Brisbane Floods, January 2011

Source: http://www.youtube.com/watch?v=kYUpkPTcqPY
The discovery of Chaos

• 1950s: Edward Lorenz discovers non-linear effects in weather forecasting, develops Chaos Theory;
  • Basis for understanding what is predictable and what isn’t

\[
\begin{align*}
\frac{dx}{dt} &= \sigma(y - x) \\
\frac{dy}{dt} &= x(\rho - z) - y \\
\frac{dz}{dt} &= xy - \beta z
\end{align*}
\]
Example of the butterfly effect

\[
\begin{align*}
\frac{dx}{dt} &= \sigma(y - x), \\
\frac{dy}{dt} &= x(\rho - z) - y, \\
\frac{dz}{dt} &= xy - \beta z.
\end{align*}
\]

Source: https://www.youtube.com/watch?v=FYE4JKAXSfY
Chaos - Key concepts

• Non-linear Dynamical Systems
  – Determinism: Can you work out future states?
  – Inputs are not proportional to outputs

• Denseness

• Attractors (Simple and Strange)

• Sensitivity to Initial Conditions
  – The “butterfly effect”

• Criticality and Tipping Points

• (Self-similarity and Fractals)
Forecasting Weather and Climate
Weather Forecasting:

- Overall climate
- Current weather
- Initial condition uncertainty

Days

Climate Prediction:

- Boundary conditions

Decades to centuries
What are the attractors here?

source: http://link.springer.com/10.1007/978-3-7091-0973-1