The climatology of the Brewer–Dobson circulation and the contribution of gravity waves

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Introduction:

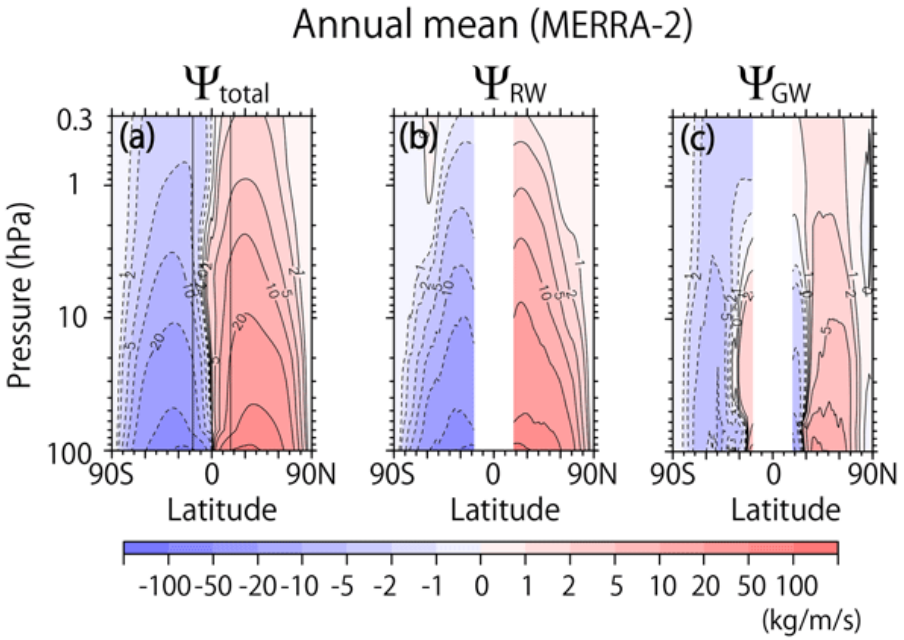
The Brewer-Dobson circulation (BDC) is an important stratospheric circulation that crucially affects the earth climate, such as transporting ozone produced in the tropics to polar regions. BDC is divided into the transport process by large-scale flow and the mixing process by turbulence generated by breaking of Rossby waves. In this study, we focused on the transport part, and analyzed it using four kinds of atmospheric reanalysis datasets. Until now, the analysis of BDC was almost limited to the summer and winter when steady state can be assumed. In this study, however, the analysis was also performed in the spring and autumn. By using the latest data, the analysis altitude range was extended to the entire stratosphere and the lower mesosphere.

Method:

A method for diagnostically examining the contribution of gravity waves, Rossby waves, and radiation using atmospheric dynamics theory was devised and used for the analysis.

Results:

1. The annual mean circulation is equatorially symmetric and goes from the equator to poles (right figure). Conventionally, BDC has been driven by Rossby waves (RW), but it can be seen that gravity waves (GW) also drive low-latitude equatorward parts and high-latitude poleward parts. The GW contributes significantly to the positioning of the turn-around latitude (TL) where the BDC changes from upward to downward, leading to the spread of BDC to higher latitudes. The streamline function at TL theoretically represents the strength of troposphere/stratosphere mass exchange, indicating that GW plays a very important role.
2. The autumn and spring circulations were thought to be equatorially symmetrical, similar to the annual average, but the autumn circulation is stronger and wider than the spring circulation. It is due to seasonal variation of middle atmosphere jet from westerly in winter to easterly in summer, caused by radiation.
3. It was suggested that both RW and GW have larger activity in March to May than in September to November in both hemispheres.



4. By comparing the GW contribution of analyzed diagnostically with the parameterized-GW, we were able to show concrete guidelines for improving GW parameterizations, which would lead to improvement in the accuracy of weather prediction and climate projection.