SPARC Workshop SHARP2016

Stratospheric influences on the tropospheric jet: Impacts of stratospheric seasonal variability and ozone depletion

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We investigate stratospheric influences on tropospheric jet location and strength using an idealized model. Firstly, we force the model with a seasonal cycle in equilibrium temperatures that is confined to the stratosphere, to investigate stratosphere-troposphere coupling on seasonal timescales. Since the troposphere has no internal seasonal cycle, any seasonal variations in the tropospheric circulation are unambiguously of stratospheric origin. We find tropospheric signals not only of stratospheric 'events', but also of the stratospheric seasonal cycle itself. The magnitude of the tropospheric response to the stratospheric seasonal cycle increases with the model's tropospheric annular mode timescale, as suggested by the fluctuation-dissipation theorem. This timescale can be varied either by the inclusion of topography or by modifying the model's tropospheric equilibrium temperature.

Secondly, we investigate the sensitivity of the model's responses to the timing of imposed polar stratospheric cooling, intended to mimic the radiative effects of ozone depletion. The model exhibits circulation responses to springtime cooling that qualitatively match both observations and the responses of comprehensive chemistry climate models. The model's surface response is sensitive to the timing of the cooling, with the onset becoming delayed with later cooling, but with the termination occurring at similar times, suggesting that the meteorology plays an important role. The model's responses are not always annular mode-like. Larger and more persistent surface responses at certain times are consistent with the model's seasonal cycle of tropospheric annular mode timescales. It is suggested that the imposed cooling, when it delays the stratospheric final warming, results in an extended period of lower stratospheric variability, which could be an important factor in producing realistic surface responses.