(2006) and IPCC report (2007) – as well as participating fully in the planning and execution of scientific campaigns for the International Polar Year, 2007-2008. If you are reading this as a newcomer to SPARC, and would like to get more involved with an extremely enthusiastic, committed scientific community, please contact us. We'd be delighted to hear from you. We also welcome comments and suggestions from the veterans of SPARC who have made this project such a success.

We thank the participation of the SSG in fleshing out the themes, tasks, etc. and the continued involvements in the workings of SPARC. The next SSG meeting will be held in Oxford, England in September of 2005. The venue for the next General Assembly will be decided at the meeting or soon after.

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Report on the SPARC 3rd General Assembly

Victoria (BC), Canada 1-6 August 2004

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Overall Structure

SPARC General Assemblies provide a venue for the exchange of scientific information related to SPARC research activities. They also provide a good venue for people to interact, one-on-one and in small groups, to discuss individual issues of mutual interest. They are held only in plenary format, *i.e.* with no parallel sessions, with a moderate number of oral contributions and an emphasis on poster sessions. As such, they are integrative in nature and complement the highly focused workshops that are the main venues for discussing some of the pressing questions addressed by SPARC. The General Assemblies also complement the mainstream large meetings, such as the American and European Geophysical Union meetings. The plenary approach and the format of the meeting allow a synthesis of information as well as discussions of the details of the science. Lastly, the General Assemblies ensure that all the activities that are integral parts of SPARC have a "home" for scientific exchanges and discussions.

Even though a very large number of research topics and areas form the "bricks and mortar" of SPARC science, they all contribute to one, or more, of the overarching three themes of SPARC: (1) Stratospheric Chemistry and Climate, (2) Stratosphere-Troposphere Dynamical Coupling, and (3) Detection, Attribution, and Prediction of Stratospheric Changes. This is the new architecture of SPARC and this Assembly, the first since the adoption of this architecture, strived to represent the science along these themes. To take into account the importance of current research focusing on the extratropical and tropical tropopause regions, the SPARC 2004 General Assembly mapped the three SPARC themes as follows: *Day 1*: Chemistry-climate coupling; *Day 2*: Extratropical Upper Troposphere/Lower Stratosphere (UT/LS); *Day 3*: Stratosphere-troposphere dynamical coupling; *Day 4*: Tropical Tropopause Layer (TTL); *Day 5*: Detection, attribution, and prediction.

The three SPARC Lectures, each one hour long, were the venue for the "grand scale" synthesis. For each of the five themes, the theme leader gave a synthesis and review of the specific theme of the session. Invited Lecturers also strived to synthesize and review information, and to offer a concise description of the state of the science. Specific research issues were addressed in contributed oral presentations and poster sessions. The half-day session on tools and techniques provided some of the "building blocks" of the science, which are essential for all the themes. They included laboratory studies, microphysics, gravity waves, and data assimilation.

The Assembly began with a SPECIAL talk by **F.S. Rowland** on "Environmental Science in the Global Arena: Stratospheric ozone to megacities to climate". This presentation put the work of SPARC in a global perspective and showed why this work is important for the good of humanity.

The poster sessions formed the backbone of the Assembly. They were the main venue for disseminating the detailed science. To ensure success of the poster sessions, and hence of the assembly, the posters were each up for two days, viewed for four 2-hour long sessions, and made more attractive by the location, availability of ample space and lighting, and food and drinks to lubricate the science. The availability of the posters for two days in the vicinity of the auditorium allowed people to look at posters even during times that were not dedicated to posters. All together there were 375 presentations at the Assembly, and roughly 340 participants from 30 countries.

Building Blocks

Laboratory studies of gas phase and heterogeneous chemical reactions, microphysical processes, and photochemical processes are crucial for understanding and modelling atmospheric chemistry. The invited talk by **J. Abbatt** highlighted the key role of laboratory experiments in deciphering chemical and cloud processes in the upper troposphere. The invited talk by **B. Kärcher** highlighted the understanding of detailed microphysical processes and the representation of these processes in models. Clearly, there has been significant progress in these areas over the years as shown by a few papers on gas phase and heterogeneous processes, as well as better calculations of the global warming potential of HFC-134a. However, new and interesting atmospheric observations such as the formation of large nitric-acid containing particles in the polar winter/spring lower stratosphere have elicited more studies in the laboratory, formulation of detailed mechanisms for their formation, and analyses of atmospheric data. Incorporation of this information into 3D chemistry models was demonstrated. The coating of atmospheric ice and other aerosols was shown to affect the reactivity and properties of the particles. Information needed to check microphysical models was shown to be available via balloon borne measurements. One laboratory study highlighting the properties of cubic ice was presented and this information will be very useful in interpreting laboratory and field data. **D. Weisenstein** hypothesized that tropospheric SO_2 from industrial sources, such as emissions from China, could have led to more aerosol formation in the tropical upper troposphere, which in turn could have led to a larger number of smaller ice particles lofted into the stratosphere. Such a temporal change in SO_2 emission was suggested to be a possible reason for the increase in water vapour in the LS over the past decade. The question of how uncertainties in input of sulphur at the tropical tropopause influence the stratospheric aerosol budget is part of the SPARC Assessment of Stratospheric Aerosol Properties, which is soon to be released.

Gravity waves (GW) play an important role in stratospheric climate, principally through GW drag which contributes to the driving of the diabatic circulation. The "cold pole problem", which is characteristic of stratospheric climate models, is attributed to missing GW drag, and the treatment of this problem through GW drag parameterization represents one of the most significant uncertainties in modelling polar ozone chemistry. **J. Alexander** reviewed the subject of GWs, and emphasized the lack of consensus among the experts concerning key aspects of GW drag parameterization. While one might hope that measurements could be brought to bear to resolve these disagreements, the interpretation of GW measurements is extremely challenging because of the mismatch between what is observed and what is needed for models (**Figure 1 p. I**); thus it takes great care to ensure that one is comparing apples with apples. However, **J. Scinocca** showed that detailed differences between GW drag parameterizations may not be so important if certain bulk properties (*e.g.* the source spectrum) are constrained to be the same. This helps to narrow the uncertainty associated with GW parameterization. On the measurement side, the availability of high-quality, high-resolution global temperature measurements from GPS occultations is an exciting development for GW studies, and several papers presented results using this data.

Data assimilation is the process by which measurements are optimally combined with models to produce the best available estimate of the state of the global atmosphere at any given time. Originally developed to determine initial conditions for weather forecasts, assimilated data sets are increasingly used for diagnostic analyses and process studies. Dynamical analyses in the stratosphere have been available from several operational weather centres for many years, and have played an important role in understanding polar ozone processes, for example. These centres are currently raising their model lids above the stratopause, and there is also a wealth of stratospheric chemical data now available from satellites. **R. Rood** reviewed the history of these developments, as well as current hopes and challenges. He specifically noted several fundamental challenges relating to bias and noise, especially as seen in chemical transport calculations which are invariably too diffusive (**Figure 2 p. I**). **S. Polavarapu** developed this issue of bias and noise, both for constituents and for dynamical fields, noting how both bias and noise become particularly severe in the upper stratosphere. Because this region also coincides with the top of the observation domain (typically the stratopause), special kinds of tensions arise between model and observations. **D. Fonteyn** highlighted the remarkable development of stratospheric chemical data assimilation in recent years, especially as applied to Envisat data, illustrated with several applications to calibration/validation and science studies.

Chemistry-Climate Coupling

The chemistry-climate coupling session consisted of a session overview talk by **C. Granier**, a SPARC Lecture, three invited talks, 7 contributed talks and 74 posters. A wide range of issues were discussed in the talks and posters, dealing with lower stratospheric ozone, tropospheric ozone, aerosols and polar stratospheric clouds (PSCs), water vapour, and the impact of climate change in the stratosphere and the troposphere. Results from observation systems, either from laboratory, ground-based or satellite-borne platforms, as well as results from chemistry-transport models and chemistry-climate models, were discussed.

The SPARC Lecture by **G. Brasseur** painted the "big picture" of the role of chemistry in the evolution of the climate system and the biosphere. Ozone plays a central role in this respect, as it filters UV radiation, warms the atmosphere, and controls the lifetime of pollutants. The first invited talk, given by **J. Pyle**, showed that the stratosphere-troposphere system is a highly coupled system, through a discussion of the response of tropospheric ozone to climate change, to changes in stratospheric ozone, and to anthropogenic emissions. In his invited presentation, **R. Garcia** compared results of simulations performed with a coupled chemistry-climate model with observations of ozone variability, and temperature and water vapour trends from 1980 to 2001. The third invited presentation, given by

W. Collins described the importance of including chemistry in global circulation models (GCMs). The talk focused on the increase of water vapour resulting from climate change and its impact on temperature, the relationship between climate and surface emissions of chemical compounds, and the impact of climate change on dynamical processes.

The contributed talk given by **J. Zawodny** discussed the 1984-2004 record of NO_2 data from SAGE, which displays a strong hemispheric asymmetry in the long-term changes in NO_2, with a positive trend in the Southern Hemisphere (SH) and a decrease in the Northern Hemisphere (NH), the largest changes being in the LS. Another analysis of satellite data was given by **M. Weber**, who discussed the links between planetary wave driving and trace gas transport and chemistry using observations from TOMS and GOME. A quantification of the relation between winter-spring loss of Arctic ozone and changes in stratospheric climate was discussed by **M. Rex**, who gave an estimation of the additional ozone loss resulting from possible stratospheric cooling linked with climate change.

J. Austin discussed the analysis of coupled chemistry-climate model (CCM) simulations, looking at a set of diagnostics: temperature, PSCs, age of air, correlations between tracers, or area of the ozone hole. **V. Eyring** discussed how a process-oriented validation of CCMs could complement traditional validation and increase confidence in the results of the models.

Within the SPARC community, transient simulations can now be performed for long periods of time, and analysis of both surface and satellite observations and model results for various periods of time (from a few years to about 45 years) were presented in both oral talks and posters. Several discussions regarding assimilation exercises and their evaluation were displayed in the posters, using observations from diverse past and current satellite data sets. The first uses of the ERA-40 reanalysis data set were reported, and preliminary results on simulations for this period were analyzed. Ozone calculations have also been included in a few global forecast models, which have been shown to reproduce reasonably well ozone fields up to at least 4-5 days ahead. For example, analyses of long-record observations were presented from surface stations such as the Dobson network, or from satellite observations, for which long records are becoming more and more available.

Simulations for future conditions were also discussed for different sets of scenarios. The impact of climate change on ozone levels and corresponding UV levels were shown for different conditions and scenarios. Solar-terrestrial interactions were also presented in several posters; the impact of the 11-year solar cycle on stratospheric and mesospheric ozone and global circulation was simulated with CCMs.

In summary, the presentations in the session showed that since the previous SPARC General Assembly in 2000, there have been large advances in both the availability and analysis of global observations in the stratosphere, troposphere and mesosphere, and in the development of CCMs, which are starting to be widely used. Several discussions focused on the best strategies for the validation of these models.

Extratropical UT/LS

J. Burrows opened the oral session with an overview of some of the current research issues in the extratropical UT/LS. Experiments using measurements and models are currently aimed at providing a much better understanding of cross-tropopause transport and the dynamics on both sides of the tropopause. **D. Fahey** gave the opening invited lecture for the session. He discussed the use of *in situ* measurements to probe the UT/LS, providing a perspective on the use of tracer correlations, and describing recent progress in this field. The latter focused on some recent aircraft measurements in the UT/LS region. Comparison of the correlations of HCl and CO with O_3 in the UT/LS demonstrates the need for an improved interpretative framework for STE. The community is well prepared to conduct the next generation of UT/LS experiments, which are now urgently required. In an invited lecture, **H. Wernli** described the key issues of Stratosphere Troposphere Exchange (STE) in the extratropics. The processes involved in STE and their timescales were discussed, with evidence for STE on many scales. Potential Vorticity (PV) streamers and cutoffs are currently considered to be more significant for STE than tropopause folds. However many processes are poorly understood — for example the importance of latent heat, radiative processes, turbulence, and deep convection, to name a few.

The morning session was completed with three contributed talks. **L. Pan** described modelling of the UT/LS. In particular, the potential to quantify the influence of mixing and transport near the subtropical jet has been investigated in a case study (**Figure 3 p. I**). The initial results show that the large-scale wind fields appear to be responsible for the observed tracer behaviour. **J.-P. Cammas** discussed recent results and analyses from the European MOZAIC project. This project, which began back in 1992, has equipped in-service aircraft with instruments for measuring ozone and water vapour. Recently, the measurement suite has been extended to include of CO and NO_y. The long haul aircraft used in MOZAIC provide some unique measurements in the UT, and vertical profiles at a series of airports around the world. **C. Schiller** introduced the SPURT (Trace gas transport in the tropopause region) study, which made measurements of water vapour and a variety of tracer substances in the tropopause region at midlatitudes. A variety of campaigns took place from 2001 to 2003.

The afternoon session began with the SPARC Lecture by **M. Schoeberl**, who described the satellite view of extratropical STE and the UT/LS. The extratropical UT/LS is a mix of tropospheric and stratospheric air, and the tropopause is not well defined for trace gases (**Figure 4**). The concept of the age of air in the stratosphere and its applications to investigate the LS were thoroughly discussed. Examples of useful satellite data from instrumentation on NASA-UARS and ESA-ENVISAT were given. The final part of the lecture addressed the potential of the instrumentation aboard AURA to investigate the UT/LS. After this exciting review and overview of different satellite observations and their applications, **H. Kanzawa** gave an invited lecture about results from the ILAS (Improved Limb Atmospheric Sounder)-I and ILAS-II instruments, which provided infrared (IR) solar occultation measurements of the atmosphere from November 1996 to June 1997 and from April to October 2003. This instrument provided measurements of key stratospheric species in the stratosphere at high latitudes.

The last session of the day was devoted to contributed talks on current research topics. **D. Knopf** described the experimental measurement and theoretical investigation of the nucleation of NAT and NAD. It appears that current laboratory data are insufficient to explain the Arctic denitrification. **L. Poole** described the first analyses of PSCs using the extended capability of the SAGE-III instrument, which is a solar occultation instrument operating in the UV-visible and near IR spectral regions. Two distinct types of PSCs and some large NAT particles were identified. **J. Logan** addressed our current understanding of the interannual variability of the vertical distribution of ozone in the UT/LS. Overall the interannual variability is poorly understood in the 80-125 hPa region. Finally, attribution of ozone recovery requires a detailed understanding of the dynamical factors influencing ozone in the LS. **G. Mullendore** described advances in modelling cross-tropopause transport in midlatitude convection, one of the three mechanisms by which tropospheric air is transported into the stratosphere.

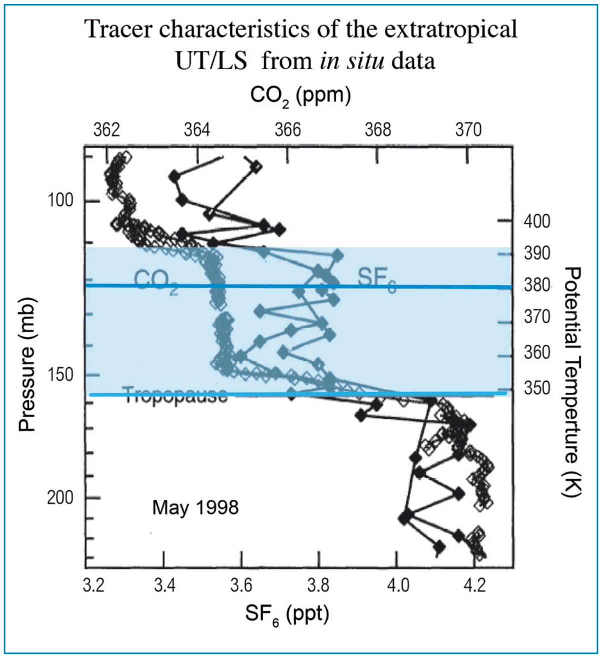

Figure 4. LACE balloon profiles at 34°N for May 1998. SF_6 and CO_2 are increasing in time so older air has lower amounts. Air above the 390 K isentrope shows distinctly older air (low values of SF_6 and CO_2), air below the 350 K isentrope shows distinctly younger, tropospheric air (high values), and air in between these two isentropes shows a mixture of tropospheric and stratospheric air. The tropopause and region near 380 K appear as transition layers in trace gases. [Ray et al., J. Geophys. Res., 104, 26565-26580, 1999].

The poster session addressed a wide range of topics including laboratory studies and analyses of data from a variety of platforms: ground based observations, aircraft and balloon campaigns and satellite observations. In total 83 posters were presented, demonstrating the continuing and growing scientific interest in this region.

Overall, it can be concluded that much progress has been made in our understanding of the extratropical UT/LS. Currently, one large focus of research activity addresses the dynamics of the UT/LS region using chemical compounds as tracers. It is however worth reconsidering whether the elementary homogeneous and multiphase physicochemical processes, which determine the behaviour of this key region, are adequately understood. Our current knowledge of the physical and chemical processes determining the behaviour of the tropopause region remains of fundamental scientific interest and a very significant limitation in the accuracy of current predictions of the impact of climate change on the stratosphere.

Stratosphere-Troposphere Dynamical Coupling

Coupling between the troposphere and stratosphere through radiative, chemical and dynamical effects is one of the central themes of SPARC. Recent observational and modelling work has re-emphasised the central role of dynamical coupling. **P. Haynes**, as session convenor, summarized the recent developments in this field and emphasized some of the remaining uncertainties.

The strong intrinsic variability of the troposphere-stratosphere system is an essential component of any consideration of dynamical coupling. **S. Yoden** emphasized that this strong variability requires a probabilistic interpretation of the response of the troposphere-stratosphere system to external change, either change imposed in a model as part of a scientific investigation, such as an imposed Quasi-Biennial Oscillation (QBO), or change imposed on the real atmosphere, such as input of volcanic aerosol or increase in source gases. He stressed the usefulness of a hierarchy of models in studying such change and described how modern computing resources (which tend to be allocated to increasingly sophisticated coupled chemistry-climate modelling, for example) could allow very long time integrations of relatively simple, but usefully realistic, atmospheric models and hence reliable computation of probability density functions and reliable assessment of the significance of apparent changes (**Figure 5 pII**).

Stratospheric sudden warmings have for the last 50 years been regarded as a remarkable example of dynamical variability and a stringent test of dynamical understanding. The sudden warming in the SH stratosphere in September 2002 emphasized some of the limitations of our current understanding. **T. Hirooka** described an investigation of this sudden warming using the Japan Meteorological Agency forecast model, examining the differences between forecasts initialized on different days, and argued that deceleration of the flow in the LS by the action of synoptic-scale eddies may have been important in allowing the subsequent upward propagation of planetary waves associated with the warming.

M. Baldwin summarized the observed characteristics of the annular modes of variability. It has been argued that these are evidence of dynamical coupling between troposphere and stratosphere. In particular, he emphasized the strong observational evidence that circulation anomalies in the mid-stratosphere are precursors to (but not necessarily the cause of) circulation anomalies in the troposphere and speculated that the stratosphere acts as an integrator of high frequency forcing from below, producing long-lived circulation anomalies that feed back to affect the troposphere. He also discussed the interesting possibilities that this picture might offer for medium-range weather forecasting and also for understanding aspects of future climate change (**Figure 6 p. II**). **B. Christiansen** developed this theme further by describing the use of stratospheric information in statistical forecasts of tropospheric circulation. He demonstrated that including lower stratospheric winds, in particular, in statistical forecasts, was an effective way of improving skill out to 30 days or more.

W. Robinson reviewed the dynamical mechanisms by which changes in the stratospheric circulation might significantly affect the troposphere. He emphasized the observational evidence that synoptic eddies played a very significant role in any tropospheric annular mode response but noted also strong observational and modelling evidence for the active role of longer planetary waves. **L. Polvani** emphasized that the anomalous stratospheric events were strongly associated with previous upward wave flux from the troposphere, but went on to present evidence (modelling work with **R. Scott** presented in a poster) that the stratosphere itself played an active role in determining this upward flux. **J. Perlwitz** argued that the dynamical link from stratosphere to troposphere may sometimes be *via* the zonal mean circulation and sometimes *via* downward propagation (reflection) of planetary waves.

Whilst the evidence for dynamical coupling between stratosphere and troposphere has renewed interest in the possibility of a significant modulation of the tropospheric circulation by the equatorial QBO, **K. Hamilton** demonstrated the difficulty of unambiguously demonstrating such modulation in limited-duration (20 years or so) GCM simulations. There is also significant interest in the role for dynamical coupling in determining tropospheric response to stratospheric injections of volcanic aerosol. **G. Stenchikov** described relevant GCM simulations and noted modelled aerosol injections appeared to cause both direct dynamical changes within the stratosphere, and indirect changes due to surface cooling in the troposphere and resulting changes in planetary waves.

Other oral presentations and many poster presentations gave different angles on many of the important dynamical and dynamical coupling issues mentioned above.

Tropical Tropopause Layer

Although the importance of the tropical tropopause as the principal source region of air entering the stratosphere was pointed out by Alan Brewer in 1949, this region is still largely "terra incognita" due to its inaccessibility. It was recognized only recently that most of the tropical deep convection does not reach the cold point tropopause but ceases a few kilometres lower, sandwiching the TTL, *i.e.* a relatively undisturbed body of air, subject to prolonged chemical processing of air parcels which may slowly ascend into the stratosphere (**Figure 7**). These background issues were reviewed by **T. Peter** in the session overview.

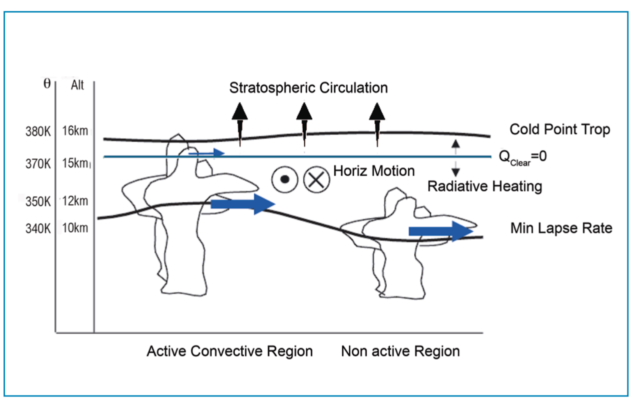

Figure 7. Schematic figure of the Tropical Tropopause Layer (TTL). The altitude of the Cold Point Tropopause (upper black line), Minimum Lapse Rate (lower black line), and Q_{Clear}=0 (blue line) are shown. The horizontal motion is indicated as vectors in and out of the page (it also occurs along the zonal dimension). Thin black arrows represent radiative heating, large black arrows are the stratospheric (Brewer-Dobson) circulation, and blue horizontal arrows are the detrainment from convection. [Gettelman and Forster, J. Met. Soc. Japan, 80 (48), 911-924, 2002].

The TTL session was kicked off by **P. Wennberg**, by asking whether deep convection could transport short-lived halogen species into the TTL. He provided lines of evidence suggesting that WMO estimates for stratospheric bromine could be low by 25%, and that calculated ozone trends are highly sensitive to assumptions about the existence of short-lived bromine compounds. **I. Folkins** generalized this aspect by pointing to the long convective replacement times making the TTL suited for chemical processing of air with significant probability of undergoing Troposphere-to-Stratosphere Transport (TST). The efficiency of these processes is determined by the average convective detrainment profile, which is not well known. Predictions of how the detrainment profile will respond to changes in sea surface temperature or in the Brewer Dobson circulation are presently uncertain. Most pronounced might be the effects of such changes on H_2O through implications for cold point temperatures.

A. Gettelman summarized the present paradigms of how air enters the stratosphere, and how this specifically differs from water entering the stratosphere: convection up to the cold point tropopause *vs.* slow radiative lifting, and moistening/dehydration mainly as convective phenomenon *vs.* the formation of cirrus, respectively. With particular view on the large scale, **A. O'Neill** highlighted various dehydration scenarios: does the tape-recorder signal originate from freeze-drying in the western Pacific ("Fountain" Hypothesis) associated with strong localized convection, or from slow, widespread up-glide associated with diabatic heating at the tropopause? Both speakers emphasised the importance of the southeast Asian monsoon, which according to model studies contributes at least 25 % of the moist signal in the tape recorder.

A. Dessler presented the first satellite-borne aerosol lidar data from IceSAT/GLAS, revealing extremely high TTL clouds. Climatologies from space-borne lidars will in future become very useful to constrain the dehydration problem. Another important aspect of the tropical water budget is high H_2O supersaturation with respect to ice outside and inside cirrus clouds. This issue was presented by **J. Smith**, showing frequent observations of clear air supersaturations, evidence for very high ice nucleation threshold (< 200 K) and for persistent in-cloud supersaturations as high as 20-30%. The in-cloud supersaturations remain a fully unexpected and not understood phenomenon: they challenge the conventional belief that any water vapour in excess of ice saturation should be depleted by crystal growth given sufficient time. **E. Jensen** presented detailed simulations of supersaturations in thin cirrus near the tropopause. Consequences are enhanced ice number densities, decreased crystal sizes, extended cloud lifetimes, increased aerial coverage of thin cirrus in the tropics, and most significantly an increase by 0.5-1 ppmv in H_2O entering the stratosphere across the tropopause cold trap. This would imply that lower tropopause temperatures are required to explain the observed stratospheric water vapour mixing ratios than previously assumed.

Global models and detailed cloud models, such as those presented by **A. O'Neill** and **E. Jensen**, leave a gap in the description of mesoscale processes.

T. Birner presented a 100km x 100km cloud-resolving model which allows this gap to be bridged. The model suggests that the final stage of dehydration is achieved by convectively generated buoyancy waves.

Isotopic composition measurements of water can help to identify dehydration processes leading to fractionation. Similarly, other compounds revealing strong enrichments of the heavy isotopes during photolysis or reaction with $O(^1D)$ could help to constrain the residence time of air in the TTL. For the free stratosphere such techniques were illustrated by **J. Kaiser** for the case of N_2O.

D. Hartmann's SPARC Lecture gave an opportunity for synopsis of fundamental aspects governing the TTL on all spatial scales, and with particular emphasis on changes of the TTL in a future, warmed world. The lecture provided arguments in support of an accelerated Brewer-Dobson circulation in a warmer world. But will this cool the tropopause? And how will convective overshoot change? While substantial progress has been made toward a quantitative understanding, many questions concerning the future TTL remain open.

In total there were 75 posters in the TTL session. These posters offered a very broad spectrum of TTL-related issues, from cubic ice in the laboratory, *via* vertical wind measurements in the TTL, to the response of global climate to El Niño.

Detection, Attribution, and Prediction

The Detection, Attribution and Prediction theme of SPARC encompasses the overall understanding of past and future stratospheric changes, and acts as an integrator of the process-oriented activities of SPARC. Accordingly, this theme occupied the last day of the General Assembly, and provided a summary for the week's activities. Themes discussed included updated observations and interpretations of past stratospheric changes, interactions with the troposphere, and predictions of future stratospheric evolution. These issues were introduced in the session overview by **W. Randel**.

There is substantial current interest in understanding changes in stratospheric water vapour, and its coupling to tropical tropopause temperature changes. **K. Rosenlof** gave an overview of observational results from different data sets, and highlighted measurement uncertainties in the LS that influence estimates of long-term changes. **L. Thomason** discussed long-term variations in stratospheric aerosols as measured by SAGE satellite observations. Current aerosol levels are at historic low values, allowing for observations of seasonal circulation effects on aerosols. The SAGE data do not show evidence for long-term trends in background aerosol amounts.

Understanding the influence of natural and forced changes on the stratospheric circulation is a key to attribution studies. **U. Langematz** presented an overview of dynamical influences on past stratospheric changes, comparing observations and simulations from several chemistry-climate models. A key result is that derived dynamical responses to imposed ozone or greenhouse gas changes vary considerably between models. **M.-L. Chanin** gave an updated view of solar cycle variability (from observations and models), and showed significant spatial structure during winter, pointing to the importance of planetary waves in the solar response. Dynamical changes in stratospheric ozone and temperatures were discussed in a number of presentations. New statistical analyses by **L. Hood** quantified dynamical influences on midlatitude ozone variability and change: the effects of planetary wave forcing of the stratosphere, plus synoptic-scale potential vorticity variations in the UT, account for over 50% of the interannual variance in NH midlatitude ozone during 1979-2002.

Direct coupling of stratospheric changes with tropospheric climate is an exciting activity within several SPARC themes, and current work aims to demonstrate and quantify these effects. **B. Santer** discussed using changes in the global tropopause as an indicator of climate variability and change, showing consistent results (increased tropopause altitude) from analyses of the ERA40 data set and climate model simulations (**Figure 8 p. III**). **N. Gillett** demonstrated the influence of Antarctic ozone depletion on tropospheric and surface climate using CGM simulations; the model results furthermore show that tropospheric eddy dynamical feedbacks are a key factor for this coupling.

Studies of model-predicted future stratospheric change were presented by several groups, based on chemistry-climate models. A key uncertainty in such models regards changes in tropospheric planetary wave forcing of the stratosphere under changing climate conditions. While past model results have shown conflicting results, a new intercomparison of model results by **N. Butchart** shows that most current models predict future increase in planetary waves, and corresponding increases in the stratospheric Brewer-Dobson circulation. This is an important result that must be considered in understanding stratosphere-troposphere coupling in future climates.

There were a total of 84 posters in the final session, which provided more details on these issues.

Overall, the body of work presented at SPARC 2004 highlights the significant strides taken by the community as a whole for understanding and quantifying the effects of stratospheric changes. These strides have been fueled by the detailed understanding of stratospheric processes, and in integrating that understanding for interpreting past and predicting future changes.

Acknowledgements

The scientific organizing committee was greatly assisted in the execution of these ideas by the Local Organizing Committee. The success of any scientific meeting depends on the local arrangements, and this assembly was no exception. The arrangements worked seamlessly and facilitated excellent scientific interaction. The travel support and the support of the meeting by various organizations is gratefully acknowledged.

Local Organizing Committee:

N. McFarlane (Chair); **M. Berkley**; **J. Fyfe**; **J. Scinocca**; **D. Tubman**; **K. von Salzen**; **V. Arora** (webmaster).

In addition, the efforts of the following people were instrumental to the smooth running of the General Assembly:

A. Chautard (WCRP), **V. De Luca** (SPARC IPO), **L. Droppleman** (NOAA), **C. Michaut** (SPARC/CNRS).