CAMP^{2}Ex AVAPS ReadMe/Quick Start Guide

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Stipulations on data use: Users are strongly encouraged to contact the PI before using these data

1 Introduction and Instrument Description

These data were acquired by 197 dropsondes during the Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP^{2}Ex) from August–October 2019. The dropsondes were part of the Airborne Vertical Atmospheric Profiling System (AVAPS), which was operated by Colorado State University onboard the NASA P-3B Orion.

Figure 1: RD41 dropsonde after being deployed. Photo adapted from Vaisala (2018)

The AVAPS system utilized during this campaign was comprised of 3 primary components onboard the aircraft: (1) 197 individual Vaisala RD41 dropsondes that were launched from the rear of the aircraft and transmitted data as they fall; (2) a launch tube at the rear of the plane with a wired GPS repeater in the tube; and (3) a hardware rack consisting of launch controls, a computer system for data logging and signal processing, and a telemetry receiver. The RD41 dropsondes consist of an instrumented cylinder, 7.0 cm in diameter and 41.0 cm in length, and a parachute that deploys upon release from the aircraft. The full sensor package can be seen in Figure 1, which shows the dropsonde's appearance after parachute deployment. The sensor package onboard the RD41 dropsondes consists of the Vaisala RSS421 pressure, temperature, and humidity sensor module and an independent GPS receiver used to calculate winds and fall speed. The manufacturer accuracy specifications for pressure, temperature, pressure, and horizontal winds are provided in Table 1 below.

Operation of the AVAPS during CAMP^{2}Ex began with "regenerating" the humidity sensor during pre-flight operations. This process uses the built-in heater on the humidity sensor to burn off any contaminants. The sensor regeneration was completed at least 16 hours before each flight. During flight, dropsondes were powered on and set to transmit at a user-selected

Table 1: Accuracy Specifications of the RD41 Sensors

Variable	Range	Uncertainty	Resolution
Pressure	1080–100 hPa	±0.5 hPa	0.01 hPa
Temperature	-90–+60 °C	±0.2 °C	0.01 °C
Relative Humidity	0–100%	±3%	0.01 %
Horizontal Wind	0–200 m s^{-1}	±0.5 m s^{-1}	0.01 m s^{-1}

frequency around 400 MHz, and then launched by loading the dropsonde into the launch tube at the rear of the P-3B and opening the hatch at the bottom of the tube. The dropsonde is then forced from the aircraft by the pressure difference between the cabin and the outside through a small vent at the top of the launch tube. During descent (nominally at 10 m s^{-1}), the dropsonde transmits pressure, temperature, and humidity data at 2 Hz and GPS data at 4 Hz.

2 Data Structure

The data are organized in separate ICARTT files for each successful dropsonde launch. It should be noted that while 197 dropsondes were launched during the campaign, only 193 ICARTT files are available for download. The four remaining dropsondes were removed from the final dataset due to launch failures and/or lack of sufficient data. In addition to the ICARTT files, Skew-T Log-P graphs of each dropsonde are included in the accompanying PNG files.

Each of the ICARTT files is named "CAMP2Ex-dropsondes_P3B_YYYYMMDD_RV_LXX.ict", where YYYY is the four digit year, MM is the two digit month, DD is the two digit day (all dates are the UTC time of takeoff per convention), V is the revision number (currently at R1), and XX is the two digit launch number. Similarly, the PNG files are named "CAMP2Ex-dropsondes-skewt-image_P3B_YYYYMMDD_RV_LXX.png". The ICARTT files are divided into two sections: the header and the data. The header contains information about the parameters of the dropsonde (such as serial number and launch time) and information about the quality control parameters and settings used in the quality control software (detailed in Section 3). The header also contains derived integrated variables from the sounding (detailed in Section 5). The data section of the ICARTT files contains 4 Hz data from the dropsonde. The variables in this section are detailed in Table 2 below.

Table 2: ICARTT Variables

Variable Name	Description
Time_Start	Time (seconds) since midnight UTC on the day that the aircraft took off. For example, if the aircraft took off at 2300Z on 24 August and the dropsonde was launched at 0100Z on 25 August, this value would start at 90000.
TimeFLStart	Time (seconds) from launch detection (note that launch time is noted in the header section as "Launch Time").
Pressure	Pressure (hPa). Note that this variable is measured at 2 Hz, so every other value will be flagged as missing.

Variable Name	Description
Temperature	Temperature (°C). Note that this variable is measured at 2 Hz, so every other value will be flagged as missing.
RH	Relative Humidity (%). Note that this variable is measured at 2 Hz, so every other value will be flagged as missing.
Speed	Wind Speed (m s^{-1}).
Direction	Wind Direction (°)
Latitude	Latitude (°, north is positive)
Longitude	Longitude (°, east is positive)
Altitude	Sonde Pressure Altitude (m)
GPS Altitude	Sonde GPS Altitude (m)
Dewpoint	Dewpoint temperature (°C)
Uwnd	Zonal winds (m s^{-1}, winds going from west to east are positive)
Vwnd	Meridional winds (m s^{-1}, winds going from south to north are positive)
Ascent	Vertical winds (m s^{-1}, upward winds are positive). Due to the uncertain characteristics of the parachute deployment and its impact on measured vertical winds, the use of this variable without careful consideration is discouraged.

3 Base Data Processing and Quality Control

Base data processing and final data quality control for the basic variables were performed by Holger Vömel, Mack Goodstein, and Clayton Arendt at the National Center for Atmospheric Research. The final data quality report and further details can be found in their Quality Control report, which is uploaded alongside this document at the LaRC Data Repository. The citation for the data Quality Control report is:

Vömel H., M. Goodstein, and C. Arendt (2020): Dropsonde Data Quality Report: Clouds, Aerosol and Monsoon Processes-Philippines Experiment (CAMP²Ex, 2019). Version 1.0. UCAR/NCAR - Earth Observing Laboratory.

3.1 Late Winds

74 of the 193 valid dropsondes with reported data failed to report valid wind data within 60 seconds of launch. These dropsondes are described as having “Late Winds”. Although this issue was first noticed in the field, the root cause of the issue was not uncovered until after the campaign. After the test flights, the GPS repeater located in the dropsonde tube became disconnected from the primary GPS receiver in the forward cabin of the P-3B. This resulted in the dropsondes not receiving a GPS signal while in the tube, which led to the failure to quickly acquire this signal after release. All in all, 72 of the 74 Late Winds dropsondes reported wind data before termination of data transmission, whereas 2 never reported winds while falling to the ocean surface. Although these drops are missing some or all of their wind data, the thermodynamic data and initial launch position are unaffected and can still be employed in data analysis.

4 Comparison of Dropsonde-collected Data to in situ P-3 Data

In order to get an overall assessment of how representative the dropsonde-collected state variable data were of those observations collected by the P-3, comparisons have been made between data collected when dropsondes were launched at the top of descending maneuvers performed by the P-3. The data presented below draw from ten independent descending maneuvers from seven different flights.

Data pairings for comparison were required to fit 3 main spatiotemporal criteria:

1. The P-3 observation must be collected within 1 hour of the dropsonde's launch time.
2. The GPS altitude of the P-3 observation and the dropsonde observation must be within 5 meters of each other.
3. The latitude and longitude of the P-3 observation must both be within 0.1 degrees of the latitude and longitude of the dropsonde observation.

Data fitting to these criteria was further controlled by manually excluding the flight-dropsonde pairings which were not associated with a box spiral or other localized descent within the immediate vicinity of the drop.

Table 3 below details the bulk statistics of the P-3 and radiosonde observations of the base state variables that were compared, with the number of comparisons for each. GPS altitude is included to indicate that there was minimal bias with respect to P-3 observations being taken at a higher or lower altitude than the sounding observations.

Table 3: Bulk Statistics of the P3-dropsonde Comparisons

Variable Name	Mean Bias (Dropsonde – P-3)	Standard Deviation	Number of Comparisons
GPS Altitude [m]	-0.0208	1.5657	4840
Temperature [°C]	0.1229	0.2341	4523
Dew Point Temperature [°C]	0.3580	0.9295	4523
Pressure [hPa]	-2.2356	1.0363	4523
Wind Speed [$m.s^{-1}$]	-0.4137	1.5615	2344
Wind Direction [°]	-2.2695	24.3186	2344

Of the state variables examined, all variables except for air pressure had a bias of zero fall within the range of the mean bias plus or minus the standard deviation. This remains the case even when removing the mean pressure offset from the dropsonde value, indicating a significant departure between the dropsonde and P-3 static air pressure values. Both temperature and dew point tend to be slightly higher for the dropsonde value than the P-3 value, whereas air pressure and wind speed tend to be slightly lower, and the dropsonde wind direction can be thought of as "lagging behind" the P-3 wind direction in a clockwise direction.

5 Derived Integrated Variables

The derived integrated variables are listed in the header, with descriptions and modes of calculation listed in Table 4 below. For the calculation of all the integrated variables, the data are linearly interpolated, allowing for the interpolation to fill in missing data for a maximum of 20 data points (5 secs). In this way, the short gaps where the receiver temporarily lost connection with the dropsonde are filled in, while reducing the amount of filled in data as much as possible. The version of MetPy used in the calculations was `1.0.0rc1`.

Table 4: Description and Calculation of Integrated Variables

Variable Name	Description	Calculation Method
Precipitable Water to top of dropsonde	The precipitable water (mm) measured from the base of the dropsonde to the highest point in altitude with a non-missing humidity measurement	MetPy's "precipitable_water" method (Salby 1996; May et al. 2020)
LCL Height	Height of the lifted condensation level (m) assuming a surface parcel	Romps (2017)
LFC Height	Height of the level of free convection (m) assuming a surface parcel	Pressure calculated with MetPy's "metpy.calc.lfc" method (United States Air Force 1990; May et al. 2020), converted to height using the hypsometric equation
Convective Inhibition	Convective inhibition (J kg^{-1}) assuming a surface parcel	CIN calculated with MetPy's "metpy.calc.cape_cin" method (Wallace and Hobbs 1977; May et al. 2020)
Sfc to 1 km Shear	Wind shear (kt) from surface to 1 km	Metpy's "metpy.calc.bulk_shear" method (May et al. 2020)
Sfc to 3 km Shear	Wind shear (kt) from surface to 3 km	Metpy's "metpy.calc.bulk_shear" method (May et al. 2020)
Sfc to 5 km Shear	Wind shear (kt) from surface to 5 km	Metpy's "metpy.calc.bulk_shear" method (May et al. 2020)

6 References

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