Solar Cyles

Team Blue

3/30/2022

Loading libraries

```
library(tidyverse)
library(lubridate)
library(timetk)
```

```
## Warning: package 'timetk' was built under R version 4.1.3
```

1

```
sunspots <- read_delim(
  "SN_d_tot_V2.0.csv",
  delim = ";",
  escape_double = FALSE,
  col_names = c(
    "year",
    "month",
    "day",
    "year_fraction",
    "ss_number",
    "sd",
    "n_obs",
    "definitive"
  ),
  col_types = "iiininii",
  na = c("-1", "-1.0"),
  trim_ws = TRUE
)
```

The variables are year, month, day, date in fraction of year, daily total sunspot number, daily standard deviation of the sunspot numbers, number of observations, and definitive/provisional indicator, respectively.

Missing values are “-1” or “-1.0”.

Nice explanation.

2

```
sunspots <- mutate(sunspots, date = make_date(year, month, day))
```

3

```
my_stamp <- function(x) {
  stamp("Tuesday, 3 December, 2019", quiet = TRUE)(x)
}

sunspots |>
  filter(is.na(ss_number)) |>
  slice_max(n = 1, date) |>
  pull(date) |>
  my_stamp()
```

For a shorter solution, you don't have to use a function and use slice_tail() instead of slice_max():
D <- spots |>
filter(is.na(ss_number)) |>
slice_tail() |>
pull(date)

stamp("Tuesday, 3 December, 2019")(D)

```
## [1] "Friday, 22 December, 1848"
```

4

```
sunspots <-
  sunspots |>
  mutate(diff_to_prev_data = date - lag(date))

# Checking if all data points have a difference of 1 day from the previous data.
all(sunspots$diff_to_prev_data == 1, na.rm = TRUE)
```

```
## [1] TRUE
```

Yes, they are all consecutive.

5

```
spots <-
  sunspots |>
  summarise_by_time(
    date,
    .by = "month",
    mean_daily_ss_number = mean(ss_number, na.rm = TRUE)
  ) |>
  filter(date >= ymd("1975-01-01"))
```

6

```
solar_cycles <-
  read_csv("solar_cycles.csv") |>
  mutate(
    `Start (Minimum)` = ym(`Start (Minimum)`),
    Maximum = ym(Maximum)
  )
```

7

```
### SOLVE###
solar_cycles <-
  solar_cycles |>
  mutate(
    isequal = round(
      interval(
        `Start (Minimum)`, Maximum
      ) / years(1),
      digits = 1
    ) == `Time of Rise (years)`
  )
table(solar_cycles$isequal)
```

A slightly shorter solution without using isequal could be done like this:

```
time_elapsed <- round(
  time_length(
    difftime(
      solar_cycles$Maximum,
      solar_cycles$`Start (Minimum)`
    ),
    "years"
  ),
  1
)
all(solar_cycles$`Time of Rise (years)` == time_elapsed)
```

```
##
## FALSE  TRUE
##     2    22
```

All are equal except two entries.

8

```
solar_cycles <- filter(solar_cycles, `Start (Minimum)` >= ymd("1975-01-01"))
```

9

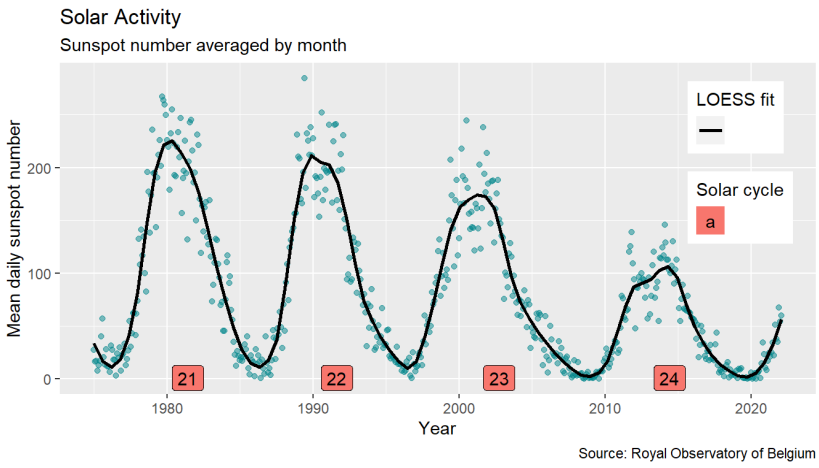
```
solar_cycles <-
  solar_cycles |>
  mutate(
    next_start = lead(`Start (Minimum)`),
    mid_date = `Start (Minimum)` + ((next_start - `Start (Minimum)`) / 2),
    next_start = NULL
  )
```

10

```
solar_cycles <-
  solar_cycles |>
  mutate(`Solar Cycle Number` = 21:25)

ggplot(data = spots, aes(date, mean_daily_ss_number)) +
  geom_point(alpha = 0.5, color = "turquoise4") +
  labs(
    title = "Solar Activity",
    subtitle = "Sunspot number averaged by month",
    caption = "Source: Royal Observatory of Belgium",
    x = "Year",
    y = "Mean daily sunspot number",
    linetype = "LOESS fit",
    label = "Solar cycle",
    fill = "Solar cycle"
  ) +
  geom_smooth(se = FALSE, span = 0.1, color = "black", aes(linetype = "")) +
  geom_label(
    data = solar_cycles,
    aes(mid_date, 1, label = `Solar Cycle Number`, fill = "")
  ) +
  theme(legend.position = c(0.9, 0.70))
```

```
## Warning: Removed 1 rows containing missing values (geom_label).
```



Nice plot!

11

The plot reveals that sunspot density generally happens in cycles. We see that there is a trough, whereby there is generally lower sunspot density around the years of 1976, 1986, 1997, 2009, 2019. We also see there is a peak, whereby there is generally higher sunspot density around the years of 1980, 1990, 2002, 2014. This is plausible, as solar eclipses and other solar occurrences also happen on a cyclical basis. What is interesting is that the peaks are seen to have a decreasing trend over the past 40 years and I speculate that this may be due to climate change. Increased CO2 in the atmosphere may reduce the number of sunspots visible on the sun.

Nice explanation and explanation behind the decreases!

Code execution - 2 marks
Code design - 1 mark
Coding style - 2 marks
Code comments - 2 marks
Text answers - 2 marks
Figures and tables - 2 marks

Total: 11/12