MATHEMATICAL MODELLING Series 2

Butterflies, maths and chaos...

Mathematics and applied mathematics are used in everyday life. Stock markets, mobile phones, car manufacturing, Google, Hollywood special effects, digital TV and satellites all use cutting-edge mathematics tools in their basic functions. The Mathematical Modelling Series presents a number of applications of mathematics in domains as varied as the human body, volcanology, telecommunications or finance.

Does the flap of a butterfly's wings in Belfast set off a tornado in Thurles?

Why is it that even with modern computers, accurate long-term weather prediction is still difficult? Why is it not uncommon for the weather forecast to be wrong? Can mathematics offer an explanation?

How it works

Back in the 1960s the meteorologist Edward Lorenz developed some simple models to describe the weather. He used a computer to solve his equations, and these simulations took a long time to run. One day, having just run one of his simulations, he decided that he wanted to look at the same sequence of weather predictions again, over a longer period of time. To save time he used numbers from part way through the printout of the previous simulation, thinking that the overlap in time would provide a good check. However, the weather predicted was completely different from the weather he'd calculated the previous time. At first he thought his computer had malfunctioned. On further examination, he found that his printer had only printed out the first three decimal places of his data, while his computer could record numbers up to six decimal places long. The numbers he'd entered from the printout differed by less than 0.1%, but a very small change in the starting conditions of his model resulted in large changes in the long-term outcome. What Lorenz had stumbled upon is what is now known as 'chaos theory'. Chaotic systems are not random; they can be completely described by a set of equations, but they are capable of unpredictable behaviour, because of their extreme sensitivity to initial conditions, because of rounding errors, or because of the flap of a butterfly's wings!

Conclusion

It is impossible to measure the starting atmospheric conditions completely accurately. In Ireland we have only 15 weather stations to measure the atmospheric conditions for the whole country. Even with modern computers weather prediction is only reliable for up to a week ahead.

Parts of the curriculum used in this project

- Differentiation
- Ordinary differential equations and applications
- Fluid mechanics
- Linear algebra

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If you want more information about MACSI and this project:

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