SEASONS (Space Environment Applications, Systems, and Operations for National Security) Conference

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ABSTRACT

SEASONS (Space Environment Applications, Systems, and Operations for National Security) is a biennial conference that brings together members of the military, government, university, and contractor sectors who have an interest and stake in the space environment. The purpose of the conference is to provide participants an opportunity to discuss the impacts of space weather on DoD and intelligence community systems, as well as the applications and requirements for space weather sensors and algorithms to mitigate these impacts and enhance operations. The SEASONS 2018 conference will be held in the Kossiakoff Center at the Johns Hopkins University Applied Physics Laboratory (APL) from Wednesday, 7 November 2018, through Friday, 9 November 2018.

INTRODUCTION

Beginning with its inaugural event in November 2008, the SEASONS (Space Environment Applications, Systems, and Operations for National Security) conference has tracked the various stages of Solar Cycle 24. The biennial conference has focused on living with solar maximum, going beyond climatology to look at the impacts of space weather events, and the future of space weather and the ongoing challenges it presents in both stormy and quiet periods. The 2018 theme, The Operational Impacts of Space Weather, will focus on evolving space weather threats to operational assets that could disrupt future missions. Conference participants will explore how new tools and mitigation strategies can be applied to improve operational outcomes despite space weather hazards.

The sixth edition of the biennial conference will be held in the Kossiakoff Center at the Johns Hopkins University Applied Physics Laboratory (APL) from Wednesday, 7 November 2018, through Friday, 9 November 2018. Figure 1 shows the save-the-date postcard. Each day of the 2018 conference will be at a different classification level. The first day consists of unclassified presentations, an afternoon poster session and cocktail hour, and a conference banquet. The unclassified session was added to the SEASONS schedule in 2014, expanding participation to include civilian agencies and experts who are not associated with national security, APL's NASA partners, and invited foreign visitors from allied countries. The second day includes some classified presentations and allows participants to hold classified discussions. On the third day, sessions are held in a facility on APL's main campus that is suitable for highly classified presentations and discussions.

MOTIVATION

The space environment can interfere with defense and intelligence operations in many ways. Strong solar flares can cause radio blackouts. Energetically charged particles (ECP) can disrupt satellites by causing internal or surface charging, single-event effects, or degradation from total dose exposure from a space weather event. Varying satellite drag from geomagnetic storms can disrupt space situational awareness. Auroral clutter can interfere with radar signals. Ionospheric irregularities can disrupt over-the-horizon radar; transionospheric radio communication; and position, navigation, and timing systems. Severe geomagnetic storms can cause power grid failures and societal disruption. Figure 2 is a graphical representation of major space weather impacts.

Figure 1. Save-the-date postcard for SEASONS 2018, to be held from 7 to 9 November 2018, at APL.

Unlike terrestrial weather phenomena, space weather phenomena are not directly observable by humans. Furthermore, many space weather effects can be caused by nonnatural events. Thus, many space weather impacts are not obviously attributable to space weather. Day-to-day space weather variations are often not significant enough to disrupt operations. An operator's first encounter with space weather may be in an explanation after a mission has already been disrupted. If that disruption is not properly attributed to space weather, there is little motivation to explore future possible impacts of space weather. Operators will naturally be drawn to other pressing matters.

The scientific community has made great advances in observing space weather, forecasting space weather events, and modeling space weather impacts. However, when presenting these developments to DoD sponsors, researchers are often met with the question, "so, what?" In other words, there is a gap between abstract scientific research and operational relevance. Even when there is a shared understanding of the operational importance of space weather, a well-defined path from research to operations is often lacking.

SEASONS exists to bridge the gap between researchers and operators in a variety of ways. Many of the necessary conversations can take place only in a classified environment, so SEASONS is held in a venue that can host discussions at multiple classification levels. The different branches of the military play different roles in space weather research, acquisitions, and operations. The Air Force's 557th Weather Wing, for example, provides space weather forecasts to Army "boots on the ground." Forecasters and end users both must be represented in a conversation about procuring and applying new space weather research to operations; SEASONS provides a forum for this conversation.

SEASONS 2018

With an 11-year solar cycle, each meeting of the biennial conference occurs at a different phase of the solar cycle. Solar Cycle 24 is currently in the declining phase. Although the sunspot number is steadily decreasing, the threat of severe geomagnetic activity is not substantially reduced. Historically, the largest magnetic storms most commonly occur in the declining phase of the solar cycle. Furthermore, magnetic storms are also sparked by solar wind streams, which occur more frequently during this period.[1]

Recent solar research does suggest that, as in Solar Cycle 24, the next few solar maxima will be small or moderate.[2] Nevertheless, space weather has significant impacts on DoD and intelligence community (IC) operations even during solar minimum. SEASONS 2018 will focus on evolving space weather threats to operational assets and the systems that are affected by the space environment every day. Session topics will include the effect of ionospheric variations on high-frequency (HF) geolocation, which measurements are needed to identify anomalies from ECP in the context of contested space, the growing need for high-latitude ionospheric measurements and models, and international perspectives on the future of space weather.

HF geolocation is a topic of interest because ionospheric irregularities will have a significant impact on HF propagation channels. Accurate modeling of the

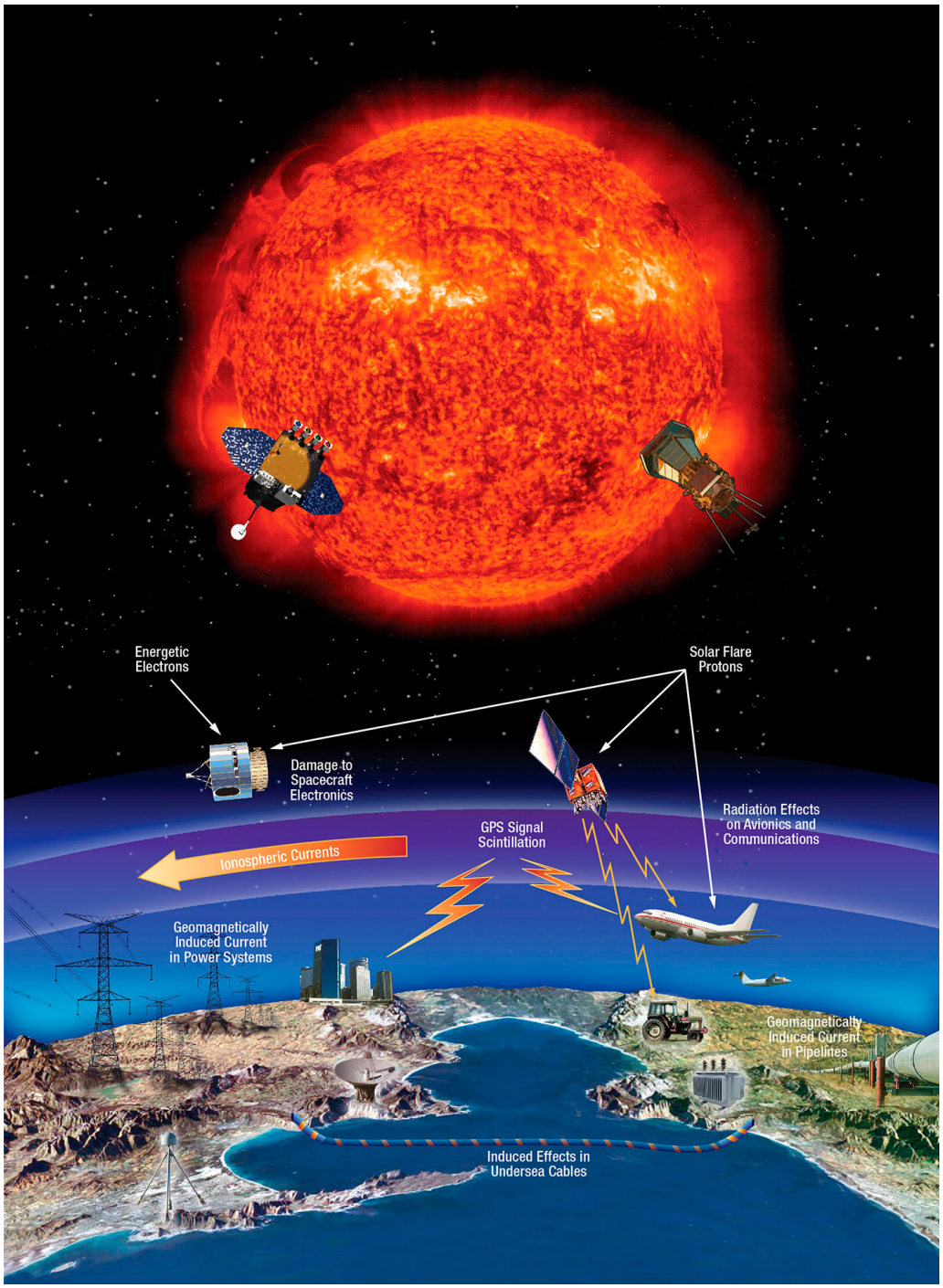

Figure 2. Space weather impacts. (Image courtesy of NASA.)

ionosphere will allow a greater understanding of changing propagation paths for over-the-horizon HF communications. ECP are a hazard for satellites at all orbits in the space environment. The four types of ECP hazards are surface charging, internal charging, single-event effects, and event total dose. High-latitude ionospheric measurements are of growing importance because the Arctic is increasingly becoming a commercial and military theater as sea ice recedes. The northern auroral oval varies quickly in response to changing space weather conditions and can cause radar clutter and scintillation of radio communication signals.

International perspectives on space weather are of growing importance to the DoD because the United States increasingly partners with allies in operations. The United Kingdom, Canada, and Australia are all directly impacted by space weather phenomena within their borders and are key scientific and strate-

gic partners for the United States. Space weather has many global impacts, and international partnerships are increasingly critical to providing the models and instruments necessary to observe and characterize the space environment.

SEASONS HIGHLIGHTS, CONTRIBUTIONS, AND TRADITIONS

Recent Highlights

SEASONS participants often demonstrate space weather's effects on the warfighter. Perhaps the best example is the work on Operation Anaconda presented by APL researchers at SEASONS 2010, 2012, and 2014. In 2010, Dr. Michael Kelly first presented research showing that space weather could have contributed to the communication outages during Operation Anaconda, during which an al-Qaeda ambush on top of Takur Ghar in Afghanistan resulted in the deaths of several U.S. military personnel. Satellite data from the Global Ultraviolet Imager on the TIMED (Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics) satellite showed a plasma irregularity in a 3-D reconstruction of the ionospheric line of sight to SATCOM satellites while a Chinook helicopter was flying to Takur Ghar, as shown in Fig. 3. A follow-up presentation in 2012 introduced the APL MIST (Mesoscale Ionospheric Simulation Testbed) model as a means for assimilating satellite UV observations, GPS measurements, and ground-based scintillation readings to produce a short-term forecast for future operations. This work led to a paper that was published in 2014,[3] and the resulting media coverage attracted the attention of retired Captain Nate Self,[4] who presented at SEASONS 2014 a first-hand account of his experiences commanding the Army Ranger unit that fought on Takur Ghar.

The SEASONS 2012 theme was Operating Through Solar Max. The biggest concern during solar maximum was the large flares' threat to power grids, which would have rivaled the historic 1859 Carrington Event. SEASONS 2012 attendees were among the first to know of the near-catastrophe in July 2012 when a massive solar flare missed Earth. The conference featured a panel entitled "Cascading Effects of Geomagnetic Storm Induced Power Grid Blackouts on DoD and IC Operations," moderated by Dr. Alenka Brown, then distinguished visiting researcher and executive advisor to the Center for Cyber Warfare under the Electrical and Computer Engineering Directorate at the Naval Post-

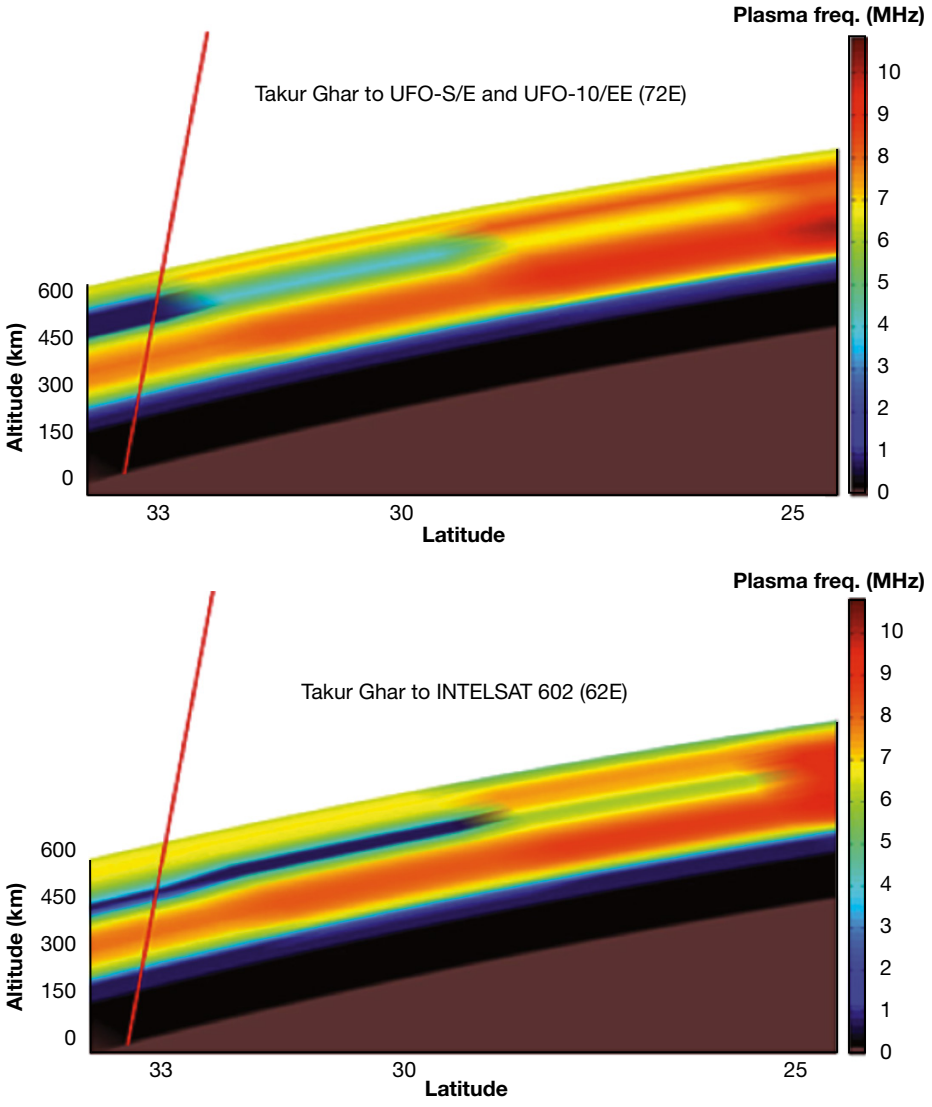

Figure 3. Lines of sight from Takur Ghar to available SATCOM satellites. Both lines of sight (red lines) pass through regions of depleted electron density (blue). The ionosphere is shown above the curved Earth (brown). (Reproduced from Ref. 3.)

graduate School National Capital Region. This panel included the following participants:

1. Dr. Bill Waugaman (national laboratories liaison to U.S. Northern Command)
2. Mr. Scott Pugh (Department of Homeland Security)
3. Dr. Daniel Baker (director, Laboratory for Atmospheric and Space Physics, University of Colorado Boulder)
4. Dr. Genene Fisher (then senior advisor for space weather, NOAA National Weather Service)

Highlights included a discussion of the more than $1 trillion economic loss that would have been caused by the July 2012 flare if it had directly impacted Earth, details of civilian and military power grid vulnerabilities and safeguards, and results of war games that assessed responses to a major geomagnetic storm impacting the power grid.

As mentioned, SEASONS 2014 included an unclassified session for the first time in the history of the conference. This addition was in response to APL's partnership with NASA as well as the DoD initiative to be more inclusive of the nation's closest allies. Ms. Christine Fox (APL) was the keynote speaker for the session and discussed ways to present space weather projects so that they clear the high bar for funding in the current environment. The conference's first international speaker was Dr. Brett Carter (RMIT University, Australia), who presented his research on equatorial plasma bubbles.[5] The 2016 conference included a full day of unclassified briefings, along with participants from the United Kingdom, Canada, and Australia.

DoD Contributions

SEASONS places the utmost value on discussion of operational support for the warfighter and continues to attract high-level DoD attendees and keynote speakers. SEASONS 2010 featured Lieutenant General Larry James (then commander, Joint Functional Component Command – Space and Commander, 14th Air Force), who gave a keynote presentation on the potential impacts of significant space weather events and the operational role of space weather alerts. The Air Force director of weather, Mr. Ralph Stoffler, and his predecessor, Dr. Fred Lewis, have presented keynotes at multiple SEASONS meetings, discussing the many ways the Air Force provides space weather support for the entire military. Indeed, each SEASONS meeting has featured keynotes from military leaders highlighting the importance of space weather to DoD operations. SEASONS is widely attended by operators in the DoD and the intelligence community, driving the interaction between scientists and operators that is uniquely characteristic of this meeting.

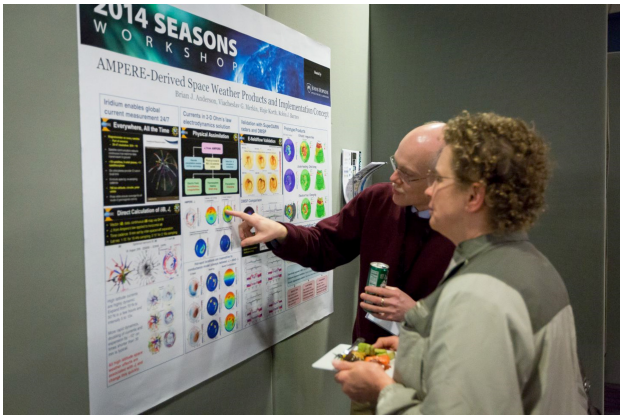

Figure 4. SEASONS attendees discuss a poster during the poster session at SEASONS 2014.

Classified Contributions

Understanding the space environment is a key for assessing future impacts of space weather on DoD and intelligence assets and missions. The ability to include classified material at SEASONS has allowed presenters to discuss technical details and lessons learned from space weather interactions during sensitive missions. Keynote addresses from Ms. Aurea Rivera (former technical director at the National Air and Space Intelligence Center) and Mr. Joseph Rouge (then technical advisor for space and cyber space intelligence, surveillance, and reconnaissance in AF/A2), as well as presentations on space environment studies with Space Tracking and Surveillance System (STSS) and Space Based Space Surveillance assets (SBSS), have provided more depth to the space weather discussions during classified sessions.

APL Contributions

APL is a leader in space weather missions, tools, and decision aids, with presentations at each SEASONS meeting demonstrating the latest developments. Dr. Larry Paxton has presented UV imaging capabilities from the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) on a series of Defense Meteorological Satellite Program (DMSP) satellites. Dr. Nicola Fox discussed the launch of the Van Allen Probes in 2012 and presented breakthrough discoveries on the Earth's radiation belts in 2014. Dr. Brian Anderson highlighted the innovative capabilities of the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) on the iridium constellation to map the dynamics of Earth's magnetic field as space weather events unfold. Figure 4 shows an AMPERE poster at SEASONS 2014. A number of other APL scientists and engineers have shown new space weather tools in oral and poster presentations.

Figure 5. Poster session and reception before the banquet during SEASONS 2014.

Figure 6. Dr. Michael Ryschkewitsch, the banquet speaker for SEASONS 2014, discusses the future of space weather.

Traditions

Every SEASONS conference has a poster session and reception (one is pictured in Fig. 5) followed immediately by a banquet with a distinguished guest speaker. This tradition began in 2008 with Dr. Robie Samanta Roy, then the assistant director for space and aeronautics from the White House Office of Science and Technology Policy. SEASONS 2010 featured Dr. Richard Fisher, then the Heliophysics Division director for the Science Mission Directorate at NASA Headquarters. At SEASONS 2012, Captain Kay Hire discussed her personal experiences with space weather from her time in space as an astronaut aboard the Space Shuttle and the International Space Station. At SEASONS 2014, Dr. Michael Ryschkewitsch, head of APL's Space Exploration Sector (pictured in Fig. 6), provided perspectives on the past and future challenges for the space weather field.

Each SEASONS meeting concludes with a highly classified half-day morning session. These sessions typically consist of several presentations followed by a lengthy group discussion of space weather impacts on very sensitive missions that are critical to national security. Past keynote speakers for this session include Dr. Stewart Cameron (National Reconnaissance Office), Mr. Bert Beaulieu (then director, NGA InnoVision), and Dr. Peter Bythrow (then chief scientist, Defense Intelligence Agency/Deputy Director for Scientific and Technical Intelligence).

CONCLUSION

SEASONS seeks to bring operators and other users of space weather products together with scientists and developers. These biennial meetings advance the understanding of the reality of space weather impacts on national security and help ensure that DoD investments in space weather research and development ultimately address the needs of the warfighter. Even in the declining phase of Solar Cycle 24, understanding the ongoing impacts of the space environment is increasingly important, and SEASONS 2016 participants discussed the future of space weather. SEASONS 2016 featured sessions at the unclassified, classified, and highly classified levels, with the expanded unclassified session focusing on collaboration with allied countries. Like the previous five SEASONS conferences, SEASONS 2018 will continue to address the critical challenge that the space environment poses for national security applications, systems, and operations.

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