Rarefaction of the Very-Slow (<350km/s) Solar Wind in Cycle 24

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The fast (700-800 km/s) and slow (300-400 km/s) solar wind are known to be associated with rarefied and dense plasma, respectively. A similar inverse relation is found between the speed and the density micro-turbulence level, delta Ne, derived from interplanetary scintillation (IPS) measurements; that is, the fast (slow) wind is associated with low (high) delta Ne (Asai et al., 1998). This fact suggests a certain level of proportionality between the density and delta Ne. Our earlier study demonstrated that delta Ne sometimes deviates from this inverse relation at a speed lower than 350 km/s, showing a marked drop in delta Ne for the very-slow solar wind (VSSW). To explore this finding further, we analyze IPS measurements during the period between 1997 and 2015; i.e. from Cycles 23 minimum and Cycle 24 maximum. As the result, we find that VSSW increases in the maximum phase of the solar cycle, and it is mostly associated with high delta Ne in Cycle 23. However, VSSW is found to be more associated with low delta Ne in Cycle 24. This fact is consistent with an increased occurrence of low-density VSSW observed in situ in Cycle 24, and it is considered as a manifestation of peculiar activity of this cycle. Our IPS data show that the significant growth of low delta Ne VSSW occurs at mid latitudes on the source surface. We investigate magnetic field properties of the source region for VSSW using the potential field analysis, and find that low-delta Ne VSSW is associated with a smaller expansion factor, a weaker photospheric field strength, and a higher source latitude than the average of all VSSW. These results suggest that more open magnetic field areas producing VSSW are formed in the quiet Sun region, and that the mass flux supply from those regions into the corona decreases in Cycle 24 owing to the weakening of the Sun’s magnetic field.

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