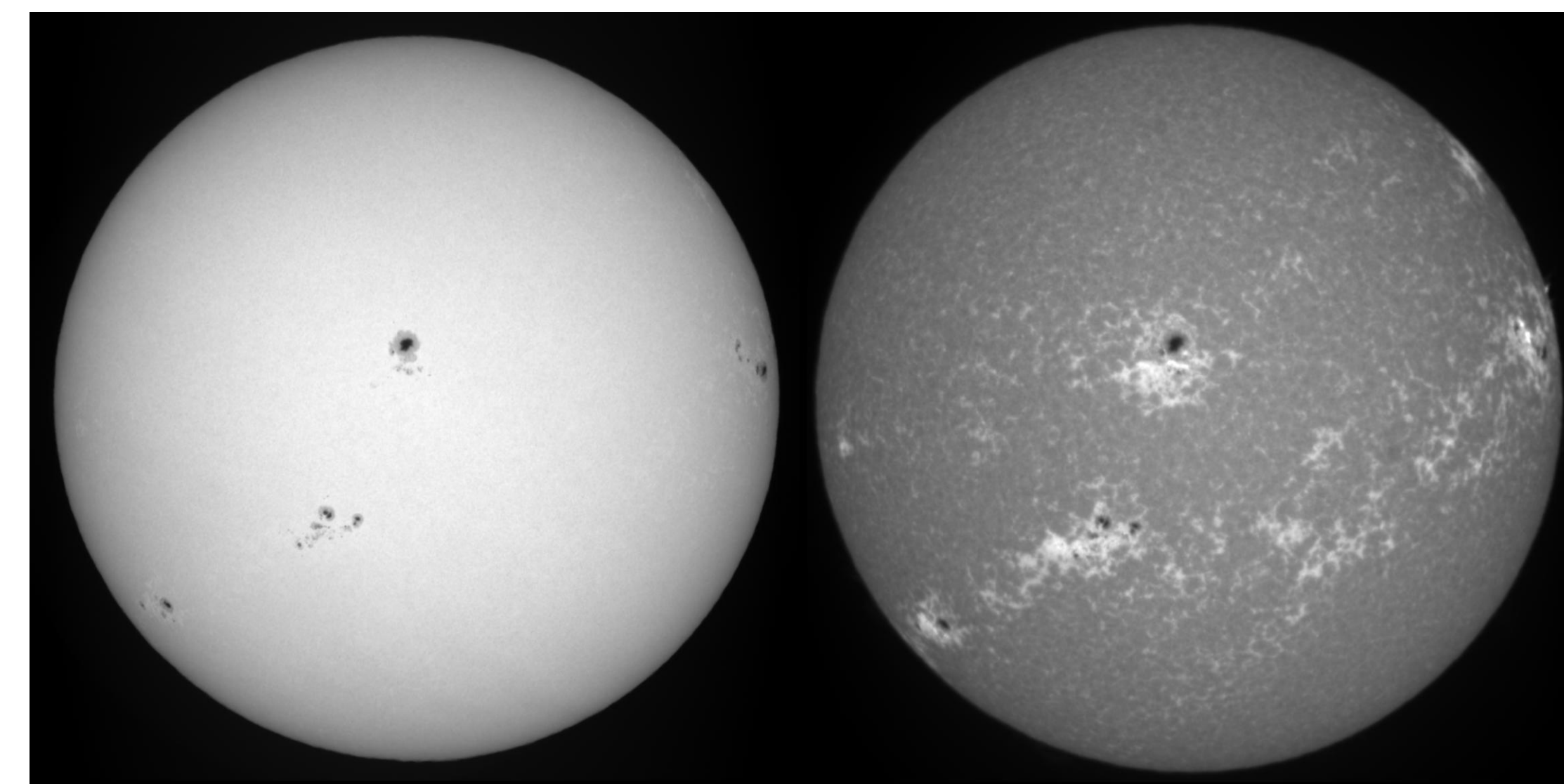


In October 2024, a severe geomagnetic storm was recorded. Auroras were visible from Belgium, Italy and Greece. Let's explore the history of this important event!

1. The story begins

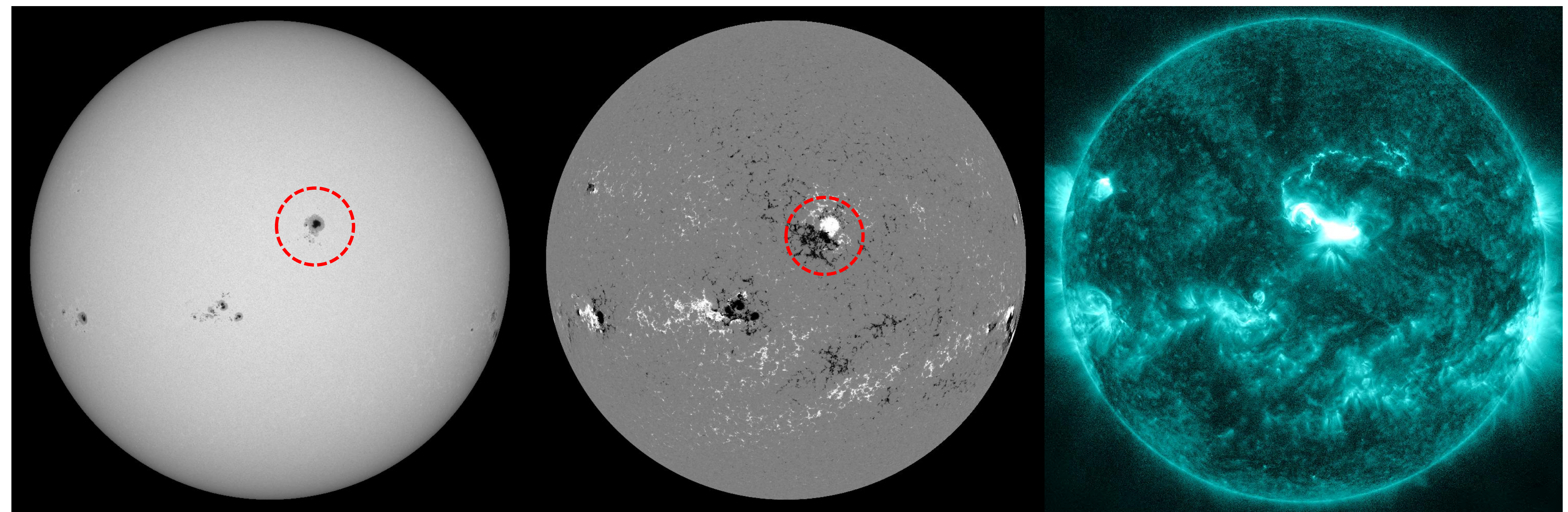
- We often see dark spots on the Sun, called *sunspots*. These *active regions* often have strong, complex magnetic fields and can be associated with energetic phenomena.
- This was the case in October 2024. Can you spot such regions in the images below ?



Images (left to right): White light and Call images of the Sun on the 8th of October 2024, obtained from USET (at ROB).

2. Something bright...

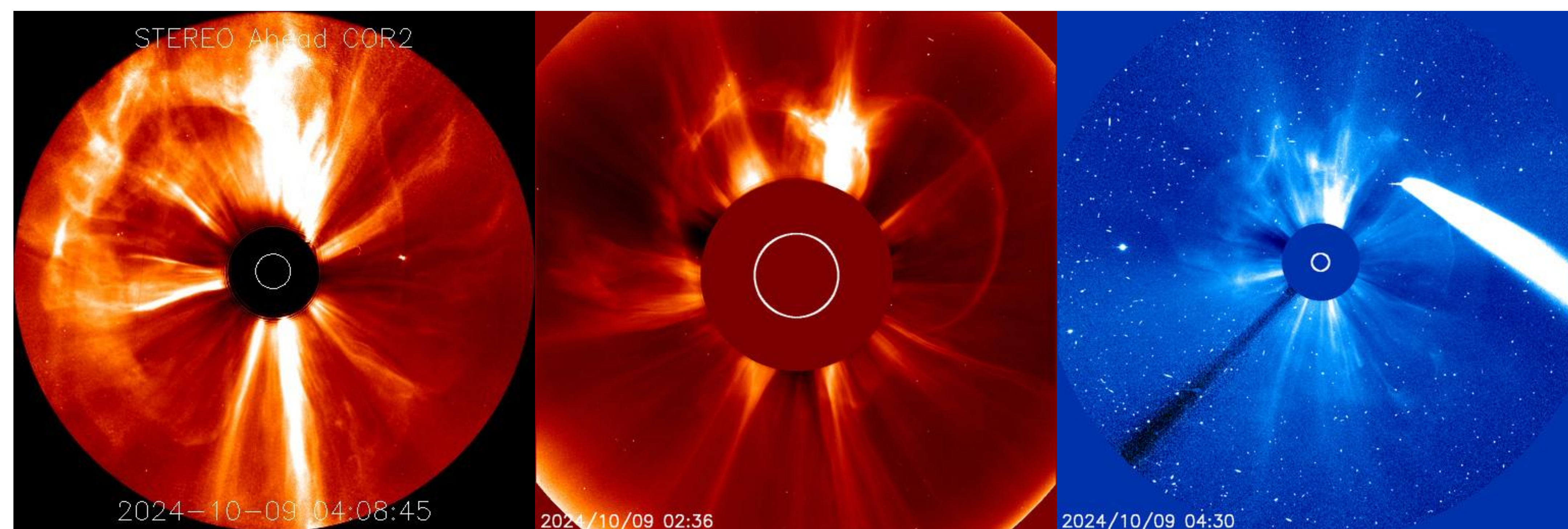
- Strong emission in X-rays, an *X1.8 flare*, observed at 01:56 UTC (02:56 local time) on the 9th of October 2024.
- The flare was associated with a large, complex sunspot group (SIDC 217 / NOAA 3848) near the center of the visible disk.
- The dark spot in the circle is a few times *larger* than the diameter of Earth!



Images (left to right): HMI Continuum, Magnetogram and 131 Å from SDO/AIA on the 9th of October 2024 at 01:45 UTC, 10min before the peak time of the flare.

3. Something big !

- An associated “explosion” & expulsion of solar material, a *coronal mass ejection (or CME for short)*, was observed in special instruments called *coronagraphs*
- It appeared as a *full halo CME* and it was Earth-directed
- The forecaster on duty predicted an arrival time around 10:30 UTC on October 10th, 2024

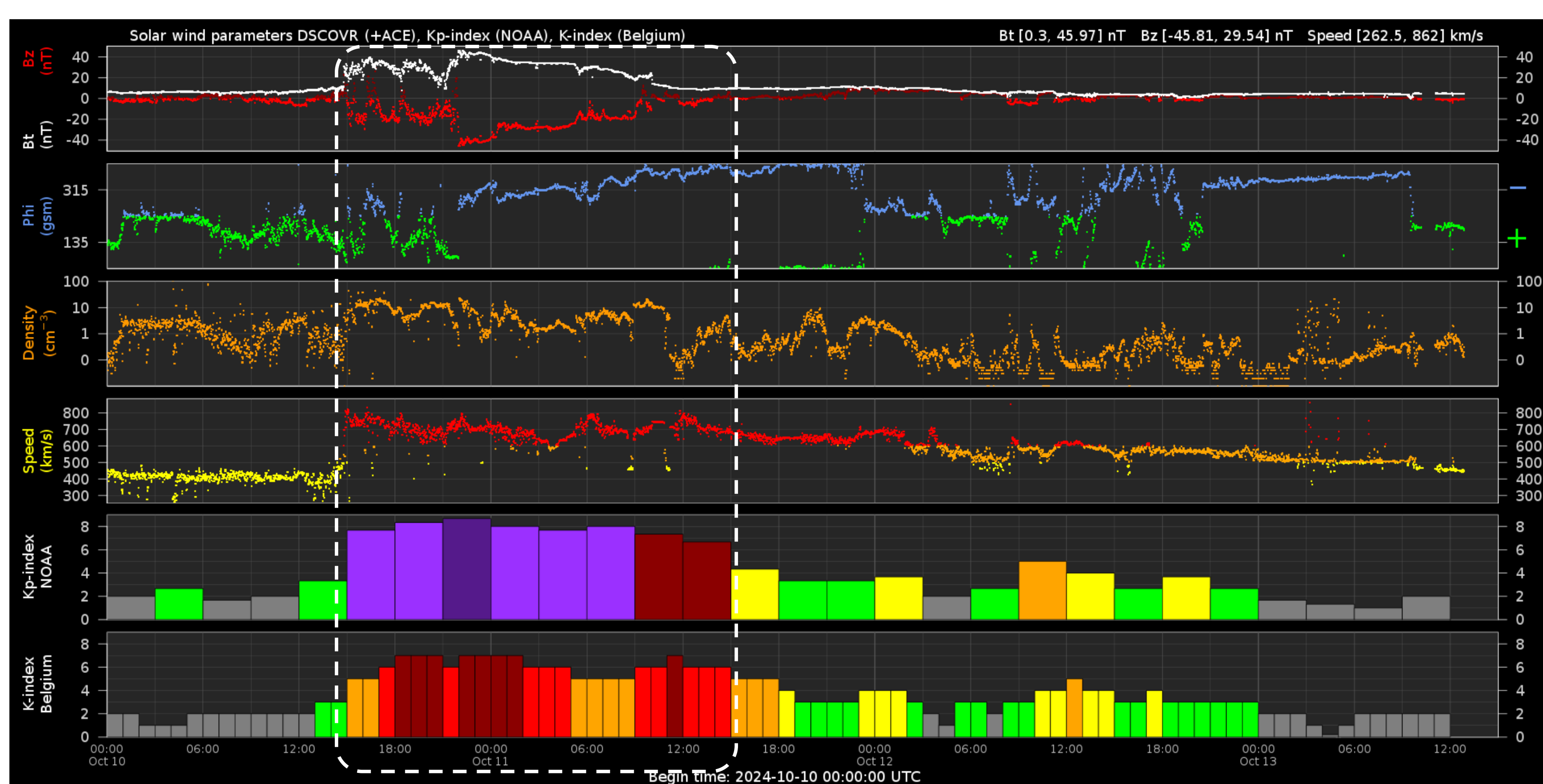


Images (left to right): From Stereo-A COR2, LASCO/C2 and LASCO/C3

4. What we saw near Earth

- A sharp increase in the magnetic field, density & speed of the solar wind was recorded by the spacecrafts DSCOVR & ACE → signature of the arrival of the CME front
- See the strong, negative Bz component of the magnetic field ? → led to severe *geomagnetic storm*, with a maximum value of the planetary geomagnetic index Kp = 9- !
- An increase in the proton flux was also observed. The flux for protons with energies > 10 MeV reached *strong radiation storm levels (S3)*

Image (top to bottom): Total magnetic field & Bz component, Magnetic field angle, Density, Speed, Kp index and K index from the Regional Warning Center Belgium.

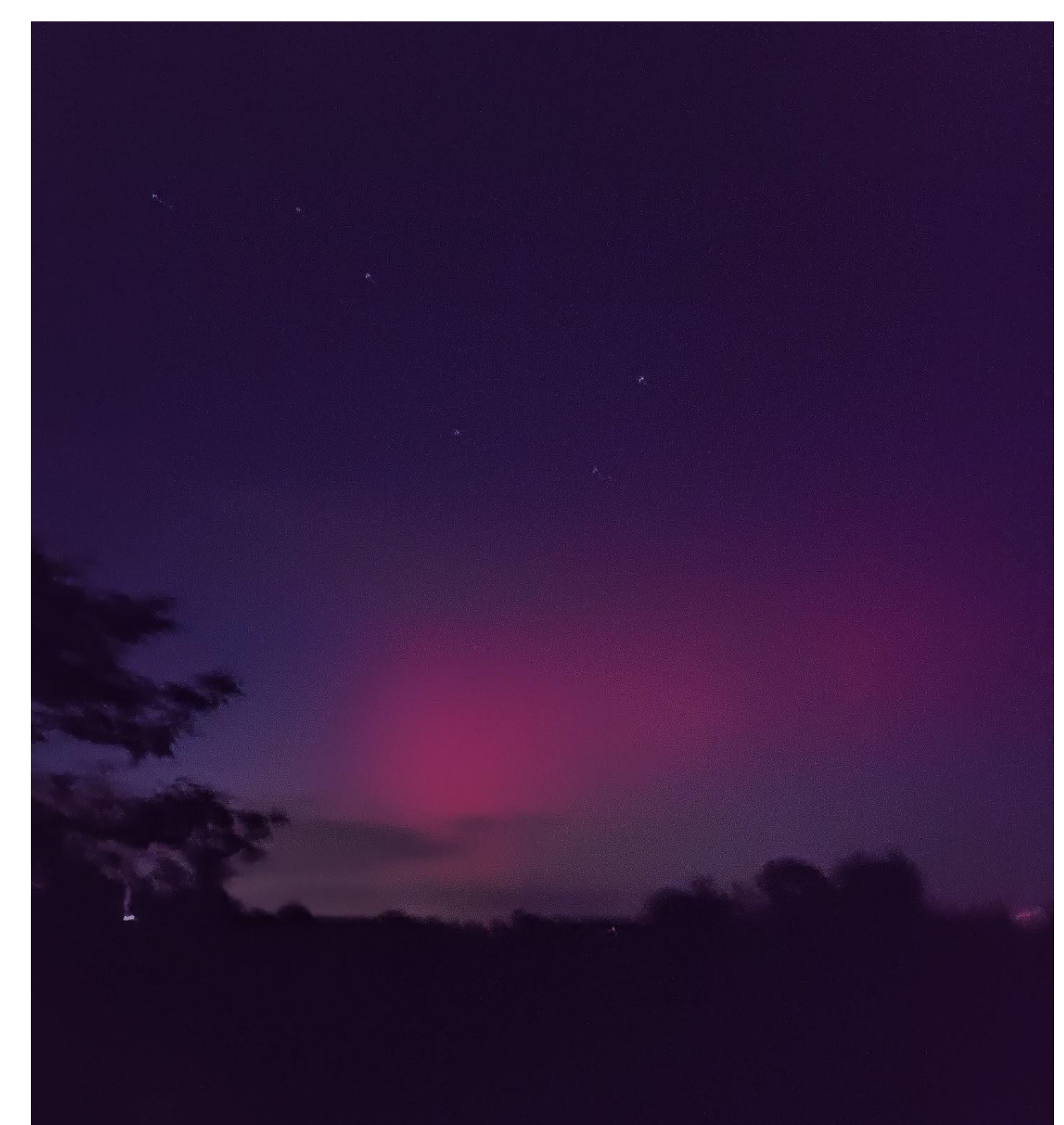


Although the storm in May 2024 was stronger, this event also had significant impact on many domains. Via our dedicated service to aviation (PECASUS), we recorded:

- HF (radio) communication impact
 - Lower frequencies (from the X1.8 flare)
 - Higher frequencies (due to the high proton flux and the severe geomagnetic storm)
- Navigation system (GNSS) impact
 - Increase of total electron content (leading to signal degradation)

However, this geomagnetic storm also held a nice surprise! Auroras were seen at lower latitudes. Unfortunately, the skies were not very clear on that day over many regions in Belgium.

Image: Aurora seen in Drenthe, The Netherlands on 10/10/2024. Photo courtesy of Emil Kraaikamp.



5. Impacts