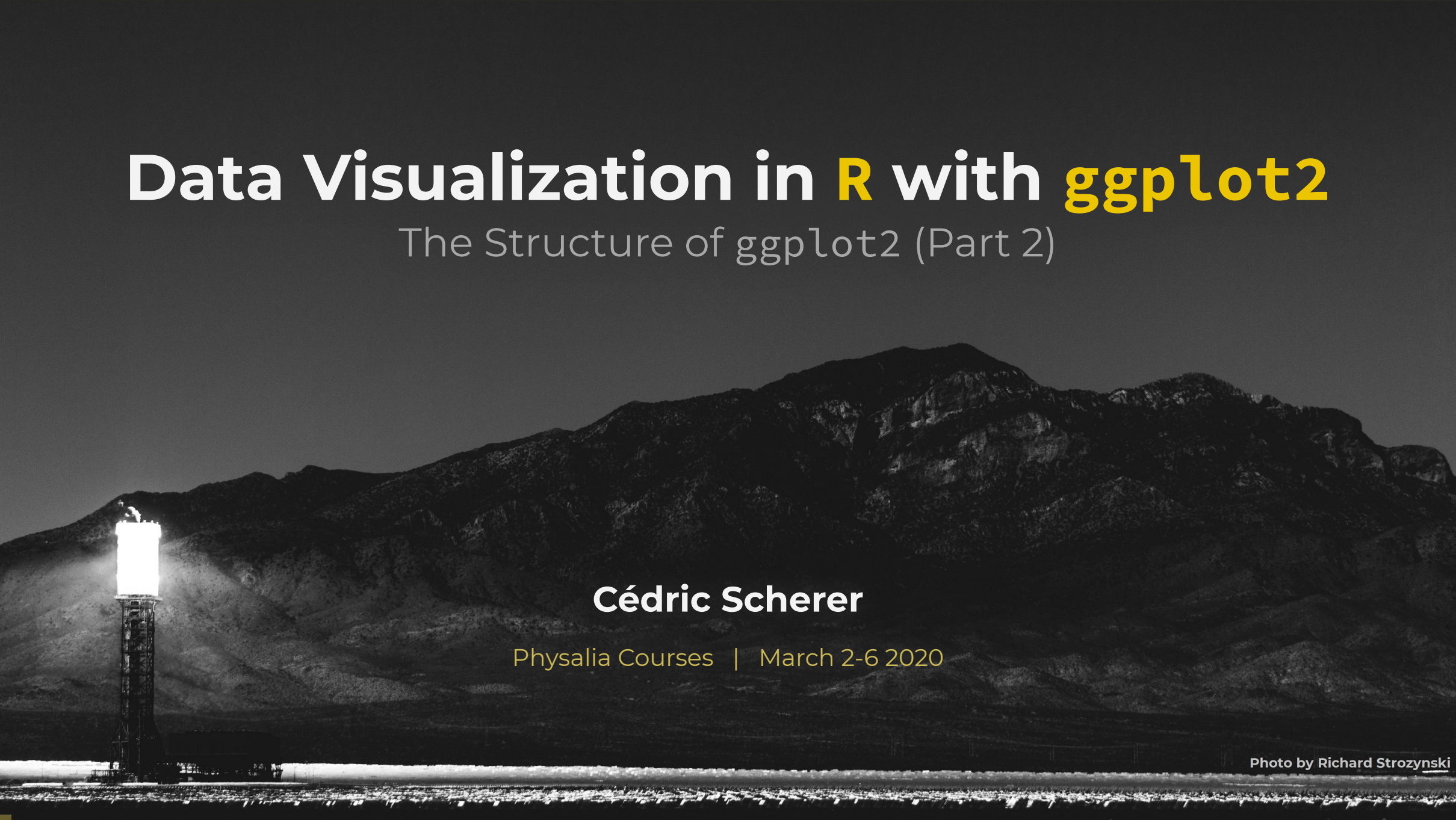
Data Visualization in R with ggplot2

The Structure of ggplot2 (Part 2)



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Physalia Courses | March 2-6 2020

Photo by Richard Strozynski

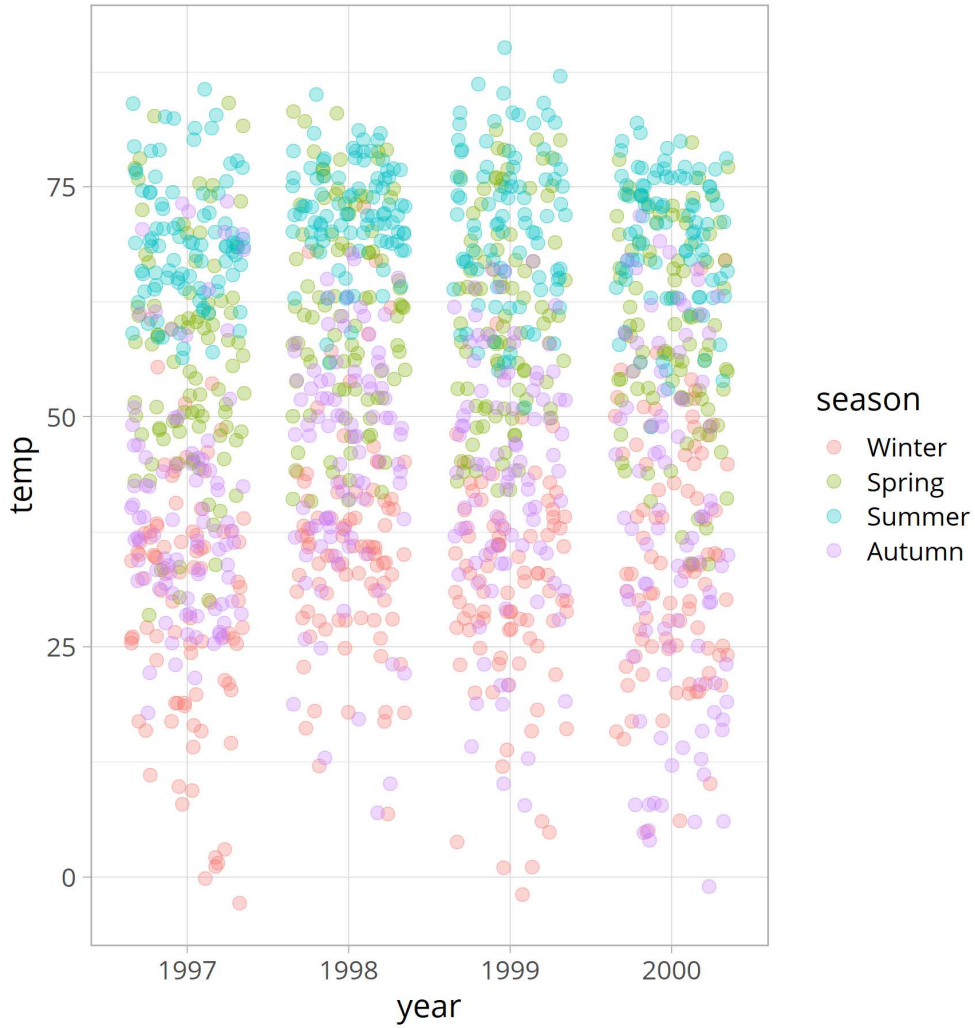
Part 2

Scales & Coordinate Systems

Illustration by Allison Horst (github.com/allisonhorst/stats-illustrations)

A Masterpiece?

```
chic <- readr::read_csv("https://raw.githu
                        col_types = cols(
                        )


(g <-
  ggplot(chic,
    aes(
      year,
      temp,
      color = season
    )) +
    geom_jitter(
      size = 3,
      alpha = .3,
      position = position_jitter(
        width = .35,
        seed = 2020
      )
    )
  )
```



The Structure of `ggplot2`

Layer	Function	Explanation
Data	`ggplot(data)`	The raw data that you want to visualise.
Aesthetics	`aes()`	Aesthetic mappings of the geometric and statistical objects.
Layers	geom_*() and `stat_*()`	The geometric shapes and statistical summaries representing the data.
Scales	`scale_*()`	Maps between the data and the aesthetic dimensions.
Coordinate System	`coord_*()`	Maps data into the plane of the data rectangle.
Facets	`facet_*()`	The arrangement of the data into a grid of plots.
Visual Themes	`theme()` and `theme_*()`	The overall visual defaults of a plot.
Annotations	`annotate()`	Add additional labels, geometries or images to a plot.

Scales

`scale_*()`

`scale_*()`

One can use `scale_*()` to change properties of all the aesthetic dimensions mapped to the data.

Consequently, there are `scale_*()` functions for all aesthetics such as:

- positions via `scale_x_*()` and `scale_y_*()`
- colors via `scale_color_*()` and `scale_fill_*()`
- sizes via `scale_size_*()` and `scale_radius_*()`
- shapes via `scale_shape_*()` and `scale_linetype_*()`
- transparency via `scale_alpha_*()`

`scale_*()`

One can use `scale_*()` to change properties of all the aesthetic dimensions mapped to the data

The extensions (`*`) can be filled by e.g.:

- `continuous()`, `discrete()`, `reverse()`, `log10()`, `sqrt()`, `date()` for positions
- `continuous()`, `discrete()`, `manual()`, `gradient()`, `gradient2()`, `brewer()` for colors
- `continuous()`, `discrete()`, `manual()`, `ordinal()`, `area()`, `date()` for sizes
- `continuous()`, `discrete()`, `manual()`, `ordinal()` for shapes
- `continuous()`, `discrete()`, `manual()`, `ordinal()`, `date()` for transparency

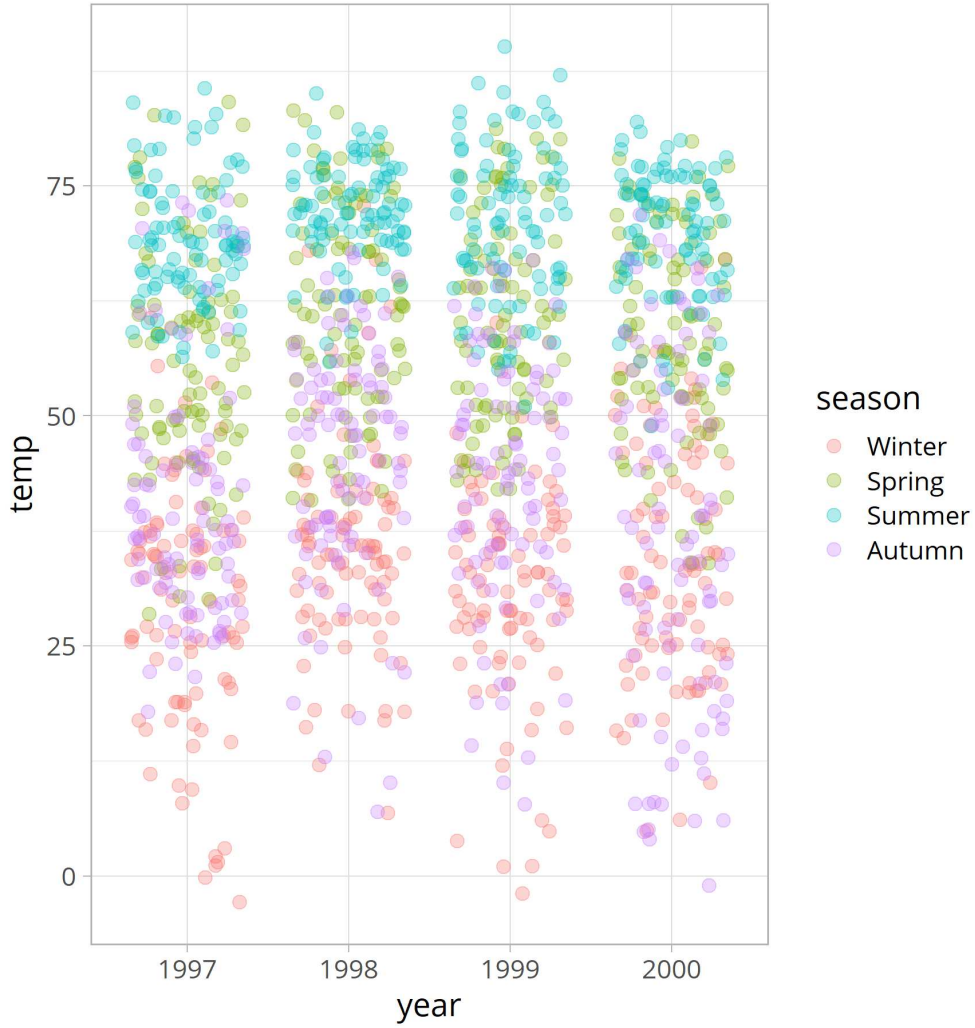
Scales

`scale_x|y_*()`

Illustration by Allison Horst (github.com/allisonhorst/stats-illustrations)

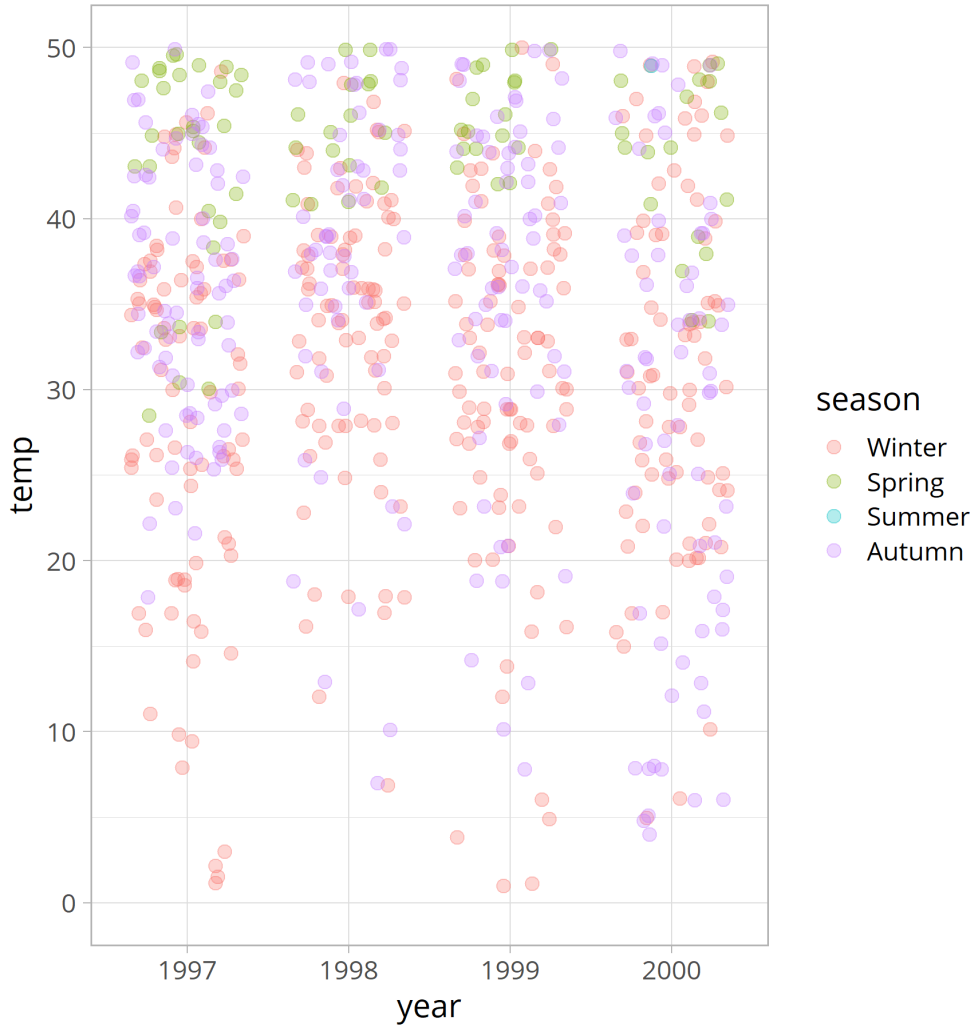
scale_x|y_continuous()

```
g
```



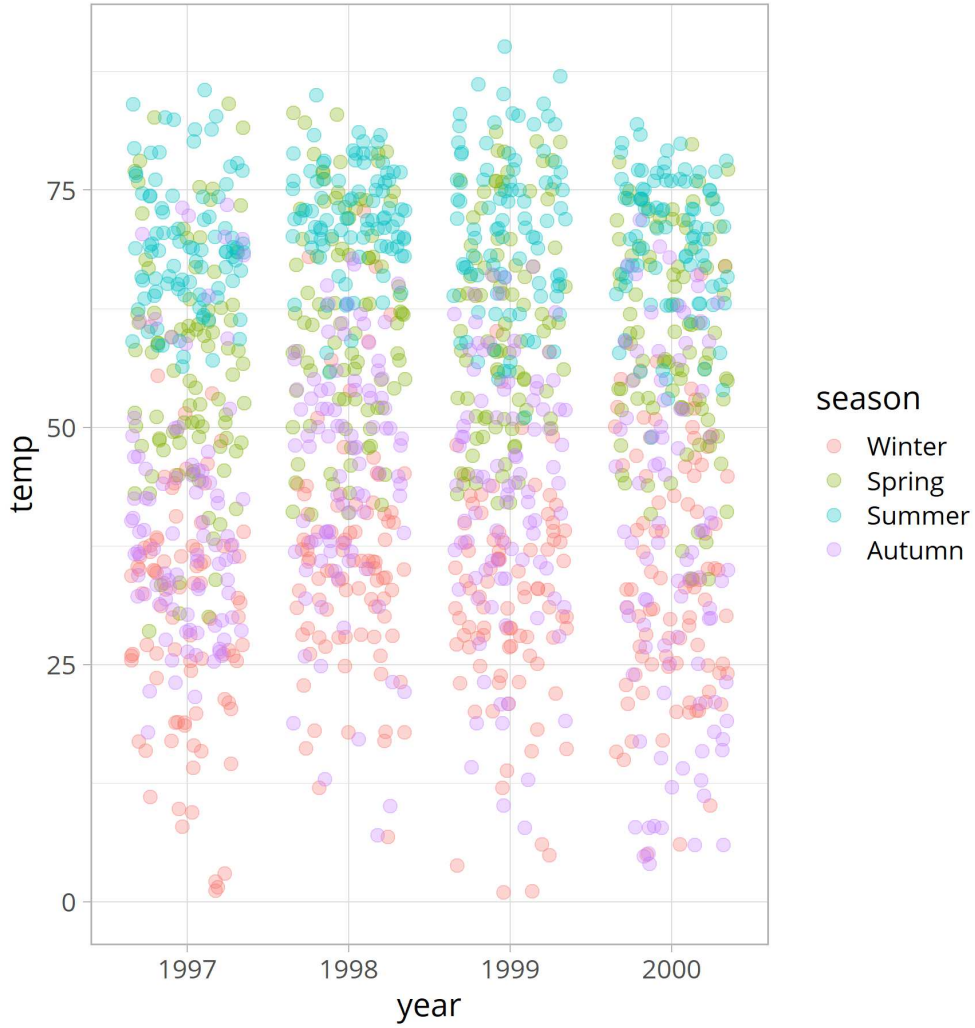
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    limits = c(0, 50)
  )
```



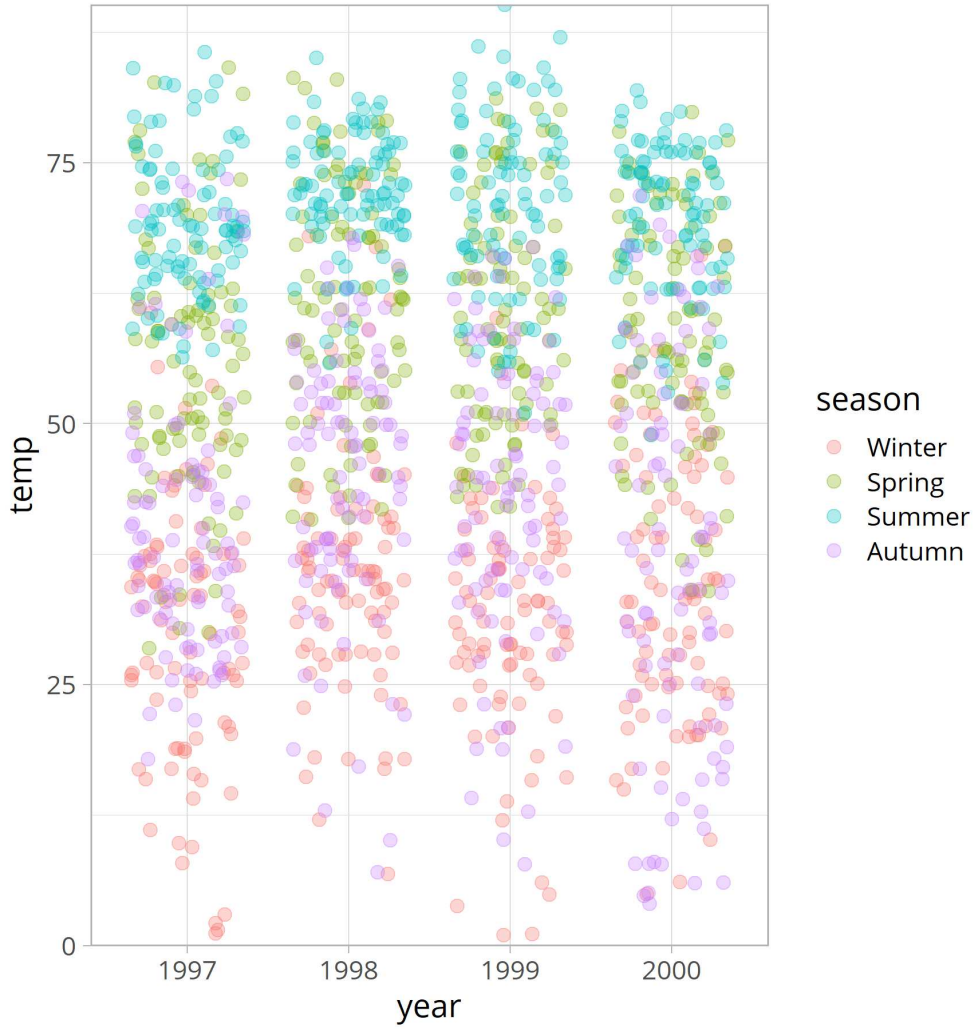
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    limits = c(0, NA)
  )
```



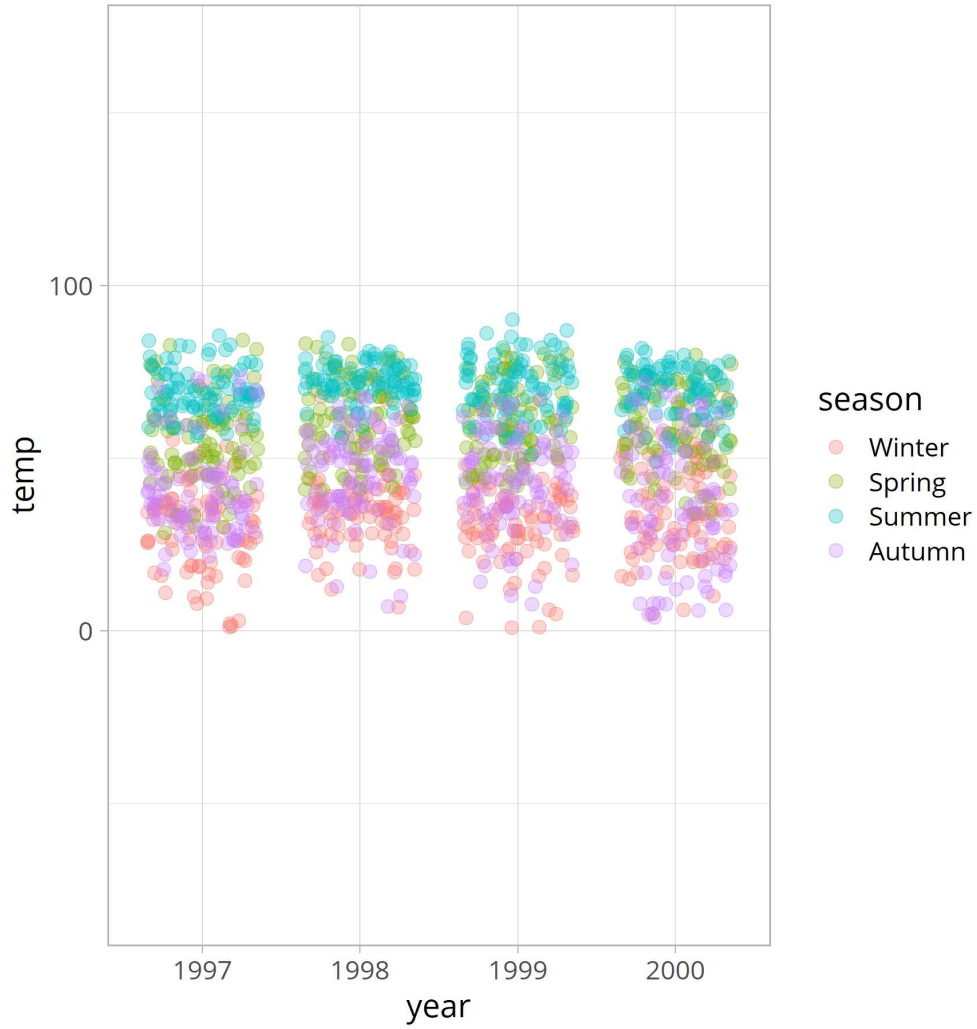
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    limits = c(0, NA),
    expand = c(0, 0)
  )
```



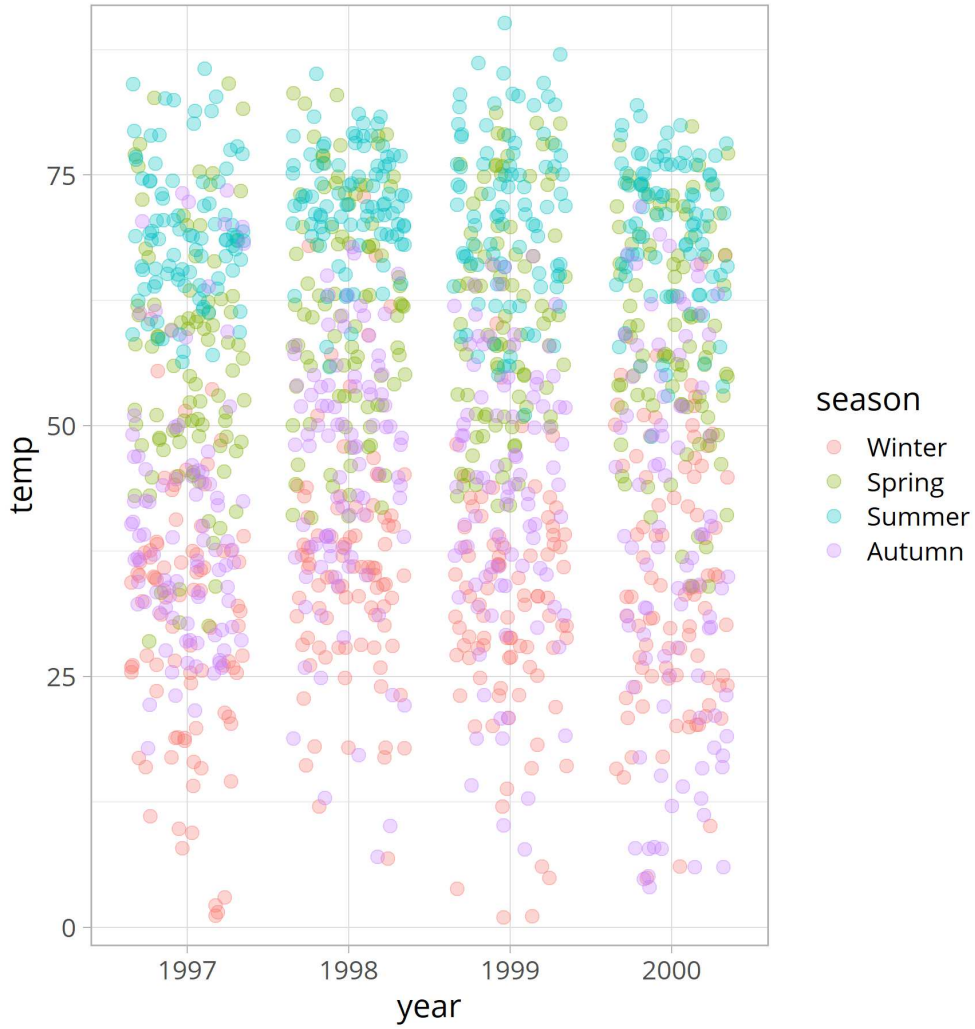
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    limits = c(0, NA),
    expand = c(1, 1)
  )
```



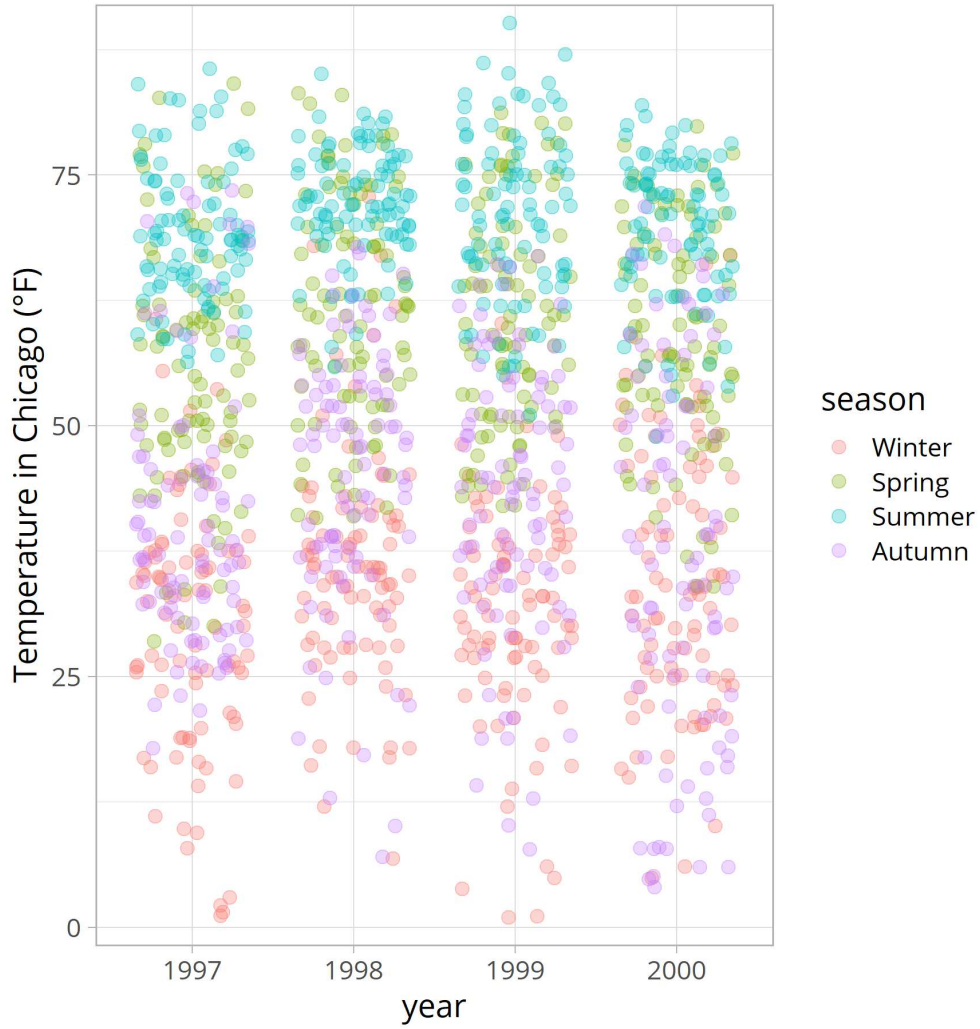
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    limits = c(0, NA),
    expand = c(.02, .02)
  )
```



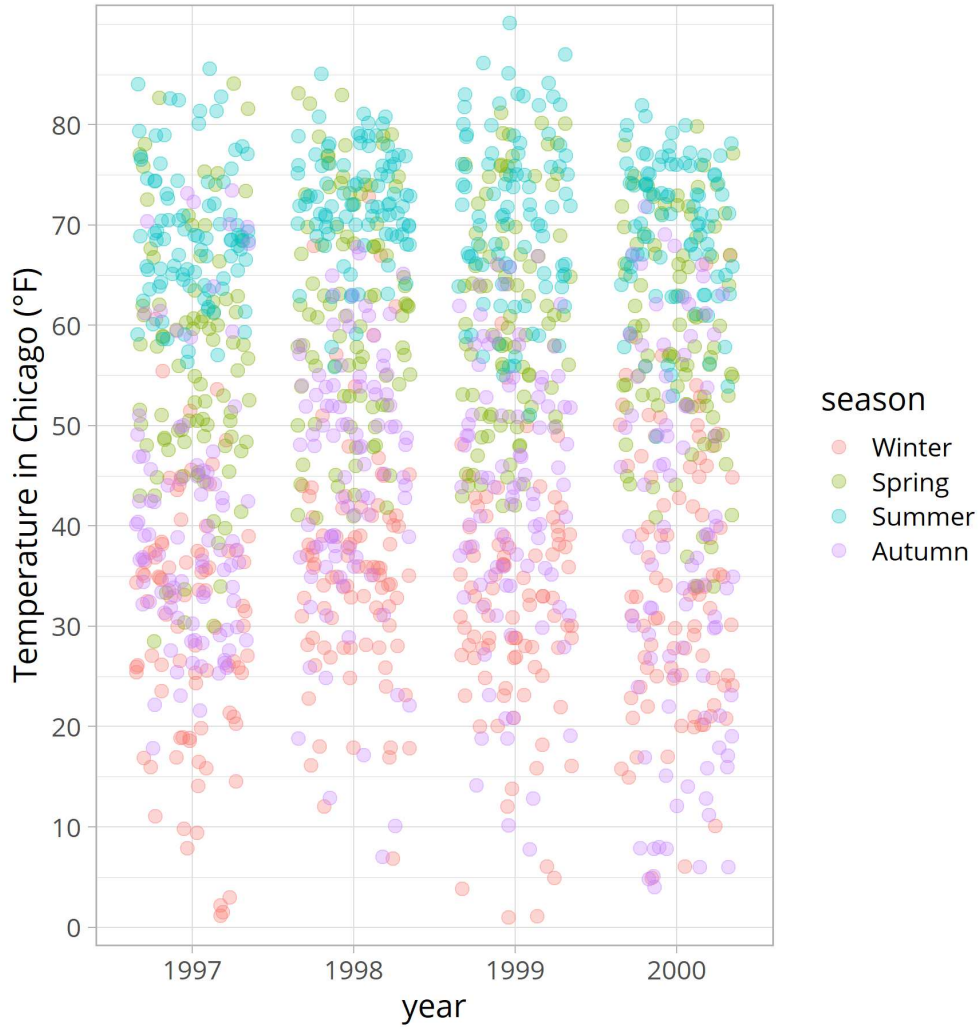
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    name = "Temperature in Chicago (°F)",
    limits = c(0, NA),
    expand = c(.02, .02)
  )
```



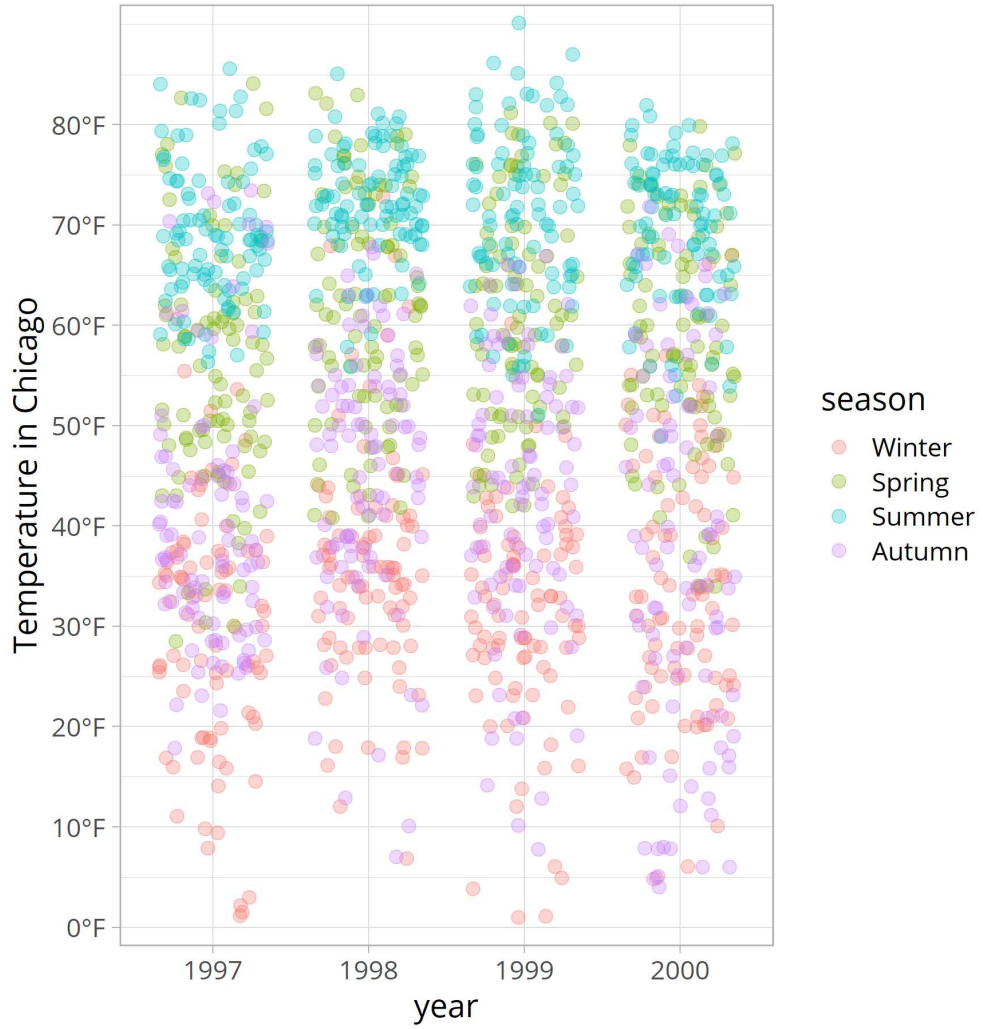
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    name = "Temperature in Chicago (°F)",
    limits = c(0, NA),
    expand = c(.02, .02),
    breaks = seq(0, 80, by = 10)
  )
```



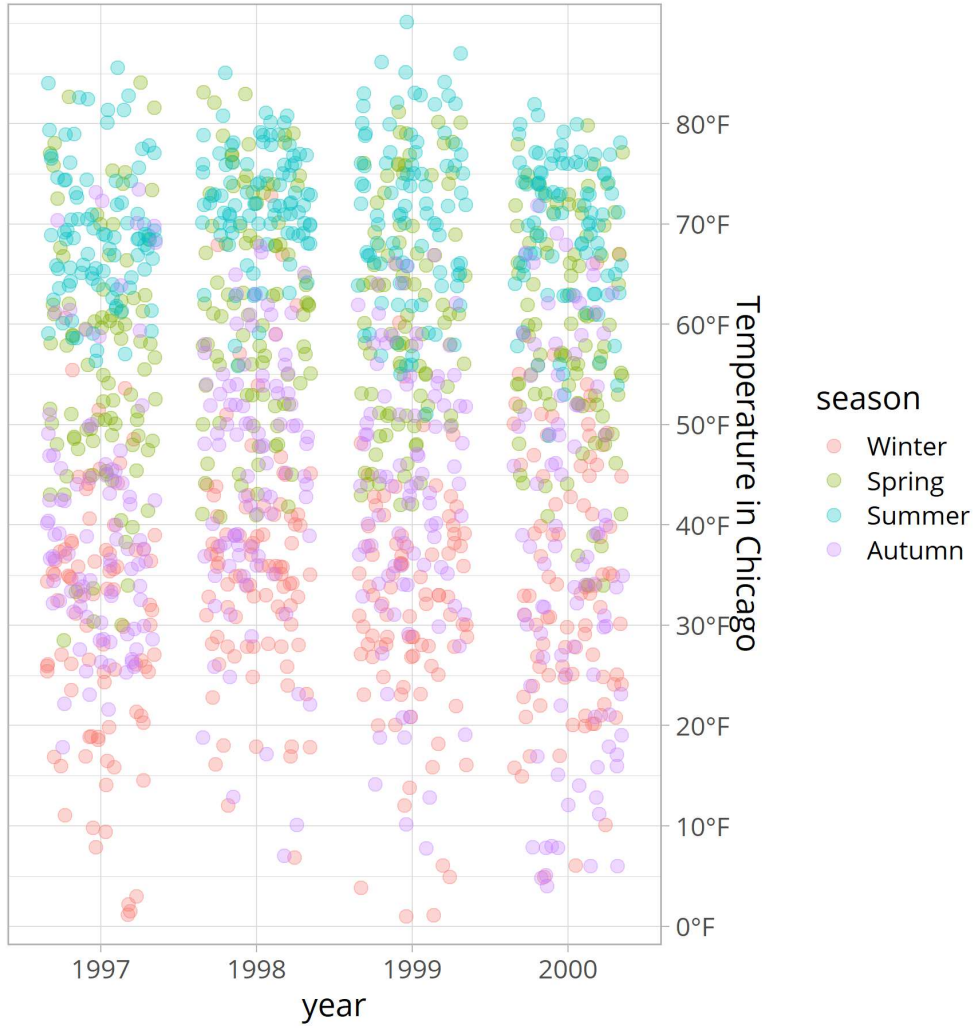
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    name = "Temperature in Chicago",
    limits = c(0, NA),
    expand = c(.02, .02),
    breaks = seq(0, 80, by = 10),
    labels = glue::glue(
      "{seq(0, 80, by = 10)}°F"
    )
  )
```



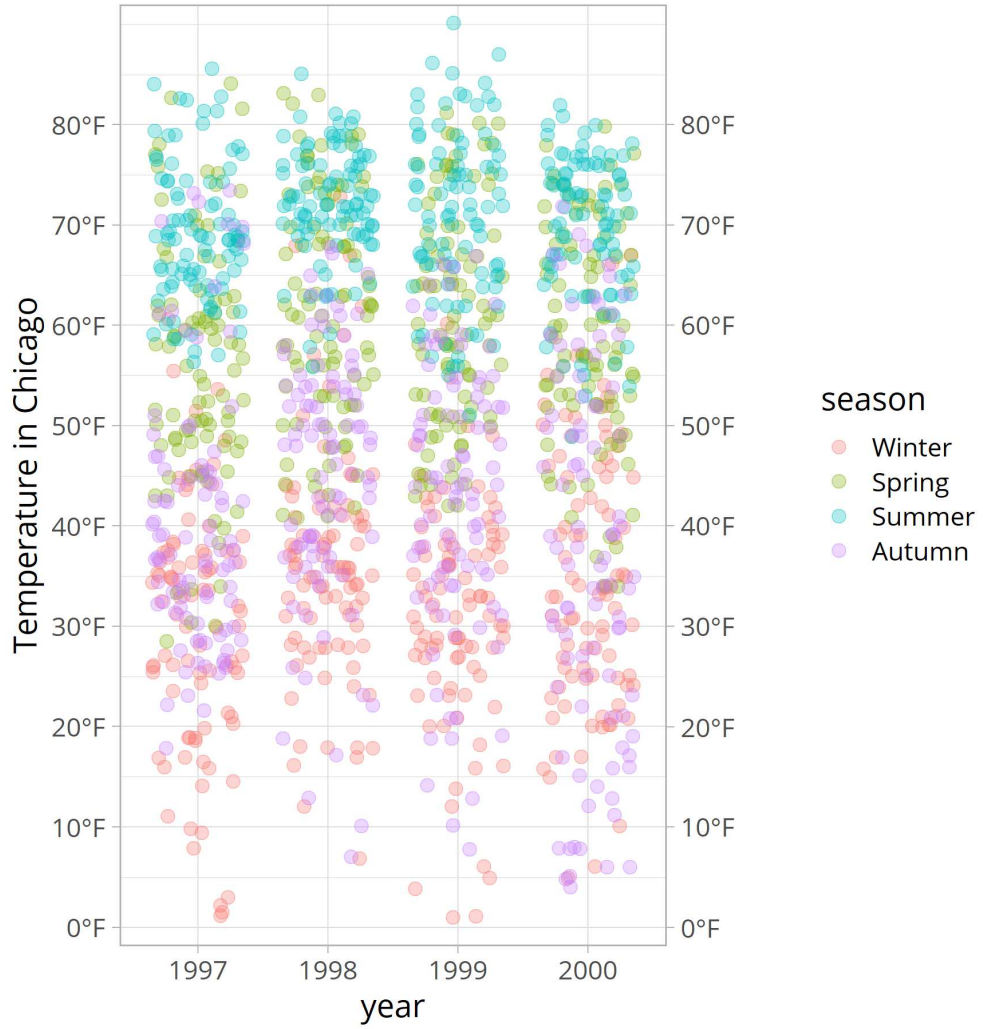
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    name = "Temperature in Chicago",
    limits = c(0, NA),
    expand = c(.02, .02),
    breaks = seq(0, 80, by = 10),
    labels = glue::glue(
        "{seq(0, 80, by = 10)}°F"
    ),
    position = "right"
  )
```



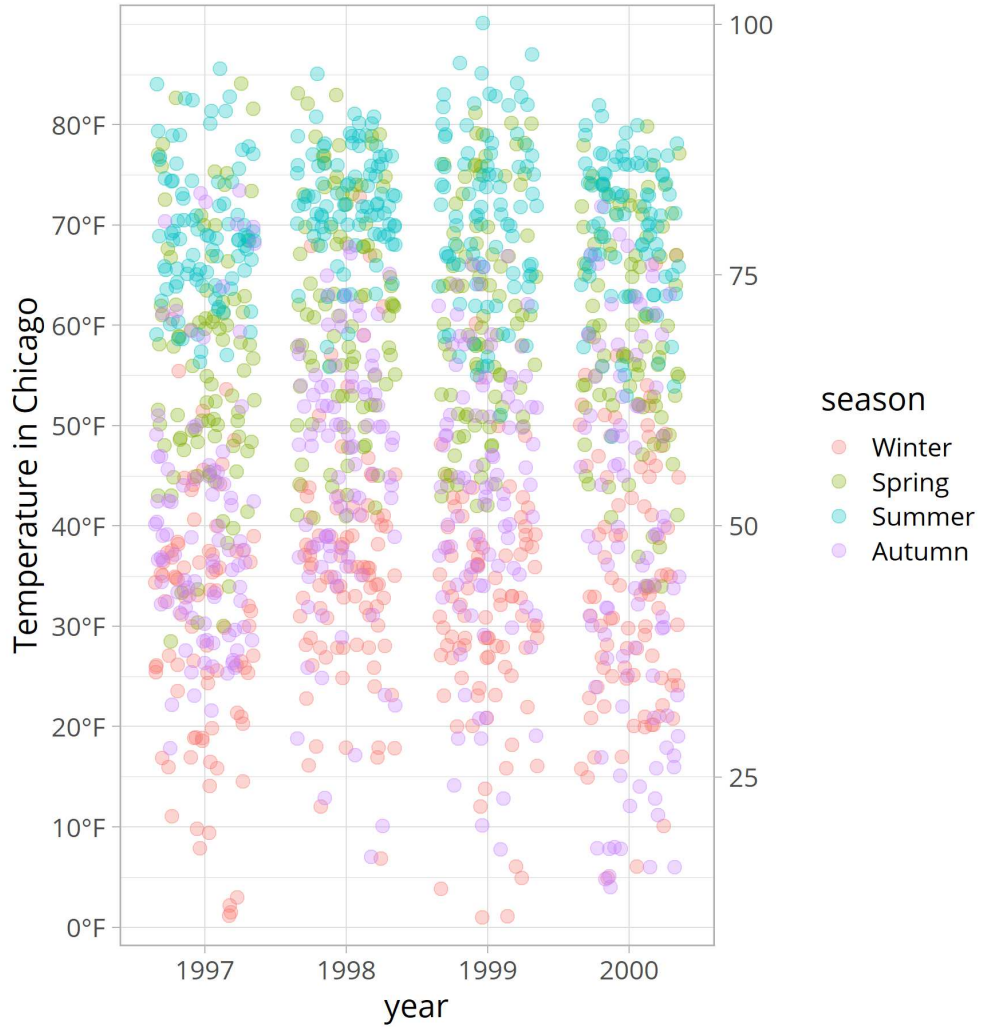
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    name = "Temperature in Chicago",
    limits = c(0, NA),
    expand = c(.02, .02),
    breaks = seq(0, 80, by = 10),
    labels = glue::glue(
        "{seq(0, 80, by = 10)}°F"
    ),
    sec.axis = dup_axis(name = "")
  )
```



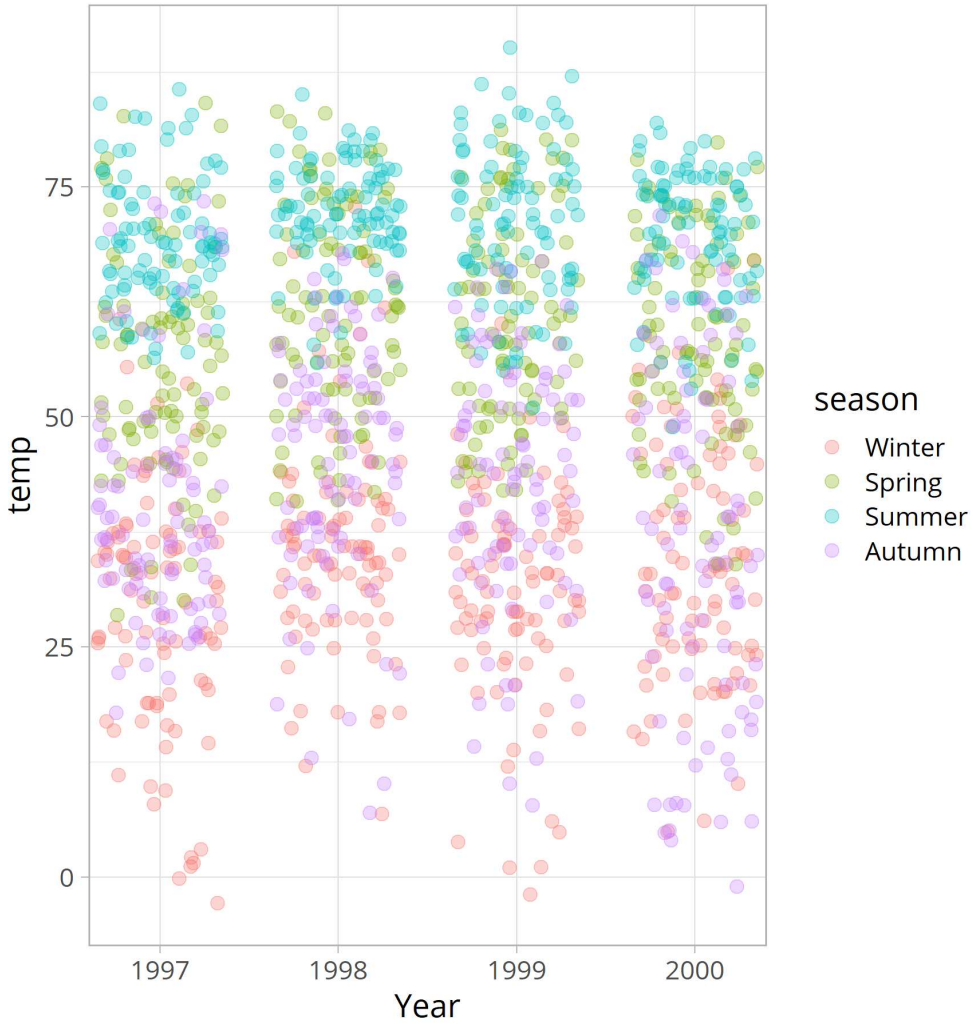
scale_x|y_continuous()

```
g +
  scale_y_continuous(
    name = "Temperature in Chicago",
    limits = c(0, NA),
    expand = c(.02, .02),
    breaks = seq(0, 80, by = 10),
    labels = glue::glue(
        "{seq(0, 80, by = 10)}°F"
    ),
    sec.axis = sec_axis(~ . + 10)
  )
```



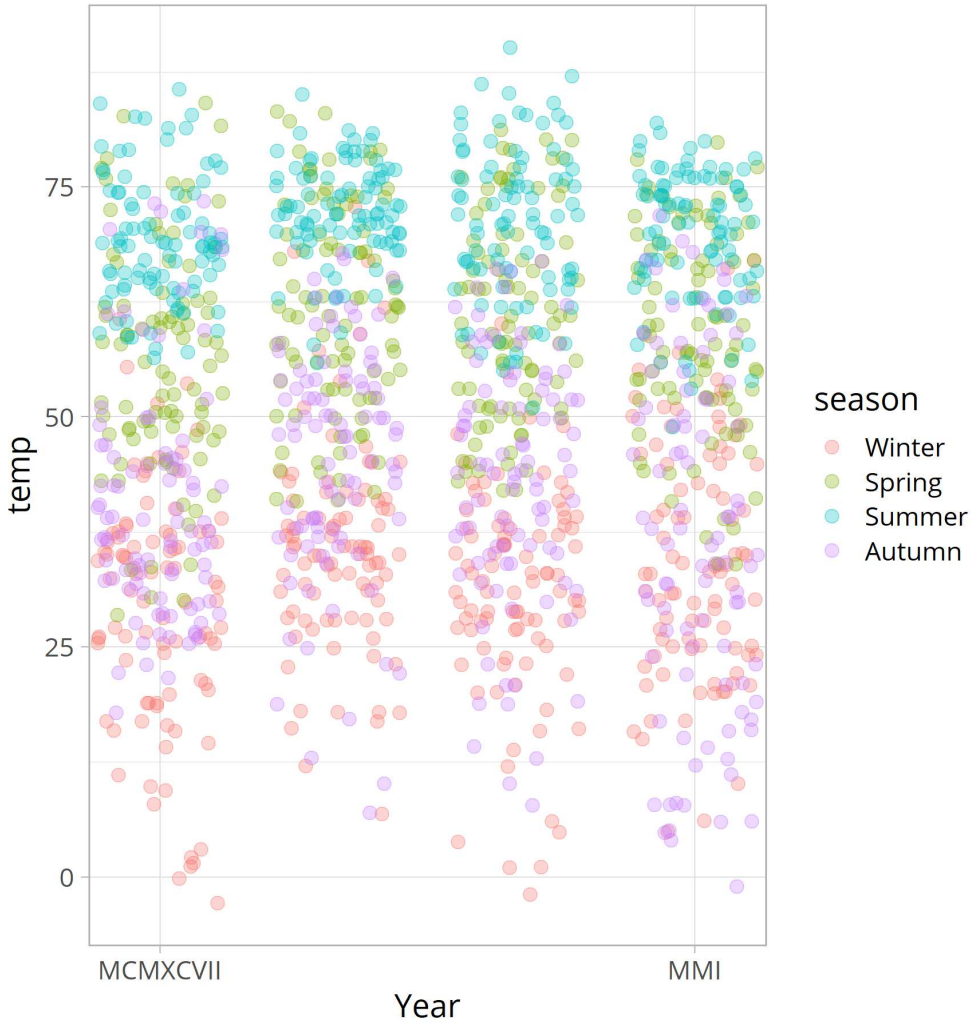
scale_x|y_discrete()

```
g +
  scale_x_discrete(
    name = "Year",
    expand = c(.1, .1)
  )
```



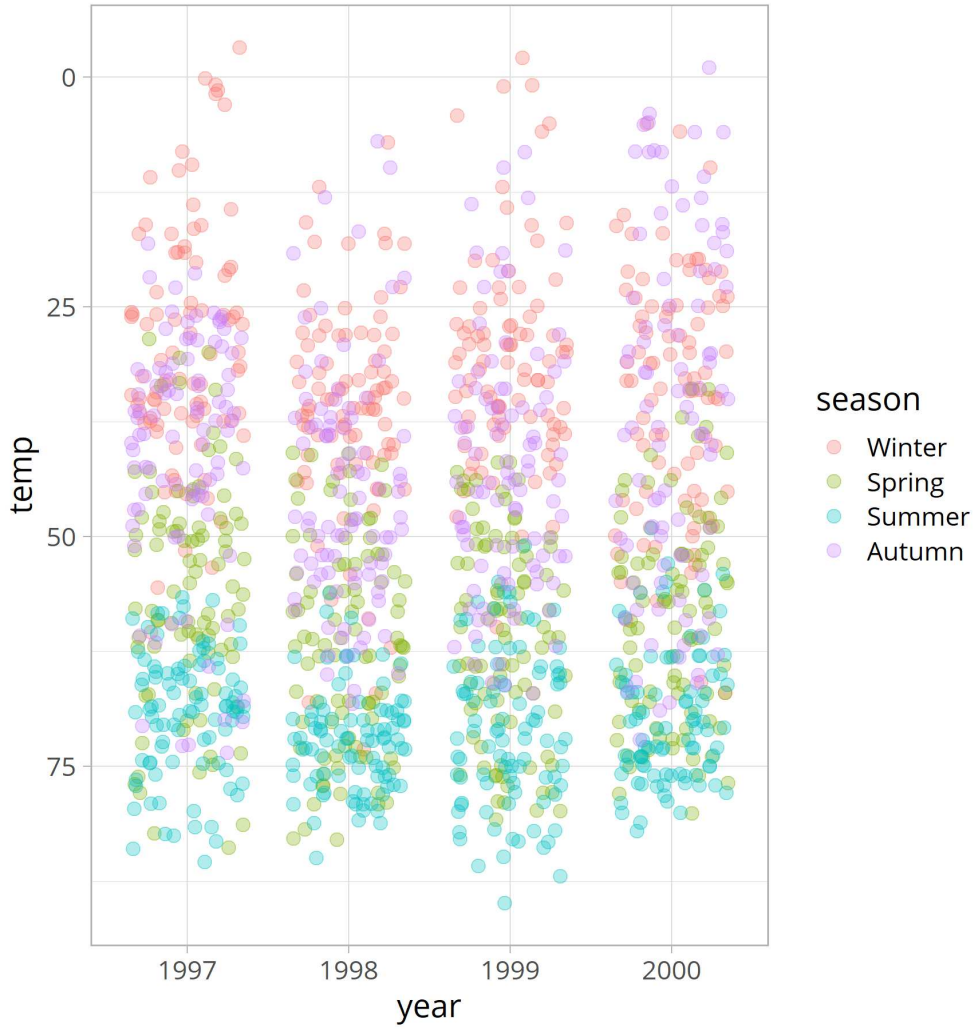
scale_x|y_discrete()

```
g +
  scale_x_discrete(
    name = "Year",
    expand = c(.1, .1),
    breaks = c(1997, 2000),
    labels = c("MCMXCVII", "MMI")
  )
```



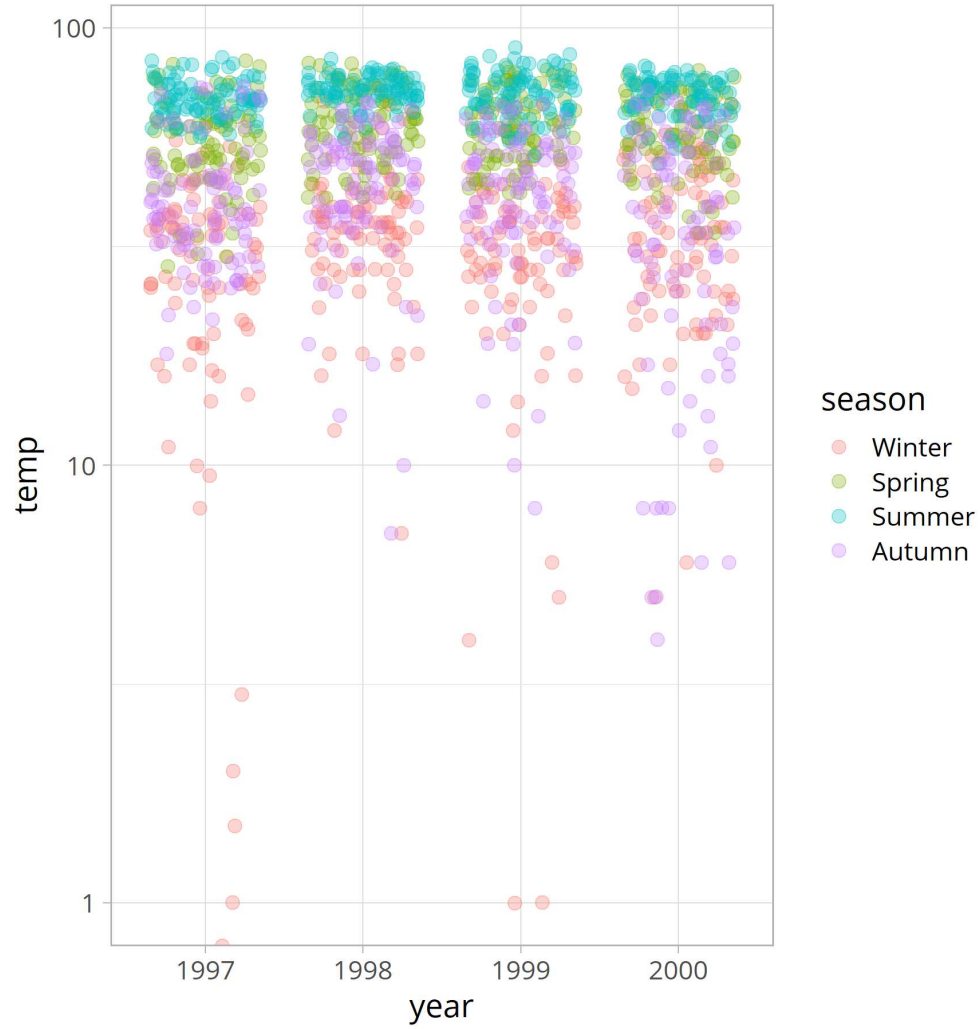
scale_x|y_reverse()

```
g +
  #scale_x_reverse() +
  ## doen't work with factors
  scale_y_reverse()
```



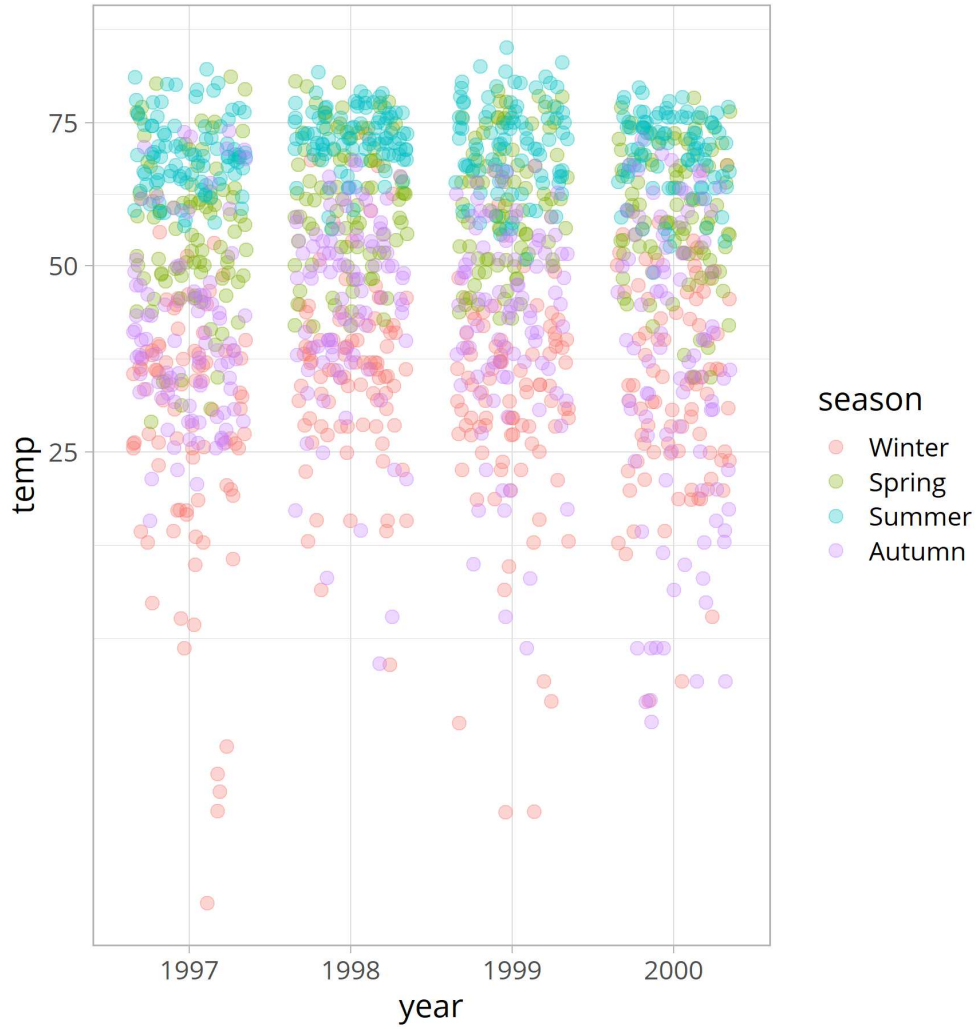
scale_x|y_log10()

```
g +
  #scale_x_log10() +
  ## doen't work with factors
  scale_y_log10()
```



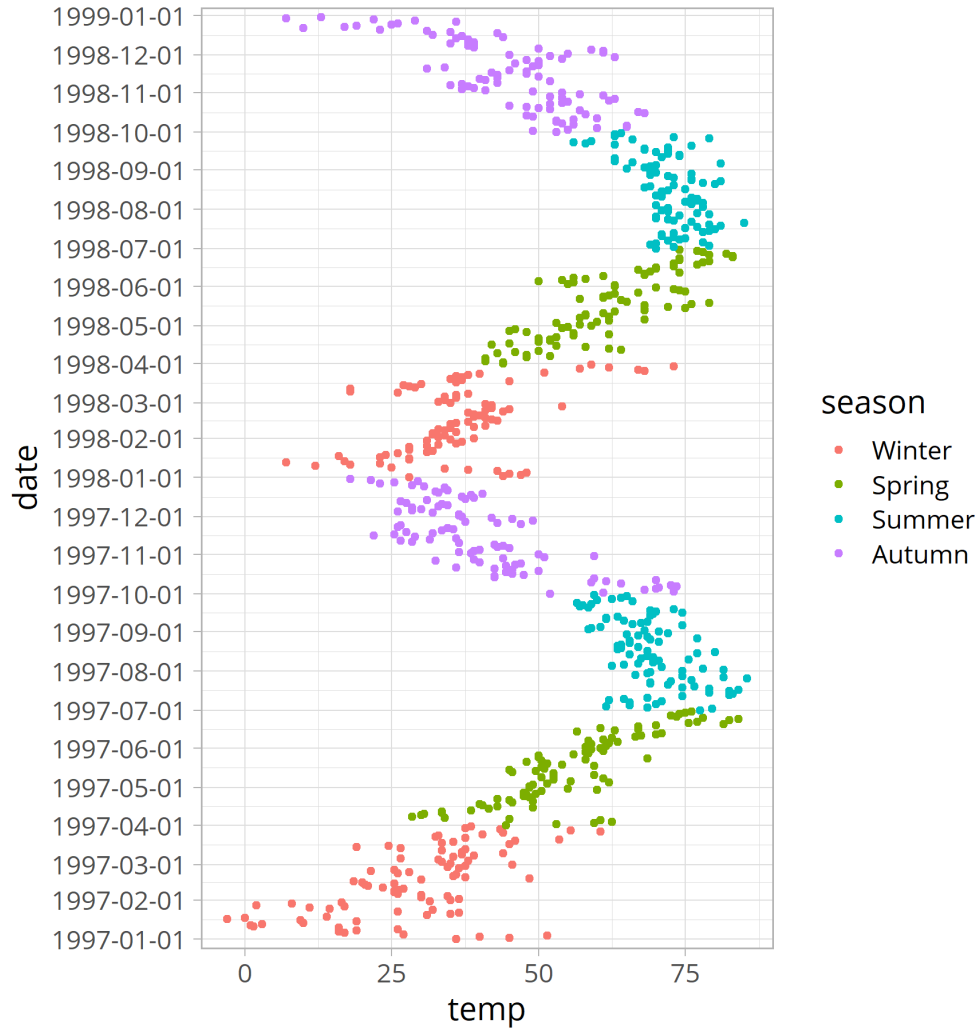
scale_x|y_sqrt()

```
g +
  #scale_x_sqrt() +
  ## doen't work with factors
  scale_y_sqrt()
```



scale_x|y_date()

```
chic %>%
  filter(year %in% 1997:1998) %>%
  ggplot(aes(temp, date)) +
    geom_point(aes(color = season)) +
    scale_y_date(
      date_breaks = "1 month",
      date_labels = "%Y-%m-%d",
      expand = c(.01, .01)
    )
```

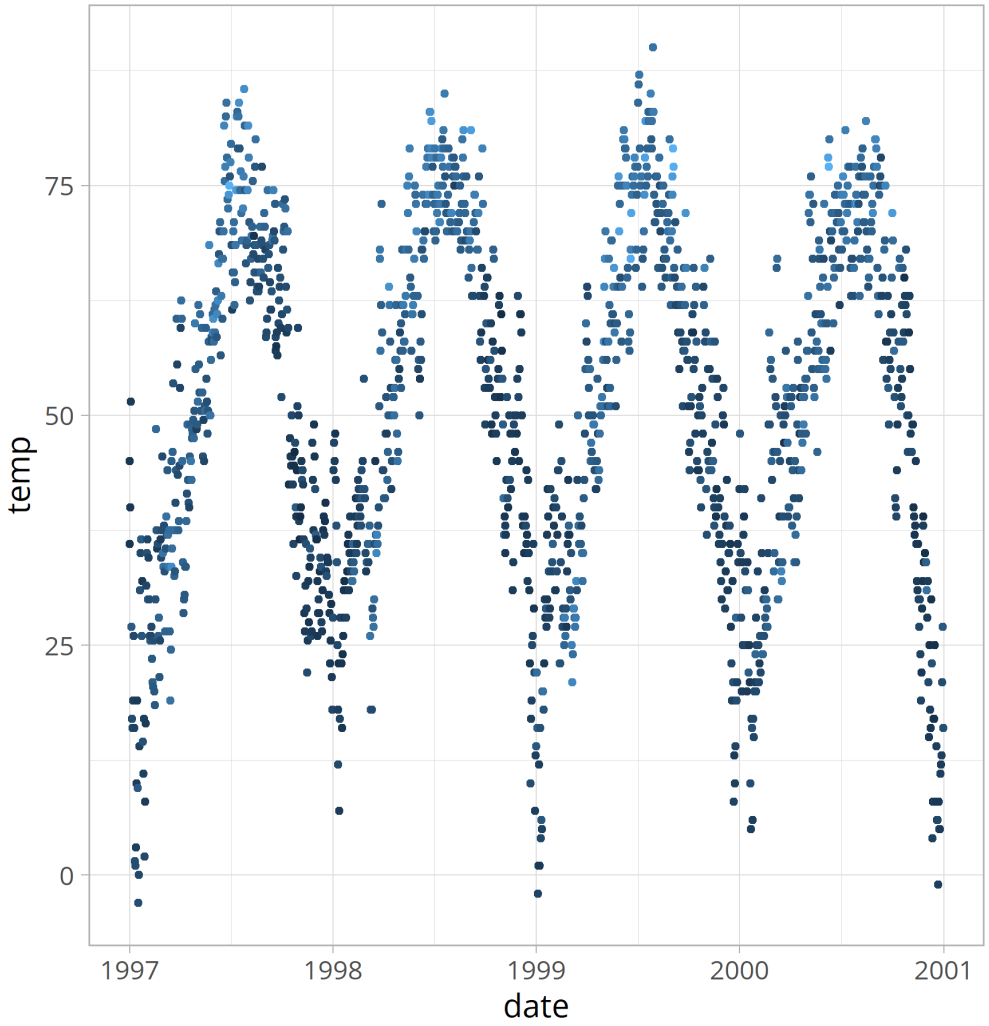


Scales

`scale_color|fill_*()`

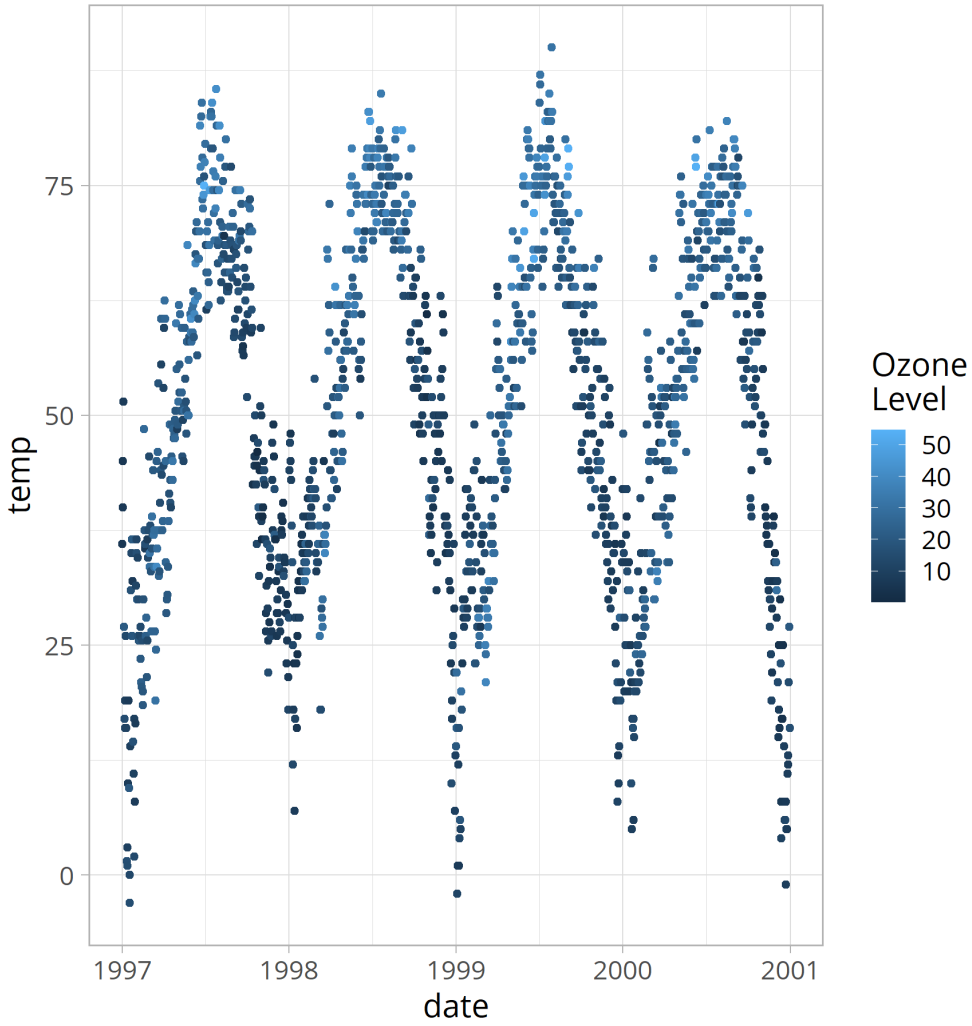
scale_color|fill_continuous()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_continuous(
    guide = FALSE
  )
```



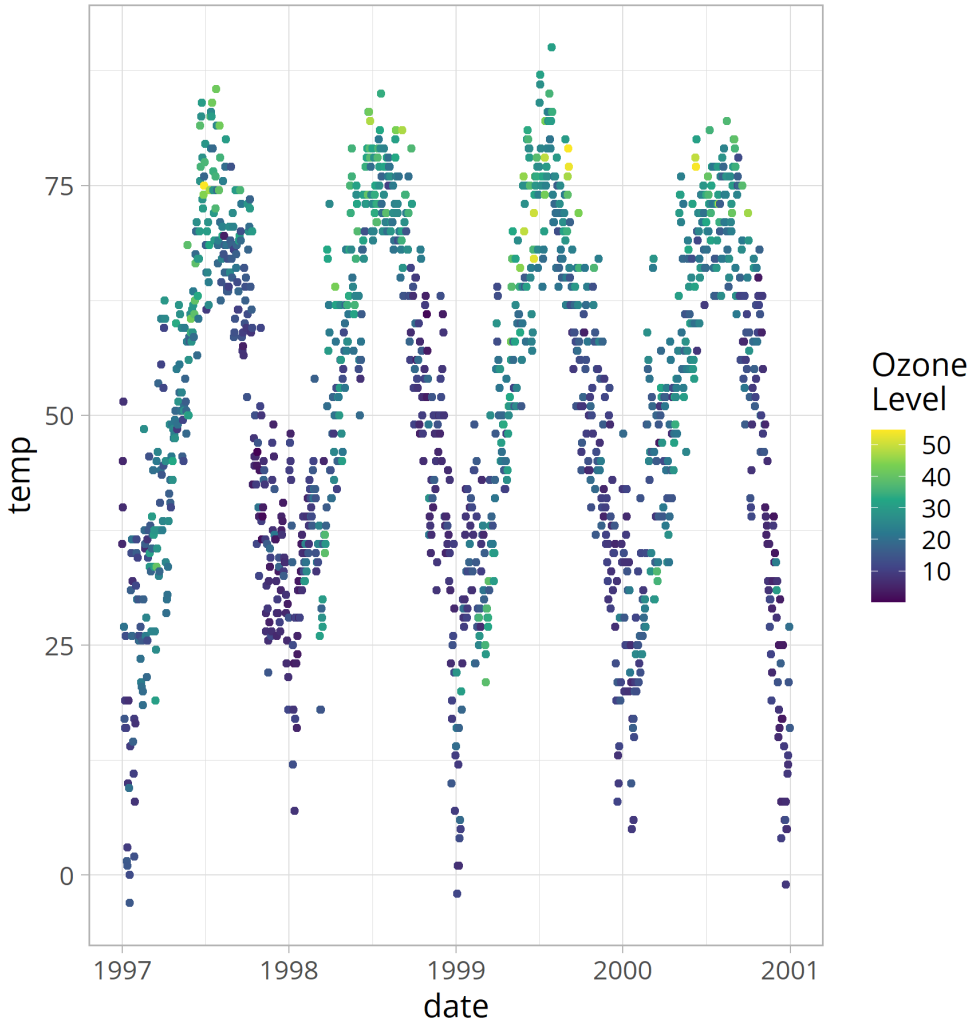
scale_color|fill_continuous()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_continuous(
    name = "Ozone\nLevel"
  )
```



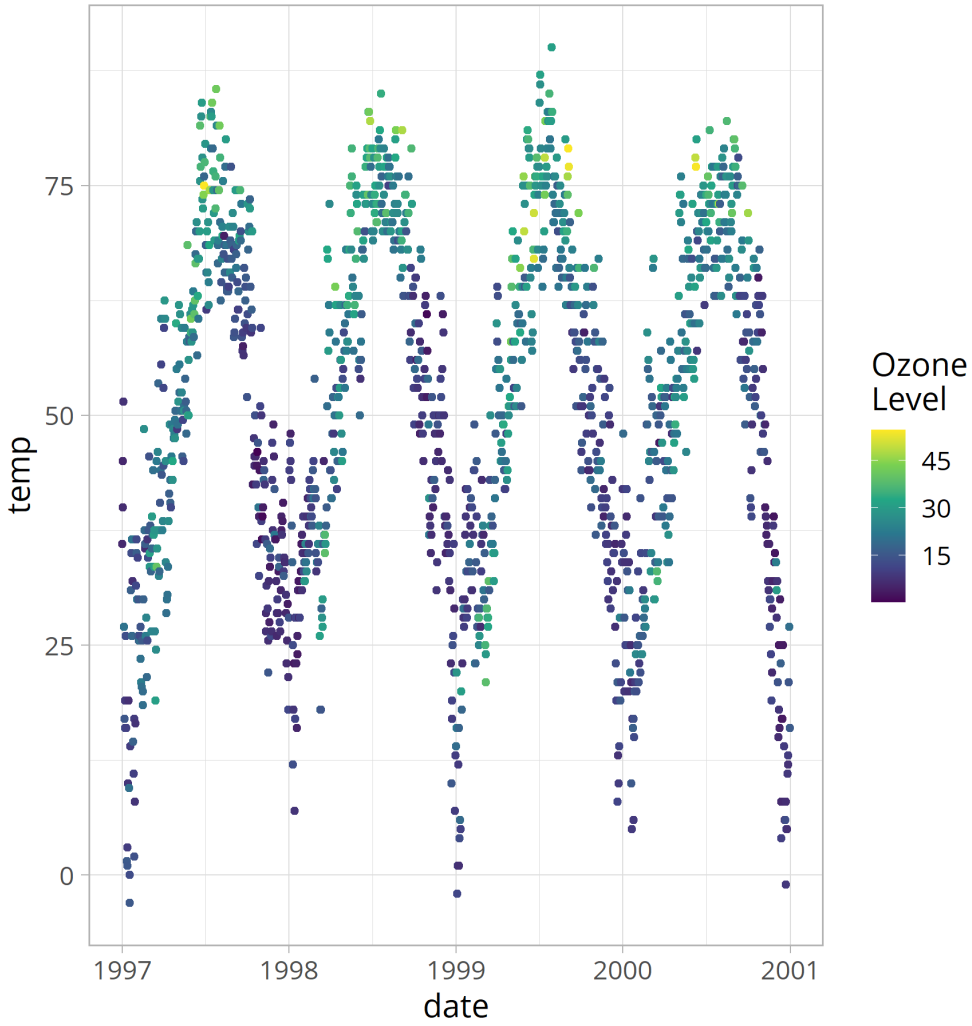
scale_color|fill_continuous()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_continuous(
    name = "Ozone\nLevel",
    type = "viridis"
  )
```



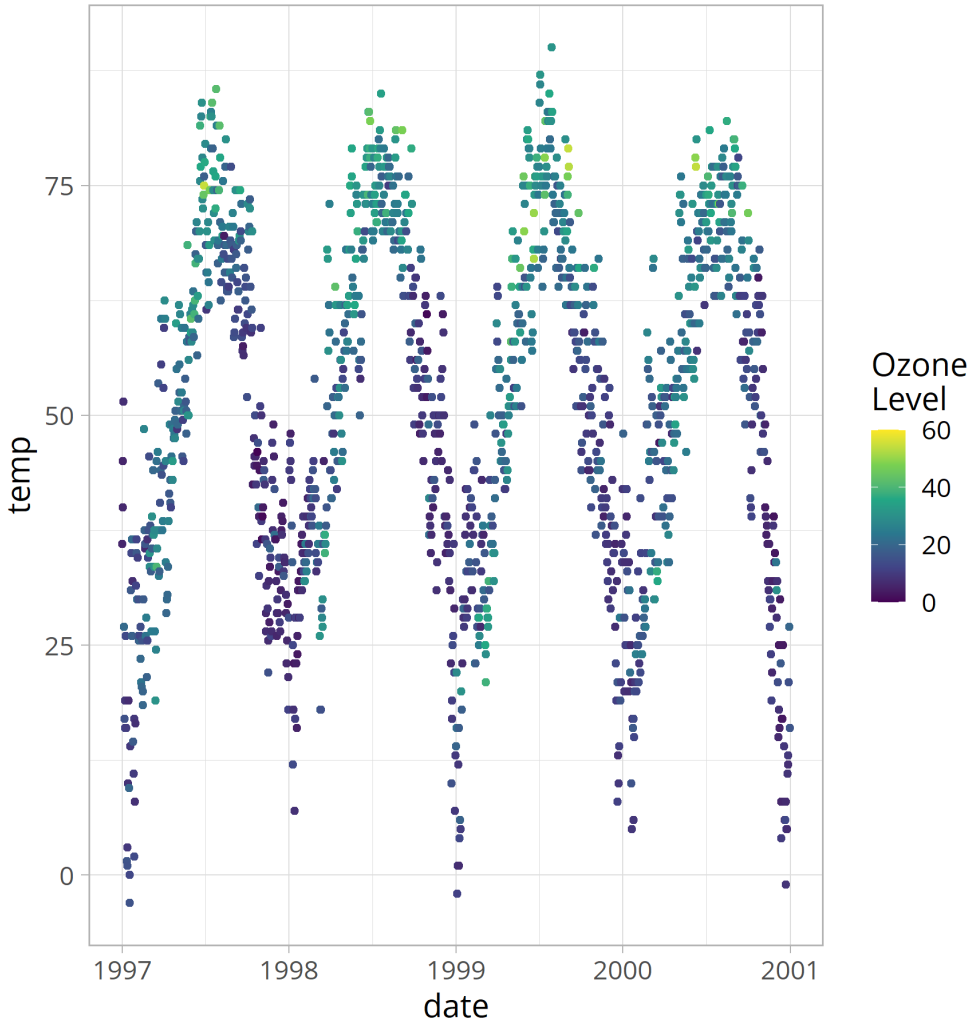
scale_color|fill_continuous()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_continuous(
    name = "Ozone\nLevel",
    type = "viridis",
    breaks = seq(0, 60, length.out = 5)
  )
```



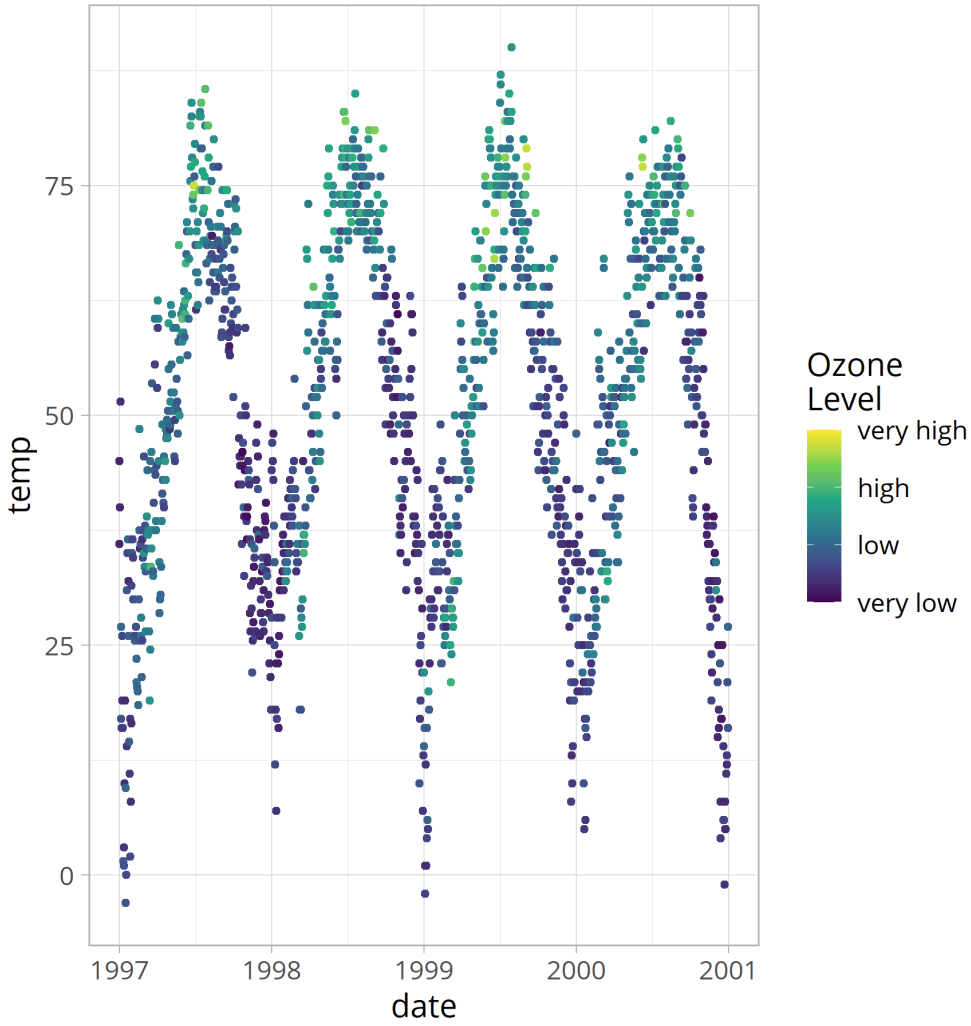
scale_color|fill_continuous()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_continuous(
    name = "Ozone\nLevel",
    type = "viridis",
    breaks = seq(0, 60, length.out = 4),
    limits = c(0, 60)
  )
```



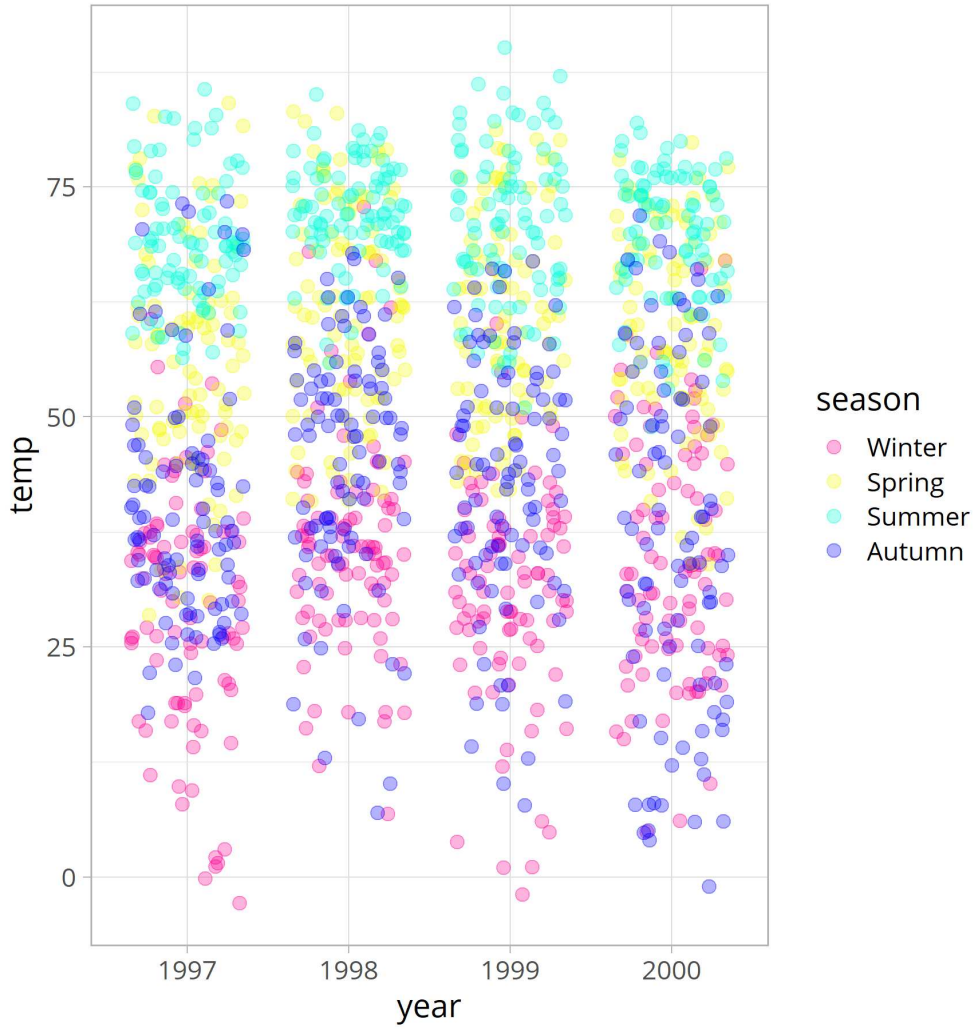
scale_color|fill_continuous()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_continuous(
    name = "Ozone\nLevel",
    type = "viridis",
    breaks = seq(0, 60, length.out = 4),
    limits = c(0, 60),
    labels = c("very low", "low",
               "high", "very high")
  )
```



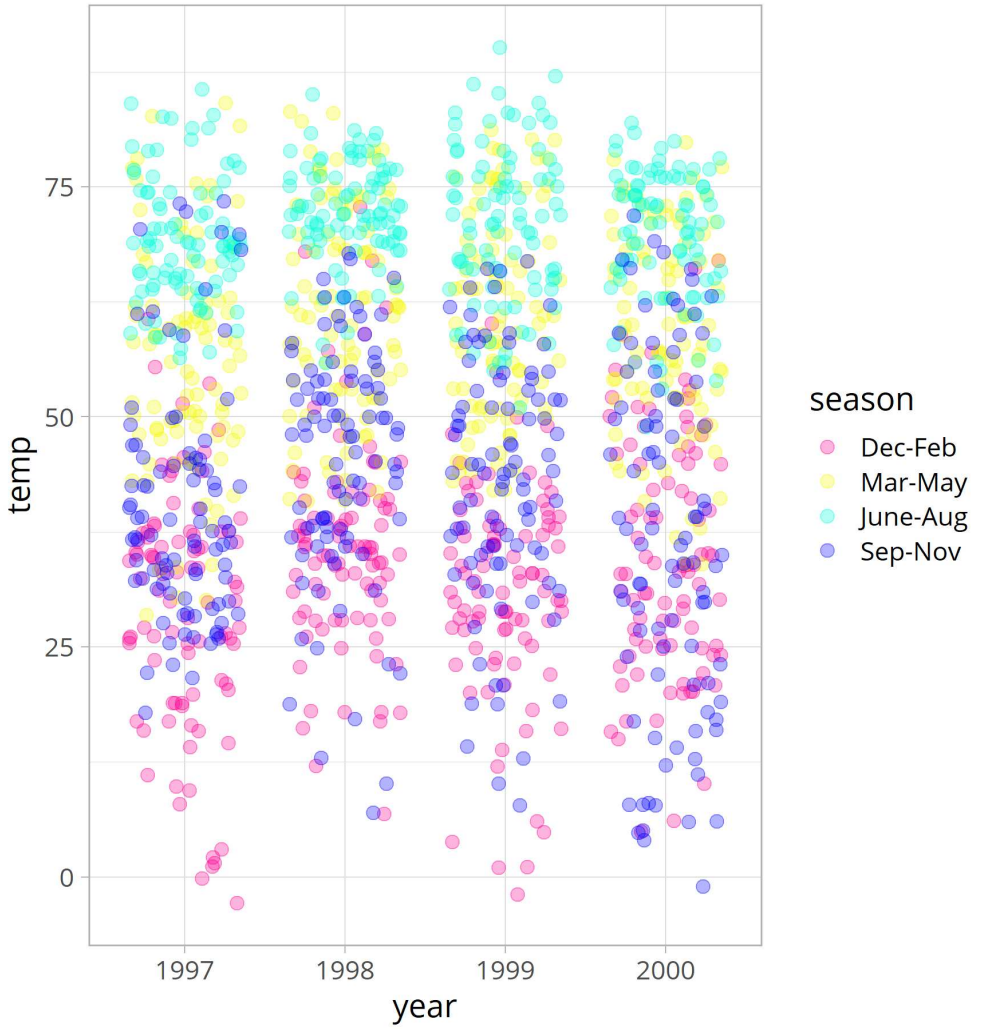
scale_color|fill_discrete()

```
g +
  scale_color_discrete(
    h = c(0, 260), ## hue: [0,360]
    c = 500, ## chroma: [0,x]
    l = 90 ## luminance: [0,100]
  )
```



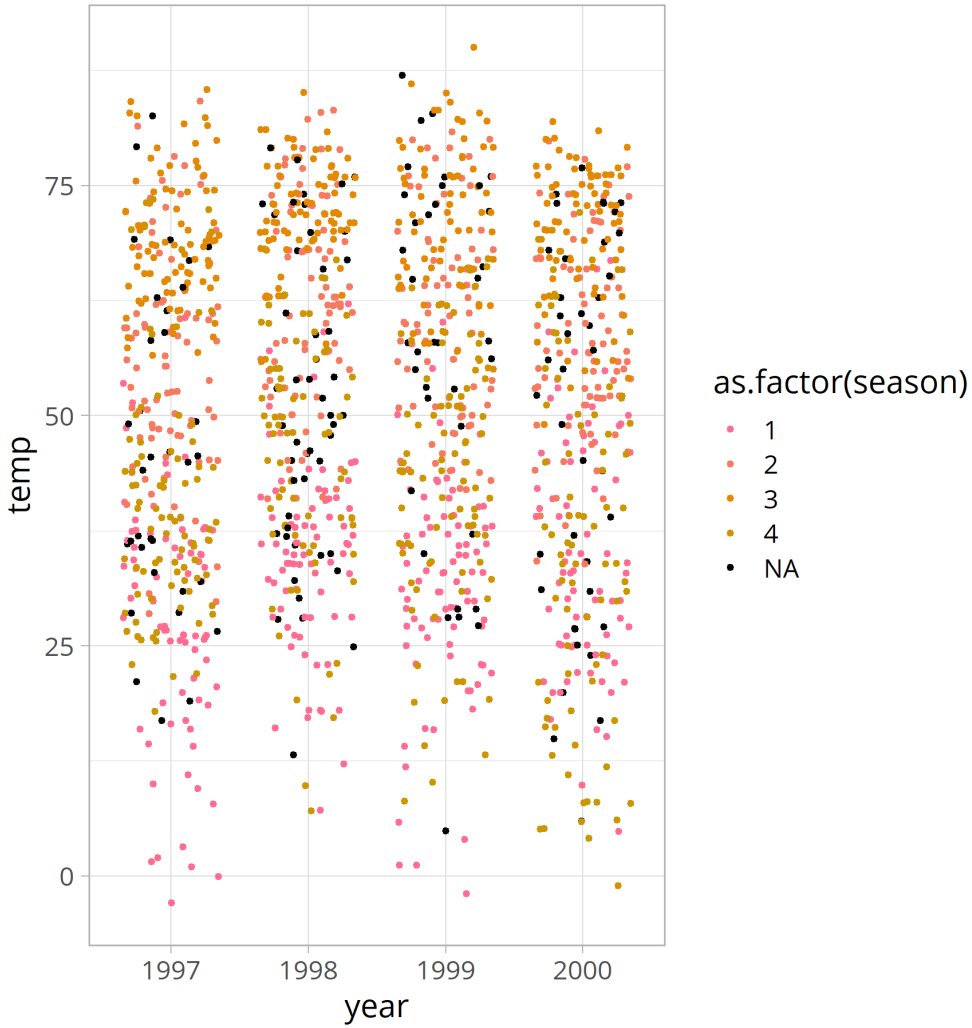
scale_color|fill_discrete()

```
g +
  scale_color_discrete(
    h = c(0, 260), ## hue: [0,360]
    c = 500, ## chroma: [0,x]
    l = 90, ## luminance: [0,100]
    labels = c("Dec-Feb", "Mar-May",
               "June-Aug", "Sep-Nov")
  )
```



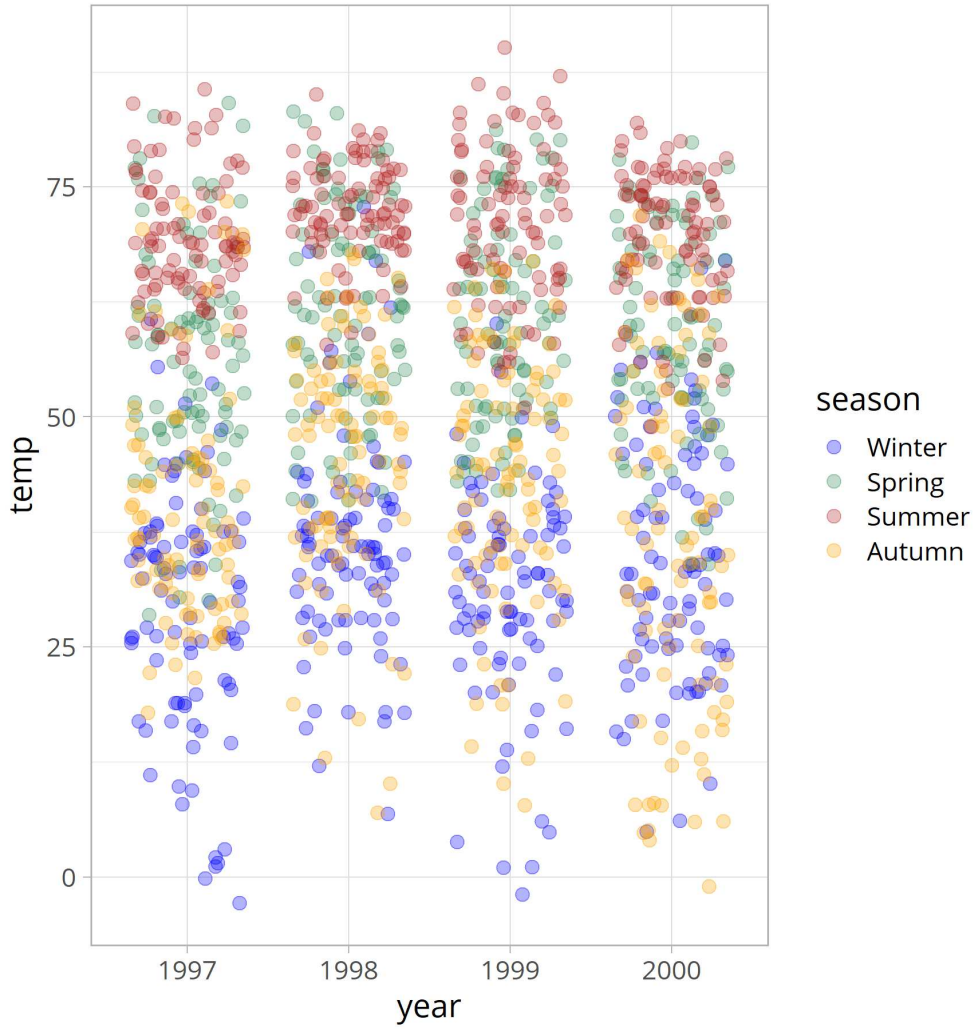
scale_color|fill_discrete()

```
chic %>%
  group_by(date) %>%
  mutate(
    season = if_else(
      runif(1, min = 0, max = 1) > .9,
      NA_integer_,
      as.integer(season)
    )) %>%
  ggplot(
    aes(
      year, temp,
      color = as.factor(season)
    )) +
    geom_jitter(
      size = 1.3,
      width = .35
    ) +
    scale_color_discrete(
      h = c(0, 60),  ## hue: [0,360]
      na.value = "black"
    )
```



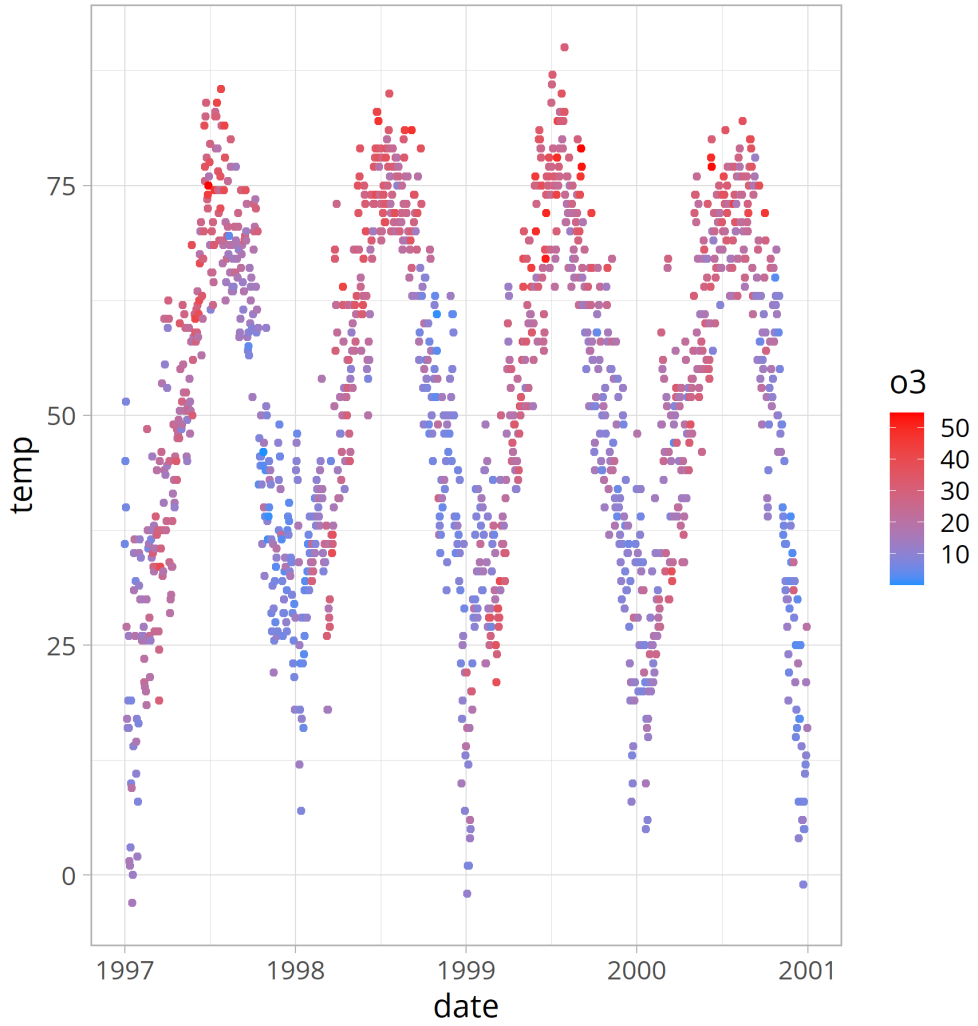
scale_color|fill_manual()

```
g +
  scale_color_manual(
    values = c("blue", "seagreen",
               "firebrick", "orange")
  )
```



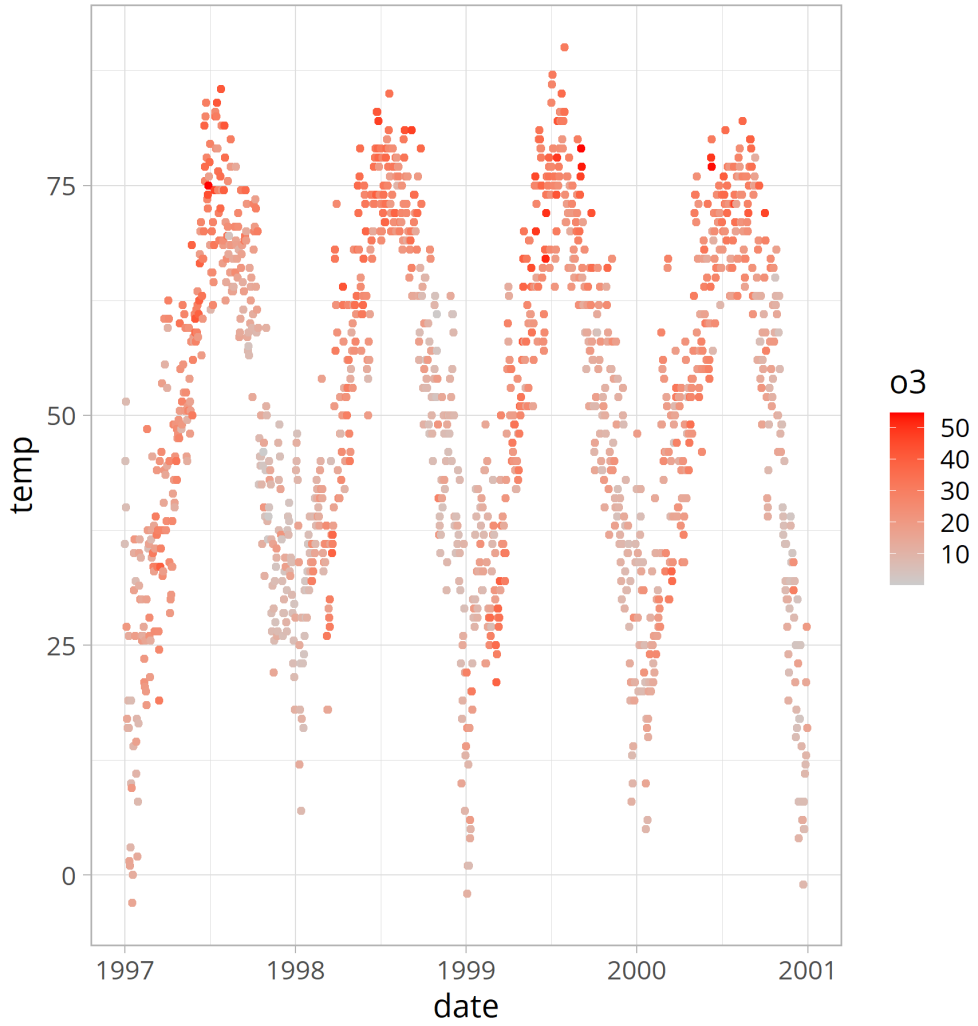
scale_color|fill_gradient()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_gradient(
    low = "dodgerblue",
    high = "red"
  )
```



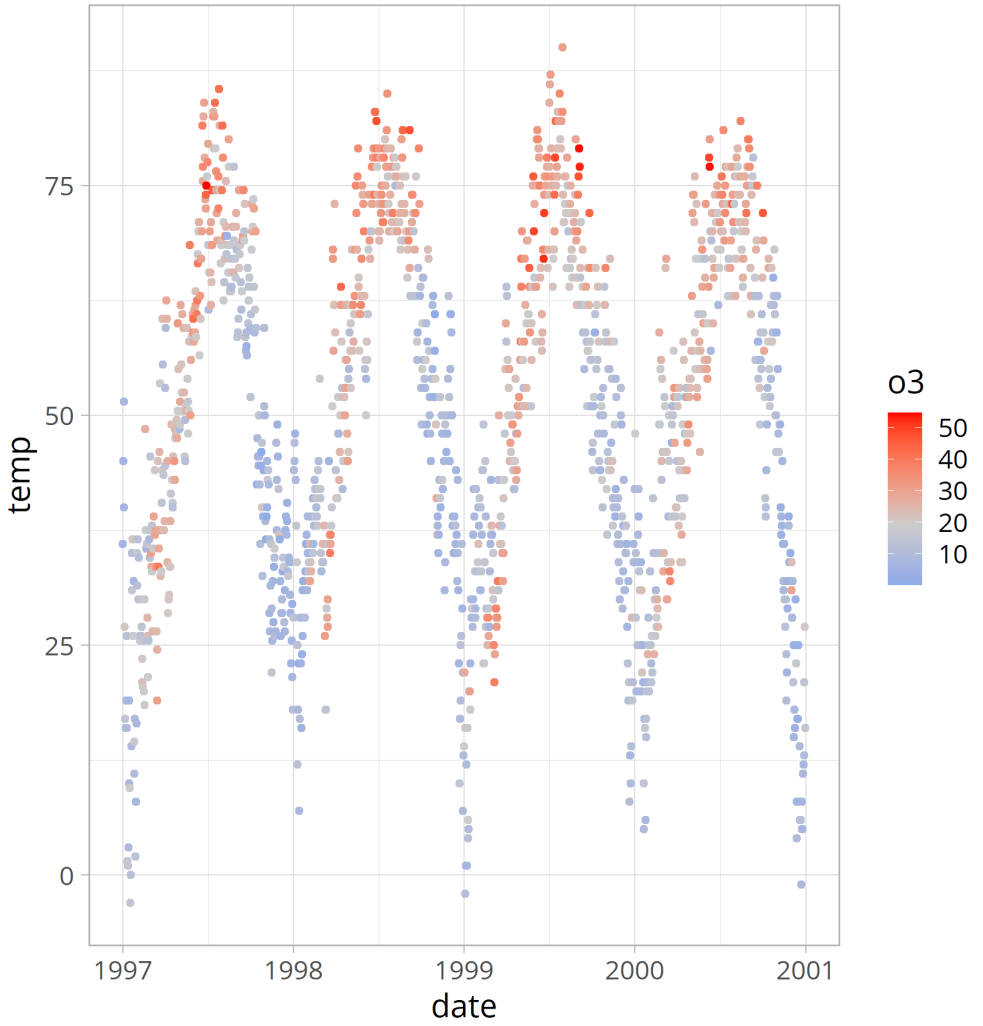
scale_color|fill_gradient2()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_gradient2(
    low = "dodgerblue",
    mid = "grey80",
    high = "red"
  )
```



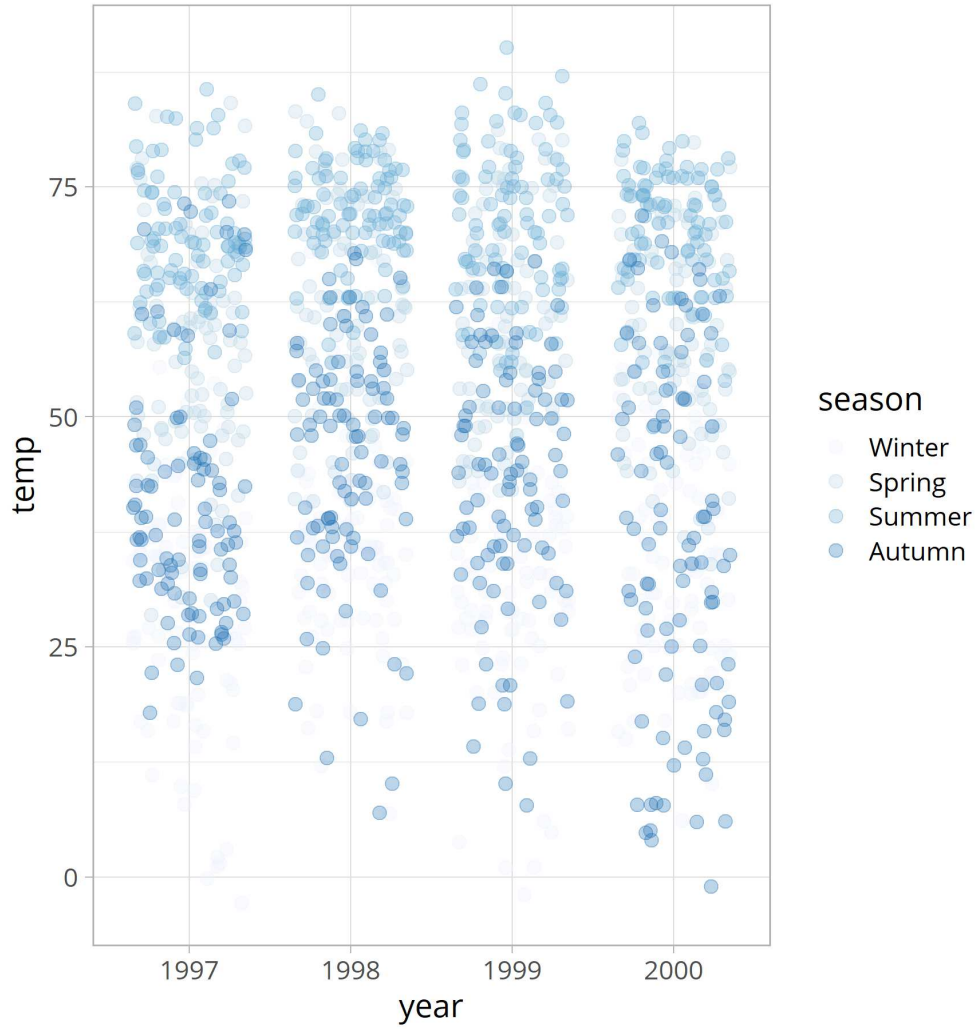
scale_color|fill_gradient2()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_gradient2(
    low = "dodgerblue",
    mid = "grey80",
    high = "red",
    midpoint = mean(chic$o3)
  )
```



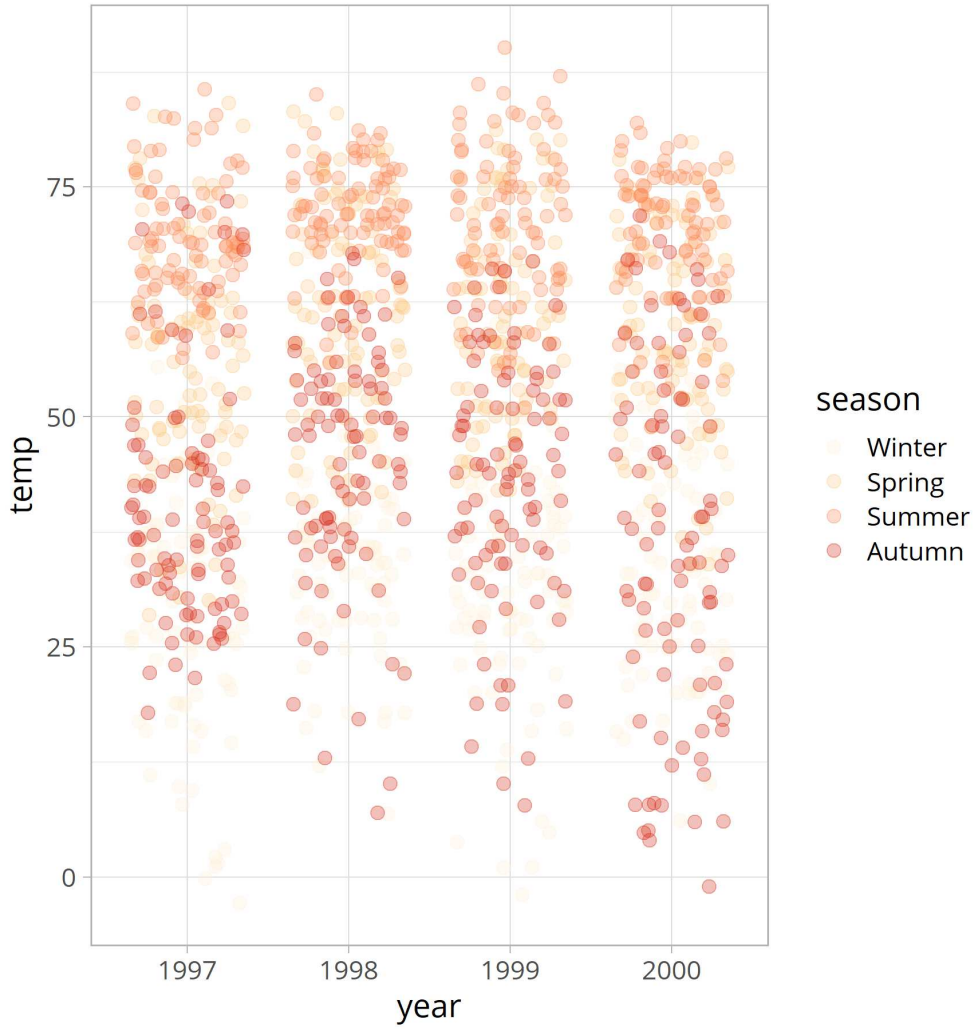
scale_color|fill_brewer()

```
g +
  scale_color_brewer()
```



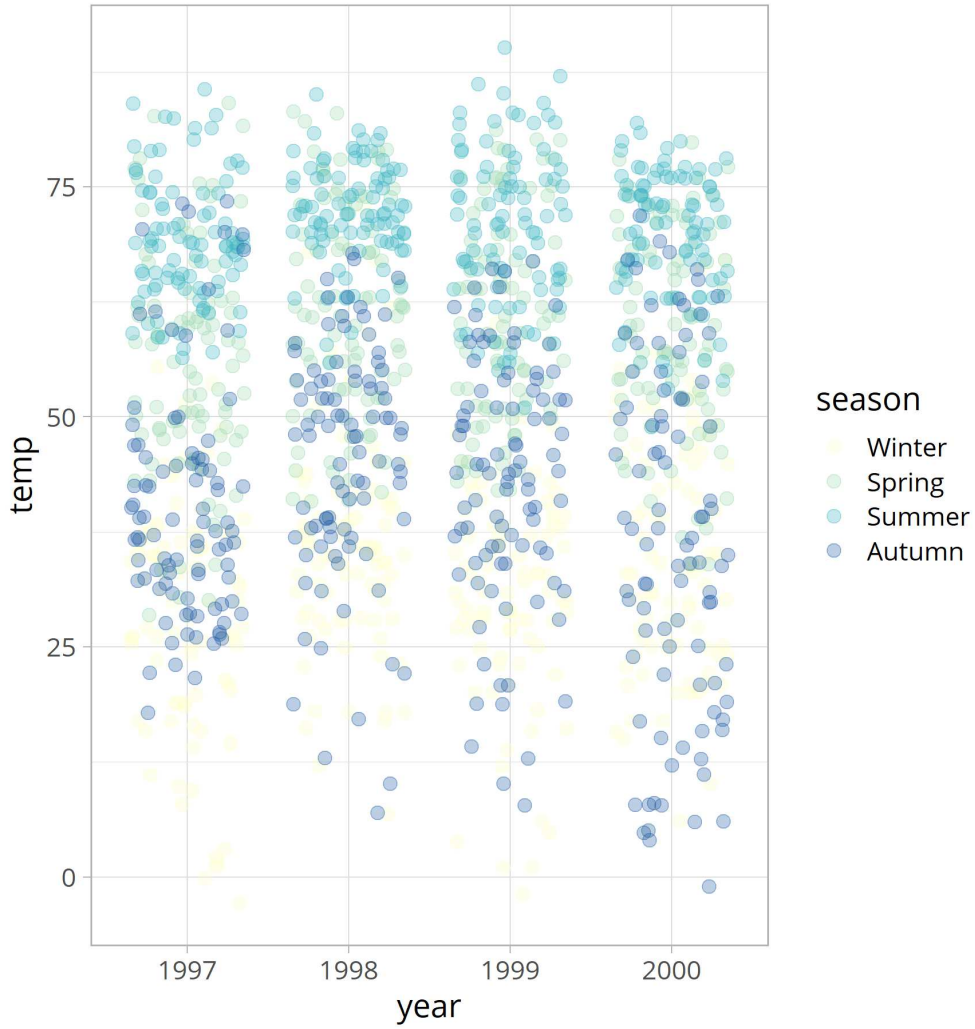
scale_color|fill_brewer()

```
g +
  scale_color_brewer(
    palette = 8
  )
```



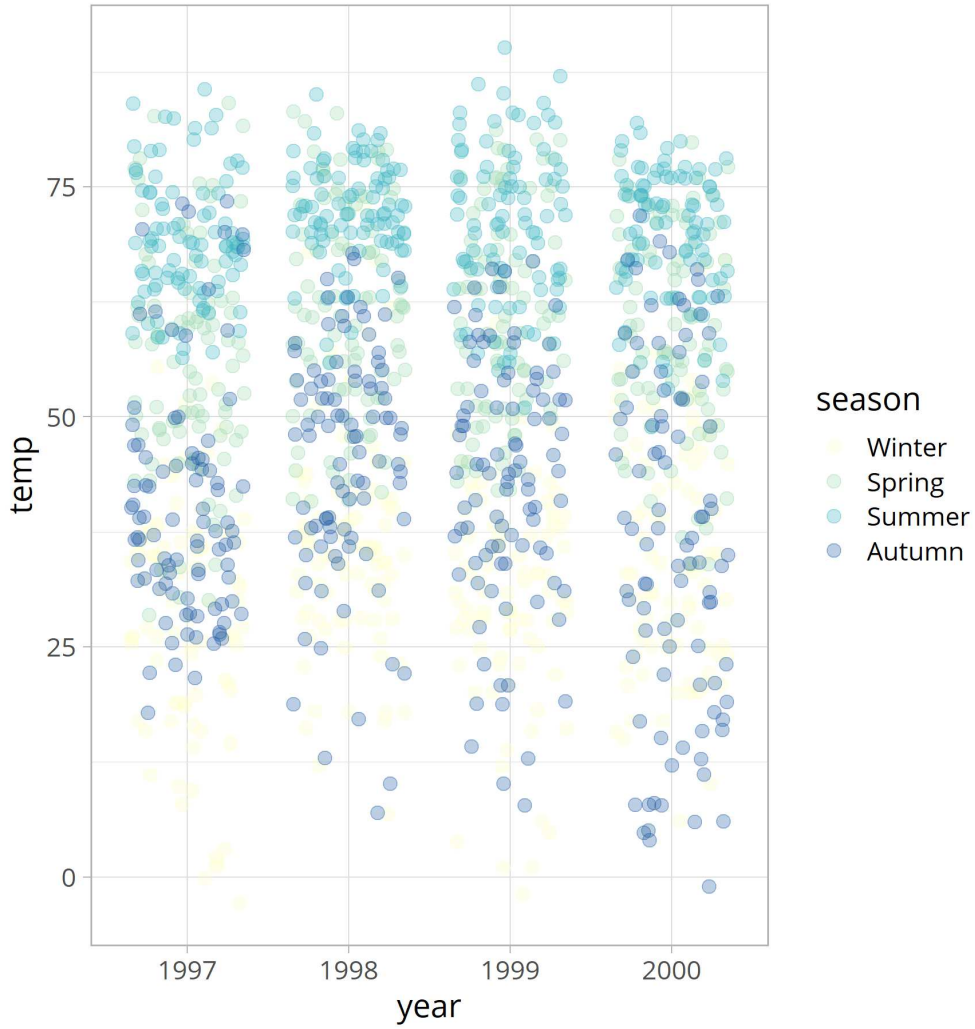
scale_color|fill_brewer()

```
g +
  scale_color_brewer(
    palette = "YlGnBu"
  )
```



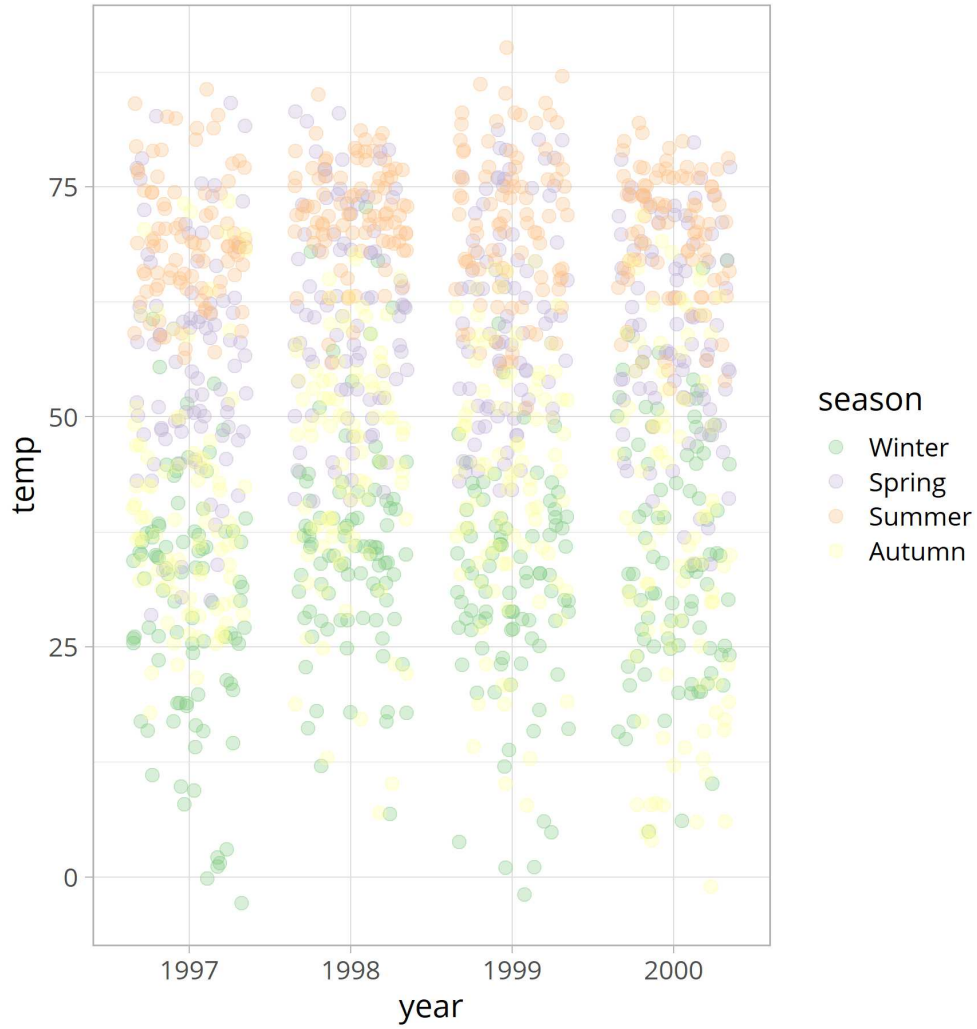
scale_color|fill_brewer()

```
g +
  scale_color_brewer(
    type = "seq", ## the default
    palette = "YlGnBu"
  )
```



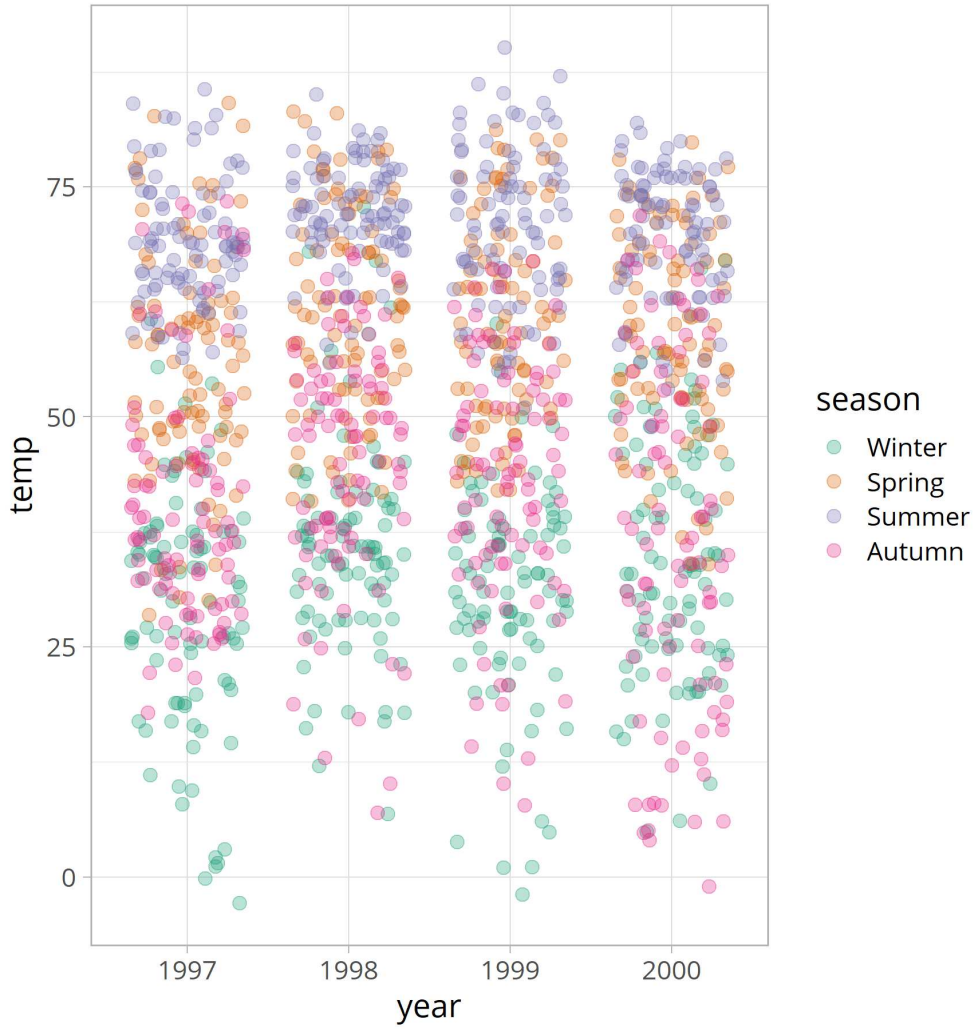
scale_color|fill_brewer()

```
g +
  scale_color_brewer(
    type = "qual"
 )
```



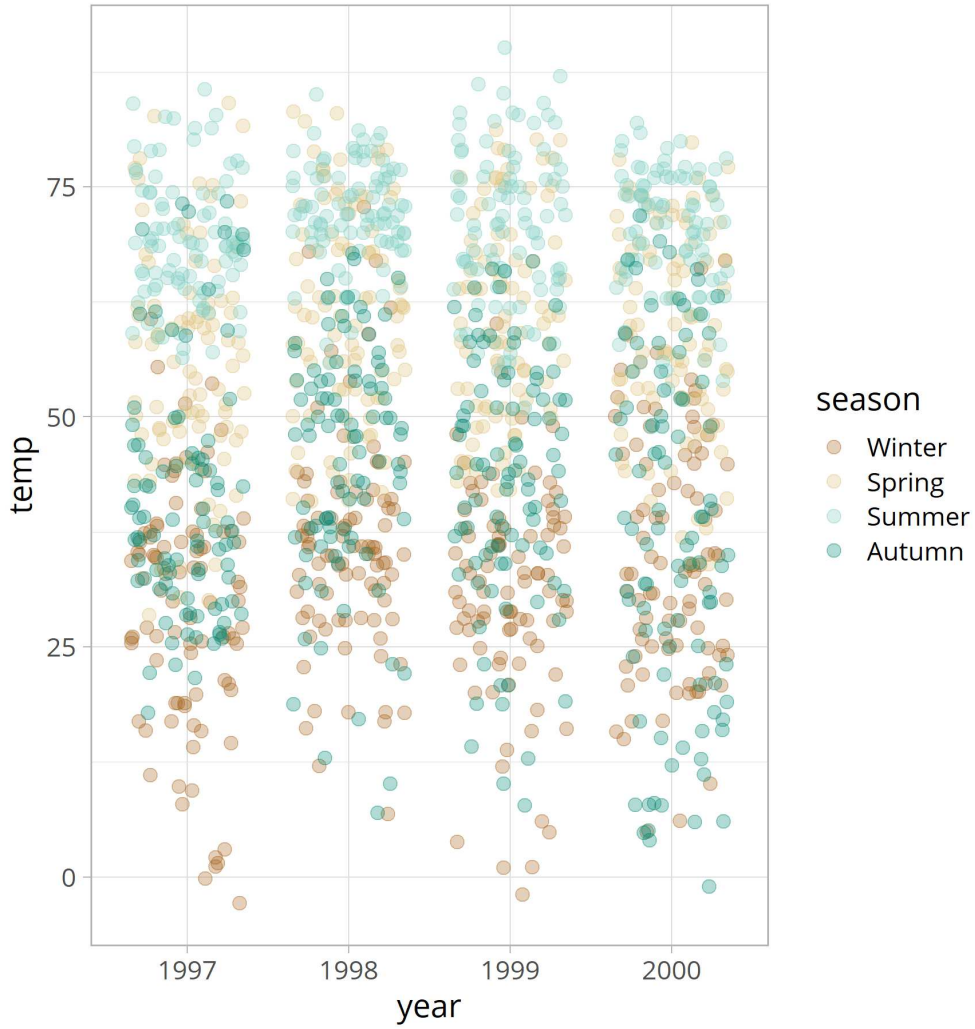
scale_color|fill_brewer()

```
g +
  scale_color_brewer(
    type = "qual",
    palette = "Dark2"
 )
```



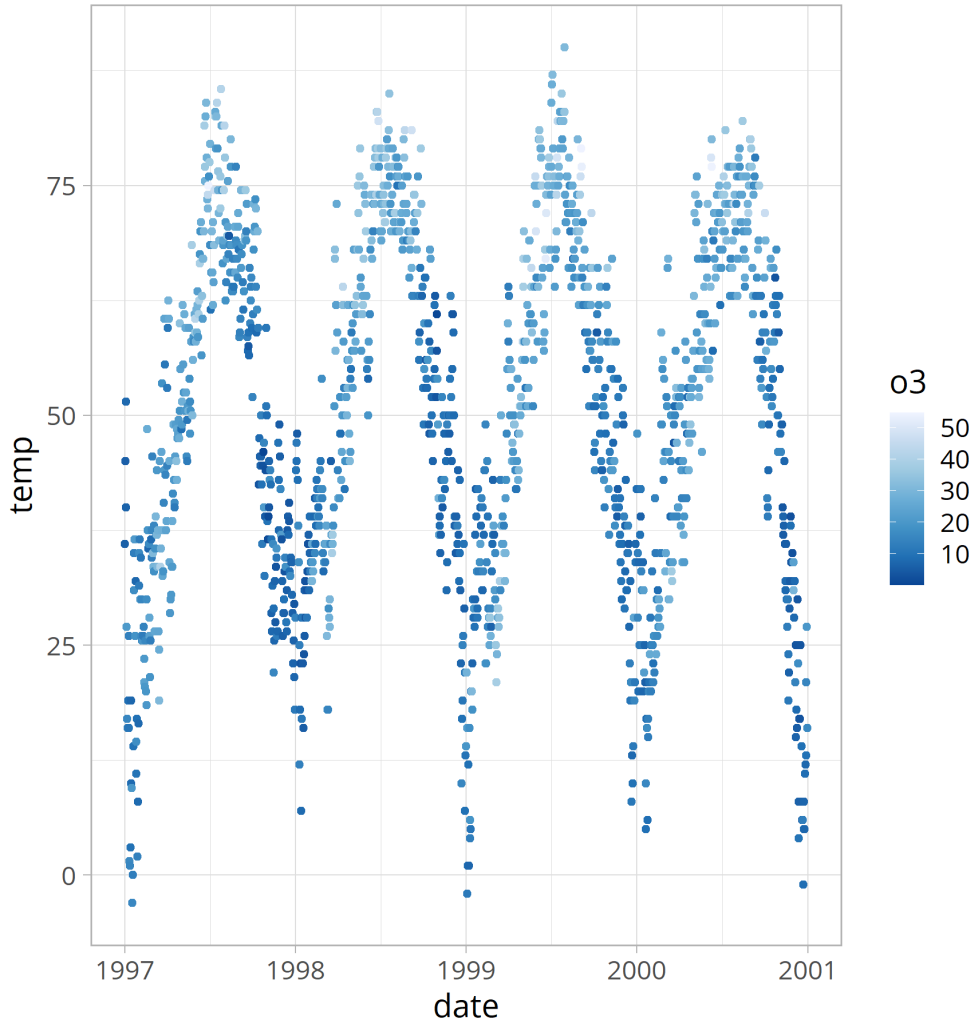
scale_color|fill_brewer()

```
g +
  scale_color_brewer(
    type = "div"
 )
```



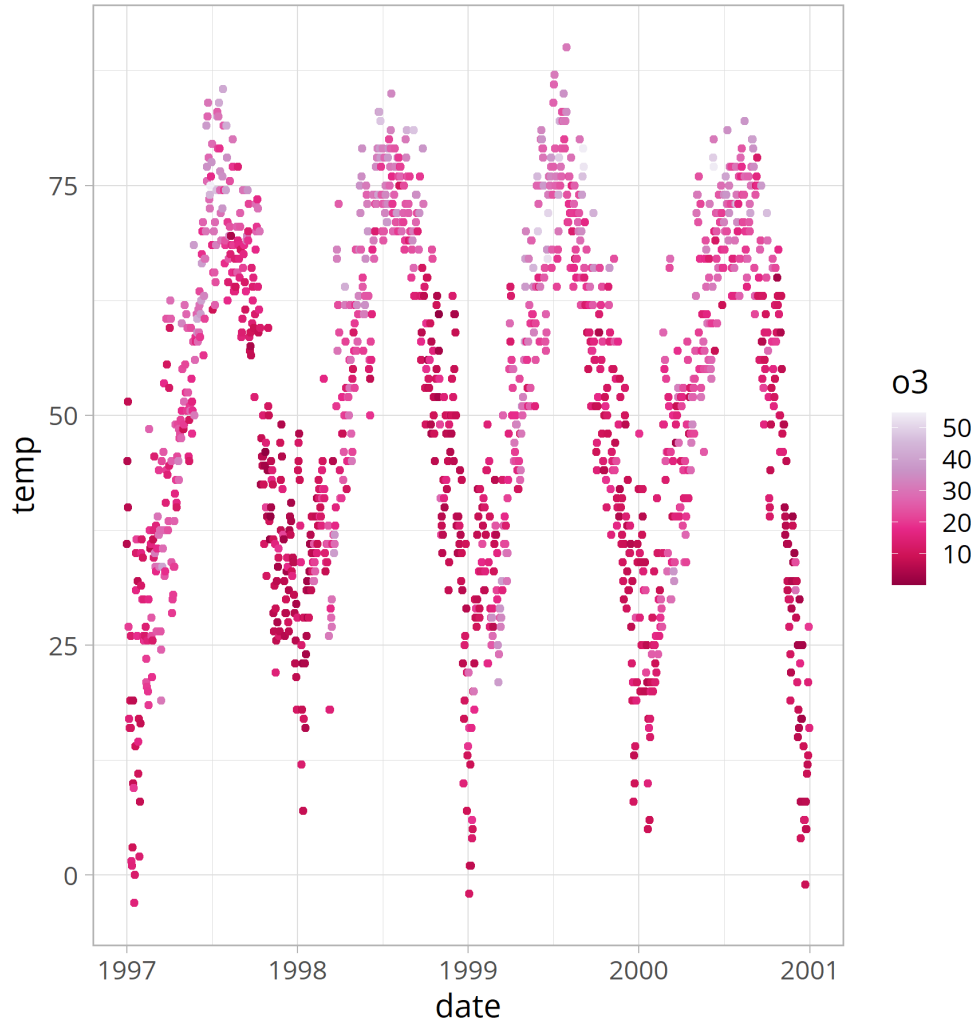
scale_color|fill_distiller()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_distiller()
```



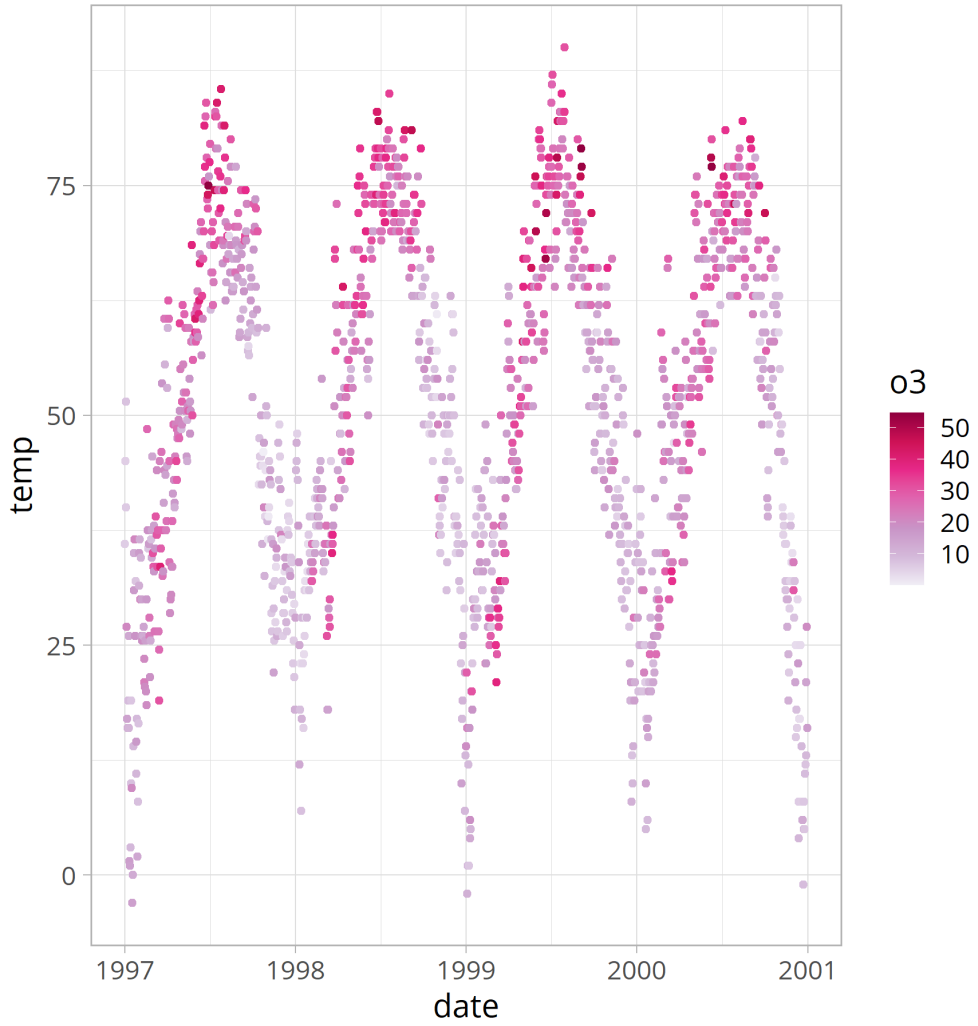
scale_color|fill_distiller()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_distiller(
    palette = "PuRd"
  )
```



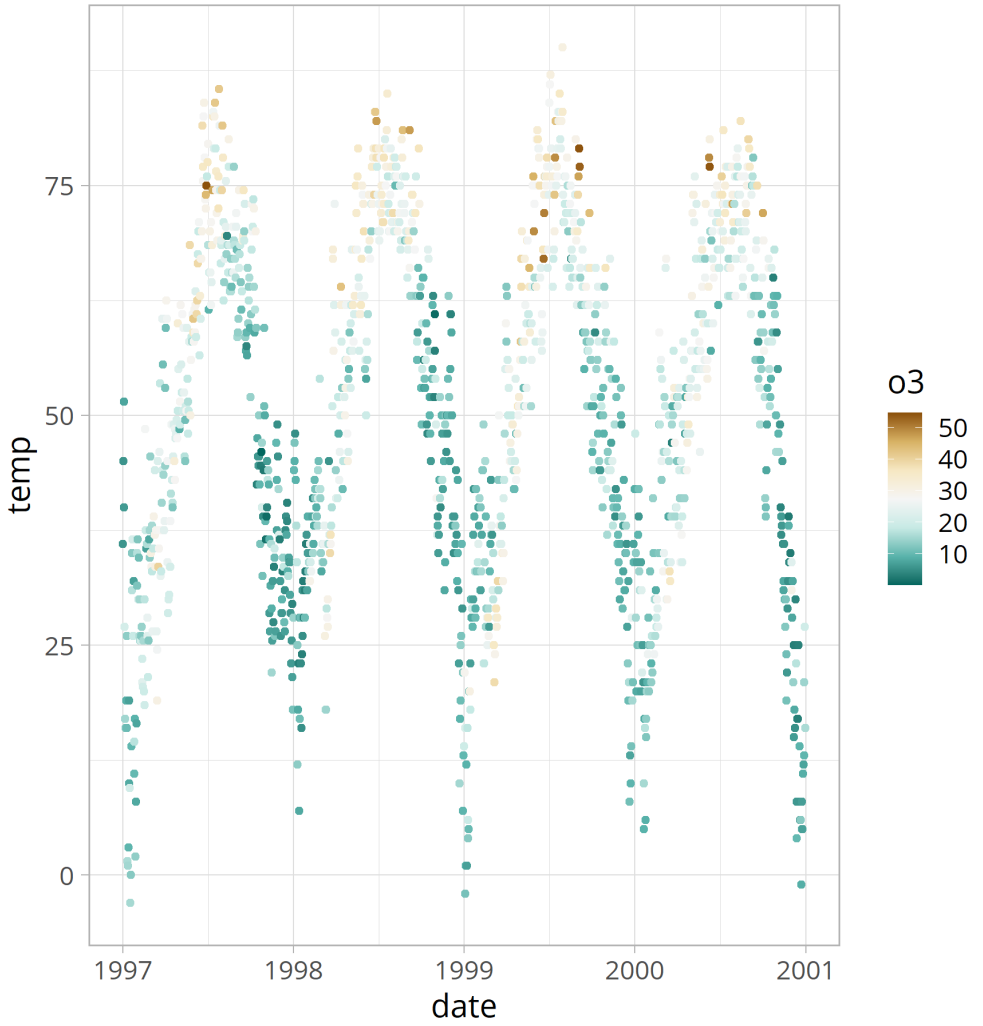
scale_color|fill_distiller()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_distiller(
    palette = "PuRd",
    direction = 1
    ## note that -1 is the default
  )
```



scale_color|fill_distiller()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_distiller(
    type = "div"
 )
```



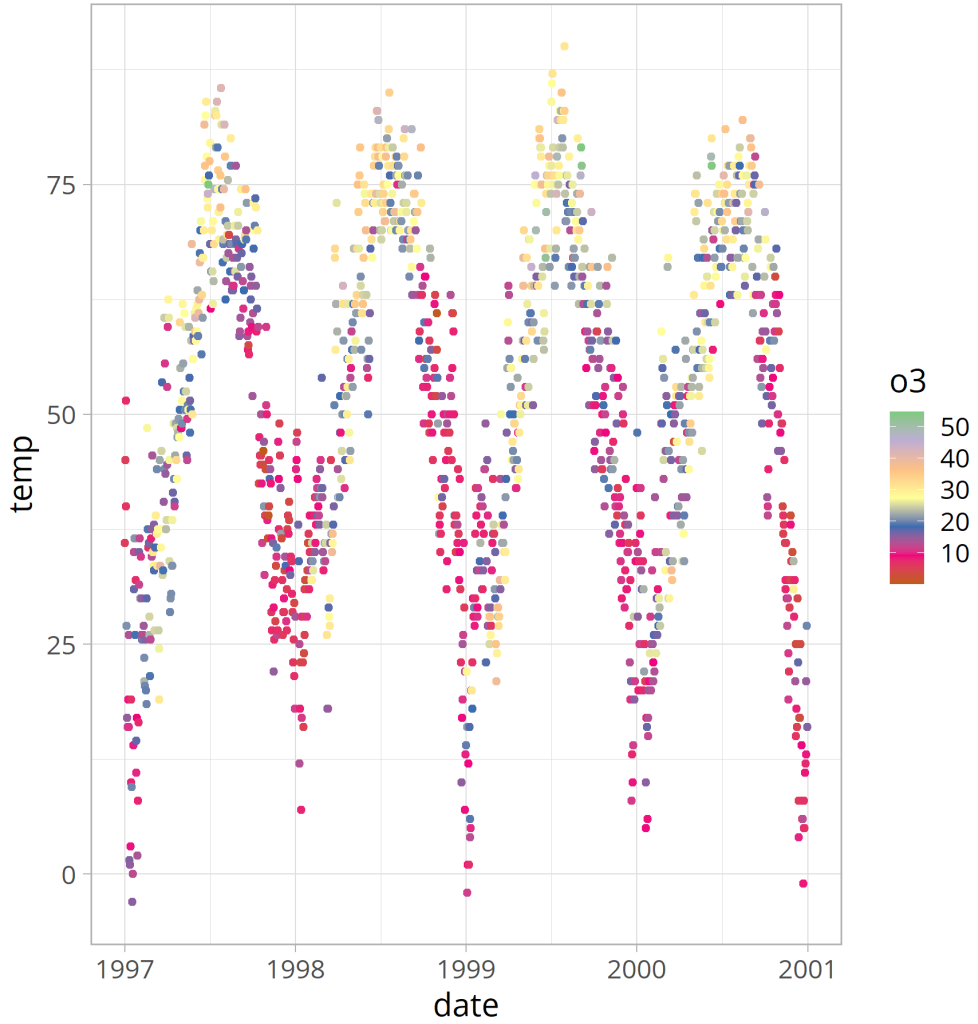
scale_color|fill_distiller()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_distiller(
    type = "div",
    palette = "Spectral"
 )
```

scale_color|fill_distiller()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scale_color_distiller(
    type = "qual"
 )
```

```
Warning message: Using a discrete colour palette
in a continuous scale. Consider using type = "seq"
or type = "div" instead.
```



`scale_color|fill_*()`

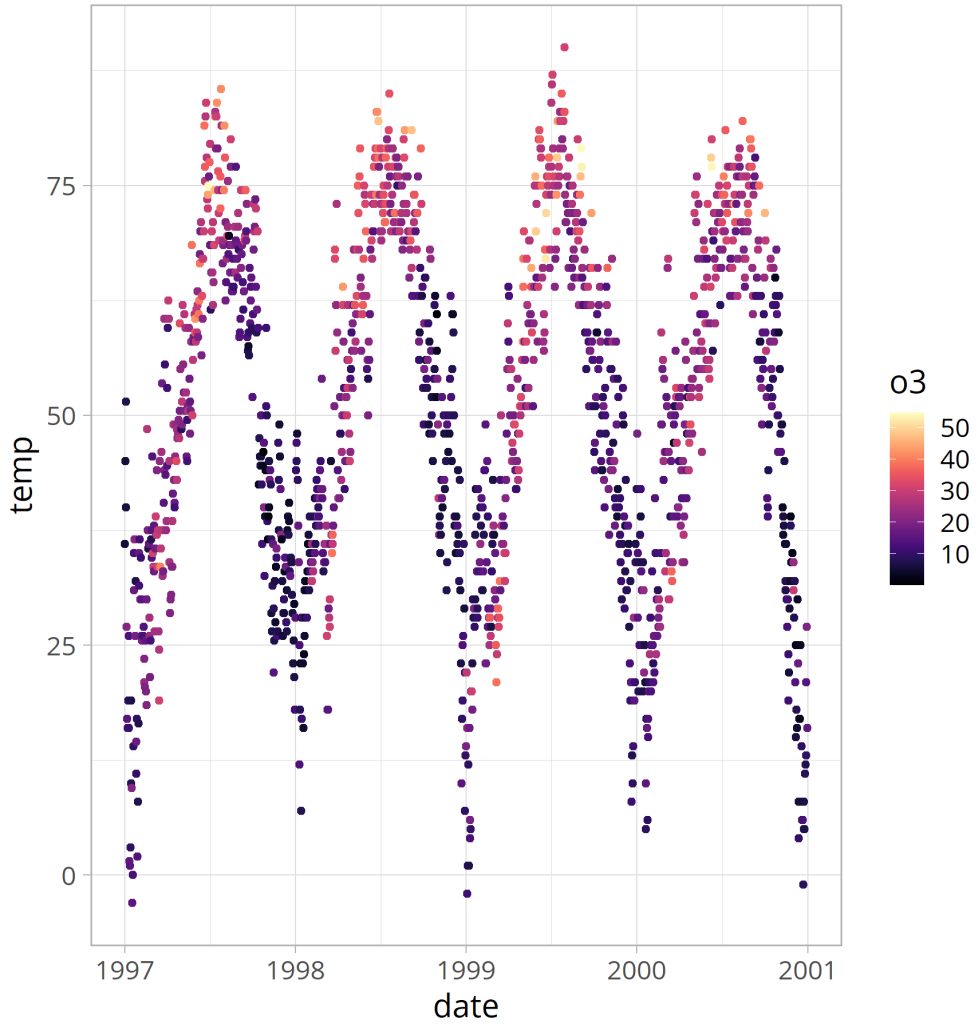
Several packages offer predefined palettes, e.g.:

- `{viridis}` for perceptually uniform palettes
- `{scico}` for more perceptually uniform palettes
- `{rcartocolor}` for map color palettes
- `{ggsci}` for scientific journal and sci-fi themed color
- `{ggthemes}` for colors of popular software & publishers
- `{LaCroixColoR}` for vibrant summery colors

Check the collection by Emil Hvitfeldt for an extensive list of color palettes available in R!

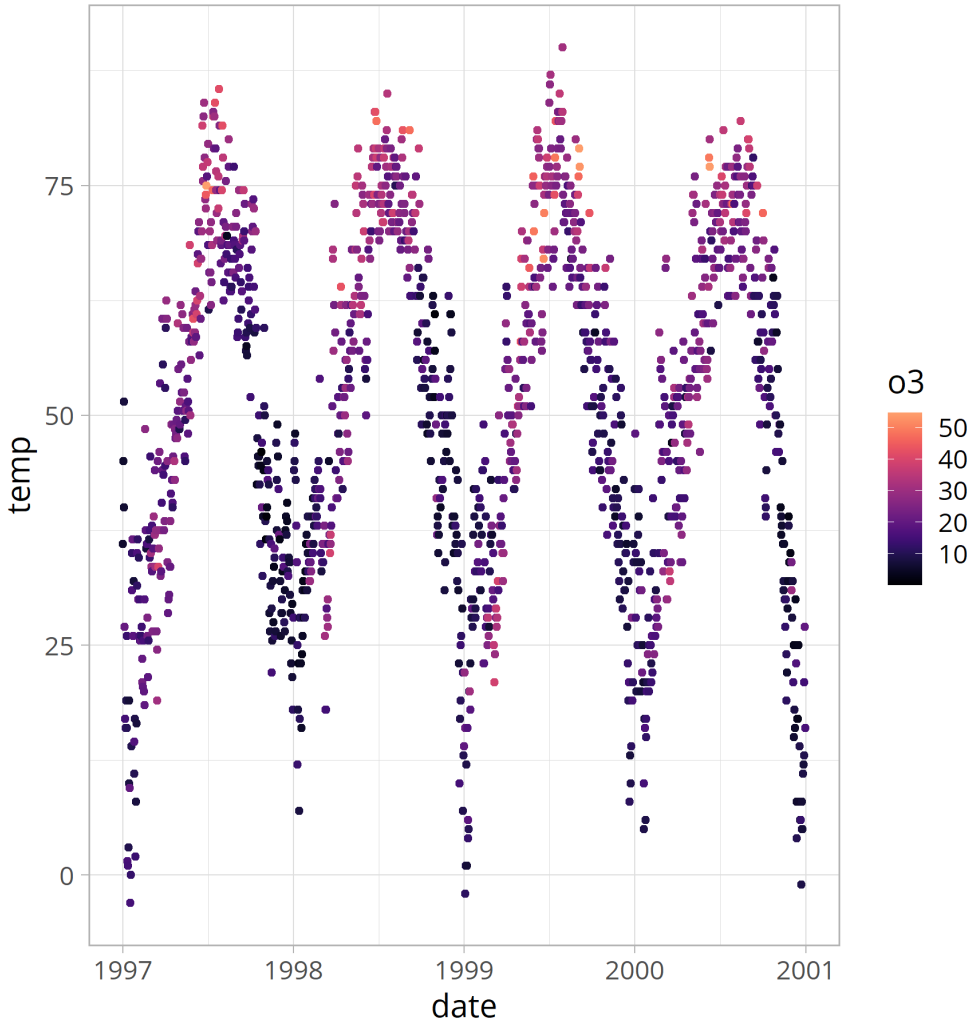
viridis::scale_color|fill_viridis()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  viridis::scale_color_viridis(
    option = "magma"
  )
```



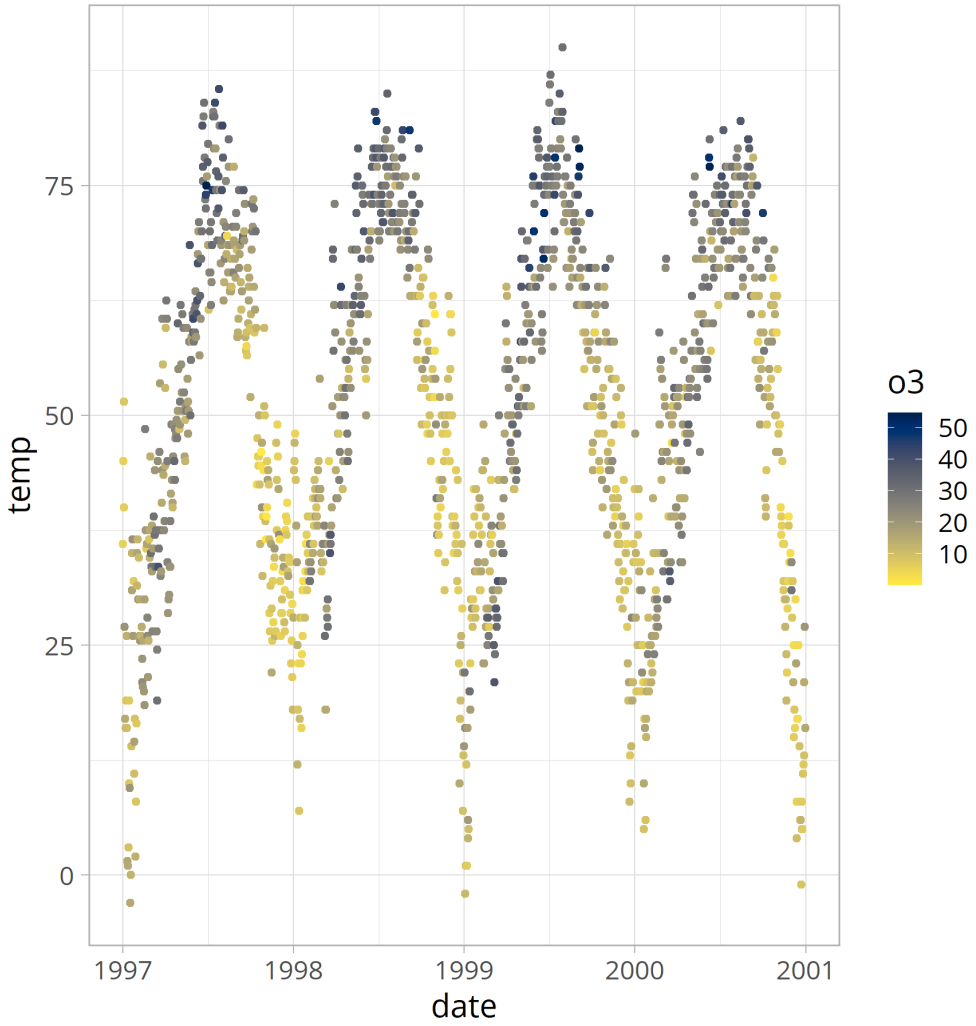
viridis::scale_color|fill_viridis()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  viridis::scale_color_viridis(
    option = "magma",
    end = .8
  )
```



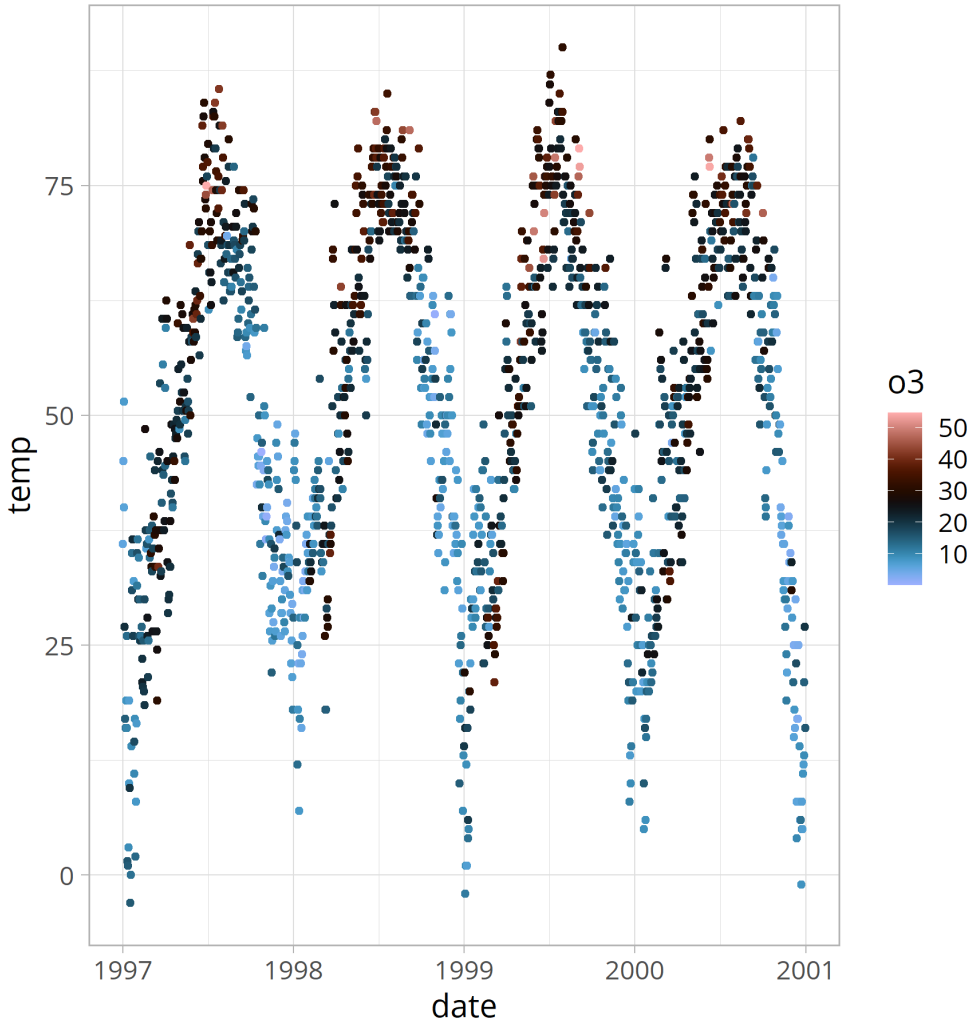
viridis::scale_color|fill_viridis()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  viridis::scale_color_viridis(
    option = "cividis",
    direction = -1
  )
```



scico::scale_color|fill_scico()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  scico::scale_color_scico(
    palette = "berlin"
  )
```

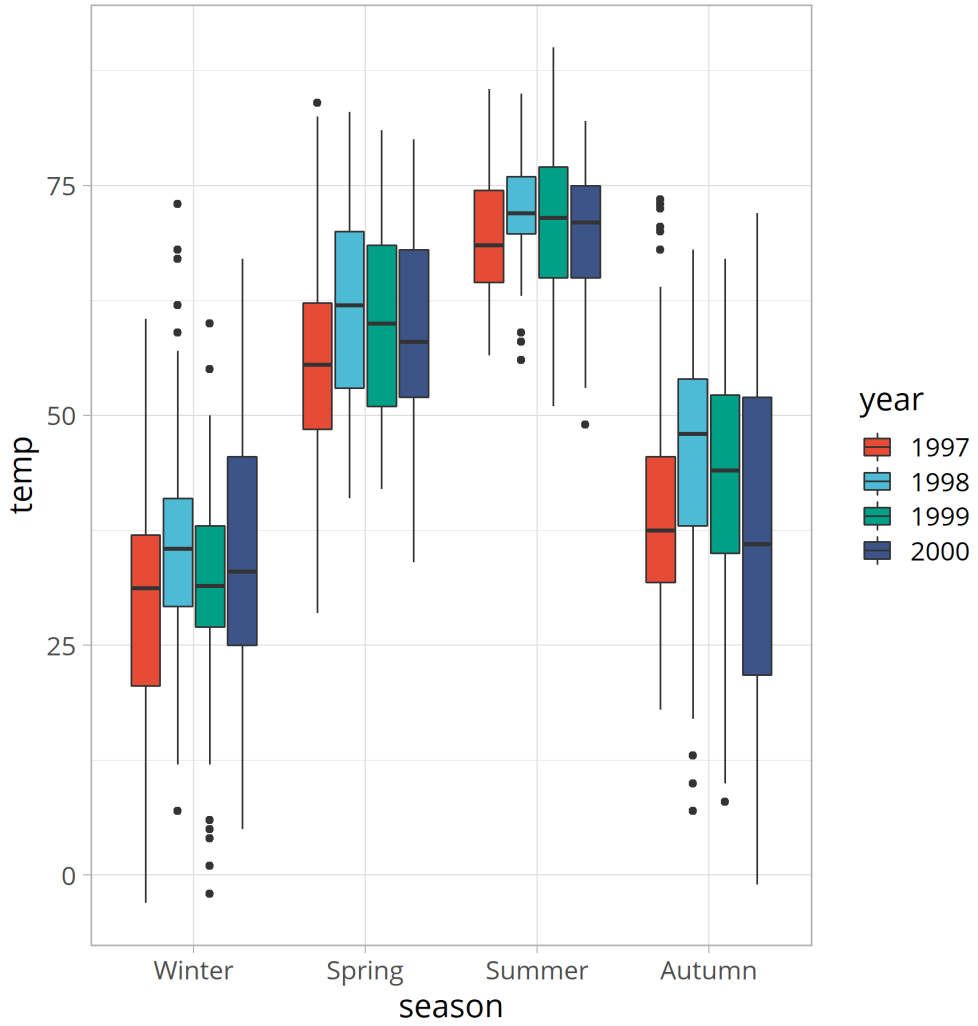


rcartocolor::scale_color|fill_carto_c()

```
ggplot(chic, aes(date, temp)) +
  geom_point(aes(color = o3)) +
  rcartocolor::scale_color_carto_c(
    palette = "Temps"
  )
```

ggsci::scale_color|fill_*()

```
ggplot(chic, aes(season, temp)) +
  geom_boxplot(aes(fill = year)) +
  ggsci::scale_fill_npg()
```

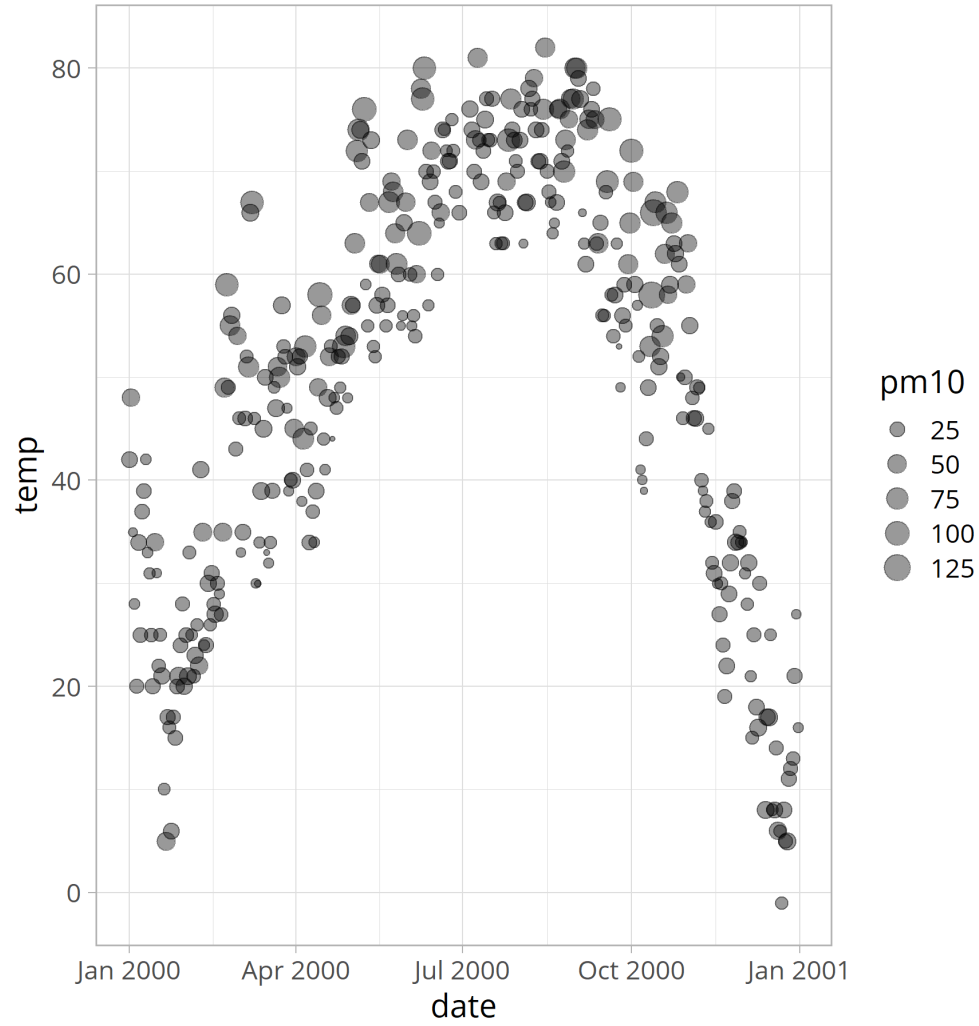


Scales

`scale_size|radius_*()`

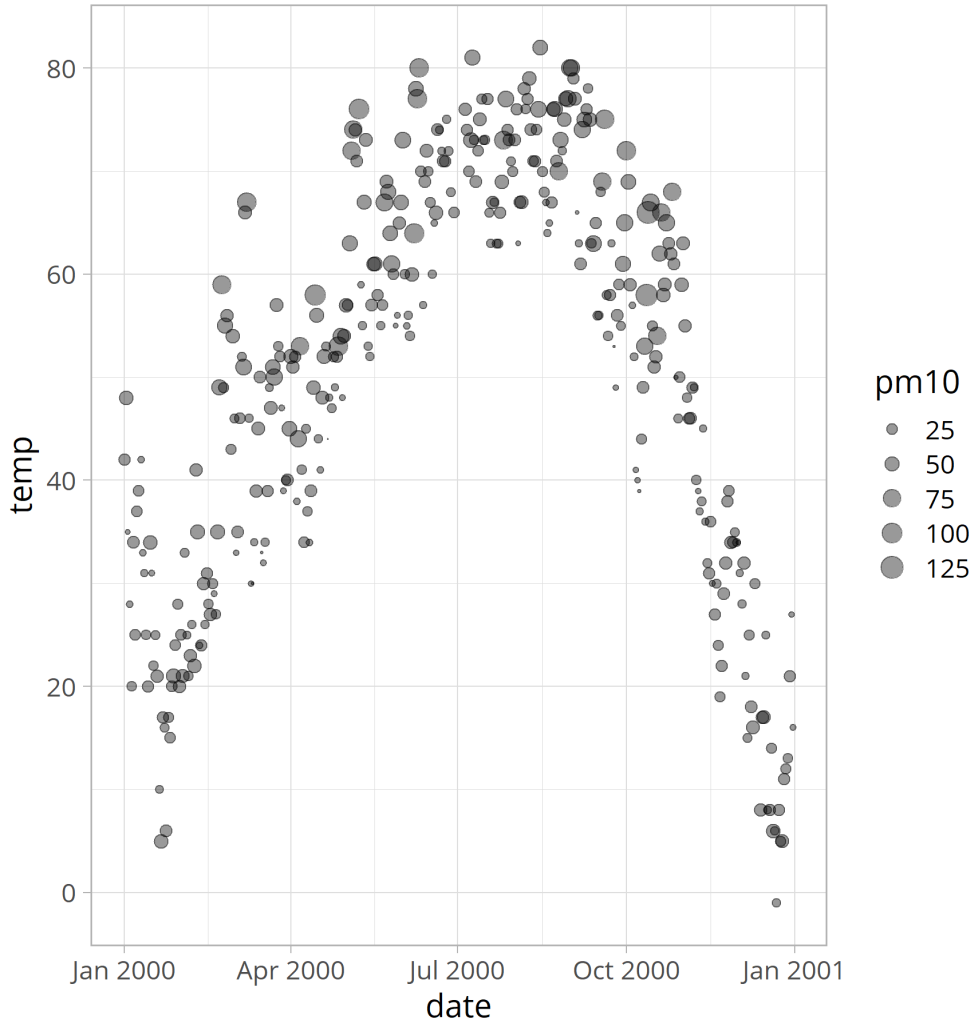
scale_size|radius_*()

```
chic2k <- filter(chic, year == 2000)

  ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(size = pm10),
    alpha = .4
  )
```



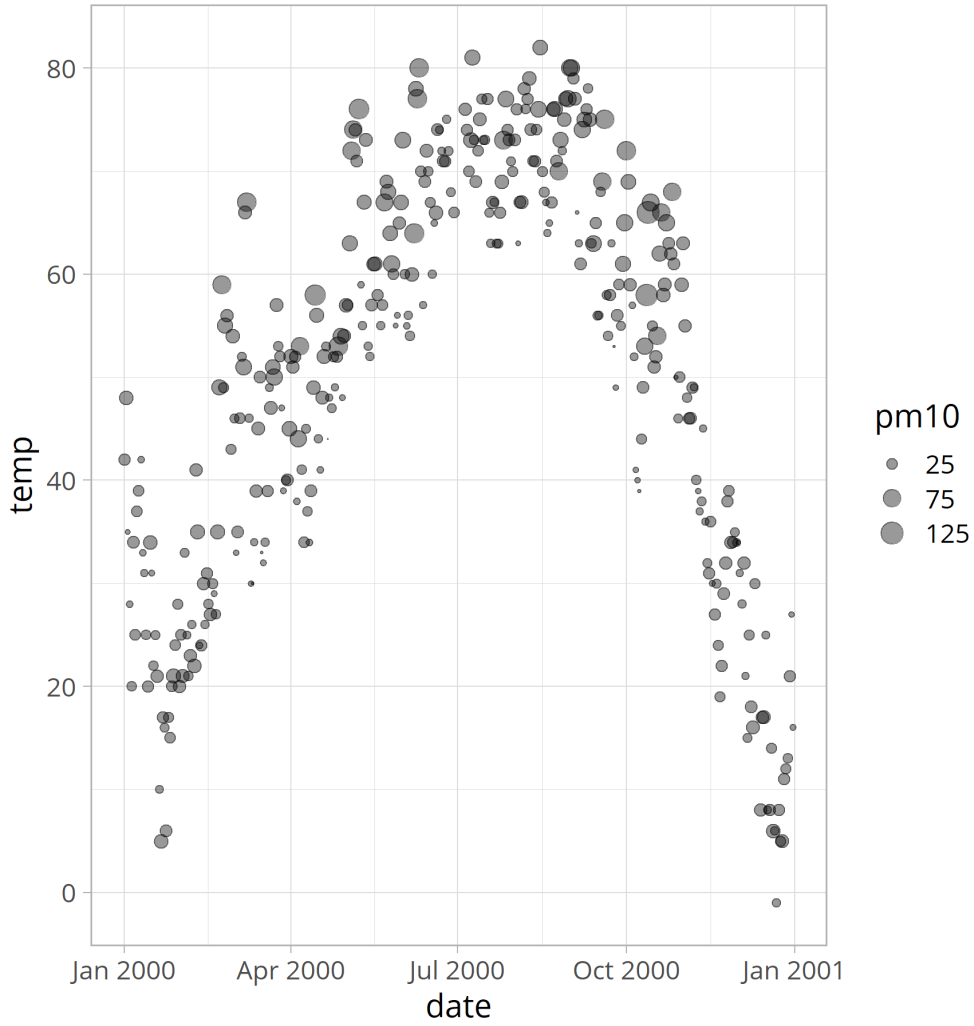
scale_size()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(size = pm10),
    alpha = .4
  ) +
  scale_size(
    range = c(.1, 5)
  )
```



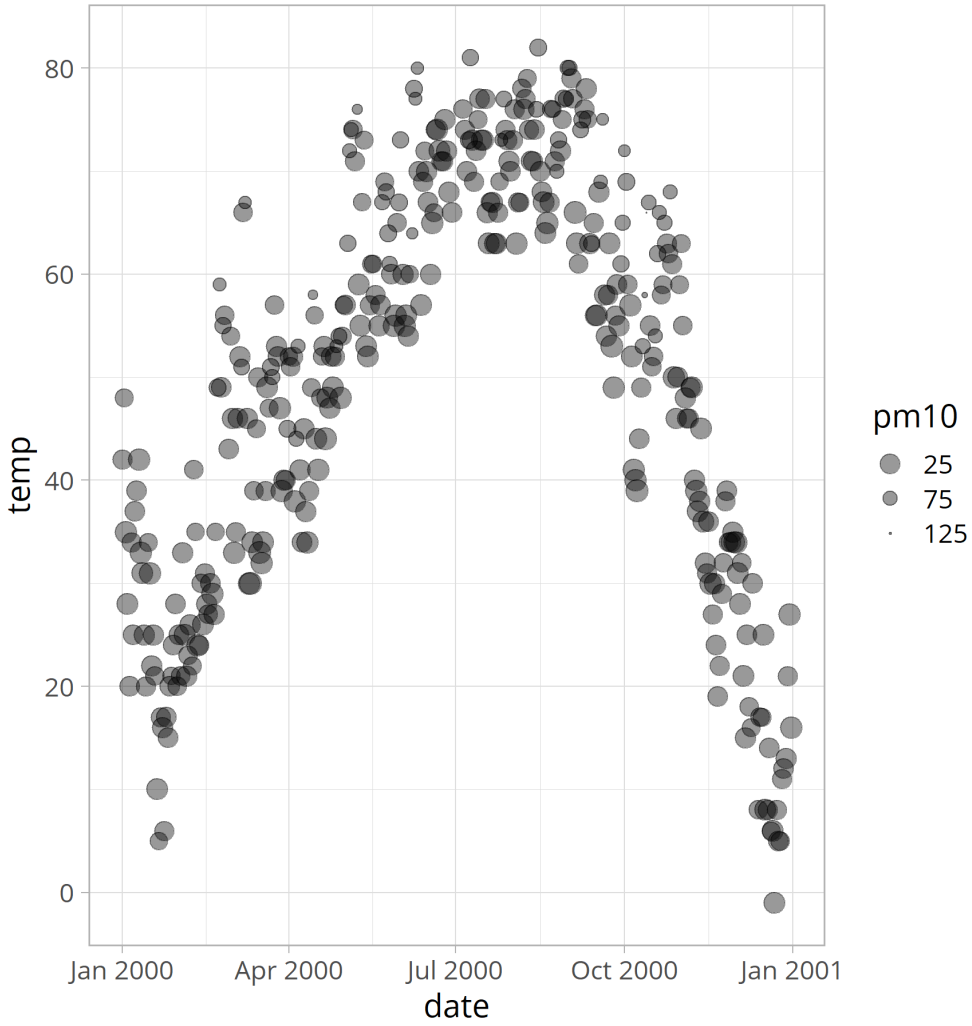
scale_size()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(size = pm10),
    alpha = .4
  ) +
  scale_size(
    range = c(.1, 5),
    breaks = c(25, 75, 125)
  )
```



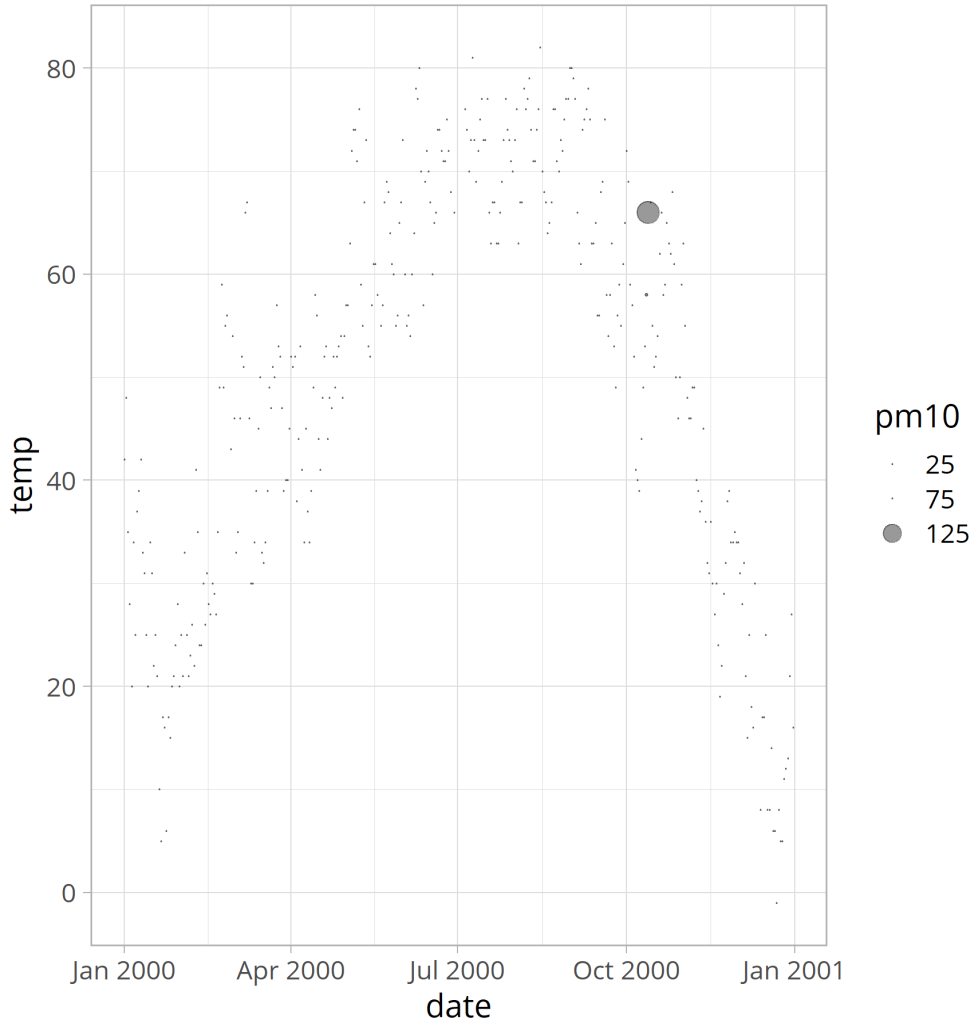
scale_size()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(size = pm10),
    alpha = .4
  ) +
  scale_size(
    range = c(.1, 5),
    breaks = c(25, 75, 125),
    trans = "reverse"
  )
```



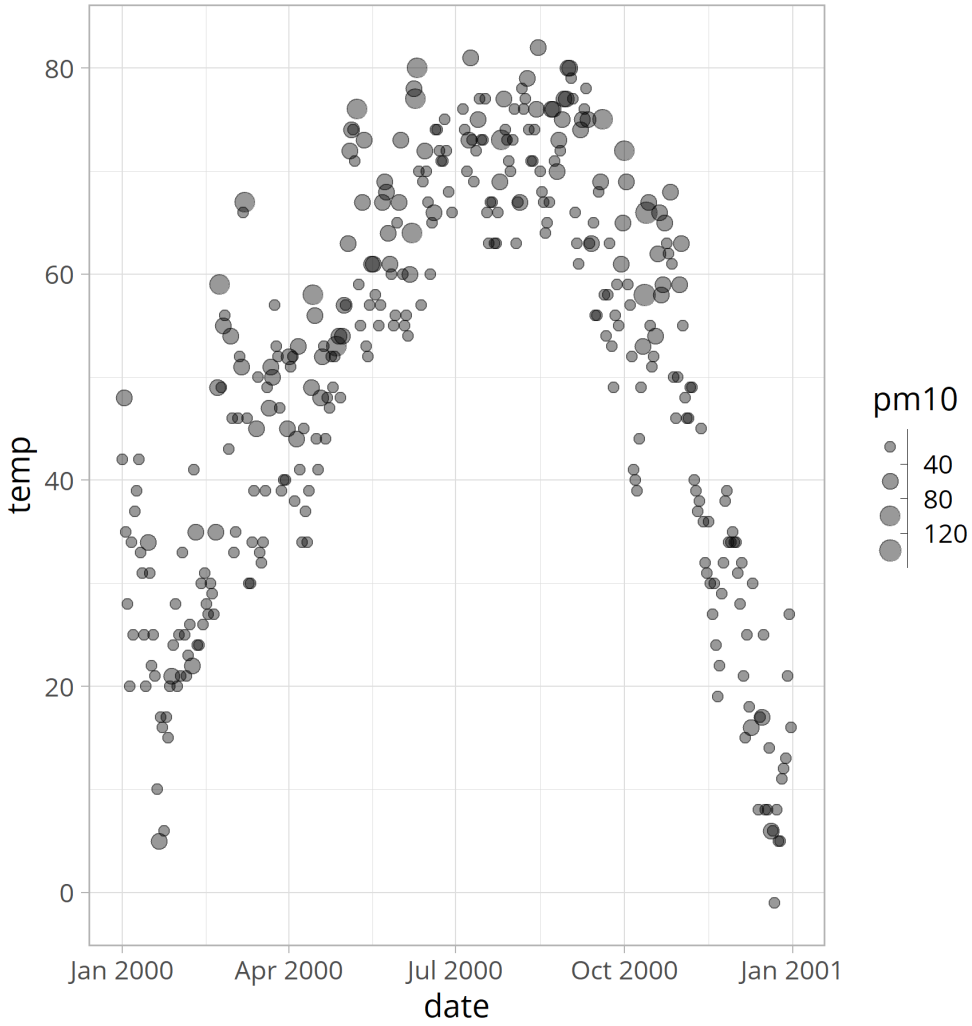
scale_size()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(size = pm10),
    alpha = .4
  ) +
  scale_size(
    range = c(.1, 5),
    breaks = c(25, 75, 125),
    trans = "exp"
  )
```



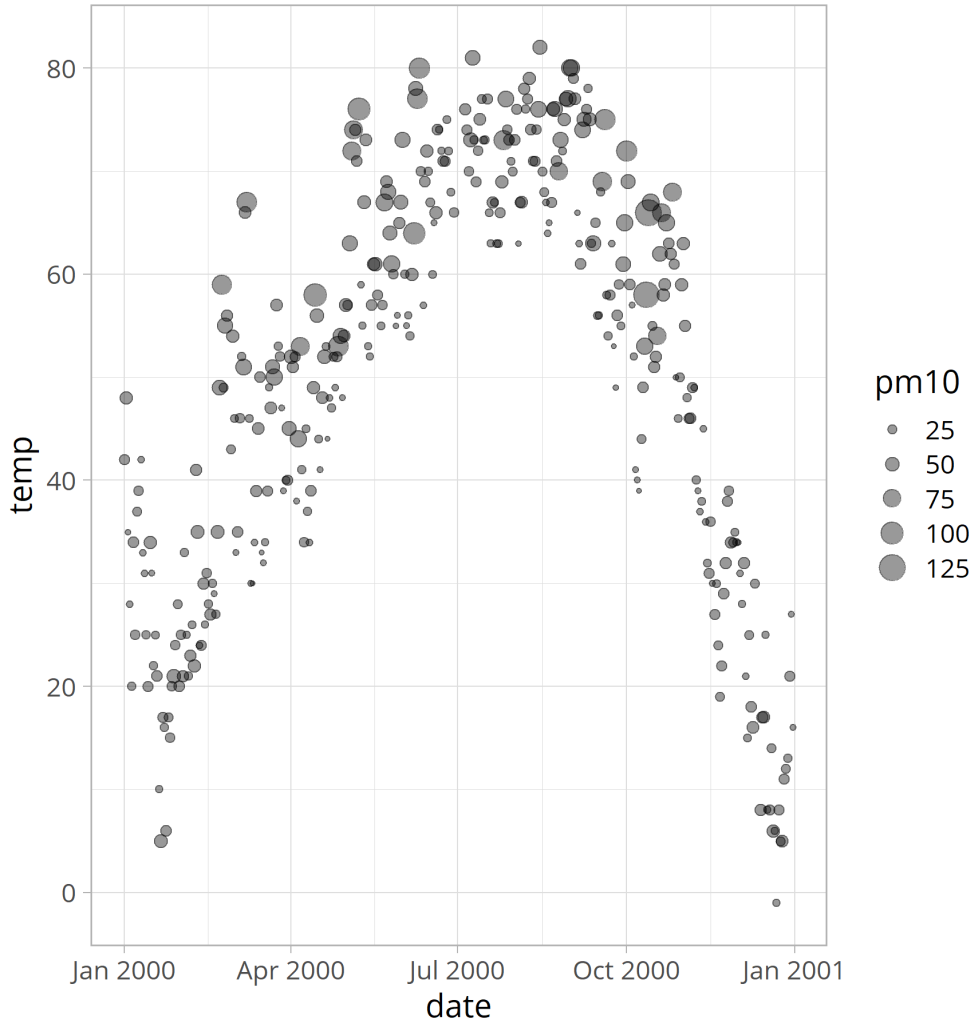
scale_size()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(size = pm10),
    alpha = .4
  ) +
  scale_size_binned(
    n.breaks = 3,
    range = c(.5, 5)
  )
```



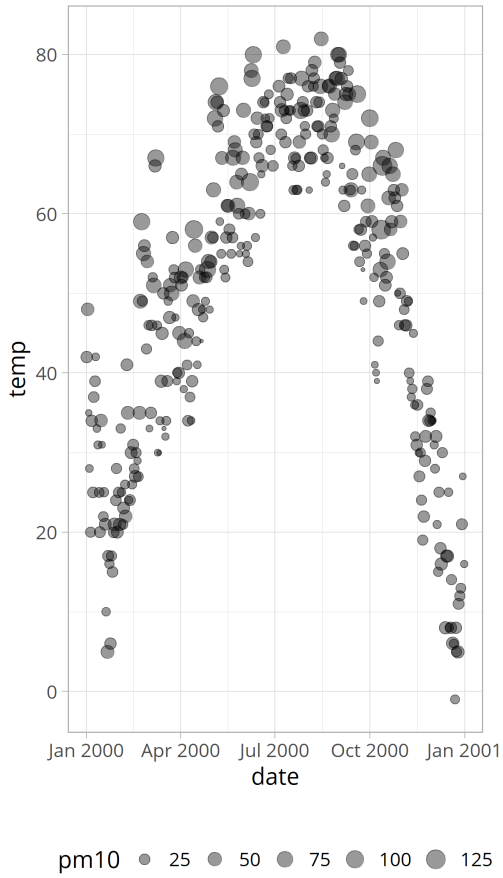
scale_radius()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(size = pm10),
    alpha = .4
  ) +
  scale_radius()
```

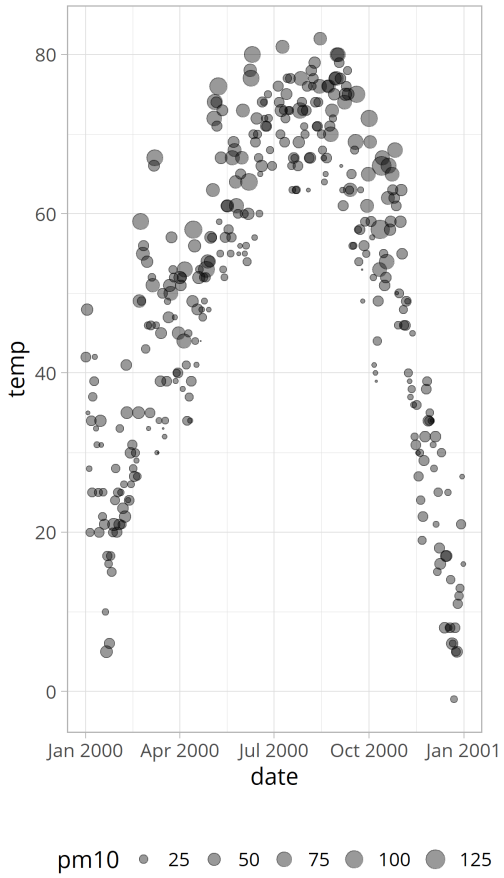


scale_size|radius_*()

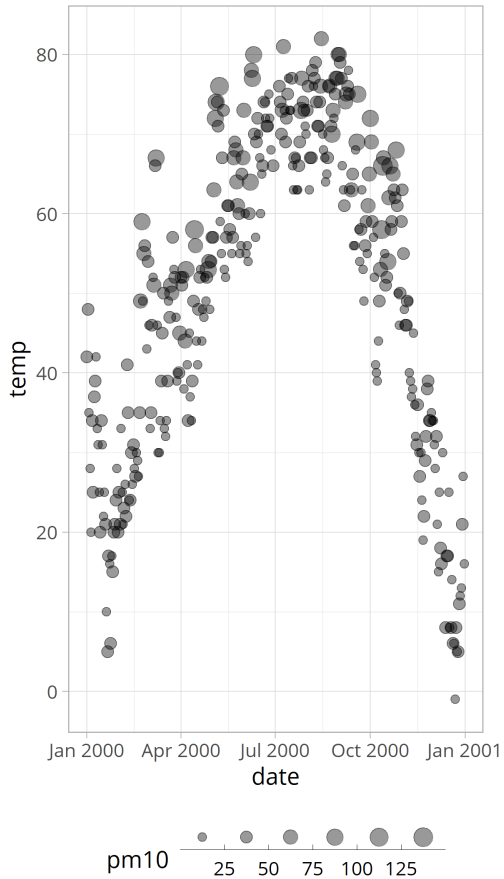
scale_size()
default



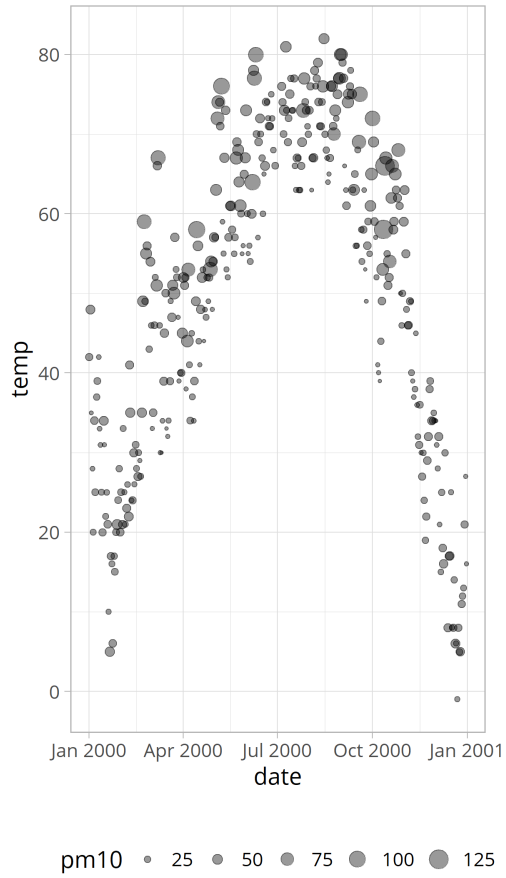
scale_size_area()



scale_size_binned()



scale_radius()

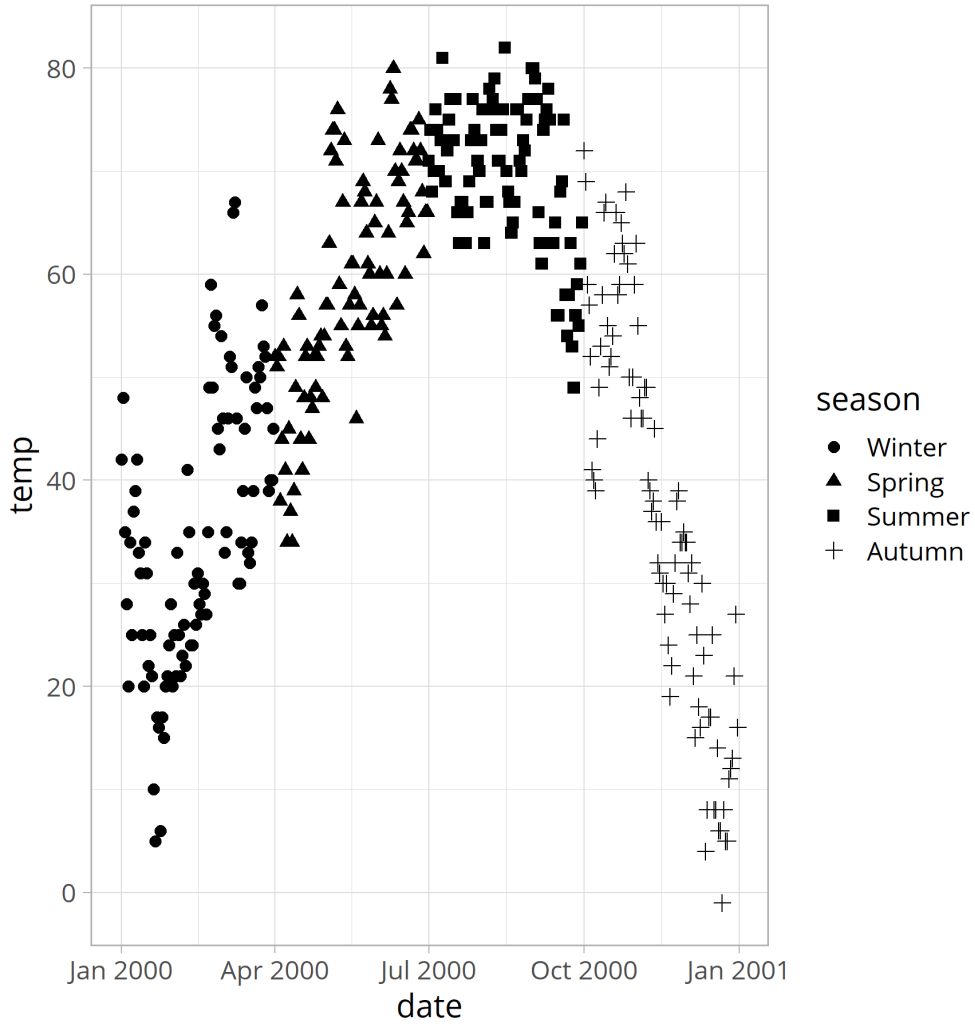


Scales

`scale_shape|linetype_*()`

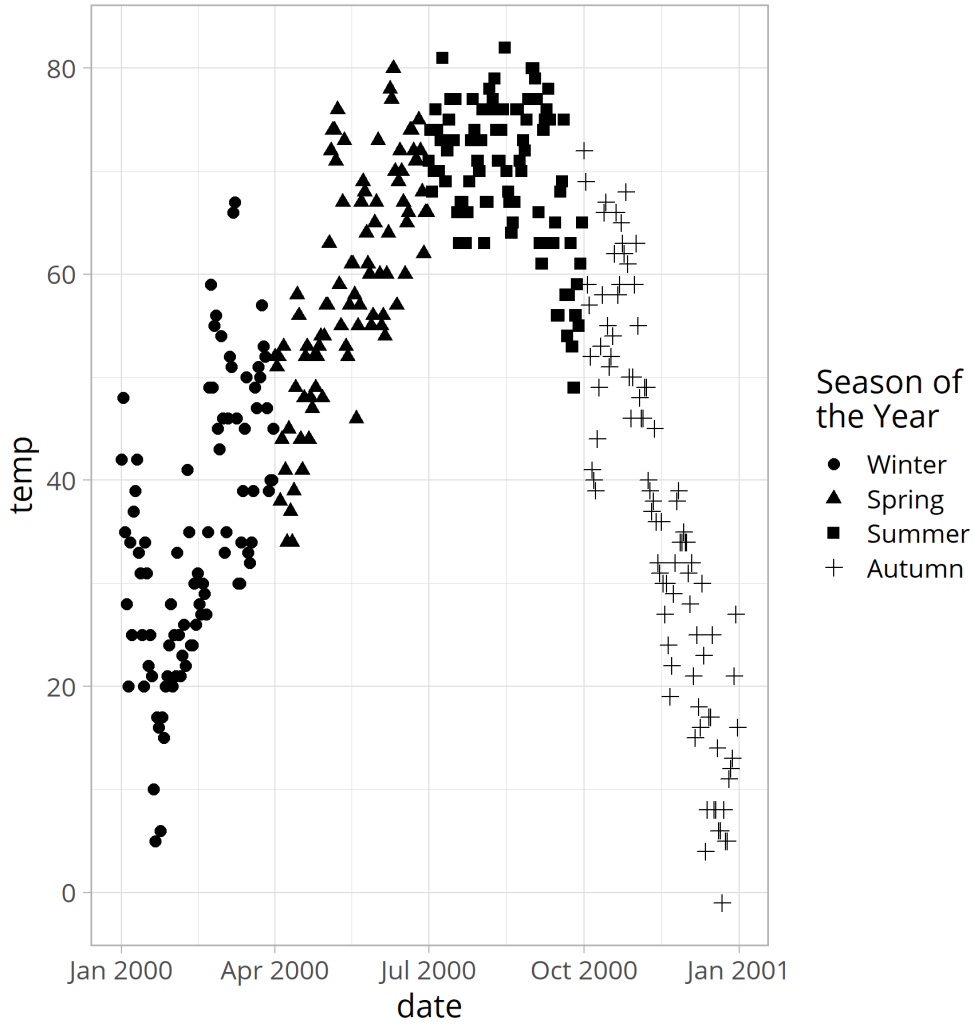
scale_shape_*()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(shape = season),
    size = 2.5
  )
```



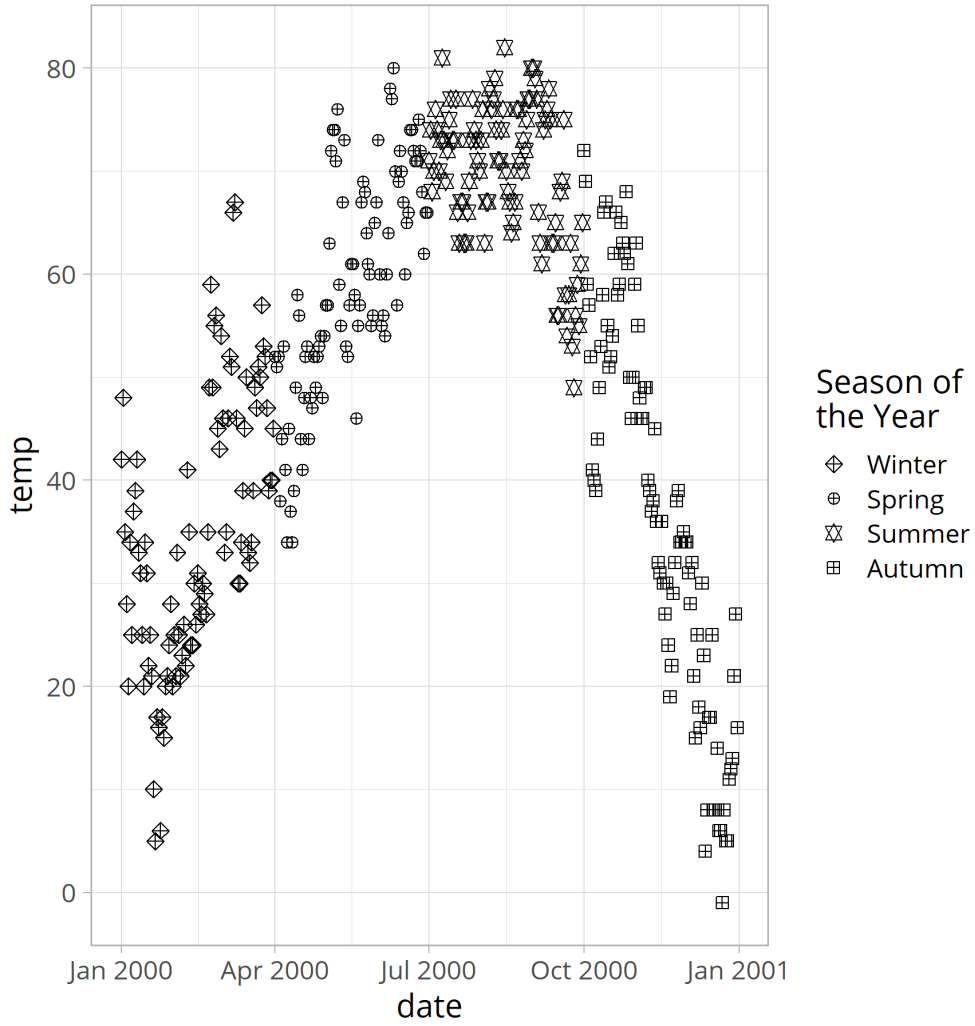
scale_shape()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(shape = season),
    size = 2.5
  ) +
  scale_shape(
    name = "Season of\nthe Year"
  )
```

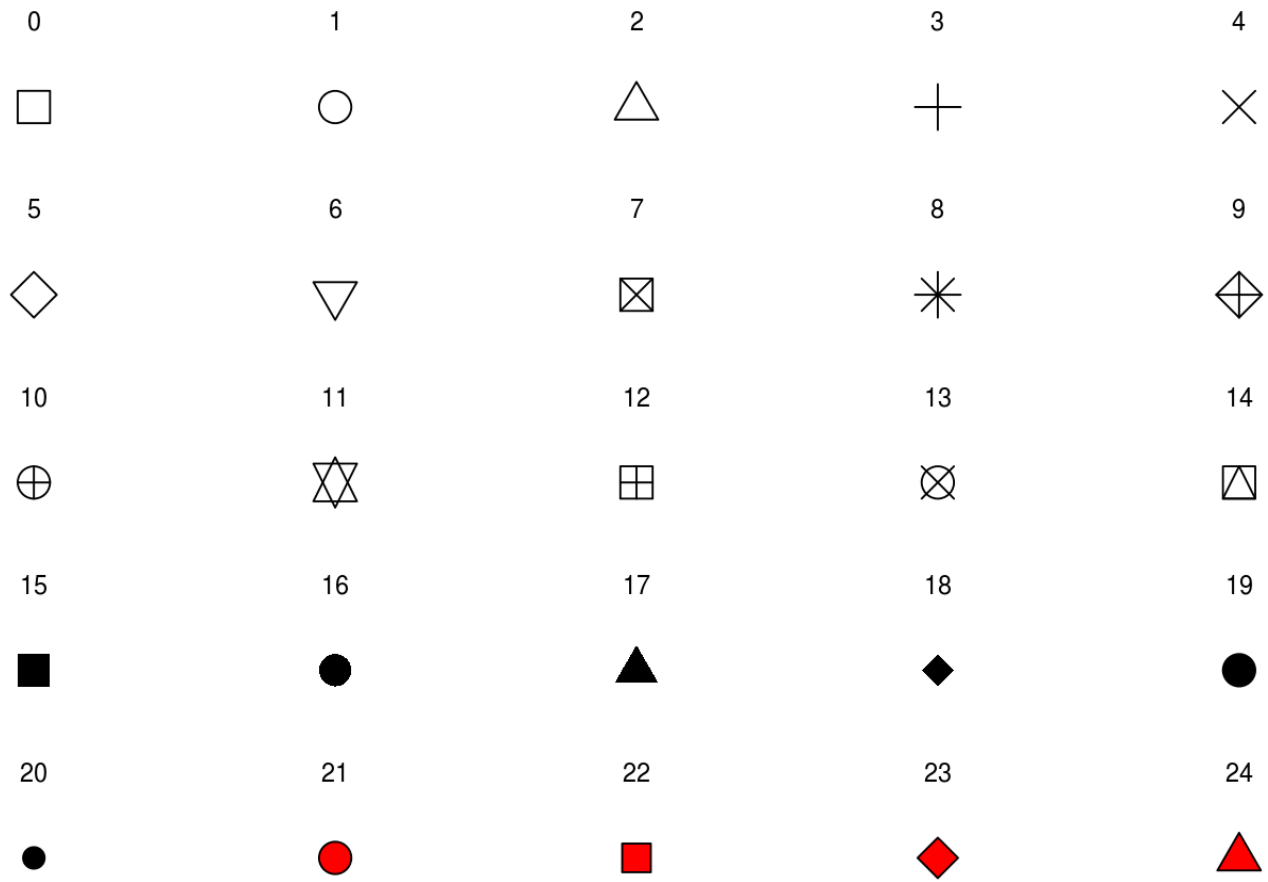


scale_shape_manual()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(shape = season),
    size = 2.5
  ) +
  scale_shape_manual(
    name = "Season of\nthe Year",
    values = 9:12
  )
```



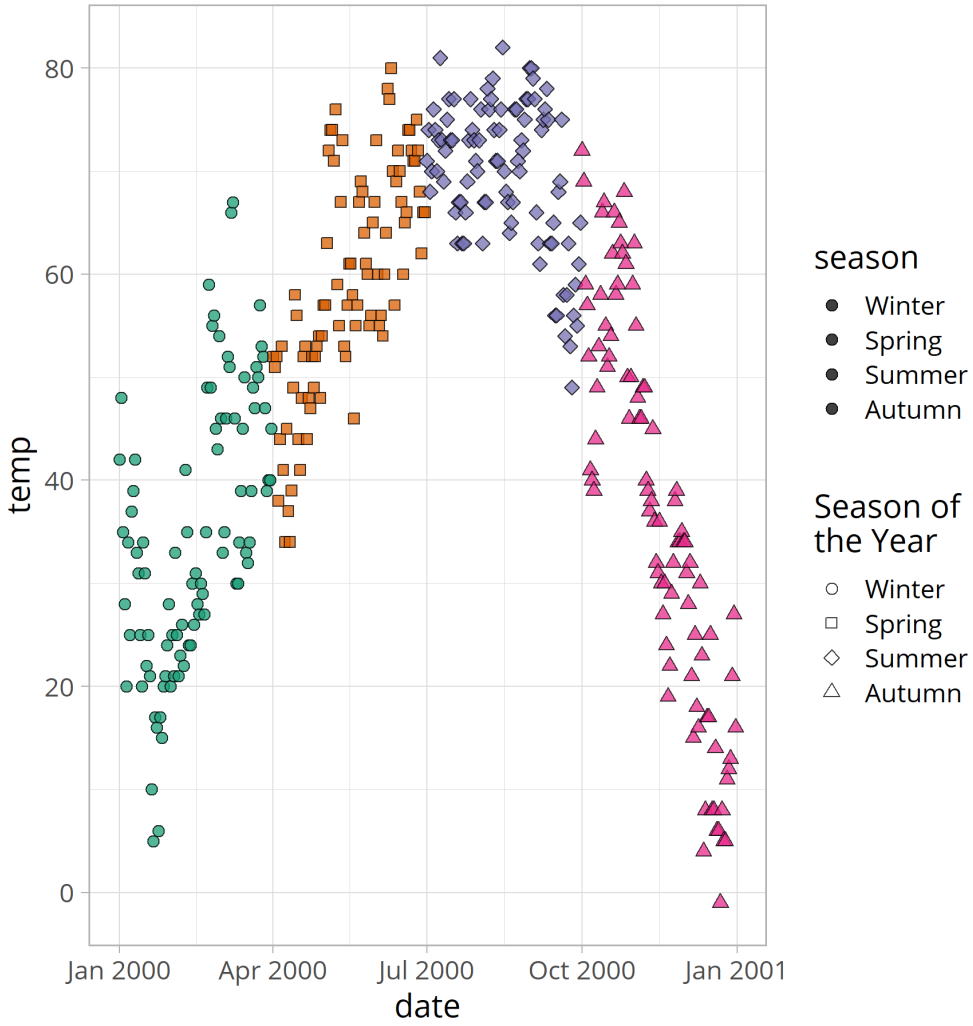
scale_shape_*()



Source: ggplot2.tidyverse.org/articles/ggplot2-specs.html

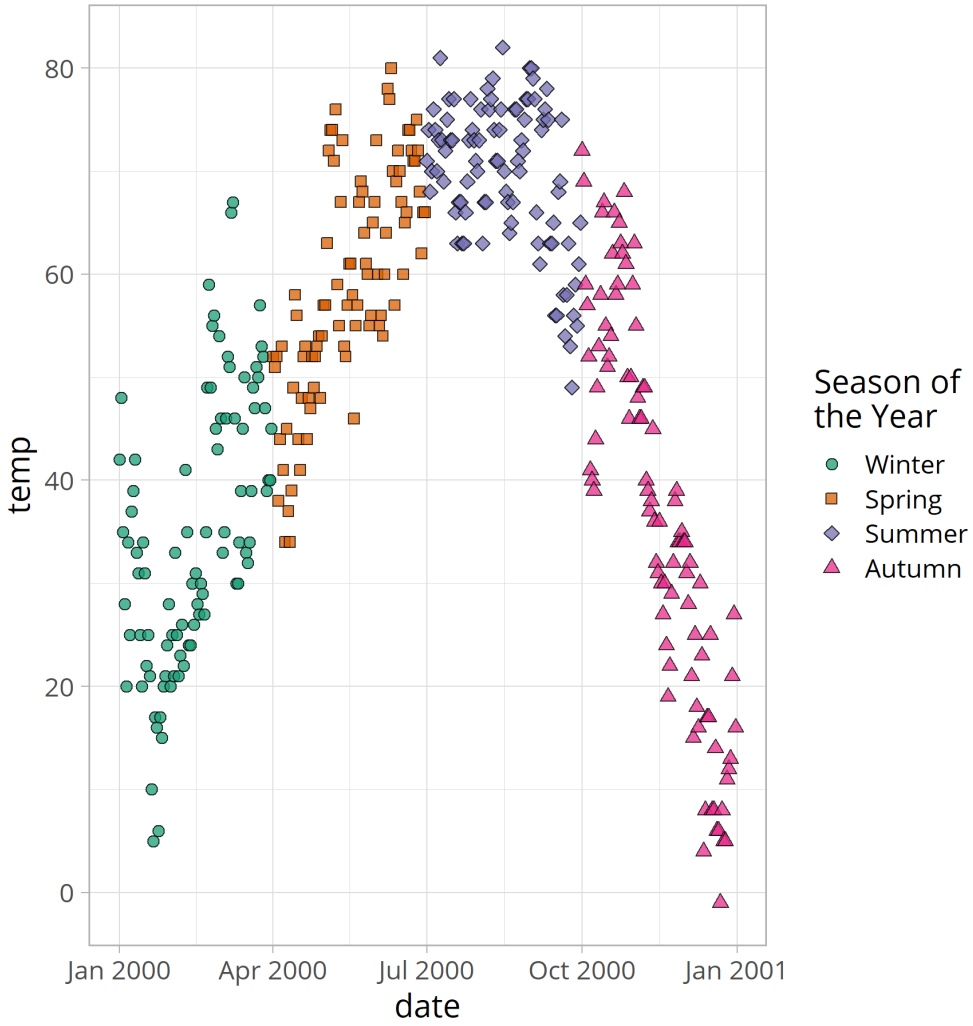
scale_shape_manual()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(
      shape = season,
      fill = season
    ),
    size = 2.5,
    alpha = .75
  ) +
  scale_shape_manual(
    name = "Season of\nthe Year",
    values = 21:24
  ) +
  scale_fill_brewer(
    palette = "Dark2"
  )
```

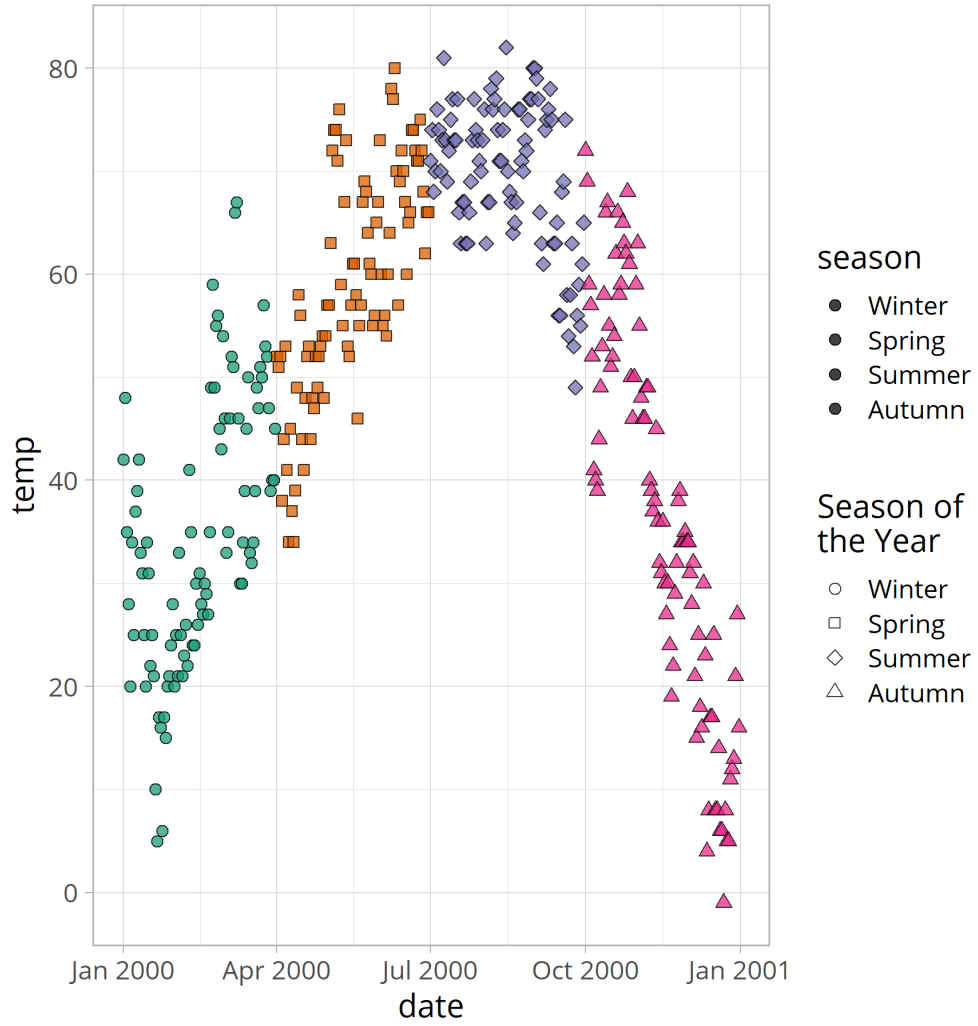


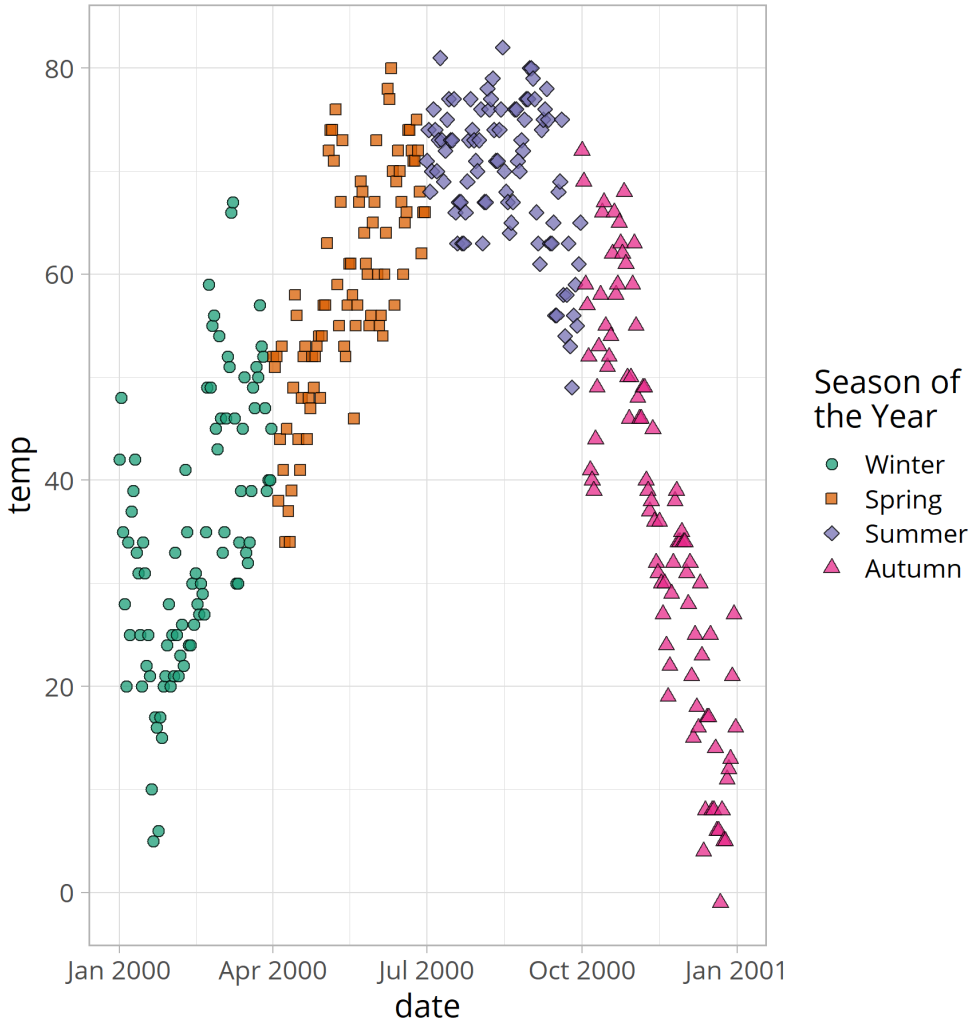
scale_shape_manual()

```
ggplot(chic2k, aes(date, temp)) +
  geom_point(
    aes(
      shape = season,
      fill = season
    ),
    size = 2.5,
    alpha = .75
  ) +
  scale_shape_manual(
    name = "Season of\nthe Year",
    values = 21:24
  ) +
  scale_fill_brewer(
    palette = "Dark2",
    name = "Season of\nthe Year"
  )
```



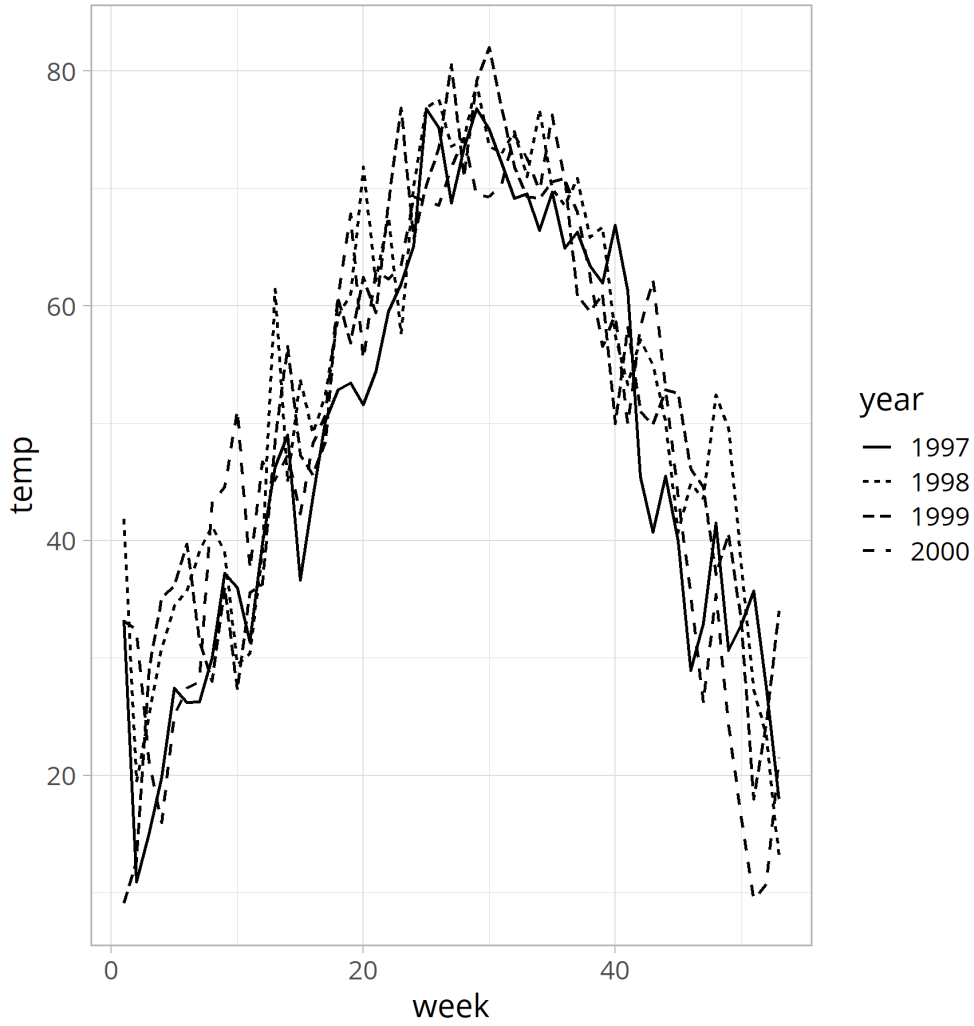
scale_shape_manual()





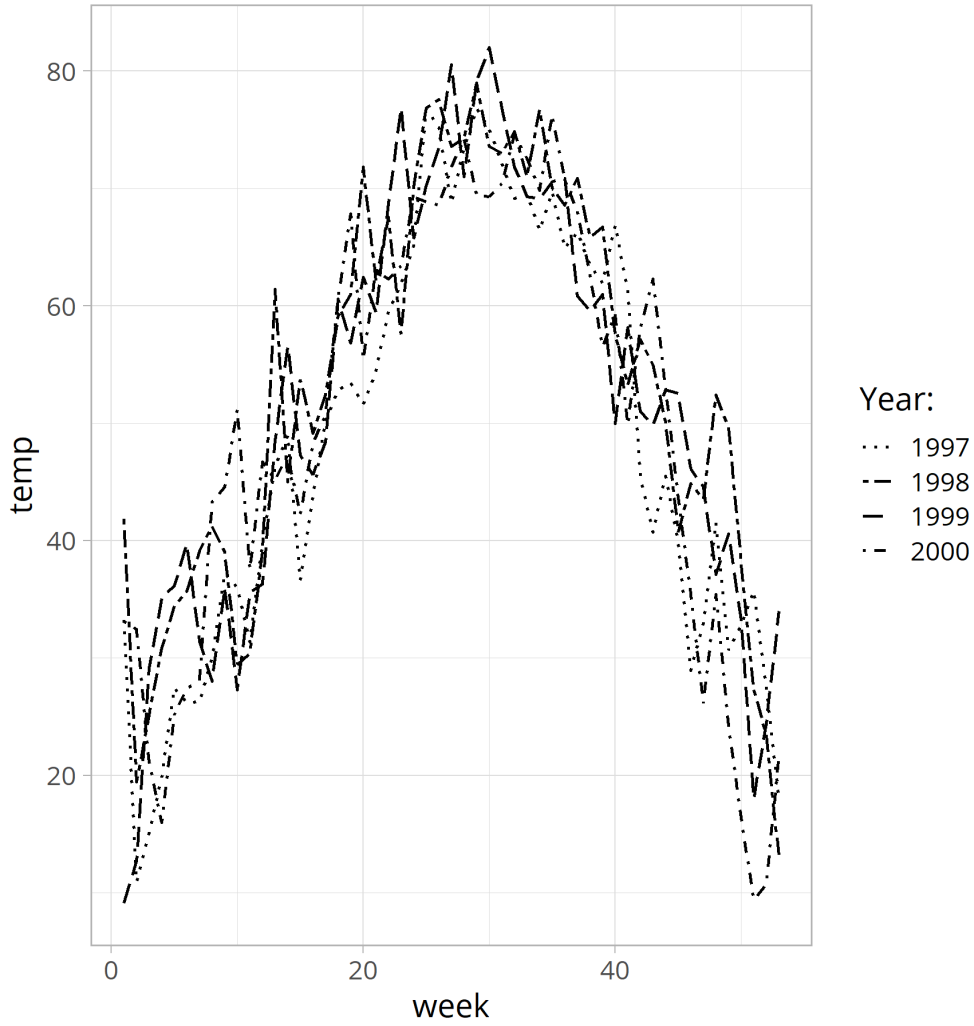
scale_linetype_*()

```
chic_wy <-
  chic %>%
  mutate(
    week = lubridate::week(date)
  ) %>%
  group_by(week, year) %>%
  summarize(temp = mean(temp))

ggplot(chic_wy, aes(week, temp)) +
  geom_line(
    aes(linetype = year),
    size = .7
  )
```

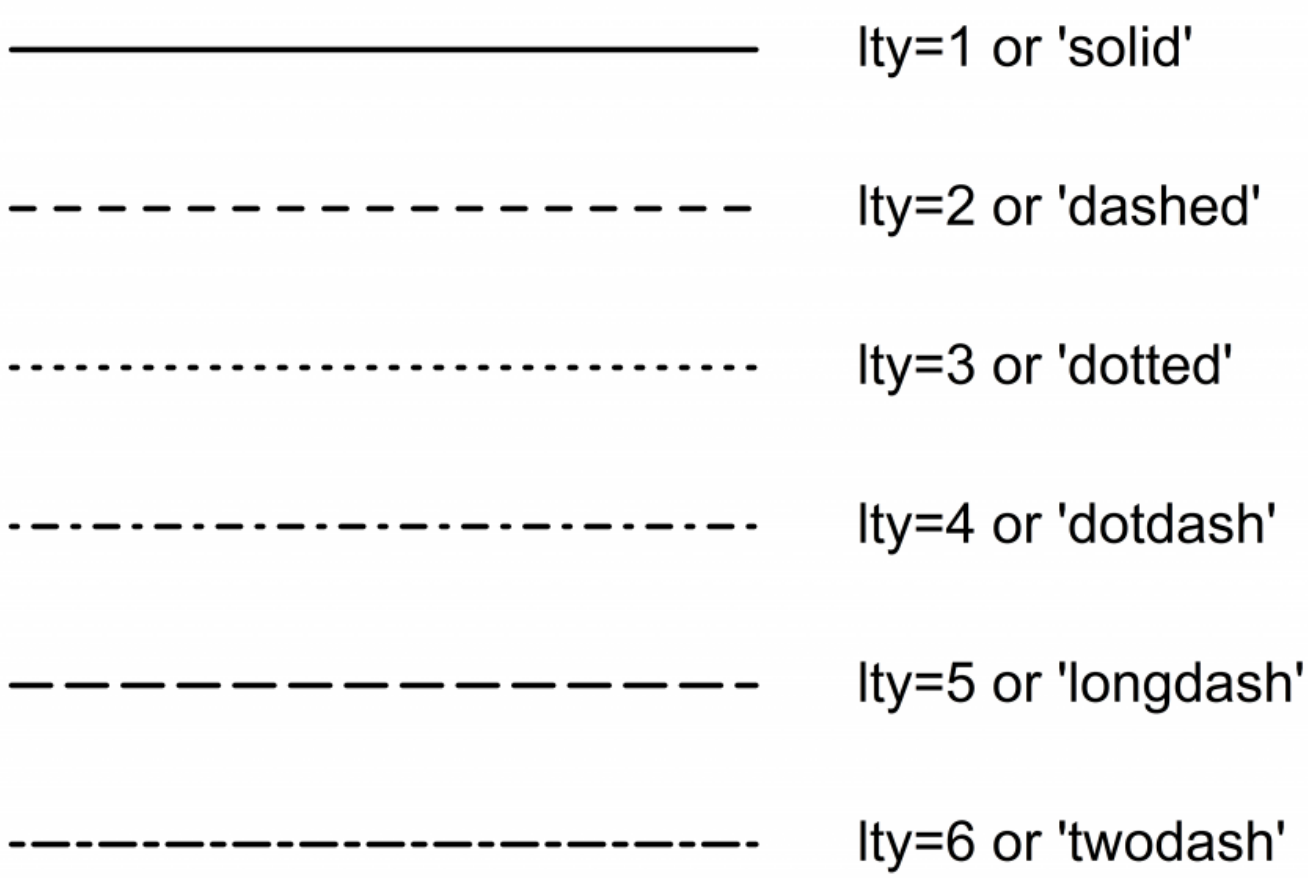


scale_linetype_manual()

```
ggplot(chic_wy, aes(week, temp)) +
  geom_line(
    aes(linetype = year),
    size = .7
  ) +
  scale_linetype_manual(
    name = "Year:",
    values = c("dotted",
               "twodash",
               "longdash",
               "dotdash")
  )
```



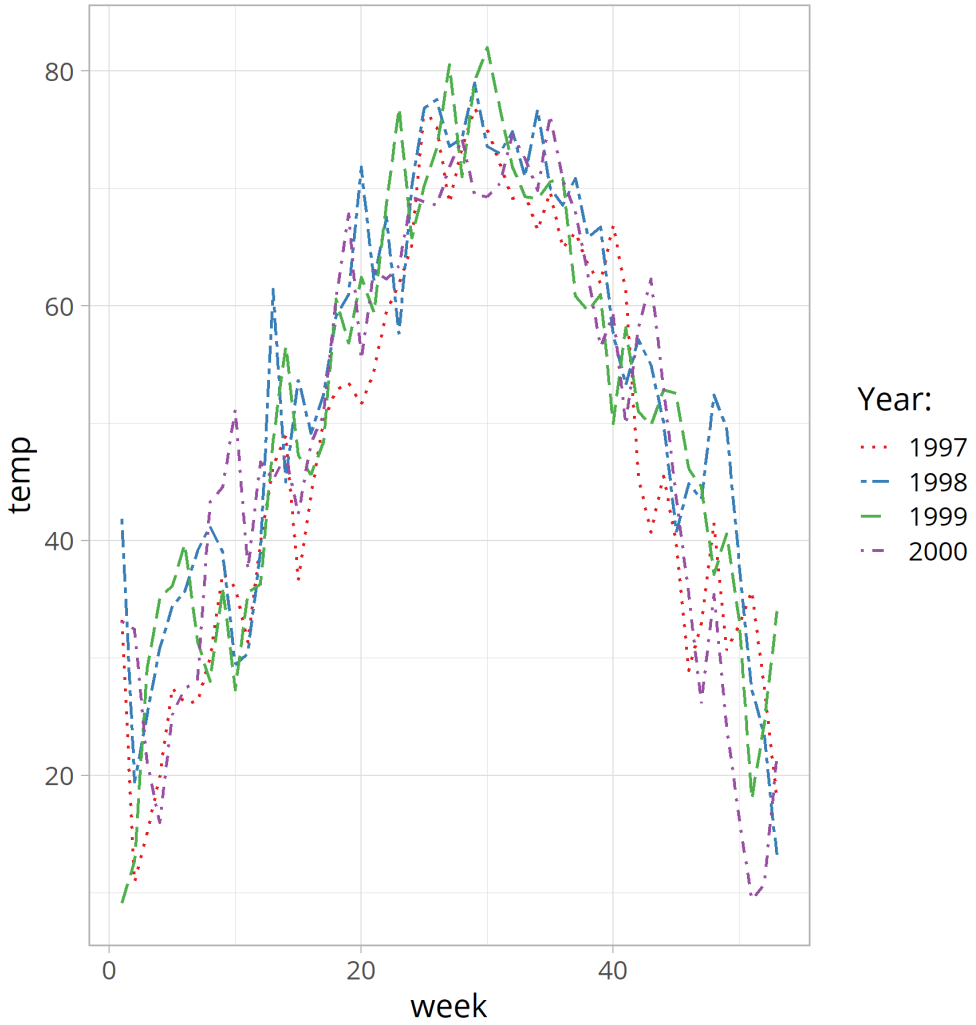
scale_linetype_*()



Source: rfriend.tistory.com

scale_linetype_manual()

```
ggplot(chic_wy, aes(week, temp)) +
  geom_line(
    aes(
      linetype = year,
      color = year
    ),
    size = .7
  ) +
  scale_linetype_manual(
    name = "Year:",
    values = c("dotted",
               "twodash",
               "longdash",
               "dotdash")
  ) +
  scale_color_brewer(
    name = "Year:",
    palette = "Set1",
  )
```



Scales

`scale_alpha_*()`

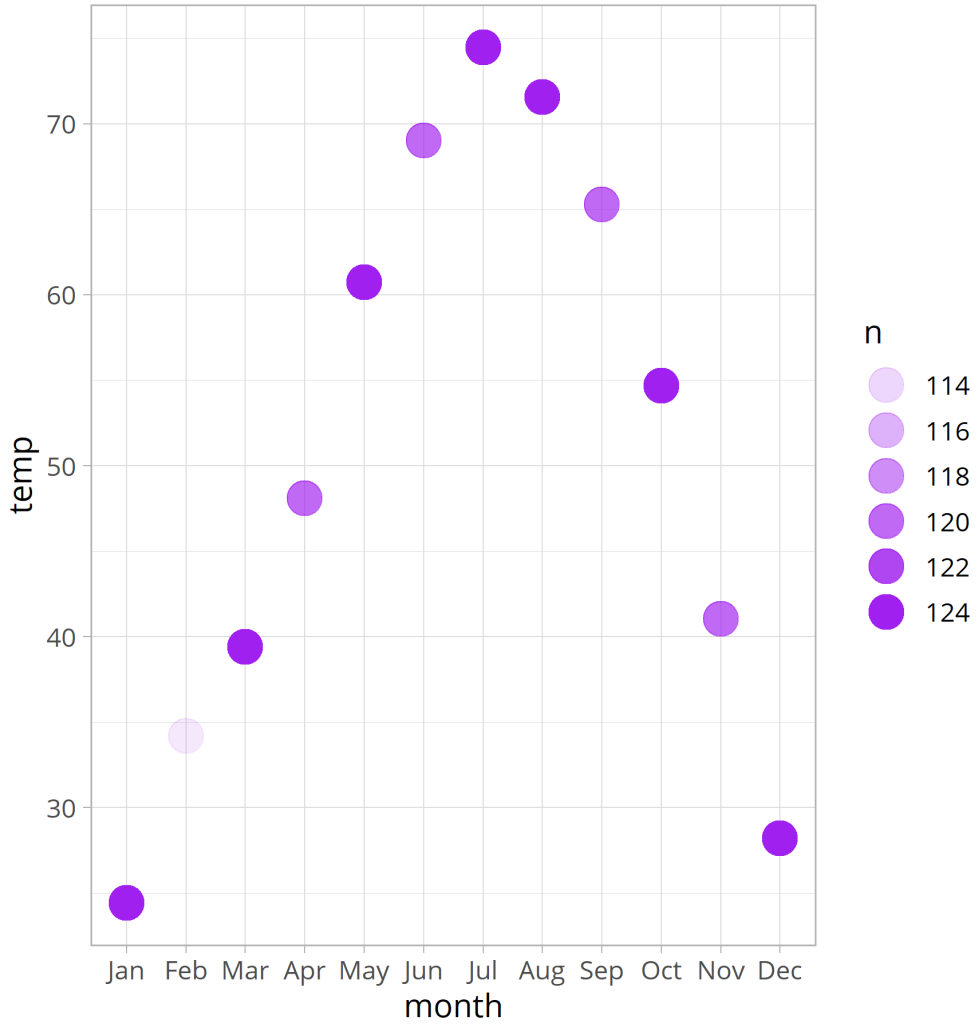
scale_alpha_*()

```
chic_month <-
  chic %>%
  mutate(
    month = lubridate::month(
      date,
      label = T
    )
  ) %>%
  group_by(month) %>%
  summarize(
    temp = mean(temp),
    n = n()
  ) %>%
  ungroup()

chic_month
```

```
## # A tibble: 12 x 3
##    month  temp     n
##    <ord> <dbl> <int>
##  1 Jan    24.4   124
##  2 Feb    34.2   113
##  3 Mar    39.4   124
##  4 Apr    48.1   120
##  5 May    60.7   124
##  6 Jun    69.0   120
##  7 Jul    74.5   124
##  8 Aug    71.6   124
##  9 Sep    65.3   120
## 10 Oct    54.7   124
## 11 Nov    41.0   120
## 12 Dec    28.2   124
```

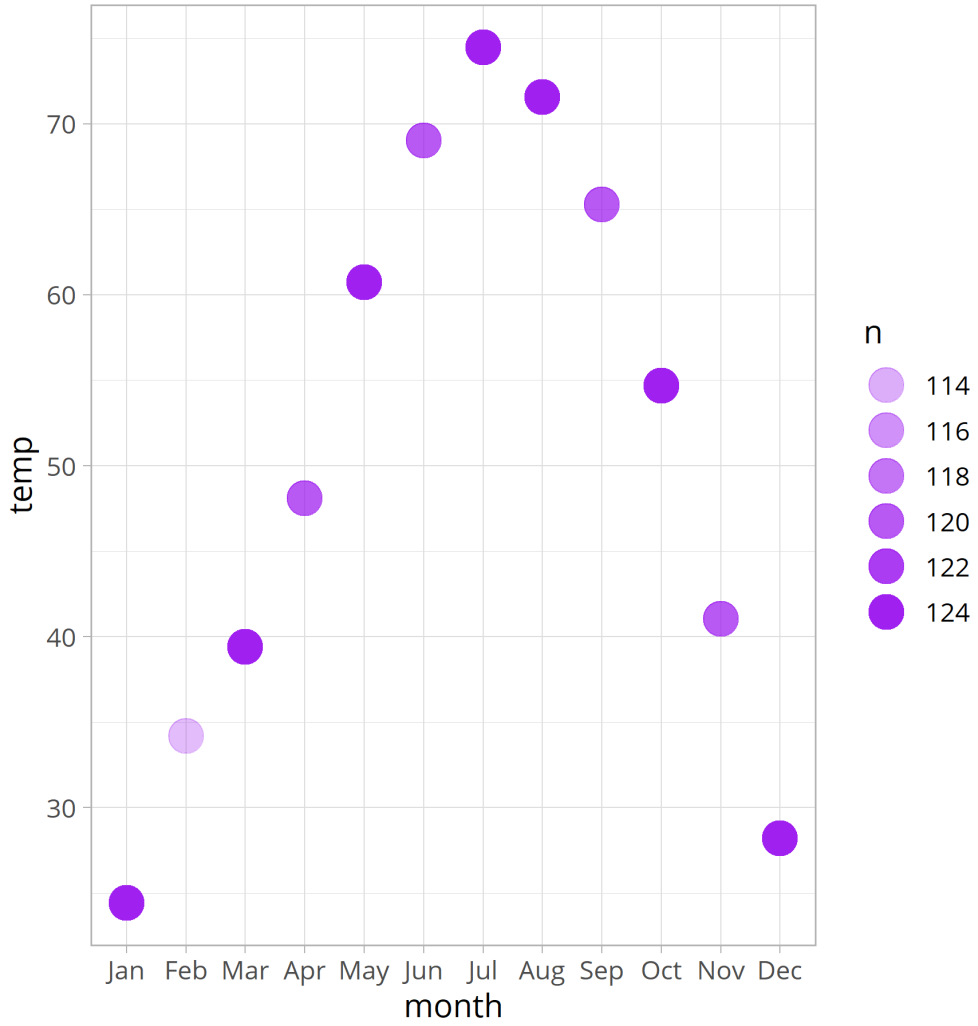
scale_alpha_*()

```
ggplot(chic_month, aes(month, temp)) +
  geom_point(
    aes(alpha = n),
    size = 8,
    color = "purple"
  )
```



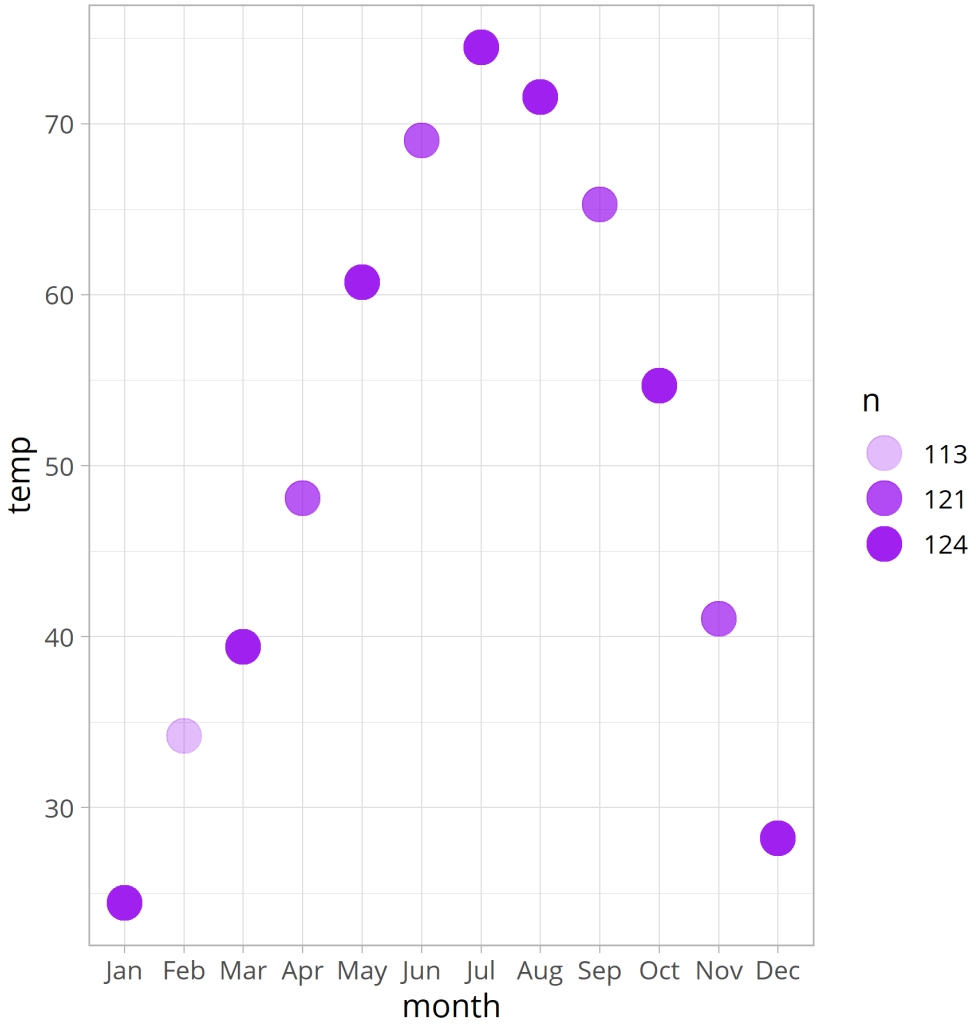
scale_alpha()

```
ggplot(chic_month, aes(month, temp)) +
  geom_point(
    aes(alpha = n),
    size = 8,
    color = "purple"
  ) +
  scale_alpha(
    range = c(.3, 1)
  )
```



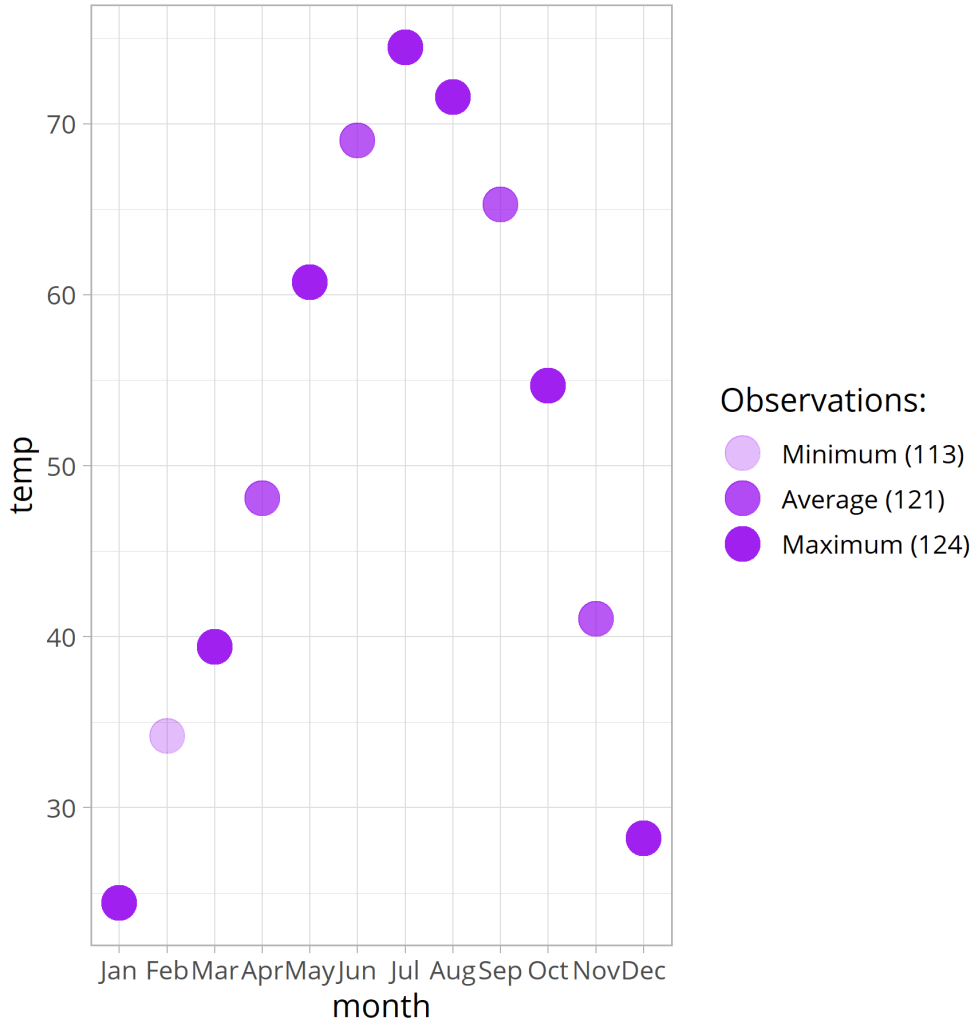
scale_alpha()

```
ggplot(chic_month, aes(month, temp)) +
  geom_point(
    aes(alpha = n),
    size = 8,
    color = "purple"
  ) +
  scale_alpha(
    range = c(.3, 1),
    breaks = c(
      min(chic_month$n),
      floor(mean(chic_month$n)),
      max(chic_month$n)
    )
  )
```



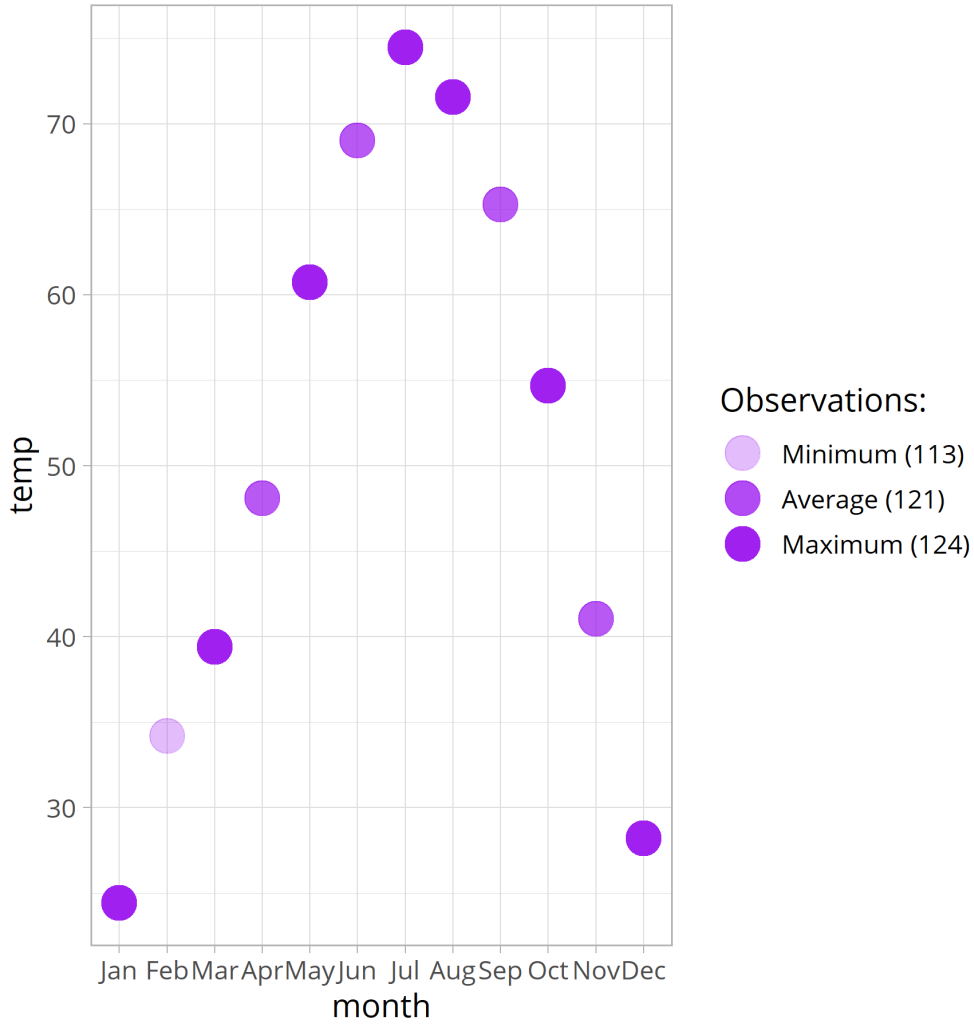
scale_alpha()

```
ggplot(chic_month, aes(month, temp)) +
  geom_point(
    aes(alpha = n),
    size = 8,
    color = "purple"
  ) +
  scale_alpha(
    name = "Observations:",
    range = c(.3, 1),
    breaks = c(
      min(chic_month$n),
      floor(mean(chic_month$n)),
      max(chic_month$n)
    ),
    labels = c(
      "Minimum (113)",
      "Average (121)",
      "Maximum (124)"
    )
  )
```



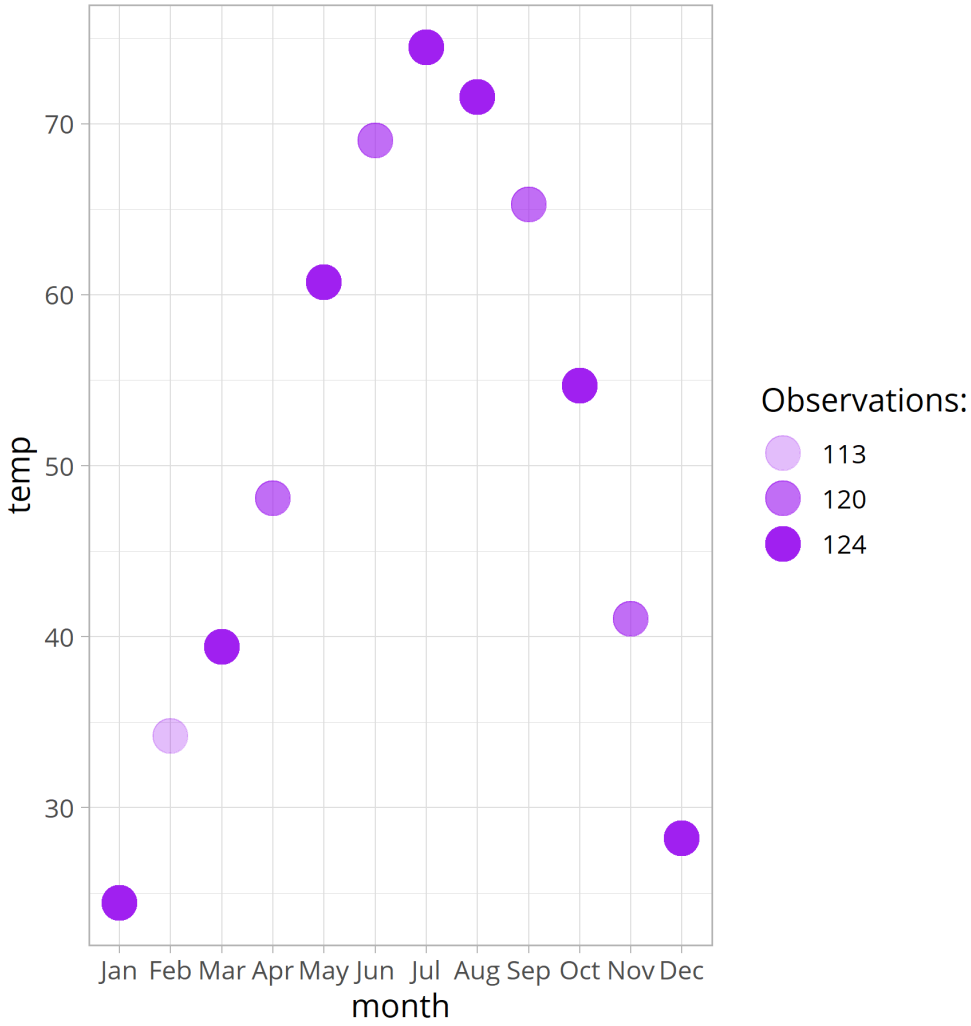
scale_alpha_continuous()

```
ggplot(chic_month, aes(month, temp)) +
  geom_point(
    aes(alpha = n),
    size = 8,
    color = "purple"
  ) +
  scale_alpha_continuous(
    name = "Observations:",
    range = c(.3, 1),
    breaks = c(
      min(chic_month$n),
      floor(mean(chic_month$n)),
      max(chic_month$n)
    ),
    labels = c(
      "Minimum (113)",
      "Average (121)",
      "Maximum (124)"
    )
  )
```



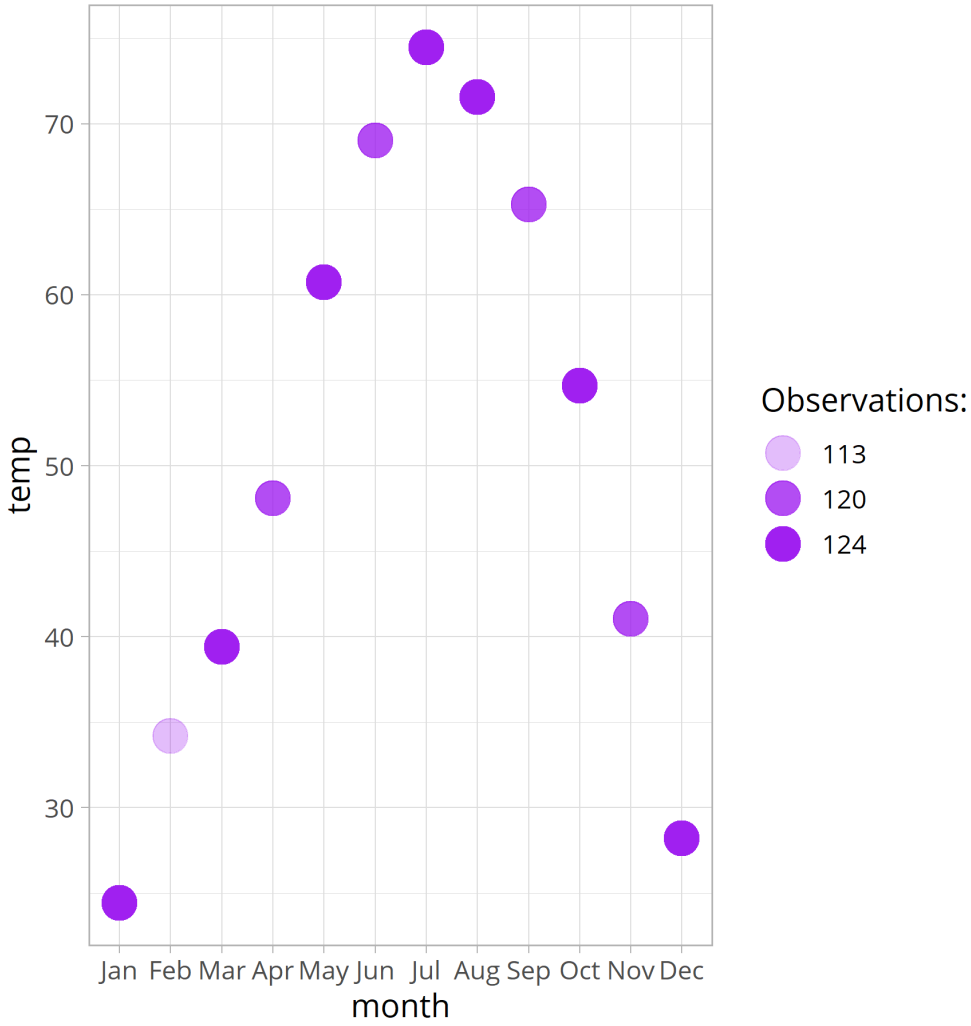
scale_alpha_discrete()

```
ggplot(chic_month, aes(month, temp)) +
  geom_point(
    aes(alpha = as.factor(n)),
    size = 8,
    color = "purple"
  ) +
  scale_alpha_discrete(
    name = "Observations:",
    range = c(.3, 1)
  )
```



scale_alpha_discrete()

```
ggplot(chic_month, aes(month, temp)) +
  geom_point(
    aes(alpha = as.factor(n)),
    size = 8,
    color = "purple"
  ) +
  scale_alpha_manual(
    name = "Observations:",
    values = c(.3, .8, 1)
  )
```



Your Turn!

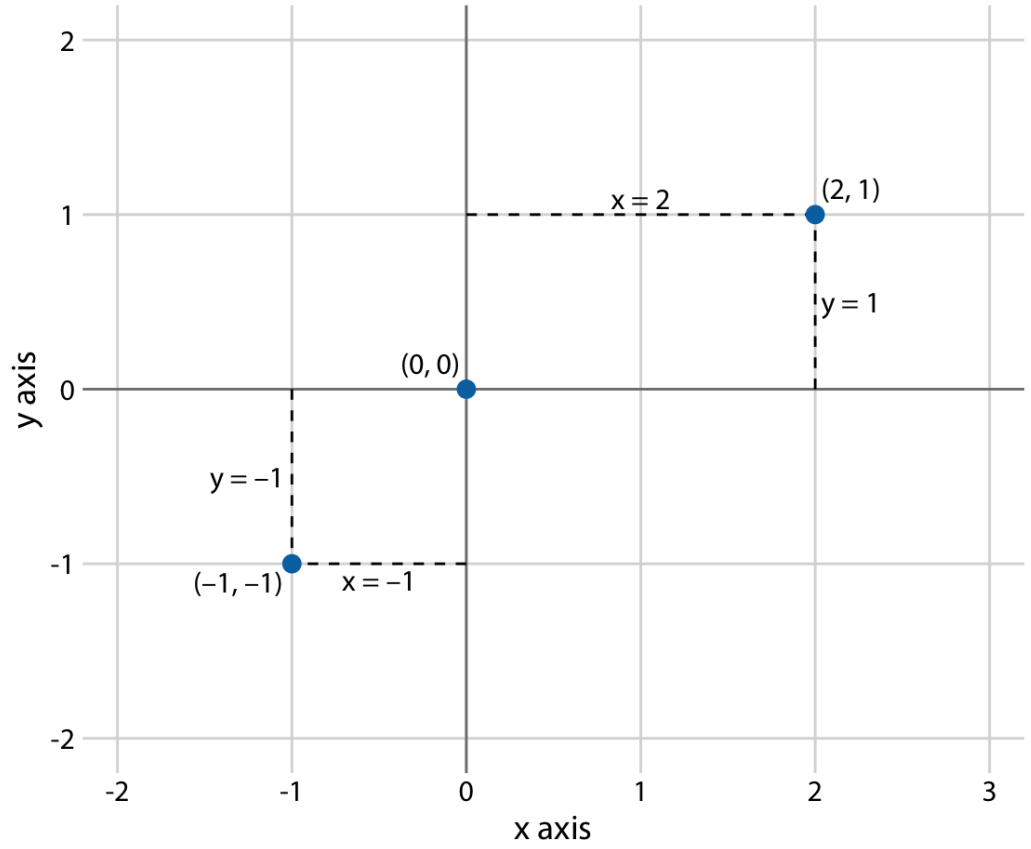
- Visualize the relationship of temperature and Ozone in Chicago using a hexagonal binning and a (non-green) viridis color palette.
- Afterwards, make the axis title more decriptive and change the legend title to "Count:".
- Now change the x axis so it shows the temperature every 10°F in a range of -10°F to 90°F.
- Turn the labels on the y axis into two string labels (e.g. "low" and "high).
- Explore some other color palettes that are available in other packages, pick one you like and change the color palette of the plot.
- Check if your final plot is color-blindness safe either online, e.g. color-blindness.com/coblis-color-blindness-simulator or using the package `colorblindr` (*Note: You need to install again some development versions of packages, follow the instructions on* https://github.com/clauswilke/colorblindr)

Coordinate System

`coord_*()`

coord_*()

Coordinate systems produce a 2d position based on the relative geometric arrangement of the two position aesthetics (usually **x** and **y**).



Source: "Fundamentals of Data Visualization" by Claus Wilke

`coord_*()`

Coordinate systems produce a 2d position based on the relative geometric arrangement of the two position aesthetics (usually `x` and `y`).

The meaning of the position aesthetics depends on the coordinate system used:

- Linear coordinate systems that preserve the shape of geoms.
- Non-linear coordinate systems that likely change the shapes.

`coord_*()`

Coordinate systems produce a 2d position based on the relative geometric arrangement of the two position aesthetics (usually `x` and `y`).

- Linear coordinate systems that preserve the shape of geoms:
  - `coord_cartesian()` and `coord_fixed()`:
    the default with two fixed perpendicular oriented axes
  - `coord_flip()`:
    a Cartesian coordinate system with flipped axes
  - `coord_fixed()`:
    a Cartesian coordinate system with a fixed aspect ratio

`coord_*()`

Coordinate systems produce a 2d position based on the relative geometric arrangement of the two position aesthetics (usually `x` and `y`).

- Linear coordinate systems that preserve the shape of geoms:
  - `coord_cartesian()` and `coord_fixed()`:
    the default with two fixed perpendicular oriented axes
  - `coord_flip()`:
    a Cartesian coordinate system with flipped axes
  - `coord_fixed()`:
    a Cartesian coordinate system with a fixed aspect ratio
- Non-linear coordinate systems that likely change the shapes:
  - `coord_map()` and `coord_sf()`:
    map projections
  - `coord_polar()`:
    a polar coordinate system
  - `coord_trans()`:
    arbitrary transformations to x and y positions

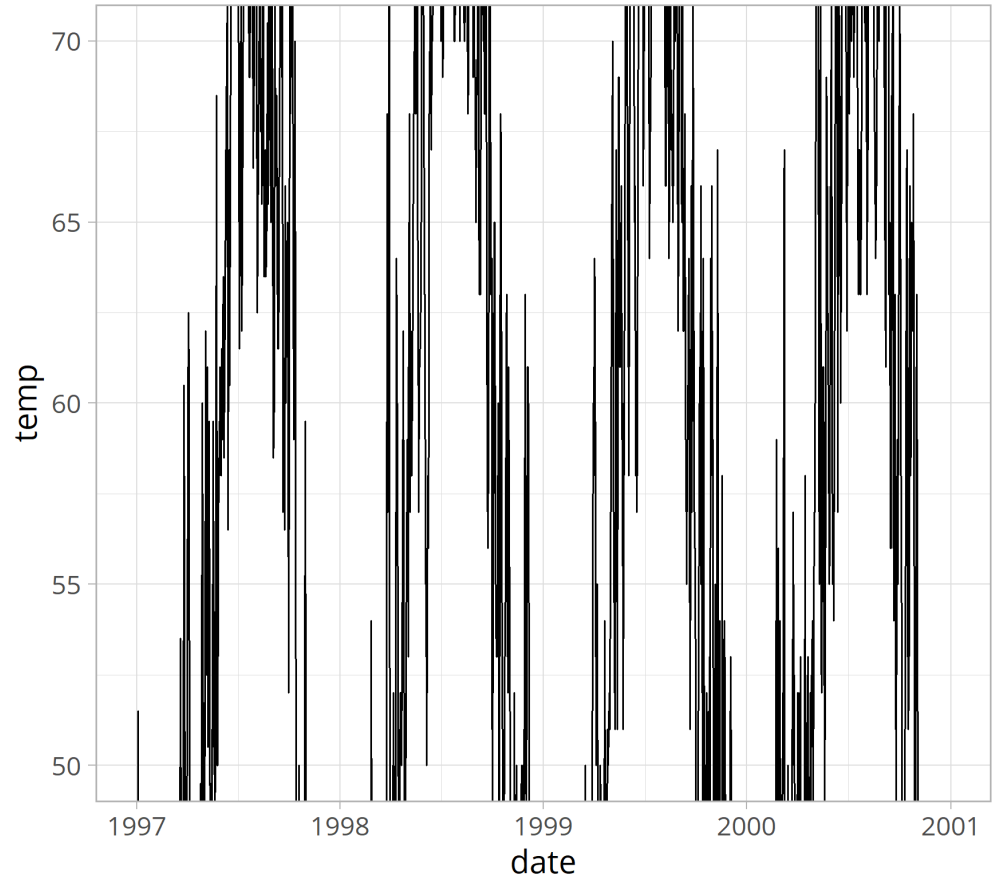
Coordinate System

`coord_cartesian()`

coord_cartesian()

`coord_*()` functions allow you to zoom in a plot:

```
ggplot(chic, aes(date, temp)) +
  geom_line() +
  coord_cartesian(
    ylim = c(50, 70)
  )
```

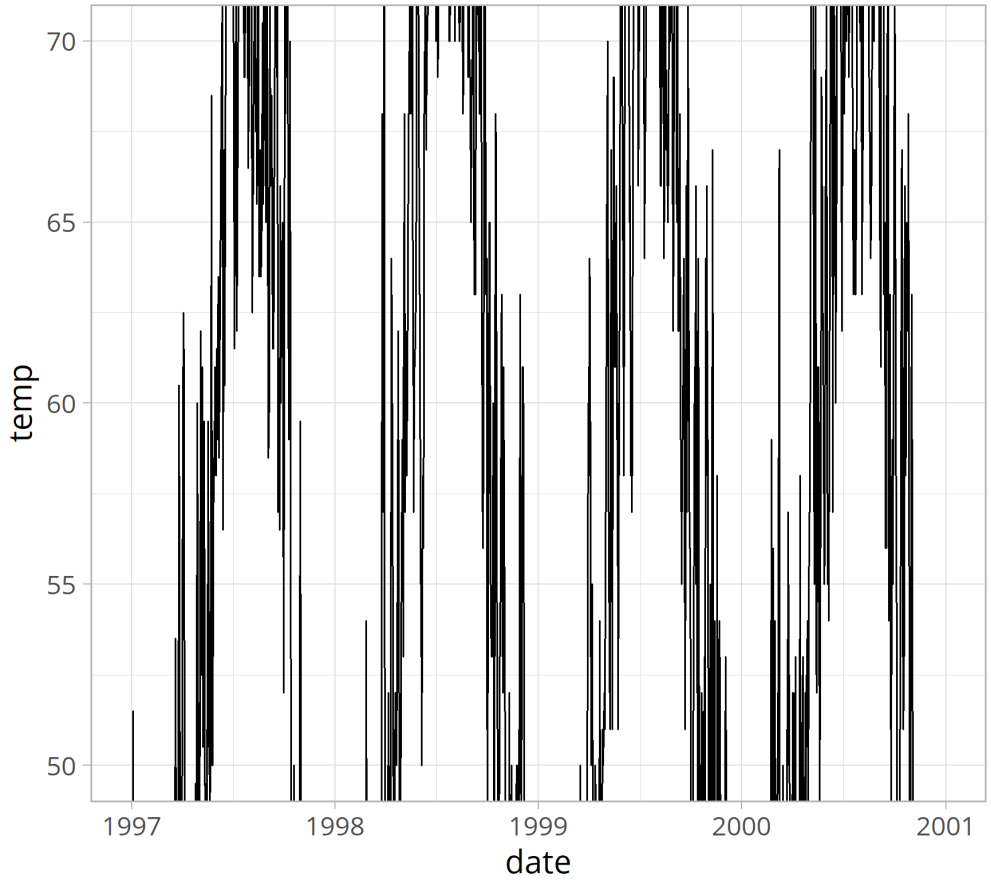


coord_cartesian()

`coord_*()` functions allow you to zoom in a plot:

```
ggplot(chic, aes(date, temp)) +
  geom_line() +
  coord_cartesian(
    ylim = c(50, 70)
  )
```

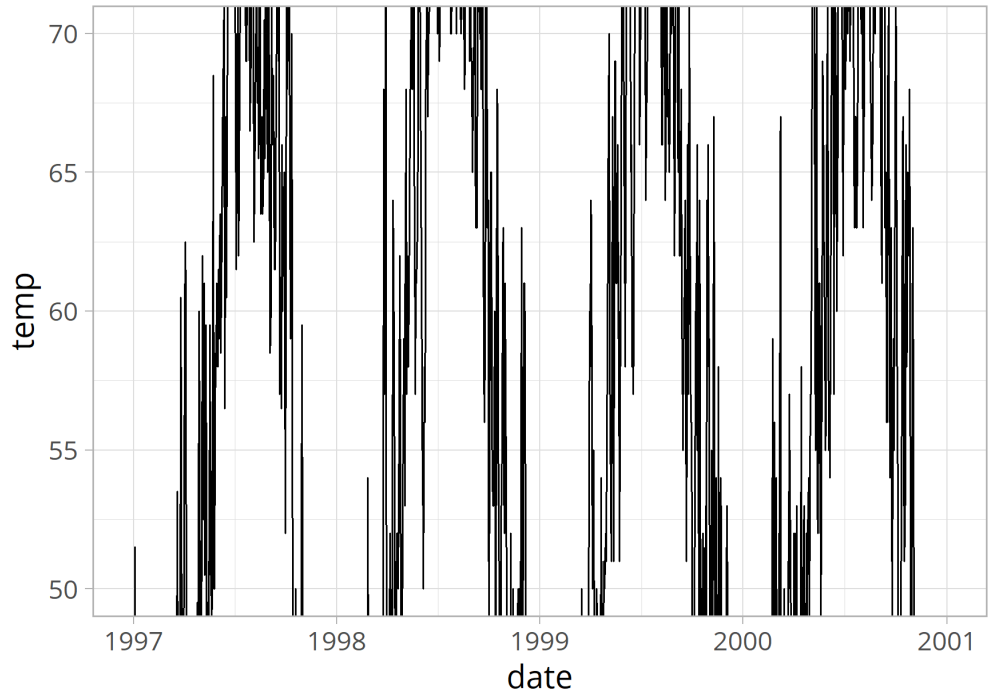
Note that data points outside the plot area are not removed!



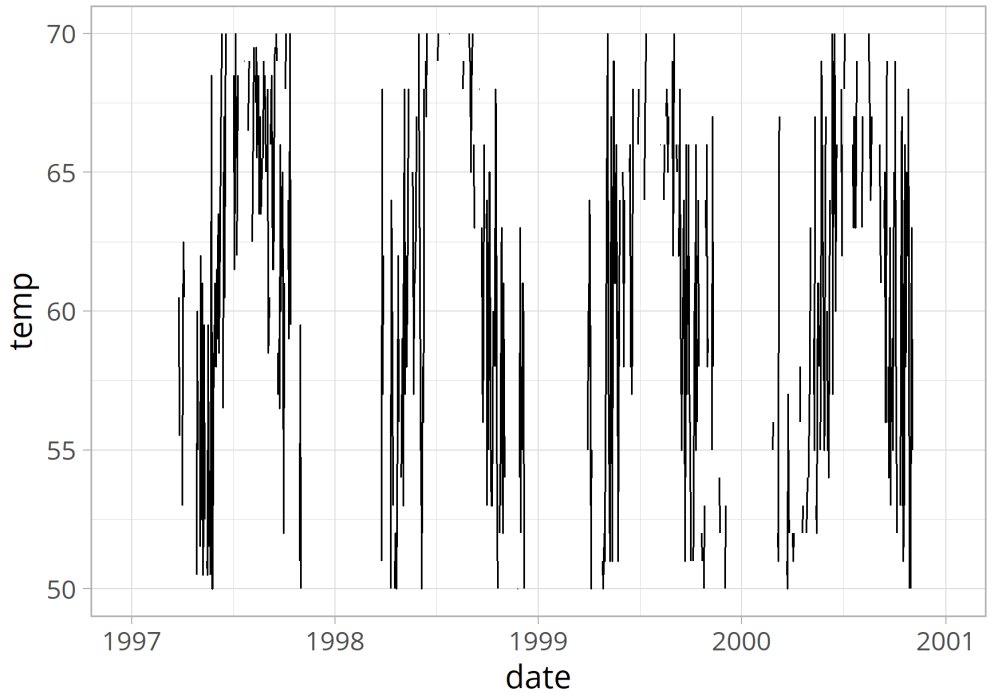
coord_cartesian()

In case you want to remove those data points, use `scale_y_continuous(limits = c(min, max))`.

```
ggplot(chic, aes(date, temp)) +
  geom_line() +
  coord_cartesian(ylim = c(50, 70))
```



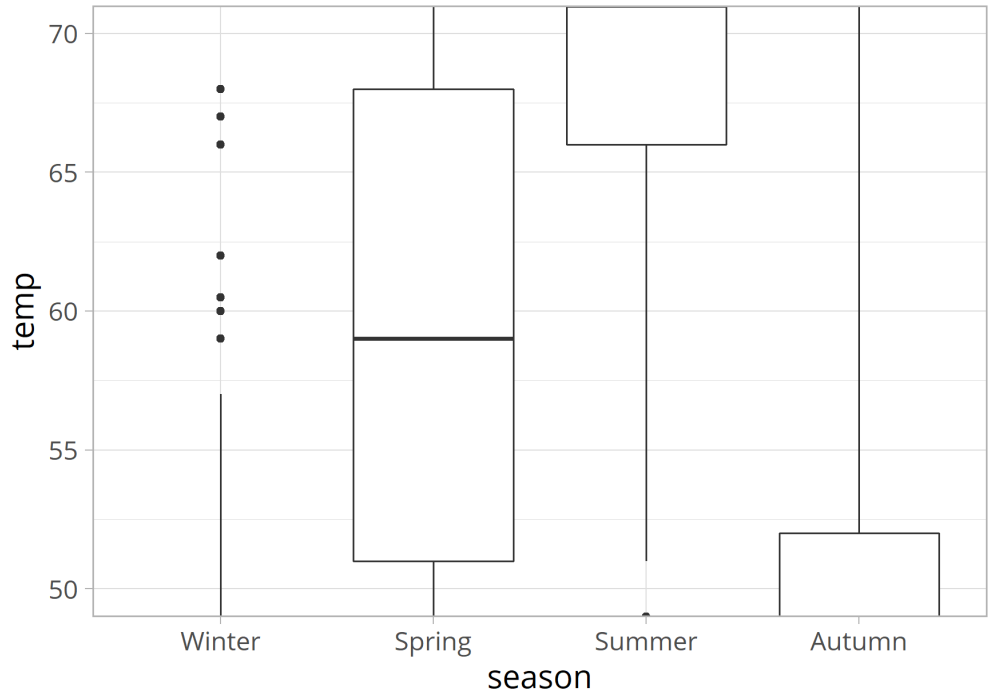

```
ggplot(chic, aes(date, temp)) +
  geom_line() +
  scale_y_continuous(limits = c(50, 70))
```



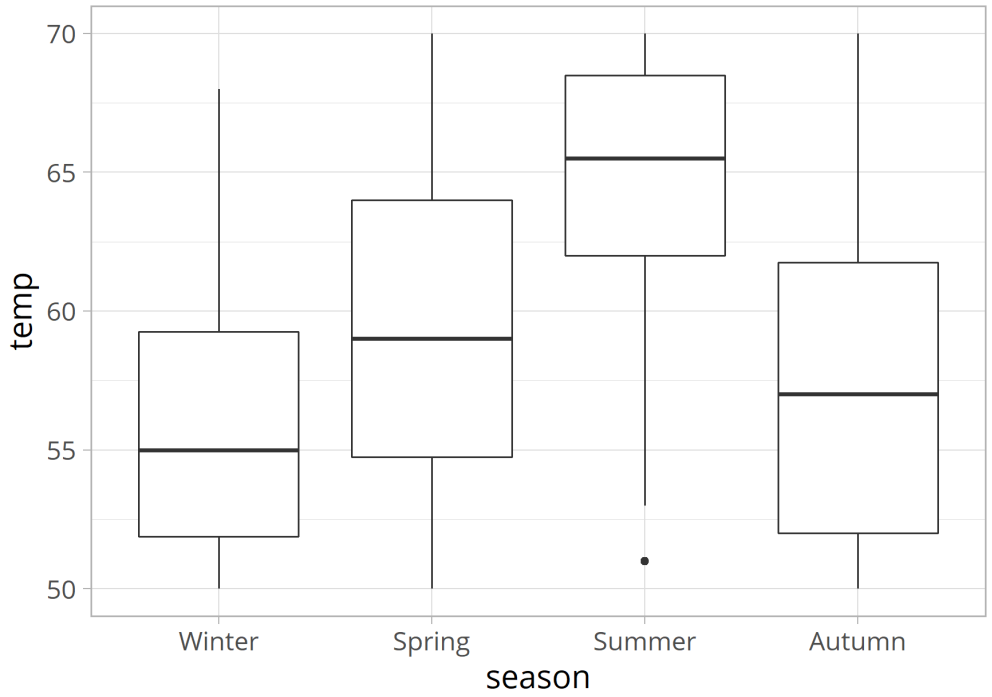
coord_cartesian()

In case you want to remove those data points, use `scale_y_continuous(limits = c(min, max))`.

```
ggplot(chic, aes(season, temp)) +
  geom_boxplot()  +
  coord_cartesian(ylim = c(50, 70))
```



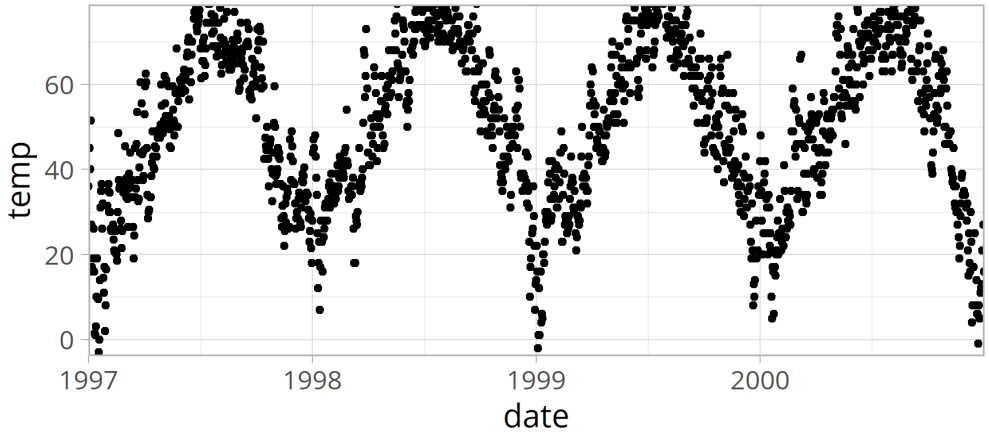

```
ggplot(chic, aes(season, temp)) +
  geom_boxplot()  +
  scale_y_continuous(limits = c(50, 70))
```



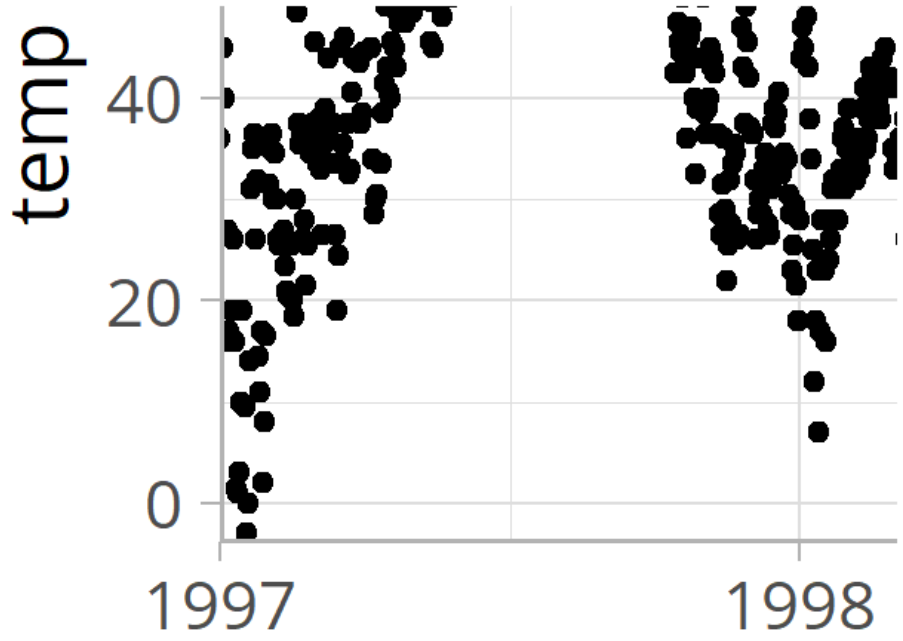
coord_cartesian()

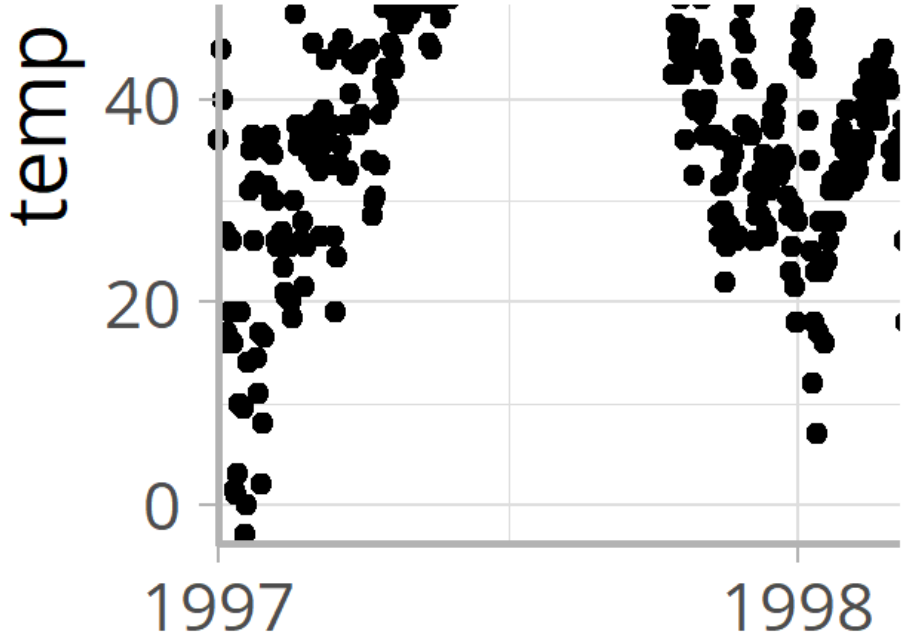
`coord_*()` is also used to *prevent clipping* of points and the correct alignment of axis ticks:

```
ggplot(chic, aes(date, temp)) +
  geom_point() +
  coord_cartesian(
    ylim = c(0, 75)
  )
```



Clipping

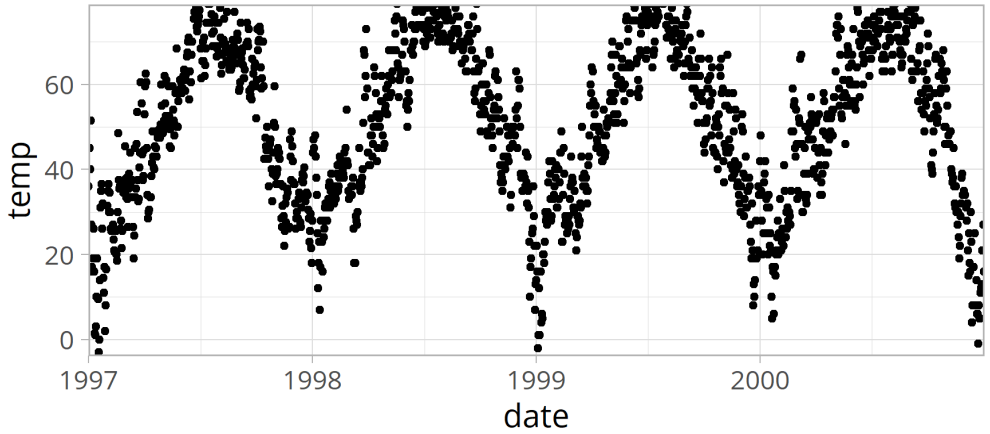




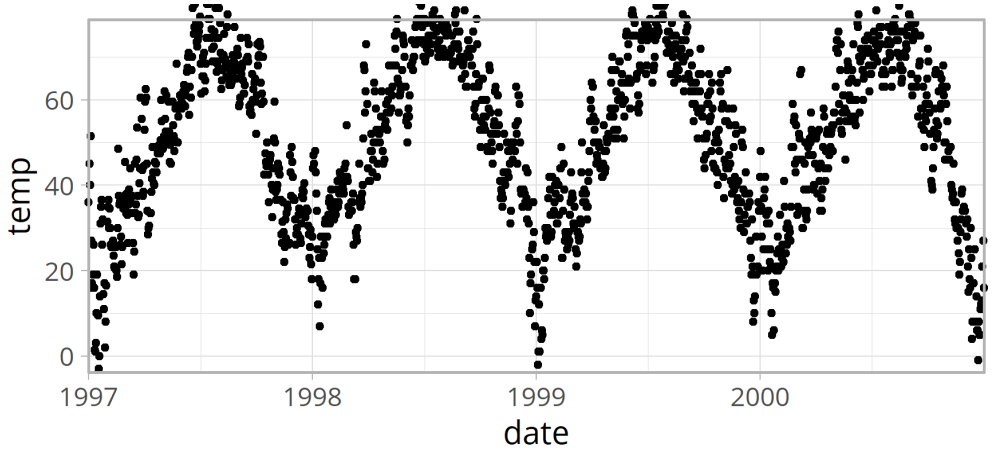
coord_cartesian()

`coord_*()` is also used to *prevent clipping* of points and correct alignment of axis ticks:

```
ggplot(chic, aes(date, temp)) +
  geom_point() +
  coord_cartesian(
    ylim = c(0, 75)
  )
```




```
ggplot(chic, aes(date, temp)) +
  geom_point() +
  coord_cartesian(
    ylim = c(0, 75),
    clip = "off"
  )
```



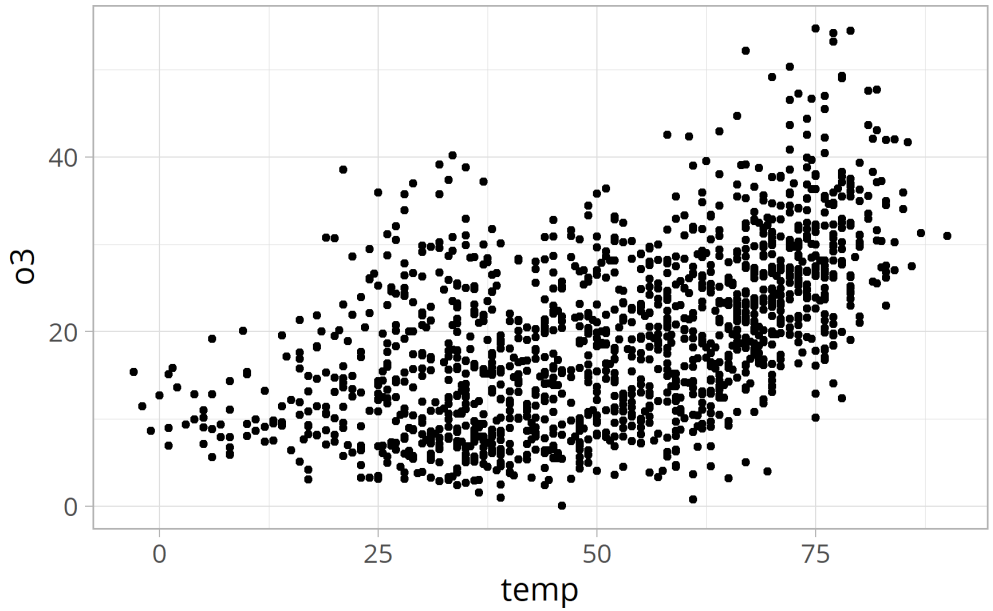
Coordinate System

`coord_fixed()`

coord_fixed()

`coord_fixed()` forces a specified ratio as physical representation of units on the axes:

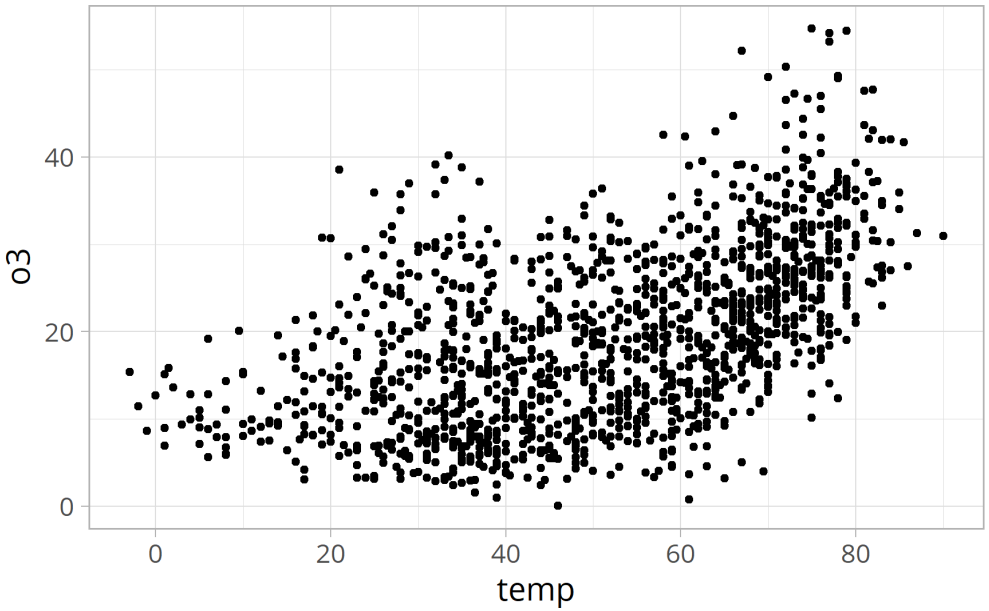
```
ggplot(chic, aes(temp, o3)) +
  geom_point() +
  coord_fixed()
```



coord_fixed()

`coord_fixed()` forces a specified ratio as physical representation of units on the axes:

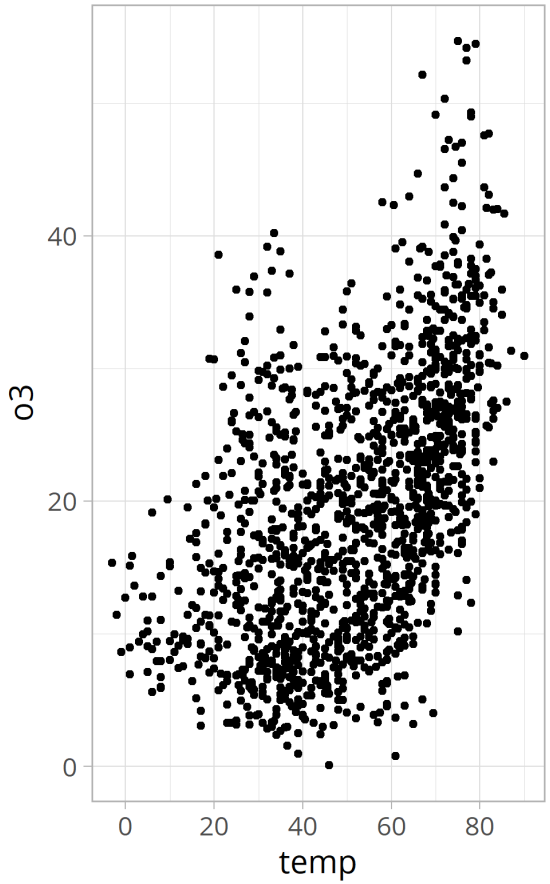
```
ggplot(chic, aes(temp, o3)) +
  geom_point() +
  coord_fixed() +
  scale_x_continuous(
    breaks = seq(0, 100, by = 20)
  )
```



coord_fixed()

`coord_fixed()` forces a specified ratio as physical representation of units on the axes:

```
ggplot(chic, aes(temp, o3)) +
  geom_point() +
  coord_fixed(
    ratio = 3
  ) +
  scale_x_continuous(
    breaks = seq(0, 100, by = 20)
  )
```



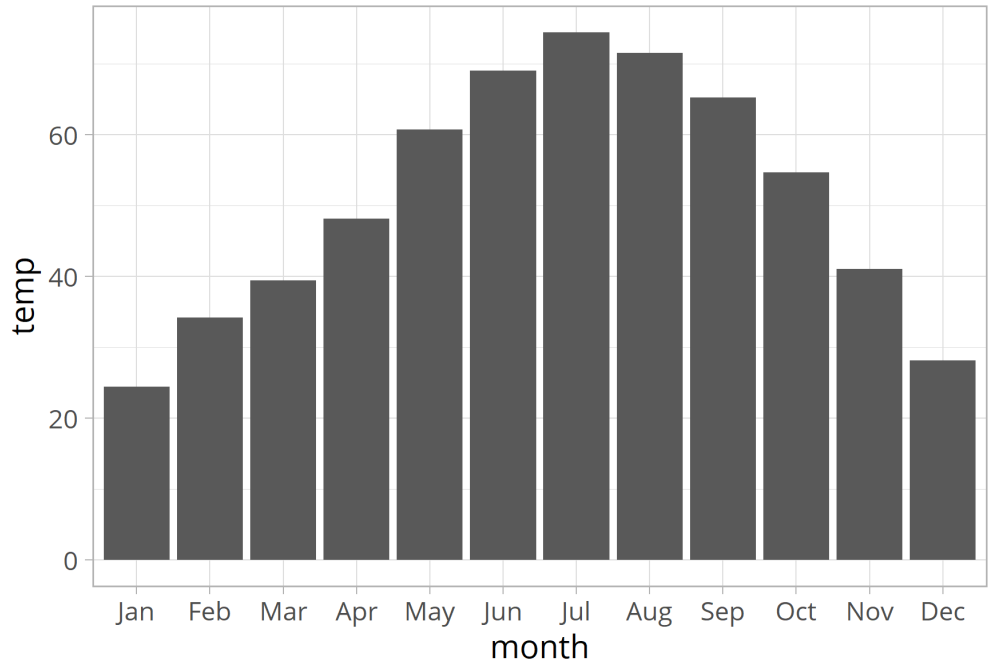
Coordinate System

`coord_flip()`

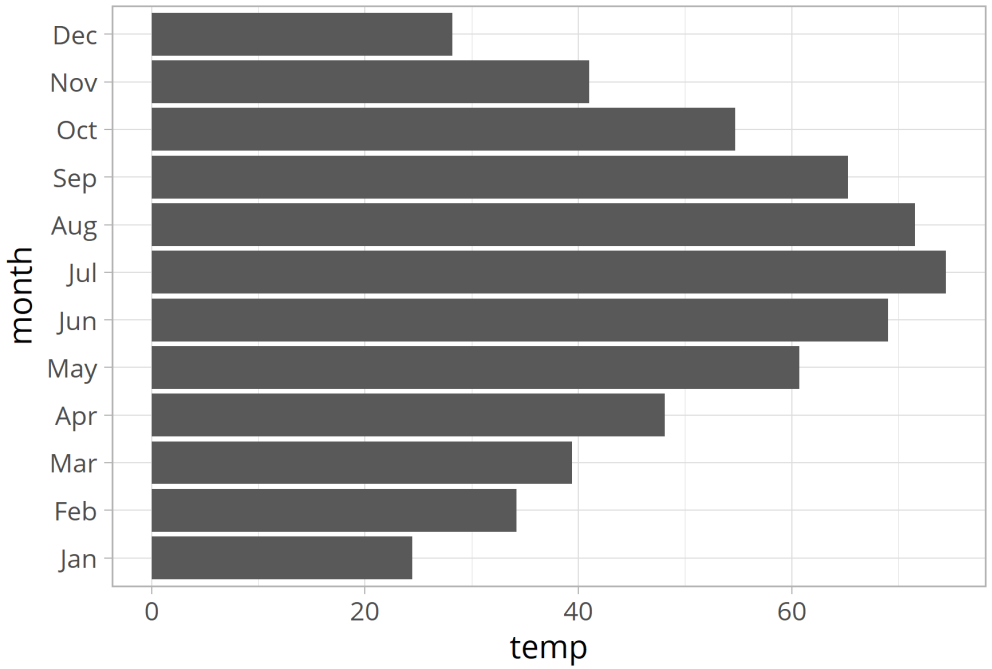
coord_flip()

`coord_flip()` allows you to flip a Cartesian coordinate system:

```
ggplot(chic_month, aes(month, temp)) +
  geom_col() +
  coord_cartesian()
```



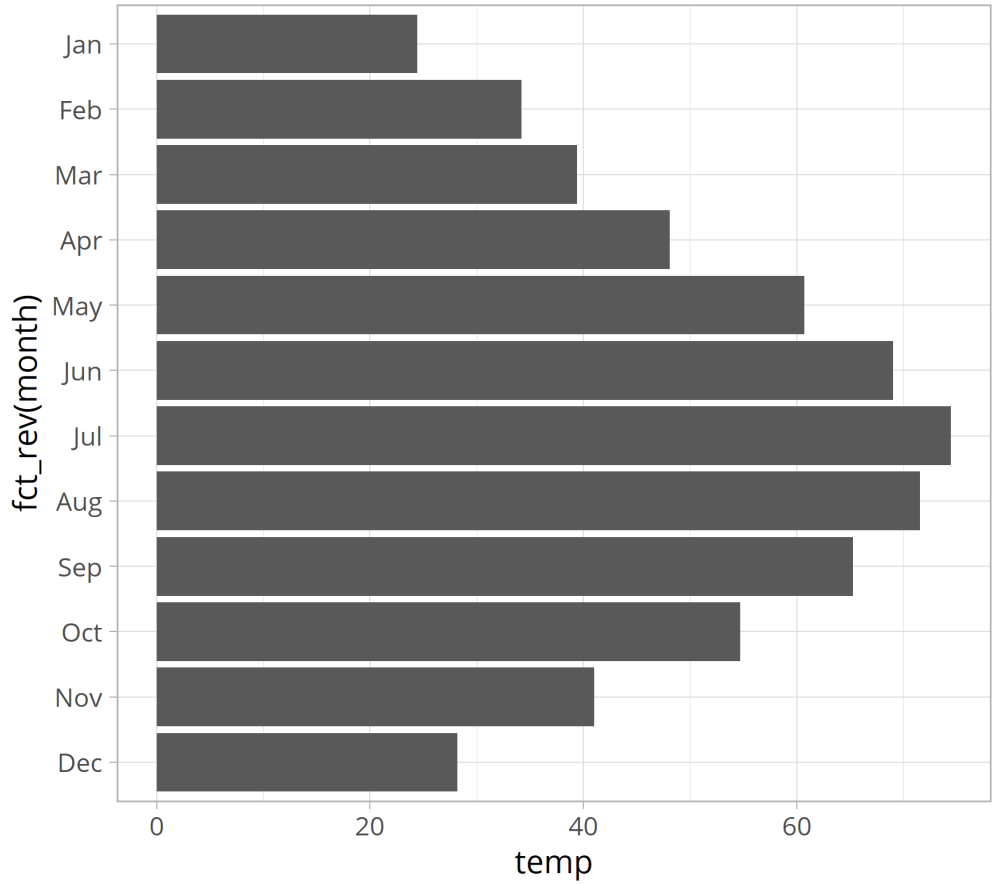

```
ggplot(chic_month, aes(month, temp)) +
  geom_col() +
  coord_flip()
```



coord_flip()

`coord_flip()` allows you to flip a Cartesian coordinate system:

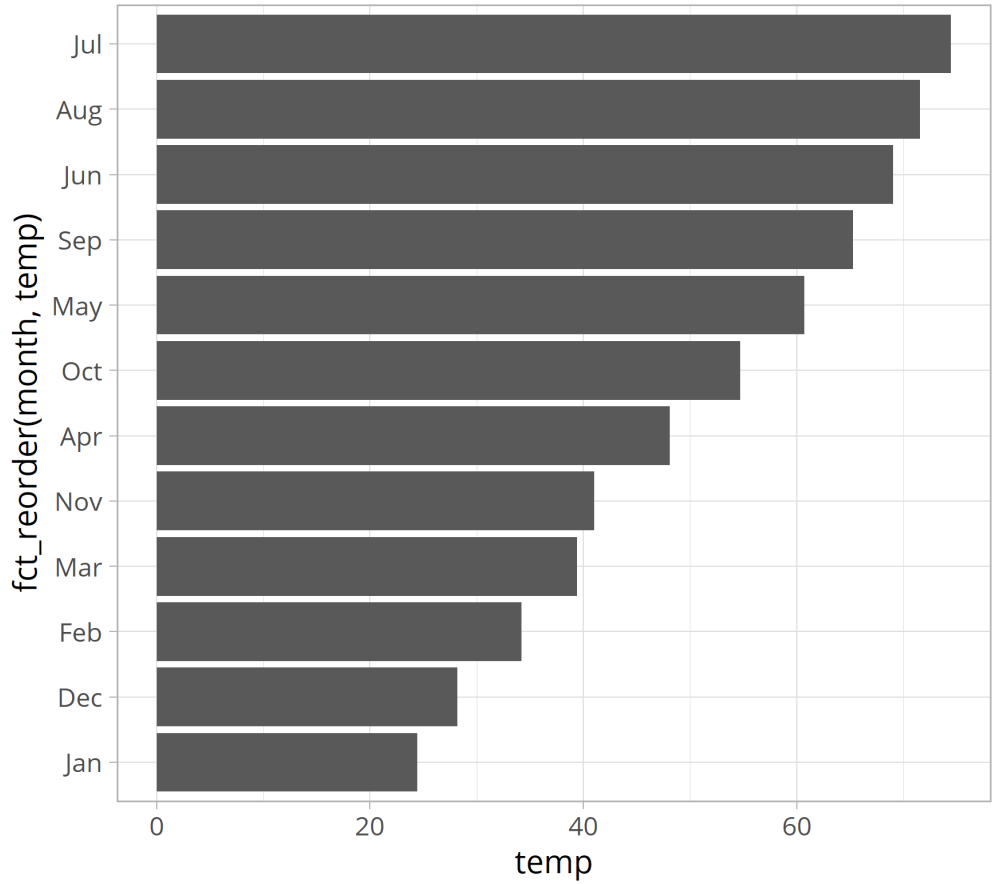
```
ggplot(
  chic_month,
  aes(
    fct_rev(month),
    temp
  )) +
  geom_col() +
  coord_flip()
```



coord_flip()

`coord_flip()` allows you to flip a Cartesian coordinate system:

```
ggplot(
  chic_month,
  aes(
    fct_reorder(month, temp),
    temp
  )) +
  geom_col() +
  coord_flip()
```



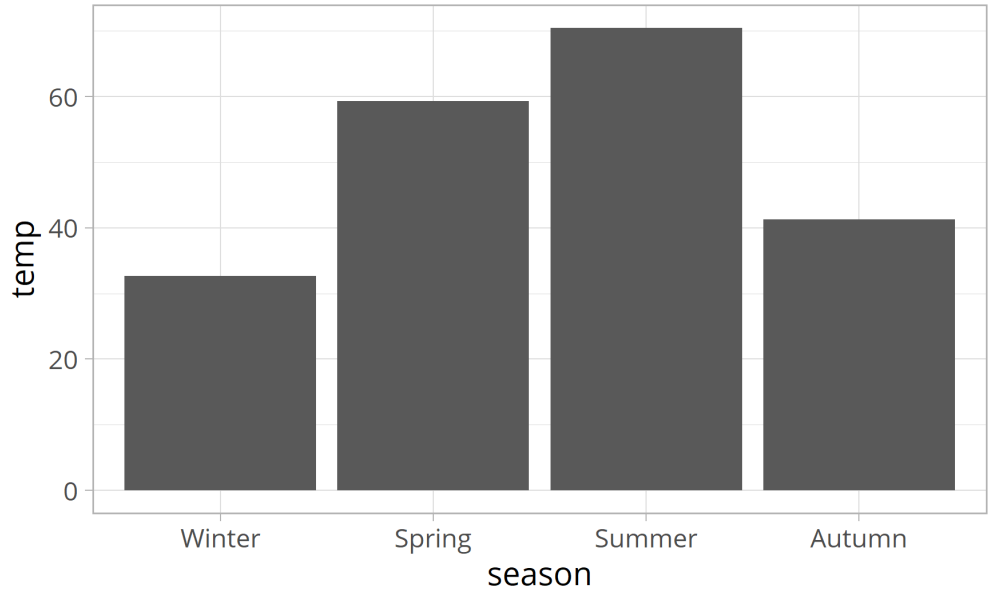
Coordinate System

`coord_polar()`

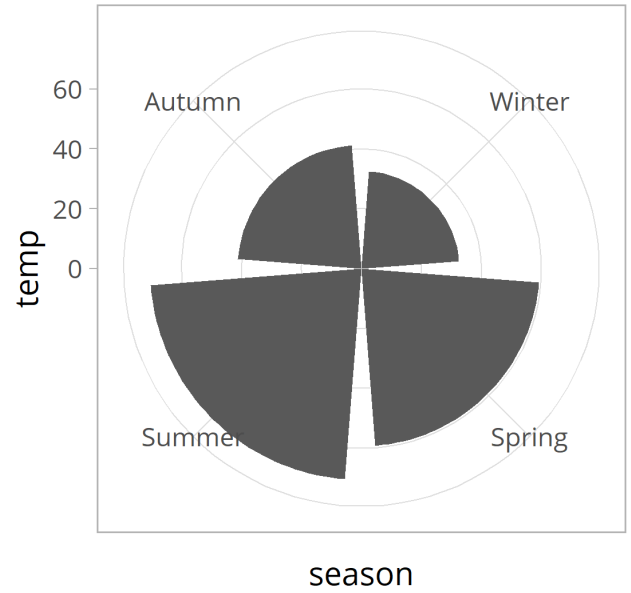
coord_polar()

You can easily transform a rectangular coordinate system into a polar one with `coord_polar()`:

```
ggplot(chic, aes(season, temp)) +
  stat_summary(fun.y = mean,
               geom = "col") +
  coord_cartesian()
```



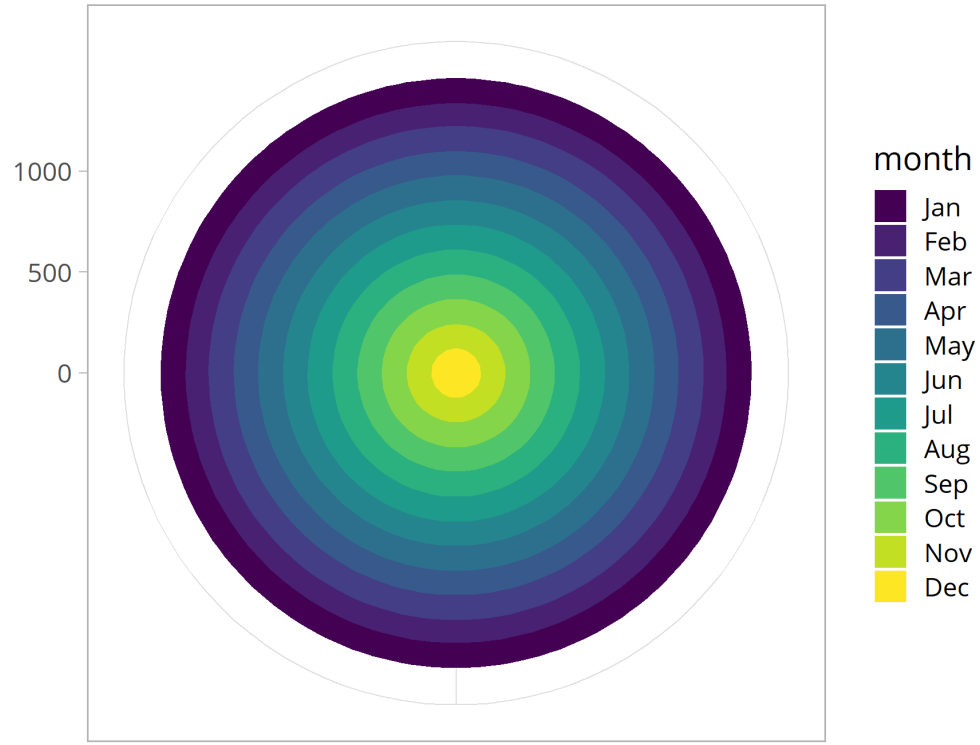

```
ggplot(chic, aes(season, temp)) +
  stat_summary(fun.y = mean,
               geom = "col") +
  coord_polar()
```



coord_polar()

This way, we can create pie charts:

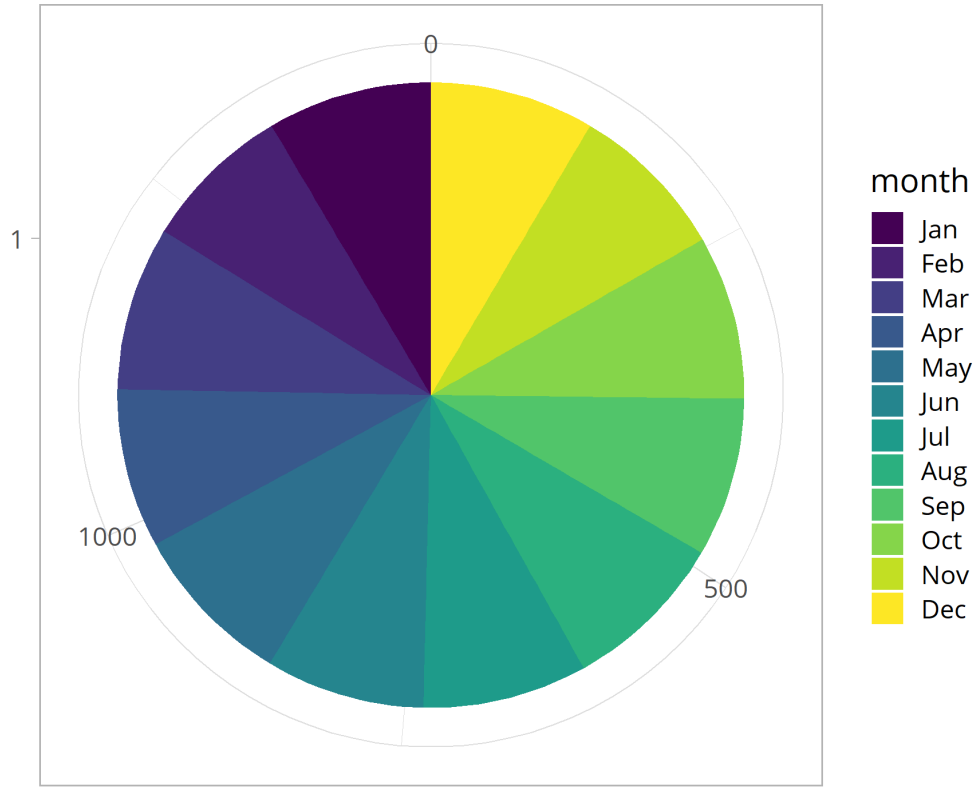
```
ggplot(
  chic_month,
  aes(
    factor(1), n,
    fill = month
  )) +
  geom_col() +
  coord_polar() +
  scale_x_discrete(
    name = NULL,
    expand = c(0, 0)
  ) +
  scale_y_continuous(
    name = NULL,
    expand = c(0, 0)
  )
```



coord_polar()

This way, we can create pie charts:

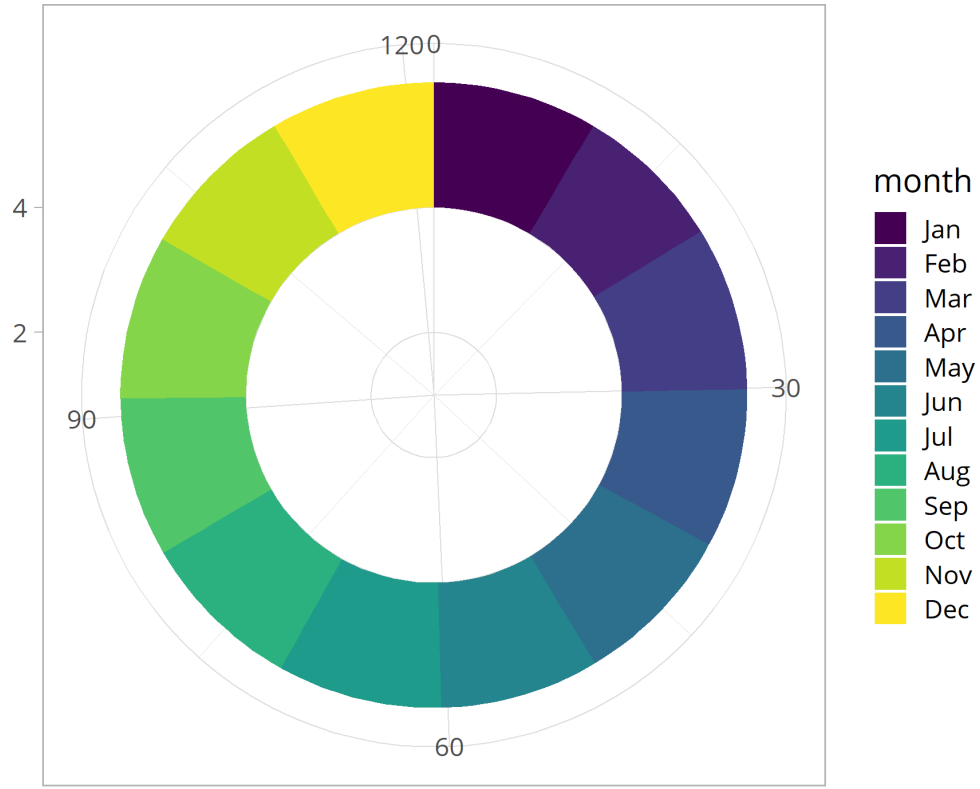
```
ggplot(
  chic_month,
  aes(
    factor(1), n,
    fill = month
  )) +
  geom_col() +
  coord_polar(theta = "y") +
  scale_x_discrete(
    name = NULL,
    expand = c(0, 0)
  ) +
  scale_y_continuous(
    name = NULL,
    expand = c(0, 0)
  )
```



coord_polar()

... and doughnut charts:

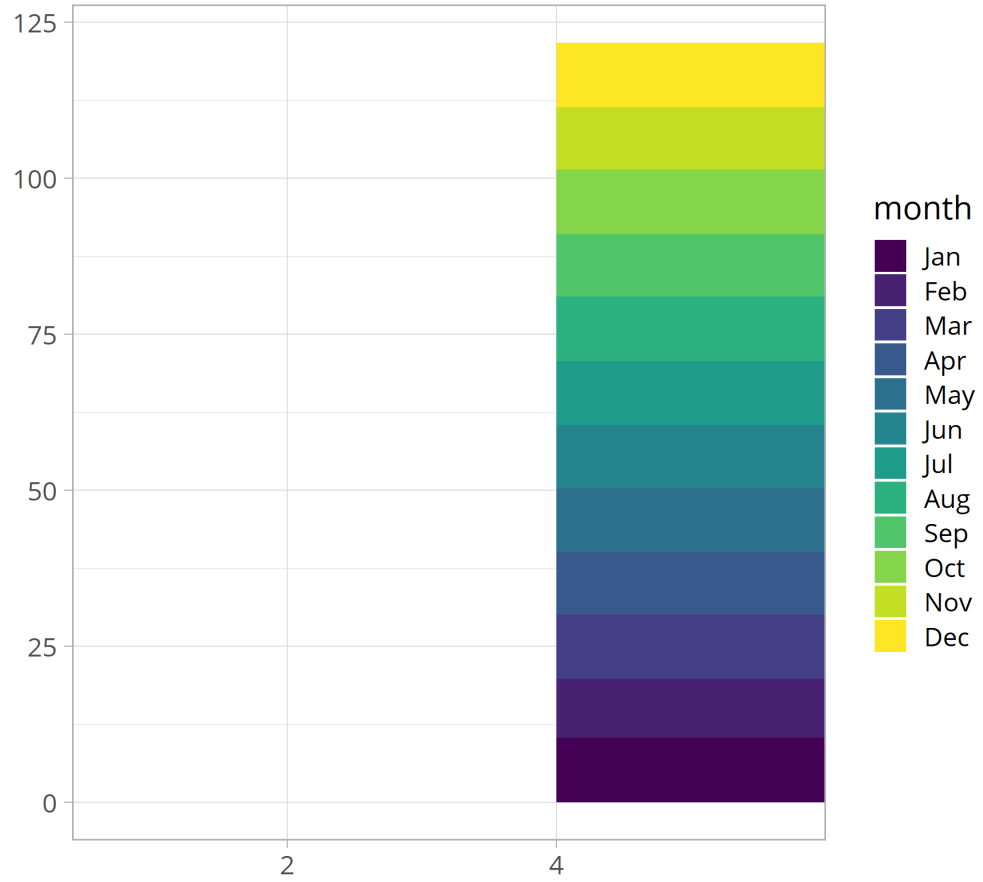
```
chic_month %>%
  mutate(
    perc = n / n(),
    ymax = cumsum(perc),
    ymin = c(0, head(ymax, n = -1))
  ) %>%
  ggplot(
    aes(
      xmin = 4, xmax = 6,
      ymin = ymin, ymax = ymax,
      fill = month
    )) +
    geom_rect() +
    coord_polar(theta = "y") +
    scale_x_discrete(
      name = NULL,
      limits = c(2, 4)
    )
```



coord_polar()

Our doughnut charts looks like this in a Cartesian coordinate system:

```
chic_month %>%
  mutate(
    perc = n / n(),
    ymax = cumsum(perc),
    ymin = c(0, head(ymax, n = -1))
  ) %>%
  ggplot(
    aes(
      xmin = 4, xmax = 6,
      ymin = ymin, ymax = ymax,
      fill = month
    )) +
    geom_rect() +
    #coord_polar(theta = "y") +
    scale_x_discrete(
      name = NULL,
      limits = c(2, 4)
    )
```



Coordinate System

`coord_map()` and `coord_sf()`

coord_map() and coord_sf()

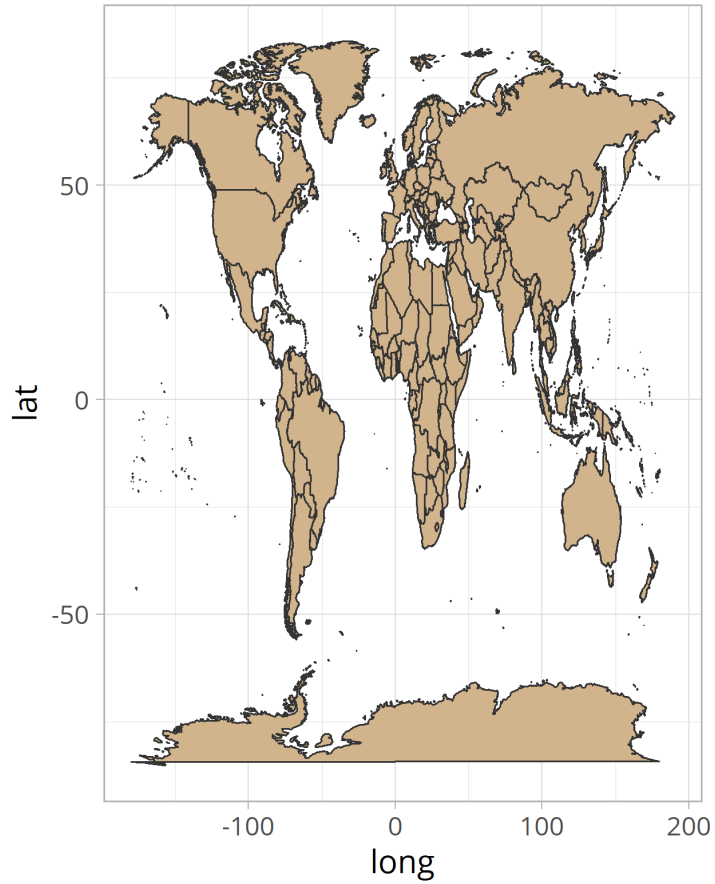
Maps often come as polygons:

```
world <- map_data("world")

head(world, 15)
##          long      lat group order      region subregion
## 1  -69.89912 12.45200     1     1       Aruba      <NA>
## 2  -69.89571 12.42300     1     2       Aruba      <NA>
## 3  -69.94219 12.43853     1     3       Aruba      <NA>
## 4  -70.00415 12.50049     1     4       Aruba      <NA>
## 5  -70.06612 12.54697     1     5       Aruba      <NA>
## 6  -70.05088 12.59707     1     6       Aruba      <NA>
## 7  -70.03511 12.61411     1     7       Aruba      <NA>
## 8  -69.97314 12.56763     1     8       Aruba      <NA>
## 9  -69.91181 12.48047     1     9       Aruba      <NA>
## 10 -69.89912 12.45200     1    10       Aruba      <NA>
## 12  74.89131 37.23164     2    12 Afghanistan      <NA>
## 13  74.84023 37.22505     2    13 Afghanistan      <NA>
## 14  74.76738 37.24917     2    14 Afghanistan      <NA>
## 15  74.73896 37.28564     2    15 Afghanistan      <NA>
## 16  74.72666 37.29072     2    16 Afghanistan      <NA>
```

`coord_map()` and `coord_sf()`

Maps often come as polygons and can be plotted via `geom_polygon()`:

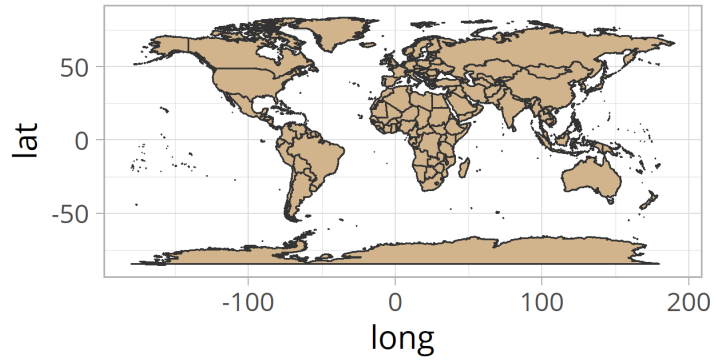
```
(g_world <-
  ggplot(
    world,
    aes(
      long, lat,
      group = group
    )) +
    geom_polygon(
      fill = "tan",
      color = "grey20"
    )
)
```



`coord_map()` and `coord_sf()`

We can fix that by using `coord_fixed()`:

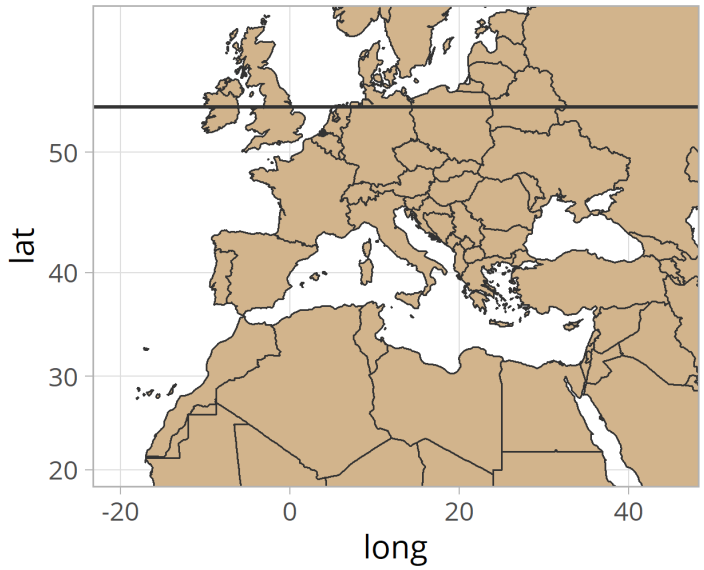
```
g_world +
  coord_fixed()
```



`coord_map()` and `coord_sf()`

We can fix that by using `coord_fixed()`:

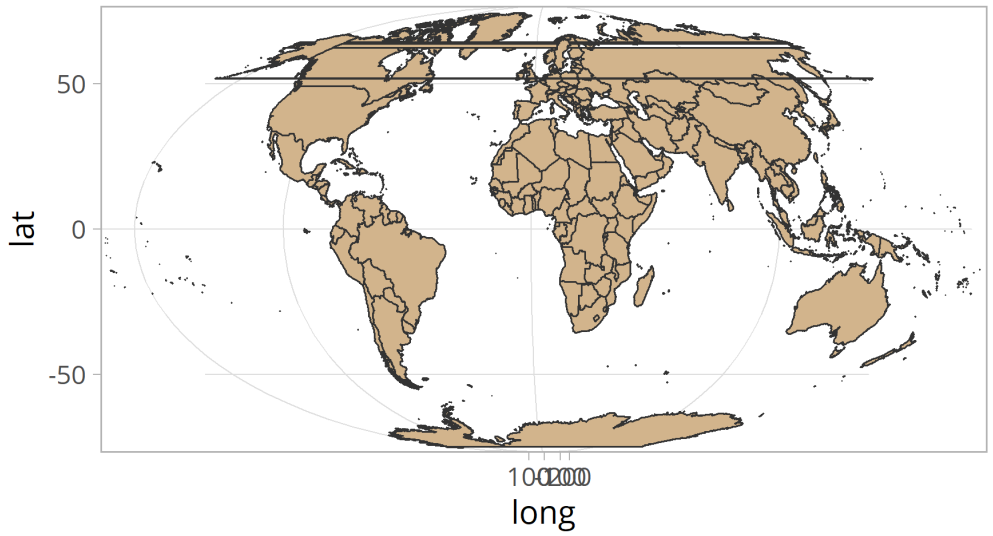
```
g_world +
  coord_map(
    xlim = c(-20, 45),
    ylim = c(20, 58)
  )
```



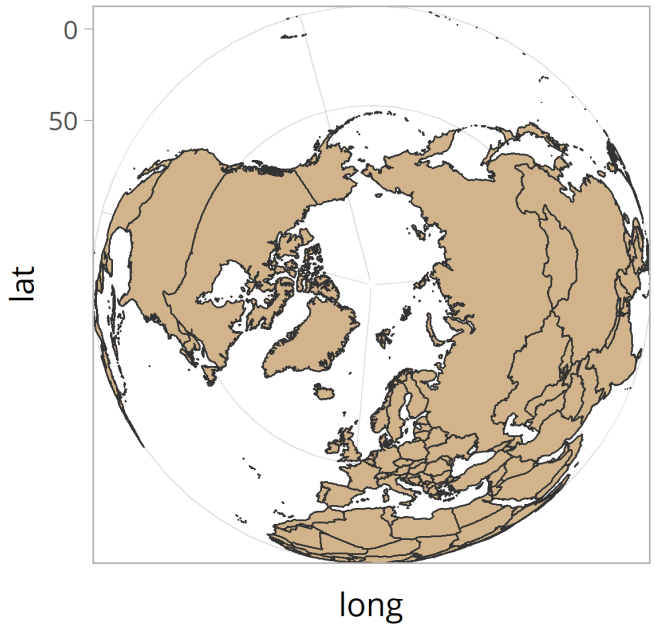
`coord_map()` and `coord_sf()`

Since maps are displaying spherical data, it's better to project the data via `coord_map()`:

```
g_world +
  coord_map("mollweide")
```




```
g_world +
  coord_map("ortho")
```



`coord_map()` and `coord_sf()`

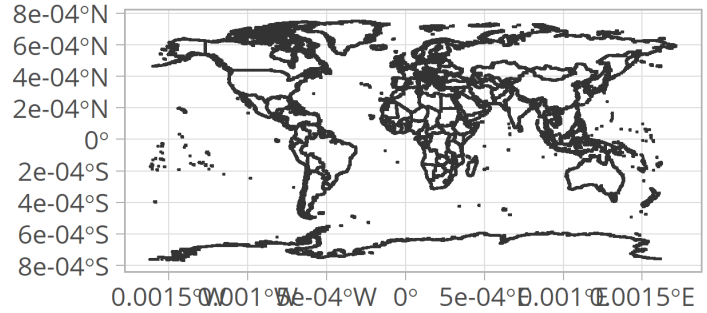
The `sf` package (`simple features`) is the new standard in geospatial computation:

```
library(sf)

sf_world <- st_as_sf(world, coords = c("long", "lat"), crs = 3786)

head(sf_world)
## Simple feature collection with 6 features and 4 fields
## geometry type:  POINT
## dimension:      XY
## bbox:           xmin: -70.06612 ymin: 12.423 xmax: -69.89571 ymax: 12.59707
## epsg (SRID):    3786
## proj4string:    +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=6371007 +b=6
##   group order region subregion                    geometry
## 1     1     1  Aruba      <NA>   POINT (-69.89912 12.452)
## 2     1     2  Aruba      <NA>   POINT (-69.89571 12.423)
## 3     1     3  Aruba      <NA> POINT (-69.94219 12.43853)
## 4     1     4  Aruba      <NA> POINT (-70.00415 12.50049)
## 5     1     5  Aruba      <NA> POINT (-70.06612 12.54697)
## 6     1     6  Aruba      <NA> POINT (-70.05088 12.59707)
```

`coord_map()` and `coord_sf()`

The `sf` package is included in `ggplot2` via `geom_sf()` and `coord_sf()`:

```
ggplot(sf_world) +
  geom_sf(
    fill = "tan",
    color = "grey20",
    size = .3
  )
```

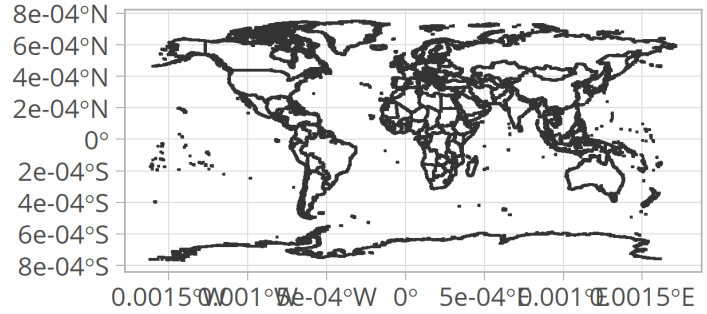


`coord_map()` and `coord_sf()`

The `sf` package is included in `ggplot2` via `geom_sf()` and `coord_sf()`:

```
ggplot(sf_world) +
  geom_sf(
    fill = "tan",
    color = "grey20",
    size = .3
  )
```

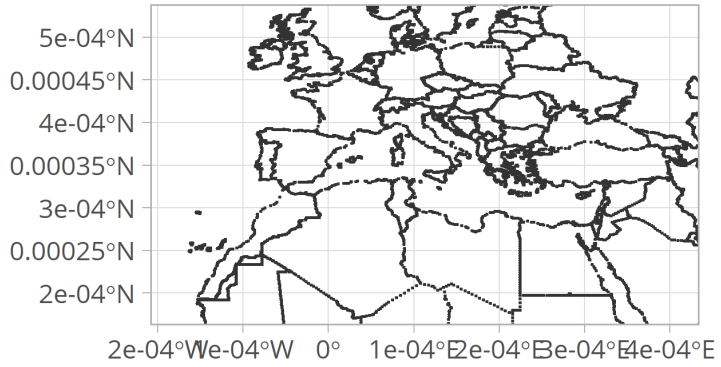
The `fill` argument doesn't work here, since it turned our polygons into points...



`coord_map()` and `coord_sf()`

The `sf` package is included in `ggplot2` via `geom_sf()` and `coord_sf()`:

```
ggplot(sf_world) +
  geom_sf(
    fill = "tan",
    color = "grey20",
    size = .3
  ) +
  coord_sf(
    xlim = c(-20, 45),
    ylim = c(20, 58)
  )
```

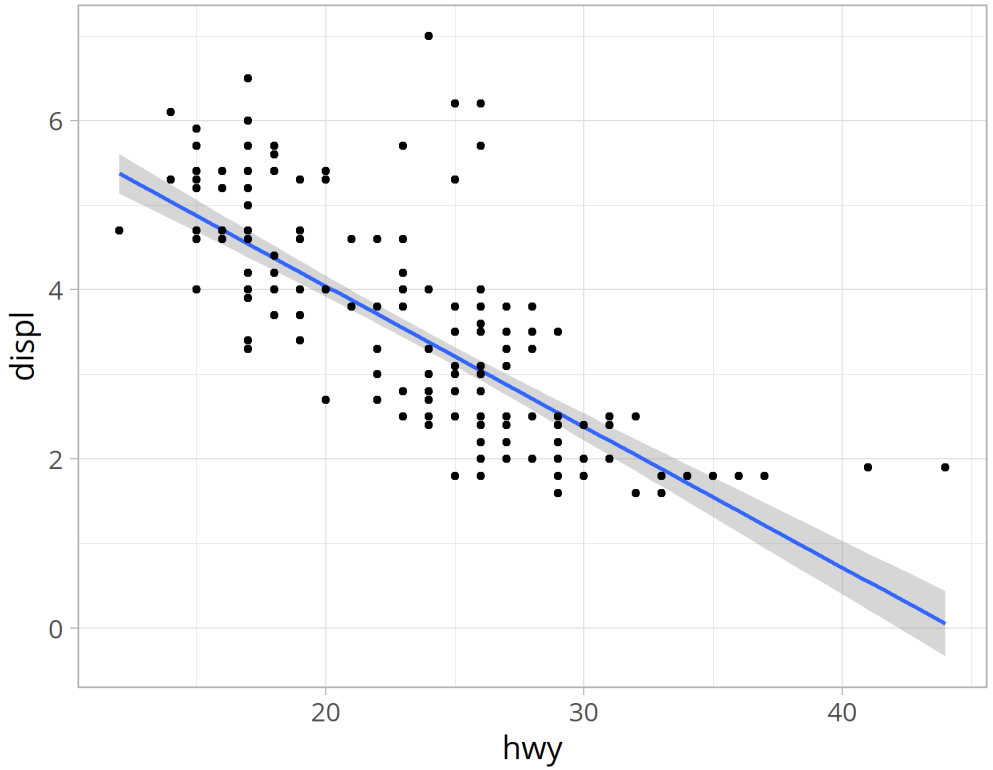


Your Turn!

- For a data set of your choice
  - create a scatter plot with a linear fitting and test how `coord_fixed()` changes the perception of the relationship
  - create a pie or doughnut chart for one variable in that data set

Your Turn: Fixed Aspect Ratio

```
ggplot(mpg, aes(hwy, displ)) +
  geom_smooth(method = "lm") +
  geom_point()
```




```
ggplot(mpg, aes(hwy, displ)) +
  geom_smooth(method = "lm") +
  geom_point() +
  coord_fixed()
```