

# Frequent GFS Biases in Winter Season Surface Forecasts

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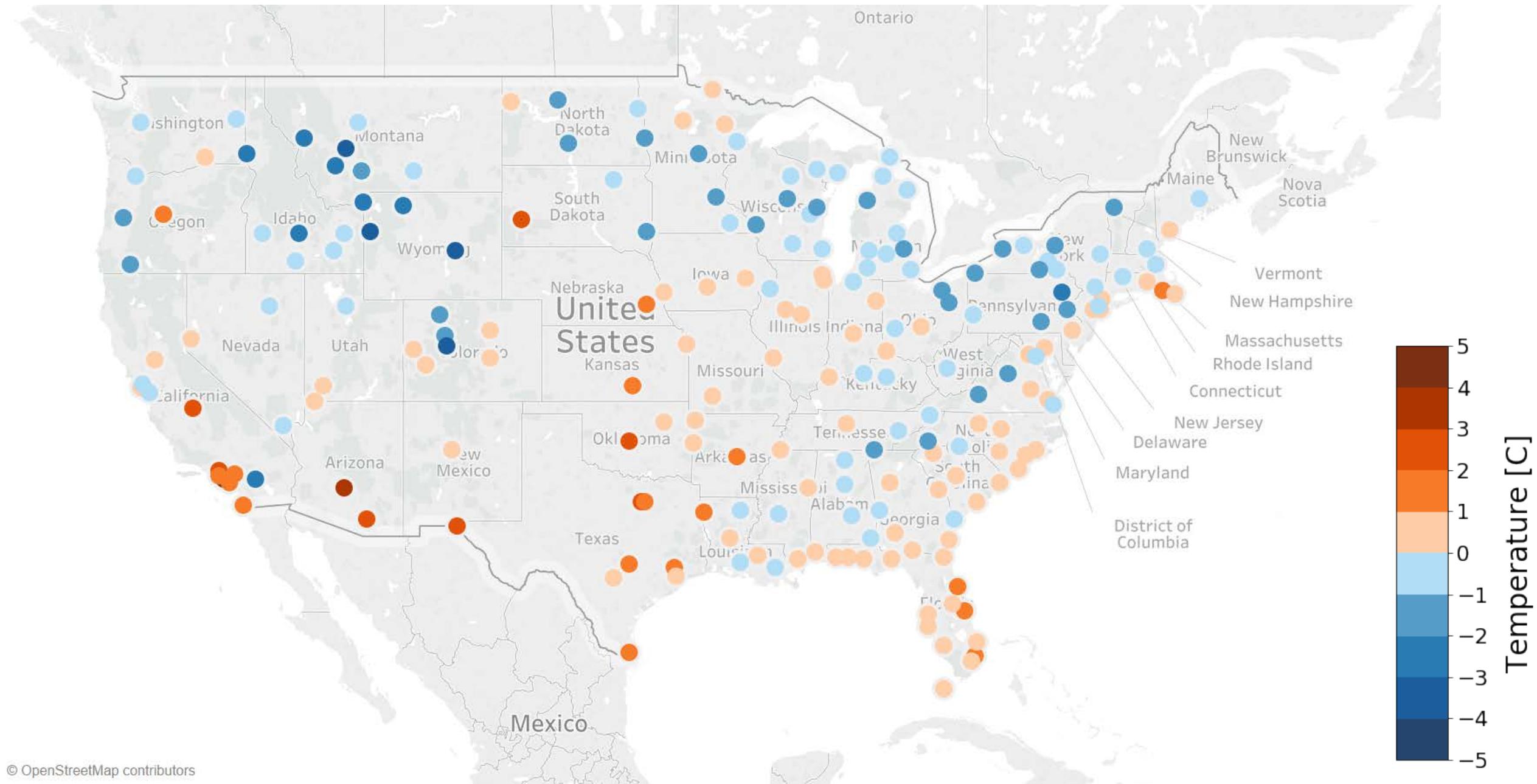
# Objectives

- Investigate frequent biases in operational GFS for surface variables that can impact airport operations
  - Daily low temperature
  - Hourly temperature and hourly precipitation (esp. snow)
  - Relation to other variables, like wind speed, sky cover, and snow cover
- Forecast lead times of >24 hours relevant to Irregular Operation planning
- This presentation shows findings for 48 hour forecast lead times

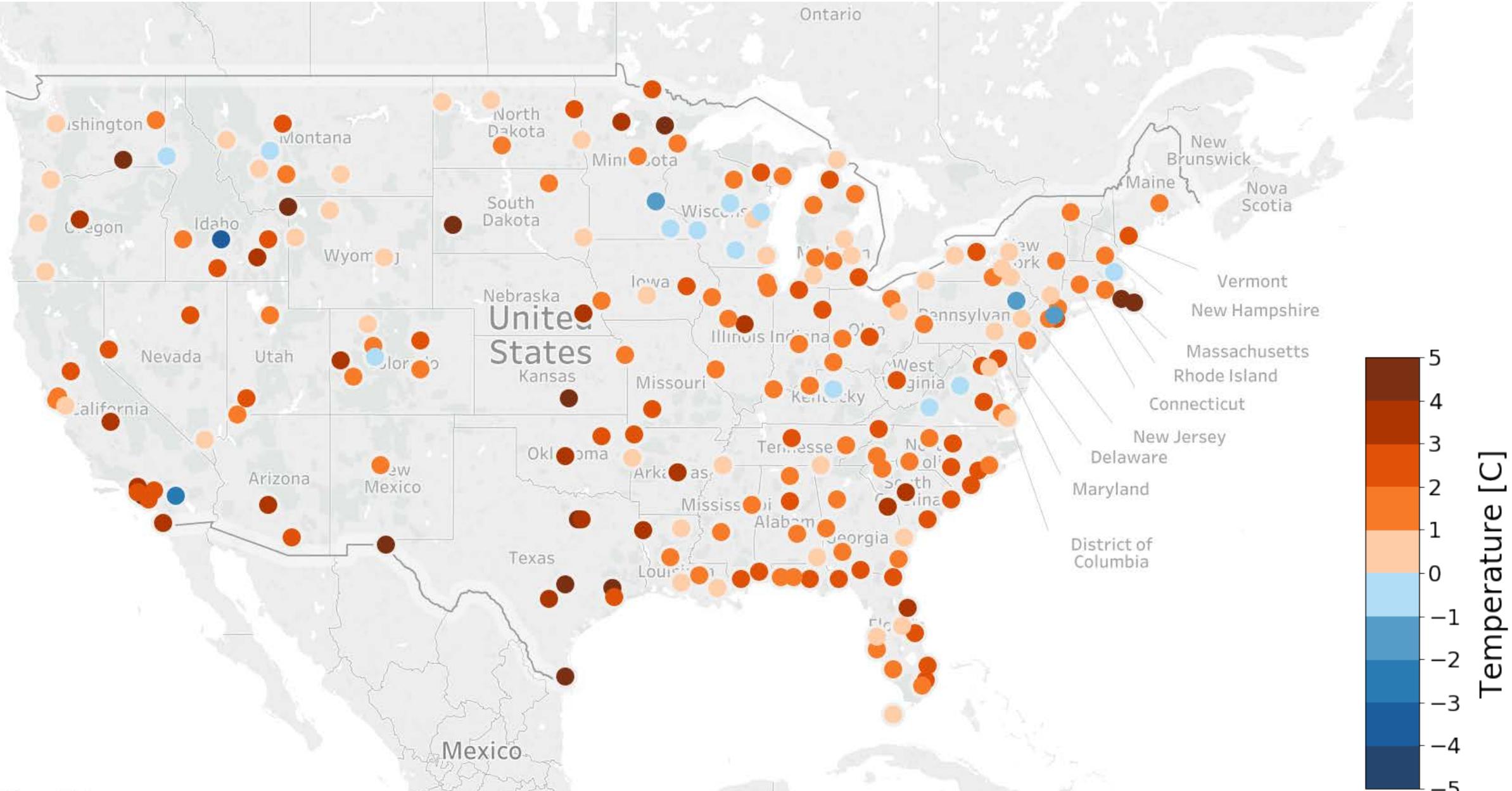
# Methods

- Obtain GFS hourly forecast output in real-time from NCEP
- Model output is interpolated to the locations of over 200 ASOS sites and then matched with observations in a relational database
- Period of analysis is November 2019 – March 2020

# GFS Low Temperature Median Bias (48hr lead time) [All]

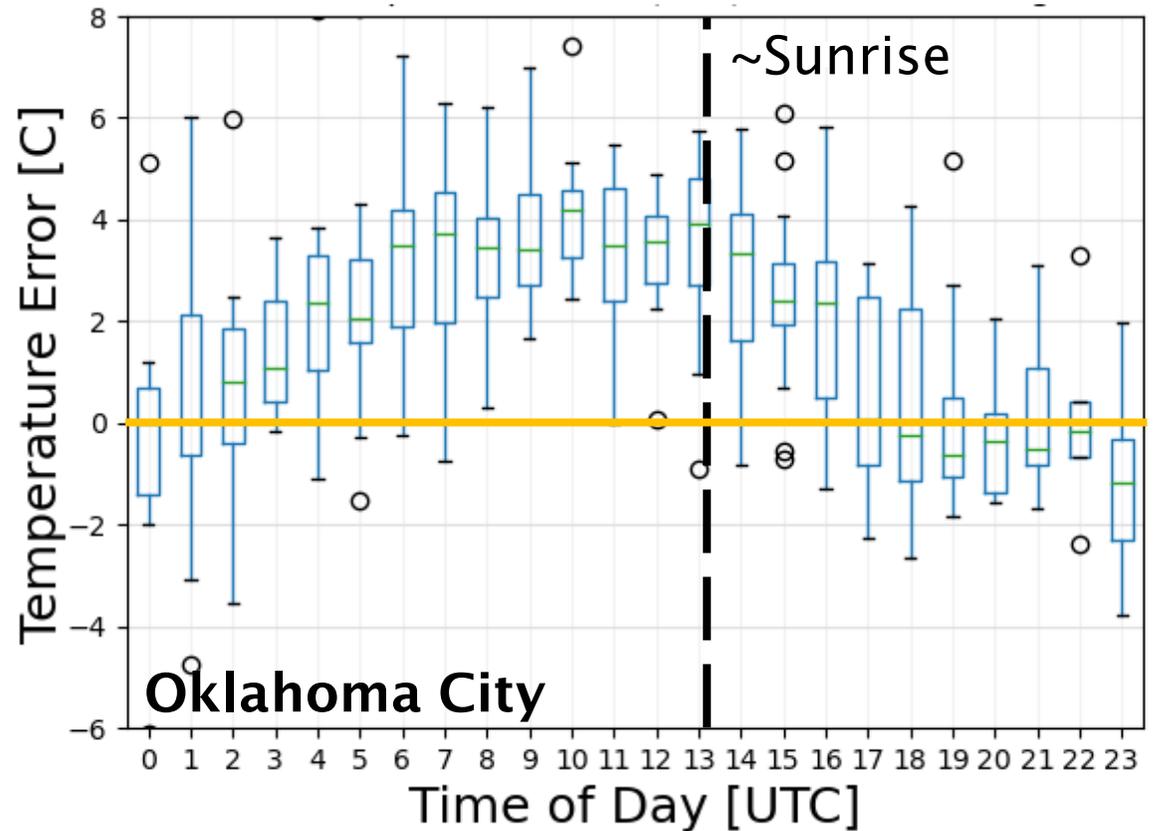
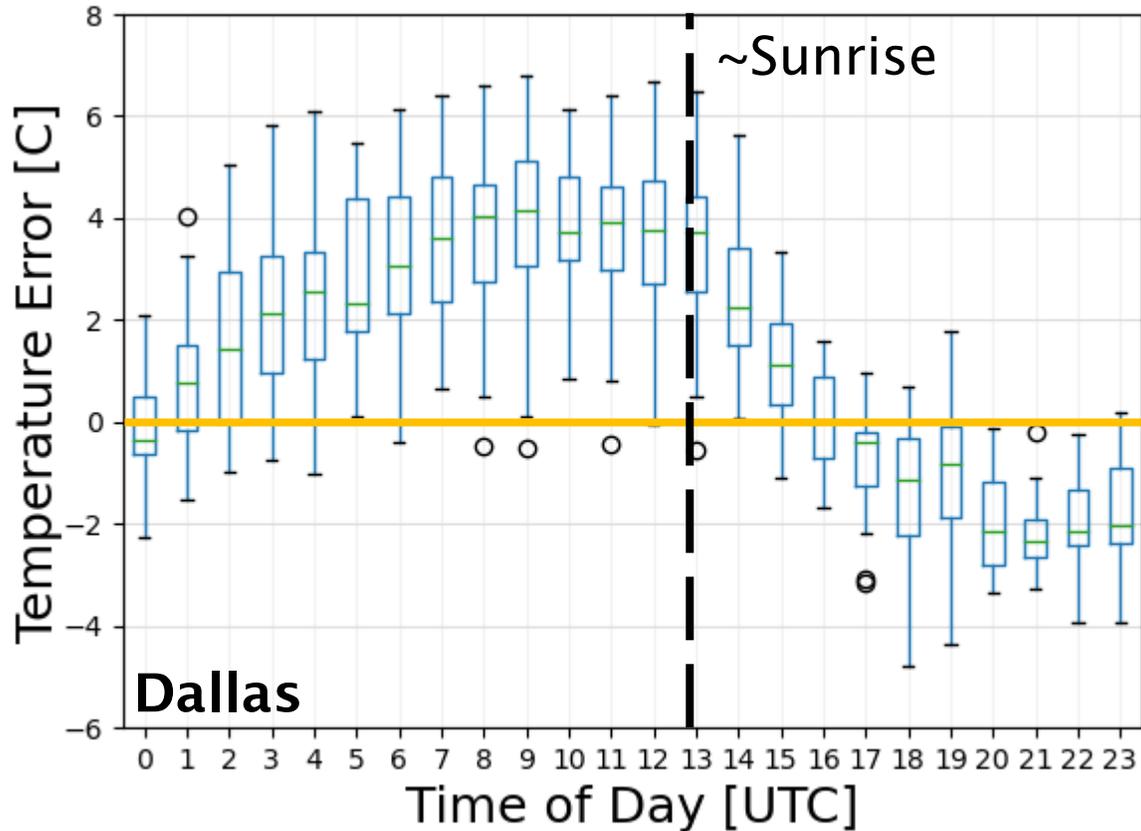
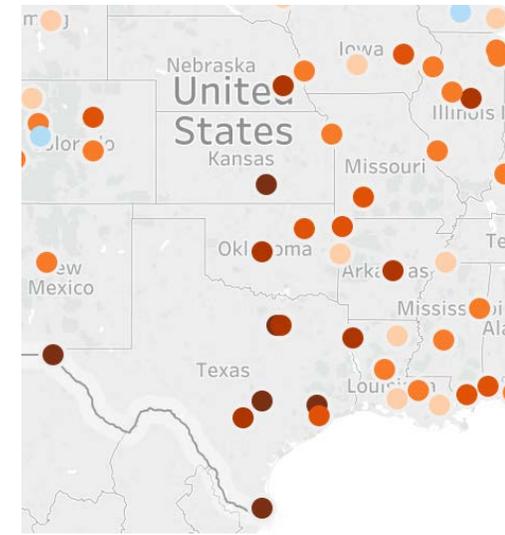


# Low Temperature Median Bias [Light Wind & <1/2 Sky Cover]



# Distribution of Temperature Errors by Time of Day

- Model temperatures in the hours just before sunrise are typically around 4°C (7°F) too warm for many airports across the Southern Plains when clear and light winds
- Difficulties with nocturnal inversions, especially in wintertime, indicative of boundary layer parameterization challenges

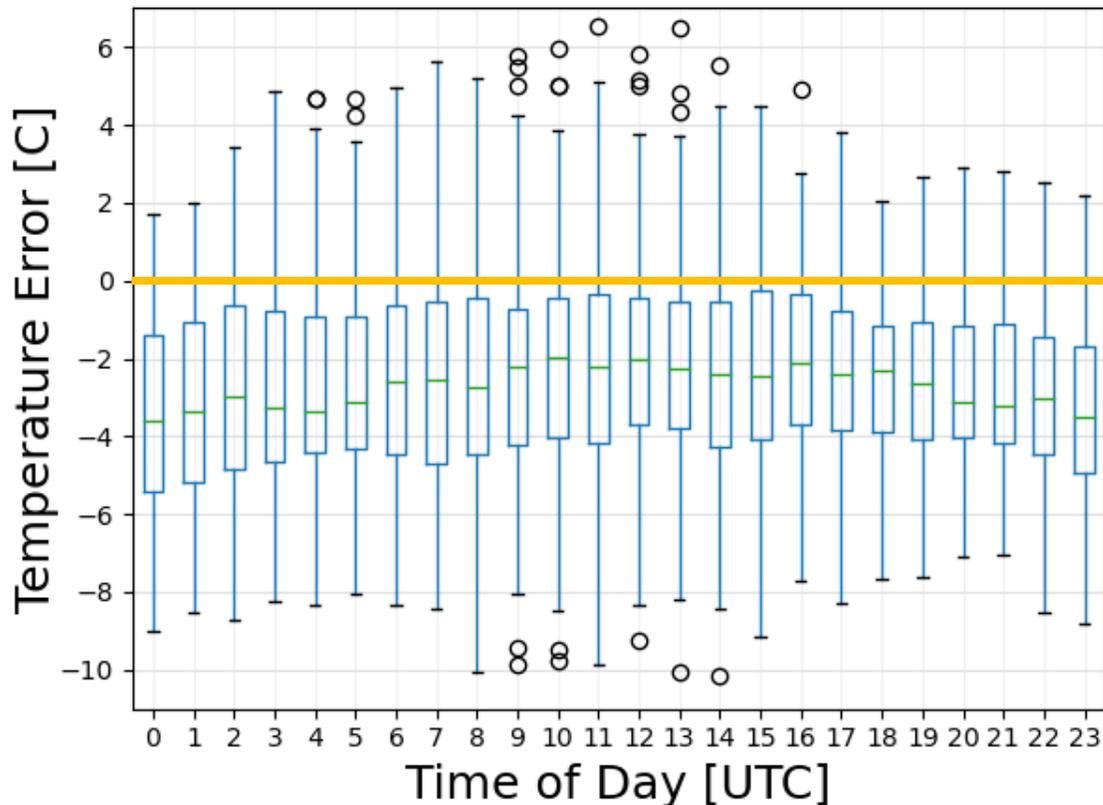




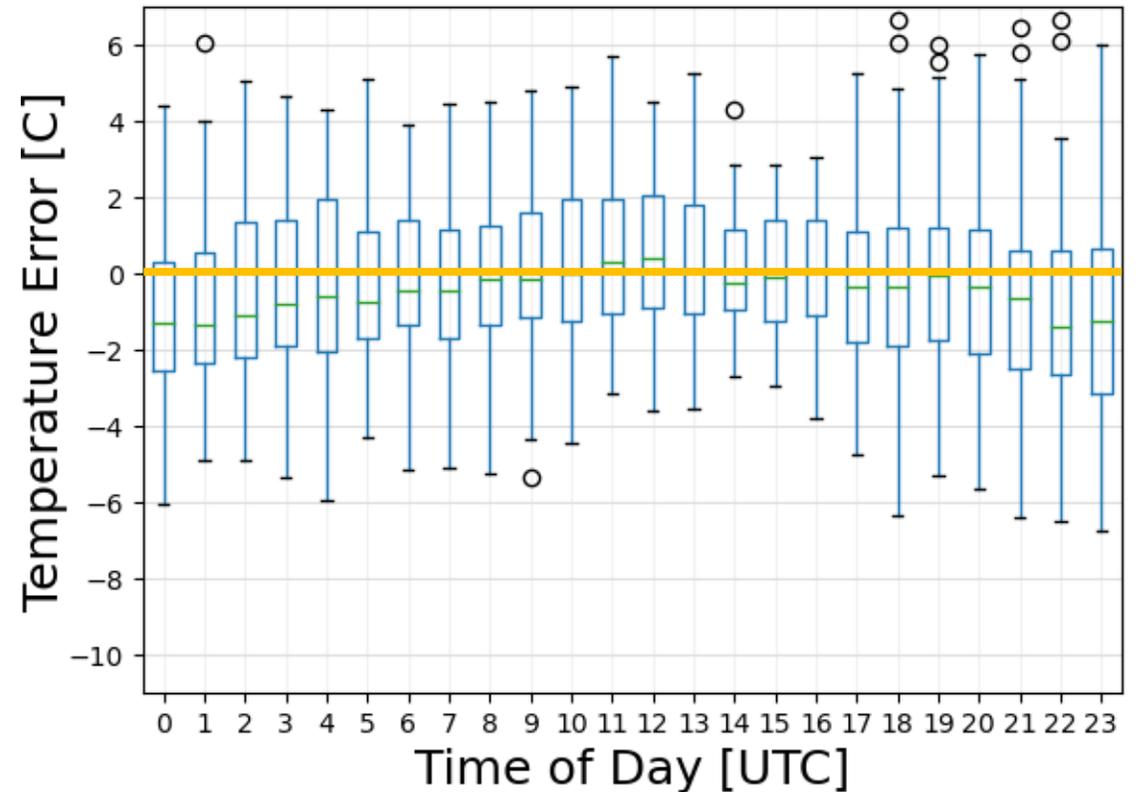
# Distribution of Temperature Errors by Time of Day Given Model Snow Cover

- Model temperatures at all times of day in locations such as Minneapolis and Sioux Falls are too cold compared to observations, with typical biases of 2-3°C (3-5°F)
- A slight cool bias without snow cover is still present through the day in some locations

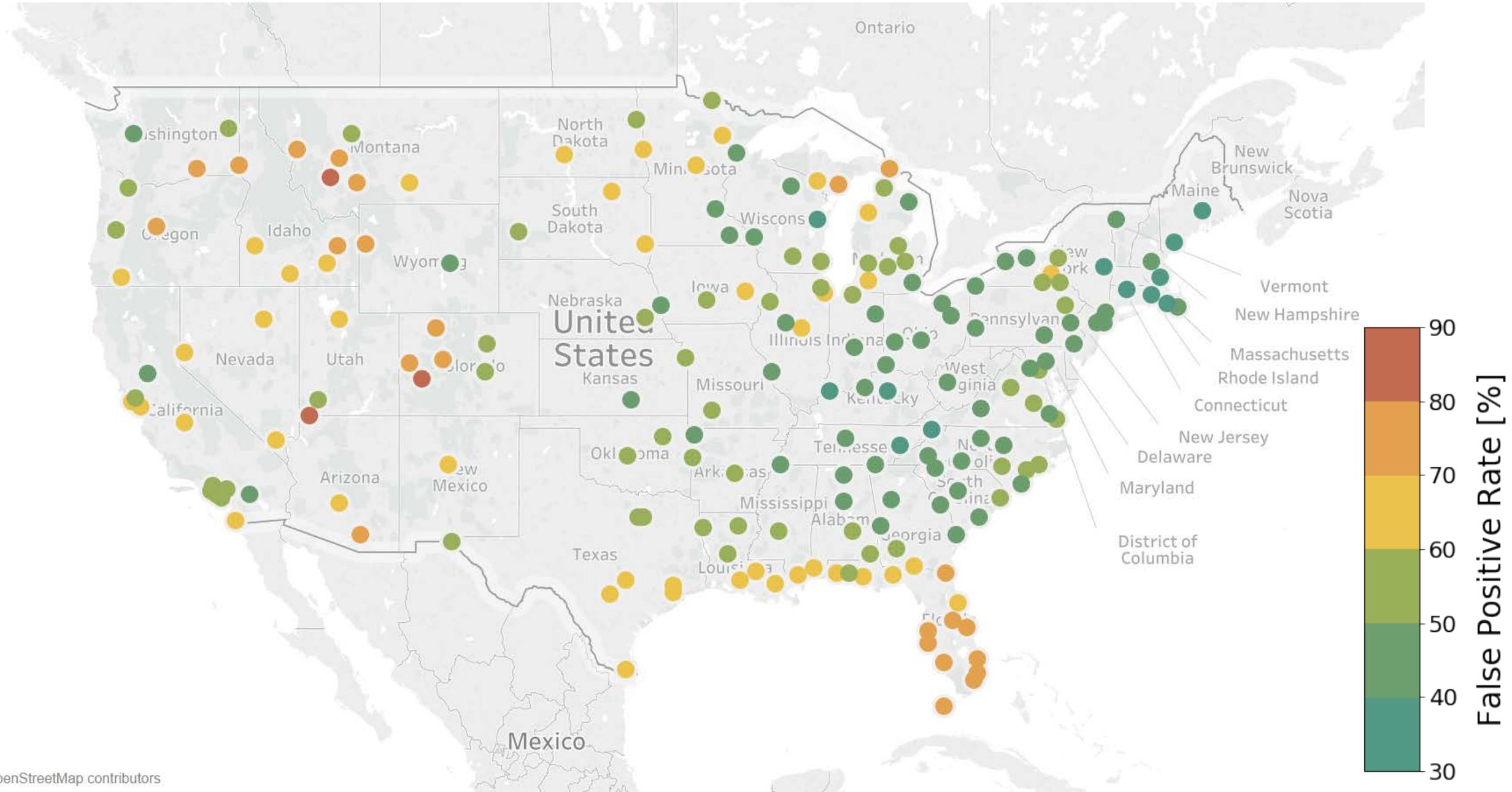
## Sioux Falls



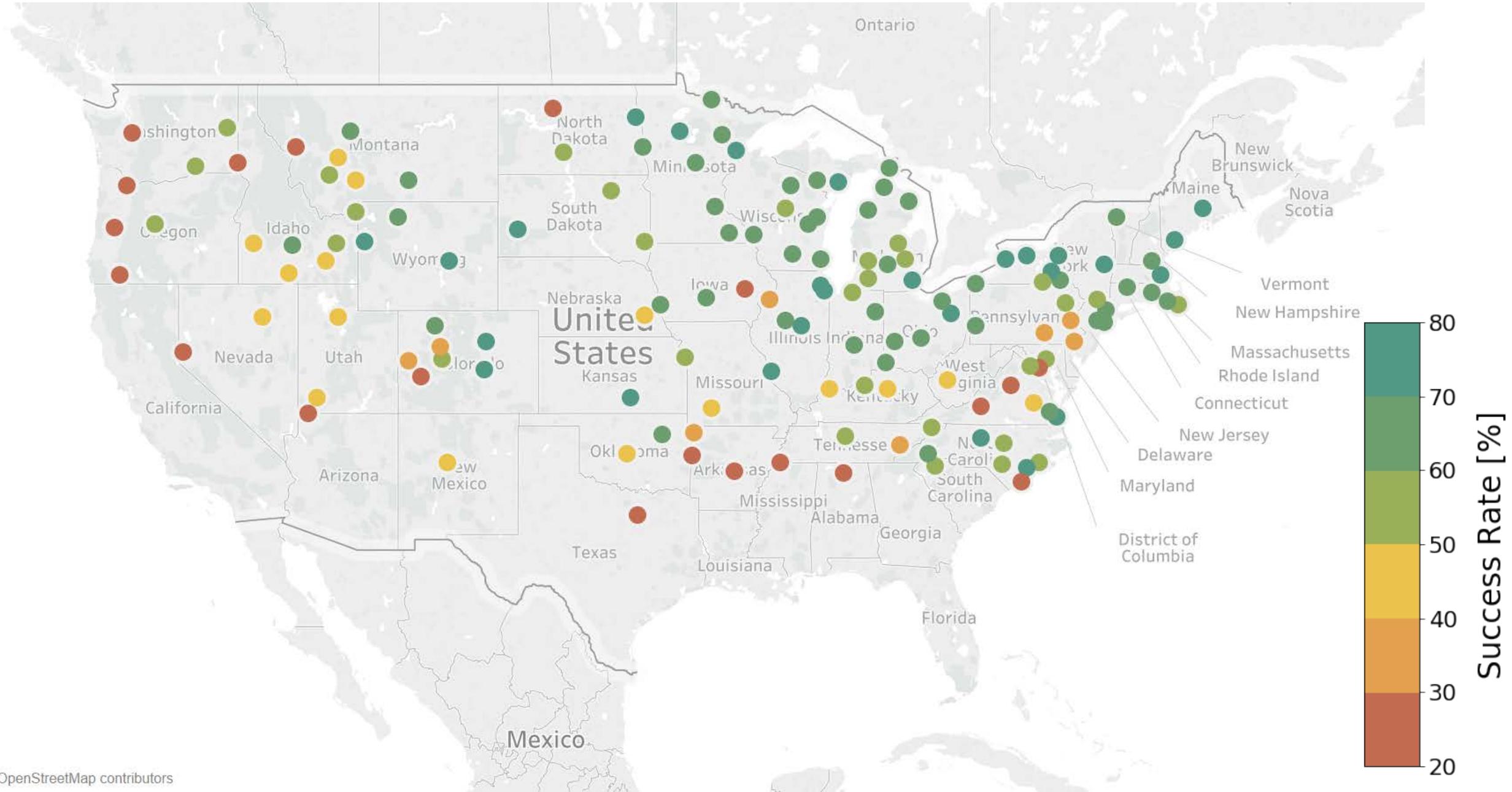
## Sioux Falls – No Snow Cover



# False Alarm Rate for Measurable Precip [48hr Lead Time]



# Success Rate for Hourly Snow Forecasts [48hr Lead Time]



# Hourly Precipitation Type: “Better” Performance

- On average, the GFS predicts snow fairly well at a 48 hour lead time in Minneapolis (MSP)
- 26% of the time when the GFS predicts snow in MSP for an hour, none falls
- 65% of the time when snow is predicted, snow actually falls
- Rain vs Snow at 48 hour lead time still a challenge

Percentages sum to 100 along a column

MSP

		None	Snow	Rain	Freezing Rain	Mixed
ASOS Observation	None	N/A (N/A)	26% (41)	26% (17)	62% (5)	0% (0)
	Snow	62% (16)	65% (102)	36% (24)	0% (0)	0% (0)
	Rain	31% (8)	2% (3)	35% (23)	25% (2)	0% (0)
	Freezing Rain	8% (2)	6% (9)	0% (0)	12% (1)	0% (0)
	Mixed	0% (0)	1% (2)	3% (2)	0% (0)	0% (0)
		None	Snow	Rain	Freezing Rain	Mixed
		GFS Forecast				

# Hourly Precipitation Type: “Worse” Performance

- On average, GFS has a large overprediction of snow in Salt Lake City, UT (SLC)
- 46% of the time when the GFS predicts snow in SLC for an hour, none falls
- 45% of the time when snow is predicted, snow actually falls
- Large False Alarm rate for rain also evident

Percentages sum to 100 along a column

SLC

		None	Snow	Rain	Freezing Rain	Mixed
ASOS Observation	None	N/A (N/A)	46% (130)	52% (46)	100% (1)	0% (0)
	Snow	33% (6)	45% (127)	7% (6)	0% (0)	0% (0)
	Rain	56% (10)	9% (26)	39% (34)	0% (0)	0% (0)
	Freezing Rain	11% (2)	0% (0)	0% (0)	0% (0)	0% (0)
	Mixed	0% (0)	0% (0)	2% (2)	0% (0)	0% (0)
		None	Snow	Rain	Freezing Rain	Mixed
		GFS Forecast				



# Findings for GFS 48-Hour Lead Time Forecasts for November 2019 – March 2020

- Large ( $>2^{\circ}\text{C}$ ) nocturnal warm biases across much of the US during clear skies and light winds
- During periods with snow cover, cool biases present at all times of day
- Overprediction of hours exceeding a low hourly precipitation threshold (0.01 in/hr) across US
  - False Alarm Rates for measurable precip ranges from 30 to 85% with large values along Gulf Coast, Florida and Intermountain West
- Overprediction of hours with snow
  - Some airports (eg. SLC & PHL) frequently observed fewer hours of snow than forecasted – difficult to trust in operations