YOSHIMURA LAB.

[Climate system and Hydrology]

Department of Human and Social Systems

Isotope hydrometeorology

Engineering/Civil Engineering

Frontier/Natural Environmental Studies

http://hydro.iis/u-tokyo.ac.jp/~kei/lab/

How would Global Hydrological Cycle Change in Changing Climate?

The wonder of the water cycle change caused by the climate change

Water circulation on the earth, which is largely affected by Climate Change, influences human life. Thinking extensively about global hydrology, Yoshimura laboratory aims to clarify its mechanism and its relationship to climate system by various approaches, in order to contribute to our society. We especially focus on ①Improvement of land-surface/hydrological models and coupling with an earth system model, ②Investigation of hydrological cycles and paleoclimate using stable water isotopes and other proxy information and ③Improvement of regional climate projection using Regional Earth System Model (RESM).

①-1 Flood Arrival Time and Planning Rainfall Duration

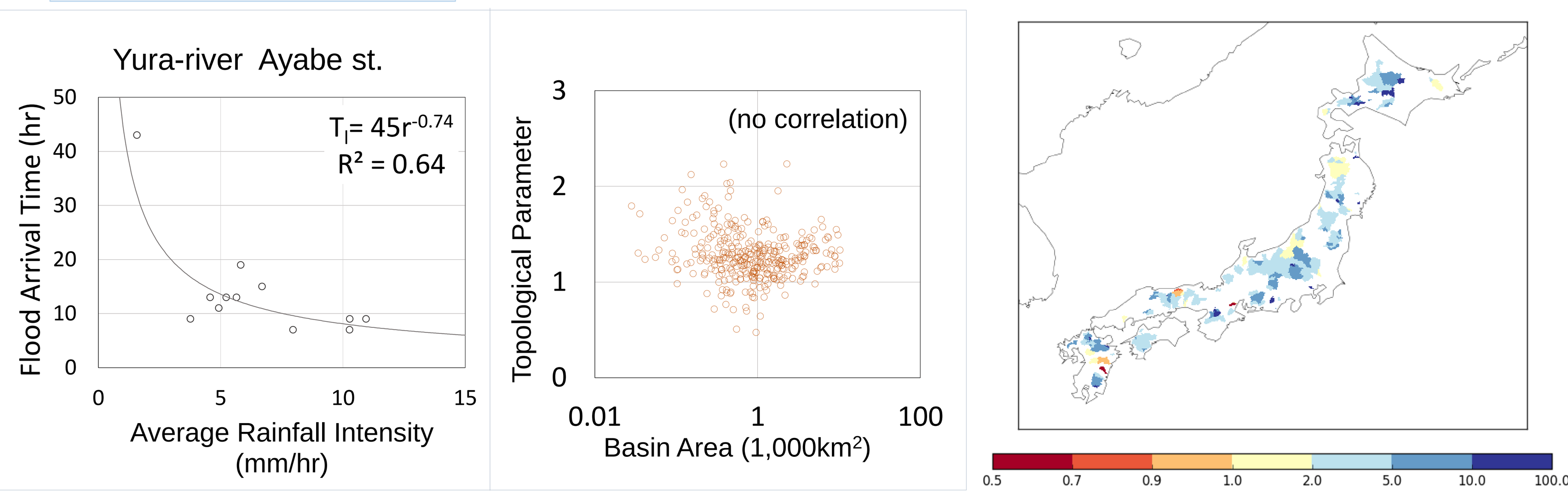
In this research we investigated the flood arrival time of A-rank rivers in whole Japan, and analyzed its relationship with the topological characteristics and planning rainfall duration.

Generally, flood arrival time is thought to rely on upper basin area, but this research revealed that the parameter of formula differs among basins, and the length of main stream is better than the basin area.

Flood Arrival Time
Old (Kakuya's formula):
$T_l = CA^{0.22} r_e^{-0.35}$
Newly Proposed:
$T_l = CL^{0.46} r^{-0.20}$

The planned rainfall duration was 2~10 times as long as the flood arrival time in around 80% of all observation points of discharge (right below).

We are going to consider the slope, soil moisture and etc., and extend the statistics period to improve the reliability.

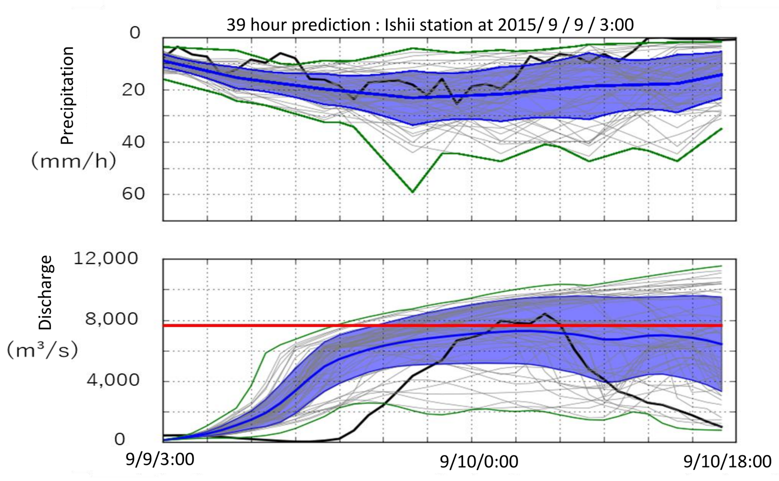


Left : Flood arrival time T_l and rainfall intensity r (example)
Center : Topological parameters of the formula and basin area
Right : Ratio of planning rainfall durations to mean flood arrival time

Planning rainfall duration was too long in most area, especially in the small basin and upper area.

[Precipitation: AMeDAS, Discharge: MLIT]

①-2 Ensemble Flood Prediction System with Weather Forecast Data



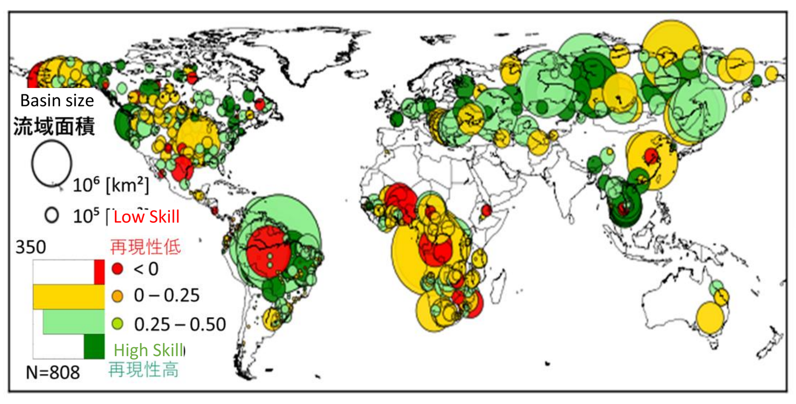
(above) 39-hour prediction of Kinu river flood, 2015 caused by Kanto-Tohoku heavy rain. Black means observation, grey means ensemble members and blue is its average. The red line shows evacuation discharge ruled by Japanese government.

The flood prediction system which calculates land surface physics from numerical weather prediction data was built.

The upper left figure shows that the system predicted flood more than 1 day before the discharge surpass the red line; evacuation discharge.

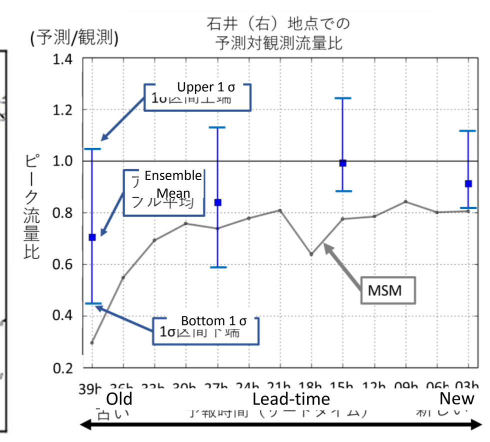
To make the prediction stable, ensemble prediction scheme was adopted. This scheme enables system to predict floods in probabilistically.

Currently we expand the system to all over the world and try to predict floods in the whole world.



(above) Flood represent-skill of the system in 1981-2000. the skill gets better if the color goes to green from red.

Discharge data are from Global Runoff Data Centre

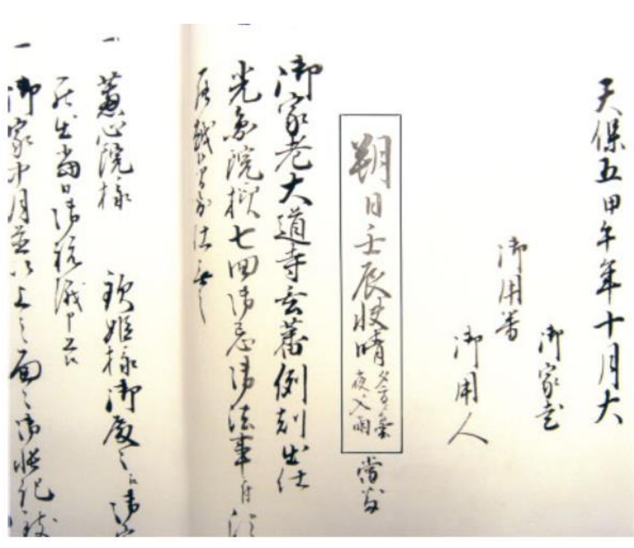


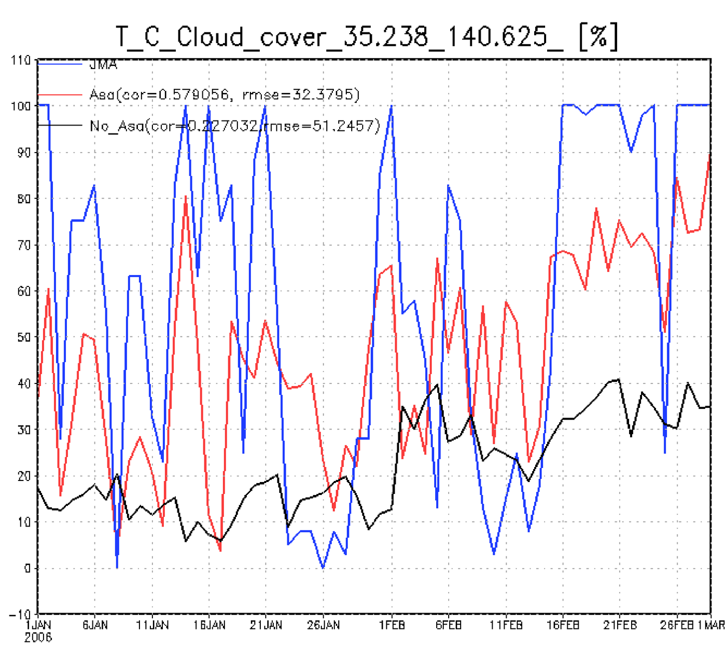
(above) The difference between ensemble forecast and single one.

The bottom left figure shows that flood represent skill in 1981 – 2000. In the Middle to small sized basin area the skill was not high. We are now trying to construct the integrated system which simulates small to large basin and short and long prediction.

② Reconstruction of Historical Weather Patterns by Data Assimilation of Old Diaries

Image of Old weather diary (T. Mikami et.al (2008))



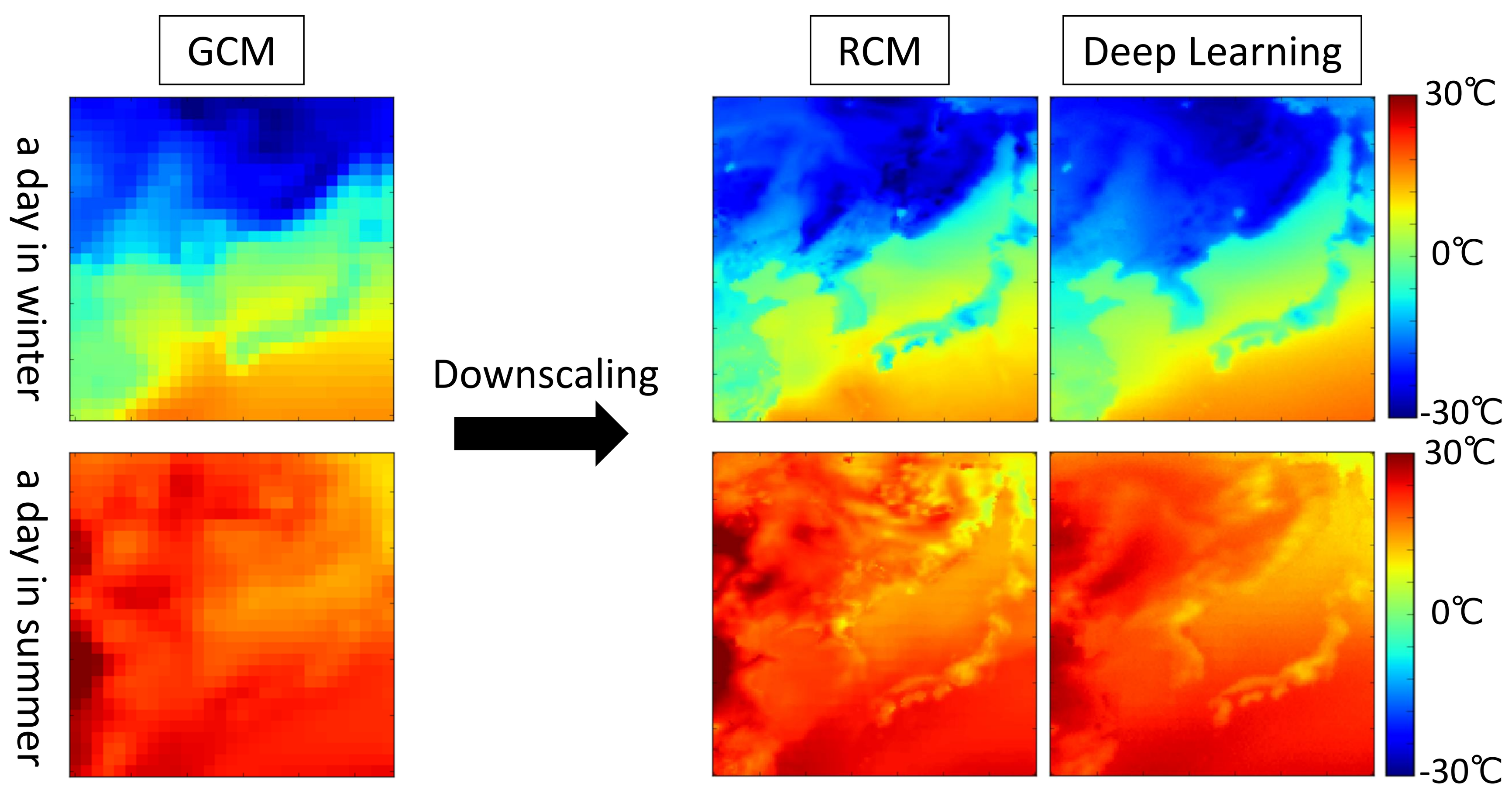


Cloud assimilation; Black: No Assimilation Red: Assimilation Blue: JMA data

Daily weather information has been recorded in personal diaries from several centuries ago and can be used as a proxy for climate reconstruction. In Japan, there are around 20 weather diaries during 18th and 19th centuries. Here we use local ensemble transformed Kalman filter (LETKF) as the data assimilation technique and the National Centers for Environmental Prediction (NCEP) Global Spectral Model (GSM) as the climate model. The idealized experiment using Japan Metrological Agency (JMA) data, revealed that there is indeed potential to analyze synoptic atmospheric conditions by using the very limited weather.

③ Super-Resolution Imaging of Hydrometeorological Field by Deep Learning

For climate studies, General Circulation Models (GCM) are run at only coarse spatial resolution. Therefore, Regional Climate Models (RCM) have been developed to obtain high resolution results from GCM output (=downscaling) for local impact studies. However, RCM is computationally expensive. This study aims to develop a neural network which emulates RCM at very low calculation cost by deep learning.



Prediction of 2m surface temperature by GCM, RCM, and Deep Learning[℃]