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Stratospheric Temperature Trends Inferred from the Merged SSU and AMSU-A Observations

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Observations from the Stratospheric Sounding Unit (SSU) on board historical NOAA polar-orbiting satellites have played a vital role in investigations of long-term trends and variability in the middle- and upper-stratospheric temperatures during 1979–2006. The successor to SSU is the Advanced Microwave Sounding Unit-A (AMSU-A) starting from 1998 until the present. Unfortunately, the two observations came from different sets of atmospheric layers, and the SSU weighting functions varied with time and location, posing a challenge to merge them with sufficient accuracy for development of an extended SSU climate data record. We propose a variational approach for the merging problem here, matching in both temperatures and weighting functions. The approach yields zero means with a small standard deviation and a negligible drift over time in the temperature differences between SSU and its extension to AMSU-A. These features made the approach appealing for reliable detection of long-term climate trends. The approach also matches weighting functions with high accuracy for SSU channels 1 and 2 and reasonable accuracy for channel 3. The total decreases in global mean temperatures found from the merged dataset were from 1.8K in the middle stratosphere to 2.4K in the upper stratosphere during 1979–2015. These temperature drops were associated with two segments of piecewise linear cooling trends, with those during the first period (1979–97) being much larger than those of the second period (1998–2015). These differences in temperature trends corresponded well to changes of the atmospheric ozone amount from depletion to recovery during the respective time periods, showing the influence of human decisions on climate change. Spatial trend pattern shows uniform cooling over the tropical region, but a wave-one cooling pattern was found over the Northern Polar region in all channels, possibly corresponding to heat transport by the stratospheric standing waves.