ALGORITHM DEVELOPMENT PROGRAM FOR THE NPOESS SPACE WEATHER PRODUCTS

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The Space Environment Monitoring package for the NPOESS (SEM-N) will provide several key Environmental Data Records (EDRs) used for producing operational space weather products by the USAF and NOAA. The ground algorithms used to process sensor Raw Data Records (RDRs) into the space environment EDRs are strongly based on heritage capabilities from DMSP and POES as well as other relevant NASA missions. This talk will discuss the status of the science algorithm development for NPOESS space EDRs, requirements for SEM-N RDRs and other ancillary data, and plans for the operational deployment of the EDR ground processing algorithms.

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Environmental Data Records (EDRs) & Space Weather Products

Requirements for NPOESS space Environmental Data Records (EDRs) are provided in the Integrated Operational Requirement Document (IORD-2). The EDRs assigned to the SEM-N sensor for NPOESS are:

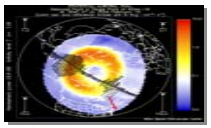
- Auroral Boundary
- Auroral Energy Deposition
- Supra-thermal through Auroral Energy Particles
- Medium Energy Charged Particles
- Energetic Ions

To a large extent, these EDRs represent measurement continuity from the Polar Operational Environmental Satellites (POES) for the DOC/NOAA and to some limited extent continuity from the Defense Meteorological Satellite Program (DMSP) for the DoD/USAF. These data are used by the NOAA Space Weather Prediction Center (SWPC) and Air Force Weather Agency (AFWA) for higher-level products and services. The SEM-N measurements in the NPOESS early afternoon orbit (@1320 LTAN for C1 and C3) when combined with SEM-2 measurements on MetOp (@2130 LTAN) provide continuous 2-orbit coverage of space weather data.

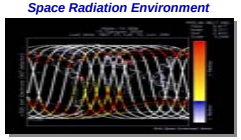
Within the SWPC, the *Statistical Auroral Oval* is a data-driven representation of the northern (& southern) oval determined by measuring the flux of precipitating charged particles. The equatorial extent of the auroral zone is an excellent indicator of the level of "space weather" stress during geomagnetic storms. Differential plots of the *Space Radiation Environment* along the satellite path are calculated using measurements of energetic electrons and ions which provide a valuable source of data relevant to manned spaceflight. Finally, *Solar Proton Monitor* plots use energetic ion data from omni-directional proton detectors which can be used to infer the presence of polar-cap absorption regions at high latitudes which can adversely affect radio-wave propagation. Sample plots are provided below.

Space Environmental Data Products

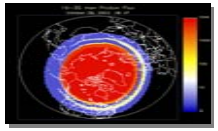
Statistical Auroral Oval



Space Radiation Environment



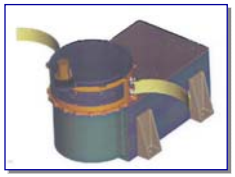
Solar Proton Monitor



Space Environment Monitor for NPOESS (SEM-N)

SEM-N consists of the space sensors and ground processing algorithms needed to produce the assigned set of space Environmental Data Records (EDRs). The Applied Physics Laboratory (APL) of the Johns Hopkins University is responsible for the development of the space sensor suite needed to measure the energetic charged particle environment in low-earth polar orbit. The nominal suite consists of three distinct sensors that address NPOESS requirements; a low-energy electron and ion spectrometer addressing the energy range from 50 eV to 20 keV; a medium energy electron (positive ion) detector covering the energy range from 30 keV to 2.5 MeV (>6.9 MeV), and a high-energy ion detector for measuring particles within the energy range of 15 MeV to 500 MeV. For the SEM-N development APL is relying on heritage operational sensor designs from DMSP and POES as well as from environmental sensors flying on NASA satellites. Nominal sensor performance references the assigned attributes from the SEM-N Suite Requirements Document (SSRD) whereas actual performance may offer capabilities for some attributes which are above the required threshold capability.

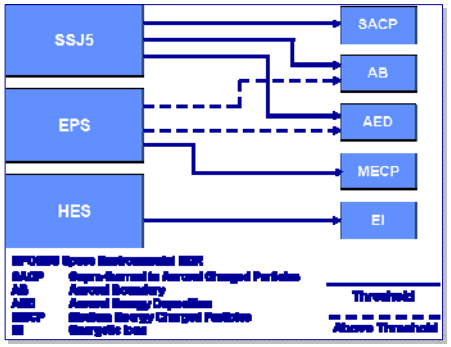
Special Sensor J5 (SSJ5)



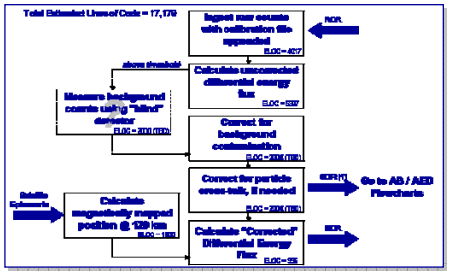
Energetic Particle Sensor (EPS)

High Energy Sensor (HES)

Science-grade SEM-N algorithms are being developed by a team of scientists having expertise in the SEM-N heritage capabilities. As in the case of the hardware development, this team is leveraging existing operational algorithms to produce the assigned set of space environmental EDRs. A nominal mapping from SEM-N instruments to EDRs is shown below.



An example of the EDR flowchart for the Supra-thermal through Auroral Energy Particles is show below. SEM-N Raw Data Records (RDRs), or counts, are ingested by the program and converted to Sensor Data Records (SDRs) after applying instrument calibration factors and correcting for background contamination. At this point, the SDRs can be used both as inputs to other EDR algorithms and to produce the final EDR by mapping the calculated flux along magnetic field lines from satellite to auroral altitudes (840 km to 120 km). Estimated lines of code for this EDR algorithm, as well as estimates for the other EDRs, are based on heritage software designs.



The sensor-to-EDR mapping indicates that in some cases multiple sensor inputs can be used to produce an EDR above threshold. Also, for some EDRs there are several possible algorithms that can be used to produce an EDR with attributes that exceed the threshold and, in some cases, the objective. A part of the developmental strategy is to explore all potential options early in the program and then down-select to one algorithm per EDR which will then be the basis of the science-grade code. An algorithm developmental test-bed will be developed and used to test the science-grade code prior to final delivery. Applicable documentation will also be developed and delivered to the program office.

Converting Science-grade Code to Operations

This developmental effort is limited to producing the NPOESS science-grade EDR algorithms for the SEM-N sensor. The IPO is investigating alternatives for converting the science-grade code to operational software and for incorporating this software into the NPOESS Interface Data Processing Segment (IDPS). The SEM-N Operational Algorithm Team (OAT) will advise the program office on all aspects of the EDR code development and implementation.

SUMMARY

The NPOESS IPO is developing the SEM-N suite to address an assigned set of space EDRs. Both the instrument hardware and the ground-processing algorithms are based on heritage capabilities from DMSP, POES and NASA. The Johns Hopkins University APL is responsible for development of the SEM-N sensor suite. Science-grade SEM-N algorithms are being developed in coordination with a government team having expertise in SEM-N heritage capabilities. The SEM-N algorithms will be converted to operational software for inclusion in the IDPS and made available for space weather operations within NOAA and the USAF.

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