DATA WRANGLING BASICS

Complex summaries: two concrete examples

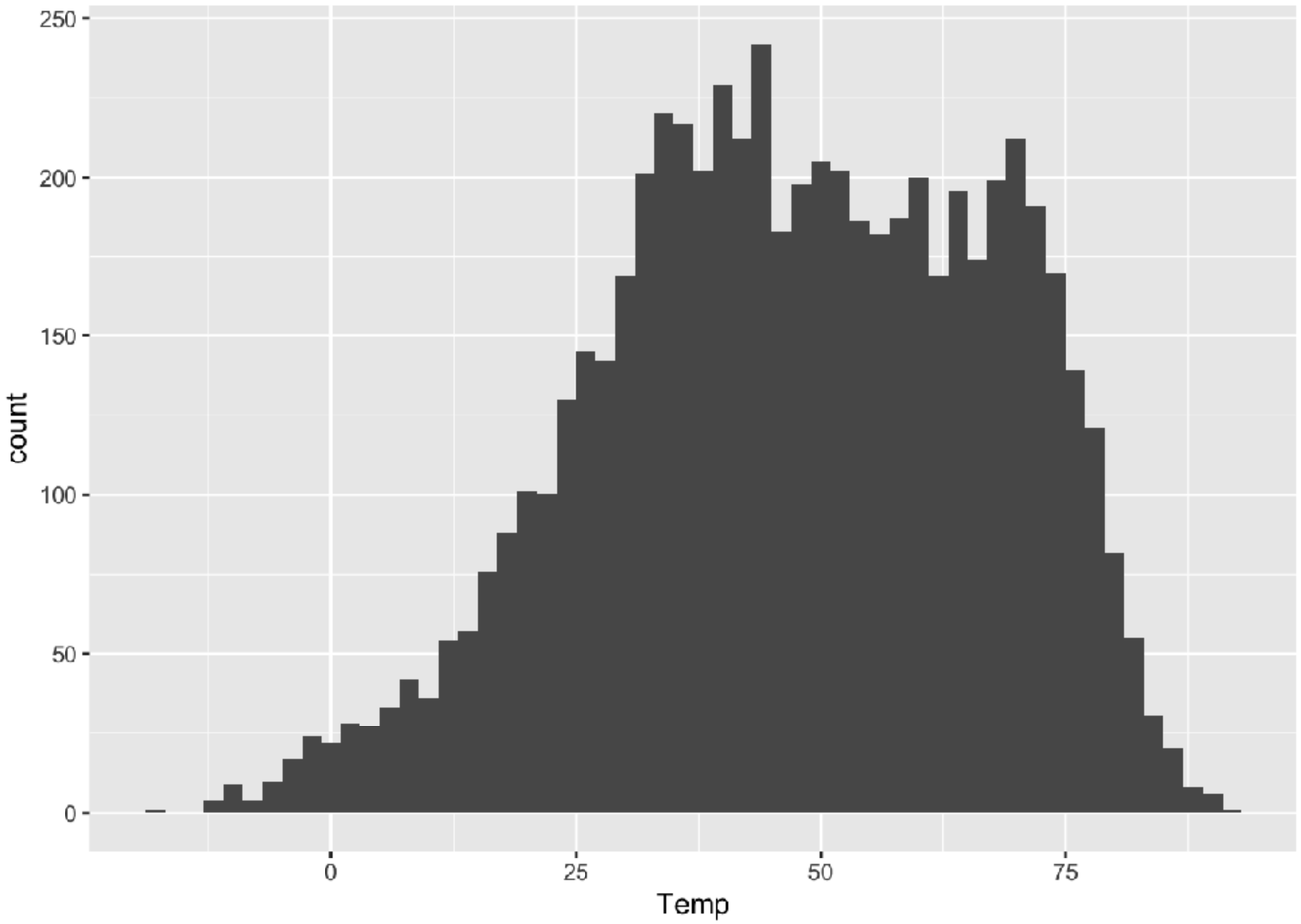
Six key data verbs

Case studies in data wrangling

SUMMARIES

- the *typical value:* what's the temperature on a typical day in Rapid City? (mean, median)
- the *shape*: is the distribution symmetric or skewed? Does it have multiple peaks?
- the *variation:* how much do the individual days vary from a "typical" day? (sd, IQR)
- the *extremes:* what temperatures should we expect on days that are unusually hot or unusually cold? (min, max, quantile, z-score)

```
ggplot(rapidcity) +
  geom_histogram(aes(x=Temp), binwidth=2)
```



Variation is reality.
Averages are abstractions.
Always plot your data.

DATA WRANGLING: AN EXAMPLE

- Consider a question like this:

  What were the five coldest individual months in Rapid City between 1995 and 2011, as measured by the average daily temperature? What were the lowest and highest daily temperatures within each of those months?

  At right are 10 random rows from the data set.

- How would you go about this complex task?

10 random rows

Year	Month	Day	Temp
1996	8	2	78.3
1996	9	15	59.6
1998	2	1	33.2
2000	6	2	50.8
2001	8	26	76.8
2003	9	8	71.9
2003	12	6	35.5
2005	12	16	18.6
2010	6	20	68.2
2010	10	16	53.2

+ more rows

AN ANALOGY: BUILDING A HOUSE

Dig Pour foundation Put on roof Move in

Plan Install footings Build walls Finish interior

There’s only one way to manage something so complex:

Break down the complex task into simpler tasks.

Sequence the tasks so that each one builds on prior tasks and feeds into subsequent tasks.

EXAMPLE 1: TEMPS

- **Consider a question like this:**

  What were the five coldest individual months in Rapid City between 1995 and 2011, as measured by the average daily temperature? What were the lowest and highest daily temperatures within each of those months?

  At right are 10 random rows from the data set.

- **How would you go about this complex task?**
- **Remember our advice:**

  Manage complexity by breaking down complex tasks into simpler tasks.

10 random rows

Year	Month	Day	Temp
1996	8	2	78.3
1996	9	15	59.6
1998	2	1	33.2
2000	6	2	50.8
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+ more rows

EXAMPLE 1: TEMPS

- **Here are the simple tasks:**

  Group the data set into individual months in individual years: January 1995, February 1995, March 1995, and so on, all the way through December 2011.

10 random rows

Year	Month	Day	Temp
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+ more rows

EXAMPLE 1: TEMPS

- **Here are the simple tasks:**

  Group the data set into individual months in individual years: January 1995, February 1995, March 1995, and so on, all the way through December 2011.

  Summarize each individual month by calculating the average, min, and max of the Temp variable.

January 2007

Year	Month	Day	Temp
2007	1	1	24.2
2007	1	2	27.6
2007	1	3	40.3
2007	1	4	39.2
2007	1	5	31.7
2007	1	6	23.5
2007	1	7	31.1
2007	1	8	37.0
2007	1	9	32.7
2007	1	10	41.2

+ more rows

mean(Temp)	min(Temp)	max(Temp)
26.28065	0.6	42.2

EXAMPLE 1: TEMPS

- Here are the simple tasks:

  Group the data set into individual months in individual years: January 1995, February 1995, March 1995, and so on, all the way through December 2011.

  Summarize each individual month by calculating the average, min, and max of the Temp variable.

  Put all the monthly summaries in a table.

Monthly summaries

Year	Month	mean_Temp	min_Temp	max_Temp
1995	1	28.0	6.2	50.9
1995	2	31.8	2.7	54.0
1995	3	33.1	-2.1	55.9
1995	4	40.0	24.4	50.8
1995	5	51.5	38.6	59.4
1995	6	63.1	43.3	77.1
1995	7	70.2	58.9	79.6
1995	8	73.1	58.6	85.0
1995	9	60.2	35.2	79.3
1995	10	46.1	29.4	65.8
1995	11	33.6	8.5	52.0
1995	12	24.7	-2.1	47.6
1996	1	14.9	-11.0	46.1
1996	2	26.8	-19.0	47.9
1996	3	25.9	-4.0	45.8
1996	4	43.5	27.2	62.6
1996	5	50.1	32.5	65.6
1996	6	65.4	54.0	77.8
1996	7	71.5	62.3	80.3
1996	8	72.8	66.1	80.8
1996	9	59.2	39.5	81.7
1996	10	47.1	25.5	64.1
1996	11	24.2	6.5	43.4
1996	12	17.5	-10.8	40.4
1997	1	18.0	-10.2	45.1

+ more rows

EXAMPLE 1: TEMPS

- **Here are the simple tasks:**

  Group the data set into individual months in individual years: January 1995, February 1995, March 1995, and so on, all the way through December 2011.

  Summarize each individual month by calculating the average, min, and max of the Temp variable.

  Put all the monthly summaries in a table.

  Arrange the months by mean temperature and examine the top 5.

Monthly summaries

Year	Month	mean_Temp	min_Temp	max_Temp
1996	1	14.9	-11.0	46.1
2009	12	16.4	-2.6	35.6
2000	12	17.3	-9.0	38.8
1996	12	17.5	-10.8	40.4
2001	2	17.6	-3.9	40.8
1997	1	18.0	-10.2	45.1
2008	12	18.1	-12.2	37.1
2011	2	19.9	-8.7	49.9
2011	1	20.6	-3.0	42.3
2010	2	20.7	2.7	34.7
2007	2	21.1	-9.9	41.5
2010	1	21.3	-9.7	39.4
2005	1	21.4	-3.9	50.0
2008	1	22.0	-0.7	44.7
2003	2	22.4	-5.0	44.9
2004	1	22.5	-5.6	40.7
2002	3	22.7	2.5	48.2
2007	12	23.4	11.0	48.4
1998	1	24.1	-4.9	53.1
1996	11	24.2	6.5	43.4
2010	12	24.2	0.9	39.8
1995	12	24.7	-2.1	47.6
1999	1	24.8	3.6	40.5
2009	1	24.9	-3.9	46.2
2005	12	25.1	-0.9	47.8

+ more rows

THE RESULT

The five coldest months in Rapid City, 1996-2011

Year	Month	mean_Temp	min_Temp	max_Temp
1996	1	14.9	-11.0	46.1
2009	12	16.4	-2.6	35.6
2000	12	17.3	-9.0	38.8
1996	12	17.5	-10.8	40.4
2001	2	17.6	-3.9	40.8

THIS IS DATA WRANGLING

- Our original data set wasn't in the form we needed to answer the question directly. This is the rule, rather than the exception, in data science.
- To get our data into a form where we could answer to our question, we had to break our complex task into simpler tasks:

  Identify the simple tasks (group, summarize, arrange, etc.)

  Sequence those tasks in the right order.
- This process is part of what's called *data wrangling*.

  Data wrangling: the process of getting your data into a useful form for visualization, summary, and modeling.

  Wrangling is an huge part of data science, because data rarely comes in precisely the form that suits some particular analysis.

HOW DOES THIS LOOK IN R?

```
rapidcity %>%
  group_by(Year, Month) %>%
  summarize(avg_temp = mean(Temp),
            coldest_day = min(Temp),
            warmest_day = max(Temp)) %>%
  arrange(avg_temp) %>%
  head(5) %>%
  round(1)
```

Group the data set according to all combos of Year and Month

HOW DOES THIS LOOK IN R?

```
rapidcity %>%
  group_by(Year, Month) %>%
  summarize(avg_temp = mean(Temp),
            coldest_day = min(Temp),
            warmest_day = max(Temp)) %>%
  arrange(avg_temp) %>%
  head(5) %>%
  round(1)
```

Calculate summary statistics for each group

Right-hand side: the summary we want to calculate

HOW DOES THIS LOOK IN R?

```
rapidcity %>%
  group_by(Year, Month) %>%
  summarize(avg_temp = mean(Temp),
            coldest_day = min(Temp),
            warmest_day = max(Temp)) %>%
  arrange(avg_temp) %>%
  head(5) %>%
  round(1)
```

Calculate summary statistics for each group

Left-hand side: the name we want to give to each summary

HOW DOES THIS LOOK IN R?

```
rapidcity %>%
  group_by(Year, Month) %>%
  summarize(avg_temp = mean(Temp),
            coldest_day = min(Temp),
            warmest_day = max(Temp)) %>%
  arrange(avg_temp) %>%
  head(5) %>%
  round(1)
```

Calculate summary statistics for each group

Multiple summaries separated by commas

HOW DOES THIS LOOK IN R?

```
rapidcity %>%
  group_by(Year, Month) %>%
  summarize(avg_temp = mean(Temp),
            coldest_day = min(Temp),
            warmest_day = max(Temp)) %>%
  arrange(avg_temp) %>%
  head(5) %>%
  round(1)
```

Arrange the table in ascending order of `avg_temp` summary

HOW DOES THIS LOOK IN R?

```
rapidcity %>%
  group_by(Year, Month) %>%
  summarize(avg_temp = mean(Temp),
            coldest_day = min(Temp),
            warmest_day = max(Temp)) %>%
  arrange(avg_temp) %>%
  head(5) %>%
  round(1)
```

Take the first 5 entries in the table and round to 1 decimal place.

HOW DOES THIS LOOK IN R?

```
rapidcity %>%
  group_by(Year, Month) %>%
  summarize(avg_temp = mean(Temp),
            coldest_day = min(Temp),
            warmest_day = max(Temp)) %>%
  arrange(avg_temp) %>%
  head(5) %>%
  round(1)
```

```
##    Year Month avg_temp coldest_day warmest_day
##   <dbl> <dbl>    <dbl>       <dbl>        <dbl>
## 1  1996     1     14.9         -11         46.1
## 2  2009    12     16.4          -2.6       35.6
## 3  2000    12     17.3          -9         38.8
## 4  1996    12     17.5         -10.8       40.4
## 5  2001     2     17.6          -3.9       40.8
```

The result

EXAMPLE 2: TITANIC SURVIVAL

- **Consider a question like this:**

  How did survival among adult passengers on the Titanic vary by sex and passenger class?

  At right are 10 random rows from the data set.

- **How would you go about this complex task?**

  ***Identify* the simple tasks.**

  ***Sequence* those tasks in the right order.**

10 random rows

Name	Survived	Sex	Age	Class
Vovk, Mr. Janko	no	male	22	3rd
Braund, Mr. Owen Harris	no	male	22	3rd
Chapman, Mr. Charles Henry	no	male	52	2nd
Osman, Mrs. Mara	yes	female	31	3rd
Assaf, Mr. Gerios	no	male	21	3rd
Norman, Mr. Robert Douglas	no	male	28	2nd
Petterson, Mr. Johan Emil	no	male	25	3rd
Holverson, Mr. Alexander Oskar	no	male	42	1st
Angheloff, Mr. Minko	no	male	26	3rd
Hood, Mr. Ambrose Jr	no	male	21	2nd

+ more rows

EXAMPLE 2: TITANIC SURVIVAL

- **Here are the simple tasks:**

  Filter the data set so that in includes only the adult passengers (age ≥ 18).

10 random rows

Name	Survived	Sex	Age	Class
Vovk, Mr. Janko	no	male	22	3rd
Braund, Mr. Owen Harris	no	male	22	3rd
Chapman, Mr. Charles Henry	no	male	52	2nd
Osman, Mrs. Mara	yes	female	31	3rd
Assaf, Mr. Gerios	no	male	21	3rd
Norman, Mr. Robert Douglas	no	male	28	2nd
Petterson, Mr. Johan Emil	no	male	25	3rd
Holverson, Mr. Alexander Oskar	no	male	42	1st
Angheloff, Mr. Minko	no	male	26	3rd
Hood, Mr. Ambrose Jr	no	male	21	2nd

+ more rows

EXAMPLE 2: TITANIC SURVIVAL

- **Here are the simple tasks:**

  Filter the data set so that in includes only the adult passengers (age ≥ 18).

  Group the passengers by sex and cabin class.

10 random rows

Name	Survived	Sex	Age	Class
Vovk, Mr. Janko	no	male	22	3rd
Braund, Mr. Owen Harris	no	male	22	3rd
Chapman, Mr. Charles Henry	no	male	52	2nd
Osman, Mrs. Mara	yes	female	31	3rd
Assaf, Mr. Gerios	no	male	21	3rd
Norman, Mr. Robert Douglas	no	male	28	2nd
Petterson, Mr. Johan Emil	no	male	25	3rd
Holverson, Mr. Alexander Oskar	no	male	42	1st
Angheloff, Mr. Minko	no	male	26	3rd
Hood, Mr. Ambrose Jr	no	male	21	2nd

+ more rows

EXAMPLE 2: TITANIC SURVIVAL

- **Here are the simple tasks:**

  Filter the data set so that in includes only the adult passengers (age ≥ 18).

  Group the passengers by sex and cabin class.

  Summarize each group by calculating the proportion of survivors.

10 random rows

Name	Survived	Sex	Age	Class
Vovk, Mr. Janko	no	male	22	3rd
Braund, Mr. Owen Harris	no	male	22	3rd
Chapman, Mr. Charles Henry	no	male	52	2nd
Osman, Mrs. Mara	yes	female	31	3rd
Assaf, Mr. Gerios	no	male	21	3rd
Norman, Mr. Robert Douglas	no	male	28	2nd
Petterson, Mr. Johan Emil	no	male	25	3rd
Holverson, Mr. Alexander Oskar	no	male	42	1st
Angheloff, Mr. Minko	no	male	26	3rd
Hood, Mr. Ambrose Jr	no	male	21	2nd

+ more rows

HOW DOES THIS LOOK IN R?

```
surv_adults = titanic %>%
  filter(age >= 18) %>%
  group_by(sex, passengerClass) %>%
  summarize(total_count = n(),
            surv_count = sum(survived == 'yes'),
            surv_pct = surv_count/total_count)
```

Filter the data so that only those 18 and over are included.

HOW DOES THIS LOOK IN R?

```
surv_adults = titanic %>%
  filter(age >= 18) %>%
  group_by(sex, passengerClass) %>%
  summarize(total_count = n(),
            surv_count = sum(survived == 'yes'),
            surv_pct = surv_count/total_count)
```

Group the remaining passengers by sex and class of travel.

HOW DOES THIS LOOK IN R?

```
surv_adults = titanic %>%
  filter(age >= 18) %>%
  group_by(sex, passengerClass) %>%
  summarize(total_count = n(),
            surv_count = sum(survived == 'yes'),
            surv_pct = surv_count/total_count)
```

Count the number in each group

HOW DOES THIS LOOK IN R?

```
surv_adults = titanic %>%
  filter(age >= 18) %>%
  group_by(sex, passengerClass) %>%
  summarize(total_count = n(),
            surv_count = sum(survived == 'yes'),
            surv_pct = surv_count/total_count)
```

Count the number that survived (== tests for equality)

HOW DOES THIS LOOK IN R?

```
surv_adults = titanic %>%
  filter(age >= 18) %>%
  group_by(sex, passengerClass) %>%
  summarize(total_count = n(),
            surv_count = sum(survived == 'yes'),
            surv_pct = surv_count/total_count)
```

Calculate the survival proportion, based on the two previous summaries.

This line works because both total_count and surv_count were defined in the “pipeline past.”

HOW DOES THIS LOOK IN R?

```
surv_adults = titanic %>%
  filter(age >= 18) %>%
  group_by(sex, passengerClass) %>%
  summarize(total_count = n(),
            surv_count = sum(survived == 'yes'),
            surv_pct = surv_count/total_count)
```

```
##   sex    passengerClass total_count surv_count surv_pct
##   <chr>  <chr>                <int>      <int>    <dbl>
## 1 female 1st                    125        121   0.968
## 2 female 2nd                     85         74   0.871
## 3 female 3rd                    106         47   0.443
## 4 male   1st                    144         47   0.326
## 5 male   2nd                    143         12   0.0839
## 6 male   3rd                    289         45   0.156
```

The result

NOW, A BAR PLOT

- **Remember that making a bar plot requires two steps:**

  1) Calculating summary statistics by group.

  2) Plotting those summaries in a bar plot.

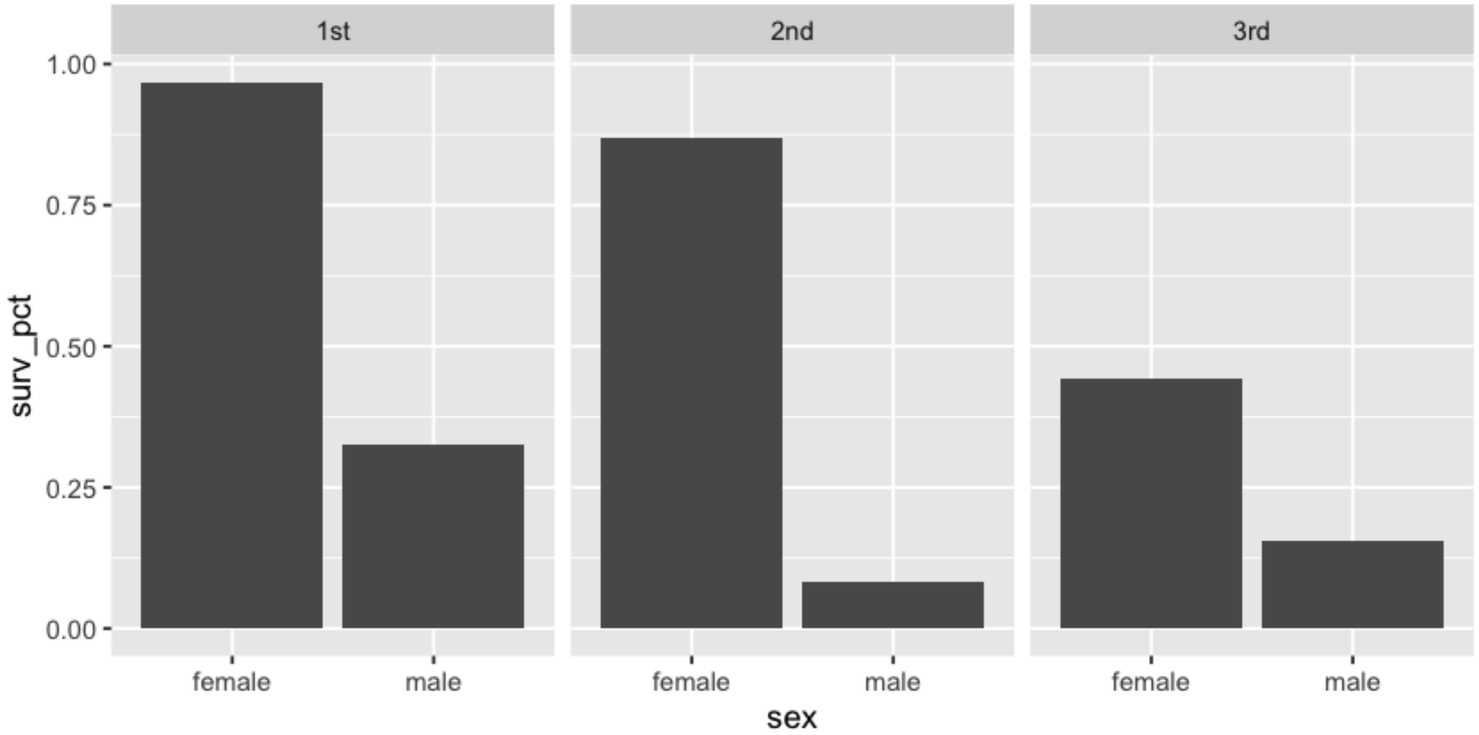
- **We just accomplished step 1:**

```
surv_adults = titanic %>%
  filter(age >= 18) %>%
  group_by(sex, passengerClass) %>%
  summarize(total_count = n(),
            surv_count = sum(survived == 'yes'),
            surv_pct = surv_count/total_count)
```

NOW, A BAR PLOT

- **And we already know how to do step 2:**

```
ggplot(surv_adults) +
  geom_col(aes(x=sex, y=surv_pct)) +
  facet_wrap(~passengerClass, nrow=1)
```



Manage complexity by breaking down complex tasks into simpler tasks.

SIX KEY DATA VERBS

- `summarize`, for calculating summary statistics
- `group_by`, for splitting a data set into groups.
- `filter`, for looking at specific rows (cases).
- `select`, for looking at specific columns (variables).
- `mutate`, for defining new variables from old ones.
- `arrange`, for sorting a data frame according some specific variable.

summarize

- **You've met this before: it's use to calculate summary statistics.**

```
rapidcity %>%
  summarize(avg_temp = mean(Temp),
            median_temp = median(Temp),
            sd_temp = sd(Temp),
            iqr_temp = IQR(Temp),
            min_temp = min(Temp),
            max_temp = max(Temp))
```

Right-hand side: the summary we want to calculate

Left-hand side: the name we want to give that summary

```
##   avg_temp median_temp  sd_temp iqr_temp min_temp max_temp
## 1 47.28159        47.6 20.05404    30.65      -19     91.9
```

group_by

- **Used to split the rows of a data set into groups.**
- **Specify groups with group_by(), then use summarize() to calculate something for each group, and return it in a nice table. Biggest powerhouse combo in R.**

```
rapidcity %>%
  group_by(Month) %>%
  summarize(avg_temp = mean(Temp),
            sd_temp = sd(Temp)) %>%
  round(1)
```

	Month	avg_temp	sd_temp
	<dbl>	<dbl>	<dbl>
1	1	24.4	13.5
2	2	27.4	13
3	3	34.2	12.7
4	4	44.5	9.7
5	5	54.3	8.3
6	6	64.3	7.7
7	7	73.7	6.6
8	8	71.9	6.1
9	9	61.4	9.1
10	10	47.9	9.7
11	11	35.1	11.5
12	12	25.7	12.4

filter

- **Keep rows that satisfy your conditions; ignore everything else.**

```
rapidcity2009 = rapidcity %>%
  filter(Year == 2009)
```

```
head(rapidcity2009)
```

```
##   Year Month Day Temp
## 1 2009     1   1 30.7
## 2 2009     1   2 20.3
## 3 2009     1   3 16.9
## 4 2009     1   4  8.0
## 5 2009     1   5 13.9
## 6 2009     1   6 28.2
```

The double-equals sign (==) inside filter is used to test for equality. That is, we are filtering the data frame to include only those cases where the Year variable is equal to 2009.

select

- **Used to select specific columns (variables) in your data frame.**
- **A frequent use case is to de-clutter output.**

```
rapidcity2009 %>%
  select(Month, Day, Temp) %>%
  head(5)
```

```
##   Month Day Temp
## 1     1   1 30.7
## 2     1   2 20.3
## 3     1   3 16.9
## 4     1   4  8.0
## 5     1   5 13.9
```

mutate

- **Add a column defined in terms of existing columns**


```
rapidcity = rapidcity %>%
  mutate(Summer = ifelse(Month == 6 | Month == 7 | Month == 8,
                         yes="summer", no="not_summer"))

sample_n(rapidcity, 5)
```

```
  Year Month Day Temp     Summer
1 2003    12   6 35.5 not_summer
2 2001     8  26 76.8     summer
3 2005    12  16 18.6 not_summer
4 1996     9  15 59.6 not_summer
5 2010     6  20 68.2     summer
```

arrange

- **Used to sort according to a variable or set of variables**

```
rapidcity %>%
  arrange(Temp) %>%
  head(10)
```

```
##    Year Month Day  Temp
## 1  1996     2   2 -19.0
## 2  2008    12  15 -12.2
## 3  1996     2   3 -11.8
## 4  2006     2  18 -11.5
## 5  1996     1  30 -11.0
## 6  1996    12  26 -10.8
## 7  1996     1  19 -10.6
## 8  1996    12  24 -10.6
## 9  1996     1  29 -10.4
## 10 1997     1  11 -10.2
```

ascending order

```
rapidcity %>%
  arrange(desc(Temp)) %>%
  head(10)
```

```
##    Year Month Day Temp
## 1  2007     7   7 91.9
## 2  2006     7  16 90.7
## 3  2006     7  30 89.8
## 4  2007     7  23 89.5
## 5  2007     7  24 89.5
## 6  2002     6  29 89.4
## 7  2002     7  15 89.3
## 8  2006     7  15 89.0
## 9  2003     8  23 88.9
## 10 2002     7  16 88.4
```

descending order

CASE STUDY: NYC FLIGHTS

- What times of year have the worst/best average departure delays, and does this vary by departure airport?
- Which routes from the NYC area gained the most time in the air, on average?
- Which carriers have the best “on-time performance,” defined as the proportion of flights arriving within 10 minutes of their scheduled arrival time? (i.e. no more than 10 minutes late).