EXPLORATION OF SPACE WEATHER DATASETS IN MIXED REALITY ENVIRONMENTS

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INTRODUCTION

We explore embodied data interaction with empirical space weather datasets in a mixed reality (MR) environment using extended reality (XR) technologies. A user study involving 54 participants tested the usability and efficacy of the newly-developed MR tool on users with no space-science expertise or prior knowledge of the datasets. The results show that even with minimal knowledge of space weather and limited experience with MR environments, the participants were able to identify correlations and begin to understand the scientific context of space weather phenomena.

At the CEDAR Workshop, we intend to broaden the demographics of the study by studying the responses of space-weather experts in order to more rigorously quantify and assess the potential impact of XR technologies on educational and analysis tools and techniques.

Pre-study Survey

To experience the demo using the mixed reality headset, please fill out the survey and go to room #

SPACE WEATHER DATASETS

Three empirical variables related to the study of solar storms over an 18-year period are shown below (Figures 1-3): SYM-H index data, sunspot number, and ground-based total electron content from the northwest sector of the continental United States.

Our **goal** is to showcase correlations among these variables in a novel MR environment and use audio and visual analytics to explore the XR capabilities to detect correlations.

We use sonification, i.e., the use of non-speech audio to convey information, and visual analytics techniques in an MR tool deployed on an MR headset (see Figure 4).

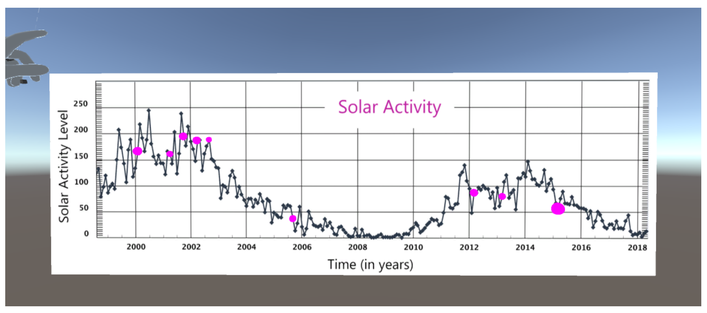

Figure 1

Sunspot Number is shown from year 1999 to 2018. The pink spheres visually mark the presence of a solar storm.

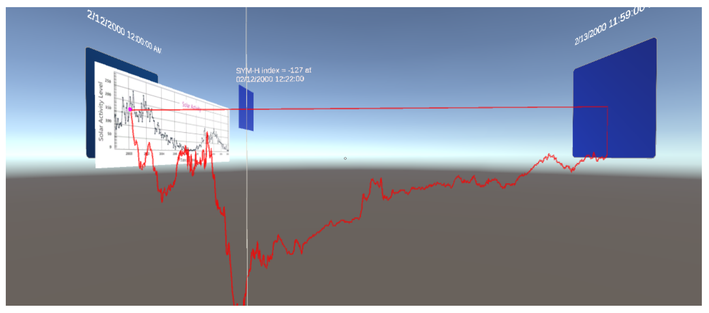

Figure 2

SYM-H index is plotted in red over a 48-hour period. SYM-H index plot and solar activity level plot are placed perpendicular to each other (Front View).

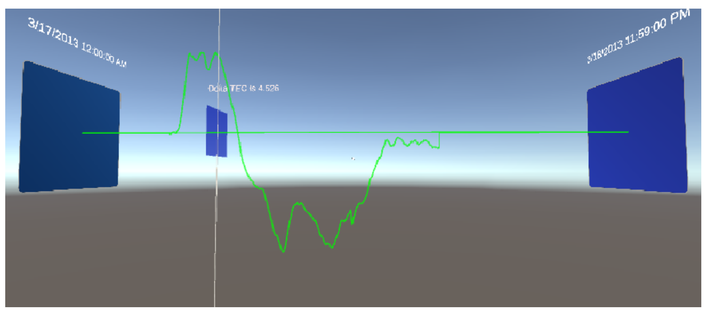

Figure 3

Delta TEC is plotted for 24 hours after the onset of the storm.

DATA EXPLORATION IN MIXED REALITY

Figure 4: Space weather datasets are shown in an MR environment.

STUDY TASK: FINDING CORRELATIONS

We study the correlation effects between the sunrise terminator and delta TEC values for different storms. The sunrise terminator at 350 km altitude on the storm day is represented by the diagonal dashed line in the lower left panel of Figure 5, while the diagonal in the upper right quadrant of the Figure represents the sunrise terminator for the day after the storm onset. It should be clear from Figure 5 that there are definite relationships between delta TEC, the sunrise terminator, and the onset time of the geomagnetic storm. The focus of this study is on storms with onset times prior to noon UT, since they show a clear correlation between the sunrise terminator and the change in TEC in the northwest US sector.

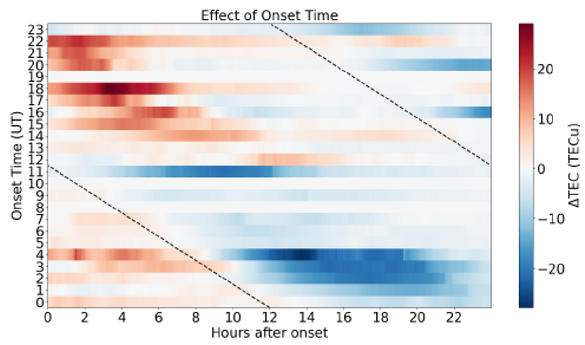

Figure 5: Temporal evolution of delta TEC in the aftermath of the 37 large storms in the northwest U.S. sector plotted over a 24-hour period following each onset time.

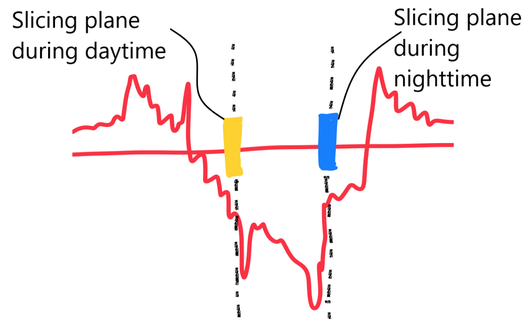

Figure 6: In the current study, the correlation is presented creatively using sound and visual representations in an immersive MR environment, and the participants are asked to find patterns in the datasets.

ACKNOWLEDGMENTS

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*Figure 5 is taken from: Debchoudhury, S., Sardana, D., & Earle, G. D. (2021). The relative importance of geomagnetic storm signatures on the total electron content perturbations over the continental US. Journal of Geophysical Research: Space Physics, 126, e2020JA028125. https://doi.org/10.1029/2020JA028125

Immersive Analytics Demo