Mean meridional circulations expressed by mass-weighted isentropic time means

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1. Introduction

Mass-weighted isentropic zonal means (MIM) can completely treat lower boundary and finite amplitude waves, and express zonal-mean meridional circulations and wave mean flow interactions (e.g., Iwasaki, 1989). Zonal-mean meridional circulations depicted by MIM shows a direct circulation in troposphere for winter hemisphere and the Brewer-Dobson circulation (BDC) in the stratosphere. However, three-dimensional structure of these circulations has not been fully understood yet. We try to clarify the three-dimensional structure based on mass-weighted isentropic time means. Particular attention is paid to bolus velocity which represents eddy correlations of mass weight and meridional velocity (Rhines, 1982).

2. Mass-weighted isentropic time mean meridional wind

We show results for the boreal winter, time mean from December to February of 1980/81-2009/10. Spatial pattern of mass-weighted isentropic time mean meridional wind roughly resembles to that of (not mass-weighted) isentropic time means. They show wave-number 3 patterns below lower stratosphere and wave-number 2 patterns in middle stratosphere at $45°$ N. Considerable differences are found in the lower and upper troposphere. Mass-weighted isentropic time means show strong northerly in the lower troposphere and strong local maxima near the tropopause.

3. Bolus velocity

Mass-weighted isentropic time mean wind can be divided into isentropic time mean wind and bolus velocity, which represents net mass transports induced by transient waves. The bolus velocity explains the differences discussed above. Spatial pattern of meridional component of bolus velocity reflects positions of storm tracks. The bolus velocity is northerly in the lower troposphere and southerly in the upper troposphere for storm track regions. It exhibits wave-number 3 patterns in the lower to middle stratosphere at $60°$ N. At the symposium, we discuss about contributions of isentropic time mean wind and bolus velocity to the BDC.

Key words: meridional circulation, isentropic analysis, bolus velocity.