Optimization Design of Windbreaks for Large-Aperture High-Precision Radio Telescope Sites Based on Numerical Simulation (Postprint)

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Abstract

As radio telescope apertures increase and observation frequencies rise, demands for pointing accuracy become increasingly stringent. However, since telescopes operate at field stations, the impact of site wind disturbances on antenna pointing accuracy cannot be ignored during high-frequency observations. Due to the time-varying nature of wind disturbances, existing wind mitigation methods cannot guarantee effective observation time for large-aperture, high-pointing-accuracy telescopes in high-frequency bands. Therefore, this paper proposes a method for improving the site wind environment through precise windbreak placement. A windbreak simulation model was constructed through numerical simulation and validated against wind tunnel measurement data, with average errors of 3.7% and 6.1% for windbreaks with two different porosities, ensuring model reliability. Taking the Xinjiang Qitai Radio Telescope (QTT) site as a case study, a computational domain model was developed based on the site' s sloping terrain. A series of wind field simulations were conducted for single windbreaks at various heights and porosities, establishing the relationship between windbreak parameters and downstream shielding effectiveness. Based on the optimal height and porosity for single windbreaks, north-south windbreak configurations were designed. Simulation results demonstrate that optimal porosities can be combined at a given height, with the 0.1-0.1 porosity combination achieving the best wind shielding performance, effectively reducing wind speed in the antenna region by over 75% for southerly winds.

Full Text

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Note: Figure translations are in progress. See original paper for figures.