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Solar-Driven Geomagnetic Disturbances Impact Homicide Rates in Europe and the USA

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ABSTRACT

We argue that the similarity in the temporal patterns of international homicide rates recommends looking beyond local environment crime conditionings. We applied OLS (Ordinary Least Squares) regressions of geomagnetic variables on yearly homicide rates to identify the planetary drivers for homicides rates in Germany, the U.K., and the USA, over 1987 through 2018. We revealed that lagged Kp index for geomagnetic disturbances explained over half the variance in homicide rates in all three countries. We also predicted homicide rates peaking in the USA for 2025 and for Germany and the U.K. in 2026. Our study suggests that extending environmental approaches to include geomagnetic disturbances may help better understand human aggressive behavior and help forensic and medical authorities prepare for likely surges in violent behavior, as the current 25th solar cycle may induce stronger and more frequent geomagnetic disturbances.

Keywords: Homicide rates; GMD (Geomagnetic Disturbances); Solar storms

INTRODUCTION

Ours is a complementary and exploratory look into the role of broader and longer-term evolving drivers of homicides.

Considerable research effort was put into understanding the local environmental factors that induce assassination. Some of the main local environmental factors brought forward point to weather, inequalities, age structure, gender, race, gun ownership, and migrations [1-9].

However, because statistical detail is more readily available in cities rather than in countries, let alone in countries across several time zones, the intensity of the focus on detail has narrowed the environmental approach as well, mostly restricting it to cities and local weather. Alternatively, our complementary bird's eye focus on homicide rates in three countries reveals that similarities in the timing of homicides across the Atlantic Ocean deserve more complete explanations than those borne out of the detailed local focus alone.

Here, we expand the environment to include space weather, as it impacts on Geomagnetic Disturbances (GMD) and we argue that space weather may have played an overlooked but critical role in triggering homicidal intent. Graph 1 illustrates the case for Germany and the U.K. with yearly homicides rates in tandem with GMD. In the graph we omitted the USA data because its much higher homicide rates would dampen the message of the graphical illustration for Germany and the U.K., both offering longer time series than the USA.

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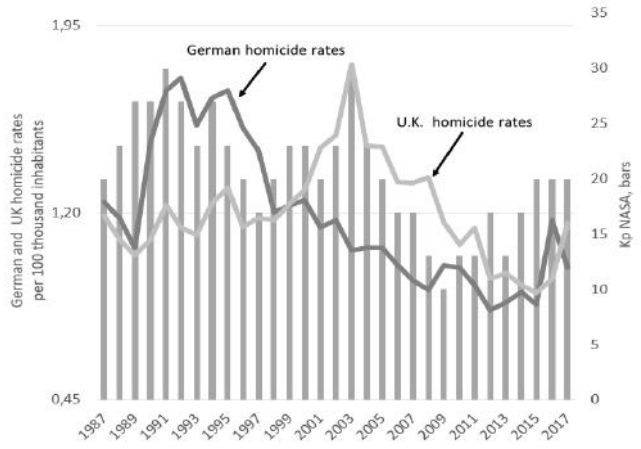

Graph 1: Solar-driven geomagnetic disturbances and homicide rates in the North Atlantic.

We measured GMD by Kp, as derived by the National Oceanic and Atmospheric Administration (NOAA) and reveal that homicide rates and Kp across countries show (1989-1995) upward trends and downward ones (2003-2012), in addition to concomitant up and down ticks through the entire period (1987-2017). During the three decades there also are remarkable periods of intense association of GMD with country homicide rates, such as in Germany from 1989 to 1999, and in the U.K. from 1998 through 2011, including for the U.K. a glaring association around the 2003 peak in both homicides and GMD.

Too focused on local conditions, mainstream explanations have not helped understand the above similarity in the pattern of homicide trends over time and across countries [10,11]. The frustration in the interpretation of homicide trends, international or not, has led to a hands-off attitude:

"Year-to-year changes in crime rates can be subject to random fluctuations..." [12].

"The real puzzle is not why crime fell in the 1990s, but rather, why crime did not begin falling earlier." [13].

"There is little consensus with respect to explanations for the falls in crime." [9].

"How much should we trust crime statistics?" [14].

We suggest we are in a Copernican moment. On the one hand, we have accumulating evidence of a temporal similarity in the homicide trends across countries; nonetheless, local environmental explanations might only perceive these facts as anomalies with no theory to interpret them.

Studies have documented the impact of GMD on human physiological disorders [15-17].

Scientists have also singled out the disruption of the circadian rhythm as a possible precursor of aggressiveness because a disruption of the circadian rhythm may excite the Hypothalamic Pituitary Adrenal (HPA) axis, causing hormonal disequilibrium, leading to aggressiveness [18-22]. There is a large body of evidence supporting hormonal influence on aggression [23-25].

The scientific evidence on GMD-induced alterations on human physiology dovetails with the Graph 1 illustration, suggesting that GMD might shape the timing of human aggressive behavior as expressed in the rate of homicides. That is why we turned to planetary factors to explain the international pattern of homicides over time.

We focused on homicides because those are well documented and more comparable across countries, and because homicides are highly correlated with other important forms violent human behavior. Our trend analysis approach suggests a complementary but overlooked element at play, triggering aggressiveness to the extent of simultaneously inducing homicidal behavior in different geographical regions with comparable forensic record-keeping development [11,26].

MATERIALS AND METHODS

Solar cycles take approximately 11 years to complete. During each solar cycle the number of sunspots and the magnitude of Kp waxes and wanes. Therefore, we needed reliable and comparable homicide data on countries that could offer it during a long period, and in the northern hemisphere, which is where 11 of the 13 stations contributing to the Kp index are seated [27]. That is why we chose to study the data on the USA, the UK and Germany, who altogether offer a population close to half a billion people.

We hypothesized that yearly homicides rates in Germany, the UK, and the USA, are affected by geomagnetic disturbances. We made publicly available all data used in our study, as well as the sources for such data.

We performed Ordinary Least-Squared (OLS) regression analysis on homicide rates where all index suffixes i varies for Germany, the UK, and the USA and t for the ones related to solar activity (Sunspots) and space weather (GMD), as in the following model:

$$\text{Homicide rate}_{it} = a_i + b_i (\text{index GMD}_{t\text{-lag}}) + \epsilon_{it}$$

We investigated the impact of GMD on homicide rates over 5-year lags (the same year of homicide to 5 years prior the event). Our analysis was performed in Excel and JASP.

RESULTS

The number of Sunspots showed a positive and relatively robust explanatory power for lags of up to four years; but the lagged Kp index for GMD produced the best fit for homicide rate trends with a two to three-year lag for all three countries. Overall, Kp explained over 50% of the variance in homicide rates for all three countries. The regression results for Kp are shown in Table 1.

	Germany	UK	USA
Yearly data lags	-2	-3	-3
Regression coefficient for Kp	0.031	0.047	0.071

Intercept	0.432	0.058	3.886
R squared	0.53	0.56	0.61
F statistic	32.61	36.36	27.80
Sample size	31	31	20

Note: Intercepts, Kp coefficients, and F Ratios are all significant at p ≤ 0,001.

Table 1: Regression results for homicide rates and geomagnetic disturbances.

Homicide rates forecast

To aid planning by public health policy and forensic bodies, we also forecasted homicide rates for the current solar cycle for the same three countries [28].

To predict homicide rates, we regressed homicide rates over total yearly Sunspot Numbers (SSN) for all countries as per the model below, where the suffix i varies for Germany, the UK, and the USA.

Homicide rate it=ai+bi (SSNt)+ϵit

We used SSN because there are reliable projections for sunspots, and because those are solar magnetic anomalies around which major expulsion of solar magnetic plasma might occur, triggering GMD on the Earth. In a sense, sunspots are an early warning of GMD, though there is uncertainty as to the attribution of some GMD to coronal mass ejections [27, 29].

Here we forecast the homicide rate based on the number of sunspots put forward by NCAR's McIntosh et al (2020a) which claims that the current 25th solar cycle might be one of the most intense in the last century and argues that the peak in the number of sunspots will take place in 2023, rather than in 2025, and that the number of sunspots might be 1.97 higher than the one offered for 2025 by the international NOAA co-chaired Solar Cycle 25 Prediction Panel (SC25PP) which has underestimated 24 times out of 25 the monthly number of sunspots since the "quiet" June 2020 month to July 2022, the last data available at the time of writing this paper. The frequent underestimation of sunspots number by SC25PP makes McIntosh's claim more attractive [30]. To our knowledge, McIntosh has not yet published his yearly sunspot number forecasts, except preliminarily through a figure in Youtube.com meeting. We grabbed the numbers from a figure offered on the 12th minute of that presentation, and we also make that data publicly available.

As shown in Table 2, our model results predict that homicide rates per 100,000 inhabitants will peak at 6.0 for the USA in 2025, implying a level of homicides not seen in the USA since 2003, a year with unusually strong GMD. The yearly homicide rate for Germany and the UK will peak a year later, in 2026, at 1.5 and 1.7, respectively, implying a level of homicides not seen in either country since the late 1990s (Table 2).

	Germany	UK	USA
Peak homicide rates, 100,000 inhabitants	1.5	1.7	6.0
predicted to peak in	2026	2026	2025
SSN yearly lags	Sunspots-3	Sunspots-4	Sunspots-3
Regression coefficients	0.002	0.002	0.005
Intercepts	2.012	1.321	4.824
R squared	0.221	0.078	0.391
F statistics	8.24	2.45	11.555
p-value, for F-stat above	0.008	0.128	0.008
Sample size	31	31	20

Table 2: OLS regression results for sunspots (SSN) over yearly homicide rates.

DISCUSSION

This is an exploratory study that relies in associating geomagnetic disturbances and homicides over three decades in three countries. However, most GMD may last hours and dissolve in days or weeks. Besides, within any year GMD differ in intensity and do not affect all regions of the world with the same energy at precisely the same time, not least because there is a nine-hour time difference between the USA West Coast and Germany. This turns our findings even more relevant, in that we managed to show an important association between GMD and homicide rates despite the paucity of the data available.

Data on GMD is available several times a day. On the other hand, internationally comparable data on homicide rates is publicly available on a yearly basis. To better match GMD to homicide rates, one would want to evaluate monthly, if not daily data, on both, GMD and on internationally comparable homicide rates. Yet, this data is unlikely to be made readily available until our exploratory hypothesis awakens more curiosity.

We did not include in our analysis the usual social environmental variables mentioned in the Introduction mostly because those variables behave monotonically (age structure, drug and alcohol use, migrations) and because they would not, as with gender or race, match the variability of the trend data on homicide rates, certainly not as well as the GMD indices, or, because, as in gun ownership and weapons of choice, the transoceanic differences are too great.

We used two planetary measurements for GMD, the Kp one provided by NOAA, and the Ap one provided by the German Helmholtz GFZ German Research Centre for Geosciences at Potsdam. The Kp index provided a marginally better fit with

homicide rates for all three countries, and the regression results we offered here reflect only the fit for Kp. The Kp index characterizes the intensity of solar storms that may impact on the Earth's magnetic field. However, yearly expressions of those are seldom localized enough to express a level of geomagnetic intensity capable of impacting behavior in each place. We admit that those geomagnetic disturbances might affect individuals differently, not least because of their specific location. Some of those differences are apparent in Graph 1, as with the higher German homicide rates than in the UK for the period 1989-1999 and their reversal for the period 2000-2015.

Forecasting sunspots for the current 25th solar cycle has proven elusive even for the NOAA co-chaired SC25PP [30]. That is why we focused our attention on the alternative proposal limited to the current 25th solar cycle. Nonetheless, for the purpose of public policy, we are most interested in short-run predictions, within half a solar cycle, or approximately five to six years, and the alternative proposal suggests we should be worried. If our hypothesis is correct, we should expect a surge in homicides, and other expressions of aggressiveness, in all three countries up until 2026, if not also beyond.

It is not practical to forecast beyond a solar cycle, and it might prove fruitless to try to do so beyond three solar cycles [31]. Nonetheless, it is important to point out that in the last almost four decades, the three consecutive solar cycles were of a decreasing intensity-lower SSN and while the earlier three were of an increasing intensity–higher SSN. If this current 25th solar cycle turned out to be the first of a series of more cycles of increasing solar activity, we should expect GMD to increase in the next three decades or more, as well as we should expect over three decades of increasing pressure on the enactment of homicides.

The evolution of humans and other living species on Earth must have accommodated moderate Sun-driven geomagnetic oscillations. On the other hand, living organisms are more likely impacted by Sun-driven geomagnetic disturbances when those are unusually intense and/or frequent [32-34]. Recent research also reported that GMD may explain annual biological oscillations that persist in the absence of environmental cycles [35]. Therefore, we believe that GMD might excite human organisms after repeated or intense oscillations of the geomagnetic field, which may explain the relatively long lags revealed in our statistical study.

Our study focuses on how GMD may impact individual behavior, as in homicides. While societal behavior cannot be fathomed from individual behavior alone, GMD may affect many individuals in a society simultaneously. This may be why two to three years lags in sunspots, are also present in Gorbanev's interpretation of impact of solar activity in economic recessions, which express a collective dimension of human behavior. Furthermore, Gorbanev also reports on how solar activity, with comparable sunspots lags, may impact on collective behavior such as revolutions.

In addition to the quantitative contribution of this work, there is an important philosophical implication to it [36,37]. However, our study has suggested that the individual's behavior may be strongly influenced by solar activity and GMD, somewhat removing the exclusive individual's responsibility for her acts, even when otherwise considered sane [38,39]. This would no doubt have a bearing on society's right to punish, rebalancing the significance of repent and forgiveness among humans, but also re-signifying humans' relationship to other species, fellows in the same earthly environment, and all subject to the same Sun's vagaries [40-44].

CONCLUSION

Our study has staged a natural experiment to explore the possible role of geomagnetic disturbances in explaining the concomitant peaks and troughs in homicide rates in three major economies: Germany, the UK, and the USA. Based on robust OLS results we have suggested that the patterns in homicides rates best respond to geomagnetic disturbances as measured by the Kp index lagged by 2 to 3 years.

Our work also has a practical public policy dimension, helping to cope with future homicide levels. Our homicide rate forecasts, under the frontier proposal, [45] arguing for a peaking number of sunspots almost twice as high as the current consensus, would bring all three countries to experience considerably higher homicide rates, at levels not seen in the past two decades. This would undoubtedly add considerable stress to public policy authorities, not least because in the last two decades, many of the most experienced officials may have retired, and the public bodies may have been downsized, reflecting the recent past downward trend in homicide rates.

Our work calls for a broadening of the conventional association between environment and behavior. The statistical results we offered, particularly the association of GMD and homicides, has proven robust enough to call for replications, particularly with monthly data, and to trigger further speculation on the importance of GMD for interpreting other areas of human behavior, as in schizophrenic onsets, and on collective human behavior, whether in apparently leaderless riots, or revolutions and wars, besides in organizational behavior.

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