Flight Report for PRF02, 31 August 2016

PRF02, 31 August 2016
Take-off time: 07:55 Z
Landing time: 15:46 Z
Duration: 07:51
Mission Type: Routine NW-SE

Goal: To provide routine mapping along the NW-SE routine flight track from 23S/13E to as far NW as is possible given the time constraint.

Flight summary: Upon takeoff the P-3 climbed and headed towards 23S/13E at 16 kft for ATC reasons. Aerosol optical depth right along the coast upon ascent out of Walvis Bay (14.5E) was 0.2-0.3 above clouds, but by the time the aircraft reached 13E and in the descent profile there was little aerosol loading, indicating that the BB layer near the coast did not extend far offshore. Clouds were present along the entire routine track on the outbound leg, but by the return the clouds had a clear southern edge around 22°S. There was significant amounts of altocumulus around 16°S, which was sampled by the cloud probes on one leg. At the southerly end of the path the Sc were present in a well-mixed PBL, but Cu under Sc were observed as the aircraft moved further NW (see photos). Aerosol loading above was very low at the start of the routine track (0.05-0.1) away from the coast but increased to maximum values of 0.7-0.8 at the northerly extent of the sampling (~12.5S/2.5E). On the return portion, the southerly edge of the main plume was evident as a thin layer that petered out to the S. Typically, a gap was present between the elevated BB layer and the cloud, and evidence for the low RH values associated with clean air are seen in Fig. 1. Figure 2 shows a schematic of the aerosol and cloud configuration in PRF02.

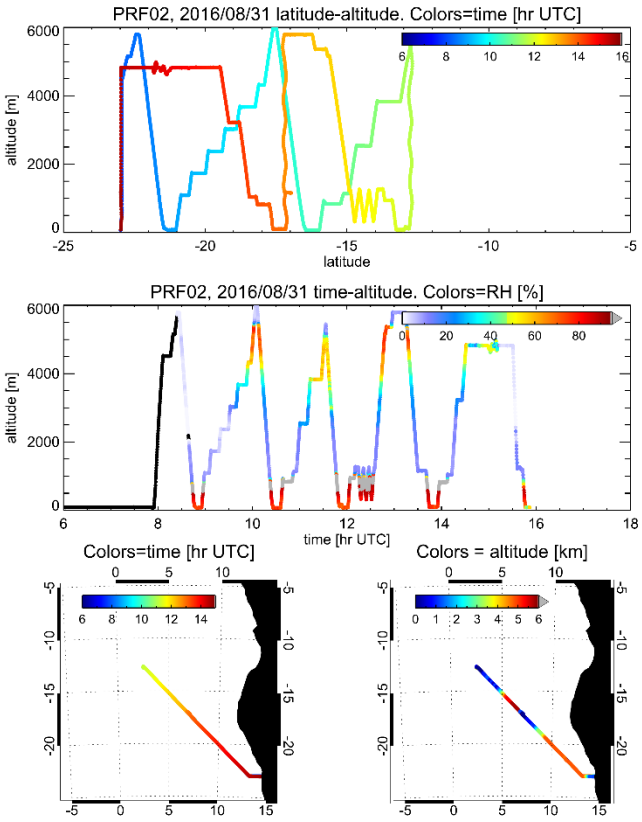


Figure 1: Top: Latitude-altitude plot from PRF02, color coded with time; Center: Time-altitude plot, color coded by relative humidity (RH); Bottom: Latitude-Longitude maps color coded by time (left) and altitude (right).

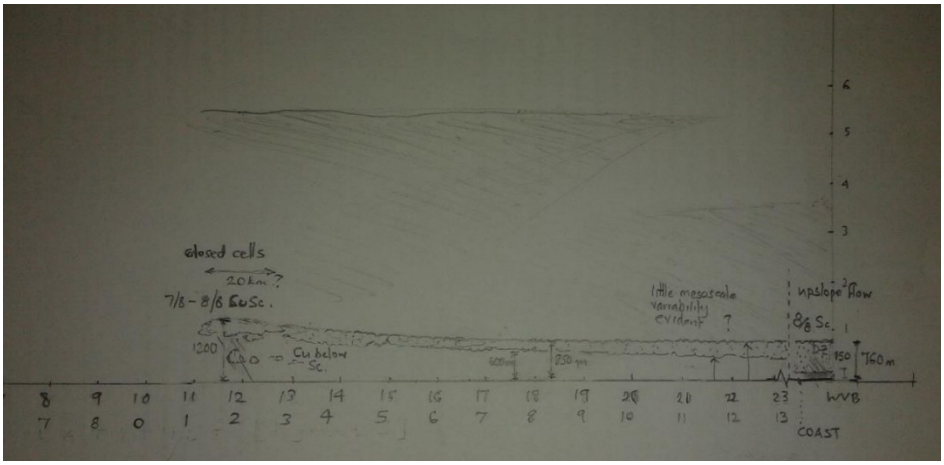
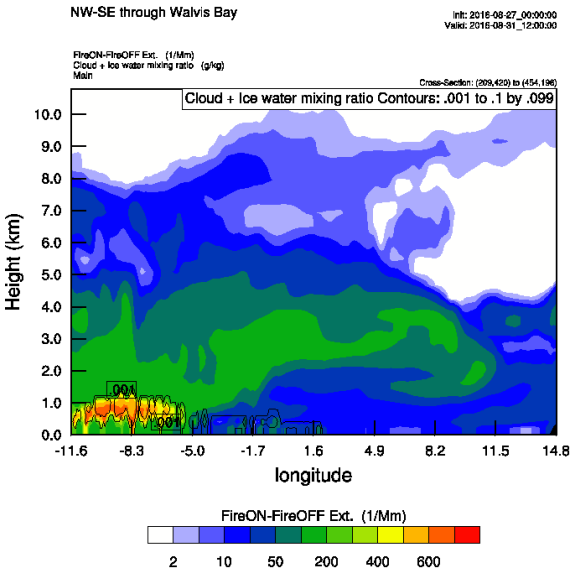


Figure 2: Schematic of cloud and aerosol plume conditions along the flight. The main BB plume (extending to 5.5 km altitude), peters out at the southerly end of the track, and another lower aerosol layer was present very close to the coast. The PBL deepened north of about 17°S and decoupled.

Forecast: WRF-Chem shows relatively low, but non-zero near-surface CO from biomass burning all along the routine flight track (Fig. 2), with the highest values towards the NW end of the track. Aerosol extinction forecasts with and without African biomass burning (Fig. 3) also show evidence of BB aerosol throughout the column, with 10-50 $(Mm)^{-1}$ up to 4-6 km.



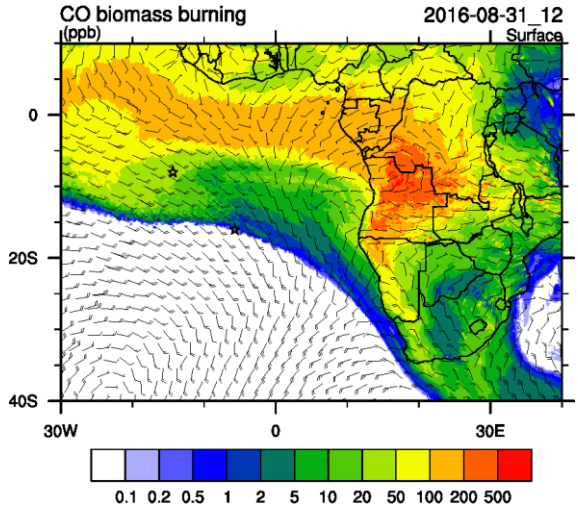


Figure 3 (left): N-S Cross section along the NW-SE track (Walvis Bay on right of plot) showing the forecast difference in aerosol extinction between simulations with and without African biomass burning.

Modeled aerosol age for the column (Fig. 4) shows that BB aerosol in the PBL has a wide age range. The main FT BB plume consists of aerosol of intermediate age (3-5 days).

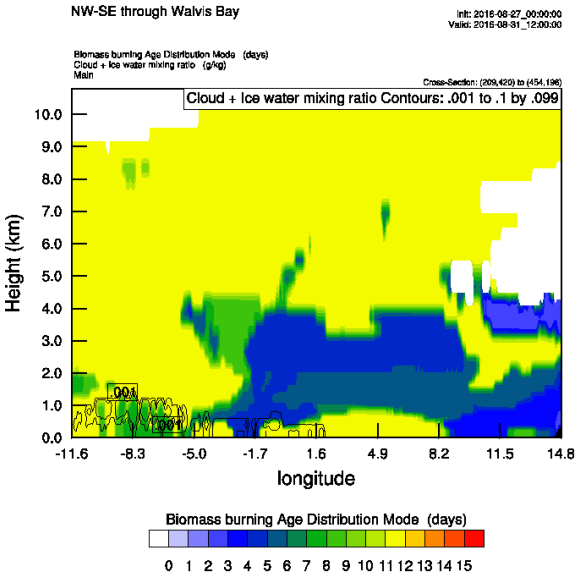


Figure 4: Modeled median age of smoke aerosols, showing 3-5 day old aerosol in the PBL at the SE end of track (8-14°E) and in the FT west of 9°E and older aerosol elsewhere.

Satellite imagery: shows that closed cell stratocumulus clouds were present along almost the entire flight track at 1200 UTC (Fig. 5, right). Some wispy high clouds can be seen in the IR image (Fig. 5, left). Cloud effective radius estimates (not shown) showed values of 6-7 micron to the SE of the track, increasing to around 10 micron at the NW end.

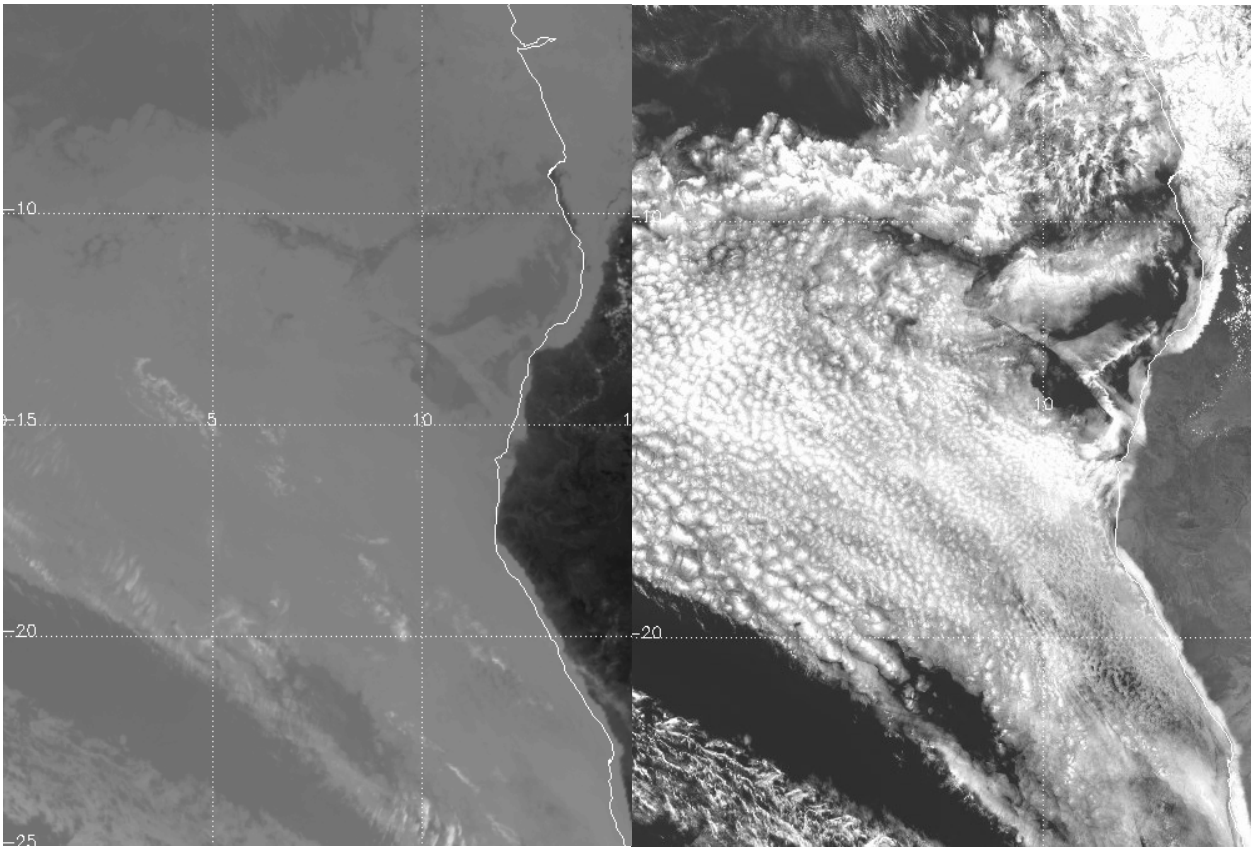


Figure 5: Above: SEVIRI geostationary Infrared imagery at 1200 UTC (before take-off). Right: High resolution visible SEVIRI imagery during flight (1200 UT). Note the patchy mid-level clouds seen in the IR (but difficult to discern from the visible imagery).

Instrument health: The King liquid water probe did not work. The CCN counter worked but had a 45 minute break in measurements. The PTI did not function. See Google sheets for more completed information about instruments on PRF05.

Legs and profiles: The sampling approach used on PRF01 was to fly a 10 minute straight and level leg near the surface below cloud (~150 m altitude), a 10 minute leg in the center of the cloud layer, a 4-5 minute leg immediately above cloud (~500 ft above cloud), and then several legs in and above the BB layer, at least one of which was at a suitable distance above cloud to make full use of the APR-3 radar. Ramp profiles were also used to profile from close to the surface to above the BB layer. A sawtooth leg was also flown between 14-15^{o}S (see Fig. 1), and spiral profiles were flown at the far NW point and on the return portion around 17^{o}S. Table 1 shows the locations, times, durations and other pertinent information about the legs flown.

Table 1: Locations, heights, durations, and other information for profiles and straight and level legs in key locations. Other information specified in square parentheses.

PROFILES [height range]	PBL LEGS [were BB aerosol present?]	CLOUD LEGS	ABOVE CLOUD LEGS [gap between cld and BB layer?]	SAWTOOTH LEGS	IN PLUME LEGS	ABOVE PLUME LEGS
RAMP 23°S,14°E 60-5700 m 23°S, 14°E 5700-60 m 16°S, 5°E 5700-60 m 15°S, 5°E 1250-5500 m 23°S 15°E 4800-60 m **SQUARE SPIRALS** 17°S, 7°E 5800-60 m 13°S, 3°E 5800-60 m	21°S, 11°E 60 m 10 min unclear 16°S, 5°E 150 m 10 min unclear 13°S, 3°E 150 m 10 min unclear 17°S, 7°E 150 m 10 min unclear	16°S, 5°E 1000 m 10 min 14°S, 4°E 1000 m 10 min 18°S, 8°E 1000 m 10 min	21°S, 11°E 1200 m 5 min Unclear 14°S, 9°E 1200 m 5 min Unclear 13°S, 3°E 1200 m 5 min Unclear 17°S, 7°E 1200 m b5 min Unclear	14°S, 4°E 20 min	23°S, 15°E 4400 m 10 min 20°S, 11°E 1700 m 10 min 19°S,10°E 2300 m 10 min 19°S,9°E 3000 m 10 min 18°S,8°E 3700 m 10 min 14°S,5°E 2500 m 10 min 13°S,3°E 3800 m 10 min 22°S,13°E 4900 m 90 min	17°S, 7°E 5800 m 15 min

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: **~ 3 hours**

SO1-2 spectral radiative fluxes **~ 1 hours (profiles+above-BLcloud)**

SO1-3 factors that control seasonal variation of aerosol **~ 2 hours**

Semi-Direct Effect

SO2-1 relative aerosol-cloud vertical structure **~2 hours (ramp+spiral profiles)**

SO2-2 constrain aerosol heating rates **~1 hour (spiral profiles)**

SO2-3 cloud response to heating **~2 hours (BL sequences)**

Indirect Effects

SO3-1 aerosol-BL mixing **~2 hour (profiles+sawtooths)**

SO3-2 aerosol-BLcloud microphysics **~2 hour**

SO3-3 precipitation susceptibility **~2 hour**

Visual Notes

Photograph above 8/8 Sc at 8:50 UTC on descent profile near 22°S out of right side of aircraft (toward NE) with elevated BB aerosol layer evident to the NE, but little aerosol evident aloft (blue sky). AOD above the aircraft here was quite low, and varied from 0.05-0.15.

Photograph below unbroken Sc (8:52 UTC). Note relatively weak winds indicated by lack of whitecapping.

Photograph above BB plume around 17°S showing some embedded altocumulus in the top, and some cirrus above (10:13 UTC)

Photograph below overcast Sc at 16°S (10:43 UTC) with Cu present below indicating decoupled PBL.

Photographs at the top of the BB plume (13:02-13:04 UTC around 16^{o}S) showing embedded altocumulus. Top: the bases of the Ac layer can be seen in the BB layer. Bottom: Ac looks to be possess significant vertical development indicating convective nature.

Photograph above 8/8 Sc at 13:38 UTC near 17°S showing elevated and relatively thick BB aerosol layer evident, but little aerosol evident aloft (blue sky). AOD indicated by 4STAR here was approximately 0.6. Contrast with photograph at 8:50 UTC

Photograph above Sc showing thinning and some breaks at 14:53 UTC near 22°S. Photograph is from 5000 m, indicating relatively low aerosol loading above cloud. At this location, the AOD above cloud dropped quite markedly as the BB aerosol layer thinned out (see Fig. 1 for associated drop in RH around 22°S).

Photograph above southerly edge of Sc deck at 15:13 UTC near 22^{o}S looking to E. Photograph is from 5000 m, indicating relatively low aerosol loading above cloud. At this location, the AOD above cloud dropped quite markedly as the BB aerosol layer thinned out (see Fig. 1 for associated drop in RH around 22^{o}S). There is evidence of a near-coastal BB layer above cloud on the horizon.

Photograph above southerly edge of Sc deck at 15:32 UTC near 23^{o}S looking to E. Photograph is from 5000 m, indicating relatively low aerosol loading above cloud. A very thin near-coastal BB layer is clearly seen.