

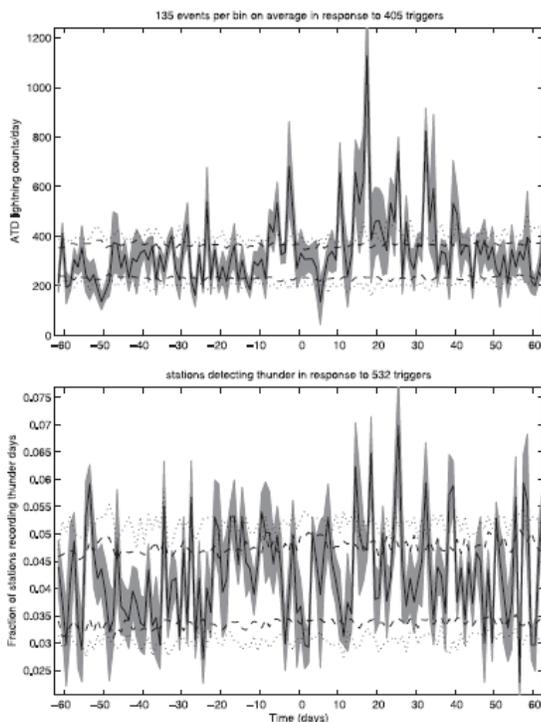


## Solar wind modulation of lightning

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Recent research by the Space & Atmospheric Electricity (SPATE) group at the university of Reading has demonstrated a clear modulation of lightning rates across Europe by the arrival of high-speed solar wind streams at Earth. Furthermore, the magnetic polarity of the solar wind has been shown to play a role. While the exact mechanism remains as yet unknown, evidence to date suggests that it could be through the modulation of galactic cosmic rays (GCRs) by the heliospheric magnetic field and/or by energetic particles within the solar wind. On arrival at Earth, these energetic particles are further affected by the Earth's magnetic field, which prevents all but the most energetic from being detected at the ground.



In this figure, taken from Scott et al. 2014, shows data from a composite analysis of many events. The top panel contains the median daily lightning rate over the UK as measured by the arrival time difference (ATD) system of the UK Met Office. The lower panel shows the median response in thunder days recorded at all UK Met Stations (scaled by the number of stations making measurements). Both show a significant enhancement to the passage of a solar wind stream at Earth (occurring at time zero)

Lightning forms part of the Global Electric Circuit, with thunderstorms acting like a battery, transferring charge from the Earth's surface to the lower ionosphere (the electrified part of the Earth's upper atmosphere starting at altitudes around 60 km). Since the ionosphere is electrically conducting, this charge is spread globally from the local thunderstorm regions, where it then leaks back to earth as a small vertical current in fair weather regions around the globe. Thus the ionosphere and the Earth's surface act as two plates of a spherical capacitor with thunderstorms charging the ionosphere to a potential of around 250 kV with respect to the surface and the weak conductivity of the atmosphere providing a pathway for this charge to leak back to the surface.

Prior research by the project supervisor has demonstrated that it is not just the lower ionosphere that is enhanced by lightning, with the concentration of electrified layers at around 100km being enhanced following lightning activity on the ground.

The ionosphere in the southern hemisphere is known to be anomalously weak compared with that in the northern hemisphere and, since most lightning occurs over landmasses in the northern hemisphere, lightning is one potential cause for this anomaly.

There is clearly much to be learned about the influence of the solar wind on the Earth's upper and lower atmospheres. Since the upper atmosphere and ionosphere are dominated by variations in solar activity and solar wind, any mechanisms which link the upper and lower atmospheres provides a conduit by which solar activity can influence the lower atmosphere. In their work to date, researchers within the SPATE group have demonstrated that the passage of a high-speed solar wind stream can increase the observed lightning rate by as much as 30%. Since such solar wind streams rotate with the 27 day rotation of the Sun, their arrival at Earth is very predictable. Such information could potentially help in forecasting the severity of lightning storms.

Having identified this new area for research, in this project, there is great scope for expanding the work to date to identify the mechanisms involved, determine the global extent of the effects and provide insight into the potential for improving lightning forecasts.

**Training opportunities:**

The student will have the opportunity to attend the two week-long STFC postgraduate summer schools on the Sun and Solar Terrestrial Physics. In addition they will be encouraged to present their work at meetings of the UK specialist communities such as the Royal Astronomical Society's Magnetosphere, Ionosphere and Solar Terrestrial (MIST) meetings, the Wilson Group and the National Astronomy Meetings. This PhD topic is of relevance to the international science community too and there will be opportunities to attend overseas meetings such as the American Geophysical Union (AGU), the European Geophysical Union (EGU) and additional smaller international meetings where possible. In addition, the research is highly relevant to meteorological forecasting and, through the department's academic partnership with the UK Met Office, there will be opportunities to discuss their work with instrumental scientists, operational forecasters and computer modellers. The student will also benefit from the academic courses taught within the department and will have the opportunity of attending numerous seminars on a wide range of topics given by world-leading national and international visiting scientists.

**Student profile:**

This project would be suitable for students with a degree in physics, mathematics or a closely related environmental or physical science. Prior knowledge of statistical techniques and the ability to write computer code are highly desirable, with additional tuition given if necessary

**References: (optional)**

Evidence for solar wind modulation of lightning

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Modulation of UK lightning by heliospheric magnetic field polarity, Owens, M. J.; Scott, C. J.; Lockwood, M.; et al., Environmental Research Letters, 9, 11, 2014

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