Radiative effects of ozone waves on the Northern Hemisphere polar vortex and its modulation by the QBO

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The radiative effects induced by the zonally asymmetric part of the ozone field have been shown to significantly change the temperature of the NH winter polar cap, and correspondingly the strength of the polar vortex. In this paper we aim to understand the physical processes behind these effects using NCAR's Whole Atmosphere Community Climate Model, run with 1960s ozone depleting substances and greenhouse gases. We find a mid-winter polar vortex influence only when considering the QBO phases separately, since ozone waves affect the vortex in an opposite manner. Specifically, the emergence of a midlatitude QBO signal is delayed by one to two months when radiative ozone wave effects are removed. The influence of ozone waves on the winter polar vortex, via their modulation of shortwave heating is not obvious, given that shortwave heating is largest during fall, when planetary stratospheric waves are weakest. Using a novel diagnostic of wave 1 temperature amplitude tendencies, and a synoptic analysis of upward planetary wave pulses, we are able to show the chain of events that lead from a direct radiative effect on weak early fall upward propagating planetary waves, to a winter polar vortex modulation. We show that an important stage of this amplification is the modulation of individual wave life cycles, which accumulate during fall and early winter, before being amplified by wave-mean flow feedbacks. We find that the evolution of these early-winter upward planetary wave pulses and their induced stratospheric zonal mean flow deceleration is qualitatively different between QBO phases, providing a new mechanistic view of the extratropical QBO signal. We further show how these differences result in opposite radiative ozone wave effects between east and west QBO.

Key words: QBO, ozone waves

References

Silverman V, Harnik N, Matthes K, Lubis S, Wahl S, *Atmospheric Chemistry and Physics*, minor revisions