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Abstract:

Sea Surface Temperature (SST) anomalies in the Pacific Ocean in ENSO years display different positions in some years. The identification of a pattern when positive SST anomalies are in central Pacific bounded by negative SST anomalies in eastern and western Pacific resulted in an El Niño type named Modoki. The objective of this study is to analyze the two types of ENSO (Canonical and Modoki) in the four seasons and their influences on South Hemisphere atmospheric circulation and precipitation over South America (SA).

Data and Methods:

Data: SST -> ERSST-V3; precipitation -> CMAP/CAMS

Period: 1979-2009.

ENSO years

- Calculate SST anomalies of four regions in each season (Fig.1);

Modoki ENSO: This method is based on Ashok et al. (2007)

- Calculate EN Modoki index:

$$EMI = [SSTA]_A - 0.5[SSTA]_B - 0.5[SSTA]_C$$

- *Modified ENSO Modoki (M.Modoki):* If the index is bigger (lesser) than $0,7\sigma_M$ and the anomaly of the region A is bigger (lesser) than $0,7\sigma_A$.

Canonical ENSO:

- If the anomaly of the Canonical region (Fig.1) is bigger (lesser) than $0,7\sigma_C$.

SST and precipitation:

- The seasonal fields of the global SST and South America (SA) precipitation are generated for each season defined as Canonical and modified ENSO Modoki.

- Global SST anomalies, SA precipitation anomalies composites of Canonical and modified Modoki years.

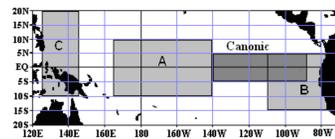


Fig. 1: Pacific regions

| | SON | DJF | MAM | JJA |
|-------------|---|---|-------------------------------------|-------------------------------------|
| ENC | 1982, 1987, 1997, 2002, 2006, 2009. | 1982, 1986, 1991, 1997, 2002, 2006. | 1983, 1987, 1992, 1993, 1998. | 1982, 1983, 1987, 1991, 1997, 2009. |
| ENM | 1986, 1991, 1994, 2004, 2009. | 1990, 1991, 1994, 2002, 2004. | 1991, 1994, 1995, 2003, 2005. | 1991, 1992, 1994, 2002, 2004. |
| LNC | 1984, 1985, 1988, 1995, 1998, 1999, 2007. | 1984, 1988, 1996, 1998, 1999, 2005, 2007. | 1985, 1988, 1989, 1996, 1999, 2007. | 1981, 1984, 1985, 1988, 1999, 2007. |
| LNLM | 1983, 1984, 1988, 1998, 1999, 2000, 2008. | 1988, 1998, 1999, 2000, 2007, 2008. | 1989, 1999, 2000, 2001, 2008. | 1998, 1999, 2008. |

Table 1: Years of Canonical EN/LN (ENC/LNC) and modified Modoki EN/LN (ENM/LNM). The emphasized years occur in the two types of events and are called EN/LN Canonical and modified Modoki (ENCM/LNCM)

Results:

• Table 1:

- Number of Canonical events are similar to M.Modoki, with exception of LN in JJA when more Canonical events than M.Modoki occur.

- All composites are made using the years exposed on Table 1, but without the years which have the two types of ENSO.

• Figures 2 and 3:

- In Canonical years: positive (negative) anomalies in Central and Eastern Pacific, in the occurrence of EN (LN), with the biggest values in the eastern side.

- In M.Modoki years: positive (negative) anomalies in Central Pacific during EN (LN).

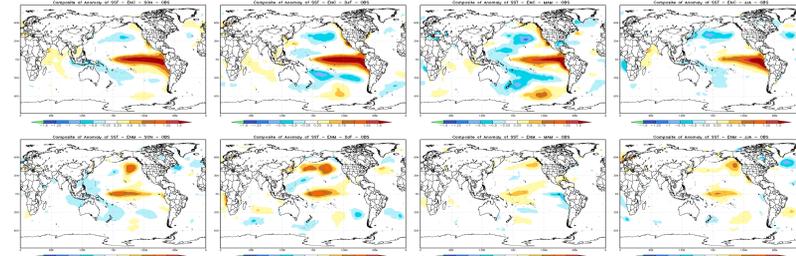


Fig. 2: Composites of SST anomalies during EN season [spring (1st column), summer (2nd), autumn (3rd), and winter (4th)]. Canonical (1st line) and M.Modoki (2nd).

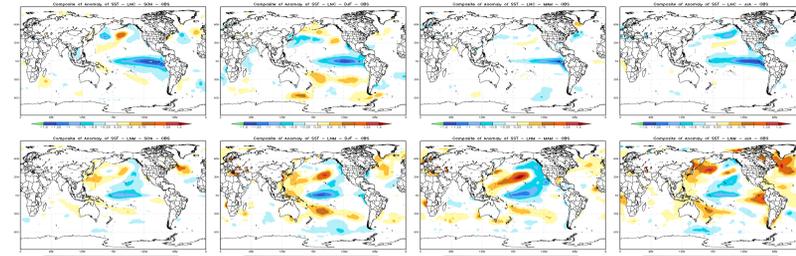


Fig. 3: Composites of SST anomalies during LN season [spring (1st column), summer (2nd), autumn (3rd), and winter (4th)]. Canonical (1st line) and M.Modoki (2nd).

• Figure 4 and 5:

- The seasonal precipitation analyses over SA during Canonical ENSO is coherent with other studies, there are more (less) precipitation than normal over southeastern SA and less (more) than normal over tropical SA;

- Analyzing ENSO M.Modoki:

SON: deficit (excess) of precipitation in eastern SA and an excess (deficit) over the northwestern SA during EN (LN);

DJF: a reduction of precipitation in the whole SA during EN, in central and eastern part of SA during LN, and an increase on northern SA, during LN.

MAM: a reduction of precipitation over the northern sector of southern Brazil, for EN and LN, and on north of Amazon region for EN. An increase of precipitation occur in the ZCIT region, for EN and LN, and in northern Amazon region, for LN.

JJA: don't show any significant pattern.

- The precipitation on southeastern SA is very much influenced by Canonical and M.Modoki ENSO. The influences are opposite between Canonical and M.Modoki events in some seasons, mainly in southeastern and southern Brazil regions.

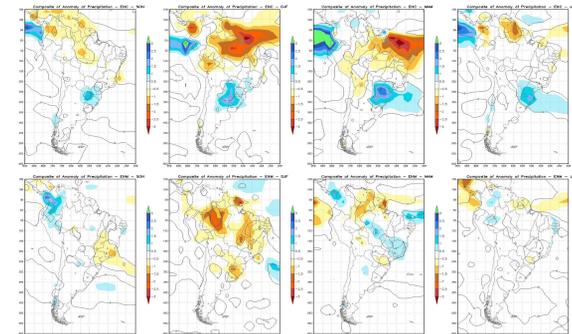


Fig. 4: Composites of anomaly precipitation during EN season [SON (1st column), DJF (2nd), MAM (3rd), and JJA (4th)]. Canonical type (1st line) and modified Modoki type (2nd). The gray lines are 90th percentile of significance

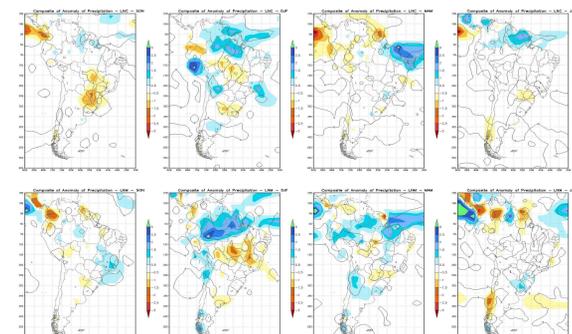


Fig. 5: Composites of anomaly precipitation during LN season [SON (1st column), DJF (2nd), MAM (3rd), and JJA (4th)]. Canonical type (1st line) and modified Modoki type (2nd). The gray lines are 90th percentile of significance

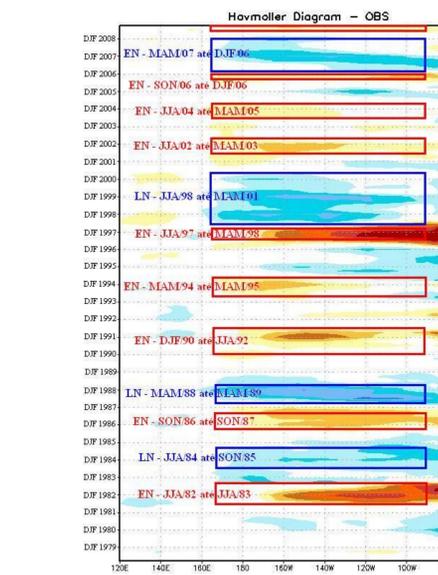


Fig. 6: Diagram of Hovmoller.

• Figure 6:

- The diagram of Hovmoller shows the ASST mean between 5°S-5°N. Compare with Table 1 to identify the two types of ENSO.

- In the majority of years, ENSO begins in JJA;

- Analysing some years (1991/92, 1998 until 2000 and 2007/2008), they show continuous SSTA, but in some seasons they are Canonical events, in others M.Modoki, and even the two events together.

• Figure 7:

- SSTA positive in Canonical region -> increase of precipitation on Southeastern SA and decrease on Northern SA. This happens during Canonical EN.

- SSTA positive in region A -> similar signal to the Canonical region on Northern SA, but over Southeastern SA this happens only during spring and summer.

- EMI positive -> the patterns are different, even opposite, from the previous, mainly in autumn and winter.

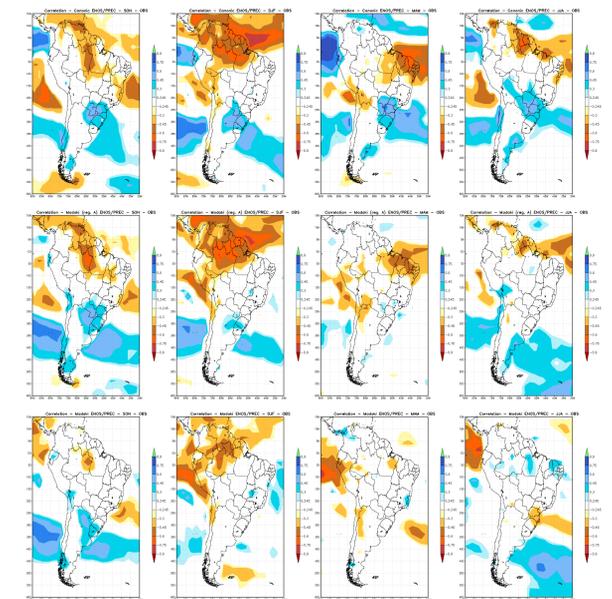


Fig. 7: Correlation between SSTA anomaly [Canonical region (1st line), region A (2nd), Modoki index (3rd line)], and precipitation on South America.

Conclusions:

During 1979 to 2009 almost the same number of Canonical and M.Modoki years occurred, therefore it is important to study both events. Canonical events have been analyzed in several previous studies, and this study aimed to identify the differences and similarities with the Modoki type with respect to the influence on South America.

M.Modoki events have a SSTA center in Central Pacific, but the expected opposite SSTAs bounding this center (Modoki) don't happen in all seasons.

Anomalous precipitation occur over South America during M.Modoki events, mainly over SE and NW of SA.

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