

# 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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Thursday, 1 November 2018, 14:00  
Seminarraum Astrophysik (SR 17, F 05.104)

## Two topics

### Title

The solar wind's geomagnetic impact and its Sun–Earth evolution

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Predictive models for space weather and for the Parker Solar Probe orbit

# Two topics

## Study 1

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

# Two topics

## 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

## 1 Solar wind

## 2 Geomagnetic impact of the solar wind

## 3 Solar wind model for the inner heliosphere

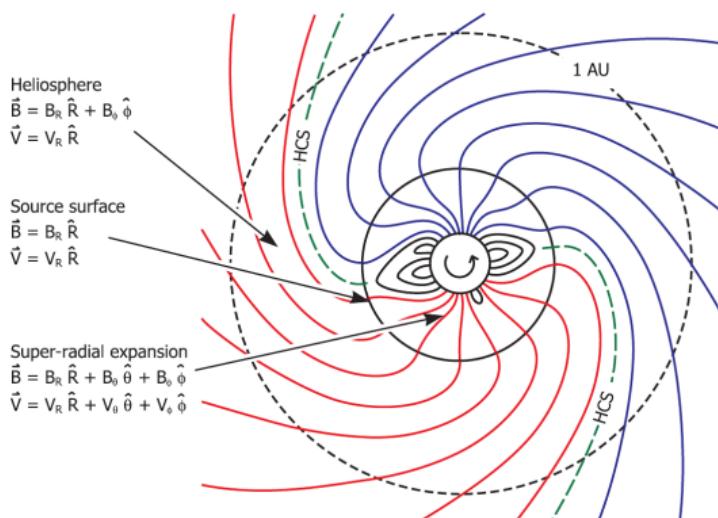
## 4 End matter

## Solar wind



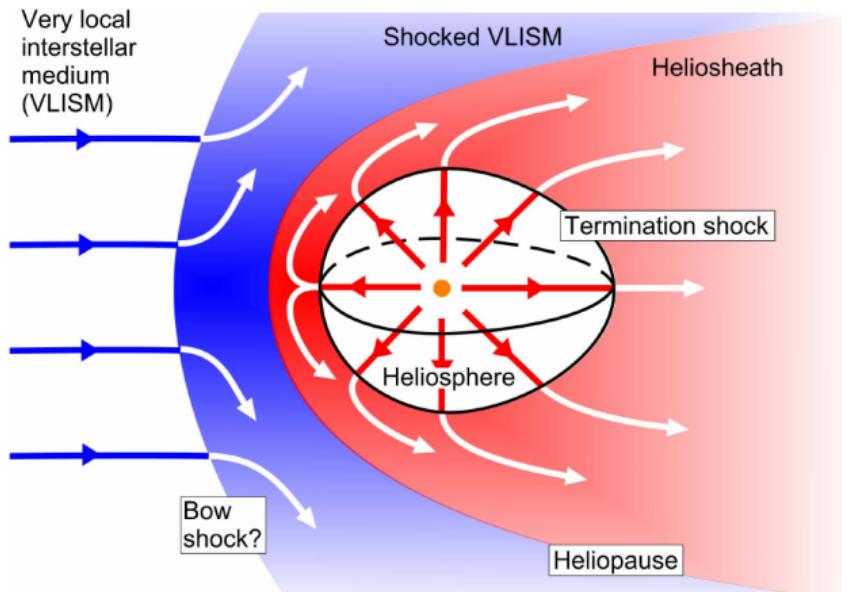
Credit: Miloslav Druckmüller, Peter Aniol, Shaddia Habbal, 2017

## Solar wind



Credit: Owens & Forsyth (2013, Fig. 1), adapted from Schatten et al. (1969, Fig. 1)

## Solar wind



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

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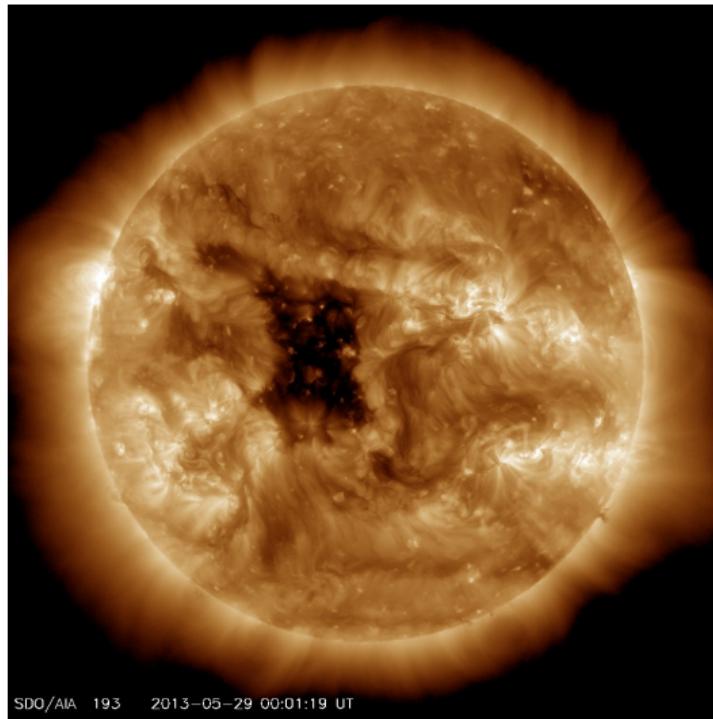
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Solar wind model for the inner heliosphere  
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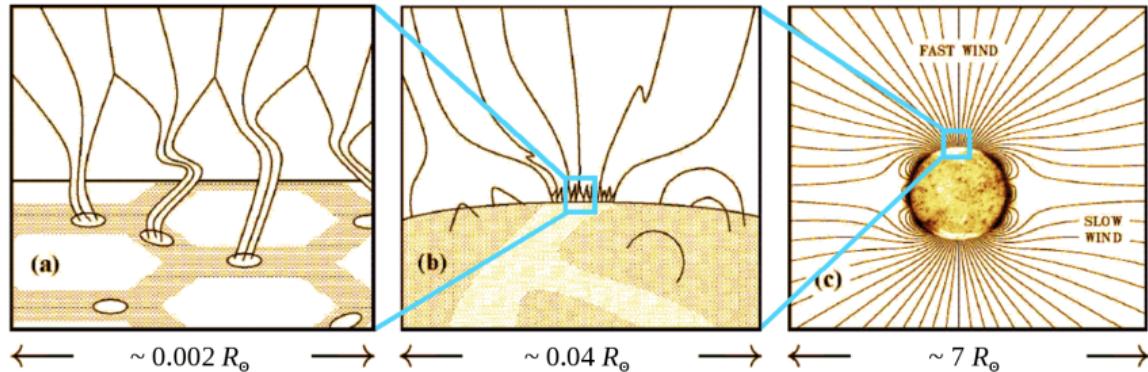
# Solar wind



SDO/AIA 193 2013-05-29 00:01:19 UT

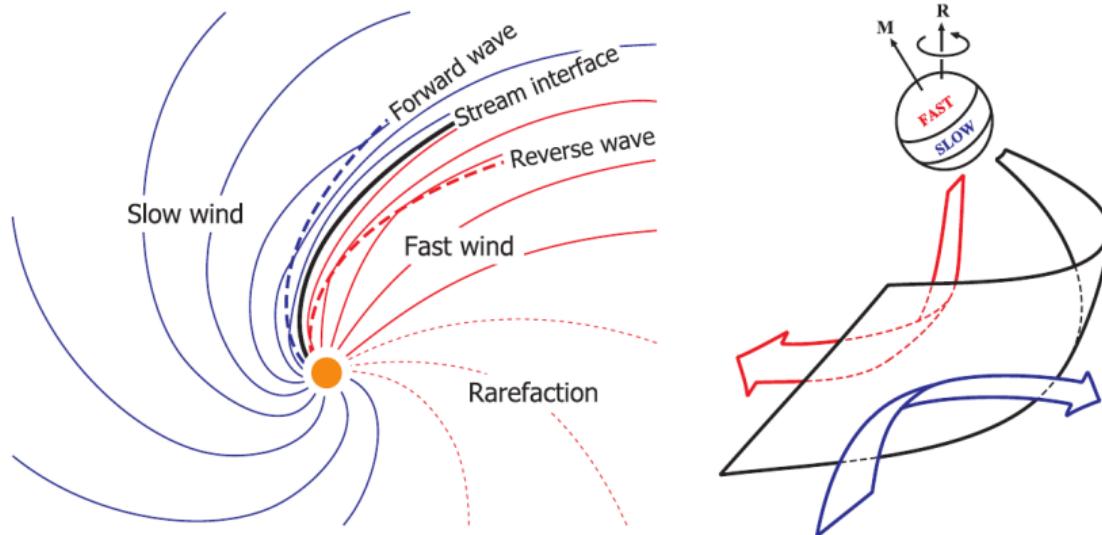
Credit: NASA/SDO and the AIA, EVE and HMI science teams

# Solar wind



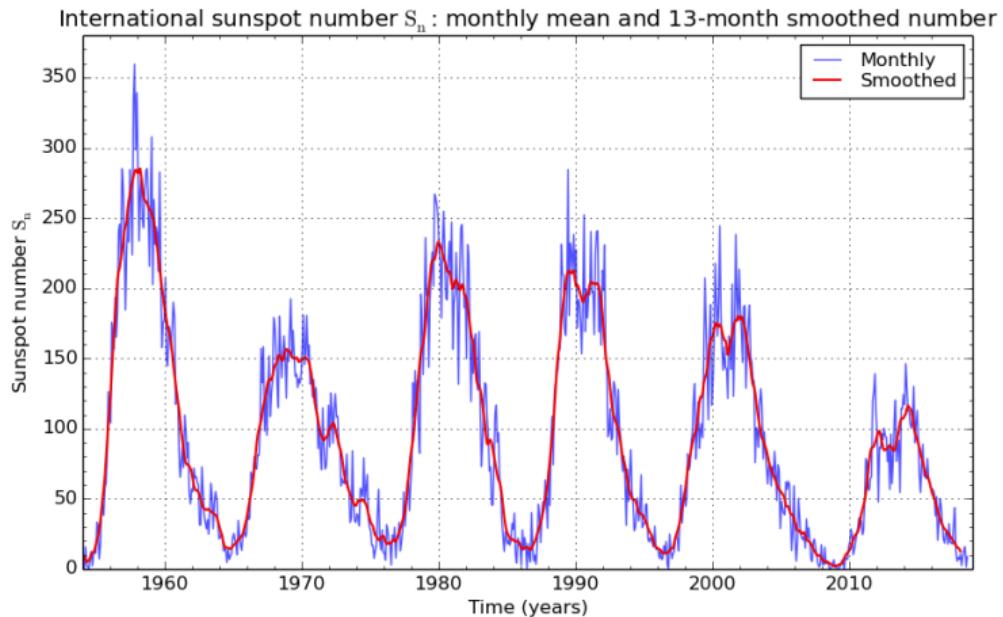
Courtesy of S. R. Cranmer

# Solar wind



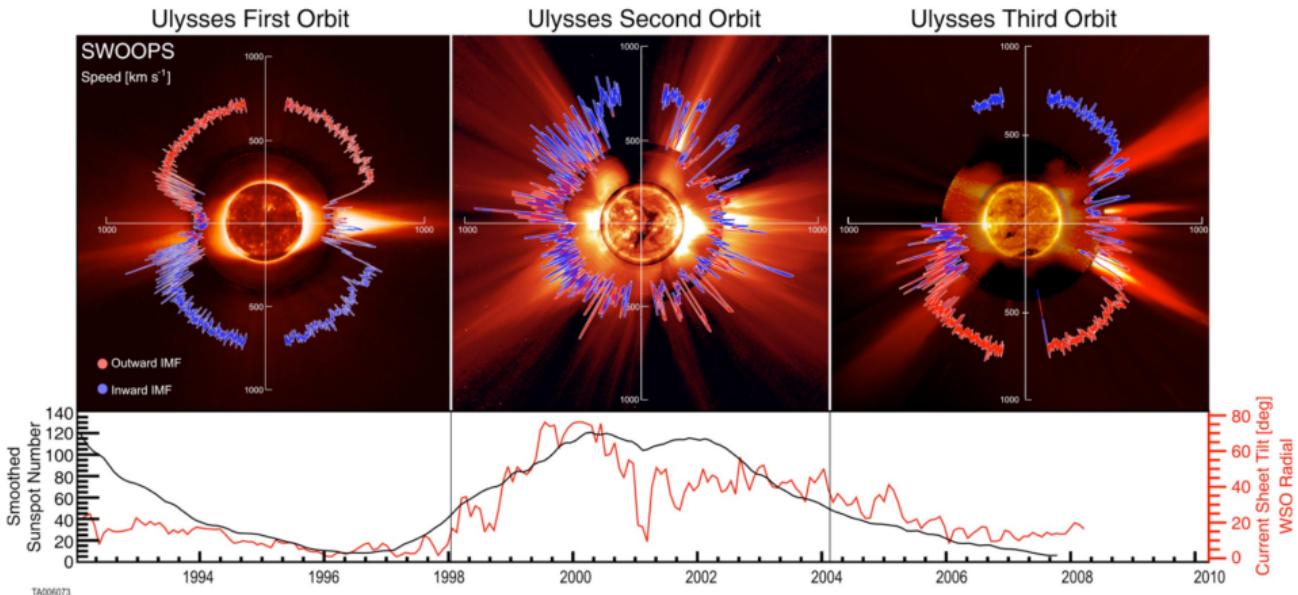
Credit: Owens & Forsyth (2013, Fig. 7); right panel adapted from Pizzo (1991, Fig. 2)

# Solar wind



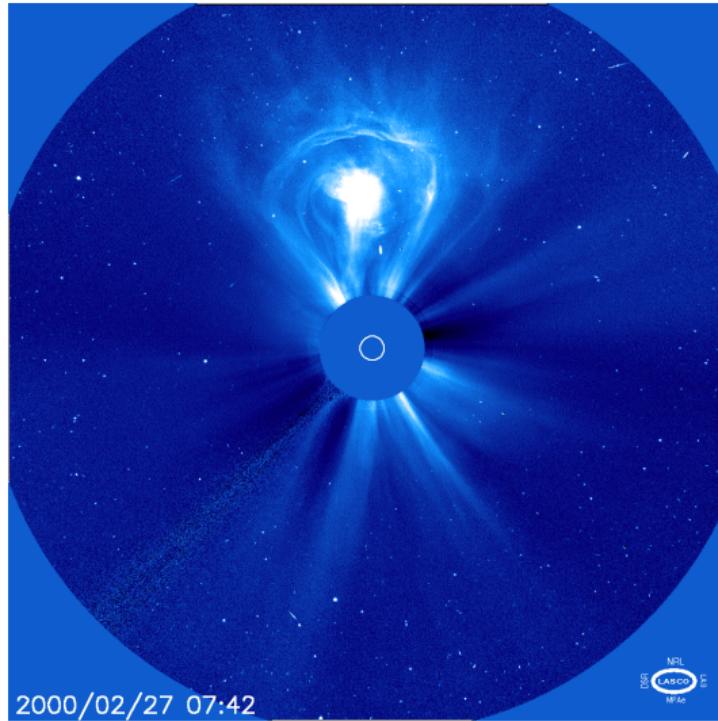
SILSO graphics (<http://sidc.be/silso>) Royal Observatory of Belgium 2018 September 1

# Solar wind



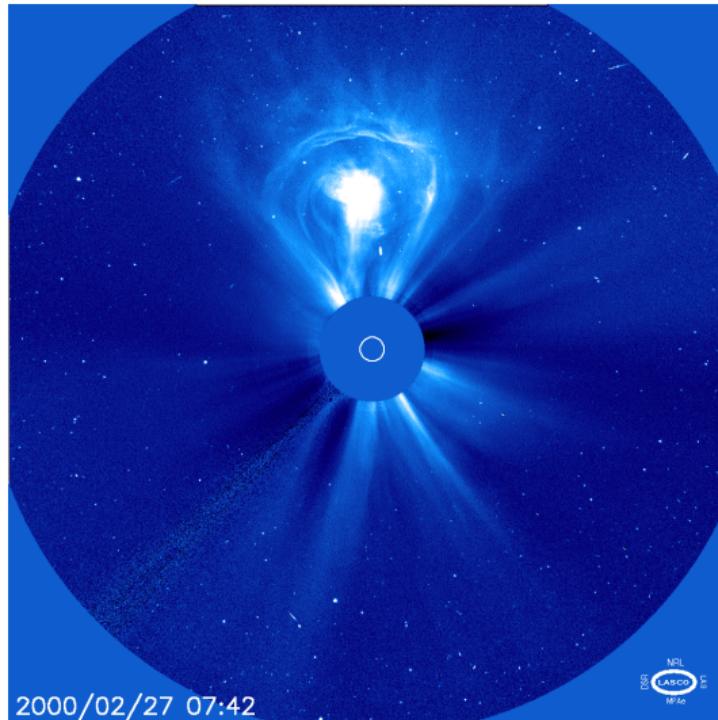
Credit: McComas et al. (2008a, Fig. 1)

# Solar wind

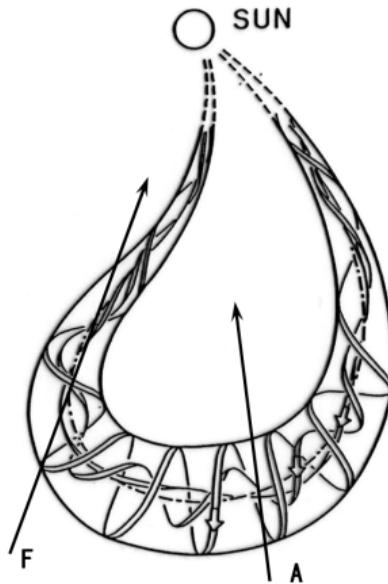


Courtesy of SOHO/LASCO consortium. SOHO is a project of international cooperation between ESA and NASA

# Solar wind

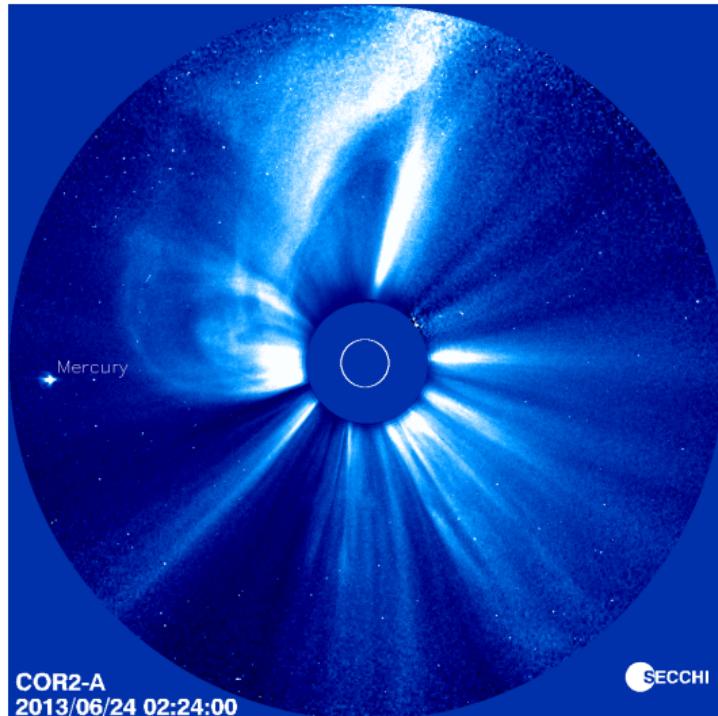


Courtesy of SOHO/LASCO consortium. SOHO is a project of international cooperation between ESA and NASA

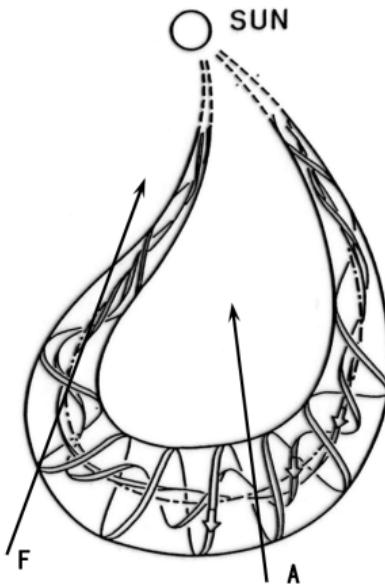


Credit: Marubashi & Lepping (2007, Fig. 1, panel (a))

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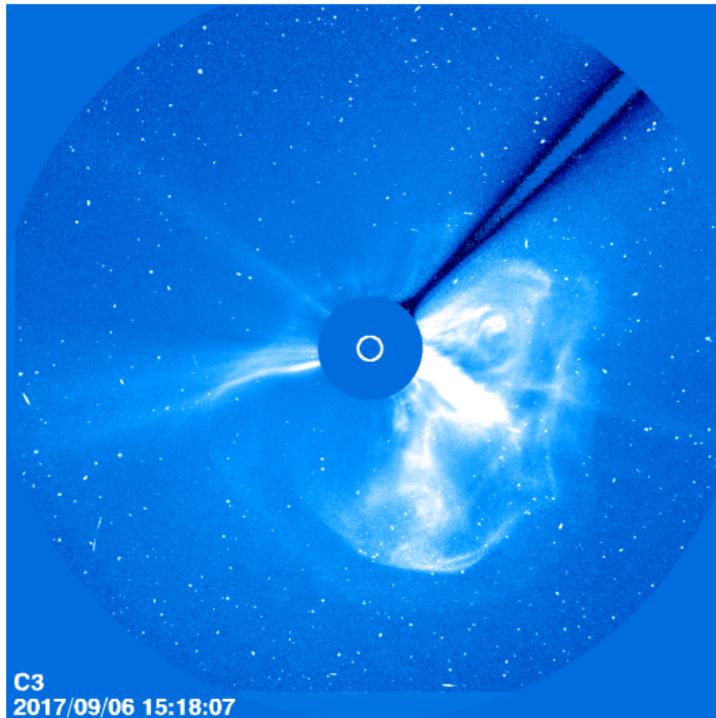


Courtesy of STEREO/COR2 consortium (NASA)

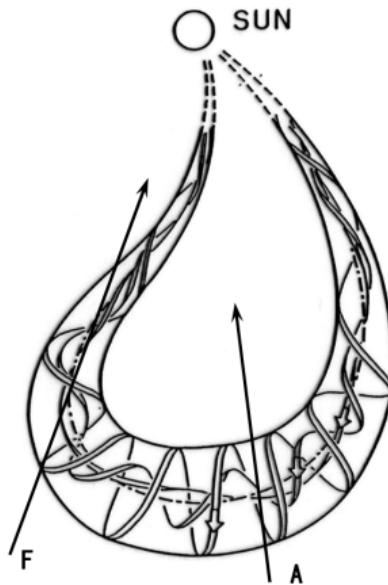


Credit: Marubashi & Lepping (2007, Fig. 1, panel (a))

# Solar wind

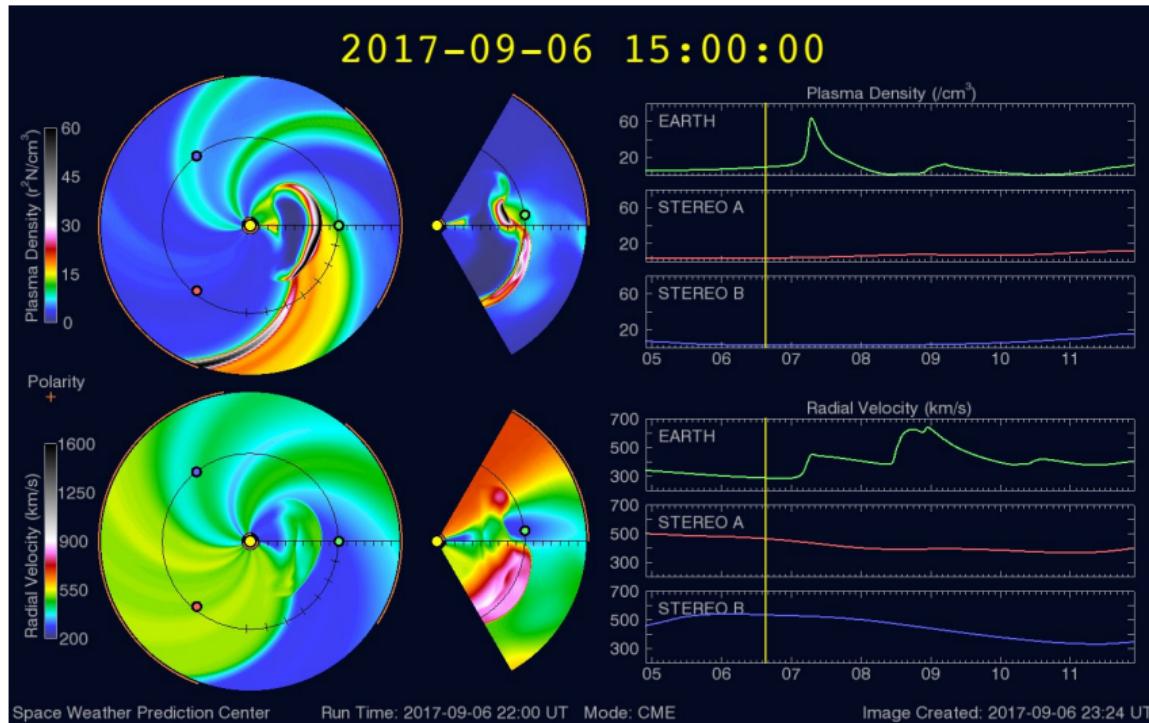


Courtesy of SOHO/LASCO consortium; SOHO is a project of international cooperation between ESA and NASA



Credit: Marubashi & Lepping (2007, Fig. 1, panel (a))

# Solar wind



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## 4 End matter

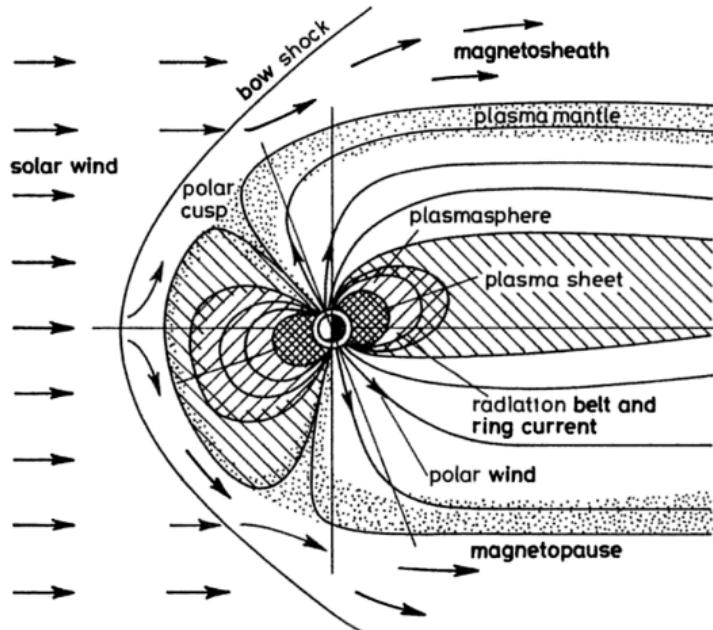
# Geomagnetic impact of the solar wind

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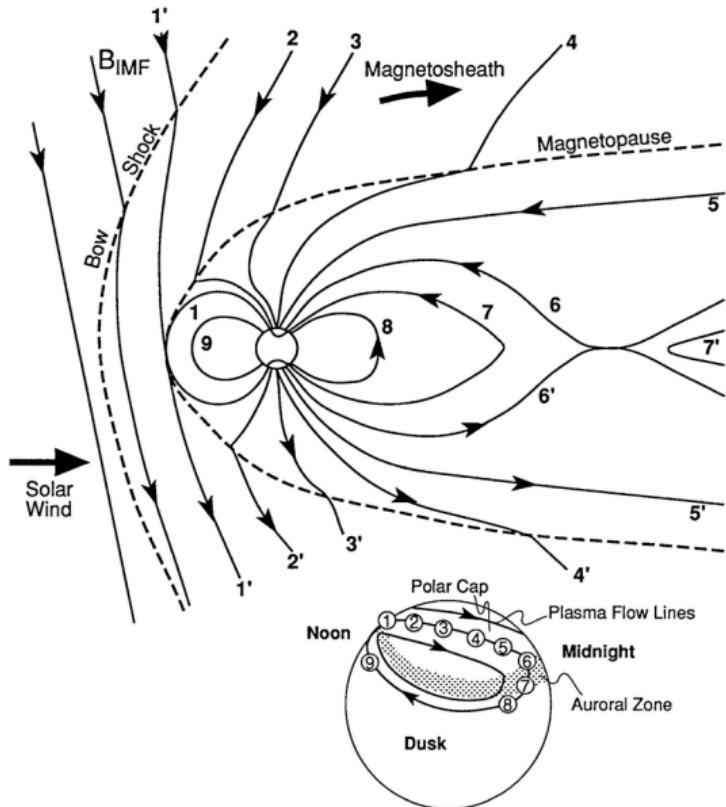
# Geomagnetic impact of the solar wind

## Aims

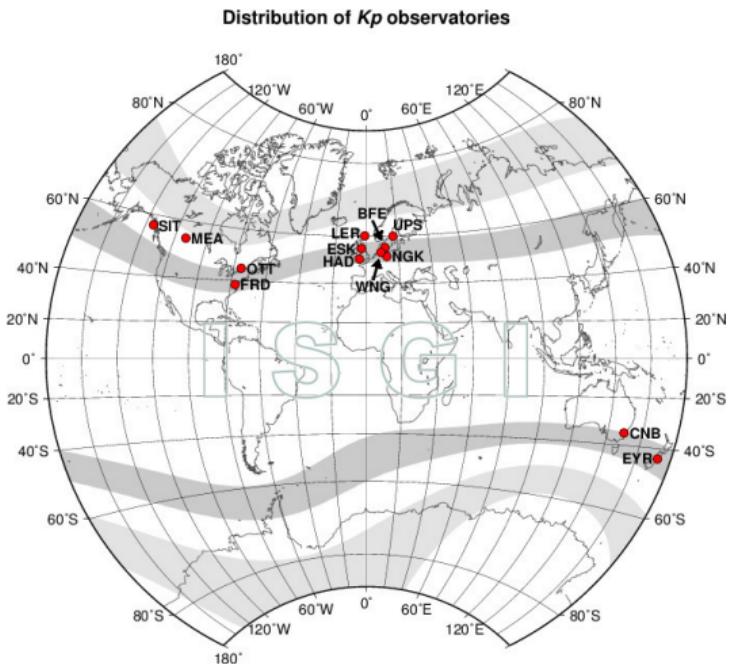
Empirical relations to predict the  $K_p$  index from solar wind electric field and from CME and stream velocity



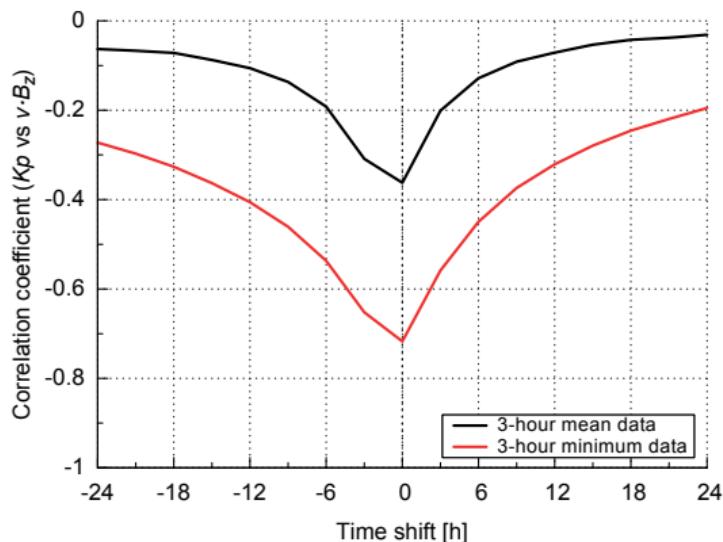
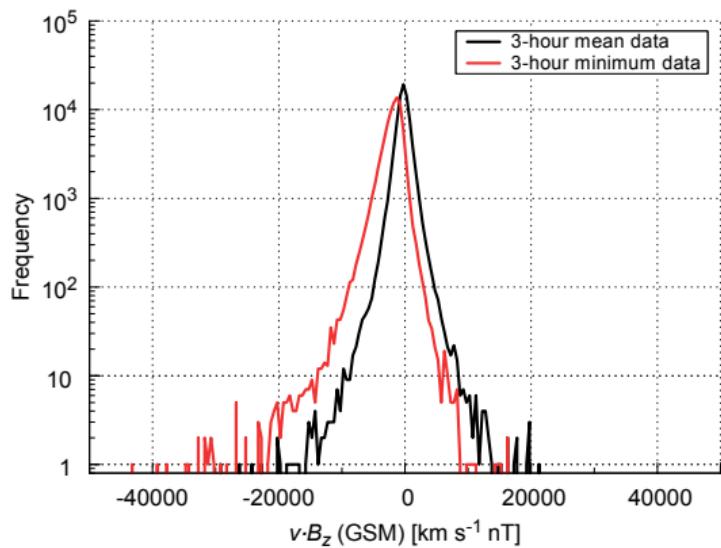
Credit: Davies (1990, Fig. 2.12)



Credit: Hughes (1995, Fig. 9.11)



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



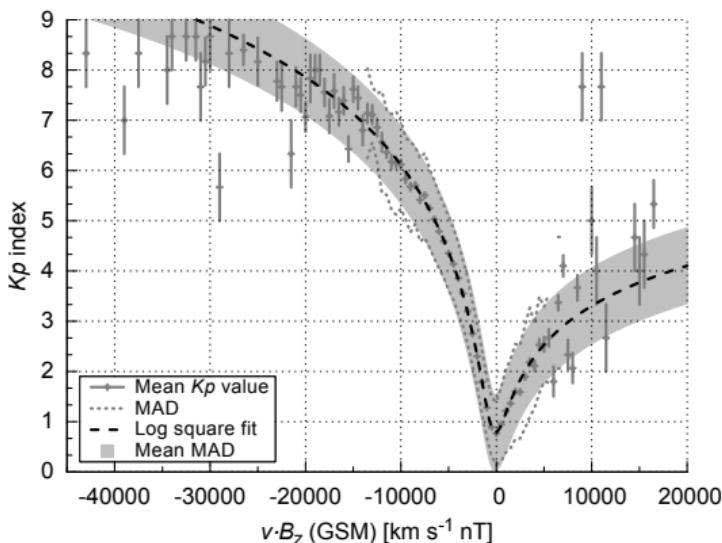
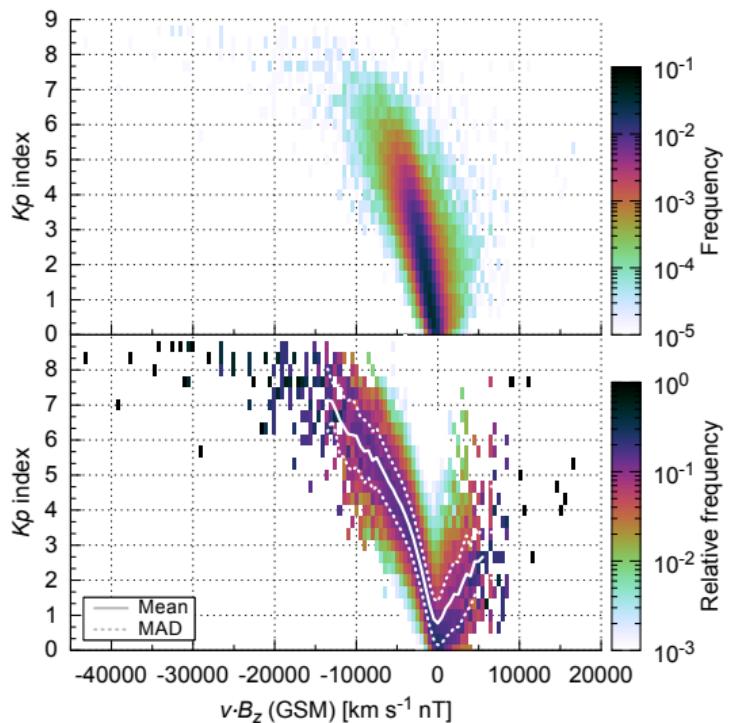
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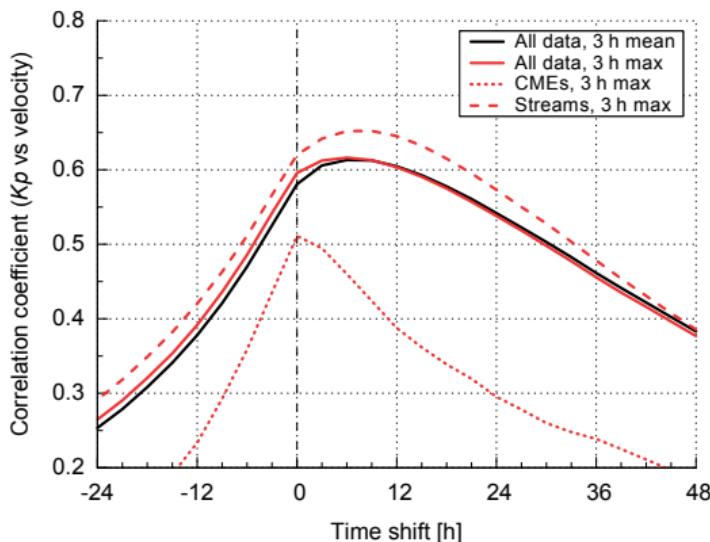
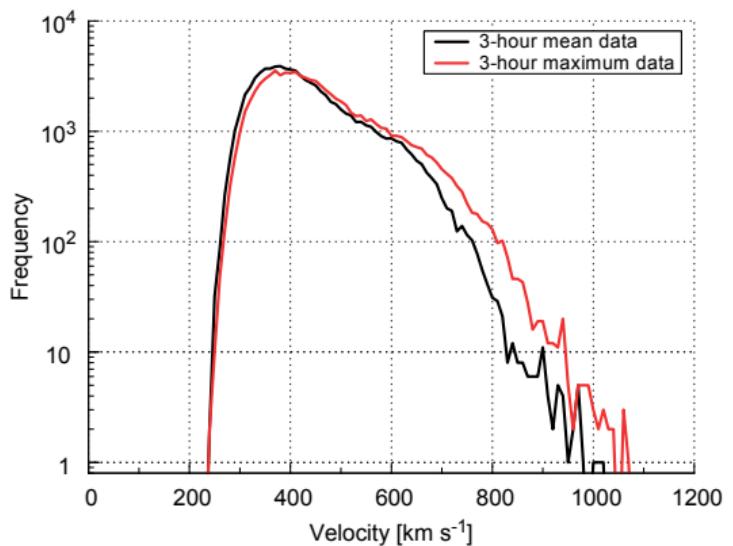
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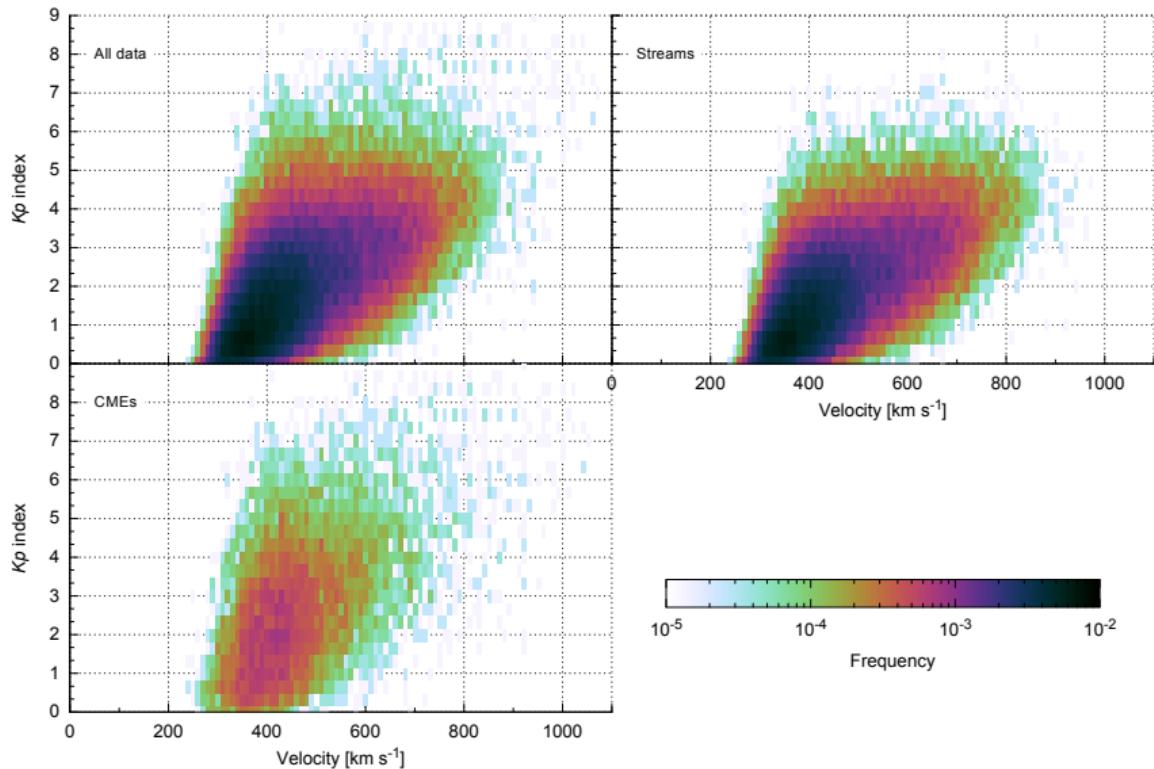
Solar wind model for the inner heliosphere  
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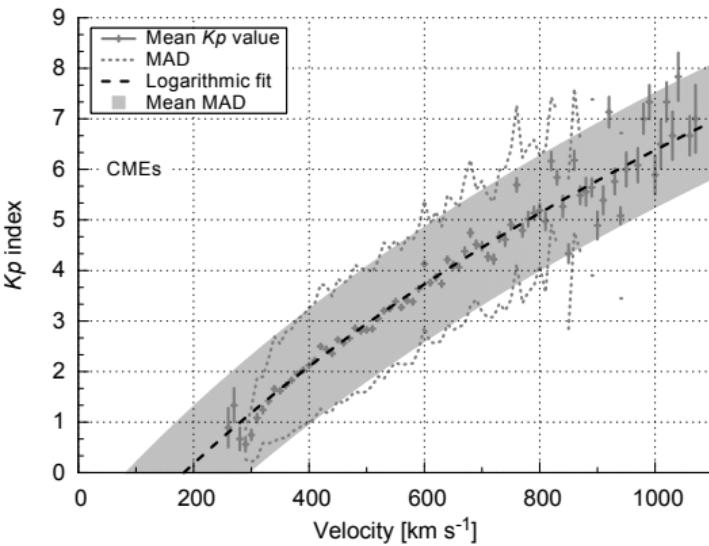
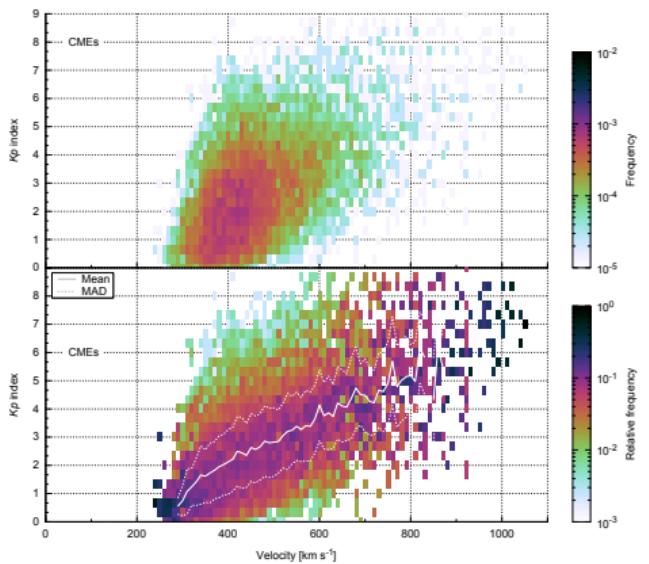
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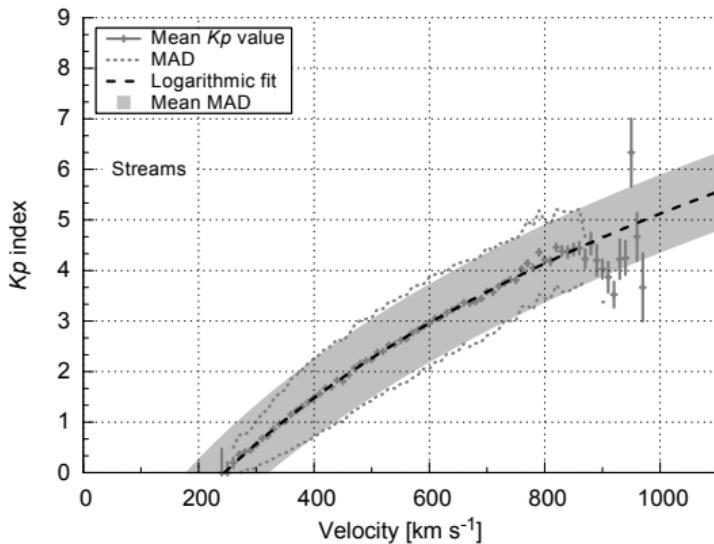
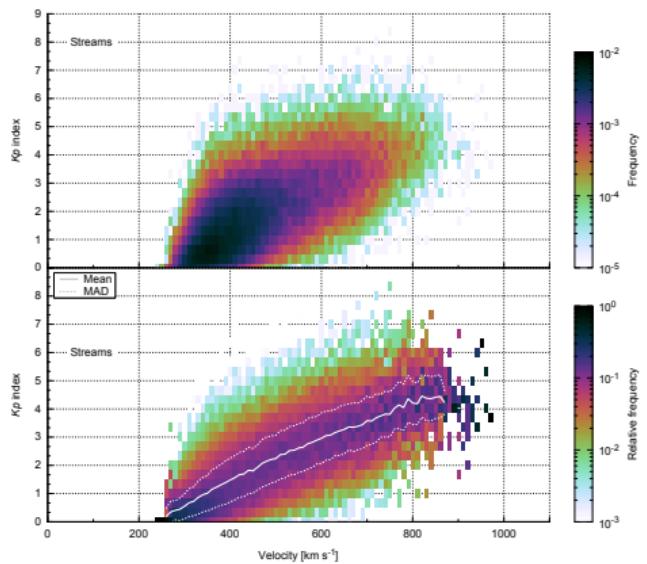
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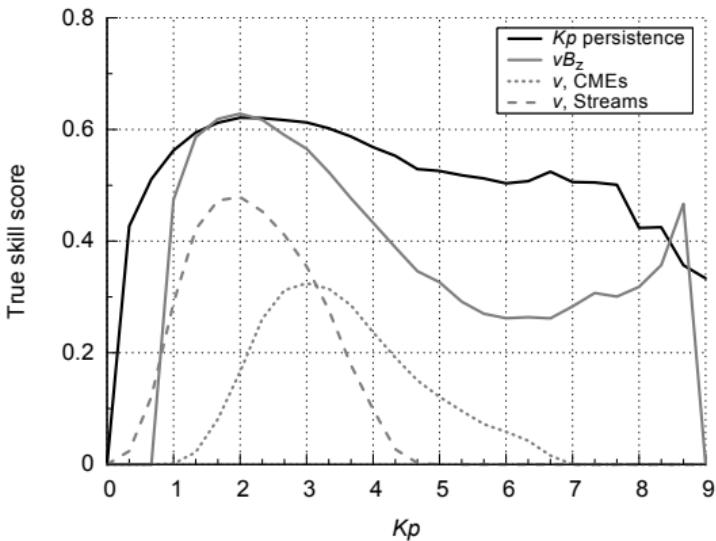
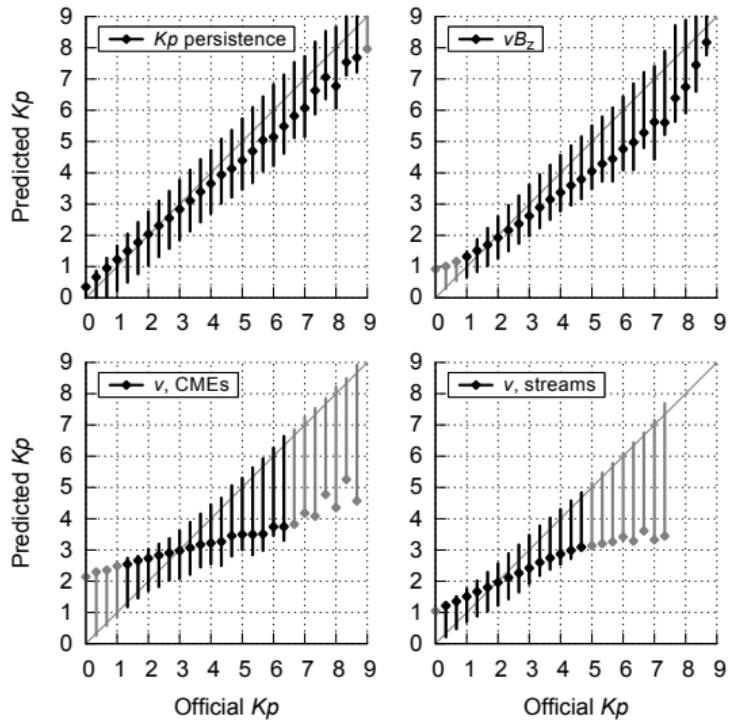
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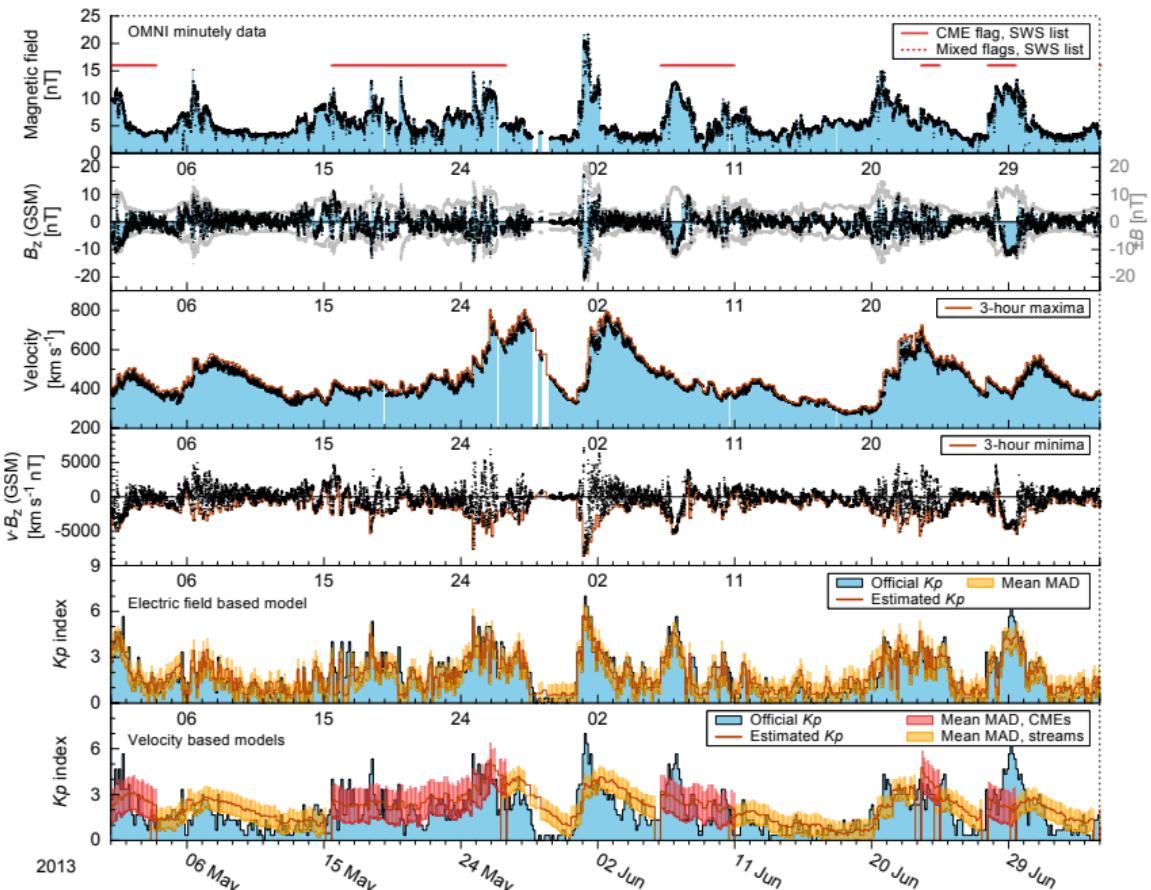
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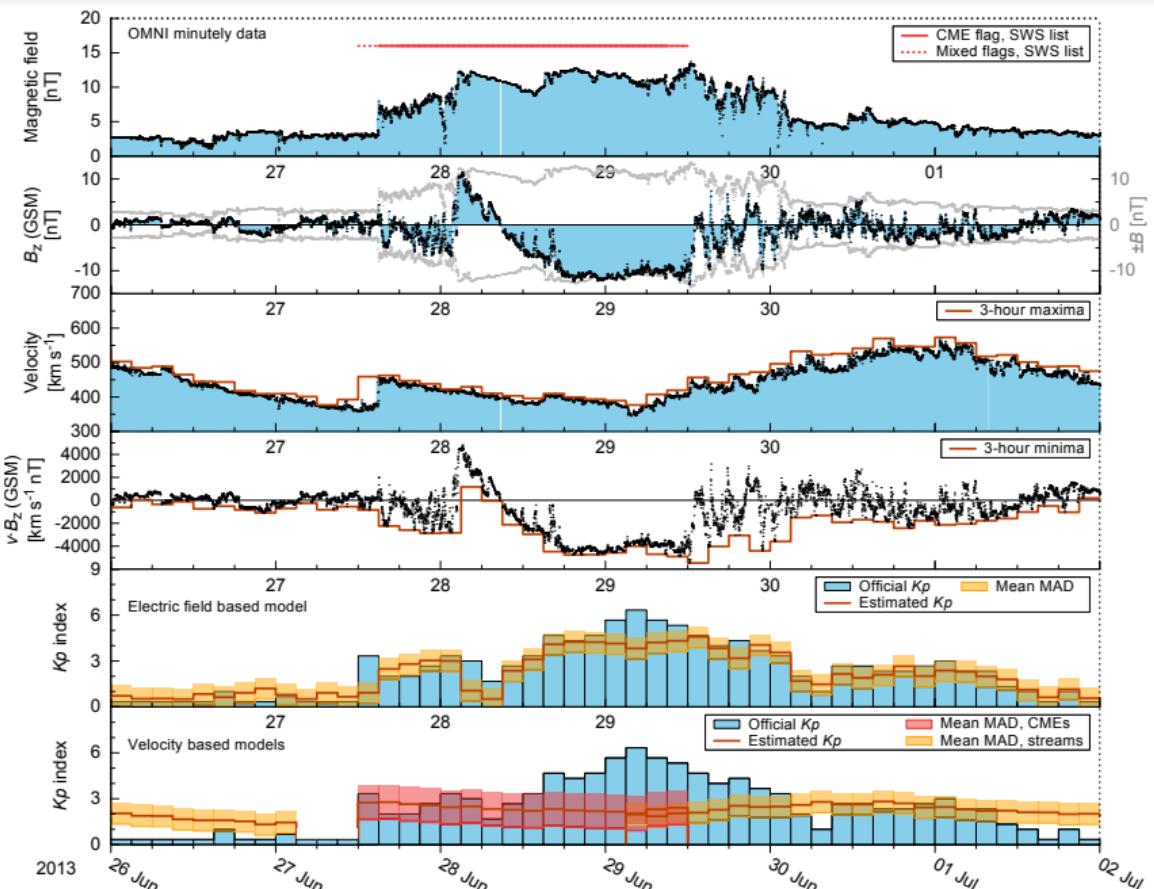
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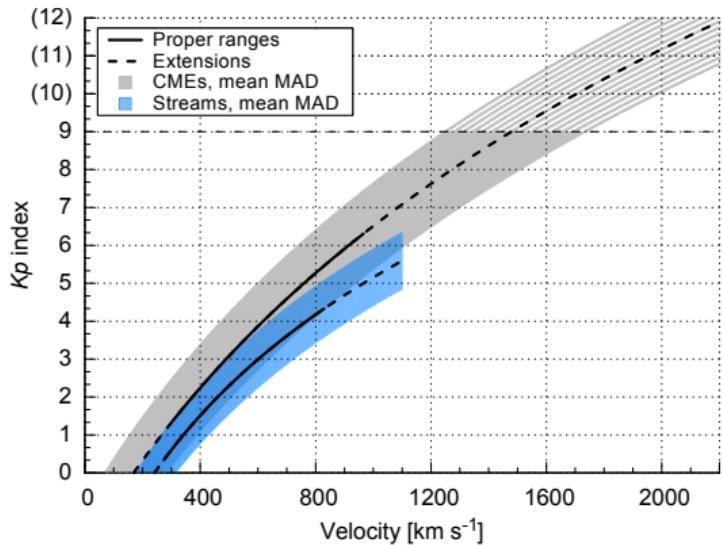
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References





# Results

Predictive  $K_p$  models based on relations with

- solar wind electric field proxy ( $vB_z$ )
- velocity of CME-associated flows ( $v_{\text{CME}}$ )
- velocity of solar wind streams ( $v_{\text{stream}}$ )

# Conclusions

- The processing of 3-hour extrema of high time resolution data captures short-term geoeffective magnetic features that are neglected when averaging over 3-hour intervals
- The isolated treatment of CMEs and streams is beneficial to the prediction accuracy of  $K_p$
- The prediction models perform well for their limited input information

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## 4 End matter

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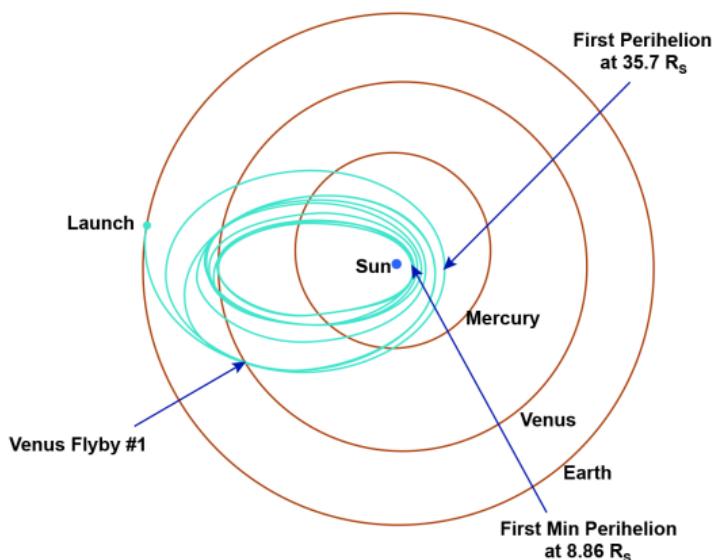
# Sun–Earth evolution of the solar wind

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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



Credit: NASA/Johns Hopkins APL, 2018

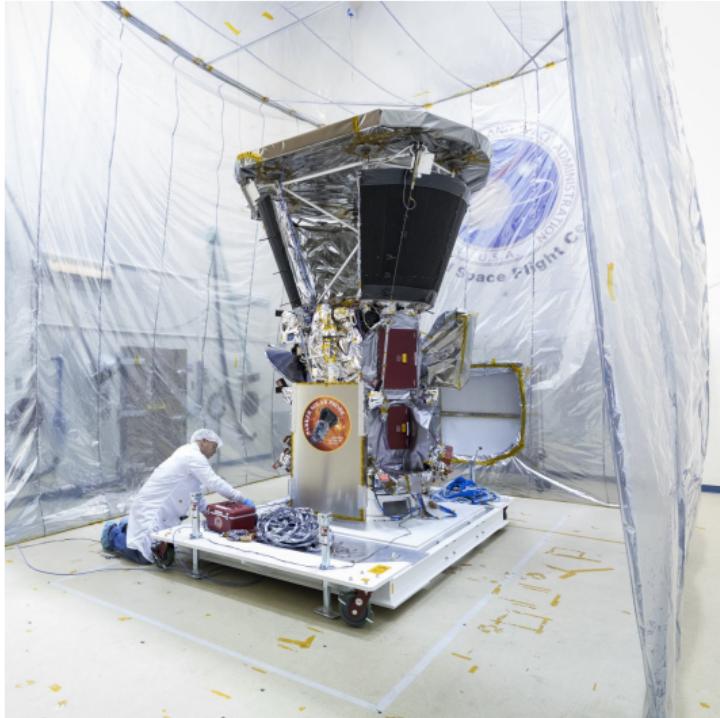
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Credit: NASA/Johns Hopkins APL/Ed Whitman, 2017

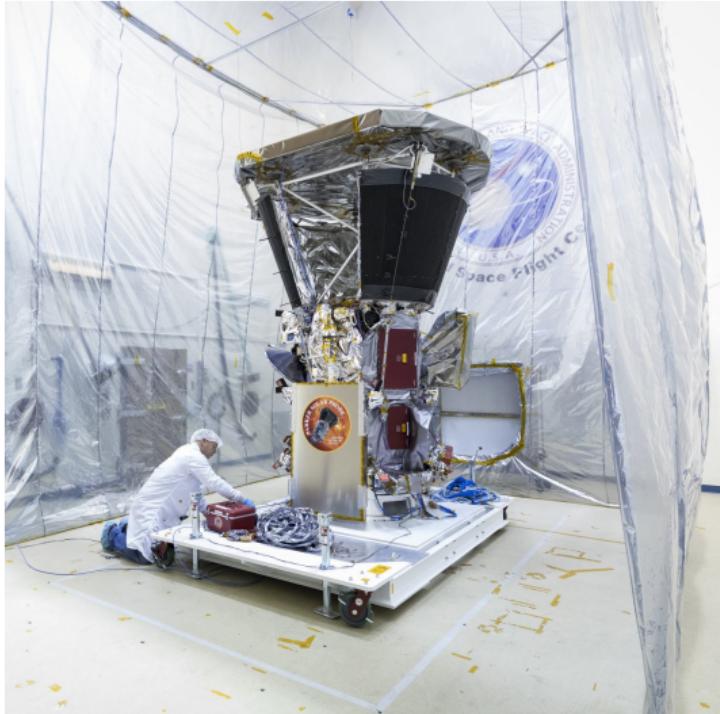
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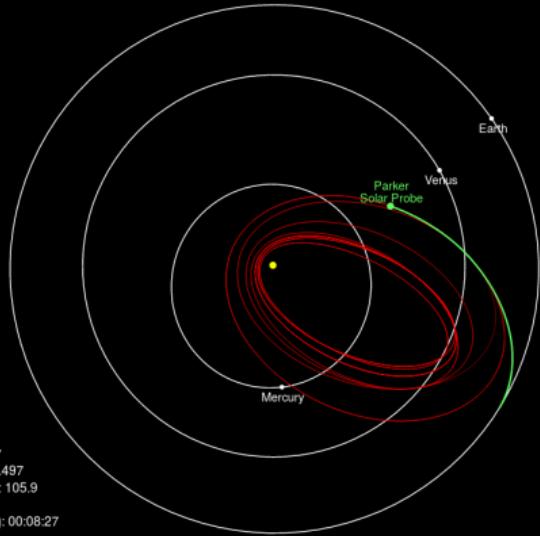
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Credit: NASA/Johns Hopkins APL/Ed Whitman, 2017

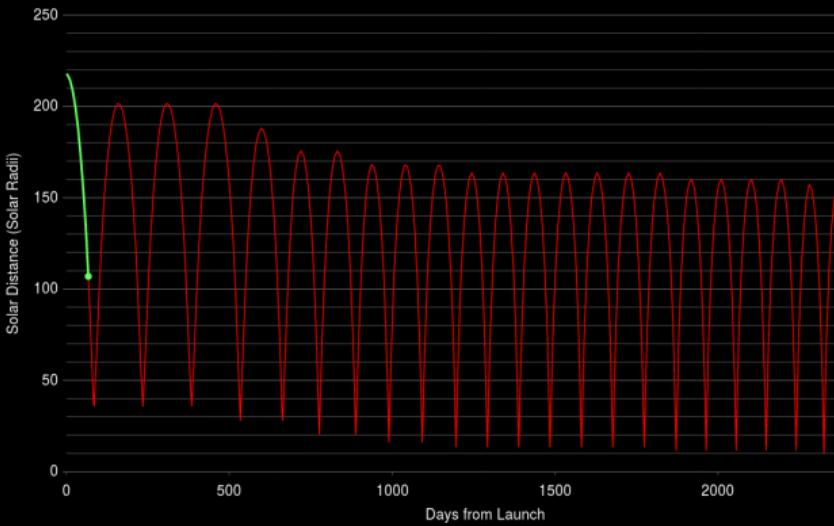


Credit: NASA/Johns Hopkins APL/Ed Whitman, 2018

**Parker Solar Probe Mission Trajectory and Current Position**

Heliocentric Velocity (km/s): 44.27  
Distance from Sun Center (AU): 0.497  
Distance from Sun's Surface ( $R_\odot$ ): 105.9  
Distance from Earth (AU): 0.508  
Round-Trip Light Time (hh:mm:ss): 00:08.27  
19 Oct 2018 14:00:00 UTC

Credit: NASA

**Parker Solar Probe Distance from Sun**

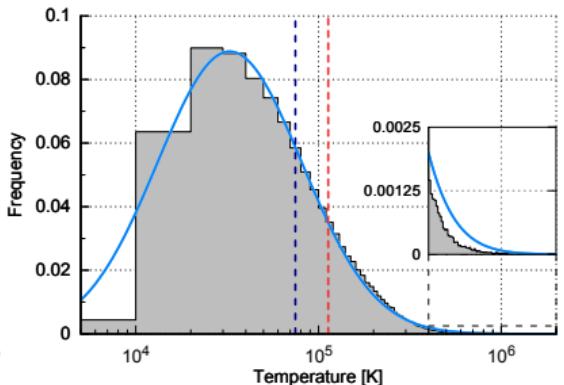
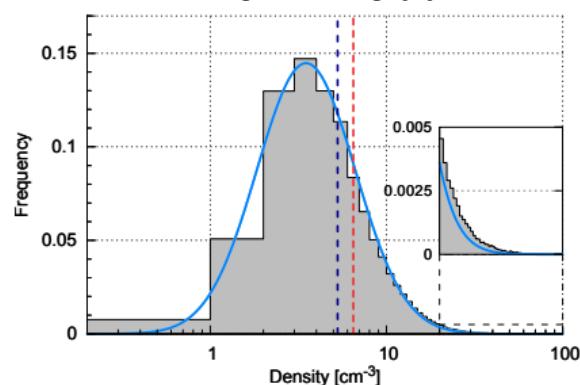
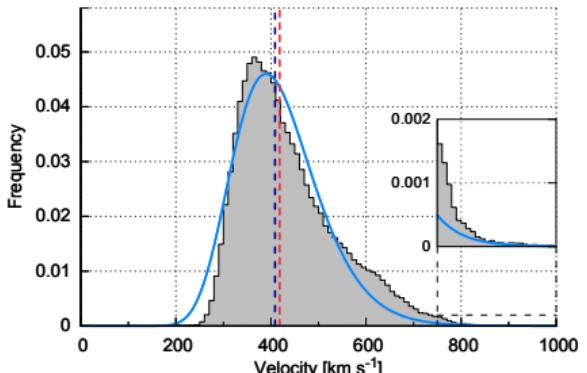
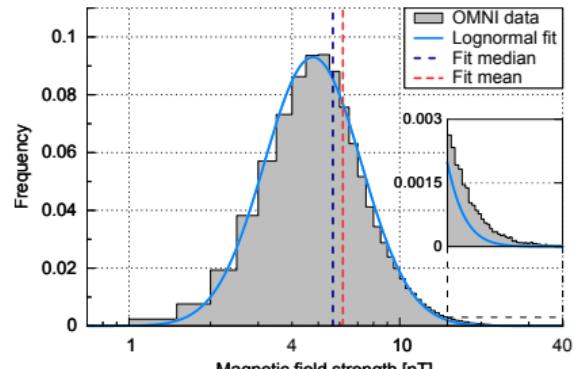
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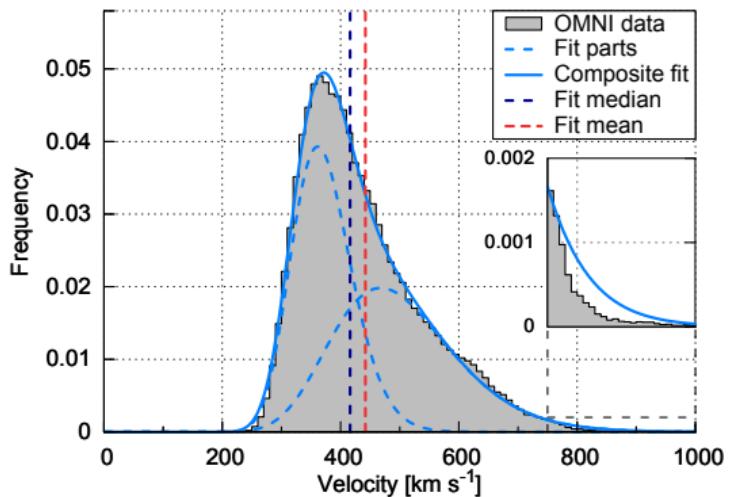
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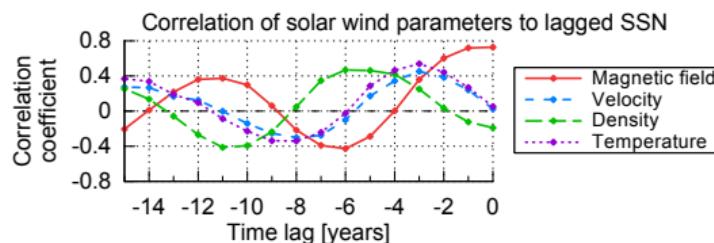
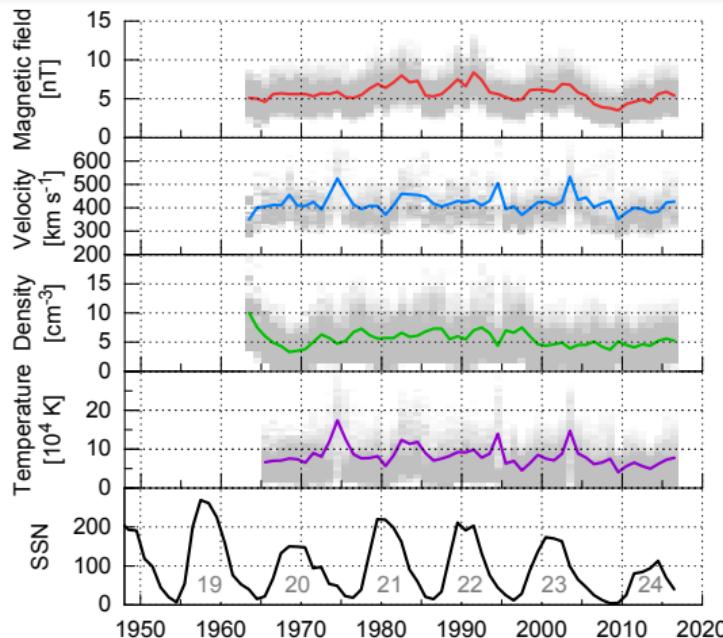
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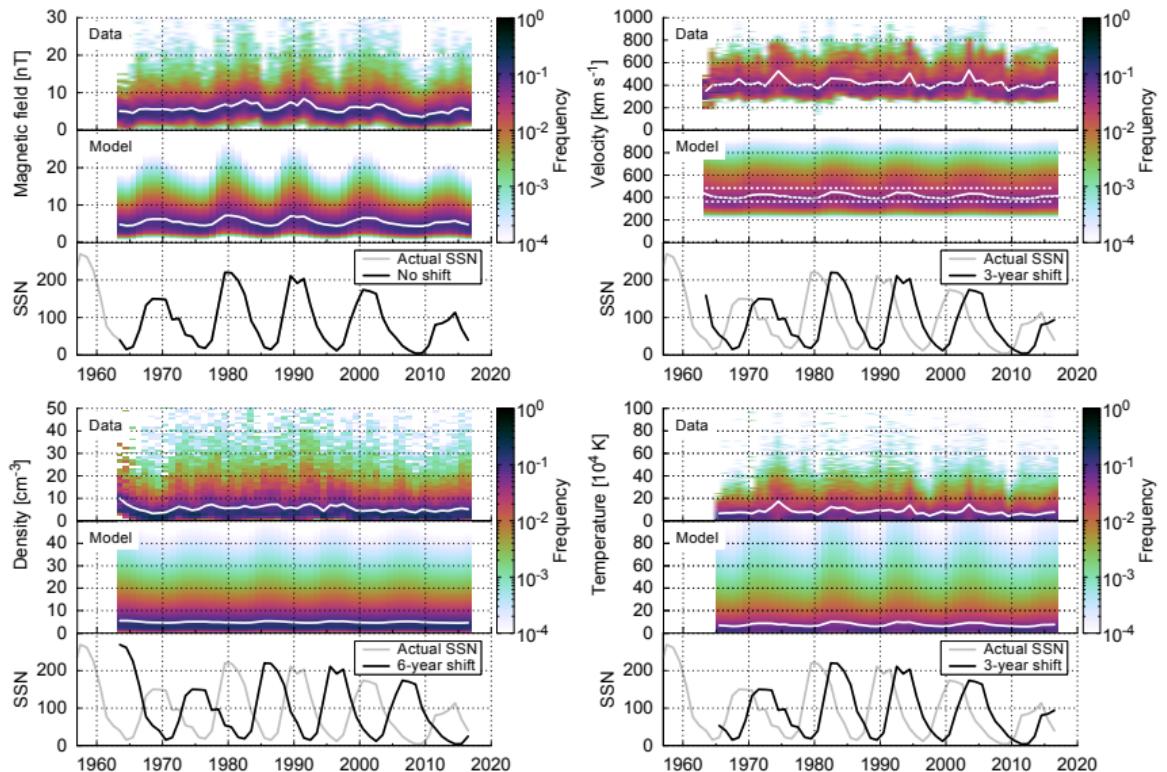
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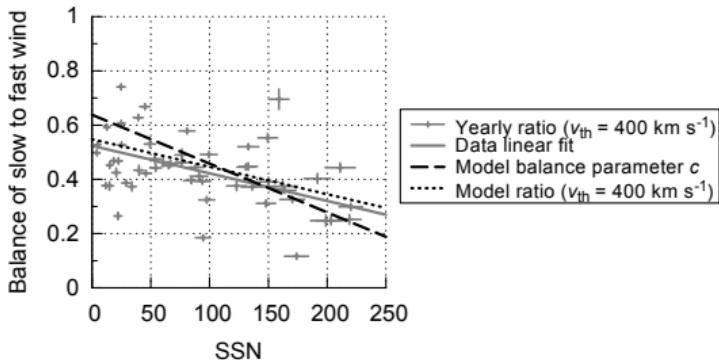
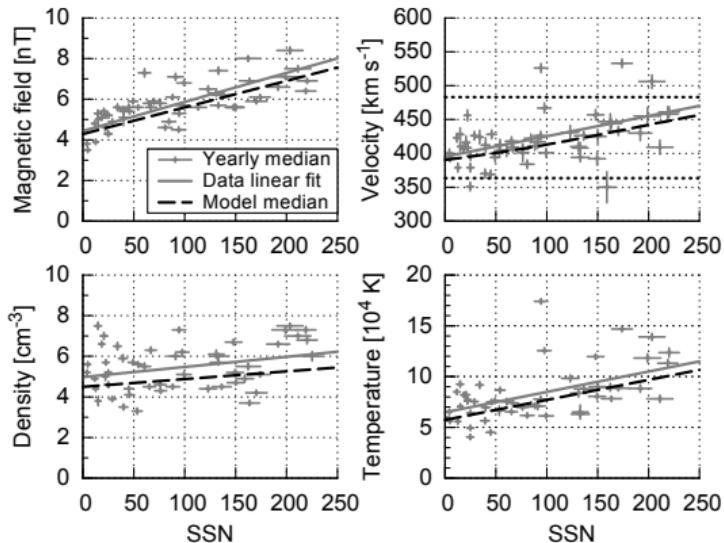
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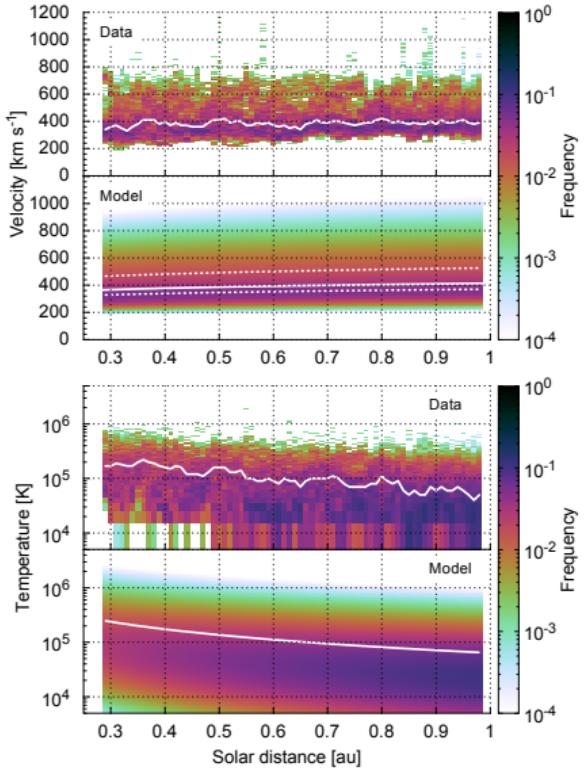
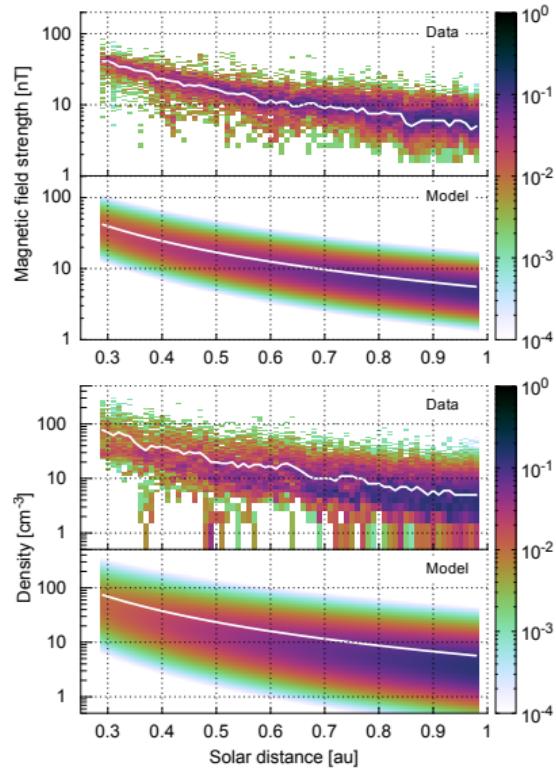
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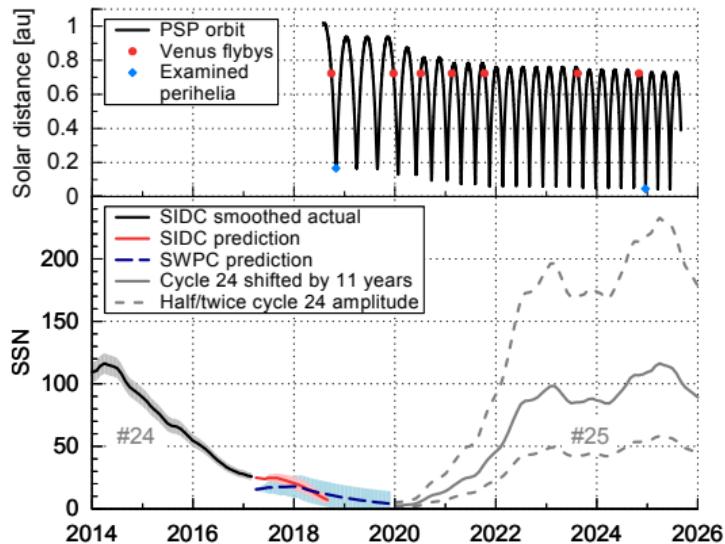
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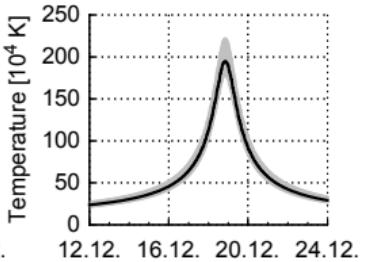
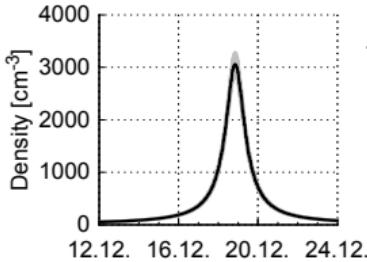
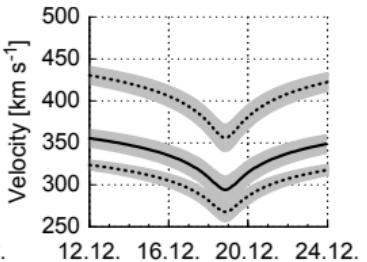
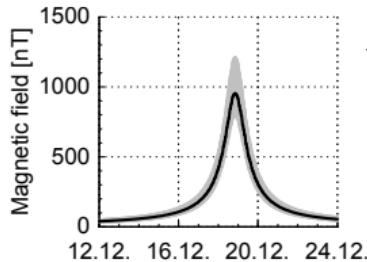
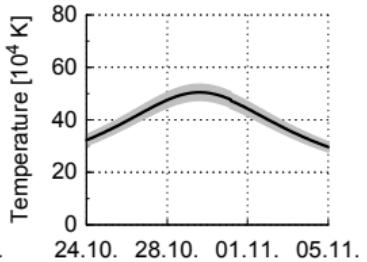
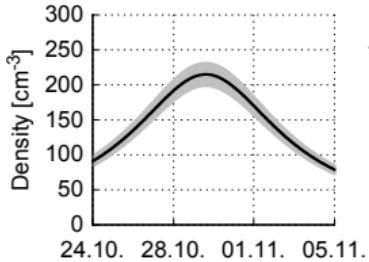
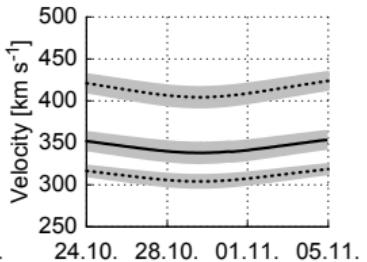
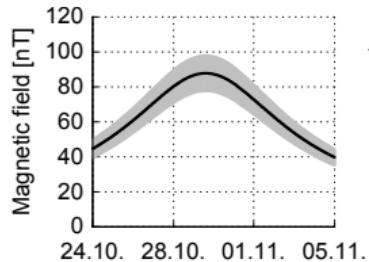
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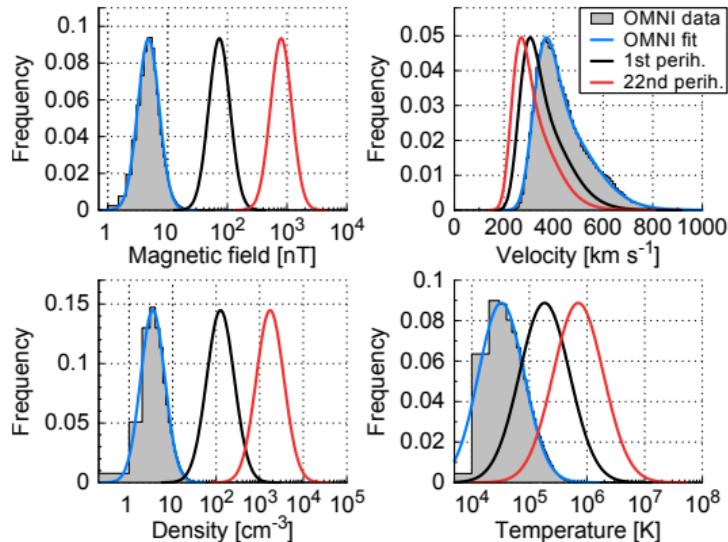
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Solar wind model for the inner heliosphere  
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References





# Results

- Empirical solar wind model for the inner heliosphere
- Solar wind predictions for the PSP orbit

# Conclusions

- Velocity discrepancy - $\downarrow$  Solar wind is still being accelerated up to  $20 R_{\odot}$
- Temperature discrepancy - $\downarrow$  Solar wind is still being heated up to  $20 R_{\odot}$

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## 4 End matter

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

Thank you!

# References |

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5 Backup slides

6 part two

7 part 3

8 Backup slides 2

# first slide

A bit more information about this

This is a text in first frame.

# first slide

A bit more information about this

This is a text in first frame. This is a text in first frame. This is a text in first frame.

## Definition

A definition

<https://www.sharelatex.com/learn/latex/Beamer>

# Ein Demotitel

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5 Backup slides

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8 Backup slides 2

## Sample frame title

In this slide, some important text will be highlighted because it's important. Please, don't abuse it.

### Examples

Sample text in green box. "Examples" is fixed as block title.

## Sample frame title

In this slide, some important text will be **highlighted** because it's important. Please, don't abuse it.

### Remark

Sample text

### Important theorem

Sample text in red box

# Sample frame title

In this slide, some important text will be **highlighted** because it's important. Please, don't abuse it.

## Remark

Sample text

## Important theorem

Sample text in red box

## Examples

Sample text in green box. "Examples" is fixed as block title.

Backup slides  
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part two  
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part 3  
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Backup slides 2  
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5 Backup slides

6 part two

7 part 3

8 Backup slides 2

## Two-column slide

This is a text in first column.

$$E = mc^2$$

- First item
- Second item

This text will be in the second column and on a second thought this is a nice looking layout in some cases (Venzmer & Bothmer, 2018).

# Sample

In this slide, some important text will be highlighted because it's important. Please, don't abuse it.

## Remark

Sample text

# Sample

In this slide, some important text will be **highlighted** because it's important. Please, don't abuse it.

## Remark

Sample text

## Examples

Sample text in green box. "Examples" is fixed as block title.

# Sample

In this slide, some important text will be **highlighted** because it's important. Please, don't abuse it.

## Remark

Sample text

## Important theorem

Sample text in red box

5 Backup slides

6 part two

7 part 3

8 Backup slides 2

Backup slides  
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# backup slide

gj