



# Space weather activities in Tunisia

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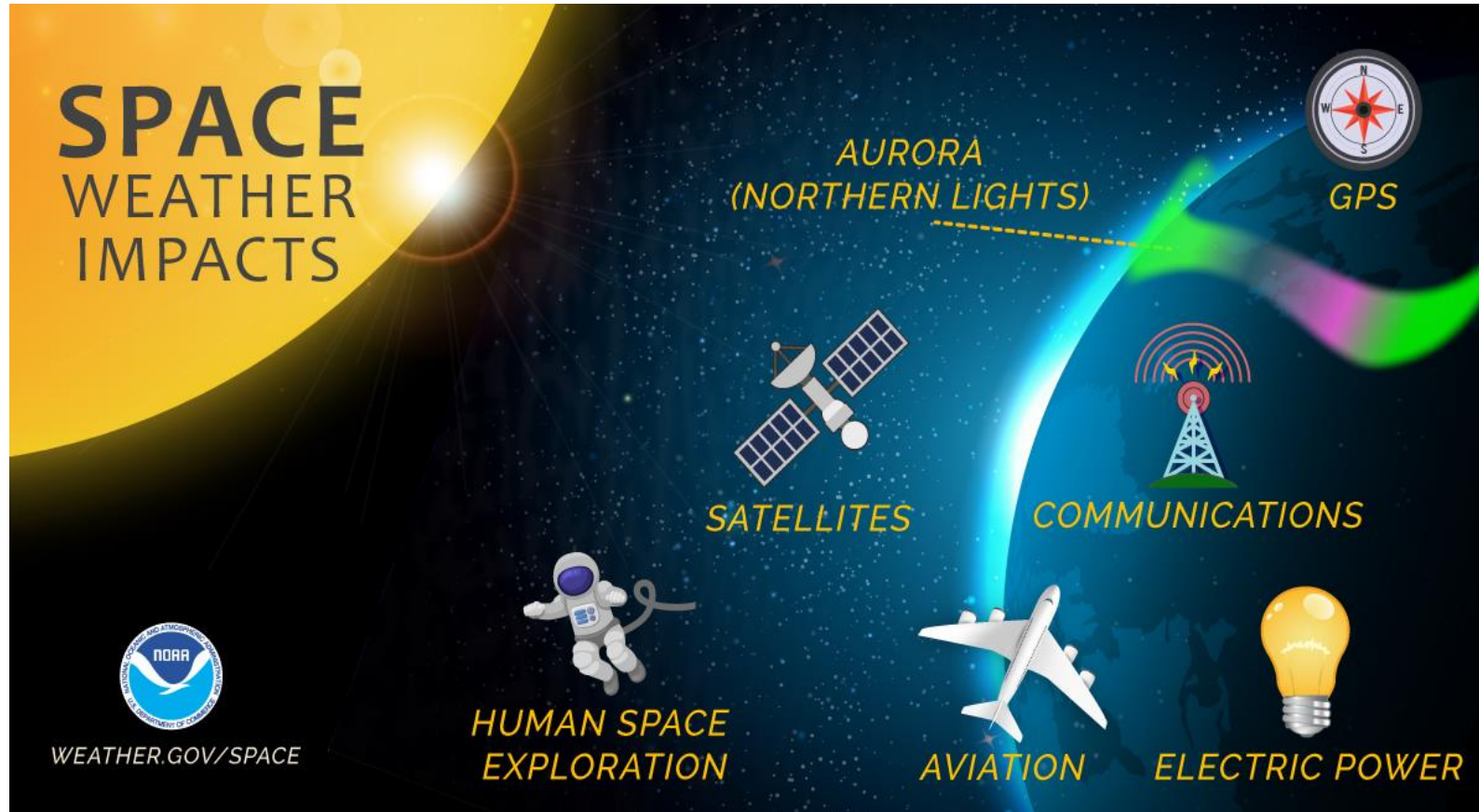
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 TUNISIA

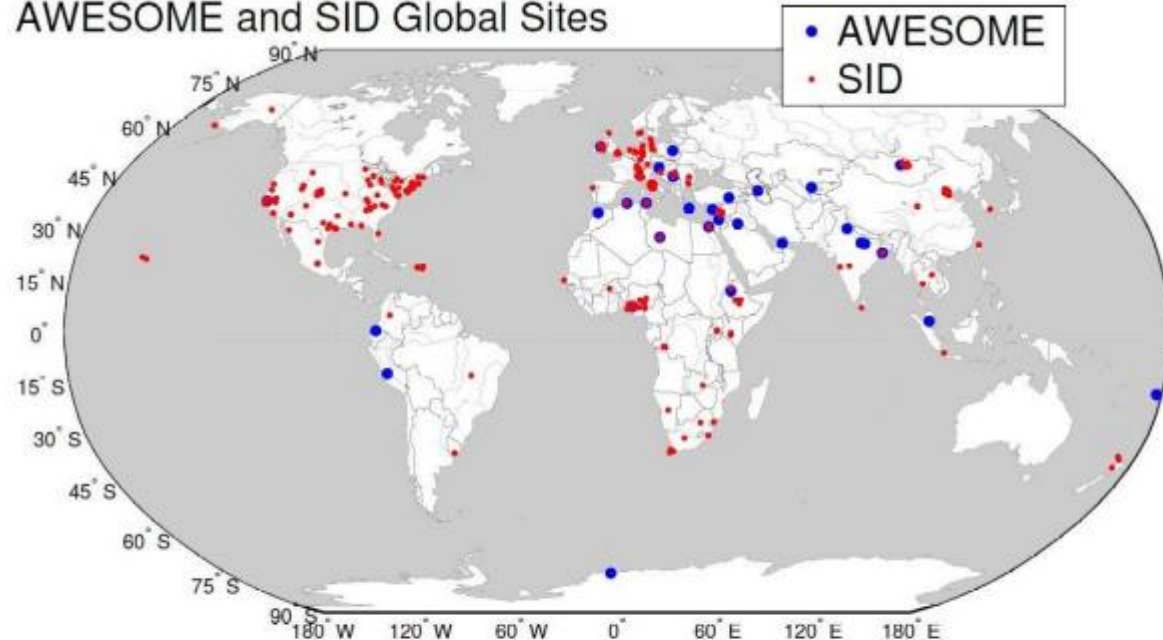
# I. VLF-LSAMA: Context of the research

## Space weather



## II. ELF/VLF/LF receiving stations (3Hz-50 kHz)

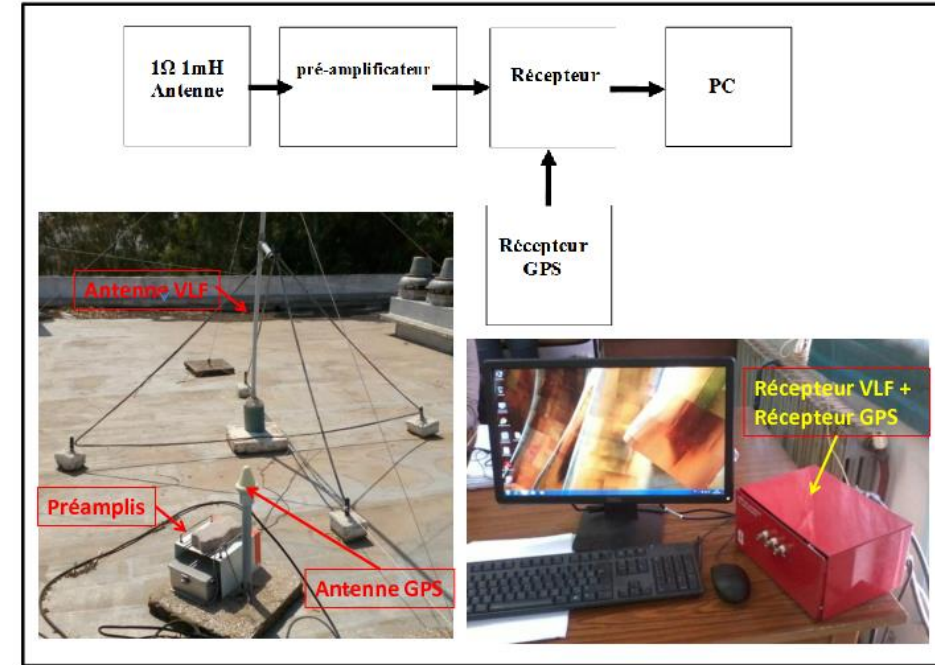
AWESOME and SID Global Sites



Georgia Institute  
of Technology

University of Colorado  
Denver

Stanford  
University



**AWESOME (Atmospheric Weather Electromagnetic System for Observation Modeling and Education)**

**Acknowledgment :**

**Dr. Morris Cohen**

Georgia Institute of Technology



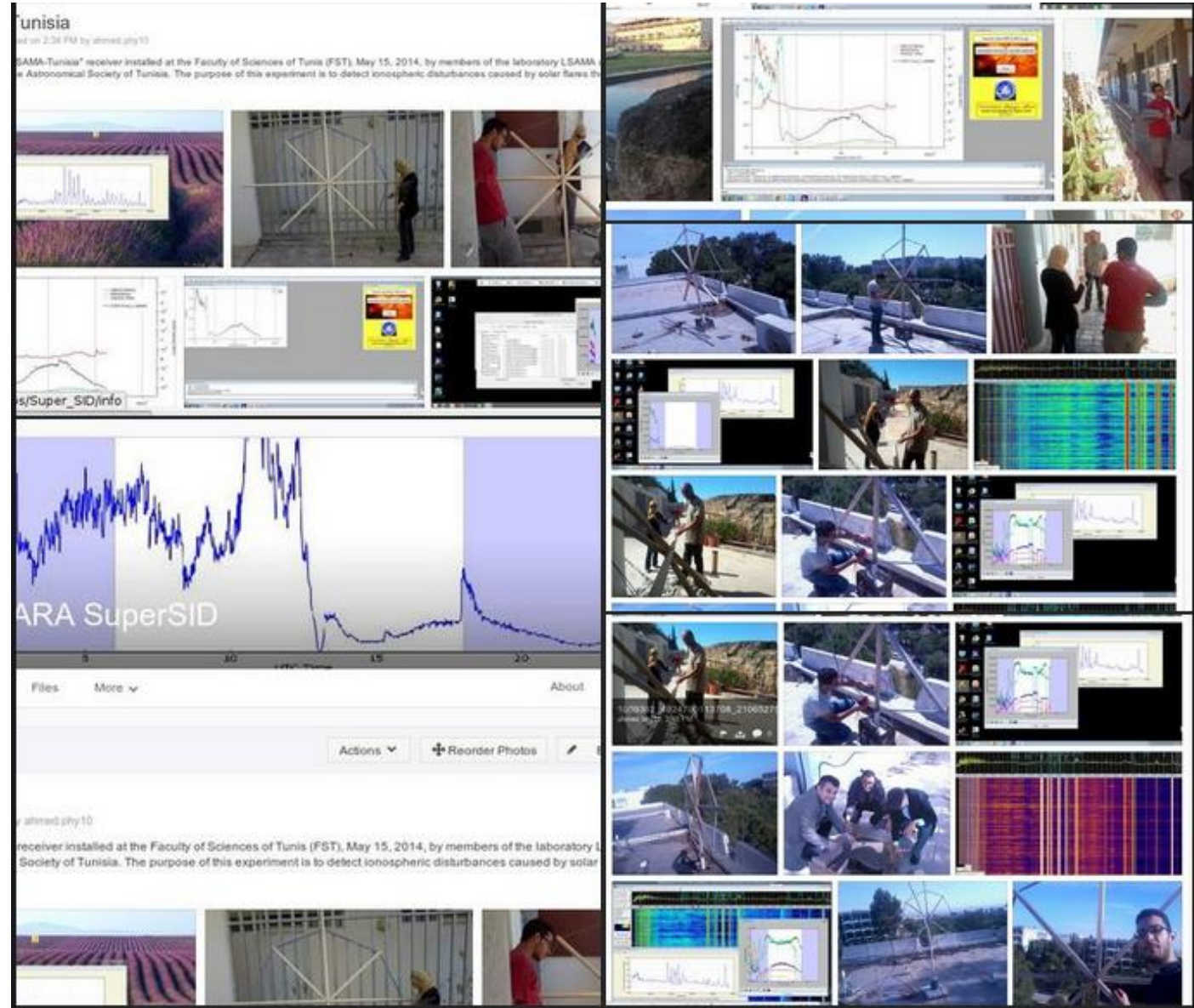
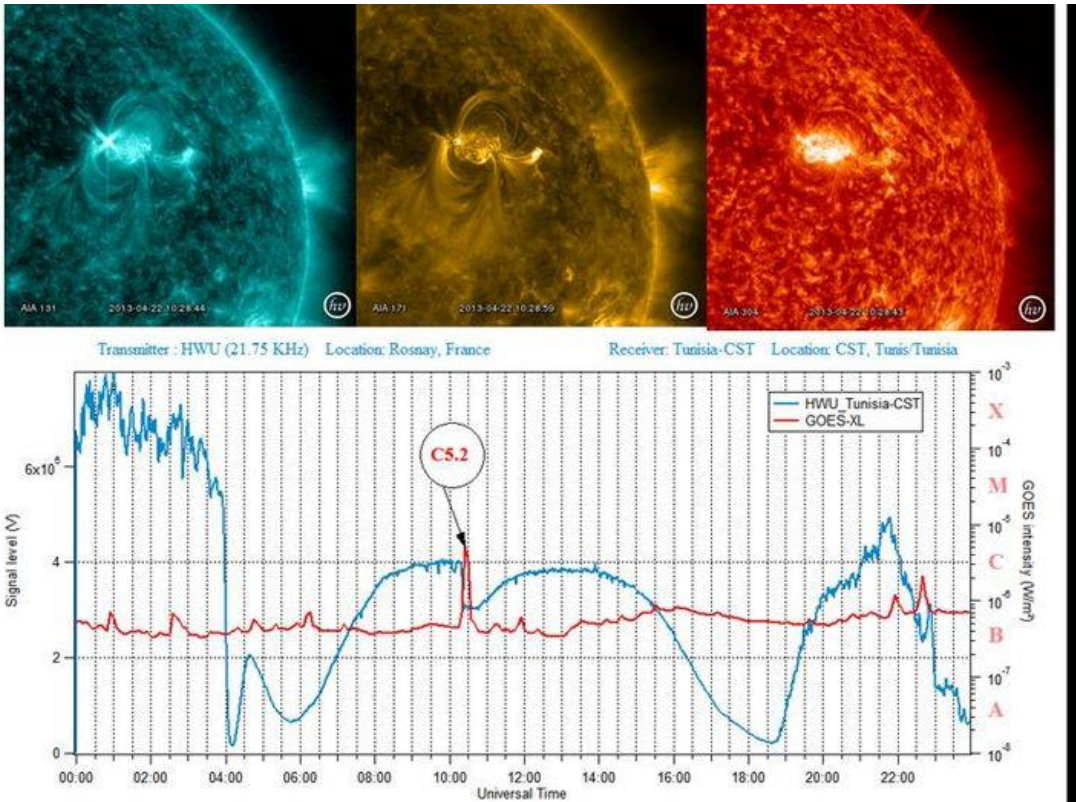
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### SuperSID instruments

**Acknowledgment :**

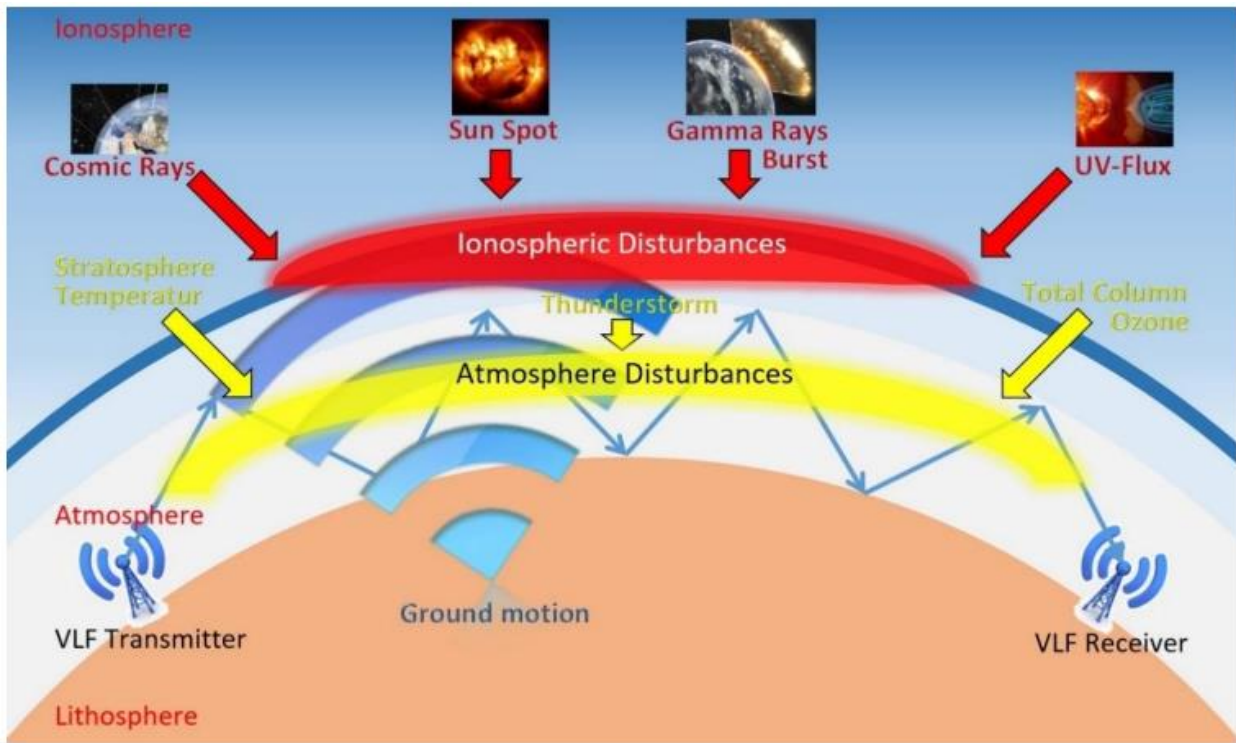
**Deborah Scherrer**

Stanford University

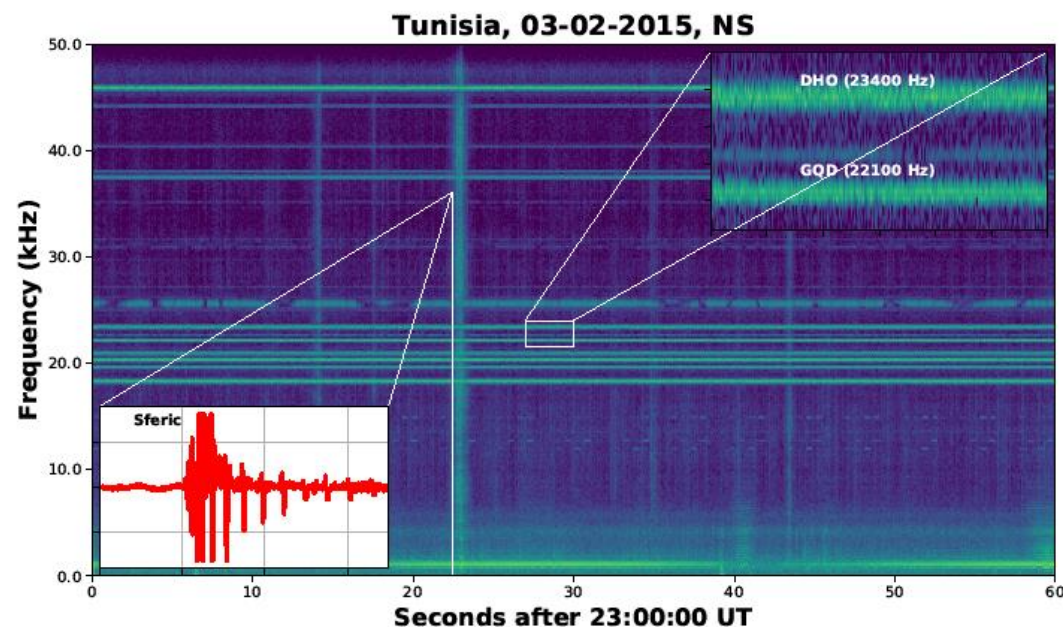
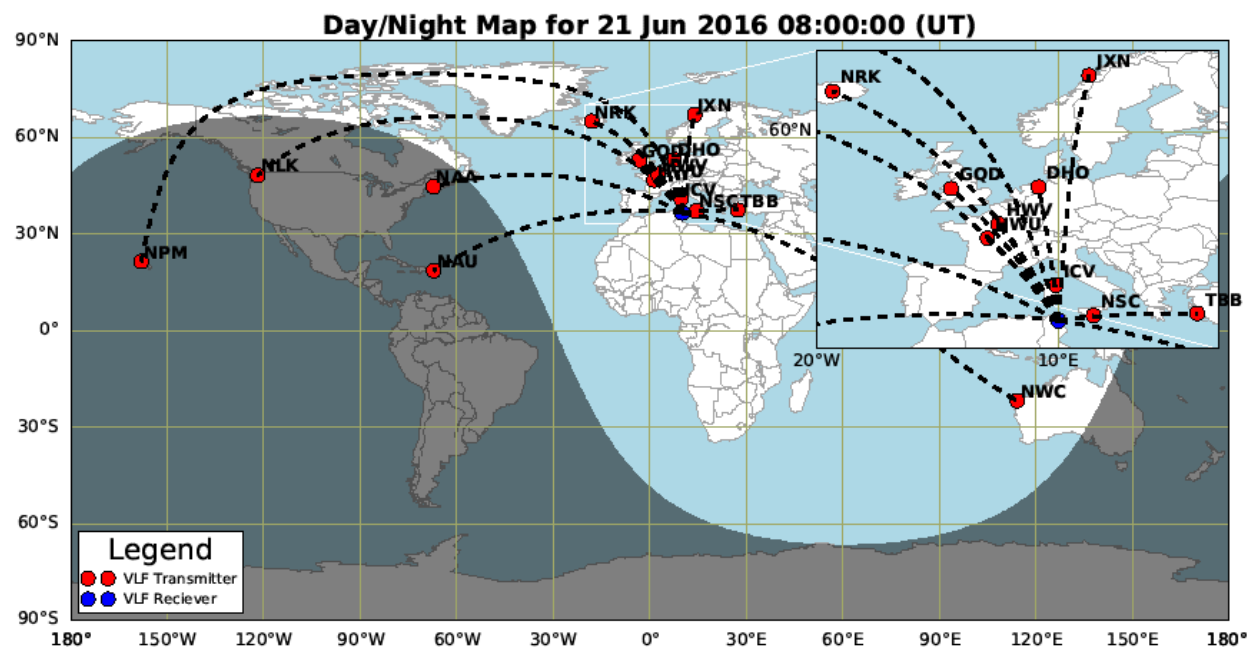




# III. Observations and measurements

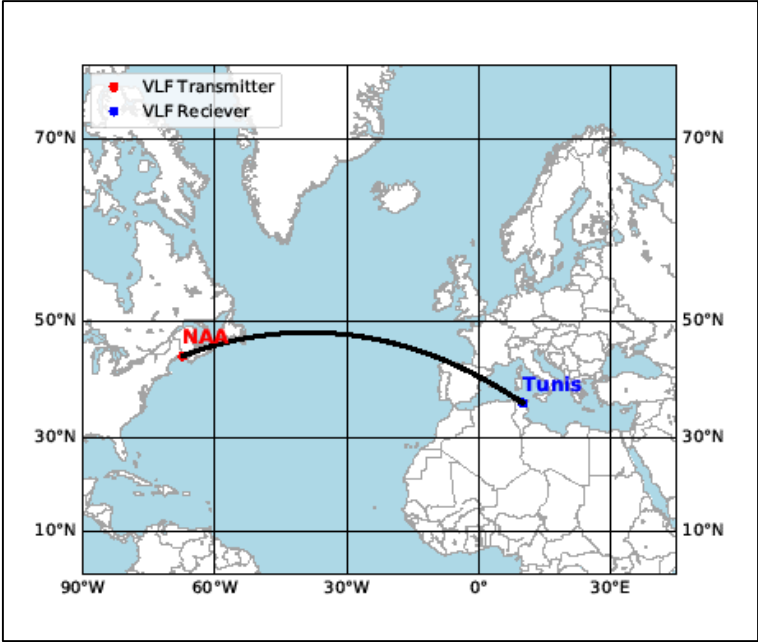
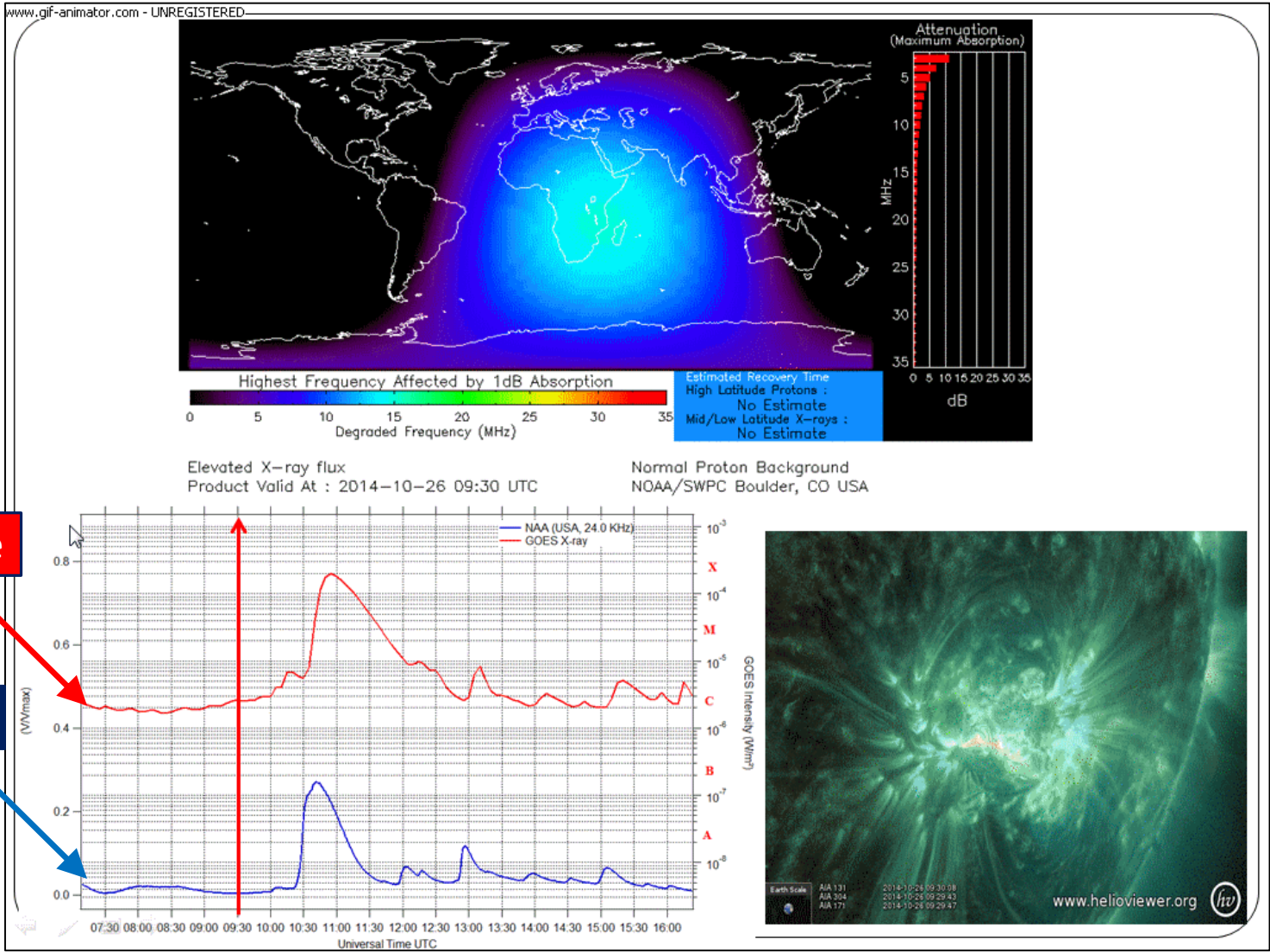


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# III. Observations and measurements

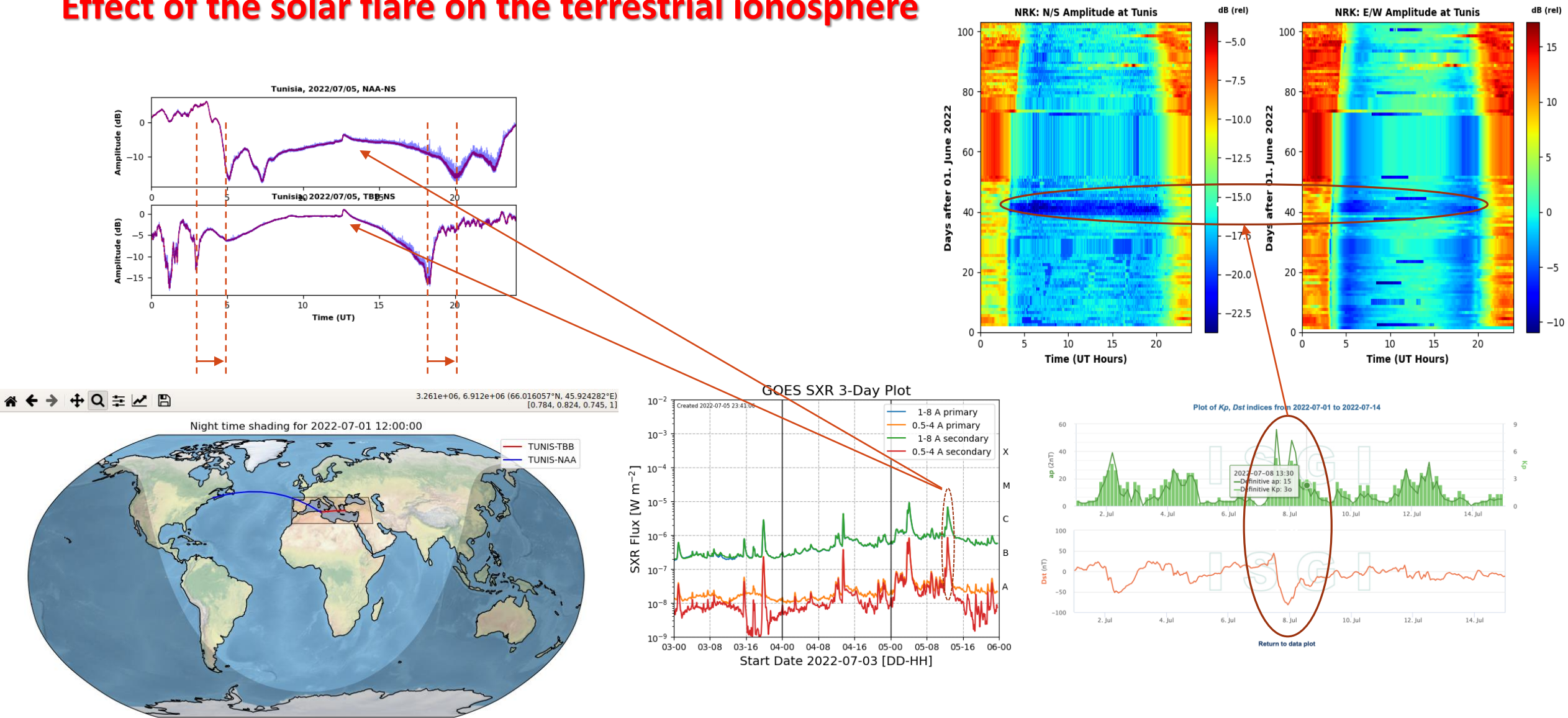
## Effect of the solar flare on the terrestrial ionosphere





# III. Observations and measurements

## Effect of the solar flare on the terrestrial ionosphere

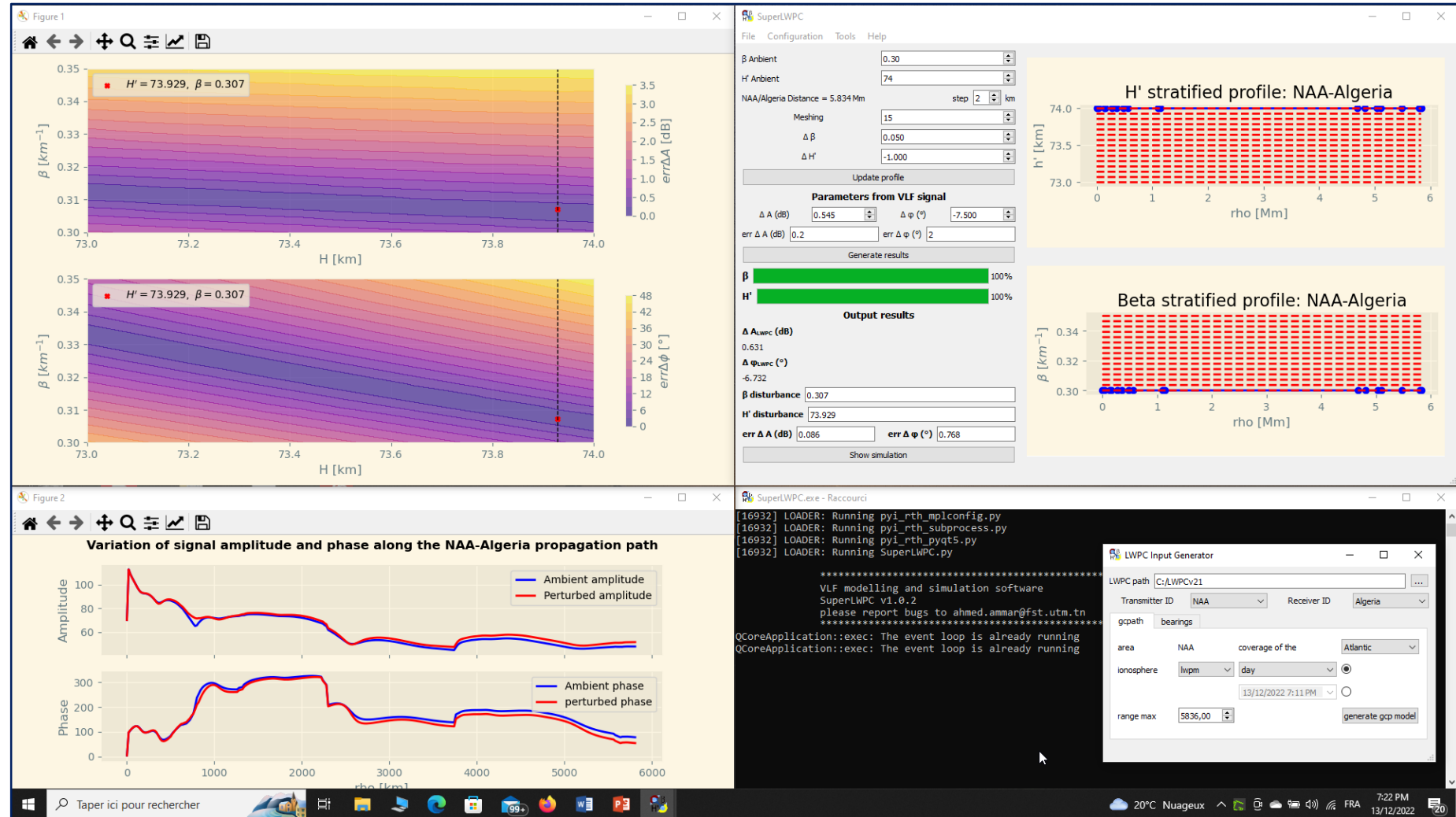


# IV. Modelling and Simulations (SuperLWPC)



Open Source software : SuperLWPC <https://github.com/lwpc-gui/SuperLWPC>

The determination of the coefficients  $H'$  and  $\beta$  is done interactively during which we seek to minimize the deviation between the measured ELF/VLF/LF signal perturbations and the introduced model.





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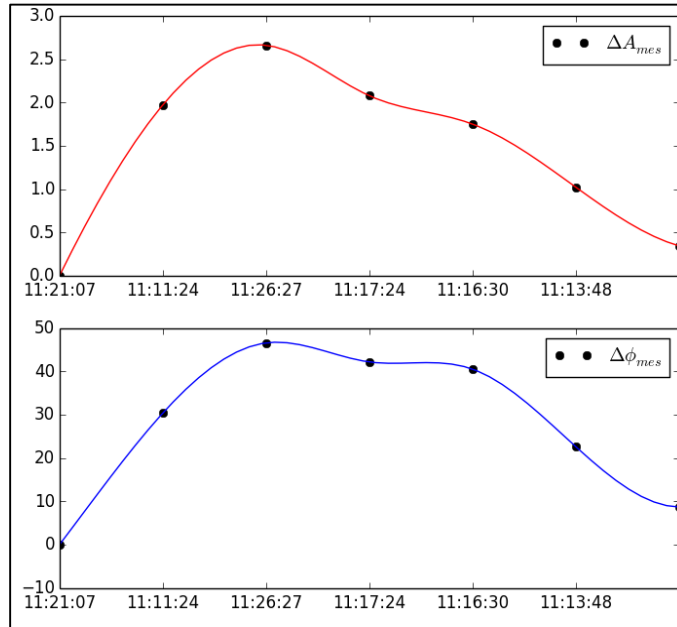
The screenshot shows the Zenodo website with the search results for 'superlwpc'. The page displays the dataset 'SuperLWPC' by Ammar, Ahmed; and Ghailia, Hassen, dated December 19, 2022 (1.0.3). The description states: 'The LWPCv21 code is a set of programs that can be used according to the user's needs. The determination of the coefficients  $H'$  and  $\beta$  is done interactively during which we seek to minimize the deviation between the measured ELF/VLF/LF signal perturbations and the introduced model. This process was done on December 26, 2022. 1 more version(s) exist for this record'. The page also includes filters for Access Right (Open), File Type (Zip), and Type (Software).

The screenshot shows the GitHub repository page for 'lwpc-gui / SuperLWPC'. The repository is public and has 13 commits. The file list includes: assets, config, gui, lwpcv21\_linux, lwpcv21\_win, .gitignore, CITATION.cff, Data\_Loader.py, LICENSE, and README.md. The repository description is: 'Graphical user interface of the LWPC code for investigating ionospheric D-region parameters.' The repository also has a README, MIT license, and 0 stars.

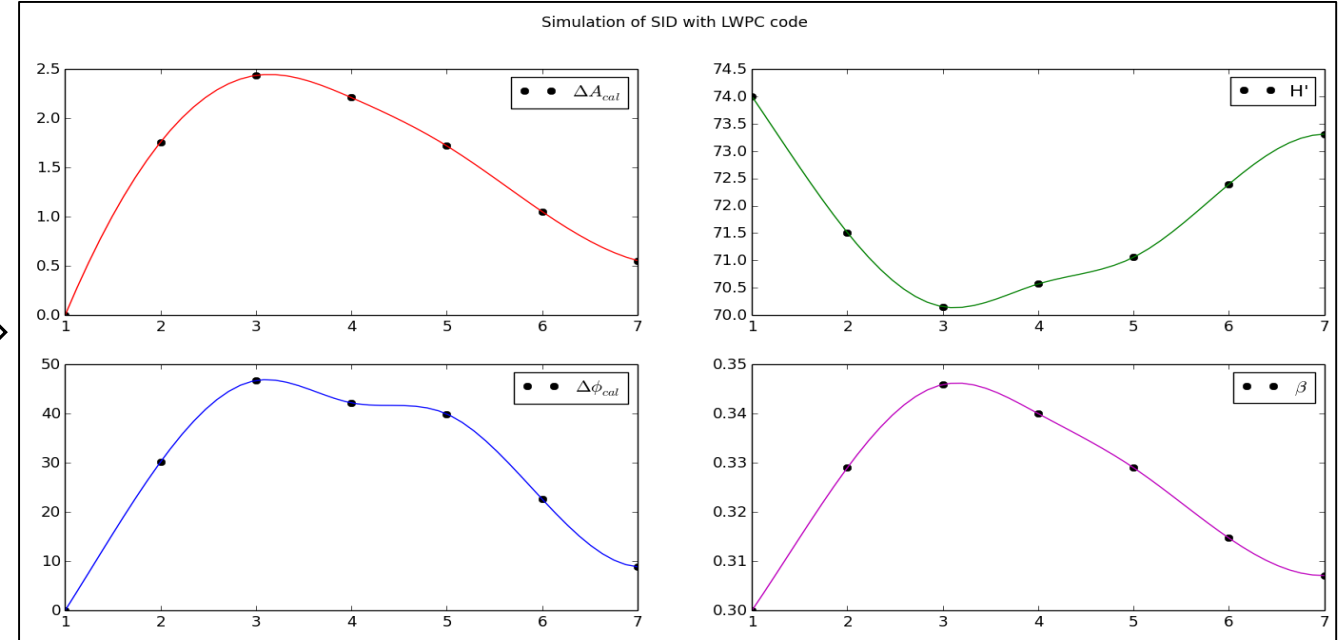
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In our study, the Long Wave Propagation Capability (SuperLWPC) software was used to model the D region ionosphere during solar flares.



MEASUREMENT OF AMPLITUDE (dB) AND PHASE (°) DURING THE RECORDING OF SOLAR FLARE



AMPLITUDE (dB) AND PHASE (°) VLF CALCULATED from the LWPC model.

Estimated values of the change in ionospheric parameters of Wait H' (km) and β (km<sup>-1</sup>)

In the LWPC, we use the empirical model of Wait (Wait and Spies, 1964) for the electron density profile valid up to 100 Km altitude.

$$N_e(h, t) = 1.43 \cdot 10^{13} e^{0.15h'(t)} e^{(\beta(t) - 0.15) \cdot (h - h'(t))} \quad (cm^{-1})$$

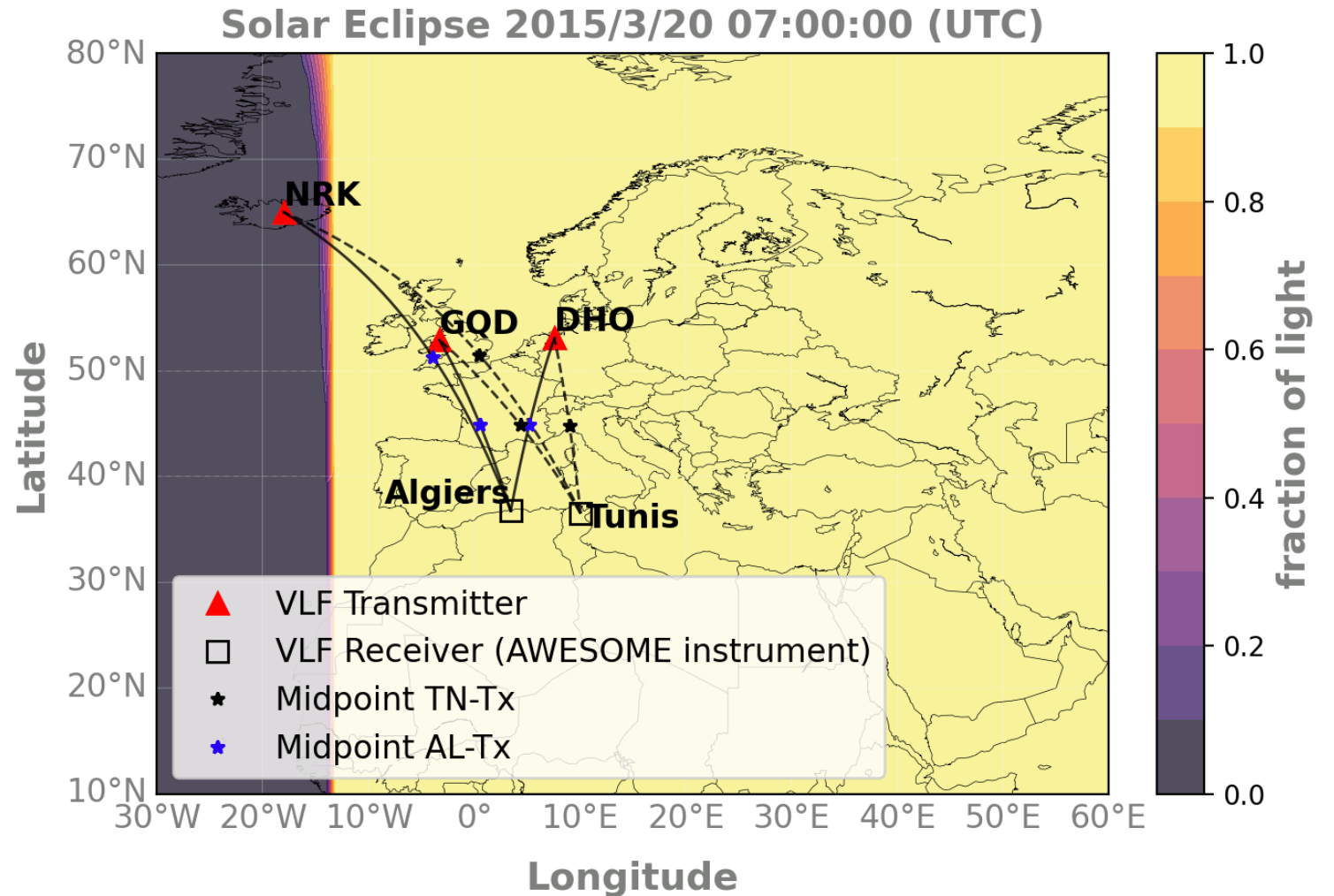
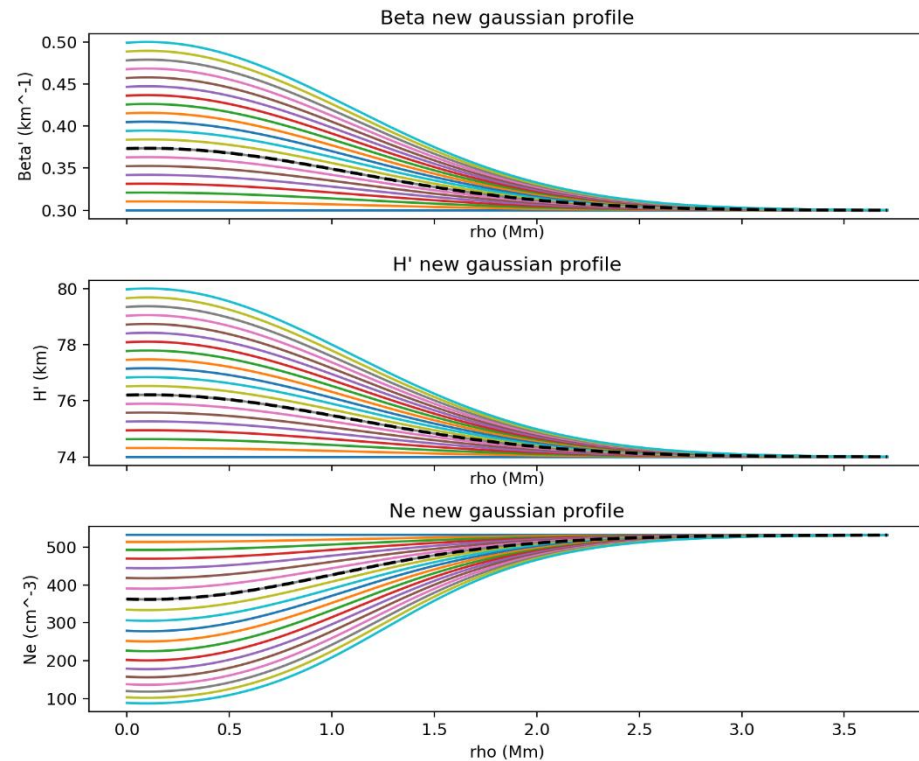
- $h'$  (km) : The effective reflection height
- $\beta$  (km<sup>-1</sup>) : The sharpness



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**THANK YOU!**