Stratospheric influence on the predictability of cold spells

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The weather-dependent planning and decision-making benefit greatly from subseasonal to seasonal (S2S) weather predictions made for up to six weeks ahead. At this timescale anomalies in the extratropical stratospheric circulation, which can last for several weeks in the Northern Hemisphere during winter, are known to affect climate at the surface and can extend the predictability of tropospheric weather conditions. The downward influence of the stratospheric circulation anomalies on the troposphere is projected by the Northern Annular Mode (NAM). Because of the long persistence of stratospheric anomalies beyond typical weather timescale, the increase in forecast skill is possible for the regions influenced by the atmospheric circulation variability associated with NAM based on the stratospheric predictor.

In this study, we investigate the predictability of the Eurasian severe and persistent cold spells during winter and its dependence on the state of the stratosphere. We first detected the below-normal surface temperature events over northern Eurasia (cold spells) in the ERA5 re-analysis. Then, to assess the predictability of these cold spells and to evaluate the skill in the probabilistic re-forecasts we divided them into groups associated with different stratospheric circulation anomalies which took place prior to the below-normal temperature events. When the stratospheric vortex is strong it is not expected to favor cold air outbreaks in this region. Therefore, in these cases, the cold air outbreaks result from internal tropospheric dynamics and their predictability is limited by the chaotic behavior of the weather systems. On the other hand, the weakening of the vortex is characterized by a more negative NAM index. This weakening is often followed by an equatorward shift of the tropospheric jets, an increase in the frequency of occurrence of tropospheric blocking, and cold air outbreaks over northern Eurasia. In these cases, the stratospheric vortex weakening can lead to the statistically significant improvement of the skill of cold air outbreak forecasts in case if the forecast model is capable of properly representing the coupling between the stratosphere and the troposphere. We show that the predictability of cold spells in the European Centre for Medium-range Weather Forecasts (ECMWF) model is enhanced under weak vortex conditions starting from week 3 before the event. We also evaluate how the surface predictability is affected by model imperfections by comparing the predictability across different S2S models.