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Interactive comment on "The North Atlantic variability structure, storm tracks, and precipitation depending on the polar vortex strength" *by* K. Walter and H.-F. Graf

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A General comments: We thank the reviewers for a very constructive review and we hope that by our response and some modifications to the original manuscript the main results of the study may become clearer. In general, the review asks for more information on the dynamical background of the structural changes described here. A more comprehensive paper dealing with this issue, mainly based on the analysis of stream function tendency, is about to be ready to be submitted. Unfortunately, it seems to be impossible to us, to include comprehensive information about these results already here, but we shall try to include at least the most necessary information in the modified manuscript.

B Specific remarks:

Reviewer 1: 6128: We will avoid to speak about upper tropospheric boundary conditions. The sign of the indices is right. 6130: Shift of air mass may be interpreted in terms of dynamic effects. This will be shown in the forthcoming paper. 6132: we will clarify that daily data are used. 6134: We will add some comments, see Rev.2: 8 and 1+2 6135/10: We do not actualy have a ready dynamic explanation fort this at hand and we would not like to speculate here. 6135/20: The statistical significance is a problem due to the double seggregation. Therefore we just use composite analysis. We shall do similar analysis with long model control runs which hopefully improves this situation (provided the models act like the real world, but this should be the case if separation is done by critical Rossby velocity and not based on statistical criteria).

Reviewer 2: 1+2: Actually we see the (lower) stratosphere as a dynamical boundary condition because of its influence on planetary wave propagation. Energy of these waves is generated in the troposphere, and under the condition of easterly winds (in winter due to major stratospheric warming) is prohibited from vertical propagation, resulting for ALL waves in a reflection back to the troposphere. The other condition of reflection of planetary waves is more complex since it depends on wavenumber, latitude, critical wind speed and vertical structure (mainly wind shear). Between the two cases (easterlies and westerlies exceeding the critical Rossby velocity) planetary waves may penetrate into the stratosphere, finally break there and result in slow signal propagation downwards. A number of model simulations and observational studies since the 1990ies clearly showed the effect of stratospheric variations (induced by volcanic aerosols after Pinatubo eruption) on tropospheric climate. This to our feeling was the first manifestation of an influence of stratosphere (polar vortex strength) on the troposphere. Other studies (like Perlwitz and Graf 2001) showed reflection of ZWNR1 from the stratosphere back to the troposphere if the polar vortex is strong, leading to anticorrelation between the two northern subpolar lows (Castanheira and Graf 2003). While these studies did not, in a comprehensive manner, study the dynamics of this

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influence, they can be seen as indicies of the influence of stratospheric conditions (in winter) on tropospheric variability - hence as dynamic boundary conditions. Since the term Ďdynamic boundary condition“ may be misinterpreted, we will avoid it. A main difference between stratospheric and tropospheric variability is in its time scale. While this is several weeks for the stratosphere, it is days to 2 weeks in the troposphere. Hence, tropospheric variablity in general undergoes several cycles during a specific phase or state of the stratospheric variability. Wheter the stratospheric state is externally forced or results from internal variability does not play a crucial role for our study. It is only the vertical wave propagation properties that count and this is the parameter we must use (in a simplified manner by applying a critical Rossby velocity for ZWN1 at 50 hPa at 65N) to distinguish between the two different stratospheric conditions for tropospheric variability.

3. By no means we intend to say that reflection, refraction and absorption are the same. What we mean is that reflection includes a direct effect of the stratospheric state back on the troposphere. It mainly occurs in the lowest stratosphere. Perlwitz' and Harnik's (2003) results are based on upper stratospheric conditions and they distinguish between absorption and succeeding downward propagation of the signal (slow process) and the faster reflection process. It happens to be that their index time series for the upper stratosphere to a large degree coincides with our index series of polar vortex strength exceeding critical Rossby velocity of 20 m/s in the lower stratosphere. However, since any analysis of EP flux clearly shows that most changes take place in the lowest stratosphere, where most wave energy is available, we suggest that our criterion based on the lower stratosphere conditions is more appropriate.

4.+5.: We base our stratification of the stratospheric regimes on monthly means and of the tropospheric teleconnection indices on filtered daily data. Storm tracks and precipitation are monthly composites. We clarify this in the modified manuscript.

6. We may increase the figure size to any size, actually we did so already, but may increase size even more.

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7. Indeed, PNA strength is correlated with the strength of the polar vortex, but the pattern remains nearly unchanged. Actually the PNA is a Normal Mode (Castanheira et al 2002), the NAO is not in the form we know it. The NA Normal Mode is a dipole over the NA, but with centers located at different places than the classic NAO. The structure known as NAO (or AO) is produced by the interaction of 4 barotropic Normal modes which are correlated to the polar vortex strenth. The interesting point ist hat while Normal Modes do not change structure, resulting patterns, like NAO do. We explain this in the revised manuscript.

8. We do not see any benefit from using statistical criteria for strong and weak vortex. Since we have a theoretical value for the critical Rossby velocity, this should be used. This makes any analysis independent of the season witht heir varying mean zonal winds. This was more extensively discussed in Castanheira and Graf (2003).

9. As mentioned in text, TC patterns are changing NOT in their general structure but in their clarity if higher frequencies are allowed. This is due to the noise coming from mainly synoptic variability.

10. Yes, we mean that monthly resolution is not adequate for studying the dynamics of the influence of stratospheric state on tropospheric variability. This is simply due to the fact that the time scale of ropospheric variability (TC) is in the order of 10-14 days, and so the dynamics woill act on these time scales as well. This can also easily be seen in correlations of zonal wind anomalies in a latitudede height cross section. It is high from the stratosphere down to 250-300 hPa, then vanishes quickly.

11. We do not quite understand what is meant here.

12. We include a more comprehensive explanation of the data analysis procedure.

13. Some text will be added.

14. Appropriate references will be added.

15. The important point is that in WVR we have 2 quasi independent TCs with their

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own storm tracks. Hence we need to look at both since they will somehow overlay each other. The main difference is indeed for the NEGATIVE phase of the TC of SVR with a storm track so different from any expectations. SVR -WVR analyses were already done, but never brought about this result when segregation of tropospheric variability mode phase was neglected. In general all publications just found that the PDF of NAO or AO was shifted towards the positive phase in SVR.

16. We would like to keep the precipitation in the figures since we think this is important information. However, we may include Eady growth rates in addition. Since Eady growth rates are nearly identical with the wind patterns in the upper troposphere, we will not show these.

17. An analysis as performed here cannot be compared with a skill score analysis since we concentrate on extremes. However, we commit that a possibility of proxy information is speculative, but probably worth trying.

18. Indeed we do, and this will be presented in a separate paper. Here it may suffice to mention that low frequency energy is strongly enhanced over central NA in case of SVR. This leads to changes in the weight of processes contributing to NAO like variability. This will be mentioned in the revised manuscript.

19. This was discussed extensively in Castanheira et al 2002

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 6127, 2004.