Models and Time-Varying Plots

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In this case, no outliers were removed.

Part of what we're interested in is estimating the mean bias and mean variance. If we assume that the "true" value is that from the wearable monitor, how do we estimate the mean bias? What about the mean variance?

Variance is defined as:

$$\text{Var}[\widehat{x}] = E[(\widehat{x} - E[\widehat{x}])^2]$$

$$\text{Var}[\widehat{x}] = E[\widehat{x}^2] - E[\widehat{x}]^2$$

Bias is defined as follows:

$$\text{Bias}[\widehat{x}] = E[\widehat{x} - x] = E[\widehat{x}] - x$$

CDPHE PM10: Bias, Mean Variance, Variance

```
## [1] -13.23269  54.01609  54.47776
```

Stationary PM10: Bias, Mean Variance, Variance

```
## [1]  -6.665394 878.225040 885.928768
```

CDPHE NO2: Bias, Mean Variance, Variance

```
## [1]  9.806204 28.941862 29.189229
```

Stationary NO2: Bias, Mean Variance, Variance

```
## [1]   0.3155416 190.2360378 191.8760036
```

CDPHE O3: Bias, Mean Variance, Variance

```
## [1] 21.16721 93.15053 93.94669
```

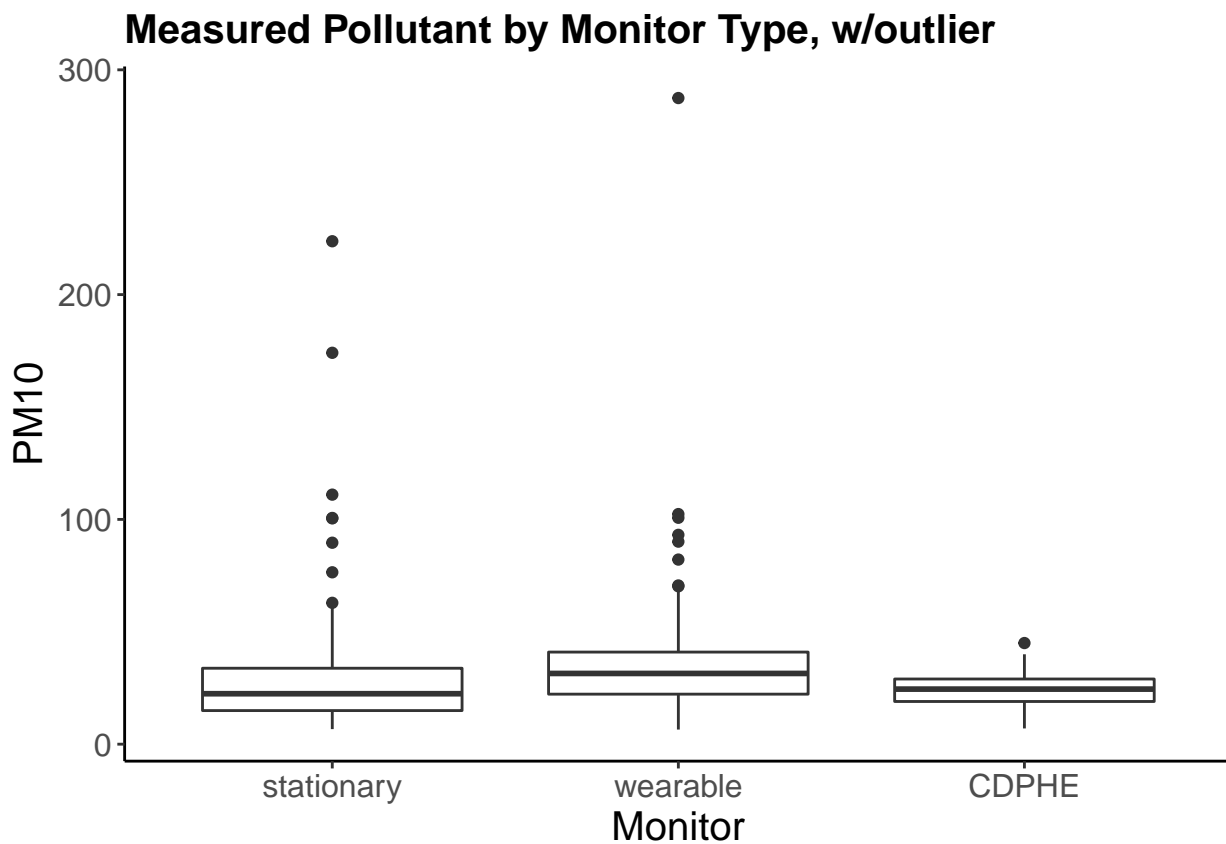# Evaluating differences between monitors using mixed models.
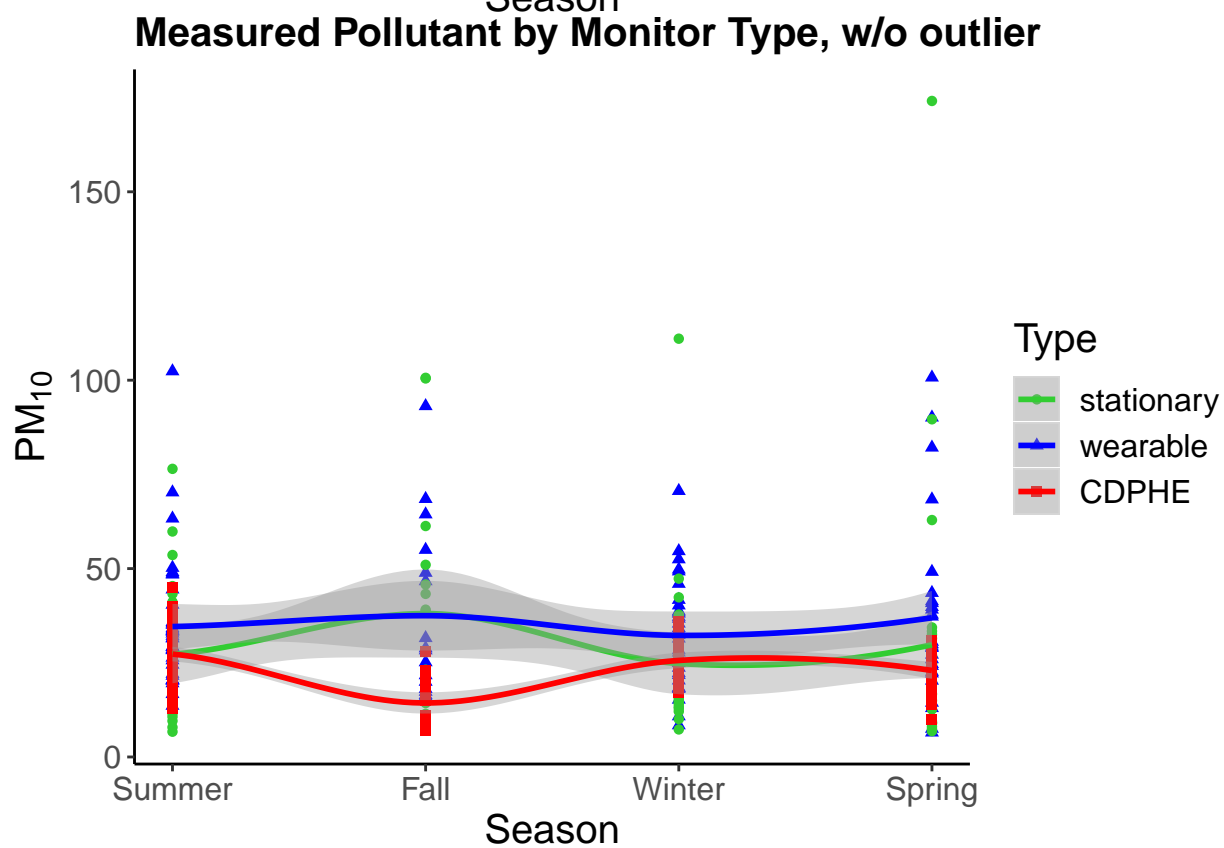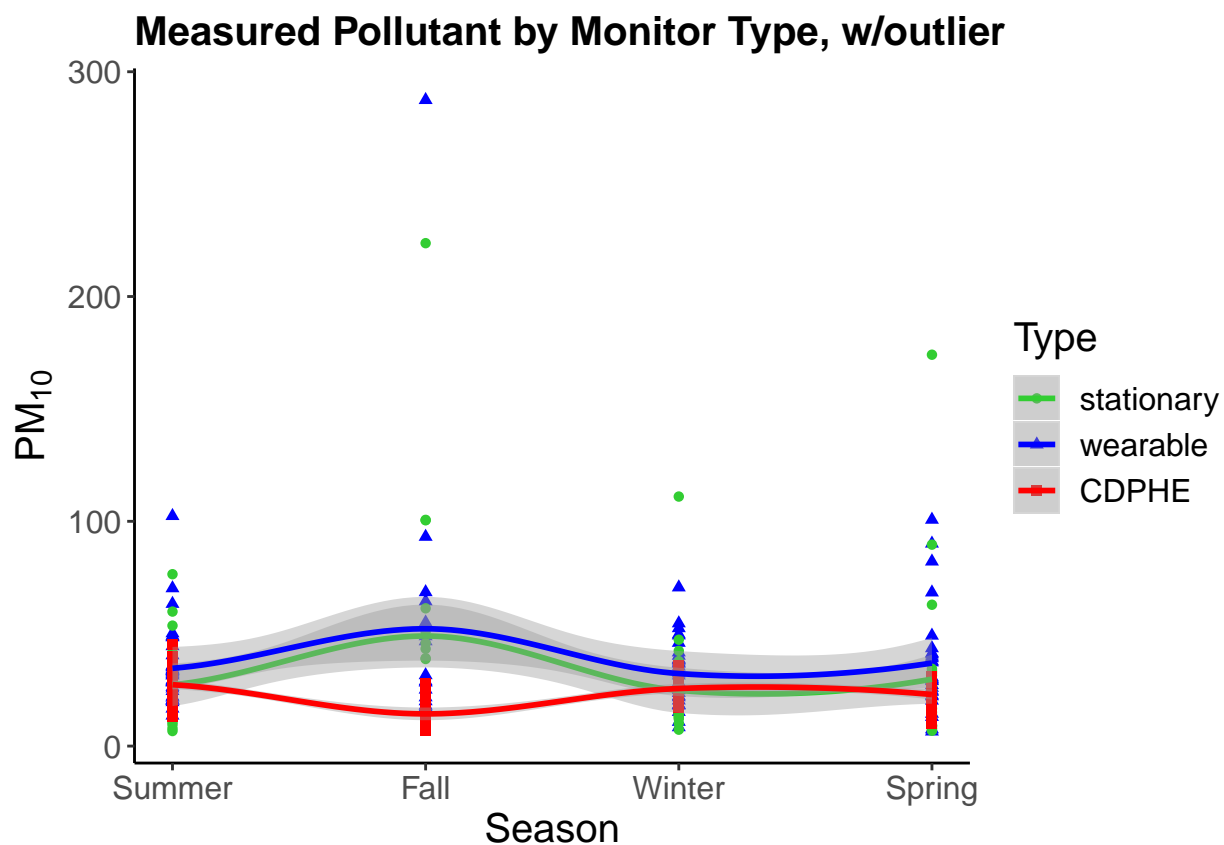
PM10, MEASUREMENT DIFFERENCES

Evaluation using a mixed model with random intercept for each id. For the first model reference categories are the wearable monitor and summer. We see a slight significant difference between the wearable monitor and the stationary monitor and a significant difference between the wearable monitor and the CDPHE monitor.

Additionally, the fall has significantly higher PM10 values than the summer. In the second model, we see again the slight difference between the wearable and stationary monitor but also a slight difference between the stationary and the CDPHE.

```
##
## PM10 Monitor Differences,ref = wearable
## ===================================================
##                              Dependent variable:
##                          ----------------------------
##                                    PM10
## ---------------------------------------------------
## Stationary                      -6.6689*
##                             (-12.8004, -0.5374)
##                                 t = -2.1317
##                                 p = 0.0331
## CDPHE                           -13.2565***
##                             (-19.3480, -7.1650)
##                                 t = -4.2653
##                                 p = 0.00002
## Fall                             8.4225*
##                             (0.4165, 16.4284)
##                                 t = 2.0619
##                                 p = 0.0393
## Winter                          -1.9939
##                             (-8.4198, 4.4320)
##                                 t = -0.6082
##                                 p = 0.5431
## Spring                          -0.7108
##                             (-7.5414, 6.1199)
##                                 t = -0.2039
##                                 p = 0.8384
## Intercept                       36.4524***
##                             (30.5299, 42.3749)
##                                 t = 12.0633
##                                 p = 0.0000
## ---------------------------------------------------
## Observations                       349
## Log Likelihood                 -1,594.9230
## Akaike Inf. Crit.               3,205.8460
## Bayesian Inf. Crit.             3,236.6870
## ===================================================
## Note:                *p<0.05; **p<0.01; ***p<0.001

##
## PM10 Monitor Differences, ref=stationary
## ===================================================
##                              Dependent variable:
##                          ----------------------------
##                                    PM10
## ---------------------------------------------------
## Wearable                         6.6689*
##                             (0.5374, 12.8004)
##                                 t = 2.1317
##                                 p = 0.0331
## CDPHE                            -6.5876*
```

```
##                            (-12.6929, -0.4823)
##                                 t = -2.1148
##                                 p = 0.0345
## Fall                              8.4225*
##                             (0.4165, 16.4284)
##                                 t = 2.0619
##                                 p = 0.0393
## Winter                            -1.9939
##                             (-8.4198, 4.4320)
##                                 t = -0.6082
##                                 p = 0.5431
## Spring                            -0.7108
##                             (-7.5414, 6.1199)
##                                 t = -0.2039
##                                 p = 0.8384
## Intercept                        29.7835***
##                             (23.8270, 35.7400)
##                                 t = 9.8001
##                                 p = 0.0000
## --------------------------------------------------
## Observations                        349
## Log Likelihood                  -1,594.9230
## Akaike Inf. Crit.                3,205.8460
## Bayesian Inf. Crit.              3,236.6870
## ==================================================
## Note:              *p<0.05; **p<0.01; ***p<0.001
```

Measured Pollutant by Monitor Type, w/outlier

Measured Pollutant by Monitor Type, w/outlier

Measured Pollutant by Monitor Type, w/o outlier
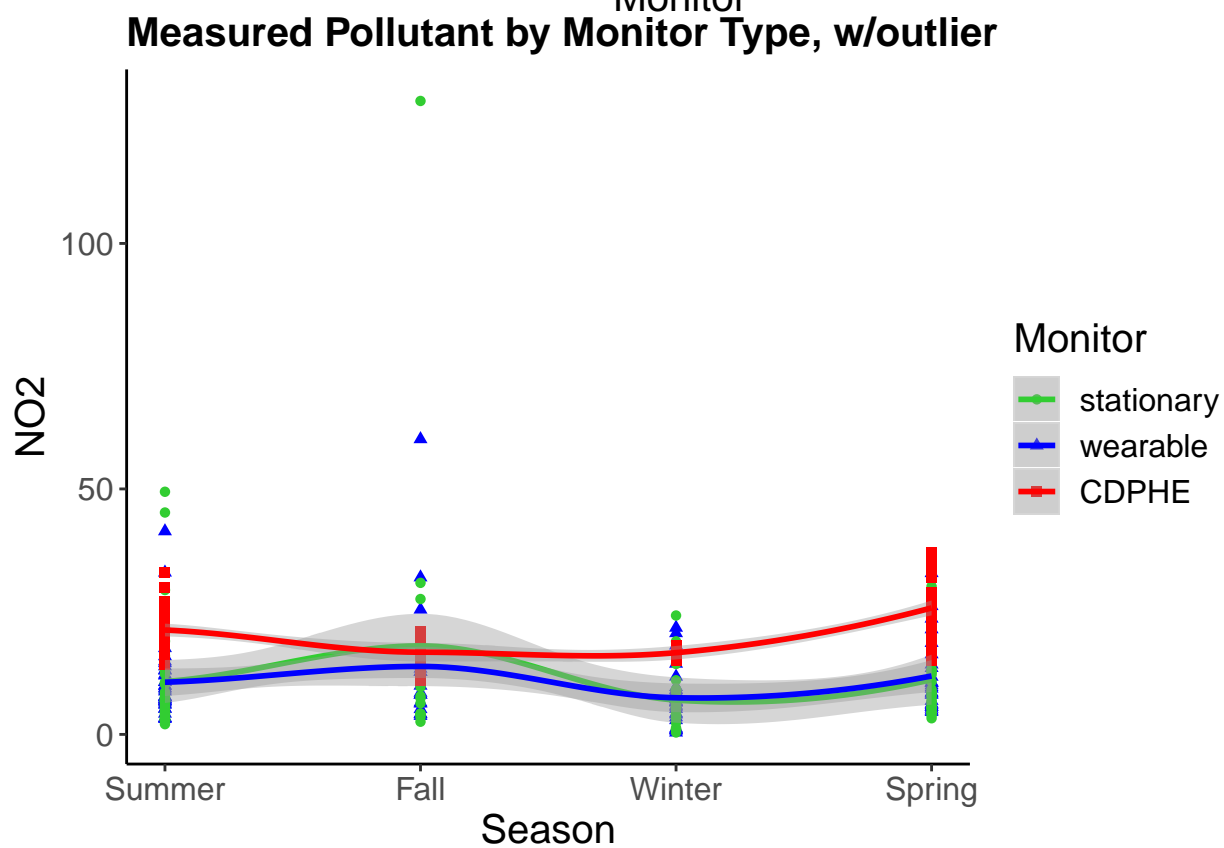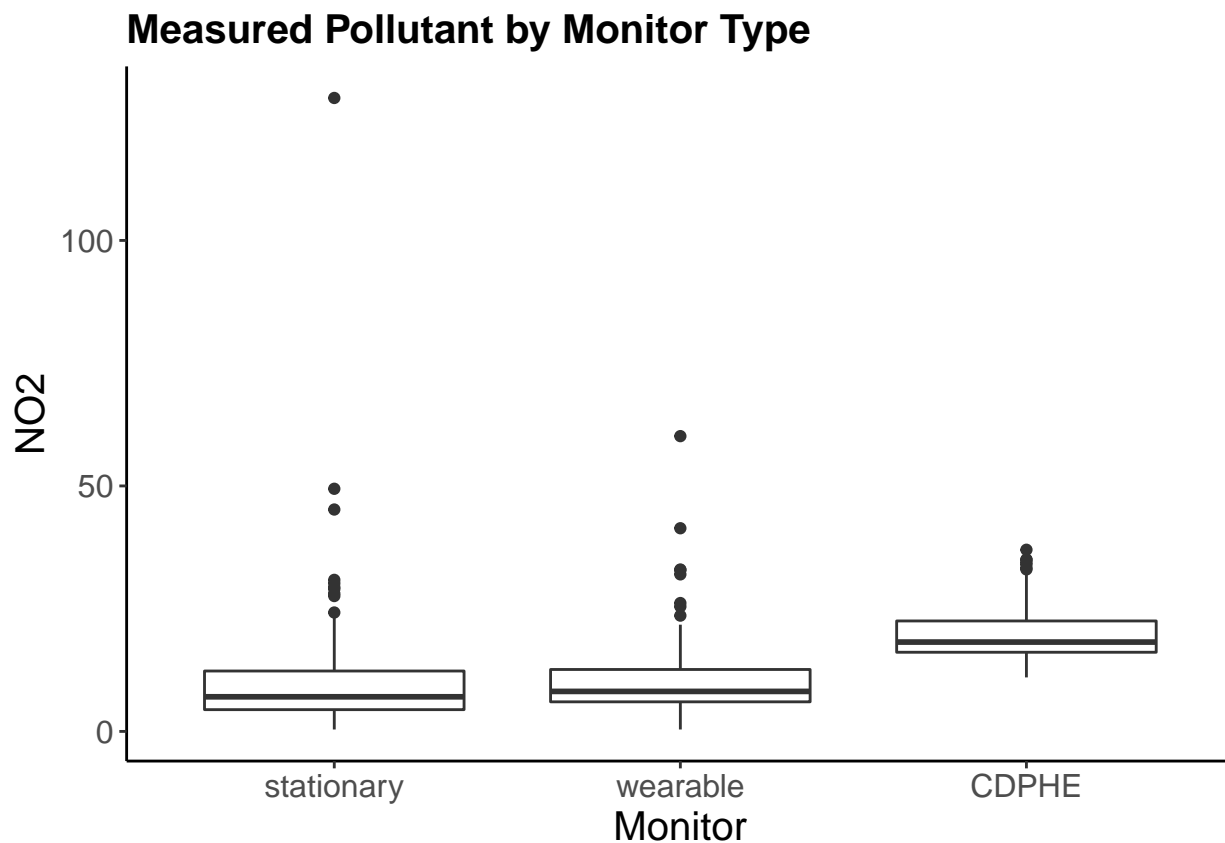
NO2 MEASUREMENT DIFFERENCES

Evaluation using a mixed model with random intercept for each id. The reference categories are the wearable monitor and summer for the first model. We see a significant difference between CDPHE measures and the wearable monitor. In the second model, the reference categories are the stationary monitor and summer. We see that there is also a significant difference between the CDPHE monitor and the stationary monitor. The stationary monitor and the wearable monitor are not significantly different from each other.
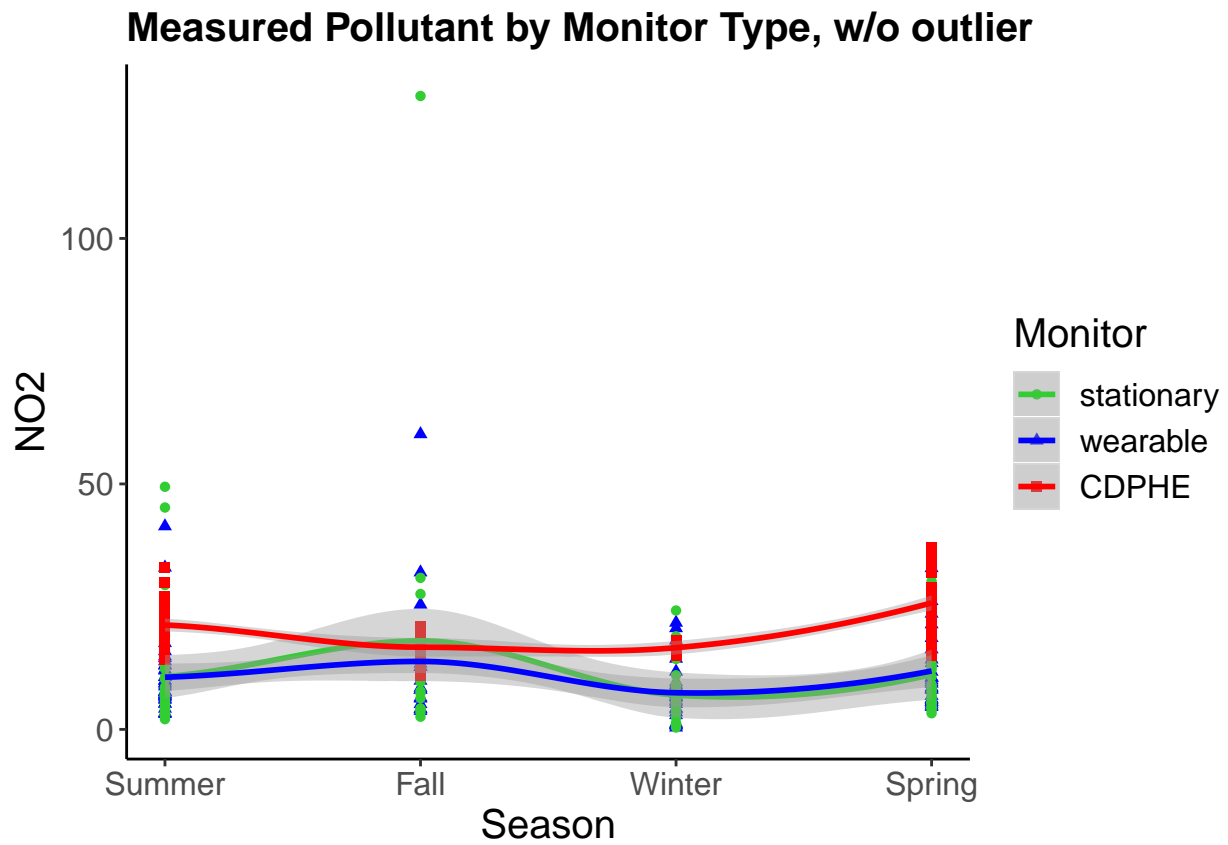
```
##
## NO2 Monitor Differences,ref = wearable
## =================================================
##                         Dependent variable:
##                     ----------------------------
##                                 NO2
## -------------------------------------------------
## Stationary                    0.2190
##                          (-1.9037, 2.3416)
##                             t = 0.2022
##                             p = 0.8398
## CDPHE                         9.7256***
##                          (7.6070, 11.8441)
##                             t = 8.9974
##                             p = 0.0000
## Fall                          0.9991
##                          (-1.8478, 3.8460)
##                             t = 0.6878
##                             p = 0.4916
## Winter                       -3.5062**
##                          (-5.7480, -1.2643)
##                             t = -3.0653
##                             p = 0.0022
## Spring                        1.9648
##                          (-0.4409, 4.3704)
##                             t = 1.6008
##                             p = 0.1095
## Intercept                    10.9277***
##                          (8.3648, 13.4905)
##                             t = 8.3571
##                             p = 0.0000
## -------------------------------------------------
## Observations                    345
## Log Likelihood              -1,234.4030
## Akaike Inf. Crit.           2,484.8070
## Bayesian Inf. Crit.         2,515.5550
## =================================================
## Note:            *p<0.05; **p<0.01; ***p<0.001
##
## NO2 Monitor Differences, ref=stationary
## =================================================
##                         Dependent variable:
##                     ----------------------------
##                                 NO2
## -------------------------------------------------
## Wearable                     -0.2190
```

```
##                                (-2.3416, 1.9037)
##                                   t = -0.2022
##                                   p = 0.8398
## CDPHE                              9.5066***
##                                (7.4258, 11.5874)
##                                   t = 8.9544
##                                   p = 0.0000
## Fall                               0.9991
##                                (-1.8478, 3.8460)
##                                   t = 0.6878
##                                   p = 0.4916
## Winter                            -3.5062**
##                                (-5.7480, -1.2643)
##                                   t = -3.0653
##                                   p = 0.0022
## Spring                             1.9648
##                                (-0.4409, 4.3704)
##                                   t = 1.6008
##                                   p = 0.1095
## Intercept                         11.1466***
##                                (8.6203, 13.6730)
##                                   t = 8.6477
##                                   p = 0.0000
## -------------------------------------------------
## Observations                        345
## Log Likelihood                   -1,234.4030
## Akaike Inf. Crit.                 2,484.8070
## Bayesian Inf. Crit.               2,515.5550
## =================================================
## Note:              *p<0.05; **p<0.01; ***p<0.001
```

Measured Pollutant by Monitor Type

Measured Pollutant by Monitor Type, w/outlier
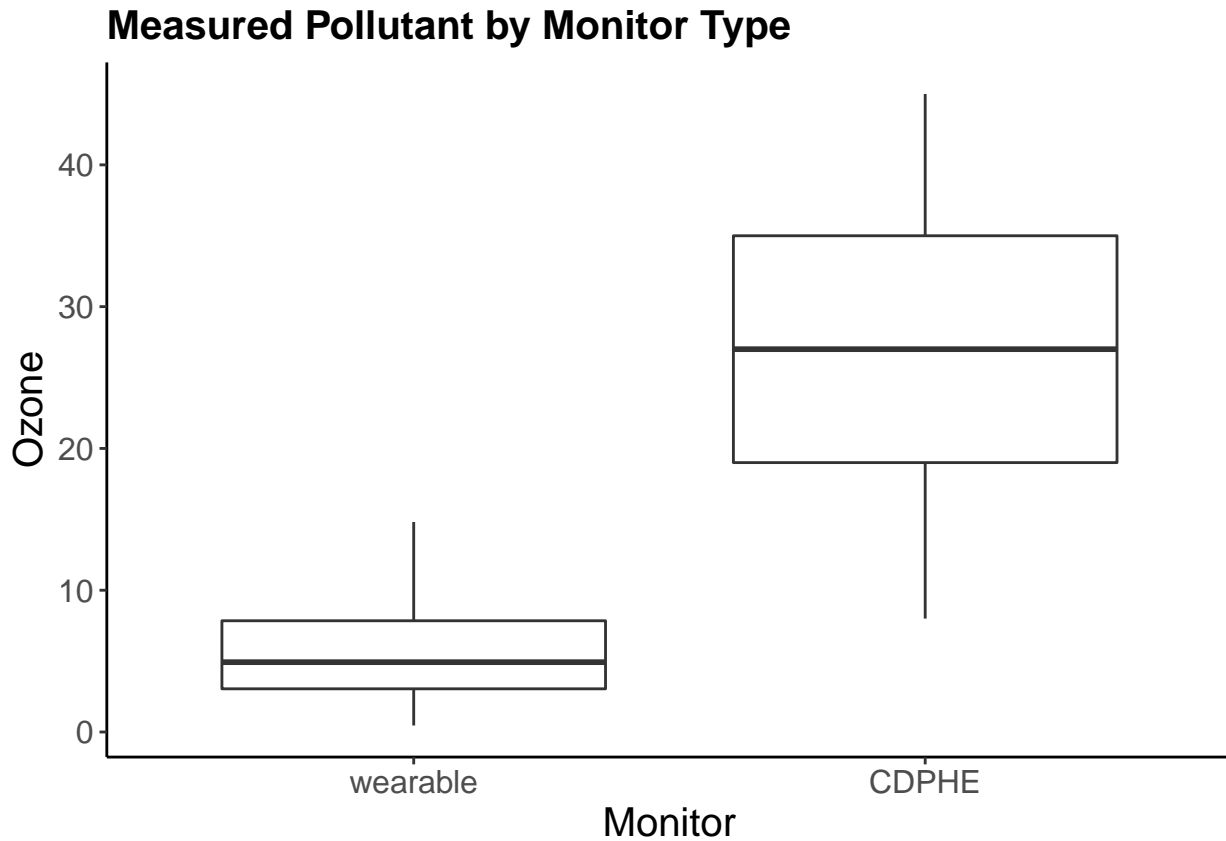
Measured Pollutant by Monitor Type, w/o outlier

OZONE MEASUREMENT DIFFERENCES

We see an unsurprising and substantial difference between the CDPHE mean value and the wearable monitor.

Measured Pollutant by Monitor Type


```
## 
## Ozone Monitor Differences
## ===============================================================
## 						Dependent variable:
## 					-------------------------------------
## 							O3
## ---------------------------------------------------------------
## CDPHE 						21.1672***
## 						(17.8459, 24.4886)
## 						 t = 12.4910
## 						 p = 0.0000
## Intercept (Wearable) 				5.5108***
## 						 (2.5844, 8.4372)
## 						 t = 3.6908
## 						 p = 0.0004
## ---------------------------------------------------------------
## Observations 					152
## R2 						0.5098
## Adjusted R2 					0.5066
## Residual Std. Error 			8.7061 (df = 150)
## F Statistic 		156.0254*** (df = 1; 150) (p = 0.0000)
## ===============================================================
## Note: 					*p<0.05; **p<0.01; ***p<0.001
```