



Four Year Report to the SCAR Executive on the Scientific Research Programme

Overall Programme Duration: 2005 – 2009

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 highlights selected progress with the implementation of ICESTAR since inception in 2005. For complete details, please visit the ICESTAR website at www.scar-icestar.org.

At the completion on the programme in 2009, ICESTAR plans to create an expert group to further develop the subject. Thus, ICESTAR will not propose for a second term as an SRP.

Steering Committee Members List

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This report was compiled by Drs. Allan Weatherwax and Kirsti Kauristie on behalf of the ICESTAR Team.

Selected key achievements

Arctic and Antarctic polar winter NO_x: ICESTAR researchers report on GOMOS nighttime observations of middle atmosphere NO₂ and O₃ profiles during eight recent polar winters in the Arctic and Antarctic. The NO₂ 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 NO₂ 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 other. Compared 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 $\lambda_s = 25^\circ, 35^\circ, 45^\circ,$ 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.

Selected contributions to IPY programmes

Heliosphere Impact on Geospace is one of the core projects of the fourth International Polar Year programme which will take place during March 2007 - March 2009. The project (IPY ID# 63) will be run by a federation of 29 international research groups from which the ICESTAR and IHY communities will carry the management responsibilities and will serve as the contact point towards the IPY Project Office.

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. See <http://www.ipy-id63.org> for complete details and <http://scar-icestar.org> for a complete overview of the workshop.

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 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 mesosphere-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 radiation 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.

Selected list of publications in peer reviewed literature

- Bhardwaj, Anil; Randall Gladstone, G.; Elsner, Ronald F.; Østgaard, Nikolai; Hunter Waite, J.; Cravens, Thomas E.; Chang, Shen-Wu; Majeed, Tariq; Metzger, Albert E.: First terrestrial soft X-ray auroral observation by the Chandra X-ray Observatory, *Journal of Atmospheric and Solar-Terrestrial Physics*, Volume 69, Issue 1-2, p. 179-187, 10.1016/j.jastp.2006.07.011, 2007.
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Selected ICESTAR 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 capabilities 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.*
- **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 features 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 collaboration, 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.*

Selected details of the SRP web site, and number of hits per web site

- **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/>

Information on SRP database(s), and amount of use of database(s)

At the 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.

GAIA Virtual Observatory

- GAIA is presently operational and managed by research groups at the University of Calgary, Lancaster University, and the Finnish Meteorological Institute: See <http://gaia-vxo.org>.
- Prof. Eric Donovan recently joined the ICESTAR team as a Thematic Action Group (TAG) leader focused on VO development.

SuperMAG

- ICESTAR scientists are key contributors to SuperMAG, an initiative which will use data from all available ground magnetometer stations.

Number and type of education/training and other capacity building activities

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 forthcoming 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.

Title, place and type of meetings/workshops, and numbers, genders and countries represented

- **International Riometer Workshop III (June 22, 2008):** Riometers are emerging as an important tool in both space science and space weather. Global networks of imaging and single beam riometers support studies of high energy CPS and radiation belt electron precipitation, dynamic magnetospheric processes such as dispersionless injections, the effect of geospace processes on high latitude atmospheric composition and dynamics, and the effects of polar cap high energy

proton precipitation on communications Agreements between data providers, under the auspices of the IPY ICESTAR and Gloria initiatives, and facilitated by the GAIA Virtual Observatory, are on the verge of enabling ready access to these data. The Third International Workshop on Riometry is being held from 9:00 AM to 5:00 PM on Sunday, June 22, 2008 at the Zermatt Resort in Utah.

- **Polar Gateways Arctic Circle Sunrise (Jan. 23-29, 2008):** ICESTAR co-sponsors the Polar Gateways Arctic Circle Sunrise 2008, Barrow, AK, Jan. 23-29, 2008
- **Greenland Space Science Symposium (May 2007):** The Greenland Space Science Symposium was arranged in May 2007 to celebrate Greenland's rich history in using arrays of scientific instruments for monitoring geospace phenomena. The program of the symposium included both historical reviews and presentations describing the latest advancements in observations and modeling of solar-terrestrial and aeronomy phenomena in polar areas. The ICESTAR project had a dedicated session in the symposium with the title "Solar Influence on Geospace as Determined by Hemispherically Conjugate Observations".
- **Heliosphere Impact on Geospace Workshop (February 5-9 2007):** The kick-off meeting of the IPY project 63 "Heliosphere Impact on Geospace" was held in Helsinki on February 5-9 2007. The meeting took place in the Dynamicum-building of the Finnish Meteorological Institute. Scientists from each of the 29 sub-projects participated. Over 16 countries were represented at this meeting.
- **ICESTAR Data Portal Workshop (July 23, 2005):** ICESTAR hosted a Data Portal and Virtual Observatory Workshop in Toulouse, France.
- **Other:** In addition, ICESTAR team members organized over 10 special science sections/session at international meeting such as AGU, IAGA, GEM etc.

Expenditure on project activities, and plans for unspent funds

PROJECTED ICESTAR BUDGET – 2008			
Scientific Research Programmes - expenditure details (in USD)			
ICESTAR EXPENDITURE 2008			Scientific Activities
Date	Item	ICESTAR	Balance
1-Jan-08	Carry forward from 2007		\$ 15,847.21
1-Jan-08	Allocation for 2008		\$ 23,000.00
		TOTAL	\$ 38,847.21
	PROJECTED ICESTARS RELATED EXPENSES		
23-Jan-08	Polar Gateways Conference, Alaska, USA		
	Kirsti Kauristie at FMI	\$ 1,500.00	\$ 37,347.21
	Kevin Hand at JPL	\$ 1,500.00	\$ 35,847.21
	Christine Prested at Boston University	\$ 1,189.96	\$ 34,657.25
	Todd Smith at APL	\$ 1,500.00	\$ 33,157.25
2-Apr-08	IPY Cluster63 Meeting, Bergen Norway	\$ 12,000.00	\$ 21,157.25
	Jesper Gjerloev	\$ 1,500.00	\$ 19,657.25
	Lucilla Alfonsi	\$ 1,500.00	\$ 18,157.25
8-Jun-08	GEM: Internatinal Riometer Workshop, USA	\$ 5,000.00	\$ 13,157.25
7-Jul-08	SCAR Meeting in St Petersburg, Russia	\$ 12,500.00	\$ 657.25
2008	ICESTAR/Meeting Web Related Expenses	\$ 500.00	\$ 157.25
TOTALS:		\$ 38,689.96	\$ 157.25