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Simulation study for ground-based millimetre-wave observations of 233.95 GHz emission by molecular oxygen ($^{18}O^{16}O$) in the polar stratosphere and mesosphere

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Molecular oxygen has a well-known mixing ratio in the atmosphere and rotational lines of the main isotopic species ($^{16}O_2$) at 60 GHz and 118 GHz are used for temperature observations by ground-based and satellite instruments. $^{18}O^{16}O$ has an atmospheric abundance 0.4% that of $^{16}O_2$, and lower opacity allows its emission from the middle and upper atmosphere at 233.95 GHz to be observed from the ground. The magnetic dipole, $2_1 \rightarrow 0_1$ rotational transition of $^{18}O^{16}O$ is Zeeman split by the Earth's magnetic field into a substructure of six separate components located within a few MHz from the line centre. The four Zeeman line σ components polarised perpendicular, and two π components polarised parallel, to the Earth's magnetic field can be resolved in the atmospheric spectrum. Emission frequencies of the Zeeman substructure are also Doppler shifted according to the line-of-sight wind speed. Forward model and retrieval simulations are performed using the Atmospheric Radiative Transfer Simulator (ARTS) to investigate the potential of ground-based passive heterodyne millimetre-wave measurements for observing $^{18}O^{16}O$ climatology, neutral winds, and perturbations to the magnetic field in the polar middle and upper atmosphere.