K. Arnason, E. Spanswick, L. Behjat, A. Fakheri Tabrizi

Data Quality Validation of Ground Based Riometers

The data recorded by ground-based riometers offers useful insight into disturbances in the ionosphere and precipitation of high-energy electrons. The University of Calgary manages a Canadian Space Agency network of riometers across Northern Canada which have been recording for approximately 30 years. The riometers present an opportunity to leverage decades of previously recorded data to predict and classify events in near real-time. However, riometers are susceptible to noise from sources such as local interference and seasonal changes. In order to utilize the data in an automated fashion we must first determine the quality of the data. Beginning with one individual riometer site we have created a prototype machine learning method to filter out unusable data and set the foundation to use these instruments for real-time monitoring. In this presentation, we discuss our methodology for producing and training a neural network to automatically classify riometer data according to the level of interference in the data. We discuss the results of our prototype model, as well as the future directions of the project.

Arnal, J., and C. Groth

Toward Heliospheric Data Assimilation of the Solar Wind: Results for One-Dimensional MHD Flows

Due to the potential risks that space weather events associated with solar-wind disturbances pose on modern technology and infrastructure, there has been increasing interest in physics-based forecasts of the solar wind. Data assimilation (DA) is a technique that formally combines measurements and the predictions of numerical models to produce improved estimates of a system. DA has been vastly successful in improving the forecast skill of atmospheric weather models. Thus, the space weather community has started to explore the use of DA schemes for improving forecasts of the solar wind via the assimilation of heliospheric observations. The ideal magnetohydrodynamic (MHD) equations provide effective approximations of the solar wind, spanning enormous spatial and temporal scales. In this presentation, we show results of the assimilation of synthetic plasma observations within a one-dimensional (1D) MHD model, setting the groundwork for ongoing research towards assimilating heliospheric measurements within a fully three-dimensional (3D) global MHD framework. We perform observing system simulation experiments and compare the errors in simulations both with and without the use of DA. We also explore the dependence of error reduction with spatial and temporal observation availability. Our findings demonstrate the potential of DA to improve MHD flow predictions. We also observe that for the same number of observations, the distributions of measurements in space tends to have a greater effect on error reduction compared to the frequency of observations in time.

Babu, S., I. Mann, S. Dimitrakoudis, L. Ozeke, I. Rae, and A. Smith

Probing the magnetospheric substorm onset mechanism using pitch angle resolved GOES satellite energetic particle data

Geomagnetic substorms are disturbances in the Earth's magnetosphere triggered by the release of stored magnetic energy in the magnetotail. Substorms consist of three phases, namely – the growth phase, the expansion phase, and the recovery phase. Even though the processes associated with these phases are clearly identified by auroral dynamics in the ionosphere, the events to which they are connected in the magnetosphere, and especially those associated with the onset of the expansion phase, are not well-known. Oberhagemann and Mann (GRL, 2020) proposed a new mechanism for substorm onset, which suggests a role for a pressure anisotropic ballooning instability. A numerical model was developed based on this hypothesis and found a transition towards a more parallel anisotropic configuration could trigger a ballooning instability they associated with substorm onset. Observational support for the association of increasingly parallel pressure with substorm onset is required. This mechanism can be better understood by analyzing satellite data sets with the required pitch angle dependence. The geosynchronous GOES satellite have accumulated a long time-base data set of energetic ion flux from the Magnetospheric Proton Detector (MAGPD instrument on the Space Environment Monitor (SEM) subsystem. When combined with data from the GOES magnetometer, this provides a measure of the pitch angle dependence of the flux. The GOES ion flux, magnetometer, and pitch angle data are used together with substorm onset indicators to look for evidence with which to test the Oberhagemann and Mann theory. To date, the GOES data have not been exploited to address this question.

Here we present results from GOES ion pitch angle distributions, derived from the nine telescopes of the MAGPD instrument along with the flux at these pitch angle values during different stages of substorm development. Raw flux data when compared with pitch angle indicates the increase of flux around 30º pitch angle. Pitch angle resolved ion flux using weighted average and Legendre polynomial fit methods clearly shows an increase in the ratio of 30º to 90º pitch angle flux and which peaks immediately before substorm expansion phase onset. Superposed epoch analysis of substorm onset times for the year 2014 using JHU APL list (Source: Jesper Gjerloev and Shin Ohtani) and the SOPHIE list (Forsyth, C., et al. JGR, 2015) also shows signatures of peaked parallel pressure anisotropy immediately before substorm onset. Future analysis using THEMIS pitch angle resolved data during Canadian overpasses will also be used to examine the relationship between parallel pressure anisotropy and substorm onset.

Baraka, S., and R. Rankin

Deriving the Earth's magnetopause shape in the equatorial plane under the influence of radial IMF as simulated by 3D Kinetic model.

The Earth's magnetopause (MP) is the boundary that separate the solar wind flow from the Earth's geomagnetic dipole fields. Southern and Northern IMF has been extensively covered in the four decades, only recently attention has been focused on radial and quasi radial IMF. We show using newly developed technique based on generated data by our Particle-In-Cell 3D Electromagnetic Global code, how radial and quasi radial IMF impact the MP size, shape and locations. Additionally, we show how these affects results in expansion of the MP in asymmetric way in both dusk-dawn and south north directions.

Billett, D., G. Perry, L. Clausen, W. Archer, K. McWilliams, S. Haaland, J. Burchill

Large scale thermospheric density enhancements in relation to downward Poynting fluxes: Statistics from CHAMP, AMPERE and SuperDARN.

Large thermospheric neutral density enhancements in the cusp region have been examined for many years. The CHAMP satellite for example has enabled many observations of the perturbation, showing that it is mesoscale in size and exists on statistical timescales. Further studies examining the relationship with magnetospheric energy input have shown that fine-scale Poynting fluxes are associated with the density perturbations on a case-by-case basis, whilst others have found that mesoscale downward fluxes also exist in the cusp region statistically.

In this study, we use nearly 8 years of the overlapping SuperDARN and AMPERE datasets to generate global-scale patterns of the high-latitude and height-integrated Poynting flux into the ionosphere, with a time resolution of two minutes. From these, average patterns are generated based on the IMF orientation. We show the cusp is indeed an important feature in the Poynting flux maps, but the magnitude does not correlate well with statistical neutral mass density perturbations observed by the CHAMP satellite on similar spatial scales. Mesoscale height-integrated Poynting fluxes thus cannot fully account for the cusp neutral mass density enhancement, meaning energy deposition in the F-region or on fine-scales, which is not captured by our analysis, could be the primary driver.

Bland, C., and A. Kouznetzov

Cosmic Ray Diurnal Variations during the Solar-Wind Disappearance Event in May 1999.

High-energetic (from hundreds MeV and up to many GeV) galactic protons called Cosmic Rays (CR) forms uniform isotropic proton bath with the solar system immersed in it. The CR interaction with the relatively weak solar wind (magnetized plasma permanently escaping from the sun) affects CR angular distribution in the vicinity of the earth. The cosmic ray flux is detected by a world-wide network of neutron monitors (NMs). A diurnal variations (DV) of ~0.4% is recorded by the Calgary NM on most quiet days. This variation is caused by CR flux anisotropy and has been explained as the net balance of radial convection and field-aligned diffusion (Ananth A.G., Agrawal S.P., and Rao U.R., 1974 Pramana 3.,2,74-88. & refs. therein).

From May 10-12,1999, the solar wind almost vanished. The cause of this event has been identified. Solar plasma outbursts occurring at the solar corona on May 5 (Janardhan P., Tripathi D., and Mason H.E., 2008 Astr.&Astrophys, 488 ,L1-L4) were the origin of an expanding plasma bubble which reached the earth 5-6 days later. We have examined data from the Calgary monitor from May1999 and found DV with greatly enhanced magnitude in the days leading to the solar wind disappearance. Fourier analysis provides the magnitude and phase of the DV first harmonic. In order to locate the extra-terrestrial direction of the DV source, it is necessary to correct for geomagnetic deflection. We find that the change in the phase of the DV reveals the arrival of the coronal bubble. Significant semi-diurnal variations have been found and warrant further investigation.

Cameron, T., R. Fiori, and T. Thayaparan

Effects of Ionospheric Disturbances on HF Radio Propagation Paths

High Frequency (HF) radio propagation is useful for long distance communications and surveillance; transmitted signals refl ected by the ionosphere may be propagated farther than line-of-sight methods would allow. Ionospheric disturbances can affect HF radio propagation by (1) increasing ionospheric absorption, and (2) significantly changing the propagation path. In this study, we focus on the latter, less studied effect. We utilize a ray tracing model to investigate how high latitude ionospheric disturbances such as polar cap patches and high latitude sporadic-E layers divert and change HF radio wave propagation paths. Rays are traced through a model ionosphere generated using the Empirical-Canadian High Arctic Ionospheric Model (E-CHAIM), where additional ionospheric disturbances have been added. We find that in some cases, these ionospheric disturbances allow signals to reach a target via off-great circle propagation paths that would otherwise not be reachable, while in other cases the ionospheric disturbances prevent HF radio waves from reaching a target. We discuss the impacts of these effects in the context of HF radio communications and Over-The-Horizon-Radar (OTHR).

Chaddock, D., E. Donovan, E. Spanswick, R. Potter, M. Gillies, R. Rankin, F. Fenrich, J. Kuzub, K. McWilliams, M. Sohrabi, and I. Rosito

AuroraX – A Scientific and Public Outreach Cyber Initiative

For some types of geospace data there are well developed systems to enable data discovery and access. These include SuperMag and SuperDARN for the global magnetometer and HF radar networks of networks. Optical auroral data has proven difficult to deal with in this sense. AuroraX is a CFI/CSA/DTU/Alberta-funded initiative to at least partially address this challenge, capitalizing on lessons learned from CSSDP, GAIA, and Swarm-Aurora. This presentation will provide an overview of the entire initiative, and a more detailed description of several of its elements that are already implemented. One of these is our 'conjunction finder' which allows rapid searches of a data base of more than 1.5 billion metadata records that allows identification of 'multiple conjunctions.' For example, a user can ask for instances when the magnetic footpoint of a Swarm satellite was within 400 km of a THEMIS-ASI which was imaging AND the magnetic footpoint of a THEMIS spacecraft is within 500 km of that same imager. A search for all instances between 2015 and 2020 of a triple conjunction between any working THEMIS-ASI, any THEMIS spacecraft, and ePOP while RFI was running took 20 minutes to run, and yielded 90 such conjunctions. We are presently developing machine learning classification of all of our auroral images and a new SuperDARN metadata product, so that for example "and there were arcs in the imager FoV" and "there were a lot of SuperDARN echoes in the imager FoV" can be added to the query chain.

Connors, M., and E. Donovan

Spectral Analysis of Pulsating Aurora Optical Emissions

High time resolution (3 s or higher cadence) imaging of pulsation auroras allows spectral analysis to be done in the frequency band below the Nyquist frequency, which is 0.5/cadence. Movies made from image sequences allow visualization of the pulsation and drift (which is sunward like the ionospheric convection), while picking off individual pixels in the movies allows making time sequences which may be Fourier analyzed. The new technique of sonification also appears to be natural in this application, and results will be presented.

Donovan, E and the SMILE-UVI Team

SMILE-UVI

With a planned 2025 launch, the joint European Space Agency-Chinese Academy of Sciences SMILE scientific satellite will carry four instruments in a highly elliptical ~20 Re apogee) polar orbit. The mission objectives are to study the causal chain of space weather processes via simultaneous observations of the solar wind plasma and magnetic field, the cusp and magnetosheath (via soft X-Ray imaging – see David Sibeck's presentation), and the system level geospace response through global (hemispheric) imaging of the UV aurora. The auroral imager, called SMILE-UVI, is being contributed to the mission by the Canadian Space Agency with funding support from the Canada Foundation for Innovation, Alberta Economic Development and Trade, the Belgian Federal Science Policy Office, and the Chinese Academy of Sciences.

This presentation will outline the SMILE-UVI scientific objectives, highlight synergies between SMILE-UVI and other programs, and outline the planned data products. A key advantage of this mission for UV imaging is that the very high apogee affords continuous viewing of the northern hemisphere auroral oval at all local times for more than forty hours, roughly three times the duration of any previous lobal aurora image sequences.

Fenrich, F., R. Rankin, D. Sydorenko, W. Archer, D. Knudsen

Birkeland Current Boundary Flows Associated with Field Line Resonances

Strong zonal flows greater than 1000 m/s are commonly observed in the nightside ionosphere with the Swarm spacecraft. These flows have upward and downward directed field-aligned current pairs located at the poleward and equatorward edges of the fast flows and thus are called Birkeland current boundary flows (BCBFs). The fast flows are also associated with ion heating and up-flow. In this work two Swarm BCBF events are investigated with high resolution plasma flow measurements made with the Super Dual Auroral Radar Network. It is found that the BCBFs are collocated with field line resonant standing wave oscillations of the earth's magnetic field lines. The fast east-west flows observed by Swarm are associated with field line resonance peak flow velocities superimposed upon the background ionospheric convection. The field line resonances are also shown to be bounded by pairs of upward and downward directed field-aligned currents similar to the BCBF field-aligned current pairs. It is important to understand the cause of these flows as they play a significant role in thermosphere-ionosphere-magnetosphere coupling.

Fraser, D., W. Ward, P. Preusse, C. Strube, S. Kristoffersen, and D. Gamblin

Ray tracing of gravity waves in the northern polar MLT

Ray tracing is applied to internal atmospheric gravity waves to diagnose their potential sources. Gravity waves (GWs) are observed in the mesosphere and lower thermosphere (MLT) through perturbations to airglow layers above Eureka, NU (80°N, 86.25°W). Data from the All-Sky Imager (ASI) and E-Region Wind Interferometer (ERWIN) at the The Polar Environment Atmospheric Research Laboratory (PEARL) are analysed for probing waves. Parameters extracted include wavenumbers, frequencies, and velocity amplitudes. The Gravity-wave Regional Or Global Ray Tracer (GROGRAT), developed by Marks and Eckermann (1995), is used for evolving the waves backwards in time to their origins. The background atmosphere is defined from the extended

Canadian Middle Atmosphere Model (CMAM) model. Various case studies are presented, and limitations described. Small-scale waves with horizontal wavelengths generally less than 100 km are found to commence near the surface around Eureka , with mainly vertical propagation noted. Larger-scale, inertia GWs travel longer distances and are traced back to the midlatitudes. This work advances the fields of internal GW detection and propagation in the Arctic upper atmosphere.

Galeschuk, D., G. Hussey, D. Huyghebaert, A. Lozinsky, K. McWilliam

Phase Calibration of the ICEBEAR radar using Cygnus A

The radio galaxy Cygnus A presents a weak but detectable signal in the ICEBEAR noise measurements. This presentation will discuss the use of the Cygnus A in generating phase callibrations for the ICEBEAR radar at the University of Saskatchewan.

Ghaly, F., E. Spanswick, and R. Gillies

Investigating Riometer Capacity for Terrestrial HF Signal Monitoring

Abstract: Riometers have been operating in Canada since the late 1980's. Some of those same instruments are still operational today, but are quickly nearing their end of life. As part of two Canada Foundation for Innovation projects, the University of Calgary is developing the next generation of riometers (both imaging and widebeam systems). These new digital riometers are fully programmable and can operate at a wide range frequencies. As part of the prototyping process, a new riometer system was deployed at Gillam in late 2019. The system was configured with an extremely wide passband (1 to 50 MHz, sampled with more than 4000 frequency bins). In this presentation, we use one day of data from this prototype instrument to discuss the riometers capacity for monitoring terrestrial HF signals (1- ~15MHz) and the implications of observed power losses during cosmic absorption events. We show preliminary results of ionospheric raytracing from known HF transmitters, and discuss the possibility of using these new riometers (along with ray tracing) to derive a minimum size of the absorbing region.

Ghadjari, H.

Analysis of Co-existence of Ionospheric Irregularities and Alfvénic Structures in the Equatorial Ionosphere

Ionospheric irregularities are fluctuations or structures of plasma density that affect the propagation of radio signals. Post-sunset ionospheric irregularities of the equatorial ionosphere are one of the major threats to the propagation of GNSS signals. In this work, we study the co-existence of post-sunset equatorial ionospheric irregularities with Alfvénic structures in order to assess the possible role of Alfvén waves in the production of irregularities. We use density, electric and magnetic field from the Swarm satellites at altitudes of ~500 km.

R. Ghaffari, C. M. Cully, C. Gabrielse

Whistler-mode Wave Generation and Pitch Angle Diffusion during Energetic Electron Injections

Energetic Electron Precipitation (EEP) associated with substorm injections typically occurs when magnetospheric waves, particularly whistler-mode waves, resonantly interact with electrons to affect their equatorial pitch angle. This can be considered as a diffusion process that scatters particles into the loss cone. In this study, we investigate whistler-mode wave generation in conjunction with electron injections using in-situ wave measurements by the Themis mission. We particularly characterize the chorus wave behavior associated with electron injections and Dipolarized Flux Bundles (DFBs). We calculate the pitch angle diffusion coefficient exerted by whistler-mode wave activity in conjunction with the electron injections to investigate the scattering efficiency during substorm injections.

Gillies, D. M., J. Liang, E. Donovan, and E. Spanswick

The Apparent Motion of STEVE and Picket Fence Phenomena

In this study, we present the first data obtained from the new Transition Region Explorer (TREx) RGB Imager, and analyze the apparent motion of STEVE and Picket Fence structures in an event on 31st August, 2019. The structures associated with STEVE are found to feature a fast westward motion (~5-10 km/s). This is consistent with the notions that STEVE is co-located with a fast subauroral ion drift (SAID) channel, and that the SAID plays a key role in the production of STEVE. The apparent motion of the Picket Fence structures is much slower (~400-600 m/s), and can be both westward and eastward. This implies that either the Picket Fence is located at different magnetic flux tubes from that of STEVE, with much slower plasma convection speed, or that the motion of Picket Fence does not follow the plasma convection.

Gillies, R., R. Varney, and E. Donovan

Polar patches created by fast azimuthal flows observed by the RISR radars

The two faces of the Resolute Bay Incoherent Scatter Radar (RISR) (the northward facing RISR-N and the southward facing, Canadian-operated RISR-C) have been operating jointly since 2015. In that time, campaigns of 5-10 days in length have been run typically once per month and in total more than 300 days of measurements are currently available. The combined fields-of-view (FOV) of the two radars cover the F-region from ~68-82° in geographic latitude (~76-87° geomagnetic latitude). The FOV of the southward pointing RISR-C is often within the area of the cusp during daytime and is therefore well suited for observing polar patch formation. It has been observed that sunlit plasma flowing into the polar cap (i.e., the tongue of ionization (TOI)) will often be interrupted or segmented into patch-like structures by fast dawn-to-dusk (i.e., azimuthal) flows. These flows are often associated with rapid changes in the Interplanetary Magnetic Field (IMF) B_y component. The fast flows and associated density depletions often have associated enhanced ion temperatures probably caused by Joule heating due to the sudden change in plasma flow direction. A decrease in the electron temperature is often also observed in the depleted region probably due to the lower density plasma being transported from the non-sunlit nightside. A survey of the ~300 days of joint RISR-C and RISR-N data found nearly 100 events of this type. A particularly well-defined example of this patch creation mechanism from March 2016 is highlighted here.

Goodwin, L., and G. Perry

Resolving F-region high-latitude plasma density structures and irregularity spectra using Resolute Bay ISR-Canada and Resolute Bay ISR-North measurements

The formation and morphology of plasma structures in the high-latitude ionosphere is a critically important space weather effect that impacts over-the-horizon radio communication and global navigation systems. However, the drivers of these irregularities, as well as their favorable conditions, locations, and scale-sizes, remains unclear. High-latitude advanced modular Incoherent Scatter Radars (ISRs), such as Resolute Bay ISR-Canada (RISR-C), Resolute Bay ISR-North (RISR-N), and Poker Flat ISR (PFISR), provide a unique opportunity to supply multiple measurements of a given plasma irregularity. By leveraging phased array ISR technology, and using the facts that cross-field diffusion is slow at scale lengths greater than 10 km, and that the magnetic field lines are nearly vertical at high-latitudes, we develop and apply a novel technique for ISR measurements to resolve high-latitude ionospheric irregularity spectra at a higher spatial-temporal resolution than has been previously possible with ground-based instruments. From these irregularity spectra, we quantify the abundance and scale-sizes of plasma structures in the high-latitude ionosphere, as well as their drivers. In this presentation, we will motivate the newly developed ISR technique, describe its methodology, demonstrate its effectiveness, and provide irregularity spectra that utilizes RISR-C and RISR-N data. This technique will enable future studies that will directly link high-latitude ionospheric plasma structure drivers to their impact on radio wave propagation.

Huyghebaert, D., K. Mcwilliams, G. Hussey, A. Howarth, S. Erion, and P. Rutledge

Comparisons Between E-region Coherent Scatter and Swarm-E Fast Auroral Imager Measurements

The Ionospheric Continuous-wave E-region Bistatic Experimental Auroral Radar (ICEBEAR) is a VHF coherent scatter radar that makes measurements of the E-region ionosphere with a field of view centered on $\approx 58^\circ$N, 106°W. This overlaps with the Saskatoon SuperDARN radar field of view, providing the opportunity for multi-frequency coherent scatter radar measurements in a similar region. In addition to these coherent scatter radar measurements, the Swarm-E, or e-POP, Fast Auroral Imager (FAI) has been used to make measurements of the auroral emissions in the 650-1100 nm wavelength band over the same field of view. The FAI is able to be slewed to a location, allowing extended conjunction windows between the imager and the coherent scatter radars. With recent advances in radar hardware and processing the temporal and spatial resolutions of these different instruments are becoming comparable, providing an excellent opportunity to study the E-region ionosphere in great detail. Comparisons between the coherent scatter radar and FAI measurements are presented, displaying how E-region coherent scatter measurements correspond to the location of auroral emissions as measured by the FAI.

Kouznetsov, A

Quantum Mechanical Correction to the Photoelectron Stopping Power

Solar photons with energies above the molecular oxygen ionization threshold are responsible for the ionization and electron heating of the ionosphere above ~100 km, but not below (**Fig. 1**). Solar photons heat the ionosphere by producing secondary photoelectrons and their interactions (elastic scattering) with plasma (ambient) electrons. We apply measured high-resolution EUV photon source (***Heroux et al., 1974***) to the top of the neutral atmosphere (***Picone, 2002***), calculating space-energy distributions of photoelectron source (**Fig. 1**) and corresponding photoelectron flux with the MCNP6 general-purpose Monte-Carlo program. Finally, we convert obtained at every altitude photoelectron spectrum $\Psi(E)$ into the photoelectron heating rate H by integrating the product of the photoelectron spectrum $\Psi(E)$ and stopping power dE/dx over the photoelectrons energy range:

$$H = -\int_E \Psi(E) \frac{dE}{dx}(E)\, dE \ , \quad \text{(Eq.1)}$$

applying different electron stopping power models. We investigate and improve existing stopping power models using quantum-mechanical (**Mott**) cross-sections to electron-electron interactions for energies above the classical limit $\frac{m \cdot e^4}{2\hbar}$ ~ 13.6 eV. We find that the widespread **Swartz et al., 1971** electron stopping power model underestimates stopping powers because of using classical (**Rutherford**) cross-sections for the scattering of an electron on free electron starting from energies ~50 eV. We upgrade stopping power calculations in the quantum limit to improve our photoelectron heating rate calculations.

Liang, J., D. Sydorenko, R. Rankin, and E. Donovan

Modeling of ionospheric UV emission for the SMILE mission

Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) is a future spacecraft mission supported by the European Space Agency and the Chinese Academy of Science. The spacecraft will be launched in 2023 and will target the magnetopause, cusp, and bow shock regions. In order to study magnetosphere-ionosphere coupling, the spacecraft will also take auroral images using an ultraviolet imager (UVI) being developed at the University of Calgary in collaboration with European and Chinese scientists. For scientific support and analysis of the data collected by the UVI, a numerical model of ionospheric UV emission is being developed in the University of Calgary and the University of Alberta.

There are two modules in the model. One module simulates production and transport of suprathermal electrons causing the emission. It considers photoelectrons produced by solar extreme UV radiation and auroral electrons. These electrons are represented as particles propagating along the geomagnetic field and performing elastic, excitation, and ionization collisions with neutrals, as well as Coulomb collisions with other charged particles. In total, 52 collisional processes between electrons and neutrals are accounted for. The module computes the fluxes and energy spectra of the suprathermal electrons along the line of sight of the satellite UV imager. The other module calculates UV emissions caused by the suprathermal electrons with the fluxes and energy spectra computed in the first module. The model contains a comprehensive set of chemical processes in the ionosphere/thermosphere, and includes all the prominent UV auroral/dayglow emission lines and band systems such as OI 130.4/135.6nm, Lyman-Birge-Hopfield (LBH) and Vegard-Kaplan (VK) bands. Eventually, by considering the actual observation geometry of the satellite and the absorption on along the line-of-sight, the integrated UV photon flux spectrum reaching each UVI pixel can be calculated.

We present two examples of practical application of our model. First, we simulate the response of the SMILE UVI with the up-to-date filter design to energetic auroral precipitations with different precipitation flux parameters. Second, we calculate UV emissions in the night sector caused by photoelectrons coming from conjugate sunlit regions of the ionosphere along the geomagnetic field, and compare the model results with actual observations.

Liu, G. and R. Marchand

Kinetic study of Langmuir probe using theoretical and regression approaches

Langmuir probes are relatively simple instruments used on satellites to measure plasma parameters. Measurements based on the Langmuir probe often require sweeping bias voltages of the probe to obtain the current-voltage curve. This, however, limits the resolution of the probe. On the other hand, fixed-bias multi-needle Langmuir probes consisting of several cylindrical probes biased at different potentials, can be used to sample plasma at a much higher frequency. The inference of plasma parameters from needle probes is typically based on the Orbit Motion Limit theory (OML) which relies on several assumptions. Some of the assumptions are very difficult to fulfill; for example, the theory assumes an infinitely long cylindrical probe, and the absence of nearby objects. Needle probes on spacecraft are of finite length, and they must be supported physically by a guard at the end of a boom. This study simulates the Norsat-1 multi-needle probe using PIC simulations. Regression models are created to infer plasma parameters using the simulated currents. Regression results and OML results will be compared and assessed when the assumptions made in the OML theory are not entirely fulfilled. The use of regression techniques rather than purely analytic expressions should lead to more accurate inference techniques when measuring plasma parameters in space.

Lomidze, L., D. Knudsen, and M. Shepherd

Observation and Multi-model Analysis of Topside Ionosphere Equinoctial Asymmetry

During similar solar activity conditions the terrestrial topside ionosphere displays significant equinoctial asymmetry despite the upper atmosphere receiving similar levels of solar ionization energy at a given location and time in Spring and Fall. This intriguing feature is not well understood or modelled, particularly in the topside part of the ionosphere. Langmuir probe data from ESA’s Swarm satellites at around 500 km altitude reveal that the daytime electron densities are larger for all latitudes during the Vernal equinox than during the Autumnal equinox, while the electron temperature shows reversed asymmetry except at low latitudes. Simultaneously obtained neutral mass density data from Swarm GPS accelerations indicate that the neutral atmosphere is denser during the Spring. The feature seen by Swarm electron density observations is also manifested in electron densities obtained using GPS radio occultation measurements from COSMIC satellites. In addition to presenting observations of the equinoctial asymmetry in the topside ionospheric parameters we employ a multi-model approach to evaluate the ability of current major ionosphere, ionosphere-thermosphere, ionosphere-thermosphere-plasmasphere, and atmosphere-ionosphere models to simulate the observed asymmetry at low and middle latitudes, and to understand its causes. For the two equinox conditions the major ionospheric drivers such as neutral winds, composition, and drifts are analyzed and compared.

Lozinsky, A., and G. Hussey

ICEBEAR-3D Advanced Target Location and Identification Techniques

Ionospheric Continuous-wave E Region Bistatic Experimental Auroural Radar 3D (ICEBEAR-3D) is the non-uniform planar receiving array successor to ICEBEAR, designed to capture azimuth an elevation data of E region instabilities by synthesis aperture imaging techniques, namely the spherical wave harmonic transform. By using a method of spatial angular frequency compression to suppress noise and dirty beam effects within images real targets are isolated for accurate locating. This technique accompanied by image processing algorithms allows for accurate target locating, target scale, and spatial distribution.

Lynch, K.

ARCS: Auroral Reconstruction CubeSwarm, a Heliophysics mission concept for a MIDEX opportunity

Abstract to follow

Madhanakumar, M., A. Kashcheyev, P. Jayachandran

On the Geometrical Dependence of Scintillation Indices

Scintillations, which are the rapid fluctuations in the amplitude and phase of a radio signal as it traverses the ionosphere due to diffraction, are a major concern as they have the potential to adversely affect the GNSS navigation and communication systems. They are caused by Fresnel scaled irregularities high up in the ionosphere which diffract the radio signals as they encounter these electron density inhomogeneities. Scintillations are quantified using the scintillation indices, S4 and Sigmaphi which are defined as the normalized standard deviation of detrended power and standard deviation of detrended phase, respectively. A concerning feature of the phase scintillation index, Sigmaphi, is that it encompasses both refractive fluctuations and diffractive variations of the signal thereby paving way for an observed increase in Sigmaphi index when compared to the S4 index which otherwise should not be the case since both the indices refer to same processes. This increase however is not real but instead is an artifact due to the improper detrending of the phase using the conventional cut-off frequency of 0.1Hz.

The objective of this study is to present statistical results obtained after an investigation of the dependence of scintillation indices on the propagation geometry of GPS satellites using the data collected by the receivers of the Canadian High Artic Ionospheric Network. Contrary to other studies which had previously shown higher variations of the Sigmaphi index as compared to the S4 index with elevation angle, our results suggest that the phase scintillation index, Sigmaphi, never exceeds S4 index if one properly detrend the phase of the signal by taking into account the dynamic nature of the Fresnel frequency at high latitudes. Moreover, it is also seen that the sudden increase in the scintillation indices as the satellite ray path aligns with the magnetic field lines is not a cause of concern at high latitudes.

Meziane, K. A. Kashcheyev, P. T. Jayachandran, and A. M. Hamza

An Empirical Model of Ionospheric Scintillation for the Polar Region

Transient events in the interplanetary medium including the Coronal Mass Ejections (ICMEs) and High—Speed Streams (HSSs) cause recurrent ionospheric disturbances. Conventional forecasting of ionospheric scintillation that is driven by solar wind transients are usually based on the probability of occurrence. For the present study, Global Positioning System (GPS) L1 frequency receivers located at high latitude are used to develop a new empirical model for ionospheric scintillation indices. The model employs indicators from the solar wind plasma and the interplanetary magnetic field as well as the Auroral Electrojet index. The model uses the Bayesian inference framework. Using a multinomial classification, preliminary results indicated that the model captures the essential features seen in the scintillation data. However, we also found that the model tends to underestimate the measurements. A comprehensive assessment of the model and the impact of each predictors in the model is not clear and remains to be investigated.

Mohandesi, A., D. Knudsen, S. Skone

A Novel Approach to Study the Vertical Distribution of Multi-Scale Equatorial Ionospheric Irregularities Using High-Rate e-POP Measurements

It is well known that signals from Global Navigation Satellite Systems (GNSS) are prone to scintillations as they pass through Equatorial Plasma Bubbles (EPBs) in the low latitude region. However, there is still inadequate knowledge of the vertical evolution of multi-scale equatorial irregularities that disturb radio communications. To fully understand this phenomenon, it is pivotal to obtain a clear picture of the physical mechanisms that control EPBs and predict the occurrence of scintillations. The GPS Attitude, Positioning, and Profiling Experiment occultation receiver (GAP-O) on board the Enhanced Polar Outflow Probe (e-POP) is a dual-frequency receiver, mounted on the anti-ram side of the spacecraft, with the antenna beam normally pointing in the horizontal direction. It is primarily used for radio occultation measurements and can operate at sampling rates of 20, 50, and 100 Hz. E-POP flies in an elliptical orbit with a perigee of 320 km and an apogee of 1500 km. This, together with its high-rate measurements, make GAP-O providing information on the altitudes at which scintillation-causing irregularities occur. In this study, while flying in the low-latitude region and during post-sunset hours, we re-oriented e-POP for short periods to make the GAP-O beam point in the zenith direction. In this novel experiment, we compute different ionospheric indices such as scintillation indices, and rate of change of total electron content (ROTI) to examine the vertical dependence of signal scintillation on ionospheric irregularities with different scale sizes in the equatorial region.

Therese Moretto Jorgensen, on behalf of the Daedalus Science Study Team

Daedalus: a Candidate ESA Earth Explorer Mission for the Exploration of the Lower Thermosphere-Ionosphere

Daedalus is a mission to explore the lower thermosphere and ionosphere (LTI). It aims at providing, for the first time, a comprehensive set of in-situ, simultaneous measurements of all key parameters to fully characterize the LTI and the significant physical processes that govern the energetics dynamics and chemistry of this region. The mission calls for in-situ measurements by spacecraft in elliptical orbits with altitude perigees around 150 km and below, gathering measurements through the ionosphere's F- and E-regions with each pass. Orbital precession and mission lifetime will be carefully selected to ensure adequate coverage of the observations in latitude, local time and altitude. A comprehensive suite of well-proven instruments provides the required in-situ measurements for more than 15 geophysical observables of the neutral atmosphere, plasma gas, energetic particles, and electric and magnetic fields. Daedalus will provide unique in-situ, low altitude measurements to address intriguing, long-standing questions concerning the LTI and its role in the atmosphere-geospace system. However, the measurements also constitute an excellent complement to other existing and planned space missions and ground-based observations in support of an even wider range of scientific studies. This talk will give a brief introduction to the Daedalus mission and point to some of the promising synergies with Canadian space physics resources, both space and ground based, that the mission offers.

Olowookere, A. and R. Marchand

Density-temperature constraint from fixed-bias spherical Langmuir probes.

In a recent paper we showed that a combination of analytic and multivariate regression models can be used to infer a satellite floating potential, from currents collected by a pair of fixed-bias spherical Langmuir probes. In this work, we show that such an instrument can also be used to infer the ratio of the plasma density and the square root of the electron temperature. This simple function in turn can provide a useful constraint, and improve accuracy, when density and temperature are measured independently in situ.

Pandey, K., E. Eyiguler, D. Danskin, G. Hussey, and A. Yau

RRI ellipticity angle investigations

Danskin et al. (JGR, Volume 123, 1648-1662, 2018) were able to characterize the orientation angle variability of ePOP-RRI passes over an HF transmitter located in Ottawa. In addition, variations in the ellipticity angle were reported. This work continues with a detailed investigation to understand the ellipticity angle behavior.

Small-Scale Pedersen Conductance and Scale Height Passive Sounding using Swarm E- and B-field Observations

Pakhotin, I., and I. Mann

Small-Scale Pedersen Conductance and Scale Height Passive Sounding using Swarm E- and B-field Observations

Abstract: with increasing instrumental sophistication, it is now possible to explore ionospheric phenomena at scales hitherto considered inaccessible. This has led to recent research focusing increasingly on the importance of small-scale geomagnetic processes, such as discrete arcs and kinetic Alfven waves, in global magnetosphere-ionosphere coupling. At the same time, to fully understand the dynamics of these processes requires an accurate assessment of the plasma environment in which they occur. Parameters such as Pedersen conductance, plasma density and ion ratios are therefore of crucial importance. Typically they are obtained using ground-based radar measurements or global empirical models. These are by their nature limited to relatively large scales and may miss small-scale localised features. This study proposes a physical framework, confirmed by some preliminary results, which potentially allows to use Swarm observations of electromagnetic disturbances to derive parameters such as Pedersen conductance and scale height at small scales by passive sounding. The parameters derived using these methods, if successful, will then make it possible to infer yet further parameters and potentially help solve outstanding science questions such as mass ratios at polar low-Earth orbit.

Parry, H., I. Mann, and R Holzworth

On the Role of Lightning in Coupling Geospace and the Neutral Atmosphere Through the Excitation of the Ionospheric Alfvén Resonator

A potentially important but poorly understood example of the interaction between the Earth's climate system and the Near-Earth space environment concerns the excitation of the ionospheric Alfvén resonator (IAR) by lightning. The motivation for this research was to examine the characteristics of the relationship and coupling between the lightning produced electromagnetic pulse and the transmission of these pulses into the IAR cavity in the form of Alfvén waves. Induction coil magnetometer data from the Canadian Array for Real-time Investigations of Magnetic Activity (CARISMA; www.carisma.ca) and lightning data from the World-Wide Lightning Location Network (WWLLN) was used to research the magnetic ground response due to lightning and the implied reflection coefficient of the IAR. Significantly, the results demonstrate clear evidence in support of local and non-local lightning as a driver of Alfvén waves in the IAR. Furthermore, evidence of ionospheric coupling is provided by the presence of a radial component in the outwardly traveling B pulse from the lightning strike which is not expected for a mode propagating in the Earth-ionosphere cavity in the absence of mode coupling into the IAR. Setting thresholds on the amplitude of the primary and reflected pulse shows a strong correlation between the number of reflective events and active IAR hours. The median ratio amplitude of these pulses was found each hour to infer an effective overall reflection coefficient of the IAR upper boundary. During active IAR, typically from around local dusk to local midnight, the inferred reflection coefficient is 0.3-0.4 reaching a maximum of 0.6. An explanation for the implied high effective reflection coefficient at Ministik station, Alberta, Canada, as compared to other stations is also discussed in the context of variations in local ground conductance. Together these findings provide important insights into lightning related electromagnetic processes which couple atmospheric electrodynamics to those in near-Earth geospace. The overall impact and consequences of such coupling remains to be fully determined.

Prikryl, P., R. Gillies, D. Themens, B. Kunduri, R. Varney, and J. Weygand

Polar cap patches, GPS TEC variations, and atmospheric gravity waves

The southward pointing field of view of the Canadian component of the Resolute Bay Incoherent Scatter Radar (RISR-C) is well suited for observing the ionospheric signatures of flux transfer events and subsequent polar patch formation in the cusp. The fast azimuthally oriented flows and associated density depletions often show an enhanced ion temperature from Joule heating caused by the sudden change in plasma flow direction. The newly formed polar patches are then observed as they propagate through the field-of-views of both RISR-C and RISR-N. In the ionosphere, the electron density gradients imposed in the cusp, and small-scale irregularities resulting from gradient-drift instability, particularly in the trailing edges of patches, cause GPS TEC and phase variations, and sometimes amplitude scintillation. The neutral atmosphere is affected by ionospheric currents resulting in Joule heating. The pulses of ionospheric currents in the cusp launch atmospheric gravity waves (AGWs) causing traveling ionospheric disturbances, as they propagate equatorward and upward. On the other hand, the downward propagating AGW packets can impact the lower atmosphere, including the troposphere. Despite significantly reduced wave amplitudes, but subject to amplification upon over-reflection in the upper troposphere, these AGWs can trigger/release existing moist instabilities, initiating convection and latent heat release, the energy leading to intensification of storms

Robert Rankin, Wei Shen, and Dmytro Sydorenko

The Ionospheric Feedback Instability: Problems and Alternatives

Much has been said about the ionospheric feedback instability but it has never been conclusively verified through observations. We review the theory of the IFI and identify obvious problems with the accepted view of this process, not least of which is the fact that the ionosphere is not, in fact, part of the theory. By introducing a physical model of the ionosphere into the formulation of the IFI, we identify flaws in the theory and discuss potential mechanisms that may explain structure in discrete aurora that do not rely upon this instability. The paper will consist of three short presentations by the authors.

Reiter, K., S. Guillon , M. Connors, B. Jackel

Impulsive Geomagnetic Events in the Auroral Zone

Impulsive changes in geomagnetic fields have been found to be associated with Space Weather impacts on ground-based technological infrastructure. These impulsive events have been found to excite geomagnetically induced currents (GIC) and produce harmonic distortion of transformer voltages. We have developed an algorithm to identify impulsive geomagnetic component variations. Cataloguing events occurring in Quebec in 2015-2020, we characterize the diurnal variations of these events at a range of latitudes ranging from sub-auroral to polar cap. We find that vertical impulsive events dominate in the auroral zone, and can be large in magnitude (> 1000 nT). Additionally, we determine the diurnal patterns of geomagnetically-triggered harmonic distortion events observed in the nearby Hydro-Quebec power transmission network. Finally, we use superposed epoch analysis to demonstrate the relationship between these impulsive events and GIC-driven harmonic distortion. We find that the nature of the geomagnetic perturbations is consistent with ionospheric current vortices in the nightside auroral zone ionosphere.

Sanchez, D., N. Frissell, G. Perry, A. Coster, P. Erickson, W. Engelke, J. Ruohoniemi6, and J. Baker

Using high frequency amateur radio transmissions to detect and study travelling ionospheric disturbances

Citizen radio science is an emerging field largely driven by the proliferation of software defined radio systems, the reduction in cost of radio hardware, and the technical expertise and tireless passion of the amateur radio community. Two remarkable examples of the amateur radio community's ingenuity are the Weak Signal Propagation Report Network (WSPRnet) and Reverse Beacon Network (RBN). The former is a digital signal protocol that allows for the identification of open propagation high frequency (HF; 3 – 30 MHz) radio channels between amateur operators, while the latter is a passive receiver network that detects HF amateur radio transmissions and records metadata related to each transmission. In this work, we demonstrate how data collected by both projects can be used to detect and study large scale travelling ionospheric disturbances (LSTIDs) over the contiguous United States. First, in a case study, we show that the LSTIDs signatures detected with WSPRnet and RBN are also present in contemporaneous Global Navigation Satellite System (GNSS) and ionosonde measurements. Then, we present the results of an analysis of 2017 WSPRnet and RBN data to show that the LSTIDs are more often present during the winter months (November through February), which is consistent with previous work based on Super Dual Auroral Radar Network (SuperDARN) measurements. A clear benefit of the WSPRnet and RBN citizen science observations is that they enable the expansion of the coverage area for the detection of TIDs and other solar-terrestrial physics phenomena to mid and low geographic latitudes, complementing the measurements provided by other instruments such as SuperDARN, whose coverage is more concentrated to higher latitudes, where fewer WSPRnet and RBN nodes exist due to the sparse population of these regions.

Shen, Y., D. Knudsen, and J. Burchill

Micro-scale plasma heating in the topside ionosphere: Results from e-POP/Swarm-E

Ionospheric ion (mainly O+) and electron energization and field-aligned transport are critical aspects of magnetosphere-ionosphere-thermosphere coupling. The Canadian Enhanced Polar Outflow Probe (e-POP) satellite carries particle and field instruments specifically designed to study micro-scale (~100 m) characteristics of ion energization and outflow processes in the topside (325 km to 1,500 km) ionosphere. The Suprathermal Electron/Ion Imager (SEI) instrument onboard e-POP has the capability of resolving two-dimensional low-energy (from sub-eV to 325 eV) particle distributions with unprecedented high resolution in space, time, energy, and pitch angle.

This talk aims to review several discoveries resulting from direct measurements of particles and waves from e-POP. In particular, we will focus on observations and test particle simulations of transverse O+ ion heating from broadband extremely low frequency (BBELF) waves in the collisional ionosphere. The measured O+ ion temperatures reach as high as 4.5 eV at altitudes as low as 350 km, a boundary that is lower than previously reported. We will also show the first direct observations of suprathermal (energies of tens to hundreds of eV) electron acceleration perpendicular to the magnetic field in the topside (900 km to 1,500 km) ionosphere. These electrons can occasionally be heated up to temperatures comparable with those found in the solar corona (~106 K). This newly observed perpendicular electron acceleration is a counterpart to transverse ion acceleration which has been reported extensively since the 1970's.

Shepherd, M., D. Billett, G. Shepherd

SuperDARN, WINDII and WACCM-X neutral and ion winds observed at high latitudes during geomagnetic disturbances

Recently *Shepherd and Shepherd* (2018) identified a band of strong westward wind (400 – 600 m/s) in the two daytime polar atmospheres, at 65° − 70° geographic latitude, imbedded in the eastward wind background, which they called a "wind wall". The observations were made with the Wind Imaging Interferometer (WINDII) on the NASA Upper Atmosphere Research Satellite (UARS), through Doppler wavelength shifts of the $O(^1S)$ atomic oxygen dayglow emission at 557.7 nm. This wind wall was not always present, but when it did it always occurred at the same geographic longitude, around 300°E in the northern hemisphere and 150°E in the southern hemisphere. The satellite observations indicated that the wall occurred only in the daytime atmosphere, roughly 3 hours on each side of local noon. A subsequent study showed that these wind walls occurred during times of enhanced solar flux (F10.7) and geomagnetic disturbance, a_p, and that the wind fields corresponded closely with those of the WACCM-X model. Although the global observation capability of a satellite instrument made possible the identification of the wind wall, it could be observed only once per day, perhaps on two or three successive orbits – the remaining orbits showing the background eastward winds. Additional information on the nature of the wind wall and its temporal behavior can be provided by simultaneous observations from a ground-based instrument, located at the appropriate latitude and longitude. It proved possible to obtain a number of coincident observations early on in the UARS mission from the Super Dual Auroral Radar Network (SuperDARN), and the results of these comparisons, together with data provided by the WACCM-X model will be presented and discussed.

Shepherd, G., and Y.-M. Cho

A New Perspective on Observing Earth's Dayglow

This presentation describes the "WINDII Empirical Model" (WEM), which provides the characteristics of the $O(^1D)$ 630.0 nm atomic oxygen dayglow emission. It includes the Integrated Emission Rate (IER), the peak Volume Emission Rate (VER), the altitude of that peak and the Full Width at Half Maximum (FWHM) as a function only of the F10.7 cm solar radio flux and the Solar Zenith Angle (SZA) of the observations. The SZA is dependent on the day of the year, the latitude of the observation and the local time so these quantities are also involved. The model incorporated 98,617 WINDII (Wind Imaging Interferometer) measurements obtained on board NASA's Upper Atmosphere Research Satellite obtained between the years 1992 and 1996. The model and observations, varying from 500 to 7,000 R, agree well with one another within a standard deviation of 588.7 R (Rayleigh, which is an integrated emission rate along the line of sight of 10^6 photons cm^{-2} sec^{-1}). The dayglow is challenging to measure with ground-based instruments, as the solar scattered light from the daytime sky must be accurately subtracted from the data. Good agreement of the WEM was found for ground-based observations from Hyderabad, India but serious differences were found for summer measurements made from Boston, which are shown to be invalid. The surprising aspect is that the $O(^1D)$ dayglow emission can be accurately described based solely on the solar input, with no significant dependence on the characteristics of the atmosphere.

Sibeck, D.

STORM: Opportunities for Joint Studies

STORM, the Solar Terrestrial Observer for the Response of the Magnetosphere, is one of 5 Medium-Class missions selected by NASA for Phase A studies. STORM is a self-standing mission in a high-inclination circular orbit with a radius of 30 RE that takes its own solar wind measurements and ground-based observations of the aurora whilst remotely imaging the dayside magnetosheath and magnetopause in soft X-rays, the auroral ovals in far ultraviolet, the ring current in energetic neutral atoms, and the exosphere in Lyman-a. STORM's central goal is to quantify the flow of solar wind mass, energy, and momentum through the magnetosphere from start to end, helping us to understand and predict space weather. Sub-objectives include: (1) quantifying the contributions of proposed magnetopause reconnection modes, (2) quantifying the significance of proposed magnetotail response modes, (3) quantifying the importance of source, transport, and loss mechanisms for the ring current, and (4) quantifying the role played by the ring current in determining magnetopause location and substorm onset. STORM provides global context for all in situ geospace projects, both ground- and space-based. In exchange, these projects can verify and validate the inferences drawn from STORM's remote imaging. If selected, STORM will be ready for launch on October 1, 2026. This presentation provides details of STORM's capabilities and suggestions for the wide variety of partnerships that will be possible with Canadian researchers.

C. Watson, D. Themens, and P. Jayachandran

Validation of High-Latitude Precipitation-Enhanced Ionosphere Density Profiles Derived from Satellite-Based UVI Imager Data

Electron density enhancements in the high-latitude ionosphere can result from the precipitation of energetic electrons and ions of magnetospheric and solar wind origin. The occurrence, intensity, and spatial distribution of high-latitude precipitation is unpredictable, and thus development of ionosphere models that can adequately capture precipitation-enhanced densities has been a challenge. In recent years, the Empirical Canadian High Artic Ionospheric Model (E-CHAIM) has emerged as the most reliable representation of electron densities at northern high latitudes, however a lack of reliable, direct, and widespread capacity for observing the E- and lower F-region at high-latitudes still limits our ability to capture precipitation enhancements in the empirical model.

We have examined the feasibility of deriving precipitation-enhanced profiles from auroral ultraviolet emission observations of the Defense Meteorological Satellite Program (DMSP) Special Sensor Ultraviolet Spectrographic Imager (SSUSI) and the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) Global Ultraviolet Imager (GUVI). Electron energy flux and mean energy of precipitating electrons are derived from SSUSI and GUVI measurements, which provides a means to characterize precipitating electron populations. Ionospheric ionization rates and precipitation-enhanced densities are subsequently calculated using the Fang-2010 parameterization scheme, which is based on first principles. For validation and optimization, precipitation-enhanced profiles are compared with incoherent scatter radar (ISR) measurements at polar cap and auroral locations. This technique significantly improves the representation of high latitude ionosphere densities and has been integrated into E-CHAIM.

Wilson, K., and J. Burchill

Characterization of Ionosphere-Thermosphere Coupling from the VISIONS-2 Mission

VISIONS-2 was a NASA sounding rocket mission consisting of two payloads flown on December 7th, 2018 from Svalbard, Norway. One of the payloads carried two electrostatic analyzers (mini-plasma imagers) that observed low energy ionospheric ions by collecting 2-dimensional images of ion arrival angles and energies. The present study aims to characterize the transition from collisionless to collision-dominated ionospheric-thermosphere interaction near 120 km altitude by determining the 3-dimensional ion drift along the VISIONS-2 trajectory. Using an instrument simulator to model the ion imagery, the ion drift is estimated at regular altitude intervals throughout the transition region. Assuming a constant electric field and zero thermospheric wind, the variation of ion drift with altitude will be used to determine the altitude at which friction balances the Lorentz force on the ions. Preliminary results will be interpreted within the context of existing in situ studies of the mechanics of ionosphere-thermosphere coupling within the E region.

Wu, J., and D. Knudsen

Swarm observations of static and Alfvénic Electrodynamics in the Auroral Region

Auroral arcs can remain quasi-static for tens of minutes, and can also appear with rapid motions and changing brightness. One of the main challenges in constructing a self-consistent theory to explain the generation and morphology of auroral arcs is an adequate description of the arc circuit. The high precision magnetic and electric field data collected by Swarm A, B and C are well suited to study both quasi-static auroral electrodynamics and waves in the low-frequency range. In this talk, we present studies about field-aligned currents (FACs) associated with multiple auroral arc systems. We found wide-spread Alfvénic fluctuations associated with both upward and downward large-scale FACs, indicating that the ultimate source of these wave regions remains an open question. The suprathermal electron imager (SEI) onboard the e-POP satellite (also known as Swarm Echo), can measure suprathermal electrons bursts (STEBs) in hundreds of eV range. The statistical repetition period of STEBs in our study is around 1 s, which is consistent with the characteristic period of the ionospheric Alfvén resonator. We also present a case event demonstrating a new feature with both normal and inverse dispersion in energy and pitch angle spectrograms. Observations presented in these studies provide important constrains in testing models of electron acceleration and theories of auroral arcs.

Zuber, S., J. Burchill, and D. Knudsen

Assessing Cusp Core Plasma Heating with Visions-2

In December of 2018, the Visualizing Ion Outflow via Neutral Atom Sensing-2 (VISIONS-2) mission launched with the aim of increasing the understanding of ionospheric ion outflow in the polar cusp. On board, two miniaturized plasma imagers collected two-dimensional distributions of ion kinetic energy and ion angle of arrival to determine core ionospheric density, velocity, and temperature. We use flight data to constrain a previously developed instrument modelling technique to assess heating of core plasma. This research establishes a foundation for future comparative analysis of core ions and energetic ions observed on VISIONS-2.

C.M.Cully, S. Lejosne, J.F. Ripoll, D.L. Turner, G. Reeves,D.M. Gillies, E.F. Donovan, E. Spanswick, S. Thaller

The association between slot-filling injections and subauroral (STEVE) emissions

Driven by large-scale electric fields in the inner magnetosphere, energetic electrons have been observed to be injected into the slot region at L<4, reaching energies up to roughly 250 keV [e.g. Turner et al., 2015]. Persistent, narrow, poleward-directed electric fields (Sub-Auroral Polarization Streams, SAPS) are associated with the injection [Lejosne et al., 2018], and are also thought to drive characteristic optical emissions known as STEVE (Strong Thermal Emission Velocity Enhancement) events [e.g. Gallardo-Lacourt et al., 2018].

Using data from the Van Allen Probes in conjunction with ground-based data from TREx, THEMIS and the Canadian Geospace Observatory, we find a very strong association between deep (L<4) electron injections and STEVE emissions. We examine the spatial and temporal relationship between the injection and the STEVE emissions, and discuss the implications for electric field structure in the inner magnetosphere.

M. Patrick, C. M. Cully, R. M. Millan, A. J. Halford, M. P. McCarthy

Retrieving Electron Precipitation Spectra from x-ray1Measurements using Constrained Tikhonov Regularization

Measurements of bremsstrahlung X-rays produced by electrons precipitating in the upper atmosphere are used to determine information about the causative electron spectrum. This is an ill-conditioned inverse problem and is suited to the application of regularization methods. We show that the use of second-order Tikhonov regularization under simple constraints retrieves electron spectra that match results from simulated data and can provide a better description of experimental data than simpler models. We also demonstrate that constrained regularization has a high resistance to noise in the measured X-ray spectrum, allowing the analysis of weaker precipitation events. The application of this method to a comparison between BARREL X-ray measurements and conjunctive RBSP MAGEIS estimates of precipitating electrons from (Halford et. al. 2015) produces a good agreement between the retrieved electron spectrum and experimental data.