Data analysis/Big data – it's all about patterns..

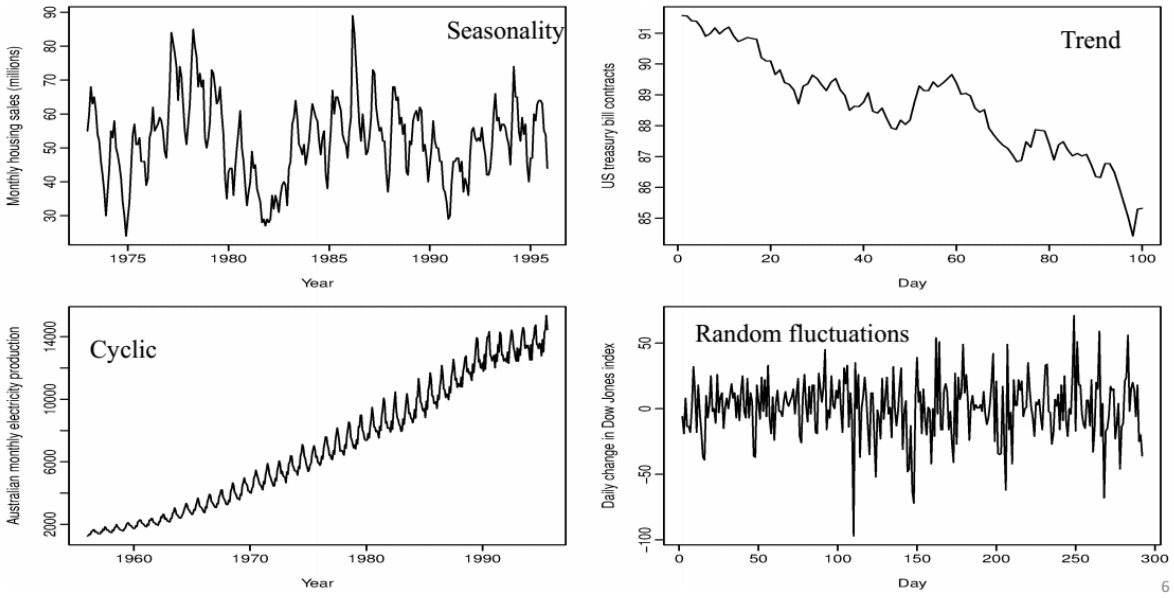
Source: chemistry2011.org

Swarm intelligence – collective behaviour of decentralized, self-organized systems.

Source: fractalsciencekit.com

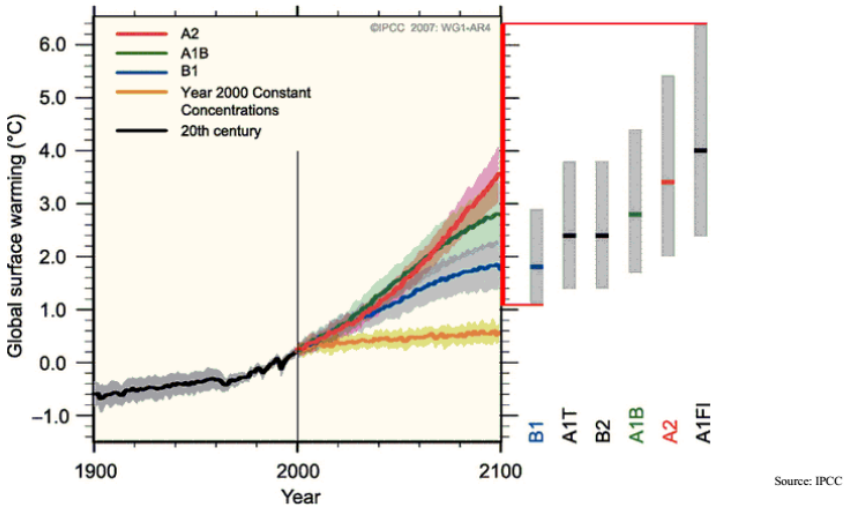
Fractals – self-similar patterns at different scales.

Patterns in time series



6

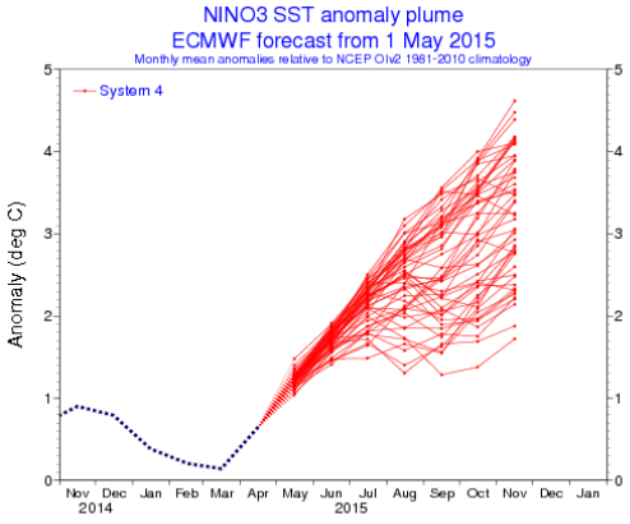
Forecasting: need and implications



Source: IPCC

- We need accurate forecasts for making informed policy and decision-making, mitigating risks by identifying potential critical transitions, and for optimizing operational costs. Always quantify and convey the **uncertainty in forecasts**

Ensemble forecasting

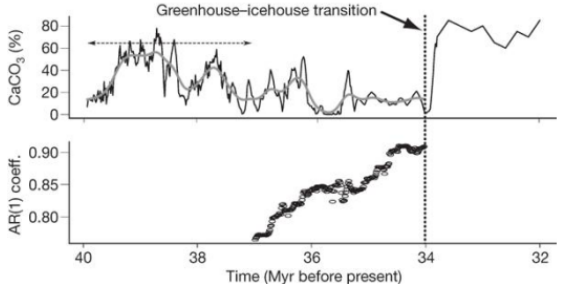


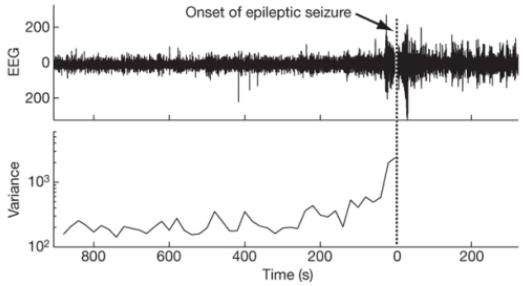
Source: ECMWF

All opinions are not equal. Some are a very great deal more robust, sophisticated and well supported in logic and argument than others – D. Adams

Critical transitions

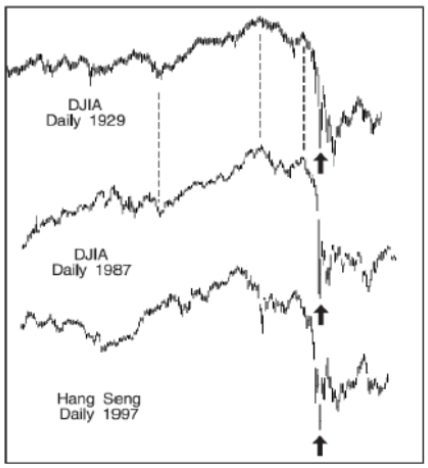
- Analysis and modelling of a time series can help us identify subtle changes in the system before a critical transition takes place.
- This can allow us create an early warning system.





Source: Scheffer *et al*. (2009). Early-warning signals for critical transitions, *Nature* 461, 53-59.

Major stock market crashes



Time series models cannot reliably forecast an event that has not been observed in the past – black swan events.

Underlying assumption – 'training' and 'test' data are realizations of the same joint distribution.

Time series forecasting

- Given a set of time ordered points $\{y_1, y_2, \ldots, y_N\}$, and independent variables $\{X_1, X_2, \ldots, X_N\}$, the aim is to create a model such as:

$$\hat{y}_{t+k} = f(X_t) + \varepsilon_t$$

where $\hat{y}_{t+k}$ is a k-step ahead model estimate for the corresponding actual observation y_{t+k}, while ε_t is a IID process. For example:

$$\hat{y}_{t+k} = a_o + a_1 X_t + \varepsilon_t$$

where a_o and a_1 are model coefficients.