airquality

About `airquality`

This data set contains the daily air quality measurements in New York, May to September 1973.

```
air_quality <- clean_names(airquality)
head(air_quality)
#>   ozone solar_r wind temp month day
#> 1    41     190  7.4   67     5   1
#> 2    36     118  8.0   72     5   2
#> 3    12     149 12.6   74     5   3
#> 4    18     313 11.5   62     5   4
#> 5    NA      NA 14.3   56     5   5
#> 6    28      NA 14.9   66     5   6
```

```
dim(air_quality)
#> [1] 153   6
```

```
colnames(air_quality)
#> [1] "ozone"   "solar_r" "wind"    "temp"    "month"   "day"
```

```
glimpse(air_quality)
#> Rows: 153
#> Columns: 6
#> $ ozone   <int> 41, 36, 12, 18, NA, 28, 23, 19, 8, NA, 7, 16, 11, 14, 18, 14, ~
#> $ solar_r <int> 190, 118, 149, 313, NA, NA, 299, 99, 19, 194, NA, 256, 290, 27~
#> $ wind    <dbl> 7.4, 8.0, 12.6, 11.5, 14.3, 14.9, 8.6, 13.8, 20.1, 8.6, 6.9, 9~
#> $ temp    <int> 67, 72, 74, 62, 56, 66, 65, 59, 61, 69, 74, 69, 66, 68, 58, 64~
#> $ month   <int> 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5,~
#> $ day     <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,~
```

Exploratory Data Analysis

Univariate non-graphical

```
summary(air_quality)
#>      ozone           solar_r           wind             temp      
#>  Min.   :  1.00   Min.   :  7.0   Min.   : 1.700   Min.   :56.00  
#>  1st Qu.: 18.00   1st Qu.:115.8   1st Qu.: 7.400   1st Qu.:72.00  
#>  Median : 31.50   Median :205.0   Median : 9.700   Median :79.00  
#>  Mean   : 42.13   Mean   :185.9   Mean   : 9.958   Mean   :77.88  
#>  3rd Qu.: 63.25   3rd Qu.:258.8   3rd Qu.:11.500   3rd Qu.:85.00  
#>  Max.   :168.00   Max.   :334.0   Max.   :20.700   Max.   :97.00  
#>  NA's   :37       NA's   :7                                       
#>      month            day        
#>  Min.   :5.000   Min.   : 1.0  
#>  1st Qu.:6.000   1st Qu.: 8.0  
```

```
#>  Median :7.000   Median :16.0
#>  Mean   :6.993   Mean   :15.8
#>  3rd Qu.:8.000   3rd Qu.:23.0
#>  Max.   :9.000   Max.   :31.0
#>
```

```
skimr::skim(air_quality)
```

Table 1: Data summary

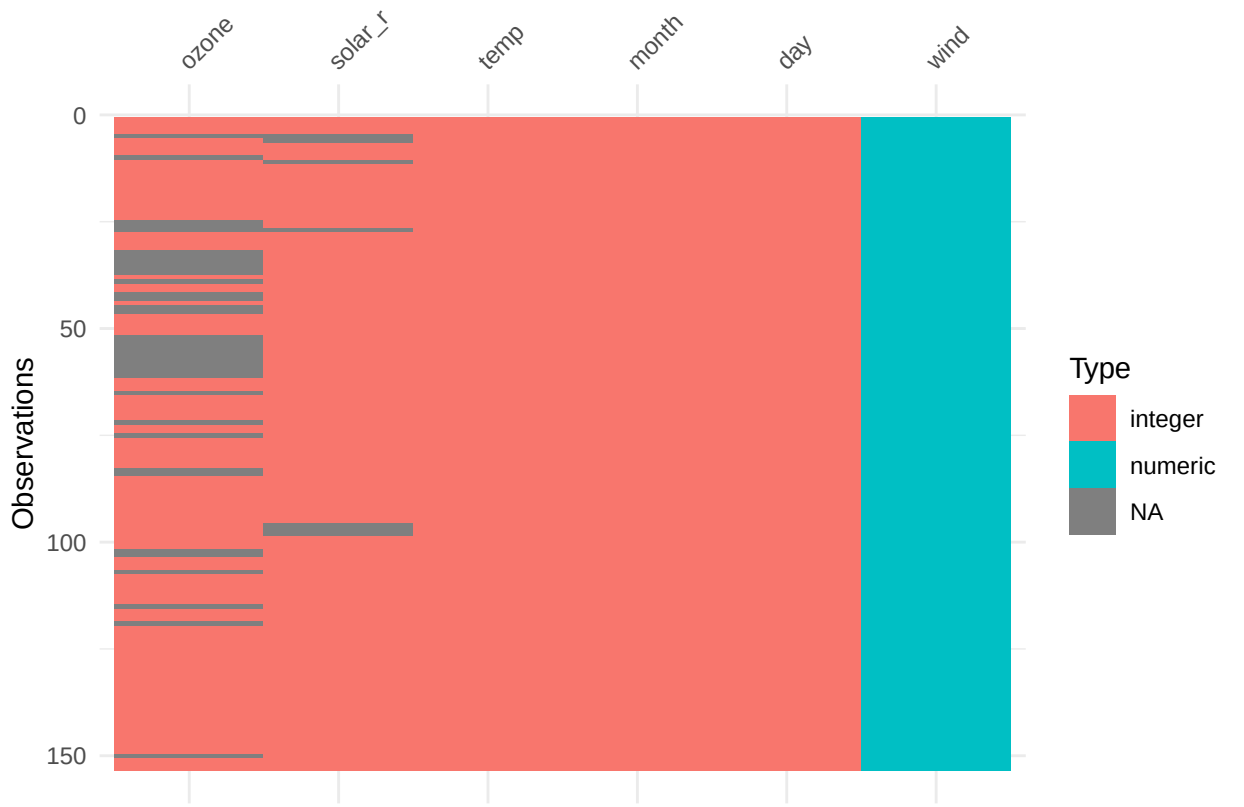
Name	air_quality
Number of rows	153
Number of columns	6
_____	
Column type frequency:	
numeric	6
_____	
Group variables	None

Variable type: numeric

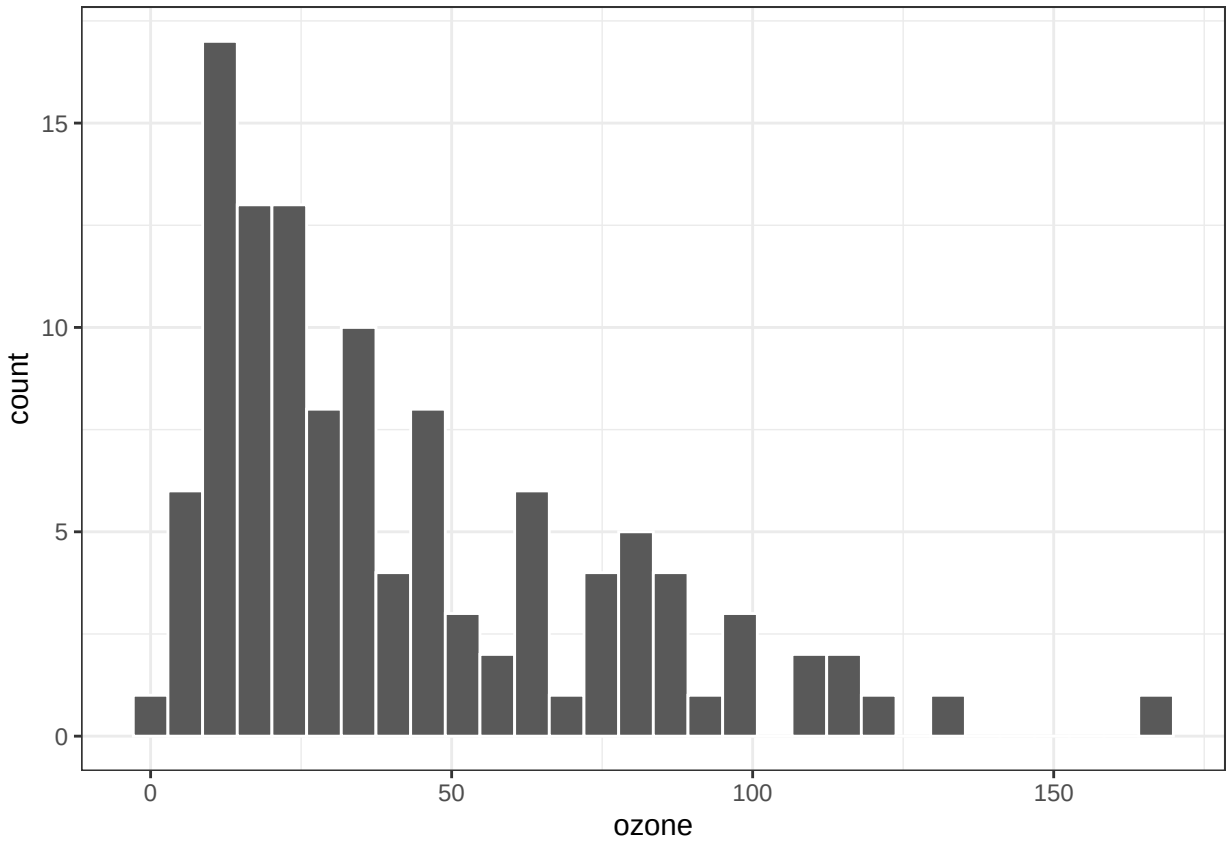
skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
ozone	37	0.76	42.13	32.99	1.0	18.00	31.5	63.25	168.0	
solar_r	7	0.95	185.93	90.06	7.0	115.75	205.0	258.75	334.0	
wind	0	1.00	9.96	3.52	1.7	7.40	9.7	11.50	20.7	
temp	0	1.00	77.88	9.47	56.0	72.00	79.0	85.00	97.0	
month	0	1.00	6.99	1.42	5.0	6.00	7.0	8.00	9.0	
day	0	1.00	15.80	8.86	1.0	8.00	16.0	23.00	31.0	

Univariate graphical

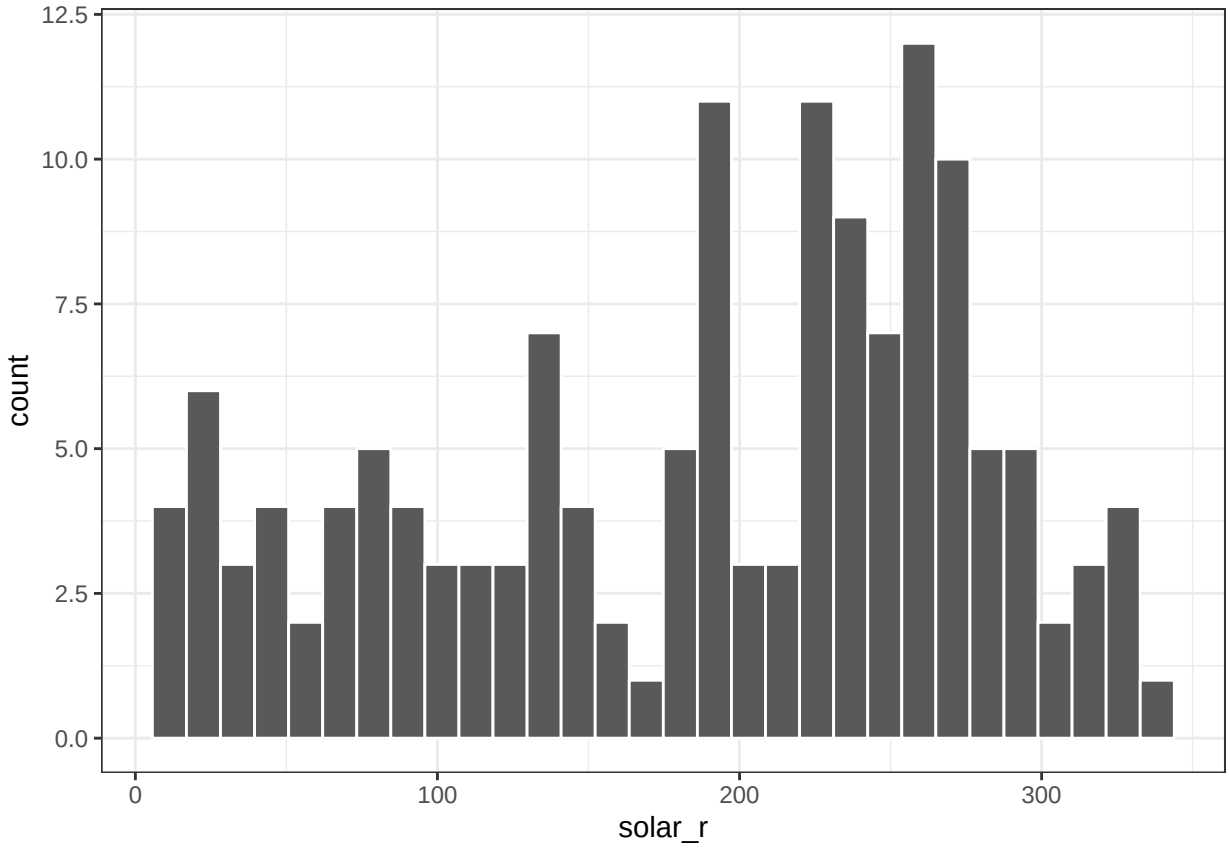
```
vis_dat(air_quality)
```



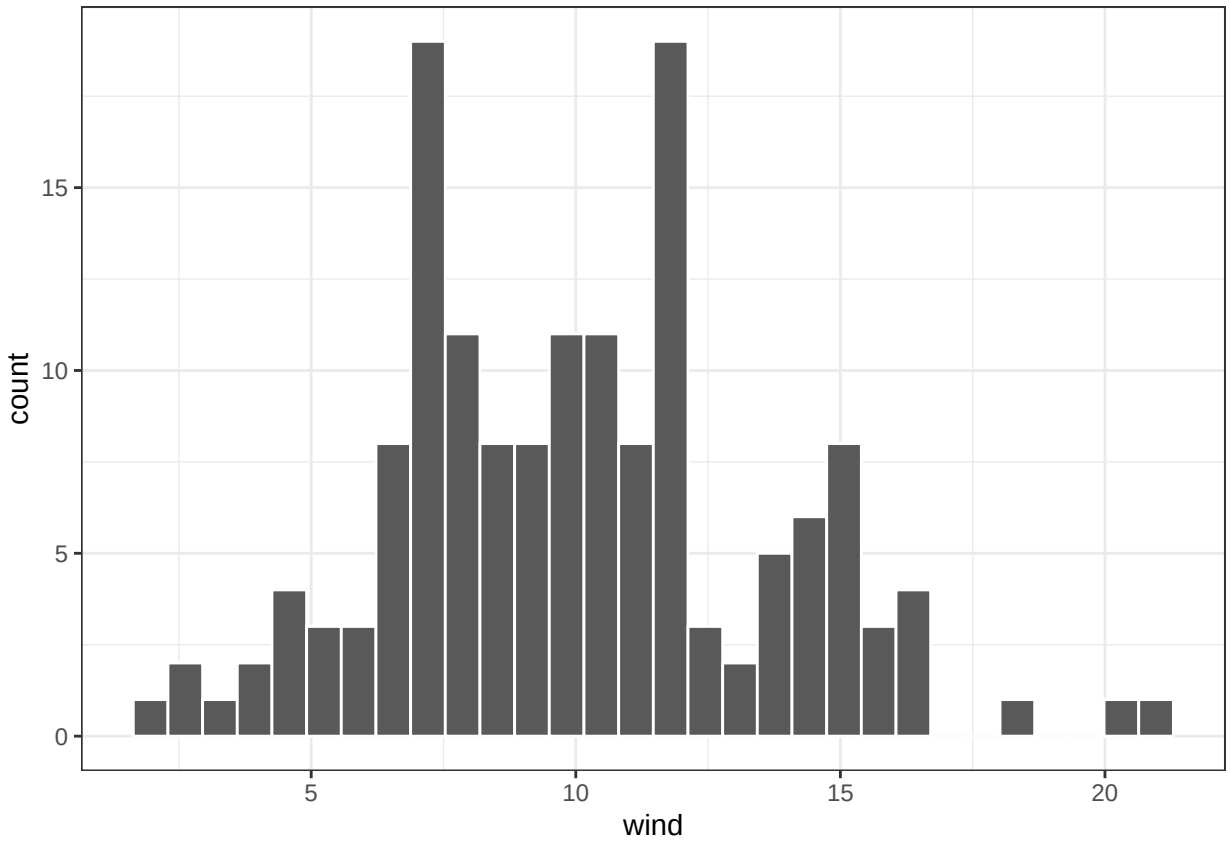

```
p1 <- ggplot(air_quality, aes(ozone)) +
  geom_histogram(color = "white")
p1
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
#> Warning: Removed 37 rows containing non-finite values (stat_bin).
```



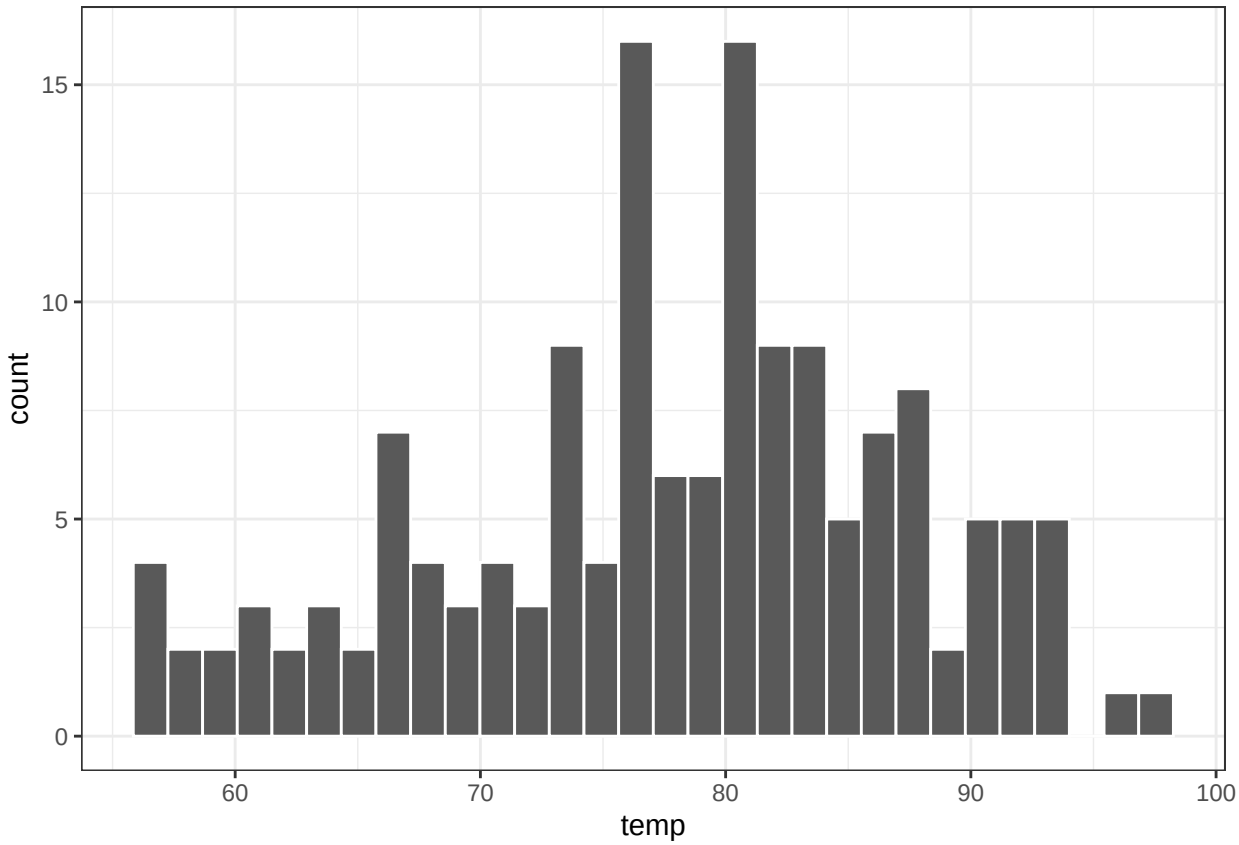

```
p2 <- ggplot(air_quality, aes(solar_r)) +
  geom_histogram(color = "white")
p2
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
#> Warning: Removed 7 rows containing non-finite values (stat_bin).
```



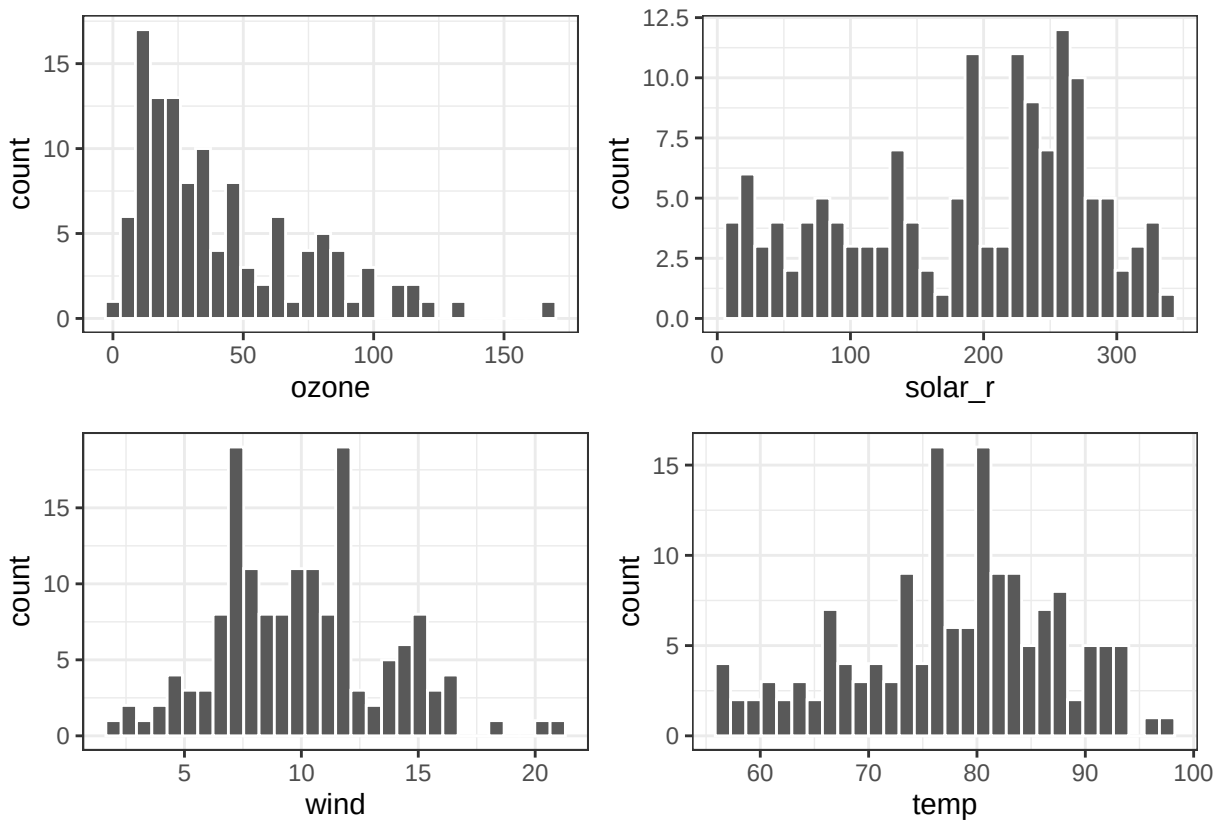

```
p3 <- ggplot(air_quality, aes(wind)) +
  geom_histogram(color = "white")
p3
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



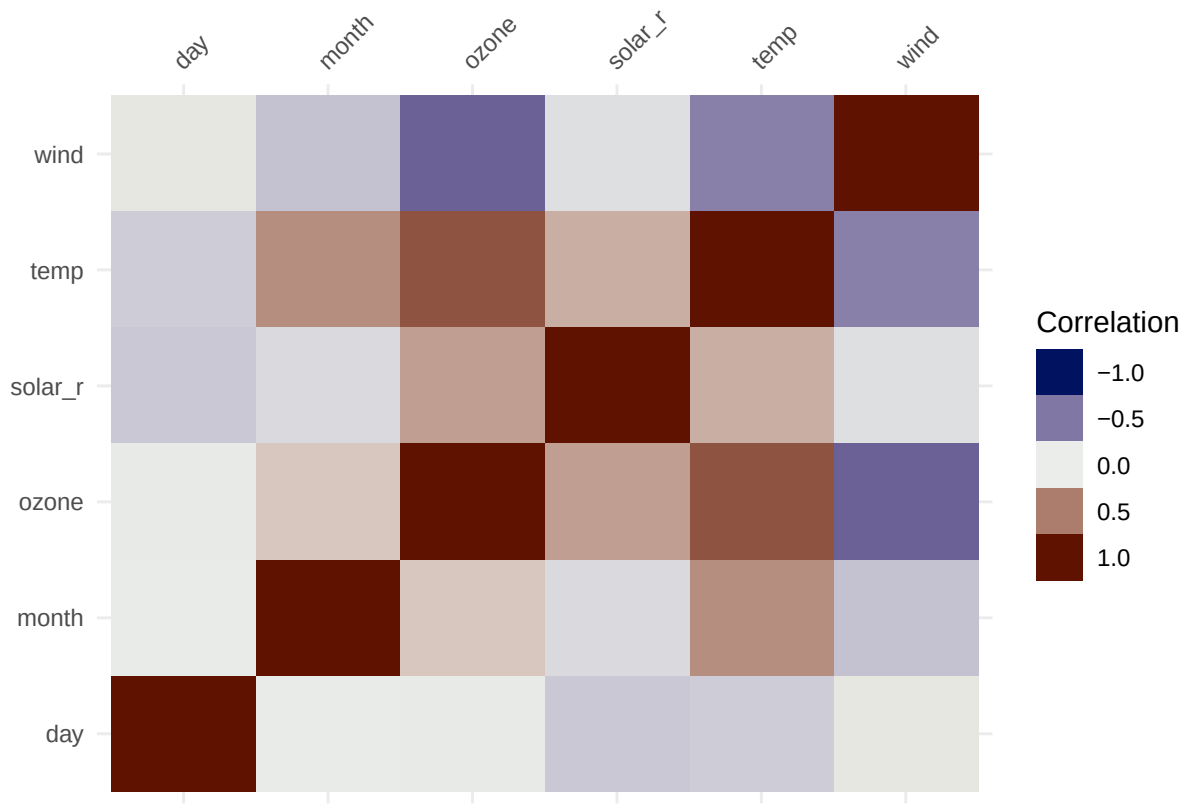

```
p4 <- ggplot(air_quality, aes(temp)) +
  geom_histogram(color = "white")
p4
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
(p1 + p2) / (p3 + p4)
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
#> Warning: Removed 37 rows containing non-finite values (stat_bin).
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
#> Warning: Removed 7 rows containing non-finite values (stat_bin).
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
vis_cor(air_quality)
```




```
air_quality <- air_quality %>%
  mutate(
    date = lubridate::make_date(year = 1973, month = month, day = day)
  )
air_quality
#>     ozone solar_r wind temp month day       date
#> 1      41     190  7.4   67     5   1 1973-05-01
#> 2      36     118  8.0   72     5   2 1973-05-02
#> 3      12     149 12.6   74     5   3 1973-05-03
#> 4      18     313 11.5   62     5   4 1973-05-04
#> 5      NA      NA 14.3   56     5   5 1973-05-05
#> 6      28      NA 14.9   66     5   6 1973-05-06
#> 7      23     299  8.6   65     5   7 1973-05-07
#> 8      19      99 13.8   59     5   8 1973-05-08
#> 9       8      19 20.1   61     5   9 1973-05-09
#> 10     NA     194  8.6   69     5  10 1973-05-10
#> 11      7      NA  6.9   74     5  11 1973-05-11
#> 12     16     256  9.7   69     5  12 1973-05-12
#> 13     11     290  9.2   66     5  13 1973-05-13
#> 14     14     274 10.9   68     5  14 1973-05-14
#> 15     18      65 13.2   58     5  15 1973-05-15
#> 16     14     334 11.5   64     5  16 1973-05-16
#> 17     34     307 12.0   66     5  17 1973-05-17
#> 18      6      78 18.4   57     5  18 1973-05-18
#> 19     30     322 11.5   68     5  19 1973-05-19
#> 20     11      44  9.7   62     5  20 1973-05-20
```

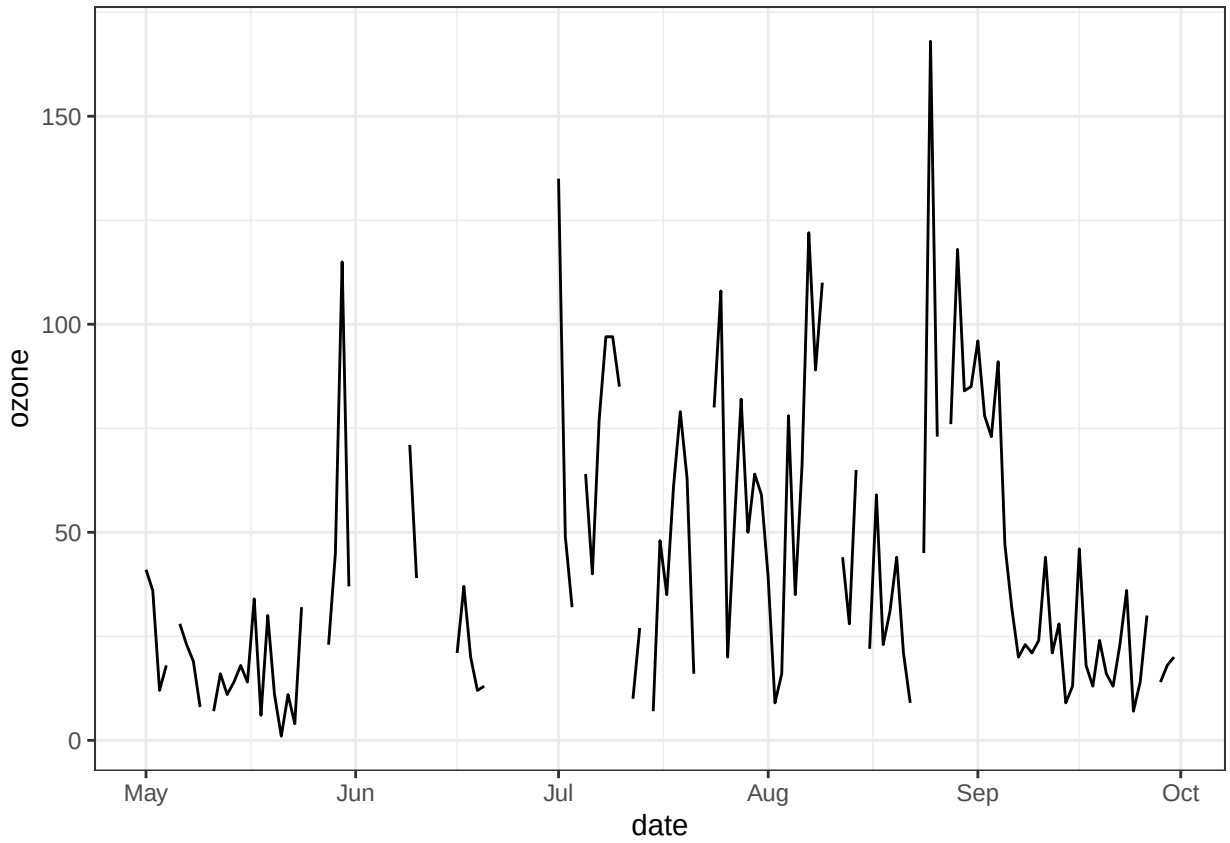
```
#> 21      1       8  9.7   59     5  21 1973-05-21
#> 22     11     320 16.6   73     5  22 1973-05-22
#> 23      4      25  9.7   61     5  23 1973-05-23
#> 24     32      92 12.0   61     5  24 1973-05-24
#> 25     NA      66 16.6   57     5  25 1973-05-25
#> 26     NA     266 14.9   58     5  26 1973-05-26
#> 27     NA      NA  8.0   57     5  27 1973-05-27
#> 28     23      13 12.0   67     5  28 1973-05-28
#> 29     45     252 14.9   81     5  29 1973-05-29
#> 30    115     223  5.7   79     5  30 1973-05-30
#> 31     37     279  7.4   76     5  31 1973-05-31
#> 32     NA     286  8.6   78     6   1 1973-06-01
#> 33     NA     287  9.7   74     6   2 1973-06-02
#> 34     NA     242 16.1   67     6   3 1973-06-03
#> 35     NA     186  9.2   84     6   4 1973-06-04
#> 36     NA     220  8.6   85     6   5 1973-06-05
#> 37     NA     264 14.3   79     6   6 1973-06-06
#> 38     29     127  9.7   82     6   7 1973-06-07
#> 39     NA     273  6.9   87     6   8 1973-06-08
#> 40     71     291 13.8   90     6   9 1973-06-09
#> 41     39     323 11.5   87     6  10 1973-06-10
#> 42     NA     259 10.9   93     6  11 1973-06-11
#> 43     NA     250  9.2   92     6  12 1973-06-12
#> 44     23     148  8.0   82     6  13 1973-06-13
#> 45     NA     332 13.8   80     6  14 1973-06-14
#> 46     NA     322 11.5   79     6  15 1973-06-15
#> 47     21     191 14.9   77     6  16 1973-06-16
#> 48     37     284 20.7   72     6  17 1973-06-17
#> 49     20      37  9.2   65     6  18 1973-06-18
#> 50     12     120 11.5   73     6  19 1973-06-19
#> 51     13     137 10.3   76     6  20 1973-06-20
#> 52     NA     150  6.3   77     6  21 1973-06-21
#> 53     NA      59  1.7   76     6  22 1973-06-22
#> 54     NA      91  4.6   76     6  23 1973-06-23
#> 55     NA     250  6.3   76     6  24 1973-06-24
#> 56     NA     135  8.0   75     6  25 1973-06-25
#> 57     NA     127  8.0   78     6  26 1973-06-26
#> 58     NA      47 10.3   73     6  27 1973-06-27
#> 59     NA      98 11.5   80     6  28 1973-06-28
#> 60     NA      31 14.9   77     6  29 1973-06-29
#> 61     NA     138  8.0   83     6  30 1973-06-30
#> 62    135     269  4.1   84     7   1 1973-07-01
#> 63     49     248  9.2   85     7   2 1973-07-02
#> 64     32     236  9.2   81     7   3 1973-07-03
#> 65     NA     101 10.9   84     7   4 1973-07-04
#> 66     64     175  4.6   83     7   5 1973-07-05
#> 67     40     314 10.9   83     7   6 1973-07-06
#> 68     77     276  5.1   88     7   7 1973-07-07
#> 69     97     267  6.3   92     7   8 1973-07-08
#> 70     97     272  5.7   92     7   9 1973-07-09
#> 71     85     175  7.4   89     7  10 1973-07-10
#> 72     NA     139  8.6   82     7  11 1973-07-11
#> 73     10     264 14.3   73     7  12 1973-07-12
```

```
#> 74     27     175 14.9   81     7  13 1973-07-13
#> 75     NA     291 14.9   91     7  14 1973-07-14
#> 76      7      48 14.3   80     7  15 1973-07-15
#> 77     48     260  6.9   81     7  16 1973-07-16
#> 78     35     274 10.3   82     7  17 1973-07-17
#> 79     61     285  6.3   84     7  18 1973-07-18
#> 80     79     187  5.1   87     7  19 1973-07-19
#> 81     63     220 11.5   85     7  20 1973-07-20
#> 82     16       7  6.9   74     7  21 1973-07-21
#> 83     NA     258  9.7   81     7  22 1973-07-22
#> 84     NA     295 11.5   82     7  23 1973-07-23
#> 85     80     294  8.6   86     7  24 1973-07-24
#> 86    108     223  8.0   85     7  25 1973-07-25
#> 87     20      81  8.6   82     7  26 1973-07-26
#> 88     52      82 12.0   86     7  27 1973-07-27
#> 89     82     213  7.4   88     7  28 1973-07-28
#> 90     50     275  7.4   86     7  29 1973-07-29
#> 91     64     253  7.4   83     7  30 1973-07-30
#> 92     59     254  9.2   81     7  31 1973-07-31
#> 93     39      83  6.9   81     8   1 1973-08-01
#> 94      9      24 13.8   81     8   2 1973-08-02
#> 95     16      77  7.4   82     8   3 1973-08-03
#> 96     78      NA  6.9   86     8   4 1973-08-04
#> 97     35      NA  7.4   85     8   5 1973-08-05
#> 98     66      NA  4.6   87     8   6 1973-08-06
#> 99    122     255  4.0   89     8   7 1973-08-07
#> 100    89     229 10.3   90     8   8 1973-08-08
#> 101   110     207  8.0   90     8   9 1973-08-09
#> 102    NA     222  8.6   92     8  10 1973-08-10
#> 103    NA     137 11.5   86     8  11 1973-08-11
#> 104    44     192 11.5   86     8  12 1973-08-12
#> 105    28     273 11.5   82     8  13 1973-08-13
#> 106    65     157  9.7   80     8  14 1973-08-14
#> 107    NA      64 11.5   79     8  15 1973-08-15
#> 108    22      71 10.3   77     8  16 1973-08-16
#> 109    59      51  6.3   79     8  17 1973-08-17
#> 110    23     115  7.4   76     8  18 1973-08-18
#> 111    31     244 10.9   78     8  19 1973-08-19
#> 112    44     190 10.3   78     8  20 1973-08-20
#> 113    21     259 15.5   77     8  21 1973-08-21
#> 114     9      36 14.3   72     8  22 1973-08-22
#> 115    NA     255 12.6   75     8  23 1973-08-23
#> 116    45     212  9.7   79     8  24 1973-08-24
#> 117   168     238  3.4   81     8  25 1973-08-25
#> 118    73     215  8.0   86     8  26 1973-08-26
#> 119    NA     153  5.7   88     8  27 1973-08-27
#> 120    76     203  9.7   97     8  28 1973-08-28
#> 121   118     225  2.3   94     8  29 1973-08-29
#> 122    84     237  6.3   96     8  30 1973-08-30
#> 123    85     188  6.3   94     8  31 1973-08-31
#> 124    96     167  6.9   91     9   1 1973-09-01
#> 125    78     197  5.1   92     9   2 1973-09-02
#> 126    73     183  2.8   93     9   3 1973-09-03
```

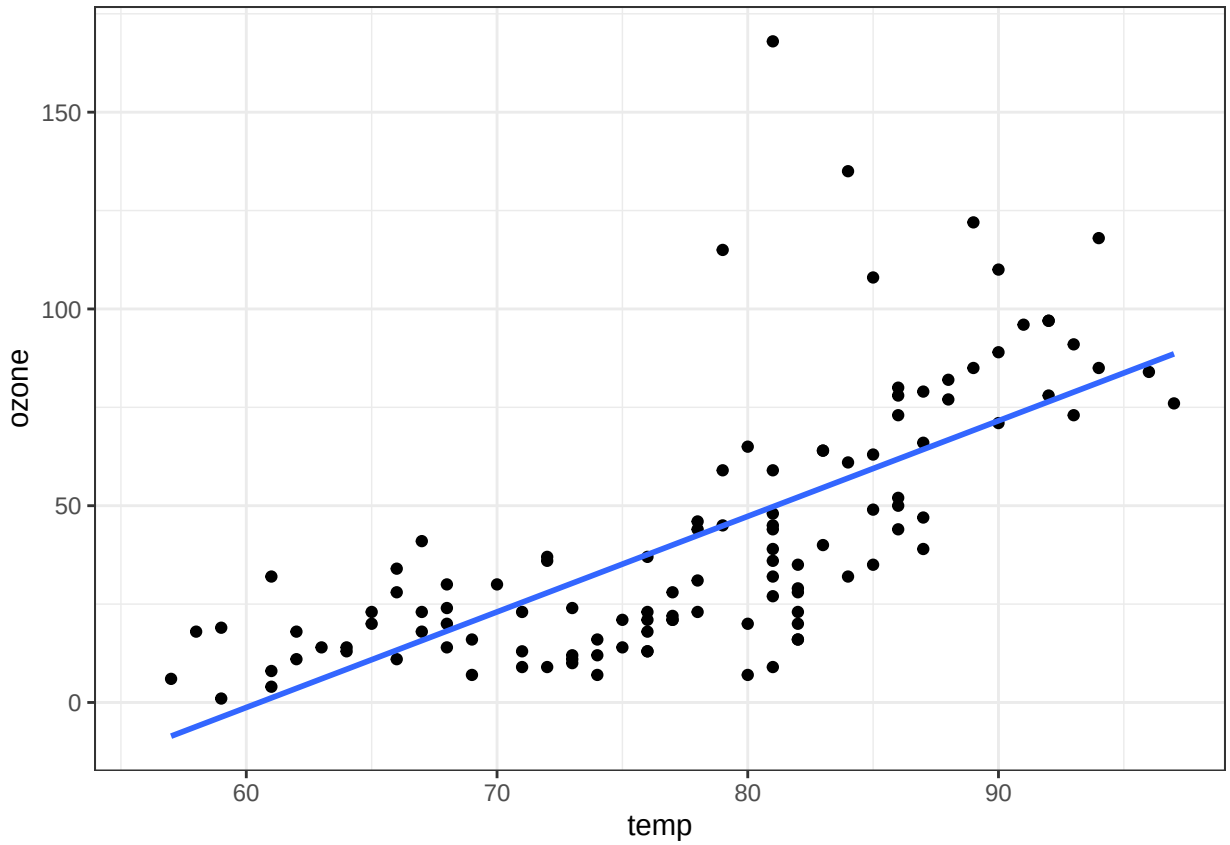
```
#> 127    91     189  4.6   93     9   4 1973-09-04
#> 128    47      95  7.4   87     9   5 1973-09-05
#> 129    32      92 15.5   84     9   6 1973-09-06
#> 130    20     252 10.9   80     9   7 1973-09-07
#> 131    23     220 10.3   78     9   8 1973-09-08
#> 132    21     230 10.9   75     9   9 1973-09-09
#> 133    24     259  9.7   73     9  10 1973-09-10
#> 134    44     236 14.9   81     9  11 1973-09-11
#> 135    21     259 15.5   76     9  12 1973-09-12
#> 136    28     238  6.3   77     9  13 1973-09-13
#> 137     9      24 10.9   71     9  14 1973-09-14
#> 138    13     112 11.5   71     9  15 1973-09-15
#> 139    46     237  6.9   78     9  16 1973-09-16
#> 140    18     224 13.8   67     9  17 1973-09-17
#> 141    13      27 10.3   76     9  18 1973-09-18
#> 142    24     238 10.3   68     9  19 1973-09-19
#> 143    16     201  8.0   82     9  20 1973-09-20
#> 144    13     238 12.6   64     9  21 1973-09-21
#> 145    23      14  9.2   71     9  22 1973-09-22
#> 146    36     139 10.3   81     9  23 1973-09-23
#> 147     7      49 10.3   69     9  24 1973-09-24
#> 148    14      20 16.6   63     9  25 1973-09-25
#> 149    30     193  6.9   70     9  26 1973-09-26
#> 150    NA     145 13.2   77     9  27 1973-09-27
#> 151    14     191 14.3   75     9  28 1973-09-28
#> 152    18     131  8.0   76     9  29 1973-09-29
#> 153    20     223 11.5   68     9  30 1973-09-30
```

```
air_quality %>%
  summarize(sum(ozone < 0, na.rm = TRUE))
#>   sum(ozone < 0, na.rm = TRUE)
#> 1                            0
```

```
ggplot(air_quality, aes(date, ozone)) +
  geom_line()
```



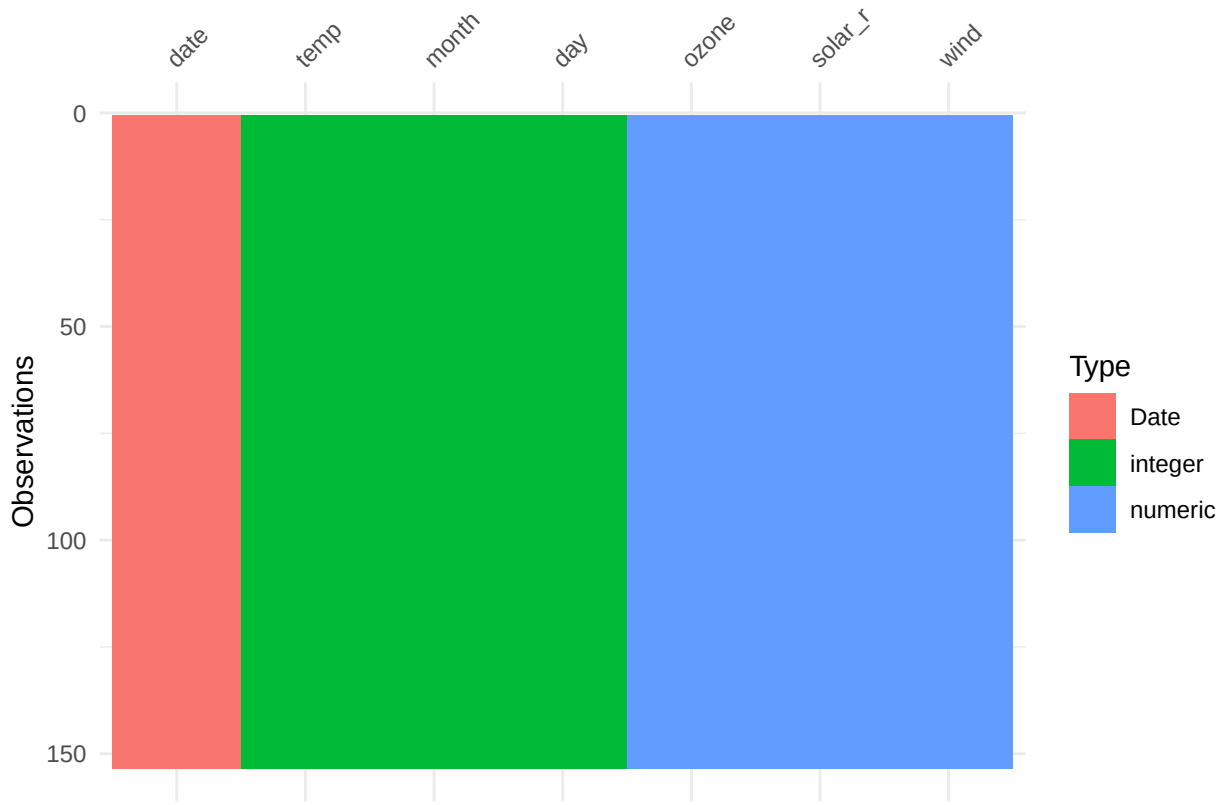

```
ggplot(air_quality, aes(temp, ozone)) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE)
#> `geom_smooth()` using formula 'y ~ x'
#> Warning: Removed 37 rows containing non-finite values (stat_smooth).
#> Warning: Removed 37 rows containing missing values (geom_point).
```




```
# Simple linear regression imputation
air_quality_imputed <- simputation::impute_lm(air_quality, ozone ~ temp)
air_quality_imputed <- simputation::impute_lm(air_quality_imputed, solar_r ~ temp + ozone)
```

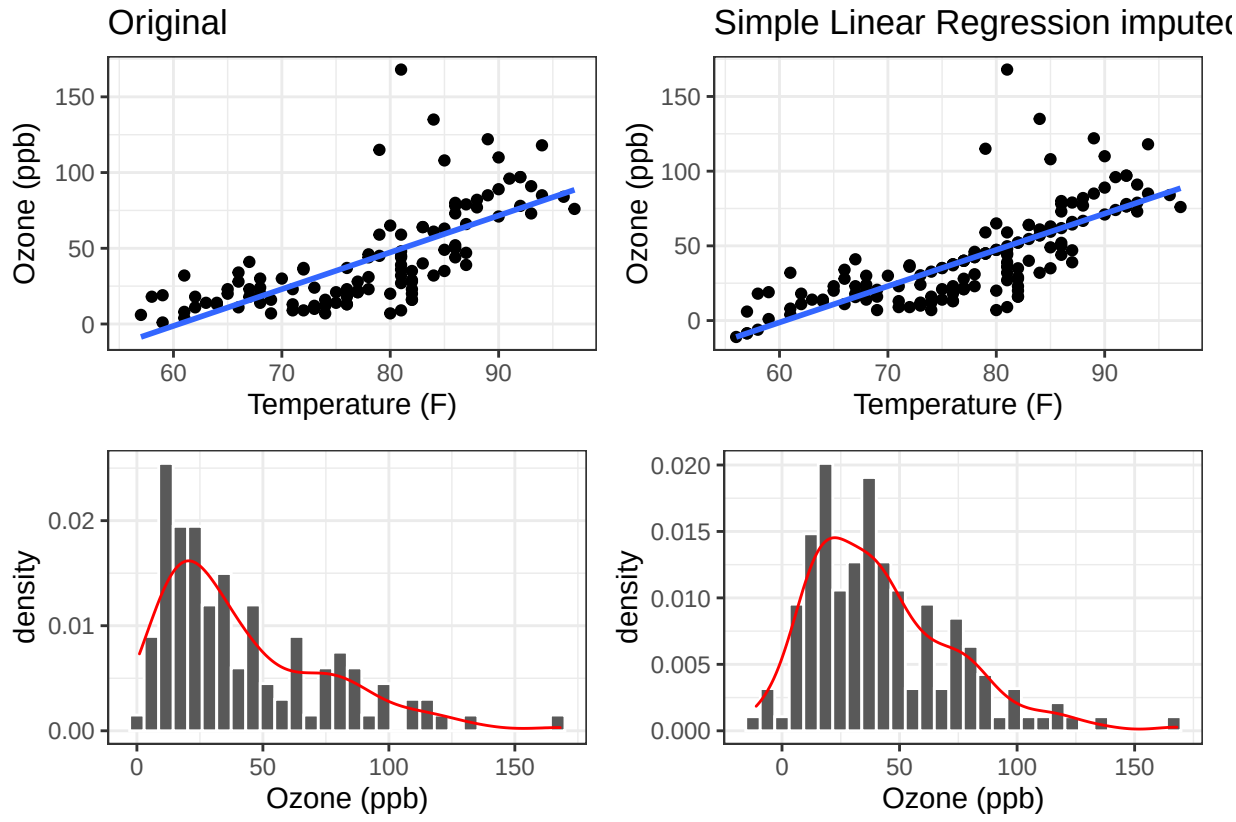
```
# Random forest imputation
air_quality_imputed2 <- simputation::impute_cart(air_quality, ozone ~ temp + wind + date)
air_quality_imputed2 <- simputation::impute_cart(air_quality_imputed2, solar_r ~ ozone + temp + wind + d
```

```
vis_dat(air_quality_imputed)
```




```
# ozone before and after imputation
before1 <- ggplot(air_quality, aes(temp, ozone)) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    x = "Temperature (F)",
    y = "Ozone (ppb)",
    title = "Original"
  )

before2 <- ggplot(air_quality, aes(ozone)) +
  geom_histogram(aes(y = ..density..), color = "white") +
  geom_density(color = "red") +
  labs(
    x = "Ozone (ppb)"
  )

after1 <- ggplot(air_quality_imputed, aes(temp, ozone)) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    x = "Temperature (F)",
    y = "Ozone (ppb)",
    title = "Simple Linear Regression imputed"
  )
```

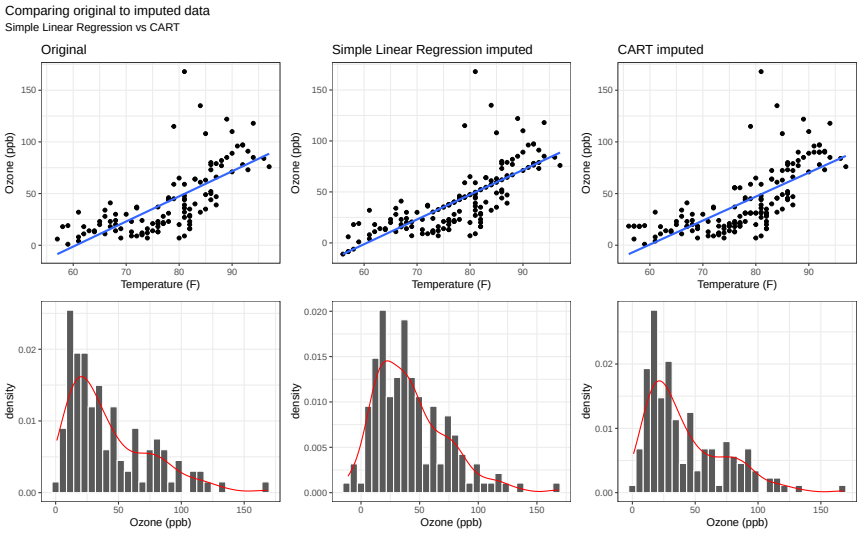
```
after2 <- ggplot(air_quality_imputed, aes(ozone)) +
  geom_histogram(aes(y = ..density..), color = "white") +
  geom_density(color = "red") +
  labs(
    x = "Ozone (ppb)"
  )

(before1 + after1) / (before2 + after2)
#> `geom_smooth()` using formula 'y ~ x'
#> Warning: Removed 37 rows containing non-finite values (stat_smooth).
#> Warning: Removed 37 rows containing missing values (geom_point).
#> `geom_smooth()` using formula 'y ~ x'
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
#> Warning: Removed 37 rows containing non-finite values (stat_bin).
#> Warning: Removed 37 rows containing non-finite values (stat_density).
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



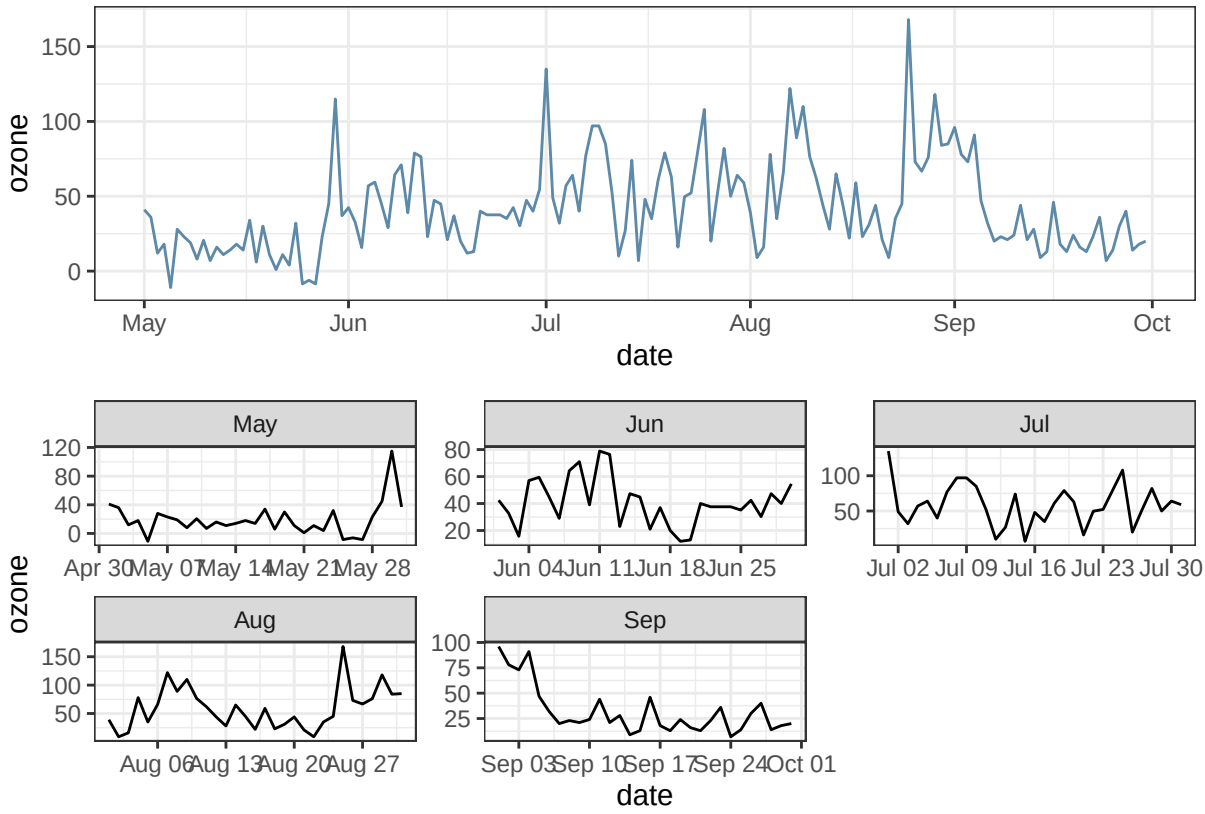
Negative ozone levels after imputation

```
after3 <- ggplot(air_quality_imputed2, aes(temp, ozone)) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    x = "Temperature (F)",
    y = "Ozone (ppb)",
    title = "CART imputed"
```

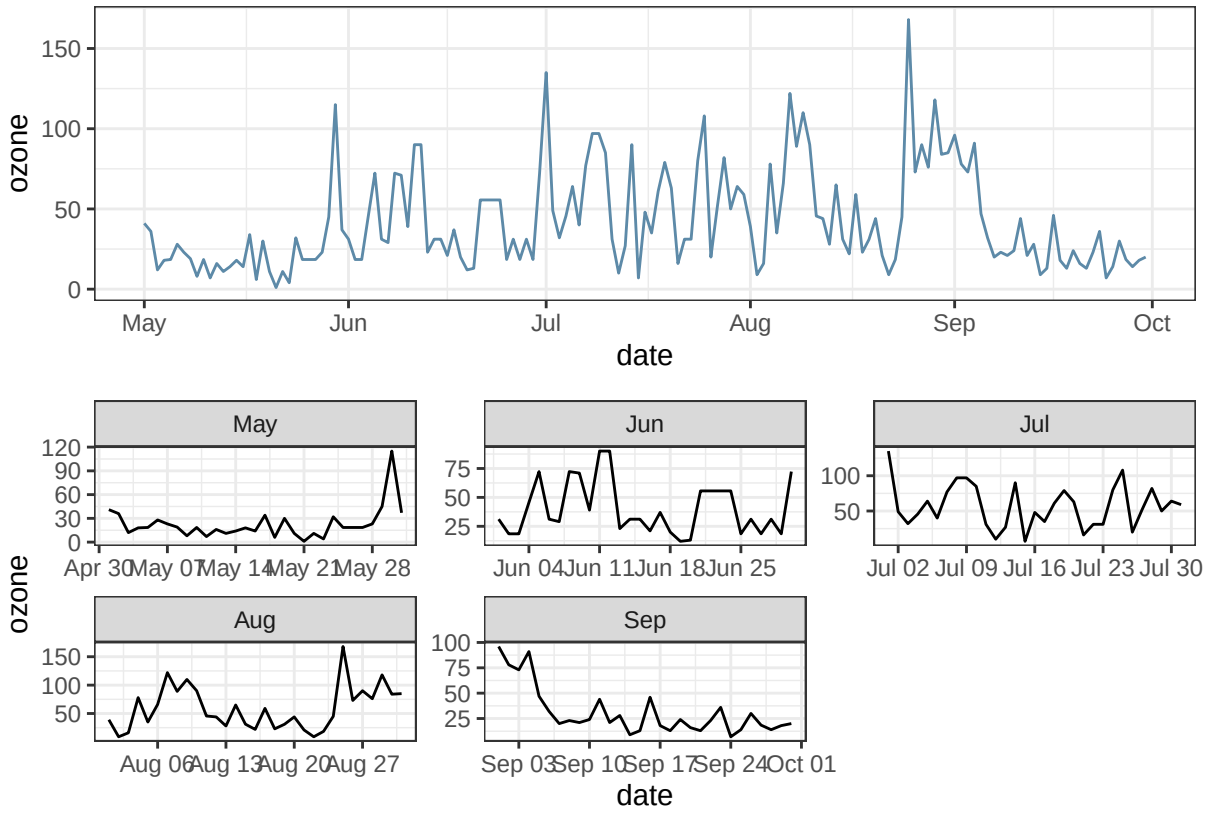
```
  )

after4 <- ggplot(air_quality_imputed2, aes(ozone)) +
  geom_histogram(aes(y = ..density..), color = "white") +
  geom_density(color = "red") +
  labs(
    x = "Ozone (ppb)"
  )

patch <- (before1 / before2) | (after1 / after2) | (after3 / after4)

ready <- patch + plot_annotation(
  title = "Comparing original to imputed data",
  subtitle = "Simple Linear Regression vs CART",
)
ready
#> `geom_smooth()` using formula 'y ~ x'
#> Warning: Removed 37 rows containing non-finite values (stat_smooth).
#> Warning: Removed 37 rows containing missing values (geom_point).
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
#> Warning: Removed 37 rows containing non-finite values (stat_bin).
#> Warning: Removed 37 rows containing non-finite values (stat_density).
#> `geom_smooth()` using formula 'y ~ x'
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
#> `geom_smooth()` using formula 'y ~ x'
#> `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



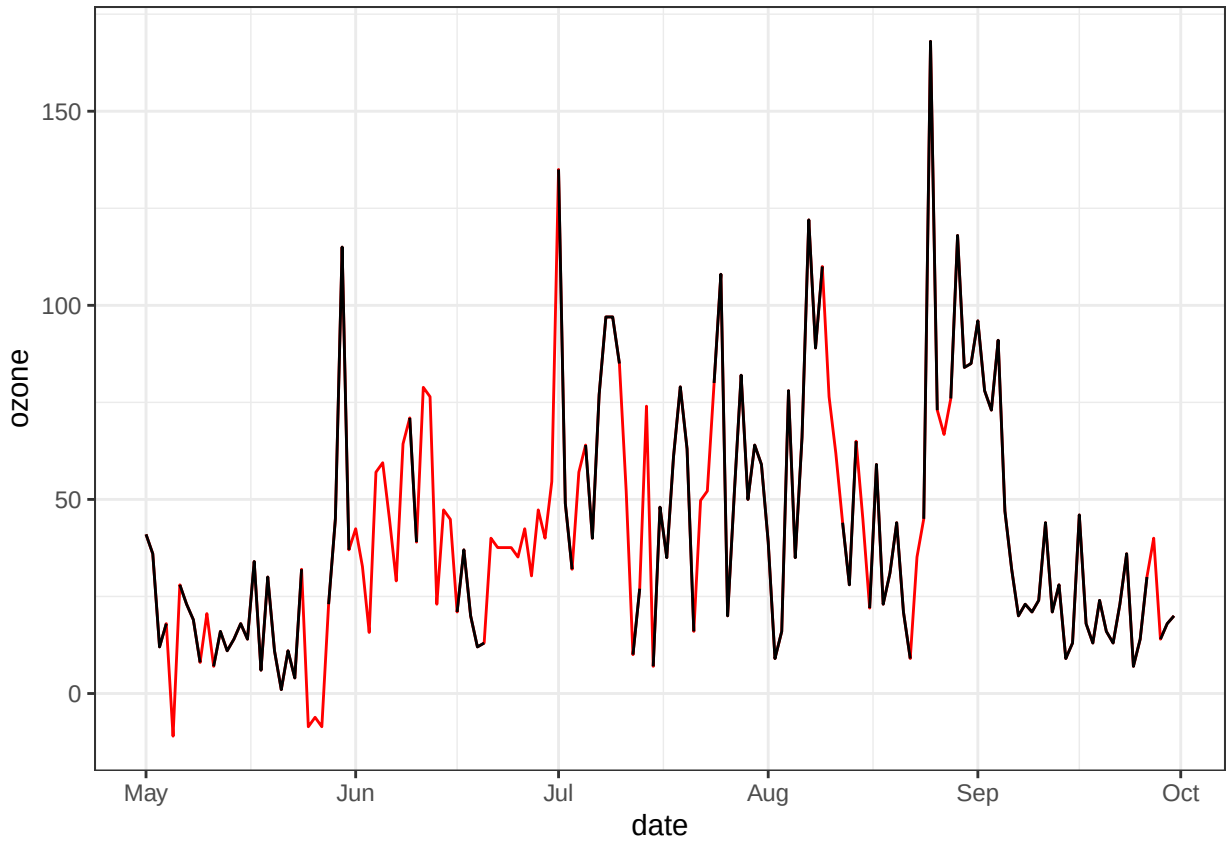

```
by_time <- ggplot(air_quality_imputed, aes(date, ozone)) +
  geom_line(color = "#5D8AA8")

by_month <- ggplot(air_quality_imputed, aes(date, ozone)) +
  geom_line() +
  facet_wrap(~lubridate::month(date, label = TRUE), scale = "free")

by_time / by_month
```




```
by_time2 <- ggplot(air_quality_imputed2, aes(date, ozone)) +
  geom_line(color = "#5D8AA8")

by_month2 <- ggplot(air_quality_imputed2, aes(date, ozone)) +
  geom_line() +
  facet_wrap(~lubridate::month(date, label = TRUE), scale = "free")

by_time2 / by_month2
```




```
ggplot(air_quality_imputed, aes(date)) +
  geom_line(aes(y = ozone), color = "red") +
  geom_line(data = air_quality, aes(y = ozone))
```


150
100
50
0
ozone
May
Jun
Jul
Aug
Sep
Oct
date