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Research Interest:

- Regional Climate Modeling
- Climate Downscaling
- Urban Climate
- Climate Change Assessment

**Urban Heat in the Kansas City Metropolitan Area and Cool Roofs' Mitigation Potential:
An Integrated Regional Modeling and Heat Mapping Campaign Study**

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INTRODUCTION

Individuals that live in metropolitan areas are in a unique position to experience greater temperatures compared to those living in more rural areas due to the urban heat island (UHI) effect. An UHI is a type of local climate that causes the temperature within cities to become significantly warmer than that of the surrounding rural areas due to human activities and infrastructure. One method that has shown promise in mitigating the UHI effect is cool roofs.

The goal of this study is to provide evidence for the effectiveness of widespread deployment of cool roofs in mitigating the UHI effect in the Kansas City metropolitan area during a July 2012 heatwave.

METHODS

- Climate simulations were performed using the Weather Research and Forecasting (WRF) model.
- The three simulations were focused over the Kansas City metro area
 - 1) Control with normal albedo (0.3)
 - 2) Cool Roofs with an albedo of 0.5 and an albedo of 0.8
- The Cool Roof cases represent widespread installation of cool roofs throughout the metro area.
- Simulations consisted of 3 domains with resolutions of 9, 3, and 1 km
- Observation data from five local stations are used for model validation
- NOAA funded Kansas City Urban Heat Mapping Campaign led by UMKC

MODELING RESULTS

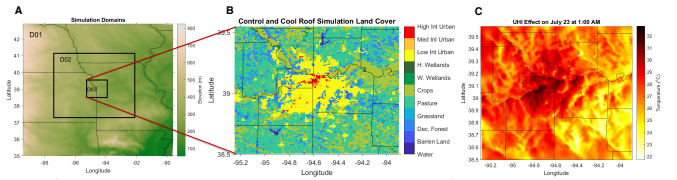


Fig 1. A) Three study domains with elevation of the coarsest domain shown. **B)** 1-km domain shown with land use categories. **C)** Example of the UHI effect in the Kansas City metropolitan area (1-km domain)

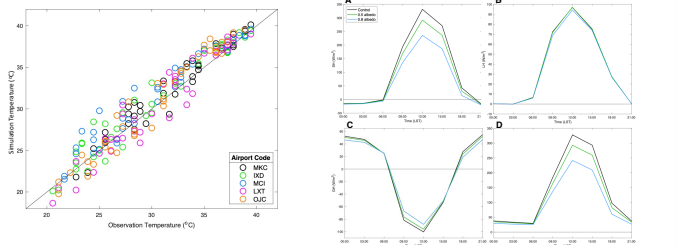


Fig 2. Comparison of observation data from five local airports to the Control simulation. Note: observation temperatures are of integer precision

Fig 3. Diurnal cycles of the A) sensible, B) latent, C) ground storage, and D) net radiation fluxes during the simulations

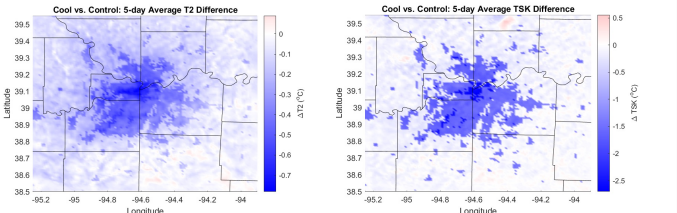


Fig 4. Impact of 0.8-albedo cool roofs on 2-m air temperature in the Kansas City metro area. Low-intensity urban land cover: -0.5°C; med and high urban categories: -0.6°C

Fig 5. Change in ground surface temperature over the entire heat wave with 0.8-albedo cool roofs. Low-intensity urban land cover: -1.6°C; med and high: -2.5°C and -2.6°C, respectively

KC URBAN HEAT MAPPING

The infographic for the Kansas City Urban Heat Mapping Campaign includes the following statistics:

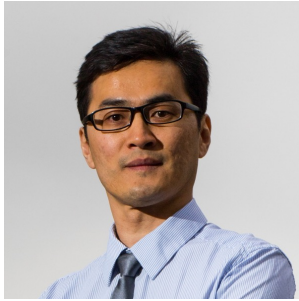
- Study Date: Aug 6th, 2021
- 50 Workshops
- 10 Routes
- 71,820 Measurements
- 93.4% Map Coverage
- 10.0' Resolution

MODELING PAPER & CAMPAIGN REPORT

QR codes linking to the modeling paper and the campaign report.

ACKNOWLEDGEMENTS

- Funding from the NSF Missouri EPSCoR, the NASA-Missouri Space Grant Consortium, and the NOAA Climate Program Office
- KC Heat Mapping Campaign Partner Organizations:
 - The Kansas City Missouri Office of Environmental Quality
 - The Mid-America Regional Council
 - The Missouri Local Science Engagement Network
 - Missouri Office of the Public Counselor
 - Evergy, Inc.
 - Bridging the Gap Inc.
 - Kansas City Teen Summit



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Investigating End-of-Century Climate Changes in Missouri

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Introduction

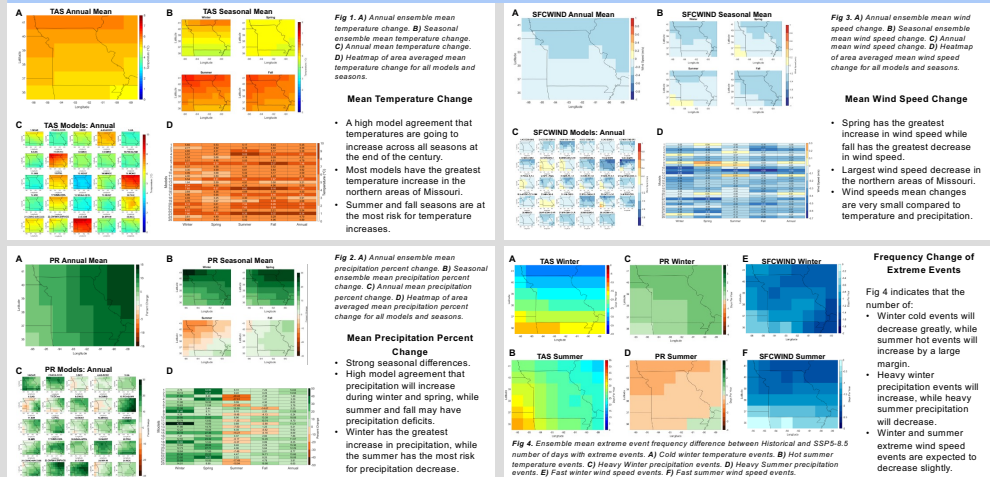
- Climate change is a significant threat to Missouri because it can increase the number of extreme weather and climate events, which will impact agriculture production and infrastructure.
- Many studies have utilized general circulation models to study climate change impacts on a global scale. However, there is a lack of regional-scale analysis.
- Regional-scale analysis is critical because the impact of climate change is not uniform. Different areas may experience very different hazards and intensities from climate change.

Aim and Objectives

This study aimed to examine the potential changes in temperature, precipitation, and wind speed for the Missouri region at the end of the century by utilizing Atmosphere-Ocean General Circulation Models from the Coupled Model Intercomparison Project's sixth phase (CMIP6) under an SSP5-8.5 emissions scenario.

- The study had two objectives to achieve this aim.
- To investigate the annual and seasonal mean changes in surface air temperature, precipitation, and wind speed.
 - To evaluate the frequency of extreme temperature, precipitation, and wind speed events during the winter and summer seasons.

Results and Discussion



Data and Methods

- CMIP6 data collected:
- Baseline Scenario: Historical (1984 to 2014)
 - Future Scenario: SSP5-8.5 (2070 to 2100)
 - Variables: Air Temperature (tas), Precipitation Flux (pr), and Near Surface Wind Speed (sfcWind).
 - Frequency: Monthly and Daily

The data was processed and analyzed by:

- Regrided to 1° to 1° grid cell size.
- Mean change was evaluated by calculating the difference between the mean future and baseline scenario values.
- Extreme tas events were investigated using a 0°C threshold for the winter season and a 35°C threshold for the summer season.
- Extreme pr and sfcWind events were both explored using 95th percentile thresholds for the winter and summer seasons.

Table 2. Models used for wind speed analysis.

| Number | Institution | Model | Grid cell size | Months | Units |
|--------|-------------|----------------|----------------|--------|-------|
| 1 | CCCMA/CCCMA | ACCESS-CM2 | 144-144 | - | - |
| 2 | CCCMA/CCCMA | ACCESS-ESM1-0 | 144-144 | - | - |
| 3 | CCCMA | MIROC6 | 144-144 | - | - |
| 4 | CCCMA | BCC-CSM2-MR | 108-108 | - | - |
| 5 | CCCMA | INM-CM4-0R | 108-108 | - | - |
| 6 | CCCMA | CMCC-CM2-3.6RS | 108-108 | - | - |
| 7 | CCCMA/CCCMA | CMCC-CM2-3.6CS | 108-108 | - | - |
| 8 | CCCMA/CCCMA | CMCC-CM2-3.6RS | 108-108 | - | - |
| 9 | CCCMA/CCCMA | CMCC-CM2-3.6RS | 108-108 | - | - |
| 10 | CCCMA/CCCMA | CMCC-CM2-3.6RS | 108-108 | - | - |
| 11 | CCCMA | CMCC-CM2-3.6RS | 108-108 | - | - |
| 12 | ECMWF/ECMWF | EC-Earth3 | 144-144 | - | - |
| 13 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 14 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 15 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 16 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 17 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 18 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 19 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 20 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 21 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 22 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 23 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 24 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 25 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 26 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 27 | ECMWF | EC-Earth3 | 144-144 | - | - |
| 28 | ECMWF | EC-Earth3 | 144-144 | - | - |

Monthly data was used to evaluate mean change, and daily data was used to explore the frequency change of extreme events.

Conclusions

- At the end of the century, Missouri is likely to have mean temperature increases all year round, precipitation increases all year round except for summer, and wind speeds decrease all year round.
- In addition, extreme cold temperature events will decrease in winter, while extreme hot temperature events will increase during the summer. Extreme precipitation events are going to increase during the winter and decrease in the summer. Lastly, extreme wind speed events will decrease in the winter and summer.
- These results indicate that Missouri is at greatest risk of increased flooding during the winter and drought during the summer.

Acknowledgements

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