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Understanding the Differences in the Sub-seasonal Predictability of Stratospheric Extreme Events

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In subseasonal-to-seasonal (S2S) prediction systems, strong vortex events are found to be more predictable than sudden stratospheric warming (SSW) events. The reason for this difference in predictability between different types of events is however not resolved. To investigate this question using a larger sample size, we extend the definition of strong vortex and SSW events to wind acceleration and deceleration events due to their similar dynamics. Specifically, we use the zonal mean zonal wind at 60°N, 10hPa from ERA-interim reanalysis for the winters of 1998/99 to 2017/18 to identify wind acceleration and deceleration events, which are defined as a wind change over a 10-day window. We then assess the predictability of the identified events using the ECMWF S2S hindcasts. It is found that wind acceleration events are more predictable than deceleration events. However, when expressing the predictability of deceleration and acceleration events as a function of event magnitude, they qualitatively exhibit the same predictability behaviour; that is, events of stronger magnitude are less predictable. We explain the observed predictability dependence from two perspectives: 1) In a statistical sense, strong magnitude events lie within the tails of the climatological distribution and thus are penalised more heavily than weak magnitude events, and 2) from a dynamical perspective, extreme stratospheric events are associated with strong anomalies in precursors such as wave activity and vortex background state, and are therefore often associated with large ensemble spread and large uncertainties. In particular, the magnitude of extremely strong wave activity is underestimated in the model for strong deceleration events. Therefore, we suggest the observed predictability difference between event types can to a large extent be explained by the difference in event magnitude between event types, i.e. the fact that wind deceleration events are associated with greater magnitudes than wind acceleration events, and that SSW events are stronger in magnitude than strong vortex events. We also suggest that a better representation of extremely strong wave activity in the prediction system can enhance the predictability of stratospheric extreme events, and by extension their impacts on surface weather and climate.