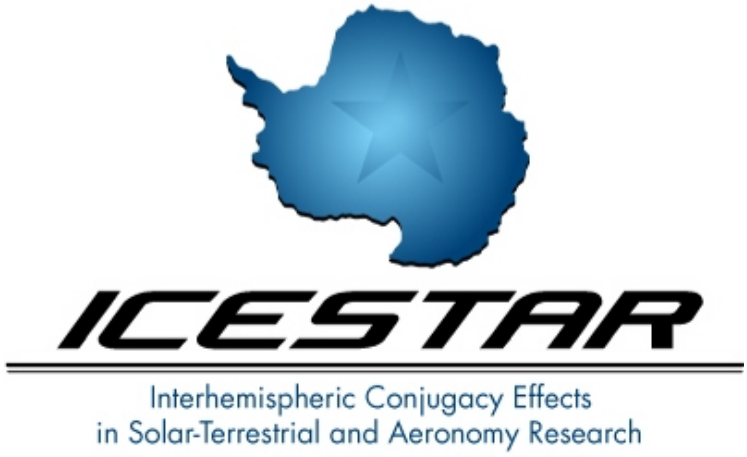
Report to the SCAR Executive on the Scientific Research Programme



The primary goal of the ICESTAR Programme is to create an integrated, quantitative description of the upper atmosphere over Antarctica, and its coupling to the global atmosphere and the geospace environment. This document reports primarily on progress with the implementation of ICESTAR since the SCAR Delegates' meeting in Hobart, Australia in July 2006. It provides details of progress with the science, lists outputs and identifies targets for the next year.

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02 July 2007

Selected Scientific Highlights

- **Arctic and Antarctic polar winter NO_x:** ICESTAR researchers report on GOMOS nighttime observations of middle atmosphere NO_2 and O_3 profiles during eight recent polar winters in the Arctic and Antarctic. The NO_2 measurements are used to study the effects of energetic particle precipitation and further downward transport of polar NO_x. During seven of the eight observed winters NO_x enhancements occur in good correlation with levels of enhanced high-energy particle precipitation and/or geomagnetic activity as indicated by the A_p index. We find a nearly linear relationship between the average winter time A_p index and upper stratospheric polar winter NO_2 column density in both hemispheres. In the Arctic winter 2005–2006 the NO_x enhancement is higher than expected from the geomagnetic conditions, indicating the importance of changing meteorological conditions. *This work was published by in Geophys. Res. Lett.,* 34, L12810, doi:10.1029/2007GL029733.

- **Auroral conjugacy studies based on global imaging:** Simultaneous global imaging in the ultraviolet wavelengths by the IMAGE and Polar satellites enabled ICESTAR researchers to examine auroral features in conjugate hemispheres. With an imaging cadence of 2 and 1 min for IMAGE-FUV and Polar VIS Earth camera, respectively, examination of dynamic features such as substorm onsets and cusp precipitation as well as slowly varying phenomena such as theta aurora was carried out. New evidence of the IMF clock angle control of the asymmetric substorm onset locations was gathered. Simultaneous images from the opposite hemispheres show asymmetric cusp auroras and their locations are controlled by IMF B_y and dipole tilt angle. The imaging results demonstrate that theta aurora can be a non-conjugate phenomenon. For substorm onset locations, there exists a systematic displacement in one hemisphere compared to the otherCompared with some of the existing magnetic field models, the observed asymmetries are an order of magnitude larger than the model predictions. *This work was published in the Journal of Atmospheric and Solar-Terrestrial Physics, 249-255, 2007.*

- **Global MHD simulation results compared with Polar and SNOE observations:** A comparison of ionospheric electron precipitation morphology and power from a global MHD simulation with direct measurements of auroral energy flux during a pair of substorms on 28–29 March 1998 was carried out. The electron precipitation power was computed directly from global images of auroral light observed by the Polar satellite ultraviolet imager (UVI). Independent of the Polar UVI measurements, the electron precipitation energy is determined from SNOE satellite observations on the atmospheric nitric oxide (NO) density. It was determined that the simulation reproduces the spatial variation of the global aurora in the sense that the onset of the substorm is shown in the simulation as enhanced precipitation in the right location at the right time. The total integrated precipitation power in the simulation is in quantitative agreement with the observations during quiet times. However, during active times, the integrated simulation precipitation is a factor of 5 lower than the observations indicate. *These results were published in Ann. Geophys., 24, 861-872, 2006.*

- **Global signatures of radiation belt electron precipitation:** Calculations of the temporal and spatial precipitation signatures of energetic radiation-belt electrons due to pitch-angle scattering by magnetospherically reflecting (MR) whistler waves generated by lightning discharges at geomagnetic source latitudes of λ_s = 25°, 35°, 45°, and 55° were studied. A major findings is that precipitation regions move to higher latitudes as a function of time, on short (0.1 sec, at the start of the event) and long (10 sec) timescales, corresponding to the first hop of the wave, and the MR portion of the whistler wave, respectively. There is also structure within the long-timescale precipitation on the order of 1 sec, reflecting the periodic MR of the underlying whistler wave. As latitude increases, an additional precipitated flux signature which is more incoherent and discontinuous, begins to form At lower L-shells, a pronounced maximum occurs in the number flux of 1 keV electrons due to the Landau resonance. The geographic hot spot affected by the precipitation can split into two separate regions per hemisphere, and occur simultaneously in both hemispheres so that up to four distinct precipitation hot spots can occur on the Earth at any instant, driven by a single lightning discharge. *This work was published by in the J. Geophys. Res., 111, A02205, 2006.*

- **Nonlinear planetary wave and tidal coupling in the mesosphere and lower thermosphere:** Temperature observations from the SABER instrument on the TIMED spacecraft were used to investigate the structure and evolution of an eastward propagating zonal wavenumber disturbance with a period near two days. The timing and location of this planetary wave is coincident with the regular quasi two-day wave intensification that occurs annually in late January. The period, wavenumber and spatial structure of the eastward propagating two-day wave are consistent with a wave that results from a nonlinear interaction between the quasi two-day wave and the migrating diurnal tide. The existence of an eastward propagating wave with a period near two days coincident with the westward propagating two day wave will have an impact on the interpretation of ground based observations. *This work was published by in Geophys. Res. Lett., 34, L07807, 2007.*

Progress Against Prior Work Plan

All ICESTAR milestones and deliverables are listed in the ICESTAR Implementation Plan available at http://www.scar-icestar.org. Because of space restrictions, only selected achievements are listed below. These include information on **1)** publications; **2)** conference presentations; **3)** the ICESTAR sponsored meeting entitled *Heliosphere Impact on Geospac;* and **4)** web/data portal products. There were no major deviations from the proposed work plan.

Outputs/Deliverables

1. Selected Publications and Refereed Journal Articles

- Aksnes, A., J. Stadsnes, N. Østgaard, G. A. Germany, K. Oksavik, R. R. Vondrak, A. Brekke, and U. P. Løvhaug (2006), Height profiles of the ionospheric electron density derived using space-based remote sensing of UV and X ray emissions and EISCAT radar data: A ground-truth experiment, *J. Geophys. Res.*, 111, A02301, doi:10.1029/2005JA011331.
- Bortnik, J., U. S. Inan, and T. F. Bell (2006), Temporal signatures of radiation belt electron precipitation induced by lightning-generated MR whistler waves: 2. Global signatures, *J. Geophys. Res.*, 111, A02205, doi:10.1029/2005JA011398.
- Ebihara Y., Y.-M. Tanaka, S. Takasaki, A. T. Weatherwax, M. Taguchi (2007), Quasi-stationary auroral patches observed at the South Pole Station, J. Geophys. Res., 112, A01201, doi:10.1029 2006JA012087.
- Kozlovsky, A., A. Aikio, T. Turunen, H. Nilsson, T. Sergienko, V. Safargaleev, and K. Kauristie (2007), Dynamics and electric currents of morningside Sun-aligned auroral arcs, *J. Geophys. Res.*, 112, A06306, doi:10.1029/2006JA012244.
- Østgaard, N., Mende, S. B., Frey, H. U., Sigwarth, J. B., Åsnes, A., and Weygand, J. M., Auroral conjugacy studies based on global imaging, *Journal of Atmospheric and Solar-Terrestrial Physics* Volume 69, Issue 3, March 2007, Pages 249-255, doi:10.1016/j.jastp.2006.05.026.
- Palo, S. E., J. M. Forbes, X. Zhang, J. M. Russell III, and M. G. Mlynczak (2007), An eastward propagating two-day wave: Evidence for nonlinear planetary wave and tidal coupling in the mesosphere and lower thermosphere, *Geophys. Res. Lett.*, 34, L07807, doi:10.1029/2006GL027728.
- Seppälä, Annika; Verronen, Pekka T.; Clilverd, Mark A.; Randall, Cora E.; Tamminen, Johanna; Sofieva, Viktoria; Backman, Leif; Kyrölä, Erkki Arctic and Antarctic polar winter NO[x] and enegetic particle precipitation in 2002-2006, *Geophys. Res. Lett.,* Vol. 34, No. 12, L12810.
- Taguchi, S., K. Hosokawa, A. Nakao, M. R. Collier, T. E. Moore, A. Yamazaki, N. Sato, and A. S. Yukimatu (2006), Neutral atom emission in the direction of the high-latitude magnetopause for northward IMF: Simultaneous observations from IMAGE spacecraft and SuperDARN radar, *Geophys. Res. Lett.*, 33, L03101, doi:10.1029/2005GL025020.
- Weatherwax, A. T., P. H. Yoon, J. M. Hughes, J. LaBelle, and L. F. Ziebell (2006), Further study of flickering auroral roar emission: 2. Theory and numerical calculations, *J. Geophys. Res.*, 111, A07302, doi:10.1029/2005JA011288.

- Zesta, E., L. Lyons, C.-P. Wang, E. Donovan, H. Frey, and T. Nagai (2006), Auroral poleward boundary intensifications (PBIs): Their two-dimensional structure and associated dynamics in the plasma sheet, *J. Geophys. Res.*, 111, A05201, doi:10.1029/2004JA010640.

2. Selected Presentations and Invited Talks

- **Heliosphere Impact on Geospace:** ICESTAR and IHY initiatives together with 27 other multinational research projects will form one of the core projects of the forthcoming International Polar Year (IPY, March 2007 - March 2009): IPY ID 63 "Heliosphere Impact on Geospace". The project has three main themes in its scientific work: (i) Coupling processes between the different atmospheric layers and their connection with solar activity, (ii) Energy and mass exchange between the ionosphere, the magnetosphere, and the heliosphere, and (iii) Inter-hemispheric similarities and asymmetries in geospace phenomena. Examples of topics to be addressed are remote sensing of ionospheric and radiation belt dynamics and of global geoelectric circuit, effects of solar energetic particles in mid-atmospheric chemistry, and planetary waves in the coupled mesosphere-thermosphere- ionosphere system. The final goal is to achieve better understanding on the geospace response to solar activity as a unified system and consequently to improve our cababilities to predict space weather phenomena. In addition to high-quality science IPY anticipates its core projects to conduct comprehensive education and public outreach activities and to develop efficient data sharing methods. *See A. T. Weatherwax, K. Kauristie et al,, Heliosphere Impact on Geospace - Solar-Terrestrial and Aeronomy Research During the IPY Years, Eos Trans. AGU, 87*(52), *Fall Meet. Suppl., Abstract U14C-01 for further details.*

- **eWorkshop System Tools and Software:** Software supporting an online conference series was developed with the purpose of catalyzing interdisciplinary investigations in Sun-Earth system science among large groups of researchers worldwide in celebration of the 50th anniversary of the International Geophysical Year in 2007. Transformative science in this area lies at the edges and intersections of individual elements (the Sun, heliosphere, magnetosphere, ionosphere and atmosphere) whose collective behavior determines the global system response. Continuing progress requires access to a vast developing cyber-infrastructure of large international data sets, high performance computing and advanced visualization. However, it also requires the development of new tools that bring these advances into contact with groups of interdisciplinary and international researchers so they can be used to attack grand challenge science issues in a manner not previously possible. This presentation describes the results of an eGY showcase project to develop a testbed online conference series for this purpose. The conference series is a collaborative effort between the CAWSES, IHY, eGY, ICESTAR, NASA/LWS and NSF Atmospheric Sciences Programs. See Kozyra et al., Developing cyber-infrastructure for addressing grand challenge questions in Sun-Earth system science: First results of a testbed worldwide online conference series, *See Kozyra*, *Eos Trans. AGU, 87*(52), *Fall Meet. Suppl., Abstract IN13B-1167.*

- **Sun-Earth eWorkshop:** During October of 2006 a Virtual Workshop (eWorkshop), sponsored by CAWSES, NASA/LWS, eGY, IHY, NSF, and ICESTAR was held to discuss the state of the Sun-Earth system during super substorms. This virtual workshop used the Internet to allow world-wide participants to discuss and exchange data using various web based tools. *See* Eos Trans. *AGU, 87(52)*, *Fall Meet. Suppl., Abstract SA43A-02 for further details.*

- **Return to the Auroral Oval:** This presentation reported on new science results from an online conference entitled "Return to the Auroral Oval for the Anniversary of the IGY" designed to bring together researchers worldwide: (1) to investigate newly reported features in the auroral oval during substorms that occur in the main phase of superstorms and how these features map throughout geospace, (2) to explore implications for the state of the geospace system, (3) to identify signatures associated with this geospace state from equatorial to polar latitudes, (4) to investigate the unusual aspects of the solar sources, and (5) to understand how propagation from Sun to Earth modified the observed solar drivers. The main focus of the first conference is on worldwide data exchange, the construction of global data products and assimilative global views, and identifying coupled chains of events from sun-to-Earth. The collaborative conference data products and enhanced understanding of the observed fea-

tures of the events will form the basis for a follow-on conference in 2007 focused primarily on theoretical studies and collaborative simulation efforts between modeling groups, observers and data analysts. This conference is the first in a series of sun-Earth connection online conferences, sponsored by CAWSES, IHY, eGY, ICESTAR, NASA/LWS, and NSF Atmospheric Science Programs, and designed to bring interdisciplinary researchers together with the vast developing cyber-infrastructure of large international data sets, high performance computing and advanced visualizations to address grand challenge science issues in a way not previously possible. *See Kozyra et al., Eos Trans. AGU, 87(52), Fall Meet. Suppl., SA43A-01.*

- **IHY/IPY study of interhemispheric Relationships:** ICESTAR (Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research) is a programme coordinating multinational research on Sun-Earth connections. ICESTAR concentrates on magnetospheric and upper atmospheric responses to solar inputs, with a particular focus on inter-hemispheric relationships. Key aspects of our approach include the networking of ground-based instruments, the closely related issue of fostering international collboration, and open web-based access to the relevant data. To accomplish the latter, we are involved in the development of virtual observatories and are adhering to the overarching philosophies of the IHY and eGY. IHY and ICESTAR have submitted a proposal for a core project status to the Joint Committee of the International Polar Year (IPY). This initiative, "ICESTAR/IHY - Interhemispheric Conjugacy in Geospace Phenomena and their Heliospheric Drivers", includes 24 research groups from more than twenty countries. Harvesting the unique opportunities of IPY in a timely fashion will be challenging. In addition to far- reaching interdisciplinary scientific work IPY is looking forward to exciting new education and outreach activities and efficient utilization of the latest advancements in computer and communications technology. Preparatory work to meet these ambitious objectives has already started within the ICESTAR/IHY community. In the presentation we outline our scientific goals and implementation plan, our progress to date, and describe activities to facilitate cooperative research. *See Donovan et al., Eos Trans. AGU, 87(36), Jt. Assem. Suppl., Abstract U34A-05.*

- **Great Observatory Missions:** An Internet-based cross-disciplinary analysis campaign that will make heavy use of Great Observatory missions as well as international satellite and ground-based assets is being undertaken with joint support from the CAWSES, IHY, LWS, and ICESTAR programs planned for late April or early May 2006. An evolving list of open science questions that serve as sun-to-Earth focus areas for the worldwide campaign were identified during a small interdisciplinary CAWSES workshop at Stanford University in December 2005 as well as during a joint CAWSES/ICESTAR session at the CEDAR meeting in Boulder the preceding summer. The analysis campaign will take place over the Internet in the form of virtual poster sessions with message boards and monitors that summarize the important science issues and new results daily. Poster authors will be asked to closely monitor their message boards during the day of their poster session as well as the following day. Outreach to other disciplines and international students will take the form of tutorial talks that place campaign science issues into the context of the current state of knowledge in each discipline area. Global models and data sets (TEC, magnetometer maps, ULF wave maps, assimilative models, MHD model outputs, continuous solar images) will be available to provide context for local and regional observations. The Community Coordinated Data Center (CCMC) is developing a small number of new data display formats that extract data from global models and place it in the same format as the observations either for ground-based stations or along satellite tracks. Other ideas being explored include real time upload of additional posters in response to issues raised during the poster session, library of related articles, reference archive of observations, etc. A summary of which aspects and/or tools worked and which were less useful will be presented. *See Kozyra et al., Eos Trans. AGU, 87*(36), *Jt. Assem. Suppl., Abstract SM23A-03.*

3. Coordinated IPY/IHY/ICESTAR Research Activities: *Heliosphere Impact on Geospace*

The kick-off meeting of the IPY core project led by ICESTAR and IHY communities was arranged in Helsinki on February 5-9, 2007. Approximately 40 scientists from 14 different countries participated the meeting which was arranged in the facilities of the Finnish Meteorological Institute. In its science planning charts the IPY Project Office has given our project the short name “Heliosphere Impact on Geospace” and our identity number is 63.

The kick-off meeting in Helsinki started with some discussions and presentations about the current state and future challenges of polar aeronomy and solar-terrestrial research. After reviewing the overall situation more detailed presentations were given about the objectives of the individual sub-projects. The opportunities for synergy in the activities were searched and routines for monitoring the scientific outcome were discussed. Special attention was paid to the data sharing issues as several Virtual Observatories tailored for geospace and aeronomy data dissemination have gradually started their operation.

Science presentations

The scientific activities of IPY cluster 63 have been grouped under three main themes which envelope the goals of ICESTAR TAGs. The IPY themes are

- Coupling processes between the different atmospheric layers and their connection with solar activity
    - Effects of solar energetic particles in mid-atmospheric chemistry
    - Global geoelectric circuit
    - Planetary and waves in the coupled mesophere-thermosphere-ionosphere system
- Energy and mass exchange between the ionosphere and the magnetosphere
    - Solar-Terrestrial plasma physics, space weather, substorms
    - Ionospheric tomography and scintillation
    - Remote sensing of radiaton belt dynamics
- Inter-hemispheric similarities and asymmetries in geospace phenomena

In the Helsinki meeting most of the contributed talks addressed either the first or second theme (8 and 16 presentations respectively) while many of the invited talks (4) discussed interhemispheric relationships. Questions related with data sharing and combining different data bases were discussed in four talks and outreach and education issues in two talks. The opportunities for the IPY cluster 63 to collaborate with other coordination activities (IHY, SCAR, COST296) were introduced in four talks. The workshop website, located at http://ipy-id63.org/, lists all presentations and items presented at the meeting.

Below we give brief summaries of a selection of talks which are relevant from the viewpoint of ICESTAR Thematic Action Groups (TAGs):

***TAG-A**: Quantification of the coupling between the polar ionosphere and neutral atmosphere from the "bottom-to-top" and the global electric circuit:*

Esa Turunen from Sodankylä Geophysical Observatory (SGO, Finland) discussed in his invited talk the effects of solar proton events and energetic auroral precipitaton on the odd nitrogen production and consequent ozone destruction in the stratosphere. Modeling results have shown that the effects of solar or aurorally generated NO can spread even in the cases of moderate activity to sub-auroral latitudes (35-40º). The Sodankylä group has investigated the vertical transportation phenomena with their ion chemistry model which describes reactions of 63 ion species (both negative and positive) within the altitude range of 20-150 km. The performance of the model in describing ozone production and loss rates during solar proton events has been evaluated with the help of satellite data (Envisat). A future challenge is to gain more understanding about the effects of energetic (even relativistic) electron precipitation. Turunen envisages that in this case the modeling results can be evaluated with auroral observations by standard cameras and ionosondes together with data from riometers and X-ray detectors.

Umran Inan from Stanford University (US) discussed in his invited presentation the opportunities of using VLF-antennas in probing lightning activity and the effects of energetic precipitation in the ionospheric D-layer. AWESOME is an education programme which maintains 13 VLF receivers in US. This system allows holographic imaging of the lower atmosphere morphology. Patches due to lightning induced electron precipitation are an example of phenomena which AWESOME can detect.

Thomas Ulich (SGO, Finland) advertised the global AARDDVARK (Antarctic-Arctic Radiation-belt-(Dynamic) Deposition –VLF Atmospheric Research Konsortia) network which continuously monitors changes in the ionization levels at altitudes 30-85 km. The network has been established as UK-NZ collaboration and its goal is to collect observations of energy coupling between the atmosphere, Sun and geospace.

TAG-B: *Quantification of the inner magnetospheric dynamics using remote sensing techniques*

In his contributed talk U. Inan introduced some scientific results based on the data from Antartic VLF-antennas. Stanford University has received support for the re-establishment of a VLF- transmitter to the South Pole. The transmitter will start operations during the season 2007-2008. With the combination of the transmitter and receivers at coastal stations the ionospheric effects of solar proton events and energetic electron precipitation from radiation belts can be investigated. Especially the latter topic offers the VLF-community opportunities to do break-through science since electron precipitation fluxes are often so weak that their detection with other instrumentation is difficult. Antarctic VLF-receivers can record also so called chorus-waves whose role in the radiation belt generation is still a widely debated question: Some theories assume chorus-waves to decrease the radiation belt electron population while some theories consider them as generators for outer radiation belt electron populations.

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.*

Nikolai Ostgaard (Bergen University, Norway) reviewed our current knowledge about interhemispheric asymmetries in solar-terrestrial phenomena. Statistical studies and theoretical models have been successful especially in resolving asymmetries related with Interplanetary Magnetic Field (IMF) and Earth's magnetic dipole tilt variations. We can describe qualitatively how these factors affect the global plasma convection pattern in the polar cap, the location of the northern and southern cusps (ionospheric footpoints of the magnetic reconnection region in the dayside magnetopause) and the intensity of auroral emissions and electric currents. According to ICESTAR objectives Ostgaard challenges scientists to sharpen the picture to include also quantitative information: what is the relative difference e.g. between the northern and southern reconnection rates (as measured e.g. with polar cap sizes, cusp spot intensities and cross polar cap potential drops) in different conditions? Data of global auroral imagers will be of key importance in such work. Thus Ostgaard encourages scientists to revisit the old imager data bases and waits forward to harvest observations from the forthcoming KuaFu satellite mission.

Akira Kadokura from the National Institute of Polar Research (NIPR) gave an overview of Japanese solar-terrestrial and aeronomy activities in the Antarctica. NIPR has more than 22 years record of doing auroral imaging with ground-based cameras located at magnetically conjugacy areas. This project has given us important quantitative information about the role of Earth's internal magnetic field's slow variations in interhemispheric relationships. The northern conjugacy region of the Antartic Syowa station has moved approximately 150 kilometers in Iceland during the 22 year period. The Iceland-Syowa pair has one of best locations on the globe to make conjugacy studies of night time auroras. Yet catching auroral nights with simultaneous northern and southern observation is a challenge since dark enough nights are available only from two week periods around the equinoxes. The few succesfull periods have given valuable new insight to the problematics of conjugacy effects in small scale and rapid auroral structures. A surprising finding related with pulsating structures is that their shape can be similar in both hemispheres but the pulsating periods are different. These interesting findings have encouraged NIPR to continue and intensify their measurements with the Iceland-Syowa facilities. In addition Japanese research groups are currently installing a network of autonomously operating magnetometers to the Syowa region and conducting feasibility studies for a new Antarctic MST/IS radar (PANSY).

Lucilla Alfonsi (Istituto Nazionale di Geofisica e Vulcanologia, INGV) gave a presentation about the multinational (Italy-Canada-UK-South Africa-Poland) UAMPY-project which conducts ionospheric research with Arctic and Antarctic networks of GPS-receivers and other instrumentation. The project's main goal is to develop models and realiable prediction routines for ionospheric small scale irregularities. These struc-

tures form steep Total Electron Content (TEC) gradients responsible for scintillations in radio signals passing through the ionospheric plasma. Small scale irregularities, their occurrence, spatial distribution, characteristics and dynamics are one of the most studied problems in the ionospheric phenomenology. Understanding the physics behind ionospheric scintillation can be considered as one of last challenges for the scientists to solve before the Global Navigation Satellite Systems (GNSS) and radio frequency (RF) communications networks can serve the mankind reliably. UAMPY collects data of ionospheric conditions in different RF regimes and uses these observations to test the reliability of existing models and, potentially, to improve them. The routines to be tested include also software developed by the European space weather community with support of ESA (ESA Space Weather Pilot Project) and EU (COST 296). UAMPY has established a working group to facilitate collaboration with the POLENET community which operates a dense network of Antartic dual-frequency GPS-receivers for tropospheric and geodetic studies. The main objective of UAMPY-POLENET collaboration is to build an efficient and centralized data sharing system for the GPS-network.

TAG-D: *Creation and management of the data portal to enable the ICESTAR programme and SCAR SSG/PS*

Vladimir Papitashvili (University of Michigan, US) brought the meeting participants some regards from the IPY Data Management subcommittee. IPY encourages its core projects to arrange their data sharing via multiple Virtual Observatories. This eliminates the voluntary need of copying data to the World Data Centers (WDC). Instead data will be available in distributed sources which form so called “Data Fabric”. WDCs still have the important role of pulling data from the different nodes of the Fabric and to create backups of the most valuable data sets. Virtual Observatory (VO) is an interface which unites distributed services and/or repositories. A general VO template includes four layers: The lowest layer includes modules for locating the data sources. The next two layers conduct the data retrieval and format conversions and the top layer takes care of the user interface with flexible data visualization tools. As a working example of this template Papitashvili demonstrated the performance of the Virtual Global Magnetic Observatory which operates at a server of Michigan University.

Mikko Syrjäsuo (University of Calgary, Canada) introduced the Cluster 63 community with the GAIA Virtual Observatory. GAIA provides tools for browsing summary images and keograms from allsky imagers (ASIs), meridional scanning photometers (MSPs), riometers, and satellite borne global imagers. These summary images and other metadata provide a quick overview of data availability, quality, and content from a number of international programs. GAIA is the VO for the optical and riometry component of ICESTAR, and is designed specifically to adhere to an open data policy consistent with the eGY "Declaration for a Geoscience Information Commons". Today the browsable data base includes already more than 10 million summary images.

Anthony van Eyken advertised in his presentation the centralized data dissemination system Madrigal for incoherent scatter radars. Madrigal has several virtues typical for a VO: It collects data from distributed sources, re-distributes them in different widely used formats and provides programming interfaces. Madrigal includes tools both for quick-look analysis and consequent event selection and for massive data mining. The system is widely used among the user groups of incoherent scatter radars. To broaden the user community EISCAT scientists in UK have started a project to integrate Madrigal to the Astrogrid VO. The objective is to get Madrigal and Astrogrid to communicate with each other so that clients of Astrogrid which typically use spaced-based data can process also radar data with those tools which they already know. This project conducts pioneering work in its attempt to get two independently developed VOs to communicate each other autonomously.

Education and Public Outreach

For direct communication with the general public ICESTAR-IHY-IPY has established an outreach programme which aims to coordinate parallel semi-annual media events in all participant countries during the IPY years. These events will be realized as press releases and popular lectures summarizing the recent scientific findings of the project. For the audience keen on observing the environment several research groups will put up web-interfaces to show real-time data from their instrumentation. The public understanding of

geospace science will be expanded also in collaboration with national research councils. The IPY 2007 Space Science Symposium and the "Life on Icy Worlds" conference, respectively, planned to be arranged in Greenland and in Alaska will be important forums for educating national science administrators and teachers about historical and forth coming research activities with the perspectives from Arctic natives, Antarctic scientists, and solar system explorers.

To educate next generation of geospace scientists ICESTAR-IHY-IPY will together with space science centres provide plenty of material for interesting and challenging exercises and thesis works. Students will participate in the measurement campaigns and in the development of the modern data-sharing systems. The easily accessible data-archives will provide important reference material for observational and theoretical investigations.

4. Web Products, Virtual Observatories and Data Portals

In the first ICESTAR workshop in July 2005 Toulouse, data sharing issues were discussed for the first time among a wider community including representatives of some of the most widely used existing geospace data servers (e.g. SPIDR and CDAWeb, for more details see the notes of this meeting in http://scar-icestar.org. It was decided in the workshop that special attention in the first phase will be paid to three data servers: VGMO (magnetometer data), GAIA (auroral precipitation data), and Madrigal (Incoherent scatter radar data). The aim is to build or upgrade these systems so that they have easily adoptable interfaces both to the direction of the users and the data providers. A more ambitious goal will be to make the systems to communicate electronically.

Web Progress

- **ICESTAR Website**: Established to facilitate international communication.
    - http://www.scar-icestar.org

- **ICESTAR-IHY-IPY Website*:*** A distinct website established to facilitate international communication on IPY Project #63, *Heliosphere Impact on Geospace.*
    - http://www.ipy-id63.org/

GAIA VO Progress

- See http://gaia-vxo.org.
- GAIA is presently operational and managed by research groups at the University of Calgary, Lancaster University, and the Finnish Meteorological Institute.
- The observatory has tools for browsing summary images from all-sky imagers, meridional scanning photometers, riometers and satellite borne global imagers.
- The system shows summary images (more than 10,000 000 images) from the MIRACLE, NORSTAR, THEMIS ASI, IRIS, and OMTI networks.
- Antarctic imaging riometer data from South Pole has recently been incorporated into GAIA.
- Currently plan for the elements of the final system:
    - the data base of metadata and summary images and keograms (development ongoing);
    - \\browsing tools (ongoing);
    - tools for integrating data from different instruments together to increase the scientific usefulness of that data (being proposed in 2007);
    - pattern recognition and content based image retrieval tools;
    - a system to provide access to full-resolution data).

VGMO.NET Data Portal Progress

- A prototype of the VO for magnetometer data, VGMO.NET, was released
    - Antarctic magnetometer data are now incorporated into VGMO.NET
    - See http://mist.engin.umich.edu/mist/vgmo/vgmo.html.

ICESTAR Budget Allocation in 2007

Scientific Research Programmes - expenditure details (in USD)					
II a	Scientific Activities	BUDGET ALLOCATION			
	ITEM	(initial)	(revision)	Carry forward	TOTAL
II a 4.4	ICESTAR	23,000.00		19,025.39	42,025.39
Budget allocations 2007					
2007	Totally allocated:	Expenditure	Expenses vs Allocation		
ICESTAR workshop Feb 2007	23,500.00	19,325.75	4,174.25		
unallocated	18,525.39		18,525.39		
TOTAL:	42,025.39	19,325.75	22,699.64		
				EXPENDITURE (USD)	
ICESTAR EXPENDITURE 2007 - (updated 8 May 2007)				II a Scientific Activities	
Date	Item	Expenditure currency	Mean exchange rate to 1 USD	ICESTAR	Balance
1-Jan-07	Opening balance				42,025.39
20-Mar-07	Rhian Salmon, ICESTAR Helsinki	259.19	0.51	503.56	41,521.83
20-Mar-07	Andrew Kavanagh, ICESTAR Helsinki	461.62	0.51	896.84	40,625.00
20-Mar-07	Richard Stamper, ICESTAR Helsinki	427.66	0.51	830.86	39,794.14
21-Mar-07	B D L Opperman, ICESTAR Helsinki			1,622.30	38,171.84
21-Mar-07	M Candidi, ICESTAR Helsinki			972.28	37,199.56
21-Mar-07	L Alfonsi, ICESTAR Helsinki			841.90	36,357.66
21-Mar-07	A T Weatherwax, ICESTAR Helsinki			1,068.48	35,289.18
21-Mar-07	U Inan, ICESTAR Helsinki			1,579.00	33,710.18
21-Mar-07	V Papitashvili, ICESTAR Helsinki			1,455.13	32,255.05
27-Mar-07	Liu R, ICESTAR Helsinki			1,573.69	30,681.36
27-Mar-07	E Tanskanen, ICESTAR Helsinki			1,295.40	29,385.96
27-Mar-07	I Sandahl, ICESTAR Helsinki			1,186.27	28,199.69
27-Mar-07	Y Stozhkoiv, ICESTAR Helsinki			755.78	27,443.91
27-Mar-07	E Correia, ICESTAR Helsinki			1,987.17	25,456.74
27-Mar-07	A S Potapov, ICESTAR Helsinki			1,306.47	24,150.27
29-Mar-07	M Candidi, ICESTAR Helsinki			144.16	24,006.11
3-Apr-07	O M Pirog, ICESTAR Helsinki			1,306.47	22,699.64
	2007 CLOSING BALANCE				
TOTALS:				19,325.75	22,699.64
*changing exchange rates may affect the final mean value of expenditure					

In addition, ICESTAR helped support travel expenses for scientist attending the Greenland Space Sciences Symposium in May 2007. ICESTAR chairs Allan Weatherwax and Kirsti Kauristie were also co-convenors of the Greenland meeting. Estimated SCAR funding required for the next year is approximately $21,000 USD. The SCAR funds will enable ICESTAR to run the following meeting and support travel.

Dates	ICESTAR Sponsored Meeting	Amount
Winter 2008	ICESTAR-IHY-IPY meeting (Site/place TBD)	$3,000
Summer 2008	SCAR Meeting Expenses	$15,000

ICESTAR will continue to provide travel to support for researchers worldwide to participate and present papers at scientific meeting and workshops. Approximately $3,000 is budgeted for such expenses.

Proposed Work Plan for the Next Year

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. During the next year, the ICESTAR programme will continue to focus on the following items:

- Continued development of data portals 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 (see GAIA and VGMO.NET above). 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.

Collaboration between Ionospheric and Meteorological Research Groups

The multidiscipline IPY project POLENET (meteorology, glaciology, volganology, seismology) will build and maintain an extensive Antarctic network of dual-frequency GPS receivers. Data of this network would be invaluable for the ICESTAR-IPY community which also maintains several GPS receiver stations in the Antartic for ionospheric research. In the SCAR Cross-Linkages workshop (arranged in November 2006 in Rome) the POLENET and ICESTAR communities agreed to start collaboration in the development of GPS data sharing systems. A dedicated Working Group with POLENET, ICESTAR, and SSG-GS representatives will start the preparatory work in early 2007.

Special Issue of JASTP

A proposed special issue of JASTP will focus on the IPY #63 project objectives "ICESTAR/IHY - Heliosphere Impact on Geospace" is planned with a publication target in the first part of 2008.

Supporting Information

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.