Autonomous ISR Systems for Operational Space Weather Applications: Lessons from AMISR and Thoughts for the Future

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Historically incoherent scatter radar (ISR) facilities have been used for basic research investigations on a campaign basis. ISRs can also provide a number of important inputs for applied research, such as radio propagation conditions, radio absorption conditions, particle precipitation rates that relate to the loss rates of energetic particles from the magnetosphere, and ionospheric electric fields that are pertinent to monitoring geoelectric hazards. Nonetheless, the operational space weather community rarely uses ISRs since the data are limited in time and space. Most operational space weather products rely on data from distributed networks of autonomous instruments such as GPS total electron content (TEC) receivers. In order to make ISRs relevant to the operational community, ISRs need 1) to be autonomous and easy to deploy in large networks, 2) to operate continuously and reliably and 3) to produce data in real time with minimal latency. Many of these requirements have already been demonstrated using the advanced modular incoherent scatter radar (AMISR) technology. The AMISR facilities in Poker Flat, Alaska, USA (PFISR) and Resolute Bay, Nunavut, Canada (RISR-N and RISR-C) operate autonomously without any site crew. PFISR operates continuously using a low duty cycle mode in between regularly scheduled high duty cycle experiments. In 2016 PFISR operated for 8459.57 out of 8784 total hours in a leap year, or 96.3% of the time. The RISR-N and RISR-C do not currently operate continuously, but they could with future investments in the power generation infrastructure. Recently we have implemented a real time data analysis system for the AMISRs. A new real-time processing server was installed at PFISR in February 2017, and we are currently generating fitted electron densities, electron temperatures, ion temperatures, line-of-sight velocities, and reconstructed vector electric fields for all experimental modes at one minute resolution with a total latency of less than two minutes. These achievements make it plausible to discuss the future deployment of large networks of autonomous ISRs for both basic and applied research.