Investigating impacts of hydrological components on the discharge of Lena watershed using a land surface model (CHANGE)

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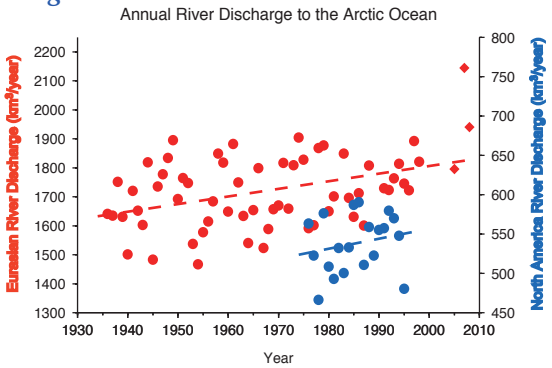
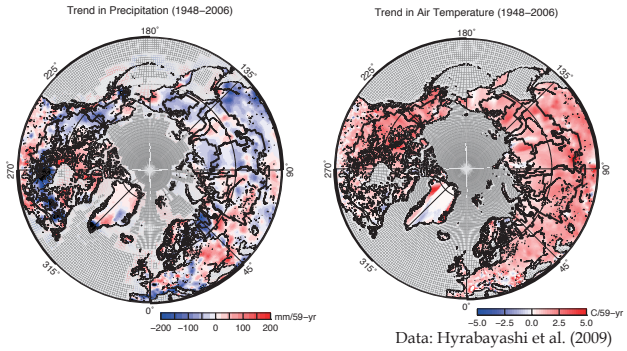
Introduction

Wide-ranging environmental changes have been documented for the Arctic over the last few decades. The documents say that the Arctic is experiencing changes never seen in historic times. The physical, biological, and chemical components of the Arctic system are interrelated through a network of linkage, feedbacks, and multi-dependent interactions, therefore a change of one variable in a part of the system can initiate a cascade of regional effects and have global ramifications. In eastern Siberia, a number of changes in terrestrial processes have documented from field measurements and simulations. The representative phenomena are the increasing river discharge, permafrost reduction, early snowmelt, expanded growth period, wetness, and so on. *To evaluate effects of some factors on river discharge*, a land surface model (CHANGE) was applied to Lena watershed over the past 20-year.

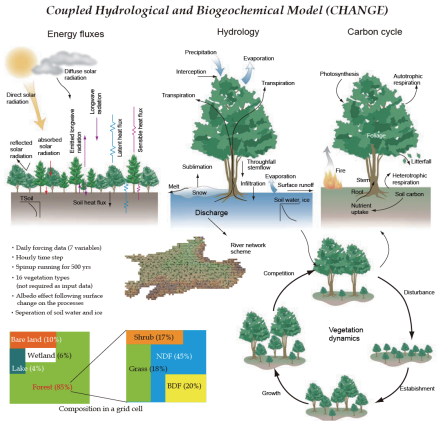
Background



Arctic river discharge showed increasing trend for the past 70-year. During the same period, air temperature was increased at the most Arctic, but the trend in precipitation was greatly different in regions. *We hypothesized that deepen active layer depth is linked to the increase of discharge in Lena.*



Data: Hyrabayashi et al. (2009)



Model characteristics

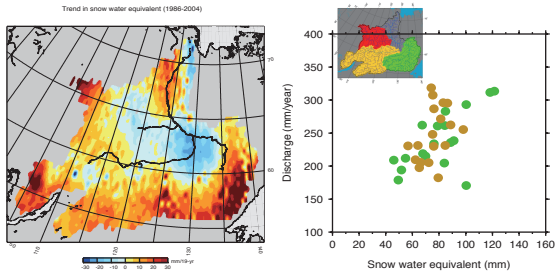
- water, energy, CO2 budget
- liquid, ice amount in soil
- snow processes
- vegetation dynamic model
- effect of soil organic matter
- root water uptake
- distributed discharge model (in coupling)

Daily forcing data

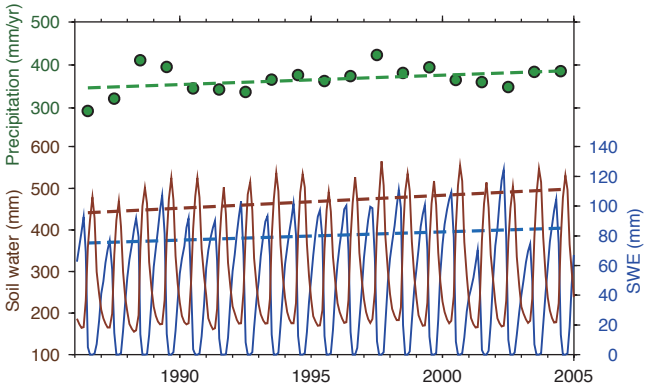
- air temperature (mean, max, min), precipitation, relative humidity, solar radiation, wind speed

- Hourly calculation based on daily forcing data at 0.5° scale.
- Soil depth of 7 m with 11 layers

Snow water equivalent (SWE) in Feburary & discharge

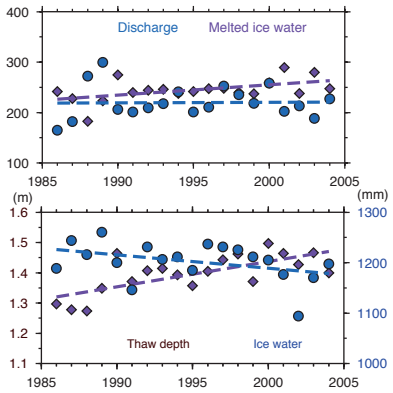


The increase in SWE in Feb. is significant in the southern area. SWE directly contributes to peak discharge, and its part goes to soil water.

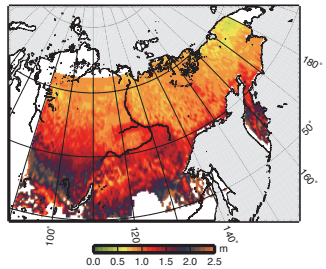


- Both SWE and soil water in Lena watershed indicate increasing trend in similar manner with precipitation. In dry years (i.e., 1986, 1992, 2002), higher SWE worked as a source of soil water.

Thaw depth & discharge (1986-2004)



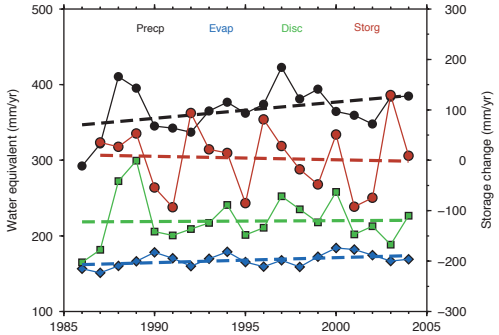
Mean thaw depth



Thaw depth in Lena watershed deepen about 20 cm during the past 20-yr.

Water yielded by ice water thawing also indicates increasing trend, which seems to contribute discharge partly. Thereby, ice water within soil is decreased.

Water budget

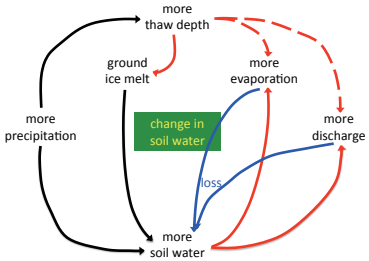


Change over 1986 to 2004 (mm)

Precp	38.6
Evap	11.6
Disch	1.8
Soil wat	25.1

Discharge is measurement at Kusur station.

Working hypothesis



Interannual variation of evapotranspiration is relatively small, compared to discharge. The contribution of increased soil water caused by soil ice thawing to discharge is probably never negligible.

Summary

In Lena watershed, increased precipitation caused higher soil water, subsequently deepen thaw depth, which in turn added to soil water, hence contributed to higher dischagre and evapotranspiration.