National Aeronautics and Space Administration

Does the Madden-Julian Oscillation Influence Wintertime Atmospheric Rivers and Snowpack in the Sierra Nevada?

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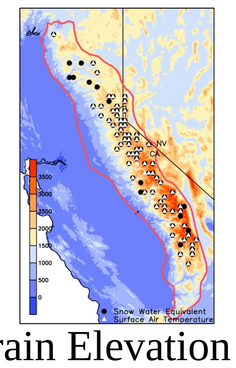
Introduction

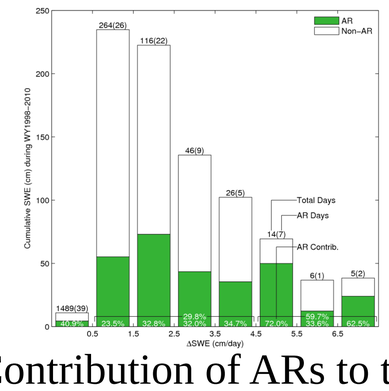
Early prediction of winter storm activities is critical to water resource management in the semi-arid western United States, where snowmelt from the seasonal snowpack forms an important water supply during the dry summer season. An improved understanding of the processes that control the timing and magnitude of snow accumulation is critical for subseasonal and longer scale projections of water availability and demand. Atmospheric rivers (ARs), in particular, concern weather forecasters and emergency managers as they are both a natural water resource and a potential flood-producing hazard.

The current study explores the largely unknown relationship between MJO and ARs based on the analysis of a relatively long period of in situ and satellite data. The importance of non-AR storms is also factored in. Focusing on snow water equivalent (SWE) in California's Sierra Nevada, the study clarifies the MJO influence on the intensity of landfalling ARs, as well as the MJO modulation of the total seasonal snow accumulation which integrates the effects from both AR and non-AR storms.

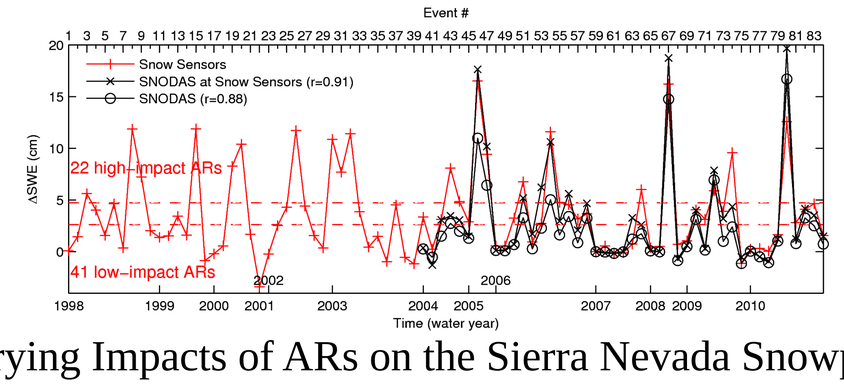
ARs Dominate Extreme Snowfall Events in the Sierra Nevada



Terrain Elevation and Snow Sensor Sites in the Sierra Nevada



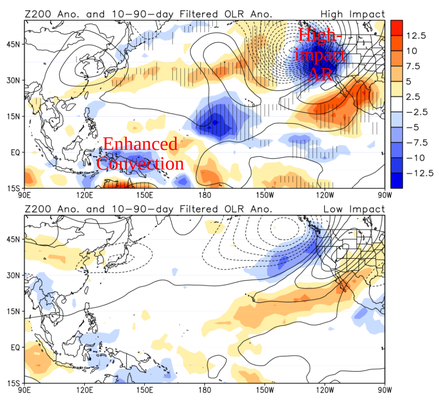
Contribution of ARs to the Sierra Nevada Snowpack



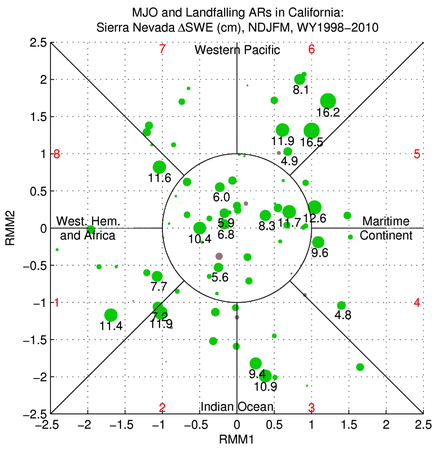
Varying Impacts of ARs on the Sierra Nevada Snowpack

MJO Affects AR Snowfall

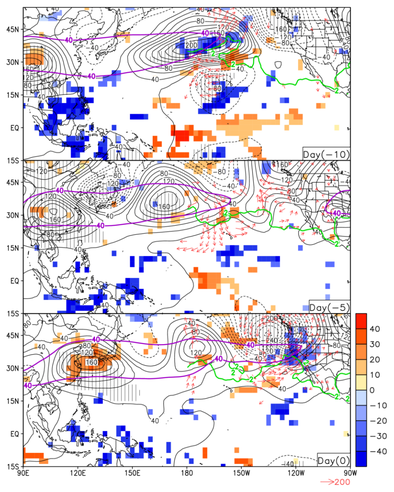
Mean Anomalies of 200-hPa Geopotential Height and 10–90-day Filtered OLR over High- and Low-impact AR Events



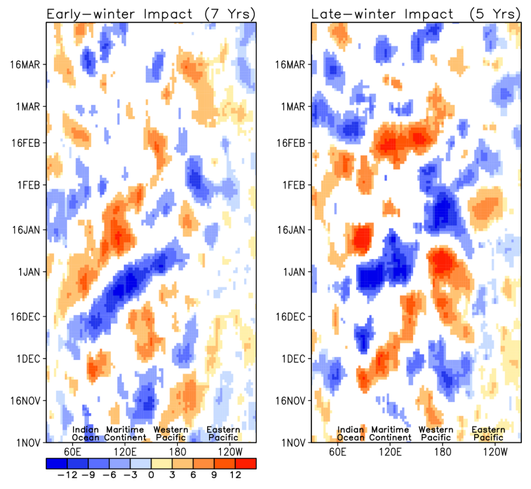
MJO and Landfalling ARs: Phase Relationship



Evolution of High-impact ARs during MJO Phase 6 (Lag Composites)



MJO Affects AR Timing



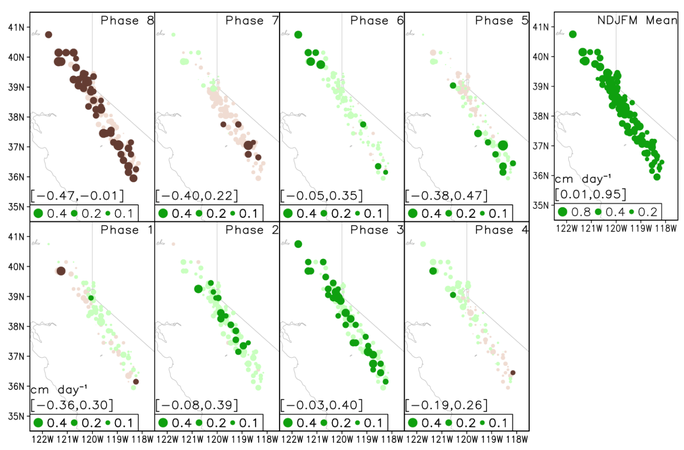
10–90-day Filtered OLR Anomalies between 15S–15N

(Left) Years with the First Occurrence of High-impact ARs on/before Jan 15

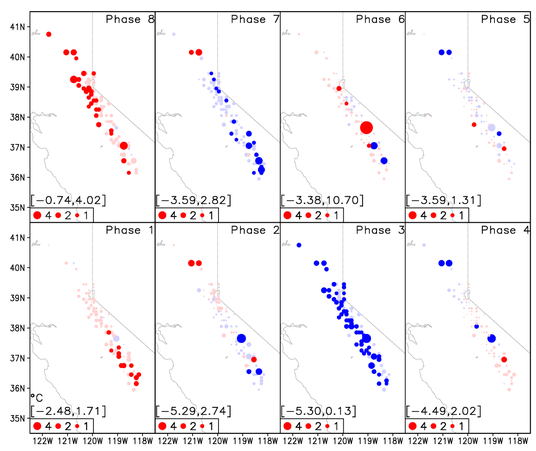
(Right) Years with the First Occurrence of High-impact ARs after Jan 15

MJO Modulates Seasonal Snow Accumulation

Mean Daily ΔSWE Anomaly Relative to the Cold-Season (NDJFM) Mean Over Each MJO Phase



As Left Except for Surface Air Temperature Anomaly



Conclusions

- Atmospheric rivers (ARs) dominate extreme snowfall events in the Sierra Nevada: ARs contribute 60% of the SWE during the days with >4.5 cm daily SWE accumulation;
- AR activity in California is most favored by enhanced convection over the far western tropical Pacific associated with MJO phase 6;†
- MJO affects the seasonal distribution of high-impact ARs;
- MJO phase 3 (8) is associated with above-average (below-average) SWE accumulation in the Sierra Nevada, with the magnitude of the daily anomaly being roughly half the seasonal mean daily accumulation.†

†Statistically significant at the 95% level based on Monte Carlo simulations.

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References

Guan, B., D. E. Waliser, N. P. Molotch, E. J. Fetzer, and P. J. Neiman: Does the Madden-Julian Oscillation influence wintertime atmospheric rivers and snowpack in the Sierra Nevada? *Mon. Wea. Rev.*, in press.

Guan, B., N. P. Molotch, D. E. Waliser, E. J. Fetzer, and P. J. Neiman, 2010: Extreme snowfall events linked to atmospheric rivers and surface air temperature via satellite measurements, *Geophys. Res. Lett.*, **37,** L20401, doi:10.1029/2010GL044696.

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