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Polar Amplification of Stratospheric Variability

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In northern winter the circulation of the stratosphere is highly variable—with occasional reversals of the usually cyclonic circulation—know as sudden stratospheric warmings. Large-scale upward-propagating waves drive a synchronised meridional circulation that moves mass into and out of the Arctic stratosphere, modulating adiabatic warming of the polar air column, and altering the strength of the stratospheric polar vortex. These stratospheric changes, with a timescale of a few weeks, are associated with substantial effects on surface weather and climate, especially on the Northern Annular Mode (NAM) with associated long-lasting shifts in the jet streams, storm tracks, precipitation, and likelihood of blocking events. Despite unambiguous observations of this phenomenon, as well as numerical simulations, a quantitative physical explanation of this downward coupling remains elusive. Here we show that stratospheric variability 1) modulates the depth of the troposphere, and 2) triggers a tropospheric feedback mechanism that amplifies polar pressure anomalies, especially at the surface. Stratospheric variability modulates the tropospheric heat flux into the polar cap, resulting in low-level polar temperature anomalies. The anomalously cold/warm polar regions induce high/low pressure anomalies of the same sign as the stratosphere—thus amplifying the stratospheric signal.