Urban Water Innovation Network

Transitioning toward sustainable urban water systems

National Science Foundation
WHERE DISCOVERIES BEGIN

Project A2-2

Land-atmosphere-hydrosphere interactions: Projecting future environmental change in urban areas

THE MODEL

The Weather Research and Forecasting model from the National Center for Atmospheric Research is freely available and widely used:

http://wrf-model.org/index.php

DATA NEEDS

As a complement to the ICLUS data set, additional high resolution projections of urban land use change over the 21st century would be helpful for the six UWIN regions (centered around the following cities):

- Portland
- Los Angeles
- Phoenix-Tucson
- Denver
- Baltimore
- Miami

Data and projections for the following (approximate) years are especially valuable: 2000, 2050, 2100.

DATA USE

These projections would provide an alternative to the ICLUS data set and would be used to test the sensitivity of our model results to urban expansion projection.

Heat waves are among the deadliest of natural phenomena, and their intensity, duration and frequency are projected to increase substantially over the 21st century due to greenhouse gas (GHG) induced climate change. Moreover, cities tend to be warmer than surrounding rural areas, and urban areas are projected to expand considerably in the coming decades.

This project investigates whether these two drivers of urban heat – climate change and urban development – dynamically interact to lessen or exacerbate projections of warming in cities. It also assesses the efficacy of various adaptation and mitigation strategies (e.g., cool and green roof implementations), and potential tradeoffs in terms of water use for irrigation. Finally, it examines impacts of climate change, urban development, and heat mitigation strategies on precipitation patterns.

These objectives are achieved with decadal-scale regional climate modelling of the continental U.S., as well as high-resolution simulations of heat wave events for all UWIN regions. The Weather Research and Forecasting (WRF) model is applied for multiple scenarios at the beginning, middle and end of the 21st century, dynamically downscaling global climate model output for the latter periods. Urban expansion scenarios are derived from the EPA Integrated Climate and Land-Use Scenarios (ICLUS) data set.

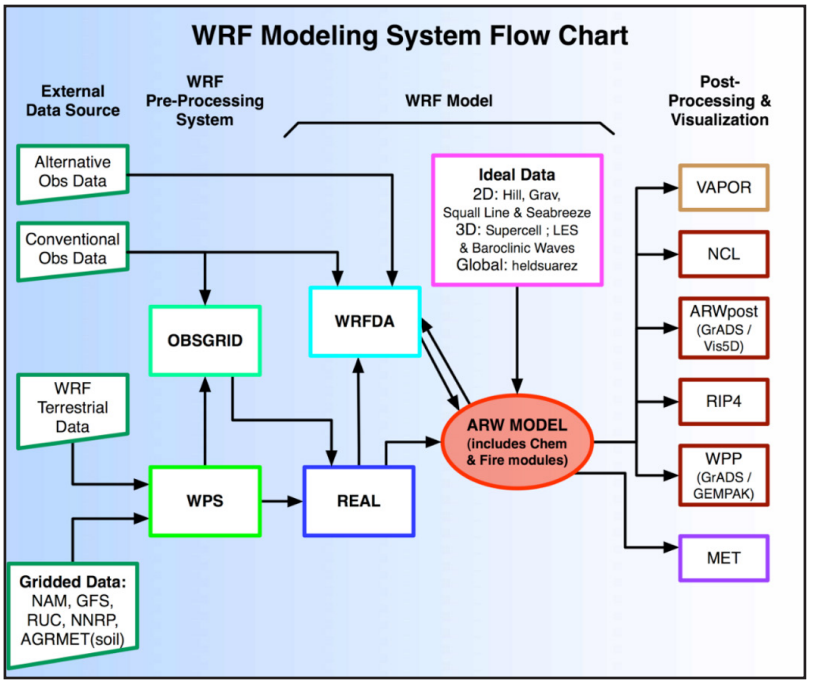

Figure 1: Component programs of the WRF Modeling System (source: WRF user's page)

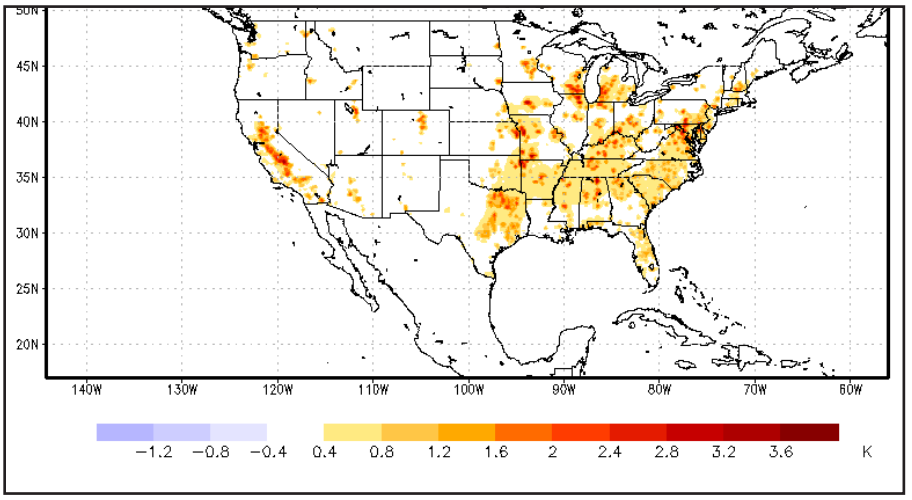

Figure 1: Dynamically-downscaled 2090-2100 mean summertime **change in near-surface air temperature due to projected urban development** between 2000 and 2100 (A2 SRES scenario). Future climate scenario is RCP 8.5; warming due to greenhouse gas induced climate change not shown.

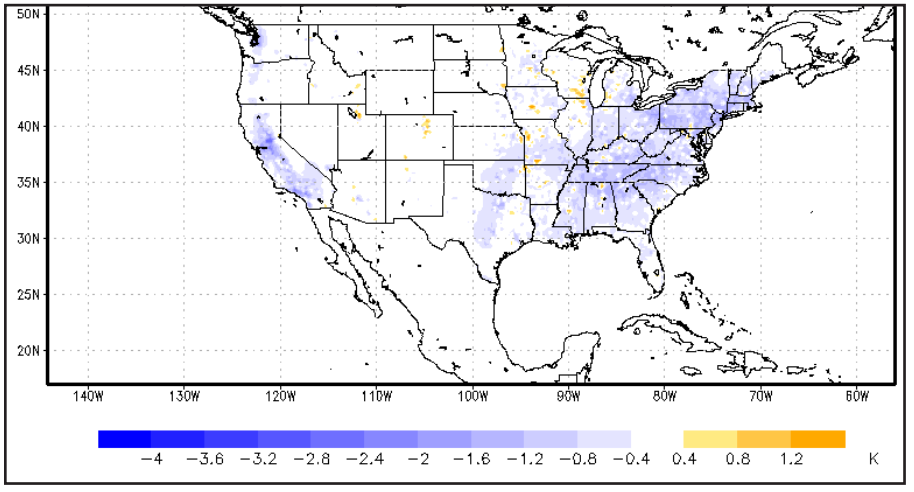

Figure 2: Same as figure one with the addition of **uniform cool roof application on roofs** in 2100.

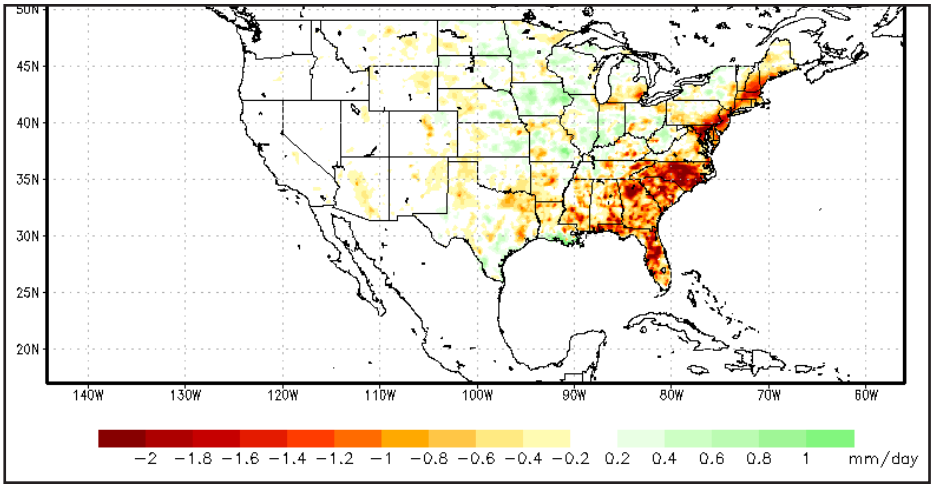

Figure 3: Same as figure 2 but for **change in precipitation** instead of temperature

PROJECT OUTPUTS

The central outputs of the model inform the efficacy of simulated urban adaptation choices. Additionally, the current model application informs the following:

- The degree to which adaptation choices can successfully reduce targeted pressures
- Resilience of adaptation strategies in the context of changing external forces
- Potential co-benefits and unintended consequences that require quantification prior to prioritization of solutions.

A key question relates to **how, or whether, judicious use of water can be successful** in reducing the UHI effect ((e.g., through incorporation of green infrastructure such as green roofs), quantifying this resultant impact on energy demand, with implications for GHG emissions, and importantly, how such targeted solutions may increase population resiliency through, for example, reduced heat related mortality and morbidity.

PROJECT CONTACT

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