



## **Feeling the Pulse of the Stratosphere: An Emerging Opportunity for Predicting Continental-Scale Cold Air Outbreaks One Month in Advance**

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Extreme weather events such as cold air outbreaks (CAOs) pose great threats to human life and socioeconomic well-being of the modern society. In the past, our capability to predict their occurrences is constrained by the 2-week predictability limit for weather. We demonstrate here for the first time that a rapid increase of air mass transported into the polar stratosphere, referred to as “the pulse of the stratosphere (PULSE)”, can often be predicted with a useful skill 4–6 weeks in advance by operational forecast models. We further show that the probability of the occurrence of continental-scale CAOs in mid-latitudes increases substantially above the normal condition within a short time period from one week before to 1–2 weeks after the peak day of a PULSE event. In particular, we reveal that the three massive CAOs over North America in January and February of 2014 were preceded by three episodes of extreme mass transport into the polar stratosphere with peak intensities reaching a trillion tons per day, twice of that on an average winter day. Therefore, our capability to predict the PULSES with operational forecast models, in conjunction with its linkage to continental-scale CAOs, opens up a new opportunity for 30–day forecasts of continental-scale CAOs, such as those occurring over North America in the 2013–14 winter. A real time forecast experiment inaugurated in the winter of 2014–15 has given support to the idea that it is feasible to forecast CAOs one month in advance.