Flight Report for PRF05, 6 September 2016

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Take-off time: 06:53 Z
Landing time: 14:39 Z
Duration: 07:46
Mission Type: Opportunity, cloud focus, S-N transect along 9°E to 10°S

Goal: To sample clouds and aerosols along a N-S line in what was anticipated to be three different aerosol conditions (aged aerosols on southern end of track, break in aerosols in the middle of the track and fresher aerosols towards the northern end of the track); the goal was to repeat a module consisting of a below cloud leg, in cloud leg, above cloud leg and sawtooths through clouds within each of these regions, followed by transit flight at higher altitude back to Walvis Bay.

Flight summary: Upon takeoff the P-3 climbed and headed towards 23S/9E at 20 kft (instead of 23 kft) for ATC reasons. Because of a lack of clouds at 23S/10E, the P-3 headed NW from the constant latitude line to intercept the constant longitude line at 22.5S/9E while descending to beneath cloud. Legs were then flown below cloud (PCASP showing ~250 to 300 cm^{-3}), within cloud (mean particle sizes about 20 mm on CAS), above cloud, followed by a saw tooth through the clouds. Thereafter the P-3 ascended to profile the free troposphere, noting that at 8000 feet were in the BB layer and that there was a gradual increase in smoke signatures as the P-3 headed north. The 8000 foot leg was extended to optimize sampling from the APR-3 and AMPR, with APR-3 detecting lots of thin cloud on 8000 foot leg with no precipitation. The second module was then flown while travelling north, again consisting of below cloud, in cloud, above cloud and sawtooth legs. 4-STAR.noted increasing AODs from 0.3 to 0.41 as headed north. After the sawtooth, a third module was started, flying below, within and above clouds, then turning around at ~9.6S and executing a sawtooth on the southbound leg. During this module, the P-3 may have crossed the boundary where aerosol was mixing into the boundary layer as the CO slowly increased while below cloud. Organics were seen in the boundary layer and while doing the sawtooth on the third leg. On the return flight home, the P-3 flew on a diagonal towards WVB. During the northern part of the leg, drizzle signatures on the APR3 were seen. A 13.5 kft above the BB layer was then performed with the top of the BB layer located at about 12 kft with an interesting absorption signature of BB from the PSAP wavelength dependence noted. A profile was also flown on the diagonal return, including a boundary layer leg, a sawtooth and an above cloud leg where a speed run was performed.

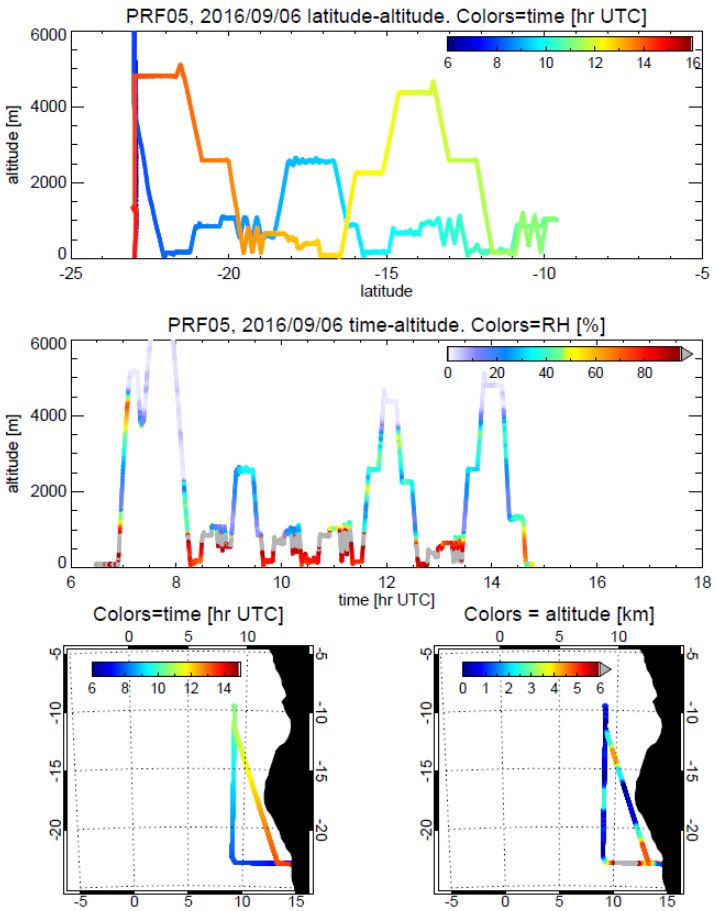


Figure 1: Top: Latitude-altitude plot from PRF05, color coded with time; Center: Time-altitude plot, color coded by relative humidity (RH); Bottom: Latitude-Longitude maps color coded by time (left) and altitude (right).

Forecast: WRF-Chem shows interesting near-surface CO from biomass burning (Fig. 2), with high values in a NW-SE band stretching from St. Helena (star at 16.0ºS, 5.7ºW) to the Southern Namibian coastline. To the NE of this band, near-surface CO was forecast to be lower, with higher values occurring only at about 10ºS.

Aerosol extinction forecasts with and without African biomass burning (Fig. 3) showed marked impacts of African BB fires in the PBL from 26-20ºS along the approximate aircraft sampling track. These correspond to the high near-surface CO values (Fig. 2). The model shows little evidence of BB aerosol above the PBL in this region. To the north of this, there appears to be BB aerosol in the free troposphere (FT), but less in the PBL (note the log scale on Fig. 2).

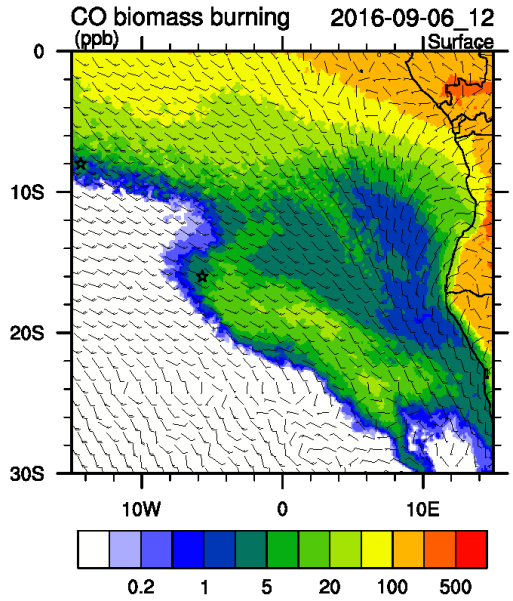


Figure 2: WRF forecast of near-surface CO from African biomass burning during RF05; Note the gradient along 9E that was the sampling target;

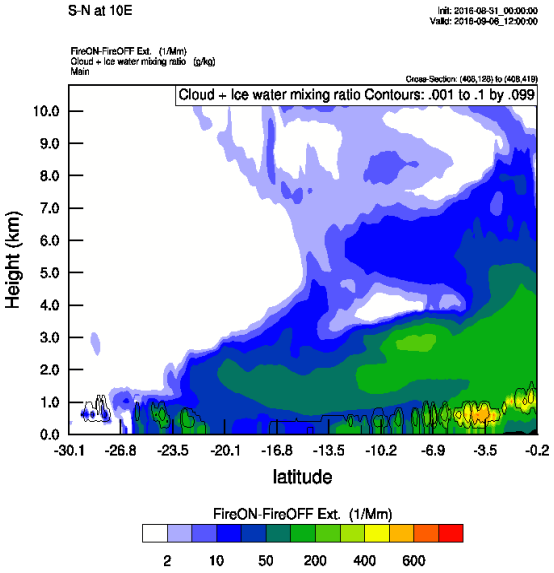


Figure 3 (left): N-S Cross section along 10ºE showing the forecast difference in aerosol extinction between simulations with and without African biomass burning.

Modeled aerosol age for the column (Fig. 4) shows that the band of BB aerosol in the PBL is extremely aged (>12 days), whereas the FT aerosol north of 20ºS is somewhat younger.

Simulations from previous days (not shown) showed that the BB band in the PBL had been entrained from the FT in the vicinity of 25-30ºS after being advected westward in the main FT BB plume and then subsided slowly southeastward over the previous few days.

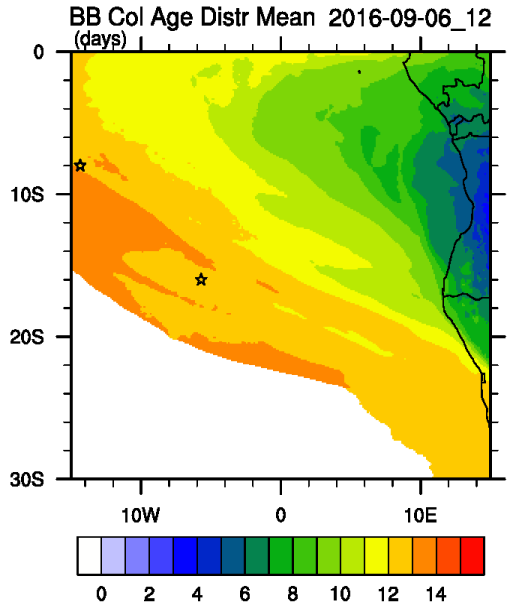


Figure 4: Modeled mean age of smoke aerosols, showing aged aerosols at southern edge of track (23S/9E) and fresher aerosols at northern edge of track (9.6S/9E).

Satellite imagery: shows that clouds were present north of 22°S along almost the entire flight track throughout the flight. Some wispy high clouds can be seen in the IR image. The cloud droplet concentration estimates from SEVIRI (Fig. 6) show a patch of high concentrations (>200 cm^{-3} along 9°E from 15-20°S) and lower concentrations to the north and south of this band. Interestingly, this differs from where one might expect the highest concentrations based on where BB aerosols are seen in the WRF-Chem forecasts (Fig. 3), which may represent timing differences in where BB aerosol layers are entrained into the PBL.

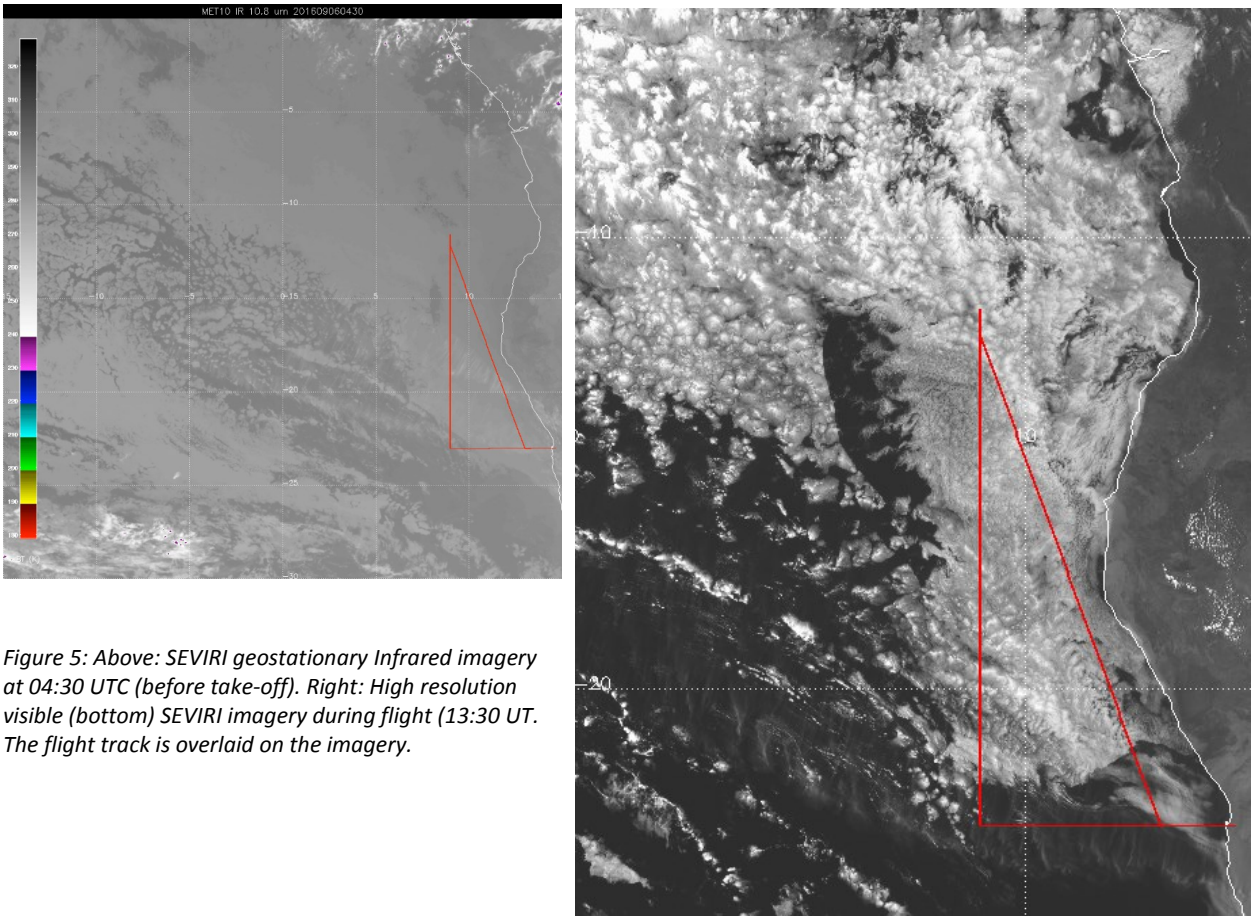


Figure 5: Above: SEVIRI geostationary Infrared imagery at 04:30 UTC (before take-off). Right: High resolution visible (bottom) SEVIRI imagery during flight (13:30 UT. The flight track is overlaid on the imagery.

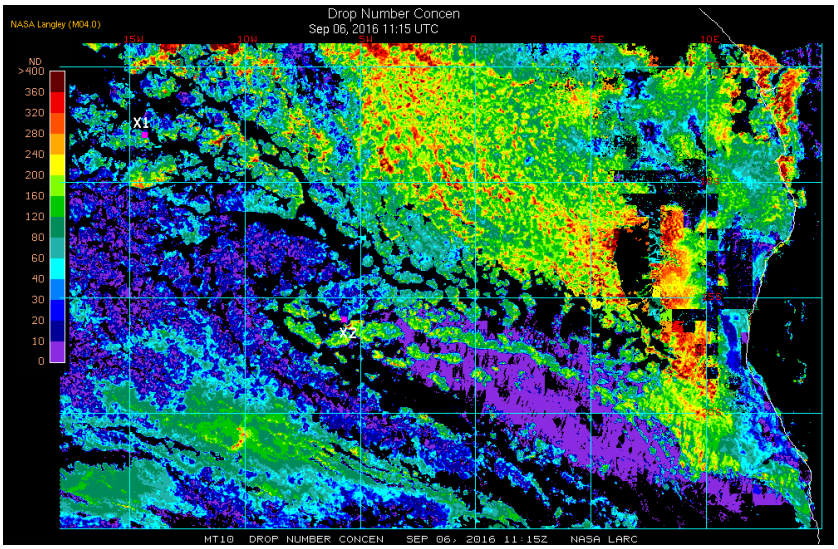


Figure 6 (left): Cloud droplet concentration at 11:15 UTC on 6th September 2016 estimated using the LaRC SEVIRI geostationary retrievals.

Instrument health: Some loss on 10 GHz AMPR channel. Issue with RSP scanner rotation rate APR: Some issues with resets and hang-ups at beginning of flight. First flight with CAPS ISOTOPES developed problem two hours before landing. See Google sheets for more completed information about instruments on PRF05.

Legs and profiles: The sampling approach used on PRF05 was to fly a 10 minute straight and level legs 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 legs in 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. 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.

RAMP 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
23°S,14°E 0-5400 m 23°S, 9°E 6700-60 m 17°S, 9°E 2600-60 m 11°S, 9°E 60-5000 m [with break for radar leg at 2600 m] 16°S 10°E 4500-60 m [with break for radar leg] 21°S, 12°E 200-5400 m [with break for radar leg] 23°S, 14°E 5000-100 m [with break for above cloud sampling]	22°S, 9°E 150 m 10 min yes/likely 16°S, 9°E 150 m 10 min yes/likely 12°S, 9°E 150 m 10 min yes/likely 11°S, 9°E 150 m 10 min yes/likely 17°S, 11°E 150 m 10 min yes/likely	21°S, 9°E 850 m 10 min 15°S, 9°E 700 m 10 min 10°S, 9°E 850 m 10 min 18°S, 11°E 650 m 10 min	20°S, 9°E 850 m 4 min Some gap 14°S, 9°E 700 m 4 min Some gap 10°S, 9°E 850 m 4 min Some gap 23°S, 14°E 1300 m 10 min Some gap	19°S, 9°E 12 min 13°S, 9°E 12 min 11°S, 9°E 12 min 19°S, 12°E 13 min	17°S, 9°E 2500 m 10 min 12°S, 9°E 2600 m 10 min 14°S,10°E 4300 m 10 min 16°S,11°E 2300 m 10 min 20°S,12°E 2600 m 10 min 23°S,13°E 4800 m 10 min	23°S, 10°E 6500 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:	**~ 2 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 profiles)**
SO2-2 constrain aerosol heating rates	**~1 hour (profiles+above-BLcloud)**
SO2-3 cloud response to heating	**~2 hours (BL sequences)**

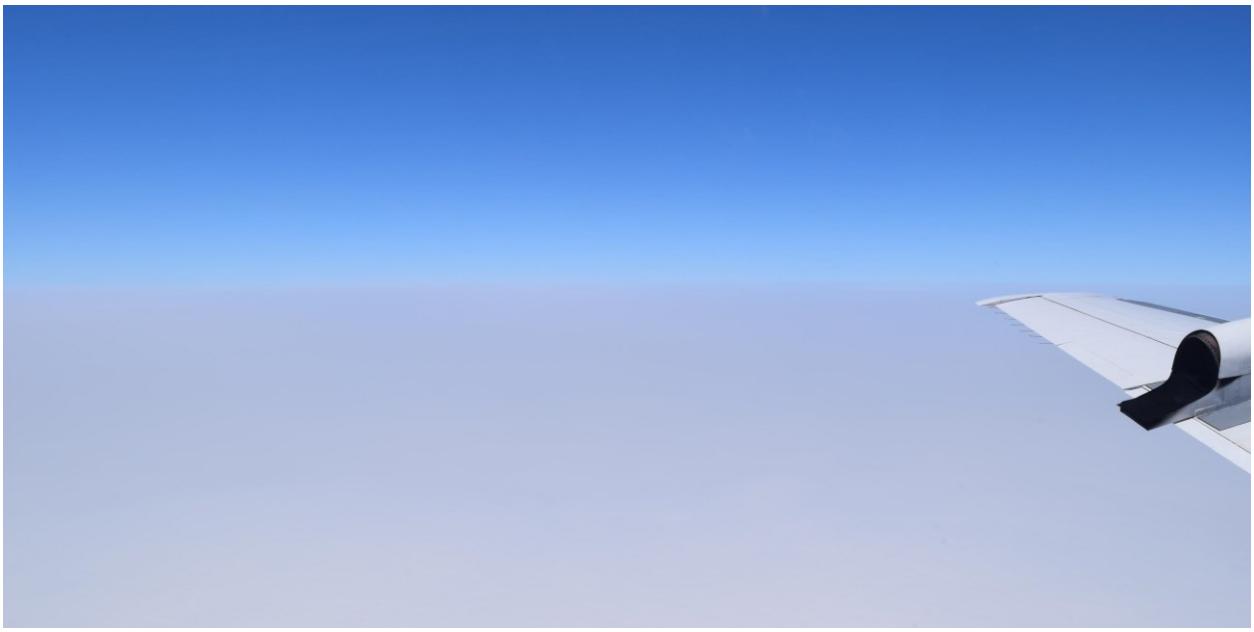
Indirect Effects

SO3-1 aerosol-BL mixing	**~3 hour (profiles+sawtooths)**
SO3-2 aerosol-BLcloud microphysics	**~2 hour**
SO3-3 precipitation susceptibility	**~2 hour**

Visual Notes

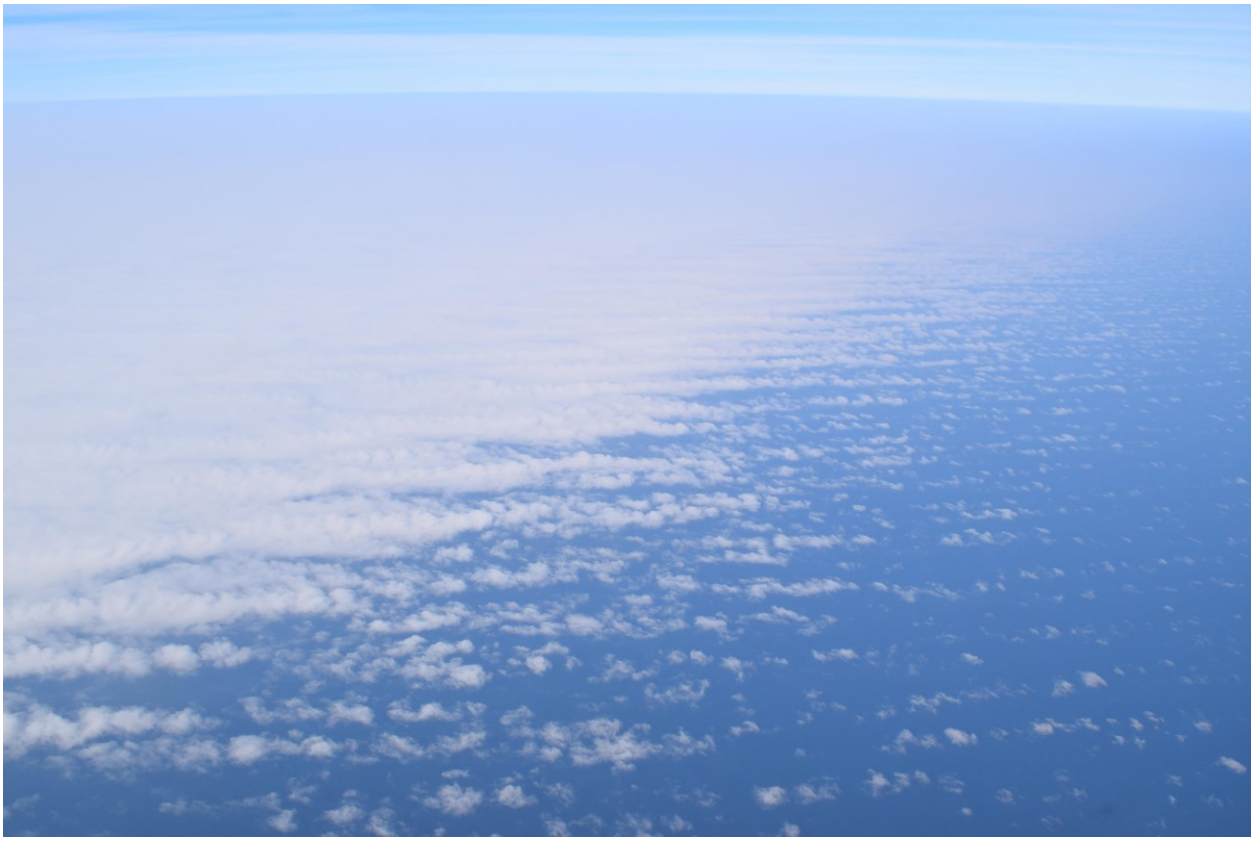
Photograph under broken Sc (8:22 UTC)

Photograph over unbroken Sc below relatively modest layer of BB aerosol (9:12 UTC). Evidence of a gap can be seen on the horizon.



Photograph above BB plume showing evidence of thin layers above (12:12 UTC)

Photograph above cloud and below BB plume showing gap between them (13:10 UTC)



Photograph showing southerly edge of cloud deck on return, with interesting linear features, probably associated with shear in the PBL (14:15 UTC)