Estimation of human impact in the presence of natural fluctuations

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Natural fluctuations in weather conditions can long conceal or distort important trends in the human impact on the environment. The IST project IMPACT provides methods and tools that will facilitate extraction of anthropogenic signals from collected data. In particular, substantial efforts are made to incorporate process-oriented deterministic models into statistical procedures for estimation of anthropogenic trends in air and water quality.

During the past few years, scientists and policy makers have become increasingly aware of the fact data regarding the state of the environment rarely speak for themselves. Simple questions regarding the effect of specific policy measures or general temporal trends in environmental quality can not be answered unless we develop efficient procedures to identify and remove natural fluctuations in measured data. In other words, we need to normalise collected data to more clearly display both the total effect of all anthropogenic activities and the effect of specific measures or activities. IMPACT has developed a theoretical framework for such normalisations and demonstrated how this framework can be used to motivate existing normalisation procedures and derive new techniques that integrate process-oriented models and various statistical tools from time series analysis and geostatistics. The theoretical achievements in the project also involve purely statistical techniques for signal extraction from time series of measured data and new significance tests for trend detection. Furthermore, we show how sensitivity and uncertainty analysis of physics-based models can shed new light on which factors that contribute to variation in the measured state of the environment.

A number of case studies of air and water quality are undertaken to illustrate the power of the tools developed. The most ambitious case study in the project aims at elucidating the changes in water quality that, after the reunification of Germany, were observed in the Elbe River and its estuary. The results obtained so far illustrate how the direct effects of reduced emissions to water were modified by important changes in aquatic processes and that the nutrient trends in the estuary are very different from the trends further upstream. Another case study of water quality focuses on nutrient trends in the Baltic sea. Preliminary results revealed that some of the water quality changes that have been attributed to reduced emissions may, in fact, be explained by natural fluctuations in the inflow of sea water from the Atlantic and river water from the drainage area. Two air quality studies focus on temporal and spatio-temporal patterns in the levels of surface ozone. One of these studies deals with the impact of traffic on ozone levels in the Paris region, and the other one addresses long-term ozone trends in remote parts of northern Europe. In both cases, the procedures developed in IMPACT have resulted in substantial spin-off effects. First, it has been demonstrated that new techniques for data analysis can contribute to more efficient procedures for quality assurance of measured data. Second, the validation of process-oriented deterministic models can be improved.

The dissemination of the results obtained in IMPACT involve targeted presentations for national and international end-users. In addition, the project is offering summer schools for young scientists and web-based tutorials.