On the variability of the Caribbean low-level jet during winter: revisited

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1. Background and Objective

The **Caribbean low-level jet (CLLJ)** is a strong wind current over the Caribbean Sea (Fig. 1). Annually it has two peak periods, with February (winter) and July (summer). The CLLJ is an important element for the climate and weather of the Central America region, due to its association with the convective activity and moisture transport from the Caribbean sea to the continental Central America. The variability of the jet and its association with climate variability modes is still little understood.

Objective: to establish what are the most important climate variability modes during winter, and characterize the mechanisms connecting the anomalies of the jet with the fluctuation of such modes.

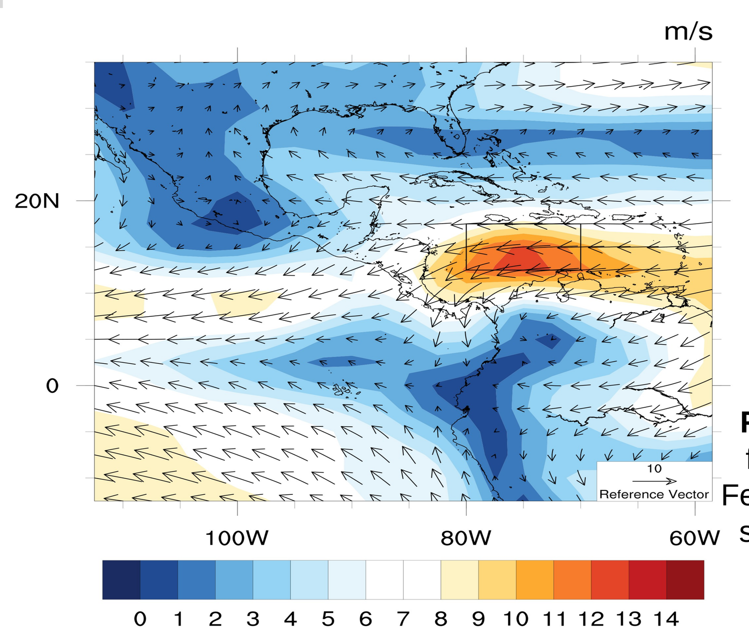

Figure 1. Horizontal wind at 925 hPa from NCEP/NCAR reanalysis during February. The colors represent the wind speed. The square shows the area in which the CLLJ index is defined.

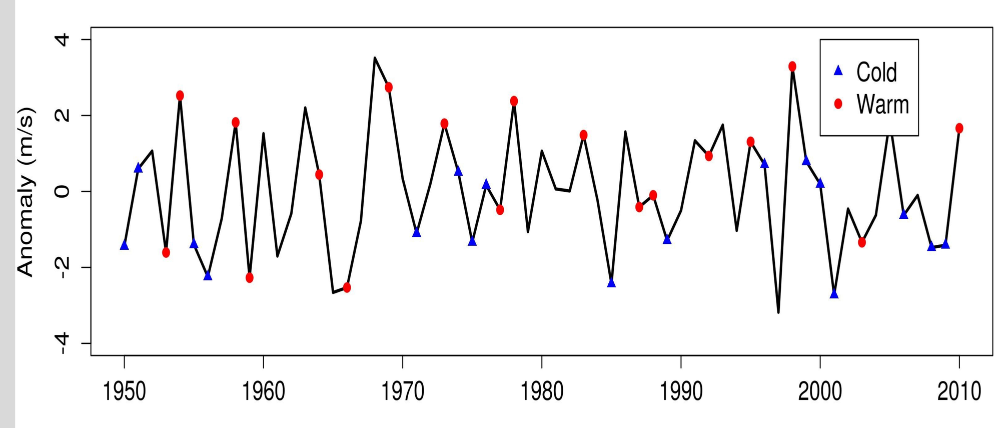

Figure 2. February time series of the CLLJ 1950-2010. Red (blue) circles (triangles) are warm (cold) ENSO episodes according to the Oceanic Niño Index (ONI*).

2. Data and methods

The horizontal wind and SLP products from the NCEP/NCAR reanalysis, and the ERSSTv3 from NOAA are used. The base period for the climatologies is from 1950-2010.

A **CLLJ index** is defined as the area average of the monthly anomalies of the zonal wind at 925 hPa, in the region bounded by 12.5° – 17.5° N and 80° – 70° W (Fig. 1 and 2) for the period 1950-2010. Note that some of the fluctuations in Fig. 2 can be related with El Niño episodes.

SST and **SLP monthly anomalies** are calculated for the domain (-22° – 63° N and 180° W – 15° E) shown in Fig. 3. Notice that this domain encloses some of the most important global climate variability indices such El Niño, the Pacific North America pattern (PNA), Pacific Decadal Oscillation (PDO), North Atlantic Oscillation (NAO) and Atlantic Multidecadal Oscillation (AMO).

Mean monthly anomalies of the composites of El Niño events and PDO phases were used to explain the correlations between CLLJ anomalies index and the modes, and to compare the main differences observed in anomalies of the CLLJ during winter.

3. Results

Correlations with SLP and SST anomalies: Fig. 3 shows the correlations between the CLLJ index and the anomalies of SLP (left) and SST (right). It is found that:

- The correlation pattern observed in both shores of the North America continent reveals that variations in the jet intensity are out of phase with the fluctuations of the SLP over those regions;
- SLP anomalies in those regions might be related to the PNA pattern, El Niño episodes and PDO phases;

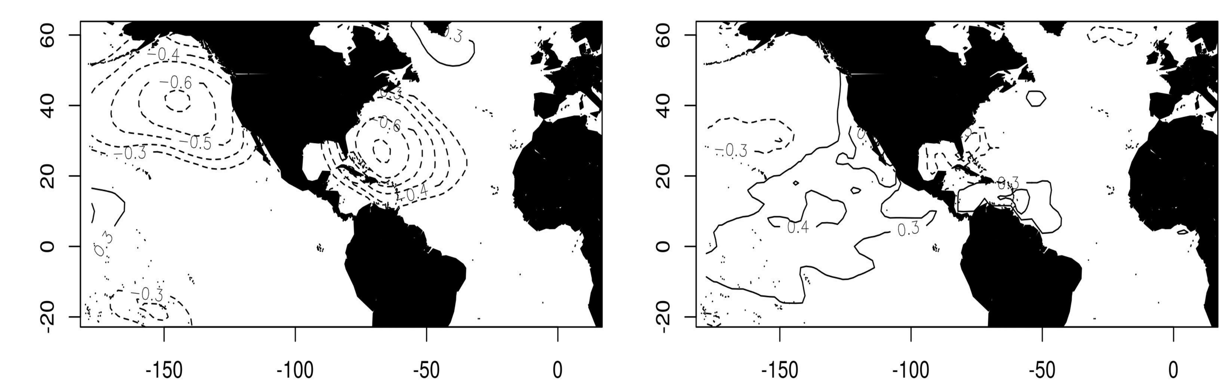

Figure 3. Correlations of the CLLJ index with the anomalies of SLP (left) and SST (right) in February. Only correlations greater than 0.3 and within the 95% of confidence level are plotted. The contour levels are each 0.1, and the positive (negative) contours are solid (dashed) lines.

- Positive correlations with the SST anomalies are found over the Caribbean sea and the west part of the Tropical North Atlantic. These results are easily explained by Ekman transport and atmosphere-ocean dynamics;
- Positive correlations are found over the Pacific Ocean, covering Niño 3.4 region and extending towards the north.

Index	Pearson correlation	p-value
Niño 3.4	***0.36***	<0.01
PDO	*0.22*	0.08
PNA	***0.35***	<0.01
NAO	-0.21	0.10
AMO	-0.02	0.90
CAR	0.13	0.33
TNA	*0.22*	0.09
WHWP	***0.31***	<0.01
MJO	***-0.40***	<0.01
CF	***0.44***	<0.01

Table 1. Correlations between the CLLJ index and some climate variability indices in February. Significance levels are *0.1*, **0.05** and ***0.01***.

Climate variability indices: Table 1 shows the results of the Pearson correlation between the CLLJ with some global and regional climate variability indices. Results show that:

- **Significant correlations between the CLLJ index and the Pacific modes were obtained.** The Atlantic modes, however, exhibit low correlation, and the NAO does not shown statistical significance, contrary to previous results.
- Other indices that shown **relatively high and significant correlation** with the **CLLJ** index were the **Madden-Julian Oscillation (MJO)** and **the number of cold fronts (CF)** and surges that reach the Caribbean during February . These indices, however, are associated with perturbations of higher temporal resolution (days, weeks).

- Regional indices such as **TNA** and **WHWP showed statistical significant correlation** that can be related again with the ocean-atmosphere dynamics.

Composites of El Niño

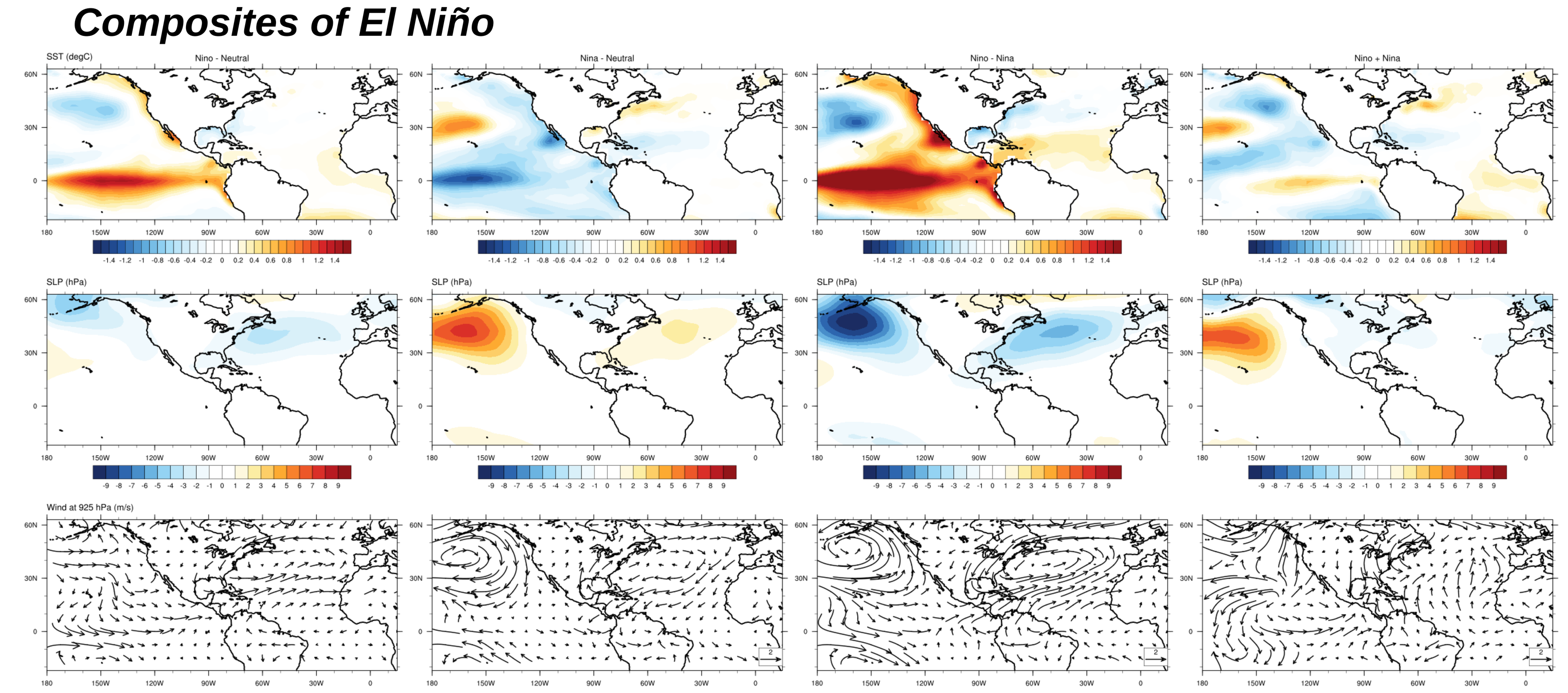

Figure 5. Mean anomalies of composites for El Niño events. Top SST, middle SLP and bottom horizontal wind.

- Composites of El Niño episodes are shown in Fig. 5. Results confirm that, in average during **El Niño (La Niña) episodes, the jet is weakened (strengthened)** due to either an increase of anomalous cyclonic (anti-cyclonic) circulation over the east coast of USA, and/or to a decrease (increase) in the gradient of SLP between the Caribbean and the east coast of USA;
- The **linear effects of El Niño in the SLP anomalies, is the dominant pattern contributing to the fluctuation of the CLLJ**. The non-linear effects of El Niño teleconnections seem not to contribute to the fluctuations of the jet intensity.

Subcomposites of El Niño and PDO

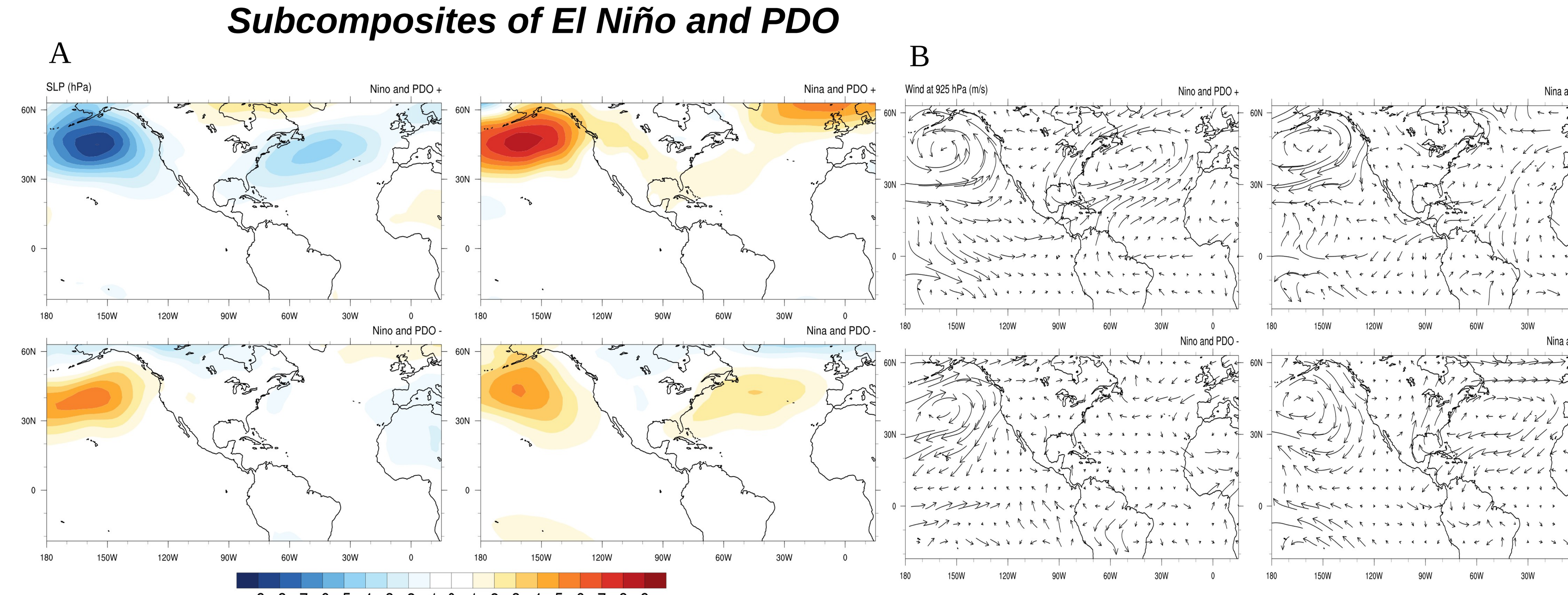

Figure 6. Sub-composites of El Niño and PDO phases for SLP (A) and horizontal wind (B). El Niño and PDO+ (top left) positive, El Niño and PDO- (bottom left), La Niña and PDO+ (top right), and La Niña and PDO- (bottom right).

Sub-composites of El Niño and the PDO phases reveal that:

- **When both modes are in phase, the SLP anomalies behave linearly, intensifying the SLP anomalies** over the North Pacific (Aleutian Peninsula) and the east coast of USA (Fig 6A);
- When both modes are out of phase, the SLP anomalies have a non linear response over the north Pacific (Fig 6A);
- **The CLLJ intensity is affected accordingly to the phases of El Niño and the PDO** (Fig. 6B).

** http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml*