

Empirical-Statistical Downscaling in Climate Modeling

PAGES 417-422

Research into possible impacts of a climate change requires descriptions of local and regional climate. For instance, the local and regional aspect of a climate change is stressed in the U.S. Strategic Plan for the Climate Change Science Program (CCSP) (<http://www.climate-science.gov/Library/stratplan2003/default.htm>). Global climate models (GCMs) are important tools for studying climate change and making projections for the future. Although GCMs provide realistic representations of large-scale aspects of climate, they generally do not give good descriptions of the local and regional scales. It is nevertheless possible to relate large-scale climatic features to smaller spatial scales.

There are two main approaches for deriving information on local or regional scales from the global climate scenarios generated by GCMs: (1) numerical downscaling (also known as "dynamical downscaling") involving a nested regional climate model (RCM) or (2) empirical-statistical downscaling employing statistical relationships between the large-scale climatic state and local variations derived from historical data records.

The former approach is typically computer intensive (requiring a supercomputer) and involves substantial efforts in adapting RCMs to the region of interest and the specific GCM. The latter method, on the other hand, can be done more inexpensively on a workstation or a personal computer. Empirical-statistical downscaling receives little attention in the CCSP document, but because it is quick and inexpensive, it is an appropriate method for generating long time series and for exploring a range of different GCM results. For instance, empirical-statistical downscaling has successfully been applied to multimodel ensembles consisting of different GCM scenarios from the Intergovernmental Panel on Climate Change (IPCC) in order to explore intermodel similarities and differences. The most severe limitation to empirical-statistical downscaling is the requirement that there be an adequate record of past observations for the local parameter of interest, which limits the downscaling to locations where there are observations.

Software Tools

There are several tools available on the Internet for empirical-statistical downscaling. These include SDSM (Statistical DownScaling Model) (freely available from <https://cc-public.llnwd.com/SDSM/>) by Dawson and Wilby; and clim.pact (freely available from CRAN (Comprehensive R Archive Network) Web site: <http://cran.r-project.org> for the R environment [Ihler, 2001]; R is a "GNU version of Splus").

Whereas SDSM is written for the Windows environment, R and clim.pact should be able to run on Linux and MacOS as well as on Windows platforms. The clim.pact package contains a bundle of R-functions for computing empirical orthogonal functions (EOFs), plotting climate data, and performing correlation and composite analysis in addition to empirical-statistical downscaling. The clim.pact package is highly flexible, as it is possible for the user to supplement clim.pact functionalities with a large number of other functions from other contributed packages or functions written especially for a particular problem. It can analyze both daily and monthly data.

A range of predictors (independent variables) can easily be incorporated into the analysis if they are stored in the netCDF (<http://www.unidata.ucar.edu/packages/netcdf/>) format. These predictors can be gridded temperature from the University of East Anglia (<http://www.cru-uea.ac.uk/cru/data/temperature/>) or reanalysis by the U.S. National Weather Service's National Centers for Environmental Prediction (NCEP) (<http://www.ncep.noaa.gov/>). The local

variable, the predictand (dependent variable), may, for instance, be taken from NASA Goddard Institute of Space Studies Surface Temperature Analysis (<http://www.giss.nasa.gov/data/updated/gistemp/>).

Transient climate scenarios from GCMs can be downloaded from the IPCC Web site (http://ipcc-dcc.cru.uea.ac.uk/dcc/index_index.html), and these can be converted to the netCDF format and used in the downscaling analysis. There are numerous ways of carrying out empirical-statistical downscaling in terms of different statistical models, such as linear modeling (regression, canonical correlation analysis, or singular vectors), analog modeling, or neural nets. At present, clim.pact incorporates both regression and analog models.

Choosing the Variable

In addition to the choice of statistical model, there are different options for the predictor. Which variable is most suitable for describing the large-scale climatic conditions that are relevant to the location in question? There may be substantial differences in local values derived from different large-scale variables [Muth, 2004]. Useful criteria include (1) large-scale parameters with a strong relationship with the predictand that reflect a well-understood physical connection, (2) predictors that are skillfully predicted by GCMs, and (3) parameters that

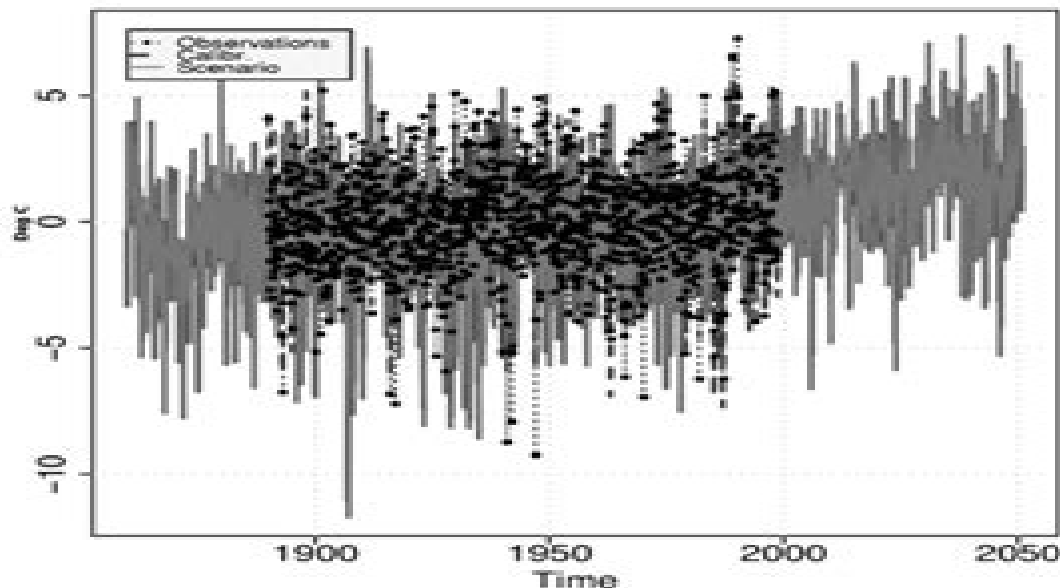


Fig. 1. Example of downscaled monthly 1890–1998 January mean temperature for Oslo-Blindern derived with clim.pact. The example is based on the ECHAM4/IPPC3 model and the IPCC IS92a-based GSDMO integration. (The GSDMO scenario includes the effects of greenhouse gases, tropospheric ozone, and direct plus indirect effects of industrial aerosols). The predictor used for calibration was gridded temperature described by Bengtsson [2001].

Empirical Statistical Downscaling

Douglas Maraun, Martin Widmann



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inhaling engine exhaust always operate the engine in a well ventilated area engine exhaust is toxic

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web jun 8 2019 figure 1 motor control module note do not ground the mcm this can result in false codes being logged the motor control module mcm incorporates a heat exchanger which uses fuel to cool the mcm the top plate of the heat exchanger incorporates the inlet and outlet fitting for fuel supply entering and exiting the heat

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web the motor control module mcm monitors the rail pressure and when rail pressure deviation is greater than 200 bar for

eight seconds the mcm sets the code this fault can occur due to the conditions listed below external fuel leakage between the high pressure pump and fuel injectors pressure limiting valve leakage internal

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