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UV Data Products Derived From Low Earth Orbit Hyperspectral Imagers - Characterizing Space Weather

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UV Hyperspectal Imager Instruments

TIMED/GUVI
First Generation

GUVI produced groundbreaking imagery of ionospheric bubbles and UV aurora. Launched over 10 years ago, GUVI is still taking spectrographic mode data.

DMSP/SSUSI
Second Generation

Three SSUSI instruments are on orbit with two more yet to be launched. SSUSI provides ionosphere/auroral characterizations at fixed local times of DMSP orbits to the GAIM assimilation model.

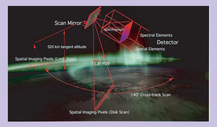
AURORA
NEXT Generation

Originally slated for launch on NPOESS this instrument concept is now under development for other platforms

UV instruments supplied by APL are hyperspectral scanning imagers. By scanning the Earth sequentially, global images are accumulated. These images result from UV light emitted by atoms in the thermosphere, and the intensities can be used to derive a wealth of products that characterize the ionosphere and aurorae. The UV derived products provide an accurate near real-time monitoring of the local space weather environment.

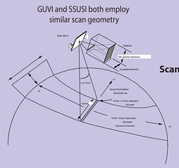
INSTRUMENT OPERATION

The UV instruments on TIMED/GUVI and DMSP/SSUSI were designed to scan both the Earth's disk and limb.



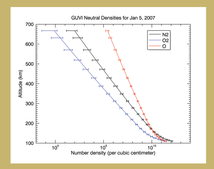
UV imagers scan as well as stare at a given strip for detailed spectroscopy.

GUVI and SSUSI both employ similar scan geometry



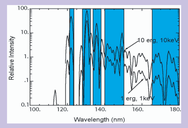
Scan detail

Dayside Neutral Density Profiles from Limb Observations



Density Profiles of the primary atmospheric components O, O_2, and N_2, can be derived from dayside limb radiances. These profiles are an important input for atmospheric drag assessments.

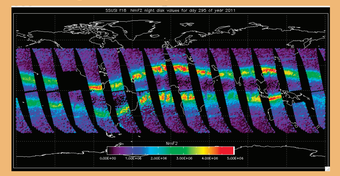
UV "colors" based on emission features.



To reduce telemetry needs, the UV hyperspectral image data are rolled up into 5 UV colors based on important bands and lines that are ionospheric and auroral indicators.

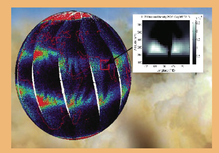
Ionosphere Monitoring

Global Nightside Ionospheric Electron Densities



Nighttime 135.6 nm radiances can be used to derive ionospheric electron densities like the ones shown above for day 295 of 2011. Over a day the polar orbiting DMSP satellites cover the entire globe. The associated radiances are an important input for global assimilation models in order to accurately model the ionosphere everywhere.

Scintillating Electron Density Bubbles



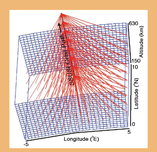
Regions of low electron density (Ionosphereic Bubbles) are areas of scintillation,,affecting communications and GPS. These bubbles are detected and characterized using the 3-D electron desnsity data products described below.

UV Data Products Meet the Top IORD-II Key Support Requirements

IORD-II solutions to satisfy the remaining Environmental Data Records (EDRs), considered as Key Support Areas (KSA), as approved by the Senior User Advisory Group in priority order and are based on recommendations from the NPOESS Joint Agency Requirements Group (red indicates a UV EDR data products):

1. Electron Density Profile
2. Ionospheric Scintillation
3. Neutral Density Profile
4. Auroral Imagery
5. Auroral Energy Deposition
6. Auroral Particles
7. Energetic Ions
8. Electric Field
9. Medium Energy Particles
10. Geomagnetic Field
11. In-Situ Plasma Temperatures
12. In-Situ Plasma Fluctuations
13. Auroral Boundary

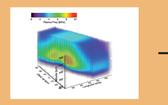
3-D Ionospheric Reconstruction



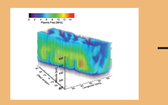
UV scanning instruments have many pixels whose look vectors pierce the ionosphere in a large number of overlapping directions. The information from the many lines of sight can be used to do tomographic reconstruction of the ionospheric electron density.

3-D Ionospheric Electron Densities and HF Propagation

HF propagation through the smooth global models like IRI can leave users expecting simple behavior.

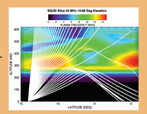


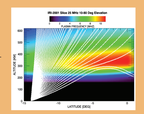
Ionospheric models such as IRI (illustrated above) show a relatively smooth and simple ionosphere.



The actual ionosphere, reconstructed from SSUSI high resolution measurements show a much richer structure full of irregularities that will affect GPS and radio signals.

Ionospheric HF Propagation



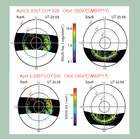


Using a more realistic ionosphere as observed by an UV instrument shows much more complex behavior.

Auroral Monitoring

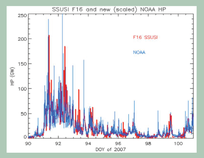
Polar orbiting UV imagers provide excellent views of the auroral conditions. Many auroral products are made from the SSUSI radiances .

Electon Mean Energy and Flux



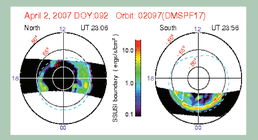
The electron mean energy and flux density are routinely retrived from the UV auroral region radiances.

Hemispheric Power

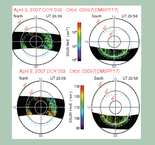


Hemispheric Power, an important input for global models is derived in near real time from SSUSI radiances. These HP estimates compare favorably with the estimates from NOAA.

Auroral Boundary Global (blue) and High Resolution Boundary (red)



E-Region Electron Density Profiles



The maximum density and height of the maximum E-region electron density are mapped in the auroral zone.

UV Data Product Summary

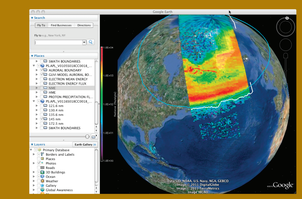
The complete list of Products derived from APL's UV hysperspectral imagers follows. Note there are dayside products in the list that are now undergoing validation and we hope to have validated dayside products soon.

Product	Description
PREP	Raw Instrument Count Rates
Level 1B	Calibrated Background subtracted geolocated Radiances
Sensor Data Records	Radiance data binned onto a larger, more uniform geographic based grid
EDR-Disk	NmF2, HmF2, [Nightside: F_1F2], [Dayside:$Q_{eqiv}O/N_2$,TEC]
EDR-Limb	NmF2, HmF2, [Nightside: VER, EDP,H_{max}], [Dayside: TEC, densities for O_2,O, N_2]
EDR-Auroral	Auroral boundary, Q, E_0, NmE, HmE gridded geomagnetically, Hemispheric power, p precipitation regions
EDR-Bubble	Number of equatorial ionospheric bubbles detected and their centroid locations; Electron densities in bubble and background ionosphere

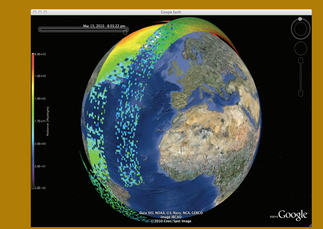
GUVI products available through the GUVI website http://guvi.jhuapl.edu. APL is currently in discussion with NOAA about making SSUSI products available through the National Geographic Data Center.

Thanks to Our Sponsor Agencies

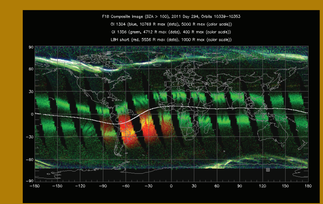
UV Product Visualization



Near realtime visualization products are created to facilitate easy monitoring of the ionosphere and auroral zones. Here the SSUSI auroral pixel boundary (white) and GUVI model fit global boundary (cyan) are shown layered over the SSUSI LBH short radiances. Google Earth visualizations made from associated SSUSI products contain informtaion in multiple layers.



SSUSI Gridded Radiances are rendered in Google Earth as multilayered KML. Radiances are binned and then rendered separately for the disk and limb data.



High Resolution Images of the SSUSI Radiances are made daily by combining UV images in RGB as blue (130.4 nm), green (135.6 nm), and red (LBH short). Note that the radiation signal from the South Atlantic Anomaly is subtracted from 130.4 and 135.6 nm colors, but not the LBH short.