Overview of CISM Data Assimilation


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Abstract

The Center for Integrated Space Weather Modeling includes a new component focused on preparing prognostic numerical models for data assimilation methodologies. This element is most developed in the ionosphere/thermosphere area, where a collaboration with the GAIM development group at Utah State has been initiated. Other disciplines within CISM are pursuing data assimilation in different ways, particularly in radiation belt physics. Due to the differences between physical regimes and modeling methods, the analogy with meteorological and oceanographic techniques has strong application in some areas and limited validity in others. CISM therefore plans a pragmatic approach where application of data to numerical models may be adopted using the most effective means to address particular problems.

Which Geophysical Systems are Most Amenable to Data Assimilation Techniques?

— To what extent do future states depend on present states?
— To what extent do future states depend on variable boundary conditions?
— To what extent are the future boundary conditions known?
— What are the timescales for which we will desire a forecast?
— Are there lags between observables and effects that can be exploited?
— Is the system persistent or compliant?

Here, persistence means that a combination of the current state plus our knowledge of physics can adequately describe future states, regardless of how boundary conditions change, and compliance means that the system responds rapidly to changing boundary conditions. Of course, a largely stationary system has the greatest persistence and is easiest to forecast, but not all persistent systems need be stationary. But it is also important to consider to what extent we can know what the boundary conditions will do in the future, particularly in the case of compliant systems.

Ionospheric Data Assimilation and Numerical Modeling

GAIM specification used to initialize the Thermosphere-Ionosphere Nested Grid (TING) model

Radiation Belt Specification and Prediction

Kalman filter method used to assimilate radiation belt data

Which Geophysical Systems are Most Amenable to Data Assimilation Techniques?

- Persistent
- Compliant

Celestial Mechanics
Ocean/Troposphere
Troposphere
Ocean/Terrestrial??

Solar/Terrestrial??

Magnetosphere
Earthquakes

BC(>0) known

BC(>0) unknown

Radiation Belts

Bz variability in LFM for 1% change in solar wind specification

Branch Prediction of Magnetospheric Dynamics

Probability-weighted boundary conditions used as input to multiple speculative runs

Assimilation of Multiple Data Sources in the ENLIL Model

Optimal interpolation method using data from ACE, WIND, IMP-8, Geotail, and Interball-1

Assimilation of Solar Photosphere Vector Magnetogram Data

Time-dependent boundary conditions

Illustration of two coupled codes using vector magnetogram data as input

Doxas, Lyon, Wiltberger, Weigel

Fischer et al.