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

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.

2. Data and methods

The horizontal wind and SLP products from the NCEP/NCAR reanalysis, and the ERSSTv4 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°N to 17.5°N and 80°W to 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.

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:

- Significant correlations between the CLLJ index and the anomalies of SLP and SST 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 SLP 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.

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 show statistical significance, contrary to previous results.

- Other indices that show relatively high and significant correlation with the CLLJ index are 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).

Table 1. Correlations of the CLLJ index with some variability indices for February. Significance levels are α=0.05 and 0.01.

<table>
<thead>
<tr>
<th>Index</th>
<th>Pearson correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niño 3.4</td>
<td>0.35</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>PDO</td>
<td>0.22</td>
<td>0.08</td>
</tr>
<tr>
<td>PNA</td>
<td>0.85</td>
<td>&lt;0.01</td>
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<tr>
<td>NAO</td>
<td>0.21</td>
<td>0.10</td>
</tr>
<tr>
<td>AMO</td>
<td>-0.02</td>
<td>0.90</td>
</tr>
<tr>
<td>CAR</td>
<td>0.13</td>
<td>0.33</td>
</tr>
<tr>
<td>TNA</td>
<td>0.22</td>
<td>0.09</td>
</tr>
<tr>
<td>WHWP</td>
<td>0.31</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>MIO</td>
<td>-0.40</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>JF</td>
<td>0.44</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

4. Conclusions

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- 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

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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.

Sub-composites of El Niño and PDO

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 6B).

- The CLLJ is affected accordingly to the phases of El Niño and the PDO (Fig. 6B).