The interaction between Gravity Waves and Solar Tides: results from *4D* Ray Tracing coupled to a Linear Tidal Model

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abstract

Gravity waves (*GWs*) and solar tides (*STs*) are major components of the mesosphere-lower-thermosphere (*MLT*) dynamics. Global scale and thermally driven, *STs* modulate all dynamical fields in the middle atmosphere. Short scale free *GWs* shape the middle atmosphere mean circulation by transporting energy and momentum from high to low density region. Mostly exited in the lower atmosphere and propagating upward, *GWs* and *STs* form the main constituents of the dynamical coupling between troposphere and *MLT*.

GWs and *STs* incorporate a huge range of scale, from small to global. But conventional *GWs* parameterizations used to describe this interaction (e.g. [1]) neglect time-dependence and horizontal gradients of the background flow, with potentially fatal effects (e.g. [2]). We here consider a step-by-step approach to study the interplay between *GWs* and diurnal *STs*.

GWs propagate in a time-dependent background flow, composed by a climatological mean and diurnal tidal fields extracted initially from a general circulation model (HAMMONIA, see [3]). The deposition of momentum and buoyancy from the *GWs* propagation is calculated. The evaluated Rayleigh-friction and temperature-relaxation coefficients impose in turn a *GW* forcing on the propagation of diurnal *STs* in a climatological mean background flow. The extracted *STs* are then used for a new computation of the *GW* fluxes. This is iterated a few times to obtain a converged result on *GW* fluxes and *STs*.

The propagation of *GWs* is modeled by a new *WKB GW* model (ray tracer). The crossing of rays (caustic problem) is prevented by implementing a new wave-action phase-space-density conservation scheme [4, 5]. The scheme attaches to each ray a finite volume in the location & wavenumber phase-space. The location-wavenumber volume is conserved during the propagation, responding in shape to the local stretching and squeezing in wave-number space. The propagation of *STs* is described in a linear version of a general circulation model (KMCM), see [6], allowing for planetary waves in the background state. *STs* are projected onto their migrating and non-migrating components DS_0, $DE_{[1,2,3]}$ and $DW_{[1,2,3]}$. In both wave propagation, the climatological mean include stationary planetary waves.

A simplified *GWs* ensemble is considered, homogenously launched in all directions, at a single launch level. The temporal dependence of the background flow leads to a modulation of the *GWs* momentum deposition. Due to constructive and destructive interferences, planeraty waves play an active role in the modulation of the *GW* fluxes but they also influence the DS_0 and $DW_{[1,2]}$ amplitudes. Because transient critical layers disappear, the horizontal and temporal dependence of the background flow reduce the amplitude of *GW* momentum and entropy. In concequence, the amplitude of the *STs* is also reduced. The seasonal variability of the *GWs-STs* interaction is studied as well.

Key words: Middle-Atmosphere dynamics, Solar Tides, Gravity Waves

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