Detecting Putative Sporadic E Propagation in WSPRNet Spot Records

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The E layer affects radio broadcasting as well as other radio communications; as such, many researchers are attempting to predict sporadic E layer cloud formation. The Japanese Space Weather Forecast Center, for example, has reported preliminary results in predicting sporadic E clouds a few days ahead of its formation (1). However, while accurate forecasting of local sporadic E clouds is highly desirable, it is still elusive. For this study, I wanted to investigate whether the massive amount of amateur radio transmission data, such as the WSPRNet data sets, could be useful in building prediction models.

WSPRNet (2) is a centralized database that collects spot records from radio stations operating weak digital modes. Each of the millions of spot records on the WSPRNet provides SNR, transmitting power, and geographic information, which can be used to estimate transmission paths. For example, the December 2020 data set alone contains 74 million records, representing 22,552 senders from 19,588 grids. While WSPRNet provides a potential big data source for radio propagation study, it is not clear if the WSPRNet data are useful in studies of sporadic E propagation. The objective of this study is to investigate whether WSRPNet data are useful for characterizing sporadic E propagation.

WSPRNet propagation data were downloaded from (http://wsprnet.org/drupal/downloads) and solar indices were from the German Research Centre for Geosciences (GFZ) (gfz-potsdam.de) in February, 2021. WSPRNet spot records of 28, 50, and 144 mHz transmissions during 2020 were then used for the analysis, combining related spot records with the same timestamp and sender call sign to remove duplicates.

Putative sporadic E propagations were identified as when a transmission's distance was about 1200 km in the above identified bands; the total number of records used for the analysis was 1,118,989. Using python 3, data analysis was performed with pandas and maidenhead packages; geopandas, matplotlib, and seaborn were used for plotting (Jupyter notebooks and intermediate data used for this analysis are available upon request from the author).

As the figures 1 and 2 show, putative sporadic E propagations seem to peak in the summer in the Northern Hemisphere; for 28 mHz and 50 mHz bands, the opening seems to start in April and mostly die down after September. The 144 mHz band has a later start around May or June and it seems to have a second peak around October. In the Southern Hemisphere, the putative sporadic E propagations are mostly shown during the winter up until March and they increase again in October for all three frequencies. It is known that the 28 mHz band supports F2 ionospheric propagation and some of the transmissions in the 50 mHz and 144 mHz bands may be through tropospheric ducting rather than sporadic E propagation. Further studies focusing on transmission paths and durations may further define the propagation modes in these putative sporadic E propagations. However, the seasonal changes of the putative sporadic E propagations seem to be consistent with what has been reported in the literature, suggesting that these records may reflect actual sporadic E propagation.

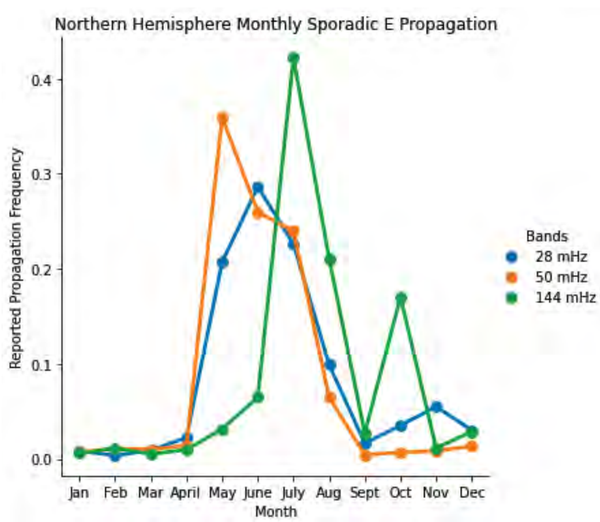

Figure 1. Northern Hemisphere Monthly Sporadic E Propagation

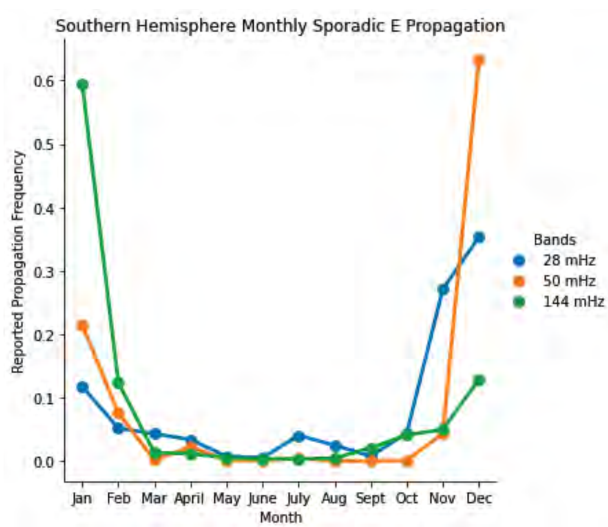

Figure 2. Southern Hemisphere Monthly Sporadic E Propagation

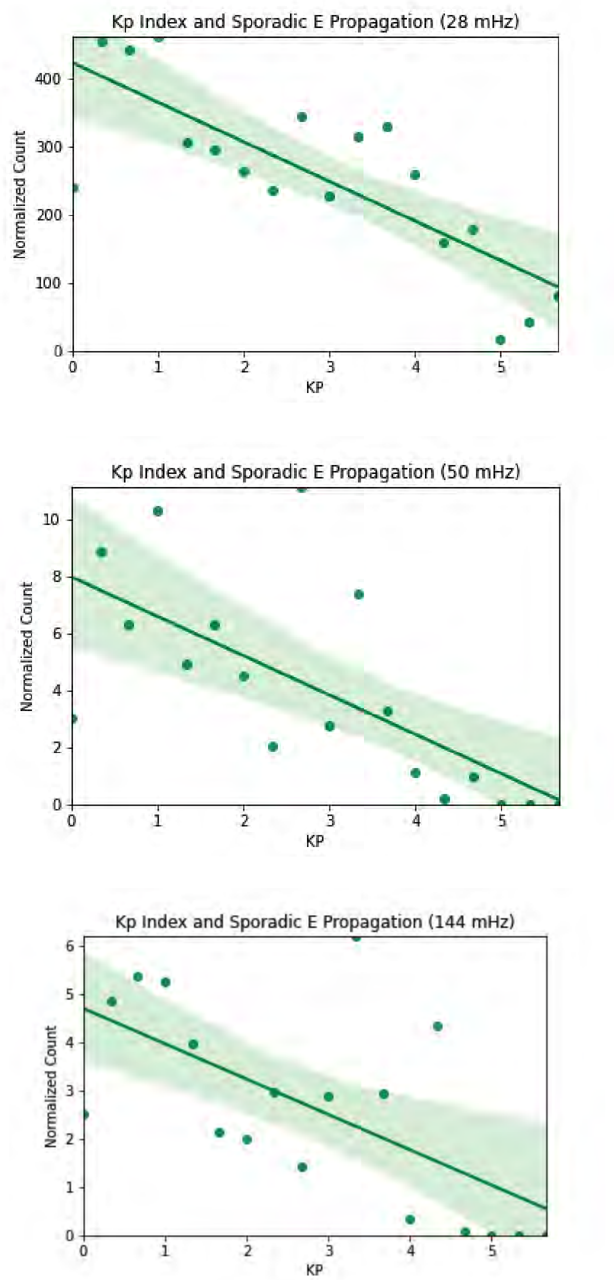

Figure 3. Kp index and Counts of Putative Sporadic E Propagation

In a final analysis of the relationship between Global Solar Indices and putative sporadic E propagation as seen in figure 3, there was not a strong relationship between F10.7 index and sporadic E propagation in the 2020 data set, which is also consistent with current literature. However, when I analyzed hourly Kp index and putative sporadic E propagation rate, there seems to be a negative correlation, with an R-Squared Value of 0.62 on 28 mHz, indicating a relatively strong effect, and an R-Squared Value of is 0.46 for Kp effect on 50 mHz and 0.40 for 144 mHz, which suggests a modest effect.

In conclusion, the putative sporadic E propagation in the WSPRNet spot records seems to be consistent with known seasonal variations of sporadic E propagation and corresponding geographic distribution, which suggests that these records provide a large number of observations that could be used to study sporadic E formation.

Exploratory data analysis also suggests that Kp index may be negatively correlated with recorded sporadic E propagation. However, further research is needed to determine whether the observed relationship between Kp index and sporadic E propagation is a simple correlation with seasonal changes or there is a causal relationship.

Note: An earlier version of this research was presented at the Hamsci WorkShop 2021.

References:

1. Shinagawa, H., Tao, C., Jin, H. et al. Numerical prediction of sporadic E layer occurrence using GAIA. Earth Planets Space 73, 28 (2021)

2. Taylor, J. (2010). WSPRing Around the World. QST November (2010), p. 30-32.

3. Whitehead JD (1989) Recent work on midlatitude and equatorial sporadic E. J Atmos Solar-Terr Phys 51:401