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Chromospheric Signatures of the Subdued Cycle 23/24 Solar Minimum in Microwaves

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Coronal holes appear brighter than the quiet Sun in microwave images, with a brightness enhancement of 500 to 2000 K. The brightness enhancement corresponds to the upper chromosphere, where the plasma temperature is about 10000 K. We constructed a microwave butterfly diagram using the synoptic images obtained by the Nobeyama radioheliograph (NoRH) showing the evolution of the polar and low latitude brightness temperature. While the polar brightness reveals the chromospheric conditions, the low latitude brightness is attributed to active regions in the corona. When we compared the microwave butterfly diagram with the magnetic butterfly diagram, we found a good correlation between the microwave brightness enhancement and the polar field strength. The microwave butterfly diagram covers part of solar cycle 22, whole of cycle 23, and part of cycle 24, thus enabling comparison between the cycle 23/24 and cycle 22/23 minima. The microwave brightness during the cycle 23/24 minimum was found to be lower than that during the cycle 22/23 minimum by ~250 K. The reduced brightness temperature is consistent with the reduced polar field strength during the cycle 23/24 minimum seen in the magnetic butterfly diagram. We suggest that the microwave brightness at the solar poles is a good indicator of the speed of the solar wind sampled by Ulysses at high latitudes.