Overview of Boundary Layer Thermodynamics and Cloud Characteristics During the Aerosol and Cloud Experiments in the Eastern North Atlantic (ACE-ENA) Intensive Observation Periods

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ABSTRACT

The Aerosol and Cloud Experiments in the Eastern North Atlantic (ACE-ENA) campaign included two Intensive Observation Periods (IOPs): 21 June through 20 July 2017 and 19 January through 19 February 2018. Each IOP involved the deployment of the ARM Gulfstream-159 (G-1) aircraft with a suite of in situ cloud and aerosol instrumentation in the vicinity of the ARM Climate Research Facility Eastern North Atlantic (ENA) site on Graciosa Island, Azores. Here we present an overview of the thermodynamic characteristics of the marine boundary layer and the variability of cloud properties as observed by the ground-based sensors at the ENA site. Analysis of atmospheric state observations from radiosonde profiles and surface meteorology is used to characterize the thermodynamic structure of the marine boundary layer including the coupling state and stability. Observations from vertically pointing cloud radar and lidar provide quantification of the macrophysical and microphysical properties of the mixed boundary layer cloud fields.

1. INTRODUCTION

- The Aerosol and Cloud Experiments in the Eastern North Atlantic (ACE-ENA; Wang et al. 2016) is a DOE-sponsored field campaign focused on the region around the ARM site at Graciosa Island, Azores (39.90 N, 28.03 W).
- Campaign conducted to fill a need for comprehensive in situ characterizations of boundary layer structure, and associated vertical distributions and horizontal variabilities of low clouds and aerosol in the ENA (Wood et al. 2016) .
- Deployment of the ARM Aerial Facility (AAF) Gulfstream-159 (G-1) aircraft during two Intensive Observation Periods (IOPs): June 21 – July 20, 2017 and January 19 – February 19, 2018.
- Science themes include:
  - Budget of marine boundary layer (MBL) cloud condensation nuclei (CCN)
  - Effects of aerosol on cloud and precipitation
  - Cloud microphysical and macrophysical structure
  - Entrainment mixing in MBL clouds
  - Retrievals of turbulence, cloud and drizzle
  - Model evaluation and process studies

https://www.arm.gov/research/campaigns/aaf2017ace-ena

2. SUMMARY OF CONDITIONS SAMPLED

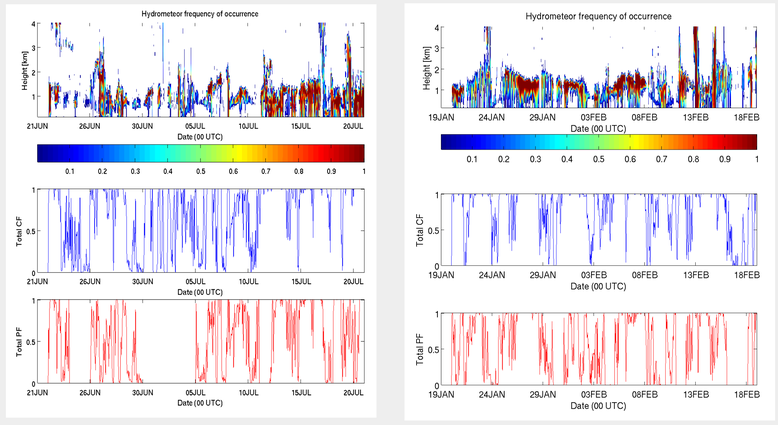
Conditions sampled during ACE-ENA campaign (20 + 19 flights)

Conditions Sampled	IOP1 (20 flights)	IOP2 (19 flights)
Aerosol (Clear)	6/23, 6/29, 7/7	2/16
Scattered Thin Clouds	**6/21**, 6/25, 7/4	2/1,2/12
Thin Stratus	6/28, 6/30, 7/7, 7/13	2/10, 2/15
Thin Stratus w/Mixed Cumulus	6/26	1/28
Solid Stratocumulus	**7/6**, 7/8, 7/15	**1/30**
Multi-Layer Stratocumulus	7/11, 7/12	1/24, 1/29, 2/8
Drizzling Stratocumulus	7/3, **7/18**, 7/19, **7/20**	**1/19, 1/25,** 1/26, 2/9, **2/11**
Cumulus	7/17	1/21, 2/17, 2/18, 2/19

Flights in blue are featured on this poster

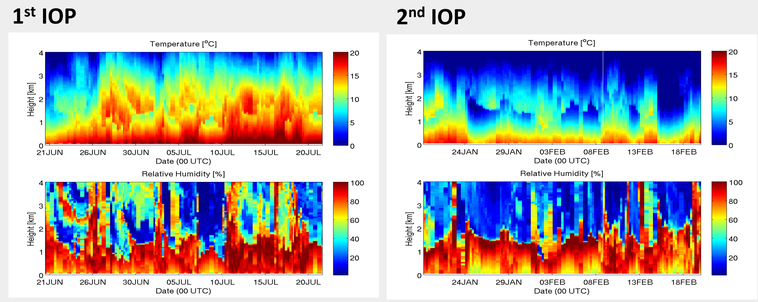
3. SUMMARY CLOUD AND THERMODYNAMIC CONDITIONS

1st IOP **2nd IOP**



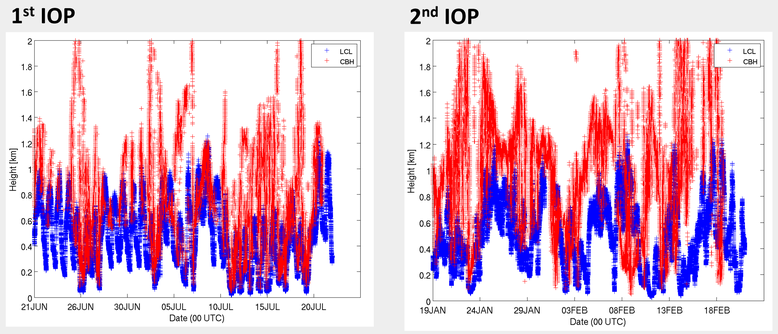
(top) Hydrometeor frequency of occurrence from combined cloud radar, micropulse lidar and ceilometer observations (Kollias et al. 2007). **(middle)** Total cloud fraction. **(bottom)** Total precipitation fraction (precipitation defined as radar echo below ceilometer cloud base height).

1st IOP **2nd IOP**



(top) Time series of the profile of dry bulb temperature from radiosonde observations **(bottom)** same for relative humidity.

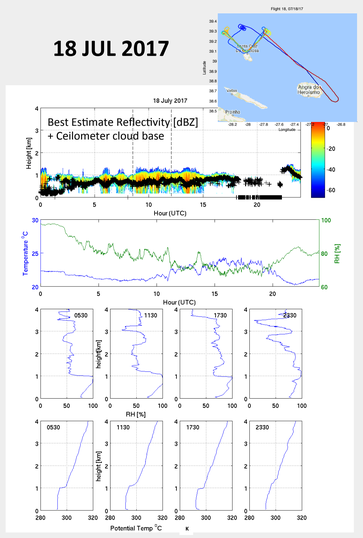
1st IOP **2nd IOP**



Time series of lifting condensation level (LCL) from surface meteorology measurements and the lowest cloud base height (CBH) as observed from the ceilometer.

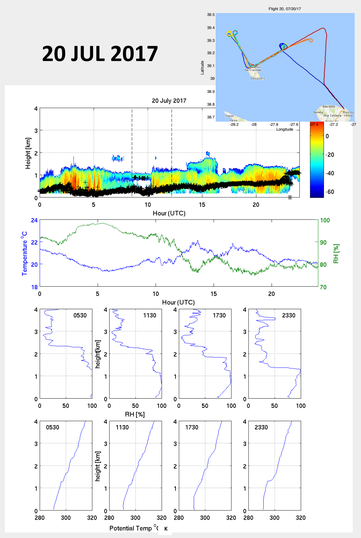
4. SOME CANDIDATE CASE STUDY DAYS (IOP1)

18 JUL 2017



- Persistent drizzle, solid SCu layer
- Well-mixed BL early with 1 km depth, deepening and decoupling with time.
- G-1 flew L-shaped pattern over ENA site

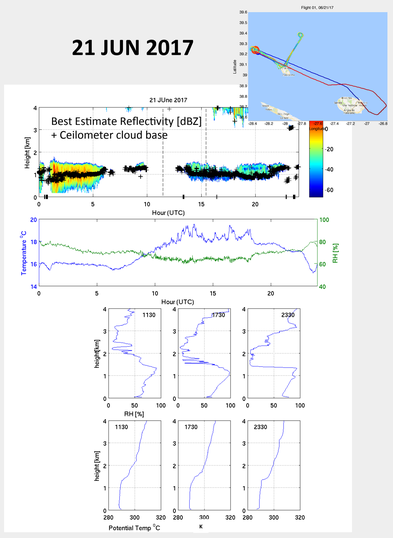
20 JUL 2017



- Multi-layer SCu, merging to single layer SCu with drizzle
- Stable BL in morning, becoming more well-mixed.
- G-1 flew L-shaped pattern over ENA site

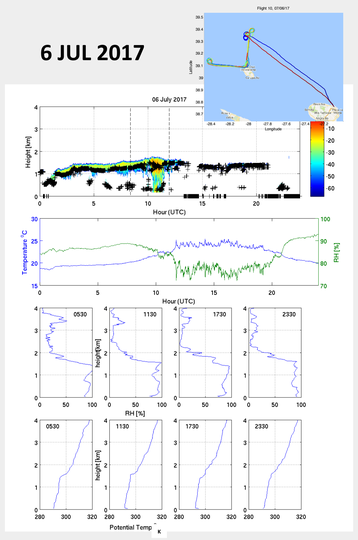
4. SOME CANDIDATE CASE STUDY DAYS (IOP1) [cont.]

21 JUN 2017



- SCu with some embedded drizzle patches
- Mostly well-mixed boundary layer approx. 1.5 km
- G-1 flew L-shaped pattern over ENA site

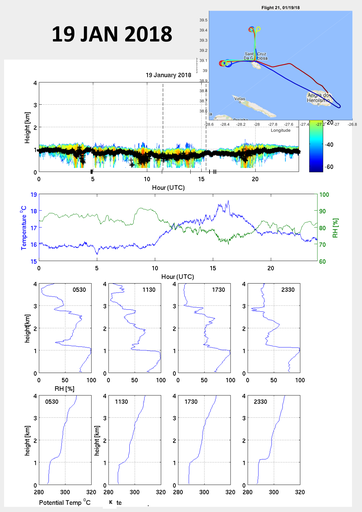
6 JUL 2017



- SCu with some embedded drizzle patches
- Decoupled boundary layer approx. 1.5 km deepening over course of day
- G-1 flew L-shaped pattern over ENA site

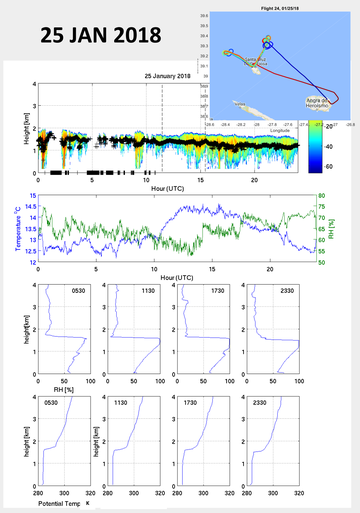
5. SOME CANDIDATE CASE STUDY DAYS (IOP2)

19 JAN 2018



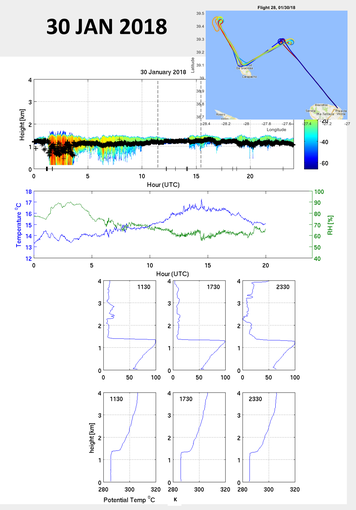
- Persistent drizzle, solid SCu layer
- Well-mixed with ~1.2 km depth
- G-1 flew L-shaped pattern over ENA site

25 JAN 2018



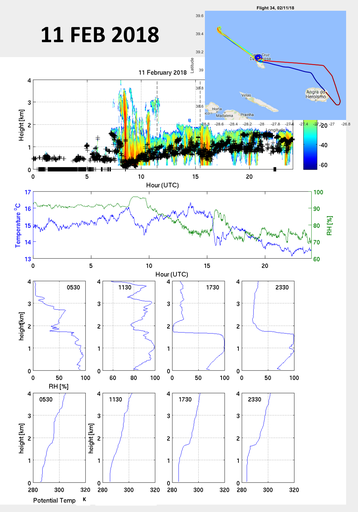
- Solid SCu with significant drizzle
- Well-mixed BL, ~1.6 km depth at 0530, decreasing
- G-1 flew L-shaped pattern over ENA site

30 JAN 2018



- Single layer SCu during flight times
- Well-mixed with ~1.4 km depth
- G-1 flew L-shaped pattern over ENA site

11 FEB 2018



- Mixture of drizzling SCu and cumulus
- Stable BL, poorly defined inversion at 0530, 1130
- G-1 flew repeated leg to NW of ENA site

6. REFERENCES

Kollias, P. et al., 2007: The Atmospheric Radiation Measurement program cloud profiling radars: Second-generation sampling strategies, processing and cloud data products. *J. Atmos. Oceanic Tech.*, **24**(7), 10.1175/jtech2033.1.

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