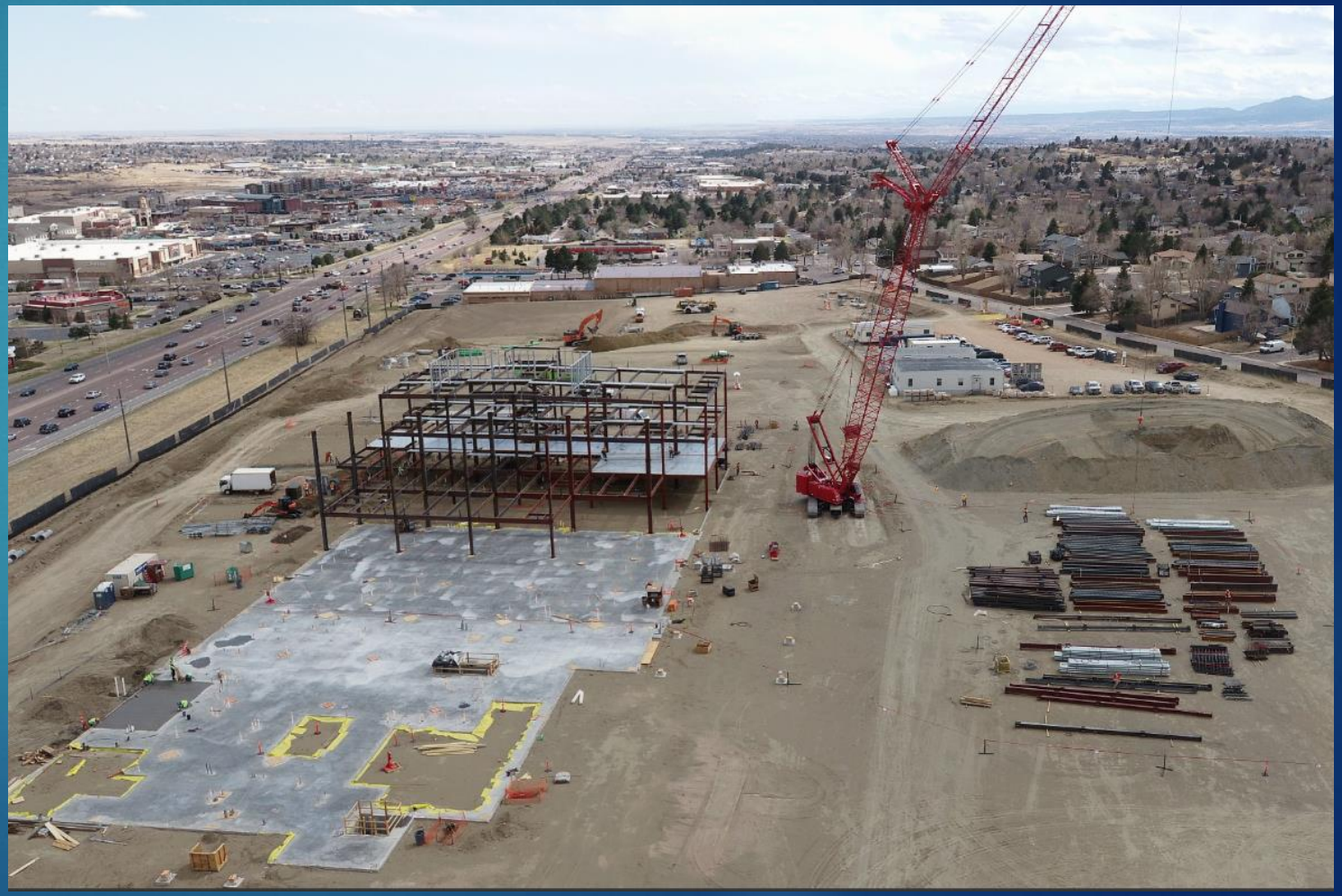
Weather Impacts on Construction Projects

Introduction: (Motivation and Drivers)

Weather has considerable impacts on construction projects including:

- Schedule delays
- Escalation of Equipment Costs
- Delay Damages, Non-Payment and Lawsuits
- Inefficient use of manpower and equipment

Ideal Situation – Dry weather, no wind, long summer days (10 hour workdays)



Weather Impacts on Construction Projects

Weather Impacts

- *Weather Day – The general definition for a delay caused by weather which impact the ability of a field crew to perform work for more than 50% of the work day.*
- *HME, Inc. supplies Structural Steel for construction and we have fairly specific definitions for "Weather Days"*
  - *Rain – Rain is typically the most common and restrictive weather condition which shuts down construction sites.*
  - *Snow – Snow is treated similar to rain in shutting down construction sites. Accumulation of snow is a safety issue.*
  - *High Winds – For safety reasons, cranes are typically not allowed to operate in wind speeds above 25 mph. High winds also make handling of roof and floor decking unsafe.*
  - *Low Temperatures impact welding operations:*
    - *Below 32 deg. F requires preheating of weld joint to 50 deg. F.*
    - *Below 0 deg. F restricts all welding*

Weather Variables Used

- *High Wind = wind speed over 15mph*
  - *Yellow condition. Crane must shut down, but other work can be performed*
- *Rain*
  - *Red condition. All work must shut down.*
- *Snow*
  - *Red condition. All work must shut down.*
- *Cold but good weather = temperatures below 32 degrees*
  - *Blue condition. No rain, snow, or high wind*
- *Extreme low temperatures = temperatures below 20 degrees*
  - *Blue condition. No rain, snow, or high wind*
- *Good weather = all conditions not listed above*
  - *Green condition*

Data Resources

- *HMEOpenLargeJobs_20231202*
  - *CSV file of current projects with location*
- *Weather API – OpenWeatherMap*
  - *Current weather*
  - *5 day/3 hour forecast*

Original CSV file

	ProjectID	Project-Number	Name	Address	Geometry	LocationJSON
0	85216	18-054	PAR 1244	5950 York St, Denver, CO 80216, USA	{"location": {"lat":39.805279,"lng":-104.958759...	{"Street1":"5950 York St","Street2":null,"City...
1	87261	18-121	SECURITY SANITATION WWTF IMPROVEMENTS	6510 Southmoor Dr, Fountain, CO 80817, USA	{"location": {"lat":38.736055,"lng":-104.737949...	{"Street1":"6510 Southmoor Dr","Street2":null,...
2	87538	18-145	WESTERN CURRENCY FACILITY EXPANSION	8776 Blue Mound Rd, Fort Worth, TX 76131, USA	{"location": {"lat":32.8943727,"lng":-97.348633...	{"Street1":"8776 Blue Mound Rd","Street2":null...
3	87544	18-147	BID PACKAGE 4.3 - LEONARD WTP YARD PIPE	361 Co Rd 4965, Leonard, TX 75452, USA	{"location": {"lat":33.383391,"lng":-96.2825639...	{"Street1":"361 Co Rd 4965","Street2":null,"Ci...
4	88609	19-040	SADDLE CREEK RTB	2520 S 64th St, Omaha, NE 68106, USA	{"location": {"lat":41.2404302,"lng":-96.011843...	{"Street1":"2520 S 64th St","Street2":null,"Ci...

Cleaned data frame

	Project-Number	Name	Address	Lat	Lng	Weather_Category	Color	Temperature_F	Windspeed_mph
0	18-054	PAR 1244	5950 York St, Denver, CO 80216, USA	39.805279	-104.958759	Cold but Good Weather	Blue	28	6
1	18-121	SECURITY SANITATION WWTF IMPROVEMENTS	6510 Southmoor Dr, Fountain, CO 80817, USA	38.736055	-104.737949	Snow	Red	30	7
2	18-145	WESTERN CURRENCY FACILITY EXPANSION	8776 Blue Mound Rd, Fort Worth, TX 76131, USA	32.894373	-97.348633	Rain	Red	52	8
3	18-147	BID PACKAGE 4.3 - LEONARD WTP YARD PIPE	361 Co Rd 4965, Leonard, TX 75452, USA	33.383391	-96.282564	Good Weather	Green	48	9
4	19-040	SADDLE CREEK RTB	2520 S 64th St, Omaha, NE 68106, USA	41.240430	-96.011843	Cold but Good Weather	Blue	31	8
5	19-048	MARCY GULCH WWTP	8700 US-85, Highlands Ranch, CO 80126, USA	39.556900	-105.033535	Cold but Good Weather	Blue	28	3

Data Prep Notebook

- *Step 1:*
  - *Deleted confidential and irrelevant information.*
- *Step 2:*
  - *Parce latitude and longitude.*
  - *Remove projects with missing latitude and longitude.*
  - *244 active projects*
- *Step 3:*
  - *Retrieve weather from open weather API*
  - *Categorize and color weather based on established variables.*
    - *Cold but good weather = Blue*
    - *Rain = Red*
    - *Snow = Red*
    - *High wind = Yellow*
    - *Good weather = Green*
- *Step 4:*
  - *Send cleaned projects_weather_data and Weather_5Day_Forecast to csv files.*

Project-Number	Name	Address	Lat	Lng	Weather_Category	Color	Temperature_F	Windspeed_mph
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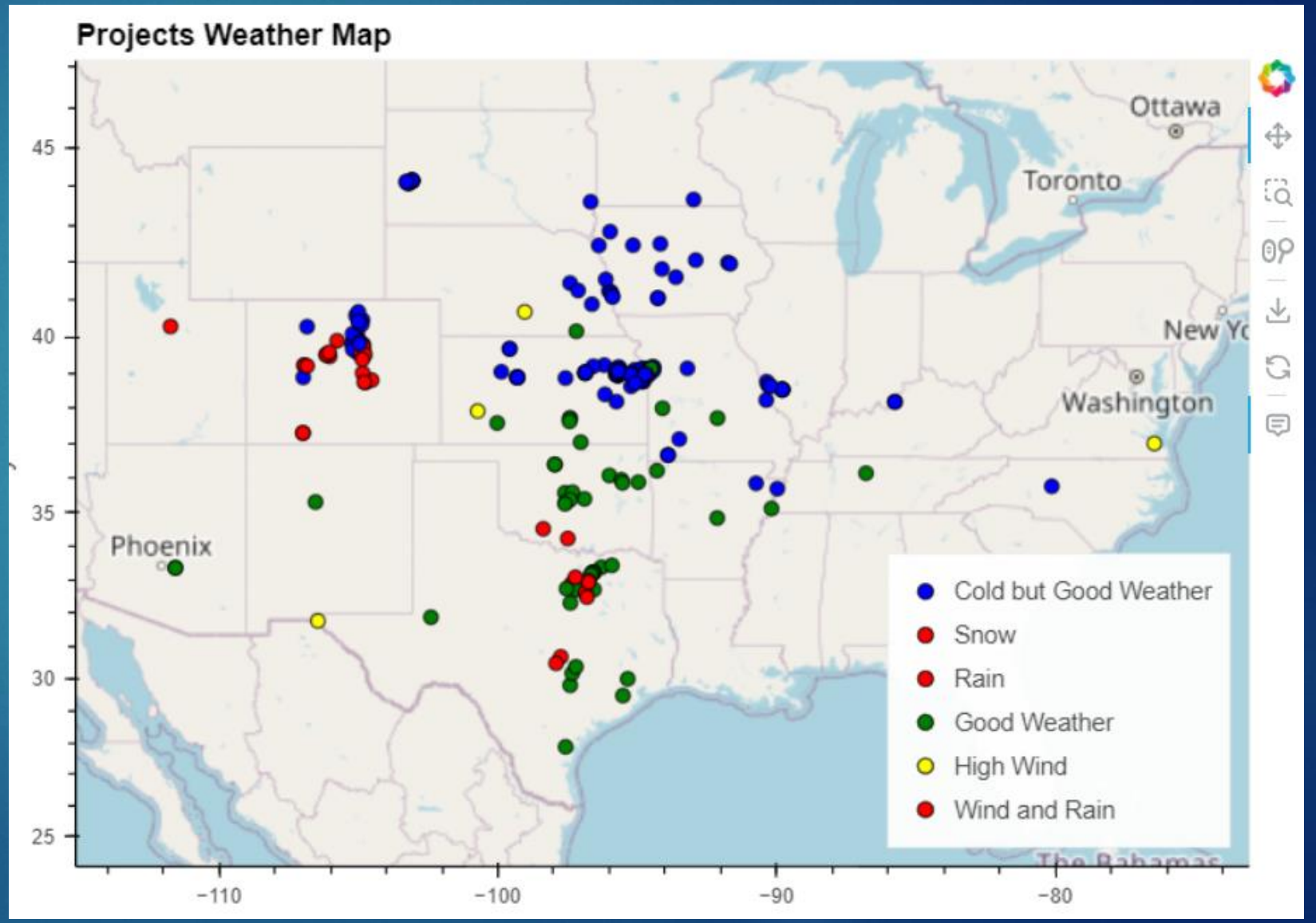
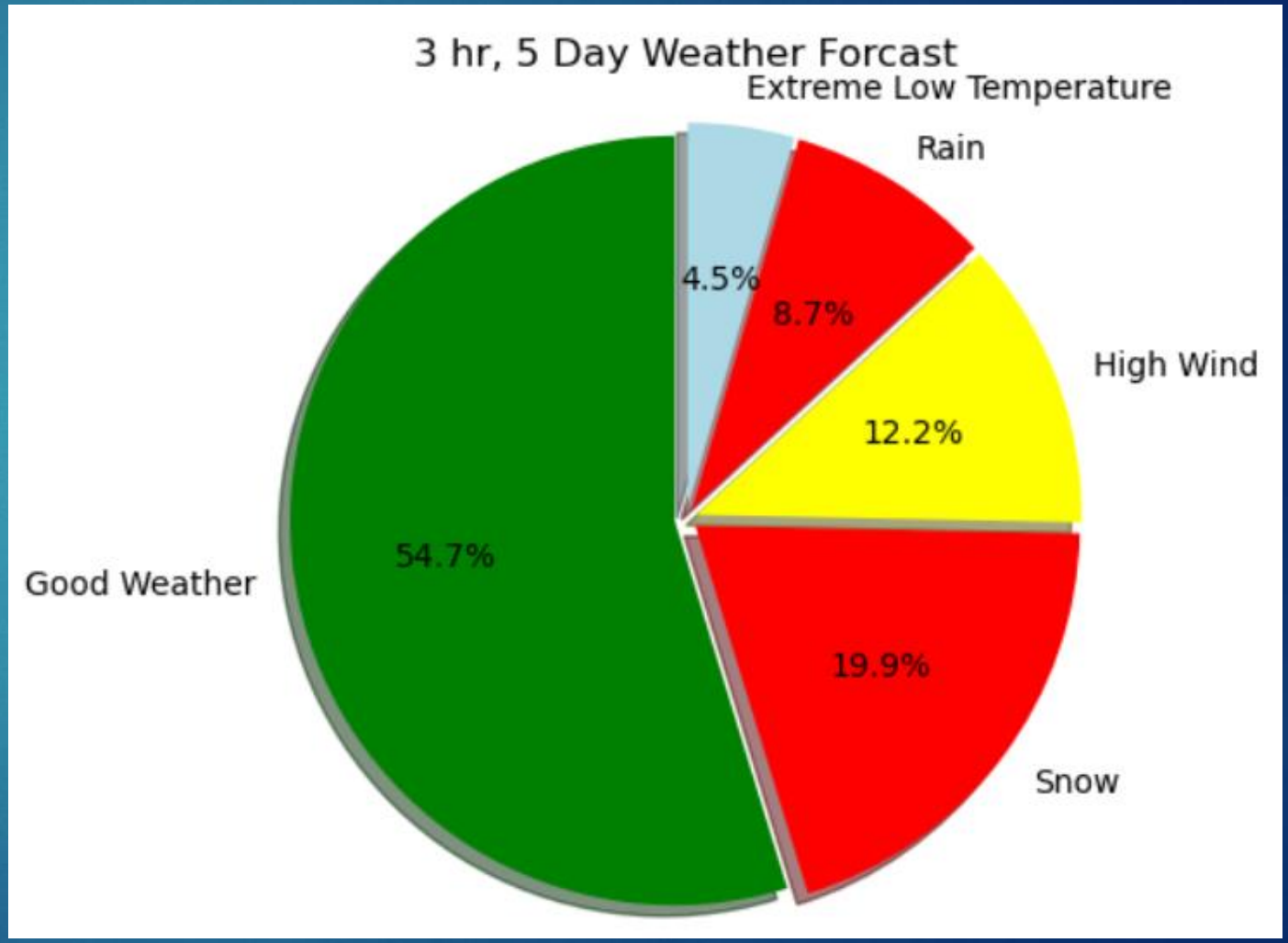
Weather Map

- *Hvplot was utilized to create a map with each project located with a dot colored by the current weather category provided in the projects_weather_data.csv generated in the data prep.*



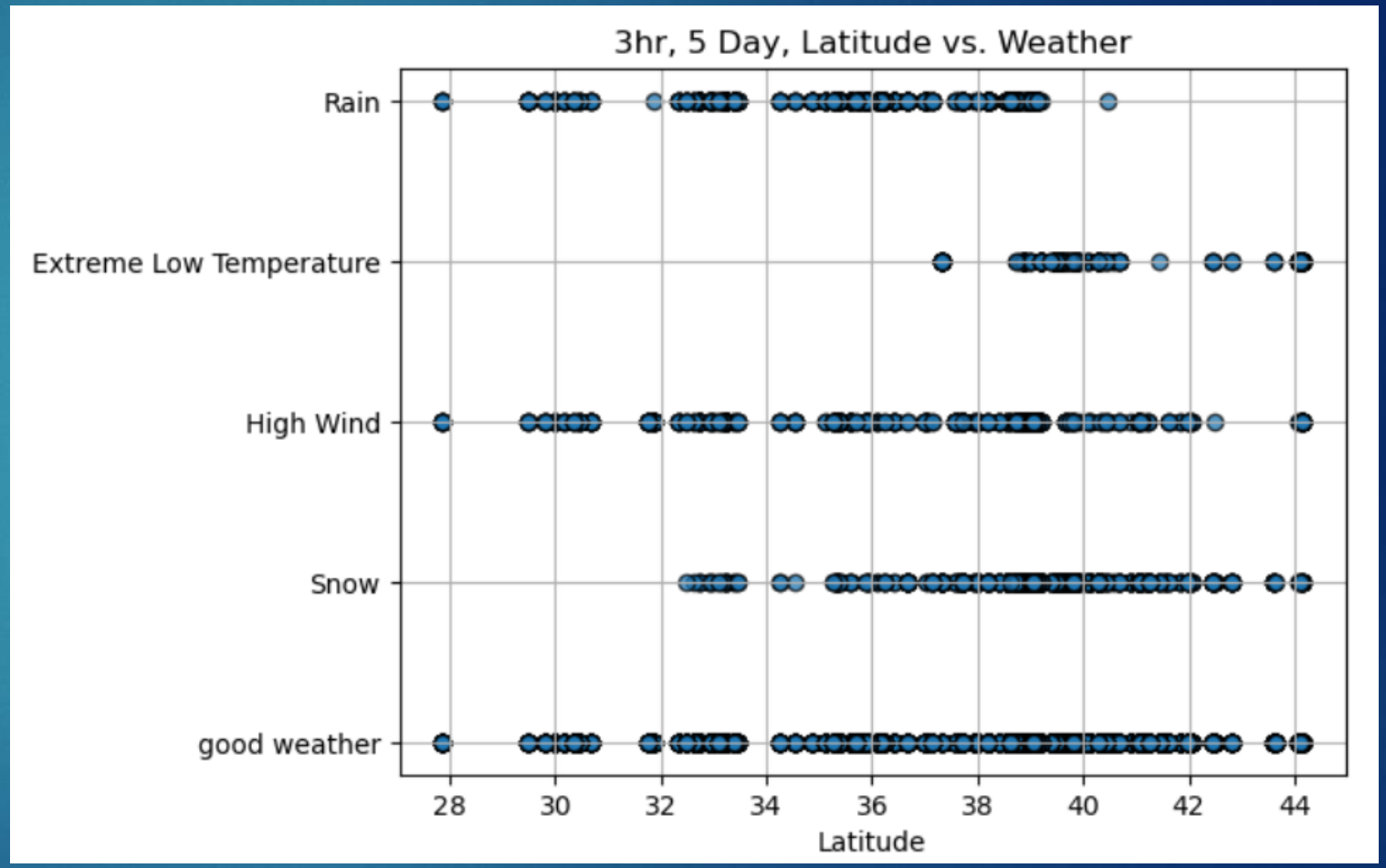
3 Hour 5 Day Forecast

- *Forecasted weather conditions were collected every 3 hours for 5 days between the hours of 6 am and 6 pm. These hours represent a construction workday. The pie chart details the forecast provided in the Weather_5Day_Forecast.csv generated in the data prep.*



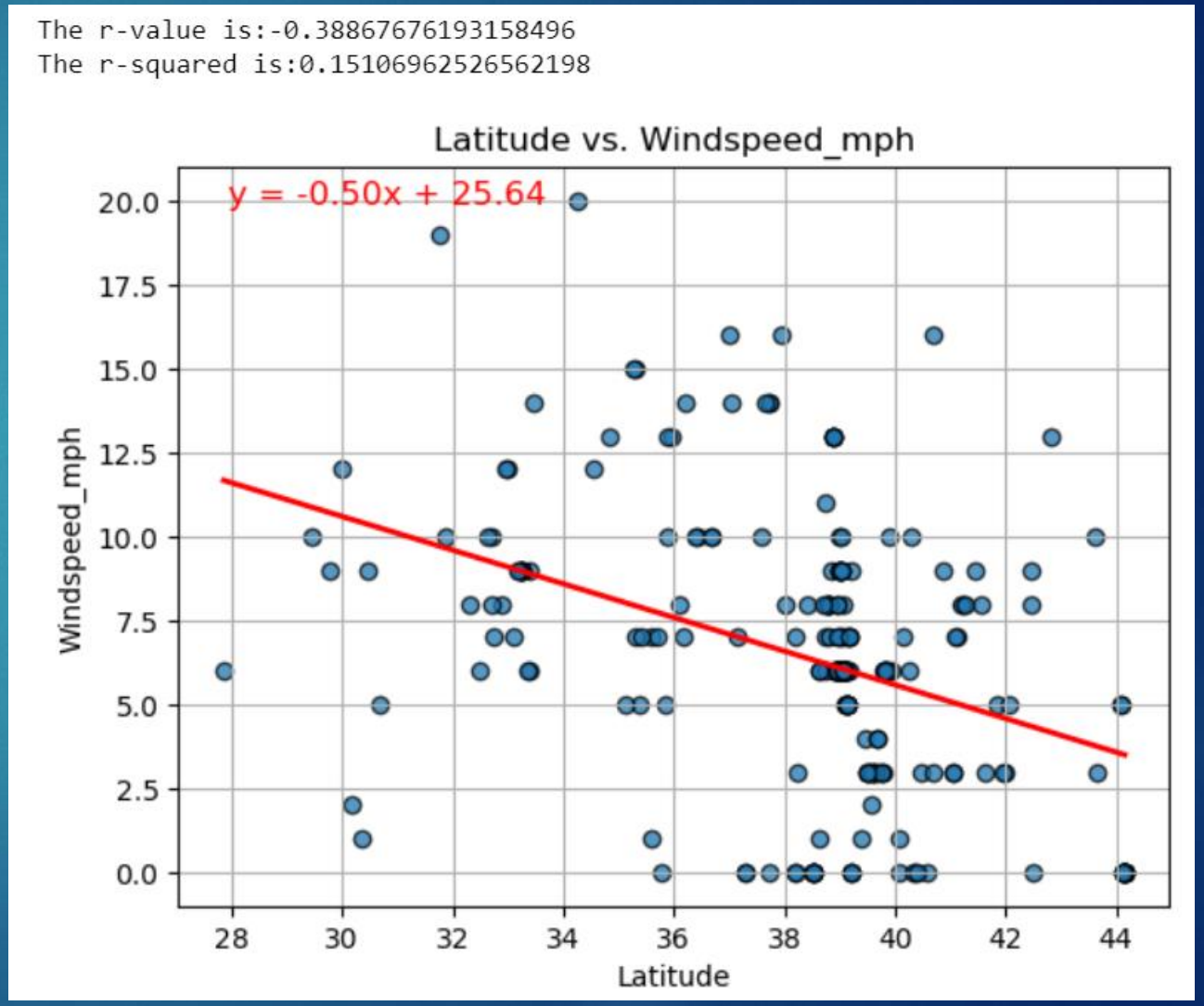
Latitude vs Forecasted Weather

- *The chart shows the relationship between latitude and weather conditions provided in the Weather_5Day_Forecast.csv generated in the data prep.*
- *Extreme low temperatures appear to start around 38 deg latitude. Snow begins around 32 degrees latitude and rain ends around 40 deg latitude.*



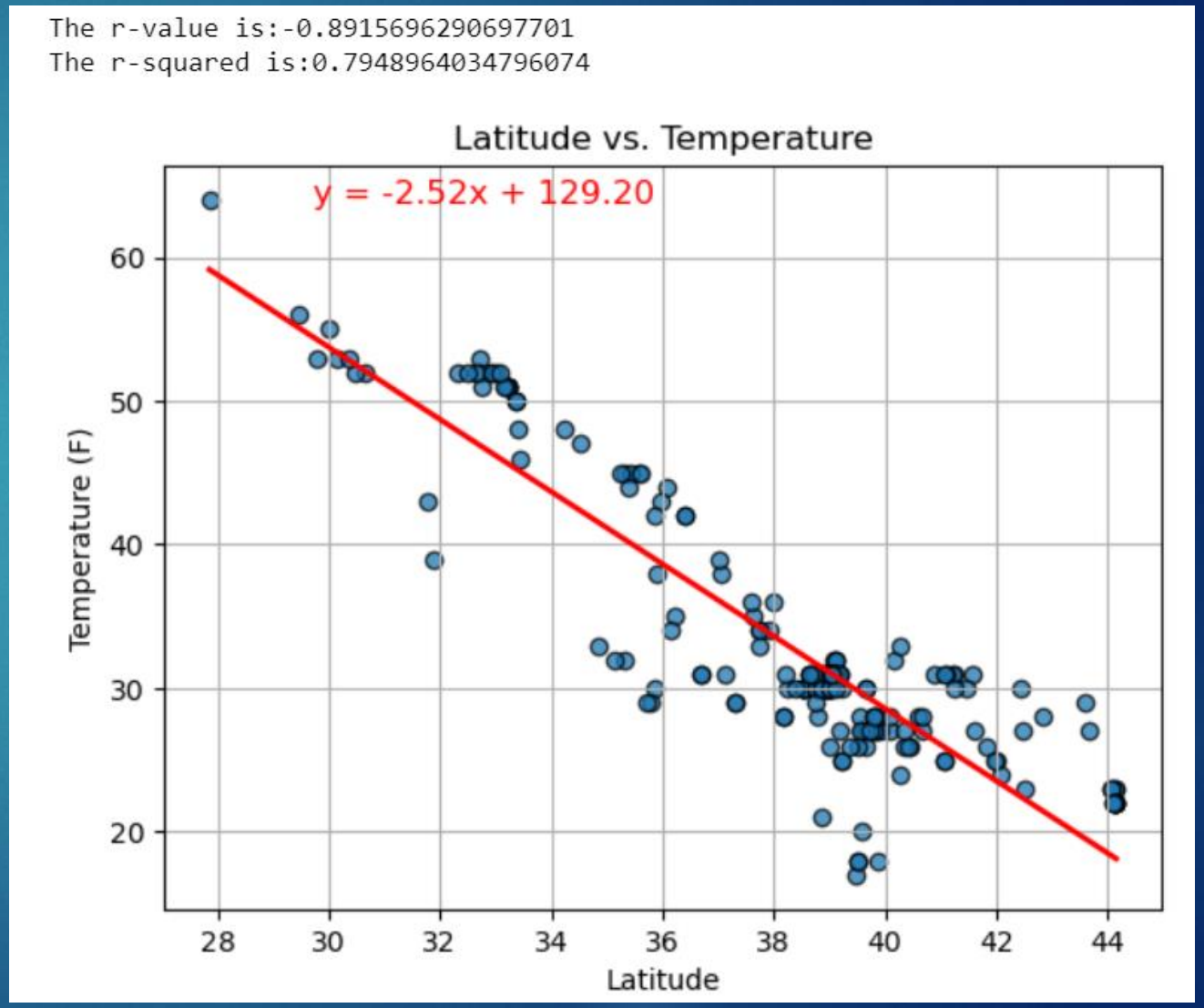
Latitude vs Windspeed

- *The plot shows the relationship between latitude and windspeed conditions provided in provided in the projects_weather_data.csv generated in the data prep.*
- *There is a weak to moderate (r-value -0.39) negative correlation between latitude and windspeed according to the scatter plot. The r-squared being 0.151 means that 15% of the target variance can be explained by the datasets.*



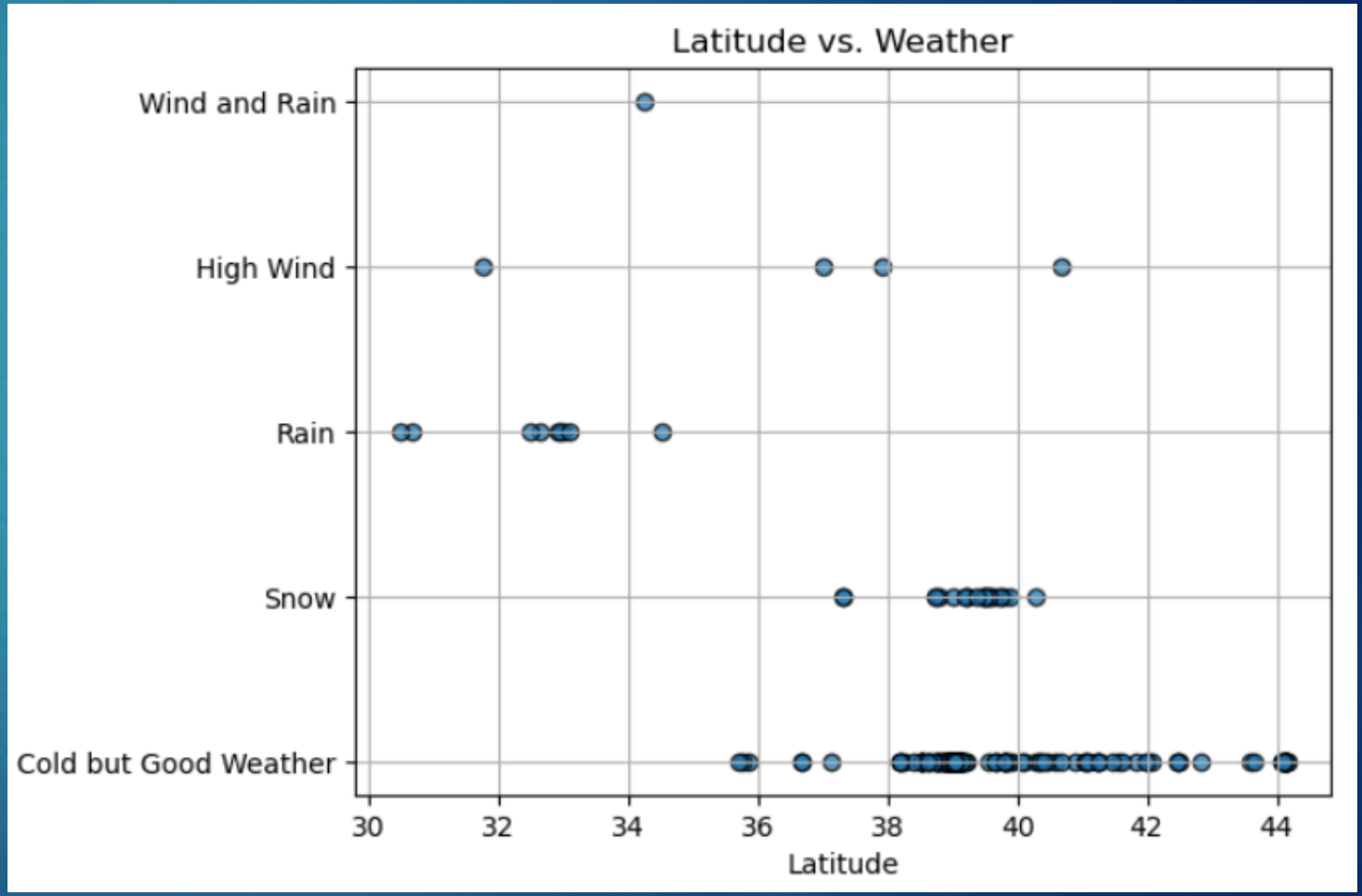
Latitude vs Temperature

- *The plot shows the relationship between latitude and temperature conditions provided in provided in the projects_weather_data.csv generated in the data prep.*
- *There is a strong negative correlation (r-value -0.89) between latitude and temperature according to the scatter plot. The r-squared being 0.79 means that 79% of the target variance can be explained by the datasets.*



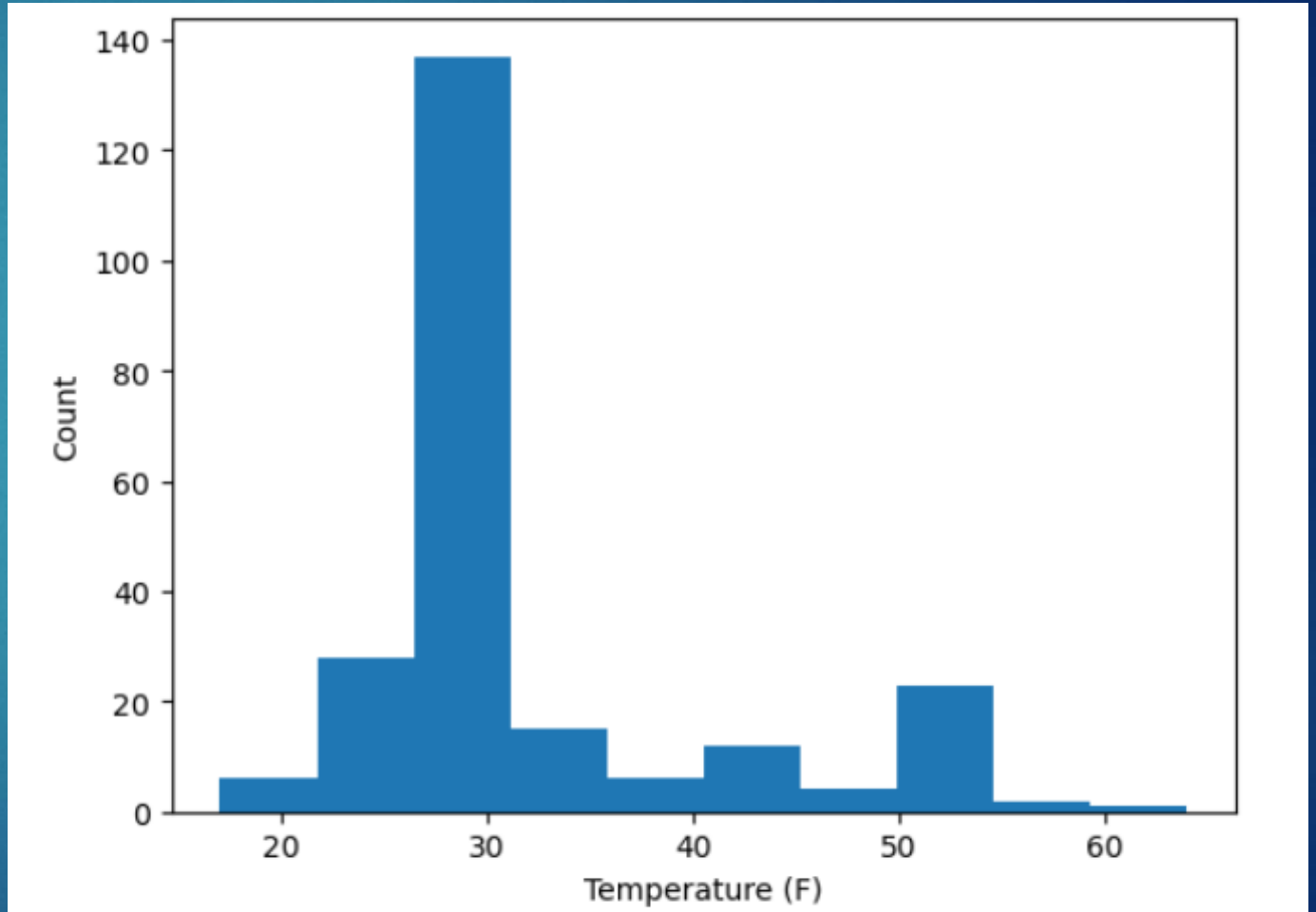
Latitude vs Weather

- *The chart shows the relationship between latitude and weather conditions provided in the Weather_5Day_Forecast.csv generated in the data prep.*
- *All projects between 30 to 35 degrees latitude had no snow and they were the only stations that recorded rainfall. The highest percentage concentration of good weather was recorded in projects located between 38 to 42 degrees latitude. It also recorded the highest percentage of projects that experienced a snow related weather. All projects located between 41 to 44 degrees latitude had cold but good weather, no snow, rain or high wind recorded. d]Both high wind and rain was only recorded between 30 – 35 degrees latitude.*



Summary Statistics for Temperature of all projects

```
Mean Temperature: 32.85470085470085
Median Temperature: 31.0
Mode Temperature: 0    31
Name: Temperature_F, dtype: int64
```




```
NormaltestResult(statistic=12.404931312848804, pvalue=0.0020244329214652644)
```

Conclusion

- *Latitude increases the number of weather days related to snow and extreme low temperatures.*
- *Latitude slightly increases the chance for weather days related to wind.*
- *The current mean temp for the 244 projects analyzed is 32.8 deg F.*
- *The 5 day forecast indicates inclement weather will impact construction schedules 45% of the time between 6am and 6pm.*

Project Assessment

- *We feel the project was extremely successful in identifying the usefulness of data analytics in construction specifically related to Weather Delays. However, to truly be a useful benefit for HME, we would need to examine the following:*
  - *Historical Weather patterns specific to project location during the timeframe the steel erection is scheduled.*
    - *Projected Weather Days could be used to predict additional costs related to weather in the estimate/bid.*
    - *If predecessor activities delay our erection schedule to a less desirable season we may be able to document weather related change order costs. I.E.*
      - *Winter conditions*
      - *Rainy Season*
    - *Seasonal Impacts could be addressed automatically in estimating software to include:*
      - *Additional equipment days related to Weather Days*
      - *Additional Per Diem days for employee living expenses*
      - *Additional days related to shortened workdays associated with daylight hours.*
  - *Daily weather conditions for the duration of the steel erection could be automatically documented and used to avoid:*
    - *Damages related to Schedule delays*
    - *Payment withholding*
    - *Lawsuits for delay of scheduled occupancy*
      - *I.E. Football Stadiums must be completed before the first home game.*