Direct forcing of the thermosphere-ionosphere by small-scale gravity waves of lower atmospheric origin

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ABSTRACT

Small-scale gravity waves (GWs) of lower atmospheric origin substantially drive the general circulation of the middle and upper atmosphere [*Yiğit and Medvedev*, 2015]. Recent studies indicate that In the upper atmosphere, small-scale GWs directly affect the thermospheric circulation by energy and momentum deposition. Their affects on the ionosphere have not been sufficiently studied. Here, we present recent progress in modeling GW effects of the lower atmospheric on the upper atmosphere and ion-neutral coupling. In particular, we will report on the finding based on the application of the whole atmosphere nonlinear GW parameterization of *Yiğit et al.* [2008] in a general circulation model of the atmosphere extending from the tropopause to the upper thermosphere. In a zonally and temporally sense, Dynamical and thermal effects of GWs in the thermosphere-ionosphere are comparable to, in terms of strength, to the effects of ion drag and Joule heating at F region heights *Yiğit and Medvedev* [2009]; *Yiğit et al.* [2009, 2012]. The GCM simulations of *Yiğit et al.* [2012] have additionally demonstrated that GW-induced effects in fact modulate ion drag effects in the ionosphere. Furthermore, gravity waves substantially cool the upper atmosphere at rate of -150 K day^{-1}. During sudden stratospheric warmings (SSWs), GW propagation into the thermosphere is enhanced up to a factor of three *Yiğit and Medvedev* [2012] and the associated changes produce a small-scale temporal variability of up to $\pm 50\%$ in the thermospheric zonal circulation *Yiğit et al.* [2014]. These effects are seen in Figure 1, where the small-scale zonal wind variability at 250 km before the warming onset and its relative percentage change during the ascending and peak phases as simulated in the extended run, i.e., including GW effects in the whole atmosphere region, are compared to the cutoff run results, i.e., GWs are not allowed to propagate above 105 km. GW-induced thermospheric small-scale variability substantially increases at the peak phase of the warming, while without direct GW propagation into the thermosphere (cutoff case), the variability is small and steady during the different phases. We discuss further effects of GWs on the ionosphere.

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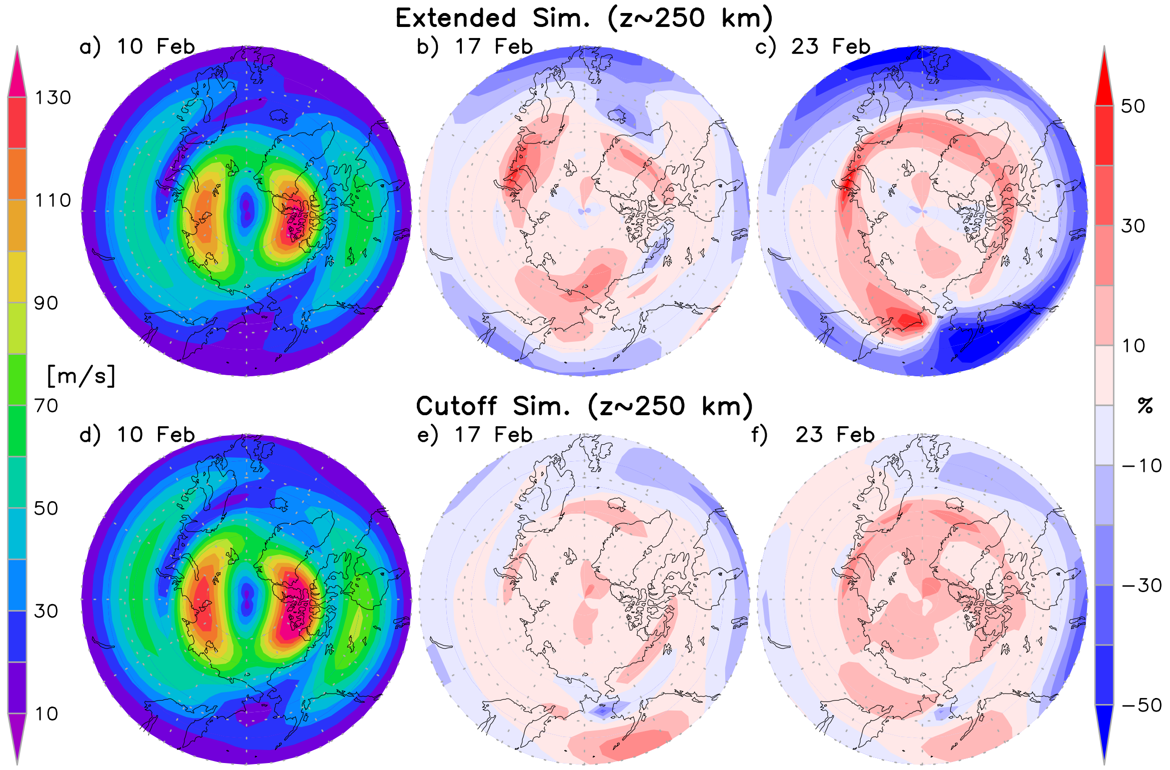

Figure 1: *First column: polar stereographic projections of smaller-scale zonal wind temporal variability (i.e., diurnal and semidiurnal components subtracted) in m s^{-1}. For 17 and 23 February, the relative percentage change of variability with respect to 10 February (warming onset) in blue-red shading. The upper projections are for the extended simulation (i.e., with GW propagation into the thermosphere), while the lower ones are for the cutoff simulation, in which GWs are not allowed to propagate above the turbopause. The same color scale is used for both simulations [Yiğit et al., 2014, Figure 4].*

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