



ENERGY STAR Connected Thermostats

Stakeholder Working Meeting

November 16, 2018



Attendees

Abigail Daken, EPA
Dan Baldewicz, ICF for EPA
Leo Rainer, LBNL
Michael Blasnik, Google/Nest
Jing Li, Carrier
Tai Tran, Carrier
Brian Rigg, JCI
Kurt Mease, LUX (JCI)
Carson Burrus, Rheem
Ulysses Grundler, EcoFactor
Brent Huchuk, ecobee
John Sartain, Emerson
Mike Lubliner, Washington State U
Charles Kim, SCE
Michael Fournier, Hydro Quebec
Ed Pike, Energy Solutions for CA IOUs
Nick Lange, VEIC

Ethan Goldman, VEIC
Dan Fredman, VEIC
Phillip Kelsven, BPA
Casey Klock, AprilAire
Wade Ferkey, AprilAire



Agenda

- Resistance Heating Utilization
 - Now with More Data
- EU General Data Protection Regulation
- Regional Baselines Discussion
 - LBNL: Leo Rainer



RHU Data Recap

- **Recap of Previous RHU Datacall:**
 - Not statistically significant in last analysis:
 - More Heat Pumps -> More Statistical Power.
 - Request for custom all Heat Pump datasets.
 - Thank you to our data submitters!
- **RHU Open Questions:**
 - Statistically significant differences in products:
 - In Oversampled Data?
 - Standard Data Submissions? Comparable?
 - Product differences in certain temp bin groups?
 - Temp bins where RHU is primarily weather driven?

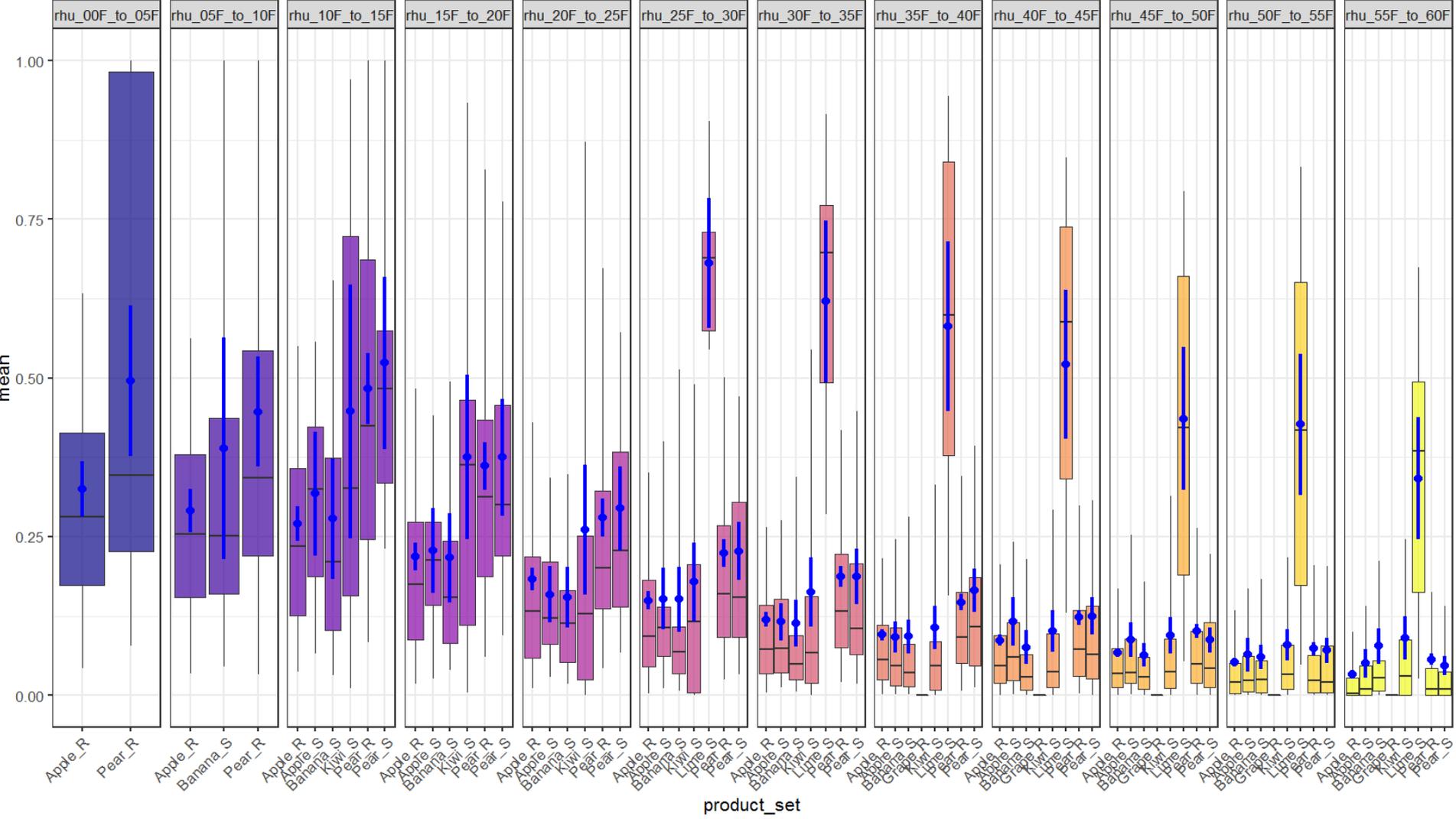
Charts: **R** – OverSample. **S** – Standard.

Paired – Only datasets with corresponding Oversample.



All Datasets, More Product Differences Noted:

Product Performance for All Climate Zone, by temp bin: N>=10
 Boxplot Upper and Lower Bounds q90 and q10, solid line mean and conf 95 bounds

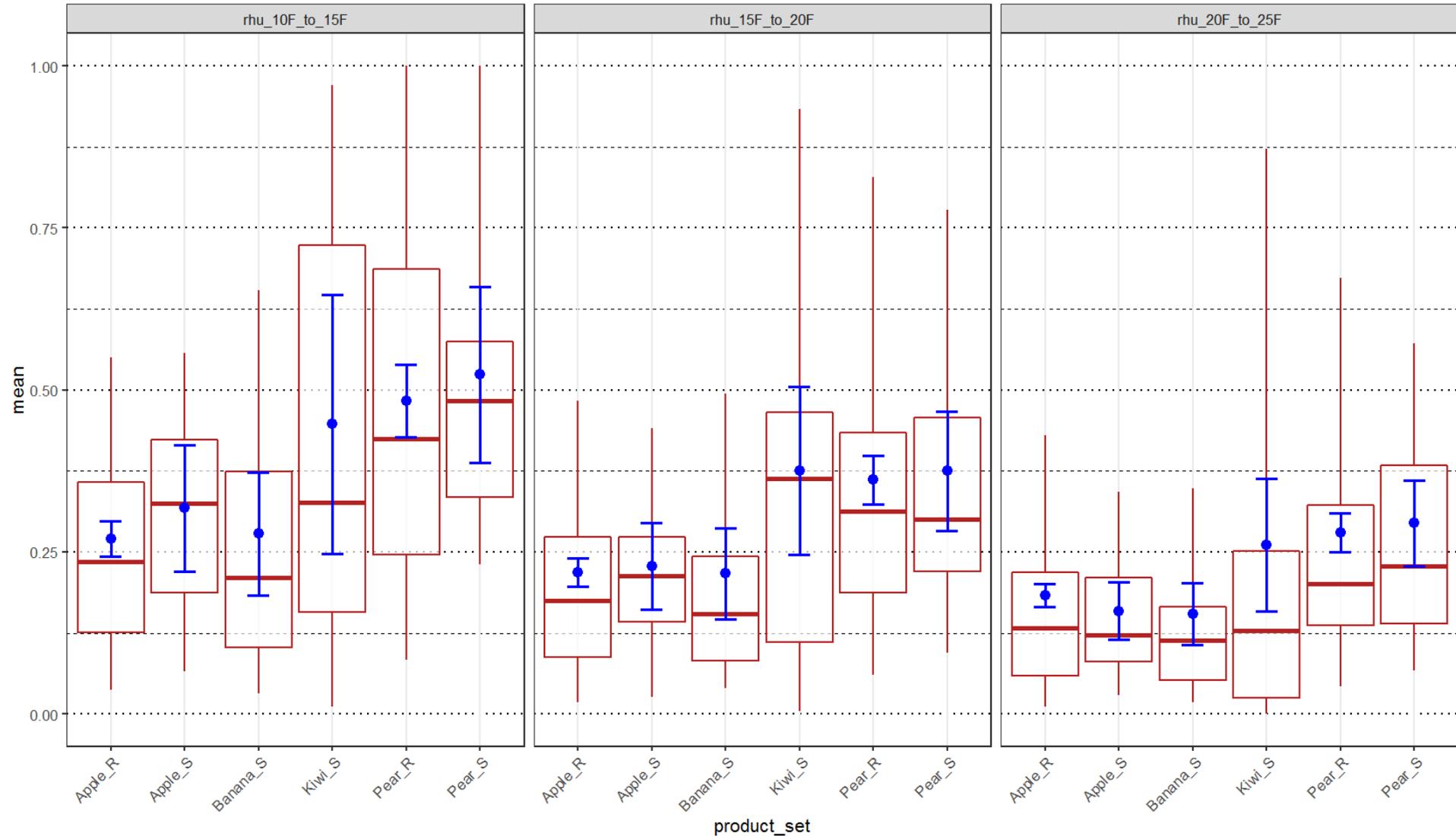




All Datasets, Closer Look (Low Bins):

Product Performance for All Climate Zone, by temp bin: N>=10

Boxplot Upper and Lower Bounds q90 and q10, solid line mean and conf 95 bounds

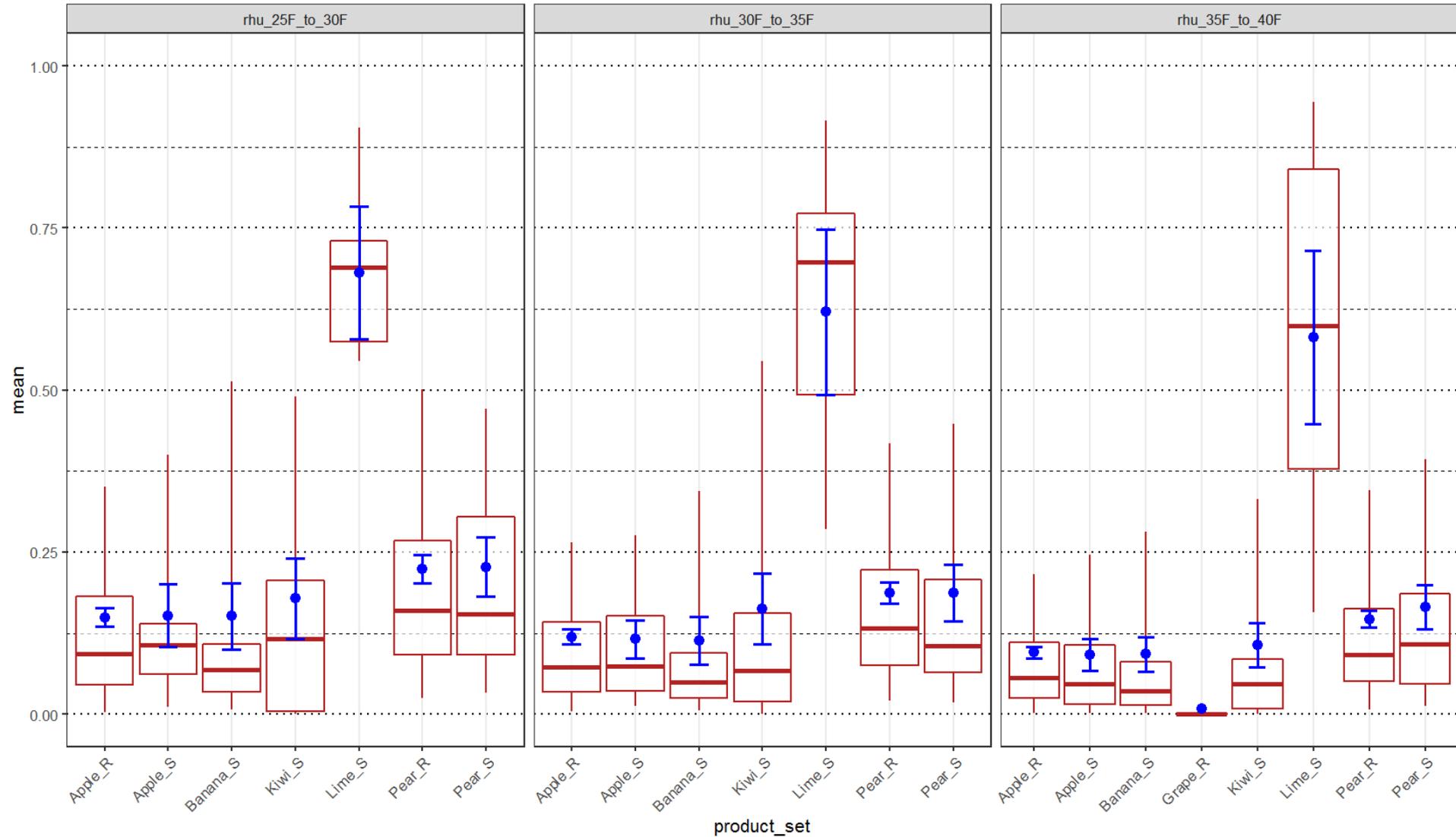




All Datasets, Closer Look (Mid Bins):

Product Performance for All Climate Zone, by temp bin: N>=10

Boxplot Upper and Lower Bounds q90 and q10, solid line mean and conf 95 bounds



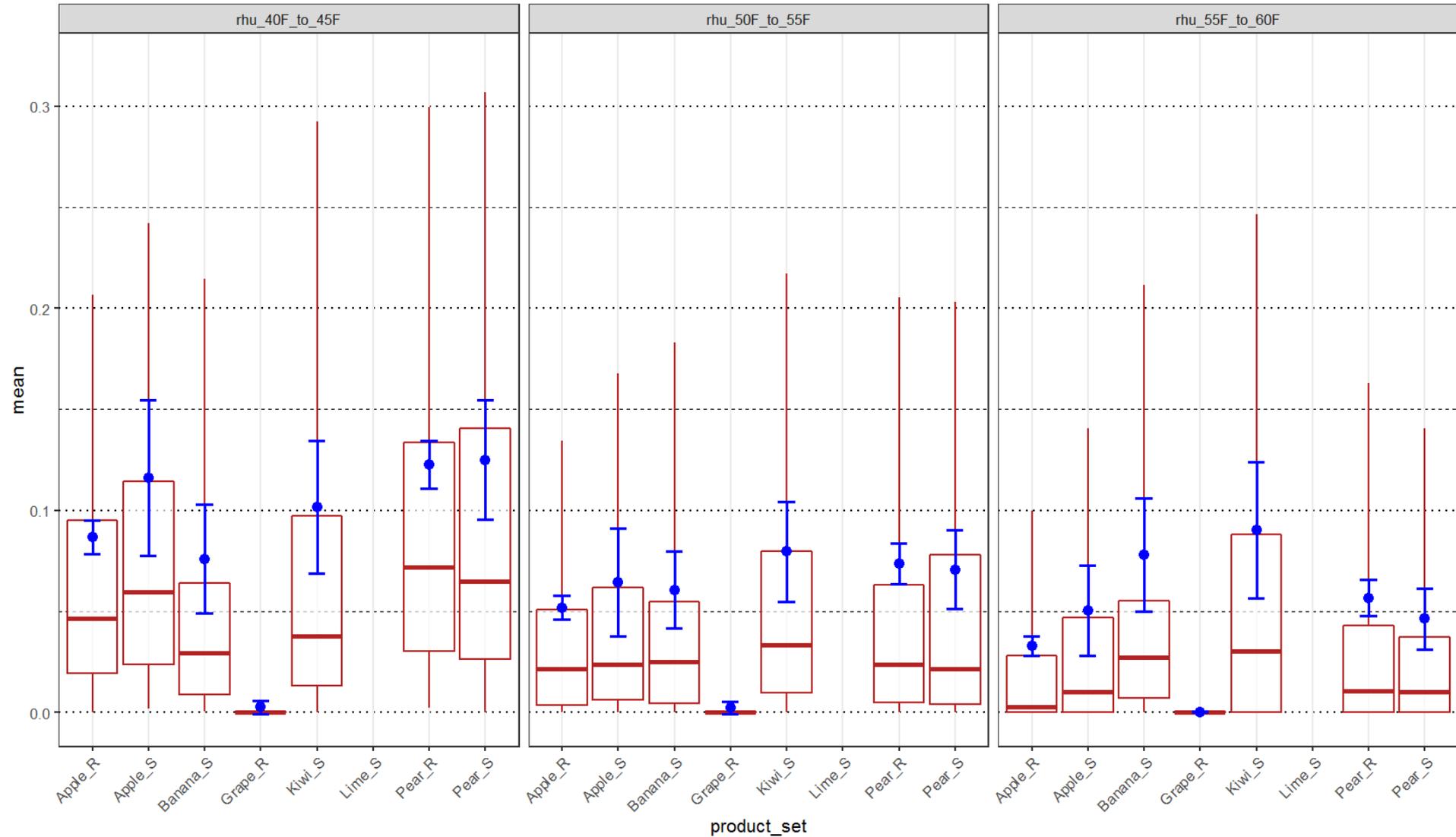


All Datasets, Closer Look* (High Bins):

Product Performance for All Climate Zone, by temp bin: N>=10

Boxplot Upper and Lower Bounds q90 and q10, solid line mean and conf 95 bounds

*Lime Excluded

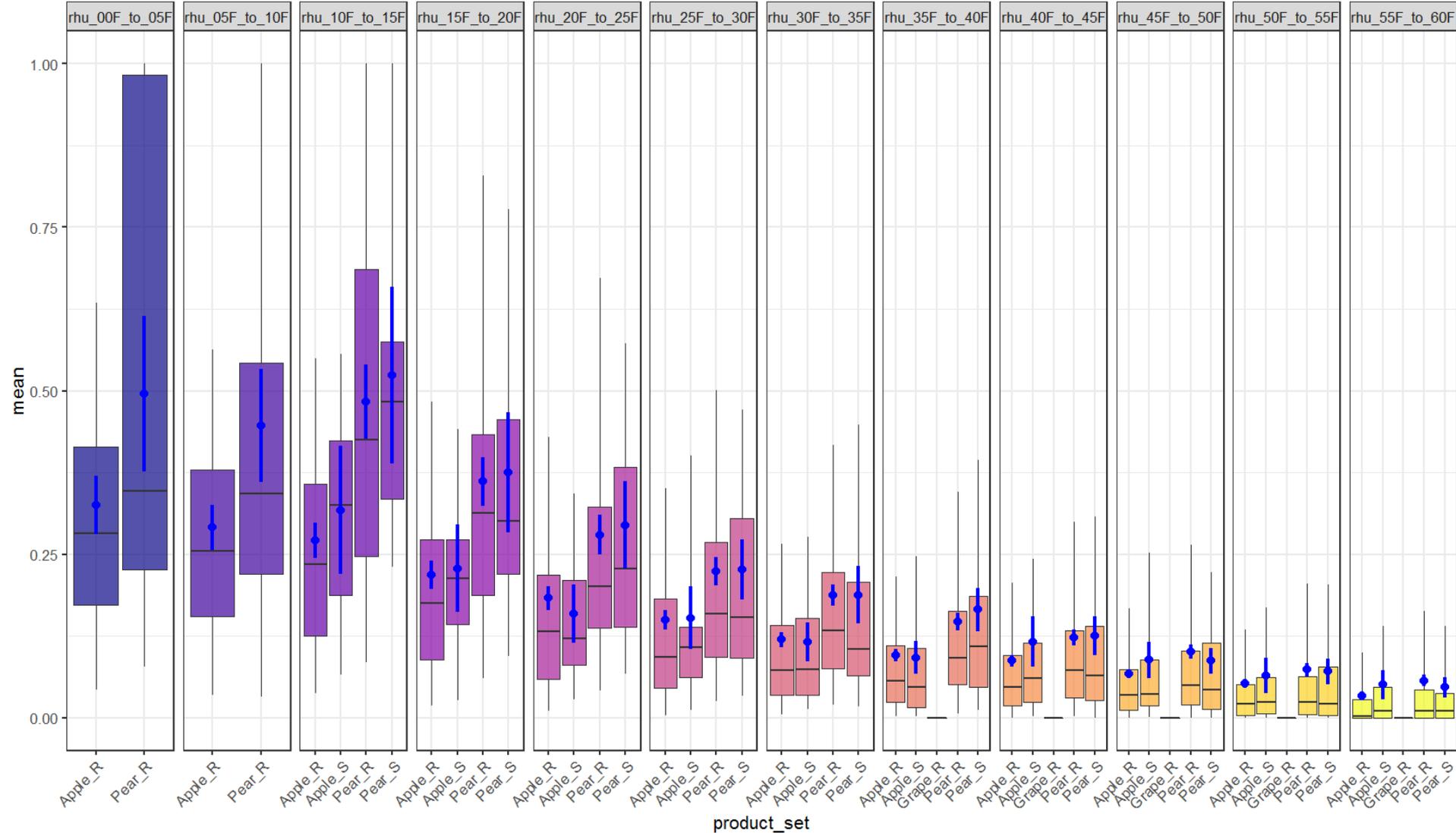




Oversampled (Paired) Data, More Statistical Power:

Product Performance for All Climate Zone, by temp bin, Paired: N>=10

Boxplot Upper and Lower Bounds q90 and q10, solid line mean and conf 95 bounds

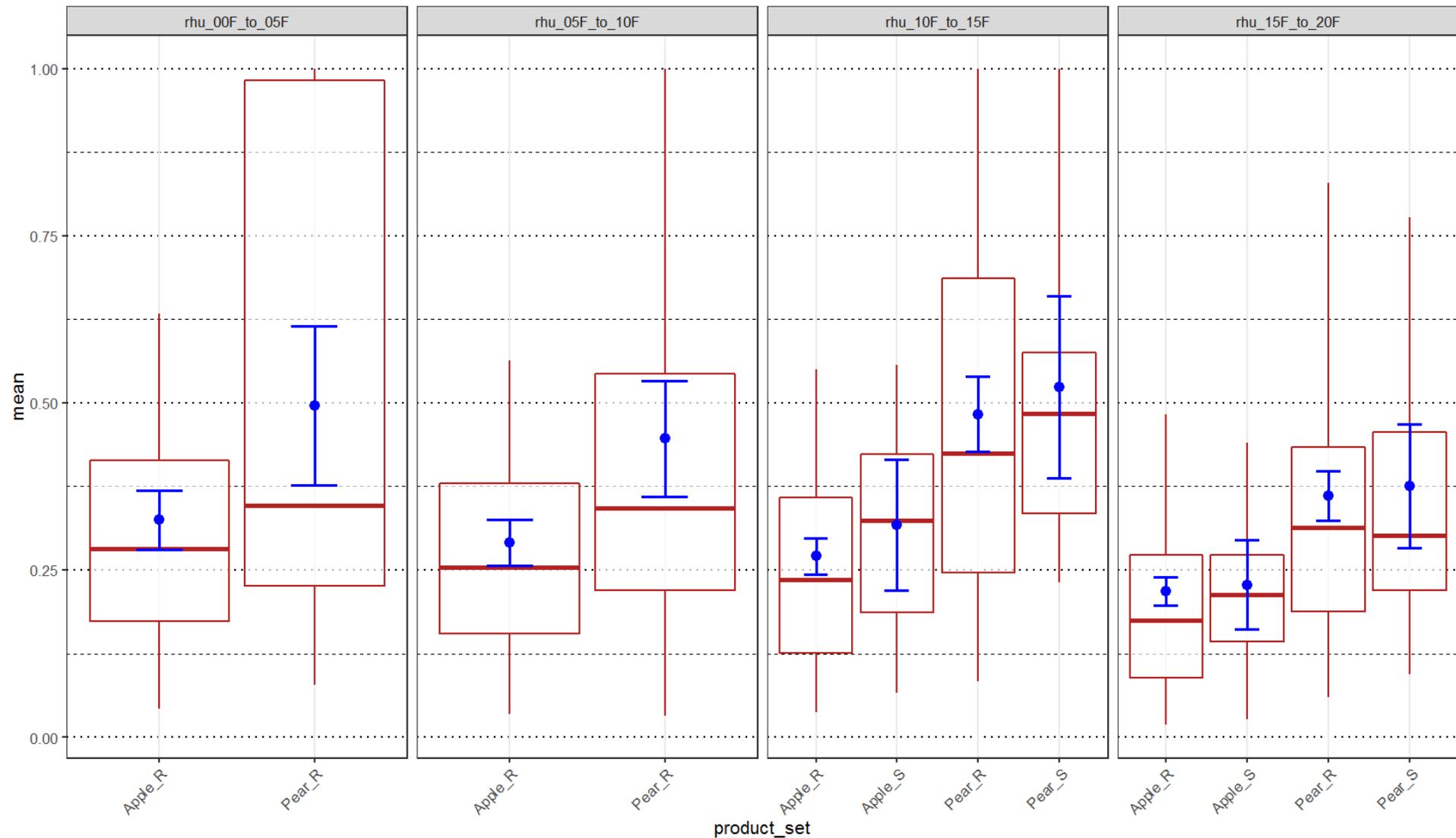




Oversampled (Paired) Data, Closer Look, Low Temp Bins:

Product Performance for All Climate Zone, Low Temp Bins (Zoom-in), Paired: N>=10

Boxplot Upper and Lower Bounds q90 and q10, solid line mean and conf 95 bounds

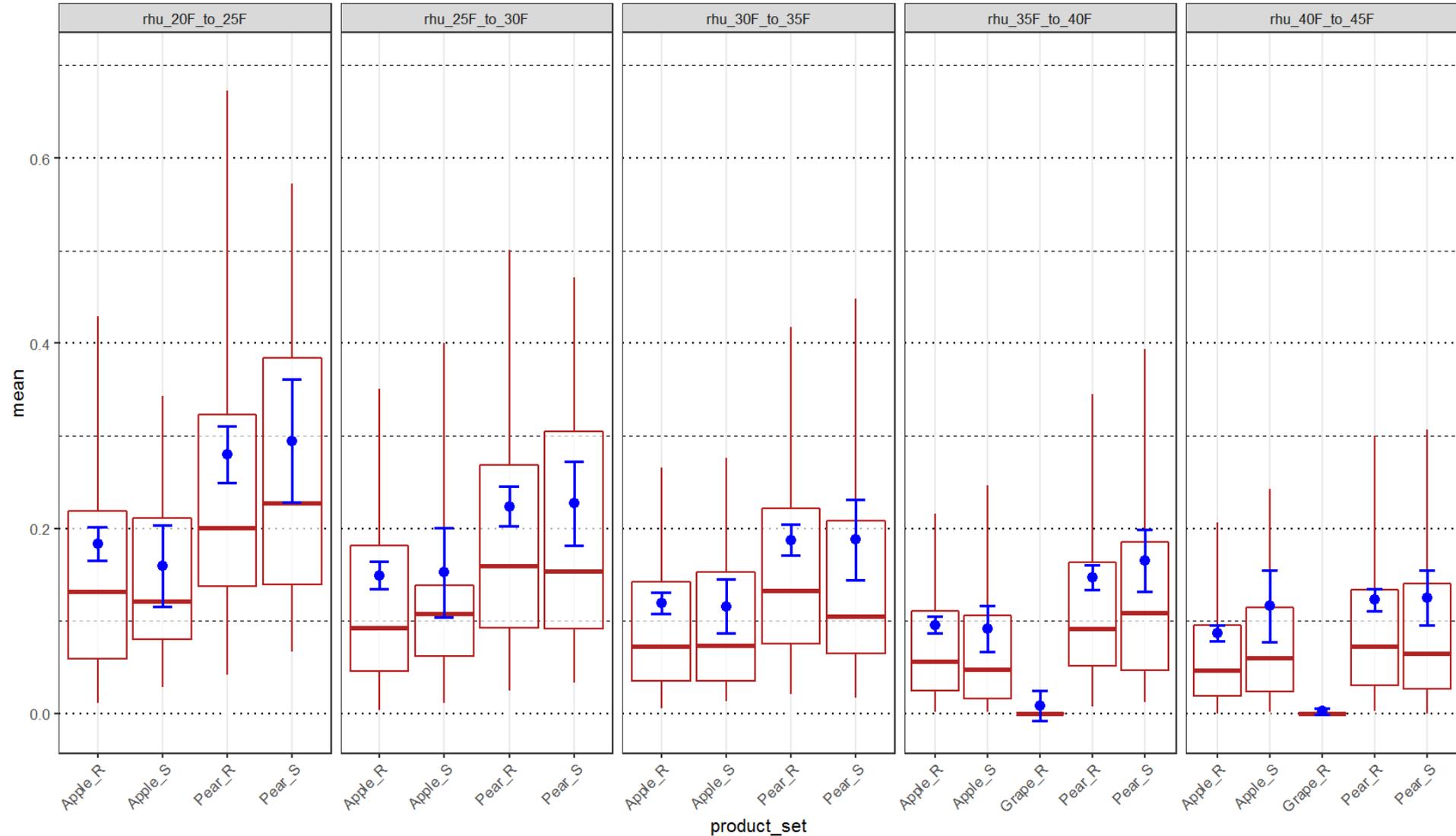




Oversampled (Paired) Data, Closer Look, Mid Temp Bins:

Product Performance for All Climate Zone, Mid Temp Bins (Zoom-in), Paired: N>=10

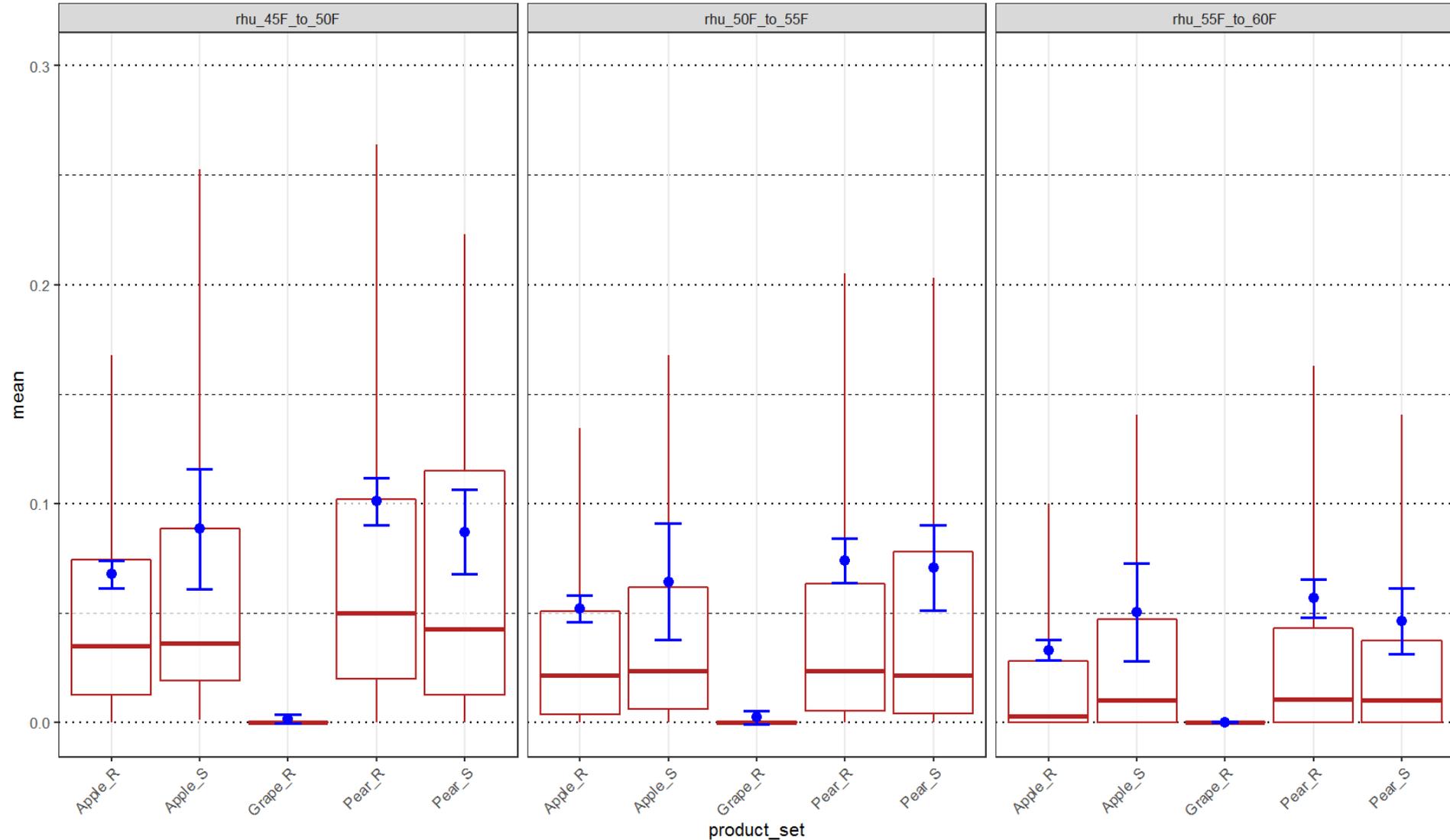
Boxplot Upper and Lower Bounds q90 and q10, solid line mean and conf 95 bounds





Oversampled (Paired) Data, Closer Look, High Temp Bins:

Product Performance for All Climate Zone, High Temp Bins (Zoom-in), Paired: N>=10
 Boxplot Upper and Lower Bounds q90 and q10, solid line mean and conf 95 bounds





Observations From RHU Data Plots (1)

- **Statistical significance:**
 - Several products sig. across most bins.
 - Some stat. sig. is between standard datasets.
 - Clearer product differentiation when using oversampled data.
- **Oversampled data:**
 - Oversample and data submission from same product generally overlap both distribution + CI95.
- **High Temp Bins:**
 - Some products have higher RHU than others.
 - Stat. sig. usually requires oversampled dataset.
 - Most distributions overlap, key differences are in Mean + CI95.



Observations From RHU Data Plots (2)

- **Mid Temp Bins:**
 - Good stat sig. between multiple standard data sets.
 - Oversample vs standard have similar distributions.
 - Some products less successful at $0.1 > x > 0$ RHU.
 - Suggests comfort oriented control algorithm.
- **Low Temp Bins:**
 - Wider distribution, highlighted in oversampled data.
 - Notable difference in 90th percentile (top tail) and highest Quartile between products.
 - Stat. sig. more difficult to confirm even on non-overlapping distributions (wider CI95). Oversampling closes this gap for comparisons.
 - Wide shifting of distributions between products.
 - $0.2 > x > 0$ RHU Performance: Setback behavior vs Aux necessary for HP Capacity/Sizing?



Observations From RHU Data Plots (3)

- **Distribution Shape:**
 - One sided about 0 in High & some Mid temp.
 - CI95 and mean higher RHU than median.
 - High temp, CI95 near 75th Percentile.
 - In Low temp bins, CI95 and median often overlap.
 - Distribution width increases as bin temp decreases: High -> Med -> Low
 - Some bi-modality?
- **Low Temp -> Wide Distributions:**
 - Low temp is forcing the heating design day and low COP behaviors of system (HP sized AC vs heat).
 - Oversampling may be picking up more segmenting.
 - Over/Right/Under-sizing, RH banks, compressor:
 - (-) RH capacity, (+) Aux Runtime
 - (+) Compressor capacity, (-) Comp. Runtime



RHU Discussion

- In most climates, compressor is sized for cooling loads; strip heat is sized for total heating load
 - Quibble: in NW, compressor may be sized for heating load; this may be true if installer is using manual S for compressor sizing
 - Less variation in relative sizing within climate zones than nationally
 - Manufacturers often add a heat pump coil to an electric furnace – so the resistance heating may be oversized.
 - **Consensus:** worthwhile to look within regions that have enough data



RHU Discussion

- For systems controlled by proprietary thermostats, resistance heat may be staged – less likely for a noncommunicating thermostat or 3rd party tstat
 - Yes, staging would not captured by RHU; all R heating is assumed the same
 - What percentage of ASHP would allow this? Many have auto staging in the unit itself – successive units automatically come on if heat call isn't satisfied
 - Time to increase R capacity isn't uniform, and some systems can stage down too
 - 30-40% single stage, balance multistage (one manufacturer)
 - Another manufacturer: majority multistage
- How much could we potentially find out about staging? Is it more consistent within one climate zone than between zones?



RHU Discussion

- Some of the long tails at high temperatures will be from systems that are just broken – the compressor isn't heating the house effectively at all, so the resistance heat will be essentially the only heating
 - Be careful about using the mean, particularly at high T, to compare products
 - Anecdotal info: heat pump problems may be missed during the winter, as the resistance heat is sufficient, and in the summer they discover there is no cooling
 - Guess: 5-10% of units have failing compressor heating and therefore high RHU
 - Can you adjust the software to detect thermostats that have this problem? Homes where lots of R heat when home temp/set temp is stable
 - Energy codes require high T aux heat lockout (seconded)



EU General Data Protection Regulation (GDPR)

- Q1: Has EU GDPR impacted your North American division / models / products?
- Q2: Has this changed any of your data storage requirements for your data warehousing systems?
 - Any impacts to US data?



EU General Data Protection Regulation (GDPR)

- Official approval to be able to store data that are required for E* certification; other raw data from thermostats get deleted after a few years
- Can you store anonymized? Yes, but you have to be unable to undo it so can't join new data to old data as by obliterating IDs
- Thinking about allowing users to see their data, and to request data deletion; when accounts are canceled, delete all information
- If a consumer asks that their data be deleted, what does that mean for data retained for E*? No PII, but (according to Google lawyers) can't keep MAC ID, or serial #
- Only applies to data collected from citizens of the EU, but Google at least has decided to apply it to all users
- Could maybe make it if you anonymize before sampling, it could work (though that's not easy to do, necessarily)
- Still working out true anonymization and what GDPR means for E* data retention

EPA Connected Thermostats Stakeholder Meeting

Regional Baselines Discussion

Leo Rainer, Alan Meier

Lawrence Berkeley National Laboratory



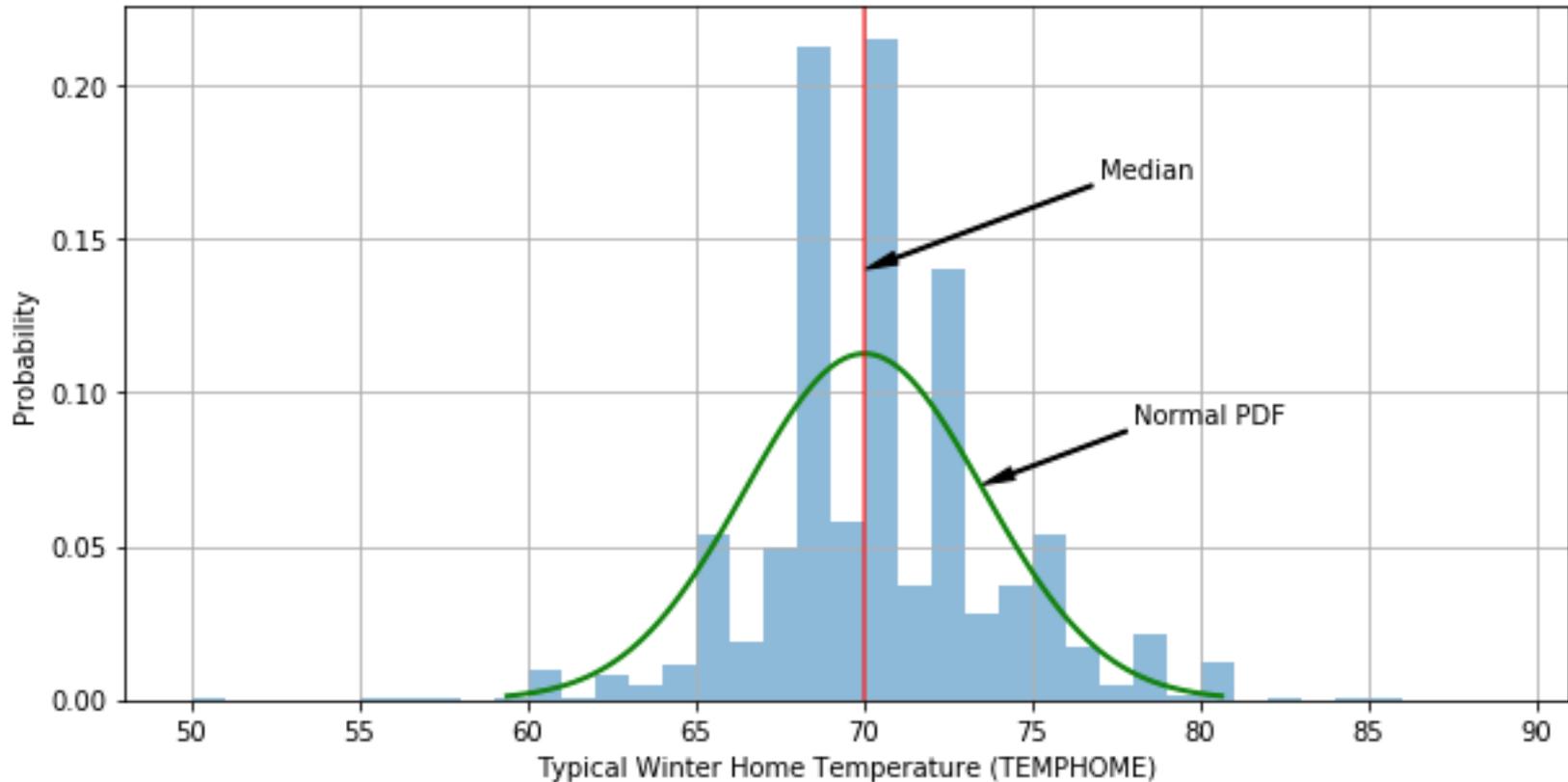
Why Consider a Regional Baseline Metric?

- ◆ Can reward both setback and setpoint changes
 - Working toward a metric that is more closely related to actual savings
- ◆ Can compare vendors
- ◆ Fixed and regionally responsive
- ◆ But...
 - Does not account for different vendor customer bases

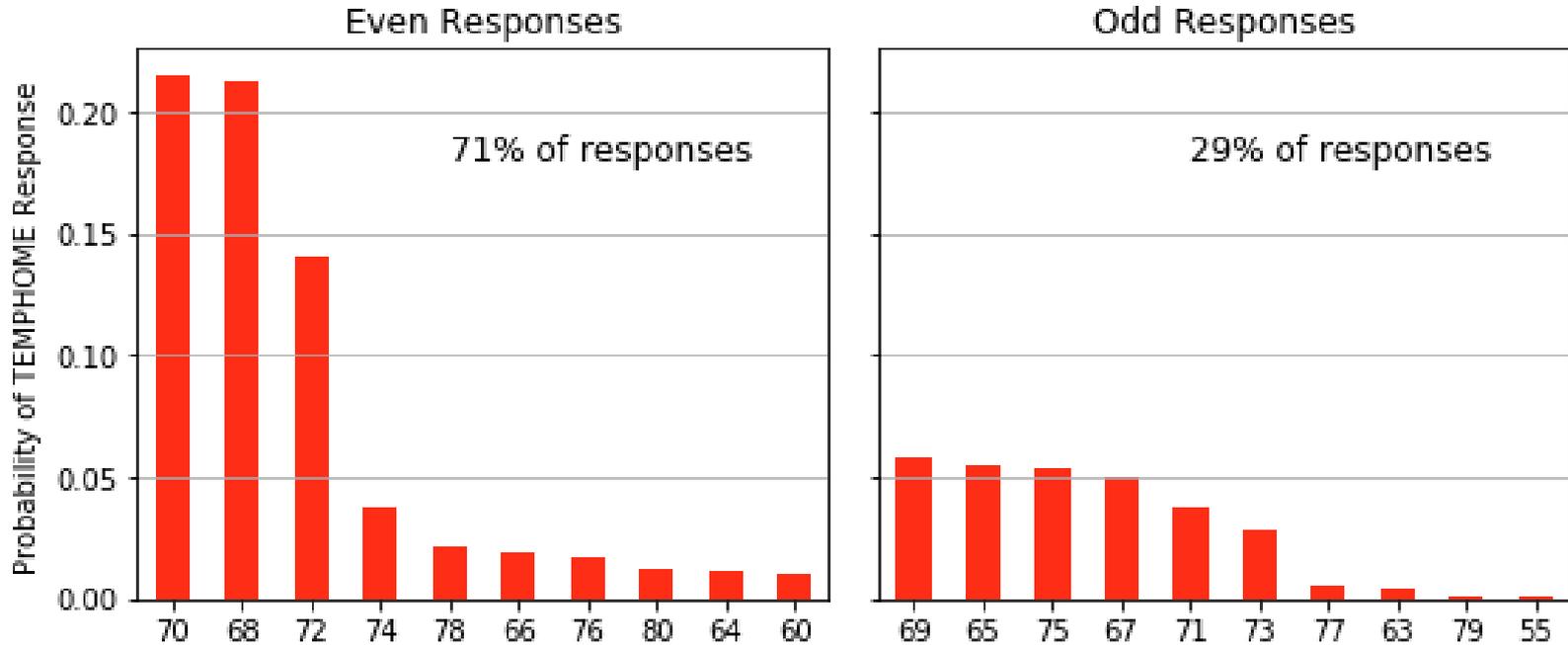
RECS

- ◆ 2015 Residential Energy Consumption Survey
- ◆ Triennial survey administered by the Energy Information Administration
- ◆ Total sample of more than 5,600 households
- ◆ Setpoint question: Asks residents to estimate the “Typical Temperature” inside their homes at various times of the day and year

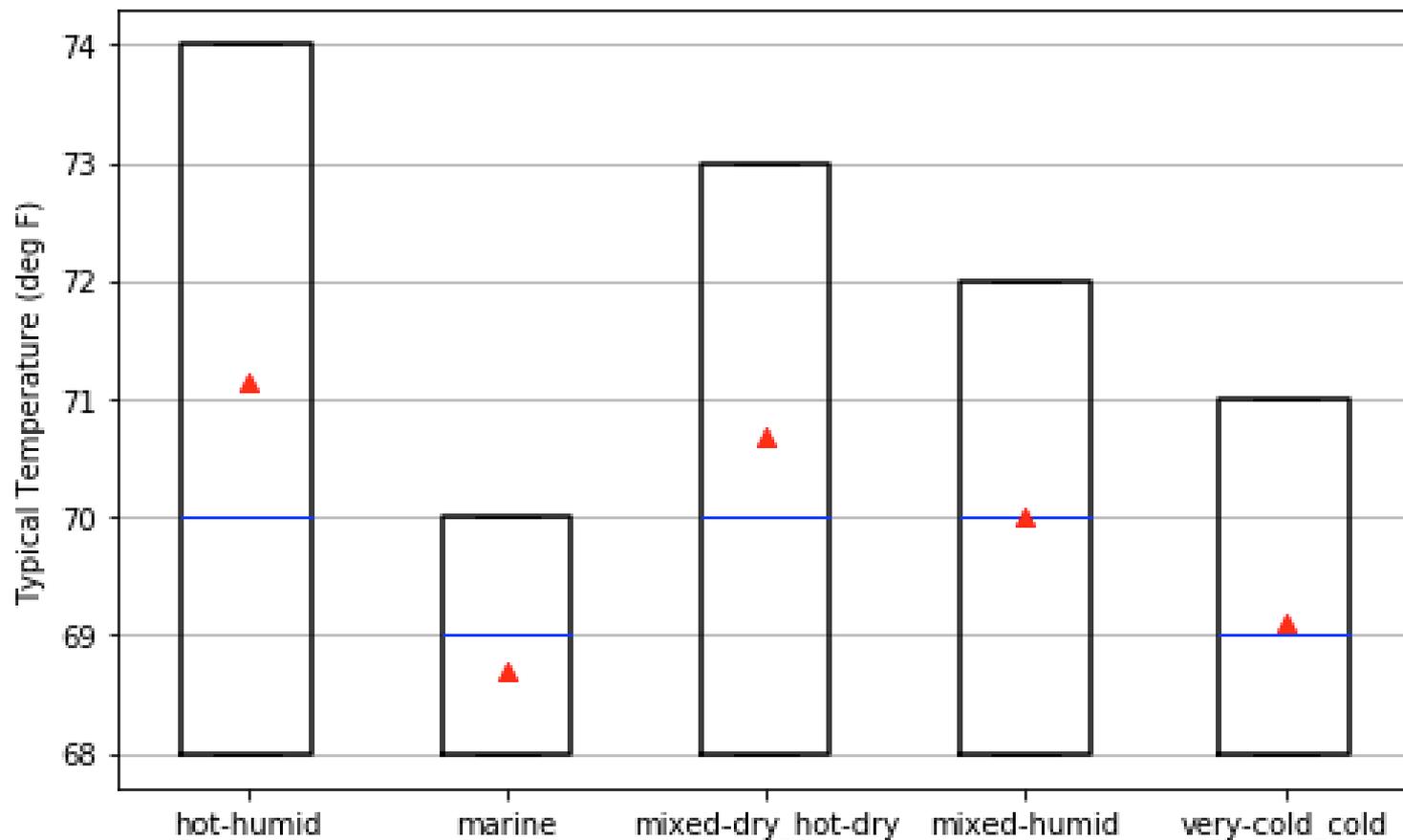
Probability Distribution of RECS TEMPHOME



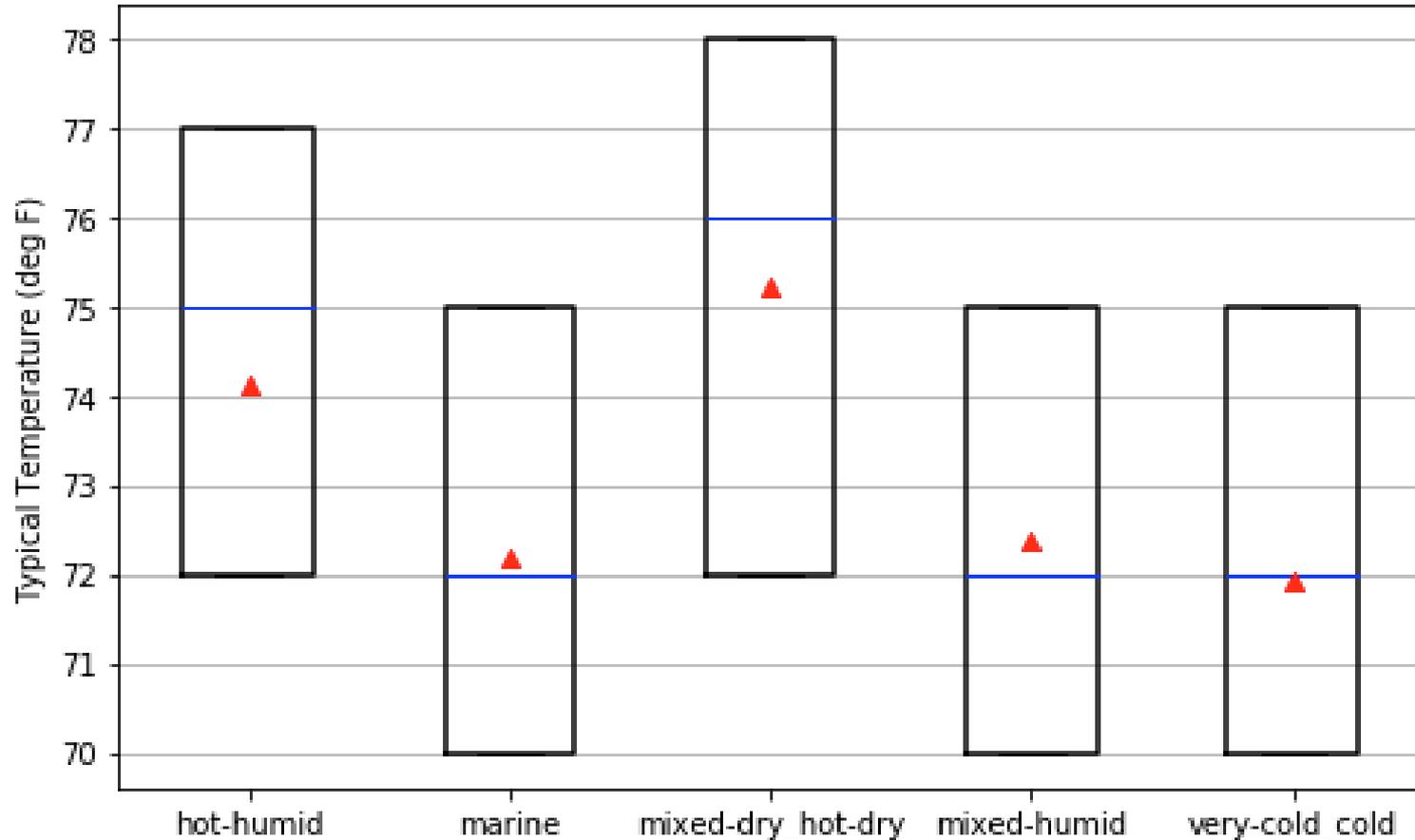
RECS Even and Odd Responses



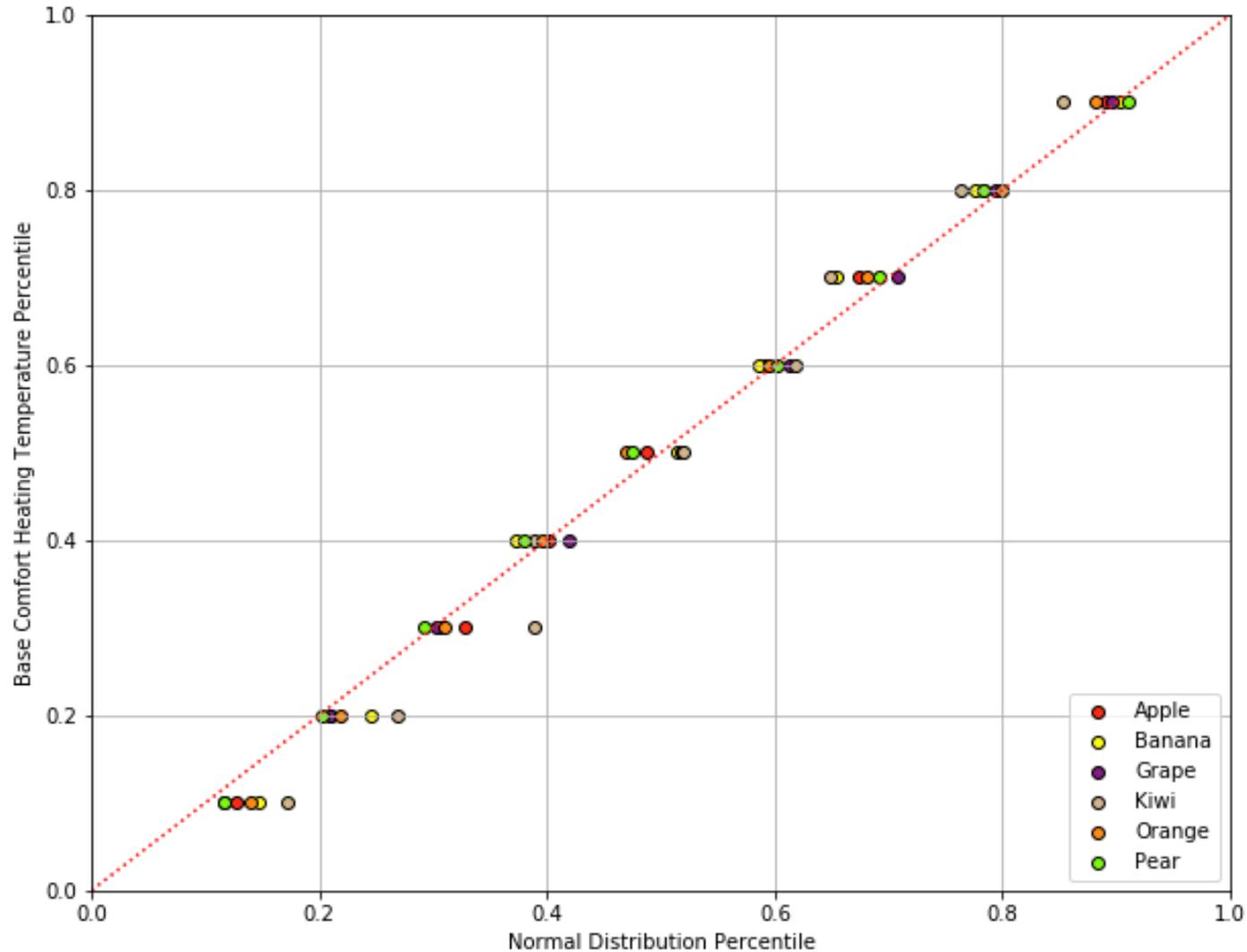
RECS Typical Heating by Region



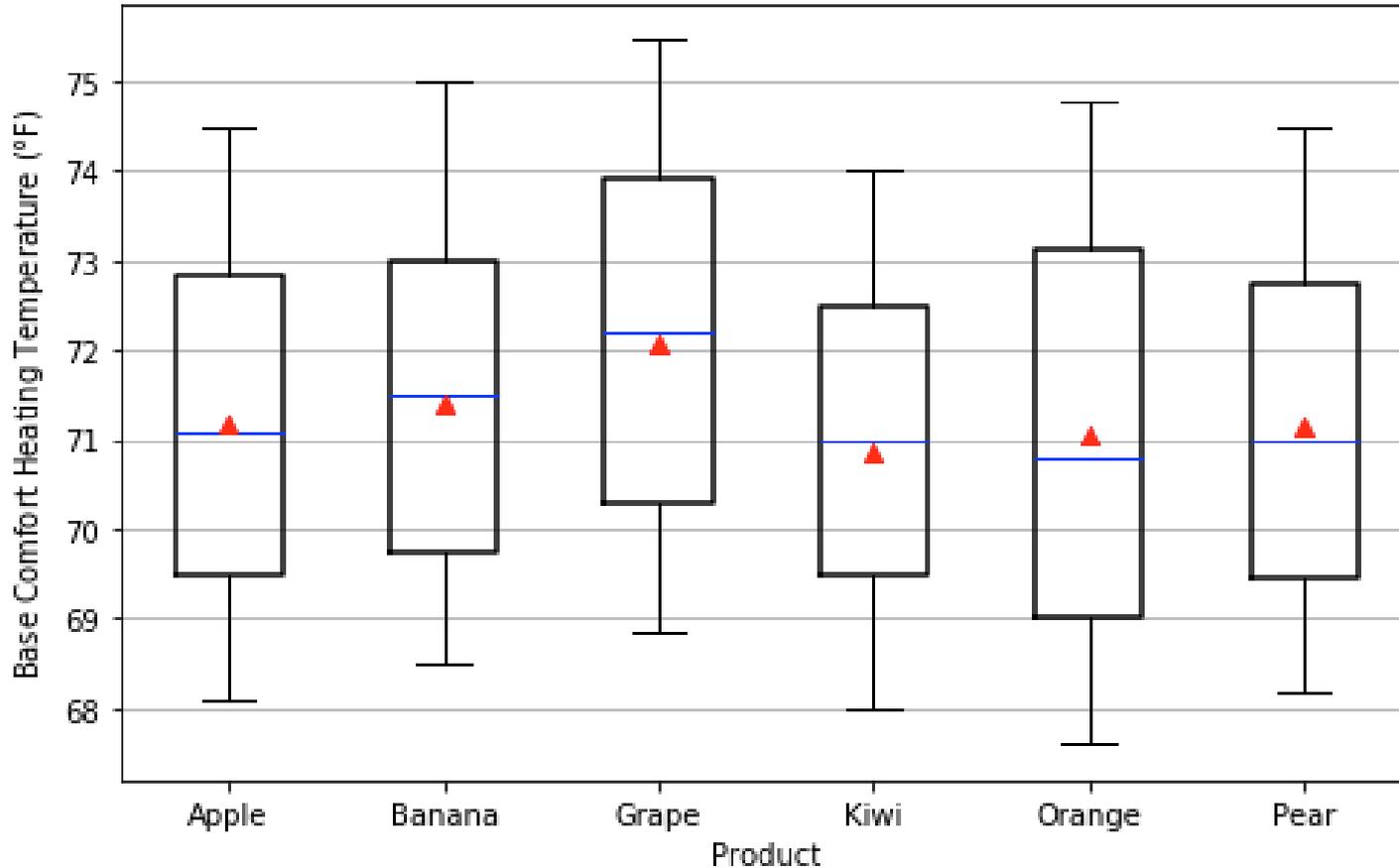
RECS Typical Cooling by Region



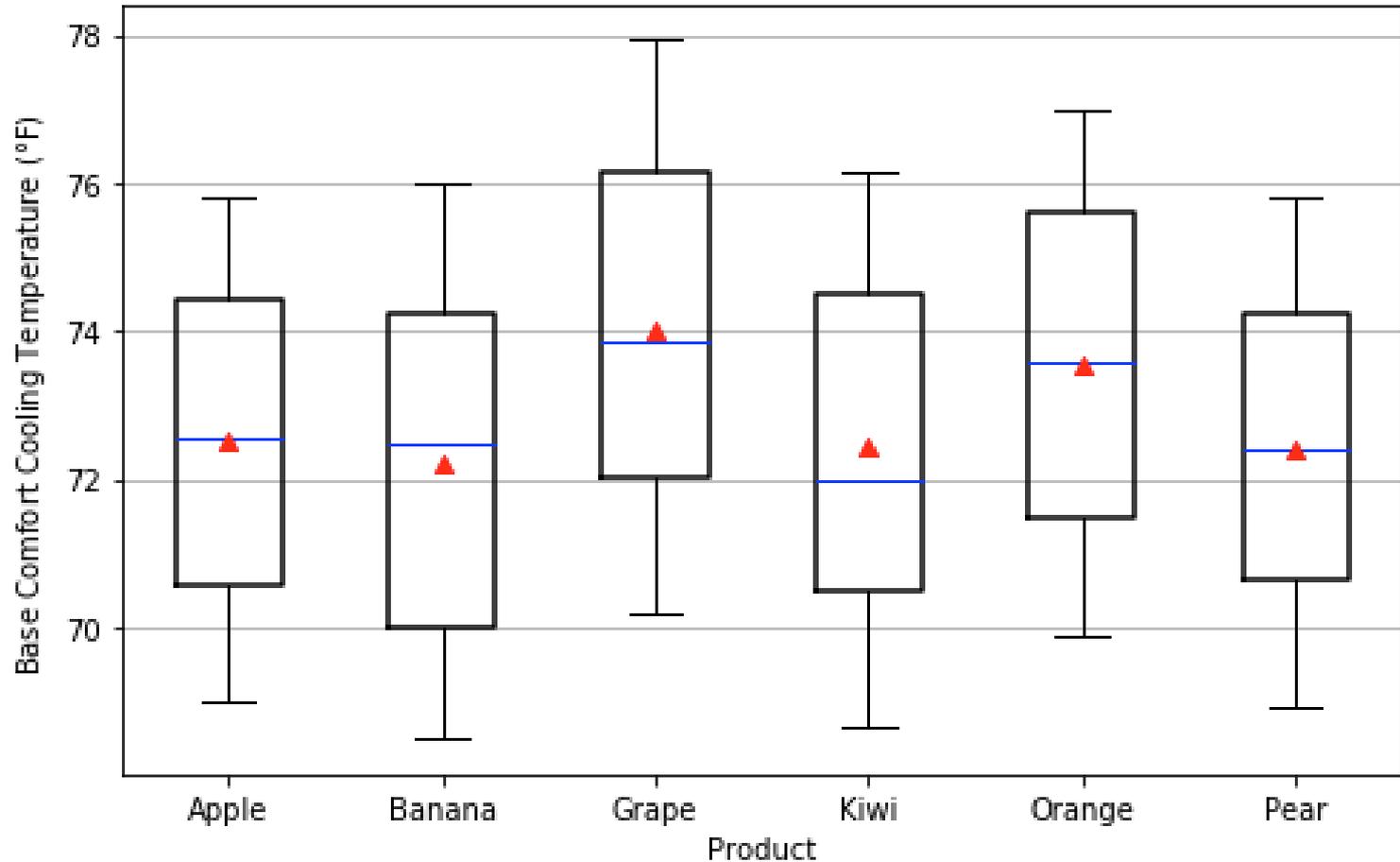
CT Base Comfort Heating Deciles



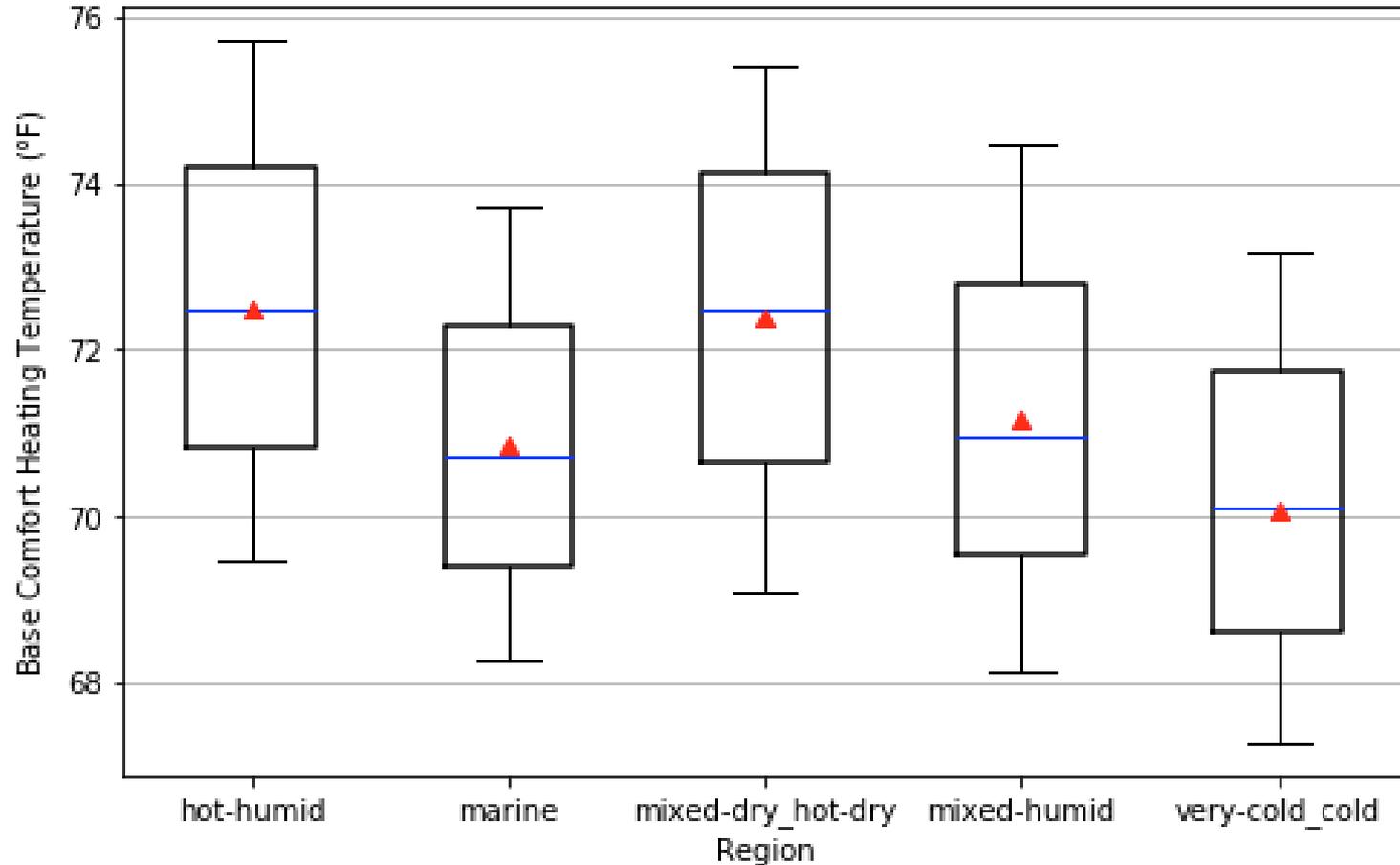
CT Base Comfort Heating by Product



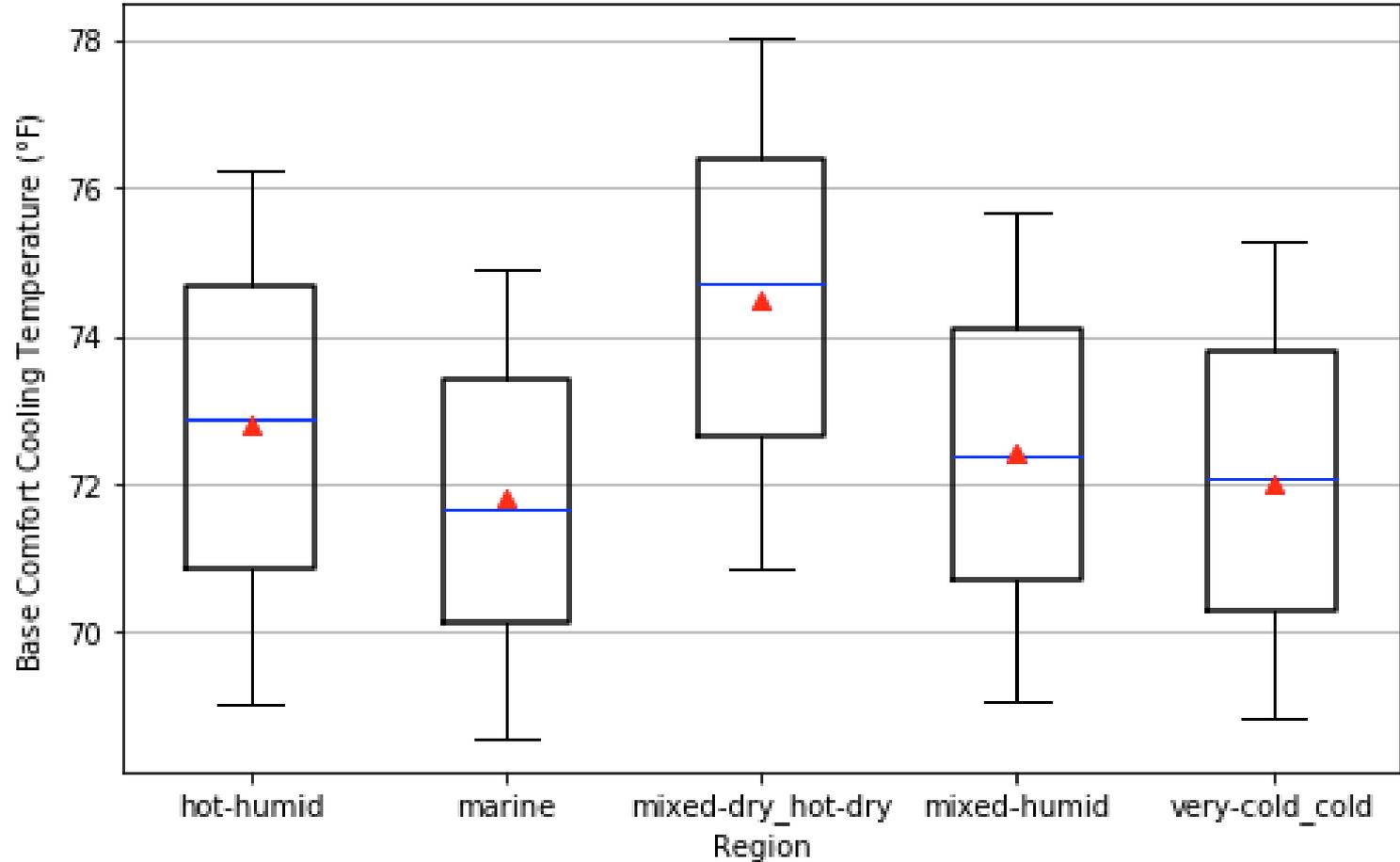
CT Base Comfort Cooling by Product



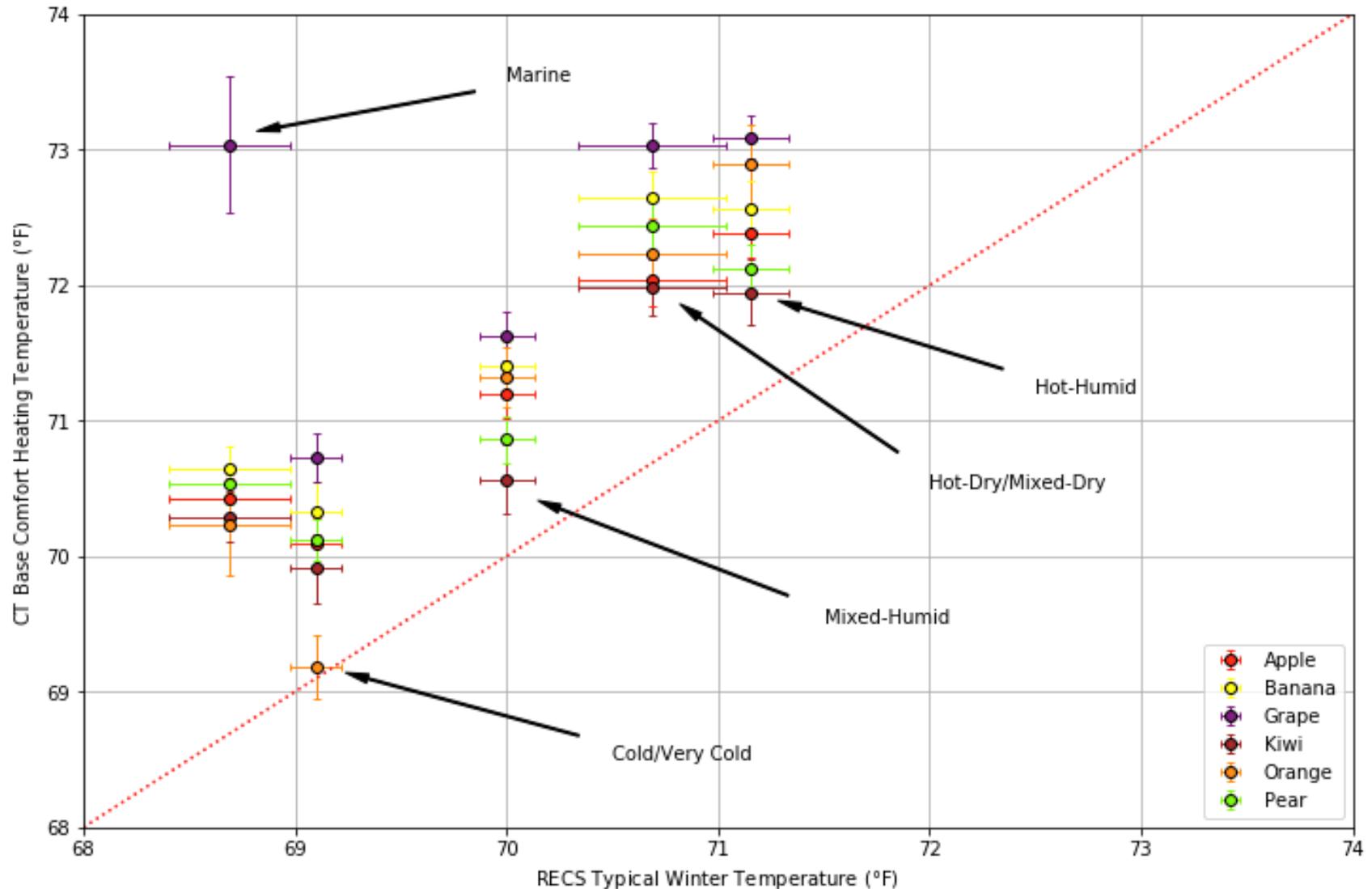
CT Base Comfort Heating by Region



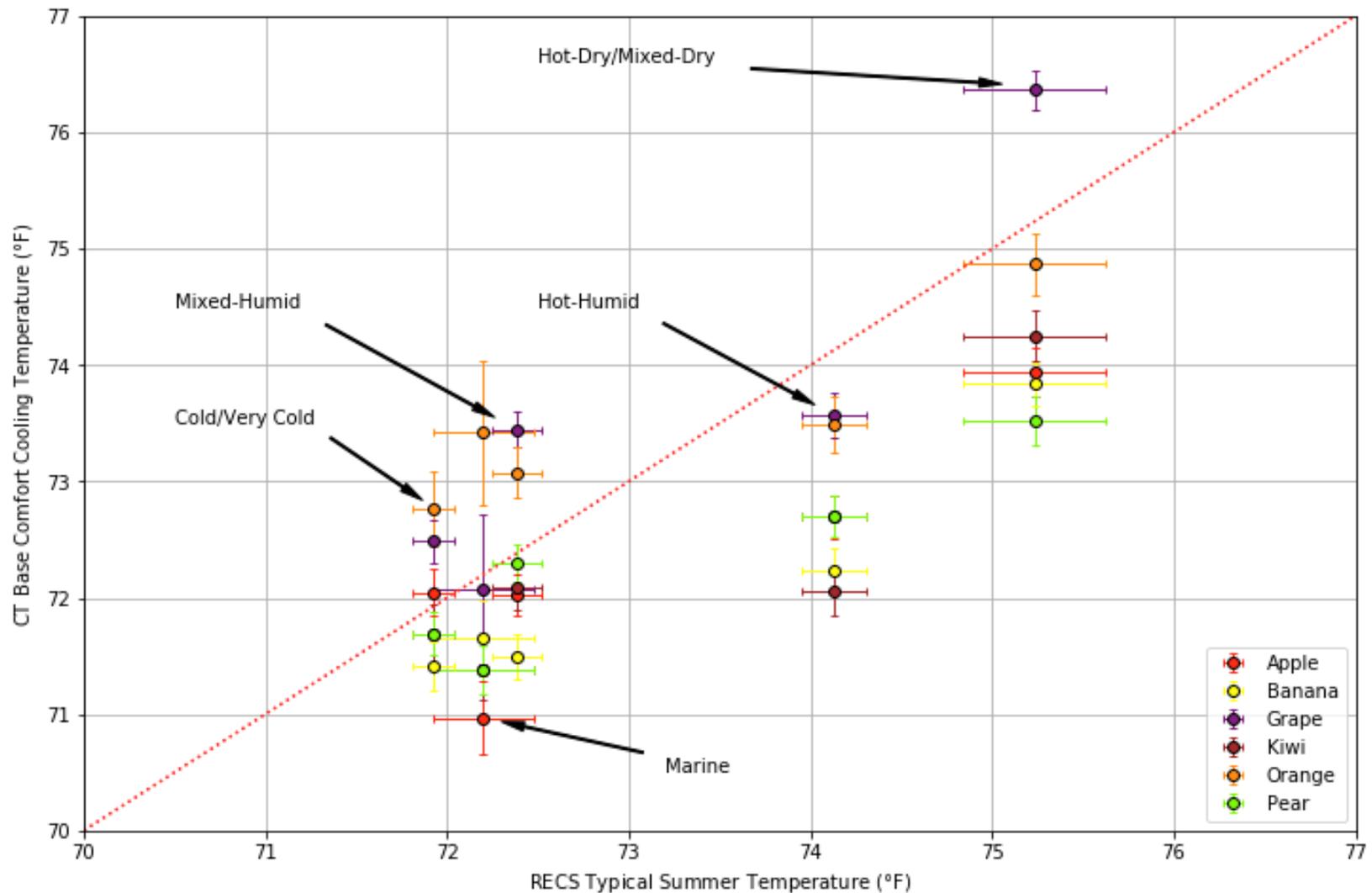
CT Base Comfort Cooling by Region



RECS/CT Heating Temperature Comparison



RECS/CT Cooling Temperature Comparison



Caveats / Comments

- ◆ Different years (RECS – 2015, CTs – 2017)
- ◆ Concept of indoor temperature is different
 - CT - measured continuous indoor (90/10 percentile)
 - RECS - survey, discrete, set point (not a normal distribution)
- ◆ Not quantitative - compare only trends, not absolute values
- ◆ Need to repeat with resubmission data
- ◆ Using ecobee Donate Your Data set to examine regionality in more detail, and at setpoint vs. indoor T



Regional Baselines Discussion

- From one vendor:
 - 90th percentile of indoor temps during core heating season are about 1 degree higher than 90th percentile of set temperatures during core heating season
 - This effect is less pronounced in summer
 - So this looks like it reproduces what we see comparing RECS set temps and indoor temperatures
- Offer of RBSA data. YES! But limited utility of regional data...
 - Includes data on equipment operation? Yes, for the 300 or so homes with detailed metering
- May also be CA data, and Pecan Street
- Using the dummy regional baseline, metric results show reasonable cooling savings, but the heating savings are zero or negative, probably because of the set vs. indoor temp issue
- Can the RECS data be examined by house vintage? Yes.