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Supplement of

An improved method for calculating the regional crop water footprint based on a hydrological process analysis

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Supplementary material

Water footprint calculation methods based on field crop water requirement and irrigation schedule

Water footprint calculation methods based on field crop water requirement (equation 2) and irrigation schedule (equation 3) are as follow (Hoekstra et al., 2011):

$$WF = WF_{green} + WF_{blue} = \frac{CWU_{green}}{Y} + \frac{CWU_{blue}}{Y} = \frac{ET_{green}}{Y} + \frac{ET_{blue}}{Y} \quad (1)$$

$$\begin{cases} ET_{green} = \min(ET_c, P_{eff}) \\ ET_{blue} = \max(0, ET_c - P_{eff}) \\ ET_c = K_c \times ET_0 \end{cases} \quad (2)$$

$$\begin{cases} ET_{blue} = \min(IRR_t, IRR_a) \\ ET_{green} = ET_a - ET_{blue} \\ ET_a = K_s \times ET_c = K_s \times K_c \times ET_0 \end{cases} \quad (3)$$

where CWU_{green} is the green component in crop water use, CWU_{blue} is the blue component in crop water use, ET_{green} is the green water evapotranspired, ET_{blue} is the blue water evapotranspired, Y is the crop yield, ET_c is the crop evapotranspiration, P_{eff} is the effective precipitation, K_c is the crop coefficient, ET_0 is the reference evapotranspiration, IRR_t is the total net irrigation, IRR_a is the actual irrigation requirement, ET_a is the adjusted crop evapotranspiration, K_s is the soil water stress coefficient, which describes the effect of water stress on crop transpiration, For soil water limiting conditions, $K_s < 1$; when there is no soil water stress, $K_s = 1$. These equations are based on CROPWAT model.

SWAT model Calibration and validation in HID

The Sequential Uncertainty Fitting (SUFI-2) algorithm in SWAT-CUP was applied for calibration and validation (Abbaspour et al., 2007; Abbaspour, 2012) by comparing the simulated stream discharge from the model with the measured discharge data. The global sensitivity analysis integrated within SUFI-2 was used to evaluate the hydrologic parameters for the discharge simulation and then the optimal simulation is established by adjusting the sensitivity parameters and through multiple iterations. The

calibration period was from 2006-2009, and the validation period was from 2010-2012.

For calibration and validation analyses, the monthly measured discharges were compared with the simulated discharge data and the model performance was evaluated using the coefficient of determination (R^2), Nash efficiency coefficient (NSE) (Nash and Sutcliffe, 1970; Moriasi et al., 2007) and percent deviation (PBIAS) (Gupta et al., 1999).

The NSE is widely applied in hydrologic models that range from negative infinity to 1 with 1 being the ideal value. The PBIAS assesses the average deviation of the simulated values from observed values with 0 as the ideal value, and a positive (negative) PBIAS value shows an underestimation (overestimation) bias of the simulated variable compared to the measured variable. The monthly model data simulation results can be classified as satisfactory if $R^2 > 0.6$, $NSE > 0.5$ and $PBIAS < \pm 25$ and can then be used for further analysis (Moriasi et al., 2007).

The SWAT-CUP parameter sensitivity analysis procedure showed that the CN2, ESCO, GW_REVAP and ALPHA_BF parameters were more sensitive. In this study, the R^2 , NSE, and BIAS for the measured and calibration period were 0.77, 0.65 and 17, respectively; and the R^2 , NSE, and PBIAS for the validation period were 0.68, 0.61 and 21, respectively (Luan et al., 2018). The model simulation result can be classified as satisfactory (Moriasi et al., 2007). Therefore, the results demonstrated that the SWAT model was applicable in HID for future hydrologic process assessments.

References:

- Abbaspour, K. C.: SWAT-CUP 2012: SWAT Calibration and Uncertainty Programs - A User Manual, Eawag: Swiss Federal Institute Science and Technology, 2012.
- Abbaspour, K. C., Vejdani M., Haghightat S.: SWAT-CUP calibration and uncertainty programs for SWAT, Modsim 2007: International Congress on Modelling and Simulation: Land, Water and

- Environmental Management: Integrated Systems for Sustainability, Christchurch, New Zealand, 2007.
- Gupta, H. V., Sorooshian, S., and Yapo, P. O.: Status of Automatic Calibration for Hydrologic Models: Comparison with Multilevel Expert Calibration, *J. HYDROL. ENG.*, 4(2), 135-143, doi: 10.1061/(ASCE)1084-0699(1999)4:2(135), 1999.
- Hoekstra, A. Y., Chapagain, A. K., Aldaya M. M., and Mekonnen M. M.: The water footprint assessment manual-setting the global standard, London • Washington, 2011.
- Luan, X. B., Wu, P. T., Sun, S. K., Wang, Y. B., Gao, X. R.: Quantitative study of the crop production water footprint using the SWAT model, *ECOL. INDIC.*, 89, 1-10, doi: 10.1016/j.ecolind.2018.01.046, 2018.
- Moriasi, D. N., Arnold, J. G., Liew, M. W. V., Bingner, R. L., Harmel, R. D., and Veith, T. L.: Model evaluation guidelines for systematic quantification of accuracy in watershed simulations, *T. ASABE*, 50, 885-900, doi: 10.13031/2013.23153, 2007.
- Nash J. E., & Sutcliffe J. V.: River flow forecasting through conceptual models Part I: A discussion of principles, *J. HYDROL*, 10, 282-290, doi: 10.1016/0022-1694(70)90255-6, 1970