Assessment of Noah model physics and various runoff parameterizations over a Tibetan River

Introduction

Noah model physics options validated for the source region of the Yellow River (SRYR, Fig. 1) are applied to investigate their ability in reproducing runoff at the catchment scale. Three sets of augmentations are implemented affecting descriptions of (i) turbulent and soil heat transport, (ii) soil water flow, and (iii) frozen ground processes. Further, runoff parameterizations currently adopted by the (i) Noah-MP model, (ii) Community Land Model (CLM), and (iii) CLM with variable infiltration capacity hydrology (CLM-VIC) are investigated.

Eight numerical experiments are conducted with the same set of atmospheric forcing, vegetation, and soil parameters. Each experiment is initialized using a single-year recurrent spin-up to achieve the equilibrium model states, and a single continuous 8.5 year simulation is then carried out from 1 July 2002 to 31 December 2010.

In situ heat flux, soil temperature (T_s), and soil liquid water (θ_{liq}) profile measurements collected from the Maqu and Maduo stations (Fig. 1) are available for point-scale assessment between November 2009 and December 2010, whereas monthly streamflow collected from the Tangnag station (Fig. 1) is utilized for the catchment-scale evaluation for the period of 2002–2009

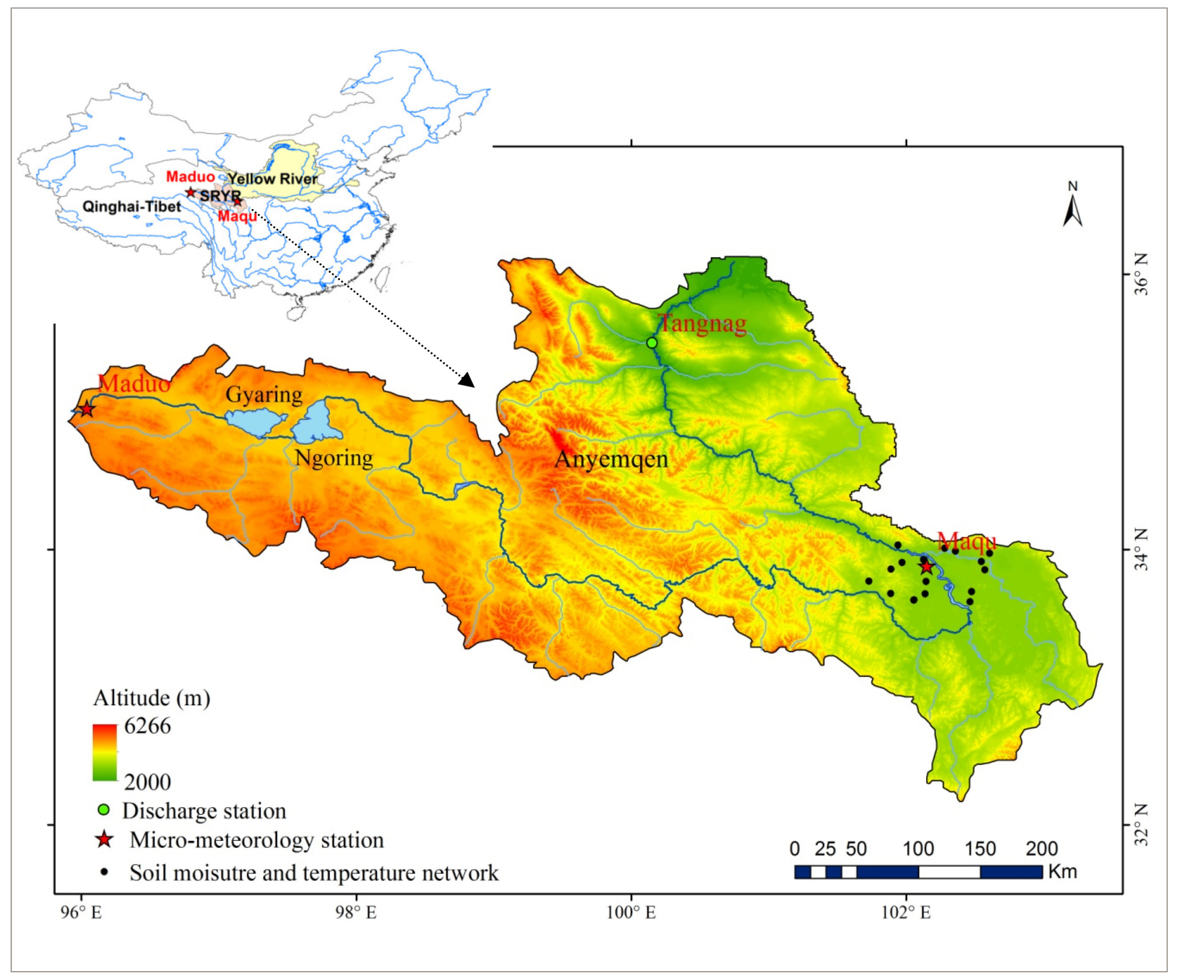

Figure 1. Location of the SRYR as well as the Maqu and Maduo stations.

Noah Model Physics and Experimental Design

The Noah model physics and the design of numerical experiments are summarized in Table 1.

Table 1. Numerical experiments and corresponding model physics and augmentations

EXP	Model Physics	Reference
Noah	Default Noah model physics	Zheng et al. 2014
Noah-H	Inclusion of a diurnally varying roughness length for heat transfer (z_{0h}) and revision of vegetation effect on heat transport	Zheng et al. 2015b
Noah-W	Inclusion of an asymptotic function for root water uptake and vertical heterogeneous hydraulic properties caused by soil organic content	Zheng et al. 2015a
Noah-F	Implementation of a new frozen ground parameterization allowing a larger liquid water movement	Zheng et al. 2016
Noah-A	All the augmentations described above	
Noah-MP	Inclusion of Noah-MP runoff scheme in the Noah-A structure	
CLM	Inclusion of CLM runoff scheme in the Noah-A structure	Zheng et al. 2017
CLM-VIC	Inclusion of CLM-VIC runoff scheme in the Noah-A structure	

Assessment of Noah Model Physics and Augmentations

1. Noah-H resolves issues with the heat flux and T_s simulations, Noah-W mitigates deficiencies in θ_{liq} simulation, and Noah-A yields improvements for both simulations (Table 2)
2. At catchment scale, the best model performance is found for Noah-A leading to a base flow-dominated runoff regime (Figs. 2 and 3)

Assessment of Various Runoff Parameterizations

1. Each runoff parameterization produces significant differences in the separation of total runoff (R) into surface and subsurface components (Fig. 3)
2. The soil water storage-based parameterizations (Noah and CLM-VIC) outperform the groundwater table-based parameterizations (Noah-MP and CLM, Fig. 2)
3. The simulations of other surface water and energy budget components (e.g. Table 2) are insensitive to the selected runoff parameterizations

Table 2. RMSE computed between the Maqu measurements and the simulated latent heat flux (LE), T_s and θ_{liq} for depths of 5 and 25 cm

RMSE	LE (W m^{-2})	T_{s5} (°C)	T_{s25} (°C)	θ_{liq5} (m^3 m^{-3})	θ_{liq25} (m^3 m^{-3})
Noah	11.66	2.05	2.56	0.090	0.084
Noah-H	**8.82**	**1.93**	**1.63**	0.074	0.072
Noah-W	12.52	2.10	2.91	**0.055**	**0.039**
Noah-F	11.76	2.06	2.69	0.083	0.099
Noah-A	**9.97**	**1.83**	**1.44**	**0.036**	**0.038**
Noah-MP	9.95	1.83	1.43	0.036	0.038
CLM	10.19	1.88	1.46	0.041	0.046
CLM-VIC	9.99	1.85	1.44	0.037	0.040

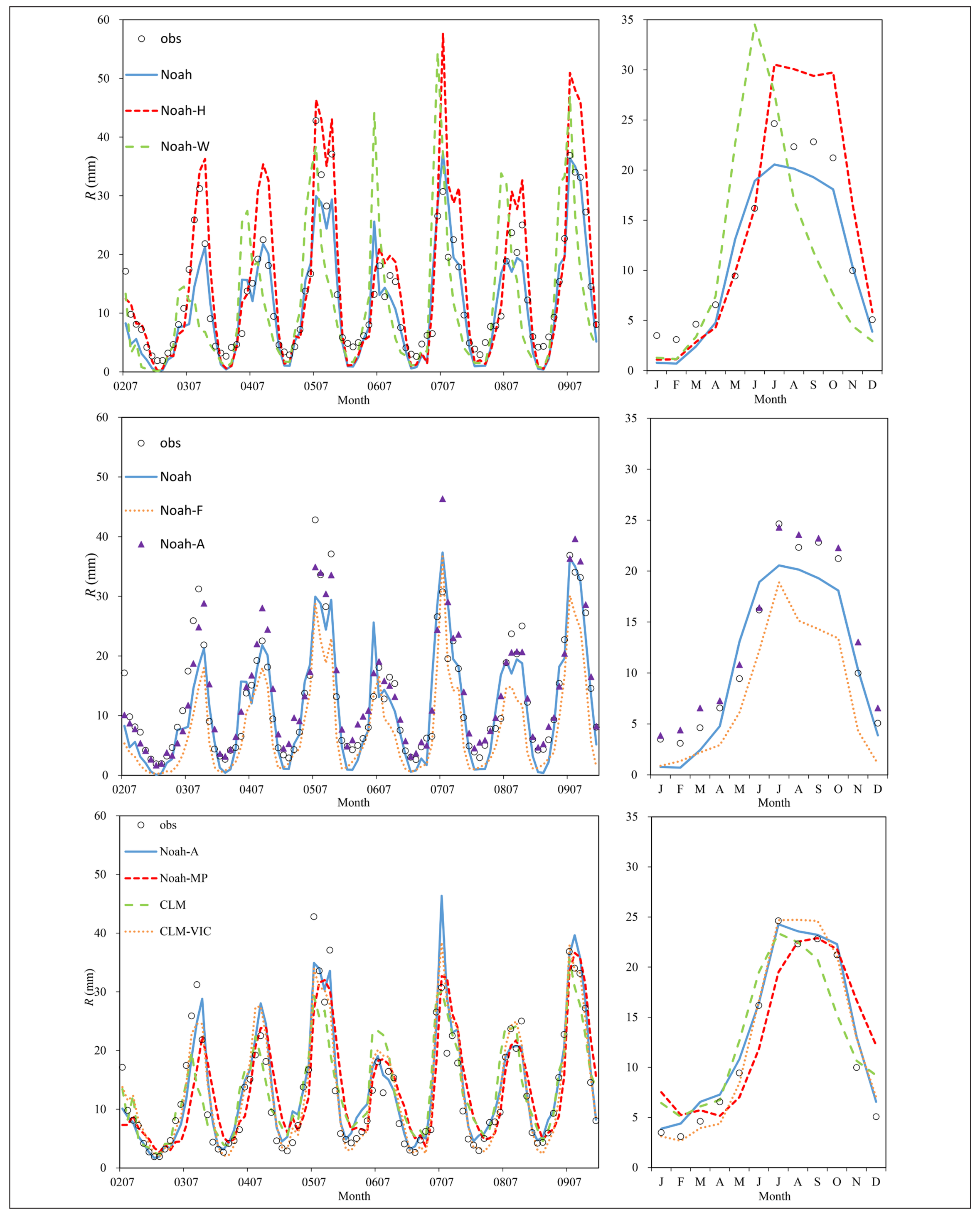

Figure 2. Comparisons of measured and simulated (left) monthly accumulated and (right) multiyear monthly averaged total runoff.

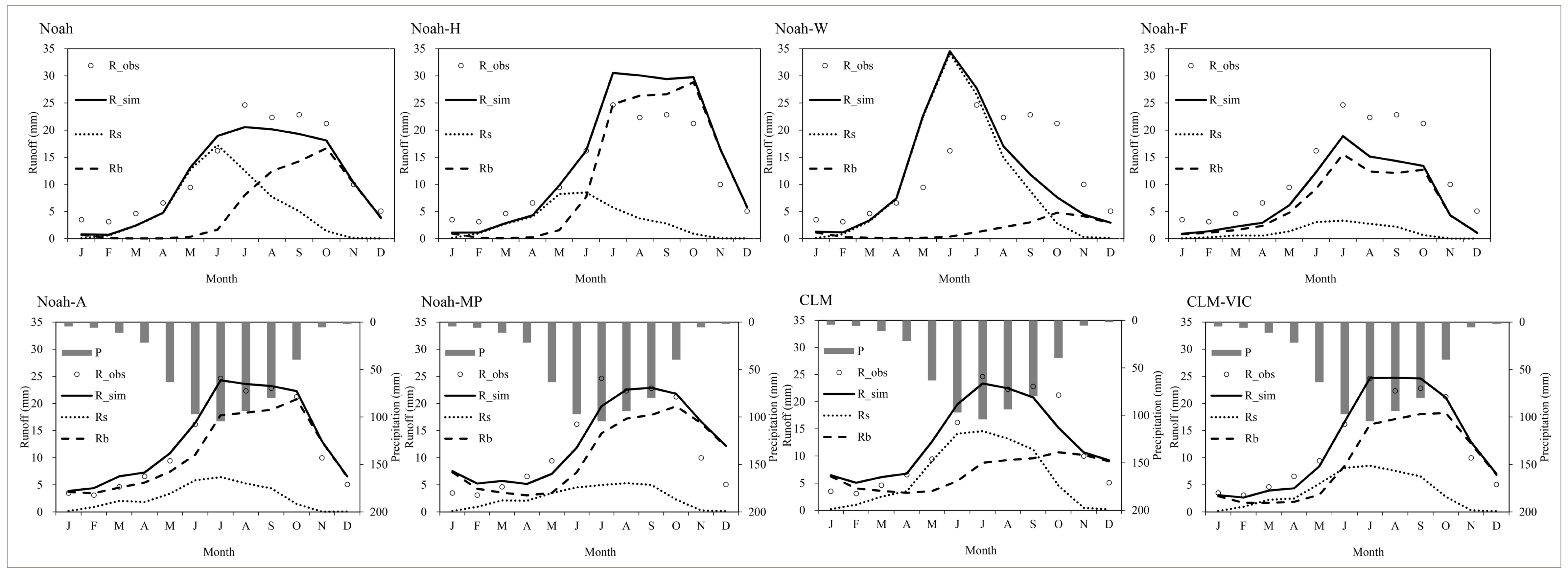

Figure 3. Monthly averaged precipitation (P), measured runoff (R_obs), simulated total runoff (R_sim), surface runoff (R_s), and baseflow (R_b).

Reference

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For more information

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