Dear Referee,

thank you very much for your efforts in performing your review of our manuscript and for your helpful remarks and corrections.

Here are our answers to all your comments:

This paper is a nice and important contribution investigating the role of liquid particles to chlorine activation. The study is based on a set of multi-year simulations performed with the chemistry-climate model EMAC. The foundation for this investigation is a socall standard simulation (Standard) and a selection of three sensitivity simulations by changing the heterogeneous chemistry on PSC particles, i.e. switching on and off the chemistry on liquid, NAT and ice particles. Differences between these simulations are presented and discussed. It is a well-written paper including the quality of the figures. The abstract is clear and the introduction section provides a good overview of the open points. The results are described sufficiently. Although the paper is short, the message is clear. Nevertheless, I have three major points which must be clarified or considered before publication.

- *1. My major point is regarding the chosen model configuration. On the one hand side you are saying that the nudging technique helps to simulate realistic synoptic conditions, which is definitely the case. But on the other hand you are using a chemistry-climate model which allows feedback of chemical and dynamical processes. This means that the four simulations (the Standard and the three sensitivity studies), although used in a nudged mode, will be different in detail (regional) regarding the simulated dynamic conditions. The synoptic conditions in all four simulations are similar, but they are not identical! This means that you cannot directly determine the absolute effects of changes by subtracting the results of the sensitivity simulations from the Standard. Your model as used here is CTM-like, but it is not a CTM. To my understanding this may not impact your general conclusions but for me it raises the question about the reliability of the estimated numbers (absolute and relative values mentioned in your paper).*

  We used the nudging technique below 1 hPa with the relaxation coefficients of $0.58 \cdot 10^{-5} s^{-1}$ for divergence, $4.63 \cdot 10^{-5} s^{-1}$ for vorticity, $1.16 \cdot 10^{-5} s^{-1}$ for temperature, and $0.58 \cdot 10^{-5} s^{-1}$ for surface pressure. In the upper levels of the nudging area the relaxations coefficients are weakening off. Because of this nudging we got in all simulations similar temperatures and wind fields. But you are right the synoptic conditions are not exactly the same. In Figs. 1 and 2 the five year means of the simulated temperatures and zonal winds (averaged from 80°S to 90°S) of the **Standard** simulation and the differences from the three sensitivity simulations are illustrated. In the simulations **Liquid** and **LiquidNAT** exit no relevant temperature or wind differences in comparison to the **Standard** simulation, but there are differences, though small, in the **NoHet** simulation. The large ozone differences between the **Standard** and **NoHet** simulation leading to different heating rates in the model which are not fully compensated by the nudging. The temperature differences leading also to a small discrepancies in the development of the PSC particles in the **NoHet** simulation (see Figs. 3 to 6).

We will integrate into our manuscript the information that the maximum temperature differences between the simulations are below 1 K and that small differences in the wind fields and also small differences in the development of NAT, ICE and liquid particles exist. We will also check the absolute and relative values and modify them if necessary.

- *2. EMAC is a well-established model system. Nevertheless, an evaluation of the Standard results with observations or other model simulations is required. It is necessary to verify the skill of your model system, in particular regarding your study. It is the basis for your assessment and reliable conclusions.*

  We agree in this point. As mentioned in the reply to Review 1 we will evaluate our results with MLS satellite data (HNO_3, ClO and O_3).

- *3. A more detailed discussion and rating of the results would be essential, e.g., how they are in line with other studies. At the end it would be helpful to discuss possible uncertainties of your findings. Or are you sure that the results are watertight? If yes (which I believe) you should explain why.*

  Thank you for this suggestion. We will discuss more in detail the possible uncertainties and compare our results with more studies.

- *Minor point: I do not understand why you only show and discuss the results from 2005-2009 (figures 2 to 5), even though you have run the model until 2012 (see description in the beginning of Section 4)!? Please clarify.*

  We understand the point made by the reviewer. The reason for our choice lies in the history of this project. We had performed our simulations, analysis and graphical representations first until 2009 and later extended the run until 2012 because we wanted to investigate also the Arctic winter of 2010/2011 (which is not part of this study). For the Antarctic case discussed in the present paper, we do not expect substantial changes in our conclusions by extending the analysis by another three years. However, in our envisaged follow up projects we will consider the entire simulated time series, which will be in particular important for the Arctic. In the present paper, we will restrict the analysis and the presentation to the 2005-2009 period, however.

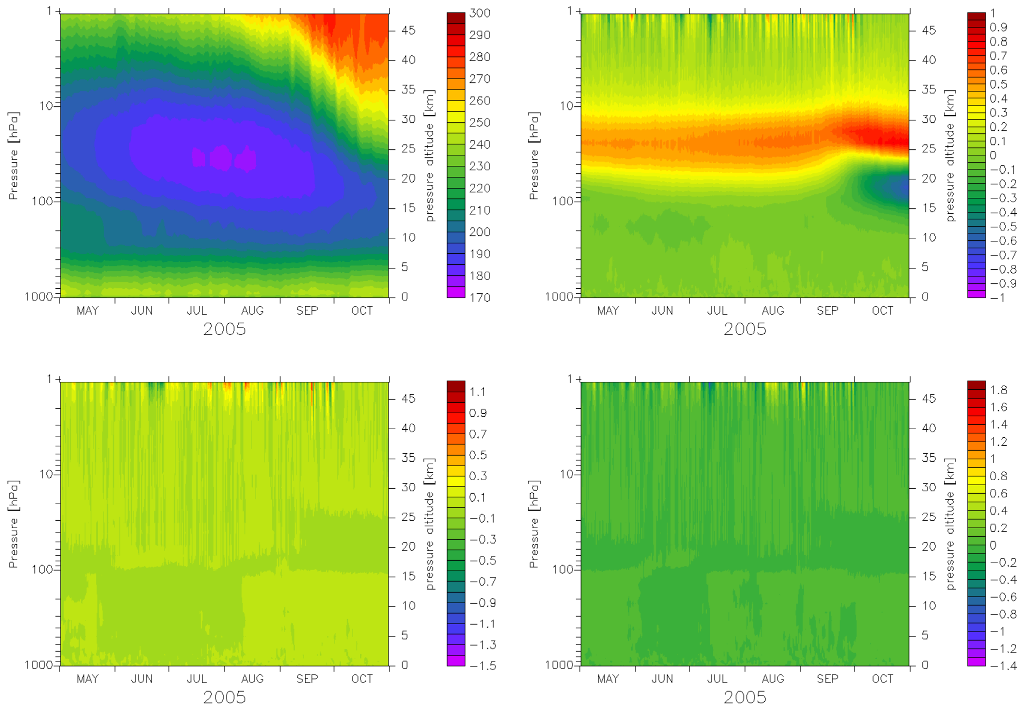

Figure 1: Time series of temperature averaged from 80° to 90°S and over the years 2005 to 2009 in the **Standard** simulation (top left) and differences (to this **Standard** simulation) in the simulations **NoHet** (top right), **Liquid** (botton left) and **LiquidNAT** (botton right).

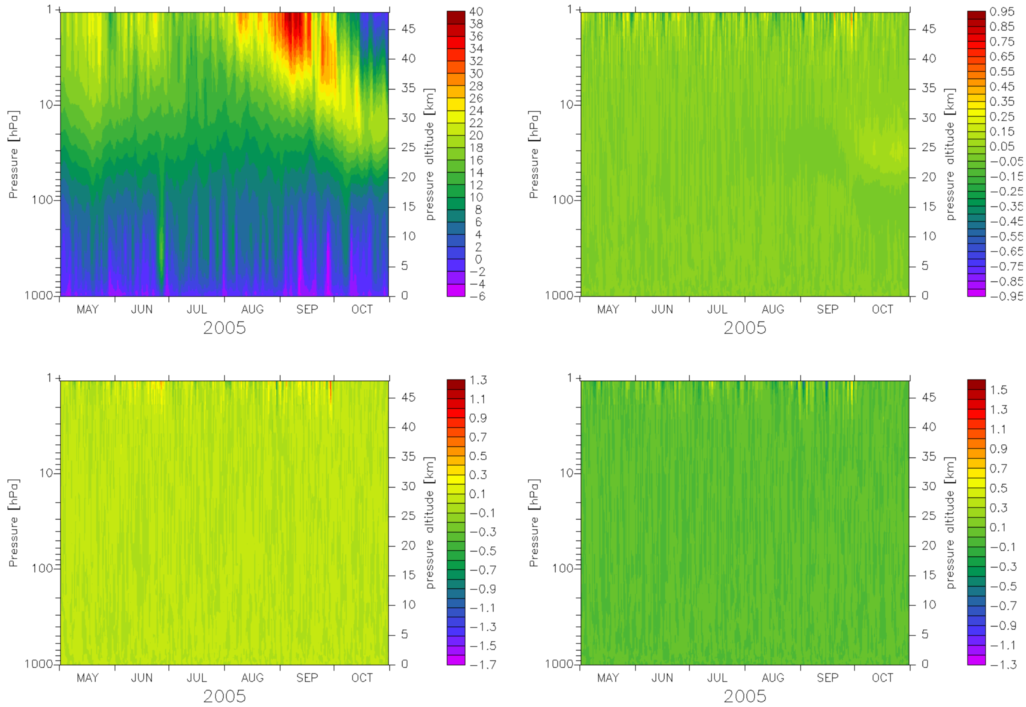

Figure 2: Time series of zonal wind averaged from 80° to 90°S and over the years 2005 to 2009 in the **Standard** simulation (top left) and differences (to this **Standard** simulation) in the simulations **NoHet** (top right), **Liquid** (botton left) and **LiquidNAT** (botton right).

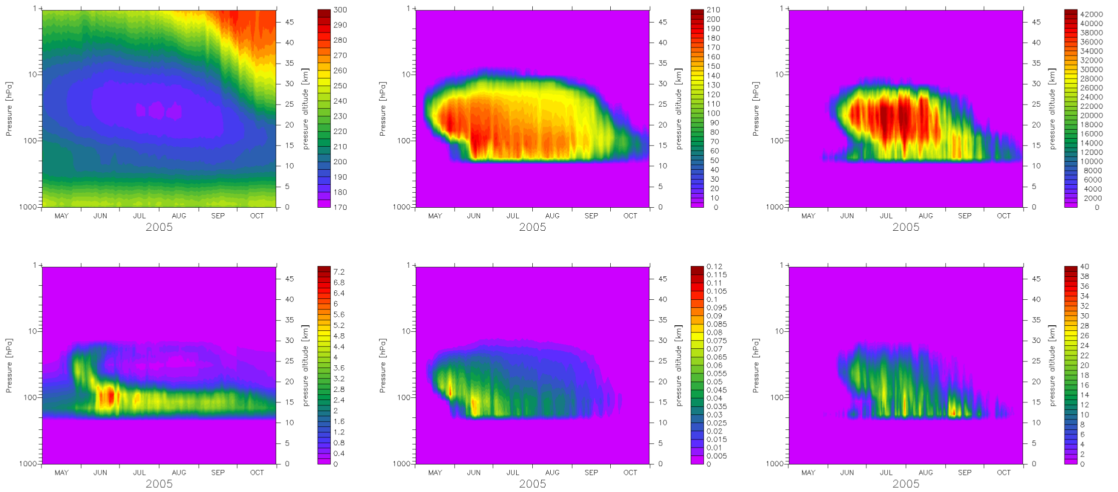

Figure 3: Stratospheric temperature, liquid and solid particles - **Standard** simulation: Time series averaged from 80° to 90°S and over the years 2005 to 2009 for temperature in K (top left), number densities of NAT (N_{NAT}) and ice particles (N_{ICE}) in m^{-3} (top center and right), as well as surface densities of liquid (A_{LIQ}), NAT (A_{NAT}) and ice particles (A_{ICE}) in $\mu m^2 cm^{-3}$ (bottom left to right).

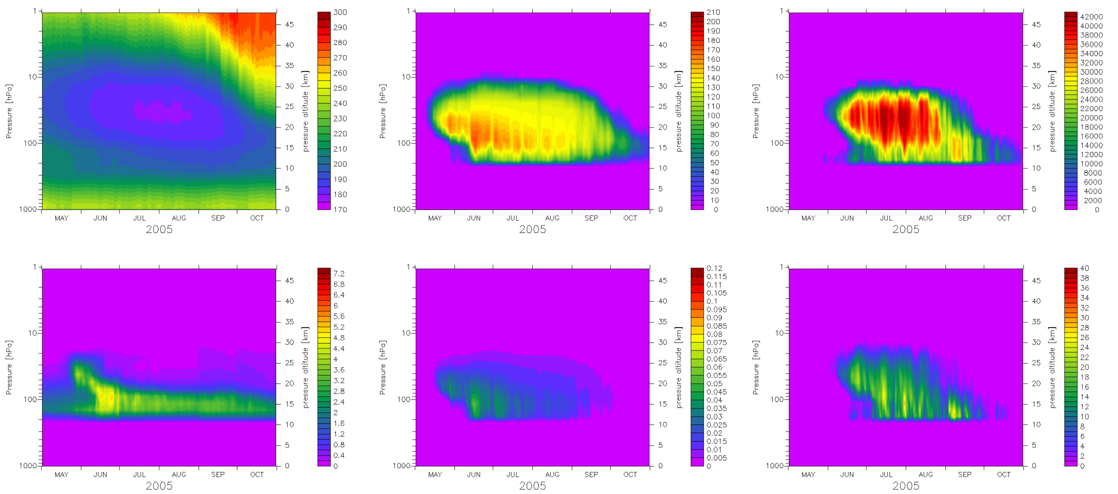

Figure 4: Same as figure 3 but results from **NoHet** simulation

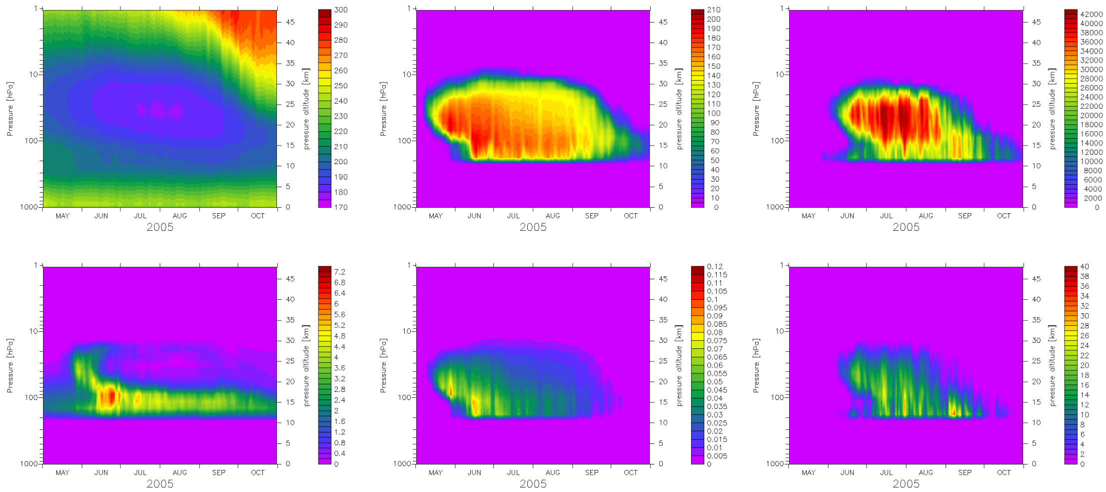

Figure 5: Same as figure 3 but results from **Liquid** simulation

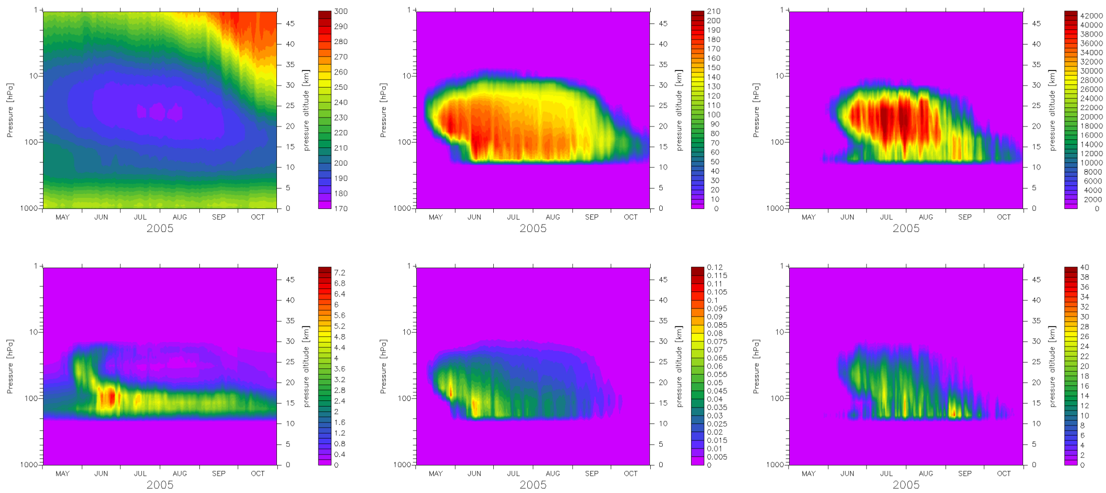

Figure 6: Same as figure 3 but results from **LiquidNAT** simulation