

# Brisbane Floods, January 2011



Source: <http://www.youtube.com/watch?v=kYUpkPTcqPY>

# The discovery of Chaos

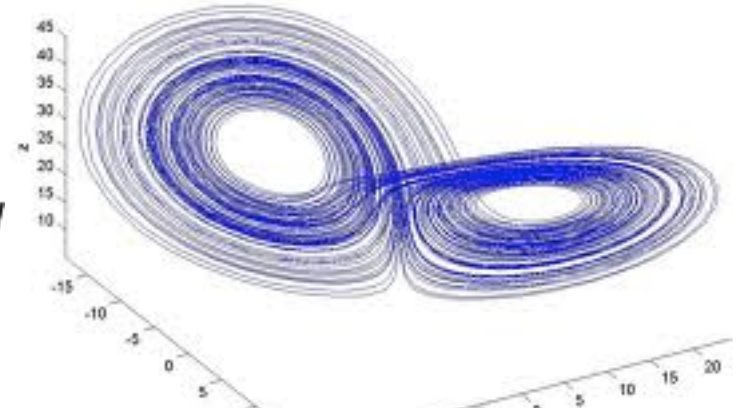
- **1950s:** Edward Lorenz discovers non-linear effects in weather forecasting, develops Chaos Theory;
  - Basis for understanding what is predictable and what isn't



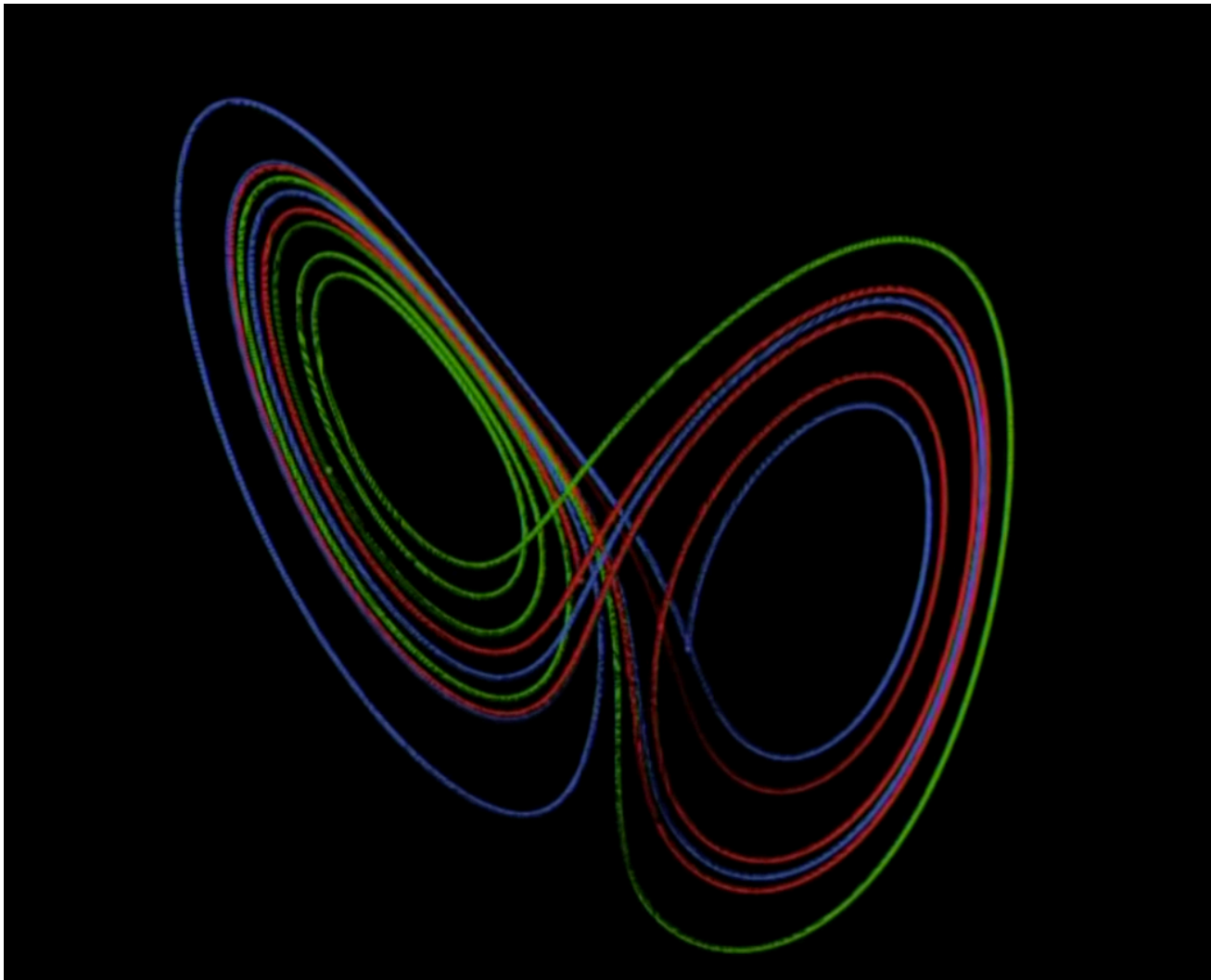
$$\frac{dx}{dt} = \sigma(y - x)$$

$$\frac{dy}{dt} = x(\rho - z) - y$$

$$\frac{dz}{dt} = xy - \beta z$$



# Example of the butterfly effect



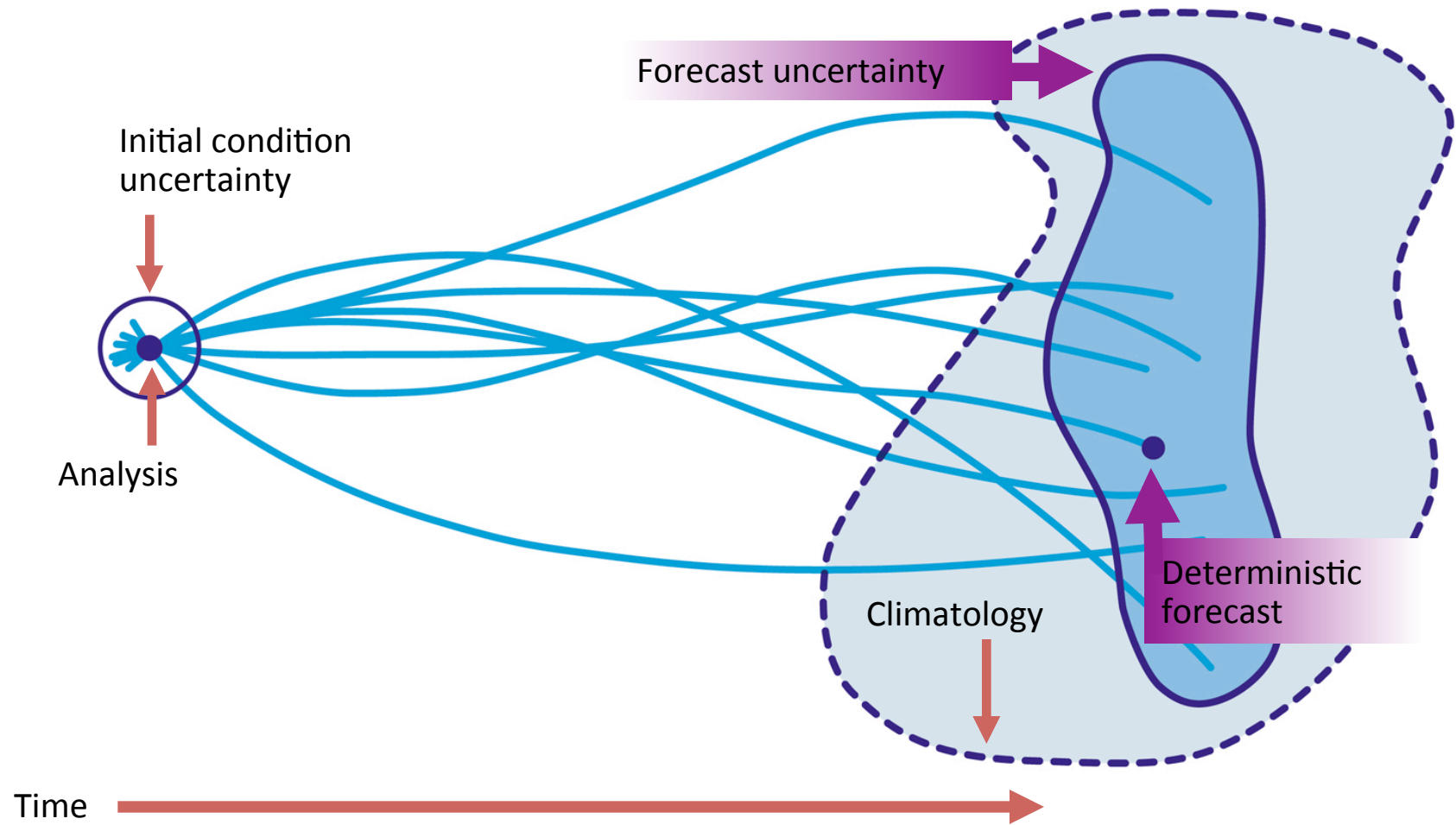
$$\begin{aligned}\frac{dx}{dt} &= \sigma(y - x), \\ \frac{dy}{dt} &= x(\rho - z) - y, \\ \frac{dz}{dt} &= xy - \beta z.\end{aligned}$$

Source: <https://www.youtube.com/watch?v=FYE4JKAXSfY>

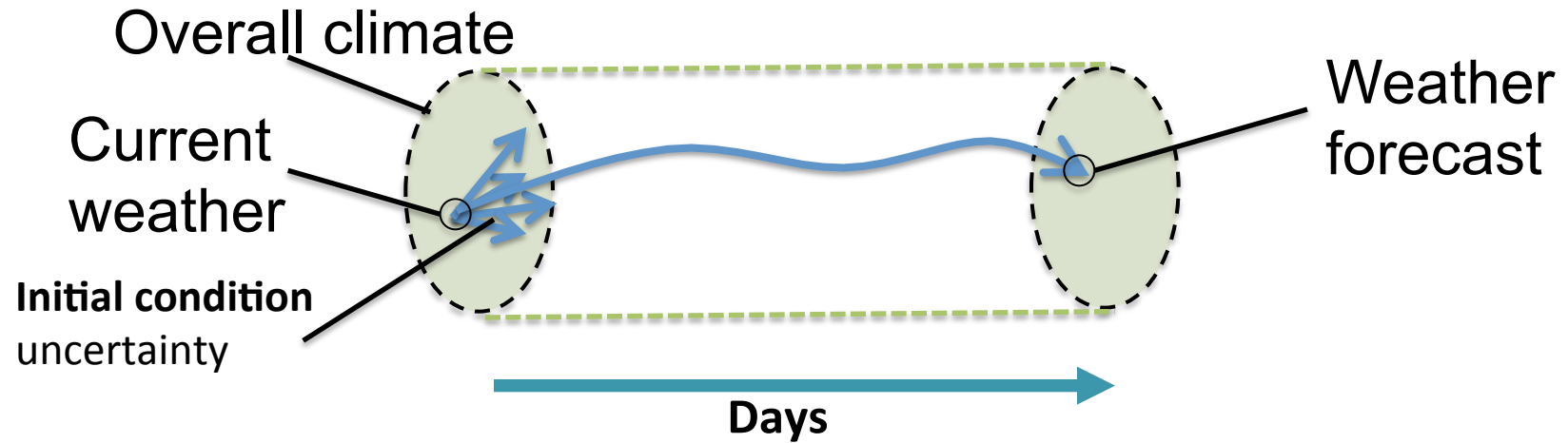
# Chaos - Key concepts

- 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)

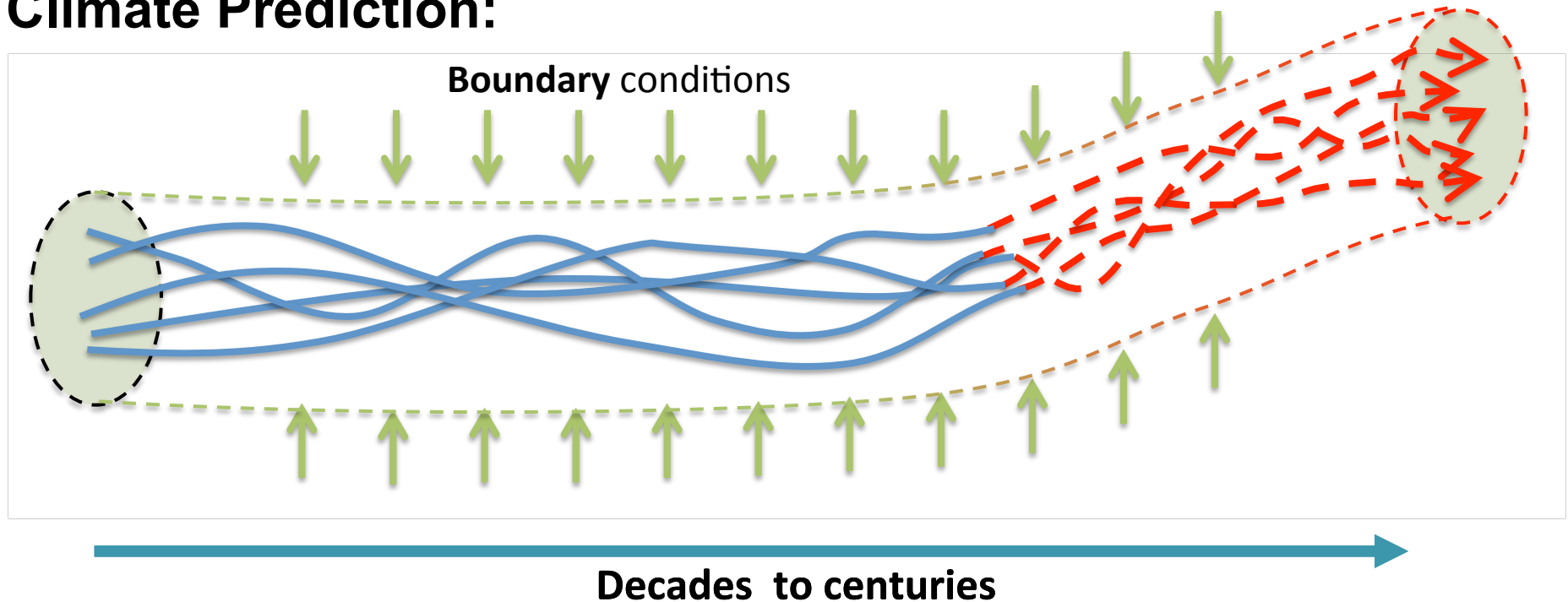
# Forecasting Weather and Climate



## Weather Forecasting:



## Climate Prediction:



# What are the attractors here?

