Radio Sun

A short introduction

Christophe Marqué - STCE - ROB

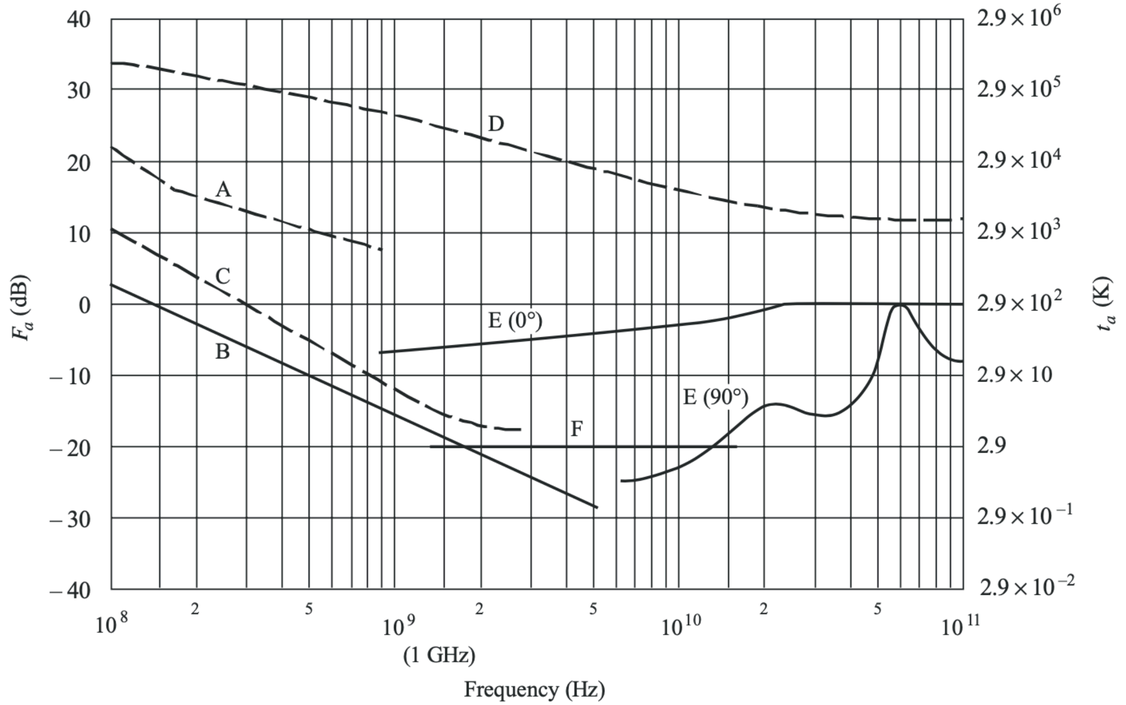
Quiet Sun

The radio Sun

The Sun is the strongest radio source in the sky above ~100 MHz

FIGURE 3

F_a versus frequency (10^8 to 10^{11} Hz)



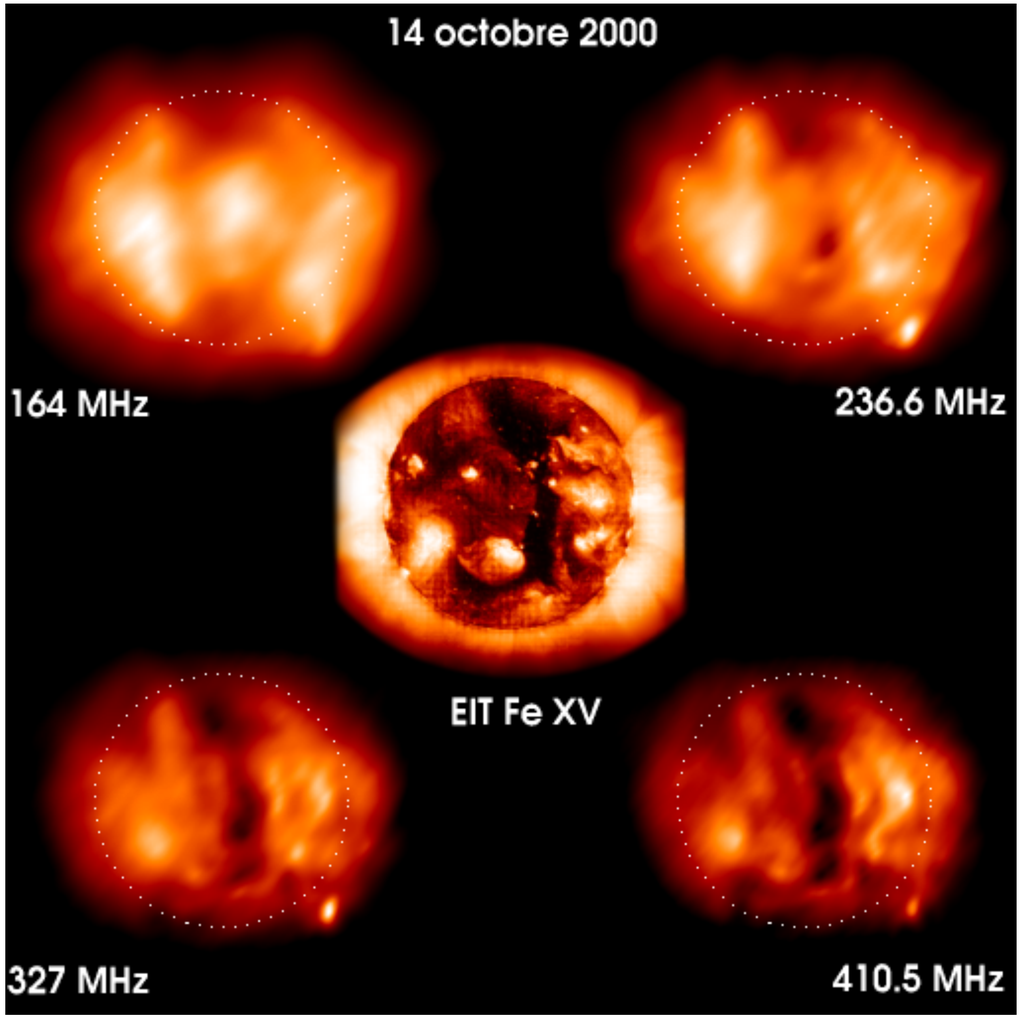
A: estimated median city area man-made noise
B: galactic noise
C: galactic noise (toward galactic centre with infinitely narrow beamwidth)
D: quiet Sun (½° beamwidth directed at Sun)
E: sky noise due to oxygen and water vapour (very narrow beam antenna); upper curve, 0° elevation angle; lower curve, 90° elevation angle
F: black body (cosmic background), 2.7 K
minimum noise level expected

P.0372-03

ITU REC 372

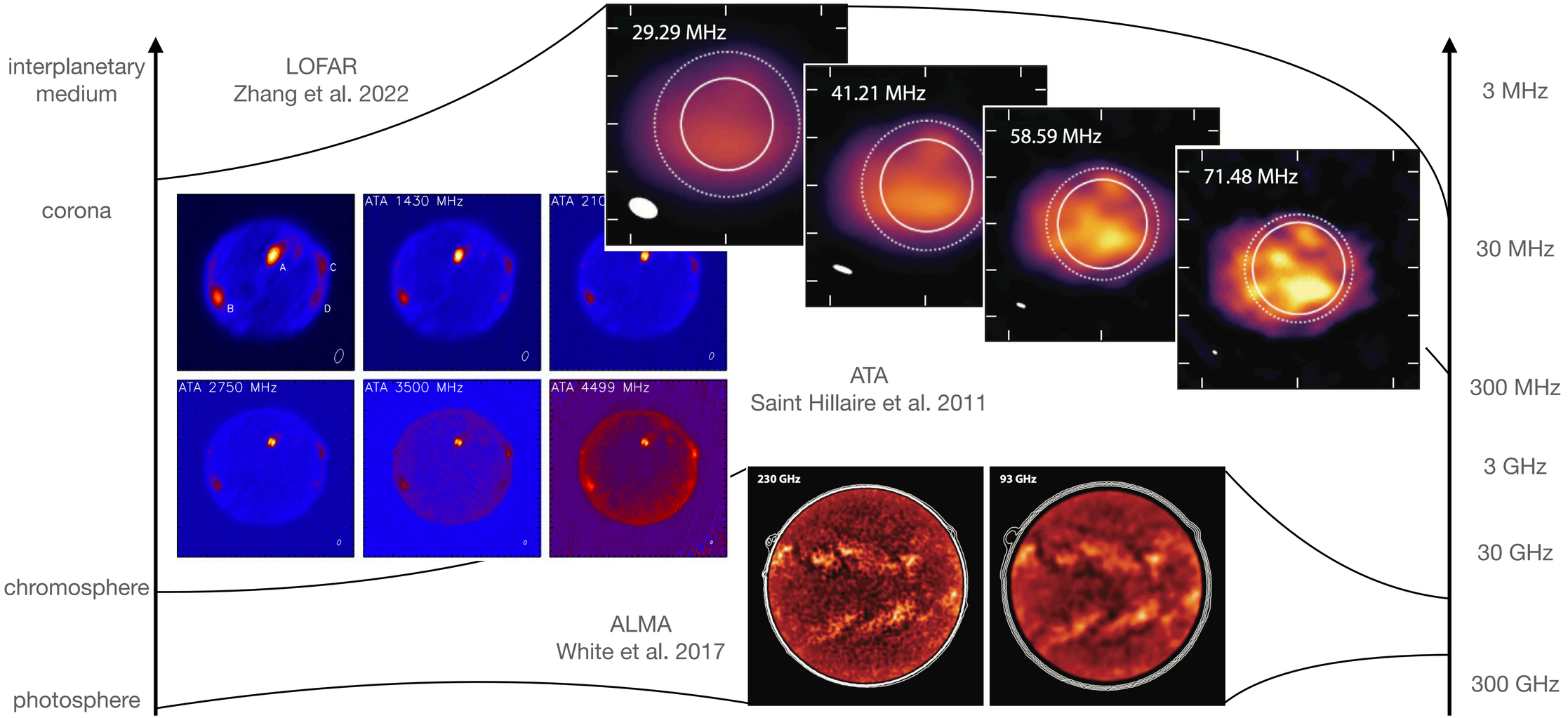
Quiet Sun

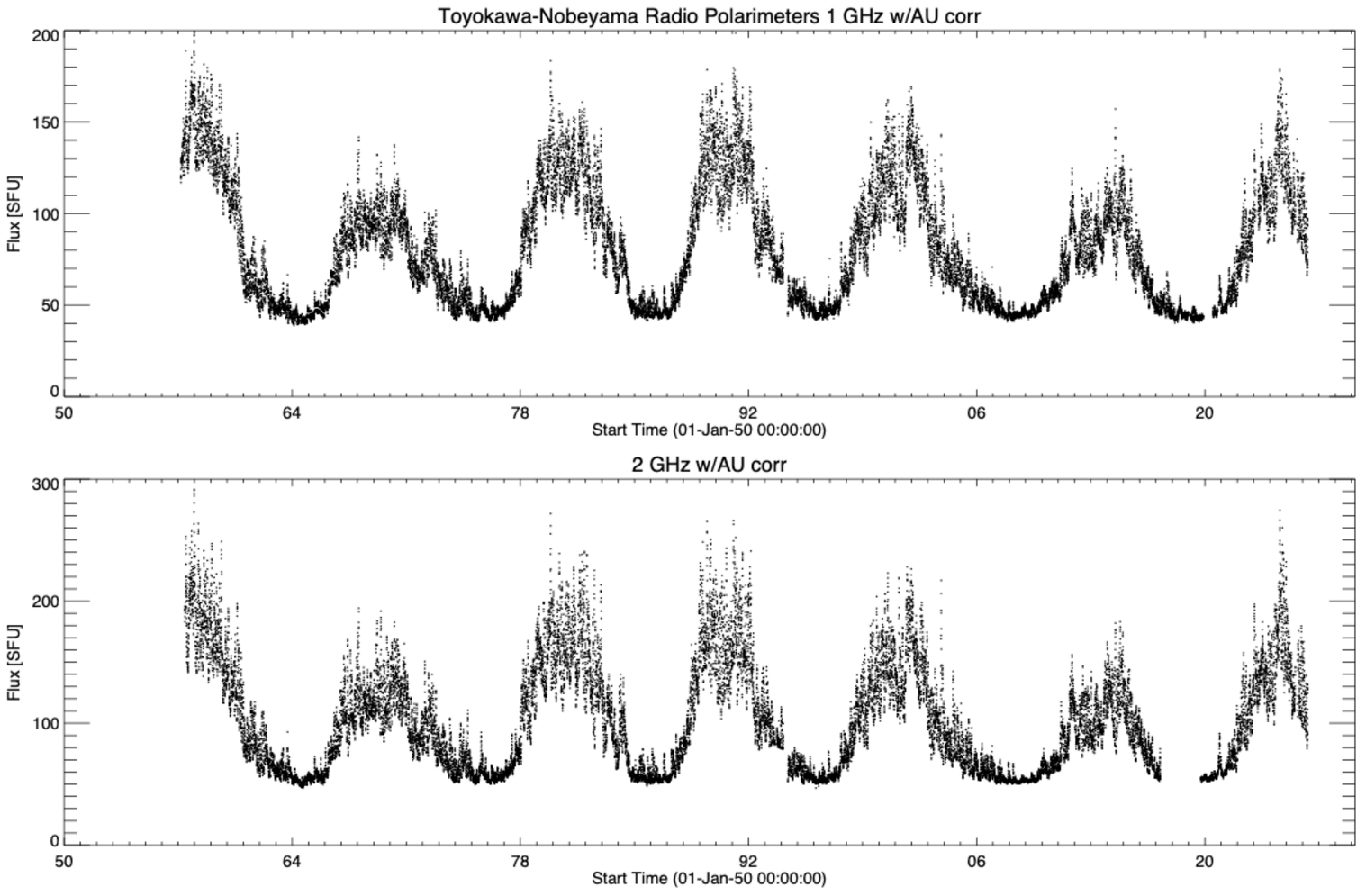
Mostly thermal emission from hot corona
@ higher frequency gyroemission

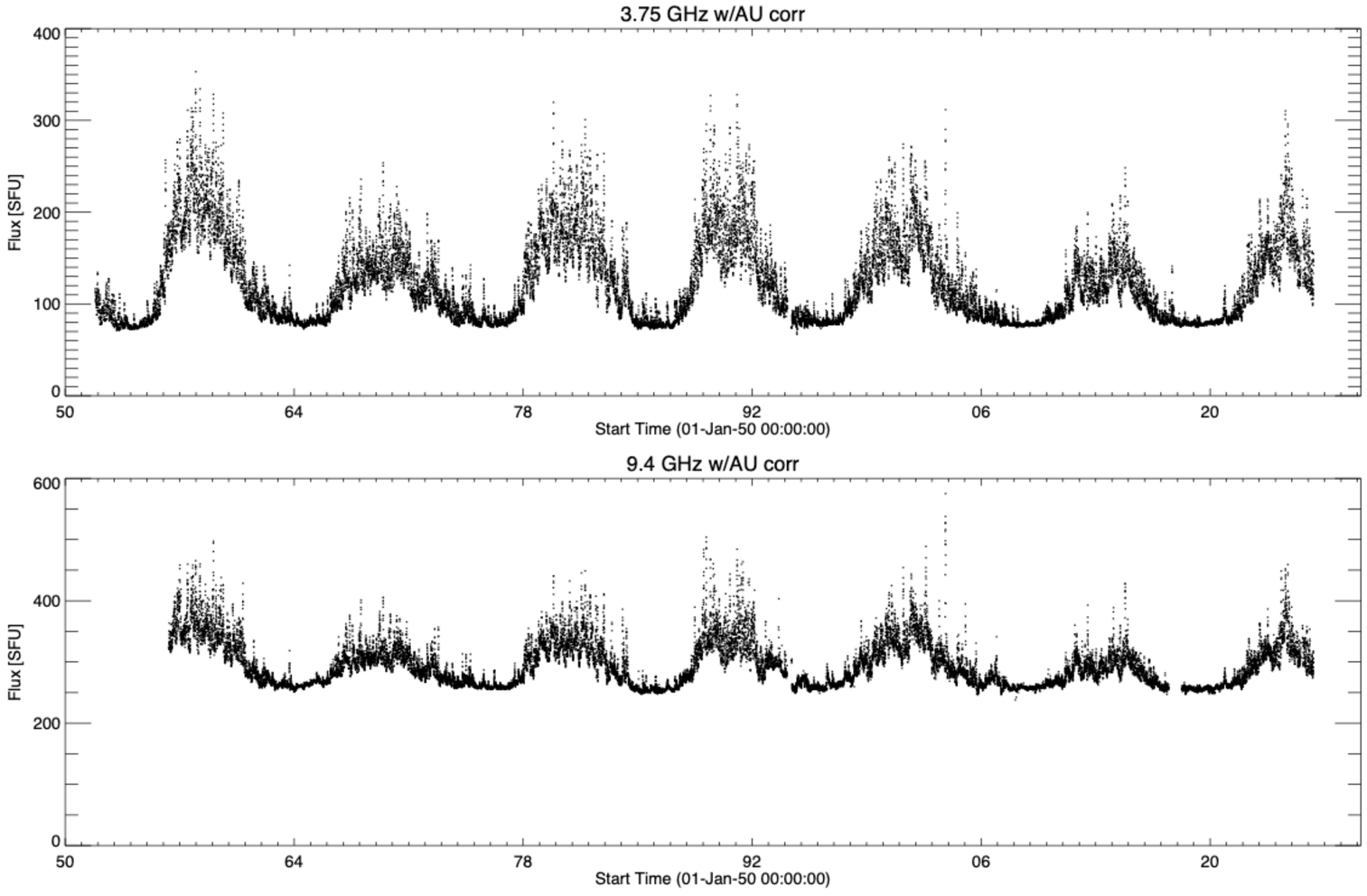


C. Marqué

All layers of the solar atmosphere are accessible to radio observations




Toyokawa-Nobeyama Radio Polarimeters 1 GHz w/AU corr
Flux [SFU]
200
150
100
50
0
50
64
78
92
06
20
Start Time (01-Jan-50 00:00:00)
2 GHz w/AU corr
Flux [SFU]
300
200
100
0
50
64
78
92
06
20
Start Time (01-Jan-50 00:00:00)


3.75 GHz w/AU corr
Flux [SFU]
400
300
200
100
0
50
64
78
92
06
20
Start Time (01-Jan-50 00:00:00)
9.4 GHz w/AU corr
Flux [SFU]
600
400
200
0
50
64
78
92
06
20
Start Time (01-Jan-50 00:00:00)

F10.7 index

$\lambda = 10.7$ cm $\equiv 2.8$ GHz



Figure 3. The flux monitors. Flux Monitor 1, the secondary instrument is in the foreground; Flux Monitor 2, the primary instrument is in the background, on the tower.

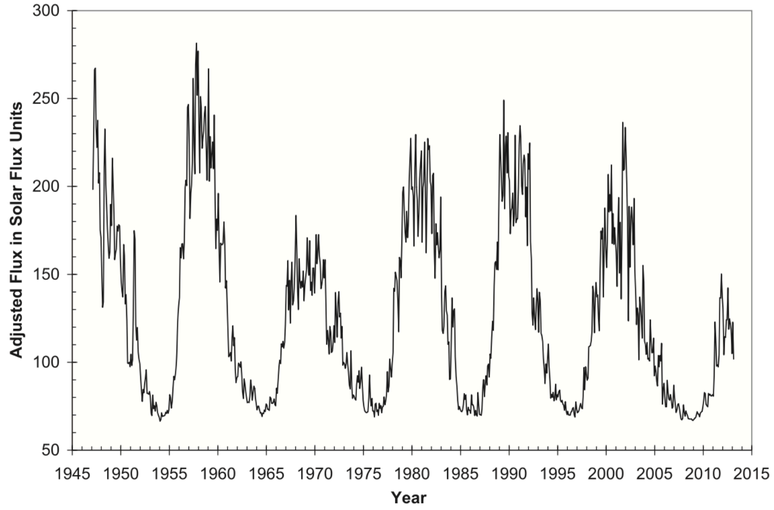


Figure 1. Monthly averages of the adjusted (scaled for an Earth-Sun distance of 1 AU) $F_{10.7}$ values since 1947.

Tapping 2013

F10.7 i

$\lambda = 10.7$ cm $\equiv 2.8$



Figure 3. The flux
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2, the primary inst
the tower.

2015

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47.

013

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Research Article

The operational and research DTM-2020 thermosphere models

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Abstract

Aims: The semi-empirical Drag Temperature Models (DTM) predict the Earth's thermosphere's temperature, density, and composition, especially for orbit computation purposes. Two new models were developed in the framework of the H2020 Space Weather Atmosphere Models and Indices (SWAMI) project. The operational model is driven by the trusted and established F10.7 and *Kp* indices for solar and geomagnetic activity. The so-called research model is more accurate, but it uses the indices F30 and the hourly Hpo, which are not yet

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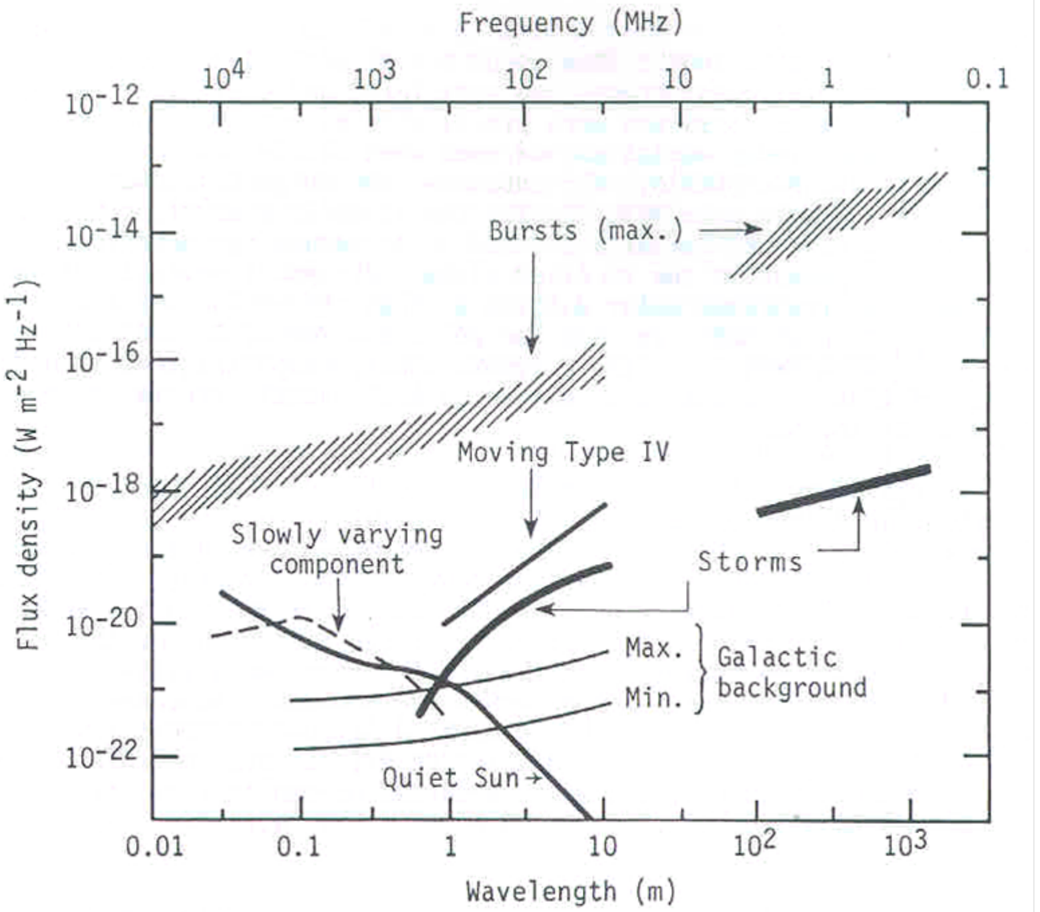
Solar radio bursts

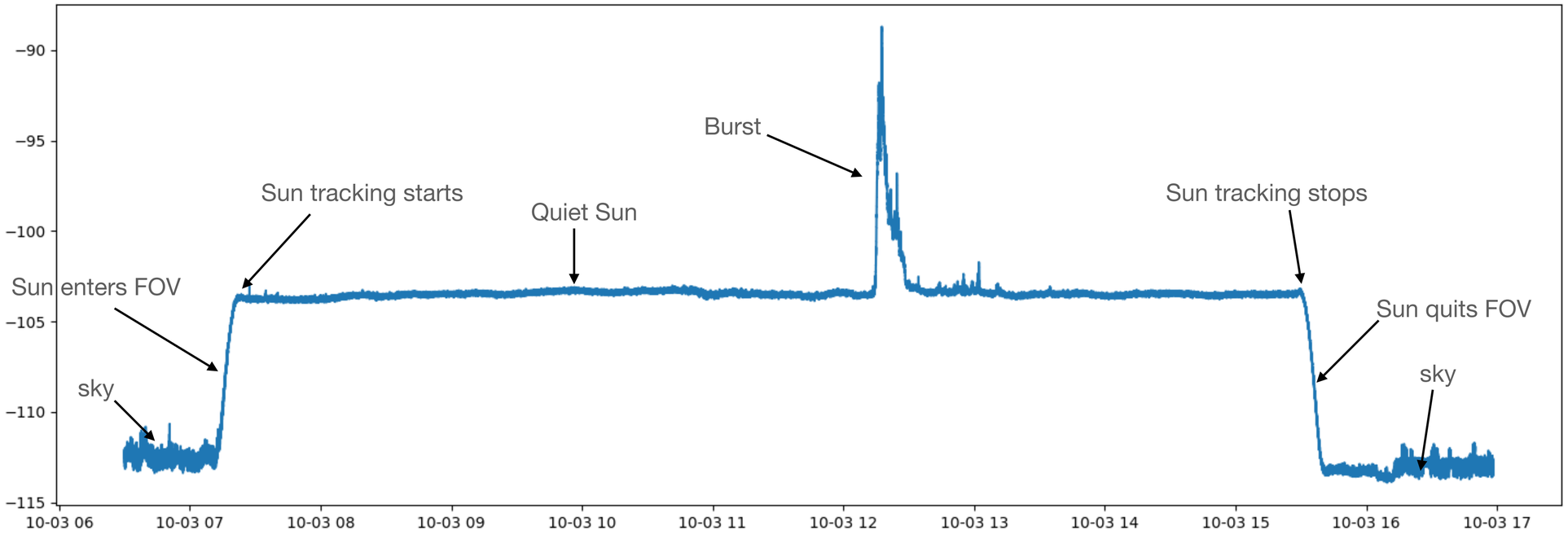
Solar radio bursts



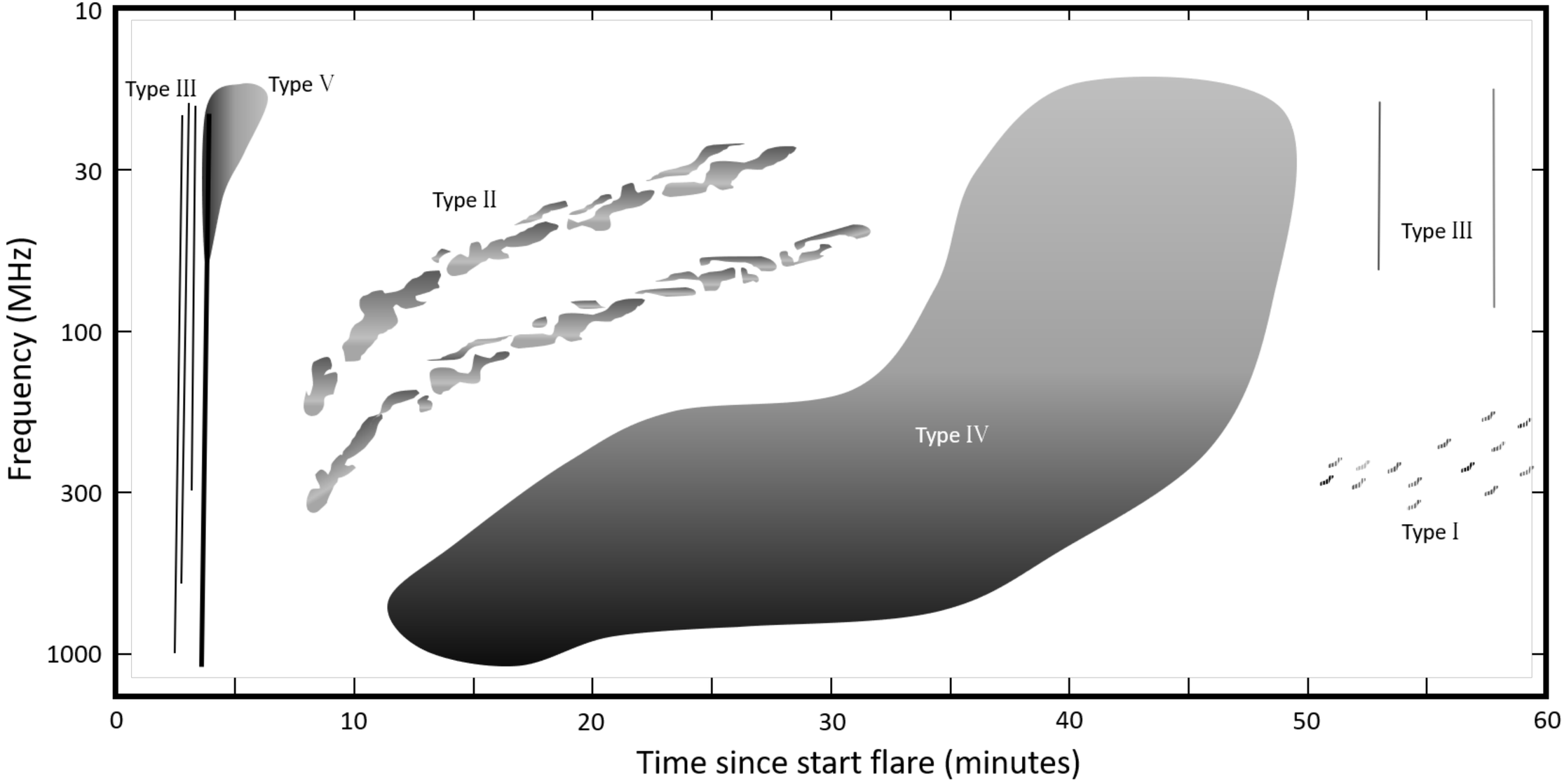
From ground, bursts are mostly intense from HF to S band

Example in L band

Solar observations from Belgium



Radio bursts



source: STCE

Radio bursts

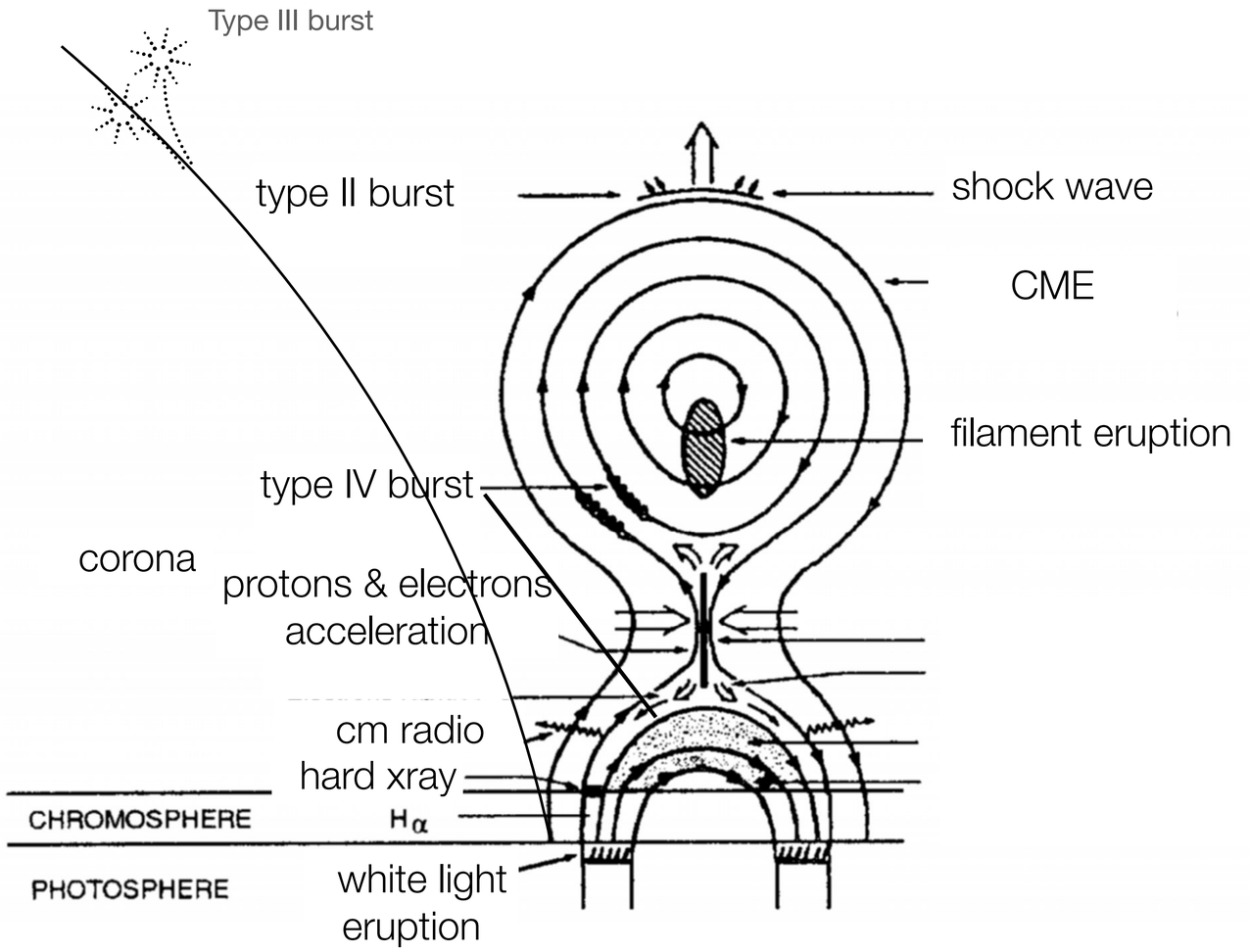
Solar radio bursts are produced by non thermal electrons accelerated during eruptive events of all magnitudes

For frequencies (f) below ~ 1- 2 GHz, the dominant emission is called plasma emission, where energetic electrons trigger local plasma oscillations which are then converted into E. M. radiations

$$f \propto \sqrt{n_e}$$

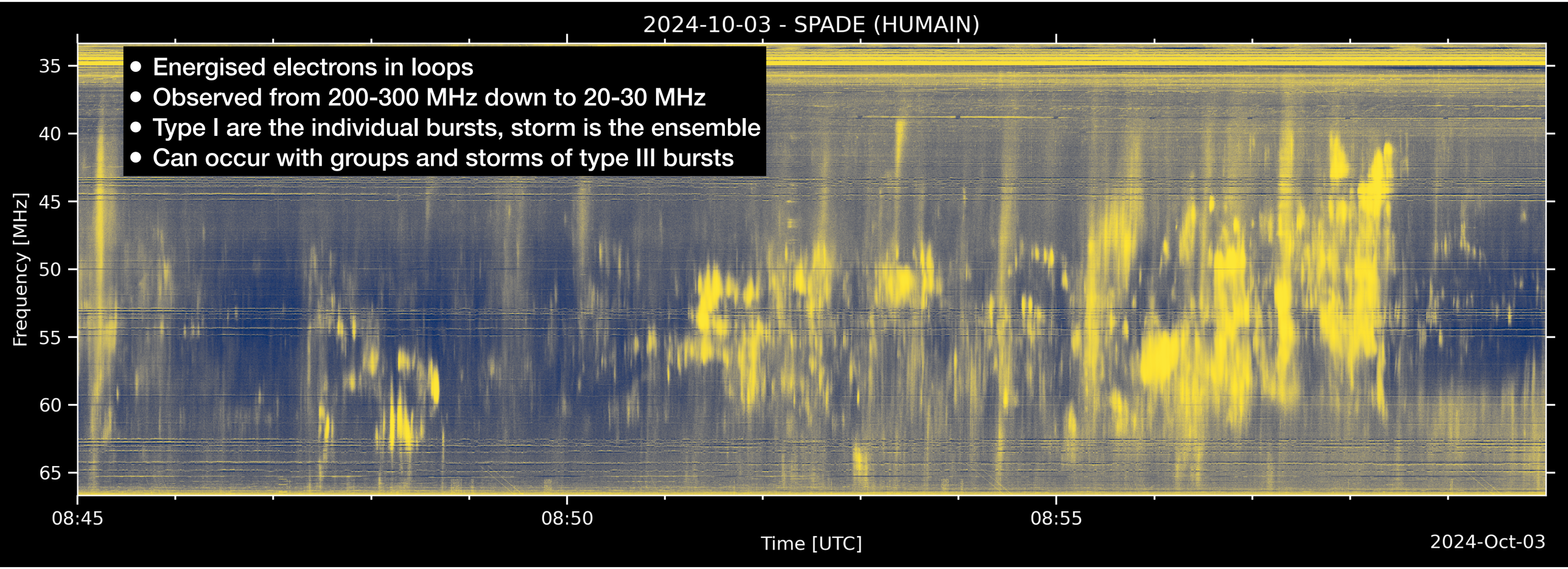
Spectral signatures (type I, type II, type III ...)

Above, gyroemissions, gyrosynchrotrons or bremstrahlung emissions dominate

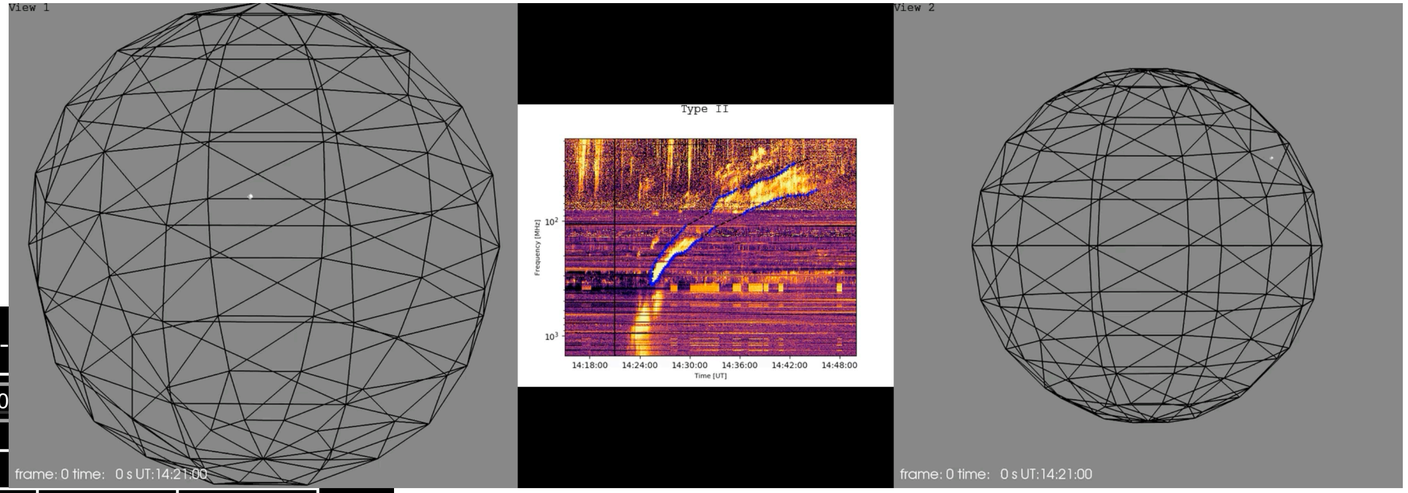


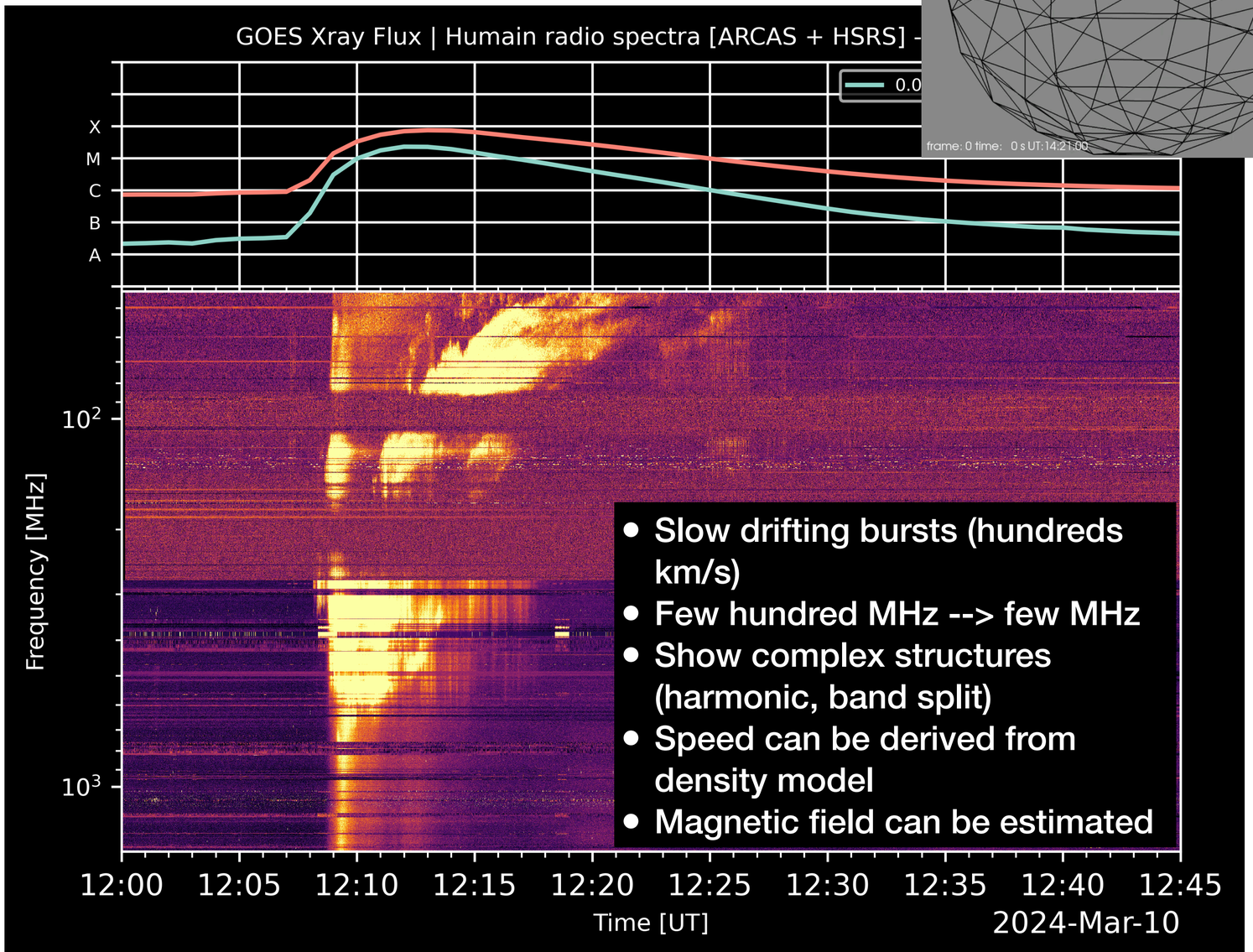
Type I & noise storms

Non flaring radio bursts linked to sunspots



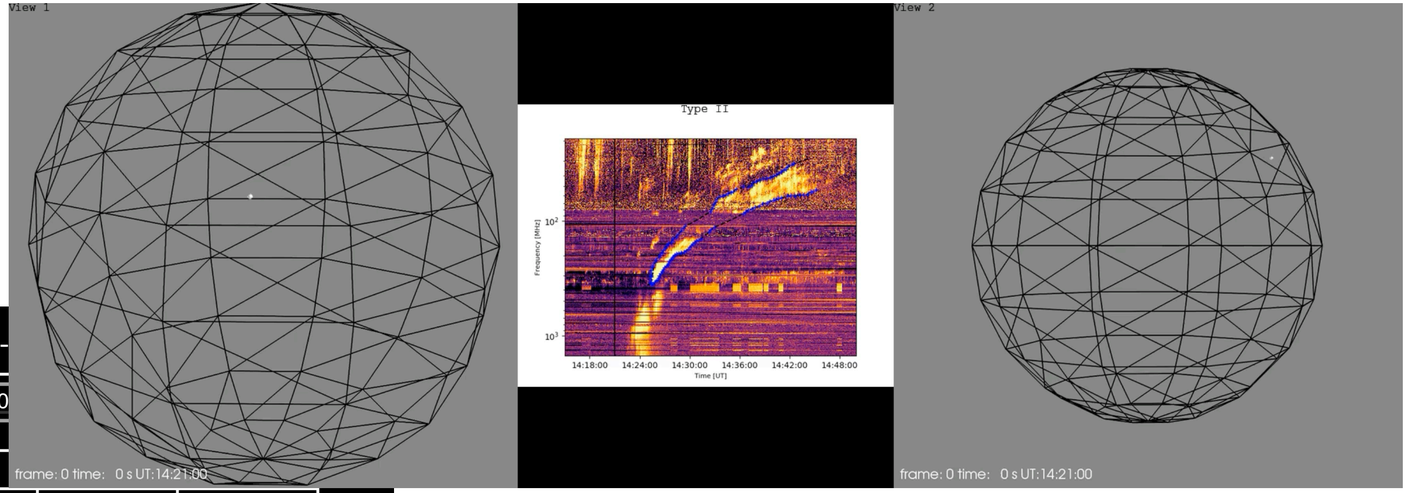
Type II bursts

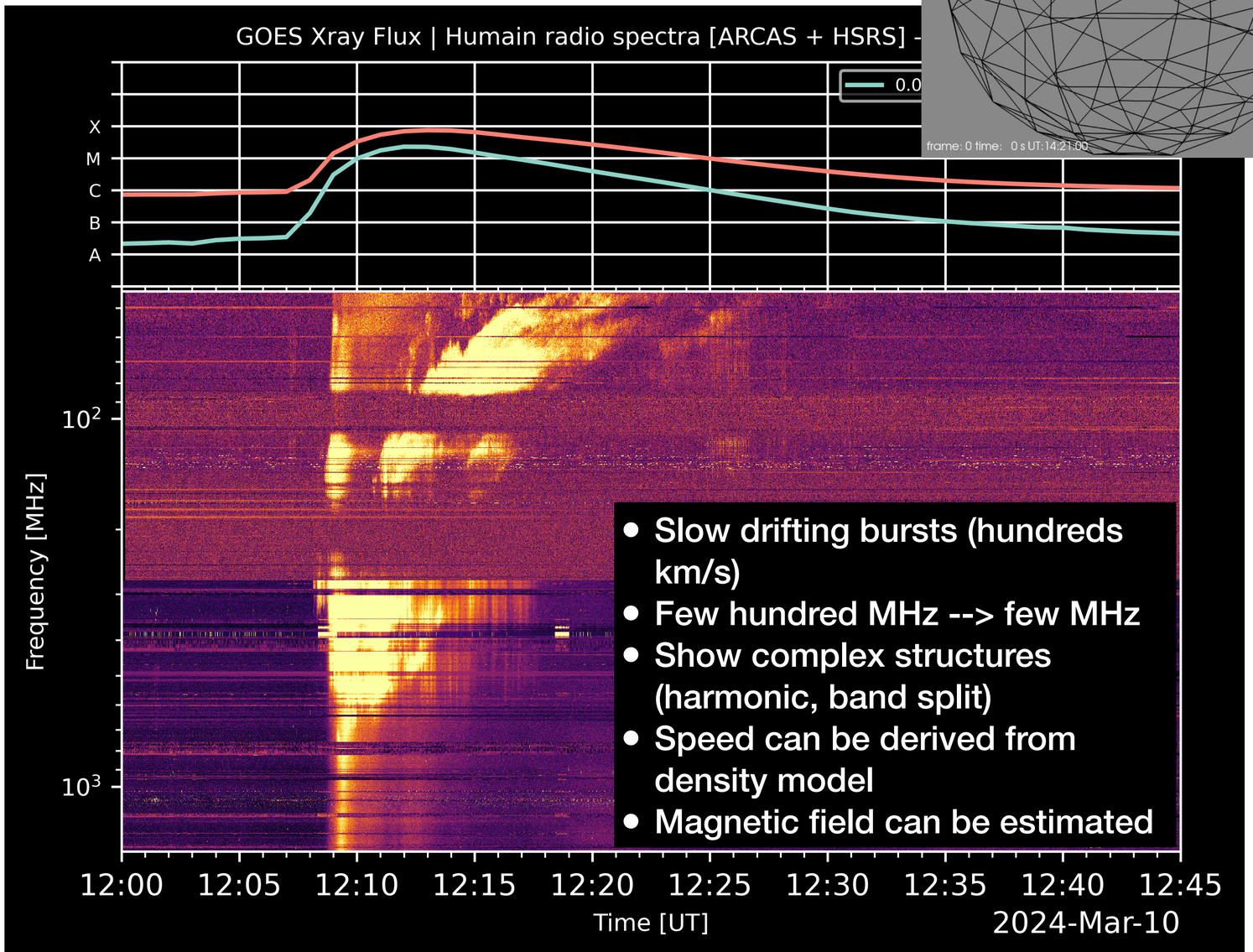




linked to shock waves propagating out in the corona

Type II bursts

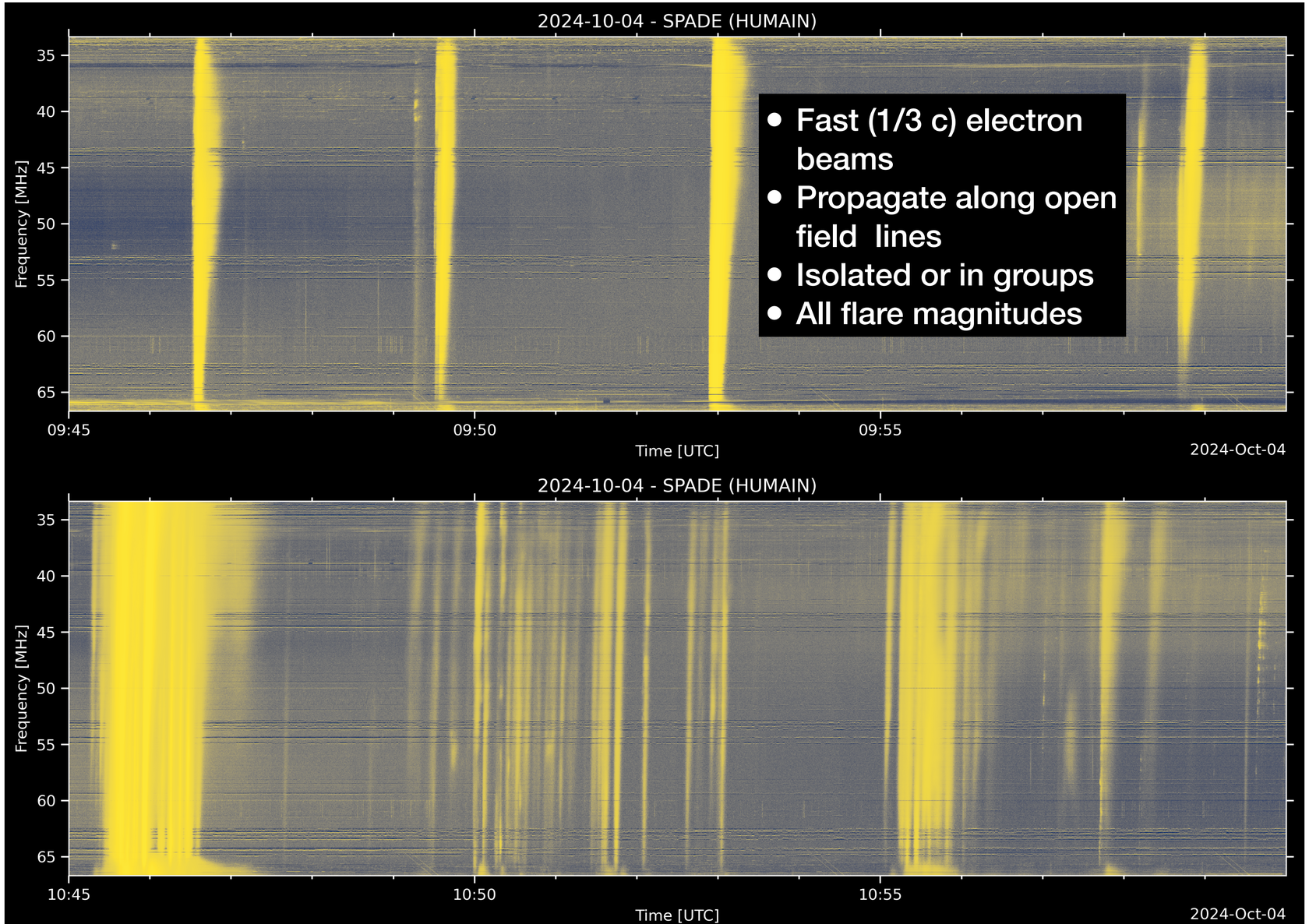




linked to shock waves propagating out in the corona

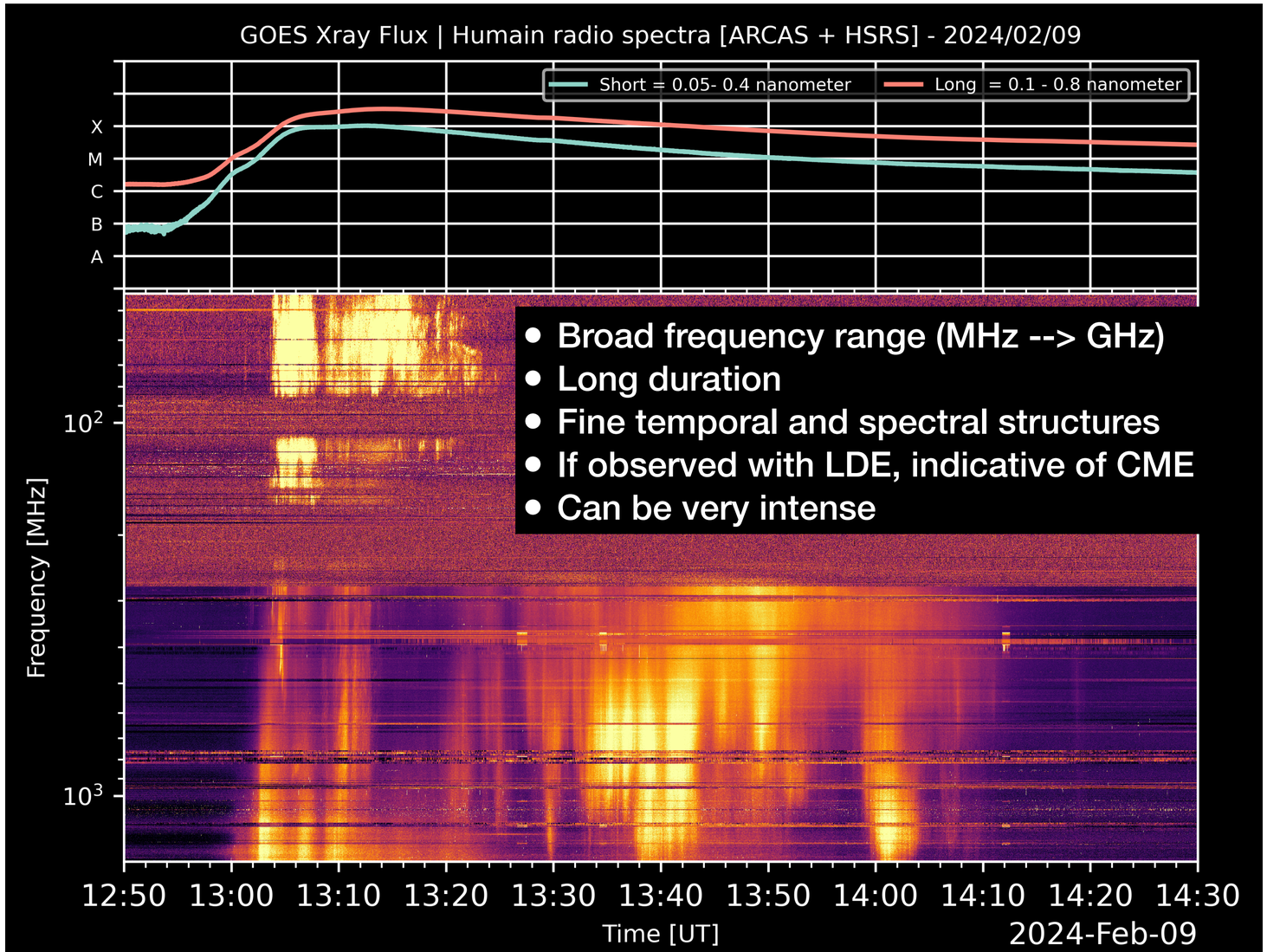
Type III bursts

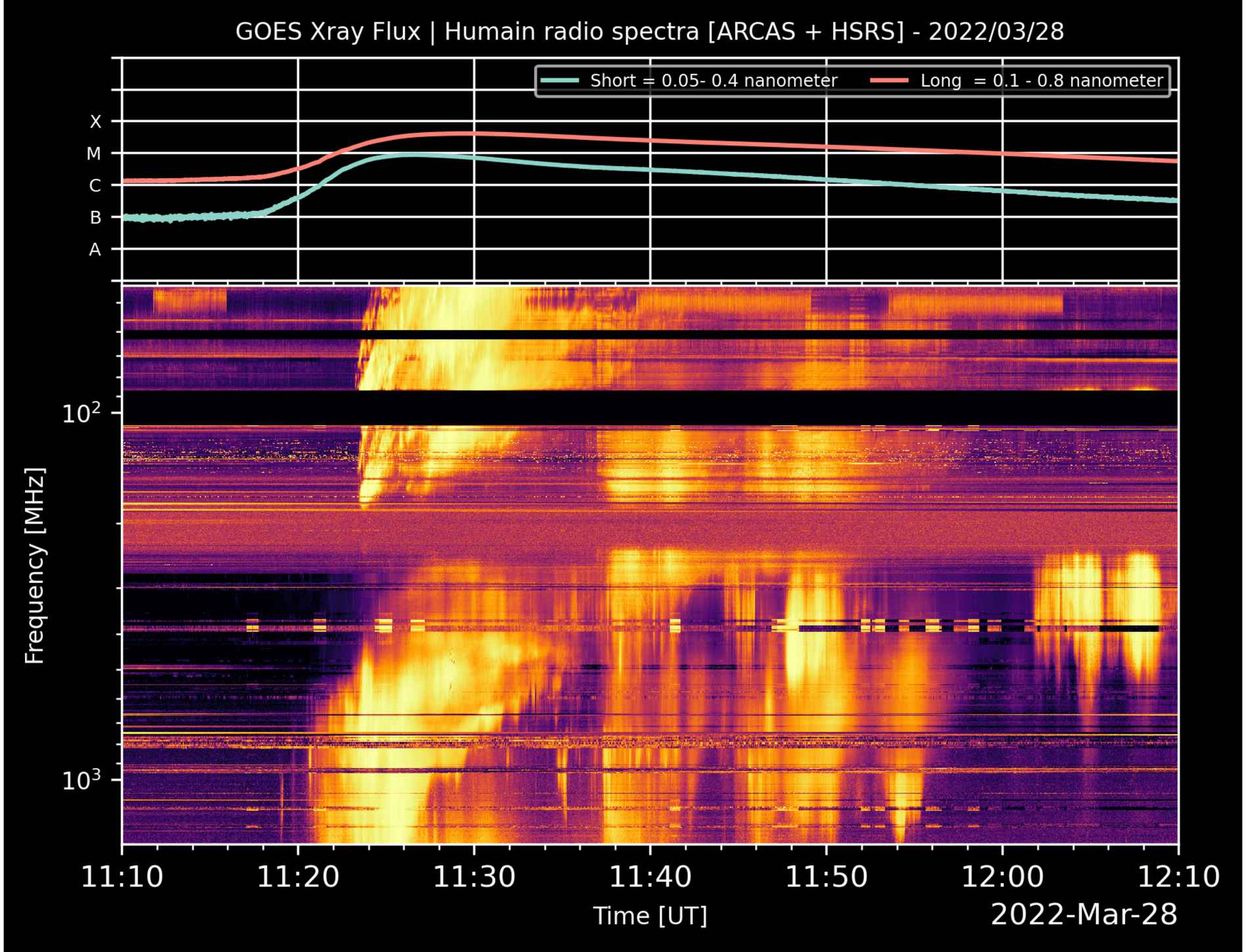
Most frequent type of bursts



Type IV bursts

Energetic electrons trapped in post-flare loops

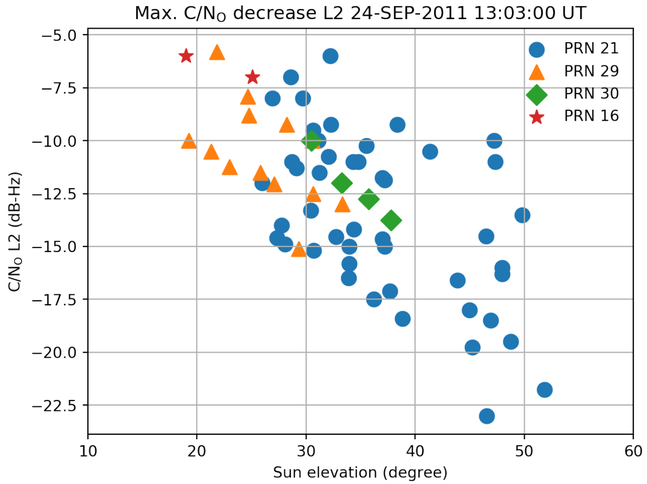


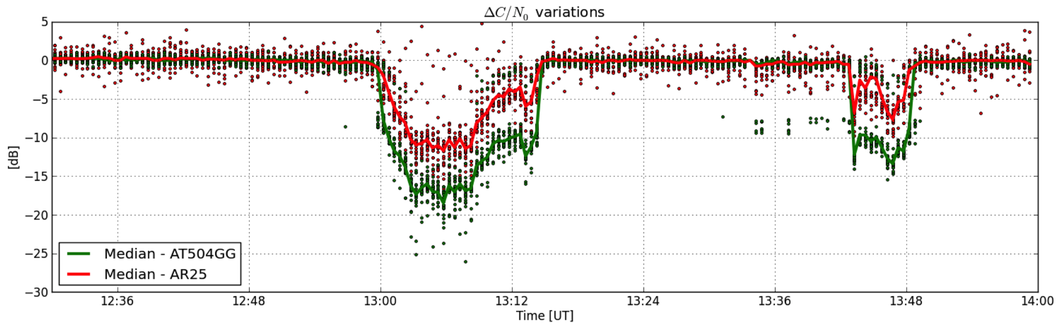

GOES Xray Flux | Humain radio spectra [ARCAS + HSRS] - 2022/03/28
Short = 0.05- 0.4 nanometer
Long = 0.1 - 0.8 nanometer
X
M
C
B
A
Frequency [MHz]
10^2
10^3
11:10
11:20
11:30
11:40
11:50
12:00
12:10
Time [UT]
2022-Mar-28

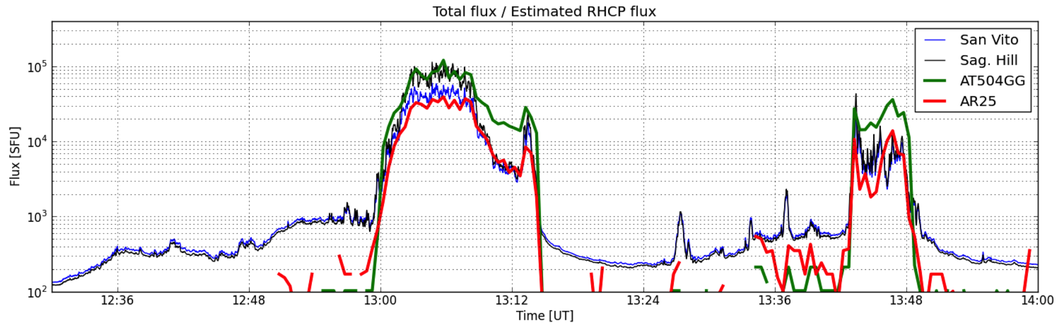
Impact of solar radio bursts

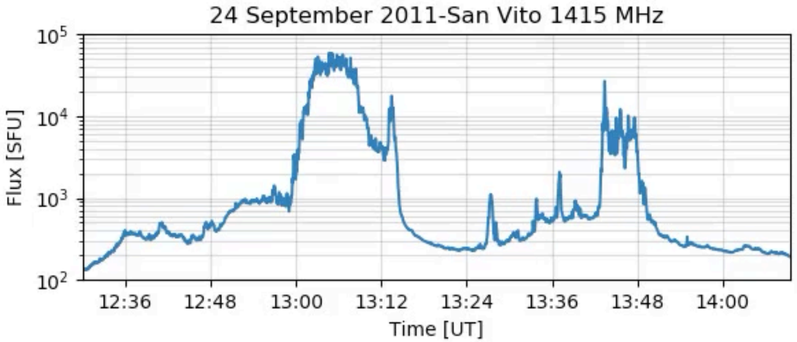
Impact on GNSS systems

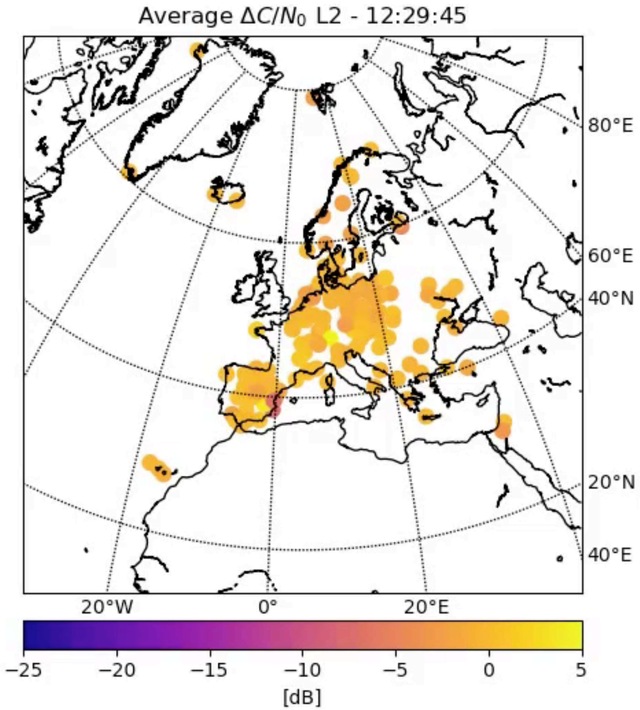
GPS September 24 2011











Marqué, Bergeot, Aerts, Chevalier et al.
(poster @ ESSW9, 2012)

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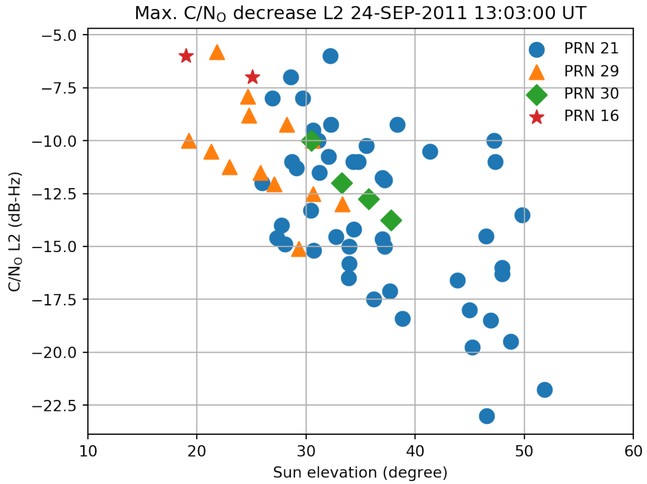
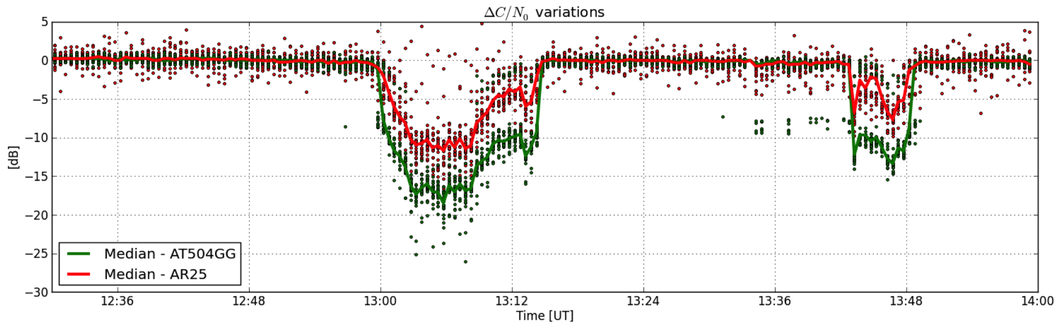
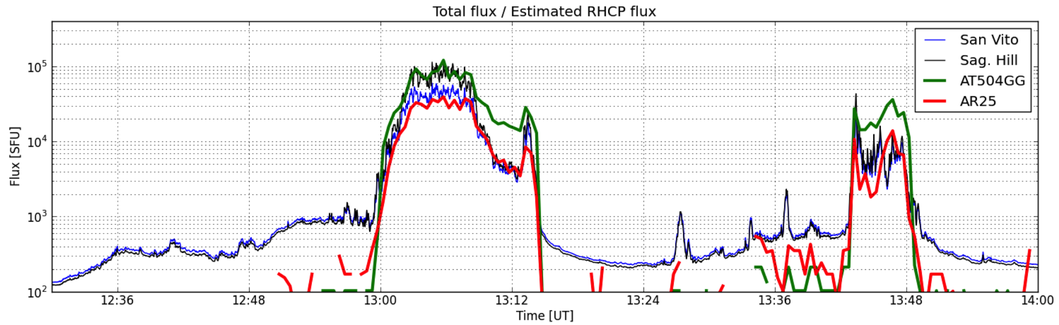
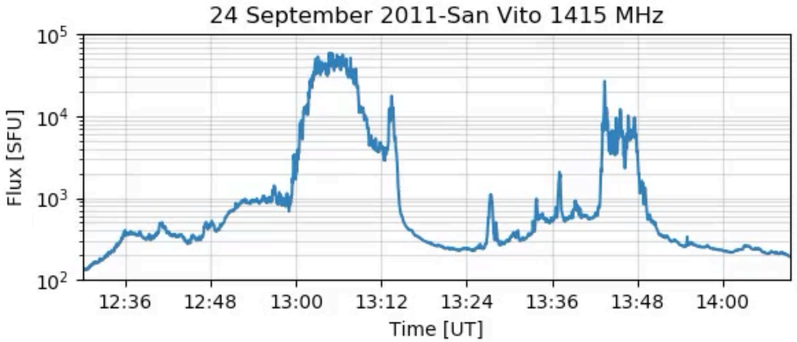
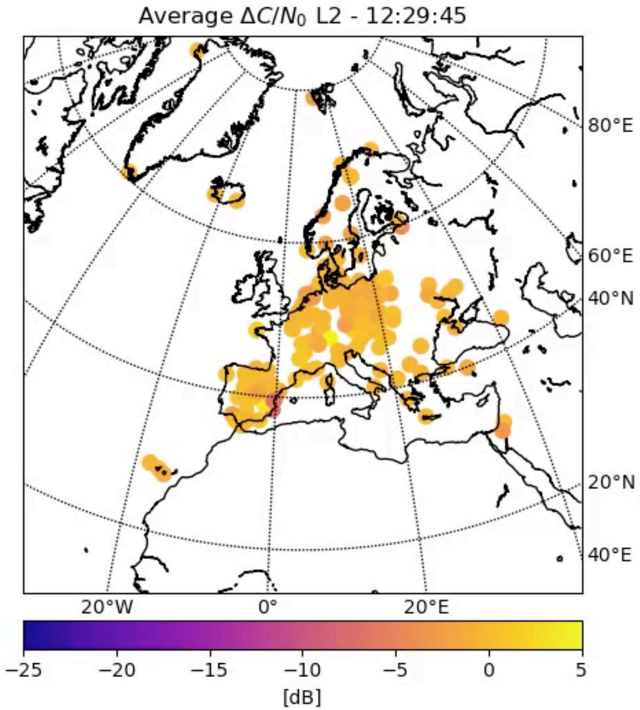








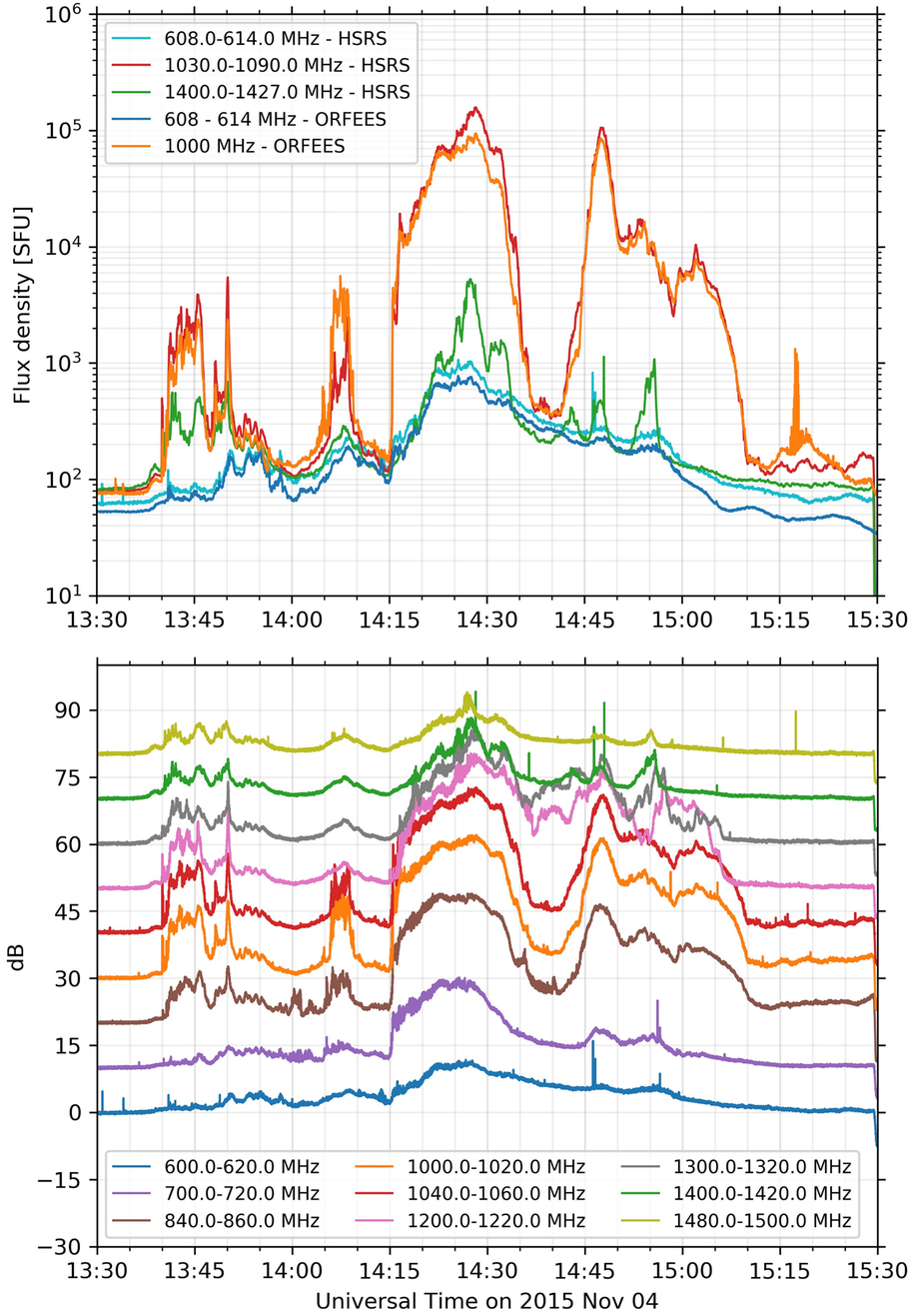


Marqué, Bergeot, Aerts, Chevalier et al.
(poster @ ESSW9, 2012)

Impact on radar systems

November 4 2015

- Sweden: ATC radars suffered severe disturbances 14:20 UT - 16:00 UT
- Sweden: Partial closure of air space for an hour
- Minor disturbances in Norway, Belgium



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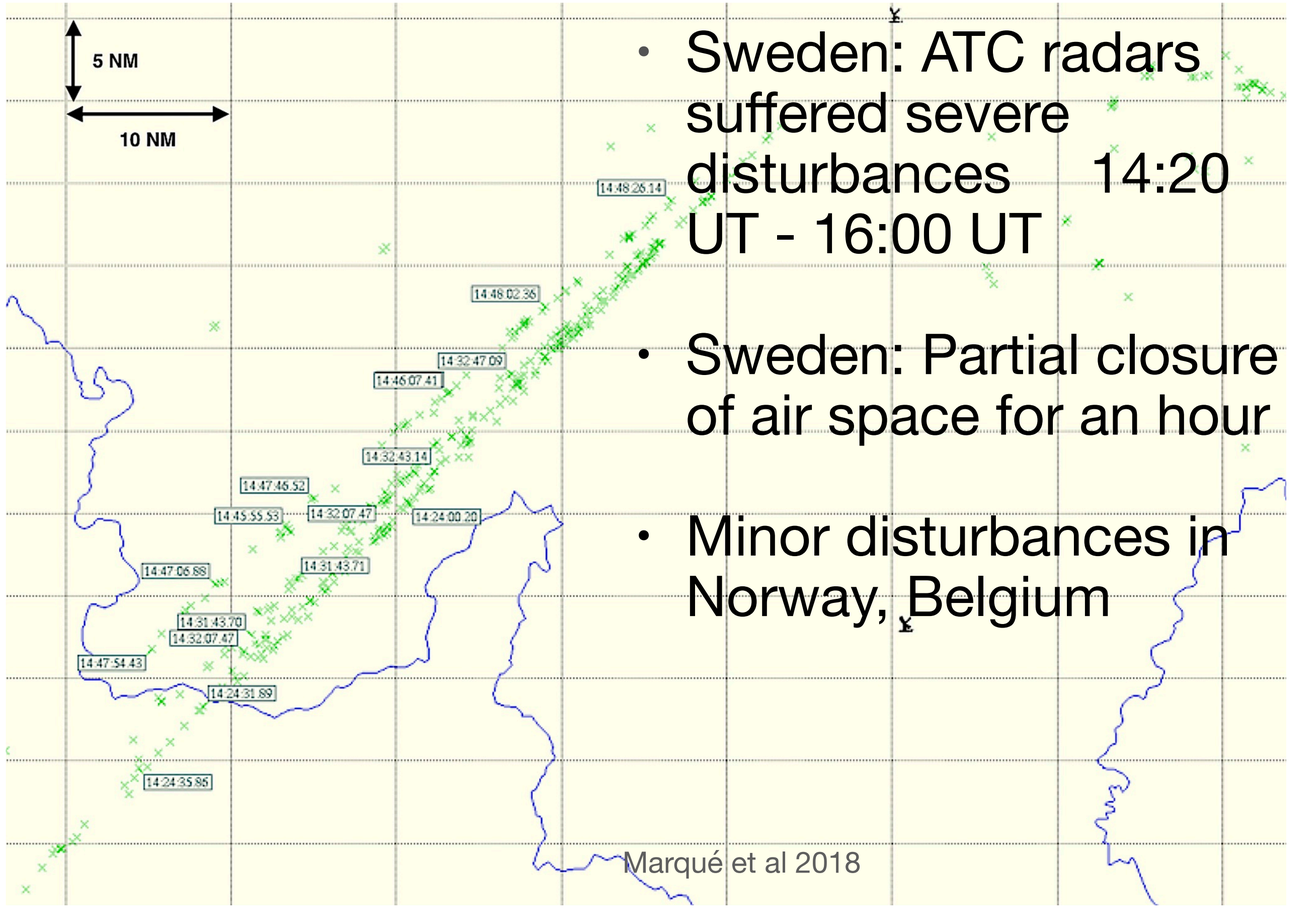

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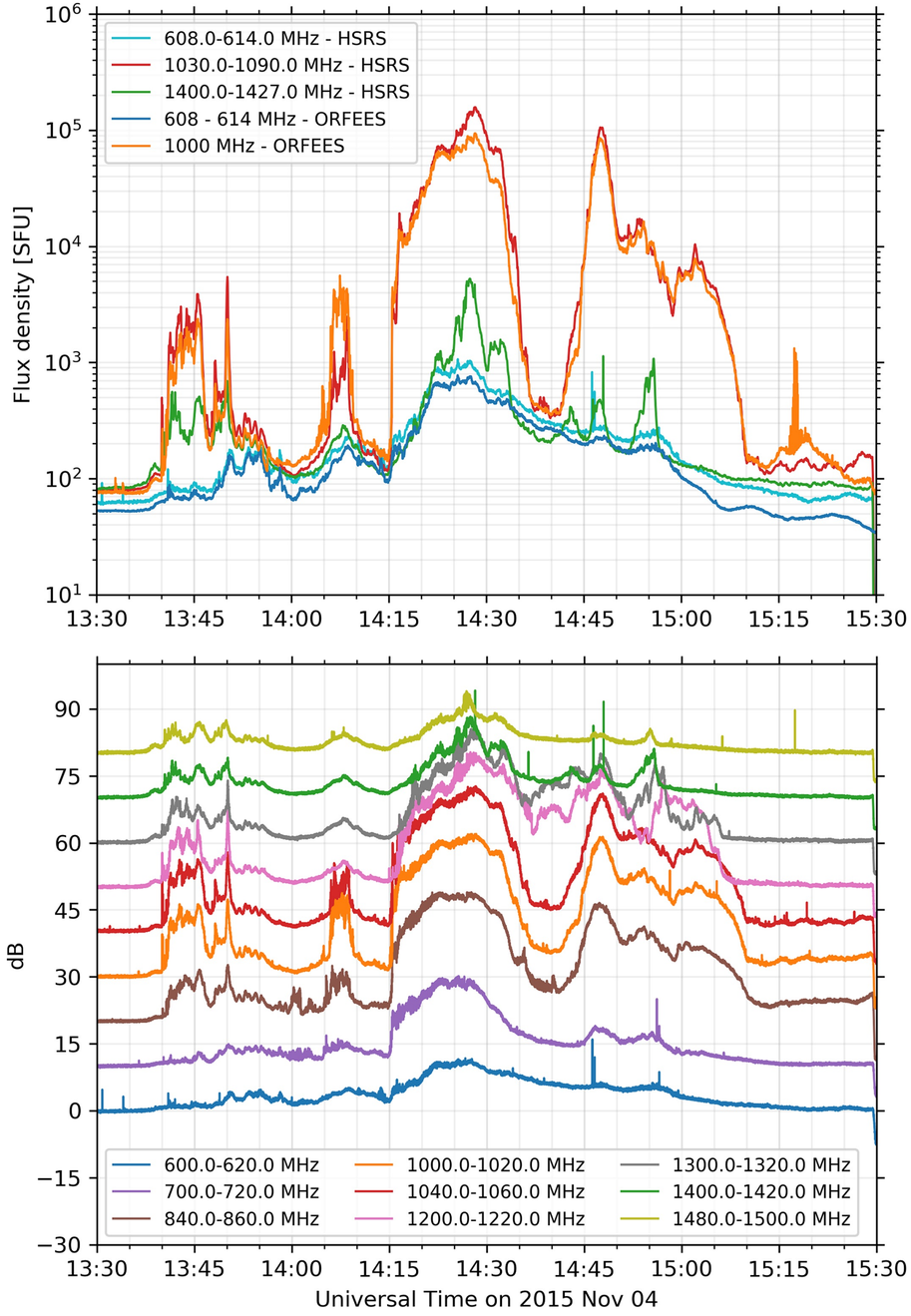
Marqué et al 2018



	Frequency range	Properties	Impact
Noise storms / Type I	HF, VHF	can be intense, long duration (days), frequent	**Possible**
Type II	HF, VHF	last few minutes, rare	**No**
Type III	HF, VHF	Intense, short duration, very frequent	**No**
Type IV	HF, VHF, UHF	Intense, long duration, broadband	**Yes**

Links

Where to find solar radio data?

burst & radio events	https://www.swpc.noaa.gov/products/solar-and-geophysical-event-reports https://www.ncei.noaa.gov/products/space-weather/partners/swpc-products-and-data
Recent radio flux	https://services.swpc.noaa.gov/text/solar_radio_flux.txt
F10.7	https://spaceweather.gc.ca/forecast-prevision/solar-solaire/solarflux/sx-5-en.php
Humain data	https://www.sidc.be/humain 🇧🇪