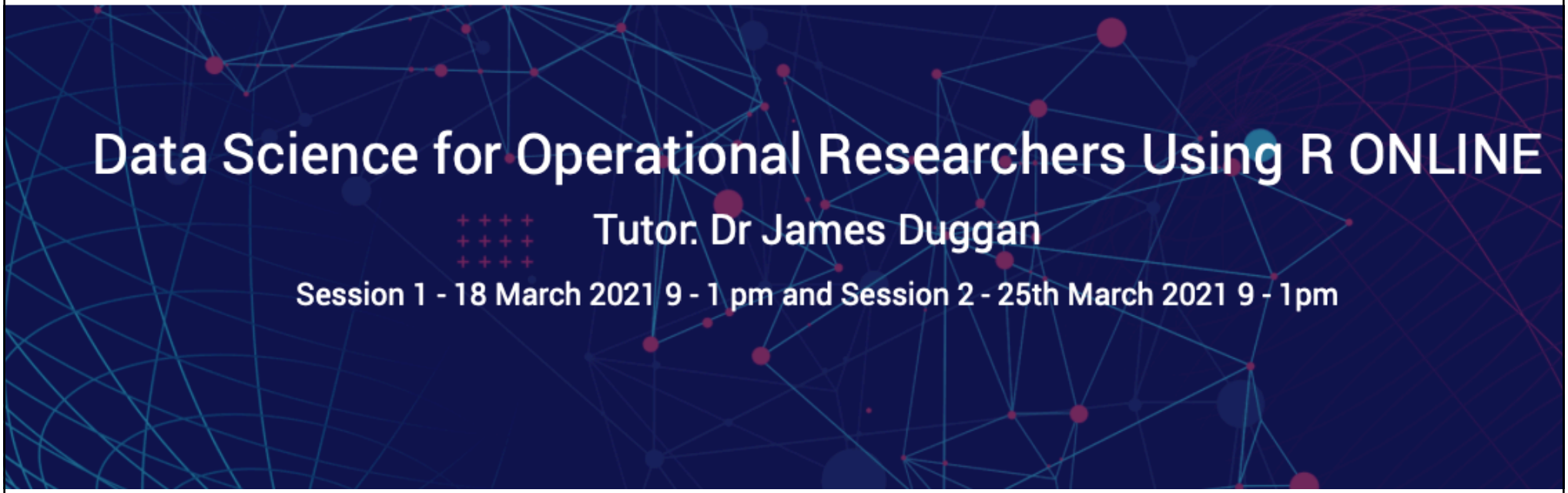


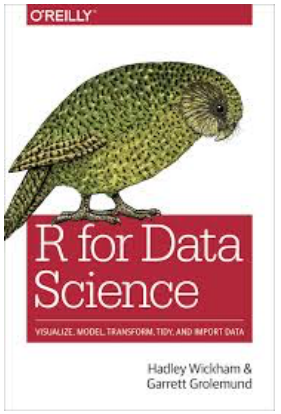
Topic 5: Data Transformation with dplyr – Part 1

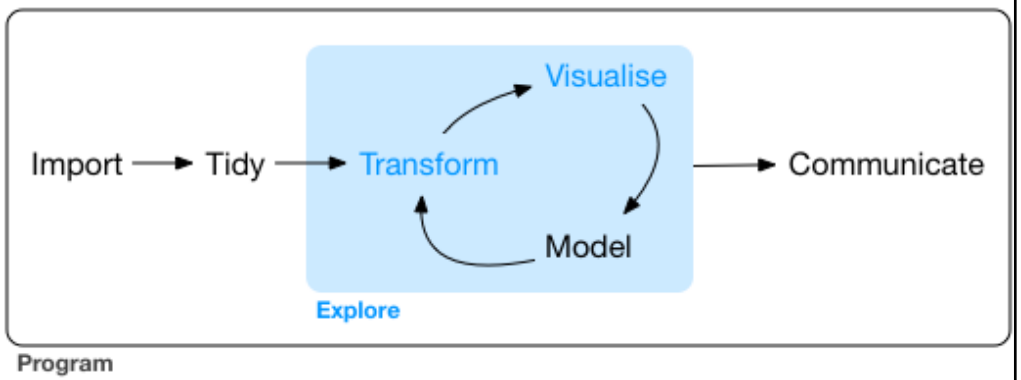
Course Overview

Topic	Description
	Session 1
1	*Introduction to R and R Studio Cloud*
2	*Exploratory Data Analysis: the tibble and ggplot2*
3	*Functions, Vectors and Lists*
4	*Introduction to Functionals with purrr*
5	*Data Transformation I with dplyr*
	Session 2
6	*Data Transformation II with dplyr*
7	*Statistical Transformation with ggplot2*
8	*Advanced Functionals and Modelling with purrr*
9	*Exploratory Data Analysis - Case Study using aimsir17*

Overview

- Visualisation is an important tool for insight generation, but it's rare that you get the data in exactly the right form you need (Wickham and Grolemund 2017)
  - Create new variables
  - Create summaries
  - Order data
- **dplyr** package is designed for data transformation





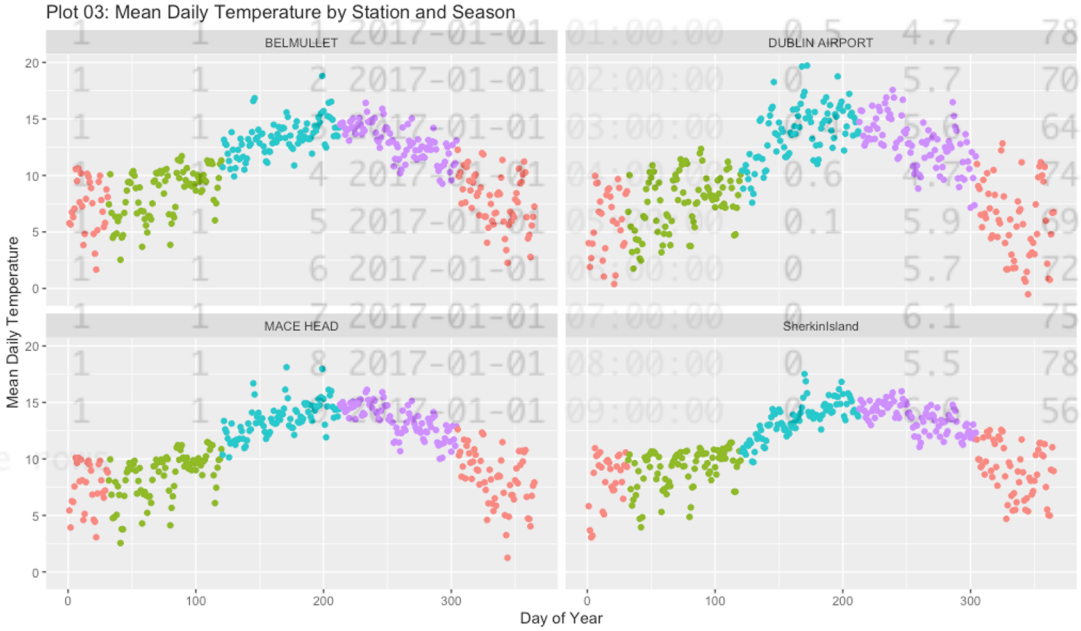
Recap - Data Frames/Tibbles

- The most common way of storing data in R
- A two-dimensional structure, with rows (observations) and columns (variables)

```
> observations
# A tibble: 219,000 x 12
   station  year month   day  hour date                rain  temp  rhum
   <chr>   <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl>
 1 ATHENRY  2017     1     1     0 2017-01-01 00:00:00   0     5.2    89
 2 ATHENRY  2017     1     1     1 2017-01-01 01:00:00   0     4.7    89
 3 ATHENRY  2017     1     1     2 2017-01-01 02:00:00   0     4.2    90
 4 ATHENRY  2017     1     1     3 2017-01-01 03:00:00   0.1   3.5    87
 5 ATHENRY  2017     1     1     4 2017-01-01 04:00:00   0.1   3.2    89
 6 ATHENRY  2017     1     1     5 2017-01-01 05:00:00   0     2.1    91
 7 ATHENRY  2017     1     1     6 2017-01-01 06:00:00   0     2      89
 8 ATHENRY  2017     1     1     7 2017-01-01 07:00:00   0     1.7    89
 9 ATHENRY  2017     1     1     8 2017-01-01 08:00:00   0     1      91
10 ATHENRY  2017     1     1     9 2017-01-01 09:00:00   0     1.1    91
# … with 218,990 more rows, and 3 more variables: msl <dbl>, wdsp <dbl>,
#   wddir <dbl>
```

aimsir17

```
> my_obs
# A tibble: 35,040 x 12
   station    year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
   <chr>     <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 BELMULLET  2017     1     1     0 2017-01-01 00:00:00     0   5.2    79  1023    13   340
 2 BELMULLET  2017     1     1     1 2017-01-01 01:00:00     0   4.7    78  1024.   15   350
 3 BELMULLET  2017     1     1     2 2017-01-01 02:00:00     0   5.7    70  1024.   16   360
 4 BELMULLET  2017     1     1     3 2017-01-01 03:00:00     0   5.6    64  1024.   19   360
 5 BELMULLET  2017     1     1     4 2017-01-01 04:00:00     0   6.1    74  1025.   20    10
 6 BELMULLET  2017     1     1     5 2017-01-01 05:00:00     0   5.9    69  1025.   20    10
 7 BELMULLET  2017     1     1     6 2017-01-01 06:00:00     0   5.7    72  1026.   20    10
 8 BELMULLET  2017     1     1     7 2017-01-01 07:00:00     0   6.1    75  1027.   21   360
 9 BELMULLET  2017     1     1     8 2017-01-01 08:00:00     0   5.5    78  1028.   24    10
10 BELMULLET  2017     1     1     9 2017-01-01 09:00:00     0   5.6    56  1028.   22    10
# … with 35,030 more
```



dplyr Basics: 5 key functions

Function	Purpose
filter()	Pick observations by their values
arrange()	Reorder the rows
select()	Pick variables by their names
mutate()	Create new variables with functions of existing variables
summarise()	Collapse many values down to a single summary

- ”A grammar of data manipulation” https://dplyr.tidyverse.org
- All verbs (functions) work similarly
  - The first argument is a data frame/tibble
  - The subsequent arguments decide what to do with the data frame/tibble
  - The result (data frame/tibble) supports chaining of steps – NOTE the “pipe operator” which we will cover later.

1. filter()

- First argument the name of the data frame
- Subsequent arguments are expressions that filter the data frame
- Subsequent arguments can be viewed as a succession of “and” statements
- Number of columns does not change
- Number of rows reduced (filtered)

```
> bel <- filter(observations,station=="BELMULLET")
> bel
# A tibble: 8,760 x 12
   station  year month   day  hour date                rain
   <chr>   <dbl> <dbl> <int> <int> <dttm>              <dbl>
 1 BELMUL… 2017     1     1     0 2017-01-01 00:00:00   0
 2 BELMUL… 2017     1     1     1 2017-01-01 01:00:00   0.5
 3 BELMUL… 2017     1     1     2 2017-01-01 02:00:00   0
 4 BELMUL… 2017     1     1     3 2017-01-01 03:00:00   0.4
 5 BELMUL… 2017     1     1     4 2017-01-01 04:00:00   0.6
 6 BELMUL… 2017     1     1     5 2017-01-01 05:00:00   0.1
 7 BELMUL… 2017     1     1     6 2017-01-01 06:00:00   0
 8 BELMUL… 2017     1     1     7 2017-01-01 07:00:00   0
 9 BELMUL… 2017     1     1     8 2017-01-01 08:00:00   0
10 BELMUL… 2017     1     1     9 2017-01-01 09:00:00   0
# … with 8,750 more rows, and 5 more variables: temp <dbl>,
#   rhum <dbl>, msl <dbl>, wdsp <dbl>, wddir <dbl>
```

Relational operators in R

Operators	Description
<	less than
<=	less than or equal to
>	greater than
>=	greater than or equal to
==	exactly equal to
!=	not equal to
!x	not x
x | y	x OR y
x & y	x AND y

```
> bel <- filter(observations,station=="BELMULLET")
> bel
# A tibble: 8,760 x 12
   station  year month   day  hour date                rain
   <chr>   <dbl> <dbl> <int> <int> <dttm>              <dbl>
 1 BELMUL… 2017     1     1     0 2017-01-01 00:00:00   0
 2 BELMUL… 2017     1     1     1 2017-01-01 01:00:00   0.5
 3 BELMUL… 2017     1     1     2 2017-01-01 02:00:00   0
 4 BELMUL… 2017     1     1     3 2017-01-01 03:00:00   0.4
 5 BELMUL… 2017     1     1     4 2017-01-01 04:00:00   0.6
 6 BELMUL… 2017     1     1     5 2017-01-01 05:00:00   0.1
 7 BELMUL… 2017     1     1     6 2017-01-01 06:00:00   0
 8 BELMUL… 2017     1     1     7 2017-01-01 07:00:00   0
 9 BELMUL… 2017     1     1     8 2017-01-01 08:00:00   0
10 BELMUL… 2017     1     1     9 2017-01-01 09:00:00   0
# … with 8,750 more rows, and 5 more variables: temp <dbl>,
#   rhum <dbl>, msl <dbl>, wdsp <dbl>, wddir <dbl>
```

Show rows for “MACE HEAD” in January

```
> mhj <- filter(observations,station=="MACE HEAD",month==1)
>
> mhj
# A tibble: 744 x 12
   station    year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
   <chr>     <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 MACE HEAD  2017     1     1     0 2017-01-01 00:00:00   0.5   5.6    88 1023.    17   340
 2 MACE HEAD  2017     1     1     1 2017-01-01 01:00:00   0     5.4    84 1023.    17   340
 3 MACE HEAD  2017     1     1     2 2017-01-01 02:00:00   0.1   4.7    87 1023.    14   340
 4 MACE HEAD  2017     1     1     3 2017-01-01 03:00:00   0     4.7    81 1023.    15   350
 5 MACE HEAD  2017     1     1     4 2017-01-01 04:00:00   0     4.5    80 1024.    12   350
 6 MACE HEAD  2017     1     1     5 2017-01-01 05:00:00   0     5      71 1024     13    20
 7 MACE HEAD  2017     1     1     6 2017-01-01 06:00:00   0     5.1    66 1024.    13    30
 8 MACE HEAD  2017     1     1     7 2017-01-01 07:00:00   0     4.8    76 1026.    19    10
 9 MACE HEAD  2017     1     1     8 2017-01-01 08:00:00   0.1   4.8    78 1026.    16   360
10 MACE HEAD  2017     1     1     9 2017-01-01 09:00:00   0.1   4.4    82 1027.    15    10
# … with 734 more rows
```

Useful approaches for filtering more than one value

- %in% operator in R

```
> filter(observations,station %in% c("ATHENRY","MACE HEAD"),month==1,day==1,hour==12)
# A tibble: 2 x 12
  station    year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
  <chr>     <dbl> <dbl> <int> <int> <dttm>             <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
1 ATHENRY    2017     1     1    12 2017-01-01 12:00:00     0   5.1    75 1027.    11   360
2 MACE HEAD  2017     1     1    12 2017-01-01 12:00:00     0   6.7    67 1028.    16    20
>
> filter(observations,station == "ATHENRY" | station == "MACE HEAD",month==1,day==1,hour==12)
# A tibble: 2 x 12
  station    year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
  <chr>     <dbl> <dbl> <int> <int> <dttm>             <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
1 ATHENRY    2017     1     1    12 2017-01-01 12:00:00     0   5.1    75 1027.    11   360
2 MACE HEAD  2017     1     1    12 2017-01-01 12:00:00     0   6.7    67 1028.    16    20
```

Challenge 5.1

- Show the weather for “ROCHES POINT” on October 16th at 12 midday

2. arrange()

- Changes the order of rows.
- Used for sorting values
- Takes a tibble and a set of column names to order by

```
> arrange(observations,temp)
# A tibble: 219,000 x 12
   station     year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
   <chr>      <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 CASEMENT    2017    12    11     4 2017-12-11 04:00:00     0  -6.2    91  989.     5   250
 2 GURTEEN     2017    12    11     3 2017-12-11 03:00:00     0  -6      94  989.     2   240
 3 GURTEEN     2017    12    11     4 2017-12-11 04:00:00     0  -6      95  990.     1   240
 4 GURTEEN     2017    12    11     1 2017-12-11 01:00:00     0  -5.9    92  988.     3   230
 5 GURTEEN     2017    12    11     5 2017-12-11 05:00:00     0  -5.8    95  990.     1   260
 6 GURTEEN     2017    12    11     0 2017-12-11 00:00:00     0  -5.7    94  988      2   280
 7 CASEMENT    2017    12    11     2 2017-12-11 02:00:00     0  -5.6    92  988.     4   230
 8 GURTEEN     2017    12    11     2 2017-12-11 02:00:00     0  -5.6    94  989.     3   230
 9 MOORE PARK  2017     1     3     9 2017-01-03 09:00:00     0  -5.6    91 1033.     1   330
10 CASEMENT    2017    12    11     3 2017-12-11 03:00:00     0  -5.4    92  988.     4   250
# … with 218,990 more rows
```

Mean Sea Level Pressure

```
> arrange(observations,msl)
# A tibble: 219,000 x 12
   station              year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
   <chr>               <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 VALENTIA OBSERVATORY 2017    10    16    11 2017-10-16 11:00:00   9.8  14.6    95  962.    24   100
 2 BELMULLET            2017     2     2    20 2017-02-02 20:00:00   2.5   9.4    94  964.    25   140
 3 BELMULLET            2017     2     2    19 2017-02-02 19:00:00   0     9.3    89  964.    15   140
 4 BELMULLET            2017     2     2    18 2017-02-02 18:00:00   0.1   9.4    87  965.    17   140
 5 MACE HEAD            2017     2     2    15 2017-02-02 15:00:00   0.2  10.1    86  965.    23   120
 6 BELMULLET            2017     2     2    17 2017-02-02 17:00:00   0.3   9.6    88  965     18   140
 7 MACE HEAD            2017     2     2    16 2017-02-02 16:00:00   0.4   9.7    90  965.    19   140
 8 MACE HEAD            2017     2     2    17 2017-02-02 17:00:00   0.2   9.5    90  965.    17   140
 9 BELMULLET            2017     2     2    16 2017-02-02 16:00:00   0    10.6    79  965.    18   140
10 MACE HEAD            2017     2     2    14 2017-02-02 14:00:00   0    10.8    82  966.    22   120
# … with 218,990 more rows
```

Humidity

```
> arrange(observations,rhum)
# A tibble: 219,000 x 12
   station        year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
   <chr>         <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 SherkinIsland  2017    11    23     5 2017-11-23 05:00:00   0     8.6    20  991.    29   260
 2 SherkinIsland  2017    11    28    13 2017-11-28 13:00:00   0     7.9    20 1019.    11   320
 3 SherkinIsland  2017    11    28    14 2017-11-28 14:00:00   0     8.1    20 1018.    11   330
 4 SherkinIsland  2017    11    18    23 2017-11-18 23:00:00   0    11.9    21 1024.    11   260
 5 SherkinIsland  2017    11    19     5 2017-11-19 05:00:00   0    11.5    21 1024.     8   260
 6 SherkinIsland  2017    11    19     7 2017-11-19 07:00:00   0    10.4    21 1024.     4   220
 7 SherkinIsland  2017    11    21     8 2017-11-21 08:00:00   1.4  12.8    21 1006.    20   200
 8 SherkinIsland  2017    11    22     1 2017-11-22 01:00:00   2.5  12.8    21  995.    19   210
 9 SherkinIsland  2017    11    23    18 2017-11-23 18:00:00   0     8.2    21 1005.     6    10
10 SherkinIsland  2017    11    24    15 2017-11-24 15:00:00   0     6.1    21 1015.     8   320
# … with 218,990 more rows
```

More than one value

```
> arrange(observations,month,temp)
# A tibble: 219,000 x 12
   station     year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
   <chr>      <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 MOORE PARK  2017     1     3     9 2017-01-03 09:00:00     0  -5.6    91 1033.     1   330
 2 MOORE PARK  2017     1     3     8 2017-01-03 08:00:00     0  -5.4    91 1033.     1   160
 3 MARKREE     2017     1    23     4 2017-01-23 04:00:00     0  -5.1    96 1024.    NA    NA
 4 MOORE PARK  2017     1     3     7 2017-01-03 07:00:00     0  -5.1    92 1033.     1   250
 5 MARKREE     2017     1    23     5 2017-01-23 05:00:00     0  -5      98 1024.    NA    NA
 6 MARKREE     2017     1    23     2 2017-01-23 02:00:00     0  -4.8    97 1025.    NA    NA
 7 MARKREE     2017     1    23     3 2017-01-23 03:00:00     0  -4.8    98 1025.    NA    NA
 8 MOORE PARK  2017     1     3     6 2017-01-03 06:00:00     0  -4.8    92 1033.     1   270
 9 MT DILLON   2017     1    21     8 2017-01-21 08:00:00     0  -4.6    96 1027.     2   350
10 MARKREE     2017     1    23     1 2017-01-23 01:00:00     0  -4.4    96 1026.    NA    NA
# … with 218,990 more rows
```

In descending order - desc()

```
> arrange(observations,desc(temp))
# A tibble: 219,000 x 12
   station       year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
   <chr>        <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 PHOENIX PARK  2017     6    21    13 2017-06-21 13:00:00   0.1  28.3    51 1010     NA    NA
 2 PHOENIX PARK  2017     6    21    12 2017-06-21 12:00:00   0    27.5    54 1011.    NA    NA
 3 PHOENIX PARK  2017     6    21    14 2017-06-21 14:00:00   0    27.5    49 1010.    NA    NA
 4 PHOENIX PARK  2017     6    21    16 2017-06-21 16:00:00   0    26.8    61 1009.    NA    NA
 5 CASEMENT      2017     6    21    12 2017-06-21 12:00:00   0    26.6    54 1011.    11   150
 6 MOORE PARK    2017     6    19    16 2017-06-19 16:00:00   0    26.6    50 1018.     3   200
 7 DUNSANY       2017     6    21    12 2017-06-21 12:00:00   0    26.5    55 1010.     8   150
 8 PHOENIX PARK  2017     6    21    11 2017-06-21 11:00:00   0    26.5    56 1011.    NA    NA
 9 PHOENIX PARK  2017     6    17    16 2017-06-17 16:00:00   0    26.4    42 1024.    NA    NA
10 PHOENIX PARK  2017     6    21    15 2017-06-21 15:00:00   0    26.4    61 1009.    NA    NA
# … with 218,990 more rows
```

Mean Sea Level Pressure

```
> arrange(observations,desc(msl))
# A tibble: 219,000 x 12
   station              year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
   <chr>               <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 VALENTIA OBSERVATORY 2017    12    22    19 2017-12-22 19:00:00   0     9.7    97 1039.    NA    NA
 2 VALENTIA OBSERVATORY 2017    12    22    18 2017-12-22 18:00:00   0     9.9    98 1039     NA    NA
 3 VALENTIA OBSERVATORY 2017    12    22    11 2017-12-22 11:00:00   0    10.3    97 1039.    NA    NA
 4 VALENTIA OBSERVATORY 2017    12    22    20 2017-12-22 20:00:00   0.2   9.5    98 1039.    NA    NA
 5 VALENTIA OBSERVATORY 2017    12    22    21 2017-12-22 21:00:00   0.2   9.5    97 1039.    NA    NA
 6 CORK AIRPORT         2017    12    22    21 2017-12-22 21:00:00   0     8.9   100 1039.     4   260
 7 CORK AIRPORT         2017    12    22    20 2017-12-22 20:00:00   0     9.4    99 1039.     3   290
 8 SherkinIsland        2017    12    22    19 2017-12-22 19:00:00   0     9      95 1039.     6   250
 9 SherkinIsland        2017    12    22    20 2017-12-22 20:00:00   0.1   9      96 1039.     3   280
10 VALENTIA OBSERVATORY 2017    12    22    12 2017-12-22 12:00:00   0    10.4    98 1039.    NA    NA
# … with 218,990 more rows
```

Windspeed

```
> arrange(observations,desc(wdsp))
# A tibble: 219,000 x 12
   station        year month   day  hour date                rain  temp  rhum   msl  wdsp wddir
   <chr>         <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 ROCHES POINT   2017    10    16    12 2017-10-16 12:00:00   1.3  12      96  983.    59   180
 2 ROCHES POINT   2017    10    16    11 2017-10-16 11:00:00   0.2  11.7    88  983.    55   160
 3 SherkinIsland  2017    10    16    11 2017-10-16 11:00:00   0    13.4    92  975.    52   170
 4 MACE HEAD      2017     2    23     2 2017-02-23 02:00:00   0     7.6    86  985.    50   250
 5 ROCHES POINT   2017    10    16    13 2017-10-16 13:00:00   1    12.9    98  986.    50   190
 6 MACE HEAD      2017     2    23     3 2017-02-23 03:00:00   0     7      84  987     48   270
 7 MALIN HEAD     2017    12    31     7 2017-12-31 07:00:00   0.1   7      84  974.    48   250
 8 SherkinIsland  2017    10    16    10 2017-10-16 10:00:00   0.7  11.4    97  974.    47   150
 9 MACE HEAD      2017     2    23     4 2017-02-23 04:00:00   0     7.2    86  990.    46   290
10 MACE HEAD      2017    12    31     2 2017-12-31 02:00:00   0     8.2    78  979.    46   240
# … with 218,990 more rows
```

Challenge 5.2

- Arrange the observations by month and by highest temperature

3. select()

- It is not uncommon to get datasets with hundreds, or even thousands, of variables
- A challenge is to narrow down on the variables of you're interested in
- select() allows you to rapidly zoom in on a useful subset using operations based on the variable names
- Number of rows does not change

```
> new_obs <- select(observations,station,year,month,day,hour,temp)
> new_obs
# A tibble: 219,000 x 6
   station  year month   day  hour  temp
   <chr>   <dbl> <dbl> <int> <int> <dbl>
 1 ATHENRY  2017     1     1     0   5.2
 2 ATHENRY  2017     1     1     1   4.7
 3 ATHENRY  2017     1     1     2   4.2
 4 ATHENRY  2017     1     1     3   3.5
 5 ATHENRY  2017     1     1     4   3.2
 6 ATHENRY  2017     1     1     5   2.1
 7 ATHENRY  2017     1     1     6   2
 8 ATHENRY  2017     1     1     7   1.7
 9 ATHENRY  2017     1     1     8   1
10 ATHENRY  2017     1     1     9   1.1
# … with 218,990 more rows
```

Useful options with select()

```
> select(observations,station:rain)
# A tibble: 219,000 x 7
   station  year month   day  hour date                rain
   <chr>   <dbl> <dbl> <int> <int> <dttm>              <dbl>
 1 ATHENRY  2017     1     1     0 2017-01-01 00:00:00   0
 2 ATHENRY  2017     1     1     1 2017-01-01 01:00:00   0
 3 ATHENRY  2017     1     1     2 2017-01-01 02:00:00   0
 4 ATHENRY  2017     1     1     3 2017-01-01 03:00:00   0.1
 5 ATHENRY  2017     1     1     4 2017-01-01 04:00:00   0.1
 6 ATHENRY  2017     1     1     5 2017-01-01 05:00:00   0
 7 ATHENRY  2017     1     1     6 2017-01-01 06:00:00   0
 8 ATHENRY  2017     1     1     7 2017-01-01 07:00:00   0
 9 ATHENRY  2017     1     1     8 2017-01-01 08:00:00   0
10 ATHENRY  2017     1     1     9 2017-01-01 09:00:00   0
# … with 218,990 more rows
```

```
> select(observations,-(station:rain))
# A tibble: 219,000 x 5
    temp  rhum   msl  wdsp wddir
   <dbl> <dbl> <dbl> <dbl> <dbl>
 1   5.2    89 1022.     8   320
 2   4.7    89 1022      9   320
 3   4.2    90 1022.     8   320
 4   3.5    87 1022.     9   330
 5   3.2    89 1023.     8   330
 6   2.1    91 1023.     8   330
 7   2      89 1024.     7   330
 8   1.7    89 1024.     7   340
 9   1      91 1025      7   330
10   1.1    91 1026.     8   330
# … with 218,990 more rows
```

Special functions with select()

Special functions

As well as using existing functions like `:` and `c`, there are a number of special functions that only work inside `select`

- `starts_with(x, ignore.case = TRUE)`: names starts with `x`
- `ends_with(x, ignore.case = TRUE)`: names ends in `x`
- `contains(x, ignore.case = TRUE)`: selects all variables whose name contains `x`
- `matches(x, ignore.case = TRUE)`: selects all variables whose name matches the regular expression `x`
- `num_range("x", 1:5, width = 2)`: selects all variables (numerically) from x01 to x05.
- `one_of("x", "y", "z")`: selects variables provided in a character vector.
- `everything()`: selects all variables.

Examples

```
> select(observations,starts_with("w"))
# A tibble: 219,000 x 2
    wdsp wddir
   <dbl> <dbl>
 1     8   320
 2     9   320
 3     8   320
 4     9   330
 5     8   330
 6     8   330
 7     7   330
 8     7   340
 9     7   330
10     8   330
# … with 218,990 more rows
```

```
> select(observations,ends_with("p"))
# A tibble: 219,000 x 2
    temp  wdsp
   <dbl> <dbl>
 1   5.2     8
 2   4.7     9
 3   4.2     8
 4   3.5     9
 5   3.2     8
 6   2.1     8
 7   2       7
 8   1.7     7
 9   1       7
10   1.1     8
# … with 218,990 more rows
```

everything()

```
> select(observations,ends_with("p"),everything())
# A tibble: 219,000 x 12
    temp  wdsp station  year month   day  hour date                rain  rhum   msl wddir
   <dbl> <dbl> <chr>   <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl>
 1   5.2     8 ATHENRY  2017     1     1     0 2017-01-01 00:00:00   0      89 1022.   320
 2   4.7     9 ATHENRY  2017     1     1     1 2017-01-01 01:00:00   0      89 1022    320
 3   4.2     8 ATHENRY  2017     1     1     2 2017-01-01 02:00:00   0      90 1022.   320
 4   3.5     9 ATHENRY  2017     1     1     3 2017-01-01 03:00:00   0.1    87 1022.   330
 5   3.2     8 ATHENRY  2017     1     1     4 2017-01-01 04:00:00   0.1    89 1023.   330
 6   2.1     8 ATHENRY  2017     1     1     5 2017-01-01 05:00:00   0      91 1023.   330
 7   2       7 ATHENRY  2017     1     1     6 2017-01-01 06:00:00   0      89 1024.   330
 8   1.7     7 ATHENRY  2017     1     1     7 2017-01-01 07:00:00   0      89 1024.   340
 9   1       7 ATHENRY  2017     1     1     8 2017-01-01 08:00:00   0      91 1025    330
10   1.1     8 ATHENRY  2017     1     1     9 2017-01-01 09:00:00   0      91 1026.   330
# … with 218,990 more rows
```

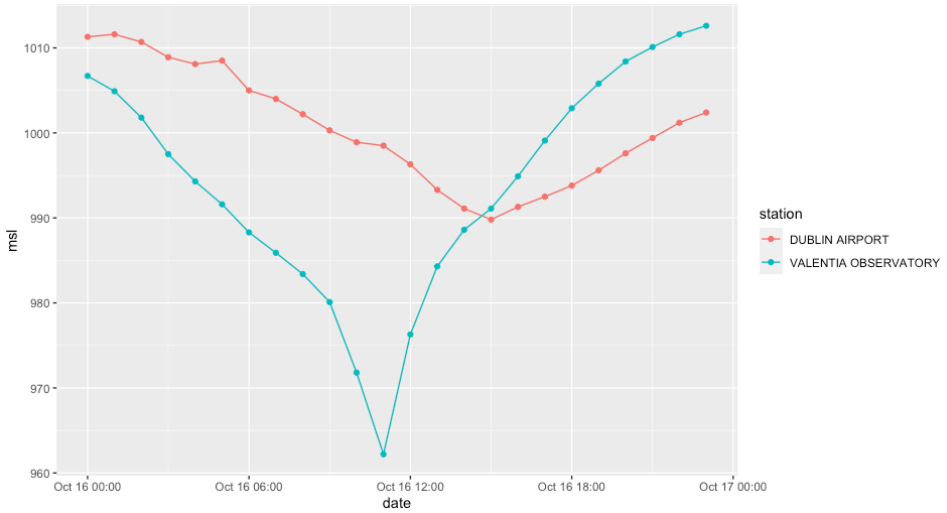
Summary: 3 of the 5 verbs

Function	Purpose
filter()	Pick observations by their values
arrange()	Reorder the rows
select()	Pick variables by their names
mutate()	*Create new variables with functions of existing variables*
summarise()	*Collapse many values down to a single summary*

- ”A grammar of data manipulation” https://dplyr.tidyverse.org
- All verbs (functions) work similarly
  - The first argument is a data frame/tibble
  - The subsequent arguments decide what to do with the data frame/tibble
  - The result (data frame/tibble) supports chaining of steps – NOTE the “pipe operator” which we will cover later.

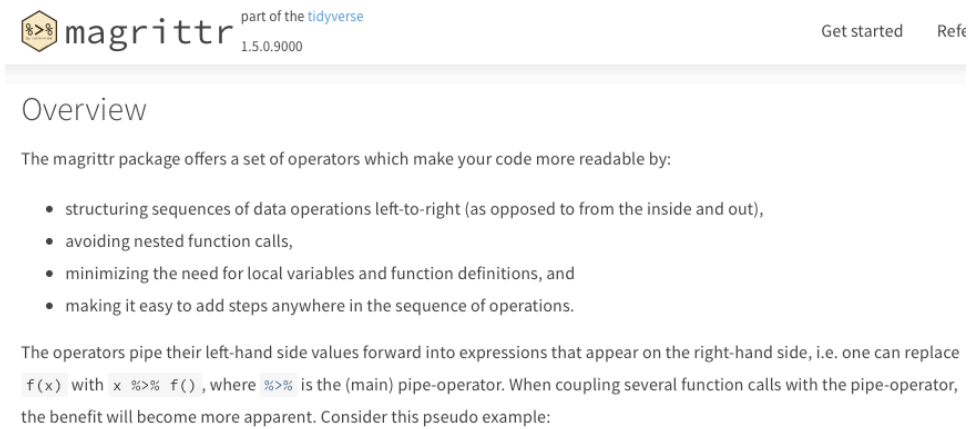
Challenge 5.3

- Create tibble one that has the columns month, hour, day, date, station and msl
- Filter the tibble to a second tibble for October 16th, and for “VALENTIA OBSERVATORY” and “DUBLIN AIRPORT”
- Display the hourly values on a time series (x axis is date) using ggplot2 with the aesthetic set to station



Combining operations with the Pipe

- The pipe %>% comes from the magrittr package (Stefan Milton Bache)
- Helps to write code that is easier to read and understand
- x %>% f(y) turns into f(x, y)
- x %>% f(y) %>% g(z) turns into g(f(x, y),z)



https://magrittr.tidyverse.org

```
> sqrt(1:5)
[1] 1.000000 1.414214 1.732051 2.000000 2.236068
> 1:5 %>% sqrt()
[1] 1.000000 1.414214 1.732051 2.000000 2.236068
```

Examples

```
> observations %>% filter(day==1,station=="ATHENRY",hour==12,month==1)
# A tibble: 1 x 12
  station  year month   day  hour date                rain  temp  rhum   msl
  <chr>   <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl>
1 ATHENRY  2017     1     1    12 2017-01-01 12:00:00     0   5.1    75 1027.
# … with 2 more variables: wdsp <dbl>, wddir <dbl>
> observations %>% filter(station=="MACE HEAD") %>% arrange(desc(temp)) %>% head()
# A tibble: 6 x 12
  station  year month   day  hour date                rain  temp  rhum   msl
  <chr>   <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl> <dbl> <dbl>
1 MACE H…  2017     6    20    17 2017-06-20 17:00:00     0  22.7    69 1015.
2 MACE H…  2017     6    20    16 2017-06-20 16:00:00     0  22.6    67 1016.
3 MACE H…  2017     6    20    18 2017-06-20 18:00:00     0  22.3    71 1015.
4 MACE H…  2017     7    18    16 2017-07-18 16:00:00     0  22.3    61 1008.
5 MACE H…  2017     7    18    18 2017-07-18 18:00:00     0  22.2    65 1007.
6 MACE H…  2017     6    20    15 2017-06-20 15:00:00     0  22.1    68 1017.
# … with 2 more variables: wdsp <dbl>, wddir <dbl>
```

dplyr Basics: 5 key functions

Function	Purpose
filter()	*Pick observations by their values*
arrange()	*Reorder the rows*
select()	*Pick variables by their names*
mutate()	Create new variables with functions of existing variables
summarise()	Collapse many values down to a single summary

- ”A grammar of data manipulation” https://dplyr.tidyverse.org
- All verbs (functions) work similarly
  - The first argument is a data frame/tibble
  - The subsequent arguments decide what to do with the data frame/tibble
  - The result (data frame/tibble) supports chaining of steps – NOTE the “pipe operator” which we will cover later.

4. mutate()

- It is often useful to add new columns that are functions of existing columns
- mutate() always adds new columns at the end of your data set.
- For example, convert the mph wind speed in observations to a new column, kph.
- Use a simplified observations tibble with day, month, station, wdsp as columns, and for “ROCHES POINT” on October 16th
- Assume 1 mi = 1.609344 km

Example of mutate

```
library(aimsir17)
library(dplyr)

CM2K <- 1.609344

obs1 <- observations %>% select(day, month, station, wdsp) %>%
          filter(station=="ROCHES POINT", day==16,month==10)

obs1 <- mutate(obs1, wdsp_kph=wdsp*CM2K)
```

```
> obs1
# A tibble: 24 x 5
     day month station       wdsp wdsp_kph
   <int> <dbl> <chr>        <dbl>    <dbl>
 1    16    10 ROCHES POINT    11     17.7
 2    16    10 ROCHES POINT    11     17.7
 3    16    10 ROCHES POINT    14     22.5
 4    16    10 ROCHES POINT    15     24.1
 5    16    10 ROCHES POINT    22     35.4
```

Useful Creation Functions

- There are many functions for creating new variables that can be used with mutate()
- The key property is that the function **must be vectorised:**
  - It must take a vector of values as input, and,
  - Return a vector with the same number of values as output

Grouping	Examples
Arithmetic Operators	+, -, *, /, ^
Modular Arithmetic	%/% - Integer division && - Remainder
Logical comparisons	<, <=, >, >=, !=
If-else Functions	ifelse(), case_when()

Challenge 8.1

- Add a new column rain_in, which measures the hourly rainfall in inches
- Assume a conversion constant of 1 mm = 0.0393701 inches

dplyr Basics: 5 key functions

Function	Purpose
filter()	Pick observations by their values
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summarise()	Collapse many values down to a single summary

- All verbs (functions) work similarly
  - The first argument is a data frame
  - The subsequent arguments decide what to do with the data frame
  - The result is a data frame (supports chaining of steps)

5. summarise()

- The last key verb is summarise()
- It collapses a data frame into a single row
- Not very useful unless paired with group_by()
- Very useful to combine with the pipe operator

```
test <- filter(observations,
               station=="MACE HEAD",
               month==10)
```

group_by()

- Most data operations are useful done on groups defined by variables in the the dataset.
- The group_by function takes an existing tbl and converts it into a grouped tbl where operations are performed "by group".

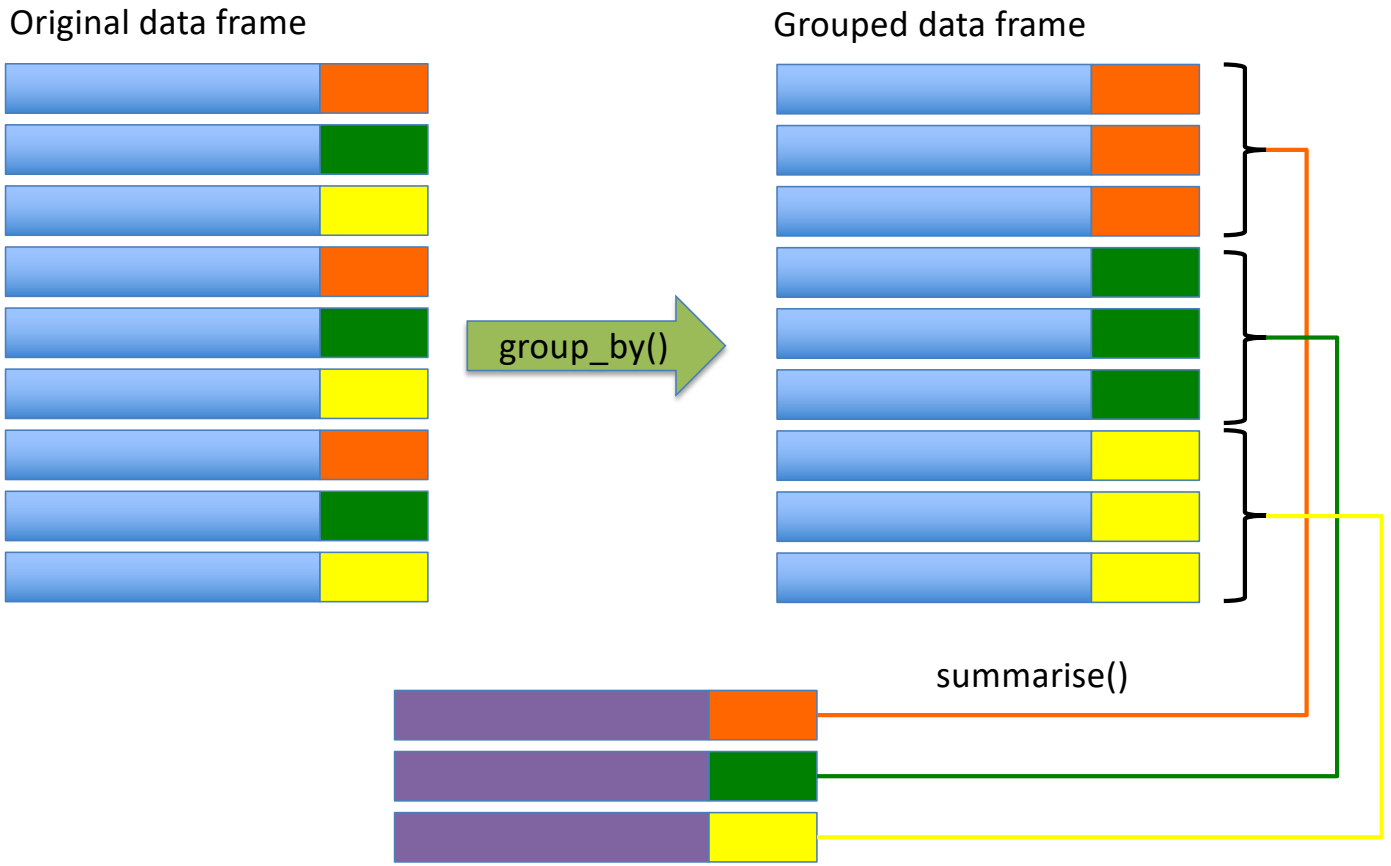
```
> test_g <- group_by(test,day)
> test_g
# A tibble: 744 x 12
# Groups:   day [31]
   station  year month   day  hour date                rain  temp
   <chr>   <dbl> <dbl> <int> <int> <dttm>              <dbl> <dbl>
 1 MACE H… 2017    10     1     0 2017-10-01 00:00:00   1.2  11.7
 2 MACE H… 2017    10     1     1 2017-10-01 01:00:00   1.9  11.3
```

Key idea

- This grouping can then be exploited by summarise

```
> summarise(test_g,TotalRainfall=sum(rain,na.rm=T))
# A tibble: 31 x 2
     day TotalRainfall
   <int>         <dbl>
 1     1           4.7
 2     2           1.3
 3     3           0
 4     4           4.2
 5     5           0.1
 6     6           3.1
 7     7           0.4
 8     8           0.3
 9     9           1.7
10    10           1.6
# … with 21 more rows
```

Overall idea…



Useful Summary Functions

Grouping	Examples
Measures of location	mean(), median()
Measures of spread	sd(), IQR(),mad()
Measures of rank	min((), quantile(), max()
Measures of position	first(), nth(), last()
Counts	n(), n_distinct()
Counts and proportions of logical values	sum(x>0) when used with numeric functions, (T,F) converted to (1,0)

Challenge 8.2

- For “BELMULLET” calculate the total daily rainfall for October, and show using ggplot.

dplyr Summary: 5 key functions

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- ”A grammar of data manipulation” https://dplyr.tidyverse.org
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dplyr 0.7.0, some new additions

- Two new data sets: starwars and storms
- pull() verb
- case_when(), valuable for mutate operations instead of nested ifs

```
> starwars
# A tibble: 87 x 13
                   name height  mass    hair_color
                  <chr>  <int> <dbl>         <chr>
 1     Luke Skywalker    172    77         blond
 2              C-3PO    167    75          <NA>
 3              R2-D2     96    32          <NA>
 4        Darth Vader    202   136          none
 5        Leia Organa    150    49         brown
 6          Owen Lars    178   120   brown, grey
 7 Beru Whitesun lars    165    75         brown
 8              R5-D4     97    32          <NA>
 9  Biggs Darklighter    183    84         black
10     Obi-Wan Kenobi    182    77 auburn, white
# ... with 77 more rows, and 9 more variables:
#   skin_color <chr>, eye_color <chr>, birth_year <dbl>,
#   gender <chr>, homeworld <chr>, species <chr>,
#   films <list>, vehicles <list>, starships <list>
```

pull() – Select 1 column as a vector

```
> select(mpg,hwy)
# A tibble: 234 x 1
     hwy
   <int>
 1    29
 2    29
 3    31
 4    30
 5    26
 6    26
 7    27
 8    26
 9    25
10    28
# ... with 224 more rows
```

```
> pull(mpg,hwy)
  [1] 29 29 31 30 26 26 27 26 25 28 27 25
 [13] 25 25 25 24 25 23 20 15 20 17 17 26
 [25] 23 26 25 24 19 14 15 17 27 30 26 29
 [37] 26 24 24 22 22 24 24 17 22 21 23 23
 [49] 19 18 17 17 19 19 12 17 15 17 17 12
 [61] 17 16 18 15 16 12 17 17 16 12 15 16
 [73] 17 15 17 17 18 17 19 17 19 19 17 17
 [85] 17 16 16 17 15 17 26 25 26 24 21 22
 [97] 23 22 20 33 32 32 29 32 34 36 36 29
[109] 26 27 30 31 26 26 28 26 29 28 27 24
[121] 24 24 22 19 20 17 12 19 18 14 15 18
[133] 18 15 17 16 18 17 19 19 17 29 27 31
[145] 32 27 26 26 25 25 17 17 20 18 26 26
[157] 27 28 25 25 24 27 25 26 23 26 26 26
[169] 26 25 27 25 27 20 20 19 17 20 17 29
```

pull() – Also works with column numbers, default is last column

```
> head(pull(mpg))
[1] "compact" "compact" "compact" "compact"
[5] "compact" "compact"
>
> head(pull(mpg,1))
[1] "audi" "audi" "audi" "audi" "audi"
[6] "audi"
>
> head(pull(mpg,-1))
[1] "compact" "compact" "compact" "compact"
[5] "compact" "compact"
```

case_when()

- This function allows you to vectorise multiple if and else if statements. It is an R equivalent of the SQL CASE WHEN statement. Arguments:
  - A sequence of two-sided formulas. The left hand side (LHS) determines which values match this case. The right hand side (RHS) provides the replacement value.
  - The LHS must evaluate to a logical vector. Each logical vector can either have length 1 or a common length. All RHSs must evaluate to the same type of vector.
  - Proceed from the most specific to the most general

Very useful in mutate()

```
starwars %>%
  select(name:mass, gender, species) %>%
  mutate(
    type = case_when(
      height > 200 | mass > 200 ~ "large",
      species == "Droid"        ~ "robot",
      TRUE                      ~  "other"
    )
  )
```

```
# A tibble: 87 x 6
                 name height  mass gender species  type
                <chr>  <int> <dbl>  <chr>   <chr> <chr>
 1     Luke Skywalker    172    77   male   Human other
 2              C-3PO    167    75   <NA>   Droid robot
```