Space Weather Workshop

Millennium Hotel – Boulder, CO
April 8 - 11, 2014

Poster Abstracts

Adams, James (University of Alabama, Huntsville)

Poster Number: S1

Poster - *A Mission Planning Tool for Solar Energetic Particle Radiation*

Authors: J.H. Adams, Jr., Z.D, Robinson, M.A. Xapsos, C. Stauffer

Abstract: A tool will be described that provides a mission-specific reference solar energetic proton environment at a user-specified confidence level.

Azeem, Irfan (Atmospheric & Space Technology Research Associates (ASTRA))

Poster Number: I3

Poster - *OSSE Experiments to Determine the Value of Various Observing Systems for Ionosphere-Thermosphere Specification*

Authors: Irfan Azeem, Geoff Crowley, and Marcin Pilinski

Abstract: Assessments of the relative value of various observing systems can be made using techniques called Observing System Simulation Experiments (OSSE's) and Observing System Evaluations (OSE's). OSEs are used to simulate the exclusion or loss of various existing instruments, platforms or missions. OSSEs are undertaken to quantitatively assess the relative value and benefits of future observing capabilities and systems, and should be conducted prior to the acquisition of major Government-owned observing systems, including polar-orbiting and geostationary satellite systems. Each of these techniques relies on the idea that data from various instruments can be assimilated to provide improved specifications of atmospheric parameters. However, the value of the various instrument types or their location on the ground or in space may not be immediately obvious. These tools provide quantitative assessments of the impact of various measurements on atmospheric specification, as defined by various metrics.

ASTRA is developing software tools to quantitatively assess the impact of various measurements for both ionospheric and thermospheric specification. These tools can simulate ionospheric plasma density and thermospheric density measurements (and the corresponding uncertainties) from in-situ and remote sensing space-based and ground-based sensors, and then ingest them using assimilation algorithms. In particular, they can aid our understanding of how much an existing or proposed observing system will improve the performance of data assimilation algorithms. The impact of the measurements can be quantitatively assessed as instruments are added or removed from the simulation.

The first tool, called Prediction of Ionospheric Observations and Nowcasting Errors with Emulation of Results (PIONEER), simulates sensor measurements of ionospheric electron density, and ingests them into a global ionospheric electron density assimilation algorithm. Current simulation capabilities for the ionosphere include ground-based GPS TEC, beacon receivers, vertical and oblique ionosondes, backscatter sounders, IS radars, space-based in-situ, UV remote sensing and GNSS radio occultation. The second tool called Simulator for Atmospheric Neutral Density Experiments (SANDE) is currently under development. It will simulate sensor measurements of thermospheric neutral density and assimilate them into a global model to assess their relative value.

The PIONEER and SANDE tools have been designed to provide full simulation of the spatial and temporal distribution of existing and planned sensors and the corresponding data and uncertainties. These tools

provide the ability to perform quantitative assessments of the utility of existing and planned sensors for ionospheric and thermospheric density specification. ASTRA's OSSE/OSE tools are designed to be flexible so they can be used to examine the impact of observations on a particular application, or to give insight into their effectiveness in a data assimilation system.

In this paper, we will describe the system architecture for the PIONEER tool, and a case study to demonstrate its unique capability of performing assessments of the utility of existing and planned sensors for global and regional ionospheric specification for Space Situational Awareness. This kind of tool is vital for 'Analysis of Alternatives' exercises, and will help to maximize the utility of new sensors and ionospheric measurement systems, such as the planned COSMIC and other Radio Occultation missions. It could also save the government millions of dollars by preventing the purchase and deployment of unnecessary or redundant sensors that provide a low return on investment.

Behlke, Rico (Polar Science and Guiding)

Poster Number: I2

Poster - *Maritime user requirements at high latitudes - the MARENOR project*

Authors: R. Behlke and the MARENOR consortium

Abstract: The ionosphere at high latitudes is characterised by a great variety of spatial and temporal variations that influence radio signals. In addition to navigation solutions that are based on Global Navigation Satellite Systems (GNSS), satellite communication systems also suffer from ionospheric degradation. This is worsened by harsh weather conditions, insufficient coverage by geostationary satellites and the absence of land-based augmentation infrastructure.

Climate change will lead to a decrease in sea ice extent and thus to an increased use of trans-polar shipping routes, presence of gas and oil industries in the High Arctic and higher focus on Search-and-Rescue (SAR) as well as sovereignty issues. These moments usually require navigation and communication solutions that are accurate and reliable.

We describe requirements presented by industrial operators on and around Svalbard. In addition, we present the MARENOR project that aims on evaluating navigation and communication systems at high latitudes including first results.

Berdermann, Jens (German Aerospace Center)

Poster Number: I15

Poster - *Forecast System Ionosphere*

Authors: AFFECTS consortium

Abstract: A Forecast System Ionosphere (FSI) is developed as part of the FP7 AFFECTS project (Advanced Forecast For Ensuring Communication Through Space*, http://www.affects-fp7.eu/) led by University Goettingen. It is intended to reduce the impact of space weather phenomena on the functionality of space based navigation and communication systems. For this purpose, an early warning message for GNSS users and forecasts of expected ionospheric perturbations are deduced from solar, geomagnetic and ionospheric data in order to provide ionospheric predictions up to 24 hours in advance. In addition, a high latitude geomagnetic monitoring tool and profiles of the vertical electron complement the FSI. The FSI is developed as a subsystem of the Space Weather Application Center - Ionosphere (SWACI) service (http://swaciweb.dlr.de/), running at the DLR in Neustrelitz, using its approved infrastructure. AFFECTS partners are contributing to the FSI either by provision of data or by delivering processing modules. Here we present the fully operational FSI system, its architecture and outputs disseminated via the SWACI-AFFECTS webpage http://swaciweb.dlr.de/affects/ .

Berger, Thomas (National Solar Observatory)

Poster Number: S12

Poster - *The Daniel K. Inouye Solar Telescope: a Space Weather Microscope*

Authors: Thomas Berger, Thomas Rimmele, David Elmore, Friedrich Woeger, Alexandra Tritschler, Kevin Reardon

Abstract: The Daniel K. Inouye Solar Telescope (DKIST, formerly the Advanced Technology Solar Telescope) is a 4-meter class solar telescope under construction on the island of Maui, Hawaii. The DKIST is designed for advanced polarimetric measurements of the solar atmosphere and will revolutionize our ability to measure magnetic fields from the photosphere out to 1.3 Solar radii in the corona. The DKIST will come on-line for full service mode operations in mid-2019 with five first light instruments: the Visible Broadband Imager (VBI) for high spatial (20 km) and temporal (30 Hz) resolution imaging of the solar atmosphere; a Visible Spectropolarimeter (ViSP) for sensitive and accurate multi-line spectropolarimetry; a Fabry-Perot Visible Tunable Filter (VTF) for high-spatial resolution spectropolarimetry; a fiber-fed Diffraction-Limited Near-Infrared Spectropolarimeter (DL-NIRSP); and a Cryogenic Near-Infrared Spectropolarimeter (Cryo-NIRSP) for coronal magnetic field measurements and on-disk observations at 4.7 microns. We are particularly interested in discussing the key measurements and operational modes of the DKIST that may benefit Space Weather research and ultimately aid in the prediction of large eruptive events.

Bisi, Mario Mark (Science and Technology Facilities Council)

Poster Number: S10

Poster - *Using Remote-Sensing Radio Observations of the Inner Heliosphere for Space Weather Science and Operations*

Authors: Mario M. Bisi, Bernard V. Jackson, Richard A. Fallows, Munetoshi Tokumaru, Barbara J. Thompson, Elizabeth A. Jensen, Lan Jian, Hsiu-Shan Yu, Ji-Hye Lee, Jung-Hoon Kim, Richard A. Harrison, Michael A. Hapgood, Chin-Chun Wu, Jackie A. Davies, Periasamy K. Manoharan, David R. Jackson, and P. Paul Hick.

Abstract: For several recent space-weather events, there has generally been little sign of an impending geoeffective large-scale heliospheric structure until it has reached the near-Earth environment. In addition, some of these space-weather events have been associated with relatively-small coronal mass ejection (CME) 'like' structures perhaps also complicated or enhanced by stream-interaction and/or co-rotating features (for example, the late-May/early-June 2013 geomagnetic storm and the recent 15-20 February 2014 events and resulting geomagnetic storm). We will present analyses of a selection of these space-weather events (showing observations of the background solar wind and CMEs etc...) including use of the University of California, San Diego (UCSD) three-dimensional (3-D) time-dependent computer-assisted tomography (CAT) routines. Over the past few years, significant progress has been made on the implementation and science of interplanetary scintillation (IPS) radio remote-sensing observations of the inner heliosphere using various radio-telescope systems located around Earth's northern hemisphere. Here, we will primarily present results from the UCSD 3-D CAT of the Solar-Terrestrial Environment Laboratory (STELab), Japan, IPS data along with, where data are available, additional targeted individual observations of IPS from other IPS-capable systems. The overall aim is to ascertain how well current IPS methods can be used for space-weather forecasting, particularly for events that are poorly forecasted by other methods. These events were generally unremarkable in coronagraph white-light observations; and considered to have little Earth-affecting potential. Beyond the coronagraph fields of view, however, their geoeffective potential was seemingly enhanced. As many forecasting models rely on coronagraph data, this may explain why such geoeffective events were then seemingly missed.

Budzien, Scott (Navel Research Laboratory)

Poster Number: I9

Poster – *GROUP-C and LITES Experiments for Ionospheric Remote Sensing aboard the ISS*

Authors: Andrew Stephan, Steven Powell, Supriya Chakrabarti

Abstract: Ionospheric irregularities, also known as ionospheric bubbles, are transient features of the low and middle latitude ionosphere with important implications for operational systems. Understanding irregularity formation, development, and evolution is vital for efforts within NASA and DoD to forecast scintillation. Irregularity structures have been studied primarily using ground-based systems, though some spaced-based remote and in-situ sensing has been performed. An ionospheric observatory aboard the International Space Station (ISS) would provide new capability to study low- and mid-latitude ionospheric structures on a global scale. The GPS Radio Occultation and Ultraviolet Photometry Colocated (GROUPC) and the Limb-imaging Ionospheric and Thermospheric Extreme-ultraviolet Spectrograph (LITES) experiments are being considered for flight aboard the Space Test Program Houston 5 (STP-H5) experiment pallet. By combining for the first time high-sensitivity in-track photometry with vertical ionospheric airglow spectrographic imagery, we demonstrate that high-fidelity optical tomographic reconstruction of bubbles can be performed from the ISS. Ground-based imagery can supplement the tomography by providing all-sky images of ionospheric structures (e.g. bubbles and TIDs) and of signatures of lower atmospheric dynamics, such as gravity waves, that may play a role in irregularity formation. The optical instrumentation can be augmented with additional sensors to provide measurements of scintillation and in situ plasma density, composition, and drifts.

Cash, Michele (NOAA Space Weather Prediction Center)

Poster Number: S17

Poster - *Ensemble Modeling of the July 23, 2012 CME Event*

Authors: M.D. Cash, D. Biesecker, G. Millward, C.N. Arge, and C. Henney

Abstract: On July 23, 2012 a large and very fast coronal mass ejection (CME) was observed by STEREO A. This CME was unusual in that the estimates of the speed of the CME ranged from 2125 km/s to 2780 km/s based on dividing the distance of STEREO A from the Sun by the transit time of the CME. Modeling of this CME event with the WSA-Enlil model has also suggested that a very fast speed is required in order to obtain the correct arrival time at 1 AU. We present a systematic study of parameter space for the July 23, 2012 CME event through an ensemble study using the WSA-Enlil model to predict the arrival time of the CME at STEREO A. We investigate how variations in the initial speed, angular width, and direction affect the predicted arrival time. We also explore how variations in the background solar wind influence CME arrival time by using varying ADAPT maps within our ensemble study. Factors involved in the fast transit time of this large CME are discussed and the optimal CME parameters are presented.

Crowley, Geoff (Atmospheric & Space Technology Research Associates (ASTRA))

Poster Number: I20

Poster - *Traveling Ionospheric Disturbances Across North America from GPS TEC Measurements*

Authors: Irfan Azeem and Adam Reynolds

Abstract: Traveling Ionospheric Disturbances (TIDs) are perturbations in ionospheric electron density caused by gravity waves traveling through the thermosphere from their source region. TIDs are ubiquitous in the ionosphere. Two main classes of TIDs are generally recognized: (a) Medium Scale TIDS (periods of 10-30 minutes, horizontal velocities of 100-300 m/s, horizontal wavelength of several hundred km), and;

(b) Large Scale TIDs (τ > 30 min, VH = 300 to 1000 m/s, and λH > 1000 km). In spite of this classification system, relatively little is known about their climatology or propagation characteristics.

ASTRA developed the 'TIDDBIT' HF sounder for mapping TIDs in the F-region ionosphere. The complete characterization of the waves from the TIDDBIT system (amplitudes, horizontal phase speeds, wavelengths, and propagation direction, vertical phase speeds all as a function of wave period) makes it possible to reconstruct the vertical displacement of radio reflection surfaces over the 200-km horizontal dimension of the sounder array. Because the TIDDBIT system measures the relative phases of each TID component, as well as the other TID parameters, a dynamic image can be constructed showing how the HF reflection surfaces are perturbed as a function of time.

ASTRA has used GPS-Total Electron Content (TEC) measurements to identify TIDs, and then used the TIDDBIT analysis software to characterize the TID spectrum and horizontal propagation characteristics. The same waves can sometimes be seen from one side of the US to the other. A time-lapse movie of the TEC perturbations in one event reveals TIDs propagating across the US towards the south-east for several hours. ASTRA used GPS receivers in Florida to identify the wave characteristics, using an analysis technique based on the TIDDBIT analysis algorithms.

We report observations of TIDs in TEC from several events, including measurements from ASTRA's CASES GPS-TEC receivers from Boulder, CO. CASES stands for Connected Autonomous Space Environment Sensor and is being produced by ASTRA as a low-cost, stand-alone, and autonomous dual frequency GPS space-weather monitoring station. It is capable of providing fully processed outputs such as scintillation severity indicators S4, τo, $\sigma\phi$, and TEC with a relative accuracy of a few 0.01 TECU. These observations of TIDs are corroborated by TEC measurements from multiple Continuously Operating Reference Station (CORS) GPS sites across the US. This paper will describe the propagation characteristics of the observed TIDs and their spatial morphology as observed in TEC measurements from distributed GPS receivers.

De Nardin, Clezio M (INPE)

Poster Number: I19

Poster - *Space weather products from the user requests to the development of regional magnetic indices and GNSS vertical error maps*

Authors: C. M. Denardini, J. E. R. Costa, H. Takahashi, O. Mendes Jr., N. SantAnna, R. Gatto, J. R. de Souza, A. L. Padilha, I. S. Batista

Abstract: On August 2007 the National Institute for Space Research started a task force to develop and operate a space weather program, which is kwon by the acronyms Embrace that stands for the Portuguese statement "Estudo e Monitoramento BRAasileiro de Clima Espacial" Program (Brazilian Space Weather Study and Monitoring program). The main purpose of the Embrace Program is to monitor the space climate and weather from sun, interplanetary space, magnetosphere and ionosphere-atmosphere, and to provide useful information to space related communities, technological, industrial and academic areas. Since then we have being visiting several different space weather costumers and we have host two workshops of Brazilian space weather users at the Embrace facilities. From the inputs and requests collected from the users the Embrace Program decided to monitored several physical parameters of the sun-earth environment through a large ground base network of scientific sensors and under collaboration with space weather centers partners. Most of these physical parameters are daily published on the Brazilian space weather program web portal, related to the entire network sensors available. A comprehensive data bank and an interface layer are under development to allow an easy and direct access to the useful information. Nowadays, the users will count on products derived from a GNSS monitor network that covers most of the South American territory; a digisonde network that monitors the ionospheric profiles in two equatorial sites and in one low latitude site; several solar radio telescopes to monitor solar activity, and a magnetometer network, besides a global ionospheric physical model. Regarding outreach, we publish a daily bulletin in Portuguese with the status of the space weather environment on the Sun, in the Interplanetary Medium and

close to the Earth. Since December 2011, all these activities are carried out at the Embrace Headquarters, a building located at the INPE's main campus. Recently, we have released brand new products, among them, some regional magnetic indices and the GNSS vertical error map over South America.

Du, Dan (CMA)

Poster Number: O2

Poster - *Space Weather Services in CMA*

Authors: Dan Du, Xiaoxin Zhang, Guanglin Yang

Abstract: The activity of space weather is conducted by the National Centre for Space Weather (NCSW) which is another role of the National Satellite Meteorological Centre of CMA. Space weather service plays an important role in relationship between space weather operation and its customers. According to the meteorological service classification in CMA, space weather services are classified into 3 categories: governmental services, public services and professional services. We have formed the service framework consisting of decision-making service, specific service, public service and user training. In the past ten years, we have provided all sorts of services, such as services for FY-2/3 series satellite launching and in orbit, Chang'e 1, Shenzhou 7/8, Tiangong 1, Beidou System, Communications Satellites, and "Wenchuan" earthquake. Especially during Shenzhou 7 mission, we successfully forecasted the time window for the space walk. Our services provide more and more important support for the social-economic development and national security of China. Based on the users' requirement for space weather we will develop prompt, regular, and specialized space weather services to improve our service ability to prepare for, avoid, mitigate, respond to, and recover from the potentially devastating impacts of space weather events on our health, economy, and national security.

Dziak-Jankowska, Beata (Space Research Centre PAS)

Poster Number: O3

Poster - *The possibility of forecasting sporadic E layer appearance*

Authors: Beata Dziak-Jankowska, Iwona Stanislawska, Mariusz Pozoga, Lukasz Tomasik, Tomasz Ernst

Abstract: The statistic concerning the accuracy of the forecast of sporadic E layer appearance on the basis of the magnetic eta index is presented. The eta index is defined as the square root of a ratio of the energy of the external part of the vertical component to that of the horizontal components. The values of eta typical ranged between 0 and 0.1 sometimes exceeds 1 or even higher values which means that the changes of the vertical component of magnetic field is larger than the changes of the horizontal magnetic field components. In most cases when eta index indicate some magnetic disturbances other magnetic indices (i.e. Kp, Dst) inform about quiet conditions. The occurrence of eta variations in quiet days suggests that the source of these magnetic disturbances is in the ionosphere. Our previous results show the increase of eta value emerges 1-2 hours before the sporadic E layer appearance. The analysis was performed for 8 pairs of ionosondes and magnetic observatories in Europe. The smaller distance between the magnetic and ionospheric observatories the better correlation between the eta index and the sporadic E layer occurrence. The previous work was performed for 3 years of prolonged solar minimum. This work presents the statistics for years 2011-2013 for Warsaw ionosonde and Belsk Magnetic Observatory. Real time magnetic data from Belsk give the possibility for on-line calculation of magnetic eta index and having information about ionospheric drifts. The autocovariance method for forecasting of the changes of eta index and in this connection for forecasting of sporadic E layer appearance was implemented. The study of the results of forecasting the sporadic E layer appearance will be presented.

Dziak-Jankowska, Beata (Space Research Centre PAS)

Poster Number: I16

Poster - *Regional Warning Centre Warsaw report and future perspectives*

Authors: Beata Dziak-Jankowska, Iwona Stanislawska

Abstract: Heliogeophysical prediction service of the Space Research Centre, operating within the global ISES system, is responsible for measurements and predictions of solar activity and related Earth phenomena.

Methods and algorithms linked directly to the radio-communication prediction and forecast domain are developed and continuously improved. The fully operational real time Vertical Total Electron Content monitoring softwarte has been developed. The data source are selected GNNS stations and EGNOS RIMS stations. The database was used for the new global expanded version of W-index, and for clonning missing ionospheric values like foF2 or M3000F2. The database can be used also for monitoring traveling ionospheric disturbances (TID), and prediction of TEC variations particularly in EGNOS boundaries.
The variability of ionospheric parameters: foF2, hmF2, M3000F2, B0, B1 for middle latitude over Warsaw were analysed. For this study Warsaw ionosonde measurements since January 2009 to the end of 2012 were used. Specific term enabled to analyse ionospheric parameters in different conditions of solar activity. Selected data were modelled by International Reference Ionosphere IRI 2012 model. Analysis contained: trend, month median differences in twenty-four-hour variability, local minimums and maximums of specified parameters and IRI submodels. The results of the study will enable to use the IRI submodels to prepare more accurate local and global ionospheric maps in the event of lack of parameters, and the more effective forecasts and predictions of ionospheric conditions.

The new ionosonde have been developed for use in propagation research and associated studies of the ionosphere. The ionosonde is known as CZAPLA and will be installed in OPN-T in Olsztyn. It is a twin unit of Warsaw ionosonde so the GPS time synchronised shot allows to proceed oblique sounding.
The ionosond İs known as CZAPLA and will be installed in OPN-T in Olsztyn. It is a twin unit of Warsaw ionosonde so the GPS time synchronized shot allows to proceed oblique sounding.

The ionosonde works with standard two delta antennas 18 meters high. Due to short distance between Olsztyn and Warsaw and designed propagation pattern the oblique sounding does not require additional antennas set.

The impact of various space weather phenomena is studied. The forecast of sporadic E layer occurring locally and sometimes nontransparent is the crucial topic for radio communication. We propose the method of forecasting sporadic E layer appearance. This method is based on magnetic data and the changes of magnetic Eta parameter defined as the square root of a ratio of the energy of the external part of the vertical component to that of the horizontal components.

The best correlation of sporadic E layer appearance occurs 1-2 hours after the increase of Eta value. The correlation between data from different European ionosondes and data from magnetic observatories lying close to the selected ionosonde was taken into account. We apply auto covariance method for prediction of the Eta index variations and in this connection the sporadic E layer appearance.

In connection with the 24th solar maximum our laboratory reacts on every public need for clarification of extreme events. We respond to questions from reporters and write announcements on social networking of our Institute.

Engell, Alec (Flare Forecast)

Poster Number: S7

Poster - *A comprehensive approach to reliable solar flare and solar energetic particle forecasting with results*

Authors: Piet Martens, Michael Schuh, Rafal Angryk, and Gary Gannon

Abstract: By utilizing a wide range of solar observations and data products combined with data mining and machine learning techniques Flare Forecast LLC has successfully produced solar flare (R1-R5) on par with current standards from NOAA and solar energetic particle (S1-S5) forecasts. We present our general approach with skill scores for both solar flare and SEP forecasts, and a proposed forecast panel with threat gauges for radio blackout storms (R1-R5) and solar radiation storms (S1-S5) is presented for feedback by the space-weather affected community. As a commercial company, we emphasize our ability to create custom forecasts for specific client needs far exceeding the limited scope of current publicly available forecasts. Through real-time forecasting of major historical events, we showcase our forecasting ability under a wide range of custom scenarios of interest to varying space-weather affected industries.

Fontenla, John (NorthWest Research Associates)

Poster Number: I17

Poster - *Solar EUV Radiation Forecast System*

Authors: SERFS Team

Abstract: We show the latest update on the SERFS system status and comparisons with recent observations of EUV solar spectral irradiance, from SDO/EVE, absolute values and rotational modulation during 2012. Also, comparison is shown of the SEM-like index, from Space Environment Technologies (SET), during 2012, and our website at http://www.galactitech.net/John/SERFS/Images/ is currently providing some images and irradiance data for current dates. These data are based on current SDO/AIA images.

Far-side input data and results are also shown, and enable the forecast of the EUV irradiance for about 2 weeks.

Gannon, Jennifer (Geosynergy, LLC)

Poster Number: M1

Poster - *Geosynergy Hazard Analysis*

Authors: Jennifer Gannon, Janet Green, and Anna Olsen

Abstract: Geosynergy specializes in the fields of space-weather physics and earthquake engineering. These distinct disciplines share a common interest in the effects of natural phenomena on the built environment. Earthquakes damage buildings and infrastructure, causing casualties and interruption of economic activities. Space weather can disrupt electricity-transmission systems, causing transformer failures and power outages.

Gopalswamy, Nat (NASA / Goddard Space Flight Center)

Poster Number: S19

Poster - *The Empirical Shock Arrival Model: Testing with STEREO and SOHO Data*

Authors: Pertti Mkel, Hong Xie, and Seiji Yashiro

Abstract: The empirical shock arrival (ESA) model was developed based on two-point observations, one near the Sun (coronagraph) and the other in the solar wind (in situ) such that the same section of a coronal mass ejection (CME) is sampled. This was possible because of quadrature configuration between P-78 (coronagraph) and Helios (in-situ) to predict the Sun-Earth travel time of CMEs [Gopalswamy et al. 2005a]. The ESA model requires earthward CME speed as input, which is not directly measurable from coronagraphs located along the Sun-Earth line. The SOHO and STEREO spacecraft were in quadrature during 2010 - 2012, which provided earthward speed of many CMEs because of the off-the-Sun-Earth-line view. For a set of 20 full halo CMEs in the field of view of SOHO we obtained the earthward speed from

STEREO coronagraphs and used as input to the ESA model. We compared the travel times observed by the L1 monitors with the ESA model results. The mean absolute and RMS errors of the ESA model prediction are 7.3 and 9.3 h, respectively, which are virtually the same as those of the WSA-ENLIL model (7.3 and 9.1 h). We also find that CME-CME and CME-coronal hole interaction can lead to large deviations from model predictions.

Hong, Sunhak (Korean Space Weather Center)

Poster Number: S15

Poster - *Sunspot Identification and Classification Capability of the Automatic Solar Synoptic Analyzer*

Authors: Sunhak Hong, Yung-Kyu Kim, Jae-Hun Kim, and Ki-Chang Yoon

Abstract: We have developed a software system of the Automatic Solar Synoptic Analyzer (ASSA) that makes real-time monitoring and identification of sunspot groups, coronal holes and filament channels, those are three major solar sources causing the space weather. In this paper, we present the ASSA's sunspot identifying and classification capabilities and its performances by analyzing the ASSA sunspot catalog, which was automatically generated by ASSA with SOHO MDI Continuum and Magnetogram images from September 1996 to January 2011, that is fully covering the Solar Cycle 23. For the period, we compared the ASSA Wolf number with the International Sunspot Number and the F10.7 solar radio flux as well. The ASSA Wolf number follows very well the curve of the International Sunspot Number and reproduces well the variation of the F10.7 solar radio flux especially in the solar maximum. We also investigated the sunspot classification rates and the flare probabilities according to the McIntosh and Mt. Wilson classification and compared between the data from ASSA sunspot catalog and NOAA's.

Huston, Stuart (AER, Inc.)

Poster Number: M11

Poster - *Near-Real-Time Low-Altitude Radiation Belt Specification*

Authors: Stuart Huston

Abstract: The 'tiger plots' based on near-real-time data from the POES/MetOp spacecraft are a widely used data product. These plots display count rates from the POES/MetOp SEM-2 instruments as a function of latitude and longitude and provide a picture of the state of particle fluxes at low altitudes. The plots are strictly valid only near the POES/MetOp altitudes of around 800 km, however, limiting their usefulness for spacecraft operating at lower altitudes. We present a technique for mapping the POES/MetOp measurements to other altitudes, a technique which would enhance this already valuable data product. We also discuss possible further extensions to the method.

Jackson, Bernard V. (University of California at San Diego)

Poster Number: S11

Poster - *ASHI – A light-weight All Sky Heliospheric Imager Design for the DISCOVR follow-on*

Authors: B.V. Jackson, A. Buffington, P.P. Hick, H.-S. Yu, and Mario M. Bisi

Abstract: The zodiacal-light photometers on the twin Helios spacecraft, the Solar Mass Ejection Imager (SMEI) on the Coriolis spacecraft, and the Heliospheric Imagers (HIs) on the Solar-TErrestrial RElations Observatory (STEREO) twin spacecraft all point the way to optimizing future remote-sensing Thomson-scattering observations from deep space. In the future, such a light-weight instrument could be provided by two very wide-angle (hemispheric) viewing systems incorporated with other instrumentation at L1 on the DISCOVR follow-on. The specifications for this instrument system include viewing the whole sky from a few degrees of the Sun, to as near anti-solar as the Moon and Earth permit from L1, with an instrument

mass of about 2.5 kg per system and ten minute integration times. Moreover, to enable useful 3-D reconstructions of solar mass ejections and co-rotating structures from the imaging system's data, a key photometric specification is 0.1% differential photometry in a one square degree sky bin. Here, we review this instrument and the optics and baffle techniques that enable this light-weight system.

Ji, Eun-Young (Kyung Hee University)

Poster Number: S5

Poster - *Forecast of solar proton flux profiles for well-connected events*

Authors: Yong-Jae Moon

Abstract: We have developed a forecast model of solar proton flux profile (> 10 MeV channel) for well-connected events. For this study, we select 49 well-connected solar proton events (SPEs) among 136 SPEs from 1986 to 2006. The well-connected SPEs are all associated with single X-ray flares stronger than M1 class and start to increase within four hours after their X-ray peak times. These events show rapid increments in proton flux. By comparing several empirical functions, we select a Weibull function, which is similar to the injection rate of particle at the solar corona, to approximate a SPE flux profile. The parameters (peak value, rise time and decay time) of this function are determined by the relationship between X-ray flare parameters (peak flux, impulsive time, and emission measure) and SPE parameters. For 49 well-connected SPEs, the linear correlation between the predicted proton peak flux and the observed one is 0.63 with the RMS error of 0.57 (log10 pfu). In addition, we determine another forecast model based on flare and CME parameters using 22 SPEs. The used CME parameters are linear speed and angular width. As a result, we find that the linear correlation between the predicted proton peak flux and the observed one is 0.83 with the RMS error of 0.35 (log10 pfu). Our study shows that it is crucial to determine CME parameters for the forecast of SPE flux profiles in near real time.

Kalafatoglu Eyiguler, Emine Ceren (ITU/ NASA-GSFC)

Poster Number: I7

Poster - *Quantifying Storm Effects on the Thermospheric Neutral Density Using Orbital Averages on Champ Satellite Track*

Authors: Ja Soon Shim, Maria M. Kuznetsova

Abstract: Validation of storm-time neutral densities holds crucial importance for both research and operational point of view as neutral densities affect the atmospheric drag acting on satellites on Low Earth Orbit. In this study, we investigate the global response of the ionosphere-thermosphere system to the geomagnetic storms by taking orbital averages of the modeled and observed neutral densities on CHAMP satellite track for all GEM-CEDAR events. GEM-CEDAR events chosen for the study include three very quiet days (Kpmax≤1) as well as four minor, two moderate, and two severe storm events paving the way for quantification according to the activity levels. We use readily available ionosphere-thermosphere model runs performed by the CCMC (Community Coordinated Modeling Center) as well as results provided by modelers (e.g., NRLMSIS) for the investigation. We find that quiet time climatology should be eliminated in order to better determine the actual storm-time response.

Kalegaev, Vladimir (Moscow State University/Skobeltsyn Inst. of Nuclear Physics)

Poster Number: O4

Poster - *Space Monitoring and Prediction Center at SINP MSU*

Authors: V. V. Kalegaev, I.N. Myagkova, W. O. Barinova, O. G. Barinov, S.Yu. Bobrovnikov, S.A. Dolenko, L.R. Mukhametdinova, V.R. Shiroky, and Yu.S.Shugay

Abstract: Space monitoring data center at Moscow State University provides operational information on radiation state of the near-Earth space. Internet portal http://swx.sinp.msu.ru/ gives access to the actual data characterizing the level of solar activity, geomagnetic and radiation conditions in the magnetosphere and heliosphere in the real time mode. Operational data coming from space missions (ACE, GOES, ELECTRO-L1, Meteor-M1) at L1, LEO and GEO and from the Earth's surface are used to represent geomagnetic and radiation state of near-Earth environment. The models of space environment working in autonomous mode are used to represent geomagnetic and radiation state of near-Earth environment. The models of space environment working in autonomous mode are used to generalize the information obtained from observations on the whole magnetosphere. Interactive applications and operational forecasting services are created on the base of these models. They automatically generate alerts on particle fluxes enhancements above the threshold values, both for SEP and relativistic electrons using data from LEO orbits. Special forecasting services give short-term forecast of SEP penetration to the Earth magnetosphere at low altitudes, as well as relativistic electron fluxes at GEO. Velocities of high speed streams in solar wind on the Earth orbit are reconstructing with advance time of 3-4 days on the basis of automatic estimation of the coronal hole areas detected on the images of the Sun received from the SDO satellite. By means of neural network approach Dst and Kp indices online forecasting at 0.5-1.5 hours forward depending on solar wind and the interplanetary magnetic field, measured by ACE satellite is carrying out. Visualization system allows to represent experimental and modeling data in 2D and 3D.

Kelly, Andrew (Bureau of Meteorology, Australia)

Poster Number: O5

Poster - *Lessons learnt from forecast verification at IPS*

Authors: Andrew Kelly, Matthew Francis

Abstract: Forecast verification is an important tool for assessing the reliability of space weather forecasts, for comparing different forecast methods and for improving forecasts over the longer term.

A number of IPS space weather forecast products have recently been subjected to forecast verification, with mixed results.

As a result of this exercise, it has become apparent that the applicability and usefulness of forecast verification depends on the forecasts being verified having certain attributes. The meaning of a forecast must be well-defined, so that it is possible to determine whether the forecast was correct. Observations must be compatible with forecasts so they can be compared. It is difficult to verify forecasts of events that occur rarely. For a forecast method to be improved, it must be deterministic (objective and repeatable).

Lessons learned from forecast verification efforts will influence future IPS products and hasten a shift from human-based to model-based forecasts.

Kilcommons, Liam M (University of Colorado, Boulder)

Poster Number: M8

Poster - *Multi-Instrument Near-Simultaneous Vector Magnetometer Measurements and Response To Solar Wind Drivers: Space Technology 5 and DMSP*

Authors: Liam Kilcommons, Delores Knipp, and Rob Redmon

Abstract: Space-based magnetometer measurements of high-latitude regions are a vital tool for understanding the electrodynamics and heating mechanisms of the low-earth orbit environment. NASA's Space Technology 5 (ST5) mission was launched in March 2006 into a highly inclined, high eccentricity orbit. The three spacecraft, flying one after another in a pearls-on-a-string configuration, provide 90 days of high quality magnetometer data, which has already provided groundbreaking insight into the variability of magnetic perturbations over short time scales (Slavin et al., 2008, Le et al., 2009; Wang et al., 2009,

Gjerloev et al., 2011). We demonstrate a new conjunction-finding tool, which works in concert with the Modified Apex coordinate system (Richmond, et. al. 1995). This tool allows us to determine instances of magnetic co-location of spacecraft from each constellation and compare near-simultaneous measurements for validation purposes (Knipp et al., 2014). We present a study of the magnetic perturbations from "magnetic conjunctions" of ST5 and Defense Meteorology Satellite Program (DMSP) spacecraft. We compare perturbation responses to several types of solar wind forcing, finding agreement between DMSP and ST5 to be quite good.

Kozarev, Kamen A. (Harvard-Smithsonian Center for Astrophysics)

Poster Number: S6

Poster - *Towards Obtaining Early-Stage SEP Spectra from High-Cadence EUV Coronal Shock Imaging*

Authors: Kamen Kozarev, John Raymond, and Michael Hammer

Abstract: Recent advances in space-based solar observing have enabled unprecedented access to high-cadence, high-resolution observations of the coronal dynamics. This is extremely important, since transient phenomena in the corona usually cover multiple scales - from the current spatial resolution limit in the case of reconnection, to several solar radii in the case of coronal waves and mass ejections. The latter are also thought to drive shocks in the corona, which in turn have been shown capable of accelerating protons, electrons, and other species up to GeV energies in a matter of tens of minutes. These solar energetic particles (SEPs) are a prime source of space weather. Historically, it has been notoriously difficult to extract information about energetic particle spectra in the corona, due to the lack of in situ measurements. It is possible, however, to use remote observations in order to deduce coronal shock dynamics and related particle spectra, with some reasonable assumptions. We present an effort towards estimating coronal SEP spectra in the early stages of real CME events, based on a combination of fast-cadence extreme ultraviolet imaging (from the SDO/AIA instrument), potential coronal magnetic field models, and time-dependent modeling of diffusive shock acceleration. The ultimate goal for this framework is to give predictions for early-stage SEP spectra for various source populations and coronal turbulence levels. It is designed in a modular fashion, and may be adapted for near real time use. This system can be applied for early warning and predicting the severity of the impulsive early stages of SEP events.

Krista, Larisza D. (NOAA/SWPC)

Poster Number: S14

Poster - *Study of the recurring dimming region detected at AR 11305 using the Coronal Dimming Tracker (CoDiT)*

Authors: Larisza D. Krista, Alysha A. Reinard

Abstract: We present a new approach to coronal dimming detection using the COronal DImming Tracker tool (CODIT), which was found to be successful in locating and tracking multiple dimming regions. This tool, an extension of a previously developed coronal hole tracking software, allows us to study the properties and the spatial evolution of dimming regions at high temporal and spatial cadence from the time of their appearance to their disappearance. We use the SDO/AIA 193 A wavelength observations and HMI magnetograms to study dimmings. As a demonstration of the detection technique we analyzed six recurrences of a dimming observed near AR 11305 between 29 September - 2 October 2011. The dimming repeatedly appeared and formed in a similar way, first expanding then shrinking and occasionally stabilizing in the same location until the next eruption. The dimming areas were studied in conjunction with the corresponding flare magnitudes and CME masses. These properties were found to follow a similar trend during the observation period, which is consistent with the idea that the magnitude of the eruption and the CME mass affect the relative sizes of the consecutive dimmings. We also present a hypothesis to explain the evolution of the recurrent single dimming through interchange reconnection. This process would accommodate the relocation of quasi-open magnetic field lines and hence allow the CME flux rope

footpoint (the dimming) to expand into quiet Sun regions. By relating the properties of dimmings, flares and CMEs we improve our understanding of the magnetic field reconfiguration caused by reconnection.

Kubo, Yuki (National Institute of Information and Communications Technology)

Poster Number: S13

Poster - *Development of new solar radio telescope in NICT*

Authors: Yuki Kubo, Shinichi Watari, Mamoru Ishii, Hiromitsu Ishibashi, and Kazumasa Iwai

Abstract: Solar radio burst is one of the most important events for not only space weather forecasting but also investigating high-energy phenomena in solar corona. The GHz solar radio waves are synchrotron radiation emitted by high energy electrons at lower corona. On the other hand, the MHz solar radio bursts, especially type II and III bursts, are radiated via mode conversion of Langmuir waves excited by high energy electrons. These high energy electrons are accelerated at reconnection regions in solar flare and shock waves in solar corona. Therefore, MHz and GHz solar radio waves are closely related each other through the accelerated high energy electrons. So, wide frequency range (MHz to GHz) radio wave observations with high time resolution are required to comprehensively understand high energy phenomena in solar corona. We have been operating solar radio spectrograph called HiRAS for over twenty years in Hiraiso Solar Observatory, National Institute of Information and Communications Technology (NICT), but the system has been decrepit and radio wave environment in Hiraiso is getting worse. So, we have developed a new solar radio telescope in Yamagawa radio observation facility, NICT. The system has very wide frequency range (70MHz-9GHz) and very high time resolution (8 msec). In this presentation, we introduce status in progress for our new solar radio telescope.

Kuznetsova, Maria M. (NASA / Goddard Space Flight Center)

Poster Number: O8

Poster - *Innovative Space Weather Tools for CME analysis, Modeling, and Community Model Validation at CCMC/SWRC*

Authors: R. E. Mullinix, C. P. Wiegand, M. L. Mays, J. Lasota, M. Maddox, M. Kuznetsova, A. Pulkkinen, A. Chulaki, P. Macneice, and A. Taktakishvili

Abstract: An important objective of the Community Coordinated Modeling Center (CCMC) is to prototype, validate, and compare various methods for CME arrival predictions. As such, CCMC has developed three CME specific tools with the goal of facilitating advanced analysis and collaboration within the space weather community. The three tools we highlight in this paper are: Stereo CME Analysis Tool (StereoCAT), WSA-ENLIL-Cone Fast Track, and Space Weather Scoreboard. These three tools allow making CME measurements, executing custom space weather model runs, and providing a systematic way for the scientific community to record and score predictions and forecasts both prior to, and after CME arrivals at 1 AU.

By using our Stereo CME Analysis Tool (StereoCAT), scientists can quickly calculate CME kinematic properties. With a few mouse clicks, StereoCAT triangulates between satellite imagery (StereoA, StereoB, SOHO) to calculate CME direction, speed and opening angle. In addition to single measurements, StereoCAT can create an ensemble of measurements. The derived CME parameters can subsequently be used by the scientist in either their own models, or they can be entered into the WSA-Enlil-Cone Fast Track tool, which will execute a custom simulation based on the parameters produced by StereoCAT. WSA-Enlil-Cone Fast Track is a quick and easy way to have CCMC perform your WSA-Enlil-Cone model run. Just enter a few parameters, and the model run is automatically executed within CCMC's dedicated high performance computing infrastructure. The end result is a set of arrival time predictions along with corresponding visualizations that illustrate the critical characteristics of the CME such as size and the

projected impact path. Forecasters can then take the results from Fast Track and enter them into the Space Weather Scoreboard.

The space weather scoreboard is a research-based forecasting methods validation activity for CME arrival time predictions which provides a central location for the community to: submit their forecast in real-time, quickly view all forecasts at once in real-time, and compare forecasting methods when the event has arrived. All types of prediction models and methods are welcome from the world-wide research community for inclusion in the space weather scoreboard, and there are currently 17 registered CME arrival time prediction methods. Users submit their predictions for ongoing CME events and most importantly can provide detailed descriptions on how their prediction was made from the model, i.e.. method, input parameters. Members of the research community can then view all of the predictions, modeling details, and the ensemble average of all predicted arrival times submitted by the community. The space weather scoreboard enables world-wide community involvement in real-time predictions and ultimately will help researchers improve CME arrival time forecasting and understanding CME propagation.

Lee, Jaejin (Korea Astronomy and Space Science Institute)

Poster Number: M9

Poster - *Radiation Belt Storm Monitoring System Developed by KASI*

Authors: Kyung-chan Kim, Jong-gil Lee, Yeonhan Kim, and Youngdeuk Park

Abstract: The radiation belt storm is dramatic changes of charged particle flux which energy is from several hundred keV to ~ MeV in the Earth magnetosphere. This storm is known to be caused by energy transfer from solar wind to Earth magnetic field while the detail mechanism is not well understood. The importance of the radiation belt monitoring has been emphasized by GEO satellite operators because a number of spacecraft anomalies have been reported to be related with the increase of energetic electrons. In order to provide current space weather data to the Korean satellite operators, Korea Astronomy and Space Science Institute(KASI) has participated into the Van Allen Probes mission program by receiving 1 kbps real-time space weather data with 7-m parabolic antenna installed in Korea. The Van Allen Probes just send in-site measured data and we calculate global 3-D particle distribution by assuming particles move on the fixed constant L* values. In addition, the radiation belt storm monitoring system displays three dimensional radiation belt particle distributions on the orbits of satellites. For the next step, we are now developing a radial diffusion model for predicting radiation storms.

Leka, KD (NWRA)

Poster Number: S8

Poster - *Forecasting Solar Flares: Recent Results from a NOAA/SBIR Phase-I Study*

Authors: KD Leka, G. Barnes, D. C. Braun, and E. L. Wagner

Abstract: We report here on the particular results from NWRA's recent NOAA/Small Business Innovative Research Phase-I project aimed at improving the published forecasts from NOAA/Space Weather Prediction Center. The Discriminant Analysis Flare Forecasting System ("DAFFS") characterizes (through parametrization) the visible solar sunspot groups and their associated magnetic fields in terms of complexity, the potential for energy storage, sub-surface flows, recent evolution, and prior flaring history. A probability for future flaring (above a given size and over a specified time-frame, presently matched to NOAA's published predictions) is then assigned based on multi-parameter evaluation using Discriminant Analysis. For performance evaluation, the resulting forecasts are evaluated based on standard skill scores. We find that while SWPC forecasts can match essentially what the "state of the art" can do in particular scenarios, the NWRA "DAFFS" algorithm performs significantly better at predicting larger flares, especially for the longer forecast outlooks. In this poster we present additional details of DAFFS and plans for the prototype development under a recently-submitted NOAA/SBIR Phase-II proposal.

Funding for this work is acknowledged from NOAA/SBIR contract WC-133R-13-CN-0079. Leka, Barnes and Wagner acknowledge additional support from NASA NNH09CE72C, NNH12CG10C, and Braun through NSF grant AGS-1127327.

Lin, Chi-Yen (CIRES-CU, NOAA-SWPC)

Poster Number: I12

Poster - *Ionospheric Assimilation of Radio Occultation and Ground-based GPS data using Non-stationary Background Model Error Covariance*

Authors: C. Y. Lin, T. Matsuo, J. Y. Liu, C. H. Lin, H. F. Tsai, and E. A. Araujo-Pradere

Abstract: Ionospheric data assimilation is a powerful approach to reconstruct the 3D distribution of the ionospheric electron density from various types of observations. We present a data assimilation model for the ionosphere, based on the Gauss-Markov Kalman filter with the International Reference Ionosphere (IRI) as the background model, to assimilate two different types of total electron content (TEC) observations from ground-based GPS and space-based FORMOSAT-3/COSMIC (F3/C) radio occultation. Covariance models for the background model error and observational error play important roles in data assimilation. The objective of this study is to investigate impacts of stationary (location-independent) and non-stationary (location-dependent) classes of the background model error covariance on the quality of assimilation analyses. Location-dependent correlations are modeled using empirical orthogonal functions computed from an ensemble of the IRI outputs, while location-independent correlations are modeled using a Gaussian function. Observing System Simulation Experiments suggest that assimilation of TEC data facilitated by the location-dependent background model error covariance yields considerably higher quality assimilation analyses. Results from assimilation of real ground-based GPS and F3/C radio occultation observations over the continental United States are presented as TEC and electron density profiles. Validation with the Millstone Hill incoherent scatter radar data and comparison with the Abel inversion results are also presented. Our new ionospheric data assimilation model that employs the location-dependent background model error covariance outperforms the earlier assimilation model with the location-independent background model error covariance, and can reconstruct the 3D ionospheric electron density distribution satisfactorily from both ground- and space-based GPS observations.

Lotz, Stefan (SANSA)

Poster Number: M5

Poster - *Predicting geomagnetic field variations for GIC modelling at a mid-latitude station*

Authors: S.I. Lotz and P.J. Cilliers

Abstract: The current state of geomagnetically induced current modelling efforts in South Africa is presented. Particularly a solar wind-based empirical model of magnetic field variability is discussed.

Love, Jeffrey J (USGS Golden)

Poster Number: M4

Poster - *Time-causal operational estimation of electric fields induced in the Earth's lithosphere during magnetic storms*

Authors: Andrei Swidinsky

Abstract: In support of projects for monitoring geomagnetic hazards for electric power grids, we develop a simple mathematical formalism, consistent with the time-causality of deterministic physics, for estimating electric fields that are induced in the Earth's lithosphere during magnetic storms. For an idealized model of

the lithosphere, an infinite half-space having uniform electrical conductivity properties described by a galvanic tensor, we work in the Laplace-transformed frequency domain to obtain a transfer function which, when convolved with measured magnetic field time series, gives an estimated electric field time series. Using data collected at the Kakioka, Japan observatory, we optimize lithospheric conductivity parameters by minimizing the discrepancy between model-estimated electric field variation and that actually measured. With our simple model, we can estimate 87% of the variance in storm time Kakioka electric field data; a more complicated model of lithospheric conductivity would be required to estimate the remaining 13% of the variance. We discuss how our estimation formalism might be implemented for geographically coordinated real-time monitoring of geoelectric fields.

Luo, Bingxian (National Space Science Center, CAS)

Poster Number: M6

Poster - *The AU/AL/AE prediction models*

Authors: X. Li, M. Temerin, S. Liu, and J. Gong

Abstract: Two empirical models, one for the AU and the other for the AL, were developed using empirical functions based on solar wind and interplanetary magnetic field parameters and the solar F10.7 index for the years 1995 to 2001. The models reflect the solar wind driving effect related to solar wind speed, IMF and dynamic pressure, characteristics of the decay of auroral electrojets, and ionization effect of the solar ultraviolet radiation on ionospheric conductivity thus the auroral current system. The annual, seasonal, diurnal, and semidiurnal variations of the indices were also taken into consideration to improve the model accuracy. The AE index is predicted using AE=AU-AL. The models predict AU/AL/AE quite well, at least for the longer timescale variations. For the years 1995 to 2001, the linear correlation coefficient (LC) between the 10 min averaged AU index and the model is 0.846. The LC for the AL model is 0.846 and the LC for the AE model is 0.888. The LC is even better when the 13-point (about 2-hr) running average of the model results are compared with the 13-point running average of the indices: LC of 0.902 for AU, 0.915 for AL, and 0.935 for AE. For the 25-point (about 4-hr) running average, the LCs are 0.923, 0.939, and 0.952 for AU, AL, and AE, respectively. The better LC of the AE model over AU and AL models is because AU and AL are better correlated than their errors. Figure 1 shows the prediction compared with the measured AU and AL indices when the smoothing number is changed. Two empirical models, one for the AU and the other for the AL, were developed using empirical functions based on solar wind and interplanetary magnetic field parameters and the solar F10.7 index for the years 1995 to 2001. The models reflect the solar wind driving effect related to solar wind speed, IMF and dynamic pressure, characteristics of the decay of auroral electrojets, and ionization effect of the solar ultraviolet radiation on ionospheric conductivity thus the auroral current system. The annual, seasonal, diurnal, and semidiurnal variations of the indices were also taken into consideration to improve the model accuracy. The AE index is predicted using AE=AU-AL.

The models predict AU/AL/AE quite well, at least for the longer timescale variations. For the years 1995 to 2001, the linear correlation coefficient (LC) between the 10 min averaged AU index and the model is 0.846. The LC for the AL model is 0.846 and the LC for the AE model is 0.888. The LC is even better when the 13-point (about 2-hr) running average of the model results are compared with the 13-point running average of the indices: LC of 0.902 for AU, 0.915 for AL, and 0.935 for AE. For the 25-point (about 4-hr) running average, the LCs are 0.923, 0.939, and 0.952 for AU, AL, and AE, respectively. The better LC of the AE model over AU and AL models is because AU and AL are better correlated than their errors. Figure 1 shows the prediction compared with the measured AU and AL indices when the smoothing number is changed.

Mays, M. Leila (NASA / Goddard Space Flight Center)

Poster Number: S18

Poster - *Real–time Ensemble Forecasting of Coronal Mass Ejections using the WSA-ENLIL+Cone Model*

Presented by: Zheng, Yihua

Authors: M. L. Mays, A. Taktakishvili, A. Pulkkinen, P. J. MacNeice, L. Rastaetter, D. Odstrcil, M. M. Kuznetsova, and J. A. LaSota

Abstract: Ensemble forecasting of coronal mass ejections (CMEs) provides significant information in that it provides an estimation of the spread or uncertainty in CME arrival time predictions. Real-time ensemble modeling of CME propagation in the heliosphere is performed by forecasters at the Space Weather Research Center (SWRC) using the WSA-ENLIL cone model available at the Community Coordinated Modeling Center (CCMC). To estimate the effect of uncertainties in determining CME input parameters on arrival time predictions, a distribution of n (routinely n=48) CME input parameter sets are generated using the CCMC Stereo CME Analysis Tool (StereoCAT) which employs geometrical triangulation techniques. These input parameters are used to perform n different simulations yielding an ensemble of solar wind parameters at various locations of interest (satellites or planets), including a probability distribution of CME shock arrival times (for hits), and geomagnetic storm strength (for Earth-directed hits).

Ensemble simulations have been performed experimentally in real-time at the CCMC/SWRC since January 2013. We present the results of ensemble simulations for a total of 18 CME events in 2013, 13 of which were performed in real-time. For ensemble runs containing hits, one can check if the observed CME arrival was within the range of ensemble arrival time predictions. The average arrival time prediction was computed for each of the 15 ensembles predicting hits and using the actual arrival time, an average absolute error of 8.1 hours was found for all 15 ensembles, which is comparable to current forecasting errors. Some considerations for the accuracy of ensemble CME arrival time predictions include the importance of the initial distribution of CME input parameters, particularly the mean and spread. When the observed arrivals are not within the predicted range, this still allows the ruling out of prediction errors caused by tested CME input parameters. Prediction errors can also arise from ambient model parameters such as the accuracy of the solar wind background, and other limitations. Additionally the ensemble modeling setup was used to complete a parametric event case study of the sensitivity of the CME arrival time prediction to free parameters for ambient solar wind model and CME. The parameter sensitivity study suggests future directions for the system, such as running ensembles using various magnetogram inputs to the WSA model.

McGranaghan, Ryan M. (University of Colorado, Boulder)

Poster Number: I4

Poster - *Forecasting the Impact of Equinoctial High-Speed Stream Structures on Thermospheric Responses*

Authors: Delores J. Knipp, Robert L. McPherron, and Linda A. Hunt

Abstract: We examine thermospheric neutral density response to 172 solar wind high-speed streams (HSSs) and the associated stream interfaces during the equinox seasons of 2002-2008. HSSs produce prolonged enhancements in satellite drag. We find responses to two drivers: 1) the equinoctial Russell-McPherron (R-M) effect, which allows the azimuthal component of the interplanetary magnetic field (IMF) to project onto Earth's vertical dipole component; and 2) coronal streamer structures, which are extensions of the Sun's meso-scale magnetic field into space. Events for which the IMF projection is antiparallel to the dipole field are classified as "Effective-E", otherwise they are "Ineffective-I". Effective orientations enhance energy deposition and subsequently thermospheric density variations. The IMF polarities preceding and following stream interfaces at Earth produce events that are: Effective-Effective-EE; Ineffective-Ineffective-II; Ineffective-Effective-IE; and Effective-Ineffective-EI. These categories are additionally organized according to their coronal source structure: helmet streamers (HS-EI and HS-IE) and pseudo-streamers (PS-EE and PS-II). Approximately 65% of these combinations are HS-EI or HS-IE. The response to HS-IE structures is smoothly varying and long-lived, while the response to PS-EE structures is erratic, short-lived, and modulated by thermospheric preconditioning. We find significant distinguishable responses to these drivers in four geomagnetically sensitive observations: low-energy particle precipitation, proxied Joule heating, nitric oxide flux, and neutral density. Distinct signatures exist in neutral density response that can be anticipated days in advance based on currently available knowledge of on-disk coronal

holes. Further, we show that the HS-IE events produce the largest neutral density disturbances, with the maximum perturbation density for HS-IE events exceeding that of HS-EI events by more than 30%.

Murphy, Joshua J. (University of Colorado, Boulder)

Poster Number: O7

Poster - *GHOST: Conception to Science*

Authors: Joshua J. Murphy, Scot R. Elkington, Mike Wiltberger, and Dan Baker

Abstract: The Geospace/ Heliosphere Observation & SimulationTool-kit (GHOSTkit) is a collection of tools designed to aid space physics researchers in streamlining their research efforts. We will outline the efforts taken thus far at achieving these goals, and will explore where the research will be heading in the future. First science results will be presented to demonstrate the usability of the tools. Future directions will focus on the automation of common and tedious tasks, automatically identify events within enormous data sets, and fostering an environment that can enable more rapid and reliable scientific discoveries.

Murray, Sophie A. (Met Office)

Poster Number: I6

Poster - *Assessing the performance of thermospheric modelling with data assimilation: results of the ATMOP project*

Authors: S. A Murray, E. M. Henley, D. R. Jackson, and S. L. Bruinsma

Abstract: The EU Framework Package 7 Advanced Thermosphere Modelling of Orbital Prediction (ATMOP) project was designed to provide a European capability for nowcasting and forecasting of the thermosphere. As part of this project, data assimilation procedures have been developed for thermospheric models using satellite density measurements. Two models were implemented; one a general circulation model, TIEGCM, and the other a semi-empirical drag temperature model, DTM. Results of runs using data assimilation with these models were compared with observations at solar maximum and minimum. The differences between the physical and the semi-empirical models have been characterised, results indicating that both models tend to show similar behaviour, underestimating densities at solar maximum, and overestimating it at solar minimum. DTM performs better at solar minimum, with both models less accurate at solar maximum. A mean improvement of ~5% was found using hourly data assimilation with TIEGCM over a 60-day period. With further improvements, the use of general circulation models in operational forecasting in addition to empirical models currently used is plausible. Future work will allow near-real-time assimilation of thermospheric data into these models for improved forecasting.

Nagatsuma, Tsutomu (National Institute of Information and Communications Technology)

Poster Number: M10

Poster - *Evaluation of Relativistic Electron Flux Forecast at GEO Satellite*

Authors: T. Nagatsuma, K. Sakaguchi, S. Saito, Y. Miyoshi, and K. Seki

Abstract: We have developed near real time prediction model for relativistic electron flux at GEO satellite. This model is based on a multivariate autoregressive model with using solar wind speed, north-south component of the magnetic field and dynanmic pressure as inputs. Detailed description of this model can be found in Sakaguchi et al. [2013]. We have started relativistic electron flux forecast service as a test product since Apr. 2013. Forecast information can be found in the following web pages (URL: http://seg-web.nict.go.jp/radi/).

There are several difficulties in operating a near-real time forecast model. One is the quality of the real-time solar wind data. Because quality of real-time solar wind density data is quite poor, we avoid using

solar wind density data for our operational model. The other one is the lead-time of the solar wind data. Currently, we can use only ACE data for solar wind input. The lead-time of this data is only about one hour. Threfore, we also 'predict' solar wind condition for two or three days in advance from current solar wind information. Anyway, prediction efficiencies of our forecast for 1day, 2day, and 3day ahead in 2013 are 81%, 63%, 48%, respectively. Evaluation and future parspective of our forecasting model will be introduced in our presentation.

Nair, Manoj C. (CIRES)

Poster Number: M3

Poster - *Predicting ground electric field due to geomagnetic disturbances*

Authors: Manoj C. Nair , Christoph P., and Alexey V. Kuvshinov

Abstract: Electric field induced in the ground by geomagnetic disturbances drives currents in the power transmission grids, telecommunication lines or buried pipelines. These currents, known as Geomagnetically Induced Currents (GIC) are known to cause service disruptions. This effect is maximal at high latitudes due to the presence of strong polar electrojet currents. However both observations and models show that GIC caused by ring current intensifications also pose a risk at low- and mid-latitude locations, where majority of systems vulnerable to GIC are installed. A technique to model geoelectric field induced by the magnetospheric currents in a 3D conductivity model of the Earth is presented by Püthe & Kuvshinov (2013). We extend this work by predicting the induced geoelectric field solely based on Disturbance storm time index (Dst), a measure of ring current activity. Two major components of this effort are 1) Pre-computed 3D electromagnetic response of the ground to a unit magnetopsheric (P01) source and 2) Forecasted Dst data (Temerin & Li, 2002; 2006) from Advanced Composition Explorer (ACE) satellite at the L1 Lagrange point. Depending on the solar wind speed, the Dst forecasts are available approximately 1 hour in advance. The pre-computed response function for a site is multiplied by the Dst data in frequency domain to obtain predicted electric field for that location. Validating our approach, the predicted geoelectric field compares favorably with observed data from an ocean bottom electromagnetic array in the Pacific Ocean during the geomagnetic storm of April 2000.

Nicholas, Andrew C. (Naval Research Laboratory)

Poster Number: I10

Poster - *WINCS/SWATS Initial On-Orbit Performance Results*

Authors: Fred Herrero, Andrew Stephan, and Ted Finne

Abstract: The Winds-Ions-Neutral Composition Suite (WINCS) instrument, also know as the Small Wind and Temperature Spectrometer (SWATS), was designed and developed jointly by the Naval Research Laboratory (NRL) and NASA/Goddard Space Flight Center (GSFC) for ionosphere-thermosphere investigations in orbit between 120 and 550 km altitude. The WINCS design provides the following measurements in a single package with a low Size, Weight, and Power (SWaP): 7.6 x 7.6 x 7.1 cm outer dimensions, 0.75 kg total mass, and about 1.3 Watt total power: neutral winds, neutral temperature, neutral density, neutral composition, ion drifts, ion temperature, ion density and ion composition. Initial on-orbit results of the first flight of the instrument will be presented.

(The authors would like to acknowledge the NRL 6.1 Base program in support of this research.)

Park, Sarah (Korean Space Weather Center)

Poster Number: S16

Poster - *Compare the CME arrival time and the predicted time on a basis of Typell solar radio bursts*

Presented by: Hong, Sunhak

Authors: Sarah Park, Sunhak Hong, and Yung-Kju Kim

Abstract: All the space weather operation centers rely on SOHO and STEREO satellites to analyze the effect of CMEs. But it has already been passed it's expected lifetime of SOHO satellite. Moreover, STEREO satellite will be located behind the Sun in an year. So, many of space weather operation centers begin to consider again to use the solar spectrograph data, TypeII speed, as a back up method for analyzing CME effect to the Earth. First, we perform comparing between the halo CME speed by SOHO/LASCO CME catalog and the speed estimated by TypeII solar radio bursts during 1997-2006. Next, we investigated the compare the CME arrival time on the Earth and the predicted time that was derived by TypeII solar radio bursts for the same period. For the studies, TypeII solar radio bursts lists are used the data provided by NOAA/SPWC and the CME arrival time is identified by the CME lists of Richardson and Cane[2010].

Parker, Linda (Jacobs Technology)

Poster Number: M13

Poster - *MSFC/EV44 Natural Environment Capabilities*

Authors: Linda Parker, Emily Willis, Joseph Minow, and Victoria Coffey

Abstract: The Natural Environments Branch at Marshall Space Flight Center is an integral part of many NASA satellite and launch vehicle programs, providing analyses of the space and terrestrial environments that are used for program development efforts, operational support, and anomaly investigations. The space environment capabilities of the Natural Environments Branch at MSFC will be presented. These capabilities include model development, analysis of space and terrestrial related data, spacecraft charging anomaly investigations, surface charging modeling (e.g., Nascap-2k), space environment definition and radiation assessments for electronic parts. All aspects of space and terrestrial design are implemented with the goal of devising missions that are successful from launch to operations in the space environment of LEO, polar, GEO, and interplanetary orbits. We will show examples of recent applications of branch capabilities to NASA missions.

Penrod, James (University of Colorado, Boulder)

Poster Number: M7

Poster - *Database Comparison to Extend the Usefulness of DMSP Derived Electric Field Data*

Authors: James Penrod, Delores Knipp, and Robert Redmon

Abstract: The Defense Meteorological Satellite Program (DMSP) is a constellation of satellites operated by the United States Air Force. Two of the DMSP space environment instruments measure local magnetic fields and plasma particle motion in Low Earth Orbit, respectively. The measurements can be then be used to derive the local electric field. These data are available at two public locations: the University of Texas at Dallas (UTD) and the National Geophysical Data Center (NGDC). The UTD data have been processed to remove biases and to apply quality flags to the data, while the NGDC data were produced by operational algorithms and thus are less processed. However, the NGDC data is up-to-date, while the UTD data only extends to 2005. In order to improve data access and conduct further research on the upper atmosphere in the auroral zones using DMSP, the NGDC data must be processed so that it achieves a suitable quality level. A data processing algorithm and a method to assign quality flags to the NGDC data is developed and applied to the data from July 1-7, 2004. The processed data are verified by comparing them to the UTD data from the same time period. Finally, the algorithm is applied to the week of May 28-June 3, 2010 as a demonstration of its functionality.

Phillips, Tony (Spaceweather.com)

Poster Number: I1

Poster – *Space Weather Ballooning*

Authors: Tony Phillips, Sam Johnson, Amelia Koske-Phillips, Michael White, Justin Gilpin, Carson Reid, Olivia Grah, Aaron Lamb, and Rachel Molina

Abstract: Supported in part by spaceweather.com, high school students in California have developed a "Rapid Response Space Weather Payload" for suborbital research helium balloons. The payload, which is relatively inexpensive and easy to assemble, can be quickly deployed by a small launch crew to measure the effect of solar and geomagnetic storms on Earth's atmosphere. Sensors include a GPS altimeter, a radiation counter, a cryogenic thermometer and, soon, an ozonesonde. Five test flights to the stratosphere since Oct. 2013 have validated our approach, which is now ready for sharing with the space weather community.

Pilinski, Marcin (ASTRA)

Poster Number: I11

Poster - *From DICE to DIME: An Evolution of CubeSat Based E-field Instrumentation*

Authors: Geoff Crowley, Irfan Azeem, Charles Swenson, Chad Fish, Tim Neilsen, Erik Stromberg, DICE Engineering Team, and A. Barjatya

Abstract: There is a need for inexpensive and robust space-weather monitoring instruments that can fill upcoming gaps in the Nation's ability to monitor critical space weather parameters and meet requirements for specification and forecasting. Foremost among the parameters that must be measured and specified are electric fields, since they drive the ionospheric behavior at both high and low latitudes, and because there are relatively few ground-based measurements. In the future, we envisage a constellation of such instruments flying on CubeSats that will provide global coverage of the electric field and its variability.

Although CubeSat technology is still in its infancy, major strides have been taken towards the development of the instruments that will be required in the near future. The DICE (Dynamic Ionosphere CubeSat Experiment) was a step in this evolution: it was an ambitious program with two identical 1.5U CubeSats, each carrying three space weather instruments: (1) double probe instruments to measure AC and DC electric fields; (2) Langmuir probes to measure ionospheric electron density, and; (3) a magnetometer to measure field-aligned currents. In addition, the DICE program resulted in the development of the most capable radio system to date for CubeSats, enabling data downloads many times faster than existing hardware. While the DICE mission had many successes, there were also lessons learned that are now being implemented in a DICE follow-on called DIME (Double-probe Instrumentation for Measuring Electric–fields).

The DICE mission was funded by the NSF CubeSat program and launched via NASA's ELaNa program from Vandenberg Air Force Base. Both DICE satellites were deployed in quick succession from a single P-POD (NASA's Poly Picosatellite Orbital Deployer) into the same orbit in October 2011. The mission focus is the characterization of Storm Enhanced Densities (SEDs) in the ionosphere, and the detection of Field Aligned Currents (FACs) at high latitudes. The DICE mission is a collaboration between ASTRA and Space Dynamics Lab/Utah State University (USU/SDL). ASTRA leads the mission science analysis, with support from USU/SDL and Embry Riddle. The DICE CubeSats were built at USU/SDL, with design support from ASTRA and Embry Riddle. The Langmuir Probes on both CubeSats were successfully deployed, and data has been collected from them as well as from the science magnetometers. In March of 2013, DICE was the first CubeSat mission to observe a Storm Enhanced Density event. DICE also achieved the highest downlink rates for any CubeSat to date, in fact the DICE CubeSats have achieved science data downlinks unprecedented in previous CubeSat missions, and consequently other missions are now taking advantage of the radio technology developed under the DICE program.

Due to attitude control anomalies encountered in orbit, the 5-meter electric field booms on DICE have not yet been deployed. In troubleshooting these anomalies, the DICE team has compiled important lessons-learned for the implementation of a spin-stabilized CubeSat, and in particular the design and performance of the Attitude Determination & Control System (ADCS). These lessons are now being implemented into our next-generation design.

ASTRA and SDL have been funded to prepare a risk-reduction mission for an enhanced version of the electric field instrument for CubeSats. This synergistic opportunity has allowed the team to apply lessons learned from DICE to address the challenges of making a CubeSat that fully enables the deployment of booms and measurement of electric fields. Because the sensor operation is enabled by the CubeSat design, we call it a Sensor-sat. Improvements in the Double Probe design are also being implemented, and the new instrument is called DIME (Double-probe Instrumentation for Measuring Electric–fields). The SensorSat and the mission are also being called DIME. The DIME SensorSat is capable of deploying flexible electric field booms up to a distance of 10-m tip-to-tip and is capable of exceeding several IORD-2 threshold requirements. This is accomplished from the volume envelope of a 1.5U CubeSat, or 10x10x15cm. The satellite will measure AC and DC electric fields, together with ion densities, and magnetic fields to characterize the performance of the sensor in different plasma environments.

In this poster, we show the utility of a constellation of electric field measurements, describe the DICE CubeSats and their current mission status, review the challenges and lessons learned from the DICE mission, describe the DIME SensorSat, showing how the various challenges are being addressed for DIME, and demonstrating how the new systems will meet or exceed IORD measurement requirements.

The evolution of CubeSat-based electric field instrumentation will lower the cost of fielding such sensors by enabling launches as secondary payloads. Furthermore, it will reduce cost to enable the flight of constellations that can, for the first time, adequately resolve the spatial and temporal variability in ionospheric electrodynamics.

Podzolko, Mikhail (Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University (SINP MSU))

Poster Number: S4

Poster - *Problems of reliability of the data on SEP measurements at different stages of data analysis and physical modeling*

Authors: M. I. Panasyuk, V. V. Kalegaev, M. V. Podzolko, L. I. Miroshnichenko, N. A. Vlasova, and Yu. I. Logachev

Abstract: Our view is presented on the problems of reliability of the data on SEP measurements at different stages of data processing. These stages are: instrument calibration itself, the artifacts of instrument functioning, data transfer and initial processing, the separation of the fluxes of solar energetic protons from the background fluxes of galactic protons, the dependence of measurement results from the spacecraft location and flux anisotropy, the dependence from the location of SEP source on the Sun and spatial extension of the region of particle injection. Current measurements of solar energetic protons by SINP MSU instrument “SKL-E” on the spacecraft “Electro-L” are described.

Sandberg, Ingmar (National Observatory of Athens)

Poster Number: S3

Poster - *Intercalibration of Solar Protons Flux measurements: IMP8, NOAA/GOES and ESA SREM*

Authors: I. Sandberg, I.A. Daglis, P. Jiggens, P. Niemninen and H. Evans

Abstract: In this work, we present on-going efforts for the intercalibration of energetic solar proton flux measurements of IMP8/GME, NOAA/GOES and ESA INTEGRAL/SREM units. We choose the IMP8/GME measurements as a reference dataset for the calibration of NOAA/GOES, and the calibrated NOAA/GOES dataset for INTEGRAL/SREM proton fluxes.

The measurements of IMP8/GME/LED channels (especially those in the energy range of 8.25-22.5 MeV) suffer from serious intermittent symptoms, from April 1984, which in turn affect the calibration of NOAA/GOES. In order to overcome the LED failure, we have developed a statistical-based scheme which allows us to correct - as possible – the IMP8 data by applying non-linear correction factors to the GME/LED measurements after April 1984.

For the calibration of NOAA/GOES, we developed a linear regression scheme that permit us to initially refine/define the effective/characteristic energy bin value of each GOES channel and then cross-calibrate the GOES measurements using the corrected IMP8/GME data. The resulted GOES fluxes are then used to cross-calibrate the INTEGRAL/SREM fluxes which are calculated through the application of a novel SVD-based unfolding technique on the SREM count-rate measurements.

The result of the whole effort leads to the creation of a cross-calibrated NOAA/GOES and ESA/SREM datasets using IMP8/GME as a reference dataset. In the future, it is planned to update the ESA SEPEM (Solar Energetic Particle Environment Modelling) system with these new processing algorithms and resulting datasets.

Shim, Ja Soon (CUA/NASA GSFC)

Poster Number: I5

Poster - *Sensitivity of Ionosphere/Thermosphere to high-latitude drivers*

Authors: J. S. Shim, M. Kuznetsova, L. Rastatter, M. Swindell, M. Codrescu, B. Emery, M. Fedrizzi, M. Foerster, B. Foster, T. Fuller-Rowell, A. J. Mannucci, A. Namgaladze, X. Pi, B. E. Prokhorov, A. Ridley, A. Coster, and L. Goncharenko

Abstract: The CCMC (Community Coordinated Modeling Center) has developed tools that can be employed for easy driver swapping for Magnetosphere-Ionosphere coupling study. The tools allow us to convert ionosphere drivers from a variety of sources. For the high-latitude ionospheric electric potential, Weimer 2005, AMIE (assimilative mapping of ionospheric electrodynamics) and global magnetosphere models (e.g. Space Weather Modeling Framework, SWMF) can be used. In addition particle precipitation models can be converted between Fuller-Rowell & Evans, Roble & Ridley, and patterns derived from the ionosphere electrodynamics in the SWMF model. Using the tools, we studied the influence of high latitude drivers on Ionosphere/Thermosphere (IT). We obtained modeled IT parameters such as Total Electron Content (TEC), NmF2 and hmF2, and electron and neutral densities during the 2006 AGU storm event. We compared the modeled values with the observations for the 2006 AGU storm period and quantified the performance of the models using skill scores. Furthermore, the skill scores are obtained for three latitude regions (low, middle and high latitudes) in order to investigate latitudinal dependence of the models' performance. This study is supported by the CCMC at the Goddard Space Flight Center. Model outputs and observational data used for the study will be permanently posted at the CCMC website (http://ccmc.gsfc.nasa.gov) as a resource for the space science communities to use.

Straus, Paul (The Aerospace Corporation)

Poster Number: I8

Poster – *COSMIC-2: A Platform for Advanced Ionospheric Observations*

Authors: Dr. Paul R Straus, The Aerospace Corporation and Mr. Andy Betz, Defense Weather Systems Directorate, Los Angeles AFB

Abstract: The equatorial component of the COSMIC-2 program will consist of 6 satellites to be flown in a 24 degree inclination/520 km altitude orbit. In addition to the primary GNSS radio occultation (RO) payload, to be provided by JPL, the USAF plans to fly a pair of space weather sensors: a multi-frequency radio beacon and the Ion Velocity Meter (IVM) in-situ plasma sensor package. These three instruments will provide data to address key issues related to the specification and forecast of ionospheric densities and the instabilities/irregularities associated with ionospheric scintillation. The TriG GNSS receiver will provide a substantial increase in the number of daily ionospheric observations relative to COSMIC-1, both in the RO limb-viewing and overhead geometries. These data are expected to provide significantly improved data refresh and coverage for assimilative ionospheric models enabling more accurate ionospheric specifications in the important equatorial region. In addition, TriG will make routine measurements of ionospheric scintillation at L-band frequencies, as pioneered by the CORISS instrument on C/NOFS. The radio beacon, together with a network of ground receivers, will enable direct measurement of scintillation effects on trans-ionospheric signal propagation across the UHF to S-band frequency spectrum. The IVM sensor will measure the in-situ density and plasma depletions associated with scintillation-producing irregularities. Together, the beacon, TriG, and IVM will provide an unprecedented ability to map equatorial ionospheric instabilities and their effects. The IVM sensor will also provide observations of plasma drifts from which electric fields, the most important physical driver for equatorial ionospheric structure, can be inferred. This will enable advancements in ionospheric models to further improve specifications and forecasts. In addition to discussing ionospheric science and operational support aspects of the COSMIC-2 mission, this presentation also discusses high level COSMIC-2 programmatic status and plans, particular with respect to the mission sensors.

Sun, Yang-Yi (CIRES-CU, NOAA-SWPC)

Poster Number: I13

Poster - *Assimilative Neutral Wind Bias Correction Scheme for Global Ionospheric Modeling at Midlatitude*

Authors: Yang-Yi Sun, Tomoko Matsuo, Naomi Maruyama, and Jann-Yenq Liu

Abstract: This study demonstrates the usage of a robust data assimilative procedure, which is applied to correct the model wind biases to enhance the capability of the global physics-based Ionosphere Plasmasphere Electrodynamics (IPE) model. The hmF2 observed by the FORMOSAT-3/COSMIC (F3/C) radio occultation (RO) technique is utilized to adjust global thermospheric field-aligned neutral winds (i.e., a component of the thermospheric neutral wind parallel to the magnetic field) at midlatitudes according to a linear relationship between time differentials of the field-aligned wind and hmF2. The adjusted winds are further applied to drive the IPE model, which is built upon the Field Line Interhemispheric Plasma (FLIP) model with a realistic geomagnetic field model and empirical model drivers. The comparison of the modeled electron density with the observations of F3/C and ground-based GPS receivers at the 2012 March Equinox suggests that the modeled electron density can be significantly improved, especially in the midlatitudes of the Southern Hemisphere. Moreover, the F3/C observation, the IPE model, and the wind bias correction scheme are applied to study the 2012 Southern Hemisphere Midlatitude Summer Nighttime Anomaly (southern MSNA)/Weddell Sea Anomaly (WSA) event at the December Solstice for examining the role of the neutral winds in controlling southern MSNA/WSA behavior over different longitudes. With the help of the wind bias correction scheme, the IPE model comprehensively reproduced the F3/C observed southern MSNA/WSA features. The apparent eastward movement of the southern MSNA/WSA features in the local time coordinate is primarily caused by the longitudinal variation in declination angle of the geomagnetic field that controls the field-aligned projection of both geographic meridional and zonal neutral winds.

Thompson, Gerald (Atmospheric & Space Technology Research Associates, LLC)

Poster Number: I21

Poster - *GPS-Aided Space Weather Monitoring*

Authors: Geoff Crowley, Irfan Azeem, and Adam Reynolds

Abstract: Signals from the Global Positioning System (GPS) are increasingly utilized for continuous monitoring of the ionosphere using arrays of dual frequency GPS receivers. The dual frequency phase measurements can be used to derive the ionospheric total electron content (TEC), and the variations of GPS signal amplitude and phase can be used to measure the magnitude of ionospheric irregularities. These receivers can be used, either individually or as an array, to study various ionospheric phenomena. They are also useful for assessing the impact of space weather phenomena on various technologies and operational systems. Atmospheric & Space Technology Research Associates (ASTRA) has developed various GPS-based ionospheric monitoring instruments. The CASES software-defined GPS receiver was built in collaboration with Cornell University and UT Austin. Following the success of CASES, ASTRA has developed a much smaller size weight and power GPS receiver, called GAMMA. The GAMMA receiver is designed to provide autonomous operation, assuring reliability while eliminating human intervention, from a variety of platforms on land and on sea. In this paper, we present GPS scintillation results from ASTRA's CASES receivers in Peru and from an Alaskan chain to highlight the variability of phase scintillations at both low and high latitudes. We also compare the tracking performance of the CASES receiver and competing commercial GPS scintillation monitors at low latitudes. Based on these comparisons, we conclude that the CASES tracking algorithms provide superior stability and robustness during severe scintillation events. We will also describe a unique capability of the GAMMA receiver, which enables measurements of TEC and scintillations from ocean-going buoys. Finally, we will describe ASTRA's renewable power and autonomous communications solution for the operation of GAMMA receivers and other equipment in remote locations.

Tobiska, W. Kent (Space Environment Technologies)

Poster Number: O6

Poster - *Operational specification and forecasting advances for Dst, LEO thermospheric densities, and aviation radiation dose and dose rate*

Authors: Ramkumar Bala, Delores Knipp, W.J. Burke, D. Bouwer, J. Bailey, M.P. Hagan, Leonid Didkovsky, Kevin Judge, Jeff Dillon, Henry Garrett, B.R. Bowman, J. Gannon, William Atwell, J. Bernard Blake, William R. Crain, Don Rice, Bob Schunk, Duane Bell, Brad Gersey, Richard Wilkins, Robert Fuschino, Chris Flynn, Kurt Cecil, Chris Mertens, Xiaojing Xu, Geoff Crowley, Adam Reynolds, Irfan Azeem, Scott Wiley, Mike Holland, and Kathleen Malone

Abstract: Space weather's effects upon the near-Earth environment are due to dynamic changes in the energy transfer processes from the Sun's photons, particles, and fields. Of the space environment domains that are affected by space weather, the magnetosphere, thermosphere, and even troposphere are key regions that are affected. Space Environment Technologies (SET) has developed and is producing innovative space weather applications. Key operational systems for providing timely information about the effects of space weather on these domains are SET's Magnetosphere Alert and Prediction System (MAPS), LEO Alert and Prediction System (LAPS), and Automated Radiation Measurements for Aviation Safety (ARMAS) system.

1. MAPS provides a forecast Dst index out to 6 days through data-driven, primary and redundant data streams. SET and Rice University have implemented a primary data stream for Dst forecasting using ENLIL data supplied by NOAA SWPC and a Dst algorithm provided by Rice University. The secondary data stream uses the Anemomilos algorithm with observational proxies for the magnitude, location, and velocity of solar ejecta events.

2. LAPS is the SET fully redundant operational system providing recent history, current epoch, and forecast solar and geomagnetic indices for use in operational versions of the JB2008 thermospheric density model. The thermospheric densities produced by that system, driven by the LAPS data, are forecast to 72-hours to provide the global mass densities for satellite operators. HASDM high-accuracy density data fields

are now available for the research community with 3-hour time granularity between 200–1000 km starting in 2000 and continuing through the present.

3. ARMAS is a project that has successfully demonstrated the operation of a micro dosimeter on aircraft to capture the real-time radiation environment due to Galactic Cosmic Rays and Solar Energetic Particles. The dose and dose-rates are captured on aircraft, downlinked in real-time via the Iridium satellites, processed on the ground, incorporated into the most recent NAIRAS global radiation climatology data runs, and made available to end users via the web and smart phone apps. ARMAS provides the "weather" of the radiation environment to improve air-crew and passenger safety. The ARMAS team is preparing an app for use by pilots and the flying public to log their accumulated dose during commercial air travel.

Many of the data products from MAPS, LAPS, and ARMAS are available on the SpaceWx smartphone app for iPhone, iPad, iPod, and Android professional users and public space weather education. We describe recent forecasting advances for moving the space weather information from these automated systems into operational, derivative products for communications, aviation, and satellite operations uses.

Viereck, Rodney (NOAA SWPC)

Poster Number: I18

Poster – *GOES Solar EUV Spectral Irradiance Observations and EUV Proxy Model*

Authors: H. Wang, R. A. Akmaev, T.-W. Fang, T. J. Fuller-Rowell, F. Wu, N. Maruyama, and M. D. Iredell

Abstract: The EUV sensor on the GOES satellite has been making continuous observations since 2009. The sensor measures the solar EUV irradiance in three spectral bands centered at 10 nm, 30.4 nm, and 120 nm and at a 10 second cadence. These data have been validated and calibrated against a number of other EUV observations. We will present the results of this calibration activity. We will also present a new proxy model of the solar EUV irradiance using the spectral bands of Solomon and Qian. We will show how this proxy model using GOES EUV Sensor data is an improvement over other proxies such as F10.7 and Mg II. These data and the the proxy model will soon be available as SWPC products.

Wang, Houjun (NOAA SWPC)

Poster Number: I14

Poster - *First forecast of a sudden stratospheric warming with a coupled whole-atmosphere/ionosphere model IDEA*

Presentend by: Akmaev, Rashid

Authors: H. Wang, R. A. Akmaev, T.W. Fang, T. J. Fuller-Rowell, F. Wu, N. Maruyama, and M. D. Iredell

Abstract: We present the first ``weather forecast'' with a coupled whole-atmosphere/ionosphere model of Integrated Dynamics in Earth's Atmosphere (IDEA) for the January 2009 Sudden Stratospheric Warming (SSW). IDEA consists of the Whole Atmosphere Model (WAM) and Global Ionosphere-Plasmasphere (GIP) model. A 30-day forecast is performed using the IDEA model initialized at 00~UT on January 13, 2009, ten days prior to the peak of the SSW. IDEA successfully predicts both the time and amplitude of the peak warming in the polar cap. This is about two days earlier than the National Centers for Environmental Prediction (NCEP) operational Global Forecast System (GFS) terrestrial weather model forecast. The forecast of the semidiurnal, westward propagating, zonal wave number 2 (SW2) tide in zonal wind also shows an increase in the amplitude and a phase shift to earlier hours in the equatorial dynamo region during and after the peak warming, before recovering to their prior values about 15 days later. The SW2 amplitude and phase changes are shown to be {\em likely} due to the stratospheric ozone {\em and/or} circulation

changes. The daytime upward plasma drift and total electron content (TEC) in the equatorial American sector show a clear shift to earlier hours and enhancement during and after the peak warming, before returning to their prior conditions. These ionospheric responses compare well with other observational studies. Therefore, the predicted ionospheric response to the January 2009 SSW can be largely explained in simple terms of the amplitude and phase changes of the SW2 zonal wind in the equatorial E region.

Watari, Shinichi (National Institute of Information and Communications Technology)

Poster Number: O1

Poster – *Renewal of NICT Reception System for Real-time Solar Wind Data*

Authors: Shinichi Watari, Yuki Kubo, and Mamoru Ishii

Abstract: It is known that intense geomagnetic storms have a potential to cause power blackouts. In-situ upstream solar wind data is important for space weather forecast to estimate the effect on Earth's Magnetosphere in advance. The first experiment of real-time solar wind warning system was made between 1980 and 1982 by a collaboration of NASA and NOAA (Joselyn, 1986). The solar wind data from ISEE-3 (International Sun-Earth Explorer 3) was used to forecast geomagnetic activities 30-60 minutes before they reached the Earth. According to this experience, NOAA proposed the real-time solar wind (RTSW) mode for Advanced Composition Explorer (ACE) to NASA (Zwickl et al., 1998) and the RTSW mode was realized in the ACE mission. Several ground stations are necessary to receive solar wind data from ACE with 24-hour coverage. National Institute of Information and Communications Technology (NICT) in Japan contributes the RTSW system to provide a ground station since the start of ACE. The antenna system of NICT for real-time solar wind data became old because it passed approximately 25 years since its production. The troubles of the system often interrupted the ACE tracking. We decided to renew our system. The new system has a capability to receive data from the Deep Space Climate Observatory (DSCOVR) mission, which is planned as a replacement of ACE by the efforts of NOAA, NASA, and AFL. In this presentation, we will introduce our new reception system of real-time solar wind data.

We acknowledge Dr. D. Biesecker, Dr. R. N. Grubb, Dr. T. DeFoor, Dr. T. Onsager, and Dr. S. West for their supports.

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Wiegand, Chiu (NASA / Goddard Space Flight Center)

Poster Number: O9

Poster - *Software Tools for Space Weather research, forecast, and anomaly analysis*

Presented by: Zheng, Yihua

Authors: C. P. Wiegand, M. Maddox, M. L. Mays, R. Mullinix, A. Pulkinnen, Y. Zheng, and M. Kuznetsova

Abstract: An important objective of the Community Coordinated Modeling Center (CCMC) is to encourage communication and collaboration within space weather research and research-to-operations communities. As such, CCMC has developed various software tools to support space weather research, space weather forecasting, and anomaly analysis. In this paper, we highlight two tools that are actively being developed at the CCMC: (1) Space Weather Database of Notifications, Knowledge, Information (SW DONKI) and (2) Space Environment Automated Alerts Anomaly Analysis Assistant (SEA5).

Before the Space Weather Database of Notifications, Knowledge, Information (SW DONKI), there was no centralized database or application that allowed space weather researchers/forecasters working with the CCMC/SWRC at NASA GSFC to record observed space weather activities. SW DONKI is being developed as an online tool for both space weather forecasters and researchers, enabling remote participation by students, world-wide partners, model developers, and forecasting technique developers. The system will serve as an archive of all space weather activities including: flares, CMEs, SEPs, and geomagnetic storms. An innovative feature of the system is the ability to generate, modify, and store complex linkages between activities - creating a comprehensive network of relationships between activities, and identifying potential cause-and-effect paradigms. The system will archive all human generated event analysis and other notifications produced by the SWRC team. In support of NASA missions, the SW DONKI will also send out both automated and human generated notifications to help operators identify and/or minimize any potential negative impact of a particular space weather event on NASA assets. These notifications will also help facilitate special observational campaigns, allowing some missions to actively target expected events.

Space Environment Automated Alerts & Anomaly Analysis Assistant (SEA5) being developed at CCMC/SWRC is a comprehensive space weather information analysis and dissemination system that will provide past, present, and predicted space environment information for specific missions, orbits, and user-specified locations throughout the heliosphere and geospace. The main objective of the tool is to provide an unprecedented capability for viewing space environment conditions for specific missions/orbits, providing automated space weather notifications for specific missions/orbits, assimilating and displaying spacecraft anomaly information, as well as managing and displaying spacecraft/mission data.

Willis, Emily (Marshall Space Flight Center)

Poster Number: M12

Poster - *CubeSat Susceptibility to Auroral Space Weather Events*

Authors: Emily M. Willis, Joseph I. Minow, and Linda Neergaard Parker

Abstract: The demand for CubeSat missions continues to grow as government, academic, and commercial programs seek quick-turnaround, low cost access to space. As the complexity of CubeSat missions increases, it is becoming more and more important to consider the effects of space weather on these small satellites. Spacecraft surface charging can be a significant issue for satellites in polar orbit due to the high energy electrons that precipitate down from the open magnetic field lines present in the auroral region. Spacecraft charging occurs when charged particles from the surrounding space plasma environment contact a spacecraft and unequal charging currents result in a net charge density accumulation on or in spacecraft materials. Charging becomes a threat when differential potentials between two points on the spacecraft or between the spacecraft and the ambient space environment build to electric field levels exceeding the electric breakdown strength of the spacecraft materials. Electrostatic discharge arcs are generated as a result of this exceedance. Electrostatic discharges resulting from spacecraft charging can adversely affect telemetry and cause irreparable damage to electronics. Other spacecraft charging effects include damage of solar arrays and thermal protection, enhancement of contamination of surfaces, and degradation of optics. Ideally, government and commercial space programs include spacecraft charging analysis as part of the design process to ensure material electric field breakdown strengths are not reached. CubeSat projects, however, usually do not have the time or funding to include a spacecraft charging analysis due to their low budget and quick-turnaround requirements. CubeSat projects also tend to rely heavily on commercial "off-the-shelf" products, many of which are not qualified for use in space, and are particularly vulnerable to the effects of the space environment. Results of surface charging analysis using Nascap-2k on a typical CubeSat design for a polar orbit scenario are illustrated. These results show that for a polar orbiting CubeSat, spacecraft charging could be an issue and steps should be taken to mitigate the effects for these small satellites.

Winter, Lisa M (AER)

Poster Number: S2

Poster - *Correlating Type II and III Radio Bursts with Solar Energetic Particle Events*

Authors: Kathryn Ledbetter and Rick Quinn

Abstract: Solar energetic particles (SEPs) are high-energy particles, such as protons, which are accelerated at the Sun and speed outward into the solar system. If they reach Earth, they can be harmful to satellites, ionospheric communications, and humans in space or on polar airline routes. NOAA defines an SEP event as an occasion when the flux of protons with energies higher than 10 MeV exceeds 10 pfu (particle flux units) as measured by the GOES satellites in geosynchronous orbit. The most intense SEP events are associated with shocks, driven by coronal mass ejections (CMEs), which accelerate particles as they move through the corona. However, very few CMEs result in SEP events. To determine what factors are most important in distinguishing the shock waves that will result in SEP acceleration toward Earth, we take into account several variables and perform a principal component analysis (PCA) to examine their correlations.

We examined Type II radio bursts, which are caused by electrons accelerating in the same CME-driven shocks that can accelerate SEPs. Using data from the WAVES instrument on the WIND satellite, these Type II radio bursts, as well as the Type III bursts that often accompany them, can be characterized by slope in 1/f space and by intensity. In addition, local Langmuir waves detected by WIND, which are caused by electrons speeding through the plasma surrounding the satellite, can be an indicator of the magnetic connectivity between the active region and Earth. Finally, X-ray flares directly preceding the Type II burst are also taken into consideration in the PCA analysis. Using PCA to determine which of these factors are most relevant to the onset, intensity, and duration of SEP events will be valuable in future work to predict such events. We present the analysis of all type II radio bursts observed by WIND between January 2010 and May 2013. Future work will include the STEREO/SWAVES data with a focus on creating an operating real-time SEP forecaster relying on radio, X-ray, and proton flux observations.

Yu, Hsiu-Shan (University of California at San Diego)

Poster Number: S9

Poster - *The 3D Reconstruction of the IPS Remote-Sensing Data: Global Solar Wind Boundaries for Driving 3D-MHD Models*

Authors: B.V. Jackson, P.P. Hick, A. Buffington, D. Odstrcil, C.-C. Wu, and M. Tokumaru

Abstract: The University of California, San Diego (UCSD) interplanetary scintillation (IPS) tomographic remote-sensing analyses of the heliosphere have reconstructed 3D solar wind velocities and densities for nearly two decades. These global results, especially using Solar-Terrestrial Environment Laboratory (STELab) IPS observations, enable a real-time forecast of solar wind density and velocity that is nearly complete over the whole heliosphere with a time cadence of about one day, using the iterative UCSD kinematic modeling technique. Additionally, inclusion of available in-situ measurements into the analysis provides a more accurate forecast of real-time in-situ density and velocity observations at Earth. The IPS volumetric velocity from this time-dependent tomography accurately convects photospheric magnetic fields from near the solar surface outward using a modified potential field model, and thus provides field values (both radial and tangential components) throughout the global volume. Moreover, precise results extracted at any solar distance are now used as inner boundary values to drive 3D-MHD models (e.g., ENLIL, and H3DMHD) allow us to explore the differences between the IPS analyses and each of the current 3D-MHD modeling techniques. These differences provide interesting insights into the physical principles governing the expulsion of CME mass.

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Poster Number: M2

Poster - *Geomagnetic Disturbances - Electric Power Grid*

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Abstract: Recent reports on the reliability of the electric power grid from national studies as well as insurance interests are reviewed. Information from recent space weather platforms are folded into operational sequences and consequences; suggestions for increased reliability are also reviewed.