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The longitude dependence of ozone trends in the Northern Hemisphere winter for the period 1979-2010

J. Zhang (1), W. Tian (2), and F. Xie (3)

(1) College of Atmospheric Sciences, Lanzhou Univeristy, Lanzhou, China (zhangjkstrato@hotmail.com), (2) College of Atmospheric Sciences, Lanzhou Univeristy, Lanzhou, China (wstian@lzu.edu.cn), (3) College of Global Change and Earth System Science, Beijing Normal University, Beijing, China (xiefei@bnu.edu.cn)

The long-term zonally asymmetric trends of the total column ozone (TCO) in the northern middle latitudes during winter and factors responsible for the trends are analyzed in this study using various observations and a linear transport ozone model as well as a chemistry-climate model. The results indicate that there are maximum negative trends in TCO over the North Pacific but positive trends over the northwestern America continents. Most of the zonally asymmetric TCO trend over the northern middle latitudes is contributed by trends in zonal departures of ozone column between 70-300 hPa and mainly depend on the interannual variations in geopotential height in the troposphere and lower stratosphere. It is found that the Aleutian Low, the Icelandic Low and the Azores High are weakened for the period 1979-2010, favorable for the formation of zonally asymmetric ozone trends. The Empirical Orthogonal Function (EOF) analysis results show that the geopontential heights from the middle troposphere to the lower stratosphere are mainly controlled by the Arctic Oscillation (AO), Cold Ocean-Warm Land (COWL) and North Pacific (NP) pattern. Also found that the trends in zonally TCO departures can be mostly reconstructed by the above three patterns. In addition, both observations and model results indicate that sea surface temperature over the North Pacific and the Atlantic Ocean can exert a significant influence on zonally asymmetric ozone trend through modulating the COWL and NP pattern. Finally, the off-line model SLIMCAT demonstrates that the evolutions in zonally asymmetric ozone chemical loss partially offsets the positive trends in zonal TCO departures over Middle Siberia and South Atlantic Ocean but amplifies those over the northwestern coast of North America, although the chemical effects are weaker than dynamical effects.