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Understanding and Predicting Wet Season Precipitation in the Ecuadorian Andes

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MOTIVATION

- Farmers in the southern Ecuadorian Andes rely on an abundant wet season (austral summer) each growing year.
- Personal communication with leaders of the Cañari community, a people indigenous to the Andes of Ecuador, revealed concern that their wet seasons were becoming less reliable.

BACKGROUND

Fig. 1. Outline of the region of interest. Background map courtesy of Maphill.com

- The normal seasonal rainfall in this region (**Fig. 1**) is driven primarily by the seasonal migration of the Intertropical Convergence Zone (ITCZ); southern Ecuador's wet season occurs during austral summer and fall when the ITCZ is at its southernmost position (Garreaud 2009).
- Previous work suggests that anthropogenic climate change could alter the seasonal migration of the ITCZ, thereby changing the seasonal precipitation pattern in the southern Ecuadorian Andes.
  - Asymmetrical hemispheric temperature change (e.g., unequal warming of the Northern Hemisphere and Southern Hemisphere) would cause the ITCZ to shift its mean position toward the warmer hemisphere (Broccoli et al. 2006; Kang et al. 2008).
  - Asymmetric hemispheric temperature change occurred during the 20th century, with the Northern Hemisphere warming more than the Southern Hemisphere (Xu and Ramanathan 2012).
- Varying phases of the El Niño-Southern Oscillation (ENSO) are associated with interannual variability in wet season precipitation in tropical South America.
- The eastern Pacific ITCZ signature varies greatly according to the ENSO phase (Zhang 2001; Lietzke 2001), suggesting that the ENSO phase could be a useful predictor of ITCZ precipitation in nearby tropical South America.

Research Questions:

1. Has the position of the ITCZ in South America during austral summer shifted northward in the last few decades?
2. Can the phase of the El Niño-Southern Oscillation (ENSO) be used to predict wet season (December–March) precipitation in the Andes of southern Ecuador?

DATA AND METHODS

1. Detection of a possible change in the mean December–March (DJFM) position of the ITCZ in South America was accomplished through examining maps of interpolated outgoing longwave radiation (OLR) provided by NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their web site at https://www.esrl.noaa.gov/psd/. The original Climate Data Record (CDR) was developed by Lee et al. (2014) for NOAA's CDR Program.

2. To determine the utility of the ENSO phase for predicting DJFM precipitation in the Andes of southern Ecuador, this study aims to fit a linear regression model to area-averaged seasonal precipitation totals using the ENSO phase as a predictor variable. Precipitation data used were NOAA's Precipitation Reconstruction over Land (PREC/L; Chen et al. 2002), provided by NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their web site at https://www.esrl.noaa.gov/psd/. Dr. Michael J. Ventrice supplied the Atmospheric ENSO Index (AEI) dataset (Ventrice 2018).

RESULTS

Area-Averaged DJFM Precipitation

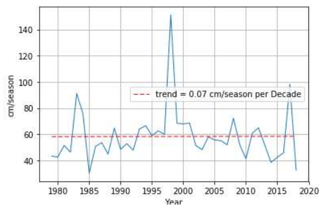

Fig. 2. 1979-2018 total seasonal DJFM precipitation (cm per season), averaged over the area of the region of interest (see Fig. 1).

- From 1979-2018, the area-averaged seasonal precipitation in the region of interest (**Fig. 2**) shows a trend of almost zero.
- Personal communication with leaders of the Cañari community began during the 2015-2016 DJFM season, the third consecutive drought season, making it the longest drought in recent memory.
- High peaks in seasonal precipitation such as in the 1997-98 and 1982-83 DJFM seasons (**Fig. 2**) appear to correspond to strong El Niño events (**Fig. 3**).

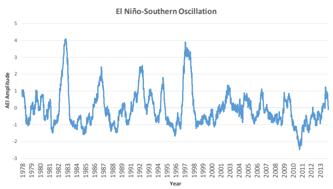

Fig. 3. 1978-2014 Atmospheric ENSO Index (AEI) Amplitude.

RESULTS (cont.)

Has the austral summer position of the ITCZ shifted?

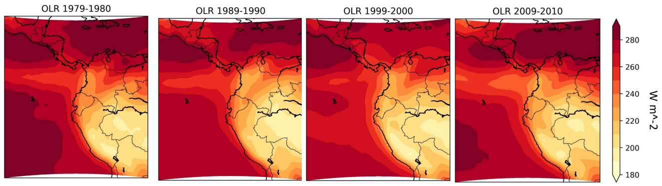

Fig. 4. Seasonal-average Outgoing Longwave Radiation for each wet season (DJFM). Four wet seasons, 1979-1980, 1989-1990, 1999-2000, and 2009-2010, are selected to show OLR signatures spanning three decades.

- The OLR signatures (**Fig. 4**) do not indicate that the austral summer position of the ITCZ in South America has shifted in the last few decades.

Can the ENSO phase predict seasonal precipitation in the Andes of southern Ecuador?

	Adjusted R^2	Residual standard error	F-statistic	p-value
Nov	0.2393	17.16	12.32	0.001253
Oct	0.2186	17.39	11.07	0.002072
Sep	0.2436	17.11	12.59	0.001126
Aug	0.2014	17.58	10.08	0.00312
Jul	0.1732	17.89	8.541	0.006048
Jun	0.08464	18.82	4.329	0.04486
May	0.007719	19.59	1.28	0.2656
Apr	-0.011	19.78	0.6084	0.4406

Table 1. Linear regression statistics generated when using the Atmospheric ENSO Index for the given month as input for predicting the subsequent DJFM precipitation.

- The average Atmospheric ENSO Index (AEI) of each month was tested as a predictor of the precipitation of the subsequent December-March season.
- September AEI is the best predictor according to all four metrics (**Table 1**).
- However, the linear model using September AEI did not meet all of the assumptions of linear regression.

CONCLUSIONS

- No shift in the austral summer (DJFM) position of the South American ITCZ has been detected.
- Although the relationship is not perfectly linear, the Atmospheric ENSO Index (AEI) of the months immediately preceding an Ecuadorian wet season have potential to predict the seasonal rainfall amounts.

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