Geophysical Research Abstracts
Vol. 20, EGU2018-10478-3, 2018
EGU General Assembly 2018

An improved implementation of the VIC (Variable Infiltration Capacity) model for Canadian basins

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Closure of water balance components across the Canadian basins, considering the complexity of hydrological processes, is a challenging task. The increase in water demands such as irrigation, glacier retreat, changing land cover and permafrost thaw are among many changes Canadian basins are facing. Decision making under both climate and anthropogenic changes are increasing needed for future water security and social prosperity. A large-scale, integrated modeling approach is needed that includes a sufficient process representation to account for aforementioned changes.

In this study, we use the Variable Infiltration Capacity (VIC) land surface model. The current version of VIC, version 5, includes a range of cold regions hydrological processes which make it suitable for application to Canadian basins. The VIC model has been traditionally set up at regular angular grids (0.5 or 1 degree for example). In this common setting, each grid can have a single configuration of soil type and soil depth but can accommodate various land covers (vegetation types). The output of each grid is an aggregation of all the fluxes and states from the various sub-grid elements (land covers).

In this study however, we set up the VIC model in a way that it handles explicitly all the information on soil, vegetation, elevation and forcing data. Unlike the traditional approach, we run VIC for units which have similar land cover, soil type, elevation and forcing data. These units are not necessarily regular. The advantages of the new implementation are as follow:

1- This is the most reasonable spatial resolution for setting up a model based on the resolution of available data. Model implementation with higher resolution or units smaller than what is implemented in this study will be essentially a computational burden.

2- The effect of each land cover, soil type and elevation zone can be separately controlled. For example, it is expected that a forested area generates less surface runoff compare to grassland or bare soil if other conditions are reasonably similar. The new implementation of VIC provides the possibility to impose relative hydrological constraints during calibration.

3- Land cover change effects can be easily evaluated. Unlike the traditional method that the percentage of land cover should be changed in the model, in the new implementation, the percentage of every land cover can be manipulated based on projected land cover change in future outside of the configuration of VIC model.

4- VIC has the ability of considering elevation zones within a grid, however VIC assumes that the land cover within the cell is equally distributed among various elevation zones. This can result in unrealistic combinations, for example forest can be allocated to elevation zones above tree line. In the new implementation, however, each land cover will have its own elevation zones. This also reduces the computational expenses.

5- The new VIC setup makes it possible to have a more effective regularization of parameters in the calibration process.