DASH Workshop 2024, Madrid, Spain

An Open Platform for Ambient Solar Wind Model Validation by NASA's CCMC

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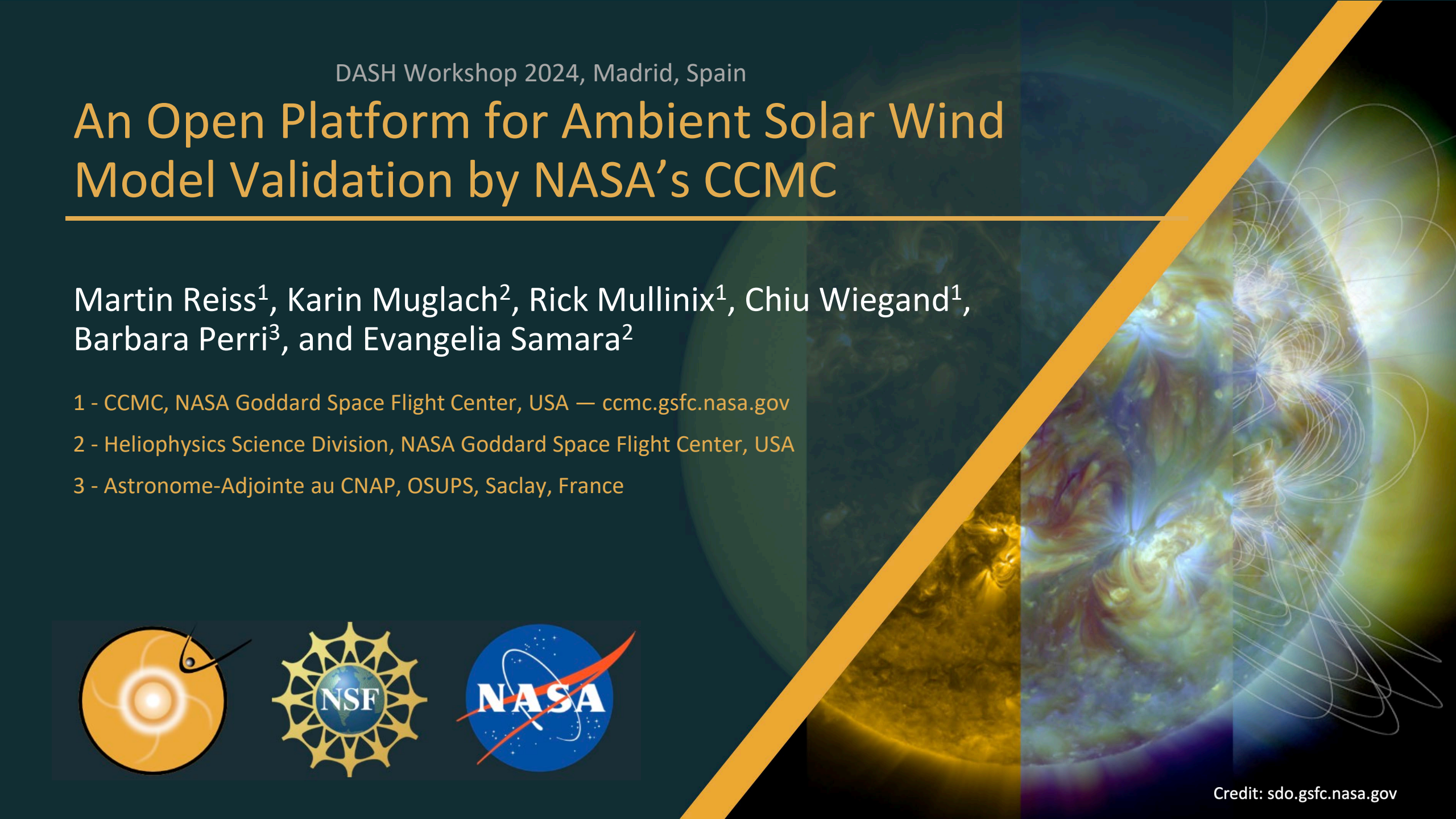


Corona

SWMF AWSoM-R

CORHEL-CME

CORHEL MAS TDm WSA

EUHFORIA Corona

NLFFF OSPREI

PFSS SPRINTS

SRPM MagPy

ASSA

MAG4

ASAP

A-EFFort

AMOS

DAFFS

NOVICE

S3EP-AC

Heliosphere

WSA-ENLIL

SWMF AWSoM-R

SWMF M-FLAMPA

CORHEL-CME

GAMERA-Helio

SEPMOD

iPATH

UMASEP

EPREM

HelTomo IPS

SEPSTER

SEPSTER2D

DBM

DIPS

PDF

HESPERIA REleASE

Motivation

Facilitate Space Weather and Space Weather Research

Facilitate R20

Find out more at ccmc.gsfc.nasa.gov

CORHEL by **Predictive** Science visualized in Open Space

Validating Models: A Core CCMC Objective

Validation Activities

- CCMC-led and supported studies
  MacNeice, 2009a, 2009b, Mays et al., 2015, Riley et al., 2018
- Community Challenges
  SHINE, GEM, CEDAR
- Community Initiatives
  ISWAT: Solar Wind (H1-01), CME (H2-01), SEP (H3-01), …

Organized by Discipline

- Solar and Heliospheric
- Magnetospheric
- Ionospheric and Thermospheric
- *Furthermore, organized by **pre-** and **post-event analysis***

Pre-Event

CME Scoreboard

SEP Scoreboard

Flare Scoreboard

Bz Scoreboard

Post-Event

CAMEL

CAMEL enables open validation of space weather and space science model solution with observational data

CAMEL
Comprehensive Assessment of Models and Events based on Library tools

Community Coordinated Modeling Center

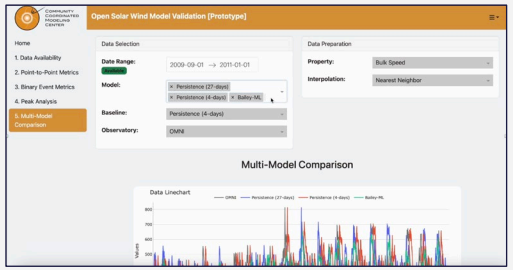
Backend

- Runs-On-Request Simulation Archive
- Post-Processing Tools
- External Simulation Output
- CCMC Metadata Registry

Request

Data

Frontend



The User Interface

Plotly Dash

- Interactive plots to compare model results with observations
- Metrics computed based on user input

User Input

Visualization

Users

CAMEL Validation Campaigns

- Neutral Density
  ISWAT G2A-01
- Ionosphere Plasma Density
  ISWAT G2B-05
- Internal Charging
  ISWAT G3-04
- Ambient Solar Wind
  ISWAT H1-01

Reiss et al., 2025 (in preparation)

CAMEL Ambient Solar Wind Validation Workflow

Runs-On-Request Simulation Archive

External Simulation Results

Process Data

Users apply interpolation to align the grid resolution of simulation results with observational data

Compare

Compare key physical properties—such as bulk speed, density, and magnetic field components—with in-situ spacecraft measurements

Validate

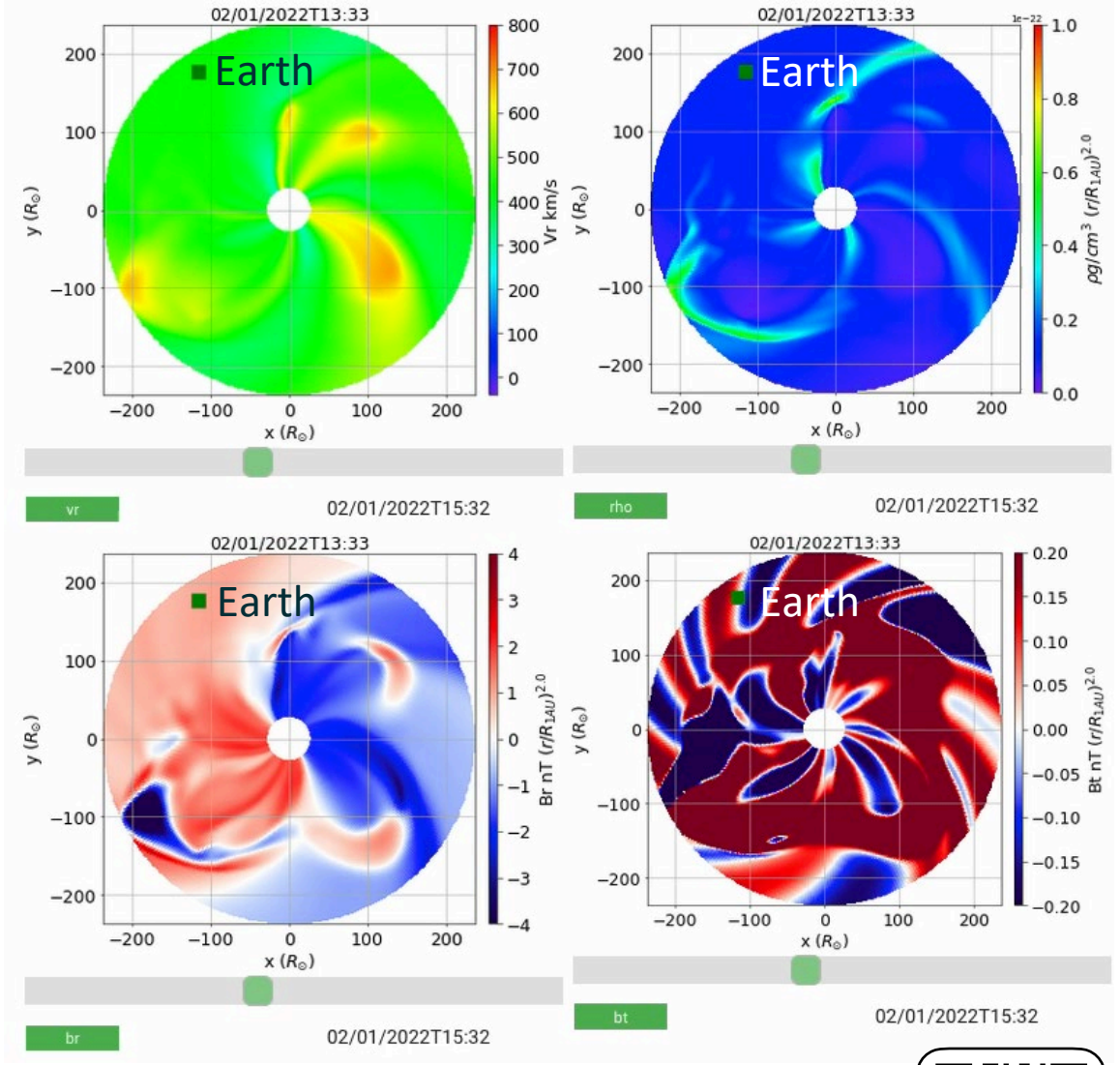
Calculate community-defined metrics to quantitatively evaluate the accuracy of simulation results

Interpret

Perform multi-model comparisons and use additional features to interpret results and generate exportable graphs

Reiss et al., 2025 (in preparation)

CORHEL hosted at NASA's CCMC



To learn more about CORHEL, please visit

ccmc.gsfc.nasa.gov/models/CORHEL-CME~1/

Learn-Build-Measure

- Frontend development guided by community feedback
- Collaboration across ISWAT, EGU, ESWW, and AGU ensures broad community involvement

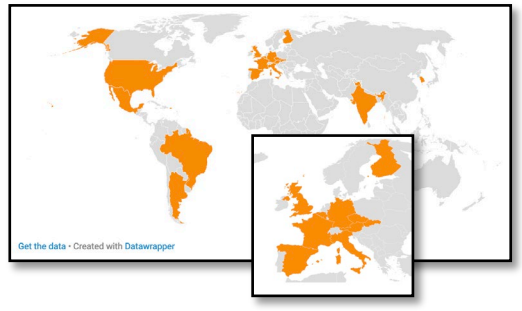
COSPAR ISWAT Team

- Feedback on CAMEL frontend design
- Consensus on forecasting goals
- Standardization of metrics and metadata

Led by Community Experts

- Metrics Repository:
  Defining and collecting standard metrics
- Metadata:
  Standardizing metadata
- Near-Real Time Validation:
  Enhancing space weather forecasting

H1-01 ISWAT Team



Historical Validation

Led by Dr. Martin REISS

Objective:
Provide an overview of the performances of ambient solar wind models for key periods

Where to find it:
https://webserver1.ccmc.gsfc.nasa.gov/camel/AmbientSolarWind/

[Rastätter+2019]

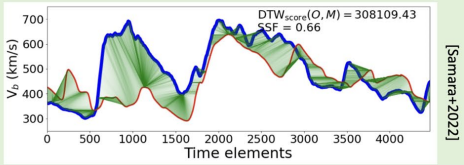
Metrics repository

Led by Dr. Evangelia SAMARA

Objective:
Provide an open-source validation skill scores library

Next steps:
Add more metrics + provide interactive examples

Where to find it:
https://github.com/nasa/camel



[Samara+2022]

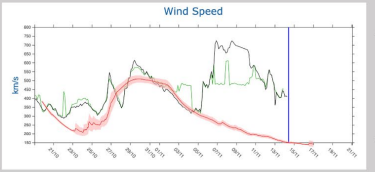
Near-Real Time Validation

Led by Dr. Barbara PERRI

Objective:
Adapt the CAMEL Web App for real-time validation

Next steps:
Survey about NRT models + design of new interface

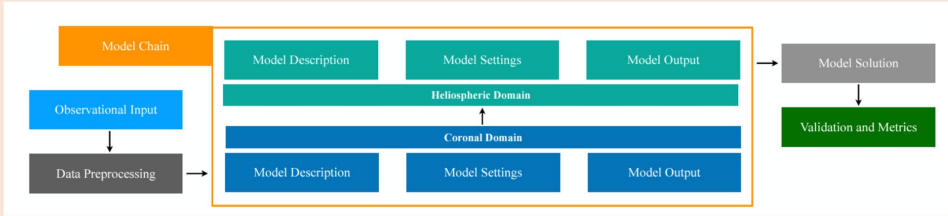
Where to find it:
https://forms.gle/HzFWQ16XFL5yusR38



[Kieokaew+2023]

Metadata

Led by Dr. Karin MUGLACH



[Reiss+2023]

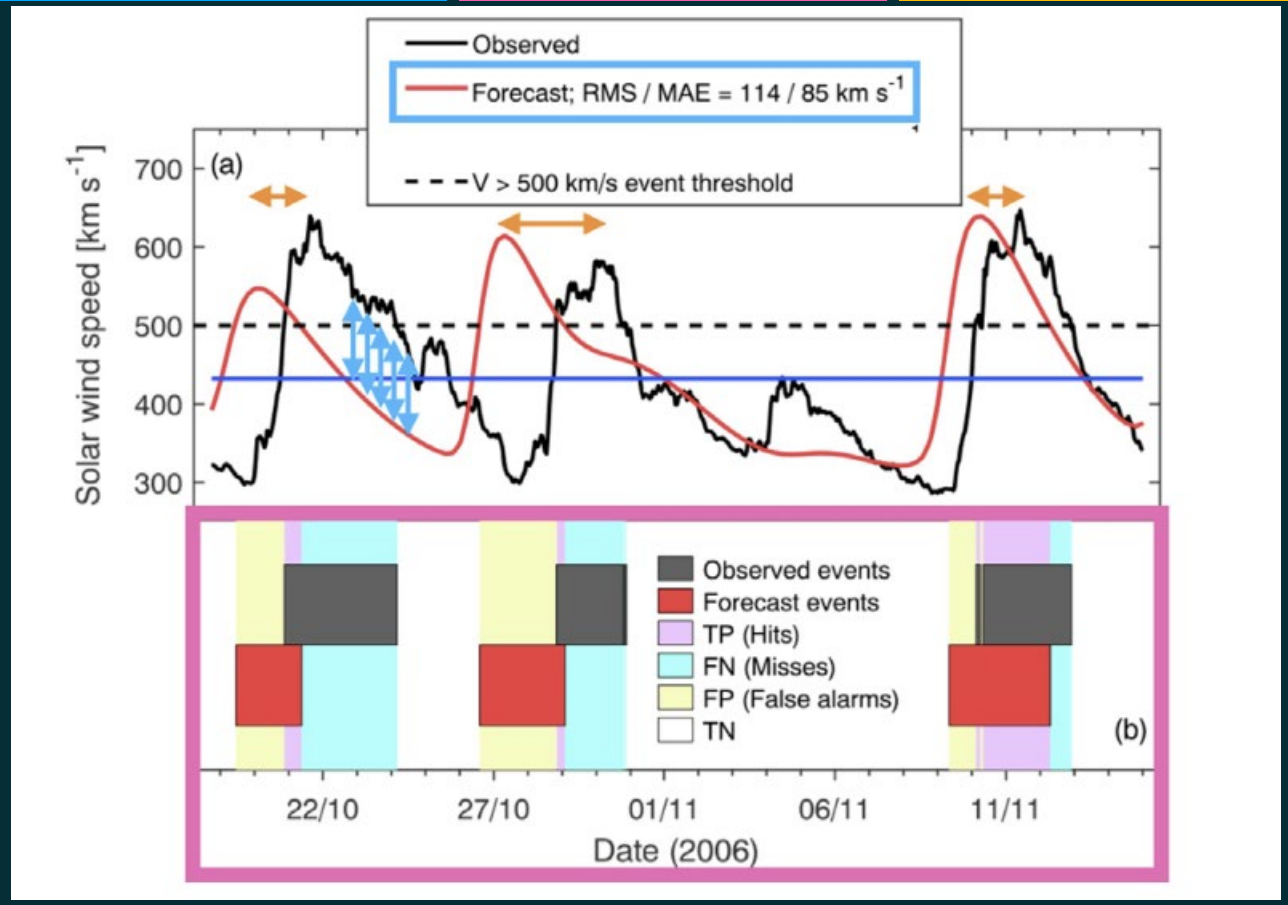
Objective:
Provide full metadata information about each model on the platform

Next steps:
Automate the metadata form + find which key information to add

Where to find it:
https://docs.google.com/document/d/105c7RPx1jBFUH5C1dxcxF29zBQVvC0f4C4VrLxh2qgs/edit

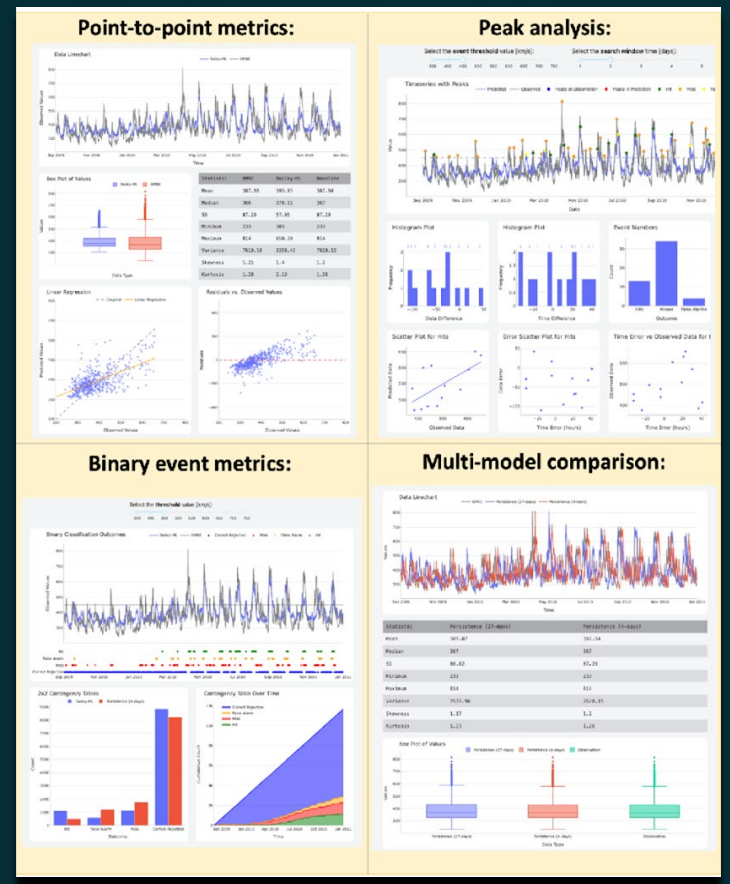
CAMEL frontend provides comprehensive validation procedures that are aligned with community standards

1. Point-to-Point Measures
2. Binary Event Measures
3. Time Series Enhancements



Reiss et al., 2022
(adapted from Owens et al., 2018)

Ambient Solar Wind Frontend



COMMUNITY COORDINATED MODELING CENTER

Open Solar Wind Model Validation [Prototype]

- Home
- 1. Data Availability
- 2. Point-to-Point Metrics
- 3. Binary Event Metrics
- 4. Peak Analysis
- 5. Multi-Model Comparison

Welcome!

Open Solar Wind Model Validation at the CCMC

1) Select Data and Check Availability
Choose data from available time periods for validation. Supports various datasets that are either hosted at the CCMC or have been provided directly by the model developers.

2) Point-to-Point Metrics
View computed metrics for point-to-point comparisons between observed and predicted data, offering basic insights into model performance.

3) Binary Event Validation Metrics
Analyze outcomes from binary event validation, where each timestep is labeled as an event or non-event based on a user-specified threshold value. Display the model performance in event prediction.

4) Peak Analysis
Identify and study peaks in time series data for both predicted and observed data. This allows for a detailed examination of detected events and the models ability to forecast increased solar wind speeds.

5) Multi-Model Comparison
This feature enables the comparison of multiple model solutions for selected time periods using widely-applied metrics.

Feedback Welcome
Please share your feedback to help improve the functionality and user experience of this open validation dashboard.

Notes

Developed by the Community Coordinated Modeling Center (I[illegible]s, Rick Mullinix) using Plotly Dash.

Open Validation Platform

- Model outputs and observational data from CAMEL campaigns are accessible via the CAMEL API and data repository

Open-Source Metrics

- CAMEL's skill score calculation library is an open-source NASA project
- Community contributions of new validation metrics and procedures are welcome

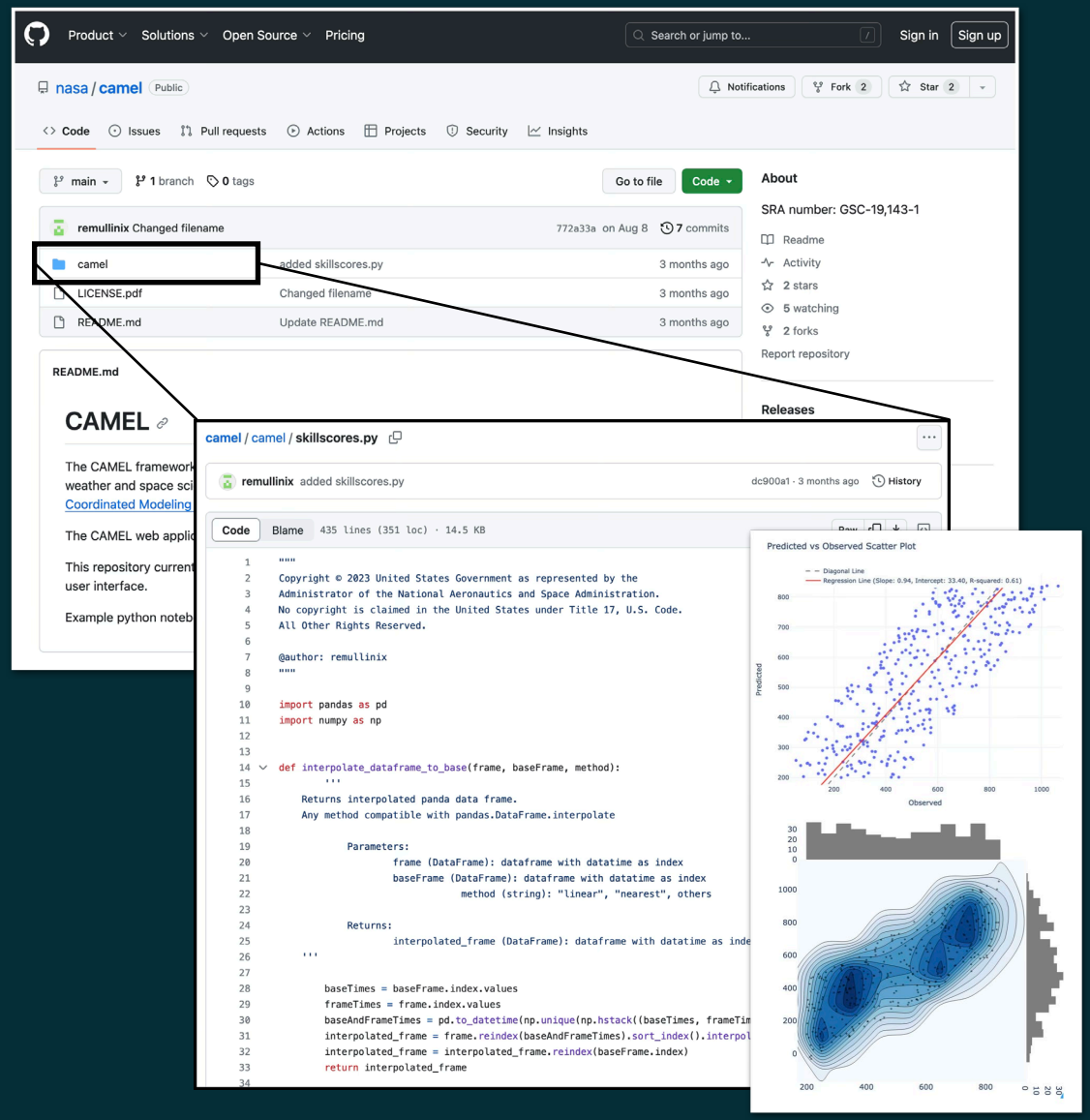
API Accessibility

- Users can download CAMEL's available datasets into their environment for further analysis through the CAMEL API.

Jupyter Notebook (coming soon)

- Jupyter Notebooks will allow expert users to recreate all results, including visualizations, on their local machines.

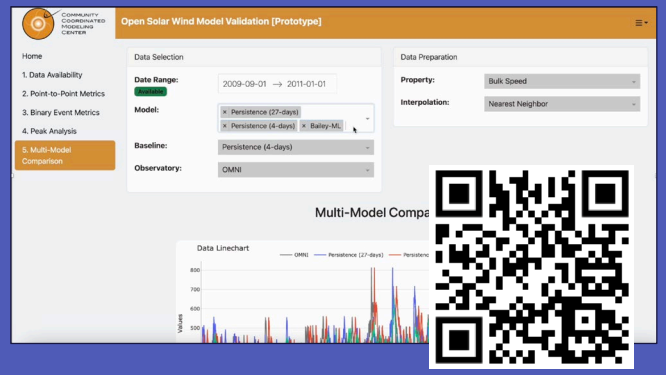
CAMEL Git Repositories



Key Takeaways

- **CAMEL enables open validation** of space weather and space science models
- **Leap forward in capability assessment** of ambient solar wind models
- **Community-agreed standards** via ISWAT (H1-01) for forecasting goals, metadata, and metrics
- **Advanced validation procedures and visualizations** included in the new CAMEL frontend
- **Open for the community** to contribute models, access data, and contribute metrics
- **Publication by Reiss et al., 2023**
- **Feedback welcome!**

Prototype Access



ccmc.gsfc.nasa.gov/tools/CAMEL/

Reiss et al. 2023

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Unifying the validation of ambient solar wind models

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