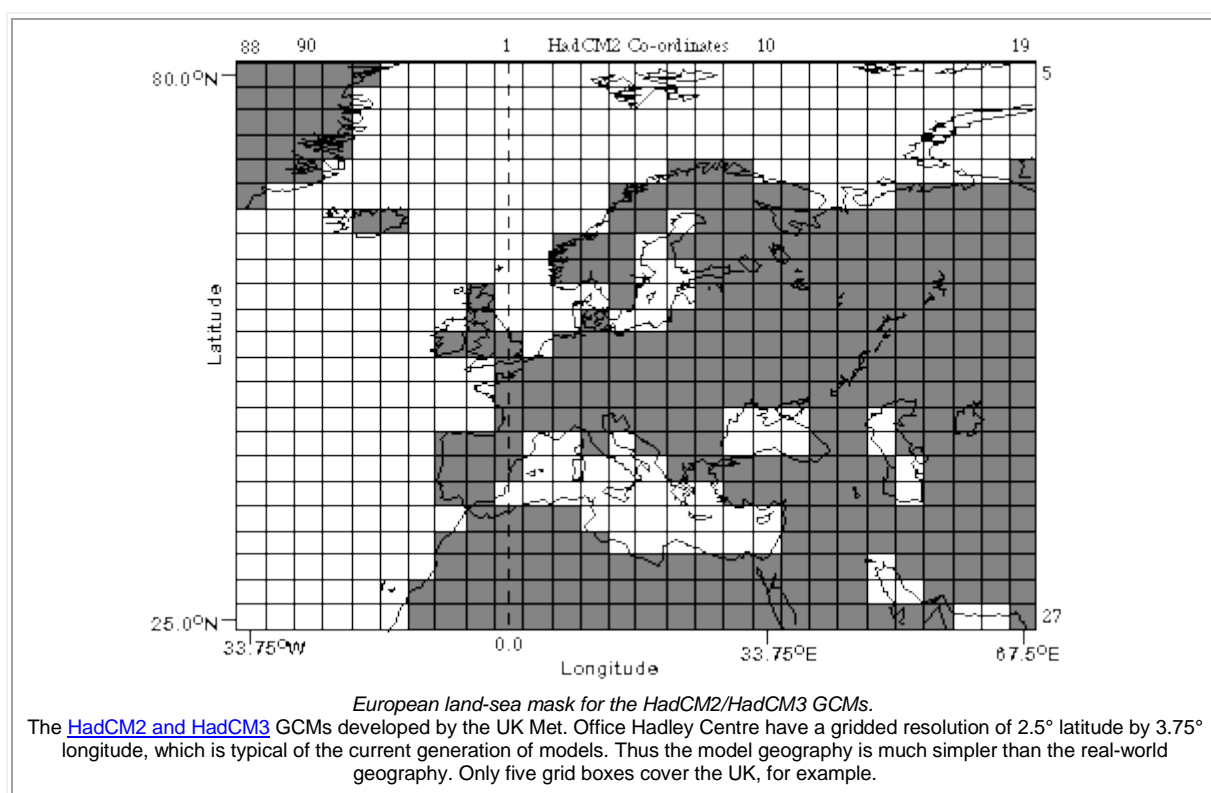


9: Climate Change Scenarios

Clare Goodess

Climate change scenarios provide the best-available means of exploring how human activities may change the composition of the atmosphere, how this may affect global climate, and how the resulting climate changes may impact upon the environment and human activities. They should not be viewed as predictions or forecasts of future climate, but as internally-consistent pictures of possible future climates, each dependent on a set of prior assumptions.

General circulation models (GCMs) (see [Information Sheet 8](#)) are complex, gridded, three-dimensional computer-based models of the climate system (developed from numerical weather forecasting models). They are considered to provide the best basis for the construction of climate change scenarios.



A number of decisions must be taken in order to construct GCM-based climate change scenarios:

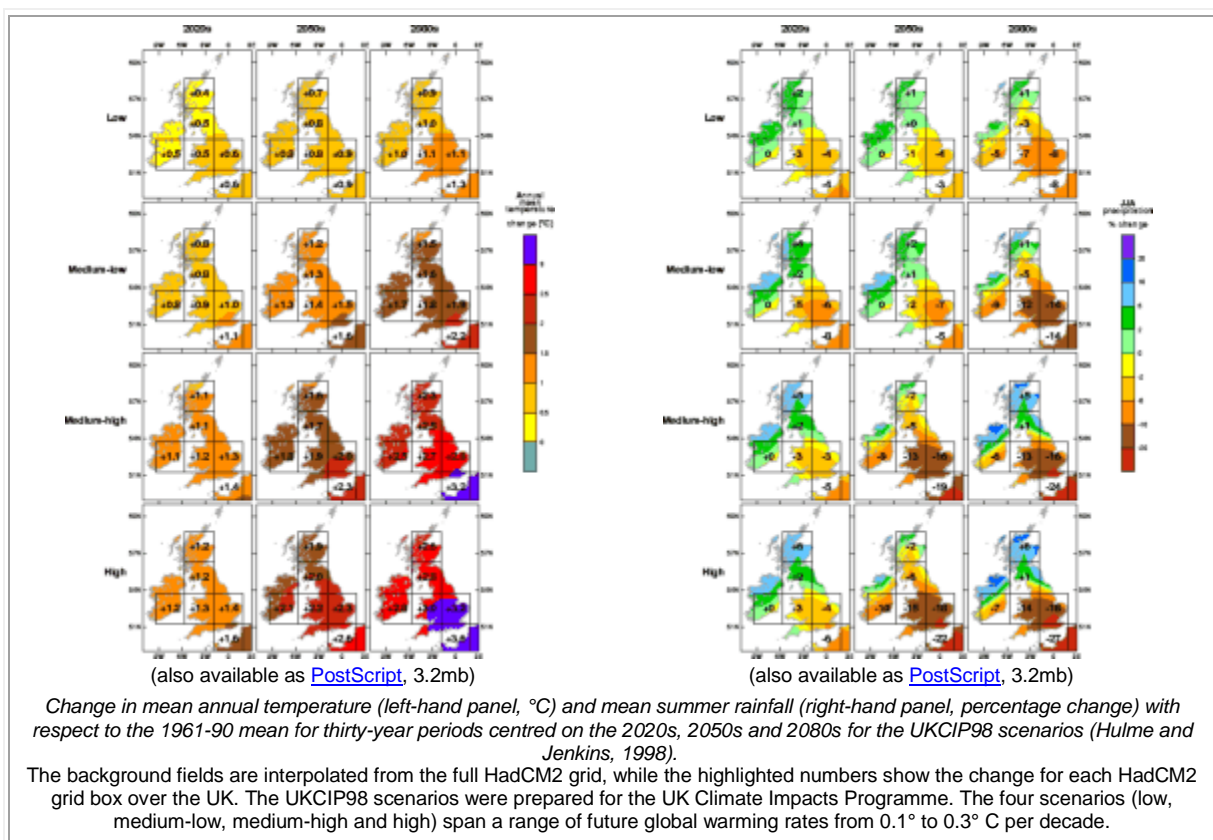
- *What underlying emissions scenarios should be used to predict atmospheric greenhouse gas and aerosol concentrations?*

A forcing of 1% per year increase in the equivalent CO₂ atmospheric concentration has been widely used as a 'business-as-usual' emissions scenario in GCM experiments. However, the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios (SRES), accepted in May 2000, identifies 40 scenarios which follow four different 'storylines' and with forcing increases ranging between 0.4% and 1.2% per year. Each of the SRES scenarios is considered equally probable.

- *Should the climate change scenarios be based on a single GCM (and if so, which) or should the results from several models be combined in order to reflect inter-model*

differences?

GCMs are run at a number of different modelling centres. The IPCC Data Distribution Centre ([IPCC DDC](#)), for example, holds GCM output from seven modelling groups based in Europe, North America, Japan and Australia. There are differences in the way physical processes and feedbacks are simulated in different GCMs. Thus the global temperature change in response to a doubling of the atmospheric CO₂ concentration (the climate sensitivity) varies from model to model (a sensitivity range of 1.5° to 4.5° C is conventionally quoted). The same GCM may give different results for the same forcing but slightly different initial conditions. Thus it may be desirable to consider results from an ensemble of runs. There are also differences in the regional estimates of climate change produced by different models (even for the same mean global warming). Identification of a single 'best' GCM is not straightforward, particularly when performance is considered across a number of different climate variables and/or regions. Climate changes from GCMs should be calculated so as to maximise signal-to-noise ratios.



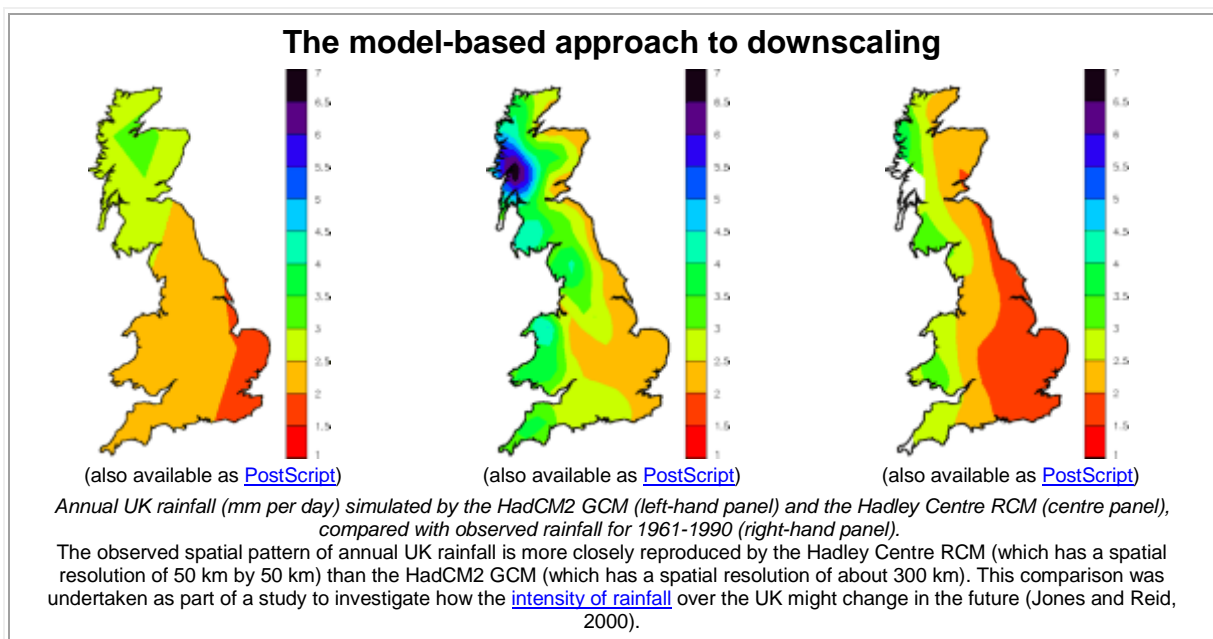
- *Should the original grid box GCM information be used (the current generation of GCMs typically provides information on a grid with a spatial resolution of about 300 km North-South, and which may vary in a West-East direction depending on latitude but will typically be about 400 km at 45° N or S) or is information required at a higher spatial resolution (for investigating the regional impacts of climate change on agriculture or water resources, for example)?*

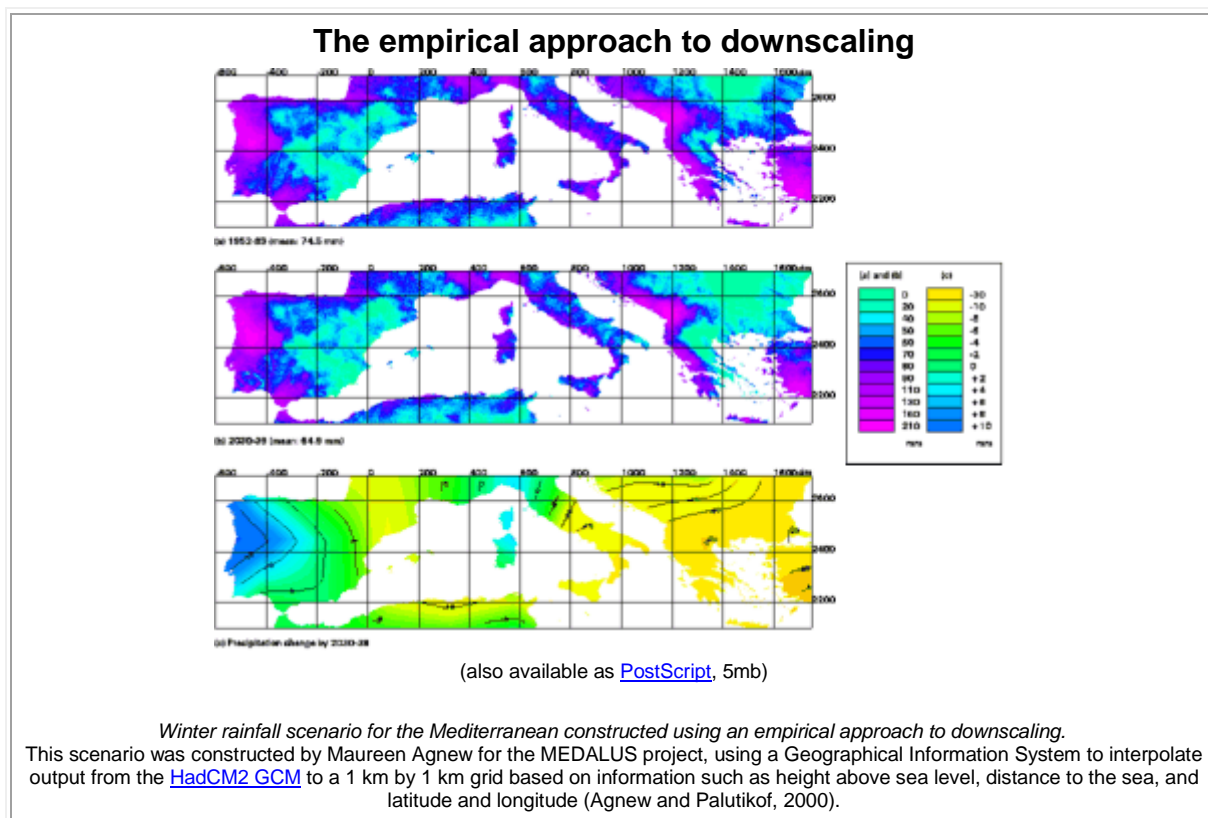
Raw output from GCMs is rarely used in assessments of the environmental and economic impacts of climate change because of the relatively coarse spatial scale. Furthermore, confidence in the reliability of the output tends to decrease moving from the global to the grid-box scale, and from the annual to the monthly and ultimately the daily time scale. In

order to address these problems of scale and reliability, various techniques have been developed for 'downscaling' from the coarse GCM scale to the finer spatial scale required for impact assessment (which may be a particular country, or a river basin or even a single site). No one method is universally appropriate and what may seem good in one region may be poor in another climate regime.

- *If scenarios with a high spatial resolution are required, what method of downscaling should be used?*

Two major approaches to downscaling can be identified: model-based and empirical. The first approach involves nesting a finer-scale Regional Climate Model (with a typical spatial resolution of 50 km) within the coarse-scale GCM. This approach is considered to have good potential, but is currently subject to a number of technical problems and limitations. The second approach, empirical downscaling, requires the identification of quantitative relationships between the observed large-scale and regional climate, which are then applied to large-scale GCM output (making the assumption that these relationships will remain unchanged in a future, warmer world). It has the advantage of requiring fewer data inputs and computing resources than the model-based approach, but there is a need for further development and comparison of both approaches to downscaling. There have been, at present, very few direct comparisons of the two approaches.





Climate change scenarios are most commonly constructed for temperature variables and, with lesser confidence, for moisture-related variables. Scenarios can, however, be constructed for other variables, such as sea level change (see [Information Sheet 10](#)).

Further reading

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- Wilby, R.L., Wigley, T.M.L., Conway, D., Jones, P.D., Hewitson, B.C., Main, J. and Wilks, D.S., 1998: 'Statistical downscaling of general circulation model output: A comparison of methods', *Water Resources Research*, **42**, 2995-3008.

Relevant web sites

- Climate Impacts [LINK](#) project: distribution centre for output (including daily data) from the UK Met. Office Hadley Centre GCMs.
- Intergovernmental Panel on Climate Change ([IPCC](#))
- IPCC Data Distribution Centre ([IPCC DDC](#)): distribution centre for monthly GCM output from seven international modelling groups and expert advice on scenario construction.
- IPCC Special Report on Emission Scenarios (SRES): Summary for Policymakers. The SRES scenarios have been constructed for the IPCC Third Assessment Report (due to be published in 2001).
- MAGICC and SCENGEN: Model for the Assessment of Greenhouse-gas Induced Climate Change and a global and regional SCENario GENERator.
- UKCIP98 climate scenarios report: Climate change scenarios for the United Kingdom, see Hulme and Jenkins (1998).

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