Have Monsoon Rains Intensified in Southern Arizona?

A Look at Rainfall from 2006–2025

Why This Question Matters

Every summer, southern Arizona relies on the monsoon season to bring much-needed rain. These storms are short, intense, and unpredictable — and while they help with water supply, they can also trigger flash flooding and road damage.

Because climate change is expected to cause more extreme weather in the Southwest, we wanted to ask a simple question:

Have monsoon rains in southern Arizona become more intense in the past two decades?

I looked at:

- How much rain falls during the monsoon season
- Whether big storm days (over 1 inch of rain) are becoming more common
- If the timing of the monsoon is changing

What I Did

I pulled hourly rainfall data from NOAA for four weather stations in southern Arizona:

- **Tucson International Airport**
- **Nogales International Airport**
- **Douglas Bisbee International Airport**
- **Safford Municipal Airport**

These stations gave us a good mix of urban and rural spots across different parts of the region.

How I Analyzed It

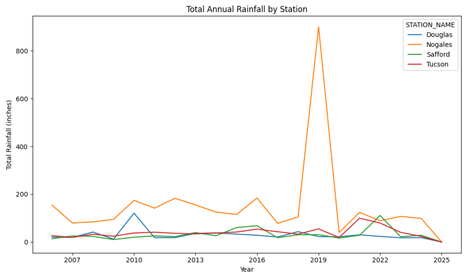
I used Python to clean and analyze data from 2005 to 2025. First, we extracted rainfall from the `AA1` field in the NOAA files (which stores hourly precipitation). I then:

- Added up rainfall each day and each year
- Focused in on monsoon months (July–September)
- Counted how many days per year had more than 1 inch of rain (which we called "heavy rain" days)
- Found the biggest single-day rain totals each year
- Looked at long-term monthly averages to see when rain happens

All the data processing and graphing was done using pandas, seaborn, and matplotlib.

What We Found

1. Total Annual Rainfall by Station



This graph shows how much rain each station received in total every year. I didn't see a clear long-term trend up or down, but I noticed big differences between the stations.

Nogales had the highest rainfall overall — often a lot more than the others in the same year. I think that's probably due to its higher elevation and topography, which may make it more exposed to strong monsoon storms.

Douglas and **Safford** were drier in most years, while **Tucson** fell somewhere in between. Tucson didn't have any record-breaking totals, but it also didn't fall too far behind the rest.

One of the most noticeable patterns was just how much rainfall varied year to year. Some years like 2019 were extremely wet across all stations, while others were much drier. Still, I didn't see any sign of a steady increase or decrease over time.

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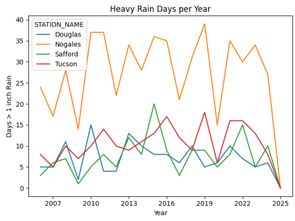
2. Heavy Rain Days per Year



This graph looks at how many days each year saw more than one inch of rain. I used that threshold as a way to capture extreme rain events — the kind that can cause localized flooding or infrastructure problems.

Once again, **Nogales** stood out. Some years it had three or four times more heavy rain days than other stations. **Douglas** and **Safford** had very few — sometimes zero in a year. **Tucson** was somewhere in the middle, with a few heavy rain days in most years but nothing too extreme.

Even though a few years had spikes, like 2021, there wasn't a clear trend toward more heavy rain days over time.

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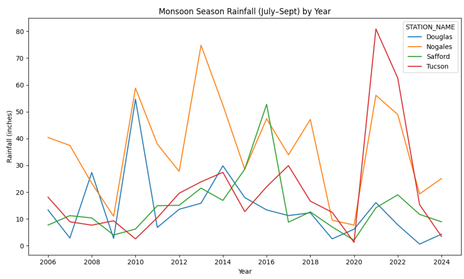
3. Monsoon Season Rainfall (July–September)



Since I focused this project on the monsoon, I zoomed in on rainfall from July to September — the months when monsoon storms usually occur.

The pattern was familiar: **Nogales** got the most rain, followed by **Tucson**, then **Douglas**, with **Safford** usually the driest. Some years, like 2021, all four stations had strong monsoon seasons. Other years, like 2019 or 2012, were much drier.

There was a lot of back-and-forth between wet and dry years, but I didn't see a clear increase in monsoon strength overall. The season still varies a lot from year to year, but it doesn't look like it's becoming more intense over time.

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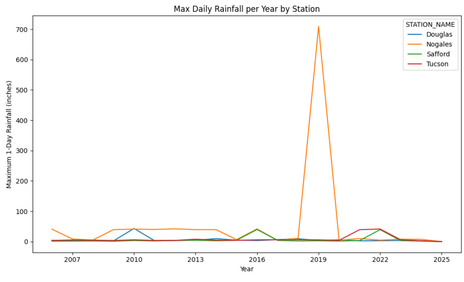
4. Max Daily Rainfall per Year



This graph shows the biggest single rainfall day each year for each station. I expected to see some large spikes, and I did — especially in **Nogales**, which had a huge rain event in 2019.

That 2019 spike doesn't show up at the other stations, so it could have been a highly localized storm or maybe even a data issue. **Douglas** and **Tucson** also had some strong single-day events, but they weren't as extreme. **Safford** stayed relatively flat across the board.

Looking at this graph, I didn't find any pattern that suggested the most intense storms are getting worse. The extreme days still happen — but not more often or more dramatically than before.

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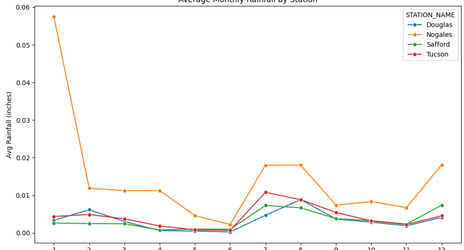
5. Average Monthly Rainfall by Station



To wrap up, I averaged rainfall by month across the full time period to look at seasonal timing.

Every station followed the same basic pattern: dry from fall through spring, then a big jump in July, a peak in **August**, and a tapering off by **September**. That confirms what I expected — the monsoon still defines the region's rainy season.

There's no sign that the monsoon is arriving earlier or later than it used to. The seasonal shape has stayed the same over time. And once again, **Nogales** was clearly the wettest during the peak months, while **Safford** was the driest.

So, Are Monsoons Getting More Intense?

Not really — at least not yet.

From 2005 to 2025, I didn't see signs that monsoon rains in southern Arizona are getting heavier or more extreme. The total amount of rain, the number of big storm days, and the timing of the monsoon all stayed pretty consistent. Some years were wetter than others, but that's part of normal variation — not a clear trend.

That said, this doesn't mean the climate isn't changing. It just means that **in this region**, **and for rainfall**, **we're not seeing those changes yet**. Other things — like rising temperatures, droughts, or earlier snowmelt in the mountains — may already be shifting.

What's Next

It'll be important to keep tracking this data over time. Climate changes often unfold slowly, and monsoon systems are especially complicated. This kind of long-term, local analysis can help spot emerging changes early — and help communities adapt.

GitHub Repository

All my code, cleaned data, and the graphs from this project are available at:
https://github.com/elliemarie024/monsoon-rainfall-analysis