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Energetic Precipitation as Monitored by Subionospheric VLF Propagation and by Bremsstrahlung X-rays on the ABOVE^2 Stratospheric Balloon Flights

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Extended Abstract

ABOVE^2 is a stratospheric balloon mission that flew over Western Canada in August 2016. With a Very Low Frequency (VLF) waves instrument and an X-ray spectrometer on each of two science flights, the mission was designed to investigate energetic electron precipitation and associated VLF wave activity near L=4. The flight path over Western Canada took the balloons underneath the Van Allen Probes footpoints and over top of multiple ground-based instrument arrays. The August 2016 timing allowed coordination of the flights with near-simultaneous BARREL flights from Sweden.

During the second science flight on 2016 August 25, we encountered energetic electron precipitation, as evidenced by increased Bremsstrahlung X-rays up to at least 150 keV. Conjugate observations by the Van Allen Probes show an injection of <250 keV particles, as well as increased whistler-mode chorus activity. Ground-based optical observations show a sudden expansion and equatorward motion of a pre-existing large-scale region of patchy pulsating aurora.

The precipitation modified the amplitude and phase of VLF signals received from several distant transmitters. Phase and amplitude changes were seen across both the ground-based ABOVE network of VLF instruments as well as the ABOVE^2 onboard receiver. The precipitation was additionally seen by a cluster of widebeam riometers near the flight path.

The Bremsstrahlung X-rays as observed on ABOVE^2 provide a more detailed and direct means to quantify the precipitation, but the observations are available only during limited campaigns. In contrast, the ground-based VLF receivers and riometers are more indirect monitors of energetic precipitation, but are available nearly continuously. The simultaneous observations of energetic precipitation by both ground-based and balloon-based instruments allows us an opportunity to validate the ground-based techniques and thereby greatly increase the extent of monitoring of energetic precipitation.

We present event-based modelling of both the X-ray and VLF responses. The X-ray response is modelled using Monte Carlo techniques for the particle and photon transport, while the VLF response is modelled by additionally coupling in a chemistry model and a wave propagation solver. We assess the consistency between the modelled and observed responses and use this to evaluate the use of VLF techniques to monitor energetic precipitation over Western Canada.