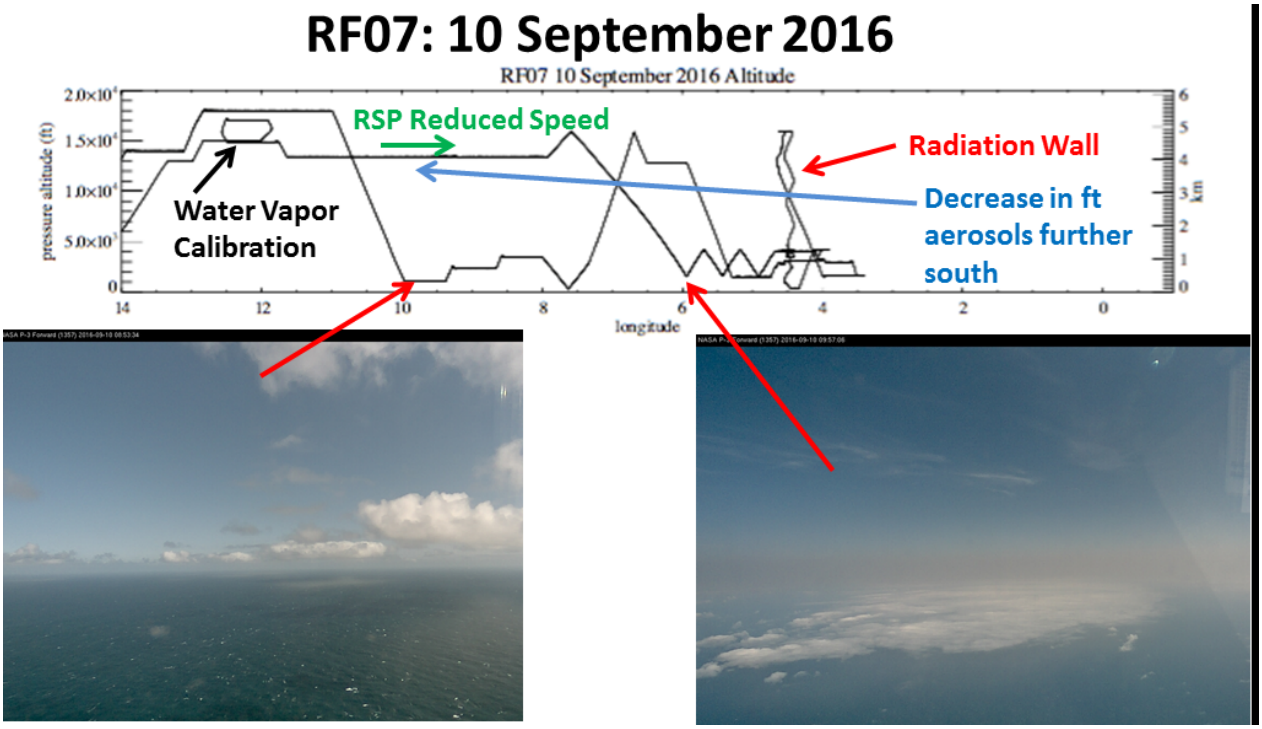
RF07 10 September 2016 Mission Report

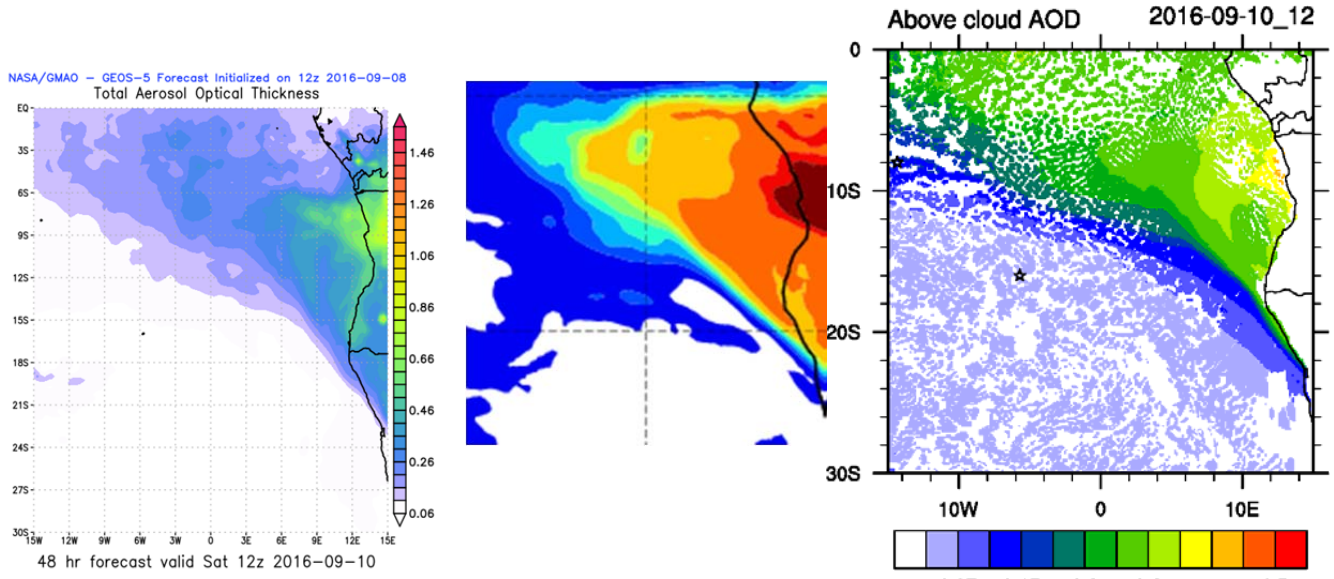
flight scientist: Greg McFarquhar
mission scientist: Paquita Zuidema

Flight plan and objective: The goal of the mission was to conduct a routine flight along the NW-SE line running from 23˚S13˚E to 10˚S0˚E, planning profiling legs (below, within, above cloud, sawtooths through cloud and profiles/constant altitude legs of free tropospheric aerosols) with 2 complete stacks both outbound and inbound, offset from each other. Coordination with the ER-2 on the inbound leg was also envisioned.

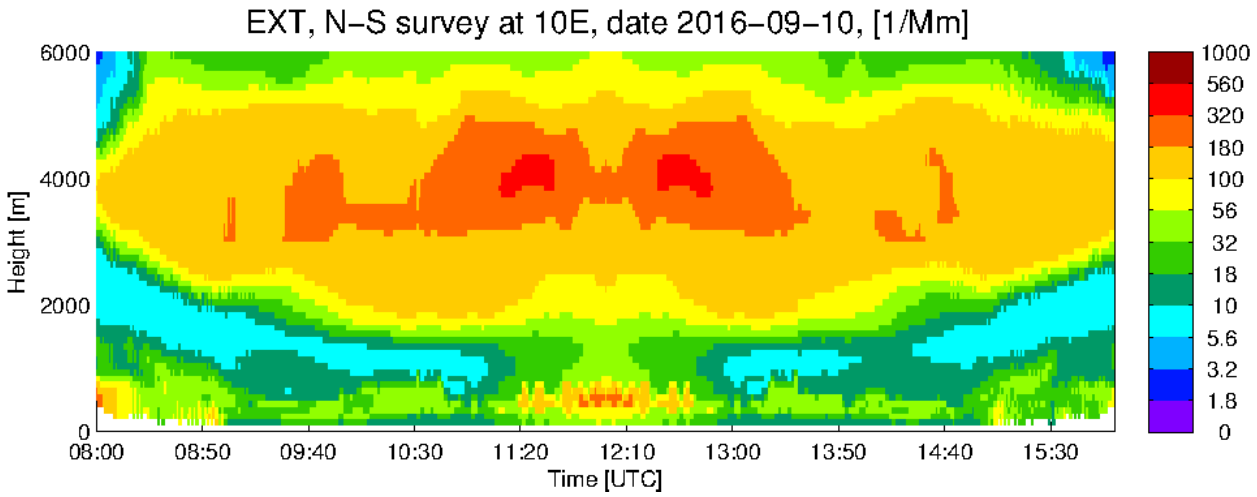
Flight Summary: Given the presence of cirrus at the northern and eastern edges of the ORACLES domain, the P-3 flew a routine mission along the NW-SE line running from 23˚S13˚E to 10˚S0˚E, together with an overflight of the ER-2 including an AirMSPI calibration. The P-3 took off at 7:31 UTC and headed for the NW-SE line. At 11˚E, the P-3 descended to start profiling the boundary layer and free troposphere. This consisted of a 10-minute leg below cloud, a 10 minute constant altitude leg through cloud, and a 10 minute leg ~500 feet above cloud. The planned sawtooth component was not flown because of the relative absence of cloud at this location. Thereafter the P-3 ascended to 16 kft to profile the free troposphere but did not execute any constant altitude legs because of the reported absence of significant amounts of aerosols. Conditions reported throughout this whole leg were quite clean. Thereafter, the P-3 descended to the boundary layer to do another profile. A 10-minute leg below cloud and a 10-minute leg within cloud were executed, and a leg above cloud was started but not completed. The concentrations in the boundary layer were quite clear just as had been reported in the previous leg. At 14˚S, the P-3 turned and headed to way point 14.45˚S/4.45˚E to meet with the ER-2 at an Air-MSPI coordination point (the meeting point was determined during flight because the ER-2 was cutting its flight short due to an issue with the HSRL). A square spiral was flown (i.e., a spiral with exception that 30 seconds of wings straight while ascending was performed every 180 degrees). The spiral was started at 500 feet and ascended into the cloud layer. Because the P-3 arrived 20 minutes before the projected 11:11 UTC arrival time of the ER-2, the P-3 ascended above cloud and executed two 3-minute long flight legs to get level legs that the SSFR requested. Thereafter the P-3 returned to cloud and continued the square spiral with timing worked out so that it was within cloud while the ER-2 flew overhead. After the ER-2 departed, the square spiral was continued up to 16 kft (at 500 feet/minute up to 4500 ft since inversion was estimated at 3800 ft, and 1000 feet/minute above). At 16 kft, special maneuvers were flown whereby 30 seconds with no turns was executed every 90˚ rather than the standard 180˚. Thereafter the P-3 returned to the routine NW/SE line, and continued to fly NW through the boundary layer in the below cloud leg, before turning around and conducting the in-cloud, above cloud and sawtooth legs travelling to the SE. The cloud droplet concentrations may have been lower on this leg, but the maximum sizes were still in the 20 to 25 micrometer range with lots of stuck bits on the 2DS reported. There was no obvious cirrus on the 4STAR. The clouds thinned out around ~14.5˚S, but another area of clouds south of 14.5˚S where seen whose tops were sampled. The largest cloud drops were seen near the top of the cloud on this leg. After ascending to 16 kft at 500 feet/minute, a layer of enhanced aerosol concentrations at 13.5 kft was identified and selected for the transit to WVB. The Black Carbon and 4-STAR OAD gradually reduced on this leg to the SE. On 13.5 kft, a test with an indicated air speed of 200 knots was executed to test RSP performance. And, a series of stacked legs from 13.5, to 15, to 17, to 15, to 13.5 kft were performed for WISPER to look for gradients in water vapor. An interesting layer to left of aircraft with clouds embedded in a haze layer was noted. Water and CO dropped consistently during the 13.5 kft leg. The CO and water vapor went up while ascending for the 15 kft leg, but then dropped off during the leg. When ascending further to 17 kft, they rose again, which was called the water isotope wall.



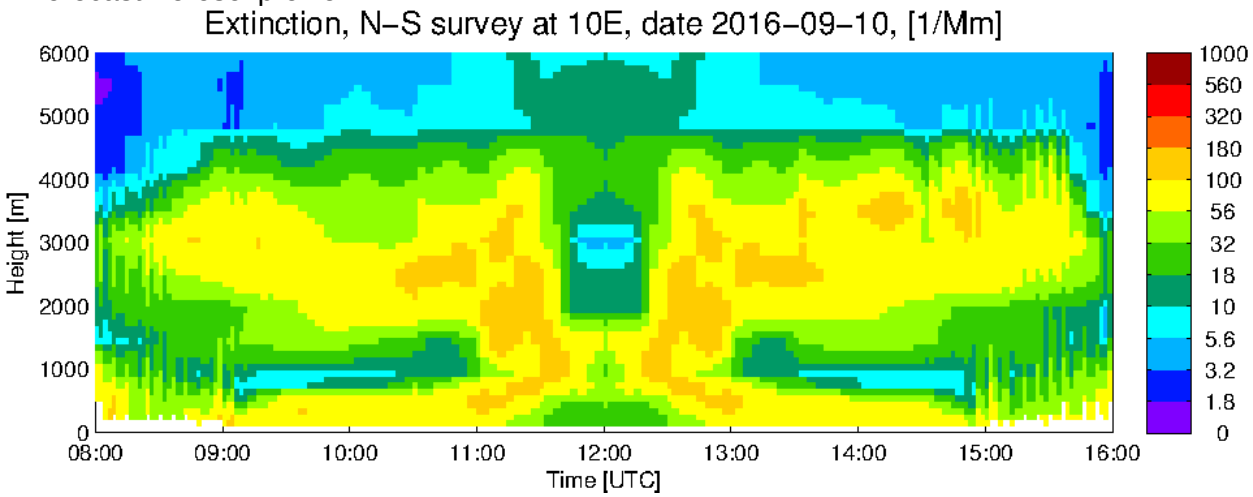
Forecast: Cirrus and middle level cloud were forecast to the north and east of the ORACLES domain. Both the UK and EC models were forecasting low cloud extending to 14˚S with a clear region of lower humidity and thinner boundary layer to the south. None of the three models were forecasting exceptionally high aerosol optical depths, with higher values typically on the northern and western ends of the tracks.



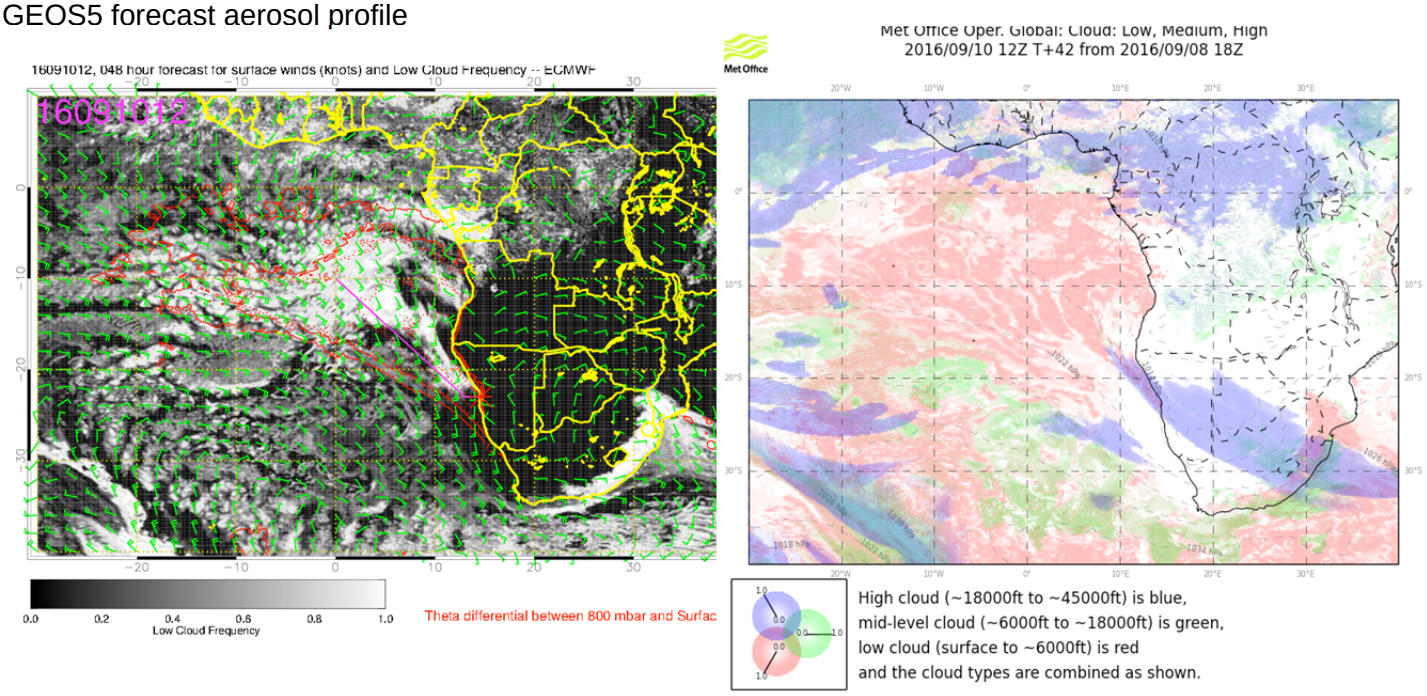
GEOS5, CAMS and WRF ACAOD aerosol optical thickness forecasts.



WRF Forecast Aerosol profile



GEOS5 forecast aerosol profile



Forecast Cloud Coverage

Notes from flight:

Manifest (full flight)

Crew (5): Michael Singer [chief pilot]/Mark Russell [co-pilot]/Brian Yates/Todd Brophy/Mike Terrell
Science (19): Greg McFarquhar [flight scientist]; Greg Sadowy, Ousmane Sy (APR); Brian Cairns (RSP); Steven Howell, Steffen Freitag, Amie Dobracki (HIGEAR, HIGEAR-AMS); Mary Kacarab (CCN); Art Sedlacek (PTI); David Noone (WISPER); Jim Podolske (COMA); Joe O'Brien (cloud Probes); Sabrina Cochrane (SSFR); Mike Delaney (Data); David Simmons (AMPR); Kristina Pistone (4STAR); Samuel LeBlanc, Sebastian Schmidt, Siddhant Gupta (Extra)
Ground mission scientist: Paquita Zuidema

General Observations: AOD was very low for most of the early flight; reported values ~0.005, though there may be an ~0.02 low bias in AOD. Once the P-3 hit the plume, AODs up to 0.4 were noted. 4STAR was in sun-tracking mode for a good portion of the flight, and in zenith for the below-cloud and in-cloud legs, and several sky scans (for both cloud and aerosol) were completed. Maximum cloud droplet sizes were 20 to 25 micrometers.

Instrument Status:

APR: Turned off for large portion of flight, saw significant echoes for part of flight, flew over one nice looking cell, and got data all 3 frequencies of that one; on earlier parts of flight had consistent returns on W-band
RSP: instrument ran well at 200 knots indicated air speed, otherwise scan drifts so not looking where should be
HIGEAR: good flight, everything was working, wasn't particularly aerosol rich flight, but there was plenty
CCN: not a lot of aerosol, tracked well with HIGEAR, couple issues, worked well
PTI: Ran well, foam insulation to dampen cabin noise caused laser to overheat (when no absorbing aerosol), absorption angstrom exponent near 1 suggesting organic aerosol not absorbing aerosol in visible region, interesting to see what remove sensors see
WISPER: delighted instrument worked almost all flight, excited that fewer aerosols so can look cleaner aerosols
COMA: worked well, both instruments, CO/CO2 and water, saw some interesting things when got into layers, figured out how to operate O3 so does not get messed up by water in it, first flight most confident about O3 from this flight
PDI: instrument seems to stop working every 20 minutes or so, so restarted quite a bit
4-STAR: Kristina worked well, some good modesl, 10 minutes on groud
SSFR: Worked well. Would prefer that spirals be continuous rather than fragmented

Run Table [UTC; times are approximate]

Run Number	Start time	End time	Altitude	Notes	SOs attempted
1	07:31:25	0829		Takeoff; going west and then diagonal northwest	

2	0829	0848	~5800m	Descent into boundary layer at 1000ft/min	SO1-1; SO1-3; SO2-1; SO2-3; SO3-1; SO3-2
3	0848	0857	~400m	10-min below cloud leg	SO2-1; SO2-2; SO2-3; O3-1; SO3-2; SO3-3
4	0858	0909	~850m	Ascent to cloud altitude, 10-min run	SO2-1; SO2-3; SO3-1; SO3-2; SO3-3
5	0909	0921	~1150m	Ascending to above cloud leg	SO2-2; SO2-1; SO1-2
6	0927	0944	0.5-16kft	Ascent profile up through biomass burning plume	SO1-1; SO1-3; SO2-2
7	0949	0959	13kft	Level leg within the plume ID'd by previous profile	SO1-1; SO1-3; SO2-1; SO2-2
8	1008	1018		Below-cloud leg (4-STAR zenith mode)	SO2-1; SO2-2; SO3-1; SO3-2; SO3-3
9	1022	1032	3150 ft	In-cloud leg (4-START zenith mode)	SO2-1; SO2-3; SO3-1; SO3-2; SO3-3
10	1058	1105		Two 3-min straight legs above cloud to do 4-STAR skyscans	SO2-1; SO2-2; SO1-2
11	~1053	~1112		Split up square spiral ascent through cloud, to coincide with ER2 overpass.	SO2-1; SO2-2; SO1-2; SO2-3; SO3-1; SO3-2; SO3-3
12	1134	1153		Descent through cloud layer	SO2-1; SO2-3; SO3-1; SO3-2; SO3-3
13	1153	1203	1600ft	Below-cloud leg, 4-STAR zenith mode	SO2-1; SO2-2; SO2-3; O3-1; SO3-2; SO3-3
14	1205	1215		In-cloud leg, 4-STAR zenith mode	SO2-1; SO2-3; SO3-1; SO3-2; SO3-3
15	~1217	~1227		Above-cloud leg	SO2-2; SO2-1; SO1-2

16	1228	1256		Sawtooths	SO2-1; SO2-3; SO3-1; SO3-2; SO3-3
17	1256	1324		Ascent to 16kft, plume encountererd ~12.5-14kft	SO1-1; SO1-2; SO1-3; SO2-1; SO2-2
18	1324	1429	13.5kft	Transit back to southeast at 13.5kft altitude, sort of towards the bottom of the plume	SO1-1; SO1-2; SO1-3; SO2-1; SO2-2
19	1429	1435	15kft	Ascent to 15kft again	SO1-1; SO1-2; SO1-3; SO2-1; SO2-2
20	1435	1445	17kft	Ascend to 17kft and turning to the northwest (Water vapor legs)	SO1-1; SO1-2; SO1-3; SO2-1; SO2-2
21	1446	1514	15kft	Descend back to 15kft, return back towards WVB	SO1-1; SO1-2; SO1-3; SO2-1; SO2-2
22	1514	15:24:55		Pilots take us back to airport	

Progress towards Science Objectives: expectation-based estimates need further analysis green-success likely red-success uncertain

Direct Forcing

SO1-1 evolution of BBA properties with transport:
SO1-2 spectral radiative fluxes
SO1-3 factors that control seasonal variation of aerosol

Semi-Direct Effect

SO2-1 relative aerosol-cloud vertical structure
SO2-2 constrain aerosol heating rates
SO2-3 cloud microphysics

Indirect Effects

SO3-1 aerosol-BL mixing
SO3-2 aerosol-BLcloud microphysics
SO3-3 precipitation susceptibility

Additional Notes and pictures available from Kristina Pistone (her notes contributed to this report)