Impact of the El Niño Southern Oscillation (ENSO) on the structure of the Brewer-Dobson circulation in the lower stratosphere

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The stratospheric Brewer-Dobson circulation crucially affects climate as it determines the transport and lifetime of key radiatively active trace gases and impacts surface climate through downward coupling. Here, we quantify the variability in the lower stratospheric circulation induced by the El Niño Southern Oscillation (ENSO) using satellite measurements and simulations with the Lagrangian chemistry transport model, CLaMS, driven by ERA-Interim and JRA-55 reanalyses.

First, we show that the low ozone (O_3), nitrous oxide (N_2O) and high carbon monoxide (CO) anomalies in the lower stratosphere during El Niño (and vice versa during La Niña) simulated by CLaMS agree well with ACE-FTS and Aura-MLS satellite observations. In particular, during the strong El Niño event in 2015-2016 both satellite observations and CLaMS simulations show lowest O_3, N_2O and highest CO mixing ratios in the record. The trace gas anomalies are consistent with increased tropical upwelling during El Niño and with decreased tropical upwelling during La Niña. Furthermore, analysis of the residual circulation shows that ENSO induces structural changes in the lower stratospheric circulation. During El Nino, upper part of the shallow branch of the BD-circulation is strengthened, while the lower part is weakened in both meteorological reanalyses (and vice versa for La Niña). Changes in the full age spectrum, calculated in the CLaMS model, consistently show an increase in the fraction of young air throughout most parts of the stratosphere, except in the subtropics below about 500 K, for El Niño. This structural lower stratospheric circulation change suggests that a shift of the ENSO basic state toward more frequent El Niño conditions in a warming climate will substantially alter the lower stratospheric trace gas distribution.

Key words: Reanalysis Inter-comparison, El Niño Southern Oscillation, structural changes in BD-circulation, Lower stratospheric trace gas distribution.