Title: CCOPE-2015 tipping bucket rain gauge data

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1.0 Data Set Overview:

This dataset contains data from data-logging tipping bucket rain gauges deployed during CCOPE-2105. Information on the overall goals of CCOPE, deployment strategy, and summary of rain gauge data are found in Massmann et al. (2017). Many of these sites are the same as used during the earlier Andean Frontal Experiment, AFEX (Garreaud et al., 2016) as summarized in Massmann et al. (2017). The locations and names of sites where CCOPE rain gauges were deployed are summarized in Table 1 and Figure 1 below. The rain gauges were located on a NW-SE transect along the Nahuelbuta Mountains in coastal southern Chile. NW winds prevails in winter storms.

 Note, data from two additional sites with CCOPE tipping bucket rain gauges attached to automatic weather stations (CRL, ARA in Table 1) are not included in this dataset and are instead included in the "CCOPE-2015 surface meteorology" dataset.

Time period covered: The gauge network observations are focused on the CCOPE-2015 operational period of 22 May 2015 to 14 August 2015. The start and end dates of observations at each specific site are listed in Table 1. Periods of missing data are noted in section 6.

Table 1: Summary of observation sites.

Abbreviated name	Full name	Latitude [deg.]	Longitude [deg.]	Elevation [m, MSL]	Observation period [yyyy/mm/dd]
SJC	San Jose de Colico	-37.3478	-73.3564	153	2015/06/24 - 2015/08/21
TNO	Torre Norte	-37.5374	-73.2663	734	2015/04/13 - 2015/06/12
TBO	Torre Bomberos	-37.5606	-73.2293	996	2015/04/13 – 2015/08/21
ETA	Escuela Trongol Alto	-37.5655	-73.1764	752	2015/04/13 – 2015/08/21
A3P	Alto Tres Pinos	-37.6293	-73.1192	1045	2015/06/26 – 2015/08/21
CAR	Cerro Alto Arauco	-37.7041	-73.1136	1384	2015/06/12 - 2015/12/22
GCA	Guadaba Central	-37.9553	-72.9102	131	2015/04/14 – 2015/12/22
ISM	Isla Santa Maria	-36.9756	-73.5287	61	2015/06/22 – 2016/01/07
*CRL**	*Curanilahue*	*-37.4753*	*-73.3423*	*137*	*2015/04/07 – 2015/08/14*
*ARA**	*Arauco*	*-37.2499*	*-73.3393*	*58*	*2015/04/07 – 2015/08/14*

* Sites with tipping bucket rain gauges connected to surface weather stations. Data from these gauges are not included in this dataset and instead are part of the "CCOPE-2015 surface meteorology" dataset.
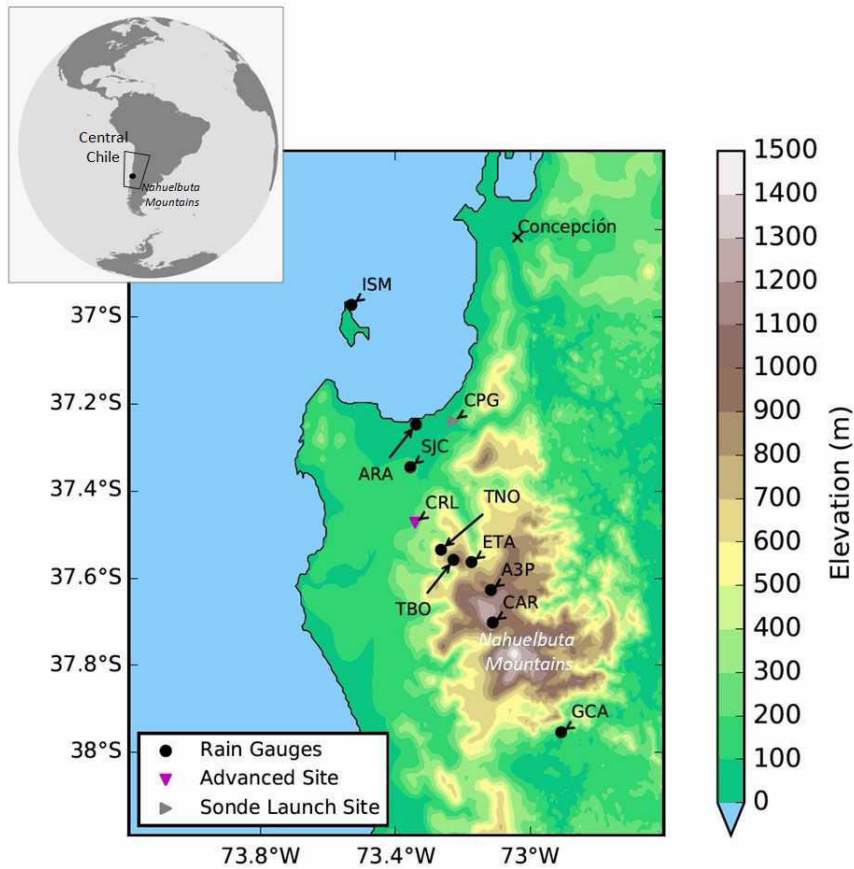
Figure 1: Locations of CCOPE rain gauge sites (black circles). Adapted from Massmann et al. (2017).

2.0 Instrument Description:

All rain gauges are Onset HOBO RG3-M tipping bucket rain gauges with a HOBO event/temperature data logger (Onset, 2017). The temperature (unshielded internal temperature of datalogger) are recorded every 15 min. Additionally, every time a tip of the rain gauge occurs (.2mm), the timestamp is logged.

Table 2: Selected instrument & logger attributes (From: Onset, 2017)

Rain gauge max rainfall rate	12.7 cm per hour
Rain gauge resolution	0.2 mm per tip
Rain gauge calibration Accuracy	+/- 1% (up to 2 cm per hour)
Rain gauge tipping bucket mechanism	Stainless steel shaft with brass bearings
Logger time stamp resolution	1.0 second
Logger time accuracy	+/- 1 minute per month (at 25°C)
Logger operating range	-20°C to 70°C
Temperature sensor measurement range	-20°C to 70°C

Temperature sensor resolution	0.1°C (at 25°C)

3.0 Data Collection and Processing:

As described in Massmann et al. (2017): "Rain gauges were generally located a horizontal distance away from surrounding obstacles equal to at least four times the height of the obstacle. Practical constraints resulted in some sites being
201 located in clearings with few upwind obstructions under prevailing winds (ISM, TBO, TNO, A3P)."

Data were logged on HOBO event/temperature data loggers. At most sites the gauges were checked, and data were downloaded, at one or more times during the project.

The data presented are raw and have not undergone any post-processing and represents the measurements reported directly by the data loggers.

Only cursory subjective quality control has been applied included checking for consistency between gauges and unrealistic rainfall rates. Based on this, a calibration error was found for the data collected at A3P prior to 12 June 2015. These data were discarded and a new gauge was deployed at that location. All other data are included. Potential sources of error are listed in section 6 below.

4.0 Data Format:

One file is produced each time an individual rain gauge is downloaded. The files are named with the following format:

raingauge_SSS_YYYYMMDD_HHMM_to_YYYYMMDD_HHMM.csv

where "SSS" is the abbreviated site name (as in Table 1) and "YYYYMMDD_HHMM_to_YYYYMMDD_HHMM" denote the start and end times (UTC) of the period covered by the data file.

Data files are in comma separated text (CSV) format. The first two lines are: (1) a header that includes the site name and (2) identifiers for each column of data.

 Data columns correspond to the following:

1) #: Record number (integer)
2) Date Time: Time stamp (UTC-04:00)
3) Temp: Temperature (15-min samples) (degrees C)
4) Event/Precipitation: Precipitation accumulation since last download (recorded at the time of each bucket tip) (mm)

5-8) Datalogger connection information

Empty fields correspond to times when a variable or flag was not recorded.

5.0 Data Remarks:

Missing data
Missing data periods during CCOPE-2015 operational phase (22 May 2015 to 14 August 2015) for each gauge are summarized in Table 2. Some data are missing due to logistical constraints on when the gauge could be deployed (e.g., ISM), whereas others were associated with instrument problems (see below).

Table 2. Missing data periods for each gauge during CCOPE-2015 operations.

Abbreviated site name	Missing data periods
SJC	22 May 2015 – 24 June 2016
TNO	12 June 2015 – 14 August 2015
TBO	12-26 June 2015
ETA	12-26 June 2015
A3P	22 May 2015 - 26 June 2015
CAR	12-26 June 2015
GCA	none
ISM	22 May 2015 – 22 June 2015
*CRL**	*none*
*ARA**	*none*

* Sites with tipping bucket rain gauges connected to surface weather stations. Data from these gauges are not included in this dataset and instead are part of the "CCOPE-2015 surface meteorology" dataset.

Instrument problems and potential biases
Since temperature measurements are unshielded internal temperature of the rain gauge housing they do not represent accurate metrological temperatures.

As described in Massmann et al. (2017): "Practical constraints resulted in some sites being located in clearings with few upwind obstructions under prevailing winds (ISM, TBO, TNO, A3P). High winds at these sites could be a source of non-negligible gauge undercatch … which could be exacerbated during rain dominated by small drops."

TBO, ETA, A3P, and CAR were not recording data during mid-June 2015, due timestamp error between shuttle and dataloggers that resulted in no data being logged.

SJC temperature was recording every 1s instead of 15min from 24 June 2015 through 4 July 2015.

Initial data from A3P was found to have a calibration error that resulted in undercatch, so data from this site before 6 June 2015 were discarded. All A3P data are from a replacement gauge installed on 6 June 2015 that began logging data on 26 June 2015.

The TNO gauge was stolen sometime on or after 12 June 2015, so no data are available after that date.

6.0 References:

Garreaud, R., Falvey, M. and Montecinos, A., 2016: Orographic Precipitation in Coastal Southern Chile: Mean Distribution, Temporal Variability, and Linear Contribution. *Journal of Hydrometeorology*, **17**(4), pp.1185-1202, https://doi.org/10.1175/JHM-D-15-0170.1

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Onset Computer Corporation, 2017: HOBO Data Logging Rain Gauge (RG3 and RG3-M) Manual. 10241-J MAN-RG3/RG3-M, 6 pp, available at: http://www.onsetcomp.com/files/manual_pdfs/10241-J MAN-RG3 and RG3-M.pdf