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North-south asymmetry in global distribution of the solar wind speed during Cycles 22-24

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The north-south (N-S) asymmetry in the solar activity is important from viewpoint of the solar dynamo theory, since the axisymmetric magnetic field cannot be maintained by the dynamo action (Cowling, 1933). The N-S asymmetry in the solar activity has been studied from observations for various kinds of solar surface phenomena. However, the heliospheric consequence caused by the N-S asymmetric solar activity is poorly understood owing to shortage of global observations. The N-S asymmetry in the heliosphere is important information to study the propagation of cosmic rays and influence on the space weather. Therefore, we have studied the N-S asymmetry in global distribution of the solar wind speed using interplanetary scintillation (IPS) observations at the Solar-Terrestrial Environment Laboratory (STEL) of Nagoya University. IPS observations enable us to investigate global distribution of the solar wind speed on the source surface for a given Carrington rotation. The period analyzed here is between 1985 and 2013 (except for 2010), corresponding to between Cycles 22 and 24. We divided our IPS data into north and south data, and calculated the fractional areas of fast, slow and intermediate speed winds for those two groups. As result, we find that significant N-S difference in fast and slow wind distributions over the poles exist particularly at solar maxima. This asymmetry results from earlier occurrence of disappearance/reformation of fast winds at the north pole than that at the south pole, and it is closely linked with the time lag of the polarity reversal at both poles. Furthermore, enhanced N-S asymmetry of polar fast wind is also found between Cycle 23 declining phase and 24 maximum. We compared our IPS data with g20/g10, where g20 and g10 are quadrupole and dipole components of harmonic coefficients derived from the potential field analysis of magnetograph observations at Wilcox Solar Observatory. As result, a weak but significant correlation are found between those quantities, and this fact suggests that higher-order magnetic moments such as quadrupole make an important contribution to the N-S asymmetry in global distribution of the solar wind speed.

Keywords: solar wind, interplanetary scintillation, solar cycle, Sun's magnetic field, heliosphere, space weather