Geophysical Research Abstracts
Vol. 19, EGU2017-4680, 2017
EGU General Assembly 2017

Simulation study for ground-based Ku-band microwave observations of ozone and hydroxyl in the polar middle atmosphere

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Commercial satellite TV broadcasting is possible due to remarkable advances in microwave electronics, enabling weak signals transmitted over 36,000 km from geostationary orbit to be received by inexpensive rooftop dishes. The Ku band satellite frequencies (10.70–14.25 GHz) overlap microwave emissions from ozone (O_3) at 11.072 GHz and hydroxyl radical (OH) at 13.44 GHz. These important chemical species in the polar middle atmosphere respond strongly to solar variability and, at high latitudes, geomagnetic activity associated with space weather. Atmospheric model calculations predict that energetic electron precipitation (EEP) driven by magnetospheric substorms produces large changes in polar mesospheric O_3 and OH. The EEP typically peaks at geomagnetic latitudes $\sim$65° (e.g. Kilpisjärvi, Finland and Syowa station, Antarctica) and evolves rapidly with time eastwards and over the geomagnetic latitude range 60°–80° (e.g. reaching Halley, Antarctica). During the substorms OH can increase by more than 1000% at 64–84 km. The substorms leave footprints of 5–55% O_3 loss lasting many hours of local time, with strong altitude and seasonal dependences. An atmospheric simulation and retrieval study is performed to determine the specification and design requirements for microwave radiometers capable of measuring O_3 and OH profiles from Arctic and Antarctic locations using accessible satellite TV receiver technology. The proposed observations are highly applicable to studies of EEP, atmospheric dynamics, planetaryscale circulation, chemical transport, and the representation of these processes in polar and global climate models. They would provide a low-cost, reliable alternative to increasingly sparse satellite measurements, extending long-term data records and also providing “ground truth” calibration data.