Understanding the impacts of agricultural and urban land use on flood prediction and mitigation

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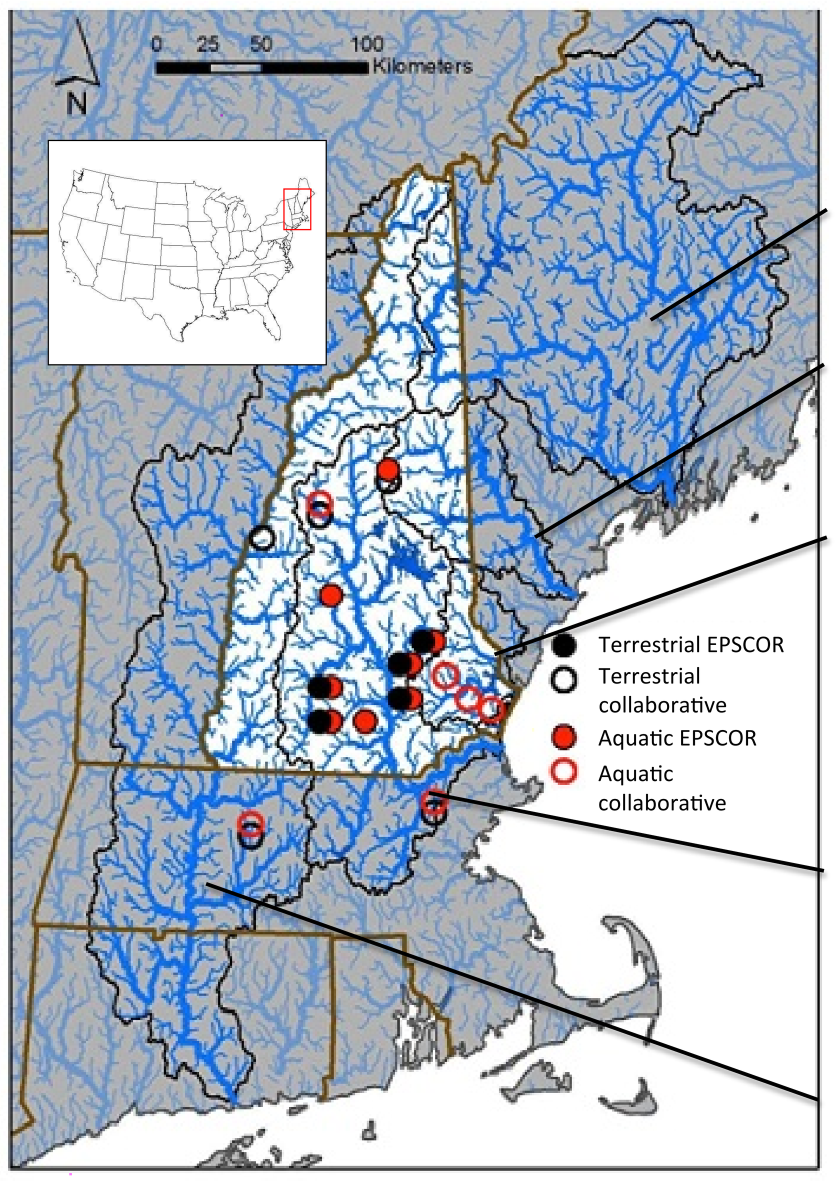
1. Abstract

Field of Study: Geosciences, Environment and Globe JSPS ID SP14024

Flood prediction and mitigation are important aspects of watershed management, especially in New England where a 30-year upward trend in floods has been attributed to a combination of urbanization and climate change. In addition to urban development, New England is currently experiencing an increase in agricultural land development. While flood risk increases from conversion of forests to urban land has been well studied, conversion from forest to agriculture requires further research. This project will investigate the impact that land use change from forest to agriculture has on flood risks in New England, and will separate impacts due to land use change alone, and impacts of combined land use and climate change. This study will couple two existing models; the first is a water balance model that represents the land surface and water management through dams, irrigation, and interbasin water transfers. The second is a flood model developed by Dr. Taikan Oki's lab that predicts flood events, flood water volume, and inundation levels. Each of these models alone could not address the research goals outlined here; coupling the models is therefore a unique solution to understanding and predicting the connections between land use change and flood risks.

2. Study area and context



River Basins

- Androscoggin
- Saco
- Piscataqua
- Merrimack
- Connecticut

These basins are the study domain of the NSF-funded EPSCOR grant: *Ecosystems and Society*. They have been equipped with sensors, and have excellent historical data on flooding and land use.

Key Point

These river basins have all experienced increased **flood frequency** and **intensity** over the past 30 years[1].

Key Questions

I. What is **causing** the increase in flooding?

a) Climate change: storms, precipitation

b) Land use change: development, deforestation

II. How will **future** development impact floods?

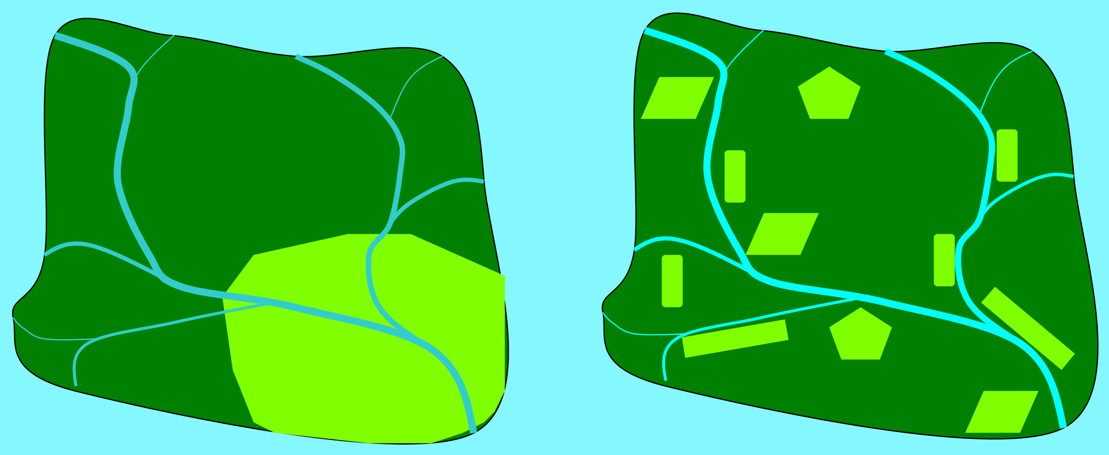
3. Theory

Seasonal Water Uptake

	Urban	Forest	Agriculture
Spring	LOW	MEDIUM - HIGH	HIGH
Winter	LOW	MEDIUM - LOW	LOW

- Urban areas increase flood risk due to impervious surfaces preventing water from seeping into the ground.
- Forests reduce flood risk by allowing water to infiltrate the ground, taking up water through tree roots, intercepting water before it reaches the ground, and stabilizing soils[2].
- Agricultural land has not been as well studied. Infiltration, water uptake, and interception occur, but the seasonal cycle is more drastic than on forested land[2].
- Concentrated development in the lower watershed, concentrated development in the upper watershed, and dispersed development can all have different flood impacts[3].

Spatial Patterns of Watershed Development



Concentrated development | Dispersed development

Key Questions

How does agriculture change the **seasonal pattern** of floods?

How does the **spatial pattern** of development on the landscape impact floods?

4. Application

Researchers on the NSF-EPSCOR grant *Ecosystems and Society* are developing multiple scenarios of future New England urban and agricultural development. The research proposed here can answer the questions:

- How will flood risk in New England change in each of the future development scenarios?
- Can New England increase its agricultural land significantly without increasing flood risk? If not, what is the minimal flood risk increase possible for different levels of agricultural development?

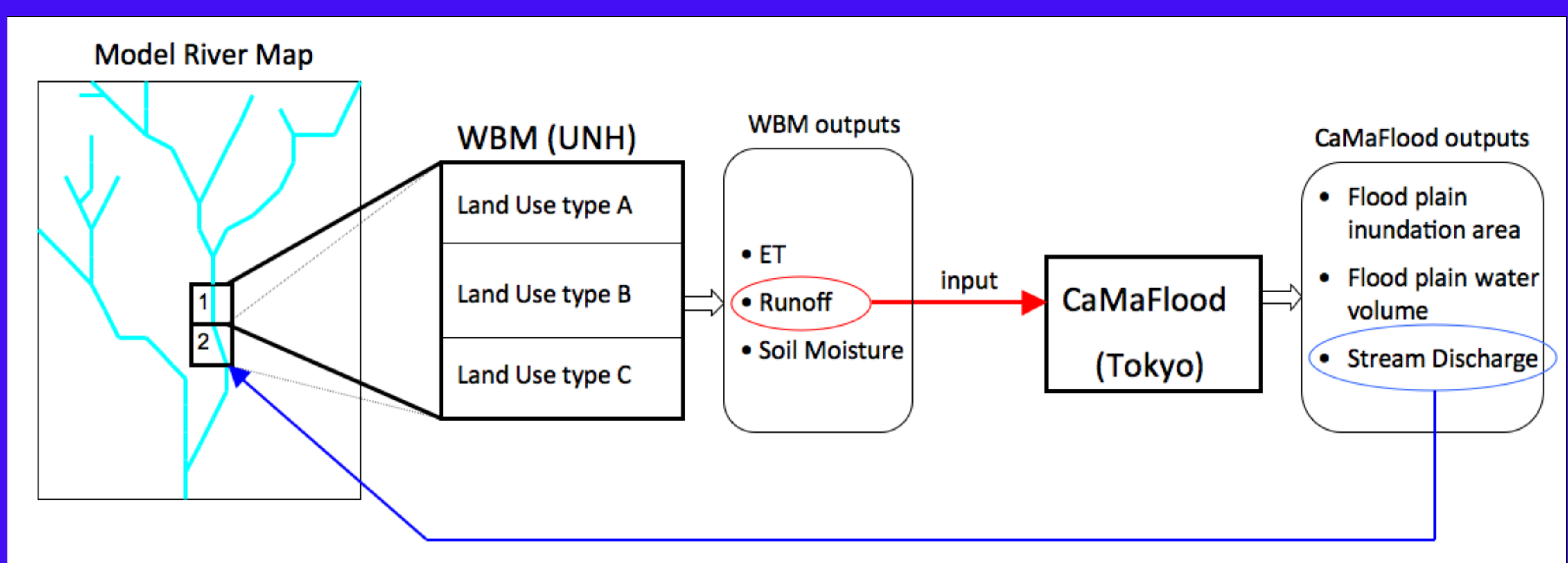
5. Methods: collaboration between UNH and The University of Tokyo

Methods Overview

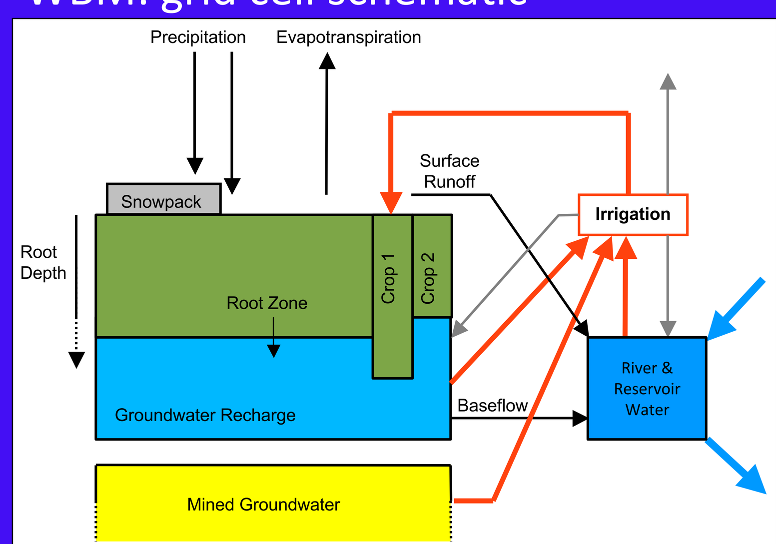
Link 2 models: UNH's Water Balance Model (WBM) and the University of Tokyo's Catchment-based Macroscale Flood Model (CaMaFlood).

WBM: Models runoff based on different land use types

CaMaFlood: Models extent and volume of flood inundation[4,5]



WBM: grid cell schematic



CaMaFlood: sub grid cell representation of flood plains

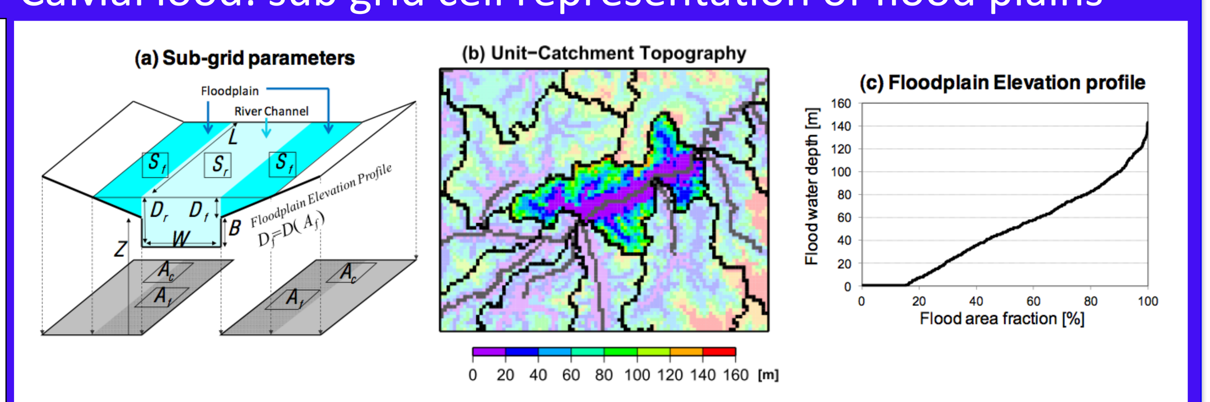


Figure from: The global river model CaMa-Flood (version 3.3.0), 2013, Yamazaki.

Works Cited:

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[3]Kim HW, Amatya DM, Chescheir GM, et al. (2013) Hydrologic effects of size and location of fields converted from drained pine forest to agricultural cropland. *J. Hydrol. Eng.*, **18**, 552-566.

[4]Yamazaki D, Oki T, Kanae S (2009) Deriving a global river network map and its sub-grid topographic characteristics for a fine-resolution flow direction map. *Hydrol. Earth Syst. Sci.*, **13**, 2241-2251.

[5]Yamazaki D, Kanae S, Kim H, Oki T (2011) A physically based description of floodplain inundation dynamics in a global river routing model. *Water Res. Res.*, **47,** W04051.