

BSEC Weather Station Network *December 2023*

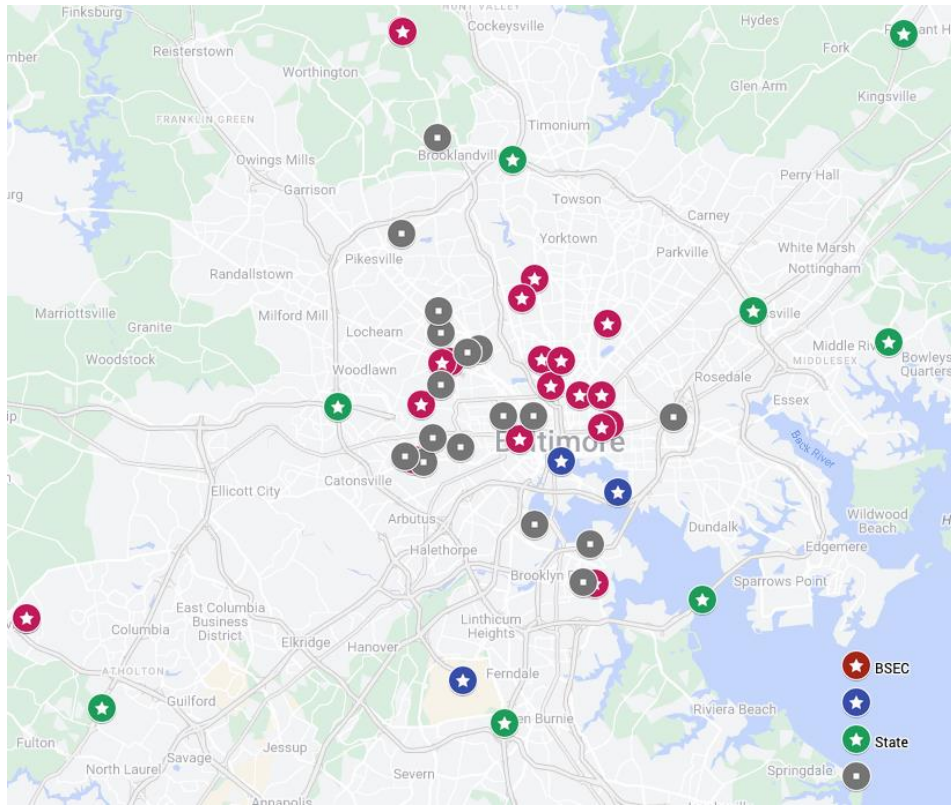
To understand the causes of, and develop equitable solutions for, urban heat, flooding, and air pollution it is necessary to have neighborhood-scale information on weather conditions (such as air temperature, humidity, and rainfall). This is particularly true as these conditions are not evenly distributed within cities. For example, low-income communities are often in the hottest neighborhoods with little vegetation, few trees, and large areas of impervious surfaces.

However, there is a lack of surface weather measurements within cities, especially in low-income communities, which prevents the needed analysis of causes of neighborhood level differences, and the efficacy of active or proposed interventions to address issues such as extreme heat, flooding, and air pollution. Federal and state agencies only make weather measurements at a few stations within or near Baltimore City (see map below). To address this lack of data, the Baltimore Social-Environmental Collaborative (BSEC) is placing weather stations across Baltimore City, with a focus on under-served neighborhoods.

Weather stations include instruments that measure temperature and moisture in the air, rainfall, wind speed and direction, surface pressure, and sunlight. In collaboration with community partners, BSEC is installing weather stations at community centers (including churches, community gardens, schools, parks, and recreation centers), private residences, and universities in the city.



The measurements from these weather stations are freely available on the web in real time (see <https://21cc.jhu.edu/bsec/bsec-maps-and-data/bsec-weather-stations/>). There are currently (December 2023) BSEC weather stations (red symbols in the map) at 18 locations in, or close to, Baltimore City. This greatly exceeds the number of federal and state weather stations (blue and green symbols), and in the coming year the BSEC team plans to at least double the number of locations (gray symbols).

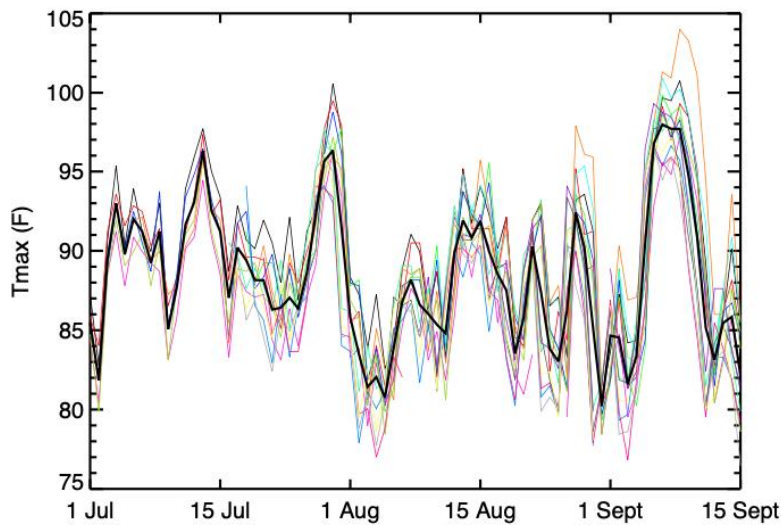


Map showing location of weather stations operated by BSEC (red), federal (blue), or state (green) agencies. Gray symbols show potential additional BSEC locations.

ID	Location (Neighborhood)	ID	Location (Neighborhood)
AAC	Allen AME Church (Popperton)	FSG	Filbert Street Garden (Curtis Bay)
ABL	Private Residence (Abell)	JHU	Johns Hopkins University (Homewood)
AGC	Amazing Grace Church (McElderry Park)	LGC	Liberty Grace Church (Forest Park)
ARK	Ark Church (Oliver)	LRT	Liberty Rec & Tech Center (Forest Park)
CARE	C.A.R.E. Neighborhood (CARE)	MSU	Morgan State University
CLV	Private Residence (Clarksville)	NRP	Private Residence (North Roland Park)
CMN	Carrie Murray Nature Center (Leakin Park)	OG	Private Residence (Old Goucher)
COV	Private Residence (Cockeysville)	RPL	Roland Park Library (Roland Park)
DSG	Duncan Street Miracle Garden (Broadway East)	SMF	Stillmeadow Community Fellowship (Beechfield)

Table: Location of currently installed weather stations.

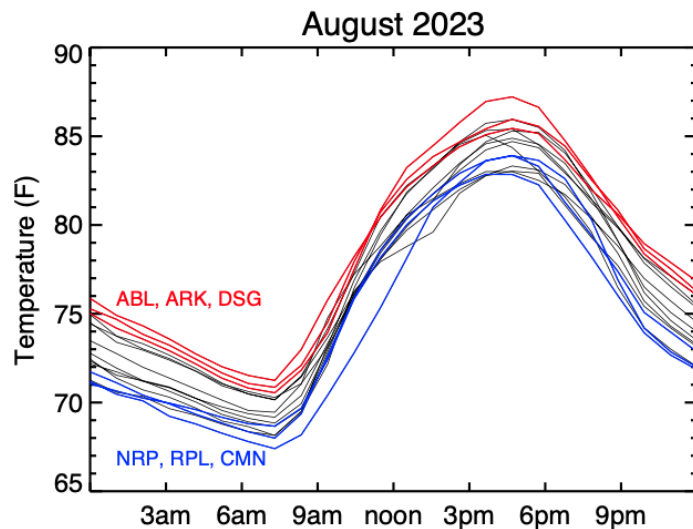
Preliminary analysis of measurements of the air temperature from the first six months of the BSEC network shows several results and notable features. For example, as shown in the plot below, there are large day-to-day variations in the temperatures measured in the city, with values around or above 100 F measured during the heat waves at the end of July and early September, but daily highs less than 80 F measured during several days in August.



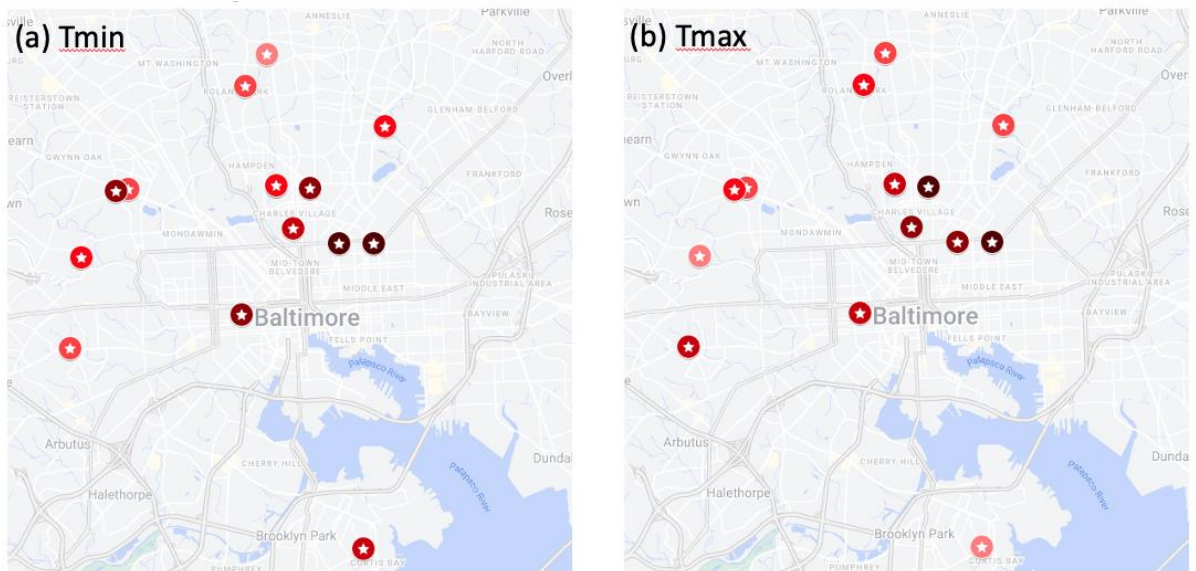
Variation of the maximum temperature measured each day (T_{max}) for each BSEC weather station in Baltimore City. The different colored curves show different stations, and the thick black curve is the mean over all stations.

All stations show large daily variability, but, for any given day, there is a spread in temperature measured among the stations. This spread is primarily due to differences in the location of the weather stations within the city: There is generally warmer air in central (more urban, less-vegetated) neighborhoods than in outer (more suburban, greener) neighborhoods. For example, the plot below shows that Broadway East and surrounding neighborhoods are on average 5 F warmer than Roland Park neighborhoods and within Leakin Park.

Variations of temperature during the day, averaged over August 2023, for each weather station. The ABL, ARK, and DSG are stations in or near the Broadway East neighborhood, and shown in red. NRP and RPL are in or near the Roland Park neighborhood, and CMN is within Leakin Park, and shown in blue.



These differences in temperature from different locations can also be seen in the maps below showing the daily minimum and maximum temperature (T_{min} and T_{max}) for August 2023. While central locations are generally warmer than more suburban locations, the maps of T_{min} and T_{max} are not exactly the same, and how temperature varies in space differs between morning and afternoon temperature. Also, a careful look at the above plot of the July to September variations in T_{max} shows that the location of the hottest temperatures varies between the July and September heat waves. The cause of these variations are being examined.



Map of average (a) minimum and (b) maximum daily temperature, for August 2023, at BSEC stations. Darker red indicates higher temperature.

In addition, we are also examining:

- The relationship between land surface and urban structures (such as tree coverage and buildings) and spatial variations in air temperature. From this we will map the temperature across the city and estimate the impact of possible mitigation strategies (tree planting) on the air temperature.
- The time and space variations in other aspects of the weather: humidity, wind speed, and rainfall.
- Differences in measurements from different types of weather stations (low cost vs. high cost).

We are also continuing to install additional weather stations. These will fill current gaps in our coverage of the city (in the Northwest, Eastern, and Southwest areas within the city) and include more locations for community and educational activities.

For **more information** on the weather stations, including current locations and access to the data, see <https://21cc.jhu.edu/bsec/bsec-maps-and-data/bsec-weather-stations/>, or contact Darryn Waugh (waugh@jhu.edu).

