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Are the CMIP5 GCMs able to simulate atmospheric blocking situations over Europe ?

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Some studies show that most General Circulation Models (GCMs) have difficulties to simulate the main observed circulation patterns and their frequencies. However, this does not only impact the GCM based projections for future climate, but also the results of downscaling methods using the circulation simulated by GCMs as forcing. Indeed, the downscaling methods are not able to correct the biases introduced by the GCM simulations in the free atmosphere. Here, we focus on the anticyclonic blocking situations over western Europe for summer (June, July and August). Indeed, these blocking situations, which are often related to droughts and heat waves, could become more frequent due to global warming. Moreover, their frequency and persistence depend on the variability of the circulation, which is known to be difficult to reproduce by the GCMs.
In order to evaluate the ability of the GCMs to reproduce the observed frequency and persistence of blocking situations, we compare them with two reanalysis datasets (NCEP-NCAR 1 and ECMWF ERA-40) by using an automatic circulation type classification. The daily geopotential height at 500 hPa over the last 30 years of the current climate simulation (Historical experiment, 1976-2005) of all available CMIP5 GCMs prepared for the upcoming IPCC report AR5 is used here. The circulation type classification groups similar daily circulation situations together on basis of a leader-algorithm to obtain a few homogeneous circulation types describing the general circulation of the region. Thus, the frequency and the persistence of each circulation type can be analysed on a daily timescale.
We show that the ability of the GCMs to reproduce the observed frequency and persistence of blocking situations is influenced by the anomalies in their circulation type frequency repartition. So, the GCMs which underestimate the frequency of the anticyclonic types tend to simulate less and shorter blocking situations. The contrary is observed for GCMs that overestimate the frequency of these circulation types. This rises questions about the reliability of the future projections for events related to blocking situations. Indeed, when applying the same approach as for the current climate to the future projections (experiments RCP4.5 and RCP8.5), it seems that the blocking situations become more frequent and persistent. However, when considering only the circulation patterns by removing the mean geopotential height increase due to global warming, there is no significant circulation change till 2100. This means that the GCMs conserve their circulation biases in spite of climate change and so, the frequency and the persistence of the blocking situations are projected to remain almost the same as those simulated for the current climate.