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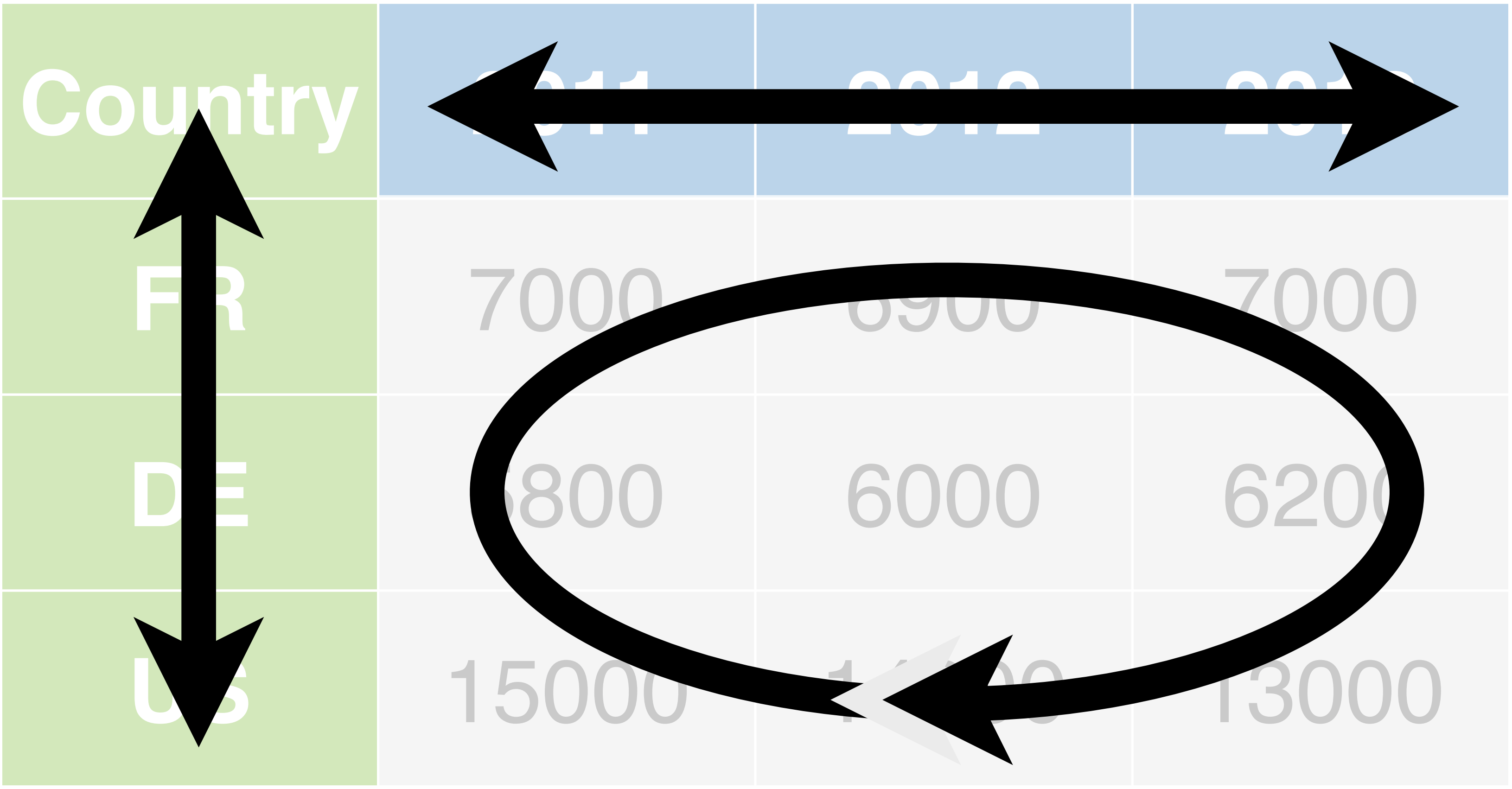
Data Wrangling with R

How to work with the structures of your data

Slides at:
bit.ly/wrangling-webinar



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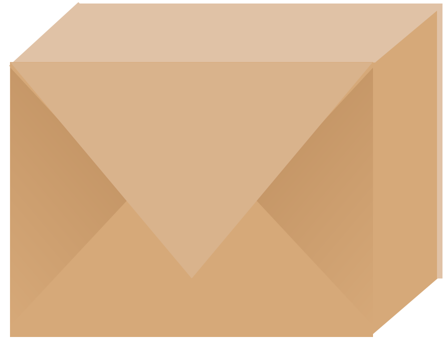
HELLO
my name is

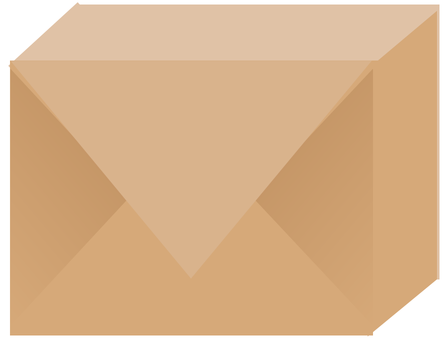
Garrett

garrett@rstudio.com
@StatGarrett

slides at: bit.ly/wrangling-webinar

Two packages to help you
work with the structure of data.

 tidyr

 dplyr

Data Wrangling with dplyr and tidyr

Cheat Sheet

R Studio

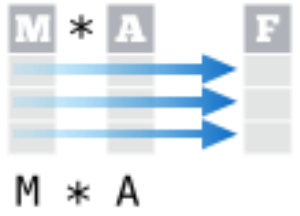
Tidy Data - A foundation for wrangling in R

In a tidy data set:

Each **variable** is saved in its own **column**

Each **observation** is saved in its own **row**

Tidy data complements R's **vectorized operations**. R will automatically preserve observations as you manipulate variables. No other format works as intuitively with R.



Syntax - Helpful conventions for wrangling

dplyr::**tbl_df(iris)**

Converts data to tbl class. tbl's are easier to examine than data frames. R displays only the data that fits onscreen:

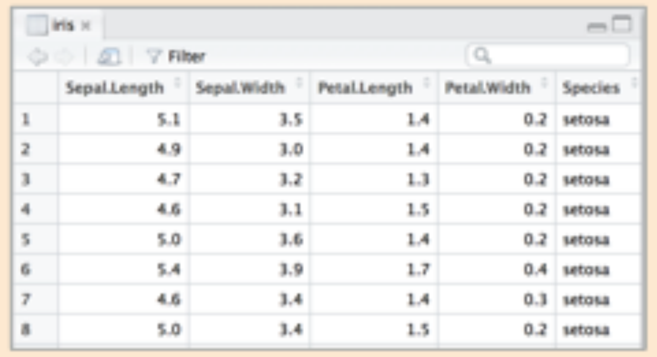
```
Source: local data frame [150 x 5]

  Sepal.Length Sepal.Width Petal.Length
1          5.1         3.5          1.4
2          4.9         3.0          1.4
3          4.7         3.2          1.3
4          4.6         3.1          1.5
5          5.0         3.6          1.4
..         ...         ...          ...
Variables not shown: Petal.Width (dbl),
  Species (fctr)
```

dplyr::**glimpse(iris)**

Information dense summary of tbl data.

utils::**View(iris)**

View data set in spreadsheet-like display (note capital V).



dplyr::**%>%**

Passes object on left hand side as first argument (or . argument) of function on righthand side.

`x %>% f(y)` *is the same as* `f(x, y)`

`y %>% f(x, ., z)` *is the same as* `f(x, y, z )`

"Piping" with %>% makes code more readable, e.g.

```
iris %>%
  group_by(Species) %>%
  summarise(avg = mean(Sepal.Width)) %>%
  arrange(avg)
```

Reshaping Data - Change the layout of a data set

tidyr::**gather(cases, "year", "n", 2:4)**

Gather columns into rows.

tidyr::**spread(pollution, size, amount)**

Spread rows into columns.

tidyr::**separate(storms, date, c("y", "m", "d"))**

Separate one column into several.

tidyr::**unite(data, col, ..., sep)**

Unite several columns into one.

dplyr::**data_frame(a = 1:3, b = 4:6)**

Combine vectors into data frame (optimized).

dplyr::**arrange(mtcars, mpg)**

Order rows by values of a column (low to high).

dplyr::**arrange(.mtcars, desc(mpg))**

Order rows by values of a column (high to low).

dplyr::**rename(tb, y = year)**

Rename the columns of a data frame.

Subset Observations (Rows)

dplyr::**filter(iris, Sepal.Length > 7)**

Extract rows that meet logical criteria.

dplyr::**distinct(iris)**

Remove duplicate rows.

dplyr::**sample_frac(iris, 0.5, replace = TRUE)**

Randomly select fraction of rows.

dplyr::**sample_n(iris, 10, replace = TRUE)**

Randomly select n rows.

dplyr::**slice(iris, 10:15)**

Select rows by position.

dplyr::**top_n(storms, 2, date)**

Select and order top n entries (by group if grouped data).

	Logic in R - ?Comparison, ?base::Logic		
<	Less than	!=	Not equal to
>	Greater than	%in%	Group membership
==	Equal to	is.na	Is NA
<=	Less than or equal to	!is.na	Is not NA
>=	Greater than or equal to	&,|,!,xor,any,all	Boolean operators

Subset Variables (Columns)

dplyr::**select(iris, Sepal.Width, Petal.Length, Species)**

Select columns by name or helper function.

Helper functions for select - ?select

select(iris, **contains**("."))

Select columns whose name contains a character string.

select(iris, **ends_with**("Length"))

Select columns whose name ends with a character string.

select(iris, **everything**())

Select every column.

select(iris, **matches**(".t."))

Select columns whose name matches a regular expression.

select(iris, **num_range**("x", 1:5))

Select columns named x1, x2, x3, x4, x5.

select(iris, **one_of**(c("Species", "Genus")))

Select columns whose names are in a group of names.

select(iris, **starts_with**("Sepal"))

Select columns whose name starts with a character string.

select(iris, Sepal.Length**:**Petal.Width)

Select all columns between Sepal.Length and Petal.Width (inclusive).

select(iris, **-**Species)

Select all columns except Species.

devtools::install_github("rstudio/EDAWR") for data sets

Learn more with **browseVignettes(package = c("dplyr", "tidyr"))** • dplyr 0.4.0• tidyr 0.2.0 • Updated: 1/15

http://www.rstudio.com/resources/cheatsheets/

Ground rules

tbl's

Just like data frames, but play better with the console window.

```
Source: local data frame [53,940 x 10]

   carat       cut color clarity depth table
1   0.23     Ideal     E     SI2  61.5    55
2   0.21   Premium     E     SI1  59.8    61
3   0.23      Good     E     VS1  56.9    65
4   0.29   Premium     I     VS2  62.4    58
5   0.31      Good     J     SI2  63.3    58
6   0.24 Very Good     J    VVS2  62.8    57
7   0.24 Very Good     I    VVS1  62.3    57
8   0.26 Very Good     H     SI1  61.9    55
9   0.22      Fair     E     VS2  65.1    61
10  0.23 Very Good     H     VS1  59.4    61
..   ...       ...   ...     ...   ...   ...
Variables not shown: price (int), x (dbl), y
  (dbl), z (dbl)
```

tbl

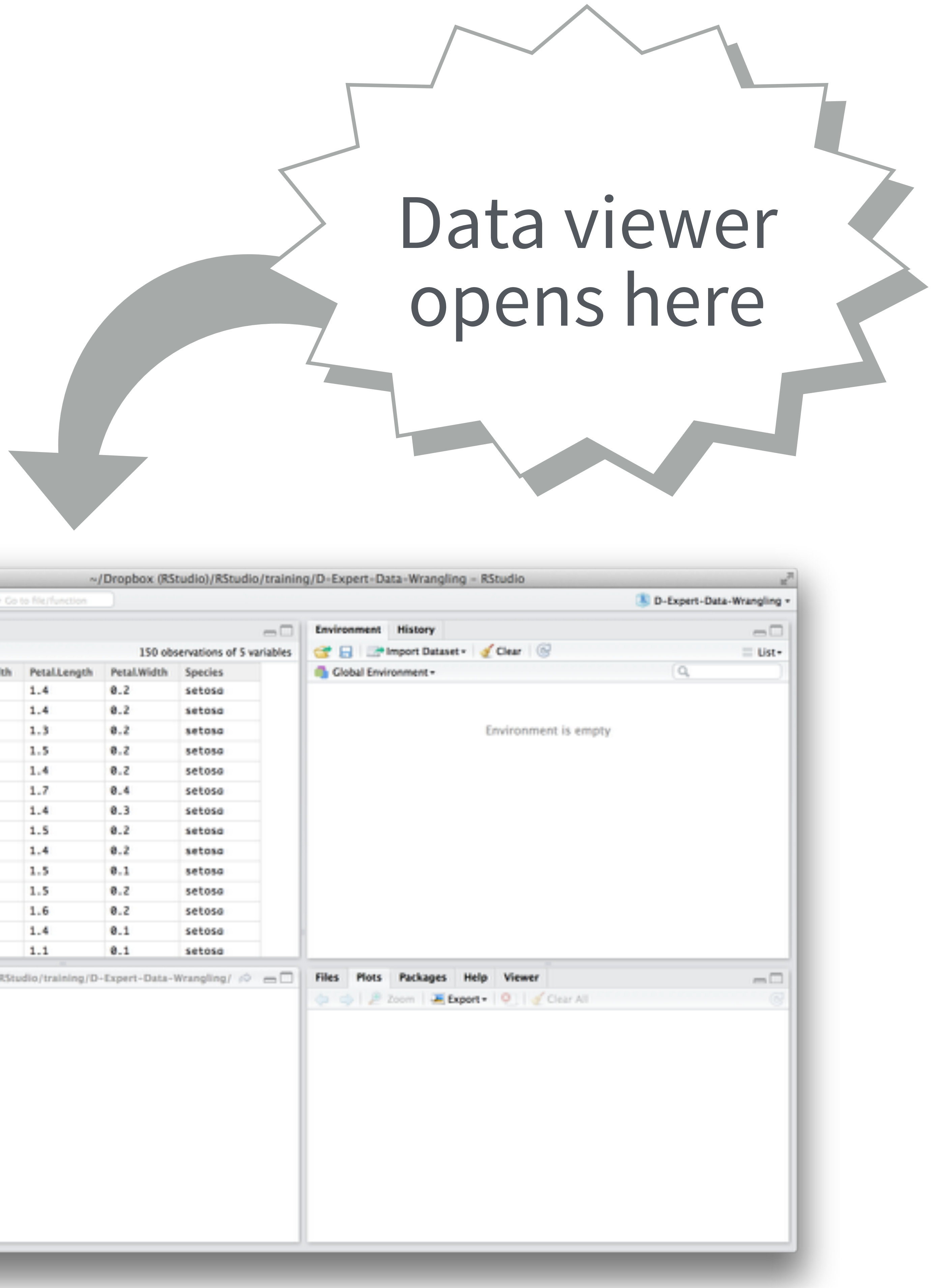
```
977     59.0  2893  6.09  6.06  3.64
978     57.0  2894  5.91  5.99  3.71
979     57.0  2894  5.96  6.00  3.72
980     56.0  2894  5.88  5.92  3.62
981     56.0  2895  5.75  5.78  3.51
982     59.0  2895  5.66  5.76  3.53
983     53.0  2895  5.71  5.75  3.56
986     63.0  2896  6.00  6.05  3.51
987     56.0  2896  5.18  5.24  3.21
988     56.0  2896  5.91  5.96  3.65
989     55.0  2896  5.82  5.86  3.59
990     56.0  2896  5.83  5.89  3.64
991     58.0  2896  5.94  5.88  3.60
992     57.0  2896  6.39  6.35  4.02
993     57.0  2896  6.46  6.45  3.97
994     57.0  2897  5.48  5.51  3.33
995     58.0  2897  5.91  5.85  3.59
996     52.0  2897  5.30  5.34  3.26
997     55.0  2897  5.69  5.74  3.57
998     61.0  2897  5.82  5.89  3.48
999     58.0  2897  5.81  5.77  3.58
1000    59.0  2898  6.68  6.61  4.03
 [ reached getOption("max.print") --
omitted 52940 rows ]
```

data.frame

View()

Examine any data set with the View() command (Capital V)

```
View(iris)
View(mtcars)
View(pressure)
```



The pipe operator %>%

```
library(dplyr)
select(tb, child:elderly)
tb %>% select(child:elderly)
```

These do the same thing
Try it!

%>%

```
tb            select( ______, child:elderly)
```

Data Wrangling

Wrangling
Munging
Janitor Work
Manipulation
Transformation

50-80%

of your time?

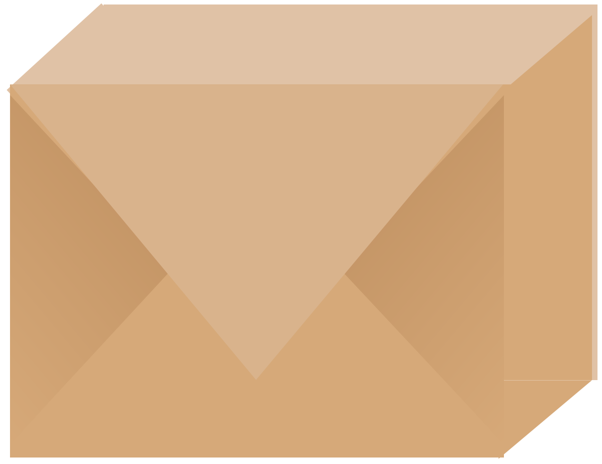
Two goals

1. Make data suitable to use with a particular piece of software
2. Reveal information

Data sets come in many formats

...but R prefers just one.

EDAWR



An R package with all of the data sets that we will use today.

```
# install.packages("devtools")
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
?storms              ?pollution
?cases               ?tb
```

```
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
```

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

cases

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

pollution

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

```r
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
```

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
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cases

Country	2011	2012	2013
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New York	large	23
New York	small	14
London	large	22
London	small	16
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- Storm name

```
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
```

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
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Beijing	large	121
Beijing	small	56

- Storm name
- Wind Speed (mph)

```
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
```

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
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- Storm name
- Wind Speed (mph)
- Air Pressure

```
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library(EDAWR)
```

storms

storm	wind	pressure	date
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cases

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- Storm name
- Wind Speed (mph)
- Air Pressure
- Date

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```

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- Storm name
- Wind Speed (mph)
- Air Pressure
- Date

cases

Country	2011	2012	2013
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- Country

pollution

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```

storms

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cases

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pollution

city	particle size	amount ($\mu g/m^3$)
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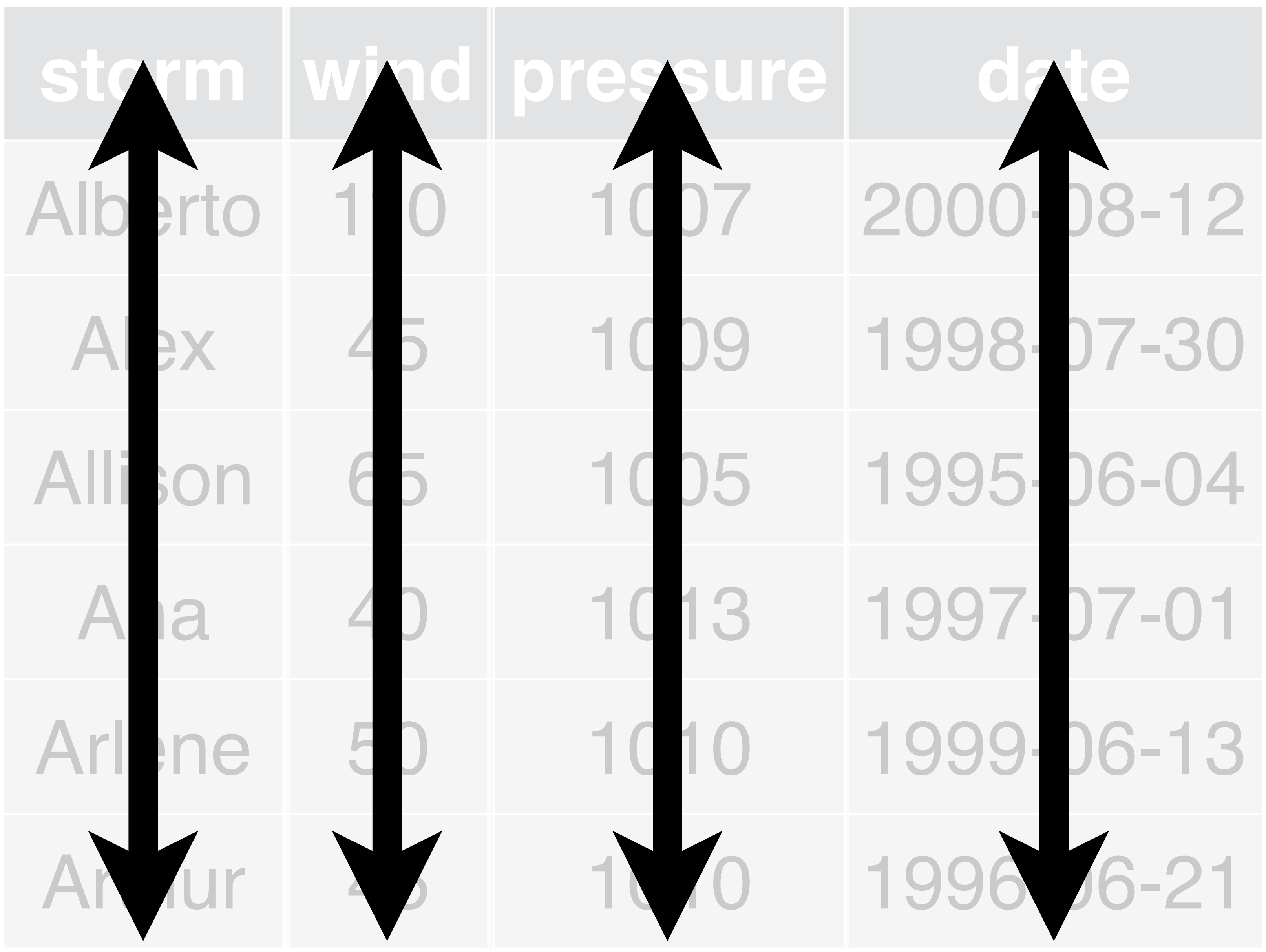
- Storm name
- Wind Speed (mph)
- Air Pressure
- Date

- Country
- Year

```
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
```

storms



cases

pollution

city	particle size	amount ($\mu g/m^3$)
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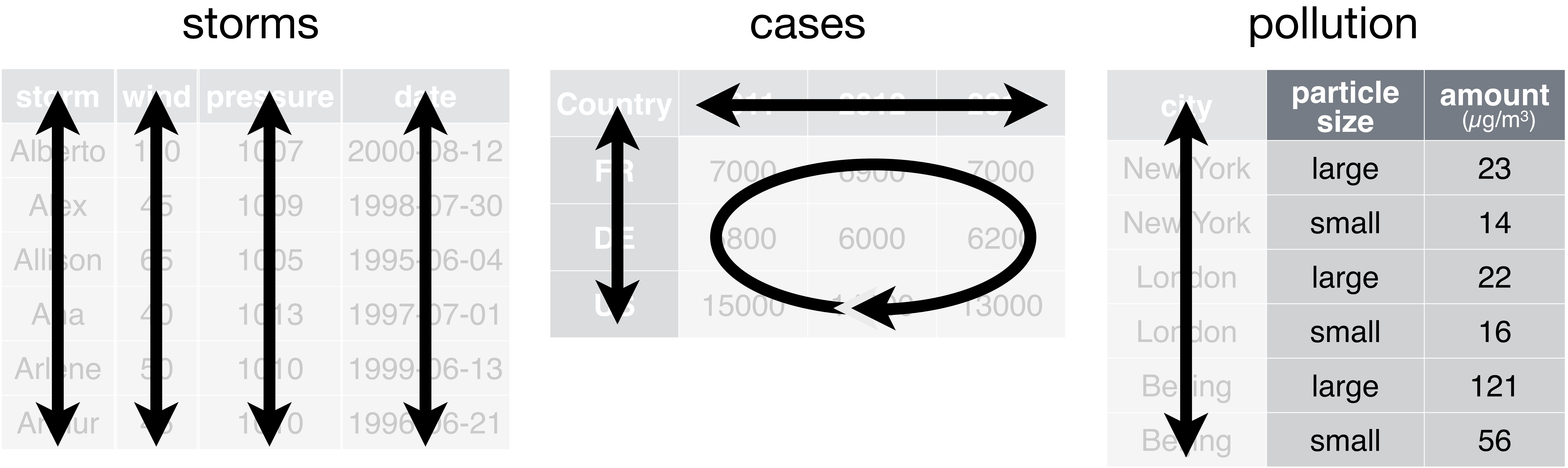
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

- Storm name
- Wind Speed (mph)
- Air Pressure
- Date

- Country
- Year
- Count

```
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
```



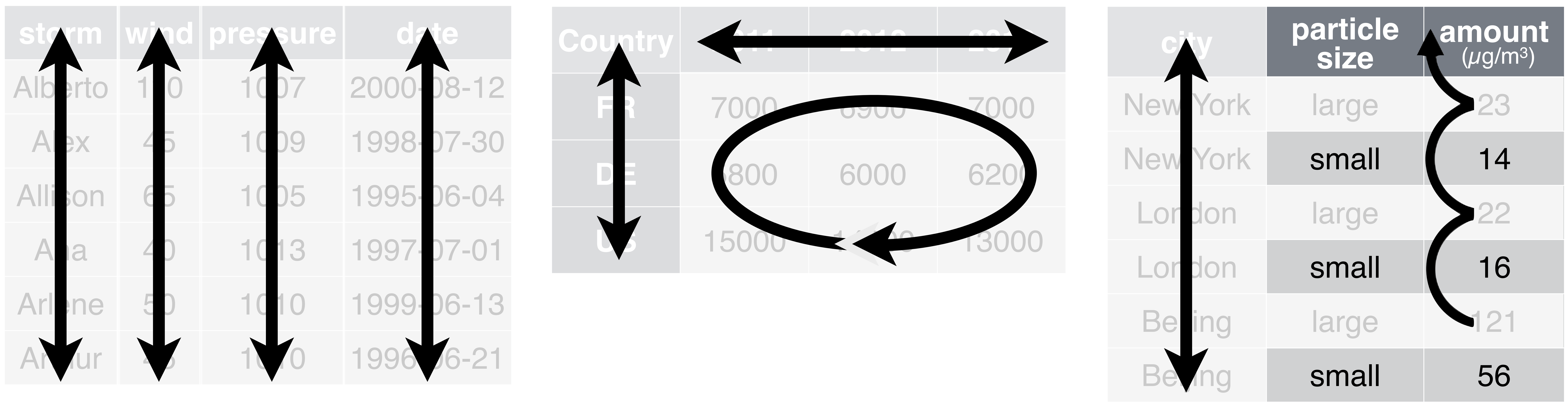
- Storm name
- Wind Speed (mph)
- Air Pressure
- Date

- Country
- Year
- Count

- City

```r
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
```

storms | cases | pollution



- Storm name
- Wind Speed (mph)
- Air Pressure
- Date

- Country
- Year
- Count

- City
- Amount of large particles

```
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
```

storms

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Alberto	110	1007	2000-08-12
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Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

- Storm name
- Wind Speed (mph)
- Air Pressure
- Date

cases

Country	2011	2012	2013
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- Country
- Year
- Count

pollution

city	particle size	amount ($\mu g/m^3$)
New York	large	23
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London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

- City
- Amount of large particles
- Amount of small particles

```
# devtools::install_github("rstudio/EDAWR")
library(EDAWR)
```

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
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Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

```
storms$storm
storms$wind
storms$pressure
storms$date
```

cases

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

```
cases$country
names(cases)[-1]
unlist(cases[1:3, 2:4])
```

pollution

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

```
pollution$city[c(1,3,5)]
pollution$amount[c(1,3,5)]
pollution$amount[c(2,4,6)]
```

$$\text{ratio} = \frac{\text{pressure}}{\text{wind}}$$

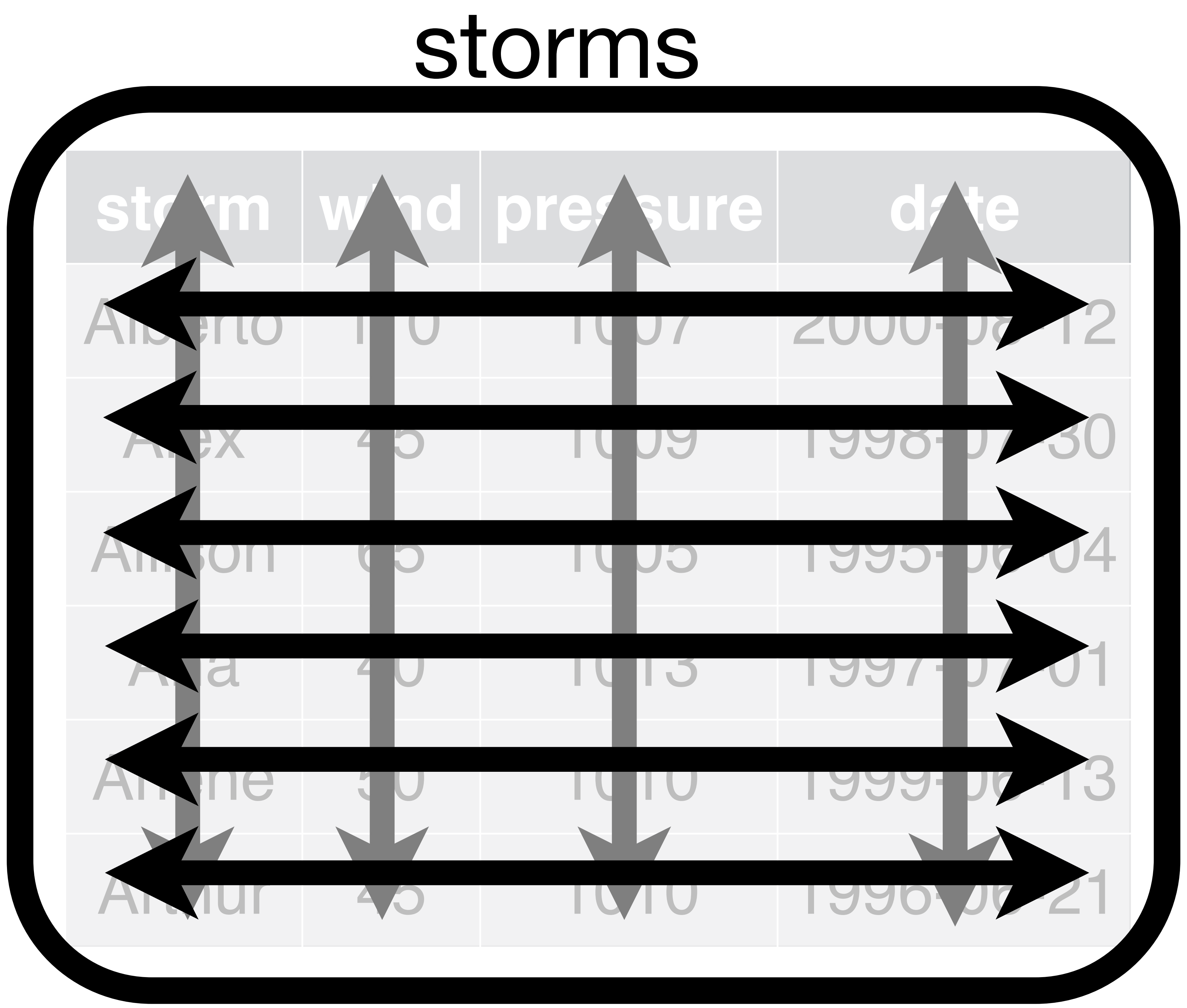
storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

```
storms$pressure / storms$wind
```

950	/	110	8.6
1003	/	45	22.3
987	/	65	15.2
1004	/	40	25.1
1006	/	50	20.1
1000	/	45	22.2

Tidy data



1. Each **variable** is saved in its own **column**.
2. Each **observation** is saved in its own **row**.
3. Each "type" of observation stored in a **single table** (here, storms).

Recap: Tidy data

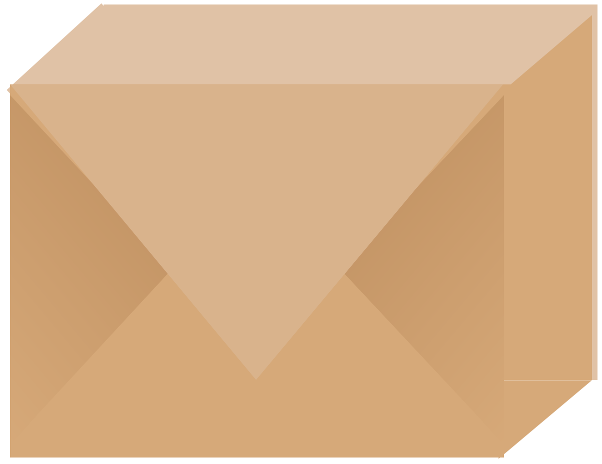
123 Variables in columns, observations in rows, each type in a table

Easy to access variables

Automatically preserves observations

tidyr

tidyr



A package that reshapes the layout of tables.

Two main functions: **gather()** and **spread()**

```
# install.packages("tidyr")
library(tidyr)
?gather
?spread
```

Your Turn

Imagine how this data would look if it were tidy with three variables: *country, year, n*

cases

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

00:30

slides at: bit.ly/wrangling-webinar

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000
US	2012	14000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000
US	2012	14000
FR	2013	7000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000
US	2012	14000
FR	2013	7000
DE	2013	6200

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000
US	2012	14000
FR	2013	7000
DE	2013	6200
US	2013	13000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000
US	2012	14000
FR	2013	7000
DE	2013	6200
US	2013	13000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

gather()

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000
US	2012	14000
FR	2013	7000
DE	2013	6200
US	2013	13000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000
US	2012	14000
FR	2013	7000
DE	2013	6200
US	2013	13000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

key (former column names)

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000
US	2012	14000
FR	2013	7000
DE	2013	6200
US	2013	13000

Country	2011	2012	2013
FR	7000	6900	7000
DE	5800	6000	6200
US	15000	14000	13000

key **value** (former cells)

Country	Year	n
FR	2011	7000
DE	2011	5800
US	2011	15000
FR	2012	6900
DE	2012	6000
US	2012	14000
FR	2013	7000
DE	2013	6200
US	2013	13000

gather()

Collapses multiple columns into two columns:

1. a **key** column that contains the former column names
2. a **value** column that contains the former column cells

```
gather(cases, "year", "n", 2:4)
```

gather()

Collapses multiple columns into two columns:

1. a **key** column that contains the former column names
2. a **value** column that contains the former column cells

```
gather(cases, "year", "n", 2:4)
```

data frame to reshape

gather()

Collapses multiple columns into two columns:

1. a **key** column that contains the former column names
2. a **value** column that contains the former column cells

```
gather(cases, "year", "n", 2:4)
```

data frame to reshape

name of the new key column (a character string)

gather()

Collapses multiple columns into two columns:

1. a **key** column that contains the former column names
2. a **value** column that contains the former column cells

```
gather(cases, "year", "n", 2:4)
```

data frame to reshape

name of the new key column (a character string)

name of the new value column (a character string)

gather()

Collapses multiple columns into two columns:

1. a **key** column that contains the former column names
2. a **value** column that contains the former column cells

```
gather(cases, "year", "n", 2:4)
```

data frame to reshape

name of the new key column (a character string)

name of the new value column (a character string)

names or numeric indexes of columns to collapse

```
##    country  2011  2012  2013
## 1       FR  7000  6900  7000
## 2       DE  5800  6000  6200
## 3       US 15000 14000 13000
```

```
##    country year     n
## 1       FR 2011  7000
## 2       DE 2011  5800
## 3       US 2011 15000
## 4       FR 2012  6900
## 5       DE 2012  6000
## 6       US 2012 14000
## 7       FR 2013  7000
## 8       DE 2013  6200
## 9       US 2013 13000
```

```
gather(cases, "year", "n", 2:4)
```

Your Turn

Imagine how the pollution data set would look tidy with three variables: *city, large, small*

pollution

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

00:30

slides at: bit.ly/wrangling-webinar

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	large	small

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	large	small
New York	23	

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	large	small
New York	23	14

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	large	small
New York	23	14
London	22	

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	large	small
New York	23	14
London	22	16

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	large	small
New York	23	14
London	22	16
Beijing	121	

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	large	small
New York	23	14
London	22	16
Beijing	121	56

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

spread()

city	large	small
New York	23	14
London	22	16
Beijing	121	56

key (new column names)

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	large	small
New York	23	14
London	22	16
Beijing	121	56

key **value** (new cells)

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	large	small
New York	23	14
London	22	16
Beijing	121	56

spread()

Generates multiple columns from two columns:

1. each unique value in the **key** column becomes a column name
2. each value in the **value** column becomes a cell in the new columns

```
spread(pollution, size, amount)
```

spread()

Generates multiple columns from two columns:

1. each unique value in the **key** column becomes a column name
2. each value in the **value** column becomes a cell in the new columns

```
spread(pollution, size, amount)
```

data frame to reshape

spread()

Generates multiple columns from two columns:

1. each unique value in the **key** column becomes a column name
2. each value in the **value** column becomes a cell in the new columns

```
spread(pollution, size, amount)
```

data frame to reshape

column to use for keys (new columns names)

spread()

Generates multiple columns from two columns:

1. each unique value in the **key** column becomes a column name
2. each value in the **value** column becomes a cell in the new columns

```
spread(pollution, size, amount)
```

data frame to reshape

column to use for keys (new columns names)

column to use for values (new column cells)

```
##        city  size amount
## 1 New York large     23
## 2 New York small     14
## 3   London large     22
## 4   London small     16
## 5  Beijing large    121
## 6  Beijing small     56
```

```
##        city large small
## 1  Beijing   121    56
## 2   London    22    16
## 3 New York    23    14
```

```
spread(pollution, size, amount)
```

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

spread()

city	large	small
New York	23	14
London	22	16
Beijing	121	56

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

spread()

gather()

city	large	small
New York	23	14
London	22	16
Beijing	121	56

unite() and separate()

There are three more variables hidden in storms:

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

- Year
- Month
- Day

separate()

Separate splits a column by a character string separator.

```
separate(storms, date, c("year", "month", "day"), sep = "-")
```

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

storms2

storm	wind	pressure	year	month	day
Alberto	110	1007	2000	08	12
Alex	45	1009	1998	07	30
Allison	65	1005	1995	06	04
Ana	40	1013	1997	07	1
Arlene	50	1010	1999	06	13
Arthur	45	1010	1996	06	21

unite()

Unite unites columns into a single column.

```
unite(storms2, "date", year, month, day, sep = "-")
```

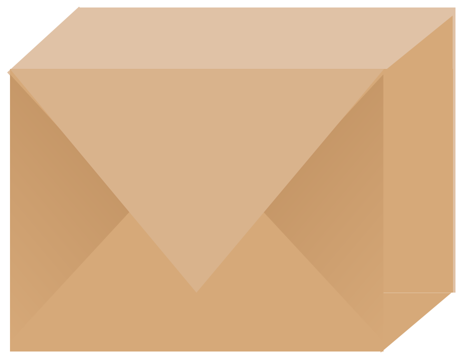
storms2

storm	wind	pressure	year	month	day
Alberto	110	1007	2000	08	12
Alex	45	1009	1998	07	30
Allison	65	1005	1995	06	04
Ana	40	1013	1997	07	1
Arlene	50	1010	1999	06	13
Arthur	45	1010	1996	06	21

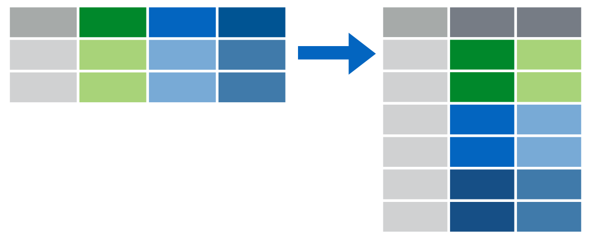
storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

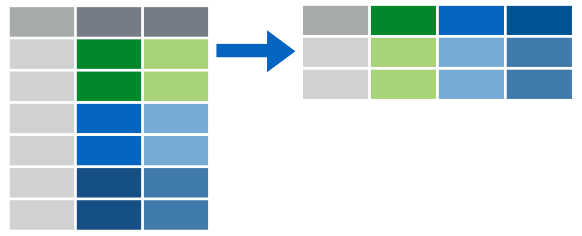
Recap: tidyr



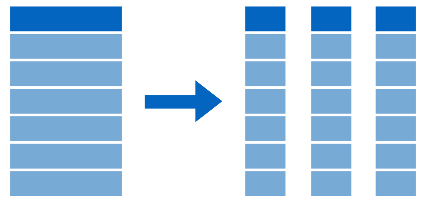
A package that reshapes the layout of data sets.



Make observations from variables with `gather()`



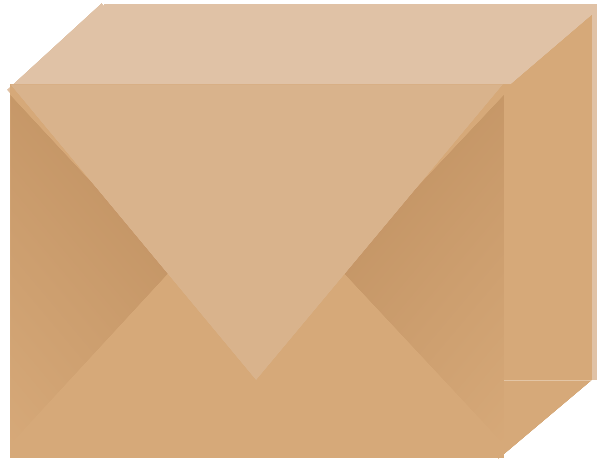
Make variables from observations with `spread()`



Split and merge columns with `unite()` and `separate()`

Data sets contain more information than they display

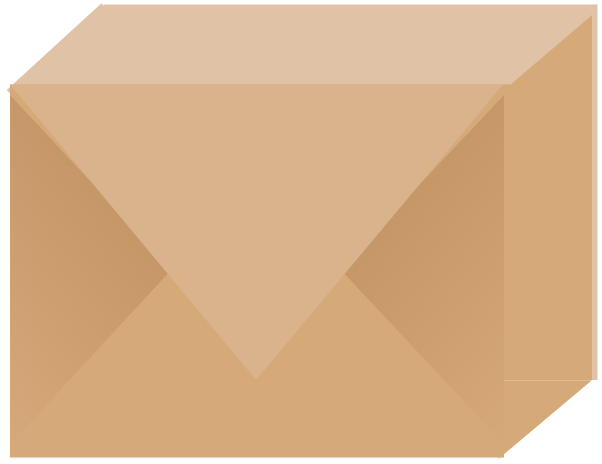
dplyr



A package that helps transform tabular data.

```
# install.packages("dplyr")
library(dplyr)
?select        ?mutate
?filter        ?summarise
?arrange       ?group_by
```

nycflights13



Data sets related to flights that departed from NYC in 2013

```
# install.packages("nycflights13")
library(nycflights13)
?airlines        ?planes
?airports        ?weather
?flights
```

Ways to access information

1	**Extract** existing variables.	select()
2	**Extract** existing observations.	filter()
3	**Derive** new variables (from existing variables)	mutate()
4	**Change** the unit of analysis	summarise()

select()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

storm	pressure
Alberto	1007
Alex	1009
Allison	1005
Ana	1013
Arlene	1010
Arthur	1010

```
select(storms, storm, pressure)
```

select()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

wind	pressure	date
110	1007	2000-08-12
45	1009	1998-07-30
65	1005	1995-06-04
40	1013	1997-07-01
50	1010	1999-06-13
45	1010	1996-06-21

```
select(storms, -storm)
# see ?select for more
```

select()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

wind	pressure	date
110	1007	2000-08-12
45	1009	1998-07-30
65	1005	1995-06-04
40	1013	1997-07-01
50	1010	1999-06-13
45	1010	1996-06-21

```
select(storms, wind:date)
# see ?select for more
```

Useful select functions

* Blue functions come in dplyr

-	Select everything but
:	Select range
contains()	Select columns whose name contains a character string
ends_with()	Select columns whose name ends with a string
everything()	Select every column
matches()	Select columns whose name matches a regular expression
num_range()	Select columns named x1, x2, x3, x4, x5
one_of()	Select columns whose names are in a group of names
starts_with()	Select columns whose name starts with a character string

filter()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Allison	65	1005	1995-06-04
Arlene	50	1010	1999-06-13

```
filter(storms, wind >= 50)
```

filter()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Allison	65	1005	1995-06-04

```
filter(storms, wind >= 50,
  storm %in% c("Alberto", "Alex", "Allison"))
```

logical tests in R

?Comparison

<	Less than
>	Greater than
==	Equal to
<=	Less than or equal to
>=	Greater than or equal to
!=	Not equal to
%in%	Group membership
is.na	Is NA
!is.na	Is not NA

?base::Logic

&	boolean and
|	boolean or
xor	exactly or
!	not
any	any true
all	all true

mutate()

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

storm	wind	pressure	date	ratio
Alberto	110	1007	2000-08-12	9.15
Alex	45	1009	1998-07-30	22.42
Allison	65	1005	1995-06-04	15.46
Ana	40	1013	1997-07-01	25.32
Arlene	50	1010	1999-06-13	20.20
Arthur	45	1010	1996-06-21	22.44

```
mutate(storms, ratio = pressure / wind)
```

mutate()

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

storm	wind	pressure	date	ratio	inverse
Alberto	110	1007	2000-08-12	9.15	0.11
Alex	45	1009	1998-07-30	22.42	0.04
Allison	65	1005	1995-06-04	15.46	0.06
Ana	40	1013	1997-07-01	25.32	0.04
Arlene	50	1010	1999-06-13	20.20	0.05
Arthur	45	1010	1996-06-21	22.44	0.04

```
mutate(storms, ratio = pressure / wind, inverse = ratio^-1)
```

Useful mutate functions

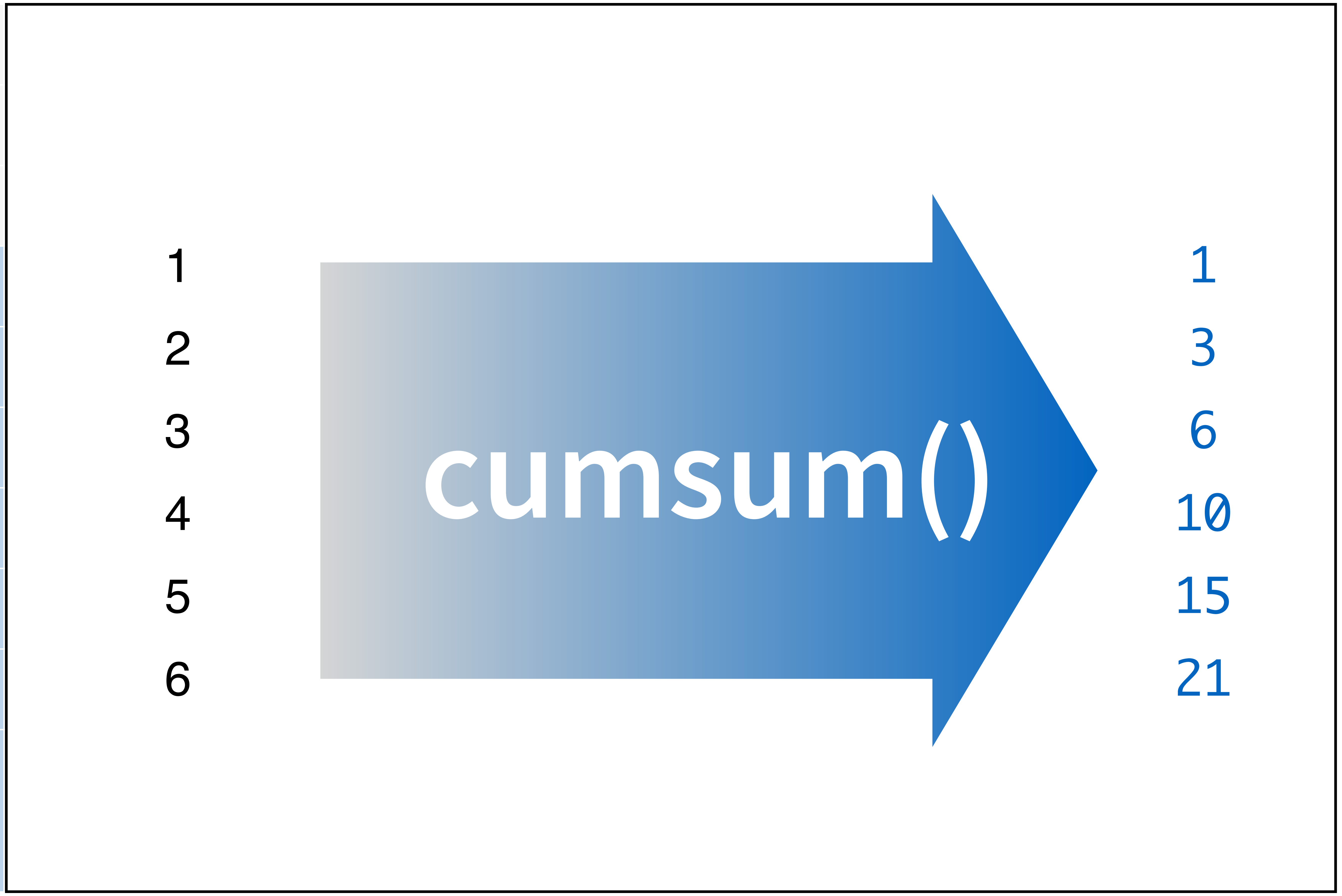
* All take a vector of values and return a vector of values
** Blue functions come in dplyr

pmin(), pmax()	Element-wise min and max
cummin(), cummax()	Cumulative min and max
cumsum(), cumprod()	Cumulative sum and product
between()	Are values between a and b?
cume_dist()	Cumulative distribution of values
cumall(), cumany()	Cumulative all and any
cummean()	Cumulative mean
lead(), lag()	Copy with values one position
ntile()	Bin vector into n buckets
dense_rank(), min_rank(), percent_rank(), row_number()	Various ranking methods

"Window" functions

* All take a vector of values and return a vector of values

pmin(), pmax()
cummin(), cummax()
cumsum(), cumprod()
between()
cume_dist()
cumall(), cumany()
cummean()
lead(), lag()
ntile()
dense_rank(), min_rank(), percent_rank(), row_number()



summarise()

city	particle size	amount (μg/m^3)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

→

median	variance
22.5	1731.6

```
pollution %>% summarise(median = median(amount), variance = var(amount))
```

summarise()

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

→

mean	sum	n
42	252	6

```
pollution %>% summarise(mean = mean(amount), sum = sum(amount), n = n())
```

Useful summary functions

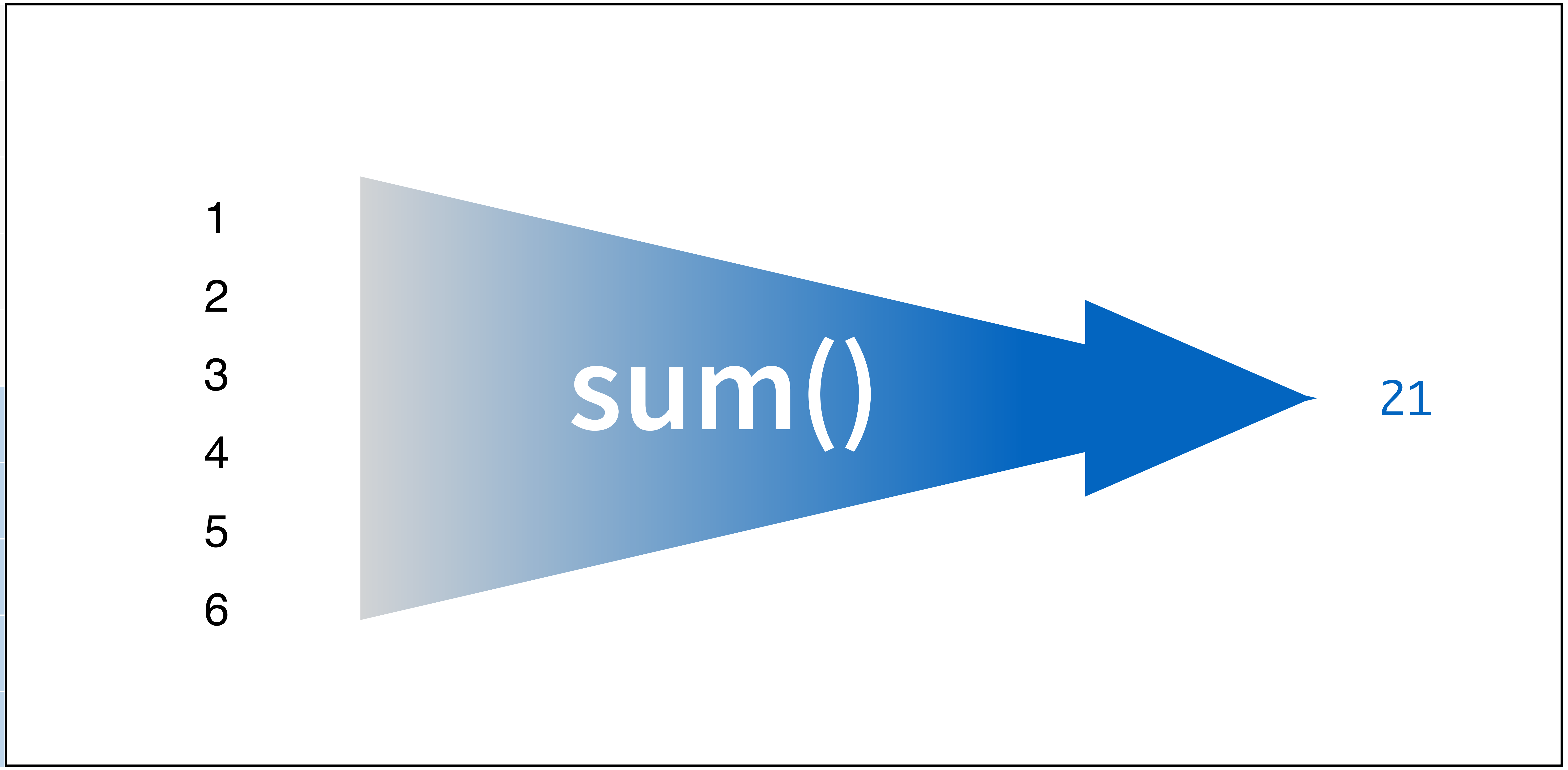
* All take a vector of values and return a single value
** Blue functions come in dplyr

min(), max()	Minimum and maximum values
mean()	Mean value
median()	Median value
sum()	Sum of values
var, sd()	Variance and standard deviation of a vector
first()	First value in a vector
last()	Last value in a vector
nth()	Nth value in a vector
n()	The number of values in a vector
n_distinct()	The number of distinct values in a vector

"Summary" functions

* All take a vector of values and return a single value

min(), max()
mean()
median()
sum()
var, sd()
first()
last()
nth()
n()
n_distinct()



arrange()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

storm	wind	pressure	date
Ana	40	1013	1997-07-01
Alex	45	1009	1998-07-30
Arthur	45	1010	1996-06-21
Arlene	50	1010	1999-06-13
Allison	65	1005	1995-06-04
Alberto	110	1007	2000-08-12

```
arrange(storms, wind)
```

arrange()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

storm	wind	pressure	date
Ana	40	1013	1997-07-01
Alex	45	1009	1998-07-30
Arthur	45	1010	1996-06-21
Arlene	50	1010	1999-06-13
Allison	65	1005	1995-06-04
Alberto	110	1007	2000-08-12

```
arrange(storms, wind)
```

arrange()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Allison	65	1005	1995-06-04
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21
Alex	45	1009	1998-07-30
Ana	40	1013	1997-07-01

```
arrange(storms, desc(wind))
```

arrange()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

storm	wind	pressure	date
Ana	40	1013	1997-07-01
Alex	45	1009	1998-07-30
Arthur	45	1010	1996-06-21
Arlene	50	1010	1999-06-13
Allison	65	1005	1995-06-04
Alberto	110	1007	2000-08-12

```
arrange(storms, wind)
```

arrange()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

storm	wind	pressure	date
Ana	40	1013	1997-07-01
Arthur	45	1010	1996-06-21
Alex	45	1009	1998-07-30
Arlene	50	1010	1999-06-13
Allison	65	1005	1995-06-04
Alberto	110	1007	2000-08-12

```
arrange(storms, wind, date)
```

The pipe operator %>%

```
library(dplyr)
select(tb, child:elderly)
tb %>% select(child:elderly)
```

These do the same thing
Try it!

%>%

```
tb              select( _____, child:elderly)
```

select()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

→

storm	pressure
Alberto	1007
Alex	1009
Allison	1005
Ana	1013
Arlene	1010
Arthur	1010

```
select(storms, storm, pressure)
```

select()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

storm	pressure
Alberto	1007
Alex	1009
Allison	1005
Ana	1013
Arlene	1010
Arthur	1010

```
storms %>% select(storm, pressure)
```

filter()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Allison	65	1005	1995-06-04
Arlene	50	1010	1999-06-13

```
filter(storms, wind >= 50)
```

filter()

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Allison	65	1005	1995-06-04
Arlene	50	1010	1999-06-13

```
storms %>% filter(wind >= 50)
```

storms

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

storm	pressure
Alberto	1007
Allison	1005
Arlene	1010

```
storms %>%
  filter(wind >= 50) %>%
  select(storm, pressure)
```

mutate()

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

?

```
storms %>%
  mutate(ratio = pressure / wind) %>%
  select(storm, ratio)
```

mutate()

storm	wind	pressure	date
Alberto	110	1007	2000-08-12
Alex	45	1009	1998-07-30
Allison	65	1005	1995-06-04
Ana	40	1013	1997-07-01
Arlene	50	1010	1999-06-13
Arthur	45	1010	1996-06-21

?

storm	ratio
Alberto	9.15
Alex	22.42
Allison	15.46
Ana	25.32
Arlene	20.20
Arthur	22.44

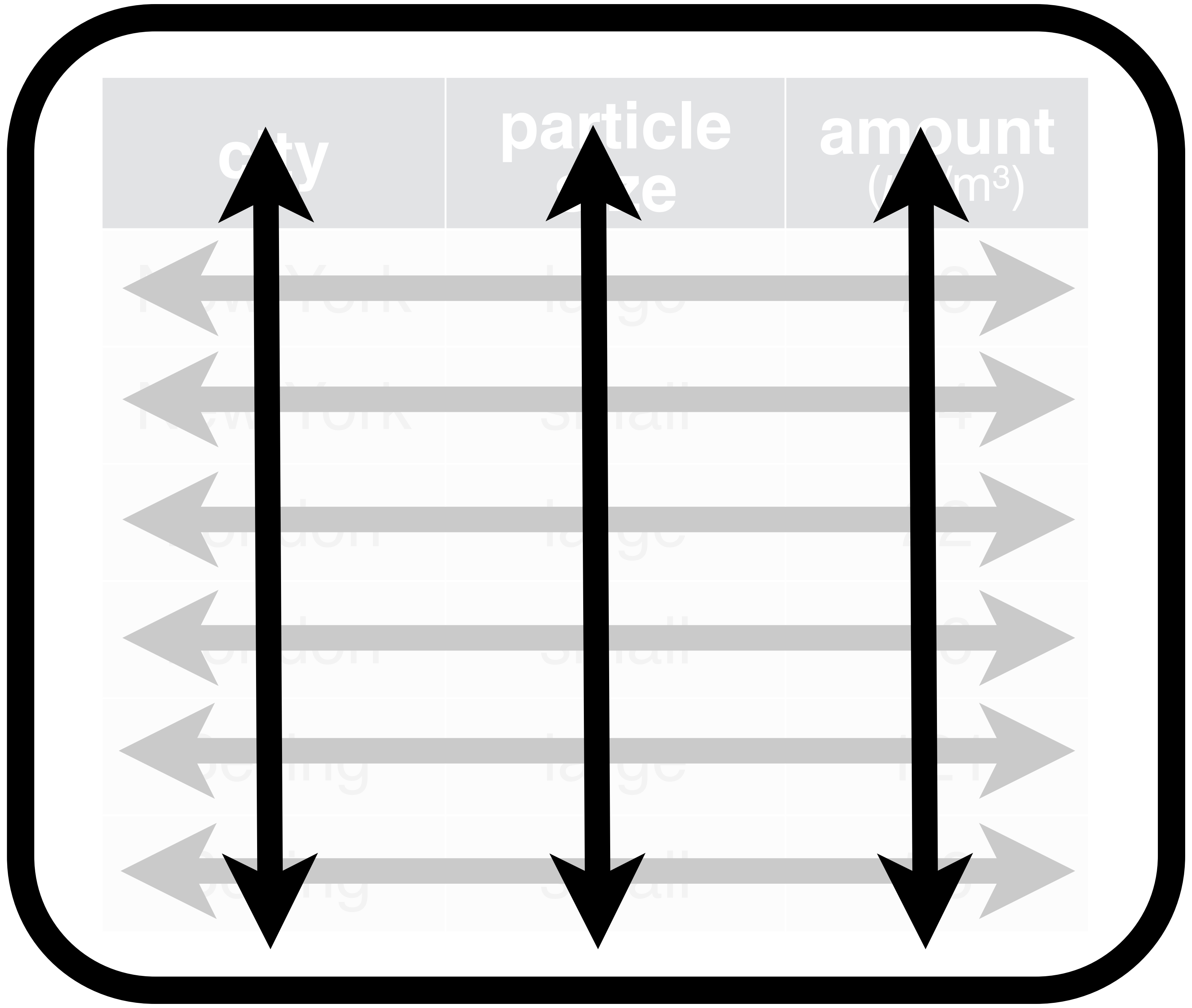
```
storms %>%
  mutate(ratio = pressure / wind) %>%
  select(storm, ratio)
```

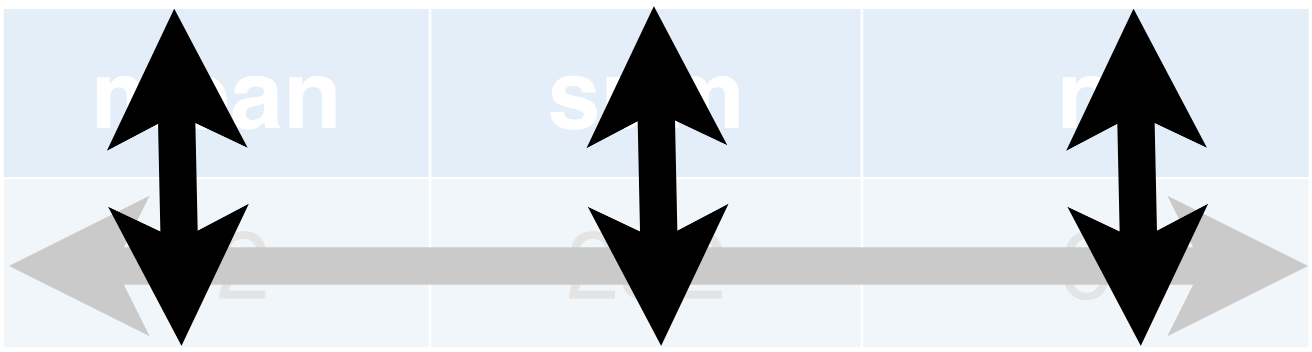
Shortcut to type %>%

Cmd + Shift + M (Mac)

Ctrl + Shift + M (Windows)

Unit of analysis


particle
amount



city	particle size	amount (μg/m³)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

mean	sum	n
42	252	6

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14

London	large	22
London	small	16

Beijing	large	121
Beijing	small	56

mean	sum	n
18.5	37	2
19.0	38	2
88.5	177	2

group_by() + summarise()

group_by()

city	particle size	amount (μg/m³)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	particle size	amount (μg/m³)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

```
pollution %>% group_by(city)
```

```
pollution %>% group_by(city)
## Source: local data frame [6 x 3]
## Groups: city
##
##       city  size amount
## 1 New York large     23
## 2 New York small     14
## 3   London large     22
## 4   London small     16
## 5  Beijing large    121
## 6  Beijing small     56
```

group_by() + summarise()

city	particle size	amount (μg/m^3)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

```
pollution %>% group_by(city) %>%
  summarise(mean = mean(amount), sum = sum(amount), n = n())
```

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14

city	mean	sum	n
New York	18.5	37	2

London	large	22
London	small	16

London	19.0	38	2

Beijing	large	121
Beijing	small	56

Beijing	88.5	177	2

```
pollution %>% group_by(city) %>%
  summarise(mean = mean(amount), sum = sum(amount), n = n())
```

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	mean	sum	n
New York	18.5	37	2

city	mean	sum	n
New York	18.5	37	2
London	19.0	38	2
Beijing	88.5	177	2

Beijing	88.5	177	2

```
pollution %>% group_by(city) %>%
  summarise(mean = mean(amount), sum = sum(amount), n = n())
```

city	particle size	amount (µg/m³)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	mean	sum	n
New York	18.5	37	2
London	19.0	38	2
Beijing	88.5	177	2

```
pollution %>% group_by(city) %>%
  summarise(mean = mean(amount), sum = sum(amount), n = n())
```

city	particle size	amount (µg/m³)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	mean	sum	n
New York	18.5	37	2
London	19.0	38	2
Beijing	88.5	177	2

```
pollution %>% group_by(city) %>%
  summarise(mean = mean(amount), sum = sum(amount), n = n())
```

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

→

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

→

city	mean
New York	18.5
London	19.0
Beijing	88.5

```
pollution %>% group_by(city) %>%  summarise(mean = mean(amount))
```

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

city	size	amount
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

size	mean
large	55.3
small	28.6

```
pollution %>% group_by(size) %>%  summarise(mean = mean(amount))
```

ungroup()

city	particle size	amount (μg/m^3)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

→

city	particle size	amount (μg/m^3)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

```
pollution %>% ungroup()
```

country	year	sex	cases
Afghanistan	1999	female	1
Afghanistan	1999	male	1
Afghanistan	2000	female	1
Afghanistan	2000	male	1
Brazil	1999	female	2
Brazil	1999	male	2
Brazil	2000	female	2
Brazil	2000	male	2
China	1999	female	3
China	1999	male	3
China	2000	female	3
China	2000	male	3

tb

country	year	sex	cases
Afghanistan	1999	female	1
Afghanistan	1999	male	1
Afghanistan	2000	female	1
Afghanistan	2000	male	1
Brazil	1999	female	2
Brazil	1999	male	2
Brazil	2000	female	2
Brazil	2000	male	2
China	1999	female	3
China	1999	male	3
China	2000	female	3
China	2000	male	3

→

country	year	sex	cases
Afghanistan	1999	female	1
Afghanistan	1999	male	1
Afghanistan	2000	female	1
Afghanistan	2000	male	1
Brazil	1999	female	2
Brazil	1999	male	2
Brazil	2000	female	2
Brazil	2000	male	2
China	1999	female	3
China	1999	male	3
China	2000	female	3
China	2000	male	3

```
tb %>%
  group_by(country, year)
```

country	year	sex	cases
Afghanistan	1999	female	1
Afghanistan	1999	male	1
Afghanistan	2000	female	1
Afghanistan	2000	male	1
Brazil	1999	female	2
Brazil	1999	male	2
Brazil	2000	female	2
Brazil	2000	male	2
China	1999	female	3
China	1999	male	3
China	2000	female	3
China	2000	male	3

country	year	sex	cases
Afghanistan	1999	female	1
Afghanistan	1999	male	1
Afghanistan	2000	female	1
Afghanistan	2000	male	1
Brazil	1999	female	2
Brazil	1999	male	2
Brazil	2000	female	2
Brazil	2000	male	2
China	1999	female	3
China	1999	male	3
China	2000	female	3
China	2000	male	3

country	year	cases
Afghanistan	1999	2
Afghanistan	2000	2
Brazil	1999	4
Brazil	2000	4
China	1999	6
China	1999	6

```
tb %>%
  group_by(country, year) %>%
  summarise(cases = sum(cases))
```

country	year	sex	cases
Afghanistan	1999	female	1
Afghanistan	1999	male	1
Afghanistan	2000	female	1
Afghanistan	2000	male	1
Brazil	1999	female	2
Brazil	1999	male	2
Brazil	2000	female	2
Brazil	2000	male	2
China	1999	female	3
China	1999	male	3
China	2000	female	3
China	2000	male	3

country	year	sex	cases
Afghanistan	1999	female	1
Afghanistan	1999	male	1
Afghanistan	2000	female	1
Afghanistan	2000	male	1
Brazil	1999	female	2
Brazil	1999	male	2
Brazil	2000	female	2
Brazil	2000	male	2
China	1999	female	3
China	1999	male	3
China	2000	female	3
China	2000	male	3

country	year	cases
Afghanistan	1999	2
Afghanistan	2000	2
Brazil	1999	4
Brazil	2000	4
China	1999	6
China	1999	6

country	cases
Afghanistan	4
Brazil	8
China	12

```
tb %>%
  group_by(country, year) %>%
  summarise(cases = sum(cases)) %>%
  summarise(cases = sum(cases))
```

Hierarchy of information

country	year	sex	cases
Afghanistan	1999	female	1
Afghanistan	1999	male	1
Afghanistan	2000	female	1
Afghanistan	2000	male	1
Brazil	1999	female	2
Brazil	1999	male	2
Brazil	2000	female	2
Brazil	2000	male	2
China	1999	female	3
China	1999	male	3
China	2000	female	3
China	2000	male	3

country	year	cases
Afghanistan	1999	2
Afghanistan	2000	2
Brazil	1999	4
Brazil	2000	4
China	1999	6
China	2000	6

country	cases
Afghanistan	4
Brazil	8
China	12

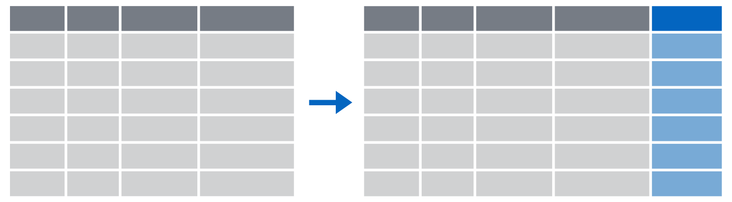
cases
24

Larger units of analysis

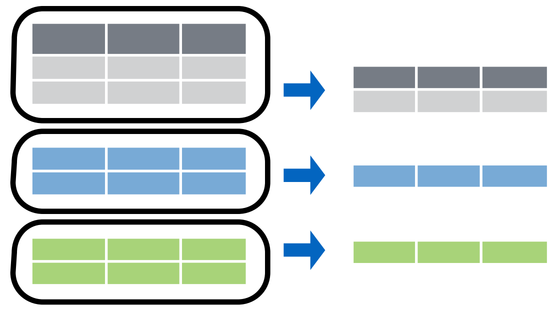
Recap: Information

Extract variables and observations with **select()** and **filter()**

Arrange observations, with **arrange()**.



Make new variables, with **mutate()**.



Make groupies observations with **group_by()** and **summarise()**.

Joining data

dplyr::**bind_cols()**

y

x1	x2
A	1
B	2
C	3

+

z

x1	x2
B	2
C	3
D	4

=

x1	x2	x1	x2
A	1	B	2
B	2	C	3
C	3	D	4

```
bind_cols(y, z)
```

dplyr::**bind_rows()**

y

x1	x2
A	1
B	2
C	3

+

z

x1	x2
B	2
C	3
D	4

=

x1	x2
A	1
B	2
C	3
B	2
C	3
D	4

```
bind_rows(y, z)
```

dplyr::**union()**

y

x1	x2
A	1
B	2
C	3

+

z

x1	x2
B	2
C	3
D	4

=

x1	x2
A	1
B	2
C	3
D	4

```
union(y, z)
```

dplyr::**intersect()**

y

x1	x2
A	1
B	2
C	3

+

z

x1	x2
B	2
C	3
D	4

=

x1	x2
B	2
C	3

```
intersect(y, z)
```

dplyr::**setdiff()**

y

x1	x2
A	1
B	2
C	3

+

z

x1	x2
B	2
C	3
D	4

=

x1	x2
A	1
D	4

```
setdiff(y, z)
```

dplyr::**left_join()**

songs

song	name
Across the Universe	John
Come Together	John
Hello, Goodbye	Paul
Peggy Sue	Buddy

+

artists

name	plays
George	sitar
John	guitar
Paul	bass
Ringo	drums

=

song	name	plays
Across the Universe	John	guitar
Come Together	John	guitar
Hello, Goodbye	Paul	bass
Peggy Sue	Buddy	**<NA>**

```
left_join(songs, artists, by = "name")
```

dplyr::**left_join()**

songs

song	name
Across the Universe	John
Come Together	John
Hello, Goodbye	Paul
Peggy Sue	Buddy

+

artists

name	plays
George	sitar
John	guitar
Paul	bass
Ringo	drums

=

song	name	plays
Across the Universe	John	guitar
Come Together	John	guitar
Hello, Goodbye	Paul	bass
Peggy Sue	Buddy	**<NA>**

```
left_join(songs, artists, by = "name")
```

dplyr::**left_join()**

songs2

song	first	last
Across the Universe	John	Lennon
Come Together	John	Lennon
Hello, Goodbye	Paul	McCartney
Peggy Sue	Buddy	Holly

+

artists2

first	last	plays
George	Harrison	sitar
John	Lennon	guitar
Paul	McCartney	bass
Ringo	Starr	drums
Paul	Simon	guitar
John	Coltranee	sax

=

song	first	last	plays
Across the Universe	John	Lennon	guitar
Come Together	John	Lennon	guitar
Hello, Goodbye	Paul	McCartney	bass
Peggy Sue	Buddy	Holly	<NA>

```
left_join(songs2, artists2, by = c("first", "last"))
```

dplyr::**left_join()**

songs2

song	first	last
Across the Universe	John	Lennon
Come Together	John	Lennon
Hello, Goodbye	Paul	McCartney
Peggy Sue	Buddy	Holly

+

artists2

first	last	plays
George	Harrison	sitar
John	Lennon	guitar
Paul	McCartney	bass
Ringo	Starr	drums
Paul	Simon	guitar
John	Coltrane	sax

=

song	first	last	plays
Across the Universe	John	Lennon	guitar
Come Together	John	Lennon	guitar
Hello, Goodbye	Paul	McCartney	bass
Peggy Sue	Buddy	Holly	**<NA>**

```
left_join(songs2, artists2, by = c("first", "last"))
```

left

left_join()

songs

song	name
Across the Universe	John
Come Together	John
Hello, Goodbye	Paul
Peggy Sue	Buddy

+

artists

name	plays
George	sitar
John	guitar
Paul	bass
Ringo	drums

=

song	name	plays
Across the Universe	John	guitar
Come Together	John	guitar
Hello, Goodbye	Paul	bass
Peggy Sue	Buddy	**<NA>**

```
left_join(songs, artists, by = "name")
```

inner_join()

inner

songs

song	name
Across the Universe	John
Come Together	John
Hello, Goodbye	Paul
Peggy Sue	Buddy

+

artists

name	plays
George	sitar
John	guitar
Paul	bass
Ringo	drums

=

song	name	plays
Across the Universe	John	guitar
Come Together	John	guitar
Hello, Goodbye	Paul	bass

```
inner_join(songs, artists, by = "name")
```

semi

semi_join()

songs

song	name
Across the Universe	John
Come Together	John
Hello, Goodbye	Paul
Peggy Sue	Buddy

+

artists

name	plays
George	sitar
John	guitar
Paul	bass
Ringo	drums

=

song	name
Across the Universe	John
Come Together	John
Hello, Goodbye	Paul

```
semi_join(songs, artists, by = "name")
```

anti

anti_join()

songs

song	name
Across the Universe	John
Come Together	John
Hello, Goodbye	Paul
Peggy Sue	Buddy

+

artists

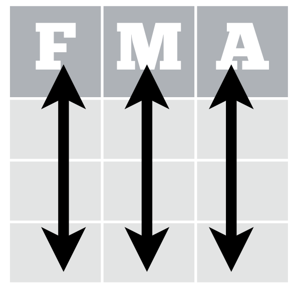
name	plays
George	sitar
John	guitar
Paul	bass
Ringo	drums

=

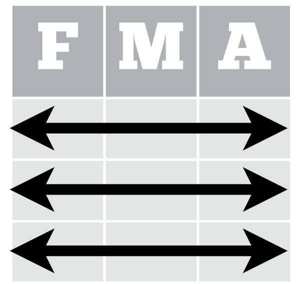
song	name
Peggy Sue	Buddy

```
anti_join(songs, artists, by = "name")
```

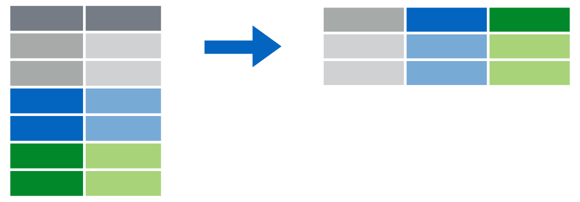
Recap: Best format for analysis



Variables in columns



Observations in rows



Separate **all variables** *implied by law, formula or goal*

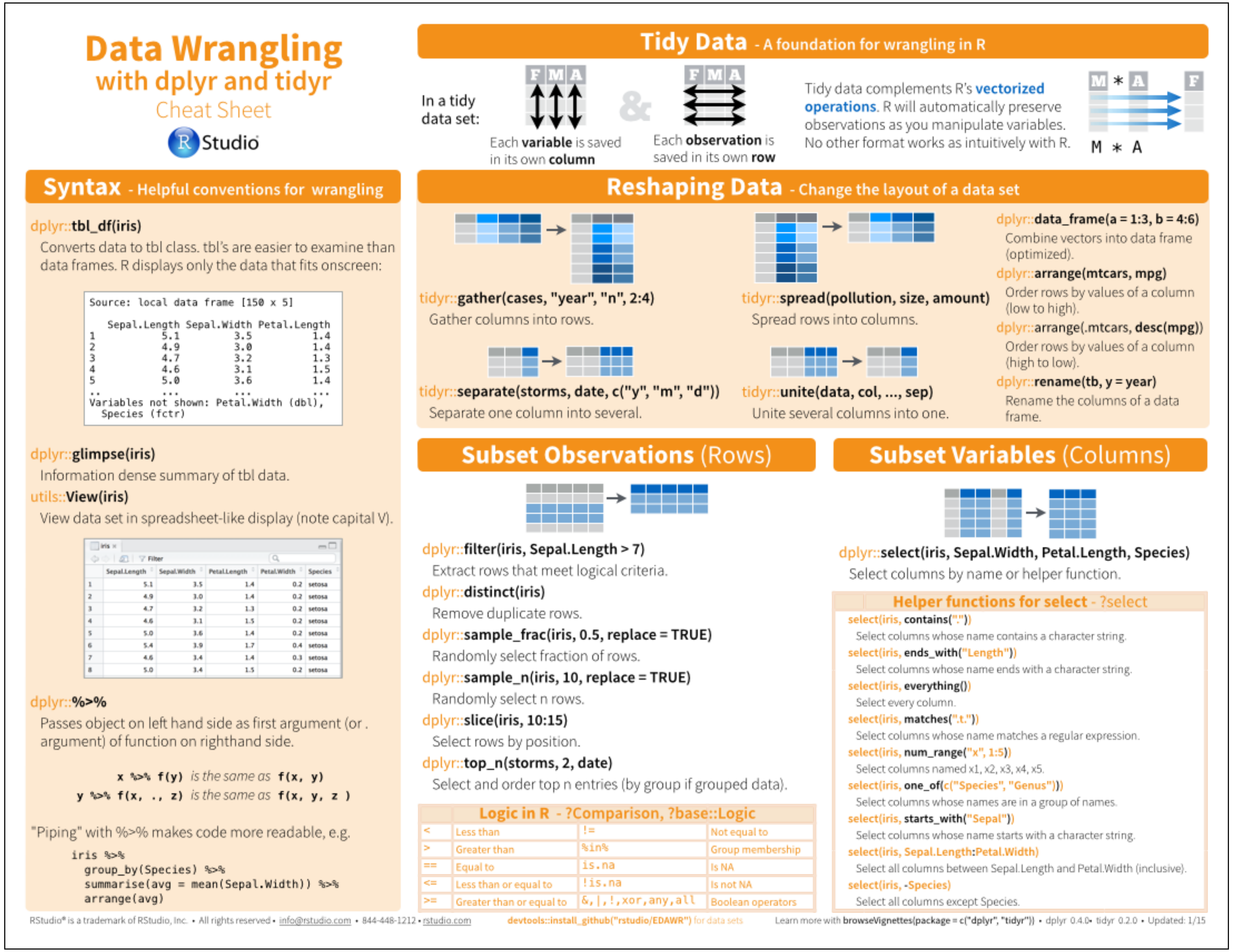
Unit of analysis matches the unit of analysis *implied by law, formula or goal*

Single table

How to learn more

RStudio

slides at: bit.ly/wrangling-webinar



Data Wrangling
with dplyr and tidyr
Cheat Sheet

RStudio

Syntax - Helpful conventions for wrangling

dplyr::**tbl_df(iris)**

Converts data to tbl class. tbl's are easier to examine than data frames. R displays only the data that fits onscreen:

```
Source: local data frame [150 x 5]

  Sepal.Length Sepal.Width Petal.Length
1          5.1         3.5          1.4
2          4.9         3.0          1.4
3          4.7         3.2          1.3
4          4.6         3.1          1.5
5          5.0         3.6          1.4
..         ...         ...          ...
Variables not shown: Petal.Width (dbl),
  Species (fctr)
```

dplyr::**glimpse(iris)**

Information dense summary of tbl data.

utils::**View(iris)**

View data set in spreadsheet-like display (note capital V).

	Sepal.Length	Sepal.Width	Petal.Length	Petal.Width	Species
1	5.1	3.5	1.4	0.2	setosa
2	4.9	3.0	1.4	0.2	setosa
3	4.7	3.2	1.3	0.2	setosa
4	4.6	3.1	1.5	0.2	setosa
5	5.0	3.6	1.4	0.2	setosa
6	5.4	3.9	1.7	0.4	setosa
7	4.6	3.4	1.4	0.3	setosa
8	5.0	3.4	1.5	0.2	setosa

dplyr::**%>%**

Passes object on left hand side as first argument (or . argument) of function on righthand side.

`x %>% f(y)` *is the same as* `f(x, y)`

`y %>% f(x, ., z)` *is the same as* `f(x, y, z )`

"Piping" with %>% makes code more readable, e.g.

```
iris %>%
  group_by(Species) %>%
  summarise(avg = mean(Sepal.Width)) %>%
  arrange(avg)
```

Tidy Data - A foundation for wrangling in R

In a tidy data set:

F M A

Each **variable** is saved in its own **column**

&

F M A

Each **observation** is saved in its own **row**

Tidy data complements R's **vectorized operations**. R will automatically preserve observations as you manipulate variables. No other format works as intuitively with R.

M * A → F

M * A

Reshaping Data - Change the layout of a data set

tidyr::**gather(cases, "year", "n", 2:4)**

Gather columns into rows.

tidyr::**spread(pollution, size, amount)**

Spread rows into columns.

tidyr::**separate(storms, date, c("y", "m", "d"))**

Separate one column into several.

tidyr::**unite(data, col, ..., sep)**

Unite several columns into one.

dplyr::**data_frame(a = 1:3, b = 4:6)**

Combine vectors into data frame (optimized).

dplyr::**arrange(mtcars, mpg)**

Order rows by values of a column (low to high).

dplyr::**arrange(.mtcars, desc(mpg))**

Order rows by values of a column (high to low).

dplyr::**rename(tb, y = year)**

Rename the columns of a data frame.

Subset Observations (Rows)

dplyr::**filter(iris, Sepal.Length > 7)**

Extract rows that meet logical criteria.

dplyr::**distinct(iris)**

Remove duplicate rows.

dplyr::**sample_frac(iris, 0.5, replace = TRUE)**

Randomly select fraction of rows.

dplyr::**sample_n(iris, 10, replace = TRUE)**

Randomly select n rows.

dplyr::**slice(iris, 10:15)**

Select rows by position.

dplyr::**top_n(storms, 2, date)**

Select and order top n entries (by group if grouped data).

Logic in R - ?Comparison, ?base::Logic

<	Less than	!=	Not equal to
>	Greater than	%in%	Group membership
==	Equal to	is.na	Is NA
<=	Less than or equal to	!is.na	Is not NA
>=	Greater than or equal to	&,|,!,xor,any,all	Boolean operators

Subset Variables (Columns)

dplyr::**select(iris, Sepal.Width, Petal.Length, Species)**

Select columns by name or helper function.

Helper functions for select - ?select

select(iris, **contains(".")**)

Select columns whose name contains a character string.

select(iris, **ends_with("Length")**)

Select columns whose name ends with a character string.

select(iris, **everything()**)

Select every column.

select(iris, **matches(".t.")**)

Select columns whose name matches a regular expression.

select(iris, **num_range("x", 1:5)**)

Select columns named x1, x2, x3, x4, x5.

select(iris, **one_of(c("Species", "Genus"))**)

Select columns whose names are in a group of names.

select(iris, **starts_with("Sepal")**)

Select columns whose name starts with a character string.

select(iris, **Sepal.Length:Petal.Width**)

Select all columns between Sepal.Length and Petal.Width (inclusive).

select(iris, **-Species**)

Select all columns except Species.

devtools::install_github("rstudio/EDAWR") for data sets

Learn more with browseVignettes(package = c("dplyr", "tidyr")) • dplyr 0.4.0• tidyr 0.2.0 • Updated: 1/15

http://www.rstudio.com/resources/cheatsheets/

dplyr and more

DataCamp

Four courses that teach dplyr, ggvis, rmarkdown, and the RStudio IDE.

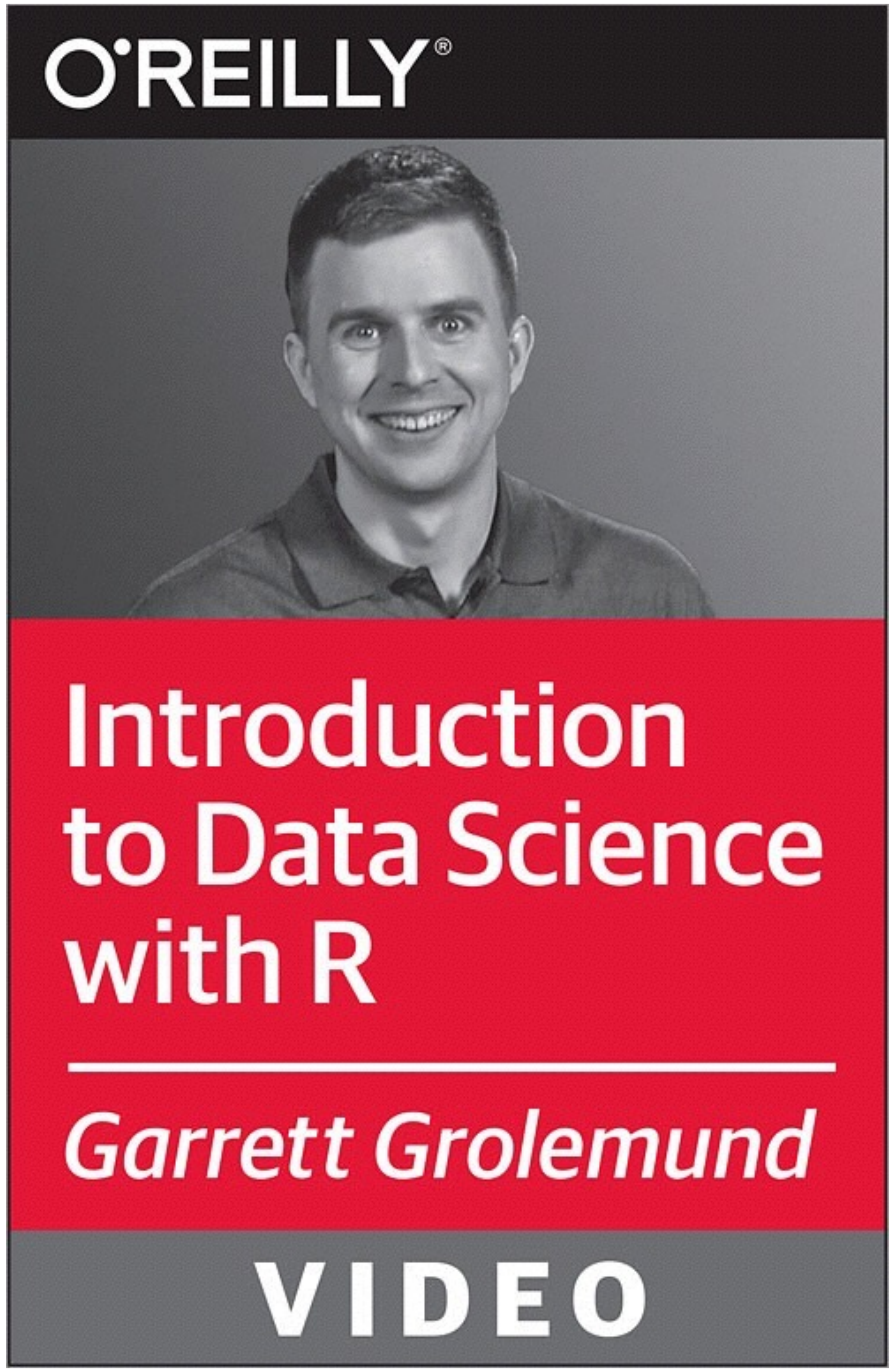
Video lessons

Live coding environment

Interactive practice

(~4 hrs worth of content for dplyr)

www.datacamp.com/tracks/rstudio-track



Data Science with R

R's tools for data science. Reshape2, dplyr, and ggplot2 packages.

- Tidy data
- Data visualization and customizing graphics
- Statistical modeling with R

bit.ly/intro-to-data-science-with-R

Expert Data Science

Coming Spring 2015

- Foundations of Data Science
- tidyr
- dplyr
- ggvis

Thank you

Data Wrangling with R

Slides at: bit.ly/wrangling-webinar