MONASH University

MONASH BUSINESS SCHOOL

Tidy Time Series & Forecasting in R

4. Seasonality and trends

robjhyndman.com/workshop2020

Outline

1. Time series decompositions
2. Lab Session 7
3. Seasonal adjustment

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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.

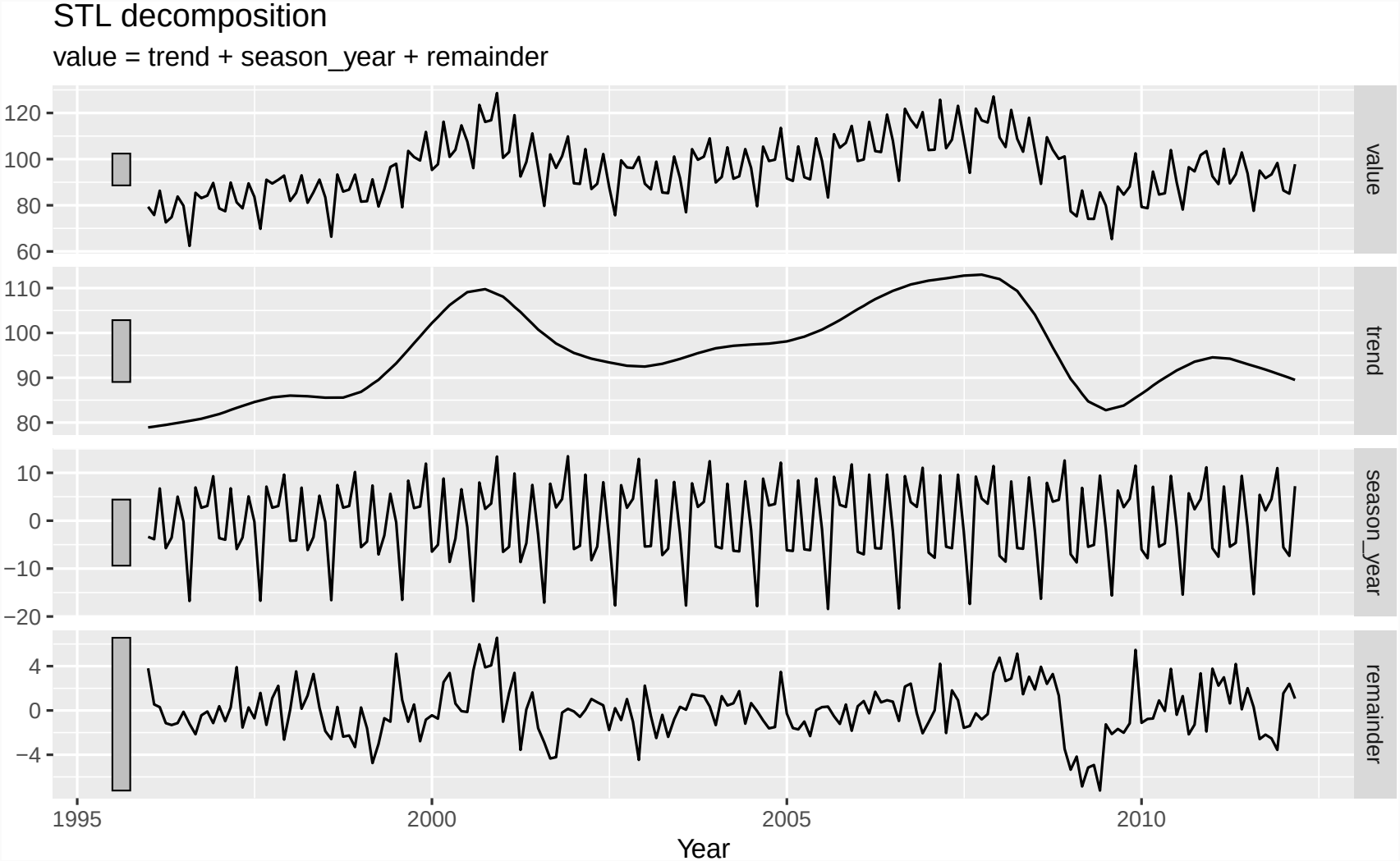
Decomposition dable

```
dcmp <- elecequip %>% STL(value ~ season(window = 7))
dcmp
```

```
## # A dable:             195 x 6 [1M]
## # STL Decomposition: value = trend + season_year +
## #   remainder
##       index value trend season_year remainder season_adjust
##       <mth> <dbl> <dbl>       <dbl>     <dbl>          <dbl>
##  1 1996 Jan  79.4  78.9      -3.37      3.81           82.7
##  2 1996 Feb  75.8  79.1      -3.87      0.547          79.7
##  3 1996 Mar  86.3  79.3       6.73      0.301          79.6
##  4 1996 Apr  72.6  79.5      -5.74     -1.15           78.3
##  5 1996 May  74.9  79.7      -3.53     -1.31           78.4
##  6 1996 Jun  83.8  79.9       5.03     -1.14           78.8
##  7 1996 Jul  79.8  80.1      -0.222    -0.119          80.0
##  8 1996 Aug  62.4  80.4     -16.8      -1.21           79.2
##  9 1996 Sep  85.4  80.6       6.94     -2.15           78.5
## 10 1996 Oct  83.1  80.9       2.70     -0.442          80.4
```

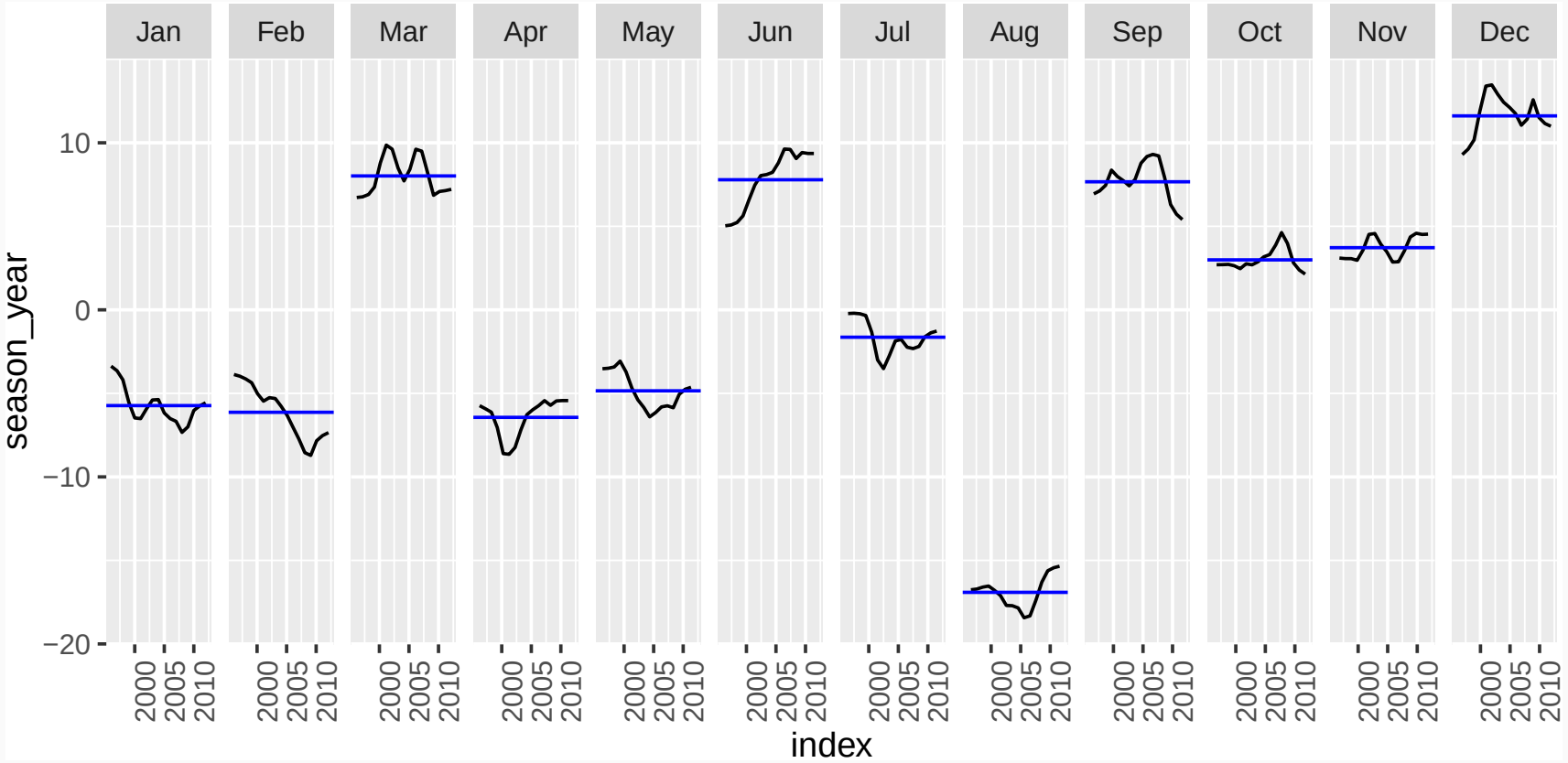
Euro electrical equipment

```
autoplot(dcmp) + xlab("Year")
```



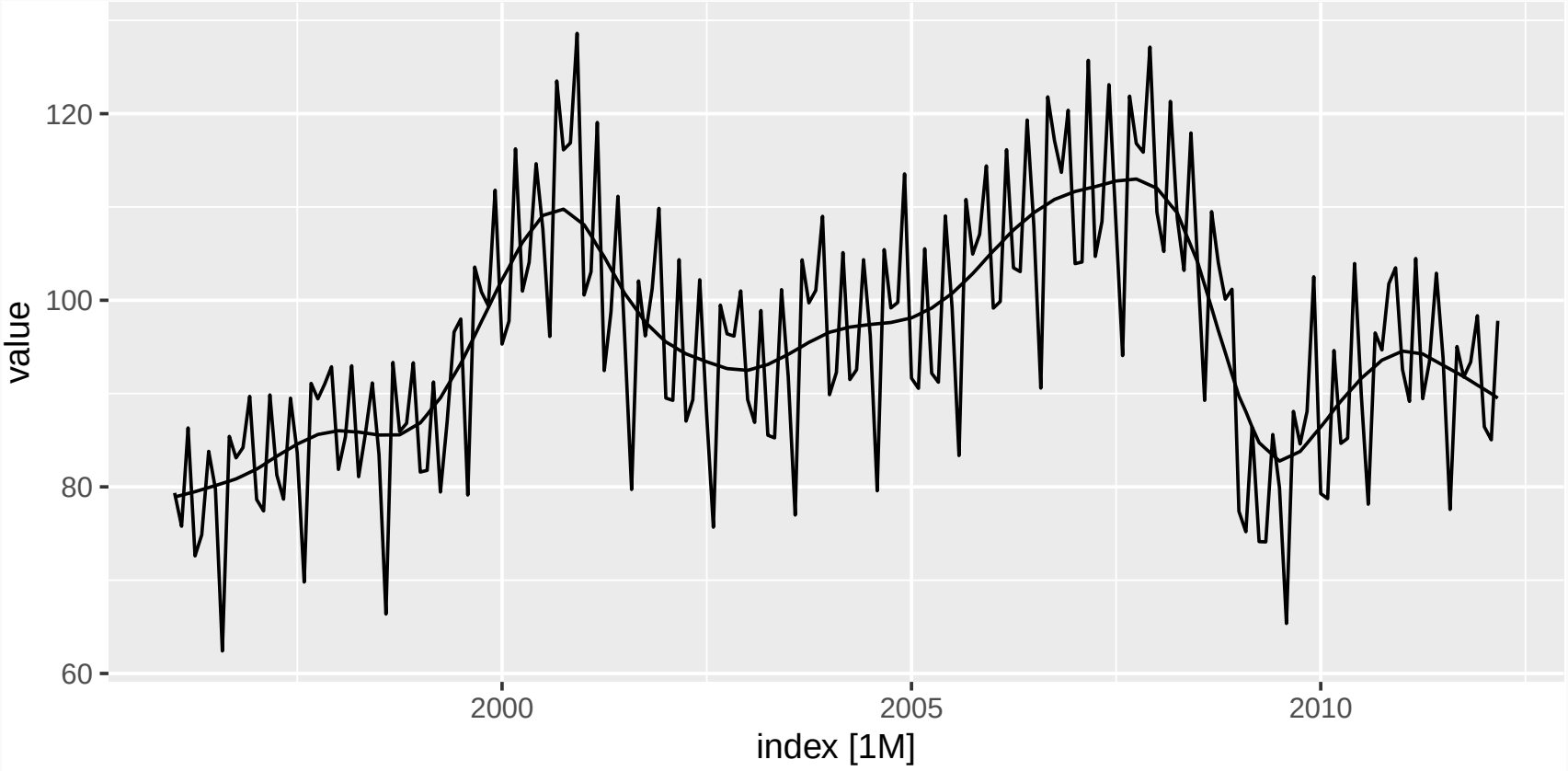
Euro electrical equipment

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



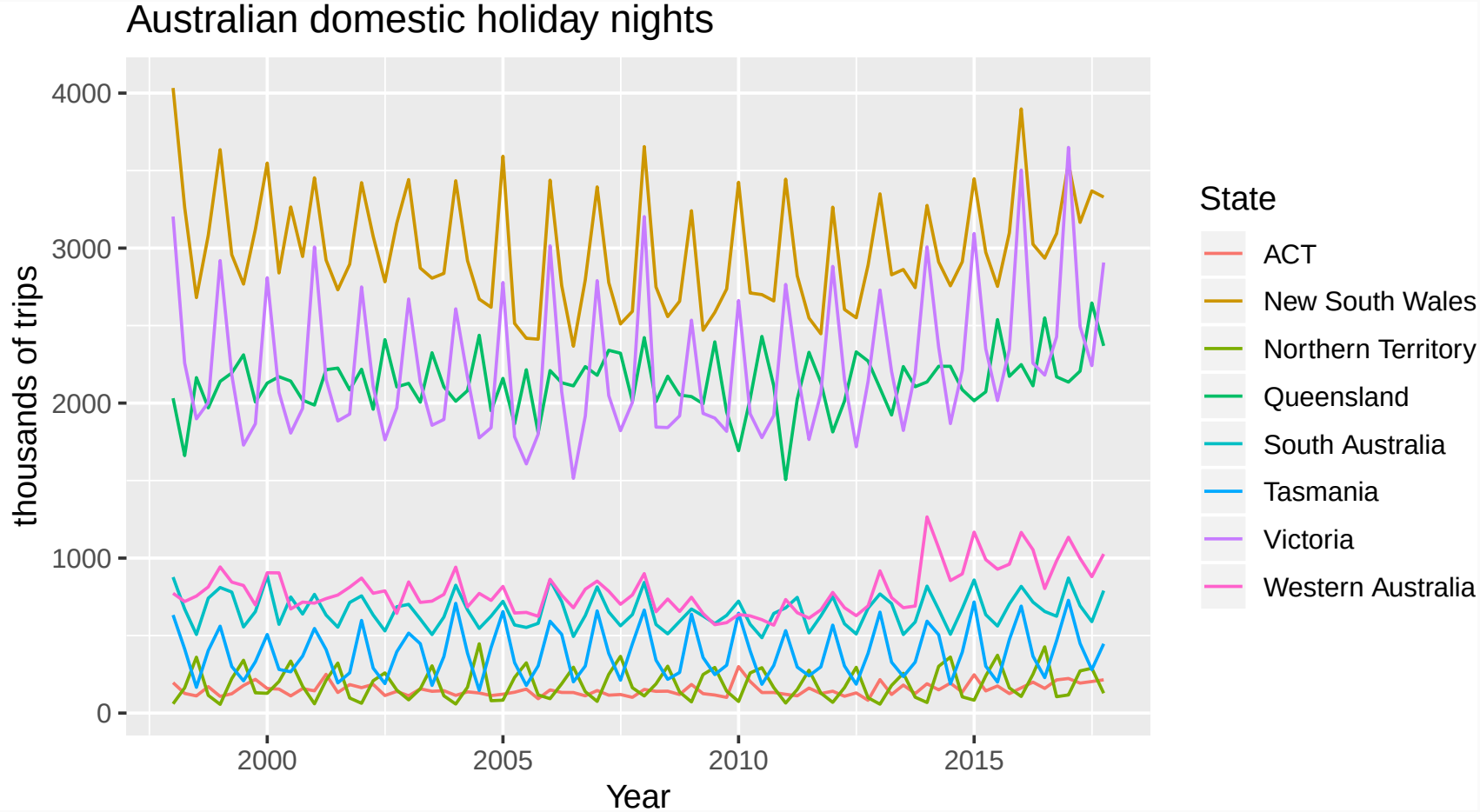
Euro electrical equipment

```
autoplot(elecequip, series="Data") +
  autolayer(dcmp, trend, series="Trend-cycle")
```



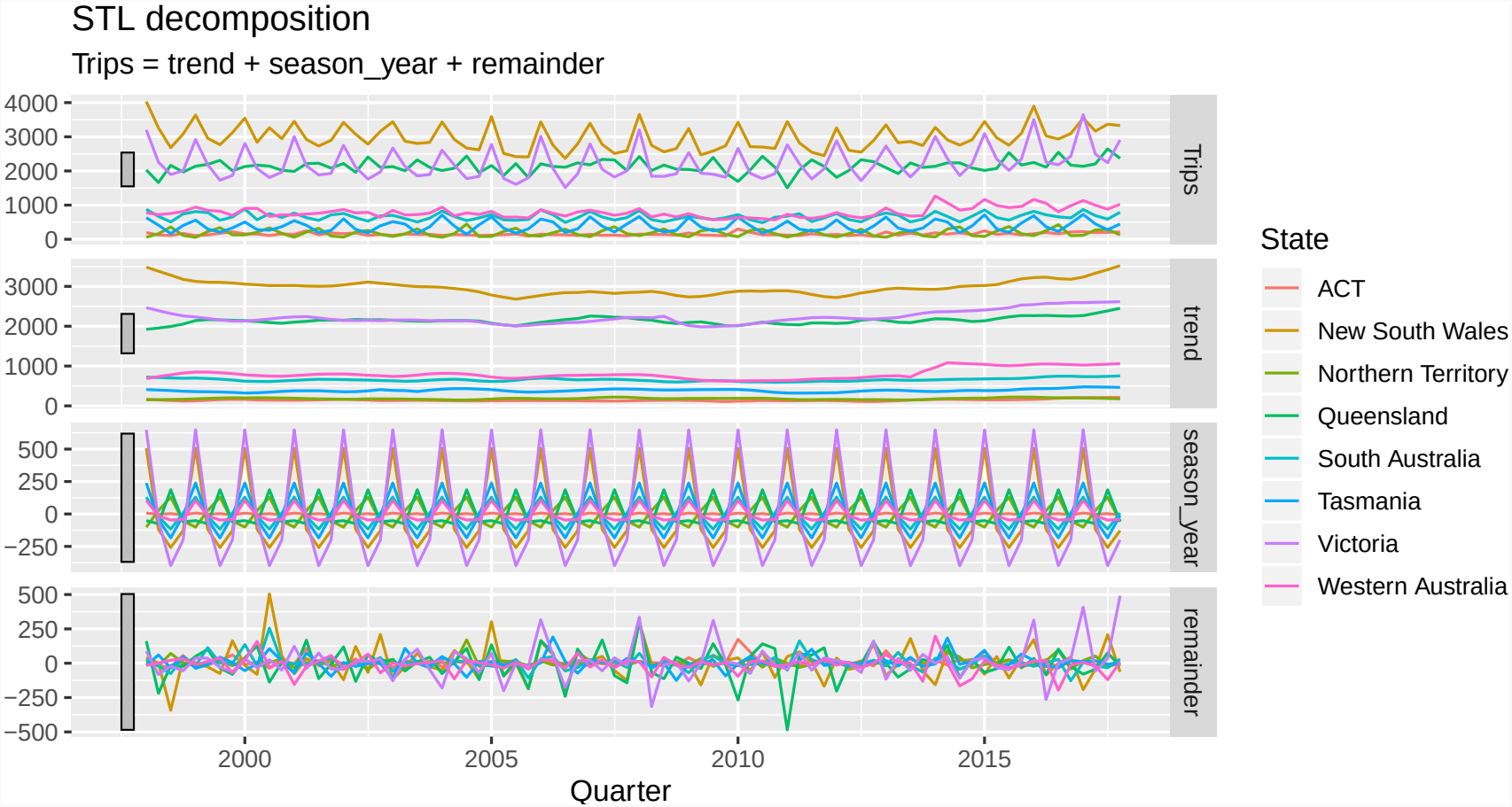
Australian holidays

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



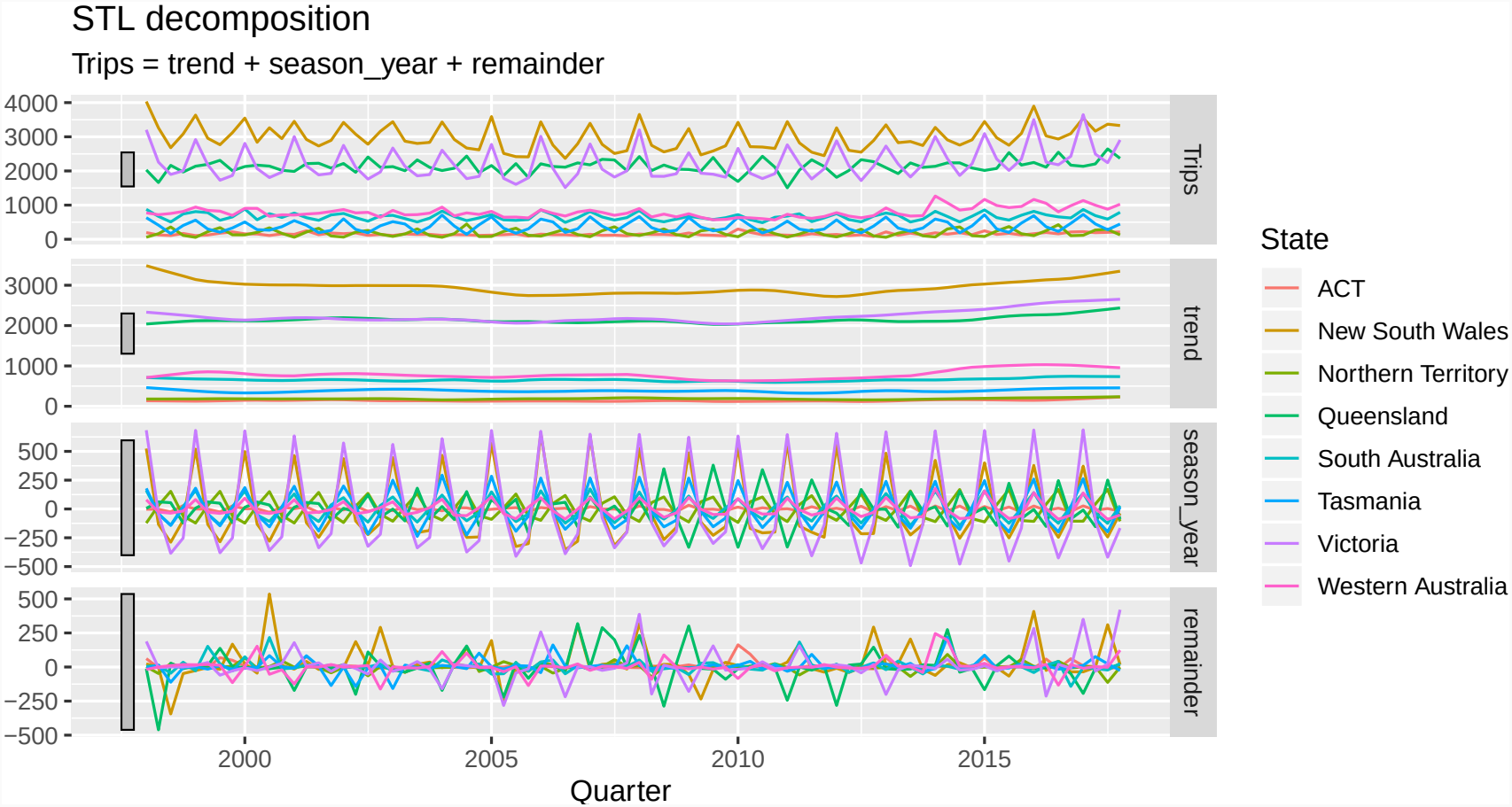
Holidays decomposition

```
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.

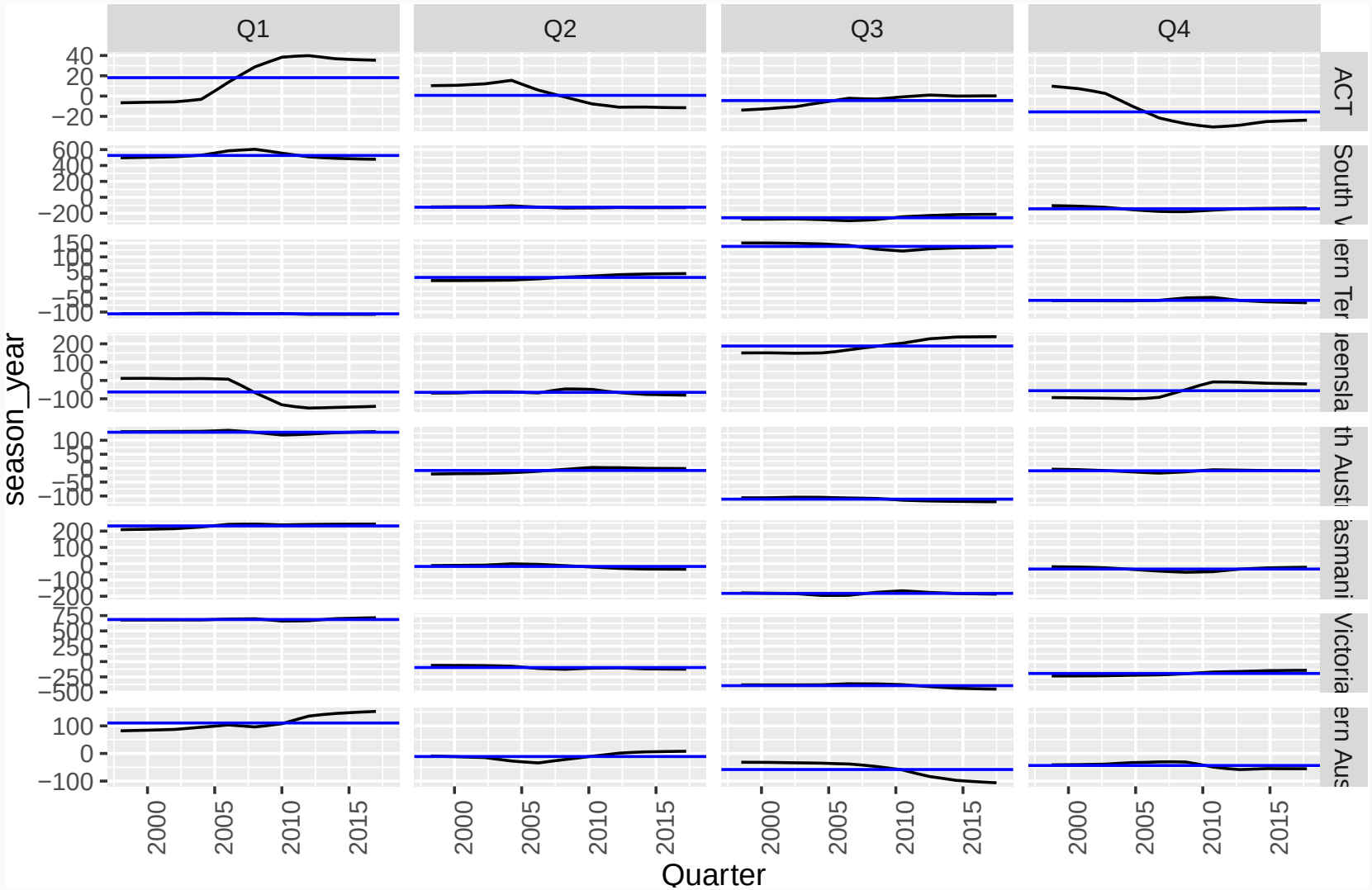
Holidays decomposition

```
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
```

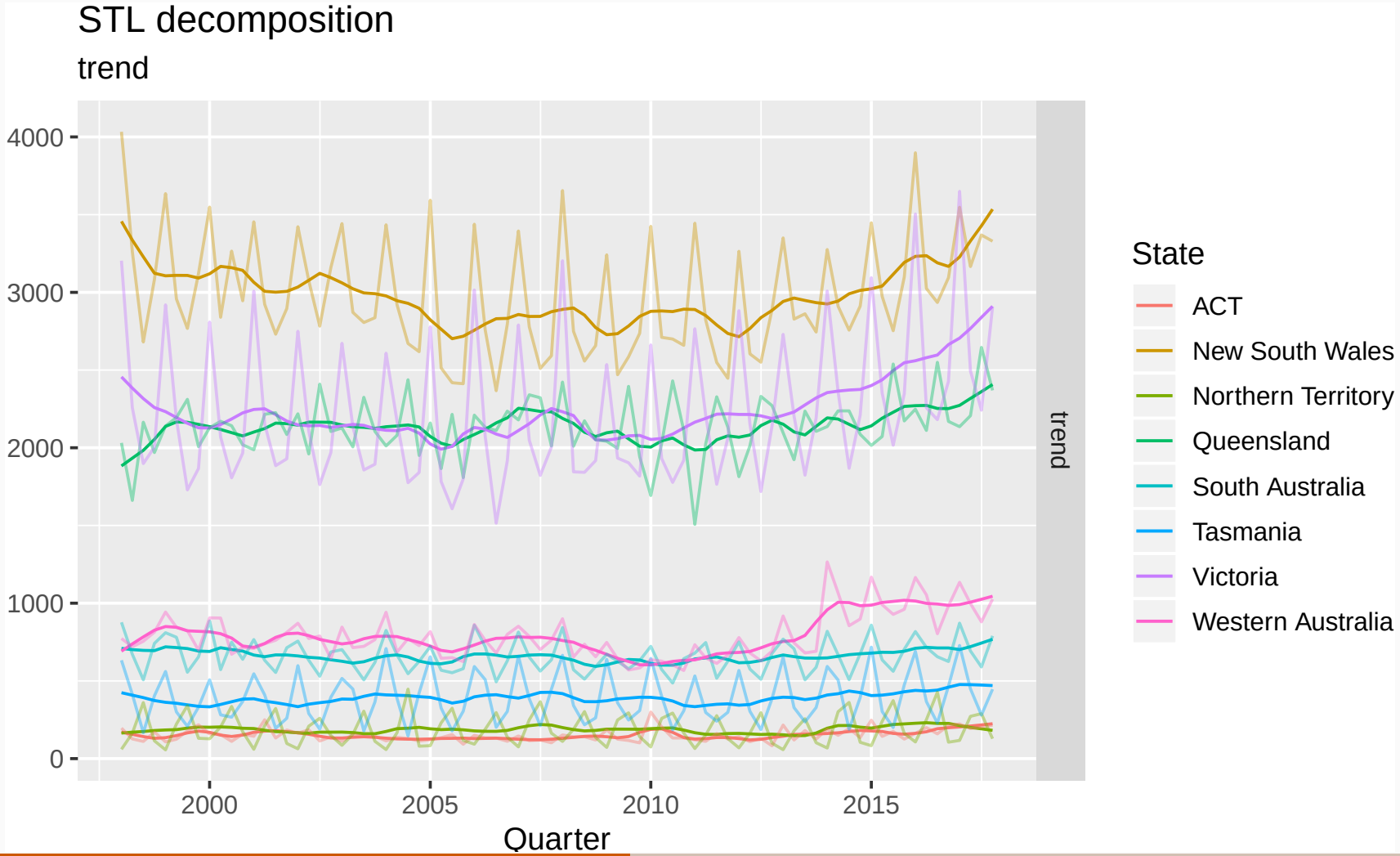
Holidays decomposition

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



Holidays decomposition

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



Outline

1 Time series decompositions

2 Lab Session 7

3 Seasonal adjustment

Lab Session 7

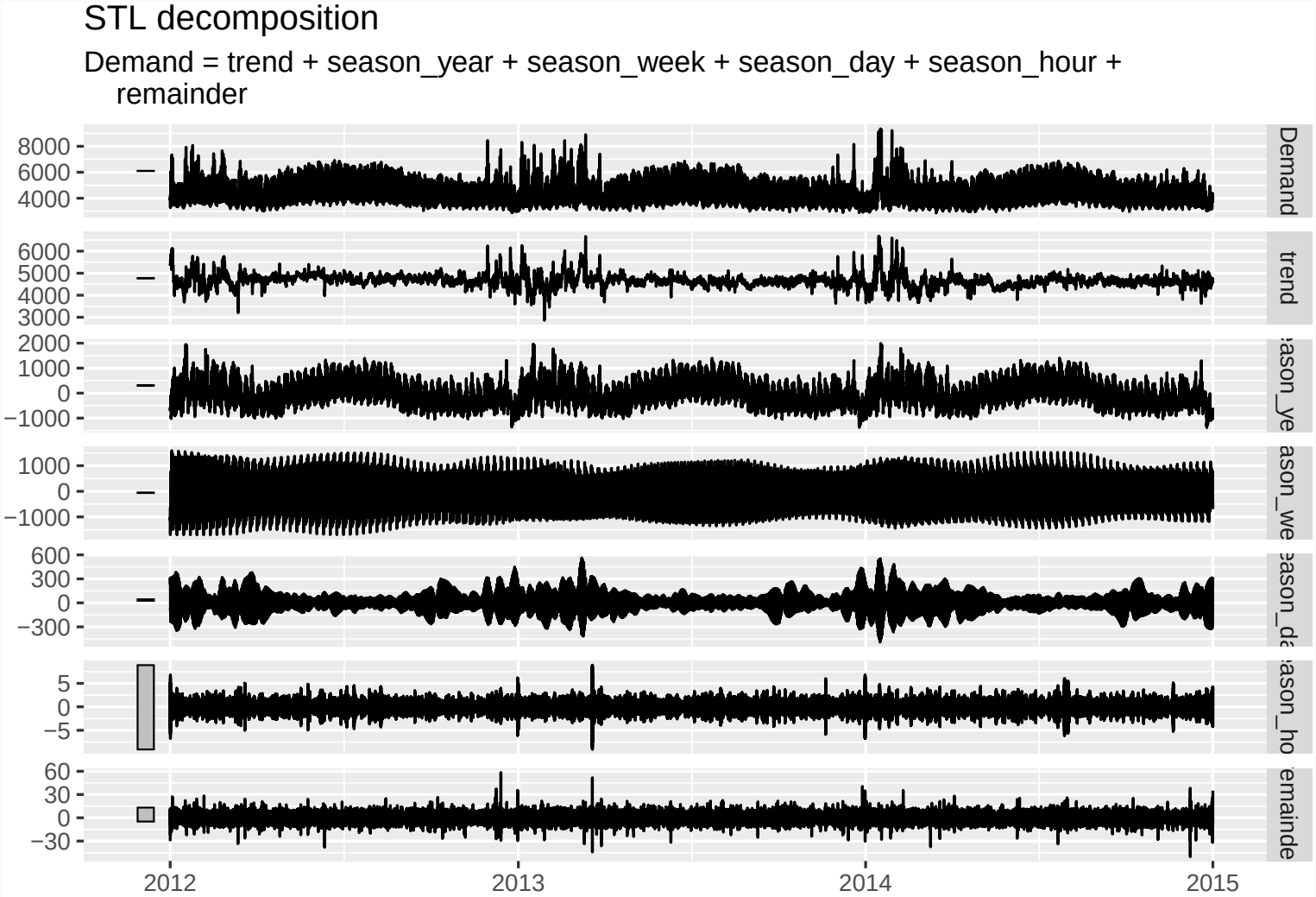
Repeat the decomposition using

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

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

Multiple seasonality

```
vic_elec %>% STL(Demand) %>% autoplot()
```



Outline

1 Time series decompositions

2 Lab Session 7

3 Seasonal adjustment

Seasonal adjustment

- Useful by-product of decomposition: an easy way to calculate seasonally adjusted data.
- Additive decomposition: seasonally adjusted data given by

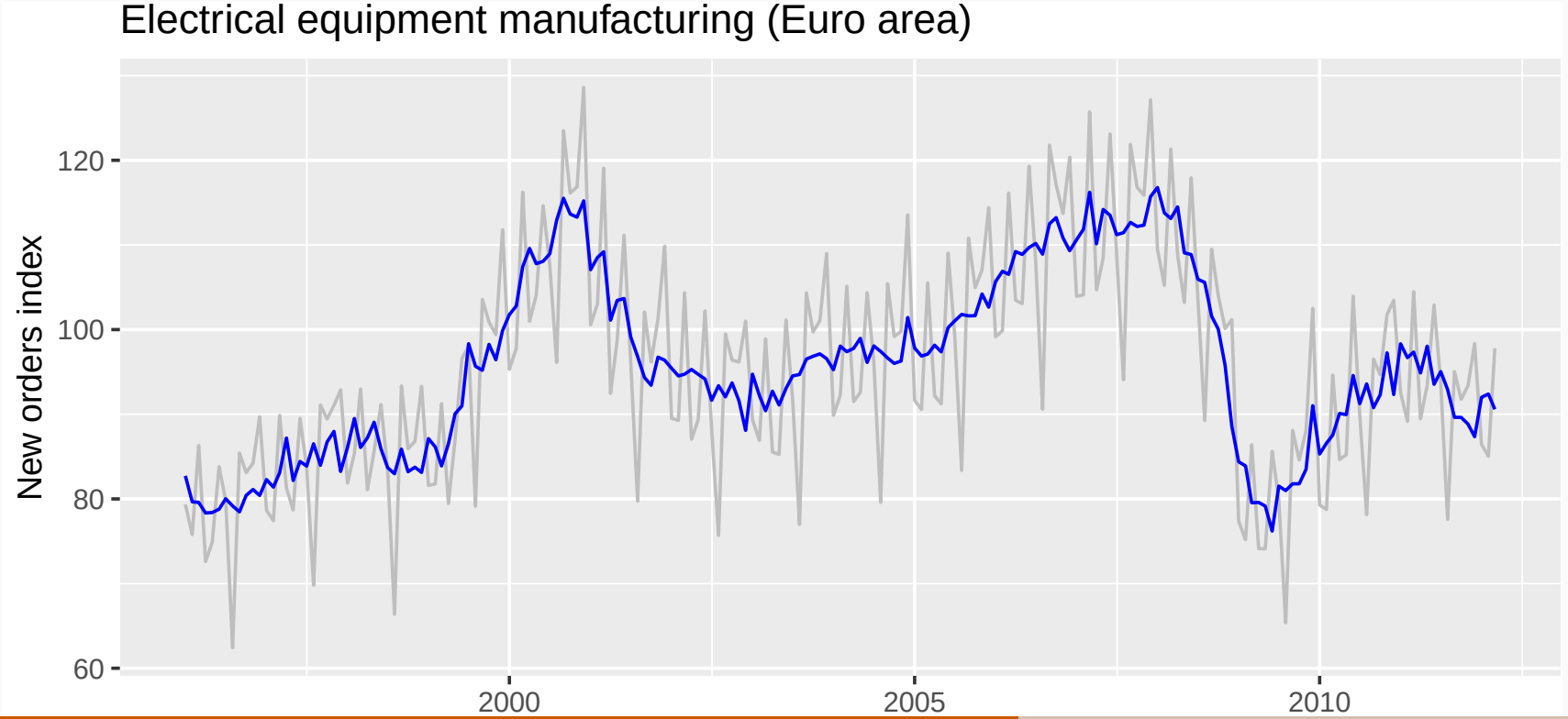
$$y_t - S_t = T_t + R_t$$

- Multiplicative decomposition: seasonally adjusted data given by

$$y_t/S_t = T_t \times R_t$$

Euro electrical equipment

```
dcmp <- elecequip %>% STL(value ~ season(window=7))
elecequip %>% autoplot(value, col='gray') +
    autolayer(dcmp, season_adjust, col='blue') +
    xlab("Year") + ylab("New orders index") +
    ggtitle("Electrical equipment manufacturing (Euro area)"
```



Seasonal adjustment

- We use estimates of *S* based on past values to seasonally adjust a current value.
- Seasonally adjusted series reflect **remainders** as well as **trend**. Therefore they are not “smooth”" and “downturns”" or “upturns” can be misleading.
- It is better to use the trend-cycle component to look for turning points.

The ABS stuff-up

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Treasurer Joe Hockey calls for answers over Australian Bureau of Statistics jobs data

By Michael Vincent and Simon Frazer

Updated 9 Oct 2014, 12:17pm

Federal Treasurer Joe Hockey says he wants answers to the problems the Australian Bureau of Statistics (ABS) has had with unemployment figures.

Mr Hockey, who is in the US to discuss Australia's G20 agenda, said last month's unemployment figures were "extraordinary".

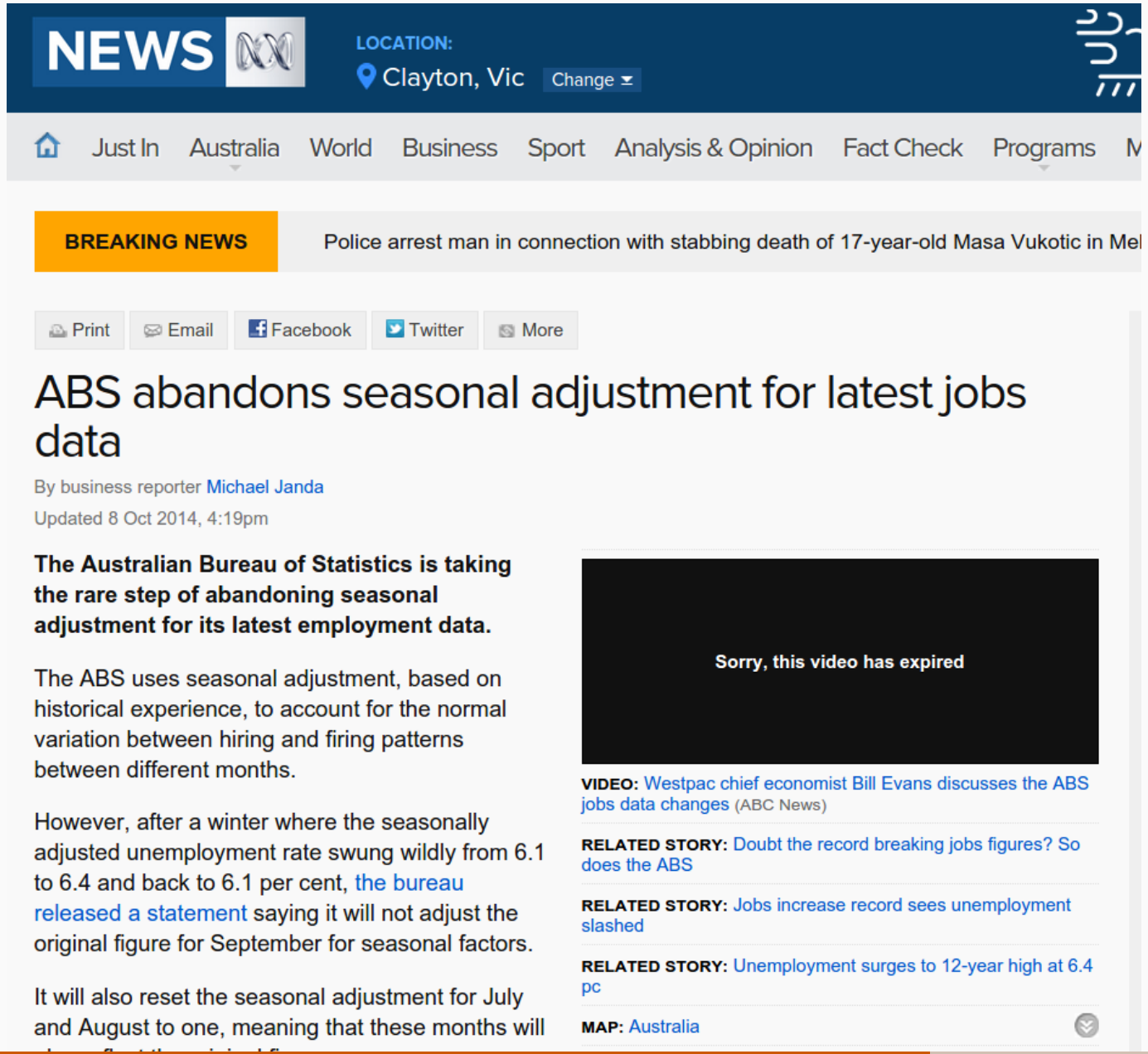
The rate was 6.1 per cent after jumping to a 12-year high of 6.4 per cent the previous month.

The ABS has now taken the rare step of abandoning seasonal adjustment for its latest employment data.

PHOTO: Joe Hockey says he is unhappy with the volatility of ABS unemployment figures. (AAP: Alan Porritt)

RELATED STORY: ABS abandons seasonal adjustment for

The ABS stuff-up



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ABS abandons seasonal adjustment for latest jobs data

By business reporter Michael Janda

Updated 8 Oct 2014, 4:19pm

The Australian Bureau of Statistics is taking the rare step of abandoning seasonal adjustment for its latest employment data.

The ABS uses seasonal adjustment, based on historical experience, to account for the normal variation between hiring and firing patterns between different months.

However, after a winter where the seasonally adjusted unemployment rate swung wildly from 6.1 to 6.4 and back to 6.1 per cent, the bureau released a statement saying it will not adjust the original figure for September for seasonal factors.

It will also reset the seasonal adjustment for July and August to one, meaning that these months will

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VIDEO: Westpac chief economist Bill Evans discusses the ABS jobs data changes (ABC News)

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MAP: Australia

The ABS stuff-up

ABS jobs and unemployment figures – key questions answered by an expert

A professor of statistics at Monash University explains exactly what is seasonal adjustment, why it matters and what went wrong in the July and August figures

School leavers come on to the jobs market at the same time, causing a seasonal fluctuation. Photograph: Brian Snyder/Reuters

The Australian Bureau of Statistics has retracted its seasonally adjusted employment data for July and August, which recorded huge swings in the jobless rate. The ABS is also planning to review the methods it uses for seasonal adjustment to ensure its figures are as accurate as possible. Rob Hyndman, a professor of statistics at Monash University and member of the bureau's

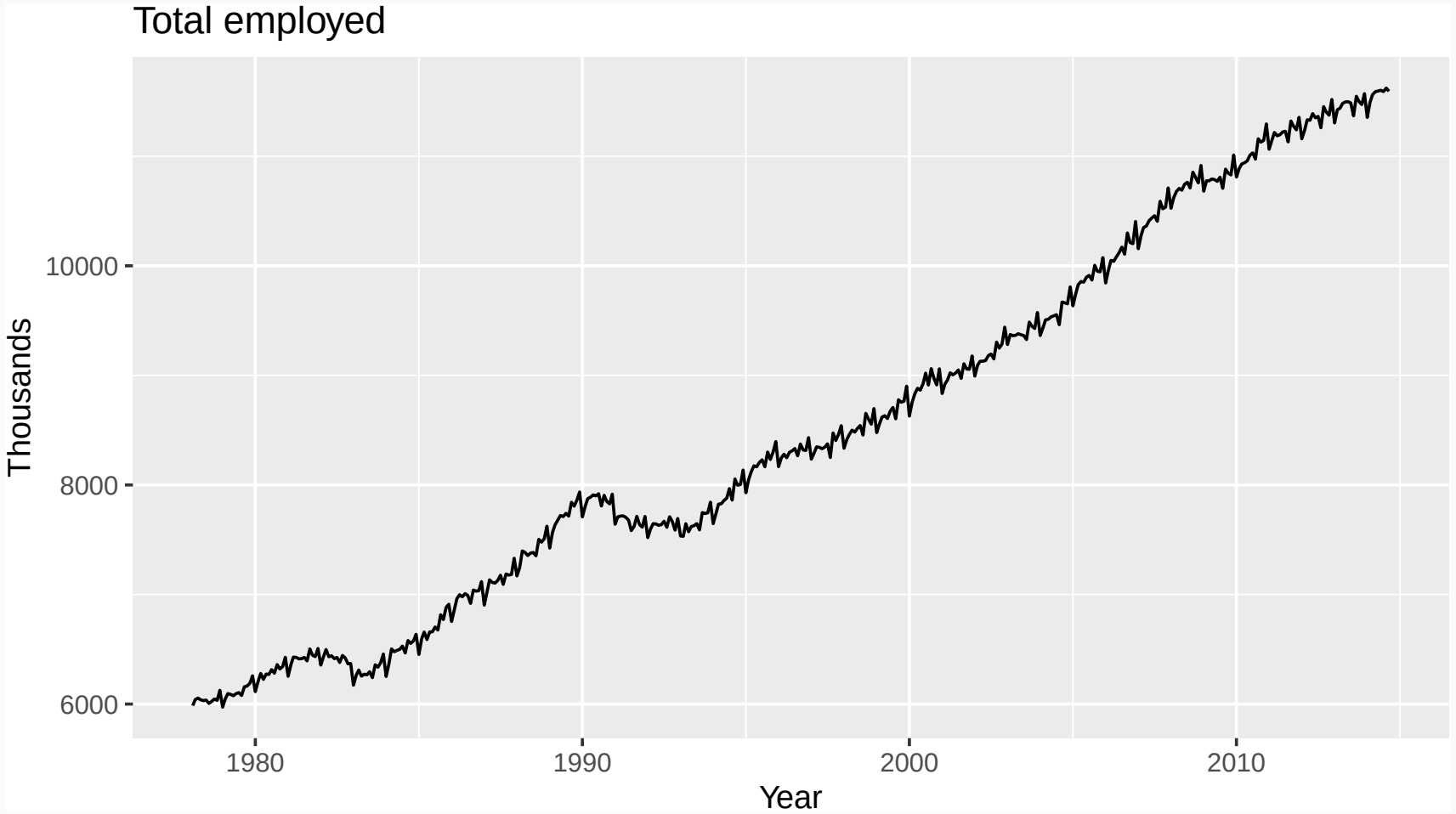
The ABS stuff-up

```
employed
```

```
## # A tsibble: 440 x 4 [1M]
##         Time Month  Year Employed
##        <mth> <ord> <dbl>    <dbl>
##  1 1978 Feb Feb    1978    5986.
##  2 1978 Mar Mar    1978    6041.
##  3 1978 Apr Apr    1978    6054.
##  4 1978 May May    1978    6038.
##  5 1978 Jun Jun    1978    6031.
##  6 1978 Jul Jul    1978    6036.
##  7 1978 Aug Aug    1978    6005.
##  8 1978 Sep Sep    1978    6024.
##  9 1978 Oct Oct    1978    6046.
## 10 1978 Nov Nov    1978    6034.
## # ... with 430 more rows
```

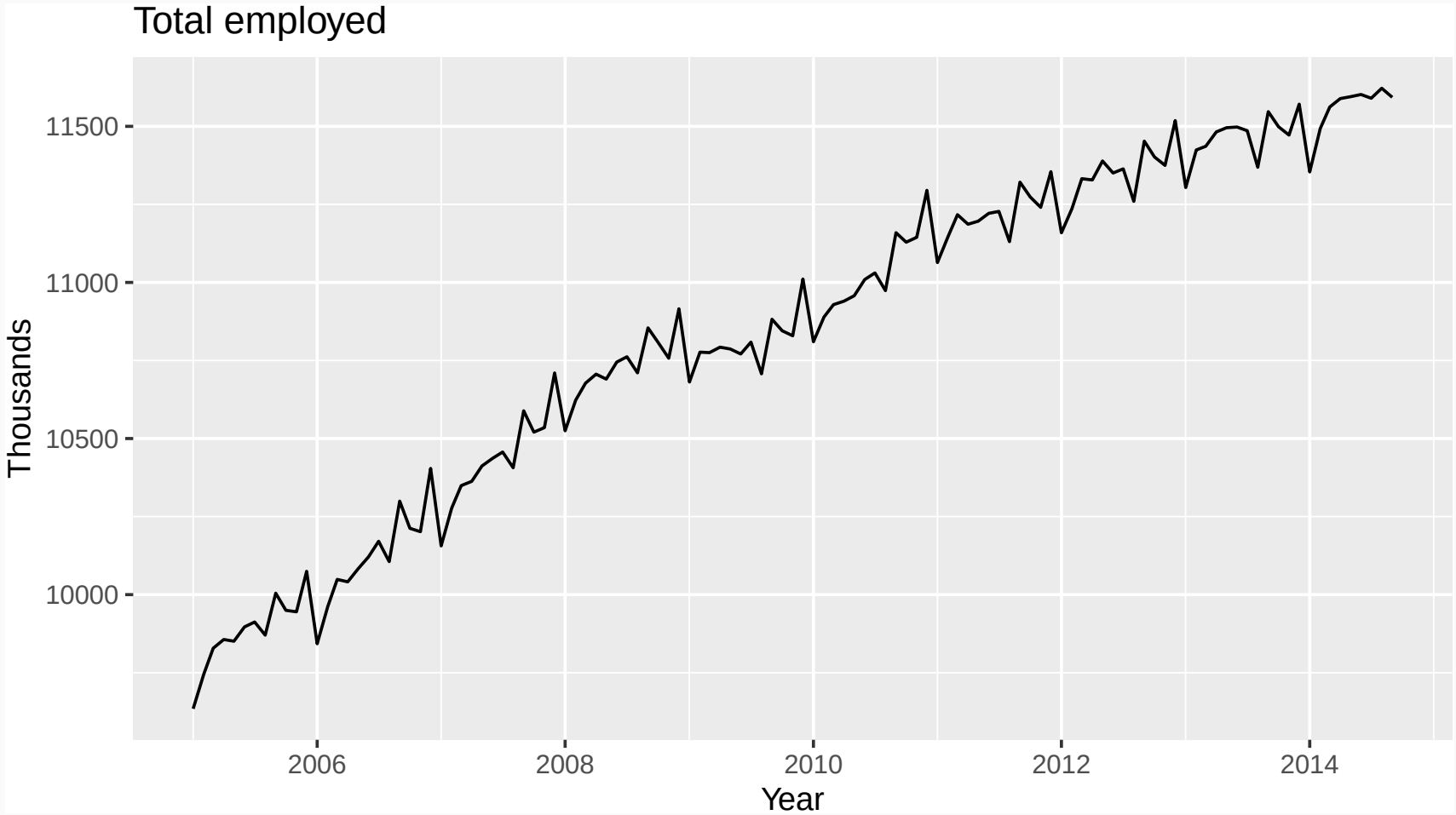
The ABS stuff-up

```
employed %>%
  autoplot(Employed) +
  ggtitle("Total employed") + ylab("Thousands") + xlab("Year")
```



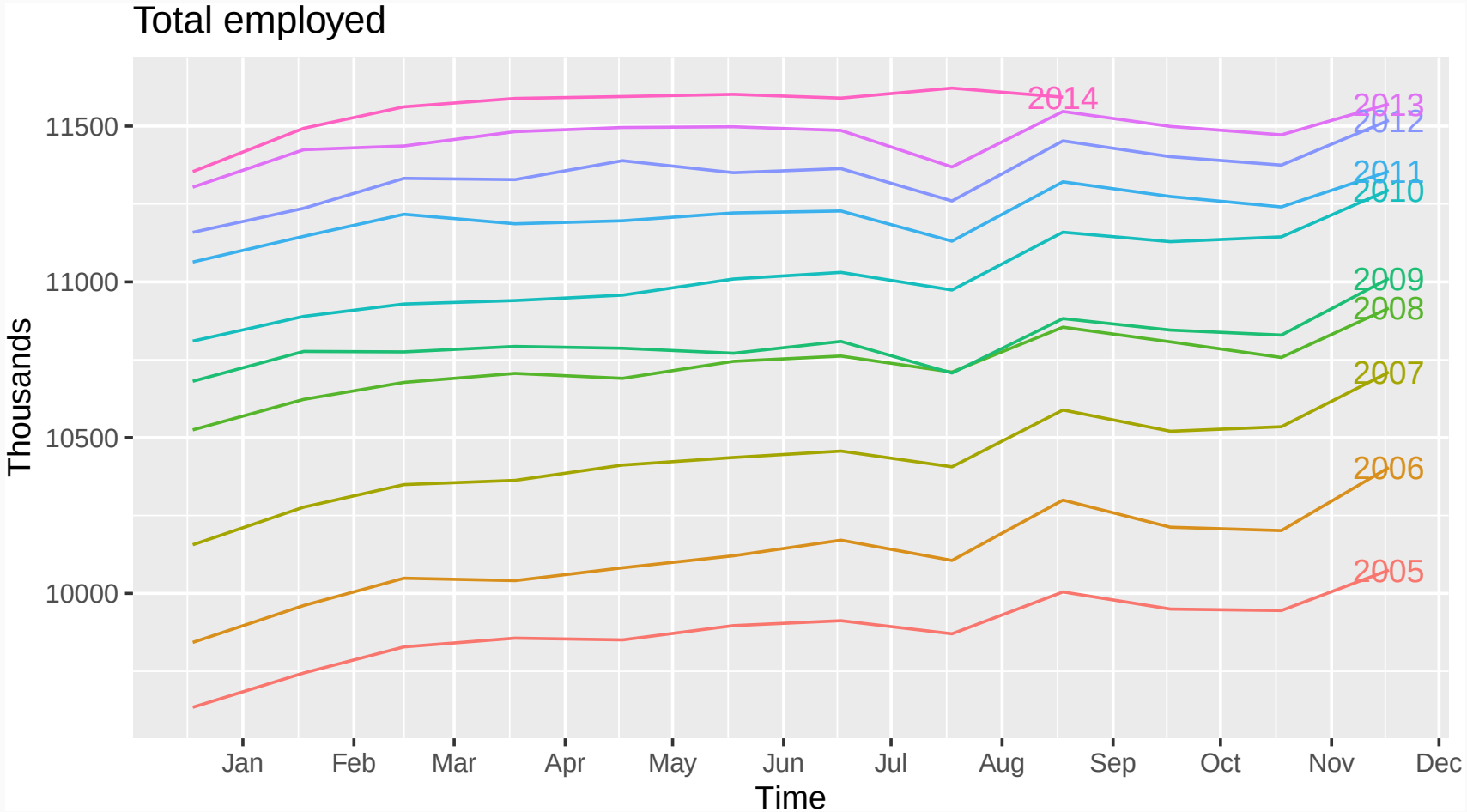
The ABS stuff-up

```
employed %>% filter(Year >= 2005) %>%
  autoplot(Employed) +
  ggtitle("Total employed") + ylab("Thousands") + xlab("Year")
```



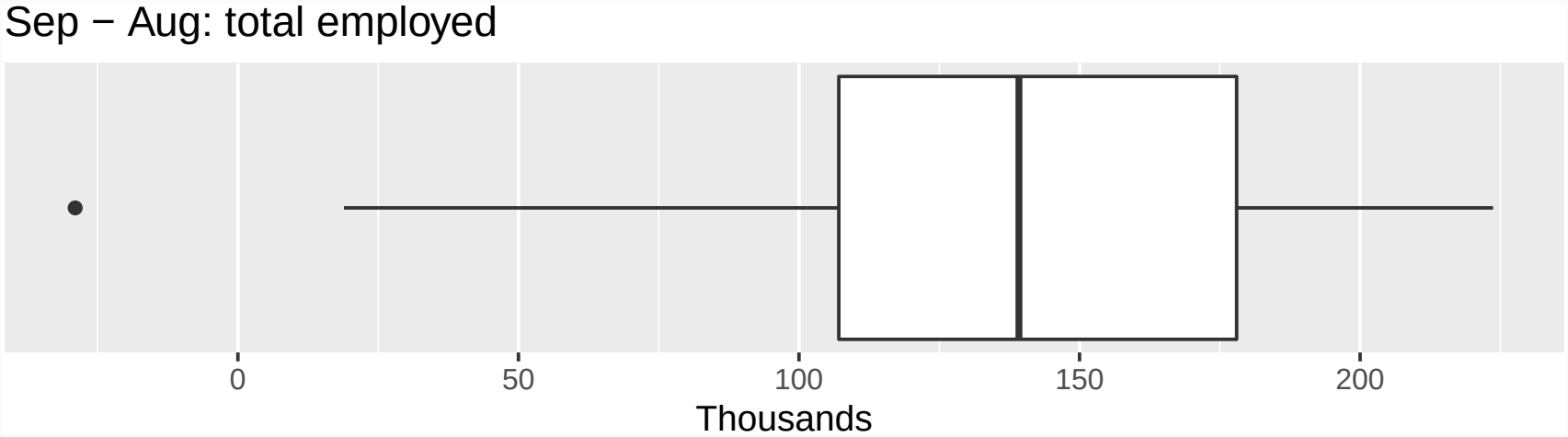
The ABS stuff-up

```
employed %>% filter(Year >= 2005) %>%
  gg_season(Employed, label='right') +
  ggtitle("Total employed") + ylab("Thousands")
```



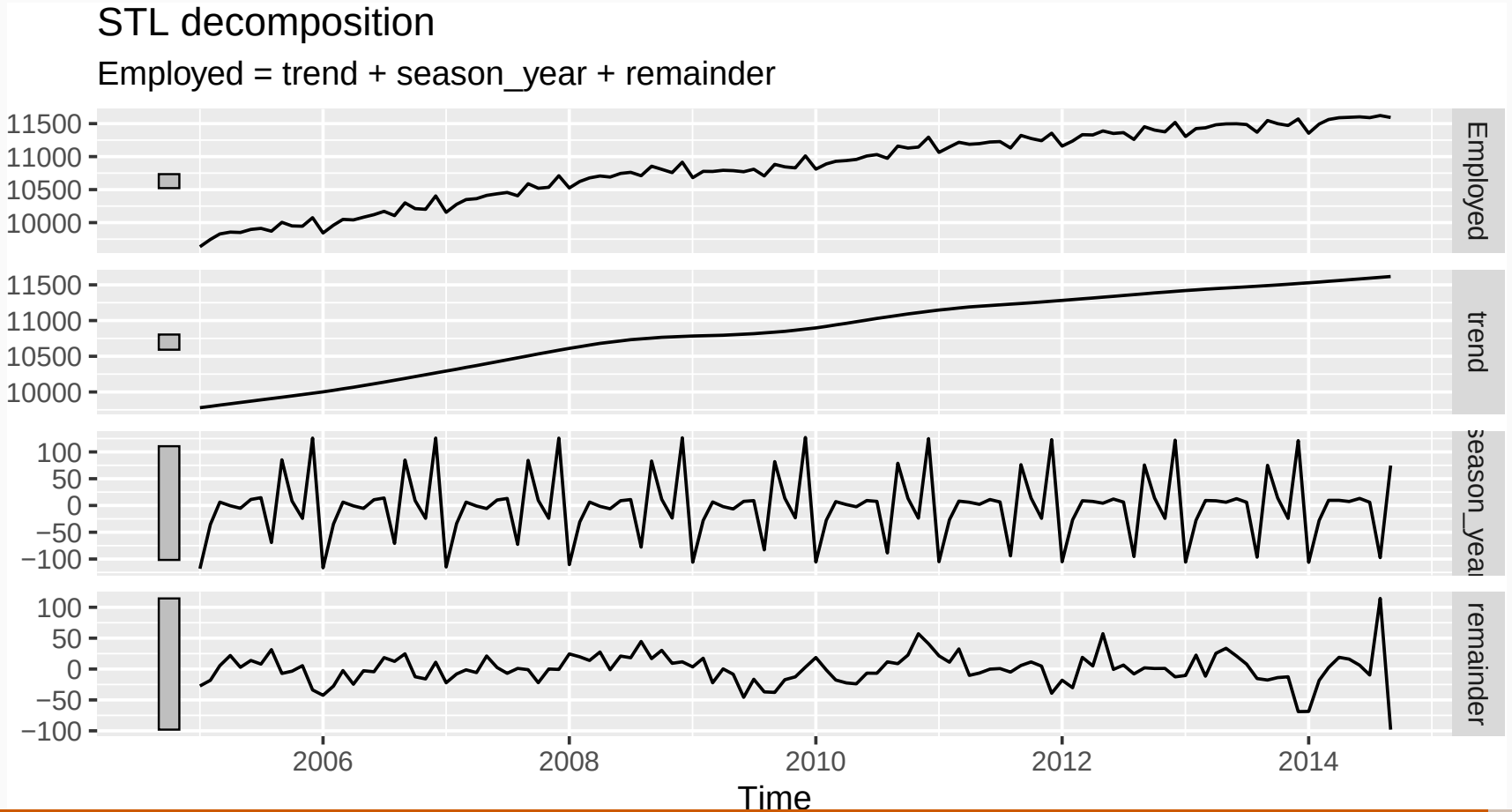
The ABS stuff-up

```
employed %>%
  mutate(diff = difference(Employed)) %>%
  filter(Month == "Sep") %>%
  ggplot(aes(y= diff, x = 1)) +
  geom_boxplot() + coord_flip() +
  ggtitle("Sep - Aug: total employed") +
  xlab("") + ylab("Thousands") +
  scale_x_continuous(breaks=NULL, labels=NULL)
```



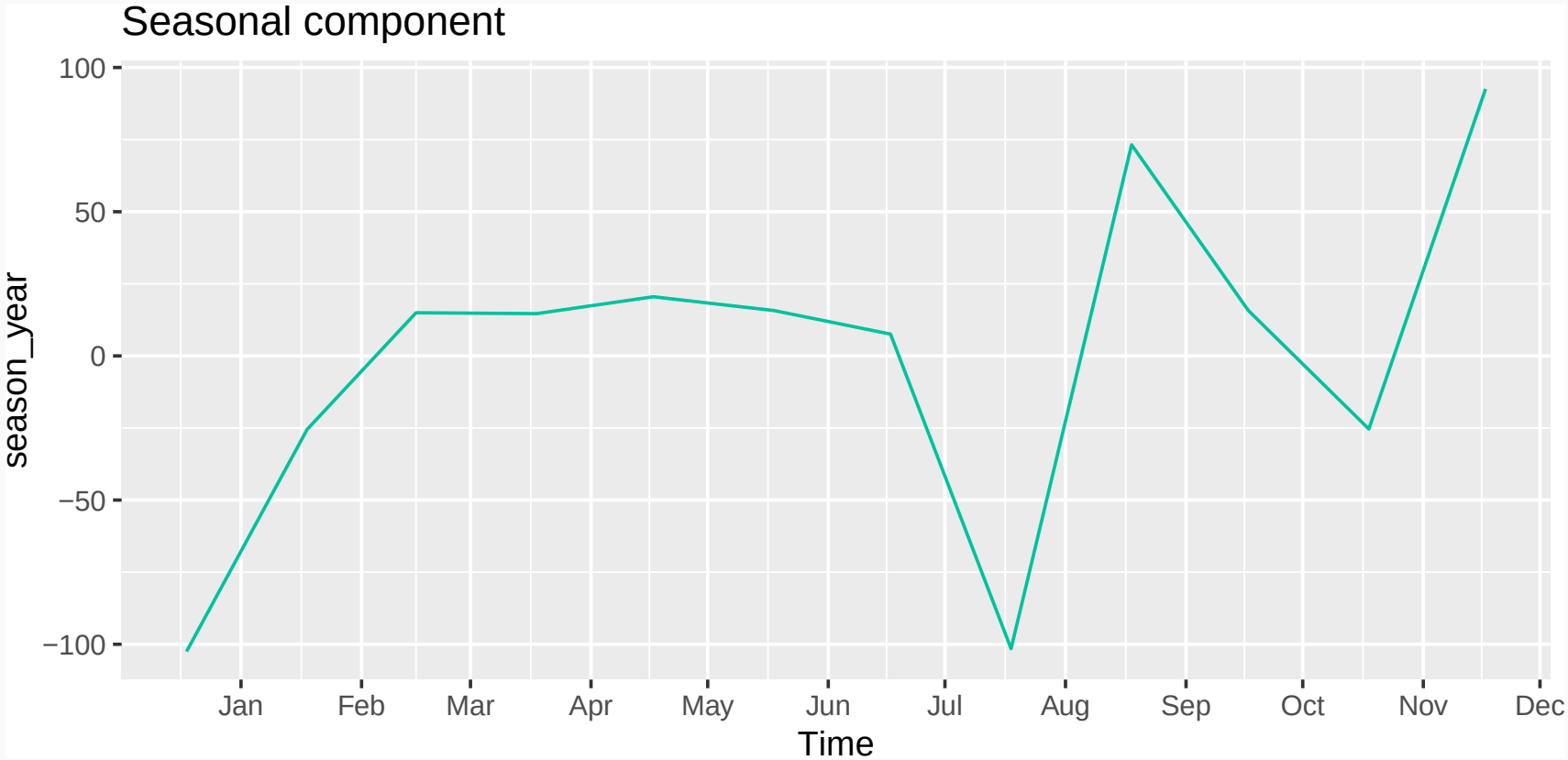
The ABS stuff-up

```
dcmp <- employed %>%
  filter(Year >= 2005) %>%
  STL(Employed ~ season(window = 11), robust = TRUE)
autoplot(dcmp)
```



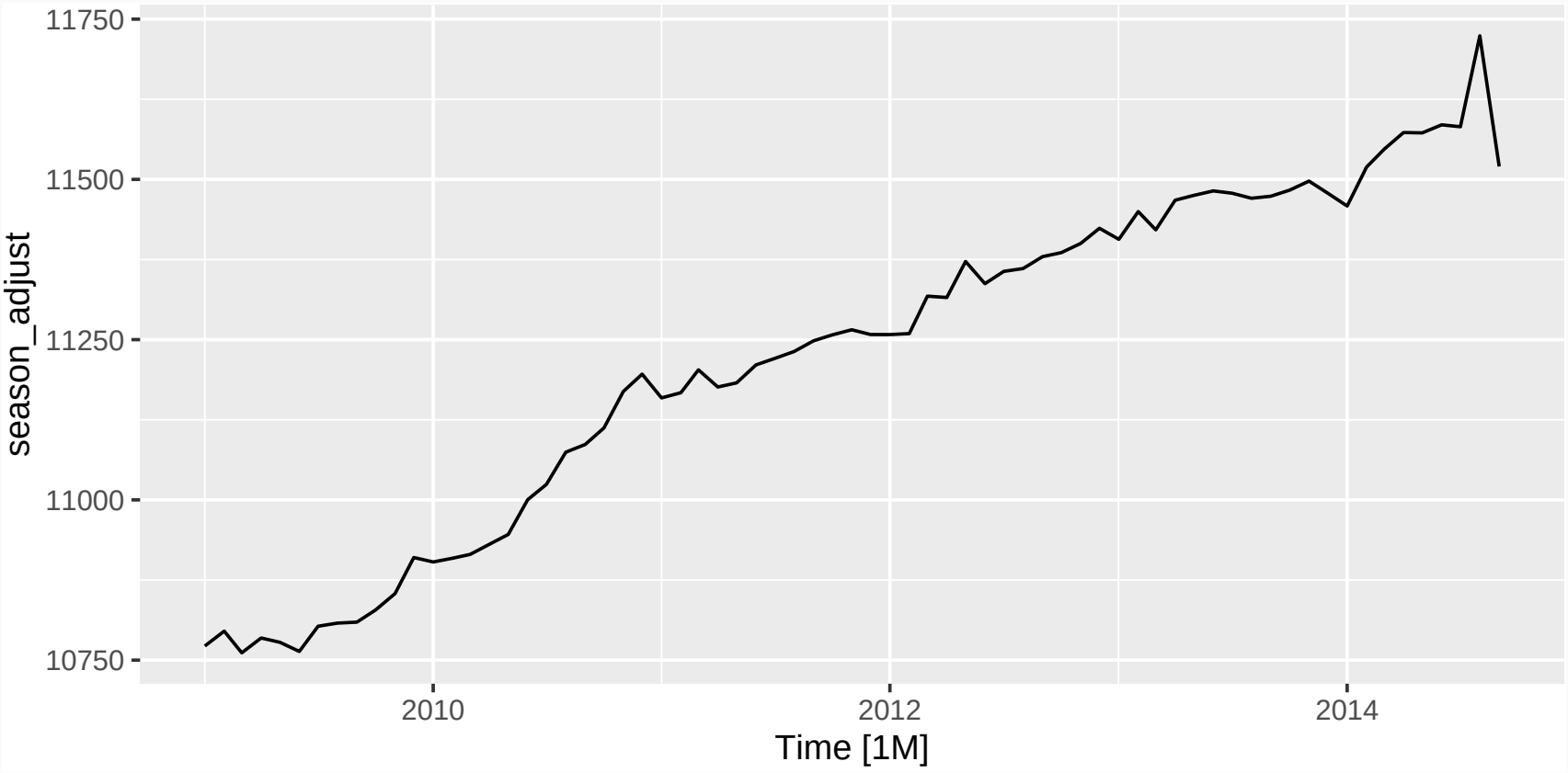
The ABS stuff-up

```
dcmp %>%
  filter(year(Time) == 2013) %>%
  gg_season(season_year) +
  ggtitle("Seasonal component") +
  guides(colour="none")
```



The ABS stuff-up

```
dcmp %>% as_tsibble %>% autoplot(season_adjust)
```



The ABS stuff-up

- August 2014 employment numbers higher than expected.
- Supplementary survey usually conducted in August for employed people.
- Most likely, some employed people were claiming to be unemployed in August to avoid supplementary questions.
- Supplementary survey not run in 2014, so no motivation to lie about employment.
- In previous years, seasonal adjustment fixed the problem.
- The ABS has now adopted a new method to avoid the bias.