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# Sudden stratospheric warmings and anomalous upward wave activity flux

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Abrupt breakdowns of the polar winter stratospheric circulation such as sudden stratospheric warmings (SSWs) are a manifestation of strong two-way interactions between upward propagating planetary waves and the mean flow. The importance of sufficient upward wave activity fluxes from the troposphere and the preceding state of the stratospheric circulation in forcing SSW-like events have long been recognized. Past research based on idealized numerical simulations has suggested that the state of the stratosphere may be more important in generating extreme stratospheric events than anomalous upward wave fluxes from the troposphere. Other studies have emphasized the role of tropospheric precursor events. Here reanalysis data combined with climate model data are used to define events of extreme stratospheric mean flow deceleration (SSWs being a subset) and events of extreme lower tropospheric upward planetary wave activity flux. While the wave fluxes leading to SSW-like events ultimately originate near the surface, the anomalous upward wave activity fluxes associated with these events primarily occur within the stratosphere. The crucial dynamics for forcing SSW-like events appear to take place in the communication layer just above the tropopause. Anomalous upward wave fluxes from the lower troposphere may play a role for some events, but seem less important for the majority of them.