The anomalous field around the North Pole associated with the solar cycle and the QBO

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The energy flux of the UV radiation changes large amount (few percent) with 11-year solar cycle (Lean et al., 1997). The temperature in the stratosphere is affected by the direct radiation, while the lower atmosphere can be influenced through the interaction with dynamics (Kodera and Kuroda, 2002). The relationship between the 11-year solar cycle and the polar temperature changes according to the phase of the Quasi-biennial Oscillation (QBO) (Labitzke, 1987). Labitzke (1987) found that on the westerly phase of the Quasi-biennial Oscillation (QBO) the NDJF mean temperature over the North Polar Region indicates warm anomaly in the HS and cold anomaly in the LS with Berlin data. But, Naito and Hirota (1997) stated that the relationship between the QBO, solar cycle and temperature over the North Polar Region is only significant in the late winter (JF); while the significant relationship is not found in the early winter (ND).

The vertical connection in the North Polar Region is modulated by the solar cycle. Kodera and Kuroda (2005) shows that the positive correlation between the zonal wind at 65 N, 10 hPa and zonal wind over troposphere is seen in the high solar period, and the waves maintain the tropospheric anomaly. While in the low solar period the downward extension is weak.

The previous studies showed that the relationship between the QBO and the polar stratospheric temperature changes with solar cycle. These studies used the Berlin data (Labitzke, 1987; Naito and Hirota, 1997), and the comparison with other dataset (e.g. NCEP/NCAR reanalysis) is required. In addition, it is important to analyze this relationship with outputs of the atmospheric general circulation model (AGCM) which can be used to indicate the mechanism of this relationship. Note that we analyze the changes with solar cycle, so we use the AGCM include the chemical interaction with ozone (Chemistry Climate Model).

In this study, we analyze the relationship between the 11-year solar cycle and the polar stratospheric temperature with the NCEP/NCAR reanalysis dataset and output of the Chemistry Climate Model (CCM). The results in NDJF mean data are compared to the results of the Labitzke (1987), and we compare the results in early and late winters to the results of the Naito and Hirota (1997). In addition, the connection between stratosphere and troposphere is analyzed.

The CCM in this study is based on the AGCM developed in Center for Climate System Research, University of Tokyo (CCSR) and National Institute for Environmental Studies (NIES). The CCM calculations include the effects of the 11-year solar cycle, QBO, and volcanic aerosol with observations (CCMVal-REF1). The analysis period is 1980-2000.

We analyze the NCEP/NCAR reanalysis dataset for 1980-2000, and the NDJF mean 30 hPa temperature in the North Polar Region is not changed between westerly and easterly phase of the QBO. In the late winter, the polar temperature is warm/cold at solar maximum/minimum in westerly phase of the QBO. The results in late winter are similar to the results in Labitzke (1987) and the late winter results in Naito and Hirota (1997). In contrast, the polar temperature in early winter is warm/cold at solar minimum/maximum in westerly phase of the QBO. This relationship is reverse of the results in late winter. We show the vertical connection and the results of the CCM in the presentation.