Geophysical Research Abstracts
Vol. 18, EGU2016-6768, 2016
EGU General Assembly 2016

A review of downscaling procedures – a contribution to the research on climate change impacts at city scale

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Human kind is currently predominantly urban based, and the majority of ever continuing population growth will take place in urban agglomerations. Urban systems are not only major drivers of climate change, but also the impact hot spots. Furthermore, climate change impacts are commonly managed at city scale. Therefore, assessing climate change impacts on urban systems is a very relevant subject of research. Climate and its impacts on all levels (local, meso and global scale) and also the inter-scale dependencies of those processes should be a subject to detail analysis. While global and regional projections of future climate are currently available, local-scale information is lacking. Hence, statistical downscaling methodologies represent a potentially efficient way to help to close this gap.

In general, the methodological reviews of downscaling procedures cover the various methods according to their application (e.g. downscaling for the hydrological modelling). Some of the most recent and comprehensive studies, such as the ESSEM COST Action ES1102 (VALUE), use the concept of Perfect Prog and MOS. Other examples of classification schemes of downscaling techniques consider three main categories: linear methods, weather classifications and weather generators.

Downscaling and climate modelling represent a multidisciplinary field, where researchers from various backgrounds intersect their efforts, resulting in specific terminology, which may be somewhat confusing. For instance, the Polynomial Regression (also called the Surface Trend Analysis) is a statistical technique. In the context of the spatial interpolation procedures, it is commonly classified as a deterministic technique, and kriging approaches are classified as stochastic. Furthermore, the terms “statistical” and “stochastic” (frequently used as names of sub-classes in downscaling methodological reviews) are not always considered as synonymous, even though both terms could be seen as identical since they are referring to methods handling input modelling factors as variables with certain probability distributions. In addition, the recent development is going towards multi-step methodologies containing deterministic and stochastic components. This evolution leads to the introduction of new terms like hybrid or semi-stochastic approaches, which makes the efforts to systematically classifying downscaling methods to the previously defined categories even more challenging.

This work presents a review of statistical downscaling procedures, which classifies the methods in two steps. In the first step, we describe several techniques that produce a single climatic surface based on observations. The methods are classified into two categories using an approximation to the broadest consensual statistical terms: linear and non-linear methods. The second step covers techniques that use simulations to generate alternative surfaces, which correspond to different realizations of the same processes. Those simulations are essential because there is a limited number of real observational data, and such procedures are crucial for modelling extremes. This work emphasises the link between statistical downscaling methods and the research of climate change impacts at city scale.