DESCRIPTION OF THE TEMPERATURE INDEX – K_T

We compared nearly 55 years of solar wind (SW) proton temperature (T) and velocity (V) observations to derive an improved expected temperature formula (T_{exp}) and temperature index values ($K_T=T/T_{exp}$) used to associate Forbush decreases (FDs) with various types of solar sources – coronal mass ejections and coronal holes (CHs). The observed to expected temperature ratio had been proposed as a criterion to identify interplanetary coronal mass ejections (ICMEs) in [Richardson I. G., Cane H. V., 1995, J. Geophys. Res., 100, 23, 397].

We obtained the new T–V dependence formula computing various regression models for the undisturbed solar wind and choosing the best model on base of the maximum correlation between calculated and observed temperature. We selected observations of the proton temperature and velocity for the undisturbed solar wind from the *OMNI* database [http://omniweb.gsfc.nasa.gov/ow.html] since 1965 to 2019 (about eighty thousand hours). The power law ($\lg T = a + b\lg V$) with an exponent $b = 3.29 \pm 0.02$ for $V < 425$ km s^{-1} and $b = 2.25 \pm 0.02$ for $V > 425$ km s^{-1} turned out the best formula describing the T–V relationship with a sufficient accuracy. These results were used to compute the expected temperature and the temperature index for all available observations during the mentioned above period (about three hundred thousand hours).

The temperature index distribution turned out to be unimodal, peaked, right-skewed with a median ≈ 1, a long tail in the region of large values ($K_{T\max}=39.5$) and most values $K_T < 3$. The behavior of the temperature index as well as cosmic rays (CR) intensity and anisotropy variations and SW parameters (proton temperature, velocity, density, plasma beta, magnetic field intensity) during FDs associated with different kinds of interplanetary disturbances was explored. Data on the SW parameters was taken from the *OMNI* database; data on the CR variations and the FDs parameters – from *Variations of Cosmic Rays* (*VCR*) and *Forbush Effects and Interplanetary Disturbances* (*FEID*) databases [http://spaceweather.izmiran.ru/eng/dbs.html] created and maintained in IZMIRAN.

We attempted to reveal critical values of the temperature index to distinguish different types of the interplanetary disturbances causing FDs: ICMEs; sheaths, magnetic clouds (MCs), corotating interaction regions (CIRs), high speed streams (HSS) from coronal holes (CHs), mixed events. For this purpose, a few hundred of FDs were selected and the behavior of the temperature index, CR variations and SW parameters was explored for each event. We also carried out statistical analysis of K_T values for two groups of FDs from 1996 May to 2016 July: MC-associated group – 125 events [MCs listed in Richardson I. G., Cane H. V., 2010, Sol. Phys., 264, 189; http://www.srl.caltech.edu/ACE/ASC/DATA/level3/icmetable2.htm] and CH-associated group – 386 events [CHs according to http://www.solen.info/solar/coronal_holes.html; https://sdo.gsfc.nasa.gov/, https://sohowww.nascom.nasa.gov]. Analyses of K_T behavior for FDs with different types of sources and statistical analyses of K_T values for the two groups of FDs reveals: there is statistically significant difference between K_T values for MCs and HSS from CHs; the temperature index is as a rule abnormally small inside MCs (mostly $K_T < 0.3$ and often $K_T < 0.1$) and increased in interaction regions of different-speed SW streams ($K_T > 1$); any value from the range $K_T > 1$ is a confident sign of the absence of ICME.

The behavior of the temperature index makes it a reliable and convenient tool to help in FD identification with different kinds of interplanetary disturbances (ICMEs, MCs, sheaths, CIRs, HSS from CHs) and solar sources (CMEs and CHs).