La Niña from onset to impacts

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The Onset of La Niña Events

• We have argued that multi-day Westerly Wind Events are fundamental to the onset of El Niño events.

• We argue here that a similar class of subseasonal equatorial wind events, Easterly Wind Surges, is fundamental to the onset of La Niña events.

• These EWSs have been overlooked because they are not obvious in the wind timeseries; rather wind stress must be examined.
Eq. Pacific zonal wind variability has a distinctive band of subseasonal variability that is important to understanding ENSO events.
WWE = 3 or more consecutive days in which WWE-region average zonal wind anomaly exceeds 2 m/s in one of 3 equatorial WWE-regions of zonal length scale ~2500 km (Harrison and Vecchi, 1997).

- Maximum zonal wind anomaly ~7m/s average (up to ~15 m/s).

- Average E-folding time scale ~ 7 days

- Cold-tongue SSTA warming of a few tenths °C follows a single WWE in ENSO-neutral conditions. This warming persists 2-3 months after wind event subsides.

- Rare in cool ENSO conditions. ~ 1 per month in ENSO-neutral and roughly double that in warm-ENSO
La Niña strengthening of the easterly trades does not occur smoothly

Using a definition based on WWE wind stress scales, we find that Easterly Wind Surge (EWS) events are a prominent component of equatorial Pacific wind stress variability.

EWSs have space/time scales roughly akin to WWEs.
EWSs occur in each season...

...and across the Pacific waveguide, though largest in number near the Date Line

Due to the background easterlies, EWS **wind speed** anomalies can be much harder to notice than WWE wind speed anomalies, even though they are comparable in terms of **wind stress**
An Easterly Wind Surge cools the Pacific Ocean waveguide by a few tenths C, just as a WWE warms it.

Although the Easterly Surge is short-lived (e-folding ~7 days) the cooling effects across the waveguide persist for 2-3 months following the wind event, just as warming does for a WWE.

Observational results are shown here. Applying an EWS to our ocean model yields qualitatively similar waveguide cooling. See Chiodi and Harrison (2014, J. Climate in press).

Composite above for EWSs observed in ENSO neutral conditions, 1986-2012.
We find Easterly Wind Surges, occur at a rate of ~ 1 per month, on average (1986-2012)

Model experiments show that a 1 per month series of EWSs alone drives and sustains ~ 0.5°C of waveguide cooling, averaged over the NINO3.4 region
As ENSO SSTA cools, the likelihood of seeing an EWS goes up (~2 per month averaged over NIÑO3.4 < -0.75°C)

A series of EWSs that includes this increase in frequency is sufficient to drive a significant La Niña in the model
**Easterly Wind Surges are associated with clear skies (increased OLR) over the Western Eq. Pac. warm pool**

OLR, SST and SLP all provide measures of the coupled anomaly state of the Trop. Pacific. But OLR is most closely linked to the tropical atmospheric heating anomalies and these “clear sky days” are associated with EWSs, that cool the waveguide over the next 2-3 months, increasing the chance of more EWSs.

The canonical La Niña decrease in deep atmos. convection over the W. Eq. Pacific is apparent on subseasonal timescales.
An OLR La Niña Index

Summing W. Tropical Pacific “clear sky days” from April until the end of the calendar year identifies a subset of La Niña events.

Six of the twelve La Niña events identified by familiar NIÑO3.4 SSTA thresholds make up the “OLR-LN” subset of events.
The 6 OLR La Niña events are distinct, based on OLR, but most do not stand out from other years based on NIÑO3.4 SSTA.
Seasonal Weather Anomalies and La Niña Events

- Using NIÑO3.4 SSTA to define LN events leads to useful composite results, but many LN events do not exhibit the composite behavior; forecast skill is pretty limited.

- *If the LN list is separated into OLR-LN and non-OLR-LN events there are very useful results for the OLR-LN events.*

- And there is little statistically useful association for the non-OLR-LN events.
Sep-Oct-Nov (Year 0) precipitation anomaly composites

Shading where stat. sig. at 90%
Dec-Jan-Feb (Year 0/1) precipitation anomaly composites

Shading where stat. sig. at 90%
La Niña Seasonal Weather Summary

• The OLR-LN precipitation anomaly patterns are basically the familiar ones from previous ENSO studies (e.g. Ropelewski and Halpert, 1989)

• The subset of other LN years have only weak weather associations

• It should now be understood that the familiar LN weather anomalies are strongly associated only with a subset of the years being identified as LN based on NIÑO3.4 SSTA and the common definitions for ENSO.

• OLR may not just be a diagnostic tool! All six of the OLR-LN years are identified by the end of November, in time to be of use to Dec-Jan-Feb and later forecasts (see manuscript for OLR-based hindcast study).

Conclusions

• EWSs are as important to the onset of La Niña events as WWEs are to El Niño events.

• **EWSs have similar space-time-stress scales to WWEs, but occur across the eq. Pac, with a near Date Line peak.**

• EWS frequency increases as NIÑO3.4 SSTA becomes more negative, giving LN positive feedback.

• **Our OLR LN index very usefully stratifies events into those with robust seasonal weather associations and those with only weak associations.**

• Useful weather associations vary with season and region of interest. Paper is in review with full figures, and available here:

Solo EWSs drive a few tenths cooling, just as solo WWEs drive a few tenths °C warming.

EWS identification example

Zonal Surface Stress Anomaly
(5°S to 5°N)

May 1988

Zonal wind stress from ERA Interim Reanalysis

Easterly Surge Anomaly

May 1988

See Chiodi and Harrison, to appear in J. Climate
Zonal wind stress from ERA Interim Reanalysis