2016 Workshop: Geospace Empirical Models

Long title
Geospace Empirical Models
CEDAR-GEM
Conveners
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Description

Empirical models, which usually incorporate key physical constraints, provide several critical functions in geospace science and space weather. Scientifically, they represent the climate of the geospace system, where climate is defined as the mean response of an environmental system to external and internal forcing, including short-term forcing. Empirical models' encapsulation of the observational record of the geospace system provides insight into the physical mechanisms underlying the system's response and serves as a stringent benchmark for validating first-principles models. Empirical models are widely used for space weather prediction, initial and boundary conditions, a priori estimation for measurement retrieval, and background conditions for wave propagation. This workshop will provide tutorials on major empirical models that are used in the geospace community, including NRLMSIS, HWM, IRI, and the Weimer high-latitude electrodynamics model. Each model's formulation and physics, assimilated data, recent development, operation, and limitations will be discussed.

Agenda

John Emmert Overview: 3 Myths about empirical models (pdf)

Stefan Maus International Geomagnetic Reference Field (IGRF) Background magnetic field vector (pdf)

John Emmert NRLMSIS Atmosphere Temperature and Composition Model Atmospheric neutral temperature, density, and composition (pdf)

Jens Oberheide Climatological Tidal Model of the Thermosphere (CTMT) Diurnal and semidiurnal tidal amplitude and phase (temperature, wind, density) (pdf)

Doug Drob Horizontal Wind Model (HWM) Atmospheric horizontal neutral wind vector (pdf)

Dieter Bilitza International Reference Ionosphere (IRI) Electron and ion density, composition, and temperature; vertical electron column density (pdf)

Dan Weimer High-latitude electric field and current models Electric potential, field-aligned currents, Poynting flux, geomagnetic field perturbations (pdf)

Paul O'Brien AE-9/AP-9 Radiation belt models Energetic electron and proton fluxes (pdf)

Justification

Empirical models underpin an astonishing quantity of geospace research and operational space weather prediction, via their applications listed above in the workshop description. Their importance to the geospace community is demonstrated by the large number of citations they receive in the literature. For example, the papers describing the three most recent versions of the MSIS atmospheric model are the 1st, 2nd, and 4th most cited papers in JGR Space Physics, and the Heppner-Maynard electric field model is the 7th most cited. International Reference Ionosphere (IRI) papers have garnered over 1800 citations. The conveners' experience indicates that there are widespread misconceptions about what empirical models are and represent, and how they should be applied. Via tutorial presentations, this workshop will enlarge the geospace community's understanding of empirical models and educate students who will be using and constructing them in the future. The workshop will also provide a forum for exchanging empirical modeling and climate science techniques. Empirical modeling and climate science inherently adopts a systems perspective to the environment, and is therefore aligned with Strategic Thrust #1 in the CEDAR Strategic Plan. The workshop also addresses:

- CEDAR Strategic Thrusts #5 ("Fuse the Knowledge Base across Disciplines") and #6 ("Manage, Mine, and Manipulate Geoscience Data and Models")

- Several GEM Focus Group topics (including “Storm-Time Inner Magnetosphere-Ionosphere Convection” and “Geospace Systems Science”)

- The Space Weather and Space Climatology Vision of the Decadal Survey for Solar and Space Physics (including the need for “robust space environment models”, the utilization of key space environment measurements in advanced models, and validation of physical models).

Summary

The workshop, which was attended by approximately 40 people, began with a short overview of the physical and statistical meaning of empirical models and their scientific contributions to aeronomy and geospace research. This was followed by tutorials on seven major atmospheric and space environment empirical models, covering the domain from the troposphere to the magnetosphere. Links to the tutorials and to model web pages are provided in the agenda above. The overview presentation includes a non-exhaustive list of other representative empirical models.

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