

ORACLES P3 Flight Scientist Post-Flight Status

Date: **10/17/2018**

Flight number: **PRF10Y18**

Routine flight or target of opportunity?: **Target of Opportunity – Hoping to sample younger aerosol off the coast of Angola. First priority is intensive in-situ aerosol sampling; if possible, get a radiation wall out of it.**

Flight scientist: **Sarah Doherty**

Ground scientist: **Rob Wood** Asst. Ground scientists: **Paquita Zuidema, Sebastian Schmidt & Michael Diamond**

Take-off: **06:52:21 UTC**

Landing: **15:07:18 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

Above cloud legs 1

Square spirals 1

Sawtooth legs 0

MBL legs 1

Plume legs 6

Cloud legs 1

Above plume legs 5

Instrument status:

Instrument	Comments
P3	All good.
4STAR	Instrument worked well. All the level legs were good. AOD up to 0.9 and a bunch of sky-scans.
HiGEAR	All worked well. By far the highest scattering they've seen since ARCTAS Max of 600Mm^{-1} green scattering Will look at whether it's chemically different.
HiGEAR-AMS	Worked great High aerosol loading compared to last year and maybe even 2016 loading. Super excited to look at data
HSRL-2	No problems. Mid-level clouds in the way but cool layers below.
RSP	Had a lot of good data both below and above clouds.
APR3	All worked well.
Cloud probes	Worked well. Still down 1 instrument. Interesting to look at difference in CDPs they switched. Liked long in-cloud leg.
CCN	Worked great. $\sim 1,500$ CCN in plume.
PDI	No one on P3 for PDI but looked like all ran fine.
Vertical winds	No one on P3 for winds but looked like all ran fine.
WISPR/CVI	No one on P3 for WISPR; CVI run by Lan (postdoc). Looked like all ran fine.
COMA	Inlet line had lots of water to start so H ₂ O vapor data not good until we turned east on 7S. After that, all good.
SSFR	All good.
data	All good.

PRF10 10/17 2018 Wednesday Mission Report

Flight Scientist: Sarah Doherty (FS)

Ground Scientist: Rob Wood (GS)

Asst. Ground scientists: Paquita Zuidema, Sebastian Schmidt & Michael Diamond

Flight plan and objective:

Takeoff STM and hit waypoint BULOS, then to 0S, 7E

Trip to 7S, 10.5E to sample fresh aerosol for 2-day plume semi-Lagrangian.

Fly south at altitude from 0S, 7E to 7S, 7E

Fly east from 7S, 7E to 7S, 10.5E and do work 10.0-10.5E on 7S.

Return at high altitude west-bound on 7S to 5E

Turn north at 7S, 5E to run a high-altitude leg north-bound 7S, 5E to 0s, 5E.

Transit home via EREGO.

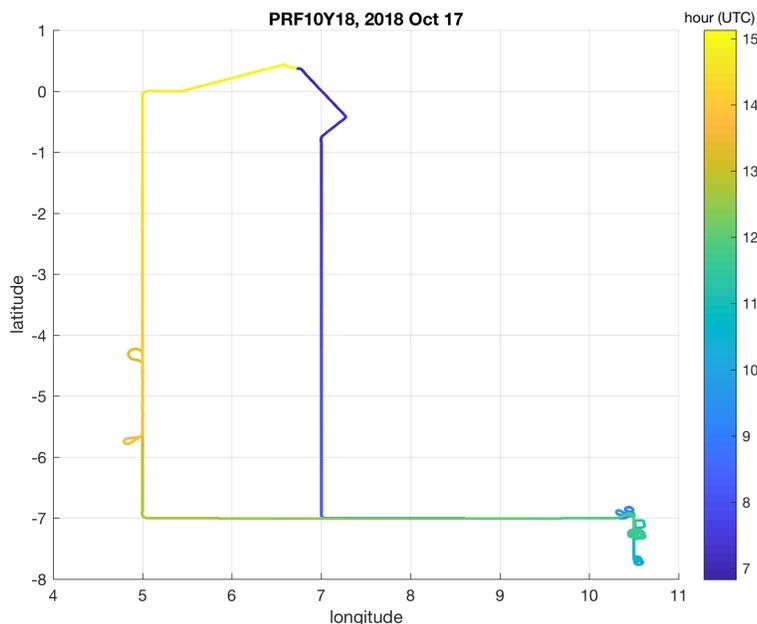
Do work/sampling on the way home as time allows.

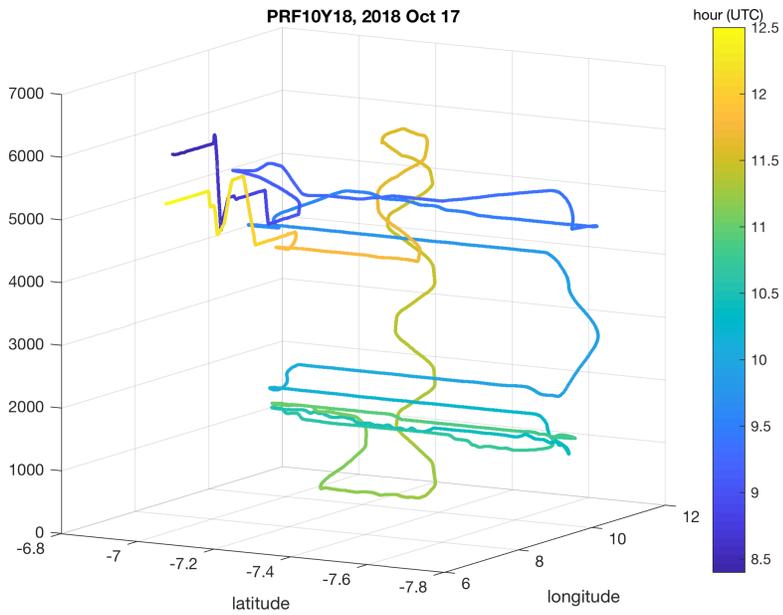
Flight Summary:

Flight was flown along the latitudes/longitudes as planned. However, when we reached 10.5E at 7S there were still mid-level clouds. In the hope that the mid-level clouds would clear, we opted to change the order of the radiation wall/spiral module, so we did the aerosol in-situ legs first (highest altitude layer to lowest altitude layer); then the below, in and above-cloud legs; then square spiral up. The highest aerosol concentrations encountered yet were found in the lower free troposphere.

A couple in-situ aerosol legs were added on the transit leg home along 5E.

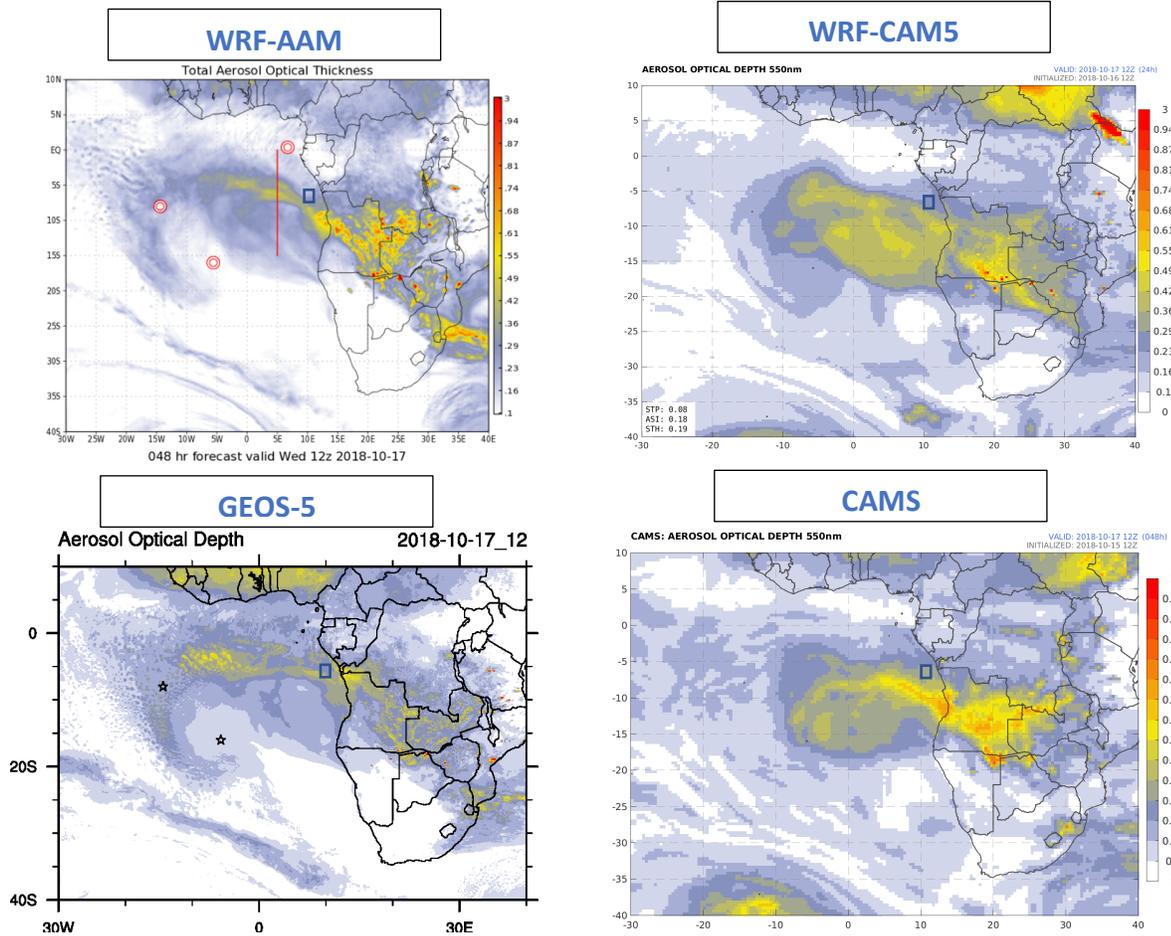
Plots showing (left) P3 lat & lon with time in color and (right) lat, lon & altitude with time in color for the ~09:00-12:00UTC radiation wall/spiral/in-situ sampling on the north-south line along 10.5E longitude.





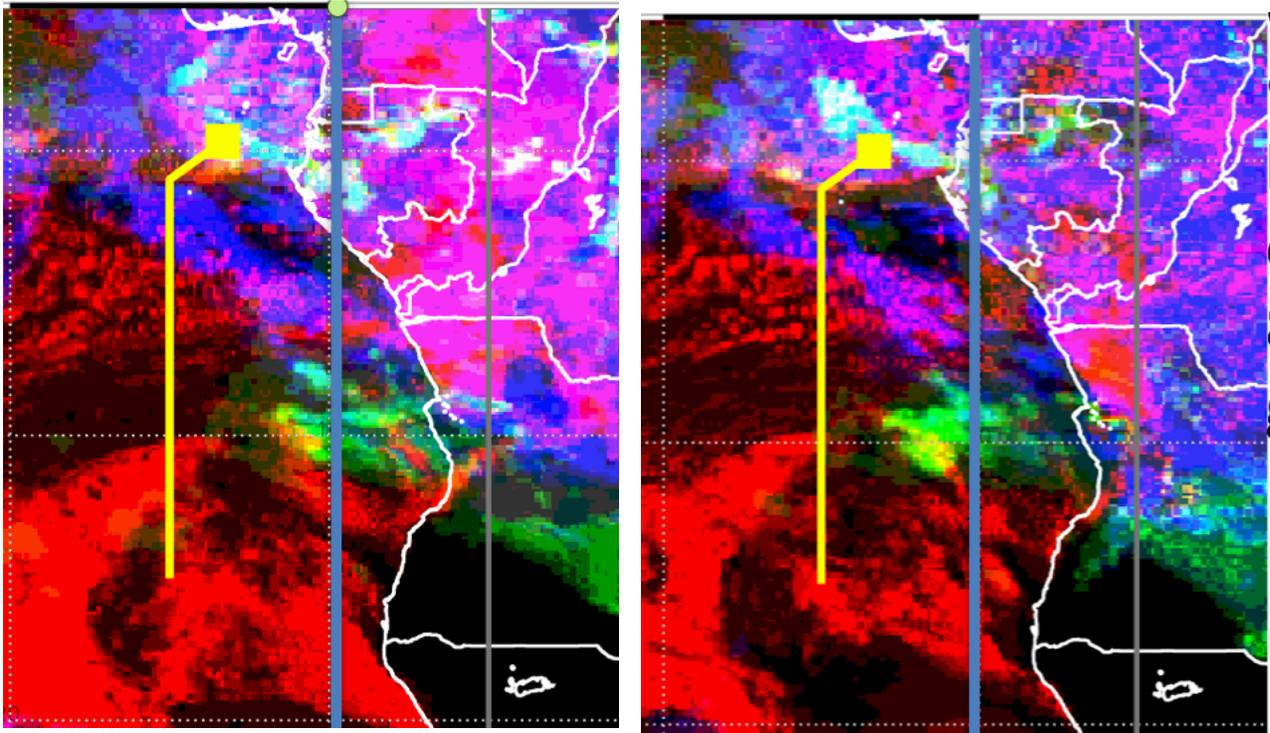
A-Priori Forecast:

AEROSOLS:



CLOUDS:

ECMWF forecast low (red), mid (green) and high (blue&magenta) clouds for 0900 (left) and 1200 (right) UTC show a risk of mid- and high clouds at 10.5E 7S...



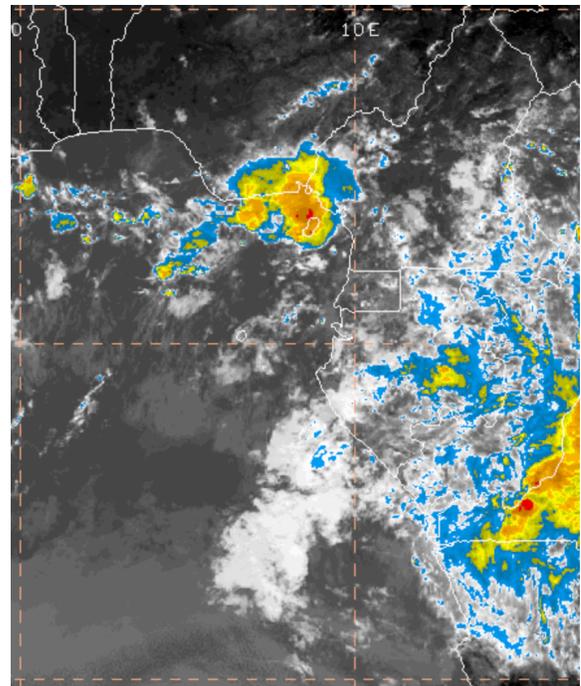
Forecast Verification:

Where ECMWF showed extensive high clouds on our north-south transit to 7S there were actually a lot of mid-level clouds. (See variations in altitude on transit legs, as we tried to get/stay below mid-level clouds). The mid-level cloud blob forecast as centered on 10S, 10E was larger and further north than in the forecast (see 11:00UTC image to the right).

Above-cloud AOD was >1.0 at 10.5E along 7-7.6S, so the aerosol plume was some combination of more intense and further north than in the model forecasts.

Flight Instrument status:

All worked well, except for water in the CVI and COMA sampling lines from recent heavy rain. Cleared both out during the high-altitude transit to work area on 10.5E, 7-7.6S.



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
Takeoff	06:52:21 UTC	X	To 17k'/ 5.5km	Headed for BULOS
CVI test	~07:35	~08:08		CVI had liquid water in it from heavy rains last evening. Run it to try to clear water from rain out of it while at altitude – and to give Lan a test-run on switching on/off CVI. Reported test worked well. H ₂ O vapor conc. dropped in lines.

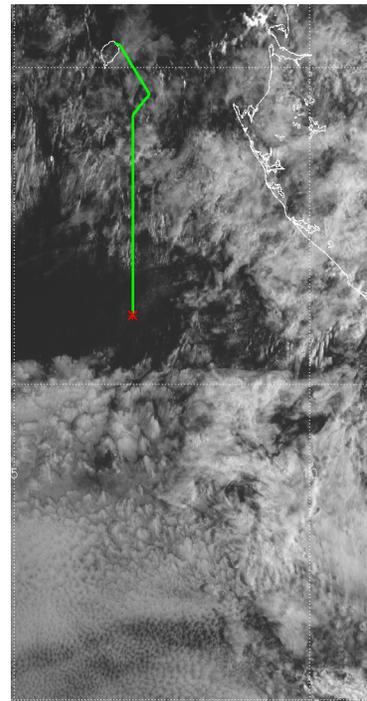
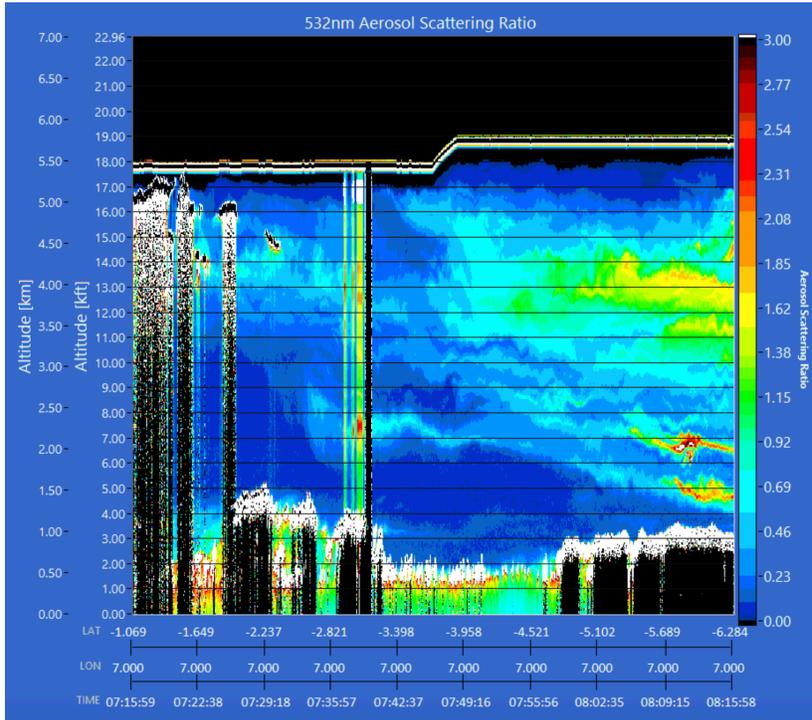


HIGH-ALTITUDE LEG south on 7E			17k'/5.5km	COMA reported H ₂ O data no good; many large pools in liquid water in the inlet line. Picarro showing high water amt
Increase altitude	07:45:30	07:48:20	17k'/5.5km → 18k'/5.8km'	Bump up fro 17k' to 18k' press alt to try & get above what looks to be aerosol (brown) but also very hazy (so maybe on the edge of being a cloud) that we're entering from the side.

→ Low clouds at TMS up to 5000 ft descending to 3000 ft. Cu under Sc with waves and mainly clean above up to 8000' at 2.5-3.2S. Two primary aerosol layers above at 7-8 kft and 12-14 kft, layers descending to south. Mid-level clouds from 14-18 kft at 0.5-2.5S
 → High-altitude layer of aerosol started at ~3.2S on 7E line. Layer is ~11-16,000' / 3.3-4.75km on HSRL. Very low depol (<5%) so probably very hydrated smoke.

description	beginning time	end time	altitude	notes
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→ 08:00 At 5S, HSRL showing AOD=0.2 with 0.05 above aircraft. Low clouds up to 3k'. Aerosol layer consolidating somewhat with horizontally extensive layer from 10-15k', and tendrils below that down to 6k'. Low cloud tops 3000 ft.



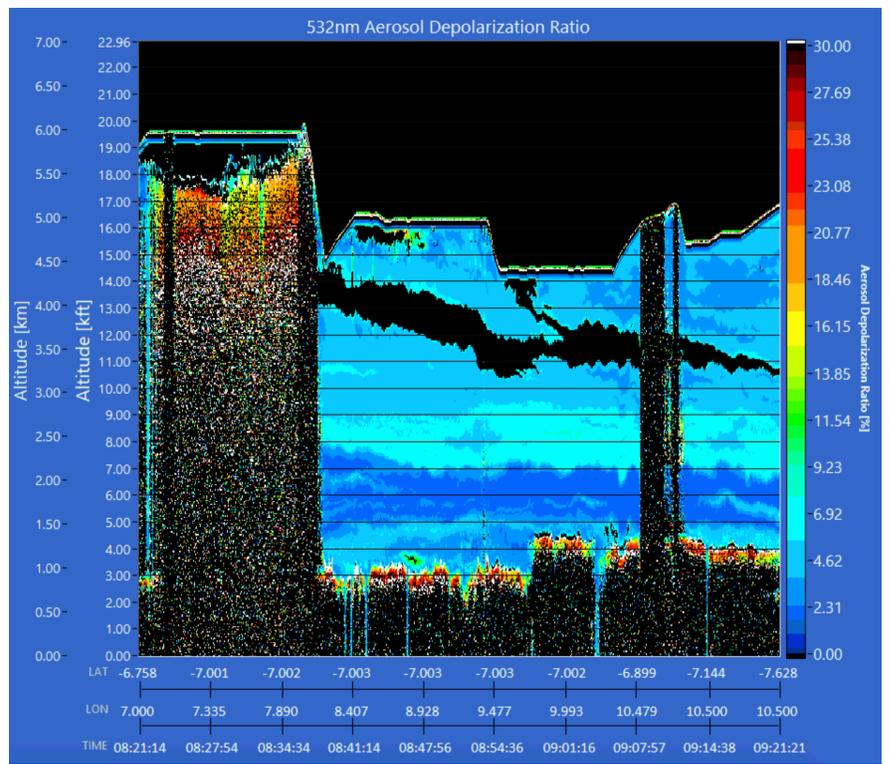
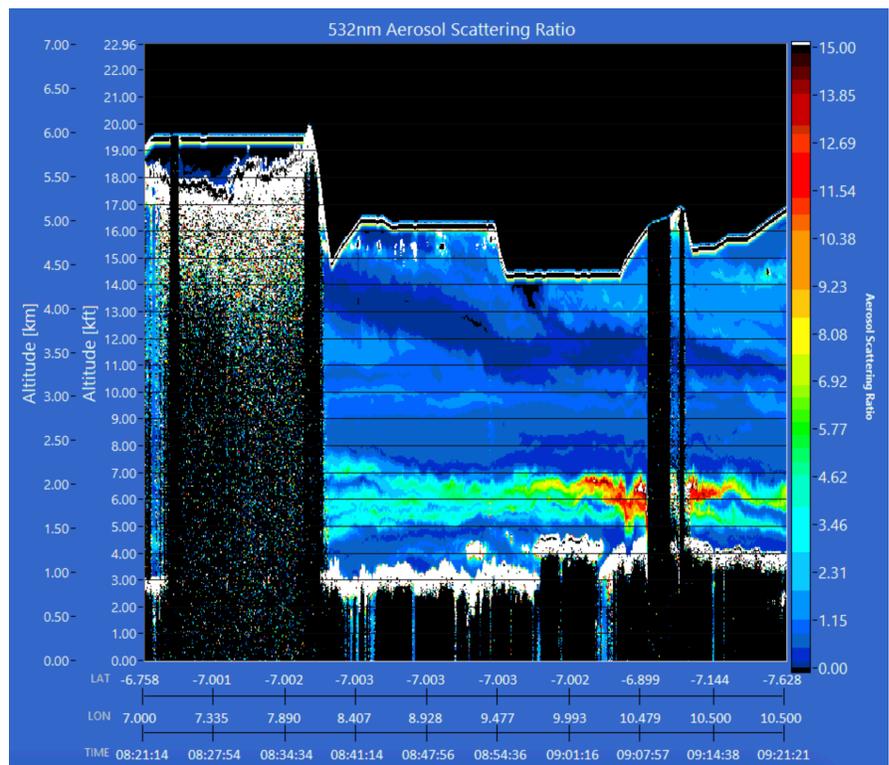
→ Decided work area would be on 10.5E running north-south on 7-7.6E
 → Decided to over-fly south-bound from 10.5E, 7.0S to 10.5E, 7.6S and then do spiral at 7.6S (rather than at 7S) so we can survey aerosol below before dropping down to do in-situ legs.

→ Seeing cirrus above from 4.8S. Evident in the AOD plot from HSRL.

Increase altitude	08:20:30	08:22	18k'/5.8km -> 18.5k'/6km	skimming the top of mid-level clouds at 18,000' so bumped up to 18,200'
Turn	08:23		18.5k' / 6km	Turning at 7S, 7E to head east-bound to 7S, 10-10.5E.
Descend in transit to 10E	08:36:25		18.5k' → 15.6k' / 5.0km	Dropping down to get below mid-level clouds for HSRL 14,800' saw a bit of a plume

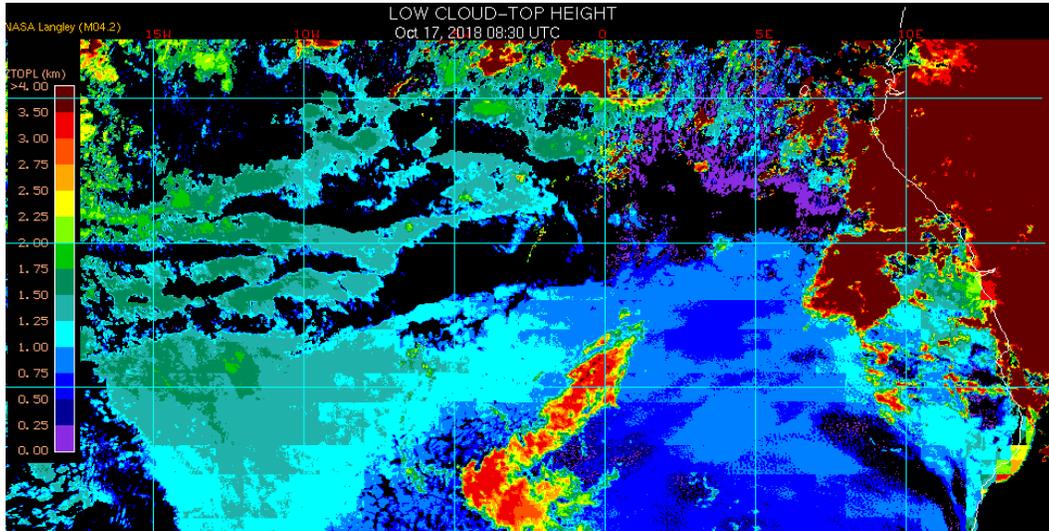
description	beginning time	end time	altitude	notes
				Popped back up to 15,600' press alt to be a bit higher but still below mid-level clouds
Altitude adjustments in-transit	08:43		~15.5k' / 5.0 km	Adjusting altitude up and down a bit to stay below mid-level clouds but as high as possible for HSRL Very low depol (<5%) layers at 4-7,000' / 1.25-2.25km (~7.0S, 8.5E)
In-transit	08:48		15.4k' / 5.0km	Entered layer at ~9E on 7S. 45 Mm ⁻¹ green scatter 4-5 ug organics CO almost 200ppbv → popped in and out of this.
Drop in altitude in-transit	08:53:40		15.4k' -> 13.7k' / 4.4km	At 7S, 9.4E: entered bottom of mid-level cloud so dropping down in altitude to get below it.
	09:07			7.0S, 10.45E HSRL ACAOD 0.55
Bump up in altitude in-transit	09:05:30	09:11:30	13.7k' -> 16k' / 5.1km	Ascent to max alt, hoping to be out of mid-level clouds...
<p>→ Decided to change sampling order a bit in hope that the mid-level clouds would clear:</p> <ul style="list-style-type: none"> • Start at high altitude and do in-situ aerosol legs, stepping down from top to bottom • Do below-/in- then above-cloud legs • Square spiral back up for SSFR <p>Hope is that mid-level clouds will disappear while doing in-situ + below-cloud leg so can get SSFR/4STAR above-cloud leg and spiral with low clouds only.</p>				
Turn	09:09	09:13	~16k'	At 7S, 10.5E → doing funky (!) turn Then head south-bound
Drop in altitude in-transit	09:11	09:13	16k' -> 14.6k' / 4.7km	dropped to 14,600' to be below mid-level clouds, which have not gone away...
HIGH ALTITUDE LEG	09:13	09:21	14.6k' / 4.7km → 16k' / 5.1km	7.0S to 7.6S on 10.5E SOUTH-BOUND High-altitude overpass of work area; Ramped ascent in-transit

description	beginning time	end time	altitude	notes
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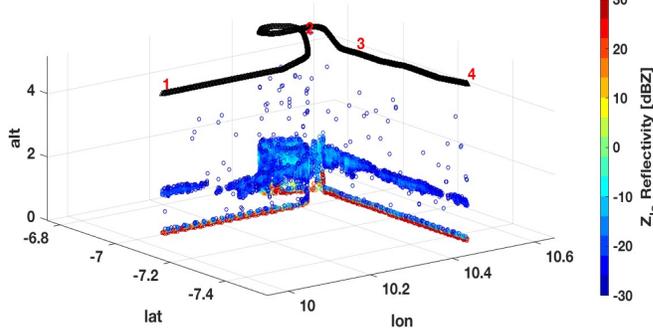


description	beginning time	end time	altitude	notes
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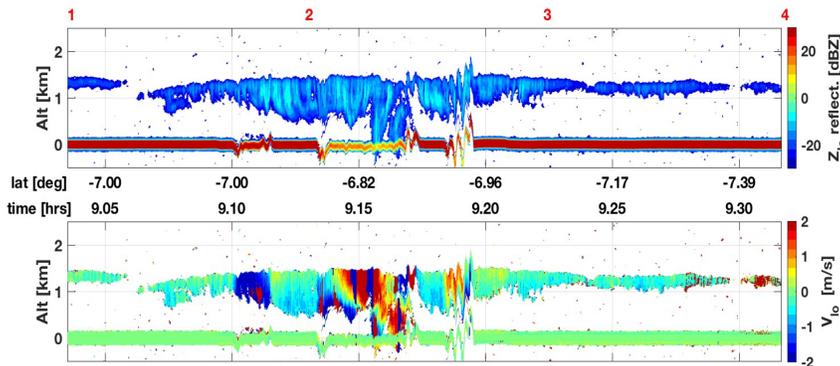
- Above shows HSRL curtain as we varied altitude to avoid mid-level clouds (starting at ~08:35) in high-altitude overpass of N-S line on 7E, running 7.0S to 7.6S. Note very high scattering ratio of the ~5-7k' "bacon layer".
- Gap between heavy aerosol layer & clouds
- Mid-level clouds appear to be super-cooled liquid clouds.
- At ~9.6S, 7E low level cloud tops jumped up to 4.5 kft, largely consistent with SEVIRI image (purple to blue)



preliminary in-field calibration - limited QC P3 ("v" black) RADAR (o color)



APR-3 imagery from 09:05-09:30 showing weakly drizzling PBL cloud up to 4500'



description	beginning time	end time	altitude	notes
Turn and descend	09:21	09:26	16k' → 14.5k' / 4.7km	Turn south-bound to north-bound and descent to first altitude for in-situ leg north-bound
IN-SITU AEROSOL LEG #1	09:26:00	09:34:30	14.5k' / 4.7km	On in-situ leg NORTH-BOUND starting at 7.7S, 10.5E, end at 7.0S, 10.5E At start of leg: BC~700ng/m ³ Green scatter ~35Mm ⁻¹ CO ~160ppbv
Stepped increase in altitude	09:29	09:32	14.5k' → 15k' / 4.9km	Stepped altitude adjustments up, 100' at a time, searching for heart of aerosol layer; wrong direction to go; flew out the top of the aerosol layer.
Turn and descend	09:34:30	09:42:00	15k' → 13k' / 4.2km	Turn north-bound to south-bound
IN-SITU AEROSOL LEG #2	09:42:00	09:51:25	13k' / 4.2km	On in-situ leg SOUTH-BOUND starting at 7.0S, 10.5E, end at 7.6S, 10.5E CO~210ppbv Green scatter ~70m ⁻¹ BC ~700ng/m ³ Plume peters out towards south end
Turn and descend	09:51:25	09:56:00	13k' → 6k' / 1.9km	Turn south-bound to north-bound
IN-SITU AEROSOL LEG #3	09:56:00	10:06:00	13k' → 13.2k' / 1.9km → 2.0km	On in-situ leg NORTH-BOUND starting at 7.7S, 10.5E, end at 7.0S, 10.5E

On this leg, highest concentrations of the year, by far!:

- 2-3ug/m³ BC
- Scattering 300-400Mm⁻¹
- CO 500ppbv; at south end 250ppbv
- Organics ~12ug
- No Rose particles at south end; started to see them toward north end.
- RH~70%

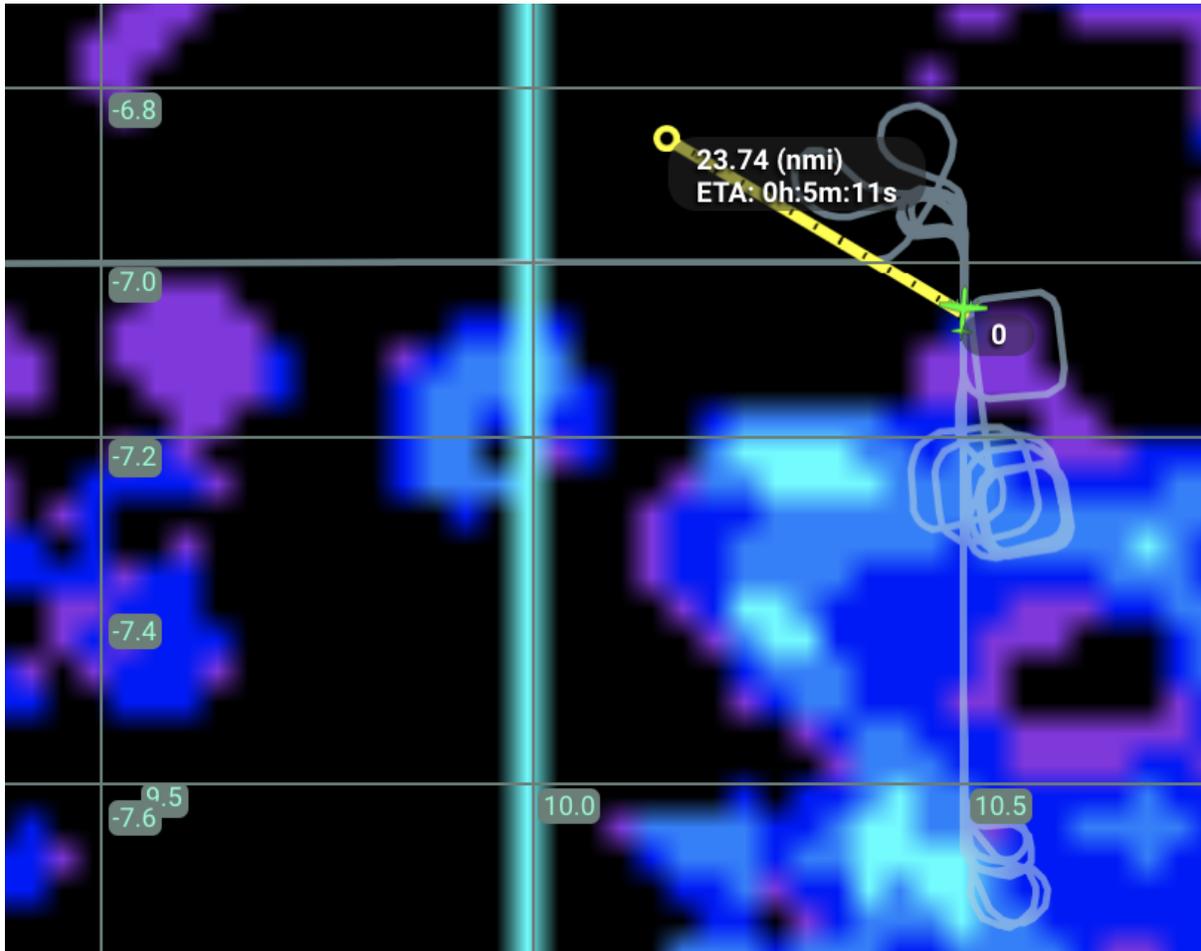
Note that on HSRL from high-alt overpass you can see a dip in the aerosol layer at

description	beginning time	end time	altitude	notes
<p>~7.2S, and north of that is heaviest concentrations in this lower altitude plume.</p> <p>Very small fraction of the particles that are super-micron – but overall the particles are large: 180-190nm particle mode – quite big</p> <p>In-situ concentrations all very variable but higher at north end. Just before end of leg, peaked out at:</p> <ul style="list-style-type: none"> • Scattering almost 600Mm⁻¹, absorption ~80Mm⁻¹ • CO in mid-500's ppbv • BC 3.5ug/cm² • ~3000 CCN • But SMALLEST conc. of large “Rose” particles we've seen. <p>Art noted that BC was heavily coated; in contrast to other flights, assuming this is the model-predicted “young aerosol”, this indicates coating goes away with aging. Would like to be able to remeasure in a couple days... but problem is that air at 5-6,000' =800-850mb is light out of west so this stuff is going back to the continent – not to the west.</p>				
Turn and descend	10:06:00	10:09:30	13.2k' / 2.0km → 5k' / 1.6km	Turn north-bound to south-bound
IN-SITU AEROSOL LEG #4	10:09:30	10:18:45	5k' / 1.6km	On in-situ leg SOUTH-BOUND start at 7.0S, 10.5E, end at 7.6S, 10.5E <ul style="list-style-type: none"> • ACAOD>1.0 • CO high 100's to mid-200's • BC ~1.5ug/m3
Turn and descend	10:18:45	10:22:30	5k' -> 3.7k' / 1.2km	Turn south-bound to north-bound and descent into cloud
	10:19:15			In-situ instruments go on CVI; getting CVI data in non-drizzling clouds. (except TDMA not on CVI)
IN-CLOUD LEG	10:22:30	10:32:10	3.7k' / 1.2km → 4.0k' / 1.3km	NORTH-BOUND cloud leg. Start at 7.6S, 10.5E, end at 7.0S, 10.5E <ul style="list-style-type: none"> • Clouds thin and a touch broken at south end; thicker to the north. • 350 droplet conc., droplet size ~1-10um • ~65ng/m3 in cloud droplets, accounting for CVI enhancement.
Turn and descend	10:32:10	10:36:00	4.0k' →	Turn north-bound to south-bound and descend to below-cloud

description	beginning time	end time	altitude	notes
BELOW-CLOUD / B.L. LEG	10:36:00	10:44:45	3.5k' / 1.14km → 3.3k' / 1.0 km	SOUTH-BOUND below-cloud leg; start at 7.0S, 10.5E, end at 7.6S, 10.5E <ul style="list-style-type: none"> • “mildly polluted” • Scattering $\sim 20\text{Mm}^{-1}$ • CO $\sim 150\text{ppb}$ • BC 300ng/m^3
Turn and ascend	10:44:45	10:49:30	3.3k' → 4.1k' / 1.3km	Turn south-bound to north-bound and ascend to above cloud
ABOVE-CLOUD LEG	10:49:45	10:59:00	4.1k' / 1.3km → 4.2k' / 1.36km	NORTH-BOUND above-cloud leg. Start at 7.6S, 10.5N, end at 7.0S, 10.5E <ul style="list-style-type: none"> • Below-cloud leg was only slightly more dirty than the above-cloud leg – but very similar. • Horizontal gradient just above-cloud: increase as we go north
Turn & descend	10:59:00	11:03:30	4.2k' → 4.05k' / 1.3km	Try to get in-cloud for going on CVI to get TDMA data missed on last in-cloud leg
In-cloud leg (attempt!)	11:03:30	11:05:45	4.05k' / 1.3km → 3.2k' / 1.0km	Started south-bound on 10.5E. Start at 7.03S, 10.5E. Entered cloud from the side at 11:03:30 but clouds petered out... Descended to try to hit clouds but no luck. 11:05:45, at 7.16S, turned and headed back north-bound.
Descend to surface in transit to 7.1S, 10.5E	11:05:45	11:10:00	3.2k' / 1.0km → 200' / 80m	Going to 7.1S to do square spiral to surface then back up to max alt – in hopefully a spot that has only a few scud clouds. Then nudged south to $\sim 7.2\text{S}$ to try and avoid mid-level clouds.
SQUARE SPIRAL ASCENT	11:10:00	11:36:00	200' / 80m → 18.4k' / 5.9km	Square spiral ascent $\sim 7.2\text{-}7.3\text{S}$, 10.5E Unfortunately, lots of mid-level clouds around... Got an AOD of ~ 0.1 with dirty window – only a few seconds long enough out of cloud to measure AOD.

description	beginning time	end time	altitude	notes
Square spiral descent back down to 12k'	11:36:00	11:44:00	18.4k' / 5.9km → 12.0k' /	Descending to 12k' to try and sample aerosol layer in-situ on transit north to 7.0S, then on west-bound leg along 7.0S.

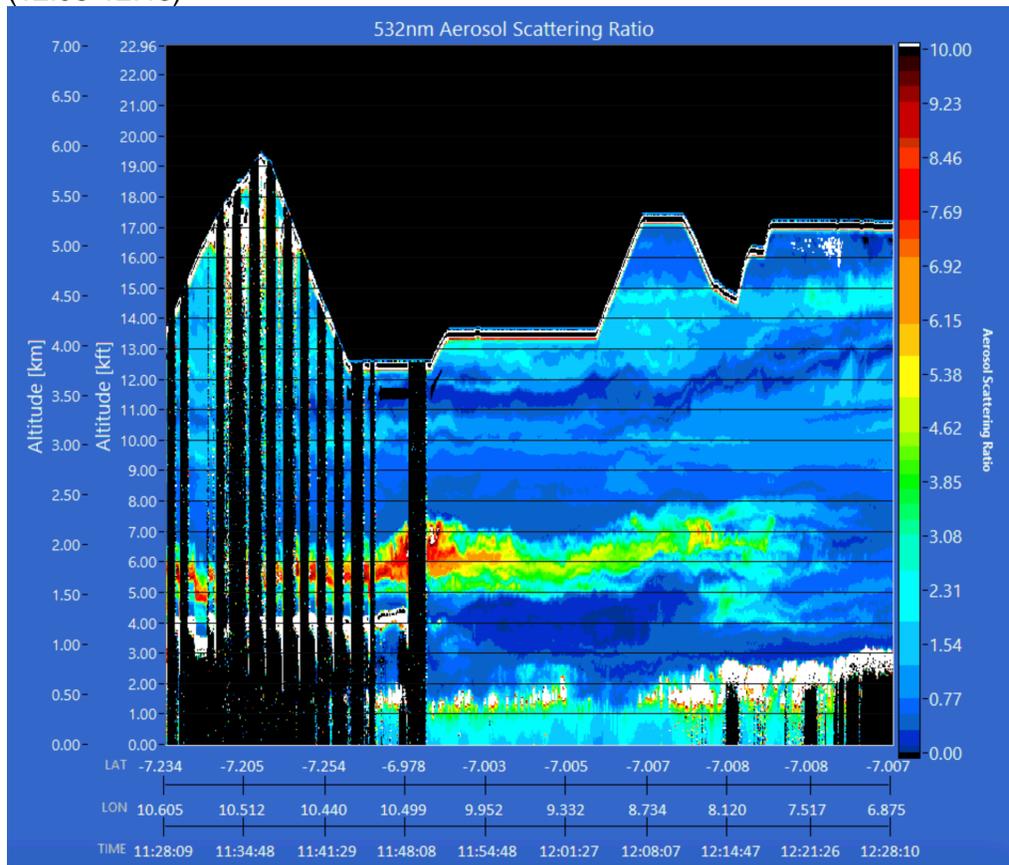
North-south "wall" on 10.5E between 7S and 7.6S; square spiral in patch of mid-level clouds (blue/purple) at 7.2-7.3S....



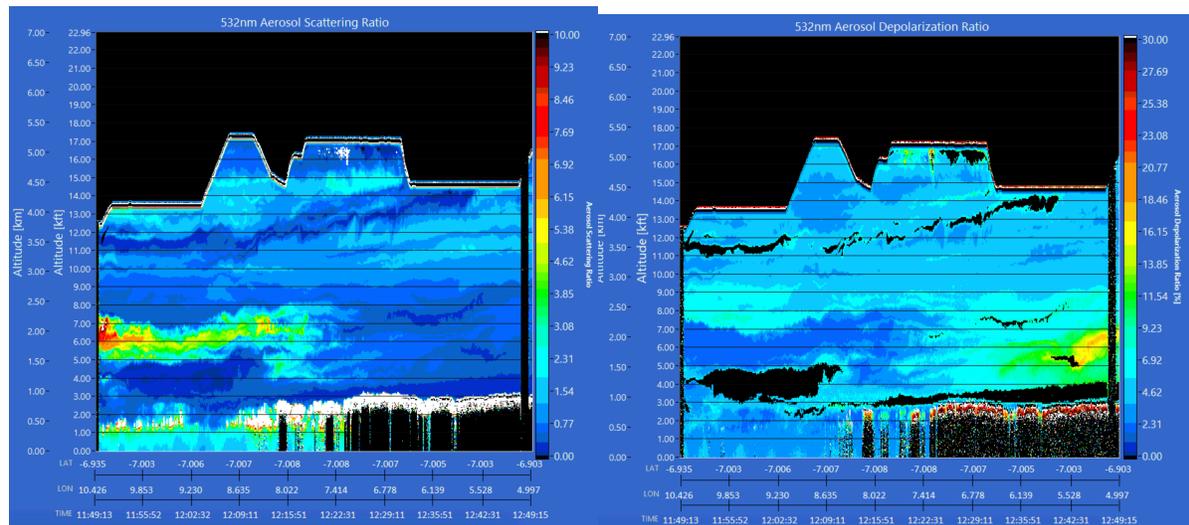
IN-SITU AEROSOL LEG	11:44:00	11:47:45	12.0k' / 3.8km	NORTH-BOUND leg on 10.5E from 7.25S to 7.0S <ul style="list-style-type: none"> • BC~0.5ug/m³ • Org ~4-5ug organics • Scattering ~30Mm⁻¹
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description	beginning time	end time	altitude	notes
Turn while doing IN-SITU LEG	11:47:45	11:51	12.0k' / 3.8km → 13.0k' / 4.2km	Turn at 7.0S, 10.5E from north-bound to west-bound. Bumping up in altitude because we seem to have gone out the side of the aerosol layer.
IN-SITU AEROSOL LEG	11:51	12:03:30	13.0k' / 4.2km	WEST-BOUND leg on 7.0S from 10.3E to 7.0S, 9.1E
Ascend in-transit	12:03:30	12:07:30	13.0k' / 4.2km → 16.5k' / 5.3km	Ascend while headed west-bound to get HSRL curtain. Levelling off at 16.5k' because we can see mid-level clouds ahead that we want to stay below. Scattering still $\sim 30\text{Mm}^{-1}$ so not out the top of it yet....

HSRL curtain from square spiral ascent (11:10-11:36); square spiral descent (11:36-11:44); 12k' in-situ aerosol leg north then west-bound (11:44-12:03); ramped ascent west-bound (12:03-12:08); then high-altitude leg with altitude adjustments to get below mid-level clouds (12:08-12:48)



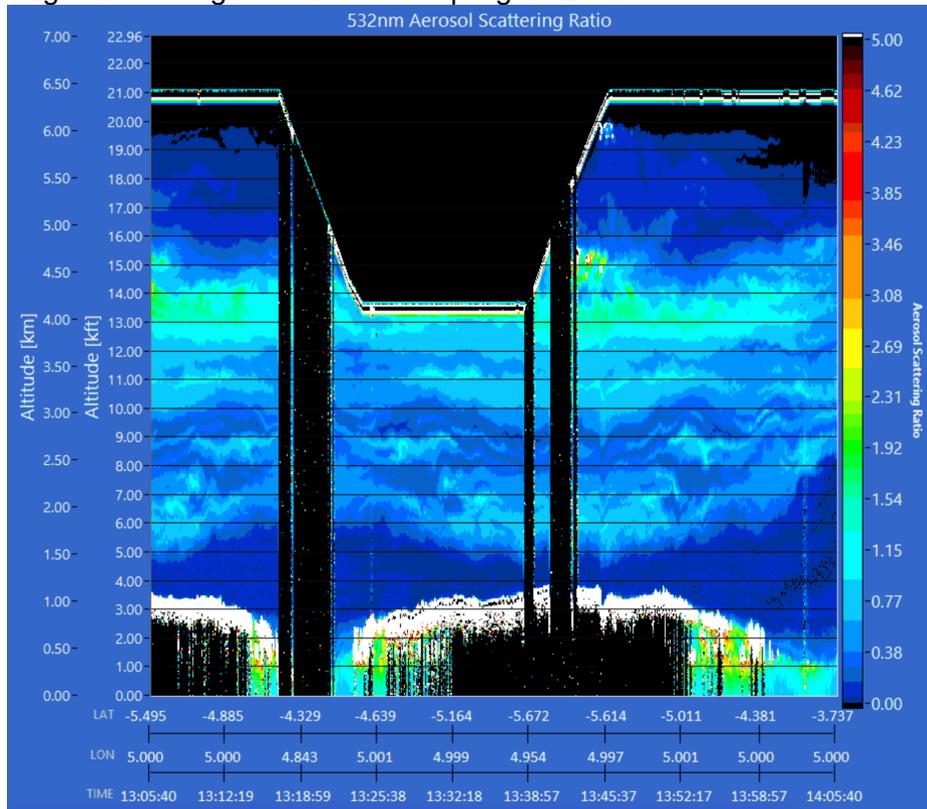
description	beginning time	end time	altitude	notes
HIGH-ALTITUDE LEG (altitude determined by mid-level clouds)	12:07:30	12:47:30	Variable; between 16.5k' and 14k'	<p>WEST-BOUND on 7.0S, 8.78E to 5.0E</p> <p>12:10:30 mid-level cloud bank ahead that we are going to go into at this altitude, so start descending.</p> <p>Multiple altitude adjustments to avoid mid-level clouds.</p> <p>12:38:30 Hit a very high humidity layer (~88%) at 14,000'.</p> <p>12:29 we're back at the 7.0E line, which we came south on in the morning</p> <p>12:42:30 Flew horizontally into aerosol at ~5.5E, 7S.</p> <p>Oscillations, pretty regular in scale/time in:</p> <ul style="list-style-type: none"> • CO 150-210ppb • BC 300-350ng • Scattering 20-65 Mm⁻¹ <p>Can see sloping layers on HSRL that we came into</p>



Turn and ascend	12:47:30	12:49	14.1k' / 4.5km → 15.6k' / 5.0km	Turn from west-bound to north-bound at 7.0S, 5.0E
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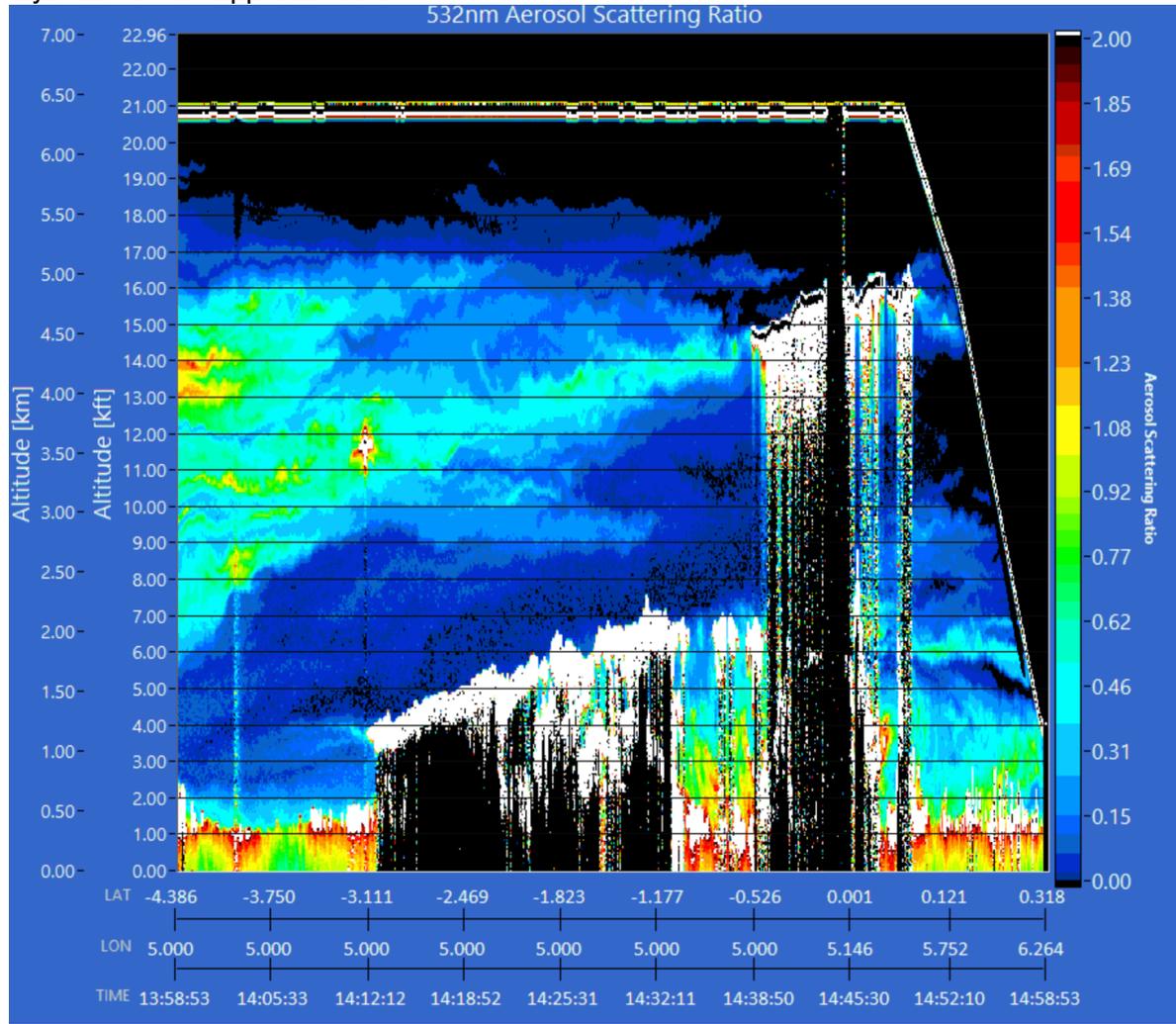
description	beginning time	end time	altitude	notes
				Ascending to max alt because it appears we just cleared mid-level clouds – so can get full HSRL curtain. North-bound at 6.9S, 5.0E at 12:49
Continue ascent north-bound	12:49	12:55	15.6k' / 5.0km → 20k' / 6.4km	Ramped ascent while north-bound on 5.0E from 6.9S to 6.45S.
HIGH-ALTITUDE LEG	12:55	13:16:30	20k' / 6.4km	NORTHBOUND on 5E, from 6.45S to 4.5S
Turn & descend	13:16:30	13:24	20k' / 6.4km → 13k' / 4.2km	Turn from north-bound to south-bound at 4.5S, 5E to get in-situ leg where HSRL just got a curtain
IN-SITU LEG	13:24	13:37:45	13k' / 4.2km	SOUTH-BOUND on 5E, from 4.5S to 5.6S
Turn & ascend	13:37:45	13:46:00	13k' / 4.2km → 20k' / 6.4km	Turn south-bound to north-bound at 5.6S, and ascend for HSRL

High-altitude legs with in-situ sampling 13:24-13:38

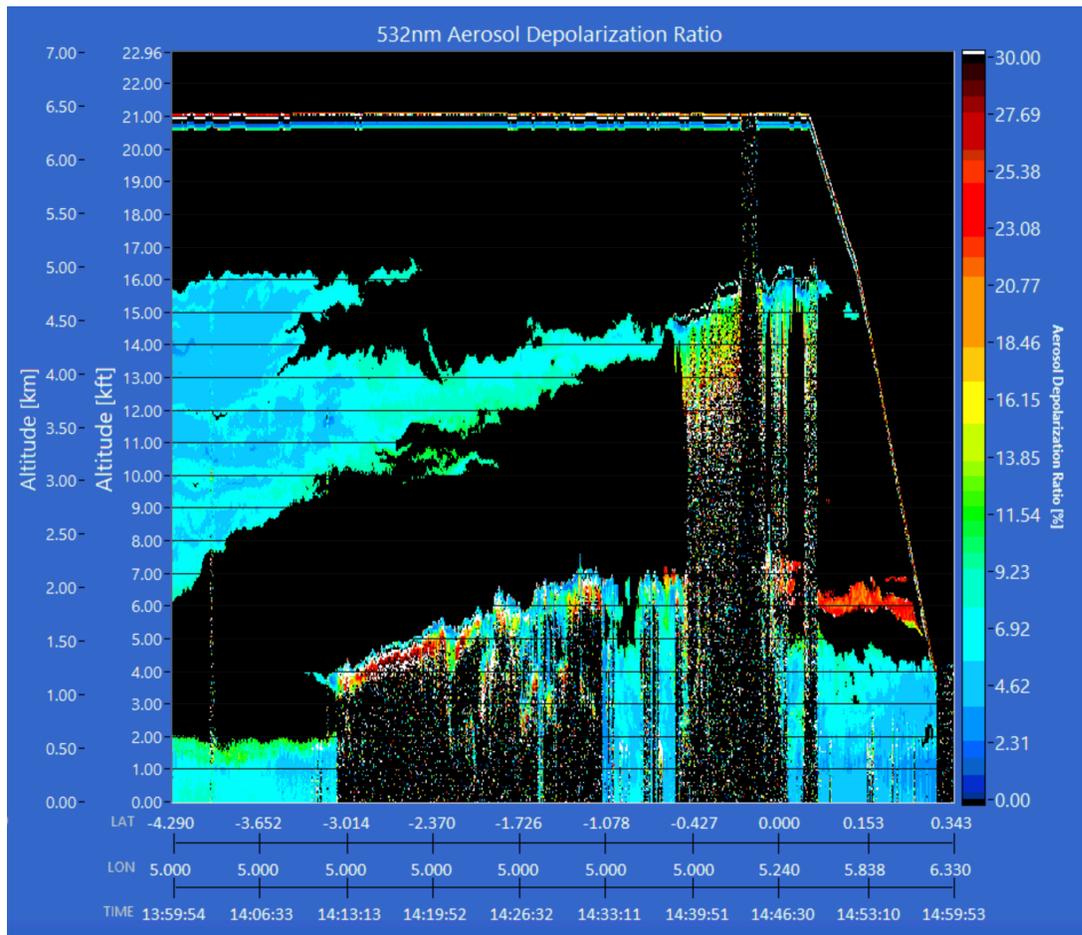


description	beginning time	end time	altitude	notes
HIGH-ALTITUDE LEG	13:46:00	14:43:20	20k' / 6.4km	NORTH-BOUND on 5E from 5.6S to 0.1S <ul style="list-style-type: none"> • At 4.1S still have AOD=0.25+ • At ~3.2S aerosol petering out; HSRL AOD full-column AOD~0.2

High-altitude leg north-bound on 5E, then descent for landing at STM; note depolarizing layer at ~6k' on approach to STM:



description	beginning time	end time	altitude	notes
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Turn north-to east-bound	14:43:20	14:45:00	20k' / 6.4km	
HIGH-ALTITUDE LEG	14:45:00	14:48:30	20k' / 6.4km	EAST-BOUND on Equator from 5E to 5.43E EREGO
Approach to land	14:48:30	15:07:18		Approach via EREGO At 6000' HSRL is seeing highly depolarizing layer maybe dust In-situ saw this at ~5,000'. There were "certainly large particles present". Accounted for ~1.3 of surface area.
LANDING	15:07:18	X		