STATUS OF THE SPACE ENVIRONMENT MONITOR FOR NPOESS (SEM-N)

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The SEM-N is the next generation operational sensor suite for measuring the characteristics of precipitating charged particles in low-earth orbit. This presentation will provide the status of the SEM-N development program including discussion of the sensor hardware and associated algorithms for the NPOESS EDRs that will be incorporated into space weather operations within the NOAA NWS Space Weather Prediction Center and the U.S. Air Force Weather Agency (abbreviated abstract).

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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:

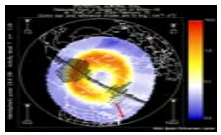
- Auroral Boundary
- Auroral Energy Deposition
- Supra-thermal through Auroral Energy Particles
- Medium Energy Charged Particles
- Energetic Ions

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 (@1330 LTAN for C1 and C3) when combined with SEM-2 measurements on MetOp (@2130 LTAN) provide continuous 2-orbit coverage of space weather data.

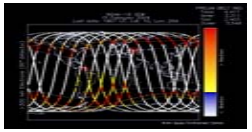
Within the SWPC, the *Statistical Auroral Oval* is a data-driven representation of the northern (& southern) oval determined by measuring the flux of precipitating charged particles. The equatorial extent of the auroral zone is an excellent indicator of the level of "space weather" stress during geomagnetic 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

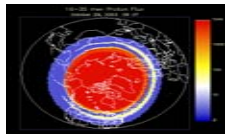
Statistical Auroral Oval



Space Radiation Environment

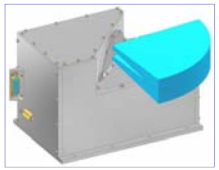


Solar Proton Monitor

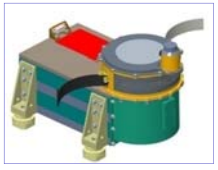


Space Environment Monitor for NPOESS (SEM-N)

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 30 eV to 30 keV; a medium energy positive ion (electron) detector covering the energy range from 30 keV to 10 MeV (1 MeV), and a high-energy ion detector for measuring particles within the energy range of 10 MeV to 250 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.



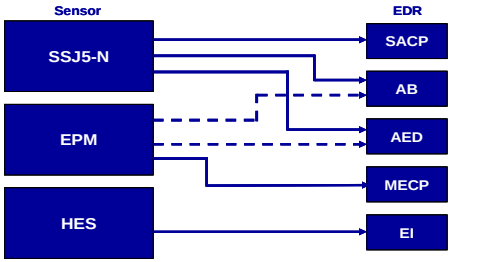
Special Sensor J5 (SSJ5-N)



Energetic Particle Monitor (EPM)

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.



NPOESS Space Environmental EDR

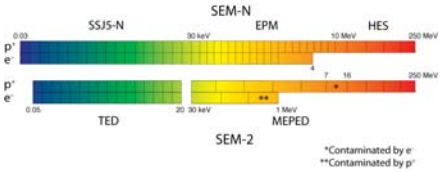
SACP	Supra-thermal to Auroral Charged Particles
AB	Auroral Boundary
AED	Auroral Energy Deposition
MECP	Medium Energy Charged Particles
EI	Energetic Ions

Threshold

Above Threshold

Developmental Status

Congressionally-mandated restructuring of the NPOESS program in 2006 directed that the program office maintain, at a minimum, the performance capabilities of the heritage POES SEM-2 sensor. The SEM-N for NPOESS satisfies this requirement but then exceeds the capabilities of the heritage sensor in several key areas. The SSJ-N measures from 30 eV to 30 keV thereby closing the 20 to 30 keV gap between the SEM-2 TED and MEPED sensors as shown in the figure below. The SSJ5-N has 19 energy channels whereas the SEM-2 had 16 channels but then decimated the downlink to only 4-5 channels using on-board processing. The SEM-N EPM measures proton fluxes in at least 18 energy channels thereby providing better energy resolution than the SEM-2 MEPED's 6 channels. The EPM also measures electrons in at least 11 channels – exceeding the SEM-2 MEPED's 3 channels and providing better spectral resolution. The EPS Time-Of-Flight (TOF) system prevents electrons from contaminating the proton signal. The EPS TOF system also prevents heavier ions from contaminating the proton signal, by separately measuring heavy ion fluxes.



The SEM-N EDR algorithms can take advantage of these improved sensor capabilities by extending the energy range used in the determination of the auroral energy deposition (specifically for the precipitating ion flux) [*Knight et al., 2008*], combining sensor outputs to better define the auroral boundary [*Newell et al., 2004*] and using the EPM TOF system to measure the mass composition of energetic ion precipitation [*Spjeldvik & Fritz, 1981*].

Both the SEM-N sensor hardware and EDR science algorithms are currently under development for a planned NPOESS launch in 2014. Initial hardware accommodations on the spacecraft have been completed and planning for the operational software implementation within the NPOESS Interface Data Processing Segment (IDPS) has begun. As the POES and DMSP systems reach end of life, continuity of the operational space weather mission in ow-earth polar orbit will be maintained by the SEM-2 and SEM-N sensors on MetOp and NPOESS, respectively.

Summary

The SEM-N sensor is currently under development for the first NPOESS launch in 2014. SEM-N consists of both the hardware and EDR algorithms required to monitor the near-earth space environment in low-earth orbit. The capabilities of the SEM-N exceed the performance of the current SEM-2 sensors and will provide improved data products for future operational space weather.

Knight, H.K., D.J. Strickland, J.H. Hecht, P.R. Straus,D. Morrison, L.J. Paxton, and D.S. Evans (2008), Evidence for significantly greater N2 Lyman-Birge-Hopfield emission efficiencies in proton versus electron aurora based on analysis of coincident DMSP SSUSI and SSJ/5 data, *J. Geophys. Res.*, *113*, A04305, doi:10.1029/2007JA012728.

Newell, P. T., J. M. Ruohoniemi, and C.-I. Meng (2004), Maps of precipitation by source region, binned by IMF, with inertial convection streamlines, *J. Geophys. Res.*, *109*, A10206, doi:10.1029/2004JA010499.

Spjeldvik, W.N. and T.A. Fritz (1981), Energetic Heavy Ions With Nuclear Charge Z > 4 in the Equatorial Radiation Belts of the Earth: Magnetic Storms, *J. Geophys. Res.*, *86*, pp 2349-2357.

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