Adapting a Global Flood Model for Regional Simulations: The CaMa-Flood Model as Applied to New England Catchments

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GC11D-0594

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I. Research Questions

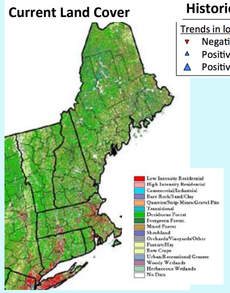
How will different scenarios of land use change in New England impact flood risks?

Will climate change exacerbate or alleviate these changes in flood risk?

II. Background

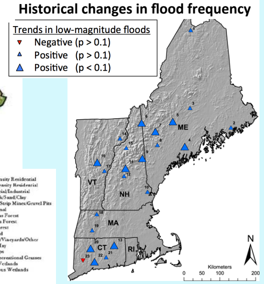
- *High-frequency/low-magnitude floods are defined as floods with a recurrence interval of < 5 years[1].*
- The magnitude of high-frequency floods in New England has increased significantly since 1970[1].
- Increased flood frequency (33% increase in low-magnitude floods) in New England has been attributed to a combination of urbanization and climate change[1,2].
- Both urbanization and precipitation intensification due to climate change are expected to increase over the next 50 to 100 years[3,4].
- Some projections of future New England land use show a significant increase in agricultural lands (3x current area)[5].
- **The impact of land use change from forest to agriculture on flood frequency is not as well understood as the impact of land use change from forest to urban[6].**

Current Land Cover



USDA.org

Historical changes in flood frequency

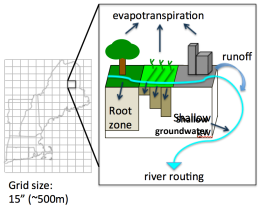


Armstrong et al. 2012 JAWRA Journal of the American Water Resources Association

III. Methods and Tools

Goal: **Use a 2-model system to simulate river system flooding in New England**

Model 1: Water Balance Model[7]

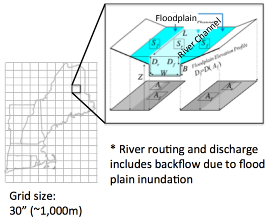


Inputs:
- Precipitation
- Temperature
- Land Use
  - Crop types
  - Forest types
- Soil properties
- River network

Outputs:
- Runoff
- River discharge
- Soil moisture
- Evapotranspiration

Detailed land surface representation

Model 2: Catchment-based Macro-scale Floodplain Model (CaMa-Flood)[8]



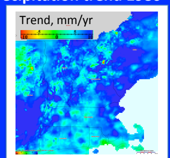
Inputs:
- Runoff
- River channel geometry
- Flood plain elevation profile
- River network

Outputs:
- River discharge
- Flood event
- Flood plain inundation
- Flood water depth

Detailed floodplain representation

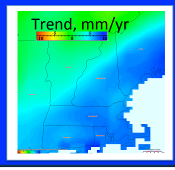
WBM: historical precipitation increases lead to modeled runoff increases by WBM

Precipitation trend 1980 - 2011



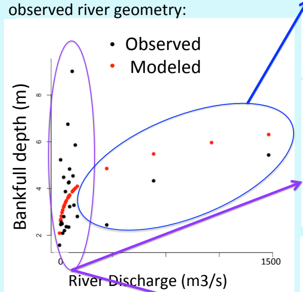
Changes in precipitation from 4 km spatial resolution fields from PRIZM

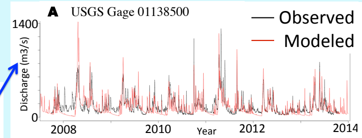
WBM Modeled runoff trend 1980 - 2011

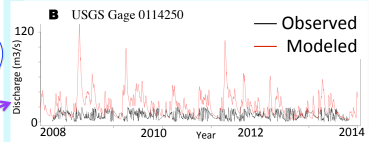


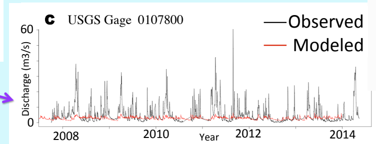
IV. Initial Combined Model Results

CaMa-Flood uses an empirical function to relate river geomorphology to discharge. For low-discharge rivers, this empirical function has a poor fit to observed river geometry:

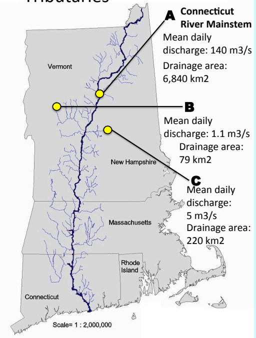








Connecticut River and Tributaries



High discharge rivers (A) are modeled well.

Low-discharge rivers (B,C) are both under- and over-estimated by the empirical river geometry function

To solve this problem, observational data of river geometry (bankfull height and width) need to replace the empirical function for low-discharge river simulations.

V. Future Work

1. **Improve model performance**
   a. **Fully integrate CaMa-Flood functionality into WBM to produce one, consistent model**
   b. **Use measured survey data of bankfull river width an depth to improve model simulations of small streams that have low discharge (e.g., Connecticut river tributaries)**
2. **Separate impact of climate from land use change on historical flood frequency changes**
   a. **Use control simulations in which:**
      i. **Climate remains constant at 1970's levels, but historical land use changes are simulated 1970-2014**
      ii. **Land use remains constant at 1970's levels, but historical climate change is simulated, 1970-2014**
3. **Use New England land use projections from the NSF-EPSCoR (NH, Ecosystems and Society) project to assess future flood risk under different land use change scenarios.**

Works Cited:
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Funding Sources:
This material is based upon work supported by the National Science Foundation under Grant No. IIA-1414500 (NSF-EAPSI joint program with JSPS)
Support for the NH EPSCoR Program is provided by the National Science Foundation's Research Infrastructure Improvement Award # EPS 1101245