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Interactive comment on "Eurasian autumn snow impact on winter North Atlantic Oscillation depends on cryospheric variability" *by* Martin Wegmann et al.

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Eurasian autumn snow impact on winter North Atlantic Oscillation depends on cryospheric variability

This study investigates the changes in the relationship between the November snow-dipole and the following winter NAO using century-long reanalyses and modern reanalysis data. The relationship between snow variability and the NAO is an important topic. The study demonstrates the correlations between the November snow-dipole, BKS sea-ice, stratospheric variability and the NAO. Using long-term reanalyses to study these correlations is a good point, although they were produced with the assimilation of limited observations. I think this is important given that most of the existing studies

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are based on short temporal-range data. However, I have a few questions with the current version of the manuscript, which may be addressed by the authors.

Major comments:

1) Conclusions in this study are drawn mostly from correlations/regressions, which would affect the robustness of them. Causality is also thus hard to determine. The November Snow-dipole does have some correlations with the following wintertime NAO variability (Fig. 2). This is also true for the November BKS sea-ice (Fig. 3a). However, the physical mechanisms remain unclear since studies often contradict each other and modeling results often don't support observational relationships. I think more analyses may be considered in order to generate more convincing evidence. In addition, as argued by Peings (2019), both anomalies in the snow/sea-ice and the winter stratospheric warmings can be driven by a common driver – Ural blocking. This raises the possibility that the correlations between snow/sea-ice and the wintertime NAO are statistical ones.

2) The authors argue that the variability of the November snow-dipole largely determines the strength of the correlations between it and the wintertime NAO. But this conclusion is inferred from the 21-year running correlations and the 21-year standard deviations of the snow-dipole. The authors actually assume that the November snow-dipole is a driver of the wintertime NAO. As also mentioned in 1), causality may not be determined only from correlations/regressions.

3) The authors attribute increased correlation of the November snow-dipole (BKS sea-ice) with the wintertime NAO in recent years to the increased variability of the November snow-dipole (BKS sea-ice). Was the standard deviation of the BKS sea-ice displayed in the figures? From the analysis presented, it is hard to see how the three are correlated in a physical sense and which component of the cryosphere is more important in contributing to the recent NAO variability. There are a few studies exploring the impacts of the Arctic sea-ice on Eurasian snow. For example, Xu et al. (2019) studied

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the correlation between Autumn Arctic sea-ice and the winter snow cover in Northern Eurasia.

4) I think the focus of this study needs to be clarified. The stratospheric pathway for either sea-ice or snow to impact the wintertime NAO variability is not new which can be found in many studies already cited in the introduction. Does the study emphasize the predictive nature of the correlation between the November snow-dipole and the wintertime NAO? If this is the case, why not consider some techniques such as cross-validation procedure to assess the predictive skills of the November snow-dipole? Empirical models such as those used in Chen et al. (2019; Section 6) may also be considered.

Minor comments:

1) In addition to Han and Sun (2018) and Gastineau et al. (2017), the November snow-dipole was identified in an EOF analysis by Ye and Wu (2017). 2) L28-29: Does the increased sea-ice variability enhanced that of the snow? 3) The section of Data and Methods may need some modification. In particular, more details of the reanalysis data may be given. In particular, recent satellite observations of the snow cover can be included in the analysis. 4) L153-154: In the analysis, were all the atmospheric fields detrended as well? 5) L244: Change 'aandd', 'bande' and 'candf' to 'a and d', 'b and e' and 'c and f'. 6) Labeling those multi-panel figures such as Figure 2 with additional text to indicate which variable is correlated with or regressed on to which variable may be considered to help the readers.

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