The QBO and 11-year solar cycle influences on the Northern Hemisphere extratropical winter circulation

Yousuke Yamashita[1,2], Hideharu Akiyoshi[1],
Theodore G. Shepherd[3], and Masaaki Takahashi[4]

[1] *National Institute for Environmental Studies, Tsukuba, Japan.*
[2] *JSPS Postdoctoral Fellow for Research Abroad, Department of Meteorology, University of Reading, Reading, UK.*
[3] *Department of Meteorology, University of Reading, Reading, UK*
[4] *Atmosphere and Ocean Research Institute, University of Tokyo, Kashiwa, Japan.*

The combined influences of westerly phase of the QBO (QBO-W) and 11-year solar maximum (S_{max}) on seasonal evolution of the Northern Hemisphere (NH) extratropical winter circulation are investigated using reanalysis data and Chemistry Climate Model (CCM) simulations. The influences of the QBO-W and S_{max} (QBO-W/S_{max}) show a strengthened polar vortex in December (early winter), leading to a weakened polar vortex in February–March (late winter). Previous studies focused on this seasonal evolution in the context of transfer of the QBO and solar signal within stratosphere/mesosphere, whereas we focus on the role of troposphere in this evolution. In December, the dynamical processes induced by QBO-W conditions around the polar vortex are similar in character to those induced by S_{max} conditions, and both processes may work in concert to strengthen the polar vortex during QBO-W/S_{max} conditions. The strengthened polar vortex in December during QBO-W/S_{max} is occurred simultaneously with a development of the North Atlantic Oscillation (NAO) like anomaly in the Atlantic sector in January, which is maintained by meridional eddy momentum transport of a zonal wavenumber 2 component. The structure of the NAO like anomaly has a zonal wavenumber 1 (WN1) component, where the anomalous waves are in phase with climatological waves. This implies the amplification of the WN1 wave and results in the enhancement of upward WN1 propagation from the troposphere into the stratosphere in January, leading to the weakened polar vortex in February–March. These results may provide a possible explanation for the mechanisms underlying the seasonal evolution of the NH extratropical winter circulation during QBO-W/S_{max} and the role of the troposphere in this evolution.

Key words: quasi-biennial oscillation (QBO), 11-year solar cycle, North Atlantic Oscillation (NAO)