The Goddard Multi-Scale Modeling System with Unified Physics

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1. Introduction

In recent years, exponentially increasing computing power has allowed the number of computational grid points in numerical models to grow from less than a thousand to close to ten million. NWP (numerical weather prediction) and mesoscale models can now use grid resolutions similar to cloud-resolving models (CRMs) through nesting techniques, which in turn also allows them to use the physical packages developed and tested for CRMs. A CRM, typically, is not a global model and can only simulate cloud ensembles over a relatively small domain. To better represent convective clouds and cloud systems in large-scale models, a coupled GCM and CRM (termed a *super-parameterization* or *multi-scale modeling framework, MMF*) is required given the feasible computational power. The use of a GCM enables global coverage, while the CRM allows for better and more sophisticated physical parameterizations (i.e., CRM-based physics). In addition, the MMF can utilize current and future satellite programs that provide cloud, precipitation, aerosol and other data at very fine spatial and temporal scales over the entire globe.

2. Goddard Multi-Scale Modeling System

Recently, a multi-scale modeling system with unified physics was developed at NASA Goddard. It consists of (1) the Goddard Cumulus Ensemble model (GCE), a CRM, (2) the NASA unified Weather Research and Forecasting Model (WRF), a region-scale model, and (3) the coupled fvGCM-GCE, the GCE coupled to a general circulation model (or GCM known as the Goddard MMF). The same cloud microphysical processes, long- and short-wave radiative transfer and land-surface processes are applied in all of the models to study explicit cloud-radiation and cloud-surface interactive processes in this multi-scale modeling system. This modeling system has been coupled with a multi-satellite simulator for comparison and validation with NASA high-resolution satellite data. The left figure shows the multi-scale modeling system with unified physics. The GCE and WRF share the same microphysical and radiative transfer processes (including the cloud-interaction) and land information system (LIS). The same GCE physics will also be utilized in the Goddard MMF. The idea to have a multi-scale modeling system with unified physics is to be able to propagate improvements made to a physical process in one component into other the components smoothly and efficiently. In addition, the Goddard Multi-scale Modeling System has been coupled with a multi-satellite simulator unit, Goddard satellite data simulator unit (SDSU). SDSU has six simulators at present: passive microwave, radar, visible-infrared spectrum, lidar, ISCCP type, and broadband. The SDSU can compute satellite-consistent radiances or backscattering signals from simulated atmospheric profiles and condensates consistent with the unified microphysics within the multi-scale modeling system (Fig. 1).

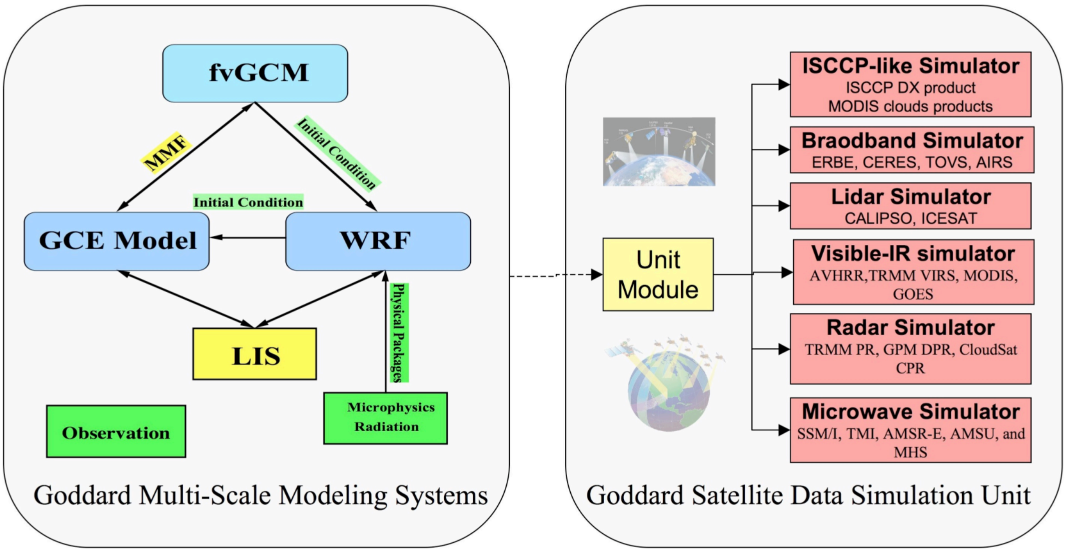

Fig. 1 Schematic diagram of the Goddard Multi-scale Modeling System with unified physics coupled with the Goddard Satellite Data Simulation Unit (SDSU).