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Selected New Articles on the Topic of Space Weather From AGU Journals: Published Between July and September 2015

Howard J. Singer

Geomagnetically Induced Currents at Low Latitudes

Geomagnetically induced currents (GICs) that can disrupt routine and dependable delivery of electric power are a major concern to modern society. These currents that can be generated during major geomagnetic storms can damage or disrupt power transmission, typically at high-geomagnetic latitudes on the nightside of Earth. In addition, as discussed in the recent paper by *Carter et al.* [2015], GICs can also occur during relatively quiet geomagnetic conditions, sometimes preceding a magnetic storm, at low latitudes on the dayside. These low-latitude GICs are generated when shock waves or "sudden impulses" in the solar wind compress Earth's magnetic field. The compression generates rapid changes in Earth's magnetic field that induces currents in Earth's crust and long-line conductors, such as power grids (Figure 1). While these features of sudden impulses are well known, Carter et al. use data from ground-based magnetometers to examine many impulses and demonstrate that in the equatorial regions the response to solar wind impulses is larger than might be expected. They demonstrate that the reason for reaching potentially damaging levels at the equator, even as large as those at high latitudes, is that the signals are amplified by the presence and strength of an overhead ionospheric current called the equatorial electrojet. These results aid in our understanding of why GICs are observed in locations such as South Africa, so far from the auroral zone.

How Localized Are Extreme Geoelectric Fields That Can Affect the Power Grid?

In the recently released White House Office of Science and Technology Policy (OSTP) National Space Weather Action Plan (https://www.whitehouse.gov/administration/eop/ostp/nstc/docsreports), there is a call for establishing benchmarks for induced geoelectric fields. This high-level national plan recognizes the need for improving our understanding and preparedness for extreme space weather events that can affect critical infrastructure such as the electric power grid. One study that is sure to contribute to these benchmarks was recently published by *Ngwira et al.* [2015]. Using data from ground-based magnetic observatories, they calculate the induced global geoelectric field for 12 extreme geomagnetic storms that occurred between 1982 and 2005. Their results illustrate that during the course of extreme storms, with widespread disturbances, there are often highly localized extreme geoelectric fields (Figure 2). (These findings are dramatically illustrated by movies that can be examined by clicking on the "supporting information" links provided with the electronic version of the paper.) Ngwira and coworkers also show that these extreme peaks occur over a wide local time range, rather than being concentrated near midnight. For the events examined in this study, the large fields also appear over a wide range of latitudes, from 50.5 to 85.8° magnetic latitude. While the authors suggest that more research needs to be carried out to understand the source of these extreme disturbances, several possible mechanisms are discussed, including an emphasis on current systems established during magnetospheric substorms.

Ionospheric Effects on GPS Signals at Equatorial and High Latitudes

Uses of the U.S. Global Positioning System (GPS), or more broadly, the Global Navigation Satellite Systems (GNSS) that include satellite systems operated by other nations, are expanding. Many modern smart phones now have built in navigation, and GNSS applications are finding their way into nearly every facet of modern society such as transportation, navigation, precision agriculture, banking, and military operations. This growing dependency on GNSS hastens the need to understand and mitigate against signal interference from ionospheric conditions that especially affect the signals in the equatorial regions and at high latitudes in the auroral zone and polar cap. Therefore, *Jiao and Morton* [2015] have carried out a study to examine and

Figure 1. Active solar conditions can cause disturbances in the solar wind that influence Earth. One type of disturbance, a sudden increase in solar wind pressure, can cause geomagnetically induced currents in power lines on Earth's dayside, even at low latitudes. Credit: K. L. Turnbull, J. A. Wild (Lancaster University), and the SOHO/Extreme ultraviolet Imaging Telescope consortium.

compare the impacts to GPS signals in these regions using several different receivers. They use data from Alaska, Jicamarca, Peru, and Ascension Island in the Atlantic (Figure 3) to examine the impact on signal amplitude and phase. Their comprehensive findings demonstrate that "scintillation in the equatorial region is typically more severe than at high latitudes with deeper and faster signal power fading and longer duration."

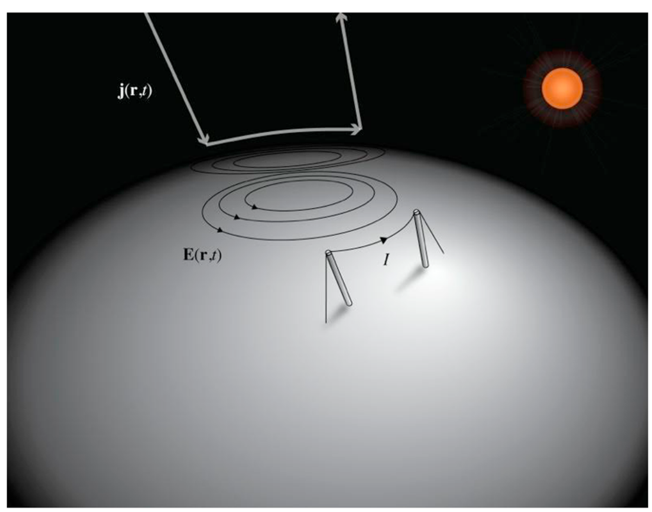

Figure 2. A cartoon illustrating the chain of events from solar disturbances to currents in space (white lines above Earth), to induced geoelectric fields on the ground, and to resulting currents that feed into the power grid. Credit A. Pulkkinen, NASA/Goddard Space Flight Center.

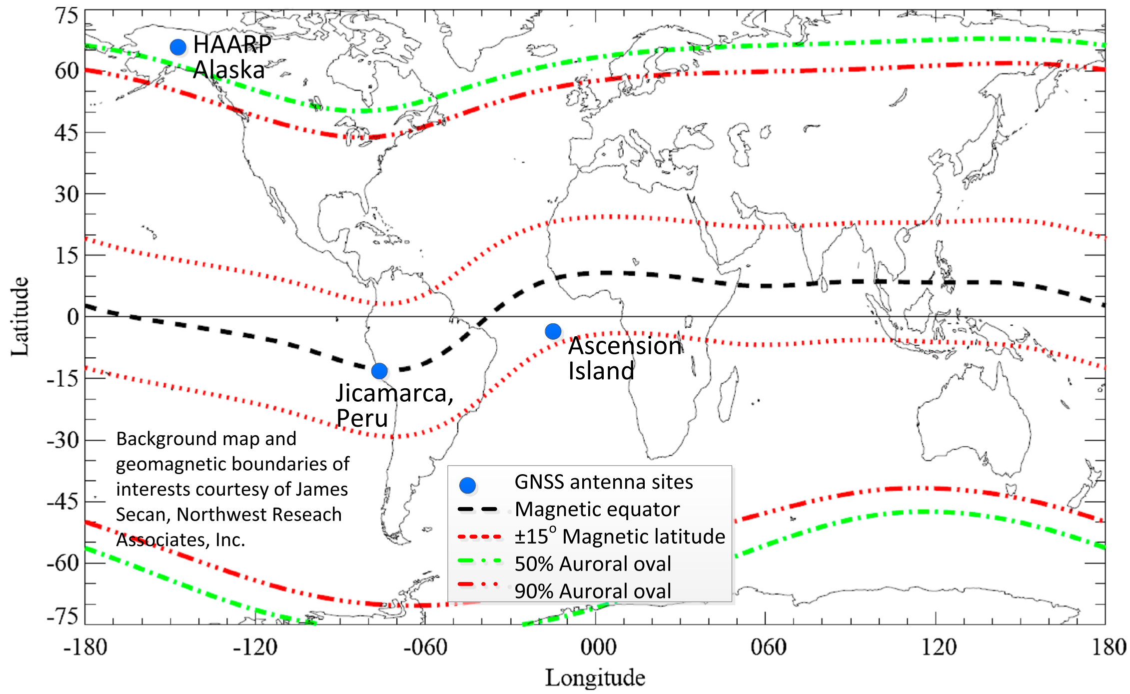

Figure 3. Global map illustrating the locations of GPS stations used in this study to characterize the effects of ionospheric scintillation on the amplitude and phase of GPS signals at auroral and equatorial locations. From Figure 1 in *Jiao and Morton* [2015], doi: 10.1002/2015RS005719.

They also show that at high latitudes, phase fluctuations are more severe than amplitude scintillation and that equatorial scintillation is largely independent of geomagnetic activity, while a positive relation with geomagnetic activity is observed at high latitudes. These results are important for forecasting scintillation and for establishing guidelines for future GPS receiver algorithms to help mitigate scintillation effects.

References

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