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Aperture synthesis radar imaging with EISCAT 3D

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EISCAT 3D [1] is a tri-static high power large aperture incoherent scatter radar under construction that will start operations in 2022. The main site will be in Skibotn, Norway, where there will be a core transmit/receive array consisting of 9919 antennas arranged into 109 antenna groups. Additionally, the site will have ten receive-only outlier array groups where the farthest will be 1.2 km from the core array intended for interferometry.

This study investigates radar imaging performance of the Skibotn core site. Both temporal and spatial resolution were investigated using a realistic model for signal to noise ratio. The achievable temporal resolution was evaluated in the E-region for electron densities between $0.5 \cdot 10^{11}$ and 10^{12} m^{-3} and range resolutions between 100 and 2000 m. The shortest achievable integration time for 2 km range gates and an electron density of 10^{12} m^{-3} was $\sim$0.2 s.

The horizontal imaging resolution depends primarily on the locations of the of antenna modules. The choice of imaging algorithm is also an important factor. Of the imaging algorithms surveyed, the singular value decomposition with regularization gave the best results and was also found to be among the most computationally efficient of those investigated. The estimated imaging performance indicated that the radar will be capable of detecting features down to approximately 90x90 m. The resulting image had an uncertainty down to 10 %.

Dividing the transmitting array into multiple independent transmitters to get at multiple-input-multiple-output system, reduced the uncertainty somewhat, but required longer integration time. Such techniques therefore seem most useful for bright targets such as meteors, naturally enhanced ion-acoustical lines, and polar mesospheric summer and winter echoes.

The conclusion is that aperture synthesis radar imaging is feasible with EISCAT 3D.

References

[1] J. Kero, D. Kastinen, J. Vierinen, T. Grydeland, C. Heinselman, J. Markkanen, and A. Tjulin, 'EISCAT3D: The next generation international atmosphere and geospace research radar," *Proceedings of the First NEO and Debris Detection Conference*, ESA Space Safety Programme Office, Darmstadt, January 2019.