IMPORTANCE OF CALIBRATION FOR RUNOFF ROUTING MODELS USED IN GCMs

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Large-scale runoff routing models (RRMs) are important as a validation tool for general circulation models (GCMs), and to close the hydrological cycle in fully-coupled climate models. The model RiTHM was developed to simulate the discharge of large rivers from the total runoff simulated by the LMD atmospheric GCM. It uses a 1024x800 grid, nested in the 64x50 grid of the LMD GCM. The runoff simulated in a GCM grid cell is uniformly distributed over the underlying cells, where a series of two reservoirs accounts for the delay related to infiltration through the unsaturated zone and aquifers. The resulting riverflow is routed assuming pure translation along the drainage network, extracted from a 5-minute digital elevation model. The transfer time from a cell to the outlet depends on topography and on a basin-wide parameter, the time of concentration.

RiTHM was calibrated in 11 of the world's largest river basins, using a realistic runoff forcing (computed by the land surface model SECHIBA from reanalyzed meteorological forcing). This led to a very satisfactory reproduction of observed hydrographs. The main problems were related to hydraulic processes neglected in RiTHM (reservoirs, diversion of riverflow because of flooding or irrigation). These results helped to validate SECHIBA, except for its snow processes, shown to be too simple. With the same parameters, RiTHM was also forced with runoff from the LMD GCM. This induced an important degradation of the simulated hydrographs, regarding both volume and timing. Given the satisfactory calibration of RiTHM, this degradation was unambiguously related to errors in precipitation, and more generally climate, in the GCM. The direct calibration of RiTHM under the GCM-runoff forcing markedly improved the timing of simulated discharge, which could be interesting for land-atmosphere-ocean coupling, even if this should remain a temporary solution until the simulated water cycle improves in GCMs.

The general lesson from this work is that the usefulness of RRMs for GCMs strongly depends on their adequate calibration. Although not new, this conclusion needs to be defended in the climate modeling community, because RRMs for GCMs often use a priori parameters without any preliminary verification.