Earth Observation

Centre for Doctoral Training

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SENSE EO CDT (FAO Eleanor Graham)

School of Geosciences

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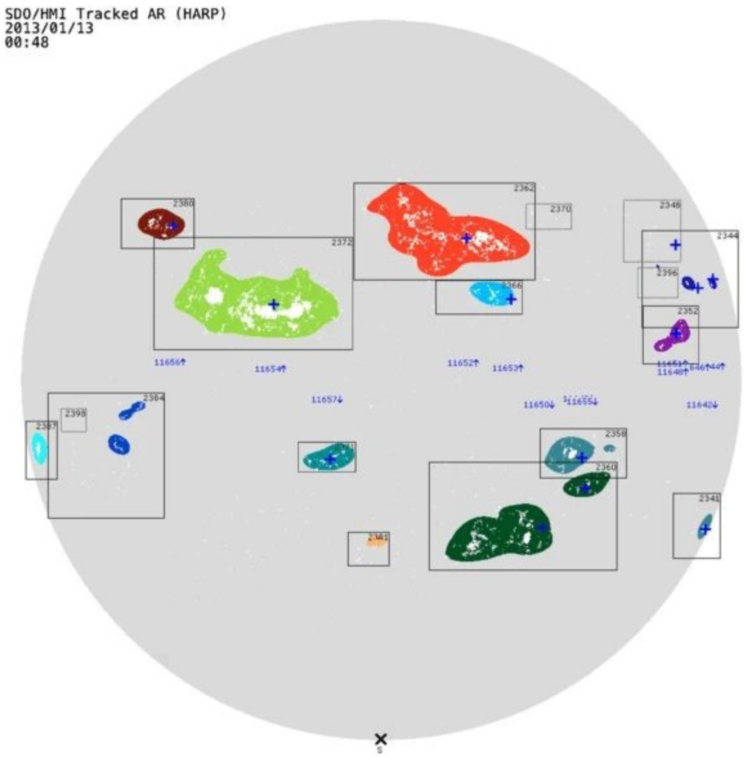
Using machine learning to predict the timing, magnitude and impact of solar flares from satellite imagery

Supervisors: Professor Kathy Whaler, Dr Ciaran Beggan (British Geological Survey)

Institute: University of Edinburgh

Department: School of Geosciences.

Please note this placement is in person only



Automatic detection and classification of active regions on the sun from magnetograms taken by the Helioseismic and Magnetic Imager on board the Solar Dynamics Observatory (Bobra et al., 2014)

Solar flares are dramatic eruptions of radiation from the Sun's surface. Magnetic flux emergence on the Sun's surface is found to be strongly linked with flare strength and likelihood [1]. The Helioseismic Magnetic Imager (HMI) aboard the Solar Dynamic Observatory (SDO) satellite takes continuous observations of the Sun's magnetic field and uses those data to calculate a number of parameters - many relating to magnetic flux [2]. Machine learning is a powerful tool and has shown strong potential for flare forecasting [3]. The aim of this project is to build on the groundwork from a summer project completed in 2021 which correlated flux emergence parameters with flare strength indicators (namely X-ray flux) and use this to develop a machine learning algorithm which can be trained on HMI data to compute a flaring probability and strength/class estimate within a set timeframe (e.g next 1, 4, 6 or 12 hours).

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The project would have four broad steps:

1: Create training and evaluation datasets which pair historic HMI data with known flare events from NOAA flare summary archive.

2: Research and then develop a neural network which takes a NOAA active region as an input, which accesses relevant HMI parameter data and calculates a probability of a flare event and class estimate. The project would initially begin with the R parameter with aim to expand to more parameters such as the total unsigned flux and helicity.

3: Train algorithm using datasets, tune model parameters, and test prediction capabilities on real time data (this stage will involve a lot of code optimisation).

4: Investigate the impacts of the findings above for space weather.

The student would visit the British Geological Survey space weather operations section (at their Lyell Centre, Riccarton office), and the Eskdalemuir Geomagnetic Observatory, where continuous ground measurements of the magnetic and electric field are made. The student would also liaise with, and hopefully visit, the University of Leeds and Dublin Institute for Advanced Studies groups working on space weather forecasting using machine learning.

[1] Schrijver. (2008). A Characteristic Magnetic Field Pattern Associated with All Major Solar Flares and Its Use in Flare Forecasting. The Astrophysical Journal Letters. 655. L117. DOI: 10.1086/511857

[2] Bobra. et al. (2014) The Helioseismic and Magnetic Imager (HMI) Vector Magnetic Field Pipeline: SHARPs - Space-Weather HMI Active Region Patches. Solar Physics, 289. DOI: 10.1007/s11207-014-0516-8

[3] Manolis. et al. (2021). The flare likelihood and region eruption forecasting (FLARECAST) project: flare forecasting in the big data & machine learning era. Space Weather Space Clim. 11 39. DOI: 10.1051/swsc/2021023

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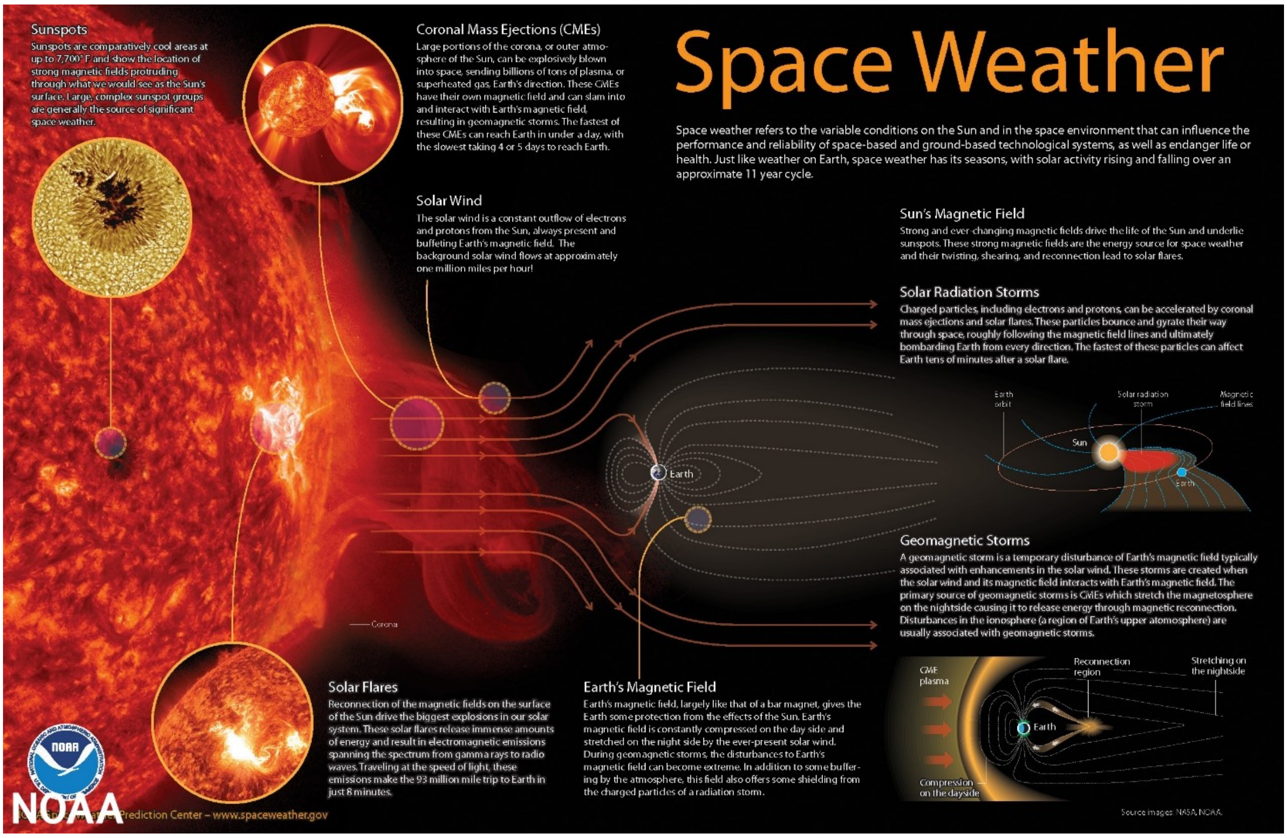

‘NOAA Infogram describing Space Weather’

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