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Coupling Earth System Models through ESMF

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The trend of Earth system model development is to couple more model components to cover more complete physical processes. Due to complexity of involved physical processes and computation-intensive nature, those model components are typically not developed in one organization. Therefore a software infrastructure is needed to facilitate this kind of coupling. Earth System Modeling Framework (ESMF) is one of those software infrastructures.

In this paper, we will present two categories of coupling through ESMF: (1) tightly coupling through data exchange frequently such as atmosphere and ocean; (2) loosely coupling through data exchange only at beginning and ending.

In the case of tightly coupling, there are two essential operations: (1) match what one model component (provider component) can provide with what another model component (user component) needs, (2) transfer the matched data from the provider component to the user component. Typically a coupler component is also needed to perform the operations of regridding for the case of different model grids and redistribution for the case of different parallel data layouts. We will discuss the tools to make this kind of coupling automatic with a user-friendly interface.

For loosely coupling, we present one use case. That is, a data assimilation system written in MPI and Fortran subroutines uses the column physics of a global circulation model (GCM) based on ESMF, a component-based framework. In this case, a driver uses N processors to run M instances of GCM. Each instance only differs in its initial condition. And there is no interaction among those instances. We will present our solution to embed the ESMF based NASA GEOS5 Column Model in a data assimilation system for precipitation observations. In addition, we will also discuss how a ‘pool-of-processor’ scheme is used to efficiently manage computational load.