BACS Drone Stack Meteorological Data

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1.0 Data Set Description

This dataset contains meteorological measurements collected by an InterMet iMet-XQ2 sensor mounted on a "stack" of DJI M600 Pro uncrewed aerial vehicles (UAVs/drones) during the BioAerosols and Convective Storms (BACS) field campaign. Flights occurred before, during, and after cold pool passages to examine changes in near-surface vertical profiles of temperature, moisture, and pressure.

Data version 1.0, 11/12/2025

Data Status: Final

Time Period: During the BACS-I and BACS-II campaigns in May and June of 2022 and 2023.

Physical Location: Within the Central Plains Experimental Range. The sensors were mounted on drones flying above the surface meteorological station located near the Semi-Arid Grasslands Research Center (40.8095 N, 104.7778 W) at varying altitudes. Ground level was approximately 1661.4m above mean sea level (msl).

Data Frequency: 1 second

Data Source: BACS PI field measurements

Project information: https://www.eol.ucar.edu/field_projects/bacs

Dataset restrictions: none

2.0 Instrument Description

1 Hz meteorological data were collected using InterMet iMet-XQ2 sensors mounted on three DJI M600 Pro drones. Drones were deployed in a "stack" at different measurement altitudes (typically 120, 235, and 350m above the ground) for simultaneous measurements over a vertical profile.

The relevant specifications of the iMet-XQ2 sensors are listed below. A full description of the instrument can be found here: https://www.intermetsystems.com/wp-content/uploads/2023/03/252013-13-iMet-XQ2-User-Guide-and-Manual.pdf

Quantity	Accuracy	Range	Resolution	Sensor(s) Used
Pressure	±1.5 hPa	1200 – 10 hPa	0.02 hPa	Digital piezoelectric (MS5607)
Temperature	±0.3ºC	-95 – 50ºC	0.01°C	NTC thermistor (PB5-41E)
Relative humidity	±5% RH	0 – 100%	0.1%	Digital capacitive (HYT 271)
GPS	±8m (horizontal), ±12m (vertical)	40km	0.01M	UBlox M8 Engine (CAM-M8Q)

3.0 Data Collection and Processing

The iMet-XQ2 sensors automatically collected data during the entire duration they were on, which was typically throughout the IOP except when drones were brought inside to avoid precipitation/extreme heat. At the end of each IOP, data were downloaded from the sensors. The final dataset here includes only the “in-stack” period when drones were stationary and hovering in formation (i.e., excludes data collected while drones were on the ground or in transit).

The data processing involves two steps: (1) identifying the “in-stack” period, and (2) quality control of meteorological data.

First, we identified the period of time when drones were “in-stack”. To determine if a drone was in stack, we checked that the XQ2 GPS sensor reported altitudes within 36m of the nominal flight altitude (thrice the stated accuracy). We also checked that the drone was no longer moving by taking the standard deviation of altitude, latitude, and longitude over a rolling 120s window, and checked that this standard deviation was less than the stated GPS accuracy. We allowed for small deviations from these criteria if the deviations were less than 30s long (which allows for e.g., temporary drift in the drone position to correct for wind gusts). We did this process separately for each sensor, since each drone may reach its place within the formation at a different time.

After visually inspecting data from each drone flight, we manually corrected the flight end times for three flights where the procedure described above was mis-identifying an “in-stack” period due to fluctuations in drone flight altitude. For Flight 52 (aspirated 350m) and Flight 75 (unaspirated 120m), the flight end times were matched to the other sensor on the same drone, which more closely aligned with the flight period from the other drones. For Flight 63, the flight end time for the 120m drone was matched to the other two drones in the stack.

Second, we quality controlled the meteorological data measured by the XQ2 sensor. We corrected the relative humidity measurement according to the procedure suggested in the iMet-XQ2 manual:

$$RH_{corrected} = RH_{raw} \times \frac{e_s(T_{RH\ sensor})}{e_s(T_{temperature\ sensor})}$$

We also screened out sudden fluctuations in the pressure, RH, and temperature when the values deviate from the 5-minute rolling median value by 5 times the stated sensor accuracy or by more than 5 times the 5-minute rolling standard deviation. For flights where there were large discontinuities in pressure (pressure changes > 5hPa within the duration of the stack segment), we remove the pressure for the entire flight. These outliers in the pressure, RH, and temperature were replaced with NaNs and are indicated by the associated quality flags.

4.0 Data Format

The data are uploaded with one file per drone flight. Typical flights had three stacked drones, which are indicated in the files by the altitude each drone is nominally flying above ground level ("nominal_altitude"). Each drone can have up to two sensors, one aspirated and one unaspirated ("sensor_type"). The naming convection for the files is "BACS-drone-met-stack_**YYYYMMDD**_IOP**XX**_F**NN**.nc". The date is written such that **YYYY** is the year, **MM** is the month, **DD** is the day of the flight in local time (MDT). **XX** is the two-digit number of the IOP and **NN** is the two-digit number of the flight (both numbered continuously from the beginning of BACS-I to the end of BACS-II). Data is in NetCDF format.

The variables are listed in the following table.

Name	Dimension	Units	Description
datetime_local	datetime_utc	Seconds since date given in the attribute "units"	Time in MDT
datetime_utc	datetime_utc	Seconds since date given in the	Time in UTC

		attribute “units”	
datetime_utc_str	Datetime_utc	N/A	String giving date in format “YYYY-mm-dd-HHMMSS”
temperature	nominal_altitude, sensor_type, datetime_utc	°C	Temperature
temperature_quality	nominal_altitude, sensor_type, datetime_utc	Unitless	Temperature quality flag: 1 if data is good, 0 if data was bad and has been removed.
rh	nominal_altitude, sensor_type, datetime_utc	%	Relative Humidity
rh_quality	nominal_altitude, sensor_type, datetime_utc	Unitless	Relative humidity quality flag: 1 if data is good, 0 if data was bad and has been removed.
pressure	nominal_altitude, sensor_type, datetime_utc	hPa	Pressure
pressure_quality	nominal_altitude, sensor_type, datetime_utc	Unitless	Pressure quality flag: 1 if data is good, 0 if data was bad and has been removed.
altitude_msl	nominal_altitude, sensor_type, datetime_utc	Meters above sea level	Altitude from iMet-XQ2 GPS
latitude	nominal_altitude, sensor_type, datetime_utc	Degrees N-S	Latitude from iMet-XQ2 GPS
longitude	nominal_altitude, sensor_type, datetime_utc	Degrees E-W	Longitude from iMet-XQ2 GPS
satellite_count	nominal_altitude, sensor_type, datetime_utc	Number	Number of satellites detected by iMet-XQ2 GPS

5.0 Remarks

Code used to produce these data files can be found at:

https://doi.org/10.5281/zenodo.17594202.

6.0 References

7.0 Appendix

GCMD science keywords:

Air Temperature

Relative Humidity

Surface Pressure