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OLYMPEX Counterflow Spectrometer and Impactor Field Campaign Report

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July 2016

ARM CLIMATE RESEARCH FACILITY

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Office of Science, Office of Biological and Environmental Research

Acronyms and Abbreviations

AAF	ARM Aerial Facility
ACE	Aerosol-Cloud Ecosystem, a NASA mission
AFB	Air Force Base
ARM	Atmospheric Radiation Measurement Climate Research Facility
ASR	Atmospheric System Research
C	celsius
CSI	Counterflow Spectrometer and Impactor
DAAC	Distributed Active Archive Center
DOE	U.S. Department of Energy
ER	Earth Resources
GPM	Global Precipitation Measurement
NASA	National Aeronautics and Space Administration
OLYMPEX	Olympic Mountain Experiment
RTD	resistive temperature device
TAS	true air speed
TDL	Tactical Data Link
UTC	Coordinated Universal Time

Contents

1.0 Summary

1.1 Background

The U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Climate Research Facility's ARM Aerial Facility (AAF) Counterflow Spectrometer and Impactor (CSI) probe was flown on the University of North Dakota Cessna Citation research aircraft during the Olympic Mountain Experiment (OLYMPEX). The field campaign took place from November 12 through December 19, 2015, over the Olympic Mountains and coastal waters of Washington State as part of a National Aeronautics and Space Administration (NASA) Global Precipitation Measurement (GPM) validation campaign. The CSI was added to the Citation instrument suite to support the NASA Aerosol-Cloud Ecosystem (ACE) satellite program and flights of the NASA Lockheed Earth Resources (ER-2) aircraft. ACE funded extra ER-2 flights to focus on clouds that are weakly precipitating, which are also of interest to the DOE Atmospheric System Research (ASR) program.

1.2 Data

The CSI probe is designed to measure total water content (liquid plus ice), which provides a reference for water mass estimates derived from particle size distributions. The instrument is a counterflow design, in which the sampling inlet is pressurized with dry air to allow only water condensate (no vapor) to enter the sampling chamber. The condensate is vaporized and the resultant water vapor content is used to calculate the mass concentration of the condensate.

The Citation flew nearly 60 science mission hours during the campaign. A summary of these missions is provided in Appendix A. The CSI data files, which include both the raw instrument output and calibrated cloud water contents along with aircraft position data, have been archived: http://www.arm.gov/campaigns/aaf2015csiolympex. The metadata file, found in the archive, is Appendix B of this report. Complementary data from other cloud microphysics instruments carried on the Citation will be available shortly at the NASA Distributed Active Archive Center (DAAC): ftp://gpm.nsstc.nasa.gov/gpm_validation/olympex/cloud_microphysics_Citation/UND_cloud_microphysics/

1.3 Data Issues

Jason Tomlinson from the ARM AAF determined during the campaign that the CSI was incorrectly applying ambient temperatures for flow controller mass to volumetric conversions. This ultimately affected sample, supply, and bypass flow rates for environments less than 0 °C. Resistive temperature devices (RTDs) were installed on 20 November, 2015 within the sample, supply, and bypass lines (after the vaporizer) in order to accurately measure the temperature within each of these lines for flow controller conversions. However, due to an incorrect instrument manual, RTD sensors did not have correct pins for secure attachment to the CSI 'diamond' board (i.e., motherboard). Multiple attempts to find the correct pins to create a secure connection failed. Unsecured RTD connections often resulted in incorrect temperature measurements, which created unstable sample, supply, and bypass flows, resulting in bad data.

Low vaporizer temperatures were noticed at the beginning of the project. When the aircraft was at high altitudes, the vaporizer temperature would fall below 0 °C, resulting in sampled particle being neither melted nor vaporized. For periods when the vaporizer temperature fell below 0 °C, the data are replaced with missing value code. After the OLYMPEX project, Jason Tomlinson tested the vaporizer and vaporizer control board and determined that while the vaporizer was functional, the vaporizer control board had failed. Interestingly, the probe manufacturer, DMT Instruments, subsequently tested the vaporizer control board and determined it was working correctly.

Due to low vaporizer temperatures, we believe that there was ice buildup within the instrument, causing the bypass and sample lines to plug. Data are replaced with missing value code during these situations. The ice buildup would melt and break up when the aircraft descended into areas of above-freezing air temperatures. The CSI Tactical Data Link (TDL) would saturate when this incompletely vaporized mass passed through it, skewing the data until the TDL became unsaturated again. These skewed data have also been removed. The low vaporizer temperatures may have also caused a hysteresis effect when exiting clouds, but these data have not been removed from the record.

The CSI pitot will plug in the majority of icing situations and in areas of large ice crystal concentrations. Modifications were made to the CSI software by Jason Tomlinson to force the CSI to continue to operate after a plugged pitot. Previous versions of the CSI software would stop recording data after true air speed (TAS) dropped below a certain threshold. Constant airspeeds that were representative of the aircraft TAS from other pitot sources were entered into the software during these periods of plugged CSI pitot.

2.0 Results

The instrument was calibrated before and after the project at the ARM AAF and calibrations applied to the data for archival purposes. Due to the above-mentioned issues with the flow controllers and possibly the vaporizer during the project, accuracy of the data was consequently affected. A thorough quality assurance process was performed and missing value codes applied to time periods when data were exceptionally questionable. Data were compared with other measures of cloud water to determine when the probe appeared to be giving good values. Additionally, the instrument was inoperable during some flights.

No additional analysis of the CSI data has yet been accomplished.

3.0 Lesson Learned

Based on deployment of the CSI instrument in two field campaigns, we recommend that use of the instrument outside of the ARM Aerial Facility be directly accomplished or assisted by on-site AAF personnel, at least until full operability of the instrument is established.

Appendix A

OLYMPEX Flight Missions

Date (UTC)	Mission Number	Takeoff (UTC)	Landing (UTC)	
11/12/15	OLYMPEX-1	19:17	22:34	Steps DOW-NPOL, then offshore
11/13/15	OLYMPEX-2	15:04	18:26	Spirals near DOW
11/14/15	OLYMPEX-3	19:45	22:29	Steps on NPOL radial offshore
11/18/15	OLYMPEX-4	21:30	00:21	Descents/climbs on NPOL radial offshore
11/23/15	OLYMPEX-5	15:08	18:17	Descents/climbs on NPOL radial offshore
11/23/15	OLYMPEX-6	20:43	23?32	Step profile offshore. Wide variety of crystals
11/24/15	OLYMPEX-7	16:12	17:40	Touch and Go profiling at Fairchild AFB
11/24/15	OLYMPEX-8	18:53	21:42	Profiling of developing cumulus offshore
12/1/15	OLYMPEX-9	23:44	02:48	Conducted stacked legs over NPOL
12/3/15	OLYMPEX-10	14:02	17:04	Conducted satellite underpass at 15:22 UTC
12/4/15	OLYMPEX-11	13:06	16:00	Early morning flight with DC8 and ER-2
12/4/15	OLYMPEX-12	17:05	20:03	Sampled developing clouds off the coast
12/5/15	OLYMPEX-13	14:35	16:00	Sampled between NPOL and east of the DOW
12/10/15	OLYMPEX-14	14:32	17:02	Spiral up offshore, steps on DOW radial
12/12/15	OLYMPEX-15	16:57	20:13	Descents/climbs offshore
12/13/15	OLYMPEX-16	15:53	19:11	Steps/descending ramp in deep cloud offshore
12/13/15	OLYMPEX-17	20:05	23:19	Steps in shallow clouds offshore
12/18/15	OLYMPEX-18	01:23	04:30	Steps/Spirals DOW-NPOL in deep cloud
12/18/15	OLYMPEX-19	05:45	08:39	Steps offshore, then profile NPOL-DOW
12/19/15	OLYMPEX-20	00:56	04:00	Offshore convective cloud sampling

Appendix B

Airborne CSI Measurements for OLYMPEX – Metadata

Metadata Creator:
Name: Michael Poellot
Email: poellot@aero.und.edu
Phone: (701) 777-3180
Street:
City: Grand Forks State:
ND Postal: 58202-9006

Contact Info:
Name: Michael Poellot
Email: poellot@atmos.und.edu
Phone: 701-777-3180
Street:
City: State:
Postal:

Investigator(s): Michael Poellot

Data Format: ICARTT File

Naming Convention: CSI_UNDCitation_yyyymmddhhmmss_R0, where yyyymmddhhmmss is the year/month/day/start time of the file

Abstract: The CSI is a counterflow virtual impactor. Dry air is supplied to back-pressure an inlet that faces into the flow. Only particles larger than a certain size (cut point) have sufficient inertia to penetrate the counterflow. These particles, nearly all of which are solid or liquid water, are then evaporated. This sample air is then passed through a TDL hygrometer to measure the resultant water vapor content. These values are adjusted for aircraft airspeed and probe enhancement to provide a cloud water content. The instrument output in these files includes flows, settings, temperatures, and other housekeeping data along with calculated cloud water parameters.

Purpose: The CSI was flown on the University of North Dakota Cessna Citation research aircraft during the NASA OLYMPEX (Olympic Mountain Experiment) project. The data are to be used to validate GPM satellite cloud and precipitation retrievals, and to improve our understanding of cloud and precipitation processes.

Data Credit: The data collection was funded through NASA Grant NNX15AL39G. Jason Tomlinson, ARM AAF, is assisting with post-project instrument tests.

Other Sites:
North West South East Olympic Peninsula, Washington, and coastal waters
48.5
-126.0
45.908
-123.67

Content Time Range:
Begin: 2015.11.12
End: 2015.12.10

Data Type: research data – External funding

Scientific Measurements(s): Measurement name Variables
Total cloud water CSI_M_Ratio CSI_CWC CSI_MR_corr
Stratum Keyword(s): Atmosphere: Troposphere

Data Quality:

Attribute Accuracy: The CSI vaporizer was not operating properly during the project, and there were also issues with the flow controllers. Accuracy was consequently affected, and missing value codes applied to time periods when data were exceptionally questionable. Additionally, there were some flights when the instrument was inoperable.

Positional Accuracy: No formal positional accuracy tests were conducted.

Consistency and Completeness Report: The instrument was calibrated before and after the project at the ARM AAF. There were issues with the flow controllers and vaporizer during the project. Extensive work was done on the instrument while in the field. Data were compared with other measures of cloud water to determine when the probe appeared to be giving good values.

Access Restriction: No access constraints are associated with this data.
Use Restrictions: No use constraints are associated with this data.

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