Quality-Control of Upper-Air Soundings for SPURS-2 (Version 1)

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1. Introduction

During the 22 October 2017 to 11 November 2017 period, upper-air soundings were collected as part of the SPURS-2 field campaign from launches conducted on the R/V Revelle over the Eastern Pacific ITCZ region. The location of the observations during the cruise is shown in Fig. 1. This report discusses the Version 1 post-processing of the radiosonde observations taken during the SPURS cruise. While Version 0 used surface data at 19 m, Version 1 used quality-controlled surface data at 10 m provided by Jim Edson.

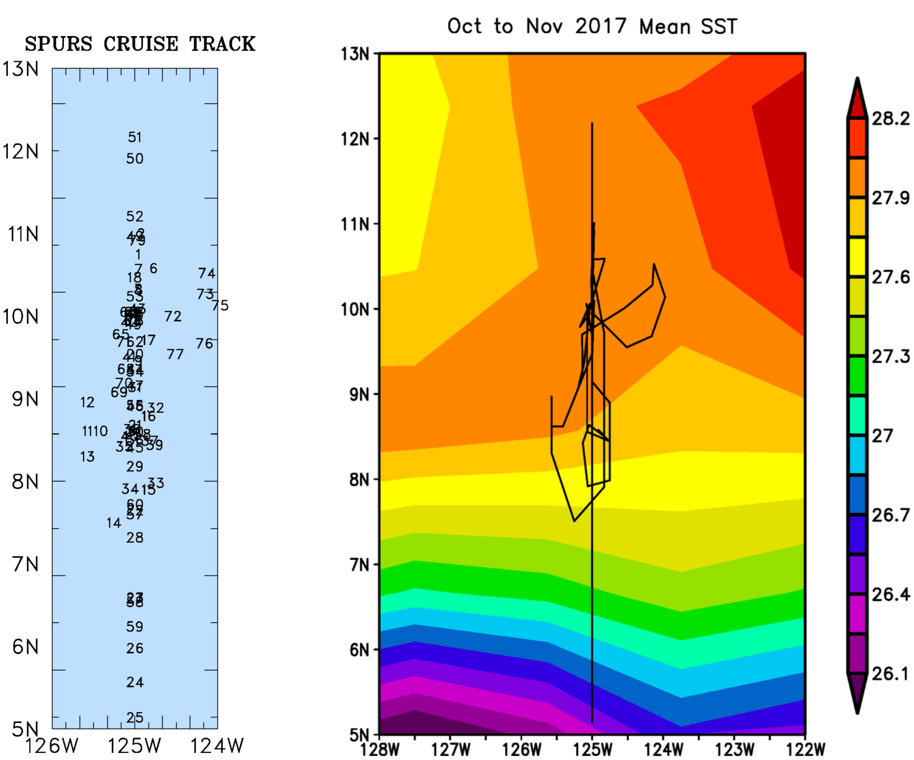

Figure 1. (left) Map showing location of the 79 upper-air soundings taken in chronological order during the SPURS-2 cruise, (right) October-November 2017 mean SST field from NCEP reanalysis along with the track of the SPURS-2 cruise (thin black line). SST scale to right of figure is in (C).

2. Overview of SPURS-2 sounding operations

A visual inventory of the sounding data taken during SPURS-2 is presented in Fig. 2. Soundings were taken four times per day (at 03, 09, 15 and 21UTC nominal time; LT = UTC-8). As seen here, all but seven soundings had data to at least 100 hPa.

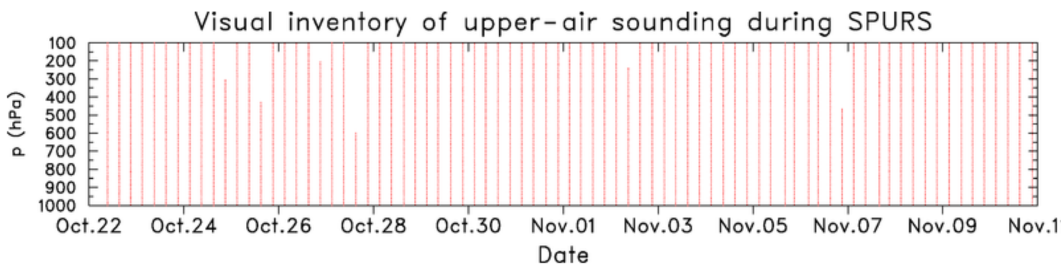

Figure 2. Visual sounding inventory of upper-air data for the period 22 October 2017 to 11 November 2017 based on Level 4 data. Each line of dots represents a successful sonde launch.

High-resolution (hi-res) sonde data (1s) were collected and processed with a Digicora MW41 system. The RS41 sondes used in SPURS-2 began with serial numbers starting with N34-N36 indicating that they were manufactured between 23 August and 04 September 2017. The ground station Digicora software used to process the RS41-SG sondes was version 2.4.0 which includes corrections to the raw humidity data for a daytime solar radiation dry bias and a time-lag error due to slow instrument response at cold temperatures. With these corrections the resulting humidity profiles in tropical soundings have been found to be quite accurate (cumulative measurement uncertainty of 4% RH as reported in Jensen et al. 2016). Wind data were based on GPS wind retrievals which have an stated accuracy of 0.15 m/s (Vaisala 2014). The RS41-SG sondes have no pressure sensor such that pressure is computed using the GPS altitude making use of the hypsometric equation. Using this equation requires an accurate starting pressure which was taken from the mast value at 19m. The station ID (99991) and call letters (KAOU) were chosen for convenience to match those used for the Revelle in the DYNAMO experiment (Ciesielski et al. 2012).

Site	Station ID	Sonde type	Resolution	No. of soundings	Dates of retrieved data
R/V Revelle	99991, KAOU	RS41-SG	1 s	79	10/22/17 - 11/11/17

Table 1. Summary information for the R/V Revelle sounding operations. Resolution refers to the native time resolution of the data.

3. Quality-control procedures

The methodology used to produce a quality-controlled (QC'ed) sounding dataset for SPURS-2 follows that described in Ciesielski et al. 2011. This procedure involves the four stages of processing outlined below.

(1) In this first stage of processing the mwx Digicora files provided by Brody Fuchs (CSU) were opened with the Digicora software on the CSU sounding system computer and saved as edited "EDT" files.

It would appear that the pressure entered to baseline the sounding data was likely the 19-m mast pressure data. Examining the L0 EDT files appeared to confirm this notion since the T and RH surface data at 3m were often quite similar to the values near 19 m. Under this premise it was decided to start the soundings at 10 m using quality-controlled (QC'ed) surface data provided by Jim Edson and eliminate data below 10 m. This QC'ed surface data at 10 m represents an average from sensors on the fore and aft of the ship to minimize flow distortion and solar heating (Jim Edson, personal communication).

This procedure has the added advantage of mitigating low-level deck heating and cooling effects (Yoneyama 2002). In reprocessing the data, the pressure at each level was recomputed with the hypsometric equation using the GPS altitude recorded in the sounding data and starting this upward integration at 10 m using the QC'ed 10-m pressure data. A similar procedure was used to process the soundings taken on the Revelle during the DYNAMO field campaign (see report at: http://data.eol.ucar.edu/datafile/nph-get/347.099/readme.DYNAMO-2011.GAUS-Revelle-3rdRelease.pdf).

These "EDT" files were then converted into

an ASCII format file (i.e., the GLS format commonly used by NCAR EOL).

(2) Next, the high-vertical resolution (1-s) sounding data were passed through a series of automated QC algorithms to systematically detect bad values. For this purpose we used ASPEN (Atmospheric Sounding Processing ENvironment), a software tool developed by NCAR EOL. In addition to removing egregious data based on several objective QC checks (e.g., gross limit, vertical consistency, etc), ASPEN filters the winds, computes geopotential height, smooths pressure and writes out the processed QC'ed sounding data in a standard ASCII format used by NCAR EOL.

Level 2 processing note: The 25 October at 1509 sounding experienced very slow and sometimes negative ascent rates beginning around 420 hPa likely due to heavy icing on the balloon. ASPEN considered height data above this level as bad and thus set the height field to missing above this level. If the user wishes to access the data above 420 hPa for this sonde, they will need to refer to the level 1 data.

(3) In Level 3 (L3) processing, sonde biases are identified and reduced if possible. Unfortunately no collocated independent measurements of PW were available to further check the reliability of the RS41 moisture data, so no corrections were applied. However the high quality of RS41 sondes, in general, gives us confidence that likely no corrections are necessary.

(4) Finally, in Level 4 (L4) processing a more "user-friendly" version of the sounding dataset was created with QC flags assigned to each variable providing a measure of the data's reliability. In L4 processing the L3 hi-res data are vertically interpolated to create values at uniform 5-hPa pressure intervals. Suspicious data were identified through application of both objective QC test as in Loehrer et al. (1996) and subjective adjustment of QC flags by visual inspection (Ciesielski et al. 2011) using an in-house developed visual sonde editor. The visual inspection was necessary to ensure a research-quality dataset since subtle errors in sonde data are often difficult to identify with objective procedures.. By flagging suspect data values, the reliable data are easily retrievable with the users deciding what level of quality is acceptable for their analyses. The definition of the QC flags used in the L4 dataset is provided in Table 3.

This second pass of QC checks and visual inspection, beyond those in L2, ensures the veracity of the data and provides yet another filter for identifying suspicious values. Note that the QC checks and visual inspection in L4 processing did not change any data values, only data quality flags. Additional details on interpolating the data to uniform pressure intervals, objective tests for assigning QC flags, and the visual editor used to expedite this processing, can be found at: www.eol.ucar.edu/projects/sondeqc/.

Flag Value	Meaning
1	parameter good
2	parameter "objectively" questionable
3	parameter "visually" questionable
4	parameter "objectively" bad
5	parameter "visually" bad
6	parameter interpolated
7	parameter estimated
8	parameter unchecked
9	parameter missing

Table 3. Convention used for the Level 4 (L4) QC flags.

4. **Data Archive and value added products**

A summary of the various sounding datasets is provided in Table 4 below.

Level 0 (L0.1)	Raw, original native resolution data (Digicora EDT format), corrected to use 10 m QC'ed data and pressure recomputed
Level 1 (L1.1)	Data in common ASCII (i.e., GLS) format, native resolution
Level 2 (L2.1)	Data processed with ASPEN. Native resolution (ASCII EOL format)
Level 3 (L3.1)	Native resolution (ASCII EOL and netcdf formats)
Level 4 (L4.1)	Soundings visually inspected with QC flags; hi-res data interpolated to uniform 5-hPa intervals (ASCII and netcdf formats); skew-T diagrams for all soundings

Table 4. Dataset summary and naming convection

Datasets are referenced by both a level number and version number. This report discusses processing of the version 1 data where the surface values represent QC'ed data at 10 m supplied by Jim Edson. In Version 0, discussed in separate report, the surface data were taken from data mounted on the mast at 19 m.

All datasets are currently available at:
http://johnson.atmos.colostate.edu/public/paulc/SPURS
Also at this link, sample fortran programs are provided to read the L1-L4 ASCII datasets.

In addition to the user-friendly L4.1 dataset, a suite of value added products were generated. These products include skew-T log-P thermodynamic diagrams for each sounding along with computation of various convective parameters (based on L4.1 data).The skew-T diagrams, an example of which is shown in Fig. 3, are provided as png images contained in single compressed tar file. Table 4 list the SPURS-2 cruise mean of the convective parameters. Here CAPE and CIN were calculated assuming pseudoadiabatic ascent using mean thermodynamic conditions in the lowest 50 hPa.

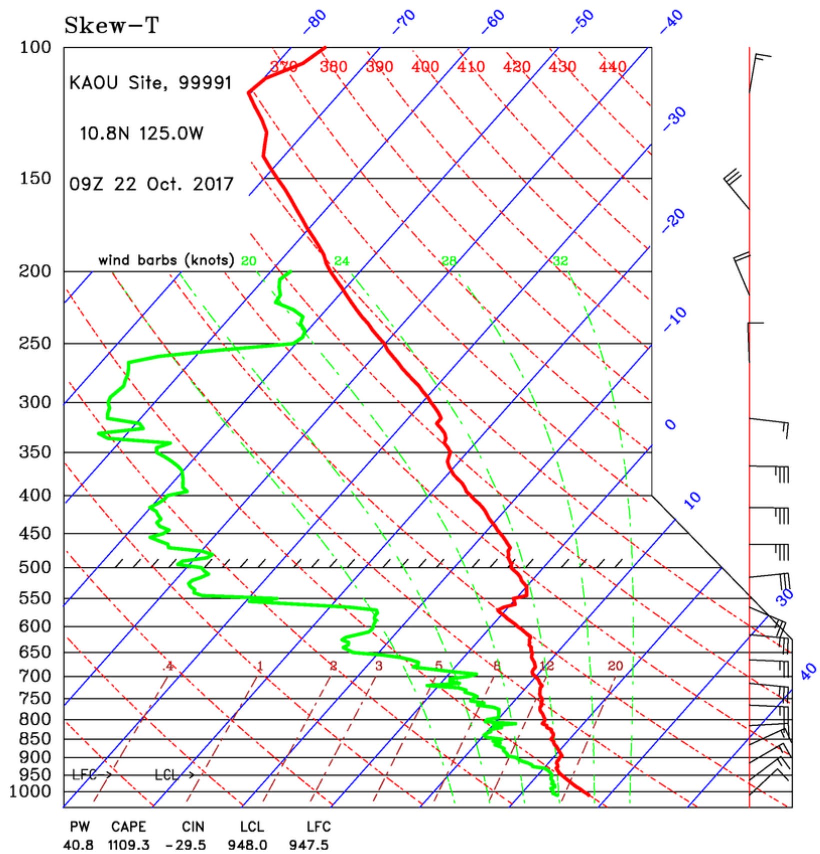

Figure 3. Skew T log-P thermodynamic diagram for 22 October 2017 at 09UTC sounding taken from the R/V Revelle. Convective parameters are listed along bottom of diagram computed using L4.1 data.

Site/ID	PW (mm)	CAPE (J kg^{-1})	CIN (J kg^{-1})	LCL (hPa)	LFC (hPa)	EL (hPa)
R/V/ Revelle 99991	54.5 (79)	1013.3 (78)	-37.6 (78)	957.1 (79)	898.8 (78)	162.5 (78)

Table 4: SPURS-2 cruise-mean convective parameters using L4.1 data: PW signifies total-column precipitable water, CAPE – convective available potential energy, CIN – convective inhibition, LCL – lifting condensation level, LFC – layer of free convection, EL – equilibrium level. Numbers in parentheses indicate the number of soundings that went into each average.

Time series of various convective parameters along with SST and the latitude location of the observations are shown in Fig. 4.

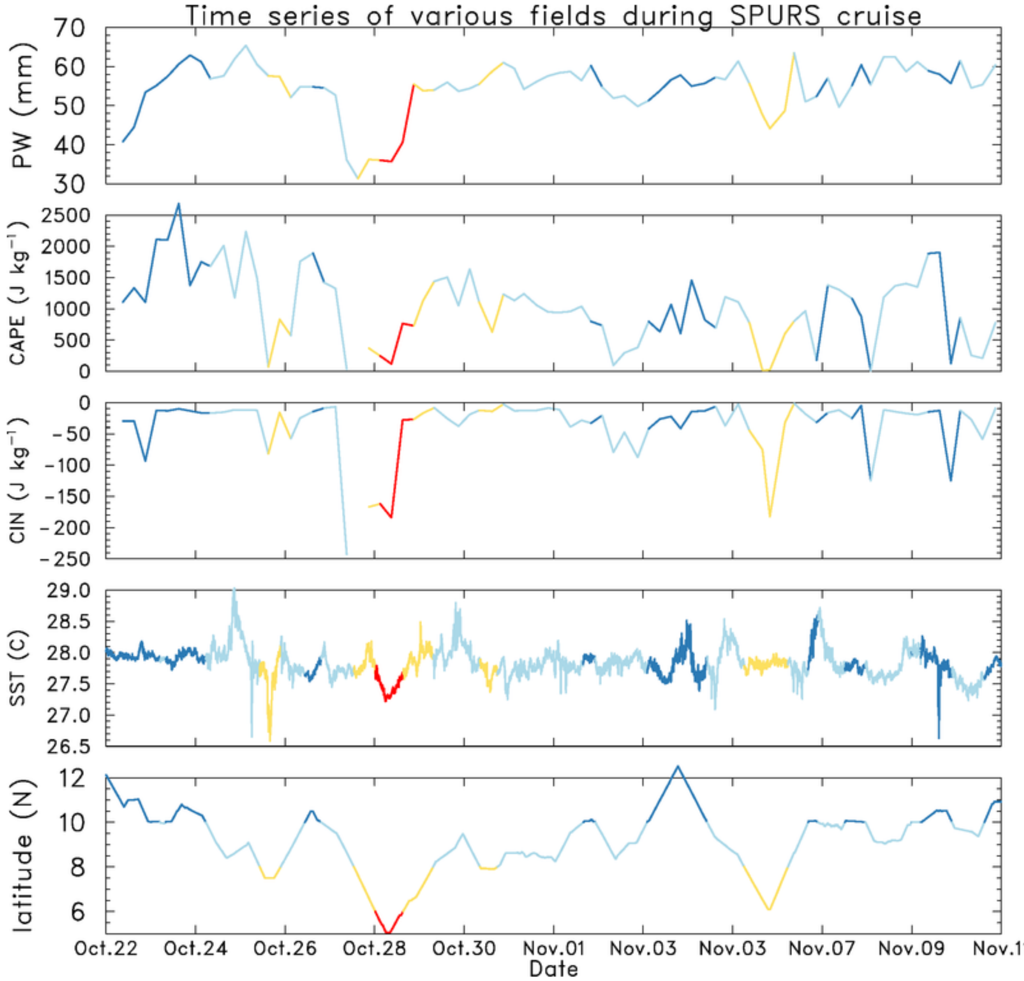

Figure 4. Time series for various field during SPURS-2 cruise. From top to bottom: PW (mm), CAPE (J/kg), CIN (J/kg), SST (C) and latitude of observations. Curves are color coded to indicate their latitude location (blue: > 10°N, light-blue: 8°-10°N, yellow 6°-8°N, red: < 6°N).

5. Summary

During the 22 October 2017 to 11 November 2017 period, 79 upper-air soundings were collected as part of the SPURS-2 field campaign from the R/V Revelle. Upper-air data from the Vaisala RS41 sondes were processed and quality-controlled to produce a high-quality sounding dataset suitable for research applications.

All datasets are currently available at:
http://johnson.atmos.colostate.edu/public/paulc/SPURS

Questions regarding SPURS-2 upper-air data and its processing should be directed to Paul Ciesielski (paulc@atmos.colostate.edu).

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6. References

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