Geophysical Research Abstracts, Vol. 7, 08397, 2005 SRef-ID: 1607-7962/gra/EGU05-A-08397 © European Geosciences Union 2005



Detecting impacts of anthropogenic climate change on terrestrial ecosystems' phenology by Bayesian concepts

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There is clear evidence that regional changes in temperature have already affected biological systems around the globe. However, among different indicators, observation of phenological phases is probably the simplest way to track changes in the ecology of species in response to climate change. The use of phenology as bio-indicator is based on the close correlation between spring / summer phenology (leaf unfolding, flowering, fruit maturation) and temperature of the preceding months.

The new method for the analysis of long-term phenological time series based on Bayesian concepts, introduced by Dose and Menzel (2004), allows a clear detection of changes by detailed analysis of the development of time series (phenology / temperature), their respective change point probabilities, and the strength of their causal interdependence. The most important aspects of the method are rigorous treatment of uncertainties, prediction of missing and future data with associated uncertainties, and quantified comparison of different models.

Here, we present results for various time series in Europe, where the broadest tradition of long-term phenological monitoring exists. There is compelling evidence for changes during the last decades: Early spring events and a longer growing season is most apparent for time series ending in the mid 1980s or later with remarkable differences between species as well as between western maritime and eastern continental parts of Europe. There are seasonal differences whether the phenological and temperature time series should be regarded as coherent or independent.