**R e p l y**

To the interactive comment on "Experiments on sensitivity of meridional circulation and ozone flux to parameterizations of orographic gravity waves and QBO phases in a general circulation model of the middle atmosphere" by A. V. Koval et al. Anonymous Referee #1

**We would like to thank the reviewer 1 for his useful comments. Our replies are given below with bold font**.

The manuscript describes the influence of the orographic gravity waves (OGW) and QBO phase on the meridional wind, vertical motions and ozone fluxes simulated by the MUAM (model of the middle atmosphere). The authors have modified the original MUAM version by adding parameterization of OGW and performed sensitivity studies analyzing the changes in the model output. Therefore, the subject of the manuscript is relevant to GMD scope. The manuscript is well structured. The quality of the figures is good.

However, I do not clearly see why the obtained results could be interesting for the wider community. The importance of OGW and QBO was recognized a long ago C1755 and the author's conclusion about the necessity of their inclusion is just a confirmation of very well know information. It is not even new for MUAM model, because the same conclusion was already made in the recently published paper by Gavrilov et al. (2015, doi:10.1186/s40623-015-0259-2).

**The conclusions about the importance of OGW and QBO are indeed not new for the community. However, these conclusions are not the main purposes of this paper. GMD editors advised us that the scope of this journal is technical descriptions of numerical models and experiments with them. We found that many of scientific papers for the subject contain results in form difficult to compare with usual outputs from numerical models. Therefore, we primarily consider the paper as semi-technical descriptions of our new parameterizations and experiments with them, to make this information useful for programmers, who might be interested to reproduce the experiments. They can take the numerical model and parameterizations from us. Compared to our previous papers, here we consider modeling of other atmospheric parameters, not considered in those papers. Obtained figures contain some new and interesting information about meridional circulation and ozone fluxes, but their deep physical analysis and explanations are out the scope of GMD specifics and are subjects for further publications. Anyway, we added some additional explanations to the paper.**

There are some other issues (see below), which should be considered by the authors before publications.

1. The review of available and already used in the models OGW parameterizations is missing. The authors should discuss the benefits of the new scheme and its place among the existing models.

T**his is not the first publication of our schemes. Their benefits are described in the previous papers. The Reviewers 2 and 3 recommend shortening the parameterization descriptions, or removing them at all. We think, we found compromise between the parameterization descriptions needed for their practical use and no repeating the previous our papers. However, we extended the introduction of the paper and included some additional references.**

2. The authors should formulate better the motivation for the study and emphasize the novelty of the undertaken research.

**From technical point of view, the motivations and novelty of undertaken research are new numerical experiments with the new parameterizations. In addition, now we make the computer code available for everybody for described experiments. We emphasize that in the paper.**

3. Section 2 of the paper can be substantially reduced, because many technical details described there have been already presented in the previous publications.

**We think it is useful for programmers to have all necessary formulae in one place. Section 2 includes 3 short pages and 4 formulas, which is about 10% of the total paper volume. We suppose this is appropriate.**

3. The model set-up should be justified. It would be interesting to know how the MUAM reproduces polar night jet and polar temperatures in case of perpetual January simulation.

**The scope of the present paper is meridional circulation. Modeling of zonal wind and temperature are considered in our previous papers. Simulated distributions of zonal wind one can find in the papers by Gavrilov et al. (2013a,b; 2015).**

4. The authors should also explain why OGW and QBO effects are considered together. Is there any relation between them? As far as I understand OGW have been parameterized while QBO has been just prescribed.

**We think that QBO are important and we should make experiments for different QBO phases separately. We do not know which QBO phase is more important. Therefore, we made modeling for both QBO phases. We found some similarities in the OGW and QBO effects on the atmospheric circulation, but this was not our primary intention.**

5. In the discussion of Figure 2a the authors did not try to compare their results with the meridional circulation obtained from the reanalysis products. It would be interesting to show whether the improved version help to obtain better agreement or not.

**Vertical velocity in the reanalysis products is not experimental, but rather the result of some numerical calculations. Its errors are substantial. In Figure 2 we added meridional circulation obtained from the UK Met. Office meteorological reanalysis data. It is similar to our simulated circulation at altitudes where both data overlap. Our simulations are for for higher altitudes (up to 150 km)**

6. I do not completely understand how exactly the statistical significance was calculated. Somehow it is missing in Figure 3, 4. Therefore, the analysis of the differences is difficult.

**We added a paragraph with descriptions of significance of the data in Figures 3 and 4.**

8. The analysis of the results is not sufficiently deep. The authors simply describe what is shown in the figures and do not try to put the obtained changes into context of the general behavior of meridional circulation.

**As mentioned above, we were instructed that deep physical analysis of the meridional circulation is out the CMD scope. This paper is mainly the semi-technical description of the numerical results, which everybody can reproduce asking the numerical model from us. However, we added some more descriptions of the results.**

9. I think that the analysis of the ozone fluxes is not instructive because the ozone field is prescribed and the changes of ozone fluxes mostly repeat the pattern of the circulation changes. The authors show that the ozone flux can change by up to 60%, therefore interactive ozone is necessary because the prescribed ozone will not be maintained. The using of 3-D ozone field in the model is also difficult to justify because it is not consistent with the simulated meridional circulation and shape of the polar vortex.

**This is true for long time modeling including climatological or seasonal changes, when the ozone source behavior in time is important. However, for the ozone flux diagnostics during a few days in the lower stratosphere assumptions of unchanged ozone sources could be appropriate. In addition, the simulated zonal and meridional circulation is adjusted to the prescribed 3-D ozone field, because the model involves ozone heating. Such diagnostics based on empirical ozone and QBO distributions may be even better for interpreting observations of the meridional circulation and ozone fluxes. We added such statement to the text.**

10. In the conclusions the authors claim that parametrized OGW and assimilated QBO improve the MUAM, but I do not see any solid confirmation of this. I guess, the improvement should be demonstrated by the comparison with observation data.

**Unfortunately, we have no reliable observations of vertical velocity in the middle atmosphere on global scale. Even in meteorological reanalysis models, the vertical velocity is mainly simulated at prescribed horizontal wind and temperature fields. We reformulated the statement in the conclusions.**

**N. M. Gavrilov, A. V. Koval, A. I. Pogoreltsev, E. N. Savenkova**