Predictability and Chaos

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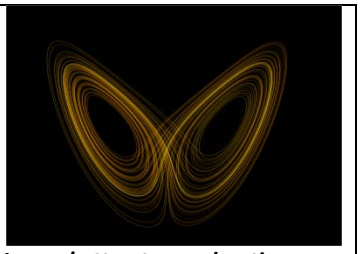
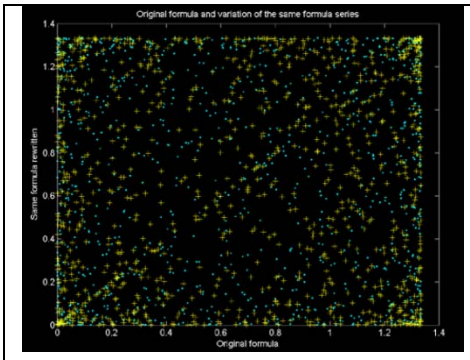
Predictability is ability to estimate the future state of a dynamical system knowing the involved physical processes and initial conditions of the system. In other words, the predictability of the system refers to the degree of accuracy with which it is possible to predict the future state of the system.
According to Lorenz (1963, 1982), we cannot make forecasts two months ahead even if we have a perfect model. Small errors (or even uncertainties) would amplify until they became too large.

Chaotic behavior:

- ***Chaos is present in many simple and complex models and algorithms.***
- ***Chaos is the aperiodic, long-term behavior of a bounded, deterministic system that exhibits sensitive dependence on initial conditions and algorithm parameters.***
- ***In essence, the computational error of a parameter grows and readily exceeds the value of the iterated (predicted) parameter. Consequently, chaos represents a break in the predictability in dynamical systems.***
- ***The roots of chaos are intrinsically linked to general number representation and the limitations of any computers in precision and algebraic operations.***
- ***Positive Ljapunov exponent is one of the measures of chaotic behavior.***



Lorenz' attractors – chaotic behavior of the set of atmospheric equations



Chaos is present in many simple non-linear systems.
Consider and iterate a formula:
$X_{n+1} = X_n + rX_n (1\text{-}X_n)$
and its identical algebraic representation:
$X_{n+1} = (1 + r)X_n - rX_n^2$
After 1000 iterations there is no correlation between these two identical formulations:

Implications for operational forecasting – use of multi-runs (ensemble members) for the same event: Example of 100 ensembles MM5 and WRF runs – 15-day predictions of the air temperature at 500 hPa (approximately 6 km from the mean sea level) at Oakland, CA.