

# **US ACCIDENTS**

**BUSINESS SLIDES BY TEAM 17**

# BRIEF PROBLEM DESCRIPTION

Car accidents result in significant financial losses and threaten public safety. Although severe accidents are relatively rare, they often have the greatest impact—making their prevention essential. Our project seeks to answer:

**“What patterns contribute to serious car accidents, and how can we use this knowledge to improve road safety?”**

By examining millions of US accident records from 2016–2023, we aim to uncover key risk factors and interactions that lead to severe outcomes. The insights gained will help authorities make informed decisions, enhance road planning, and implement proactive measures to reduce the severity and impact of accidents.

# DATA VISUALIZATION & INSIGHTS

## 1. HOW DO WEATHER CONDITIONS, TIME OF DAY, AND ROAD FEATURES (E.G., TRAFFIC\_SIGNAL, JUNCTION) INTERACT TO INFLUENCE ACCIDENT SEVERITY ACROSS DIFFERENT STATES?

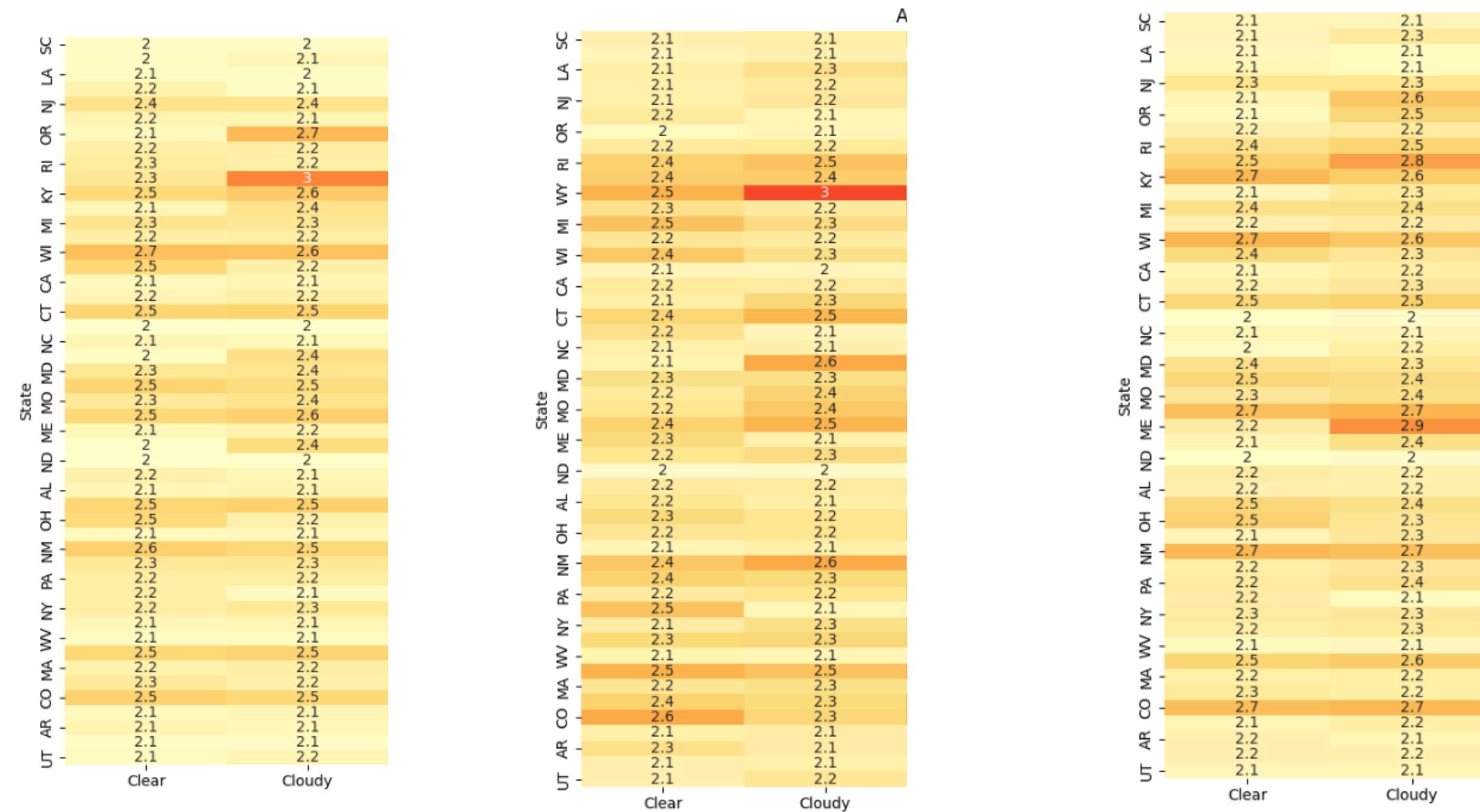
- **Clear & Cloudy:**
  - Generally associated with lower accident severity.
- **Morning vs Night in General:**
  - Lead to higher severity accidents across most states.
- **Snowy & Rainy Nights:**
  - Severity peaks during nighttime under these conditions.
- **Traffic Signals:**
  - Accidents involving traffic signals show higher severity at all times.
- **Junctions:**
  - Higher severity observed in evening and night accidents at junctions.

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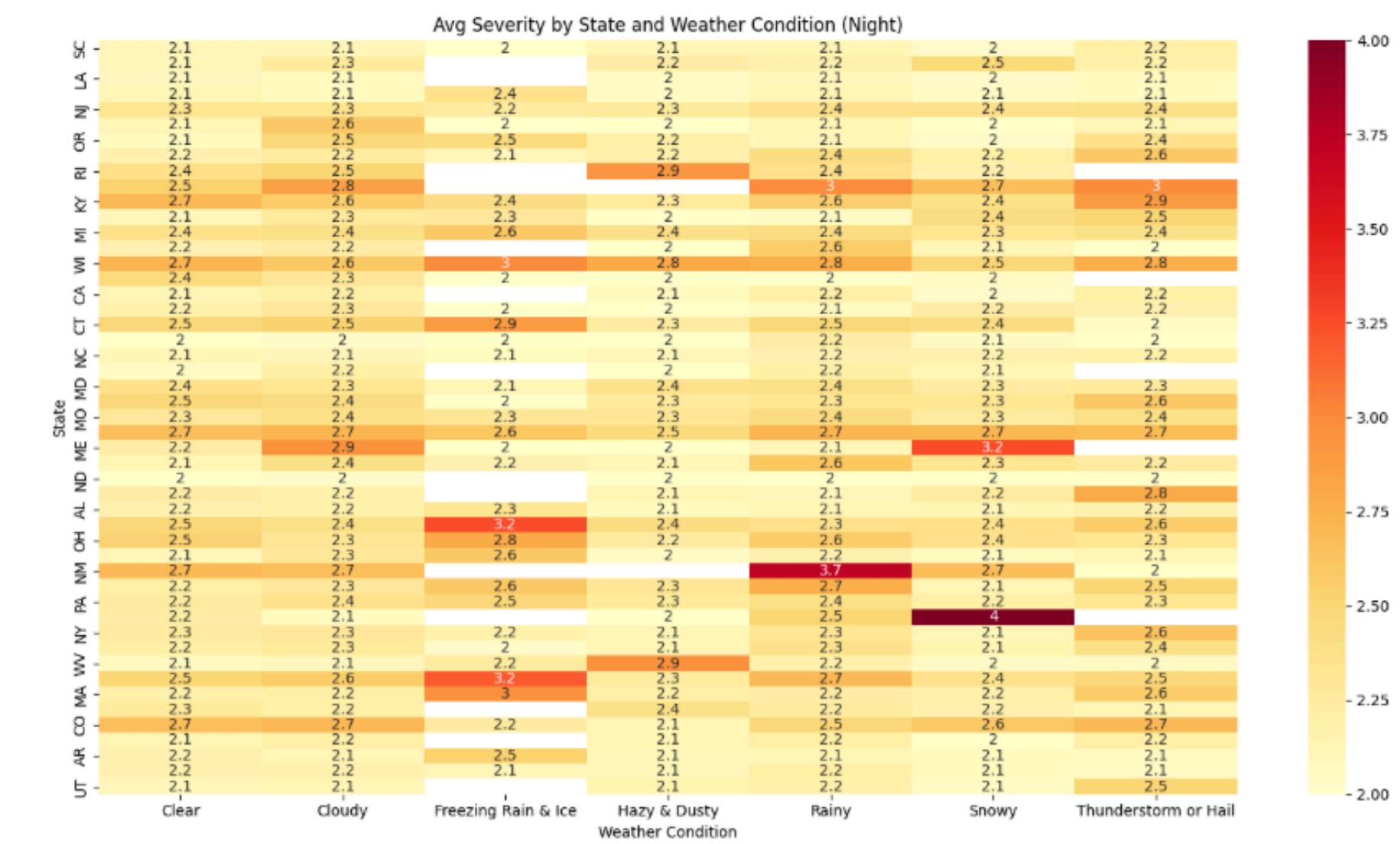
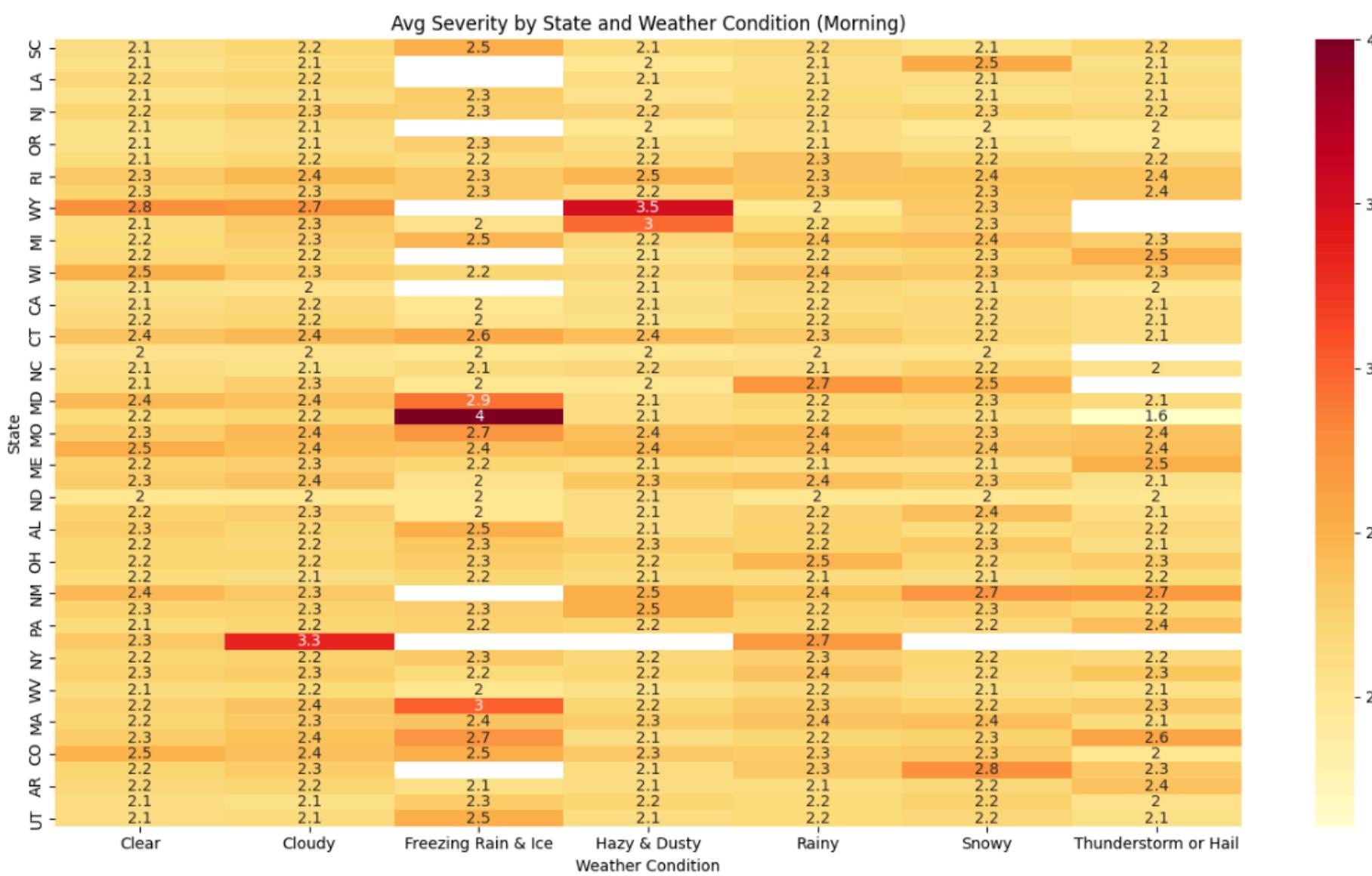
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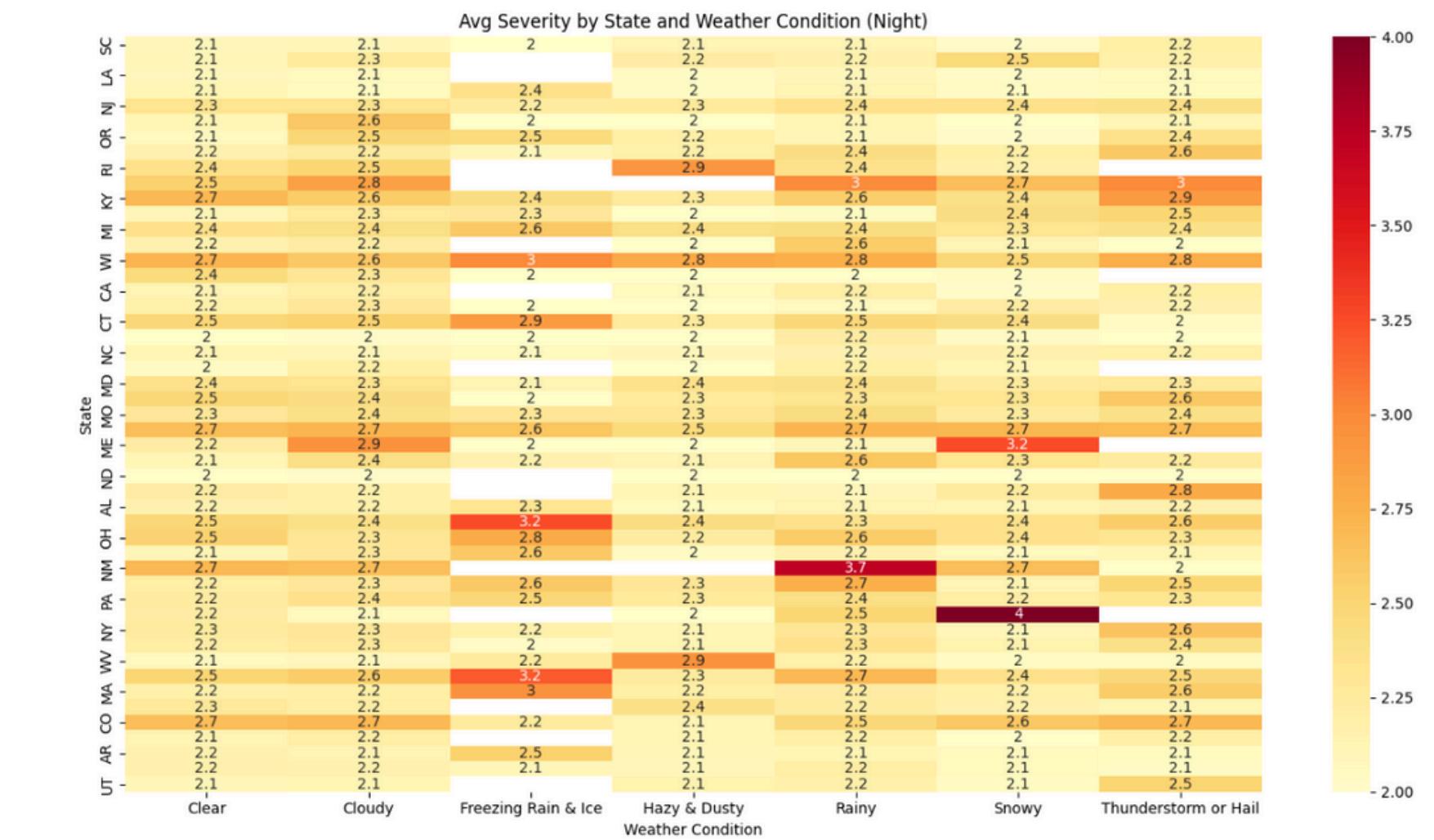
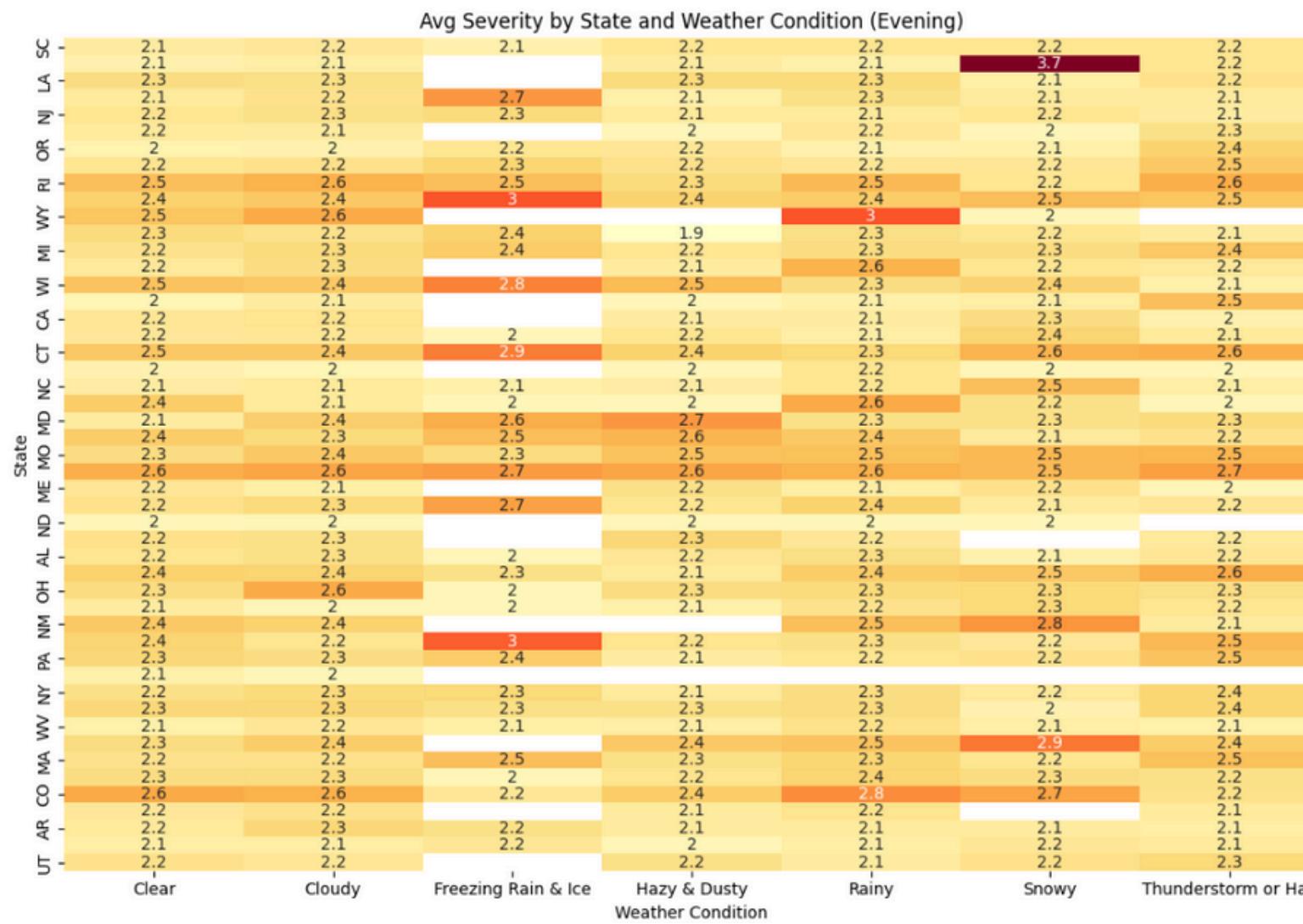
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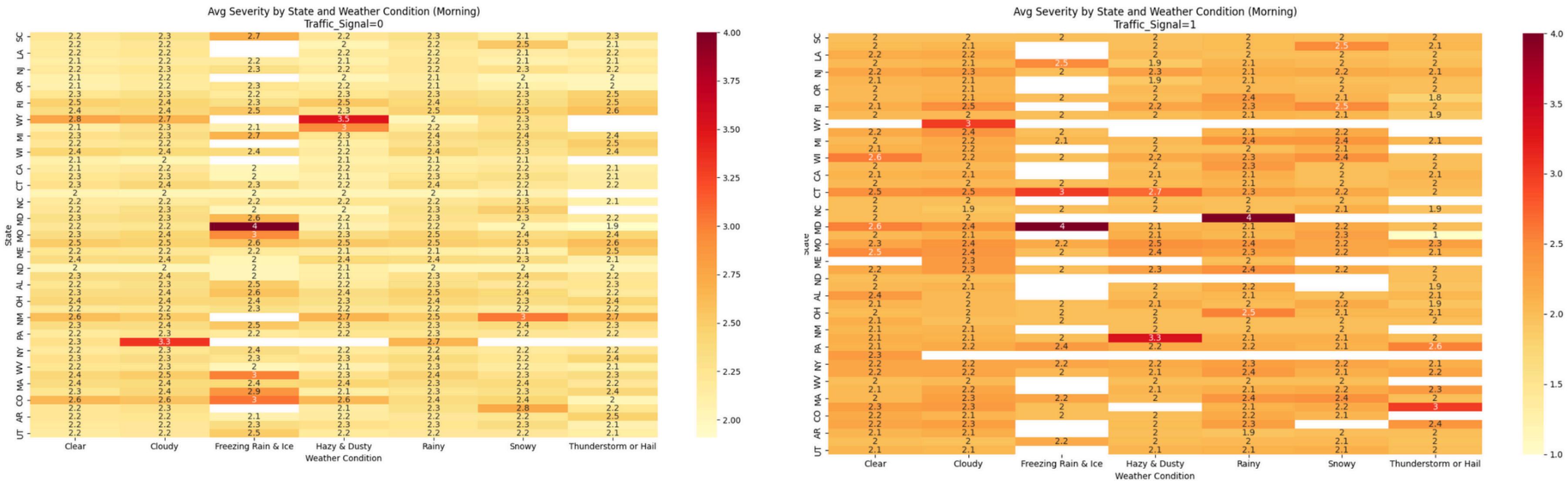


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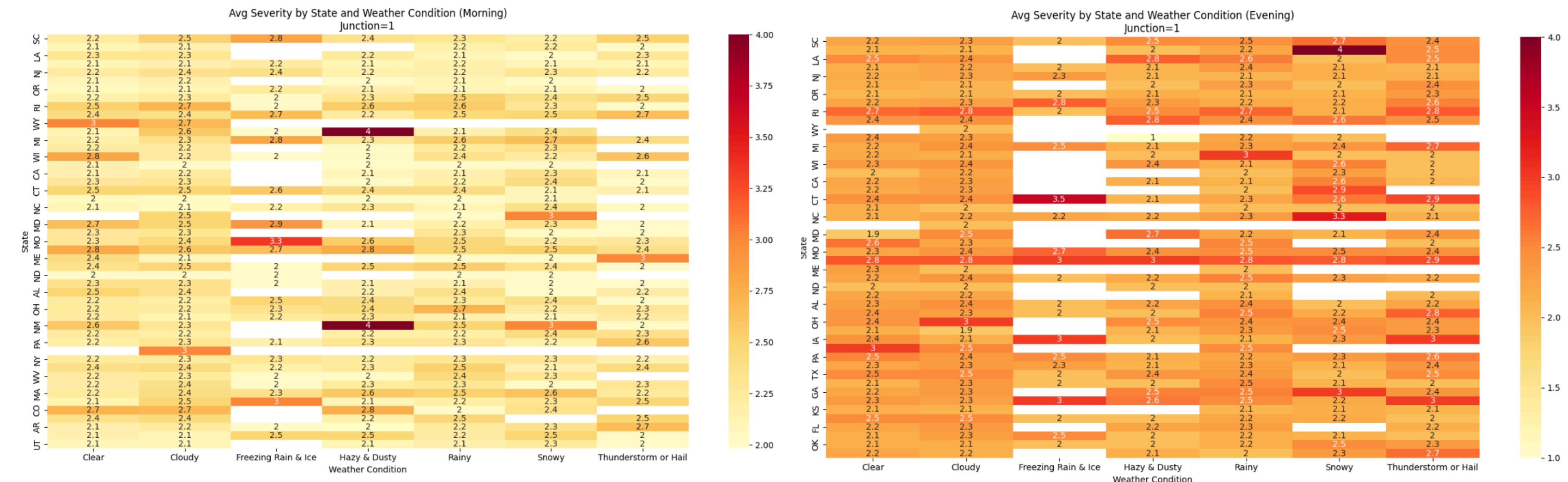


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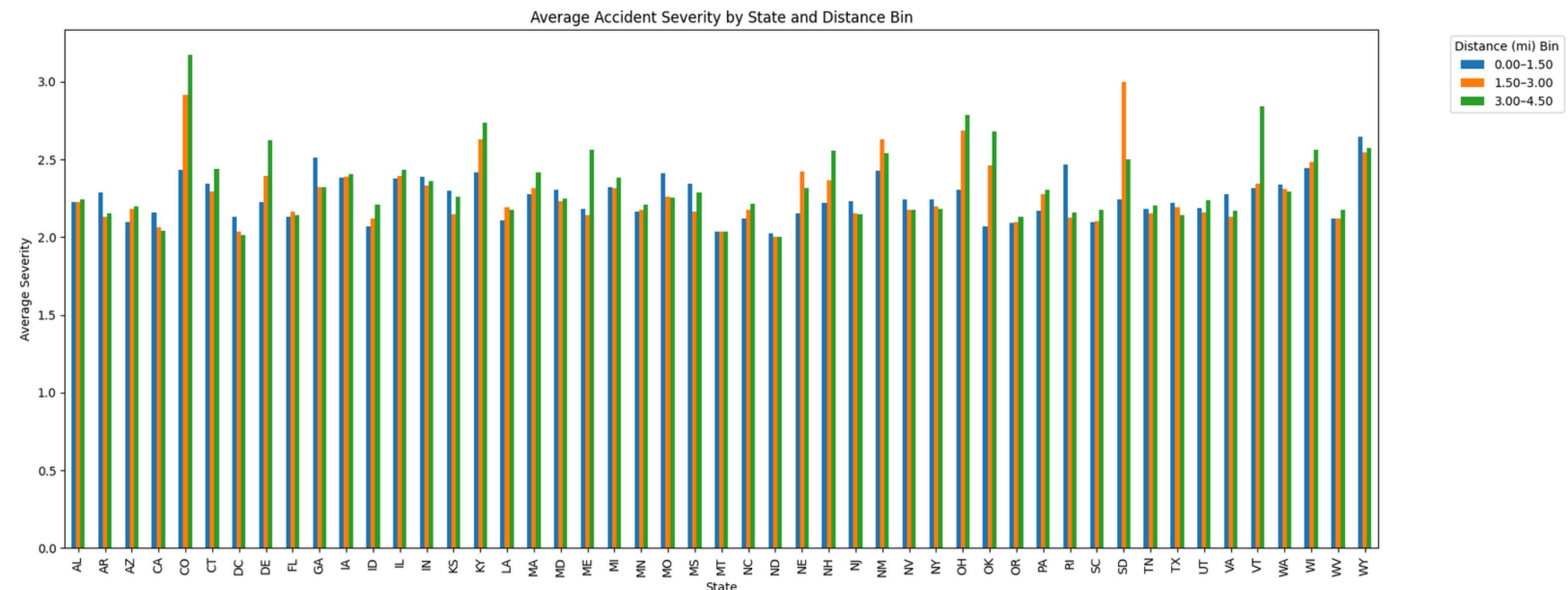
- Higher severity observed in evening and night accidents at junctions



# DATA VISUALIZATION & INSIGHTS

## 2. ARE LONGER ACCIDENTS (BY DISTANCE) MORE SEVERE IN CERTAIN STATES OR CITIES?

- **Distance(mi)** = Length of road extent affected by the accident in miles.
- **Impact:** Identifies high-risk zones where longer road extents correlate with higher severity.
- **Insight:** Enables targeted interventions:
  - Speed regulations and road design improvements
  - Enhanced emergency response for longer highway extents such as Colorado State

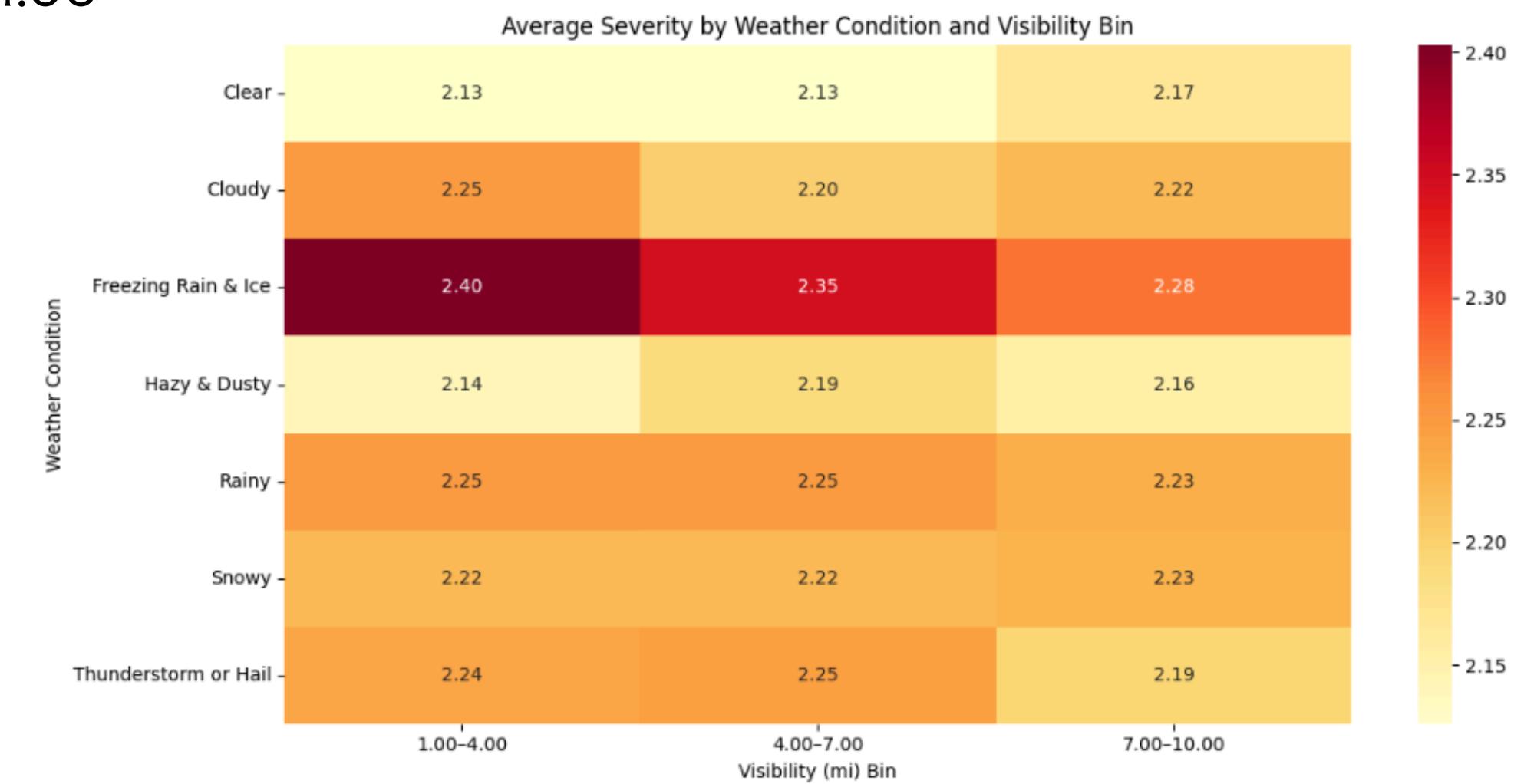
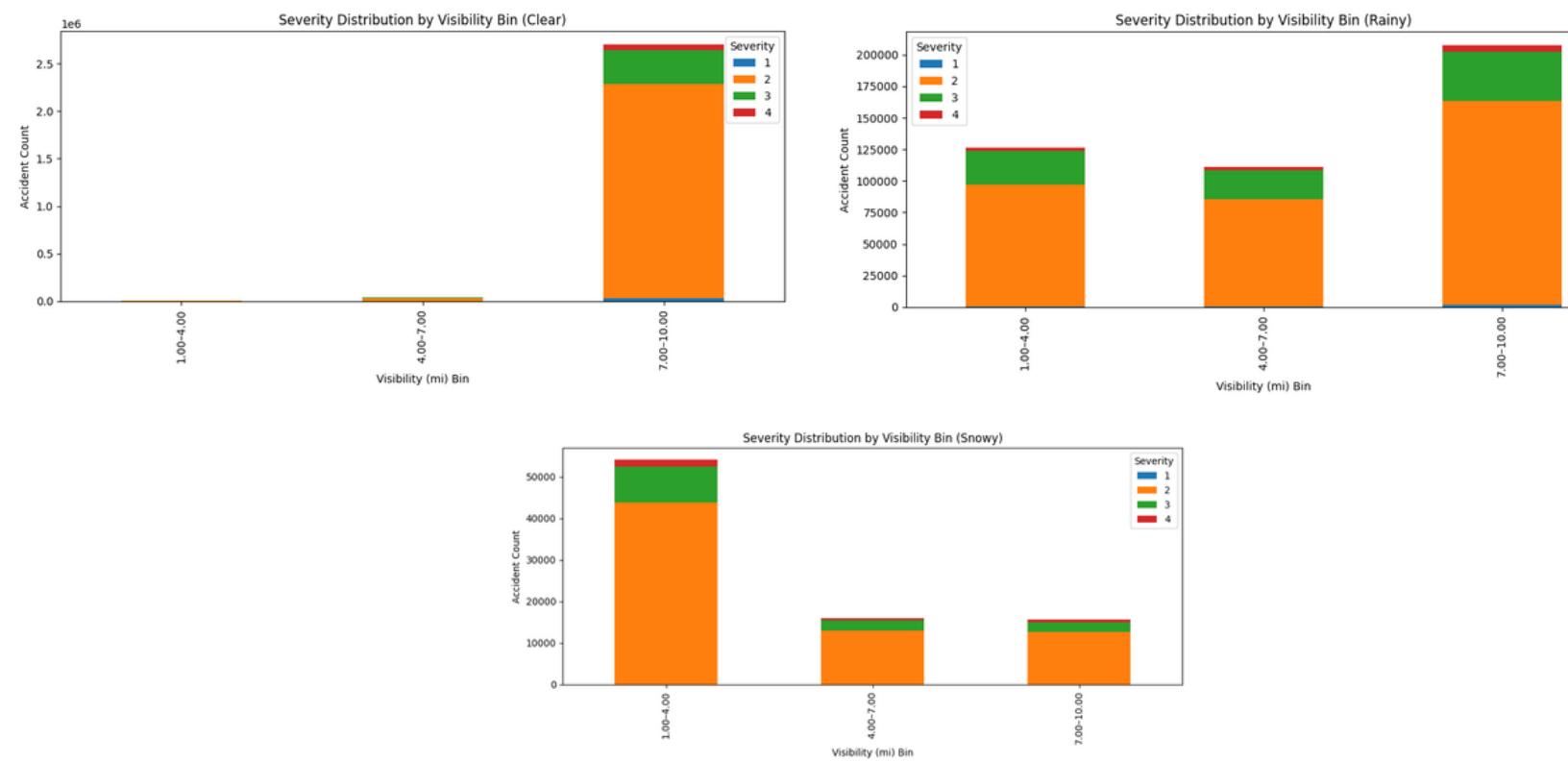


Most of states: blue → yellow → green  
(Severity proportional with Distance)

# DATA VISUALIZATION & INSIGHTS

## 3. WHAT IS THE RELATIONSHIP BETWEEN VISIBILITY CONDITIONS AND ACCIDENT FREQUENCY/SEVERITY DURING DIFFERENT WEATHER TYPES?

- Key Insight:** Lower visibility (1.00–4.00 mi) increases severity in adverse weather.
- Freezing Rain & Ice:** Highest severity (2.40).
- Rainy:** Severity (2.25); high frequency at 1.00–4.00 mi (~1.25M) and 7.00–10.00 mi (~1.75M).
- Snowy:** Most accidents at 1.00–4.00 mi (~450k); rise in severity 3 and 4.
- Clear Weather:** High visibility (7.00–10.00 mi, ~2.5M accidents); stable severity (~2).
- Business Value:**
  - Implement dynamic warning systems when visibility < 4.00 mi in Freezing Rain & Ice or Snowy conditions.

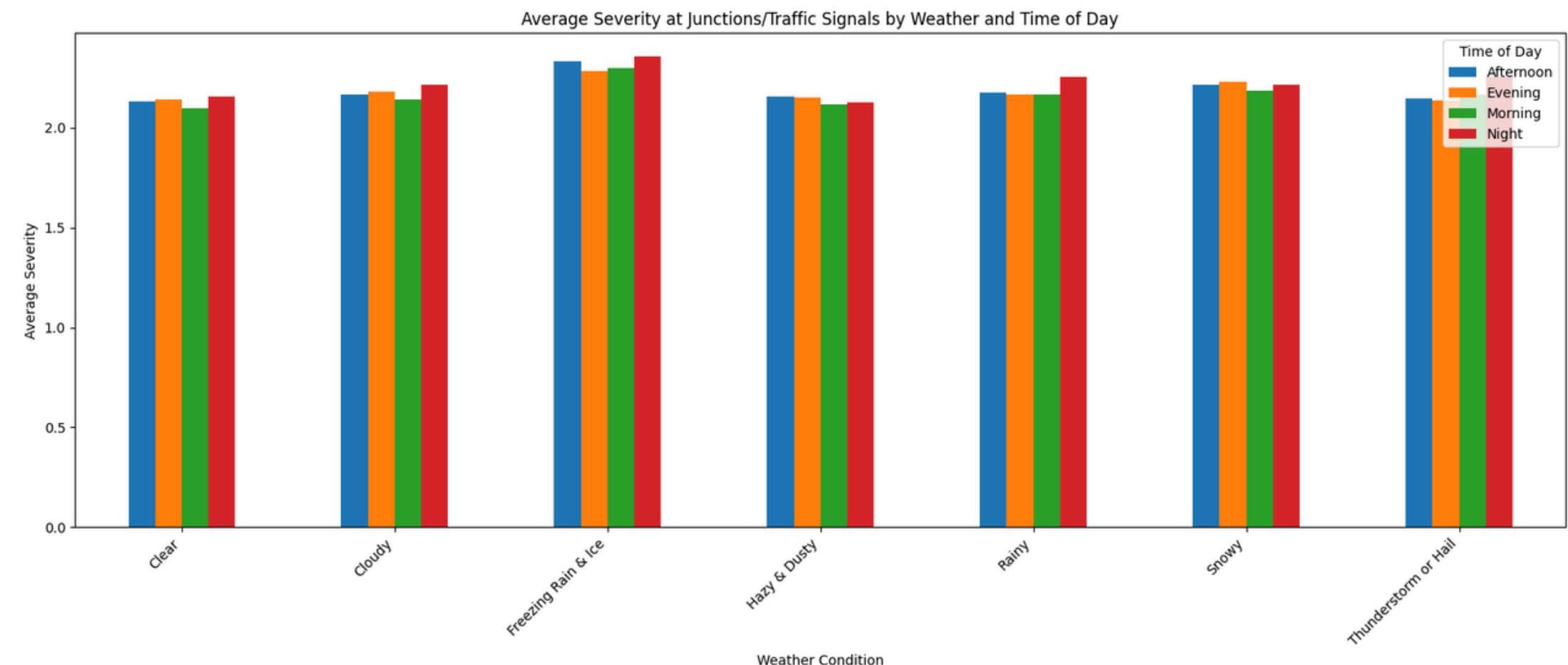


# DATA VISUALIZATION & INSIGHTS

## 4. DO CERTAIN ROAD FEATURES (E.G., JUNCTION, TRAFFIC\_SIGNAL) CORRELATE WITH HIGHER ACCIDENT SEVERITY UNDER SPECIFIC WEATHER OR TIME CONDITIONS?

- **Key Insight:** Severity peaks at junctions/traffic signals during:
  - **Freezing Rain & Ice & Thunderstorm:** Night
  - **Snowy:** Uniform severity across all times; consistent hazards.
  - **Morning:** Lowest severity in most cases.

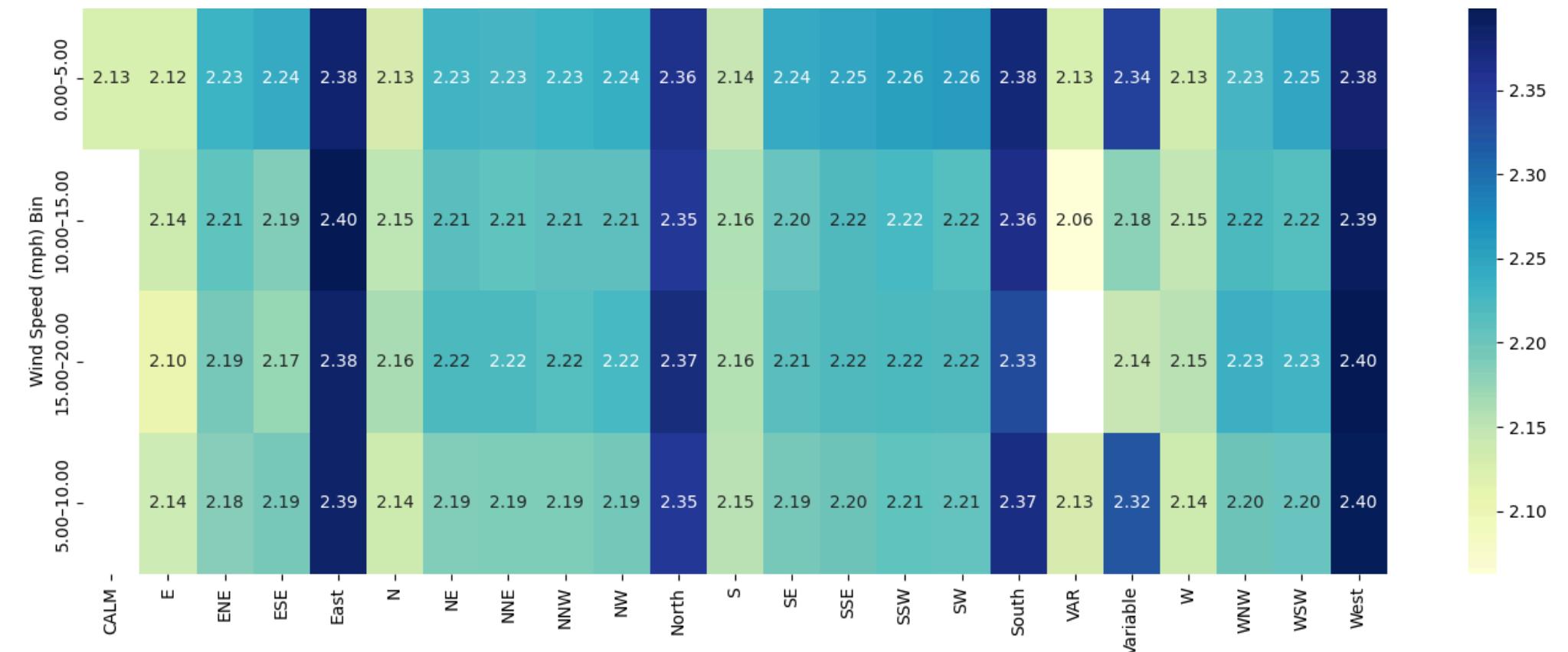
- **Business Value:** Enhance infrastructure:  
better lighting, dynamic signal adjustments.
  - Prioritize Night improvements during adverse weather (e.g., Freezing Rain & Ice, Thunderstorm).
  - Apply consistent measures (e.g., de-icing) for Snowy conditions.



# DATA VISUALIZATION & INSIGHTS

## 5. HOW DOES ACCIDENT SEVERITY CHANGE WITH WIND SPEED AND DIRECTION?

- **Key Insight:**
  - Wind speed and direction have minimal impact on accident severity (2.10–2.40 range). Other factors like road conditions or driver behavior likely play a larger role.
- **Business Value:**
  - Focus on general safety enhancements in high-risk areas: improve signage, lighting, and traffic monitoring, regardless of wind conditions.



# DATA VISUALIZATION & INSIGHTS

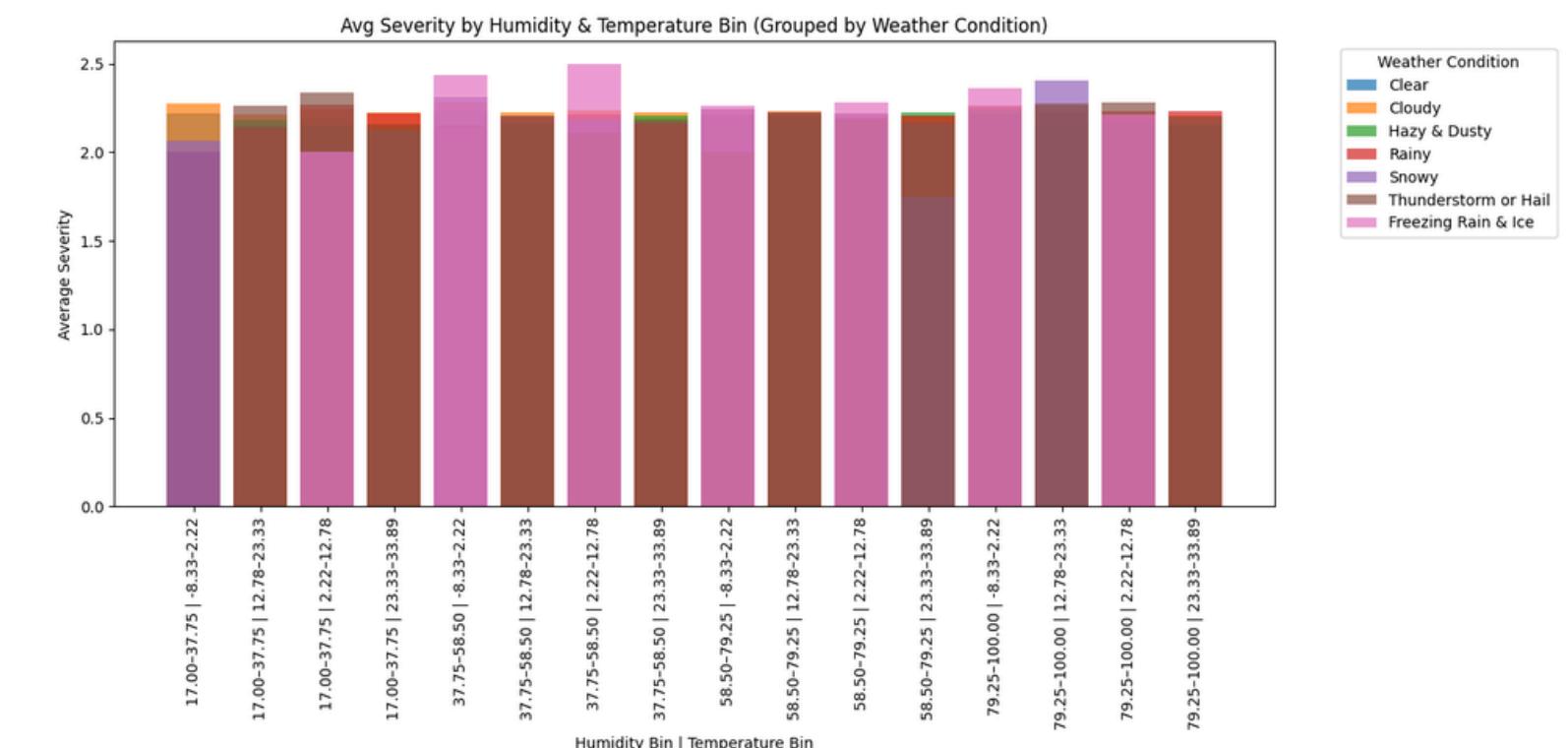
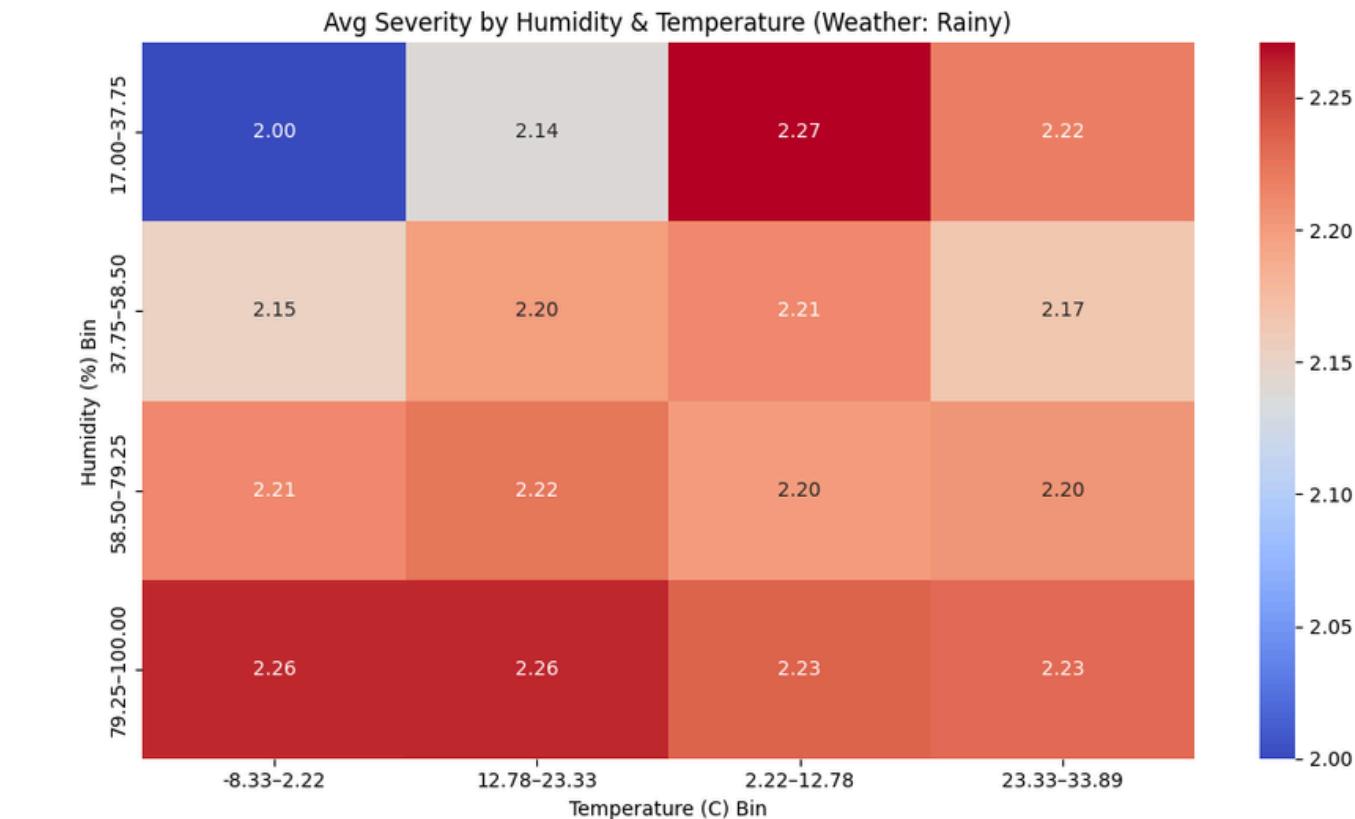
## **6. ARE THERE PATTERNS IN ACCIDENT SEVERITY BASED ON HUMIDITY, TEMPERATURE, AND WEATHER CONDITION COMBINATIONS?**

- **Key Insight:**

- High humidity (79.25–100.00%) in Rainy conditions Severity (2.23–2.26); peaks at colder temps (-8.33–12.78°C, 2.26); risks from wet roads/reduced visibility.
  - Freezing Rain & Ice: Highest severity (~2.45) at 17.00–37.75% humidity, 12.78–23.33°C; hazardous due to unexpected ice formation.
  - Low humidity (17.00–37.75%) with moderate temps (12.78–23.33°C): Elevated severity in Rainy (2.27) and Freezing Rain & Ice (2.45).

## • Business Value:

- Target high humidity/colder temps in Rainy and icy conditions for risk mitigation.

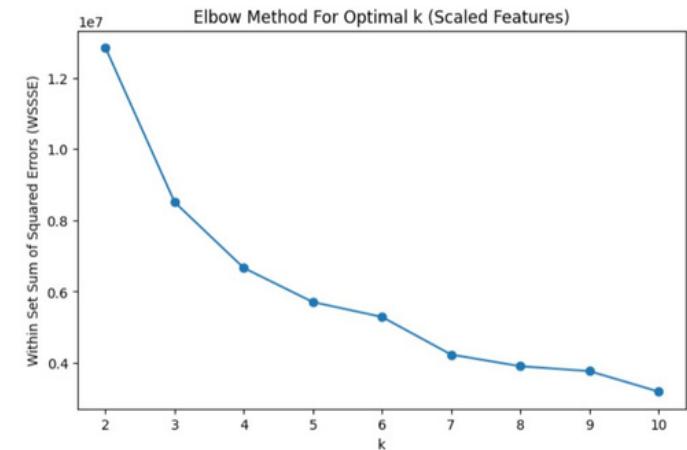


# DATA VISUALIZATION & INSIGHTS

## 6. CLUSTERING QUESTION: HOW DO ACCIDENTS IN THE UNITED STATES CLUSTER BASED ON ENVIRONMENTAL FACTORS SUCH AS TEMPERATURE, HUMIDITY, AND ACCIDENT SEVERITY? WHAT PATTERNS CAN WE OBSERVE REGARDING WEATHER CONDITIONS AND THE SEVERITY OF ACCIDENTS?

- **Key Insight:**

- Cluster 1 (Red): moderate severity; warm, dry regions.
- Cluster 2 (Green): highest severity; urban Southeast/Midwest.
- Cluster 3 (Blue): moderate severity; Northeast/Midwest, winter risks.
- Cluster 4 (Orange): low severity; humid tropics (FL, Gulf Coast).

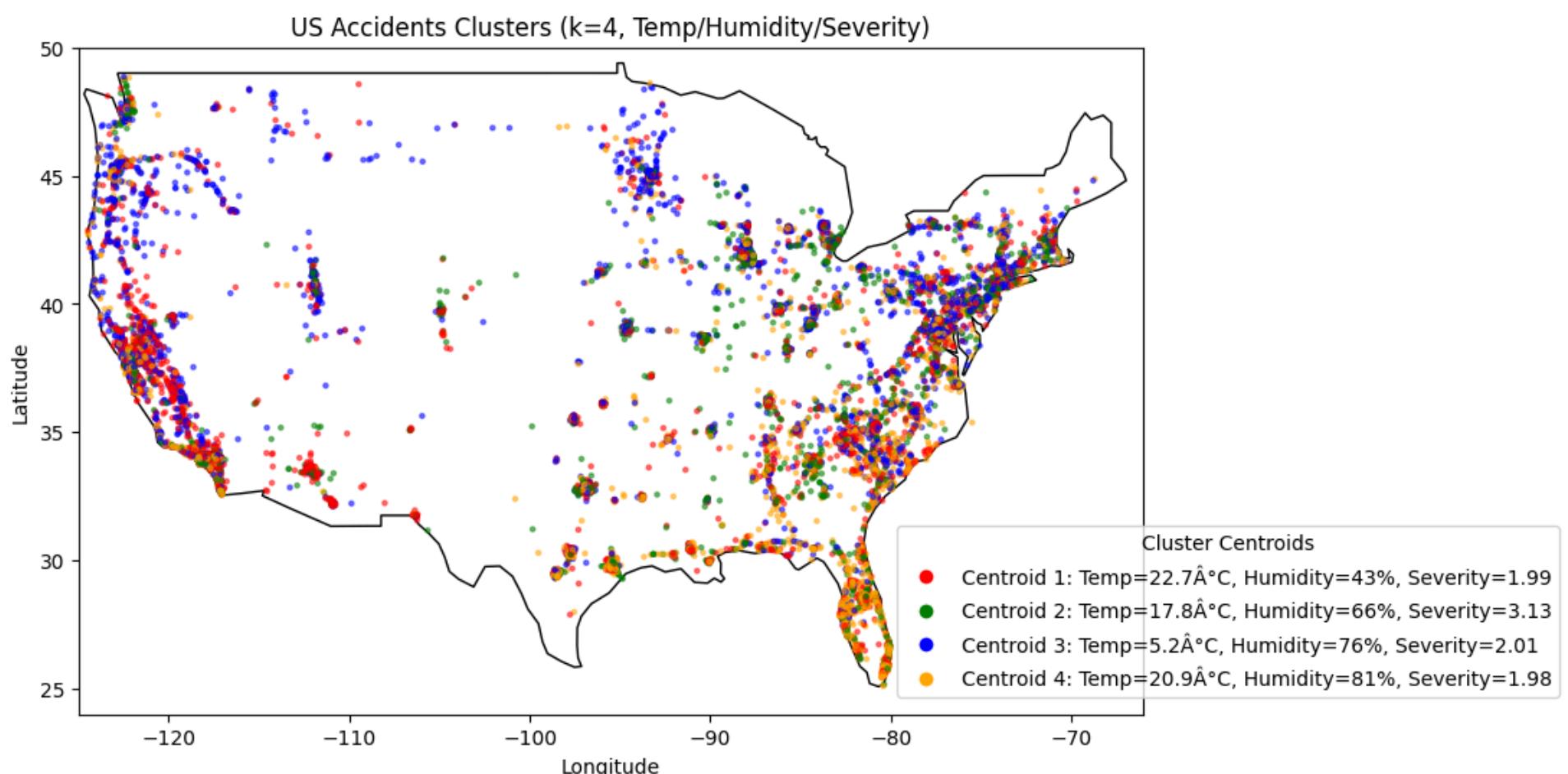


- **General Pattern:**

- High-density regions driven by traffic volume link to highest severity.

- **Business Value:**

- Target safety measures for moderate weather in urban areas.



# DATA VISUALIZATION & INSIGHTS

## 7. WHICH COMBINATIONS OF ENVIRONMENTAL FACTORS AND ACCIDENT CHARACTERISTICS ARE MOST ASSOCIATED WITH PROLONGED ACCIDENTS?

- **Key Insight:**

- Low visibility (0.00–4.00 mi) + cold temps (-8.33–2.22°C) + moderate severity (2.0–2.5): Longest durations (8,000–16,000 secs); hazardous conditions delay resolution of accident.
- Long distances (10.00–11 mi) + low visibility + cold temps: Durations up to 16,000 secs; challenges for emergency response.

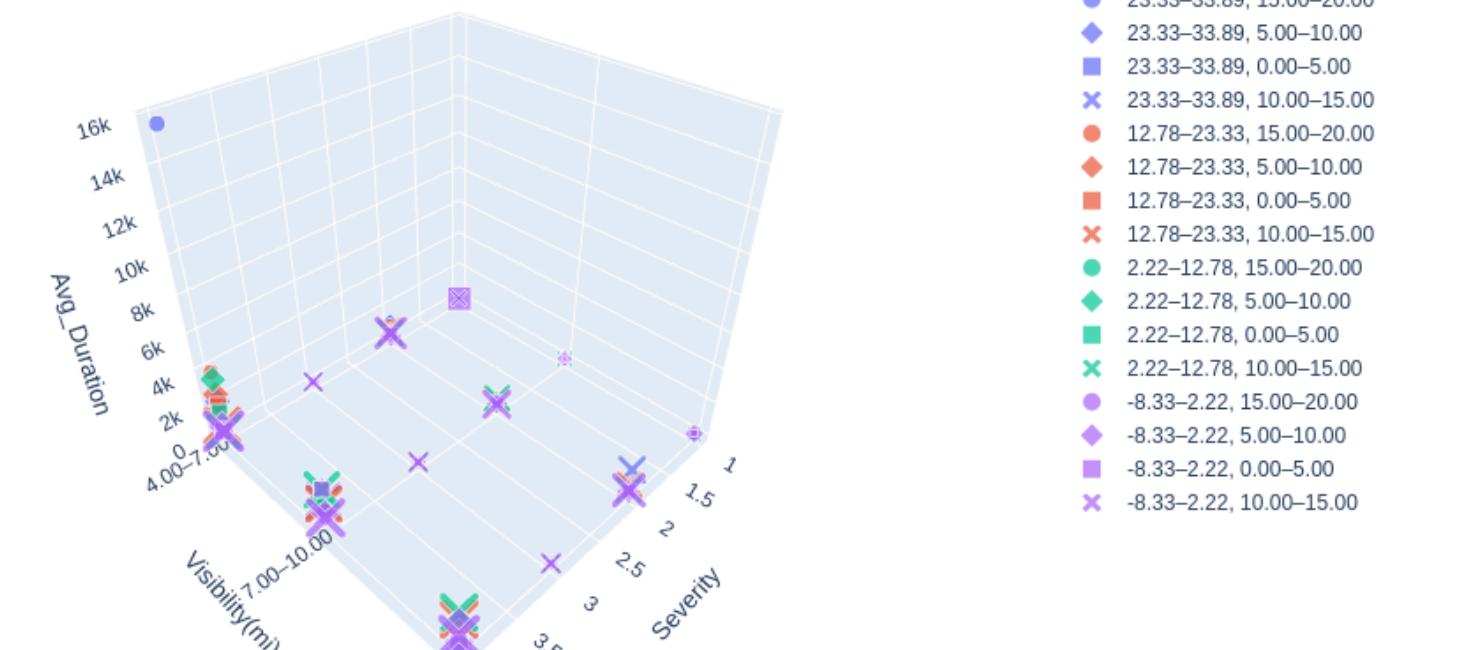
- **Severity-Duration Correlation:**

- Moderate (0.347); longest durations at moderate severity (2.0–2.5), driven by visibility/distance.
- Cold temps (-8.33–2.22°C) + low visibility: Higher severity and longer durations.
- Warm temps (23.33–33.89°C) + high visibility (7.00–10.00 mi): Shorter durations (0–4,000 secs); faster resolution.

- **Business Value:**

- Optimize emergency response and reduce congestion.
- Prioritize resources for cold, low-visibility scenarios with long distances.

Accident Duration by Severity, Visibility, Temperature, Wind



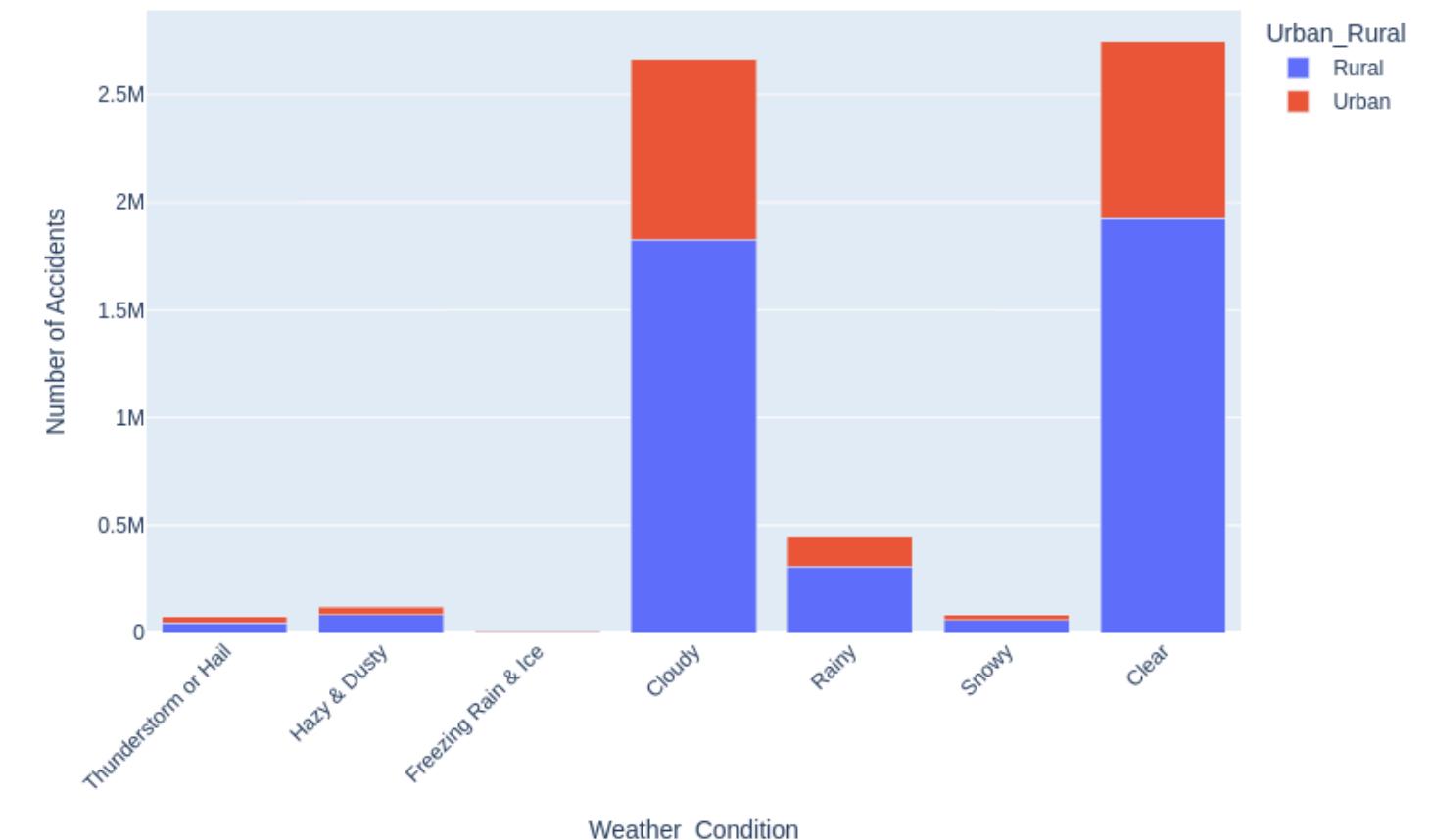
# DATA VISUALIZATION & INSIGHTS

## 8. WHAT IS THE COMBINED IMPACT OF WEATHER AND URBAN/RURAL(INTERNAL DATASET) SETTINGS ON ACCIDENT SEVERITY AND FREQUENCY?

### Key Insight:

- Severity: Freezing Rain & Ice increases severity; rural (~3.0) > urban (~2.5); rural roads riskier during icy conditions.
  - Frequency: Rural areas have more accidents overall, despite urban areas showing higher counts in Clear/Cloudy conditions (~1.5M each, urban).
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- Business Value:
    - Prioritize rural safety: improve road conditions to reduce severity and frequency of accidents.

Accident Frequency by Weather Condition and Setting



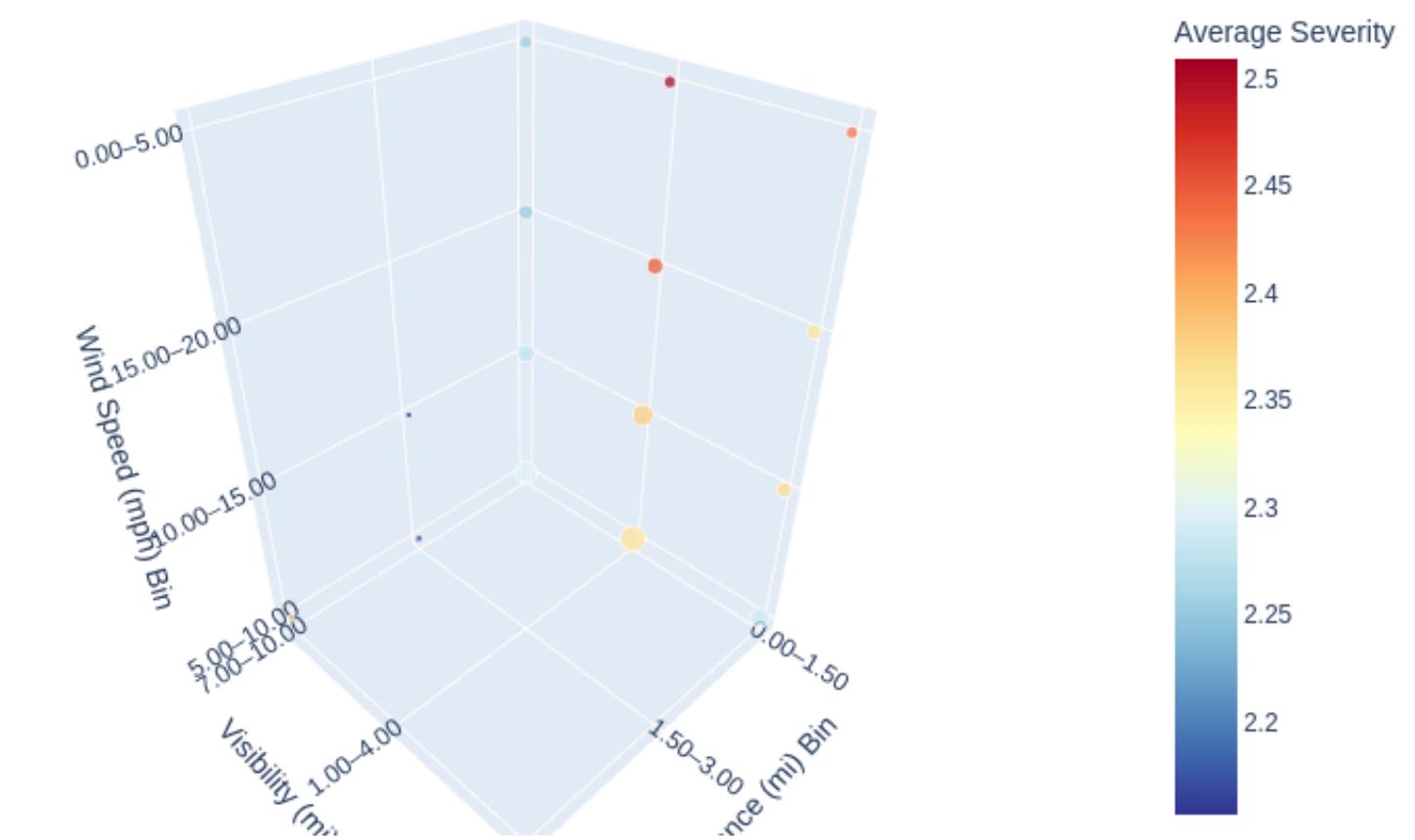
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## 9. HOW DOES THE COMBINATION OF DISCRETIZED DISTANCE(MI), VISIBILITY(MI), AND WIND\_SPEED(MPH) AFFECT ACCIDENT SEVERITY DURING SPECIFIC WEATHER CONDITIONS (E.G., RAIN, SNOW)?

- **Key Insight:**

- Freezing Rain & Ice: Highest severity (2.5); low visibility (1.00–4.00 mi), high wind speed (15.00–20.00 mph), longer distances (1.50–3.00 mi).

Severity by Distance, Visibility, Wind Speed (Freezing Rain & Ice)



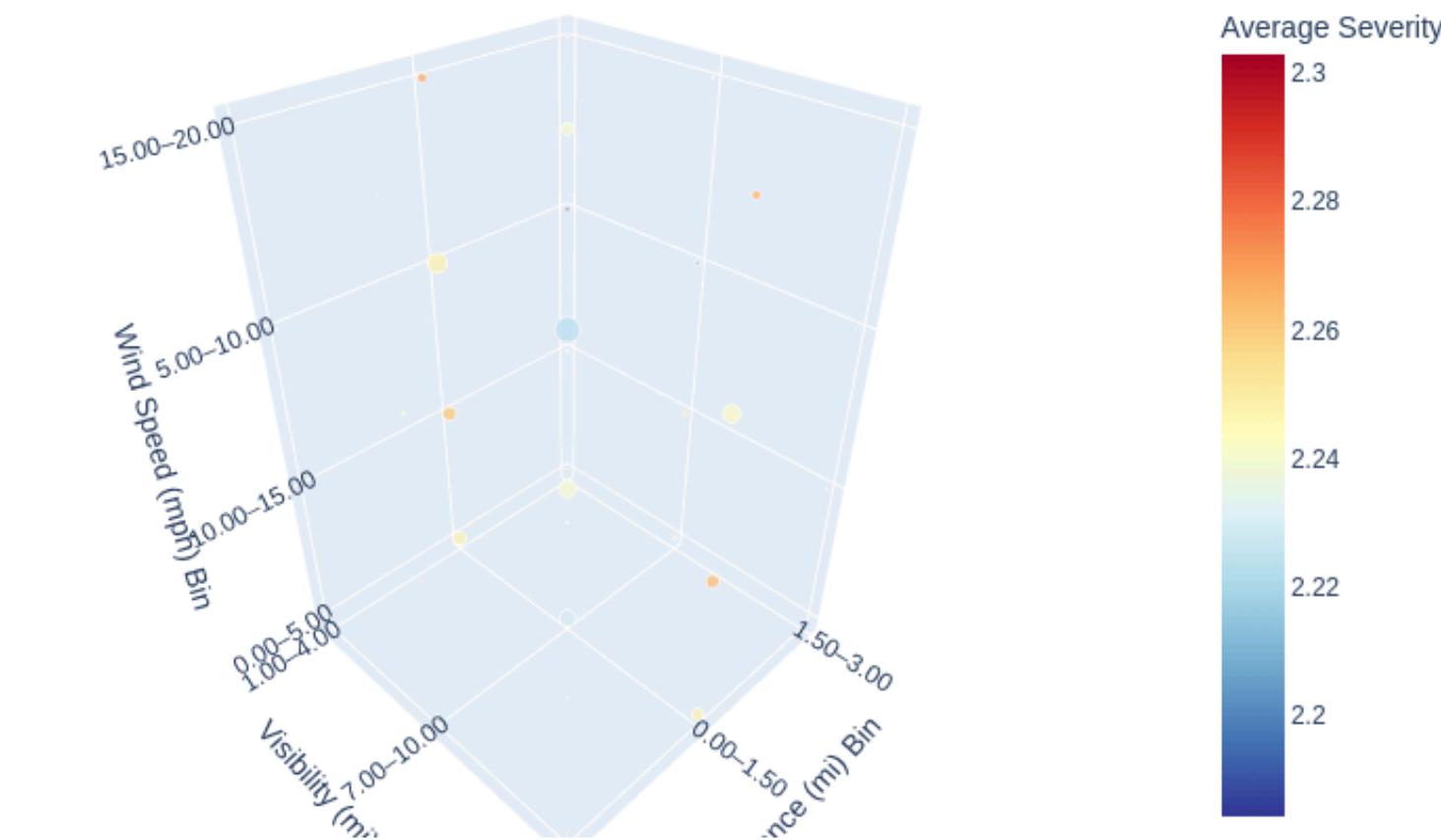
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- Key Insight:

- Rainy: Severity (2.3); low visibility (1.00–4.00 mi), moderate wind (5.00–10.00 mph), short distances (0.00–1.50 mi).

Severity by Distance, Visibility, Wind Speed (Rainy)



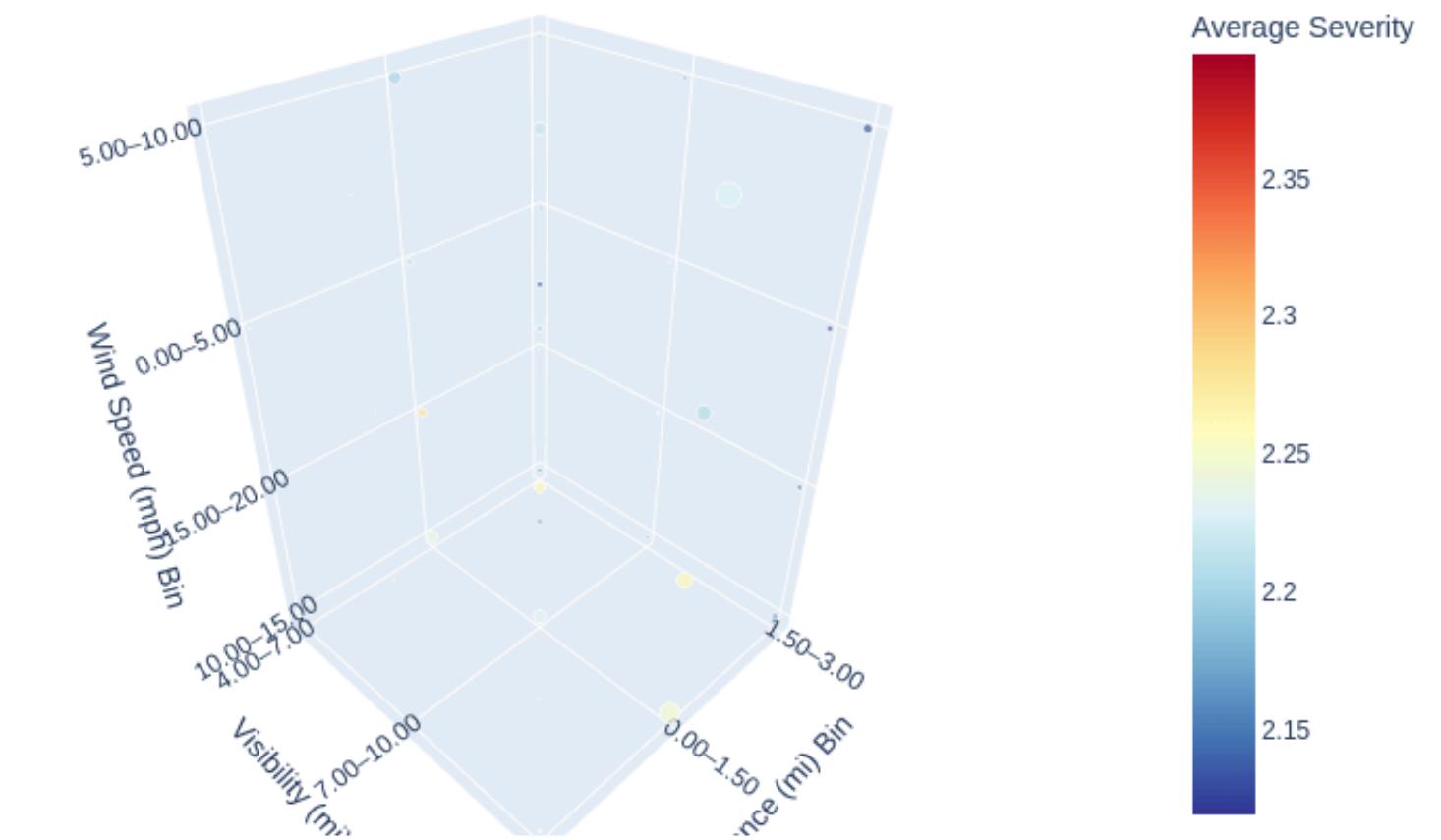
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- **Key Insight:**

- Snowy: Severity (2.35); low visibility, higher wind (10.00–15.00 mph), short distances.

Severity by Distance, Visibility, Wind Speed (Snowy)



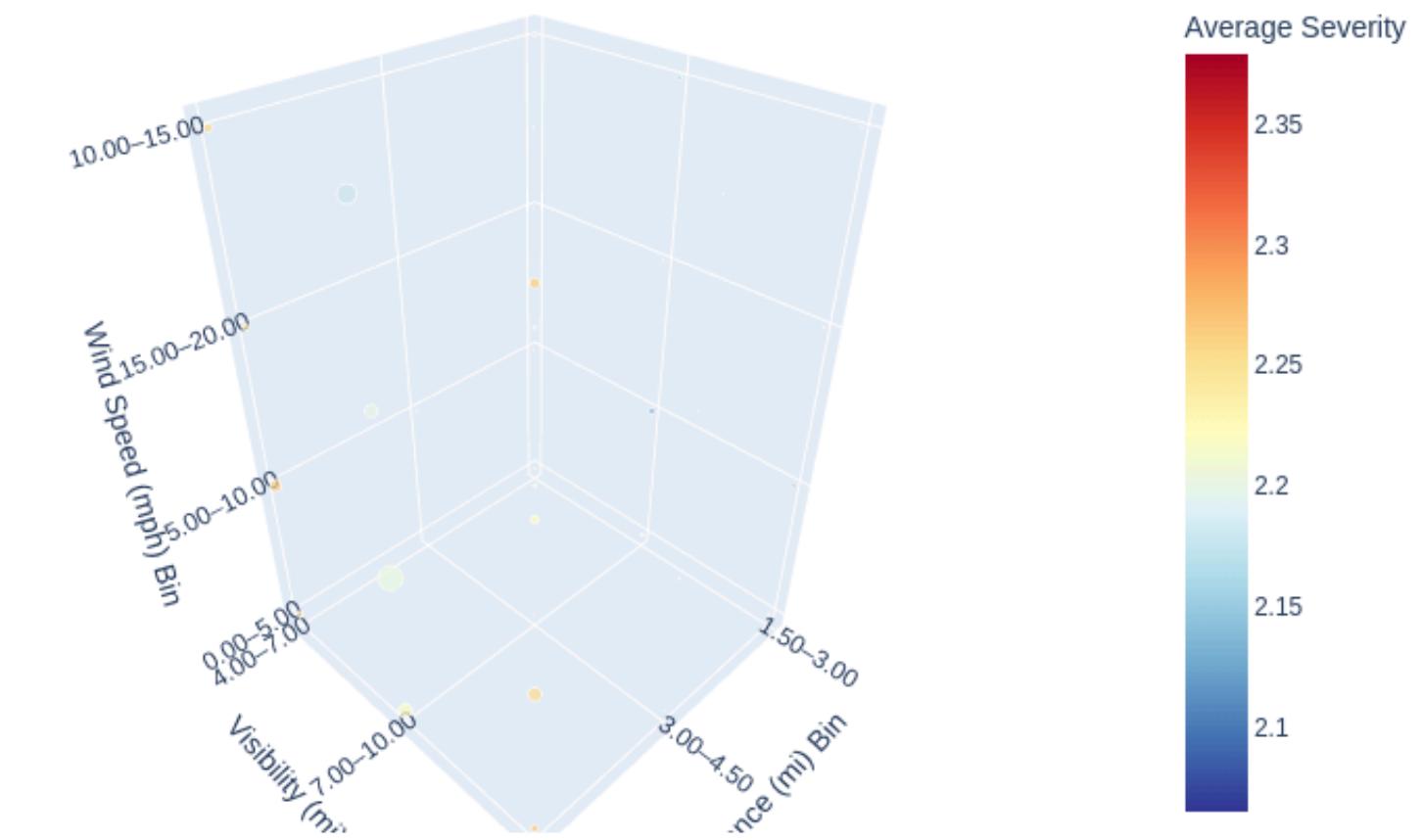
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- **Key Insight:**

- Thunderstorm or Hail: Severity (2.35); low visibility, high wind, short distances.

Severity by Distance, Visibility, Wind Speed (Thunderstorm or Hail)



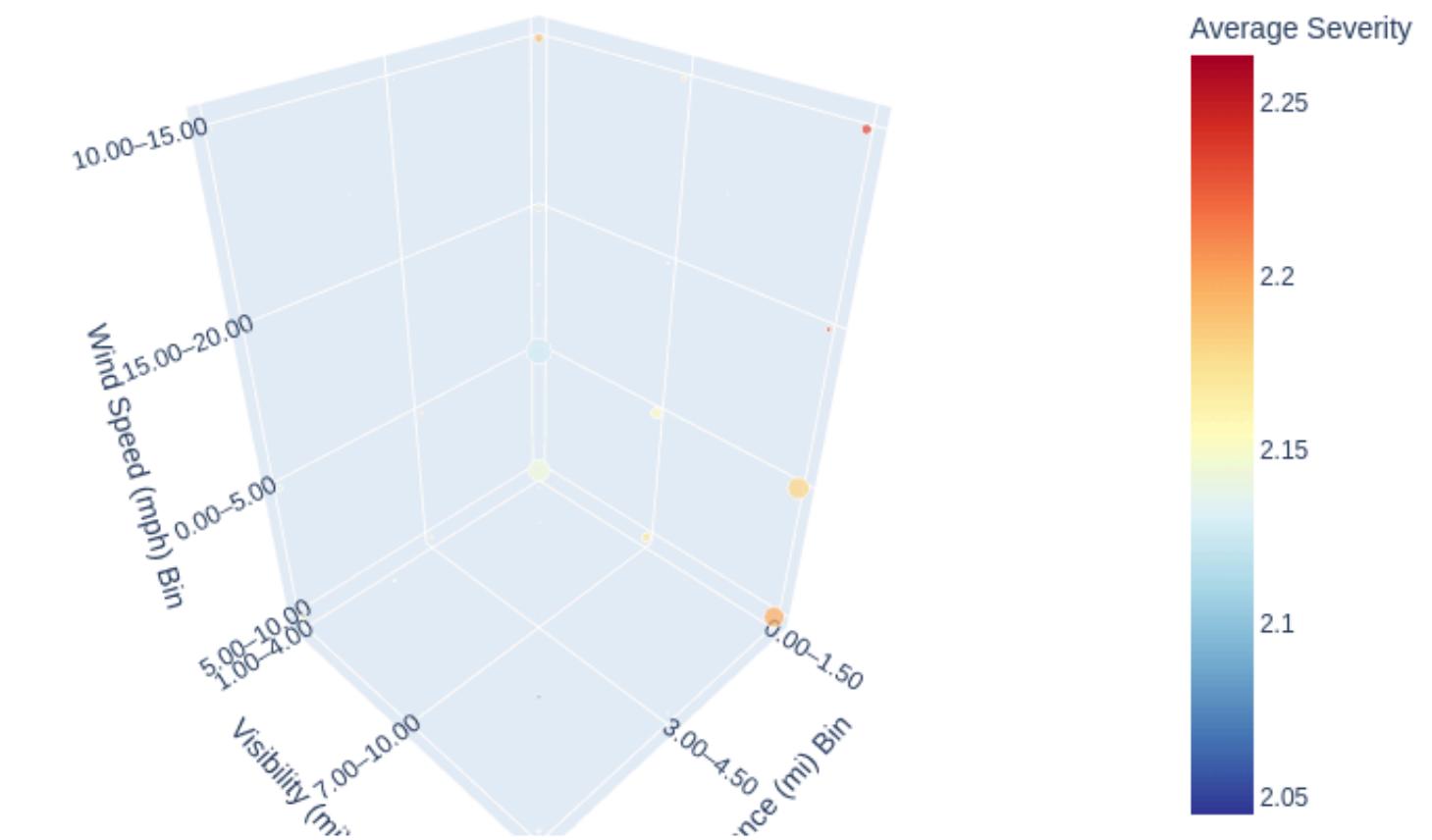
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- Key Insight:

- Hazy & Dusty: Severity (2.25); very low visibility, moderate wind, short distances.

Severity by Distance, Visibility, Wind Speed (Hazy & Dusty)



# DATA VISUALIZATION & INSIGHTS

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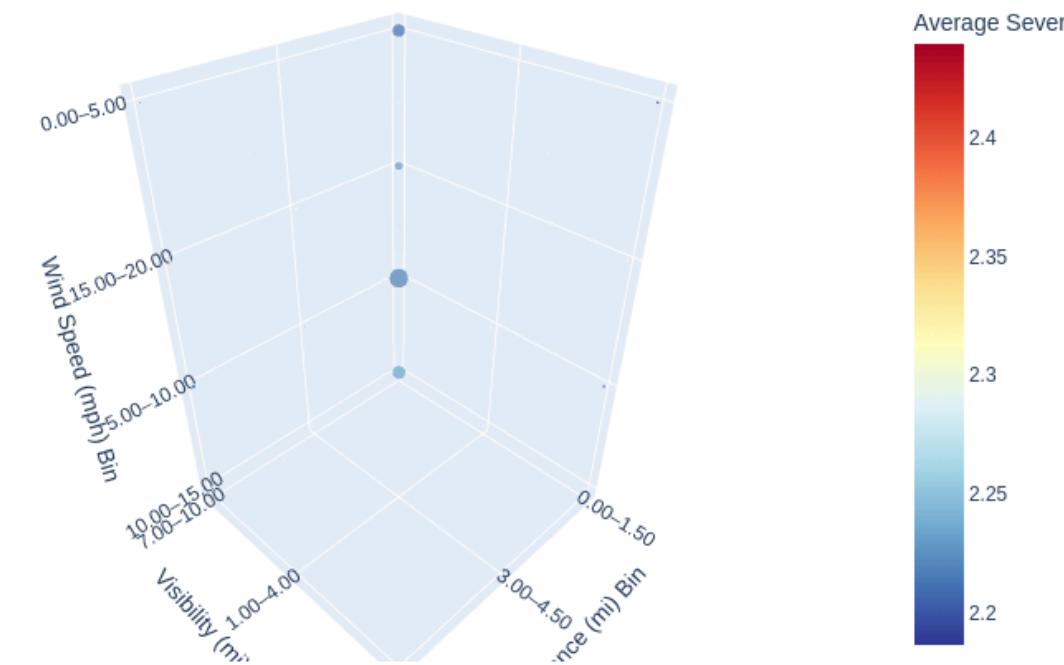
- **Key Insight:**

- Clear/Cloudy: Lower severity (2.18–2.4); higher visibility (7.00–10.00 mi), low wind (0.00–5.00 mph).

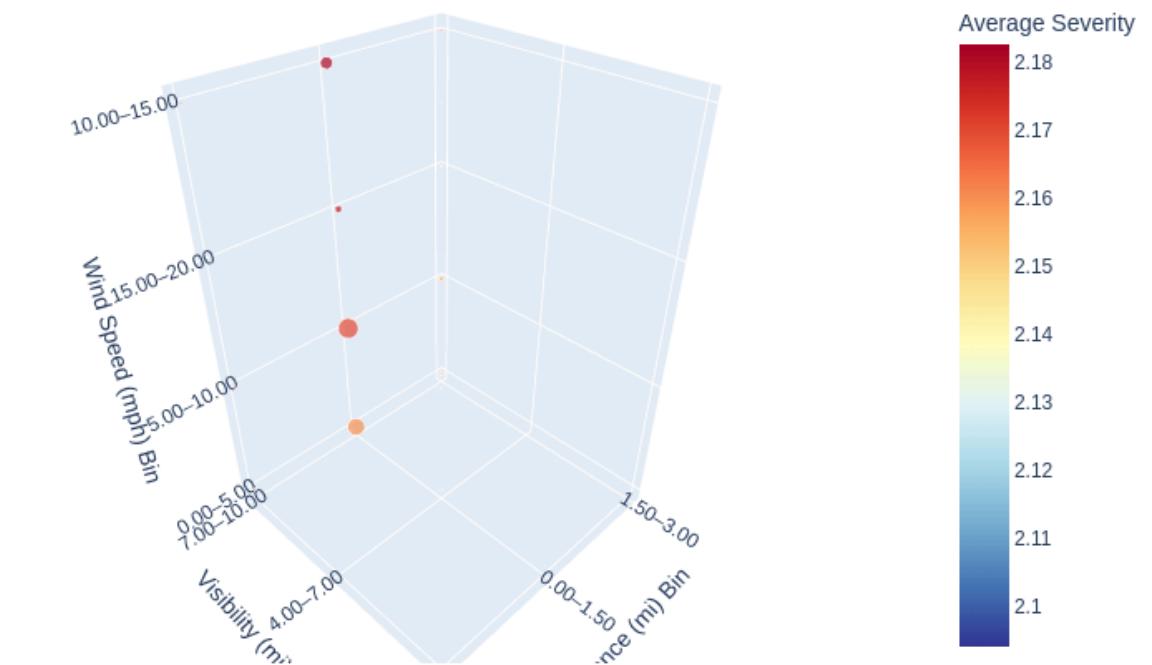
- **Business Value:**

- Enable dynamic traffic management such as real-time alerts regarding visibility and wind.
- Focus on low visibility (<4.00 mi) and high wind (>10.00 mph) in adverse weather.

Severity by Distance, Visibility, Wind Speed (Cloudy)



Severity by Distance, Visibility, Wind Speed (Clear)

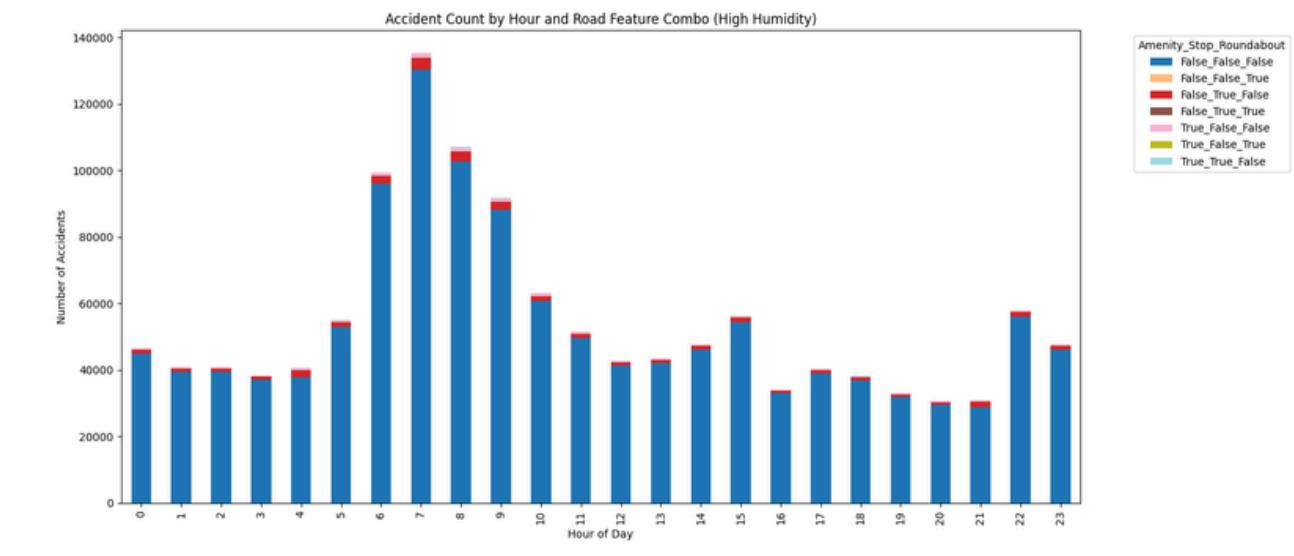


# DATA VISUALIZATION & INSIGHTS

## 10. WHICH COMBINATIONS OF ROAD FEATURES (E.G., AMENITY, STOP, ROUNDABOUT) AND TIME-BASED FACTORS (E.G., HOUR OF START\_TIME, SUNRISE\_SUNSET) ARE MOST ASSOCIATED WITH ACCIDENTS IN HIGH-HUMIDITY CONDITIONS ( $HUMIDITY(\%) \geq 79.25$ )?

- **Key Insight:**

- Peak Hours: 6–9 AM (highest at 7 AM); secondary peak 3–5 PM (~80,000); rush-hour risks due to slippery roads.
- Road Features: Most accidents with "False\_False\_False" (no Amenity/Stop/Roundabout, ~120,000 at 7 AM); "Stop" reduces frequency slightly (~20,000).
- Time Patterns (Association Rules):
  - $[Hour\_23] \rightarrow [Sunrise\_Night]$  (lift 2.19); nighttime risk due to low visibility.
- Frequent Itemsets:  $[Sunrise\_Day]$  (1,063,532),  $[Sunrise\_Night]$  (891,220), morning/night risks.



- **Business Value:**

- Guide infrastructure upgrades: add stop signs/roundabouts on busy roads.
- Schedule patrols: 6–9 AM, 10 PM–midnight; improve outside peak hours.

antecedent consequent	confidence lift	support
[[Hour_15]   [Sunrise_Day]]   1.0	1.837981367744459   0.028811839046590054	
[[Hour_23]   [Sunrise_Night]]   1.0	2.193343955476762   0.02448904004190813	
[[Hour_0]   [Sunrise_Night]]   1.0	2.193343955476762   0.023821947745801	
[[Hour_14]   [Sunrise_Day]]   1.0	1.837981367744459   0.02442509331106964	
[[Hour_3]   [Sunrise_Night]]   1.0	2.193343955476762   0.0196556903382117	
[[Hour_2]   [Sunrise_Night]]   1.0	2.193343955476762   0.020939229119601874	
[[Hour_13]   [Sunrise_Day]]   1.0	1.837981367744459   0.0222391382640867	
[[Hour_10]   [Sunrise_Day]]   1.0	1.837981367744459   0.032299237959597944	
[[Hour_22]   [Sunrise_Night]]   1.0	2.193343955476762   0.029662074779818616	
[[Hour_12]   [Sunrise_Day]]   1.0	1.837981367744459   0.021931170808368528	

only showing top 10 rows

# DATA VISUALIZATION & INSIGHTS

## 11. WHERE ARE THE MOST DANGEROUS ACCIDENT HOTSPOTS?

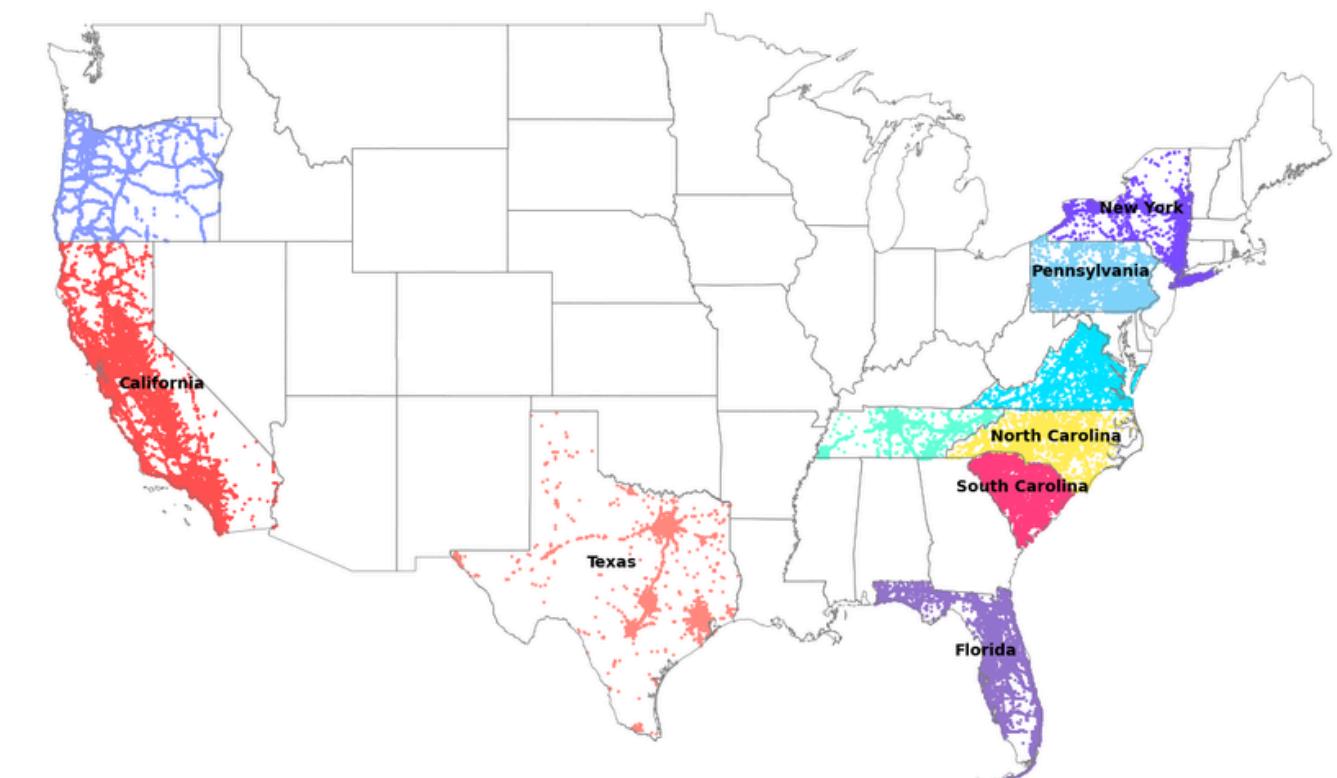
- **Key Insight:**

- Top Hotspots: CA (1,392,322 cases), FL (785,650), TX (464,347); dense clusters in coastal CA, southeast FL, central/east TX.
- Other Clusters: SC (325,493), NC (290,244) along highways; NY (274,610), PA (238,142) in urban areas; OR (139,487) on major highways.
- Patterns: Urban/coastal areas with high traffic (CA, FL, TX) and highway clusters (SC, NC, OR) indicate risks from density, infrastructure strain, or weather/road design.

Visualization of Top 10 Accident Prone States in US

- **Business Value:**

- Transportation: Prioritize CA, FL, TX for infrastructure upgrades
- Insurance: more on standby rescue team



# DATA VISUALIZATION & INSIGHTS

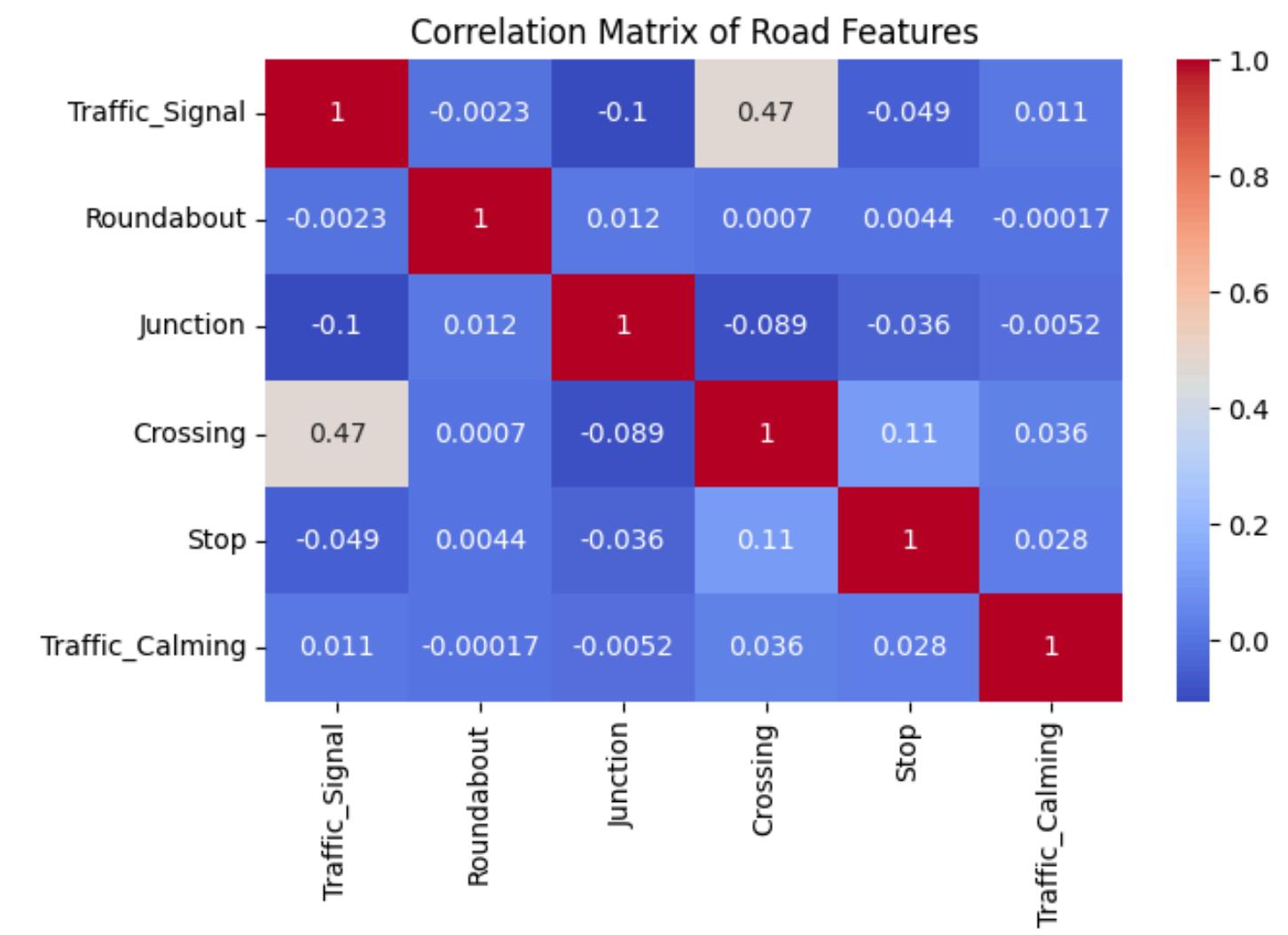
## 12. WHICH COMBINATIONS OF ROAD FEATURES BEST REDUCE ACCIDENT SEVERITY?

- **Key Insight:**

- Feature Correlations:
  - Crossing & Stop (0.11), co-occurrence may amplify safety.
  - Traffic\_Signal & Crossing (0.47)

- **Business Value:**

- Prioritize traffic signal installation at high-risk intersections.
- Test combined features (e.g., Crossing + Stop or Crossing + Traffic Signal) in pedestrian zones.

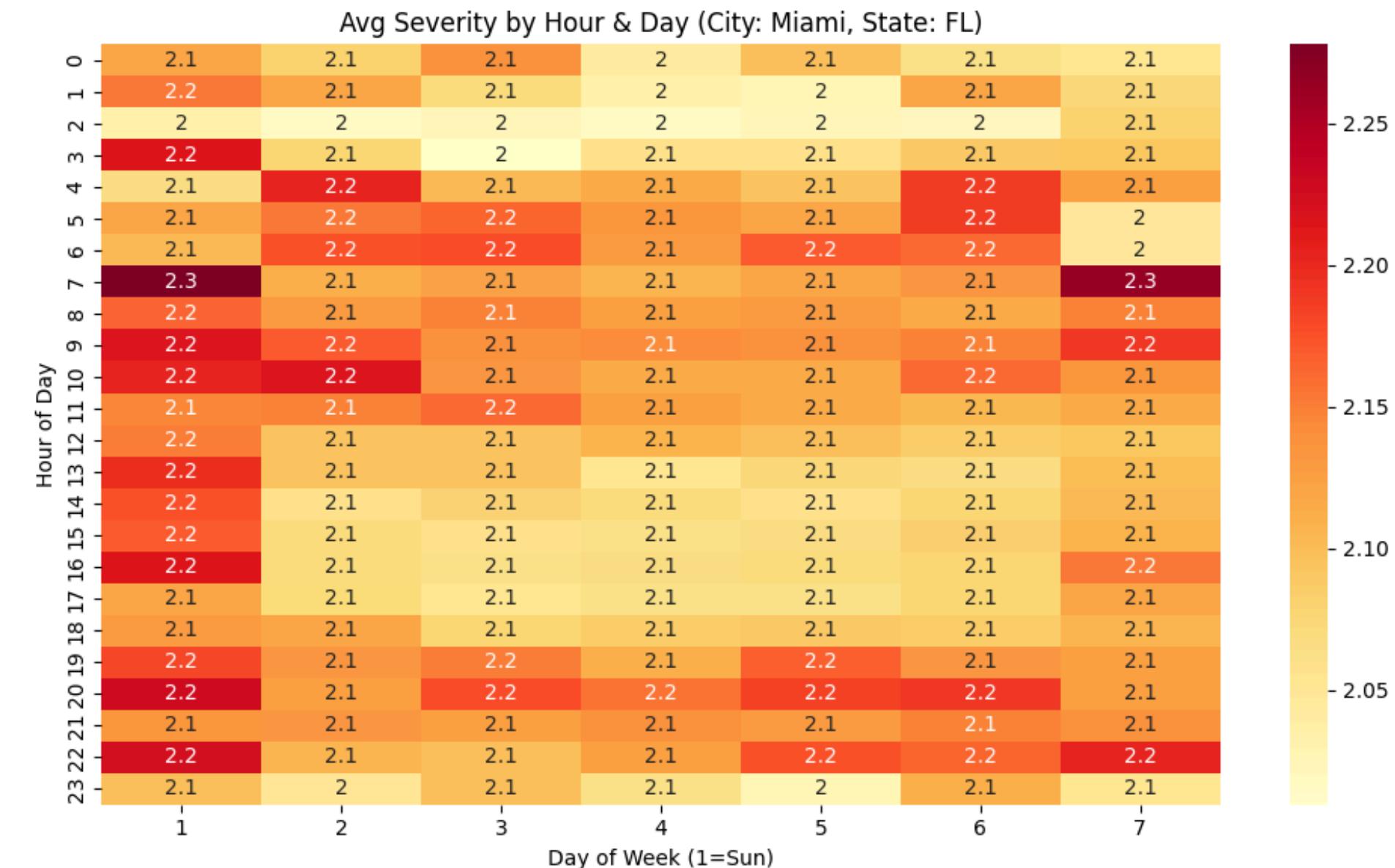
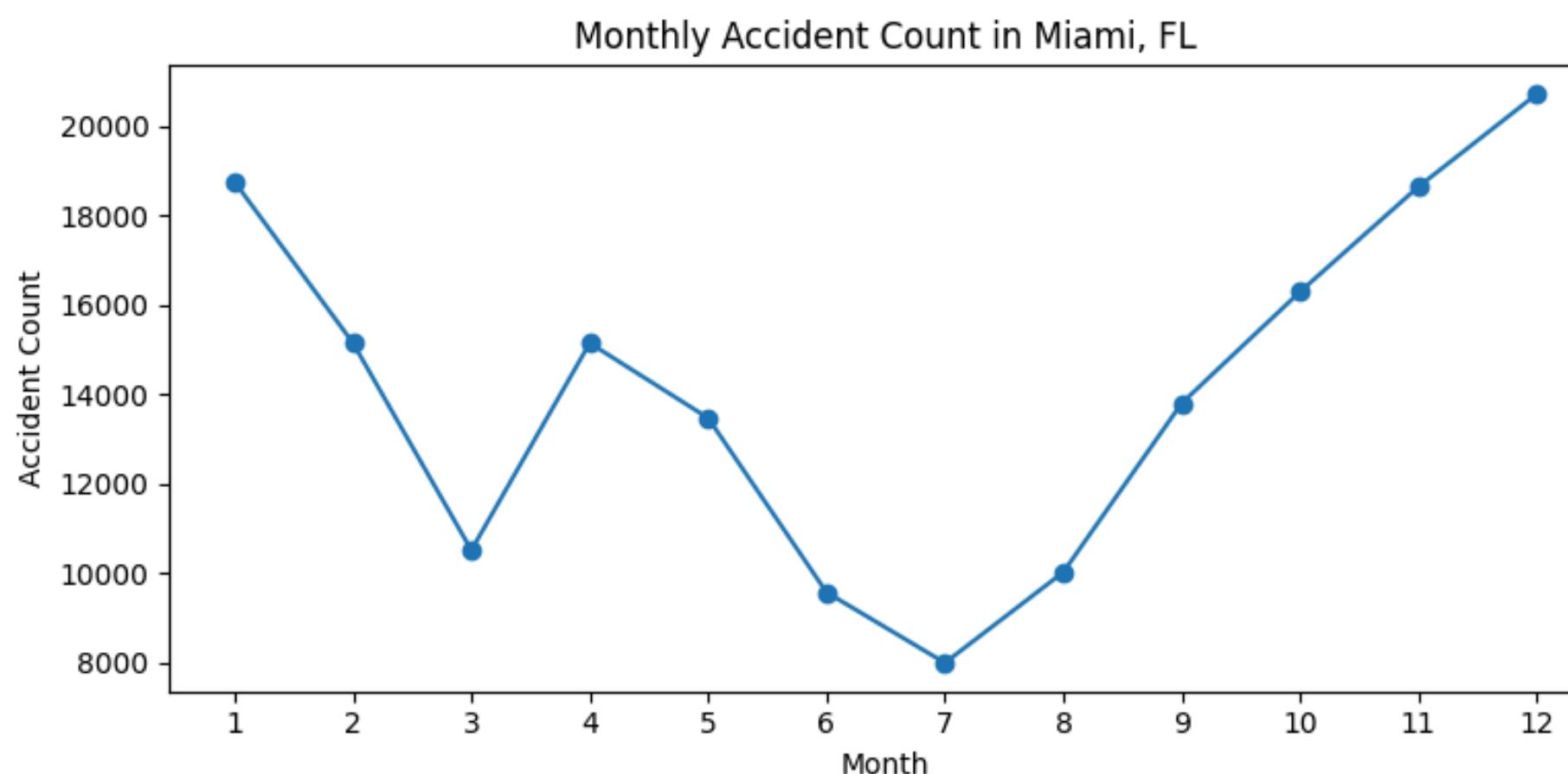


# DATA VISUALIZATION & INSIGHTS

## 13. HOW DO ACCIDENT CHARACTERISTICS VARY BY TIME AND LOCATION?

- **Key Insight:**

- Miami, FL (Severity): Highest severity (2.3) on Mondays (7 AM) and Saturdays (8 AM); stable (2.0–2.2) otherwise, peaks at 6–8 AM, 9–11 PM.
- Miami, FL (Frequency): Peaks in Dec/Jan (~20,000/18,000), lowest in July (~8,000); holiday/tourist impact.



# DATA VISUALIZATION & INSIGHTS

## 13. HOW DO ACCIDENT CHARACTERISTICS VARY BY TIME AND LOCATION?

- **Key Insight:**

- Danger Times Across Cities: Visalia, CA: Hour 12, Severity 4.0 (lunch-hour risk).
- Evansville, IN: Hour 20, Severity 3.862 (evening commute).
- West Plains, MO: Hour 21, Severity 3.809 (evening).
- Santa Barbara, CA: Hour 8, Severity 3.798 (morning rush).
- Lake Carlisle, NY: Hour 20, Severity 3.086 (evening).

Top danger hour for each city (highest avg severity):

	State	City	Hour	Avg_Severity
466	CA	Visalia	12	4.000000
973	IN	Evansville	20	3.862069
1205	MO	West Plains	21	3.809524
18	AL	Montgomery	12	3.724138
434	CA	Santa Barbara	8	3.703704
1339	NY	Lake George	7	3.217391
1494	PA	Carlisle	20	3.080000
1277	NJ	Brick	7	3.000000
1190	MO	Kansas City	19	2.961538
1514	PA	Mercer	15	2.933333

- **Business Value:**

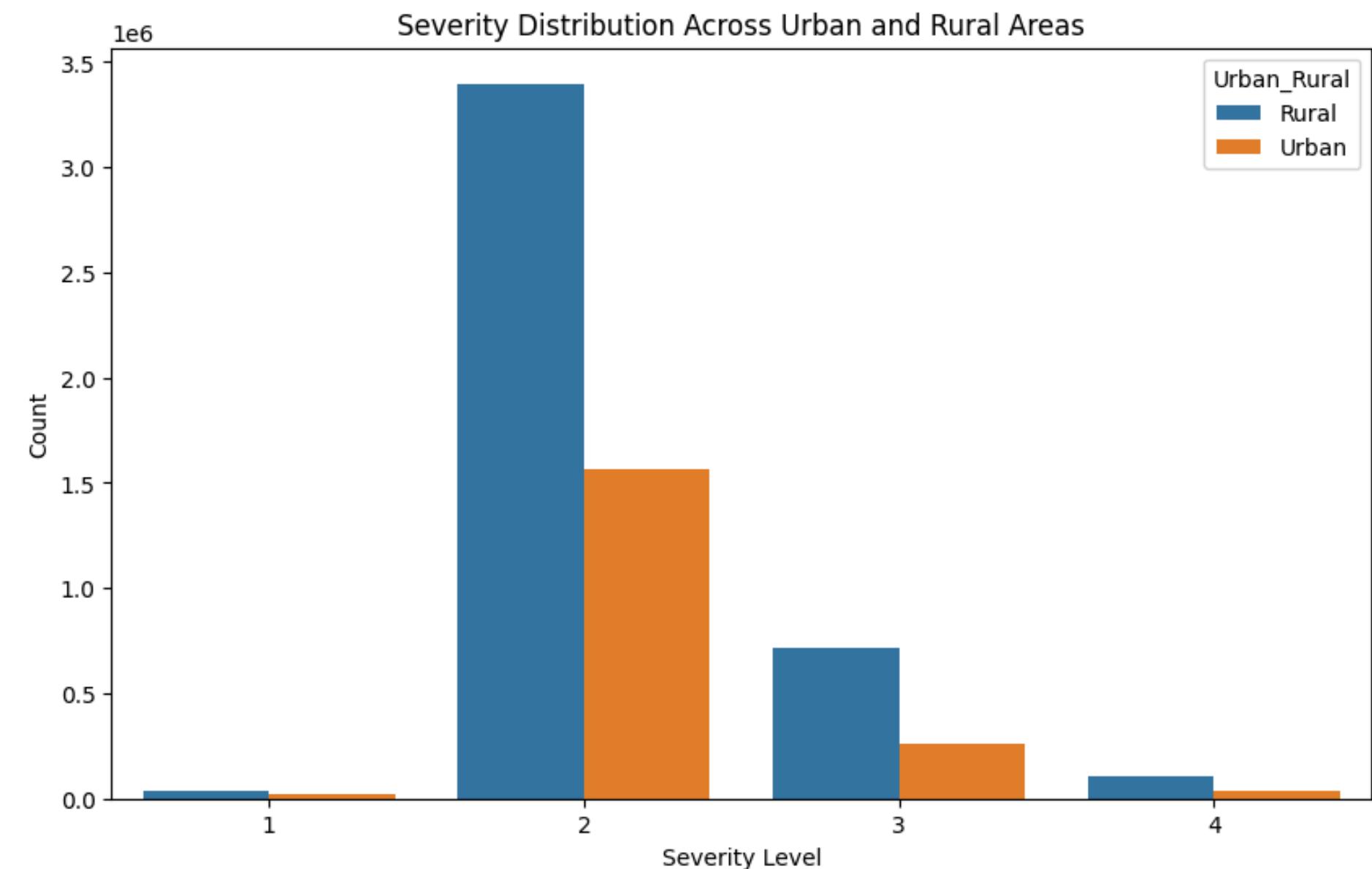
- Optimize emergency response for peak times
- Tailor safety campaigns: Morning rush in Santa Barbara, evening/night in Evansville, holiday focus in Miami.

# DATA VISUALIZATION & INSIGHTS

## 14. HOW DO ACCIDENT PATTERNS DIFFER BETWEEN POPULATION DENSITIES (URBAN VS. RURAL)?

- Key Insight:

- Severity: Rural areas have more Severity 2 accidents vs. urban; rural slightly higher at Severity 3.

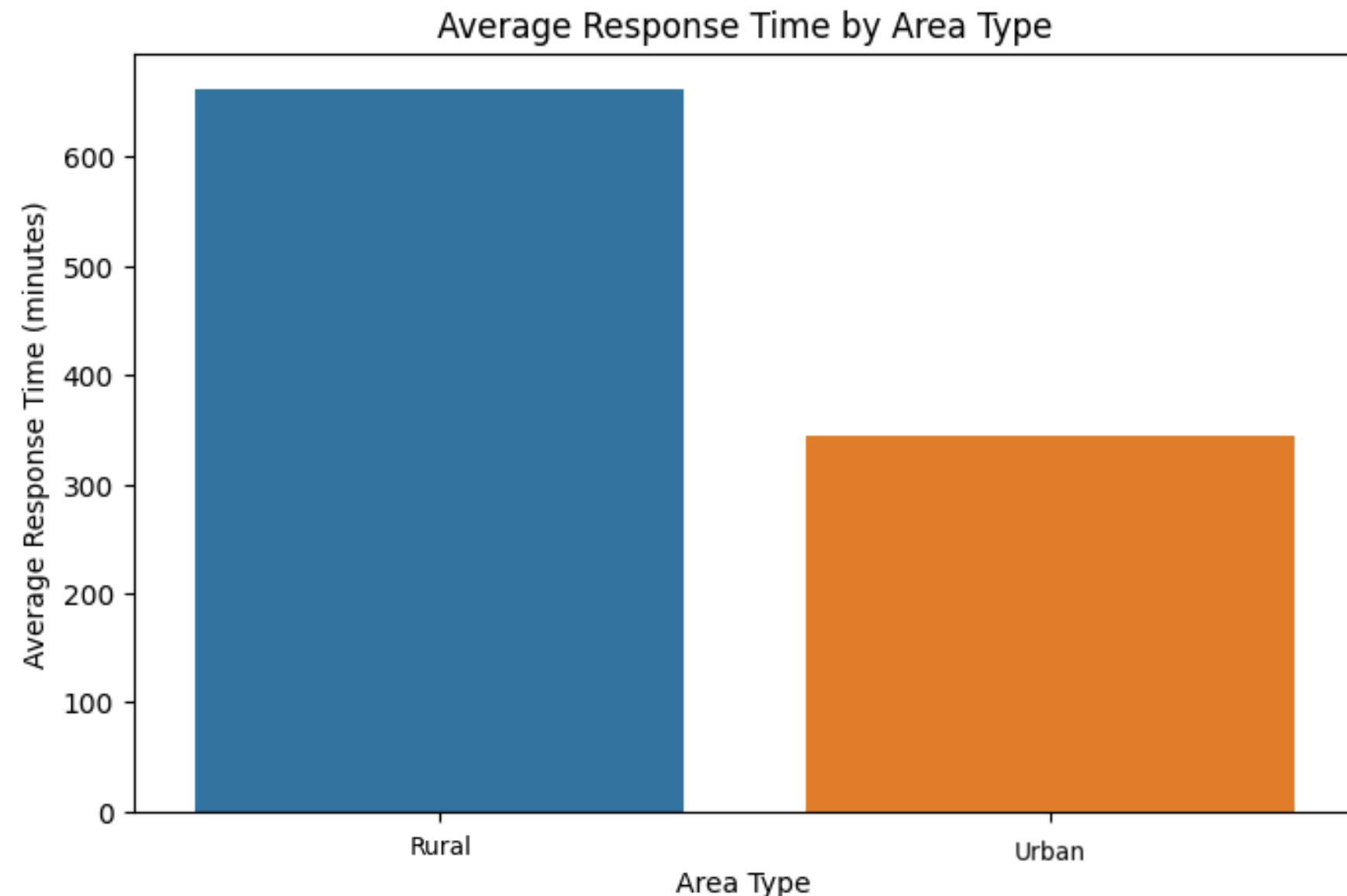


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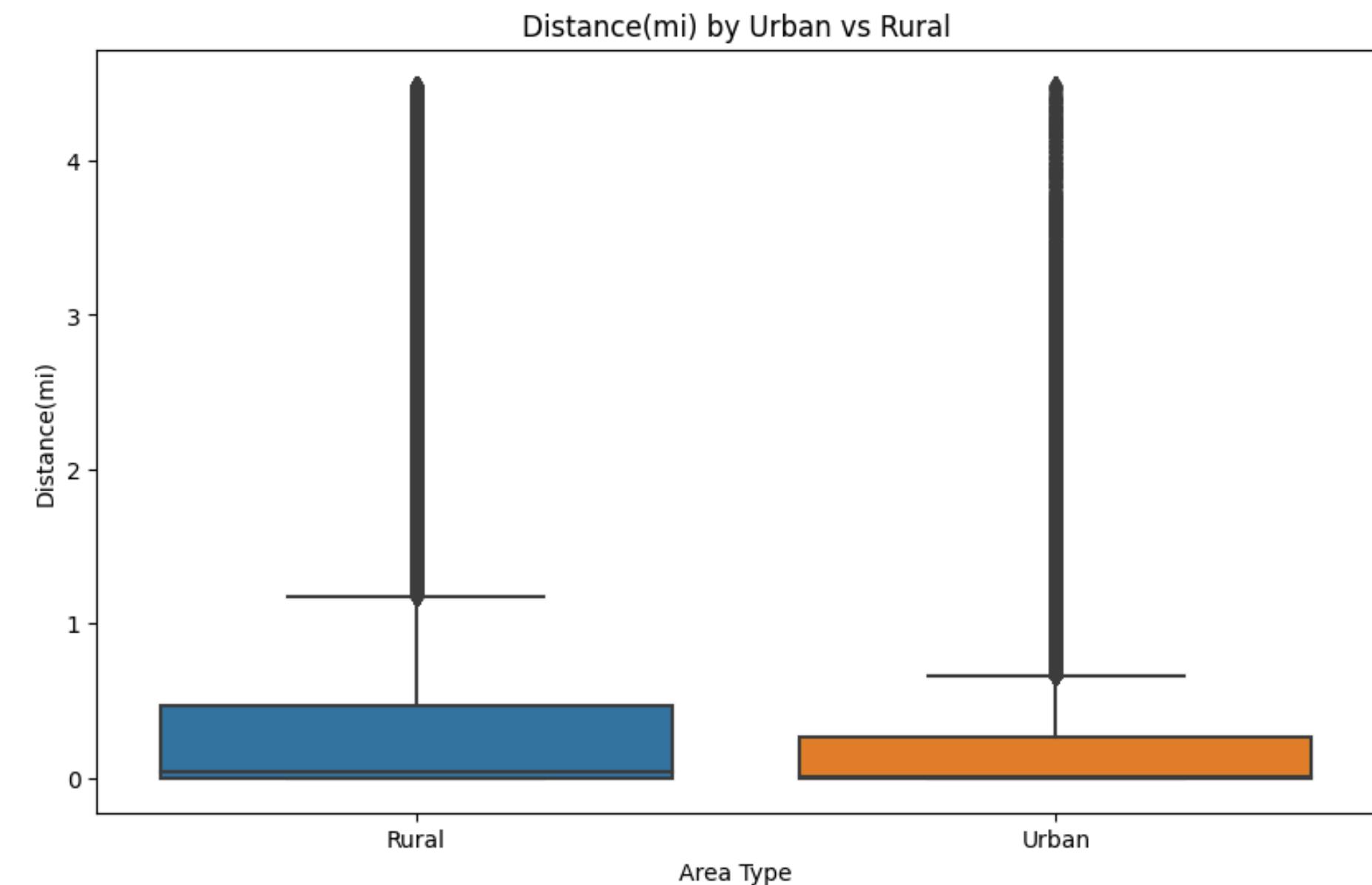
- Response Time: Urban: ~350 mins; Rural: ~650 mins; rural faces service access challenges.



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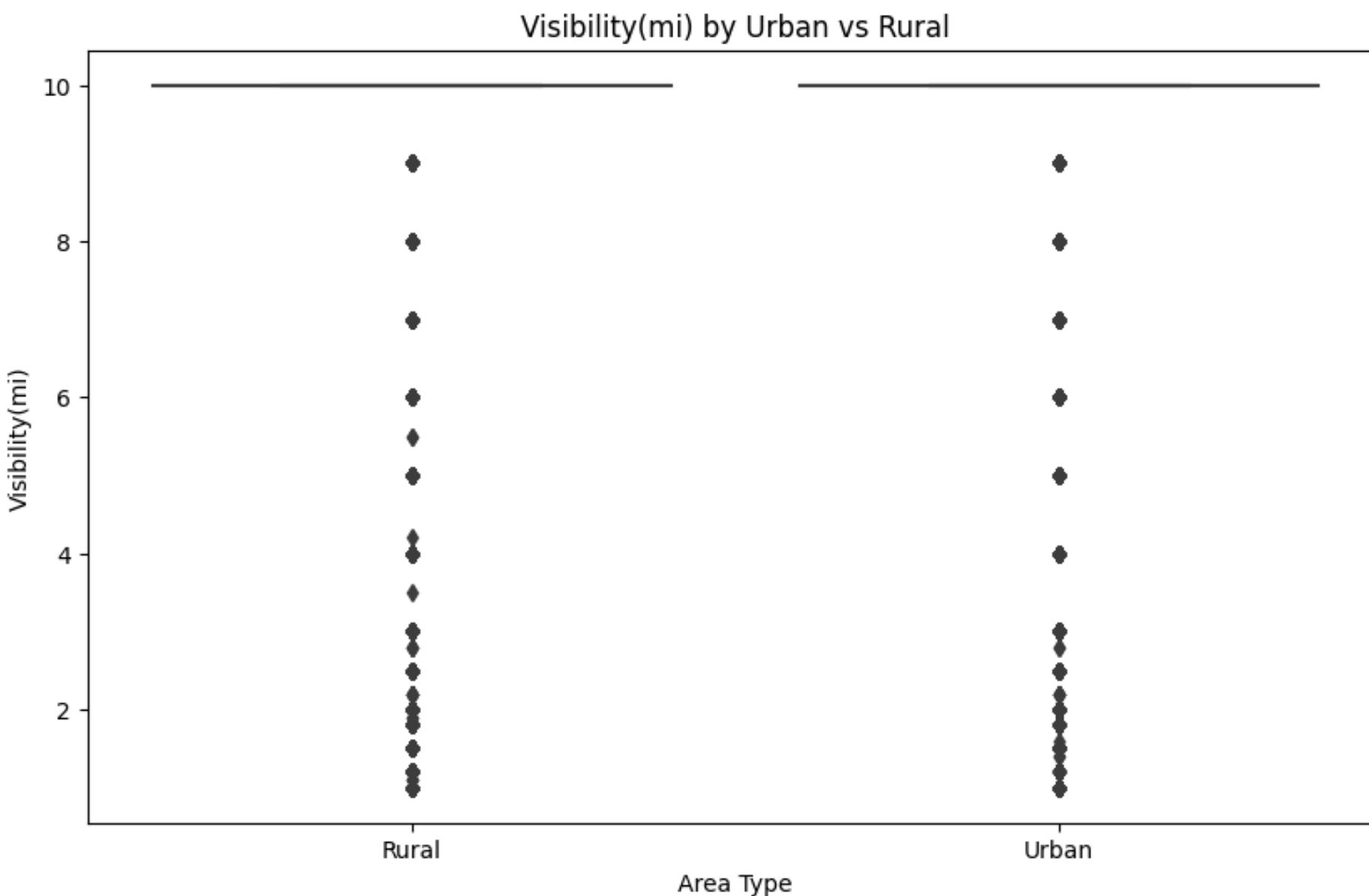
- Key Insight:
  - Distance: Rural: Longer



# DATA VISUALIZATION & INSIGHTS

## 14. HOW DO ACCIDENT PATTERNS DIFFER BETWEEN POPULATION DENSITIES (URBAN VS. RURAL)?

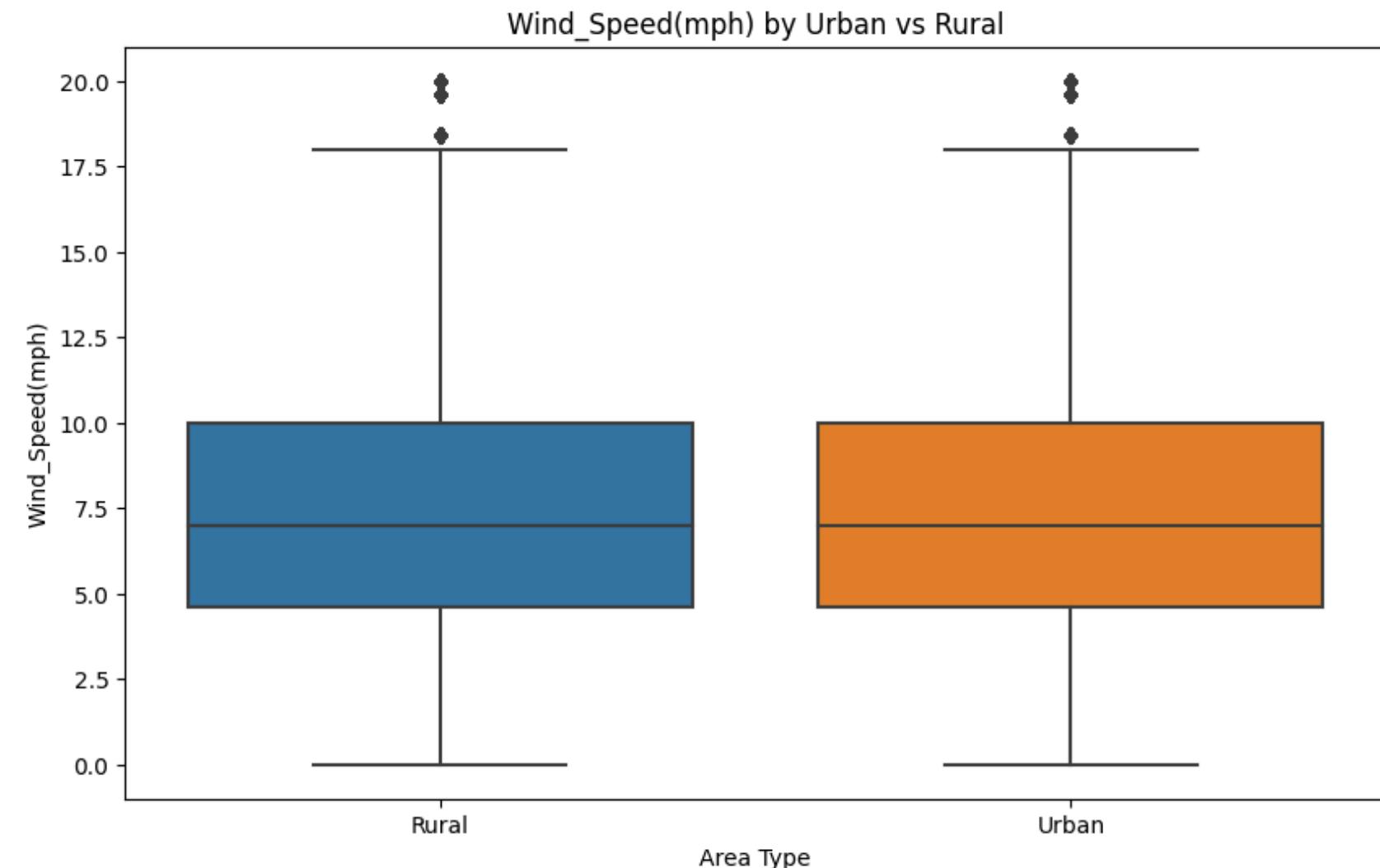
- Key Insight:
  - Visibility: Similar



# DATA VISUALIZATION & INSIGHTS

## 14. HOW DO ACCIDENT PATTERNS DIFFER BETWEEN POPULATION DENSITIES (URBAN VS. RURAL)?

- **Key Insight:**
  - Wind Speed: Similar
- **Business Value:**
  - Make Access easier in Rural to improve accident duration time and infrastructure more reliable to deal with longer distance accidents.



# DATA VISUALIZATION & INSIGHTS

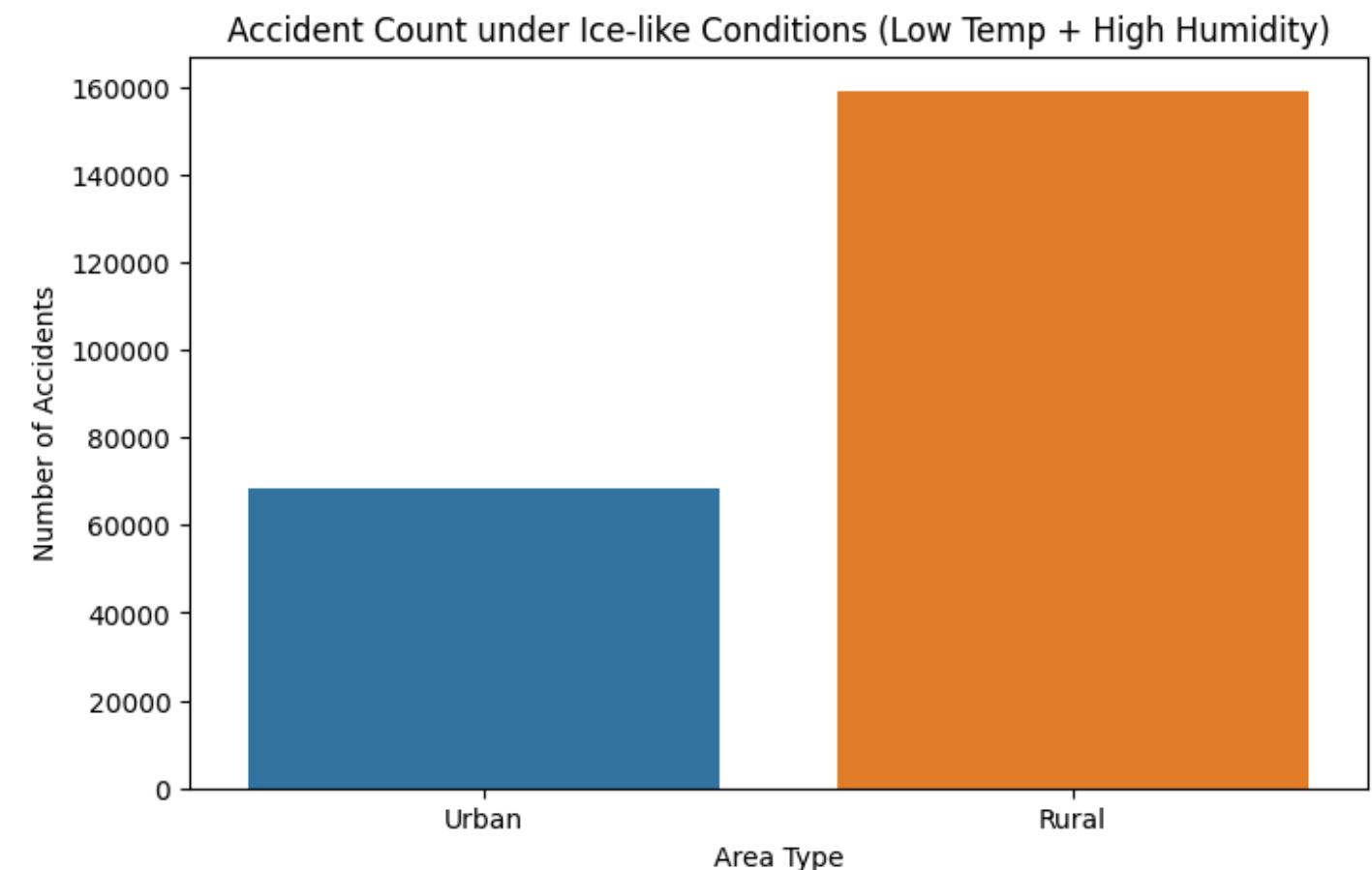
## 15. DOES THE IMPACT OF COMBINED ENVIRONMENTAL FACTORS (E.G., LOW TEMPERATURE(C) BIN AND HIGH HUMIDITY(%) BIN, SUGGESTING POTENTIAL ICE) ON ACCIDENT FREQUENCY AND SEVERITY DIFFER BETWEEN URBAN (HIGH-DENSITY CITY/COUNTY) AND RURAL AREAS?

- **Key Insight:**

- Frequency: Rural: ~160,000 accidents; Urban: ~60,000; rural roads more exposed to ice.

- **Business Value:**

- Infrastructure:
    - Prioritize ice-resistant materials
  - De-Icing Schedules:
    - Aggressive, frequent;
  - Safety Campaigns:
    - Educate on high risk, promote winter tires;

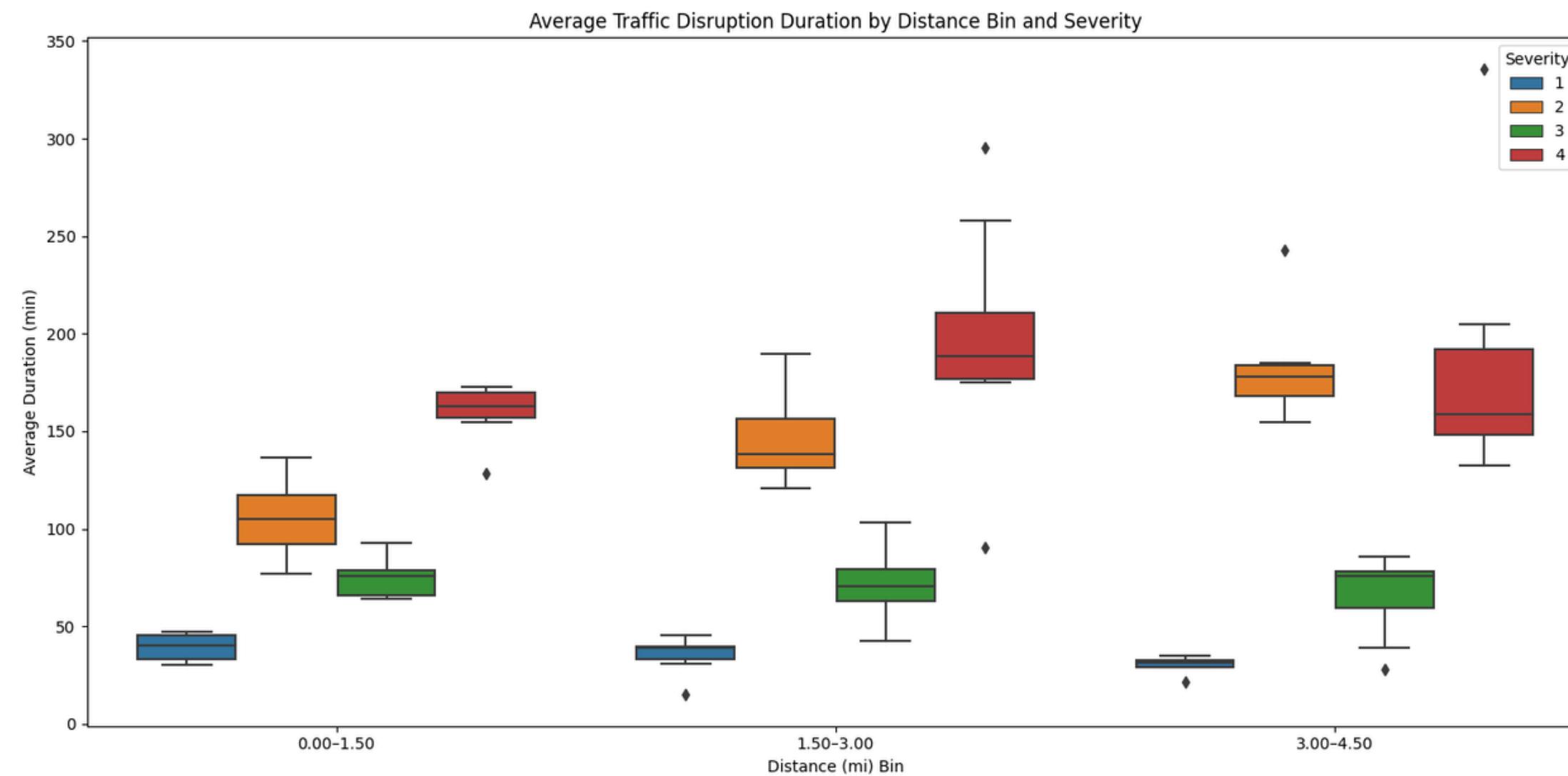


# DATA VISUALIZATION & INSIGHTS

## 16. HOW DOES THE DURATION OF TRAFFIC DISRUPTION (CALCULATED FROM START\_TIME, END\_TIME) VARY BASED ON THE COMBINATION OF SEVERITY, DISTANCE(MI) (DISCRETIZED), AND THE PRESENCE OF KEY ROAD FEATURES (TRAFFIC\_SIGNAL, JUNCTION, CROSSING)?

- Key Insight:

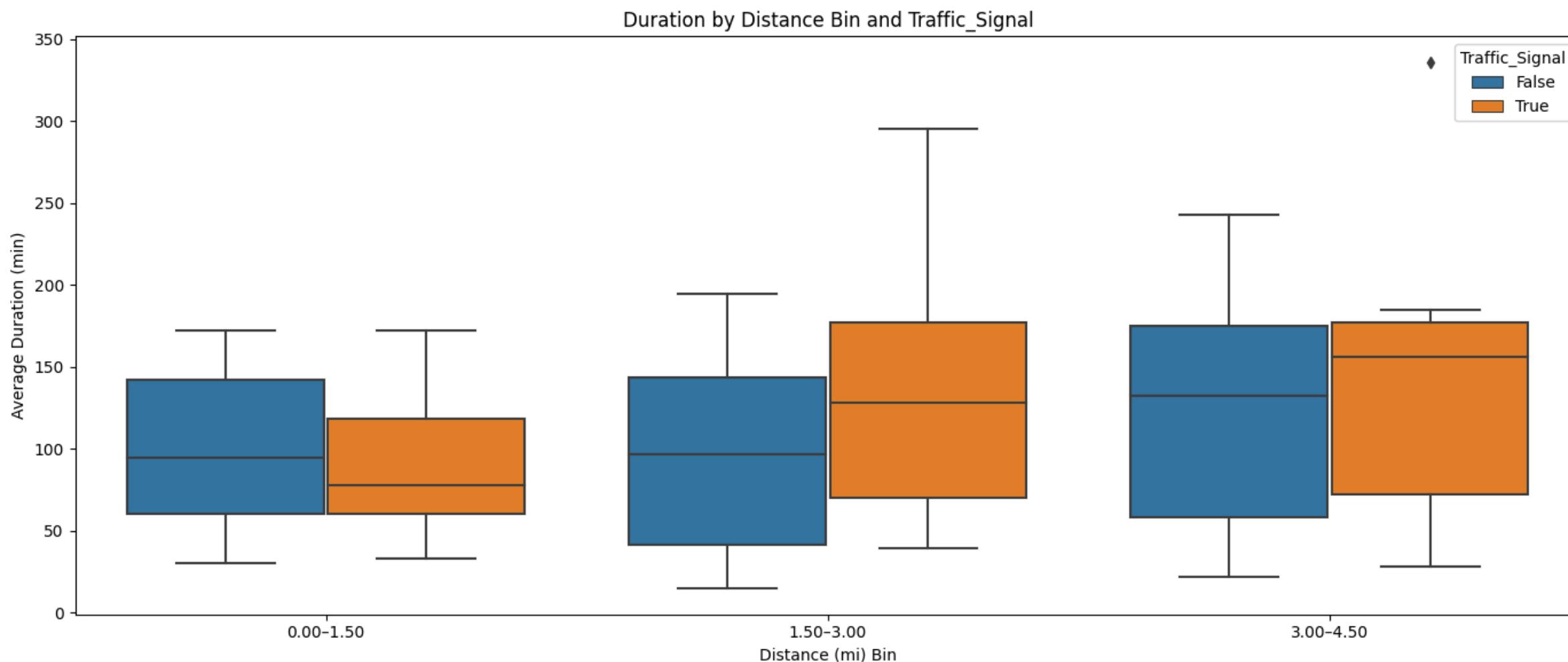
- Distance Impact: Shortest bin (0.00–1.50 mi): Lowest disruptions; 3.00–4.50 mi: Longest, likely due to easier detours.



# DATA VISUALIZATION & INSIGHTS

**16. HOW DOES THE DURATION OF TRAFFIC DISRUPTION (CALCULATED FROM START\_TIME, END\_TIME) VARY BASED ON THE COMBINATION OF SEVERITY, DISTANCE(MI) (DISCRETIZED), AND THE PRESENCE OF KEY ROAD FEATURES (TRAFFIC\_SIGNAL, JUNCTION, CROSSING)?**

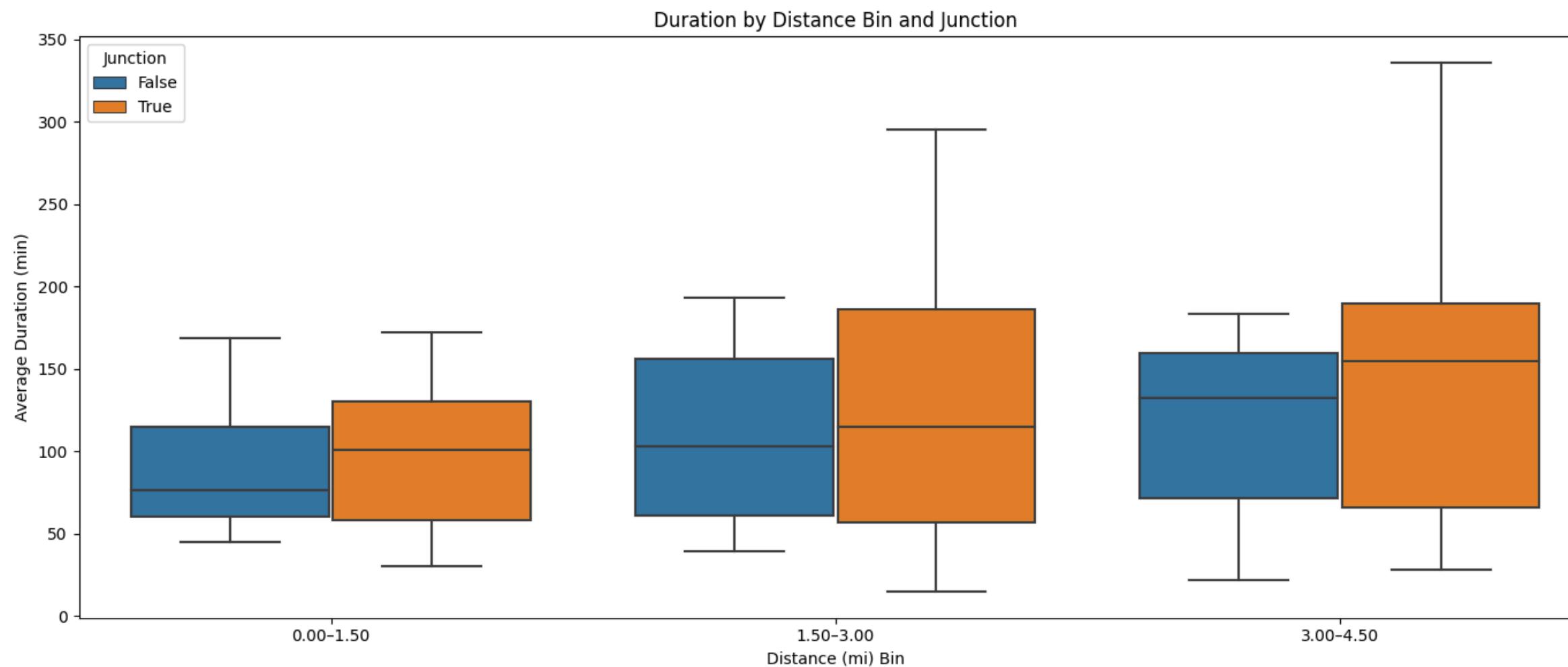
- **Key Insight:**
  - Traffic Worsens duration and creates congestion in longer distances



# DATA VISUALIZATION & INSIGHTS

**16. HOW DOES THE DURATION OF TRAFFIC DISRUPTION (CALCULATED FROM START\_TIME, END\_TIME) VARY BASED ON THE COMBINATION OF SEVERITY, DISTANCE(MI) (DISCRETIZED), AND THE PRESENCE OF KEY ROAD FEATURES (TRAFFIC\_SIGNAL, JUNCTION, CROSSING)?**

- Key Insight:
  - Same with Junction



# DATA VISUALIZATION & INSIGHTS

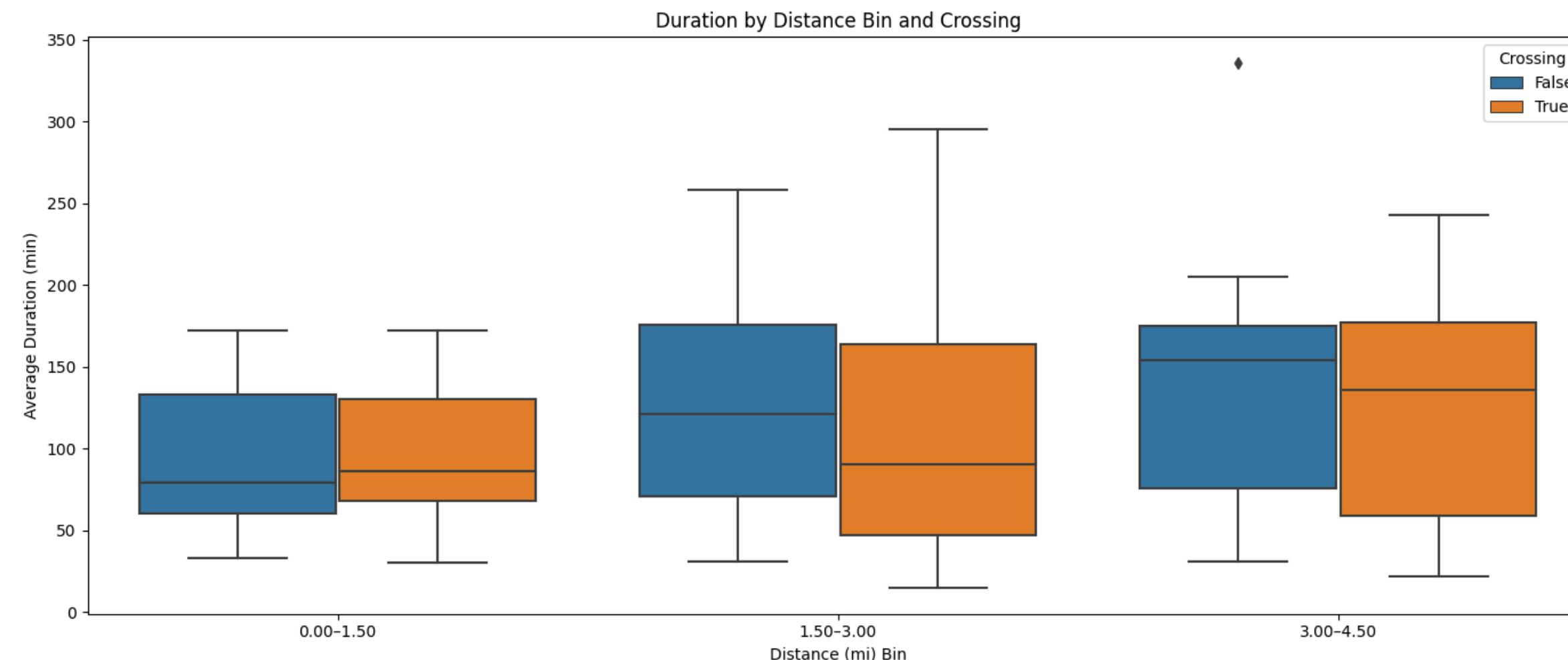
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- **Key Insight:**

- Crossing Effect: pedestrian/vehicle interactions doesn't affect that much

- **Business Value:**

- Infrastructure upgrades: Prioritize junctions/traffic for smart signals, widened lanes.



# MODEL INSIGHTS

## PREDICTING HIGH-SEVERITY ACCIDENTS (SEVERITY=4)

### **Focus:** Predicting the Most Severe Accidents

- We prioritize and focus on Severity=4 accidents — the most critical and impactful incidents.
- Early prediction helps prevent fatalities, allocate resources efficiently, and improve public safety.
- Achieved 0.86 test accuracy.

### **Key Insights**

- Environmental factors (e.g., low visibility, bad weather, wind direction) strongly impact accident severity.
- Location context (urban/rural, crossings, traffic signals) significantly correlates with high-severity incidents.
- Time of day (sunrise/sunset) adds valuable predictive power.

### **Business Value**

- **Proactive resource allocation:** Deploy emergency teams before accidents escalate.
- **Urban planning insights:** Improve infrastructure at high-risk locations.
- **Insurance and policy making:** Smarter risk profiling and premium adjustment.

**THANK**

**YOU**