Collaborations

SHARP international collaborations with:

> North West Research Associates (USA)
Dr. Mark Baldwin,

> Colorado State University (USA)
Prof. Dr. Thomas Birner,

> Bodeker Scientific (New Zealand)
Dr. Gregory Bodeker,

> University of Cambridge (UK)
Dr. Peter Braesicke,

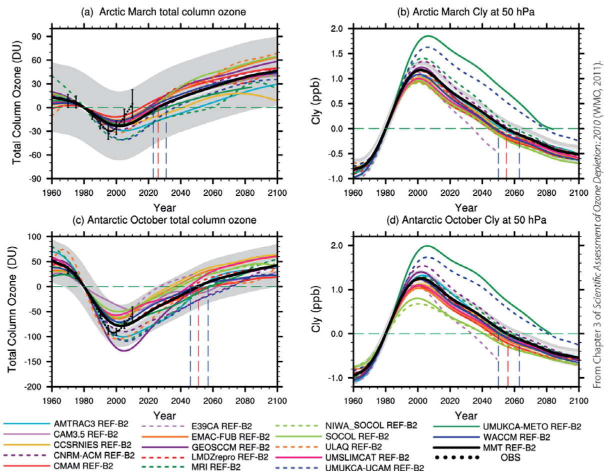
> University of Utrecht (The Netherlands)
Prof. Dr. Thomas Röckmann,

> Hadley Centre, UK Met Office (UK)
Dr. Adam Scaife.

Collaborations with other national and international projects and programmes:

> EU: SHIVA
> BMBF: ROMIC
> BMBF MiKlip: STRATO and FAST-O3
> ESA Climate Change Initiative: Ozone_cci

Contribution to WMO



1980 baseline-adjusted multi-model trend estimates and individual model trends (coloured lines) of annually averaged total column ozone (DU; left) and Cly at 50 hPa (ppb; right) for the latitude range 60°N–90°N in March (upper row) and the latitude range 60°S–90°S in October (lower row). The red vertical dashed line indicates the year when the multi-model trend in total column ozone and Cly at 50 hPa returns to 1980 values and the blue vertical dashed lines indicate the uncertainty in these return dates. The black dotted lines in the left panels show observed total column ozone (from Chapter 3 of 'Scientific Assessment of Ozone Depletion: 2010 (WMO, 2011)).

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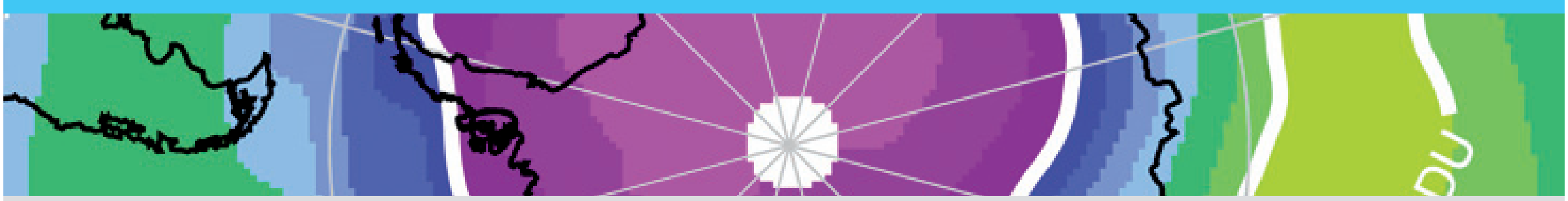

SHARP

Stratospheric Change and its Role for Climate Prediction

DFG Research Group FOR 1095
Speaker: Prof. Dr. Ulrike Langematz

About SHARP

Future global climate change resulting from anthropogenic activity is now inevitable. The consequences for the stratosphere are poorly understood. A better understanding of the interactions between atmospheric chemistry and climate change is urgently required. This is a prerequisite for impact assessment and the definition of mitigation strategies.

The DFG Research Unit *Stratospheric Change and its Role for Climate Prediction* (SHARP) addresses this issue and aims to improve our understanding and ability to predict global climate change and its interplay with the stratosphere. SHARP follows the recommendations for research, formulated by the *Stratospheric Processes and their Role in Climate* (SPARC) Programme of the *World Climate Research Programme* (WCRP). SHARP focuses on the quantitative detection, attribution and prediction of changes in stratospheric dynamics and composition linked to climate change and their implications for the troposphere.

To study the complex scientific issues and variety of disciplines involved in climate change SHARP brings together the German expertise from four universities and three large research facilities in the relevant disciplines of atmospheric science. A focus of SHARP is the development of long-term, global observational datasets of atmospheric composition from remote sensing instruments in space (e.g., MIPAS and SCIAMACHY). Complementary analyses of balloon measurements provide valuable information on the long-term behaviour of atmospheric composition. The development and application of a new generation of Earth System and Chemistry-Climate Models to project the future evolution of climate and stratospheric ozone provides an important contribution by German scientists to the international WMO/UNEP and IPCC assessments. SHARP is structured in four scientific projects addressing the Brewer-Dobson circulation, stratospheric ozone and other trace gases, stratospheric water vapour and stratosphere-troposphere coupling.

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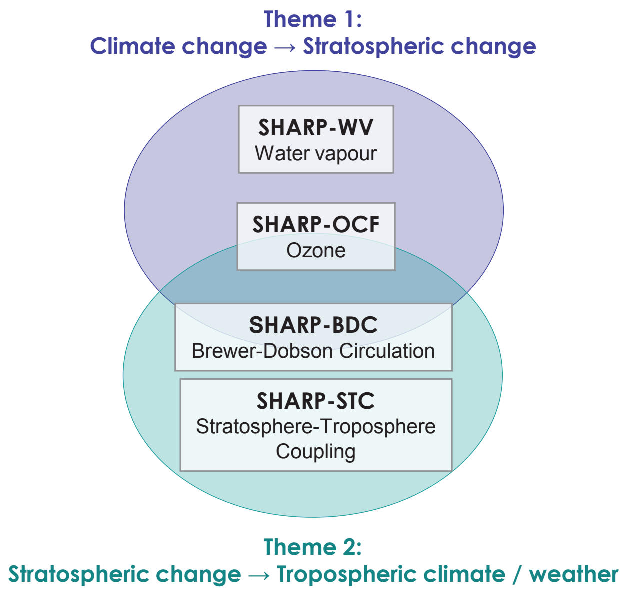
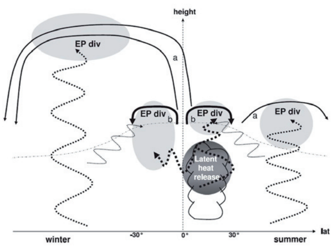
Interactions



SHARP-BDC

How is the Brewer-Dobson circulation affected by climate change, and which processes are relevant?

SHARP-BDC aims to identify and quantify dynamical, physical and chemical processes as well as feedback effects affecting the stratospheric circulation (Brewer-Dobson circulation, BDC), which is responsible for the transport of stratospheric air masses from tropical to higher latitudes. Climate change is expected to modify the motion and mass exchange rates of air within the stratosphere and therefore the residence time and distribution of chemical substances. There are still open issues about atmospheric processes and feedbacks impacting the long-term changes of the BDC. So far, analyses of observations and results from numerical model simulations do not indicate a consistent picture. Multi-decadal transient simulations with numerical models of the atmosphere together with assembled, consistent long-term observations (derived from space-borne, balloon-, aircraft- and ground-based instruments) are used to study atmospheric processes affecting the BDC.

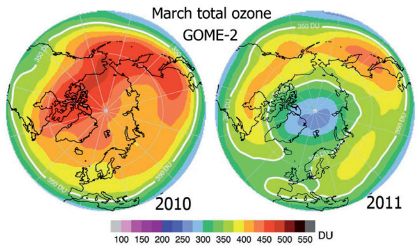


The Brewer-Dobson circulation leads to an upward transport of air in the tropics, followed by a poleward transport and sinking at higher latitudes in the winter stratosphere. A secondary branch exists in the (sub-)tropical lower stratosphere. Both cells are driven by dissipating waves.

SHARP-OCF

How is the evolution of stratospheric ozone affected by climate change, and how strong is the feedback?

SHARP-OCF analyses observational trace gas data together with state-of-the art models in order to obtain a better understanding of the interaction between ozone and climate change and the underlying dynamical and chemical processes. New updated satellite, balloon and aircraft observations in combination with improved calculations from numerical models are used to further reduce the uncertainties in the bromine budget, in particular the contribution from VSLS (very short lived substances) and to further elucidate on the role of iodine in the stratosphere. Furthermore detailed studies on the long-term evolution (trends and variability) of observed stratospheric trace gases with an emphasis on profiles of ozone, NO_2 and aerosols from the satellite instrument SCIAMACHY are carried out. The future evolution of stratospheric ozone is investigated using simulations with Chemistry-Climate Models. Particular emphasis is given to the increasing role of N_2O and greenhouse gas emissions in the future.

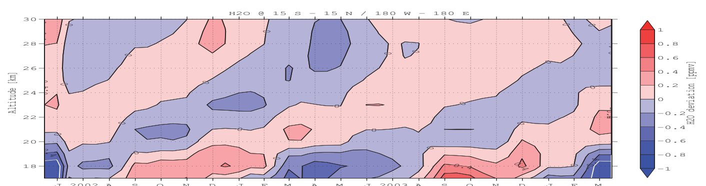


High ozone column values were observed by the GOME-2 instrument in the northern polar atmosphere during spring 2010. In contrast, a decline in polar ozone occurred in spring 2011 favoured by the meteorological conditions.

SHARP-WV

How is stratospheric water vapour affected by climate change, and which processes are responsible?

SHARP-WV analyses observational data sets from the satellite instruments MIPAS and SCIAMACHY, merged with earlier satellite data records as HALOE or SAGE, and from long-term simulations with Chemistry-Climate Models in order to improve the understanding of past variations and trends in stratospheric water vapour, and to assess the future evolution of the stratospheric water vapour budget in a changing climate. The satellite observations are used to study the stratospheric water vapour distribution and its temporal and spatial anomalies as well as changes on a decadal scale. Simulations from Chemistry-Climate Models and an Earth System Model are compared to the observational data sets regarding the past evolution of stratospheric water vapour, with emphasis on specific events like the circulation change around the year 2000, or volcanic and El Niño-Southern Oscillation impacts.

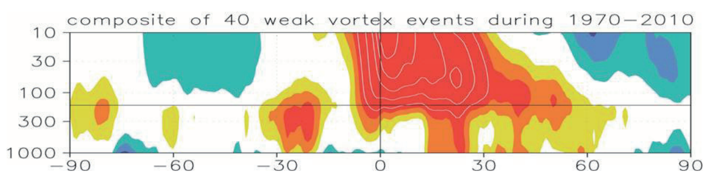


Seasonal variation of tropical water vapour from MIPAS observations of July 2002 to March 2004. The signal with low anomalies in winter and high anomalies in summer travels upwards from the tropopause and is known as the tape recorder signal.

SHARP-STC

How is the coupling of the stratosphere and troposphere affected by climate change, and how strong is the feedback on climate?

The focus of SHARP-STC is to determine the role of the interaction between the stratosphere and troposphere in a changing climate, in particular to assess the impact of a changing stratosphere on the troposphere-surface system. Observations and model studies have shown that the troposphere and stratosphere influence each other on different time scales, but the mechanisms responsible are not well understood. The project addresses the questions if the importance of the coupling between the stratosphere and the troposphere will change in a changing climate and what the consequences will be for surface climate and weather. Transient simulations of the past and future as well as complementary sensitivity simulations with state-of-the-art Chemistry-Climate Models are performed and analysed to study how well current models are able to reproduce the observed coupling, to understand the responsible mechanisms, and to predict its future evolution.



Anomalies of the Northern Annular Mode (NAM) index after weak stratospheric vortex events between 1970 and 2010, simulated with a Chemistry-Climate Model. Stratospheric circulation anomalies influence the troposphere with a time lag of up to 2 months.