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Interactive comment on "Tropospheric eddy feedback to different stratospheric conditions in idealised baroclinic life cycles" *by* Philip Rupp and Thomas Birner

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We thank the referee for carefully reading our manuscript, and for their constructive comments. In the following we will respond to the various comments and point out any changes we intend to make to the paper based on them. Note that we have not provided exact manuscript corrections at this point, but we have provided the outline of planned changes. Line numbers and figure references in the reviewer's comments refer to the original manuscript. The reviewer's comments are in black italics; our responses are in blue.

In this manuscript, the authors use an idealized model to investigate the role of the

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Discussion paper

stratospheric polar vortex on influencing the tropospheric jet. Specifically, they test the sensitivity of the NAM-like equatorward jet shift associated with a weak or reversed stratospheric polar vortex to the height of the vertical winds in the polar jet, and to the magnitude of surface friction. They find that the tropospheric response is sensitive to changes in winds in the lower stratospheric polar vortex, but not to winds in the upper stratosphere. Additionally, they find that surface friction enhances the tropospheric response to stratospheric vortex changes, and that friction acts to bring nearly barotropic anomalies all the way down to the surface.

Although the findings in general agree with previous studies, the consolidation of the impacts of surface friction and lower-stratospheric anomalies using a coherent model framework produces a compelling standalone study with implications for our dynamical understanding of sudden stratospheric warmings. The manuscript is well-written, well-organized, and the scientific questions well-constructed, and I only have a couple minor comments and questions. Most of my corrections and minor questions can be found in the attached manuscript.

The main additional question I have is if the authors think this study can provide insight into the observed differences in timing between "Displacement" type sudden stratospheric warming events, and "Split" type sudden stratospheric warming events. Specifically, Splits are observed to show an almost-instantaneous NAM-like response to SSWs, whereas for Displacements, the response tends to occur with a significant lag on the order of weeks. Could this be related to a difference in the vertical structure of the polar vortex in Displacement versus Split events? For example, is it possible that Displacement events show anomalies that start higher up in the stratosphere and work their way downwards, while Split events produce a strong signal in the lower stratosphere almost immediately? I am not sure why or how surface friction could play a role, since I can't imagine any way in which surface friction could depend on the type of vortex breakdown.

The idea of obtaining insights into differences between displacement and split events is surely interesting. Smy and Scott (2009) perform life cycle experiments with initial conditions modelling a polar vortex in a split or displacement state based on an imposed PV field and a corresponding PV inversion.

Directly inferring results from the present experiments regarding different SSW states might be a bit speculative and go beyond the scope of this study. However, we think the described set-up and methodology is in general suitable to study such problems and we intend to perform life cycle experiments with more realistic initial conditions (including split and displacement states) at some point. We will add a short note in the discussion about potential extensions of this study.

Line 155: Should we expect the influence of the stratospheric jet on the tropospheric circulation to peak for tropospheric zonal wave numbers of 6 and 7? Does it have something to do with the relative baroclinic instability for each zonal wave number?

The strength of the baroclinic life cycle (in our setup) is strongest for wave numbers 6 and 7. When using different wave number perturbations (e.g. 5) the life cycle is in general weaker and therefore the absolute anomaly induced by the inclusion of stratospheric winds is expected to be weaker, too. We will slightly extend the note regarding this wave number sensitivity in our manuscript.

Various typos have been corrected based on the notes within the supplementary material provided by the referee.

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