

Atmosphere-Ionosphere Coupling during Stratospheric Sudden Warmings

Applicants: L. P. Goncharenko (Coordinator), J. Chau, T. Fuller-Rowell, B. Funke, K. Hocke, P. Hoffmann, H.-L. Liu, M. Lopez-Puertas, S. Nozawa, D. Pancheva, A. Plumb, H. Schmidt, Ch. Zülicke

Abstract

The dynamic coupling of the atmosphere-ionosphere system is a complex interdisciplinary problem. Over the last three years our understanding of the relationship between the neutral atmosphere and ionosphere has been dramatically altered due to the research strategy focused on sudden stratospheric warmings (SSW), which are the clearest and strongest manifestation of the coupling in the atmosphere-ionosphere system. SSW events hold a special status in the arena of atmospheric coupling research, as it is a large-scale, well-defined, long-lasting, and predictable phenomenon. As such, it represents a “natural laboratory” experiment wherein theory and measurement can be compared. Research in this direction has been accelerated in recent years mainly due to: (1) occurrence of unusually strong, frequent or prolonged SSW events, (2) advent of whole atmosphere modeling, (3) extensive observational campaigns and high-quality satellite data. Recent studies suggested that a SSW couples all atmospheric layers from the ground to the thermosphere and from the poles to the equator. However, the mechanism of this coupling is only partly resolved. While the processes in the lower and middle atmosphere are related to planetary wave anomalies, the coupling to the upper layers and the role of gravity waves and tides are less clear. The strong influences of SSW events on chemical composition, electrodynamics, mixing and transport processes of the atmosphere and ionosphere have just started to be explored.

We propose to study dynamical coupling processes by bringing together experts specializing in the middle and upper atmosphere. As significant observational data have been already accumulated, we aim to focus on results from different ground-based and satellite-based observations, including global maps of tropospheric/stratospheric water vapor, stratospheric ozone, stratospheric and mesospheric temperatures, ionospheric plasma density, and electrodynamics. These global maps will be analyzed in conjunction with specialized datasets collected by microwave radiometers at altitudes 30-70 km, medium frequency and meteor radars in the mesosphere-lower thermosphere (MLT) region at altitudes 70–100 km and incoherent scatter radars at altitudes 100-800 km. The interpretation of the observations and the elucidation of the impact of the associated processes on the MLT and ionosphere will be provided by focused modeling efforts.

Scientific rationale, goals

This proposal arises as a continuation of the ISSI project started in 2008 and titled “Bridging the gap between the middle and upper atmosphere: coupling processes due to winds and waves over an extended altitude range”, team leader P. Hoffmann. Analysis of the results identified studies of SSW events and other extreme events as a promising path towards better understanding of vertical and horizontal coupling of atmospheric layers. It also indicated that a joint analysis of different altitudinal regions is necessary to fully understand coupling processes.

Several tasks have been identified for the proposed study:

1. *Specification of anomalies associated with SSW at mesospheric and lower thermospheric altitudes.*

It is well known that stratospheric warmings lead to a cooling at mesospheric altitudes. This cooling is also associated with large dynamical changes in the mesosphere. These include zonal wind reversal, enhanced energy dissipation rates, increases in planetary wave activity and changes in the gravity wave activity. Recent observational results also indicate a secondary warming at the altitudes of the lower thermosphere, which is consistent with the modeling predictions.

There are a number of unanswered questions, including the magnitude, duration, the onset time, and the latitudinal and longitudinal extent of these variations. We will investigate variations in the zonal and meridional prevailing wind and tidal amplitudes and phases using already available medium frequency, meteor radar, and incoherent scatter radar data. We will also determine a global structure of temperature changes in the MLT region and in the upper thermosphere using MLS, TIMED SABER and ENVISAT MIPAS observations, and compare them to temperature changes from several incoherent scatter radars to investigate vertical coupling. The observed variations in multiple parameters will be compared with WACCM, TIMEGCM, KMCM, WAM, and HAMMONIA model predictions. The goal of this task is the search for mesospheric and lower thermospheric harbingers of SSW events in both models and experimental data.

2. *Understanding of temporal development in stratospheric, mesospheric, thermospheric, and ionospheric anomalies associated with lower atmospheric forcing.*

The mesospheric cooling, wind reversal, and number of associated variations in the mesosphere reportedly occur 1-2 weeks prior to stratospheric warming events and maximize at high latitudes, while the largest disturbances in the ionosphere are reported within several days (3-6) after the peak of the warming, and are observed in the low-latitude ionosphere. We will investigate the reasons of the apparent discrepancy, focusing on the following questions: What are the time scales of the mesospheric, lower thermospheric, and ionospheric disturbances in relationship to stratospheric disturbances? What is the sequence of events in the development of variations at different altitudes? What is the role of longitudinal variability in the reported anomalies?

3. *Identification and characterization of anomalies associated with SSW in ionospheric parameters.*

Multiple studies have indicated dramatic disturbances associated with SSW in various ionospheric parameters: electric fields, total electron content, peak electron density. The largest reported anomaly is a semidiurnal variation in ionospheric parameters, which is interpreted as a result of non-migrating tides generated due to the nonlinear interaction of quasistationary planetary wave with migrating semidiurnal tide. Other observed phenomena include decrease in the global mean and in the diurnal variation of peak electron density. We will investigate in details these and other variations, including variations in tidal structures in ionospheric parameters (8-hour, 12-hour, 24-hour, migrating and non-migrating tides). Knowledge of the ionospheric variations is of high interest for radio communication and navigation as well as for the space weather field.

4. Study of gravity wave activity before, during, and after SSW

To get a statistically significant picture on the gravity wave propagation and dissipation and their interaction with tides and planetary waves, we plan to construct a composite behavior of these waves. This work will be based on available experimental data from MF and meteor radars and will include all SSW events since 1999.

Recent modeling studies suggest that gravity waves can be generated by the change of stratospheric jet during SSW. Because these waves are not represented in current GW parameterization in GCMs, their impacts are not well understood. We propose to study the impact by including the wave generation in GW parameterization scheme.

5. Exploring the signatures of SSWs and planetary waves in geographical maps of tropospheric water vapour, stratospheric ozone, and total electron content.

Global maps of tropospheric water vapour, stratospheric ozone, and ionospheric plasma density are currently available with a time resolution of 1 day or better. These maps of atmospheric composition will be utilized for tracing of atmospheric dynamics. We will examine the radiative forcing of asymmetric distributions of water vapour and ozone on atmospheric dynamics, as well as meridional and vertical mixing processes of atmospheric composition during SSWs.

We propose to combine our knowledge about oscillations in water vapour, ozone, and plasma density in order to understand vertical coupling processes of atmospheric layers during SSW events. Oscillations with planetary wave periods will be compared throughout the atmosphere, including planetary wave activity in the stratosphere, middle atmosphere, and ionosphere. In particular, we will focus on nonlinear wave-mean flow interactions arising from planetary waves, tides, and gravity waves as a key to the phenomenon of sudden stratospheric warming.

We will focus on the series of recent stratospheric sudden warmings during 2008-2011. The team members have collected comprehensive experimental datasets for this time period. New sets of data will be added during the lifetime of the project, which will allow characterization of atmospheric and ionospheric disturbances associated with SSWs during the rising solar activity. The team members have access to all necessary data and within the last few years have authored/coauthored multiple papers on different aspects of the proposed project.

Expected output

Results of the proposed project will be presented at multiple national and international conferences, including EGU meetings, CEDAR meetings (June 2012, 2013, USA), Fall AGU meetings (Dec 2011, 2012, USA), ISEA13 meeting (Mar 2012, Peru). Several members of the team are actively involved as organizers, conveners, and invited speakers at these meetings.

We will combine in-depth case studies of these events with summarizing of main dynamical features observed in multiple events in order to generate a set of dynamical benchmarks for the modelling community. We expect to submit three or four papers to the leading peer-reviewed journals.

The added value of ISSI

The project Team members are the leading experts in different aspects of the proposed topic from several European countries, as well as USA, Japan, and Peru. Due to the interdisciplinary nature of this research as well as limited resources within a particular sub discipline and country, these experts do not have an opportunity to jointly address the research topic in a systematic and comprehensive manner. The ISSI offers a unique opportunity to bring together many experts. The synergy of this team therefore warrants a major impulse to this research. Additional added value for ISSI is advanced diagnostics of coupling processes with ENVISAT satellite data.

Most of the team members were actively involved with previous ISSI Teams and ISSI workshops, and have a good understanding of ISSI operation mode.

List of confirmed participants and their areas of expertise

The project Team includes a group of experts in the dynamics of the middle and upper atmosphere as well as in ionospheric processes. The Team membership covers the necessary competences, there are no deficiencies. The scientists in the Team have worked with various ground-based and satellite instruments and variety of models.

Larisa Goncharenko (Coordinator), MIT Haystack Observatory, USA [Ionospheric physics, ionosphere-thermosphere coupling, waves and tides in the lower thermosphere, ion-neutral coupling. Data: incoherent scatter radars (Millstone Hill, Sondrestrom, PFISR, RISR, Arecibo), GPS TEC]

Peter Hoffmann, Leibniz Institute of Atmospheric Physics at the University of Rostock, Germany [Middle atmosphere dynamics, winds and waves at different altitudes ranges. Data: Andenes and Juliusruh MF and meteor radar observations]

Christoph Zülicke, Leibniz Institute of Atmospheric Physics at the University of Rostock, Germany [Middle atmosphere and mesosphere dynamics. Data: KMCM model]

Hauke Schmidt, Max Planck Institute for Meteorology, Germany [Dynamics, chemistry and energetics of the middle and upper atmosphere. Data: HAMMONIA model]

Klemens Hocke, Institute of Applied Physics, University of Bern, Switzerland [Atmospheric dynamics. Data: GROMOS O3, MIAWARA H2O]

Dora Pancheva, Geophysical Institute, Bulgarian Academy of Sciences, Bulgaria [Atmospheric dynamics, planetary waves and tides. Data: FORMOSAT COSMIC satellites electron density, TIMED SABER temperature]

Manuel Lopez-Puertas, Instituto de Astrofísica de Andalucía, Spain [Composition and energy balance of planetary atmospheres. Data: Envisat MIPAS, TIMED SABER]

Bernd Funke, Instituto de Astrofísica de Andalucía, Spain [Composition and energy balance of planetary atmospheres. Data: Envisat MIPAS, TIMED SABER]

Satoru Nozawa, Solar-Terrestrial Environment Laboratory, Nagoya University, Japan [Auroral MLT region, winds and waves. Data: EISCAT incoherent scatter radars (Tromso and Svalbard), Bear Island meteor radar, Tromso MF radar, Tromso sodium LIDAR]

Jorge Chau, Jicamarca Radio Observatory, Peru [Equatorial neutral atmosphere and ionosphere. Data: Jicamarca ISR, JULIA, GPS TEC, magnetometers]

Hanli Liu, National Center for Atmospheric Research, USA [Coupling of the atmosphere regions through dynamical, chemical, radiative and electrodynamic processes. Data: WACCM model, TIMEGCM model]

Alan Plumb, MIT, Earth, Atmosphere, and Planetary Science Department, USA [Stratospheric dynamics, Data: ERA-40]

Timothy Fuller-Rowell, CIRES, University of Colorado, USA, [Dynamics, energetics, chemistry, and electrodynamic of the thermosphere and ionosphere. Data: WAM model]

Schedule of the project

All team members confirm availability and willingness to attend the proposed ISSI workshop on the planned dates. Team members will also make every effort to attend at alternate times if the dates would be adjusted in consultation with ISSI.

Before first meeting: Preparation of the initial material by each group member. Every team member shall inspect their data and provide a list of SSWs that he/she is able to analyze but that need other inputs that can help to advance the understanding of the coupling phenomenon.

- First meeting (September-October 2011): Joint analysis of the selected events. Identification of anomalies at different altitude regions in different sets of data and model outputs.
- Second meeting (September - October 2012): Comparison of obtained results and preparation of initial publications.
- Third meeting, if needed (September-October 2013): Preparation of final version of manuscripts to be submitted.

Between the team meetings at ISSI, we plan to study the selected cases in every institution, providing results to all team members. Series of online meetings is proposed within 5-6 months after meetings at ISSI.

Facilities required

- One meeting room
- Internet access for laptops.
- Printer connection for laptops (or access to a computer with a printer).

Financial support requested of ISSI

- Per diem to individual team members to cover living expenses while in Bern.
- Team leader travel costs.

JORGE L. CHAU

Senior Research Associate
Radio Observatorio de Jicamarca
Apartado 13-0207
Lima 13, Peru

Education

Ph.D., Electrical and Computer Engineering, University of Colorado, Boulder, CO, 1998

M.S., Electrical and Computer Engineering, University of Colorado, Boulder, CO, 1995

Engineer, Industrial Engineering, Universidad de Piura, Peru, 1992

Experience

Director, Radio Observatorio de Jicamarca, (12/2000-Present)

Part-time Professor, Applied Physics, Pontificia Universidad Católica del Perú (03/2005 – Present).

Visiting Professor, Engineering Department, Universidad de Piura (09/1998-03/2003).

Postdoctoral Research Associate, Cornell University (07/1998 -12/2000)

Postdoctoral Research Associate, CIRES, University of Colorado, (01/1998-06/1998)

Selected Publications

Chau, J. L., B. G. Fejer, L. P. Goncharenko, Quiet variability of equatorial $E \times B$ drifts during a sudden stratospheric warming event, *Geophysical Research Letters*, 36, L05101, doi:10.1029/2008GL036785, 2009.

Chau, J. L., R. F. Woodman, and F. Galindo, Sporadic meteor sources as observed by the Jicamarca high-power large-aperture VHF radar, *Icarus*, 188, 162–174, doi:10.1016/j.icarus.2006.11.006, 2007.

Chau, J. L. and E. Kudeki, First E and D region incoherent scatter spectra observed over Jicamarca, *Ann. Geophys.*, 24, 1295-1303, 2006 (ISEA11 Special Issue).

Chau, J. L., Unexpected spectral characteristics of VHF radar signals from 150-km region over Jicamarca, *Geophys. Res. Lett.*, 31, L23803 10.1029/2004GL021620, 2004.

Other Publications

Hysell, D. L., F. S. Rodrigues, J. L. Chau, and J. D. Huba, Full profile incoherent scatter analysis at Jicamarca, *Annales Geophys.*, 26,59-75, 2008

Kudeki, E., A. Akgiray, M. Milla, J. L. Chau, D. L. Hysell, Equatorial spread-F initiation: post-sunset vortex, thermospheric winds, gravity waves, *J. Atmos. Solar-Terr. Phys.*, 69, 2416-2427, 2007

Hysell, D. L. and J. L. Chau, Optimal aperture synthesis radar imaging, *Radio Sci.*, VOL. 41, RS2003, doi:10.1029/2005RS003383, 2006.

Janches, D., C. J. Heinselman, J. L. Chau, A. Chandran, R. F. Woodman, Modeling the Global Micrometeor Input Function in the Upper Atmosphere Observed by High Power and Large Aperture Radars, *J. Geophys. Res.*, 111, A07317, doi:10.1029/2006JA011628,2006.

Synergistic Activities

- AGU, EGS, IEEE, URSI, and Peruvian Academy of Sciences Member
- Convener and co-convener of a sessions at international meetings (MST10, MST11, ISEA10, ISEA11, ISEA12, CEDAR Workshops, URSI GA)
- Chair of the Jicamarca 40th Anniversary Workshop, Lima, Peru (2002)
- Co-chair of the MST10 Workshop, Piura, Peru (2003), MST11 Workshop, Tirupati, India (2005), ISEA11 Taipei, Taiwan (2005) and ISEA12 Crete, Greece (2008).
- Member of the CEDAR Scientific Science Committee (2005-2008)
- International Member of the EISCAT Scientific Oversight Committee (2008-2009)
- Co-guest editor of the Jicamarca 40th anniversary, ISEA11 and ISEA12 special issues in *Annales Geophysicae*.

Timothy J. Fuller-Rowell

Senior Research Associate and Fellow of CIRES,
Cooperative Institute for Research in Environmental Sciences, University of Colorado,
Director of CIRES Center for Space Weather, Head of Atmosphere Ionosphere Modeling Research Group
Tel: 303-497-5763; Fax: 303-497-3645; E-mail: tim.fuller-rowell@noaa.gov

Professional Preparation

1974 B.Sc. (Honors.) in Physics, University College London (UCL), Dept. of Physics and Astronomy
1981 Ph.D. A Global Three-Dimensional Time-Dependent Thermosphere Model, UCL, Dept of Physics and Astronomy

Appointments

Fellow of CIRES, 1996-present
Senior Research Scientist at Space Environment Center, NOAA
Senior Research Associate, CIRES, University of Colorado, 1992-present
Research Associate, CIRES, University of Colorado, 1990-1992
SERC Advanced Fellowship, University College London, 1984-1990
Research Fellow, Advanced Study Program, NCAR, Boulder, 1982-1984
Research Assistant, UCL, Department of Physics and Astronomy, 1978-1982

Membership, Service and Awards

Member of the EISCAT Project Committee, 1986-1989.
Chairman of Dynamic Modeling Sub-Comm. of the Lower Thermosphere Coupling Study.
Co-Chair, NSF CEDAR PRIMO and GIFT Workshops, 1994-present
Chair, NSF CEDAR METRICS Workshop, 1998
Chair of I-T Metrics Panel and Member of Steering Comm. for Establishing Metrics for the NSWP
Guest Editor for Special Section on T-I Storms for J. of Atmos. and Solar Terr. Physics
Tutorial Lecture, Polar Aeronomy, NSF CEDAR 1998
Member of NPOESS Atmospheric Drag Working Group
Visiting Professor, Solar Terrestrial Environment Lab., Nagoya University, Japan, 1996
Editorial Board of Journal of Atmospheric and Solar Terrestrial Physics
Member of the COSPAR Panel for Space Weather
Space Environment Center Director's Award 1998-1999
NOAA Partner of the Month, April 2002
Member of Atmosphere-Ionosphere-Magnetosphere NRC Decadal Survey Committee
Member of the NASA-Living With a Star Geospace Mission Definition Team
Member of the International Heliospherical Year (IHY) Organizing Committee
Member AGU Student Awards Committee
Recognized in "Significant Papers from the First 50 Years of the Boulder Labs."
NASA-LWS Team Lead on "Electrodynamics" Focused Science Topic
AFOSR-MURI on Atmospheric Neutral Density Prediction
Co-Chair of IHY-Africa Workshop International Scientific Organizing Committee
Organizing and Editorial Committee for MIDD Chapman Conference and AGU Monograph
Served on the organizing committee for numerous other national and international meetings

Selected Bibliography (from a total of about 180 journal articles and book chapters)

Fuller-Rowell, T. J. et al., Impact of terrestrial weather on the upper atmosphere, *Geophys. Res. Lett.*, 35, L09808, doi:10.1029/2007GL032911, 2008.
Fuller-Rowell, T.J., A. Richmond, and N. Maruyama, Global modeling of storm-time dynamics and electrodynamic, AGU Monograph on Mid-latitude Ionospheric Dynamics and Disturbances, 2008.
Fuller-Rowell, T., F. Wu, R. Akmaev, T. W. Fang, and E. Araujo-Pradere, A whole atmosphere model simulation of the impact of a sudden stratospheric warming on thermosphere dynamics and electrodynamic, *J. Geophys. Res.*, 115, A00G08, doi:10.1029/2010JA015524, 2010.

Curriculum vitae: Bernd Rainer Funke

Staff Scientist

Instituto de Astrofísica de Andalucía (CSIC), Glorieta de la Astronomía, s/n, 18080 Granada

Tel. 958-230522, email: bernd@iaa.es

Date of Birth: 17-09-1968, Nationality: German (born in Hannover)

ACADEMIC DEGREES

1996	Master (Diploma degree) in Physics	Univ. of Karlsruhe
1999	Ph.D. in Physics	Univ. of Karlsruhe

RESEARCH EXPERIENCE

1996 - 1999	Pre-Doctoral Researcher	Univ. of Karlsruhe
1999 - 2000	Post-doctoral Researcher	Univ. of Karlsruhe
2000 - 2002	MC Host fellow	IAA (CSIC)
2002 - 2003	Post-Doctoral Researcher.	IAA (CSIC)
2003 - 2008	"Ramón y Cajal" Researcher	IAA (CSIC)
2009 -	Staff Scientist	IAA (CSIC)

TEACHING EXPERIENCE

2005 - Master Teacher (Dept. of Applied Physics) Univ. of Granada

RESEARCH TOPICS AND EXPERIENCE

Composition, chemistry, dynamics, energy balance, and non-LTE processes in the planetary atmospheres:

- 10 years experience in development of algorithms for the retrieval of stratospheric and mesospheric trace gases, as well as thermospheric NO and kinetic temperature from MIPAS/Envisat (responsible scientist at IAA/IMK). Member of the MIPAS Quality working Group.
- EPP direct and indirect effects and dynamical coupling processes connecting the middle and upper atmosphere: 8 years experience in the analysis of observational data (MIPAS) and coordinated model-data intercomparisons (HEPPA).
- Analysis of radiative cooling mechanisms in the thermosphere by means of SABER data
- Study of long-range transport in the upper troposphere and UTLS exchange with MIPAS data

PARTICIPATION IN RESEARCH PROJECTS

- Principal investigator of 2 research projects of Spanish CICYT.
- Co-investigator of 4 research projects of Spanish CICYT
- Co-Investigator of 3 research projects of EC.
- Co investigator of 1 research project of German BmBF
- Co-investigator of 3 research contracts with the European Space Agency (ESA)

PUBLICATIONS

International Journals (SCI indexed)	95	(1100 citations, h-factor: 19)
Invited papers in books/journals	2	
Proceedings, Journals not included in SCI, Reports	33	
Contributions to Congresses	>150	(9 invited)

OTHER ACTIVITIES AND MERITS

- Member of the International Commission of the Middle Atmosphere (ICMA)
- Associate Editor of the Journal "*Atmospheric Measurement Techniques*" (Copernicus)
- Member of the Quality Working Group of the MIPAS/Envisat instrument (ESA).
- Member of the Atmospheric Trace Gas Data Set Inter-Comparison Project of SPARC
- Member of the CAWSES II Task 4 Working Group 4
- Regular referee of *Adv. Space Res.*, *J. Geophys. Res.*, *Geophys. Res. Letters*, *Atmos. Chem. Phys.* and *J. Atmos. Solar-Terrest. Phys.*, *IEEE Transactions on Geo-Science and Remote Sensing*
- Supervisor of 2 Ph. D. Thesis and Member of Ph. D. examination panel of the Univ. of Granada.

LARISA P. GONCHARENKO

Research Scientist, MIT Haystack Observatory

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Professional preparation

Kharkov National Polytechnic University, Ukraine	Physics (with honors) M.S., 1988
Kharkov National Polytechnic University, Ukraine	Radiophysics 1991-1996
Haystack Observatory, MIT, USA	Post-Doc Fellow 1996-1997

Appointments

11/97 - present	Haystack Observatory, MIT, USA, Research Scientist
03/96 - 10/97	Haystack Observatory, MIT, USA, Post-Doctoral Fellow
03/88 - 02/96	Institute of Ionosphere, Kharkov, Ukraine, Research Fellow, Junior Research Fellow

Professional Interests

- Ionosphere-thermosphere-mesosphere-middle atmosphere coupling
- Physics of ionosphere and thermosphere, with emphasis on the processes in the mid-latitude lower thermosphere
- Waves and tides in the thermosphere
- Neutral winds, electric fields and ion-neutral coupling

Synergistic activities

- Secretary, American Geophysical Union, Space Physics and Aeronomy section (2008-2010 term, 2010-2012 term).
- Member of the CEDAR (Coupling, Energetics, and Dynamics of Atmospheric Regions) Science Steering Committee (2008-2011 term)
- Lead guest editor on the special issue of *Journal of Geophysical Research* COUPLING1 (joint between JGR-Space Physics and JGR-Atmospheres)
- Recipient of NASA Group Achievement Award (2008)
- Recipient of MIT Excellence Award (2003)
- Regular service on NSF, NASA, and NERC proposal reviews and review panels; organizer and convener of multiple sessions at AGU and CEDAR meetings

Most relevant publications

Goncharenko, L. P., J. Chau, H.-L. Liu, and A. J. Coster (2010), Unexpected connections between the stratosphere and ionosphere, *Geophys. Res. Lett.*, 37, L10101, doi:10.1029/2010GL043125.

Goncharenko, L. P., A. J. Coster, J. Chau, and C. Valladares (2010), Impact of sudden stratospheric warmings on equatorial ionization anomaly, *J. Geophys. Res.*, 115, A00G07, doi:10.1029/2010JA015400.

Chau, J. L., B. G. Fejer, and L. P. Goncharenko (2009), Quiet variability of equatorial ExB drifts during a sudden stratospheric warming event, *Geophys. Res. Lett.*, 36, L05101, doi:10.1029/2008GL036785.

Goncharenko, L. and S. Zhang, Ionospheric signatures of sudden stratospheric warming: ion temperature at middle latitude (2008), *Geoph. Res. Lett.*, 35, L21103, doi:10.1029/2008GL035684.

Curriculum Vitae

Klemens Hocke,

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Date of birth: 1 January 1964, Place of birth: Blankenstein/Germany

9 Jun. 83	Final examinations of Gymnasium Holthausen in Hattingen
Oct. 83 – Feb. 85	Civilian service
Mar. 85	Start of study of physics at University of Bochum
28. Nov. 86	Pre-degree in physics
May 89 – Sep. 91	Diploma work „Investigation of He II emission of Be stars“ supervised by Prof. J. Dachs at Astronomical Institute Bochum
2. Jan. 91	Physics Diploma (very good)
Oct. 91 – Apr. 94	Ph.D. thesis „Investigation of phases and amplitudes of traveling ionospheric disturbances by means of EISCAT radar data“ supervised by Prof. K. Schlegel at MPI for Solar System Research (Katlenburg)
29. Apr. 94	Ph.D. examination in physics at University of Göttingen (very good)
May 94 – Dec. 95	Postdoc fellow at MPI for Solar System Research
Jan. 96 – Nov. 96	Scientist at Institute of Geophysics, Astronomy and Meteorology, University Graz, Theme: GPS radio occultation, ESA satellite project
Dec.96–Feb.98	Guest scientist at Space Science Division of Communications Research Laboratory, Tokyo, Theme: Data processing and analysis of MF radars, dynamics of the mesosphere
Feb. 98 – Jul. 99	Project scientist at German Aerospace Center (DLR, Neustrelitz), Theme: Software for GPS occultations of the CHAMP satellite
Jul. 99 – Jul. 00	Continuation of work on CHAMP satellite project at GeoForschungs-Zentrum Potsdam
Sep.00–Feb.01	Guest professor at Kyoto University, Radio Science Center for Space and Atmosphere, Theme: GPS radio occultation
Feb.01–Feb.03	Fellow at National Institute of Information and Communications Technology (NICT), Tokyo, Theme: GPS radio occultation, simulation of wave propagation, Sun-Earth connections
Feb.03–Aug. 04	Hospital stay after accident, rehabilitation phase
Sep.04–Dez.04	Trainee teacher in Mülheim/Ruhr
since Apr. 05	Assistant at Institute of Applied Physics and Oeschger Centre for Climate Change Research of University of Bern, Switzerland. Theme: Passive microwave radiometry of ozone and water vapour
since Jan. 09	Member of the Oeschger Centre for Climate Change Research, University of Bern
Sept. 10	Submission of a habilitation thesis at University of Bern
since Oct. 10	Member of Swiss Commission for Remote Sensing (SCRS)

Project and Public Outreach:

- Swiss National Science Foundation “Climatology of gravity wave-induced ozone perturbations”, time interval: March 2009 to August 2011 (supervision of a Ph.D. thesis)
- K. Hocke has published about 60 articles (senior and joint author) in peer-reviewed journals

Dr. Peter Hoffmann Curriculum vitae

Birth Date: 23. 8. 1947
Nationality: German
Current status: Scientist at the Leibniz-Institute of Atmospheric Physics
Department 'Radar Sounding and Sounding Rockets'
D-18225 Kühlungsborn, Germany
Phone: +49 38293 68220
E-Mail: hoffmann@iap-kborn.de

Scientific interests and duties:

Middle atmosphere dynamics; winds, tides and gravity waves in the MLT region (MF and meteor radars); gravity waves in the troposphere / lower stratosphere; influence of waves on polar mesosphere summer echoes and noctilucent clouds; dynamical coupling processes, particularly influence of sudden stratospheric warmings on the mesosphere; Experimental work with MF and meteor radar data at mid latitudes (Germany) and at high latitudes (Andenes, Northern Norway)

Education and Career:

1966 university-entrance diploma (Abitur)
1966 - 1971 Study of Mathematics, University Rostock
1971 Diploma - degree (Dipl.-Math)
1971 – 1981 Scientific coworker at the Technical College Rostock-Warnemünde, department Computer-Technique
1981 -1991 Scientist at the Observatory for Atmospheric Research Kühlungsborn,
1991 Graduation 1991 Ph.D. (Dr. rer. nat) at the University of Leipzig, Department Geophysics, with "Determination of the wind field in the altitude range from 70 to 90 km on the base of partial reflections measured with a FM-CW radar"
Since 1992 Scientist at the Leibniz-Institute of Atmospheric Physics at the Rostock University, Kühlungsborn

Membership:

American Geophysical Union (AGU)

Selected latest and relevant publications

1. **Hoffmann, P.**, M. Rapp, W. Singer, and D. Keuer (2011), Trends of mesospheric gravity waves at middle latitudes during summer, submitted to *J. Geophys. Res.*, 26.1.2011.
2. Offermann, D., **P. Hoffmann**, P. Knieling, R. Koppmann, J. Oberheide, D. M. Riggin, V. M. Tunbridge, W. Steinbrecht (2011), Quasi-Two Day Waves in the summer mesosphere: Triple structure of amplitudes and long-term development, *J. Geophys. Res.*, doi:10.1029/2010JD015051. (in press).
3. Placke, M., **P. Hoffmann**, E. Becker, Ch. Jacobi, M. Rapp, and W. Singer (2011), Gravity wave momentum fluxes in the MLT – Part II: Meteor radar investigations at high and mid latitudes in comparison with modeling studies, *J. Atmos. Solar-Terr. Phys.*, doi:10.1016/j.jastp.2010.05.007, 2010, (in press)
4. **Hoffmann, P.**, E. Becker, W. Singer, M. Placke, Seasonal variation of mesospheric waves at northern middle and high latitudes, *Journal of Atmospheric and Solar-Terrestrial Physics*, 72, 1068 – 1079, (2010), doi:10.1016/j.jastp.2010.07.002.
5. Ward, W.E., J. Oberheide, L.P. Goncharenko, T. Nakamura, **P. Hoffmann**, W. Singer, L.C.Chang, J. Du, D.-Y Wang, P. Batista, B. Clemesha, A.H. Manson, D.M. Riggin, C.-Y. She, T. Tsuda and T. Yuan, On the consistency of model, ground-based and satellite observations of tidal signatures: Initial results from the CAWSES tidal campaigns, *J. Geophys. Res.*, 115, D07107, doi: 10.1029/2009JD012593, 2010.
6. **Hoffmann, P.**, W. Singer, D. Keuer, W. K. Hocking, M. Kunze, and Y. Murayama, Latitudinal and longitudinal variability of mesospheric winds and temperatures during stratospheric warming, *JASTP*, 69, 2355-2366, 2007.
7. Keuer, D., **P. Hoffmann**, W. Singer, and J. Bremer, Long-term variations of the mesospheric wind field at mid-latitudes, *Ann. Geophys.*, 25, 1779–1790, 2007.
8. **Hoffmann, P.**, W. Singer, and D. Keuer, Variability of the mesospheric wind field at middle and Arctic latitudes in winter and its relation to stratospheric circulation disturbances, *J. Atmos. Solar Terr. Phys.*, 64, 1229–1240, 2002.

Han-Li Liu
Co-Investigator

Education:

The University of Michigan	Atmospheric and Space Physics	Ph.D., 1996
The University of Science and Technology of China	Fluid Mechanics	B.S., 1989

Experience Relevant to Project Role and Responsibilities:

Dr. Han-Li Liu has been a scientist at the National Center for Atmospheric Research since 1999. His main research interests are atmospheric dynamics, with emphasis on wave dynamics, and the coupling of the atmosphere regions through dynamical, chemical, radiative and electrodynamic processes. He has developed a mesoscale gravity wave model and participated in the development of NCAR Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIME-GCM), and the Whole Atmosphere Community Climate Model (WACCM). He is leading the effort to develop the thermosphere and ionosphere extension of the WACCM.

Selected Publications Relevant to Proposed Work:

- Liu, H.-L. B. T. Foster, M. E. Hagan, J. M. McInerney, A. Maute, L. Qian, A. D. Richmond, R. G. Roble, S. C. Solomon, R. R. Garcia, D. Kinnison, D. R. Marsh, A. K. Smith, J. Richter, F. Sassi, and J. Oberheide, Thermosphere extension of the Whole Atmosphere Community Climate Model, *J. Geophys. Res.*, 115, doi:10.1029/2010JA015586, 2010.
- Liu, H.-L., W. Wang, A. D. Richmond, and R. G. Roble, Ionospheric variability due to planetary waves and tides for solar minimum conditions, *J. Geophys. Res.*, 115, A00G01, doi:10.1029/2009JA015188, 2010.
- Goncharenko, L. P., J. Chau, H.-L. Liu and A. J. Coster, Unexpected connections between the stratosphere and ionosphere, *Geophys. Res. Lett.*, 37, L10101, doi:10.1029/2010GL043125, 2010.
- Yamashita, C. H.-L. Liu, and X. Chu, Responses of mesosphere and lower thermosphere temperatures to gravity wave forcing during stratospheric sudden warming, *Geophys. Res. Lett.*, 37, L09803, doi:10.1029/2009GL042351, 2010.
- Liu, H.-L., D. R. Marsh, C.-Y. She, Q. Wu, and J. Xu, Momentum balance and gravity wave forcing in the mesosphere and lower thermosphere, *Geophys. Res. Lett.*, 36, L07805, doi:10.1029/2009GL037252, 2009.

Professional Affiliations:

2007–Present	Adjunct Associate Professor	University of Colorado, Boulder.
2006–Present	Scientist III	NCAR/HAO
2003–2006	Scientist II	NCAR/HAO
1999–2003	Scientist I	NCAR/HAO

CURRICULUM VITAE

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Citizenship: Japan

EDUCATION

Ph.D. (Physics) Nagoya University - 1991

M.S. (Physics) Nagoya University - 1988

B.S. (Physics) Nagoya University - 1986

EMPLOYMENT

February 2002- present

Associate Professor

Solar-Terrestrial Environment Laboratory, Nagoya University

September 1989- January 2002

Research Associate

Solar-Terrestrial Environment Laboratory, Nagoya University

LONG-TERM VISIT

February - December, 1992 The Auroral Observatory, The University of Tromsø, Tromsø, Norway

June - October, 1996 HAO, NCAR, UCAR, Boulder, USA

MEMBERSHIP IN SCHOLARLY SOCIETIES

[The Society of Geomagnetism and Earth, Planetary and Space Sciences \(SGEPSS\)](#)

[American Geophysical Union \(AGU\)](#)

FELLOWSHIP

April - August, 1989 Fellowships of the Japan Society for the Promotion of Science for Japanese Junior Scientists

Number of publications (refereed): 93 (13 papers as the first author)

CV – Dora Pancheva

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Graduated from the Physical Faculty at Sofia University “St. Kl. Okhridski”, 1973
Awarded PhD degree (Dr.) -1977.
Doctor of Physical Sciences (D.Sc.) – 2008

Geophysical Institute – BAS, Physicist -1977
Geophysical Institute – BAS, Research Scientist -1981
Geophysical Institute- BAS, Senior Research Scientist -1987
Post Doc Position at Physics Department, University of Wales, Aberystwyth, UK – 1999-2002
Research Scientist at Dept. Electronic & Electrical Eng., University of Bath, UK – 2002-2007
Geophysical Institute – BAS, Professor, 2008
Chief of Department “Physics of Ionosphere” – 2008
Scientific Secretary of Geophysical Institute – 2008-2010

Member of COSPAR Sub-commission C.2 "*Middle Atmosphere and Lower Ionosphere*"- 1992
Member of IAGA Commission D, II Division "*External Forcing of the Middle Atmosphere*", as well as of IAGA Commission C, II Division "*Meteorological Effects on the Ionosphere*" - 1995
Chair of IAGA Commission C, II Division "*Meteorological Effects on the Ionosphere*" –1999-2007
Co-Chair of IAGA Division II "*Aeronomic Phenomena*" - 2007
SCOSTEP Scientific Discipline Representative (SDR) –2008
President of National Committee of Geodesy and Geophysics for IUGG - 2009

Major Field of Scientific Research: Physics of Atmosphere and Ionosphere
Specific Topics of Expertise: (i) Dynamics of Middle and Upper Atmosphere, and (ii) – Coupling processes in the Atmosphere-Ionosphere System

Publications: 163 in peer review journals and 24 published in full text presentations at international meetings.

Associate Editor of JGR – Space Physics - 2010

Curriculum Vitae - Raymond Alan Plumb

March 24, 2011

Born: 30 March 1948; Ripon, North Yorks, England
 Citizenship: U.K., Permanent Resident status in U.S.

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(a) Education:

Manchester	Physics, I Hons	B. Sc.	1969
Manchester	Astronomy	Ph. D.	1972

(b) Appointments:

2003-2008. Director, Program in Atmospheres, Oceans and Climate, M. I. T.
 1988-present Professor, Dept of Earth, Atmospheric and Planetary Sciences, M. I. T.
 1982: Visiting Scientist, NOAA/Geophysical Fluid Dynamics Laboratory, Princeton NJ.
 1976-88: Research Scientist/Senior Principal Research Scientist, CSIRO, Australia
 1972-76: Scientific Officer/Senior Scientific Officer, U. K. Meteorological Office.

(c) Awards

Fellow of the Royal Society, May 1998.
 American Geophysical Union, Fellow, 2000.
 American Meteorological Society, Haurwitz Memorial Lecturer, 2001.
 American Meteorological Society, Fellow, 2002.

(d) Publications:

98 publications in the refereed literature, plus one edited book, and two co-authored books["Atmosphere, Ocean, and Climate Dynamics" (with J. Marshall), and "The Asian Monsoon" (with P. Clift)]. These publications are listed on: **eaps.mit.edu/~rap/papers.html**

(e) Other activities

(i) Professional Journals.

Editor, *Pure and Applied Geophysics*, 1980-84.; Associate Editor, *Journal of the Atmospheric Sciences*, 1985-89; Editor, *Journal of the Atmospheric Sciences*, 1990-93.

Guest Editor of special issues of *Pure and Applied Geophysics*, *Geophysical Research Letters*, and *Journal of the Atmospheric Sciences*.

(ii) Recent service on committees, panels:

NASA "Living with a Star" review panel, 2010, 2011

NASA/WMO "Ozone Assessment" panel, 2006: reviewer.

MIT, Committee on Academic Performance, 2002-2005.

Royal Society, member Sectional Committee 5 (Earth and Space Sciences), 2001-04.

NASA/Goddard Institute for Space Studies, Review Panel, 2000-03.

University of Cambridge, Elector to the G.I. Taylor Professorship of Fluid Mechanics, 1998-2002.

Curriculum Vitae of Manuel López Puertas

Professor of Research, Inst. Astrofísica de Andalucía (CSIC), Glorieta de la Astronomía s/n, 18008, Granada

Born: Calahonda (Granada, Spain) 04.09.1956

Phone: 34-958-230507; Email: puertas@iaa.es

ACADEMIC DEGREES

1978 Graduate in Physics. Univ. of Granada. First Class Honors.

1982 D. Phil. in Physics, Univ. of Granada. First Class Honors "Cum Laude".

TEACHING EXPERIENCE

1978 – 1982 Assistant Professor, Faculty of Sciences (Univ. of Granada).

1983 – 1986 Reader, Faculty of Sciences (Univ. of Granada).

1992 – ... Master Teacher (Dept. of Applied Physics) (Univ. of Granada).

RESEARCH EXPERIENCE

1979 – 1981 Ph. D. Student (Univ. Granada).

1979 – 1982 Member of the Planetary Atmospheres Group (IAA, CSIC)

1983 – 1984 European Space Agency Fellow (Oxford University, UK)

1984 – 1987 Associated Doctor, Inst. de Astrofísica de Andalucía (CSIC)

1987 – 2000 Staff Scientist (Instituto de Astrofísica de Andalucía, CSIC)

2000 – 2004 Scientific Researcher (Instituto de Astrofísica de Andalucía, CSIC)

2004 – ... Professor of Research (Instituto de Astrofísica de Andalucía, CSIC)

TOPICS OF RESEARCH

– Composition and energy balance of planetary atmospheres. Radiative transfer. Retrieval of satellite data. Remote sensing. Infrared emissions. Non-local thermodynamics equilibrium (non-LTE). Sun-Earth connection.

RESEARCH PROJECTS LED IN THE LAST 10 YEARS

– Principal investigator of 5 research projects of Spanish CICYT.

– Responsible investigator of 5 research contracts with the European Space Agency (ESA)

– Responsible investigator of 3 research projects of EC.

– Responsible investigator of 3 research projects of NASA.

– Responsible investigator of 1 research project of INTAS.

PUBLICATIONS

Books	1
Books (Editor)	1
Invited papers in books/journals/enciclopedia	6
Author or co-author of papers in international journals (SCI indexed)	128
Author or co-author of papers in collective books	36
Scientific Reports (ESA, NASA, Others)	7
Papers on education and public outreach activities	7
Meeting (Invited talks, Member of SOCs, Convener)	20

OTHER ACTIVITIES AND MERITS

– Supervisor of 7 Ph. D. Thesis

– Invited talks in International Conferences ... 12.

– More than 2000 citations in SCI-indexed journals and in 2 textbooks. *h* index: 26.

– Co-investigator of the SABER instrument of the TIMED NASA mission.

– Member of the Science Advisory Group of the MIPAS/Envisat instrument (ESA).

– Member of the scientific teams of the ATMOS and ISAMS instruments.

– Reviewer of research proposals for Spanish ANEP since 1991; for the NASA/NRA program; NERC (UK); NSERC (Canada); for ESA; for the AFO2000 German project, Marsden Foundation (Roy. Soc. Nueva Zelanda), etc.

– Member of Ph. D. examination panels of Oxford, Helsinki, and several Spanish Universities.

Curriculum Vitae

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Personalities

Birth: October 29, 1968, in Lübeck, Germany
Nationality: German

Research

since 01/02	Scientist at the “Max-Planck-Institute for Meteorology” in Hamburg, Germany
since 04/07	Head of the “Middle and Upper Atmosphere Modeling Group”
since 01/10	Deputy director of the department “Atmosphere in the Earth System”
04/06 – 03/07	Visiting Scientist at NCAR, Boulder, CO, USA
06/99 – 12/01	Post-doc at the “Laboratoire du Météorologie Dynamique, Ecole Polytechnique” in Paris, France

Education

05/96 – 05/99	PhD Study of Geophysics at the University of Cologne, Germany
06/99	PhD, mark: “sehr gut mit Auszeichnung” (“summa cum laude”) Thesis: “Four-Dimensional Variational Data Assimilation for a Mesoscale Chemistry Transport Model” (in german)
05/96 – 05/99	Research Assistant at the Department for Geophysics and Meteorology
04/90 – 04/96	Study of Geophysics at the University of Cologne, Germany and Meteorology
04/96	M.Sc. (“Diplom”) in Geophysics, mark: “sehr gut” (A level) Special coursework: Meteorology, Theoretical Physics, Geology

CURRICULUM VITAE

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Academic qualifications:

- M. Sc. (Diploma): 1983 – 1987, Humboldt University at Berlin, Germany
- Ph. D. (Thesis): 1987 – 1990, Humboldt University at Berlin, Germany

Academic positions:

- 1990 – 1992: Research assistant at Humboldt University at Berlin, Germany (HUB)
- 1992 – 1994: Postdoc at the Institute of Remote Sensing Applications, Ispra, Italy
- 1995 – 1999: Scientific coworker at the Leibniz Institute for Baltic Sea Research, Warnemünde, Germany (IOW)
- 2000: Guest scientist at IOW
- 2001: Scientific coworker at HUB
- 2001 – 2006: Scientific coworker at the Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany (IAP)
- 2006 – 2009: Scientific coworker at IOW
- 2009 - ...: Senior scientist at IAP

Research fields:

- structure formation with noise and diffusion
- air-sea fluxes and turbulence
- atmospheric waves, circulation and climate

Selected Publications:

- Peters, D. and Ch. Zülicke, 2006: Atmospheric Angular Momentum Balance for the Southern Hemisphere During the Polar Vortex Break-up of September 2002. *Tellus* 58A: 508 - 519, doi: 10.1111/j.1600-0870.2006.00187.x
- Zülicke, Ch. and D. Peters, 2006: Simulation of inertia-gravity waves in a poleward breaking Rossby wave. *J. Atmos. Sci.* 63, 12: 3253 - 3276, doi:10.1175/JAS3805.1
- Serafimovich, A., Ch. Zülicke, P. Hoffmann, D. Peters, P. Dalin and W. Singer, 2006: Inertia gravity waves in the upper troposphere during the MaCWACE winter campaign, Part II: Experimental and mesoscale modelling studies. *Ann. Geophys.* 24: 2863 - 2875
- Zülicke, Ch. and D. Peters, 2008: Parameterization of strong stratospheric inertia-gravity waves forced by poleward breaking Rossby waves. *Mon. Wea. Rev.* 136, 1: 98 - 119, doi:10.1175/2007MWR2060.1
- Zülicke, Ch. and D.H.W. Peters, 2010: On the estimation of persistence in geophysical time series. *Eur. Phys. J. - Special Topics* 187: 101 - 108. doi: 10.1140/epjst/e2010-01275-2
- 24 in total with a Hirsch index of 9 according to *Web of Science – Citation Report*