Dynamics of Sudden Stratospheric Warmings

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Abstract:

Sudden stratospheric warmings (SSWs) are midwinter events in which the primary stratospheric circulation, which is characterised by a strong cyclonic vortex over the polar cap, abruptly breaks down leading to an explosive warming of the polar stratosphere. SSWs modify the circulation throughout the stratospheric column. Furthermore, it is now well established that they tend to modify the large-scale circulation near the surface for up to 2 months following the stratospheric event. Fundamentally, SSWs are a manifestation of anomalously strong two-way interactions between upward propagating planetary waves and the mean flow. However, the conditions that trigger anomalously strong wave-mean flow coupling leading to an SSW are still not well understood. While tropospheric precursors to SSWs have often been noted (e.g., blocking), SSWs have also been shown to spontaneously arise due to fortuitous coupling of a fixed wave field provided by the troposphere and the concurrently evolving state of the stratosphere. Here we present evidence based on reanalysis data and climate model simulations that the explosive dynamics associated with SSWs primarily take place within the stratosphere. Anomalous upward wave fluxes from the lower troposphere may play a role for some events, but seem less important for the majority of them. The crucial dynamics for forcing SSWs appear to take place across the "communication layer" just above the tropopause. Consequences for stratosphere-troposphere coupling will be discussed.