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Interactive comment on "Orographic and convective gravity waves above the Alps and Andes mountains during GPS radio occultation events — a case study" *by* Rodrigo Hierro et al.

Anonymous Referee #1

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General Comment

In my AMTD access review several major concerns were raised which showed that a major rewriting and refocusing of the manuscript would be required, probably exceeding the time usually allotted for revisions of a paper under review. Therefore my recommendation at this stage was to reject the paper. Since then, only minor changes were made. This is why this recommendation is repeated.

Of course, having a collocation database between RO events and convection over orographic regions is a valuable contribution, same as the detailed discussion of two cases of WRF simulations. The comparison of RO events and WRF simulations, however, which is the core part of the paper, is incomplete and based on wrong assumptions.

Still, I think that the two selected cases are good examples for discussing several important aspects that have to be considered when comparing high resolution simulations with real observations. Therefore resubmission of a revised manuscript is encouraged.

If the manuscript were to be revised and resubmitted, several major issues have to be addressed.

Major Concerns

(I) Firstly, it is obvious that for both detailed comparisons, the Alps and Andes cases, the waves simulated with WRF are not seen in the corresponding RO soundings.

Following Alexander et al. (2008), the amplitude attenuation factor E can be calculated.

For the Alps case, E is $<10^{-11}$

For the Andes case, E is <0.03

Amplitudes in the RO soundings are 2K, sometimes more. For explaining these amplitudes with the WRF simulations, simulated amplitudes would have to be >60K. This is physically not reasonable.

In the Andes case the tangent points do not even hit the region of simulated wave trains. Further, the simulated wave trains are quite fuzzy, suggesting that amplitude attenuation should be even stronger. Details on the calculation of E are given below in a separate section.

(II) This clearly shows that the WRF simulations alone are not sufficient to explain the observations. In some cases they may be sufficient, but generally they are not.

The simplest explanation is that horizontal wavelengths of the observed waves are usually much longer than those of the simulated waves. This possibility and its consequences are not discussed and completely ignored. The wavelet analysis even stops at 120km, which is at the verge of the range of waves that can be seen by GPS RO.

One explanation could be mountain waves and convective waves of longer scales that are not captured by the WRF simulations, but co-exist with the simulated short scale wave modes.

Another explanation could be **gravity waves emitted from jets and fronts**. Surprisingly, this third major source of gravity waves has been completely disregarded in the manuscript. Just as an example, in the beginning of the abstract only orography and convection are listed as major wave sources.

Usually gravity waves emitted from jets and fronts are of larger scale and could co-exist with the small scale waves that occur in the WRF simulations. Since the Alps case is in the winter season when gravity waves emitted from jets and fronts are quite abundant, ignoring this wave source is not possible.

(III) Thirdly, since the WRF simulations are insufficient to describe the observed waves, meteorological data sets, such as ECMWF analyses, could be investigated whether larger scale wave patterns are found that can explain the RO observations.

GPS RO measures temperatures. Therefore analysis of temperature fluctuations is preferable to the analysis of vertical wind w', also in the WRF simulations. Focusing too much on w' will bias any analysis towards high-frequency waves that are difficult for GPS RO to observe. Moreover, a direct comparison of amplitudes is not possible.

(IV) Fourthly, including a detailed discussion of vertical wavelength biases in the manuscript will distract the readers. For the examples given, observed and simulated waves are obviously different and wavelengths extracted from the simulations cannot be assumed for the observations. Therefore it is not clear whether these sampling biases apply.

Amplitude attenuation factors for the Alps and Andes cases

For GPS RO an amplitude attenuation factor E was deduced by Alexander et al. (2008)

$$E = \exp\left(-\frac{R_E}{2H}\tan^2(\gamma)\cos^2(\Theta)\right) \tag{1}$$

The aspect ratio α_h is the ratio of vertical to horizontal wavelength $\alpha_h = \lambda_z/\lambda_h$. The tilt angle of the wavefronts with respect to the horizontal surface is called γ, α_h = $|\tan(\gamma)|$. The angle Θ is the angle between the LOS and the horizontal projection of the wave vector. $R_E = 6371km$ is the Earth radius, $H = 7km$ the scale height.

Citation: Alexander, P., A. de la Torre, and P. Llamedo (2008), Interpretation of gravity wave signatures in GPS radio occultations, J. Geophys. Res., 113, D16117, doi:10.1029/2007JD009390.

If the waves simulated with WRF are observable with GPS RO, the wave parameters taken from the simulations have to result in reasonable values of E well above 0.1, which is however not fulfilled.

E in the Alps case

From the manuscript, we read:
l.321: Θ=0deg   l.220: λ_h=20 or 60km   l.283: λ_z=15km
These numbers are inserted into Eq. (1).

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for λ_h=20km: $\tan\gamma$=15/20=0.75 $\rightarrow E = 7 \cdot 10^{-112}$

for λ_h=60km: $\tan\gamma$=15/60=0.25 $\rightarrow E = 4 \cdot 10^{-13}$

E in the Andes case

From the manuscript, we read:
l.397: Θ=80deg l.374, l375: λ_h=20 or 40km l.382: λ_z=20 to 25km, 20km is used here
These numbers are inserted into Eq. (1).

for λ_h=20km: $\tan\gamma$=20/20=1 $\rightarrow E = 10^{-6}$

for λ_h=40km: $\tan\gamma$=20/40=0.5 $\rightarrow E = 0.03$

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