OTREC2019 Santa Cruz quality checked radiosonde data

Field campaign: Organization of Eastern Pacific Convection 2019 (OTREC2019)

Quality check:

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1.0 Data Set Overview

For an overview of the scientific goals of OTREC2019 please refer to the EOL campaign web page (https://www.eol.ucar.edu/field_projects/otrec).

The Santa Cruz radiosondes were launched from the University of Costa Rica campus in collaboration with Marcial Garbanzo and Anna Maria Duran of the Costa Rica University. The team performed mandatory launches at 00 and 12 UTC, and often more than two launches per day. 131 launches were performed from 20 Aug to 30 Sep 2019, which includes intensive launch periods. Table 1 summarizes the number of launches per day for different time periods. Figure 1 summarizes the radiosonde flight paths from the launch location.

Table 1: Radiosonde launch frequency.

Date(s)	**Number of launches per day**
Aug 20-30, Sep 16, 25-26, 28	2
Sep 1-2, 9-15, 18-21, 24, 27,29	3
Sep 17	4
Sep 6, 22	5
Sep 3, 8	6
Sep 4-5, 7, 23	7

2.0 Instrument Description

Radiosonde sounding system Intermet iMet-3050A Portable 403MHz Antenna/Receiver was used with the iMet-4 radiosonde (specifications are attached at the end of this summary file). iMetOS-II (version 3.127.1) radiosonde receiver software was used to receive and record the data in 1 second intervals.

3.0 Data Collection and Processing

The iMet software automatically does some corrections such as time-lag, according to Miloshevich et al. (2004), and it corrects for the temperature difference between the sensor and the air temperature as well, by using:

$$CorrectedRH = RawRH * \frac{saturation\ vapor\ pressure(RH\ sensor\ temperature)}{saturation\ vapor\ pressure\ (AT\ sensor\ temperature)}$$

Challenges of radiosonde relative humidity measurements in the upper troposphere and stratosphere are outlined in Nash (2015) and Miloshevich et al. (2001). Note that the iMet-4 radiosonde has a thin-film capacitor if you choose to explore the Nash (2015) report in chapter 5 on relative humidity measurements. We left relative humidity data unaltered above 11 km, but suggest to the user to apply some smoothing above 11 km.

In addition to above automatic quality control we did a subjective visual inspection of the radiosonde data, and deleted suspicious spikes and bad data. We provide this quality checked data in this dataset.

4.0 Data Format

We provide the data in a ASCII space delimited format. Table 2 lists all the provided quality checked variables. We use the following format for the written data: "%6.1f %10.2f %10.1f %10.6f %10.6f %10.2f %10.2f %10.2f %10.1f %5i %10.1f %10.1f %10.2f %10.1f\n". Missing or bad data was replaced with -9999.

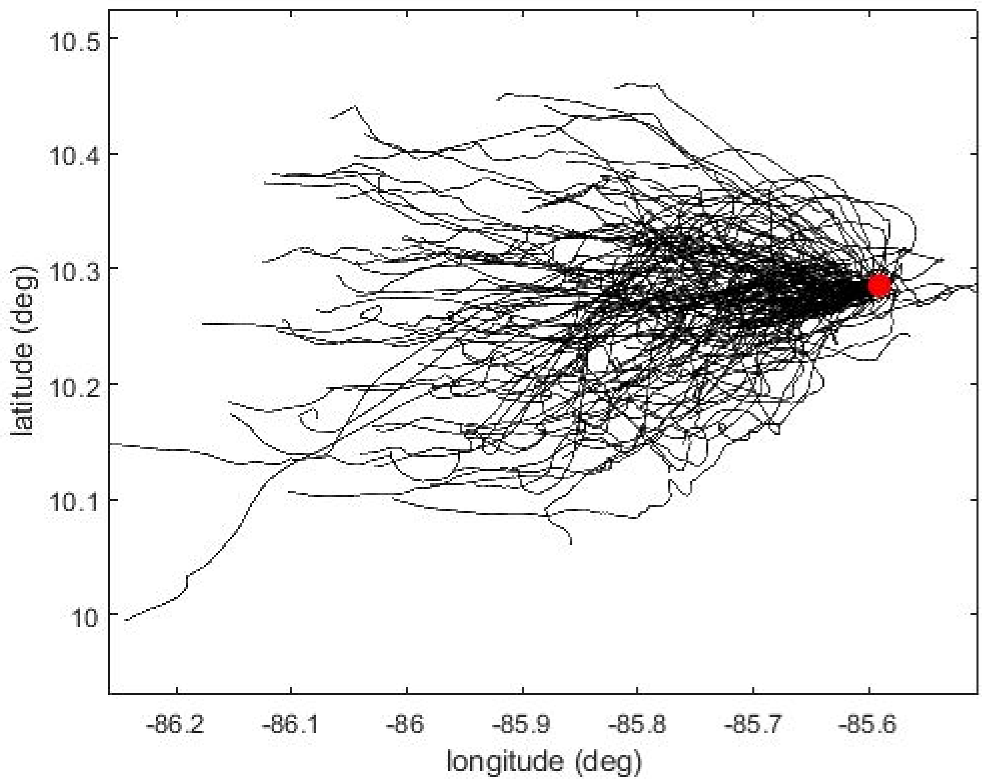

Figure 1: Radiosonde paths (a total of 131), relative to the launch site (Santa Cruz, red point). Maximum deviation from the launch site is -0.6669 degrees longitude, and about -0.2909 degrees latitude.

Table 2: Provided data and units. See attached radiosonde specification sheet for measurement accuracy and uncertainty.

Field	Unit	Note
time	seconds	Radiosonde flight time
pressure	hPa	Barometric pressure
MSL height	meters	Mean sea level height
longitude	degrees	Longitude east
latitude	degrees	Latitude north
temperature	degrees C	
virtual t.	Degrees C	Virtual temperature
RH	%	Relative humidity
wind speed	m/s	
wind dir.	degrees	Wind direction
u	m/s	Zonal wind component
v	m/s	Meridional wind component
ascent rate	m/s	Radiosonde ascent rate
GPMMSL	m	GPS mean see level height

5.0 Data Remarks

Using visual quality checking we found the following issues:

1) Sonde on 2019-08-27, 12:01, bad data 12.7-13.2 km,14.81-14.83km, in temperatures, and relative humidity.
2) Sonde on 2019-09-05, 13:51, bad relative humidity 8.66-8.71km, bad temperatures 9.14-9.17 km, and 9.38-9.41 km.
3) Sonde on 2019-09-05, 23:51, bad relative humidity 6.65 - 6.72 km.
4) Sonde on 2019-09-06, 21:54, bad sonde, there was a lot of missing data in this sonde, which the radiosonde software interpolated. Also it is incomplete, goes up to 7 km only.

5) Sonde on 2019-09-08, 21:53, bad temperatures and relative humidity data 1-7 km.
6) Sonde on 2019-09-15, 23:40 incomplete. Goes up to about 5 km.
7) Sonde on 2019-09-18, 17:57, bad temperatures data from 4 to 7.7 km.
8) Sonde on 2019-09-19, 23:41, incomplete. Goes up to 6 km.
9) Sonde on 2019-09-20, 23:51, incomplete. Goes up to 1.4 km.
10) Sonde on 2019-09-21, 17:49, bad relative humidity data 7.8-8 km.
11) Sonde on 2019-09-22, 8:55, bad temperatures and relative humidity data 4.6-5.8 km.
12) Sonde on 2019-09-22, 11:54, bad temperatures and relative humidity data 2.5 - 7.1 km.
13) Sonde on 2019-09-26, 18:16, incomplete. Goes up to about 1.2 km.
14) Sonde on 2019-09-27, 17:52, bad temperatures and relative humidity data from 6 to 7.7 km.

All the bad data above was replaced with a '-9999' value. We see that sondes under items 4, 5, 7, 11, 12, and 14 have large chunks of missing data, and that sondes under items 4, 6, 8, 9, and 13 are incomplete, i.e. do not cover the whole troposphere.

6.0 References

Miloshevich, L.M., A. Paukkunen, H. Vömel, and S.J. Oltmans, 2004: Development and Validation of a Time-Lag Correction for Vaisala Radiosonde Humidity Measurements. J. Atmos. Oceanic Technol., 21, 1305–1327.

Miloshevich, L.M., H. Vömel, A. Paukkunen, A.J. Heymsfield, and S.J. Oltmans, 2001: Characterization and Correction of Relative Humidity Measurements from Vaisala RS80-A Radiosondes at Cold Temperatures. J. Atmos. Oceanic Technol., 18, 135–156.

Nash, J., 2015, Measurement of upper-air pressure, temperature, and humidity. World Meteorological Organization, Instrument and Observing Methods, report #121, United Kingdom.

iMet-4 Radiosonde

403 MHz GPS Synoptic Technical Data Sheet

Temperature and Humidity

The iMet-4 measures air temperature with a small glass bead thermistor. Its small size minimizes effects caused by long and short-wave radiation and ensures fast response times.

The humidity sensor is a thin-film capacitive polymer that responds directly to relative humidity. The sensor incorporates a temperature sensor to minimize errors caused by solar heating.

Pressure and Height

As recommended by GRUAN[3], the iMet-4 is equipped with a pressure sensor to calculate height at lower levels in the atmosphere. Once the radiosonde reaches the optimal height, pressure is derived using GPS altitude combined with temperature and humidity data.

The pressure sensor facilitates the use of the sonde in field campaigns where a calibrated barometer is not available to establish an accurate ground observation for GPS-derived pressure. For synoptic use, the sensor is bias adjusted at ground level.

Winds

Data from the radiosonde's GPS receiver is used to calculate wind speed and direction.

Radiosonde Data Transmission

The iMet-4 radiosonde can transmit to an effective range of over 250 km*.

A 6 kHz peak-to-peak FM transmission maximizes efficiency and makes more channels available for operational use. Seven frequency selections are pre-programmed - with custom programming available.

Calibration

The iMet-4's temperature and humidity sensors are calibrated using NIST traceable references to yield the highest data quality.

Benefits

- Superior PTU performance
- Lightweight, compact design
- No assembly or recalibration required
- GRUAN[3] qualified (pending)
- Status LED indicates transmit frequency selection and 3-D GPS solution
- Simple one-button user interface

** Subject to ground station, balloon size and atmospheric conditions*
[1] All uncertainties expressed at a 95% confidence level
[2] Primary atmospheric pressure derived by GPS altitude
[3] GECOS Reference Upper-Air Network
Specifications subject to change without notice, Rev 11 190801

InterMet
International Met Systems
Grand Rapids, MI USA
www.intermetsystems.com

MEASUREMENTS

Measurement cycle	1 Hz

TEMPERATURE SENSORS	Glass Bead
Manufacturer	Shibaura
Measurement range	+60°C to -90°C
Resolution	0.01°C
Response time: still air/ 5 ms^{-1} (1000 hPa)	2 / < 1 sec
Repeatability in Calibration	0.2 C
Combined Uncertainty/Reproducibility [1]	
> 100 hPa	0.5 C / 0.3 C
< 100 hPa	1.0 C / 0.75 C
Night flight	0.3 C / 0.3 C
Solar correction	≤ 1.2 C

HUMIDITY SENSOR	Capacitive Polymer
Manufacturer	IST
Measurement range	0-100 % RH
Resolution	0.1%
Response time	
@ 25C	0.6 seconds
@ 5C	5.2 seconds
@ -10C	11 seconds
@ -40C	61 seconds
Repeatability in Calibration	5 %
Uncertainty/Reproducibility [1]	
> 0 C	5% / 3%
-40 to 0 C	5% / 5%

PRESSURE [2]	Sensor
Manufacturer	Measurement Specialties
Measurement range	1200 hPa - 10 hPa
Resolution	0.01 hPa
Response time	0.5 milliseconds
Uncertainty/Reproducibility [1]	
Whole range	2.0 / 1.5 hPa
1200 - 400 hPa	1.0 / 0.75 hPa
400 hPa - 10 hPa	2.0 / 1.5 hPa

PRESSURE	GPS derived
Measurement range	SFC to 3 hPa
Resolution	0.1 hPa
Uncertainty/Reproducibility [1]	
1080 - 400 hPa	2.0 / 1.5 hPa
400 hPa - 3 hPa	0.5 / 0.25 hPa

GEOPOTENTIAL HEIGHT	Pressure derived
Measurement range	SFC to 40 km
Resolution	0.1 m
Combined Uncertainty/Reproducibility [1]	
1080 - 400 hPa	15 m / 10 m
400 - 10 hPa	200 m / 150 m

GEOPOTENTIAL HEIGHT	GPS derived
Measurement range	SFC to 40 km
Resolution	0.1 m
Combined Uncertainty/Reproducibility [1]	
1080 - 400 hPa	30 m / 15 m
400 - 3 hPa	60 m / 20 m

WIND SPEED AND DIRECTION	
Resolution	0.1 m/s / 1 degree
Speed	
Combined Uncertainty/Reproducibility [1]	0.5 / 0.25 m/s
Direction	
Combined Uncertainty/Reproducibility [1]	1 degree

TELEMETRY

Transmission type	Synthesized
Maximum Range	> 250 km
Frequency stability	± 3 kHz
Deviation, peak to peak	6 kHz
Output Power	~ 30 – 200 mW
Modulation	AFSK
Data Rate	1200 Baud
Standard Frequencies	402, 402.5, 403, 403.5 404, 404.5, 405
Custom Frequencies	Available

GPS RECEIVER	
Manufacturer / Type	U-Blox CAM-M8
Cold Start Time	< 60 seconds (typical)

OPERATIONAL DATA

Battery	Lithium
Operating time	> 135 minutes
Weight	120 grams
Dimensions	Body (LWH): 139x67x31
	With boom (LWH): 235x67x31
Calibration Stability	2 years

** Subject to ground station, balloon size and atmospheric conditions*
[1] All uncertainties expressed at a 95% confidence level
[2] Primary atmospheric pressure derived by GPS altitude
[3] GECOS Reference Upper-Air Network
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