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Interactive comment on "Tracking the Choco jet since the 19th Century by using historical wind direction measurements" *by* David Gallego et al.

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The use of ICOADS data wind direction data to document long time variability of the Choco Jet seems to be OK, but the uncertainties in the use of this data in the long term trend analysis starting ion the XIX Century may be complicated by uncertainties in this early data, as compared to the NCEP reanalyses. I have marked directly on the PDF version some comments, doubts and questions I have for the authors. I am not sure if with this merging of ICOAS and NCEP reanalyses one is able to study trend, decadal variations or even the stability of interconnection patterns. There is a need for some physical explanations of some of the correlation patterns investigated here, for instance, that correlation between the Choco jet and SST in Nino3.4 months later. Figure 7 needs some indicators of uncertainties in the ICOADS data, because these uncertainties are perhaps higher than those from recent decades from the reanalysis.

RESPONSE: Most of the referee concerns are related to the uncertainties of our data and results. We make a somewhat "innovative" use of ICOADS that probably needs additional explanation. As demonstrated by Prieto et al. (2005, Climatic Change, 73, DOI:https://doi.org/10.1007/s10584-005-6956-2), early wind speed observations have some uncertainty related to the fact that these observations were not instrumental (this uncertainty depends on multiple factors such as the evolution of the language, the observer nationality, etc.). In order to avoid this uncertainty, we used directly the raw ICOADS database which contains every individual observation of wind speed and direction separately. We did not use the speed observation in order to design an index exclusively based on wind direction. We needed to envision a method to aggregate the wind direction data producing an index significantly related with the strength (speed) of the Choco Jet. Our calibration against NCEP/NCAR data for the 1948-2014 confirmed that the CHOCO-D is significantly related with the wind speed at the core of the Choco Jet. The advantage of our approach is that we can compute an index for the Choco Jet since long before anemometers were widely available. The "instrumental" errors in the original wind directions are unknown, but early wind direction measurements were usually taken making use of a 16 or 32-point compass. They can be corrected for magnetic declination and they are regarded as precise as the equivalent modern ones (Barriopedro et al., 2013, Clim. Dyn, DOI: https://doi.org/10.1007/s00382-013-1957-8). We assumed that the raw observations were essentially free of error. In this regard, recent research demonstrates that this is a trustworthy assumption, as small changes in historical wind direction contained on ICOADS have been even used to quantify subtle details of the atmospheric circulation, as it is the case of the date of the Indian Summer Monsoon onset (Ordoñez et al, 2016, J. Climate, doi:10.1175/JCLI-D-15-0788.1, 2016). Notwithstanding, even assuming that the original observations are precise, early observation networks were spatially sparser than today's, and for years prior to the 1930's one is forced to compute the CHOCO-D from a relatively small sample of measurements. Incidentally, the number of observations does have an effect on the index uncertainty. Because of this, we developed a method to estimate this uncertainty as the expected standard deviation of the CHOCO-D index as a function of the number of observations available each month. Typical uncertainties of the CHOCO-D index range between +/- 15% (end of the 19th Century) and +/- 6% (late 20th century) (see Figure 4 of our original manuscript). These concepts were included in our original manuscript, but we will clarify them in the revised version. In particular we will expand our explanation of the characteristics of the observations, the procedure to compute the uncertainty of the CHOCO-D and the interpretation of the error-bars in Figure 7. Regarding the merging of ICOADS and NCEP reanalyses commented by the referee, it is worth noting that our index has been exclusively computed from ICOADS wind direction observations. NCEP/NCAR data are uniquely used to calibrate the index, but both databases are never mixed. This characteristic of our method was probably not clear in our original manuscript, since both referees have expressed comparable concerns about this issue. In our revised manuscript we will explicitly incorporate a discussion on this topic, making particular emphasis on the homogeneity of our index. It is the use of ICOADS as our single data source, what makes the CHOCO-D particularly adequate to estimate long term trends and changes in correlations. Finally, it is suggested that the explanation of the relation between El Niño and the CHOCO-D should be improved. This point has also been raised by referee #2. In essence, the Choco Jet can be seen as the final stretch of a low level wind current that starts in the Southern Hemisphere trade wind belt. North of the equator, the change in the sign of the Coriolis term, deflects the current to the east, entering northern South America at 5°N as a low level westerly jet. Concerning the relation with ENSO, the weakening of the trade winds characteristic of a developing El Niño event is accompanied by a subsequent decrease in the trades and thus in the Choco Jet. Therefore, positive SST anomalies associated with an El Niño event (Niño3.4>0) are concurrent to weak Choco jets (standardised CHOCO-D index<0) and the negative correlation we found in Figure 9 was expected. We consider important, as suggested, to clarify this point in the revised paper and further stress the novelty of our result (the stability of the relation for long periods). Additionally, new in-phase and out of phase correlations will be added in this point in response to the concerns expressed by referee #2 further improving the ENSO-Choco Jet section (please see also our response to the last question in this document).

Minor and major comments are included directly in the PDF version of the paper.

RESPONSE: A number of the comments included in the supplementary material (annotated manuscript) have to do with the origin of the data or the uncertainty and physical meaning of the ENSO/Choco Jet relation. They have been partly answered in the previous paragraphs. Other comments are formal corrections/considerations/erratum that can be easily implemented in the revised paper (we thank the referee for his/her detailed review). In the following lines, we respond to other considerations included in the supplementary material not yet fully answered:

Page 3, line 19. To the best of our knowledge, the first work explicitly referring to the "Choco Jet" as such, was published by Poveda and Mesa (1999). We will add this precision and the corresponding reference in the revised paper.

Page 3, lines 20 and 23: The Choco Jet modulates the moisture transport from the Pacific into large parts of Central America and northern South America. In some areas, the resulting precipitation can exceed 10,000 mm per year. Characterising the long term variability of the system responsible of the moisture transport toward one of rainiest places on Earth is quite relevant from a climatological point of view. This idea will be stressed in our revised version.

Page 3, line 27 and page 4, line 24: Most of the raw wind force observations were codified using the Beaufort scale. However this was not always the case. It was frequent the use of not standard language or the inclusion of modifiers which are hard (uncertain) to convert into numbers. This is why we decided to develop an index based only on wind direction. Of course, we lose some information, but the one we maintain is free of the uncertainty associated to the observational procedure. In our revised text we will clarify this concept by expanding our description of the data source.

Page 4, line 30. The CHOCO-D index is not sensitive to changes in the percentage in the order of +/- 15%. We will change our phrase "...proves that the CHOCO-D index is scarcely sensitive to changes in the percentage..." to "...shows that variations in this optimal percentage of up to +/- 15% produces only minor changes in the resulting CHOCO-D..."

Page 5, line 5: That's correct, the double maxima is related with the meridional migration of the ITCZ. In the revised version we will change our introduction to incorporate a complete explanation of the climatology of the region in which we will explicitly include the relation of the jet with the ITCZ. Page 6, line 7: Positive and negative phases of the CHOCO-D are defined as months with a CHOCO-D index below/above one standard deviation of its average value for the 1901-2013 period. We will clarify this definition in the revised text.

Page 6, line 24: We meant "eastern Pacific" instead of "Pacific". We'll correct it in the revised version.

Page 7, line 1: We checked the possible relations of the CHOCO-D with NAO, AMO, PDO and ENSO. We only found consistent correlations for the latter, so we decided to limit our discussion to the link between ENSO and the Choco Jet.

Page 7, line 20: In response to the "veracity" of the climate shift that shows the CHOCO-D around the 1930s, this is an extremely difficult issue to judge. We would need comparable reconstructions at monthly resolution to compare with. For the moment, the only independent observational series that we could use to test our finding is the precipitation. As shown in figure 8 of our original manuscript, we found, at least, a change in precipitation consistent with the shift we found in the CHOCO-D. However, this comparison is also problematic. First because the precipitation associated to the Choco Jet it is estimated to be around 30% of the total precipitation (Duran-Quesada et al 2010, J. Geophys. Res., 115, doi: 10.1029/2009JD012455), so any shift in the

Choco jet would be only responsible of a part of the total precipitation variability. Second, because precipitation series in the first decade of the 20th century in northern South America are quite scarce. However, for the first time, there is a continuous series of the strength of the Choco Jet lasting more than a century, and we considered interesting to include a short discussion on this topic. We hope this could trigger new research.

Page 9 line 9: The main implication of being able to construct an index for the Choco Jet without using the wind speed is the possibility of quantifying the variability of this system for years prior to the mid-20th Century in a homogeneous form. This is probably the central point of our research.

Page 9 line 24: We do not mix reanalysis and ICOADS data. We exclusively use ICOADS to generate our index. Reanalysis is only used to calibrate the new CHOCO-D index for the 1948-2014 period. In this regard, we are pretty sure about the homogeneity of our series. However, the CHOCO-D has some uncertainty related to the number of observations, as previously indicated. This uncertainty is discussed in the original manuscript, but in Figure 7 of our original manuscript it is not completely clear the relevance of the error-bars. We will enhance the presentation of this uncertainty in the revised version.

Page 9, line 34: This is a relevant point. In our work, the stability of the teleconnection patterns is evaluated without using reanalysed datasets. Both El Niño3.4 and CHOCO-D series are instrumental and independent. Although both series have some uncertainty, they are quite adequate to analyse changes in the ENSO-Choco Jet relation at decadal scale. This idea will be clarified in the revised paper.

Page 23 (Figure 9 caption): We concur. Our original Figure 9 is probably not clear enough and the implications for the ENSO-Choco Jet relationship can be improved. We have performed a more complete analysis (including other lagged correlations) that completes our discussion (Figure 1 below). In summary we have computed the following correlations: El Niño index (JJA and DJF+1) vs. CHOCO-D (JJA); and El Niño index (JJA and SON) vs. CHOCO-D (SON). We found that a weak jet in JJA tends to be followed by SST increases (El Niño conditions) the following winter and that these negative correlations are also found for the in-phase JJA series. The relevant result here is that these relations have been remarkably stable along the 20th century. On the other hand, we found that a weak jet during SON is also typically concurrent to in-phase warmer SSTs, while warm SSTs during JJA tend to be followed by a weaker jet. For this extended analysis we have found that the stability of the relations involving the SON-averaged CHOCO-D has changed along the 20th century, being clearly weaker prior to the 1930s. This finding is probably related to the shift from negative to positive anomalies around the 1930s we found for the September and October CHOCO-D series (see Figure 7 of our original manuscript). We consider these results quite relevant for stimulating future research, so we will include this discussion in the revised paper, replacing Figure 9 with the new Figure 1 in this document.

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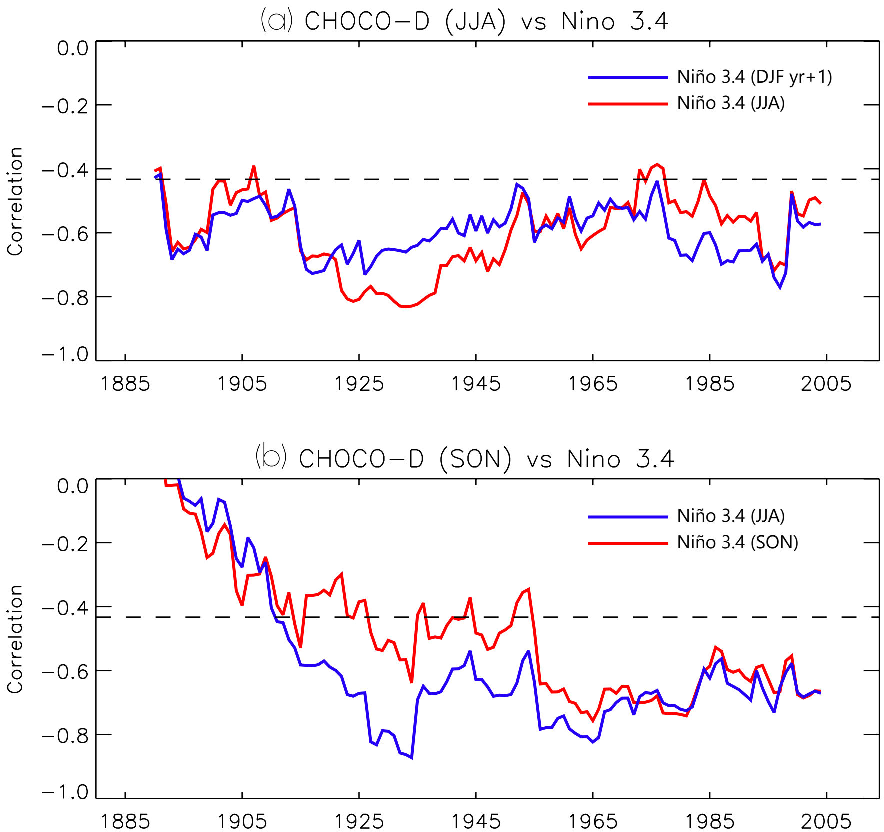

Fig. 1. 21-yr running Pearson's correlation coefficient between CHOCO-D and El Niño3-4 for in-phase and lagged cases.