More on Time Series & ARIMA

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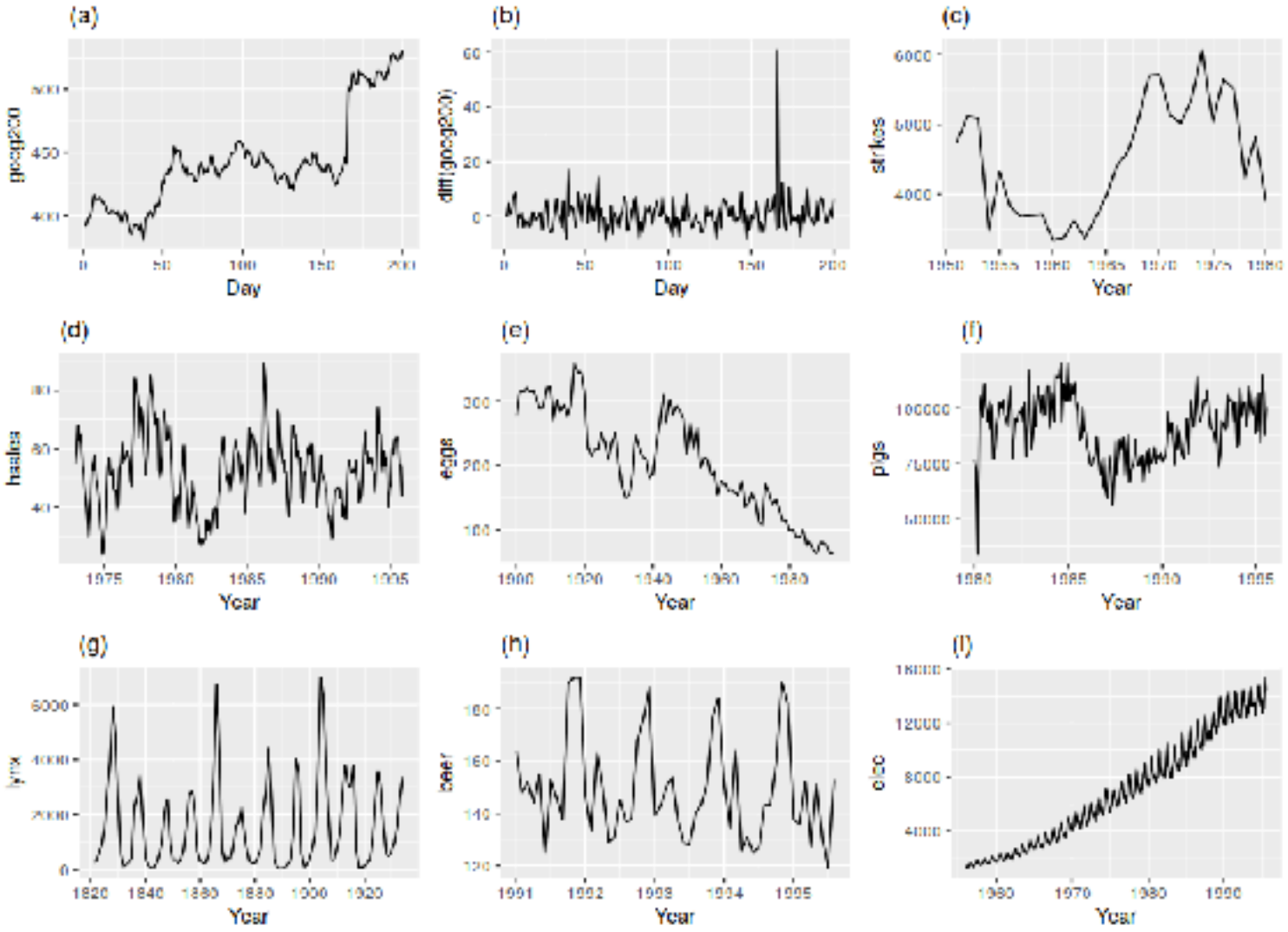
What is ARIMA?

- ARIMA has 3 components
  - Integrated: need differencing to make stationary
    - D=0 means original time series
    - D=1 means time series of differences to previous time
    - D=2 means difference of differences (2nd order)
  - AutoRegression: lags of stationarized series are correlated
  - Moving Average: lags in forecast error needed
- Advanced Notes: Link

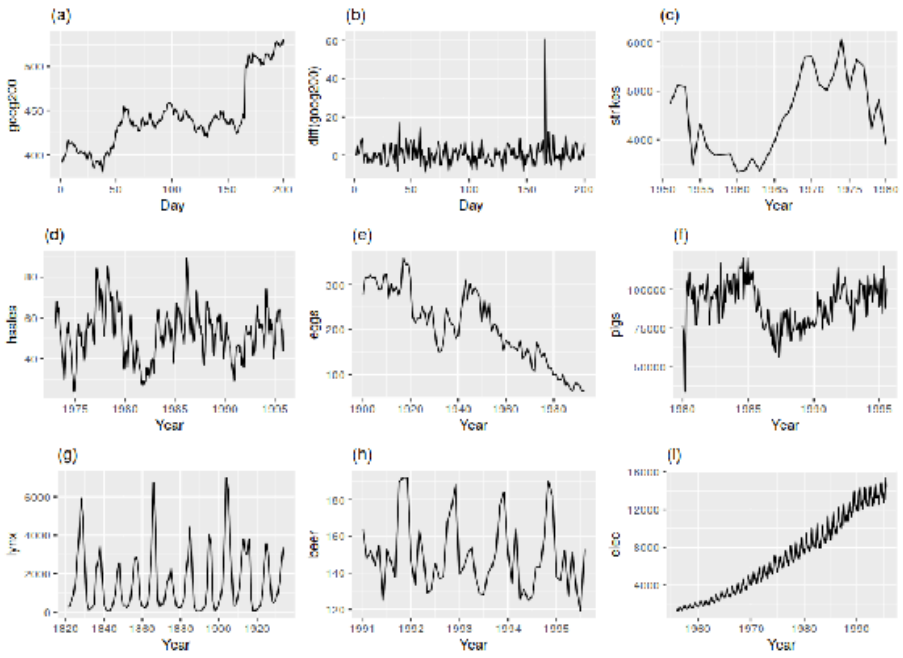
Stationarity

- **Stationary** time series
  - constant statistical properties independent of time
  - Example: white noise, non-seasonal cyclic behavior
- Which properties?
  - **Mean**: No trend (avg)
  - **Variance**: no heteroscedasticity
  - **Autocorrelations**: constant degree of "wiggliness"
- ARIMA assumes time series is non-stationary and model incorporates above 3 properties

Which of these are stationary?



Which of these are stationary?



- Seasonal:
  - (d), (h) and (i)
- Trends & Changing Levels:
  - (a), (c), (e), (f), (i)
- Increasing Variance:
  - (i)
- **Stationary**:
  - (b) and (g)

More details on ARIMA

- Understanding Differencing
  - https://otexts.com/fpp2/stationarity.html
- Understanding Autoregression
  - https://otexts.com/fpp2/AR.html
- Understanding Moving Averages
  - https://otexts.com/fpp2/MA.html
- How to model with ARIMA
  - https://otexts.com/fpp2/arima-r.html
- How to forecast with ARIMA
  - https://otexts.com/fpp2/arima-forecasting.html

Generalized ARIMA model

- A nonseasonal ARIMA model is classified as an **ARIMA**(**p**,**d**,**q**) model, where:
  - **p** = # of autoregressive terms,
  - **d** = # non-seasonal differences for stationary,
  - **q** = # lagged forecast errors in prediction equation.

ARIMA Models

- **ARIMA(0,1,0)** model
  - $\hat{Y}_t = \mu + Y_{t-1}$
- **ARIMA(1,1,0)** model
  - $\hat{Y}_t = \mu + Y_{t-1} + \phi_1 (Y_{t-1} - Y_{t-2})$
- **ARIMA(0,1,1)** model
  - $\hat{Y}_t = Y_{t-1} - (1-\alpha)e_{t-1}$
- **ARIMA(1,1,2)** model
  - $\hat{Y}_t = Y_{t-1} + \phi_1 (Y_{t-1} - Y_{t-2}) - \theta_1 e_{t-1} - \theta_1 e_{t-1}$

More detailed examples

- https://www.machinelearningplus.com/time-series/time-series-analysis-python/