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Effects of Urbanization on Water Yield, Ecosystem Productivity, and Micro-Climate: Case studies in the United States and Eastern China

Ge Sun[1*] (ge.sun@usda.gov), Cheng Li[2], Lu Hao[3], Erika Mack[1], Johnny Boggs[1], Steve McNulty[1], Peter Caldwell[1], Georgina M. Sanchez[4], Ross Meentemeyer[4]

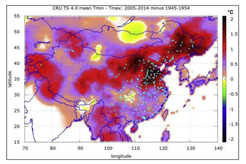
[1]USDA Forest Service, RTP, NC; [2]Guangdong Institute of Eco-Environmental Science and Technology, Guangdong, China , 3. Nanjing University of Information Science & Technology, Nanjing, China; 4. North Carolina State University, Raleigh, NC;

INTRODUCTION

- **World's urban population is projected to rise to 66% by 2050**
- **China's urban population passed 50% in 2011**
- **Global urban land uses increased by over 34% from 1980 to 2000; projected to double by 2030, mostly in developing counties**
- **Urbanization affects global water and energy cycles by removing vegetation covers**
- **Water, energy, and carbon cycles are coupled in watersheds**
- **Feedbacks between vegetation, land cover and climate exist *(Urban Heat Island, Dry Island, Wet Island, Rain Island, Dirty Island; flooding and heat waves)***

Urban Flooding

Urban Heat islands



OBJECTIVES

❖**Empirically examine how urbanization affects watershed hydrology and meteorology**

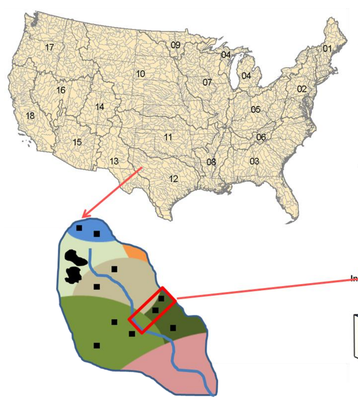
❖**Project effects of urbanization on water and carbon balances at the 12-digit Hydrologic Unit Code (HUC) watershed scale across the continental United States in the next 100 years**

❖**Compare environmental effects of urbanization between eastern China and the U.S. under a humid subtropical climate**

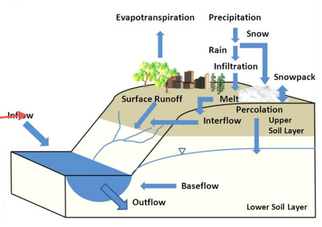
DATA & METHODS

- ❖ Hydrological gaging station flow data
- ❖ Eddyflux data used for model validation on evapotranspiration
- ❖ Water and carbon balance model, Water Supply Stress Model (WaSSI)
- ❖ MODIS-based estimate of leaf area index (LAI), GPP for model validation and application
- ❖ Solar-induced chlorophyll fluorescence (SIF) products for GPP validation
- ❖ SEBAL, SWAT, MIKE SHE energy balance and hydrological models for Qinhuai River Basin
- ❖ EPA Integrated Climate and Land Use Scenarios (ICLUS) data for future land use change projection for 2000, 2010, 2050, 2100

WaSSI Ecohydrology Model

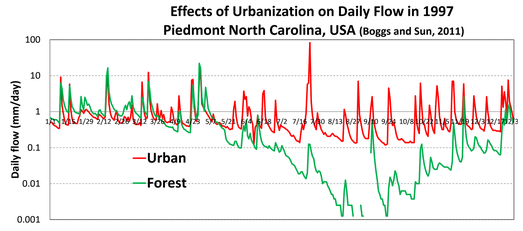


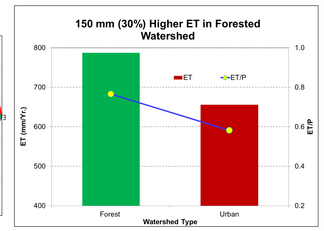
- Water balance and flow routing
- Monthly time-step
- HUC12 resolution
- Accounts for land cover effects on ET and water yield

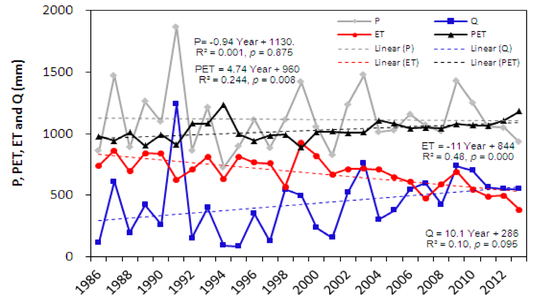


Sun et al. JGR, 2011; Caldwell et al. 2014 SRS-GTR-197

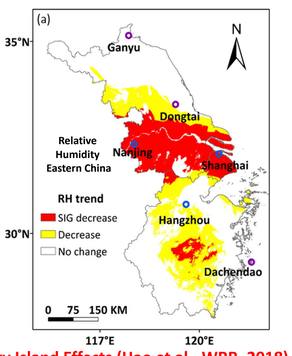
RESULTS





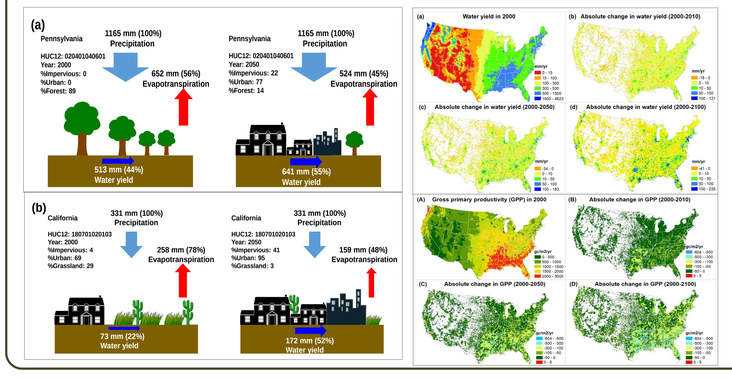


Urbanization increased flow, decreased ET in the rice paddy dominated Qinhuai River Basin, Nanjing, southern China (Hao et al., HESS, 2015)



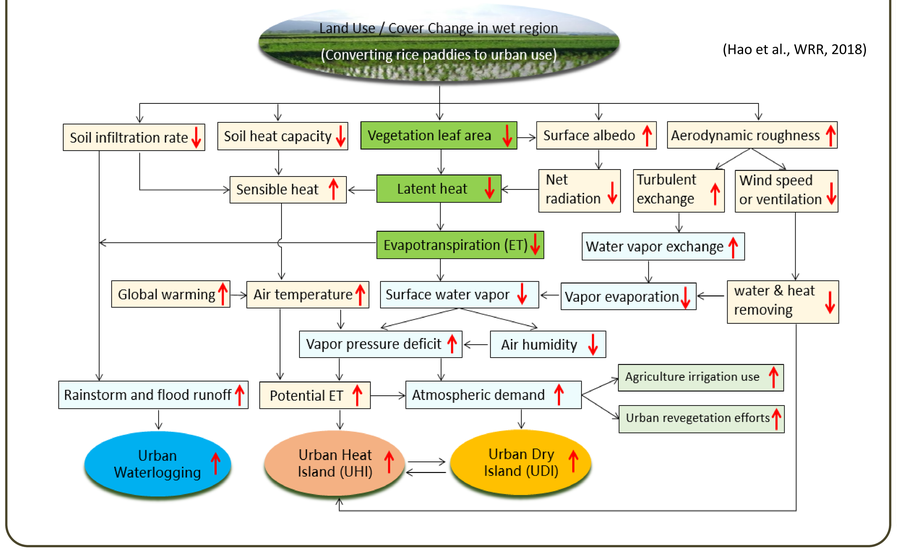
Urban Dry Island Effects (Hao et al., WRR, 2018)

Simulated U.S. Watershed Water and Carbon Balances *(Li et al., WRR ; J hydrology in review)*



Water Yield

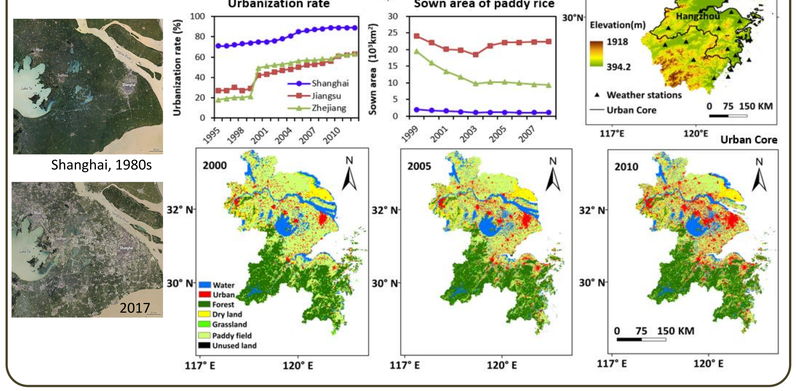
Gross Primary Productivity



(Hao et al., WRR, 2018)

Urbanization in the Yangtze River Delta, China

(Hao et al., WRR, 2018)



KEY FINDINGS

- ✓ **Wetland or forest dominated watersheds show pronounced change in flow (>50%) and "Urban Dry Island" effect.**
- ✓ **Impacts of U.S. urbanization on water yield and GPP were influenced by background climate, previous land cover. characteristics, and the magnitudes of land-use change (e.g., impervious surface) .**
- ✓ **"Impacts of urbanization on water yield and GPP are not created equal".**
- ✓ **The role of vegetation in moderating impacts of urbanization on water and carbon might have been under-estimated (i.e., EPA guidelines on storm water management).**