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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Gravity-wave effects on tracer gases and stratospheric aerosol concentrations during the 2013 ChArMEx campaign" *by* Fabrice Chane Ming et al.

Anonymous Referee #2

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The paper by Chane-Ming et al. uses a number of well established technique for an in-detail case study on GWs observed above southern France. There is need on more detailed studies on the interaction of GWs with tracers, one main focus of this paper. Also, there is a discussion on aerosols. However, there are several major points which need to be addressed before the paper can be published in ACP.

Major comments:

1.) GW source:

There are a number of questions related to the source process. The wave properties from ECMWF are largely consistent with the observations. If the patterns in ECMWF

capture the truth, they can point to the source. Given the concentric nature of the GW patterns that would be a point source at 2.5E, 46N; a point which is also passed by the backward trajectories. The authors should investigate the vicinity of that point.

2.) Horizontal wavelength from triples

The only thing you can learn from that analysis is that the wavelength is mesoscale. I therefore recommend to move the analysis to an appendix and include only a few sentences in the body of the text. Details below.

3.) There are some inaccuracies in discussions and descriptions, see the specific comments below

4.) Language

I did not make many language comments, but the English needs to be improved. In addition it would be nice to have some introductory or explaining sentences why you do something and not only how.

5.) Conclusion A large part of the paper deals with the analysis and potential source of the GWs. This is not reflected in the conclusions which focus almost entirely on aerosol processes.

6.) Last but not least: Improve the figure quality!

I have noted so as a main point in my prereview and was disappointed to see that nothing changed. The single panels are mostly o.k., but combined they look awkward. Panels of the same format have different sizes. Color bars are sometimes at the side, sometimes below the plot - have it one way if you combine in one figure!

6b) and consistency of the maps

You show the same region of Europe with four different quantities (horizontal wind, vertical wind/GWs, GPS-RO measurements, clouds and trajectories) and you use as many different map limits! It would make comparison much easier to use the same!

Specific comments

P7L11 Average of what?

P9L1 In the present study, RS and RO temperature ... The described method is based on the assumption that the same wave is observed in several profiles. Since the limit is given by the visibility filter of the instrument, you cannot beat the shorter limit of these previous study.

P9L28 This is inaccurate: GROGRAT has quite a large number of criteria to stop a raytrace. When you use backtracing the following may be source indicative: There are a number of criteria in GROGRAT which at the end all apply to the ray approaching a critical level. In that case the *wavenumber*, i.e. the inverse of the wavelength approaches inifinity. In forward raytracing this just denotes a critical level which the GW cannot pass and below which it deposits its momentum. In backward raytracing the wave must origin above the critical level and wind shear is likely involved in the wave excitation (cf. also discussions in Preusse et al. 2014, Pramitha et al., 2015). GROGRAT also monitors, whether the WKB assumption that the background is changing slowly compared to the vertical wavelength is still valid. A WKB violation may be indicative of a source due to spontaneous imbalance (cf. Hertzog et al., 2001). Whether GROGRAT terminates the ray calculation at a point of WKB violation actually is the choice of the user. A vertical wavelength approaching infinity would point to total reflection (or, at start, to an evanescent wave) which however I would not associate with a source process. There is no limit to the rate with which the vertical wavelength changes. Please reformulate!

P11L9 better such features play

P11L13 severely impact on severe I would more connect with the impact of the weather on people and property -> have large influence on (control would be stronger but that is, I think, more than the authors found and which was more like a seeding process)

P11LL29/Figure2: Please motivate why you combine winds at 300hPa with geopoten-

tial at 500hPa.

Figure 4: The panel labels should be at the upper left. The individual panels, though using the same format, are of different size. I had commented on this in the prereview - it is not really much work to improve this and it indicates some carelessness inappropriate to a scientific publication in a high level journal such as ACP.

P14L6 What precisely is in quadrature? Temperature and winds along the main axis should be ... For the winds it should depend on the orientation of the wave vector / main axis, but that is determined from the winds?. Please explain.

P14LL20 The waves have nowhere plane wave fronts. They have a close-to-semicircle shape. Accordingly, the wavelengths projected to the west-east direction become (seemingly) longer the further you move away from the circle center. Just on looking at the picture, in 2D the wavelengths are pretty similar for all latitudes. Though 5c is somewhat scattered in principle one can see that effect.

Fig 5b: I guess you calculate this from F5c? By averaging over the spectral bins? If yes, I think integrating would be preferable for the following reasons: According to Parseval theorem the integral of the variance is the integral over all spectral components. FT than distributes the variance to a larger number of spectral bins for the shorter wavelengths which provide better spectral resolution. In that sense an integral would be more adequate as it represents the total variance in that wavelength range. Use an integral would hence less overemphasize the long horizontal wavelengths. In addition, from F5a the largest total variance is clearly at 46N. Now it appears to be at 48N. The really interesting variance in the red curve is almost disappearing.

Fig 5d The peaks in the spectra seem to be at 400km, 800km and 1600km. This could potentially suggest that you see a main wavelength and the subharmonics due to the fact that the amplitudes varies spatially.

Figure 6a: The map shows a much larger region than needed for the discussion.

P15 first paragraph: The correspondence of figures and text should be improved. F6a shows the location of the profiles. The position of the bracket in the text suggests it is the wavelength. That is then shown in F6b again with bad reference. ... And so it goes on!

Why not something like:

The waves from this event can be identified in GPS-RO soundings as well. Figure 6a shows an overview of the GPS-RO soundings over western Europe for the days 26 to 29 July, 2013. We selected profiles for longitudes of 2.5°-6°E and latitudes of 40-50°N for spectral analysis of the altitude range xx-yy km. The results are shown in Figure 6b. The individual spectra are labelled by the day and UTC of the measurement (e.g. 2605 for 26 July; 05 UTC) and marked also accordingly in Figure 6a. As can be seen from the consecutive days, GWs are enhanced starting from 27 July, peak at 28 July and are still active on 29 July. Intensity peaks are found for wavelengths 2-3.5 km.

Still no clue for which altitude range this is, but I hope for the lower stratosphere. A paper should not be a puzzle!

Also the following lines: You can't say anything about horizontal structures from the observations yet!

Table 1: Why do you have two/three values of horizontal wavelength for the same vertical wavelength? Please include in table caption!

P16LL12 You describe in the text that you have quite a number of reasons for uncertainty: a) close to Nyquist b) additional phase shift by radiative transfer / retrieval c) temporal development as the profiles are not measured simultaneously (needs to be included)

If you had very long wavelengths, you could identify them using the method, everything else is not sure. I recommend to move the details of the analysis (P16L12 to P16L33) into an appendix and include into the text only a few lines such as:

We have also combined radisonde and GPS-RO profiles to triples and applied the phase difference method of Faber et al (2013) to estimate the horizontal wavelength (see appendix 1 for details). We result in a horizontal wavelength of 400km consistent to ECMWF results, but any other (in particular shorter) mesoscale wavelength such as found from the radiosondes analysis (Table 1) would be also compatible inside the error range. Since the horizontal wavelength is likely overestimated, a GWMF estimate of 0.03 m2/s2 is somewhat lower but compatible with the estimate from the radiosondes alone, which is 0.05 m2/s2.

Move P15L9-L13 to the conclusion of this paragraph.

Page 18L1: GROGRAT adjusts the time step according to an internal accuracy estimate. Omit: "and a time step of 6 min."

P18 first paragraph: I have questions and, overall, I don't agree with your conclusion.

First to the questions: All your backward trajectories seem to end at the same altitude. To my experience in a well-setup simulation the termination altitude varies when the input parameters are varied. What is the termination condition? GROGRAT provides it!

If it were WKB: are you sure it is not simply because of the tropopause? The tropopause is a steep gradient in N, which almost always causes some WKB violation, if adequately resolved. It is in this case not indicative of a source.

Second to the comment: The source could be also above, somewhere along the ray trajectories. All trajectories pass close to 2.5E, 46N. This location seems the origin of the semi-circle (maybe even concentric, just weaker to the west) wave patterns in ECMWF. The values from the radiosondes seem to be consistent with ECMWF: southeastward propagating waves with mesoscale wavelengths: At least the direction if not the wavelength is consistent with the circular wave patterns.

If we believe in the circular wave patterns, this shines a different light on the wave

source mechanism, though. There are two kind of waves associated with jets and fronts: 1. GWs from spontaneous adjustment are generated in the jet-exit region and wave fronts are roughly perpendicular to the main flow. They would be organized in bow-shaped structures but not in circles. 2. Waves from the front have wave fronts parallel to the front and parallel to the main wind. Both don't cause circles. Circular patterns are much more likely to be generated by e.g. thunderstorms.

You reported thunderstorms in the beginning of the paper. Was there a thunderstorm close to 2.5E, 46N?

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