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Aerial Assessment of Liquid in Clouds at Oliktok Field Campaign Report

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ARM

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Acronyms and Abbreviations

AALCO	Aerial Assessment of Liquid in Clouds at Oliktok
AMF	ARM mobile facility
ARM	Atmospheric Radiation Measurement
DOE	U.S. Department of Energy
DTS	distributed temperature sensor
IOP	intensive operational period
LES	large-eddy simulation
SAM	System for Atmospheric Modeling
SLWC	super-cooled liquid water sensor
TBS	tethered balloon system

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1.0 Summary

The Aerial Assessment of Liquid in Clouds at Oliktok (AALCO) Intensive Operation Period (IOP) began in October 2016 and ended in October 2017 at the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) third Mobile Facility (AMF3) at Oliktok Point, Alaska (https://www.arm.gov/research/campaigns/amf2016aalco). The operations tested super-cooled liquid water sensors (SLWCs), leaf-wetness sensors, radiosondes, and a distributed temperature sensor (DTS) on tethered balloon system (TBS) platforms throughout the period. An auto-reeler system, a helikite, and an aerostat were tested. When conditions were optimal, the aerostat was preferred to the helikite and the auto-reeler. It was found that the SLWCs had better transmission and sensitivity to relay information about the near-surface cloudy boundary layer than the leaf-wetness sensors. The DTS was also found to give useful information about the atmospheric column and deployment is condition-dependent. Results from the SLWCs and DTS are being compared with high-resolution large-eddy simulations (LES) in the System for Atmospheric Modeling (SAM) (Khairoutdinov and Randall, 2003).

An overview of the flights conducted is provided in Table 1. Many of the flights piggy-backed on other IOPs. The results section shows some data from a campaign in October 2017 and simulation output from SAM. Publications from AALCO are in preparation.

Table 1. AALCO flights and dates.

Month, Year (DTS dates bold)	Dates
1. October 2015	26, 27, 28
2. April 2016	18, 19
3. May 2016 **(DTS)**	**14, 15, 16**
4. June 2016 **(DTS)**	**6, 7, 10, 11**
5. July 2016	26, 27
6. October 2016 **(DTS)**	**15, 17, 19, 20**
7. November 2016	15, 16, 17
8. April 2017	3
9. May 2017 **(DTS)**	15, 16, **18**, 20, 21, **23**, 24
10. August 2017	6
11. October 2017	13, 15, 17, 22

2.0 Results

Interesting results were obtained during AALCO from the SLWC and DTS. First, understanding how to best use the SLWC was gained by low-altitude flights. Throughout the duration of an AALCO, we sought ways to validate and constrain SLWC measurements from other ARM data products such as cloud base, cloud height, temperature, and liquid water content. We found it difficult to validate and constrain the SLWC measurements as value-added products because liquid water content from the microwave radiometer was not absolutely validated itself and was unavailable for most of the flights.

The figure below shows the balloon in the air during October 2017 flights, the SLWC and radiosonde on the tether, raw data output from the SLWC as it penetrates the cloud, and computed data after acquisition.

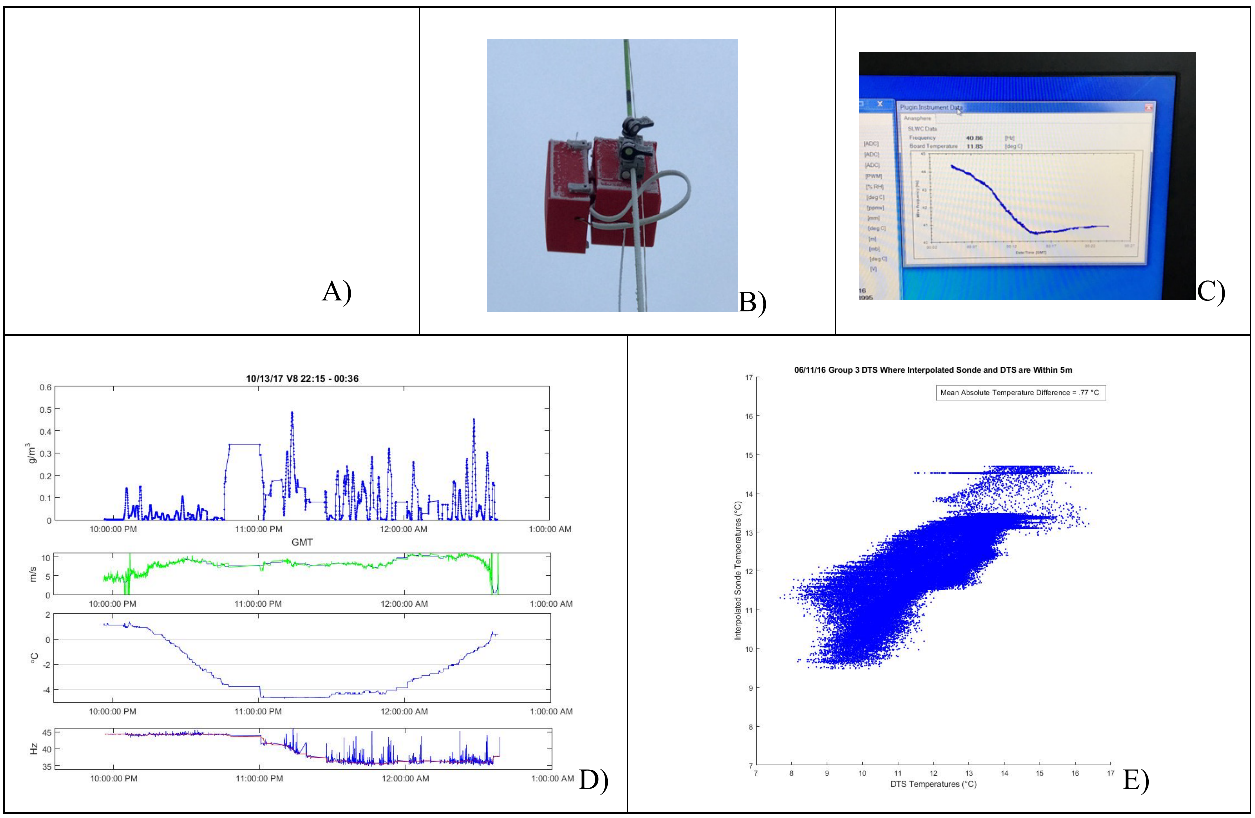

Figure 1. Data and pictures from flights at Oliktok Point AMF3 in October 2017. A) Tethered balloon in flight at Oliktok Point. B) Icing on tether and iMet and SLWC boxes. Tether is neon green. C) Depression of SLWC wire frequency upon entry into cloud, then increase upon sensor exiting cloud top. D) Initial SLWC data from tethersonde SLWC where top plot is computed SLWC over the course of the flight, top middle is velocity, bottom middle is temperature, and bottom is frequency of vibrating wire. E) Measurements from the Distributed Temperature System compared with the ARM interpolated sonde data that was used to initialize and force the SAM model.

The data from the SLWC is being used to constrain and improve atmospheric models and understanding of mixed-phase clouds. On October 13, 2017, flights with the aerostat balloon took measurements of a mixed-phase boundary layer cloud. The atmospheric model, SAM, forced with interpolated sonde ARM data products, produced a mixed-phase cloud at approximately the same time and height as observed.

SAM had a resolution of dx = dy = 200 m, dz = 40 m, a total domain size of Lx = Ly = 25.6 km; Lz = 5.1 km, and was diagnosed to have an ice crystal concentration of 0.1 crystals per liter. The figure below shows the simulation output of (top to bottom) total liquid water mass mixing ratio, total ice water mass mixing ratio, super-cooled liquid water content with the SLWC measurements as color-contoured dots, the temperature, and the measurements of SLWC from the SLWC sensors in blue, red, and green.

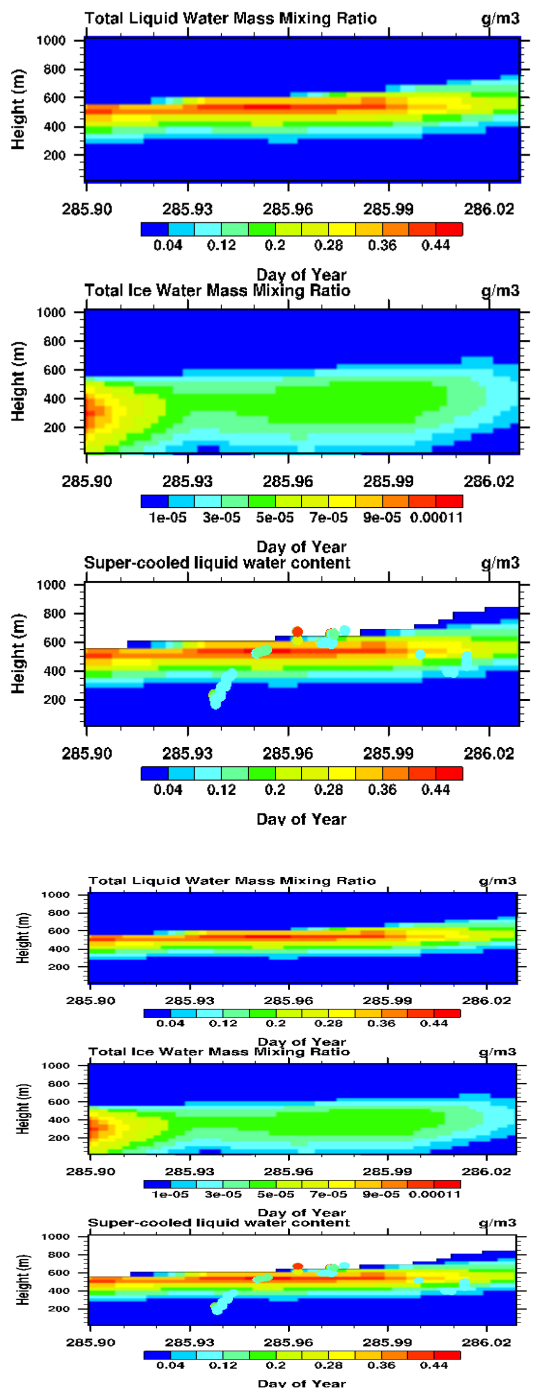

Figure 2. SAM simulations compared with SLWC measurements.

3.0 References

Results have been presented by Roesler, Dexheimer, and Hillman at the American Geophysical Union Fall Meeting, American Meteorological Society Annual Meetings, and ARM/Atmospheric System Research (ASR) principle investigator meetings in 2017 and 2018. Results were also presented at Polar 2018 in Davos, Switzerland.

Publications

Khairoutdinov, MF, and DA Randall. 2003. "Cloud-resolving modeling of the ARM summer 1997 IOP: Model formulation, results, uncertainties, and sensitivities." *Journal of the Atmospheric Sciences* 60(4): 607–625, https://journals.ametsoc.org/doi/10.1175/1520-0469%282003%29060%3C0607%3ACRMOTA%3E2.0.CO%3B2.

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