STREAMFLOW MODELING OF A LARGE ARID CATCHMENT USING SEMI-DISTRIBUTED HYDROLOGICAL MODEL AND MODULAR NEURAL NETWORK

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ABSTRACT

Calibration and validation of hydrological models for simulating stream flow can usually be a promising procedure for future sustainable watershed development. Therefore, development of hydrological models with attributed capabilities is vital to explore the models. Recently, arid climate regions are facing critical water resource problems due to elevated water scarcity. The main objective of this research is to compare the Soil and Water Assessment Tool (SWAT), a knowledge driven by semi-distributed hydrological model, with the Modular Neural Network (MNN), a data driven technique, in predicting the daily flow in arid and large scale. Development of SWAT required digital elevation map, hydro-meteorological data, land use map, and soil maps; whilst, the MNN only needed hydro-meteorological data. For both models, a sensitivity analysis that included both calibration and validation with individual uncertainty evaluation methods was carried out. Generally, results for relative errors such as Nash-Sutcliffe, coefficient of determination and percent of bias favored the SWAT for the validation period. Not only that, the absolute error criteria such as root mean square error, mean square error and mean relative error obtained were close to zero for the SWAT as well within the same period. The mean absolute error for both models was similar during the validation period. Results of the uncertainty evaluation were in satisfactory range. Both models had given similar trend for flow prediction during the validation period. Results of box plot, according to 50% (median) of daily flow, showed that both models had respectively overestimated (MNN) and underestimated (SWAT) the daily flow during validation period. Evaluation on runoff volume for each year showed that both models had a one-year underestimation and three-year overestimation in the same period. However, the overestimation of MNN was more obvious. As a conclusion, this study showed that both models have promising prediction performance for daily flow in a large scale watershed with arid climate.

ABSTRAK

Kalibrasi dan validasi model hidrologi untuk simulasi aliran sungai biasanya boleh menjadi prosedur yang paling sesuai untuk pembangunan kawasan tadah air lestari di masa depan. Oleh itu, pembangunan model-model hidrologi yang berkebolehupayaannya adalah penting untuk meneroka model-model berkenaan. Baru-baru ini, kawasan beriklim kering sedang menghadapi masalah kekurangan air yang semakin kritikal. Objektif utama penyelidikan ini adalah untuk membanding satu kaedah penilaian air dan tanah (SWAT), iaitu satu model hidrologi separa-teragih berdasarkan penggunaan segala maklumat legeh, dengan satu rangkaian neural modular (MNN), iaitu satu teknik penggunaan data untuk ramalan aliran harian dalam kawasan kering dan luas. Pembangunan SWAT memerlukan peta digital aras ketinggian, data hidro-meteorologi, peta digital -guna tanah dan peta tanah-tanih; sementara MNN hanya memerlukan data hidro-meteorologi. Analisis sensitif, kalibrasi dan validasi, dan analisis ketidaktentuan telah dilaksanakan untuk kedua-dua model dengan kaedah masing-masing. Secara amnya, keputusan ralat relatif seperti Nash-Sutcliffe, pekali penentuan dan peratus kecenderungan menyebelahi SWAT dalam waktu validasi. Kriteria ralat yang lain seperti ralat minimum punca kuasa dua, ralat purata kuasa dua dan ralat purata relatif yang diperolehi juga telah menghampiri nilai sifar untuk SWAT pada waktu yang sama. Ralat mutlak purata untuk kedua-dua model menunjukkan kebolehupayaan yang sama semasa waktu validasi. Keputusan analisis ketidaktentuan adalah dalam julat yang memuaskan. Kedua-dua model telah menghasilkan tahap kecenderungan yang sama untuk peramalan aliran dalam waktu validasi. Keputusan (box plot) berdasarkan 50%(median) aliran harian menunjukkan bahawa kedua-dua model telah masing-masing terlebih anggaran (MNN) dan terkurang anggaran (SWAT) aliran seharian dalam waktu validasi. Anggaran isipadu air larian untuk setiap tahun menunjukkan bahawa kedua-dua model telah masing-masing memberikan satu tahun terkurang anggaran dan tiga tahun terlebih anggaran dalam waktu yang sama. Terlebih anggaran dalam tahun yang sama oleh MNN adalah lebih jelas. Kesimpulannya, kajian ini telah menunjukkan kemampuan yang meyakinkan untuk peramalan aliran harian dalam kawasan tadahan yang sangat luas dan beriklim kering bagi kedua-dua model.