Time series graphics

1. Time plots
2. Seasonal plots
3. Seasonal polar plots
4. Seasonal subseries plots
5. Lag plots and autocorrelation
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Time plots

`autoplot(USAccDeaths) +
  ylab("Total deaths") + xlab("Year")`
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Seasonal plots

```r
ggseasonplot(USAccDeaths, year.labels=TRUE, year.labels.left=TRUE) + ylab("Total deaths")
```
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: `ggseasonplot()`
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Seasonal polar plots

```r
ggseasonplot(USAccDeaths, year.labels=TRUE, polar=TRUE) + ylab("Total deaths")
```
Seasonal polar plots

```r
ggseasonplot(USAccDeaths, year.labels=TRUE, polar=TRUE) + ylab("Total deaths")
```

Only change is to switch to polar coordinates.
Seasonal subseries plots

ggsubseriesplot(USAccDeaths) +
ylab("Total deaths")
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: `ggsubseriesplot()`
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Lagged scatterplots

```r
gglagplot(USAccDeaths/1000, lags=9)
```
Lagged scatterplots

`gglagplot(USAccDeaths/1000, lags=9, do.lines=FALSE)`
Lagged scatterplots

\begin{verbatim}
gglagplot(USAccDeaths/1000, lags=9, do.lines=FALSE)
\end{verbatim}

Each graph shows $y_t$ plotted against $y_{t-k}$ for different values of $k$.

- Autocorrelations are correlations associated with these scatterplots.
We denote the sample autocovariance at lag $k$ by $c_k$ and the sample autocorrelation at lag $k$ by $r_k$. Then define

$$c_k = \frac{1}{T} \sum_{t=k+1}^{T} (y_t - \bar{y})(y_{t-k} - \bar{y})$$

and

$$r_k = \frac{c_k}{c_0}$$
We denote the sample autocovariance at lag $k$ by $c_k$ and the sample autocorrelation at lag $k$ by $r_k$. Then define

$$c_k = \frac{1}{T} \sum_{t=k+1}^{T} (y_t - \bar{y})(y_{t-k} - \bar{y})$$

and

$$r_k = \frac{c_k}{c_0}$$

- $r_1$ indicates how successive values of $y$ relate to each other
- $r_2$ indicates how $y$ values two periods apart relate to each other
- $r_k$ is *almost* the same as the sample correlation between $y_t$ and $y_{t-k}$. 
### Autocorrelation

Results for first 9 lags for USAccDeaths data:

<table>
<thead>
<tr>
<th></th>
<th>$r_1$</th>
<th>$r_2$</th>
<th>$r_3$</th>
<th>$r_4$</th>
<th>$r_5$</th>
<th>$r_6$</th>
<th>$r_7$</th>
<th>$r_8$</th>
<th>$r_9$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.707</td>
<td>0.409</td>
<td>0.084</td>
<td>-0.182</td>
<td>-0.294</td>
<td>-0.423</td>
<td>-0.346</td>
<td>-0.285</td>
<td>-0.065</td>
</tr>
</tbody>
</table>

#### ggAcf(USAccDeaths)

![Autocorrelation plot for USAccDeaths data](chart.png)