Contrasting ENSO transition complexities between El Niño and La Niña: The underlying complexity dynamics and future changes

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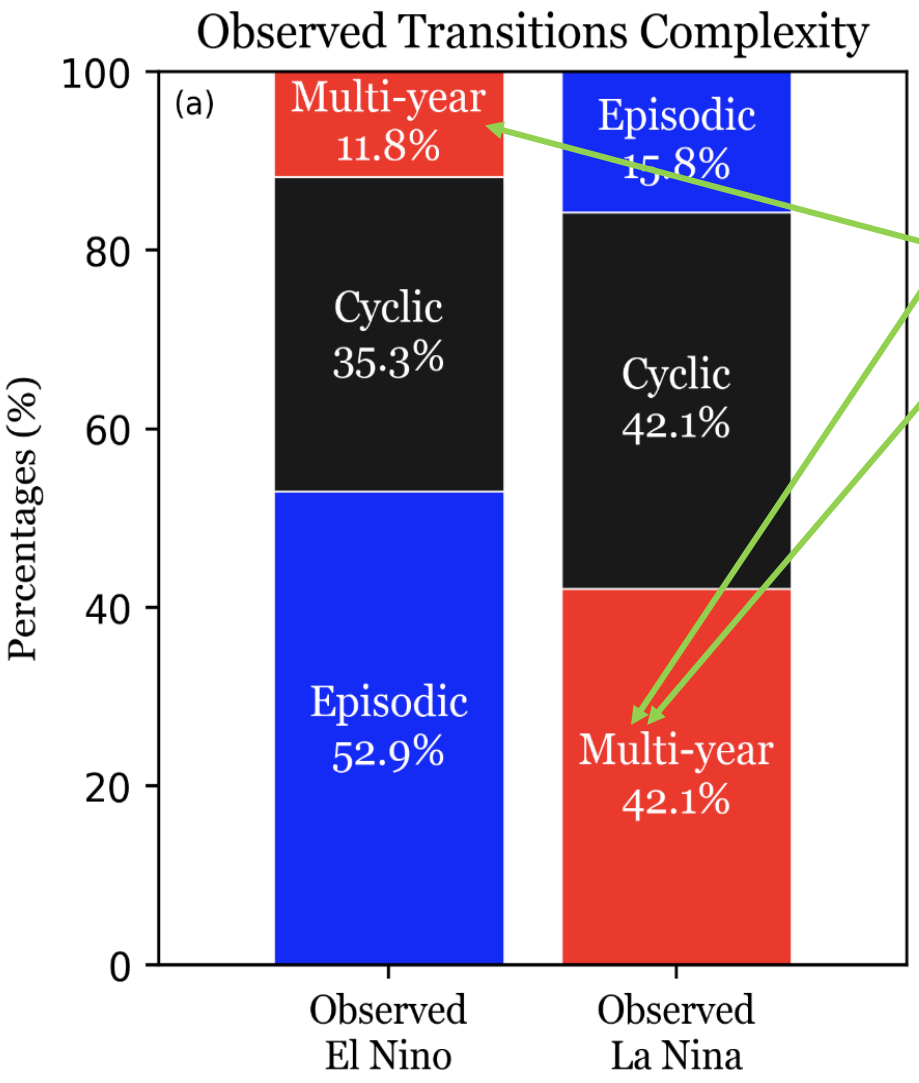
Abstract

An ENSO event can transition from one event to another in complex ways. An El Niño (La Niña) event can be preceded by a La Niña (El Niño) event to become a cyclic ENSO, by a neutral event to become an episodic ENSO, or by another El Niño (La Niña) event to become a multi-year ENSO. We find that the observed El Niño and La Niña exhibit different complexities in their event-to-event transition patterns. The El Niño is dominated in order by episodic, cyclic, and multi-year transitions, but the reversed order is found in the La Niña. This difference in the transition complexity arises from a subtropical Pacific forcing mechanism that triggers ENSO events. Using observational analyses and forced atmospheric model experiments, we show that a preceding ENSO event can activate a subtropical Pacific forcing mechanism to trigger another ENSO event during the following year. These tropical-subtropical Pacific interactions result in a cyclic ENSO transition if the two ENSO events are of opposite signs or a multi-year ENSO transition if they are of the same sign. The preceding ENSO event should excite deep convections in the tropical Pacific in order to activate the subtropical Pacific mechanism. This requirement enables mean temperatures in the cold tongue and warm pool to respectively control how easily the cyclic and multi-year transitions can occur. This mean state control enables the subtropical Pacific forcing mechanism to result in more multi-year transitions for La Niña than El Niño and more episodic transitions for El Niño than La Niña. Furthermore, a future warmer tropical Pacific is projected to decrease the frequency of occurrence of multi-year ENSO transitions but increase the occurrence of cyclic ENSO transitions.. We find that the CMIP5 and CMIP6 models can reproduce the transition complexity for El Niño but not for La Niña. The models tend to produce too many episodic La Niña events and too few multi-year La Niña events. We are able to link the former deficiency to a weaker than observed subtropical Pacific forcing mechanism in the CMIP5/6 models and the latter to a cold bias in mean state SSTs in the equatorial Pacific in the CMIP5/6 models. To achieve better simulations of ENSO transition complexity, further efforts are to improve the model deficiencies in simulating the SP-onset mechanism and mean SSTs in the equatorial Pacific.

Opposite Transition Complexities btw El Niño and La Niña

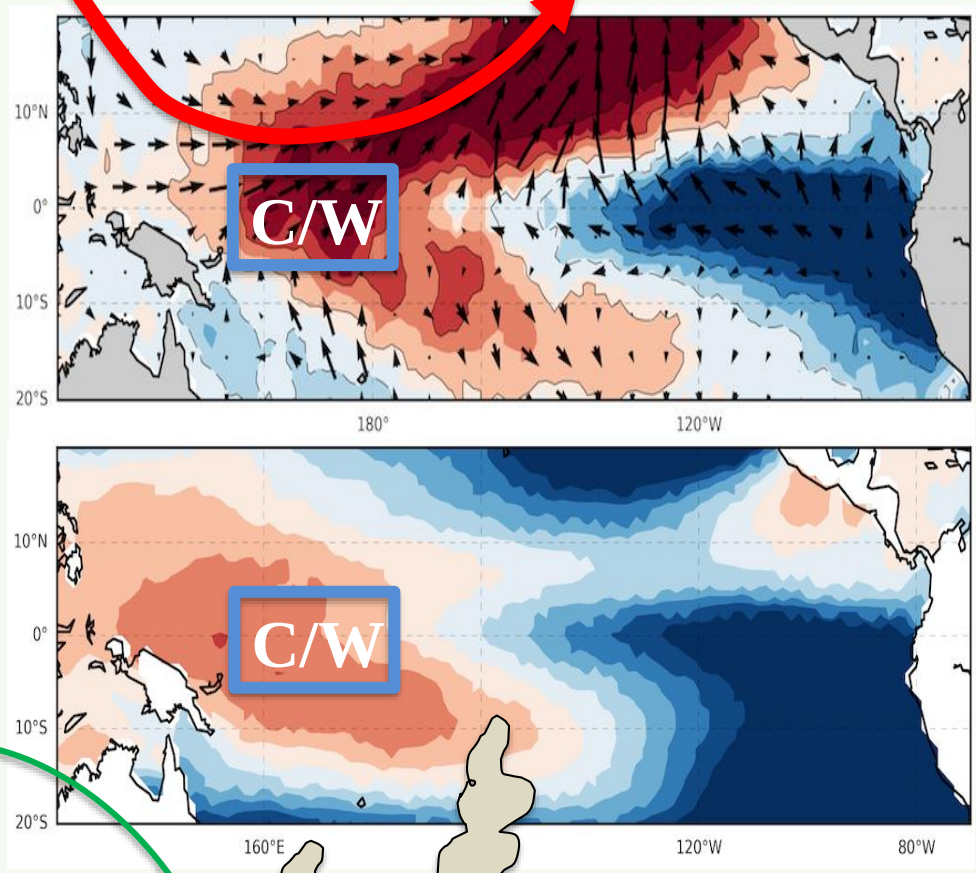
Year 1948–2016



- La Niña is dominated by the multi-year transition pattern.
- There are more multi-year La Niña events than multi-year El Niño events.

➔ **What is the reason for this El Niño-La Niña asymmetry?**

A Tropical Mean State Control of the SP Mechanism



Mean SSTs in the eastern edge of the Indo-Pacific warm pool control how easily the multi-year El Niño and La Niña can occur via this process.

Easier to produce Multi-year La Niña

Large ΔQ(-)

Small ΔQ (+)

28˚C

La Niña

mean

El Niño

CMIP5 Projections of ENSO Transition Complexity

In the future warming world, cyclic ENSO transition events may increase while multi-year ENSO events may decarese.