Long-term observation of mid-latitude quasi 2-day waves by a water vapor radiometer

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Responses to comments on ACPD paper acp-2017-115

Color Code: Referee comments, Authors response

We would like to thank all anonymous referees for their comments to our ACPD paper.

Please find our general responses to Reviewers #1 and #2 below.

1 Response to Referee #1

The quasi 2-day waves are one of the most extensively observed planetary waves by different ground based and satellite instruments. In this way the most prominent features of the global space distribution and seasonal and intra-seasonal variabilities of these planetary waves have been already known. Most of these features are also well numerically simulated. This paper presents long-term observations of the quasi 2-day waves by a water vapor radiometer at a mid latitude station Bern. The use of water vapor for studying the planetary waves in the middle atmosphere is not a new practice; there are several reports for different planetary waves, as Nielsen et al. (JGR, 2010), Scheiben at al. (ACP, 2014), etc. and particularly for the quasi 2-day waves for example, McCormack et al. (JGR, 2009). There are only a few studies on the interannual variability of the quasi 2-day waves which however have not been able to present convincing results mainly because of not enough long time observations. According to the title of the present paper we expected its main contribution to be namely in clarifying the interannual variability of these waves. However the use of only seven years (October 2010 September 2017) of water vapor radiometer measurements is shorter time interval than previously used measurements (as for example, Huang et al. (2013) used 10 years of SABER temperature data) and definitely not enough for considering the interannual variability. The use of only single station measurements significantly limits the ability for studying the spatial structures of these waves; only their vertical structure could be considered. The authors however presented only the vertical structure of the wave amplitudes. There is no any information about the wave phases, i.e. it is not possible to understand if the found waves are vertically propagating or trapped waves. The only convincing result from the data analysis is that the quasi 2-day wave activity is stronger in winter than in summer (probably because the summer observations are limited up to about 70 km height). It is mentioned that the large winter wave amplitudes are likely related to SSW but this issue is not particularly investigated. The bicoherence spectra

indicated some nonlinear coupling between the quasi 2-day wave, diurnal tide and quasi 18-hour oscillation, but this is a well known result reported in many papers.

General comment: This study suffers from the lack of new scientific results. If the authors want to add values to these single station measurements they have to combine them with the satellite observations and to make an attempt to clarify if the quasi-2-day waves they observe belong to some of the known modes or are a combination of a few modes. Without such information and the lack of any phase results the present paper shows only the observations of quasi-2-day oscillations, nothing more.

- Ground-based observations of quasi 2-day waves are rare and there are no studies on Q2DWs from ground over such a long period of 7 years. The MIAWARA observations rank among the longest records of microwave radiometric H_2O measurements in the strato- and mesosphere from ground. We think that satellite data can be problematic for these short term variabilities due to long reoccurrence times over the same location. To investigate non-linear interactions to tides on a single event basis is not possible with e.g. Aura MLS data.
- We agree that with our H_2O profile data it is not possible to study detailed structures or wave characteristics (e.g. phases, wavenumbers). Due to the low vertical resolution of MIAWARA, which is in the order of 10 km, it is also difficult to detect vertical wave structures.
- The reviewer stated that there are many papers showing nonlinear coupling between the quasi 2-day wave, diurnal tide and quasi 18-hour oscillation. We are aware of some numerical investigations about this (e.g. McCormack et al., 2010; Lieberman et al., 2017) and a few papers on meteor radar observations (e.g. Huang et al., 2013). We would appreciate if the referee could point us to the many papers we are missing. With our measurements we showed that these interactions can be determined also by the use of water vapor data.

2 Response to Referee #2

Radio aeronomy has matured to an established technique for remote sensing of the middle atmosphere. Ground-based measurements of the middle atmosphere will play a very important role in the future since several of the satellite systems, dedicated for middle atmospheric studies, are aging and few replacements are planned.

It has become more and more clear that wave activity in the middle atmosphere can have an impact on the troposphere. This means that the kind of studies, described in this paper, are of utmost importance.

In my opinion the paper is very interesting, well written and easy to follow. My only

concern is why the authors do not compare their results with model data like WACCM or datasets like ECMWF. Such a comparison would give additional strength to the paper.

If the authors justify why no comparisons have been made, I consider the article to be published in ACP.

- The reason why we did not compare Q2DW results to ECMWF model data is because in general H_2O volume mixing ratios in the middle atmosphere are badly represented in the model analyses. The discrepancies between measurements and model analyses in the amount of H_2O are up to around 20 % with an underestimation of the model. In the past we also compared results from WACCM simulations to our observed oscillations in H_2O, but in case of the quasi 18-hour oscillation (Lainer et al., 2017) no obvious 18 h variability could be found. That is also the reason why we thought it is not worth to include WACCM in the study of quasi 2-day waves.

References

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