Earth Syst. Dynam. Discuss.,
https://doi.org/10.5194/esd-2018-54-RC2, 2018

Earth System Dynamics Discussions

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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Received and published: 1 November 2018

General Comment.

I commend the authors for their interest in this relevant and singular feature (westerlies!) within the low-level atmospheric circulation over the tropical far eastern Pacific. In particular, I find it very relevant their objective of tracking the Choco jet since the 19th Century using historical wind observations, by introducing and computing the so-called CHOCO-D index. That said, I think that the manuscript is far from being ready for publication in Earth Syst. Dynam., and that major and minor comments need to be dealt with in detail in the revised version.

Major Comments:

1. The Choco low-level jet (LJJ) was introduced in the literature as one of the mechanisms that contribute to explain the existence of one of the rainiest regions on Earth over the Pacific coast of Colombia (Poveda et al., 1998; Poveda & Mesa, 1999a, 1999b, 2000). In particular, the locality of Lloró witnesses mean annual rainfall rates on the order or 13,000 mm, with years such as 1974 with 26,000 mm. Such world-record breaking rainfall intensity would not be possible were if not for the large amounts of moisture transported by the Choco jet into the Colombian Pacific coast. The original Choco Jet was defined at the region between 2°N-8°N and 80°W [77°W-82°W], either using the averaged horizontal zonal wind velocities or the transport of moisture by the zonal winds (Poveda et al., 2006, Rueda and Poveda, 2006) at 925 hPa, the vertical location of its core, as it is constrained between 1000 and 850 hPa. As referred to by the authors, more recent studies have shown that the Chocó Jet is an important mechanism of the Central American isthmus weather and climate. Within that geographical region, the Choco Jet satisfies all the criteria mentioned by Stensrud (1996) to identify a low-level jet.

2. Also, the geographical region associated with the original Choco Jet allowed to differentiate it from the activity of the Caribbean LLJ, at the time referred to as the San Andres LLJ (Poveda and Mesa, 1999a, 2000) given that it crosses over the San Andres archipelago in the Colombian Caribbean. Figures 1 and 2 show, respectively, the distribution of the zonal and meridional components of the horizontal winds at 925 hPa over the far eastern Pacific, northwestern South America and the southwestern Caribbean Sea. It can be seen that that the region is crossed by the westerly and easterly winds of both jets (Figure 1), but also by meridional winds associated with both jets (Figure 2). Furthermore, the original Choco Jet was also constrained vertically, given that the westerly wind flow was evident from 1000 to 850 hPa, but also to differentiate its dynamics from the mid-tropospheric jet (700-600 hPa) (Hastenrath,1991, 1999; Poveda and Mesa, 1999a, 1999b, 2000) which is also seen in Figures 3 to 6.

3. This previous introduction was deem necessary to point out one of the major

concerns with the manuscript, regarding the region defined for the newly introduced CHOCO-D index: the area [4° N-15° N; 120° W-84° W] plus the area [4° N - 9° N; 84° W-77.5° W]. Such region mixes up regions influenced by the opposite seasonal dynamics of both the Choco and the Caribbean LLJs. In particular, during December-January-February (DJF), the easterly Caribbean LLJ crosses the Mesoamerican isthmus, and three distinct wind jets form across the major gaps of the Central American mountain range in the Gulfs of Tehuantepec, Papagayo, and Panama (Chelton et al., 2000; Xie et al., 2005; Serra et al., 2010; Poveda et al., 2014).

4. Therefore, I think it is a mistake to state that the Choco Jet constitutes a monsoonal circulation. What is really going on is a "tug of war" between two different LLJs acting over the proposed region through the seasonal cycle. As defined originally, the Choco Jet does not reverse once a year as evidenced in Figures 1 and 2. Furthermore, Figures 3 to 6 show the vertical distribution of the zonal winds at 80° W between 5°S and 15°N, using data from four different reanalysis: NCEP/NCAR, ERA-Interim, MERRA2, and 20th Century V2c Reanalysis. All of them confirm that the original Choco Jet maintains its westerly direction and a very well-defined seasonal variability. Therefore, we are not in the presence of a monsoonal circulation but of two different LLJs acting over the region simultaneously. The situation is even more complex, given that during the DJF season the Caribbean jet, after crossing over the Panama Gulf gets merged with the Choco Jet and then inland over western Colombia (Poveda and Mesa, 1999a; 2000; Sakamoto et al., 2011; Poveda et al., 2001, 2006, 2014).

5. Besides the mentioned shortcomings of the chosen region, the definition of the CHOCO-D index is based upon criteria defined by the NCEP/NACR reanalysis. Figures 3 to 6 show that the different reanalysis capture the seasonal cycle of the Choco Jet, albeit with different core velocities, range of extent of peak velocities, and zonal wind velocities at 850 hPa (top of the Choco LLJ), also shown in Table 1.

6. Also, I find it confusing to discuss the dynamics involved from a summer-winter perspective, given its very equatorial setting. The area proposed for the new CHOCO-

D index also mixes up regions whose annual rainfall regime is bi-modal (as per the passage of the Intertropical Convergence Zone), and unimodal as per their location on the northern hemisphere.

7. Lines 18-19. "In the case of precipitation, monsoonal areas are usually demarcated as those where the local summer minus winter precipitation rate exceeds 2 mm day-1."

Comment: Again, the consideration of summer and winter precipitation is misleading here, since this area contains regions exhibiting a bi-modal annual cycle of rainfall owing to the meridional oscillation of the ITCZ, passing twice per year over this region, but also regions with uni-modal annul cycle of rainfall.

8. Lines 28-29: ". . .it is necessary to identify regions where the monsoonal wind reversal found at the 850 hPa level is also found at the surface."

Comment: This is not the case of the Choco Jet as shown in the mentioned reanalysis.

9. Line 32: ". . .in a 2.5° x 2.5° grid where the last release of the ICOADS database currently has two or more wind direction observations per month for the summer months for at least 90 years in the 1900-2014 period."

Comment: Such spatial resolution seems too gross to perform detailed analyses of this LLJ.

10. Lines 13-14, p. 3. "CHorro del Occidente COlombiano" (Western Colombian Jet) and as the place name "Chocó", one of the Colombia's regions most affected by this wind reversal."

Comment: There is no wind reversal in the Choco Jet as shown by the different reanalyses.

11. Lines 14-16. Between May and November, the winter wind regime characterized by predominant north-easterly winds in this part of the world is replaced by south westerlies at low levels".

Comment: Again, it does not seem appropriate to talk about winter wind regime over this tropical region, since the winds are quite different during MAM, when the ITCZ is heading in a northward direction, while in SON the ITCZ is heading in a southward direction.

12. Lines 17-18. "... and it has a profound impact on the western coast, from Costa Rica to northern Colombia, which, as a result, are among the rainiest places on earth (Poveda et al., 2014)."

Comment: This is quite true. Perhaps the community needs to be aware that this world record breaking rainy region has been recognized in the literature since long: Murphy (1939), Schmidt (1952), Trojer (1958), Arnett and Steadman (1970), Snow (1976, p. 371), Meisner and Arkin (1987), Eslava (1993, 1994), Janowiak et al. (1994), Poveda and Mesa (1999a, 2000), Jaramillo et al. (2017), King et al. (2017), among others.

13. Lines 27-29, p. 4: "This percentage was set as the one maximizing the average correlation between June and October for the 1948-2014 period with the NCEP/NCAR monthly zonal wind at 925 hPa averaged over the area [5° N-7.5 $^\circ$N; 90° W-80° W], which is considered a good representation of strength of the Choco jet core (Poveda and Mesa, 2000)".

Comment: Again, restricting analysis to June-October is misleading since the Choco Jet is permanent (although seasonally-variable) throughout the year.

14. Figure 3 caption. "Numbers over the CHOCO-D values indicates the monthly correlation between both series for the 1948-2014 period."

Comment: The mean annual cycle of the new proposed index shows easterly (negative) winds from January to April, which is not the case for the original definition. No wonder why the lack of correlation between the newly proposed index and the original one.

15. Also Fig 3 caption: "... b) Standardized temporal series (June to October average)

of the CHOCO-D index and the NCEP-NCAR zonal wind at 925 hPa averaged over the [5° N-7.5° N; 90° W-80° W] (blue dashed line)."

Comment: Again, June-October is not completely appropriate to judge the newly proposed index.

16. Lines 12-13, p.5: "These values indicate that the CHOCO-D captures a significant part of the variability of the zonal winds at the core of the Choco jet."

Comment: Please quantify correlation among these two series and p value.

17. Line 23, p.5: "... as a function of N between May and November is shown in Fig. 4 for the period 1971-2010."

Comment: Again. May-November is not an appropriate period for this Equatorial region, since it contains winds from two different LLJs exhibiting opposite directions depending on the month of the year.

18. Lines 14-15, p. 6: "The connection of these rainfall anomalies with the moisture advection has been assessed by computing the vertically integrated moisture transport through the 1000-700 hPa levels and the corresponding moisture convergence (Fig. 6)."

Comment: The original westerly Choco jet is confined between 1000 and 850 hPa as shown in Figures 3 to 6. Above 850 hPa the winds are clearly easterlies, and therefore the 1000-700 hPa layer contains winds from opposite directions.

19. Lines 24 and 25, p. 7: "Ultimately the Choco jet originates in the southerly trade winds, making it strongly dependent on the meridional SST gradient along the Eastern Equatorial Pacific (Martinez et al., 2003)."

Comment: Please acknowledge that this explanation was originally introduced by Poveda and Mesa (1999a, 2000), and has been further discussed by Poveda et al. (2001, 2006 and 2014).

20. Last line, p. 7 and first line p. 8: “Figure 9 shows the correlation of the CHOCO-D index between July and September and the following El Niño3.4 index (December to February of the following year) for variable timescales.”

Comment: I find it difficult to understand why the authors estimate seasonal lagged-correlations between the newly proposed CHOCO-D index and the following El Niño3.4 index. It would make much more physical sense to estimate the simultaneous and lagged (El Niño index leading, instead of lagging) seasonal correlations among El Niño3.4 index and the CHOCO-D index. Another point worth commenting is the selection of the seasons. I suggest estimating the simultaneous and lagged correlations for the following cases: El Niño index (JJA) vs. CHOCO-D (JJA), El Niño index (JJA) vs. CHOCO-D (SON), El Niño index (SON) vs. CHOCO-D (SON), El Niño index (SON) vs. CHOCO-D (DJF, year +1), and El Niño index (DJF, year +1) vs. CHOCO-D (DJF, year +1).

21. Lines 18-19, p.8: “This is because the exceptionally large latitude range where the monsoon-like changes in the wind direction can be related to the Choco jet.”

Comment: This is one of the problems of the manuscript. Changes in the wind direction are not solely related to the Choco Jet, but to the dynamics of the Caribbean LLJ over such a wide region.

22. Lines 7-8, p.9: “This structure explains the excellent response of the CHOCO-D to the seasonal march of the Choco jet.”

Comment: This seems to be an overstatement as per results shown in Figure 3a.

Minor Comments:

1. Line 23, p.6: Change pacific for Pacific.

2. Line 28, p. 7: “In this way, a year with weak (strong) jet tends to be followed by El Niño (La Niña) conditions.”

Comment: For the sake of clarity, I suggest rephrasing this sentence as: In fact, the transport of moisture by the jet is weakened during El Niño events, and enhanced during La Niña events (e.g. Figure 9 of Poveda et al., 2006).

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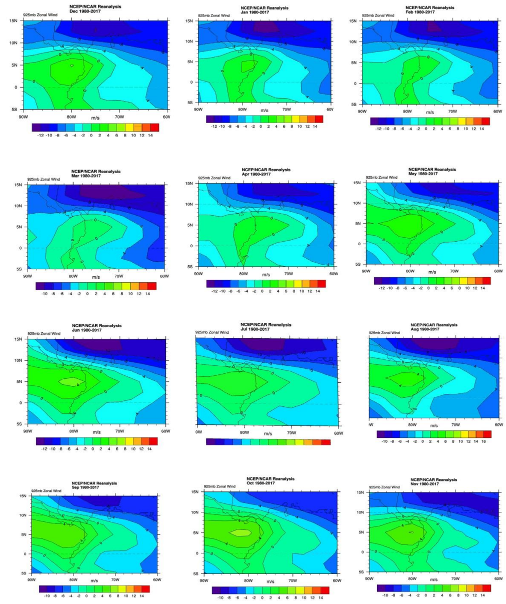

Fig. 1. Annual cycle of the monthly average (1980-2017) zonal winds at 925 hPa over the far eastern Pacific, northwestern South America and the southwestern Caribbean Sea. Data source: NCEP/NCAR Rea

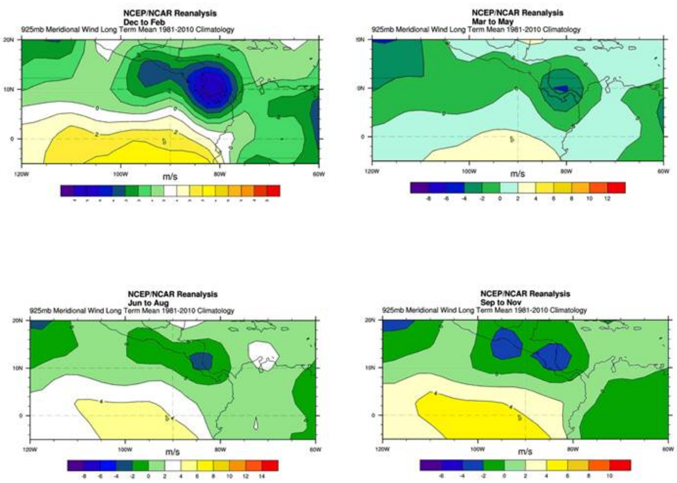

Fig. 2. Annual cycle of the monthly average (1890-2017) meridional winds at 925 hPa over the far eastern Pacific, northwestern South America and the southwestern Caribbean Sea. Data source: NCEP/NCAR Reanalys

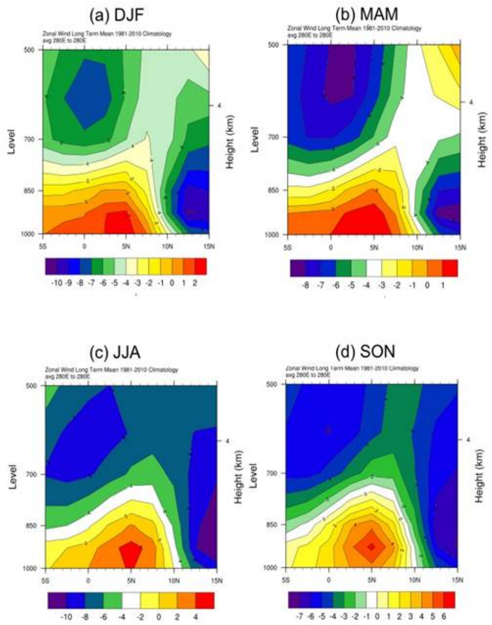

Fig. 3. Height-Latitude cross sections of the seasonal long-term mean (1980-2010) zonal winds as seen by the NCEP/NCAR reanalysis.

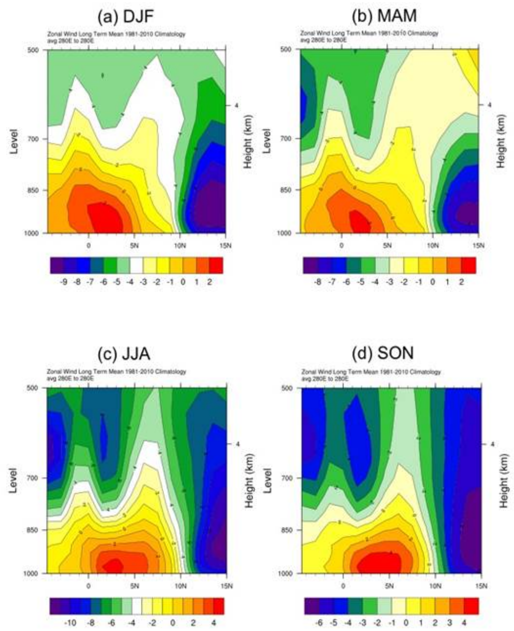

Fig. 4. As in Figure 1 for the ERA-Interim Reanalysis.

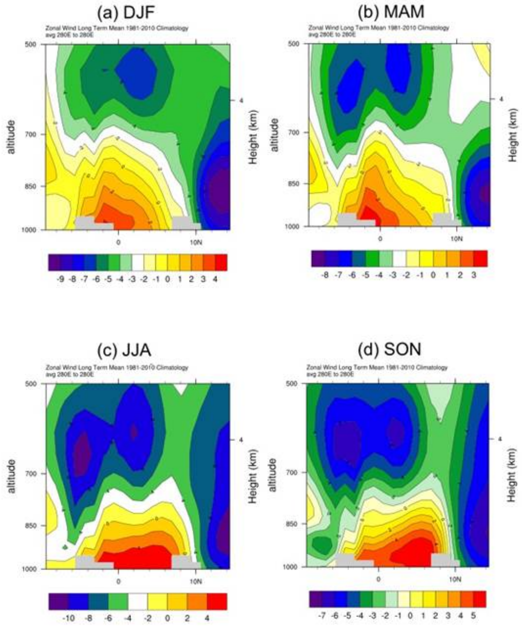

Fig. 5. As in Figure 1 for the MERRA-2 Reanalysis.

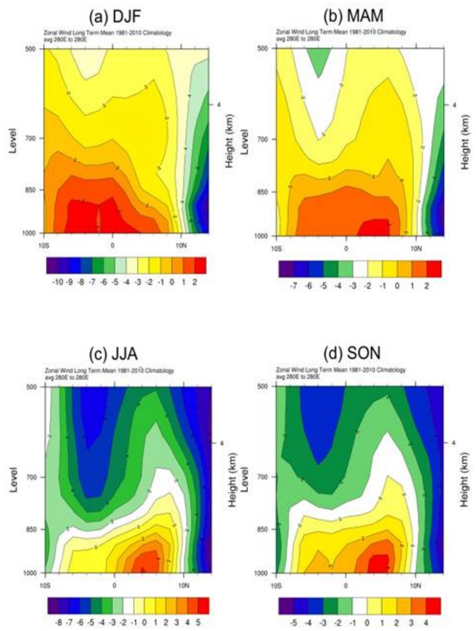

Fig. 6. As in Figure 1 for the 20th Century Reanalysis V2c.

Table 1. Seasonal characteristics of the Choco Jet as seen by diverse reanalysis, including location of the core, maximum velocity at the core and latitudinal extent of such velocity, and velocity at 850 hPa.

	Core Location				Max Velocity and Latitudinal Extent				Velocity at 850 hPa (m/s)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
NCEP-NCAR	4°N	4°N	5°N	5°N	2-3 m/s 3.5-6°N	1-2 m/s Eq. to 7°N	3 m/s 4.5 to 5.5°N	6-7 m/s 3 to 7°N	0	1	3	2
ERA-Interim	2°N	2°N	3.5°N	4°N	2-3 m/s 1°S to 5°N	2-3m/s Eq to 5°N	5 m/s 1°N to 6°N	5 m/s 2°N to 6°N	2	2	0	2
MERRA2	2°S	1°S	3.5°N	5°N	4-5 m/s 3°S to 2°N.	3-4 m/s 3°S to Eq.	4-6 m/s 3°S to 8°N	5-6 m/s 2°N to 7°N	2	2	3	4
20th Century Reanalysis V2c	2°S	4°N	4°N	5°N	2-3 m/s 7°S to 4°N	2-3 m/s 2°N to 6°N	5-6 m/s 3.5° to 4.5°N	4-5 m/s 3°N to 6°N	1-2	1-2	2	2

Fig. 7. Table 1