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Markov chain analysis of global water vapour and surface temperature interaction

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From thermodynamics the strong coupling between temperature and water vapour is well known. This relationship has been shown e.g. for measurements of annual means of the near surface temperature and the total water vapour column.

Environmental parameters such as temperature and water vapour are often autocorrelated and also cross correlated. Our approach is to reduce the bivariate set of data (water vapour and temperature) to a univariate sequence of symbols, which can be described as a discrete stochastic process, a Markov chain. This Markov chain represents the water vapour - temperature interaction or state of a region. Several descriptors, which are new in environmental science, can be calculated, such as *persistence*, *replacement of* and *entropy* and are characteristic for the climate system.

The method does not require normally distributed data and can also be applied to unevenly sampled measurements. In the context of climate change the Markovian analysis is an underrepresented, but powerful tool to account for the complexity of climate systems and for the detection of shifts or changes. Here we show a first application of the Markov chain analysis on the combined climate parameters, water vapour and temperature on a global scale.

Total water vapour columns are provided by the Global Ozone Monitoring Experiment (GOME) flying on ERS-2 which was launched in April 1995 and the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) onboard ENVISAT and yield a time series from 1996 to now. Global near surface temperatures are provided by the Goddard Institute of Space Studies (GISS) and cover a time span from 1880 to 2005. The temperature data are retrieved from ground stations and mainly based on the Global Historical Climatology Network (GHCN).