EGU23-14636, updated on 19 Apr 2024
https://doi.org/10.5194/egusphere-egu23-14636
EGU General Assembly 2023

Evaluation of a high-resolution high-performance routing scheme for regional to global scale applications within Earth System Models

Deniz Kilic[1], Yann Meurdesoif[2,3], Agnès Ducharne[1,3], Jan Polcher[4], and Josefine Ghattas[3]
[1]Sorbonne Université, CNRS , UMR METIS, 75005 Paris, France (deniz.kilic@upmc.fr)
[2]Laboratoire des Sciences du Climat et de l'Environnement, 91190 Saint-Aubin, France
[3]Institut Pierre Simon Laplace (IPSL), Sorbonne Université, CNRS, CEA, 75005 Paris, France
[4]Laboratoire de Météorologie Dynamique, IPSL, CNRS, Palaiseau, France

River routing is a critical component of land surface models (LSMs), as it plays a significant role in the closure of the water balance at global scale, linking the estimation of river discharge to the one of sea level. The estimation of river discharge within LSMs also enables researchers to use widely available discharge observations to evaluate their models, and to study the human impact on discharge. However, river discharge calculation is often simplified in continental to global scale applications, as topography varies at a much smaller scale than the one of LSM grid-scales, which requires sub-grid parameterizations.

In this study, we present a revision of the current routing module of the ORCHIDEE LSM (Nguyen-Quang et al., 2018) that aims to improve the accuracy of discharge estimation in an agile way. We propose a simple, parallelized, conservative routing module that is based on principal flow directions at the digital elevation model (DEM) scale and independent of the LSM grid cell, enabling the use of routing maps at various resolutions. The influence of topography is factored in by the topographic index, i.e. a product of slope and pixel length in each routing cell. The routing can be solved directly on DEM native grid using conservative interpolations of run-off and drainage computed from LSM. To reduce the computational cost, we developed an upscaling method by aggregating DEM pixels into irregular hydrological transfer units (HTUs), which respect the basin hierarchy by construction, therefore making the computation of effective topographic index straightforward, and which is constrained by validity of the numerical stability criteria. This upscaling method drastically reduces the computational cost, by a factor depending on the targeted resolution, without compromising the discharge estimation.

We test this new routing module via offline simulations, to evaluate the discharge within 10 of the world's largest river basins, at the outlet and in upstream sub-catchments. To this end we use a 2km version of the MERIT global DEM to derive information on flow direction, slope and pixel length; and the GRDC global river discharge observation dataset to evaluate the simulated river discharge. First, using the routing at the DEM pixel scale, we will tune the lag time of reservoirs to improve the discharge estimation. Then, we will test the stability of performances when upscaling the routing over a range of HTU lengths. This work is pivotal for the use of ORCHIDEE and its

routing scale at various spatial scales, either off-line or coupled to the IPSL climate model, especially with its scalable atmospheric dynamical core, which is based on a quasi-uniform icosahedral-hexagonal mesh, and can be used for both global or limited-area simulations (Dubos et al., 2015).

References:

Dubos, T., Dubey, S., Tort, M., Mittal, R., Meurdesoif, Y., and Hourdin, F.: DYNAMICO-1.0, an icosahedral hydrostatic dynamical core designed for consistency and versatility, Geosci. Model Dev., 8, 3131–3150, https://doi.org/10.5194/gmd-8-3131-2015, 2015.

Nguyen-Quang, T., Polcher, J., Ducharne, A., Arsouze, T., Zhou, X., Schneider, A., and Fita, L.: ORCHIDEE-ROUTING: revising the river routing scheme using a high-resolution hydrological database, Geosci. Model Dev., 11(12), 4965-4985, https://doi.org/10.5194/gmd-11-4965-2018, 2018.