Do you Ever Wonder what People Actually *DO* with their Thermostats? - This Talk is for You

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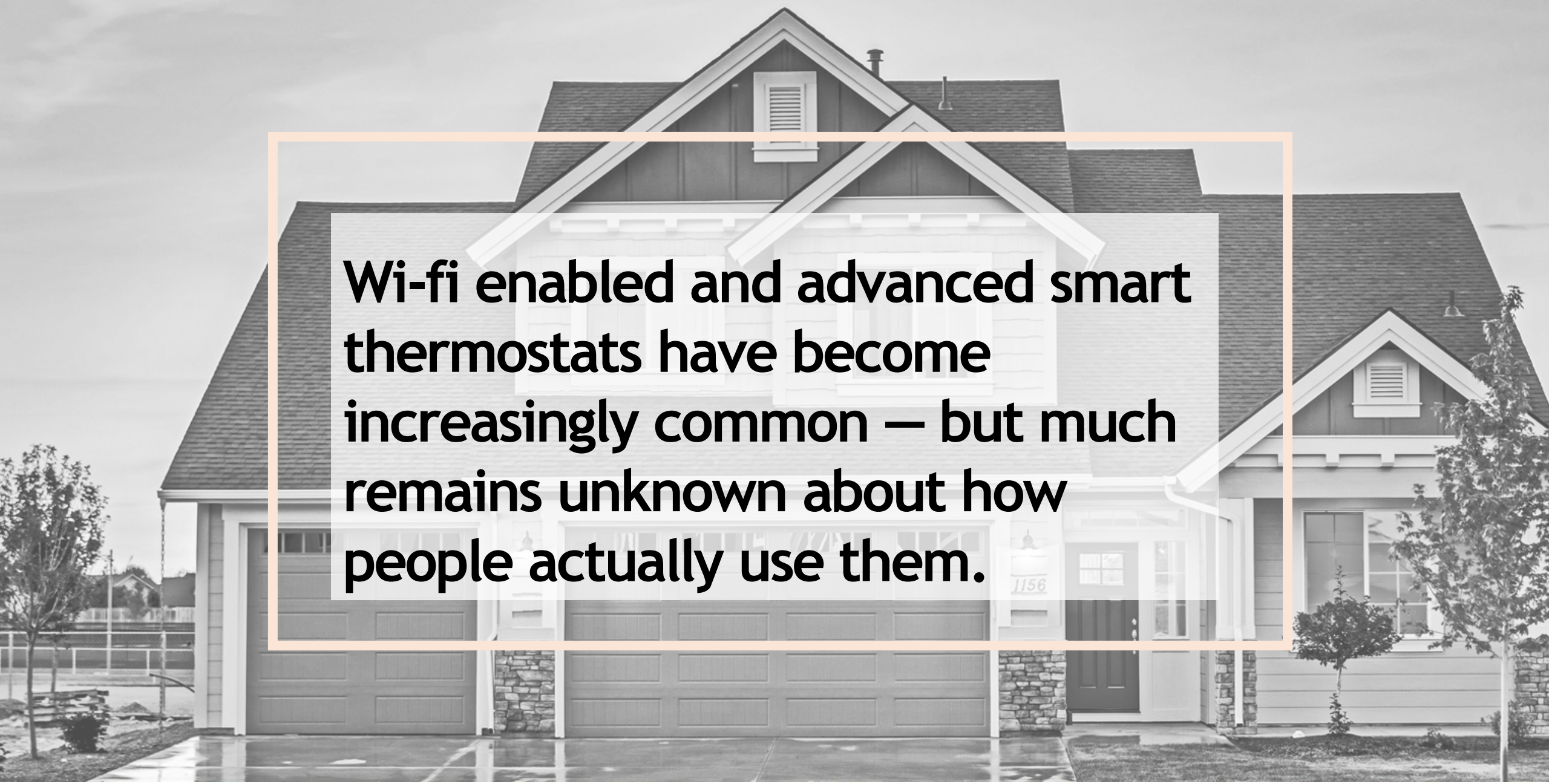
Eileen Hannigan, *ILLUME*


Wi-fi enabled and advanced smart thermostats have become increasingly common — but much remains unknown about how people actually use them.

Navigant and ILLUME performed a comprehensive analysis to better understand how people use their thermostats and AC.

AMI data for 16,000 Worcester, MA customers throughout summer 2014

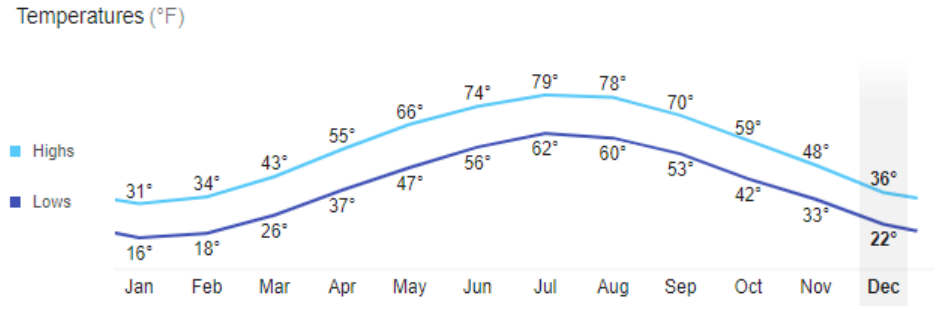
Thermostat telemetry data for subset of 250 customers

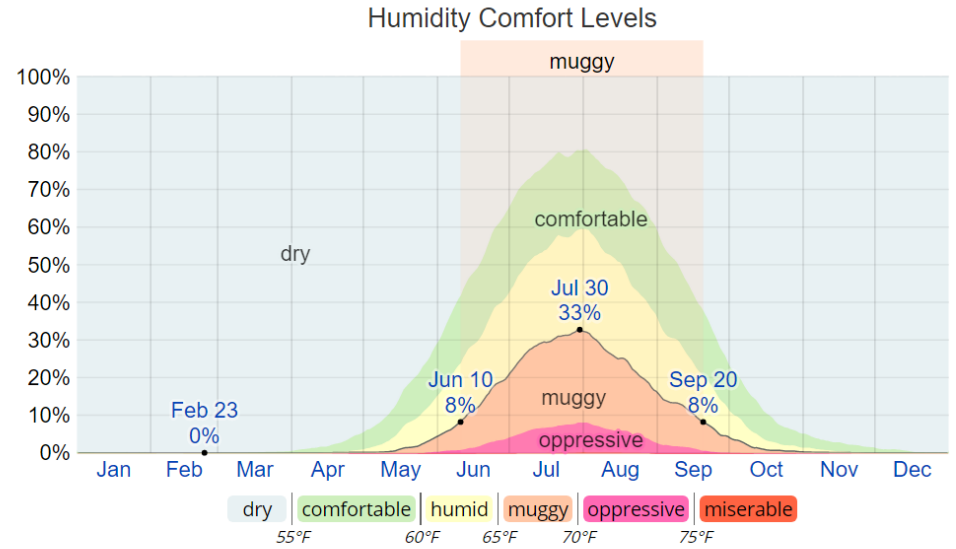
Detailed picture of how people use their thermostats and AC, particularly in response to weather

Worcester, Massachusetts:

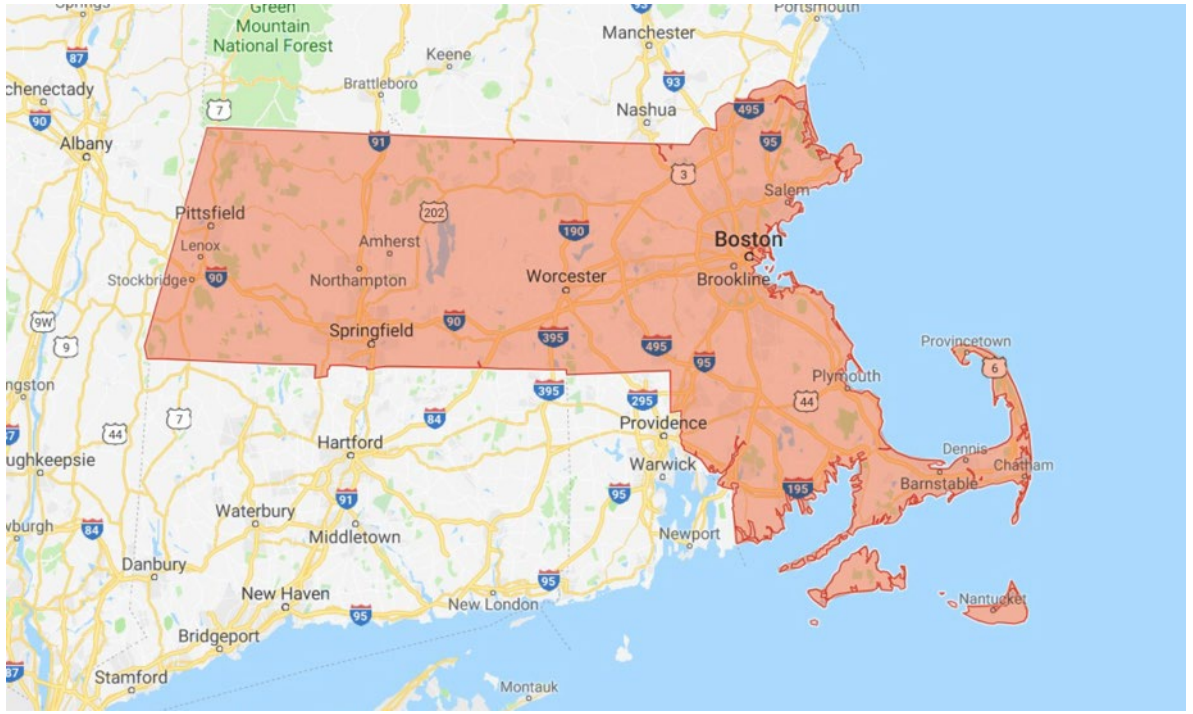
Hot, Humid Summers and Older Homes

48% of homes built before 1940





The percentage of time spent at various humidity comfort levels, categorized by dew point.



Research Question

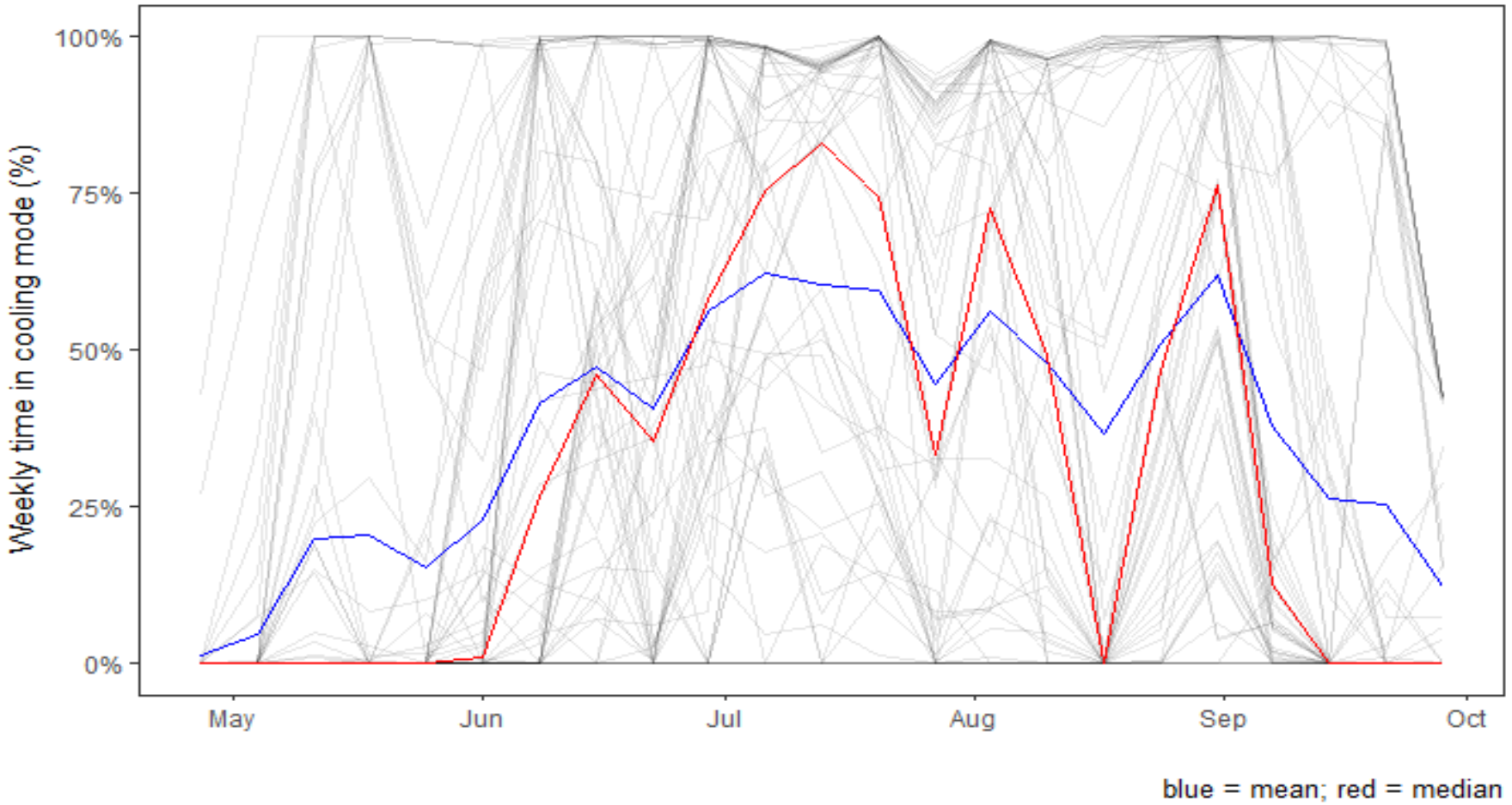
How do people use their thermostats:

Can we identify customers as different AC user types?

Secondary literature suggests that users can be categorized by type: E.g. Always on; Valvers; Set it and forget it

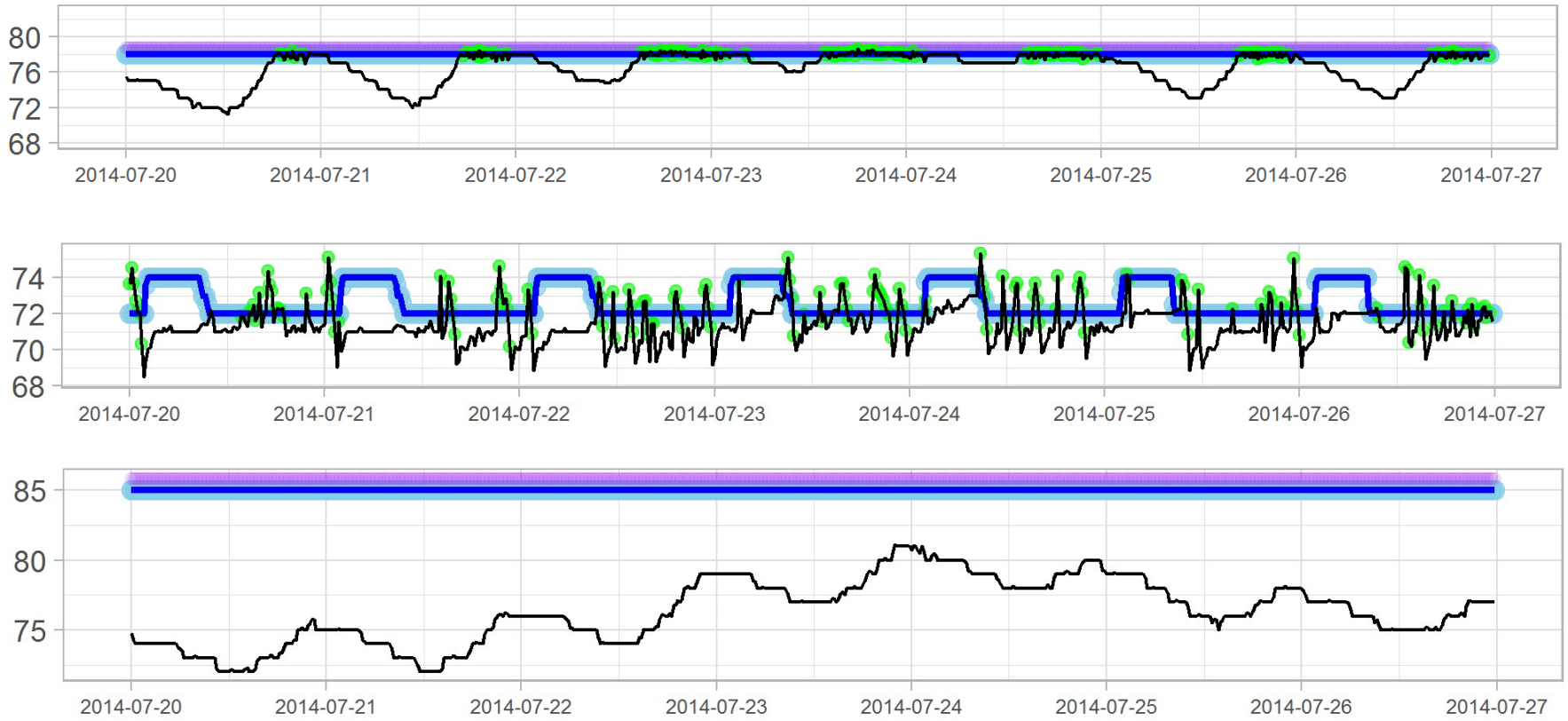
User behavior varies greatly even for a single user within a season: Static archetypes can be misleading

Weekly Time Spent in Cooling Mode by Device-- Summer



Thermostat user behavior varies widely between users reacting to the same weather, and changes for individual users even throughout a week

First Week of July—Three Different Devices



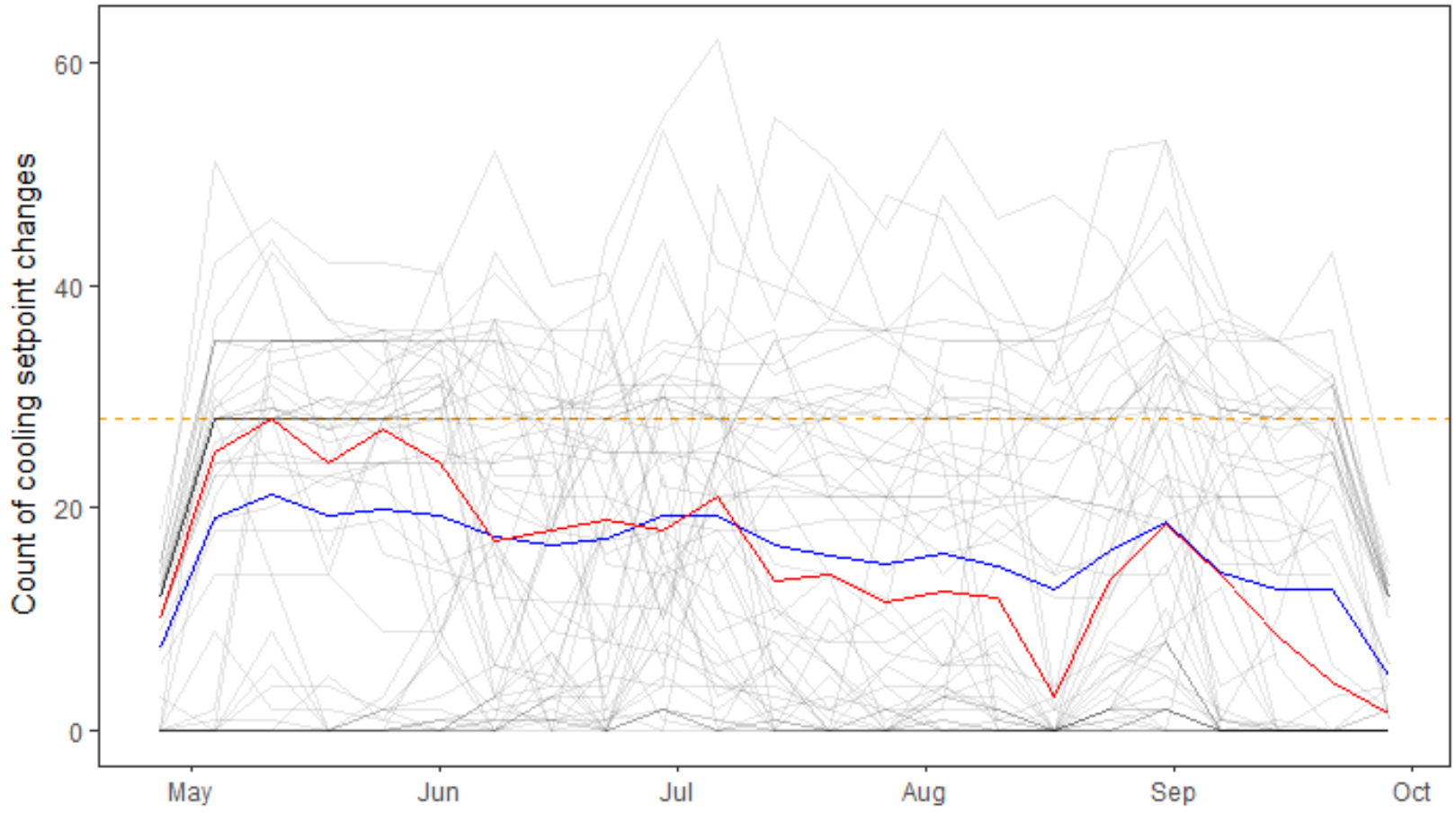
Research Question

How do people use their thermostats:

Do they use set points?

Most customers have less than 28 weekly cooling set point changes: Suggests fewer than 4 programmed daily setpoints.

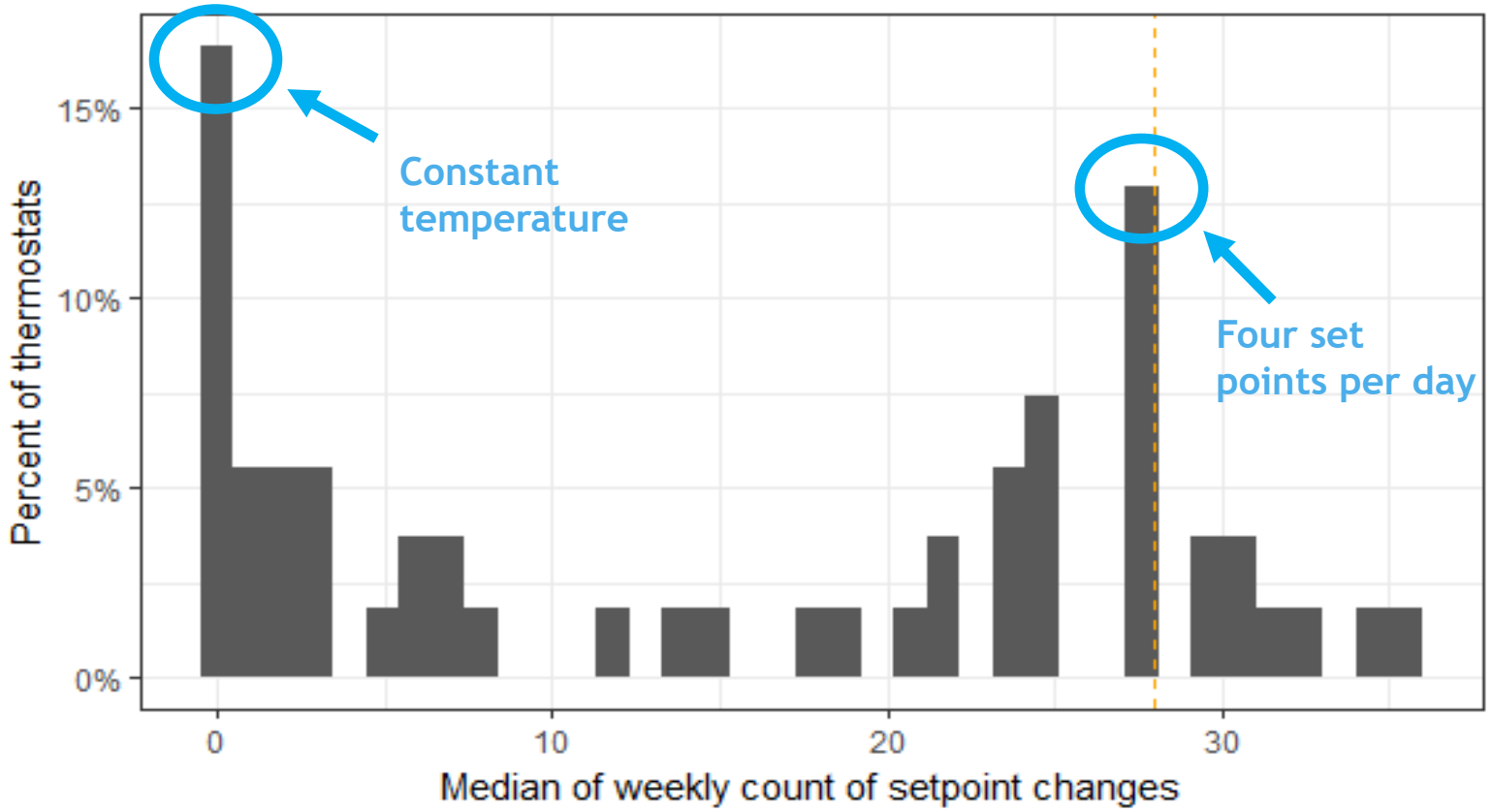
Weekly Count of Cooling Set Point Changes by Customer



orange dashed: 4 changes/day; blue: mean; red: median

Over 15% of the population typically keeps their set point at a constant temperature (no changes); **Another 13%** generally follows a four set point per day schedule.

Distribution of the Median Count of Cooling Set point Changes per Week



RECOMMENDATIONS

Message to user behaviors, not user archetypes

Educate users who over-use the “hold” setting to set more rational setpoints

Message differently to users with high versus low setpoints

Incentivize thermostats that account for humidity and can turn off “hold”

Research Question

How does the weather affect the timing of first use of AC systems during the cooling season?

Is it the heat? The humidity? Something else?

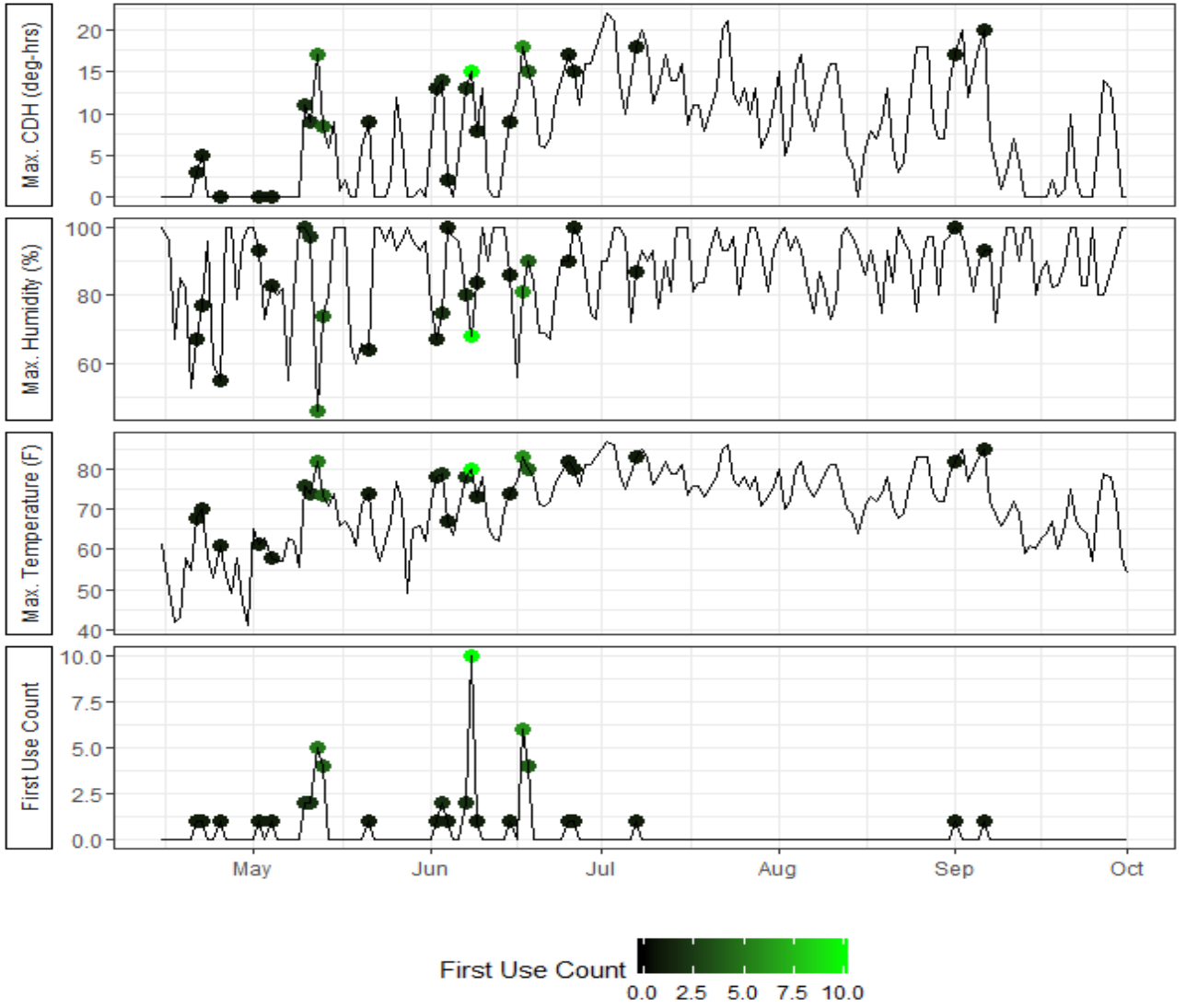
First use of AC in the season depends strongly on **heat**, but **not** on humidity.

Number of Customers Turning on AC for First Time Plotted in Relation to Weather Factors

Cooling degree hours →

Maximum daily humidity →

Maximum daily temperature →



Logistic regression of the likelihood of turning AC on for the first time in the season confirms the role of heat and humidity

Increases likelihood of turning AC on	Decreases likelihood of turning AC on
Cooling Degree Hours: Every 1°F-hour increase in the day's maximum CDH value, increases the probability of turning on AC by approximately 1 percentage point.	**Humidity:** Every 1% increase in the day's maximum relative humidity level decreases the probability of turning on AC by 0.05 percentage points
Weekends: Customers are 2 percentage points more likely to turn on their ACs for the first time on the weekend than they are on weekdays.	

RECOMMENDATIONS

Encourage customers to turn their AC on later in the season

Encourage customers to leave their homes on weekends to postpone first use

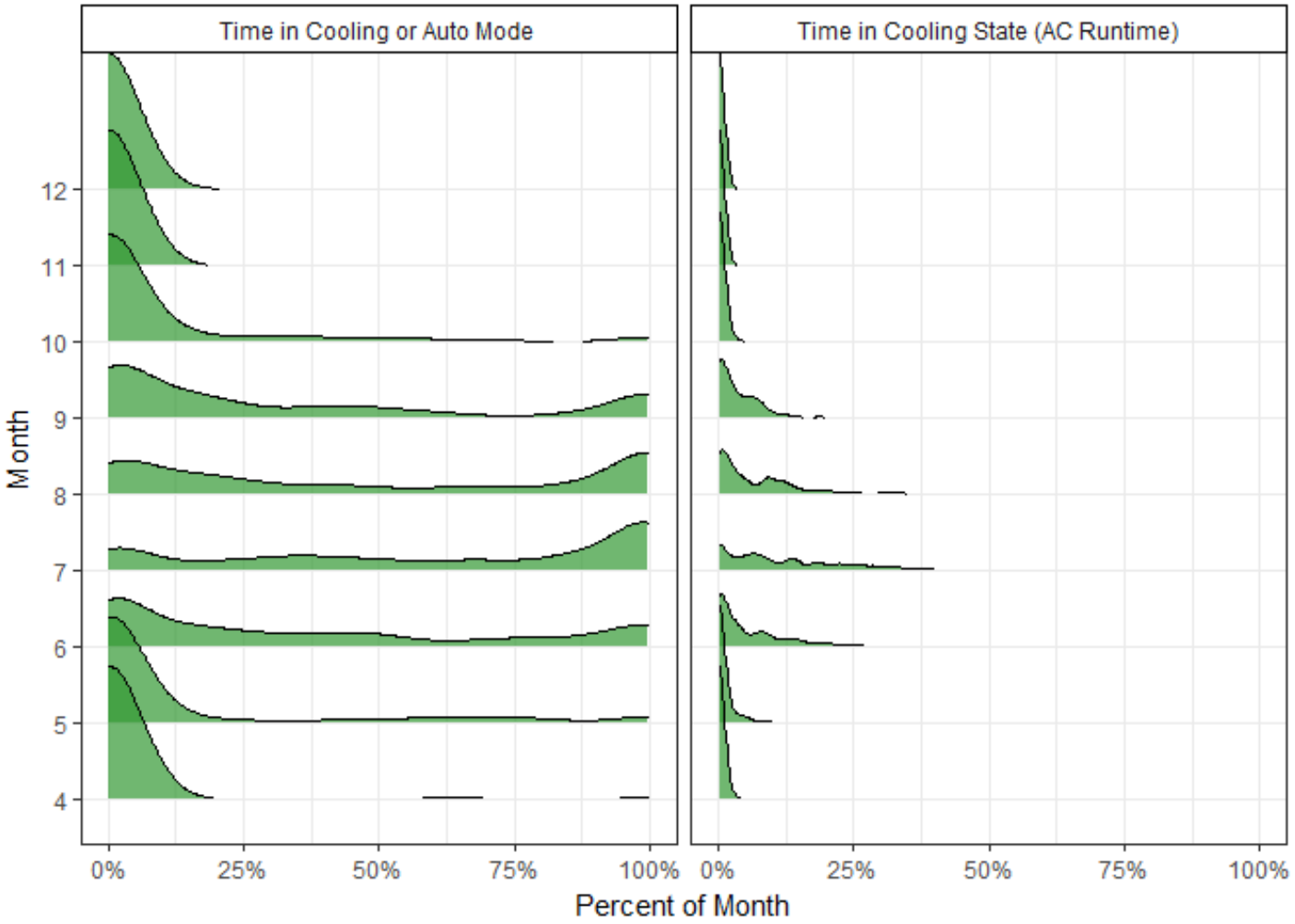
Encourage customers to shut their AC off earlier in the season

Research Question

How does the weather affect AC Use throughout the season?

Is the heat? The humidity? Something else?

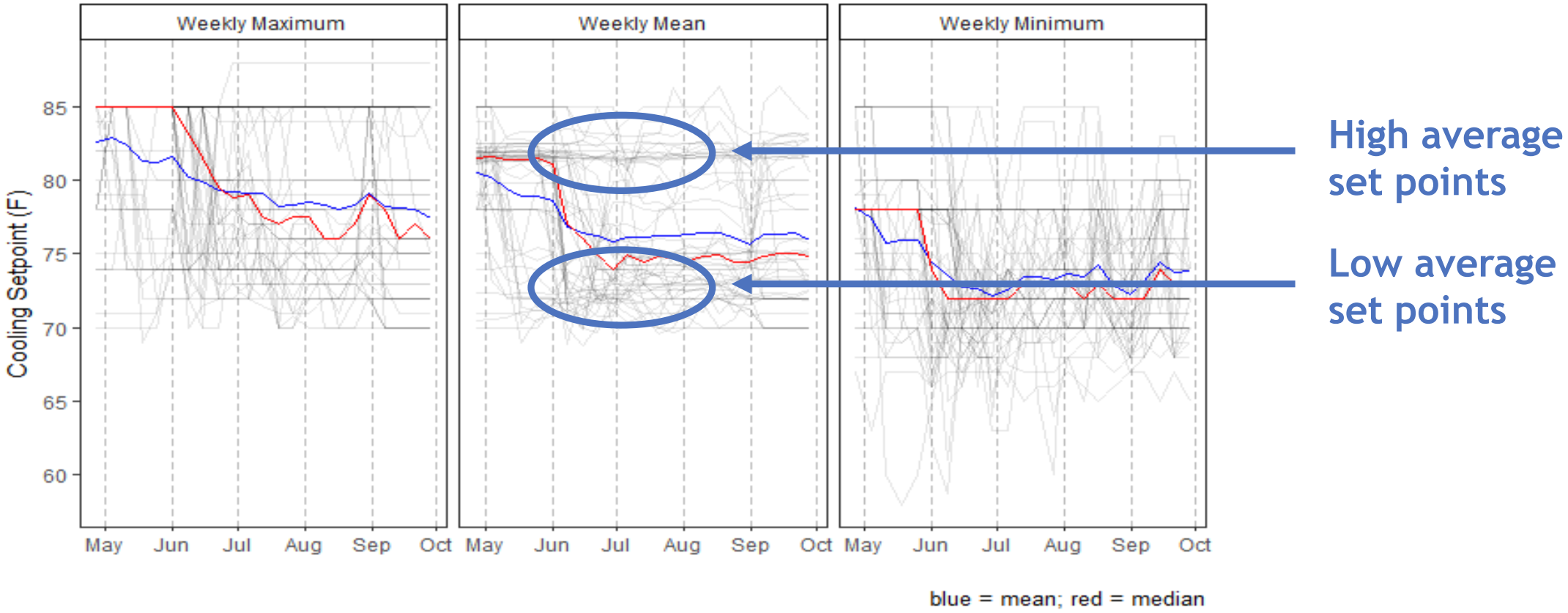
The typical device cools for just over 10% of the time during the hottest months, but less than 10% most of the time.



Humidity alone, and combined with heat, is a strong predictor of AC use throughout the season.

Increases AC use		Less effect on AC use	
	**Heat**: For every 3˚F over 68˚F, the model predicts roughly 1.1 kWh more usage per customer.		**Fatigue:** Day-of heat and humidity cause the majority of AC use, with the weather on preceding days increasing AC usage by a small amount
	**Humidity:** A difference of 50% humidity alone (e.g., the difference between 40% and 90% humidity), not in combination with heat, increases daily use by 1.5 kWh		
	**Heat & Humidity:** Above 77˚F, high humidity progressively adds to the CI and to increased usage: 90˚F and 90% humidity translates to 2.2 kWh additional AC usage		

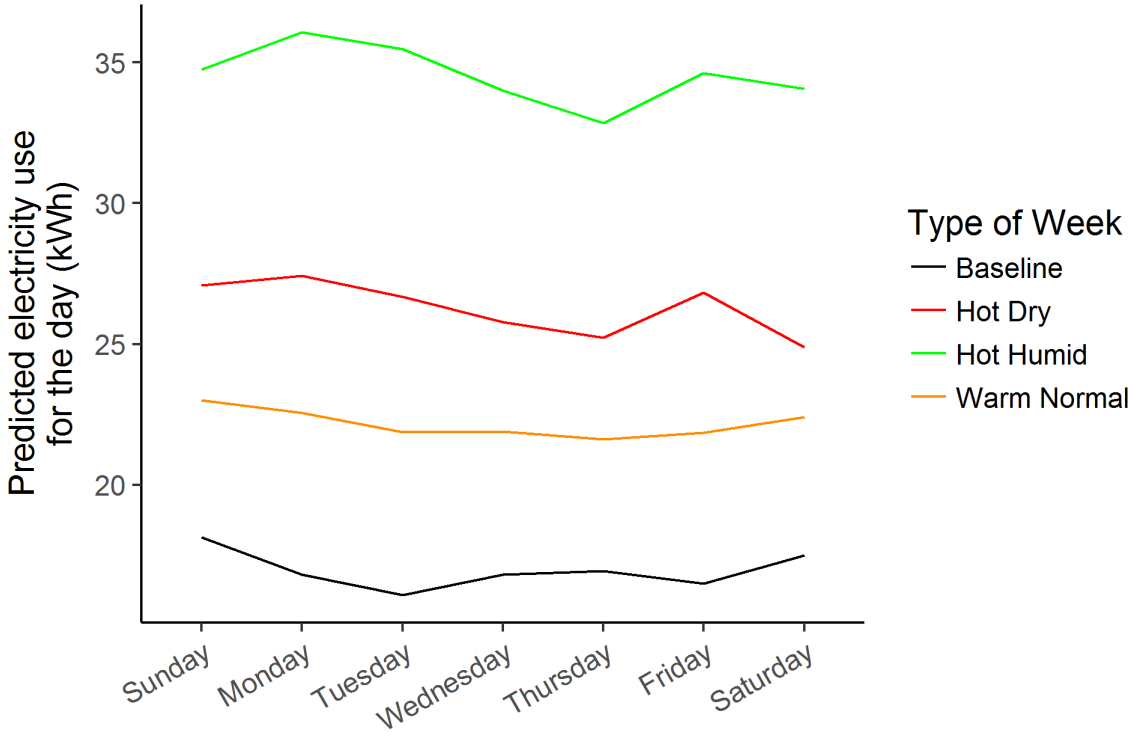
With the onset of high temperatures, customers diverge into two major categories: those with relatively high average weekly setpoints (85 degrees F) and low setpoints (73 degrees F)



Models based on AMI data can predict usage

The team tested the predictive capabilities of AMI data and found forecasted use was consistent with expectations based on weather.

- **Highest usage during hot, humid days**
- **Second highest during hot, dry days**
- **Baseline or warm conditions result in constant usage throughout the week**
- **Heat and humidity result in more variation throughout the week**



RECOMMENDATIONS

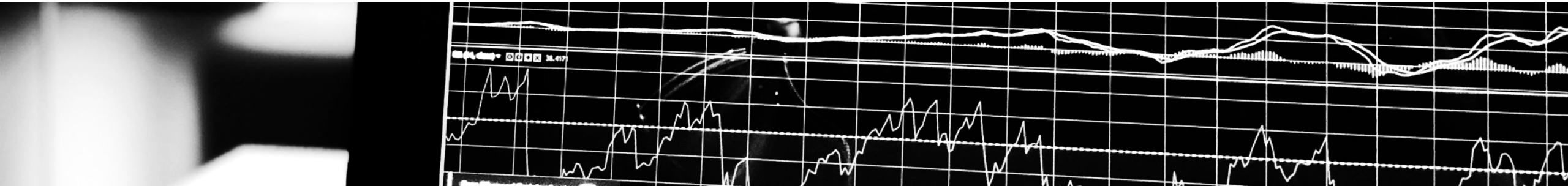
- Strategies to decrease AC usage should focus on both heat and humidity
- Focus less on fatigue and more on “in-the-moment” interventions

Conclusions and Future Research

- With a larger set of thermostat telemetry data (we had 250 customers) to pair to AMI data (we had over 15,000 customers), even more granular and precise results could be achieved.

- Relatively mild temperatures in the Northeast during Summer 2014 suggest in order to study behavior under extreme weather conditions, the study should be extended to years with hotter weather.

- Future research might gain valuable insights through a greater focus on sub-hourly behaviors in relation to weather, where this study focused on the hourly relationship between weather and AC use throughout the summer.



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Thank you for attending!

We'll see you at AESP 2019 Spring Conference

May 6-8 | Seattle