Evaluating Future Heat Health Emergencies in Philadelphia, PA: Blending Model Projections, Observations, and Downscaling Methods

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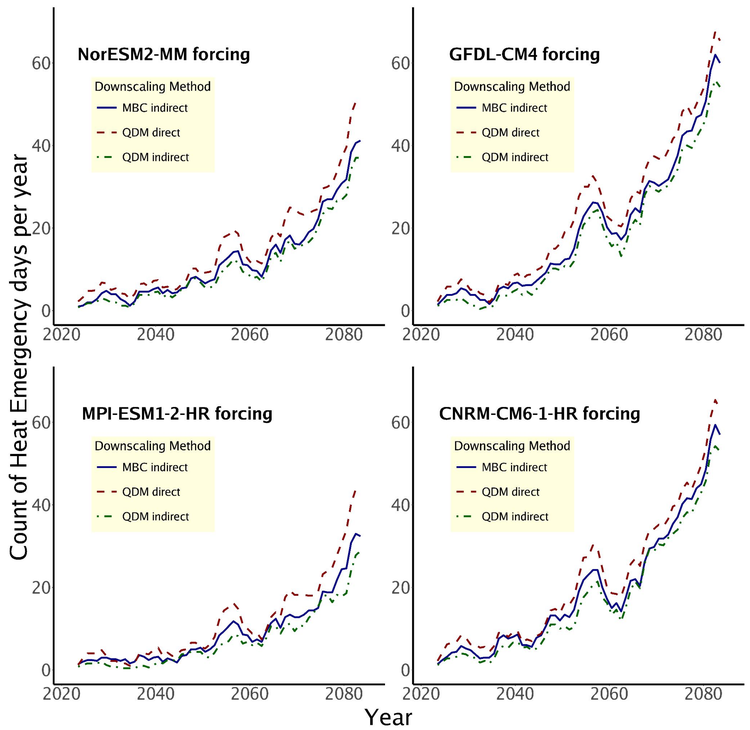
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Downscaled climate projections can play a key role in the development of local-scale adaptation and resiliency strategies for the current climate and for upcoming decades. One such example is city officials and their utilization of heat predictions and projections in Philadelphia, PA. The Philadelphia Department of Public Health defines **Heat Health Emergencies** (HHE) and **Heat Cautions** (HC) events based on daily maximum **heat index thresholds** (a combination of temperature and relative humidity), duration of the exceedance of these thresholds, and time of year. Operationally, these extreme events are declared based on National Weather Service forecasts of temperatures and humidity at the Philadelphia International Airport weather station. When **HHEs** are declared, the public is informed via multiple communications channels and the city begins to take action, such as opening cooling centers and mobilizing other city services.

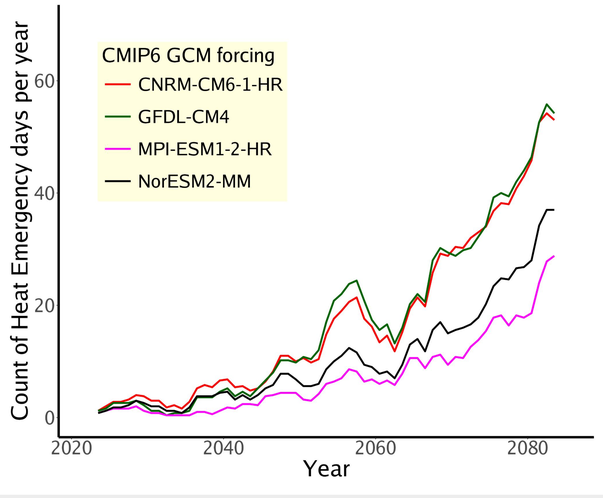
	Timeframe	Heat Caution	Heat Health Emergency
Short Duration **Heat Index** Threshold	May 1 - June 30	**2** consecutive days of **95-100℉**	**2** consecutive days **101℉ & above**
	July 1 - Sept 30	**2** consecutive days of **98-105℉**	**2** consecutive days **106℉ & above**
Long Duration **Heat Index** Threshold	May 1 - June 30	**3+** consecutive days of **93-97℉**	**3+** consecutive days **98℉ & above**
	July 1 - Sept 30	**3+** consecutive days of **95-102℉**	**3+** consecutive days **103℉ & above**

Using 400m resolution SURFEX model output focused on Philadelphia (Le Roy et al. 2024), driven by a combination of reanalysis data and climate change signals from four CMIP6 Global Climate Models (GCMs), we examine future projections of the occurrence of heat events, using the same objective heat index criteria employed by the city. We refined the projections using observational data from the Philadelphia Airport and three bias correction/ statistical downscaling methods. A **direct QDM** approach to downscale the maximum heat index of 24 hours (hismax24), a component or **indirect QDM** approach to downscale minimum relative humidity (hursmin) and maximum temperature (tasmax) separately then calculate the maximum estimated heat index (hismaxest), and a component multivariate **MBC** approach that jointly downscales the individual tasmax and hursmin then calculates hismaxest.

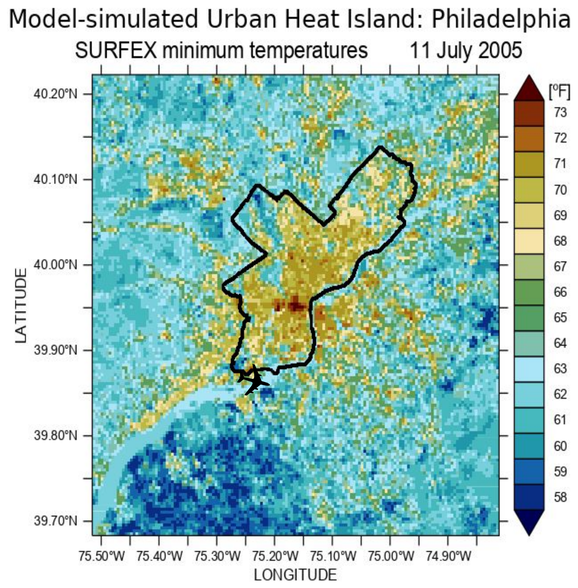
We found that the number of both **HHE** and **HC** events are projected to increase in the coming decades. In the early part of the century (2020-2040), the method of downscaling adds roughly the same amount of uncertainty as the driving model's climate change signal adds. By 2050, the majority of the uncertainty in the projections come from the GCM's climate change signal. When these uncertainty factors are communicated to and appreciated by practitioners involved with the delivery of climate services, it can promote better informed decision-making and contribute to the development of effective adaptation strategies.



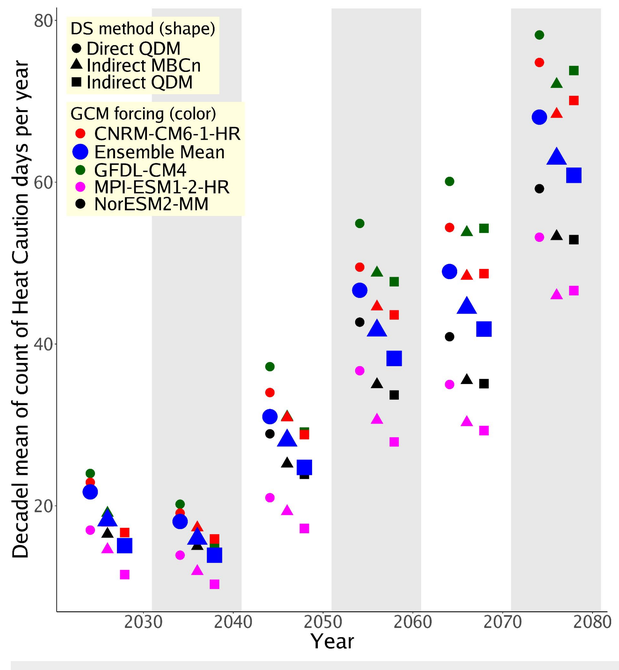
Bias Correction Method Uncertainty in 5 year rolling mean of annual count of **HHE days** for 2021-2085. Each panel represents the driving GCM and lines indicate the bias correction downscaling method: direct QDM downscaling, indirect QDM downscaling, & indirect MBC downscaling.



Model Forcing Uncertainty as seen in 5 year rolling mean of annual counts of **HHE days** calculated from projected hismax24 in four runs of SURFEX driven by 4 CMIP6 GCMs and refined by direct QDM downscaling methods.



Modeling grid domain for the SURFEX PHL model 150x150 (i,j) grid with 400m grid spacing. PHL Airport weather station indicated by the black symbol.



Decadal mean count of **Heat Caution days per year** for each model and each method along with an **ensemble mean** (large symbol) for the 4 models.

Le Roy, B., K. W. Dixon, and D. Adams-Smith, 2024: High-resolution urban climate simulations for heat and health applications in Philadelphia. *Urban Climate*, 57, 102114, https://doi.org/10.1016/j.uclim.2024.102114.