A characteristic response of the northern middle atmosphere to elevated stratopause

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Sudden stratospheric warmings (SSW) are striking dynamical events in the winter middle atmosphere. The stratopause descends significantly and the stratosphere becomes roughly isothermal during major SSW events. After some major SSW events, the stratopause reforms at a quite high altitude of about 80km. This is referred to as an elevated stratopause event (ESE) and has been actively studied recently.

This study investigates the characteristics of the zonal mean structures during the SSW events followed by the ESE in the Northern Hemisphere by using Microwave Limb Sounder satellite data in the time period, from 2004-2016. Three ESE occurred during almost the same calendar days during the analyzed time period. A regression analysis is made to elucidate the effect of ESE on the zonal mean zonal winds, temperature, EP flux, and EP flux divergence in the meridional cross section from January to February. The reference time series is yearly zonal-mean temperature that was averaged for the 75-80km heights, for the 72.5-82.5N latitudes and for February 16-28 where the temperature maximum is observed. The results are shown in Figure 1. When the SSW occurred in the first half of January, significant negative EP flux divergence is observed, which likely results in a deceleration of the eastward stratospheric jet as observed in the second half of January. The warming of the stratosphere observed in the second half of January. This is likely caused by a poleward and downward circulation associated with the EP flux divergence and lasts until the latter half of January. An enhanced eastward wind is observed in the mesosphere (~70km) and seems to be related to the positive EP flux divergence during the first half of February. Because of the eastward wind, gravity wave forcing should be westward in the MLT, resulting in a poleward and downward circulation, which is attributable to the formation of ES. It is interesting that this characteristic structure associated with ESE gradually descends.

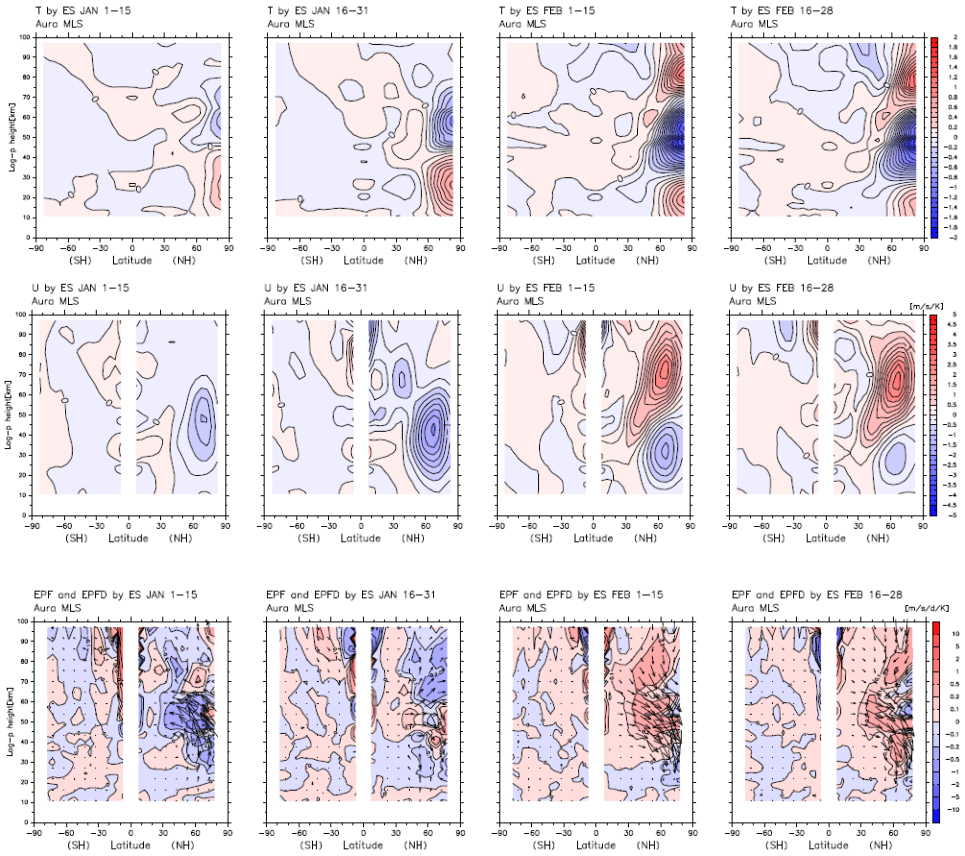

Figure 1. The meridional cross section of the zonal mean temperature (top), zonal mean zonal wind (middle), EP flux, and EP flux divergence (bottom) from the first half of January (left) to the second half of Feburuary (right) which are regressed onto the reference time series of the zonal mean temperature for 75-80km heights, for the 72.5-82.5N latitudes and for February 16-28.