G. Exceptions and Special Cases

I. Ice–Ocean Stress

For the cavitating fluid ice model used in the NCAR CSM, the stress between the ice and the ocean is defined by

$$\vec{\tau}_4 = C_w \Big[\big\{ \mathbf{u}_H^G - \mathbf{u}_C \big\} \ cos\phi + \mathbf{k} \times \{ \mathbf{u}_H^G - \mathbf{u}_C \} \ sin\phi \Big]. \qquad (G1)$$

In equation (G1), $\mathbf{u}_H^G$ is the geostrophic surface velocity of the ocean, $\mathbf{u}_C$ is the ice velocity, C_w is a constant coefficient, and ϕ is the turning angle taken to be $\pm 25°$ in the Arctic and Antarctic. Although the surface ocean velocity is passed to the coupler, it is not used in the calculation of the ice–ocean stress; instead the ocean surface geostrophic velocity is calculated from the ocean surface slope $\nabla\eta$, which is also passed to the coupler, by

$$\mathbf{u}_H^G = \frac{g}{f} \ \mathbf{k} \times \nabla\eta, \qquad (G2)$$

where g is the gravitational acceleration and f is the Coriolis frequency. A term proportional to $\nabla\eta$ appears as a forcing term in the right-hand-side of the equation for ice velocity. The ice model solves for the ice velocity by transferring the terms proportional to $\mathbf{u}_C$ in (G1) to the left-hand-side of the equation and adding them to the Coriolis terms. Details can be found in the sea–ice model document. However, the resulting stress needed for the right-hand-side of the ice velocity equation is

$$\vec{\tau}_c = \vec{\tau}_1 + C_w \Big[\mathbf{u}_H^G \ cos\phi + \mathbf{k} \times \mathbf{u}_H^G \ sin\phi \Big], \qquad (G3)$$

where $\vec{\tau}_1$ is the stress on the ice from the atmosphere. $\vec{\tau}_c$ is what is presently sent by the coupler to the ice model instead of the vector difference between the wind stress on the ice minus the stress of the ice on the underlying water. However, the ice–ocean stress that the coupler sends to force the ocean model is $\vec{\tau}_4$ given by equation (G1). Thus, there is a mismatch in the definition of the ice–ocean stress because of the method used by the ice model to determine ice velocity. In the coupler code there is one location where the names of stress arrays contain the number 2; this is to address this situation where there are two forms of the ice–ocean stress.

II. Balancing Precipitation and Evaporation

In the Climate System Model, fresh water should be conserved. Fresh water goes into the ocean through river run–off, as well as by precipitation. The present CSM does not have a river run–off component and, in addition, the marginal seas do not exchange water with the rest of the global ocean domain. So, a short–term fix has been implemented in the coupler so that the net fresh water in the active domain of the ocean model is conserved. The fix is to calculate the area averages over the active ocean domain of both precipitation,

$< P >$, and the evaporation, $< E >$. Then the precipitation coming from the atmosphere model over the active ocean is multiplied by a factor, f_p, given by

$$f_p = \frac{< E >}{< P >}, \tag{G4}$$

Thus, the fresh water budget over the active ocean is balanced. This balancing is done as frequently in time as the precipitation and evaporation fields are sent to the coupler. Values of f_p at different times can vary somewhat, but time–averaged values of f_p are usually between 1.02 and 1.03. This is consistent with river run–off into the ocean being between 2% and 3% of the globally averaged precipitation falling on the ocean surface.