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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Horizontal divergence of typhoon-generated gravity waves in the upper troposphere and lower stratosphere (UTLS) and its influence on typhoon evolution" *by* S. H. Kim et al.

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The paper presents new evidence on the connection of GWs and a typhoon. A comprehensive data set by a state-of-the-art model is investigated and new insight into GWs generated by a typhoon is provided. An interesting suggestion of GWs influencing the typhoon itself is made. The paper is generally well written and well to read. Therefore I strongly recommend the paper for publication in ACP. However, there are some points which need to be improved. The description of the methods applied is too short and the discussion of some of the correlation/correspondence between various time series presented need to be strenthened. Moreover, there remains a certain hen-egg problem



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about the mutual influence of GW and typhoon. A detailed discussion is given below.

Major comments:

1.) Description of the methods: In order to separate between total and GW realted horizontal divergence some kind of frequency identification / filtering is required. This process is not described in the paper. Even if the details should be provided elsewhere (please provide the reference), a short description of the applied method must be given here. There are certain details (cf. specific comments) in the relation between GW realted and total horizontal divergence, which cannot be understood without knowing the methods.

2.) Figure 1 is used to give evidence that mesoscale GWs have a major influence on the development of the typhoon. There are several problems with this part, however. First, the argumentation is based on similar patterns in various time series. Such correspondence (called correlation in the paper, but I miss the analysis) is evident in some cases, but some described patterns need to be made more evident. Either these points need to be better described or the authors could actually perform correlation analysis. In this case they will need to decide on the relevant time scales. A few more questions with this regard are formulted in the specific comments.

Second, accepting the similarity/correlation in the curves this only shows that there is some connection but a correlation cannot tell apart cause and effect. Is the GW divergence field cause of changes in the typhoon? Or does the typhoon cause more GWs? Or is there a larger scale GW influencing the typhoon which in turn causes small scale GWs? Unless some clear idea of a mechanism is presented this point remains unsolved. Some ideas for a mechanism are presented in Koch and Siedlarz (1999). The authors indicate further work. In all this they assume that mesoscale GWs most dominant in their simulation are the main driver.

I would like to suggest an alternative: the presence of a large scale GW may explain some features rather nicely. It should not be filtered in calculating HDTGW,



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if this is properly set-up. A large-scale GW would have a close to 24 hour period and a propagating feature and it is less noticeable in horizontal divergence than the smaller scale, short-period waves. While the shorter horizontal scales average out, as nicely described in the paper, the long horizontal-wavelength GW would not. Such a wave has been detected in CRISTA data (cf. Figure 52 of Preusse, 2001 showing the temperature structure of a large scale GW with approx. 3000km horizontal wavelength and 24h period (note that panels a and b are approx. 12h appart). Figures 56 and 57 then indicate that the oscillation is also present in cloud-top height. The thesis can be found at http://elpub.bib.uni-wuppertal.de/servlets/DerivateServlet/Derivate-412/d080111.pdf). Also global scale modeling suggests the presence of such large scale GWs (e.g. Evan et al., 2012). Whether it is able to propagte into the stratosphere of course would depend on the actual phase speed of the wave in the model and the background wind conditions. It would be interesting to look into smoothed horizontal divergence fields and maybe also in variables such as temperature. Also it would be interesting to investigate whether other convective events in the vicinity show a similar oscillation.

I should add that this point does not need to be completely resolved before publication of the paper. Even the suggestion is worthwhile. But the discussion can and needs to be strengthend.

3.) A general comment on all Figures: The numbers at the axes and color bars are tiny. This should be improved.

Specific comments:

Obviously the current paper is strongly based on the previous publications KC10 and KC11. The introduction should clarify the relation of these three publications.

You use both the domain-integrated total divergence and the divergence by TGWs. It remains unclear in this paper how these are defined. A short definition/description needs to be given! The current paper must be readible without reading KC11. HDT-



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GWs refers to the horizontal divergence. That is singular. Therefore I would find an abbreviation indicating singular easier to read: HDTGW. And please, use it consistently throughout the text.

P955L19 Only trivial processes can be understood "precisely", a complex system like a typhoon will always have to rely on some approximations.

Fig1: Axis notations and color bar legends are very small, in some cases much too small. Panel c) at normal size the solid and dotted line are hard to distinguish. Please use colors and bolder lines.

P957L9 over -> above

P957L14 significant correlation -> close correspondence I see a certain correspondence, but it looks to me whether on shorter timescales and in general trends the two quantities correspond, but that there is also a development on the scale of a day in total divergence which is not contained in HDTGW. I definitely do not recognize any particularly highlighted or exceptional periods. For instance, from 15UTC8 to 3UTC9 every small scale structure is contained in both quantities but the larger trend is somehwat different.

P957L17 "During this period, IGWs contribute to the total divergence about 30% in UTLS." How do you reach this conclusion?

If you claim a "correlation" you should calculate correlation coefficients. If you want this time dependent you could do it in sliding windows.

P957L27 "Strong correlations between the total divergence and minimum SLP, HDTGW and minimum SLP, and total divergence and HDTGW in UTLS during the rapidly developing period demonstrate the contribution of IGWs to typhoon evolution." How do you know what is cause and what is effect? Please expand the argument.

P958L5 "The domain-averaged vertical velocity averaged over 3–15 km a.g.l. and domain averaged 30 min accumulated precipitation amount (Fig. 1c) is generally well



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matched throughout the whole 48 h, except in a decaying period after 00:00UTC 10." At this point I really would like to ask you to calculate a correlation. My impression is that the two curves are not particularly similar except the fact that they seem to have similar auto-correlation time scales. If you think that at this position an intensification of the typhoon is most likely caused by the divergence fields then argue along these lines.

P958L5 peaks -> peak

P959L2 If you say primary / secondary peak I would expect two distinct spectral features. For me this looks like a single broad peak.

P960L25 How did you calculate the phase differences? Please describe.

P961L2 "especially in the inner-core region" To me it appears at least as obvious in the SW. I think a method to analyze this would be to use averages over suited subdomains (e.g. 200km x 200km). If there are general bisaes these should become visible. This could be also helpful to detect phase changes of a larger scale GW (cf. major comments).

P961L5 Why refer to KC11, was that not shown in Fig1b?

P961L14 And no reader (or reviewer) can follow (or help with) it, since the methods are not described! Actually, this finding worries me. General biases are one thing, but almost the same structures at just larger amplitudes and a shifted phase could point to a problem with the method you use to isolate the horizontal divergence of the GWs.

P961L15 While Typhoon Saomai was rapidly developing, a strong outflow layer developed near the tropopause.

Fig2e) In panels a,c white at the typhoon center presumably marked values out of the color scale. I presume that happens in panel e, too. It would be better to use a "saturated" color scale, i.e. to use the largest (largest negative) value for all values exceeding the color scale. In any case you need to mention this point in the text.



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