Santa Ana (SA) Events in California:
Global Scale Teleconnections and Potential S2S Predictability

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Initial Results

25 years ago today:
Wildfire smoke, fire, and burned houses in San Diego, California, late October 2003

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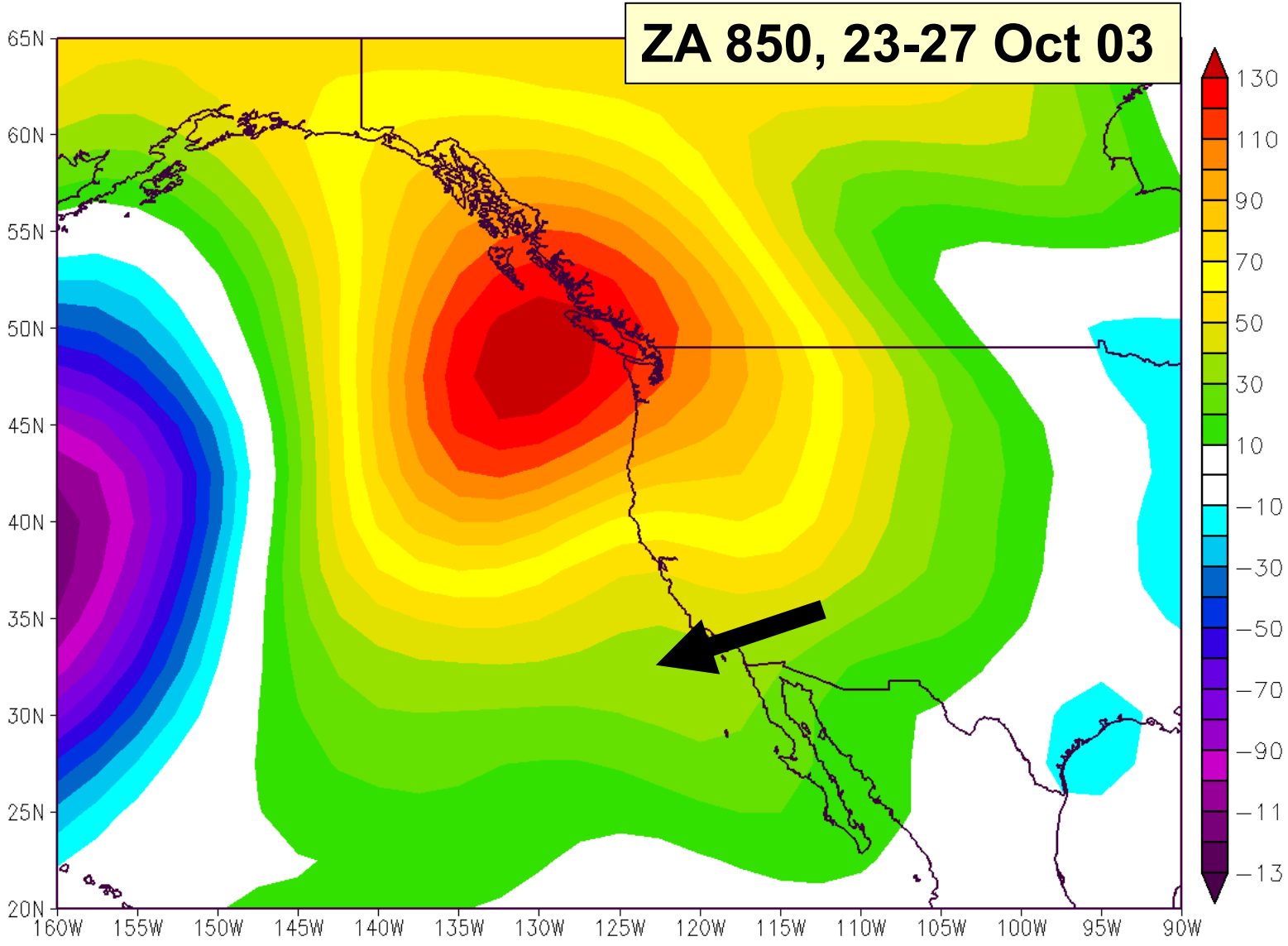
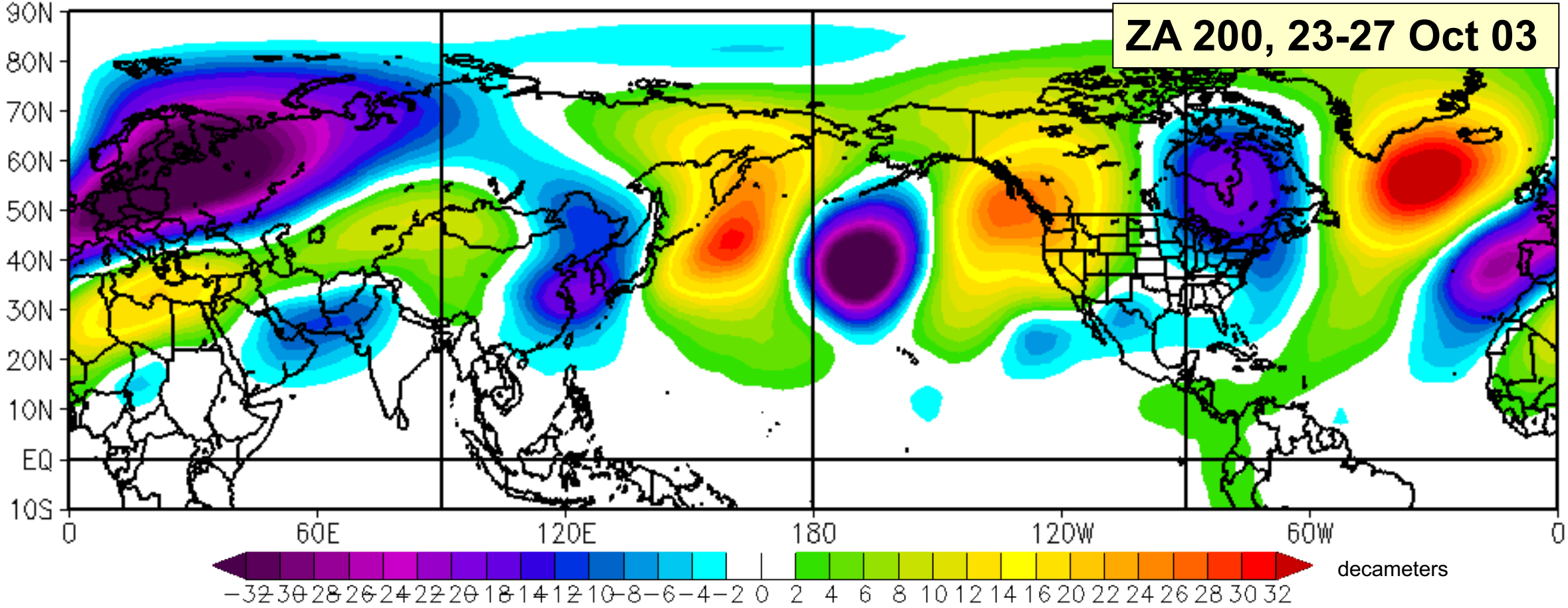
Santa Ana Event (SA) Characteristics: Regional Perspective

1. Anomalous low level high over western North America.
2. Low level winds over California: offshore, downslope, warm, dry
3. Typically last several days or longer.
4. Occur mainly in October-March
5. Can recur several times in a month.
6. Impacts: hydrologic anomalies, wildfires (esp. fall & early winter); societal disruptions (e.g., schools, businesses, power outages, evacuations)
7. SAs commonly thought of as synoptic events.
8. Several names (e.g., Diablo winds in central-northern California).

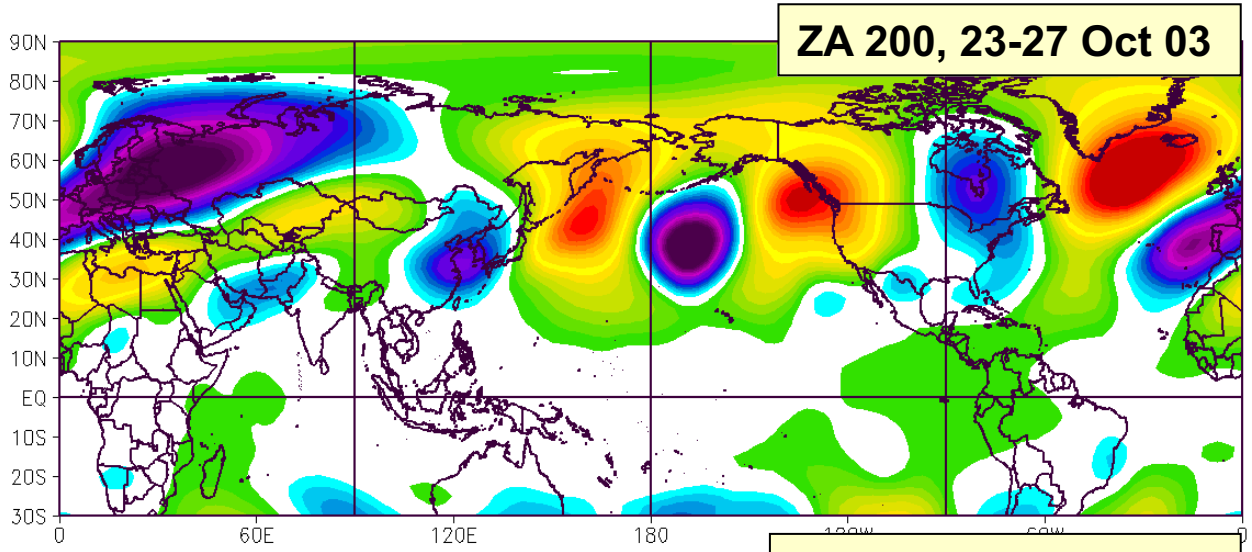


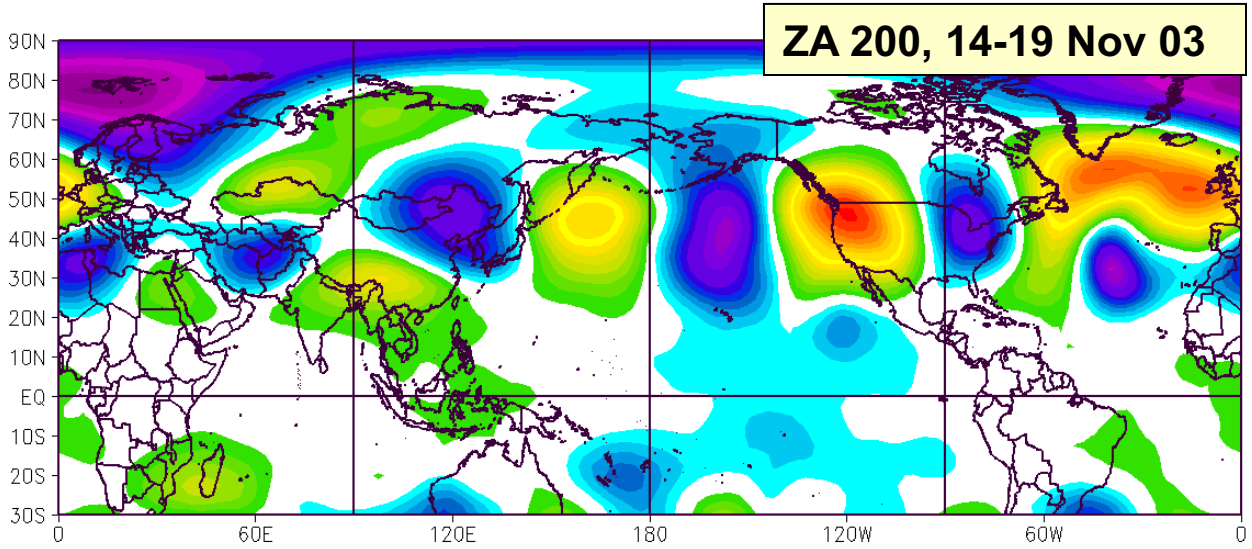
Santa Ana Event (SA) Characteristics: Global Perspective

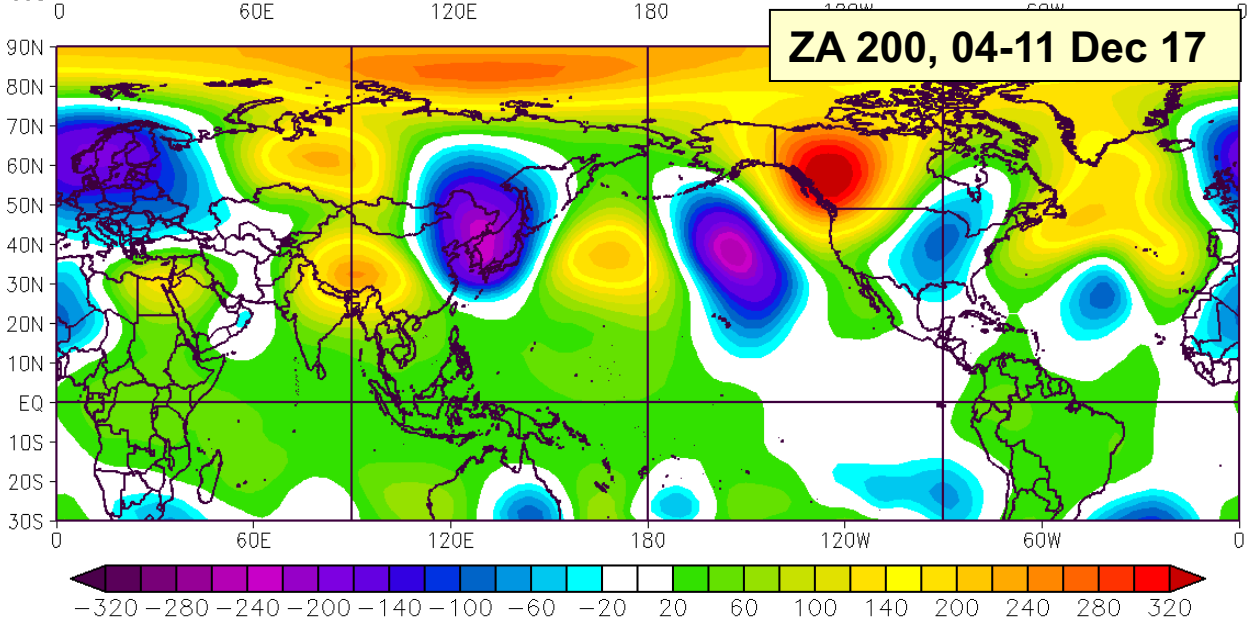


1. Anomalous ridging / blocking over western North America part of global anomaly pattern
2. Key feature: quasi-stationary wave train throughout northern hemisphere (NH)
3. Wave train suggests:
    a. potential remote precursors to SA events
    b. predictability at S2S lead times

Santa Ana (SA) Events: ZA 200 for Individual Events







Individual SA events:

1. **Anomalous ridge over western NA**
2. **Part of anomalous wave train around NH:**
   - **20N-70N**
   - **Zonal wave number 4-5**
   - **Zonal pattern over Africa-Asia**
   - **Arcing pattern over NP-NA-NA**
   - **Dipole anomaly pattern over NA**

Santa Ana (SA) Events: Questions

1. How are SA events related to global scale variations?

2. What process set up SA-favorable conditions over western North America?

3. Can climate variation information be used to improve understanding and forecasting of SA events?

4. What is the potential for skillful S2S prediction of SA events?

5. What can SA events teach us about general S2S variability in western North America?

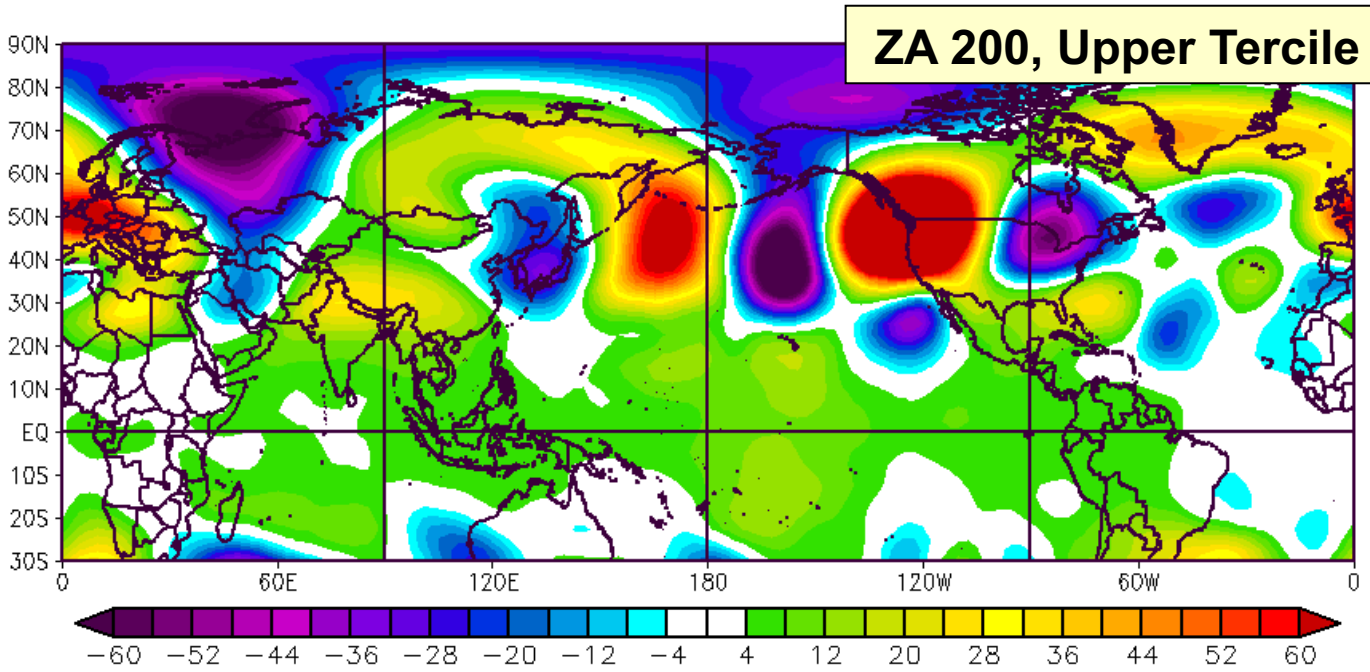
Santa Ana (SA) Events: Data and Methods

1. **Data**
    a. Monthly and daily mean data from R1 and CFSRV2
    b. Interpolated OLR data
    c. Daily u 850 winds over MEI and MJO index data (RMM1/2)
    d. Oct-Mar 1974-2018

2. **Methods**
    a. Create SA index based on u 850 over coastal southern California (< 0 for SA)
    b. Conditional composite and correlation analyses:
        1. Anomalous quasi-stationary wave trains
        2. Tropical OLR
        3. Evolution of teleconnections between California and ENLN, MJO

3. **Focus for this talk**
    a. November (end of dry season), southern California (large impacts)
    b. But focus results are representative of results for Oct-Mar, and for much of western North America

Santa Ana (SA) Events: Composite ZA 200 for Strongest SA Events in Nov

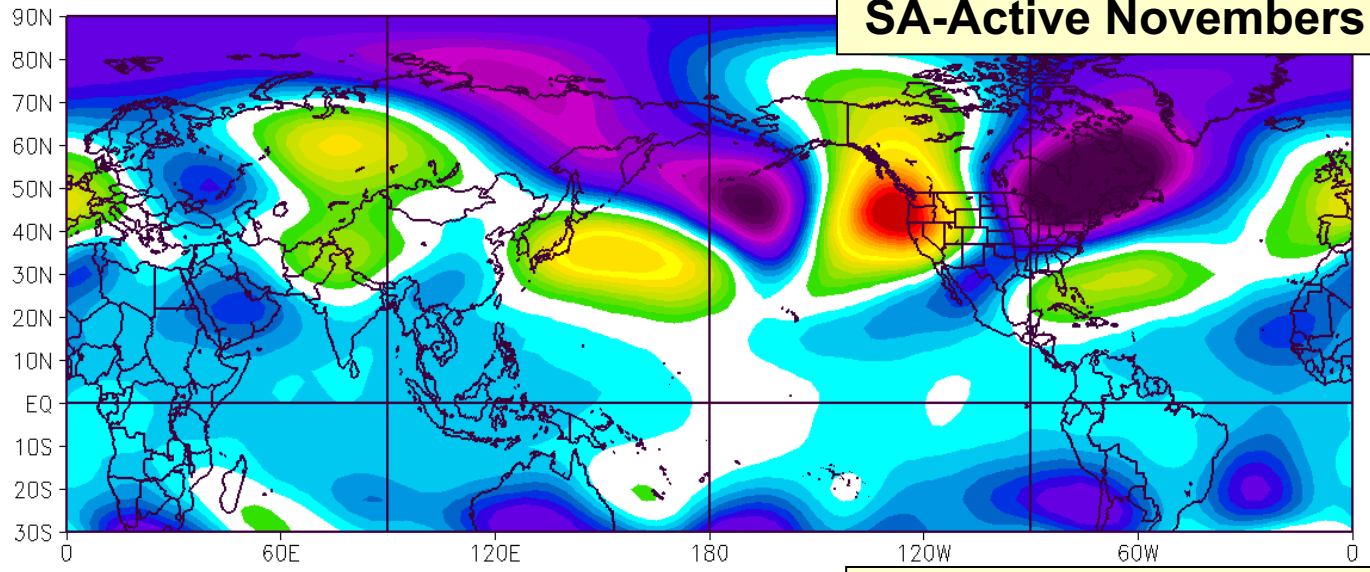


Composite SA:

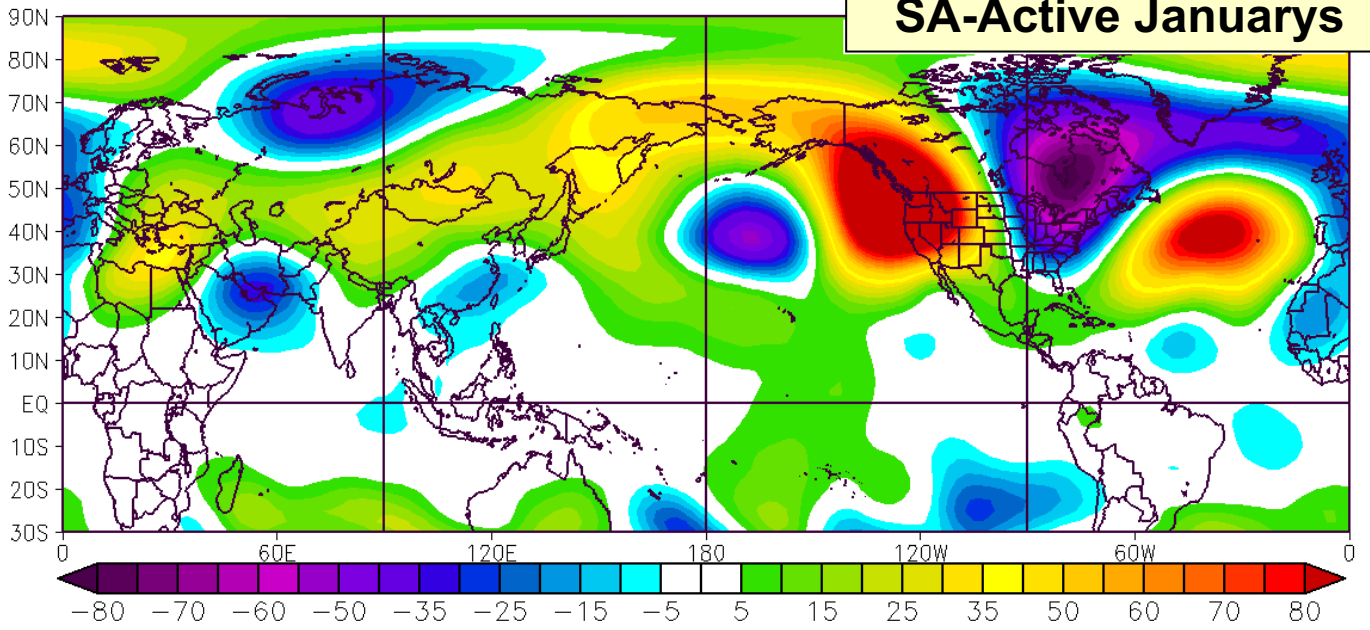
1. **Anomalous ridge over western NA**
2. **Part of anomalous NH wave train:**
   - **20N-70N**
   - **Zonal wave number 4-5**
   - **Strongest: East Asia - E NA**

Santa Ana (SA) Events: Composite Monthly Mean ZA 200 for SA-Active Months

SA-Active Novembers



SA-Active Januarys



- **SA-active months show anomalous wave trains similar to those for individual SA events.**
- **Similar results for each month, Oct-Mar.**
- **Not the +PNA or -PNA**

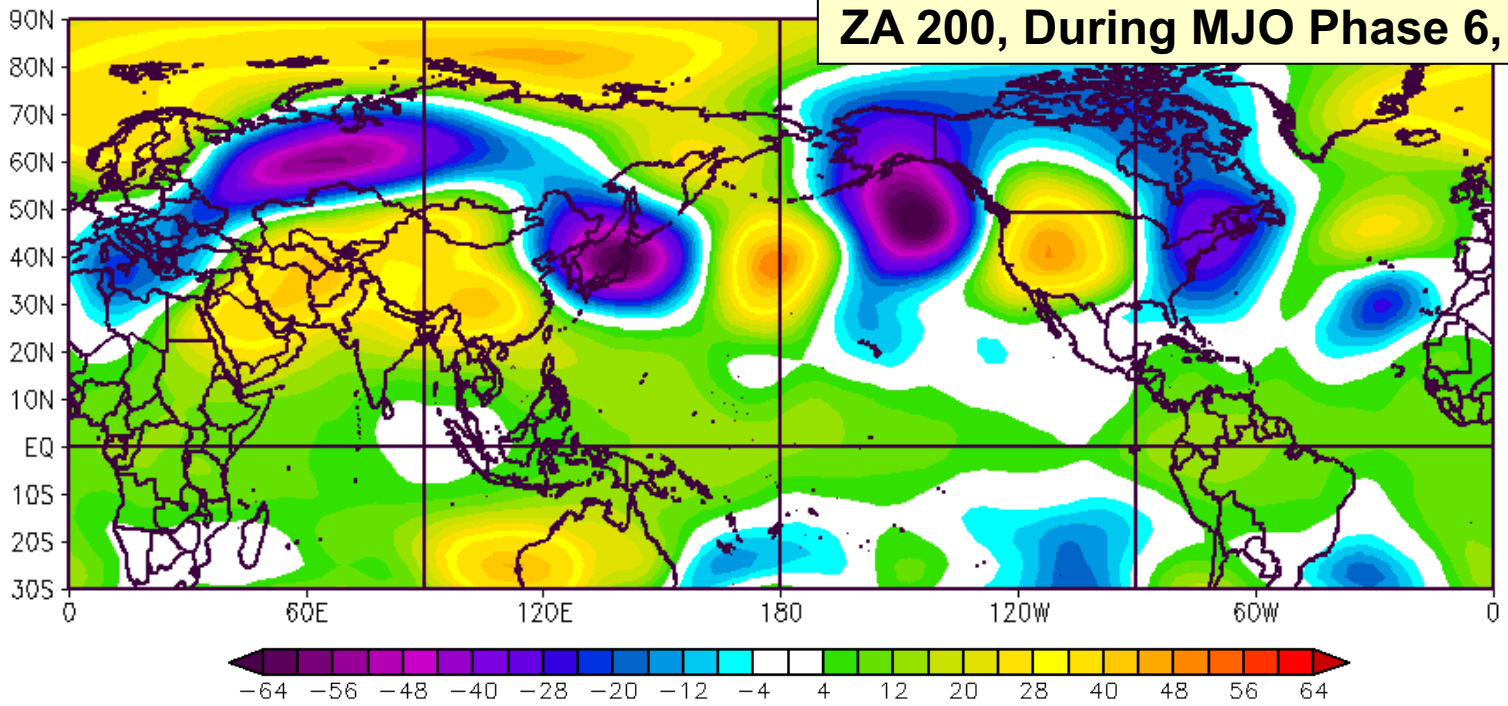
Nov: 1976, 1980, 1986, 1989, 1992, 2007

Jan: 1984, 1992, 2003, 2009, 2014, 2015 (includes ridiculously resilient ridge in Jan 2015)

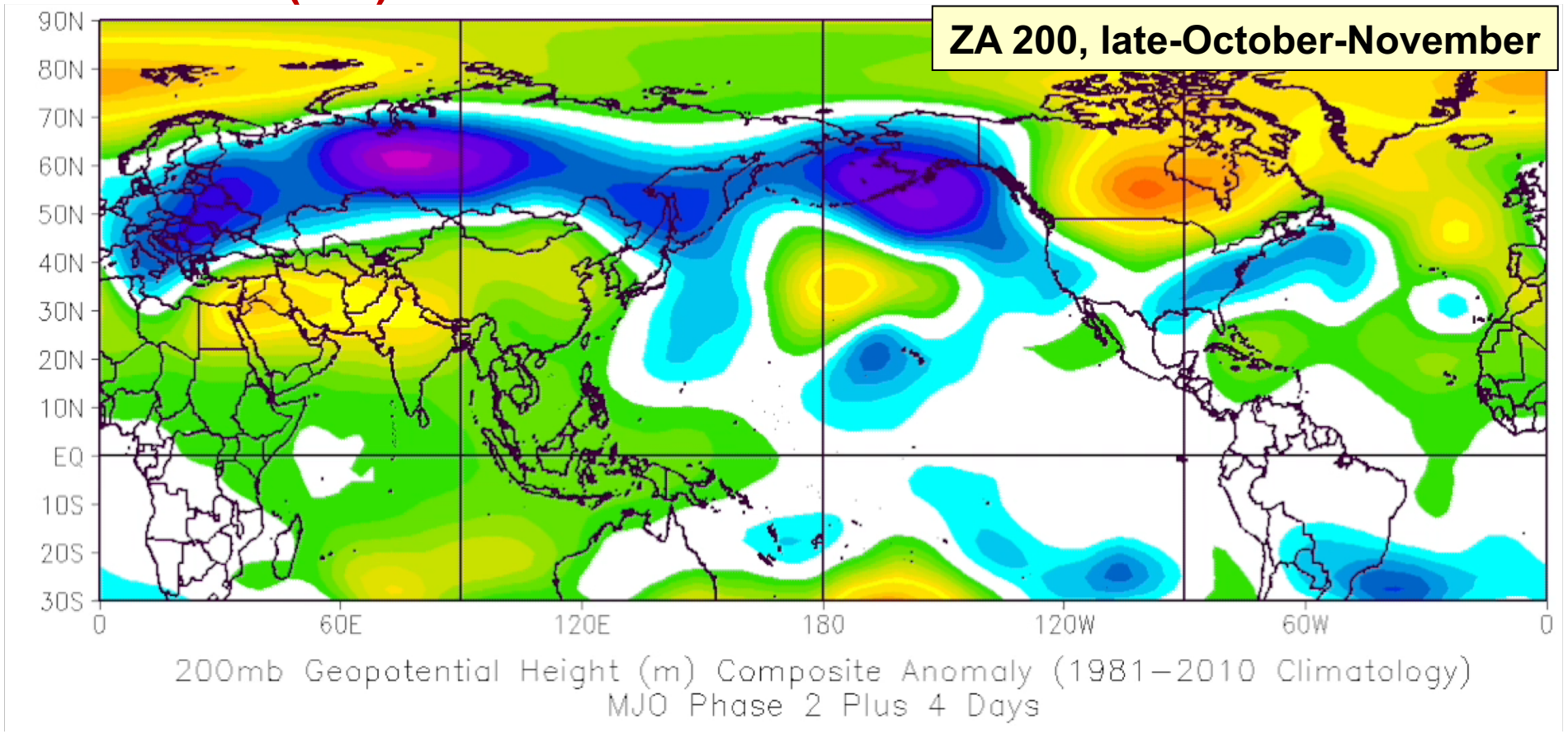
Santa Ana (SA) Events: MJO Role

Many reasons to investigate potential for MJO to induce SA conditions

ZA 200, During MJO Phase 6, November



Santa Ana (SA) Events: Co-Evolution of ZA 200 and MJO

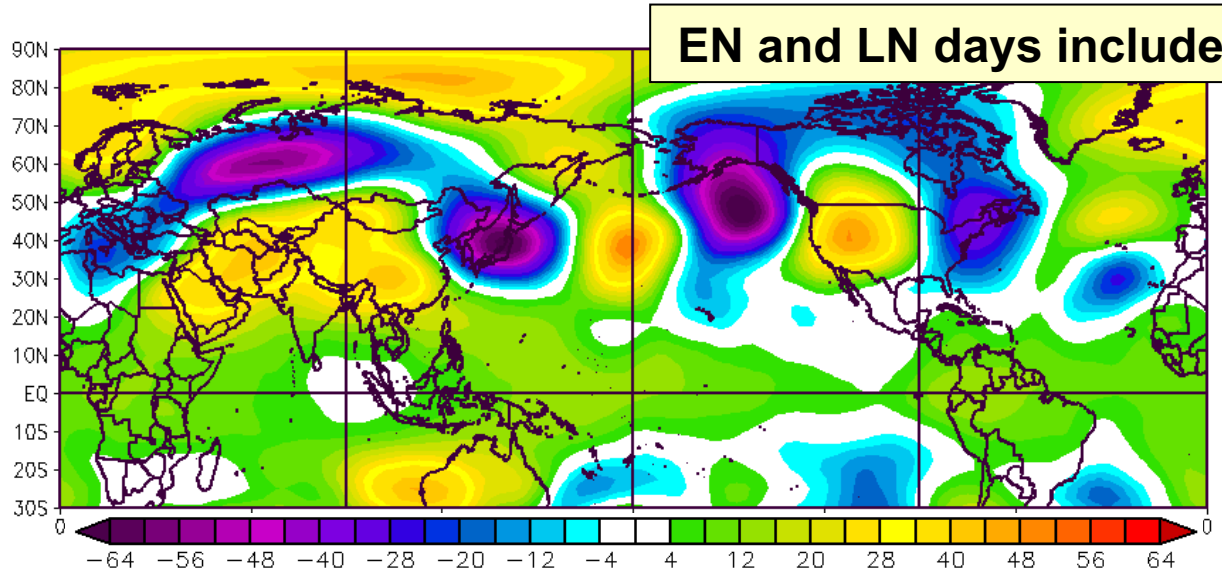


Note:

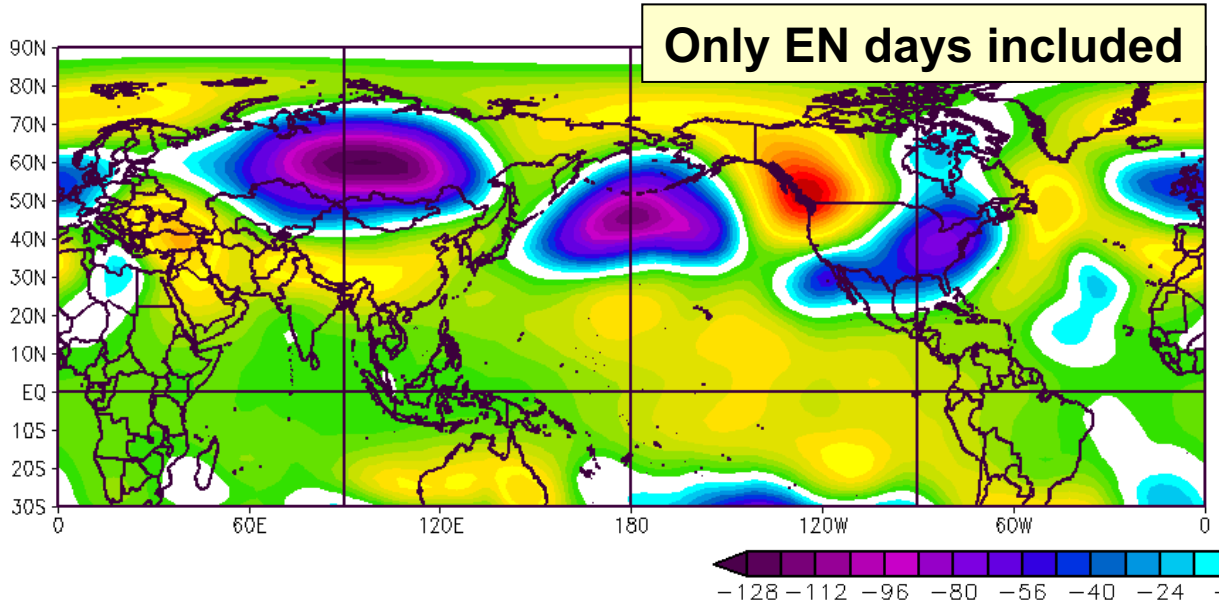
1. **Evolution of tropical Rossby-Kelvin wave response to MJO convection**
2. **Set-up of extratropical wave train about 10 days after Phase 2**
3. **Strongest SA related wave train about 20 days after phase 2**

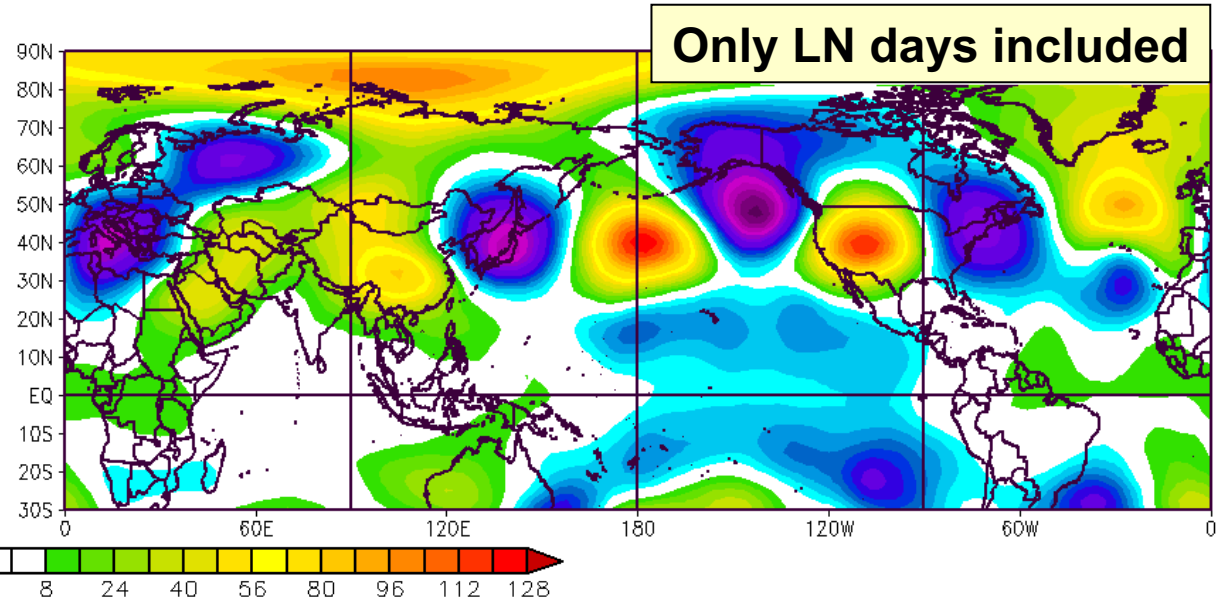
ZA 200, late Oct-Nov, 4 to 24 days after peak MJO Phase 2 conditions, 122 days per frame

Santa Ana (SA) Events: Nov ZA 200, MJO Phase 2 +20 Days, by ENLN State



EN and LN alter MJO related wave trains, especially position and orientation over NP-NA.





Santa Ana (SA) Events: Summary

1. SA events are part of global S2S processes.

2. MJO appears to be a key part of this process, especially phases 1-2-3.

3. EN and LN may substantially alter MJO effects on SA events.

4. 2-4 week lead forecasting of SA events maybe possible but will require skill in forecasting:
    a. MJO --- and ENLN, IOD, AO, …?
    b. Extratropical processes that determine wave train response to MJO (especially background ET flow that affects Rossby wave dynamics)

5. Parallel findings for anti-SA events (not shown).

Santa Ana (SA) Events: Summary

Related problems and convergence of interests

1. Stationary Rossby wave dynamics (Simmons et al., Hoskins et al., …)
2. MJO role in high precip events in western NA (Mo, Higgins, Jones, …)
3. Low skill in upper level forecasting for west coast (DeWitt talk)
4. Atmospheric rivers (SAs are anti-ARs; SAs suppress AR activity)
5. Alaska forecasting, Alaska ridge, Ridiculously Resilient Ridge, ridge forecasting, NA dipole, NA drought/floods (many talks)
6. Extremes outside of western NA created by same processes that create SAs

Proposal: Coordinated, integrated effort to improve analyses and predictions of North American ridging / troughing and their impacts