Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

AAS003-P07 会場:コンベンションホール 時間: 5月27日17:15-18:45

成層圏突然昇温の熱帯への影響

Impacts of stratospheric sudden warming on tropics

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The impact of the stratospheric sudden warming (SSW) on the Tropical Tropopause Layer (TTL) was investigated based on satellite data (CALIOP and EOS MLS). The results inferred that the SSW modulated the large-scale convective system in the troposphere and the Stratosphere-Troposphere Exchange (STE) in the TTL was active after the onset of the SSW.

The linkage between the SSW during the winter seasons and persistent cirrus and pronounced convections in the TTL have been discussed elsewhere [Kodera and Yamada, Pap. Meteorol. Geophys., 2004; Eguchi and Kodera, GRL, 2007; Eguchi and Kodera, GRL, under review]. A notable SSW occurred in January 2009, in the northern hemisphere (hereafter denoted as SSW09). This study attempts to further expand the previous understandings on the impact of SSW on the tropics by investigating into the case of SSW09.

During the month of January 2009, a vertical propagation of planetary waves in the northern middle latitudes started on the 12th and intensified afterward. Enhanced activities of planetary waves are known to drive stratospheric meridional circulations. According to the increasing of the temperature at 10 hPa in the Arctic, the gradual cooling of the equatorial tropopause region was observed; zonal mean temperatures fell down as much as 2 K in 20 days, and a large increase of the polar stratospheric temperature followed later around the 20th (the onset date of SSW09) when planetary waves focused on the polar region. In the present study, the periods of January 10-15, January 16-21, and January 22-27 can be roughly classified as the pre-warming, mature and declining phases, respectively.

During the pre-warming phase, convections over the tropical Africa, the maritime continents and South America were active. The month of January in 2009 is cold phase of the El Nino Southern Oscillation (ENSO), therefore the SPCZ (South Pacific Convergence Zone) in the western Pacific was also seen clearly. The temperatures at 100 hPa (almost the middle layer of TTL) over these convective regions were colder than that of the rest in the tropics, in particular the coldest region was occurred over the area between the eastern Indian Ocean and the western Pacific. The temperature structure exhibits Kelvin-wave response. The dry air and high cirrus cloud frequency were seen over the cold areas.

During the mature phase of the SSW09, the tropical convections disappeared or attenuated and then the temperature and water vapor became warmer and wetter than those in the previous period, respectively. Further, the convections became the smaller horizontal scales. The distribution of velocity potential at 200 hPa shows that the large-scale tropospheric circulation was changed from the Walker circulation (zonal direction) to the Hadley circulation (meridional direction).

During the declining phase, the convection occurred mainly at the south side of the equator especially over the Africa, between the middle of Indian Ocean and the western Pacific, and the South America. This feature was followed by the Hadley circulation. The water vapor and carbon monoxide (CO) distributions at 100 hPa became patchy. The scatter plot between CO and ozone regarded as the indicator of STE activity shows that the mixing in the TTL became frequently after the onset due to the convection with small horizontal scale.

At the presentation, we will show the details of the analysis, especially the relationships between stratospheric dynamics (e.g. circulation and STE) associated with SSW09 and the parameters (e. g. cirrus clouds and water vapor) in the TTL.

キーワード:成層圏,突然昇温

Keywords: stratosphere, sudden warming