Origins of Multi-decadal Variability in Sudden Stratospheric Warmings

Oscar Dimdore-Miles, Lesley Gray, and Scott Osprey
University of Oxford, Physics, Atmospheric, Oceanic and Planetary Physics, United Kingdom of Great Britain – England, Scotland, Wales (oscar.dimdore-miles@physics.ox.ac.uk)

Sudden Stratospheric Warmings (SSWs) are major disruptions of the Northern Hemisphere (NH) stratospheric polar vortex and occur on average approximately 6 times per decade in observation based records. However, within these records, intervals of significantly higher and lower SSW rates are observed suggesting the possibility of low frequency variations in event occurrence. A better understanding of factors that influence this decadal variability may help to improve predictability of NH mid-latitude surface climate, through stratosphere-troposphere coupling. In this work, multi-decadal variability of SSW events is examined in a 1000-yr pre-industrial simulation of a coupled Atmosphere-Ocean-Land-Sea ice model. Using a wavelet spectral decomposition method, we show that hiatus events (intervals of a decade or more with no SSWs) and consecutive SSW events (extended intervals with at least one SSW in each year) vary on multi-decadal timescales of period between 60 and 90 years. Signals on these timescales are present for approximately 450 years of the simulation. We investigate the possible source of these long-term signals and find that the direct impact of variability in tropical sea surface temperatures, as well as the associated Aleutian Low, can account for only a small portion of the SSW variability. Instead, the major influence on long-term SSW variability is associated with long-term variability in amplitude of the stratospheric quasi biennial oscillation (QBO). The QBO influence is consistent with the well known Holton-Tan relationship, with SSW hiatus intervals associated with extended periods of particularly strong, deep QBO westerly phases. The results support recent studies that have highlighted the role of vertical coherence in the QBO when considering coupling between the QBO, the polar vortex and tropospheric circulation.