Implementation Plan

Interhemispheric Conjugacy Effects in

ICESTAR

Solar-Terrestrial and Aeronomy Research

Expected Programme duration: 2005 – 2009
ICESTAR Website: http://www.siena.edu/physics/icestar/

Programme Summary

A major challenge facing environmental science and policy is understanding the interactions between, and collective behavior of, the many component parts of the Earth system, including the interaction between the natural environment and human society. This requires both the specification and prediction of the state of the system, involving the assimilation and integration of data from disparate sources (disparate instruments, sampling various locations, operated by different people and organizations). Near-Earth space (geospace) is an integral part of the Earth system, providing the material link between the Sun and Earth, primarily through the polar regions, and posing a potential hazard to space-borne and ground based technology on which Society is increasingly dependent. Understanding of the complex geospace environment has matured to the level of being able to describe many of its component parts and a major goal now is to seek a unified framework that can specify and predict its global state and, therefore, space weather. To enable this, this programme will establish a forum and working groups to provide a portal on the World Wide Web to all Antarctic geospace data and metadata, and tools for extracting and reducing these data into value-added products, similar to those available or being developed in other areas of SCAR science.

Antarctica is uniquely positioned to remotely sense the vast region of geospace (extending over millions kilometers from the planet) because the Earth's magnetic field focuses the effects of geospace into the polar regions and Antarctica has a land mass on which to base instruments at high latitudes, yet Antarctica has been under-exploited relative to the Arctic. Recently there has been substantial investment by a number of countries in sophisticated instrumentation providing a grid of instruments over much of the Southern Polar Region. Further instruments are to be installed in the near future that will provide coverage equal to and in some cases better than that in the Northern Polar Region. There is now the capability to investigate conjugate relationships at an unprecedented level of detail. ICESTAR is designed to exploit this and one of the main results of the programme will be the enhanced visibility, accessibility, and usability of the Antarctic geospace data to enable whole-system geospace research, including interhemispheric and ground-space studies, and new cross-disciplinary research such as teleconnections between the upper and lower levels of the atmosphere.

Programme Rationale

The ICESTAR Programme will create an integrated, quantitative description of the upper atmosphere over Antarctica, and its coupling to the global atmosphere and the geospace environment. The reasons to embark on the endeavor now are outlined below.

The Emergence of New Datasets. The volume of experimental data has been increasing significantly in recent years. In addition, many new datasets are expected to come on-line in the near future. At this time, there are new magnetometer chains, new polar orbiting satellites which allow the simultaneous view of the Southern and Northern polar regions, new ionospheric (SuperDARN, AMISR, and EISCAT) radars, new mesospheric/thermospheric wind measurements (meteor radars, FPIs), new digisonde and TEC data. It is the right time to begin to create tools to examine the entire system as a whole.

Emergence of Grid technology. The 'Grid' is just starting to be defined, and has yet to find a real niche. The seamless sharing of data is one possibility, and is one of the main goals of the ICESTAR programme. The creation of visualization tools that can utilize globally distributed data sets will push the limits of the current technologies and will spark the creation of new Grid functions. In addition, enabling the convergence of data and models is another strong goal of the Grid technology, which is synergistic with the programme goals.

Enable Easy Access to Distributed Data. Many research groups are creating data assimilation tools that require the use of as many data sources as possible. The creation of the ICESTAR data portal and use of the Antarctic Data Master Directory will enable these developments to grow significantly.

Uniqueness of Antarctica. The Antarctic continent offers a unique vantage point for examining the near-Earth space environment, spanning from the top of the troposphere, through the stratosphere, mesosphere, thermosphere, and ionosphere, and into the magnetosphere. Here we underscore some of the similarities and differences between the Arctic and Antarctic:

- Very different underlying neutral atmosphere, e.g., planetary waves and gravity waves morphology is very different, and more intense jet stream exists in the Antarctic;
- Much larger displacement of the magnetic dip pole in the South than in the North, which means it is much easier to separate effects that are controlled by solar radiation;
- The geomagnetic field is weakest in the South Atlantic sector, thus the flux of energetic particles is higher than anywhere else allowing to studying the atmospheric consequences of energetic particle precipitation

Focused Science. The ICESTAR programme will enable focused upper atmosphere scientific research from Antarctica. One goal is to determine how this region of space fits within the global system. No other programme exists which is focused specifically on the quantitative understanding of the upper atmosphere above the Antarctic continent.

International Cooperation: Studies of the polar upper atmosphere fundamentally require international collaboration. Consider first the deployment of instruments across Antarctica. These instruments are either located at manned bases or are remotely deployed and serviced from such bases. From a logistical and financial standpoint, it is not feasible to deploy a network of instrumentation in Antarctica without international collaboration. The problem is even more complex in the Arctic as individual countries there have control over portions of the region. With instruments being deployed and operated by different countries, international collaboration is essential so that data can be exchanged and integrated.

Programme Organization and Management

Implementing the multi-national ICESTAR programme requires careful management. The Steering Committee, led by two Co-Chairs and guided by the SSG/PS leadership *ex officio*, will provide the overall management and guidance of the programme.

- **Co-Chair:** Allan Weatherwax, Siena College (U.S.A.)
- **Co-Chair:** Kirsti Kauristie, Finnish Meteorological Institute (Finland)
- Brian Fraser, University of Newcastle (Australia)
- Martin Fullekrug, University of Bath (U.K.)
- Ruiyuan Liu, Polar Research Institute (China)
- Nikolai Østgaard, University of Bergen (Norway)
- Scott Palo, University of Colorado (U.S.A.)
- Aaron Ridley, University of Michigan (U.S.A.)
- Natsuo Sato, National Institute of Polar Research (Japan)
- Eftyhia Zesta, University of California - Los Angeles (U.S.A.)
- Maurizio Candidi, SCAR SSG/PS (Italy), *ex officio*

The Steering Committee will meet every year to determine the programme progress and outline the venues for international collaboration. ICESTAR will hold scientific workshops either separately or in conjunction with the biennial SCAR Science Meetings. Specifically, ICESTAR will have four working groups that will focus on the following broad science objectives:

- Quantifying the atmospheric consequences of the global electric circuit and further understanding the electric circuit in the middle atmosphere as guided by the electric fields generated at the solar wind--magnetosphere interface;
- Quantifying the effects on the polar ionosphere and atmosphere of the magnetospheric electromagnetic fields and plasma populations, from the radiation belts to the tail plasma;
- Quantifying and understanding the similarities and differences between the Northern and Southern polar upper atmospheres, under the varying influence of the solar electromagnetic radiation and of the solar wind;
- Creating a data portal that will integrate all of the polar data sets and modeling results. This data portal will enable the research to be conducted by the other working groups.

The above-listed objectives will be the focus of four Thematic Action Groups (TAGs) established to coordinate research activities:

TAG-A: Quantification of the coupling between the polar ionosphere and neutral atmosphere from the bottom-to-top and the global electric circuit.
Leader: Martin Fullekrug, University of Bath (U.K.)

TAG-B: Quantification of the inner magnetospheric dynamics using remote sensing techniques.
Leader: Eftyhia Zesta, UCLA (U.S.A.)

TAG-C: Quantification of the state of the upper atmosphere, ionosphere, and magnetosphere over the Antarctic continent and how it differs from the Northern hemisphere during a wide range of geophysical conditions.
Co-Leader, Nikolai Østgaard, University of Bergen (Norway)
Co-Leader, Scott Palo, University of Colorado (U.S.A.)

TAG-D: Creation and management of the data portal.
Leader: Aaron Ridley, University of Michigan (U.S.A.)

Each TAG will establish and maintain liaison with the National Antarctic Programs through SCAR and its relevant scientific groups and committees: ADD (Antarctic Digital Database), MAGMAP (Magnetic Anomaly Map), and READER (Reference Antarctic Data for Environmental Research). The programme goals and objectives will be detailed together with the SSG/PS Expert Group on Solar-Terrestrial Processes and Space weather (STEPS) and the relevant Action Groups APTIC (Antarctic Peninsula Troposphere - Ionosphere Coupling) and MADREP (Middle Atmospheric Dynamics and Relativistic Electron Precipitation). Similar collaboration will be established with relevant projects of the International Arctic Science Committee (IASC; http://www.iasc.no). The ICESTAR activities will also be coordinated with the Working Group on Polar Research of the International Association of Geomagnetism and Aeronomy (IAGA) and with the new international programmes Climate and Weather in the Sun-Earth System (CAWSES) sponsored by SCOSTEP and International Heliospheric Year (IHY) endorsed by COSPAR, IAU, and by UN Office for Outer Space Affairs. Finally, the proposed period for ICESTAR (2005-2009) overlaps the planned research activities in the framework of fourth International Polar Year (IPY, 2007-2008), during which ICESTAR and IHY together will coordinate the research of 29 multinational consortia to form a geospace focused core programme in the IPY network.

The following key solar-terrestrial physics and polar aeronomy questions provide a sound scientific background for the ICESTAR TAG team leaders to help address:

- How is Earth's magnetosphere different qualitatively and quantitatively under extreme, moderate, and quiet solar wind conditions?
- What is common and what is different in the solar-terrestrial and aeronomical phenomena observed over both the Arctic and Antarctic?
- Does auroral activity during substorms arise from instabilities in the ionosphere or does this aurora simply mirror plasma motions in the outer magnetosphere?
- How much do dark and sunlit ionospheres control polar substorm dynamics?
- To what extent are the ionized and neutral high-latitude upper atmospheric regions affected by mechanical and electrodynamic inputs from the lower atmosphere?
- How does the global electric circuit affect the ionosphere state?
- How is the global electric circuit closed between the low and high latitudes?

It is important and timely to act now to study the polar-regions in their interhemispheric context from observations in space and over the Arctic and Antarctic. The ICESTAR TAG team leaders will provide international guidance in addressing these, and other, important problems.

Overarching Deliverables

The ICESTAR programme will deliver a wide variety of products ranging from a better scientific understanding of the polar atmosphere to a data portal that will enable scientists to create a systems-view of the polar region. Specifically, the ICESTAR programme will focus on delivering:

- A data portal linking together a large number of polar sites with diverse datasets. This data portal will have visualization and data translation modules that will allow users to examine the data and download it in formats that they can easily understand. The following data types will be provided to the portal by the associated groups: magnetometers, HF and MST radars, lidars, passive optical instrumentation, digisondes, riometers, VLF/ULF receivers, TEC measurements, and atmospheric electric field observations.
- Quantification of the role of seasonal differences in polar ionospheric conductance and the effects on magnetospheric, ionospheric, and thermospheric dynamics.

- Constraints on models based on conjugate remote sensing of inner magnetospheric dynamics.
- Characterization of the spatial and temporal properties of mesoscale convection in the ionosphere.
- Characterization of the basic state of the polar middle atmosphere.
- Quantification of the AC and DC global atmospheric circuit and its effects on the ionospheric state.

Milestones

2005–2006: Start of ICESTAR Programme – Collect information and coordinate observations at the existing instrumental arrays in the Arctic and Antarctic, aiming specifically at interhemispheric studies, including global development of the magnetic storms and substorms over the polar regions. Promote the deployment of new instruments where current gaps exist.

2007–2008: Main Phase (coincides with IPY) – Develop time-dependent geospace models controlled by external (i.e., solar wind) drivers; couple these models with the potential input from atmospheric processes including the global electric circuit and thunderstorms.

2009–future: Closure or Renewal Phase – Consider termination or extension of the ICESTAR Programme based on its progress and accomplishments.

Timetable of Activities

As this is a revision of the original implementation plan submitted in April 2005, we list not only goals but also accomplishments when appropriate.

Summer 2005

Goals

- Collect information and coordinate observations at the existing instrumental arrays in the Arctic and Antarctic aiming specifically at interhemispheric studies, including global development of the magnetic storms and substorms over the polar-regions. Promote the deployment of new instruments where current gaps exist.
- Conduct first technical workshop: First Specification for a reasonable VO overall structure. The VO could have e.g. the following elements: Distributed archives, adaptive metadata thesaurus, unified Graphics User Interface, possibilities to do context-based searching (e.g. searching SD-potential patterns with the criteria of certain cross polar cap potential drop) and distributed computing, procedures for monitoring usage statistics, and educator's interface for public outreach.
- Project meetings in EGU (Vienna) and IAGA (Toulouse): Specifications for the design reference models for each TAG. Specifications of the initial VO component archives (institutes, their data and software).

Accomplishments

- **ICESTAR Website:** Established to facilitate international communication.
- **CEDAR/GEM Meeting 2005:** ICESTAR team member Allan Weatherwax helped organize the Coupled Geospace Workshop at the 2005 Santa Fe CEDAR/GEM Meeting .
- **Polar Research Working Group II-G:** ICESTAR coordinated activities with the IAGA Polar Research Working Group. Future collaborative endeavours are underway with this IAGA working group.
- **ICESTAR Data Portal Workshop:** The ICESTAR Data Portal and Virtual Observatory Workshop was held on 23 July 2005 in conjunction with the IAGA 2005 Scientific Assembly, Toulouse, France. There were more than 35 in attendance. A full report is given at: http://www.siena.edu/physics/icestar.
- **Prototype Virtual Observatories and Data Portals:**
  - A prototype of the VO for optical data (browser for quicklook data) was released: see http://gaia-vxo.org.
  - A prototype of the VO for magnetometer data, VGMO.NET, was released: see http://mist.engin.umich.edu/mist/vgmo/vgmo.html.
  - A prototype of the VO for the multi-instrument data sets at South Pole Station was released: see http://siena.isti.com/.
- **ICESTAR and IPY:** ICESTAR, under the direction of Kirsti Kauristie of the Finnish Meteorological Institute, submitted on 10 Jan 2005 an Expression of Interest to the Joint Committee of IPY. IPY JC selected the programme to the second round of core project candidates and encouraged collaboration with the IHY EoI in order to establish an umbrella organization for 24 geospace oriented projects. The ICESTAR/IHY programme was endorsed on Dec 1 2005 as one of the IPY core projects. After that five more EoIs has joined the initiative. IPY will publish the final list of the core projects in March 2006.
- **Meeting on Atmospheric Studies by Optical Methods**: Prof. Scott Palo presented an invited talk about the ICESTAR program at the 32nd Annual European Meeting on Atmospheric Studies by Optical Methods, 01 September 2005, London, Ontario
- **EGU General Assembly Special Session Announced**: TAG Team leader Nikolai Ostgaard announces the session, Interhemispheric similarities and asymmetries in geospace phenomena. He will chair this session together with Janet Kozyra who is a work package leader in the CAWSES programme.
- **Presentation:** TAG Team Leader Nikolai Østgaard gave a talk on conjugate imaging of cusp aurora at the IHY meeting in Paris.

Autumn 2005

Goals

- Establish project management:

1. Core group (e.g. chairpersons and Aaron Ridley): Budget matters, Public outreach, contact towards SCAR, overall control on the VO development schedule
2. Scientific and Technical Board (e.g. ICESTAR steering committee + representatives from the distributed archives): Making specifications, finding resources for the actual development work, evaluating the outcome

- First meeting of the Scientific and Technical board: What elements in the VO specification are necessary and what properties they should have to meet the demands of the design reference models? Recommendations to the community to fill the most critical gaps in the measurement instrumentation. Output: the URD (User Requirements Definition).

Accomplishments

Fall AGU 2005 - ICESTAR Related Talks and Presentations

1. Deploying a Low Cost Virtual Observatory and Data Portal at a Small Liberal Arts College by H. Schechner and A. T. Weatherwax
2. Geospace Climatology: A Window to the Heliosphere Through Polar Regions by V. O. Papitashvili
3. The Future of Systems Aeronomy in Addressing New Science Frontiers by J. U. Kozyra, L. J. Paxton and A. Ridley.
4. GAIA - A Virtual Auroral Observatory by E. Donovan.
5. Polar Gateways to Exploration of Icy Worlds in the Solar System by J. Cooper.

Winter/Spring 2006

Goals

- Second Technical workshop: Specification for the technical solutions to meet the needs of the URD. Search for the most suitable options for the programming languages, for data catalogue structures, for visualization tools and input and output data formats. The second updated version of the Optical VxO will be released.
- Build prototype of federated distributed archives and metadata collection routines.
- Convene "Coupling from the Sun to the Ground" - Special Session for 2006 Spring AGU. See the website http://www.siena.edu/physics/ICESTAR/special_session_spring_agu_2006.htm for full details of this special session:
- Preparatory work for the IPY activities begins: ICESTAR research groups are invited to submit proposals for Coordinated Investigation Programmes (CIP) to the Discipline Planners of IHY. CIPs will facilitate especially the arrangement of coordinated multi-instrumental measurement campaigns but can also serve as an efficient procedure for collaboration in modeling and outreach activities. For more details, see http://www.ihy.rl.ac.uk/HowCIPsWork.shtm.

Accomplishments to Date

- Negotiations about ICESTAR-IHY collaborations: Kirsti Kauristie attended the first European General Assembly of IHY (Jan 10-13 2006), gave there an invited presentation about ICESTAR and discusses with the European IHY coordinators (Prof. R. A. Harrison, R. Stamper, and C. Briand) about the future ICESTAR-IHY activities.
- Activities in the EGU-meeting: TAG Team Leader Nikolai Østgaard will give an invited talk about the ICESTAR science and coordination activities in an EGU Union Symposium hosted by Dr J. C. Ellis-Evans.

- EGU General Assembly Special Session: ST5.5 Inter-hemispheric similarities and asymmetries in geospace phenomena', will be convened by TAG-C Team leader Nikolai Østgaard. He will chair this session together with Janet Kozyra who is a work package leader in the CAWSES programme. We will have an invited talk by Aaron Ridley (given by Gombosi) and an ICESTAR/IHY paper by L. Alofnsi.
    - http://www.cosis.net/members/meetings/sessions/information.php?p_id=186&s_id=3523
- TAG Team Leader Nikolai Østgaard will give an invited talk at the International Conference on Substorms-8 on conjugate imaging of substorms.
- Co-director Allan Weatherwax presented an ICESTAR related seminar at South Pole Station during a visit to Antarctica to conduct fieldwork.

Summer 2006

Goals

- Present ICESTAR papers at SCAR XXIX Open Science Conference:
    - Vertical Electrodynamic Coupling by Martin Fullekrug
    - Auroral Conjugacy Studies - by Nikolai Østgaard et al.
    - Deploying Data Portals and Virtual Observatories - by Allan Weatherwax et al.
    - Pi1B Pulsations and their Association with Substorm Onset - by H. Kim et al.
    - ICESTAR: Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research - by Vladimir Papitashvili and the ICESTAR Team

Autumn 2006

Goals

- Build the User Interface and other necessary elements.
- Test the prototype system with the design reference models. Test results presented e.g. in a CAWSES-ICESTAR workshop.
- Adjust the system according to the feedback from the first test runs.
- IHY Discipline Planners will categorize the submitted CIPs according to Universal Processes and present the implementation plans for coordinated campaigns during the IPY years (Reconnection and wave-particle interactions are examples of Universal Processes with common ICESTAR and IHY interests).
- Foster the first measurements of the NASA THEMIS mission (especially TAG-B and C)

Winter/Spring 2007

Goals

- Second meeting of the Scientific and Technical Board: Mid-term review.
- Introduce the VO to the IPY community and expanding the system with new data archives and software.
- Establish reliable monitoring routines for user statistics (both for VO and for the individual data archives)
- Publish the results of the design reference models.

Autumn 2007- Spring 2009

Goals

- Collaborate with the IPY community, presenting results in international meetings.
- Expand the VO according to the needs of the user community and upgrading its distributed computing capabilities.
- Publish results of IPY studies.
- Third meeting of the Scientific and Technical Board**:** Evaluation of the user statistics and decision about continuation or closure.