A. Introduction

The purpose of this document is to describe in detail the code known as the CSM Flux Coupler. This code was developed to serve two specific functions within the NCAR Climate System Model. First, it controls the execution of the complete CSM by controlling the various component models, such as ocean, atmosphere, land and sea–ice. It does this by controlling the exchange of information between the component models. Second, it computes the interfacial fluxes between the various component models of the CSM, based on state variables and surface fluxes that are passed to it from the component models.

A primary requirement of the Flux Coupler is to ensure that conservative properties, such as momentum, heat and freshwater, are neither created nor destroyed as they are exchanged between CSM model components. Satisfying this requirement is the cause of much of the code's complexity, expecially in the usual case of different resolutions in the component models. Often the resolution of the ocean component is finer than that of the atmospheric component. Heat is not conserved if the long wave radiation in the atmosphere component uses the average sea surface temperature (SST), while in the ocean it uses individual grid point SSTs, because this flux is proportional to SST^4. Another problem arises when an atmospheric grid box covers both land and ocean, and fluxes are first computed on the larger atmospheric grid and then interpolated to the finer ocean grid. If a large land roughness is used to compute the windstress, then interpolated coastal ocean windstress will be considerably higher than it should be. This procedure can lead to unrealistic coastal ocean circulations. Care must also be taken when high albedo sea–ice and low albedo open ocean are both present below a single atmospheric grid box.

The approach taken by the Flux Coupler to get around these problems is to compute the interfacial fluxes on the finest of the model grids. Then, for example, the roughness value in an ocean grid box will be that for the ocean, which means that the coastal wind stresses are not overestimated. Also, longwave radiation on the fine grid can be conservatively accommodated over the coarser grid. In general, this means that the spatial information of the finest model is retained and reflected in the interfacial fluxes rather than the fluxes being computed on the coarsest grid. This is accomplished by sending the necessary interfacial fields from all the component models to the coupler. Those on the coarsest grid, usually the atmosphere, are then interpolated to the finest grid, usually the ocean. The fluxes are then calculated on the finest grid. These are then ready to be sent to those models on the finest grid. The fluxes have to be averaged onto coarser grids before being sent to the component models with the coarse grid. This is the general procedure, but there are several special cases that must be accommodated. For example, net downward solar radiation and precipitation are both interface fluxes, but are both calculated internally in the atmosphere. These fluxes are passed to the coupler and are interpolated to the finest grid in a conservative manner before being passed onto the ocean or ice. In the present configuration, both the sea–ice and ocean models are on the same grid, which simplifies what the present version of the Flux Coupler does, but is not a general requirement of the ocean and sea–ice models.

Considerable care has been taken so that the calculated interfacial fluxes of heat and fresh water are conserved numerically. Then the total heat leaving the base of the atmosphere matches that being received by the land, sea–ice and ocean models. Thus, the heat content of the climate system is conserved, providing none is gained or lost to the top of the atmosphere. Fresh water will not be conserved until a river run–off model is implemented that takes net precipitation over land and puts it into the ocean at the appropriate locations. A short term partial fix has been implemented in the Flux Coupler to overcome this problem. It is to balance globally averaged precipitation and evaporation over the active ocean and sea–ice regions: details can be found in section G.

In Section H there is pseudo-code of the flux coupler. This code provides a specific description of the top level structure of the coupler, and indicates the ways in which component models will interface with the coupler. This pseudo-code is not necessarily intended to describe a final design of a CSM flux coupler, but rather a simplified design for the initial CSM release.