Earth Syst. Sci. Data Discuss.,
https://doi.org/10.5194/essd-2017-126-AC3, 2018

Interactive comment on "Central-Pacific surface meteorology from the 2016 El Niño Rapid Response (ENRR) field campaign" *by* Leslie M. Hartten et al.

Leslie M. Hartten et al.

leslie.m.hartten@noaa.gov

Received and published: 23 April 2018

Response to Referee #2 of essd-2017-126

Referee comments are in *italics*; our responses follow each comment. A track-changes revised manuscript is uploaded as a supplement; it contains changes made in response to Anonymous Referee #2's comments on top of changes made in response to Anonymous Referee #1's comments and some edits we have made on our own. In the interests of reducing the size of the resulting file, we have "accepted" the deletion of several figures. However, the insertions of their replacements have not been

Printer-friendly version

Discussion paper

"accepted" and so are clearly marked.

Referee #2 General comments:

• **(excerpt):** *When possible use full doi prefix, e.g. https:// doi.org/ 10.7289/ V51Z42H4 in preference to doi:10.7289/V51Z42H4.*

RESPONSE: We checked with the ESSD editorial office and discovered that this is now the preferred method. We were unaware of that, and thank Referee #2 for drawing it to our attention.

ACTION TAKEN: Changed throughout.

• **(excerpt):** *The NASA Ames (.na) format seems like a legacy format of the research aviation community, still used by, for example, NCAR. The authors do a good job of explaining NASA Ames format in their Section 5 and a search in ESSD shows at least one other data set in NASA Ames format. But international surface met data, as presented in several other ESSD data sets, often come in more generic formats, e.g. .tsv or .csv, or - maintaining full metadata - as NetCDF. Provide a NetCDF version or mention a link to a translator?.*

RESPONSE: NASA Ames format is common enough to be one of the accepted formats at the Centre for Environmental Data Analysis (CEDA, formed in part from the British Atmospheric Data Centre (BADC)). We do not think that this format, which has space-delimited data below a header, differs significantly from tab-delimited (.tsv) or comma-delimited (.csv) files except for this: it has a metadata-rich header format which has stood the test of time, or at least the test of 20 years. Hartten has in the course of her career repeatedly developed her own ASCII data headers, inevitably finding them insufficient several years later, and is glad to take advantage of someone else's wellthought-out system.

We do not want to provide our data in multiple formats, as it greatly increases the overhead on our end and also increases the likelihood of version control issues. We have done some research into extant software that can convert NASA-Ames format to netCDF. The "NAPPy" software at https://github.com/cedadev/nappy was originally developed at BADC by Ag Stephens, who is now at CEDA. Two of our local data set experts have tried it with some of our ENRR files; they report that it does work, although the metadata contained in "special comment" and "normal comment" lines is concatenated in a fashion that is difficult to read by eye. The software is not python 3 compliant (A. Stephens, 2018, personal communication) and conversion between NASA-Ames format and netCDF is only available for unix or linux platforms. Another package that we found was built for that institution's very specific requirements and does not properly convert our data, nor does it save any of the metadata contained in our "special comment" and "normal comment" lines.

ACTION TAKEN: We have added text to Section 5 pointing interested users to the NAPPy software.

Referee #2 Specific comments:

- **Page 4, line 5.** *"Global Class" research vessel. NOAA or UNOLS designation? Eliminate or explain for an international audience.*

RESPONSE: We are not sure who designates vessels as being of a certain class, nor if the designations vary between countries. The NOAA Ship *Ronald H. Brown* is part of the (U.S.) Federal Oceanographic Fleet, and is described as Global Class by the (U.S.) Interagency Working Group on Facilities and Infrastructure (IWG-FI) and its predecessor body (see JSOST 2007, 2013, 2016). The U.S.A.'s University-National

Oceanographic Laboratory System (UNOLS) website, which lists it amongst the UNOLS vessels (https://www.unols.org/ships-facilities/unols-vessels) as a "NOAA Global Class Vessel ... scheduled in cooperation with UNOLS", seems to rely on external determinations of vessel class.

If the reviewer is looking for something that points to the specifications (e.g. size, capacity, speed, cruise duration) of a Global Class vessel, the cited JSOST documents make it clear that the definition of "Global Class" is evolving and no longer includes any numerical specifications of that nature.

Joint Subcommittee on Ocean Science and Technology (JSOST): Federal Oceanographic Fleet Status Report, Washington, D.C., 40, available at http://www.nopp.org/wp-content/uploads/2010/03/IWG-F-Fleet-Status-Report-Final.pdf, 2007.

Joint Subcommittee on Ocean Science and Technology (JSOST): Federal Oceanographic Fleet Status Report, Washington, D.C., 42, available at http://www.nopp.org/wp-content/uploads/2010/03/federal_oceanographic_fleet_status_report.pdf, 2013.

Joint Subcommittee on Ocean Science and Technology (JSOST): Federal Fleet Status Report: Current Capacity and Near-Term Priorities, Washington, D.C., 18, available at http://www.nopp.org/wp-content/uploads/2016/06/federal_fleet_status_report_final_03.2016.pdf, 2016.

ACTION TAKEN: Added a footnote giving the most recent applicable definition of Global Class from JSOST (2016) and added that document to the References.

• **Page 6, line 4.** *"replaced suspicious data with flags." In looking at the Kiritimati data file, I did not see flag values other than standard missing data designated by 9999. Did the authors insert additional flag indicators? If so, we should know their value and meaning? If not, we should know that we can not distinguish them from other 9999.*

data?

RESPONSE: This is a fair point.

ACTION TAKEN: Changed to "...have replaced suspicious data with the flags used to indicate missing data".

• **Page 10, section 3.2.4.** *Winds: Here the authors ask us to accept a very large assumption, that winds and therefore intercomparisons and corrections from a different cruise of the same ship but much farther north (in a different wind regime) and one year earlier will also apply to the ENRR data. Without a working bow anemometer for the ENRR cruise the authors probably have little choice ... but some larger context would help. In these strong ENSO or pre-strong ENSO conditions, the authors could give us a short (one paragraph?) summary of large scale wind, convection and SST conditions that would help our understanding and acceptance of wind, radiation and ocean temperature corrections? Figure 4 provides a large scale picture of SST for the entire cruise of RV Brown but we could see similar fields of surface wind or pressure anomalies or of cloud top height / temperatures as an indication of convection? If this time period represented an anomalous period for winds or convection then we have greater reason to worry about corrections based on 'mean' conditions or literature values? In other words, other than for a very warm SST, do the authors consider this time period normal (for the location, season, ENSO index, etc.) or highly unusual?*

RESPONSE: Our "intercomparisons and corrections from a different cruise of the same ship" concern only biases that are specifically associated with winds encountering the superstructure of the ship. This requires any sample of winds that encounter the ship (for example, the observations during CalWater), and requires no assumptions about the similarity in conditions between the two cruises. The only real assumption we are making is that the superstructure of the ship and the positions of the bridge anemometers are the same; to the best of our knowledge, this is true.

ACTION TAKEN: None.

• **Page 12, Section 4.** *Surface flux calculations. Do we need a sentence that gives the explicit formulation of this version of the COARE algorithm?*

ACTION TAKEN: We added a one-sentence comment about the algorithm in response to Anonymous Referee #1; we think that may help address your concern as well. We have also changed the citation to “Fairall et al., 1996, 2003; most recently updated in Edson et al. 2013”.

• **Page 12, Section 4 (paragraph-long comments/questions broken into 4 segments for clarity).** *After reading this section this review suspects some circular logic involved? Use radiosonde data prior to launch to correct or validate some aspects of surface met data. But (and presumably documented in the upper air data set) then use the surface met data to properly initialise the radiosonde data.*

RESPONSE: Referee #2 is correct; surface observations are used to provide an estimate of the atmospheric state at the time and place of each radiosonde launch, and constitute the first point in the sounding. Those observations will affect the final sounding profiles of temperature, humidity, and winds in the lower part of the sounding. (The exact distances through which the effects occur are not documented in any literature we are aware of.) They will also have some affect throughout the depth of the pressure and/or height profiles if integration of the hypsometric equation is used to obtain either of those quantities. Ideally the surface observations are independent ones, but values from the radiosonde can also be used (Vaisala Oyj, 2010).

But we do not believe that we are using circular logic in our handling of the surface data sets described in this manuscript.

Hartten et al. 2018 (formerly Hartten et al. 2017a) describes how we prepared radiosondes for launch. The first step is to use the Vaisala ground check set and the DigiCORA software to “recondition” the radiosonde’s humidity sensors (to remove possible contaminants) and to then perform a “ground check”, recalibrating the humidity sensors (against a built-in 0% relative humidity reference), the temperature sensor (against a built-in independent temperature reference), and the barometer (against a hand-entered independent pressure, if available).

With regards to the surface data sets, data from the radiosondes were only used as follows:

- to convince us to check the CXENRR barometer against a calibrated standard after the field campaign, which led us to adjust the surface pressure observations based on that recalibration and to use those values in the CXENRR data set described here;
- to detect a mean pressure bias in the WTEC observations that was a function of ship-relative wind direction, which led to no changes to the surface pressure observations presented in the data sets described here;
- to identify mean biases in the humidity measurements at both CXENRR and WTEC, which led us to remove those mean biases from the surface observations before creation of the data sets described here.

Putting all this information together with respect to humidity, which is the only variable in the surface data set that was changed based on comparisons with radiosonde

Printer-friendly version

Discussion paper

measurements: Each radiosonde's humidity sensors were calibrated against an independent transfer standard during the ground-check phase of pre-launch operations. At each site, we have identified a mean bias between more-or-less collocated humidity measurements made by those calibrated radiosonde sensors and our surface humidity instrument, and removed the mean bias from each site's surface humidity observations before including them in these data sets. In essence, during post-processing we calibrated our surface humidity instruments against a sequence of calibrated radiosonde humidity sensors.

Vaisala Oyj: DigiCORA® User's Guide, M210488EN-F, Vaisala Oyj, Helsinki, Finland, 113 pp., available from www.vaisala.com, 2010.

Updated reference for Hartten et al. (formerly 2017a):

Hartten, L. M., Cox, C. J., Johnston, P. E., Wolfe, D. E., Abbott, S., McColl, H. A., Quan, X.-W., and Winterkorn, M. G.: Ship- and island-based soundings from the 2016 El Niño Rapid Response (ENRR) field campaign, Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2018-7, in review, 2018.

ACTION TAKEN: Added a summary sentence in Sections 3.1.2 and 3.2.3, and updated Hartten et al. (2017a) reference.

- **Page 12, Section 4 (con't).** *Then, to calculate LWD contribution to fluxes, use the radiosonde data, at least for H2O, to estimate column profile of RH as it would influence LWD at the surface if measurements had included direct LWD. Somehow this reviewer gets the uncomfortable feeling that upper air data corrected originally by surface data then became themselves an upper air input to a surface calculation? Perhaps unavoidable but not ideal, deserves notice?*

RESPONSE: Continuing from the previous response . . . We did use post-processed

WTEC radiosonde profiles of RH to estimate the column H_2O profile that was one component of our surface LWD estimation process. Those radiosonde profiles were anchored by a surface humidity value, as is the usual practice for RS92 radiosondes; it is incorrect to say that the upper-air data were "corrected originally by surface data". As described above, that surface humidity value had been adjusted during post-processing. The adjustment removed a long-term mean bias between our surface humidity sensor and a sequence of freshly calibrated humidity sensors. Such a comparison against a transfer standard is one classic way to calibrate an instrument; the fact that the freshly calibrated sensors were part of the radiosonde package is irrelevant.

Atmospheric profiles from RS92 radiosondes always include a surface measurement. Our text is very clear that our LWD estimation process used radiosonde profiles of both temperature and H_2O profiles. The text also states that the "full COARE flux algorithm requires some atmosphere/ocean quantities that were not measured during the cruises", that "[u]nfortunately" LWD was among those, and that some variables the algorithm can compute were not produced because we did not have the quantities required to calculate them. We respectfully believe that this qualifies as clear notice that estimating LWD is not as good as measuring LWD would have been, but that it was necessary so that we could produce an estimate of the net surface heat flux.

ACTION TAKEN: None.

• **Page 12, Section 4 (con't).** *Also, rather than assuming vertical cloud distributions centered at 1 km (about optical depth I concede the authors assumptions), the radiosonde RH profiles probably indicate cloud layers, at least generally? Or, would these assumptions and calculations prove insensitive to cloud layer height?*

RESPONSE: We visually inspected each sounding and subjectively estimated a cloud base height, as you suggested. We found it quite hard to do. (Estimating cloud top would have been easier because of the cloud-top inversion, but cloud base was more important for the calculations performed here.) Our estimates looked plausible, with higher cloud bases to the north of the warm pool and lower ones (close to the marine boundary layer) near the equator, and the average of the estimated heights was 0.82 km, which is quite close to the nominal height of 1 km used in the manuscript. However, we are not particularly comfortable with these cloud-base height estimates and are not prepared to defend them, so we would not want to use them individually, nor in average or median form.

We have therefore tested the LWD sensitivity to cloud layer height by re-calculating the fluxes for various cloud heights, assuming bases from 0.25 km by 0.25 km to 5 km (193 sondes at 20 heights = 3860 calculations). As stated in the manuscript, the mean cloud radiative effect LWCRE for a cloud base at 1 km, averaged over all 193 radiosondes, is 31.1 W m^{-2}. Because the cloud temperature gets colder as height increases, the cloud forcing (and thus LWD) decreases with increasing cloud height at a rate of about –2.7 W m^{-2} per extra 1 km of height. While small, relative to the estimated cloud forcing, it is not negligible (about 9% of cloud forcing per km).

ACTION TAKEN: We have added text clarifying why we assumed the cloud bases were at 1 km, and have also briefly noted the sensitivity of our results to that assumption.

• **Page 12, Section 4 (con't).** *As I remember, NCAR and Vaisala originally published a correction to COARE radiosonde RH values, particularly to address erroneous surface dry layers. Now we use the radiosonde pre- launch surface RH values to calibrate surface RH sensors?*

RESPONSE: Yes, we do. Referee #2 is correct that NCAR and Vaisala developed a set of humidity corrections for the RS80 radiosondes used in COARE (Wang et al.

2002) that addressed low-level dry biases among other things. For ENRR we used Vaisala RS92 radiosondes, which have different humidity sensors (Wang et al. 2013), together with DigiCORA sounding software v3.64.1 (Vaisala Oyj, 2010), which includes a humidity correction for the daytime solar radiation dry bias identified in the RS92 by Vömel et al. (2007). Ciesielski et al. (2014) determined that tropical soundings collected over the Indian Ocean and west Pacific warm pool during the Dynamics of the Madden-Julian Oscillation (DYNAMO) field campaign at "sites using VRS92 sondes with D3.64 software need[ed] no further humidity corrections".

Note also that Wang et al. (2002) say the following in the final paragraph of their article: "Comparisons of prelaunch radiosonde data with the surface data from independent surface sensors can always be used to evaluate the accuracy of radiosonde data (and/or surface data), and may provide some guidance on how to correct the data."

Ciesielski, P. E., Yu, H., Johnson, R. H., Yoneyama, K., Katsumata, M., Long, C. N., Wang, J., Loehrer, S. M., Young, K., Williams, S. F., Brown, W., Braun, J., and Van Hove, T.: Quality-Controlled Upper-Air Sounding Dataset for DYNAMO/CINDY/AMIE: Development and Corrections, Journal of Atmospheric and Oceanic Technology, 31, 741-764, https://doi.org/10.1175/jtech-d-13-00165.1, 2014.

Vömel, H., Selkirk, H., Miloshevich, L., Valverde-Canossa, J., Valdés, J., Kyrö, E., Kivi, R., Stolz, W., Peng, G., and Diaz, J. A.: Radiation Dry Bias of the Vaisala RS92 Humidity Sensor, Journal of Atmospheric and Oceanic Technology, 24, 953-963, https://doi.org/10.1175/jtech2019.1, 2007.

Wang, J., Cole, H. L., Carlson, D. J., Miller, E. R., Beierle, K., Paukkunen, A., and Laine, T. K.: Corrections of Humidity Measurement Errors from the Vaisala RS80 RadiosondeâĂŤApplication to TOGA COARE Data, Journal of Atmospheric and Oceanic Technology, 19, 981-1002, https://doi.org/10.1175/1520-0426(2002)019<0981:Cohmef>2.0.Co;2, 2002.

Wang, J., Zhang, L., Dai, A., Immler, F., Sommer, M., and Vömel, H.: Radiation Dry Bias Correction of

Vaisala RS92 Humidity Data and Its Impacts on Historical Radiosonde Data, Journal of Atmospheric and Oceanic Technology, 30, 197-214, https://doi.org/10.1175/jtech-d-12-00113.1, 2013.

ACTION TAKEN: We have added the quote from Wang et al. (2002) to section 3.1, where the issue first arises. Citations to Vaisala documentation of the RS92 radiosondes and the ground check were added in response to comments from Referee #1.

• **Page 12, line 9.** *Fairall et al 1996 does not represent the most recent version of the COARE bulk flux algorithm as implied in this sentence? Later the authors cite Edson 2013 for more recent versions?*

ACTION TAKEN: Changed citation to read "Fairall et al., 1996, 2003; most recently updated in Edson et al. 2013".

• **Various.** *Although the text maintains a very good record of reporting uncertainties, the figures often fail to show uncertainty. Figure 13 represents a nice exception that proves the point? Showing uncertainty bands would make some figures unreadable? We need either explicit inclusion of uncertainties where appropriate or valid explanation of their absence? Perhaps particularly for figures 19 and 20?*

RESPONSE: Throughout the manuscript we have plotted data in ways that we felt best helped us to tell our story; sometimes plots lent themselves to also visualizing uncertainty, and sometimes they did not (for instance, when uncertainty bands would be indistinguishable on the plot scale, or when they would render portions of the plot unreadable). We agree that explicitly including uncertainties for our estimated LWD and our computed Q_0 is important.

ACTION TAKEN: Added Table 7 and text to Sections 4.2 and 4.3 to summarize estimated uncertainties in the individual heat budget terms, as well as the combined surface heat budget uncertainty, which we estimate to be 20.8 W m^{-2}. The largest sources of uncertainty are from the assumed albedo (0.055) and the calculation of LWD.

• **Figure 8.** *RH does not go much higher than 95% during periods of heavy rain?*

RESPONSE: That is correct, and commonplace in the tropics (C. Fairall 2018, personal communication; M. A. LeMone 2018, personal communication) unless there is fog (P. E. Ciesielski 2018, personal communication). Figure 1 (below) shows the relative humidity and accumulated precipitation measured aboard the R/V Roger Revelle during three cruise legs of the DYNAMO field campaign in the equatorial Indian Ocean (Yoneyama et al. 2013). Leg 1 is omitted because only 35 mm of rain was recorded during the three-week long cruise. During Legs 2–4, even when rainfall was heavy surface humidities were usually below 95%, and any excursions above 95% were short-lived.

Yoneyama, K., Zhang, C., and Long, C. N.: Tracking pulses of the Madden–Julian Oscillation, B. Am. Meteorol. Soc., 94, 1871-1891, https://doi.org/10.1175/bams-d-12-00157.1, 2013.

ACTION TAKEN: None.

• **Figure 10.** *showing the rain events would also prove helpful here*

ACTION TAKEN: Shading indicating the heavy rain events has been added.

• **Figure 20.** *not clear why panel C (lat, lon) has relevance to upper two panels*

RESPONSE: It is provided as a reference for those who might want to get a quick look at how Q_0, *T*, and/or SST vary with ship position.

ACTION TAKEN: None.

• **Table 6.** *vertical grid for RRTM: not sure the utility of this*

RESPONSE: It is provided as a reference for those who might want to know the atmospheric structure our estimation method could possibly contain.

ACTION TAKEN: None