Univariate time series

Introduction

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The object of study

A **time series** is set of observations recorded in time order.

Many fields

- history (e.g. industrial revolution),
- geography (e.g. migratory flows),
- demography (e.g. growth of a population),
- economics (e.g. rate of inflation),
- finance (e.g. stock price),
- meteorology (e.g. temperatures),
- medicine (e.g. electrocardiogram),
- epidemiology (e.g. spread of a disease),
- geophysics (e.g. earthquakes),
- communication (e.g. digital television),
- energy (e.g. load curve, wind and solar generation),
- ...

Some general questions

- Forecast and/or explain ?

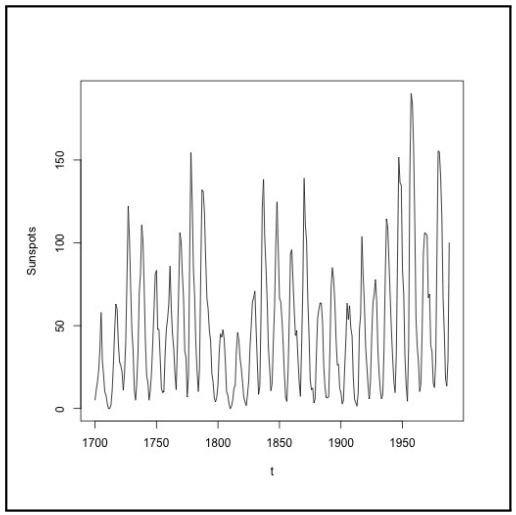

Figure: Sunspot number from 1790 to 1970

- Forecast interval.
- Cost of the forecasting error.
- Agreggate experts ?
- Univariate or multivariate time series ?

History of times series analysis

1. Graphic period
   From 10th century (earlier ?), with astronomy:

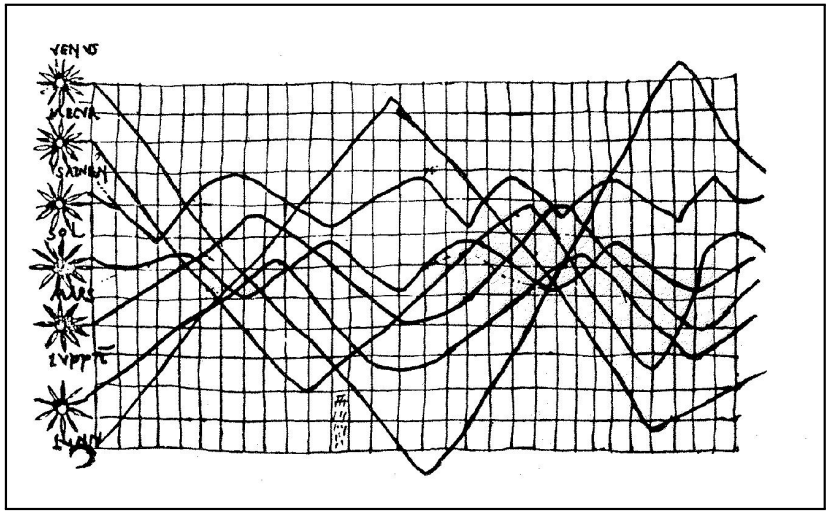

Figure: A.T. Macrobius, 10th century [4]

2. Deterministic period
   From 18th century, with frequency analysis (Fourier, Stokes, Schuster) and trend-seasonality decomposition (Pearson).
3. Probabilistic period
   From 20th century (Yule, Cramer, Wold, Kolmogorov).

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Music score

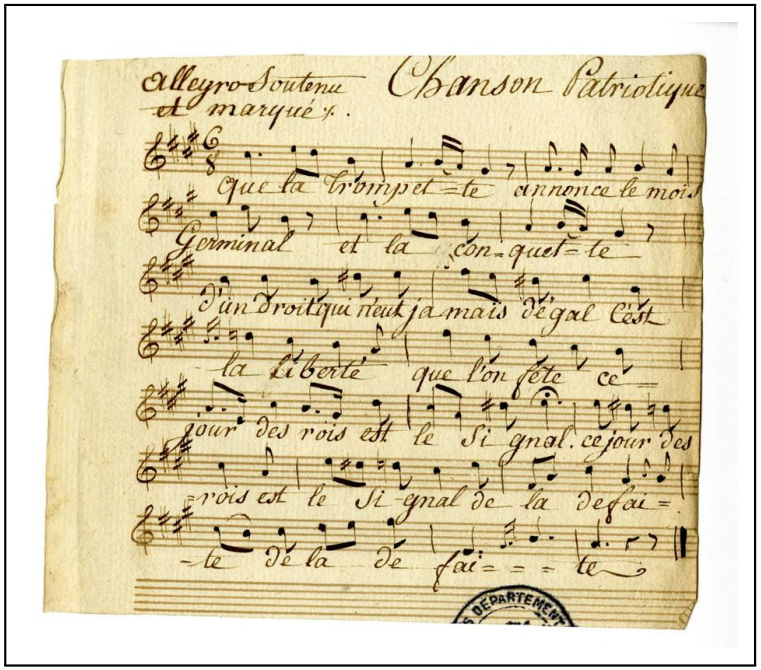

Figure: French song 18th century (Archives dpartementales du Pas-de-Calais)

White noise

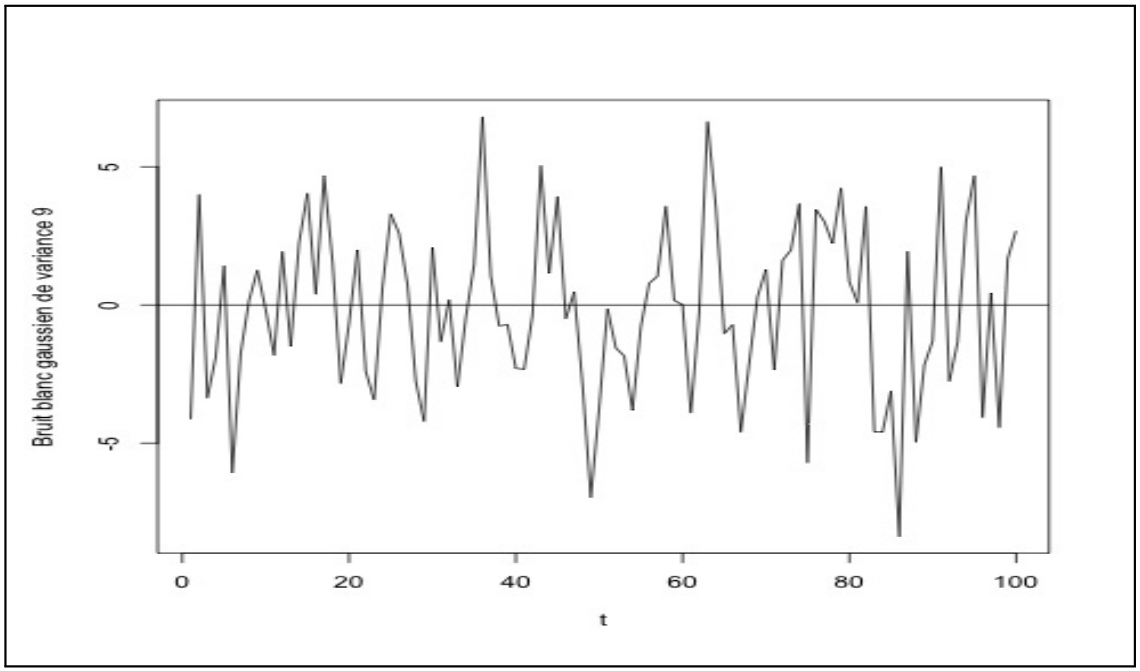

Figure: Gaussian noise with variance 9 (n=100)

USA population

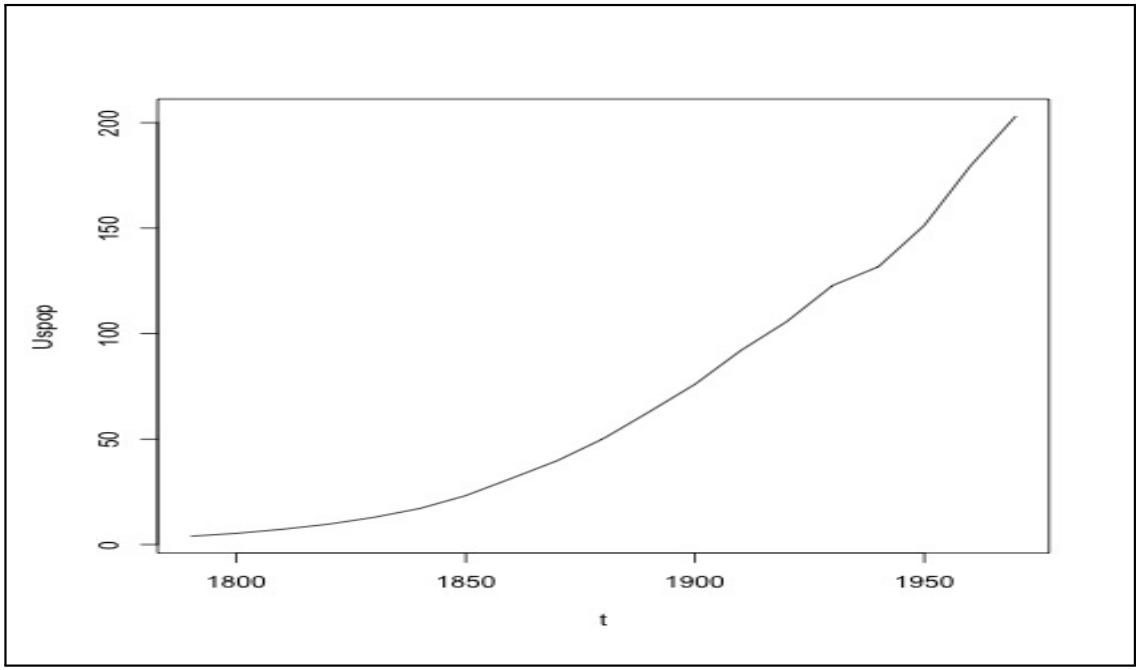

Figure: USA population from 1790 to 1990

Airline passengers

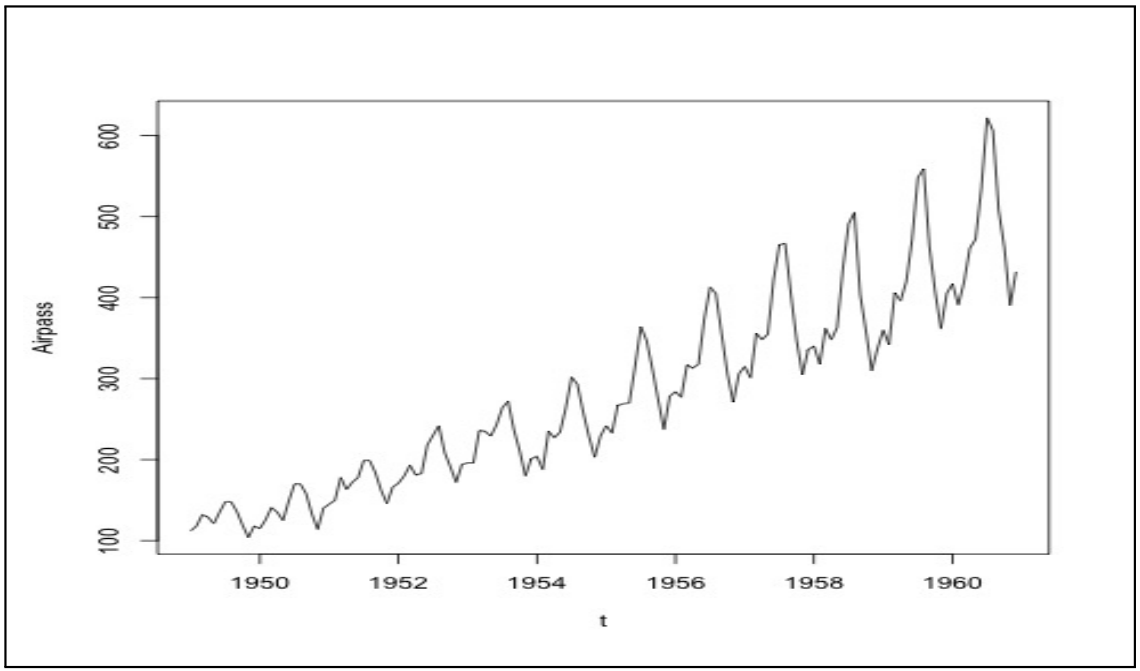

Figure: International air passengers from january 1960 to december 1971

Airline passengers (logarithm)

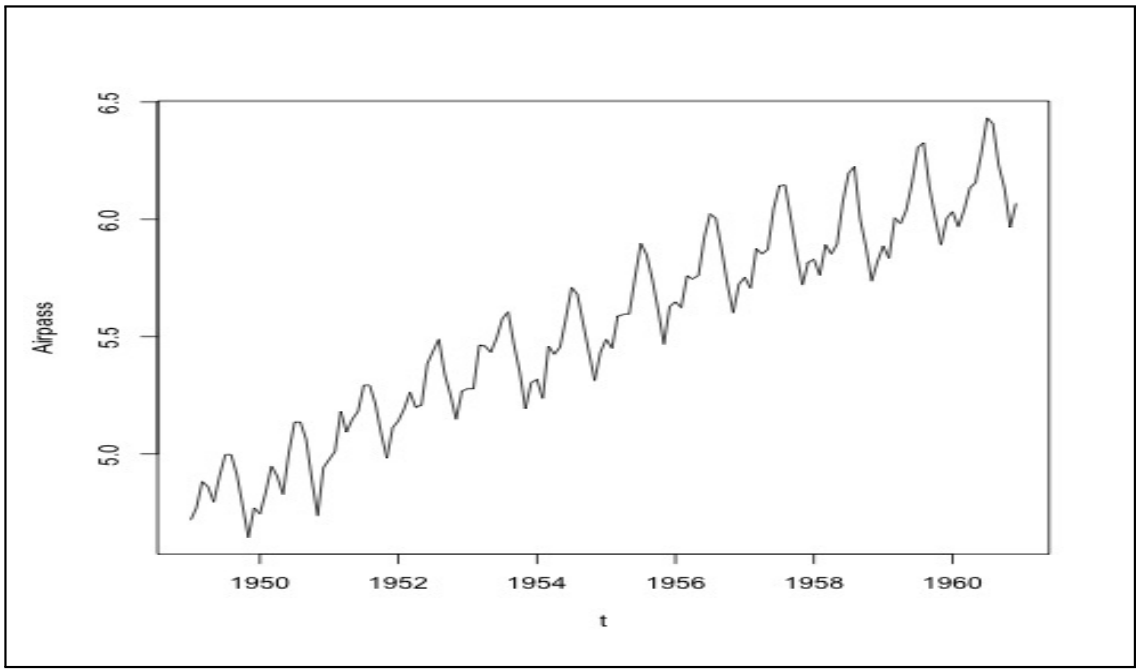

Figure: Logarithm of the international air passengers from january 1960 to december 1971

Australian beer production

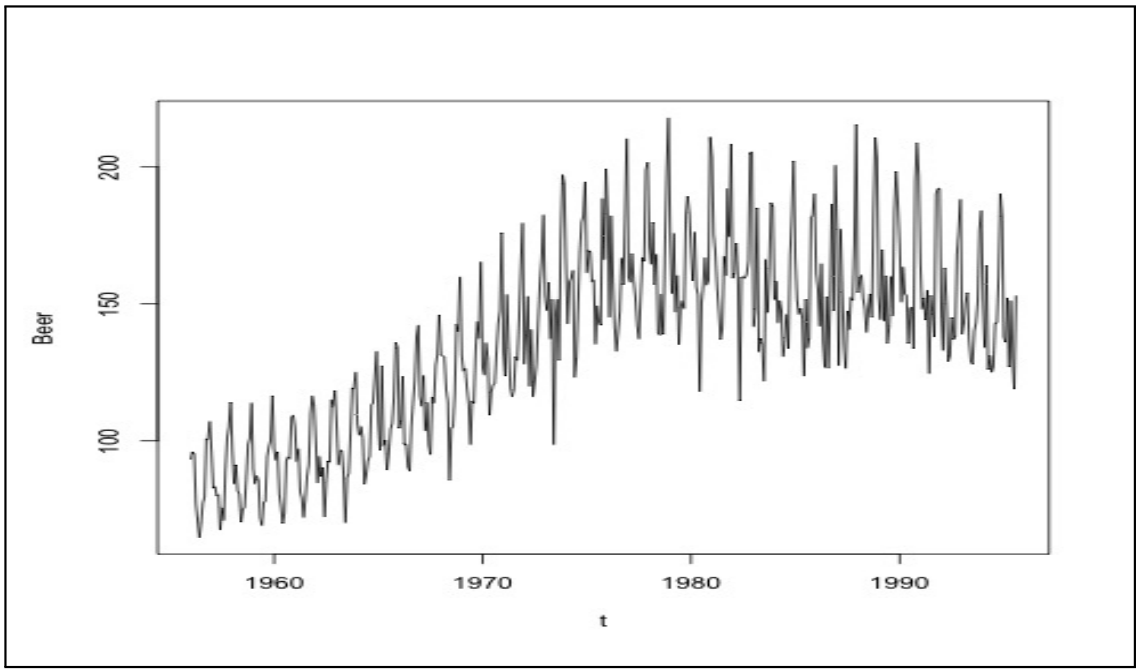

Figure: Australian beer production from january 1956 to february 1991

Numbers of annual lynx trappings in Canada

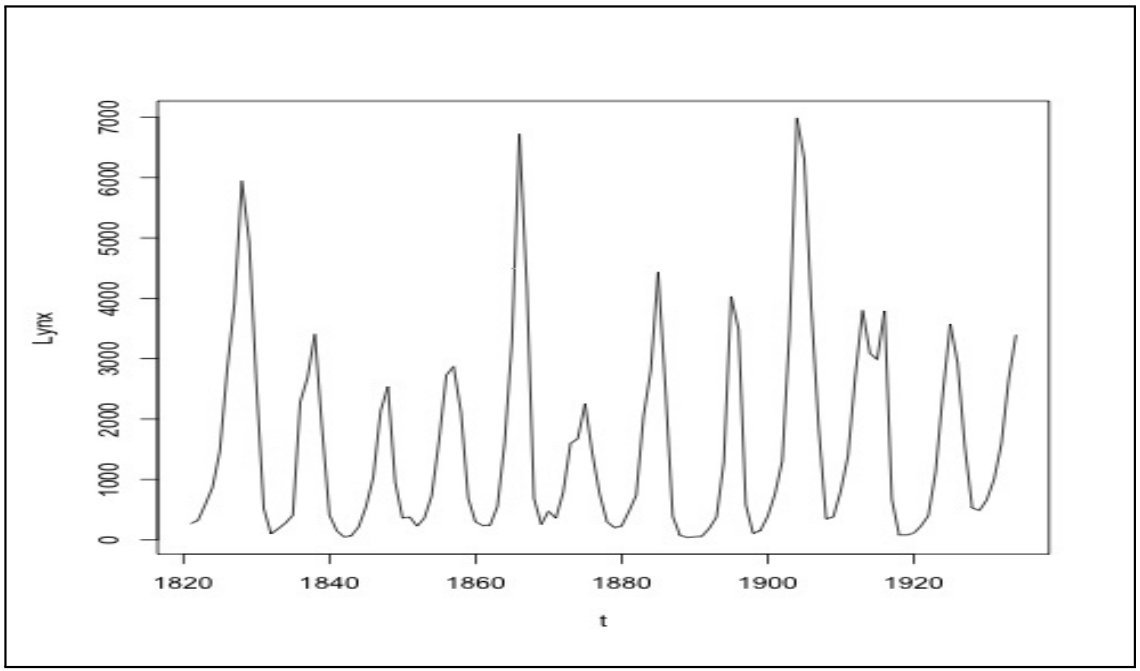

Figure: Numbers of annual lynx trappings in Canada from 1821 to 1934

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Course aims

- understand the problematic of time dependent data (stationarity),
- use simple signal processing tools (periodogram),
- be able to use a linear modeling on time series,
- and forecast.

References

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[4] Michael Friendly. A brief history of data visualization. In Chun-houh Chen, Wolfgang Härdle, and Antony Unwin, editors, *Handbook of data visualization*, chapter II.1, pages 15–56. Springer, 2008.

[5] Alan Pankratz. *Forecasting with dynamic regression models*. Wiley, 1991.

[6] Robert H. Shumway and David S. Stoffer. *Time series analysis and its applications. With R examples*. Springer Texts in Statistics. Springer, 3 edition, 2011.