Urban Water Innovation Network

Transitioning toward sustainable urban water systems

National Science Foundation
WHERE DISCOVERIES BEGIN

Project A2-1

Land-Atmosphere-Hydrosphere Interactions in Urban Terrain

THE MODEL

The model consists of three coupled elements:

- Weather Research and Forecasting (WRF) atmospheric model
- ParFlow subsurface flow model
- Advanced Urban Canopy Model (UCM) for the urban surface (interface between atmosphere and subsurface) (Fig. 2).

These are highly complex models that require extensive computing and skill to execute. Thus they will be shared only within the scientific community.

However, based on these models' outputs, we could consider the development of simplified interactive tools that can help decision makers understand the benefits and consequences of certain actions and mitigation scenarios we have assessed in our work.

PROJECT KEYWORDS

- Urban Microclimate
- Urban Hydrology
- Urban Canopy

The overarching aim of the project is to build the next-generation urban hydro-climatological simulation platform that will combine the state of the science in atmospheric, urban surface, and groundwater models.

Specifically, we will couple the Weather Research and Forecasting (WRF) atmospheric model with the ParFlow subsurface flow model. At the urban interface of these two domains, we will implement and further develop an Urban Canopy Model (UCM) that captures the wide range of radiative, thermodynamic, fluid dynamic, and hydrologic processes operating in urban terrain (Fig. 1).

The new simulation platform will have capabilities that are not available in any current model. Specifically, we aim to use the new model to assess:

- Water demand and cooling impact of canyon trees
- Total urban water demand and how it is modulated by weather
- Influence of surface-groundwater coupling and decoupling on the urban microclimate
- Complex water-climate-energy repercussions of green infrastructure systems (urban irrigation, rainwater tanks, biofiltration systems, green roofs, etc.)
- Thermal comfort in the urban outdoor space

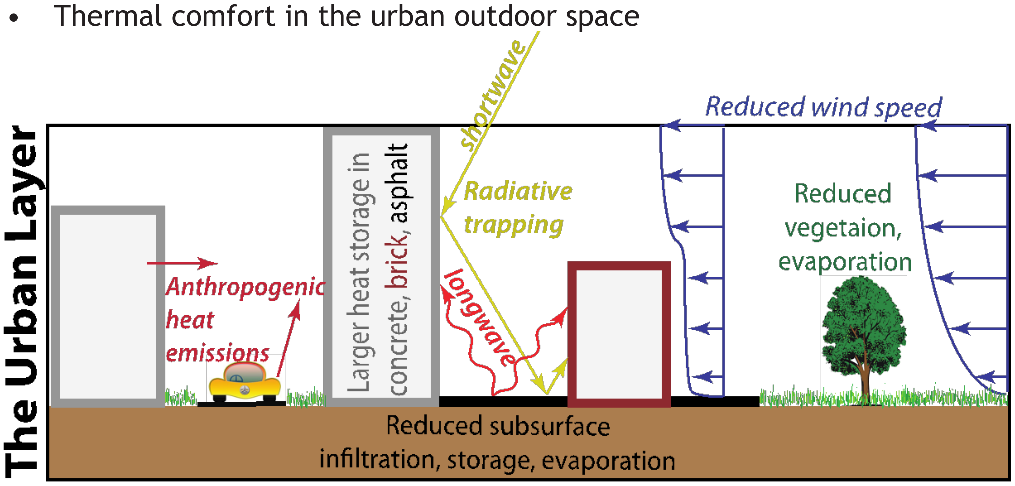

Figure 1. Hydro-climatic processes modified by the urbanization of the land surface

These applications will help us better understand urban sustainability under historic extreme events (e.g., heat waves, floods, droughts) and present conditions. Furthermore, the modeling advances will also be transferred to other teams who are focusing on the impact of future extreme events, and how the cities of the future can reduce their resource use and improve their resilience and sustainability.

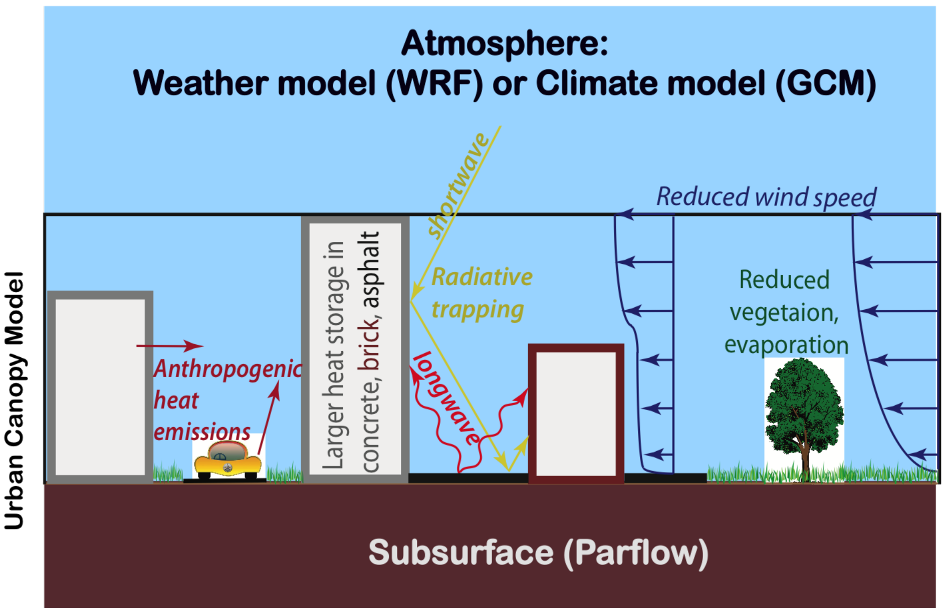

Figure 2: Coupled three models platform

The research team focuses on the urban environment under a changing climate, including land-atmosphere interactions, urban heat islands and the long-term sustainability of cities.

The team's primary objective is to advance the understanding of urban climate in the scientific community, as well as to foster sustainable urban development for future generations.

Dr. Bou-Zeid's current research specifically focuses on combining numerical, experimental, and analytical tools to study the basic dynamics of flow and transport in environmental systems.

Dr. Welty is interested in developing an end-to-end system of field-deployed sensors and fully coupled groundwater-surface water mathematical models to quantify and predict the urban hydrologic cycle and coupled biogeochemical cycles from neighborhood to regional scales.

Groups developing new technologies or interested in the assessment of existing ones can collaborate with this project to develop assessment studies for these technologies.

DATA REQUESTS

The project will require current and past land use data and data for urban water and energy consumption.

DATA USE

The data will be used as input to the simulations, and to develop mitigation scenarios.

OUTPUTS

The project deliverables can be categorized into:

1.) Advanced urban models that can be transferred to other groups and that allow the investigation of processes and mitigation options that have thus far been over-simplified in models such as urban trees and subsurface-surface coupling.

2.) Assessment of various mitigation technologies that can reduce water and energy use in cities.

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