

Achieving Regional Climate Information Through Model Evaluation And Diagnostics

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There are various approaches towards obtaining climate change scenarios at regional scales, typically using output from GCMs or RCMs either directly or via some statistically-based or empirically-based transformation. An assessment of the reliability of such scenarios is as important as the scenarios themselves. This talk will outline (with some examples) one approach to this problem, through the evaluation of model simulations (either GCMs or RCMs) by comparison with observations. We cannot wait until the end of the 21st century to evaluate their simulation of regional climate change, but it *is* possible to consider variations on shorter time scales and use this evaluation to inform decisions about the reliability and use of model output for various locations, variables and seasons. In certain situations, such evaluation may provide the opportunity not only to identify bias, but also to apply quantitative corrections to yield usable results.

An evaluation-based approach benefits from a separation of the expected climate change signal into several components, so that these can be compared with observations in a way that is appropriate to each component. One such separation might be (for temperature, precipitation or some other variable): (i) atmospheric circulation response to climate change; (ii) change in climate variable driven by atmospheric circulation change; (iii) change in climate variable not driven by atmospheric circulation change. Relationships between circulation and climate variables [i.e., component (ii)] are perhaps the easiest to evaluate, building on statistical/empirical downscaling techniques (though only down to the scale of a model grid box). The dynamical response of atmospheric circulation [i.e., component (i)] is harder to evaluate, though it is an *a priori* assumption of statistical/empirical downscaling techniques that this component *is* more reliably simulated than some smaller scale climate features. Inter-model spread might be one evaluation technique for (i); alternatively we might consider the response to lower boundary conditions, such as interannual SST variations or the regular annual cycle of climate, or atmospheric forcing, such as volcanic aerosols, in comparison to the observed response. The residual variations [i.e., component (iii)] aren't attributed to any particular mechanism, so here all we can evaluate is the changes during the past century against those simulated during appropriately forced model simulations. Such changes are typically rather small, and not very detectable at the regional or local scale, though it should be noted that the removal of the circulation-related variations [(i) and (ii)] actually improves the detectability of the residuals [(iii)].

This approach can be extended to a finer separation, though we are usually limited by availability of observational data (and maybe by appropriate model

experiments and archived output). For precipitation, we might consider a further separation into the components (i) and (ii) listed above, plus (iii) the changes in atmospheric moisture (e.g., specific humidity); (iv) the response of precipitation to atmospheric moisture; and (v) the residual precipitation variations not associated with either atmospheric circulation or moisture changes. The new component (iv) is perhaps the simplest to evaluate, when data is available. As the signal is separated into more components, the residuals [i.e., component (v) now] can be expected to lose their initial improved detectability and become more dominated by noise – thus harder to evaluate, but also less important for the models to simulate reliably.

The outlined approach provides the basis for a step-by-step evaluation of model simulations, and therefore the quantification of reliability or uncertainty. In addition to providing an evaluation, the differences between observed and simulated relationships [i.e., components (ii) and (iv)] could be used to adjust for bias in the simulated climate. The approach can also identify both the need and the potential for use of statistical/empirical downscaling approaches. Finally, the most direct form of model evaluation is detection of the climate change signal in the observed record; at present, signal detection and attribution studies use only very large scale signals because the detectability at smaller scales is weak, and thus detection cannot help in evaluating regional scale climate model reliability. The separation of the climate change signal into the various components can, as mentioned above, improve the detectability; since this improvement will be greatest at the regional scale, it may offer the possibility of using signal detection to assess regional-scale model reliability.