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SOUTH ATLANTIC ANOMALY AND CUBESAT DESIGN CONSIDERATIONS

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South Atlantic Anomaly and CubeSat Design Considerations

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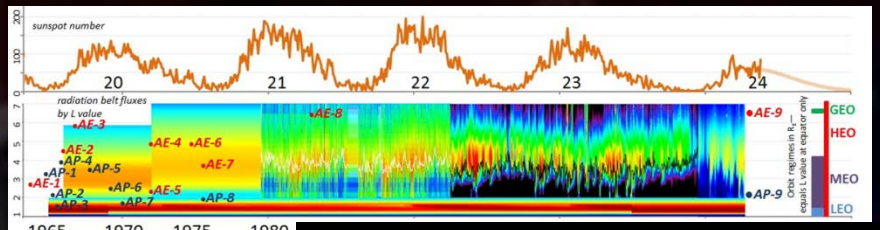
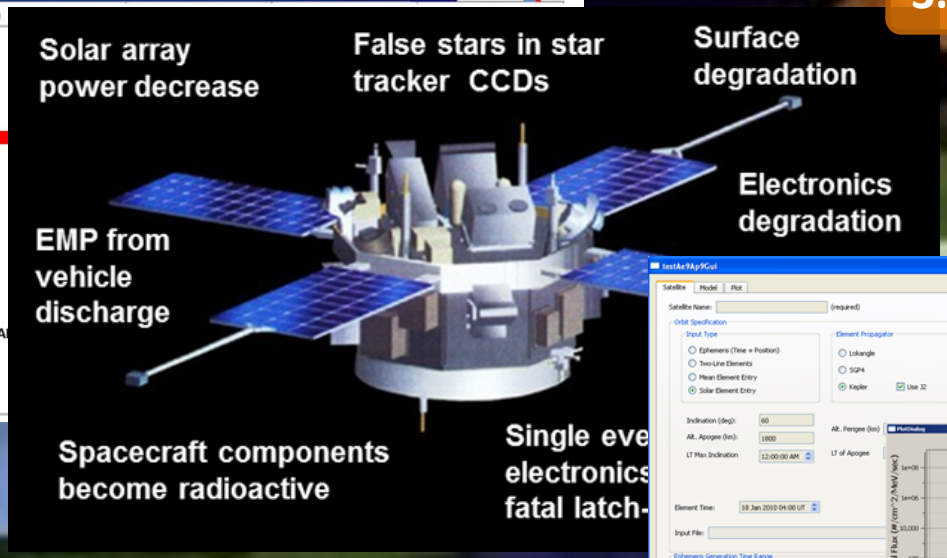
South Atlantic Anomaly (SAA) & CubeSat Design Considerations

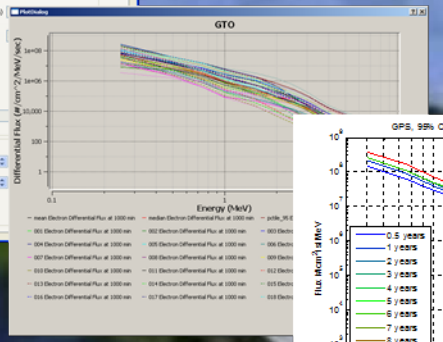
1.0 SAA Space Environment

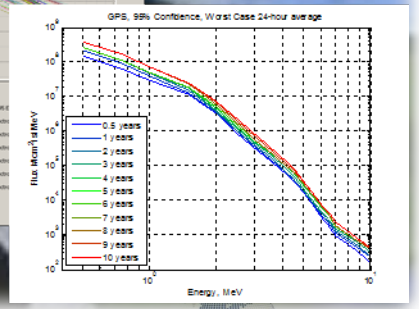
2.0 Space Effects in the SAA

3.0 SAA Mitigation Strategies





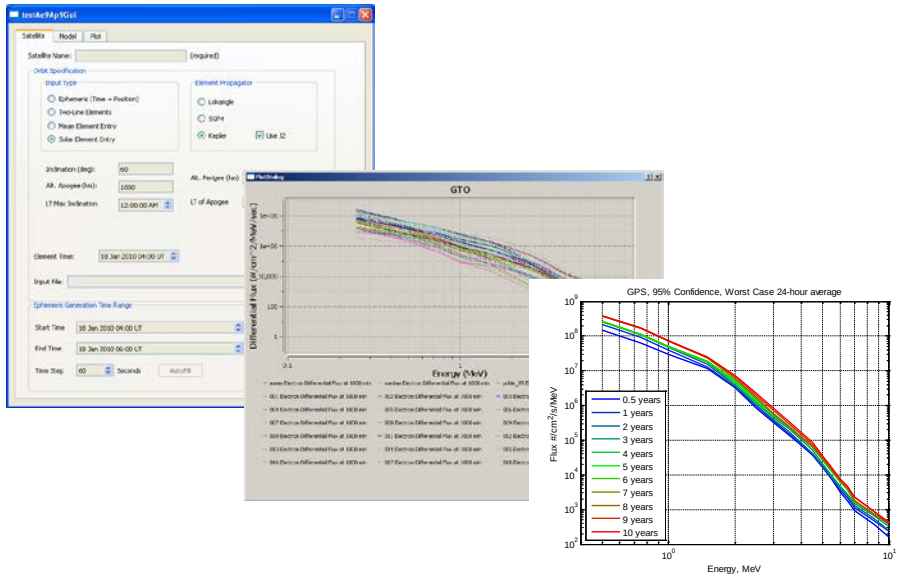




AE9/AP9/SPM Radiation Model Design and Mission Planning

- Using a new combined set of models for the space environment determination needed for CubeSat design and mission planning
- Expanded energy coverage: keV plasma to GeV protons
- Spatial coverage for all orbit regimes, including tailored coverage for high resolution in LEO

Model	AE9	AP9	SPM
Species	e^-	H^+	e^-, H^+, He^+, O^+
Energies	40 keV—10 MeV	100 keV—2 GeV (V1.20)	1—40 keV (e^-); 1.15—164 keV (H^+, He^+, O^+)
Range in L	$0.98 < L^* < 12.4$	$0.98 < L^* < 12.4$	$2 < L_m < 10$

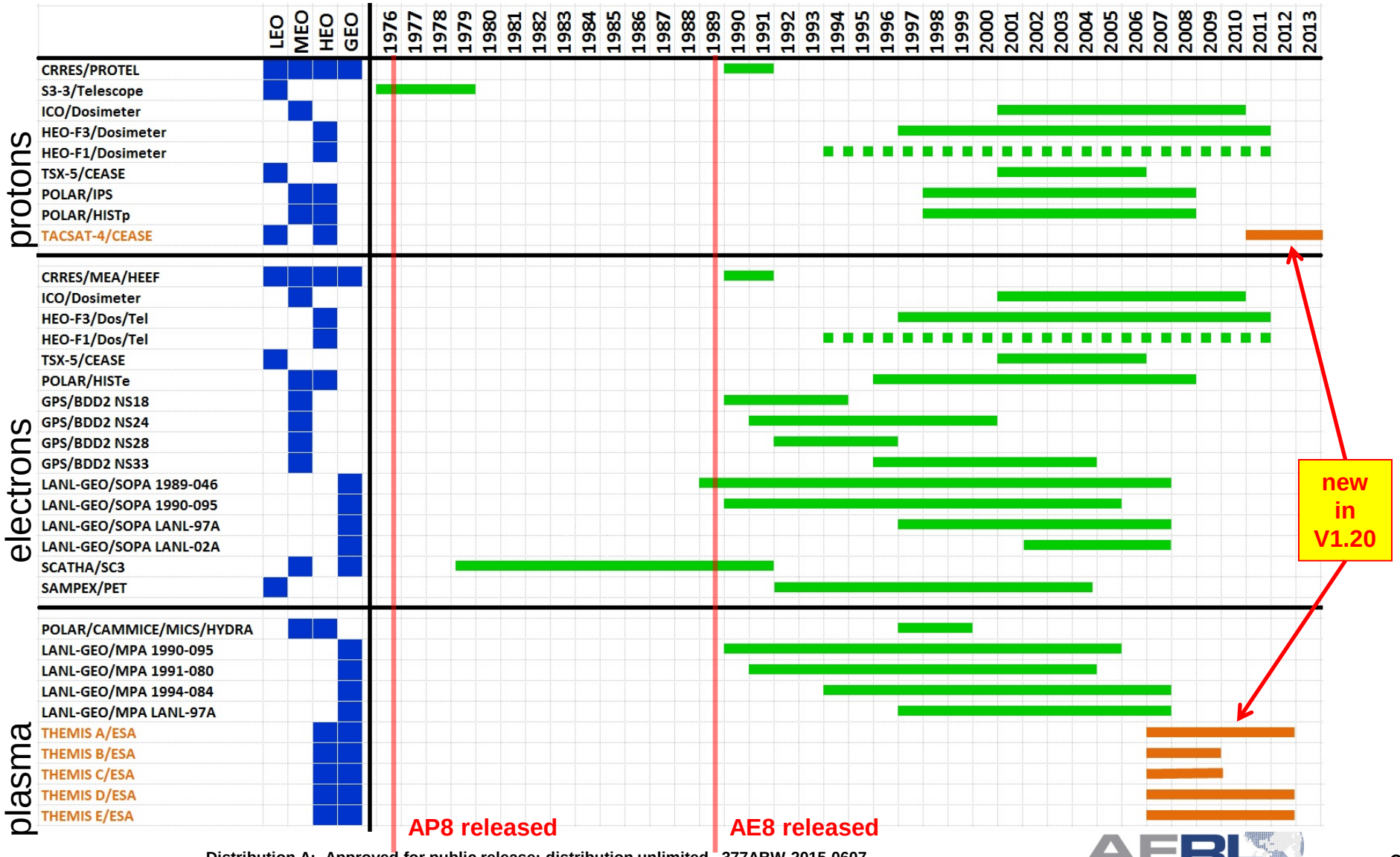


What Type of Run

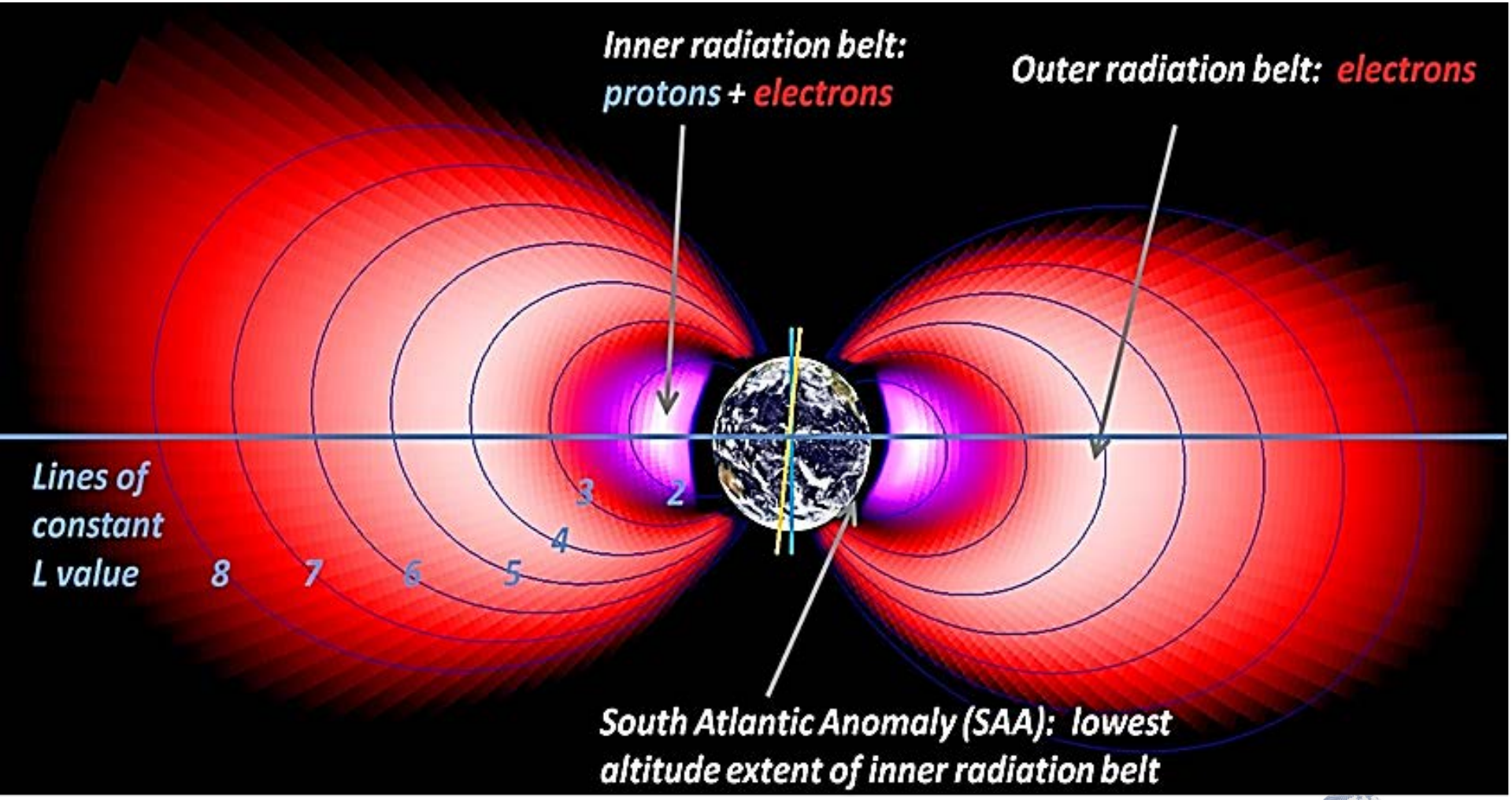
Spec Type	Type of Run	Duration	Notes
Total Dose	Perturbed Mean	Several orbits or days	SPME+AE9, SPMH+AP9+Solar
Displacement Damage (proton fluence)	Perturbed Mean	Several orbits or days	AP9+Solar
Proton SEE (proton worst case)	Monte Carlo	Full Mission	AP9+Solar
Internal Charging (electron worst case)	Monte Carlo	Full Mission	AE9 (no SPME)

- **Run 40 scenarios through either static Perturbed Mean or dynamic Monte Carlo**
- **Compute statistics by comparing results across scenarios (e.g., in what fraction of scenarios does the design succeed)**
- **Do not include plasma (SPM*) models in worst case runs**

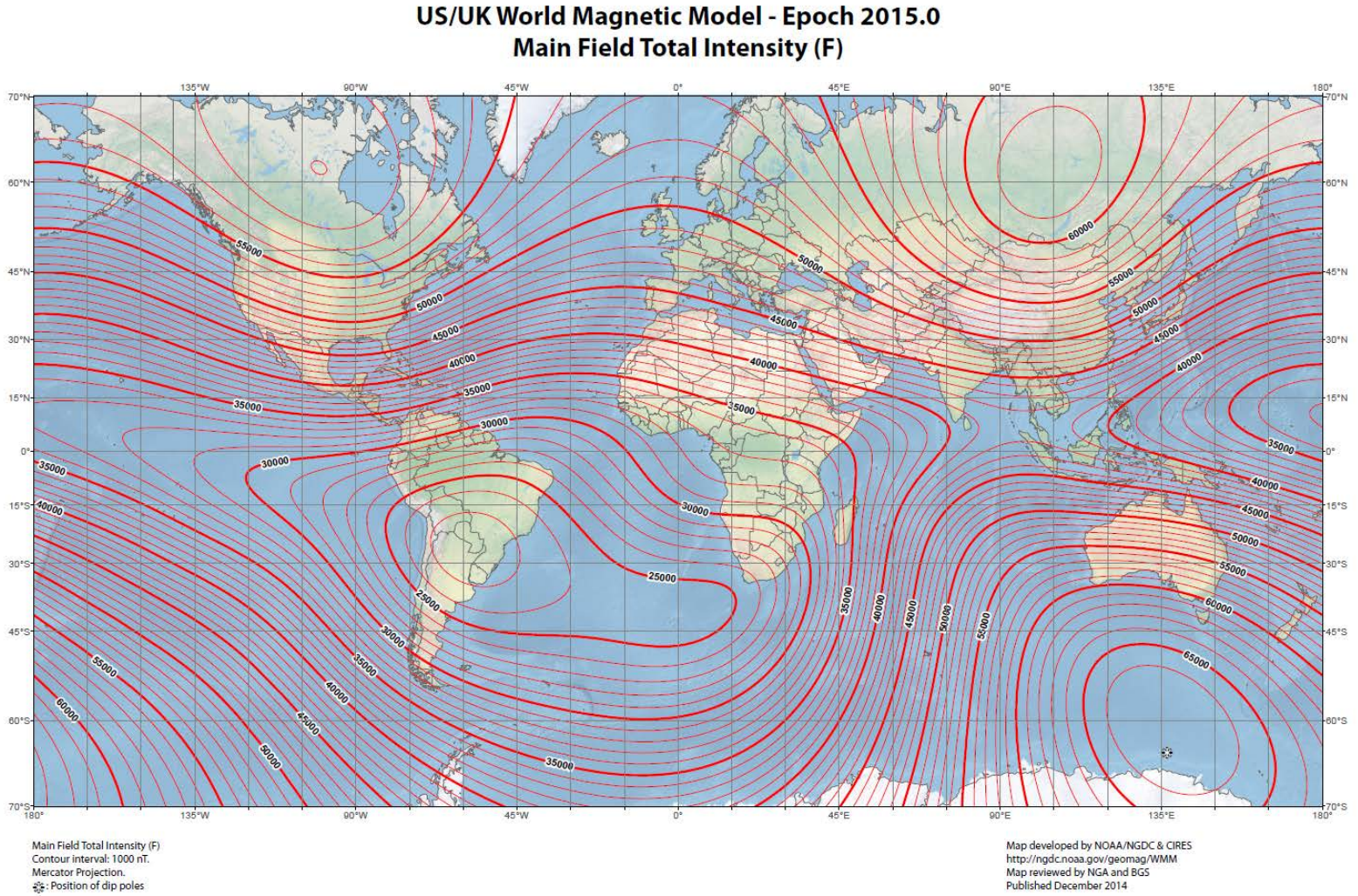
Data Sets—Temporal Coverage



SAA Proton Flux Source: Horn of the Inner Radiation Belt



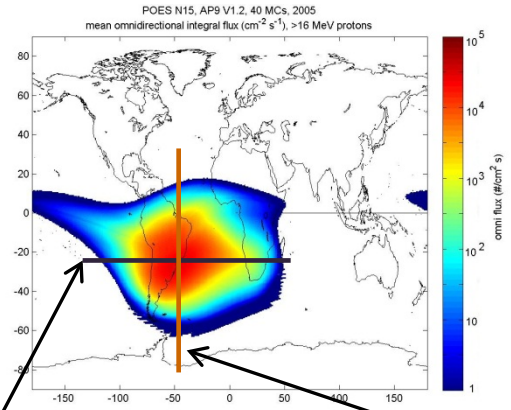
SAA Couples Horn With a Weak Surface Magnetic Field



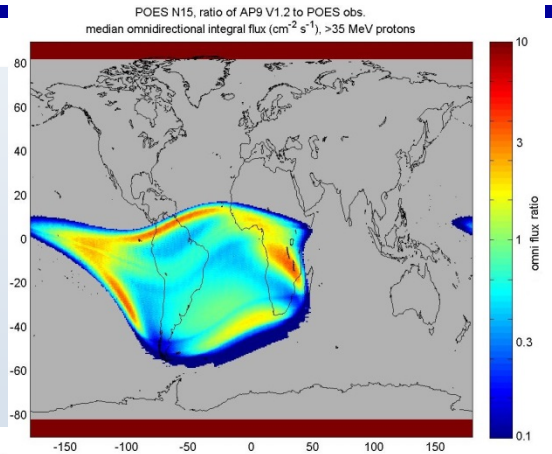
AP9 V1.20 Validation—SAA

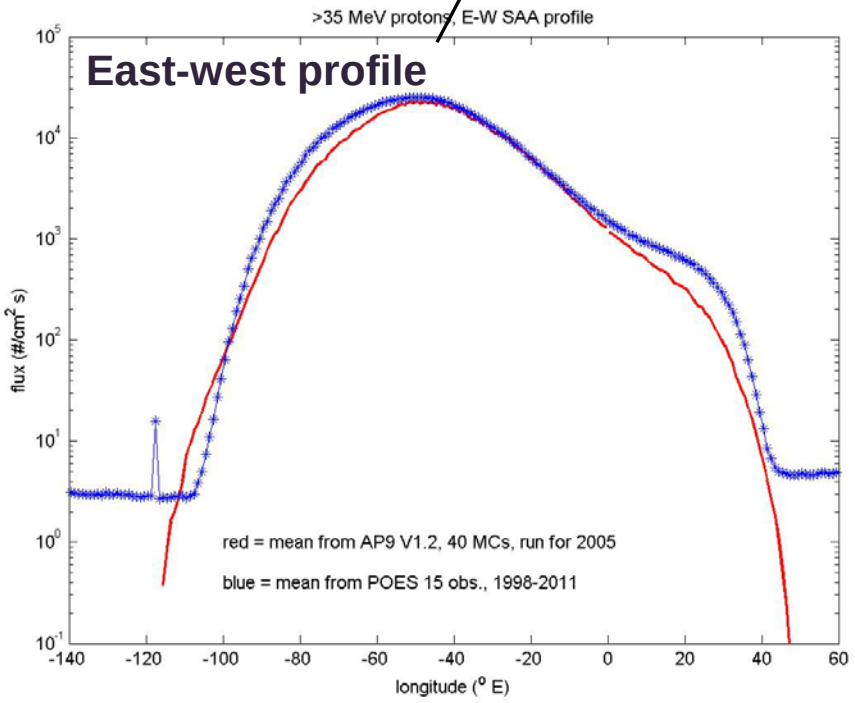
>35 MeV protons

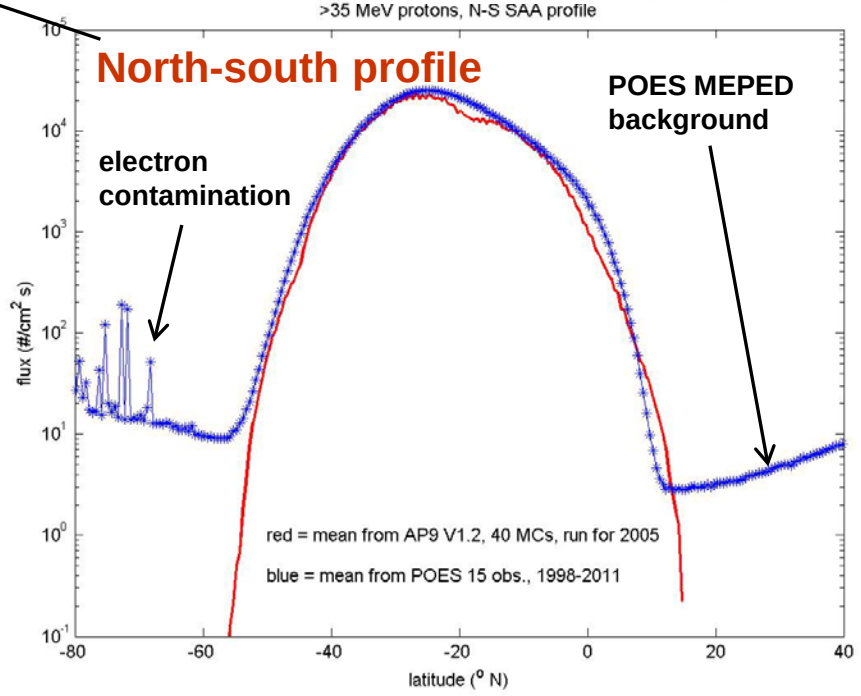
SAA flux profiles are improved in V1.20 as compared to POES observations



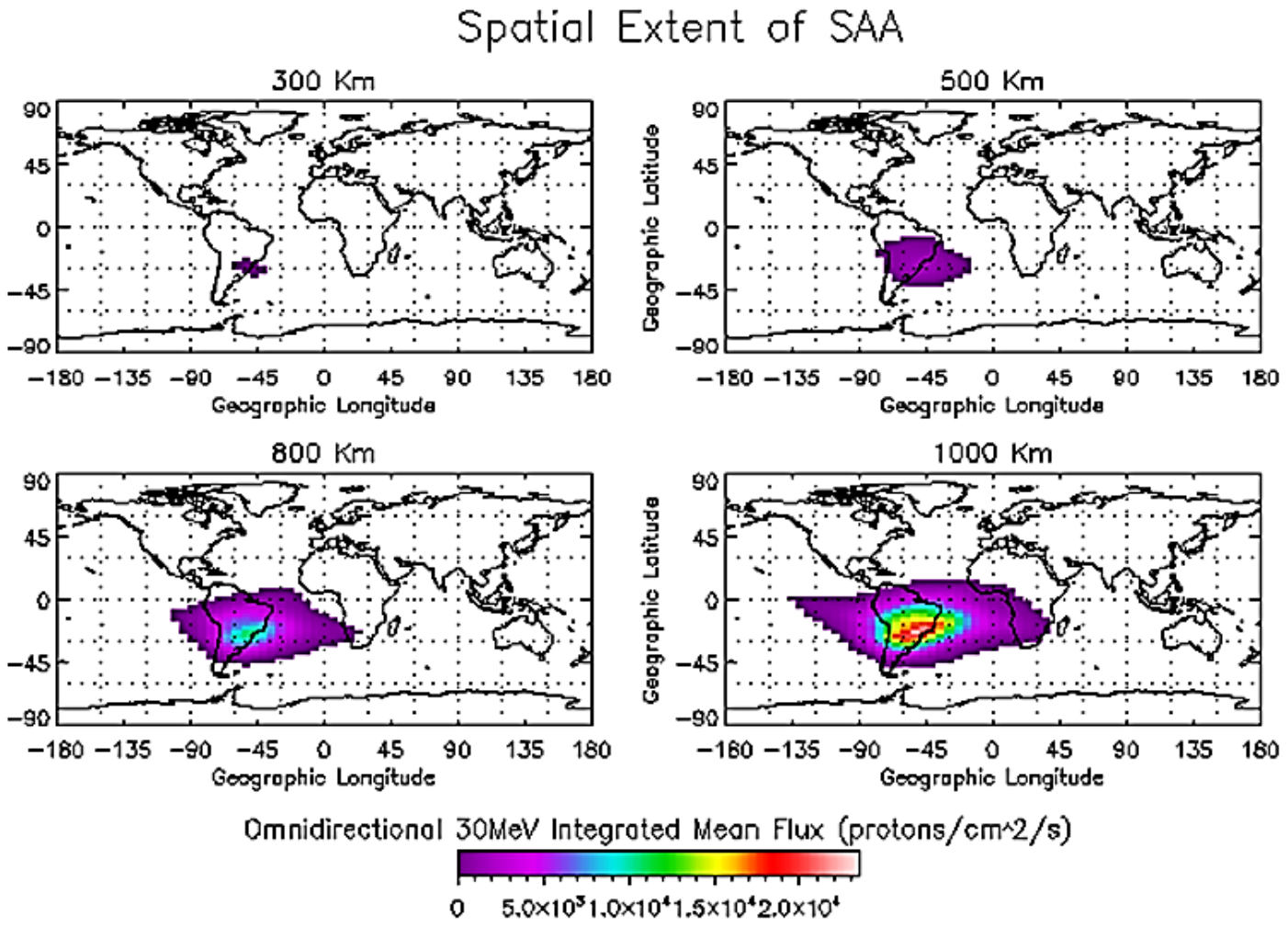
Ratio of AP9 V1.20 median to POES data



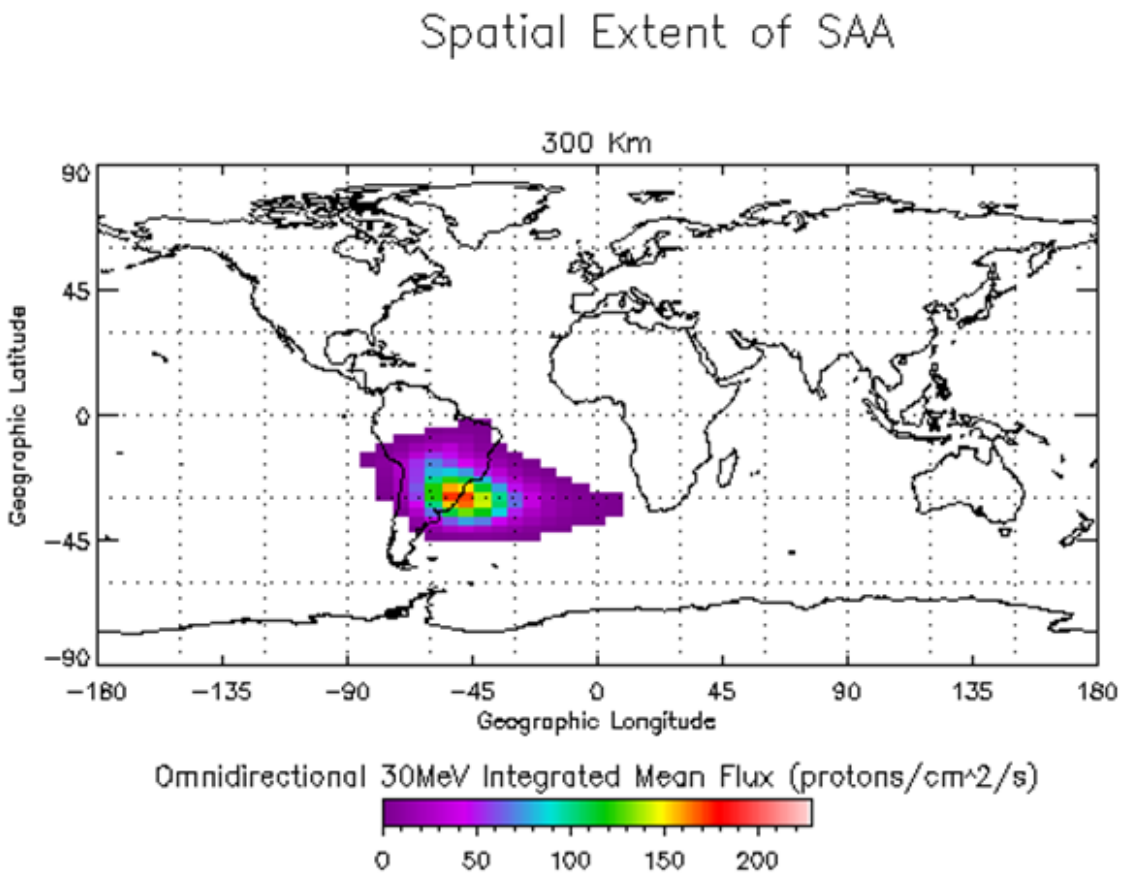




SAA Spatial Extent: AE9/AP9/SPM Radiation Model



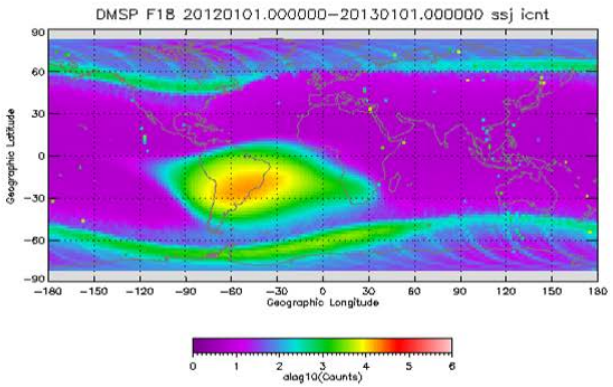
SAA Spatial Extent (300Km): AE9/AP9/SPM Radiation Model



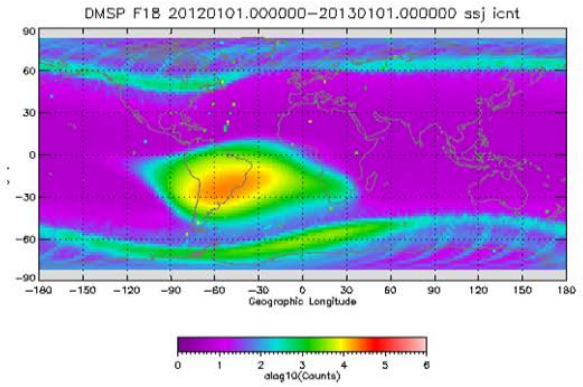
Use Directional or Omnidirectional Fluxes?

DMSP-F18 2012 Average Background Counts

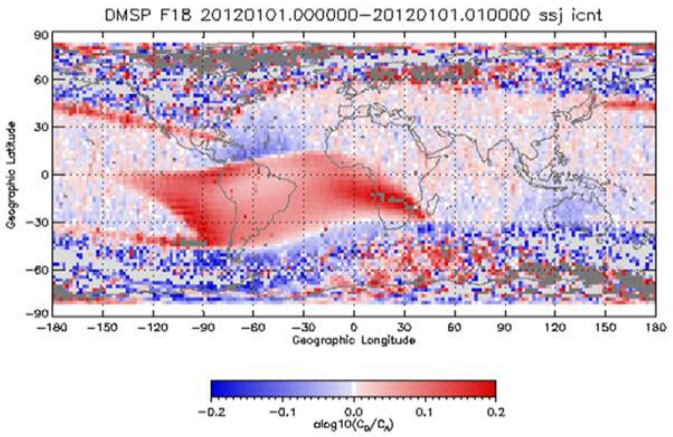
Ascending



Descending



Log_{10}(Descending/Ascending)



- Directional Flux for Fixed Orientation with respect to Earth
- Omnidirectional Flux for Random Orientation

SAA Drift Rate Over Time

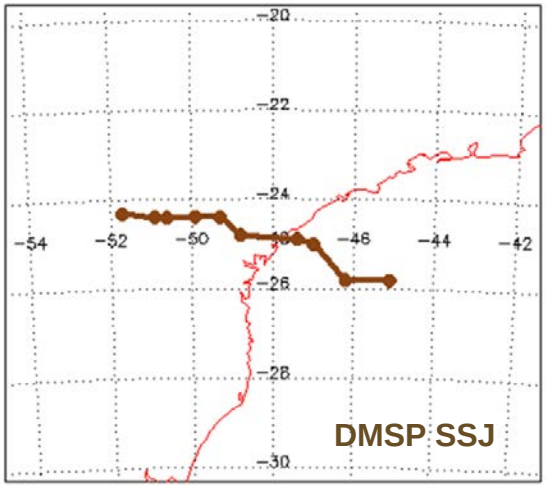
From DMSP SSJ contamination

Satellite	Year	Latitude	Longitude
F08	1989	-25.8	-45.1
F11	1993	-25.8	-46.2
F12	1998	-25.0	-47.0
F12	2001	-24.9	-47.4
F15	2004	-24.8	-48.8
F15	2006	-24.4	-49.3
F16	2008	-24.4	-49.9
F16	2010	-24.4	-50.6
F16	2012	-24.4	-50.9
F16	2014	-24.3	-51.7

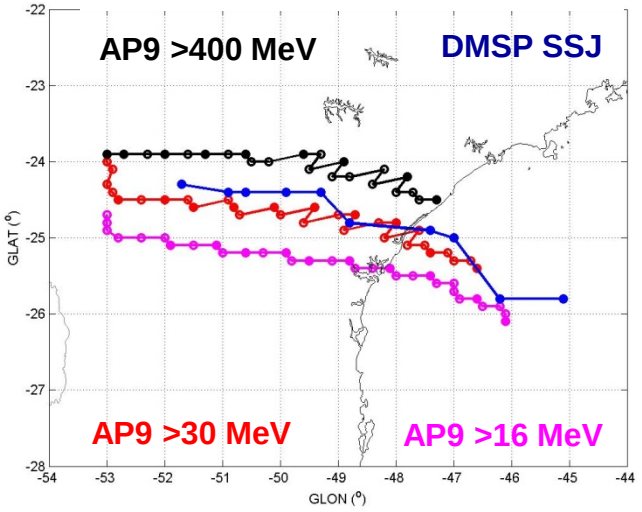
From AP9 V1.20 mean >30 MeV

Year	Latitude	Longitude
1989	-25.4	-46.6
1994	-25.1	-47.5
1997	-25.0	-48.2
2000	-24.9	-48.9
2003	-24.8	-49.6
2006	-24.6	-50.1
2009	-24.5	-50.9
2012	-24.5	-52.0
2014	-24.5	-52.8
2020	-23.9	-53.0

location of SAA peak, 1989-2014

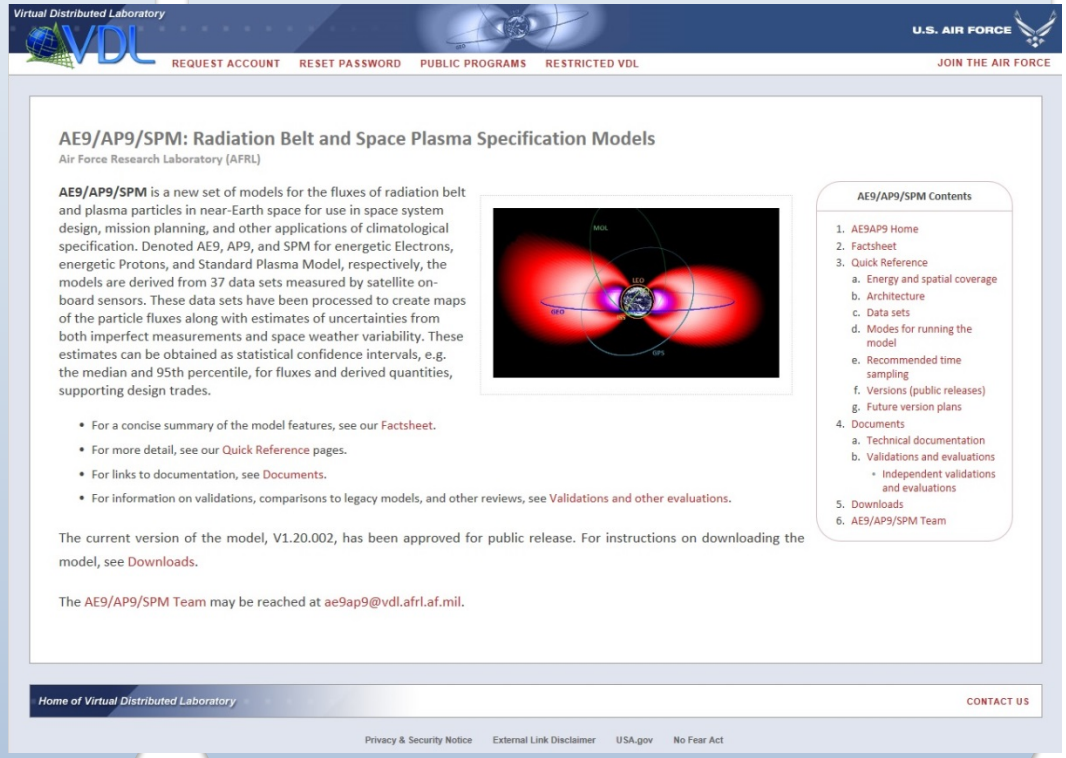


location of SAA peak, 1989-2020



AE9/AP9 Website

- **We have launched a dedicated web site for the AE9/AP9 project hosted by AFRL's Virtual Distributed Laboratory: https://www.vdl.afrl.af.mil/programs/ae9ap9**
- **The latest version of the model may be downloaded from this site after creating an account**
- **Summaries and model documentation are also available (no account needed)**
- **Future news and releases will be announced through the website**

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