



## Circulation patterns and their differences – A probabilistic point of view

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The comparison of circulation patterns (CP) obtained from reanalysis data to those from general circulation model (GCM) simulations is a frequent task for model validation, downscaling of GCM simulations or other climate change related studies. Here, we suggest a set of measures to quantify the differences between CPs. A combination of clustering using Gaussian mixture models with a set of related difference measures allows to take cluster size and shape into account and thus provides more information for comparison than the Euclidean distances of cluster centroids. The characteristics of the various distance measures are illustrated with a simple simulated example. Subsequently, we use a Gaussian mixture model to define and compare circulation patterns obtained for the North Atlantic region among reanalysis data and GCM simulations. The CPs are independently obtained for NCEP/NCAR and ERA-40 reanalyses, as well as for 20th century simulations from several GCMs of the IPCC-AR4 database. The performance of GCMs in reproducing reanalysis CPs strongly depends on the CPs looked at. The relative performance of individual GCMs furthermore depends on the measure used to quantify the difference, e.g., if size and shape information are considered or not. Especially the latter highlights the complementarity of the suggested measures to the classical Euclidean distance.