Large-scale Circulation Context for Atmospheric Rivers: Influence of Subseasonal Winter Teleconnections

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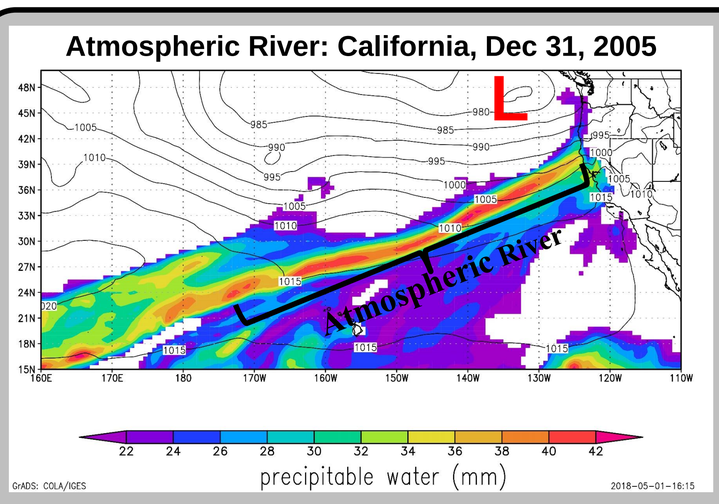

Figure 1. Precipitable water values above 20 mm are shown (values < 20 mm are masked out) for an atmospheric river event that inundated California with flood waters for multiple days.

Background

- Prevalent in winter months
- Poleward transfer of water vapor
- "Filaments" of integrated water vapor (Newell & Zhu, 1998)
- Occasional features in mid-latitude cyclones, where moisture is drawn in from the low-level jet in front of the cold front (warm sector)

Detection:

-Integrated Water Vapor (IWV)

$$= \frac{1}{g}\int_{p_{sfc}}^{p_{top}} q\, dp$$

ARs > 20 mm

-Integrated Vapor Transport (IVT)

$$= \frac{1}{g}\int_{p_{sfc}}^{p_{top}} q\mathbf{V}\, dp$$

ARs > 100 $kgm^{-1}s^{-1}$

Objective

Investigate the influence of subseasonal winter circulation variability (teleconnections) on the spatial and temporal distribution of Atmospheric Rivers (ARs).

Datasets

Dataset	Spatial Resolution	Temporal Resolution	Variables
MERRA-2 Reanalysis	0.5 ° x 0.625 °	1 Hour	• Bias Corrected Precipitation, U/V Flux of Vertically Integrated Water Vapor, 850mb Hgt
AR Database (uses MERRA-2 Reanalysis)	0.5 ° x 0.625 °	6 hours	• Shape of Atmospheric River
CFSR Reanalysis	2.5 ° x 2.5 °	Pentad	• 200mb Geopotential Hgt Principal Components
ERA-Interim	0.75 ° x 0.75 °	1 Hour	• Sea Surface Temperature

Table 1. MERRA-2 was the basis for the majority of the analysis, as the atmospheric river database utilized MERRA-2 IVT values to identify pixels containing such an event.

Methods

- Processed the AR database: defined grid cells containing an AR as having a value of 1 and grid cells without an AR as having a value of 0
- Re-binned MERRA-2 and ERA-Interim variables (including AR database) to 5-day time steps (pentads)
- Computed climatological averages and anomalies for each pentad (1980-2007)
- Defined a Niño3.4 index using the area-averaged sea surface temperature anomalies (120W-170W and -5S-5S)
- Constrained each variable to span only the winter months – December, January, and February
- Regressed (lead/lag) the AR shapes, 850mb Heights, precipitation, and U/V fluxes of integrated water vapor onto the 7 principal components (each representing a different teleconnection) and calculated Niño3.4 index
- Analyzed the dynamics of the regressions with the greatest AR impact on the west coast of the US

Results

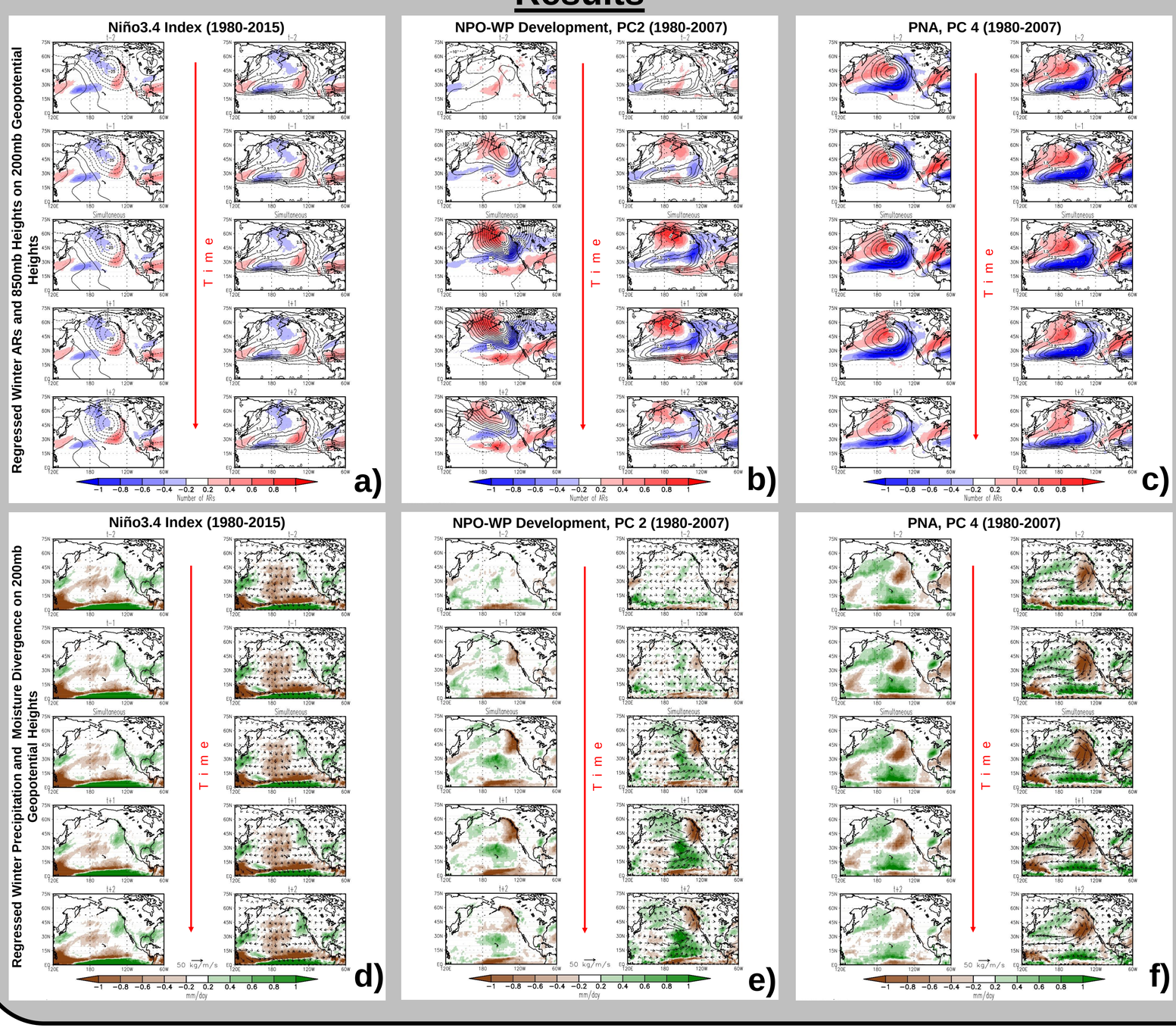

Figure 2. *(Top, Left Columns)* Lead/lag regressions shown for winter AR (shaded) and 850mb height (contour) anomalies.

***(Top, Right Columns)* The winter AR anomaly (shaded) and climatology (contour) are displayed.**

***(Bottom, Left Columns)* Lead/lag regressions are shown for winter precipitation anomalies.**

***(Bottom, Right Columns)* Regressions shown for winter integrated moisture divergence anomalies (shaded) / direction of moisture flux (vector). The panels refer to regressions onto the Niño3.4 SST Index (a and d), NPO-WP development (b and e), and PNA (c and f) teleconnection patterns.**

Conclusion / Summary

Teleconnections are anomalous circulation patterns in our atmosphere, changing the distribution of AR landfalls and regional precipitation patterns. The west coast of the US typically receives a majority of their annual rainfall in the winter months due to the increase in moisture fluxes.

El Niño

- Positive (El Niño) phase
- Low pressure brings SW winds to the west coast, bringing moisture-rich air to the region → more landfalling ARs
- Moisture fluxes are weaker than those for other teleconnection patterns

North Pacific Oscillation – Western Pacific (NPO-WP)

- Positive phase
- Increased moisture flux due to tightening gradient (simultaneous and t+1) in 850mb heights from Aleutian high pressure system → increase in dry winds coming from the west coast and Pacific northwest → fewer ARs on west coast from moisture divergence
- As West-Pacific mode develops (lower pressure and heights), moisture-laden air pushes into Baja Peninsula and western Mexico, increasing the number of landfalling ARs → shift south in ARs from climatological mean

Pacific North American Pattern (PNA)

- Positive phase
- Increased moisture flux due to tightening gradient (t-1 and simultaneous) in 850mb heights → high pressure system south of the Aleutian Islands → fluxes are higher in this teleconnection pattern by nearly twice the magnitude of those in the NPO-WP pattern
- SW winds bring moisture from the western Pacific to central Pacific and coastal, mountainous regions of the Pacific northwest
- Northern winds bring dry air to most of the west coast; ARs don't match up perfectly with precipitation, especially over land where moisture is affected by orographic lifting

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