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The Myth of Lorenz Butterflies - Or the Misunderstanding of Atmospheric Chaos

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This presentation's objective is to demystify the confusion between the expressions 'atmospheric chaos' and 'deterministic chaos'. This confusion can lead to an erroneous conclusion: if the atmosphere would be 'chaotic', nothing could be made to extend the weather forecast beyond two weeks, being chaos a physical limitation of the atmosphere itself.

The great contribution of Lorenz (1963) to weather forecasting is the use of ensembles, aiming not only to improve the quality of weather forecasts but also to increase the predictable term of the dynamic models used for this purpose. Lorenz's system of nonlinear equations was a model that features the classical "chaotic" behavior known as "deterministic chaos", unlike what happens in linear models. Lorenz, proposed the "chaos theory" supported by mathematical models, not by any physical behavior of the atmosphere. A nonlinear system of differential equations can lead to unstable results even in deterministic systems, because they are highly sensitive to disturbances, resulting in solutions that are unpredictable or "chaotic". The nonlinearity and the large number of interactions between components of the model, may lead to a random result. Also, the shortcomings of models result from our very limited understanding of what is actually occurring in nature.

Kalnay states: "even with perfect models and perfect observations, the 'chaotic' nature of the atmosphere would impose a finite limit of about two weeks to the predictability of the weather" (Kalnay, 2003). This affirmative proposition would be based on studies mostly conducted by Lorenz, especially in his 1963 and 1965 articles. Observational experience, however, suggests that the atmosphere does not behave in a "chaotic" way. In contrast to Kalnay's consideration, the predictability being restricted to just two weeks, this limitation does not come from a supposedly "chaotic" nature of the atmosphere, but rather from the nonlinear models. Therefore, this is a problem of mathematical order because those equations always lead to differing responses due to small differences in the initial conditions in the model variables.

There is no physical explanation for what qualifies as "atmospheric chaos" or any reason to consider the atmosphere in a state of disarray. In fact, it is not possible to prove yet if the atmosphere is "chaotic" because of the absence of experiments for this purpose. Even the physical explanation of Lorenz (1963) that the flapping of a butterfly's wings could lead to "chaos" in the atmosphere would be difficult to prove scientifically.