The Butterfly Effect
Valid, But Widely Misrepresented

The butterfly effect is usually described by a statement similar to:

A butterfly flapping its wings in China can cause a tornado in Little Rock

This statement as well as many other ones commonly made is incorrect. More correctly:

A butterfly flapping its wings in China can make the difference between a tornado occuring in Little Rock, or not, at some day in the future that can not be known from first principles.

But, this is not the only thing that causes Chaos to be commonly misunderstood and prevents valid decision-making with respect to calculations involving non-linear systems. Specifically:

- Chaos is a valid concept, but it does not evolve from fist principles (such as F = ma, or better yet force is the time derivative of momentum). It is an empirical observation resulting from multiple computer runs. *Most unsettling to a 19th century mind-set*.
- The principle (if there is one) is that calculations of a non-linear system are infinitely dependent on initial conditions. The slightest difference in any input parameter will result in two calculations differing by an unbounded value after an unknown number of iterations.
- The behavior of non-linear in general cannot be described by a closed form equation (such as potential energy equals mass times the difference in elevation). *Newton is rolling over in his grave.* Rather it can only be calculated by iterative calculations, each of which is not exact.
- Chaos does *not* assert randomness. It is unrelated to quantum mechanics. *Again, very unsettling.*

So, what does this mean with respect to decisions that society must make with respect to predictions of non-linear system behavior, such as climate?

- Climate is driven by physical processes. Major events, such as volcanic eruptions clearly affect climate, and the effect is clearly predictable for at least a short time.
- It is not possible to know ahead of time what “a short time” means.
- It is important to develop climate models, but also to acknowledge their limitations. And one must be prepared to discover climate processes not currently included in the models.