

Impacts of low-level polar cold air outbreaks on Brewer-Dobson circulations

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1. Introduction

We study the driving of Brewer-Dobson circulation by cold air outbreaks in the lower troposphere. It is well-known that intermittent cold air outbreaks frequently occur both in the East Asia and in the east coast of North America. Gravity waves and Rossby waves excited by low-level equatorward outbreaks propagates upward, makes flux convergence in the upper troposphere and stratosphere, and drives poleward flows. Isentropic coordinates facilitate analyzing the whole processes of wave-mean flow interactions, including the lower boundary conditions.

2. Temporal behavior of East-Asian polar cold air outbreaks

The polar cold air mass is defined below an isentropic temperature, so that the hemispheric total cold air mass is a conserving parameter under the adiabatic condition. The horizontal cold air mass flux clearly shows both of the East Asian stream and North American stream. With a focus on the East Asian stream, the temporal variation of equatorward mass flux is monitored quantitatively by the equatorward cold air mass flux integrated between 90-180E at 45N. According to autocorrelation, the outbreak has a pulsating feature with a half width of about 5 days.

3. Mean meridional circulation induced by East Asian outbreaks

Mass-weighted isentropic zonal mean (MIM) equations are allowed us to interpret mean-meridional mass circulation and wave-mean interactions, including the lower boundary conditions (e.g., Iwasaki, 1989). The extratropical pumping relations work even in the low-level equatorward mass flux (e.g., Iwasaki and Mochizuki, 2012). The lag correlation with the equatorward cold air mass flux (90-180E, 45N) indicates that pulsating cold outbreaks are accompanied by E-P flux divergence near the surface and followed by upward E-P flux anomaly and enhancement of poleward flow.

The lag correlations are also studied of temporal three-dimensional structure of meridional flow anomalies. In the extratropical stratosphere, the meridional mass flux is prevailed by the eastward propagating wavenumber 3 anomalies prior to the low-level outbreaks. This may be closely related to the preconditioning of Siberian High which induces the typical polar cold air outbreaks.