An Approach to Comprehensive and Sustainable Solar Wind Model Validation

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Introduction

This talk will advocate for the modeling community to commit to engaging in automated model validation.

- Independent model validation is one of the CCMC's charter roles.

- When the CCMC first started in the early 2000s, entirely in-house validation of the small list of available models was a manageable challenge.

- That is no longer the case. We as a community need to realize this and buy into a more automated validation process.

Take Away Message

✓ Independent model validation is a critical foundation for operational forecasting.

- The proliferation of models and model inputs and the limited manpower available to perform validation makes **automated validation a necessity**.

- We have built a prototype system to support automated 'scientific' model validation of **coronal and solar wind** models.

- Our experience has demonstrated that it will only succeed if the modeling community engages with it as an **integral part of their model development cycle**.

Why Automating the Validation Process is a Necessity!

Solar wind models

- WSA
- ENLIL/WSA
- Corhel – MASP, MAST
- AWSoM
- HelTomo
- LFM-Helio
- EUHFORIA
- Susanoo

Magnetograms

- GONG
- HMI
- NSO
- MDI
- WSO
- MWO

Modeling of surf. field

- ADAPT (12/144 realizations)
- SURF

Diagnostics

(operat. forecasting)

- Ambient wind
  - V, Dens., Temp.
  - IMF polarity
  - SIR/CIR locat.
  - Sector bnd.
- CME cases
  - Arrival times
  - ICME density and ram press.
  - Bz

Even More Variation

- Models are updated frequently – major upgrades every 2-5 years

CONCLUSION : The front end of any comprehensive validation effort MUST be automated!

What are the challenges to setting something like this up?

- It requires model developer participation, but they are busy people and need to be convinced.

- What are their concerns?
  - It might make their model look bad
  - It will take up too much of their time

Overcoming these objections

- Structure the system to examine all aspects of the solutions – reduces chance of exposing of one particular algorithms weakness not shared by others
- Have multiple cases – reduces the possibility that one model might accidentally get 'luckier' than the others
- Give the developer the final say on whether a diagnostic from their model is approved for public viewing
- Use test cases chosen by the modelers themselves, that can be easily incorporated into their pre-release testing

Prototype Scientific Validation System

- We created an initial prototype system about 5-6 years ago
- Used SHINE to discuss/promote it

- Details
  - Semi-automated
  - Web based
  - Built and hosted at CCMC
  - Focused on ambient corona and solar wind
  - Identified 2 CRs at Solar minimum as initial test cases
  - Goals
    - To publically post 'apples to apples' comparison of results from different models
    - Conclusions to be drawn by the viewer

Submission Process

Step 1 : Register run, describe data format and identify suitable diagnostics

Step 2 : CCMC acknowledges registration and returns submission instructions

Step 3 : Submit your results file and a description text file to the CCMC anonymous ftp server

CCMC ftp Server
CCMC Web Server

Diagnostics selection for SHINE Challenge

Model and run information
Please do not use special characters such as *,/,&,(), etc. in your input.

Your first name: Peter

Your last name: MacNeice

Email address: Peter.J.MacNeice@nasa.gov

Model or model combination (with model version, if applicable, e.g. ENLIL2.7)
PFSS_MacNeice

Unique run identifier (to distinguish this run of your model from other runs of this model)
run001

Submission number (if you are making multiple submissions on the same day)
1

Select appropriate diagnostics for your model

Select a **SHINE Test Case:**
Case 2: CR2062 - Ambient Corona

Indicate appropriate **post-processing diagnostics** (one or more) you would like generated for your model output:

☑ **Diagnostic 1: Full Disk EUV Images**
  ☑ AIA-94
  ☑ AIA-131
  ☑ AIA-171
  ☑ AIA-193
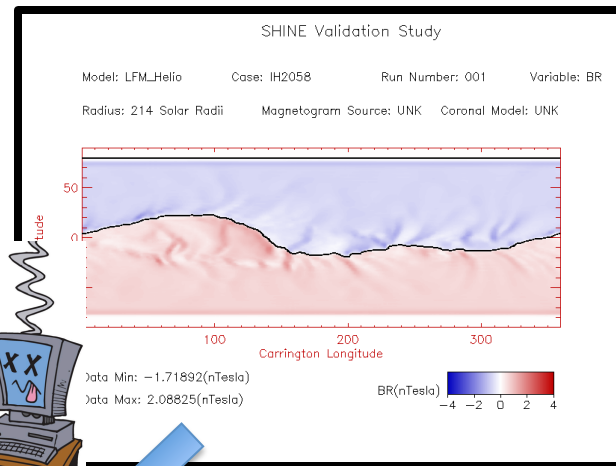 ☑ AIA-211
  ☑ AIA-304
  ☑ AIA-335

Processing and Review

Step 4 : CCMC system generates relevant validation graphics for this model and posts on private web page for model developer

Step 5 : Model developer reviews their model's graphics and approves or denies for public viewing.

CCMC auto Processing

CCMC Web Server

Private URL

Public Dissemination

Step 6 : Approved graphics are pushed to publicly viewable web pages.

CCMC Web Server

Diagnostics Implemented

- Planar cuts
  - Synoptic Plots at variable solar distances
  - Equatorial cuts
  - Longitudinal cuts
- Generalized Timelines
  - Planet and spacecraft trajectories
  - Line cuts
  - Comparative
- Synthetic EUV Images (contrib. by Sarah Gibson)
- Synthetic Heliograph Images (contrib. by D.Odstrcil)
- Support for fieldline plotting with SWx2

SHINE Validation Study

SHINE MODEL VALIDATION STUDY
Grey Scale Range : −19.4329 to −16.1319

SHINE Validation Study

Model: ENLIL-2.8b-ccmc   Case: IH2058   Run Number: 001   Current Sheet Height above Equator

Magnetogram Source: gong   Coronal Model: WSA_V2.2

Data Min: -144.149(Solar Radii)
Data Max: 165.453(Solar Radii)   HCS Height(Solar Radii)

Longitude 0
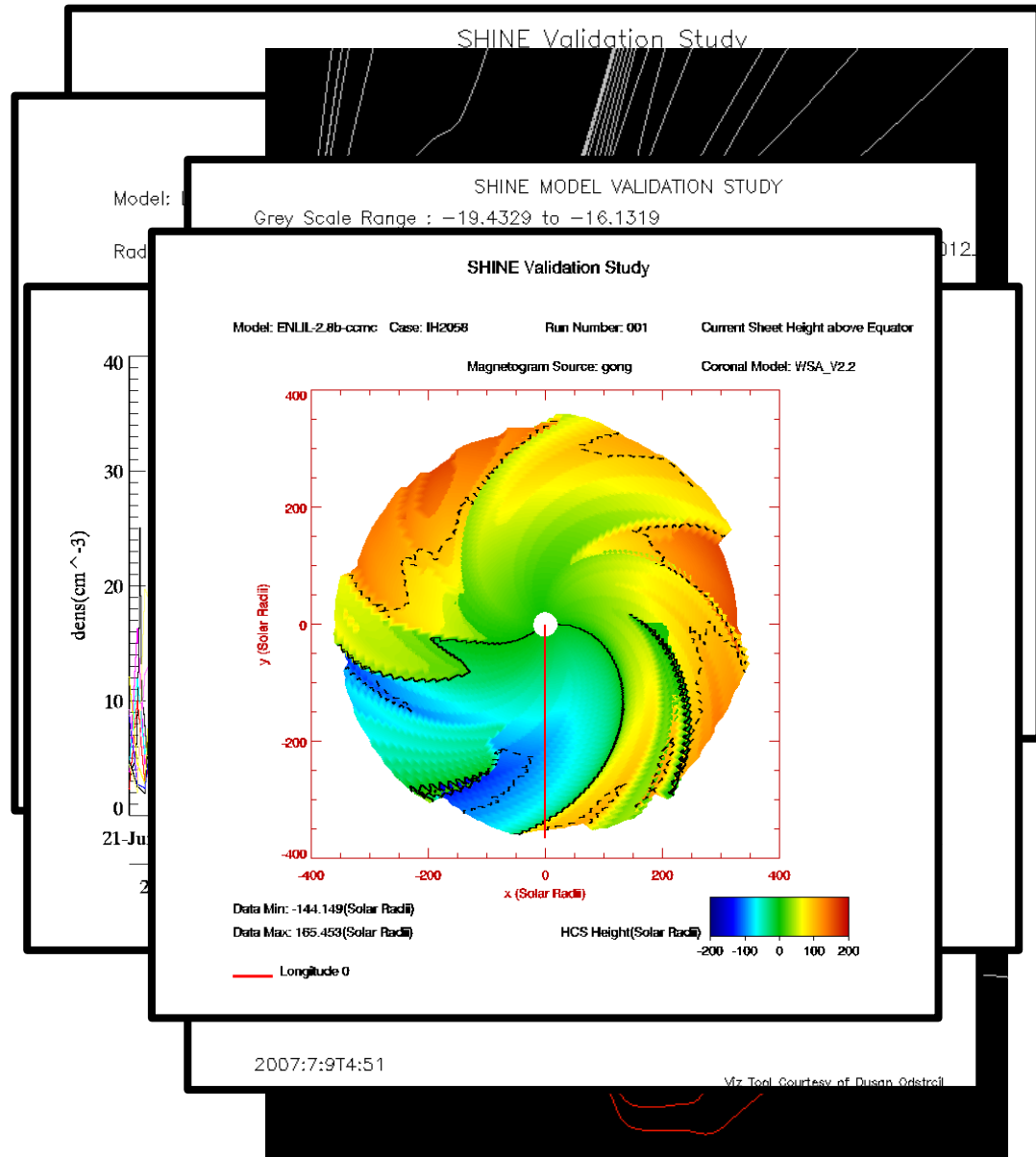
2007:7:9T4:51

Viz Tool Courtesy of Dusan Odstrcil

What happened when we built it?

- Contacted developers for results
- Negotiated details of initial test cases with model developers
- Intentionally designed to put minimal burden on developers
- Got 9 models to contribute
- Developed a large set of graphics
- Hoped to see developers post new results as part of model upgrade cycle
- Received nothing
- Lesson learned:

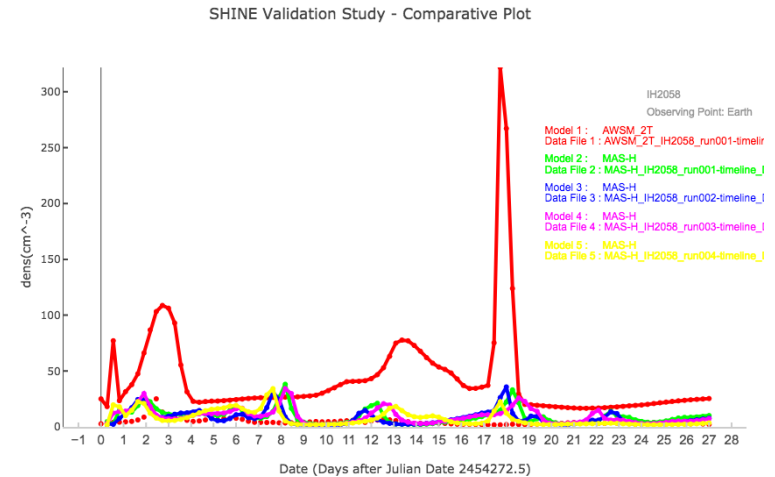**Process needs to be energized from our end!**

System Revival

Have revived system to support the

Space Weather Modeling Capabilities Assessment Forum

tasked to inform the NASA Living With a Star Program

Ongoing activities

- Updating system – graphics and data base foundation

   – Transitioning displays to *interactive graphics*

- Working with NOAA to assess impact of ADAPT maps on WSA/ENLIL forecasts of CME arrival times: CCMC and NOAA SWPC WSA-ENLIL validation project (33 events) : `https://ccmc.gsfc.nasa.gov/annex`

Related Validation Working Teams – please join!
`https://ccmc.gsfc.nasa.gov/assessment/`

CME Arrival and Impact Working Team

- Consider all types of CME events, start with single CMEs
    - Keep track of the different types
- Validation set : 100 events

User needs

Science needs
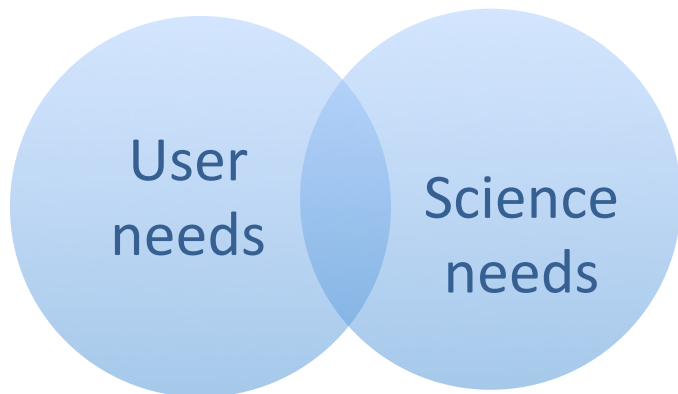
IMF Bz at L1 Working Team

- Currently in community discussions on how to best verify IMF Bz forecasts.

- Forecast a single sentence that identifies 3 quantities:

    – A duration window for the forecast in the future

    – A field strength to exceed

    – A probability of uncertainty

3D CME Kinematics and Topology Working Team

- CME parameters used inner boundary conditions for simulations

- Measurement methods are getting more sophisticated, but assessment of absolute accuracy is still difficult

- Goal: Providing a range of possible solution values

- Next steps: define necessary meta-data

END