# Decadal-interdecadal variability of the Hadley and Walker Circulations

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## Introduction

The Hadley and Walker circulation are fundamental structures of the Earth's atmospheric, and hence their year-to-year variability is clearly of scientific value. Although the relation between the Walker circulation to the interannual varying El Ninos/Southern Oscillation are widely known (e.g., Oort and Yienger 1996), decadal-to-centennial changes of Hadley and Walker circulations have not been known adequately. Recently, Goswami and Thomas (2000) identified the leading modes for the Hadley and Walker circulations using the NCEP/NCAR reanalysis data; the first mode, however, involves a substantial trend, whose reliability can be questionable in association with possible artificial trends in the reanalysis data. In the present paper, we focus on relations between a Bi-Decadal Oscillation (BDO) and the atmospheric circulation anomalies in the Hadley and Walker circulations. The BDO is one of the most prominent decadal-to-centennial climate variability hold (for a summary review of the BDO see Minobe et al., 2002), and the BDO distributes both the northern and southern hemispheres, suggesting that significant relation between the BDO and the Hadley and Walker circulations may.

## Data and method

As a representative time series of the BDO, we use an index of Aleutian low strength known as North Pacific Index (NPI, Trenberth and Hurrell 1996) in boreal winter with a 10–30-year band-pass filter. Although it is not still clear whether the BDO arise from a single physical mechanism or multiple mechanisms, most of previous studies agreed that the Aleutian low variability is a major feature of the BDO. The same strategy was employed for a study of global precipitation changes (Minobe and Nakanowatari 2002).

A relation between the Hadley circulation and the BDO is examined calculating correlation and regression coefficients between the 10–30-year filtered vertical-meridional mass stream function and the NPI. The stream function is estimated by integrating zonally averaged meridional velocities in each season from the top of the atmosphere to 1000 hPa based on NCEP/NCAR reanalysis data from 1949–2002. For the Walker circulation, meridionally averaged zonal velocity anomalies between 10°S–10°N are used.

## Results

The most well organized structures in the correlations are observed in winter season for both the Hadley and Walker circulations. The distribution of the correlations of the meridional-vertical stream function in the tropics is dominated by a symmetric pattern with respect to the equator, with centers at 20°S and 35°N (Fig. 1). The symmetry is less prominent in regressions, which are much intense in the northern hemisphere. Dominant positive correlations and regressions indicate that when an Aleutian low is strong accompanied by a negative NPI, northward (southward) winds generally prevail in the lower (upper) troposphere in the off-equatorial tropics.

Figure 2 shows core of the correlations and regressions of the equatorial zonal wind speeds onto the NPI are located in the middle of the troposphere over the western equatorial Pacific. Thus, anomalous zonal circulations associated with the BDO cannot be explained by quantitative changes of mean Walker circulations.

## Conclusions

The present results indicate that the BDO influences the Hadley and Walker circulations substantially. The correlations of stream functions prevailing over both the northern and southern hemispheres have significant implications on the inter-hemispheric distribution of the BDO.

## References


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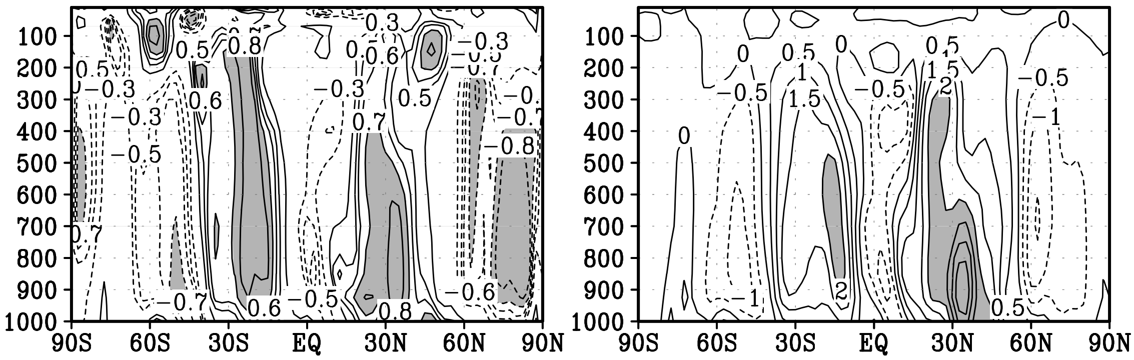


Fig. 1. Correlation (left) and regression (right) coefficients between vertical-meridional mass stream function and the NPI for the period from 1949–2002. A 10–30-year band-pass filter was applied to respective time series before calculating correlations and regressions. For correlations, contour levels are ±0.3, 0.5, 0.6, 0.7, 0.8, and 0.9, and the absolute values of the correlations larger than 0.7 are shaded. For regressions, contour interval is $0.5\times10^9$ kg $s^{-1}$, and the absolute values of the regressions larger than $2\times10^9$ kg $s^{-1}$ are shaded. Positive anomalies of the stream function are associated with clockwise rotation.

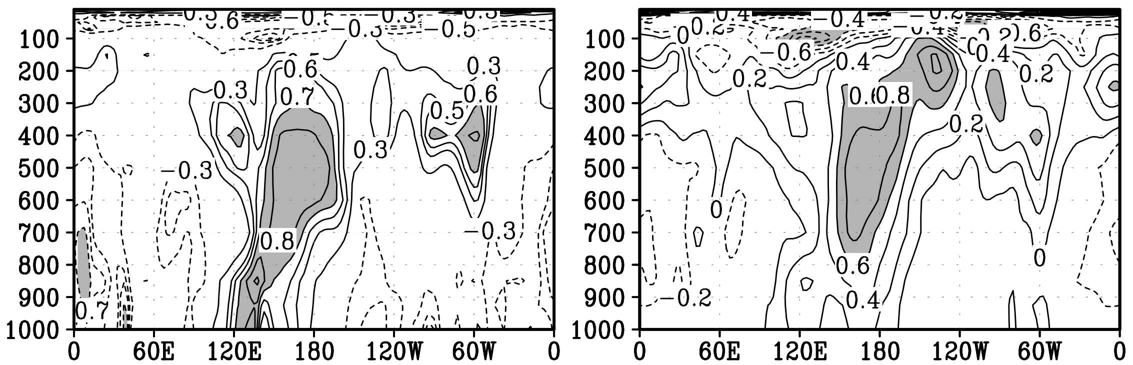


Fig. 2. Same as Fig. 1, but correlation (left) and regression (right) coefficients between zonal wind speeds averaged between 10°S–10°N and the NPI. Contour interval for the regressions is 0.2 m $s^{-1}$, and the absolute values of the regressions larger than 0.6 m $s^{-1}$ are shaded.