Enhance Exceptional Event Demonstrations for Wildfire Events using a New Modeling Approach

AAPCA 2023 Fall Meeting

Raleigh, NC

August 29, 2024

Josh Shapiro, Governor

Jessica Shirley, Acting Secretary

Ozone Exceptional Events

- EPA's Exceptional Events Rule lets air agencies exclude air quality data affected by wildfire smoke from NAAQS evaluations.
- Air agencies must provide strong evidence showing a clear link between the event and the exceedance.
- Identifying and analyzing each monitoring site and date for exceptional events is time-consuming.

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Goal & Objectives

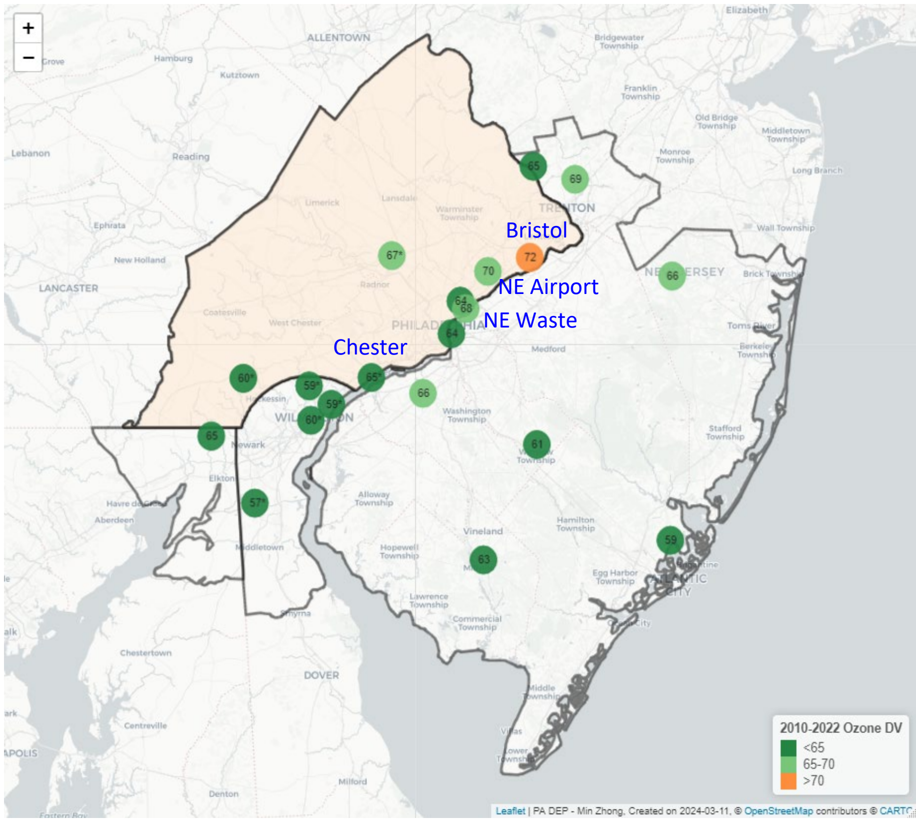
- **Goal**: to enhance the EE demo process and provide additional evidences

- **Objectives:**

  - create a screening tool for selecting sites and dates

  - quantify the contribution of smoke to ozone

The Philadelphia Nonattainment Area



- The Philadelphia – Wilmington – Atlantic City, PA-NJ-MD-DE Nonattainment Area is a multi-state “serious” nonattainment area
- This study focuses on four sites in the Philadelphia area

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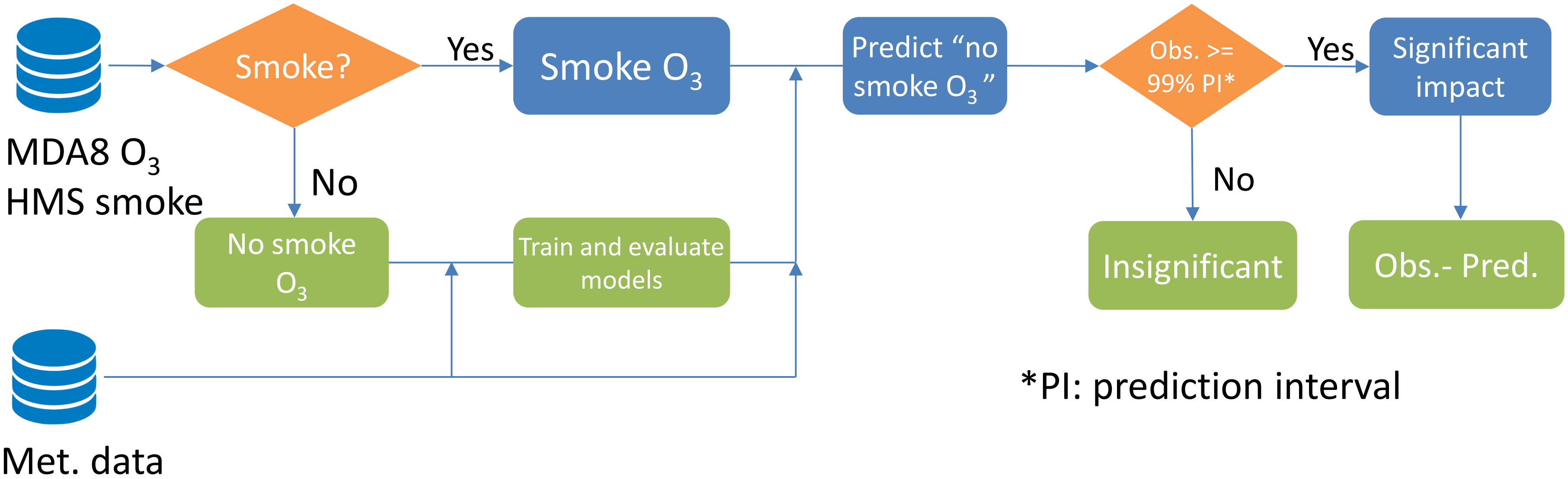
Approach



*PI: prediction interval

Jaffe, Daniel A, Evaluation of Ozone Patterns and Trends in 8 Major Metropolitan Areas in the U.S. March 2021, CRC Report No. A-124
Cisneros et al, Determining the Impact of Wildland Fires on Ground Level Ambient Ozone Levels in California, Atmosphere, 2020, 11, 1131

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Data Sources and Preprocessing

- **Daily maximum 8-h average (MDA8) O_3** : 2016-2023 (Apr – Sep), EPA AQS
- **Hazard Mapping System (HMS) smoke product:** 2016-2023, NOAA
  https://www.ospo.noaa.gov/Products/land/hms.html
- **Meteorology data:** two nearby airports

  https://mesonet.agron.iastate.edu/request/download.phtml

  - aggregate hourly temp, wind speed/direction, RH to daily data

- **Additional parameters**: year, month, days of the week, days of the year
- Each ozone monitor was paired with the nearest airport for met parameters

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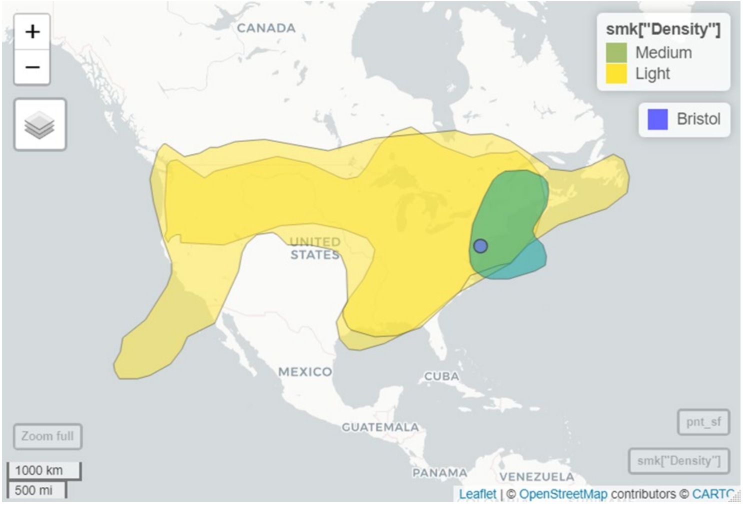
How to Sort Ozone Days?

- Create a 10 km buffer zone around a site
- Check if there is HMS smoke overhead

  - Yes, that day was labeled as “smoke”
  - 3 days before and 3 days after that day were also labeled as “smoke”
  - The remaining days were “no smoke”



Site Name	No smoke	Smoke	Total
Bristol	611	756	1367
Chester	580	730	1310
Northeast Airport	622	795	1417
Northeast Waste	614	791	1405

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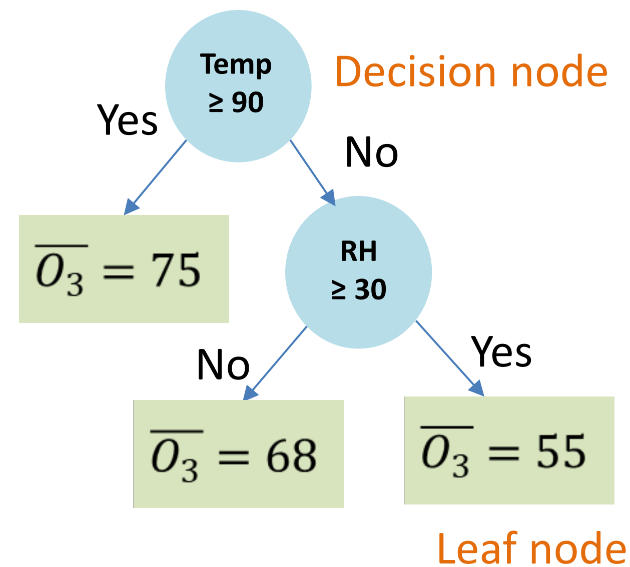
Model

- Bayesian Additive Regression Trees (BART)

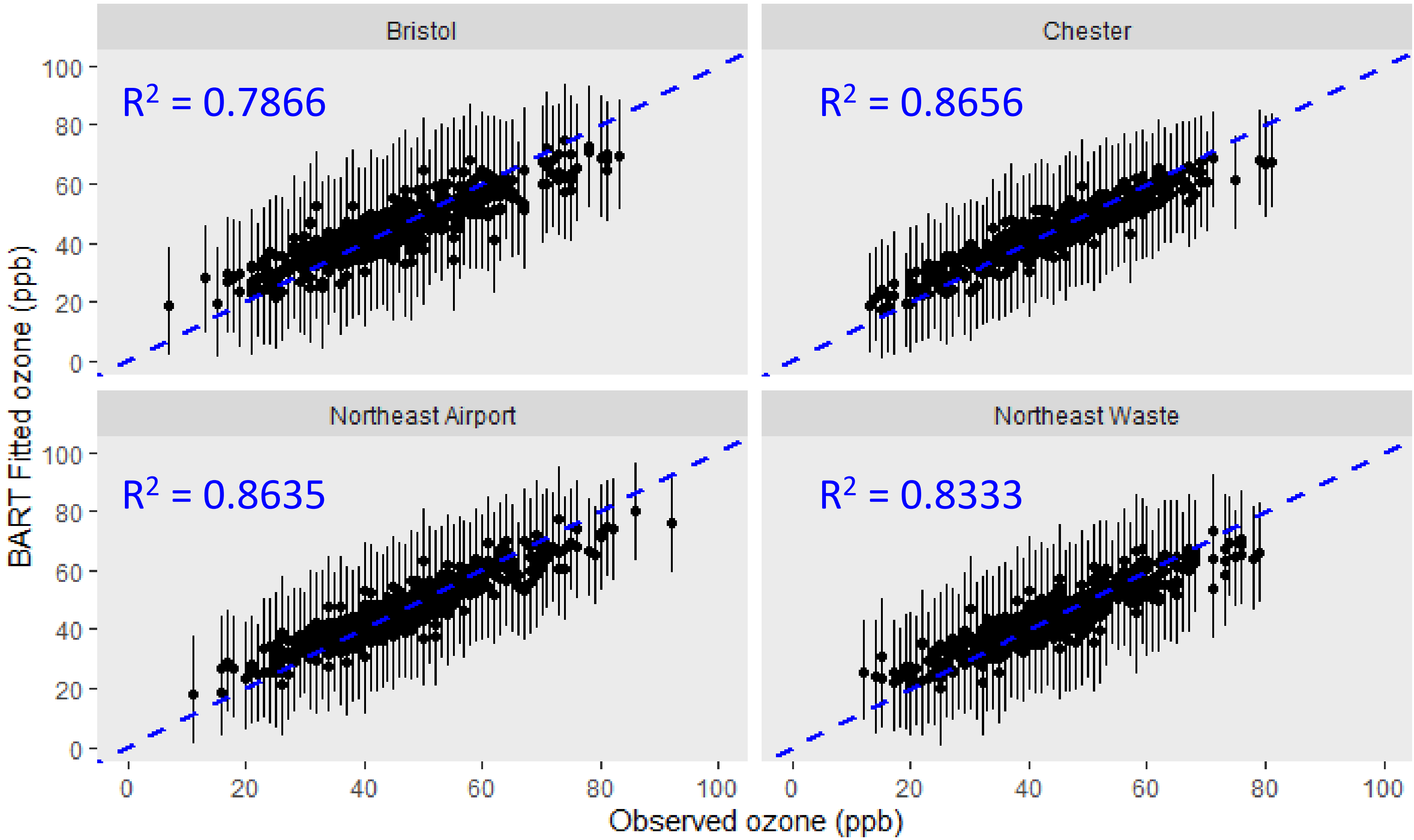
$$O_{3i} = g_1(temp_i, RH_i, \ldots) + g_2(temp_i, RH_i \ldots) + \ \ldots + \varepsilon_i$$

where $g()$ denotes the fit from a decision tree

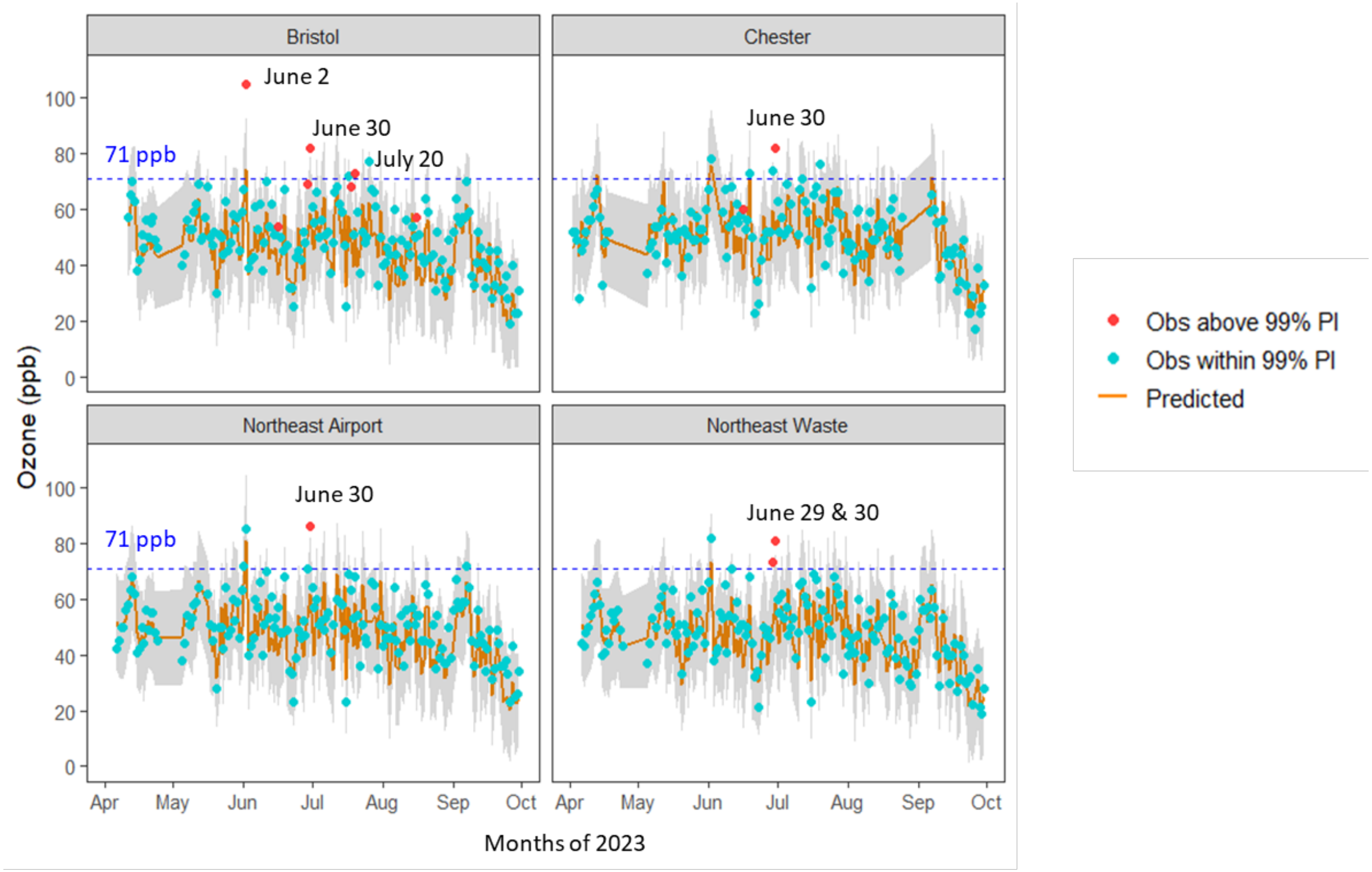
```r
#-----fit BART-----
bart_model <- bartMachineCV(X = trn_x,
                            y = trn_y,
                            k_cvs = c(2, 3, 5),
                            num_tree_cvs = c(50, 100, 200))

# get prediction
pred_test <- predict(bart_model, test_x)

# get prediction interval
pred_interval <- calc_prediction_intervals(bart_model, test_x, pi_conf = 0.99)

bart_pi <- pred_interval$interval %>%
  as.data.frame() %>%
  mutate(pred = pred_test) %>%
  mutate(diff = pi_upper_bd - pred)
```



Observed vs Fitted on “no smoke ” Days



Observed vs Predicted on "smoke" Days



Smoke Contribution

Site Name	Date	Obs (ppb)	Smoke index	Obs - Pred (BART)	Obs - Pred (*NOAA CMAQ)
Bristol	6/2/2023	105	2	30.9	29.3
	6/30/2023	82	2	23.4	17.2
Chester	6/2/2023	78	2	2.5	12.7
	6/29/2023	74	3	14.4	24.0
	6/30/2023	82	2	29.4	27.5
Northeast Airport	6/1/2023	72	2	6.7	17.8
	6/2/2023	85	2	3.9	7.3
	6/29/2023	71	3	17.9	22.3
	6/30/2023	86	2	24.4	19.6
Northeast Waste	6/2/2023	82	2	8.7	11.8
	6/29/2023	73	3	22.4	22.3
	6/30/2023	81	2	22.6	18.8

✓ During the two events (June 1-2 & June 29-30), smoke contributed 17.3 ± 6.3 ppb ozone estimated by BART or 19.2 ± 4.1 ppb by NOAA CMAQ.

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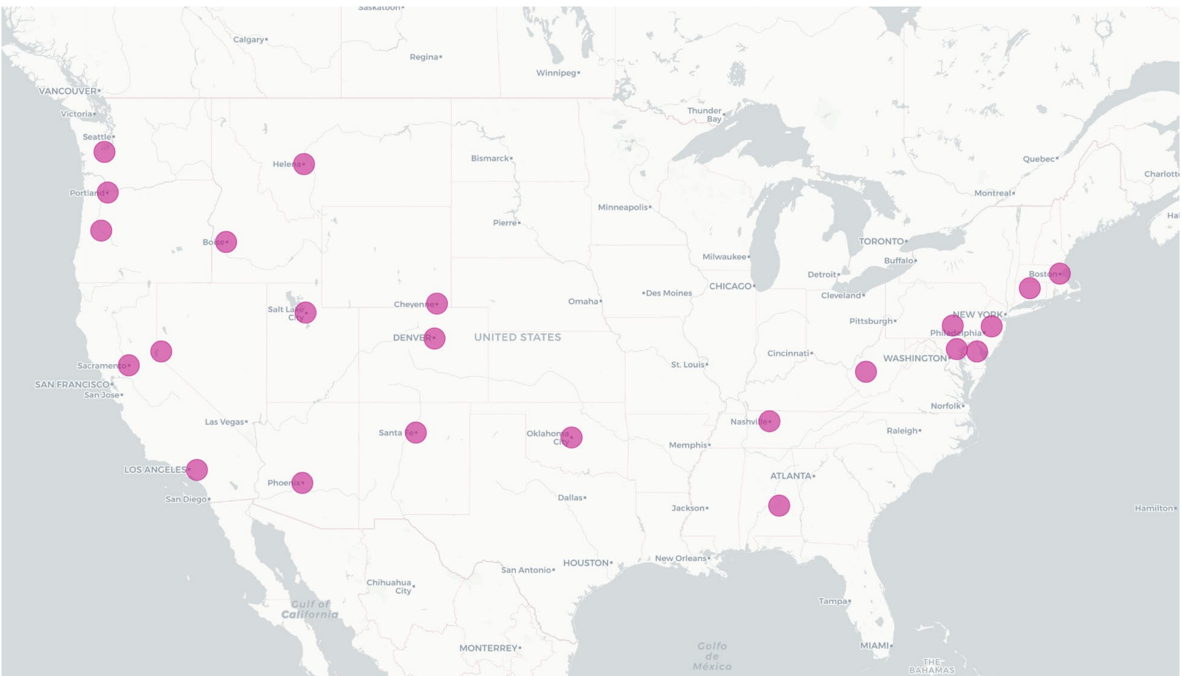
Transferability

- The current approach requires a good understanding of basic R programming
- MARAMA’s R Exchange Workgroup

Transferability

- Summer Basic R Training
- 6 weeks, Tuesday & Thursday at 1 pm, 7/23 –8/30, 2024

Trainees' Air Agencies



- 8 instructors
- 90 trainees
- 23 air agencies
- 2 MJOs

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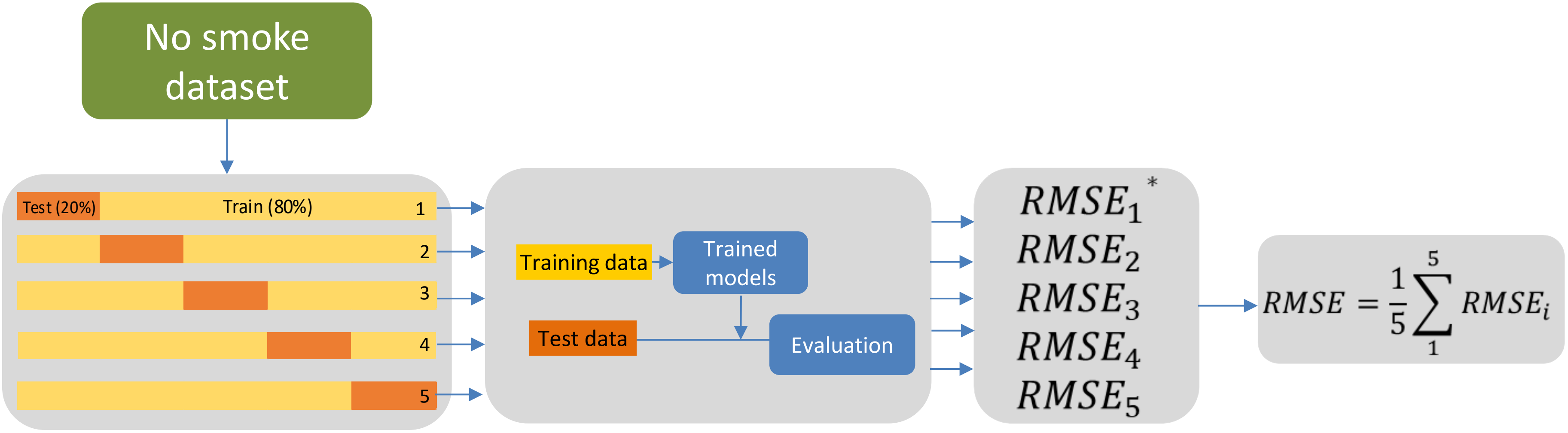
Train and Evaluate Model on “no smoke” Days

- 5-fold cross-validation was used for model training and evaluation



*RMSE: Root mean squared error

Performance Comparison

Better performance means smaller RMSE & higher R^2

Site Name	Model	Training		Test	
		RMSE	R^2	RMSE	R^2
Bristol	BART	5.00	0.84	7.48	0.63
	GAM	7.00	0.68	7.93	0.59
	MLR	8.25	0.55	8.75	0.50
Chester	BART	4.31	0.87	7.11	0.64
	GAM	6.60	0.68	7.59	0.59
	MLR	7.54	0.58	8.00	0.54
Northeast Airport	BART	4.88	0.85	7.33	0.64
	GAM	6.64	0.70	7.64	0.61
	MLR	7.85	0.58	8.36	0.54
Northeast Waste	BART	4.70	0.85	7.14	0.65
	GAM	6.54	0.70	7.55	0.61
	MLR	7.79	0.58	8.32	0.53

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