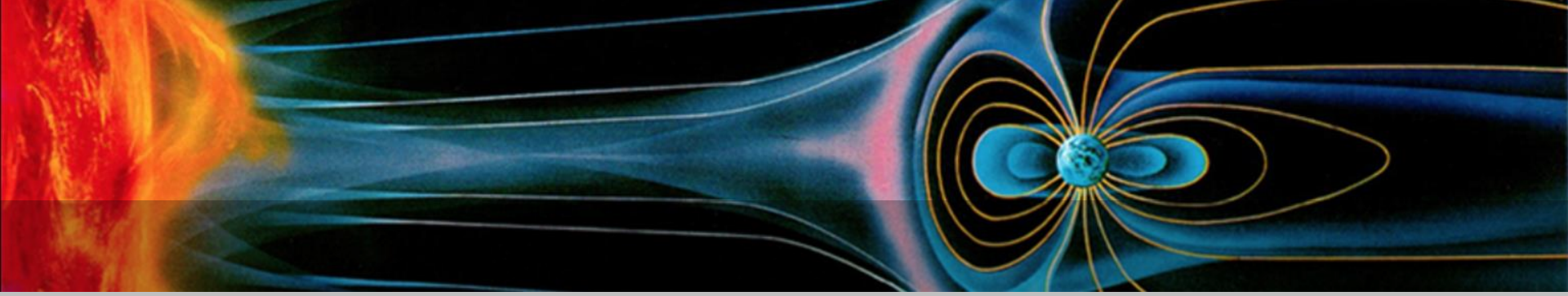

September 2017 Space Weather
An Overview

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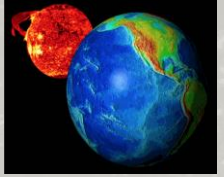
NOAA's National Centers for Environmental Information (NCEI)
Space Weather Prediction Center (SWPC)

Contributors: D. Seaton, J. He, J. V. Rodriguez

Tuesday, 17 April, 2018

Outline



- Summary
- Evolution of Active Region AR12673
- Earthward ICMEs and their Response
- Hurricane Season and Space Weather

Space Weather Summary: Sep-4 → Sep-13

Date	Flares ≥M5	SWPC Storm Scales *Alerts*				CME (Earthward)	GMC (GOES)	Geom. Indices	Space Haz	System Impacts
		Radio R	SEP (S, >100)	Geomag G	2MeV e-					
Sep-4	M5.5 (20:28)	R2			**Y**	CME0 Ejected			IC	
Sep-5			S2	G1	**Y**				IC	
Sep-6	**X2.2 (08:57)** **X9.3 (11:53)**	**R3**	S2		**Y**	CME0 Arrived CME1 Ejected			IC	***HF Ground*** ***HF Aviation***
Sep-7	M7.3 (10:11) **X1.3 (14:20)**	**R3**	S2	G3	**Y**	CME1 Arrived	**Y**		IC	
Sep-8	M8.1 (07:40)	R2	S2	**G4**	**Y**				IC	Check WAAS/EGNOS
Sep-9					**Y**				IC	
Sep-10	**X8.2 (15:35)**	**R3**	**S3, Yes**		**Y**	CME2 Ejected			IC SEE	***HF Ground***
Sep-11			**GLE72**		**Y**				IC SEE	
Sep-12			S2	G1	**Y**	CME2 Arrived			IC	
Sep-13			S1	G1						

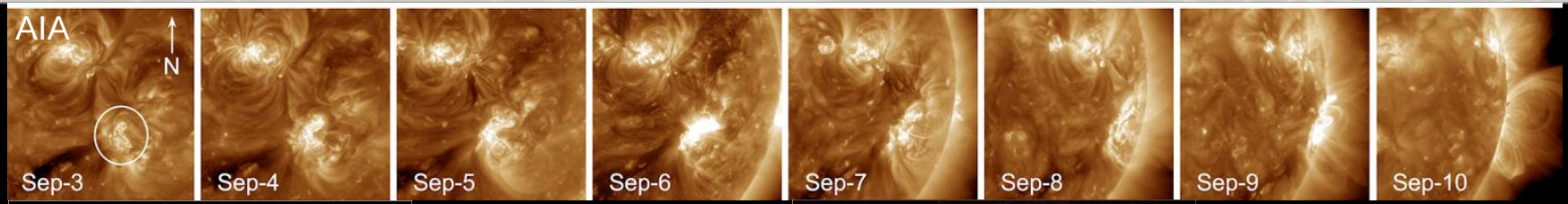
Sep-8:

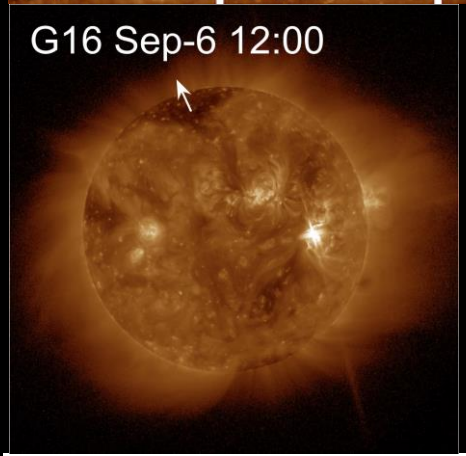
Kp_{max} 8.3

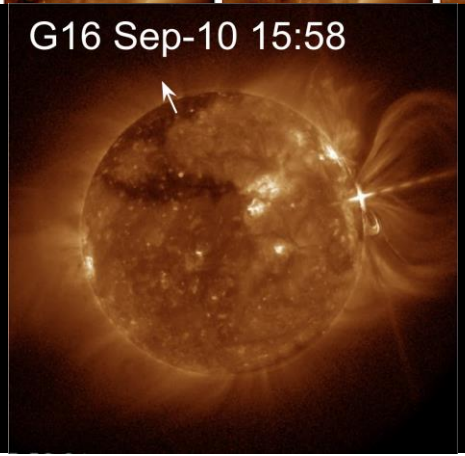
Dst_{min} -142nT (Kyoto)

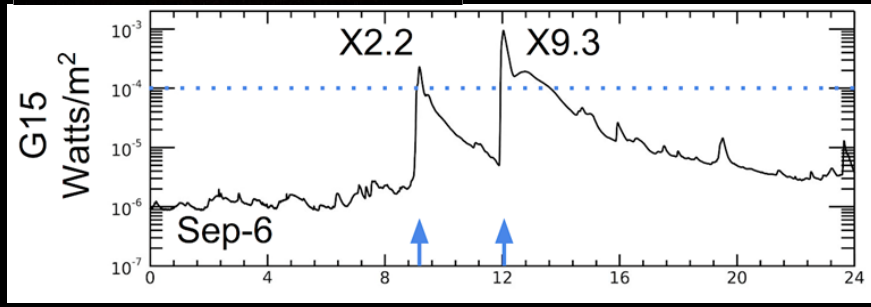
-234 nT (LASP)

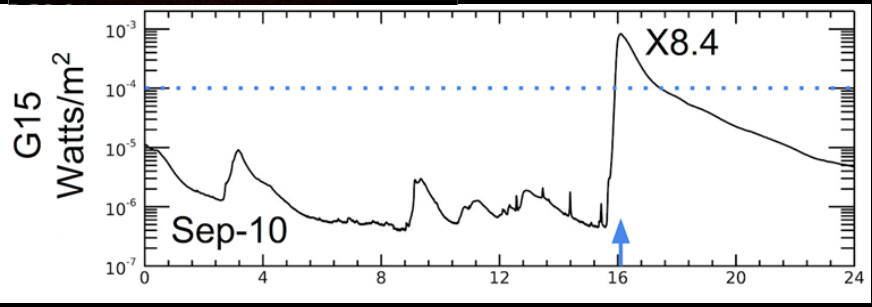
Evolution of AR12673





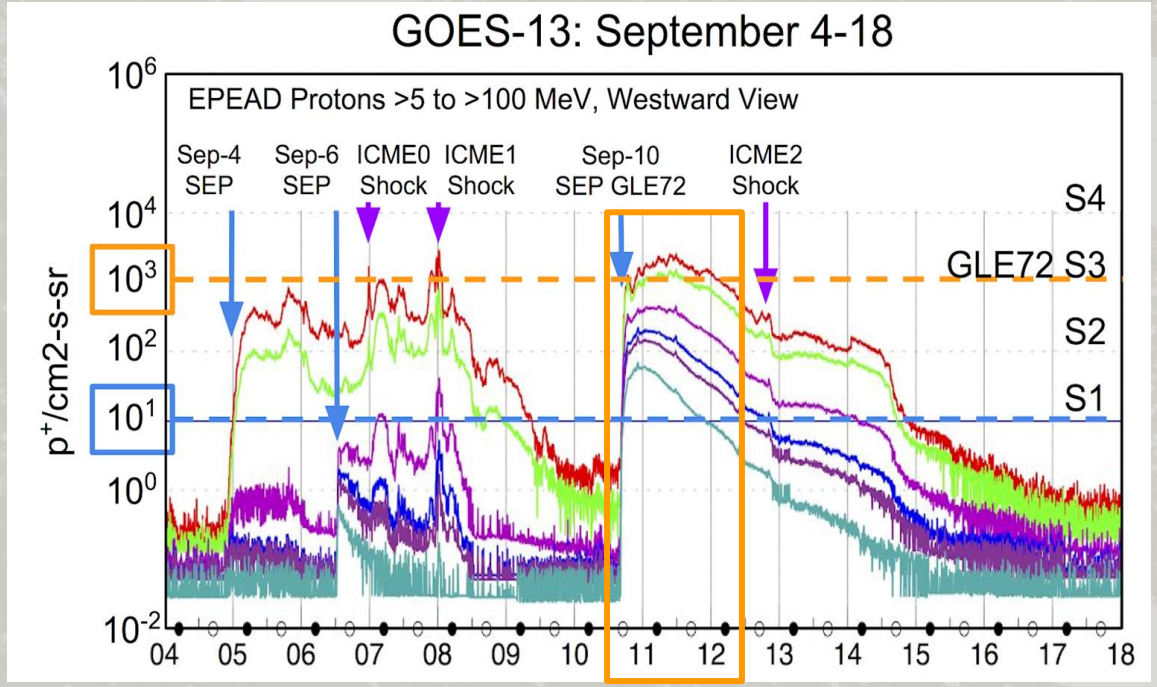


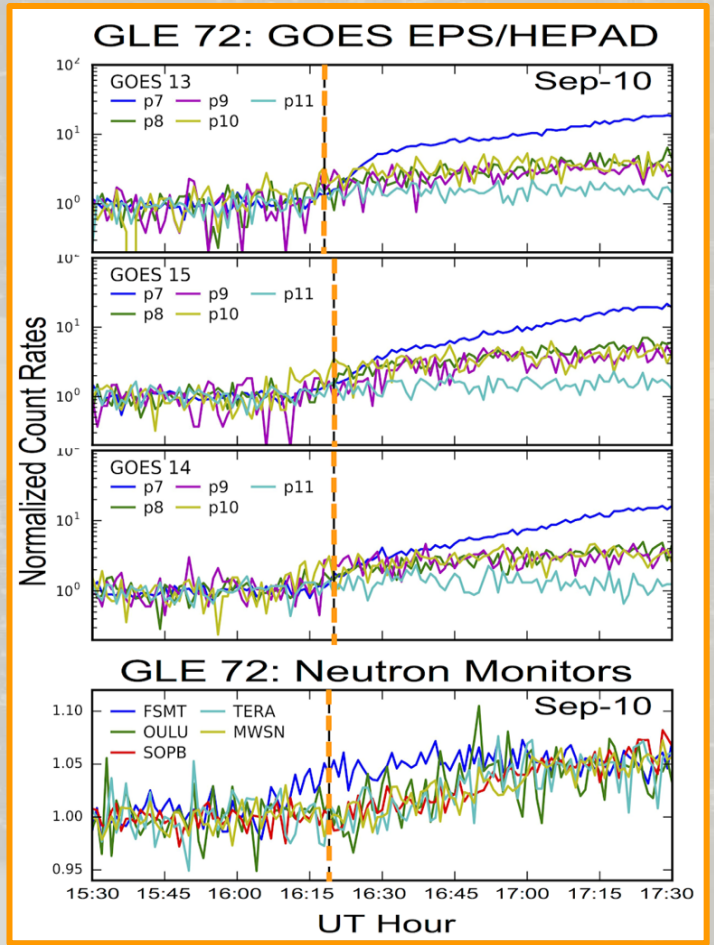




Solar Energetic Particles (SEP)

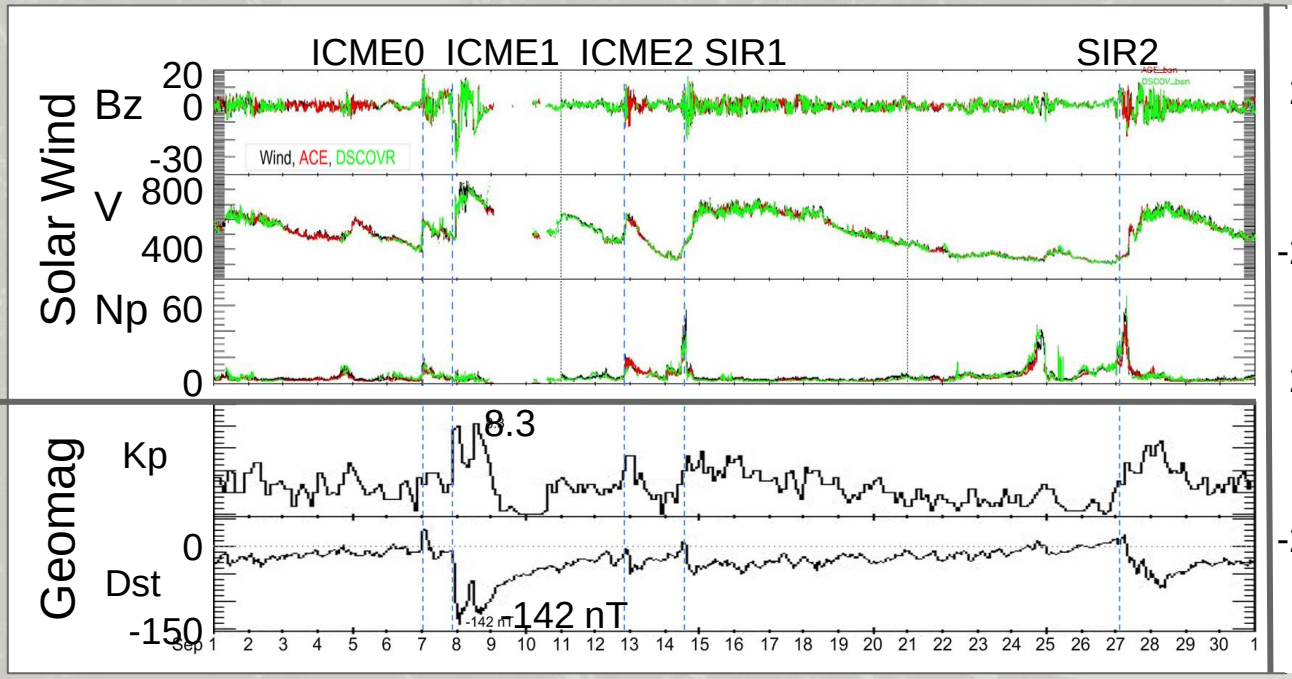
- Multiple SEP increases via solar eruption and ICME
- Space haz. risks elevated for most of September (>S1)
- First GLE since 2012 → SWPC S3 Alert
  - First detected by GOES-13, followed closely by Neutron Monitors and GOES-14 and GOES-15.

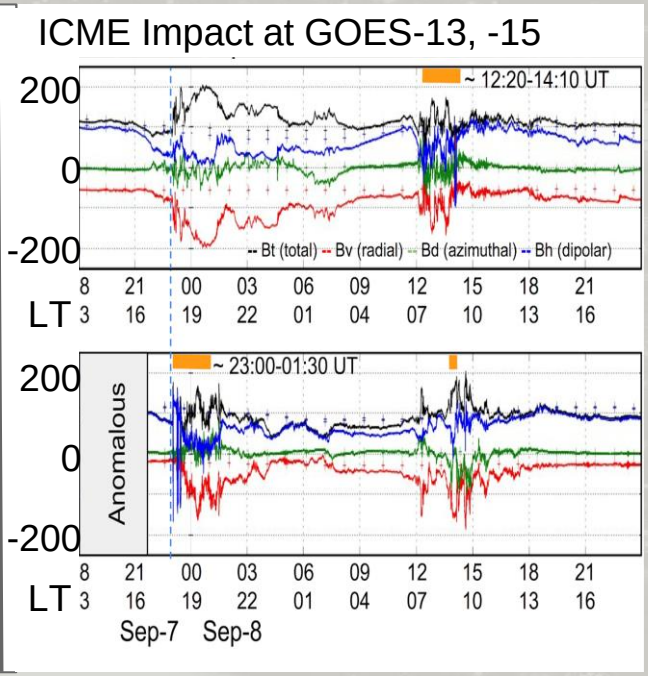




Solar Wind and Geomagnetic Response

- September included 3 significant ICMEs and 2 SIRs
- ICMEs resulted in compression/erosion of dayside magnetosphere
  - GOES-13 and GOES-15 found themselves inside the magnetosheath
- Sep-7/8 Geomagnetic response resulted in a G4 storm and enhanced >2 MeV e- fluxes
  - Kp ~ 8.3, Dstmin -142 nT (preliminary) to -234 nT (predicted)

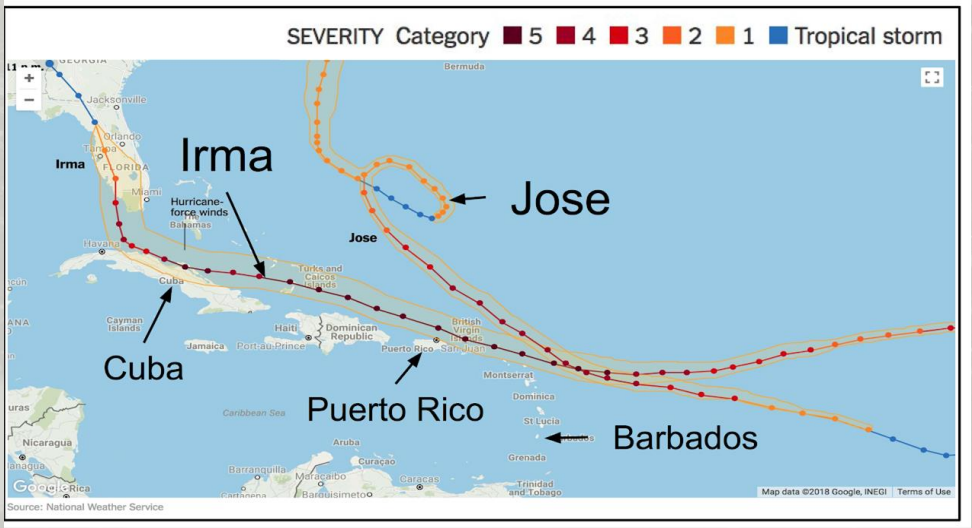




Hurricane Season Worsened by Space Weather

Hurricane Watch Net (HWN)

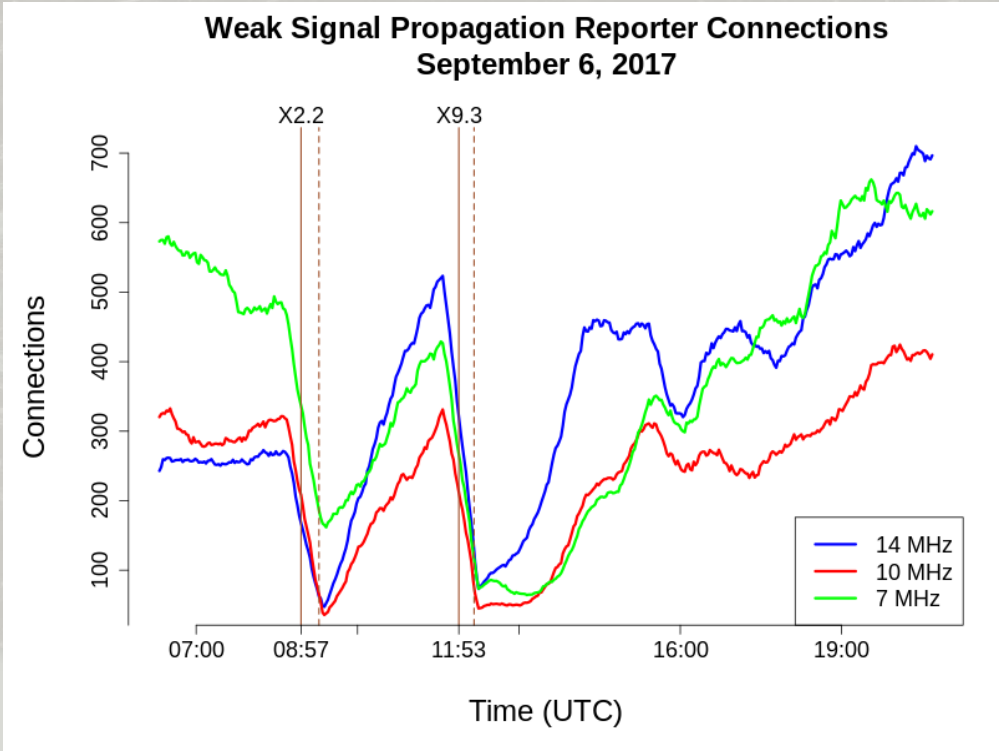
"In addition to the mix of three hurricanes, the HWN has been hassled by a series of solar flares — one a massive Class X-9.3, said to be the most powerful flare in more than a decade. 'This solar flare caused a **near-total communications blackout for most of the morning and early afternoon**,' Graves recounted." (HWN Manager Bobby Graves)



HF Impacts

Weak Signal Propagation Report (WSPR)

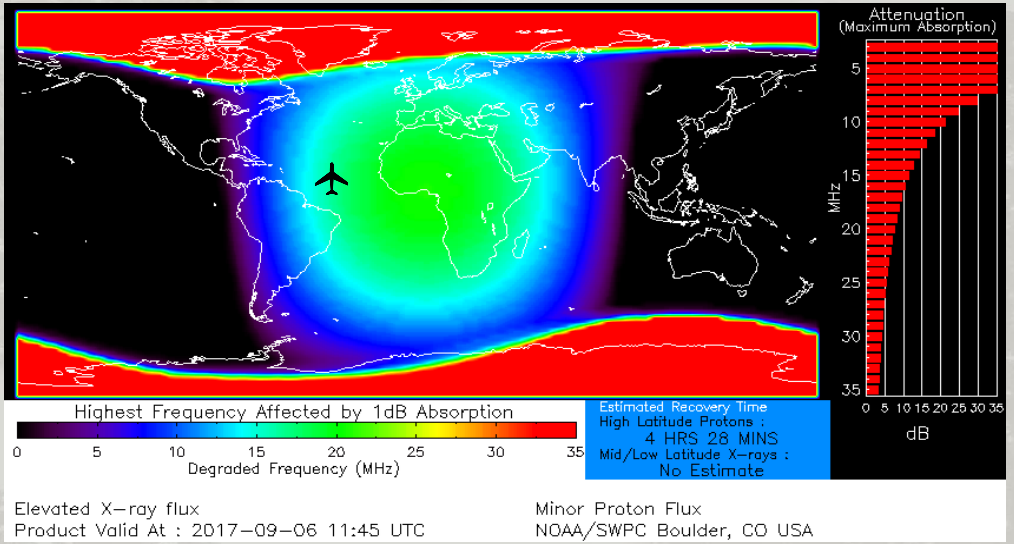
This program is designed for sending and receiving low-power transmissions to test propagation paths on the MF and HF bands. Users with internet access can watch results in real time at WSPRnet.



Aviation Impacts

French Civil Aviation Authority

"French Civil Aviation authorities reported that **HF radio contact was lost** with one non-Controller Pilot Data Link Communications (CPDLC) equipped aircraft off the coasts of Brazil and French Guyana f**or approximately 90 minutes**, triggering an alert phase until a position report was received by New York radio"

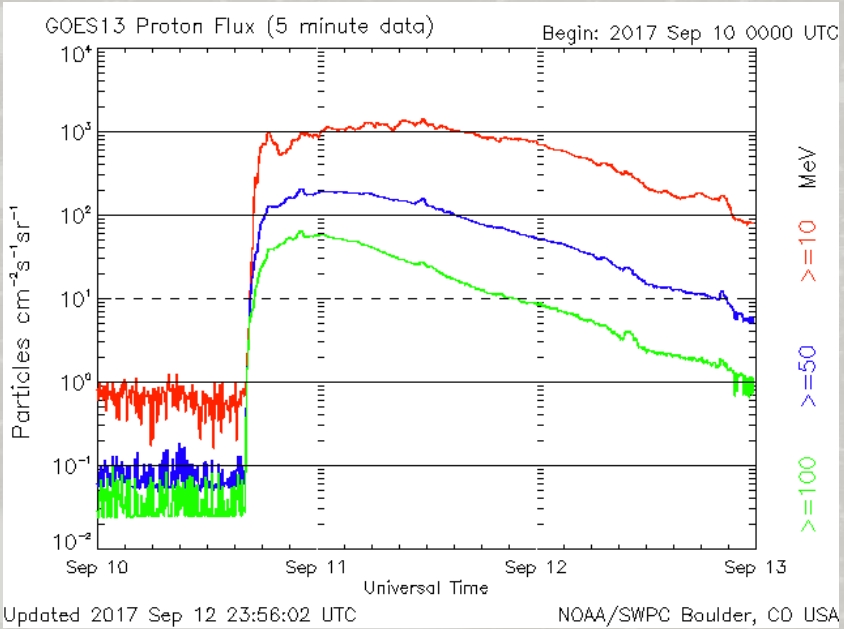


Aviation Impacts

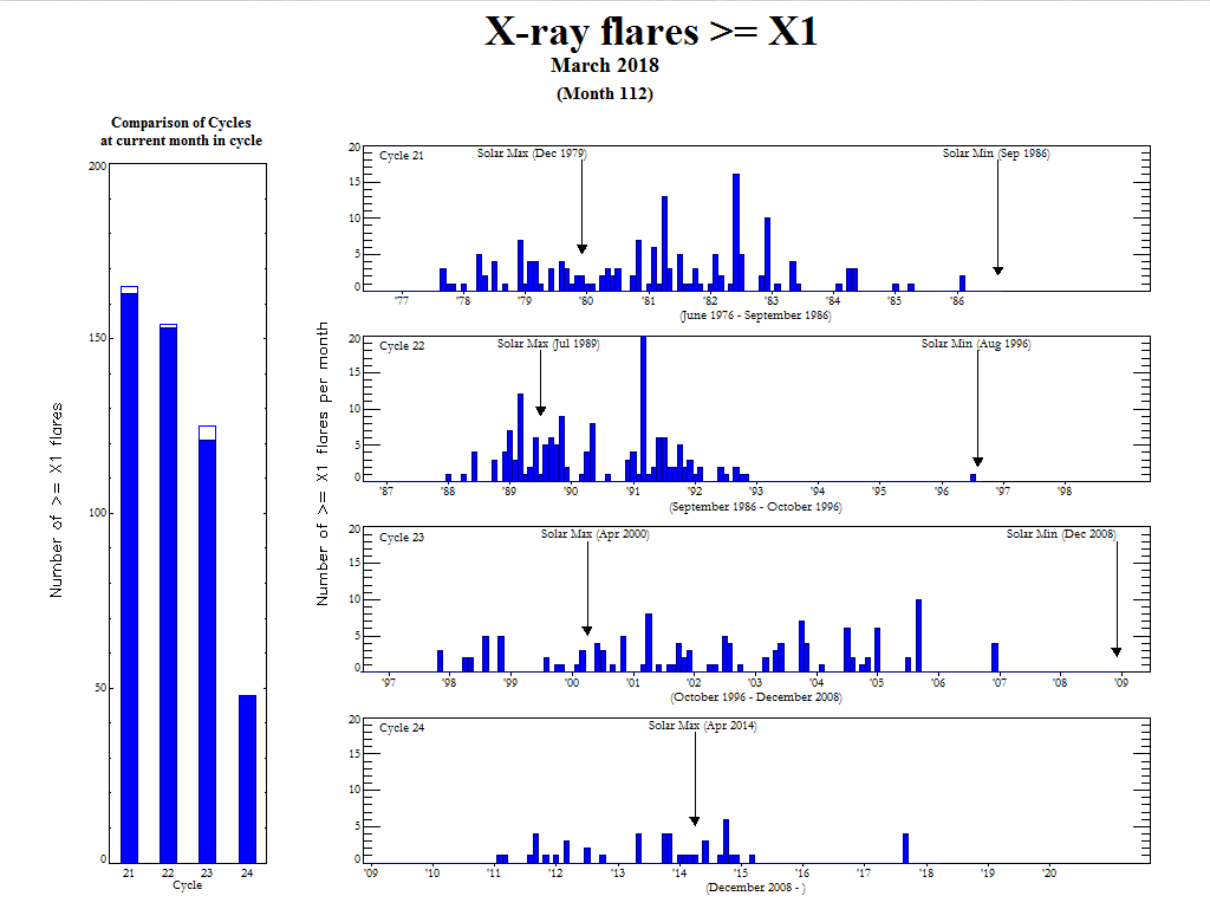
FAA Civil Aerospace Medical Institute

"High-latitude solar dose rates began to rise between 1600 UT and 1700 UT, reaching alert levels (20 microsieverts per hour at 70,000 ft) at just after 1800 UT. The added solar dose during a flight at 40,000 feet in the later part of 10 Sept. would approximately equal the normal expected dose from galactic cosmic radiation for the same flight."

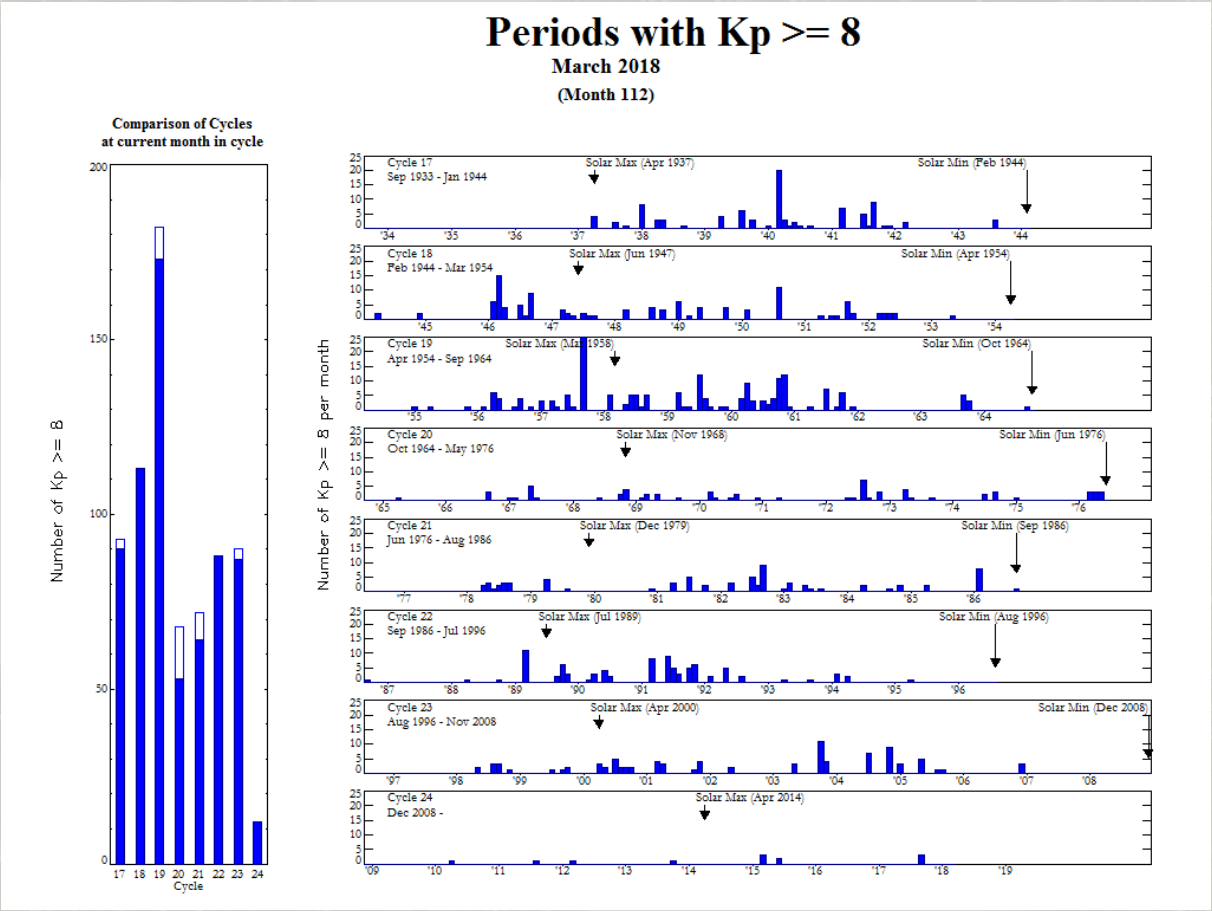
Flight Altitude	Peak Dose Rate (microsieverts/hour) Solar	Galactic
30000 ft.	3	4
40000 ft.	12	8
50000 ft.	43	13



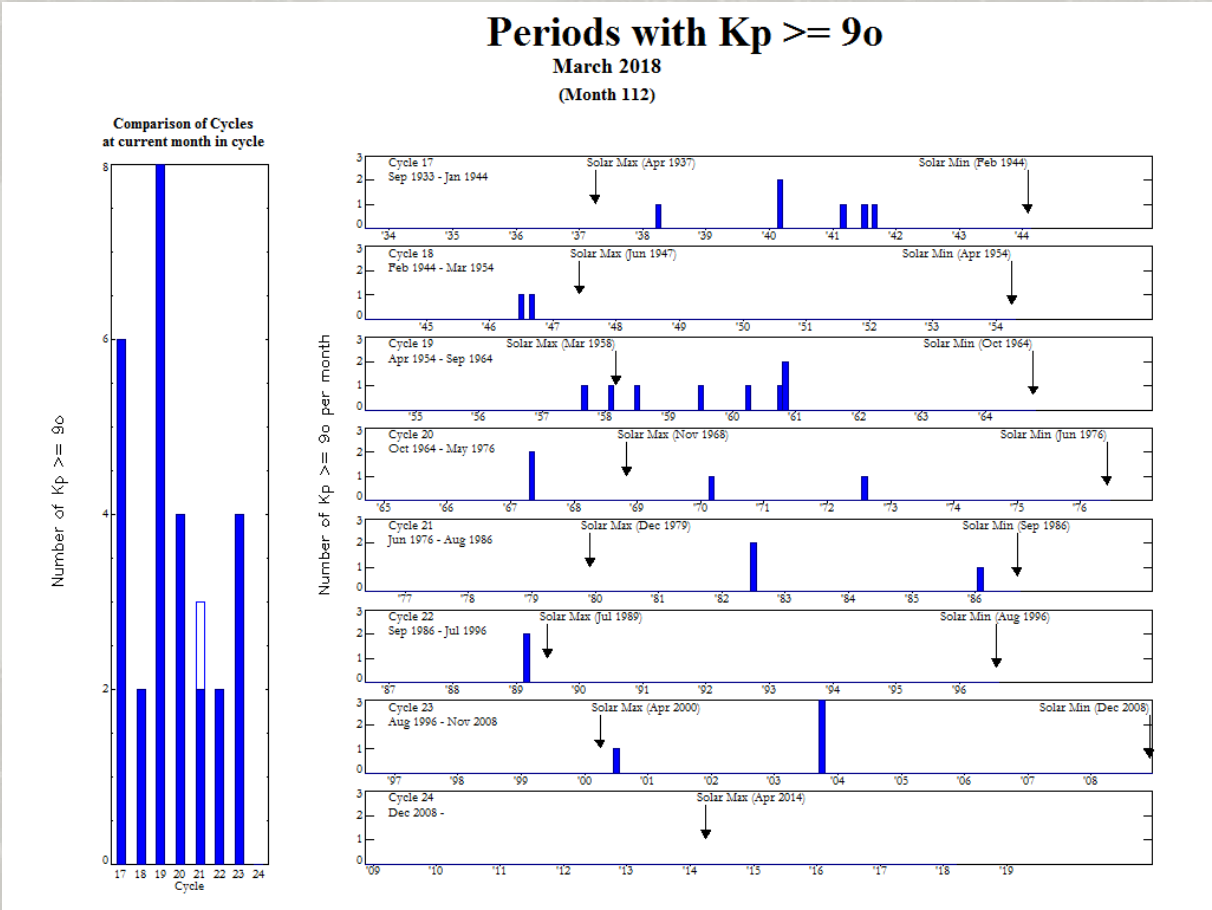
Broader Context



Broader Context



Broader Context



Near Miss

SOHO/LASCO HALO CME September 10, 2017

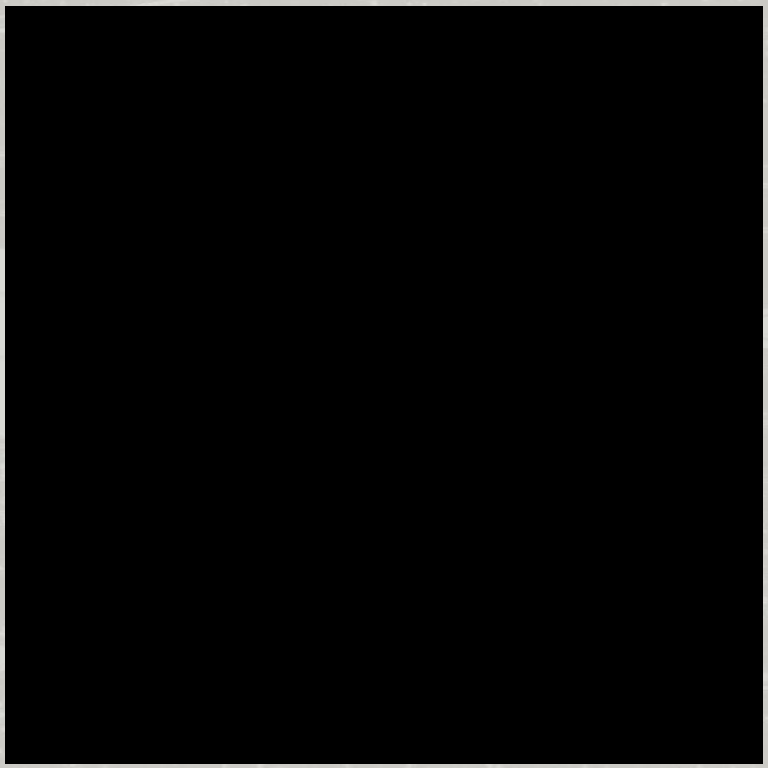
C2 Start Time: 16:00 UT
C3 Start Time: 16:06 - 18:18 UT

Type of CME:
Asymmetric HALO CME — FRONTSIDE
pa1: 253 pa2: 252 Total Width: 360 degrees

Velocity Measurements:
C2 1 points ****.* km/sec @ PA 253
C3 5 points 3212.4 km/sec @ PA 253
Average through both fields: 3287.6 km/sec

COMMENT: AIA 193 shows a long duration (LDE) impulsive flare event of AR 12673 at location [S08, W88] beginning 15:45 - 16:51 UT. The event produces an EUV wave and a dimming across the disk, followed by a post loop arcade.
LASCO shows extreme proton flux in the field of view (SEP).

STEREO Beacon Data
COR2 A, in progress 16:24 - 16:40 UT; shows an asymmetric HALO CME
Preliminary time/height measure gives 2630.4 km/sec @ 110 degrees.
NOAA/GOES reports a X8.2 class X-ray flare of AR12673 15:35/16:06/16:31 UT.
NOAA/GOES shows a increases in proton particles with flux >100 MeV
and surpasses solar storm threshold conditions.



Summary

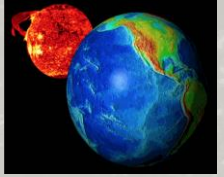
Key Points:

- Solar Active Region AR12673 released 4 X-class flares, 3 coronal mass ejections and a solar energetic particle event with GLE.
- High-latitude solar dose rates reached alert levels (20 microsieverts per hour at 70,000 ft) for Sep-10.
- These events impacted HF radio links for ground and aviation communication.
- Radio communications used in hurricane emergency and disaster relief management were affected, especially in the Caribbean.

See Also:

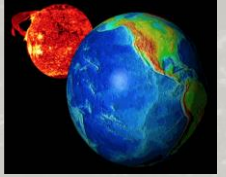
- Value of GPS particle measurements by Steve Morley on Wednesday.
- GOES-16 observations by Juan Rodriguez on Thursday AM.
- GLE72: Nathan Schwadron's talk on Thursday PM.
- Preprint of Redmon et al 2018 (in review) will be available soon.

Valuable Data Sources



Domain	Platform	Provider	Access
Solar Imagery	GOES-16	NCEI	https://www.ngdc.noaa.gov/stp/satellite/goes-r.html The SUVI data used in this study were created in a non-operational environment and are considered to be of "beta" maturity.
	SDO	NASA	http://www.jhelioviewer.org/
	SOHO	NASA	http://www.jhelioviewer.org/
Solar Wind	DSCOVR	NCEI	https://www.ngdc.noaa.gov/dscovr/portal/
	ACE, Wind, DSCOVR	NASA OMNIWeb	https://omniweb.sci.gsfc.nasa.gov/form/sc_merge_min1.html
Solar Energetic Particles	GOES SEM	NCEI	https://www.ngdc.noaa.gov/stp/satellite/goes/
	Neutron Monitors	NMDB	http://www.nmdb.eu/
Radiation Belts	GOES SEM	NCEI	https://www.ngdc.noaa.gov/stp/satellite/goes/
	POES/Metop SEM	NCEI	https://www.ngdc.noaa.gov/stp/satellite/poes/
	Belt Indices	NCEI	https://satdat.ngdc.noaa.gov/sem/poes/data/belt_indices/
Indices	Kp, Dst	NASA	https://cdaweb.sci.gsfc.nasa.gov/index.html/ The Dst index used is from the "definitive" OMNI database.

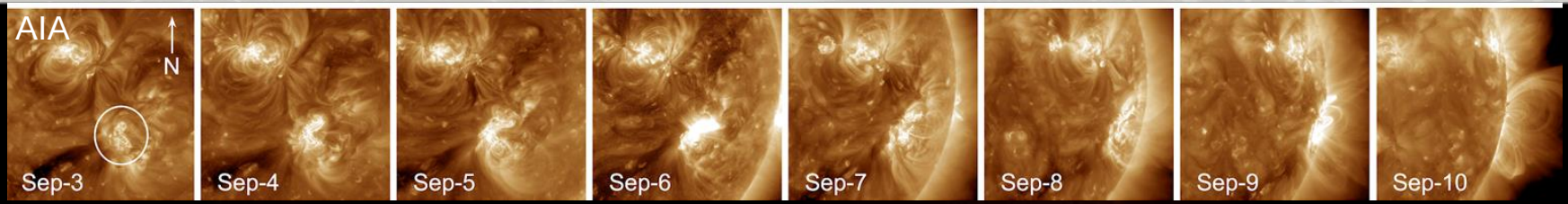
Valuable Data Sources Cont'd



Domain	Platform	Provider	Access
Ionosphere	DRAP	NCEI	https://www.ngdc.noaa.gov/stp/drap/
	Madrigal	MIT Haystack	http://madrigal.haystack.mit.edu/madrigal/experiments/2017/gps/08sep17/images/
Alerts	Radio, Radiation, Geomagnetic	SWPC	Scales: www.swpc.noaa.gov/noaa-scales-explanation Timeline: www.swpc.noaa.gov/products/notifications-timeline Alerts and Warnings Timeline: ftp.swpc.noaa.gov/pub/alerts/archive_20170901.html Events: ftp://ftp.swpc.noaa.gov/pub/indices/events/
Sun to Earth	Various	spaceweather.com	http://spaceweather.com/
Earth	DSCOVR EPIC	NASA	https://epic.gsfc.nasa.gov/?date=2017-09-12
Night Lights	Suomi NPP	NCEI	https://www.ngdc.noaa.gov/eog/interest/maria.html

BACKUP

Evolution of AR12673



GOES-16 SUVI

GOES-16 SUVI