Ministerio del Ambiente
Instituto Geofísico del Perú - IGP

Impacts of different ENSO flavors and tropical Pacific convection variability (ITCZ and SPCZ) on austral summer rainfall in South America, with a focus on Peru

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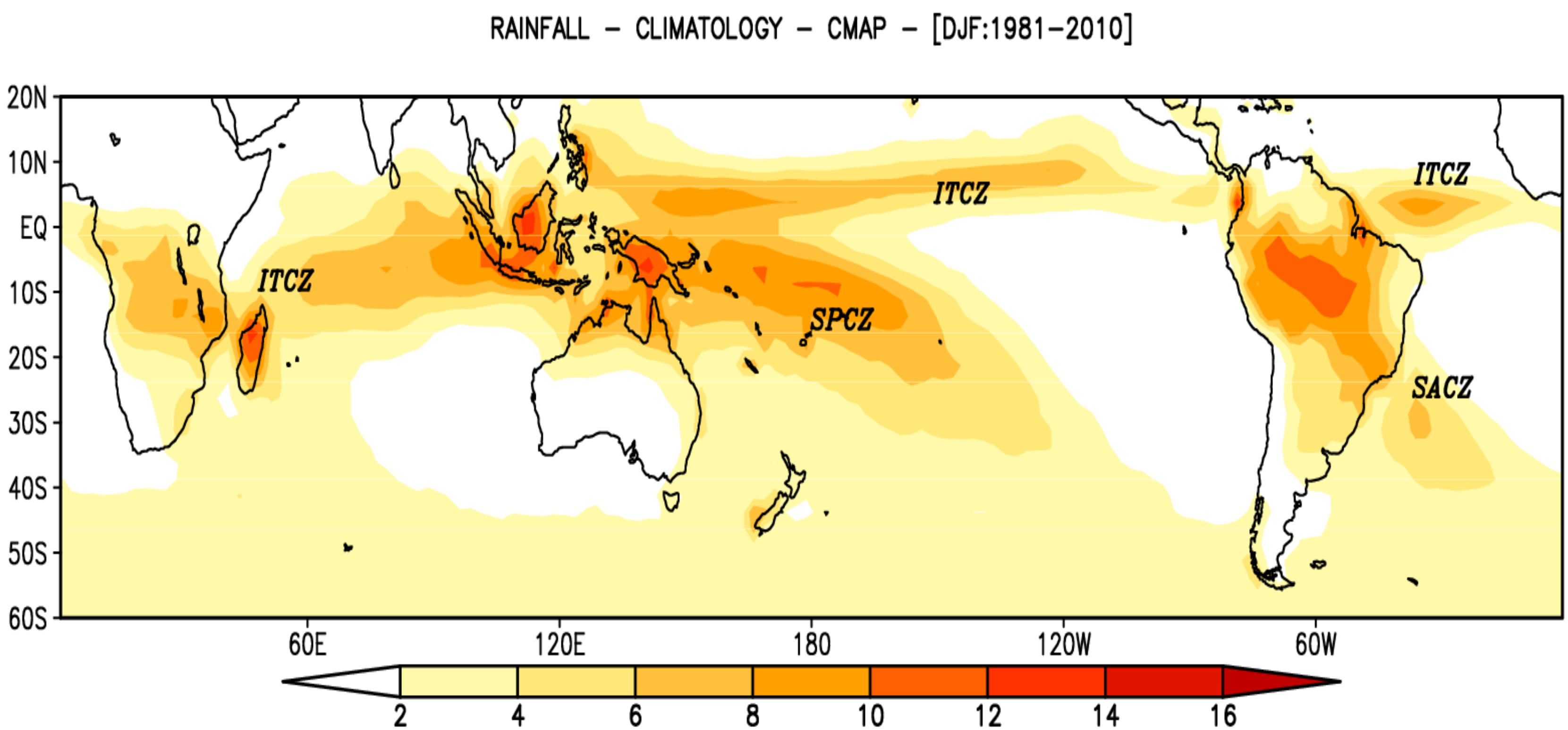
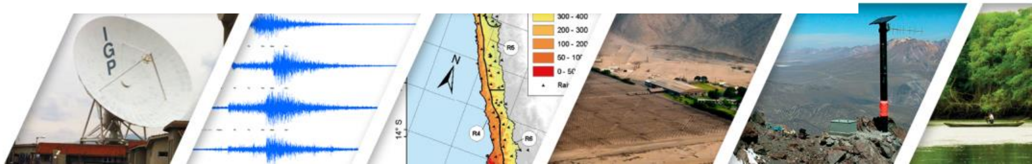
INTRODUCTION

a. DJF - Rainfall of the Southern Hemisphere

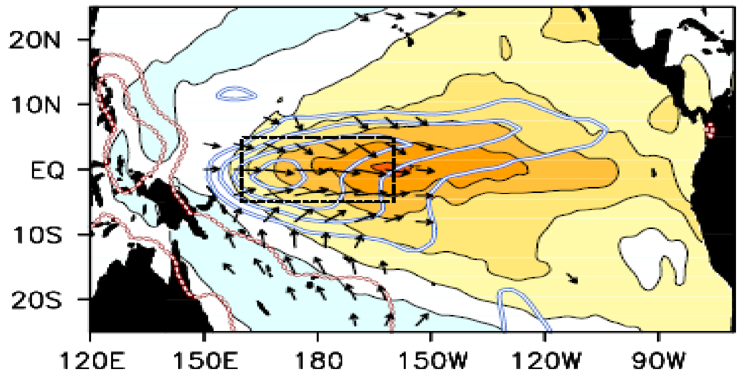


Intertropical Convergence Zone (ITCZ)
South Pacific Convergence Zone (SPCZ)
South Atlantic Convergence Zone (SACZ)

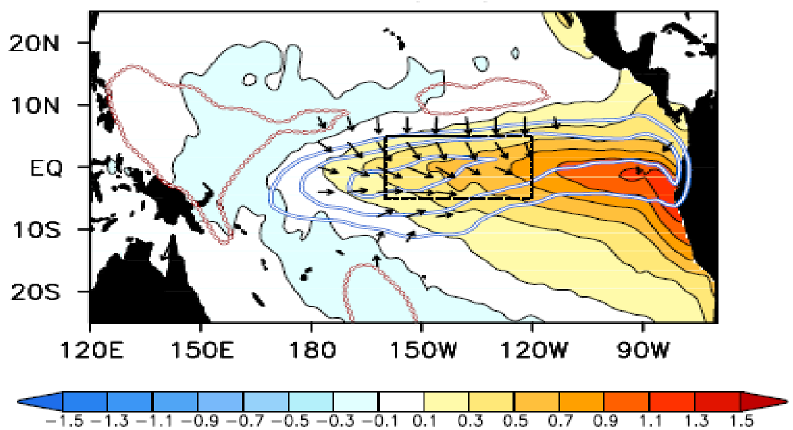


b. El Niño Flavors (C and E)

a) Central El Niño (C)



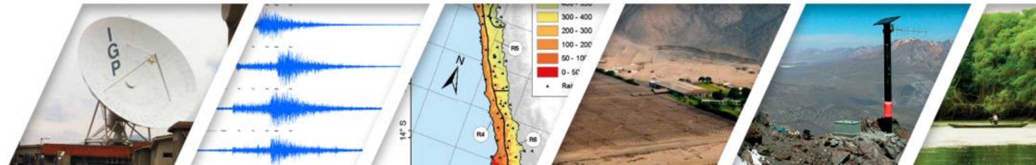
b) Eastern El Niño (E)



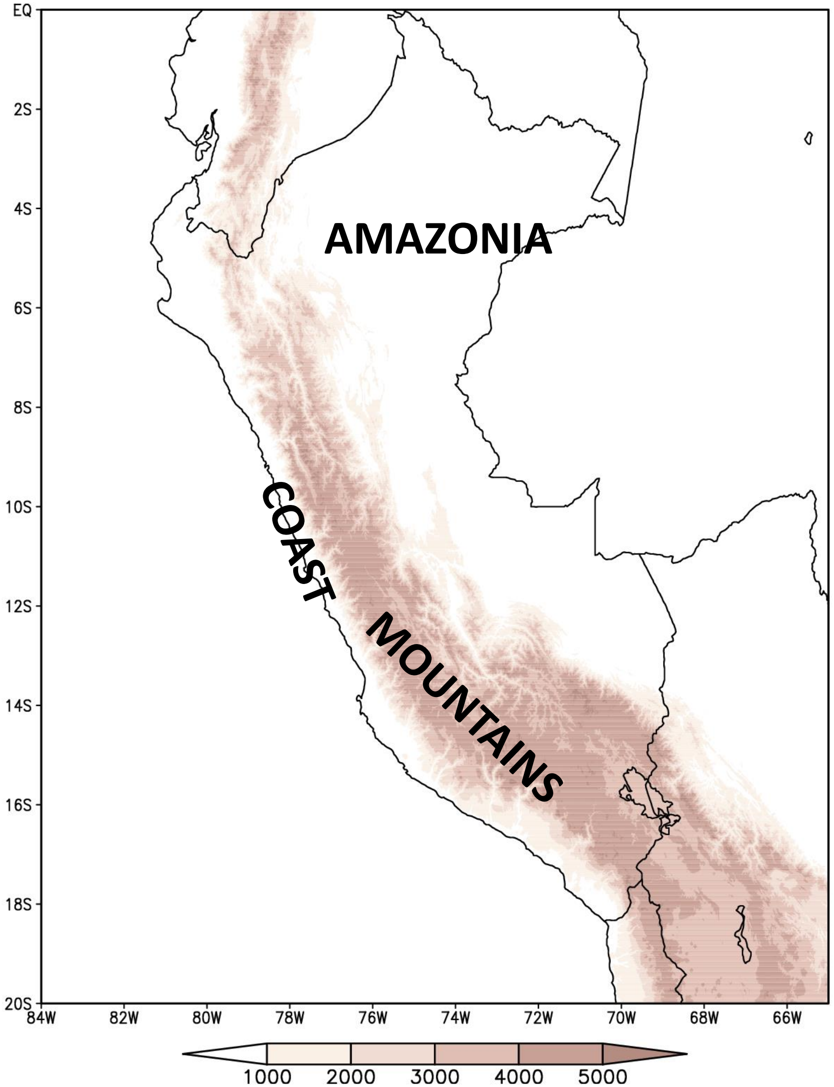
From Takahashi and Dewitte (2016)

a) Central El Niño (C)
Maximum SST, precipitation, westerly wind anomalies and convection activity are observed in the western Pacific Ocean (Fig. a).

b) Eastern El Niño (E)
Precipitation, westerly wind anomalies and convection activity are observed over central Pacific Ocean while maximum SST are located over far-eastern Pacific Ocean (Fig. b).



c. Study Area: Peru

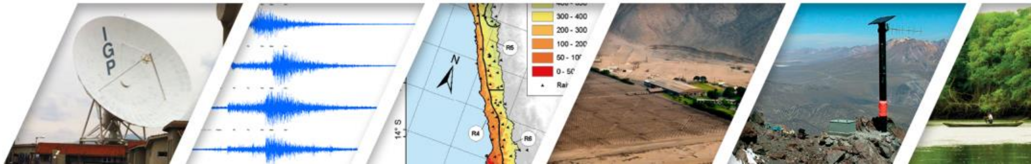


- Peru is located along the central western coast of South America (18.2°S-0°S, 81.7°W-68.6°W). The maximum (peak) height of the Peruvian territory exceeds 6000 m.
- Peru contains 71% of all tropical glaciers in the world (Rabatel et al., 2013).
- Most Peruvian regions register their wet season during austral summer (DJF). Rainfall has an important role in numerous socioeconomic activities such as agriculture, energy generation, potable water supply, etc.
- However, the relationship between rainfall and El Niño flavors and tropical Pacific convective regions are poorly understood.

d. Main objective

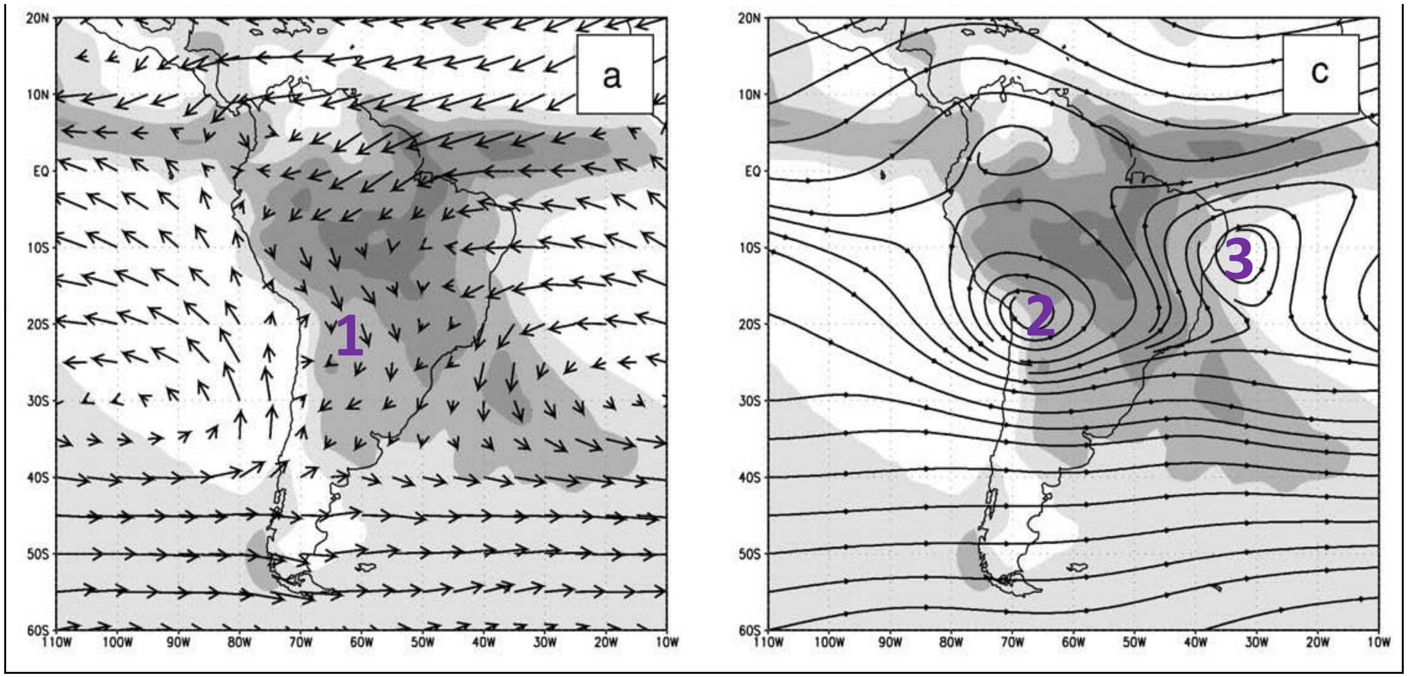
a. Characterization of the rainfall pattern of South America associated with each El Niño flavor (C and E) and tropical Pacific convective regions (SPCZ and ITCZ) during the austral summer (DJF).

b. Identification of the large-scale atmospheric circulation over South America associated with El Niño flavors (C and E) and tropical Pacific convective regions (SPCZ and ITCZ) during the austral summer (DJF).



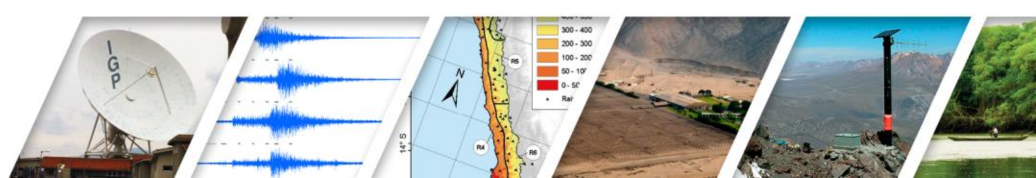
1. DJF – REGIONAL ATMOSPHERIC CIRCULATION AND RAINFALL OVER SOUTH AMERICA

January 925 hPa　　　　January 300 hPa



1. South American Low-level Jet (SALLJ)
2. Bolivian High (BH)
3. Nordeste Low (NL)

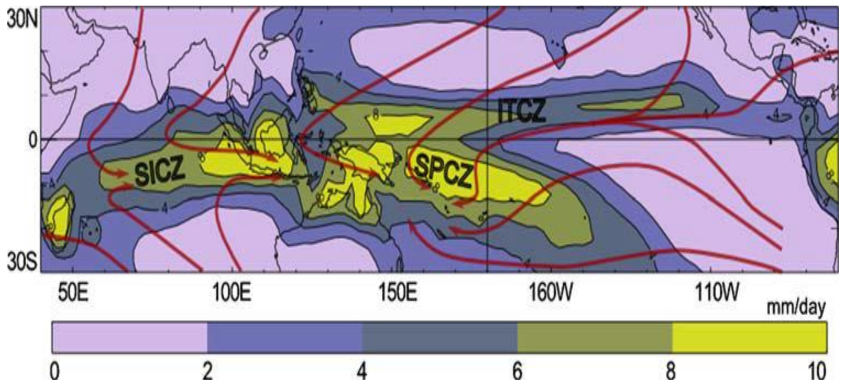
* Shaded represents precipitation



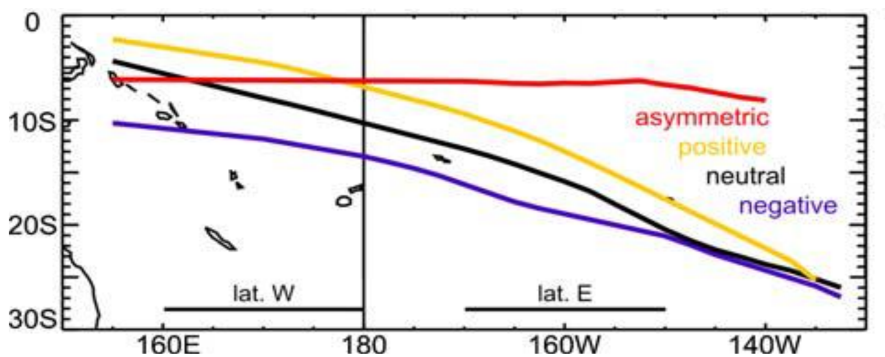
2. TROPICAL PACIFIC CONVECTIVE REGIONS

2a. South Pacific Convergence Zone (SPCZ)

a) Location of SPCZ



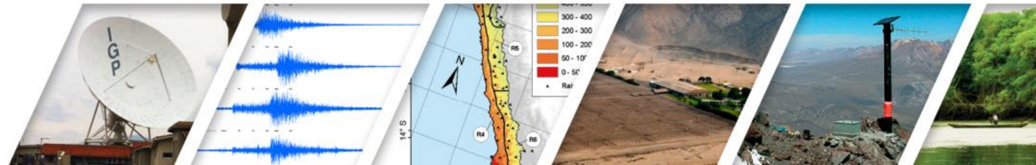
b) Four positions of SPCZ



Adapted from Vincent et al. (2009)

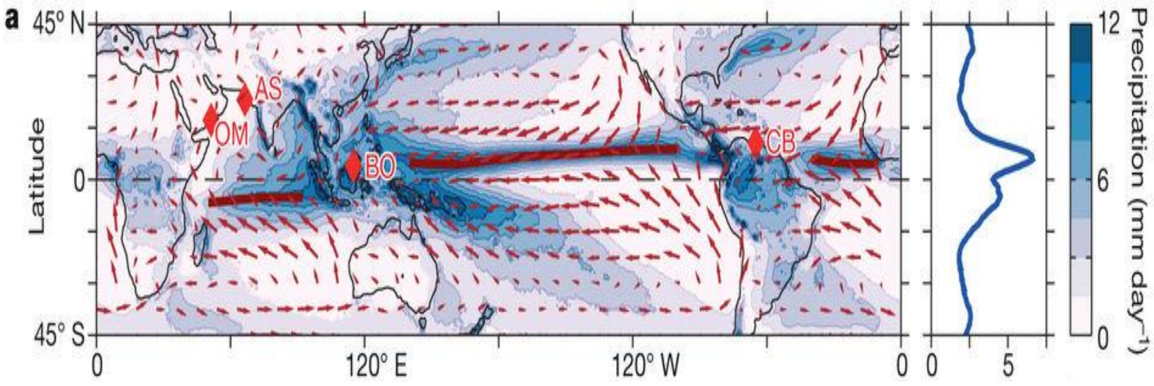
- SPCZ is a convective band extended obliquely from New Guinea toward central and subtropical part of Pacific Ocean (Fig. a). Maximum peaks of the SPCZ occur during the austral summer (DJF).

- ENSO modulates the position and length of the SPCZ (Fig. b). The horizontal position of the SPCZ tends to occur during extreme El Niño episodes (Takahashi and Battisti, 2007).

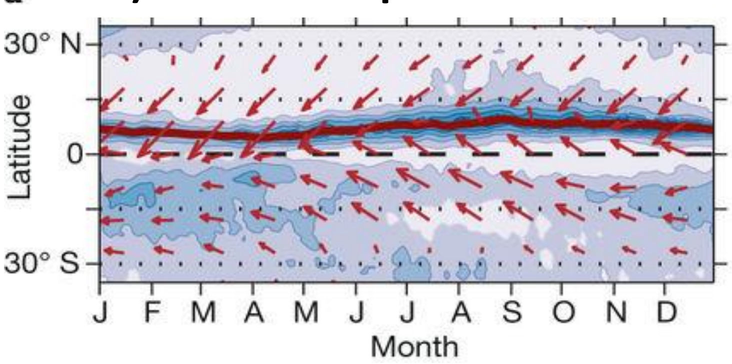


2b. Intertropical Convergence Zone (ITCZ)

a) Location of ITCZ

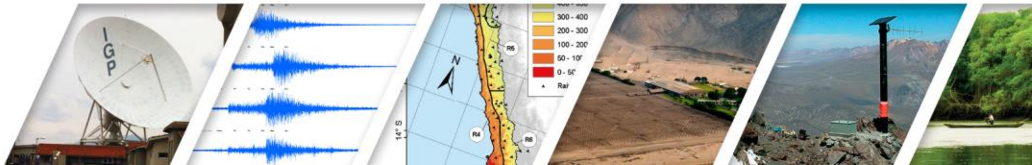


b) Latitudinal position of ITCZ



Adapted from Schneider et al. (2014)

- ITCZ is a convective band extended horizontally in the Northern Hemisphere north of the equator around 9°N (Fig. a).
- On interannual timescales, the latitudinal position of ITCZ varies very little (Fig. b).
- ITCZ only moves toward Southern Hemisphere during extreme El Niño episodes (Takahashi and Battisti, 2007).



3. DATA

a. Monthly timeseries of ENSO indices (C and E) (Takahashi et al. 2011; http://www.met.igp.gob.pe/datos/EC.txt) for the period 1979-2016.

b. Monthly record of the Niño 3.4 index from (NOAA CPC; http://www.cpc.ncep.noaa.gov/data/indices/ersst4.nino.mth.81-10.ascii) for the period 1979-2016

c. Gridded monthly precipitation datasets:

GPCP (2.5°x2.5°; Adler *et al.* 2003) for the period 1979-2016.

University of Delaware (0.5°x0.5°; Matsuura and Willmott, 2015) for the period 1979-2014

PISCO (Peruvian-interpolated data of the SENAMHI's climatological and hydrological observations) (0.05°x0.05°, Lavado *et al.* 2016) for the period 1981-2016

d. ERA Interim reanalysis (0.75°x0.75°; Dee et al. 2011):

Zonal and meridional wind, geopotential height and specific humidity in all tropospheric levels (1000 – 100 hPa) for the period 1979-2016.

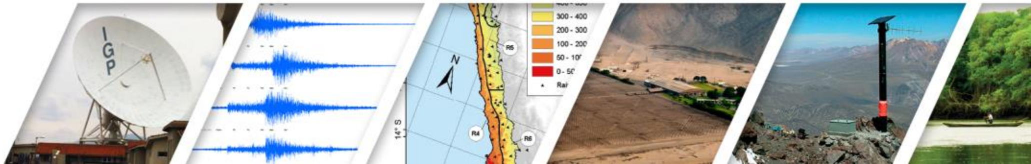
4. METHODOLOGY

a. To characterize SPCZ and ITCZ, we defined the following indices:

- latW : latitude averaged between 170°W and 150°W (Vincent et al., 2009)
- latE : latitude averaged between 160°E and 180°E (Vincent et al., 2009)
- ITCZC : difference between the boxes (153.75°-123.75°W, 1.25°S-8.75°N) and (153.75°-123.75°W, 11.25°-21.15°N)
- ITCZE: precipitation averaged inside the region (118.75°-91.25°W, 6.25°S-6.25°N)

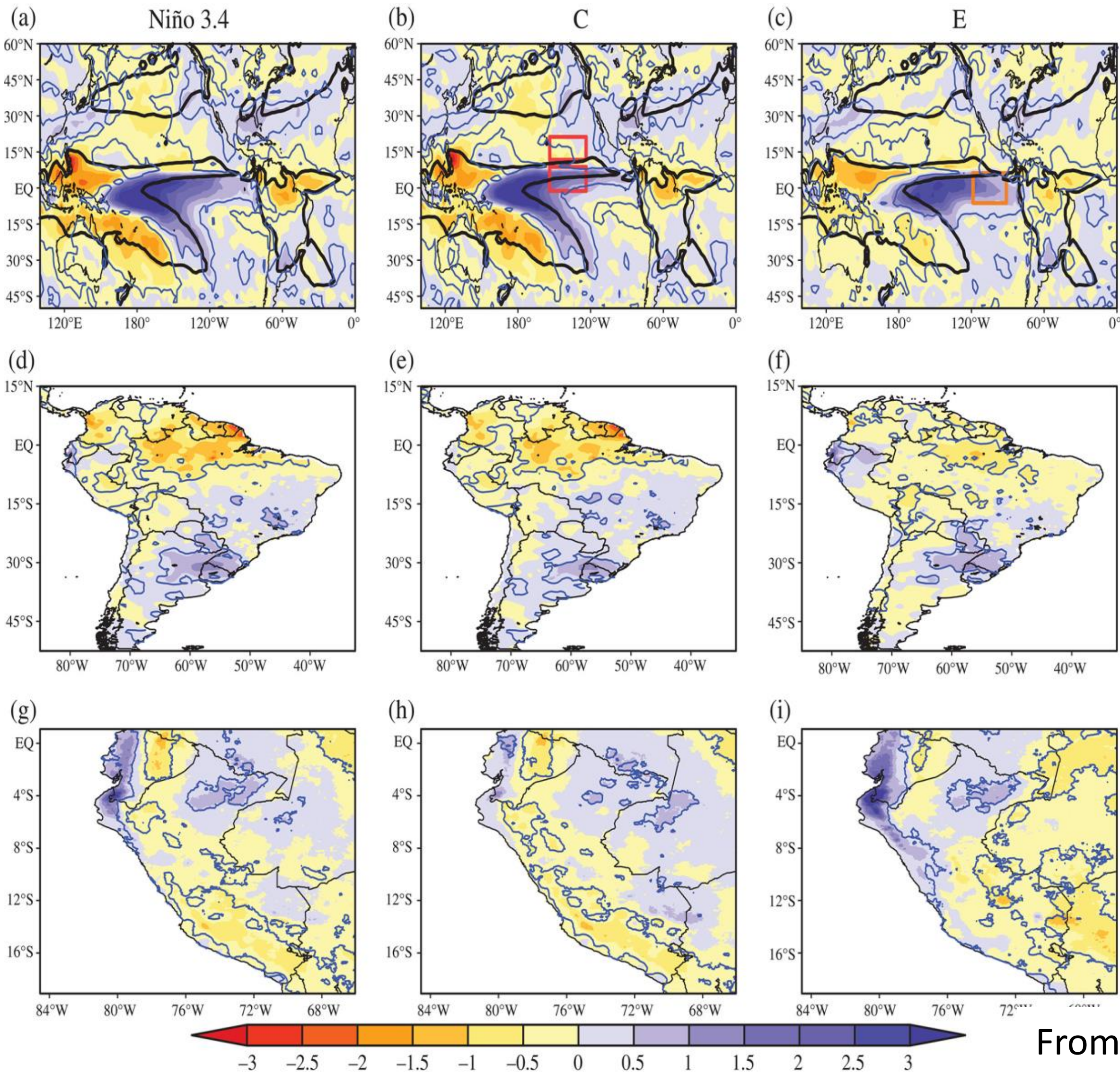
b. Linear regressions were used for characterizing the patterns of rainfall and large-scale atmospheric circulation associated with ENSO flavors (C and E).

c. Multiple linear regressions were used for characterizing the patterns of rainfall and large-scale atmospheric circulation associated with SPCZ and Pacific ITCZ.



5. RESULTS

5a. DJF - Rainfall patterns associated with El Niño indices (Niño 3.4, C and E)



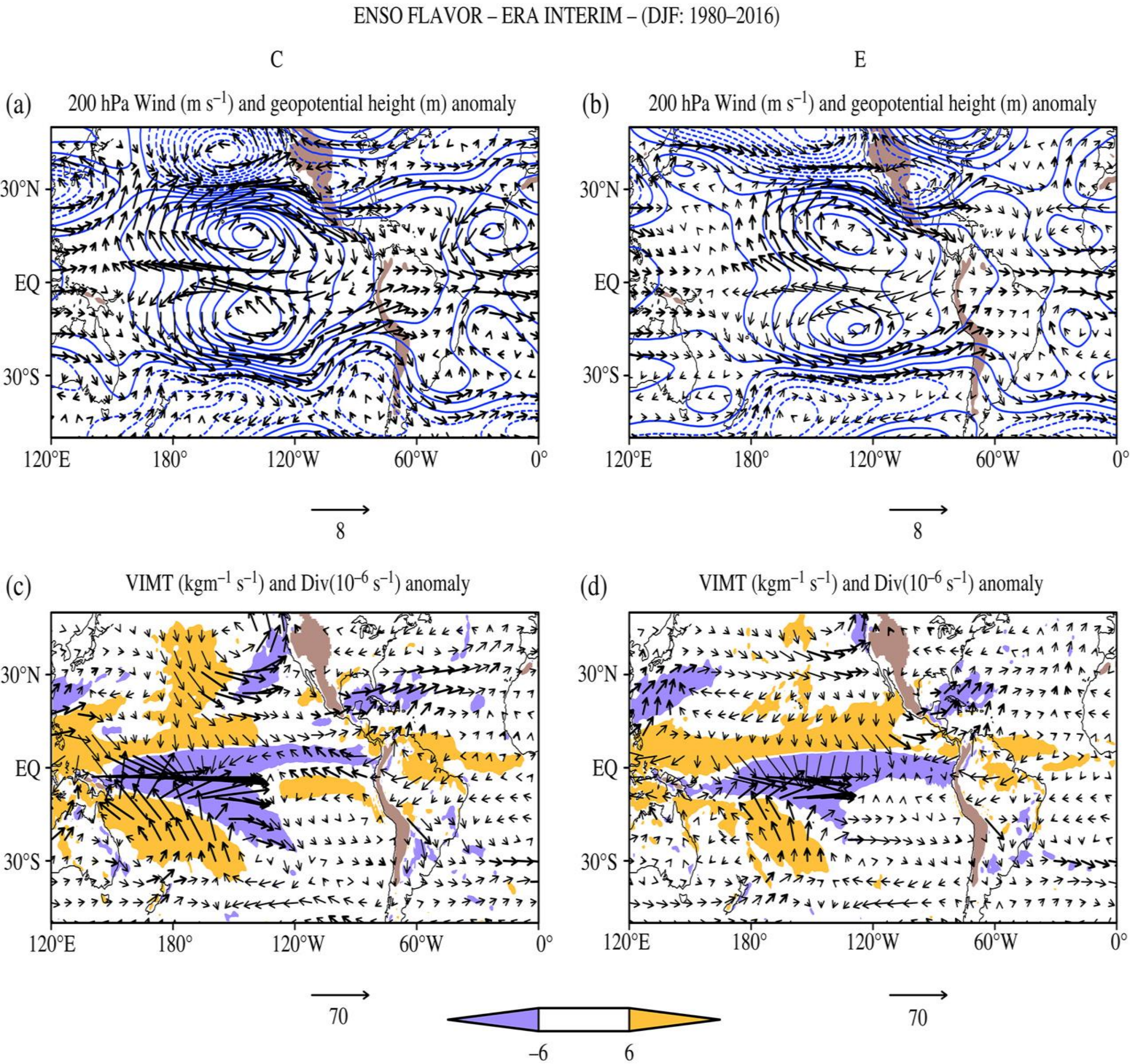
a) Central El Niño (C) induces dry conditions along Tropical Andes (Peru, Bolivia, and Ecuador).

b) Eastern El Niño (E) induces wet conditions in the central and northern Peruvian and coasts of southern Ecuador.
Dry conditions in the Peruvian Altiplano and northwestern Bolivia.

c) El Niño induces rainfall in the northeastern Peruvian Amazonia because all El Niño indices (Niño 3.4, C and E) register this signal.

From Sulca et al., (2017)

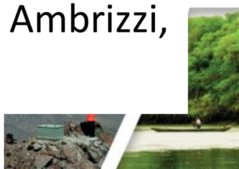
5b. DJF – 200 hPa-large-scale atmospheric circulation associated with El Niño Flavors (C and E)



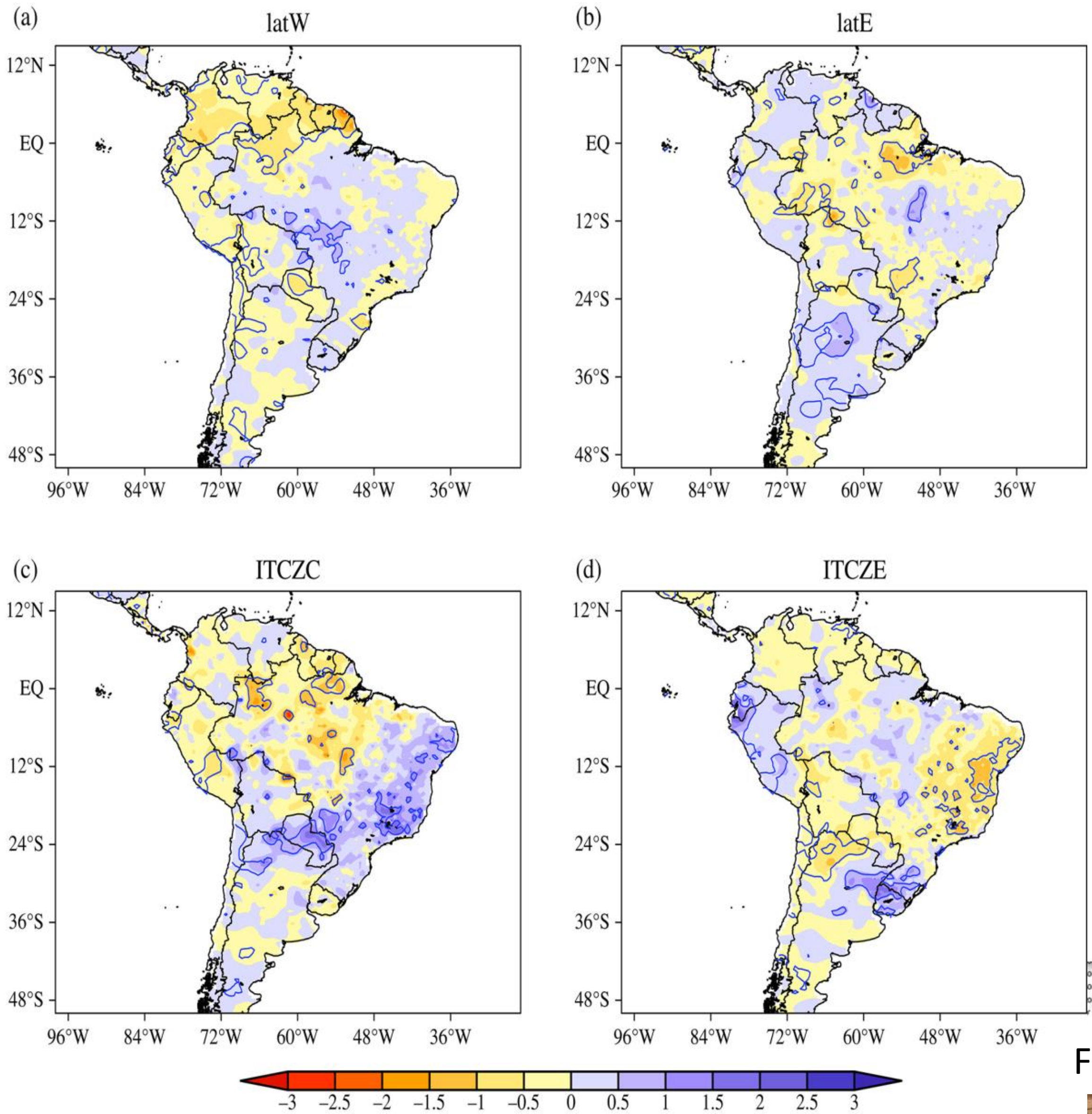
a) Central El Niño (C):
Warming in the central Pacific Ocean (CPO) induces a stable Rossby wave at upper tropospheric levels (Gill, 1980).
200 hPa-westerly wind anomalies over entire Peru.

b) Eastern El Niño (E):
Stationary Rossby wave at upper tropospheric levels over CPO, but is weaker than during Central El Niño.
200hPa-southeasterly wind anomalies over southern Peru are induced by short Rossby wave trains released by the deep convection over far-eastern Pacific Ocean (Hoskins and Ambrizzi, 1993).

From Sulca et al., (2017)

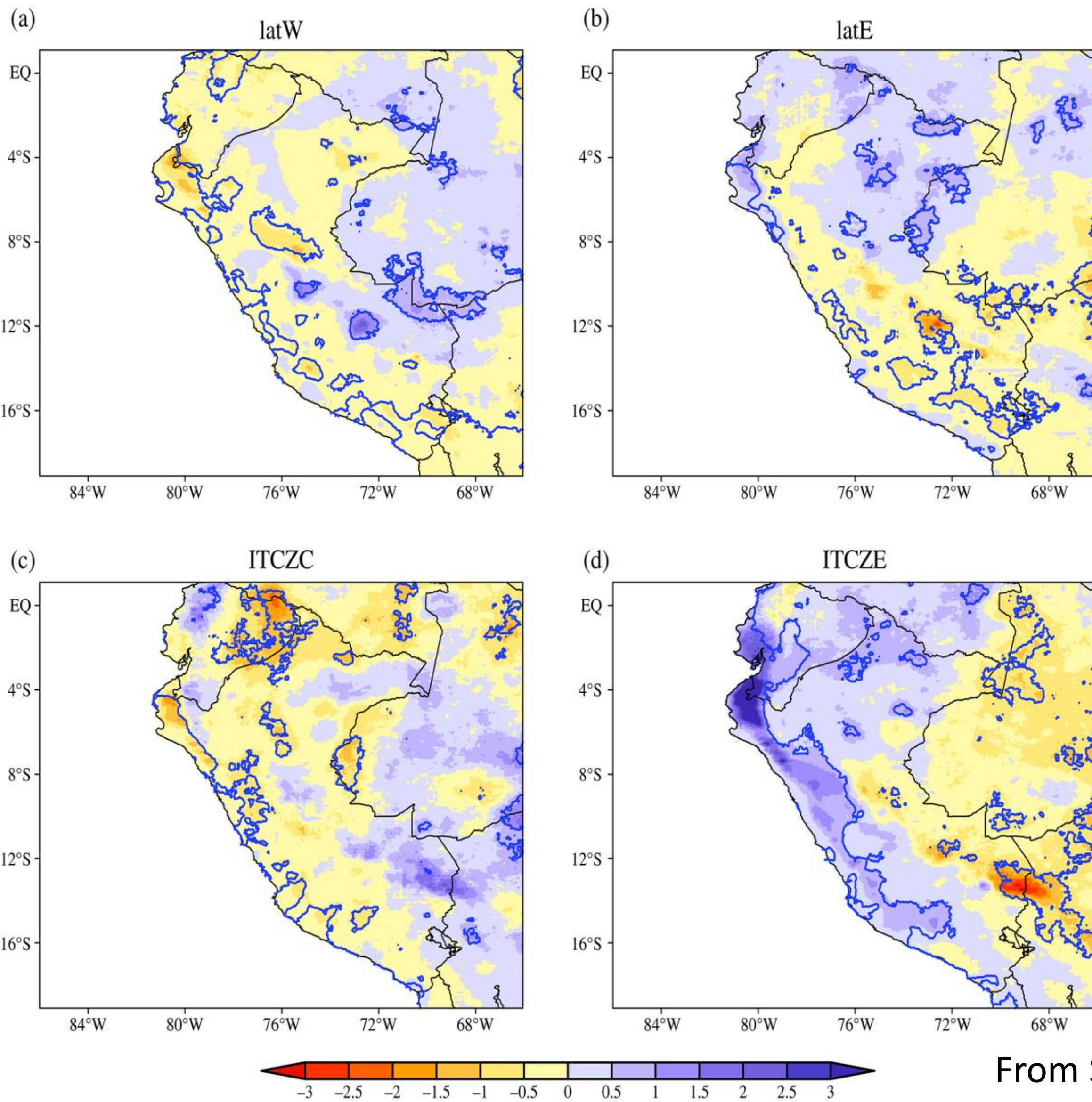


5c.1 DJF - Rainfall patterns associated with tropical Pacific convective regions: SA



From Sulca et al., (2017)

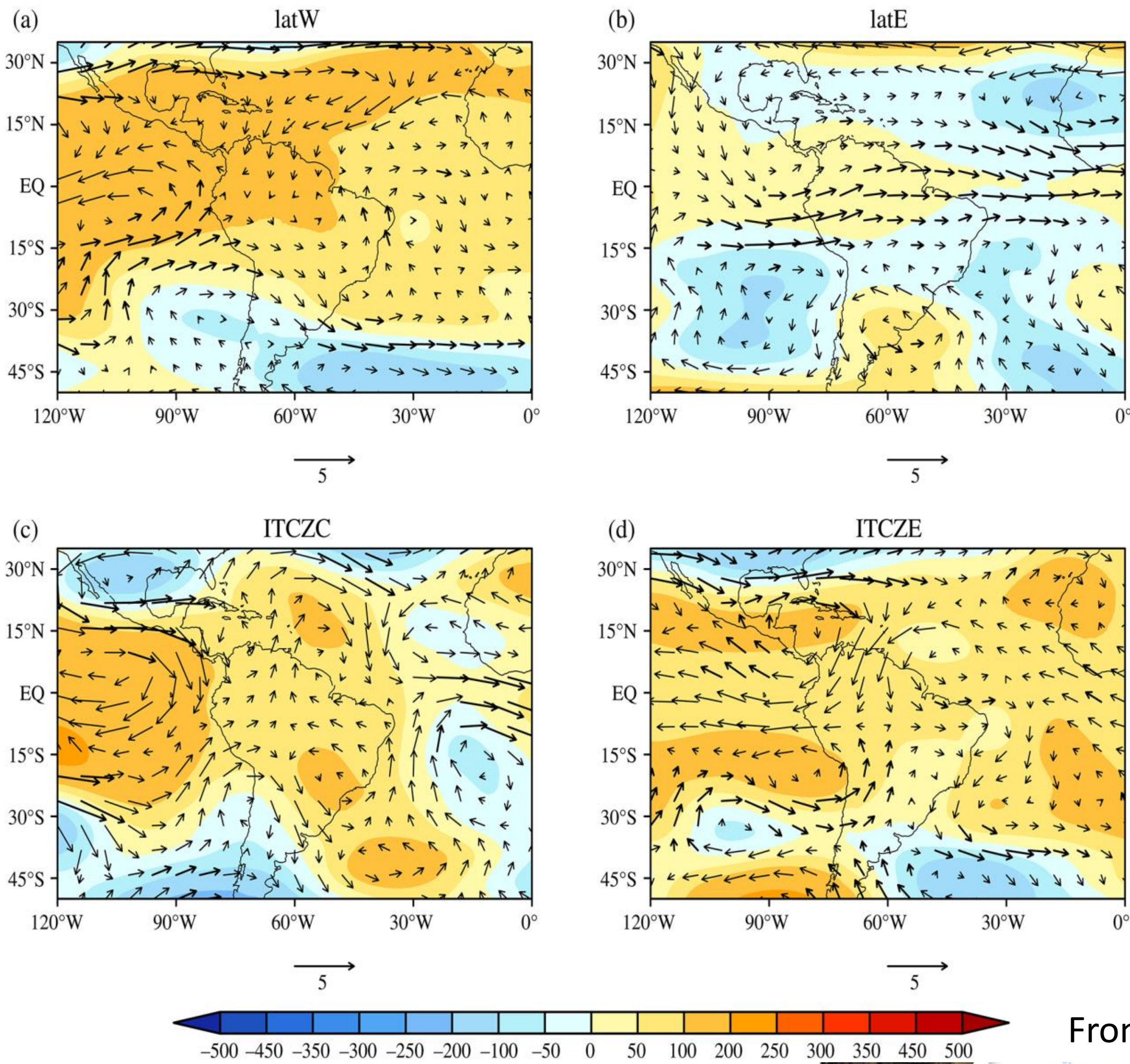
5c.2. DJF - Rainfall patterns associated with tropical convective regions: Peru



- LatW inhibits rainfall in the peaks of the western Peruvian Andes and Altiplano region (Peru-Bolivia).
- LatE inhibits rainfall along the peaks of western Peruvian Andes and eastern Peruvian Andes.
- ITCZC inhibits rainfall in the entire Peruvian Andes.
- ITCZE induces rainfall over coast and Andes of Peru, while tends to suppress rainfall in Peruvian Altiplano, although not statistically significant.

From Sulca et al., (2017)

5d. DJF – 200 hPa wind and geopotential height anomalies associated with tropical convective regions



- LatW is associated with westerly wind anomalies over central- and southern Peru at 200 hPa.
- LatE is associated with westerly wind anomalies over all of Peru at 200 hPa, albeit not statistically significant over southern Peruvian Andes.
- ITCZC is associated with westerly wind anomalies over Peru at 200 hPa, albeit not statistically significant.
- ITCZE is associated with easterly wind anomalies over Peru at 200 hPa, albeit not statistically significant.

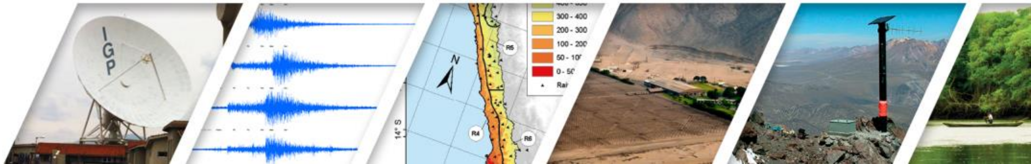
From Sulca et al., (2017)

6. CONCLUSIONS (1 of 2)

a) Central and Eastern El Niño modulate the summer precipitation of Peru, but have different patterns.

- Central El Niño (C) inhibits rainfall along Tropical Andes.
- Eastern El Niño (E) induces rainfall in all of Peruvian coast while at the same time inhibiting rainfall in the Peruvian Altiplano.

b) El Niño induces rainfall over the northeastern Peruvian Amazonia because all El Niño indices (Niño 3.4, C and E) register this signal.



CONCLUSIONS (2 of 2)

c) Change of position (longitudinal and meridional) of the SPCZ impacts the summer precipitation of Peru.

- Positive latW, which represents a northeastern displacement of SPCZ, inhibits rainfall in the south-western Peruvian Andes.

- Positive latE, which represents zonal position of the SPCZ, inhibits rainfall over western part of the central and southern Peruvian Andes.

d) Change of meridional position of the central and eastern Pacific ITCZ impacts the summer precipitation of Peru.

- Positive ITCZC, which represents southward displacement of Central ITCZ, inhibits rainfall over entire coast and Peruvian Andes.

- Positive ITCZE, which represents southward displacement of Eastern ITCZ, induces rainfall over entire coast and Peruvian Andes while inhibits rainfall over Lake Titicaca .

ACKNOWLEDGMENTS

- PPR 068 “Reduccion de vulnerabilidad y atencion de emergencias por desastres”.

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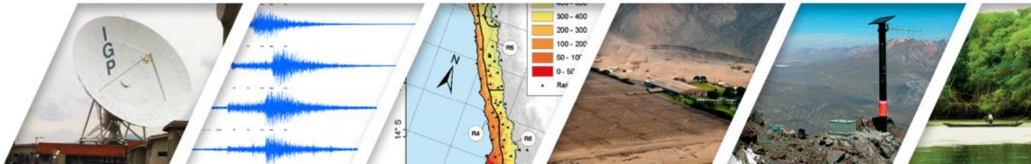
- UNESCO for the travel award to attend to the IV INTERNATIONAL CONFERENCE ON ENSO.



THANK YOU