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Towards understanding the nature of any relationship between Solar Activity and Cosmic Rays with thunderstorm activity and lightning discharge

J. O'Regan, J-P. Muller, and S. Matthews

Mullard Space Science Laboratory (MSSL), University College London (UCL), Holmbury St. Mary, Dorking, RH5 6NT, United Kingdom (jjo2@mssl.ucl.ac.uk)

The runaway breakdown hypothesis of lightning discharge has predicted relationships between cosmic rays' interactions with the atmosphere and thunderstorm production and lightning activity. Precipitating energetic particles lead to the injection of MeV-energy electrons into electrified thunderclouds [1,2], resulting in runaway breakdown occurring, and assisting in the process of charge separation [2]. Previous lightning studies show that correlations to solar activity are weak but significant, with better correlations to solar activity and cosmic rays when carried out over smaller geographical areas [3,4,5,6] and over longer timescales [6].

In this work, correlations are explored between variations of SEPs and lightning activity levels at various spatio-temporal scales. Temporal scales span from short-term (days) scales surrounding large Earth-directed coronal mass ejection (CME) events to long-term (years) scales. Similarly, spatial scales span from 1-degree x 1-degree latitudinal-longitudinal grid scales to an entirely global study, for varying timescales. Additionally, investigation of correlation sign and statistical significance by 1-degree latitudinal bands is also employed, allowing a comparative study of lightning activity relative to regions of greatest – and contrasting regions of relative absence of – energetic particle precipitation. These regions are determined from electron and proton flux maps, derived from measurements from the Medium Energy Proton and Electron Detector (MEPED) onboard the Polar Orbiting Environmental Satellite (POES) system.

Lightning data is obtained from the World Wide Lightning Location Network (WWLLN) for the period 2005 to 2011. The correlations of lightning strike rates are carried out with respect to Relative Sunspot Number (R), 10.7cm Solar radio flux (F10.7), Galactic Cosmic Ray (GCR) neutron monitor flux, the Ap geomagnetic activity index, and Disturbance Storm Time (DST) index.

Correlations show dramatic variations in both sign and significance over small geographic distances, similar to previous results [3,4,6], highlighting the complexity of the atmospheric processes contributing to the mechanism of thunderstorm generation and lightning discharge. We find correlations are generally more significant over larger timescales, as daily meteorological variability is smoothened out, suggesting a role for changing Solar activity levels in influencing thunderstorm development and onset of lightning discharge.

Comparisons of small-scale correlation results to planetary wave patterns suggests an influence over the correlations of lightning activity to the above indices, as proposed by Schlegel et al. [6], and previously suggested by the results of Fritz [3] and Brooks [4]. Our results show agreement with Schlegel et al. [6] for the same region over Germany, but are in disagreement with their results for Austria. This lends support to the idea of the theory of planetary waves influence over correlation signs and significance across short geographic distances, as discussed by Schlegel et al. [6].

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[1] Ermakov, V.I. and Stozhkov, Yu.I., 2003. Cosmic rays in the mechanism of thundercloud production. 28th International Cosmic Ray Conference, pp. 4157–4160.

[2] Kirkby, J., 2007. Cosmic rays and climate. Surv Geophys, vol. 28 (5-6) pp. 333-375.

[3] Fritz, H., 1878. Die wichtigsten periodischen Erscheinungen der Meteorologie und Kosmologie. Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem, Deel III, Haarlem.

[4] Brooks, C.E.P., 1934. The variation of the annual frequency of thunderstorms in relation to sunspots. Quarterly Journal of the Royal Meteorological Society 60, 153–165.

[5] Stringfellow, M.F., 1974. Lightning incidence in Britain and the solar cycle. Nature 249, 332–333.

[6] Schlegel, K. et al, 2001. Thunderstorms, lightning and solar activity - Middle Europe. J Atmos Sol-Terr Phy vol. 63 (16) pp. 1705-1713