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Monitoring Ionospheric Space Weather in the Arctic with the MACAWS network: Observations from 2017-2022

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The Monitors for Alaskan and Canadian Auroral Weather in Space (MACAWS) project consists of a sensor web network that provides both real-time and historical GNSS TEC and scintillation data products. A major goal of the MACAWS network was to fill a gap in space weather monitoring systems in northern Alaska and northwestern Canada. Up until recently, GNSS arrays in Alaska have been primarily deployed by geodetic groups concerned with plate motion and earthquake prediction, as well as oil exploration. Because of this, the area where most space weather events that impact the continental US begin lacked coverage. The placement of the MACAWS receivers was designed to remedy this. The majority of the 35 PolaRx5S Septentrio GNSS receivers of the final network have now been deployed in northern Alaska and northwestern Canada and all data are being incorporated directly into the CEDAR Madrigal database. New software has been developed that enables the easy integration of GNSS total electron content (TEC) observations with the MACAWS scintillation measurements, the auroral images from the THEMIS all-sky imaging (ASI) network, and the estimated SUPERDARN convection pattern. By merging these various data types onto uniform geographic coordinates, the relationship of GNSS scintillation can be correlated with the intensification of the visible aurora and the TEC. Movies of these events are automatically generated and provide the time history of aurora and the development of scintillation. We measure the observed increase of TEC associated with particle precipitation and note its duration for a number of storms. Further analysis of SuperDARN convection patterns and Ampere science products provides additional information about plasma transport and magnetospheric energy input to the auroral ionosphere during geomagnetic disturbances. For this study, we have selected geomagnetic storms and substorms from the 2017-2021 period to illustrate the insights provided by this joint analysis. We will summarize our findings for a variety of different geomagnetic storms. We will also closely evaluate the measured increase in the TEC during these storms due to precipitating particles.