Role of the Ionosphere & SPWx in Military Communications

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https://www.esa.int/ESA_Multimedia/Images/2018/01/Space_weather_effects

Space weather refers to the environmental conditions in space as influenced by solar activity.

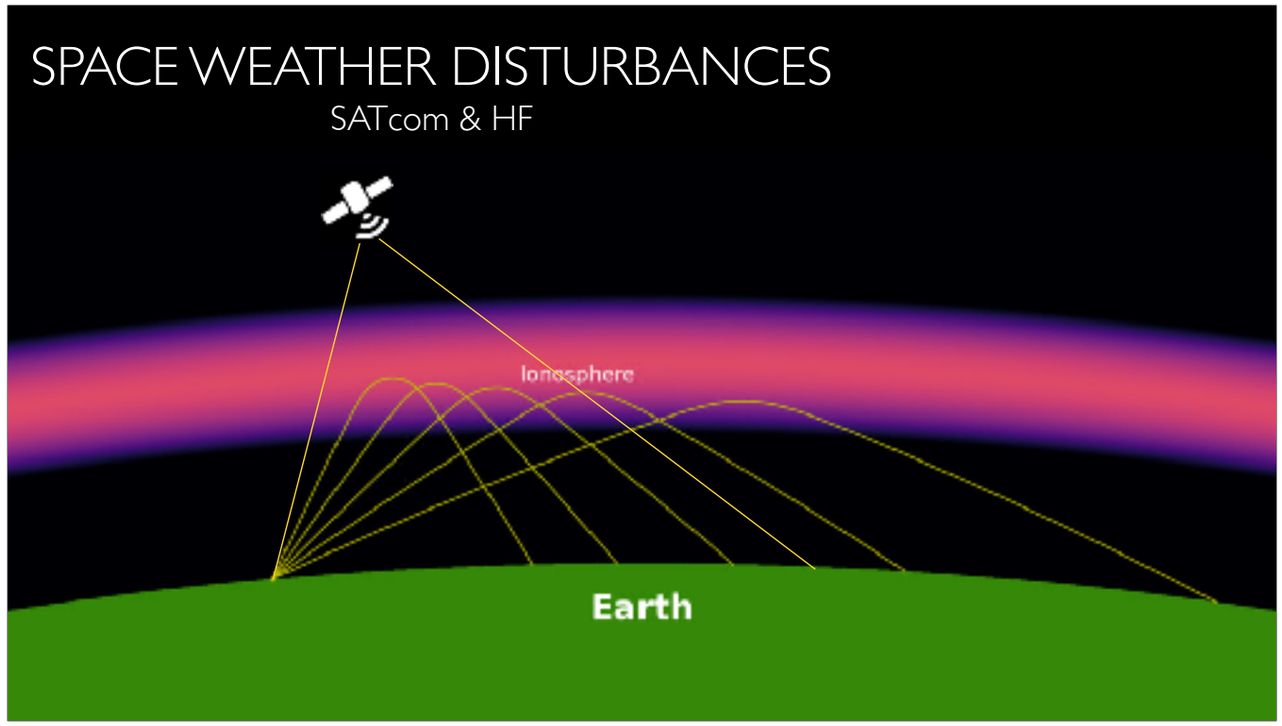
In Europe’s economy today, numerous sectors can be affected by space weather. These range from space-based telecommunications, broadcasting, weather services and navigation, through to power distribution and terrestrial communications, especially at northern latitudes.

One significant influence of solar activity is seen in disturbances in satellite navigation services, like Galileo, due to space weather effects on the upper atmosphere. This in turn can affect aviation, road transport, shipping and any other activities that depend on precise positioning.

For satellites in orbit, the effects of space weather can be seen in the degradation of communications, performance, reliability and overall lifetime. For example, the solar panels that convert sunlight to electrical power on most spacecraft will steadily generate less power over the course of a mission, and this degradation must be taken into account in designing the satellite.

In addition, increased radiation due to space weather may lead to increased health risks for astronauts, both today on board the International Space Station in low orbit and in future on voyages to the Moon or Mars.

On Earth, commercial airlines may also experience damage to aircraft electronics and increased radiation doses to crews (at long-haul aircraft altitudes) during large space weather events. Space weather effects on ground can include damage and disruption to power distribution networks, increased pipeline corrosion and degradation of radio communications.



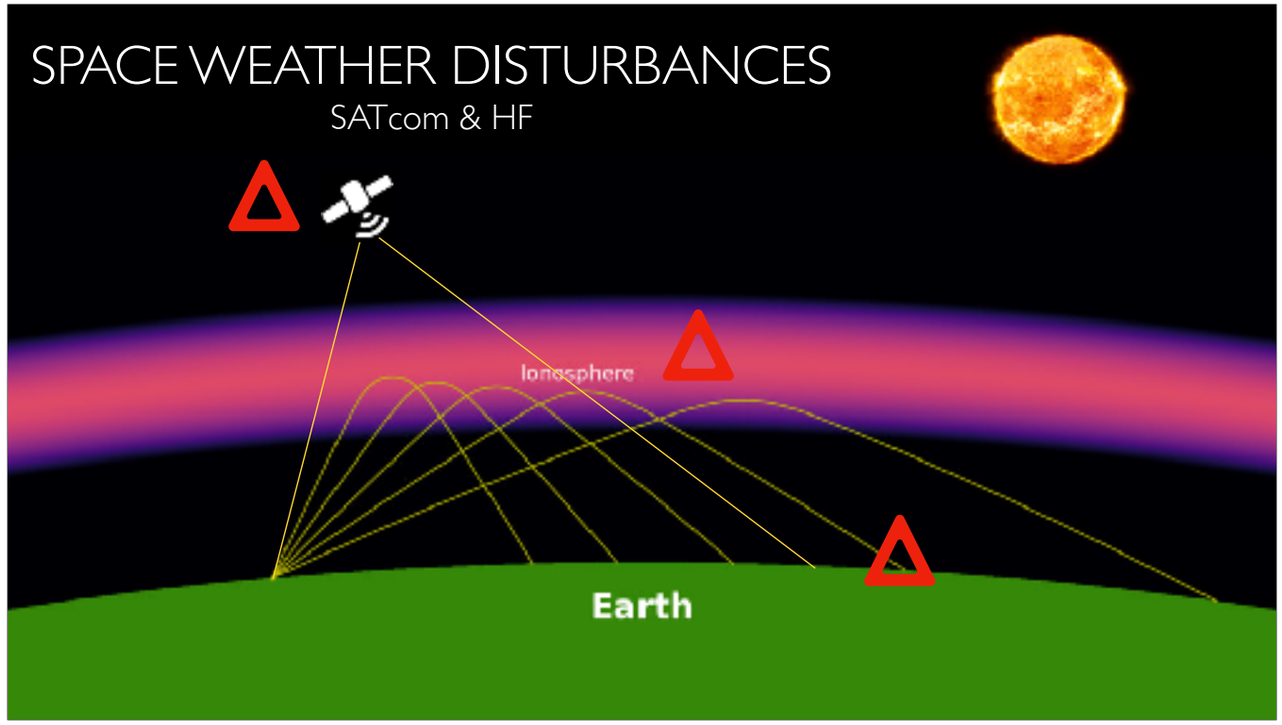
https://svs.gsfc.nasa.gov/5240

Emitter - transmitter - receiver
Transmitting Earth station – uplink – Hub – downlink – receiving Earth station

Hub=satellite: relays and amplifies
Hub=ionosphere: relays

https://en.wikipedia.org/wiki/Communications_satellite
A communications satellite is an artificial satellite that relays and amplifies radio telecommunication signals via a transponder; it creates a communication channel between a source transmitter and a receiver at different locations on Earth. Communications satellites are used for **television, telephone, radio, internet, and military applications**.

- Many communications satellites are in **geostationary orbit 35,900 km above the equator**, so that the satellite appears stationary at the same point in the sky; **therefore the satellite dish antennas of ground stations can be aimed permanently at that spot and do not have to move to track the satellite**.
- Others form satellite constellations in **low Earth orbit**, where **antennas on the ground have to follow the position of the satellites and switch between satellites frequently.**



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Emitter - transmission - receiver

space weather impact

- On the area where the transmission occurs/signal passes
- On the reflecting system: natural reflector or a satellite
- The receiving capabilities: trouble in receiving the signal because it has changed or receiving other signals (with solar origin or human origin)

April 2010

As you are aware there was a very interesting geomagnetic storm period over the Easter period this year, this period was particularly significant as the disturbed space environment caused a number of spacecraft anomalies, including the well publicised Galaxy 15 failure suffered by our competitor Intelsat. The Presto Alerts and Daily Bulletins ('URSIGRAM') issued by SIDC at the time were superior to alternative products issued by NOAA SWPC, both in terms of timeliness and content.

In general I find that the level of technical content and commentary included in your Daily Bulletins and other products are exactly what we need as a spacecraft operator, and I find that these products compare very favourably with the alternative products issued by NOAA SWPC. You are tending to include greater detail in your commentary regarding events observed on the sun and the effects likely to be experience at earth, we value this additional detail.

I hope these comments are of use and trust that your team will keep up the good work!

Email from a satellite operator to Ronald
Subject SIDC URSIGRAMS / GEOALERTS & PRESTO ALERTS - SOME FEEDBACK

Galaxy is owned by Intelsat
Geostationary satellite

SES (Société Européenne des Satellites) company Satellite Communications Service Provider

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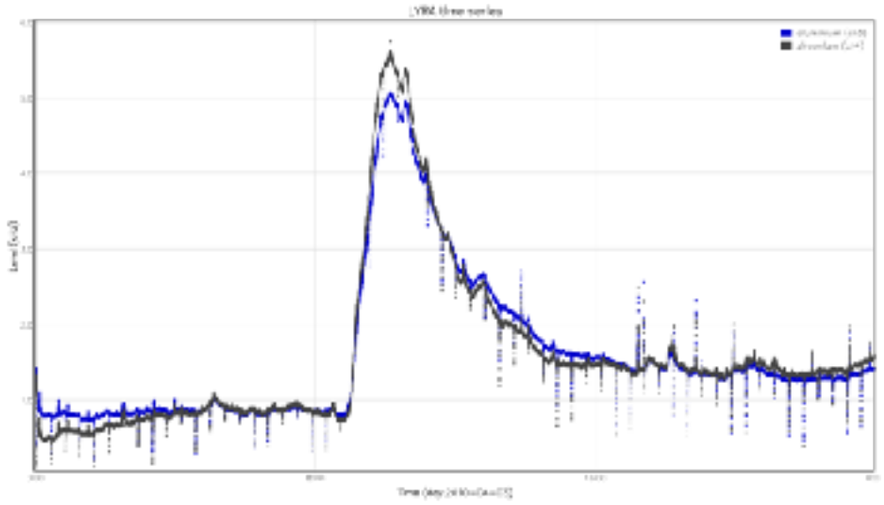
April 3, 2010



On April 03, 2010, the SIDC sent out a PRESTO message alerting about the halo CME heading for Earth. PROBA2 witnesses the radiation flare associated with the plasma eruption.

A B7.4 flare peaking at 09:54 UT was detected today in the Catania sunspot group 56 (NOAA AR 1059) located around S25W05. It was accompanied by a post-eruption arcade, coronal dimmings, possibly an EIT wave and a partial halo CME (angular width around 210 degrees). The CME was first detected at 10:33 UT (by LASCO) and at 09:54 UT (by SECCHI/COR2 on STEREO A). The CME was moving at a projected plane-of-the-sky speed of around 250 km/s (according to the LASCO data). Using some reasonable assumptions on the CME geometry, the true radial CME speed can be estimated to be around 600 km/s. The arrival of the corresponding ICME (possibly an interplanetary flux rope) at the Earth is thus expected in the morning of April 6. The flux rope orientation as inferred from the SOHO/EIT and SOHO/MDI data is ESW, although it may change during propagation. STEREO A and B data indicate that the bulk of the CME was propagating to the south of the ecliptic (according to the COR2 data). If the flux rope will arrive at the Earth, we expect a strong geomagnetic disturbance. Currently, the Earth is inside a slow solar wind flow (460 km/s) with average (5 nT) interplanetary magnetic field magnitude. Geomagnetic conditions are expected to remain quiet in the coming hours.

August 10, 2022

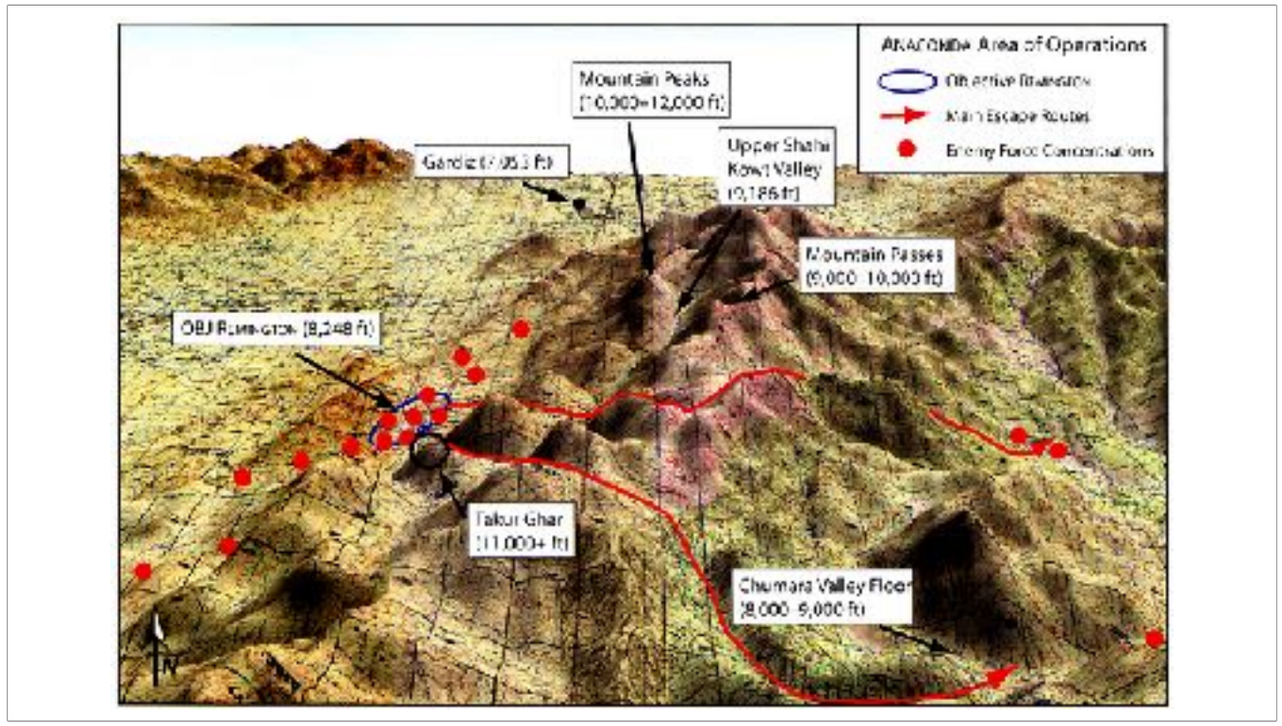
Intelsat Loses Command of Galaxy 15 Satellite

By Rachel Jewett | August 11, 2022

Intelsat has lost the ability to command its Galaxy 15 satellite after an anomaly caused by a space weather event. The anomaly caused the loss of commanding links, which is the signal used to fly the satellite and to receive telemetry data, an Intelsat spokesperson told Via Satellite.

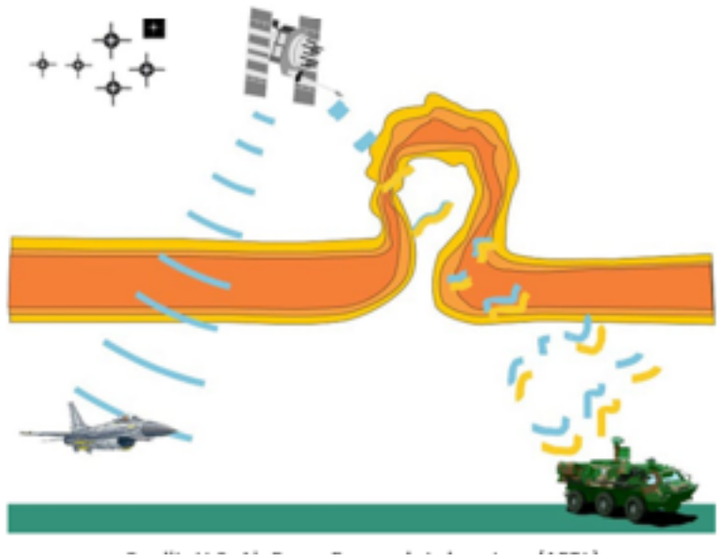
"Intelsat, working with the satellite manufacturer, has concluded that the anomaly is likely due to a lock up of both baseband electronics units triggered by space weather, i.e., solar eruptions of plasma and magnetic fields that create extreme currents," the spokesperson said.

On 10 August 2022, Intelsat again lost control of Galaxy 15 attributing this to a space weather event.



Outage due to ionospheric scintillation

Battle of Takur GHar - Afghanistan
Tactical impact of SWx
Navy seals were under fire in montainous region. A chinook heli was sent to rescue them. To avoid hot landing a UHF message was sent but never received by the chinook.
The radio was blamed but after investigation, this wasn't the only reason. Ionospheric perturbation led to the loss of the signal due to plasma bubbles in the ionosphere.



Source: U.S. Air Force Research Laboratory (AFRL)

Sept 2017 - Hurricane train

During September 2017, a significant number of solar flares and geomagnetic activity occurred.
Simultaneously, major hurricanes, including Hurricane Irma and Hurricane Jose, caused situations in the **Caribbean region requiring the use of emergency HF communications,** often provided by ham (amateur) radio operators.

Ham radio hobbyists routinely volunteer to disseminate hazard information from the National Weather Service to island communities and ships during major storms, report real-time ground conditions and damages back to the National Hurricane Center, and assist the Red Cross with communications.

Even in the modern age of space-borne relays and widely distributed Internet availability, HF radio remains a key technology for long-distance communications.
It is actively used by aircraft, by ships at sea, in military operations, for disaster relief efforts, and by amateur radio operators. HF radio is particularly attractive in a backup or emergency communications role because of its ad hoc and agile nature, relatively low cost, and ability to communicate across large distances. In September 2017, HF amateur radio was called upon to provide emergency communications to the Caribbean Region in response to the devastation caused by Hurricanes Irma and Jose (American Radio Relay League, 2018).

https://news.agu.org/press-release/solar-flares-disrupted-radio-communications-during-september-2017-atlantic-hurricane-relief-effort/

https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2018SW001897

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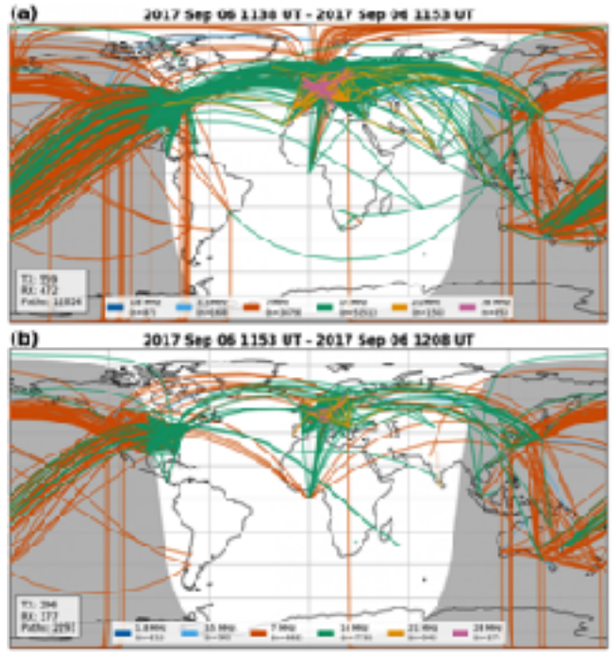
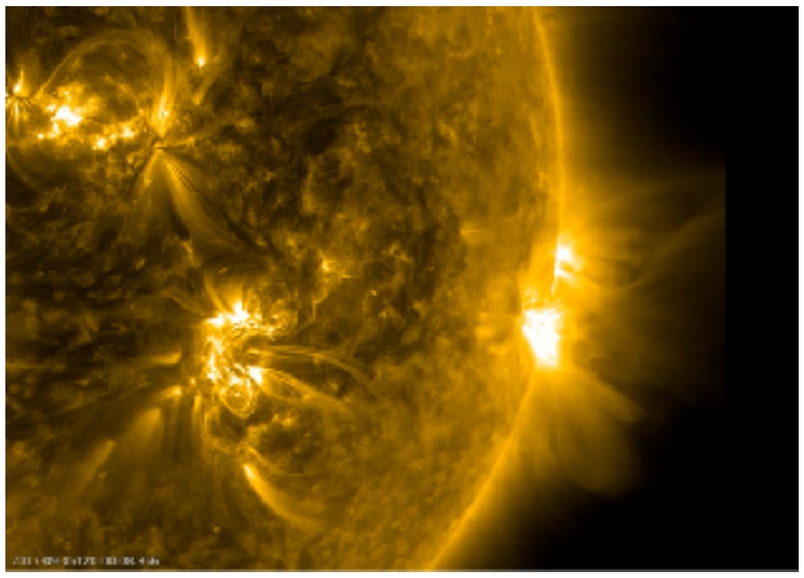


Amateur radio reporting network results for the (a) 15 min prior to and (b) 15 min following the X9.3 solar flare on 6 September 2017 1153 UT. The propagation paths are color-coded based on the amateur radio frequency on which the report occurred. The gray and white background shows the diurnal boundary. A reduction in reports can be seen across all frequencies with 7 MHz (dark orange), 14 MHz (bluish green), and 21 MHz (light orange) being the most affected across Europe. (Figure from Frissell et al. 2019)

Sept 2017 - Earth and Space weather aligned



X2.2 and X9.3 flare on Sept 6 —> Magnetic Storm on Sept 7
X8.2 flare on Sept 10 —>Magnetic Storm on Sept 12

Numerous solar flares and CME-induced interplanetary shocks associated with solar active region AR12673 caused disturbances to terrestrial HF (3–30 MHz) radio communications from 4–14 September 2017. Simultaneously, Hurricanes Irma and Jose caused significant damage to the Caribbean Islands and parts of Florida. The coincidental timing of both the space weather activity and hurricanes was unfortunate, as HF radio was needed for emergency communications. …….. Specifically, X-class flares on 6, 7, and 10 September caused acute radio blackouts during the day in the Caribbean with recovery times of tens of minutes to hours, based on the decay time of the flare. **A severe geomagnetic storm** with Kpmax = 8+ and SYM-Hmin = −146 nT **occurring 7–10 September wiped out ionospheric communications first on 14 MHz and then on 7 MHz starting at ~1200 UT 8 September.** This storm, combined with effects from additional flare and geomagnetic activity, contributed to a significant **suppression of effective HF propagation** bands both globally and in the Caribbean **for a period of 12 to 15 days**.

https://news.agu.org/press-release/solar-flares-disrupted-radio-communications-during-september-2017-atlantic-hurricane-relief-effort/

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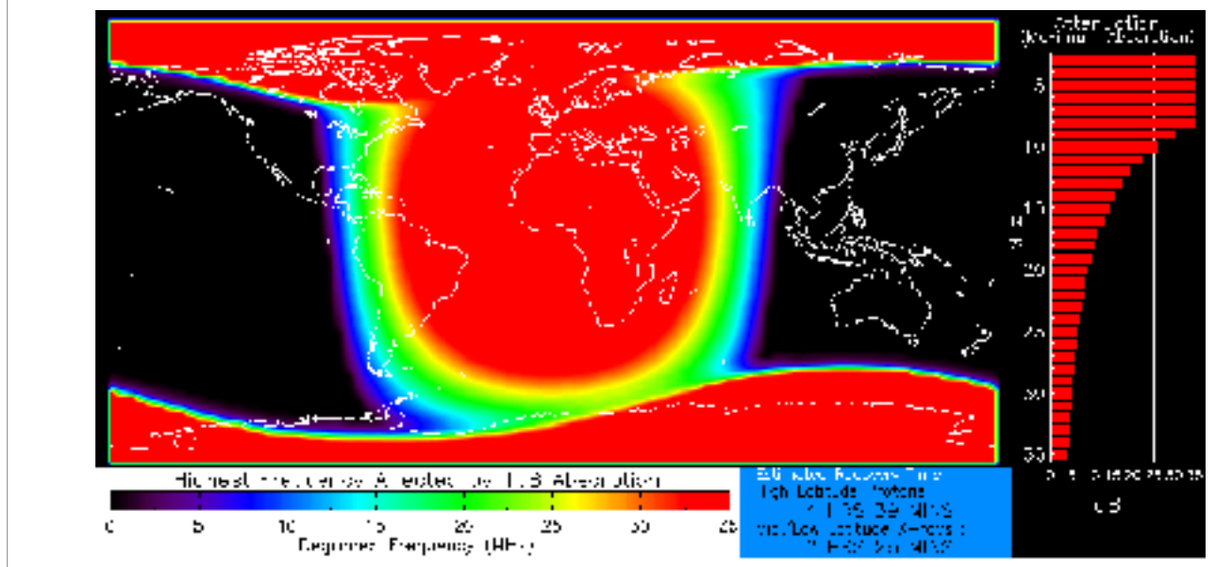
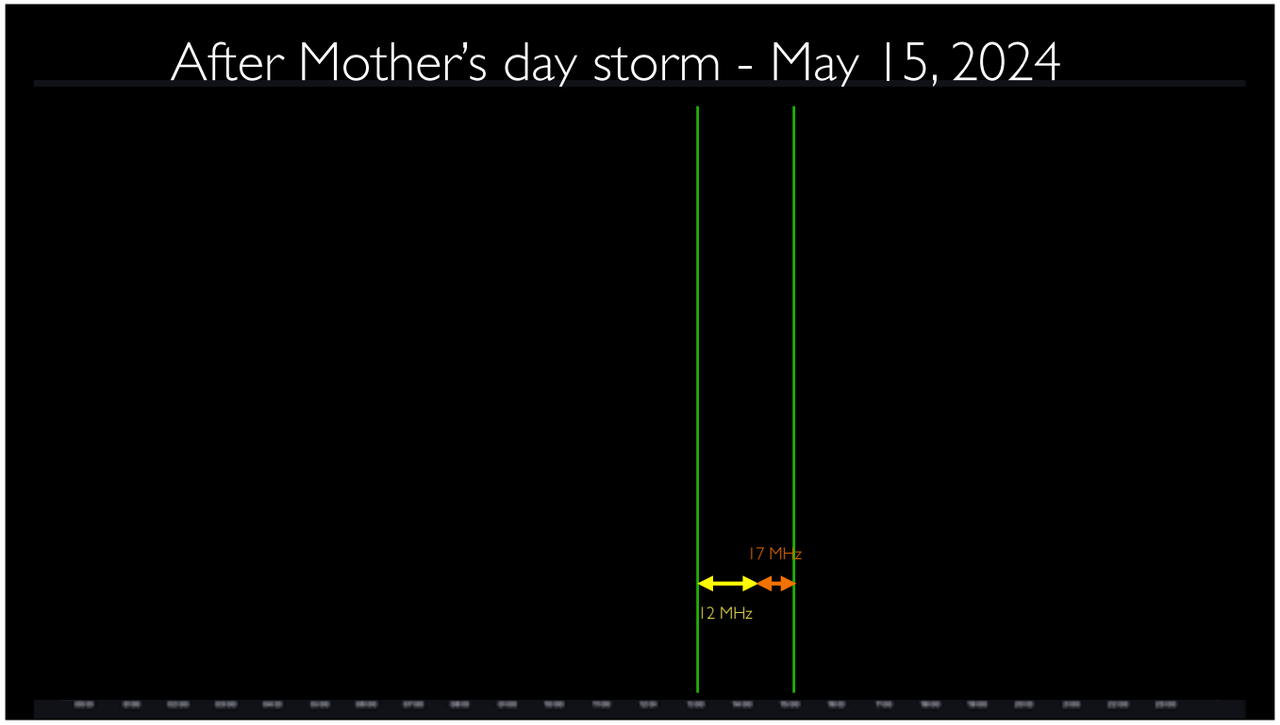


Modelled impact on HF radio frequencies

15 mei was een test tussen België en Canada.



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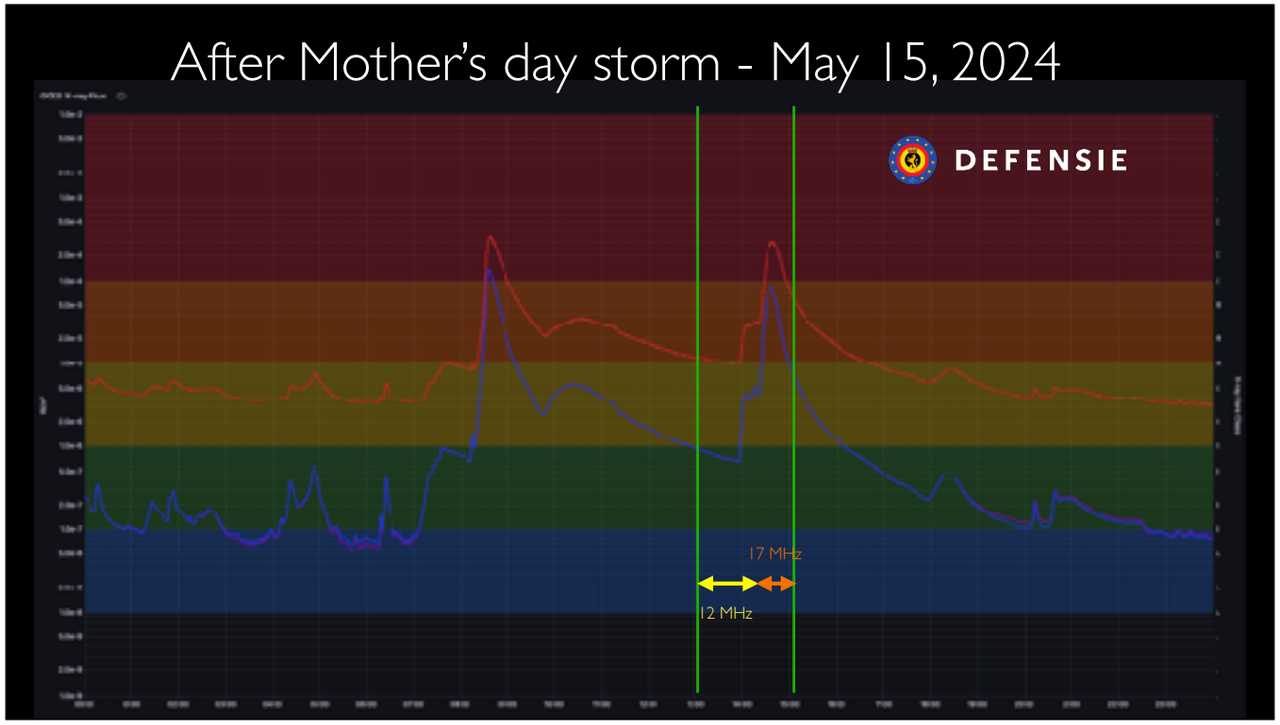
13u-14u: Gestart op 12 MHz, mogelijks niet een ideale frequentie, maar ik denk het eigenlijk wel. Ik denk dat er hier niets gelukt was wegens andere verkeerde instellingen. Rond 14u zijn ze dan overgeschakeld naar 17 MHz, maar het is net op dat moment dat er een M class flare begon, gevolgd door een X class flare! Spreekt voor zich dat er met die ionosfeer niet te veel meer aan te vangen viel.
Men is dan blijven testen op 17 MHz, maar dat is waarschijnlijk al te hoogfrequent, en zeker naar de avond toe.

De volgende dag heeft men de testen hervat in de namiddag, toen was er een Kp van 4, ook toen kwam er niets door.



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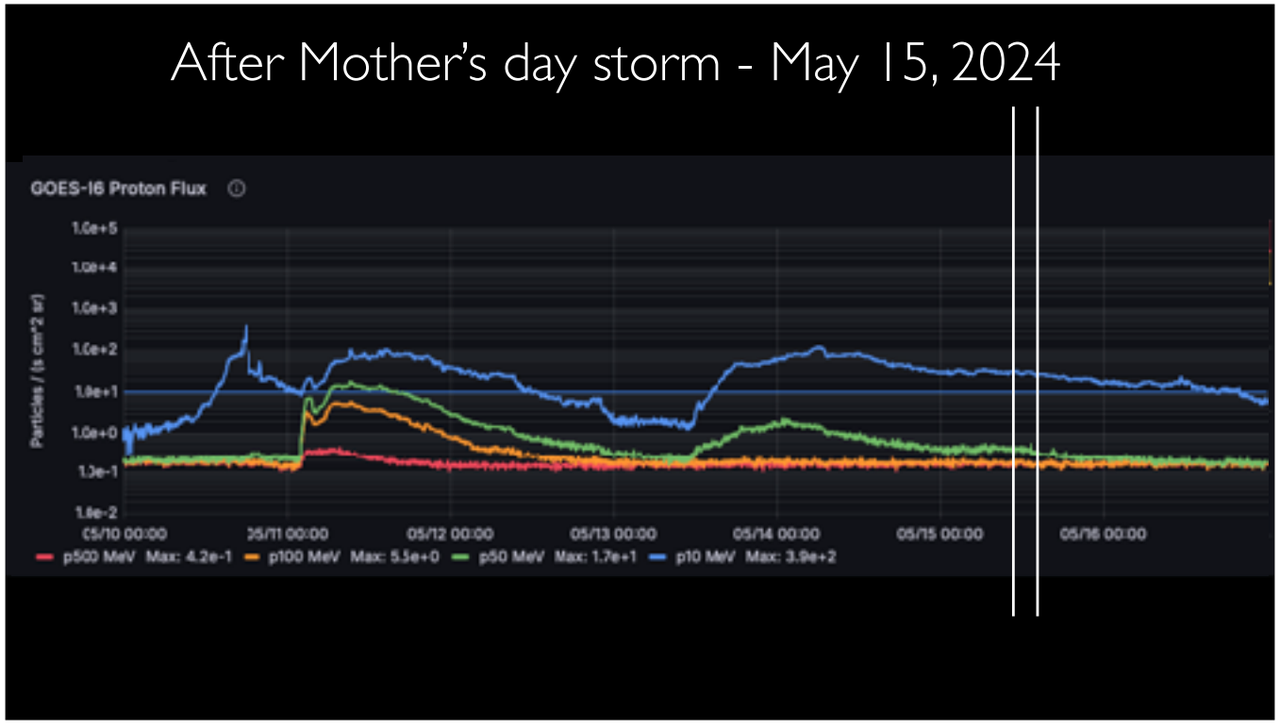

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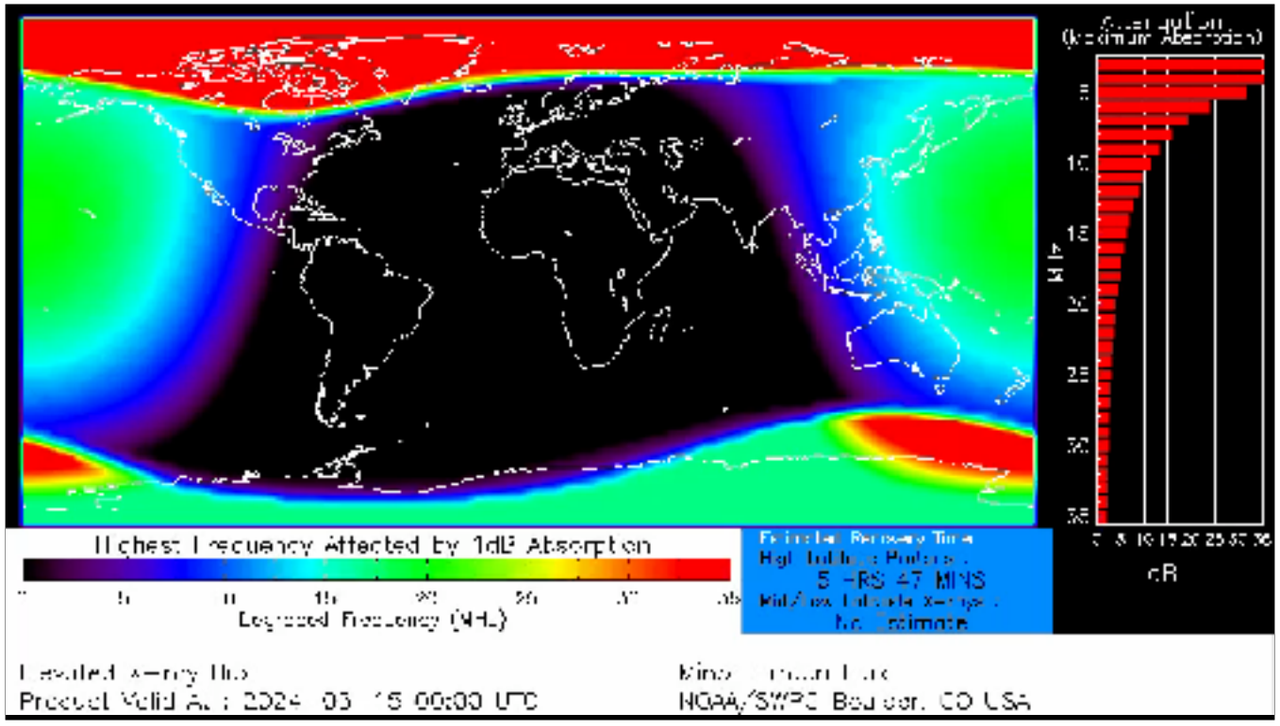
Highest Frequency Affected by 1dB Absorption
Depressed Frequency (MHz)
5 HRS 47 MINS
NOAA/SWPC Boulder, CO USA