

**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  
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Seminarraum Astrophysik (SR 17, F 05.104)

1 2 3

Solar wind Geomagnetic impact of the solar wind Solar wind model for the inner heliosphere End matter References

**Two topics**

**Title**  
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 orbit

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Solar wind Geomagnetic impact of the solar wind Solar wind model for the inner heliosphere End matter References

**Solar wind**

- Solar wind
- Geomagnetic impact of the solar wind
- Solar wind model for the inner heliosphere
- End matter

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**Solar wind**

- flow of magnetized plasma  
- consists of electrons, protons and 5% helium

Credit: Michael Druckmüller, Peter Auri, Shadid Habib, 2017

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**Solar wind**

Credit: Owen & Forsyth (2013, Fig. 9)

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**Solar wind**

Credit: Owen & Forsyth (2013, Fig. 9)

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**Solar magnetic field**

Credit: S. M. Cowley

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**Solar magnetic field**

Credit: Owen & Forsyth (2013, Fig. 1), adapted from Schatten et al. (1989, Fig. 1)

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**Slow and fast solar wind**

Credit: NASA/SOHO and the MA, EVE and EIT science teams

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**Slow and fast solar wind**

Credit: Owen & Forsyth (2013, Fig. 7); right panel adapted from Pizzo (1991, Fig. 2)

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**Solar wind in-situ example**

Credit: ACE 844 098

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**Solar activity**  
Sunspots

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**Solar activity**

International sunspot number  $s_{\text{int}}$ , monthly mean and 13-month smoothed number

Magnetic butterfly diagram

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**Solar activity**

Ulysses First Orbit Ulysses Second Orbit Ulysses Third Orbit

Credit: McGuire et al. (2008a, Fig. 1)

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**Coronal mass ejections**

2020/02/27 07:42

Credit: LASCO/C2, LASCO consortium, TONC, a project of international cooperation between ESA and NASA

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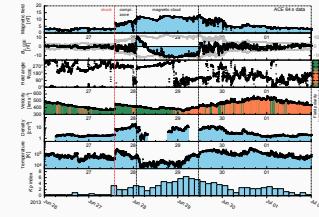
**CME orientation**

Magnetic polarity of sunspot Structure of filaments Flare type of magnetic clouds

Credit: Bothmer & Schwenn (1990, Fig. 10)

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## In-situ CMEs



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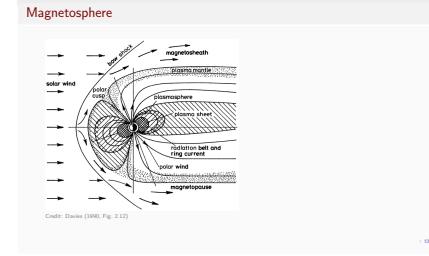
## Geomagnetic impact of the solar wind

Aims

Empirical relations to predict the  $K_p$  index from solar wind electric field and from CME and stream velocity

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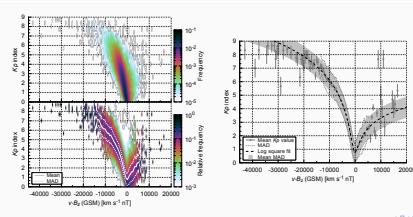
## Magnetosphere



4 factors for merging flux rate

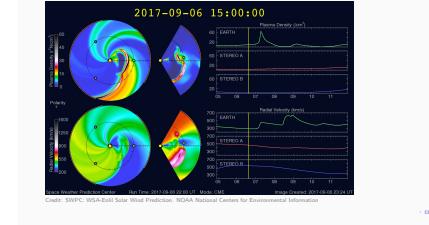
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## Solar wind electric field



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## Solar wind and CME forecast



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## Solar wind model for the inner heliosphere

Solar wind

Geomagnetic impact of the solar wind

Solar wind model for the inner heliosphere

End matter

## Geomagnetic impact of the solar wind

images...

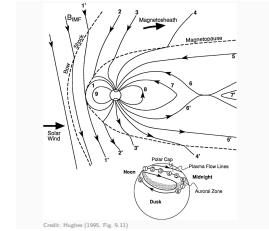
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## Magnetosphere

## Magnetosphere

4 interaction mechanisms

## Magnetosphere

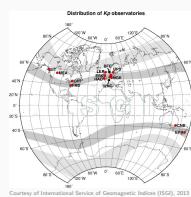


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## Kp index

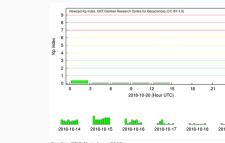


13 observatories...



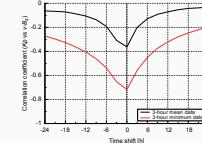
Courtesy of International Service of Geomagnetic Indices (ISGI), 2013

## Kp index Quicklook Kp



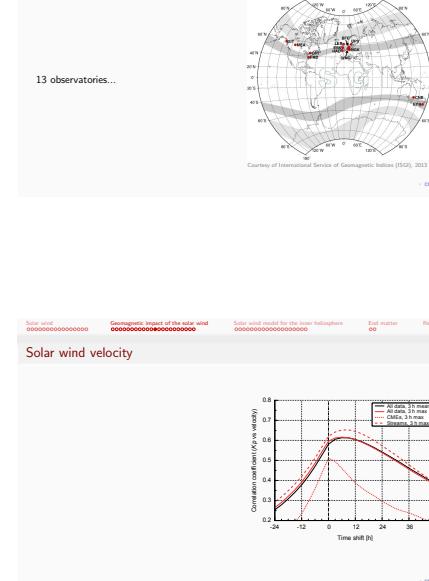
Credit: GFZ Potsdam, 2018

## Solar wind electric field



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## Solar wind velocity

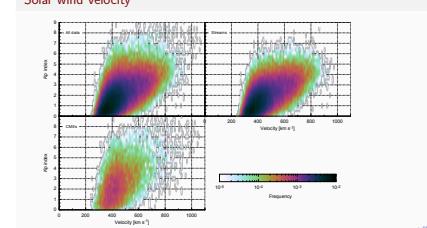


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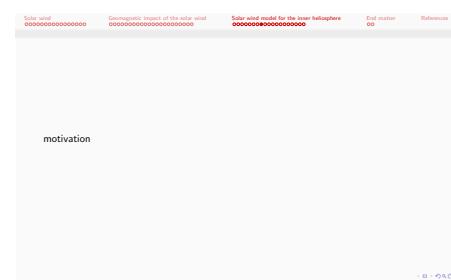
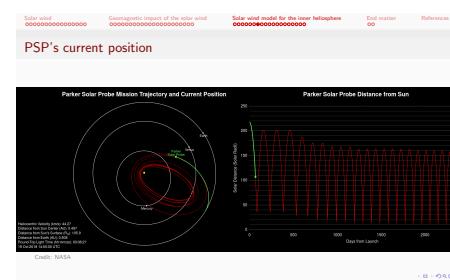
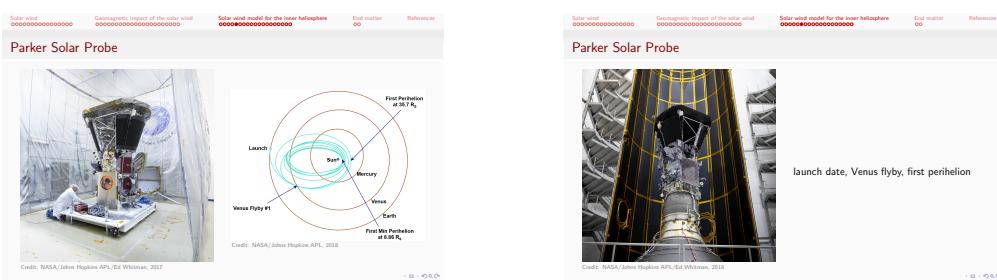
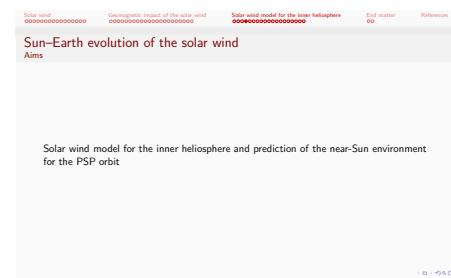
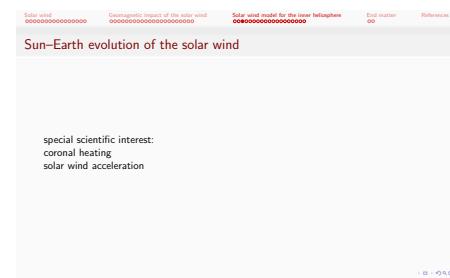
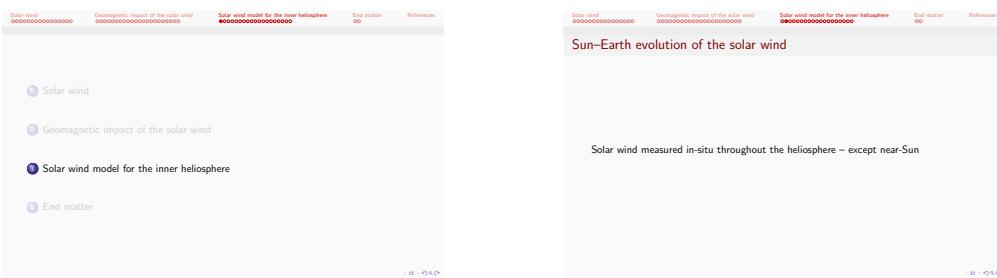
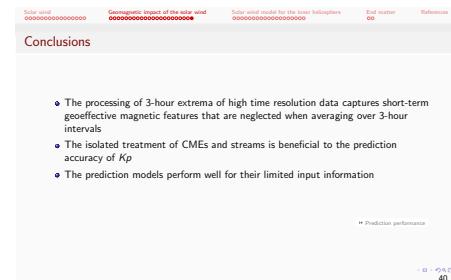
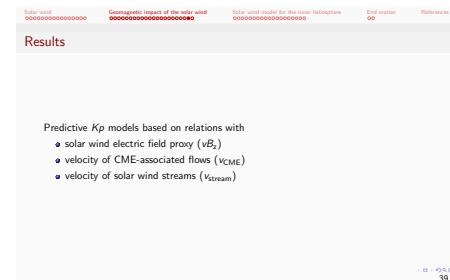
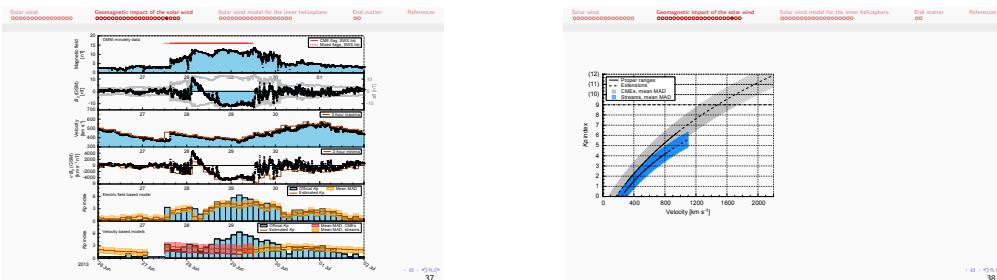
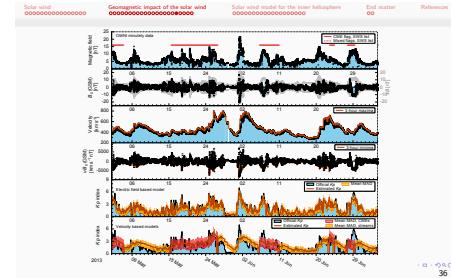
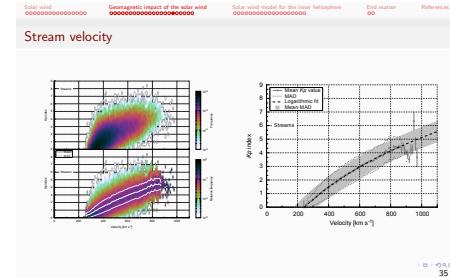
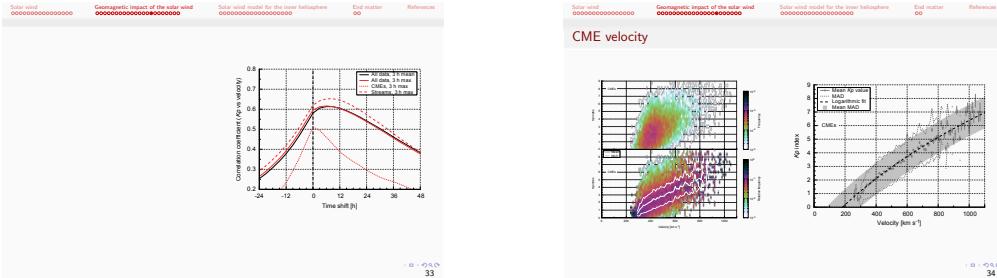
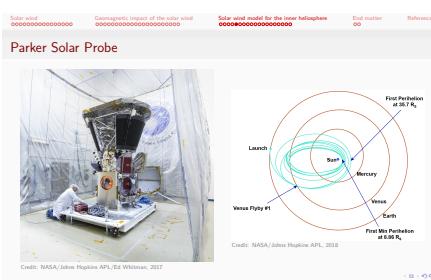
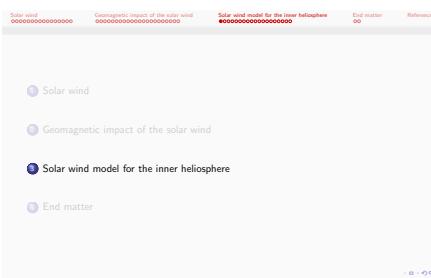
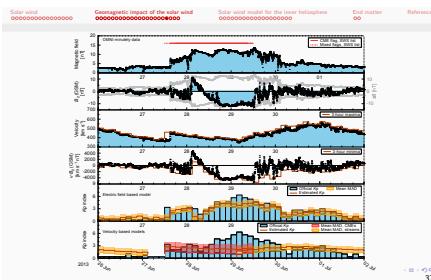
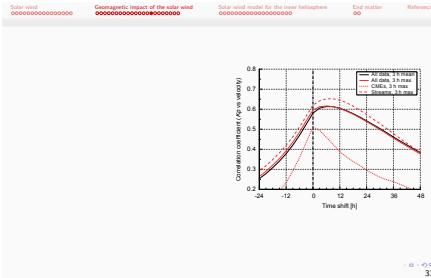
## Solar wind velocity

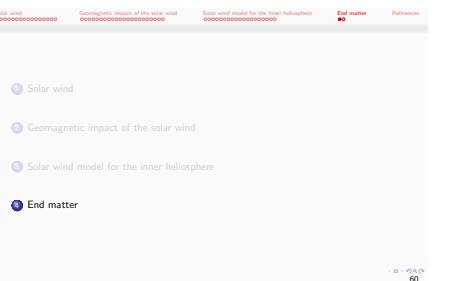
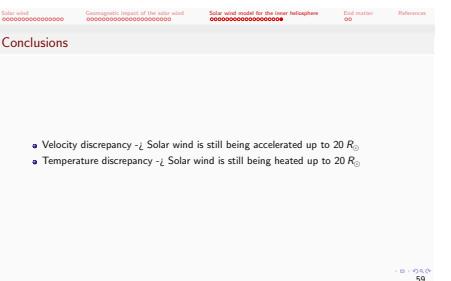
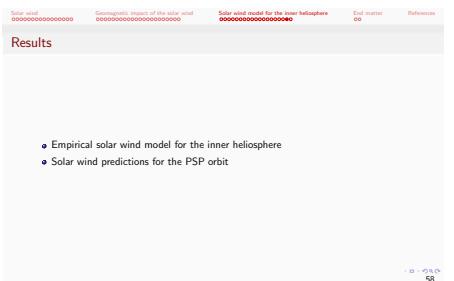
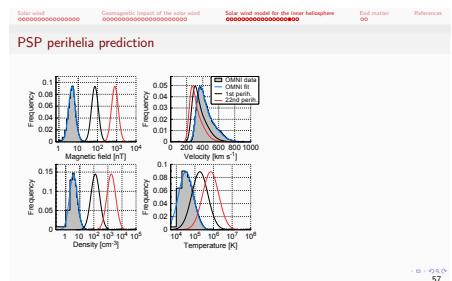
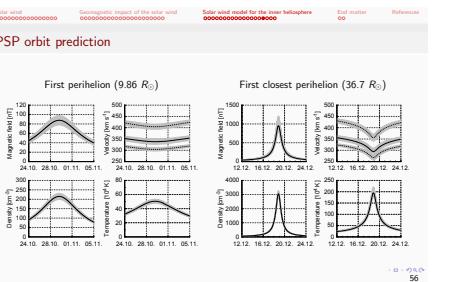
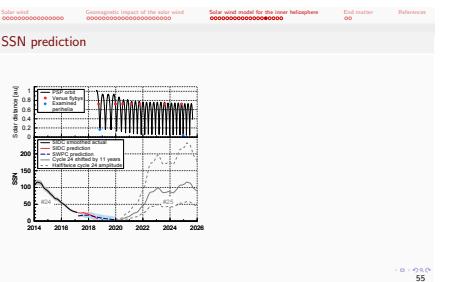
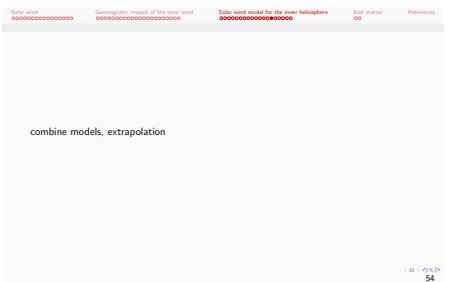
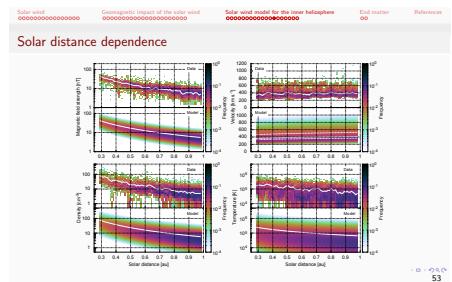
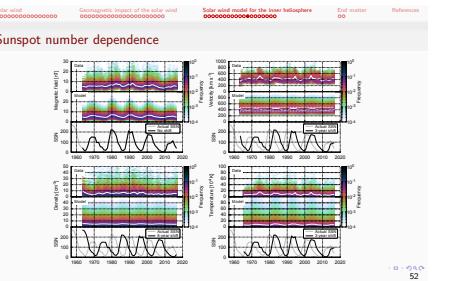
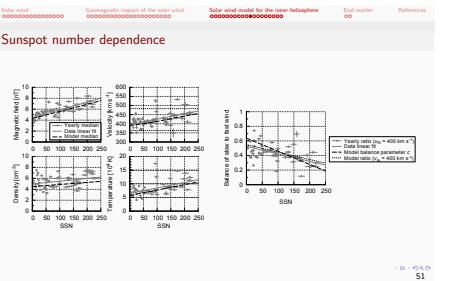
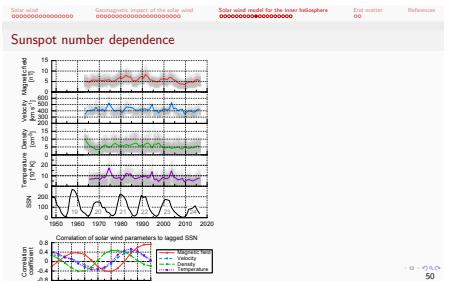
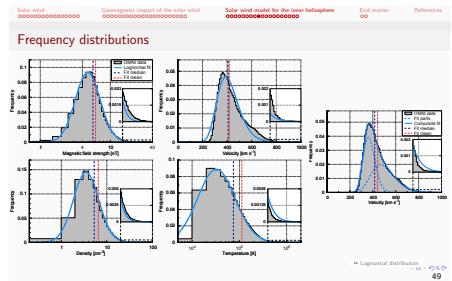
CME – stream separation  
Solar Wind Structures list

## Solar wind velocity

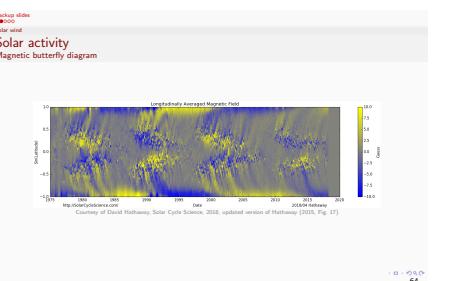
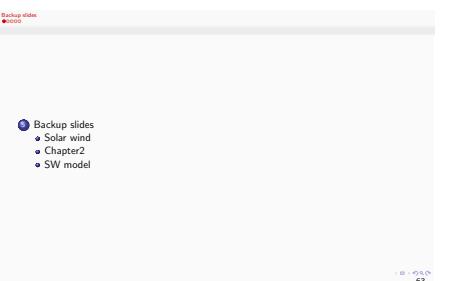


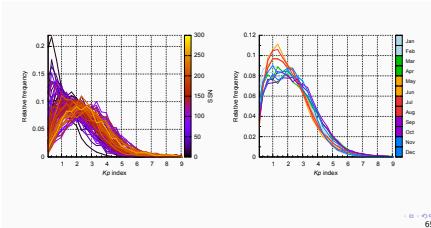
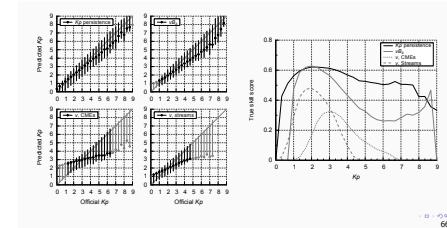
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**K<sub>p</sub> long-term variations****Prediction performance****Lognormal distribution**