H. Allison, R. Horne, S. Glauert - Study of the magnetic local time variation of lower energy electrons in the radiation belt region using POES data

Following substorms, electrons from the plasmasheet at energies of a few keV to a few hundred keV move under the influence of the convection electric field, travelling from the night-side, past dawn, and out through the magnetopause. This can have important implications for current 3D radiation belt models which work on a drift average approximation, essentially assuming that the flux does not change notably with magnetic local time. Significant variations over a drift orbit may result in acceleration or losses being underestimated in these radiation belt calculations. Using fourteen years of electron flux data from the National Oceanic and Atmospheric Administration Polar Operational Environmental Satellites (POES), the extent of the magnetic local time asymmetry is investigated across a range of activity levels, defined by AE, AE*, Kp, and solar wind velocity. Three electron energies are considered, >30, >100, and >300 keV. During periods when AE exceeds 811 nT, an asymmetry of a factor larger than 20 is observed between the dawn and dusk sectors in the >30 and >100 keV flux. For electrons with >300 keV energies, a magnetic local time variation is also observed, with the ratio of the mean dawn and dusk sector flux greater than 8. It is unlikely that convection alone is responsible for this significant variation observed in the >300 keV flux. Since the timescale for acceleration is comparable to that for drift, we suggest that very rapid local acceleration mechanisms in the dawn sector may contribute to this asymmetry.

M.O. Archer - The MUSICS (Magnetospheric Undulations Sonified Incorporating Citizen Scientists) project

One area of study in space weather research is that of ultra-low frequency (ULF) waves in Earth's magnetosphere, since these play several key roles such as the transport, acceleration and loss of electrons in the radiation belts. A number of different driving mechanisms of ULF waves modes exist (e.g. Kelvin-Helmholtz instability, solar wind pressure variations, foreshock phenomena etc.) depending on the solar wind conditions and numerous modes of wave (e.g. surface waves, field line resonances, cavity or waveguide modes etc.), both directly driven and resonantly excited, may or may not be supported within the highly variable magnetospheric system, again dependent on the specific conditions at the time. These waves are routinely measured by ground-based (e.g. magnetometer and radar networks) and space-based instrumentation (e.g. GOES, THEMIS, Cluster). MUSICS is a "Research in Schools" outreach and citizen science project which provides sonified ULF wave data for analysis in Audacity audio software by school students. This project was piloted last year with four London schools who were each given one year of GOES magnetometer data for analysis. The project has now expanded to 10 schools and covers 8 years of data. MUSICS provides a way not only of enthusing school students with contemporary research, but allows the manual identification of ULF wave phenomena (still highly prevalent within current ULF wave research) by a large number of citizen scientists for use in tackling our current questions about their occurrence, nature and impact.

S. Bentley, C. Watt and M. Owens - Characterising magnetospheric ULF wave power by solar wind conditions

There are several possible mechanisms enabling the transfer of energy from the driving solar wind flow and heliospheric magnetic field to ULF wave power in the magnetosphere. However, at present the relative contributions from each mechanism are poorly quantified. Characterising ULF power in terms of the driving solar wind conditions would allow us to distinguish physical mechanisms and to model the diffusion and energisation of high-energy particles in the radiation belts in terms of observed solar wind parameters, paving the way for predictive models of radiation belt dynamics. Therefore we present an analysis of fifteen years of observed power and incoming solar wind data which are used to determine the relative contribution of each solar wind property. We describe the techniques used to deal with these large datasets and parameter spaces. Considering the interdependence of these parameters and their occurrence distributions enable us to distinguish the dominant transfer mechanisms and to identify which observed solar wind properties should be used for future modelling work.

M. J. Birch, J. K. Hargreaves - Deduction of a high-latitude, low-altitude absorption layer using the EISCAT Svalbard radar

In 2015, observations of the electron density on February 27-28 and March 1-2 using the EISCAT Svalbard radar revealed evidence of an absorption layer peaking at 81-83 km. The estimated absorption was about 0.01 dB at 38.2 MHz, which would be undetectable by a riometer such as that at Longyearbyen. Most AA events peak around 90 km so, although of quite low intensity, it is significant that this layer is at a relatively low altitude. The deduced spectrum of the precipitating electron flux causing the absorption had an average characteristic energy of 41.1 keV, which is well above that from normal AA features, usually about 14 keV. The spectrum is very similar to that measured by the Wind spacecraft close to the L1 point, which suggests that the source of the electron flux is the solar wind.

S. Browett, R. C. Fear, A. Fazakerley, C. Forsyth, A. J. Kavanagh, B. S. Lanchester, I. McCrea - Inferring the spatial extent of the magnetospheric cusp

The cusp region of the magnetosphere allows for direct injection of solar wind particles into the ionosphere in the dayside sector of the polar cap and so knowing the spatial extent of this region is important for knowing what area of the ionosphere is affected by it. Simultaneous spacecraft observations at large separations are rare, hence estimates of the spatial extent of the cusp are primarily statistical. We attempt to constrain a value for the instantaneous spatial extent by examining data from the Cluster satellites using observations from a joint Cluster-EISCAT campaign during which the Cluster spacecraft were spaced at large separations. On the 7th of April 2013 between approximately 10:00 UT and 11:30 UT the Cluster satellites passed through the cusp region whilst the separation of the spacecraft was very large. We examine the electron differential energy flux, as measured by Cluster, to identify periods where multiple spacecraft detect the boundary of the cusp simultaneously. The large separation of the spacecraft at this time provides information on the spatial extent of the cusp. The spacecraft tetrahedron during this event had an approximate spatial extent, in Geocentric Solar Ecliptic (GSE) coordinates, of [0.9, 1.3, 0.4]Re. The entire spacecraft tetrahedron was found to be contained within the cusp at one time; the spacecraft separation therefore gives a value for the minimum spatial extent the cusp had at that time. This separation is then compared to EISCAT data in order to obtain simultaneously measured ground based data for validation of the space based observations made by Cluster.

A. G. Burrell, T. K. Yeoman, S. E. Milan, M. Lester - Solar cycle variations in polar ionospheric convection

Plasma convection over the poles shows the result of direct interactions between the terrestrial atmosphere, magnetosphere, and the sun. The paths that the ionospheric plasma takes in the polar cap form a variety of patterns, which have been shown to depend strongly on the direction of the Interplanetary Magnetic Field (IMF) and the reconnection rate. While the IMF and level of geomagnetic activity clearly alter the plasma convection patterns, the influence of changing solar irradiance is also important. The solar irradiance and magnetospheric particle precipitation regulate the rate of plasma production, and thus the ionospheric conductivity. Previous work has demonstrated how season alters the convection patterns observed over the poles, demonstrating the importance that solar photoionisation has on plasma convection. This study investigates the role of solar photoionisation on convection more directly, using measurements of ionospheric convection made by the Super Dual Auroral Radar Network (SuperDARN) in the northern hemisphere near the autumnal equinox over the 23rd solar cycle.

J. M. Chadney, D. K. Whiter - Determining OH(8-3) temperatures with the HiTIES instrument

Using the High Throughput Imaging Echelle Spectrograph (HiTIES), installed at the Kjell Henrilsen Observatory in Svalbard, we measure OH(8-3) airglow emission between 730 – 740 nm. By taking ratios of the P-branch emission lines, we determine the temperature of the neutral atmosphere near the mesopause. OH airglow, normally present during clear sky conditions, can be obscured by N2 and O+ emissions during auroral events. We have thus developed a novel method to fit all the components of the measured spectra, allowing OH emission intensities to be extracted even during aurorae. We also take into account absorption by atmospheric water vapour, allowing a more precise temperature estimation. We present temperatures obtained from measurements in the last week of December 2003, revealing variations in temperature on different timescales.

S. C. Chapman, J. Dods, J. Gjerloev - Dynamical networks formed from SuperMAG characterize the spatially correlated ionospheric current response to southward and northward IMF turnings

Network science is a valuable tool in characterizing dynamically evolving pattern in datasets where there are many simultaneous observations. Whilst networks are in widespread use in the data analytics of societal and commercial data, there are additional challenges in their application to physical timeseries. Determining whether two nodes (here, ground based magnetometer stations) are connected in a network (seeing the same dynamics) requires normalization w.r.t. the detailed sensitivities and dynamical responses of specific observing stations. We have addressed this for the SuperMAG set of magnetometers [Dods et al, 2015].

Here, [Dods et al, 2016] we use this dynamical network methodology to characterise the response of the quiet-time large scale spatial pattern of ionospheric current, which reflects the ionospheric convection system, to north-south and south-north IMF turnings. Quiet-time conditions are times in which no storms or substorms are occurring. Canonical cross-correlation between all pairs of SuperMAG magnetometer stations in the northern hemisphere (MLat 50-82◦) is used to establish the extent of near-simultaneous magnetic response between regions of MLT-MLat. Parameters and correlation maps that describe the spatial-temporal distribution of cross-correlation are used to characterise the system and its response to the turnings aggregated over several hundred events. We find that regions that experience large increases in spatial correlation post-turning coincide with typical locations of a two cell convection system and are influenced by the IMF By. Our method estimates the time between the turnings reaching the magnetopause and a network response, and the time taken for changes in spatial correlation to propagate from the dayside to the nightside.

C. H. K. Chen, S. Boldyrev - Nature of kinetic scale turbulence in the Earth's magnetosheath

The Magnetospheric Multi-Scale (MMS) mission, launched last year, has provided us with the highest resolution measurements to date of the near-Earth space plasma environment. Here, we present new MMS measurements and corresponding new theoretical results on turbulence at kinetic scales in the Earth's magnetosheath. In many respects, this turbulence is similar to that in the upstream solar wind, but one key difference is that whereas in the solar wind the ion and electron temperatures are typically comparable, $T_i \sim T_e$, in the magnetosheath, the ions are typically much hotter $T_i \gg T_e$ as a result of processing by the Earth's bow shock. This leads to a new type of turbulence at kinetic scales which we have measured with MMS. A new theory for this turbulence is developed, and this compares favourably with the MMS measurements.

J. C. Coxon, I. J. Rae, C. Forsyth, C. M. Jackman, R. C. Fear - The morphology of the Birkeland current system during substorms

Birkeland (field-aligned) currents link the magnetosphere to the ionosphere, communicating stresses through the system. In the case of substorms, field-aligned currents are enhanced as a result of cross-tail current disruption in the tail. Global-scale current maps can be obtained from the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE). To identify the morphology of the field-aligned currents near the time of substorm onset it is necessary to correctly identify the time, latitude and longitude of onset. We perform a superposed epoch analysis of the morphology of the Birkeland currents during substorms accounting for all relevant temporal and spatial boundaries. We use substorm expansion phase onsets identified using the Substorm Onsets and Phases from Indices of the Electrojet (SOPHIE) technique and calculate average current maps of the current systems for two hours prior, and subsequent, to onset. We bin the onsets by the latitude of the current oval at onset, and we rotate each current map by the MLT at which the substorm onset was recorded.

In this way, we investigate the spatial and temporal characteristics of the currents flowing during a substorm. We observe a large-scale structuring in the currents in the same sense as the substorm current wedge. Furthermore, we do not see any statistical signature in these current systems that is consistent with a drop in the current magnitude prior to auroral dimming. We discuss this result in the context of other recent studies of the spatial studies of Birkeland currents during substorms and discuss possible reasons as to why these results differ from some previous studies.

T.W. David, D.M. Wright and S.E. Milan - Ion upwelling from the Earth's upper atmosphere

We have studied the ionospheric upflow flux with magnitude above using the data during the IPY-ESR 2007 campaign. We further classify this strong flux into low, medium and high upflow. It is discovered that the high flux rarely occur while the low category is a frequent phenomenon. Analysis of the ESR data shows that the occurrence frequency maximizes around local noon for all classes of flux, however, the upflow flux is skewed to the night side for the low class. A further analysis of upflow flux in relation with geomagnetic index, Kp, indicates that upflow occurrence increases as the level of geomagnetic disturbance increases. About 31%, 16% and 2% occurrence peak is observed in the respective low, medium and high upflow during geomagnetically disturbed period. In addition, we have attempted to distinguish between ambipolar and joule heating effects using the pressure balance equation. Periods of strong ambipolar electric force leading to ion upflow are observed both around the cusp and nightside aurora.

R. T. Desai, A. J. Coates, D. O. Kataria, A. Wellbrock, G. J. Jones, G. R. Lewis - Cassini identification of carbon chain anions and further intermediary species in the primary stages of haze formation at Titan

Cassini Plasma Spectrometer (CAPS) Electron Spectrometer (ELS) observations of Titan's upper atmosphere revealed how a reducing Planetary atmosphere can efficiently synthesize large and predominantly negatively charged organic molecules up to 13,800m/z [1][2][3][4][5]. Large haze-type 'tholins' have now also been observed at Pluto[6] and are thought to play a role in further Nitrogen and Methane-dominated atmospheres such as that of Triton[7] and the early Earth's[8]. In previous studies the intrinsic $\Delta E/E$ energy resolution of the CAPS-ELS did not allow specific negative ions to be positively identified in Titan's upper atmosphere and the detections were classified into broad mass ranges of candidate species. The tholins were shown to increase in both mass and density with decreasing altitude [3,5] in an apparent agglomeration process [9]. Here, we use an enhanced fitting methodology to statistically identify the ethynyl and/or cyano carbon chain anion species, C_2H^-/CN^- and C_4H^-/C_3N^- within the negative ion mass per charge spectrum. At lower altitudes we are able to resolve further intermediary species at >100m/z, which are suggested to be polycyclic and aromatic in structure and evidence of the transfer of negative charge from chains to more complex structures. These intermediary species markedly deplete in density as the aerosols/tholins rapidly increase in both size and abundance, demonstrating their direct coupling to the aerosol growth process and likely inclusion within the haze particles observed at lower altitudes.

C. Forsyth, M. Shortt, J. C. Coxon, I. J. Rae, M. P. Freeman, N. M. E. Kalmoni, C. M. Jackman, B. J. Anderson - Distinguishing dayside and nightside field-aligned current drivers

Field-aligned currents (FACs), also known as Birkeland currents, are the agents by which energy and momentum is transferred to the ionosphere from the magnetosphere and solar wind. This coupling is thought to enhance a substorm onset through the formation of the substorm current wedge. Using FAC data from the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) project and substorm expansion phase onsets identified using the Substorm Onsets and Phases from Indices of the Electrojet (SOPHIE) technique, we examine the FACs in the noon, dusk, dawn and midnight sectors. Our results show that the rates of increase and decrease of the dawn and dusk FACs match the dayside reconnection rates. The dayside FACs show little or no variation throughout the substorm cycle. The nightside FACs show two intervals of increase prior to substorm onset with the current during the latter period increasing at twice the rate of the R1/R2 currents. Following substorm onset, the nightside FACs and SuperMAG AL index follow the Weimer [1994] model. Overall, our results show that the growth and decay rates of the Region 1 and 2 current systems are directly driven by the solar wind, whereas the growth and decay rates of the substorm current system on the nightside are independent of the upstream driver. This implies that the growth of the nightside currents is controlled internally to the magnetosphere, possibly through the action of ionospheric and magnetospheric instabilities.

M. P. Freeman, M. M. Lam, and G. Chisham - The temperature signature of an IMF-driven change to the global atmospheric electric circuit (GEC) in the Antarctic troposphere

We use National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) reanalysis data to show that Antarctic surface air temperature anomalies result from differences in the daily-mean duskward component, B_y, of the interplanetary magnetic field (IMF). We find the anomalies have strong geographical and seasonal variations. Regional anomalies are evident poleward of 60°S and are of diminishing representative peak amplitude from autumn (3.2°C) to winter (2.4°C) to spring (1.6°C) to summer (0.9°C). We demonstrate that anomalies of statistically-significant amplitude are due to geostrophic wind anomalies, resulting from the same B_y changes, moving air across large meridional gradients in zonal mean air temperature between 60 and 80°S. Additionally, we find that the mean tropospheric temperature anomaly for geographical latitudes ≤ -70° peaks at about 0.7 K and is statistically significant at the 1 - 5% level between air pressures of 1000 and 500 hPa (i.e., ~0.1 to 5.6 km altitude above sea level) and for time lags with respect to the IMF of up to 7 days. The signature propagates vertically between air pressure p ≥ 850 hPa (≤ 1.5 km) and p = 500 hPa (~5.6 km). The characteristics of prompt response and vertical propagation within the troposphere have previously been seen in the correlation between the IMF and high-latitude air pressure anomalies, known as the Mansurov effect, at higher statistical significances (1%).

We conclude that we have identified the temperature signature of the Mansurov effect in the Antarctic troposphere. Since these tropospheric anomalies have been associated with B_y-driven anomalies in the electric potential of the ionosphere, we further conclude that they are caused by IMF-induced changes to the global atmospheric electric circuit (GEC). Our results support the view that variations in the ionospheric potential act on the troposphere via the action of resulting variations in the downwards current of the GEC on tropospheric clouds.

S. A. Glauert, R. B. Horne, N. P. Meredith - Recreating the state of the radiation belts for the last 30 years

Understanding the electron radiation environment at medium earth orbit (MEO) is becoming increasingly important. Global navigation satellites operate here and satellites that use electric orbit raising to reach geostationary orbit (GEO) can also spend hundreds of days in this region of space. Unfortunately, there is limited data on the high-energy electron flux, responsible for internal charging in satellites, in this region. One approach to this problem is to use models to recreate the environment. As part of the EU-FP7 SPACESTORM project, the BAS Radiation Belt Model (BAS-RBM) has been used to recreate the high-energy electron environment (E > ~500 keV) from the outer edge of the inner belt and to GEO, for the last 30 years.

The >2 MeV electron flux has been measured at GEO by the GOES spacecraft for more than 30 years, providing a data set from which the outer radial boundary condition for the BAS-RBM can be derived. The resulting 30 year-long simulation illustrates both the long and short term variability of the outer radiation belt and slot region.

The Standard Radiation Environment Monitor (SREM) on the Galileo In-Orbit Validation Element-B (GIOVE-B) spacecraft provided count rates for the high-energy electrons in MEO for about 4 years (2008-2012). This data set can be used to validate the BAS-RBM results during this period and we will present a comparison between the simulation and the GIOVE-B data.

G. A. Graham, I. J. Rae, C. J. Owen, A. P. Walsh, C. S. Arridge, L. Gilbert, G. R. Lewis, G H. Jones, C. Forsyth, A. J. Coates & J. H. Waite - Heliospheric radial evolution of strahl: Cassini observations en-route to Saturn

Suprathermal electrons in the solar wind can be separated into two component populations, a field aligned beam known as 'strahl' and a relatively isotropic 'halo'. Decades of observations mean that these populations can be well characterized however, the formation and interplanetary evolution of these solar wind suprathermals is yet to be fully understood. Strahl electrons at 1 AU have been observed to be broader than theoretically expected and it has also been demonstrated that, on average, strahl beam width broadens with heliospheric distance. This is contrary to the effect of adiabatic focusing expected for electrons moving into regions of decreasing magnetic field strength. Strahl must therefore be subjected to some form of scattering, and as coulomb collisions are not a feasible explanation in such a tenuous plasma, wave-particle interactions are frequently invoked. In this study we use Cassini electron measurements to examine suprathermal electron pitch angle distributions across a distance range of approximately 8 AU. We find that, in general, there is a relatively constant rate of broadening of strahl beam between ~ 1 - 5.5 AU. Our results from beyond this distance indicate that the strahl population is likely to be completely scattered, presumably to form part of the halo. Our results extend previous observations and provide clear constraints for potential scattering mechanisms of strahl electrons.

R. L. Gray, S. V. Badman, E. E. Woodfield, J. D. Nichols - Generation of the Jovian secondary auroral oval

The secondary oval is a feature of the Jovian outer auroral emission seen as sections of discrete arcs of varying length, equatorward of the main auroral oval. The secondary oval is associated with a transition region located at 10-17 Rj in the magnetosphere called the ‘Pitch Angle Distribution’ (PAD) boundary where electrons change from a pancake (maximal at 90°) to bi-directional (more field parallel) pitch angle distribution. This is thought to be due to wave-particle interactions leading to increased electron scattering.

Hot plasma injections are known to occur in the inner magnetosphere and are caused by both tail reconnection inflows and the process of centrifugal interchange driven by outflow of the internal plasma source - the Io Plasma Torus. Hot plasma injections in the PAD transition region may act as a particle source for wave-particle interactions and a source of energy for wave growth, and therefore increase scattering into the ionosphere, causing the secondary oval to become more visible. This study aims to quantify the location and intensification of the second oval feature during sequences of images taken by the Hubble Space Telescope. Small sections of the feature can be picked out in most images, particularly at longitudes < 150°, however the feature appears brighter and extended longitudinally 1-2 days after large injection signatures. The feature lies close to the latitude of the Ganymede auroral footprint.

B.E.S. Hall, M. Lester, B. Sanchez-Cano, J. D. Nichols, D. J. Andrews, N. J. T. Edberg, H. J. Opgenoorth, M. Fränz, M. Holmstrom, R. Ramstad, M. Cartacci, A. Cicchetti, R. Noschese, O.Witasse - Annual and solar cycle variations in the location of the martian bow shock: A Mars Express study

When the supersonic and super-Alfvénic flowing solar wind reaches a planetary magnetosphere or ionosphere, it is directed around it. For this to occur, the flow must first be slowed, leading to the formation of a bow shock upstream of the planet. At Mars, the effective obstacle to the solar wind is the ionosphere and upper atmosphere. Additionally, Mars' eccentric heliocentric orbit leads to annual variations in the solar wind dynamic pressure and solar extreme ultraviolet (EUV) flux, both of which are understood to have an impact on the Martian ionosphere, and resultantly the bow shock's location throughout the orbit of Mars about the sun. In this work we first present how these annual variations in the interplanetary solar environment can modulate the Martian bow shock location, and then use this information to evaluate the existence of any solar cycle related variations. For the first time, we find that the annual variations in the Martian bow shock location are of the order of an 11% increase in altitude when Mars moves from its aphelion to perihelion position. We also confirm the existence of a solar cycle variation in the bow shock location, but note that the total variation from the solar minimum to maximum phases is of a similar order to the annual variations. We conclude that bow shock motion is particularly sensitive to variations in the solar EUV flux.

R. Hood, J. Woodroffe, S. Morley, A. Aruliah - The evolution of the magnetospheric response during the 22-29 July 2004 stormtime interval

The 22-29 July 2004 geomagnetic storm resulted in ground-level geomagnetic disturbances twice the magnitude of previous storms of similar Dst intensities. Here the state of the magnetosphere and its corresponding influence on the ground via field-aligned currents (FAC) is assessed using the CHAllenging Mini-satellite Payload (CHAMP) fluxgate magnetometer to derive the latter and magnetospheric indices to infer the former. Several relations are realised, including a strong correlation between dayside FAC magnetic latitudes and IMF Bz, corresponding to magnetopause reconnection, as well as trends with the SYM-H and Auroral Electrojet indices. The most equatorward FACs occur on the nightside and are shown to depend on storm intensity as defined by the SYM-H index. Finally, ground magnetometer data from the SuperMAG initiative is used to relate the ground effects to the FAC-ionosphere system.

R. B Horne and Y. Miyoshi - Propagation and linear mode conversion of magnetosonic and electromagnetic ion cyclotron waves in the radiation belts

Magnetosonic waves and electromagnetic ion cyclotron (EMIC) waves are important for electron acceleration and loss from the radiation belts. It is generally understood that these waves are generated by unstable ion distributions that form during geomagnetically disturbed times. Here we show that magnetosonic waves could be a source of EMIC waves as a result of propagation and a process of linear mode conversion. The converse is also possible. We present ray tracing to show how magnetosonic (EMIC) waves launched with large (small) wave normal angles can reach a location where the wave normal angle is zero and the wave frequency equals the so-called cross-over frequency whereupon energy can be converted from one mode to another without attenuation. While EMIC waves could be a source of magnetosonic waves below the cross-over frequency magnetosonic waves could be a source of hydrogen band waves but not helium band waves.

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M. James, S. M. Imber, E. J. Bunce, T. K. Yeoman and M. Lockwood - Interplanetary magnetic field properties and timescales near Mercury's orbit

An extensive study of interplanetary magnetic field (IMF) characteristics and stability is undertaken using MESSENGER magnetometer data collected while exposed to the solar wind. We characterise typical distributions of IMF field strength, clock angle and cone angle and how they varied throughout the duration of MESSENGER's mission. Clock and cone angle distributions collected during the first Earth year of the mission indicate that there was a significant north-south asymmetry in the locations of the heliospheric current sheet during this period. The stability of IMF magnitude, clock angle, cone angle and IMF Bz polarity is quantified for the entire mission. Changes in IMF Bz polarity and magnitude are found to be less likely for higher initial field magnitudes. Stability in IMF conditions is also found to be higher at aphelion than at perihelion.

R. Johnson, T. Stallard, H. Melin, S. Miller & J. Nichols - Mapping ion winds in Jupiter's auroral ionosphere

The origin of Jupiter's main auroral oval is well studied and linked to the corotation breakdown in the middle magnetosphere; however the mechanisms which drive the polar aurora are less un3derstood. The dynamics of the jovian ionosphere can be revealed using infrared observations of H+ emission at Jupiter. Previous observations of ion flows in Jupiter's auroral ionosphere, using the long-slit echelle spectrometer CSHELL (NASA-IRTF) to measure the Doppler shifted H3+ v2 Q(1,0−) line at 3.953μm, have shown a stationary region within the location of the polar aurora. This region is held at a zero inertial velocity, suggesting an interaction with the solar wind through either an Earth like Dungey cycle restricted to a single cell or viscous interaction moderated by Kelvin- Helmholtz instabilities. Here, we present a new, significantly more detailed study which uses data taken on the 31st December 2012 with the long-slit echelle spectrometer CRIRES (ESO-VLT). The entire auroral region was observed using a rigorous scanning motion of the telescope, providing a highly detailed view of the different regimes of flows within the ionosphere for the first time. The stationary region of the polar aurora is now observed completely co-incident with a region known to have very weak auroral emission in both UV and infrared, suggestive of field lines empty of plasma. This perhaps more strongly suggests that this region, close to the main auroral emission, is open to the solar wind. Additionally we reveal new flows inside the main emission and a region of super rotation located equatorward of the main emission on the dawn side of the planet.

R. Kieokaew, C. Foullon, B. Lavraud - Magnetic curvature analysis on Kelvin-Helmholtz Waves: a MHD simulation study

Four-spacecraft missions are probing the Earth's magnetospheric environment with high potential for revealing spatial and temporal scales of a variety of in-situ phenomena. Magnetic curvatures are intrinsic to curved magnetic fields where the magnetic energy is stored in the form of magnetic tension. In-situ magnetic curvatures have been resolved by the four-spacecraft technique called "magnetic curvature analysis" (MCA). The MCA technique has been used in various plasma structures identified as current sheets, plasmoids, and magnetic reconnection diffusion regions. We investigate the robustness of the method to interpret applications in the real data. Here, for the first time, we test the MCA on a 2.5D MHD simulation of curved magnetic structures induced by Kelvin-Helmholtz (KH) waves. Increasing (regular) tetrahedron sizes of virtual spacecraft are used to measure the curvatures of KH vortices. We investigate the magnetopause curvature for two main locations of KH vortex and we produce time series corresponding to these positions (for static spacecraft in the boundary layers). We have found variations of the curvature vectors both in radii and orientations depending on the sizes of the tetrahedron. This is helpful to better understand the MCA measures when the technique is applied to in-situ data without knowing the scale sizes of plasma structures under consideration. This study lends support for cross-scale observations to better understand the nature of curvature and its role in plasma phenomena.

J. Kinrade, S. V. Badman, G. Provan - Rotational modulation of Saturn's UV auroras in 2014

Surveys of magnetic field perturbations associated with Saturn's rotating planetary-period oscillation (PPO) current systems have revealed that regions of upward and downward PPO field- aligned current can modulate the steady-state field-aligned currents that drive the main auroral emission. The latitude and width of the main auroral current layer also change in phase with the PPO system rotation (Hunt et al. 2015). Images of the UV aurora from the Hubble Space Telescope (HST) show a statistical modulation of emission intensity and latitude by the rotating PPO currents, but the intensifications and suppression are not always in phase with the maxima and minima expected from the PPO models.

Using the PPO current model derived from Cassini MAG data and images of the northern UV aurora from HST during 2014, we show how the auroral emissions and oval position were modulated by the rotating currents. This interval is of particular interest because the northern and southern PPO system were phase-locked. We find that the northern UV auroral intensity was organised by the phase-locked northern and southern PPO currents, but the peak intensity lagged ~90-180o of phase behind the respective model upward current maxima. The mean centre point of the northern oval was shifted away from the planetary rotational and magnetic axis towards the nightside by several degrees, however we see no clear displacement of the oval latitude with PPO phase as observed in previous auroral imaging campaigns [Nichols et al. 2008; 2010; 2015].

M. Lang, P. Browne, P. J. van Leeuwen, M. Owens, L. Barnard - Data Assimilation in the Solar Wind: Challenges and First Results

Data assimilation (DA) is currently underused in the solar wind field to improve the modelled variables using observations. Data assimilation has been used in Numerical Weather Prediction (NWP) models with great success, and it can be seen that the improvement of DA methods in NWP modelling has led to improvements in forecasting skill over the past 20-30 years. The state of the art DA methods developed for NWP modelling have never been applied to space weather models, hence it is important to implement the improvements that can be gained from these methods to improve our understanding of the solar wind and how to model it.

The ENLIL solar wind model has been coupled to the EMPIRE data assimilation library in order to apply these advanced data assimilation methods to a space weather model. This coupling allows multiple data assimilation methods to be applied to ENLIL with relative ease.

I shall discuss twin experiments that have been undertaken, applying the LETKF to the ENLIL model when a CME occurs in the observation and when it does not. These experiments show that there is potential in the application of advanced data assimilation methods to the solar wind field, however, there is still a long way to go until it can be applied effectively. I shall discuss these issues and suggest potential avenues for future research in this area.

R. P. Leyser, S. M. Imber, S. E. Milan - MESSENGER observations of flux transfer events near Mercury's dayside magnetopause

The magnetosphere of Mercury is highly dynamic, very strongly driven by magnetic reconnection between the interplanetary and Hermean magnetic fields, as evidenced by the significant flux transfer event (FTE) activity observed at the magnetopause by the magnetometer onboard the MErcury Surface, Space ENvironment, GEochemistry and Ranging (MESSENGER) spacecraft. Recent studies, based on limited observations, have suggested that reconnection occurs independently of the interplanetary magnetic field (IMF) clock angle at Mercury, and reported that there is a significant dawn-dusk asymmetry in FTE occurrence, indicating a considerable difference from Earth. In this study we have used MESSENGER data to identify FTEs during the first four Hermean years of its orbit around Mercury. Here we present a statistical study of those FTEs. The results show that the formation of flux transfer events depends strongly on the orientation of the magnetosheath field, with a clear preference for solar wind clock angles close to 180 degrees. It is therefore inferred that reconnection occurs most strongly at Mercury for near-southward IMF. Additionally, we find further evidence of a dawn-dusk asymmetry in the formation of FTEs at Mercury.

D. McKay - All-sky optical-riometric imaging of aurorae

The recently-developed all-sky interferometric riometry technique has resulted in a new capability in spatially-resolved ionospheric monitoring. It is now possible to measure high-energy electron precipitation to the D region of the ionosphere through the use of all-sky interferometric imaging. The first all-sky riometric imaging was carried out in Arctic Finland by the Kilpisjärvi Atmospheric Imaging Receiver Array (KAIRA) in late 2013. More, recently, multi-frequency and high-time resolution capability have been added allowing new investigations. Since the first observations, a large interferometric riometry data set of many polar magnetospheric substorm events has been accumulated. These events have been compared to co-located, co-temporal observations made at optical wavelengths. Analysis of these events, in conjunction with the energy derivation based on the optical observations, indicates discrepancies in our current understanding and the discovery of unexpected electron presence. This presentation describes the technique, reviews the current state of observations and highlights some of the significant results that have been found through optical-riometric comparisons.

A. R. Macneil, C. J. Owen, R. T. Wicks - Tests for coronal electron temperature signatures in suprathermal electron populations at 1 AU

Developing knowledge of how the solar wind coronal origin affects its in-situ properties is key in understanding how the Sun produces the heliosphere. Such knowledge will only increase in value following the launch of Solar Orbiter, which will investigate the Sun-heliosphere connection with in-situ and remote sensing instruments at distances closer to the Sun than ever before. Properties of the solar wind plasma are initially defined by their coronal source region, but the link between source and wind is obscured due to transport effects which develop as the solar wind propagates further from the Sun. Establishing solar wind populations for which these properties are preserved further out into the heliosphere, specifically to distances at which in-situ spacecraft measurements can be made, provides additional tools with which to probe the source of solar wind plasma. Analysing ACE/SWICS and WIND/3DP data spanning over 12 years, we test properties of solar wind suprathermal electron distributions, consisting of the quasi-isotropic halo and field-aligned strahl, for coronal temperature signatures in the solar wind at 1 AU. We do so by testing a previous suggestion that these correlate with the oxygen charge state ratio O7+/O6+, which is known to act as a tracer of coronal electron temperature. We find a very weak and variable correlation between suprathermal electron temperatures and O7+/O6+. The size of the correlation coefficients found, in the context of the interconnected nature of solar wind properties, do not signify a meaningful relationship. The weak nature of the correlation leads us to conclude, in contrast to earlier results, that either coronal thermal electron temperature at the oxygen freeze-in height has no bearing on the energetics of suprathermal electrons, or that there is an initial relationship which is largely smeared out by processing in the solar wind. The nature of the variation leads us to favour the interpretation that suprathermal electrons do bear some initial sensitivity to coronal electron temperature. However, the initial relationship is lost when they become subject to scattering in the solar wind which weakens the coronal temperature imprint on the suprathermal populations.

C. Martin, C. S. Arridge, M.K. Dougherty - Structure and propagation of waves seen on Saturn’s equatorial current sheet

Saturn’s equatorial current sheet experiences many perturbations. Firstly, a 10.7-hour periodic wave similar to Jupiter’s distinctive flapping wave, and secondly, non- periodic waves. The Cassini magnetometer is used to identify these waves from all equatorial revolutions of the spacecraft from 2005 – 2012. These waves are seen most commonly as an anti-phase excursion through the current sheet and back again in the radial and azimuthal components of the magnetic field. A model based on a Harris current sheet and deformed by a Gaussian pulse wave function is fitted to the magnetometer data. This facilitates the resolution of variables such as wave number, angular frequency, amplitude of the wave and scale height of the current sheet. Once fitted we find that, statistically, the amplitude of the waves and scale height of the current sheet increase radially with the largest amplitudes and scale heights found just inside the magnetopause and in the far tail. In this presentation we present statistical results on the properties of the current sheet using these current sheet encounters. We also examine the direction of propagation of the waves using an analysis of the radial and azimuthal wave numbers and comment on the origin of these waves.

L. Matteini, T. Horbury, and D. Stansby - Small scale speed modulation in the fast solar wind: a possible Solar origin?

Disentangling local plasma properties and Solar origin structures in situ data is a crucial aspect for the understanding of solar wind acceleration and evolution. This is particularly challenging at 1 AU and beyond, where structures of various origin have had time to interact and merge, smoothing out their main characteristics. Observations of more pristine plasma closer to the Sun are therefore needed. Helios observations as close as to 0.3 AU – although old, not yet fully exploited - can be used to test our expectations and make new predictions.

Recent observations (Matteini et al. 2014, 2015) have outlined the presence of intense (up to ~1000km/s) and short-living velocity peaks that ubiquitously characterize the typical profile of the fast solar wind at 0.3 AU, suggesting that these features could be remnants of processes occurring in the Solar atmosphere and a signature of intermittent solar wind acceleration from coronal holes. We discuss preliminary results about statistics of these events, characterizing their physical properties and trying to link them with typical Solar temporal and spatial scales. We also discuss how future exploration of the inner heliosphere by Solar Orbiter and Solar Probe Plus will address these peaks in more detail.

H. Melin, T. Stallard, L. Fletcher, R. Johnson, S. Miller, L. Trafton - Detection of Uranus' H3+ aurorae

We present H3+ observations of Uranus from 11 October 2016 using the new iSHELL instrument on the NASA Infrared Telescope Facility. This high resolution spectrograph allows for measurements of both ionospheric temperature and ion winds. Aligning the slit East-West on the planet, we observed the ionosphere as it rotated beneath the instrument, revealing a bright spot at dawn in the southern hemisphere. This is the first unambiguous detection of Uranus' aurora in the infrared. We discuss the implications for the dynamics that drive this interaction.

N. P. Meredith, R. B. Horne, J. D. Isles, and J. V. Rodriguez - Extreme relativistic electron fluxes at geosynchronous orbit: Analysis of GOES E > 2 MeV electrons

Relativistic electrons (E >1 MeV) cause internal charging on satellites and are an important space weather hazard. A key requirement in space weather research concerns extreme events and knowledge of the largest flux expected to be encountered over the lifetime of a satellite mission. This is interesting both from scientific and practical points of view since satellite operators, engineers, and the insurance industry need this information to better evaluate the effects of extreme events on their spacecraft. Here we conduct an extreme value analysis of daily averaged E >2 MeV electron fluxes from the Geostationary Operational Environmental Satellites (GOES) during the 19.5 year period from 1 January 1995 to 30 June 2014. We find that the daily averaged flux measured at GOES West is typically a factor of about 2.5 higher than that measured at GOES East, and we conduct independent analyses for these two locations.

The 1 in 10, 1 in 50, and 1 in 100 year daily averaged E > 2 MeV electron fluxes at GOES West are 1.84 × 10^5, 5.00 × 10^5, and 7.68 × 10^5 cm^−2 s^−1 sr^−1, respectively. The corresponding fluxes at GOES East are 6.53 × 10^4, 1.98 × 10^5, and 3.25 × 10^5 cm^−2 s^−1 sr^−1, respectively. The largest fluxes seen during the 19.5 year period on

29 July 2004 were particularly extreme and were seen by satellites at GOES West and GOES East. The extreme value analysis suggests that this event was a 1 in 50 year event.

C. Mitchell - Space weather data assimilation

Space Weather is the rapidly-changing environment of electromagnetic radiation and particles that originate from the Sun and can impact the Earth. As our technology advances and relies on more electronic systems our vulnerability to space weather increases. The ionosphere, which is the ionized part of the upper atmosphere, is a dynamic and critical part of the entire space-weather system and many electronic systems such as satellite navigation and communications and low-frequency radars can be severely disrupted by changes in the ionosphere. Forecasting the behaviour of the ionosphere is thus an essential to forecasting space weather impacts on vital technological systems. However, the ionosphere is notoriously difficult to forecast because it is driven by complex inputs from both the space environment and the underlying neutral atmosphere.

The assimilation of data and models together is a key technique in space weather forecasting. The talk will cover the basics of data assimilation applied to the ionosphere and discuss the implications for protecting the UK technology and infrastructure in a large space weather storm.

J. D. Nichols, J. T. Clarke, G. S. Orton, S. W. H. Cowley, E. J. Bunce, T. Stallard, S. V. Badman, D. C. Grodent, B. Bonfond, A. Radioti, J.-C. M. C. Gérard, R. Gladstone, F. Bagenal, J. E. P. Connerney, P. W. Valek, R. W. Ebert, D. J. McComas, B. Mauk, G. B. Clark, W. S. Kurth, I. Yoshikawa, T. Kimura, M. Fujimoto, C. Tao, S. J. Bolton - Jupiter's auroras during the Juno approach phase as observed by the Hubble Space Telescope

We present movies of the Hubble Space Telescope (HST) observations of Jupiter's FUV auroras observed during the Juno approach phase and first capture orbit, and compare with Juno observations of the interplanetary medium near Jupiter and inside the magnetosphere. Jupiter's FUV auroras indicate the nature of the dynamic processes occurring in Jupiter's magnetosphere, and the approach phase provided a unique opportunity to obtain a full set of interplanetary data near to Jupiter at the time of a program of HST observations, along with the first simultaneous with Juno observations inside the magnetosphere. The overall goal was to determine the nature of the solar wind effect on Jupiter's magnetosphere. HST observations were obtained with typically 1 orbit per day over three intervals: 16 May – 7 June, 22-30 June and 11-18 July, i.e. while Juno was in the solar wind, around the bow shock and magnetosphere crossings, and in the mid-latitude middle-outer magnetospheres. We show that these intervals are characterised by particularly dynamic polar auroras, and significant variations in the auroral power output caused by e.g. dawn storms, intense main emission and poleward forms. We compare the variation of these features with Juno observations of interplanetary compression regions and the magnetospheric environment during the intervals of these observations.

G. Provan, S. W. H. Cowley and E. J. Bunce - Juno at Jupiter: modelling magnetosphere-ionosphere coupling in the Jovian system

Juno arrived at Jupiter in July 2016, heralding an exciting new era of exploration of the Jovian system. Juno is the first spacecraft at Jupiter that will examine Jupiter's high-latitude polar regions, giving us unique information on the field-aligned currents that couple Jupiter's powerful magnetospheres with its ionospheric region. In order to relate Juno's orbits to the structure of Jupiter's magnetosphere, a magnetic field model is needed. We will describe Leicester's coupled solar wind-magnetosphere-ionosphere model of the Jovian environment [Cowley et al., 2005, 2007, 2008]. The model determines the structure of Jupiter's magnetic field along the spacecraft's trajectory, in conjunction with auroral parameters including the zonal flows, equatorward Pedersen current and the height of the auroral acceleration region. Using Juno's orbital trajectory we will predict the field-aligned acceleration parameters and magnetic field that Juno will observe along its orbits. In particular we will focus on the azimuthal field component as the field-aligned coupling currents associated with the modelled current systems produce a readily-observable azimuthal field signature that bends the field lines out of magnetic meridians.

K. Raymer, S.M. Imber and S.E. Milan - Solar cycle influences on the shape and location of the Earth's magnetopause

We have developed an automated routine to determine the location of the Earth's magnetopause using a combination of in situ plasma and magnetic field data. The technique has been applied to almost two solar cycles of Geotail spacecraft data (1996 – 2015), producing a database of 8561 magnetopause crossings. The magnetopause crossings are normalised for solar wind dynamic pressure, and the shape of the magnetopause is modelled with the functional form of the Shue et al. (1997) empirical model for each of the 20 years of data. We find that the yearly averaged level of flaring in the magnetotail and magnetopause standoff distance vary significantly throughout the solar cycle, and that our improved coverage of the flanks is essential for accurately characterising the flaring of the nightside magnetopause. We also find that the shape of the magnetopause depends on the ring current strength and the amount of open magnetic flux in the system.

J. J. Reed, C. M. Jackman, D. Whiter, L. Lamy, W. S. Kurth - Low frequency extensions of the Saturn kilometric radiation as a proxy for magnetospheric dynamics

Saturn Kilometric Radiation (SKR) is a radio emission formed via the cyclotron maser instability on field aligned currents near the auroral regions of Saturn. The SKR has been found to respond to both internal and external driving, and to be linked to both solar wind compressions and magnetotail reconnection events. The radio emission is remotely sensed quasi-continuously and therefore offers the potential to be used as a proxy for magnetospheric activity when the spacecraft is not in an ideal viewing region for observing signatures of reconnection.

In this work we use data taken by the Cassini magnetometer and radio and plasma wave sensor while Cassini was executing its deepest tail orbits in 2006. We characterise the behaviour of the SKR over this period and develop an automatic method for finding low frequency extensions (LFE), where the SKR emission extends down to lower frequencies below the main band. LFEs have been shown to occur in response to reconnection at Saturn (Jackman et al, 2009) and their appearance in Earth's analogous Auroral Kilometric Radiation (AKR) has been shown to coincide with substorm onset (e.g. Morioka et al, 2007).

Using a new catalogue of LFEs we discuss their correlation with known tail reconnection events and solar wind shocks (as inferred from the use of propagated solar wind models). We also look at their properties such as length and recurrence rate, as well as their relationship to the planetary periodicities.

J. A. Reidy, R. C. Fear, D. K. Whiter, B. S. Lanchester, A. J. Kavanagh - Multi-instrument observation of simultaneous polar cap aurora occurring on open and closed field lines

High latitude aurora are a phenomena associated with periods of northwards IMF. By studying their appearance and formation, we can gain valuable information on the configuration of Earth's magnetosphere during the less understood `quiet' periods that occur approximately half of the time. Observations of high latitude aurora from multiple instruments on 19 January 2008 are presented, including almost simultaneous observations of the northern and southern auroral regions from the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) instruments on board Defense Meteorological Satellite Programme (DMSP) spacecraft F16 and F17. SuperDARN flows are also explored in both hemispheres during the event. In the northern hemisphere, two high latitude structures were seen on opposite sides of the polar cap during the same interval. The energies of the precipitating electrons above the structure on the duskside was estimated to vary between 2-11 keV using the Auroral Structure and Kinetics (ASK) instrument in conjunction with the Southampton ion chemistry model. Further analysis of this structure revealed it to be formed on closed field lines that had protruded into the polar cap, consistent with the mechanism proposed for transpolar arcs. However this structure did not cross the entire polar cap but remained, in the northern hemisphere, at approximately 80° magnetic latitude for at least 40 minutes. This protrusion is hence suggested to be an example of a `failed transpolar arc'. The structure seen on the dawnside of the northern polar cap was analysed using DMSP particle spectrograph data. It was found to be associated with electron precipitation energies lower than 1 keV and no ion signature were present. Hence it is suggested that this sun-aligned structure is consistent with the common low intensity arcs formed by accelerated polar rain. The study shows there are at least two types of high latitude aurora occurring simultaneously during northwards IMF.

A. Ronksley, A. Wood, A. Aruliah - The impact of the thermosphere on plasma structures in the high-latitude ionosphere

Plasma structures in the ionosphere can disrupt trans-ionospheric radio signals, such as those used by the Global Navigation Satellite Systems (GNSS). Large-scale structures (10-100s km across) are associated with small-scale structures. These large-scale structures are known to be dependent on UT, season, solar cycle, geomagnetic activity, solar wind conditions and location. The dependence of these structures on the thermosphere has never been fully established, despite the well-understood ionosphere-thermosphere coupling mechanism. The thermosphere is a key parameter in the Joule heating equation. It influences the vertical dynamics of the atmosphere which, in turn, alters the density profile of the thermosphere and hence the lifetime of the plasma density structures. Only recently has the high temporal (few minutes) and spatial (100km) scales of variability of the thermosphere been established.

Ionospheric measurements from the EISCAT (European Incoherent Scatter) Svalbard Radar and thermospheric measurements from the UCL Fabry Perot Interferometers have been compared across a solar cycle and the statistical relationship between these parameters has been determined. The thermospheric parameters can be added to a model to predict the amount of plasma structuring in the ionosphere and the steps required to implement this are discussed.

B. Sánchez-Cano, O. Witasse, M. Lester, S.W.H. Cowley, D. Andrews, J. Espley, J. Guo, D. M. Hassler, B.E.S. Hall, R. Lillis, H. Opgenoorth, J. J. Plaut and R. F. Wimmer-Schweingruber - High energetic particles measured at Mars from the Siding-Spring comet encounter

Siding Spring (C/2013 A1) is an Oort cloud comet, that transited Mars very closely on 19 October 2014, at a distance of only 141,000 km. Its coma washed over Mars, temporarily disturbing the solar wind, and interacted with the Mars' plasma environment. This unique event allows us to investigate the response of the Mars' upper atmosphere to such a rare encounter. Additionally, one of the largest Coronal Mass Ejections (CME) of the current solar cycle hit Mars about 38 hours before the comet flyby, creating a strong perturbation in the system that, although somewhat diminished over the following hours, was still present during the comet passage. In this study, we assess the influence of the CME and of the comet's coma on the high energetic particles that reached Mars during the 10h of encounter, and on the oxygen pick-up ions created and deposited in the Martian atmosphere during the following days. We conclude that the comet had a similar influence on the atmosphere as a solar storm. This study is based on the global analysis of several datasets from Mars Express, MAVEN, Mars Odyssey and MSL missions.

R. Shore, M. P. Freeman, J. Wild, J. Gjerloev - Seasonal and solar-cycle variations of disturbance-polar (DP) type magnetic fields resolved via EOF analysis

We apply a meteorological analysis method (Empirical Orthogonal Functions [EOF]) to ground magnetometer measurements. The EOF method is used to characterise and separate contributions to the variability of the Earth's external magnetic field (EMF) in the northern polar region. EOFs decompose the noisy EMF data into a small number of independent spatio-temporal basis functions, which collectively describe the majority of the magnetic field variance. We use these basis functions (computed monthly) to infill where data are missing, providing a self-consistent description of the EMF at 5-minute resolution spanning 1997—2009 (solar cycle 23).

Each of the EOF basis functions can typically be associated with one of the DP-type current systems (e.g. DP2, DP1, DPY, DP0), or with the motion of these systems. This association allows us to describe the varying behaviour of the current systems over the 144 months (i.e. 1997—2009) of our reanalysis. However, the EOF basis functions are (by definition) ranked by their contribution to the total variance, thus a given current system may be described by a different rank of basis vector from month to month. We use graph theory to find clusters of quantifiably-similar spatial basis functions, and thereby track a given pattern throughout the span of 144 months. Via this method, we present the seasonal and solar cycle variations in the polar current systems.

D. Stansby, T. Horbury, C. Chen, L. Matteini - Experimental whistler wave dispersion relation in the solar wind

The solar wind often hosts large amplitude coherent whistler waves that are observable above the background turbulence around 10% of the time. The fluctuations are short lived (< 5s) individual wave packets, with multiple wave packets found in larger intervals spanning up to 4 hours. We have utilized single spacecraft electric and magnetic field waveform measurements from the ARTEMIS spacecraft in order to calculate the plasma frame frequency and wavevector of individual whistler wave packets. This allows us to present an experimental dispersion relation for whistler waves in the solar wind for the first time.

Using the dispersion relation we have investigated how the wave properties depend on the local plasma conditions, and show that the electron parallel beta strongly affects the dispersion, in agreement with linear theory. We also show that the properties measured are consistent with the electron heat flux instability acting in the solar wind to generate these waves. Finally, we discuss the implications of our measurements for electron scattering by whistler waves in the solar wind.

J. E. Stawarz, S. Eriksson, F. D. Wilder, R. E. Ergun, S. J. Schwartz, A. Pouquet, J. L. Burch, B. L. Giles, Y. Khotyaintsev, O. Le Contel, P.-A. Lindqvist, W. Magnes, C. J. Pollock, C. T. Russell, R. J. Strangeway, R. B. Torbert, L.A. Avanov, J. C. Dorelli, J. P. Eastwood, D. J. Gershman, K. A. Goodrich, D. M. Malaspina, G. T. Marklund, L.

Mirioni, and A. P. Sturner - Observations of turbulence in a Kelvin-Helmholtz event on the Earth's magnetopause by the Magnetospheric Multiscale Mission

Spatial and high-time-resolution properties of the velocities, magnetic field, and 3D electric field within plasma turbulence are examined observationally using data from the Magnetospheric Multiscale Mission. Observations from a Kelvin-Helmholtz instability (KHI) on the Earth's magnetopause are examined, which both provides a series of repeatable intervals to analyze, giving better statistics, and provides a first look at the properties of turbulence in the KHI. For the first time direct observations of both the high-frequency ion and electron velocity spectra are examined, showing differing ion and electron behavior at kinetic scales. Temporal spectra exhibit power law behavior with changes in slope near the ion gyrofrequency and lower-hybrid frequency. The work provides the first observational evidence for turbulent intermittency and anisotropy consistent with quasi-two-dimensional turbulence in association with the KHI. The behavior of kinetic scale intermittency is found to have differences from previous studies of solar wind turbulence, leading to novel insights on the turbulent dynamics in the KHI.

S. A. Taylor, A. J. Coates, G. H. Jones, A. Wellbrock, J. H. Waite - Modelling photoelectron production in the Enceladus plume and comparison with observations by CAPS-ELS

The Electron Spectrometer (ELS) of the Cassini Plasma Spectrometer (CAPS) measures electrons in the energy range 0.6-28,000 eV with an energy resolution of 16.7%. ELS has observed photoelectrons produced in the plume of Enceladus. These photoelectrons are found during Enceladus encounters in the energetic particle shadow where the spacecraft is shielded from penetrating radiation by the moon [Coates et al., 2013]. Observable is a population of photoelectrons at ≈20-30eV, which are seen at other bodies in the solar system and are usually associated with ionisation by the strong solar He II (30.4 nm) line. We have identified secondary peaks at ≈40-50eV detected by ELS which are also interpreted as a warmer population of photoelectrons created through the ionisation of neutrals in the Enceladus torus. We have constructed a model of photoelectron production in the plume and compared it with ELS Enceladus flyby data using automated fitting procedures. This has yielded estimates for electron temperature and density as well as a spacecraft potential estimate which is corrected for.

S. R. Thomas, A. Fazakerley, R. Wicks and L. Green - Evaluating the skill of forecasts of the near-Earth solar wind using a space weather monitor at L5

There is a considerable amount of interest from space agencies about sending a space weather monitor to Lagrangian point 5 (L5). The aim of such a mission would be to enable the forecasting of the near-Earth solar wind and transient features embedded within in, such as coronal mass ejections and corotating interaction regions, from taking measurements at L5. Here, we use data from the STEREO and ACE missions to find times when there are two spacecraft 60 degrees apart to simulate this L5 to L1 scenario. When mapping the solar wind data, we take into account the different orbits of the spacecraft and the varying solar wind speed. We find that the predicted and observed solar wind data are in generally very good agreement for each of the periods. Using skill scores derived from meteorological forecasting, we find that it is possible predict the solar wind much more effectively from L5 than using a persistence forecast based on one solar rotation before, with positive skill scores found for almost all events in a number of important solar wind parameters. The skill improves further for all time periods when removing coronal mass ejections which cannot be predicted in this method.

E. Tindale and S.C. Chapman - Dependence of the statistical distribution of solar wind-magnetosphere coupling parameters on the solar cycle and on fast vs slow solar wind

Solar-terrestrial physics (STP) datasets now extend over several solar cycles and so are amenable to the quantification of changes both between solar maximum and solar minimum, and between successive solar maxima and minima which have exhibited different levels of activity.

We recently introduced a new data analysis approach to STP data, the data-data quantile-quantile (DQQ) plot [Tindale et al, 2016] as a tool for comparing the statistical distribution of solar wind-magnetosphere coupling parameters at different phases of the solar activity cycle. Here, we focus on solar wind-magnetosphere coupling parameters including the Akasofu ε, Milan Φ and Newell $d\Phi/dt$, and use DQQ plots to quantify how sensitive these are to solar cycle changes, and how they depend on the underlying plasma parameters in the solar wind such as velocity, magnetic field, magnetic energy density and Poynting flux. We find that the solar wind-magnetosphere coupling parameters are not equally efficient at sensing how the solar wind is changing with the solar cycle, and that this depends both on the amplitude of the parameters, and whether the solar wind is fast or slow.

S. Turnpenney, J. D. Nichols, G. Wynn - Auroral radio emissions at ultra cool dwarfs

A number of ultra cool dwarfs (UCDs) are observed to emit pulsed coherent radiation, attributed to the electron cyclotron maser instability, a process associated with strong auroral emission at solar system planets. In this paper we examine the magnetosphere-ionosphere coupling currents expected for both open and closed magnetospheres. We consider the angular velocity gradient arising from a Hill (1979)-type steady outward flux of angular momentum, as analogous to the jovian main oval current system, as well as that for an open-closed field line boundary at which the angular velocity transitions to a value given by the Isbell et al. (1984) formula. We present the results of an investigation over a range of relevant plasma and magnetosphere-ionosphere coupling parameters, which are unknown at UCDs, in order to determine the regimes consistent with observed radio luminosities (~1 MW Hz^{-1}). Our results show the large magnetic fields of UCDs are such that the angular velocity of the plasma in the closed magnetosphere does not deviate significantly from rigid corotation, such that for a given set of parameters, the radio power expected from an open magnetosphere is in general significantly higher than for a closed magnetosphere.

M.-T. Walach, S. E. Milan, K. R. Murphy, J. A. Carter and B. A. Hubert - Comparative study of auroral signatures of substorms, steady magnetospheric convection events and sawtooth events

We investigate the auroral evolution during different magnetospheric modes at Earth: Substorms, Steady Magnetospheric Convection and Sawtooth Events.

Substorms are fuelled by dayside reconnection, which is followed by dominating nightside reconnection and an explosive brightening of the nightside aurora. Sawtooth Events are thought to be of a similar nature, but they occur when the dayside reconnection rates are much higher, such that the magnetosphere responds with quasi-periodic particle injections into the inner magnetosphere. Steady Magnetospheric Convection Events on the other hand represent cases when the system is continuously

driven, such that day- and nightside reconnection rates can balance.
Using a superposed epoch analysis using data from the IMAGE FUV (Imager for Magnetopause to Aurora Global Exploration Far Ultraviolet) SI12 (spectrographic imager) and WIC (wideband imaging camera), which show the proton and electron aurora respectively, for each of these event types, we explore the average extent of onset brightenings and their recovery time in the Earth's auroral oval. We find that on average, the brightening at substorm onset starts near 23 MLT and then spreads dusk- and dawnward. After this, the proton aurora starts its recovery to pre-onset intensities earlier than the electron aurora, but with a longer recovery time. Whilst Sawtooth Events are expected to behave similar to substorms, we find that the brightening after onset recovers much more quickly to pre-onset intensity levels, despite much higher levels of dayside driving. Unlike for substorms, we find that after Sawtooth Event onset, it is the proton aurora which recovers quickest.
Similar to Sawtooth Events, Steady Magnetospheric Convection Events occur during continued dayside driving of the system. After a Substorm, the magnetosphere continues to undergo dayside reconnection, such that we do not see a decrease back to pre-onset brightness levels of the aurora for many hours after onset.