Variation of the atmospheric angular momentum in the stratosphere and its relation to the ozone transport

Shintaro Ozaki
Laboratory of atmospheric environmental information analysis, RISH, Kyoto University

Since 1970s the satellite measurement has been successful in the atmospheric observations, and we acquired the global ozone distribution in the latter half of 1970s. Since then we have recognized the Antarctic ozone hole, and the distribution of ozone in the global scale has become one the most important factors controlling the earth's climate. As the photochemical lifetime of ozone in the lower stratosphere is very long, the ozone distribution is highly affected by the atmospheric transport. As a result we need to know not only the ozone production/loss but also the effect of the transport to understand the global distribution of ozone.

The stratosphere has its nature of very stable stratification in vertical direction, as the atmosphere absorbs the sun's ultraviolet radiation in the upper stratosphere. In such a stratified region the atmospheric waves generated in the lower part of the atmosphere can propagate and affect to the state of the general circulation. When these waves break under some conditions, it is expected from the atmospheric wave theory that they transfer wave momentum to the background flow. To describe this quantity we usually use one of the useful physical parameters called the E-P flux.

In this paper we investigate the angular momentum transferred from waves propagating in the atmosphere and its relation to the atmospheric angular momentum in the stratosphere. Two case studies were performed: one for the stratospheric sudden warming in the northern hemisphere, and the other for the poleward and downward shift of the westerly jet in the southern hemisphere. Though the time scales of these events are rather rapid in about a week, the atmospheric angular momentum for each case did not show such a rapid change but represents a part of the slow change of the whole stratosphere.

In the time scale of a month the vertical component of the E-P flux (Fz) and the change in the monthly mean stratospheric angular momentum was compared. We found that the stratospheric angular momentum is decreasing, as a result of the vertical transport of the negative angular momentum as indicated in Fz of both hemispheres. The correlation is strong during the winter in both hemispheres, representing the typical atmospheric conditions in the winter stratosphere. During the springtime in the northern hemisphere it is well known that the ozone amount is highly affected by the atmospheric condition and its interannual variability. Thus the change in the angular momentum during the winter was investigated in association with the ozone amount in the following spring, and we found that the two physical quantities are closely related with each other; when the decrease of the angular momentum is larger, the ozone amount during the spring is richer, and vise versa. In the southern hemisphere we see characteristic signatures similar to the northern hemisphere. Moreover in the southern hemisphere the atmospheric angular momentum can be used as an index of the strength of the polar vortex. It is suggested that the index also indicates how easy the heterogeneous reaction can be introduced on the polar stratospheric clouds (PSCs).