Space Weather Workshop

Millennium Hotel – Boulder, CO
April 24 - 27, 2012

Poster Abstracts

Aggarwal, Malini (Korea Astronomy and Space Science Research Institute)
Poster Number: I-13

Poster – *Multi-technique Observation of Ionospheric Irregularities During Disturbed Period*

Malini Aggarwal, Y. S. Kwak, H. P. Joshi, K. N. Iyer, A. K. Patra, Smitha V. Thampi

During geo-magnetic disturbed conditions, the ionosphere becomes highly turbulent and small scale (from centimeters to a few kilometers) irregularities, typically enhancements or depletions of the electron density embedded in the ambient ionosphere are formed. In order to investigate the dynamics of plasma density irregularities of different scale sizes, a campaign was carried out during 11 to 15 September 2005 at Gadanki (geog.13.45N, 79.17E, geomag. 4.44N, 151.73E), an off-equatorial Indian station. During the campaign, an equatorial spread F event occurred on the night of 15 September 2005 during geomagnetic disturbed period (Dst~ -86 nT around 1700 UT). The development and dynamics of equatorial ionospheric plasma bubble irregularity on this night are investigated using the data collected by multi-instrument operated at equatorial (Trivandrum, geog. 8.50N, 77E, dip angle 0.50N) and low latitude (Gadanki, 13.45N, 79.17E, dip angle 12.50N and Sriharikota, 14.0N, 80.0E, dip angle 14.0N) stations using GPS receiver, VHF coherent backscatter radar, and Digisondes. The range type spread F on ionograms and radar plume signatures on range-time-intensity maps from the VHF radar on the same day were observed. Using the GPS receiver, association of the fluctuations in the signal intensity (S4 ~ 0.36 and 0.39) with the depletions in total electron content (5 and 12 TECU) is seen on the same day which affect the positional accuracy of the GPS by 0.8m and 1.92m. The results of the campaign will be presented.

Arge, Charles N. (Air Force Research Laboratory)
Poster Number: S-8

Poster – *Wang Sheeley Arge-Coronal Analysis Tool (WSA-CAT)*

C. Nick Arge, David MacKenzie, Leslie Mayer

The Wang Sheeley Arge-Coronal Analysis Tool (WSA-CAT) is a user friendly interactive tool developed with significant input and feedback from space weather forecasters. It allows forecasters to easily compare WSA model predictions with observations in real-time.

In particular, the tool displays 3-day advanced WSA model predictions of solar wind speed and magnetic field polarity at Earth along with model-determined magnetic connectivity of the solar wind near Earth to its sources (i.e., coronal holes) on the Sun. Continuously updated comparisons of WSA solar wind predictions with ACE observations over the previous 28 days are displayed by WSA-CAT allowing forecasters to immediately assess the model's performance. WSA-CAT also directly compares model determined coronal holes with the latest SDO EUV observations. The coronal magnetic field configuration on a sphere positioned at 5 Rs is displayed by WSA-CAT, allowing forecasters to visualize the heliospheric current sheet and to easily determine when the magnetic field lines connecting the Earth to the Sun are located near it. Finally, the tool permits one to easily scan through all of the above mentioned comparisons over the previous 28 days, providing users with the ability to, for example, see how a coronal hole or the sources of the solar wind change over time.

Berdermann, Jens (DLR - German Aerospace Center)
Poster Number: I-2

Poster – *Recent Efforts Towards an Ionospheric Monitoring and Prediction Center at the German Aerospace Center*

Claudia Borries, Jens Berdermann, Norbert Jakowski

Starting in 2007 the research project Space Weather Application Center Ionosphere (SWACI) has grown from simply mapping the total electron content over Europe to a powerful monitoring and prediction tool of the global ionosphere.

Products designed within SWACI have improved awareness for space weather research and its applications, giving new insights for scientists and operators of GNSS based services.
SWACI maps of the total electron content (TEC) and its model predictions, as well as the electron density profiles retrieved from radio occultation, topside reconstructions of the electron density and slab thickness values over selected European ionosonde stations are of great interest for the scientific community.

The German Aerospace Center has plans to establish an Ionospheric Monitoring and Prediction Center (IMPC) as successor of SWACI.
The IMPC will be a continuous and highly reliable service to strengthen the cooperation with international partners and to increase visibility and usability to an even broader group of customers. Taking into account their needs, our current work focuses on developing perturbation models appropriable for predictions.
Via an international cooperation including also NOAA, actual solar wind information from the ACE satellite shall be used to estimate in particular the space weather impacts on GNSS applications.

We will present achievements of SWACI and give an overview about recent and future activities in respect to space weather services and research at the DLR in Neustrelitz.

Bloomfield, D. Shaun (Trinity College Dublin)
Poster Number: S-12

Poster – *Max Millennium Program, Major Flares, & Your Own Observing Plan*

Richard C. Canfield, William H. Marquette, D. Shaun Bloomfield, R. T. James McAteer, Ryan O. Milligan, Claire L. Raftery

The primary goal of the Max Millennium Program is to maximize the scientific return of solar flare data. This has been achieved in several ways since the maximum phase of solar cycle 23, from daily solar activity alerts and observing campaigns to electronic preprint archives. The top priority of the program, which is sponsored by the RHESSI team, is to foster collaboration of multiple space- and ground-based observatories by facilitating the collection of co-spatial and co-temporal data. A new complement of space- and ground-based instruments is poised for the increased activity expected during cycle 24. The Max Millennium team aims to continue its service to the solar flare community via continued Messages of the Day, the Solar Physics E-Print Archive, and coordination with mission planners and ground-based observers to optimize the scientific return on their data. Here we discuss the success of the program in catching major flares during cycle 23 and how you can get involved by generating a Max Millennium Observing Plan.

Bloomfield, D. Shaun (Trinity College Dublin)
Poster Number: S-13

Poster – *Solar Flare Forecasting: From Probabilities to Targeted Predictions*

D. Shaun Bloomfield, Paul A. Higgins, R. T. James McAteer, Peter T. Gallagher

Solar flares contribute to space weather through significant increases in UV and X-ray flux and the acceleration of energetic particles. To date, it is unclear how the probability of producing a flare of a given magnitude relates to the characteristics of a sunspot group. Here, we use GOES flares and McIntosh group classifications from solar cycles 21 and 22 to calculate average flare rates for each McIntosh class and use these to determine Poisson probabilities for different flare magnitudes. Forecast verification measures are studied to find optimum thresholds to convert Poisson flare probabilities into yes/no predictions of cycle 23 flares. A case is made to adopt the sample-invariant true skill statistic (TSS) as a standard for forecast comparison over the commonly used sample-dependent Heidke skill score (HSS). In addition, a framework for tailoring forecasts to various space weather interest groups is presented. The optimal TSS values found show that Poisson probabilities have similar performance to some more complex prediction systems, but the relatively low scores highlight the problem of using average values to represent flaring rate distributions.

Bobra, Monica (Stanford University)
Poster Number: S-5

Poster – *SHARPs - A New Near-Real-Time Space Weather Data Product from Solar Dynamics Observatory*

Bobra, M., Hoeksema, J. T,; Sun, X., Turmon, M.

A new data product from the Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO) called Space-weather HMI Active Region Patches (SHARPs) is now available. SDO/HMI is the first space-based instrument to measure the full-disk, 3-component photospheric vector magnetic field from space. HMI active region patches (HARPs) are automatically identified in line-of-sight magnetograms collected every 12 minutes.

SHARPs are space weather quantities computed in the tracked patches of photospheric vector magnetic field data that encapsulate active regions. Fifteen space weather quantities useful for prediction -- such as emerging flux, field gradients, current, helicity, free energy, and more -- are calculated for each patch, and are available on a 12-minute cadence as soon as the computations are completed.

Bonadonna, Michael F. (Office of the Federal Coordinator for Meteorology)
Poster Number: G-2

Poster – *The National Space Weather Program: Implementing National Capability*

Samuel P. Williamson, Office of the Federal Coordinator for Meteorology, Silver Spring, MD; and M. F. Bonadonna

As we approach the next peak of solar activity expected in 2013, our Nation faces many uncertainties from increasing reliance on space weather-affected technologies for communications, navigation, security, and other activities, many of which underpin our national infrastructure and economy. The National Space Weather Program (NSWP) is a Federal interagency initiative established in 1995 to improve timely and reliable predictions of significant disturbances in space weather and to provide tailored information specific to those who may be affected. The NSWP Council, through its Committee for Space Weather (CSW) and other elements, seeks to speed improvement of space weather products and services through research, transition of research to operations, and improvements in operational capability to better prepare the United States for the effects of space weather on technological systems, activities, and human health. In order to accelerate progress towards improve national space weather capabilities, the NSWP Council tasked the CSW to develop an Integrated Action Plan (IAP) to achieve key improvements for a new Unified National Space Weather Capability (UNSWC) that will leverage the best abilities of all the NSWP agencies. Also in 2011, the NSWP responded to The White House Office of Science and Technology Policy and produced an assessment of current and planned space weather observing systems capabilities. The NSWP Council established the JAG for Space Environmental Gap Analysis to determine how well current systems were meeting observational requirements and to determine how that capability would change over the next decade. Again in 2011, the Council organized and hosted the fifth Space Weather Enterprise Forum (SWEF) with the theme of Solar Maximum: Can We Weather the Storm? Over 210 attendees came together at the National Press Club in Washington DC to share information and ideas among policymakers, senior government leaders, researchers, service-provider agencies, private-sector service providers, space weather information users, media, and legislators and staff from Capitol Hill to raise awareness of space weather and its effects on society. This year, we continued this outreach but sharpened the focus on critical infrastructure protection and human health and safety, with the necessary underpinnings of research, improved products and services, and applications to serve a broad and growing user community. In 2012, the Council will move forward under the vision of the new Strategic Plan, beginning to chart specific courses to realize these strategic goals and continue raising awareness of and building resiliency against the effects of space weather. The CSW will begin work on the NSWP Science Plan in 2012 incorporating elements of the IAP, output from the National Academy of Sciences Decadal Survey on Solar and Space Physics, and other important documents. Finally, the NSWP plans to conduct the 6th SWEF at the National Press Club in Washington DC on June 5, 2012.

Cesaroni, Claudio (Istituto Nazionale Geofisica e Vulcanologia)
Poster Number: I-12

Poster – *Improvements on Ionospheric E-F Valley Model Using Extraordinary Ray: A Preliminary Study*

C. Cesaroni 1,2 , C. Scotto 1, A. Ippolito1,2

In addition to the usual ordinary trace reconstruction, the electron density profile produced by Autoscala can also be used to reconstruct the extraordinary trace, applying the appropriate refractive index. In general, when a restored ordinary trace closely matches the corresponding recording, a comparable close agreement is also observed for the extraordinary trace. However, in a significant number of cases appreciable discrepancies are observed

A statistical study carried out using about 6000 ionograms recorded at the ionospheric station of Rome has permitted to assign a “quality factor” to the ionograms traces restored by automatic scaling software Autoscala. We have seen that, in a significant number of cases, the restored ordinary trace has a good agreement with the recorded one but the extraordinary reconstructed trace is not well recognized. The studying of the density distribution of these cases as a function of the Solar zenith angle shows a relationship with the diurnal evolution of electron density within the E-F valley. The investigation of some particular cases has suggested the possibility of obtaining useful information to improve the electron density estimation provided by Autoscala in E and E-F valley regions.

1 Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy
2 Università di Bolgna, Bologna, Italy

Chen, Yanhong (Center for Space Science and Applied Research)
Poster Number: I-1

Poster – *The Ionosphere Application Research in Space Environment Prediction Center, CSSAR*

Yanhong Chen, Wengeng Huang, Siqing Liu, Hua Shen, Guoqi Liu

The earth’s ionosphere is an important part of the near space environment. Its variation and disturbance is the important content of space weather forecast, as the severe ionospheric perturbations can cause serious technological problems in applications based on Global Navigation Satellite Systems (GNSS). Space Environment Prediction Center (SEPC) in CSSAR made efforts to carry out ionosphere application research. First, the GPS observation in low latitudes was paid more attention, especially in scintillation monitoring. Now we have five station’s scintillation data in Chinese low latitude region. The scintillation’s character in the region has been analyzed. Second, we are developing total electron content (TEC) model based on the GPS dual frequency observation. The TEC model in single station was obtained using Kalman filter estimator, which has been used in Chinese Meridian Project for providing near real-time TEC. The regional TEC map in Chinese low latitudes was derived using the least-square technique. At last, the investigation about ionospheric disturbance index is also in progress in SEPC. The current TEC-based indices are compared in several geomagnetic disturbance periods. The primary result indicates the regional disturbance index (RIDXr) can well reflect the TEC variation in different latitude range.

Clark, Richard D. (Millersville University)
Poster Number: G-9

Poster – *From Weather to Space Weather: Proficiencies for the Undergraduate*

Richard D. Clark and Sean Hendrick

A curriculum that conforms to the AMS Guidelines for a B.S. degree in meteorology or atmospheric science will not provide sufficient underpinning in certain areas of physics to adequately prepare an undergraduate student for graduate work in space physics or a career in operational space weather prediction. Conversely, we see very few physics majors that are enticed by operational forecasting, and more specifically, space weather prediction. Meanwhile, there is growing number of students majoring in meteorology who are interested, if not passionate, about the prospect of a career in space weather prediction. How do we responsibly prepare students for entry into the field of space weather? Millersville University is addressing this challenge by developing a minor is space physics that will provide fundamental physics as a supplement to an already rigorous undergraduate program in meteorology. Meteorology majors are already required to complete Calculus-based Physics I and II. The space physics minor will consist of 18 additional hours of course work in the following subject areas: modern theories of waves and particles (3); electromagnetic fields I and II (6); multiparticle quantum systems and statistical physics

(3); either statistical mechanics or techniques in mathematical physics (3); and as a capstone, space weather and environment (3), which is an existing meteorology elective. This presentation will discuss the need for this specialization, cost-benefit to the student, and intended outcomes for the program and students.

Connor, Hyun Ju (University of New Hampshire)
Poster Number: M-7

Poster – *Cusp Ion Structures and their Relation to Dayside Reconnection*

Hyun Ju Connor and Joachim Raeder

Magnetic reconnection is a key mechanism for transferring solar wind energy into the Earth's magnetosphere, causing various geomagnetic effects such as magnetic storms, substorms, and auroras. However, reconnection happens on scales of a few inertial lengths of ions and electrons, and direct observation of reconnection is very difficult with the small number of satellites. With this restriction, scientists focus on dynamic results of reconnection which can be observed far from the reconnection sites. Dispersed ion signatures observed near the magnetosphere cusps, called cusp ion structures, have long been used to infer locations and properties of reconnection at the Earth's magnetopause. In this poster, we introduce a dynamic model of cusp ion structures using OpenGGCM 3D global MHD model and Liouville Theorem Particle Tracer, and investigate the general relation between cusp ion structures and dayside reconnection processes during four different IMF clock angles of 0°, 60°, 120°, and 180°. Our model produces a reverse dispersion, double reverse dispersions, a flat and dispersed signature, and a normal dispersion under each IMF condition. From the detailed study of the ion entry points and the reconnection patterns on the magnetopause, we find that lobe reconnection, recurring FTE formation, coexistence of component and anti-parallel reconnection, and subsolar reconnection cause those cusp structures, respectively. We also find that cusp ions during northward IMF originate from an anti-parallel reconnection zone whose shear angle is over 170°. Conversely, during southward IMF ions precipitate not only from a high shear angle zone but also from a very low shear angle zone.

Danskin, Donald (Natural Resources Canada)
Poster Number: I-15

Poster – *Radio Wave Absorption Measured During Extreme Proton Events of 2012*

D.W. Danskin

During the extreme proton events of January and March 2012, radio wave communication was impacted in the Northern Polar regions. Using the extensive riometer network in Canada, direct measurements of radio wave absorption have been collected during the polar cap absorption event that ensued as a result of the proton events. Using data from the entire network, the results of the analysis indicate the spatial extent of absorbing region.

Darnel, Jonathan (NGDC/CIRES)
Poster Number: M-8

Poster – *Implementation of Space Environmental Anomalies Expert System Real Time*

Jonathan Darnel, Janet Green, William Denig

The National Geophysical Data Center (NGDC) has implemented the Space Environmental Anomalies Expert System Real Time (SEAESRT) system within NOAA. Originally developed by The Aerospace Corporation, the algorithms that comprise the SEAESRT system provide near-real-time estimates of the likelihood of spacecraft anomalies for satellites in geostationary orbit. Spacecraft anomalies are strongly correlated with the local radiation environment and the general level of geomagnetic activity. SEAESRT uses space weather data available from NOAA's Geostationary Operational Environmental Satellite (GOES) at a particular local time along with other ancillary real-time data and calculates a set of hazard quotients associated with the geostationary environment at all local times. NGDC is validating the SEAESRT results before making SEAESRT available for implementation in operations. We present here initial results and a demonstration of the utility of SEAESRT.

Davis, Chris (STFC Rutherford Appleton Laboratory)
Poster Number: S-22

Poster – *HAGRID - a Low-cost Heliospheric Imager Mission for Operational Space Weather*

Chris Davis, Doug Griffin, Christina McQuirk, Aron Kisdi, Chris Eyles, Steve Ecclesley, Matthew Stuttard, Jackie Davies, Richard Harrison

HAGRID - Heliospheric Imaging for Assessment of Global and Regional Infrastructure Damage - is a technology demonstrator for a future operational space weather alerting system based on lessons learned from the SOHO, STEREO, Coriolis missions.

The STEREO Heliospheric Imagers have demonstrated that imaging the solar wind from a vantage point outside the Sun-Earth line enables tracking of Earth-directed solar transients such as coronal mass ejections and co-rotating interaction regions.

HAGRID uses techniques developed during the STEREO and Coriolis missions to determine the speed and direction of solar transients from a single spacecraft orbiting ahead of the Earth at a fixed distance relative to the planet. The mission was designed to provide accurate warning at least 10 hours in advance of a significant Earth-impacting space weather event.

DiTommaso, Joseph H. (University Of Alaska, Fairbanks)
Poster Number: M-3

Poster – *Analysis of Ground-Based Magnetometer Data for Regional Correlation and Space Wx Risk Assessment*

Joseph H. DiTommaso

One of the oldest and most ubiquitous instruments for the behavior of the magnetosphere is the ground-based magnetometer. With stations from the Arctic to India, magnetometer installations have collected a large and extensive data set of geomagnetic measurements at the Earth's surface. This data set provides an interesting opportunity to investigate signals of the magnetic field at varying latitudes for different events and timescales. Underlying complex dynamical relationships may be evident in these data sets, and as such could be utilized to understand regional correlations. To investigate these relations, several analyses including Probability Distribution Function (PDF) and the Hurst R/S test are used, searching for heavy tail signals for large impact events. Cross-correlation analysis will also be run to search for these possible latitudinal-spanning relationships. If these correlations are observed, it may be possible to extrapolate prediction of large event frequencies for low latitude, high population areas using the more active and sampled data of the northern latitudes. The poster demonstrates preliminary analyses of several stations across high and low magnetic latitude over the past decade.

Falconer, David (UAH/NSSTC/MSFC)
Poster Number: S-9

Poster – *Forecasting Space Weather from Magnetograms*

David A. Falconer (UAHuntsville/MSFC), Ronald L. Moore (MSFC), Abdulnasser F. Barghouty (MSFC), Igor Khazanov (UAHutsville)

Large flares and fast CMEs are the drivers of the most severe space weather including Solar Energetic Particle Events (SEP Events). Large flares and their co-produced CMEs are powered by the explosive release of free magnetic energy stored in non-potential magnetic fields of sunspot active regions. The free energy is stored in and released from the low-beta regime of the active region's magnetic field above the photosphere, in the chromosphere and low corona. From our work over the past decade and from similar work of several other groups, it is now well established that (1) a proxy of the free magnetic energy stored above the photosphere can be measured from photospheric magnetograms, maps of the measured field in the photosphere, and (2) an active region's rate of production of major CME/flare eruptions in the coming day or so is strongly correlated with its present measured value of the free-energy proxy. These results have led us to use the large database of SOHO/MDI full-disk magnetograms spanning Solar Cycle 23 to obtain empirical forecasting curves that from an active region's present measured value of the free-energy proxy give the active region's expected rates of

production of major flares, CMEs, fast CMEs, and SEP Events in the coming day or so (Falconer et al 2011, Space Weather, 9, S04003). For each type of event, the expected rate is readily converted to the chance that the active region will produce such an event in any given forward time window of a day or so. If the chance is small enough (e.g. <5%), the forecast is All Clear for that type of event. We will present these forecasting curves and demonstrate the accuracy of their forecasts. In addition, we will show that the forecasts for major flares and fast CMEs can be made significantly more accurate by taking into account not only the value of the free energy proxy but also the active region's recent productivity of major flares; specifically, whether the active region has produced a major flare (GOES class M or X) during the past 24 hours before the time of the measured magnetogram.
This work has been funded by NASA's Heliophysics Division, NSF's Division of Atmospheric Sciences, and AFOSR's MURI Program. Development of this forecasting tool for JSC/Space Radiation Analysis Group was supported by NASA's Office of Chief Engineer Technical Excellence Initiative and is supported by NASA's AES (Advance Exploration Systems) Program.

Fennell, Joseph (The Aerospace Corporation)
Poster Number: M-13

Poster – *Charge Deposition Behind Known Shielding in Highly Inclined Orbits*

J. F. Fennell

We use data taken by shielded dosimeters on satellites in HEO/Molniya and MEO orbits to measure the electron deposition rates that can cause internal charging. The dosimeters use silicon diode detectors to measure both the total energy deposited (dose) and the omni-directional fluxes of electrons and protons that penetrate the shielding. The shielding levels that are used for this study range from 5 to 472 mils Al. The data set from HEO covers a 12-year interval, or a full solar cycle, while the MEO data covers ~7.5 years. We show examples of charge deposition rates during times of nominal and high levels of penetrating fluxes in the inner magnetosphere. The charge deposition rates will be related to charging levels that could be experienced by shielded dielectrics with different resistivity. We will show the long term charge deposition-rate temporal profiles and estimated charge density levels as an indicator of the internal charging rates that satellites in the inner magnetosphere could experience.

Fisher, George H. (Space Sciences Laboratory, UC Berkeley)
Poster Number: S-14

Poster – *Global Forces in Eruptive Solar Flares: The Lorentz Force Acting on the Solar Atmosphere and the Solar Interior*

Fisher, G. H., Bercik, D. J., Welsch, B. T., Hudson, H. S.

We compute the change in the Lorentz force integrated over the outer solar atmosphere implied by observed changes in vector magnetograms that occur during large, eruptive solar flares. This force perturbation should be balanced by an equal and opposite force perturbation acting on the solar photosphere and solar interior. The resulting expression for the estimated force change in the solar interior generalizes the earlier expression presented by Hudson, Fisher, and Welsch (Astron. Soc. Pac. CS-383, 221, 2008), providing horizontal as well as vertical force components, and provides a more accurate result for the vertical component of the perturbed force. We show that magnetic eruptions should result in the magnetic field at the photosphere becoming more horizontal, and hence should result in a downward (toward the solar interior) force change acting on the photosphere and solar interior, as recently argued from an analysis of magnetogram data by Wang and Liu (Astrophys. J. Lett. 716, L195, 2010). We suggest the existence of an observational relationship between the force change computed from changes in the vector magnetograms, the outward momentum carried by the ejecta from the flare, and the properties of the helioseismic disturbance driven by the downward force change. We use the impulse driven by the Lorentz-force change in the outer solar atmosphere to derive an upper limit to the mass of erupting plasma that can escape from the Sun. Finally, we compare the expected Lorentz-force change at the photosphere with simple estimates from flare-driven gasdynamic disturbances and from an estimate of the perturbed pressure from radiative backwarming of the photosphere in flaring conditions.

Fry, Craig (Ghee) (Exploration Physics International, Inc.)
Poster Number: S-1

Poster – *The Radiation, Interplanetary Shocks, and Coronal Sources (RISCS) Toolset*

Ghee Fry, Gary Zank, Elizabeth Newton and James Adams

We outline the development of a physics based predictive toolset RISCS to describe the interplanetary energetic particle and radiation environment throughout the inner heliosphere, including at the Earth. To forecast and "nowcast" the radiation environment requires the fusing of three components: 1) the ability to provide probabilities for incipient solar activity; 2) the use of these probabilities and daily coronal and solar wind observations to model the 3D spatial and temporal heliosphere, including magnetic field structure and transients, within 10 AU; and 3) the ability to model the acceleration and transport of energetic particles based on current and anticipated coronal and heliospheric conditions. We describe how to address 1) – 3) based on our existing, well developed, and validated codes and models. The RISCS toolset would provide an operational forecast and "nowcast" capability that will provide 1) predicted solar energetic particle intensities (SEP), spectra, anisotropies; 2) predicted maximum energies and their duration; 3) SEP composition; 4) cosmic ray intensities, and 5) plasma parameters, including shock arrival times, strength and obliquity at any given heliospheric location and time. The toolset would have a 72 hour predicative capability, with associated probabilistic bounds, that would be updated hourly thereafter to improve the predicted event(s) and reduce the associated probability bounds. The RISCS toolset would be highly portable and capable of running on a variety of platforms including those of the Community Coordinated Modeling Center (CCMC).

Gentile, Louise C. (Air Force Research Laboratory)
Poster Number: I-21

Poster – *C/NOFS Highlights 2012*

L. C. Gentile and the C/NOFS Science Team
Air Force Research Laboratory Space Vehicles Directorate

The Communication/Navigation Outage Forecasting System (C/NOFS) mission was designed to specify and predict geophysical conditions that degrade the transionospheric propagation of radio signals at low latitudes. Its two major constituents are the C/NOFS satellite and the Scintillation Network Decision Aid (SCINDA) global network of ground stations that monitor the quality of UHF and L-band transmissions through the low latitude ionosphere. The C/NOFS satellite was launched into a 13° inclined orbit with initial apogee and perigee near 850 and 400 km, respectively. Although designed to observe solar maximum conditions, C/NOFS has taught us much about the recent unusual solar minimum and continues to provide critical insights during the transition to solar maximum.

Hampton, Donald L. (University of Alaska Fairbanks)
Poster Number: M-5

Poster – *Using Auroral Patch Motion to Measure Magnetospheric Convection - Preliminary Results*

Donald L. Hampton

The motion of auroral forms has long been known to generally follow magnetospheric polar cap convection patterns - moving east to west pre-midnight and west to east post-midnight - but this pattern has not been exploited. With the recent advances in unprecedented sensitivity and cadence of auroral imagery, including periods of "moon-up" conditions, the potential for using imagery as a remote sensing tool for convection patterns can be realized. We have recently initiated a program to apply image motion detection techniques to auroral forms, specifically post-midnight stable and pulsating patches, to determine their speed and direction of motion. The images are from all-sky cameras at Poker Flat Research Range and other Alaska sites. The co-location of the Poker Flat AMISR facility and SuperDARN coverage from the Kodiak station allow us to compare the results of the optical analyses to those from well-established drift measurements. We will present preliminary results from events in the last two seasons, and discuss variations in the optical technique compared to the well-established radar measurements.

Hapgood, Mike (STFC Rutherford Appleton Laboratory)
Poster Number: G-10

Poster – *ESPAS, the Near-Earth Space Data Infrastructure for e-Science*

Mike Hapgood, Anna Belehaki, Bruno Zolesi and the ESPAS consortium

ESPAS is a new European cyberinfrastructure project (www.espas-fp7.eu), funded under the e-infrastructure component of the EU Framework 7 programme. It will provide enhanced access to observations made in near-Earth space, including the thermosphere, ionosphere, plasmasphere, radiation belts and magnetosphere and near-Earth solar wind. It will give users a uniform interface to find, access, and use resources relating to near-Earth space environment observations – including data from both ground-based and space-borne instruments and data from distributed data repositories. A key objective of this enhanced access to data is facilitate the use of those data to challenge predictive models of the near-Earth space environment. This will stimulate work to refine predictive capabilities, leading to better forecasting and mitigation of adverse space weather across many domains (including the ionospheric, thermospheric, magnetospheric and space climate communities, space communications engineering, high-frequency radio users, satellite operators, navigation and surveillance systems, and space agencies). This poster will outline plans for the first phase of ESPAS development – the design and development of the core data model and the release of a prototype system through which we can validate and refine the ESPAS concept. It will also outline longer-term plans for engaging a wider community in the use of ESPAS, e.g. through workshops that give potential users the opportunity for hands-on training and to feed back ideas to the development team.

Hartley, David (Lancaster University)
Poster Number: M-14

Poster – *Electron Observations at GEO During the High Speed Stream (HSS) Commencing on January 6th 2011*

D. P. Hartley, M. H. Denton, J. C. Green, T. Onsager, J. V. Rodriguez, H. J. Singer

High Speed Stream (HSS) events exhibit characteristic structure in the solar wind which, when studied in conjunction with in situ observations at geostationary orbit (GEO) from GOES 13, allows us to establish and understand the temporal evolution of the magnetosphere. Using the pitch angle resolved Magnetospheric Electron Detector (MAGED) data, we look at the evolution of perpendicular (pitch angle between 75 and 105 degrees) and parallel (pitch angle less than 30 degrees) electron flux in the 350-600 keV energy range. For this event, commencing on January 6th 2011, the flux takes ~1.5 hours to dropout by two orders of magnitude from its pre onset level. Taking partial moments of the available electron distribution (30-600 keV) we observe the number density recover quickly, as well as the flux of the lower energy channels, however the highest energy channel takes ~18 hours to recover to an approximately constant level. This indicates that the electrons quickly reappear at GEO following the dropout before being heated over a period of days. This is consistent with the temperature values presented, showing an increase in temperature post onset, peaking after ~3 days. The temperature increase occurs due to elevating fluxes at higher energies resulting in an overall increase in the temperature of the distribution. Additionally, we present the magnetic field data showing compression of the magnetosphere on the dayside (prior to the dropout), as well as the elongation on the nightside (during the dropout) resulting in a large stretching angle and ultimately depolarisation. This study provides independent confirmation of earlier statistical work and is a first step in gaining understanding of the electron radiation belt dropout/recovery phenomena, in conjunction with coincident magnetic field measurements.

Henney, Carl (Boston College)
Poster Number: S-17

Poster – *Forecasting F10.7 with ADAPT*

C. J. Henney, C. N. Arge, W. A. Toussaint, S. M. White

A new method to forecast the solar 10.7 cm (2.8 GHz) radio flux, abbreviated F10.7, is presented here utilizing advanced predictions of the global solar magnetic field generated by the ADAPT (Air Force Data Assimilation Photospheric Flux Transport) model. Using indices derived from the absolute value of the solar magnetic field, we find good correlation between the observed photospheric magnetic activity and the observed F10.7 values. Comparing magnetogram data observed within 6 hours of the F10.7 measurements during the years 1993 through 2010, the Spearman correlation coefficient for an empirical model of F10.7 is found to be 0.98. In addition, we find little change in the empirical model coefficients and correlations between the first and second 9 year intervals of the 18 year period investigated. By evolving solar magnetic synoptic maps forward 1–7 days, this new method provides a realistic estimation of the Earth-side solar magnetic field distribution used to forecast F10.7. Spearman correlation values of approximately 0.97, 0.95, and 0.93 are found for 1 day, 3 day, and 7 day

forecasts, respectively. The method presented here can be expanded to forecast other space weather parameters, e.g., total solar irradiance and extreme ultraviolet flux. In addition, near-term improvements to the F10.7 forecasting method, e.g., including far-side magnetic data with solar magnetic flux transport, are discussed. This work was recently published (Henney et al. 2012, Space Weather, 10, S02011, doi:10.1029/2011SW000748) and partially supported by the AFRL's (Air Force Research Laboratory) Space Weather Forecasting Laboratory (SWFL). The ADAPT software used in this work was developed with support by a grant from the AFOSR (Air Force Office of Scientific Research).

Henney, Carl (Boston College)
Poster Number: S-16

Poster – *Solar Flare Detection with SWIFT and GONG H-alpha Images*

C. J. Henney, D.T. MacKenzie, F. Hill, B. Mills, J. Pietrzak

The Air Force Weather Agency (AFWA) has begun the process of upgrading the Solar Observing Optical Network (SOON) with an Improved-SOON (ISOON). During the interim period, AFWA is supporting the addition and operation of a solar H-alpha (Hydrogen-alpha, 656.3 nm) full-disk image network utilizing the light feed from the National Solar Observatory's existing GONG (Global Oscillation Network Group) instruments. The H-alpha instruments at the GONG sites have been in operation collectively since the beginning of 2011, providing one to three H-alpha images per minute. Cross-site comparison and calibration of flare detection has begun using an image analysis tool called SWIFT (SWFL/ISOON Flare-cast Tool). SWIFT is a unique and versatile software package, designed originally for ISOON data, that has been attuned to ingest and display GONG H-alpha images in real-time. The SWIFT software allows a user to detect and analyze optical flares from solar active regions. The SWIFT software is in the process of being beta-tested at AFWA in collaboration with the Space Weather Center of Excellence's SWFL (Space Weather Forecasting Laboratory) to better forecast space weather events. Solar flares are of great interest to the Air Force Research Laboratory's Space Vehicles Directorate because they can trigger energetic particle events or coronal mass ejection events that impact the Earth's magnetosphere creating geomagnetic storms. Such events can result in satellite charging damage, increased satellite drag, power grid disruption, navigation system anomalies, and communication fadeouts. An overview of SWIFT, along with preliminary flare detection comparisons between GONG sites and the SOON flare reports, will be presented.

Huang, Yanshi (University of Texas at Arlington)
Poster Number: I-16

Poster – *Altitudinal Distribution of Joule Heating and its Influence on the thermosphere*

Yanshi Huang, Arthur Richmond, Yue Deng, Ray Roble

Studies of the thermospheric response to Joule heating cannot consider only the height-integrated heating, as approximated by the downward Poynting flux above the ionosphere, but must also consider how this heat is distributed in altitude. The National Center for Atmospheric Research Thermosphere-Ionosphere-Electrodynamics General Circulation Model (NCAR TIE-GCM) is employed to quantify the influence of Joule heating at different altitudes on the neutral temperature and density at 400km for both solar minimum and maximum conditions. The results show that high-altitude Joule heating is more efficient than low-altitude heating in affecting the upper thermosphere. Most of the Joule heating is deposited under 150km, and the largest Joule heating deposition per scale height happens at about 125km, independent of solar activity. However, the temperature and density changes at 400km are largest for heat deposited at about 140km for solar minimum and about 263km for solar maximum. The time scale for the thermospheric response varies with the altitude of heating. Joule heating deposited at lower heights needs more time to conduct upward, and it takes more time for the thermosphere at 400km to approach a steady state. A simple one-dimensional model is utilized to explain how the amplitude and characteristic time scale of the upper thermosphere response to Joule heating depends on the height of heat input. The characteristic response time scale for heat deposited around 135km is 6 hours, while that for heat deposited around 238km is about 0.5 hours. The initial temperature response at 400km to the high-altitude heating is much stronger than the response to the low-altitude heating, but the responses become comparable after about 4 days.

Jackson, Bernard V. (CASS/UCSD)
Poster Number: S-23

Poster – The 3-D Forecast of Inner Heliosphere Solar Wind Parameters from Remote-sensing and In-situ Data

B.V. Jackson, Hsiu-Shan Yu, P.P. Hick, A. Buffington, J.M. Clover, M. Tokumaru, L. Jian

At UCSD, remote-sensing forecast analyses of the inner heliosphere have been regularly carried out using interplanetary scintillation (IPS) data. These analyses have measured and reconstructed the 3-D time-dependent solar wind structure for almost two decades using Solar-Terrestrial Environment Laboratory (STELab) IPS observations. More recently we have provided an even more accurate 3-D forecast analysis by incorporating in-situ spacecraft measurements into these remotely-sensed volumes. When using the IPS velocity analyses we can accurately convect-outward solar surface magnetic fields using potential field model techniques, and thus also provide values of the field throughout the global volume. These extrapolations allow an immediate relationship of any remote heliospheric position to the corresponding location on an inner boundary near the solar surface and an instantaneous trace-back to this boundary in order to estimate potential solar particle propagation paths. This forecast analysis is being operated in real time at the UCSD website http://ips.ucsd.edu, and at the NASA GSFC Community Coordinated Modeling Center (CCMC) website: http://iswa.ccmc.gsfc.nasa.gov:8080/IswaSystemWebApp/index.jsp? The archival results of these time-dependent 3-D analyses of density, velocity, and vector magnetic field are compared with in-situ measurements obtained near Earth, and at STEREO, Mars, Venus, MESSENGER, and the Ulysses spacecraft.

Jeong, Cheol-Oh (ETRI)
Poster Number: S-18

Poster – *Windband Solar Radio Flux Monitor*

Cheol-Oh Jeong, Jung-Hoon Kim, Jincheol No, Yong-Sun Park

Wideband solar radio flux monitor system is implemented at Korean Space Weather Center (KSWC), which is a Regional Warning Center (RWC) of ISES, in Jeju island, Korea. The system consists of two parabolic antennas, 3M and 1.8M each, and one log-periodic antenna covering the frequency ranges of 0.5 GHz to 18GHz. The RSTN of US air force have similar functionality, but with this new system, solar flux values at 20 different frequencies can be measured simultaneously in near real time with surrounding radio spectrum of bandwidth 20MHz at each measuring points. Also each measuring frequency points can be changed with 1 MHz step.

The main purpose of the system is to monitor quantitatively the effect of solar background radio noise to the modern communication system including ground and satellite radio communication, broadcasting etc. It is expected that the solar radio flux monitor can provide absolute radio flux values, in SFU unit, in addition to current 9 frequencies measured routinely by RSTN and Canada.

Kataria, Dhirendra (University College London)
Poster Number: I-17

Poster – *Nanosatellites for In-situ Studies of the Earth's Ionosphere and Thermosphere – Exploiting the QB50 Mission Opportunity for Space Weather Science*

Dhiren Kataria, Anasuya Aruliah, Alan Smith, Rahil Chaudery

With the rapid development of miniaturised platform and payload technologies, nanosatellites, in particular in the CubeSat form factor, provide an attractive low cost platform for in-situ monitoring of the Earth's upper atmosphere. Funded under the space call of the European Union's 7th Framework Programme, the QB50 mission will launch up to 50 CubeSats from a rocket to an altitude of 300km and the satellites will then be allowed to undergo a decaying orbit until they burn up at around 90km. Instruments have been chosen to make in-situ measurements of plasma and neutral atmosphere parameters in this altitude region where few measurements have been made before. The mission will develop a number of capabilities suitable for exploitation on space weather science as well as monitoring missions. This includes launch and deployment, sensors and a number of CubeSat–based technology demonstrators. This paper will present an overview of the QB50 mission, discuss some of the miniaturised sensors that are being developed at MSSL and discuss the opportunity that the mission presents for space weather science.

Kim, Dohyeong (Korea Meteorological Administration)
Poster Number: G-3

Poster – *Current Status and Future Plan for Space Weather Operation in KMA*

Dohyeong Kim, Gunseok Park, Hee Sang Lee

Korea Meteorological Administration (hereafter, KMA) has newly joined the global space weather community in 2010. The main goal of KMA's space weather activities are to operate safely the new geosynchronous meteorological satellite COMS (Communication, Oceanic and Meteorological Satellite), which was launched in June 2010.

As the recent activities of KMA in space weather, First, KMA started to offer the space weather public service. In order to forecast the space weather effect to climate, weather and COMS caused by the space environmental disturbances, KMA operates Space Weather Prediction Laboratory and 24-hour monitoring system in NMSC (National Meteorological Satellite Center) / KMA. Second, KMA space weather web site (http://swfc.kma.go.kr) is publicly available. The web site provide the information of important parameters of space environment such as the magnetopause projection with COMS, SDO solar images, GOES x-ray flux, proton flux, Interplanetary Magnetic Fields, Kp index and Dst index for safe operation of COMS. Third, SWx forecasting models are under development to operate SWx forecasting in 2014. Fourth, KMA established the integration system of GNSS data from 88 local observatories in Korea. The system can provide the total water vapor amount for NWP and ionospheric TEC map service over the Korean Peninsula. Finally, KMA will develop the payload for space weather monitoring to support the space weather operation including the safe operation for Geo-KOMPSAT-2A, COMS follow-on.

Kim, Jung-Hoon (SETsystem, Inc.)
Poster Number: S-21

Poster – *Introducing Solar Wind Observing Facility: Korean IPS Array*

Jung-Hoon Kim, Yong-Sun Park, Jincheol No

Radio Research Agency (RRA), a government research institute, starts recently the operation of Korean Space Weather Centre (KSWC, 33.4N, 126.3E),which is a Regional Warning Center(RWC) of ISES, at Jeju Island in Korea.

One of the main facilities of the centre is IPS array. In early stage of design, we have studied two types of IPS system. One is SWIFT in STEL, Nagoya University, Japan, the other is MWA in Australia. The Korean IPS array, which recently installed in Jeju Island, has 32 tiles which is deployed over 300m x400 m area. Each tile consists of 24 dual dipole antennas with LNA, a beam former and a receiver. The system temperature including Galactic background will be < 200K. The operation frequency is 327MHz with 10MHz band width. The RFI survey shows that 327MHz is a good candidate of IPS array in Jeju Island. The RF signal from 4 tiles are grouped, digitized and transferred to host system. All the post-processing is carried out by S/W.

Kim, Yeon-Han (Korea Astronomy and Space Science Institute)
Poster Number: G-4

Poster – *Recent Space Weather Activities in KASI*

Yeon-Han Kim, Young-Deuk Park, Jae-Jin Lee, Sung-Hwan Choi, Ji-Hye Baek, Kyung-Suk Cho, Su-Chan Bong, Young-Sil Kwak, Junga Hwang

The Korea Astronomy and Space Science Institute (KASI) is actively involved in the front line research in the field of solar activity and space weather. Currently we are managing several observation facilities for solar and space weather research: the solar flare telescope, the solar spectroscopy telescope, the sunspot telescope, the solar radio spectrograph, magnetometers, the scintillation monitor, and the all-sky imager. Since 2007, the KASI has been performing a research project for the construction of KASI Space Weather Prediction Center (SWPC) to prepare for the upcoming solar maximum (~2013). In this poster, we briefly introduce the recent progress of KASI space weather project; extension of ground observation system, construction of space weather database and

network, development of prediction models, and space weather studies. In addition, recent international collaborations with NASA and STEL in Nagoya University will be described.

Kinrade, Joe (University of Bath)
Poster Number: I-14

Poster – *First Results from a GPS Scintillation Receiver and Co-located All-sky Imager at the Geographic South Pole*

Joe Kinrade, Cathryn Mitchell, Nathan Smith, Yusuke Ebihara, Allan Weatherwax, Gary Bust

Ionospheric irregularities have influential effects on the propagation of GNSS signals, causing radio scintillations. These manifest themselves as rapid fluctuations of the amplitude and phase of the signals. Particle precipitation from the magnetosphere into the ionosphere, following major solar events, is known to be an important production mechanism for ionospheric irregularities at high latitudes. Particle precipitation is also known to cause the aurorae. However, although a coincidence of aurorae and GNSS scintillation events is considered likely, it is not well established in the scientific literature. This presentation highlights the first results from a study into the spatial and temporal correlation using instrumentation located at South Pole Station.

An all-sky imager provides a temporal and spatial measure of optical auroral emission intensities within the Southern Polar Cap during the dark Antarctic winter months. A co-located GPS antenna and scintillation receiver facilitates the direct superimposition of optical emission images and GPS signal phase measurements. A number of auroral events have been investigated to date, ranging in their optical emission intensity and structuring; discrete and static arcing, dynamic wisps and curls, and softer diffuse brightening.

Cross-correlation statistics are produced by tracking both mean optical emission intensity (557.7 nm, atomic oxygen) and GPS L1 phase variance at E-region heights. Early results indicate a relationship between intense and prolonged arc emissions and GPS signal phase variance. For example strong correlation was found across the majority of observed satellites with ray paths traversing through a discrete and persistent auroral arc structure on August 9th 2010.

An extensive study of optical aurora and GPS scintillation in the Antarctic is planned to further investigate this relationship. This is particularly useful because a longstanding question about GPS scintillation is ‘how many satellites will be affected simultaneously?’ The results presented here open up the possibility that comprehensive databases of optical emissions from the aurorae could be used to assess the likelihood of full-sky, multiple satellite scintillation activity at high latitudes. The probability of scintillation-induced GPS outages is of significant interest for surveying, aircraft navigation and maritime operations at high latitudes.

Knipp, Delores J. (University of Colorado)
Poster Number: G-11

Poster – *Undergraduate Textbook: Understanding Space Weather and the Physics Behind It*

Delores J. Knipp

Communicating space weather drivers and effects to undergraduate science, technology, engineering, and mathematics (STEM) students has many challenges. A new textbook entitled, Understanding Space Weather and the Physics Behind It, interleaves the physics of energy, current and fields, and plasma with the phenomena of space weather. The first block of material includes an overview chapter and chapters on aspects of the quiescent Sun, solar wind, magnetosphere and upper atmosphere. Each of these chapters and the intervening physics chapters contains numerous examples. The second block of chapters is dedicated to disturbed space weather phenomena. The final two chapters address space weather effects of humans and hardware and signals and systems. This poster will outline the text and provide examples of the worked problems and other features of the text.

Kress, Brian T. (Dartmouth College)
Poster Number: M-16

Poster – *Geomagnetic Cutoffs at Synchronous Altitude Revisited*

B. T. Kress and J. V. Rodriguez

Solar and galactic cosmic ray cutoffs at geosynchronous are sensitive to moderate geomagnetic disturbances and undergo daily variations due to the day-night asymmetry of the magnetosphere. The sensitivity of geomagnetic cutoffs to the outer magnetospheric field configuration poses difficulties for modeling SEP access to geostationary spacecraft. Observations of solar protons at synchronous altitude were first made in the late 1960s. Solar protons measured with detectors aboard the geostationary ATS-1 satellite showed that MeV solar protons penetrate to L-shells below what is predicted by Stormer theory [Paulikas and Blake, 1969]. Cutoff computations performed by Gall et al. [1970; 1971], in a geomagnetic field model that accounted for daily variation but did not include geomagnetic activity, showed closer agreement with observations. In this work, the SEP intensity at geosynchronous is directly compared with flux inferred from cutoff rigidities modeled in the Tsyganenko and Sitnov [2005] (TS05) field model. Cutoffs computed in TS05 follow variations driven by geomagnetic activity well, but as in previous studies are in general too high.

Gall, R., and S. Bravo (1970), Geostationary Satellites and the Anisotropies of Cosmic-Ray Propagation in the Interplanetary Medium, J. Geophys. Res., 75(34), 7284-7289, doi:10.1029/JA075i034p07284.

Paulikas, G. A., and J. B. Blake (1969), Penetration of Solar Protons to Synchronous Altitude, J. Geophys. Res., 74(9), 2161-2168, doi:10.1029/JA074i009p02161.

Tsyganenko, N. A. and M. I. Sitnov (2005), Modeling the dynamics of the inner magnetosphere during strong geomagnetic storms, J. Geophys. Res., 110, A03208, doi:10.1029/2004JA010798.

Krista, Larisza D. (NOAA/SWPC)
Poster Number: S-7
Poster – *The Automated Detection and Analysis of Short-term Changes in Coronal Dimmings*

Larisza D. Krista and Alysha A. Reinard

We present a new approach to the detection of coronal dimming regions. The Coronal Hole Evolution (CHEVOL; Krista 2011) algorithm was adapted to study the temporal evolution of dimming region properties using either SDO/AIA and HMI or SOHO/EIT and MDI data. The algorithm was found successful in locating dimming regions with relatively low intensities and clear boundaries. The area, location and magnetic properties of dimming regions were determined at high temporal cadence from the time of their appearance to the time of their disappearance. As a result, we were able to study the properties and spatial evolution of the dimming regions. Four dimming regions were analyzed, including a recurring dimming near the same active region. The recurring dimming appeared to be formed in a very similar way first expanding then shrinking and stabilizing as a coronal hole. The repeated similar behavior may indicate a quasi-steady magnetic configuration.

With an extended dimming list, the method will be used to study the magnetic field reconfiguration caused by reconnection and to relate dimming region properties to those of CME's.

Kwak, Young-Sil (Korea Astronomy and Space Science Institute)
Poster Number: I-19

Poster – *Variation of the Hemispheric Asymmetry of the Equatorial Ionization Anomaly with Solar Cycle*

Young-Sil Kwak, Hyosub Kil, Wookyoung Lee

The equatorial ionization anomaly (EIA) region has a practical importance because the most severe radio scintillation occurs at the EIA. During the solar minimum, the EIA shows an opposite hemispheric asymmetry in the morning and afternoon during solstices. This phenomenon is explained by the combined effects of fountain process and interhemispheric wind. However, the proposed mechanism has not yet been tested with observations during other periods of the solar cycle. We examine the variability of the hemispheric asymmetry of the EIA in 2001–2008 using the measurements of the electron density by the CHAllenging Minisatellite Payload (CHAMP) satellite and the total electron content maps provided by the ground global positioning system network. In general, a stronger EIA appears in the winter hemisphere in the morning during both the solar minimum and maximum. In the afternoon, the occurrence hemisphere of a stronger EIA transits from the winter hemisphere to the summer hemisphere following the declining of the solar cycle. The creation of a stronger EIA in the winter hemisphere in the morning is explained by the occurrence of a strong fountain effect and the promotion of the equatorial plasma

diffusion into the winter hemisphere by the summer-to-winter wind. These mechanisms are seen to be effective in the afternoon during the solar maximum and maintain a stronger EIA in the winter hemisphere. The reversal of the hemispheric asymmetry in the afternoon during the solar minimum is explained by the weakening of the fountain effect.

Lanzerotti, Louis (New Jersey Institute of Technology)
Poster Number: G-1

Poster – *Space Weather: The International Journal of Research and Applications*

Louis J. Lanzerotti

Since the era of development of electrical telegraph systems in the early 19th century, the solar-terrestrial environment has influenced the design and operations of ever-increasing and sophisticated technical systems. Space Weather: The International Journal of Research and Applications is an online publication devoted to the field of space weather and its impact on technical systems, including telecommunications, electric power, and satellite navigation. A hardcopy Space Weather Quarterly magazine is also published. The on-line journal and the Quarterly magazine publishes (a) peer-reviewed articles presenting the latest engineering and science research in the field, including studies of the response of technical systems to specific space weather events, predictions of detrimental space weather impacts, and effects of natural radiation on aerospace systems; (b) news and feature articles providing up-to-date coverage of government agency initiatives worldwide and space weather activities of the commercial sector; (c) letters and opinion articles offering an exchange of ideas; and (d) editorial comments on current issues facing the community of interest. Space Weather is published by the American Geophysical Union (AGU).

Li, Wenhui (University of New Hampshire)
Poster Number: I-18

Poster – *Thermospheric Density Enhancements During Quiet Time and Storm Time -comparisons Between OpenGGCM-CTIM and CHAMP Observations*

Wenhui Li, Joachim Raeder, Jiuhou Lei, Delores Knipp, Naomi Maruyama, Mariangel Fedrizzi, Tim Fuller-Rowell

Under relatively quiet geomagnetic conditions, the Challenging Minisatellite Payload (CHAMP) satellite often observes regions of enhanced density at ~ 400 km altitude in the noon sector at high latitudes correlated with small-scale field-aligned currents (FACs) associated with the dayside cusp. We show that the coupled global magnetosphere-ionosphere-thermosphere model OpenGGCM-CTIM successfully captures this phenomenon in the simulation of three events with such anomaly thermospheric density enhancements. We also show the thermospheric neutral densities from OpenGGCM-CTIM simulation, from CTIPe simulation, and from CHAMP for the magnetic storm in January, 2005.

Liu, Siqing (Center for Space Science and Applied Research)
Poster Number: M-1
Poster – *Improvement of Geomagnetic Disturbance Level Forecast Skill*

Siqing Liu and Bingxian Luo

The geomagnetic disturbance level forecast is crucially important and extremely hard. Recently we present an index (Pch) which can reflect the impact of coronal holes on geomagnetic field. Based on the quantity of Pch, the storm level caused by coronal hole can be well estimated in advance. Furthermore, we also tried to develop higher time resolution geomagnetic disturbance index which can be used to issue geomagnetic storm alerts promptly in less than 3 hours.

Lohmeyer, Whitney (Massachusetts Institute of Technology)
Poster Number: M-10

Poster – *A Correlation of Space Weather Events to GEO Satellite Anomalies for Improved Fleet System Performance*

Whitney Lohmeyer, Kerri Cahoy, Marcus Vilaca, Mark Dickinson

The UK satellite telecommunications company Inmarsat has been operating its GEO COMSAT fleet since 1990. For these spacecraft, the company maintains an archive of component housekeeping data that monitors primary system functions. The overall satellite performance and component anomalies are detected with component thresholds that filter the real-time data transmitted from space. However, outside of fleet maintenance, additional analysis to understand the physical causes of historic performance changes and component anomalies has yet to be conducted.

It is widely acknowledged that space weather affects the performance and overall lifetime of GEO satellites. However, much work remains to be completed to arrive at an in-depth understanding of the specific types of space weather events that significantly impact component health.

For this research, we mine three primary sources for data: Inmarsat's historical archives, ESA's SPENVIS (The Space Environment Information System), and the NSF funded, MIT-Haystack Madrigal. From the gathered results, we map major space weather events including solar activity, magnetometer measurements, and magnetic field indices (such as DST, Kp, and Ap), and correlate these with significant GEO satellite anomalies since the year 1995. This work also considers other factors such as orbital positioning, and whether the anomaly is the result of a single upset, or the summation of a series of space weather events. Ultimately, this analysis will improve the understanding of Inmarsat's communication system performance as a function of space weather, and help better define real-time and preventative thresholds.

Love, Jeffrey J. (USGS Geomagnetism Program)
Poster Number: M-2

Poster – *Geomagnetic Detection of the Sectorial Solar Magnetic Field and the Historical Peculiarity of Minimum 23–24*

Jeffrey J. Love, E. Joshua Rigler, Sarah E. Gibson

Analysis is made of the geomagnetic-activity aa index covering solar cycle 11 to the beginning of 24, 1868–2011. Autocorrelation shows 27.0-d recurrent geomagnetic activity that is well-known to be prominent during solar-cycle minima; some minima also exhibit a smaller amount of 13.5-d recurrence. Previous work has shown that the recent solar minimum 23–24 exhibited 9.0 and 6.7-d recurrence in geomagnetic and heliospheric data, but those recurrence intervals were not prominently present during the preceding minima 21–22 and 22–23. Using annual-averages and solar-cycle averages of autocorrelations of the historical aa data, we put these observations into a long-term perspective: none of the 12 minima preceding 23–24 exhibited prominent 9.0 and 6.7-d geomagnetic activity recurrence. We show that the detection of these recurrence intervals can be traced to an unusual combination of sectorial spherical-harmonic structure in the solar magnetic field and anomalously low sunspot number. We speculate that 9.0 and 6.7-d recurrence is related to transient large-scale, low-latitude organization of the solar dynamo, such as seen in some numerical simulations.

Maruyama, Naomi (NOAA/SWPC and CU/CIRES)
Poster Number: I-10

Poster – *Ionosphere and Plasmasphere Electrodynamics (IPE) Model*

Naomi Maruyama, Phil Richards, Tzu-Wei Fang, Leslie Mayer, Catalin Negrea, Tim Fuller-Rowell, George Millward, Mihail Codrescu, Art Richmond, Astrid Maute

We have developed the new Ionosphere-Plasmasphere-Electrodynamics (IPE) model. It consists of a physics based model of an ionosphere and plasmasphere using the IGRF geomagnetic field configuration. Furthermore, the global ionospheric potential is solved self-consistently on the same grid as the Ionosphere-Plasmasphere model. In this presentation, comparisons of the modeled properties of the ionosphere and plasmasphere will be made with some observations, with a special focus on the longitudinal variations. We will evaluate the impact of the use of the IGRF geomagnetic field on the modeled plasma dynamics and energetics.

McCrea, Ian (STFC Rutherford Appleton Laboratory)
Poster Number: I-5

Poster – *EISCAT_3D: A Three-dimensional Imaging Radar for Atmospheric and Geospace Research*

Ian McCrea, on behalf of the EISCAT_3D project consortium

For thirty years, the EISCAT Scientific Association (www.eiscat.se) has operated Europe's flagship facilities for ground-based research in solar-terrestrial physics. The UHF and VHF radars at Tromso in northern Norway, together with the UHF receiver sites at Kiruna, Sweden and Sodankyla, Finland and the EISCAT Svalbard Radar near Longyearbyen, represent a uniquely capable group of instruments serving a worldwide user community.

The EISCAT mainland radars in particular, however, are based on aging transmitters and antennas which are slow-moving and increasingly hard to maintain. For some years now, EISCAT (with support from international partners including the European Union) has been exploring how to replace the current set of mainland radars with a new state-of-the-art radar system, better suited to the current needs of the research community.

EISCAT_3D (www.eiscat3d.se) will be the next-generation radar for the high-latitude atmosphere and geospace, with capabilities going beyond anything currently available. The facility will consist of large phased arrays in three countries. Depending on funding, EISCAT_3D will comprise tens of thousands, up to more than 100 000, antenna elements.

EISCAT_3D combines volumetric imaging and tracking, aperture synthesis imaging, multistatic configuration, improved sensitivity and transmitter flexibility. At the passive sites, the design allows the full extent of the transmitted beam to be imaged using holographic techniques. EISCAT_3D will be a modular system, allowing an array to be split into sections for imaging. The result will be a new data product, range-dependent images of small structures, with sizes down to 20m.

EISCAT_3D will be the first multistatic phased array ISR. A minimum of five sites is envisaged, with receivers located around 120 km and 250 km from the active site, providing optimal geometry for vectors in the middle and upper atmosphere. The antenna gain and array size will deliver large increases in the figure-of-merit relative to EISCAT's existing radars. An active site comprising 16,000 elements will exceed the sensitivity of the present VHF radar by an order of magnitude.

Because the frequency chosen for EISCAT_3D (233 MHz) within the frequency range of LOFAR and the SKA, there is considerable potential scope for technology sharing between EISCAT and the next generation of radio astronomy projects. With funding from the University of Oulu, EISCAT has recently procured a LOFAR international station, which has now been partially installed at Kilpisjarvi in northern Finland, for evaluation as a potential EISCAT_3D receiver. This is the KAIRA project (http://kaira.sgo.fi). Installation and commissioning of the KAIRA array will be completed this summer, after which it will be used in joint experiments with the existing EISCAT VHF radar, and will be available for radio astronomy applications with the rest of the LOFAR network.

In this poster the technical specifications and science case for EISCAT_3D will be discussed and the current progress reviewed.

Meehan, Jennifer (Utah State University)
Poster Number: I-6

Poster – *Improvements to GPS and Communication Technology at USU SWC*

Jinni Meehan, W. Kent Tobiska, Jan Sojka, Robert Schunk, Don Rice, Jared Fulgham, Eric Hunsaker, Chris Tschan, Herb Carlson, Vince Eccles, Larry Gardner, Ludger Scherliess

The Space Weather Center (SWC) at Utah State University (USU) is developing essential, fully operational real-time products for customers that will help mitigate adverse space weather effects on radio communication and navigation systems. Physics-based models of the ionosphere as well as data assimilation are used to create such products and come at a critical time of an approaching solar maximum. Improvements to GPS uncertainty characterization in real-time are demonstrated, especially capabilities that can improve use of signals affected by scintillation. A case study is shown with the USU's Global Assimilation of Ionospheric Measurement – Gauss Markov (GAIM-GM) model, run in real-time by the US Air Force Weather Agency (AFWA) to provide both specification and forecasts of the ionosphere. At USU for development, validation and testing versions of GAIM-GM are run in the SWC. This case study describes the results of substituting a test set of ionosonde data for GPS TEC data in GAIM-GM. Also, our team shows the wealth of new information available, including global and regional HF signal propagation strength at various frequencies. This information can be obtained in real-time or in a 3-hour forecast.

Meier, Matthias M. (DLR - German Aerospace Center)
Poster Number: G-13

Poster – *The Importance of Space Weather Awareness in Airborne Radiation Monitoring after the Nuclear Disaster of Fukushima*

N. Santen, M. Meier, D. Matthiae

After the Fukushima Daiichi power plant accident in Japan in March 2011, large amounts of radioactive isotopes such as I-131 and Cs-137 were released and spread across the entire globe. Atmospheric transport models predicted that a radioactive cloud might reach central Europe about two weeks later. In order to gain information about and samples from the radioactively unpolluted atmosphere at aviation altitudes in Germany, the German Aerospace Center (DLR) performed a measuring flight twelve days after the accident.
Radiation protection of aircrew and scientists required online-monitoring of the dose rate aboard the research aircraft in order to detect potential elevated airborne radioactivity, in addition to the radiation exposure at aviation altitudes due to galactic cosmic rays, and to prevent the aircraft from contamination.

The fact that two days before the measuring flight NOAA had issued an alert due to a solar radiation storm, which indicated the possibility of an event that could lead to increased dose rates at aviation altitudes as well, required the permanent observation of the space weather situation: during planning, performance of the flight and for the evaluation of the results in order to attribute a possible additional contribution to either a space weather event or the nuclear accident in Japan.

Messerotti, Mauro (INAF-Astronomical Observatory of Trieste)
Poster Number: I-7

Poster – *Solar Radio Frequency Interferences to GPS Networks: Analysis of the 24 September 2011 Event*

M. Messerotti, V. Alberti, A. Santin, A. Marassi

Intense solar radio bursts occurring in the L-Band can interfere with GPS receivers on the whole sunlit hemisphere of the Earth when the circular polarisation of the radio emission is right-handed due to the significant decrease of the Signal-to-Noise-Ratio (SNR) which can lead to the complete loss of lock. In fact, significant experimental evidence was found that high-precision GPS positioning on Earth's entire sunlit side was partially disrupted for more than 10–15 min by solar radio bursts with unprecedented radio flux density during X6.5 and X3.4 solar flares on 6 and 13 December 2006. Hence, solar radio bursts are a potential threat to life-critical systems based on a Global Navigation Satellite System (GNSS), and they deserve diachronic monitoring for proper warnings to be issued to GPS service customers. Despite such relevant experimental evidence, not enough emphasis is given to this phenomenology which is characterized by low probability occurrence, but also by high impact when it occurs. Therefore, more detailed studies and analyses have to be carried out in order to build consistent statistics and to identify possible precursors, e.g. by analyzing the associated triggering flares.

In the light of the above, we present the analysis of the effect of an intense solar radio burst observed on 24 September 2011 on the GPS network of the Region Friuli-Venezia Giulia (Italy), which clearly shows the signature of the interference affecting all network receivers by diminishing the SNR by 8-10 dB-Hz.

Min, Kyungguk (New Jersey Institute of Technology)
Poster Number: M-17

Poster – *Properties of Electromagnetic Ion Cyclotron Waves Measured by the THEMIS Mission*

Kyungguk Min, Jeongwoo Lee, Kunihiro Keika, Wen Li

Electromagnetic ion cyclotron (EMIC) waves play an important role in magnetospheric dynamics and their global distribution and properties have recently been of great interest.

We have investigated the distribution and properties of EMIC waves over a broader range than ever before, as enabled by observations with the Time History of Events and Macroscale Interactions during Substorms (THEMIS) spacecraft from 2007 to 2010. We separated the observed EMIC waves into two groups: H and He band waves. We found that the EMIC waves mostly occur in dusk and dawn regions for $8 < L < 12$ RE. The He

band waves dominantly occur at dusk while the H band waves occur at dawn region. The dusk waves are characterized by left-hand polarized, small normal-angle (<30 deg) waves with strong wave power (~10 nT^2/Hz) while the dawn waves by linear polarized, large normal-angle (>45 deg) waves with weaker wave power (~3 nT^2/Hz) than the dusk waves. Based on the linear EMIC instability model presented by Horne and Thorne [JGR, 1994], we suggest that the main underlying factor for the observed spatial variations of these wave properties would be local density of cold plasma and chemical abundance.

We have also attempted to measure the dimension of the EMIC wave source transverse to the local magnetic field around the magnetic equator. The method includes the calculation of the correlation coefficients among the simultaneously observed EMIC waves by two adjacent spacecraft, and an exponential function fit of the resulting distribution of the correlation versus separation distance. We have found that despite somewhat large standard deviation, the 1/e folding distance, taken as the characteristic scale for the source dimension, is approximately one proton gyro-radius scale.

Murphy, Joshua (University of Colorado)
Poster Number: S-6

Poster – *Developing New 3D Visualization Tools for the CISM Models*

Joshua J. Murphy, Scot R. Elkington, Peter J. Schmitt, Michael Wiltberger, Daniel N. Baker

Simulation models of the heliospheric and geospace environments can provide key insights into the geoeffective potential of solar disturbances such as Coronal Mass Ejections and High Speed Solar Wind Streams. Analysis and prediction tools for post processing and visualizing simulation results greatly enhance the utility of these models in aiding space weather forecasters to predict the terrestrial consequences of these events.

The Center For Integrated Space Weather Modeling (CISM) Knowledge Transfer (KT) group is developing an integrated post-processing and analysis tool based upon the ParaView open source visualization framework. This tool will allow the use of the same post-processing environment for the majority of visualization and analysis tasks, and allow the same workflow to be applied to multiple types of models. With this work we are tackling critical challenges, such as in-situ analysis of data and high quality 3-D interactive visualizations of real-time simulation results.

This poster will discuss the goals of the CISM KT program, and our progress toward creating a flexible, common interface for the visualization and analysis of simulation results.

Nedie, Abiyu (University of Alberta)
Poster Number: M-18

Poster – *A Field Line Resonance Excited by a Solar Wind Driven Magnetopause Oscillation: Observation and Modelling*

Abiyu Nedie, Frances Fenrich, Robert Rankin, Alex Degeling

In this presentation, we trace a quasi-monochromatic 2.5 mHz discrete wave oscillation in By at the location of the bow shock at noon, and use the multi-spacecraft CLUSTER mission to fully characterize the signature of the wave near the dusk magnetopause and within the magnetosphere. A detailed analysis of the noon and dusk signature of the wave has been carried out using measurements from the CLUSTER CP-FGM-SPIN flux gate magnetometer and PP-CIS “Prime Parameters”, which show signatures of magnetic field and plasma flow oscillations at the same discrete frequency. The SuperDARN Saskatoon radar in the pre-dawn sector also reveals the footprint of an FLR structure with anti-sunward phase propagation that appears to be linked to a solar wind driven magnetopause oscillation. The CLUSTER and SuperDARN observations support the conjecture that a source in the solar wind can excite FLR’s within the magnetosphere. To our knowledge, this is the first work that relates a solar wind driven magnetopause oscillation with a discrete frequency FLR in the magnetosphere. We demonstrate this scenario using a ULF wave model with a source placed in the solar wind. The wave is found to penetrate through the magnetopause boundary into the magnetosphere where it excites an FLR at the same frequency as the source.

Oh, Suyeon (Chungnam National University)
Poster Number: S-20

Poster – *Forecast of Solar Proton Radiation Intensity Using South Pole Neutron Monitor*

Suyeon Oh, John W. Bieber, John Clem, Paul Evenson, Roger Pyle, Yu Yi

We introduce a practical system for forecasting peak intensity and fluence of solar energetic protons in the tens to hundreds of MeV energy range. The system could be useful for forecasting radiation hazard, because peak intensity and fluence are closely related to the medical physics quantities peak dose rate and total dose. There are two types of neutron monitor at South Pole – a standard 3NM64 and a set of “bare” (without the lead producer but enclosed in polyethylene moderators) BP-28 detectors. The method, what is called “Polar Bare Method” uses these detectors located at the South Pole to make a measurement of the solar particle energy spectrum at relativistic (GeV) energies, and it then extrapolates this spectrum downward in energy to make a prediction of the peak intensity and fluence at lower energies. A validation study based upon 12 large solar particle events compared the prediction with measurements made aboard GOES spacecraft. This study shows that useful predictions (logarithmic correlation greater than 50 %) can be made down to energies of 40-80 MeV (GOES channel P5) in the case of peak intensity, with the prediction leading the observation by 166 minutes on average. For higher energy GOES channels, the lead-times are less, but the correlation coefficients are larger.

Ozhogin, Pavel (University of Massachusetts - Lowell)
Poster Number: I-11

Poster – *Field-aligned Distribution of the Plasmaspheric Electron Density: An Empirical Model Derived from the IMAGE RPI Measurements*

Pavel Ozhogin, Jiannan Tu, Paul Song, Bodo Reinisch

We present a newly developed empirical model of the plasma density in the plasmasphere. It is based on more than 700 density profiles along field lines derived from active sounding measurements made by the radio plasma imager on IMAGE between June 2000 and July 2005. The measurements cover all magnetic local times and vary from L = 1.6 to L = 4 spatially, with every case manually confirmed to be within the plasmasphere by studying the corresponding dynamic spectrogram. The resulting model depends not only on L-shell but also on magnetic latitude and can be applied to altitudes higher than 2000 km. It consists of two parts: the equatorial density, which falls off exponentially as a function of L-shell; and the field-aligned dependence on magnetic latitude and L-shell (in the form of invariant magnetic latitude). The fluctuations of density appear to be greater than what could be explained by a possible dependence on magnetic local time or season, and the dependence on geomagnetic activity is weak and cannot be discerned. The solar cycle effect is not included because the database covers only a fraction of a solar cycle. The performance of the model is evaluated by comparison to four previously developed plasmaspheric models and is further tested against the in situ passive IMAGE RPI measurements of the upper hybrid resonance frequency. While the equatorial densities of different models are mostly within the statistical uncertainties (after L = 3), the clear latitudinal dependence of the RPI model presents an improvement over previous models. The model shows that the field-aligned density distribution can be treated neither as constant nor as a simple diffusive equilibrium distribution profile. The electron density model can be used to estimate the time for an Alfven wave to propagate from one hemisphere to the other if it is assumed that the mass composition does not change along the field, to determine the plasma frequencies along a field line, and to calculate the ray paths for high frequency waves propagating in the plasmasphere.

Paxton, Larry J. (JHU/APL)
Poster Number: I-3

Poster – *Operational Space Weather from UV Sensing: Current Capabilities and the Way Forward*

Larry J Paxton, Robert K Schaefer, Michele Weiss, Bernie Ogorzalek, Yongliang Zhang, Ethan S Miller, Joseph Comberiate, Hyosub Kil, Brian Wolven, Giuseppe Romeo

The SSUSI sensor on DMSP F16, F17, and F18 provides a wide range of operational space weather data products to AFWA. These products include ionospheric profiles, images of ionospheric bubbles, neutral density information, and auroral characterization and imagery, and the list is still expanding. SSUSI is a cross-track spectrographic imager. The original SSUSI sensors were built between 1992 and 1996. Three of the five have

flown with two more slated for flight in this decade. Considerable effort and research expertise has been invested to develop products useful to people in the operational community and those doing basic research. New products were developed, beyond the scope envisioned 20 years ago, with an eye toward greatly improving near-Earth space weather situational awareness. One key new product is a 3-D tomographic reconstruction of the ionosphere that gives a full characterization of ionospheric bubbles (location, size, density, etc.) and can be used to infer regions where UHF/HF communications can be problematic, and where scintillation is likely to occur. The SSUSI auroral imagery is also important for determining the 2-D auroral boundary location and identifying areas where radar clutter will arise. Additional products (e.g., the South Atlantic Anomaly visualization, poleward auroral boundary) are being developed and tested at APL and will be more generally distributed in the near future. For the longer term, the next generation of SSUSI-like sensor has been designed and is called AURORA. This new design puts it well within the capabilities of hosted payloads or small satellites. AURORA allows us to retain heritage optical and mechanical design elements while addressing electronics parts obsolescence in a compact, full-performance implementation of the key elements of the SSUSI and GUVI design. As ionospheric imagers, both SSUSI and AURORA provide complete global coverage and return more than 50,000 soundings of the ionosphere each day for each sensor.

Pi, Xiaoqing (Jet Propulsion Laboratory, California Institute of Technology)
Poster Number: I-8

Poster – *Impact of the COSMIC-2 Mission on Global Assimilative Ionospheric Modeling*

Xiaoqing Pi, Olga Verkhoglyadova, Anthony J. Mannucci, Byron A. Iijima, Brian D. Wilson, Attila Komjathy, Vardan Akopian, and Mark Butala

An Ionospheric simulation System for satellite Observations and Global Assimilative Model Experiments (ISOGAME) has been developed at the Jet Propulsion Laboratory. The software makes use of the Global Assimilative Ionospheric Model (GAIM) and a GNSS-Inferred Positioning System and Orbit Analysis Simulation Software (GIPSY-OASIS) to simulate ionospheric observations from low Earth orbiter (LEO) missions that carry GNSS radio occultation (RO) receivers. Incorporating a first-principles physics model and data assimilation modules, GAIM computes volume densities of multiple ion species and electron on a global 3D geomagnetic frame. The data assimilation modules assimilate GNSS-derived total electron content measurements made from ground-based global networks and LEO constellation. GAIM is capable of modeling weather conditions of ionospheric state (electron densities) and drivers, such as electric fields, winds and ionization. This presentation will highlight the results of OSSE's conducted at the Jet Propulsion Laboratory with the planned COSMIC-2 orbits and GNSS RO receivers, and assess the impact of the mission on global assimilative ionospheric modeling.

Rachman, Abdul (LAPAN)
Poster Number: M-11

Poster – *The Study of the Relation Between Space Weather and Satellite Anomalies in Indonesia*

Abdul Rachman, Neflia and Dhani Herdiwijaya

The study of the relation between space weather and satellite anomalies in Indonesia has been in progress and has given some results. National Institute of Aeronautics and Space (LAPAN) is developing an early warning system against operational disruption for LEO and GEO satellites. The system utilizes two-line element data and some parameters of space weather such as SSN, F10.7, Kp and Dst index and the flux of energetic particles. This system has been used to analyze the problems ever experienced by LAPAN-TUBSAT and Garuda 1. LAPAN has also conducted a study on the relationship between CME and satellite anomalies using satellite anomaly events available on the internet. The results of the analysis form the basis for the database that associates the reported anomalies with the geomagnetic storm and SEP. In addition to LAPAN, Bandung Institute of Technology (ITB) has also made progress in this field. ITB has studied space charging as a function of SEP energy and satellite's altitude. ITB also has studied the South Atlantic Anomaly and the appropriate material for reducing the effects of space environment on satellites. The conclusion is aluminum is suitable for reducing the effects from space charging and gold is suitable for reducing the effects from SEU. Currently, LAPAN is studying the effects of CME and CIR on Indonesia's GSO satellites using the satellite's telemetry data from the related operator. LAPAN is also testing the hypothesis that CIR-driven storms pose more of a problem for the satellites than CME-driven storms. This study is still in its early stages so there are no results that can be delivered to date.

Rigler, E. Joshua (HAO/NCAR)
Poster Number: M-12

Poster – *Identifying Space Weather Events Using a Multichannel Statistical Classifier*

E. J. Rigler, S. M. Hill, J. L. Gannon, A. A. Reinard, R. A. Steenburgh, J. M. Darnel, J. Vickroy

The next generation of GOES satellites, slated for launch ~2015, will carry the Solar UltraViolet Imager (SUVI), a high resolution, multichannel extreme ultra-violet (EUV) sensor that promises to increase the flow of operational space weather data to forecasters by at least an order of magnitude. Additional space weather-related instruments, both on and off the GOES satellites, will increase their data flow by similar degrees. It therefore becomes necessary to process and automatically segregate these data into categories, or "themes" that can be efficiently sorted, analyzed, and assimilated into additional space weather data products and operational forecasts.

We developed a Bayesian statistical multichannel pixel classifier to generate thematic maps of the sun for space weather applications. This tool distills the combined experience of space weather experts into a set of statistical parameters that, combined with real time solar imagery, assigns a most-probable theme to a given solar pixel. Possible pixel themes are a run-time configuration, but may include items like "flare", "coronal hole", etc. We validated this tool using images from NASA's Solar Dynamics Observatory (SDO) Atmospheric Imaging Array (AIA), a science-grade EUV imager similar in design to SUVI. Motivated by early promising results from this general-purpose statistical classifier, we proceeded to apply it to non-image multichannel data (e.g., geomagnetic observations, in situ solar wind measurements, etc.) in order to automatically segregate other space weather observations into relevant themes. In this presentation, we review the theory behind our classifier, present results from our validation study, and share early results from attempts to apply our classifier to a broader set of inputs and identify more general space weather events.

Rodriguez, Juan V. (NOAA/NGDC - CIRES)
Poster Number: M-15

Poster – *New Space Weather Particle and Magnetic Field Products at NGDC*

J. Rodriguez, J. Green, W. Denig, J. Darnel, J. Machol, R. Redmon, W. Rowland, M. Shouldis, D. Wilkinson

In addition to its scientific stewardship responsibility for data processed by the Space Weather Prediction Center (SWPC), the National Geophysical Data Center (NGDC) has several new space weather products either planned or under consideration. Supported by NOAA/NESDIS Satellite Products and Services Review Board, NGDC is currently completing development of a new real-time processing system for the Space Environment Monitor (SEM-2) charged particle data from the NOAA Polar Operational Environmental Satellites and the EUMETSAT MetOp satellites. Improvements over the prior processing system include better instrument response characterization, such as the sensitivity of a proton channel to >1 MeV electron fluxes, and calculation of absolute proton fluxes from the omnidirectional measurements. NGDC is also implementing the Spacecraft Environmental Anomalies Expert System – Real Time (SEAESRT) methodology developed by The Aerospace Corporation in order to provide hazard quotients for internal charging, surface charging, single event upsets, and total dose events in geostationary orbit. SEAESRT ingests real-time GOES particle measurements and Kp-index estimates from SWPC. Candidates for future implementation as GOES 13-15 products include particle- and magnetic field-based products (such as densities, temperatures and coordinate transformations) already developed under the auspices of the GOES-R Risk Reduction program. These products eventually will be made available, both in real-time and retrospectively, via the Satellite Portal for Anomaly Analysis Data (SPAAD) in support of satellite anomaly assessment. We seek feedback from the user community on possible products based on NOAA measurements.

Scherrer, P. H. (HEPL, Stanford University)
Poster Number: S-4

Poster – *Helioseismology Data Products from SDO for Space Weather Research*

P. H. Scherrer, C. Baldner, R. Bogart, T.L. Duvall, Jr., T. Hartlep, S. Ilonidis, A. G. Kosovichev, K. V. Parchevsky, J. Zhao

The Helioseismic and Magnetic Imager (HMI) instrument provides uninterrupted high-resolution Dopplergrams and magnetograms of the whole solar disk. The data are processed in near-real time at the Stanford Joint Science Operations Center (JSOC), and present new unique capabilities for Space Weather research. In particular, the analysis of Dopplergrams by local helioseismology techniques provides maps of subsurface large-scale plasma flows that control the magnetic flux transport and evolution of active regions, allows us to detect emerging magnetic field in the deep interior 24-72 hour before it forms active regions, and also gives images of active regions on the far side of the Sun. We present the current status of these SDO/HMI data products and discuss their potential applications for long- and short-term space weather predictions.

Scotto, Carlo (Istituto Nazionale di Geofisica e Vulcanologia)
Poster Number: I-20

Poster – *No Evidence of Long Term Changes of hmF2 in the Ionospheric Data Records*

Carlo Scotto

The study of a long series of simulated ionograms automatically interpreted by Autoscala shows that the accuracy of the estimation of the real height of the F2 layer hmF2 would be sufficient to put in evidence its long term lowering. It also demonstrated that the long term lowering would be in many circumstances sufficient to mask the geomagnetic control. It is concluded that in ionospheric data records there is no signature of long term effects upon hmF2.

Shi, Liqin (Chinese Academy of Science)
Poster Number: G-5

Poster – *Space Environment Monitoring Network in Chinese Academy of Sciences*

Liqin Shi, Siqing Liu, Yanhong Chen

The space environment monitoring network (SEMnet) in Chinese Academy of Sciences(CAS) will be completed in June 2012. SEMnet is constructed under the growing requirements of real time space environment monitoring and space weather prediction, with the coming of the 24th solar maximum. SEMnet is composed of 17 stations with more than 40 ground-based instruments, and a processing and prediction center in Beijing. The stations and instruments are selected because of their good operational ability with stable, continuous observation and high reliable data. SEMnet can give the observation of solar photosphere, solar chromosphere, cosmic ray, geomagnetic field, ionosphere and middle to upper atmosphere. All the station's data will be transmitted to space environment prediction center (SEPC) in Beijing. SEPC will process the data promptly and issues them on website. Meanwhile the forecasters make space weather prediction using the SEMnet's monitoring data as well as other public data.

Spann, James F. (NASA/MSFC)
Poster Number: G-7

Poster – *Lessons Learned from Successful Earth Science Research-to-Applications Efforts*

James F. Spann, Gary Jedlovec, Dan Irwin

Drawing from the demonstrated success of transitioning NASA observations and investigations to decision makers worldwide and national weather offices through the SERVIR and SPoRTprograms in Earth Science, a list of things that worked and recommendations are presented that apply to the space weather. The SERVIR program is a partnership of NASA and the US State Department USAID that provides decision-making tools to developing nations across the globe using NASA and other space-based observations. The Short-term Prediction Research and Prediction Center (SPoRT) is a NASA project to transition unique observations and research capabilities to the operational weather community to improve short-term forecasts on a regional scale. It has established a close partnership with various NOAA National Weather Service offices across the country.

Steward, Graham A. (IPS Radio and Space Services)
Poster Number: S-15

Poster – *Automatic Recognition of Complex Magnetic Regions on the Sun in GONG Magnetogram Images and Prediction of Flares: Techniques for the Flare Warning Program Flarecast*

Graham A. Steward, Vasili V. Lobzin, Phil J. Wilkinson, Iver H. Cairns, Peter A. Robinson

In the present poster, Global Oscillation Network Group (GONG) solar magnetograms are used to automatically identify active regions by thresholding the line-of-sight component of the solar magnetic field. The flare potential of the regions is predicted by locating strong-gradient polarity inversion lines (SPILs) and estimating their parameters. The parameters of interest are the length of the SPIL, a proxy for its curvature; the maximum west-east and south-north gradients of the magnetic field in its vicinity; and a sum of the magnetic field gradients, the summation being performed along the SPIL. Analysis for thresholding of one, two, and three parameters and the corresponding probabilities for correct prediction of flares are presented and compared. The probability for correct prediction of X-ray flares of class C or greater in a 24 h window exceeds 88%, while the probability of false alarms is less than 10% if the decision rule involves thresholding of three specific parameters. These parameters are the steepest south-north gradient of the magnetic field, the maximum curvature of the SPILs, and the length of the longest SPIL, all being calculated for the entire region rather than for a particular SPIL. The steepest south-north gradient of the magnetic field is also used to estimate the probabilities for a flare to belong to classes C, M, or X. These techniques are now implemented in the flare warning program Flarecast. The first automatically predictedM- and X-class flares are presented, and Flarecast is found to predict well the observed X-ray flares.

Thompson, Barbara J. (NASA Goddard Space Flight Center)
Poster Number: S-3

Poster – *Comparison of Prominence Structures with Instances of Flux Rope CMEs in STEREO Data*

Amy C. Rager, Barbara J. Thompson, O. C. St. Cyr, Arnaud Thernisien, William T. Thompson

STEREO A and B CME data have been visually searched for instances of flux ropes, signified by a concave outward cavity feature in the COR1 coronagraph. The flux rope events selected were observed by both spacecraft, and also had visible prominences in both EUVI-A and EUVI-B. The appearance of a flux rope was compared to the angle of the inferred magnetic neutral line of the CME to discover if a relationship existed. The GCS CME flux rope model was fit to the COR1 data, allowing for a clearer representation of the flux rope structure to compare with the magnetic neutral line.

Thompson, Barbara J. (NASA Goddard Space Flight Center)
Poster Number: S-2

Poster – *Space Weather Living History: Connecting the Pioneers, Current Leaders and the Nature of Space Weather with the Public*

Barbara J. Thompson, Carolyn Ng, Troy Cline, Elaine Lewis, Beth Barbier, Sten Odenwald, James Spadaccini, Nathan James, Bryan Stephenson, Hilaire B. Davis, Eugene R. Major

The Space Weather Living History program will explore and share the breakthrough science and captivating stories of space environments and space weather by interviewing space physics pioneers and leaders active from the International Geophysical Year (IGY) to the present. Our multi-mission project will capture, document and preserve the living history of space weather utilizing original historical materials (primary sources). The resulting products will allow us to tell the stories of those involved in interactive new media to address important STEM needs, inspire the next generation of explorers, and feature women as role models. The project is divided into several stages, and the first stage, which began in mid-2011, focuses on resource gathering. The goal is to capture not just anecdotes, but the careful analogies and insights of researchers and historians associated with the programs and events. The Space Weather Living History Program has a Scientific Advisory Board, and with the Board's input our team will determine the chronology, key researchers, events, missions and discoveries for interviews. Education activities will be designed to utilize autobiographies, newspapers, interviews, research reports, journal articles, conference proceedings, dissertations, websites, diaries, letters, and artworks. With the

help of a multimedia firm, we will use some of these materials to develop an interactive timeline on the web, and as a downloadable application in a kiosk and on tablet computers. In summary, our project augments the existing historical records with education technologies, connect the pioneers, current leaders and the nature and history of space weather with K-12 classrooms and the general public, covering all areas of studies in Heliophysics.

Thompson, Donald C. (Air Force Research Laboratory)
Poster Number: I-22

Poster – *Space Environmental NanoSat Experiment (SENSE)*

Capt Paul La Tour, Space and Missiles Center Development Planning Directorate (SMC/XR)
D. C. Thompson, L. C. Gentile, K. I. Kalamaroff, D. L. Cooke, and N. Bonito
Air Force Research Laboratory, Space Vehicles Directorate

The Space Environmental NanoSat Experiment (SENSE) program is a rapid development effort of the USAF Space and Missiles Center Development Planning Directorate (SMC/XR) which will demonstrate the capability of NanoSats to perform space missions in an affordable and resilient manner. The three primary objectives for the SENSE mission are: 1) to develop best practices for operational CubeSat/NanoSat procurement, development, test, and operations; 2) to mature CubeSat bus and sensor component Technology Readiness Levels; and 3) to demonstrate the operational utility of CubeSat measurements by flowing validated, low-latency data into operational space weather models. SENSE consists of two 3-U CubeSats scheduled for launch in July 2013. Both satellites are 3-axis stabilized with star cameras for attitude determination and are equipped with a Compact Total Electron Density Sensor (CTECS) to provide radio occultation measurements of total electron content and L-band scintillation. One satellite also has a Cubesat Tiny Ionospheric Photometer (CTIP) monitoring 135.6 nm photons produced by the recombination of O+ ions and electrons. The other satellite has a Wind Ion Neutral Composite Suite (WINCS) to acquire simultaneous co-located, *in situ* measurements of atmospheric and ionospheric density, composition, temperature and winds/drifts. Mission data will be used to improve current and future space weather models and demonstrate the utility of data from CubeSats for operational weather requirements.

Tschan, Christopher R. (Aerospace Corporation)
Poster Number: M-9

Poster – *Methodology to Determine System Sensitivity to Space Weather*

Christopher Bowman 1, Christopher Tschan 2, and Kent Tobiska 3

The relationship between space weather warnings and actual effects on a space system is not well established. Many warnings can be issued before a serious effect is observed. This work attempts to help understand and quantify the space weather-to-effects relationship by documenting the increase in abnormal conditions on a satellite by exploitation of existing state of health telemetry on the system. A data-driven application is used to detect abnormal conditions on the system, tracks them and archives them. A correlation analysis is performed between known space weather phenomena and the abnormal variables on the effected system. The results are used to establish reliable system specific space weather phenomena thresholds for (a) the onset of space weather effects as well as (b) the onset of more serious impacts to the system.

1 Data Fusion and Neural Networks, Broomfield, CO
2 The Aerospace Corporation, Colorado Springs, CO
3 Space Environment Technologies, Pacific Palisades, CA

Urban, Kevin (New Jersey Institute of Technology)
Poster Number: M-6

Poster – *Synoptic-scale Magnetometer Observations of the Open-closed Field Line Boundary*

Kevin Urban, Andrew Gerrard, Louis Lanzerotti

The open-closed field line boundary (OCB) of Earth's magnetosphere can be utilized as a window into the global state of the magnetospheric system. During various geomagnetic events, the OCB can vary in both size and shape; the extent of this variability is a vital component of space weather research and modeling. During the

2007-2009 solar quiet period there was a unique opportunity to identify and study the synoptic-scale variability of the OCB during such events through use of the Polar Experiment Network for Geophysical Upper-atmosphere Investigations-Automatic Geophysical Observatory (PENGUIn-AGO) network of ground-based fluxgate magnetometers on the Antarctic continent. The magnetometers, spanning a range of latitudes and local times, measure the occurrence of standing Pc5 modes on closed magnetic field lines, as well as a long period band indicative of closed field lines extending into the magnetotail. Synthesis of this information can lead to isolating the structure and dynamics of the OCB, for example, before and during the passage of a co-rotating interaction region (CIR) or coronal mass ejection (CME).

Observations were compared with results from the BATSRUS space weather model and show 83% agreement during geomagnetic quiescence. The model and the data differ during a geomagnetic storm driven by a CIR. Discrepancies between the data and the model are currently being investigated.

Welling, Daniel (University of Michigan)
Poster Number: M-4

Poster – *Synthetic KP Index from Global Magnetohydrodynamics*

Daniel Welling, Nicholas Perlongo, Jennifer Gannon, Yiqun Yu, Aaron Ridley

KP, a global index of geomagnetic activity obtained from ground-based magnetometers, has a long history of use both in research and in operations. It is used in many capacities, from serving as a simple indicator of magnetospheric disturbance to input for many empirical and numerical models. These uses translate to space weather applications: the index is an important real-time indicator of activity as well as an important input for models that have forecasting potential.

This paper describes a new, synthetic KP index derived from the BATS-R-US global magnetohydrodynamic (MHD) model. It is obtained through virtual magnetometers that capture disturbances from global MHD currents, field-aligned currents mapped between the inner boundary of the MHD code and the ionosphere model, and Hall and Pedersen currents in the ionosphere. To validate the synthetic values, they are compared against observed KP for several storm events. Agreement is varied but overall positive. Examples of how synthetic KP and local-K values used in the derivation can be used to monitor local activity are also demonstrated.

Wiltberger, Michael (NCAR/HAO)
Poster Number: G-12

Poster – *The Space Weather Summer School by The Center for Integrated Space Weather Modeling*

M. Wiltberger and N. Gross

The Center for Integrated Space Weather Modeling (CISM) has offered a Space Weather Summer School (SWSS) every year for over a decade. The CISM Summer School is intended to give students a comprehensive immersion in the subject of space weather: what it is, what it does, and what can be done about it. The two week program is designed to introduce new graduate students to the field and provide other space weather professionals - space weather forecasters from SWPC and AFRL, NASA radiation analysts, and airline pilots - with a system wide perspective of space weather. The daily schedule includes three morning lectures by experts in the field along with an afternoon laboratory session that allows students to use data and simulation results to explore the concepts discussed in the morning lecture. This poster will provide an overview of the Summer School, a sample daily agenda, a list of past and current instructors, and a detailed description of the activities.

This year the Summer School will be hosted by NCAR in Boulder, Colorado from July 16th - July 27th.
Application Forms can be found at http://www.bu.edu/cism/SummerSchool/application.html
Further information can be found at http://www.bu.edu/cism/SummerSchool/overview.html

Xue, Bingsen (China Meteorological Administration)
Poster Number: G-6

Poster – *Recent Progress in Space Weather Forecast in CMA*

Bingsen Xue

The new round of solar cycle provide us more opportunity to improve our technology of space weather forecasting. More information about solar activity, interplanetary disturbance, near earth environment was employed in practice routine job. In order to cope with large amount of data, an automatic access system was built to browse and compare a variety of photos, analysis the revolution and trend of parameters, help the forecaster to make decision and even help in the production and releasing process. Many algorithms were also implied in forecasting practice, such as solar flare alerting system which predict the peak flux of flare 10-20 minutes earlier, energetic electron prediction software which employ the radiation belt index of SWPC and ANN algorithm. The joining of data from Chinese satellite and ground base data also help to improve our capability of forecasting.

Yue, Xinan (UCAR/COSMIC)
Poster Number: I-9

Poster – *Global Ionospheric Electron Density Reanalysis by Multi-Source Data Assimilation*

Xinan Yue, William S. Schreiner, Ying-Hwa Kuo

In this paper, a global ionospheric data assimilation model is developed using Kalman filter method. A data process function of both ground and LEO satellite based GNSS observations is nested in this assimilation model. We then reanalyzed the monthly global ionospheric electron density during 2002-2011 by assimilating the quiet days observations from ground based GNSS stations, GPS observations from CHAMP, GRACE, COSMIC, SAC-C, Metop-A, and TerraSAR-X satellites, and nadir vertical TEC from Jason-1/2 altimeters, into the IRI model. The output is 3-D gridded electron density with temporal and spatial resolutions of 1 hour in universal time, 5o in latitude, 10o in longitude, and ~ 30 km in altitude. The climate features of the reanalysis results including solar activity variation, seasonal variations, and various anomaly accord well with the empirical models and observations. IGS GIM derived GEC, PFISR observed electron density profile during 2007-2010, and global Ionosonde network observed foF2 during 2002-2011 are used to make the independent evaluation. All the comparison results show that the reanalysis results have less deviations and bias in comparison with IRI predictions. Especially after April 2006, during when the six COSMIC satellites are launched, the reanalysis show big improvements on the IRI predictions. The obvious overestimation made by the IRI model during this solar minimum is corrected well by the assimilation. The reanalysis results can be used for ionospheric weather and climate monitoring and scientific research. It can be improved in the future by better model and observation error and ionospheric correlation representation, more available data, and higher spatial and temporal resolution.

Zanetti, Lawrence J. (Johns Hopkins University)
Poster Number: G-8

Poster – *Advanced Techniques for Space Weather Predictions*

L. J. Zanetti, R. E. Erlandson, M. Kelly, G. Ho, D. Haggerty, D. N. Baker, J. C. Kasper

The major grant funding agencies of NSF, NASA and the DoD have recognized this need for systems research to solutions of space weather problems and have over the past 10-15 years emphasized such an approach. Agencies that fund missions have also focused on observations critical to the understanding of space weather phenomena of the Sun-heliosphere-geospace and near-Earth space as a system, including routine broadcasts of real-time observations. Controversial proposals have also been put forth of possible connections of solar variability and long-term (centuries) climate change.

Advanced measurements, such as those on ACE and STEREO along with high and low altitude Geospace missions, are crucial for advances in research, modeling and future prediction capability. STEREO and ACE energetic particle research and chronograph images have proven the outstanding vantage points of L5 as well as L1 for space weather warnings; mission concepts are presented that will satisfy the real-time space weather requirements as well as provide advanced measurement techniques to verify models and to increase space weather storm warning times

Zhang, Yongliang (Johns Hopkins University)
Poster Number: I-4

Poster – *A Solar Wind and IMF Driven Empirical Model of Precipitating Electrons in Auroral Oval*

Yongliang Zhang, Larry J. Paxton, Hypsub Kil

Based on TIMED/GUVI auroral images, a new empirical auroral model is under development. This model is driven by solar wind and interplanetary magnetic field (IMF) through a dayside magnetic merging rate[Newell et al., 2007 JGR]. Preliminary results on the model outputs will be discussed. This model allows forecast of precipitating electrons for 30-60 minutes based on real time solar wind and IMF measurements from ACE satellite or days using simulated solar wind and IMF.

Zhong, Qiuzhen (National Space Science Center)
Poster Number: S-19

Poster – *SPE Warning Research Based on Real-Time Energetic Particles Flux Data from ACE Satellite*

Qiuzhen Zhong, Senlin Xiong, Yanmei Cui, Siqing Liu

Solar Proton Events (SPE) brought a significant radiation hazard to astronaut and spacecraft in space. An accuracy short-term SPE forecast model is meaningful to reduce the abundant radiation astronaut and spacecraft would suffer. We try to use the ACE satellite data to set a new SPE onset warning method and five-minute average real time integral energetic proton flux on GOES from Aug 7th 2001 to Feb 20th 2012 was utilized to check the model result. Five-minute average real-time integral energetic solar protons flux data (mainly above 10MeV) from ACE satellite and GOES in Solar Proton Events period was analyzed and correlation coefficients between two kinds of data were calculated. The best correlation coefficients were satisfactory and they shown that flux data from GOES have tens minutes up to several hours lag time than that from ACE. This new method own low false probabilities (11.7%) and fairly good SPE probabilities of detection (71.4%) in SPE onset forecast.

Zucca, Pietro (Trinity College Dublin)
Poster Number: S-10

Poster – *SolarMonitor.org: Providing access to Solar and Space Weather Data in Near-Realtime*

David Perez-Suarez, Paul A. Higgins, D. Shaun Bloomfield, Iain Billet, David O'Callaghan, Peter T. Gallagher

SolarMonitor.org is an online tool that gives solar scientists, instrument operations teams, space weather forecasters, and the general public, access to near-realtime solar and space weather data. The website includes full-Sun images of solar magnetic fields and emission in optical, UV, EUV, and X-ray wavelengths from various space- and ground-based observatories. It also provides characteristics of active regions as classified by NOAA, zoomed-in active region images, in-situ particle measurements from ACE, and X-ray time series from GOES. Recently, new capabilities have been added to SolarMonitor, including near-realtime characterization of coronal holes and active regions, current and predicted states of Earth's auroral oval, and active region flare forecasts. Furthermore, users can now use the full functionality of SolarMonitor.org from their portable devices.

Zucca, Pietro (Trinity College Dublin)
Poster Number: S-11

Poster –*Observations of Low Frequency Solar Radio Bursts from the Rosse Solar-Terrestrial Observatory*

P. Zucca, E. P. Carley, J. McCauley, P. T. Gallagher, C. Monstein, R. T. J. McAteer

The Rosse Solar-Terrestrial Observatory (RSTO; www.rosseobservatory.ie) was established at Birr Castle, Co. Offaly, Ireland (53 05'38.9", 7 55'12.7") in 2010 to study solar radio bursts and the response of the Earth's ionosphere and geomagnetic field. To date, three Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO) spectrometers have been installed, with the capability of observing in the frequency range 10-870 MHz. The receivers are fed simultaneously by biconical and log-periodic antennas. Nominally, frequency spectra in the range 10-400 MHz are obtained with 4 sweeps per second over 600 channels. Here, we describe the RSTO solar radio spectrometer set-up, and present dynamic spectra of a sample of Type II, III and IV radio bursts. In particular, we describe fine-scale structure observed in Type II bursts, including band splitting and rapidly varying herringbone features.