Episodes of extreme events, such as droughts and floods, can have serious societal, agricultural, economic, and ecological impacts. Basin-wide tropical sea surface temperature anomalies are known to play a major role in causing these extreme events. The linkage of these extreme hydrological events to tropical sea surface temperature anomalies allows us to predict them with useful skill at a long lead time in advance ranging from few months to few years. This project aims to explore the idea for the first time to utilize the information of spring land surface temperature/subsurface temperature anomalies over the western high elevation areas in North America and East Asia for the prediction of late spring/summer droughts or floods over the eastern part of the continents. The results from this research would be useful for the sub-seasonal to seasonal prediction community. This project is a direct response to the new initiative “Impact of initialized land temperature and snowpack on sub-seasonal to seasonal prediction” recently developed by the Global Energy and Water Exchanges (GEWEX) Program, which involves more than 30 institutions worldwide. Findings of this NSF project should provide valuable information to the GRWEX community. The PI will disseminate the knowledge gained in this research through the class and shout course training as well as the GEWEX initiative.

Unlike predictions using sea surface temperature, which uses sea surface temperature as a lower boundary condition for atmospheric models, the PI will use the information of spring land surface temperature (LST) and subsurface temperature (SUBT) anomalies as initial conditions in the land component of coupled climate models. The main hypothesis is that LST and SUBT anomalies in early Spring hold the information about the abundance of water locked in frozen ground (i.e., the amount of snow/ice on the ground and in the frozen surface layer below) to be melted in later Spring and early Summer. The more snow/ice on the ground and in the frozen surface layer below is, the longer the seasonal transition from Spring to Summer is. The timing of such seasonal transition over high elevation areas in the west plays an important role in setting up the circulation pattern downstream over the low elevation areas in the east. The strength as well as length of its interactions with the circulation pattern over the low elevation areas controlled by land-ocean temperature contrast would affect the occurrence of droughts or floods in late spring/summer over the eastern part of the continents. The research will run various numerical simulations using global and regional models under different climate and weather conditions (i) to understand the mechanisms for the downstream influences of LST/SUBT anomalies, (ii) to compare their effects with SST anomalies, (iii) to identify and distinguish roles of snow and soil moisture in contributing to soil memory and preserving the LST/SUBT anomalies, and (iv) to explore characteristics of soil layer memory and LST/SUBT anomalies and the causes of the spring LST/SUBT anomalies. The project will also develop a new SUBT initialization methodology for operational models to better utilize SUBT information for sub-seasonal/seasonal forecasts in spring/summer seasons.