GeoSpace at the System-Level

Abstract

We propose an ISSI study group to define the science questions and experimental programs necessary to understand geospace at the system level. Our overarching objective is to bring focus and clarity to system-level geospace science, producing a set of review papers that will in effect be an international "decadal survey". The outcome will be a touchstone for future work that targets understanding geospace as a whole. It will enable, for example, future global imaging missions that are essential to our ability to bring closure to an entire class of geospace research questions, but are at the same time proving difficult to get approved because of our inability to identify closable science questions related to geospace as a whole. We are bringing together a team of researchers with expertise in global modelling, natural complexity, and a range of synoptic observations, to carry out seven tasks. This work includes definition of science questions, establishment of observational requirements to address those questions, and a survey of new observation techniques that will meet those requirements. The final task will be to outline a strategy for the closure of key questions through theoretical and computational studies. To the best of our knowledge this study is unique in its objectives and scope. Due to the breadth of scope, and multidisciplinary nature of the work, we believe that ISSI will provide the best and possibly only opportunity for an international group of this type to devote the time necessary to achieve our objectives.

Scientific rationale

Numerous plasma processes mediate energy, momentum and mass transfer from the solar wind to the magnetosphere, and subsequent transport through the system and deposition in the sinks. These include magnetic reconnection, plasma waves, wave-particle interactions, magnetohydrodynamic (MHD) instabilities, and parallel electric fields. Understanding these geospace processes is important because they are of obvious significance to not only expand our fundamental knowledge of cosmic physical processes but also to determine causes and effects of space weather that can impact technological systems. For a "fundamental knowledge" example, the Sun-Earth system is the only astrophysical object in which magnetic reconnection and its consequences can be directly observed. Collisionless shocks, turbulence, and self-organized plasma dynamics are among other important questions to which geospace study can provide crucial insight. For examples of real-world applications with societal and economic effects, magnetic storms and MHD waves enhance radiation belt fluxes of charged particles that pose a danger to satellites and astronauts, magnetic storms have knocked out power grids, and there are possible links between geospace phenomena and climate. Our field has mapped out the overall magnetospheric topology, and identified interesting plasma physical processes. We are now moving from a predominantly *discovery* mode into what can reasonably be called the *quantitative era of geospace science*. The scientific objectives are to go beyond phenomenology, and quantify effects of key geospace processes and develop predictive capabilities that both test our understanding against observation, and bring this developing knowledge to real world applications.

Compared to thermodynamics as an ideal of system science (where a few variables describe the system behavior), geospace is qualitatively different and considerably more complex. Each of its components is in imperfect thermal contact with its neighbors, and no state equivalent to thermal equilibrium exists. This off-equilibrium perspective highlights two essential aspects of geospace:

multiscale coupling and intermittent boundary layer dynamics in facilitating energy transfer within the system. While geospace can be described hierarchically, research has shown that each scale hierarchy is strongly coupled to the next, both in forward (cascade) and backward (avalanche) directions. The importance of boundary dynamics, when suitably relaxed to include kinetic-scale structures, covers reconnection on both the dayside magnetosphere and in the tail, particle injection into the ring current, topside magnetosphere-ionosphere coupling, as well as many plasma instabilities associated with a thin current sheet. Interactions and self-organization across scales is a major unsolved problem in our field.

Figure 1 illustrates our view of geospace as a *complex coupled system*. All the energy and much of the mass that populates geospace comes from the Sun, represented by the box on the left ("sources"). Ultimately, energy and mass end up in a number of "sinks" listed in the box on the right. Physical processes affect how energy and mass are transported from the source to the sinks. These operate in geospace, and are numerous (we have listed just a few at the center of the diagram). The processes interact with each other, and are integral to the multi-scale nature of geospace. Many of these processes are understood only empirically, and some are understood only through simulation and theory. Furthermore, we do not know right now which of these processes are dominant in terms of global mass and energy budget or when a certain process is dominant. In other words, while some of these processes occur in the system, it may be that if they were excised, there would not be any measurable effect on the global dynamic. For example, Kelvin-Helmholtz and other surface waves certainly exist on the magnetopause, but if the boundary was somehow changed so that it could not support their existence, would the ULF wave power distribution in the magnetosphere be measurably different? Would the radiation belt evolution be different? Would the MI coupling be different in its overall effect? Moreover, these processes interact with each other, there is interaction between the sinks and these processes, and interaction between the sinks (the latter in some sense being the mission deliverable of IMAGE). So it is not as simple as source, process, and sink. Geospace is a complex coupled system that is more than a simple passive recipient of solar energy - it is an active participant and source of much of the observed dynamics.

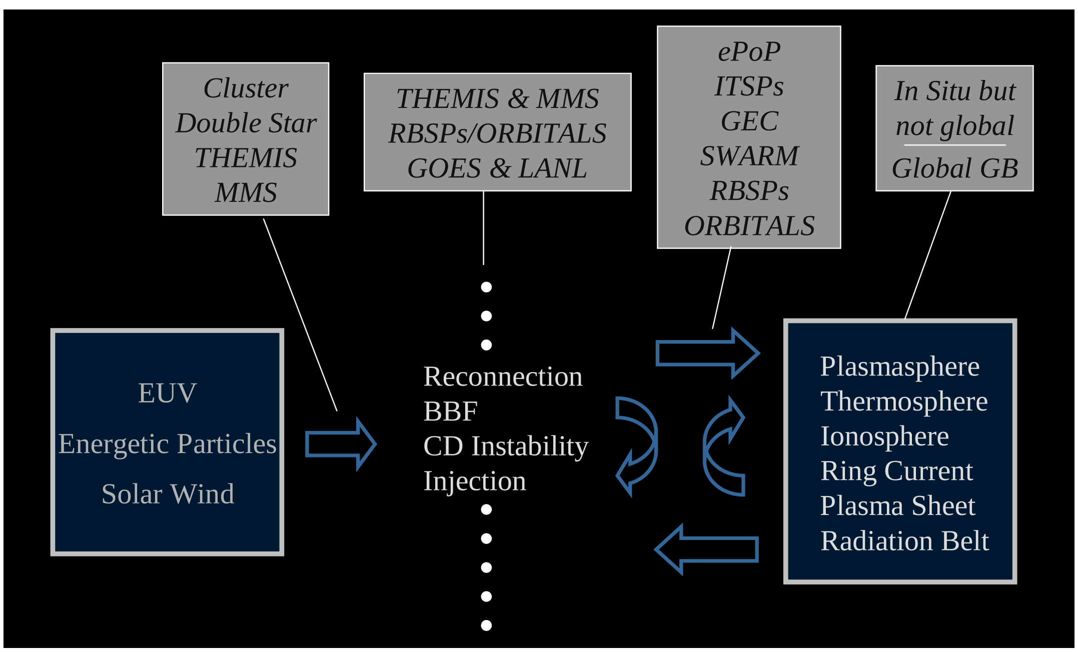

Figure 1: Geospace at the systems level. See Text for complete description.

On the one hand, there is very little in GeoSpace that we do not know something concrete about. *On the other hand, however, the long sought after system level understanding has largely eluded our grasp*. This is not at all surprising, for even the ISTP constellation never really allowed for simultaneous observations all the way along the energy/mass transport path. Further, the ISTP studies clarified *what we need to do*. The need to resolve the order of events in substorm onset led to THEMIS. The need for kinetic scale observations in the reconnection region led directly to the Magnetospheric Multi-Scale (MMS) mission. ISTP moved us forward, but in doing so uncovered deeper mysteries that have in turn led to more sophisticated missions targeted at exploration of specific physical processes. In fact, this push to explore fundamental physical processes in geospace to understand what drives them and what they affect has led not only to THEMIS, and MMS, but also planned and proposed missions including ePOP, the RBSPs, ORBITALS, ERG, the ITSPs, and in the longer term Cross Scale.

The plethora of new missions that have been approved and that target specific processes with *in situ* observations represents a remarkable opportunity for our field. As innovative and exciting as these missions are, however, they will provide only part of the overall picture. Obviously, system-level science can only be achieved once we succeed in marrying *in-situ* with global measurements Providing global observations has been the primary motivator behind SuperDARN, MIRACLE, Canadian Geospace Monitoring, and previous space missions in which global imaging of the aurora, ring current, and plasmasphere has been carried out. It is the motivation for current activities designed to create virtual observatory networks of magnetometers, riometers, and all-sky imagers that span the globe. This includes the planned United States Distributed Arrays of Small Instruments (DASI) initiative, which if it goes forward will involve the deployment of a worldwide array of ground-based geospace instrumentation, with the stated objective being to facilitate system level science. Regardless of the capabilities of these and other ground-based observing programs, it is understood that global imaging from space is an important part of an overall international program aimed at system-level geospace science. It is worrisome, then, that while we are coming into a period during which our *in situ* capabilities will be better than they have ever been, there are no approved geospace global imaging projects on the horizon.

We propose an ISSI study group focused on System-Level Geospace Science. Our tasks are daunting, but very necessary at this juncture in the evolution of our field. The following are challenges to our collective efforts to achieve system-level understanding of geospace:

1. The lack of approved global imaging missions.
2. The fact that in the proposal stage system-level investigations are broad and often unfocussed, so that the "science" is often difficult to identify.
3. A dearth of practical tools to merge global imaging, in-situ, and ground-based observation to render a more complete picture of geospace.
4. A need to expand our conceptual framework toward the closure of system-level science challenges with new theoretical and modeling techniques to complement what exists today.

In response to the above challenges, we set the objectives of this study group as follows:

1. Review published works in which system-level aspects of geospace have been addressed.
2. Review techniques for obtaining information at the system-level (e.g., global) from the ground and in space. This will include space-based systems such as Energetic Neutral Atom, X-Ray, and auroral imagers, as well as global networks of ground-based instruments (GPS, magnetometers, riometers, optical instruments, HF, VHF, and UHF radars, etc.).

3. Clarify the set of questions that must be addressed in order for us to achieve a system-level understanding of geospace (see below).
4. Develop a set of "observational requirements" that must be met in order to address the questions listed in 3. Addressing the set of questions we will develop will require better observations. For example, addressing issues related to natural complexity will drive us to obtain simultaneous spectra of spatial and temporal fluctuations of various geospace parameters.
5. Review new technologies that are practical to implement and that can provide new insights into geospace on the global scale. Possible new systems for obtaining global-scale information about geospace include the planned Distributed Arrays of Small Instrumentation program, imagers with better temporal, spatial, and spectral resolution than previously obtained, and tomographic observations of large parts of the magnetospheric and ionosphere.
6. Using the results of 3-5, develop a realistic plan for global-scale observations that will, together with the above-mentioned upcoming *in situ* programs, allow us to achieve true system-level understanding of geospace over the next several decades.
7. Outline a strategy for the closure of key questions through theoretical and computational studies.

Referring in particular to 3, above, we will endeavor to identify science objectives that embody system-level science and that are both focused and closeable. This is a challenging task, but must be addressed to enable, for example, future global imaging missions. While defining these questions is part of the work we are proposing, we suggest two here in brief as examples of what we are talking about:

3.1 Our field has traditionally approached problems on the global scale in a reductionist and deterministic fashion. In recent years, work on nonlinear dynamics, threshold physics, and natural complexity have called such approaches into question. One example of a problem we will clarify is "*What aspects of geospace system-level dynamics are deterministic and therefore predictable in principle at least*?"

3.2 In the inner magnetosphere the ring current, plasmaspheric, and ion and electron CPS populations overlap in space and interact. In recent years (e.g., from IMAGE), we have obtained evidence of how this interaction leads to wave-particle interactions and subsequent particle loss, distortions of boundaries, transport of plasma in phase space, and other global effects. Upcoming *in situ* missions will clarify the role smaller-scale processes play in these interactions; however, we need to advance our understanding of the global dynamic. Specific questions may include *"How does the CPS feed particles to the ring current?" "What are the global-scale consequences of wave-particle interactions?" "What is the role of the substorm in the storm?"*

As an example of how the questions developed in 3 will flow through to observational requirements, we refer to the specific examples 3.1 and 3.2 listed above. For example, the question posed in 3.1 will require synoptic observations on multiple scales in time and space. In task 4 we will attempt to quantify what set of parameters is best suited to address this problem, and at what range of scales. Questions of the sort raised in 3.2 require synoptic observations of the inner magnetospheric plasma populations. We will, for example, investigate what orbital configuration, number of vantage points, and what ENA mass resolution are needed to provide ring current and higher energy ion CPS observations sufficient to address the questions posed. We will do the same for the global auroral, and plasmaspheric observations, and E and B-field specification.

To address the seven objectives listed above, we have assembled a team of active researchers with significant expertise in global modeling, natural complexity, and the various modes of global observation that are likely to be important in the years to come. In our opinion, this group has the correct mix of skills and experience to face the ambitious challenges we have set for ourselves in the above list. The results of this ISSI study group will provide an important touchstone for system-level studies. More importantly, these results will enable research teams to more effectively pursue funding for ground-based systems and missions aimed at global studies of geospace. Most importantly, our team will hopefully provide a paradigm for discussing global system-level geospace science, taking into account both targeted *in situ* and global observations.

Expected output

We plan to complete a book which will contain a series of reviews of the current knowledge of physics, the status of instrumentation, and outstanding questions that together form a framework for future studies of geospace at the system level. This book will be an important information source for future mission planning, will clarify what we as a field mean by "system-level science", and will present a clear science vision for such studies in the future.

Added Value of ISSI and ISSI Facilities Required

ISSI provides a unique environment in which groups of likeminded researchers can be brought together to complete a set of tasks. This is particularly relevant for this proposed work. We are not aware of any previous efforts to formulate a framework for system-level studies in geospace. The work is new, broad in scope, and multi-disciplinary. Carrying this work out would elucidate paths for future research, and enable system-level studies by providing a framework for proposals for large-scale studies including satellite missions. Further, the proposed work is ambitious. We feel that the program of work described in this proposal would not be done without this environment and the resources available at ISSI. In addition, ISSI can provide the support for the production of a book which contains the material that will be produced from this ambitious but necessary program. The work described here requires such a text in order to keep the linked material together.

The group will require the standard facilities available at ISSI, e.g. access to internet, the institute library, meeting rooms, break out rooms.

Strawman Schedule

Pre Meeting 1: Organizers to identify detailed topics for discussion at first meeting

Meeting 1 (September 07 – one week duration): The structure of the programme will be determined; initial distribution of tasks will be agreed; sub-groups will start work on tasks 1 – 4.

Meeting 2 (March 08 – one week duration): Based upon work done between meetings tasks 1 – 4 will be completed and draft "chapters" will be prepared. Tasks 5 and 6 will be initiated.

Meeting 3 (February 09): Early chapters will be reviewed between meetings and finalised at this meeting. One week during which Tasks 4 – 6 will be completed and draft chapters prepared. Completion of final chapters will be done in period after this meeting but before the end of the two year period.

Financial Support

The ambitious programme that we have set ourselves, as illustrated in the Schedule above, requires the group to have 3 full meetings. We, therefore, request support for the travel expenses of the organizer of this session (Dr. Mark Lester) which will be ~1500 Euros per trip, plus the subsistence costs for the members of working team for each of the meetings.

Appendix A

Confirmed Participants

The organizer of the study group will be Mark Lester of Leicester University (UK). The team has been selected to bring together the elements of global imaging, global ground-based networks, global modeling, and natural complexity. This team is well positioned to and capable of developing a vision for system-level studies of geospace.

Brandt, Pontus	brandpc1@jhuapl.edu	USA
Denton, Mick	m.denton@lancaster.ac.uk	UK
Donovan, Eric	eric@phys.ucalgary.ca	Canada
Frey, Harald	hfrey@apollo.ssl.berkeley.edu	USA
Lester, Mark	mle@ion.le.ac.uk	UK
Liemohn, Michael	liemohn@umich.edu	USA
Liu, William	William.liu@space.gc.ca	Canada
Milan, Steve	ets@ion.le.ac.uk	UK
Østgard, Nikolai	nikost@ift.uib.no	Norway
Palmrooth, Minna	Minna.Palmroth@fmi.fi	Finland
Ridley, Aaron	ridley@umich.edu	USA
Uritsky, Vadim	Vadim@phas.ucalgary.ca	Canada
Zhang, Xiaoxin	xxzhang@spaceweather.ac.cn	China

Appendix B Short CVs of Proposed Participants in Team

Curriculum Vitae of Dr. Pontus C. Brandt

Short History

2000-: PDF and Senior Professional Staff Scientist at APL (supervisor: R. W. McEntire).

1994-1999: PhD Umea University: thesis entitled “ENA imaging of planetary magnetospheres”.

Pontus Brandt focus emerged out of the innovative new technique of Energetic Neutral Atom (ENA) imaging. He has taken advantage of ENA instruments not only on satellites in orbit around the Earth (e.g. IMAGE/HENA), but also on planetary probes allowing studies of the plasma environments around other planets and moons. His projects have included observational and theoretical studies of the low-altitude ring current-upper atmosphere interaction and of ion outflow from the polar cap, Saturn’s magnetospheric dynamics and plasma interactions with Titan, energization of plasma during storms, and ring current interactions with the plasmasphere. His paper on ENA substorm observations was highlighted in GRL Volume 29, number 20. DR. Brandt has been PI or CoI on 5 NASA and NSF grants over the past several years including bein PI on the SEC Guest Investigator project entitled “The relationship between the ring current and electric fields in the inner magnetosphere during storms”. He has developed code for the analysis of IMAGE/HENA and Cassini/INCA data, and to infer currents and magnetic fields from pressure distributions obtained by ENA imagers. He is a Scientific Co-I on Mars-Express/Aspera-3, Venus Express/Aspera-4, Double Star/NUADU, and is involved in the mission definition for Ravens, and KuaFu-B.

Representative Publications

Brandt, P. C., J. Goldstein, P. C. Anderson, B. J. Anderson, R. DeMajistre, E. C. Roelof, and D. G. Mitchell, On the relation between the ring current and electric fields, AGU Geophysical Monograph Series 155, doi: 10.1029/155GM19, p. 163-172, 2005.

Brandt, P. C., J. Goldstein, P. C. Anderson, B. J. Anderson, R. DeMajistre, E. C. Roelof, and D. G. Mitchell, On the relation between electric fields in the inner magnetosphere, ring current, auroral conductance, and plasmapause motion, AGU Geophysical Monograph Series 159, doi: 10.1029/159GM12, p. 159-166, 2005.

Brandt, P. C., D. G. Mitchell, R. DeMajistre, E. C. Roelof, S. Ohtani, J. –M. Jahn, C. J. Pollock and G. D. Reeves, Storm-Substorm Relationships During the 4 October, 2000 Storm. IMAGE Global ENA Imaging Results, *AGU Geophys. Monogr.*, Vol. 104, p. 103-118, doi: 10.1029/142GM10, 2004.

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Mitchell D. G., Brandt, P. C., Roelof, E. C., Dandouras, I., Krimigis, S. M., and Mauk, B. H., **“**Energetic Neutral Atom Emissions from Titan Interaction with Saturn's Magnetosphere”, *Science*, 308, 989-992, doi:10.1126/science.1109805, 2005.

Roelof, E. C., P. C. Brandt, and D. G. Mitchell, Derivation of currents and diamagnetic effects from global pressure distributions obtained by IMAGE/HENA, Adv. Space Res., 33/5, 747–751, doi:10.1016/S0273-1177(03)00633-1, 2004.

Research Profile

Michael H. Denton was recently appointed to a lectureship at Lancaster University (UK) and the Department of Communication Systems (August 2006). The appointment is recognition for an extensive and productive research career that has focused on the theoretical and practical applications of research into near-Earth space.

An author of over 20 publications in peer-reviewed international journals, Dr. Denton began his research career after completing an undergraduate degree in physics at University of Sheffield (UK). A PPARC-sponsored Ph.D in the Applied Mathematics Department, also at University of Sheffield, concerned computational mathematical modelling of the near-Earth environment. Extensive modelling work revealed the importance of the ionised helium content in the refilling of magnetic flux tubes in the Earth's plasmasphere and ionosphere following geomagnetic storms. A three-year PPARC sponsored post-doctoral appointment at the University of Wales, Aberystwyth (UK) brought valuable experimental experience. Dr. Denton was responsible for the day-to-day operation of a complex tomographic experiment located in the high-Arctic. Radio receivers, deployed on the northern coast of Norway and within the Svalbard archipelago, revealed the structure of the ionosphere, the layer of the atmosphere directly responsible for HF radio communications. In 2002 Dr. Denton worked on the specification and purchase of a major upgrade to the experiment.

Following these early successes, Dr. Denton accepted a position as post-doctoral Fellow at the US-government Los Alamos National Laboratory (LANL). In the period between 2003 and 2005, his appointment led to the publication of four first-author papers, eleven co-authored papers, and presentations at sixteen national and international conferences and workshops. The collaborations made during this period are still being exploited. Most of the work carried out at whilst at LANL, and Dr. Denton's current research, concerns the space environment, and its effects upon hardware and orbital assets. A recent collaboration between Dr. Denton, The Boeing Corporation, and LANL indicates the practical applications and industrial interest in this area of study. Immediately prior to his lectureship appointment, Dr. Denton was a PPARC post-doctoral researcher at University of Southampton (UK). Collaborations with LANL continue as evinced by the recent visit of Dr. Joseph Borovsky (LANL) to Southampton in February 2006 and to Lancaster in September 2006.

Dr. Denton teaches two undergraduate courses at Lancaster and is Publicity Officer for the department. He has been instrumental in the design and approval of a new joint degree scheme with the Physics Department at Lancaster.

- Convenor and co-organiser of the international workshop on High Speed Solar Wind Streams, to be held in Ambleside, UK in September 2007 (*www.dcs.lancs.ac.uk/iono/hssgi2007*).
- Coordinator for the NASA IMAGE/MENA instrument input to the US National Science Foundation (NSF) Inner-Magnetosphere Working Group (GEM), 2003-2006.
- Member of the NSF Ionosphere/Plasmasphere Working Group (GEM), 2004-2006.
- Editor's Highlight" in Geophysical Research Letters [*GRL, 33, L20101, doi:10.1029/2006GL026519, 2006*]. The study details how the cold plasma from the Earth's atmosphere can interact with, and suppress the coupling between the Earth's magnetic field and the solar wind.
- A study of the radiation dosage that spacecraft in geosynchronous orbit receive is completed in collaboration with LANL and The Boeing Corporation [*Space Weather, (in press), 2007*]. The study details the solar cycle variation in the incident flux - an essential parameter to identify when hardening spacecraft electronics to radiation effects.
- Co-convenor of the session "Geoeffectiveness in solar wind/magnetosphere coupling" at the American Geophysical Union Fall meeting, 2006. The session resulted in a press conference at the meeting.
- Series of publications detailing the spacecraft environment, particularly for satellites in geosynchronous orbit. For the first time, it is shown that so-called CIR storms create a higher, and potentially more damaging spacecraft potential than so-called CME storms [*JGR, 111, A07S07, doi:10.1029/2005JA011436, 2006*].
- Co-organiser of the Inaugural Taos Workshop of Sawtooth Events, 2004.
- LAPBIAT (Lapland research) fellowship. The fellowship funded an eight week visit to the Sodankylä Geophysical Observatory in Finland. Research and modelling carried out in a study of the ionosphere over the Arctic region, 2003.
- Award of a prestigious Winston Churchill Travelling Fellowship. The award funded a visit to University of Texas at Dallas where data from the DMSP series of spacecraft was obtained and analysed, 1999.

Eric Donovan - Curriculum Vitae (Abridged)

Present Position: Associate Professor and Canada Research Chair (Tier II)

Contact: Department of Physics and Astronomy, U. Calgary, Calgary, T2N 1N4, Canada
+1-403-220-6337(W); eric@phys.ucalgary.ca

Short History: NSERC PDF, Swedish Institute of Space Physics, Supervisor H. Opgenoorth, 1994-1995
Ph.D. (Physics), University of Alberta, Supervisor G. Rostoker, 1988-1993

Research Activity

The overall theme of Dr. Donovan's research is **energy and mass transport in the magnetosphere**, with recent focus on (1) terrestrial ion outflow and its role in magnetospheric dynamics, (2) the *instantaneous* global convection response to changes in the solar-wind driver, (3) processes that mitigate the brightness and latitude of the proton auroral distribution, (4) the ionospheric signature of rapid plasma flows in the CPS. The ion outflow work involved development of an empirical model of thermal and suprathermal ion outflow based on a ten year Akebono (SMS) data set, and the use of that model as input to a test-particle simulation of ion transport to the CPS. The main result was a characterization of ion fluence to the neutral sheet. The work was carried out primarily by Dr. Donovan's MSc student (Chris Cully), and publications are listed below. The other three studies listed relied heavily on the use of ground-based optical and magnetic field observations. For example, Dr. Donovan is currently working with his PhD student Emma Spanswick on high energy electron precipitation during the substorm expansive phase.

Dr. Donovan is the PI of NORSTAR, the auroral imaging component of Canadian GeoSpace Monitoring (CGSM). At present, NORSTAR consists of 11 (15 as of fall 2007) multispectral ASIs, 3 MSPs, and 12 riometers. Dr. Donovan's group is deploying, operating, and recovering the data from 16 white light ASIs spread across Canada as part of the Berkeley-led THEMIS mission. Together with Drs. Trondsen, and Cogger, he is developing the concept of Ravens, a two-satellite auroral imaging mission. This led directly to the Chinese KuaFu-B satellite pair which, if it flies, will carry auroral imagers from Dr. Donovan's group. Dr. Donovan is on the KuaFu Mission Design team. Together with Drs. Samson and Voronkov, he wrote the science plan for the second phase of the CANOPUS project. Currently, he is in his second term as chair of the CGSM Program Supervisory Group. As well, he was the convenor of ICS-8 which was held in Banff in March 2006. Dr. Donovan has been the author or co-author of over 75 refereed publications, 20 non-refereed publications, and has given over 30 invited talks, colloquia, and seminars. Five of his students (Cully, Nicholson, Spanswick, Prosolin, and Hiebert) have, between them, received 2 ICS, 2 DASP, and 4 AGU Outstanding Student Paper Awards.

Representative Publications (underline indicates members of Donovan's research group).

Spanswick, E., E. Donovan, R. Friedel, and A. Korth, Ground based identification of dispersionless electron injections, *Geophys. Res. Lett.*, 34, L03101, doi:10.1029/2006GL028329, 2007.

Partamies, N., K. Kauristie, E. Donovan, E. Spanswick, and K. Liou, Meso-scale aurora within the expansion phase bulge, *Annales Geophysicae*, *24*:2209-2218, 2006

Rae, I., E. Donovan, I. Mann, F. Fenrich, C. Watt, D. Milling, M. Lester, B. Lavraud, J. Wild, H. Singer, H. Rème, and A. Balogh, Evolution and characteristics of global Pc5 waves during a high solar wind speed interval, *J. Geophys. Res.*, *110*, doi:10.1029/ 2005JA011007 2005.

Spanswick, E., E. Donovan, W. Liu, D. Wallis, A. Aasnes, T. Hiebert, B. Jackel, M. Henderson, and H. Frey, Substorm Associated Spikes in High Energy Particle Precipitation, in *The Inner Magnetosphere: Physics and Modelling*, AGU Monograph 155, 2005.

Syrjäsuo, M., and E. Donovan, Diurnal Auroral Occurrence Statistics Obtained Via Machine Vision, *Ann. Geophys.*, *22*, 1103, 2004.

Baker, G., E. Donovan, and B. Jackel, A comprehensive survey of auroral latitude Pc5 pulsation characteristics, *J. Geophys. Res.*, *108*(A10), 1384, doi:1029/ 2002JA009801, 2003.

Donovan, E., B. Jackel, I. Voronkov, T. Sotirelis, F. Creutzberg, and N. Nicholson, Ground-based optical determination of the b2i boundary: a basis for an optical MT-index, *J. Geophys. Res.*, *108*(A3), 1115, doi:1029/ 2001JA009198, 2003.

Cully, C., E. Donovan, A. Yau, and H. Opgenoorth, Supply of ionospheric ions to the Central Plasma Sheet, *J. Geophys. Res.*, *108*(A2), doi:1029/ 2002JA009457, 2003.

Cully, C., E. Donovan, A. Yau, and G. Arkos, Akebono/Suprathermal Mass Spectrometer observations of low-energy ion outflow: dependence on magnetic activity and solar wind conditions, *J. Geophys. Res.*, *108*(A2) , doi:1029/ 2001JA009200, 2003.

Voronkov, I., E. Donovan, and J. Samson, Pseudo-breakup, breakup of a full substorm onset, and poleward border intensifications compared, *J. Geophys. Res.*, *108*(A2), 1073, doi:10.1029/2002JA009314, 2003.

Donovan, E., B. Jackel, D. Klumpar, and R. Strangeway, Energy dependence of the isotropy boundary latitude, Proc. of Atmos. Studies by Optical Methods, 2003.

Harald U. Frey
University of California, Space Sciences Laboratory, 7 Gauss Way, Berkeley, CA 94720-7450

EDUCATION:
University of Leipzig, Germany, Ph.D. (1986), magna cum laude on thesis about "Trace element analysis in biological and semiconductor material using Proton Induced X-ray Emission (PIXE)"
University of Leipzig, Germany, M.S. (Diplom, 1983) , Physics
University of Leipzig, Germany, B.S. (Vordiplom, 1980), Mathematics and Physics

EXPERIENCE:
since 2006 Research Physicist at the Space Sciences Laboratory of the University of California at Berkeley. Working in the space plasma research group on physics of the aurora and on atmospheric emissions from airglow and sprites. Data analysis and digital image processing.
Co-I of the Polar Experiment Network for Geophysical Upper-Atmosphere Investigations.
Instrument scientist and mainly involved in the ground test, calibration, and integration of the FUV instrument on the IMAGE spacecraft. After the launch of the IMAGE satellite responsible for the FUV science planning, instrument operation, and development of data analysis tools.
Project scientist of the Imager for Sprites and Upper Atmospheric Lightning (ISUAL) project for the FORMOSAT-2 satellite, instrument environmental and science performance test. Responsible for instrument commissioning, procedure development, on-orbit test, and verification.
Member of the ground-based observatories (GBO) team of the THEMIS project.
2001-2006 Associate Research Physicist at the SSL of the University of California at Berkeley.
1997-2001 Assistant Research Physicist at the SSL of the University of California at Berkeley.
1991-1997 Research scientist at the Max-Planck-Institute for extraterrestrial physics, auroral research with ground-based optical equipment (CCD cameras), ionospheric radar, and satellite/rocket data, development and calibration of a CCD camera system for stereoscopic auroral observations, data analysis and digital image processing. Development and successful use of a method for the 3D tomographic reconstruction of the volume emission in an auroral arc.
1987-1990 Research physicist in the research center of a semiconductor company (ERMIC GmbH) on development and use of analytical methods for research and development
1986-1987 Research assistant at the physics department of the University Leipzig, application of nuclear analytical methods on trace element analysis in semiconductors and biological samples
1984-1986 Teaching assistant for undergraduate physics education

PROFESSIONAL ACTIVITIES:
Red team member for Stardust@Home
Reviewer for journals: J. Geophys. Res., Geophys. Res. Lett, Ann. Geophys., Space Science Rev., Publications of the Astronomical Society of Australia (PASA), Optical Engineering, IEEE Trans. on Geoscience and Remote Sensing, Radio Science, Earth Planets and Space (EPS)
Reviewer for proposals to NASA, NSF, Canadian Space Agency, Swedish National Space Board, Austrian Academy of Sciences
Panel member for NASA SR&T 2001, 2006

AWARDS:
Scholarship of the University of Leipzig 1981-1986; Georg Mayer Award of the University of Leipzig for outstanding diploma 1983; Scholarship for International Space University by DARA 1992; NASA Group Achievement Award for IMAGE mission team 2001; ESA recognition of outstanding contribution to Cluster 2005; Fellowship at Tohoku University by JSPS 2006

PUBLICATIONS:
24 refereed publications as first author, 114 refereed publications as co-author

Mark Lester Curriculum Vitae (Abridged)

Present Position: Professor of Solar Terrestrial Physics.

Contact: Department of physics and astronomy, University of Leiecster, Leicester, LE1 7RH. Telephone 00-44-116-2523580. Fax: 00-44-11-2523555. E-mail: mle@ion.le.ac.uk

Research Experience and Interests:
Prof. Lester is the PI for the CUTLASS HF radars which form part of the Super Dual Auroral radar Network (SuperDARN). In addition for the last three years he has been the Chairman of the SuperDARN Executive Council. He has over thirty years of experience in the field of Space Plasma physics and has worked on a range of science problems, all of which are related to the transfer of mass, momentum and energy through the Geospace system. His interests are now in the global impact of the energy transfer from the solar wind into the magnetosphere, with particular reference to understanding the system as a whole rather than as individual elements. This work is supported through his involvement in SuperDARN as well as the proposed KuaFu mission, on which he is the leader of the team proposing a wide field auroral imager for KuaFu B.

Selected Recent Publications

Lockwood, M., B.S. Lanchester, S.K. Morley, K. Throp, S.E. Milan, **M. Lester** and H. Frey, Modelling the observed proton aurora and ionospheric convection responses to changes in the IMF clock angle: 2. The persistence of ionospheric convection, *J. Geophys. Res.*, **111**, A02306, doi:10.1029/2003JA010307, 2006.

Karhunen, T.J.T., N.F. Arnold, T.R. Robinson and **M. Lester**, Determination of the parameters of traveling ionospheric disturbances in the high-latitude ionosphere using CUTLASS coherent-scatter radars, *J. Atmos. Solar Terr. Phys*., **68**, 558 - 567, 2006.

Oksavik, K., J.M. Ruohoniemi, R.A. Greenwald, J.B.H. Baker, J. Moen, H.C. Carlson, T.K. Yeoman and **M. Lester**, Observations of isolated polar cap patches by the European Incoherent Scatter (EISCAT) Svalbard and Super Dual Auroral Radar Network (SuperDARN) Finland radars, *J. Geophys. Res*., **111**, A05310, doi:10.1029/2005JA011400, 2006.

Hu, H., T.K. Yeoman, **M. Lester**, R. Lui and H. Yang, Dayside flow bursts and high latitude reconnection when the IMF is strongly northward, *Annales Geophysicae,* **24**, 2227 - 2242, 2006.

Eriksson, S., G. Provan, F.J. Rich, **M. Lester**, S.E. Milan, S. Massetti, J.T. Gosling, M.W. Dunlop and H. Reme, Electrodynamics of a split transpolar arc, *J. Geophys. Res.*, **111**, A11319, doi:10.1029/2006JA011976, 2006.

Grocott, A., **M. Lester**, M.L. Parkinson, T.K. Yeoman, P.L.Dyson, J.C. Devlin and H.U. Frey, Towards a synthesis of substormelectrodynamics: HF radar and auroral observations, *Annales Geophysicae*, **24**, 3365-3381, 2006.

Lester, M., S.E. Milan, G. Provan and J.A. Wild, The impact of solar wind magnetosphere coupling on the ionosphere, *Space Science Reviews,* DOI: 10.1007/s11214-006-9132-8, 2006.

Parkinson, M.L. J. A. Wild, C. L. Waters, **M. Lester**, E.A. Lucek, P.M.E. Decreau, An auroral westward flow channel (AWFC) and its relationship to field-aligned current, ring current, and plasmapause location determined using multiple spacecraft observations, *Annales Geophysicae*, **25**, 59 – 76, SRef-ID:1432-0576/anngeo/2007-25-59, 2007.

Bannister, N.P., E.J. Bunce, S.W.H. Cowley, R. Fairbend, G.W. Fraser, F.J. Hamilton, J.S. Lapington, J.E. Lees, **M. Lester**, S.E. Milan, J.F. Pearson, G.J. Price and R. Willingale, A wide field auroral imager (WFAI) for low earth orbit missions, *Annales Geophysicae*, 26, 519 – 532, SRef-ID:1432-0576/anngeo/2007-25-519, 2007.

MICHAEL W. LIEMOHN
Research Associate Professor
Space Physics Research Laboratory
University Of Michigan, Ann Arbor

Education:

1997: Ph.D. in Atmospheric and Space Science, University of Michigan, Ann Arbor
1995: M.S. in Atmospheric and Space Science, University of Michigan, Ann Arbor
1992: B.S. in Physics and Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN

Professional Activities:

September 2006 - present:	Associate Professor, Atmospheric, Oceanic, and Space Science Department, University of Michigan, Ann Arbor
September 2003 - August 2006:	Research Associate Professor, AOSS Dept, U. Michigan
August 1998 - July 2003:	Assistant Research Scientist, AOSS Dept, U. Michigan
February 1997 - August 1998:	National Research Council Resident Research Associate, NASA Marshall Space Flight Center, Huntsville, AL

Research Summary:

My current research activities include modeling of the stormtime inner magnetosphere (electrons, ring current, and plasmasphere) and understanding both the large-scale and small-scale processes of relevance. My work includes extensive comparisons with data, including in situ particle data and remote sensing observations (emissions, energetic neutral atoms, and ground-based magnetic perturbations). Of special significance lately is the quantification of the ionospheric control on the inner magnetospheric plasma, namely the role of the nightside conductance pattern (and its variability) as a modulator of the electric potential. I am also involved in Mars electron data analysis transport modeling around Mars, comparing against .

Selected Publications (out of 86 peer-reviewed papers in print, press, or submitted):

Liemohn, M. W., and A. A. Chan, Unraveling the mechanisms responsible for radiation belt enhancements, Eos, submitted, doi: 10.1029/2006ES001612, 2007.

Liemohn, M. W., J. U. Kozyra, A. J. Ridley, M. F. Thomsen, M. G. Henderson, P. C. Brandt, and D. G. Mitchell, Modeling the ring current response to a sawtooth oscillation event, *J. Atmos. Solar-Terr. Phys., 69*, 67, 2007.

Liemohn, M. W., A. J. Ridley, J. U. Kozyra, D. L. Gallagher, M. F. Thomsen, M. G. Henderson, M. H. Denton, P. C. Brandt, and J. Goldstein, Analyzing electric field morphology through data-model comparisons of the GEM IM/S Assessment Challenge events, *J. Geophys. Res., 111*, A11S11, doi: 10.1029/2006JA011700, 2006.

Liemohn, M. W., Introduction to the GEM Inner Magnetosphere/Storms Assessment Challenge, *J. Geophys. Res., 111*. A11S01, doi: 10.1029/2006JA011970, 2006.

Liemohn, M. W., A. J. Ridley, P. C. Brandt, D. L. Gallagher, J. U. Kozyra, D. G. Mitchell, E. C. Roelof, and R. DeMajistre, Parametric analysis of nightside conductance effects on inner magnetospheric dynamics for the 17 April 2002 storm, *J. Geophys. Res., 110*, A12S22, 2005.

Liemohn, M. W., and P. C. Brandt, Small-scale structure in the stormtime ring current, *Inner Magnetosphere Interactions: New Perspectives from Imaging, AGU Monogr. Ser.*, vol. 159, ed. by J. L. Burch, M. Schulz, and H. Spence, p. 167, Am. Geophys. Un., Washington, D. C., 2005.

Liemohn, M. W., A. J. Ridley, D. L. Gallagher, D. M. Ober, and J. U. Kozyra, Dependence of plasmaspheric morphology on the electric field description during the recovery phase of the April 17, 2002 magnetic storm, *J. Geophys. Res., 109*(A3), A03209, doi: 10.1029/2003JA010304, 2004.

Liemohn, M. W., J. U. Kozyra, M. F. Thomsen, J. L. Roeder, G. Lu, J. E. Borovsky, and T. E. Cayton, Dominant role of the asymmetric ring current in producing the stormtime Dst*, *J. Geophys. Res., 106*, 10,883, 2001.

Liemohn, M. W., J. U. Kozyra, V. K. Jordanova, G. V. Khazanov, M. F. Thomsen, and T. E. Cayton, Analysis of early phase ring current recovery mechanisms during geomagnetic storms, *Geophys. Res. Lett., 25*, 2845, 1999.

W. WILLIAM LIU

Current Position: Senior Scientist, Canadian Space Agency
Contact Information: 6767 route de l'Aéroport, Canadian Space Agency, Saint-Hubert, Québec J3Y 8Y9, Canada. Tel. 450-926-4510. email : William.liu@space.gc.ca
Professional History: Ph.D., 1988 (Rice University); PDF, 1988-1990, University of Alberta; 1990-1995, Scientist, Canadian Network for Space Research; 1995-present, various roles and posts, Canadian Space Agency.

Research Interests and Activity: Dr. Liu's research interest is magnetospheric physics. His most significant research contributions include: 1) non-resonant, nonadiabatic acceleration of relativistic electrons in the radiation belt by magnetic pumping (with Rostoker and Baker); 2) identification of the unstable ballooning mode in a high-beta plasma; 3) theoretical work foreshadowing the subsequent identification of Poleward Boundary Intensification (with Xu, Samson, Rostoker); 4) avalanche models of magnetospheric substorms (with Charbonneau). Of late, Dr. Liu, along with PDF Dr. Jun Liang, started a very productive collaboration with Dr. Eric Donovan and his group to tackle a host of questions concerning substorm onset and expansion, among which are: magnetospheric physics underlying riometer observations; proton auroral fading in the substorm growth phase; "string-trigger" of magnetospheric substorms; and patchy pulsating aurora. The collaboration with Dr. Paul Charbonneau has also yielded very interesting results, which shed light on the physical basis for the simultaneous presence of scale-free auroral distributions and quasi-periodic distribution of substorm onsets, as well as intriguing spatial propagation patterns reminiscent of BBF. Dr. Liu also carries out research on theoretical problems such as pulsed dayside magnetic reconnection, one-fluid reformulation of Rice Convection Model, and polar-cap potential saturation. Dr. Liu is author of 45 refereed publications (most as first author), have given more than 30 invited talks, have been convenor, co-convenor, or program committee member of more than 20 conferences/workshops or sessions thereof. Dr. Liu is a permanent member of International Living With a Star Steering Committee and served as its Chair between in 2005 and 2006. Dr. Liu is active also in a number of international scientific organizations and societies.

Refereed publications since 2005

Liu, W. W., Liang, J., Spanswick, E., Donovan, E. F. (2007), Remote sensing magnetospheric dynamics with riometers: Observations and Theory, *J. Geophys. Res.*, in press.

Donovan, E. F., J., Spann, W. W. Liu., T. Trondsen, L. L., Cogger, J. S., Murphree, E. Spanswick, E. Henderson, J. Gerard, J. Spann, R. Rankin, A. Ridley, J. Raeder, G. Sofko, J. Foster, R. Friedel, T. I. Pulkkinen, R. Heelis, H. Frey, S. Mende, and M. Lester (2007), Global Imaging During the ILWS Era as an Essential Element of "Systems Level Science", in press, *Adv. Space Res.*

Liu, W. W. (2006), Heat flux in magnetospheric convection: A calculation based on adiabatic drift theory, *Geophys. Res Lett.*, *33*, L19104, doi:10.1029/2006GL027218.

Liu, W. W., P. Charbonneau, K. Thibault, and L. Morales (2006), Energy avalanches in the central plasma sheet, *Geophys Res. Lett.*, *33*, L19106, doi:10.1029/2006GL027282.

Yau, A., G. James, and W. Liu (2006), The Canadian Enhanced Polar Outflow Probe (e-POP) Mission in ILWS, *Adv. Space Res.*, *38*, 1870-1877.

Liu, W. W., J. Burchill, E. Donovan, G. James, D. Kendall, D. Knudsen, J. Lu, I. Mann, R. Michaud, R. Rankin, E. Spanswick, G. Sofko, and A. Yau (2005), Multiscale geospace physics in Canada, *Multiscale Phenomena in Sun-Earth Connection*, edited by A. T. Y. Lui and Consolini, Elsevier, 487-508.

Liu, W. W. (2005), Energization of the inner magnetosphere by solar wind pressure pulses, *Physics and Modeling of the Inner Magnetosphere, AGU Geophys. Mono*, edited by T. I. Pulkkinen, N. A. Tsyganenko, and R. H. Friedel, p. 113, AGU, Washington, DC.

Liu, W. W. (2005), Canada's Space Environment Program and International Living With a Star, *Adv. Space Res.*, 6949, doi:10.1016/j.asr.2004.09.011, 2005.

Liu, W. W., E. Donovan, D. Knudsen, A. Yau, R. Rankin, I. Mann, and P. Charbonneau (2005), Solar and space physics in the era of International Living With a Star, *Phys. in Canada,* (Feature Article), *61*.

Spanswick, E., E. Donovan, W. Liu, D. Wallis, A. Aasnes, T. Hiebert, B. Jackel, and M. Henderson (2005), Substorm associated spikes in high-energy particle precipitation, *Physics and Modeling of the Inner Magnetosphere, AGU Book Series*, edited by T. I. Pulkkinen, N. A. Tsyganenko, and R. H. Friedel, p. 227.

Dr. Steve Milan

Lecturer, Department of Physics and Astronomy, University of Leicester, Leicester LE1 7RH, UK
Tel: +44 116 223 1896, Fax: +44 116 252 3555, steve.milan@ion.le.ac.uk

Education:

1990	B.Sc. (Physics with Astrophysics), University of Leicester.
1990	Ph.D. (HF radiowave propagation at polar latitudes), University of Leicester.

Awards:

1996	"Young Scientist Award", URSI.
2001	"Young Scientists' Publication Award", European Geophysical Society.
2005	ESA award for outstanding contribution to the Cluster mission.

Positions held:

2003—	Principle Investigator of ground-based support for Cluster and Double Star Program satellite missions.
2005—	Member (chair) of ESA Cluster Active Archive (CAA) review board.
2006—	Secretary for Magnetospheres, EGU Division of Solar-Terrestrial Sciences.
2007—	Associate Editor, *Geophysical Research Letters*.

Instrument involvement:

Co-I	CUTLASS (Co-ordinated UK Twin-Located Auroral Sounding System).
Co-I	WFAI (Wide-Field Auroral Imager) instrument, KuaFu-B.
Co-I	IES/IPS (Imaging Electron and Proton Sensor) instrument, KuaFu-B.
Co-I	MIXS (Mercury Imaging X-ray Spectrometer) instrument, BepiColombo.

Research interests:

Magnetospheric physics; planetary magnetospheres, Mercury, Earth, Jupiter, Saturn;
Solar wind-magnetosphere-ionosphere coupling; ionospheric convection;
Coordinated ground- and space-based studies; auroral physics and imagery;
Magnetic reconnection, flux transfer events;
Magnetospheric structure and dynamics, esp. substorm cycle, magnetotail;
Magnetohydrodynamic waves, esp. ULF waves;
Ionospheric physics; ionospheric morphology; auroral ionosphere;
Collisional plasma instability mechanisms; E region irregularities;
Radar techniques; HF radio propagation; impact of auroral processes on HF radio propagation.

Related publications:

Milan, S. E., M. Lester, S. W. H. Cowley, and M. Brittnacher, The convection and auroral response to a southward turning of the IMF: POLAR UVI, CUTLASS, and IMAGE signatures of transient magnetic flux transfer at the magnetopause, *J. Geophys. Res.*, 105, 15741-15756, 2000.

Milan, S. E., M. Lester, S. W. H. Cowley, J. Moen, P. E. Sandholt, and C. J. Owen, Meridian-scanning photometer, coherent HF radar, and magnetometer observations of the cusp: a case study, *Ann. Geophysicae*, 17, 159-172, 1999.

Milan, S. E., and M. Lester, Interhemispheric differences in the HF radar signature of the cusp region: A review through the study of a case example, *Adv. Polar Upper Atmos. Res.*, 15, 159-177, 2001.

Milan, S. E., M. Lester, S. W. H. Cowley, K. Oksavik, M. Brittnacher, R. A. Greenwald, G. Sofko, and J.-P. Villain, Variations in polar cap area during two substorm cycles, *Ann. Geophysicae*, 21, 1121-1140, 2003.

Milan, S. E., S. W. H. Cowley, M. Lester, D. M. Wright, J. A. Slavin, M. Fillingim, C. W. Carlson and H. J. Singer, Response of the magnetotail to changes in open flux content of the magnetosphere, *J. Geophys. Res.*, 109, A04220, doi: 10.1029/2003JA010350, 2004.

Milan, S. E., G. Provan, and B. Hubert, Magnetic flux transport in the Dungey cycle: A survey of dayside and nightside reconnection rates, *J. Geophys. Res.*, *112*, A01209, doi: 10.1029/-2006JA011642, 2007.

Curriculum Vitae for Nikolai Østgaard

Address:	Department of Physics and Technology, University of Bergen, Allegt 55, N-5007, Norway		
Fax:	(+47) 5558 9440		
Phone:	(+47) 5558 2794	Email:	Nikolai.Ostgaard@ift.uib.no

Graduate education and postdoctoral training:

2000—2001:	Post. Doc. at the University of Oslo, Norway, incl. one year stay at NASA/ GSFC, USA.
1999:	Doct. Scient. Degree (PhD), University of Bergen
1996:	Cand. Scient. Degree (MD), University of Bergen

Professional Background:

2004--present:	Professor at the University of Bergen, Norway
2004:	Associate Professor at the University of Bergen, Norway
2004--2006:	Associate Professor II at the University of Oslo, Norway
2001--2004:	Assistant Research Physicist, University of California, Berkeley, USA
1996:	Research Assistant, Dept. of Physics, University of Bergen, Norway

Research overview:

My background is in auroral imaging from space. I have showed how global energy deposition from particle precipitation can be estimated from global UV- and X-ray imaging. From geocoronal imaging data I have developed an empirical model of the Earth's neutral hydrogen density distribution at high altitudes. During the last years, my main focus has been to analyze simultaneous global imaging data from IMAGE FUV and Polar VIS Earth camera, which has led to the discoveries that the theta aurora can be a non-conjugate phenomenon, that the nightside magnetotail is more twisted than existing magnetic field models predict as well as presenting the first simultaneous observations of cusp aurora in the conjugate hemispheres. I am currently a co-leader in the program 'Interhemispherical Conjugacy Effects in Solar-Terrestrial and Aeronomy Research' (ICESTAR) and PI on the Norwegian IPY-ICESTAR, PI on the Norwegian Cluster studies and a co-investigator on the Atmosphere-Space Interaction Monitor (ASIM) and PI on the Norwegian contribution to the X-ray detector on ASIM. ASIM is designed to study transient luminous events (sprites etc.) and terrestrial gamma flashes (TGFs) over thunderstorm systems and especially where and how the TGFs are produced. I am currently editor for Space Science in Geophysical Research Letter.

Publications

- N. Østgaard , S. B. Mende, H. U. Frey, J. B. Sigwarth, A. Aasnes, J. Weygand. Auroral conjugacy studies based on global imaging J. Atmos. Solar-Terr. Phys., special issue from Yosemite 2006, 69, 249-255, 2007.
- N. Østgaard, S. B. Mende , H. U. Frey , J. B. Sigwarth. Simultaneous imaging of the reconnection spot in the conjugate hemispheres during northward IMF. Highlighted in Geophys. Res. Lett., Vol. 32, No. 21, L21104, doi: 10.1029/2005GL024491, 2005.
- N. Østgaard, N. A. Tsyganenko, S. B. Mende , H. U. Frey , T. J. Immel, M. Fillingim, L. A. Frank, J. B. Sigwarth. Observations and model predictions of substorm auroral asymmetries in the conjugate hemispheres. Geophys. Res. Lett., 32, 5, L05111, doi:10.1029/2004GL022166, 2005.
- N. Østgaard, J. Moen, S. B. Mende, H. U. Frey, T. J. Immel, P. Gallop, K. Oksavik, M. Fujimoto. Estimates of magnetotail reconnection rate based on IMAGE FUV and EISCAT measurements
  Ann. Geophys. (Eleventh International EISCAT Workshop), 23 (1), 123-134, 2005.
- N. Østgaard, S. B. Mende , H. U. Frey , T. J. Immel, L. A. Frank, J. B. Sigwarth, T. J. Stubbs. Interplanetary magnetic field control of the location of substorm onset and auroral features in the conjugate hemispheres. J. Geophys. Res., Vol. 109, No. A7, A07204, 10.1029/2003JA010370, 2004
- N. Østgaard, S. B. Mende, H. U. Frey, L. A. Frank , J. B. Sigwarth. Observations of non-conjugate theta aurora. Geophys. Res. Lett., Vol. 30, No. 21, 2125, doi: 10.1029/2003GL017914, 2003.
- N. Østgaard, S. B. Mende, H. U. Frey, G. R. Gladstone, H. Lauche. Neutral hydrogen density profiles derived from geocoronal imaging. J. Geophys. Res., Vol. 108, No. A7, 1300, doi:10.1029/2002JA009749, 2003.

Minna Palmroth – Curriculum Vitae

Present position: Scientist
Contact: Finnish Meteorological Institute, Space Research, Helsinki, Finland
+358-9-19294696 (W), +358-40-5311745 (H), minna.palmroth@fmi.fi
Short history: PhD (Physics), University of Helsinki, Finland, 2003
PI, Programme of Distinguished Post-Doctoral Researchers,
Academy of Finland, 2005-2008

Research activities:
The topic of Dr. Palmroth's scientific activities is the **energy transfer and dissipation in the solar wind – magnetosphere – ionosphere system**. She has studied the theme both observationally and using a global magnetohydrodynamic (MHD) simulation. From the observational side, Dr. Palmroth has concentrated on the 1) magnetospheric cusp properties and location, 2) the role of solar wind dynamic pressure in driving ionospheric energy consumption and 3) the coupling efficiency between the solar wind and the magnetosphere and its dependence on the interplanetary discontinuities. From the modelling point of view, Dr. Palmroth has pioneered in developing different methods to quantitatively address the energy transfer and dissipation using global MHD simulations. The focus has been 4) quantitative energy and mass transfer through the magnetopause, 5) energy and mass circulation within the magnetosphere, and 6) quantitative ionospheric power consumption carried out through comparisons with measurements from auroral imagers, ground-based radars and magnetometer networks. Dr. Palmroth's recent activities have included advising of a PhD student, who has developed further methods for quantitative characterization of the magnetospheric tail and magnetopause reconnection morphology and efficiency as functions of solar wind parameters.

Dr. Palmroth is the chair of the Astrophysics and Space Physics Division in the Finnish Physical Society. She is the author of 21 peer-reviewed publications, 9 proceedings papers, and has given 7 invited talks. Dr. Palmroth has supervised one MSc thesis, and has been the Acting Supervisor of a PhD student. She has convened sessions in international conferences, and is a frequent referee for leading international journals and different funding organizations. She has also managed a software project Vipunen monitoring and managing scientific work and public outreach activities.

Representative publications
Palmroth, M., H. Laakso, and T. I. Pulkkinen, Location of high-altitude cusp during steady solar wind conditions, *J. Geophys. Res.*, *106*, 21,109-21,122, 2001.
Palmroth, M., P. Janhunen, T. Pulkkinen and W. K. Peterson, Cusp and magnetopause locations in global MHD simulation, *J. Geophys. Res., 106*, 29,435-29,450, 2001.
Palmroth, M., T.I. Pulkkinen, P. Janhunen, C.-C. Wu, Stormtime energy transfer in global MHD simulation, *J. Geophys. Res.*, *108(A1)*, 1048, doi:101029/2002JA009446, 2003
Palmroth, M., Janhunen, P., Pulkkinen, T. I., and Koskinen, H. E. J., Ionospheric energy input as a function of solar wind parameters: global MHD simulation results, *Ann. Geophys.*, *22*, 549 566, 2004.
Palmroth, M., Pulkkinen, T. I., Janhunen, P., McComas, D. J., Smith, C., and Koskinen, H. E. J., Role of solar wind dynamic pressure in driving ionospheric Joule heating *J. Geophys. Res., 109*, A11302, doi:10.1029/2004JA010529, 2004.
Palmroth, M., Janhunen, P., Pulkkinen, T. I., Aksnes, A., Lu, G., Østgaard, N., Watermann, J., Reeves, G. D., and Germany, G. A., Assessment of ionospheric Joule heating by GUMICS-4 MHD simulation, AMIE, and satellite-based statistics: Towards a synthesis, *Ann. Geophys. 23,* 2051-2068, 2005.
Palmroth, M., Janhunen, P., Germany, G. A., Lummerzheim, D., Liou, K., Baker, D. N., Barth, C., Weatherwax, A. T., Watermann, J., Precipitation and total power consumption in the ionosphere: Global MHD simulation results compared with Polar and SNOE observations, *Ann. Geophys. 24*, 861-872, 2006.
Palmroth, M., Janhunen, P., and Pulkkinen, T. I., Hysteresis in solar wind power input to the magnetosphere, *Geophys. Res. Lett., 33*, L03107, doi:10.1029/2005GL025188, 2006.
Palmroth, M., Laitinen, T. V., and Pulkkinen, T. I., Magnetopause energy and mass transfer: Results from a global MHD simulation, *Ann. Geophys.,* 24, 3467-3480, 2006.
Palmroth, M., Partamies, N., Polvi, J., Pulkkinen, T. I., McComas, D. J., Barnes, R. J., Stauning, P., Smith, C. W., Singer, H. J., and Vainio, R., Solar wind - magnetosphere coupling efficiency for solar wind pressure impulses, submitted to *Geophys. Res. Lett.*, 2006.

Aaron J. Ridley

Professional Preparation

- B.S. in Physics, Eastern Michigan University, 1992.
- M.S. in Atmospheric and Space Sciences, University of Michigan, 1995.
- Ph.D. in Atmospheric and Space Sciences, University of Michigan, 1997.

Appointments

- Associate Professor, University of Michigan, Ann Arbor, 2006-.
- Associate Research Professor, University of Michigan, Ann Arbor, 2005-.
- Associate Research Scientist, University of Michigan, Ann Arbor, 2003-2005.
- Assistant Research Scientist, University of Michigan, Ann Arbor, 2000-2003.
- Research Scientist, Southwest Research Institute, San Antonio, Texas, 1997-1999.
- Research Assistant, High Altitude Observatory, NCAR, Boulder, CO, 1996-1997

Awards

- University of Michigan's College of Engineering Outstanding Research Scientist Award, 2004.

Research Activities

- Understanding the magnetosphere during extremely strong driving conditions, including the saturation of the ionospheric cross polar cap potential. These studies are being conducted using both modeling result and data analysis.
- Understanding the coupling between the ionosphere, thermosphere, and magnetosphere through the polar wind, conductance, neutral winds, and aurora.
- Understanding the controlling mechanisms for thermospheric Joule heating and the neutral winds.
- Understanding the magnetospheres of Saturn and Jupiter during different solar wind drivers and mass loading rates.
- Validation of various global models during both quiet and super-storm time periods utilizing large amounts of data.
- Membership on several national and international scientific committees, including: the GEM steering committee (2002-), NASA's SEC Data and Computing Working Group (2002-), IUGG committee on Geophysics: The Future (2001-2003), ICESTAR (2004-), NOAA Data Archive Access Requirements Working Group (2006-).

Most Relevant Publications

1. Y. Deng and **A.J. Ridley**, Possible reasons for underestimating Joule heating in global models: E-field variability, spatial resolution and vertical velocity, *J. Geophys. Res.*, Submitted, 2006.
2. **A.J. Ridley**, Y. Deng, G. Tóth, The global ionosphere-thermosphere model, *J. Atmos. Sol-Terr. Phys., 68*, 839, 2006.
3. Deng Y., **A. J. Ridley**, Dependence of neutral winds on convection E-field, solar EUV, and auroral particle precipitation at high latitudes, *J. Geophys. Res., 111*, A09306, doi:10.1029/2005JA011368, 2006.
4. Deng Y., **A. J. Ridley**, Role of vertical ion convection in the high-latitude ionospheric plasma distribution, *J. Geophys. Res., 111*, A09314, doi:10.1029/2006JA011637, 2006.
5. **A. J. Ridley**, T.I. Gombosi, D.L. De Zeeuw, C.R. Clauer, Ionospheric control of the magnetospheric configuration: Thermospheric neutral winds, *J. Geophys. Res., 108*(A8), 1328, doi: 10.1029/2002JA009464, 2003.

Most Significant Publications

1. **A.J. Ridley**, Alfvén wings at Earth's magnetosphere, *Annales Geophys.*, In Press, 2006.
2. Glocer A., T. I. Gombosi, G. Toth, K. C. Hansen, **A. J. Ridley**, A. Nagy, Polar wind outflow model: Saturn results, *J. Geophys. Res., 112*, A01304, doi:10.1029/2006JA011755, 2007.
3. **A.J. Ridley**, A new formulation for the ionospheric cross polar cap potential including saturation effects, *Annales Geophys., 23*, 3522, 2005.
4. **A.J. Ridley** and E.A. Kihn, Polar cap index comparisons with AMIE cross polar cap potential, electric field, and polar cap area, *Geophys. Res. Lett., 31*, doi:10.1029/2003GL019113, 2004.
5. **A.J. Ridley**, T.I. Gombosi, and D.L. De Zeeuw, Ionospheric control of the magnetosphere: Conductance, *Annales Geophysicae, 22*, 567, 2004.

Vadim M. Uritsky – Curriculum Vitae

Current positions: Adjunct Assistant Professor (U of Calgary), Associate Professor (U of St.Petersburg, Russia)

Contact: Physics and Astronomy Dept., SB 605, U of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4; phone 1-(403) 210-1865; email: vuritsky@phas.ucalgary.ca

Brief bio: Dr. Vadim Markovich Uritsky received his Ph.D. degree from St. Petersburg State University in 1998. He is a recipient of a number of professional awards, including the National Research Council Resident Research Associateship Award from the U.S. National Academies (1999). In 2005, Dr. Uritsky was granted the title of *Doktor Nauk* (Grant Doctor of Science), the highest academic degree in Russian Federation. Dr.Uritsky is an author of more than 60 scientific publications and is an expert reviewer for major scientific journals in nonlinear dynamics, space- and geosciences as well as for the National Science Foundation. Dr. Uritsky has participated in international research programs involving CIS, Japan, Germany, Greece, Italy, USA, and other countries, and has contributed to the organization of international scientific meetings as a session chair/convener and an invited lecturer.

Ongoing research projects: dynamical complexity in solar wind-magnetosphere-ionosphere system; signatures of self-organized criticality and intermittent turbulence in solar corona; intermittent turbulence in hydrodynamic and resistive MHD simulations; long-range correlations in non-Abelian sandpile models; complex networks; methods of analysis and visualization of multiscale spatiotemporal signals.

Selected publications:

1. Uritsky, V.M., A.J. Klimas, and D. Vassiliadis, Critical Finite-Size Scaling of Energy and Lifetime Probability Distributions of Auroral Emissions, Geophysical Research Letters, 33, L08102, 2006.

2. Uritsky, V.M., A.J. Klimas, and D. Vassiliadis, Analysis and Prediction of High-Latitude Geomagnetic Disturbances Based on a Self-Organized Criticality Framework, Advances in Space Research, 37(3), 539-546, 2006.

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7. Uritsky, V.M., A.J. Klimas, and D. Vassiliadis, Comparative Study of Dynamical Critical Scaling in the Auroral Electrojet Index Versus Solar Wind Fluctuations, Geophysical Research Letters, 28 (19), p.3809-3812, 2001.

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XiaoXin Zhang - Curriculum Vitae

<u>Personal Information</u>:

Zhang, XiaoXin, Professor, National Center for Space Weather, China Meteorological Administration, 46 S. Zhongguancun St. Haidian, Beijing, 100081, China, +86-10-68409837 (O); xxzhang@cma.gov.cn

<u>Short History</u>:

- Ph. D. in Physics from Auburn University, AL, USA, 2003
- B.S. in physics from Jilin University, Changchun, China, 1987
- <u>Research Scientist (6/2005-5/2006)</u> at Physics department of Auburn University.
- <u>Research Associate (3/2003-2/2004)</u> in in CSPAR of the University of Alabama in Huntsville.
- <u>Visiting Scientist (2/1996-2/1998)</u> at Physics department of Auburn University.
- <u>Visiting Scientist (7/1994-1/1996)</u> in the High Altitude Observatory (HAO) of National Center for Atmospheric Research (NCAR) of USA.

<u>Research Activities</u>:

Dr. Zhang's research focuses on (1) Studying the disturbances of the solar wind and interplanetary magnetic field in the near-Earth space environments, (2) Investigating the effects of the energetic particle in geo-space or space environment on a detector and spacecraft charging (3) Studying Energetic neutral atom (ENA) images which are used to remotely monitor the global structure and dynamic property of the Earth's ring current via image inversion techniques.(4) Developing forecast models of space environment for scientific and operational use from the Sun to the interplanetary space, magnetosphere, thermosphere and ionosphere. (5)Studying the global patterns of Joule Heating in high-latitude ionosphere and the MIT coupling, etc.

Dr. Zhang is the secretary of Kuafu Scientific Committee of KuaFu mission. He participated in the Sino-American joint project: theoretical study of Langmuir electric probe in space. He was the PI of the NSFC project of studying FTE signatures under conditions of the solar wind dynamic pressure pulses near the magnetopause, and CoIs of a lot of other projects in USA and China. He received one AGU outstanding Student paper award and his paper entitled as "Proton temperatures in the ring current from ENA images and in situ measurements" was recognized as **GRL Journal Highlight.** He currently is a reviewer for "Science bulletin in China, "Journal of Atmospheric Sun-Terrestrial Physics ", "Journal of Geophysics Research","Annales Geophysicae", etc.

<u>Representative Publications</u>:

1. **Zhang, X. X.**, C. Wang, T. Chen, Y. L. Wang, A. Tan, T. S. Wu, G. A. Germany, and W. B. Wang (2005), The Global Patterns of Joule Heating in the High Latitude Ionosphere, ***J. Geophys. Res.***, Vol. 110, doi:10.1029/2005JA011222.
2. **Zhang, X. X.**, J. D. Perez, T. Chen, C. Wang, P. C. Brandt, D. G. Mitchell, and Y. L. Wang (2005), Proton temperatures in the ring current from ENA images and in situ measurements, ***Geophys. Res. Lett.***, *32*, L16101, doi:10.1029/2005GL023481.
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5. Fok, M.-C., T. E. Moore, G. R. Wilson, J. D. Perez, **X. X. Zhang**, P. C:son Brandt, D.G., Mitchell, E. C. Roelof, J.-M. Jahn, C. J. Pollock, and R. A. Wolf, Global ENA IMAGE Simulations, ***Space Science Reviews,*** 109 (1-4): 77-103, 2003.