1. **Discussion**

We started the development of the empirical solar wind environment modeling 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 40~years of in situ near-Earth 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 OMNI multi-satellite solar wind data is intercalibrated, 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 53~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 herefrom derived power law fit functions were used to scale the formerly prior calculated SSN-dependent 1 au distribution fit functions to the PSP orbit, correlated combined with SSN predictions for the years 2018–2025, i.e., for the prime mission phase that gets PSP to a closest periheliaon 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 Though, 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 and on the evolution and interaction of individual solar wind streams and superimposed CMEs and shocks.
However, the derived results are in good agreement comparison with existing studies models for the about near-Sun solar wind magnetic field strenghts and densities as shown in Sect. 6. The from direct measurements differing velocity and temperature extrapolations below 20~solar radii indicate that PSP will indeed dive into the acceleration and heating regions of the solar wind to be expected at these distances (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 in average around 17~Rs (e.g., 0.6~Rs Schatten 1969, 17~Rs Sittler1999, 17~Rs Exarhos2000) and correlates with solar activity between 15~Rs in minimum and 30~Rs in maximum (19~Rs Katsikas2010, 15–30~Rs Goelzer2014).

In our study we have not specifically investigated the occurrences of extreme solar wind parameters caused by CMEs or enhanced values due to stream interaction (SIs) or co-rotatingon 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, velocities 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 into end of Sect. 5!

As the OMNI data are time-shifted to the nose of the Earth's bow shock, this leads to yearly solar distance variations of +-1.67 % as it the Earth orbits the Sun.
The maximal solar wind parameter variation amplitudes over the year can thus be estimated from the derived power law exponents to about X % for the m, to X % for the v, … calculate them and put them into Tab. 3.
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.

To be moved into Sect. 5!

Bruno (1986) and Balogh et al. (p. 162, 1999) have pointed out, that the solar wind parameters also vary with latitudinal separation from the heliospheric current sheet (HCS). Its The HCS's position in heliographic latitude is highly variable around the solar equator (Schwenn 1990, p. 126), furthermore, the Earth's orbit varies over the course of the year by +-7.2◦ in latitude. However, the additional analysis of 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 representations 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 these frequency distributions functions on the solar activity cycle and on radial distance to the Sun have been modeled with analytical relations and extrapolated to the Parker Solar Probe orbit with a first minimum perihelion of 9.86 Rs in 2024, taking into account predictions of the sunspot number.

This empirical CGAUSS solar wind model for PSP, representing the solar wind's solar activity and distance behavior, yields the following main results for the bulk normal solar wind without extreme values possible in extreme CME events:

parameter relationships as bullets...

B_median(SSN,r) = …
…
We estimated solar wind median values during PSP's first perihelion and the values for PSP's first minimum perihelion of 9.86 Rs in 2024.

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

Implications for WISPR mission operations and SoloHI on Solar Orbiter…
The knowledge of the expected solar wind environment helps to optimize the WISPR and PSP preplanning of the science operations. This also applies for the Heliospheric Imager (SoloHI) onboard the Solar Orbiter spacecraft (Howard2013).

~~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.~~

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