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Recent studies using IMAGE/LENA observations have shown that significant brightening between the direction of the Sun and the Earth under certain conditions is the result of solar wind ions charge-exchanging with geocoronal neutral hydrogen atoms in the flow in the magnetosheath, and that the brightening tends to increase when the subsolar standoff distance is reduced. The inward motion of the magnetopause is caused by the increase of the solar wind dynamic pressure and that of a southward component of IMF, and the latter also causes the cusp entry region to move equatorward. We test if LENA can monitor the magnetopause inward/outward motion and the cusp equatorward/poleward motion simultaneously to identify dynamical features of these two types of motion. First, from the intervals of IMAGE noon-midnight orbits, we surveyed for events when the magnetopause was inside of geosynchronous orbit and at the same time either GOES 8 or GOES 10 observed magnetosheath magnetic field near the subsolar point. We also required that LENA hydrogen counts from the sun direction during a selected interval are not correlated with the variations of the ACE/EPAM flux data for ions with energies between 47 and 65 keV/e so as to exclude a possibility that the count enhancements are due to suprathermal ions penetrating collimator. LENA observations taken at Z=4 Re in the dayside magnetosphere on April 11, 2001 show the continuous and correlated motion of two hydrogen peaks coming from the mid- and low-latitude sheath direction. When a sphere with a radius of geosynchronous orbit (=6.6 Re) is assumed around the Earth, the line of sight of these mid- and low-latitude enhancements intersects the sphere at 5-6 Re and a few Re away from the equatorial plane, respectively. We show how these motions can be related to the dynamics of the magnetopause, and their characteristics are discussed in terms of solar wind data measured by ACE and sheath magnetic field data from GOES 8/10.

SM62A-0506 1330h POSTER

The Diamagnetic Cavity in the Exterior Cusp and "Stagnation Region" as it is Seen From Interball-Tail.

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Interball-Tail orbits were traced in the special coordinate system based on the Tsyganenko-96 geomagnetic field model which moves relative to GSM depending on the season and interplanetary conditions. Plasma parameters and magnetic field magnitude in this system indicate an existence of spatially confined region where magnetic field is significantly less than the Tsyganenko-96 model prediction, and plasma number density is close to the magnetosheath plasma density. The ion temperature in this region is unexpectedly high and convection velocity is small. This is generally inconsistent with the model which consideres the cusp as a region of reconnected field lines convection. This region was statistically investigated to clarify the problems as follows: 1) the mechanism of plasma heating in the "diamagnetic cavity", 2) the nature of the magnetopause in this region, 3) the reason of plasma stagnation.

SM62A-0507 1330h POSTER

A Vlasov Simulation Study of Electrostatic Shocks in Collisionless Plasmas

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We have developed a low-noise non-periodic electrostatic Vlasov simulation code to simulate electrons' motion across a shock ramp of an ion acoustic shock. Our results indicate that the electric field at the shock ramp, due to electron thermal pressure gradient across the shock ramp, can decelerate incoming upstream ions and accelerate incoming electrons. A cold electron beam is formed downstream from the shock ramp. A perturbation that the electron beam received at the shock ramp, was amplified by two-stream instability due to interaction between cold electron beam and hot downstream plasmas. A phase mixing region can be found at the leading edge of the accelerated electron beam. The phase mixing region forms an electron hole which propagates toward downstream side at a speed slightly greater than the electron thermal speed. The size of the electron hole, or the size of phase mixing region, increases with increasing downstream electron temperature. The propagation speed of the electrostatic solitary wave increases with increasing the size of phase mixing region. Relationship between solitary waves observed in our simulation and the fast upward going electrostatic solitary waves in the downward filed-aligned current region of the auroral zone will be discussed.

SM62B MCC: 123 Saturday 1330h

Coupling of the Subauroral Ionosphere, Plasmasphere, and Magnetosphere I *(joint with SA)*

Presiding: **F J Rich,** Air Force Research Laboratory**; A J Ridley,** University of Michigan

SM62B-01 1335h INVITED

The Subauroral Polarization Stream and Observations of Disturbance Electric Fields at Mid Latitudes

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Electric fields often appear in regions of low ionospheric conductivity equatorward of auroral electron precipitation during disturbed geomagnetic conditions. Strong, poleward-directed electric fields driving sunward plasma convection at sub-auroral latitudes in the evening local time sector were termed polarization jets by Galperin et al. [Ann. Geophys., 1974]. Similar intense, latitudinally narrow structures are usually referred to as sub-auroral ion drifts (SAID) [Spiro et al., J. Geophys. Res., 1979]) in the US literature. Yeh et al. [J. Geophys. Res., 1991] described broader regions of sunward plasma drift, equatorward of and separated from the evening auroral convection cell. The term Subauroral Polarization Stream (SAPS) has been proposed by Foster and Burke [EOS, 2002] as an inclusive term for both these types of subauroral electric field disturbance phenomena. The observational characteristics of SAID and SAPS will be reviewed.

Observations of subauroral plasma convection with DMSP and other satellites, and with the Millstone Hill incoherent scatter radar, are used to characterize SAPS phenomenology and to address its causes and effects in the coupled inner-magnetosphere / ionosphere system. A database of ~10,000 radar scans has been examined to determine the average characteristics of the disturbance convection electric field in the midlatitude ionosphere. SAPS is seen as a persistent secondary westward convection peak which lies equatorward of the auroral two-cell convection and spans the nightside from dusk to the early morning sector for all Kp greater than 4. Pre-midnight, the SAPS westward convection lies equatorward $60^\circ\Lambda$, spans 3° - 5° of latitude, and has an average peak amplitude of >900 m/s. In the predawn sector, SAPS is seen as a region of antisunward convection equatorward $\sim 55^\circ\Lambda$, spanning $\sim 3^\circ$ of latitude, with an average peak amplitude of 400 m/s.

The radar observations find that SAPS occurrence probability is greater than 50% between 20 MLT and 02 MLT for Kp >~5. For Kp ~5+, the SAPS probability exceeds 80% between 20 MLT and 00 MLT and is greatest near dusk (16-18 MLT). An occurrence probability >40% extends to near dawn (06 MLT) for Kp ~5.

SM62B-02 1355h INVITED

Low Latitude Ionospheric Storm Time Electric Fields

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Ionospheric electric fields and currents exhibit strong perturbations with a large range of time scales during periods of enhanced high latitude currents and energy deposition. At low and equatorial latitudes, the strongest ionospheric and thermospheric storm effects are driven by zonal prompt penetration and disturbance dynamo electric fields, which can significantly alter the altitudinal/latitudinal distributions of ionization over a large area of the globe, and control the occurrence of ionospheric santillations and equatorial spread-F. Over the last decade major progress has been made in quantifying the climatological storm time dependent responses of low latitude electric fields and currents to changes in magnetospheric convection, and in the validation of global models. However, there are still fundamental unanswered questions dealing with the large variability of the perturbation electric fields, particularly during strongly active times. Important sources of disturbance electric field variability may include changes in the high latitude potential and conductivity distributions, magnetospheric reconfiguration, and season and solar cycle dependent conductivities. In this talk, we will present the major characteristics of the low latitude disturbance electric fields and we will discuss some recent experimental and modeling efforts aimed at improving their understanding.

SM62B-03 1415h

A Modeling Study of the Ionospheric Response to SAPS

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The Sub-Auroral Polarization Stream (SAPS) has been identified as a region of enhanced westward plasma flow in the night-time mid-latitude ionosphere during geomagnetically disturbed conditions. A description of the SAPS electric field, based on observations from the Millstone Hill incoherent scatter radar, is used here as a driver for the Utah State University Time Dependent Ionospheric Model (TDIM) in order to assess the effect of the SAPS on the mid-latitude night-time F-region. Tests are conducted for various effective durations of the SAPS, up to seven hours, as well as for different background convection patterns. A longitudinal, or UT, dependence of the ionospheric response is examined. It is found that within the SAPS region, a large amount of density structuring occurs, including regions of enhancements and depletions; in some cases the difference in N_mF_2 is as large as a factor of 20.

SM62B-04 1430h

The relation of sub-auroral electron and proton precipitation to plasmaspheric and magnetospheric conditions

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During the first two years of the NASA IMAGE mission, global-scale images of auroral precipitation have revealed electron and proton precipitation away from the main auroral oval. The most common manifestations include detached proton arcs in the dusk sector, and impulsive precipitation of electrons and protons on the dayside. A third type of auroral form was observed

during the recovery phase of the July 15-17, 2000, magnetic storm, where continuous precipitation of low energy electrons and protons is observed in a dayside detached arc extending over several hours of local time.

In this investigation, the relation of each of these events to magnetospheric conditions, particularly convection electric fields and field-aligned currents, is examined using the AMIE electric field model. Additionally, the IMAGE satellite regularly observes the extent and morphology of the plasmasphere. The role of the interaction of cold and energetic plasmas can therefore also be studied. In-situ satellite data aid the study by providing precipitating particle and electric field information with each pass.

SM62B-05 1445h

Plasmaspheric Erosion

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The plasmapause is the outer boundary of the Earth's plasmasphere. Decades of in situ and ground-based whistler observations have shown that a picture involving an interplay between co-rotation and convection can serve as a starting point for understanding the physics of plasmaspheric erosion. However, the details of this erosion process remain unknown. The IMAGE satellite's extreme ultraviolet (EUV) imager, which routinely obtains full global images of the plasmasphere as seen in 30.4 nm light, directly observed plasmaspheric erosion on 2000 July 10 and 2001 June 2. We investigate the problem of plasmaspheric erosion, presenting IMAGE observations of erosion events, and simulation results of the Rice Convection Model (RCM) and Magnetospheric Specification Model (MSM). As a byproduct of the erosion process, the dayside is apparently filled with a "cape" of eroded plasma that gradually (over the course of hours) evolves into a duskside plasmaspheric tail. We also study this tail formation process as seen by EUV, RCM and MSM.

SM62B-06 1520h INVITED

Evidence for Subauroral Electric Fields from IMAGE EUV

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The IMAGE Mission Extreme Ultraviolet Imager routinely provides global snapshots of the plasmasphere from high latitude. In these 10-minute images, intensity edges have been identified with the plasmapause and other strong gradients in plasmaspheric density. In addition to the classic sunward directed convection tail and its entrainment in corotation during storm-time recovery, the plasmapause boundary reveals a wide variety of structures thought to result from penetration of the solar wind induced convection electric field to subauroral latitudes. The so-called shoulder feature has most prominently been discussed in the context of under shielding in response to changes in the convection electric field strength. It is not yet clear whether all of the observed surface structures on the plasmasphere can be explained in this manner. The types of structures observed and their frequency of occurrence will be presented. A statistical view of these structures and associated solar wind conditions will also be presented.

SM62B-07 1540h INVITED

Quantifying the Magnitude of the Stormtime Subauroral Currents and Electric Fields From Data-Theory Comparisons

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The longitudinal asymmetry of the stormtime ring current necessitates field-aligned currents (FACs) into and out of the subauroral ionosphere. The closure of these FACs through the ionosphere creates cross-B-field electric fields in this region. These electric fields can then alter the flow of plasma through the inner magnetosphere and thus the spatial configuration of the ring current. This feedback loop is simulated using a self-consistently coupled kinetic transport model for the hot ions and ionospheric potential solver. It is shown that the electric fields from the stormtime asymmetric ring current are capable of significantly deforming the ring current and plasmasphere, creating noticeable features in the global morphology of these plasma populations. Focus is given to the magnetic storm of April 11-12, 2001 because of its isolation from other events and the optimal viewing orientation of the IMAGE satellite during the event. The accuracy and validity of the simulation results are checked through comparisons with satellite and ground-based magnetometer observations.

SM62B-08 1600h

Penetration Electric Fields and Magnetospheric Convection During Geomagnetic Storms

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Knowledge of the magnetospheric convection electric field pattern is essential to any study of the inner magnetosphere. While a number of empirical and theoretical electric field models have been developed in the past, none of them contains a good description of the stormtime magnetospheric electric fields, in particular the electric fields that penetrate to low L-values as a result of the breakdown of the shielding near the inner edge of the ring current. The potential drop equatorward/earthward of the auroral oval/electron plasma sheet can exceed 60 kV, a substantial fraction of the total potential drop across the polar cap/magnetosphere. The Defense Meteorological Satellite Program (DMSP) spacecraft have been providing ion drift measurements in the ionosphere since 1988 as well as precipitating auroral particle measurements since 1982 and geomagnetic field measurements since 1994. At times, these measurements have been provided simultaneously by 5 separate spacecraft. We have analyzed a number of geomagnetic storms, focusing on the penetration of the stormtime electric fields to latitudes well below the equatorward edge of the electron plasma sheet. The ion drift measurements can be mapped to the magnetosphere and combined to derive realistic parameterized stormtime magnetospheric electric field patterns.

SM62B-09 1615h

Convection measurements in the inner magnetosphere by Cluster

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We report convection in the inner magnetosphere between the perigee of $\sim 4\ R_E$ and the Alfvén layer from the Electron Drift Instrument (EDI) on Cluster. Both components of the convection perpendicular to the ambient magnetic field are mapped into the equatorial plane with a magnetic field model by Tsyganenko. The interval of the data used in this study is more than one year so that full magnetic local time is covered. The convection basically follows the corotation especially close to the perigee, although there are deviations from this. One reason for the deviations is subauroral ion drifts (SAID) at the evening sector of magnetic local time during the period of high geomagnetic activity. The ionospheric Sq current system might be another reason during the low geomagnetic activity. In this study, the average values and standard deviations are presented in a statistical base sorted with the geomagnetic activity.

SM62B-10 1630h

Simulations of Stormtime Ion Ring Current Formation with AMIE Electric Field

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In the past we have traced the bounce-averaged drift motions of particles conserving their first two adiabatic invariants (μ and J) in simplified models of the magnetospheric convection electric field, so as to explain their inward transport to form the ring current. Recently we have begun to trace such guiding-center motions in the more realistic AMIE electric field. The magnetic field model we use for these studies is the Dungey model, which consists of a dipole field plus a uniform southward "tail" field (which some interpret as the IMF). Here we map an analytical expansion of the AMIE ionospheric electric potential, expressed as a function of magnetic latitude and magnetic local time, along magnetic field lines (at least for $L \geq 2$) throughout this model magnetosphere and thereby trace the guiding-center drifts of representative singly charged ions for μ values of $1 - 30$ MeV/G (corresponding for $J = 0$ to energies of $11 - 330$ keV at $L = 3$). Using these simulation results, we map proton phase space densities according to Liouvilles theorem but taking into account losses due to charge exchange. For the purpose of phase space mapping we specify an "initial" proton ring current distribution by solving the steady-state transport equation that balances quiescent radial diffusion against charge exchange. We use MLT-binned quiet time LANL ion data of $Korthetal.$ [JGR, 104, $25,047 - 25,061$, 1999] as the reference phase space density at geosynchronous altitude. For our stormtime boundary conditions we make use of the Kp-dependent LANL ion data but map them adiabatically (conserving μ while maintaining $J = 0$) to the boundary of our model magnetosphere. For this study we have performed simulations of the large 19 October 1998 storm and of the extremely large 15 July 2000 "Bastille Day" storm. During the 19 October 1998 storm the large AMIE electric field in the evening sector would have led to much faster (access time $\sim$ 20 minutes) inward transport from the plasma sheet to where the partial ring current is formed than in the simplified electric field model that we had previously used (access time $\sim$ 1 hour). We can thus account for the observed rapid formation of the partial ring current, as well as for the drifts by which the ring current subsequently became more nearly symmetric later in the storms main phase. For the extremely large 15 July 2000 ("Bastille Day") storm, in which large stormtime electric fields were observed measured by DMSP even at $L \sim 2$, we find deep penetration of ring current ions to as low as $L \sim 2$. This deep penetration and corresponding ion energization can account for the extremely strong ring current observed.

SM

SM62B-11 1645h

Post-Midnight Enhancements in the Storm Time Ring Current

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In the traditional picture of development of the storm-time ring current, most of the ions that are injected on the night side gradient-curvature drift westward around the Earth, causing the main-phase ring current to peak near local dusk. In contrast, previous simulations carried out with the Rice Convection Model (RCM), typically showed a ring current with a maximum near midnight. Recent neutral atom images of the ring current from IMAGE/HENA reveal strong enhancements in the post-midnight sector during storm main phases, even further from the traditional picture. The local times of the maximum flux seem to vary with IMF By and solar wind velocity. Simulations carried out with the Comprehensive Ring Current Model, which couples the RCM and Fok's ring current model, showed remarkably good agreement with the IMAGE/HENA data. Preliminary analysis shows that magnetosphere-ionosphere coupling plays an important role in the formation of these post-midnight enhancements. This paper will explore the physical processes that control this local-time asymmetry. We seek to understand how these mechanisms control the effects of solar wind, convection, and ionospheric conductances on observed ring current local-time distribution.

SM71A MCC: Hall D Sunday 0830h

Substorms and Storms II Posters

Presiding: **T Hsu,** University of California, Los Angeles**; J W Gjerloev,** NASA Goddard Space Flight Center

SM71A-0561 0830h POSTER

Average characteristics of triggered and non-triggered substorm-like events: Can a substorm occur without triggering?

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An outstanding question in magnetospheric physics is whether substorms are always triggered externally by changes in the interplanetary magnetic field (IMF) or solar wind plasma, or whether they sometimes occur spontaneously as a result of internal processes. Over the past decade, arguments have been made on both sides of this issue. Horwitz [1985] and McPherron [1986] suggested that substorms usually appear to be initiated by an internal instability. However, Lyons [1995; 1996] argued that substorms must be triggered by external changes in the IMF and/or the solar wind. Specifically, Lyons [1996] argued that events without apparent triggers were likely to be a non-substorm disturbance such as a convection bay [Pytte et al., 1978].

To examine this issue, Henderson et al. [1996] have presented several examples to demonstrate that non-triggered events do have substorm like signatures on the ground and at geosynchronous orbit. It seems evident from their study that substorms can occur without apparent IMF triggers.

However, a stasitical analysis to examine the average characteristics of triggered and non-triggered substorm has never been performed. In this study, we use the substorm onset list established by Hsu and McPherron [2002], which covers the spring and fall onset list of 1978 and 1979 to investigate the tail and geosynchronous response for both triggered and non-triggered substorms. It was found that the average respone in the tail suggest no difference. However, the magnitude response seems different for both classes.

SM71A-0562 0830h POSTER

Diamagnetic Processes of Substorms: Fundamental Results and a New Perspective

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By virtue of the Geotail magnetic field and low-energy-particle data, we have investigated the characteristics of substorms that observed in the near-to-mid magnetotail plasma sheet. We focused on the changes of three kinds of energy density considering their primary importance, their relationship and their flux transport. We divided the substorms into the Pi2 oscillatory variation (with a period of 40-150 s) and the background disturbances. Characteristics of the expansion phase determined here include the following: (1) Plasma thermal pressure and the magnetic pressure change exactly out-of-phase. The intensity of the energy flux is stronger in the direction parallel to the magnetic field than in the direction transverse to it. The plasma fluid clearly exhibits the diamagnetic properties; (2) Characteristics are seen on almost all time scales relevant to substorms (both in the Pi2s and background disturbances), and in almost all of the 139 examples. The substance of magnetotail Pi2 is the slow MHD wave, and the nature of background disturbances indicates slow MHD disturbances.

SM71A-0563 0830h POSTER

Forecasting the Global and Multi-scale Features of Magnetospheric Dynamics During Substorms

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The magnetospheric dynamics during substorms reveals both globally coherent and multi-scale features. The coherent nature of magnetospheric dynamic is evident in a variety of large-scale processes such as plasmoid formation and ejection, large-scale convection, global current systems. However, a number of small-scale substorm phenomena such as MHD turbulence, pseudo breakups, BBFs, etc. have multi-scale nature, viz. they have broad band power spectra in a wide range of perturbation scales. To model such a complex dynamics a combined model STADY is proposed. The model is derived directly from solar wind (VBs) and geomagnetic indices (AL) data using techniques of nonlinear dynamics and statistical physics. The coherent component of magnetospheric dynamics is modeled with the use of local-linear filters (LLF) and yield accurate iterative predictions of the main trend of AL data. However, due to the high dimensional nature of the small-scale component of magnetospheric dynamics LLF fail to predict the abrupt variations and sharp peaks in the data. To model the high dimensional remainder of the time series the probabilistic approach is used. In STADY the probability distribution function of AL-VBs data is calculated in the reconstructed input-output embedding space which yields the range for a predicted AL as well as the likelihood for each value in the range.

SM71A-0564 0830h POSTER

Multi-scale Properties of Solar Wind - Magnetosphere Coupling During Substorms

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The global features of the magnetosphere during substorms is well known from many studies based on observations, modeling and simulations. These arise from processes such as plasmoid formation and ejection, global convection, etc. The analysis of the time series data using nonlinear dynamical techniques has characterized the global dynamics in terms of low dimensional behavior. On the other hand the multi-scale features evident in the power law distribution of many physical variables are not well understood. This property arises from physical processes such as MHD turbulence, bursty bulk flows, current disruption, etc. and are characteristic of open systems in general. These two aspects of the coupled solar wind - magnetosphere are studied by reconstructing a phase space from the time series data such that the trajectories in this space adequately describe the dynamics. The global features, obtained by an averaging of the dynamical trajectories, are described in the mean field manner and are represented by a first order phase transition. The multi-scale substorm activity has features of second-order phase transitions and is characterized by a critical exponent. The power law nature of the the multi-scale behavior then arises from the critical behavior associated with the sudden transitions in the magnetosphere during substorms. The probability distribution functions computed for differnet states show the existence of a two-state system, with the transition between these states exhibiting multi-scale properties.

SM71A-0565 0830h POSTER

Using Branch Prediction and Speculative Execution to Forecast Space Weather with a Cluster of Standard PCs

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Branch prediction and speculative execution consist of making probabilistic predictions about the likely near-term evolution of the near-Earth space, and distributing among the cluster machines simulations that assume each of the probabilistically predicted outcomes as initial conditions. As the near-Earth space evolves and real-time satellite data get assimilated into the algorithm, some of the speculatively executed simulations will be proved wrong. At that point the machines that were executing them will be reassigned either to new lines of speculative simulation, or to increase the processing power devoted to more promising simulations already executing. Branch prediction and speculative execution have been very successful in the design of microprocessors, allowing CPUs to attain average processing speeds much higher than linear code execution would permit.

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A cumulant-based statistical analysis of the magnetospheric response to the solar wind input

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It is well known that the magnetospheric response to the solar wind is nonlinear. In this work, we characterize the nonlinear dynamics underlying the evolution of the Kp index, given solar wind magnetic field and plasma input, using a nonparametric cumulant-based statistical approach. We examine the underlying dynamics of the system, the temporal statistical dependencies, the degree of nonlinearity, and the rate of information loss. A practical example of the usefulness of this approach is that it is possible to determine time intervals where the system is most predictable i.e. the information is most significant. By determining which periods are most predictable it would be possible to avoid training a neural network on irrelevant noise that would normally spoil the network. This approach also has the advantage that it is reliable even in the case of small data sets and therefore it is possible to avoid the assumption of stationarity, which allows for a measure of predictability even when the underlying system dynamics may change character. Evaluations of several leading Kp prediction models indicate that their performances are sub-optimal during active times. Possible improvements of these models using our results are discussed.