Quantifying hemispheric differences in particle forcing effects on stratospheric ozone

Proposal for the International Space Science Institute 2012 Call for International Teams in Space and Earth Science

Team leader: Dan Marsh, NCAR, Boulder, USA

Abstract

Significant progress has been made in the understanding of energetic particle precipitation (EPP) and its effects on the middle and upper atmosphere. Model simulations now include the chemical and energetic forcing from a broad range of energetic particles. Comparisons of simulation results with observations have shown that the production of odd-nitrogen species and the subsequent catalytic loss of ozone are well simulated. It is becoming clear that the dynamics of the winter polar stratosphere in the Northern Hemisphere play a vital role in transport of NOx and ozone loss. Major stratospheric sudden warmings, which have a frequency of approximately 0.6/y, appear to either enhance or reduce NOx downward transport. In contrast, the lack of variability of the winds in the Southern Hemisphere winter results in a consistent conduit of upper atmospheric NOx into the stratosphere. This study will use a combination of satellite data (e.g., from ENVISAT) and model simulations to quantify hemispheric differences in wintertime EPP NOx and its effects on stratospheric ozone. We aim to assess which hemisphere responds more directly to EPP forcing on timescales up to the 11-year solar cycle, and how that varies with meteorology. This is a necessary first step in understanding the role of stratospheric EPP-induced ozone loss in driving tropospheric climate variability.

Scientific Rationale, goals and timeline of project

EPP is thought to be one of the ways the geospace environment can affect the middle and lower atmosphere. Energetic particles that precipitate into the stratosphere, mesosphere and lower thermosphere (SMLT) include auroral electrons (energies from 1-30 keV), medium energy electrons (MEE, 30 keV - 300 keV), and energetic protons (1-300 MeV). EPP leads to ionization of the major molecular species, and through a series of neutral and ion reactions produces odd-hydrogen (HOx = {H, OH, HO_2}) and odd-nitrogen (NOx = {N, NO, NO_2}). These species are of interest because they can catalytically destroy ozone in the SMLT. The lifetime for HOx in the mesosphere is short and so it is not effectively transported into the stratosphere by the mean meridional winds, which have vertical velocities of a few cm/s downward over the winter pole. In contrast, the absence of NO photolysis during polar night

Table 1: Observations and models available to be used in this project.

Observation	**Data**	**Team member(s)**
AARDDVARK	energetic particle fluxes	Rodger, Clilverd
POES	”	Rodger, Clilverd
GOES	”	Jackman
Envisat/Sciamachy	NO	Sinnhuber
Envisat/GOMOS	O_3, NO_2	Seppälä
Envisat/MIPAS	NO, NO_2, O_3, HNO_3, N_2O, N_2O_5, HNO_4, ClO, HOCl, $ClONO_2$	Funke
Odin/OSIRIS	NO, NO_2, O_3	Urban, Seppälä
Odin/SMR	NO, O_3, HNO_3, N_2O, H_2O, CO, T	Urban
Aura/MLS	O_3, HNO_3, N_2O, H_2O, CO, T	Randall
TIMED/SABER	O_3, T	Randall
SciSat-1/ACE-FTS	same as MIPAS + CH_4	Randall
Model	**Output**	**Team member(s)**
AIMOS	ionization rates	Wissing
SIC	NO_y production rates	Verronen, Seppälä
FinROSE	3-D chemical densities and reaction rates	Verronen
B3dCTM	”	Sinnhuber
EMAC	”	Versick
WACCM	”	Marsh, Jackman

dramatically lengthens the lifetime of NO, such that it is effectively transported into the stratosphere from the mesosphere and lower thermosphere.

Randall et al. [2007] examined observational timeseries of EPP NOx in the Southern Hemisphere (SH) and the energy flux of both auroral electrons and MEE (both producing ionization mainly above the stratopause). This was perhaps the first time the interannual varibility in EPP NOx was quantified. In their study, EPP NOx is identified using UARS HALOE observations by selecting only data in the upper stratosphere where NOx is elevated but methane (CH_4) is low. Since CH_4 is a long-lived tracer whose mixing ratio drops off with increasing altitude, low mixing ratios in a particular air parcel indicate that it originated in the upper atmosphere, in which case the elevated NOx must have been the result of EPP in the upper atmosphere. Giving further credence to the attribution of the elevated NOx to EPP was the strong correlation between EPP NOx and energetic particle fluxes averaged between May and July (correlation coefficients of 0.88 for auroral electrons and 0.85 for medium energy electrons). Randall et al. [2007] calculate the amount of EPP NOx entering the stratosphere is between 0.1 and 2.6 gigamoles per year.

Goal 1 of this project is to reassess the estimate of EPP NOx entering the stratosphere in light of new satellite observations listed in Table 1. This will be evaluated not only for the SH but for the Northern Hemisphere where

Stratospheric Sudden Warmings (SSWs, see e.g., Manney et al. [2009] and Randall et al. [2009]) lead to significant variations in the transport of EPP NOx in the wintertime.

The observation-derived estimates of EPP NOx will be compared with those calculated from 3-dimensional chemical transport models that have been driven with meteorological data from reanalysis covering the period of observations. The models to be used are B3dCTM, EMAC, FinROSE, and WACCM. The Team members listed in Table 1 have used these models extensively to simulate EPP effects in the atmosphere. All models were used in the recent model/measurement intercomparison activity on High Energy Particle Precipitation in the Atmosphere described by B. Funke et al. [2011]. To force the models correctly over the long-term we will take energetic particle fluxes from AARDDVARK, POES and GOES and calculate ionization rates and NO_x production rates using Atmospheric Ionization Module Osnabrück (AIMOS, [Wissing and Kallenrode, 2009]) and the Sodankylä Ion and Neutral Chemistry model (SIC, [Verronen et al., 2005]). Estimating the amount of EPP NOx in the stratosphere can be done in two ways. The first will follow the same technique as used in the observations, i.e., using long-lived tracers to identify NOx produced by EPP. The second is to do parallel simulations forced with identical meteorology, but without particle precipitation. Since variability in dynamics is the same across these runs, the budget of EPP NOx in the stratosphere can be calculated by simply differencing these runs.

Once the NOx enters the stratosphere it can be transformed into other chemical species. It is usual to refer to these species as NOy, which is comprised of N, NO, NO_2, NO_3, HNO_3, $ClONO_2$, $BrONO_2$, N_2O_5, and HNO_3. Randall et al. [2007] estimate EPP NOx contributes up to 10% of the global NOy budget and 40% of the NOy in the polar regions, although they suggest that this is a conservative estimate since HALOE did not observe poleward of 50°S during winter. Randall et al. [2007] were not able to quantify the loss of ozone in the stratosphere due to EPP NOx. After entering the stratosphere it becomes distributed both in the vertical and horizontal and is mixed with NOy that originates in the troposphere as N_2O. It is therefore not feasible to directly observe its long-term effect on the distribution of O_3. They conclude, "quantifying contributions of the EPP [Indirect Effect] to interannual variations in stratospheric O_3, and understanding any implications this might have for O_3 trends and climate, requires global, three-dimensional models to separate chemical and dynamical effects."

Goal 2 of this project is to calculate the contribution of EPP NO_x to O_3 loss and its long-term effect on the distribution of ozone. To do this we will compare O_3 chemical loss rates and distributions averaged over an extended period in the two model simulations described above (with and without EPP NO_x). In doing this we will quantify the effect of EPP NO_x on stratospheric O_3. This will provide a basis for assessing the radiative impact of EPP in the long term, and if, through coupling between the middle and lower atmosphere, it could affect tropospheric climate.

We expect to focus primarily on Goal 1 in the first meeting, and Goal 2 in the second meeting.

Added value provided by ISSI

ISSI will provide the opportunity to bring together observers and modelers to work together to achieve the project goals. Observations are necessary to calculate the correct EPP model forcing and for validation of the model simulations. Models are necessary to understand the physical mechanisms that drive variability in the observational record. Team members have gained valuable experience by participating in the HEPPA model/measurement intercomparison activities that focussed on dramatic short-term events. This project extends that work by examining a period more relevant to climate variability. Without the close interaction of Team members in both the model and measurement communities, this project would not be practical.

Expected Outcome

Through the use of both observational data and modeling we expect to produce a quantitative estimate of the long-term contribution of EPP to the production of stratospheric NOy and related O_3 loss. The degree to which this varies between the hemispheres will be assessed. These estimates will be presented in a series of refereed journal publications.

Confirmed Team Members

Dr. Mark Clilverd, British Antarctic Survey, United Kingdom
Dr. Bernd Funke, Instituto de Astrofsica de Andaluca, Spain
Dr. Charles Jackman, NASA/Goddard Space Flight Center, USA
Dr. Dan Marsh, National Center for Atmospheric Research, USA
Prof. Cora Randall, University of Colorado, USA
Prof. Craig Rodger, University of Otago, New Zealand
Dr. Annika Seppälä, Finnish Meteorological Institute, Finland
Dr. Miriam Sinnhuber, Karlsruhe Institute of Technology, Germany
Dr. Joachim Urban, Chalmers University of Technology, Sweden
Dr. Pekka Verronen, Finnish Meteorological Institute, Finland
Dr. Stefan Versick, Karlsruhe Institute of Technology, Germany
Dr. Jan Maik Wissing, University of Osnabrück, Germany

Project Schedule

We propose to meet for two one-week meetings to be held at ISSI facilities in Bern over the duration of 18 months. We anticipate the meetings to take place in the first quarter of 2013 and in the first or second quarter of 2014.

Facilities Required

We will require access to wireless network and the internet. We expect most participants to bring with them their own computers. We also require access to printing facilities. A meeting room large enough to accommodate 15 people with projection facilities and a white board is required.

Financial support requested of ISSI

The proposal is submitted on the basis of per diem to individual Team members and travel cost for the Team leader.

References

B. Funke et al. Composition changes after the "halloween" solar proton event: the high energy particle precipitation in the atmosphere (heppa) model versus mipas data intercomparison study. *Atmospheric Chemistry and Physics*, 11(17):9089–9139, 2011. doi: 10.5194/acp-11-9089-2011. URL `http://www.atmos-chem-phys.net/11/9089/2011/`.

G. L. Manney, M. J. Schwartz, K. Krüger, M. L. Santee, S. Pawson, J. N. Lee, W. H. Daffer, R. A. Fuller, and N. J. Livesey. Aura Microwave Limb Sounder observations of dynamics and transport during the record-breaking 2009 Arctic stratospheric major warming. *Geophys. Res. Lett.*, 36:L12815, 2009. doi: 10.1029/2009GL038586.

C. E. Randall, V. L. Harvey, C. S. Singleton, S. M. Bailey, P. F. Bernath, M. Codrescu, H. Nakajima, and J. M. Russell III. Energetic particle precipitation effects on the Southern Hemisphere stratosphere in 1992-2005. *J. Geophys. Res.*, art. D08308, 2007. doi: 10.1029/2006JD007696.

C. E. Randall, V. L. Harvey, D. E. Siskind, J. France, P. F. Bernath, C. D. Boone, and K. A. Walker. NO(x) descent in the Arctic middle atmosphere in early 2009. *Geophys. Res. Lett.*, 36, SEP 25 2009. ISSN 0094-8276. doi: 10.1029/2009GL039706.

P. T. Verronen, E. Kyrölä, J. Tamminen, B. Funke, S. Gil-López, M. Kaufmann, M. López-Puertas, T. v. Clarmann, G. Stiller, U. Grabowski, and M. Höpfner. A comparison of night-time GOMOS and MIPAS ozone profiles in the stratosphere and mesosphere. 36: 958–966, 2005.

J. M. Wissing and M. B. Kallenrode. Atmospheric Ionization Module Osnabruck (AIMOS): A 3-D model to determine atmospheric ionization by energetic charged particles from different populations. *J. Geophys. Res.*, 114, 2009. doi: 10.1029/2008JA013884.

A Contact information of confirmed participants

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B Short CVs of confirmed members

MARK A. CLILVERD

Tertiary Education
BSc (Hons) University of Southampton 1984
PhD University of Sheffield 1990

Distinctions/Honours
International Union of Radio Science (URSI) representative to the Scientific Committee on Antarctic Research, an interdisciplinary committee of the International Council for Science. 2005-

UK representative, URSI Commission H, 2002-2005.

Polar Medal for services to Science in the Antarctic, presented by H.M. The Queen, 1998.

Laws prize awarded to outstanding young scientists of the British Antarctic Survey for Antarctic research, 1994.

Royal Society Post-doctoral Fellowship in Physics, undertaken at the Department of Physics, University of Otago, 1990-1991.

Employment Record
Principal Scientific Officer (Grade 7), Physical Sciences Division, British Antarctic Survey, 2000 (October) -

Senior Scientific Officer, Upper Atmosphere Research Division, British Antarctic Survey, 1995 (October) - 2000 (October)

Higher Scientific Officer, Upper Atmosphere Research Division, British Antarctic Survey, 1991 (November) - 1995 (October)

Royal Society Post-doctoral Fellowship in Physics, undertaken at the Department of Physics, University of Otago, 1990-1991.

Contract Physicist, British Antarctic Survey, 1990 (July-August)

Contract Physicist, British Antarctic Survey, 30 months of which undertaken at Faraday, Antarctica 1984-1987

Other Information:
Active collaborations with researchers from: Australia, Finland, New Zealand , UK, USA, Canada, Hungary, Norway.
Principle Investigator NERC grant NE/HO 14888/1 Autonomous observations of energetic particle effects on the Antarctic atmosphere.
Work package leader of FP7 Space weather project PLASMON.

Total Number of refereed publications:	119
Major publications (in the last five years).	44

Research Interests
- Upper Atmosphere and Space Physics focused on the impact of energetic particle effects on the Earth's atmosphere and climate system.
- Long-term change in solar and geomagnetic activity.
- Principal investigator (with C. J. Rodger) of the Antarctic-Arctic Radiation-belt (Dynamic) Deposition - VLF Atmospheric Research Konsortium (AARDDVARK).
- Member of the CHemical Aeronomy in the Mesosphere and Ozone in the Stratosphere (CHAMOS) science team.

Curriculum vitae: Bernd 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 and the Atmospheric Trace Gas Data Set Inter-Comparison Project of SPARC.
- 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 (Coordinator of SPARC's HEPPA-MMI working group, Member of CAWSES II Task 4 WG).
- 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)	109 (>1400 citations, h-factor: 21)
Invited papers in books/journals	2
Proceedings, Journals not included in SCI, Reports	>30
Contributions to Congresses	>200 (10 invited)

OTHER ACTIVITIES AND MERITS

- Member of the International Commission of the Middle Atmosphere (ICMA)
- Associate Editor of the Journal *"Atmospheric Measurement Techniques"* (Copernicus)
- Regular referee of *Adv. Space Res.*, *J. Geophys. Res.*, *Geophys. Res. Letters*, *Atmos. Chem. Phys.* and *J. Atmos. Solar-Terrestr. 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.

Curriculum Vitae

Charles H. Jackman

Physical Scientist (since 1980 with NASA)
Atmospheric Chemistry and Dynamics Branch
NASA Goddard Space Flight Center
Greenbelt, MD 20771 U.S.A.

Further information at: http://acd-ext.gsfc.nasa.gov/People/Jackman/

RESEARCH AREA EXPERIENCE: Data analysis and multi-dimensional modeling of the natural and anthropogenic variations in the stratosphere and mesosphere, chemistry and dynamics of the stratosphere and mesosphere, proton and electron energy degradation and atmospheric interactions, and atomic physics

EDUCATION: 1972 - B.S. - (Highest Distinction) - Physics and Mathematics, Nebraska Wesleyan University, Lincoln, NE
1978 - Ph.D. - Aeronomy (Department of Physics and Astronomy), University of Florida, Gainesville, FL

PROFESSIONAL SOCIETY MEMBERSHIPS: Sigma Pi Sigma, Phi Kappa Phi, American Geophysical Union, Sigma Xi, Phi Beta Kappa

SPECIAL EXPERIENCE (selected):

1) Project Scientist for UARS (Feb. 1999-Dec. 2005); Dep. Proj. Sci. for UARS (Jul. 1993–Feb. 1999).
2) Project Scientist for the Aeronomy of Ice in the Mesosphere (AIM) Mission (since March 2009).
3) Member of Scientific Committee for the First International High-Energy Particle Precipitation in the Atmosphere (HEPPA) Workship, held in Helsinki, Finland in May 2008.
4) Member of Scientific Committee for the Second International High-Energy Particle Precipitation in the Atmosphere (HEPPA) Workship, held in Boulder, CO in October 2009.
5) Co-chair of the "Global Change and the Solar-Terrestrial Environment Workshop" in June 2010 held in Aspen, CO.

SELECTED PUBLICATIONS OF C. JACKMAN:

"Composition changes after the "Halloween" solar proton event: the High Energy Particle Precipitation in the Atmosphere (HEPPA) model versus MIPAS data intercomparison study," B. Funke et al., *Atmos.Chem.Phys.* **11**, 9089-9139, 2011.

"Northern Hemisphere atmospheric influence of the solar proton events and ground level enhancement in January 2005, " C. H. Jackman, D. R. Marsh, F. M. Vitt, R. G. Roble, C. E. Randall, P. F. Bernath, B. Funke, M. Lopez-Puertas, S. Versick, G. P. Stiller, A. J. Tylka, and E. L. Fleming, *Atmos. Chem. Phys.,* **11**, 6153-6166, 2011.

"Long-term middle atmospheric influences of very large solar proton events," C. H. Jackman, D. R. Marsh, F. M. Vitt, R. R. Garcia, C. E. Randall, E. L. Fleming, S. M. Frith, *J.Geophys.Res.,114*,D11304,doi:10.1029/2008JD011415, 2009.

"Short- and medium-term atmospheric effects of very large solar proton events," C. H. Jackman, D. R. Marsh, F. M. Vitt, R. R. Garcia, E. L. Fleming, G. J. Labow, C. E. Randall, M. Lopez-Puertas, B. Funke, T. von Clarmann, and G. P. Stiller, *Atmos. Chem. Phys., 8, 765-785, 2008*.

"Mesospheric dynamical changes induced by the solar proton events in October-November 2003," C. H. Jackman, R. G. Roble, and E. L. Fleming, *Geophys. Res. Lett., 34*, L04812, doi:10.1029/2006GL028328, 2007.

"Satellite measurements of middle atmospheric impacts by solar proton events in solar cycle 23," C. H. Jackman, M. T. DeLand, G. J. Labow, E. L. Fleming, and M. Lopez-Puertas, *Space Science Reviews, 125*, 381-391, 2006.

"Neutral atmospheric influences of the solar proton events in October-November 2003," C. H. Jackman, M. T. DeLand, G. J. Labow, E. L. Fleming, D. K. Weisenstein, M. K. W. Ko, M. Sinnhuber, and J. M. Russell, *J. Geophys. Res., 110*, A09S27, doi:10.1029/2004JA010888, 2005.

"The influence of the several very large solar proton events in years 2000-2003 on the neutral middle atmosphere," C. H. Jackman, M. T. DeLand, G. J. Labow, E. L. Fleming, D. K. Weisenstein, M. K. W. Ko, M. Sinnhuber, J. Anderson, and J. M. Russell, *Adv. Space Res.,* **35**, 445-450, 2005.

DANIEL MARSH

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Education

1999 Ph.D. Atmospheric and Space Sciences, University of Michigan
1996 M.Sc. Atmospheric and Space Sciences, University of Michigan
1988 B.Sc. Mathematics and Physics, University of California Berkeley

Professional Experience

2001-Present	Scientist, Atmospheric Chemistry Division, National Center for Atmospheric Research, Boulder, CO
1999-2001	Post-doctoral fellow, Advanced Study Program, National Center for Atmospheric Research, Boulder, CO
1994-1999	Graduate Research Associate, Space Physics Research Laboratory, University of Michigan, Ann Arbor, MI
1991-1994	Staff Research Associate, Space Sciences Laboratory, University of California, Berkeley, CA

Selected Refereed Publications

Damiani, A. et al. (2012), Impact of January 2005 solar proton events on chlorine species, *Atmos. Chem. Phys. Discuss.*, 12, 1935-1978, doi:10.5194/acpd-12-1935-2012.

Funke, B. et al. (2011), Composition changes after the "Halloween" solar proton event: the High-Energy Particle Precipitation in the Atmosphere (HEPPA) model versus MIPAS data intercomparison study, *Atmos. Chem. Phys. Discuss.*, 11, 9407-9514, doi:10.5194/acpd-11-9407-2011.

Jackman, C.H. et al. (2011), Northern Hemisphere atmospheric influence of the solar proton events and ground level enhancement in January 2005, *Atmos. Chem. Phys. Discuss.*, 11, 7715-7755.

Jackman, C. H., D. R. Marsh, F. M. Vitt, R. R. Garcia, C. E. Randall, E. L. Fleming, and S. M. Frith (2009), Long-term middle atmospheric influence of very large solar proton events, *J. Geophys. Res.*, 114, D11304, doi:10.1029/2008JD011415.

Marsh, D.R., R.R. Garcia, D.E. Kinnison, B.A. Boville, F. Sassi, S.C. Solomon, and K.Matthes (2007), Modeling the whole atmosphere response to solar cycle changes in radiative and geomagnetic forcing, *J. Geophys. Res.*, 112, D23306, doi:10.1029/2006JD008306.

Marsh, D.R., S.C. Solomon, and A.E. Reynolds (2004), Empirical model of nitric oxide in the lower thermosphere, *J. Geophys. Res.*, 109, A07301, doi: 10.1029/2003JA010199.

Professional Service

President, International Commission on the Middle Atmosphere (2011 - present).
Task Group Leader, SCOSTEP-CAWSES-II (2009 - present).
Co-chair, CCSM Whole Atmosphere Working Group (2008-2011)

CORA EINTERZ RANDALL

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Education

B.A. / Chemistry, with Honors. State University of New York, College at Purchase. 1982.
M.S. / Chemistry. University of California at Santa Cruz. 1983.
Ph.D. / Chemistry. University of California at Santa Cruz. 1985.

Professional Experience

5/10 – present:	Professor, University of Colorado, Dept. Atmospheric & Oceanic Sciences (ATOC) and Laboratory for Atmospheric & Space Science (LASP)
1/06 – 4/10:	Associate Professor, University of Colorado, ATOC/LASP
9/89 – 12/05:	Research Scientist, CU/LASP
9/87 – 8/89:	Research Scientist, University of California, Santa Cruz
9/86 – 8/87:	Post-doctoral Research Scientist, Carnegie Mellon University
1/86 – 8/86:	Post-doctoral Research Scientist, UC Santa Cruz
9/85 – 12/85:	Lecturer, Physical Chemistry (quantum mechanics/kinetics), UC Santa Cruz

Research at UC Santa Cruz and Carnegie Mellon University focused on laser spectroscopy and time resolved measurements of protein folding. Research at CU has focused on satellite remote sensing of the Earth and comets. Primary areas of expertise are atmospheric effects of energetic particle precipitation, stratospheric ozone depletion, polar mesospheric clouds, and satellite measurement validation. Currently principal Investigator on the NASA Aeronomy of Ice in the Mesosphere Cloud Imaging and Particle Size instrument. Current or previous member of numerous satellite science teams including AIM (NASA), ACE-FTS (Canada), HIRDLS (NASA), SOSST (NASA), ILAS2 (Japan), SAGE II (NASA), POAM (DOD), and HST/GHRS (NASA).

Honors

Elected Fellow of the American Geophysical Union, 2012
University of Colorado Excellence in Leadership Program Fellow, 2010-2011
University of Colorado Provost's Faculty Achievement Award, 2008
NASA Group Achievement Awards: AIM, 2008; Aura, 2005; SOLVE-II, 2004; HST, 1991
Alan Berman Research Publications Awards, Department of the Navy, 1996; 2003
Editors' Citation for Excellence in Refereeing, *Geophysical Research Letters*, 1998
University of California Regents Fellowship, University of California at Santa Cruz, 1982-1983
Outstanding Freshman Chemistry Award, American Chemical Society; Westchester, NY, 1979

Selected Publications

Randall, C.E., et al., NO_x descent in the Arctic middle atmosphere in early 2009, *Geophys. Res. Lett*. 36, L18811, doi:10.1029/2009GL039706, 2009. **AGU Editor's Highlight**.

Randall, C.E., et al., Energetic particle precipitation effects on the southern hemisphere stratosphere in 1992-2005, *J. Geophys. Res.*, 112, D08308, doi:10.1029/2006JD007696, 2007.

Randall, C.E., et al., Enhanced NO_x in 2006 Linked to Strong Upper Stratospheric Arctic Vortex, *Geophys. Res. Lett*., 33, L18811, doi:10.1029/2006GL027160, 2006.

Randall, C.E., et al., Stratospheric effects of energetic particle precipitation in 2003-2004, *Geophys. Res. Lett*. 32, L05802, doi:10.1029/2004GL02203, 2005. **AGU Editor's Highlight**.

Randall, C.E., et al., Stratospheric NO_x Enhancements in the Southern Hemisphere Polar Vortex in Winter and Spring of 2000, *Geophys. Res. Lett.* 28, 2385-2388, 2001.

CURRICULUM VITAE

Name of Researcher: Assoc. Prof. Craig J. Rodger

Tertiary Education:

BSc (Hons)	University of Otago	December 1993
PhD	University of Otago	August, 1997

Distinctions/Honours:

- Member of the NASA Small Explorer Review Panel (Washington DC, US$300 million, Feb-March 2008). Also member of the NASA Radiation Belt Storm Probes mission panel (US$100 million, Feb-March 2006), the NASA Heliophysics Guest Investigators Program (US$4.5 million, August 2006), and the Living With a Star TR&T Program Review Panel (US$14 million, 2-4 Feb. 2011).
- University of Otago Excellence in Teaching Award (2011).
- Conclusions of study [*Howitt et al.,* 2011] selected as a Research Highlight in the December 2011 edition of Nature Climate Change.
- Conclusions of study [*Seppälä et al.,* 2009] selected as a highlight in the 2010 science activities of the British Antarctic Survey and featured in their Annual Report.
- Conclusions of studies [*Sauvaud et al.*, 2008; *Gamble et al.*, 2008] described in New Scientist website, Physics Today (Vol. 61, No 7, August 2008) and Pour la Science magazines (No. 307, August 2008). Study picked as editors highlight of the American Geophysical Union journal Geophysics Research Letters.
- Conclusions of study [*Rodger et al.*, 2006] described in *New Scientist* (issue 2565, 19 Aug. 2006), selected as NERC 2006 highlight.
- Otago Univ. Early Career Award for Distinction in Research (2004)
- Elected Co-chair of the IAGA/ URSI joint working group on VLF/ ELF Remote Sensing of Ionospheres and Magnetospheres (VERSIM), 2003-
- Papers selected as scientific highlight of that month's *Geophysical Research Letters* [*Rodger et al.*, 2001; *Rodger and Clilverd*, 2002].
- First-ever southern hemisphere lead author to gain the cover image of *Geophysical Research Letters* [*Rodger et al.*, 2001].
- Inaugural Hatherton Award, *Royal Society of New Zealand*, 1997.

Publications:

122 papers in international peer-reviewed journals.
30 non-refereed outputs.
Author on 36 invited presentations at conferences and 1 plenary lecture.

Current Position:

- Associate Professor, Department of Physics, University of Otago.

Other Information:

Marsden Fund Contracts

- Principal Investigator (NZ$700k) UOO1012, 2011-2014
- Principal Investigator (FastStart, NZ$375k) UOO214, 2003-2005
- Associate Investigator LFE801, 1998-2001
- Contributing Researcher UOO519, 1995-1998

Other Research Funding awarded

- European Union FP7 Work Package Leader (€1.97 million), 2011-2014
- PI of Antarctica New Zealand Event K060 (deployed December 2008)
- International network partner in the THERMES project funded by the Academy of Finland (€383,000/year)

CURRICULUM VITAE

PERSONAL INFORMATION

NAME Annika Seppälä. NATIONALITY Finn. E-MAIL annika.seppala@fmi.fi

HIGHER EDUCATION

Ph. D., Physics, University of Helsinki, Finland, October 2007.
Doctoral Thesis: Observations of production and transport of NO_x formed by energetic particle precipitation in the polar night atmosphere.

M. Sc., Physics, University of Helsinki, Finland, June 2003.

PROFESSIONAL INTERESTS

Effects of Energetic Particle Precipitation (EPP) on the polar atmosphere. Roles of solar, geomagnetic and EPP activity in polar climate variability. Coupling processes in the atmosphere. Atmospheric and climate modelling. Increased understanding of particle precipitation sources. Atmospheric observations and satellite measurements.

CURRENT POSITIONS

Research Scientist, Earth Observation, Finnish Meteorological Institute, Helsinki, Finland.
COST ES1005 action (*Towards a more complete assessment of the impact of solar variability on the Earth's climate*) Management Committee.
Co-leader of SCOSTEP CAWSES-II Task 1 *What is the solar influence on climate?*
EGU Solar-Terrestrial Sciences Division's Education, Outreach and News Liaison Officer.
Scientific Organising Committee, SCOSTEP CAWSES-II International Symposium, Nov 2013, Nagoya, Japan.

CAREER

British Antarctic Survey/NERC. Marie Curie Fellow, 2009–2011.
Finnish Meteorological Institute, Earth Observation. Research scientist, 2003–Present.
Finnish Meteorological Institute, Geophysical Research. Research scientist, 2002–2003.
University of Oulu, Sodankylä Geophysical Observatory. Research assistant, 2001–2002.
Finnish Meteorological Institute, Geophysical Research. Research assistant, 2001.

VISITING SCIENTIST

Marie Curie Fellow, Climate program, British Antarctic Survey, Cambridge, UK. (2009–2011)
Physical Sciences Division, British Antarctic Survey, Cambridge, UK. (2005, -06, -07, -08, -09)
Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, USA. (2005)
Centre for Space Physics, Boston University, Boston, USA. (2006)
Space Physics Group, University of Otago, Dunedin, New Zealand (2006, -07)

DISTINCTIONS/HONOURS

Marie Curie Fellowship, 2009.
Academy of Finland Postdoctoral researcher, 2009.
IAGA Young Scientist Presentation Award, 2nd HEPPA Workshop, 2009.
ISSI International Team, Team leader, 2009–2011.
IAGA Young Scientist Presentation Award, 2nd VERSIM Workshop, 2006.

PUBLICATION ACTIVITY

Over 40 refereed publications, over 10 invited presentations.

March 21, 2012

Dr. Miriam Sinnhuber

CV

Born February 11, 1971, in Göttingen, Germany

2000, PhD in atmospheric physics, University of Bremen, topic of thesis: "Chlorine activation and PSC formation in the Arctic stratosphere”

October - December 2000, Post-doc, Space Research Organisation of the Netherlands, Groningen

01/2001 – 12/2001, Guest scientist, School of the Environment, University of Leeds, UK, topic of research: modelling of stratospheric and mesospheric chemistry

03/2001, Guest scientist, NASA Goddard Space Flight Center, MD, US, topic of research: modelling the impact of solar proton events on the middle atmosphere

2001 – 2003, Post-doc, Institute of Environmental Physics, University of Bremen, Topic of research: model studies of the impact of solar proton events onto the middle atmosphere in a changing magnetic field

12/2003 – 08/2010, Group Leader of the 'Mesosphere' research group, Institute of Environmental Physics, University of Bremen, Topic of Research: Modelling of mesospheric chemistry and it's impact on the stratosphere, energetic particle precipitation

08/2010 – present, Senior Scientist and Helmholtz Young Investigators' Group Leader “Solar variability, climate, and the role of the mesosphere / lower thermosphere”, Karlsruhe Institute of Technology

Awards, Honours, and Related

NASA Group Achievement Award "in recognition of outstanding accomplishments and contributions to the extremely successful SAGE III Ozone Loss and Validation Experiment", 2001

Editors Citation for excellence in refereeing for outstanding service to the authors and readers of Journal of Geophysical Research - Space Physics, May 2006

Nominated associate editor of the Journal of Geophysical Research - Space Physics, January 2006 - December 2007

Dr. Joachim Urban

Chalmers University of Technology, Dept. of Earth and Space Sciences, 412 96 Gothenburg, Sweden
phone: ++46/(0)31/772-1839 fax: ++46/(0)31/772-1884 e-mail: joaurb@chalmers.se

Professional Experience:

- from September 2004: Research Scientist at the Chalmers University of Technology (Gothenburg, Sweden).
- June 2000 - June 2004: Ingénieur de Recherche at the Observatoire de l'Université Bordeaux 1, CNRS/INSU (France).
- July 1998 - May 2000: Research scientist at the Observatoire de l'Université Bordeaux 1, CNRS/INSU (France).
- December 1997- June 1998: Research scientist at the Institute of Remote Sensing, University of Bremen (Germany).

Education:

- 11 March 2008: Docent, Chalmers University of Technology (Gothenburg, Sweden).
- 19 June 2007 Habilitation à Diriger des Recherches (HDR), Université Bordeaux 1 (France).
- 27 November 1997: Ph.D. (Dr.rer.nat.), University of Bremen (Germany).
- 1993 - 1997: Research associate / Ph.D.-student at the Institute of Environmental Physics, University of Bremen (Germany).
- 20 April 1993: Diploma in Physics, University of Bremen (Germany).

Selection of relevant publications:

Orsolini, Y.J., J. Urban, D.P. Murtagh, S. Lossow, and V. Limpasuvan, Descent from the polar mesosphere and anomalously high stratopause observed in 8 years of water vapor and temperature satellite observations by the Odin Sub-Millimetre Radiometer, J. Geophys. Res., 115, D12305, doi:10.1029/2009JD013501, June 2010.

Urban, J., M. Pommier, D.P. Murtagh, M. Santee, and Y. Orsolini, Nitric acid in the stratosphere based on Odin observations from 2001 to 2009: Part 1: A global climatology, Atmos. Chem. Phys., 9, 7031-7044, September 2009.

Orsolini, Y., J. Urban, D.P. Murtagh, Nitric acid in the stratosphere based on Odin observations from 2001 to 2009: Part 2: High-altitude polar enhancements, Atmos. Chem. Phys., 9, 7045-7052, September 2009.

Jin, J.J., K. Semeniuk, S.R. Beagley, V.I. Fomichev, A.I. Jonsson, J.C. McConnell, J. Urban, D.P. Murtagh, G.L. Manney, C.D. Boone, P.F. Bernath, K.A. Walker, B. Barret, P. Ricaud, and E. Dupuy, Comparison of CMAM simulations of carbon monoxide (CO), nitrous oxide (N2O), and methane (CH4) with observations from Odin/SMR, ACE-FTS, and Aura/MLS, Atmos. Chem. Phys., 9, 3233-3252, May 2009.

S. Lossow, J. Urban, H. Schmidt, D.R. Marsh, J. Gumbel, P. Eriksson , D.P. Murtagh, Wintertime water vapour in the polar upper mesosphere and lower thermosphere - first satellite observations by Odin/SMR, J. Geophys. Res. 114, D10304, doi:10.1029/2008JD011462.

Lossow, S., J. Urban, J. Gumbel, P. Eriksson and D.P. Murtagh, Observations of the mesospheric semi-annual oscillation (MSAO) in water vapour by Odin/SMR, Atmospheric Chemistry and Physics, 8, 21, 6527-6540, 2008.

CV

23rd March 2012

PERSONAL DETAILS

Name	Pekka Tapani Verronen
Date of birth	October 26, 1970
Place of birth	Rautio, Finland
Work address	Finnish Meteorological Institute, P.O. Box 503 (Erik Palménin aukio 1), FI-00101 Helsinki, Finland
Telephone	+358-9-19294642, +358-44-5333109
Telefax	+358-9-19293146
Email	pekka.verronen@fmi.fi

EDUCATION

Ph.D. (Physics)	University of Helsinki, June 16, 2006.
Lic. Phil. (Physics)	University of Helsinki, October 12, 2001.
M. Sci. (Physics)	University of Jyväskylä, December 3, 1997.
Dipl. Phys.	University of Kent at Canterbury, July 1, 1996.

CAREER

Academy Research Fellow	Academy of Finland/Finnish Meteorological Institute, Earth Observation, since August 2010.
Senior Research Scientist	Finnish Meteorological Institute, Earth Observation, from June 2006 to July 2010.
Research Scientist	Finnish Meteorological Institute, Geophysical Research/Earth Observation, from November 1997 to May 2006.

SCIENTIFIC PUBLICATIONS SUMMARY

- 45 peer-reviewed papers on middle atmospheric and ionospheric physics and chemistry (first author or co-author, full list at www.ava.fmi.fi/∼verronen/pubList.pdf). More than 500 citations, h-index 13.

LATESTS INVITED TALKS

1. Invited presentation entitled *Particle effects on different layers in numerical models*, given at the 1st science meeting of COST Action ES1005: Towards a more complete assessment of the impact of solar variability on the Earth's climate, November 2011, Potsdam, Germany.

2. Invited presentation entitled *Ionic Production of Hydroxyl and Nitric Acid in the Mesosphere During Solar Proton Events* given at the XXV General Assembly of the International Union of Geodesy and Geophysics (IUGG), July 2011, Melbourne, Australia.

Curriculum vitae: Stefan Versick

Personal Details

Name:	Stefan Versick
Date of birth:	June 24, 1980
Place of birth:	Heidelberg, Germany
Current position:	Research scientist, Karlsruhe Institute of Technology, Steinbuch Centre for Computing, Simulation Lab Climate and Environment

Education

2000–2006	Diploma in Meteorology at University of Karlsruhe (TH)
2006–2010	Dr. rer. nat., University of Karlsruhe/Karlsruhe Institute of Technology

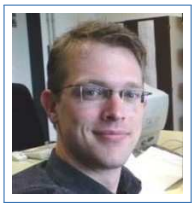
Doctoral Thesis

Original title:	*Ableitung von H2O2 aus MIPAS/ENVISAT-Beobachtungen und Untersuchung der Wirkung von energetischen Teilchen auf den chemischen Zustand der mittleren Atmosphäre*
Engl. title:	*Retrieval of H2O2 from MIPAS/ENVISAT-observations and investigation of energetic particle effects on the chemistry of the middle atmosphere*
Supervisor:	Prof. Dr. Herbert Fischer

Scientific Publications related to the Research Study Project

2010	T. Reddmann, R. Ruhnke, S. Versick, W. Kouker; Modeling disturbed stratospheric chemistry during solar-induced NOx enhancements observed with MIPAS/ENVISAT, Journal of Geophysical Research, 115(D00I11)
2011	B. Funke et al.; Composition changes after the "Halloween" solar proton event: the High Energy Particle Precipitation in the Atmosphere (HEPPA) model versus MIPAS data intercomparison study. Atmos.Chem.Phys., 11, 9089-9139
2011	C.H. Jackman et al.; Northern Hemisphere atmospheric influence of the solar proton events and ground level enhancement in January 2005, Atmos.Chem.Phys., 11, 6153-6166

March 28, 2012



Jan Maik Wissing

Dr. rer. nat.

Personal Information

born **February 20th, 1980**.

recent position **Research Scientist**, *University of Osnabrück, Numerical Physics, Space Physics*.

Education

2000–2005 **Diploma in Physics**, *University of Osnabrück*.

2006–2011 **Dr. rer. nat.**, *University of Osnabrück*.

Doctoral Thesis

title *Analysis of Particle Precipitation and Development of the Atmospheric Ionization Module OSnabrück - AIMOS*

supervisor Prof. Dr. May-Britt Kallenrode

Selected Presentations

- 2011 - International Living with a Star (ILWS) Workshop Beijing, *invited talk*
- 2011 - IUGG Melbourne, *invited talk*
- 2011 - 3rd High Energy Particle Precipitation in the Atmosphere (HEPPA) Granada

Selected Publications relevant to the Research Study Project

J. M. Wissing and M.-B. Kallenrode. Atmospheric Ionization Module OSnabrück (AIMOS): A 3-D model to determine atmospheric ionization by energetic charged particles from different populations. *J. Geophys. Res.*, 114(A06104), 2009. doi:10.1029/2008JA013884.

J. M. Wissing, M.-B. Kallenrode, J. Kieser, H. Schmidt, M. Rietveld, A. Strømme, and P. Erickson. Atmospheric Ionization Module OSnabrück (AIMOS) 3: Comparison of electron density simulations by AIMOS-HAMMONIA and incoherent scatter radar measurements. *J. Geophys. Res.*, 116(A08305), 2011. doi:10.1029/2010JA016300.

B. Funke et al. (incl. J. M. Wissing). Composition changes after the "Halloween" solar proton event: the High-Energy Particle Precipitation in the Atmosphere (HEPPA) model versus MIPAS data inter-comparison study. *Atmospheric Chemistry and Physics*, 11(acp-2010-1001):9089–9139, 2011.

Award

- Cospar Outstanding Paper Award For Young Scientists for the paper entitled "Variation of Energetic Particle Precipitation with Local Magnetic Time" published in Advances in Space Research, 2008

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http://sun.physik.uos.de/~maik/publications.html