NESC Space Environment Activities

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11th Space Exploration and Space Weather Workshop

17 October 2019, GSFC, Greenbelt, MD

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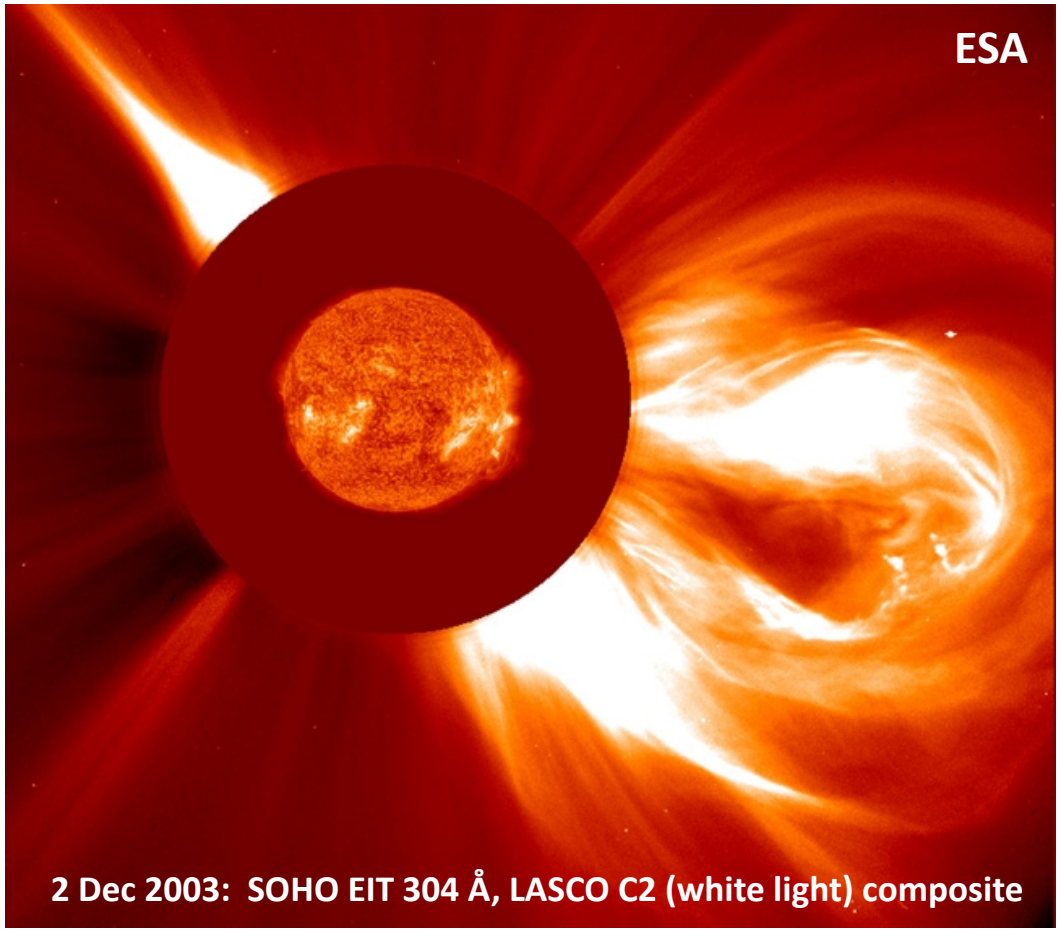
Outline

The theme of the workshop this year is "*Moon to Mars – Artemis 2024.*" Todays presentation is an overview of NESC space environment and space weather activities relevant to the Moon, Mars theme….



2 Dec 2003: SOHO EIT 304 Å, LASCO C2 (white light) composite

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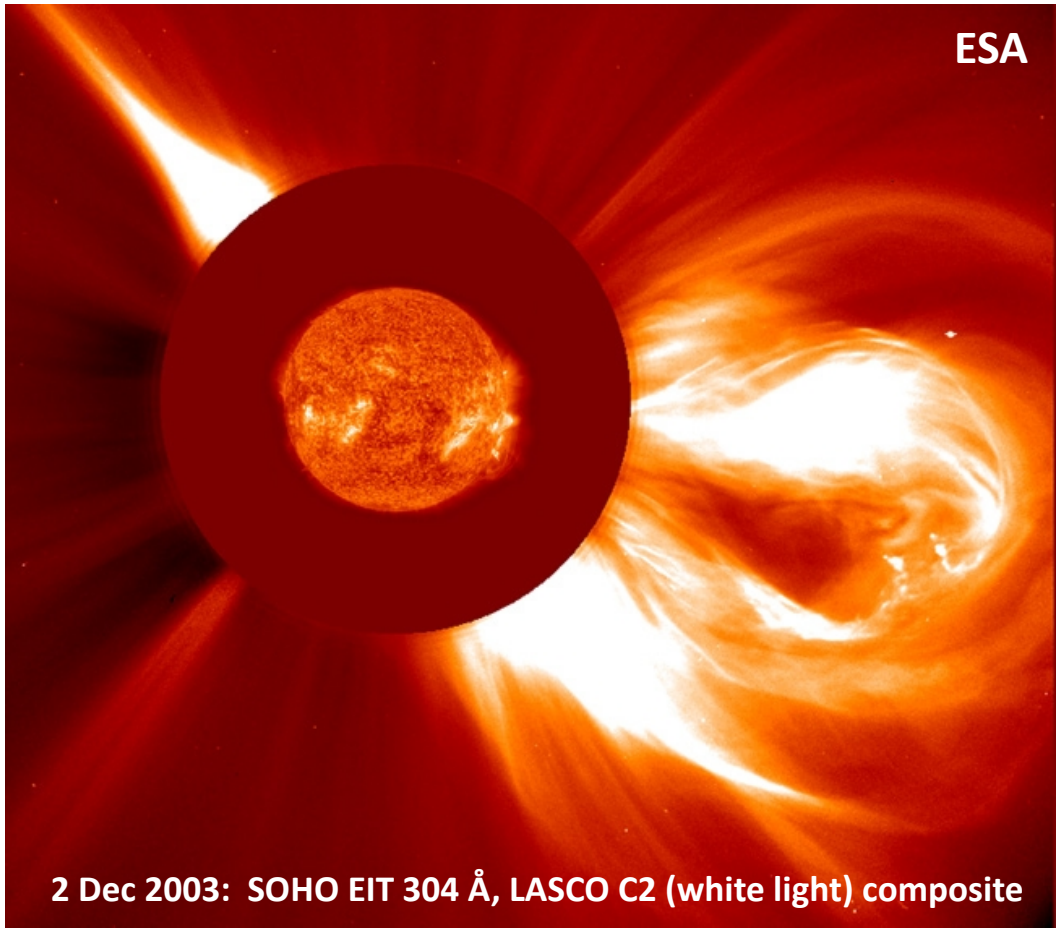
Outline

- Space Weather Architecture
- ACE RTSW Data Status
- SCMD/Electrical Properties of Materials
- Southern Hemisphere Meteoroid Measurements
- FPMU Data Processing and Analysis
- New FY20 Projects
- ASEC 2019



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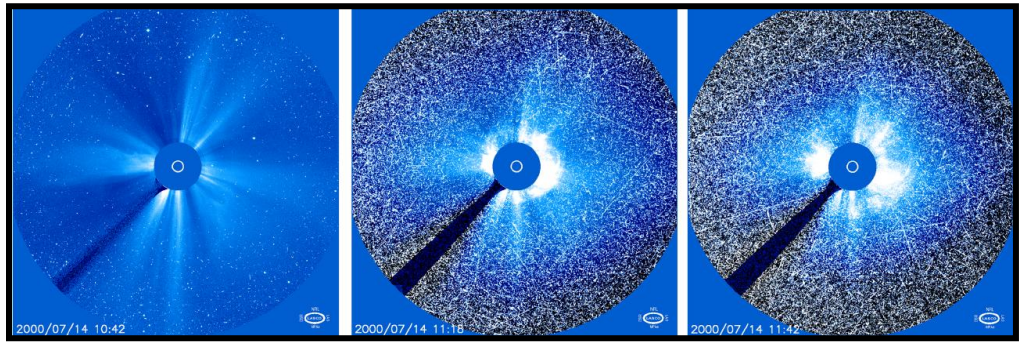
Space Weather Architecture Assessment

- Evaluate options for cost-effective space environment monitoring and forecasting architectures to reduce space radiation risks for human and robotic deep space exploration
  - *In-situ* radiation monitoring hardware planned for deployment on exploration vehicles
  - Utilize existing space environment sensors from NASA, NOAA, DOD, and other organizations to the greatest extent possible
  - A minimal set of new hardware only where necessary

- Team includes personnel from NESC, GSFC, JPL, JSC, LaRC, HQ, NOAA SWPC, and AFRL working on six tasks:
  - Task 1: Review of background materials on SWx monitoring to protect flight crews from radiation
  - Task 2: Operational response needs for space weather monitoring
  - Task 3: Solar particle event forecasting tools
  - Task 4: Solar energetic particle thresholds for operational alerts
  - Task 5: Monitoring and forecast architecture options
  - Task 6: Cost estimate for space weather architecture options

- Estimated completion date is by end of CY19

SOHO/LASCO



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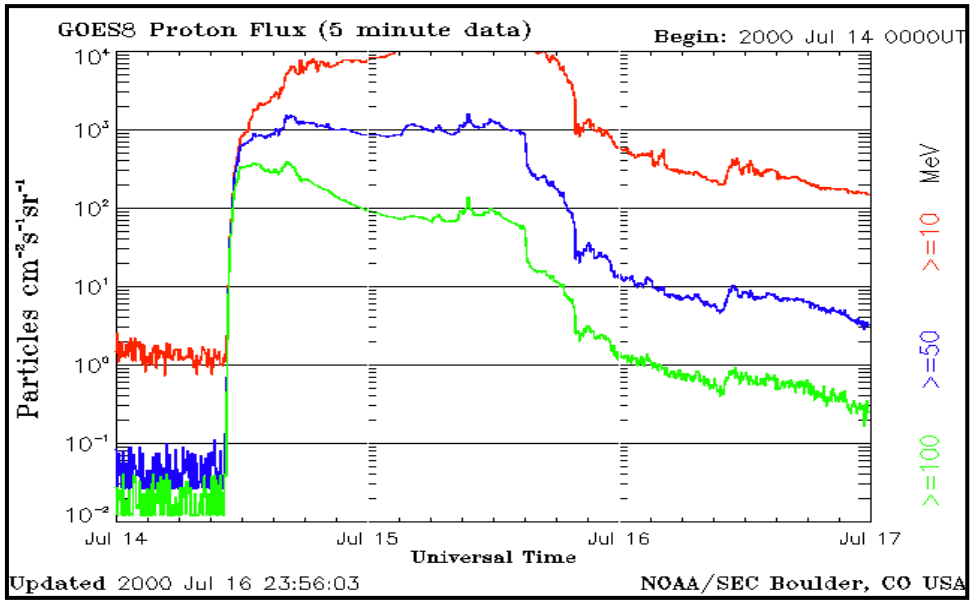


ACE Real-Time Solar Wind (RTSW) Data Status

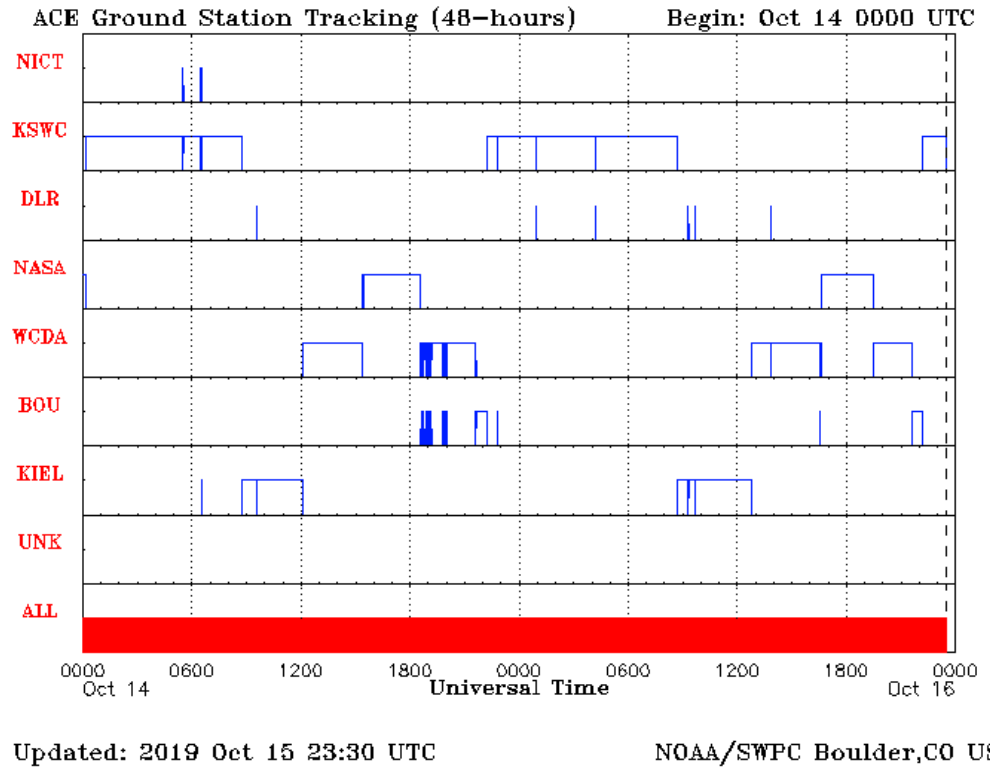
- NASA, NOAA have an agreement to continue acquisition, processing, and distribution of the ACE RTSW data stream to support Chandra X-Ray Observatory radiation mitigation operations

- Tracking assets in North America (NASA, NOAA) and Europe (DLR, Univ. of Kiel) provide regular coverage

- Korean Space Weather Center currently tracking ACE due to hardware issues with tracking assets and DSCOVR
  - May acquire data from both ACE and DSCOVR when hardware issues are resolved
  - NASA will continue to work to identify additional ground station assets in Asia if required

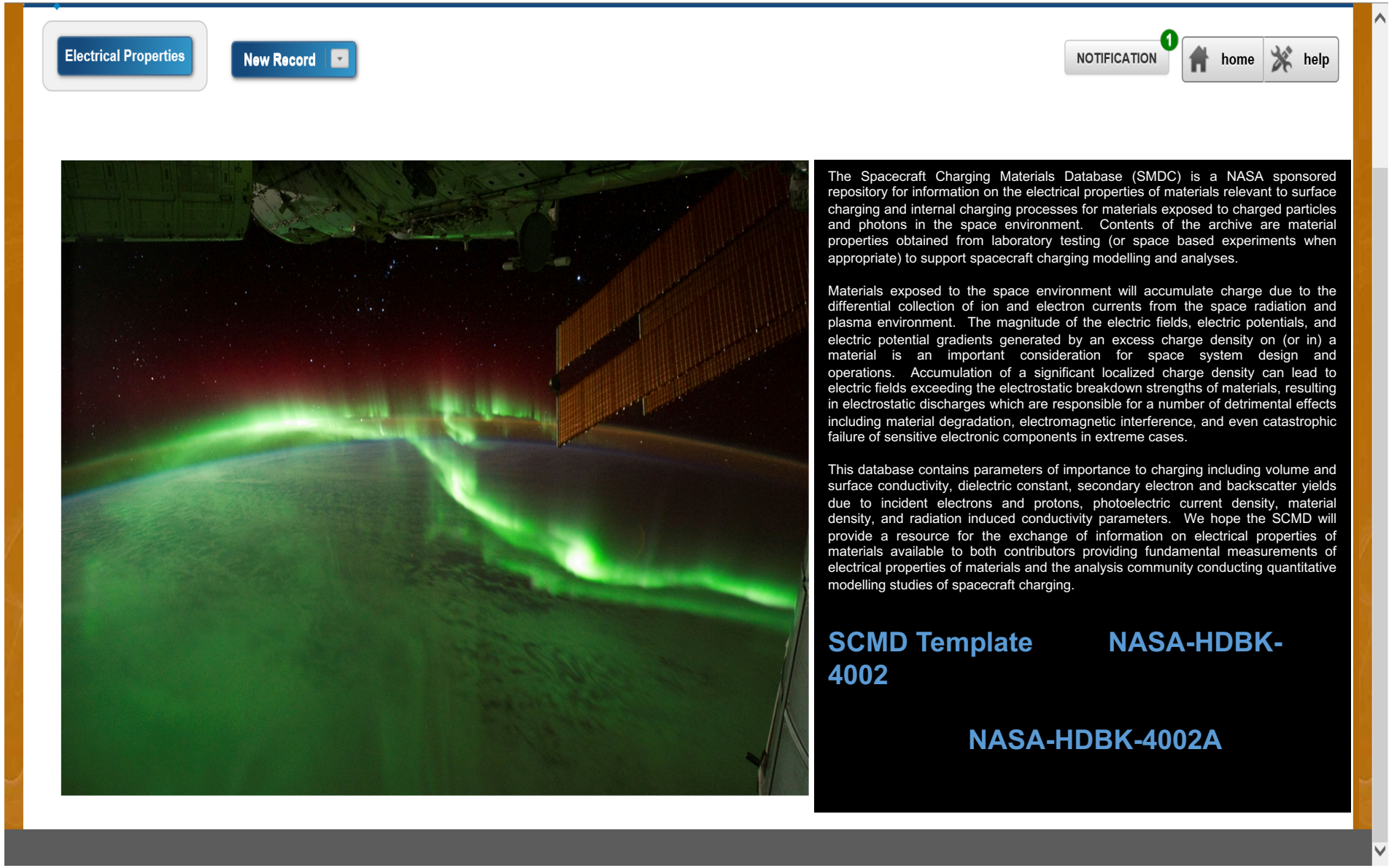
- NASA declared ACE an "*infrastructure asset*" for space weather applications in 2019, removing it from annual senior review process and assuring access to data for space weather activities

- ACE RTSW continues with only small data gaps typically an hour or less over a 24 hour period



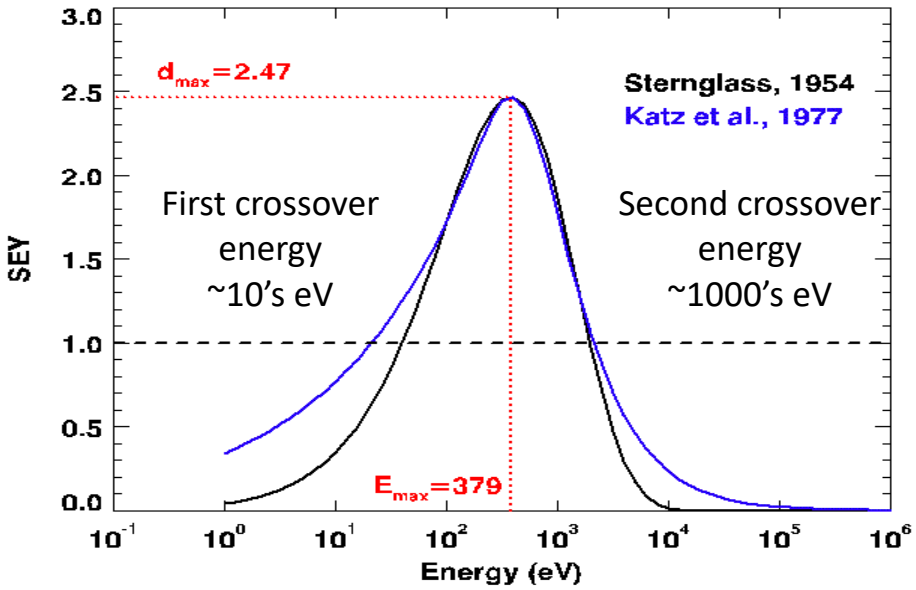
Source: https://services.swpc.noaa.gov/images/ace-tracking-48-hour.gif

Spacecraft Charging Materials Database (SCMD)



Electrical Properties of Materials

- Spacecraft charging analyses require quantitative measurements of electrical properties of materials in relevant space environments
  - Surface and volume resistivity, secondary emission yield, photoemission yields, dielectric strength
  - Vacuum, cryogenic temperatures, high temperatures
  - Spacecraft Charging Materials Database (SCMD) implemented in FY18 is attracting interest from user community, but to date we have received no contributions to expand the database holdings
- NESC/Gateway material electrical properties support activity
  - Utah State University, Department of Physics support to JSC, MSFC teams conducting charging analyses for Orion, Gateway vehicles
  - Gateway provided funds for initial characterization of Orion, Gateway materials used in NASA Docking System Block 2, Gateway hardware
  - NESC funded task to complete test reports from USU electrical property measurements of a variety of spacecraft materials
- New materials property data from support activity will be incorporated into the SCMD improving the database



***Sternglass*, 1954**

$$\delta_e(E,\theta) = \delta_{e,\max}\frac{E}{E_{\max}}\exp\left(2-2\sqrt{E/E_{\max}}\right)\exp[2(1-\cos\theta)]$$

***Katz et al.*, 1977; *Whipple*, 1981**

$$\delta_e(E,\theta) = \frac{1.114\delta_{e,\max}}{\cos\theta}\left[\frac{E}{E_{\max}}\right]^{0.35}\left\{1-\exp\left[-2.28\cos\theta\left[\frac{E_{\max}}{E}\right]^{1.35}\right]\right\}$$

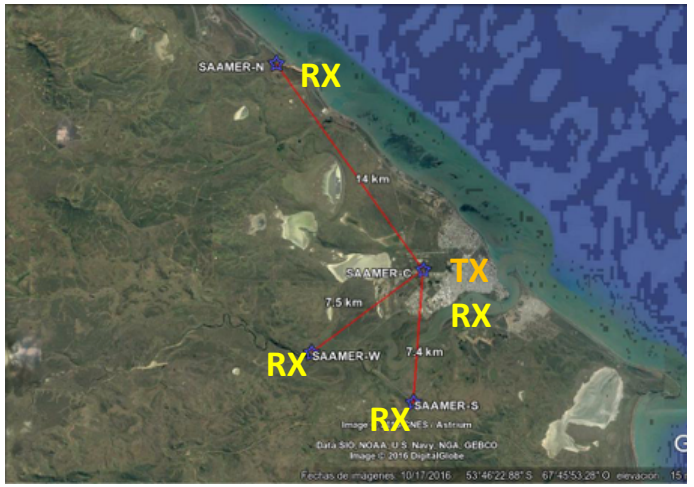
Southern Hemisphere Meteoroid Measurements

- Hypervelocity impact damage from meteoroids are a potential threat to spacecraft in lunar environments (orbital and surface)

- NESC/GSFC/MSFC/JSC team conducting assessment to characterize southern hemisphere meteoroid environments including
  - Upgrade of the Southern Argentina Agile Meteor Radar (SAAMER) facility to function as a meteoroid patrol radar (primary mission is science investigation of upper atmosphere winds)
  - Conduct southern hemisphere meteoroid survey for two full years including head echo observations during the 2019 Beta Taurid Meteor shower
  - Calibrate the SAAMER data with optical observations to complement the Canadian Meteor Orbit Radar (CMOR) observations to provide meteoroid fluxes and mass indices in the mass range that pose a threat to spacecraft

- SAAMER radar hardware modifications complete and camera system deployed. System is operational and returning southern hemisphere meteor data

SAAMER-C: 53.786°S, 67.751° W



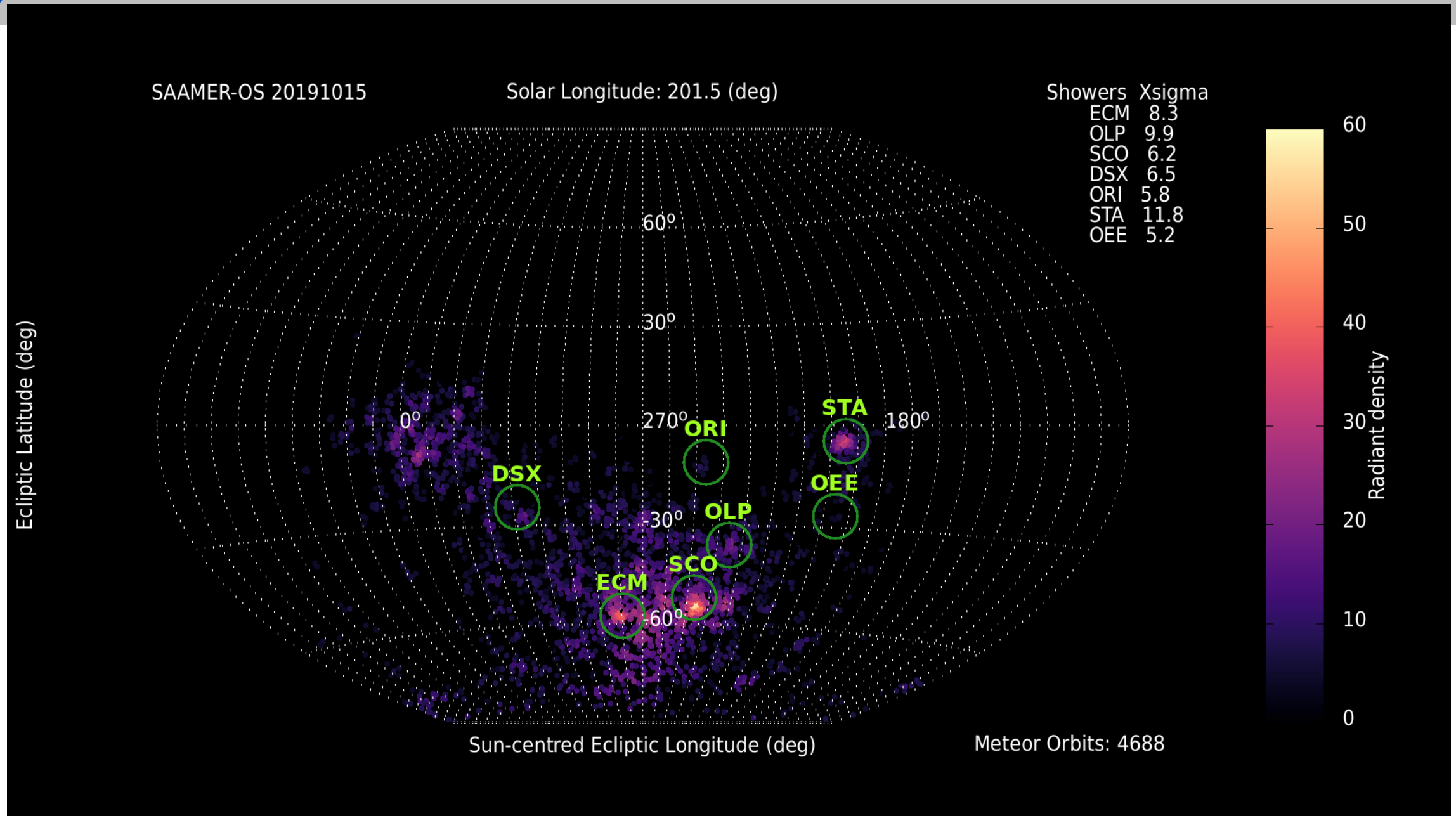
Images: D. Janches/GSFC

SAAMER – Orbital System Summary (---preliminary---)

#SAAMER Daily meteor shower search report #of 20191015 Solar longitude: 201.50 deg
#Interval of Julian Days: 2458771.499899 and 2458772.499901
#Station meteor counts: CNW__ 585 CN_S_ 333 C_WS_ 1052 CNWS_ 2895 C 4865
#File: ROBORB_20191015.sl has 4689 meteor orbits
#Reference Database: METEORDB_2018.db
#Current Database: ROBORB_20191015.db
#Wavelet run parameters: angular probe size: 2.5deg
velocity probe size: 15%
time-window: 0.5deg
0.5 deg angular resolution and 5% in vg
ll0_min 0 ll0_max 360 beta_min -90 beta_max 40
vg_min 11 vg_max 78 slon_min 201.50 slon_max 201.50
Meteor speeds corrected for deceleration following Brown et al 2005.
#
#
#Shower association: 3 deg and 15% in vg of known shower radiants.
xsigma > 3.0 and rcnt > 30

ll0	beta	vg	wc	wcerr	radcount	xsigma	med	sigma	std	shower
279.500	-57.500	33.785	73.670	38.263	272.000	8.343	1.957	8.595	8.866	ECM
235.000	-36.000	26.472	65.264	29.303	125.000	9.945	0.126	6.550	6.093	OLP
247.000	-52.000	35.474	53.971	37.750	278.000	6.155	1.818	8.474	8.614	SCO
318.500	-24.500	27.795	30.297	21.247	69.000	6.457	-0.643	4.792	5.291	DSX
246.500	-11.000	63.706	16.561	9.706	33.000	5.777	2.505	2.433	5.425	ORI
194.500	-4.500	29.185	120.344	28.787	133.000	11.817	20.029	8.489	26.002	STA
195.000	-26.500	27.795	22.312	18.796	54.000	5.177	0.070	4.296	5.668	OEE

SAAMER – Orbital System Summary (**preliminary**)



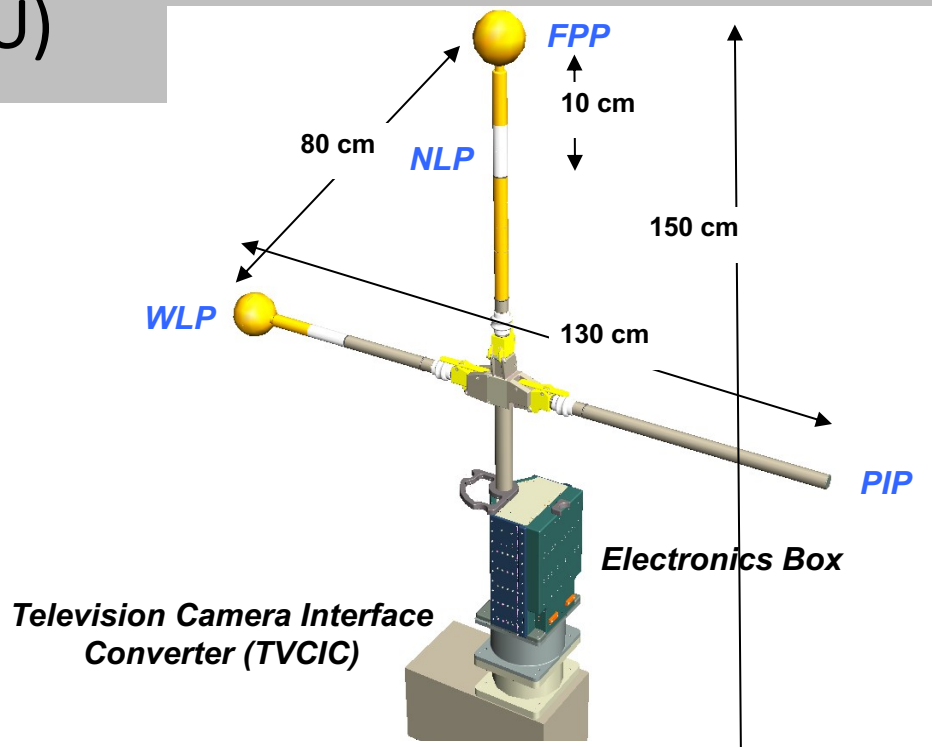
SAAMER Orbital System
Daily Summary

Floating Potential Measurement Unit (FPMU)

- FPMU deployed on the International Space Station (ISS) in August 2006:
  - Wide Langmuir Probe (WLP), Narrow Langmuir Probe (NLP), Floating Potential Probe (FPP), and Plasma Impedance Probe (PIP)
  - Provides redundant measurements of ISS floating potential to monitor charging, electron density (N_e), ion density (N_i), and electron temperature (T_e)

- Primary use is ISS engineering:
  - Characterize US high-voltage (160 V) solar array interactions with plasma environment
  - Evaluate ISS extravehicular activity plasma hazard environments and vehicle charging
  - Validate the Plasma Interaction Model (PIM) used to compute ISS frame potentials
  - Anomaly investigations

- Secondary use is science applications:
  - Collaborations with ISS science payloads, other spacecraft, and ground-based ionosphere observations
  - Support studies of the topside ionosphere near electron density peak
  - Data provided to science community through GSFC's SPDF
  - Auroral charging and ISS space weather interactions
  - Characterize geophysical events and spacecraft plasma interactions



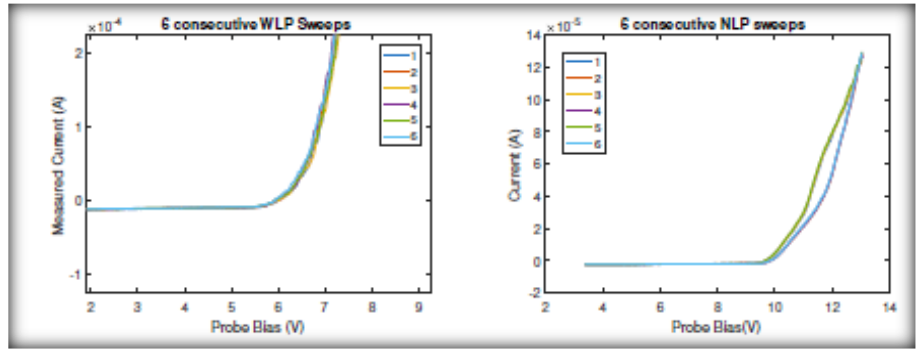
Floating Potential Measurement Unit (FPMU)

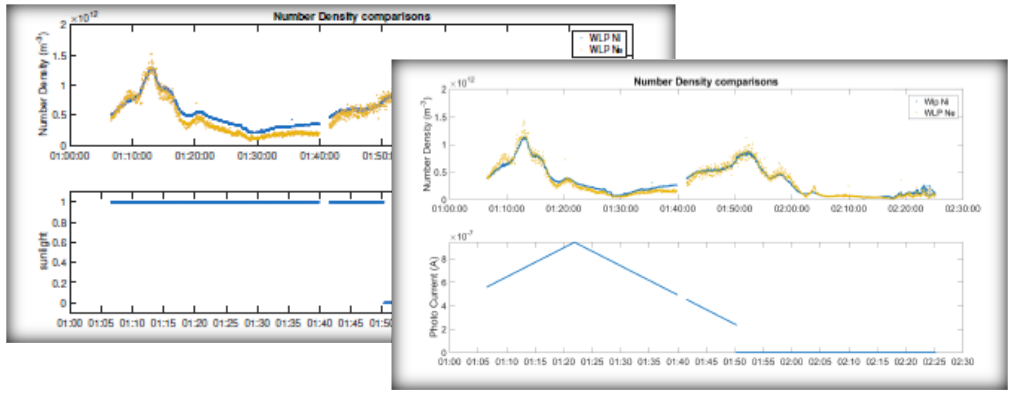
- Current FPMU data processing algorithms were only designed for rapid processing, not optimal data quality:
  - A number of features in the data impact processed data quality.
  - Data processing algorithms need to be updated and improved to provide the best data quality for science and engineering applications.

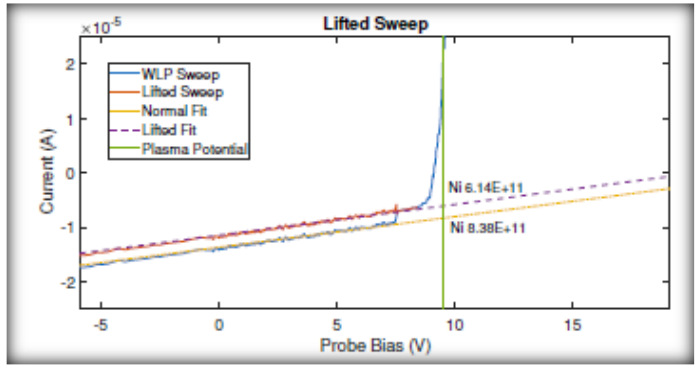
- FPMU deployed in August 2006:
  - FPMU designed for 3-year life; operational unit on ISS has been exposed to space environment for 13+ years.
  - Aging issues are starting to appear, with impacts on data quality.

- NESC-funded* analysis by Embry-Riddle Aeronautical University (ERAU) identified areas where FPMU data need improvement:
  - Hysteresis (ambiguity in T_e)
  - Offset in low to high gain (noise in N_i)
  - Photoemission (error in N_i)

*TI-16-01108, ISS Plasma Interaction Model Independent Assessment



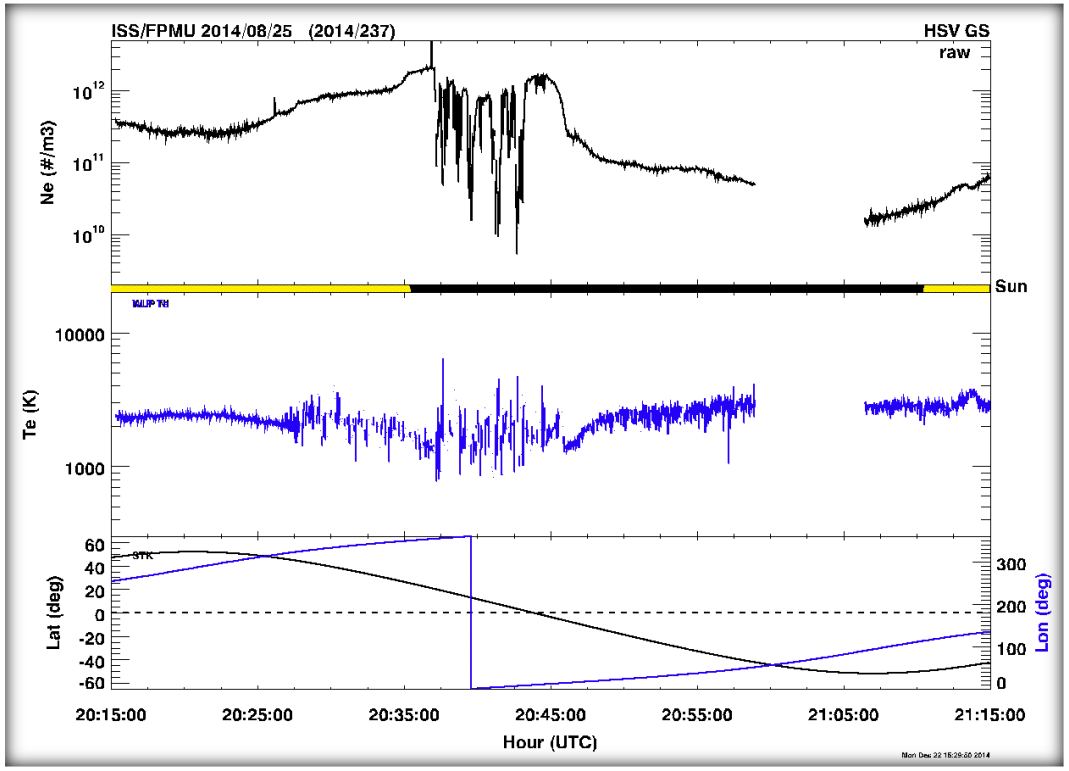


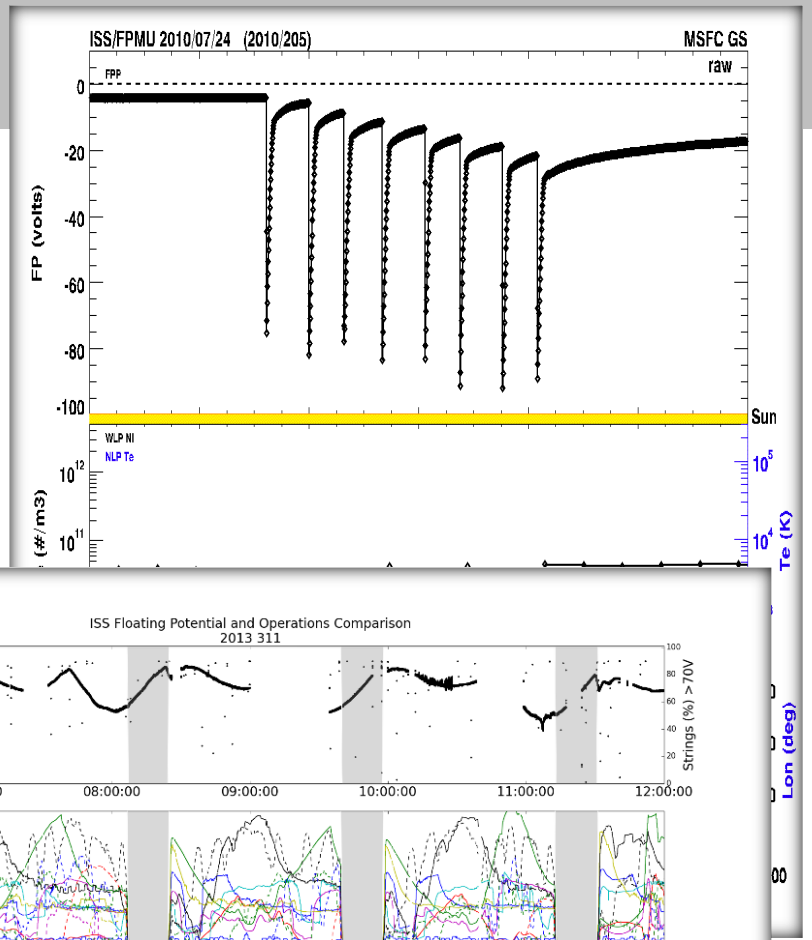


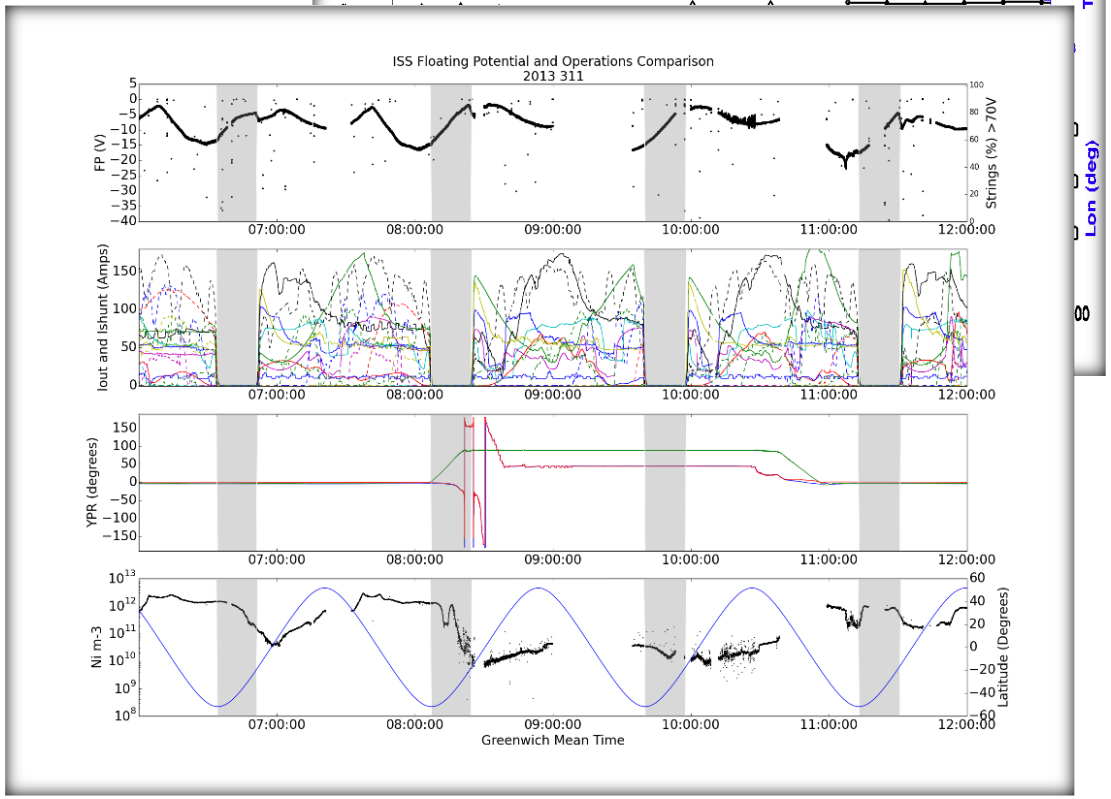
William Merritt, MS Thesis, ERAU, 2018

Floating Potential Measurement Unit (FPMU)

- NESC two-year assessment, ERAU post-doc working with MSFC FPMU team on FPMU data processing algorithms and analysis of complex geophysical and spacecraft/plasma interactions including:
  - Plasma wakes
  - Equatorial spread F
  - Rapid ISS charging during solar array unshunt operations

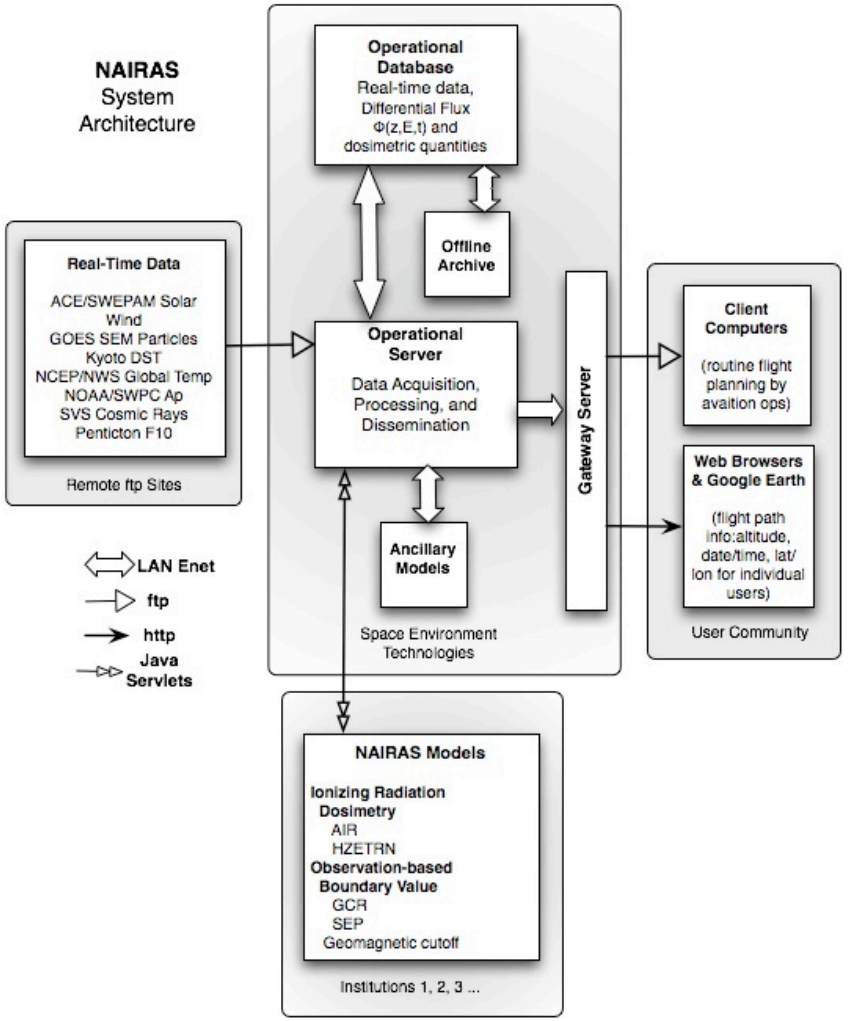






New FY20 Projects

- Modify *Nowcast of Atmospheric Ionizing Radiation System* (NAIRAS) aeronautical radiation dose prediction software to provide NASA Commercial Crew Program with tailored post-flight reference radiation environment data (LaRC, GSFC, JPL)
- Improvements to Badhwar-O'Neill Galactic Cosmic Ray model (JSC, Univ. of Hawaii, LaRC, JPL)
- Payload for Antimatter Matter Exploration and Light nuclei Astrophysics (PAMELA) data recovery, new low Earth orbit data for AE9/AP9/IRENE to constrain LEO radiation environments (JSC, GSFC)
- NASCAP surface charging model improvements funded by OCE Engineering Research & Analysis program (Leidos, MSFC, AFRL)
- Solar wind radiation damage of metallic coatings (LaRC, MSFC, Georgia Tech, Idaho National Lab, academic partner)



https://sol.spacenvironment.net/nairas/

Applied Space Environments Conference (ASEC) 2019

- 12 – 17 May 2019, Universal Hilton in Studio City, Los Angeles
- Forum for the space environments community to
  - Report recent advances in the discipline
  - Discuss the community's ability to support current space programs
  - Identify knowledge and technology gaps that must be addressed to support space system design and operations in future programs
- Organized by USRA, NASA (Space Environments TDT, JPL)
- Financial support provided by National Science Foundation, The Aerospace Corporation, Experimental & Mathematical Physics Consultants (EMPC), Harris Corporation, and Lockheed Martin Space
- Biennial event…next ASEC to be held in Huntsville, AL in 2021

	2017	2019
Abstracts	71	127
Registrations	115	150
US/Foreign	114/1	120/30
Government	58%	47%
Industry	26%	25%
Academia	16%	28%

Questions?