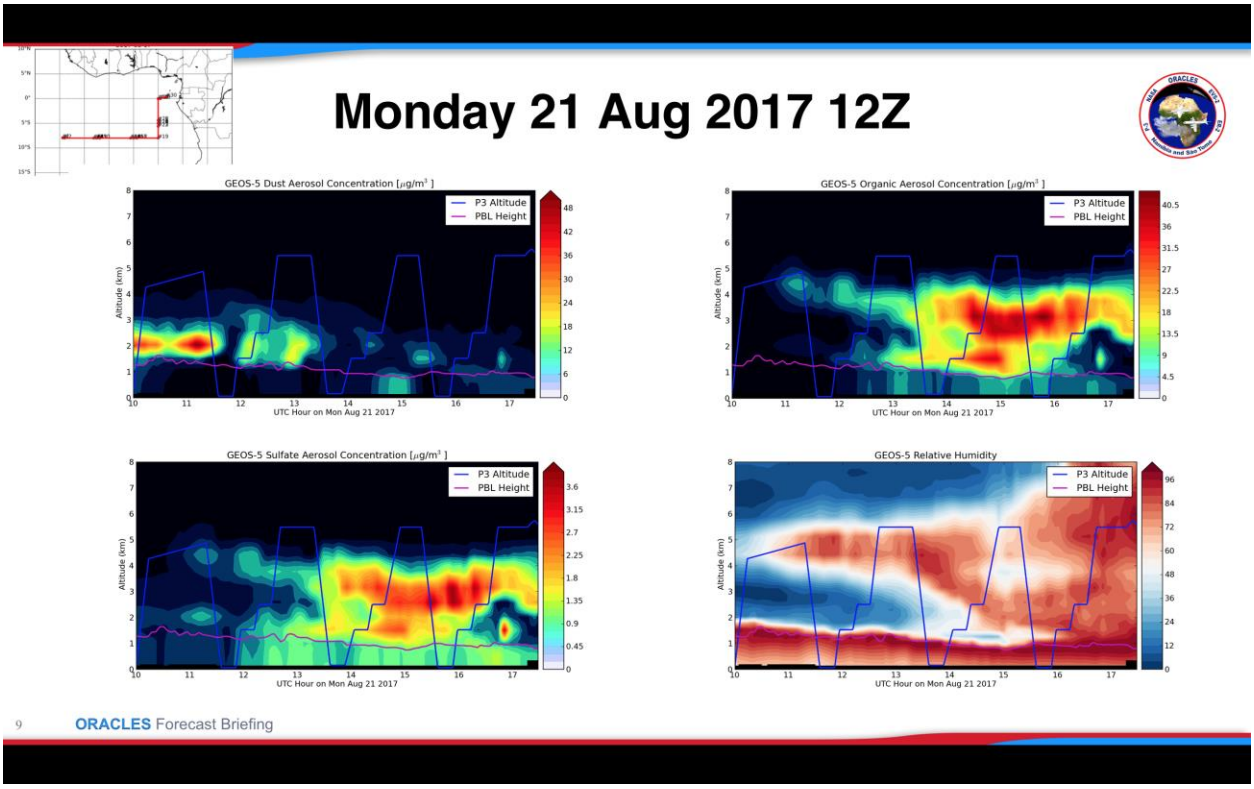
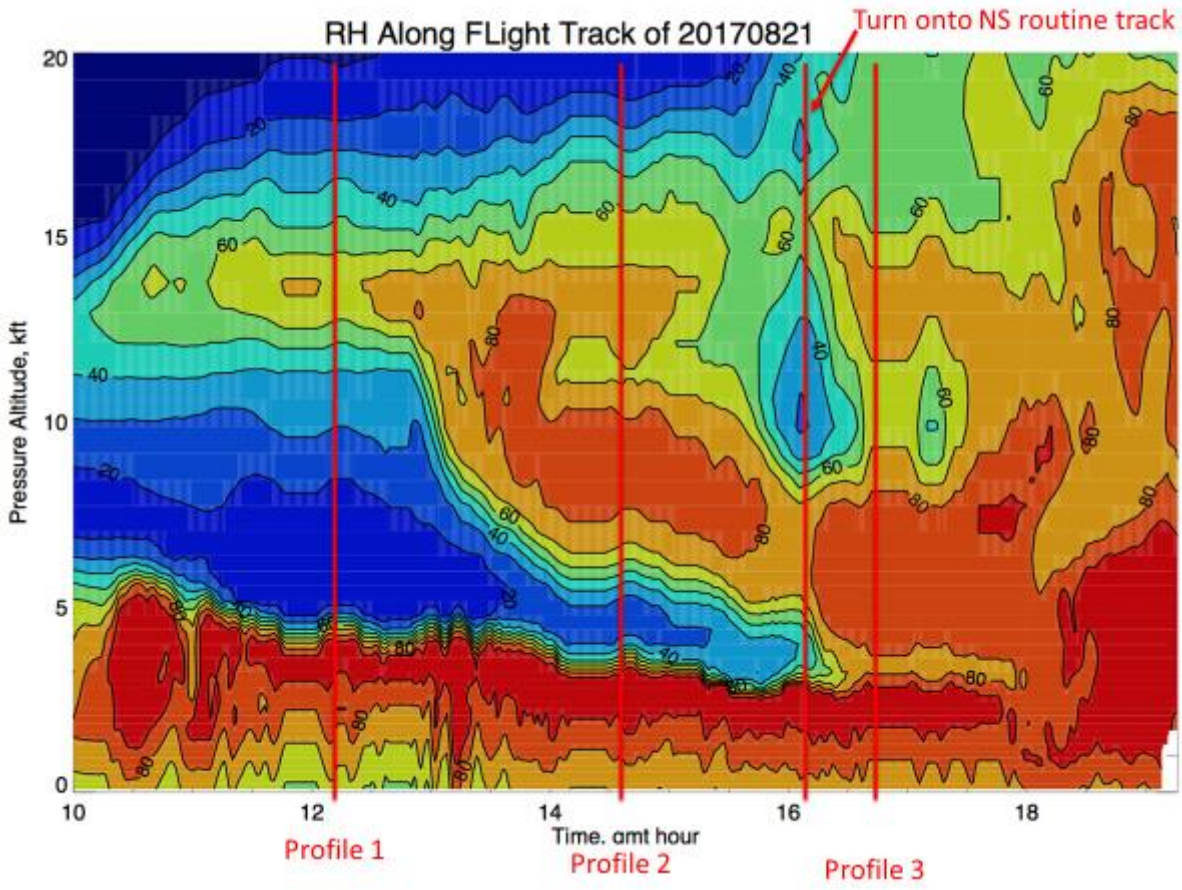
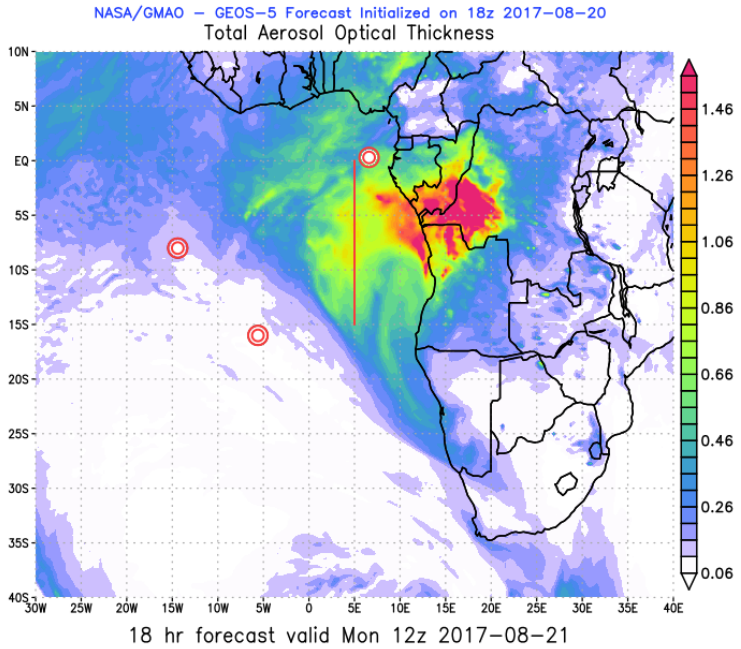
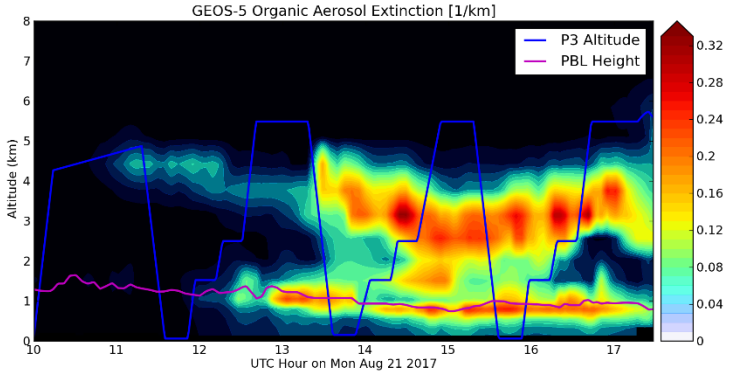

Monday 21 Aug 2017 12Z
GEOS-5 Dust Aerosol Concentration [μg/m³]
GEOS-5 Organic Aerosol Concentration [μg/m³]
GEOS-5 Sulfate Aerosol Concentration [μg/m³]
GEOS-5 Relative Humidity
P3 Altitude
PBL Height
Altitude (km)
UTC Hour on Mon Aug 21 2017
9
ORACLES Forecast Briefing

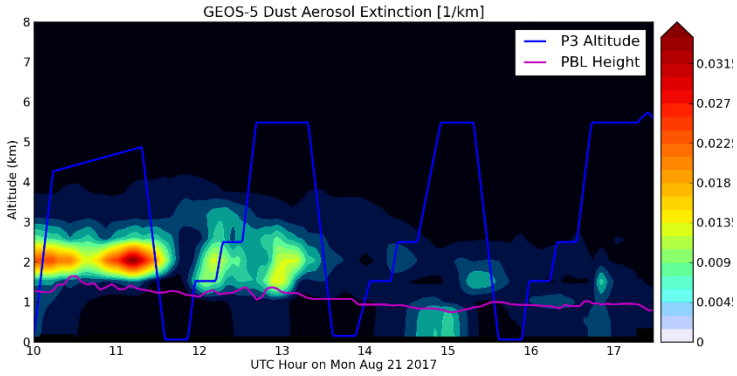




Aerosol forecast:
Strong E-W gradient in AOD along 8S E-W planned track.
High AOD (~1.0) along planned N-S track 8S to Equator along 5E.

This is qualititively consistent with what was observed, though max AOD (0.7) was observed at ~8S, 2.5E, which is quite a bit west of where it was forecast.





A low-concentration dust layer was forecast near Ascension. This was observed with HSRL on ascent and transit out of Ascension. Depolarization of this layer was ~20-25%, so it may have had a mix of dust and pollution.

Biomass burning aerosol was forecast to be largely confined to east of 4.5W.
HSRL showed a low concentration biomass burning plume with a base at ~3.75km. Unknown where top of plume was, because aircraft limited to lower altitude. There is only a hint of the BB plume reaching this far west in the forecast (upper cross-section panel). Higher altitude (~4-4.5km) layer continued to grow as we transited east. A second plume ~2.75-3.0km altitude showed up on HSRL at ~10E on 8S line.

Flight Instrument status: See table above

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

Run Table [UTC; approximate times okay, lack of detail okay. Just note major transitions, such as takeoff, time at point of furthest extent, time at beginning and end of major profiles with their detail relegated to the notes, such as spirals, level legs, straight profiling, and landing time**]**

description	beginning time	end time	altitude	notes
	09:40			bleed air leak being fixed, delaying take-off by ~1hr
Takeoff	11:13:03 UTC	X		Takeoff delayed by need to replace a bleed air gasket.
Ascent	11:13	11:32	Surface to 4.1m	On climb-out: • green scattering only ~10Mm^{-1} from surface to ~800m. CO ~70ppb • 800m-2km scattering down to 2-3Mm^{-1}, CO ~80ppb • At 2km, sharp increase in scattering (to 15-20Mm^{-1}) then slow decline to 4 Mm^{-1} at 3.5km. In this band, CO ~120ppb. • 3.5km-4.1 km altitude, slow climb in scattering from 3 Mm^{-1} to 60 Mm^{-1}; CO 200ppb. • scattered clouds near ASI Per HSRL2 depol (~22% 2-2.5km and ~25% 2.5-3.5km) these layers are a mix of dust and biomass burning particles.
	11:22			Clouds getting thicker - pix

description	beginning time	end time	altitude	notes
				
Transit eastward	11:32	12:02	4.1km	Transit at 4.1km (13,600') • scattering variable, 40-60 Mm^{-1}; decreased along leg to ~45 Mm^{-1} • CO ~220-200ppb; decreased along leg to ~170ppb • SP2 ~250/cc; decreased along leg to 215ppb
	11:42			transiting at 13kft. Some BC in the low dust layer during climb-out; in plume: 8-12ug total aerosol, over half organic, some nitrates and sulfates; 50Mm-1; peculiar clouds below: visible in Ka band, but not precipitating to the ground
	11:50			low clouds very broken now

description	beginning time	end time	altitude	notes
				
	12:04			climbing to 16kft (based on aircraft performance)
Ascent & transit	12:09	12:23	4.1km to 5.1km	CO ~120-140ppb Came out of aerosol ~5km altitude
	12:20			at profile location, (7.5W) we expect cloud tops somewhere from 1.25 to 1.75 km, 4000 to 5000 ft, Polluted. High CDNC, still with gap between BB aerosol and cloud, but maybe dust layer right above cloud, based on models.
Ascent & transit	12:23	12:33	5.1 to 5.8km	Nudging higher to get full HSRL curtain of plume; ascend out of aerosol layer.
	12:29			High altitude pollution layer visibly less brown
Transit	12:33	12:44	5.8km	• scattering <3 Mm^{-1} • CO ~100ppb • SP2 ~2/cc

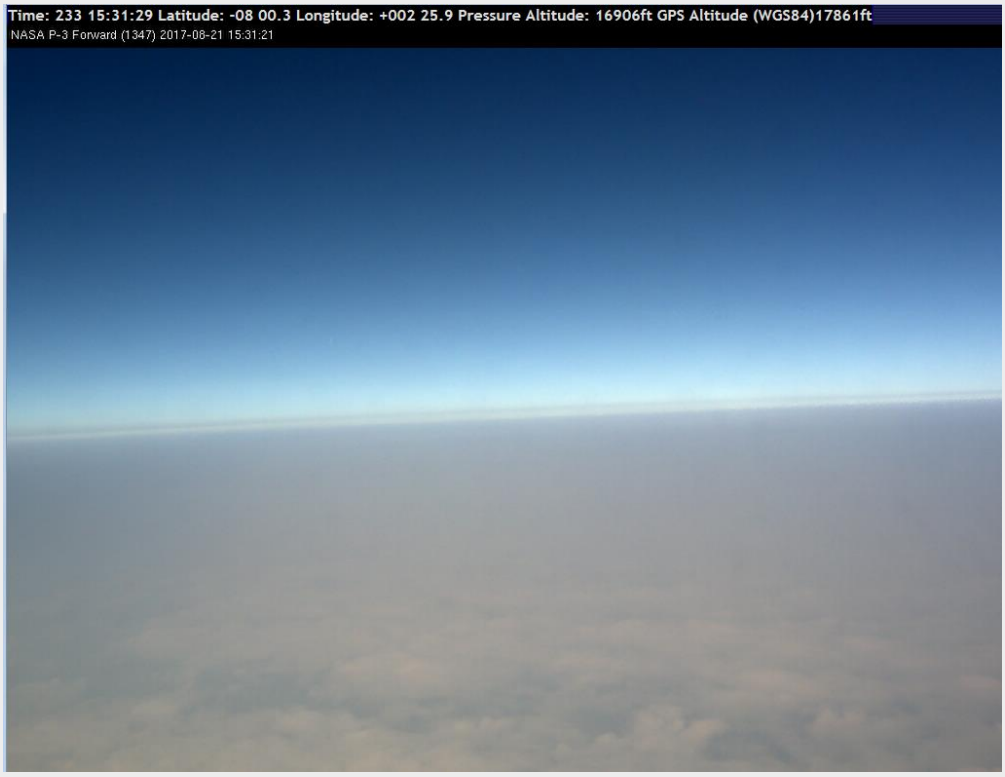
description	beginning time	end time	altitude	notes
	12:35			cloud tops are at 6000ft, cloud only 500m thick
Square spiral descent	12:44	13:03	5.8km to 80m	Centered on 7.92S, 7.5W (South edge of spiral is on 8S) somewhat broken clouds, thicker behind us – pix • Went through three scattering peaks of ~60-90 Mm^{-1}, ~200-220ppb CO on descent.
				
	12:49			CO going up at 13.2kftGPS
	12:55			distinct separation between upper level BB layer
	13:04			complicated cloud scene (some large breaks), AOD above cloud 0.25, with 0.23 of that in BB smoke, full column AOD ~0.35; layer at cloud top has some BB signature

description	beginning time	end time	altitude	notes
Min-altitude leg	13:05	13:15	80m	Head west-bound from 8.0S, ~7.52W to get to where clouds are • scattering 20 Mm^{-1} • CO ~80ppb • SP2 variable; ~60-80/cc Leg end at 8.0S, 8.24W
	13:07			APR indicates thickest cloud directly at 8W
Turn from west-bound to east-bound; ascend via a single square spiral	13:15	13:22	To 1.9km (6,400')	• scattering ~15-20 Mm^{-1}; no apparent trend but an odd high spike; not sure if real or not • CO increased 80ppb to 100ppb • SP2 near zero counts
	13:20			4.6kft cloud base
	13:26			3.6-4.8kft = cloud
Cloud sawtooth then small altitude changes ~1300m to stay in-cloud	13.22	13:37	Between ~1.3km and 2.0m	Heading east-bound from 8.2W 13:23UTC start sawtooth down from 2.0km to ~1.3km, then bouncing 1350-1500m (P3 reported clouds are at 3.6-4.8kft) 13:32UTC back at 7.5W, where we did the square spiral down.
	13:30			interrupting sawtooth for 3min above cloud, AOD = 0.25
Ascent	13:37	13:38	To 1.6km	To go above-cloud
Above-cloud (completely?)	13:38	13:42	1.6km	10min run 600ft above cloud top; at 5,300ft we are running into large plume variability (possibly "scavenging layer" or horizontal variability), deciding to go up 200ft for run Above-cloud AOD 0.3 8.0S, ~6.8W

description	beginning time	end time	altitude	notes
				"10min run 600ft above cloud top; at 5,300ft we are running into large plume variability (possibly "scavenging layer" or horizontal variability), deciding to go up 200ft"
Above-cloud leg	13:42	13:49	1.75km	East-bound leg • scattering climbed from ~25 Mm^{-1} to ~50-90 Mm^{-1} • CO increased 80ppb to 200-250ppb • SP2 from 200/cc to ~400-500/cc P3 reports small patches of virga below.
Ascent	13:49	13:53	To 2.8km	ascending to 9kft, climbing to 9.5kft, descending to 9.3kft in search of plume Scattering & CO both very variable with ascent; moderate decreases from concentrations in above-cloud leg.
Plume leg	13:53	14:03	2.8km to 3.0km - 2.9km	Start leg at approx. 6W. Concentrations declined along the leg • scattering ~60 to ~20Mm^{-1} • CO 200ppb to 130ppb • SP2 variable; ~400 down to ~100/cc Leg end at 8.0S, 5.3W
	14:02			mid-level moisture/clouds starting to be visible in forward camera

description	beginning time	end time	altitude	notes
				
Ascent & transit	14:03	14:16	To 5.5km (18kft)	8.0S, 5.3W to 8.0S, 4.4W
High-altitude leg	14:16	15:32	5.5km/ 18kft	8.0S, 4.4W to 8.0S, 2.6E • scattering <5 Mm^{-1} • CO ~130-140ppb • SP2 0-10/cc • 4STAR AOD ~0.06 ~HSRL curtain shows plume appearing at ~3W at ~4km altitude; plume continues eastward Radar showed drizzle ~15:25UTC Cirrus 0deg-2degE as viewed from P3
	14:58			high clouds visible as we approach 0W, trying to outrun high clouds and find at least some low clouds

description	beginning time	end time	altitude	notes
				
Spiral descent	15:32	15:51	5.5km to 70m	Centered on 2.5E, bottom edge of spiral on 8.0S. ~5km altitude scattering etc. climbed steeply, peaking at ~2100m altitude • scattering peaked at ~300 Mm^{-1}, then dropped back down to 40-60 Mm^{-1} • CO peaked at 500ppb then dropped back down to ~200ppb • SP2 peaked at 1,300/cc, then dropped back down to ~225/cc • fairly broken clouds • cloud between 2.3 and 3.5kft • APR sees drizzle on AOD ~0.72 On HSRL, cloud tops are at 1-1.25km (15:51-15:55 UTC completing spiral to get back on 8S track)

description	beginning time	end time	altitude	notes
				
Min altitude leg	15:55	16:06	70m	At 8.0S, 2.5E back on 8.0S track heading eastbound End leg at 8.0S, 3.2E start of 10min run along forward track at 200ft, solid overcast, increasing – pix; finding some drizzle, ramping up to above cloud for 4STAR sky scan with AOD 0.73; reversing course and increasing altitude to 800ft above cloud for APR leg

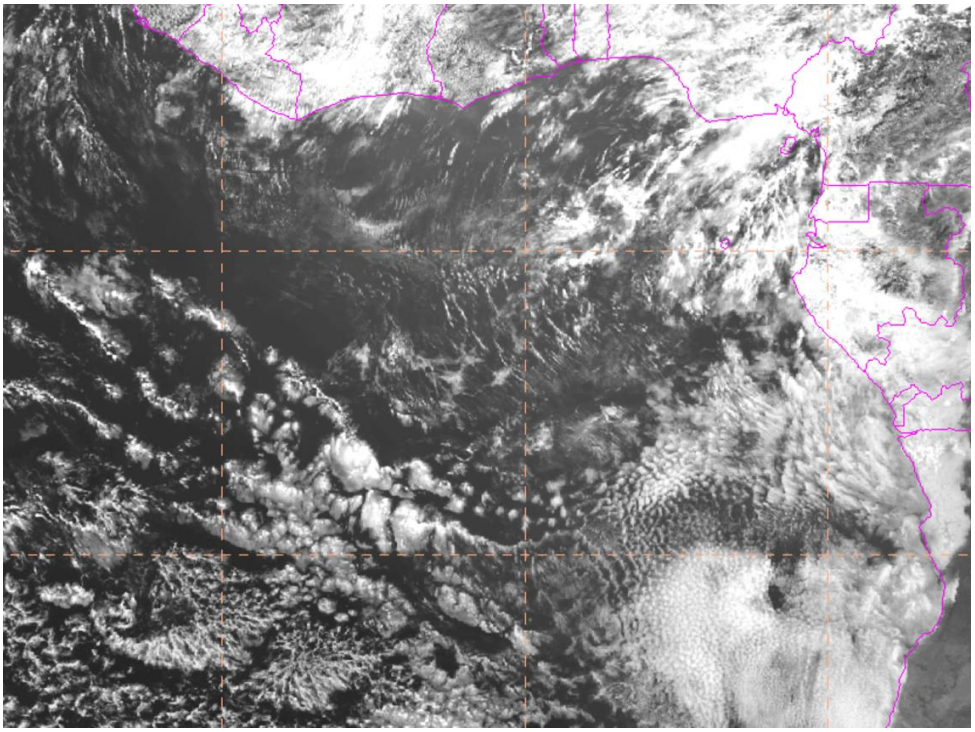
description	beginning time	end time	altitude	notes
				
Ascent	16:06	16:10	To 1.3km	
Cloud? leg	16:10	16:13	1.3km	? getting above-cloud?
Turn E-bound to W-bound and ascend	16:13	16:17	To 1.45km	Square spiral pattern 180deg turn from eastbound to westbound, between 3.6 and 3.5E.
Above-cloud leg	16:17	16:26	1.45km	Westbound on 8S at 1.45km AOD decreased 0.75-0.70 • scattering very variable ~75 Mm^{-1} initially, then up to ~140 Mm^{-1} • CO increased 240ppb then up to ~300ppb • SP2 ~400/cc up to ~600/cc End of leg at 2.8E
Turn W-bound to E-bound & descend	16:26	16:30	1.45km to 940m	Jens on P3: “making a lot of radar and in situ people happy. we found some drizzling cells that we underflew, then overflew, now we are going for straight

description	beginning time	end time	altitude	notes
				and level inside cloud; at 3.1kft, ran out of the side of it at~16:34”
In-cloud level leg	16:30	16:37	~950m	• scattering variable ~35-50 Mm^{-1} • CO 110-120ppb • SP2 500-600/cc Leg end at 3.2E
Ascent	16:37	16:46	To 2.9km	Brief level section at 1250m At 1250m, CO ~250ppb, scattering ~100Mm-1 then both increased rapidly 1250m to 2300m
	16:39			ascending for in plume run
Plume leg	16:46	16:57	2.9km	Leg start at 8.0S, 3.8E • scattering ~250 Mm^{-1} • CO ~430ppb • SP2 1100/cc
Ascent	16:57	17:09	To 5.8km	Concentrations plummet at ~3.3km altitude 17:02 UTC turn onto Routine track at 8.0S, 5.0E.
High altitude leg / transit	17:09	17:31	5.8km	HSRL shows aerosol layer between 2.25km (*sharp* boundary) and 3.25km (more variable boundary).
Descent	17:31	18:00	To 950m	500ft/min ramped descent HSRL showed 2 cloud layers starting at 5.9S. Distinct cloud layer at 1km and a second solid cloud layer at ~2.25km (7-8,000’). Upper cloud layer is downright embedded in the aerosol layer! Cleaner between cloud altitudes and above upper cloud. ~200Mm^{-1} at top of cloud at 2.8km.
Level cloud leg	18:00	18:11	950m	Scattering was ~40Mm^{-1} at cloud top; CO~200ppb

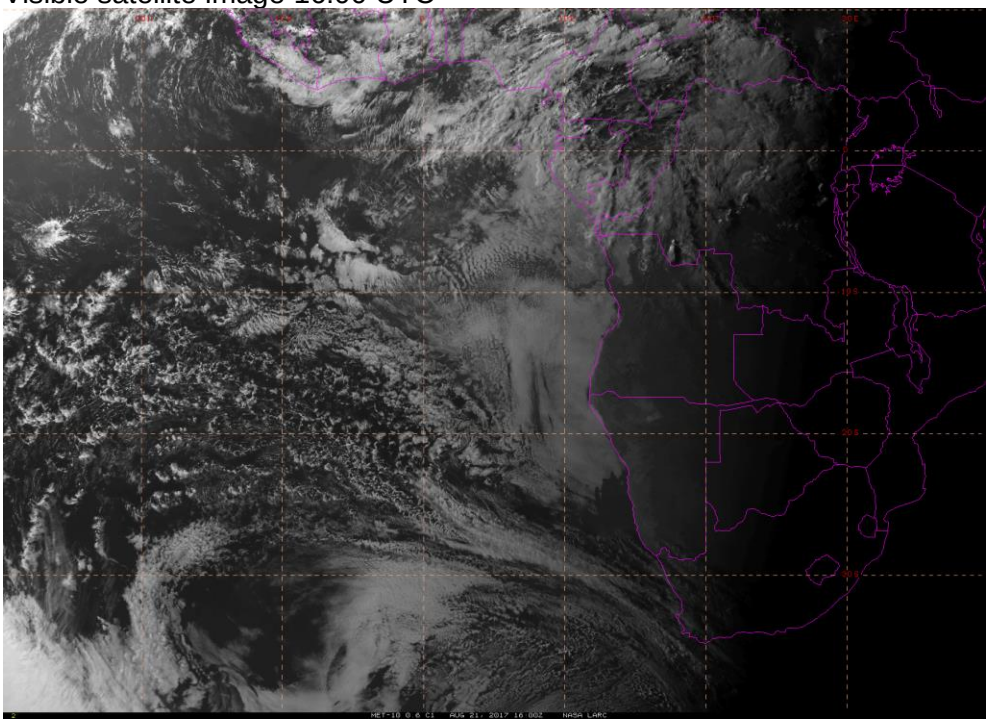
description	beginning time	end time	altitude	notes
	18:01			targeting low cloud on NS leg at 3,150ft
	18:04			HSRL beam visible in nadir camera ☺
Descent	18:11	18:13	To 340m	
Below-cloud/MBL leg	18:13	18:19	340m (250m 18:18-18:19)	below cloud straight and level at 1050 ft • scattering ~65 Mm^{-1} • CO ~120ppb • SP2 ~225-250/cc
Mini-stepped ascent	18:19	18:21	To 780m	ascending to 500ft above cloud
Mini-stepped ascent	18:22	18:23	To 950m	
Mini-stepped ascent	18:24	18:25	To 1.1km	
Mini-stepped ascent	18:25	18:28	To 1.9km	
Above-cloud leg	18:28	18:33	1.9km	• scattering ~45 Mm^{-1} • CO ~170ppb • SP2 ~200/cc
Ascent	18:33	18:40	To 3.8km	
In-plume leg	18:40			start of SNL at 12.5kft, incl turn towards EREGO

visual notes:

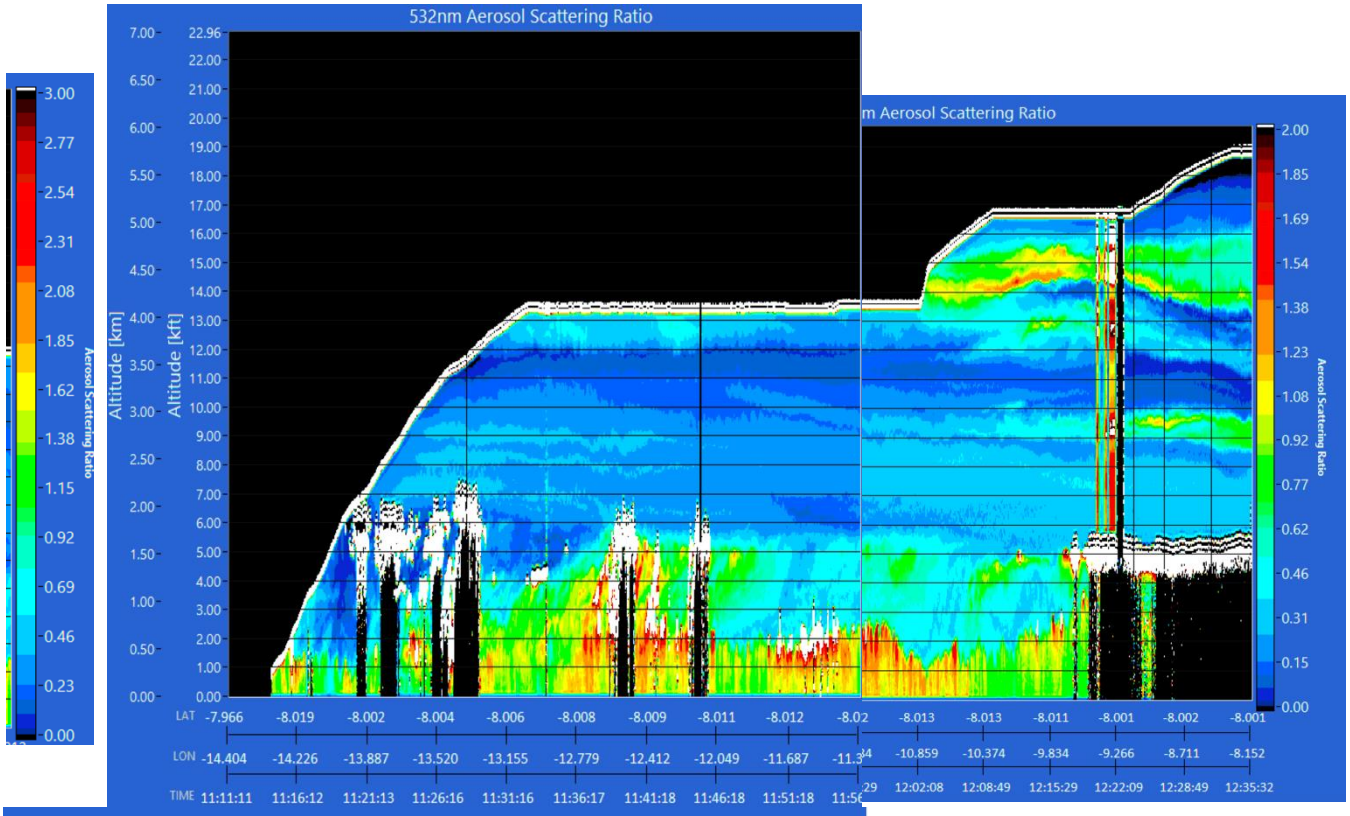
Visible satellite image 12:00 UTC



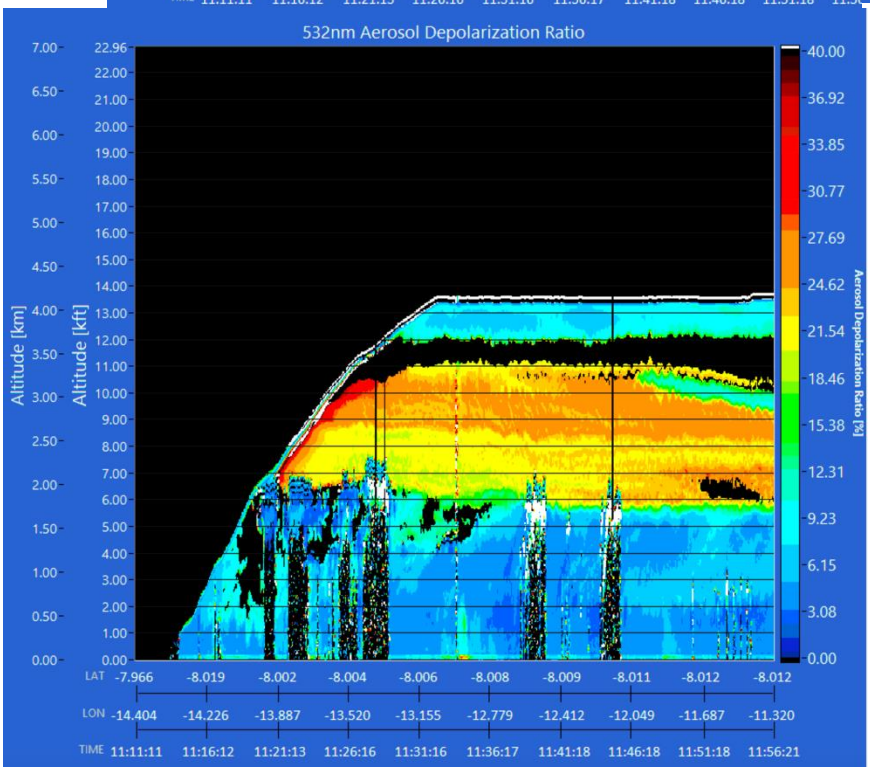
Visible satellite image 16:00 UTC



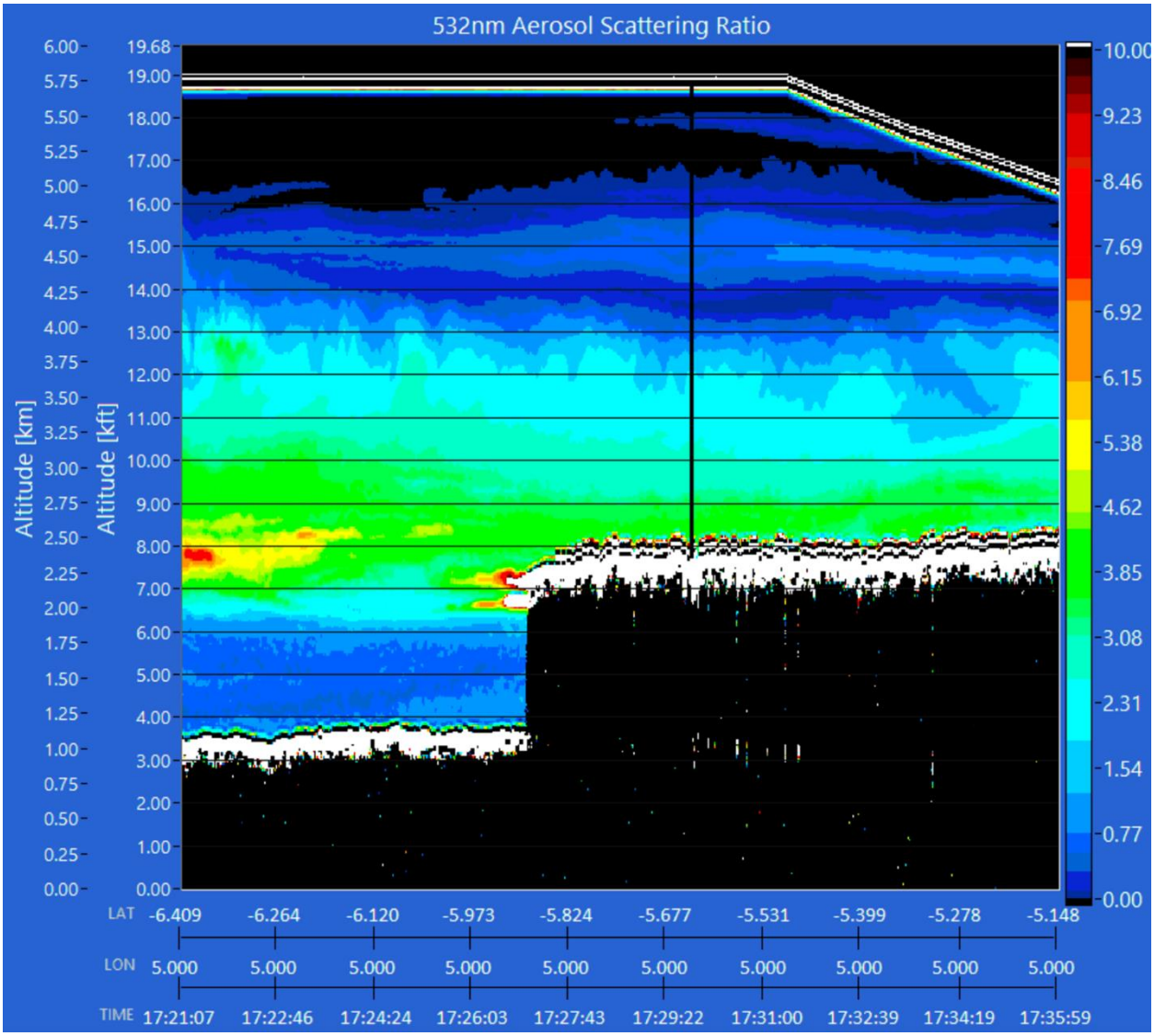
HSRL 14.4W to 8.1W along 8.0S (left panel on left scale, right panel on right scale)



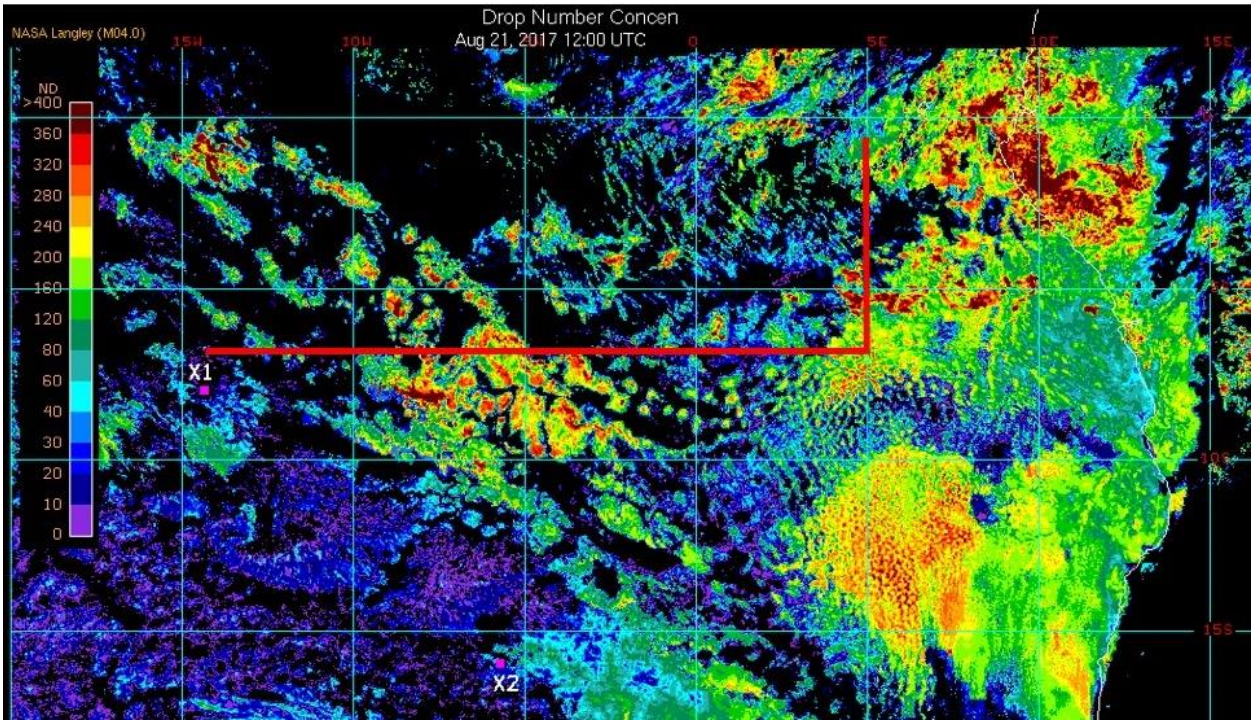
Depolarization in layer aloft ascending out of Ascension of ~20-25%. Pure dust depol is ~35%.



HSRL image of double cloud deck, with upper cloud deck at ~2.25km coincident with aerosol layer.



12:00 UTC Satellite-retrieved cloud droplet number concentration, with flight track.


Drop Number Concen
Aug 21, 2017 12:00 UTC
NASA Langley (M04.0)
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