

DC-8 Flight 18, 1 July 2008

Our second local sortie had multiple objectives related to characterizing biomass burning emissions and their evolution over time. We planned to sample the north Saskatchewan fires both in the very near field and downwind at distances where the smoke ranged from minutes to several days. In addition, the plume from the California fires was expected to be overhead during much of our flight. The CTM forecasts suggested that transport of this plume from CA to our sampling region above Saskatchewan and Alberta had taken about a week.

Multiple satellite products revealed nearly 50 hotspots in the elliptical region roughly bounded by 55 N, 102 W and 59 N, 108 W. This region had cloud decks at multiple levels, but smoke plumes could be seen streaming southward from several of the most intense hot spots as early as 8:00 local time. A fire at 56.5 N and 106.8 W was selected for detailed near-field sampling, since there were no large fires evident up or downwind. The intent was to focus on this isolated plume for several hours starting at 14:00 local and again near 20:00 local. After the first detailed sampling interval we planned to fly downwind in the merged plumes from multiple fires as far as time allowed., possibly sampling smoke from the Athabasca/Reindeer Lake region that had aged for 2-3 days at our furthest point downwind. Throughout the transit to the fire region and while traversing the broad combined plumes southward, we were using DIAL to look for elevated plumes overhead.

Take off time was 19:10 UTC (13:10 local). Zenith DIAL images taken about 12:00 local and as soon as they came on-line in flight showed layers with enhanced O₃ and some enhanced scattering near 20 kft. We ascended through these layers to 25 kft enroute to the fires, and passed through them again on the way down to set up our pattern over the target fire, but did not try to spend time directly in a layer for insitu sampling.

Our planned pattern consisted of a 50 km long high level pass in the downwind direction, passing over the center of the fire and along the smoke plume centerline, followed by a perpendicular pass over the smoke column and flame front. These legs were flown at 16 kft, below a nearly overcast deck and above a broken cloud layer. DIAL was able to observe the smoke beneath us often enough to indicate that the plume essentially filled the column between surface and the base of lower clouds. After descent to 2 kft AGL, perpendicular plume crossings were performed at the following nominal distances from the fire: 0, 10, 20, 35, 45, 100 and 110 km. The upwind crossing (0 km) passed between the back fire and the smoke column at 2 kft AGL and actually penetrated thick smoke (highest CO of the flight). At all down wind passes legs were flown at 2 kft AGL and just below cloud base at ~ 4.5 kft pressure altitude. For the 35-45 km orbit an additional circuit was made just below the top of the cloud deck to examine entrainment of the smoke into the clouds. Little to no smoke was visible just above the clouds, but it was thick both within and between them.

After the targeted work on this isolated plume we proceed to ~ 55 N, 102.5 W at 5 kft to pass downwind of the two largest fires observed by satellite in the study region. We then

meandered toward 52 N, 102 W repeatedly crossing the plumes from these 2 fires (and multiple smaller fires) along the way. Extending south of ~52 N caused us to pass beyond the thick smoke, which was veering eastward (as forecasted). We flew a short leg eastward to confirm that the plumes were making that turn, but it was time to start the return trip (4.5 hours after takeoff).

Plan was to retrace our track at a level high enough to map the plumes with DIAL and visually see the "big picture" since visibility at 5 kft had been poor most of the time. As soon as we were above the clouds DIAL saw a strong layer about a km thick centered near 15 kft. We requested permission to ascend into this layer, but were denied. Repeated requests to ascend eventually got us permission to fly at 14.5 kft, but only within a specified 60 km E-W by 30 km N-S box. When we got to 14.5 kft we found evidence of biomass burning tracers, but also signs of stratospheric influence, suggesting that the fire plume was capped by a stratospheric filament. Rather than orbiting within this box we descended back to 12.5 kft and continued back up our original track. Zenith DIAL observations indicated that the layer persisted above us, with reduced or no stratospheric influence further north, but we were still not allowed to ascend under VFR.

Our intent was to repeat the entire detailed plume sampling pattern a second time. However, when we returned to that same fire we found that clouds prevented identification of the plume (visually or with DIAL) from flight levels above the lower cloud layer (which had bases near 9 kft by this time). The high level runs down the plume axis and across the fire front were scrapped. Two passes were made at 2 kft AGL along the 0 km track between the back and front of the fire. Small or no enhancements were observed in most of our fire tracers. Downwind crossings at 2 and 7 kft were made at 10 and 20 km. The higher crossing at 10 km distance was the last of this set and we found that the smoke plume was below the altitude of the DC-8. Observations of the flaming front a few km upwind showed that the fire was "lying down" for the night (time was ~ 2:00 UTC, 20:00 local). We proceeded down wind and made the full set of 4 crossings at 35/45 km. This far from the fire smoke was still present between the surface and cloud base, However it was quite dark below the cloud deck, so we decided to give up the orbits at 100/110 km in favor of flying down the plume axis downwind as far as we could stay in it. When we did "lose" the plume we were only about 20 minutes from Cold Lake, so we headed back there and landed after an 8 hour flight.

All instruments reported they were working well shortly before landing. HOx CIMS lost several hours early in the flight due to failure of an HV power supply but they repaired it when we turned back north and flew above smoke and clouds at 12.5 kft.