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## Using MIPAS Tracer Measurements to Investigate the Quasi-Biennial Oscillation and Mean Meridional Circulation

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This study investigates the Quasi-Biennial Oscillation (QBO) influence on the mean meridional circulation during the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) operational period (2002-2012). We employ ERA-Interim, JRA-55, and ERA5 reanalysis data alongside MIPAS tracer-derived velocities. Following the SPARC Reanalysis Intercomparison Project (S-RIP) methodology, we deseasonalize and composite QBO-W onsets at 20 hPa. This allows for comparisons of zonal-mean vertical and meridional velocities derived from MIPAS tracers with reanalysis data.

To derive effective transport velocities within the 2-dimensional atmosphere, we leverage a direct inversion technique based on MIPAS tracer measurements. This method, as detailed in *Clarmann et al. (2016)*, integrates the continuity equation over time to determine mean velocities that replicate observed trace gas distributions. This approach offers observation-based insights into the mean meridional circulation independent of dynamical models. We analyze various atmospheric layers for the tracers CH<sub>4</sub>, CO, H<sub>2</sub>O, and N<sub>2</sub>O, and supplement them with SF<sub>6</sub> and CCl<sub>4</sub> to mitigate uncertainties.

Our analysis reveals distinct QBO patterns in tracer-retrieved velocities, demonstrating good qualitative agreement with ERA5, ERA-Interim, and JRA-55 reanalysis results. However, comparisons also expose differences, potentially highlighting areas for improvement in current models or limitations inherent to tracer-based continuity equation inversions.

These findings emphasize the significance of MIPAS tracer measurements for enhancing our understanding and modelling of the mean meridional circulation in Earth's atmosphere.

von Clarmann, T. and Grabowski, U.: *Direct inversion of circulation and mixing from tracer measurements – Part 1: Method*, *Atmos. Chem. Phys.*, 16, 14563–14584, <https://doi.org/10.5194/acp-16-14563-2016>, 2016.