ORACLES P3 Flight Scientist Post-Flight Status

Date: **09/02/2017**

Flight number: **PRF13Y17**

Routine flight or target of opportunity?: **Target of Opportunity**

- **Measure BB aerosol at north end of study area, where airmass it may have experienced wet convection; sampling to date has been of the plume further south where airmasses mostly experience only dry convection**
- **Get AeroNet-like retrieval from 4STAR when there is a mix of biomass burning smoke & dust in the column. Supplement with in-situ and HSRL measurements to test the AeroNet retrieval of column absorption and attribution of absorption to smoke vs dust.**
- **Sample in area near ASI where forward trajectories indicate that air we sampled on Routine Track on 8/30 and just west of prime meridian on 8/31 is now present.**

Flight scientist: **Sarah Doherty**

Ground scientist: **Jens Redemann**

Take-off: **09:15 UTC**

Landing: **17:30 UTC**

Quick summary:

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

Did the flight cross a gradient in aerosol loading?
Yes/No/Unclear

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 1

Square spirals 3 full; 3 partial ascents

MBL legs 1

Cloud legs 2

Above cloud legs 3 (brief; for 4STAR sky-scans) + 1 full circle above-cloud (for APR)

Sawtooth legs 1

Plume legs 4

Above plume legs 3 long legs

Instrument status:

Instrument	Comments
P3	Clogged filter in engine 3 on start-up. Cleared it & did "penalty runs" on tarmac to test engine. Then good to go; no problems after that.
4STAR	All worked well.
HiGEAR	Had a PSAP issue on back rack PSAP (see notes below) but only last a few minutes' data. Got good test for droplet shatter on CVI on the TDMA. Does not appear to be droplet shatter artefact but will need to process data.
HiGEAR-AMS	Had a brief period, simultaneous with PSAP issue, when AMS had anomalously low concentrations. Only a few minutes; otherwise all good.
HSRL-2	All good.
RSP	All good.
APR3	All good.
Cloud probes	All good.
CCN	(no one on plane to report but no apparent problems)
PDI	(no one on plane to report but no apparent problems)
Vertical winds	(no one on plane to report but no apparent problems)
WISPR/CVI	All good.
COMA	(no one on plane to report but no apparent problems)
SSFR	All good.
data	All good.

PRF09 09/02 2017 Saturday Mission Report

flight scientist: Sarah Doherty (FS)
ground scientist: Jens Redemann (GS)

Flight plan and objective:

Science in-transit from São Tomé (TMS) to Ascension (ASI). Three nominal objectives:

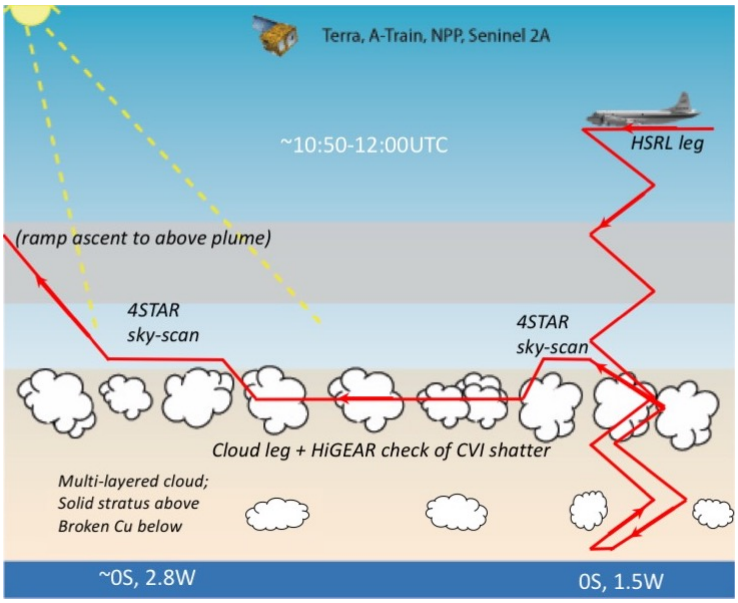
- Get 4STAR "AeroNet-like" sky-scans below layers of dust plus smoke, then sample the smoke layer in-situ to test AeroNet retrievals. Also get vertically-resolved curtain from HSRL. Test AeroNet retrieval of column absorption/SSA and different methods of attributing column absorption to dust and carbonaceous aerosol.
- Sample smoke aerosol in northern end of study area to see if it is chemically/optically different than smoke to the south. Expect that aerosol in northern area more influenced by wet convection; southern area aerosol more influenced by dry convection.
- Plume sampled along 5E on Aug 30, then re-sampled (per forward trajectories) on Aug 31 is expected to be just NE of ASI on 2 Sept. On approach to ASI, re-sample this aerosol to add to "Lagrangian"/aging study.
- Nominally also include 10min leg in-cloud for HiGEAR to check for droplet shatter in CVI

Flight plan is to follow equator west from TMS to 10W then head SW directly to ASI. Ideally do spiral descents with stacked legs at two locations, approximately (0S, 1W) and (0S, 4W), where a mix of dust and smoke are forecast to be present in the same vertical column.
Dust is forecast to be primarily at ~850mb level; smoke at ~700mb level. A question is whether we can get below both or if dust will be mixed into/below clouds.

Flight Summary:

Ended up going to 1.5W for first spiral descent because the cloud deck looked solid there. Not enough cloud east of there and west of there the cloud deck was dissipating. HSRL indicated that aerosol here is all smoke; so not yet in dust.

Pilots were indicating we may be limited on flight time/fuel and may not be able to backtrack at both this location and further west, so decided to save the stacked legs for the western profile point.

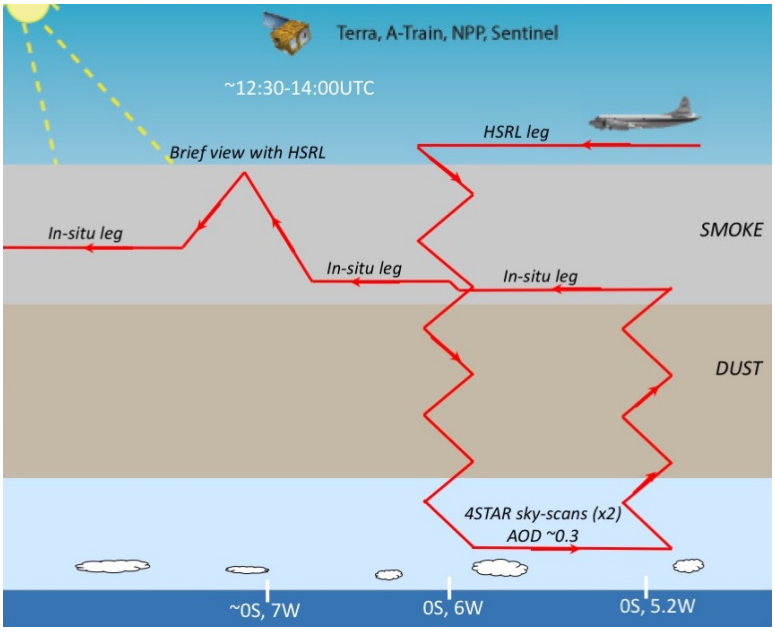


At 0S, 1.5W did:

- Square spiral descent to surface, then square spiral ascent back to above cloud
- 3min above-cloud leg for 4STAR sky scan (west-bound)

- in-cloud leg (west-bound) – *tested HiGEAR CVI for shatter*
- 6min above-cloud (west-bound) for 4STAR sky scans
- At ~2.8W, ramped ascent for HSRL high-altitude leg

Continued west until 0S, 6W where satellite image indicated it should be cloud free, allowing us to get a full-column 4STAR sky-scan with assurance we can get below the dust.
HSRL indicated that we transitioned into a region with dust at lower altitudes while we were doing in-transit cloud/above-cloud legs. (See HSRL images below covering 11:35-12:35UTC). Dust is below ~2.5km (8k') and is both above cloud and in boundary layer.

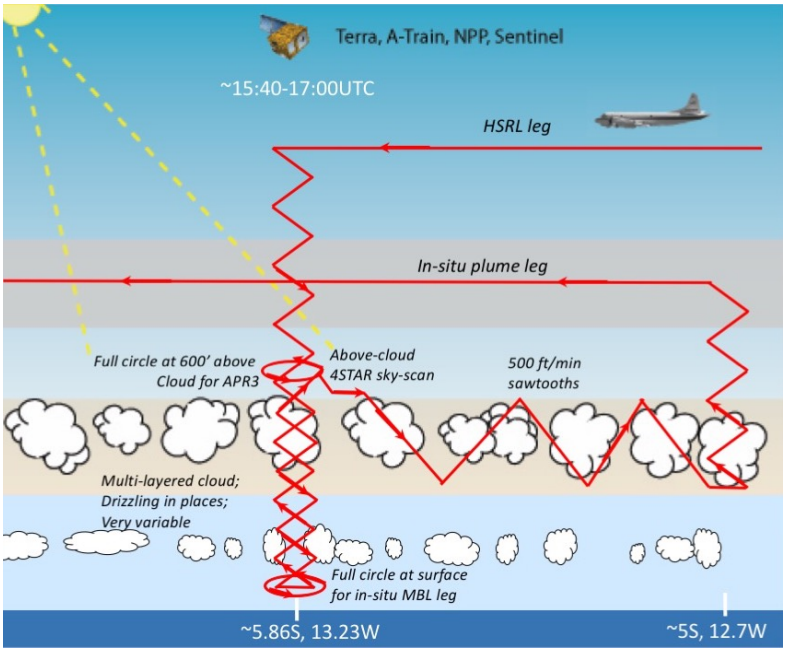


At 0S, 6W did:

- Square spiral descent to ~2k'/650m to be above small, scattered bits of clouds just below this
- Level leg at 650m for 4STAR sky-scans (x2); AOD 0.3 [eastbound] ~6min
- Square spiral ascent to 10k'/3.3 km to get into smoke plume
- Level leg at 3.3-3.4km for in-situ aerosol sampling directly above where took sky-scan [west-bound] 15 min leg.
- Ascended for HSRL but decided to descend again to get in-situ more in the heart of the plume. Sampled plume west-bound an additional 15min.

During rest of transit to Ascension did:

- High altitude leg for HSRL (~15min)
- Plume leg (~15min)
- Above cloud leg (~8min; cloud disappeared while on this leg)
- High altitude leg for HSRL (~10min)

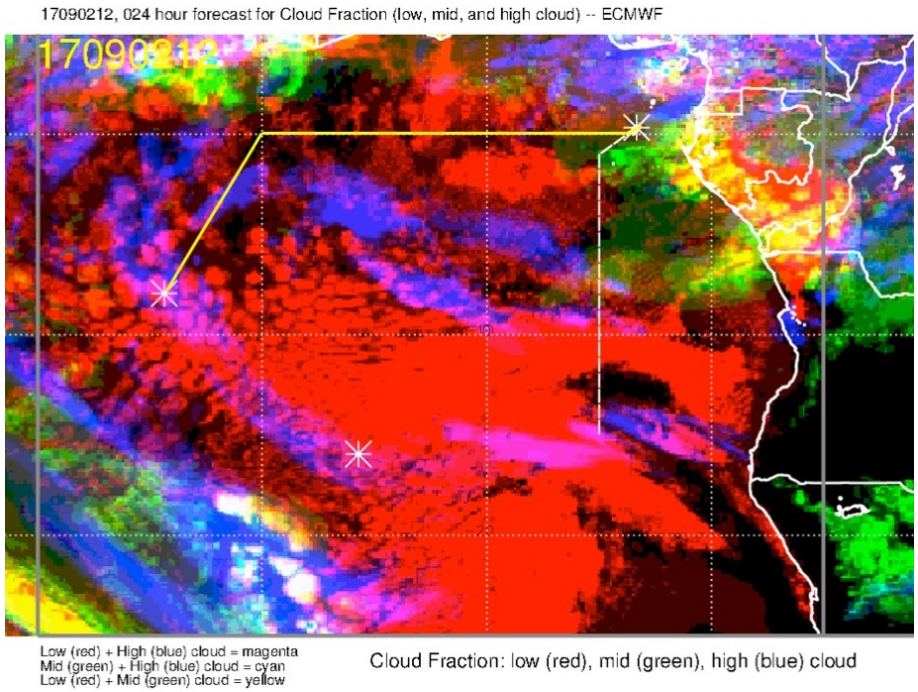


- Series of legs to study cloudy region just to NE of ASI where there appears to be a clear gap above clouds and a nice thick cloud layer. While heading SW towards ASI:
    - Spiral descent to surface through cloud, with some parts of cloud drizzling and cloud thin enough in other places for sun to peak through. Multiple layers of clouds.
    - Full circle at surface for in-situ MBL sampling
    - Spiral ascent to 600' above cloud for APR; with full circle above-cloud
    - On NE-bound heading (backtracking) do an above-cloud for just enough time for 3STAR sky-scan
    - Continue NE heading & do sawtooth legs at 500 ft/min ascent/descent rate; 8min leg, with clouds running out at end of leg
    - Square spiral ascent to plume level
    - SW-bound leg in plume (13min) stacked above in-cloud leg
    - NOTE: Both HSRL and in-situ data indicate a clean layer just above cloud-top. Possibly due to cloud processing, esp since boundary layer was found to be polluted.

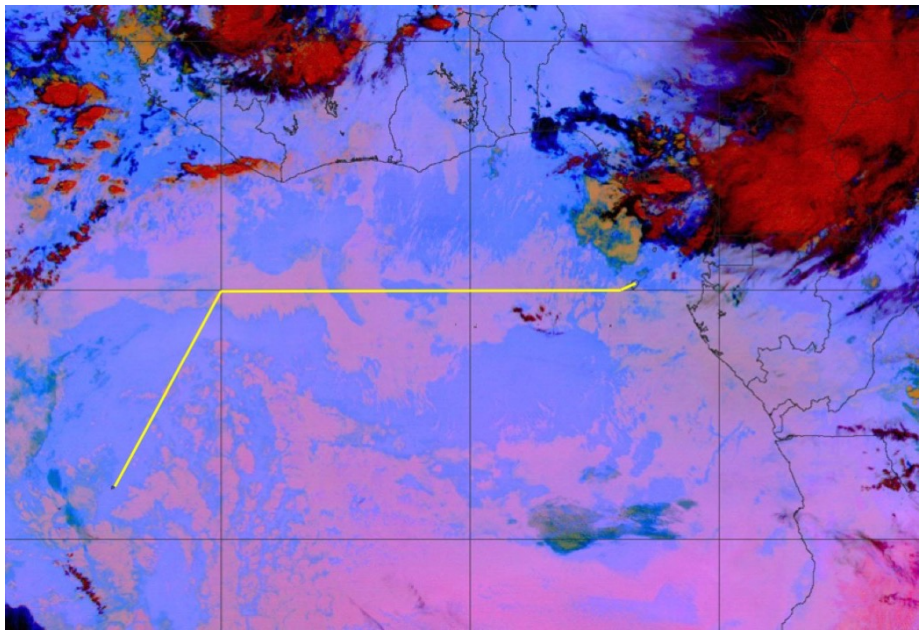
- Remained at plume level on approach to ASI, then descended and landed.

A-Priori Forecast & Forecast Verification:

CLOUDS:



Forecast was for high chance of cirrus along 5E/Routine Track as well as along the 8S E-W track we'd considered as a "southern option" for today's flight.

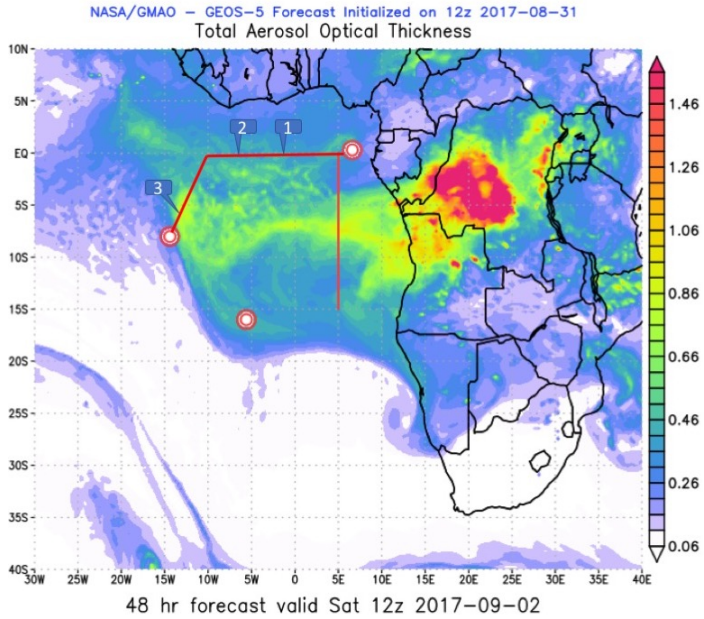


03:00UTC IR image showed this to be a "forecast bust". Very little cirrus, other than just south of the Equator east of the Prime Meridian. Fairly big area of mid-level cloud ~8-10S and 2-8E.

Low cloud cover looked good along northern route.

Given satellite images, don't expect cirrus or mid-level clouds to threaten northern route.

AEROSOL:



Forecast was for high AOD in E-W band along 8S, and high AOD near/NE of Ascension (left), resulting from rapid zonal transport of aerosol measured on the 5E "Routine track" on 30 Aug.

At north end of study region, forecast was for a mix of dust (mostly at ~850mb) and smoke (mostly at ~700mb), with each contributing significantly to total AOD.

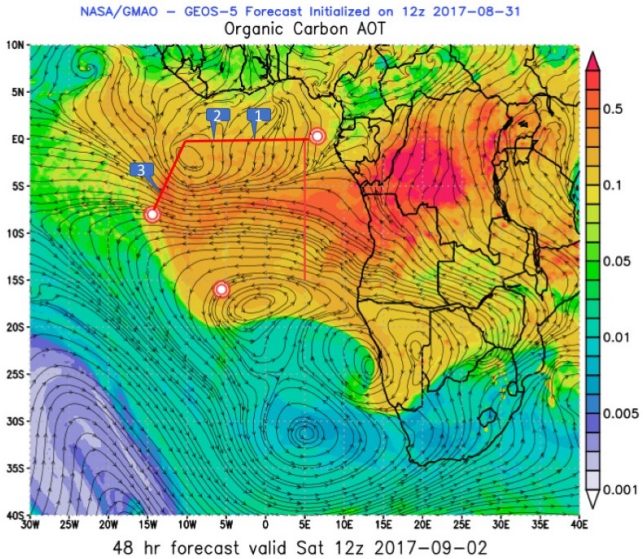
The locations of our three vertical profiles (depicted & described above) are labeled 1, 2 & 3 in the three aerosol graphics shown here.

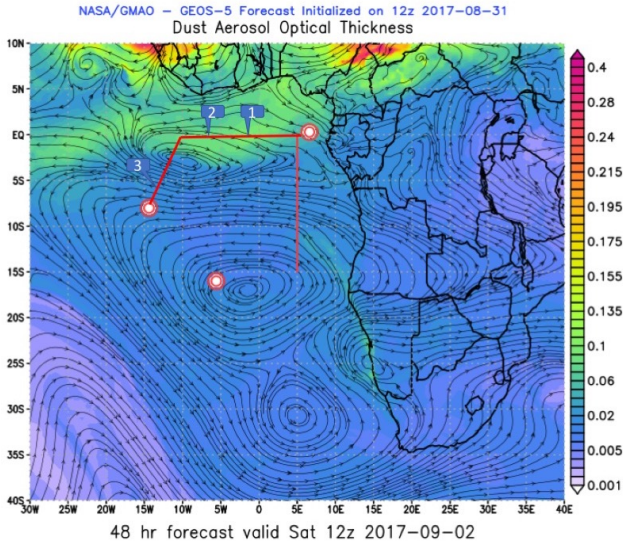
At (0S, 1.5W) we found above-cloud AOD of ~0.3. Essentially all of this was smoke (low depolarization on HSRL). When we ascended at ~2.5-3.0W there were high depol values, indicating dust, so the dust plume started somewhere west of 1.5W – not at 5 E as forecast (image below, right).

The AOD of ~0.3 at both locations on the Equator was lower than given by the forecast (above)

At 0S, 5W the (nearly) total-column AOD was 0.3 and there was a mix of dust (below ~2.5-3km GPS altitude) and smoke (f~3.0-4.75km GPS altitude), roughly as forecast.

AOD increased as we approach Ascension Island, consistent with the forecasts for total AOD (above).





Flight Instrument status:

P3 had a clogged oil line filter that had to be cleared, resulting in delayed takeoff. Once cleared, no further problems.

Brief data losses from HiGEAR PSAP and AMS due to apparent flow issue. Resolved itself and did not reoccur.

Otherwise, all instruments worked well – including HSRL, which was out the previous day due to chiller failure.

Flight Instrument/logistics notes:

HSRL extremely helpful for identification of location with dust and smoke layers.
APR identified lots of interesting cloud activity, helping with in-flight fine-tuning of flight plan.

Selection of cloud for sampling:

- Sampled clouds just west of 0S, 1.5E for HiGEAR to test for droplet shatter effects in CVI. Also the first measurements of clouds in this region. This was a level cloud leg.
- Sampled clouds on approach to ASI, where cloud was very thick and there appeared to be a gap between cloud and aerosol layer. Sawtooth leg at 500 ft/min ascent/descent rate.

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**]**

NOTE: GPS altitude is about 10% higher than pressure altitude.

description	beginning time	end time	altitude	notes
Takeoff	09:15 UTC	X		Climbed up through broken clouds. Pretty clear day in TMS. 4STAR reported 0.2-0.3 AOD on the ground. Near TMS, aerosol layer of ~40Mm^{-1} up to ~4k' then smaller layer of ~30Mm^{-1} ~7-9k' Narrower layer of ~50Mm^{-1} at ~10?-11?k'. 14+k' before we really came out of these layers. Decoupled BL; low clouds up to ~1km; mid-level clouds 2.25-2.5k' (higher to the west)
Ascent	09:15	09:35	Up to 16k'; 5.4km	
Ferry leg	09:35	10:52	16k' -18k' pres alt.; 5.4-6.0km	HSRL ran cals ~10:03-10:08 Still not completely out of aerosol at 16k'/5.4km 10:05 bumped up from 5.4 to 6.0km.
Square spiral descent at 0S, 1.5W	10:52	11:20	18k' to surface; 6.0km to surface	Cloud deck below is solid. APR says "really wet BL below". ~4.7km altitude sharp increase in aerosol but then dropped off; main aerosol layer is ~2.7-3.3km. 11:05 at cloud top. NE and SE corners of spiral it's raining; rest is cloud w/ drizzle. 0.7 g/m^3 LWC towards top of cloud. Cloud probes reported large droplets. Rain on the windshield starting in bottom half of cloud. And turbulent. 1.6 g/m^3 near bottom of cloud. ~2500' press alt/800m out of bottom of cloud, with scattered Cu's below.

description	beginning time	end time	altitude	notes
Square spiral ascent at 500'/min to just above cloud	11:20	11:35	Up to 7200' pres alt.; 2.4km	
Above-cloud leg	11:35	11:38	7200' pres alt; 2.4km	For 4STAR sky-scan
Descend into cloud	11:38	11:40		
In-cloud leg	11:40	11:48	6500' press alt; 2.2km	Leg for HiGEAR to check for CVI shatter. HiGEAR says these clouds are very very clean. ~3/cc on SP2; CN count also low.
Ascend to above cloud	11:48	11:50	To 6900' pres alt; 2.3km	
Above-cloud leg	11:50	11:56	6900'-7100' pres alt; 2.3-2.4km	For 4STAR sky-scan. Started a scan but then bumped up to 7100' pres alt/7.1km so needed to start another. 1st scan won't be good but 2nd will. AOD ~0.3
Ramp ascent	11:56	12:07		Sulfate: 8ug/cm^3 – very high. Almost max sulfate of the campaign. But BC not so high. SP2 750/cc Dust?
High alt leg	12:07	12:31	16k' pres alt; 5.4km	Start leg at 0S, ~4W heading west-bound to get HSRL scan. On HSRL we can see a high depol layer just above clouds. Clouds go up to ~7000'/2.3km. Layer that is dust-like is at ~8000'/2.6 km. On ascent APS showed larger size particles. AMS had high sulfate concentrations in this layer as well. Some BC but not as much as you'd

description	beginning time	end time	altitude	notes
				expect for the amount of sulfate. So seems we do now have dust. As transited west, top of dust layer went up in altitude but petered out, but retained a lot of dust in boundary layer. Clouds also dissipated.
Square spiral descent	12:31	12:54	16000' to 2000' pres. alt.; 5.4km to 650m	At 0S, 6W. Tiny bits of clouds west and east of here; on HSRL the ones to the east appear to be at only ~1000' so decided to descend to just above them for sky-scans. Went to 1500' press alt, then back up to 2000' press alt., because we could see bits of them out the window. 8300'press alt/8700'GPS alt; just got a peak in APS – larger particles. Dust? ~5000' press alt large particles increasing, sulfate going back up At 2k' scattering down to ~25Mm^{-1} with ~0.3 AOD above.
East-bound level leg	12:54:30	13:00	2000' pres alt; 650m	Below BB plume/ dust layers; above bits of low cloud. 4STAR sky scans x2 AOD 0.3
Square spiral ascent	13:00	13:19	10k' pres alt.; 3.3km	At 0S, 5.2W Up to 10,000'pres alt/11,000' GPS alt/3.3km GPS alt. per peak in BB layer in HSRL image.
Plume leg	13:21	13:34	10.3k' pres alt; 3.5km	13:21 bump up from 10k' pres alt (3.3km) to 10.3k' (3.5km) pres alt. Scat ~60Mm-1 green. ~13:28 back at ~6W – end of stacked legs

description	beginning time	end time	altitude	notes
Ascent	13:34	13:43	Headed for 16k' press alt, but only went to 15k' (5km)	Ascended for HSRL curtain. On ascent found that our plume leg was just above the dust layer. It was in plume, but not in the heart of it. On ascent we saw that the peak in plume was at 11,000GPS alt/11,200 press alt. So going back down in altitude to that to sample it.
Descent	13:43	13:50:30	To 11.2k' press alt; 3.7km	
Plume leg	13:51	14:06	11.2k' press alt; 3.7km	Start just east of 0S, 8W ~100Mm^{-1} green scatter 13:55 "Rear" PSAP not reading anything, and AMS (in same rack) concentrations are lower than expected. Not sure if it's real or not~ LDMA in same rack is seeing stuff. Cycled power on PSAP. AMS fixed itself (?) and was good for last 7min of leg. ~7.9 W the dust petered out in the HSRL image~
Ascent	14:06	14:19:30	To 18k' press alt; 6.0 km	For HSRL curtain Clean slot at ~13k' press alt Plume dropped off at ~15k' press alt.; went higher to get above wispy layer at 17k' 14:17:40 at 0S, 10W; turned SW towards ASI
High-alt leg	14:19:30	14:42:20	18k' pres alt.; 6.0km	HSRL curtain Shows fairly uniform aerosol layer ~2.5-4.0km / 8-13k'GPS alt.
Descent to plume	14:42:20	14:52:30	To 8700' pres alt; 2.9km	
Plume leg	14:52:30	15:06	8700' pres alt; 2.9km	Cloud deck filled in during this leg. Scattering ~160Mm-1 in this layer. Have made our way back into the northern end of the plume.

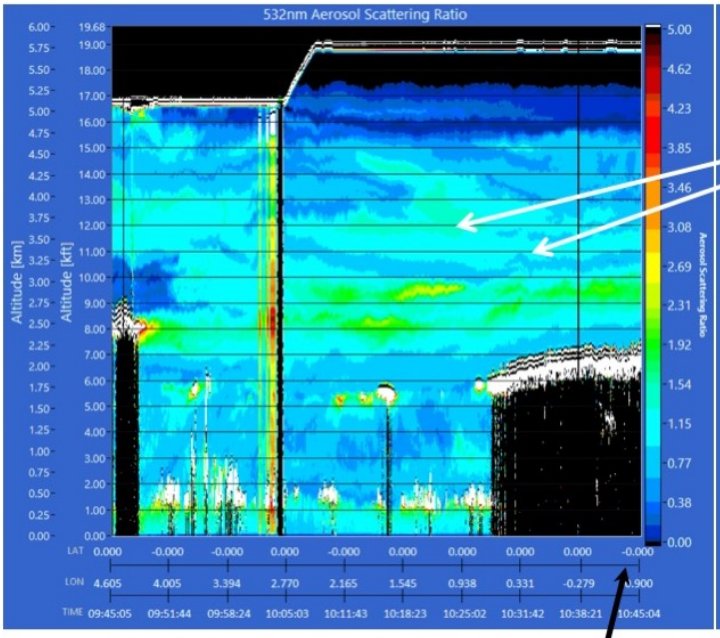
description	beginning time	end time	altitude	notes
Descent to just above cloud	15:06	15:09	6500' press alt; 2.2 km	
Above-cloud leg	15:09	15:17:30	6200' press alt; 2.2km	AOD ~0.4; maybe 200' above cloud SP2 ~100/cc Scattering <20Mm-1; maybe less Pretty clean slot above cloud Very dry; Clouds disappeared while we were flying above them…
Ascend	15:17:30	15:28:30	To 16k' press alt; 5.3km	
High-alt leg	15:28:30	15:39:40	16k' press alt; 5.3km	HSRL curtain to 6S,13.3W Aerosol layer 9-12.5k' GPS
Spiral descent to surface	15:39:40	16:09	To min alt	At 6S, 13.3W Drizzling cloud. 100-150micron size drops. But in other parts of spiral, sun peaking through. Multiple layers of clouds; thicker clouds above (tops at ~2km) and scattered Cu below. Includes full spiral/circle at surface for in-situ sampling of MBL air. Large raindrops reported by cloud probes. 16:03 at surface doing surface-layer circle. NOTES: Very clean layer above cloud top, about 0.6 or so km high. Fairly homogeneous very mild depol in the elevated layer, variable mild depol in the boundary layer, not enough ASR in the clean layer to say anything about depol. Boundary layer is polluted, so it appears we were seeing cloud processing of the aerosol going in this clean "gap" above cloud.

description	beginning time	end time	altitude	notes
Spiral ascent	16:09	16:16:18	To 6800' press alt; 2.3km	600' above cloud for APR; include a full circle in the spiral just above cloud
Circle above cloud	16:18	16:25+ a few minutes for repositioning	6800' press alt; 2.3km	For APR
Above-cloud leg	16:28	16:30	6500' press alt; 2.2km	Heading NE at 5.6'S, 13.1'W For 4STAR scan
Sawtooths/ cloud leg	16:30	16:38	5100'-6400' press alt; 1.7-2.1km	Heading back NE (backtracking) 500'/min ascent/descent rate for sawtooths. Few hundred meters thick cloud deck with some "hints of production" of precip. On CVI, HiGEAR reports essentially zero BC; very clean clouds **except** right at the base the BC and CO jump up. Small droplets, no drizzle production. Clouds thinned out as we went along leg and disappeared so ended leg early.
Square spiral ascent	16:38	16:45	To 10k' press alt; 3.3km	To plume level. Consistent with HSRL leg SW-bound over this area earlier HiGEAR reports small gap in scattering between cloud top and plume.
Plume leg	16:45	16:58	10k' press alt; 3.3 km	SW bound leg; so have HSRL above; 4STAR scan at SW end of leg below; in-cloud sawtooths; and plume leg, all between 5S, 12.7W and 5.86S, 13.23W. APR reports "massive rain below us" (for ORACLES standard) at SW end of leg

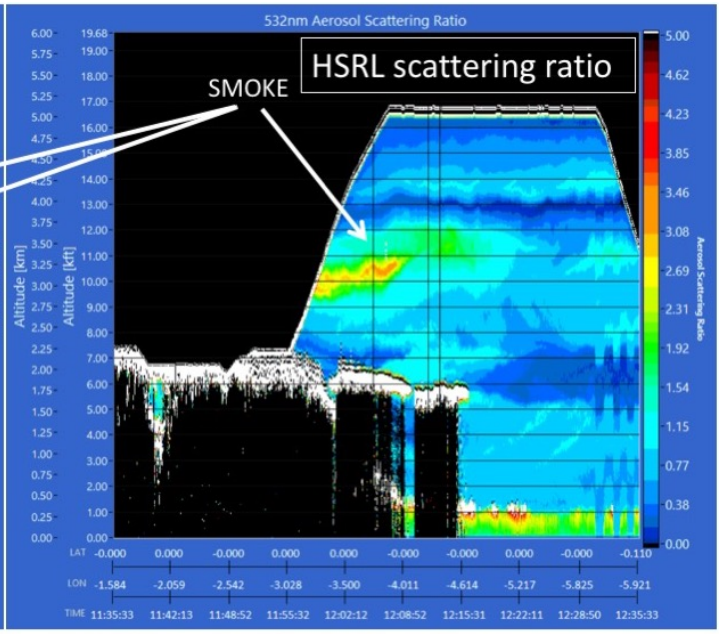
description	beginning time	end time	altitude	notes
Plume leg	16:58	17:17	10k' press alt; 3.3 km	Continue in plume towards ASI To 7 24.0S, 14, 4.7W
Start descent into ASI	17:17	X		
LANDED	17:30	X		

visual notes:

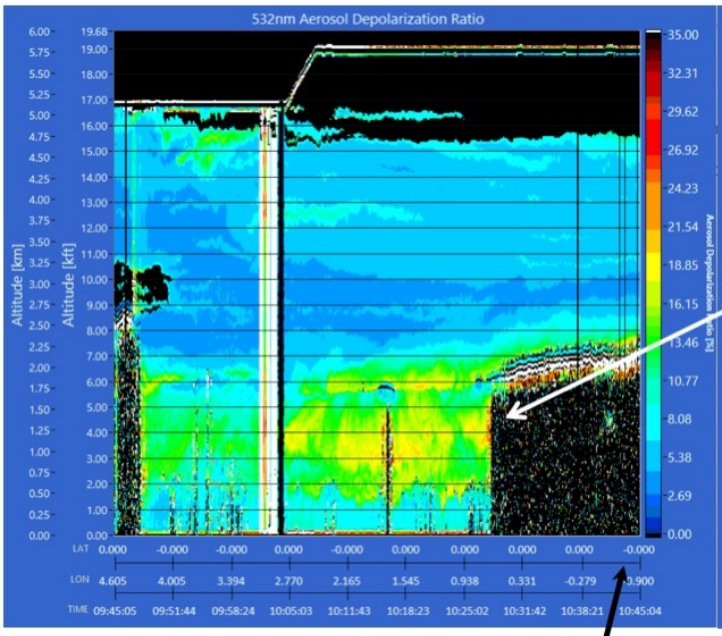
HSRL curtains: Spiral descent & in-transit cloud/above-cloud/plume legs on 0S starting at 1.5W.



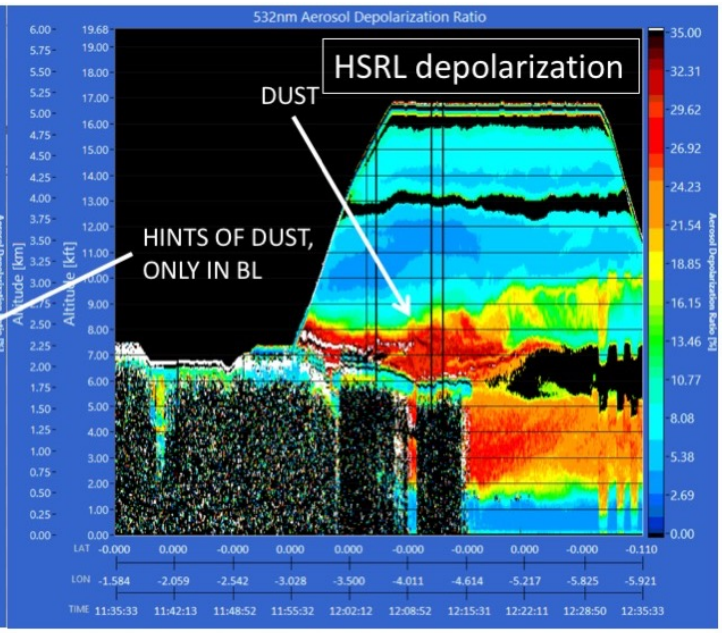
Spiral descent at 0S, 1.5W just after this, at 10:52UTC



End of above-cloud/in-cloud legs after spiral descent. All legs in-transit east-bound.



Spiral descent at 0S, 1.5W just after this, at 10:52UTC



End of above-cloud/in-cloud legs after spiral descent. All legs in-transit east-bound.

HSRL curtains: Spiral descent + stacked near-surface and plume legs on 0S between ~5.2W and 6.0W: