ARISTO 16 PROJECT Report

The MARLi Raman lidar was completed in the spring of 2016 and mounted and flown on the University of Wyoming King Air in June of 2016. An important part of this instrumentation development project was to insure that the MARLi could be deployed on the NCAR C130. Our goals in ARISTO16 were to overcome the formidable challenges in providing power and cooling for the lidar, and to successfully mount, deploy and collect data during the campaign.

With a significant support effort from the Research Aviation Facility (RAF) at NCAR to design and manufacture mounting structure (see **Figure 1**), we tested MARLi on the C-130 during July-August 2016 as a part of ARISTO-16 (https://www.eol.ucar.edu/content/aristo-2016-instruments). Other than the aircraft optical window air leak and optical window contamination by aircraft hydraulic oil leaking during the first test flight, MARLi worked flawlessly and collected over 20 hours of interesting data.

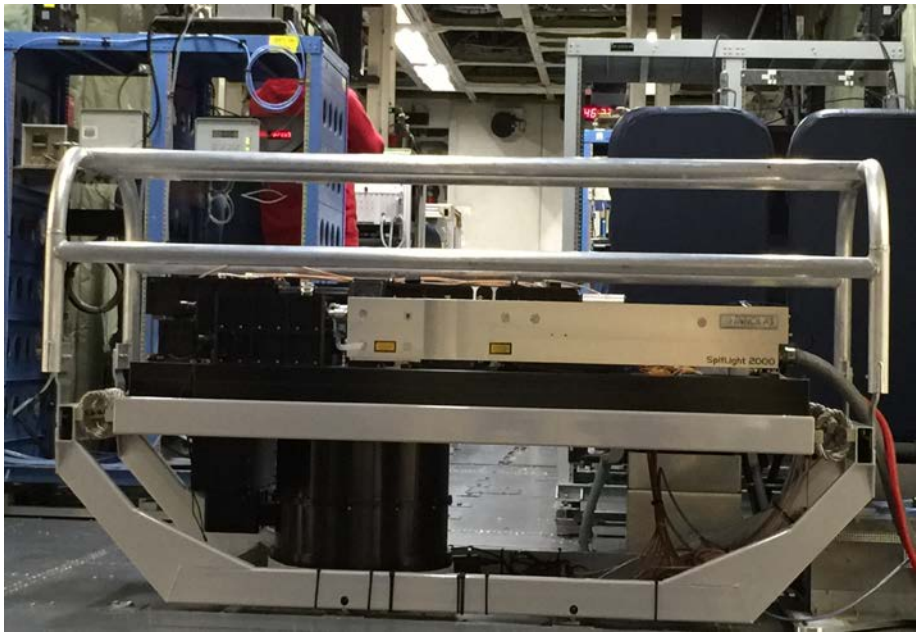

Figure 1. MARLi transmitting-receiving system installation on NSF/NCAR C-130.

Measurement examples of mixing across the stratocumulus (Sc)-topped MABL and a weak cold pool from C-130 are presented here. The entrainment or mixing over Sc top is an important processes controlling Sc evolution. But the process is difficult to observe and poorly simulated in models. **Figure 2** shows that when the C-130 flies close to the cloud top, MARLi can provide fine scale water vapor, aerosol, and temperature structures above Sc to facilitate related process studies. The general feature of Sc-topped MABL is the strong temperature inversion above Sc, which is clearly illustrated by MARLi temperature measurements shown in **Figure 2c**. Due to strong moisture and temperature gradients across the inversion, mixing/entrainment happens across the inversion. The consequence of mixing/entrainment processes is decreasing cloud water content/extinction and increasing water vapor above as indicated by WVMR and LSR measurements. As illustrated in **Figure 2d**, Sc changed from more cellular clouds to

homogeneous cloud deck along the C-130 track. MARLi measurements show much stronger mixing (deep water vapor layer above the inversion layer and more noticeable cloud dissipation near cloud top) over the cellular region than over the homogenous deck. The stronger mixing in the cellular region could be a result of weaker temperature inversion strength in the region, which could be affected by other factors. Therefore, MARLi will provide important measurements to better study cloud top and lateral mixing, which is an important factor influencing shallow cumulus and cumulus congestus development.

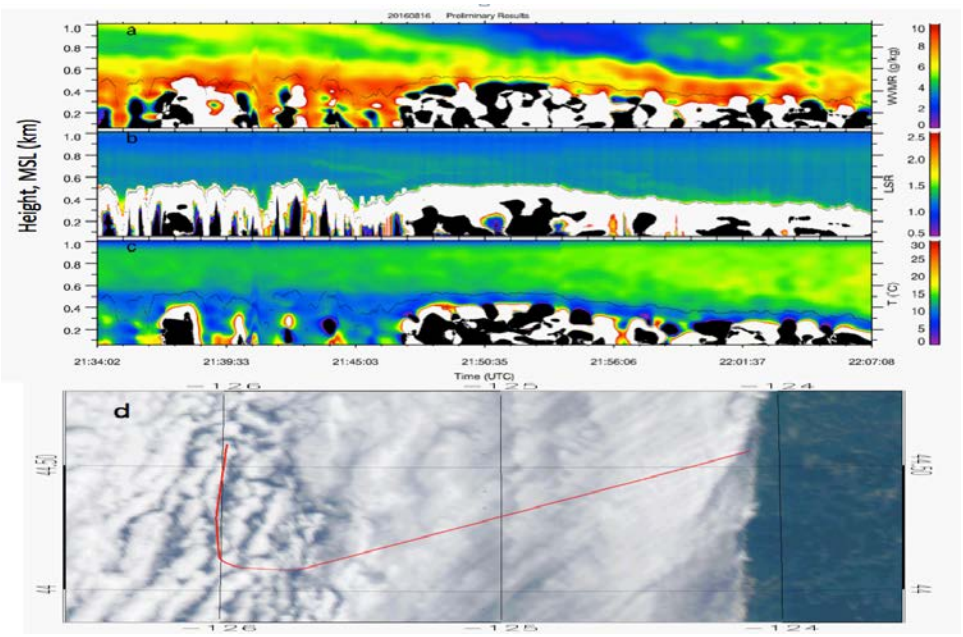

Figure 2. Fine-scale structure of WVMR (a), LSR (b), and temperature (c) above the stratocumulus cloud top observed by MARLi on August 16, 2016 over Oregon coast from NSF/NCAR C-130. The flight track (from ocean to the coast, in red line) is over plotted in MODIS true color images (around 21:20 UTC) in (d).

Observing fine scale meteorology features such as cold pools, and strongly controlled aerosol variations is important for weather and climate research. MARLi has the potential to resolve 2-D structures of water vapor and temperature associated with common fine scale meteorology features. **Figure 3** presents a weak cold pool case observed by MARLi on C-130 near Boulder, Colorado. Flight level temperature indicates ~1 degree temperature drop, which is accompanied by increasing WVMR and sudden jumps in vertical and horizontal wind speed (**Figs. 3a and b**) around 02:31 UTC, when C-130 enter into a weak cold pool generated by a storm nearby. The vertical structures of the cold pool are clearly displayed by water vapor, aerosol, and temperature measurements. Temperature field **(Fig. 3f**) shows slightly stronger cooling near the surface where has significant higher WVMR **(Fig. 3c**). The fine structure of the cold pool is more clearly displayed by aerosol properties (**Figs. 3d and e**). Dusty aerosols generated with storm high wind were revealed by both higher aerosol LSR and depolarization near the surface.

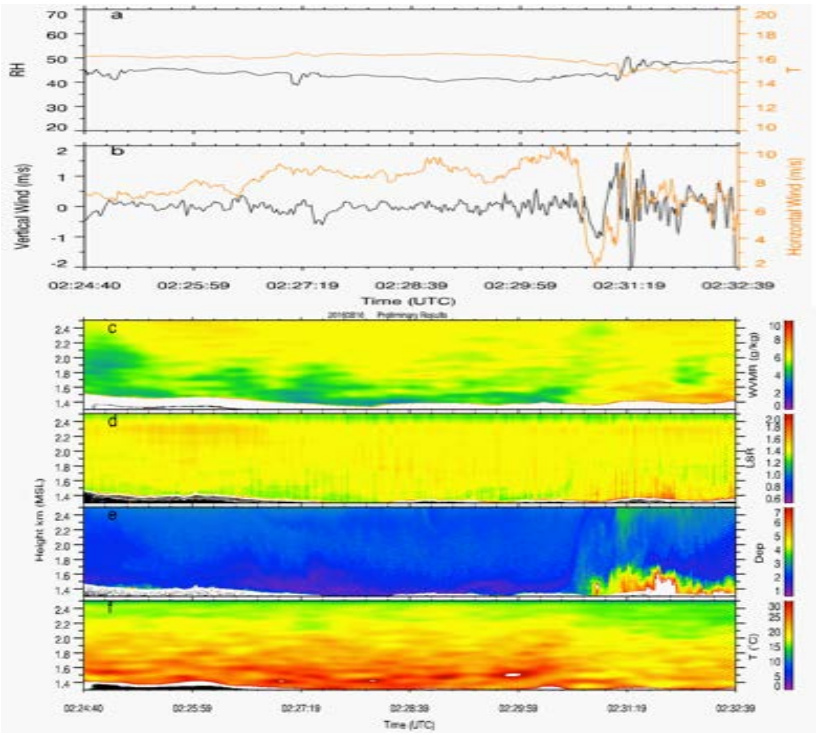

Figure 3. Fine-scale structure of WVMR (a), LSR (b), and temperature (c) above the stratocumulus cloud top observed by MARLi on August 16, 2016 over Oregon coast from NSF/NCAR C-130.

We consider the ARISTO16 deployment to have been a success. We are very grateful for the support and high degree of professionalism exhibited by the RAF group during this effort.