MONASH University

MONASH BUSINESS SCHOOL

High dimensional time series analysis

2. Time series graphics

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Outline

1. Time plots
2. Lab Session 2
3. Seasonal plots
4. Lab Session 3
5. Decompositions
6. Lab Session 4

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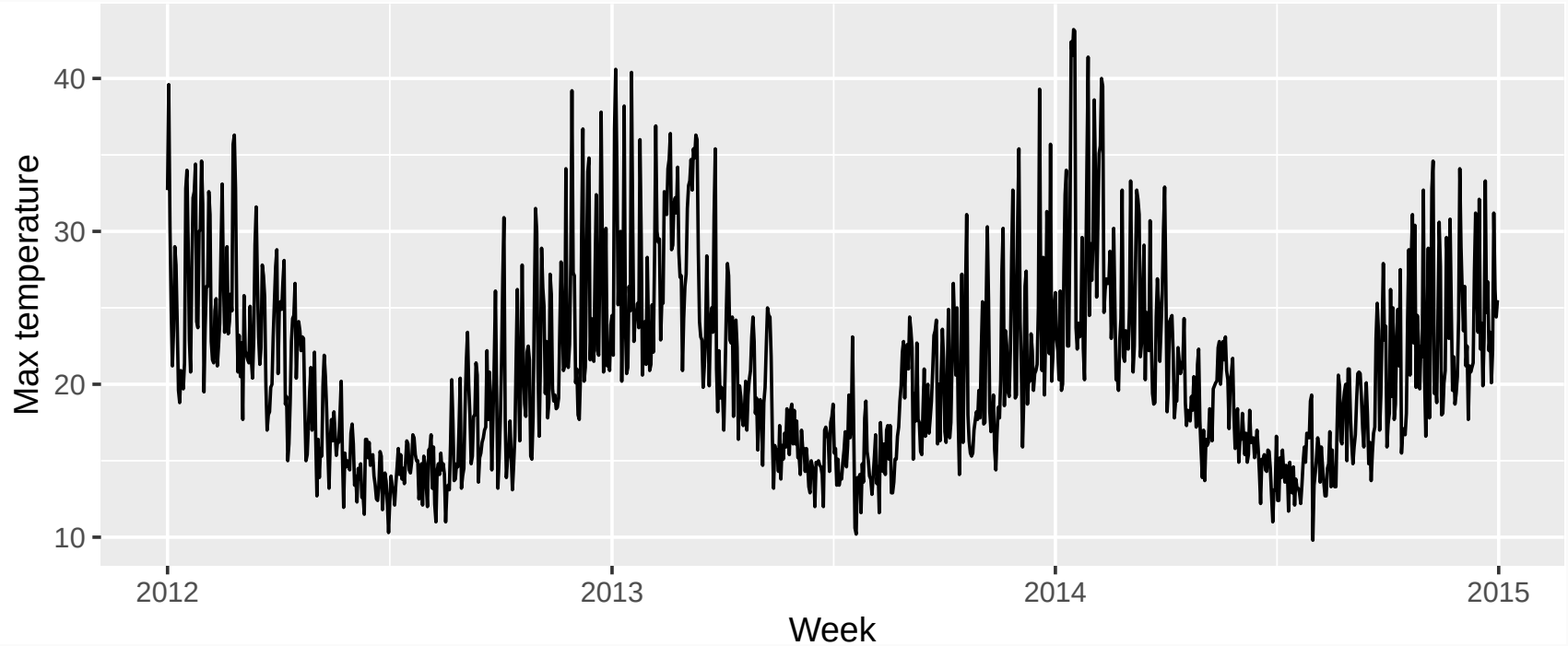
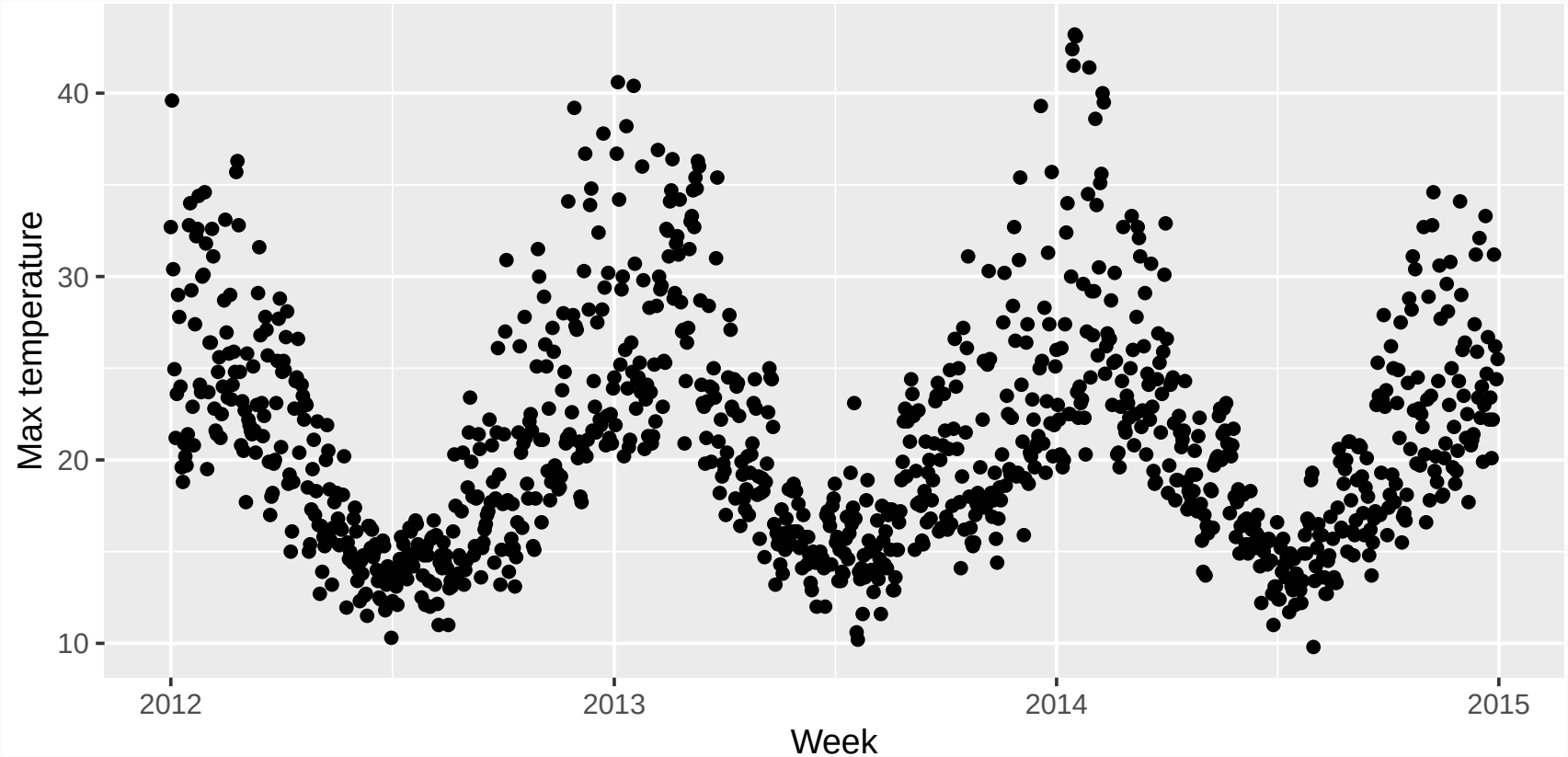
Are line plots best?

```
maxtemp <- vic_elec %>%
  index_by(Day = date(Time)) %>%
  summarise(Temperature = max(Temperature))
maxtemp %>%
  autoplot(Temperature) +
  xlab("Week") + ylab("Max temperature")
```



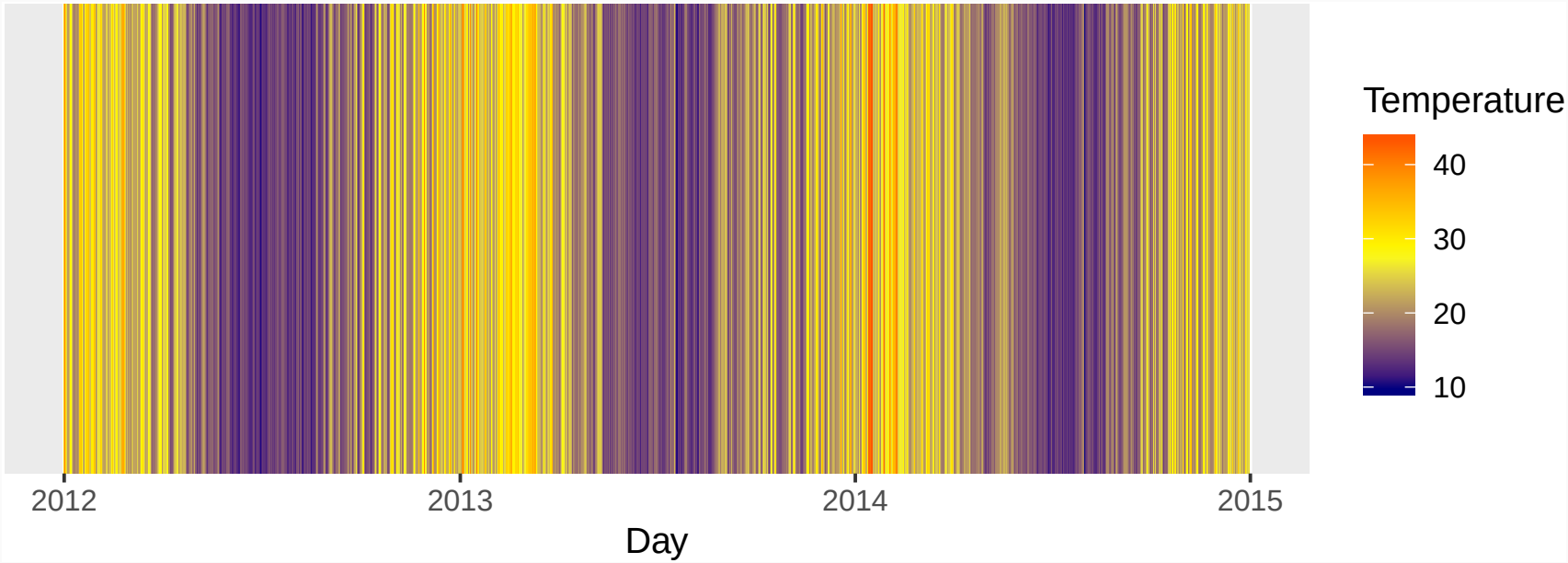
Are line plots best?

```
maxtemp %>%
  ggplot(aes(x = Day, y = Temperature)) +
  geom_point() +
  xlab("Week") + ylab("Max temperature")
```



Are line plots best?

```
maxtemp %>%
  ggplot(aes(x = Day, y = 1)) +
  geom_tile(aes(fill = Temperature)) +
  scale_fill_gradient2(low = "navy", mid = "yellow",
                       high = "red", midpoint=28) +
  ylab("") + scale_y_discrete(expand=c(0,0))
```

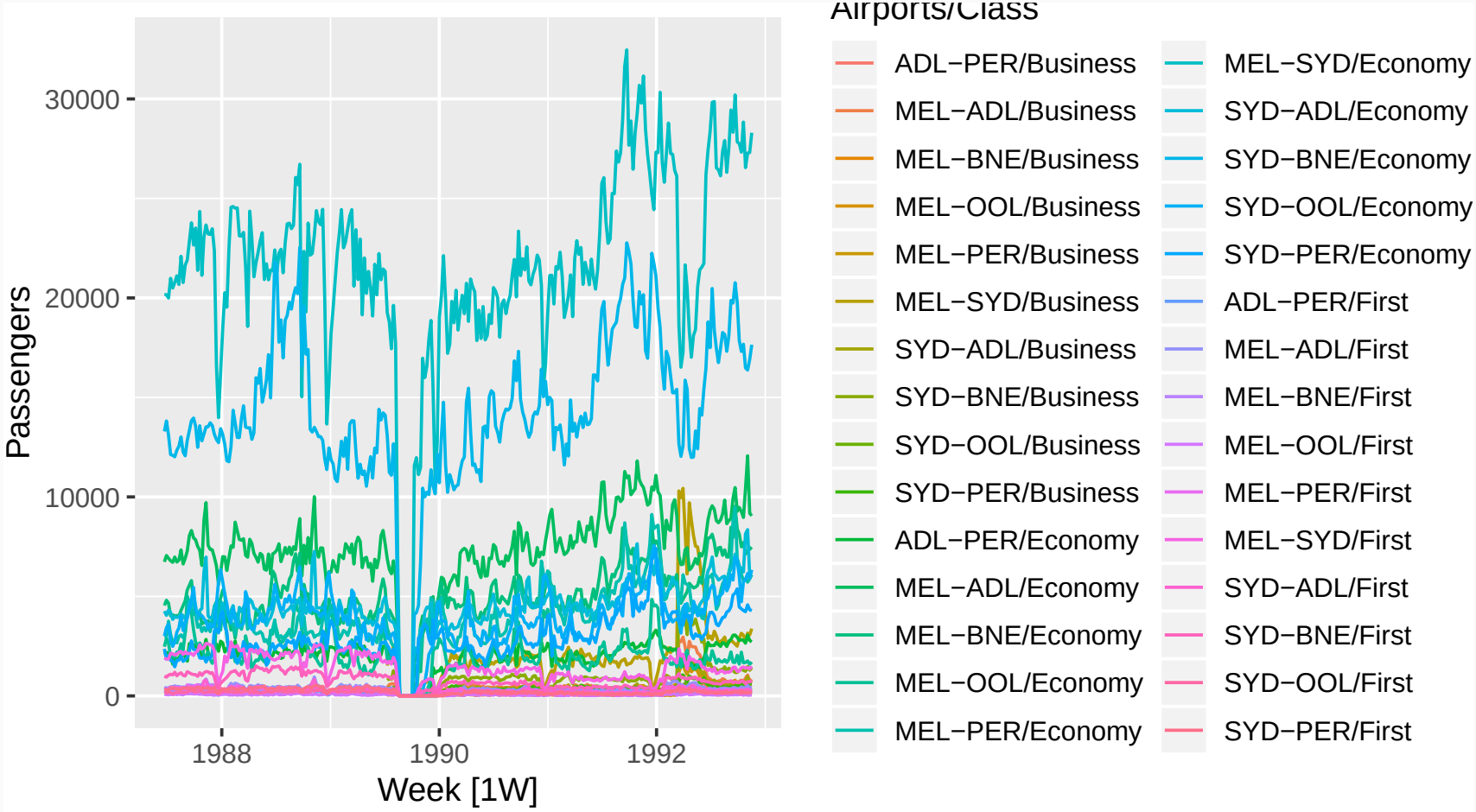


Are line plots best?

Ansett airlines

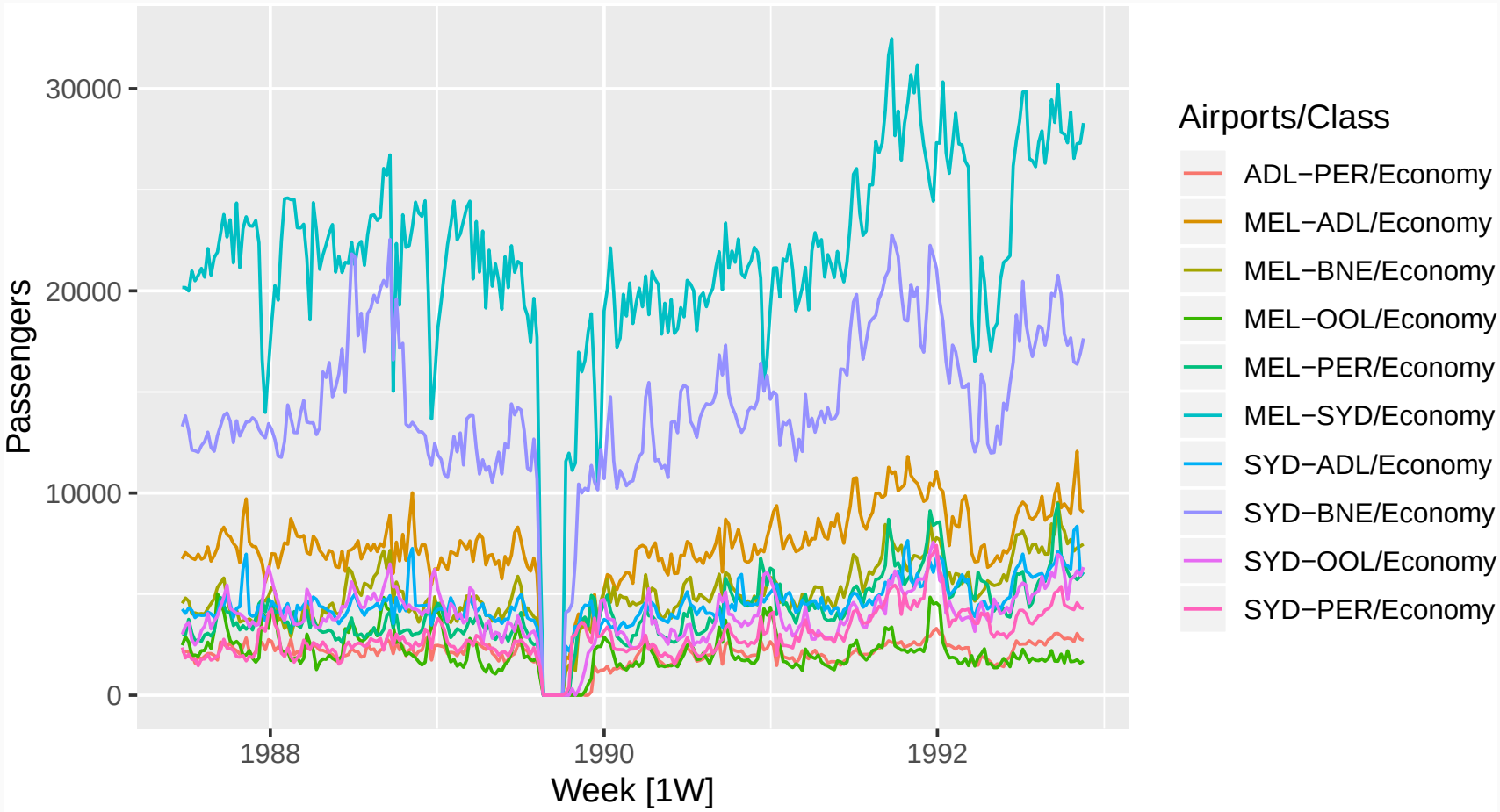
Ansett airlines

```
ansett %>%
  autoplot(Passengers)
```



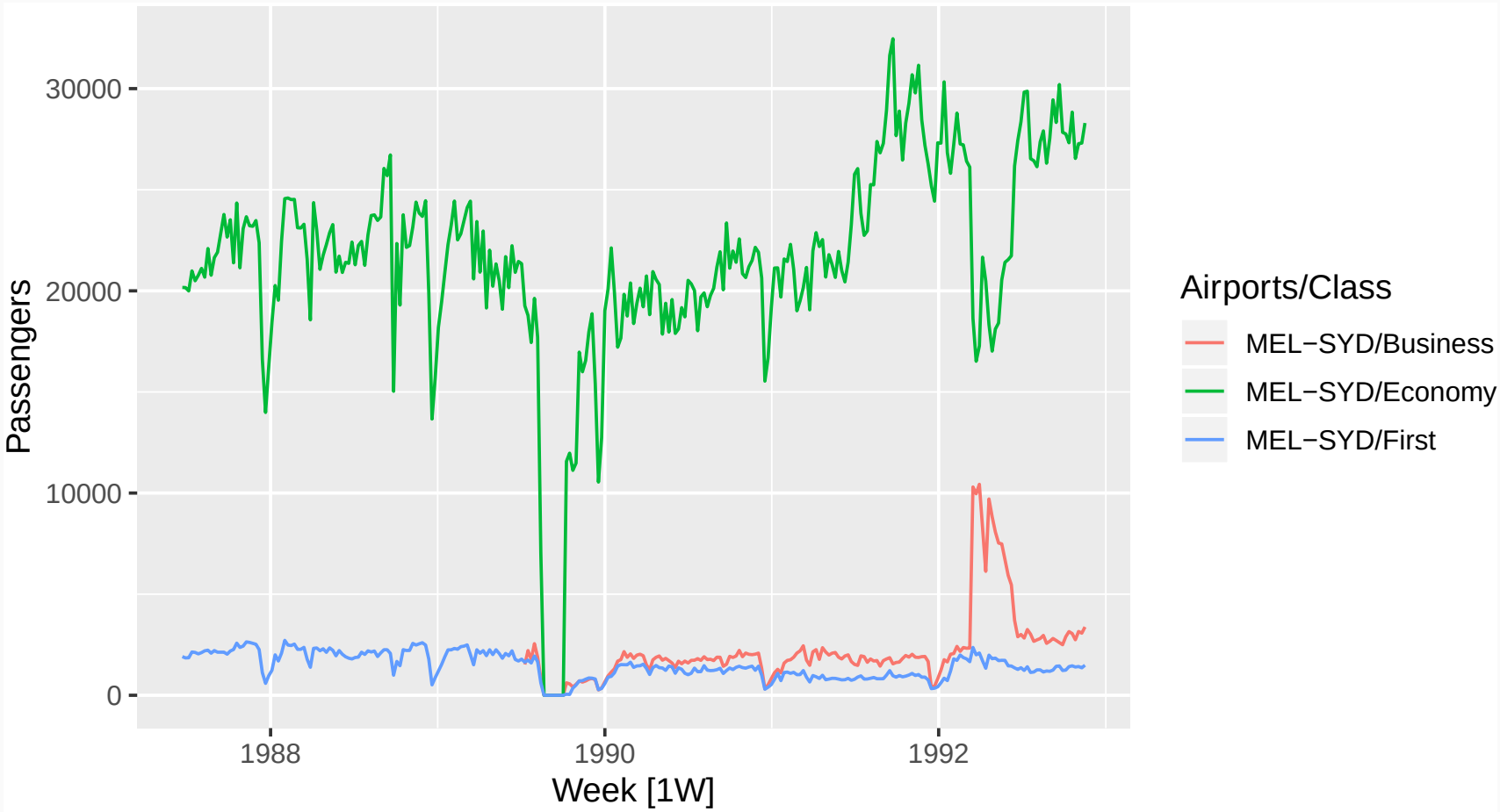
Ansett airlines

```
ansett %>%
  filter(Class=="Economy") %>%
  autoplot(Passengers)
```



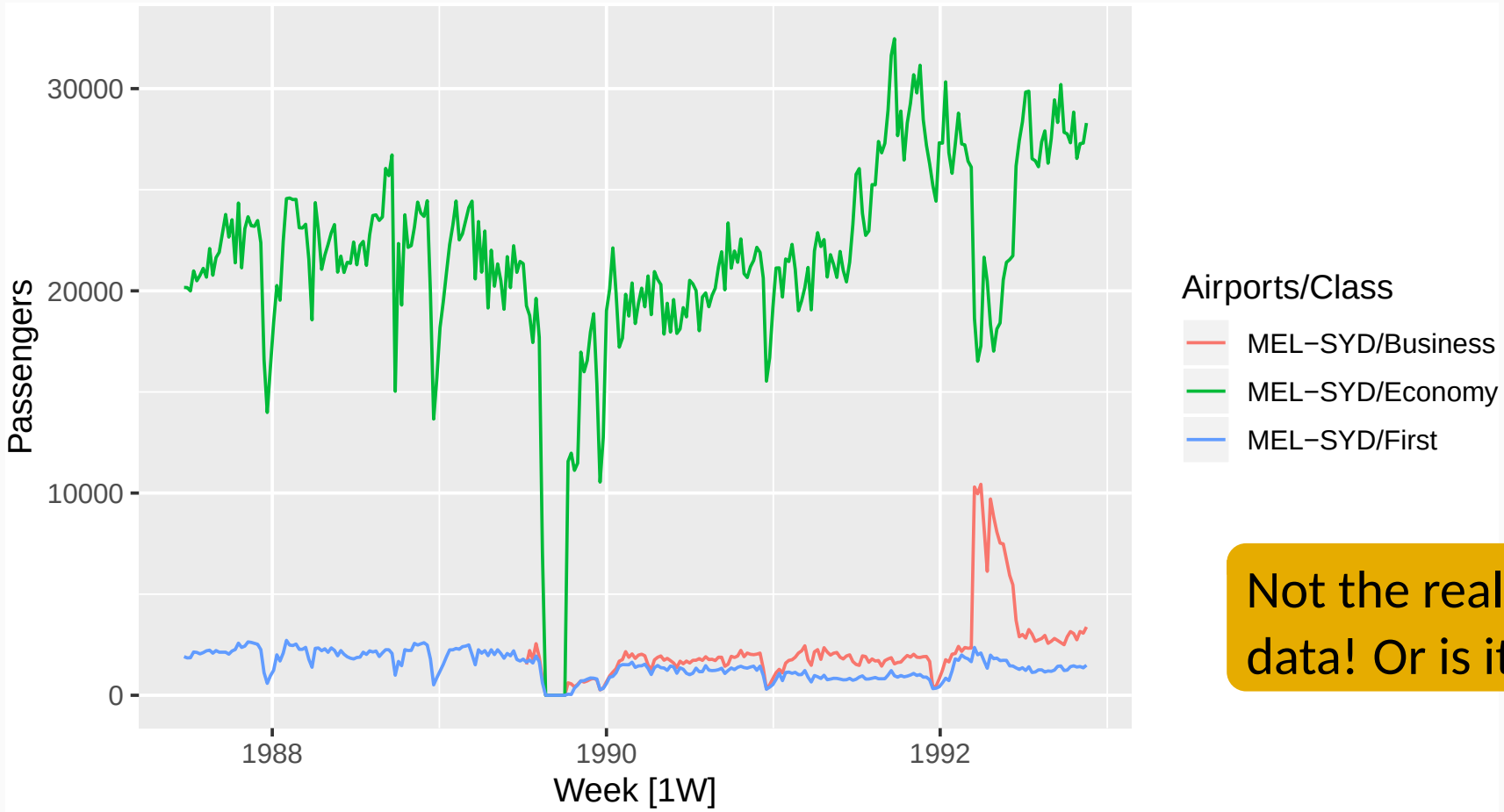
Ansett airlines

```
ansett %>%
  filter(Airports=="MEL-SYD") %>%
  autoplot(Passengers)
```



Ansett airlines

```
ansett %>%
  filter(Airports=="MEL-SYD") %>%
  autoplot(Passengers)
```



Not the real data! Or is it?

Australian holidays

```
holidays <- tourism %>%
  filter(Purpose=="Holiday") %>%
  group_by(State) %>%
  summarise(Trips = sum(Trips))
```

```
## # A tsibble: 640 x 3 [1Q]
## # Key:       State [8]
##    State Quarter Trips
##    <chr>   <qtr> <dbl>
##  1 ACT   1998 Q1  196.
##  2 ACT   1998 Q2  127.
##  3 ACT   1998 Q3  111.
##  4 ACT   1998 Q4  170.
##  5 ACT   1999 Q1  108.
##  6 ACT   1999 Q2  125.
##  7 ACT   1999 Q3  178.
##  8 ACT   1999 Q4  218.
##  9 ACT   2000 Q1  158.
## 10 ACT   2000 Q2  155.
```

Australian holidays

```
holidays %>% autoplot(Trips) +
  ylab("thousands of trips") + xlab("Year") +
  ggtitle("Australian domestic holiday nights")
```

Outline

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Lab Session 2

- Create time plots of the following time series: `Beer` from `aus_production`, `Lynx` from `pelt`, `Close` from `gafa_stock`
- Use `help()` to find out about the data in each series.
- For the last plot, modify the axis labels and title.

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The seasonal period

- Seasonal period = no. observations before seasonal pattern repeats.
- Usually automatically detected using time index.
- Daily & sub-daily time series can have multiple periods.

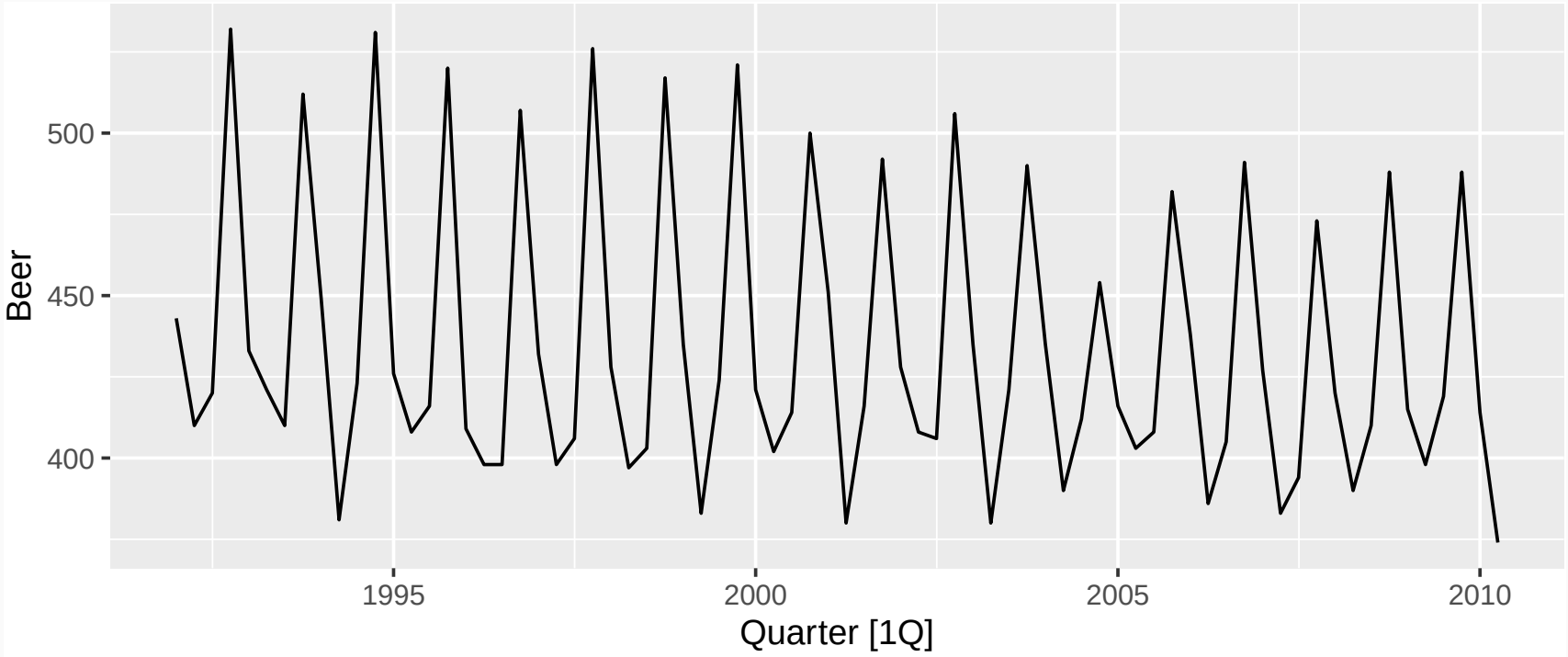
Data	Minute	Hour	Day	Week	Year
Quarters					4
Months					12
Weeks					52
Days				7	365.25
Hours			24	168	8766
Minutes		60	1440	10080	525960
Seconds	60	3600	86400	604800	31557600

Seasonal plots

- Data plotted against the individual “seasons” in which the data were observed. (In this case a “season” is a month.)
- Something like a time plot except that the data from each season are overlapped.
- Enables the underlying seasonal pattern to be seen more clearly, and also allows any substantial departures from the seasonal pattern to be easily identified.
- In R: `gg_season()`

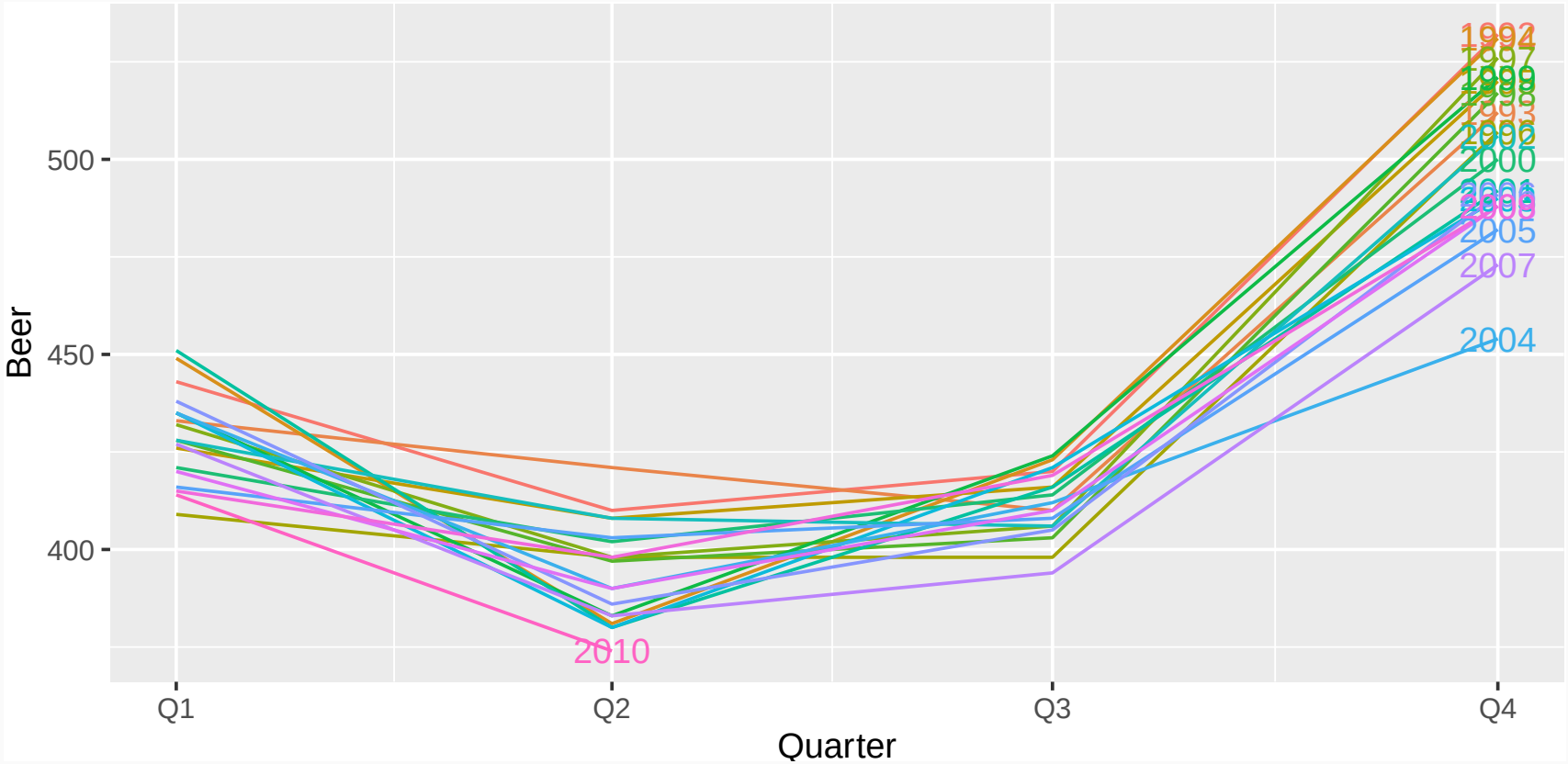
Quarterly Australian Beer Production

```
beer <- aus_production %>%
  select(Quarter, Beer) %>%
  filter(year(Quarter) >= 1992)
beer %>% autoplot(Beer)
```



Quarterly Australian Beer Production

```
beer %>% gg_season(Beer, labels="right")
```

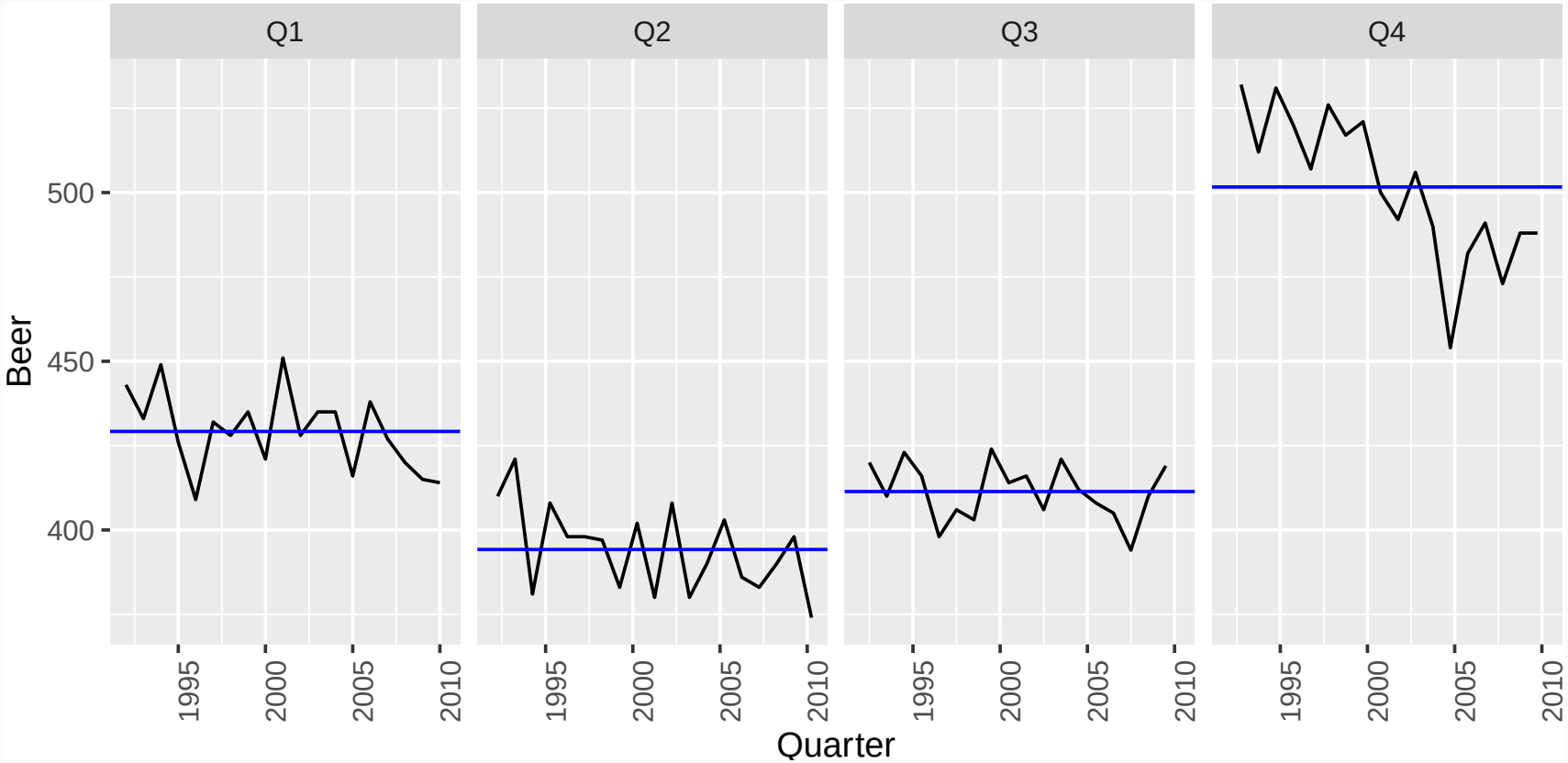


Seasonal subseries plots

- Data for each season collected together in time plot as separate time series.
- Enables the underlying seasonal pattern to be seen clearly, and changes in seasonality over time to be visualized.
- In R: `gg_subseries()`

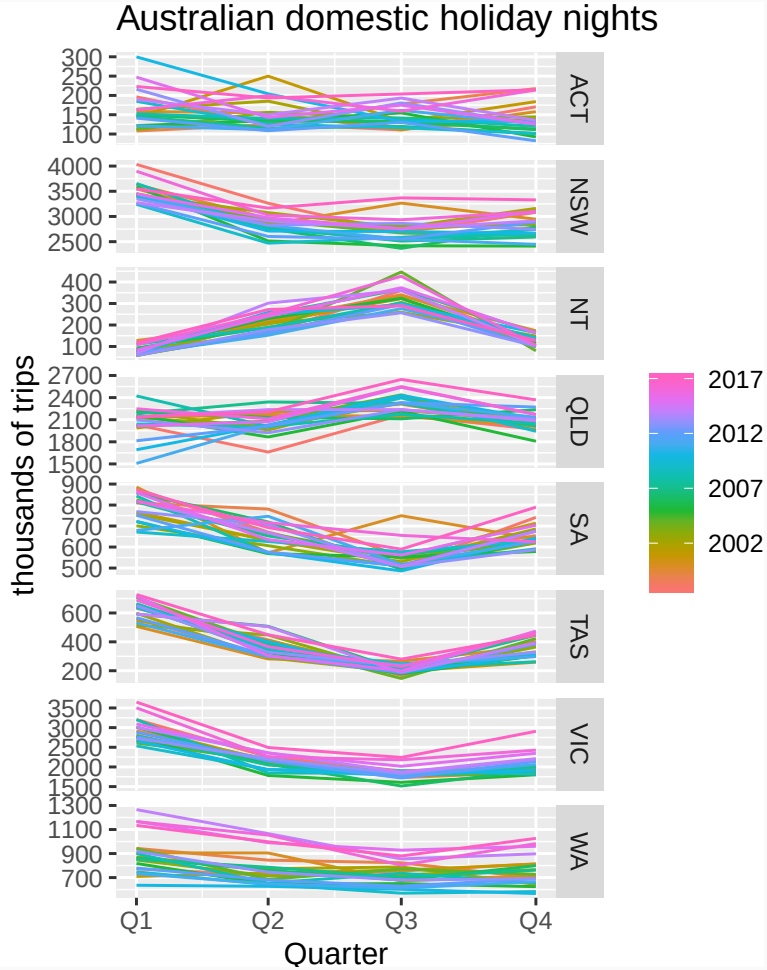
Quarterly Australian Beer Production

```
beer %>% gg_subseries(Beer)
```



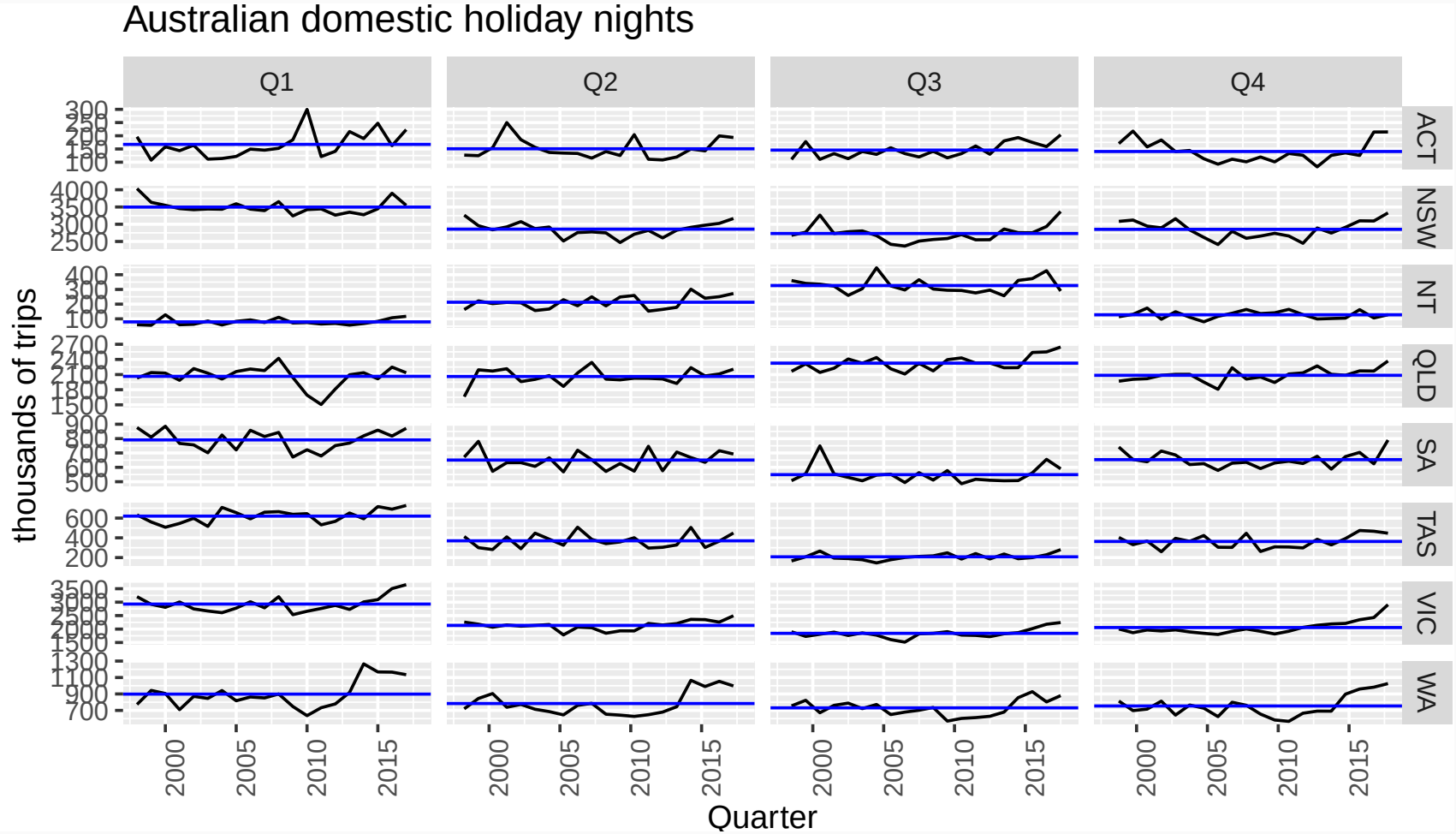
Seasonal plots

```
holidays %>% gg_season(Trips) +
  ylab("thousands of trips") +
  ggtitle("Australian domestic holiday nights")
```



Seasonal subseries plots

```
holidays %>%
  gg_subseries(Trips) + ylab("thousands of trips") +
  ggtitle("Australian domestic holiday nights")
```



Outline

Lab Session 3

Look at the quarterly tourism data for the Snowy Mountains

```
snowy <- filter(tourism,
  Region == "Snowy Mountains")
```

- Use `autoplot()`, `gg_season()` and `gg_subseries()` to explore the data.
- What do you learn?

Outline

Time series decomposition

Trend-Cycle aperiodic changes in level over time.

Seasonal (almost) periodic changes in level due to seasonal factors (e.g., the quarter of the year, the month, or day of the week).

Additive decomposition

$$y_t = S_t + T_t + R_t$$

where y_t = data at period t

T_t = trend-cycle component at period t

S_t = seasonal component at period t

R_t = remainder component at period t

STL decomposition

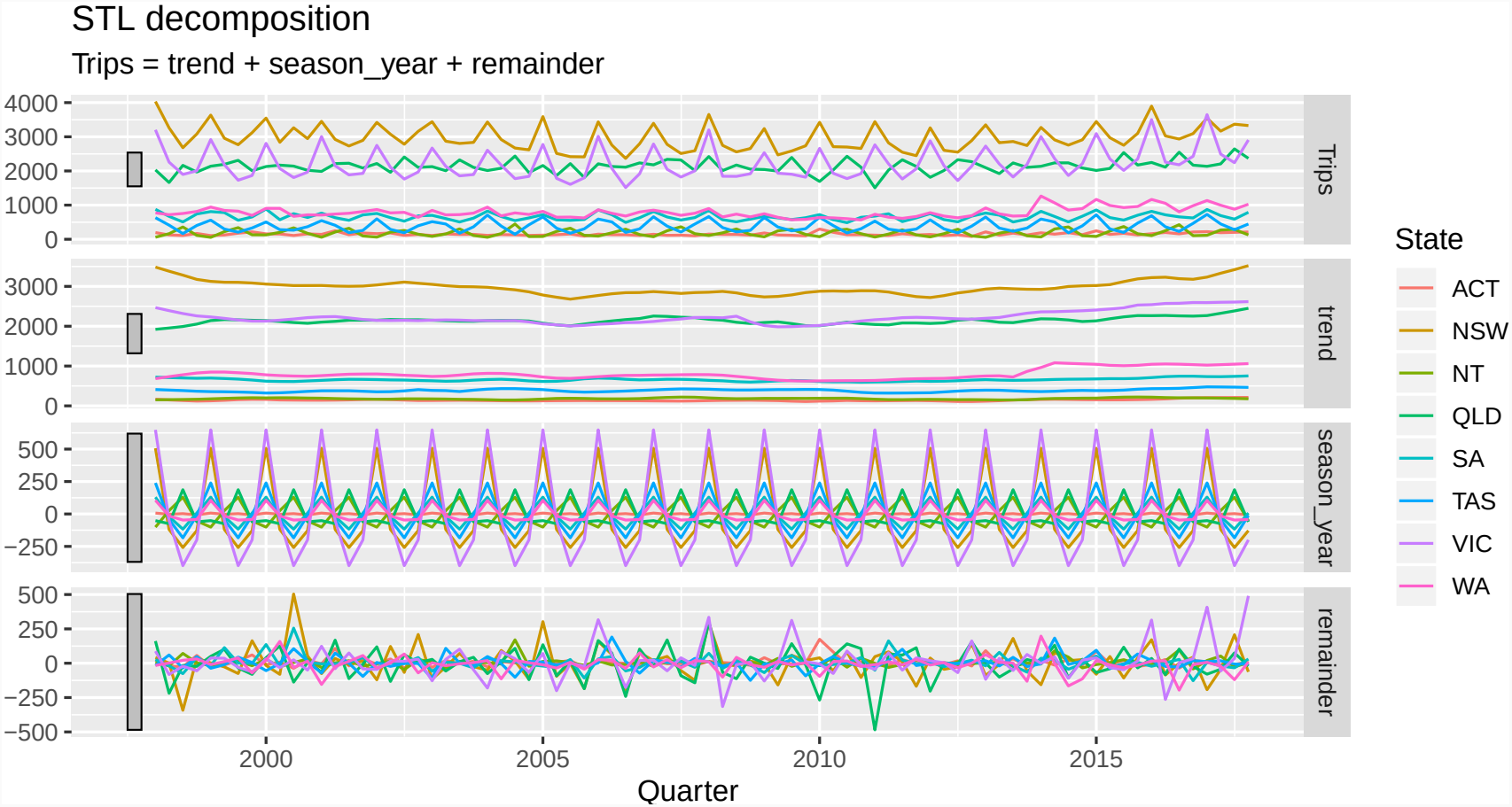
- STL: “Seasonal and Trend decomposition using Loess”
- Very versatile and robust.
- Seasonal component allowed to change over time, and rate of change controlled by user.
- Smoothness of trend-cycle also controlled by user.
- Optionally robust to outliers
- Not trading day or calendar adjustments.
- Only additive.
- Take logs to get multiplicative decomposition.
- Use Box-Cox transformations to get other decompositions.

Australian holidays

```
holidays %>% autoplot(Trips) +
  ylab("thousands of trips") + xlab("Year") +
  ggtitle("Australian domestic holiday nights")
```

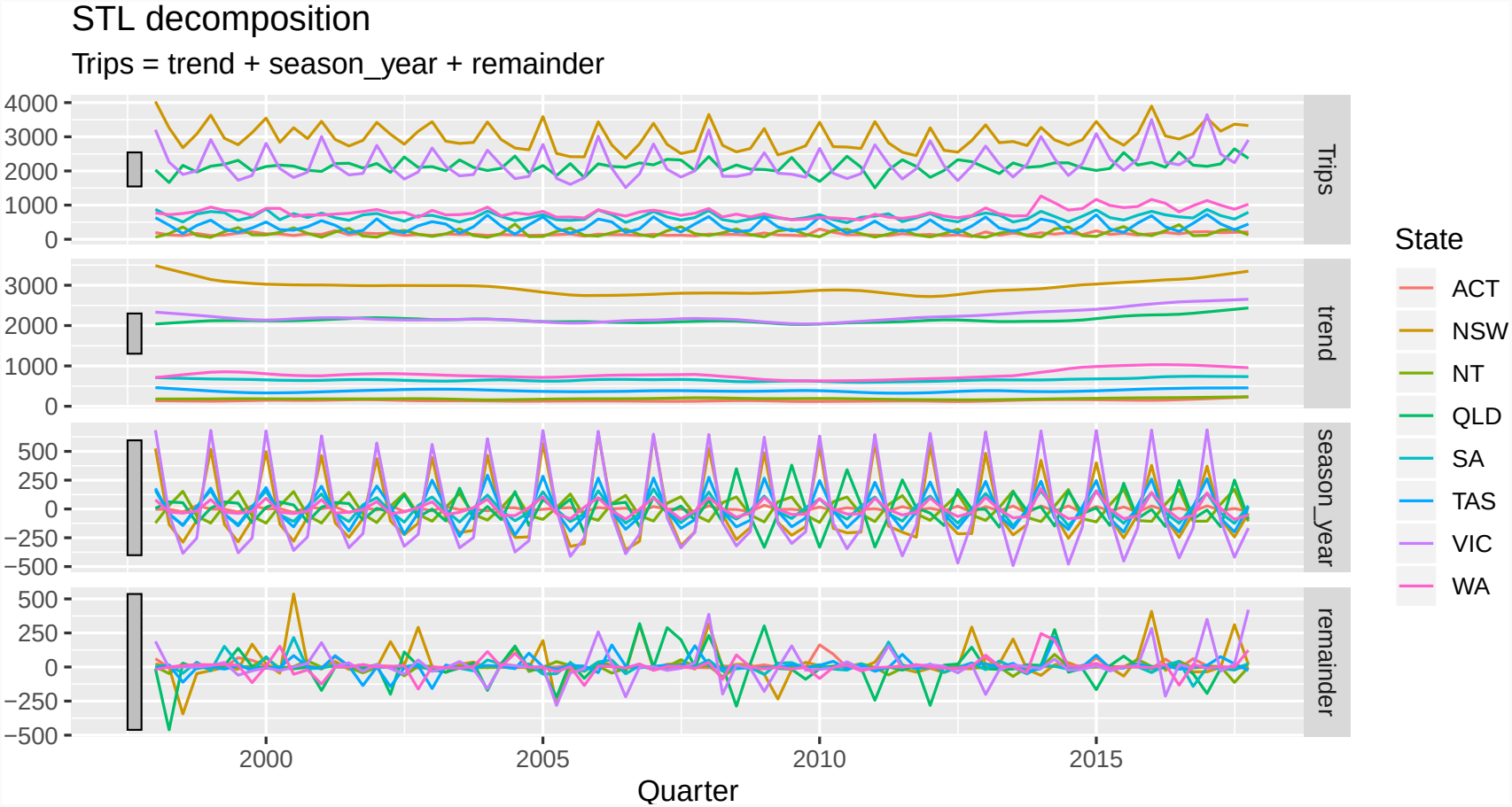
Holidays decomposition

```
holidays %>%
  STL(Trips ~ season(window="periodic"), robust=TRUE) %>%
  autoplot()
```



Holidays decomposition

```
holidays %>%
  STL(Trips ~ season(window = 5), robust = TRUE) %>%
  autoplot()
```



STL decomposition

```
holidays %>%
  STL(Trips ~ trend(window=15) + season(window=13),
      robust = TRUE)
```

- `trend(window = ?)` controls wiggliness of trend component.
- `season(window = ?)` controls variation on seasonal component.
- `STL()` chooses `season(window=13)` by default
- A large seasonal window is equivalent to setting `window="periodic"`.
- Odd numbers should be used for symmetry.

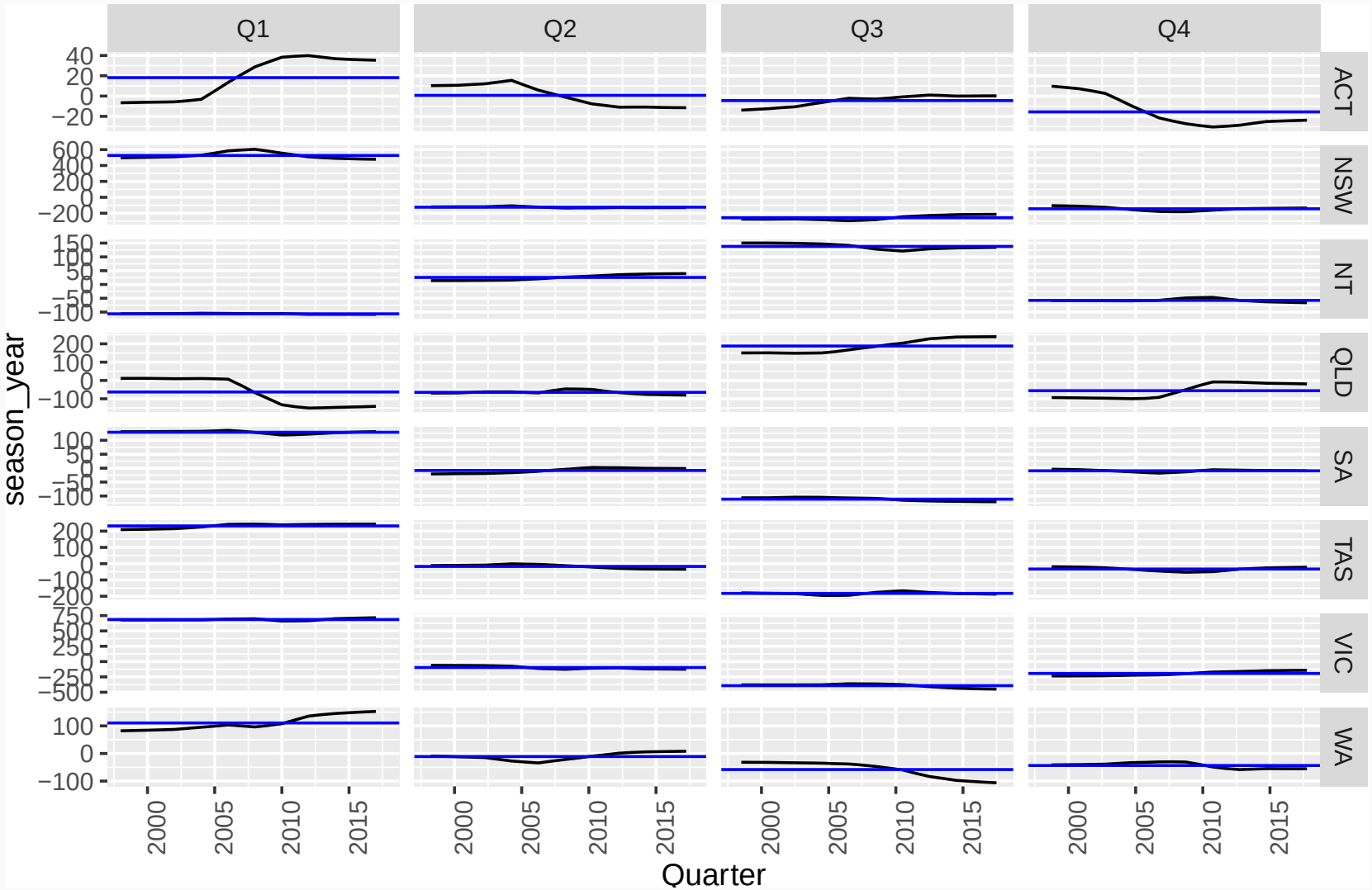
Holidays decomposition

```
dcmp <- holidays %>% STL(Trips)
dcmp
```

```
## # A dable:           640 x 7 [1Q]
## # Key:               State [8]
## # STL Decomposition: Trips = trend + season_year +
## #   remainder
##    State    Quarter Trips trend season_year remainder
##    <chr>      <qtr> <dbl> <dbl>       <dbl>     <dbl>
##  1 ACT      1998 Q1  196.  171.       -6.60     32.3
##  2 ACT      1998 Q2  127.  156.       10.3     -39.7
##  3 ACT      1998 Q3  111.  142.      -13.9     -17.2
##  4 ACT      1998 Q4  170.  130.        9.76     30.3
##  5 ACT      1999 Q1  108.  135.       -6.35    -20.7
##  6 ACT      1999 Q2  125.  148.       10.5     -33.9
##  7 ACT      1999 Q3  178.  166.      -13.2       25.5
##  8 ACT      1999 Q4  218.  177.        8.56     32.0
##  9 ACT      2000 Q1  158.  169.       -6.09     -4.74
## 10 ACT      2000 Q2  155.  151.       10.7      -7.00
```

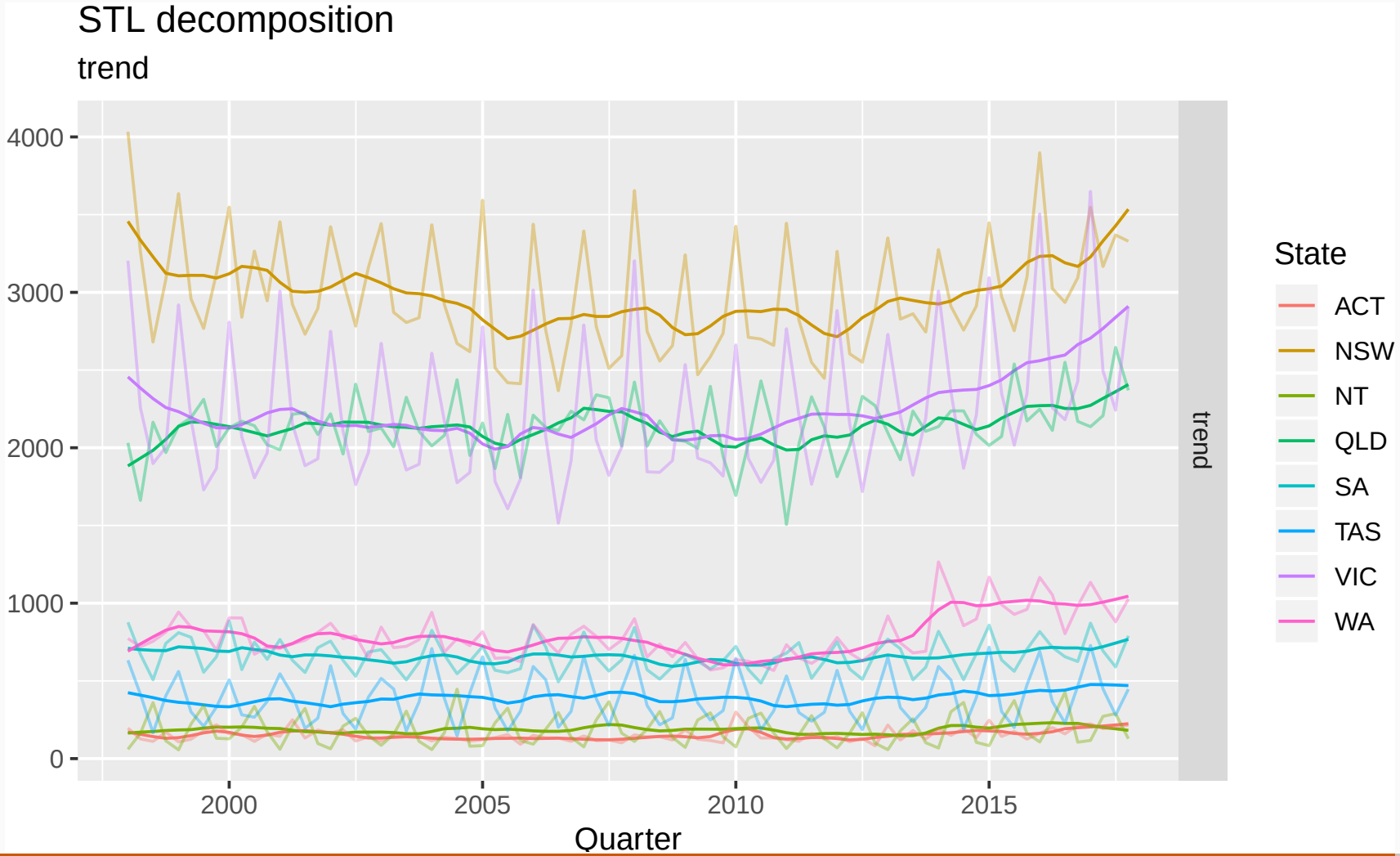
Holidays decomposition

```
dcmp %>% gg_subseries(season_year)
```



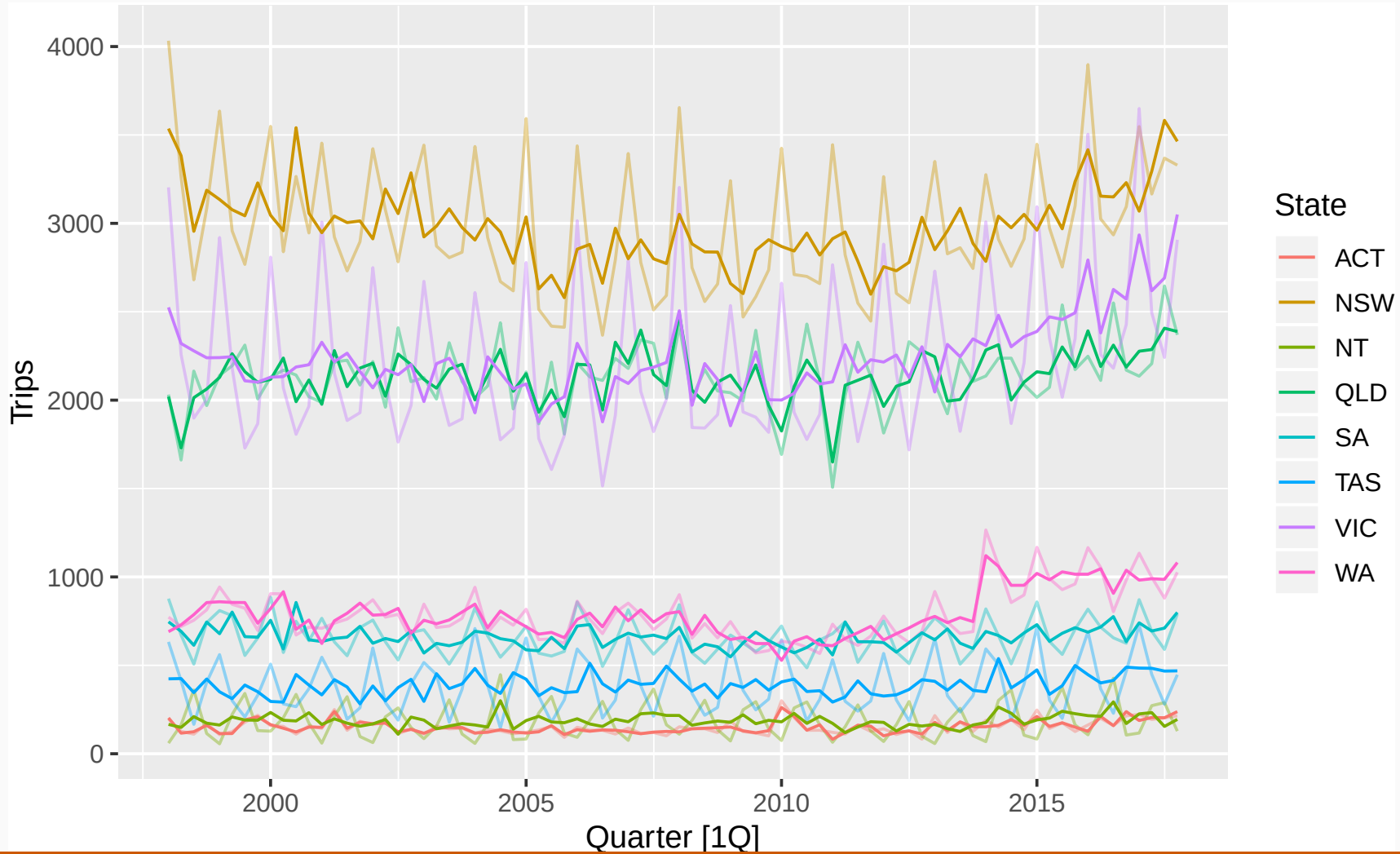
Holidays decomposition

```
autoplot(dcmp, trend, scale_bars=FALSE) +
  autolayer(holidays, alpha=0.4)
```



Holidays decomposition

```
autoplot(holidays, Trips, alpha=0.4) +
  autolayer(dcmp, season_adjust)
```



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Lab Session 4

Repeat the decomposition using

```
holidays %>%
  STL(Trips ~ season(window=7) + trend(window=11)) %>%
  autoplot()
```

What happens as you change `season(window = ???)` and `trend(window = ???)`?