Space Weather Prediction Center Highlights

Space Weather Workshop 2015

Dr. Thomas Berger
Director

National Weather Service

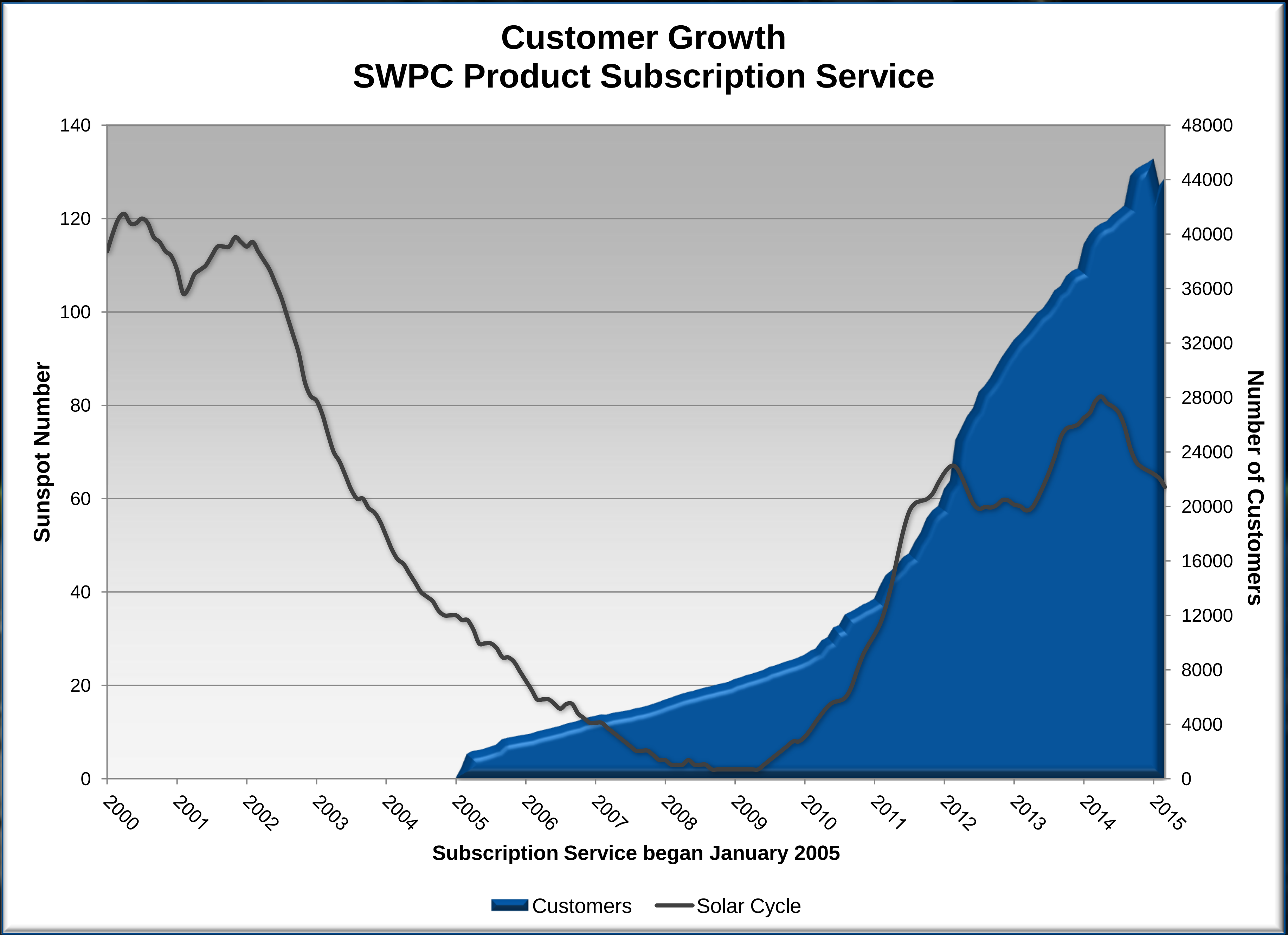
SWPC Organization

SWPC Partnerships

557th Weather Wing

- NOAA
- USGS science for a changing world
- Federal Aviation Administration
- Naval Research Laboratory
- Air Force Research Laboratory
- NSF
- Department of the Navy ONR Science & Technology
- ACSWA
- NASA
- Met Office
- Korean Space Weather Center RRA National Radio Research Agency
- Academia
- ICAO OACI ИКАО
- ISES

SWPC Customers



Satellite companies	Banking	FEMA	Academia	FAA
Shipping	Automobile industry	Communication companies	Oil drilling	Electric utilities
State Departments of Transportation	Precision agriculture	Major Airlines	Manned space flight	Surveying groups

SWPC Space Weather Scales

Radio Blackouts

			GOES X-ray peak brightness by class and by flux*	Number of events when flux level was met; (number of storm days)
R		HF Radio: Complete HF (high frequency**) radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners and en route aviators in this sector.	X20 $(2x10^{-3})$	Fewer than 1 per cycle
R				
R				
R				
R				

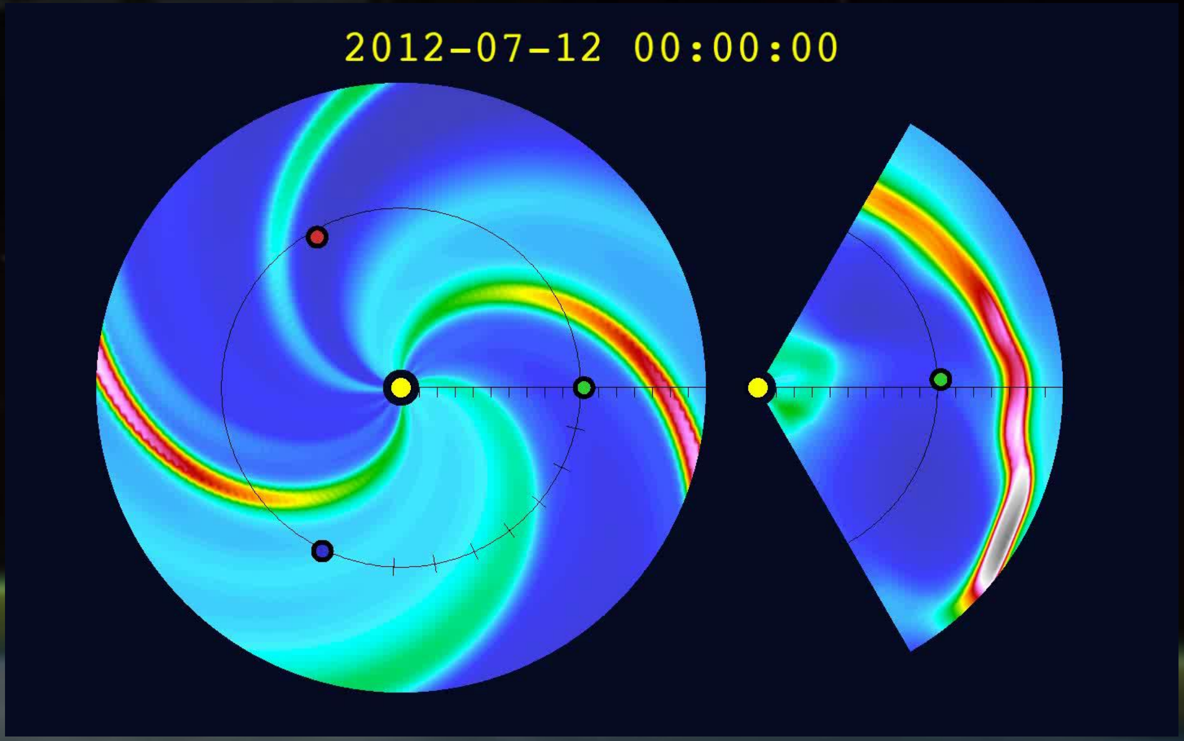
Solar Radiation Storms

			Flux level of ≥ 10 MeV particles (ions)*	Number of events when flux level was met**
S 5	Extreme	Biological: unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. *** Satellite operations: satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible.	10^5	Fewer than 1 per cycle
S 4				
S 3				
S 2				
S1				

Geomagnetic Storms

Category		Effect	Physical measure	Average Frequency (1 cycle = 11 years)
Scale	Descriptor	Duration of event will influence severity of effects		
			Kp values* determined every 3 hours	Number of storm events when Kp level was met; (number of storm days)
G 5	Extreme	Power systems: widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage. Spacecraft operations: may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites. Other systems: pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.).**	Kp=9	4 per cycle (4 days per cycle)
G 4	Severe	Power systems: possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid. Spacecraft operations: may experience surface charging and tracking problems, corrections may be needed for orientation problems. Other systems: induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.).**	Kp=8	100 per cycle (60 days per cycle)
G 3	Strong	Power systems: voltage corrections may be required, false alarms triggered on some protection devices. Spacecraft operations: surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems. Other systems: intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.).**	Kp=7	200 per cycle (130 days per cycle)
G 2	Moderate	Power systems: high-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage. Spacecraft operations: corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions. Other systems: HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.).**	Kp=6	600 per cycle (360 days per cycle)
G 1	Minor	Power systems: weak power grid fluctuations can occur. Spacecraft operations: minor impact on satellite operations possible. Other systems: migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine).**	Kp=5	1700 per cycle (900 days per cycle)

SWPC Geomagnetic Storm Forecasts



1. Geomagnetic Storm Watch
Issued upon detection of Earth-directed CME and WSA-Enlil model run

- **1-3 day forecast**

2. Geomagnetic Storm Warning
Issued upon detection at the ACE (soon DSCOVR) spacecraft at the L1 Lagrange point

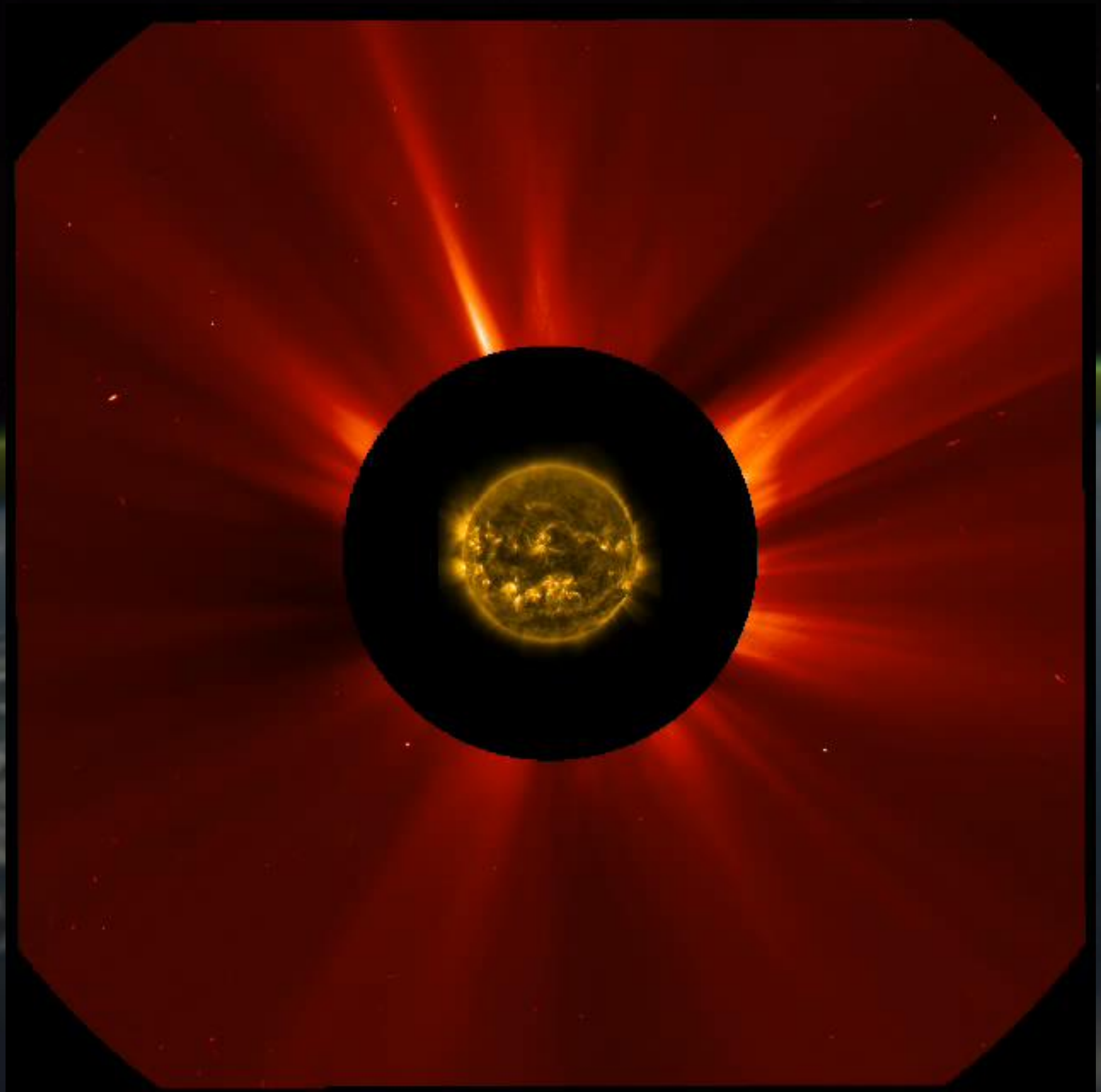
- **15-50 minutes before impacting Earth**

3. Geomagnetic Storm Alert
Issued when geomagnetic storm is detected on USGS and international partner magnetometers

- **Current condition**

SWPC in the News

- September 12th 2014 “Double CME” impact
- G3 Geomagnetic storm



X1.6 Flare/CME 10-Sep-2014 following M4 flare/CME on 9-Sep-2014

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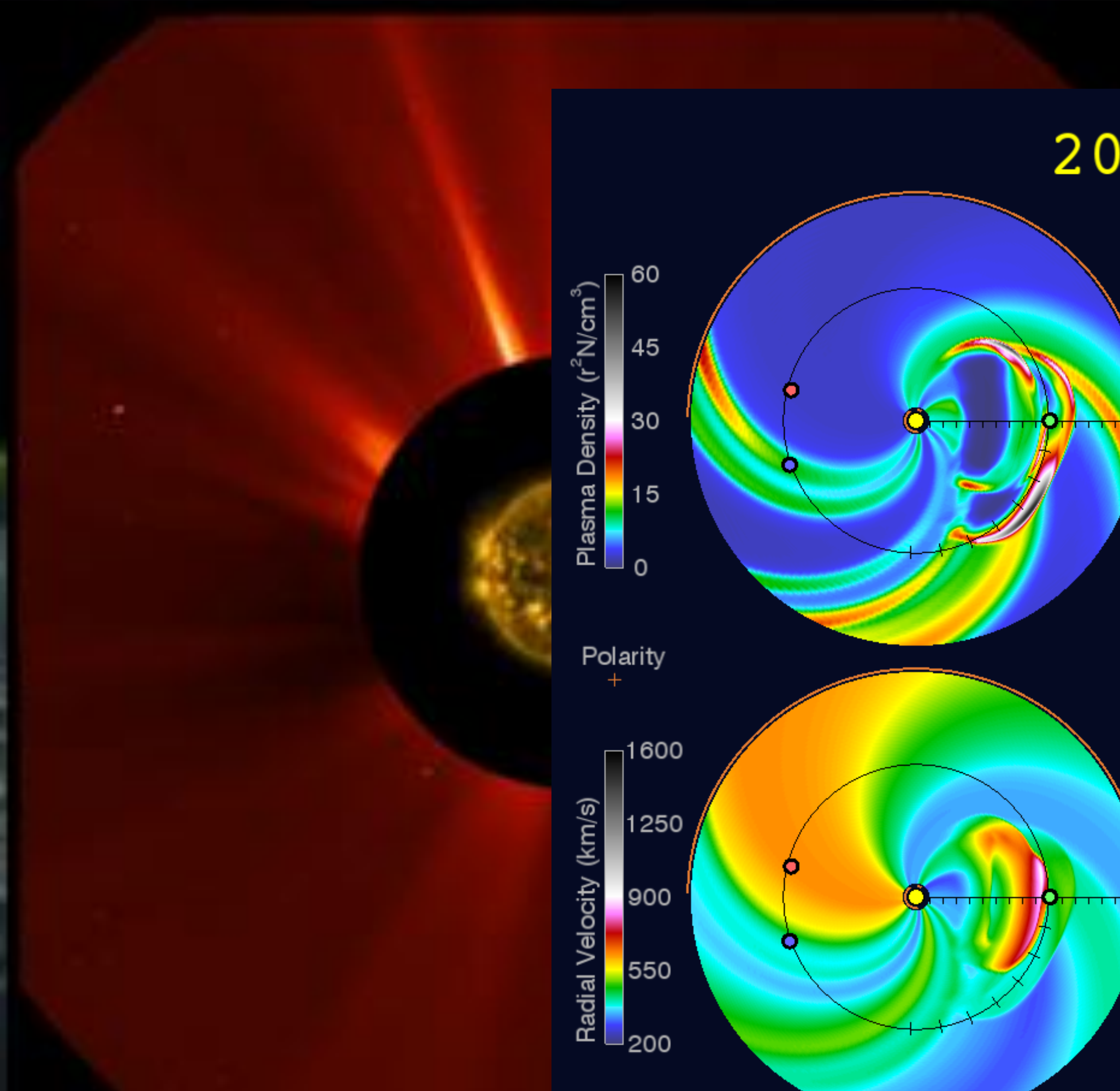
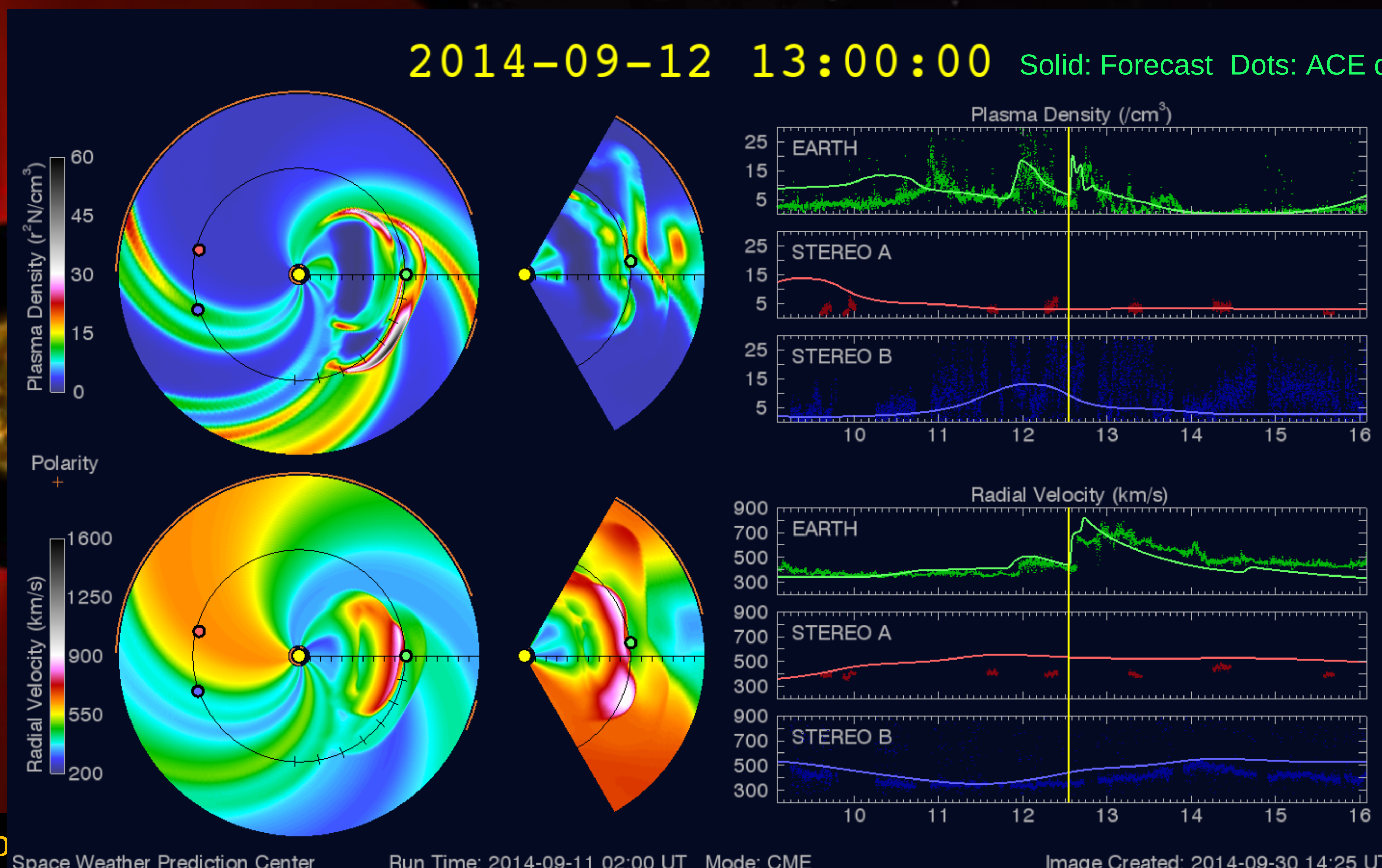


X1.6 Flare/CME 10-Sep



Accuracy of forecast arrival time: <1.5 hr for both CMEs!

New Observations: DSCOVR!

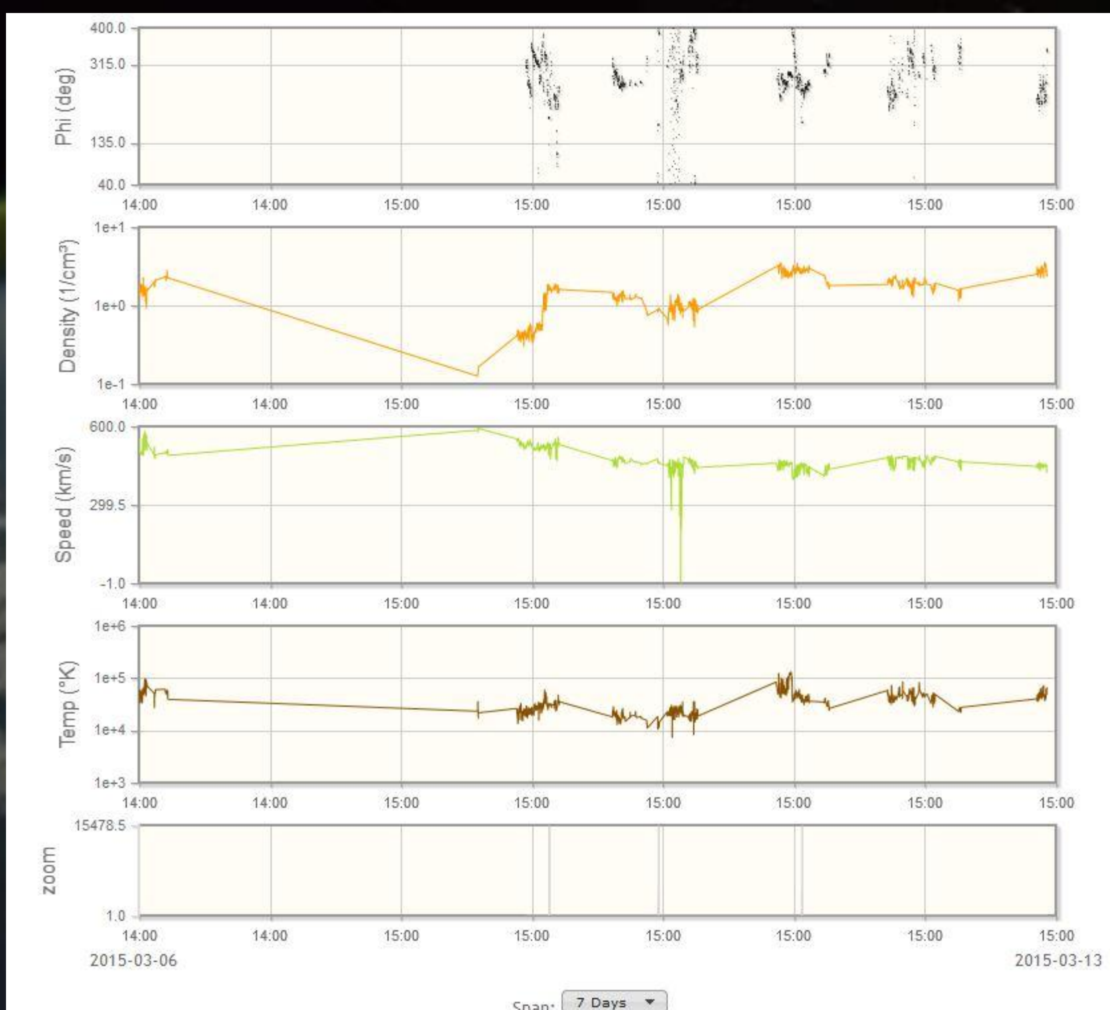
Falcon 9 Launch, 11-Feb-2015

Courtesy of SpaceX

New Observations: DSCOVR

- In transit to L1: Lissajous orbit insertion ~June 7– 8.
- All Space Weather instruments turned on and functional.
- Transition to NOAA Operations: ~July 15.

DSCOVR First Wind!



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Solar wind
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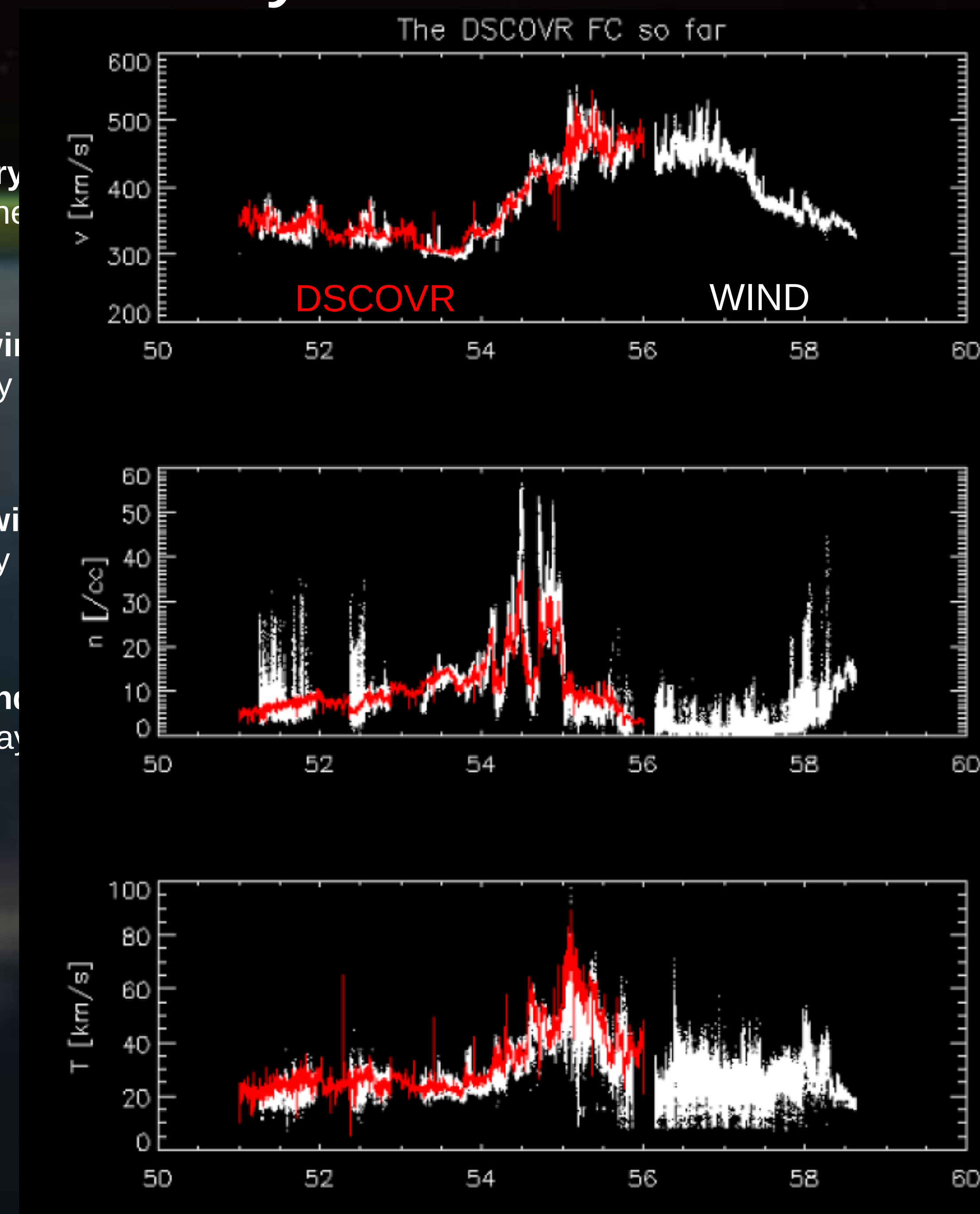
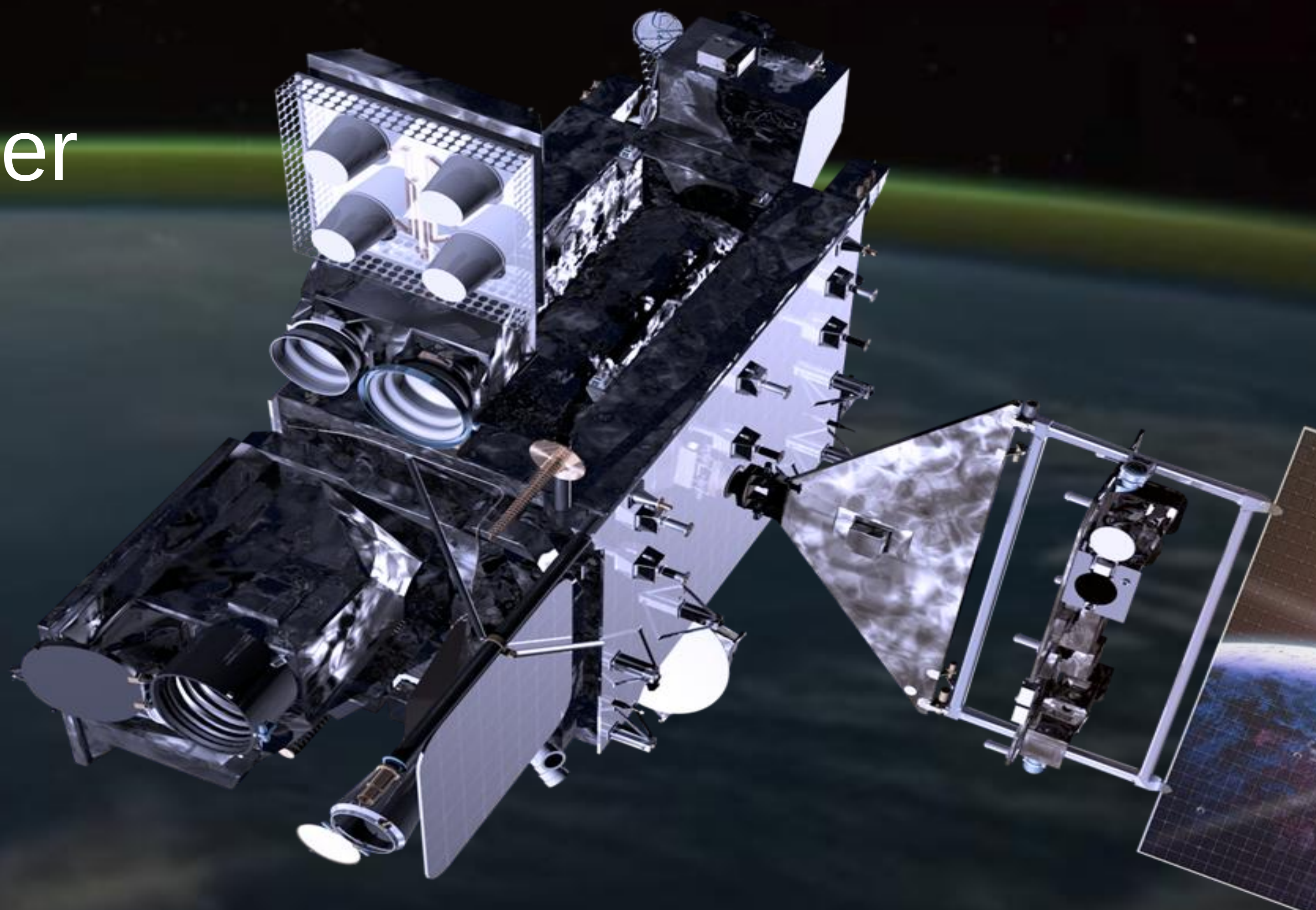


National Weather Service

New Observations: GOES-R

- EXIS – X-ray and EUV sensor, expanded dynamic range and flare location
- SEISS – significant increase in range of energetic particle measurements
- SUVI – new UV solar imager
- MAG – high sample rate magnetometer



NOAA GOES-R
Launching to Geosynch in early 2016!

Future Observations

- NOAA “Space Weather Follow-on”
- Launch: ~2020
- Primary mission: operational (real-time) coronagraph at L1 to replace the SOHO/LASCO – 20 years old this year…
- Mission studies currently being conducted.

Figure 1-4. CCOR Comparison to Heritage SECCHI/COR2 Design

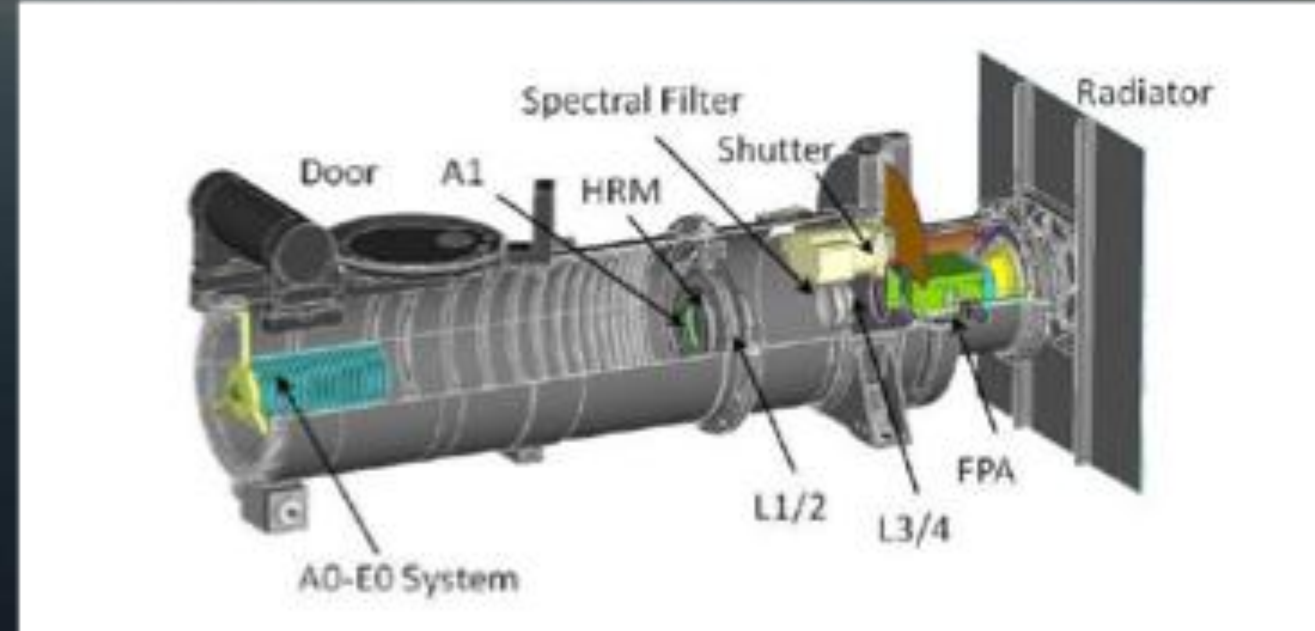


Figure 1-3. CCOR Conceptual Design

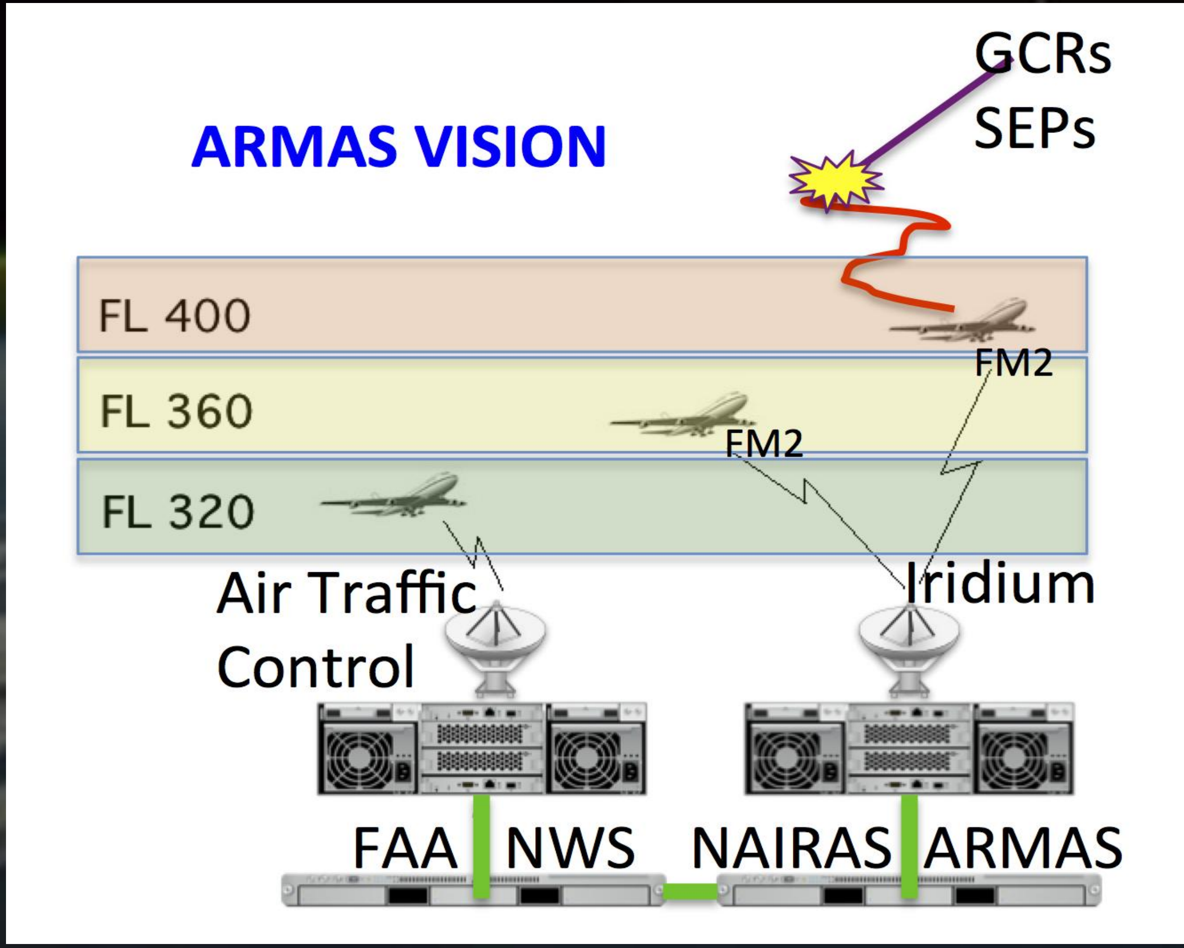
Compact Coronagraph

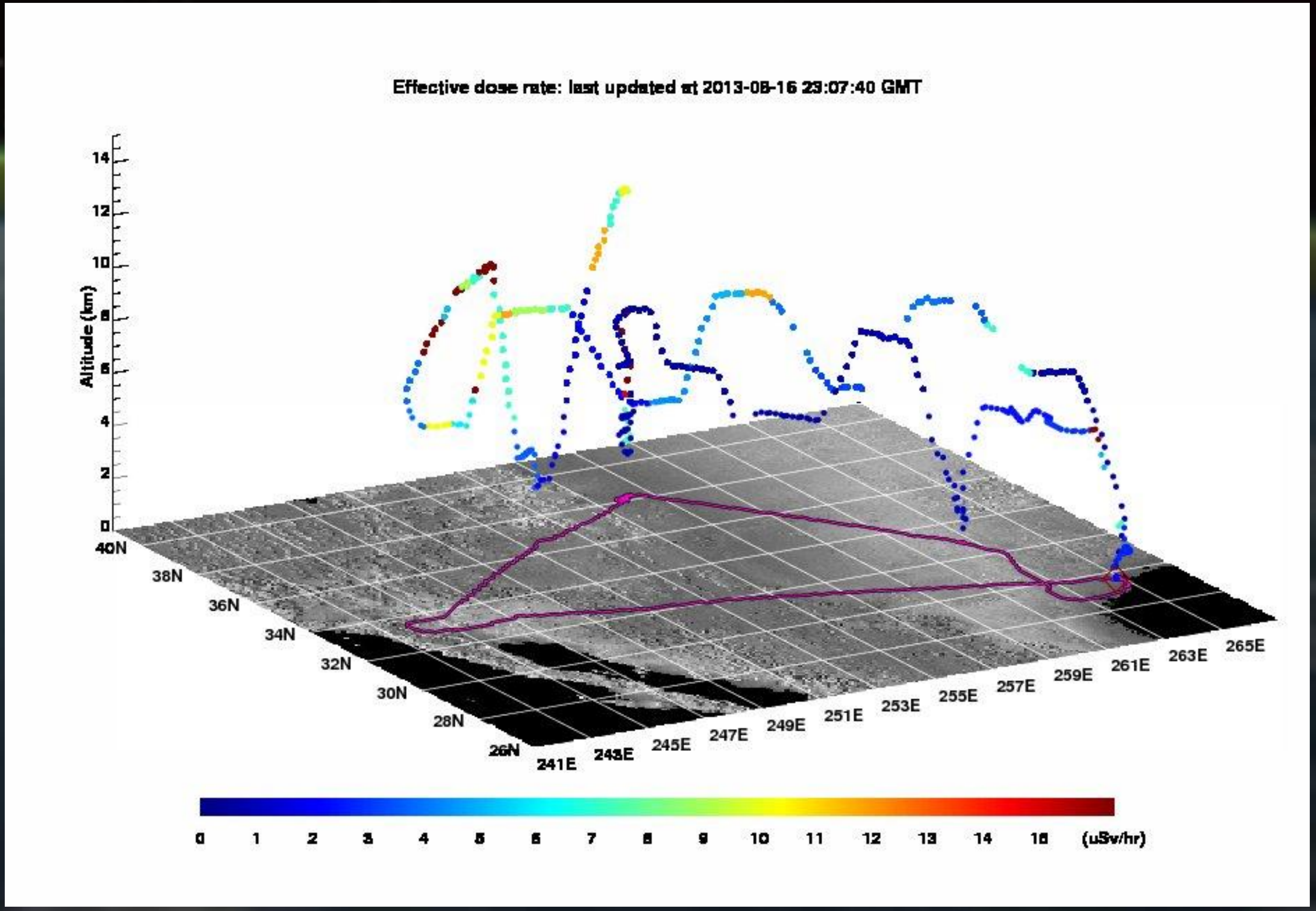
Courtesy of NRL

Future Products: ARMAS

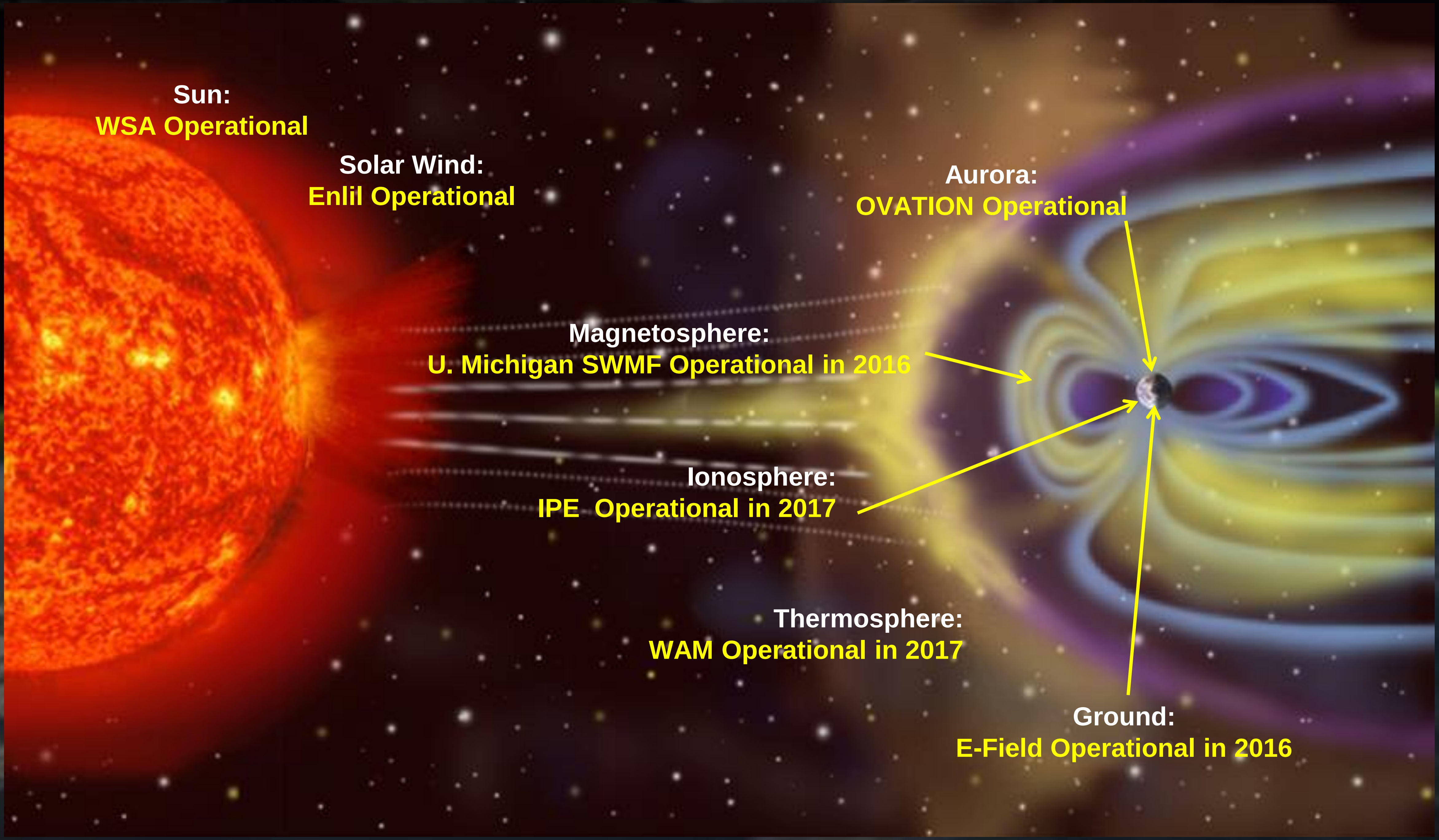
- Automated Radiation Measurements for Aerospace Safety.
- Joint Korea-US Collaboration

RRA/KSWC, SET, NOAA/SWPC, NASA/LaRC, NSF/NCAR





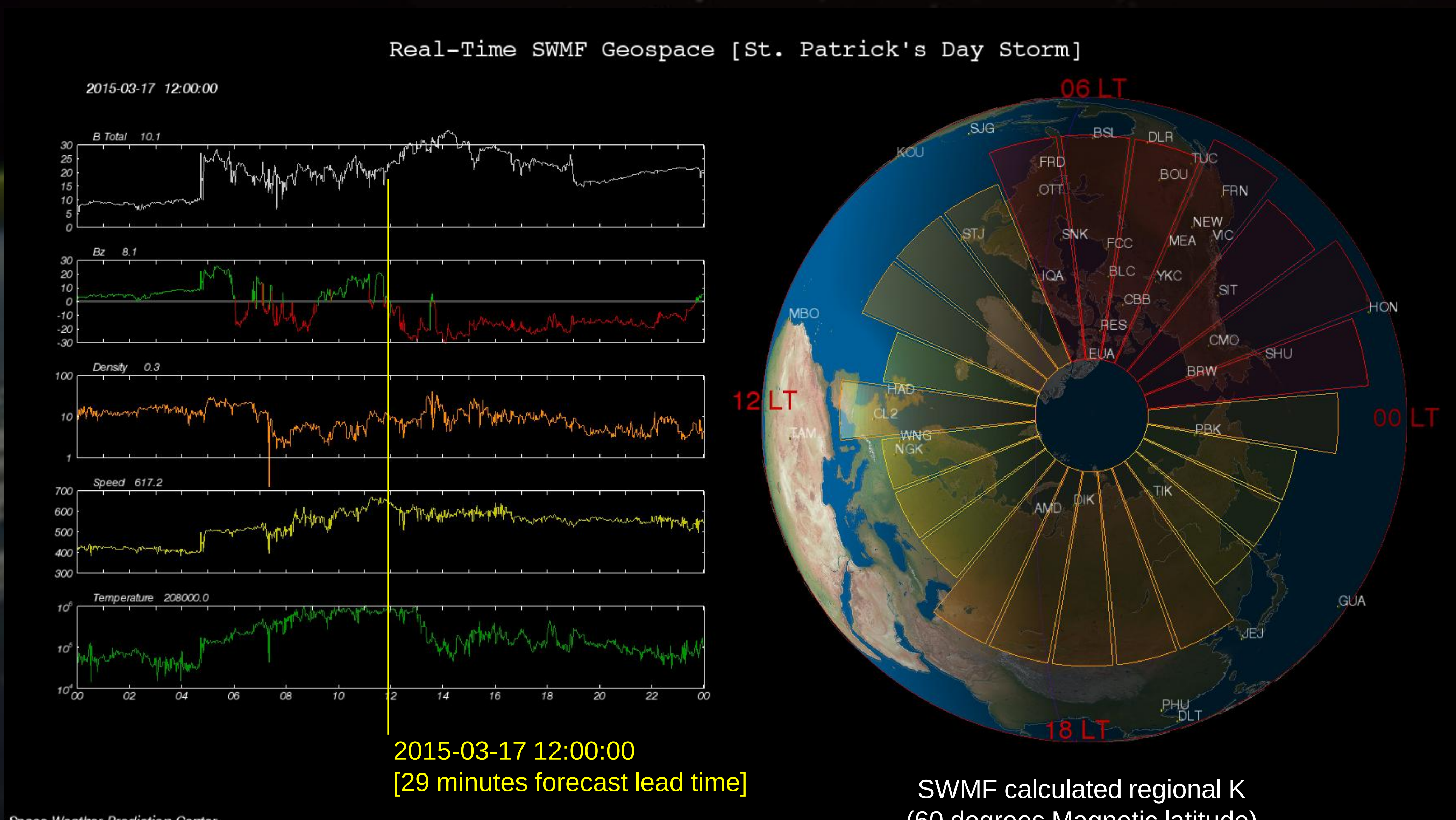
SWPC Modeling Efforts



FY16 PBR: +$2.5M for SWPC R2O “Testbed” activities

New Models: U. Mich. "Geospace"

- Real-time operations on NWS supercomputer in 2016.
- Working with U. Mich, NCEP/NCO, and NASA/CCMC.
- Accurate "re-Forecast" of St. Patrick's Day G4 storm!



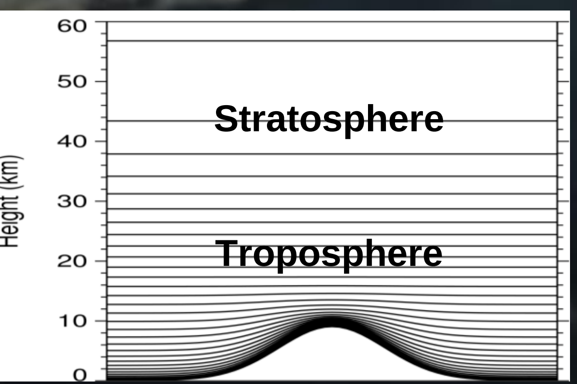
SWMF calculated regional K
(60 degrees Magnetic latitude)

K = 5, 6 | K = 7 | K = 8, 9

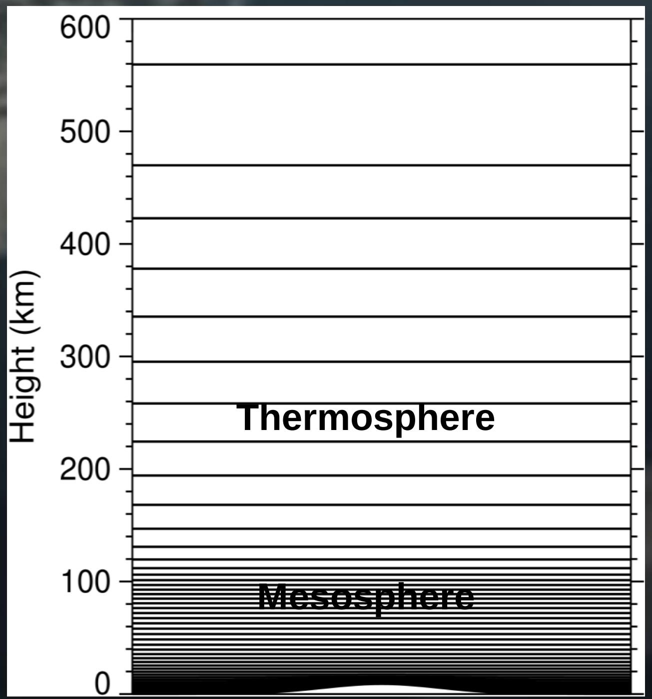
New Models: WAM/IDEA

- Operational Global Forecasting System (GFS) model extended to 600 km (WAM) + Ionospheric Model (IPE)
- Joint SWPC, UC/CIRES, NCEP/EMC, NOAA/OAR.
- Ionospheric forecast products in 2017.

Operational GFS
0 – 60 km

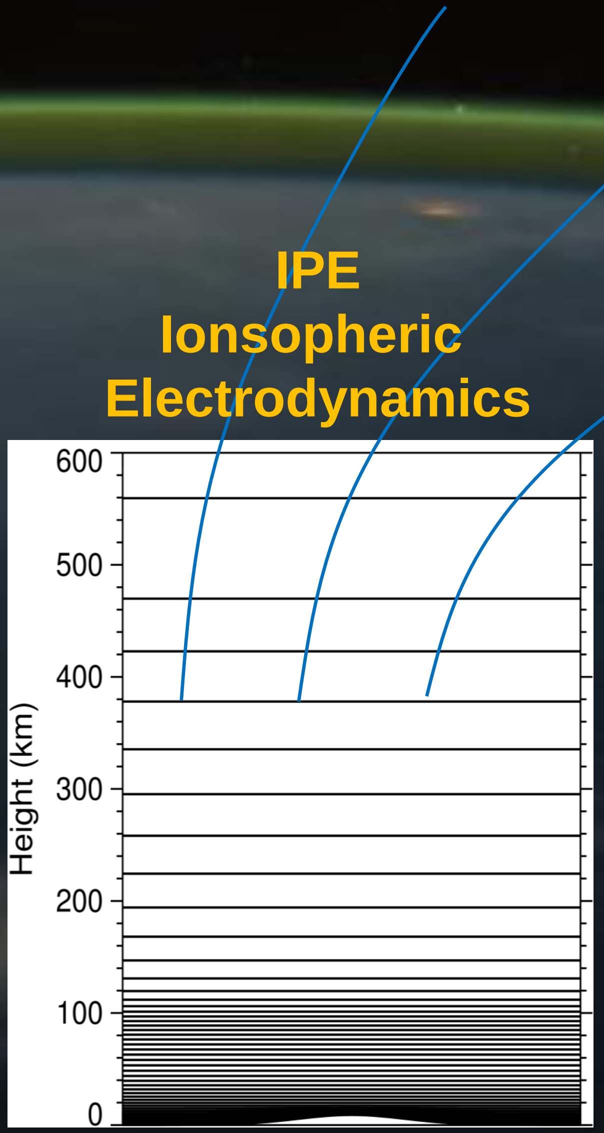


WAM
Neutral Atmosphere
0 – 600 km

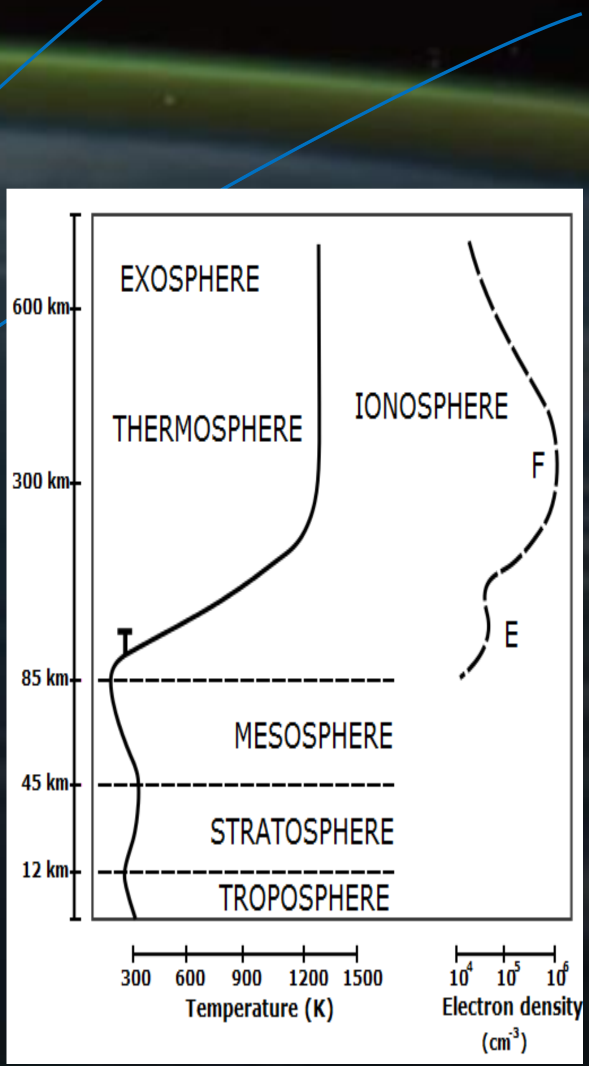


2015

IPE
Ionospheric
Electrodynamics



2017—2019



50 years of space weather forecasts from Boulder!

WELCOME!