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Estimating Brewer-Dobson circulation trends from the stratospheric water vapour changes: method sensitivity

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The Brewer-Dobson circulation (BDC) is an important factor controlling the composition of the upper troposphere and lower stratosphere (UTLS), which, in turn, crucially affects the global radiation budget and climate. Therefore, changes in the BDC with global warming may induce important feedback mechanisms on climate. However, the BDC is a zonal mean residual circulation and can not be measured directly. Thus, it is necessary to infer BDC trends from the changes in the trace gas measurements. Such a method based on stratospheric water vapour measurements from satellite instruments has been recently published by Hegglin et al. (2014), and has shown evidence for an accelerating BDC in the lower stratosphere.

We assess the sensitivity of estimating long-term BDC changes from stratospheric water vapour. For that purpose, we apply three different reconstruction methods based on: (I) the full age spectrum (method A in the following), (II) mean age-of-air (method B), and (III) the approximate method of Hegglin et al. (2014) (method C). Each of these methods assumes that stratospheric water vapour changes can be divided into changes in the water vapour entry value, changes in the methane entry value, and changes in the fractional release factor which, in turn, are related to changes in the BDC. For method A, we calculate the trace gas mixing ratios through the convolution of the stratospheric entry values with the age-spectrum. For method B, we estimate the trace gas mixing ratios as the entry values lagged by the mean age of air. For method C, we follow even simpler assumptions, for instance, negligible changes in entry mixing ratios and in methane-age correlations over time. For our sensitivity studies, the water vapour and methane mixing ratios, age spectrum and mean age are derived from the Chemical Lagrangian Model of the Stratosphere (ClaMS).

Our results show that calculated BDC changes depend on the reconstruction method used. Methods A and B give very similar results, consistent with the actual mean age change in the model simulation. The approximate method C, on the other hand, shows differences in derived mean age changes. While the overall resulting mean age change pattern is similar, clear divergence occur in the exact strength of the trends and in the more detailed structure. In specific regions of the stratosphere, derived mean age trends following the method C may even differ in sign drawing different pictures of BDC changes.

The results of this work could be used for assessing the uncertainty in estimates of stratospheric circulation changes from global satellite measurements.

References:
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