Data Transformations: ncyflights13$flights_1

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Note: The purpose of this document is to showcase a sample of skills covered in *R for Data Science* (chapter: Data Transformations) by Garrett Grolemund and Hadley Wickham. All scripts were taken from https://r4ds.had.co.nz/transform.html and https://jrnold.github.io/r4ds-exercise-solutions/index.html. The code for each exercise was studied carefully for understanding and then was retyped manually into R to maximize the learning experience; however, many of the original scripts were altered for further experimentation and presentation aesthetics.

The skills that I focused on include:

- Filter rows with *filter()*
- Arrange rows with *arrange()*
- Select columns with *select()*
- Add new variables with *mutate()*
- Grouped summaries with *summarise()*
- Grouped mutates (and filters)

```r
# View first row of data
head(flights, 1)
```

```
## # A tibble: 1 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1     1      517            515         2      830            819
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

Find flights that arrived more than two hours late, but didn't leave late.

```r
head(filter(flights, dep_delay <= 0, arr_delay > 120))
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1    27     1419           1420        -1     1754           1550
## 2  2013    10     7     1350           1350         0     1736           1526
## 3  2013    10     7     1357           1359        -2     1858           1654
## 4  2013    10    16      657            700        -3     1258           1056
## 5  2013    11     1      658            700        -2     1329           1015
## 6  2013     3    18     1844           1847        -3       39           2219
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

Find flights that flew to Houston (IAH or HOU).

```r
head(filter(flights, dest == "IAH" | dest == "HOU")) # characters need quotation marks
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1     1      517            515         2      830            819
## 2  2013     1     1      533            529         4      850            830
## 3  2013     1     1      623            627        -4      933            932
## 4  2013     1     1      728            732        -4     1041           1038
## 5  2013     1     1      739            739         0     1104           1038
## 6  2013     1     1      908            908         0     1228           1219
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

Find flights that were operated by United, American, or Delta.

```
airlines # to lookup airline codes
```

```
## # A tibble: 16 x 2
##    carrier name
##    <chr>   <chr>
##  1 9E      Endeavor Air Inc.
##  2 AA      American Airlines Inc.
##  3 AS      Alaska Airlines Inc.
##  4 B6      JetBlue Airways
##  5 DL      Delta Air Lines Inc.
##  6 EV      ExpressJet Airlines Inc.
##  7 F9      Frontier Airlines Inc.
##  8 FL      AirTran Airways Corporation
##  9 HA      Hawaiian Airlines Inc.
## 10 MQ      Envoy Air
## 11 OO      SkyWest Airlines Inc.
## 12 UA      United Air Lines Inc.
## 13 US      US Airways Inc.
## 14 VX      Virgin America
## 15 WN      Southwest Airlines Co.
## 16 YV      Mesa Airlines Inc.
```

```
head(filter(flights, carrier == "UA" | carrier == "AA" | carrier == "DL"))
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1     1      517            515         2      830            819
## 2  2013     1     1      533            529         4      850            830
## 3  2013     1     1      542            540         2      923            850
## 4  2013     1     1      554            600        -6      812            837
## 5  2013     1     1      554            558        -4      740            728
## 6  2013     1     1      558            600        -2      753            745
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

Find flights that do NOT have a greater delay than 120 minutes.

```
head(filter(flights, !(arr_delay > 120 | dep_delay >120)))
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1     1      517            515         2      830            819
## 2  2013     1     1      533            529         4      850            830
## 3  2013     1     1      542            540         2      923            850
## 4  2013     1     1      544            545        -1     1004           1022
## 5  2013     1     1      554            600        -6      812            837
## 6  2013     1     1      554            558        -4      740            728
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

Find flights that do have a delay that is less than 120 minutes.

```
head(filter(flights, arr_delay <= 120, dep_delay <= 120))
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1     1      517            515         2      830            819
## 2  2013     1     1      533            529         4      850            830
## 3  2013     1     1      542            540         2      923            850
## 4  2013     1     1      544            545        -1     1004           1022
## 5  2013     1     1      554            600        -6      812            837
## 6  2013     1     1      554            558        -4      740            728
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

Find flights that had an arrival delay of two or more hours.

```
head(filter(flights, arr_delay >=120))
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1     1      811            630       101     1047            830
## 2  2013     1     1      848           1835       853     1001           1950
## 3  2013     1     1      957            733       144     1056            853
## 4  2013     1     1     1114            900       134     1447           1222
## 5  2013     1     1     1505           1310       115     1638           1431
## 6  2013     1     1     1525           1340       105     1831           1626
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

Find flights that were delayed by at least an hour, but made up over 30 minutes in flight.

```
head(filter(flights, dep_delay >= 60, dep_delay - arr_delay > 30))
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1     1     2205           1720       285       46           2040
## 2  2013     1     1     2326           2130       116      131             18
## 3  2013     1     3     1503           1221       162     1803           1555
## 4  2013     1     3     1839           1700        99     2056           1950
## 5  2013     1     3     1850           1745        65     2148           2120
## 6  2013     1     3     1941           1759       102     2246           2139
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

Find flights that departed between midnight and 6am (inclusive).

```
summary(flights$dep_time) # to find if midnight is denoted as 2400 or 0.
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##       1     907    1401    1349    1744    2400    8255
```

```
head(filter(flights, dep_time == 2400 | dep_time <= 6000))
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1     1      517            515         2      830            819
## 2  2013     1     1      533            529         4      850            830
## 3  2013     1     1      542            540         2      923            850
## 4  2013     1     1      544            545        -1     1004           1022
## 5  2013     1     1      554            600        -6      812            837
## 6  2013     1     1      554            558        -4      740            728
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

Sort flights to find the most delayed flight in the dataset.

Flight HA 5 from JFK to HNL had a 1301 minute (21.68 hours) delay on January 9th, 2013.

```
slice_head(flights %>%
       select(dep_delay, carrier, flight, origin, dest, month, day, year) %>%
       arrange(desc(dep_delay)))
```

```
## # A tibble: 1 x 8
##   dep_delay carrier flight origin dest  month   day  year
##       <dbl> <chr>    <int> <chr>  <chr> <int> <int> <int>
## 1      1301 HA          51 JFK    HNL       1     9  2013
```

Find the flight that left the earliest in the dataset.

Flight B6 97 from JFK to DEN departed 43 minutes early than scheduled on December 7th, 2013.

```
slice_head(flights %>%
       select(dep_delay, carrier, flight, origin, dest, month, day, year) %>%
       arrange(dep_delay))
```

```
## # A tibble: 1 x 8
##   dep_delay carrier flight origin dest  month   day  year
##       <dbl> <chr>    <int> <chr>  <chr> <int> <int> <int>
## 1       -43 B6          97 JFK    DEN      12     7  2013
```

Sort flights to find the fastest (highest speed) flight in the dataset.

Flight DL 1499 had the fastest average ground speed of 703.38 miles/hour.

```
slice_head(flights %>%
       mutate(ground_speed = distance/(air_time/60)) %>% # create a new variable, ground_speed
       arrange(desc(distance/air_time)) %>%
       select(ground_speed, carrier, flight, origin, dest, month, day, year))
```

```
## # A tibble: 1 x 8
##   ground_speed carrier flight origin dest  month   day  year
##          <dbl> <chr>    <int> <chr>  <chr> <int> <int> <int>
## 1         703. DL        1499 LGA    ATL       5    25  2013
```

Which flights traveled the farthest?

Flight HA 51 from JFK to HNL is the longest #flight with a distance of 4,983 miles.

```
slice_head((flights %>%
       select(distance, carrier, flight, origin, dest) %>%
       arrange(desc(distance))))
```

```
## # A tibble: 1 x 5
##   distance carrier flight origin dest
##      <dbl> <chr>    <int> <chr>  <chr>
## 1     4983 HA          51 JFK    HNL
```

Which flight traveled the shortest?

Flight US 1632 from EWR to LGA is the shortest flight with a distance of 17 miles.

```
slice_head(flights %>%
       select(distance, carrier, flight, origin, dest) %>%
       arrange(distance))
```

```
## # A tibble: 1 x 5
##   distance carrier flight origin dest
##      <dbl> <chr>    <int> <chr>  <chr>
## 1       17 US        1632 EWR    LGA
```

For the flights that have a missing dep_time, what other variables are missing? What might these other missing rows represent?

Since arrive_time is also missing, these may be cancelled flights.

```
head(filter(flights, is.na(dep_time)))
```

```
## # A tibble: 6 x 19
##    year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int>    <int>          <int>     <dbl>    <int>          <int>
## 1  2013     1     1       NA           1630        NA       NA           1815
## 2  2013     1     1       NA           1935        NA       NA           2240
## 3  2013     1     1       NA           1500        NA       NA           1825
## 4  2013     1     1       NA            600        NA       NA            901
## 5  2013     1     2       NA           1540        NA       NA           1747
## 6  2013     1     2       NA           1620        NA       NA           1746
## # ... with 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dttm>
```

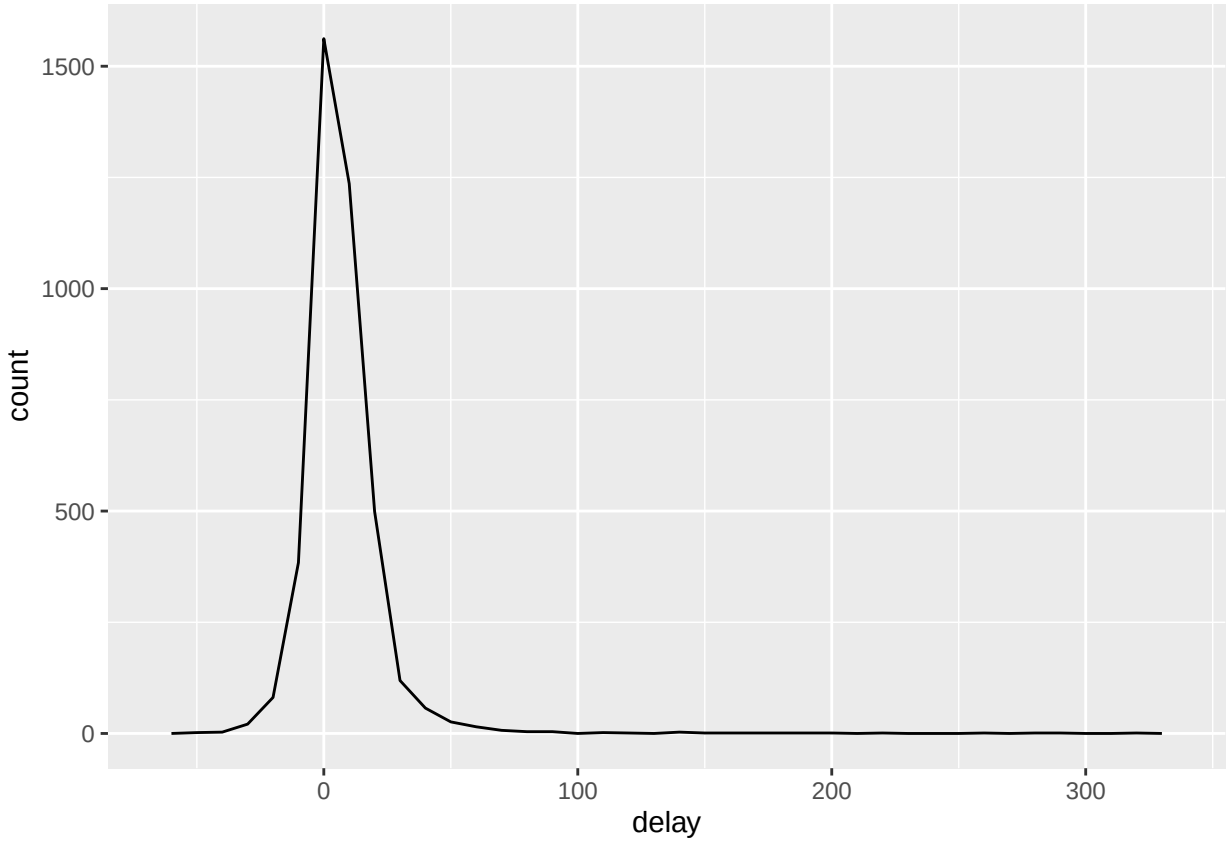
Identify flights which were not cancelled.

```
not_cancelled <- flights %>%
  filter(!is.na(dep_delay), !is.na(arr_delay))

head(not_cancelled %>%
  group_by(year, month, day) %>%
  summarise(mean=mean(dep_delay)))
```

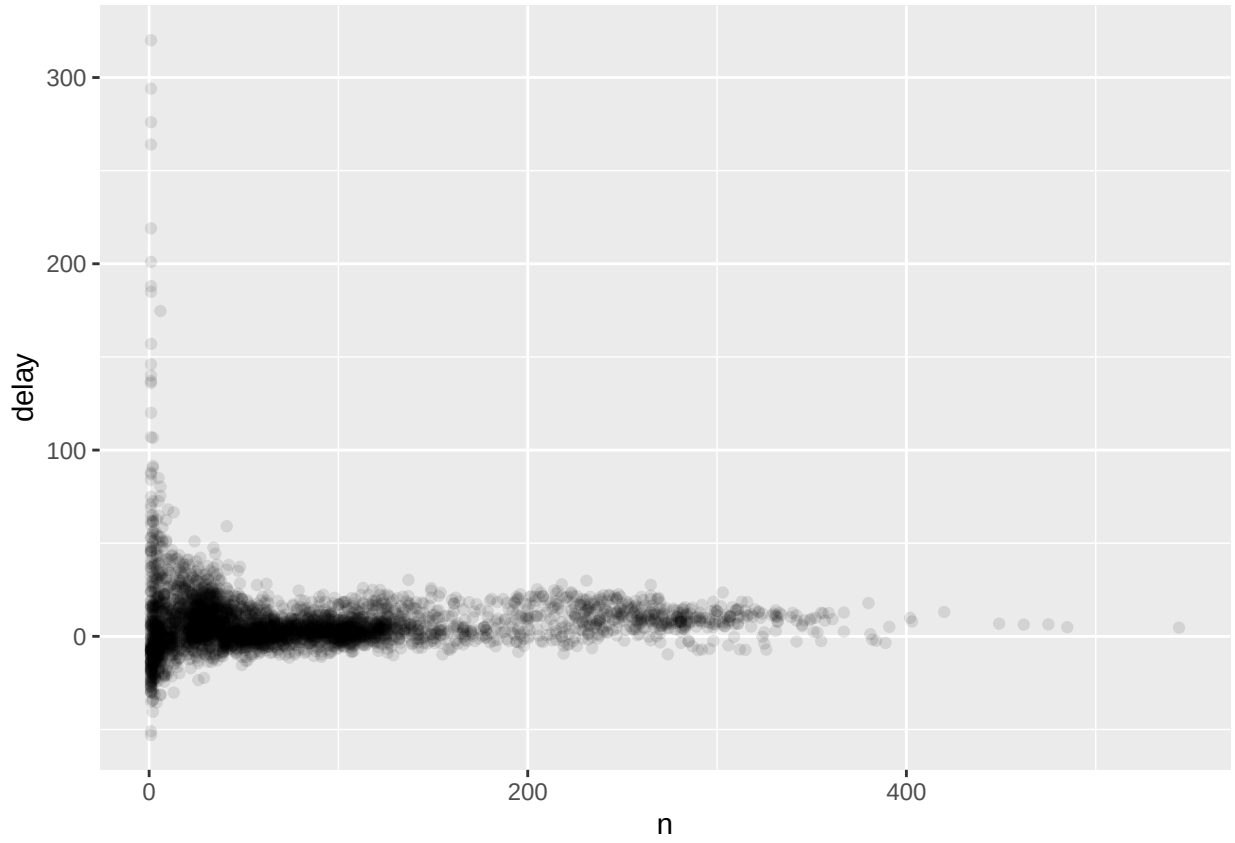
```
## # A tibble: 6 x 4
## # Groups:   year, month [1]
##    year month   day  mean
##   <int> <int> <int> <dbl>
## 1  2013     1     1 11.4
## 2  2013     1     2 13.7
## 3  2013     1     3 10.9
## 4  2013     1     4  8.97
## 5  2013     1     5  5.73
## 6  2013     1     6  7.15
```

Planes (identified by their tail number) that have the highest average delays

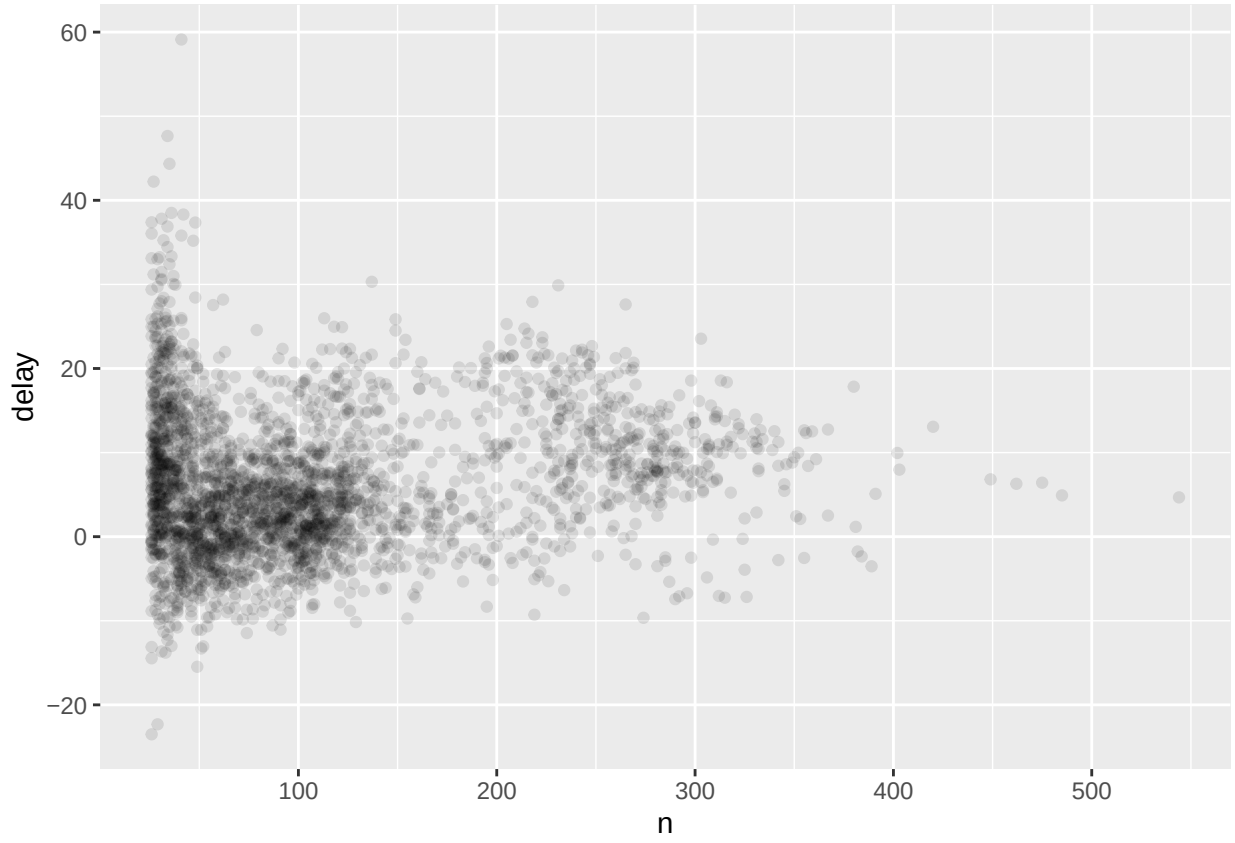
```
delays <- not_cancelled %>%
  group_by(tailnum) %>%
  summarise(
    delay = mean(arr_delay)
  )

ggplot(data = delays, mapping = aes(x=delay)) +
  geom_freqpoly(binwidth=10)
```



```r
#scatterplot of number of flights vs. average delay

delays <- not_cancelled %>%
  group_by(tailnum) %>%
  summarise(
    delay = mean(arr_delay, na.rm = TRUE),
    n=n()
  )

ggplot(data = delays, mapping = aes(x=n, y =delay))+ geom_point(alpha=1/10)
```



```r
# useful to filter out the groups with the smallest numbers of observations,
#so you can see more of the pattern
#and less of the extreme variation in the smallest groups.

delays %>%
  filter(n>25) %>%
  ggplot(mapping = aes(x=n, y=delay)) +
  geom_point(alpha=1/10)
```



Using measures of location:mean(x), median(x)

```
head(not_cancelled %>%
  group_by(year, month, day) %>%
  summarise(
    avg_delay1 = mean(arr_delay),
    avg_delay2 = mean(arr_delay[arr_delay > 0]) # average positive delay
  ))
```

```
## # A tibble: 6 x 5
## # Groups:   year, month [1]
##    year month   day avg_delay1 avg_delay2
##   <int> <int> <int>      <dbl>      <dbl>
## 1  2013     1     1      12.7        32.5
## 2  2013     1     2      12.7        32.0
## 3  2013     1     3       5.73       27.7
## 4  2013     1     4      -1.93       28.3
## 5  2013     1     5      -1.53       22.6
## 6  2013     1     6       4.24       24.4
```

Using measures of spread: sd(x), IQR(x), mad(x)

```
head(not_cancelled %>%
  group_by(dest) %>%
  summarize(distance_sd=sd(distance)) %>%
  arrange(desc(distance_sd)))
```

```
## # A tibble: 6 x 2
##   dest  distance_sd
##   <chr>       <dbl>
## 1 EGE         10.5
## 2 SAN         10.4
## 3 SFO         10.2
## 4 HNL         10.0
## 5 SEA          9.98
## 6 LAS          9.91
```

Measures of rank: min(x), quantile(x, 0.25), max(x)

Question: When do the first and last flights leave each day?

```
head(not_cancelled %>%
  group_by(year, month, day) %>%
  summarise(
    first = min(dep_time),
    last = max (dep_time)
  ))
```

```
## # A tibble: 6 x 5
## # Groups:   year, month [1]
##    year month   day first  last
##   <int> <int> <int> <int> <int>
## 1  2013     1     1   517  2356
## 2  2013     1     2    42  2354
## 3  2013     1     3    32  2349
## 4  2013     1     4    25  2358
## 5  2013     1     5    14  2357
## 6  2013     1     6    16  2355
```

```
# Counts: n() -> returns the size of the current group
# sum(!is.na(x)) -> count the number of non-missing values
# n_distinct(x) -> count the number of distinct (unique) values

head(not_cancelled %>%
  group_by(dest) %>%
  summarise(carriers =n_distinct(carrier)) %>%
  arrange(desc(carriers)))
```

```
## # A tibble: 6 x 2
##   dest  carriers
##   <chr>    <int>
## 1 ATL          7
## 2 BOS          7
## 3 CLT          7
## 4 ORD          7
## 5 TPA          7
## 6 AUS          6
```

```
head(not_cancelled %>%
  count(dest))
```

```
## # A tibble: 6 x 2
##   dest      n
##   <chr> <int>
## 1 ABQ     254
## 2 ACK     264
## 3 ALB     418
## 4 ANC       8
## 5 ATL   16837
## 6 AUS    2411
```

The total number of miles a plane flew:

```
head(not_cancelled %>%
  count(tailnum, wt =distance))
```

```
## # A tibble: 6 x 2
##   tailnum      n
##   <chr>    <dbl>
## 1 D942DN    3418
## 2 N0EGMQ  239143
## 3 N10156  109664
## 4 N102UW   25722
## 5 N103US   24619
## 6 N104UW   24616
```

How many flights left before 5am?

```
head(not_cancelled %>%
  group_by(year, month) %>%
  summarise(n_early = sum(dep_time < 500)))
```

```
## # A tibble: 6 x 3
## # Groups:   year [1]
##    year month n_early
##   <int> <int>   <int>
## 1  2013     1      75
## 2  2013     2      84
## 3  2013     3     147
## 4  2013     4     148
## 5  2013     5     120
## 6  2013     6     219
```

What proportion of flights are delayed by more than an hour?

```
head(not_cancelled %>%
  group_by(year, month) %>%
  summarise(hour_prop = mean(arr_delay > 60)))
```

```
## # A tibble: 6 x 3
## # Groups:   year [1]
##    year month hour_prop
##   <int> <int>     <dbl>
## 1  2013     1    0.0705
## 2  2013     2    0.0689
## 3  2013     3    0.0837
## 4  2013     4    0.102
## 5  2013     5    0.0795
## 6  2013     6    0.142
```

Compare air_time with arr_time - dep_time. What do you expect to see?

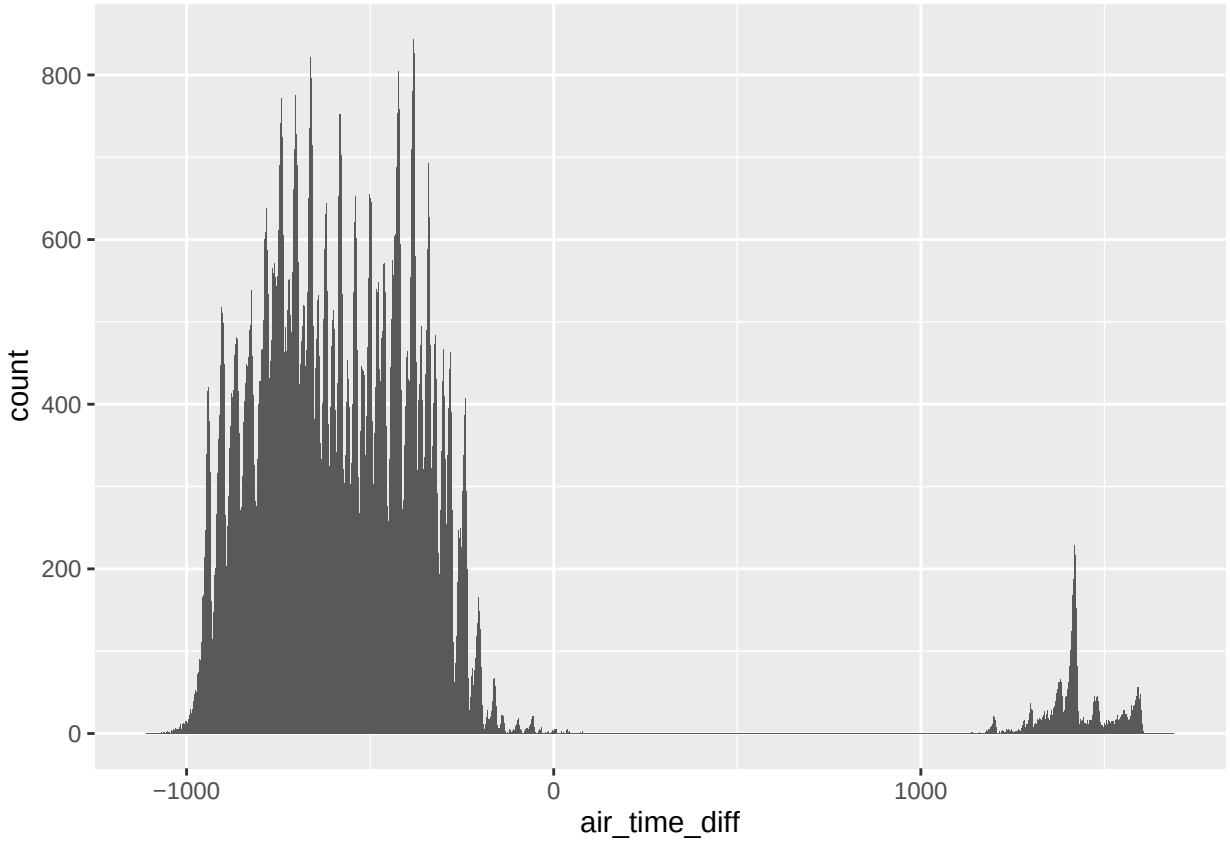
```
# My hypothesis is that air_time = arr_time - dep_time.

# Step 1. Convert time information.

flights_airtime <-
  mutate(flights,
         dep_time = (dep_time %/% 100 * 60 + dep_time %% 100) %% 1440,
         arr_rime = (arr_time %/% 100 * 60 + arr_time %% 100) %% 1440,
         air_time_diff = air_time - arr_time + dep_time)

# Step 2. Identify if there are any flights with non-zero values for air_time_diff
#since our hypothesis is that air_time = arr_time - dep_time.

nrow(filter(flights, air_time !=0))
```

```
## [1] 327346
```

327346 flights have had air_time with a non-sero value. Some reasons may include:

- If the flight passes midnight, arr_time < dep_time, so the differences in time should be by 24 hours.
- If the flight crosses time zones, the total air time will be offset by hours. Since the flights dataset show domestic flights that have departed from NYC, the differences due to time zone changes should be:60 minutes (Central) 120 minutes (Mountain), 180 minutes (Pacific), 240 minutes (Alaska), or 300 minutes (Hawaii).

```
## Step 3. I plot the distribution of air_time_diff
# to see if the spikes of air_time_diff are at multiples of 60.

ggplot(flights_airtime, aes(x=air_time_diff)) +
  geom_histogram(binwidth = 1)
```




```
## Conclusion: Not all numbers are multiples of 60. When rereading documentation, air_time
# does not include time spent taxiing or on the runway.
```

Rank airlines by the number of destinations that they fly to, considering only those airports that are flown to by two or more airlines.

```
flights %>%
  # find all airports with > 1 carrier
  group_by(dest) %>%
  mutate(n_carriers = n_distinct(carrier)) %>%
  # n_distinct is a faster and more concise equivalent of length(unique(x)) - counts the number of uniq
  filter(n_carriers > 1) %>%

  # rank carriers by number of destinations

  group_by(carrier) %>%
  summarise(n_dest = n_distinct(dest)) %>%
  arrange(desc(n_dest))
```

```
## # A tibble: 16 x 2
##    carrier n_dest
##    <chr>    <int>
##  1 EV          51
##  2 9E          48
##  3 UA          42
##  4 DL          39
##  5 B6          35
##  6 AA          19
##  7 MQ          19
##  8 WN          10
##  9 OO           5
## 10 US           5
## 11 VX           4
## 12 YV           3
## 13 FL           2
## 14 AS           1
## 15 F9           1
## 16 HA           1
```

```
# What airline does the "EV" carrier code correspond to?

filter(airlines, carrier == "EV" )
```

```
## # A tibble: 1 x 2
##   carrier name
##   <chr>   <chr>
## 1 EV      ExpressJet Airlines Inc.
```

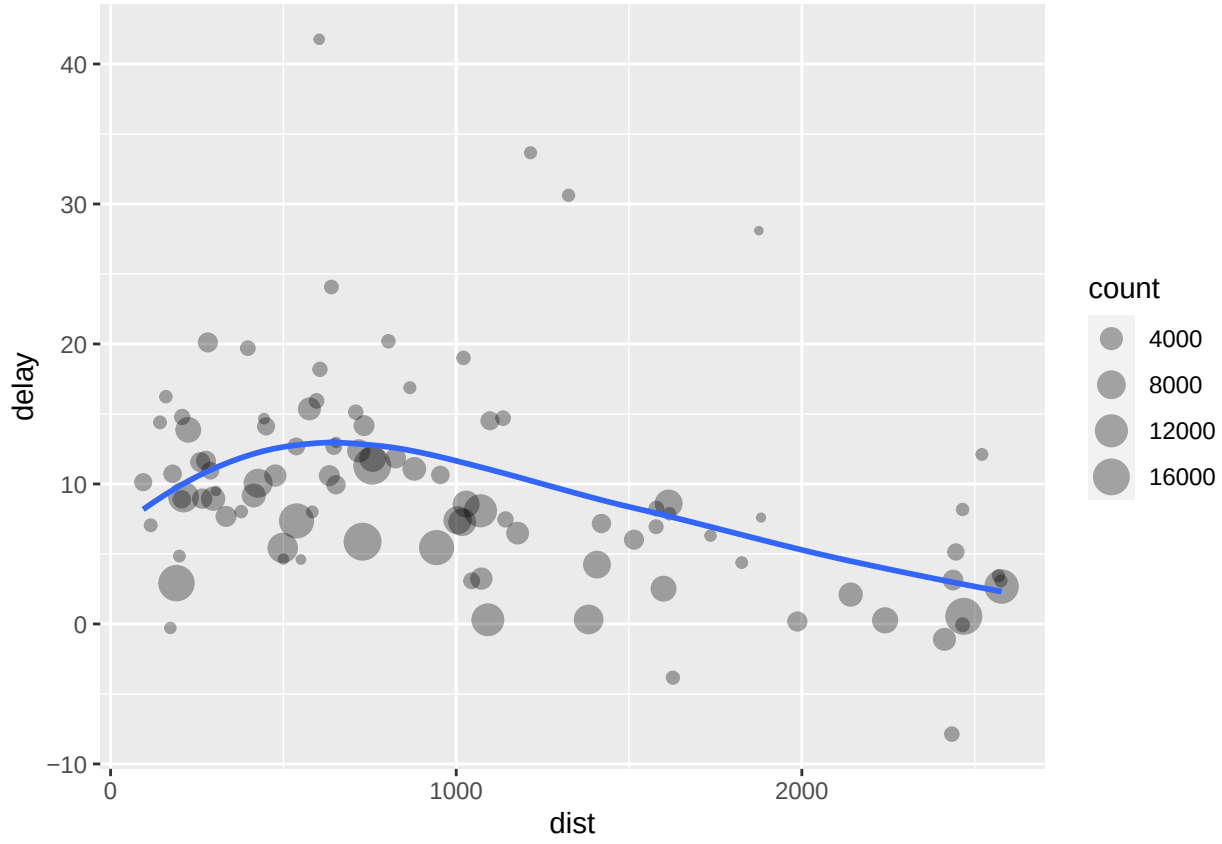
Find the 10 most delayed flights using a ranking function.

```
flights_delayed <- top_n(flights, 10, dep_delay)
select(flights_delayed, month, day, carrier, flight, dep_delay)
```

```
## # A tibble: 10 x 5
##    month   day carrier flight dep_delay
##    <int> <int> <chr>    <int>     <dbl>
##  1     1     9 HA          51      1301
##  2     1    10 MQ        3695      1126
##  3    12     5 AA         172       896
##  4     3    17 DL        2119       911
##  5     4    10 DL        2391       960
##  6     6    15 MQ        3535      1137
##  7     6    27 DL        2007       899
##  8     7    22 MQ        3075      1005
##  9     7    22 DL        2047       898
## 10     9    20 AA         177      1014
```

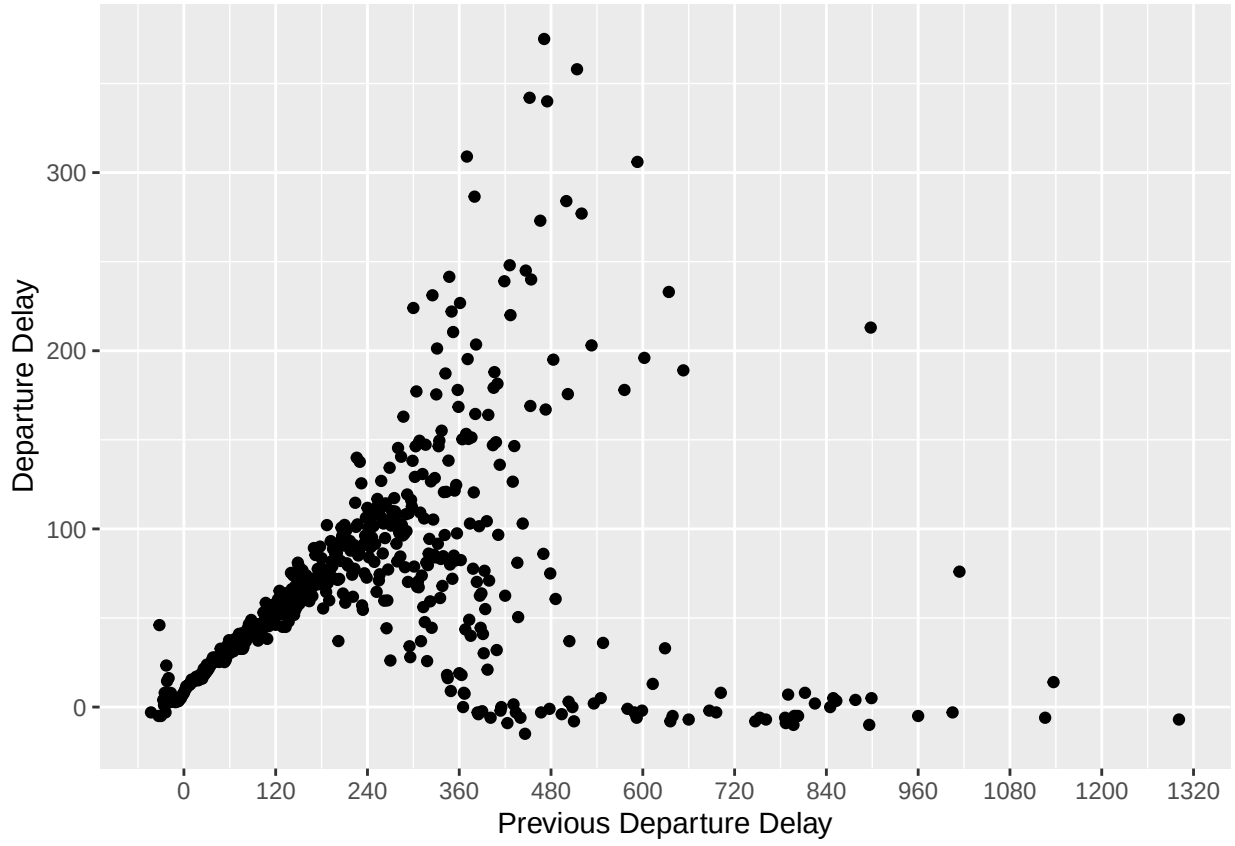
Show graphically the relationship between the distance and average delay for each location.

```
delays <- flights %>%
  group_by(dest) %>%
  summarise(
    count=n(),
    dist= mean(distance, na.rm=TRUE), delay = mean(arr_delay, na.rm=TRUE)
  ) %>%
  filter(count >20, dest != "HNL")

ggplot(data= delays, mapping=aes(x=dist, y = delay)) +
  geom_point(aes(size=count), alpha=1/3) +
  geom_smooth(se=FALSE)
```



Delays are typically temporally correlated: even once the problem that caused the initial delay has been resolved, later flights are delayed to allow earlier flights to leave. Using lag() explore how the delay of a flight is related to the delay of the immediately preceding flight.

```
# This calculates the departure delay of the preceding flight from the same airport.

lagged_delays <- flights %>%
  arrange(origin, month, day, dep_time) %>%
  group_by(origin) %>%
  mutate(dep_delay_lag = lag(dep_delay)) %>%
  filter(!is.na(dep_delay), !is.na(dep_delay_lag))

# plots the relationship between the mean delay of a flight for all values of the previous flight.
# There seems to be an inverse "U" relationship
# between mean delay of a flight and the mean delay of the preceding flight.

lagged_delays %>%
  group_by(dep_delay_lag) %>%
  summarise(dep_delay_mean = mean(dep_delay)) %>%
  ggplot(aes(y= dep_delay_mean, x=dep_delay_lag)) +
  geom_point() +
  scale_x_continuous(breaks = seq(0, 1500, by = 120)) +
  labs(y = "Departure Delay", x = "Previous Departure Delay")
```



```r
# The overall relationship looks similar in all three origin airports.

lagged_delays %>%
  group_by(origin, dep_delay_lag) %>%
  summarise(dep_delay_mean = mean(dep_delay)) %>%
  ggplot(aes(y = dep_delay_mean, x = dep_delay_lag)) +
  geom_point() +
  facet_wrap(~ origin, ncol=1) +
  labs(y = "Departure Delay", x = "Previous Departure Delay")
```