DLR

DKRZ – project 782
The Stratosphere in a changing climate: Studies at the DLR-Institute of Atmospheric Physics

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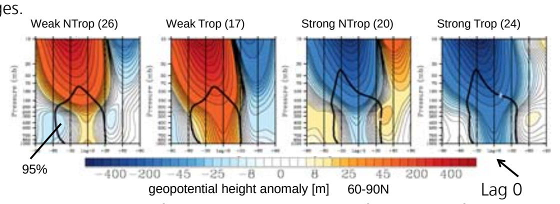
Introduction

Stratospheric composition and dynamics significantly influence tropospheric climate through radiative and dynamical feedbacks. To study various processes affecting the chemical composition of the stratosphere, its dynamical state and its influence on tropospheric climate and weather, in addition to long-term transient simulations with the global chemistry-climate model ECHAM/MESSy-Atmospheric Chemistry (EMAC) (in the consortium ESCIMO), targeted sensitivity studies will be performed. The aims of individual projects conducted at the DLR-IPA within DKRZ project 782 are presented on this poster.

Stratosphere-Troposphere Coupling (SHARP-STC)

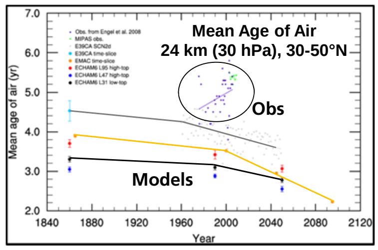
A better understanding of the causes and impacts of the coupling of stratosphere and troposphere is necessary to improve the seasonal weather forecast. To understand changes in tropospheric dynamics which may be caused by changes in the stratospheric dynamics, a new method for analysing the processes involved in STC was developed. Long term transient simulations as well as sensitivity studies are necessary to obtain robust results with this new method concerning the importance of the stratosphere for tropospheric changes.



Downward propagation of stratospheric anomalies for weak (left) and strong (right) polar vortex events classified into events that propagate into to the lower troposphere (Trop) and that show no significant downward propagation (NTrop).

The Brewer-Dobson Circulation (SHARP-BDC)

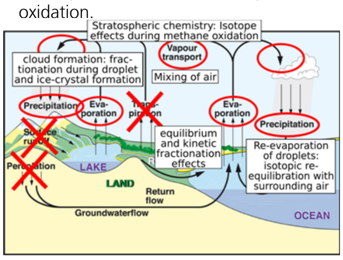
The BDC is projected to intensify in a changing climate by global climate models. However, there is little evidence from observations on changes in the BDC. Therefore, the circulation changes need to be better understood both in the models and in comparison to observations to resolve the apparent discrepancies. While effects of resolved waves in the models are mostly understood, the role of gravity waves (GW), that are parameterized, remains questionable. The sensitivity of BDC changes to the GW settings will be tested in sensitivity studies.



Mean age of stratospheric air in the middle stratosphere from different global model simulations and derived from observations of SF_6 and CO_2.

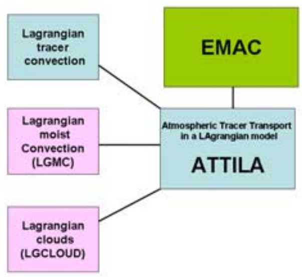
Isotopes of water (SHARP-WV)

HDO is included into the EMAC model to investigate the respective impacts of the processes controlling the stratospheric water vapour budget. Isotope-fractionation processes leave a fingerprint in the HDO/H2O-ratio, conserving information about the process-based history in the water compound. This allows us to study the relative importance of a) direct injection of water and ice into the stratosphere by overshooting convection, b) dehydration of air in the TTL during ascent by cirrus cloud formation and c) the in-mixing of older stratospheric air which has experienced H_2O and HDO formation from CH_4-oxidation.



A model simulation for a comparison with satellite observations of the 'tape-recorder'-signal from the MIPAS instrument will be performed. Moreover we will carry out a sensitivity study with different convection schemes. This will provide an estimate of the uncertainty range of the impact of overshooting convection on the stratospheric water vapour budget.

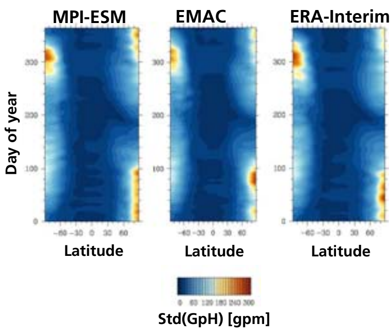
Lagrangian studies of water vapour transport (SHARP-WV)



EMAC/ATTILA forms the basis for the full representation of the atmospheric hydrological cycle in a Lagrangian manner. It will enable us to simulate water vapour influenced by advection, convection and cloud processes directly on the air parcels. This will improve our understanding of the underlying mechanisms of water vapour variability and trends in the stratosphere. The budget of water vapour with respect to its origin can then easily be calculated for the analysis of its transports through the UTLS.

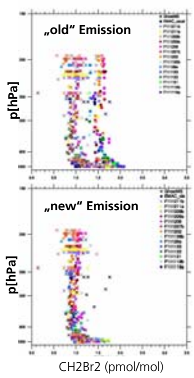
The role of the Stratosphere for decadal prediction (Miklip STRATO)

Analysis of observational data sets as well as numerical model simulations show clear evidence of troposphere-stratosphere coupling. The dynamical coupling is based on planetary wave activity which has a great impact on the internal stratospheric variability. The aim of MiKlip-STRATO is to quantify the influence of stratospheric variability for decadal forecast.



The Figure shows a comparison of two global model (left and middle) and reanalysis (right) data sets of the climatological (1979 - 2005) annual cycle of a 30-day running standard deviation of geopotential height at 30 hPa.

The influence of VSLS on stratospheric ozone (SHIVA)



In recent years, it was suggested that natural very short-lived halogenated substances (VSLS) provide an additional source for the stratospheric halogen budget. VSLS measurements conducted within the EU-Project SHIVA (Stratospheric Ozone: Halogen Impacts in a Varying Atmosphere) were compared to results of various model simulations computed with the chemistry-climate model EMAC.

Two different emission fields of the substances $CHBr_3$, CH_2Br_2 and CH_3I were used as input parameters („old" and „new"). It was found that by using the new emission fields the model is able to reproduce the measurements better than with the previous input data (see Figure: Measurements (crosses) and model results (dots) of CH_2Br_2 for all flights (colours) during the SHIVA campaign).

Further simulations are planned to analyse how VSLS will influence stratospheric ozone in a changing climate.

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