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The interaction between gravity waves and solar tides: results from 4-D ray tracing fully coupled to a linear tidal model

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The interaction between solar tides (STs) and gravity waves (GWs) is studied via a fully coupled system of a three-dimensional ray-tracer model and a linear tidal model.

The tidal model describes the propagation of STs on a monthly mean climatology, allowing STs to interact with stationary planetary waves. The tidal model has been obtained by linearization of the primitive equations about the climatology. STs are being forced by a climatological diurnal heating and by the (instantaneous) GWs flux convergences of momentum and buoyancy. The GW forcing is calculated (at each time step) by the ray tracer model.

The ray tracer model describes GW dynamics on a spatially and time dependent background formed by a monthly mean climatology and STs, the last being calculated (at each time step) by the linear tidal model. It does not suffer from typical simplifications of conventional GW parameterizations, where horizontal GW propagation is neglected, as are the effects of horizontal background gradients on GW dynamics. The ray tracer model uses a variant of Wentzel-Kramers-Brillouin (WKB) theory where a spectral description in position-wavenumber space is helping to avoid numerical instabilities otherwise likely to occur in caustic like situations.

Notwithstanding the simplicity of the employed GW source many aspects of observed tidal dynamics are reproduced. Under the conventional “single-column” approximation, GW impacts are shown to be significantly overestimated. Those overestimated GW flux convergences lead to significant changes in ST amplitudes and phases, pointing at a sensitive issue of GW parameterizations in general. Non-diurnal STs, whose existence is in this model set-up exclusively due to the GW forcing, are studied and shown to be more important near the poles, giving a partial explanation of STs amplitudes in these latitudes.