Unifying the Validation of Ambient Solar Wind Models

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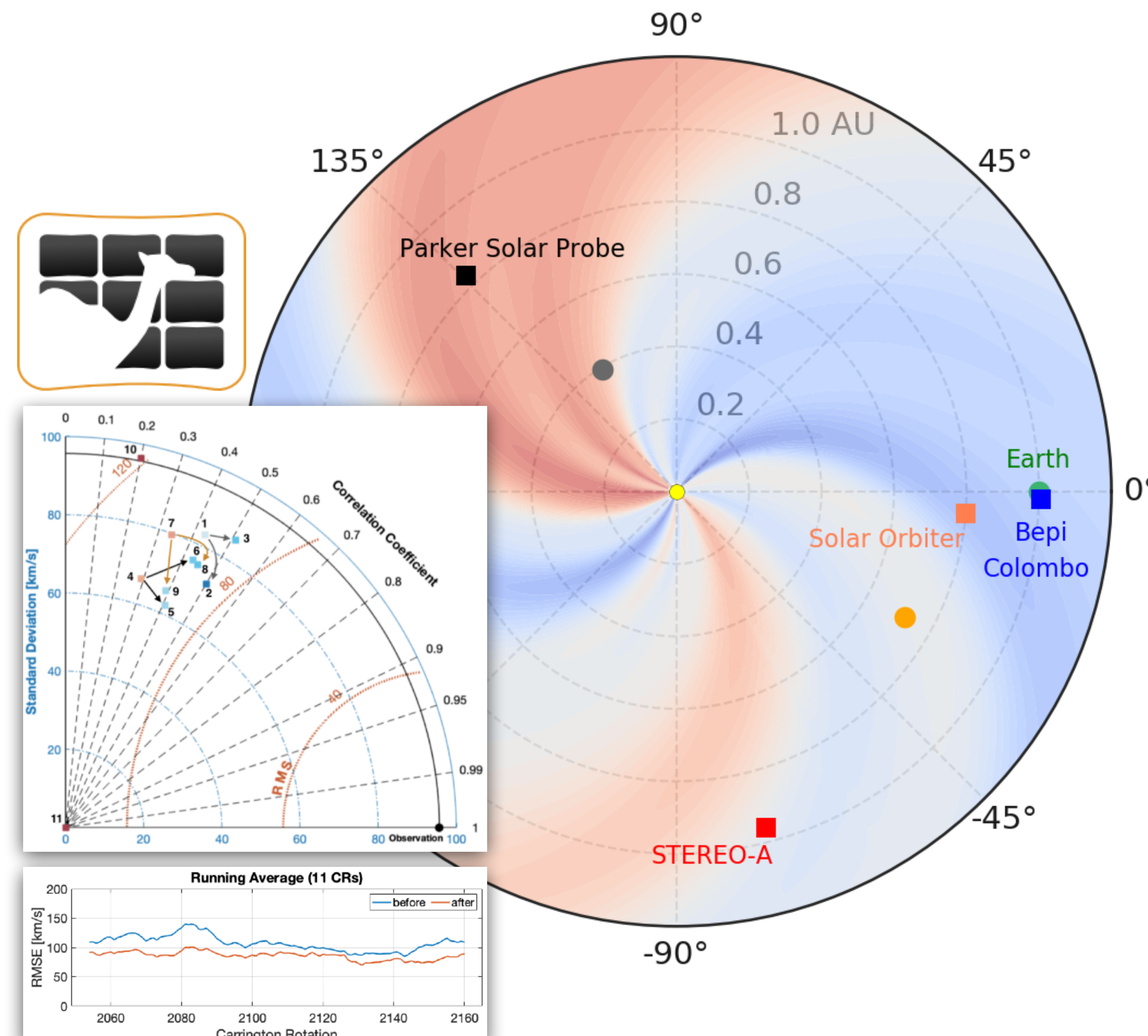

AUSTRIAN SCIENCE FUND
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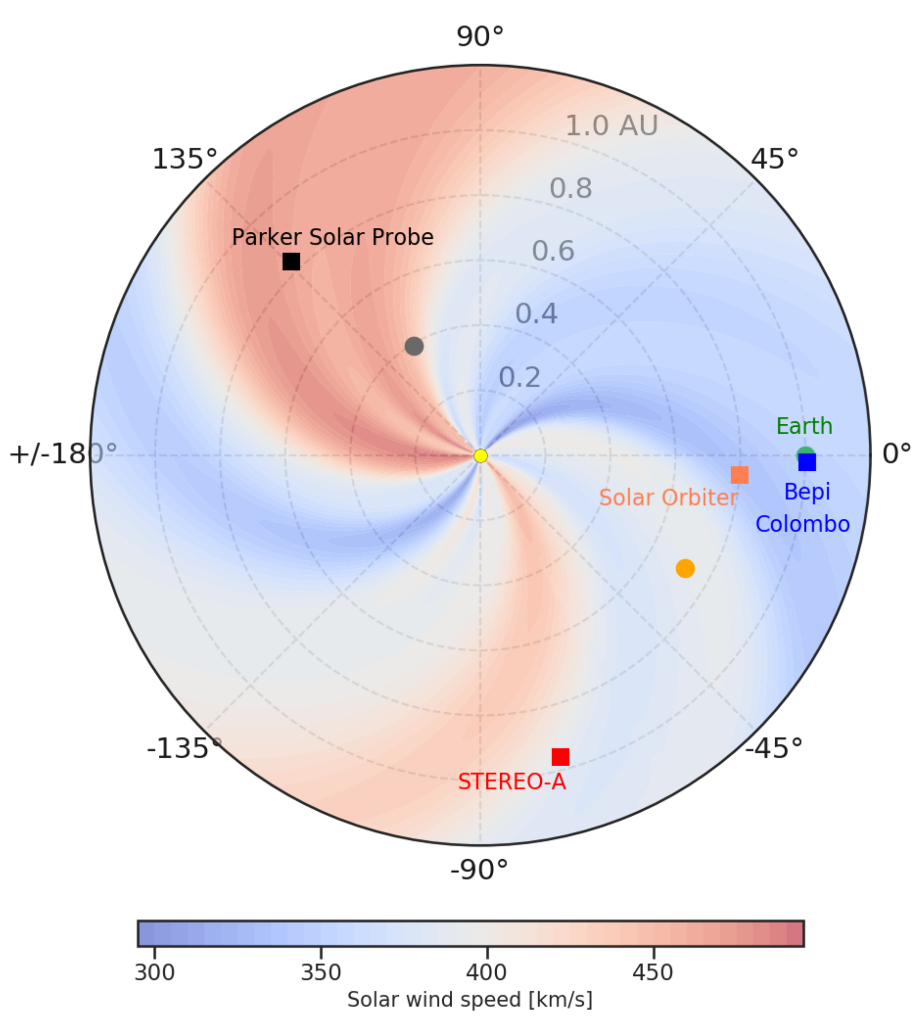
Community Coordinated Modeling Center

This talk presents a team effort for tying the community together for the unified validation of ambient solar wind models



Rastätter et al., 2019

CAMEL

developed by the CMCC

I. Why does ambient solar wind modeling matter?

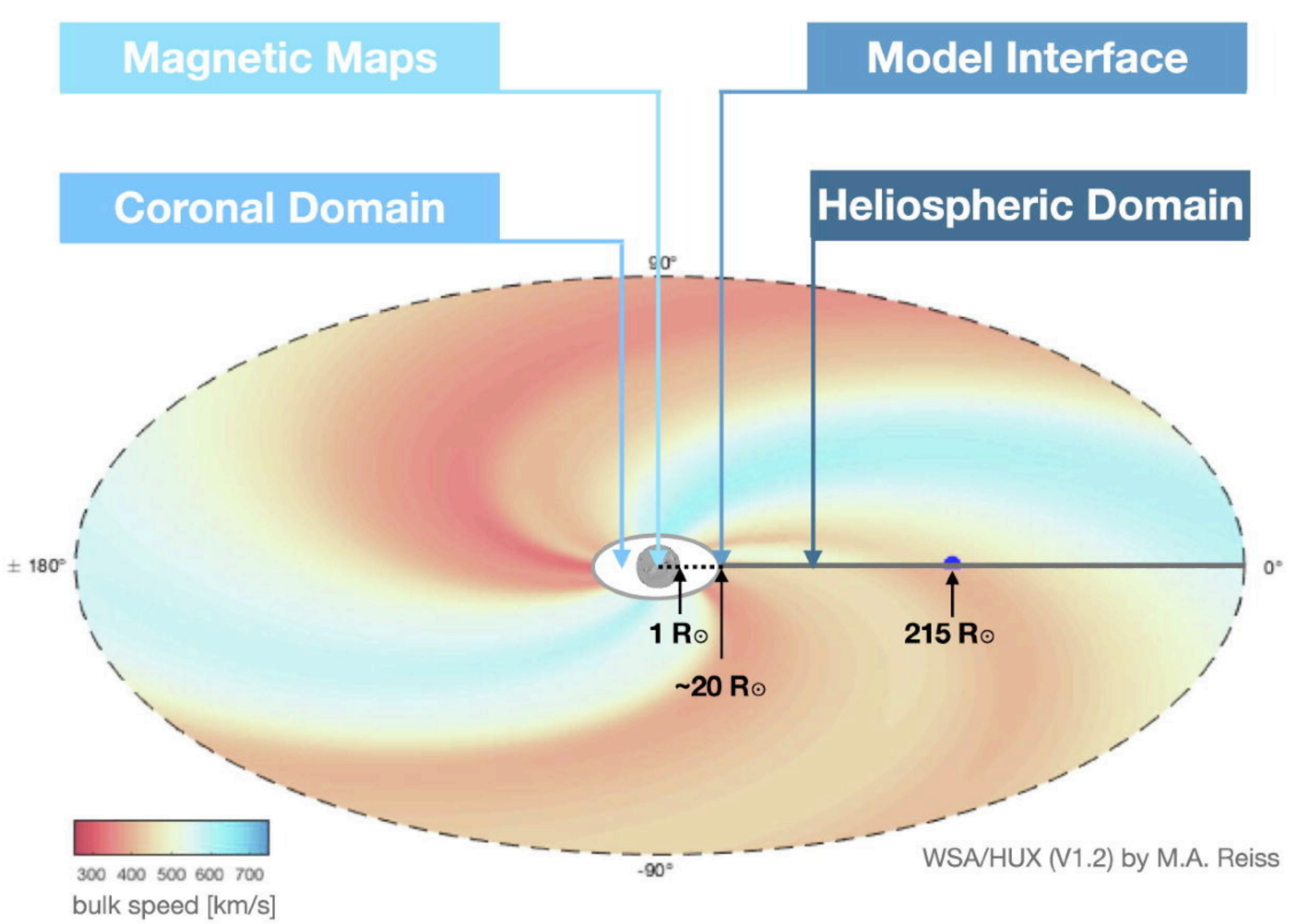
II. What are the problems? How do we tackle these issues?

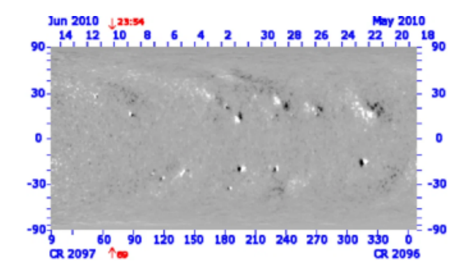
III. Where does our ISWAT team stand and what are our future steps?

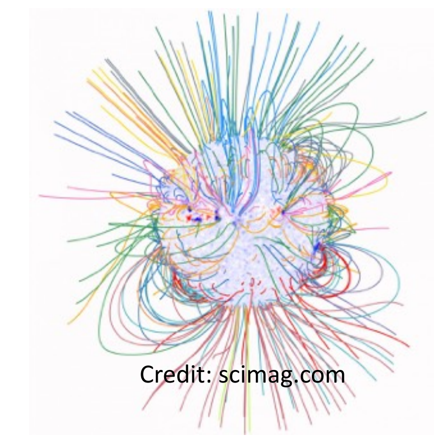
more about ISWAT: www.iswat-cospar.org

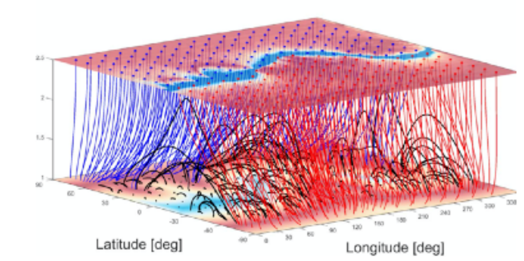
Accurate models of the large-scale corona and heliosphere are a bottleneck in solar and heliospheric research

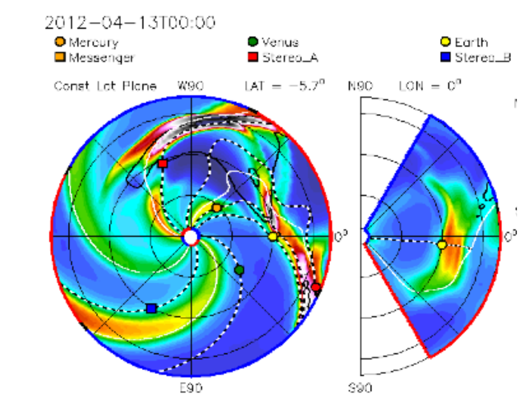
An (incomplete) „family portrait“:











Magnetic Maps	Coronal Domain	Model Interface*	Heliospheric Domain
GONG	CESE-HLLD Li et al., 2018, 2020	DCHB Model Riley et al., 2015	CESE-HLLD Li et al., 2018, 2020
WSO	MAS Linker et al., 1999	WS Model Wang and Sheeley, 1990	Enlil Odstrcil et al., 2003
MWO	MULTI-VP Pinto and Rouillard, 2017	WSA Model Arge et al., 2003	EUHFORIA Pomoell and Poedts, 2018
NSO SOLIS	PFSS Altschuler and Newkirk, 1969	Adaptive-WSA Model Reiss et al., 2020	HelioMAS Linker et al., 1999
HMI	AWSoM Van der Holst et al., 2014		LFM-helio Merkin et al., 2016
	WindPredict-AW Reville et al., 2020		HUX, THUX Riley and Lionello, 2011
			HUXt Owens et al., 2020
			SWMF Tóth et al., 2005

* Note that an empirical model at the interface is not always needed.

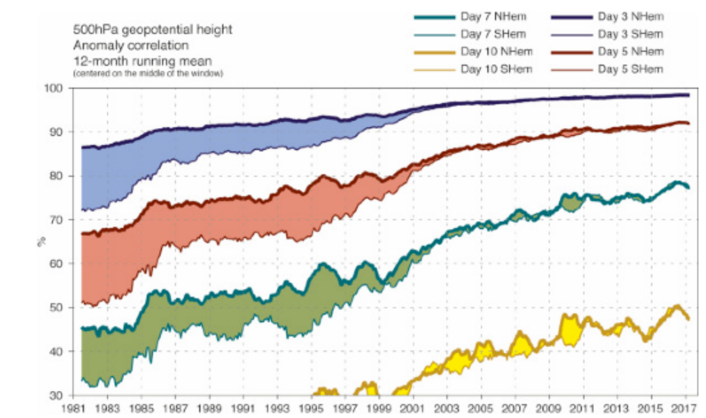
Flow of Models from the Sun into our Solar System

from Reiss et al., 2022 (published in ASR)

What are the problems with ambient solar wind model validation?

- keeping up with the ever-growing number of models, and different versions thereof. (Problem 1)
- no agreement on forecasting goals and metrics. (Problem 2)
- slow iterative process between model developers and end-users (see MacNeice et al., 2018). (Problem 3)
- increasingly versatile user needs. End-users have to rely on metrics selected by authors of validation studies. (Problem 4)
- challenging to trace the progress of models over time. (Problem 5)

Meteorology



Progress over time

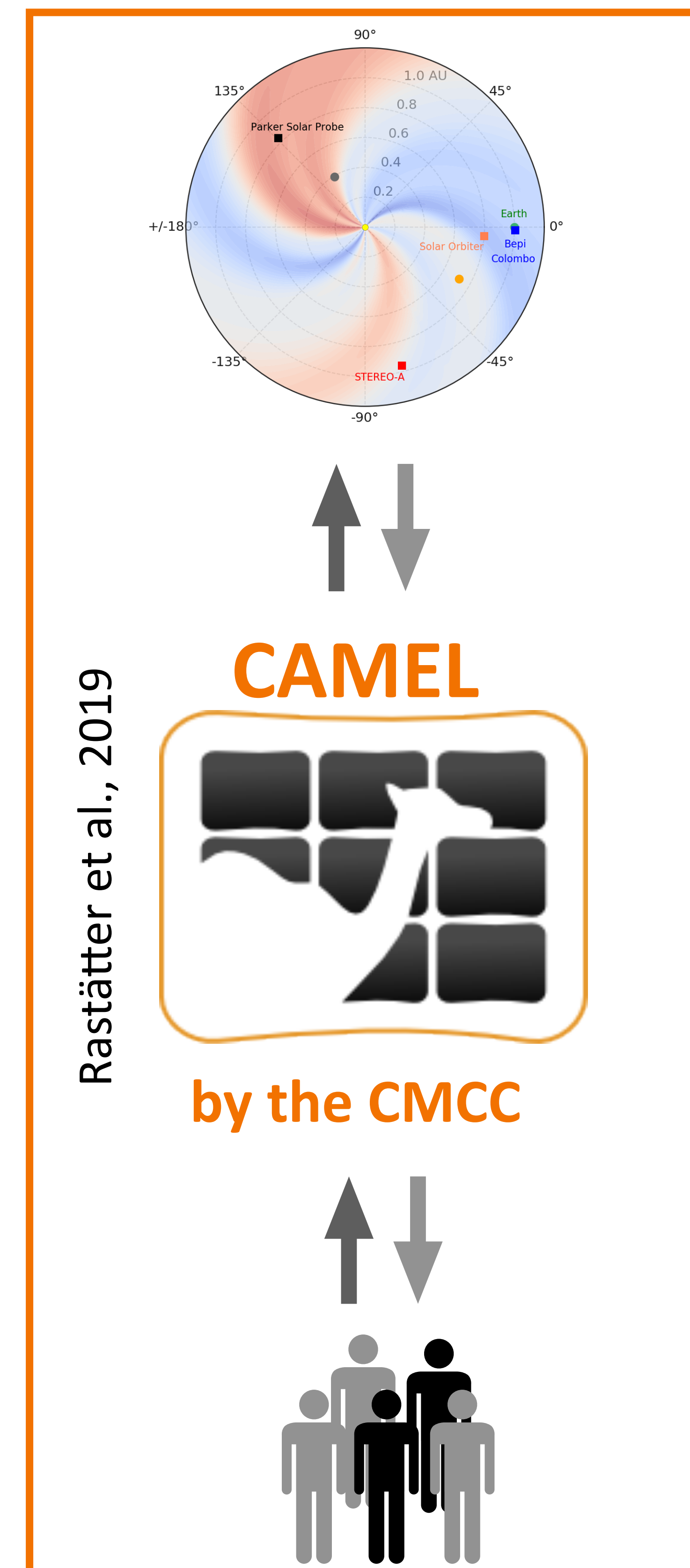
Space Weather

?

Progress over time

Our vision is to develop an online validation platform in a bottom-up approach from the community

- → Enables a fast online illustration of state-of-the-art solar wind model solutions. (Problem 1)
- → Use metrics agreed on by the space weather community. (Problem 2)
- → New model versions can be instantly made available online. (Problem 3)
- → End-users can select metrics. (Problem 4)
- → Trace our progress over time. (Problem 5)

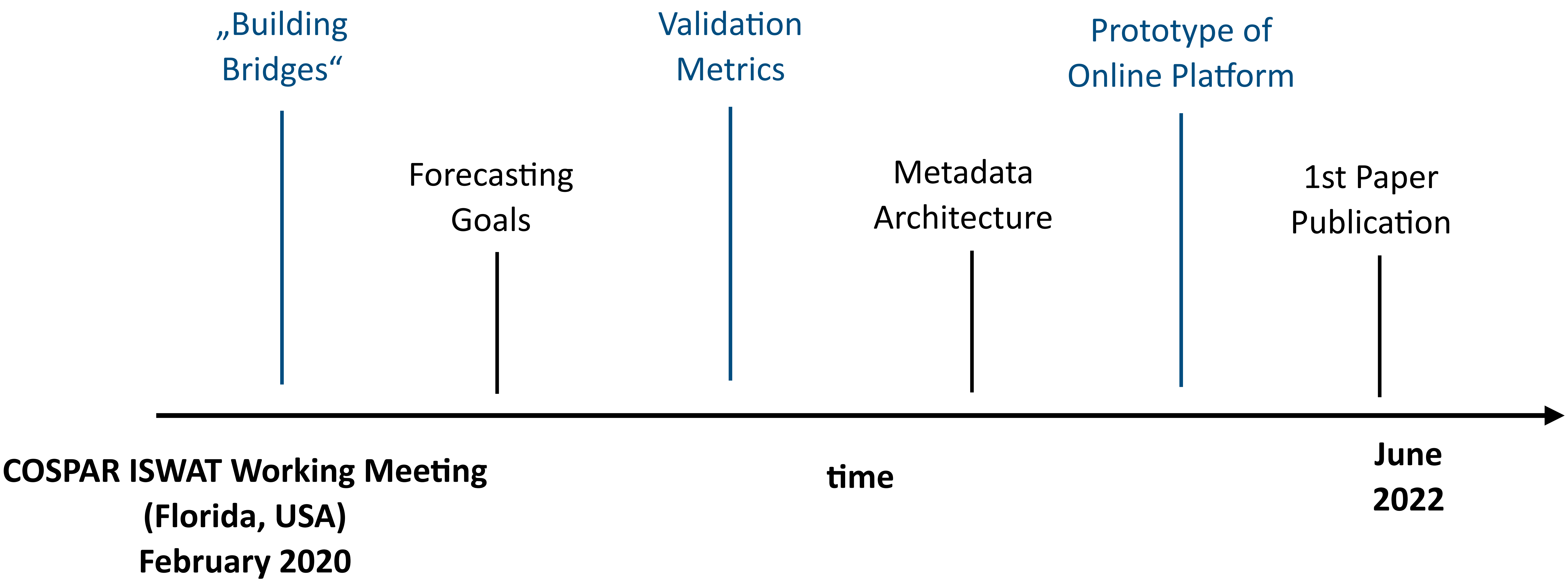


H1-01: Ambient Solar Wind Validation Team

A central platform for validation analysis can be leverage for innovation

Find out more at
www.iswat-cospar.org/h1-01

Since the beginnings of this initiative, we have achieved our first milestones



Find out more at
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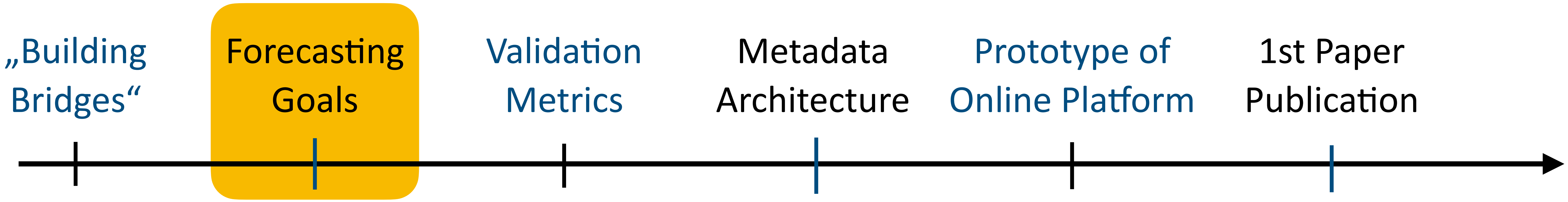


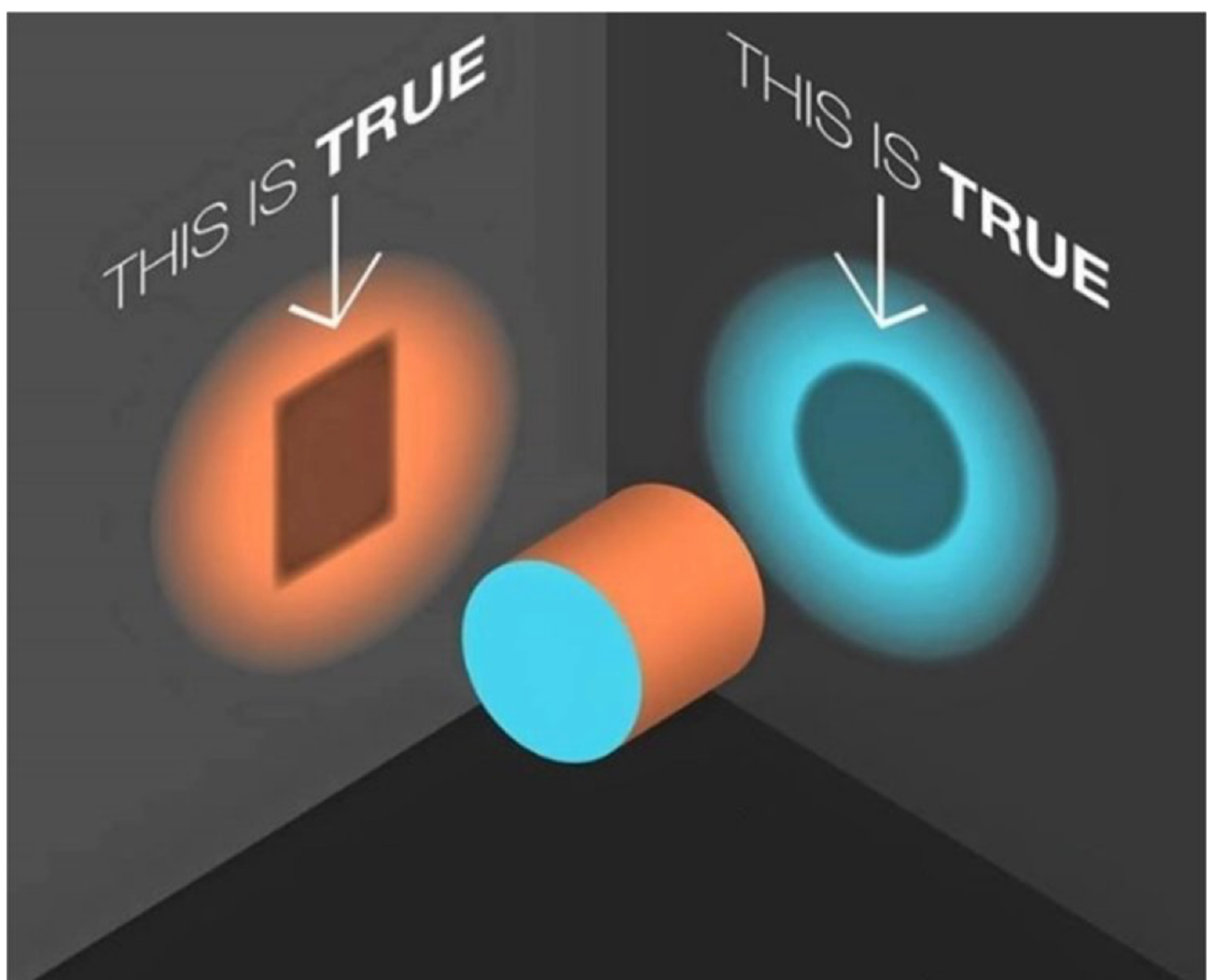
After collecting feedback from the community, we recommend testing the quality of community models in the online platform based on two forecasting goals:

1) The ability of the solar wind model to output the **temporal evolution of the solar wind speed**, as well as **abrupt changes from slow to fast solar wind**.

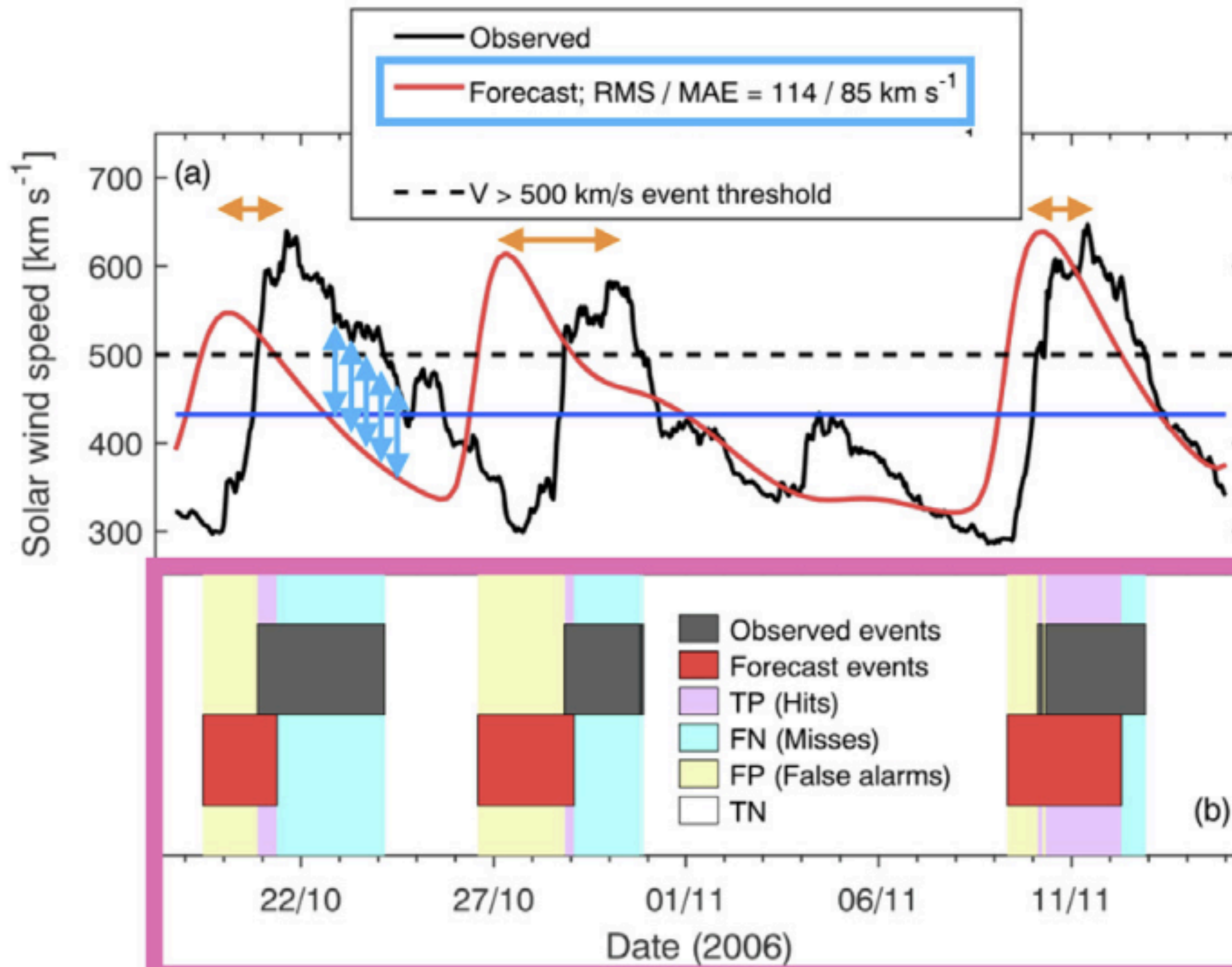
2) The ability of the solar wind model to output the **magnetic polarity** and **magnetic sector boundary crossings**.

Find out more at
www.iswat-cospar.org/h1-01

„Building Bridges“ | Forecasting Goals | **Validation Metrics** | Metadata Architecture | Prototype of Online Platform | 1st Paper Publication



Credit: transformativeinsights.co.nz



Reiss et al., 2022
Owens et al., 2018

Find out more at
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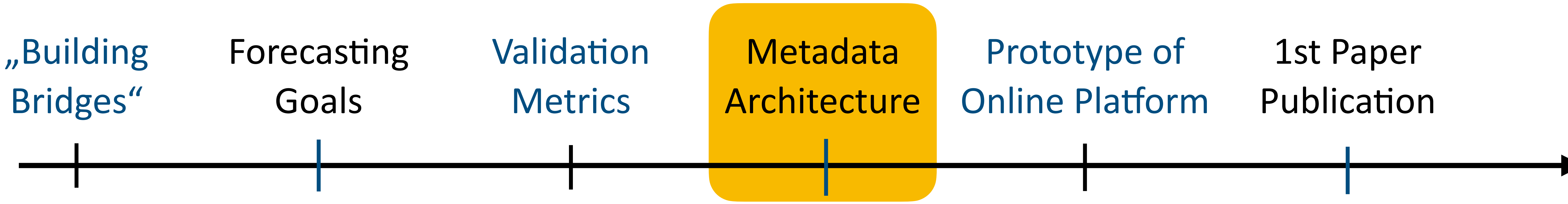
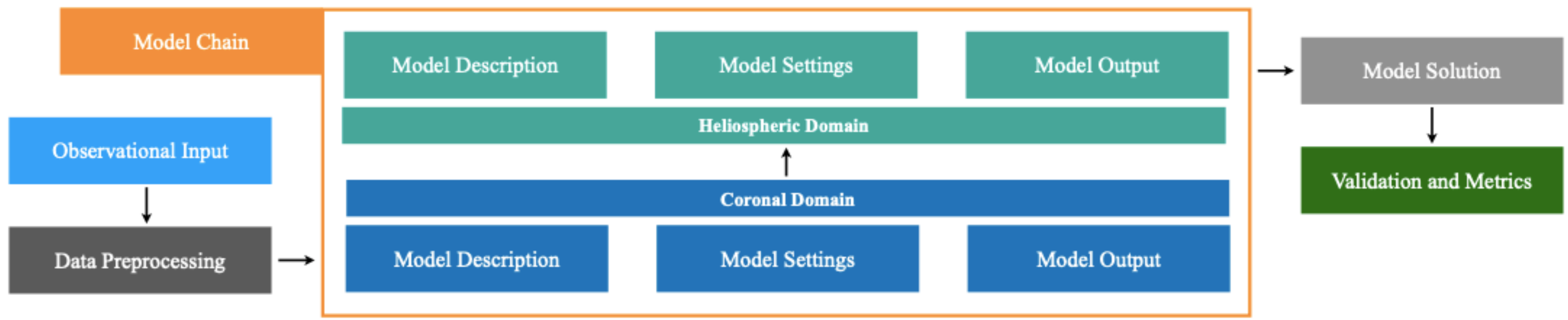




Section 3.1: Observational Input	
Input type	Type of observations (e.g., magnetograms, etc.)
Observatory	Name of the observatory
Instrument	Instruments used for the observation
Input description	Description of the model chain input
Date and Time	Date of the observation
Data Level	Level of data used for the observation
Publications	List of publications
Comments	Additional information on observational input

Section 3.3: Model Description	
Model name	Official model name
Model domain	Description of the model domain (e.g., solar, etc.)
Model type	Type of model (empirical, semi-empirical, full physics-based)
Model description	Short description of the model
Model version	Model version number
Language	Programming language of the model
Publications	List of publications
Contacts	List of model developers and contacts
Comments	Additional information on model description

Section 3.4: Model Settings	
Metadata link	Link to the model description metadata
Model parameters	List of model parameters
Grid parameters	List of grid parameters
Other parameters	List of other parameters
Ensemble	Description of ensemble approach
Ensemble settings	List of parameters to create the ensemble run
Ensemble output	Ensemble output (e.g., median value)
Empirical relationships	Empirical relationships and parameter settings used to run the model
Comments	Additional information on model settings

Section 3.5: Model Output	
Metadata link	Link to the model settings metadata
Model output	Description of the model output
Model output	Description of the model output format
Model output grid	Description of the model output grid (e.g., temporal and spatial resolution)
Model output ensemble	Explanation of the output ensemble
Post-processing	Description of the post-processing steps
Publications	List of publications

Section 3.2: Data Preprocessing	
Model name	Official model name
Model description	Description of the preprocessing steps
Publications	List of publications
Contacts	List of model developers and contacts

Section 3.6: Model Chain	
Metadata link	Link to the model settings metadata
Model chain	Description of how the individual models are combined.
Boundary conditions	Description of the boundary conditions at the coronal and heliospheric model interface.
Publications	Related publications where this model combination is explained in detail.
Miscellaneous	Other comments

Section 3.7: Model Solution	
Model solutions	List of physical properties computed from the model chain
Model solution grid	Description of the resolution used for the model. (For models that produce time-series only, the time cadence is required here.)
Missions for validation	List of space missions that can test the model solutions.

Reiss et al., 2022

„Building Bridges“ — Forecasting Goals — Validation Metrics — Metadata Architecture — **Prototype of Online Platform** — 1st Paper Publication

1. Select time interval of interest

L. Rastätter et al., 2019

Thanks to Richard Mullinix, Chiu Wiegand, and the CCMC team!

„Building Bridges“ | Forecasting Goals | Validation Metrics | Metadata Architecture | **Prototype of Online Platform** | 1st Paper Publication

1. Select time interval of interest

2. Select solar wind models

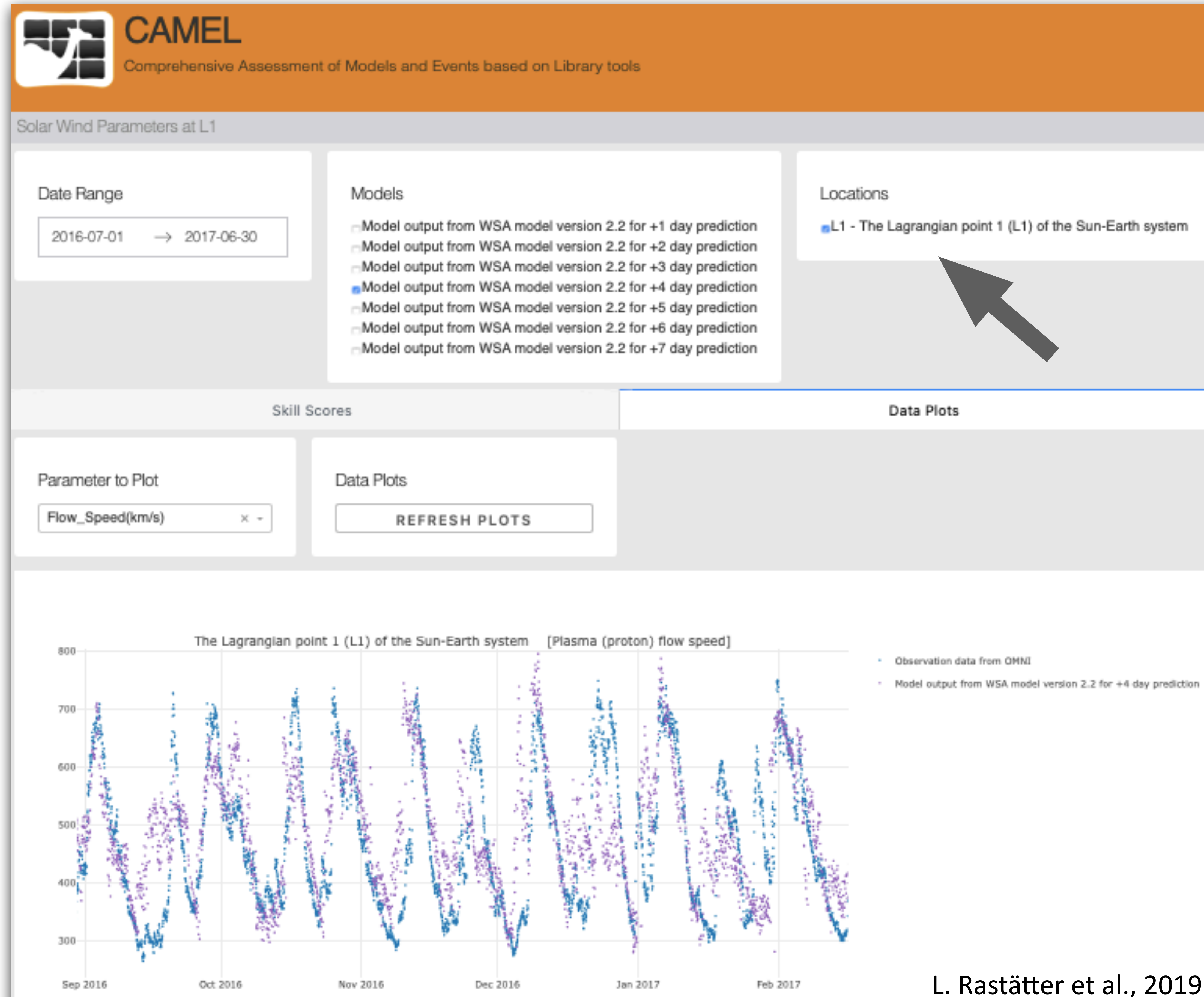
L. Rastätter et al., 2019

„Building Bridges“ — Forecasting Goals — Validation Metrics — Metadata Architecture — **Prototype of Online Platform** — 1st Paper Publication

1. Select time interval of interest

2. Select solar wind models

3. Choose location



L. Rastätter et al., 2019

„Building Bridges“ — Forecasting Goals — Validation Metrics — Metadata Architecture — **Prototype of Online Platform** — 1st Paper Publication

1. Select time interval of interest

2. Select solar wind models

3. Choose location

4. Select solar wind property

L. Rastätter et al., 2019

„Building Bridges“ — Forecasting Goals — Validation Metrics — Metadata Architecture — **Prototype of Online Platform** — 1st Paper Publication

1. Select time interval of interest
2. Select solar wind models
3. Choose location
4. Select solar wind property
5. Display the model solutions

L. Rastätter et al., 2019

„Building Bridges“ — Forecasting Goals — Validation Metrics — Metadata Architecture — **Prototype of Online Platform** — 1st Paper Publication

1. Select time interval of interest

2. Select solar wind models

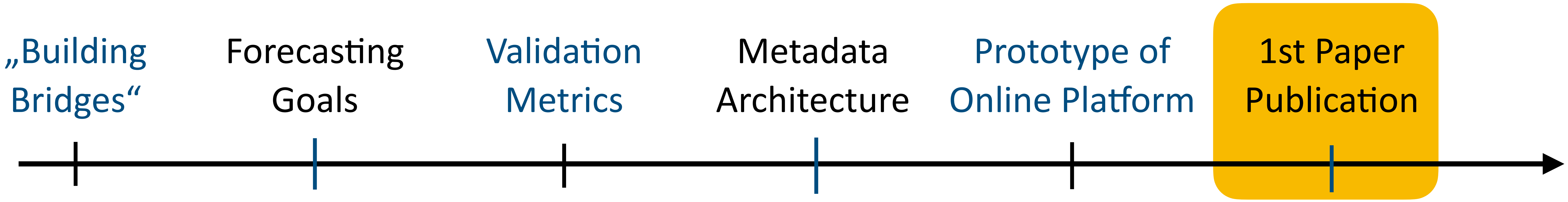
3. Choose location

4. Select solar wind property

5. Display the model solutions

6. Run your validation analysis

L. Rastätter et al., 2019



Title

Unifying the validation of ambient solar wind models [Link]

Authors

Martin A. Reiss, Karin Muglach, and H1-01 team members.

Questions we discuss in the paper

- Why is ambient solar wind modeling important?
- What is the current state-of-the-art in solar wind forecasting at Earth?
- What are the problems in assessing solar wind models? How can we close these gaps?
- What advantages does the online platform bring?
- Why should model developers and end-users be interested in using the platform?
- What kind of metrics/metadata could be useful?

What are the next steps for 2022+ ?

Current Priorities

- Make metadata accessible via CAMEL
- Implement (all) the proposed metrics in CAMEL
- Release 1st version of the online platform
- Invite model developers to participate

Next Meeting

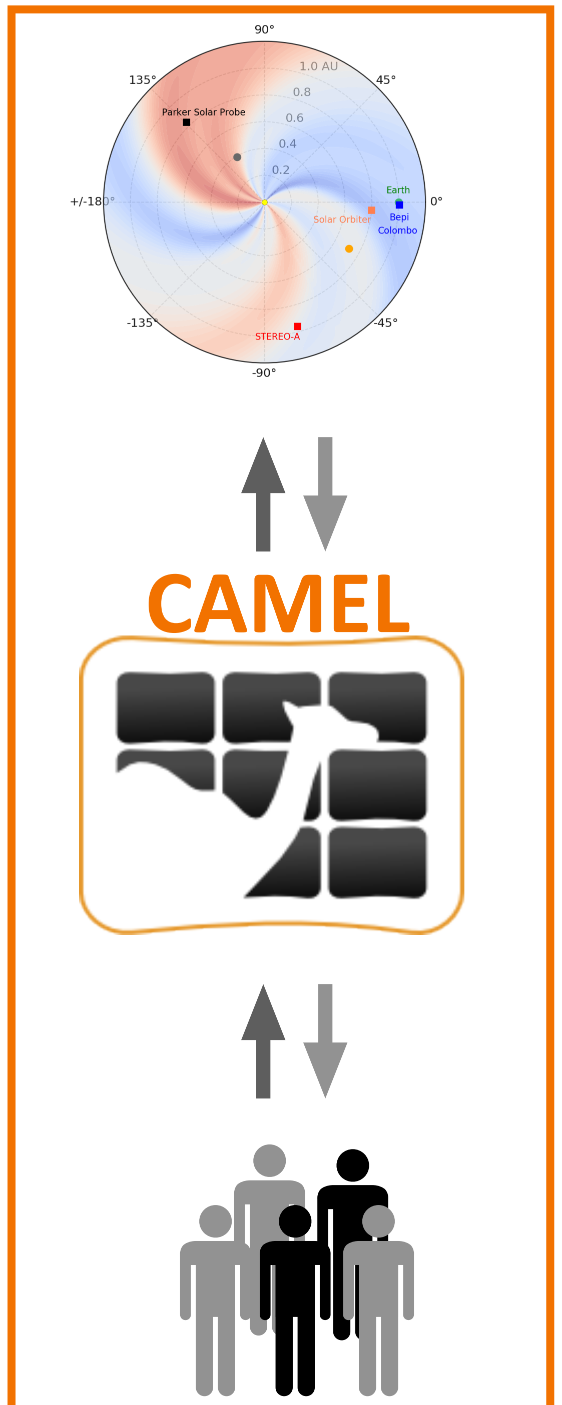
Session during the COSPAR ISWAT Working Meeting in Coimbra, Portugal (September 2022)

- Collect **feedback** from team members and the community on what else is needed.
- Develop plan for the **transition from historical validation to real-time validation**.
- Develop concept of what could be included in an „**Ambient Solar Wind Scoreboard**“.

www.iswat-cospar.org/wm2022

Summary - Unifying the Validation of Ambient Solar Wind Models

H1-01: Ambient Solar Wind Validation Team



<u>The mission of our ISWAT team:</u>

- Develop a **comprehensive model metadata architecture including metrics** agreed upon by the community.
- Implement an **open online platform** in collaboration with NASA's CCMC to validate solar wind models with **streamlined metrics**.
- Quantitatively **assess the state-of-the-art** in forecasting the solar wind conditions at Earth and other planetary environments.
- Use our developed infrastructure to **maintain up-to-date validation** results in the future.

Useful Links

www.iswat-cospar.org

www.iswat-cospar.org/H1-01

Acknowledgements

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