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On the application of WKB theory for the simulation of weakly nonlinear dynamics of gravity waves

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It is well known that gravity waves play an important role in the circulation of the atmosphere. Since even the highest-resolution weather-forecast models cannot resolve the entire range of gravity wave scales, much less the even smaller scales involved in gravity wave breaking and wave-turbulence interactions, the smaller scale waves and their effect on the large scale flow must be parameterized. Many gravity wave parameterizations are based on WKB theory, where the amplitude, wavenumber and frequency of the wave field are represented as slowly varying functions of space and time. Indications are that when there are significant interactions between gravity waves and solar tides (Senf and Achatz, 2011) or between small-scale (parameterized) and large-scale explicitly resolved gravity waves, the propagation of the waves and their feedback on the large-scale flow can depend strongly on horizontal gradients and transience in the latter. Common parameterization schemes neglect these effects, which can lead to caustics (where the wavenumber becomes a multivalued function of position) and hence the breakdown of standard WKB theory.

In this study the caustics problem is avoided by casting the complete WKB equations in the form of a transport equation for wave action density in position-wavenumber "phase-space" (Herzog et al., 2002) coupled to an equation in physical space for the time-dependent large-scale flow. Two numerical implementations of these equations will be presented. The first solves the wave-action density equation using a finite-volume method and the other using an efficient "ray tracer" that exploits the area-preserving property of the phase-space flow.

Results will be presented from case studies of a packet of small-scale gravity waves propagating upward through a background with varying stratification or through a wind jet. Depending on the strength of the jet, the latter case may involve the reflection of the wave packet, a process that cannot be described by standard WKB theory. The results from the WKB models are in good agreement with simulations using a weakly nonlinear wave-resolving model as well as with the fully nonlinear large-eddy simulation code INCA (Hickel et al, 2006).

REFERENCES

[1] F. Senf and U. Achatz, 2011: *On the impact of middle-atmosphere thermal tides on the propagation and dissipation of gravity waves*, J. Geophys. Res., 116, D24110, doi:10.1029/2011JD015794.

[2] A. Herzog, C. Souprayen and A. Hauchecorne, 2002: *Eikonal simulations for the formation and the maintenance of atmospheric gravity wave spectra*, J. Geophys. Res., 107, D12,4145, doi:10.1029/2001JD000815

[3] S. Hickel, N. Adams and A. Domaradzki, 2006: *An adaptive local deconvolution method for implicit LES*, J. Comput. Phys. 213, 413-436.