THE IMPACT OF ICE-JAM FLOOD OF LENA RIVER

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KEY WORDS: Global warming, Ice-jam flood, Landsat ETM+, Siberia

1. INTRODUCTION

High-latitude regions of the northern hemisphere are the most vulnerable ecosystems to climate change. The mean annual air temperature have risen by 2 - 6°C for the last 100 years due to the increased concentration of greenhouse gases, which is much higher than that of global average of 0.7°C (IPCC 2007). The changes in air temperature affect the hydrologic cycle through three phases of water (i.e. vapour, liquid and solid). The warmer-than-normal air temperature in the spring thaws more river ice and snow at the timing of 0°C air temperature, and results in an increase of river discharge. A rapid increase of river discharge enhances a probability of extreme hydrologic events, such as ice-jam flood and snowmelt flood. The frequency and magnitude of spring floods are actually increasing in the last decades in Siberia, and are predicted to further increase in the future climate change scenario (IPCC 2007).

As extreme floods not only affect human activities but also affect various components of the ecosystem, the effects of flood to climate change seem to be more complex for humanity and nature. An existing flood risk management may not suite under the large and fast changes in climate. Understanding the potential impacts of climate change on floods is needed to construct a sustainable flood risk management in the long term. However, it is hard to assess the impacts in an experimental way. Most of our understanding of environmental influences on floods comes from short-term plot-scale studies. For example, previous studies have shown the importance of hydrograph, ice thickness and strength, snow depth, and cumulative temperature in degree-days to predict the timing of spring floods (Beltaos 1990, 1997; Ma and Fukushima 2003; Prowse and Conly 1998; Shulyakovskii 1972). These experimental field data are valuable but relatively infrequent in space and time due to high cost of data acquisition, and thus experimental results may only be representative of local areas. Hydrologic responses to climate change depend on basin size and location. Even maintaining the same climate conditions at downstream, extreme floods can occur if large amount of river ice and snow thaws at upstream. The development of methodologies for monitoring the entire river basin is expected for evaluating the relationship between flood occurrence and climate change.

Satellite remote sensing is considered as one of the most efficient and economically viable methodology for large scale monitoring. The continuous monitoring for over twenty years provides seasonal to interannual trends of land surface attributes as driven by climate change. The use of remote sensing data for identification of land surface attributes has been demonstrated in a number of studies (Alves et al. 1999; Yang and Lo 2002; Crews-Meyer 2004; Lo and Choi 2004; Dwivedi et al. 2005). Xiao et al. (2005, 2006) have developed a methodology to detect water-related areas in paddy fields using highly sensitive sensors to moisture content in the soil. The location and extend of flooded areas are detected from spatial and temporal changes in surface water during flood periods (Justice et al. 1985; Malingreau 1986; Pettorelli et al. 2005; Sakamoto et al. 2007). However, the change detection based on time series of wide-field-of-view sensors such as SPOT Vegetation and MODIS is problematic, because most of the channel width is often less than 1 km. The assumption of a single land cover type for the entire 1 km pixel results in over- or underestimation of the area. Although the availability of high spatial resolution sensors is an aid in identifying extent and location of flooded areas, there are tradeoffs between spatial resolution and image footprint. A total of 29 Landsat-like images (e.g.,with a 30 m spatial resolution and 185 km wide swath), or 4444 high spatial resolution images (e.g. 5 m spatial resolution, 15 km wide swath) is required to cover one million square kilometers. The selection of suitable sensors for monitoring large areas for a long time is a major challenge. In this study, Landsat TM/ETM+ imagery is used to understand spatial and temporal dynamics of flood at Lena river basin.