An objective classification scheme for Central European "Großwetterlagen" and its application on AOGCMs

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European "Großwetterlagen" (GWL) are continental scale patterns that dominate European weather over a time period of several days. They differ from Circulation Weather Types (CWT) as they represent periods with the same basic large-scale flow, rather than variations due to travelling lows and highs on a (sub-)daily basis. They are operationally identified by forecasters of the German Weather Service (DWD) on a subjective basis since 1881. An objective classification scheme has been developed in order to define European GWL from ERA40 re-analysis and Atmosphere-Ocean coupled General Circulation Model (AOGCM) data. For a comparison the objective classification is applied to the ERA40 data and two coupled AOGCMs (ECHAM4/OPYC3 and ECHAM5/MPI-OM1).

Method

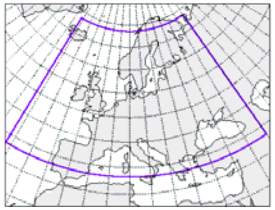

Fig. 1: Calculation area: 22.5°W to 45°E; 68°N to 38°N.

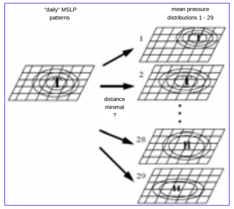

Fig. 2: Process of GWL assignment.

A simple objective classification scheme has been developed in order to define European GWL from re-analysis and GCM data. The method is based on the calculation of the average sea level pressure pattern (MSLP) for each GWL, using the operational subjective classifications as a basis. The considered domain is shown in Figure 1. Using these pressure patterns, an objective classification is carried out by identifying the closest GWL pattern for each day in the re-analysis data (cf. Fig. 2). A previous study based on NCEP winter half-year data has an agreement of 39 %. The simple change of the data base (currently ERA40) increases the hit rate to 40.1 %. In particular, it is demonstrated that a better agreement between subjective and objective GWL is obtained by using the 850 hPa geopotential height (GPH) for the classification process for the summer season (Tab. 1, right column). On the other hand better agreement for the winter half-year is obtained from MSLP data classification (Tab. 1, central column). Using the combination of both levels (winter MSLP and summer 850 hPa), the method is able to classify 36.8 % of all GWL.

	winter	summer
850 hPa GPH	37.9	33.8
MSLP	40.1	31.2

Tab. 1: Agreement between subjective and objective classified GWL in percent.

Present climate

ERA40 vs. ECHAM

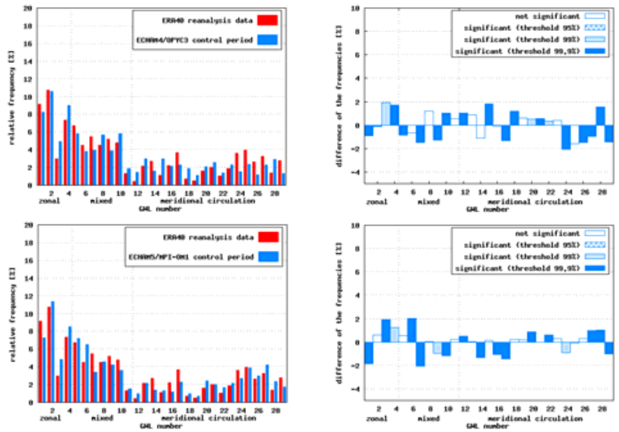

Fig. 3: Comparison of the relative frequencies for the objective GWL classification (left) in percent of the ERA40 re-analysis data and the ECHAM4/OPYC3 control period (1880 – 1929) for the winter (top, MSLP data) and the differences between ERA40 and control period in percent and their significance. Bottom: Same comparison of the ERA40 and ECHAM5/MPI-OM1 winter half-year.

Due to the weaker pressure gradients in the summer half-year, the results show better skills for the winter half-year. Nevertheless, the assignments of the method are - by and large - comparable. Here, we restrict to winter half-year results. The comparison of ERA40 and ECHAM4/5 data show similar climatologies (Fig. 3 – left panels). The maximum difference between the classification on basis of re-analysis and model output data comprises two percent (GWL 6 and 7). However, this difference is significant at the level of 0.01 % for several GWL (dark blue shading).

AOGCM climate signal

ECHAM4/OPYC3 (IS92a)

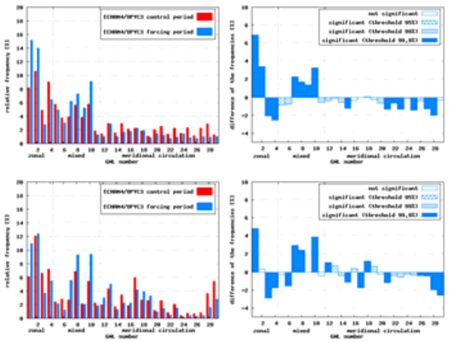

Fig. 4: Relative frequencies for the objective GWL classification (left) in percent of the ECHAM4/OPYC3 control (1880 - 1929) and forcing period (2040 - 2089) for the winter (top, MSLP data) and the summer half-year (bottom, 850 hPa GPH) and the differences between forcing and control period in percent and their significance.

ECHAM5/MPI-OM1 (A1B)

(Ensemble mean)

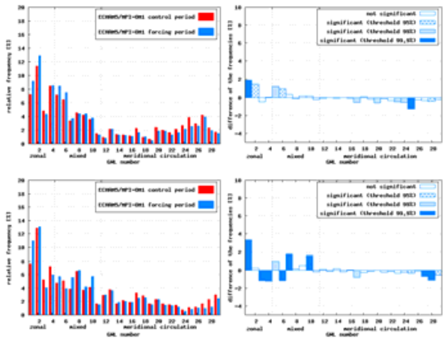

Fig. 5: Relative frequencies for the objective GWL classification (left) in percent of the ECHAM5/MPI-OM1 control (1940 - 1989) and forcing period (2040 - 2089) for the winter (top, MSLP data) and the summer half-year (bottom, 850 hPa GPH) and the differences between forcing and control period in percent and their significance.

In general, the objective classification for the AOGCMs shows an increased zonal and mixed circulation with greenhouse gas (GHG) forcing, and a decreased meridional circulation for the compared periods. The strongest signal is visible for the ECHAM4/OPYC3 winter classification (cf. Fig. 4, top). A somewhat weaker signal is found for the summer season. The differences between GWL frequencies, determined on basis of forcing and control period of the ECHAM5/MPI-OM1, ensemble are less pronounced than the ECHAM4/OPYC3 results (cf. Fig. 5). In general, there is a development within the zonal GWL (Numbers 1 to 4), indicating a shift to the northerly types (GWL 1 and 2).

One may speculate that the increase of winter precipitation over Northern Europe found in other climate change studies with the ECHAM GCMs, as well as the corresponding decrease in the Mediterranean, can at least partly be explained by the GWL changes. A changed scenario cyclonic activity as obtained by Pinto et al. (2006 and 2007) support these assumption.

Conclusion & Outlook

The presented scheme enables the objective classification of GWL on basis of MSLP for winter and 850 hPa GPH for summer in a suitable way. The comparison of ERA40 data with the control period of ECHAM4/OPYC3 reveals an overestimation of zonal account for meridional flow types. The climate signal of the two regarded AOGCMs shows similar tendencies for both half-years: an increase of the zonal and mixed and a decrease of the meridional GWL is visible. The future increase of westerly flow, as indicated by the presented results, suggests the enhanced transport of humid air from the Atlantic to the Central European region. This comes along with a higher potential for trough passages for Northern and Central Europe and is able to enhance local precipitation rates. Similar results for zonal and meridional flow were obtained by Donat et al. on basis of a CWT classification (Session NH1.2).

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