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Uncertainties in the Climate Mean State of Global Reanalyses, Observations, and the GFDL Climate Model

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Developing and validating climate models depends crucially on the availability of realistic atmospheric data. For many quantities, reanalyses are commonly used for this type of work. However, climate models are continuously improving, whereas some reanalyses depend on models developed more than a decade ago. This and other issues pose the question of how accurate reanalyses represent the true climate mean state of the atmosphere, and whether it is still appropriate to validate climate models against reanalyses.

Here, we investigate data from four popular global reanalysis products over the period 1979-1999. For a wide range of quantities, we document the reanalysis errors by comparing against multiple observations and by calculating normalized root-mean-square errors for different seasons and regions. In order to provide a benchmark for the comparison, we also include the output of the GFDL climate model. Furthermore, we estimate the magnitude of observational uncertainties from comparing multiple observational data against each other.

We find that the accuracy with which reanalyses reproduce observed climate varies widely, with radiative quantities having the largest biases. The different reanalysis products share many common systematic errors, but overall the ERA-40 reanalysis are closest to the observations. Surprisingly, the mean state simulated by the GFDL climate model is often more realistic than that of the reanalysis. We discuss the significance of our results in light of the specific uncertainties associated with the individual

products and in comparison with conventional observations. This provides important details on how to best utilize existing reanalyses for model validation and climate change studies, and it gives some guidance for the design of future reanalysis products.