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STRATOSPHERIC PROCESSES AND THEIR ROLE IN CLIMATE
A Project of the World Climate Research Programme

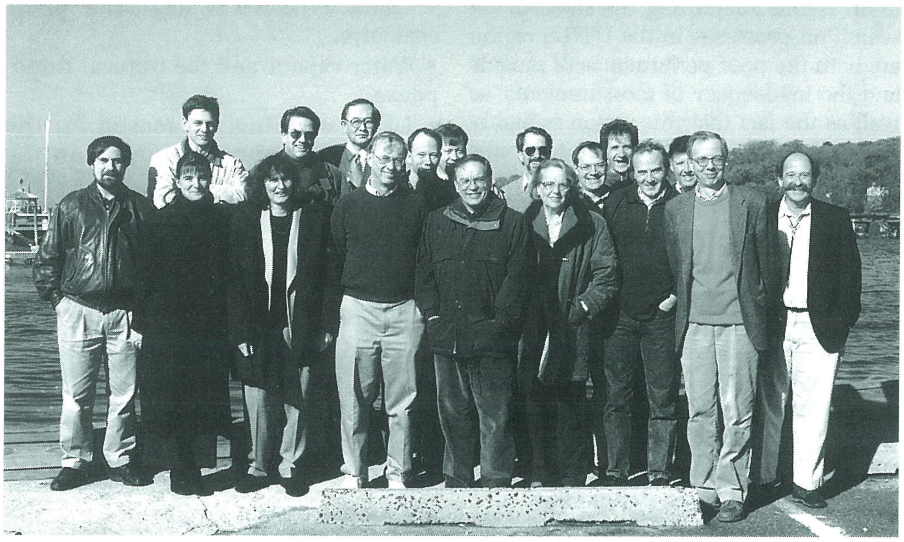
Fifth session of the Scientific Steering Group on Stratospheric Processes and their Role in Climate

Port Jefferson, NY, November 17-20, 1997

At the suggestion of Marvin Geller, the fifth session of the Scientific Steering Group (SSG) of SPARC took place at Port Jefferson, Long Island, NY, close to the State University of New York (SUNY), from November 17th to 20th 1997. M. Geller, Co-chair of the SPARC SSG, opened the session by welcoming all the participants, especially the newly named members of the SSG.

The presentations and discussions which took place during this session were mainly focused on the completion of the SPARC Implementation Plan which was reviewed in its draft version and is being finalised to be submitted to the next meeting of the JSC in March 1998. Reports from two conferences held since the last SSG session contributed to this process of revisiting SPARC activities. The IGAC/SPARC/GAW Conference on Global Measurements systems for Atmospheric Composition contributed to an enlargement of the SPARC-IGAC cooperation (see further in this report), and the Conference on the WCRP Achievements, Benefits and Challenges (see report in this issue), led to place more emphasis within SPARC on quantification of stratospheric climate forcing.

As an appropriate introduction to this discussion, J. Hansen was invited to present his recent results on ozone and climate change (JGR, 102, 1997), and to review the needs of climate modellers



Participants of the SSG in Port Jefferson : From left to right ; 1st row : K. Hamilton, C. Phillips, C. Granier, J. Gille, P. McCormick, M.-L. Chanin, A. O'Neill, P. Simon, M. Geller. 2nd row : S. Pawson, U. Schmidt, H. Tanaka, M. Baldwin, H. Harris, D. Karoly, T. Shepherd, T. Peter, R. Newson.

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which the SPARC community could provide, e.g.: ozone and aerosol forcing, solar irradiance in UV... These needs were discussed further during the meeting and led to the creation of a small ad hoc study group on "Stratospheric Aspects of Climate Forcing". M. Geller also reported on new results obtained by A. Robock on stratospheric aerosol forcing.

The review of on-going activities was provided by the leaders of the various SPARC Initiatives and discussed in relation to the overall Implementation Plan.

Stratospheric Processes and their relation to climate

The complex interaction of the issues grouped within this section was discussed at length, in particular the respective role of the two study groups on "Stratosphere-Troposphere Exchange" and "Upper Tropospheric/Lower Stratospheric ozone, aerosols and climate". The main issues sustaining the need of research on processes in the UT/LS region are both the poor performance of models and the inadequacy of measurements, as well as the fact that this region is highly critical for climate. The two study groups should put emphasis on both transport and dynamics for the first one and on chemistry for the later one. The different character of the gravity wave issue was stressed; and it was recognised that there is a need for field campaigns to aim towards understanding all the processes of interest in this UT/LS region: water vapour, particle formation, tropical tropopause, as well as gravity waves...

Gravity Wave Processes and their Parameterisation

The Gravity Wave climatology from world-wide radiosonde observations from more than 180 stations is now in a phase of analysis and the first results should be available in January 1999.

The detailed plans for a 2-month intensive field experiment were discussed. Planned for the Darwin Australian area, the CEGWE campaign should take place in the period mid-October-mid-December either in 2000 or 2001. A preliminary description of the campaign was given by K. Hamilton in SPARC Newsletter 9. One of its main goals is to see how the characteristics of gravity waves entering the lower stratosphere depend on the intensity, suddenness and mesoscale organisation of convection, and to verify whether the convection induced by gravity waves is correctly described by satellite observations and resolved by models.

The need to enlarge the scope of the campaign by adding experiments on cloud microphysics and cirrus-chemistry studies was discussed as an opportunity to relate cloud microphysics, chemistry, radiation and dynamics. The possibility of a European contribution to this project, including eventually the use of the Geophysika aircraft and the study of water vapour and particle formation, should be discussed during a workshop planned in Europe in early 1998. Cooperation with GEWEX is clearly to be envisaged.

Stratosphere-Troposphere Exchange or Transport and Dynamics in UT/LS region

A review of the recent developments on the issue of transport and mixing in this region was given by T. Shepherd in the SPARC Newsletter 9. The key questions have been identified as follows:

- Quantification of STE and its seasonal evolution for various tracers (esp.: O_3, H_2O).
- Characterisation of mesoscale tracer structure.
- Water vapour and the tropical tropopause.
- Understanding the reason for the poor performance of models in the UT/LS region.

The missing elements to answer those questions are:

- Accurate measurements of the tropopause height and of trace species in UT/LS region.
- Measurements of tropical winds to represent the transport.
- Measurements of water vapour and condensed matter at the tropical tropopause.
- Comparison of measurements and models.

However a detailed strategy required to resolve these issues has yet to be defined.

Upper Tropospheric/Lower Stratospheric ozone, aerosols and climate

The lower stratosphere (LS) is still a region were the unexpected ozone loss due to chlorine and bromine is badly quantified and explained. At the same time such a change plays an important role on climate and the impact of changes in the LS are important in the UT. The recent volcanic eruptions of El Chichon and Mt. Pinatubo have also shown that the impact of aerosols are important for both temperature and ozone concentration in the LS region. Such issues are of interest for other "activities" of SPARC (STE, O_3 and T° trends) and in general to assess the role of the stratosphere in climate change.

The upper troposphere (UT) is also very important for climate, as well as for studying the impact of aviation. It is a region of the lowest temperature, of high water vapour and where the origin of ozone is difficult to identify: STE or in-situ production? There are similarities between UT and LS (temperature, role of particles, distance to source regions and long lifetimes), but also differences (rapid mixing in UT versus slow mixing in LS, differences in NOx levels...). These differences need to be further identified.

After the very successful Workshop on "Heterogeneous Chemistry" that was held in Strasbourg in October 1996 and reported in SPARC Newsletter 9, a more complete report is expected for 1998. A second workshop on "Gas Phase Chemistry" is envisaged for the future.

The main role of this ad hoc Study Group in the future is to succeed to establish a connection with, according to A.R. Ravishankara's words, "a community of Orphans" of Atmospheric Science the "Intangibles".

The priority of activities for this ad hoc group in the future should be :

- Compile data and evaluate their quality, in support of current activities of NASA/JPL and IUPAC, in close connection with IGAC.
- Identify areas that require evaluations : microphysics formulations, reactions in liquids (e.g. H_2SO_4), chemistry of UT "Hydrocarbons".
- Write review papers on UT Chemistry, Cirrus cloud chemistry...
- Facilitate the exchange of information between the different scientific communities.
- These activities should be carried out in cooperation with IGAC.

The Quasi-Biennial Oscillation and its possible role in coupling the stratosphere and the troposphere

Intriguing results have suggested that the QBO affects the troposphere. They are not well understood but the possible role of the QBO in the coupling between the stratosphere and the troposphere led the SSG, at its meeting in 1996, to push for an investigation on this issue. However the workshop planned could not take place in 1997, due to financial reasons, but is now planned for early 1998 in San Diego. Therefore the plans for future work on this topic have not moved forward as quickly as hoped. Professor Hirota has accepted to lead this activity and M. Baldwin will act as co-chair; he reported on the purpose of the workshop :

• To assess the current state of research concerning all aspects of the QBO.

• To identify the most promising areas of QBO research, especially those relevant to the SPARC mission.

• To provide a report to the SPARC SSG, making recommendations as to whether or not a SPARC initiative relative to the QBO should be established, and if so, what its focus should be.

• To publish a review article on the QBO, authored by workshop participants.

Stratospheric indicators of Climate Change

The role of SPARC in carrying out the assessment of stratospheric temperature trends and the reanalysis of trends in the vertical profiles of ozone was recognised by the WMO-UNEP Chairmen, and the work done under the auspices of SPARC will be an important contribution to the WMO-UNEP Ozone Assessment of 1998.

Assessment of stratospheric temperature trends

V. Ramaswamy presented the main results and conclusions of the temperature assessment which will be the subject of a SPARC report in early 1998 and which are being used for the WMO-UNEP Assessment. He confirmed the significance of the cooling observed in the lower stratosphere at mid and high latitudes and its attribution to the ozone depletion. Most of the discrepancies between the data sets, as they were presented at the last SSG meeting, have been understood and reduced by considering the exact same periods for the data set. It is to be noticed that the cooling trend is larger in the period starting in 1979 than in 1966. V. Ramaswamy also presented new results concerning the higher stratosphere resulting from rockets, lidars and satellites. The results are much more confusing than in the lower region as the amplitude and the sign vary with latitude. The attribution of the changes (ozone depletion and greenhouse effect) is also more complex, and should lead to further work in order to ensure improvements for the future assessment.

Understanding ozone trends

N. Harris presented the progress achieved by the SPARC initiative on "Understanding Ozone Trends". The main activity has been the assessment of trends in the vertical distribution of ozone. A summary of the results are given in a special SPARC-IOC report in this issue. It is worth noting here that the response of the scientific community has been amazing. Over 100 scientists have been involved and have all put in significant amount of time and effort, and their commitment is reflected in the quality of the final report to be issued early in 1998. The results are being used in several chapters of the 1998 WMO-UNEP assessment.

The future plans laid out in the SPARC Implementation Plan were also discussed. Two main initiatives are foreseen. First SPARC should maintain a presence in the on-going discussions about a strategy for future ozone measurements (a CEOS-IGOS initiative). SPARC presence should ensure that the concerns of particular importance towards the LS/UT are kept in mind. To complement this, and to benefit from what was learned during the preparation of the SPARC-IOC assessment, a SPARC working group will be set-up to consider how stability of multi-year series of ozone measurements can be best validated.

The second main area of interest will be the understanding of the ozone changes, in order to quantitatively explain the observed trends. This will be done in close cooperation with several other SPARC groups and reflects a change in emphasis from the calculation of linear trends ("detection" in climate change terms) to "attribution" to particular mechanisms.

Lower stratosphere water vapour climatology

J. Gille reminded the SSG of the main thrusts of the effort :

• Develop climatologies of the present distribution of UT/LS water vapour.

• Understand processes that maintain the present distribution of stratospheric water vapour.

• Determine long-term trends of water vapour.

• Develop ability to model the present water vapour, distribution and the capability to predict responses to future changes.

Among ways to understand the mechanisms to explain water vapour distribution, the prospect of the SOWER campaign was highly praised (see description of SOWER in this issue), as well as aircraft measurements of water vapour of the type made by MOZAIC (see SPARC Newsletter 7).

During the last year the development of water vapour climatologies has moved forward mostly due to the UARS/HALOE data (W. Randel), the SAGE II data (Chiou *et al.*) as well as work by Rosenlof and Mote. In view of the availability of new water vapour data, the possibility of preparing a water vapour assessment for IPCC 2000 can be envisaged and should be pursued by the study group. With this in mind, a workshop is planned to be held in Summer 1998 and participants should include scientists involved in satellite data analysis, in-situ observers, modellers as well as members of the GEWEX community.

Trends in dynamical activity

Trends in ozone and temperature could be influenced by trends in dynamical activity, or in turn they could generate trends in transport. In any case, spatial and seasonal structure of ozone, temperature, water vapour trends can only be understood from a dynamical point of view. This issue may not induce the formation of an independent ad hoc study group, as it is closely coupled to existing ones, but the importance of the issue is such that it was decided that it will be the topic of consideration in the Implementation Plan.

Modelling stratospheric effects on climate

Stratospheric Reference Climatology

In the absence of W. Randel, M. Geller reviewed the progress in this activity. Phase 1 of the Reference Climatology work, which is presently well advanced, involves compiling a set of global meteorological statistics derived from operational analysis, together with data sets describing tropical wind variability, mesospheric wind and temperature structure, and a climatology of selected trace gases. One of the questions raised by several members dealt with the time span of the data set used to make this climatology. This is mostly critical in view of the fact that the UARS data set coincides with an unusual period in terms of aerosols and therefore in terms of composition of the atmosphere. However many data sets exist only in this period. The question of extending the data set in the past as far as possible has been discussed with W. Randel. The addition of an aerosol climatology to this set of data was also suggested, and P. McCormick, who attended the whole meeting representing IGAC, offered to contribute with the climatology being compiled by IGAC/SUTA project (Stratosphere and Upper Troposphere Aerosol).

The setting up of the SPARC Data Center was discussed in relationship with this issue, as the key data set assembled for the Reference Climatology will be assembled there to be available to interested scientists. M. Geller had submitted a

proposal of funding to NASA which was still pending at the time of the SSG. Recently he received indications that this proposal will be funded, albeit with a somewhat lower budget than proposed. This will delay the beginning of the SPARC Data Center about six months.

Climate-Middle Atmosphere modelling GRIPS

Dr S. Pawson reported on the progress in this activity. Phase 1 is progressing very well with 13 modelling groups participating, though it was noted with regret that the GISS group is not yet involved in GRIPS. Data from these 13 models have been collected, quality controlled and partially plotted and examined. The main results were presented by S. Pawson at the Japanese SPARC Conference in Tsukuba in October 1997 and can be summarised as follows:

- All models reproduce the latitudinal and vertical structure of the zonal mean state of the atmosphere. However, there are some important discrepancies: e.g., systematic temperature errors (sometimes large); the strength and location of the major jets; the position of the tropical tropopause. GRIPS needs to ask why this is (e.g. radiation, convection parameterisation) because such errors have important implications for our ability to couple climate models to global chemical cycles and to predict future climatic change.
- The stationary planetary waves in the northern winter troposphere and stratosphere can differ widely from observations. Quantitative investigations of the causes of these discrepancies are necessary.
- The low-frequency oscillations in the tropical stratosphere are generally deficient: no QBO; SAO of variable quality.

Phase 2 has already started with the following actions:

- Radiative schemes intercomparison: trace gas climatologies are almost ready for distribution, and hopefully the results of the intercomparison will be available at the 1998 workshop.
- Gravity wave drag experiments were formulated and distributed in July 1997. Some results may be available in 1998.

Following the Victoria Workshop in March 1996, and the Berlin Workshop in March 1997, a new workshop is planned for March 1998 at the GSFC, Greenbelt, (MD), to present the progress and the results of the subgroup, to discuss new ideas and define future experiments.

Unfortunately the financial support for the whole GRIPS project is in some question. A letter was written to the European Commission to recommend the continued support of the EUROGRIPS project.

New issues to be considered within SPARC

Stratospheric Aspects of Climate Forcing

The objective of this new SPARC ad hoc study group placed under the leadership of D. Karoly will be to provide the climate modelling community with the current best estimates of appropriate parameters which determine stratospheric aspects of recent time-varying climate forcing.

To do so, the group will consolidate existing information and provide best estimates of time-varying distributions over the period 1880-present, together with estimates of uncertainty. The parameters to be documented would be : ozone, stratospheric aerosols, solar forcing and well-mixed greenhouse gases. (It was suggested that the compilation of solar UV and irradiance data should be carried out together with SCOSTEP).

By the end of 1988, the Group should produce a SPARC technical report including data sets and software and a peer-reviewed paper describing the data sets, so that they would be acceptable to IPCC.

Meetings of the new group, still in formation, are scheduled for March 1998, in Bracknell, in conjunction with the EU Workshop on Climate Change Detection and Attribution, and in October 1998, in Melbourne, where the Group would present a draft report to the WCRP Working Group on Coupled Modelling.

Penetration of UV radiation in the lower stratosphere and the troposphere

This area is currently neglected by the existing research programmes (SPARC, IGAC and GAW), even though it is highly important to know the actinic flux distribution in the lower stratosphere and the troposphere and to determine the climatology of the J factors as a function of altitude.

P. Simon was asked at the last SSG meeting to make a presentation on the subject at the present SSG. He showed why and how this UV flux should and could be measured. He concluded that SPARC and IGAC have a common scientific interest in establishing a climatology of J values and UV irradiance/actinic measurements as a function of altitude. It relates to the global quantification of photolysis frequencies of atmospheric species, the oxidising capacity and the lifetime of radiatively active gases. The modelling initiative for UV radiative transfer in the troposphere defined under the auspices of IGAC and WMO (UV monitoring Programme) will highly benefit from co-ordinated actinic flux observations needed to meet the SPARC objectives. This topic is also fully relevant for the GTOP scientific objectives.

The SPARC SSG decided to propose a cooperation with IGAC on this issue (see next paragraph).

Relationship with other programmes

IGAC

The SPARC SSG identified issues of concern to both SPARC and IGAC, taking into account the recent re-focusing of IGAC. The discussions benefited from the participation of A. Pzsenny and P. McCormick and the SSG members noted with satisfaction the designation of S. Penkett as the IGAC liaison to SPARC. Four activities were identified in particular which could be carried jointly when cooperation would be beneficial. They are listed below :

- **Laboratory studies**

Joint activities in this area would include :

- Compilation and evaluation of laboratory data for gas phase chemistry, microphysical processes, multiphase reactions, heterogeneous chemistry on solids and the chemistry of hydrocarbons.

A.R. Ravishankara currently coordinates SPARC activities in this field, together with R.A. Cox on IGAC side.

- Measurement of the vertical distribution of UV irradiance and photolysis rates.

Paul Simon has accepted to lead this activity for SPARC, in liaison with a representative of IGAC.

- **Stratosphere and Upper Troposphere Aerosols (SUTA)**

SPARC is interested in compiling a climatology for aerosols in the stratosphere and upper troposphere and assessing the effects, direct and indirect, of aerosols on climate. P. McCormick informed the SPARC SSG of the efforts of the IGAC project, SUTA, in this area. T. Peter has accepted to help define future collaboration with SUTA, discussions which will also include H. Graf from IGAC.

- **GTOP (Global Tropospheric Ozone Project)**

SPARC is interested in improving knowledge of the distribution of ozone and other species related to ozone chemistry in the UT/LS and wishes to collaborate in the activities of the GTOP project. Initially SPARC could contribute to the development of the GTOP science plan. The SPARC SSG proposed that C. Granier, N. Harris and F. Hasebe could play such a role through close links with J. Fishman and M. Beckman.

• **GLOCHEM**

The SPARC SSG has designated C. Granier to contact the GLOCHEM convener to look into possible common goals and report to the SSG during its next meeting.

SCOSTEP

The newly proposed project on "Stratospheric Aspects of Climate Forcing" includes the compilation of time-varying distributions solar UV and total irradiance. It was suggested by the SPARC Co-chairs (who have been, during the STEP period, also Co-chairs of STEP WG 4) to ask SCOSTEP which, with the ending of STEP, has no more focused activity on solar-terrestrial climate effects, to take the lead in this activity. A letter was sent to C.H. Liu, President of SCOSTEP to make this suggestion.

The SPARC Office

The activity of the SPARC Office in 1997 has been essentially dedicated to the preparation and edition of the Newsletter on one hand, and to the preparation of the glossy brochure and of the Implementation Plan on the other hand. Yuri Koshelkov, on leave from CAO in Moscow for two months twice a year, is responsible for preparing the Newsletter. Céline Phillips has edited the glossy brochure distributed with Newsletter 9 and updated the SPARC home page regularly. She has also coordinated the preparation of the Implementation Plan, liaising with the SSG members and Study Group leaders.

Marie-Christine Gaucher takes the responsibility of keeping up with the updating of the Directory and keeps the contact with the SPARC Community. She assembled the Proceedings of the SPARC General Assembly which appeared as a two-volumes issue of the WCRP Reports (WCRP-99). If readers of the SPARC Newsletters would like to receive a sample of these Proceedings, there are still copies available in Geneva. They can be obtained by asking Ann Clarke (WMO-WCRP, 41 avenue Giuseppe Motta, CP 2300, CH-1211 Geneva 2, Switzerland, email: aclarke@netra1.wmo.ch).

1998 promises to be very intense with the preparation of several SPARC Reports (Temperature trends, ozone vertical profiles trends, water vapour, heterogeneous chemistry, GRIPS Phase 1, Reference Climatology, QBO Workshop...) and the organisation of a large number of workshops and SPARC sponsored meetings, in addition to the general activity.

Next session of the SPARC Scientific Steering Group

An invitation was kindly made by H. Tanaka to hold the next SSG meeting in Japan. The exact place and date of the meeting are still to be decided upon, but 2 possible dates have been selected: October 26-30 or December 1-4, 1998

Next SPARC General Assembly

Two invitations have been received at this date to hold the next SPARC General Assembly, one from G. Beig in Pune India, and one from P. Canziani in Buenos Aires or Mar del Plata, Argentina. After discussion, the choice of the site of Mar del Plata, Argentina, has been made for the General Assembly to be held in December 2000, and P. Canziani will be the local organiser.

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Conference on the World Climate Research Programme: Achievements, Benefits and Challenges

26-28 August 1997, Geneva, Switzerland

The purpose of this conference was to have research scientists, policy and decision-makers and government scientific advisers review the accomplishments of the World Climate Research Programme (WCRP) and to advise on the strategy and plans to be followed by the WCRP in the future, to address the scientific and political priorities and to decide on actions to resolve uncertainties identified in the IPCC Second Assessment report.

One of the major results to date comes from the WCRP-TOGA (Tropical Oceans and the Global Atmosphere) project, and the improvement in the seasonal prediction of ENSO was the subject of several presentations and discussions during the conference.

Most relevant to SPARC were the presentations of future directions to be taken by SPARC by M. Geller (see the text of his presentation in this issue) and two lectures on some results and future challenges. P. Crutzen's talk focused on "the changing chemistry of the atmosphere". He gave an overview of current knowledge of atmospheric chemistry and its relation to climate. He presented some research efforts which are needed to advance knowledge in these areas through both the WCRP-SPARC and the IGBP-IGAC Projects. He stressed particularly the needs for research in the tropics and subtropics and gave as an example the clouds of high ozone concentration recently observed over the Atlantic by the MOZAIC aircraft (see Nature, 388, 625, 1997). He also highlighted the need for better description of the transfer processes across the tropopause. In his presentation on "Detection of climate change and attribution of causes", B. D. Santer emphasised needs for improvement in the climate simulation of vertical temperature changes through consideration of multiple human forcings of climate, including the forcing due to stratospheric ozone changes. His recent results indicate how the observed signal of anthropogenically produced climate change comes out of the noise of the normal climate natural variability.

Recommendations were prepared by three working groups on the following topics:

1 - future research directions and priorities,

2 - data needs for research and services and the institutional framework,

3 - capacity building.

SPARC is especially concerned with the following recommendations:

1 - to better quantify the radiative forcings from ozone change (both tropospheric and stratospheric), aerosols and solar activity,

2 - to better understand the natural variability, including external forcing (in particular solar variability) on decadal to centennial timescales,

3 - to advance in the detection and attribution of climate change,

4 - to understand the physics and chemistry of the upper troposphere-lower stratosphere, as a joint initiative of WCRP-SPARC and IGBP-IGAC including stratosphere-troposphere exchanges of energy, water vapour and chemicals.

A plea for ensuring the long term continuity of data and the need to fill in the existing gaps in the equatorial region and southern hemisphere was stressed by most of the atmospheric participants.

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