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Modes of blocking variability in the Atlantic European region and their relationship with interannual to multidecadal variability of extreme climate phenomena over Europe

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The dominant modes of blocking frequency variability in the Atlantic-European region are evaluated for the 1871–2010 period. An Empirical Orthogonal Function (EOF) analysis of a two-dimensional blocking indicator field reveals three dominant patterns of interannual to multidecadal blocking variability. The first pattern captures an out-of-phase blocking frequency anomaly over Greenland and Western Europe regions. The second pattern shows a dominant center over the North Sea region as well as a less pronounced center with anomalies of the same sign over southeastern Greenland. The third pattern is an east-west dipole of blocking frequency anomalies from Scandinavian and southern Greenland regions. The link between these patterns of blocking variability and stable oxygen isotope variability is explored by using an isotope simulation from a general circulation model (ECHAM5) where the 3-dimensional wind fields are nudged to those of NCEP/NCAR reanalysis. It is shown that the first mode of blocking variability is related to stable oxygen isotope variability over entire Greenland with strongest correlation in the south. The second and the third mode of blocking variability show the strongest correlations with oxygen isotope variability from central and eastern Greenland respectively. These relationships are demonstrated further using high resolution ice core records of stable isotopes from these regions. In particular we show that decadal to multidecadal variations of a stable isotope record from central Greenland, covering the last millennium, are in phase with decadal to multidecadal variations of the second pattern of blocking variability during the common period. We identify also coherent variations in the third mode of blocking variability and Greenland stable isotopes at $\sim$20 years time scales. Using observed gridded data (E-OBS data set) of daily minimum and maximum temperature and daily precipitation amounts we calculate several cold, warm, heat and rain climate extreme indices over Europe and the corresponding anomaly patterns associated to the dominant modes of blocking variability. Coherent interannual to multidecadal variations in these patterns of extreme climate indices variability, blocking and Greenland ice core records were detected. We suggest that stable isotopes records from southern, central and eastern Greenland can be used to reconstruct part of the interannual to multidecadal blocking variability and associated extreme climate indices over Europe.