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DEMETER observations of subprotonospheric whistlers and their analysis

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We report observations of an interesting class of whistlers trapped in the ionosphere, so called SubProtonospheric (SP) whistlers. The SP whistler consists of a series of low dispersion echoes that result from repeated reflections between the base of the ionosphere and the altitudes up to ~1000 km. We use wave normal angles and plasma characteristics measured by the DEMETER microsatellite as an input for a three dimensional ray tracing technique. For several SP whistlers we have also succeeded in finding the causative lightning. We show that the reflections and formation of the SP whistlers takes place owing to an oblique propagation, with respect to the magnetic field, in the wave guide formed by a profile of the increasing LHR frequency in the upper ionosphere and the base of the ionosphere. We have observed propagation across the magnetic meridian planes. We conclude that the individual components of the SP whistler propagate along different ray paths. The reflected components enter the ionosphere at relatively large distances from the satellite foot print and experience a spread of wave normal angles during this entry. Depending on the initial wave normal angle, these waves undergo a different number of reflections before reaching the satellite, thus arriving with different time delays. However, the first component observed of a SP whistler is formed by waves entering the ionosphere at relatively small distances from the satellite foot print and propagating at relatively small wave normal angles. These waves do not reflect above the satellite, but propagate to the opposite hemisphere.