Coordinating international atmospheric research

Professor Johannes Staehelin explains the SPARC project's role within the wider atmospheric science community and the process by which the team organises the focus of vital research activities

How does the Stratosphere-troposphere Processes and their Role in Climate (SPARC) project contribute to international research regarding the Earth system?

SPARC's goal is to coordinate international research in the domain of climate research, particularly in the upper atmosphere (the stratosphere), which extends from approximately 10-50 km in height depending on the latitude. At the annual Scientific Steering Group (SSG) meetings, key topics are identified that would significantly benefit from international cooperation and the sharing of expertise and resources. SPARC can provide travel support for activity meetings through its parent organisation, the World Climate Research Programme (WCRP); however, funding for the research studies that contribute to each activity is sourced by individual researchers and research groups. SPARC's continuing success relies on the hard work of all scientists contributing to its initiatives and activities.

The project's mission is to contribute to setting the international agenda for stratospheric research, and improving our understanding of atmospheric chemical, physical and dynamical processes and their interactions, as well as those aspects of tropospheric climate that have a link to the stratosphere. Key results from SPARC activities are published in reviewed reports and open access scientific literature.

Can you outline SPARC's role within WCRP's broader remit?

WCRP's research is devoted to studying climate, its variability and the effect of human influence, particularly focusing on those aspects most relevant to society. It has become increasingly evident that the climate system is not only affected by tropospheric processes, but also the multiple interactions that take place between all parts of the Earth system. WCRP's individual

At the International Foundation High Altitude Research Stations Jungfraujoch and Gornergrat (HFSJG) important long-term measurements of ozone depleting and climatically relevant trace gases are performed. We gratefully thank HFSJG for providing access to their research infrastructures and providing the Photo. © Jungfrau Railways.

core projects therefore focus on the main parts of the Earth System: SPARC studies the processes related to the interface between the stratosphere and troposphere; the Climate Variability and Predictability (CLIVAR) project focuses on processes related to the ocean; the Global Energy and Water Cycle Experiment (GEWEX) studies processes particularly relevant for the water cycle; and Climate and Cryosphere (CliC) deals with the cryosphere (ice sheets, glaciers, etc.).

How has SPARC contributed to international understanding of Earth system processes?

Important climate processes include chemical and physical interactions of all parts of the system, extending from the ocean and land surface to the upper atmosphere. Describing these complex interactions requires comprehensive numerical models, which can also be used for climate projections such as those reviewed by the Intergovernmental Panel on Climate Change (IPCC – see p6). One of SPARC's largest activities – the Chemical Climate Modelling Initiative (CCMI) – supports the development of complex climate models that describe the different components of the Earth System, as well as the multiple feedbacks and interactions between these parts. SPARC is responsible for the international coordination of such activities, which, in the case of CCMI, enables in-depth comparisons between respective models, as well as between models and measurements.

Why is SPARC's research focused specifically on chemistry-climate interactions?

Chemistry plays a vital role in Earth's climate system because most important greenhouse gases (besides carbon dioxide) are destroyed by chemical reactions in the atmosphere, while ozone – also a greenhouse gas in the troposphere – is both produced and destroyed in the atmosphere. This chemistry therefore needs to be studied to better understand the multiple impacts it might have on climate.

Are there additional challenges for SPARC in the future?

SPARC's mandate has recently been extended not only to cover processes in the stratosphere, but also chemical and large-scale dynamical processes in the (upper) troposphere. As a first step of this extension, the CCMI not only describes stratospheric processes but also covers the troposphere.

Finally, can you highlight SPARC's activities beyond fundamental research? How do you disseminate your findings?

One of SPARC's most important products is its biannual newsletter. SPARC newsletter articles are often cited in peer-reviewed literature because of their high quality. The newsletters are widely distributed and allow the dissemination of key scientific results from SPARC activities much faster than through reviewed journals. Another of SPARC's important tasks is the organisation of its General Assemblies, which take place approximately every four years. These conferences bring together hundreds of senior and early-career scientists from around the globe to learn about the status of SPARC research, state-of-the-art tools and methods, and emerging topics that require the attention of the SPARC community in future. Last but not least, the SPARC website is an incredibly important communication tool for the project.

Stratospheric phenomena and climate change

The study of the stratosphere is of primary importance for research furthering our understanding of climate. **SPARC** is a long-term project developed with an emphasis on encouraging international collaboration, and providing a high-level vision of the direction in which atmospheric research should be going

STRATOSPHERIC PROCESSES PLAY a significant role in determining Earth's climate. The stratosphere's importance was first highlighted in the mass media when scientists shed light on the detrimental effects of ozone-depleting chlorofluorocarbons. Such anthropogenic emissions cause a thinning of the ozone layer, with severe repercussions on the biota at the surface. The implementation of the Montreal Protocol, which entered into force in 1989, has significantly reduced levels of ozone-depleting chemicals released into the atmosphere. These concerns were at the forefront of both politics and public awareness when the Stratosphere-troposphere Processes and their Role in Climate (SPARC) project was established in 1992.

A core project of the World Climate Research Programme (WCRP), SPARC is an international organisation that brings together experts from the field of atmospheric science in order to better understand climate variability, prediction and change. The project's primary aim is to further international cooperation and coordinate future directions of research with principal themes ranging from climate variability and change, to ozone, atmospheric chemistry and aerosols, and polar processes.

STUDYING THE STRATOSPHERE AND ITS LINKS TO THE TROPOSPHERE

Work in this field requires investigation of both natural and anthropogenic impacts on the atmosphere. Natural effects typically manifest themselves as periodic fluctuations (for instance, the 11-year solar cycle) or by more irregular events such as large volcanic eruptions. In contrast, human-derived influences are characterised by longer-term changes linked to emissions of various substances.

Interactions between atmospheric layers are also highly significant. The troposphere is the lowest part of the Earth's atmosphere, with a height of up to ~10 km above mean sea level, and is home to the majority of clouds. The stratosphere, which is ~10-50 km in height, lies directly above the troposphere. These two adjacent layers interact with significant consequences: for example, the ozone hole (a stratospheric phenomenon) over the Antarctic has strengthened tropospheric westerly winds in the Southern Hemisphere, which in turn has affected precipitation patterns in this area. This example – which has significant repercussions for climate at the surface – highlights the necessity of understanding interactions between these coupled systems.

The primary instance of stratosphere and troposphere coupling is the Brewer Dobson circulation, which corresponds to upward flow at the tropics and downward flow over the polar regions. This circulation causes an exchange of substances between the two atmospheric layers. Current simulations project an increase of this circulation in the future, but scientists

SPARC

OBJECTIVES

The SPARC International Project Office provides support to the SPARC project, including: editing and producing of SPARC newsletters and reports, maintaining the SPARC website, assistance with the organisation of SPARC meetings (eg. the annual Scientific Steering Group (SSG) meetings), and assistance with the organisation of travel support for SPARC meetings.

PARTNERS

At present, the SPARC Office staff includes: **Carolin Arndt** (science communication manager), **Fiona Tummon** (project scientist), **Anke Wittten** and **Petra Bratfisch** (office managers); **Diane Pendlebury** (project scientist working in Toronto, Canada).

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need to confirm this prediction using long-term measurements. "At present, the most important method applied to study these processes, as well as the feedbacks between them, is the use of complex numerical models, which must be validated using suitable measurements," explains SPARC Office Director Johannes Staehelin. Measurements used in the study of the atmosphere are carried out by instruments on the Earth's surface, in the atmosphere (such as aircraft and balloons), as well as by satellites orbiting the planet. An important aspect of SPARC's work involves carrying out comparisons of data from different instruments measuring the same quantity, in order to minimise uncertainties inherent in stratospheric and tropospheric measurements.

The group's assessments are published in reports following expert review. The use of complex models and the wealth of data available to researchers make SPARC's mission to provide global reports and assessments all the more important. The results from SPARC's activities feed into major international assessments advising policy makers.

STRUCTURE OF THE ORGANISATION

SPARC is headed by a Scientific Steering Group (SSG) led by co-Chairs Greg Bodeker and Joan Alexander. Annual SSG meetings enable researchers to put forward project proposals that are subsequently discussed in order to decide whether SPARC should promote them. Successful proposals move from an emerging activity to a fully-fledged SPARC activity. There are currently two emerging activities (the SPARC Reanalysis/Analysis Intercomparison Project and the Stratospheric Network for the Assessment of Predictability) and 11 SPARC activities. The annual SSG meetings also review the ongoing SPARC activities to discuss their progress and future direction.

SPARC research falls into three themes: the first is chemistry-climate interactions, which concerns the stratosphere and its relation to Earth's climate. The second is detection, attribution and prediction of atmospheric change, which looks into the evolution of the atmosphere (for instance by looking at anthropogenic impacts). The final theme is stratosphere-troposphere dynamical coupling, which investigates mutual interactions and their effect on climate. Dividing the organisation into three themes enables SPARC to closely follow the WCRP's strategic framework.

SPARC's activities have also led to collaborations with a number of organisations such as the Atmospheric Observations Panel for Climate and the Working Group for Numerical Experimentation (WGNE). A SPARC representative attends WGNE meetings in order to facilitate interactions and increase collaborations (by holding joint workshops for instance).

SPARC OUTPUT: SCIENTIFIC ASSESSMENTS AND CONFERENCES

SPARC's publications include scientific assessment reports, annual reports, and newsletters; published biannually, containing reports of the annual SSG meetings, workshops and other meetings. The most important SPARC product is its assessment reports, which provide in-depth accounts of the state of current research falling within SPARC's remit. These reports are all peer reviewed and used by the World Meteorological Organization (WMO) and the Intergovernmental Panel on Climate Change (see p6) in their assessments.

SPARC also organises conferences to bring together researchers to present and discuss the most recent results in stratosphere-troposphere research. The next conference is planned for January 2014 in Queenstown, New Zealand. Workshops also comprise an important part of SPARC's efforts to facilitate knowledge sharing, with events organised in Europe, Asia and North and South America in 2012. Recent workshops have focused on a variety of topics including climatic effects of ozone depletion in the Southern Hemisphere as well as modelling the dynamics and variability of the stratosphere-troposphere system.

SPARC relies on a bottom-up approach, providing a coordinated framework within which researchers can carry out their research and continuously receive feedback from the scientific community in order to decide the direction of future projects. The group's central position within the wider community of scientists working on atmospheric science means the presentation of up-to-date results in a coherent manner is vital. The knowledge generated and disseminated by SPARC is used by other organisations to coordinate the international response to climate change and as such, the group continues to play a key role in bridging the gap between researchers and decision makers at the highest level.