1. **Discussion**

We started the development of the empirical solar wind environment modelling for the near ecliptic PSP orbit described in detail in the previous sections, including the mathematical methods and statistical errors, by lognormally fitting the about 50 years of solar wind data obtained by near-Earth satellites intercalibrated data collected in the OMNI database, using the frequency distributions of the key solar wind parameters magnetic field strength B, velocity V, density N and temperature T. The database covers almost five solar cycles and thus represents solar wind gathered at different phases of solar activity in the ecliptic plane, with a negligible asymmetry in terms of activity. In the next step we have investigated the yearly variation of the solar wind distribution functions along with the SSN over 50 years and derived linear dependencies of the solar wind parameters with the SSN. The radial dependencies of the solar wind distribution functions were then analyzed using Helios 1 and 2 data for the distance range 0.29--0.98 au in bins of 0.01 au. The derived power law fit functions were used to scale the formerly calculated 1 au distribution fit functions to the PSP orbit, correlated with SSN predictions for the year 2018--2025, i.e., for the prime mission phase that gets PSP to a closest perihelion of 9.86 solar radii distance to the Sun. The reason for performing the analysis this way is based on the fact that the OMNI 1 au solar wind database is much larger than the Helios database. However, it is clear that the calculated distribution functions just represent first order estimates of the real solar wind to be encountered by PSP. The solar wind environment to be encountered will depend at times of PSP on the structure of the solar corona and underlying photospheric magnetic field, as shown by xxx (ref.), or the evolution and interaction of individual solar wind streams and superimposed CMEs and shocks. However, the derived results are in good comparison with existing models for the solar wind density and magnetic field strength as shown in Sect. 6. The velocity and temperature extrapolations indicate that PSP will dive indeed into the acceleration and heating regions of the solar wind to be expected below 20 solar radii (see Figure 11).

The near-Sun solar wind velocity at PSP perihelion is also expected to be slower than our model estimates, because the region of the Alfvénic critical source surface up to which the solar wind is believed to be accelerated is predicted to lie between 15–30 R (Schatten 1969, Sittler1999, Exarhos2000, Katsikas2010, Goelzer2014).

In our study we have not investigated the occurrences of extreme solar wind parameters caused by CMEs or enhanced values due to stream interaction (SIs) or co-rotation interaction regions. The Helios solar wind measurements plotted over radial distance in Fig. 7 show several extreme values far above the usual solar wind magnetic field strengths, speeds, densities, and temperatures likely to be associated with individual CMEs. The results by Srivastava et al. (2017) indicate that due to the solar wind drag the speeds of fast CMEs will commonly slow down substantially up to distances of 40 solar radii. Therefore, it is expected that PSP will encounter CMEs with much higher speeds than those observed during the Helios mission. Also, the magnetic field, density and temperature values are expected to be much larger than in the average solar wind in individual fast shock associated CME events. PSP will thus also substantially improve our understanding of the near-Sun evolution of CMEs and their expansion with radial distance.

To be moved!

The OMNI data are time-shifted to the nose of the Earth's bow shock. This leads to yearly solar distance variations of >2 % as the Earth orbits the Sun. The error estimation over the year caused by this varying radial difference can be expected to be smaller than 5 % derived from investigation of the power law exponents of the solar wind parameters. Furthermore, the Earth's orbit varies over the course of the year by +-7.2◦ in heliographic latitude. Schwenn (1990~~, p. 127 ff.?~~), Bruno (ref.) and Balogh et al. (1999) have pointed out that the solar wind parameters also vary with latitudinal separation from the heliospheric current sheet (HCS), but this aspect is beyond the scope of this study.
~~-> error estimation?~~

~~validity and estimation of error size outside of valid model range...~~
~~derive heliocentric distance depending error...~~
~~list simplifications/approximations...~~
~~error estimation for general model and extreme value tendencies~~
~~error sources:~~
~~- extrapolation~~
~~- lognormal model~~
~~- SSN variance~~
~~all estimates outside these boundaries are extrapolations with large uncertainties.~~

~~discuss results:~~
~~- empirical solar wind model for inner heliosphere within ecliptic~~
~~- low velocity at 0.0459~au~~
~~- slow/fast ratio SSN dependency~~
~~- application validity of lognormal distributions~~
~~--> B inversion of frequency distribution~~
~~---> magnetic field distribution's with distance increasing high value tail -> source are compression regions (why with density no increase?); look into Parker1958's B-field formula...~~
~~varying shape with distance is indicator for internal physical processes (mixing/turbulence…)~~

~~The Parker (1958) model of an isothermal expanding corona with a temperature of 10^6 K and a critical radius of 5.8 R .~~

~~individual velocity part discussion -> there is no specific velocity threshold between slow and fast solar wind types, the velocity ranges of both types overlap.~~
~~Not only the slowest wind but also the fastest wind is expected to converge to the average speed (Sanchez-Diaz2016 p. 2835, using MHD-model -> very slow solar wind is continuation of slow wind) (because of interaction).~~

~~The ratio of both varies with solar activity, e.g., 3 years~~

~~after maximum, polar coronal holes are observed to often have equatorial extensions (cite?). see and use Bougeret et al. (1984) p. 498…~~

~~for the overlapping velocity model the SSN dependency is steeper than for a simple threshold~~

~~approaching these regions, acceleration plays a role~~
~~Alfvénic critical surface i.e. source surface (see Fox before 2.1) in direction to the Sun is at about 2.5 R the source surface (Schatten1969)~~
~~sonic and Alfvénic critical point positions (see Sittler & Guhathakurta (1999))~~
~~sonic point and slow solar wind origin (Sheeley et al. 1997)~~

~~Balogh et al. (1999) p. 162 ff (origin and formation of CIRs in inner heliosphere with Helios data; latitude V dependence)~~
~~Balogh2009 (HMF review + inner heliosheath)~~
~~Aschwanden2004, p. 29~~

2. Summary of the results

For the near Earth solar wind OMNI data and the Helios 1 and 2 data obtained over the distance range 0.29--0.98 au we derived lognormal fits of the frequency distributions' shapes of the four key solar wind parameters magnetic field strength B, proton velocity V, proton density N and proton temperature T. These dependencies of the distribution functions on the solar activity cycle and on radial distance to the Sun have been modeled and extrapolated to the Parker Solar Probe orbit, with a minimum perihelion of 9.86 Rs in 2025, taking into account predictions of the sunspot number. This empirical CGAUSS solar wind model for PSP yields the following main results for the normal solar wind without extreme values possible in extreme CME events...:

bullets

The velocity and temperature values are overestimated below 20 R in comparison with existing observations. This shows that solar wind acceleration and heating processes below 20 R limit the simple back-extrapolation from existing in situ measurements.

WISPR mission operations implications…

Implications for SoloHI on Solar Orbiter …

~~We obtained lognormal representations of the frequency distributions' shapes of the four key solar wind parameters magnetic field strength, proton velocity, density and temperature. We derived analytical relations for the parameters' solar activity dependencies and for their solar distance scaling. An empirical solar wind model was build from the combination of the obtained frequency distributions, SSN dependence relations and solar distance dependence functions, representing the solar wind's solar activity and distance behavior. This empirical model was fed with SSN predictions and extrapolated to the orbit of PSP. We estimated solar wind median values during PSP's first perihelion and modeled the values for PSP's closest perihelia.~~
~~The velocity and temperature values are overestimated below 20 R in comparison with existing observations. This shows that solar wind acceleration and heating processes below 20 R limit the simple back-extrapolation from existing in situ measurements.~~

~~WISPR mission operations implications...~~
~~- further investigations should be done into structure extrapolations~~
~~- outward extension of model seems feasable (e.g., to Mars)~~