Title: Emergence of multiple time scales

Subtitle: Alerting examples from modelling matter, life, and economy

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Abstract. Transforming for sustainability and mitigating climate change hazards depends decisively on the broad support of an informed public. In our contribution, we point to the multiscale aspects in climate change and sustainable development. Greenhouse gases accumulate *rapidly* in the atmosphere with *immediate* changes in the radiation pattern while secondary effects develop *slowly* like the release of methane from the oceans and perm freezing areas and, in the opposite direction, the binding and storage of CO_2 in the oceans. Such huge differences between characteristic time lengths provide not only difficulties in mathematical modelling, statistical sampling, and numerical simulation but can become misleading in communicating threats and solutions. Disregard of the multiscale aspects of a problem can either induce overestimations in the short run and underestimations in the end, i.e., the ominous cry wolf effect, and/or underestimation in the short run and overestimation in the end, resulting in fatalistic forfeiting or preposterous activism.

We show the universality of two characteristic times in modelling matter, life and economy by taking a closer look at three striking examples: viscosity of soft materials; biphasic insulin secretion of pancreatic beta cells; and long- and short-term cycles in macroeconomics. To make people familiar with the counterintuitive effects of two characteristic times, we provide simple mathematical models of intricate systems with two characteristic times: a simple system of coupled ordinary differential equations and a simple slow-fast system in complex polynomial dynamics. We draw conclusions for scientific, communicative and political challenges.

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