Hydrological analysis of the current and future runoff of snowy mountainous basins in Japan

Kazumasa Fujimura[1], Yoshihiko Iseri[2], Shinjiro Kanae[3] & Masahiro Murakami[4]

[1] Meisei Univ., Hino City, Tokyo, Japan, [2] UC Davis, [3] Tokyo Institute of Technology, and [4] Kochi University of Technology

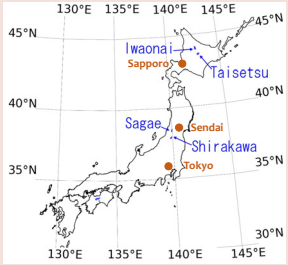
Introduction

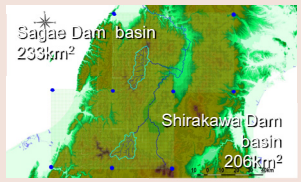
Because mountains occupy about 70% of the land of Japan, which basins are the strategic area of both water resources and flood control. In order to develop reliable hydrological model, this study investigate the property of the parameters in the storage–discharge relationship for low flows and floods. In addition, the hydrological analysis is carried out to estimate the runoff variation in the future using GCM data.

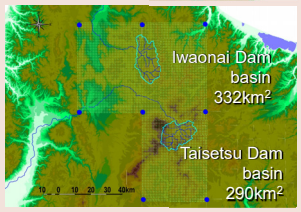
Study basins and data

Hydrological data:
Japan Water Agency and the Ministry of Land, Infrastructure and Transport.
- Hourly data
- Rainfall and dam inflow

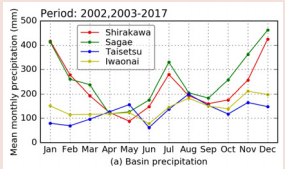
GCM data:
ISIMIP, MIROC5, RCP8.5
- 0.5 degrees
- Present 1986-2005
- Future 2080-2099

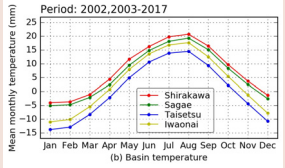


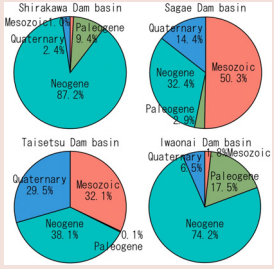




Climate and geology

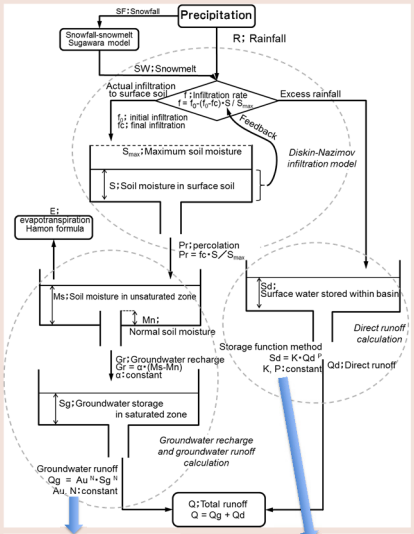






Hydrological Model

- The structure is conceptual and simple.
- The performance is approximately well.
- Website opened data are useful.



Low flow

$$Q_g = A_u^N S_g^N$$

Au, N: constant

Flood runoff

$$S = k Q^p$$

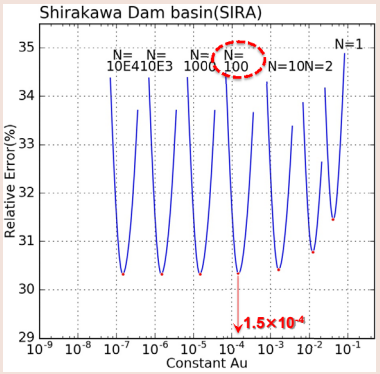
p,k: constant

The storage-discharge relation for low flow and flood runoff have been widely used as the basic equation in runoff models. However, the two parameters are different in each basin and each flood event. Their features are still not fully understood. This uncertainty of the parameters makes it difficult to accurately estimate and forecast flood runoff discharge.

Parameter optimization

We present a representative of the basin optimum parameters by performing calibrations, which are carried out while changing the values of two parameters.

Optimizing parameter for lowflow

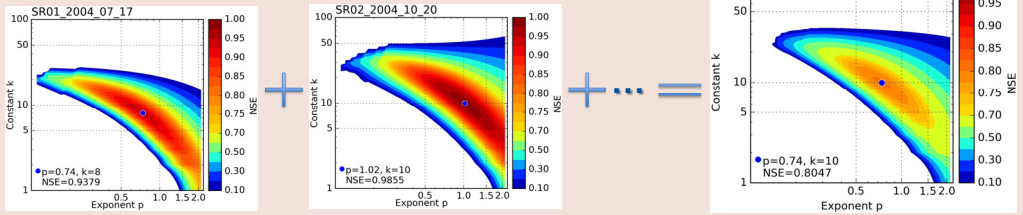


N	Optimizing for parameter Au			Error (%)
	Range	Step	Opt.	
1	2.6E-02～8.4E-02	2E-03	4.2E-02	31.5
2	7E-03～21.5E-03	5E-04	12.5E-03	30.8
10	8E-04～37E-04	1E-04	1.6E-03	30.4
100	7E-05～36E-05	1E-05	1.5E-04	30.3
1,000	7E-06～36E-06	1E-06	1.5E-05	30.326
1E04	7E-07～36E-07	1E-07	1.5E-06	30.3255
1E05	7E-08～36E-08	1E-08	1.5E-07	30.3254

Optimum parameter for lowflow (N=100)

Basin	Period	Au	ADRE(%)
Shirakawa	2003-2017	1.5×10^{-4}	30.3
Sagae	2002-2017	7.2×10^{-5}	26.0
Taisetsu	2002-2017	5.3×10^{-5}	21.3
Iwaonai	2002-2017	2.3×10^{-4}	30.9

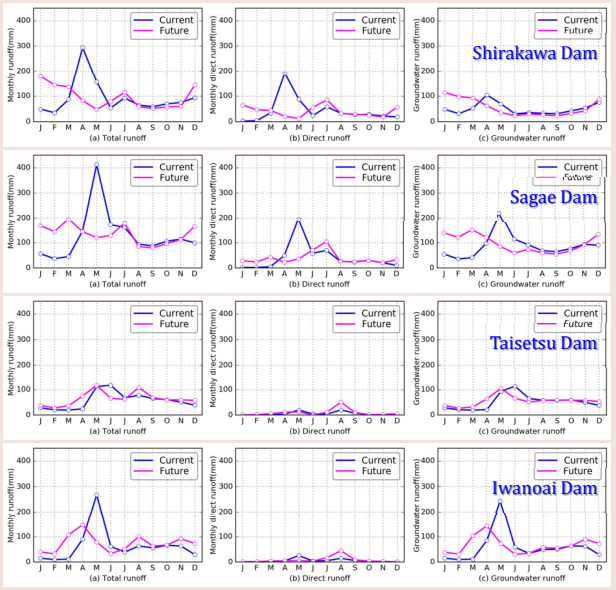
The visualized Nash-Sutcliffe values (NSE) are superimposed to one NSE graph.



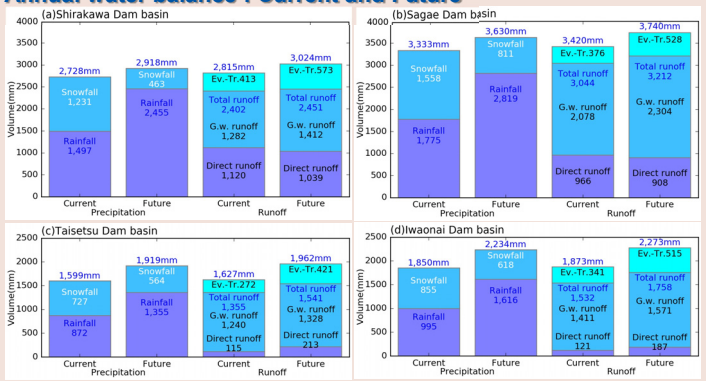
Basin parameter for flood runoff

Basin	Floods	p	k	Nash
Shirakawa	13	0.74	10	0.8047
Sagae	17	0.80	7	0.8949
Taisetsu	10	0.77	10	0.8323
Iwaonai	9	1.17	17	0.8592

Predicting future runoff



Annual water balance : Current and Future



Summary

- Two runoff parameters of the storage discharge equation could be identified as the basin value.
- Runoff variation in current and future for two snowy basin have quite different in summer and winter, however another two snowy basin is not so different.
- When the hydrographs summarize to the annual water balance, ratio of rainfall and snowfall is different, however ratio of direct runoff and groundwater runoff is not so different, for the study basins.