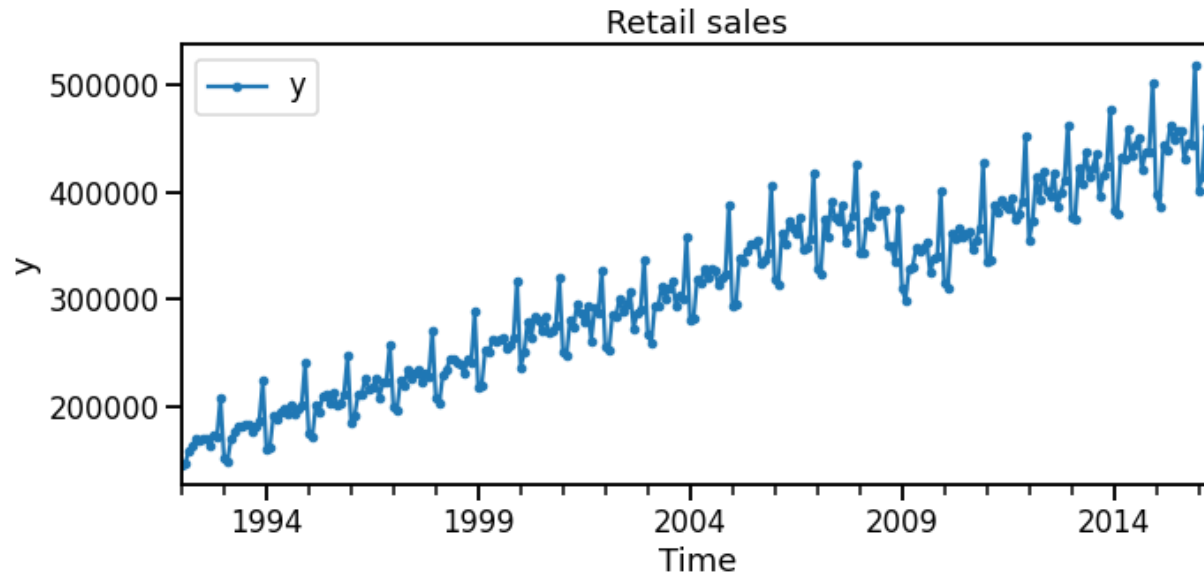# Multi-seasonal time series

Time series decomposition

So far we've shown time series with one seasonality

Retail sales

Additive decomposition
$$y_t = \hat{T}_t + \hat{S}_t + \hat{R}_t$$

Multiplicative decomposition
$$y_t = \hat{T}_t \times \hat{S}_t \times \hat{R}_t$$

Trend component   Seasonal component   Residual component

- Retail sales at monthly granularity just shows yearly seasonality.
- This is partly an artifact of aggregating.
- If we had more granular data we might uncover other seasonal components (e.g., daily, weekly).

What about multi-seasonal time series?

- Multi-seasonality: time series has multiple repeating patterns at different time scales (e.g., daily and weekly)

- What can cause multi-seasonality?

- Weather
  – Sunshine & daylight (daily and yearly)
  – Temperature (daily and yearly)
  – Monsoon seasons (yearly)
- Human behaviour
  – Workday patterns (daily)
  – Weekdays vs weekends (weekly)
  – Monthly pay checks (monthly)
  – Summer holidays (yearly)

- Time series from air pollution to restaurant demand have multiple seasonalities.
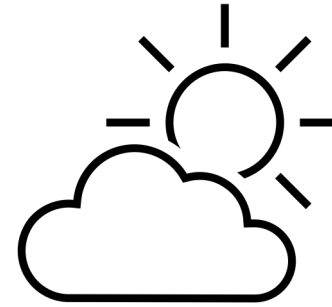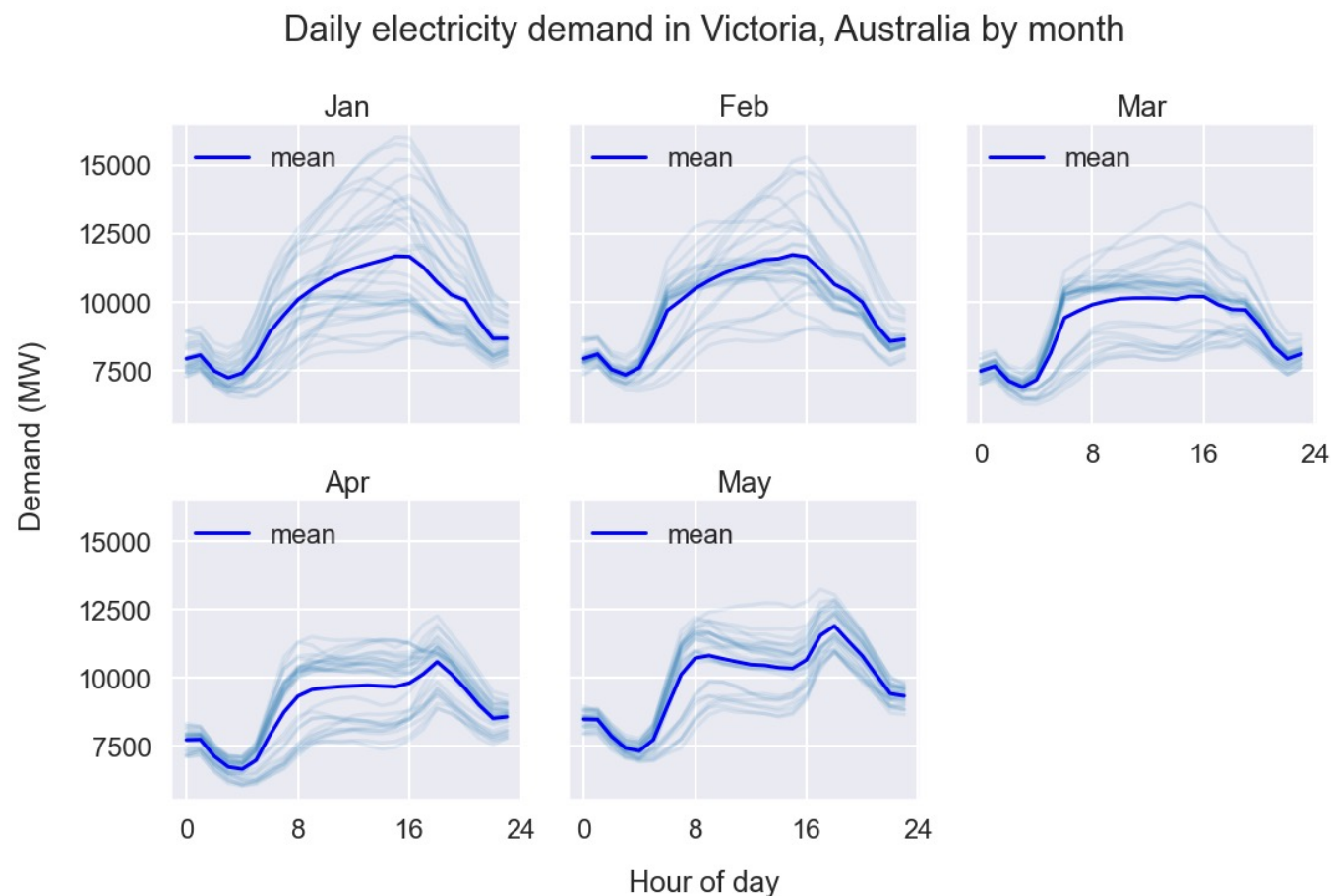
Electricity demand example

- Hourly electricity demand in Victoria, Austrailia.
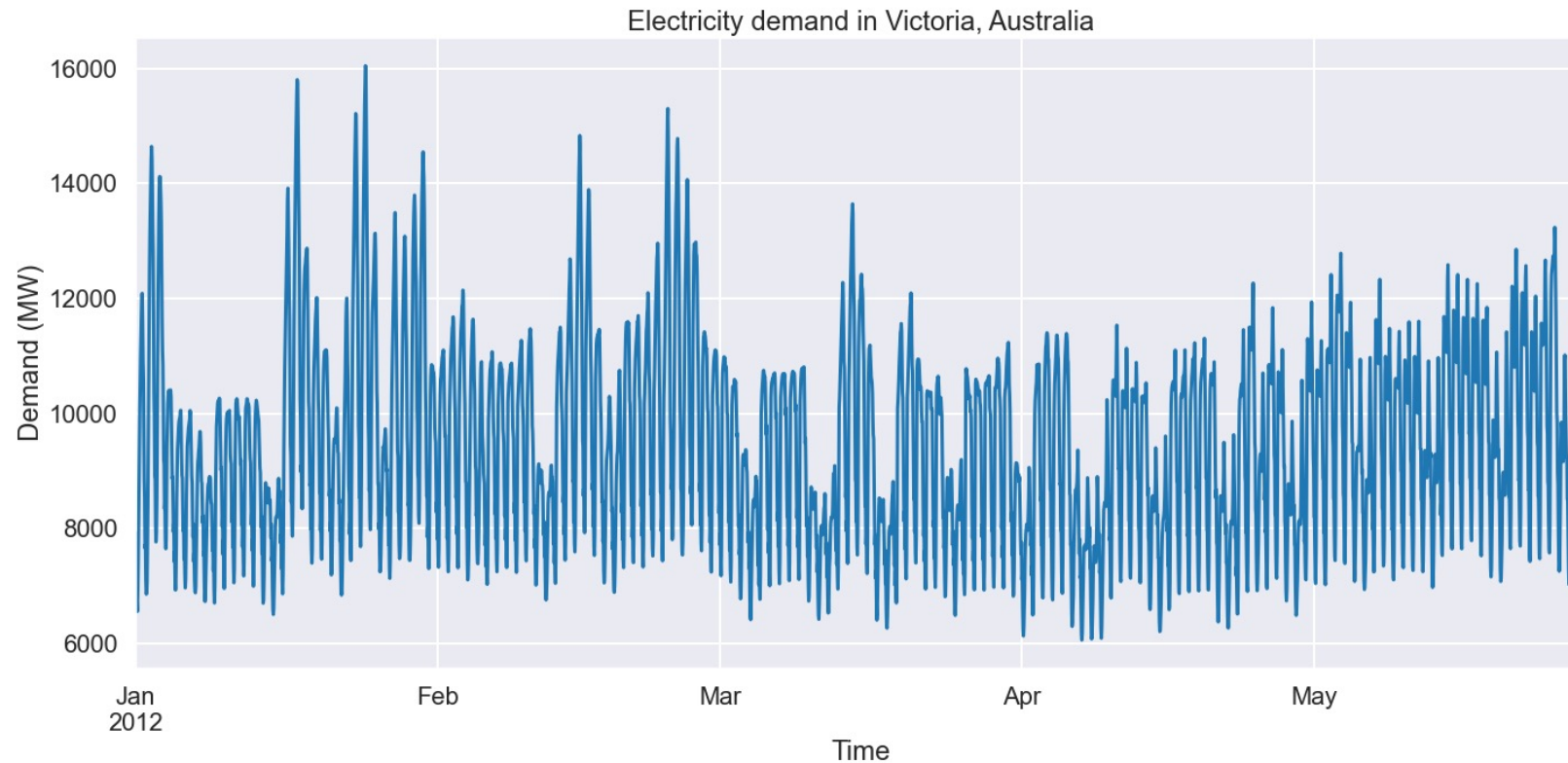
Electricity demand in Victoria, Australia
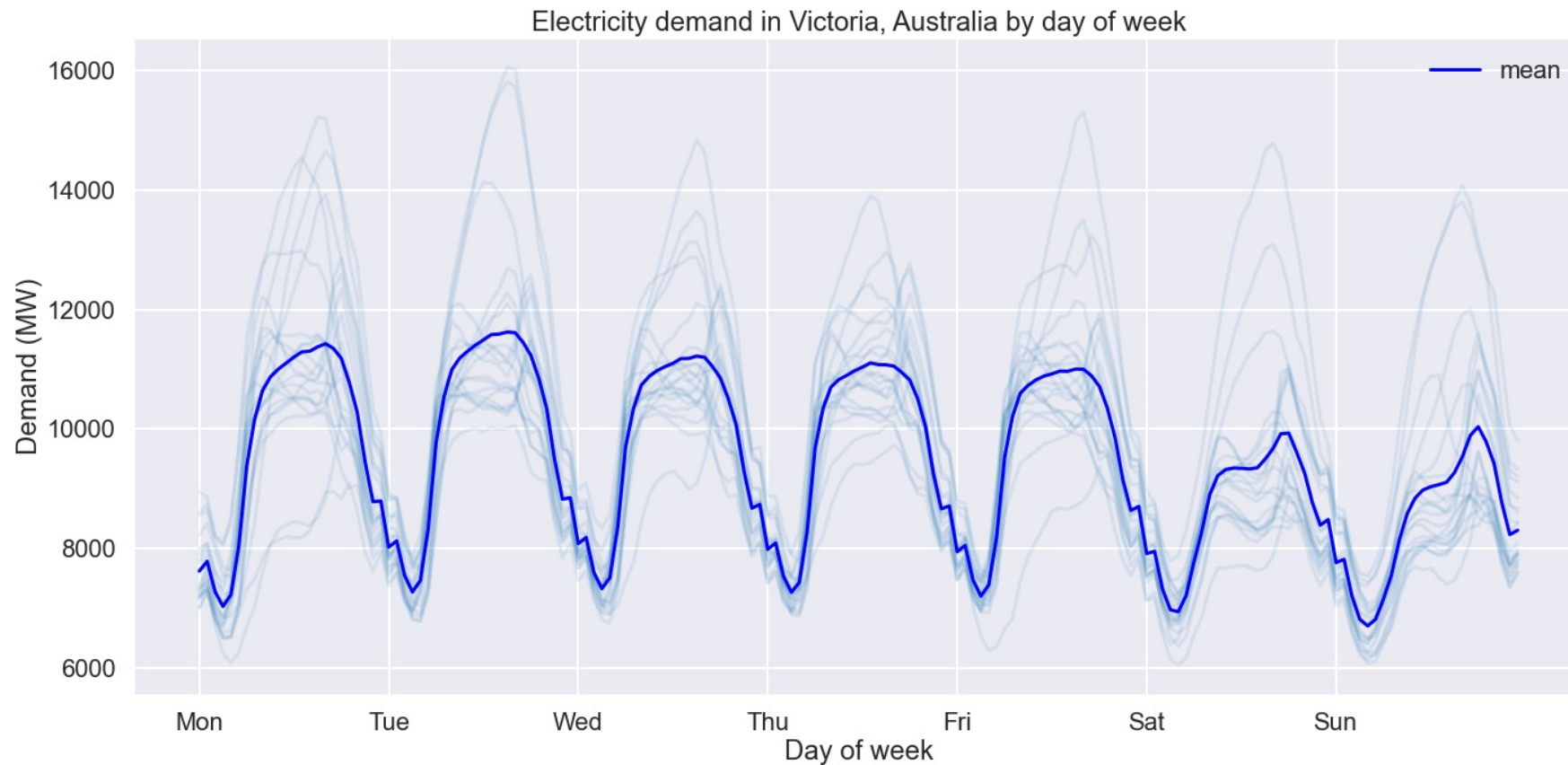
Electricity demand example

- There is daily seasonality which changes with the time of year.


Daily electricity demand in Victoria, Australia by month

Electricity demand example

- There is weekly seasonality from changes in demand in the weekdays vs the weekends.

Electricity demand in Victoria, Australia by day of week

Electricity demand example

- There is yearly seasonality from changes in temperature over the winter and summer.

Average electricity demand in Victoria, Australia, by month of year
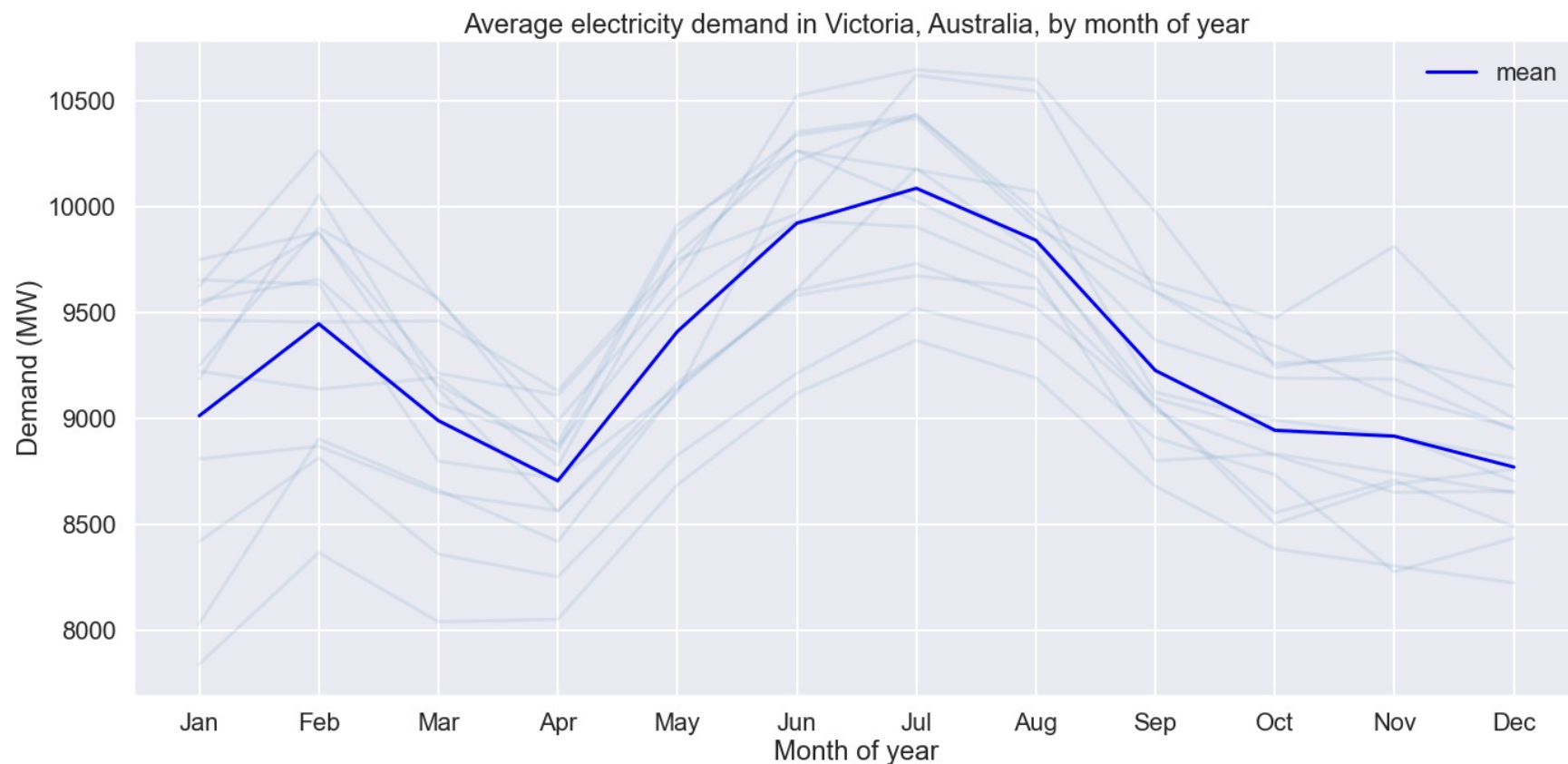
Electricity demand example

- This time series has daily, weekly, and yearly seasonality.

- In general, as data becomes more granular we start to see more seasonal patterns.

- We want to be able to decompose it into a trend and multiple seasonal components.

- In the next lecture we'll discuss multi-seasonal decomposition methods.

Electricity demand in Victoria, Australia
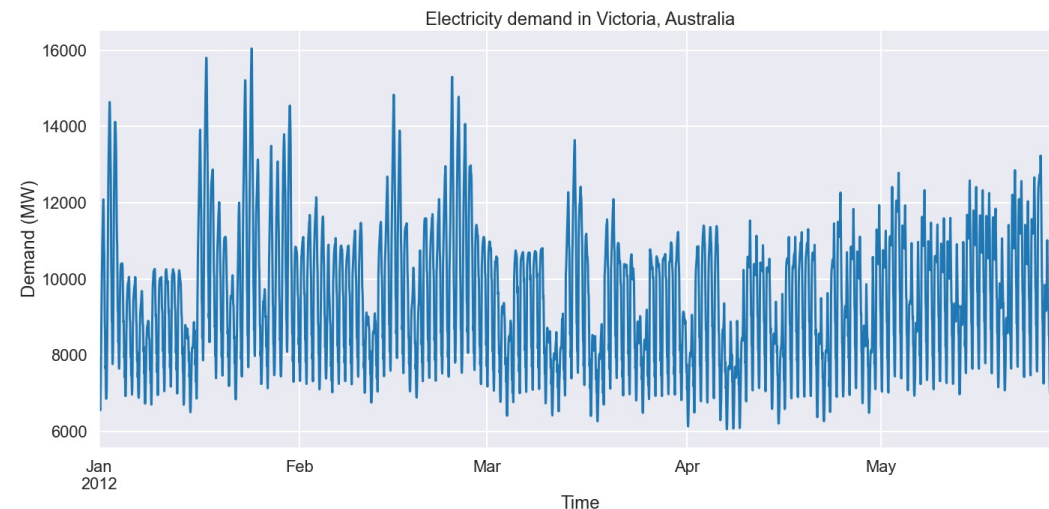
$$y_t = \hat{T}_t + \hat{S}_t^{(1)} + \hat{S}_t^{(2)} + \cdots + \hat{S}_t^{(N)} + \hat{R}_t$$

Trend component Seasonal components Residual component

Summary

Time series can have multiple seasonal components (e.g., daily and weekly).

This can be driven by a range of factors from weather to human behaviour.

Need to use specific methods to decompose multi-seasonal time series.