Oceanic and Atmospheric Feedbacks Associated with the Spreading of Pacific Coastal Niño Events

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Key Points:

- **Coastal Niño Events can be purely generated by wind stress anomaly**
- **Positive Cloud-SST-Feedback decreases heat flux damping**
- **Heat flux damping stronger for events in January/February**
- **Re-strengthening of coastal winds ends coastal warming**

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The 2017 Coastal Niño Event

- Coastal heatwave with SST anomalies of up to 5K
- Lasted roughly 3 months
- Severe impacts on coastal regions (Rainfall, Flooding)
- Central equatorial Pacific did not show significant warming
- Different forcing mechanisms discussed in recent literature *[e.g. Peng et al. 2019]*

Which Mechanisms are involved in the evolution of Coastal Niño Events?

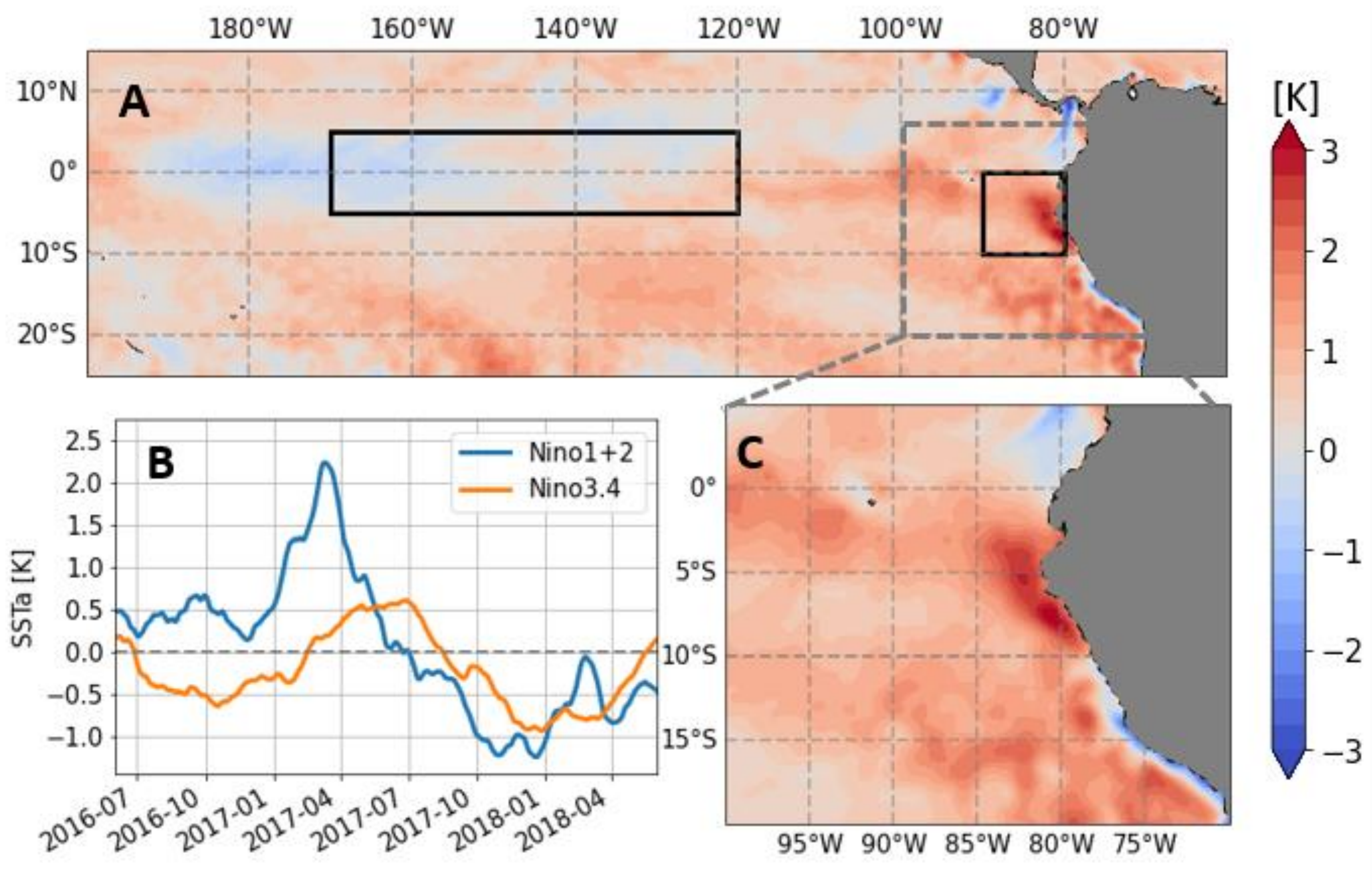
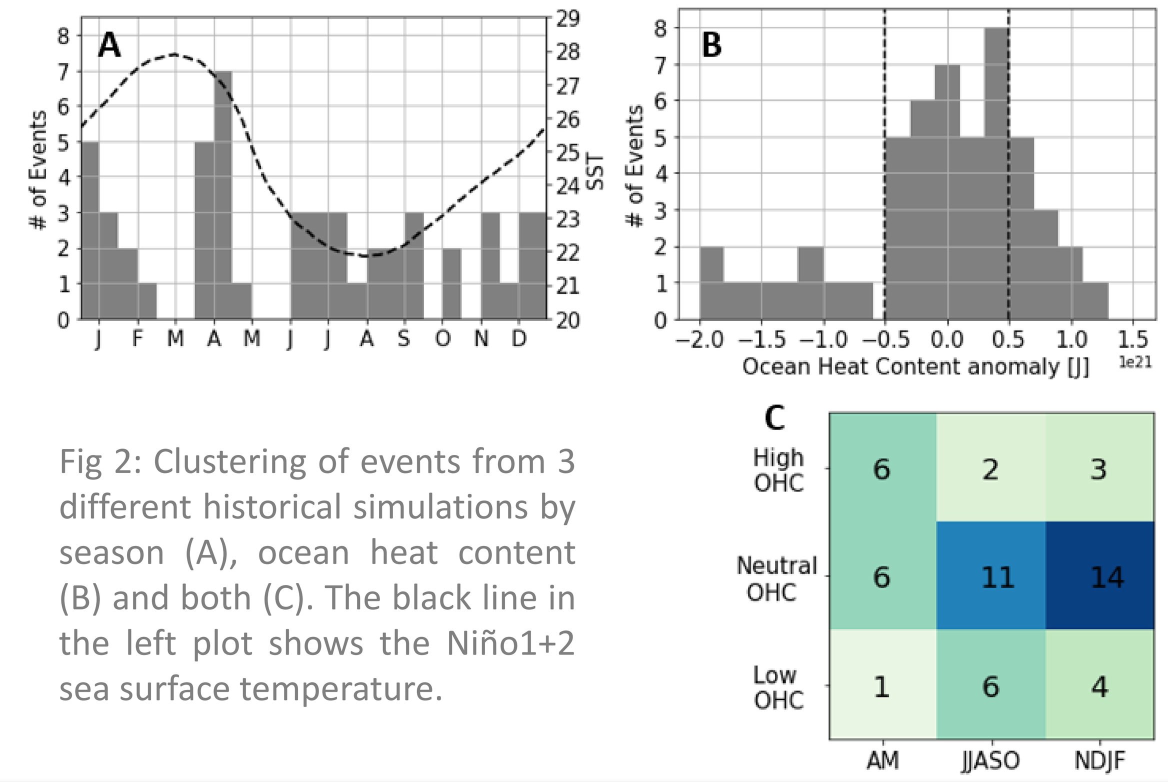


Fig 1: Sea surface temperature anomalies during February 2017 from NOAA OISST v2 (A, C) and time series of Niño1+2 and Niño3.4 SSTa in (B). The solid rectangles in A indicate Niño1+2 and Niño3.4 regions.

Historical Simulations

- FOCI Model (ECHAM coupled with NEMO)
- 3 model runs with historical forcing (1850 -2013)
- Events with high ocean heat content (OHC) tend to develop into basin-wide warmings *[Lübbecke et al. 2019]*
- Warmings in April/May (AM) are stronger



	AM	JJASO	NDJF
High OHC	6	2	3
Neutral OHC	6	11	14
Low OHC	1	6	4

Fig 2: Clustering of events from 3 different historical simulations by season (A), ocean heat content (B) and both (C). The black line in the left plot shows the Niño1+2 sea surface temperature.

Partial Coupling Experiments

- 2-year long model experiments (partial coupling)
- ECHAM: 1.75° resolution, NEMO: 0.5° resolution
- Prescribed wind stress to force coastal warming
- 40 day long forcing applied in JAN or APR for selected years with low / high OHC

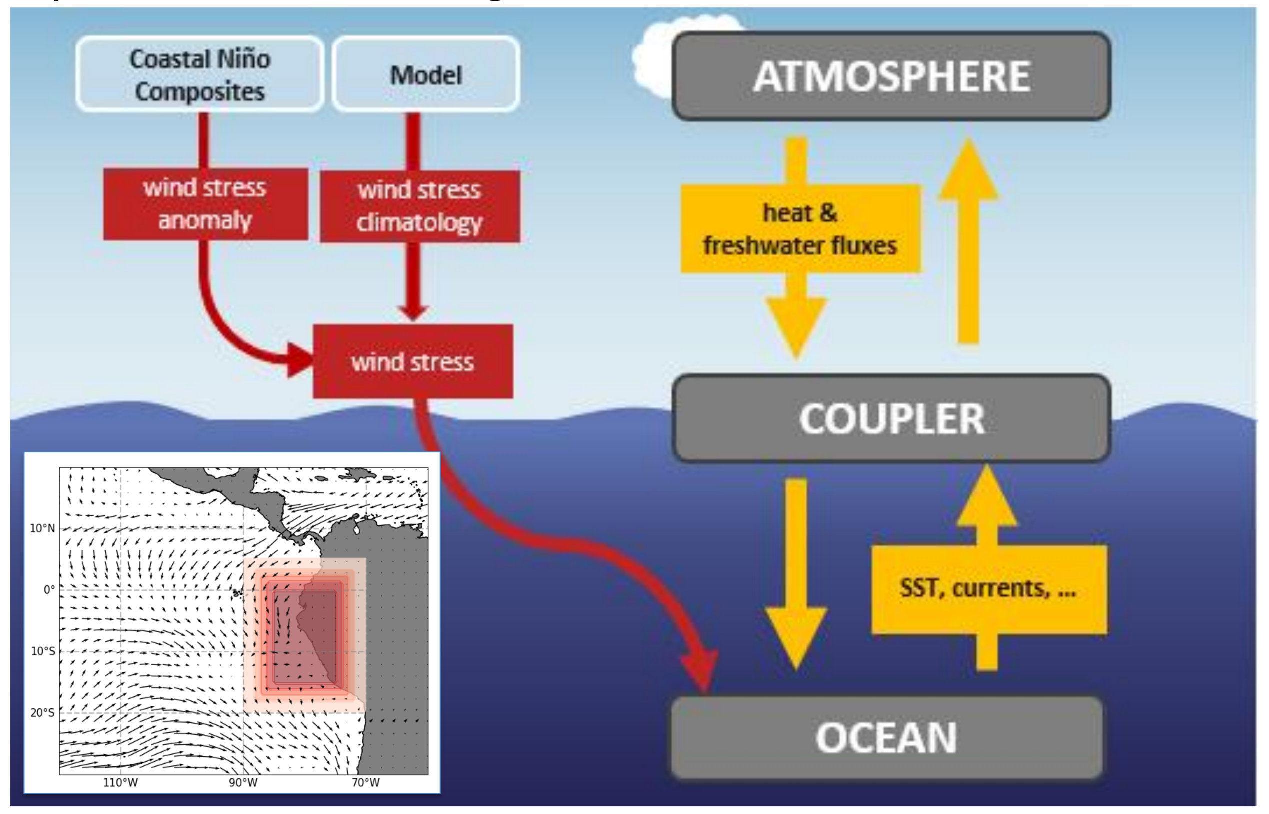
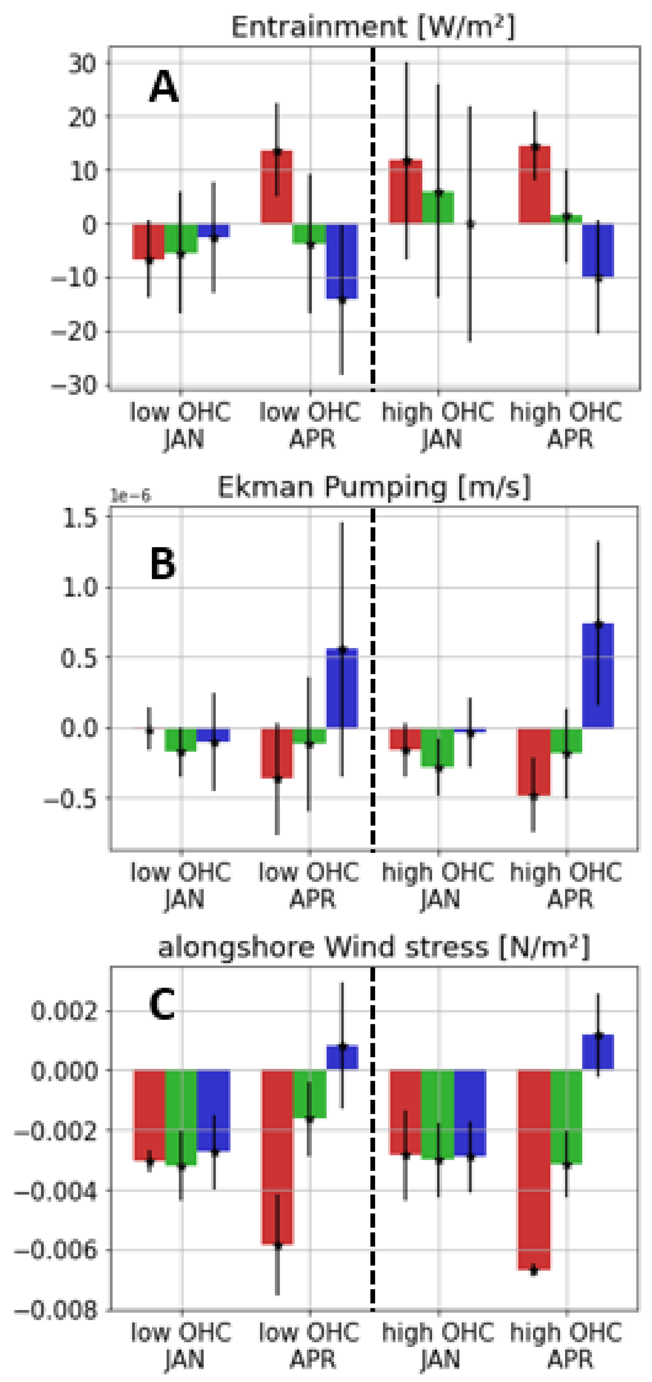


Fig3: Schematic for partial coupling method

How are Seasonality and Ocean Heat Content Influencing Mechanisms Involved in Coastal Niño Events?

Results



- Events forced by entrainment anomalies
- Positive Cloud-SST-Feedback →stronger in APR
- Strong Heat flux damping in JAN
- Re-strengthening of winds during decay phases
- JAN Events damped away by heat flux alone
- APR Events by entrainment as important as heat fluxes

Fig 4: Entrainment (A), Ekman Pumping velocities (B) and alongshore wind stress (C) for different phases averaged for Niño1+2 region
red: build-up, green: peak, blue: decay)

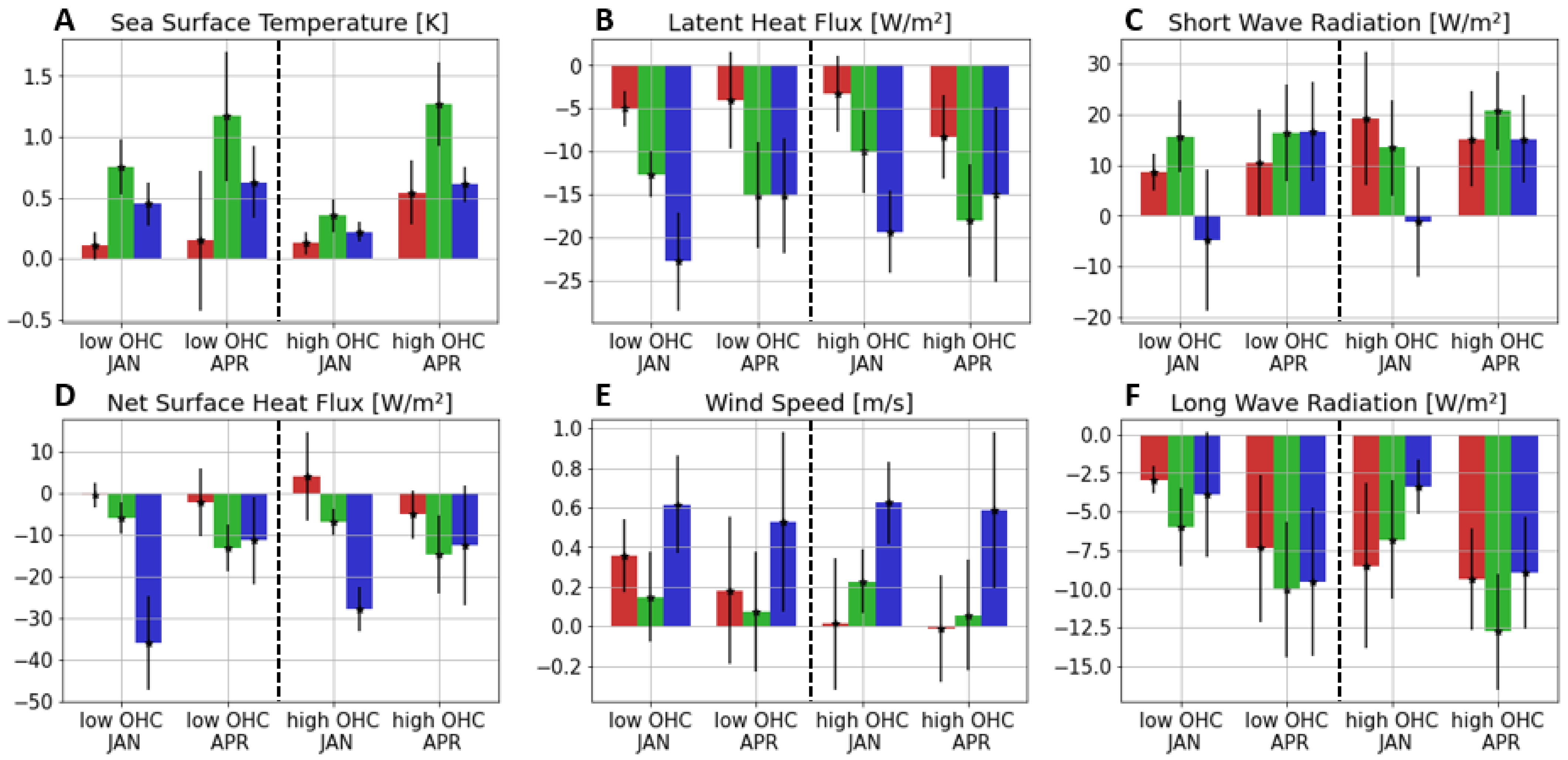


Fig 5: Parameters for different phases of events from 4 different ensembles of model experiments. Red bars are build-up phase, green bars peak phase and blue ones decay. Vertical bars denote the standard deviations.

Conclusion

- Local wind stress anomaly can cause coastal warming similar to the 2017 event
- Cloud-SST-Feedback stronger/more persistent during late boreal spring

Outlook

- No clear spreading of the warm anomalies into the central Pacific in forced experiments
→ **Hypothesis**: Only statistical connection between spreading and OHC due to higher effectiveness of equatorial Kelvin Waves

References:
Lübbecke, Joke F., Daniel Rudloff, and Lothar Stramma. "Stand-alone eastern Pacific Coastal Warming events." *Geophysical Research Letters* 46.21 (2019): 12360-12367.
Peng, Qihua, et al. "Coupled ocean-atmosphere dynamics of the 2017 extreme coastal El Niño." *Nature communications* 10.1 (2019): 298.

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