2021 Workshop: Synergy of Models

Long title
Synergy Between First-Principles and Data-Informed Modeling
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Description

In recent years, data analysis and machine learning techniques helped make significant progress in understanding and predicting the I-T system’s conditions. These techniques will continue to improve as more data becomes available with the advances in instrumental coverage and functionality. Traditionally, first-principles models also utilize statistical analysis of data to specify the boundary conditions. These statistical and empirical models have been performing quite well to describe large-scale conditions; however, various issues can arise during geomagnetically activity intervals. As the first-principles models' performance heavily relies on the boundary conditions, data analysis and machine learning progress will positively affect the results achieved by the first-principles models. We invite presentations on the following topics to explore synergies between data-informed and first-principles models.

- New data processing techniques

- New data assimilation tools

- New machine learning models

- New interfacing options between first-principles and data-informed models

- Reduced-order models

Agenda

1. **Tomoko Matsuo**, "Data-Driven Ensemble Modeling of the Upper Atmosphere"
2. **Phil Chamberlin**, "FISM v.02"

3. **Qingyu Zhu**, "ASHLEY"
4. **David Themens**, "Empirical Ionospheric Electron Density Models: Advantages and Challenges"
5. **Bharat Kunduri**, "A Deep Learning-Based Approach for Modeling the Dynamics of AMPERE Birkeland Currents"
6. **Bashi Ferdousi**, "GIC estimates using spherical harmonics"
7. **David Richardson**, "Modelling Variations in the D-region Ionosphere via Machine Learning based Remote Sensing"
8. **Yang Pan**, "Global TEC map completion using GAN models"
9. **Hanli Liu**, "Updates on SIMA/WACCM-X"
10. **Karl Laundal**, "Local Mapping of Polar Ionospheric Electrodynamics"
11. **Nithin Sividas**, "Are we underestimating the effect of space weather?: Taking solar wind measurement uncertainty seriously."

Justification

The first-principles models have been instrumental in understanding how the I-T system responds to various types of forcing. However, these models' performance depends on the boundary conditions used in describing the energy, mass, and momentum transfer, especially during high geomagnetic activities. These boundary conditions can be further improved by employing new data-informed models enabled by powerful tools like machine learning (ML) and data assimilation techniques. Similarly, the ML and data assimilation efforts could benefit from the physical constraints that the first-principles models provide. This workshop aims to explore the synergy between first-principles and data-informed models by discussing the following questions.

Questions:

1.What are some of the new techniques for incorporating data analysis into first-principles models? How can we advance these models by Machine Learning and data assimilation?

2.What are the common issues (i.e: spatiotemporal resolution, region, compatibility, etc.) with coupling data-informed and first-principles models?

3.How can self-consistency be achieved between data-informed and first-principle models?

4.How can first-principles models improve the feature selection and prediction processes for predictive machine learning and data assimilation models?

5.How can first-principles models and measurement data be used to cross-validate the new data-informed models?

How the questions will be addressed:

- Updates on new first-principles models and applications

- Updates on new data analysis and processing techniques

- Updates on new data assimilation and machine learning models

- Group discussion at the end of the session

What resources exist, are planned, or are needed:

- New data assimilation and machine learning working groups: ISWAT, ISSI, IAGA, CCMC, AMGeo, InGeO, Advisory committees

- New funding opportunities

- New tools and open-source models

- New data sets

How progress should be measured:

- Surveys before and after the sessions

- Slack channel to facilitate and encourage collaboration

- Cross-platform usage of different models

Relevance to CEDAR: By employing a systems science perspective to discuss the integration of data products and improving the predictive capabilities of numerical models, the proposed workshop will support the implementation of CEDAR Strategic

Thrusts 1 - “Encourage and Undertake a Systems Perspective of Geospace” and 6 - “Manage, Mine and Manipulate Geoscience Data and Models”. The proposed workshop will also aim to improve model interfacing across the Magnetosphere, Ionosphere and Thermosphere systems, which closely aligns it with the CEDAR Strategic Thrust 2 - “Explore Exchange Processes at Boundaries and Transitions” mission.

With the new Decadal Survey efforts in progress, innovative workshops such as the proposed one would help materialize the interest in the community into collaboration and funding opportunities.

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