ENSO's different flavors and global patterns of seasonal climate anomalies in troposphere and stratosphere

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During the last decades, the global teleconnectivity of the El Niño Southern Oscillation (ENSO) as one of the most prominent patterns of interannual climate variability has been a subject of many studies. In particular, it has been shown that the strongly positive (El Niño) and negative ENSO phases (La Niña) have strong impacts on meteorological conditions in remote regions. Thereby, knowledge of the present ENSO state provides enhanced skills to global weather predictions.

Recent studies point towards a heterogeneity of spatio-temporal correlation patterns in the global climate system associated with different El Niño and La Niña events and their specific teleconnections, which have motivated a classification of both types of climate events into East Pacific (standard) and Central Pacific (Modoki) flavors. In this work, we study the likelihood of co-occurrence of these different flavors with seasonal extremes in surface temperature, precipitation, geopotential height at 850 hPa and heat flux at 100 hPa all around the globe and stratospheric temperatures at 10 hPa from 20°N to 90°N.

For our study, we utilize gridded precipitation data provided by the Global Precipitation Climatology Centre (GPCC) v7 and temperature (1000 hPa, 100 hPa and 10 hPa), geopotential height (850 hPa) and wind fields from NCEP/NCAR Reanalysis 1 with a spatial resolution of 2.5° x 2.5°. From the monthly values, we calculate seasonal aggregates as averages (temperature, geopotential height, heat flux) and sums (precipitation).

For each grid point, we then determine anomalous years as years where the corresponding values exceed the local 80th, or fall below the local 20th percentile of all values for this season at the given site. For both, positive and negative anomalies, we then estimate the likelihood of co-occurrence with any type of ENSO period (i.e., East or Central Pacific El Niño or La Niña). Within the framework of event coincidence analysis, we finally test the obtained likelihoods for all combinations of events for their significance against the null hypothesis of independent and randomly distributed events. Recording only those event combinations with resulting *p*-values below 0.05 allows identifying characteristic spatial patterns highlighting those regions where seasonal climate anomalies are likely related with any of the different types of ENSO phases.

Our results reveal several important facts: (1) The characteristic patterns of anomalous seasonal climate conditions differ between EP and CP type events, pointing towards essentially different teleconnectivity structures controlling the emergence of extraordinary climate conditions. (2) In some areas, we identify even opposite behaviors during EP and CP type events. (3) Our results unveil some regions where the effect changes qualitatively between subsequent seasons. (4) Finally, the stratospheric coupling pathway between ENSO and the northern winter polar vortex is enforced during El Niño events on the basis of an increased heat flux at 100 hPa, indicating a high amount of tropospheric waves propagating into the stratosphere.

Key words: ENSO, Teleconnections, Stratosphere-Troposphere Coupling, Event Coincidence Analysis