# Providing Forecasts of Dangerous Thunderstorms to Operators of Outdoor Concert Venues

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**August 6, 2020**

## Introduction/Business Problem

According to the National Oceanic and Atmospheric Administration (NOAA)--which the U.S. government agency in charge of issuing public weather forecasts and hazardous weather warnings--around 50 people are killed and hundreds are injured from lightning strikes each year in the U.S.

Outdoor music festivals and concerts in the U.S. are attended by hundreds of thousands of people each year. According to the website https://www.statista.com/chart/17757/total-attendance-of-music-festivals/ a total of 770,000 people attended Summerfest in Milwaukee, Wisconsin and 430,000 people attended Lollapalooza in Chicago, Illinois in 2018.

Imagine you are head of operations for one of these venues and ultimately responsible for the safety of everyone attending an outdoor music event. There are two hundred thousand people enjoying music on a warm, humid evening and lightning from an approaching thunderstorm is seen in the distance and thunder rumbles overhead—loud enough to be heard over the sound system and singing fans. In addition, this approaching thunderstorm is causing wind gusts over 50 mph (80 kph) that can turn unsecured objects into deadly projectiles. You have an evacuation plan in case of this scenario, but the plan only goes into action upon hearing thunder. Not good enough. You must get two hundred thousand people to safety and it could take 1 hour to accomplish this. You need to know if thunderstorms and the potential hazards are a risk days ahead of time so you can be prepared well in advance of a hazardous weather event.

On August 13, 2011 at the Indiana State Fairgrounds in Indianapolis, Indiana, country music group Sugarland was getting ready to perform when a severe thunderstorm moved over the venue. A strong gust of wind from the thunderstorm caused part of the stage to collapse onto people that were near the stage. Seven (7) people were killed and dozens more were injured. In total, 18 defendants of a class action lawsuit that was filed had to pay out a total of $39 million U.S. dollars to the plaintiffs (source: https://www.rollingstone.com/music/music-country/settlement-reached-in-sugarland-stage-collapse-229652/). As head of operations of an outdoor concert venue, this is likely your worst nightmare and you have no advanced forecast notification. This is a problem, but one which has a solution.

## Data

The Foursquare API will be used to look up the location of outdoor concert venues across the United States. The locations will be plotted on a map.

For weather forecast information, the AccuWeather API will be used to look up 10-day weather forecasts for each outdoor concert venue. The format is JSON and will be queried by U.S. location key. The location key can be acquired in the AccuWeather location API by using the location's postal code. Below is a screen shot of what the AccuWeather API looks like.


```
{
    "Date": "2020-06-27T07:00:00-05:00",
    "EpochDate": 1593259200,
    "Temperature": {
        "Minimum": {
            "Value": 71,
            "Unit": "F",
            "UnitType": 18
        },
        "Maximum": {
            "Value": 89,
            "Unit": "F",
            "UnitType": 18
        }
    },
    "Day": {
        "Icon": 17,
        "IconPhrase": "Partly sunny w/ t-storms",
        "HasPrecipitation": true,
        "PrecipitationType": "Rain",
        "PrecipitationIntensity": "Heavy"
    },
    "Night": {
        "Icon": 42,
        "IconPhrase": "Mostly cloudy w/ t-storms",
        "HasPrecipitation": true,
        "PrecipitationType": "Rain",
        "PrecipitationIntensity": "Light"
```


## Methodology

The Foursquare API can be searched by venue type, but I was limited how the search was conducted based on my subscription level. I could not do a search query by country, so I needed to come up with a list of larger cities or known city locations of existing outdoor concert venues. I manually created a csv file containing the city and state.

A search query of 'Amphitheatre' was used for the API request URL since this is a common venue type for outdoor concert venues. A for loop was used to search for 'Amphitheatre' in 52 cities in the U.S. at a radius of 75,000 meters. I limited the search results to 15 venues. This returned a total of 256 venues but did include some duplicates and venues that were clearly not for concerts. The search returned the location of an AT&T store.

The data frame of venues was cleaned by removing duplicates and venues that were clearly not for concerts. After cleaning, I had 118 total outdoor concert venues. The data frame contained the venue name, city, state, postal code (zip code), latitude and longitude.

I chose AccuWeather's forecast API because…I work there as a senior meteorologist!

In the AccuWeather forecast API link, there is no way to call the API for a forecast based on zip code. Rather, the API uses a 'location key'. The good news is there is an AccuWeather locations API that returns a location key based on the zip code.

Since I had the zip code of each venue, I created a for loop to get the locations API URL. From the JSON, I created a data frame that contain among other items, the location key, postal code and country. The locations API does return locations outside of the U.S. The data frame was cleaned to remove locations outside of the U.S. and the other information that was not needed. This left me with a data frame that contained the location key, postal code and country code.

Since both of those data frames have postal code as a common column, I performed a simple merge to create a single data frame that contained all of the pertinent information on the venue and the location key we will need for the AccuWeather forecast API.

Using another for loop, I called the forecast API for each forecast location key.

The AccuWeather forecast API contains information for each day such as: maximum/minimum temperature, precipitation type, precipitation intensity, the forecast icon number and a short forecast phrase based on the icon. The data in the API is in JSON format.

For the purposes of this project, I did not use the temperature forecast information. I did parse from the JSON all the information related to the precipitation forecast.

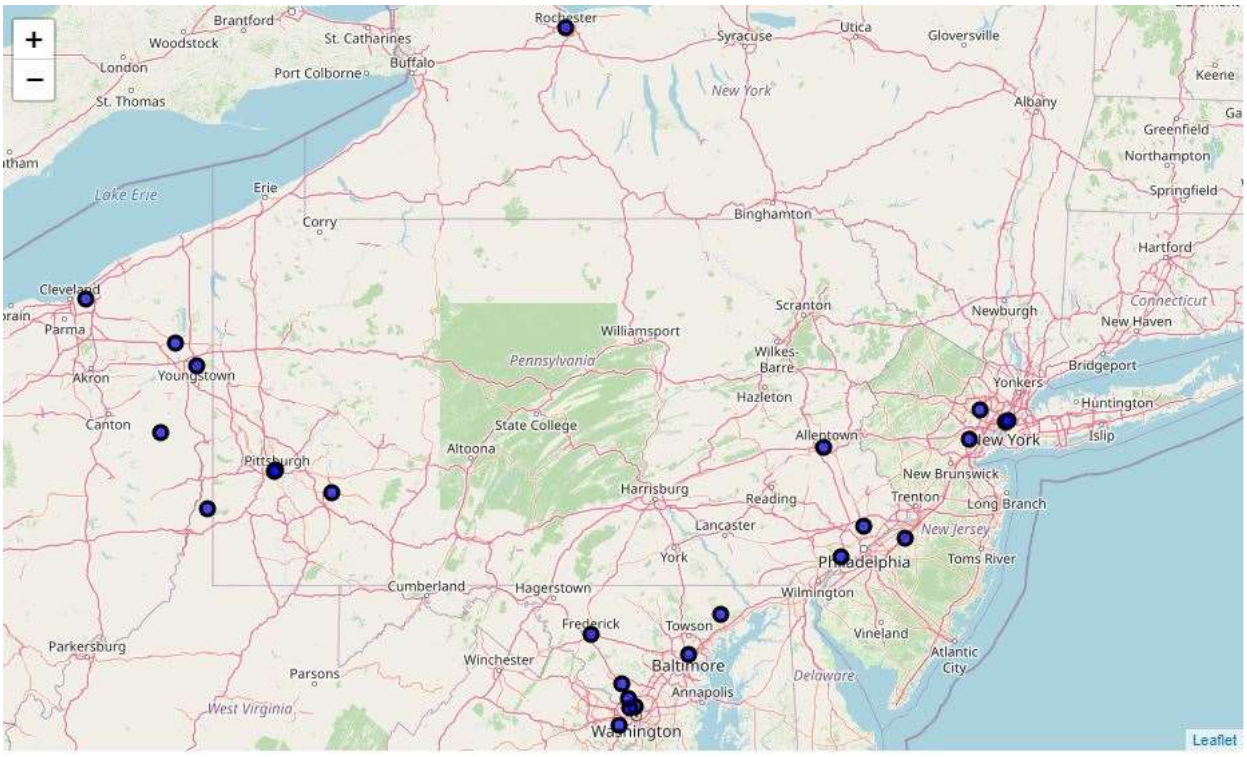
Any thunderstorm can be dangerous to anyone outdoors as they produce life-threatening cloud-to-ground lightning. The most intense thunderstorms have other hazards, such as high winds, hail, tornadoes and flooding rainfall. While there is no information in the API that says what hazards, if any, are forecast with the thunderstorms, there are 3 categories for precipitation intensity: light, moderate and heavy. In the forecast API these are only assigned if precipitation is in the forecast. If the forecast is for dry weather, there is no intensity flag.

Using another for loop, I called the 10-day forecast API using the location key for all 118 venues. The venue forecasts were converted into a data frame, which was cleaned to remove columns that contained information that was not needed. The forecast API does not contain the forecast location key. My idea was to merge the forecast data frame with the venue information data frame using location key as a common column. Luckily, the API contains a link to the forecast on AccuWeather.com. I had to parse out the location key from the URL and add to the data frame. From there, after creating a pivot table, I was able to merge the two data frames that contained all the information needed to plot on a map.

I decide to create a popup box that contained the forecast information when the user clicked on the location on the map. I did not want to just have the raw forecast information but rather make it actionable. Concert venue operators are not meteorologists. They need easy to understand information that is actionable. I created a color-code system based on the forecast. If the forecast is 'green' on a day that means no thunderstorms are in the forecast. Yellow means thunderstorms are in the forecast but are not forecast to contain high winds, hail or tornadoes. Red means thunderstorms are forecast and can cause high winds, hail and/or tornadoes. If the intensity in the forecast API was light or moderate, I assigned this to be yellow. If the intensity is heavy, I assigned this to be red.

**Results**

I was able to successfully create a product using my Python skills developed throughout this course. A map of the U.S. with outdoor concert venues plotted and clickable to reveal a 10-day thunderstorm risk assessment. Below are some examples of what the product looks like.




*The above screen shot shows the locations of outdoor concert venues gathered from the Foursquare API. These are venues located in and around Cleveland, Pittsburgh, New York City, Philadelphia, Baltimore and Washington, D.C.*


*Examples (above and below) of the contents of the popup text when the user clicks on the venue location. The name of the venue and color code for each of the next days.*


Seeing a forecast of 'Red', the venue operator can plan ahead for severe weather by reviewing evacuation procedures with security staff. The venue operator can supplement this information by contracting with a weather forecast vendor like AccuWeather for Business to

receive warnings and the ability to consult 24/7 with a professional Meteorologist. Having all this information can help venue operators make decisions to keep concert attendees, the musical act, crew and equipment safe.

## Discussion

The Foursquare API contains a wealth of information. However, a search of 'Amphitheatre' yielded less than ideal results that required extra work to clean the data. An AT&T Store and some indoor venues showed up in the results. An already existing dataset of outdoor venues would have made the process smoother.

Because the AccuWeather forecast API is global, products can be developed for venue operators anywhere in the world. My Python skills limited my ability to create a more visually pleasing product, but I was pleased with the final result. There is another forecast API available from AccuWeather that contains more detailed weather information at hourly and minute-by-minute temporal resolution. More detail would be a nice value add.

## Conclusion

Using Foursquare's API to get locations of outdoor concert venues and combining that with weather forecasts from AccuWeather's API, I was able to create a user friendly, easy to understand product for venue operators to use to make decisions to help keep attendees, musicians, crew and equipment safe. Locations were plotted on an interactive map where the user can click on the location to reveal a popup box containing the name of the venue and the thunderstorm risk forecast for the next 10-days. The information is actionable and frees up the staff at the venue from playing meteorologist. Creating weather forecasts and interpreting weather information is best left to those trained to do so. As a meteorologist myself, I would not tell venue security how to evacuate the venue in the event of a severe thunderstorm. That is beyond my area of expertise.