Modeling Investigation of Atmospheric Moisture Transport over the North Pacific Ocean: Role of Pacific Decadal Oscillation

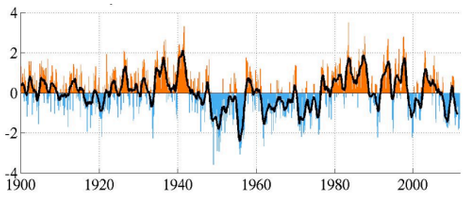
Cecilia Borries **Xiangdong Zhang**

International Arctic Research Center, University of Alaska Fairbanks

Motivation

Atmospheric moisture content over the North Pacific Ocean can fluctuate under the influence of the Pacific Decadal Oscillation (PDO). For a better understanding of the role which the PDO plays in the North Pacific water budgets and pathways, we conducted sensitivity experiments to examine how atmospheric moisture transport responds to sea surface temperature (SST) anomalies associated with the PDO phases transitions.

This study has important implications for improving understanding of precipitation events in areas surrounding the North Pacific.



Monthly values for the PDO index.
http://jisao.washington.edu/pdo/

Method

We employed the NCAR Community Atmosphere Model 5.0 (CAM5) at a resolution of 0.9˚ x 1.25˚. For our experiments, the boundary conditions of observed sea surface temperatures (SST's) were provided from the Hadley Observational Center.

Our experiment domain is the area of the North Pacific Ocean (10˚ N to 75˚ N and 150˚ E to 140˚ W). SST values outside of this region were set to their climatological values.

To obtain the SST anomalies, PDO index data from the Joint Institute for the Study of the Atmosphere and Ocean at the University of Washington was used to determine the years during the negative and positive PDO phases. From this data, our study period is from the years 1945 to 2000 in order to encompass both a negative and a positive phase of the PDO.

Acknowledgements

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Results

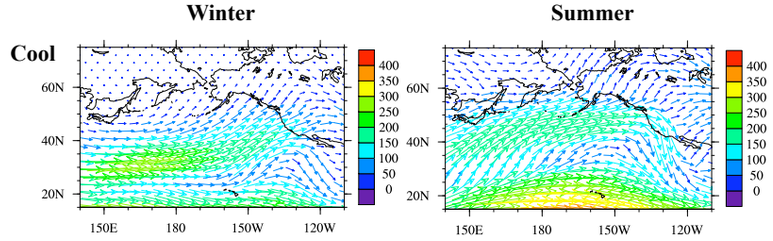
- Moisture Transport

At a single pressure level, total moisture transport is defined as the sum of the time mean plus deviations from the mean:

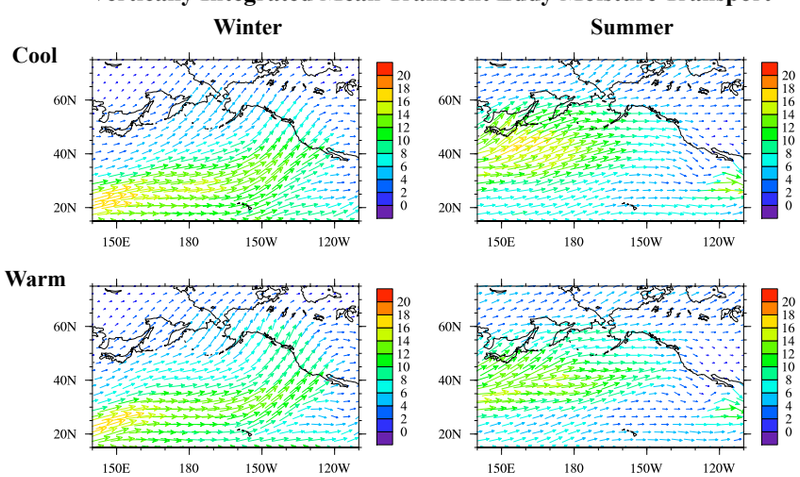
$$q\,\mathbf{v} = \overline{q}\,\overline{\mathbf{v}} + q'\,\mathbf{v}'$$

Therefore, changes in moisture transport are explained by the changes in the transient eddy term, $q'\,\mathbf{v}'$.

Vertically Integrated Mean Moisture Transport



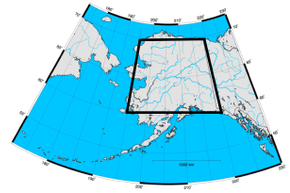
Vertically Integrated Mean Transient Eddy Moisture Transport



Winter/summer, cool/warm phase vertically integrated mean moisture transport (top) and vertically integrated mean transient eddy moisture transport (bottom).

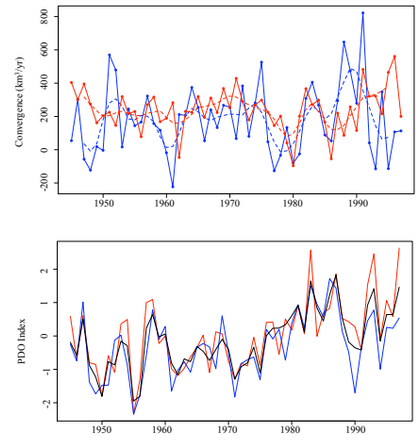
- Moisture Convergence

Moisture convergence into Alaska follows the same trend as the transient eddy transport. Convergence in winter increases in the warm phase and decreases in summer.



Region of study.

Seasonal Moisture Convergence into Alaska Compared with Seasonal PDO Indices

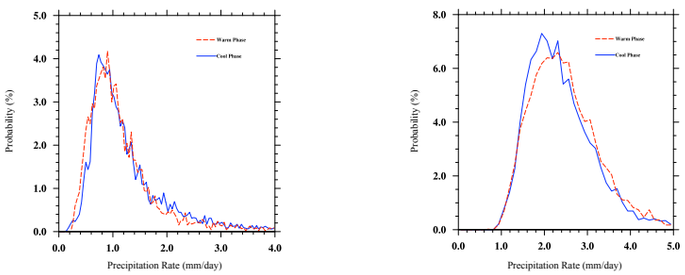


Top: Winter (blue) and summer (red) timeseries of moisture convergence into Alaska with decadal variability. Bottom: Winter (blue) and summer (red) timeseries of PDO indices with annual indices (black).

- Precipitation

Based on the probability distribution function of precipitation rate, the peak of the precipitation rate shifts: from 0.85 (cool) to 1 mm/day (warm) in winter, and from 2 (cool) to 2.2 (warm) mm/day in the summer.

Precipitation Rate PDF for Alaska



Winter (left) and summer (right) precipitation rate probability distribution function for the cool phase (blue) and the warm phase (red).

Conclusions

The differences between the cool phase and warm phase in the winter are summarized by:

- increase in transient eddy moisture transport
- increase in moisture convergence
- increase in light precipitation (0-2 mm/day)
- shift in peak precipitation rate
- decrease in moderate precipitation (2-3 mm/day)

In the summer:

- decrease in transient eddy moisture transport across the southern portion of Alaska
- decrease in moisture convergence
- decrease in light precipitation (1.5-2 mm/day)
- increase in moderate precipitation (2-4 mm/day)