Concept of IC-Ratio in River Discharge Simulation
using Distributed Hydrological Model

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INTRODUCTION

Discharge simulation, probably the most repeated work of hydrologists is still a challenging job. Distributed hydrological models are being successfully used recently for discharge simulation, but still it needs improvements. Use of a macro scale grid based distributed hydrological model[1] that simulates water movement, following automated procedures like basin partitioning, sub-basin hydrological modeling and linking sub-basin models together to produce total run-off has made easier to simulate the river discharges.

A question of suitable data resolution always comes ahead while using distributed hydrological models. Very high-resolution data may not be necessary to get good result in discharge simulation especially for larger catchment[3]. Very high-resolution data preferably may be avoided to increase slight more efficiency in modeling. By observing **IC ratio** (**Ratio** between **I**nput grid resolution and **C**atchment size) and simulation efficiencies with different forcing data resolution, the threshold value of **IC ratio** is discussed in this study for discharge simulation.

Grid precipitation and actual evapo- transpiration data, referred from (1) HUBEX IOP EEWB data[4] (5-minute spatial resolution) (2) GAME Reanalysis 1.25-degree data[5] (Version 1.1) and (3) GAME Reanalysis 2.5-degree data[4] (Version 1.1) for the period from May1 to August 31, 1998. Experiments are conducted for Huaihe river basin in China with the catchments namely Bengbu (132350 km^2), Wangjiaba (29844 km^2) and Suiping (2093 km^2), which represent the large, medium and small river basins. A brief description of the analysis are presented in this paper.

DISCHARGE SIMULATION RESULTS

Discharge simulation is performed using the pre-described data. A grid-based macro scale distributed hydrological model is used, which includes independent runoff process and flow routing process within grid cell before constructing a total runoff simulation. It gives the simulation result for the tested basins as shown in figures 1, 2, & 3 respectively.

The results has much variations. Among the various possibilities to cause such variations, the grid resolution effect is thought eminently to disregard diverse local hydrological and meteorological behaviors, when it becomes coarse. This leads to the idea of existence of some threshold value, which gives the indication that while IC-Ratio is kept above that value, the model perfomes at satisfactory level.

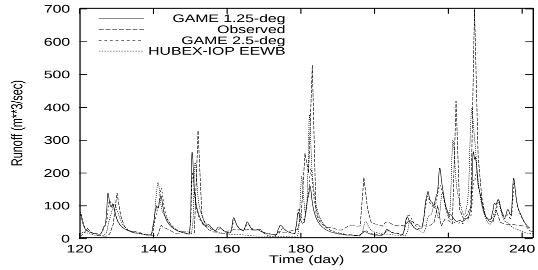

Fig.1 Simulation result for Suiping.

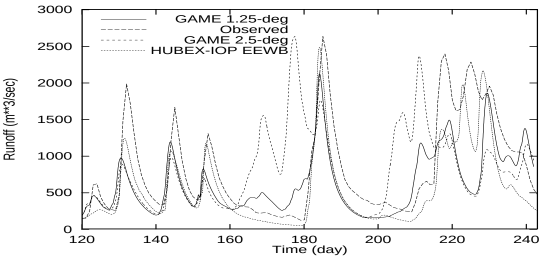

Fig.2 Simulation result for Wangjiba.

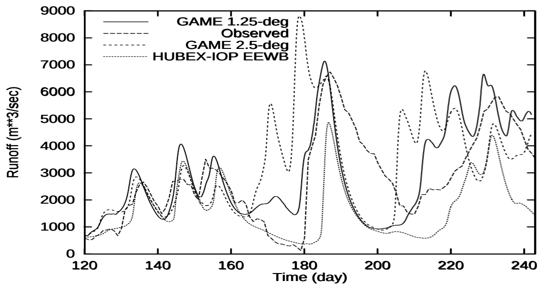

Fig.3 Simulation result for Bengbu.

PERFORMANCE INDEX

Simulation results are examined using 3 popular performance measures. They are: [1] Pearson's Product Moment Correlation Coefficient (PPMCC) [2] Nash-Sutcliffe's Coefficient of efficiency (NSC) and [3] Index of agreemet (IoA). A summary of IC-Ratios and performance index values are presented in Table 1, 2, 3 and 4 respectively.

PPMCC (Table-2) and IoA (Table-4) values swings between 0 and 1 but NSC (Table-3) ranges from $-\infty$ to 1. Value 1 indicates best performance in all cases. The obtained values in present analysis provides ground to conclude the satisfactory performance of model while

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the IC-Ratio value exceeds 1:11.78. It may be better to search a nearest valid whole number to suggest a marginal IC-Ratio. Since NSC values may reach to $-\infty$, this index is omitted in further analysis.

Table 1 Input-resolution-Catchment (IC) Ratio.

Resolution	Bengbu	Wangjiba	Suiping
2.5-degree (GAME)	1: 3.3	1: 0.75	1: 0.05
1.25-degree (GAME)	1: 13.24	1: 2.98	1: 0.21
10-min (HIOP EEWB)	1: 744.5	1: 167.9	1: 11.78

Table 2 Pearson's product moment correlation coefficient.

Resolution	Bengbu	Wangjiba	Suiping
2.5-degree (GAME)	0.2516	0.1297	0.4405
1.25-degree (GAME)	0.7287	0.7607	0.4557
10-min (HIOP EEWB)	0.6771	0.9108	0.7267

Table 3 Nash Sutcliffes' coefficient of efficiency.

Resolution	Bengbu	Wangjiba	Suiping
GAME 2.5-degree	-0.7372	-0.4738	0.1801
GAME 1.25-degree	0.4333	0.4654	0.1904
H-IOP EEWB 10-min	-0.0307	0.6346	0.5161

Table 4 Index of Agreement coefficient.

Resolution	Bengbu	Wangjiba	Suiping
GAME 2.5-degree	0.5594	0.4766	0.5452
GAME 1.25-degree	0.8507	0.8022	0.5819
H-IOP EEWB 10-min	0.6916	0.8925	0.8277

While plotting, the graph of IC ratio and the perfomance indexes, it clearly shows that it follows some trend. The fitted curve appears something like S-curve. The S-shape becomes more distinct with logarithmic-scale in the axis corresponding to IC-Ratio values (see figs. 4 & 5). A best fit curve using the PPMCC values with 3rd order polynomial is found to be as shown in equation (1), with R^2 value 0.6933;

$$y = -0.0505x^3 + 0.1496x^2 + 0.1938x + 0.3578 \text{..........(1)}$$

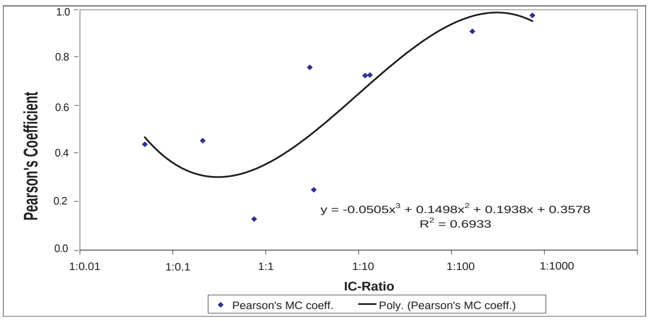

Fig.4 Best-fit curve with PPMCC values.

Similary the best fit curve using the IoA values with 3rd order polynomial is found to be as shown in equation (2), with R^2 value 0.803;

$$y = -0.0227x^3 + 0.0587x^2 + 0.1478x + 0.5934 \text{............(2)}$$

The point of inflection for the equation (1) is at the value of x = 0.9887, which corresponds to IC-Ratio 1:9.745. Similarly the point of inflection for the equation (2) is at the value of x = 0.862, which corresponds to IC-Ratio 1:7.277.

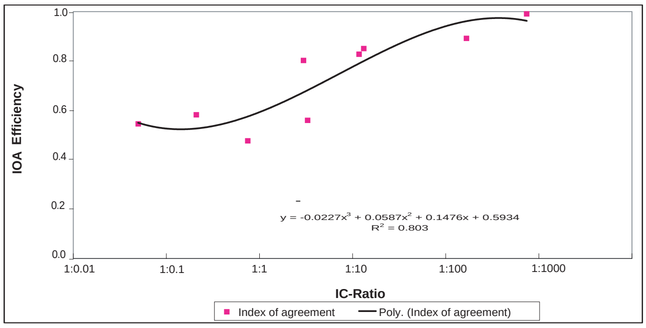

Fig.5 Best-fit curve with IoA values.

In a preliminary study, the marginal value of IC-Ratio is suggested to be 1:10. The present results also reinforce the same figure. Additionally, this study illustrates that model performance improvement rate accelerates with increase in IC-Ratio until the marginal value. The improvement rate gradually decreases beyond that IC-Ratio, however, it does not mean that the improvement rate goes to negative.

CONCLUSION

The obtained results clearly indicate that concept of IC-Ratio may stand as a criterion in modeling with distributed hydrological models. Better simulations are achieved while the IC-Ratio (Input-resolution-Catchment ratio) is more than 1:10. This preliminary criteria may be useful to define the necessity of forcing data resolution on the basis of catchment size in distributed hydrological modeling.

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