

Space Weather and Society: CITEUC's contributions



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Space Weather: societal impact



***What about
Portugal/Coimbra?***



- OGAUC's produces solar and geomagnetic observations relevant for the study of S.W.
- CITEUC's know-how in wide array of fields:
Astrophysics, Geophysics, Remote sensing, Geology, Physics. Mathematics, etc.
- Decided to create a laboratory for the monitorization and mitigation of SW effects: Space-Planetary Interactions Monitoring and Forecasting Laboratory
Pi: T. Barata & J. Fernandes
- Service to be used as a support to human activities
- Feb. 2018 - web portal for the monitorisation of SW events:
http://mat.uc.pt/~obsv/SPINLab/SPINLab_home.php

SPINLab portal

SL SPINLab

www.mat.uc.pt/~obsv/SPINLab/SPINLab_home.php

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CENTRO DE INVESTIGAÇÃO
DA TERRA E DO ESPAÇO
UNIVERSIDADE DE COIMBRA

SPINLab
Space-Planetary Interactions Monitoring and Forecasting
Laboratory

Observatório Geofísico e Astronómico
UNIVERSIDADE DE COIMBRA

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SPINLab - Home

The Space-Planetary Interactions monitoring and forecasting Laboratory (SPINLab) is dedicated to Space Weather. Space Weather describes the variations in solar activity that by interacting with Earth affect the performance of technological systems with an impact on economical activities and the life of populations.

SPINLab has access to 150 years of continuous observations of the geomagnetic field and the Sun acquired by University of Coimbra, counting also on the expertise in this field of Centro de Investigação da Terra e do Espaço da Universidade de Coimbra's (CITEUC) researchers.

This web portal makes available the most recent data that allow to follow the Space Weather conditions.

Space-Weather current conditions

X-Ray flux

GOES X-ray Flux (1-minute data) Begin: 2019 Jun 29 00:00 UTC

Updated 2019 Jul 1 15:11:12 UTC NOAA/SWPC Boulder, CO, USA

Proton flux

GOES15 Proton Flux (5 minute data) Begin: 2019 Jun 29 00:00 UTC

Updated 2019 Jul 1 15:11:02 UTC NOAA/SWPC Boulder, CO, USA

Local K index

Kcoi

PT EN

News:

- 25/19 20:00 UTC
Identification of a possible mechanism for the sudden variations (jerks) of the secular variation of Earth's magnetic field that occur every 3 to 12 years. This phenomenon seems to be correlated with rising blobs of metal formed at Earth's core. (Source: [ESA](#))
- 15/1/19 18:00 UTC
The International Civil Aviation Organization (ICAO) selected SANSa (South African National Space Agency) as a regional provider of space weather information to all flights crossing African airspace. (Source: [SANSa](#))

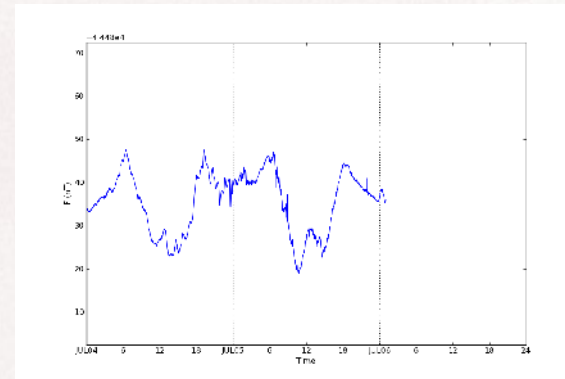
Alerts:

- 16/12/18
Warning: Electron 2MeV Integral Flux exceeded 1000pfu - Begin Time: 2018 Dec 10 2010 UTC - Potential Impacts: Satellite systems may experience significant charging resulting in increased risk to satellite systems. (source: [NOAA/SWPC](#))
- 21/11/18
Warning: Repairs at COI geomagnetic station's facilities make it difficult to access its data from the outside.
- 13/11/18
Warning: COI geomagnetic

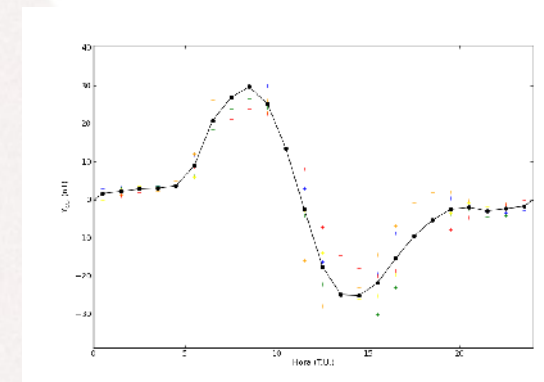
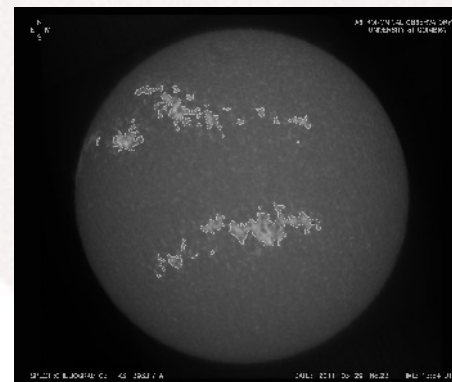
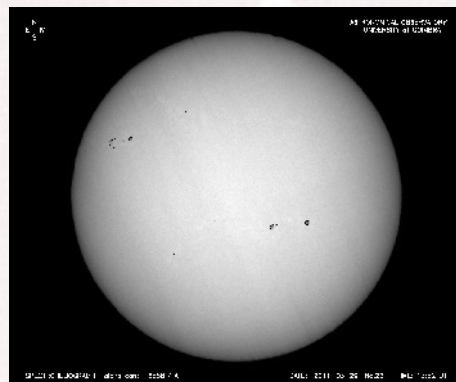
- OGAUC's solar & geomagnetic obs.
- CITEUC & UNINOVA's processed data
- Relevant data from other sources: NOAA, NASA, DLR, SILSO, WDC-Kyoto, GFZ-Potsdam, etc.
- NOAA/SWPC's forecast

SPINLab portal

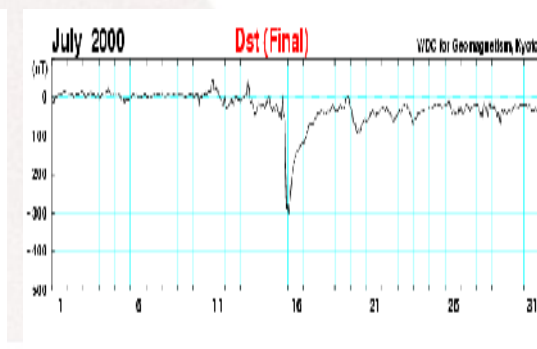
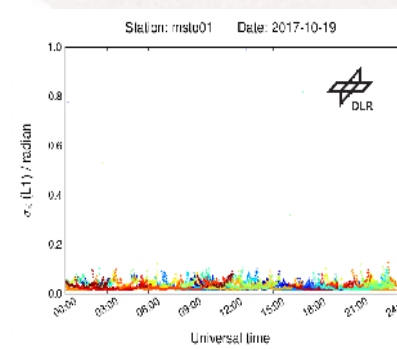
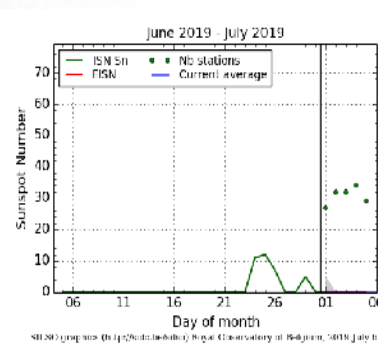
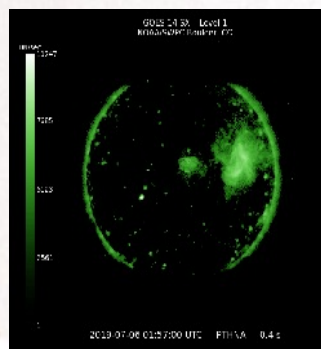
- OGAUC



- CITEUC



- Other



SPINLab portal



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Light pollution

Zenithal night sky brightness is one of the most used measurements of the level of light pollution on a given place. Using the standard measurement of magnitude per squared arcsecond (mag/arcsec^2 or mpsas), higher values represent darker skies. Far from light pollution sources, it is possible to reach above 22 mpsas on clear moonless nights, during astronomical night (Sun 18° below the horizon). That is the case of a pristine sky, nowadays rare. By contrast, the values of measurements over a light polluted city centre under the same astronomical conditions may not exceed 18 or 19 mpsas.

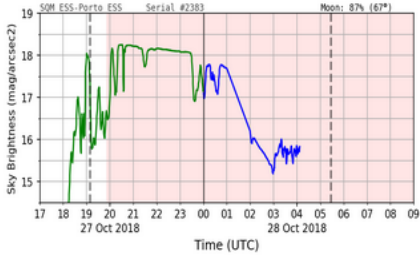
The measurements of the night sky brightness are dependent of the presence of clouds. Every estimate of the light pollution on a given place has to attend to this factor. The presence of clouds can be inferred from the graphs. On a strongly light polluted site, artificial light is reflected off the clouds increasing the total night sky brightness, when values as low as 14 or 13 mpsas could be reached. On a dark sky site, the opposite happens: clouds block the tenuous light from the stars, the natural skyglow and the Milky Way. In those circumstances, values could reach 23 mpsas.

Our measurements are taken every night using dedicated photometers, Unihedron Dark Sky Meters (one SQM-LU model, mounted at the Astronomical Observatory of Coimbra, and one SQM-LR model, installed at Escola Superior de Saúde do Politécnico do Porto). The SQM mounted at Escola Superior de Saúde do Politécnico do Porto courtesy of Salvador Bará – Faculdade de Física da Universidade de Santiago de Compostela, Galicia. Open access data. Please credit as: "Data from Raul C. Lima (CITEUC & ESS- PPorto), available from the Space Weather service SPINLab (Space-Planetary Interactions Monitoring and Forecasting Laboratory)."

The plots are produced using the free software **PySQM**. PySQM is a multi-platform, open-source software designed to read and plot data from Unihedron SQM-LE and SQM-LU photometers, giving as output files complying with the International Dark Sky Association (IDA) NSBM Community Standards for Reporting Skyglow Observations (<http://www.darksky.org/night-sky-conservation/248>). PySQM is distributed under GNU GPL, either version 3 of the License, or (at your option) any later version. See the file LICENSE.txt for details. This software has been developed by Mireia Nieves (UCM) with the invaluable help of: Jaime Zamorano (UCM), Laura Barbas (OAN) & Pablo de Vicente (OAN).

Coordinates of the SQM at ESS-PPorto: [Porto, 41.17734693977744N, - 8.606102155804138, alt. 109 m](#)

Sky brightness



SQM ESS-Porto ESS Serial #2383 Moon: 87% (67°)

Sky Brightness (mag/arcsec^2)

Time (UTC)

PT  EN 

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

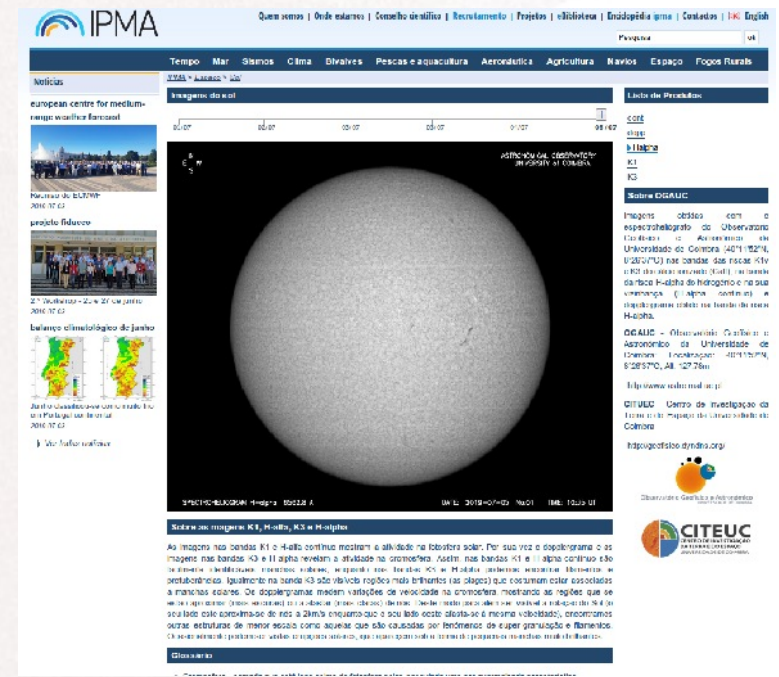
COMPETE 2020  PORTUGAL 2020

 UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional

- Other observ.:
light pollution
COI seismic data
- CITEUC's S.W.
publications &
communications
- S.W. Glossary
- Links

S.W. beyond SPINLab

- UC's data shared with IPMA
- Outreach & Education



ISWI's goals include outreach & education
Pt coordinator: T. Barata (mtbarata@gmail.com)

Outreach activities incl. school/public visits,
participation in events (e.g. Ciência Viva no Verão)

PhD & MSc thesis: Y. Castillho, J Domingos, S. Carvalho,
A. Vasconcelos, S. Gomes, C. Francisco





What else?

Solar Risk Service - PTTI



- Portuguese Technology Transfer Initiative



- Identification of best business opportunities in oil, gas & aviation

PRESENT
TECHNOLOGIES

CITEUC
CENTRO DE INVESTIGACÃO E
DESENVOLVIMENTO TECNOLÓGICO



bluecover
SOLUTIONS BASED TECHNOLOGY

DCventures

EUC's coord. T. Barata



Air navigation



- ILS landing procedures are being replaced by GNSS procedures
- These are subject to S.W. events and jamming
- No European company currently addressing this issue

SWAIR – ESA Small ARTES



- 2015
- Viability study
- Identification of stakeholders
- CITEUC's coord. T. Barata

SWAIR – ARTES 20 Demonstrator



PRESENT
TECHNOLOGIES

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CORPORATE INSURANCE TECHNOLOGIES

CITEUC
CENTRO DE INVESTIGACOES E TRANSFERENCIA DE TECNOLOGIA DA UNIVERSIDADE DE COIMBRA

- 2017
- 600 k€
- UC's contribution:
 - UC's solar and geomagnetic data
 - CITEUC's know-how incl. S.W., data processing & analysis
- CITEUC's coord.: T. Barata

Other collaborators:

NAV
NAV Portugal, S. R. L.

ANAC
Autoridade Nacional de Aviao e Segurana
Portuguesa e Europeia

IPMA
Instituto Português
do Mar e de Atmosfera

NETJETS

SWAIR – ARTES 20 Demonstrator



Operational Status Monitoring

Provides real-time information about GNSS signal quality, delivers real-time alerts of signal discontinuities and monitors Space Weather events



GNSS Performance Assessment

Includes reports on the signal's performance over time, detailing accuracy, integrity, continuity and availability of the signal



Forecast & Planning

Provides short-term forecast of potential discontinuities in the GNSS signal due to Space Weather events

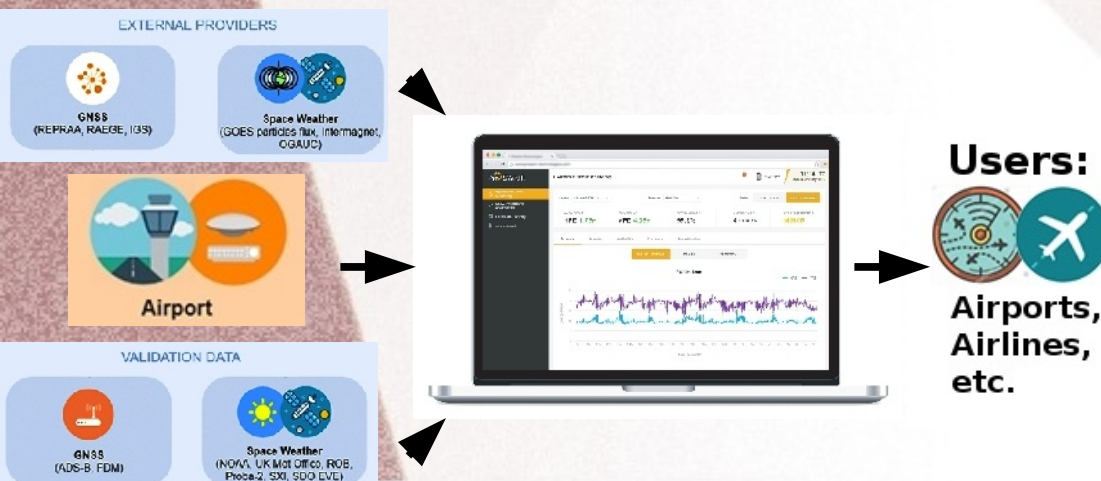


GNSS Data Recording

Raw GNSS data recording compliant with the ICAO regulations to assist in post-incident and accident investigations

- **Milestones:**

- **Baseline Design (actors & requirements)**
- **System Architecture and prototyping**



<https://swair.ptech.io/>

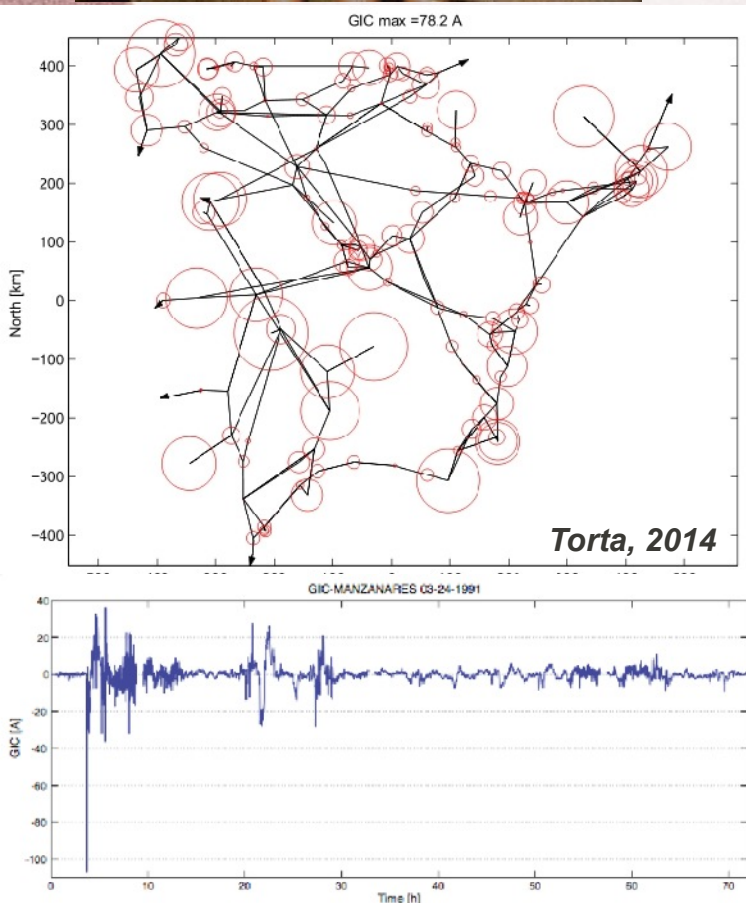


That's not all!

Geomagnetic Induced Currents



- Geomagnetic storms can induce currents in high voltage power grid (GICs), that enter through the grounding points → power transf.



- Despite being associated with high latitudes, intermediate latitude countries are conducting their own GIC studies
- What about Portugal?
(GIC accouts in telegraph lines)



FCT's 2017 call:

MAG-GIC - Geomagnetically induced currents in Portugal mainland (PTDC/CTA-GEO/31744/2017)

~240k€

PI: M.A. Pais (CITEUC)

Partnership:



**INSTITUTO
DOM LUIZ**

- **Project to assess the risk of GICs on the national high voltage power network**
- **Identification of magnetospheric currents causing GICs at intermediate latitudes**
- **Magnetotelluric survey of Portugal**
- **Transfer of COI magnetic station**



MAG-GIC partners/tasks:

- Relocation of the COI magnetic station (P. Ribeiro, CITEUC)
- Analysis of GIC inducing sources (A. Morozova, CITEUC)
- Crustal conductivity models (F. Santos, IDL)
- GIC simulations in the power grid (F. Pinheiro, CITEUC)
- Identification of magnetospheric GIC sources (M.A. Pais)
- Extra: detector for GIC measurements (J. Cardoso, UC)

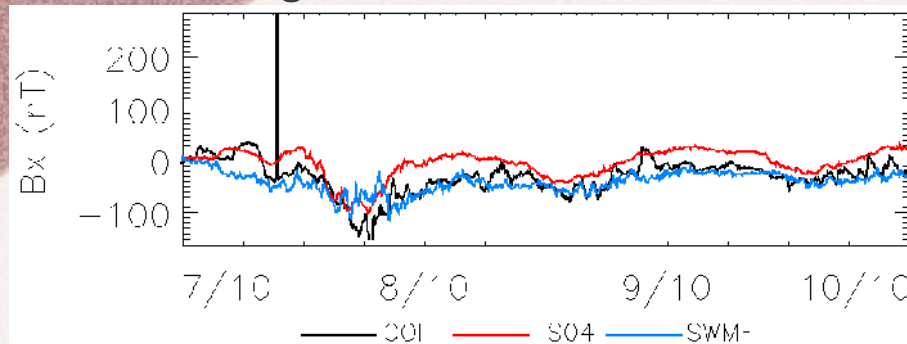
Other participants: J. Fernandes (CITEUC), M. Miranda (IDL/IPMA), J. Ribeiro

Collaborators/consultants: J. Cruz (IPMA), M. Mandaia (IAGA), M. Torta,



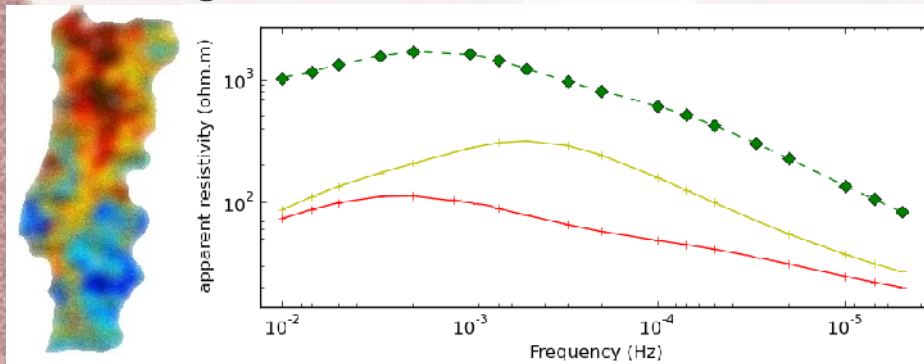
Computing MAG-GICs

Geomagnetic storm data

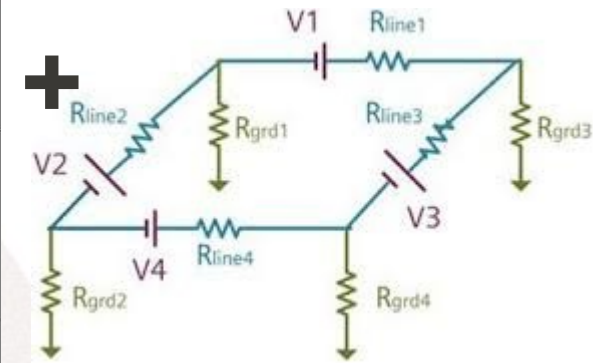


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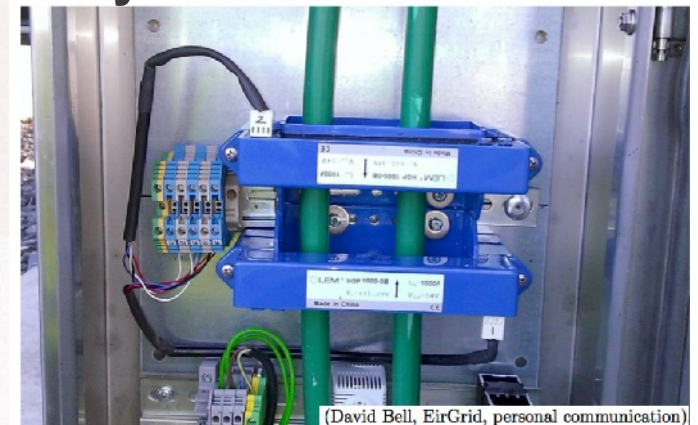
Magnetotelluric model



$$\begin{bmatrix} E_x & E_y \end{bmatrix} = \frac{1}{\mu_0} \begin{bmatrix} Z_{xx} & Z_{xy} \\ Z_{yx} & Z_{yy} \end{bmatrix} \begin{bmatrix} B_x & B_y \end{bmatrix}$$



Reality check...



(David Bell, EirGrid, personal communication)

Bonus: scientific outputs

@ EGU General Assembly 2019:

- Ionosphere vertical TEC calculated from GNSS receiver data in Lisbon: comparison with observations, T. Barlyaeva, T. Barata, A. Morozova (SWAIR)
- Scanning the crust with magnetospheric currents; F. Pinheiro, F. Santos, M. Pais, A. Morozova, P. Ribeiro, Y. Castillo, C. Francisco, J. Fernandes, M. Miranda (MAG-GIC)

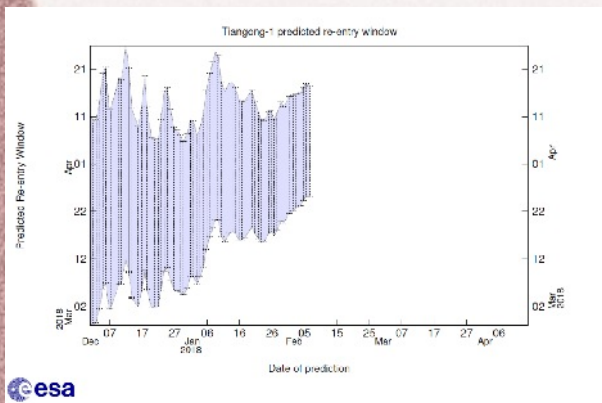
in the near future:

- **MAGIBER** (Sep. 2019): Observatórios e Estações magnéticas em Portugal: entre a tradição e a modernidade; P. Ribeiro, J. Cruz., F. Pinheiro, M. Pais, M. Cruz
- **ESWW** (Nov. 2019): Geomagnetic induced currents in south-western Iberia. F. Pinheiro, J. Ribeiro, F. Santos, M. Pais, A. Morozova, P. Ribeiro, Y. Castillo, C. Francisco, J. Fernandes

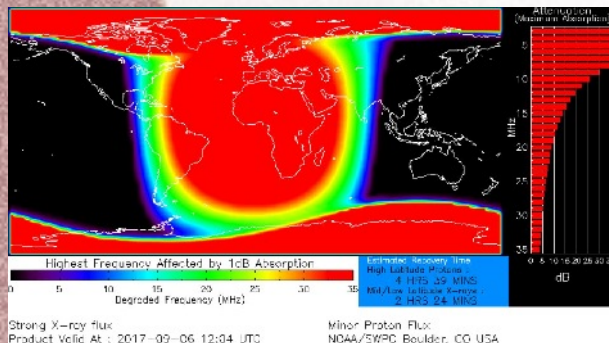
Future



- Further developments of SPINLab: tools, calibrated data, applications...
- Several sectors remain unexplored → New partnerships to develop...



- CITEUC has the skills and willpower to tackle these challenges



“His move testifies of a broader scientific view and of a flexible approach to problem solving”
FCT evaluation panel

Conclusions

- **SW can have impact in Portuguese human activities
→ threat & opportunity**
- **Portuguese fundamental space science institutions can
generate knowledge with societal applications**
- **CITEUC is a good example of that: SWAIR (global nav.)
& MAG-GIC (power transmission)**
- **Applied science projects can still be used to achieve
fundamental science results
*just be creative!...***

Thank you!!!

Cofinanciado por:



UNIÃO EUROPEIA
Fundo Europeu
de Desenvolvimento Regional