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How long is long enough in ecosystem observation?

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It is a common fate of long-term ecosystem observation programs that, after some years, the merit of continuation is put to question. The reason for such doubt in their value is not due to operating costs alone, but is rooted in the common view that long-term observations smack of "monitoring": simple stockpiling of data, passive lying in wait for potential serendipitous discoveries, endeavors that have little in common with the accepted way to conduct hypothesis or question driven research. Our claims and postulates are examined at the hand of examples of long-term measurements of ecosystem-atmosphere exchange measurements over forests in the US Midwest and Southern Germany.

We argue that a comprehensive long-term observation program, with continuous data quality control, analysis and interpretation, combined with modeling, goes far beyond mere fishing for serendipity. Such programs are invaluable tools to detect the scales of environmental variability and long-term trends; they form the basis for the identification of anomalies and their underlying processes; they are the most important data source for the independent evaluation of Earth-system-climate models.

The most obvious significance of continuous long-term observations is their utility for continuous evaluation of a model over long time periods. A more subtle point arises from the recognition that every environmental observation site is to a certain extent unique, and thus the dimensionality of the manifold of drivers and forcings in which a measured parameter assumes a given value at a given time is very large. In consequence, every observation must be seen a-priori as a unique value in a non-stationary, non-homogeneous field, collected in a unique set of conditions. Without the availability of an associated value, to which it can directly be compared (e.g., a known reference) it is not possible to obtain a well constrained estimate of its uncertainty. Without a measure for uncertainty, the utility of such observations for comparison with others or with modeling results is jeopardized. However, if the data point is embedded in a comprehensive long-term series, including observations that characterize the environmental forcing conditions in which the data were collected, it is possible to stratify the data set and objectively select a sample with comparable environmental conditions. Because the stratified sub-set exhibits a degree of homogeneity, it is permissible to use it for statistical analysis and uncertainty estimation. Clearly, the probability that a sufficient number of data points that meet given comparability criteria within a narrowly stratified data set can be identified, increases with the length of the data series. Thus, long-term observations provide an essential tool for environmental science to escape a fundamental methodological dilemma.