Development of a distributed modeling framework considering spatiotemporally varying hydrological processes for sub-daily flood forecasting

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Introduction

The complex and varied climatic conditions, short duration and high intensity of rainfall, and complex subsurface properties of semi-humid and semi-arid watersheds pose challenges for sub-daily flood forecasting. Existing distributed models do not adequately characterize the high spatiotemporal variability in sub-daily hydrological processes. **A distributed modeling framework (GDHF)** was proposed that is extended from a lumped model and accounts for the effects of time-varying rainfall intensity and reservoir regulation on hydrological processes.

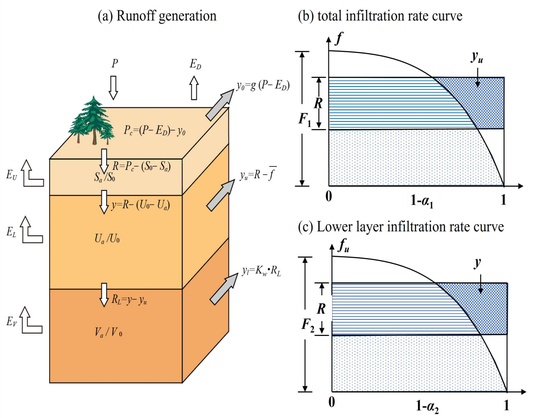
GDHF model

GDHF model was extended from lumped Dahuofang (DHF) model, which is widely employed in northern China, especially for the Song-Liao watershed in the Northeast China.

• Runoff generation module

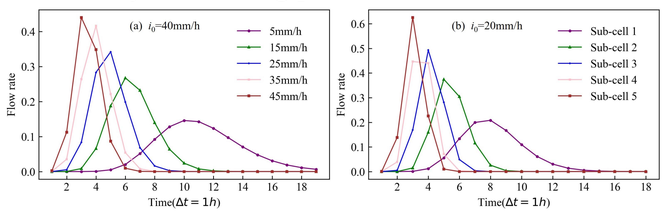
Three layers soil ARNO model

Two–layer infiltration curve



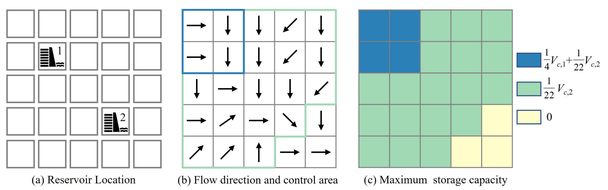
• Routing module

A time-varying unit hydrograph (TVUH) considering rainfall intensity was proposed to address the high nonlinearity of flooding processes.



• Reservoir module

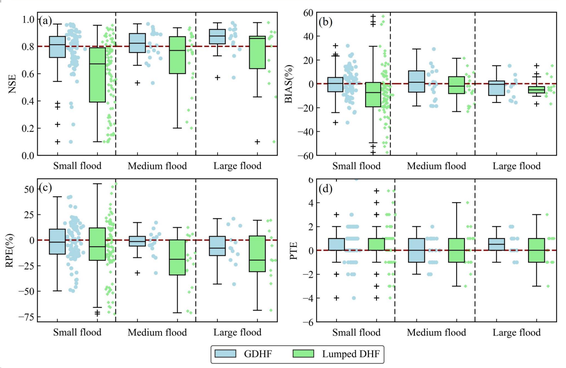
A reservoir module was established that **describes the effect of reservoir regulation on flooding processes**.



Results

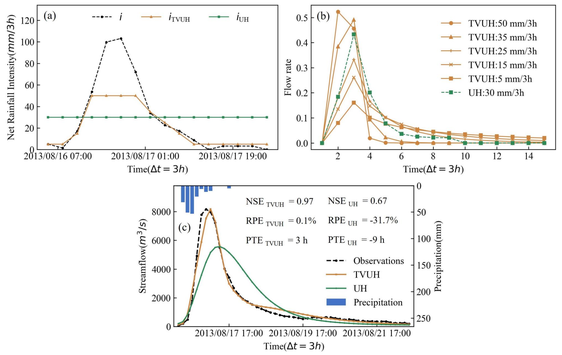
• Simulating flood events

GDHF could simulate sub-daily flood events well, which are superior to lumped DHF.



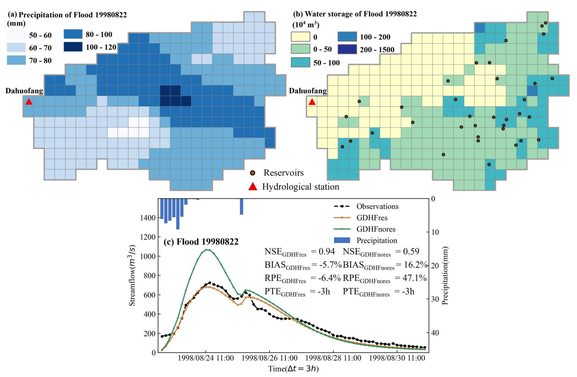
• Routing result analysis

TVUH method considers the rainfall intensity, which is more consistent with the actual routing processes.



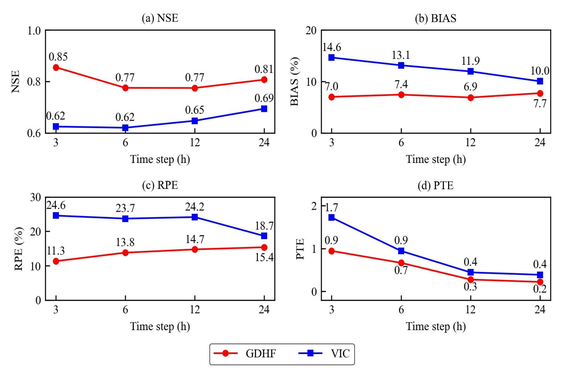
• Reservoir regulation analysis

After considering the effect of the reservoirs, the performance for flood events was significantly enhanced.



• Comparison between GDHF and VIC

GDHF performed better than VIC, **especially at the 3-h time step**.



Conclusions

- The GDHF model outperformed the lumped DHF model in simulating sub-daily flood events because the model **adequately accounted for the spatial and temporal distributions of hydrological features**.
- Compared to VIC model, the GDHF model could better capture the flooding processes at shorter time steps, especially at 3 h. Therefore, it could be considered **a practical tool for sub-daily flood forecasting** in semi-humid and semi-arid watersheds.