Canadian Solar Workshop: 2004

21-23 November, 2004

Geomagnetic Laboratory

Natural Resources Canada

2617 Anderson Road

Ottawa, Ontario

After more than a decade of fragmentation, Canadian scientists who are working on solar and solar-related phenomena face tremendous new opportunities. The increased political and community interest in the Sun as something that affects our lives in many ways, technical and environmental, could be very positive, and the Canadian Geospace Monitoring Programme is an initiative that can benefit the community in many ways. It is therefore timely to have a solar workshop to see where we're at, and where we can go. This informal workshop is intended to provide members of the Canadian solar community with an opportunity to report on their programmes and scientific activities, and to discuss where we should go from here.

The Workshop

The Workshop consists of three sessions:

- Session 1: Short descriptions of programmes currently running, with scientific overviews.
- Session 2: Science presentations.
- Session 3: Where do we go from here?

The time allocation will depend upon the number of submissions, however we anticipate Session 2 as being the main session.

Presentations

On the basis of submissions received and time available, each speaker will be allocated 20 minutes for their presentation, plus a few minutes for questions discussion.

The primary presentation aid will be a video projector and screen, driven by a laptop computer with a CD drive. PowerPoint and Adobe Acrobat software will be available. Presenters are invited to submit their presentation files before the beginning of the session. We could make available those presentations afterwards.

Registration

We would like to know you're coming in time to ensure there is enough coffee, cups, chairs etc. The registration fee is $25.00 to be paid in cash upon arrival. This fee is just to cover the coffee, doughnuts and other things consumed during the meeting.

Submission of Talk Titles and Abstracts

There are two main categories: reports of programmes and departmental activities, and scientific presentations on current research. An ascii file comprising the talk title, author(s) and a short abstract (a paragraph or two) would suffice. How we apportion session and talk length will depend upon the number of submissions. You are welcome to submit multiple abstracts. If you want to make a presentation in Session 3, please let us know. Abstracts should be sent to Ken Tapping (ken.tapping@nrc-cnrc.gc.ca).

For more information contact the Organizing Committee, which is:

David Boteler – DBoteler@NRCan.gc.ca

Ken Tapping – ken.tapping@nrc-cnrc.gc.ca

Getting to the Lab.

<u>For those coming from Montreal</u>: take the Anderson Road exit from Hwy 417 just before you reach Ottawa. Proceed north on Anderson Road until you see the 'Geological Survey of Canada' signs on the right.

<u>For those coming from Kingston</u>: Take Hwy 416 to Ottawa, head east across the city on the Queensway. At the split between Hwys 174 and 417 take Hwy 174 (left 2 lanes). After the split, take the first exit (Blair) turn left to head south on Blair Road. At second traffic lights turn left onto Innes Road. Proceed east on Innes and take the first street on the right (Anderson Road). At the 3-way stop, go right (the continuation of Anderson Road). Carry on along Anderson Road, up a small hill, then 300 metres along you will see the 'Geological Survey of Canada' signs on the left.

If you get lost phone David Boteler (837-2035) or the Geomagnetic Laboratory commissionaire (837-4241)

Confirmed Attendees:

Name	Institution	E-Mail Address
Nabil Ayad	U. Montréal	nabilayad@ASTRO.UMontreal.CA
Eric Belanger	U. Montréal	Belanger@ASTRO.Umontreal.CA
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Larisa Trichtchenko	NRCan	larisa@geolab.nrcan.gc.ca

The Meeting

Sunday 21 Nov

12:00 **Catered Lunch at the Geomagnetic Lab**

1.15 pm **Welcome and Introductions**

1.30 pm **SESSION 1:**

PROGRAMMES, PROJECTS AND PRIORITIES

1.30

S1.1: SOLAR RADIO MONITORING: THE 10.7 CM SOLAR RADIO FLUX

Ken Tapping, National Research Council (ken.tapping@nrc-cnrc.gc.ca)

2.00

S1.2: RESEARCH IN SOLAR PHYSICS AT THE UNIVERSITÉ DE MONTRÉAL

Paul Charbonneau, Département de Physique, Université de Montréal

2.30

S1.3: RESEARCH IN SOLAR PHYSICS AT QUEEN'S UNIVERSITY

David Thomson, Maths Department, Queen's University

3.00

Coffee Break

3.30

S1.4: CANADA SPACE WEATHER FORECASTS AND SOLAR UNCERTAINTIES

Larisa Trichtchenko, Geomagnetic Laboratory, Natural Resources Canada

4.00

S1.5: THE CANADIAN GEOSPACE MONITORING PROGRAMME

Eric Donovan, (U. Calgary) and William Liu (CSA)

Monday 22 Nov

9:00 am **SESSION 2: SCIENCE**

9:00 am

S2.1: A NEW SOLAR CYCLE MODEL

A. Ayad, P. Charbonneau, Département de Physique, Université de Montréal

9:30 am

S2.2: INTERMITTENCY AND PHASE PERSISTENCE IN A BABCOCK-LEIGHTON MODEL OF THE SOLAR CYCLE

Paul Charbonneau, Guillaume Blais-Laurier, and Cédric St-Jean

Département de Physique, Université de Montréal

10:00-10:30 am: Coffee Break

S2.3: THE SLOWLY-VARYING COMPONENT AT 21CM WAVELENGTH: ITS RELATIONSHIP WITH THE HOST ACTIVE REGIONS OVER THE SOLAR CYCLE

Ken Tapping, National Research Council

11 :00 am

S2.4: ACTIVE REGION AREA EVOLUTION AND THE TOTAL SOLAR IRRADIANCE

Ashley Crouch and Paul Charbonneau, Université de Montréal

11 :30 am

S2.5: THE INFLUENCE OF SOLAR WIND ON THE EARTH'S ATMOSPHERE THROUGH THE ACTION OF ATMOSPHERIC GRAVITY WAVES

P. Prikryl(1), D. B. Muldrew(1), G. J. Sofko(2)

(1)CRC, Ottawa, (2)ISAS, University of Saskatchewan, Saskatoon,

12 :00-13:30: Lunch at Blackburn Arms

S2.6: WHAT PROCESS CREATES THE NON-POTENTIAL MAGNETIC FIELDS THAT SUPPORT AND SUSTAIN SOLAR PROMINENCES?

V. Gaizauskas, Herzberg Institute of Astrophysics/NRCC

2 :00 pm

S2.7: A NEW AVALANCHE MODEL FOR SOLAR FLARES

L.F. Morales, P. Charbonneau, Département de Physique Université de Montréal

2 :30 pm

S2.8: SOLAR FLARES MODELS AND DATA ASSIMILATION.

Eric Belanger, University of Montreal

3 :00-3:30 pm: Coffee Break

S2.9: THE QUEEN'S SOLAR RADIO TELESCOPE
Benjamin L. Gardiner,
Math and Statistics, Queen's University, Kingston, Ontario

4 :00 pm

S2.10: SUNSPOT SEISMOLOGY

Ashley Crouch, Paul Cally, Paul Charbonneau, and Michele Desjardins.

Département de Physique, Université de Montréal

4 :30 pm

S2.11: ON BOUNDARIES, SHOCKS AND DISCONTINUITIES: THE CASE OF THE SOLAR-TERRESTRIAL BOW SHOCK

A.M. Hanza and K. Meziane, University of New Brunswick

5:00 pm

S2.12: SHOCK-ASSOCIATED ENERGETIC PARTICLES IN SPACE
K Meziane & A. M. Hamza, University of New Brunswick

Tuesday 23 Nov

9:00 am SESSION 2 cont: SCIENCE

9 :00 am

S2.13: SPACE RADIATION MONITORS – RECENT EXPERIENCES

Ian Thomson

9:30 am

S2.14: PREDICTION OF RELATIVISTIC ELECTRON FLUENCE BASED ON ITS RELATIONSHIP WITH GEOMAGNETIC ACTIVITY OVER A SOLAR CYCLE

Hing-Lan Lam, Geomagnetic Laboratory, Natural Resources Canada

10:00-10:30 am: Coffee Break

S2.15: TRACING SPACE WEATHER DISTURBANCES FROM THE SUN THROUGH TO THEIR EFFECTS ON THE GROUND

D.H. Boteler (NRCan) and K.F. Tapping (HIA, NRC)

11:00 am

S2.16: MAGNETOMETER ARRAYS IN EASTERN CANADA'S AURORAL ZONE

Martin Connors, Athabasca University

11:30 am

S2.17: SOLAR OSCILLATIONS AND COMMUNICATIONS SYSTEMS

David J. Thomson
Queen's University, Kingston Ontario,
(djt@mast.queensu.ca) (613) 533-2426

12:00 pm

S2.18: THE SUN FOR DUMMIES (AND MANAGERS)

William Liu (A Non-manager), Canadian Space Agency

12:30 –2:00 pm: Lunch at the Blackburn Arms

1:30 pm SESSION 3: WHERE DO WE GO FROM HERE?

Agenda to be produced and circulated at meeting.

Abstracts Received So Far

SESSION 1: PROGRAMMES, PROJECTS AND PRIORITIES

S1.1: SOLAR RADIO MONITORING: THE 10.7 CM SOLAR RADIO FLUX

Ken Tapping, National Research Council (ken.tapping@nrc-cnrc.gc.ca)

Solar radio monitoring started in Canada in 1946, and has been supported by the National Research Council until 2003, at which point it became a joint programme of the National Research Council and the Canadian Space Agency. The programme, located at the Dominion Radio Astrophysical Observatory, at Penticton, BC, provides three daily absolute measurements of the solar flux density at 10.7 cm wavelength (these values are known as the 10.7cm Solar Radio Flux – $F_{10.7}$), which is used internationally as a standard index of solar activity. The programme also includes a daily patrol for flares and other transient solar activity. The data now form a continuous, consistent record of solar activity spanning more than 50 years.

Solar activity is fundamentally a magnetic phenomenon, with the classical activity indices being measures of solar phenomena strongly modulated by magnetic activity. $F_{10.7}$ is a measurement of the slowly-varying component of solar radio emission at a wavelength close to its intensity peak. The slowly-varying, or S-component is the integrated emission from plasmas trapped in the magnetic fields overlying active regions. The emission is due to three emission mechanisms: thermal, free-free emission, thermal gyroresonance and non-thermal, gyrosynchrotron emission. With its strong dependence upon the total magnetic flux in active regions, $F_{10.7}$ correlates strongly other phenomena affected by magnetic activity, such as total irradiance, uv irradiance, total magnetic flux and various spectral indices to the point where it can be used as a proxy.

In this talk we will discuss the origins of F10.7, its relationship with magnetic activity, its extrapolation to other frequencies and its value as a proxy, and also report on the progress of the current upgrade.

S1.2: RESEARCH IN SOLAR PHYSICS AT THE UNIVERSITÉ DE MONTRÉAL

Paul Charbonneau, Département de Physique, Université de Montréal

In this talk I will give an overview of the research topics currently being pursued at the Physics Department of the Université de Montréal, in the general area of Solar Physics. These include (1) Numerical modelling of the solar cycle, with particular emphasis on the mechanism(s) leading to amplitude fluctuation and intermittency, and links to solar irradiance variations; (2) flare energy release, with emphasis on avalanche models based on the idea of self-organized criticality; (3) sunspot seismology, with emphasis on the role of magnetic field in absorbing p-modes.

S1.3: RESEARCH IN SOLAR PHYSICS AT QUEEN'S UNIVERSITY

David Thomson, Mathematics Department, Queen's University

S1.4: CANADA SPACE WEATHER FORECASTS AND SOLAR UNCERTAINTIES

Larisa Trichtchenko, on behalf of the forecast group:
R.L.Coles, H.-L .Lam, D.H. Boteler, D.Danskin and L.McKee
and system support personnel:
J. Parmelee, R. Shaughnessy and S. Souksaly

Canadian Space Weather Forecast Centre is one of the regional warning centers of the International Space Environment Service. Our group specializes in the geomagnetic forecasts and effects of the geomagnetic disturbances on ground technology. We are providing 24/7 forecast and nowcast service, which consists of short-term and long-term forecasts of geomagnetic activity across Canada as well as forecast of electron fluence at the geostationary orbit. The forecast system is quite complicated and will be presented as a map with some basic explanations.

To succeed, we need to monitor solar activity and make some assumptions on the arrival time and geo-effectiveness of the solar disturbances. Sometimes these assumptions look reasonable, other times not. We present examples with our forecasting successes and problems, which arise out of the uncertainties of our knowledge on the eruptions coming from the Sun.

S1.5: THE CANADIAN GEOSPACE MONITORING PROGRAMME

Eric Donovan, (U. Calgary) and William Liu (CSA)

Canadian GeoSpace Monitoring (CGSM) is motivated by the recognized need for greater fundamental understanding of planetary environments that are affected by short and long term variability of our star - the Sun. The Sun and Earth form a tightly coupled system, with solar variability driving effects on space weather and climate, the creation of harsh radiation environments and the generation of the aurora. The CGSM program seeks to understand this fundamental solar-terrestrial coupling and its influence on our planetary environment.
The overarching scientific goal of CGSM is to understand the transport of mass and energy across multiple scales throughout the entire solar-terrestrial system. The primary CGSM scientific objective is to elucidate the fundamental processes that cause and control:

I. convection within and energy injection into the global magnetosphere,
II. magnetotail instabilities and flows,
III. auroral particle acceleration,
IV. energization, transport and loss of energetic magnetospheric particles,
V. injection, transport, and loss of low energy magnetospheric particles.

CGSM is a coordinated observation, data assimilation, and modeling program. Our observational program employs an integrated continent-scale array of radio, magnetic, and optical instruments. Following a significant expansion utilizing state-of-the-art technology, CGSM instrumentation will represent an internationally unique facility with which to pursue fundamentally new solar-terrestrial science. Owing to Canada’s geographic position of having the largest readily accessible landmass under the auroral and polar regions, CGSM will enable Canadian scientists to play a leading role in International Living With a Star (ILWS), a major multi-agency, multi-spacecraft, solar-terrestrial applied and fundamental science program.

SESSION 2: SCIENCE

S2.1: A NEW SOLAR CYCLE MODEL

A. Ayad, P. Charbonneau

Département de Physiquem Université de Montréal

Montréal, Québec

We are still far from an understanding of how the Sun generates its magnetic field.

Nowadays, it is commonly believed that the occurrence of such phenomena in the Sun is governed by a dynamo mechanism that acts at the interface between the convective layer and the underlying radiative envelope. This mechanism is based on the mutual interaction between rotation, convection and magnetic fields. We are developing a new model of the solar cycle that combines two types of well-understood numerical simulations and operates with dynamo ingredients such as differential rotation, meridional circulation, the large-scale poloidal field, the toroidal field and sunspots.

The basic idea is to initialize the model with a surface evolution model of solar magnetic flux as a 2-D problem in latitude and longitude (θ,ϕ). We then use results from this simulation to do an axisymmetric (r,θ) model for the transport and shearing of the solar magnetic field. This latter model then provides further input to the surface evolution model, leading to a self-consistent Babcock-Leighton dynamo model that avoids the *ad hoc* source term that up to noow has always had to be incorporated into such models. The competititive role of the convective and diffusive terms in the induction equation determines the time evolution of the magnetic field.

I will show an example of each of the two models, and explain how they will be meshed into one another to produce the cyclical magnetic pattern.

S2.2: INTERMITTENCY AND PHASE PERSISTENCE IN A BABCOCK-LEIGHTON MODEL OF THE SOLAR CYCLE

Paul Charbonneau, Guillaume Blais-Laurier, and Cédric St-Jean

Département de Physique

Université de Montréal

paulchar@ASTRO.UMontreal.CA

I will present and discuss a numerical simulation of the solar cycle based on the Babcock-Leighton mechanism of poloidal field regeneration by the surface decay of sunspots. The simulation includes low-amplitude stochastic noise, and exhibits intermittency, i.e. quiescent episodes of strongly reduced amplitude irregularly interspersed between epochs of "normal" cyclic behaviour. I will show that the phase of the cycle can persists across these quiescent episodes, a feature normally not expected from intermittency. We ascribe this behaviour to the regulatory influence of meridional circulation in the solar convective envelope, which is known to be the primary determinant of cycle period in this class of dynamo models. I will also discuss similarities and differences between these results and the behaviour of the sunspot cycle during the Maunder minimum of solar activity.

S2.3: THE SLOWLY-VARYING COMPONENT AT 21CM WAVELENGTH: ITS RELATIONSHIP WITH THE HOST ACTIVE REGIONS OVER THE SOLAR CYCLE

Ken Tapping, National Research Council (ken.tapping@nrc-cnrc.gc.ca)

Since 1992 we have used the Synthesis Radio Telescope at the Dominion Radio Astrophysical Observatory, Penticton to map the solar disc at 21cm wavelength. The angular resolution is about an arc-minute, which is insufficient to map the distribution of emission within active regions, but more than adequate for measuring the contribution made by each active region to the total emission. At 21 cm wavelength the emission is almost completely due to free-free thermal processes, so modelling it is much simpler than is the case at other wavelengths. The objectives of this ongoing programme are to use the radio information to estimate conditions in the trapped plasmas and to examine changes in the relationship between other active region indices over the solar cycle.

S2.4: ACTIVE REGION AREA EVOLUTION AND THE TOTAL SOLAR IRRADIANCE

Ashley Crouch and Paul Charbonneau.

Observational evidence suggests that active region area decay is due, at least in part, to a fragmentation process. At the University of Montreal, we have developed a model for the area evolution of magnetically active regions where the rate of decay can be dependent on the area and/or the perimeter of the active region (we will discuss the evidence for and against the two different dependencies). By driving the system with time-dependent active region emergence data, the fragmentation process results in a size distribution of magnetic flux tubes over the solar hemisphere, ranging from large tubes (such as sunspots) to tubes of the smallest observable scales (fibrils). The simplicity of our model allows us to track the evolution of this size distribution over very long time scales (many solar cycles, though we only have emergence data for post-1917). There are several applications for such a model, for example the total solar irradiance. The irradiance contribution from various magnetic features depends on their size (large features, such as sunspots, are dark, whereas small flux tubes tend to be bright). By combining this property with our area evolution model we show that the resultant system can produce a solar irradiance contribution that behaves very much like the observed total solar irradiance (with a peak at solar maximum and a trough at solar minimum). We discuss the dependence of the model on its input parameters, and also further possible applications.

S2.5: THE INFLUENCE OF SOLAR WIND ON THE EARTH'S ATMOSPHERE THROUGH THE ACTION OF ATMOSPHERIC GRAVITY WAVES

P. Prikryl[(1)], D. B. Muldrew[(1)], G. J. Sofko[(2)]

[(1)]*Communications Research Centre Canada, Ottawa, ON, Canada*

[(2)]*Institute of Space and Atmospheric Studies, University of Saskatchewan, Saskatoon, SK, Canada*

High-speed plasma streams from coronal holes are the major sources of solar wind energy flow towards the Earth. The fast solar wind is permeated with plasma fluctuations, which are due to Alfvén waves and are thought to be the remnants of waves generated near the Sun. As the fast solar wind overtakes slower solar wind plasma, the interaction between the two regions generates large-amplitude magneto-hydrodynamic waves and shocks. The bulk of this highly variable wave energy is channeled to the auroral ovals and deposited in the upper atmosphere, much of it in the form of Joule heating. On time scales from tens of minutes to a few hours the auroral electrojets generate atmospheric gravity waves that cause travelling ionospheric disturbances (TIDs). The SuperDARN radar ground-scatter signatures of TIDs are traced to a source at auroral latitudes, namely pulsed ionospheric flows due to enhancements in the convection electric field and/or the associated ionospheric current fluctuations inferred from ground magnetic field perturbations. A correlation between solar wind Alfvén waves and TIDs points to very direct coupling of energy in the solar wind into subauroral atmosphere. Assuming that the sources of gravity waves are quasi-periodic convection/current pulses, a simplified ray tracing of gravity waves based on Snell's law in a spherically stratified atmosphere is conducted to support the observations. The gravity wave dispersion relation allows both up-going and down-going gravity waves. The down-going waves may be reflected from temperature gradients in the upper mesosphere or troposphere. The gravity waves interact with neutral winds and deposit their momentum in the neutral atmosphere. A possibility that the ionospherically generated gravity waves seed convective instabilities in the troposphere is investigated.

S2.6: WHAT PROCESS CREATES THE NON-POTENTIAL MAGNETIC FIELDS THAT SUPPORT AND SUSTAIN SOLAR PROMINENCES?

V. Gaizauskas

Herzberg Institute of Astrophysics/NRCC

100 Sussex Drive

Ottawa, Ontario K1A 0R6

Solar prominences (filaments when on the disk) are cool (<20,000 K) dense structures suspended in the hot solar corona (>1,000,000 K) and insulated from it by field lines that are presumably distorted to provide the necessary magnetic tension. They are blade-like structures that can in extreme cases exceed a solar radius in length. Prominences invariably follow a polarity inversion in the line-of-sight component of the magnetic field mapped over the Sun's photospheric surface. A significant number of prominences disrupt violently, often in conjunction with a flare and/or a coronal mass ejection, with a consequent possibility for a geomagnetic disturbance by an ejected plasmoidal cloud. But there is no direct way to measure the full 3D geometry of the magnetic field inside a prominence. In order to understand how magnetic instabilities can be triggered, many competing models have been proposed for creating and supporting prominences. Recent observational studies that constrain the choice of models will be described.

S2.7: A NEW AVALANCHE MODEL FOR SOLAR FLARES

L.F. Morales, P. Charbonneau

Département de Physiquem Université de Montréal

Montréal, Québec

Solar Flares are manifestations of sudden, intense and spatially localized energy release in the solar atmosphere that may raise the coronal temperature up to 10^7 K.

It is generally agreed (Kulsrud, 1998, and Priest and Forbes, 2000) that the energy source comes from *magnetic reconnection*, which provides a mechanism for the topological rearrangement of the magnetic field lines and liberates thermal and kinetic energy. In 1998, E.N. Parker suggested a physical mechanism for coronal heating based on so-called “nano-eruptions”. Parker’s idea is that stochastic photospheric fluid motions shuffle the footpoints of magnetic coronal loops. The magnetic field is “frozen” into the plasma (because of the high electrical conductivity), so that the relaxation of the loops results in a complex, tangled magnetic field that is force-free everywhere but in numerous small electrical current sheets. When the current in the sheets goes beyond certain thresholds, magnetic reconnection takes place.

Parker’s model includes all the ingredients to produce a self-regulated (SOC state, Bak, 1996): a dissipative system subject to local instability requiring a triggering condition (magnetic reconnection), a slowly driven open system, and an external forcing mechanism on a long time scale compared with dynamic timescales.

In the last decade, many efforts have been made to provide an SOC model for solar flares (see Charbonneau *et al.*, 2001 and references therein). One of the weak points of those SOC models is that it is difficult to identify in the numerical model the main quantities involved in the magnetic reconnection phenomena. In this work we develop a new generation of SOC models. We construct a 2D lattice formed of parallel “field lines” that are randomly deformed, leading to the development of discontinuities in the field lines. This simple device is a working scheme that will lead us to a more physically realistic SOC numerical model for solar flares.

Bak, P. *How nature works* (Springer, New York, 1996)

Charbonneau P., McIntosh W., Liu H., Bogdan T.J., *Solar Phys.,* **203**, 231 (2001)

Kulsrud R.M., *Phys. Plasmas*, **5**, 1599 (1998)

Priest E., Forbes T. *Magnetic Reconnection : MHD Theory and Applications* (Cambridge University Press, Cambridge, England, 2000).

S2.8: SOLAR FLARES MODELS AND DATA ASSIMILATION.

Eric Belanger, University of Montreal

belanger@ASTRO.Umontreal.CA

Solar flares play an important part in space meteorology because they can eject charged particles which are the source of the geomagnetic storms on Earth. These storms can interfere with the communication satellites and overload electric transformers, thus the need for a better understanding of solar flares. During the last years, the satellites (SOHO, TRACE) observing the Sun have been collecting data with an improved spatial and temporal resolution. Several attempts to explain the mechanism of solar flares were suggested.

First, we will present these different models. There is the self-organized criticality (or avalanche) model where an instability related to the reconnection of the magnetic field lines is propagated, and the more complex magnetohydrodynamic models. We will introduce the methods of data assimilation which generates better forecasts by taking advantage of both the theoretical/numerical models and the observations. Some preliminary results of the implementation of the 4D-VAR data assimilation method to a 1D avalanche model will be presented.

S2.9: THE QUEEN'S SOLAR RADIO TELESCOPE

Benjamin L. Gardiner,
Math and Statistics, Queen's University, Kingston, Ontario
(blg@mast.queensu.ca)

The correlation between cell-phone dropped call rates and solar radio burst has been confirmed (Lanzerotti, Thomson, and Maclennan, 1999) It is not clear what the noise power in-band is for this correlation, nor is it clear whether the noise causing dropped calls had any non-stationary character.

The uncertainties were a result of the limitations of the radio telescope on which the observations were performed - The Murray Hill Radio Telescope. D.J. Thomson has initiated a project for the construction of a solar radio telescope at Queen's University. The scope needs to be able to observe solar emissions in-band of cellular communications systems, and thus will have an active noise cancellation system. The scope will be able to switch to a low gain channel in the event of a sudden rise in energy output of the sun. The scope will also be required to capture an entire cellular communications channel of no more than 50MHz bandwidth anywhere in the range of 500MHz to 18GHz.
Reasoning behind the requirements as well as full planned specifications will be covered. A brief overview of the proposed active noise cancellation algorithm will be presented.

S2.10: SUNSPOT SEISMOLOGY

Ashley Crouch, Paul Cally, Paul Charbonneau, and Michele Desjardins.

Due to convective motions in its outer layers, the Sun oscillates like a drum. Helioseismology is the science of determining the structure of the solar interior by analysing the oscillations that are observed at the surface. Local helioseismology focuses on non-global features such as sub-surface flows and sunspots. In the late Eighties, it was discovered that sunspots affect incident oscillations in two ways: some of their energy is absorbed by the sunspot and their phase is shifted (meaning the wave speed is modified). It was first hoped that these observations could be used to gain information about the

sub-surface structure of sunspot magnetic fields. However, until recently, sunspot models could not adequately account for the observations, in particular, the absorption. The most promising absorption mechanism now appears to be the partial conversion of the solar oscillations to magnetic waves, that guide energy along the sunspot magnetic fields. Jointly at the University of Montreal and Monash University in Australia, we have developed sunspot models which include the radial variation of the field strength and field inclination, along with the vertical variation of the density, pressure, and adiabatic index. The model parameters (field strength and inclination) are adjusted by a genetic algorithm to minimise the discrepancy between the model predictions and the observations. We discuss these results and show that the model performs remarkably well despite its simplicity.

S2.11: ON BOUNDARIES, SHOCKS AND DISCONTINUITIES: THE CASE OF THE SOLAR-TERRESTRIAL BOW SHOCK

A.M. Hanza and K. Meziane University of New Brunswick (ahanza@unb.ca)

The primary goal of this talk is to discuss to some extent fluid boundaries. The general jump conditions will be derived with the Rankine-Hugoniot conditions treated as a special case. The jump conditions are illustrated for different geometries and the cases of contact, tangential and rotational discontinuities treated explicitely. This talk will introduce the MHD bow shock.

S2.12: SHOCK-ASSOCIATED ENERGETIC PARTICLES IN SPACE

K Meziane & A. M. Hamza, University of New Brunswick

Due to solar activity, travelling magnetohydrodynamic shock waves are frequently observed in the interplanetary space. Complex physical processes occur at the shock layer and their study is fundamental to cosmic electrodynamics. Dissipation processes are relevant at these shocks and constitute the source mechanisms for accelerating particles to very high energy. We will focus on strong shocks such as the Earth's bow shock and Interplanetary shocks driven by Corotating Interaction Regions (CIR) or/and Coronal Mass Ejection (CME). We will present and discuss the main types of ion distributions observed upstream and downstream of the shock. Some physical models involving shock acceleration will be presented and discussed as possible explanation of the observed ion properties.

S2.13: SPACE RADIATION MONITORS – RECENT EXPERIENCES

Ian Thomson

Thomson & Nielsen, 25B Northside Rd., Nepean, Ontario K2H 8S1

The space radiation environment has a direct impact on satellite performance and human safety and there is a need for on-board radiation monitors to quantify these effects. One example of recent work in this area is EVARM (Extra Vehicular Activity Radiation Monitoring) - an experiment currently on International Space Station. Results from this experiment will be used to illustrate the effects of space weather on radiation doses to astronauts. A description of small real-time radiation monitors developed by for the STRV-1c (Science and Technology Research Vehicle) spacecraft will also be presented. The purpose of this mission was to monitor electronic radiation effects e.g. Total Dose and Single Event Upsets in GTO. Current activities are focussed on the development of a new generation of small real-time radiation monitors based on STRV-1c with a 2005 launch date. This current work will be discussed in the context of monitoring the effects of solar activity on satellite and human safety.

S2.14: PREDICTION OF RELATIVISTIC ELECTRON FLUENCE BASED ON ITS RELATIONSHIP WITH GEOMAGNETIC ACTIVITY OVER A SOLAR CYCLE

H.-L. Lam, Geomagnetic Laboratory, Natural Resources Canada, 7 Observatory Cr., Ottawa (HLam@NRCan.gc.ca)

A study has been carried out to determine the relationship between high energy relativistic (>2 MeV) electron fluence and auroral zone geomagnetic activity for a solar cycle. Data for 1987-1997, spanning Solar Cycle 22, were used in the study. The relativistic electron fluence data were based on fluxes observed by the GOES geosynchronous satellites. The geomagnetic data were the DRX indices derived from a Canadian magnetic observatory located in the auroral zone at Fort Churchill, near the footprint of field lines passing through geostationary satellites. This work, based on data from a solar cycle, confirms earlier findings using limited data from segments of a solar cycle of enhancement in fluence 2-3 days after increases in geomagnetic activity, and shows the cycle dependence of fluence with respect to geomagnetic activity. This study underlines the influence of recurrent coronal holes on fluence level as well as the possible role of Pc5 magnetic pulsations as an electron acceleration mechanism, and highlights the predictability of fluence from ground geomagnetic data. A fluence prediction algorithm can now solely be based on derived expressions relating fluence and DRX. Thus, a simple fluence prediction scheme can easily be implemented to provide a 2-3 day advance warning of space weather conditions hazardous to geosynchronous satellites, since during days of high fluence, the likelihood of internal charging in a satellite is high, with possible discharges that could result in satellite operational anomalies. For verification purpose, daily values of fluence for 1997-2000 and for January 1994 were postcast using the derived expressions. The postcast values were validated, and the results give credence to the fluence prediction scheme.

S2.15: TRACING SPACE WEATHER DISTURBANCES FROM THE SUN THROUGH TO THEIR EFFECTS ON THE GROUND

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Radio flux measurements provide valuable information on the timing and speed of eruptions rising from the Sun's surface. Recordings from the RTSN and Penticton radio telescopes are used to investigate the solar eruptions that gave rise to major magnetic disturbances and power system problems on the Earth. Using the delays in increased flux at different frequencies we determine the speed of eruptions up through different heights in the solar atmosphere. These speeds provide a guide to when each eruption should arrive at the earth that can be correlated with times of geomagnetic disturbances. Times of shock arrivals and the subsequent evolution of the geomagnetic disturbance are examined to identify the specific causes of power system problems on the ground.

S2.16: MAGNETOMETER ARRAYS IN EASTERN CANADA'S AURORAL ZONE

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At present there is only one fully functional magnetometer in Canada east of the CANOPUS Churchill line and between magnetic latitudes 60 and 70. That is the NRCan instrument at Poste-de-la-Baleine. Kanji Hayashi's STEP Polar Network featured three instrument pairs (fluxgate and induction coil) at Goose Bay, Schefferville, and Kuujuaq. Of these possibly Kuujuaq is still able to gather data, we are in the process of having Goose Bay re-installed but anticipate radar interference, and we would like to collaborate with McGill University to re-establish Schefferville. Mark Moldwin's MEASURE Network has been funded by NSF to extend northward toward (and possibly beyond) and a subauroral fluxgate was installed at Mont Megantic QC in collaboration with the Universite de Montreal. One of Connors' fluxgates originally intended for western Canada will likely join this effort. Add in the several THEMIS instruments expected, and eastern Canada, Quebec in particular, should soon have very good coverage. Aspects of what is desirable include meridian chains, longitudinal spacing away from the GOES footpoint, and conjugacy with Antarctic instruments. In addition, a more easterly location on the continent offers space weather monitoring capapility, and in an area with bedrock which makes GIC problematic. The new dawn in Canadian ground-based arrays may rise in the East.

S2.17: SOLAR OSCILLATIONS AND COMMUNICATIONS SYSTEMS

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In this talk I describe some of the background and results of the study of solar oscillations and their effects on communications systems. This work began with the study of time--series of interplanetary particles, low energy electrons and protons measured by the Ulysses spacecraft, as part of an investigation of a series of satellite failures around the 1990 solar maximum.

A major conclusion of this study, Nature 376, pp 139-144 (1995), was that the temporal structure of the interplanetary magnetic field was dominated by solar oscillations with both p and g modes being seen. These observations are repeatable and the modes couple through the Earth's bow-shock into the magnetosphere.

The next stage began about 1996 with an investigation of dropped--calls in cellular phone systems. Time series of dropped call rates at one hour resolution were collected from a major market. These are dominated by rapid irregular fluctuations and a marked seasonal component. Attempts to correlate this data with numerous potential explanatory variables showed that weather and solar processes were dominant and also correlated. In particular the dropped call rate was coherent with the USAF solar flux data. This coherence is peculiar in that it has a bimodal distribution with low coherence overall but very high coherence at the modal frequencies previously seen in the Ulysses data. The mechanism that couples solar oscillations, and g-modes in particular, to whatever causes cellular phone calls to drop remains unknown.

S2.18: THE SUN FOR DUMMIES (AND MANAGERS)

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I present a non-managerial perspective, based on trademark ignorance and ignorant audacity, on the future of solar physics in Canada. The Sun is a magnetic star, and the magnetic field is one of the most ubiquitous features of the Universe (more so even than light). Understanding the generation, destruction, and interaction with matter of the magnetic field on a cosmic scale is a singular contribution to fundamental science solar research offers. Observational evidences, recent and archaic, have shown that behind the first-order periodicity of the solar cycle, the Sun is exceedingly complex, subtle, and managerially cunning. Explanation of these complex behaviours in turn raises some most challenging theoretical and computational problems. While this non-manager has not been a solar physicist, he has stayed in Holiday Inn Express a few times. In this talk, we will see how smart lodging in HIE really makes people.

SESSION 3: WHERE DO WE GO FROM HERE

(This is an ad-hoc discussion, but there is room for a prepared presentation or two)

Subjects that could be included here are: towards a Canadian centralized site for solar and terrestrial data, and the Canadian Geospace Monitoring Programme.