シリーズ「発想のたまご」

Improving Understanding of Present Glacier Runoff
and Future Water Availability in Endorheic Basins

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Currently, I work as a postdoc researcher at the Hirabayashi Lab., Shibaura Institute of Technology in the field of Hydrology. I obtained my Ph.D. in the field of environmental remote sensing at Chiba University in March 2017. During my student life (Master & Doctoral Course), I performed research on “mapping and monitoring of glacier (especially: debris-covered glacier) using Satellite Remote Sensing”. Now, I am working on a research project about the investigating potential impact of global warming on historical floods in Asia using large ensemble climate experiments. Here, take advantage of this platform, I want to share the research idea about improving understanding of present glacier runoff and future water availability in endorheic basins.

Endorheic basins are closed hydrological systems where surface waters having no access to discharge into the sea. Endorheic regions can occur in any climate but are most commonly found in desert locations, for example: Western and Central Asia. Glaciers in endorheic regions are important contributors to river runoff in one of the most populated areas of the world. Especially, meltwater from the glacier in endorheic basins is the only freshwater resource available during dry seasons. Millions of people that live in the downstream of endorheic basins depend on glacier melt water for irrigation, hydropower, and sanitation. Water stress impact this vulnerable economically and socially region with drought, therefore glaciers are considered as a drought-resilient source of water. However, much faster warming (2.1 °C) was projected in the Asian mountainous region compared to the increase in global average temperature (1.5 °C). Therefore, this makes endorheic basins more vulnerable to climate change compared to most other places on the planet. Hence, high temporal frequency and long-term monitoring of the glaciers in endorheic basins is crucial to predict their future behaviors and consequently the future water supply. However, accurate monitoring of glacier dynamic and precise simulation of glacier runoff are often

difficult due to various type of debris rock on the glacier surface.

Particularly, debris cover enhances glacier ice melt when the ice is covered with very thin debris (1-2 cm), as a result of increases the absorption of solar heat. In contrast, a thick debris layer plays the role as an insulator: less heat energy can be transferred underneath to the glacier ice surface, which reduces glacier melting. In this way, a glacier's response to climate change can be modulated. On the other hand, regional studies reported the increased area of debris-covered ice. Few physically-based energy balance models based on meteorological variables have been proposed to investigate ice melt from debris-covered glaciers with limited results due to the non-consideration of the spatial distribution of debris thickness for constraining the debris layer. Moreover, field measurements are intense time consuming, can only be conducted on a relatively small area and, require the region easy to access. For this reason, most of glacier runoff studies did not take account for melting from debris effect due to knowledge about the fraction and thickness of debris cover on the glaciers is still sparse.

Fortunately, debris thickness can be estimated using the energy-balance model in conjunction with reanalysis data and thermal satellite images. Present and future runoff can be simulated based on interoperating multi-information [such as debris thickness maps, climate data (air temperature, precipitation, and cloudiness), High Mountain Asia 8-meter Digital Elevation Models (DEMs), and glacier outline] to a fully-distributed physically-based hydrologic model TOPKAPI-ETH. The TOPKAPI-ETH model simulates all the major components of the water balance (storage change, snow/ice/debris-covered ice melt, evapotranspiration, rain, and runoff) and has been applied in high-elevation watersheds in the Andes, the Alps as well as the Karakoram. Finally, a calibration-validation will be conducted to optimize the model parameter that model the best the discharge observation.

Importantly, information of present and future glacier runoff will provide knowledge-based climate mitigation and adaptation suggestion to policymakers. Knowledge's include the optimal location for new hydropower dam construction, management of water resource (water recycling location, conservation in dry seasons), land-use and agriculture management (irrigation planning).