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Use of an adjoint technique to investigate the Southern Hemisphere Major Warming, September 2002.

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In September 2002, the stratospheric polar vortex in the Southern Hemisphere split in two, undergoing a major stratospheric sudden warming. Prior to this, major warming events were believed to be confined to the Northern Hemisphere. Most dynamical studies of this event, suggest that its prime cause was increased tropospheric planetary wave activity during winter and spring 2002. This research project presents an alternative dynamical hypothesis into the causality of the 2002 Southern Hemisphere major warming . It is proposed that cyclogenesis in the troposphere under the tip of an elongated stratospheric vortex contributed to the split, and that in its elongated state the stratospheric vortex was conditionally unstable. This hypothesis is tested using a version of ECMWF's global atmospheric model by using an adjoint technique, to calculate the linear dynamical sensitivity of the stratospheric polar vortex to perturbations in the troposphere. A region of high sensitivity, underneath the tip of the elongated polar vortex is highlighted, in a similar position and of a similar spatial scale as a tropospheric PV anomaly associated with strong cyclogenesis. An iterative procedure is used to calculate a set of optimal perturbations which prevent the vortex from splitting. To examine the non-linear impact of the optimal perturbations, 10 day forecasts, free running after 48 hours, are used. Perturbations confined to the entire tropospheric domain are able to successfully prevent a major stratospheric sudden warming at 10 hPa. In a further set of experiments optimal perturbations are then confined to a region in the same location and of the same size as the PV anomaly directly underneath the elongated tip of the polar vortex. The evolution of the polar vortex is again highly distorted and the major warming is prevented. The results lend support to the alternative hypothesis, and provide a useful perspective on the validity of the localised view. The research concludes by outlining the wider potential of the adjoint technique for dynamical studies of troposphere-stratosphere interactions.