

**The solar wind's geomagnetic impact and its Sun-Earth evolution**  
Predictive models for space weather and for the Parker Solar Probe orbit

PhD defense by  
Malte Venzmer

PhD student  
within the doctoral program ProPhys,  
Georg-August University School of Science  
(GAUSS)  
Institute for Astrophysics  
Georg-August Universität Göttingen

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Seminarraum Astrophysik (SR 17, F 05.104)

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Geomagnetic impact of the solar wind Solar wind model End matter References

**Two topics**

**The solar wind's geomagnetic impact and its Sun-Earth evolution**  
Predictive models for space weather and for the Parker Solar Probe orbit

**Study 1**  
The solar wind's geomagnetic impact – Predictive models for space weather

**Study 2**  
The solar wind's Sun-Earth evolution – Predictive models for the Parker Solar Probe

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**Contents**

- Study 1 – A brief summary
- Study 2 – More detailed
  - Intro
  - Parker Solar Probe
  - Solar wind model
  - Prediction for PSP

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**Geomagnetic impact of the solar wind**

Solar wind – solar system bodies  
CMEs – geomagnetic storms – effects  
importance of prediction of onset/magnitude  
The study addresses: deriving predictive models

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**Geomagnetic impact of the solar wind**

Relations between the  $K_p$  index and solar wind parameters:
 

- Electric field proxy ( $vB_z$ )
- Velocity of CMEs and streams

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**Solar wind**

- E. Parker's theoretical model  
- confirmation by in-situ measurements  
- monitored continuously near Earth since measured in-situ throughout the heliosphere:  
- Voyager – heliopause  
- Ulysses – high heliolatitudes  
- Helios – Mercury

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**Solar wind**

The near-Sun region is of special scientific interest:  
- coronal heating  
- solar wind acceleration  
list potential mechanisms...

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**Parker Solar Probe**

Credit: Miles Duley, Peter Avrett, Shadoka Padur, 2017

Launch  
Venus Flyby #1  
Mercury  
Venus  
Earth  
First Perihelion at 38 R<sub>sun</sub>

Credit: NASA/JHUAPL/Ed Whitman, 2018

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**Parker Solar Probe**

12 August 2018: launched  
3 October: Venus flyby  
29 October: closest s/c ever (0.35 R<sub>sun</sub>)  
6 November: first perihelion (36.7 R<sub>sun</sub>)  
24 December 2024: first closest perihelion (9.86 R<sub>sun</sub>)

Credit: NASA/JHUAPL/Ed Whitman, 2018

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**Parker Solar Probe**

PSP mission goals (Fox et al., 2015):  
- Trace flow of energy that heats and accelerates the corona and solar wind  
- Determine the structure and dynamics of the plasma and magnetic fields at the sources of the solar wind  
- Explore the mechanisms that accelerate and transport solar energetic particles

WISPR coronagraph (Wide-Field Imager for Solar Probe)  
This study is based on work performed for the CGAUSS (Coronagraphic German and US Solar Probe Plus Survey) project

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**Solar wind model**

Aim  
use existing solar wind data  
empirical solar wind model  
extrapolate model to PSP orbit

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**Solar wind model**

Model concept  
Four solar wind key parameters  
- Magnetic field strength  
- Velocity  
- Density  
- Temperature  
values shifted according to solar activity and solar distance  
unique: frequency distributions

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**OMNI data set**

OMNI data set (King & Papitashvili, 2005)
 

- intercalibrated multi-spacecraft data

- time-shifted to the bow shock of the magnetosphere  
- 1963–2016

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Geomagnetic impact of the solar wind Solar wind model End matter References

**OMNI data set**

example data plots...

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**Frequency distributions**

Magnetic field strength [G]

Velocity [km/s]

Density [ $\text{cm}^{-3}$ ]

Temperature [K]

Luminous distribution

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**Solar activity**

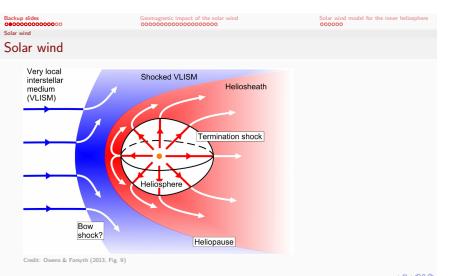
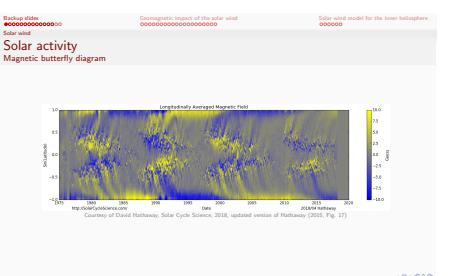
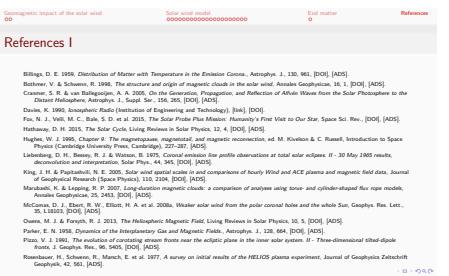
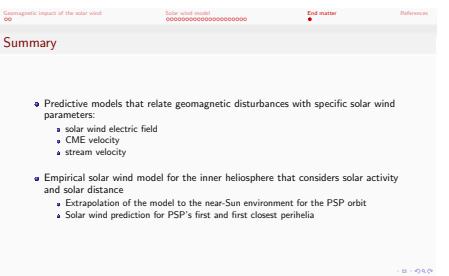
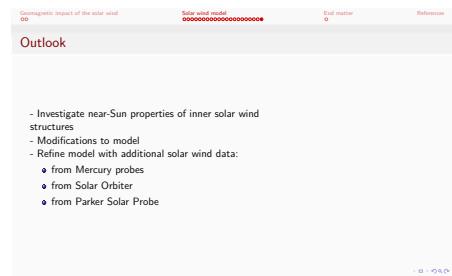
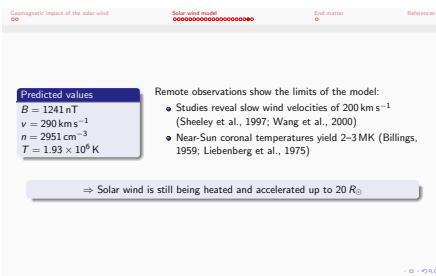
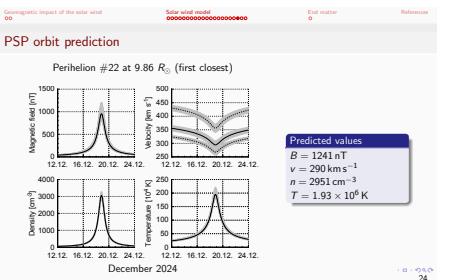
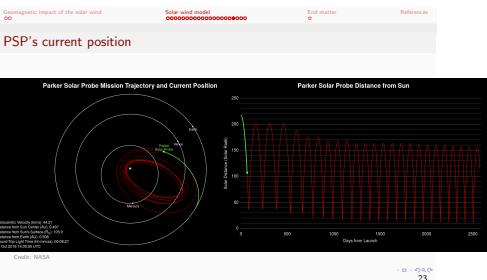
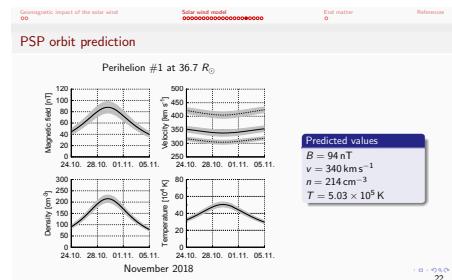
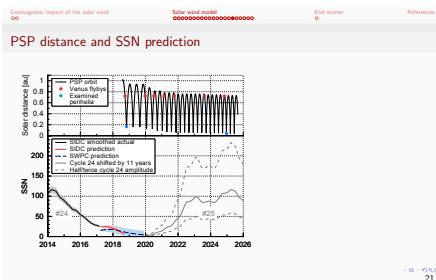
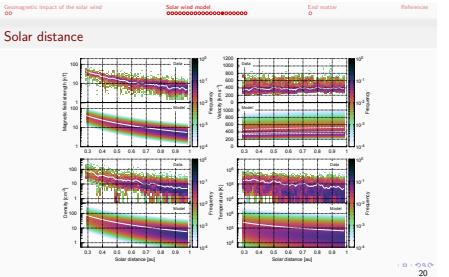
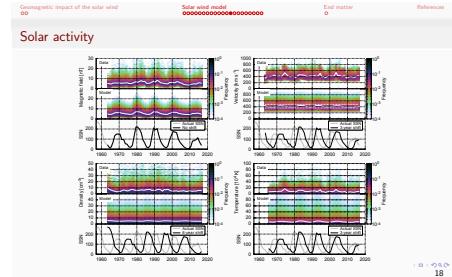
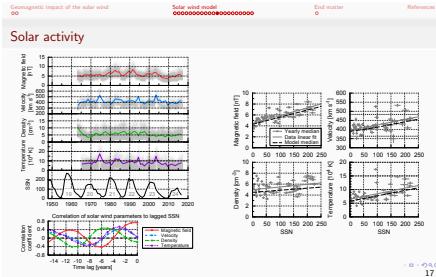
sunspot images...

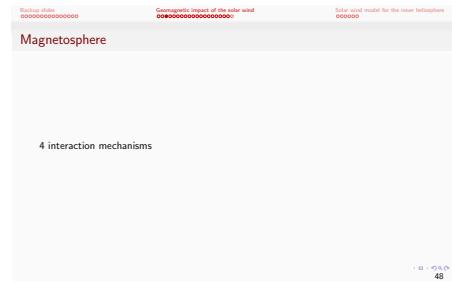
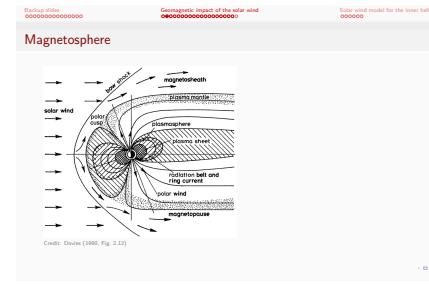
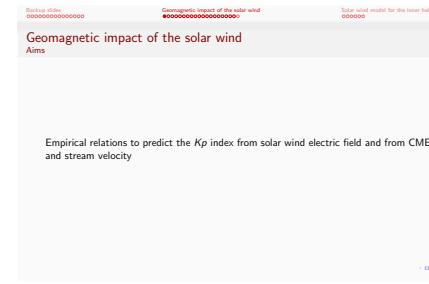
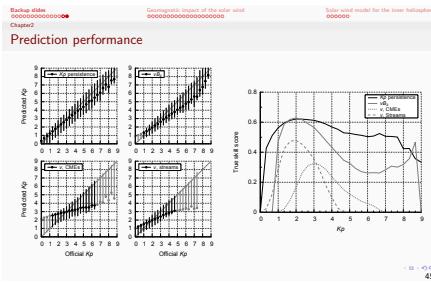
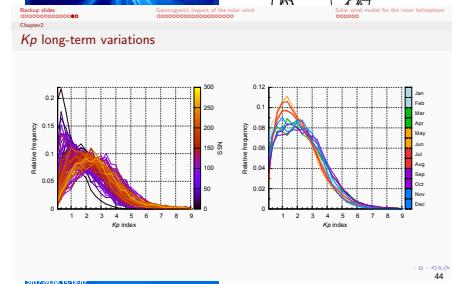
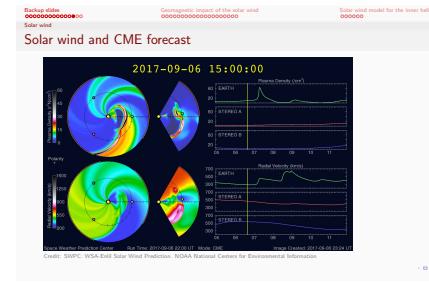
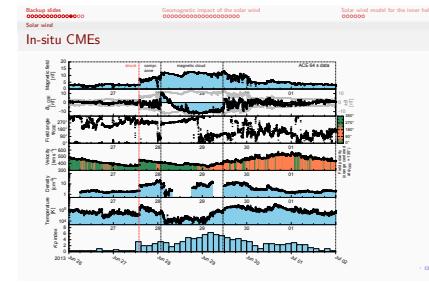
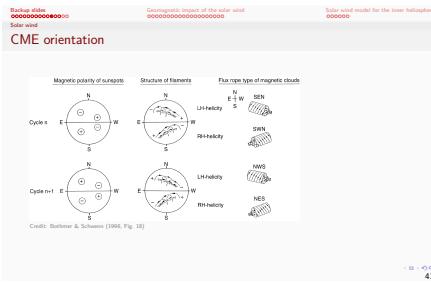
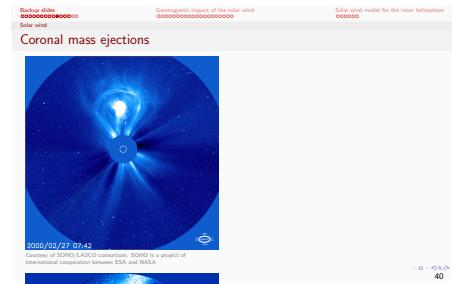
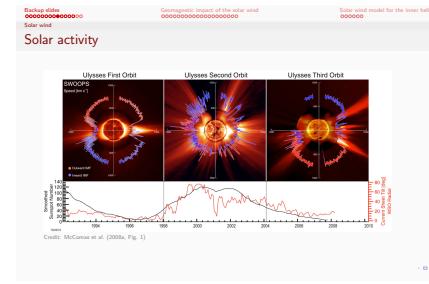
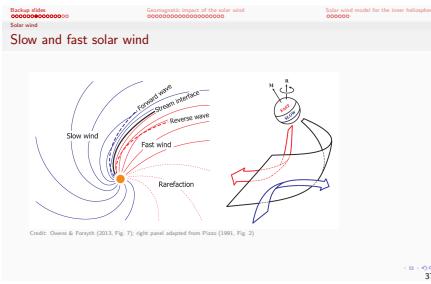
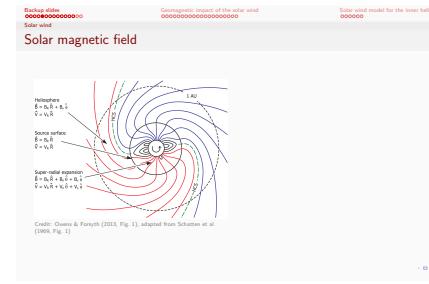
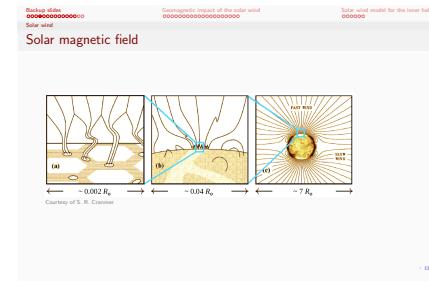
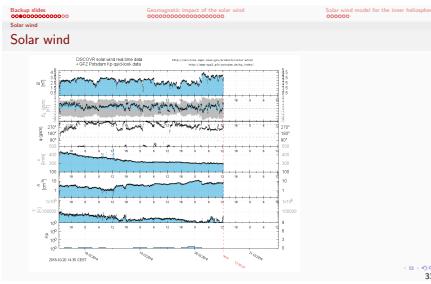
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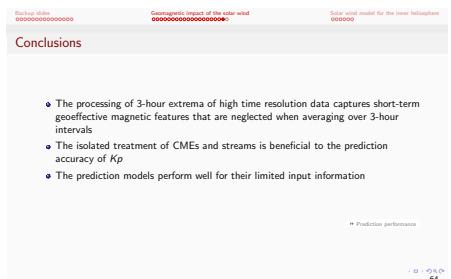
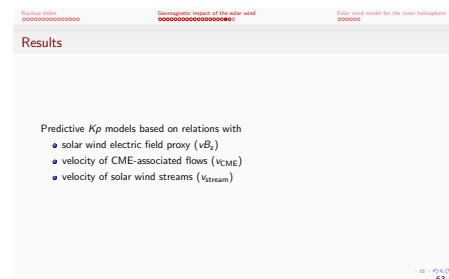
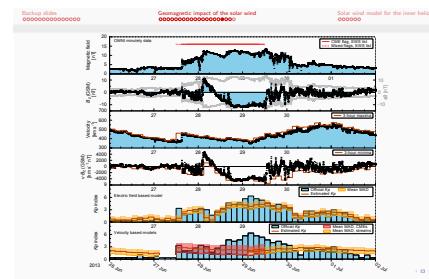
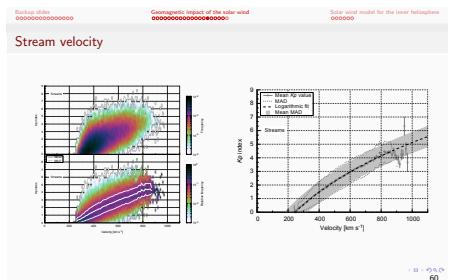
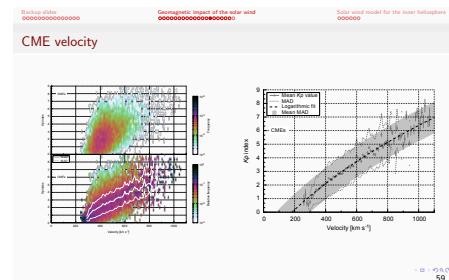
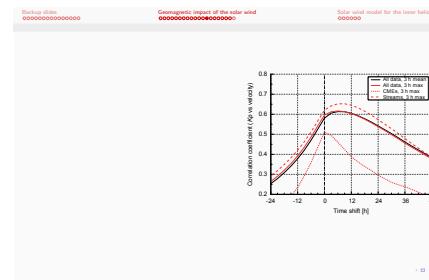
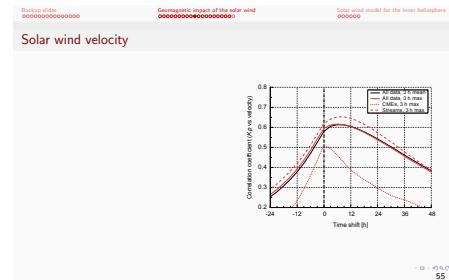
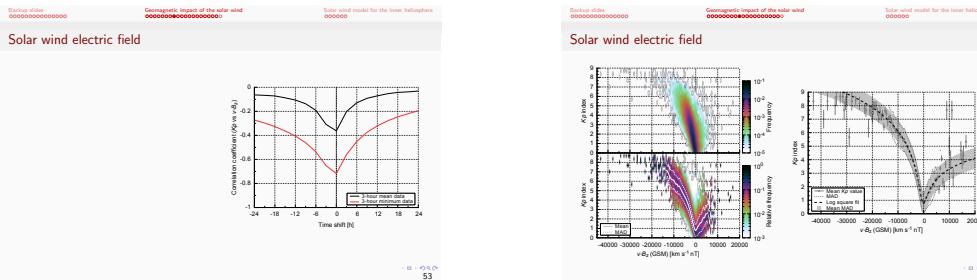
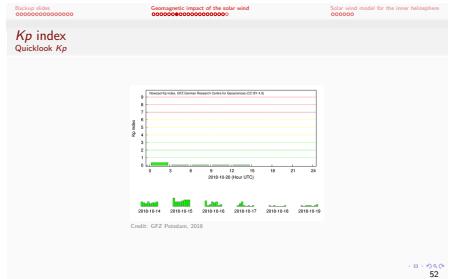
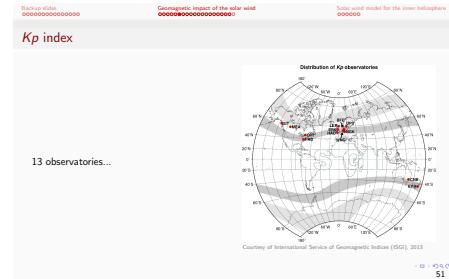
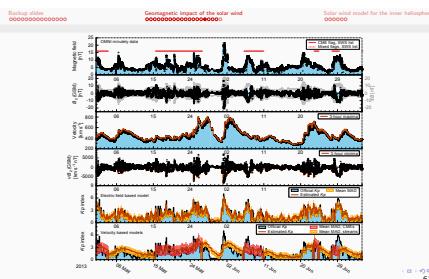
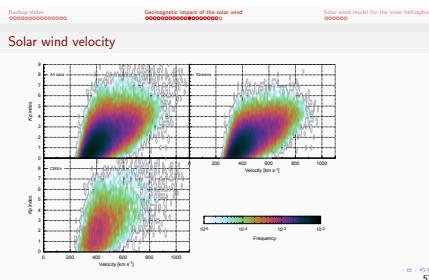
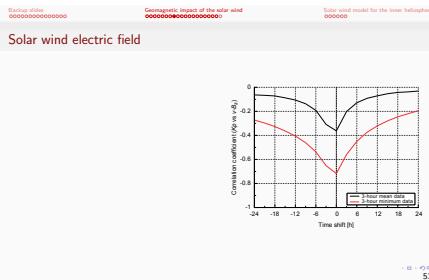
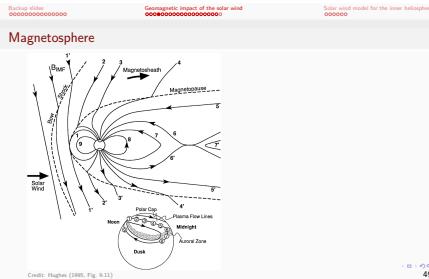
RELIABILITY INDEX (0.0 TO 1.0)

Magnetic field intensity diagram

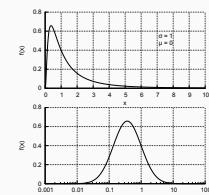
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### Normal distribution



Probability density function:  

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Location ( $\mu$ ) and shape parameter ( $\sigma$ )

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### Sun-Earth evolution of the solar wind

Solar wind measured in-situ throughout the heliosphere – except near-Sun

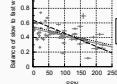
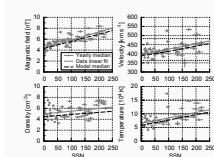
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### Sun-Earth evolution of the solar wind

special scientific interest:  
 coronal heating  
 solar wind acceleration

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### Solar activity



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### Sun-Earth evolution of the solar wind

Aims

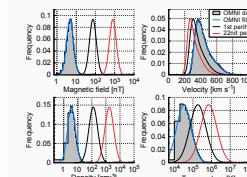
Solar wind model for the inner heliosphere and prediction of the near-Sun environment for the PSP orbit

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combine models, extrapolation

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### PSP perihelia prediction



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