Interactive Framework to Support Open Model-Data Validation Efforts at the CCMC

Presented by Lutz Rastaetter with contributions from the CCMC Team

NASA Goddard Space Flight Center, Greenbelt Maryland

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Legacy Validation Campaigns

- **Geospace Environment Modeling (GEM) campaign (2008-2015):**
  - Magnetic Fields in Geosynchronous Orbit, Magnetopause Crossings, Magnetic Perturbations on the Ground, Dst
- **Model Validation to select geospace model for SWPC operations (2010-2012):**
  - Magnetic Perturbations on the Ground, dB/dt on the ground (12 magnetometer locations), Kp
  - Coupled global magnetosphere-ionosphere models, statistical models of dB/dt and Kp
- **Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR) ETI study (2010-2014):**
  - Neutral and electron densities, TEC
  - Ionosonde locations, 2D global maps
- **Solar Heliospheric and INterplanetary Environment (SHINE) solar coronal and heliosphere modeling (2010-2014):**
  - Modeler submitted data
  - Model-model comparisons; no in-situ observations to compare against.

Capabilities Used

- **Run-on-Request:**
  - **1D time series plotting** and data extraction from model runs at the CCMC
    - Satellite trajectory or fixed position; each model run visualized separately
  - **2D slices through 2D and 3D outputs**
    - Separate for each run in CCMC online visualization with images aggregated in publications
    - More recently, option to plot (few) similar runs with same time, cut plane location and extent side by side.
- **Dedicated validation tool:**
  - **1D timeseries comparison**
    - Compare model results with observations
    - Fixed selection of skill scores calculated (RMS error, Prediction Efficiency, Pearson Correlation, …)
    - Only one location / satellite orbit at a time.

Comprehensive Analysis of Models and Events based on Library tools (CAMEL)

Goals:

- CAMEL is a Continuous Open Validation Effort
  - Any modeler can submit their model outputs to test how well the model is doing in comparison to other models.
- Use Essential Space Environment Quantities (delta-B, neutral density, fluxes at VAP, geosynchronous orbit, …)
  - indicative of space weather impacts,
  - can be derived from observational data and model outputs.
- Demonstrate potential of new models and simulation settings
  - improve space weather forecasting capabilities
  - trace progress over time by adding newer model versions or run settings.

Features:

- Continuous development of min-CAMELs supporting International Space Weather Action Teams
  - Thermosphere Model Assessment and Improvement
  - Internal Charging Effects and Relevant Space Environment
  - Ambient Solar Wind Validation
- Metric (Skill Score) and utility metrics thresholds selected from library most relevant for specific applications
- Assessment done based on observation location (local time, dayside/nightside)
- Assessment based on phase of phenomenon (storm vs. quiet times, storm main or recovery phase)

CAMEL Demo

CAMEL

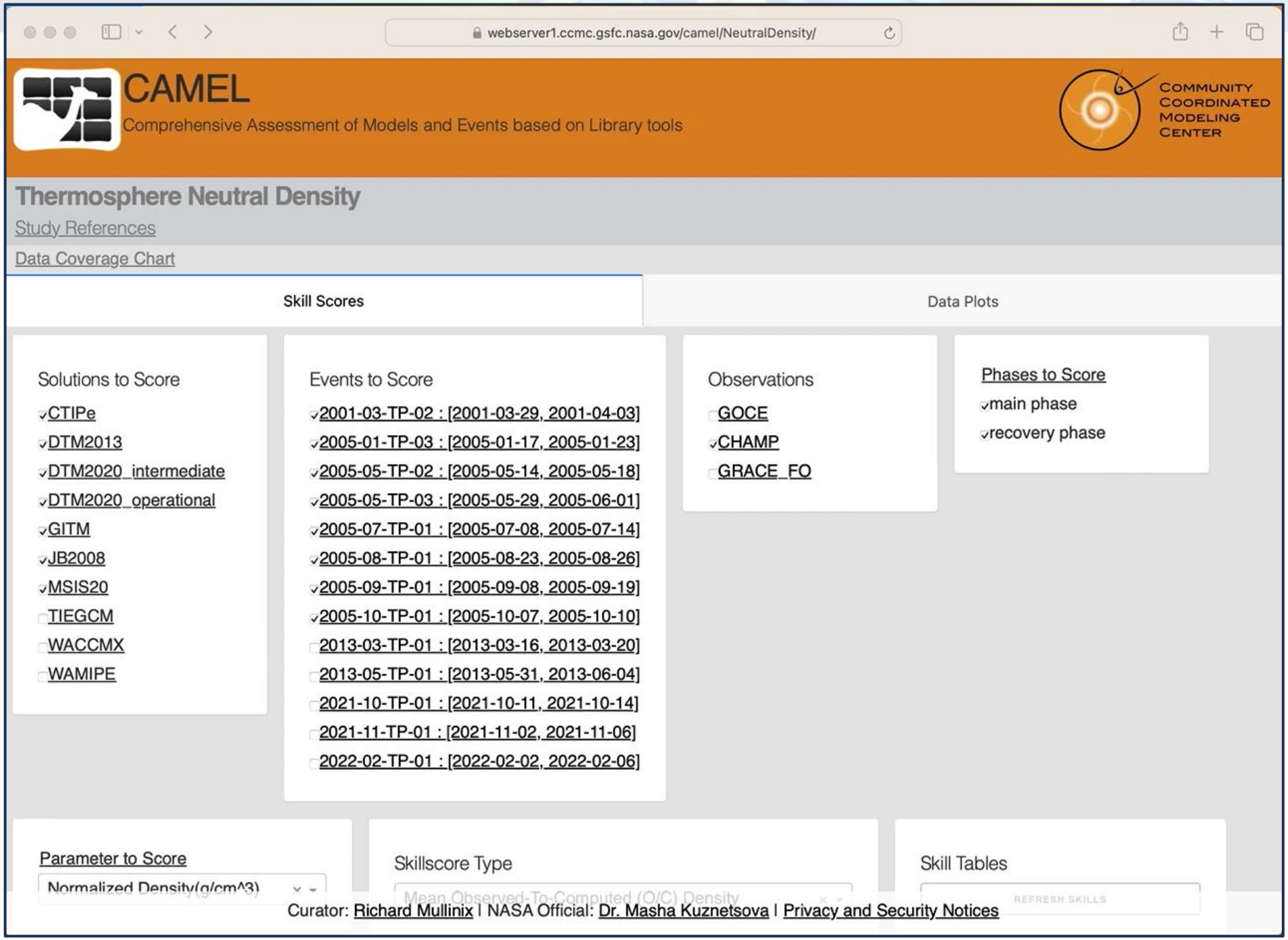
Comprehensive Assessment of Models and Events based on Library tools

Validation Studies

- GEM2008 Ground Magnetic Perturbations
- Radiation Belt Effects: Initial Results from the GEM Challenge on the Spacecraft Surface Charging Environment
- Solar Wind Parameters at L1
- Total Electron Content at various Ionosonde Stations
- COSPAR ISWAT TEAM ID: H1-01 (Ambient Solar Wind) [BETA]
- 900keV and 1800keV at Van Allen Probe A/B [BETA]
- Neutral Density [BETA]

We will look at this one!

Available on
https://webserver1.ccmc.gsfc.nasa.gov/camel/


webserver1.ccmc.gsfc.nasa.gov/camel/NeutralDensity/
CAMEL
Comprehensive Assessment of Models and Events based on Library tools
COMMUNITY COORDINATED MODELING CENTER
Thermosphere Neutral Density
Study References
Data Coverage Chart
Skill Scores
Data Plots
Solutions to Score
CTIPe
DTM2013
DTM2020_intermediate
DTM2020_operational
GITM
JB2008
MSIS20
TIEGCM
WACCMX
WAMIPE
Events to Score
2001-03-TP-02 : [2001-03-29, 2001-04-03]
2005-01-TP-03 : [2005-01-17, 2005-01-23]
2005-05-TP-02 : [2005-05-14, 2005-05-18]
2005-05-TP-03 : [2005-05-29, 2005-06-01]
2005-07-TP-01 : [2005-07-08, 2005-07-14]
2005-08-TP-01 : [2005-08-23, 2005-08-26]
2005-09-TP-01 : [2005-09-08, 2005-09-19]
2005-10-TP-01 : [2005-10-07, 2005-10-10]
2013-03-TP-01 : [2013-03-16, 2013-03-20]
2013-05-TP-01 : [2013-05-31, 2013-06-04]
2021-10-TP-01 : [2021-10-11, 2021-10-14]
2021-11-TP-01 : [2021-11-02, 2021-11-06]
2022-02-TP-01 : [2022-02-02, 2022-02-06]
Observations
GOCE
CHAMP
GRACE_FO
Phases to Score
main phase
recovery phase
Parameter to Score
Normalized Density(g/cm^3)
Skillscore Type
Mean Observed-To-Computed (O/C) Density
Skill Tables
REFRESH SKILLS
Curator: Richard Mullinix | NASA Official: Dr. Masha Kuznetsova | Privacy and Security Notices

Summary

Audience:

- Scientists, Operational Space Weather Agencies, Researchers

Problems Addressed:

- Continuous and open validation framework for the community to track progress over time
  - All data and output is publicly available via a public repository or API
  - The skill scores calculation library is open source

Future Plans:

- Continue to develop and improve active mini-campaigns as they all have different sets of requirements,
- Support analyses beyond using 1-D time series for validation,
- Open source the post-processing and visualization code.