

Crime Scene Investigation: Rozhen

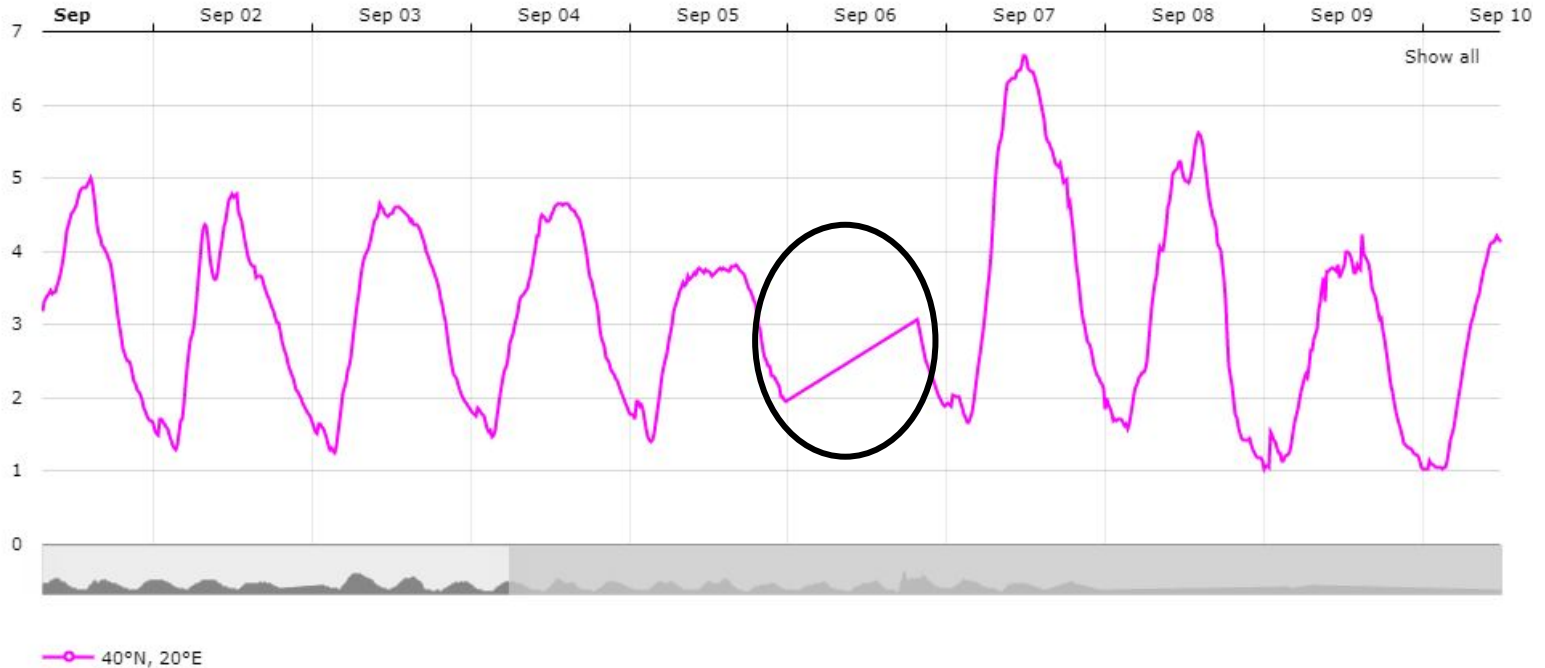
# The Curious Case of September 2017 Geo-Storm

Mohamed Nedal, Hanna Dühnen, Lyubomira Raykova, Miroslav Kostov

2nd Summer School on Space Research, Technology and Applications, Rozhen, Bulgaria,  
3-10 July 2022

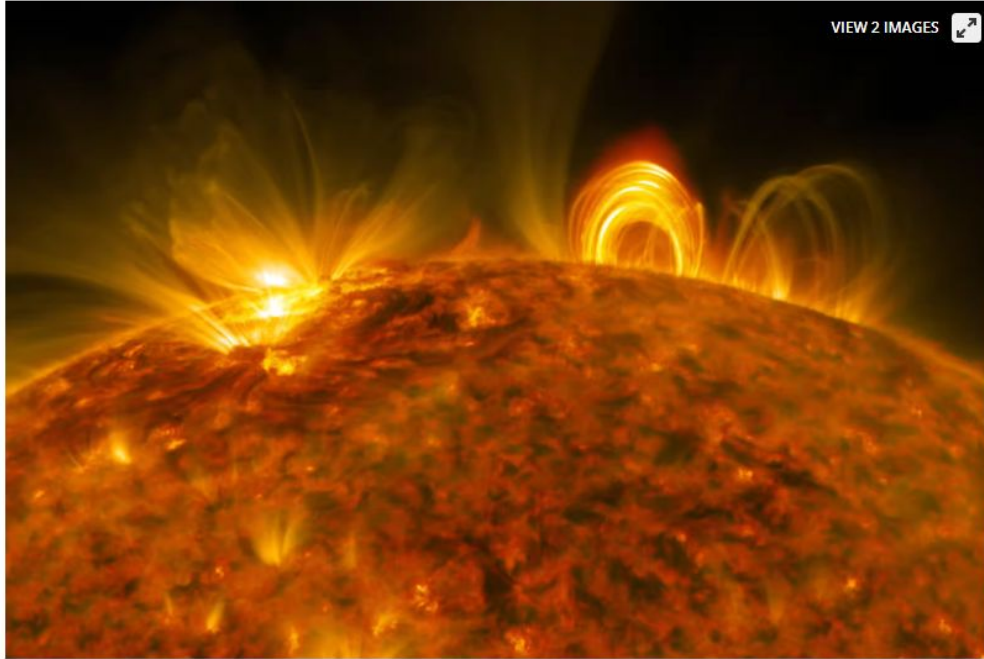
# Victim I: Range Error of GPS Signal in Bulgaria

Range error of GPS L5 in meter



# Radio blackouts caused by intense solar storms complicated 2017 hurricane relief efforts

By Anthony Wood  
July 31, 2018



The September 10 2017 solar flare seen here erupting from the Sun's surface by NASA's Solar Dynamics Observatory NASA/Goddard/SDO

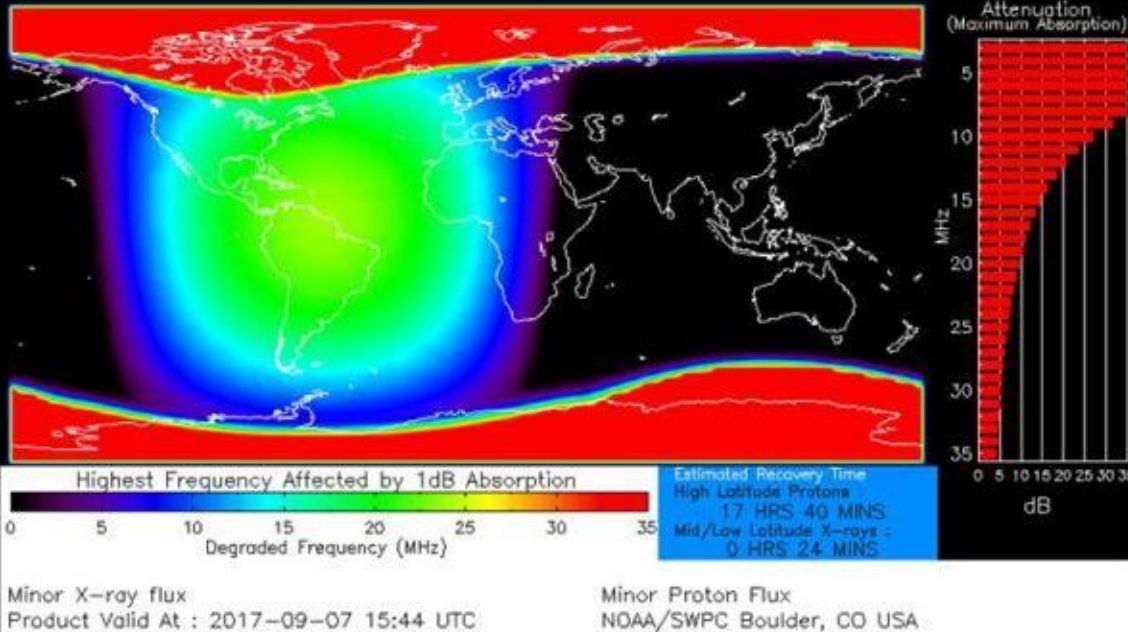
## Victim II

'According to the authors, the space weather led to a loss of radio communication for most of the early morning, going on through to the early afternoon of September 6, which also resulted in a blackout of communications with a French cargo plane that lasted for a full 90 minutes. High frequency radio systems used by airplanes, maritime, emergency bands were inoperable for roughly eight hours.

The large solar flare that occurred on September 10 caused a further three-hour blackout period for radio communications, which took place during a critical period in the wake of hurricanes Jose and Irma's assault on several islands, including the Bahamas and Cuba.'

# Strong Radio Blackout 07/1436 UTC

# R3



## PRIMARY AREA of IMPACTS

Large portions of sunlit side of Earth

## POSSIBLE EFFECTS

HF Radio: Wide area of blackouts; loss of contact for up to an hour over sunlit side of Earth

Navigation: Low frequency communication degraded for about an hour

# Investigation



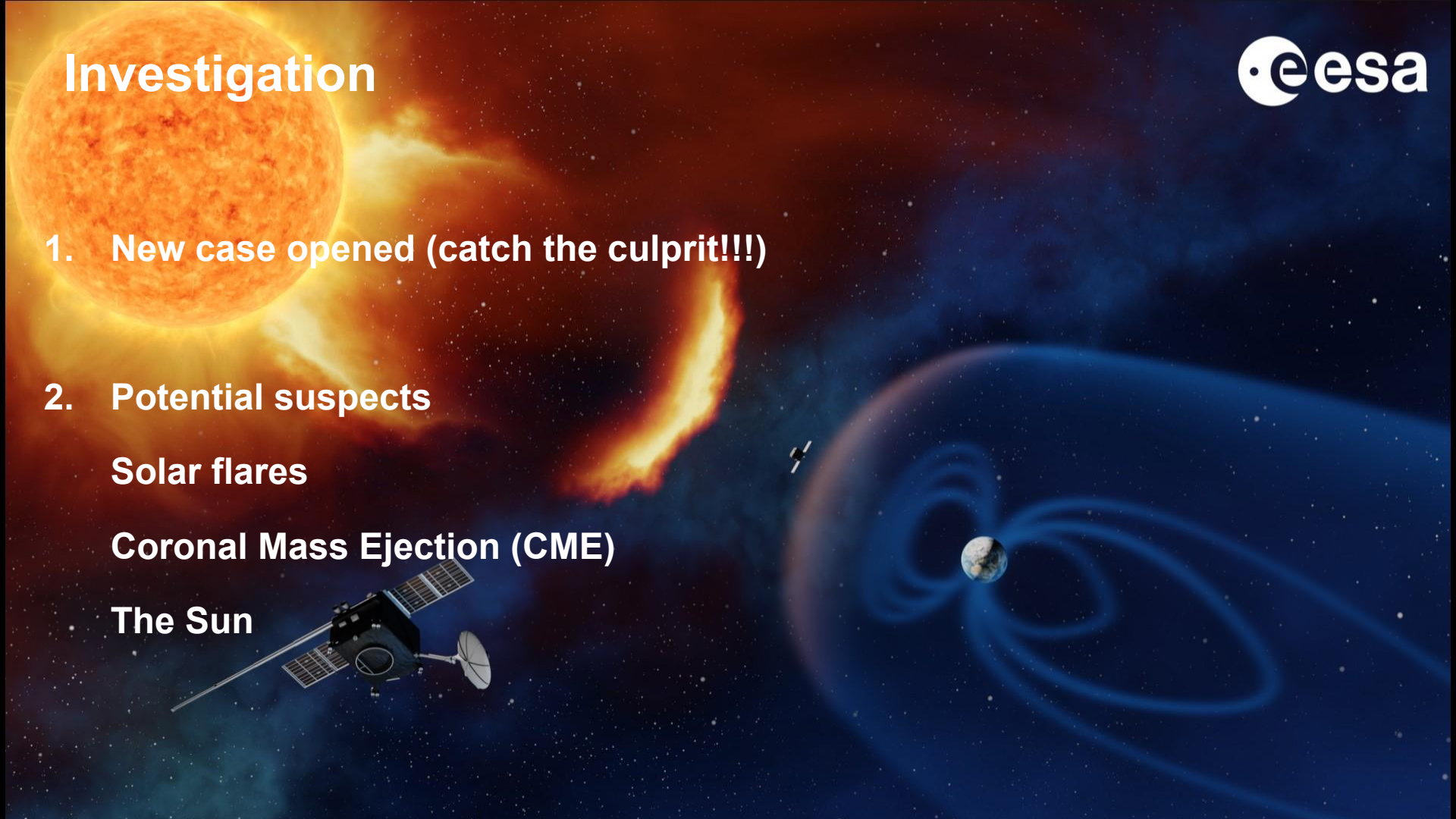
1. **New case opened (catch the culprit!!!)**

2. **Potential suspects**

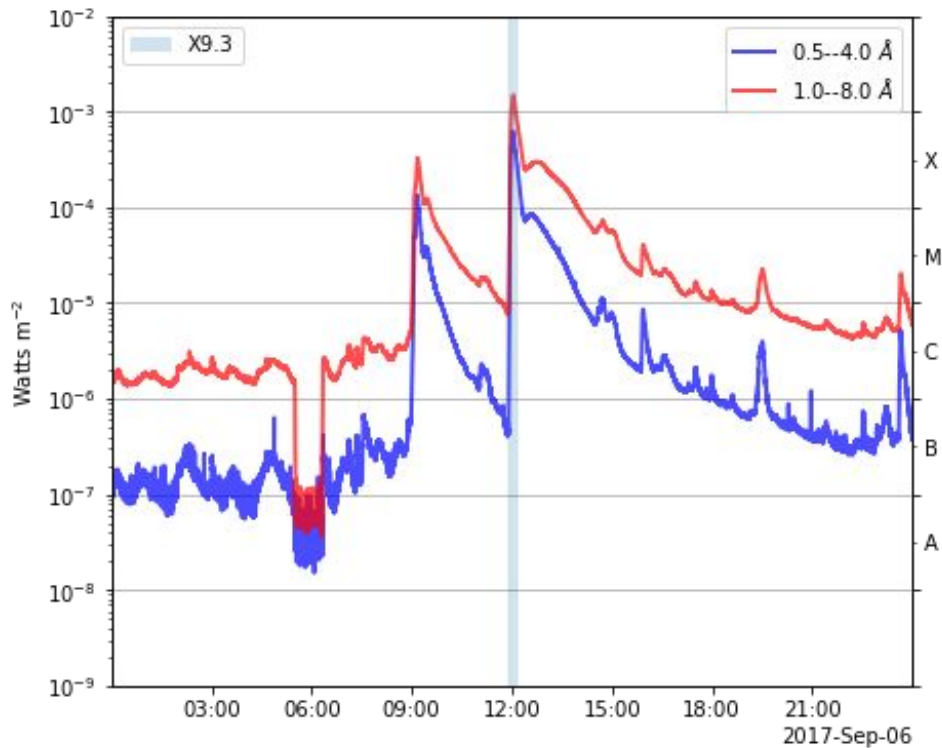
**Solar flares**

**Coronal Mass Ejection (CME)**

**The Sun**



**Same Day ...**



## Suspect I: Double solar flares

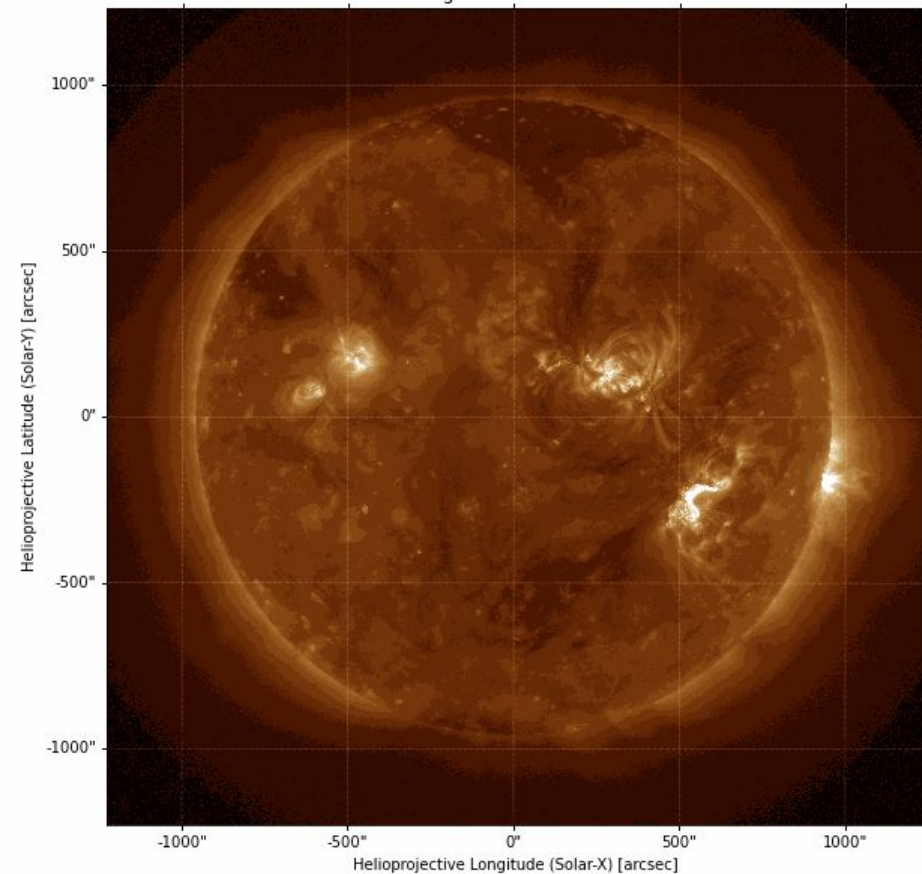
6-Sep-2017

X2.2  
08:57  
09:10  
09:17  
S07W33

X9.3  
11:53 UT  
12:02 UT  
12:10 UT  
S08W33

The X-ray flux as measured by GOES-16 satellite

AIA 193.0 Angstrom 2017-09-06 11:01:04



## Suspect I: Solar flare II?

6-Sep-2017

Start: 11:53 UT

Max: 12:02 UT

End: 12:10 UT

Class: X9.3

AR: 2673

Loc: S08W33

The solar flare event as observed by the AIA instrument onboard SDO satellite, 193 A° channel.



# The partners in crime

**SEP:**

13:52 UT

22:13 UT

**CME:**

12:24 UT

V: 1571 km/s

AW: 360 deg. (halo)

MPA (direction): 201 (south-west)

**SF II**

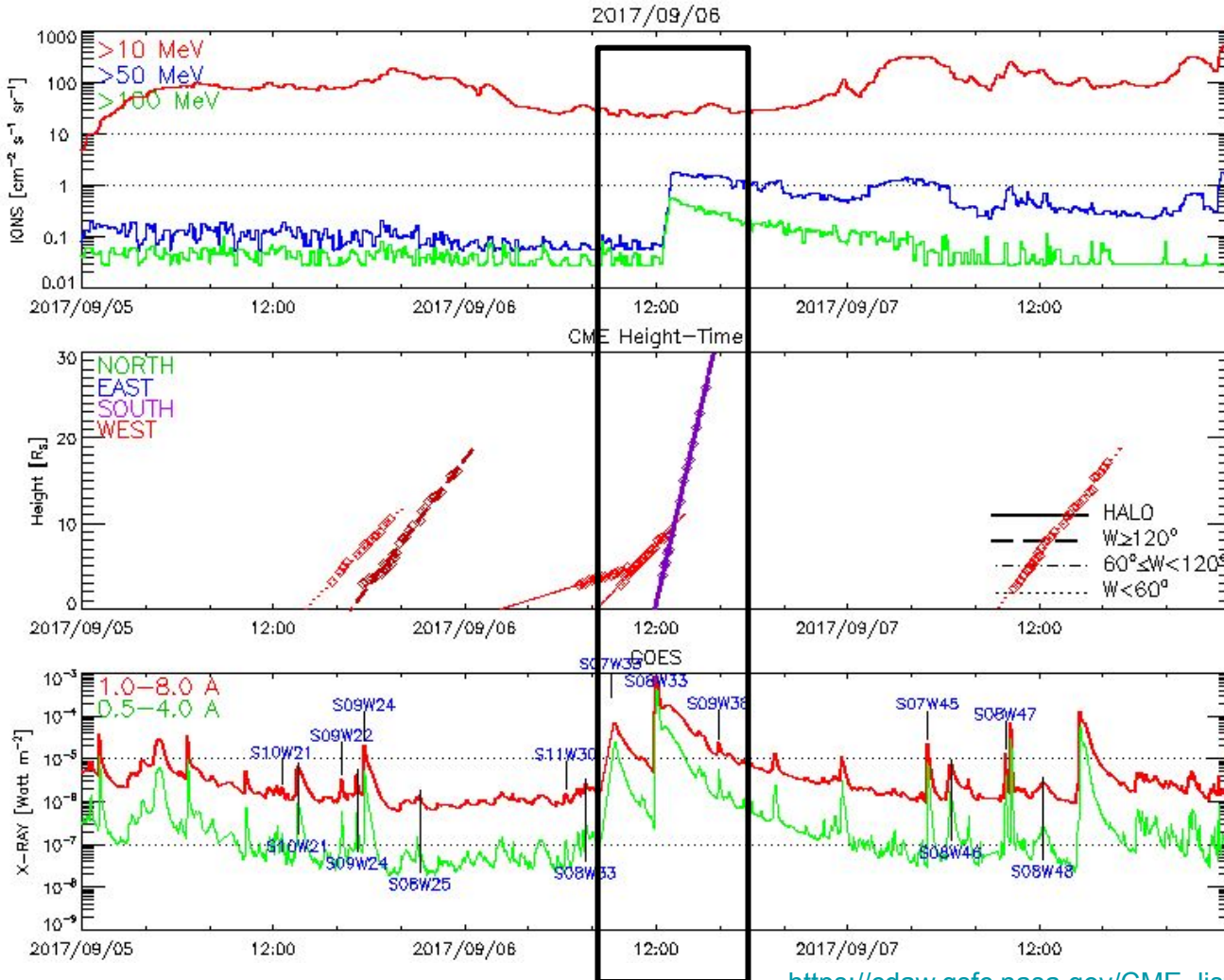
X9.3

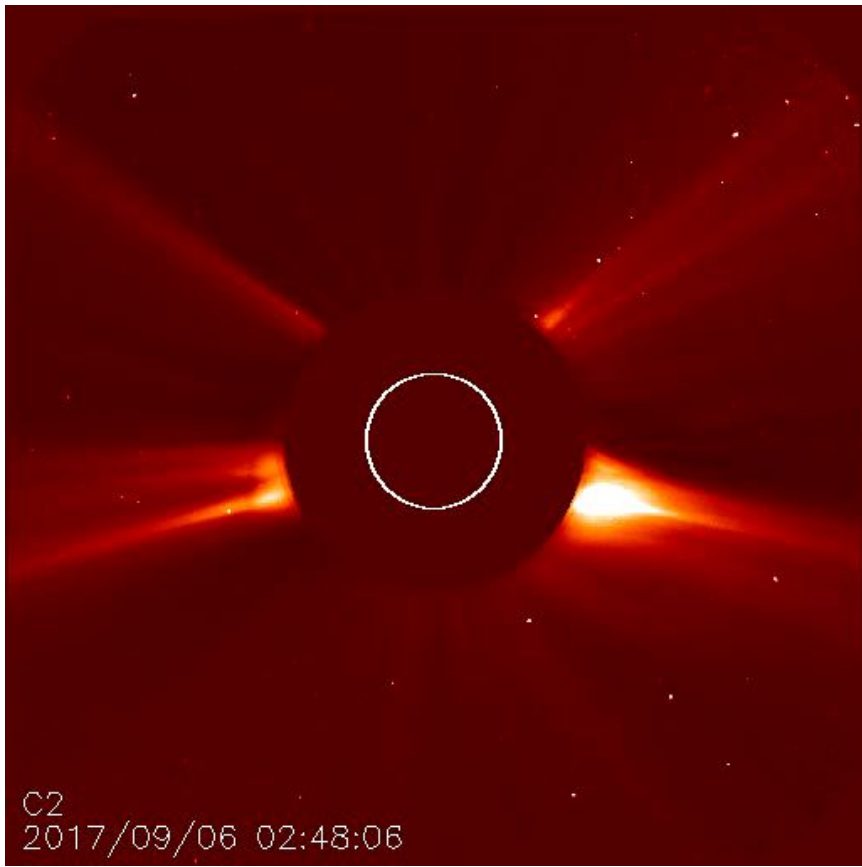
11:53 UT

12:02 UT

12:10 UT

S08W33





## Suspect II: Coronal Mass Ejection (CME)

6-Sep-2017

First occurrence: 12:24 UT

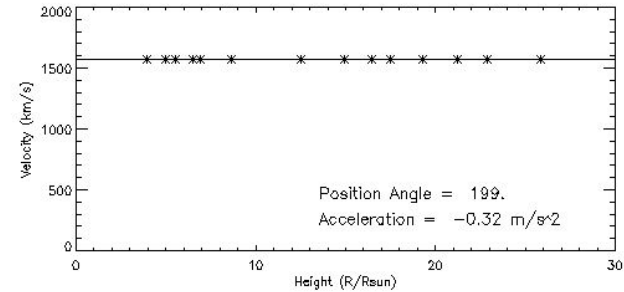
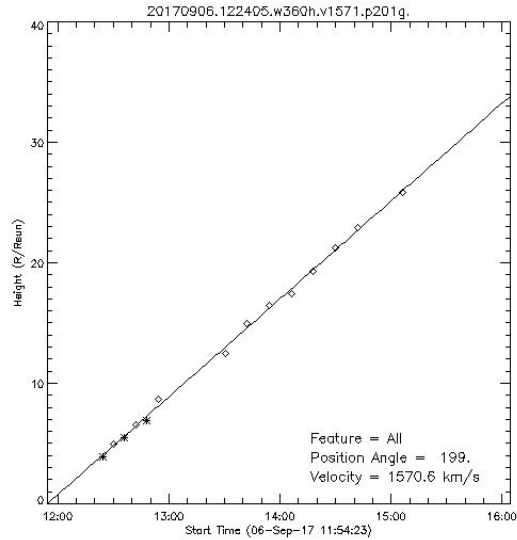
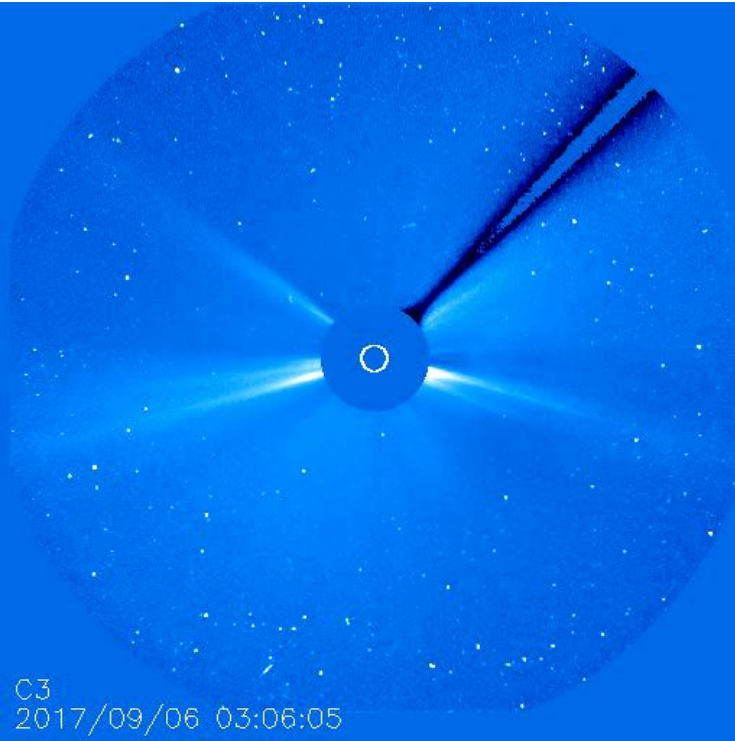
Speed: 1571 km/s

Angular width: 360 degrees (halo)

MPA (direction): 201 (south-west)

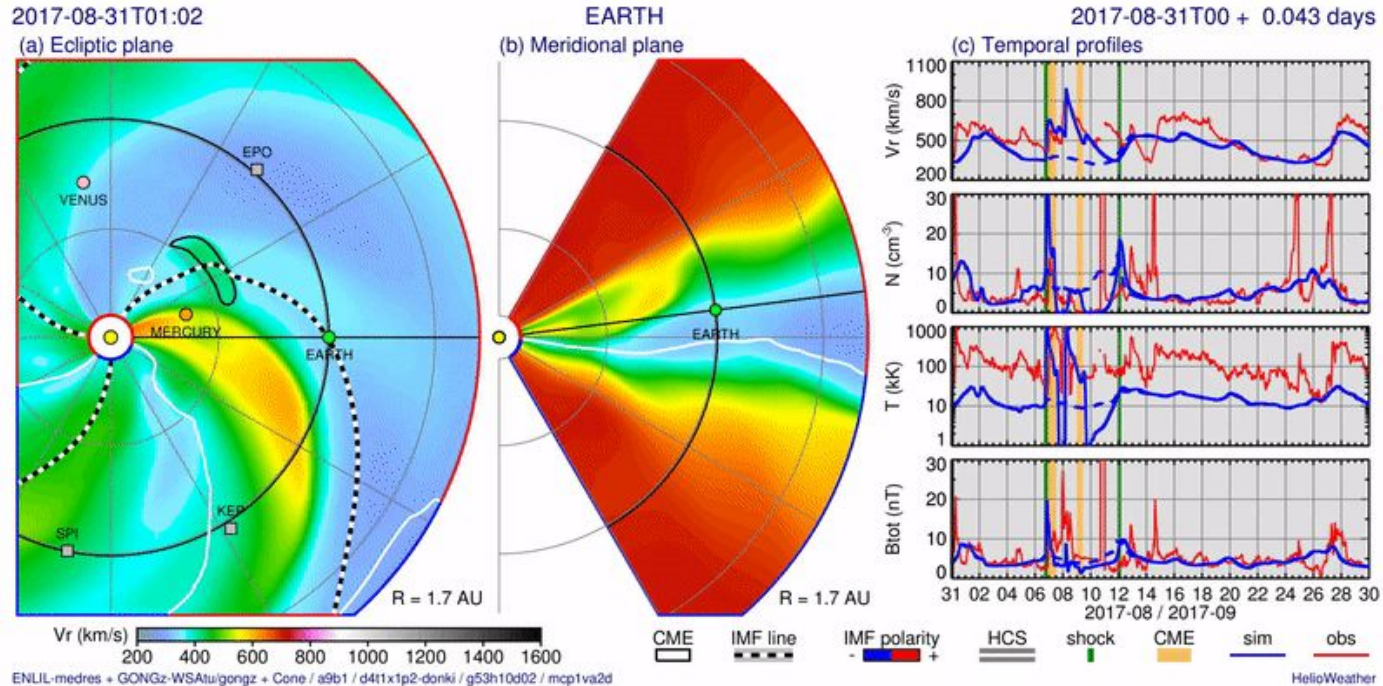
SOHO/LASCO [https://cdaw.gsfc.nasa.gov/CME\\_list/](https://cdaw.gsfc.nasa.gov/CME_list/)

## Suspect II: Coronal Mass Ejection (CME)



SOHO/LASCO [https://cdaw.gsfc.nasa.gov/CME\\_list/](https://cdaw.gsfc.nasa.gov/CME_list/)

# Suspect II: (I)CME



Simulation of the solar wind transients produced by WSA-ENLIL model

**1 Day Later ...**



**L1: near  
Earth  
space**

a shock has  
arrived!!!

The solar wind parameters and the interplanetary magnetic field indices (IMF) in-situ data as recorded by the OMNI database

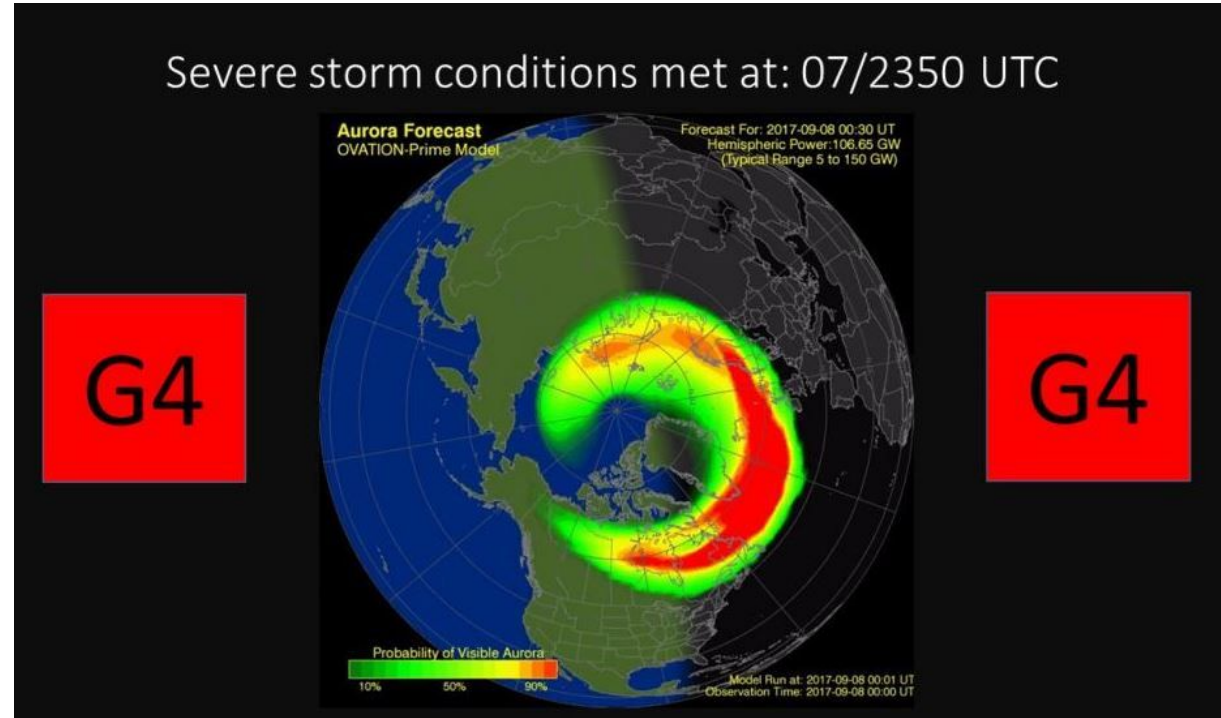
**2 Days Later ...**

**CME IMPACT SPARKS AURORAS, STOPS TRAFFIC:** The debris from Wednesday's monster X9-class solar flare reached Earth last night--and its impact was everything forecasters expected. A severe [G4-class](#) geomagnetic storm commenced, sparking auroras over Scandinavia so bright they actually stopped traffic. "I was driving home when the CME hit," reports Jani Ylinampa of Rovaniemi, Finland. "It was such an amazing display, I really had to pull over and shoot some photos."

# Evidence: Aurora



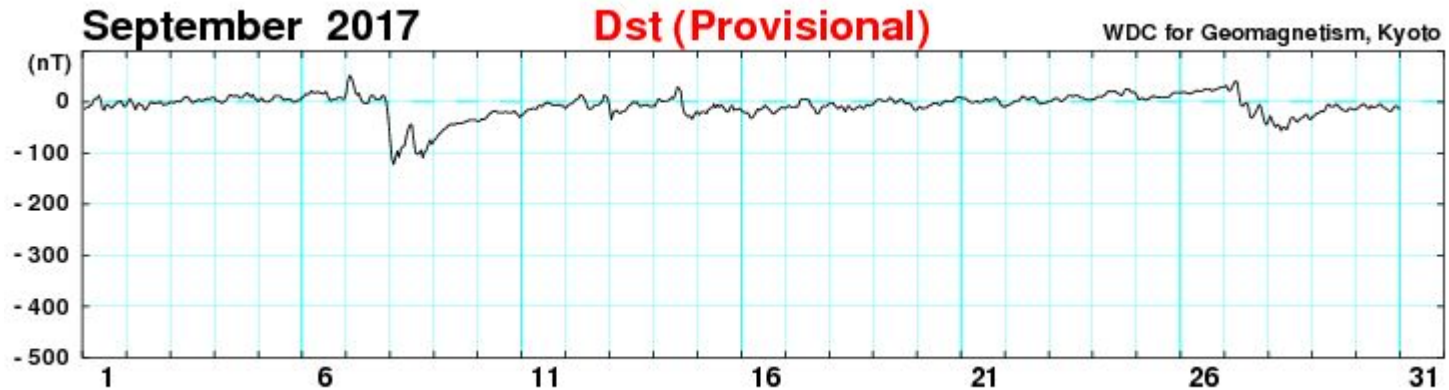
"The full Moon dampened the lights a bit," says Ylinampa, "but it was a great show."



<https://blogs.agu.org/thefield/2017/09/08/now-september-solar-surprise/>



# Witness I: Kyoto (geomagnetic storm!!!)



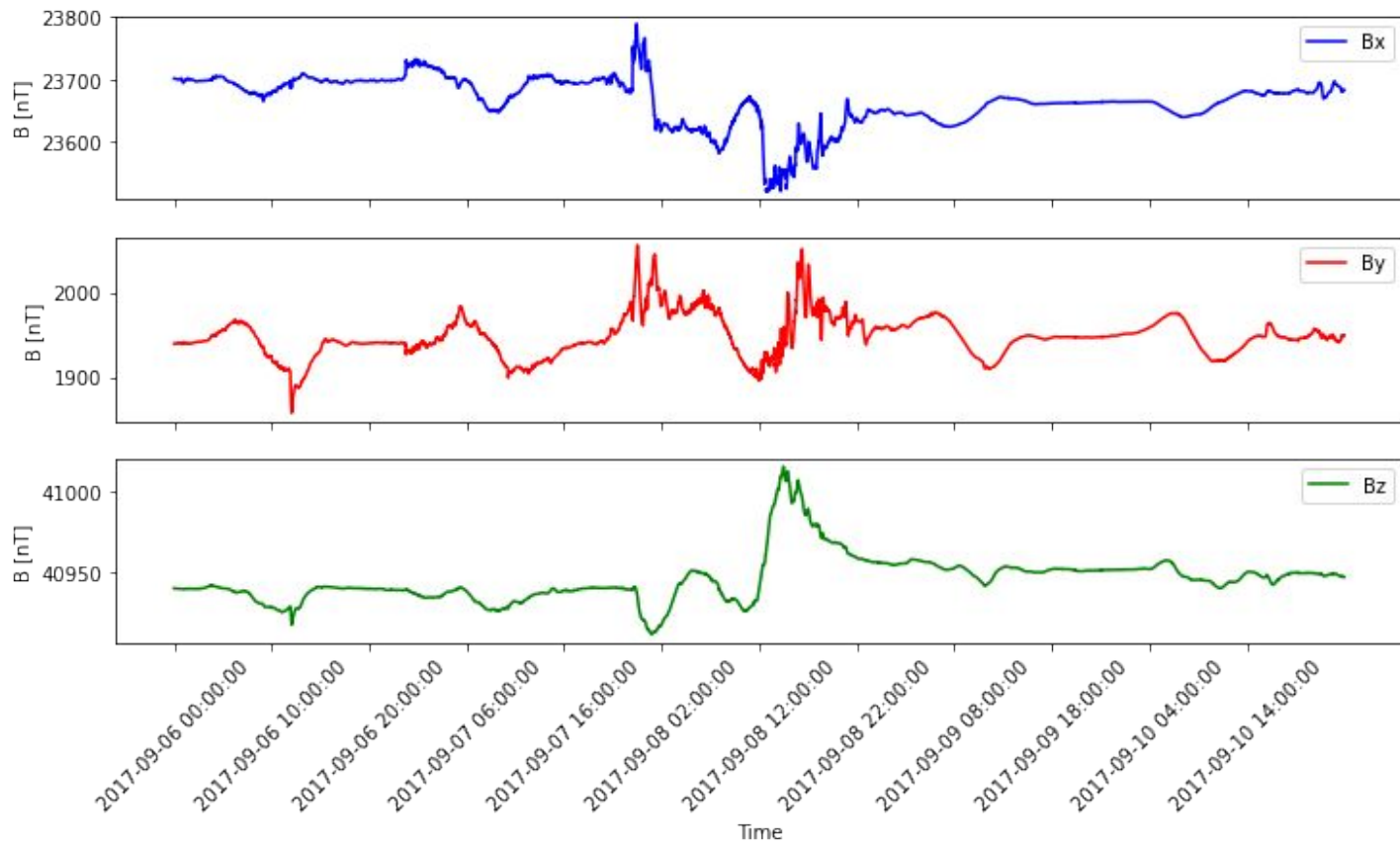
Min Dst: -122 nT

[https://wdc.kugi.kyoto-u.ac.jp/dst\\_provisional/201709/index.html](https://wdc.kugi.kyoto-u.ac.jp/dst_provisional/201709/index.html)

**Witness II:**  
**“Panagjurishte Geomagnetic Observatory” (PAG), Bulgaria**  
**(42.5/24.2)**



# Witness II: Magnetic Field measured at PAG



# Results

Evidence I - GPS error: flare I & II seem late in time: further investigation is needed!

Evidence II - Radio blackout: flare II is the prime suspect!

Evidence III - Aurora: CME is the prime suspect!



# The big boss & his gang: Sun



# Case closed

Detective 1: Mohamed Nedal

Detective 2: Hanna Dühren

Detective 3: Lyubomira Raykova

Detective 4: Miroslav Kostov\*

Chief Detective 1: Rositsa Miteva

Chief Detective 2: Susan Samwel

\* kidnapped during investigation

