第Ⅱ部門

Processing Topographic Data for Hydrological Models Using Scale-free Gridded River Network Dataset

Kyoto University, Student Member Duc Toan DUONG
Kyoto University, Member Yasuto TACHIKAWA
Kyoto University, Member Michiharu SHIIBA

Global warming has been having serious impacts on the Earth and its residents. Many researches have shown that even if the emission of greenhouse gases is reduced drastically, climate change will be irreversible in coming centuries. Frequencies and magnitudes of water-related disasters such as floods, droughts and water scarcity are predicted to increase due to changes in precipitation extremes.

To cope with water-related disasters induced by global warming mentioned above, prediction of river discharge is necessary. In this regards, hydrological and flow routing models play an important role in transferring the climate model outputs into river discharge. Many researchers analyzed changes in future risks of floods and droughts using different scale and spatial resolution hydrological models: global scale with 1-degree spatial resolution runoff model (Hirabayashi et al., 2008); regional scale with 2-minute spatial resolution hydrological model (Kiem et al., 2008); and basin scale with 1-km spatial resolution runoff model (Hunukumbura et al., 2012).

In general, the selection of Digital Elevation Model (DEM) resolution for simulation applications depends on many factors such as scale of the processes being modeled, numerical simulation approach and specific topographic parameters that are to be extracted from the DEM. Moreover, the selection of DEM resolution for a particular application is often driven by data availability, purpose of the research, and computational resources. For hydrological models which are grid based, topographic parameters (elevation, river length, flow direction, etc.) and simulation processes are determined at every grid cell. So, the data volume and computational resources are proportional to the number of grid cells which themselves increase quadratically for each doubling of the horizontal spatial resolution. As a result, finer spatial resolution grids require higher computational resources.

Therefore, to ensure the balance of spatial resolution, computational resources, and application of hydrological models, several algorithms for generating stream-flow networks for macro-scale hydrological models have been presented. Masutani et al. (2006) developed a scale-free global stream-flow network creation method as the basis of basin-wide hydrologic analyses for any integrated river basins. The most important advantage of this method is to conserve fundamental hydraulic information based on the finest-resolution stream-flow channel network, on any spatial scale. They provided a dataset of stream-flow networks with 11 different scales from high resolution (3s ≈ 90 meters, 6s, 9s, 12s, 15s), medium resolution (30s, 1 min, 2 min, 3 min), to low resolution (5 min, 10 min ≈ 20 km). And it enables hydrological models independent of spatial resolution.

However, the dataset consists of topographic data of individual river basins. To run a hydrological model with study area covering many river basins, it is needed to join those individual topographic data into a large topographic map that suits the study area. Hence, required physiographic information for hydrological models such as catchment area, river length, elevation, slope, and flow direction will be processed and joined into a large topographic map. An example of joining flow direction data is showed in Fig. 1a and Fig. 1b.

One of the most important things that need to be considered to join individual river basins data into a large topographic map is how to process the data of overlapped grid cells at the boundary of those river basins.

In this study, two solutions to process the data of overlapped grid cells at the boundary of joined river basins will be presented.

Duc Toan DUONG, Yasuto TACHIKAWA, Michiharu SHIIBA
duong@hywr.kuciv.kyoto-u.ac.jp

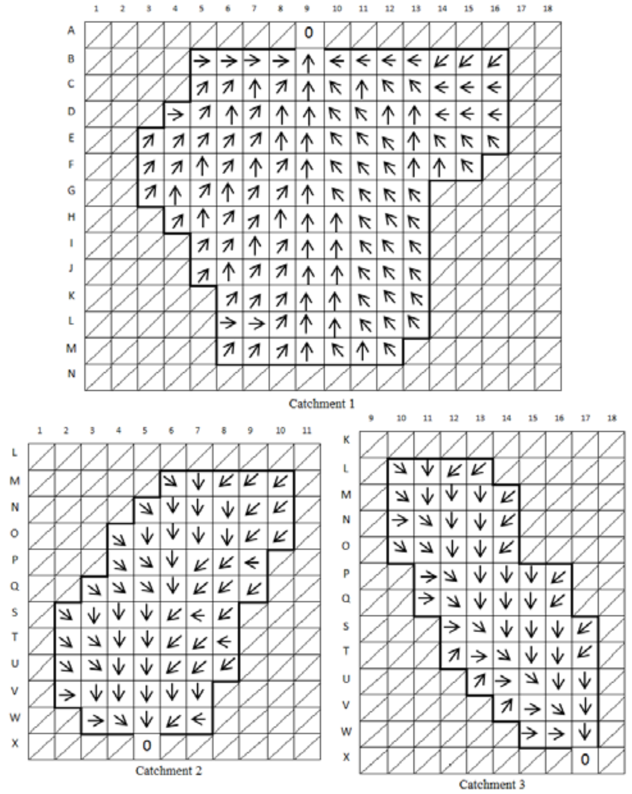

Figure 1a. An example of flow direction data before joining (Arrows indicate flow direction)

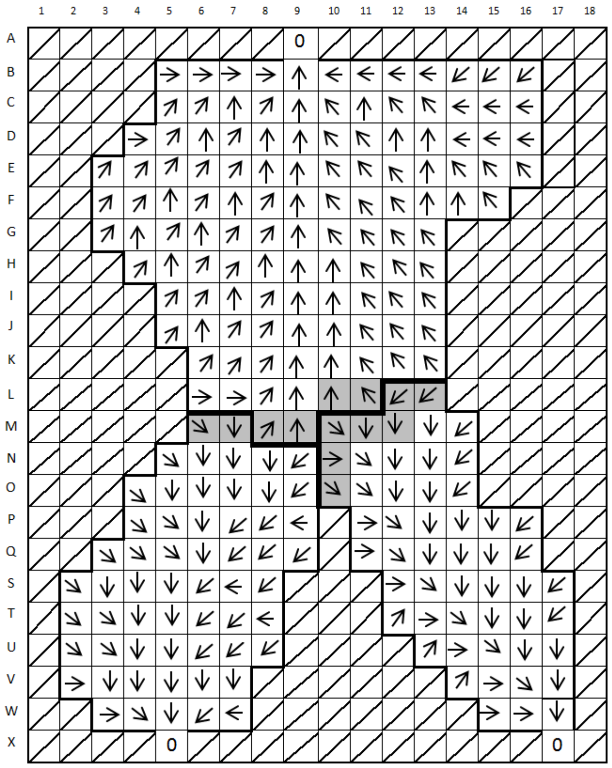

Figure 1b. Flow direction after joining (Gray cells: overlapped cells; bold lines: basin divides)

The first solution, which also is the simplest solution, is to keep the topographic information of overlapped grid cells that have larger area. Grid cells with smaller area will be removed. And flow direction of grid cells that flow into removed cells will be changed to neighbor cells in the same basin. In this solution, area of river basins that contain removed cells will be reduced.

In the second solution, there is one difference from the first one. Overlapped grid cells with smaller area will also be removed but cell area will be added into the neighbor cells following its flow direction. This will keep catchments area unchanged when they are joined into a large topographic map. Flow direction of grid cells that flow into removed cells will be changed to neighbor cells in the same basin.

Thereafter, sensitivity analysis will be carried out to see the effect of each solution on hydrological model outputs. And the better solution will be used to process free-scale topographic data for future researches related to impacts of climate change on water resources using hydrological models.

References

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