

GOES-R Solar and Space Environment Data Products: Benefiting Users

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Outline:

- GOES Space Weather Instruments
- The Airline Industry as a Customer
- New Product Development at SWPC



AMS Meeting
New Orleans, LA
January 20-24, 2008



Selected Space Weather Observations

Other Observations

- GPS (Ground & Space Elements)
- Magnetometers (NOAA/USGS)
- Thule Riometer and Neutron monitor (USAF)
- SOON Sites (USAF)
- RSTN (USAF)
- Telescopes and Magnetographs
- Ionosondes (AF, ISES)

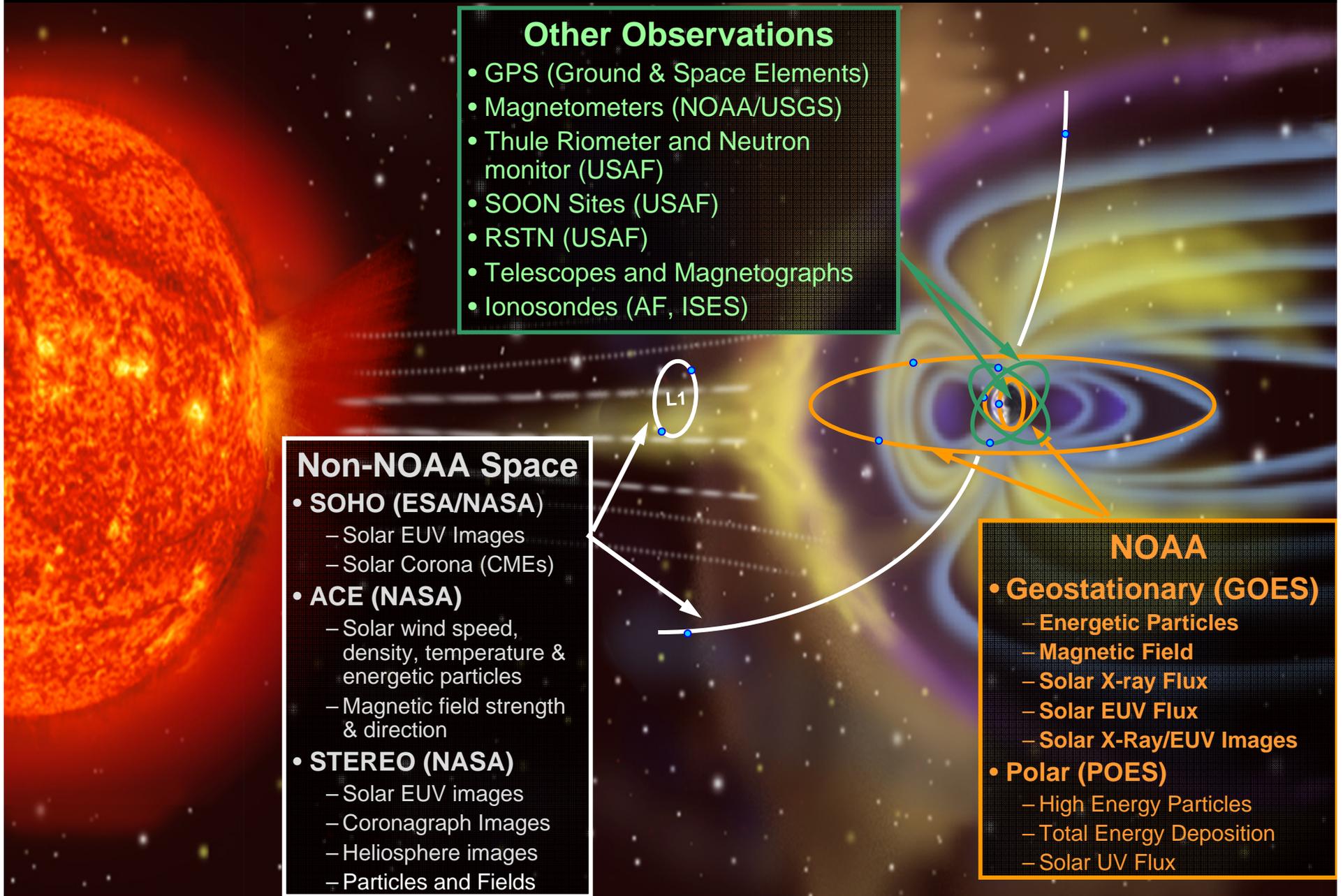
Non-NOAA Space

- **SOHO (ESA/NASA)**
 - Solar EUV Images
 - Solar Corona (CMEs)
- **ACE (NASA)**
 - Solar wind speed, density, temperature & energetic particles
 - Magnetic field strength & direction
- **STEREO (NASA)**
 - Solar EUV images
 - Coronagraph Images
 - Heliosphere images
 - Particles and Fields

NOAA

- **Geostationary (GOES)**
 - Energetic Particles
 - Magnetic Field
 - Solar X-ray Flux
 - Solar EUV Flux
 - Solar X-Ray/EUV Images
- **Polar (POES)**
 - High Energy Particles
 - Total Energy Deposition
 - Solar UV Flux

L1



History of GOES SWx Instrumentation

		Remote Sensing				Geostationary Particles and Fields				
		Solar Irradiance		Solar Imaging		B-Field	Magnetospheric Electrons and Protons		Solar & Galactic Protons	Heavy Ions
GOES	1 st Launch	X-ray	EUV	X-ray	EUV		Low E	Med & High E		
1-7	1975	XRS	-	-	-	MAG	-	EPS (limited coverage, e.g. alphas only for heavy ions)		
8-11	1994									
12	2001									
13-OP	2006			SXI						
R/S	2014			-					SUVI	SEISS
			EUVS					MAGED/PD, HEPAD, EPEAD		

Priority for GOES-R/S Space Weather instruments is to maintain continuity with earlier GOES measurements in a cost-effective manner

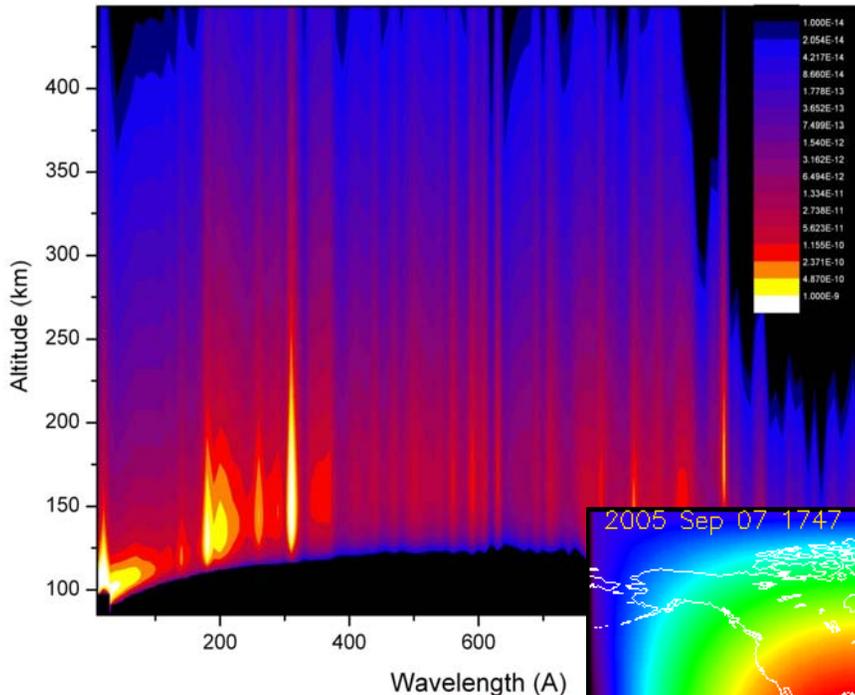
Solar Observations

Irradiance (EXIS) Imaging (SUVI)

Extreme Ultraviolet and X-ray Irradiance Suite

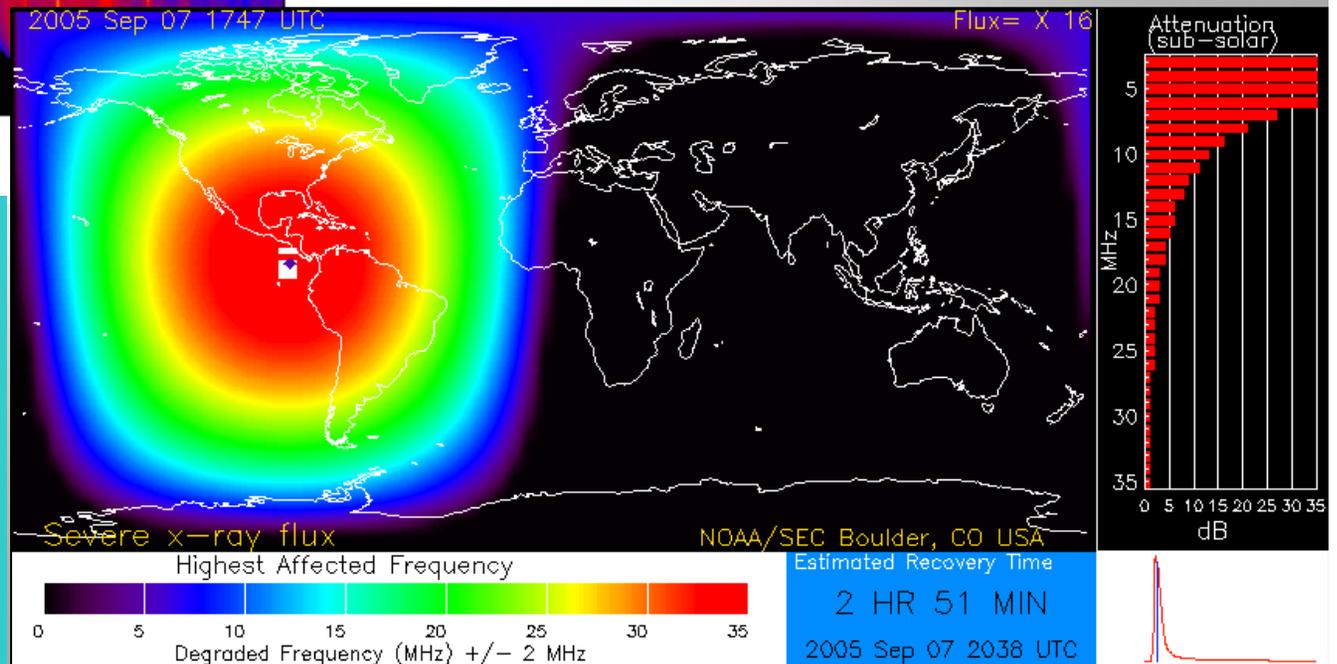
EUV Sensor (EUVS)

Measures the solar EUV energy input to the upper atmosphere and improves the ability to predict upper atmospheric and ionospheric conditions.



X-Ray Sensor (XRS)

Monitors whole-Sun X-ray irradiance in two bands and drives the Radio Blackout portion of NOAA's Space Weather Scales.

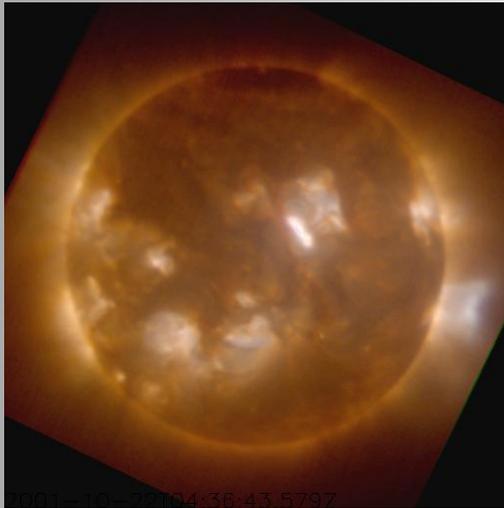


Solar Observations

Irradiance (EXIS) **Imaging (SUVI)**

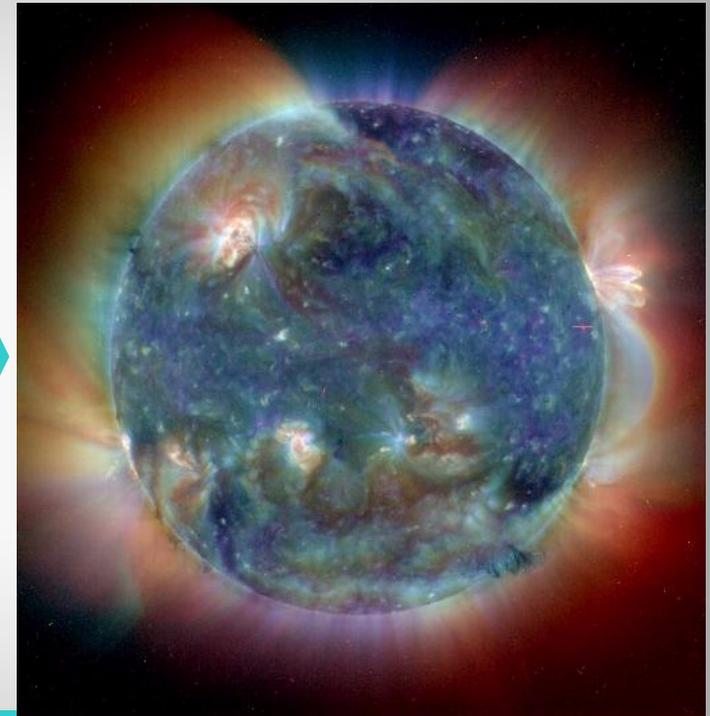
Solar Ultraviolet Imager

GOES-12 SXI color composite.



SUVI will image the same portions of the Sun's atmosphere as SXI, but in different spectral bands that provide better access to temperature and density.

SUVI will locate coronal holes, flares, and coronal mass ejection source regions. It will also detect "Over the horizon" active regions and observe active region complexity. Together, these observations support *all* space weather customers.



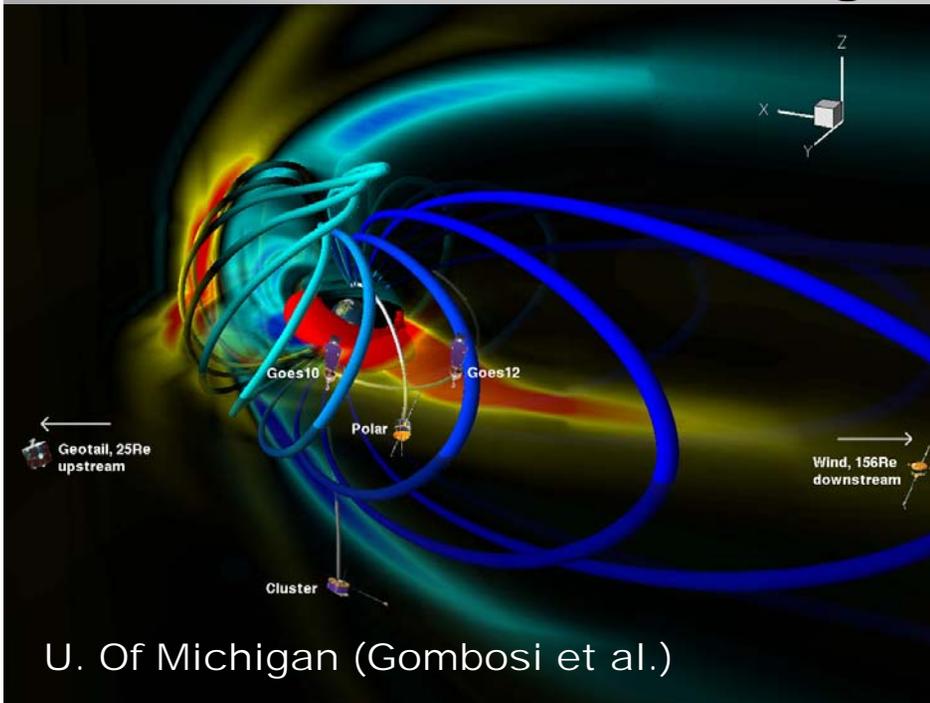
Simulated GOES-R SUVI color composite (SOHO EIT data, a joint NASA/ESA research program).

In Situ Observations

Magnetic Field (MAG) Particles (SEISS)

Magnetometer

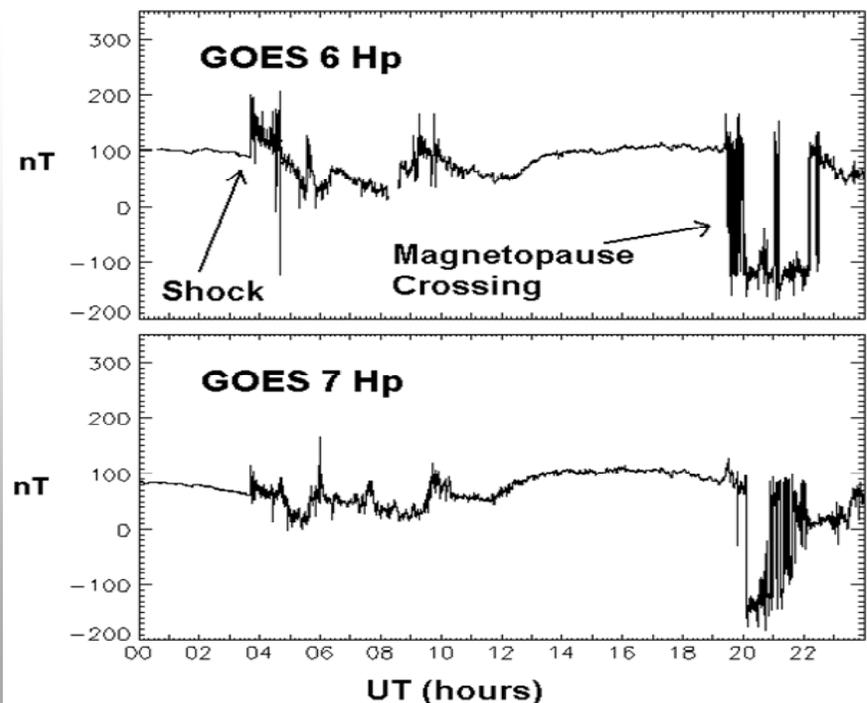
The primary operational customers are satellite operators, who, for example had to implement “manual attitude control” for a number of TV and Pay Radio satellites due to magnetopause crossings during October 2003 storms.



U. Of Michigan (Gombosi et al.)

The magnetometer measures the time-varying magnetic field at geostationary orbit. It provides the only measure of the impact of geomagnetic storms at geosynchronous orbit and is key for interpreting solar radiation storm measurements by SEISS.

March 24, 1991 Day 83

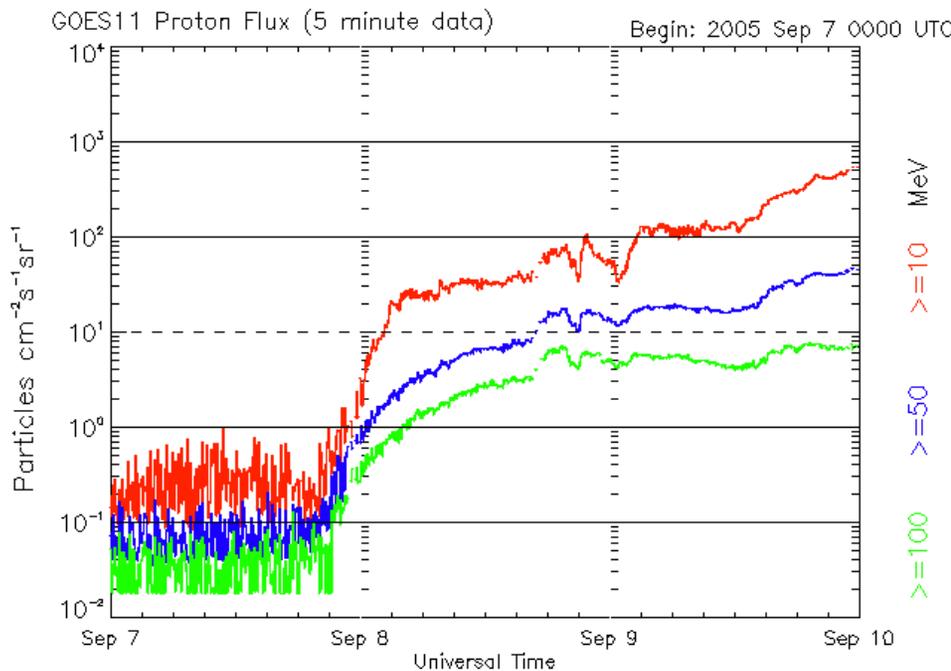
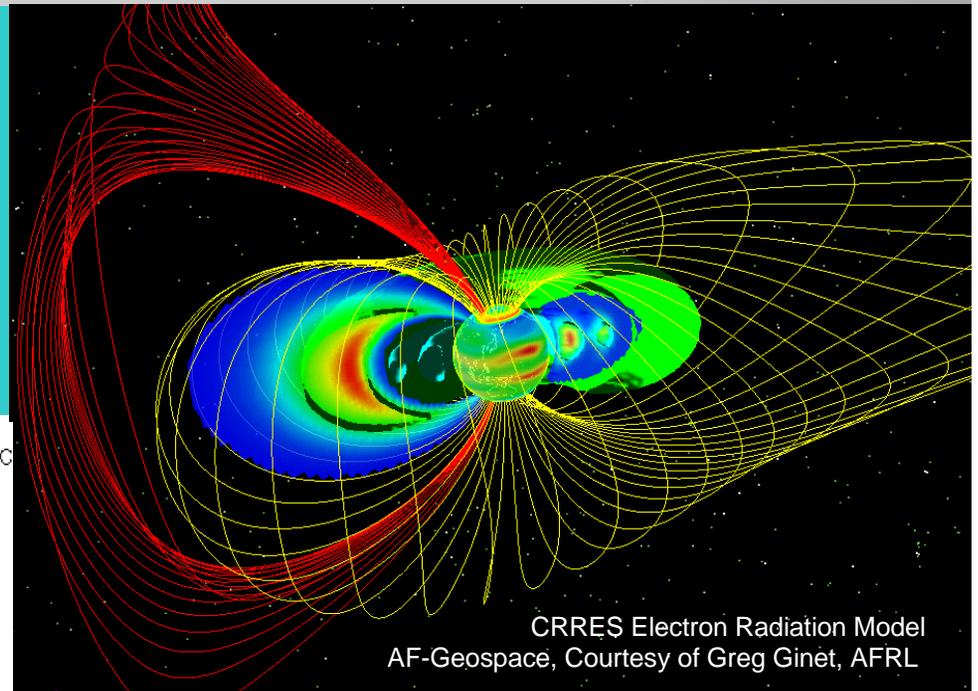


In Situ Observations

Magnetic Field (MAG) **Particles (SEISS)**

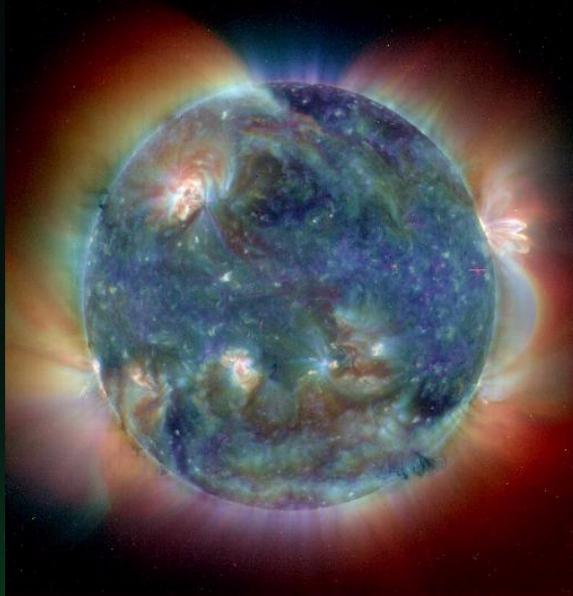
Space Environment *In Situ* Suite

The SEISS is an ensemble of electron, proton, and heavy ion detecting telescopes. SEISS data drives Solar Radiation Storm portion of NOAA's Space Weather Scales.

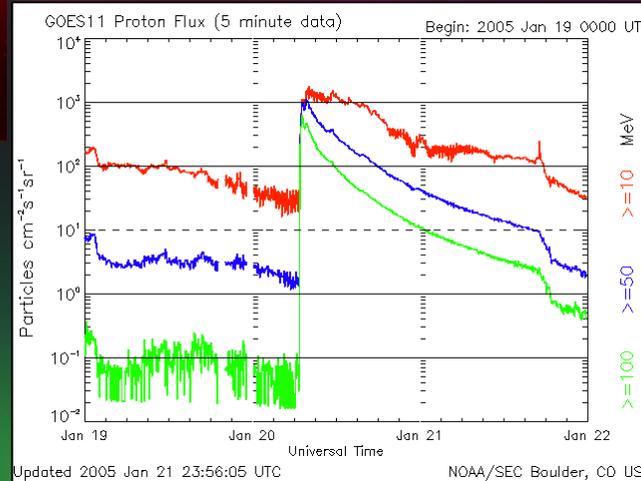


SEISS products serve user communities in the airline industry, the satellite industry, and manned space flight operations.

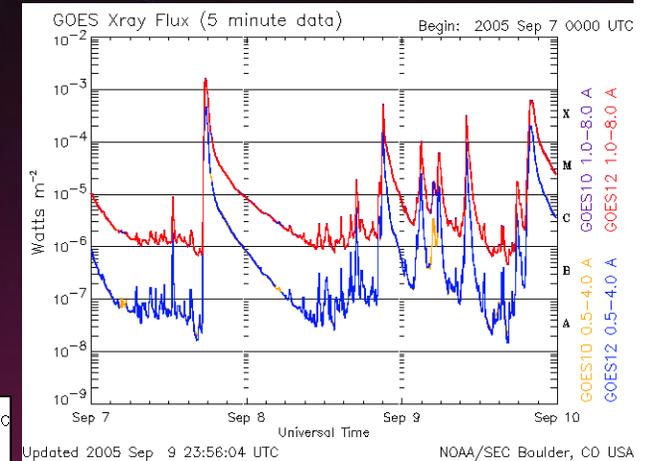
A GOES Space Weather Customer: The Airline Industry



GOES SUVI



GOES SEISS



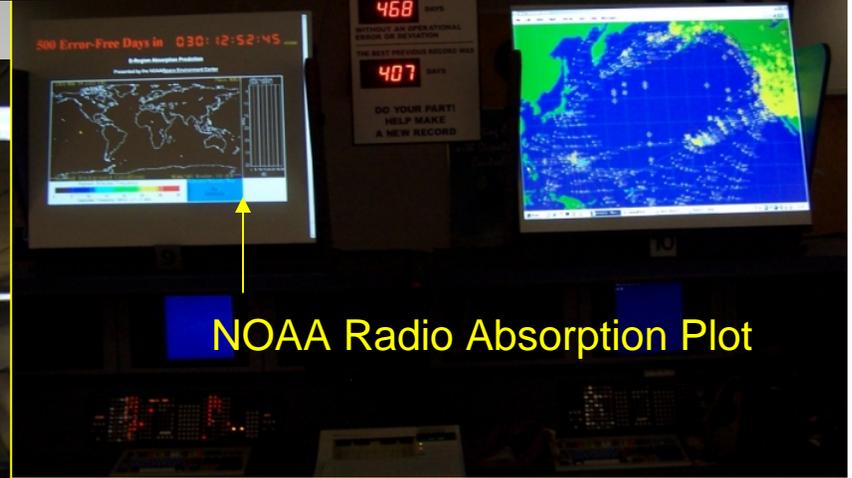
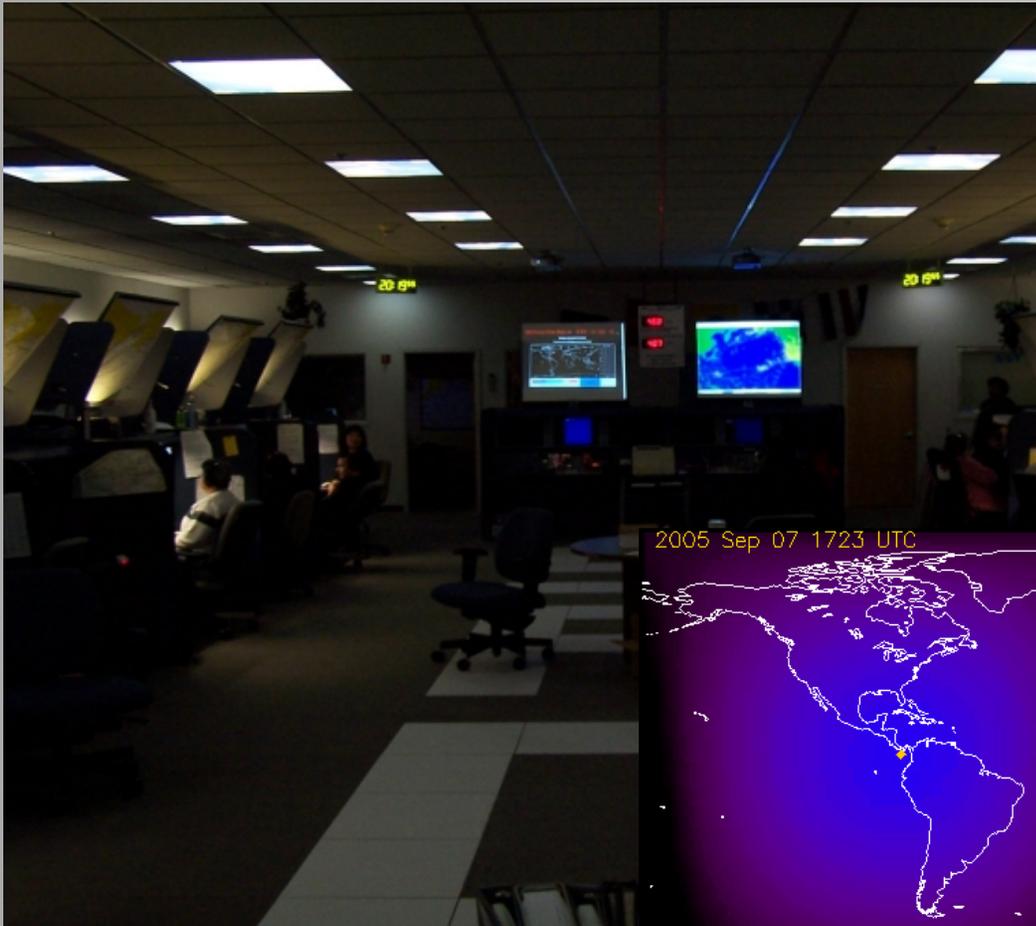
GOES EXIS

**Airline customers are interested in HF communications
blackouts and radiation doses**

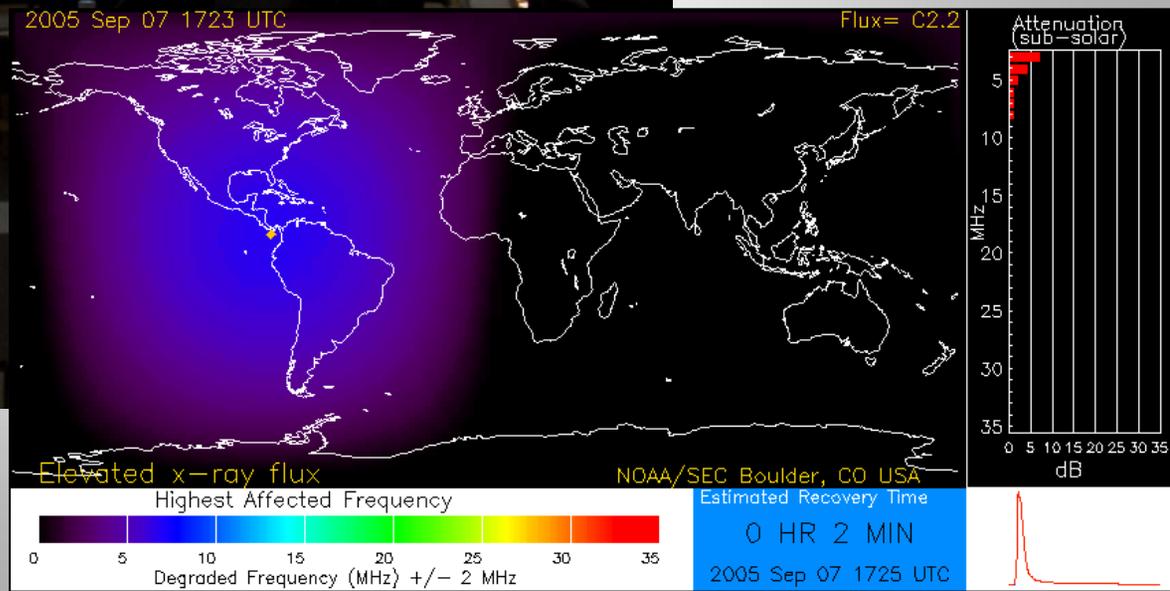
SWPC Customers - Aviation Groups

Aer Lingus	Boeing / Flight Test	Northwest Airlines
AFA	British Airways	Oslo Lufthavn AS
Air Canada	Bushmail	PrivateSky
Air China	Cathay Pacific Airway	Qantas Airways
Air Europa	CBAir, LLC	Ravenware Aviation
Air Line Crew Delta	Colegio de Pilotos de Aviacion	Raytheon Aircraft Co.
Air Line Pilots Association	Continental Airlines	SCTA
Air New Zealand	Emirates	SkyWest Airlines
Air Routing Intl	FedEx	Sun Country airlines
AirMed Inc.	German ALPA	Sundt air (Norway)
Airservices Australia	Icelandic ALPA	Swales Aerospace
Alaska airlines	Irish Aviation Authority	United Airlines
Allied Pilots Association	Jet Aviation Business Jets	APLA, Argentina
ALPA Japan	korean air	ARINC
American Airlines	Lufthansa	ATA Airlines
American Eagle airlines	Lufthansa / German ALPA	NetJets
American Trans Air	Lufthansa Cargo	North American Airlignes

San Francisco Air Traffic Communications Center



NOAA Radio Absorption Plot



Airline Communication Impacts...

The New York Comm Center reported:

07Sep 1800Z: Solar activity severely impacted all HFcomms. Higher frequencies utilized with little effect. 24 aircraft position reports and NYC ATC messages were relayed via sat-voice between 1040Z and 1939Z. **Severe operational impact.**

13Sep 1929Z: HF Comms severely impacted, complete loss of HF comms for about one hour. Aircraft position reports and ATC message delivery delayed. Sat-voice used as able.

The San Francisco/SFO Comm Center reported:

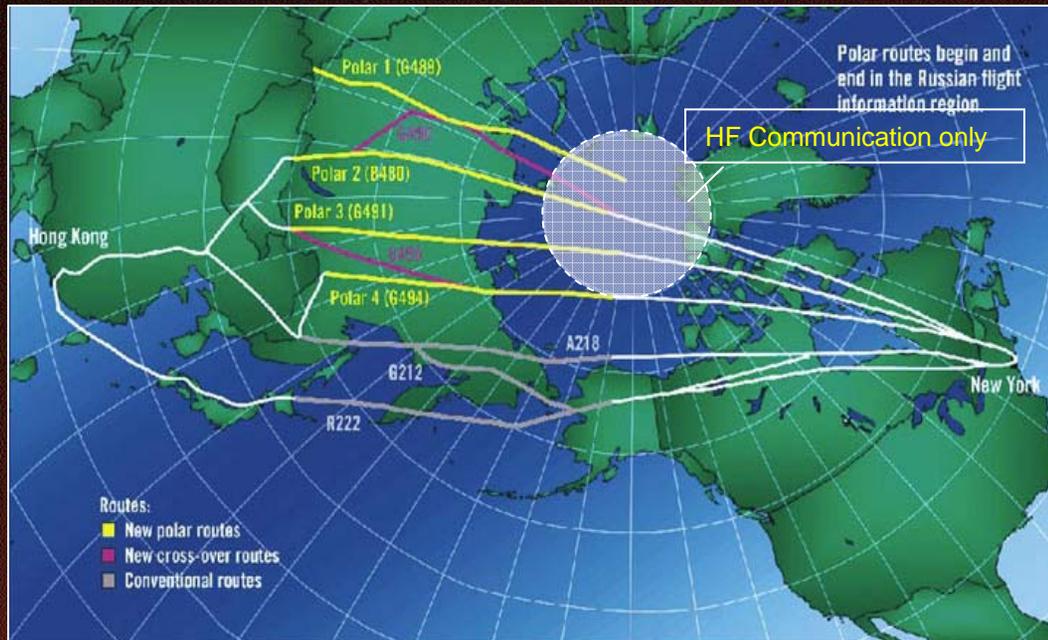
07Sep 1755Z: SFO sends ARINC Solar Flare Activity Advisory of moderate to severe impact to HF comms to airline customers. **SFO experiencing extreme HF "white-out" conditions virtually wiping out all Pacific HF.**

07Sep 2220Z: Solar impact persists, numerous delays in receiving aircraft position reports and in delivery of ATC messages to aircraft. Ross using higher frequencies and Sat-Voice.

11Sep 0050Z: Tokyo and Port Moresby Radio having difficulties, SFO will assist as needed.

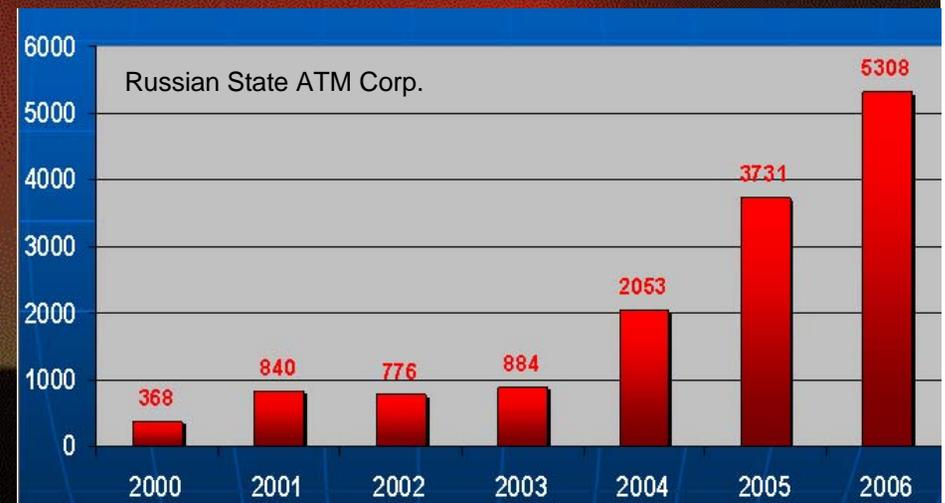
13Sep 1930Z: Solar activity severely disrupting HF comms in all Pacific areas throughout daylight hours. **Severe communication impact and severe operational/service impact.**

Airlines and the Polar Routes

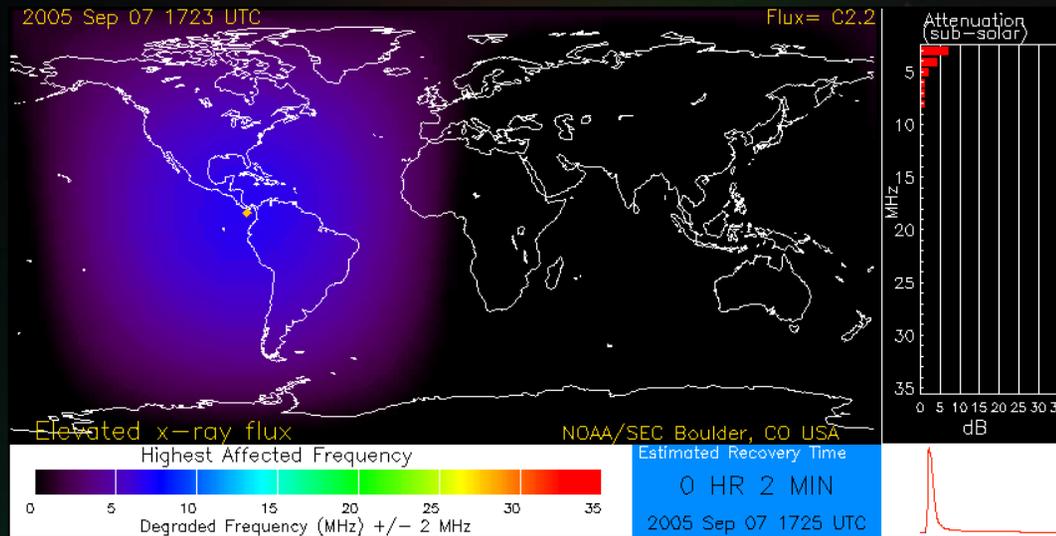


- Flights rely on HF (3 – 30 MHz) communication inside the 82 degree circle.
- Federal Aviation Regulation Sec. 121.99 – aircraft must have two-way radio communication over the entire route with dispatch office and air traffic control.

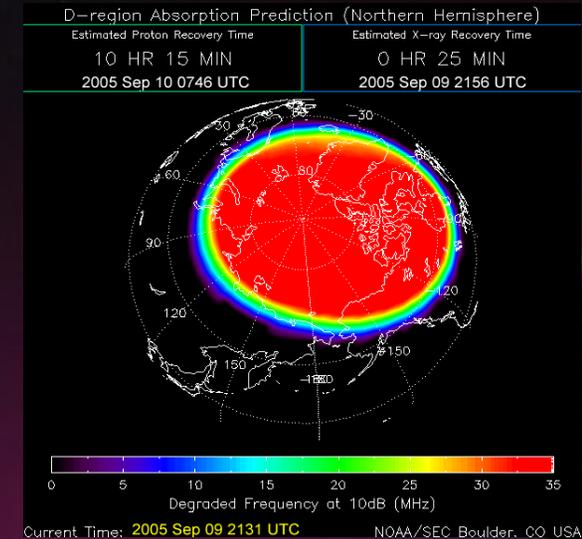
- Airlines will often re-route flights away from polar routes during radiation and geomagnetic storms at a cost that can exceed \$100,000 per flight.
- Expectations are for cross polar flights 8000 flights in 2008



Coupling Low-Mid Latitudes with High Latitudes



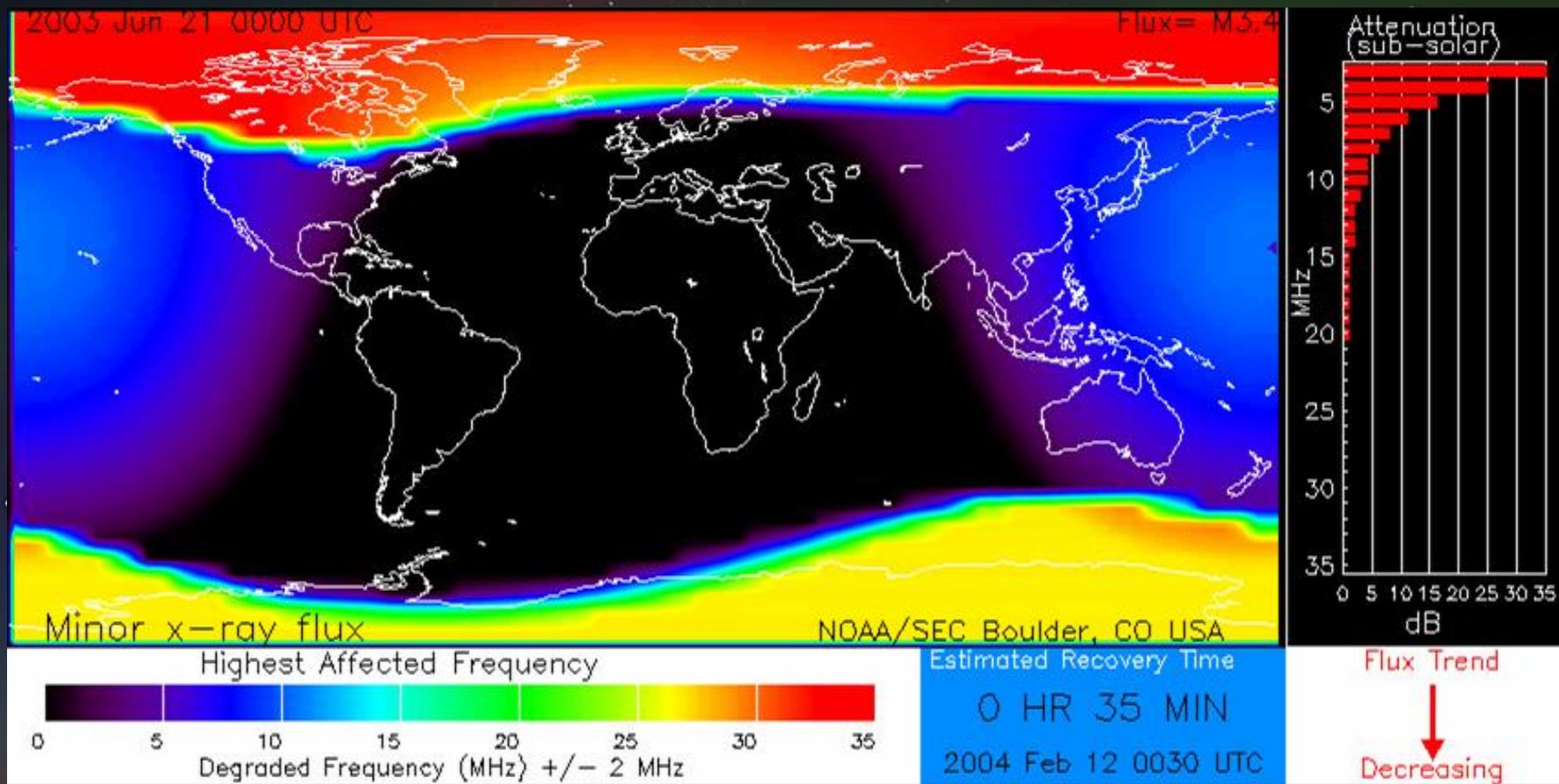
Low-and-middle latitude HF absorption



High latitude HF absorption

- **SWPC reorganization emphasizes transitioning new models to operations**
- **SWPC participating in GOES-R Algorithm Working Group to create GOES-R Space Weather Products**
- **New product to combine polar and low latitude HF absorption**
- **Both use GOES inputs, polar HF absorption also uses non-GOES data**

High-Latitude D-Region HF Radio Absorption



- One-stop shopping for HF fade anywhere on the planet
- Deployment as a tool later this year

Summary

- **GOES R will continue and extend space environment measurements begun over thirty years ago**
- **These observations are critical for supporting our customers**
- **GOES data supports and drives our product and model development**

A photograph of the Aurora Borealis (Northern Lights) over a dark forest silhouette. The sky is a mix of green and purple, with stars visible. The text is overlaid on the left side of the image.

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