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Collaboration to foster studies on stratospheric dynamics – drivers, effects and future changes

Effects of missing gravity waves on stratospheric dynamics – part 1: climatology

- Analysing inter - actions of with gravity waves (GWs) and of their influence on the stratospheric zonal winds as well as on the Brewer-Dobson circulation (BDC)
- Inter-hemispheric differences in BDC changes can be explained by wave compensation and amplification effects

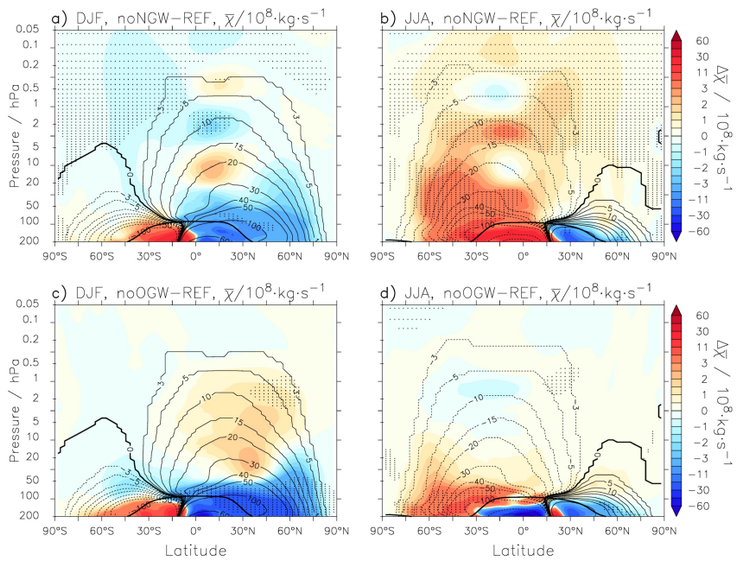

Fig. 1: Climatological differences of the zonal mean streamfunction χ. The contour lines show the reference climatology and the thick black line denotes the tropopause. Dotted regions show where the differences are significant.

- A larger ratio of planetary waves to GWs leads to enhanced mixing, which can strongly impact stratospheric tracer distributions and cannot be compensated
- A follow-up study investigates the influence of missing GWs in the transition to a possible future climate state

Eichinger, R., Garny, H., Šácha, P., Danker, J., Dietmüller, S. And Oberländer-Hayn, S.: Effects of missing gravity waves on stratospheric dynamics; part 1: climatology. Clim Dyn 54, 3165–3183, DOI: 10.1007/s00382-020-05166-w, 2020.

Overestimated acceleration of the advective Brewer–Dobson circulation due to stratospheric cooling

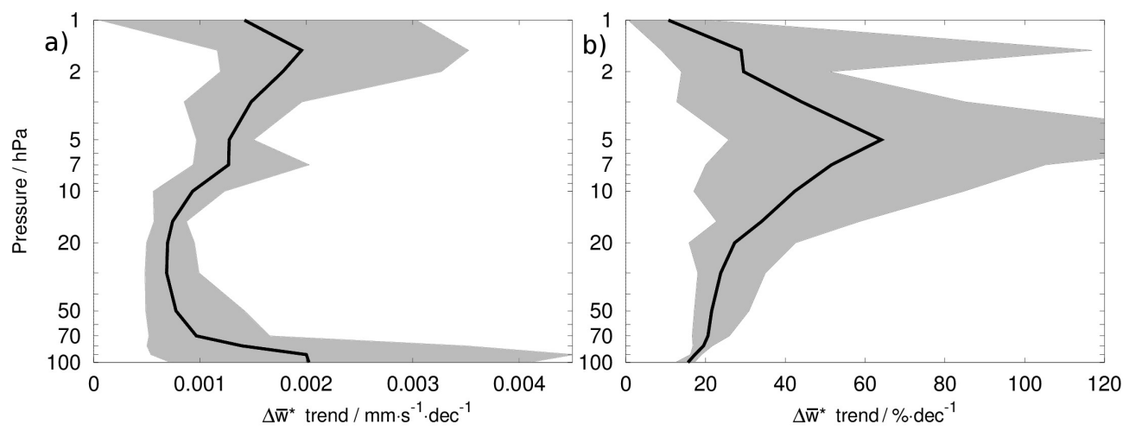

Fig. 2: (a) Absolute and (b) relative CCMI-1 multi-model mean differences of the tropical w* trends over the 1960–2100 period. The grey regions show the model range.

- Stratospheric cooling causes reduction of geometrical distance between pressure levels, which is implicitly neglected in CCMI-1 data request (through usage of log-pressure formulae with constant scale height)
- Past studies that based w* trend analyses on log-pressure w* overestimated advective BDC acceleration by ~20%
- Implications for data processing tools and data requests of multi-model projects to avoid inaccuracies

Eichinger R. and Šácha P.: Overestimated acceleration of the advective Brewer–Dobson circulation due to stratospheric cooling. QJR Meteorol Soc. 2020; 1–15, DOI:10.1002/qj.3876, 2020.

On the intermittency of orographic gravity wave hotspots and its importance for middle atmosphere dynamics

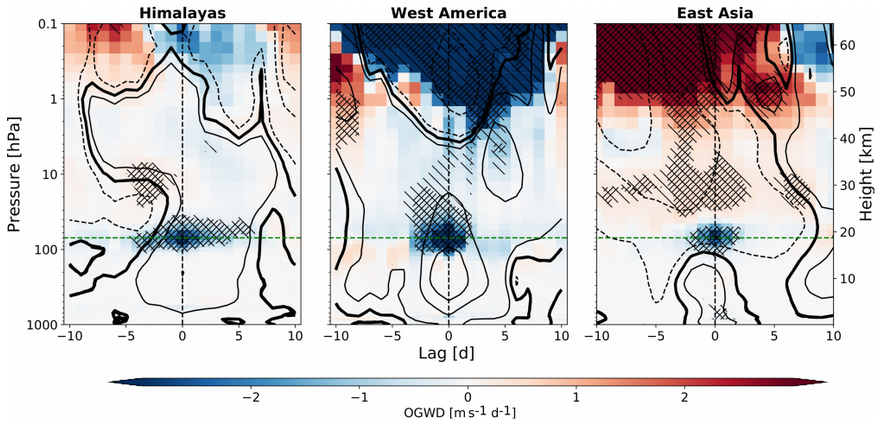

Fig. 3: Composite anomalies of OGWD within the selected hotspot areas. Green lines represent the composite level 70 hPa. Hatching represents significance. The contour lines represent zonal wind anomalies.

- Investigation of asymmetrical distribution of 3-D orographic (O)GW drag for three selected hotspot regions
- Peak-detection algorithm captures OGW intermittency and allows to assess composites for the three hotspots.
- LS peak OGW events can have opposing effects on the middle atmosphere depending on the hotspot region
- A follow-up study shows that strong GW events strongly alter stratospheric resolved waves, thereby influencing winds and wave transience

Kuchar, A., Sacha, P., Eichinger, R., Jacobi, C., Pisoft, P., and Rieder, H. E.: On the intermittency of orographic gravity wave hotspots and its importance for middle atmosphere dynamics, Weather Clim. Dynam., 1, 481–495, DOI: 10.5194/wcd-1-481-2020, 2020.

Stratospheric contraction caused by increasing greenhouse gases

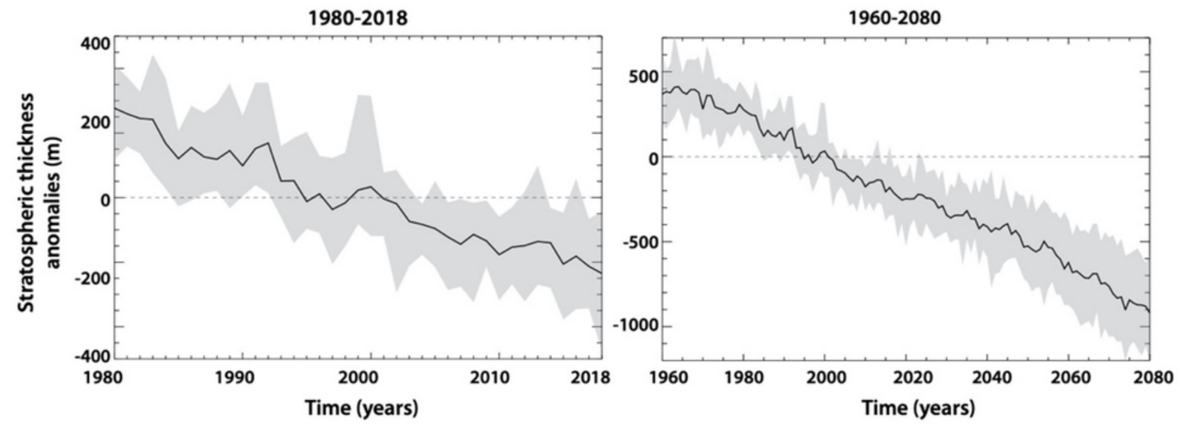

Fig. 4: Stratospheric thickness anomalies. The black line illustrates the CCMI model mean and the shaded areas the model spread.

- The stratosphere has contracted substantially over the last decades, the main driver are increasing GHGs
- The trend will continue if emission trends are not reversed, and will influence satellite trajectories and space-based navigational systems
- Stratospheric contraction is not a mere response to stratospheric cooling, changes in both tropopause and stratopause pressure contribute significantly to it

Pisoft, P., Sacha, P., Polvani, L. M., Añel, J. A., de la Torre, L., Eichinger, R., Foelsche, U., Huszar, P., Jacobi, C., Karlicky, J., Kuchar, A., Miksovsky, J., Zak, M., Rieder, H. E.: Stratospheric contraction caused by increasing greenhouse gases; in review at Nature Climate Change, 2020

Bayerische Staatskanzlei

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