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Long-term prediction of Sudden Stratospheric Warmings

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Polar vortex is a system of strong westerly winds which forms each winter in the polar stratosphere. Sometimes, roughly every other winter, the polar vortex in the Northern Hemisphere experiences a dramatic breakdown after associated warming of the polar stratosphere. Such events are called Sudden Stratospheric Warmings (SSWs). SSWs are known to have a significant influence on ground winter weather by leaking cold and harsh air, e.g., to Northern Eurasia and to large parts of North America. It is commonly thought that SSWs are generated by enhanced planetary waves, which propagate from the troposphere to the stratosphere. The waves break in the stratosphere and deposit their momentum there, which decelerates the vortex and leads to its breakdown.

It has been known for a long that the easterly direction of equatorial stratospheric QBO (Quasi-Biennial Oscillation) winds favors a weakening and eventual breaking of the northern polar vortex (the so-called Holton-Tan mechanism). However, it was recently shown that the occurrence rate of SSWs also depends strongly on geomagnetic activity. Breaking of the polar vortex is very likely to occur if the geomagnetic activity is weak and QBO winds are easterly. Weak geomagnetic activity corresponds to a low level of solar wind-driven energetic particle precipitation into the polar stratosphere, while the easterly QBO phase guides the planetary waves preferentially into the polar vortex.

Here we examine the possibility of using these results to predict the occurrence probability of SSWs with a long lead time of several months. We formulate a model, where the SSW probability depends on geomagnetic activity represented by Aa index and on the QBO phase. We evaluate the optimal lead times for geomagnetic activity and the QBO phase, and the optimal altitude level where the QBO has the greatest influence on the SSW probability. We will also estimate the statistical confidence limits for the derived probability.