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SPATIAL-TEMPORAL CHANGES OF METEOROLOGICAL PARAMETERS IN SELECTED CIRCULATION PATTERNS

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ABSTRACT

The study presents temporal and spatial changes of characteristics of different meteorological parameters within several circulation patterns. The frequently used Großwetterlagen by Hess/Brezowsky and daily values of 11 meteorological parameters of 270 climate stations and 2072 precipitation stations for the period 1951–2006 are the data basis. It is obvious that several parameters show a trend within the Großwetterlagen and that these changes are not spatially uniform over time. The strength and direction of tendencies depend on the meteorological parameter, the Großwetterlage and the season. Amongst other things, we could show that a distinct positive temperature trend can be verified for the Großwetterlagen WZ in winter and for HM and BM in summer. The more or less differentiated results of the other parameters examined will be discussed. These results have to be taken into consideration if statistical downscaling methods are used.

1 INTRODUCTION

Downscaling methods are developed to obtain local-scale surface weather from regional-scale atmospheric variables provided by general circulation models (GCMs) or derived from observed circulation patterns known as Großwetterlagen. The method according to Comrie (1992) by which one can divide a climate signal from an underlying synoptic signal may serve as an example. Besides the dynamical downscaling (Hay & Clark 2003) the statistical downscaling can be divided into four categories: regression methods, weather pattern-based approaches, stochastic weather generators and limited-area modelling (Wilby & Wigley 1997). 'The main drawbacks of statistical downscaling methods are that they assume that the derived cross-scale relationships remain stable when the climate is perturbed, they cannot effectively accommodate regional feedbacks and, in some methods, can lack coherency among multiple climate variables' (IPCC 2007, see also Matulla & Haas 2003).

In this connection changes, for instance of the frequency of Großwetterlagen (GWL), have already been tracked within the context of regular publications on the cataloguing and accompanying statistical analyses of Großwetterlagen in Europe (Fricke 2002, Stehlik & Bárdossy 2003, Gerstengarbe & Werner 2005, Planchon et al. 2009). Analyses recently conducted show that such changes which, moreover, differ spatially in their occurrence may not be neglected (Bissolli & Müller-Westermeier 2005, van den Besselaar et al. 2010). Also of interest is the problem of temporal changes in the statistical relations between large-scale circulation and smaller-scale weather (Mauraun et al. 2010). On the basis of selected examples, we will show that such changes exist in an extended sense. For the following study the Großwetterlagen by Hess/Brezowsky (Werner & Gerstengarbe 2010) were used. Most classifications are based on variables describing baric fields (sea level pressure, geopotential height), usually gridded or in map form (Huth et al. 2005). Because of this the results of the following investigation are valid generally for all GWL.

In order to receive stable estimations of the statistics of the meteorological parameters, only frequently occurring GWL were examined. The study focuses on 12 different meteorological parameters. Germany was chosen as the target region since it lies approximately in the centre of GWL patterns.

The 2nd section gives an overview of the data used in this investigation followed by a description of the methods in section 3. The results are discussed in section 4. The paper ends with some conclusions (section 5).

2 DATA

Although GWL information spans more than 125 years (1881–2009) (Werner & Gerstengarbe 2010), the daily values of the 11 meteorological parameters were available for the more limited time period 1951–2006 at 270 climate stations, including five stations in Austria and Switzerland. Additionally, 2072 precipitation stations were used with interpolated values of the 10 parameters from the climate stations. All time series were tested for completeness and homogeneity so that a consistent data set was available in the end. Figure 1 illustrates the position of the stations in the investigation area.

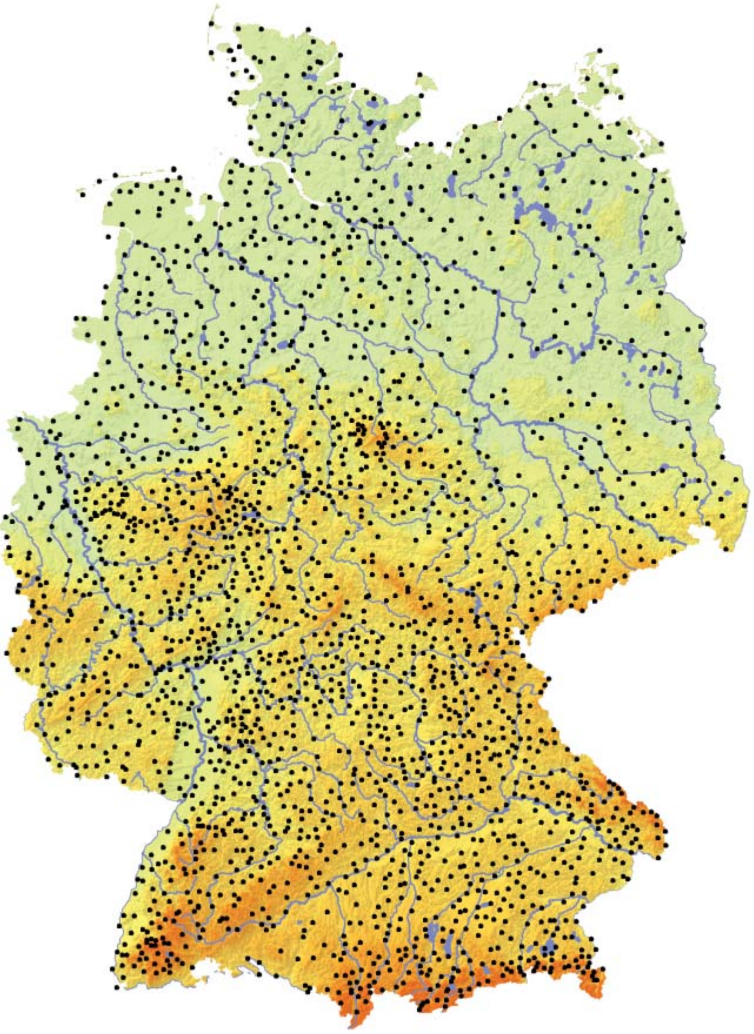

Figure 1: Meteorological stations

The chosen parameters were maximum, mean, and minimum of air temperature [°C] (tmax, tmean, tmin); precipitation [mm] (prec); relative air humidity [%] (rehu); air pressure [hPa] at station altitude (airp); water vapour pressure [hPa] (wvap); sunshine duration [h] (sund); cloud amount [eighths] (cloa); global radiation [J cm^{-2}] (grad); and wind velocity [m s^{-1}] (wind). The Austrian and Swiss stations were included in order to obtain better conclusions for the orographically heavily structured alpine region. Additionally, the daily amplitude [K] of air temperature (tamp) was derived. Basically, the investigations refer to the Großwetterlagen ‘west, cyclonic’ (WZ), ‘high, Central Europe’ (HM) and ‘high pressure ridge, Central Europe’ (BM). The patterns of these Großwetterlagen are shown in Figure 2a–c. These are the most frequent Großwetterlagen with an annual mean occurrence between approx. 8 % and 16 % (Werner & Gerstengarbe 2010). This relates to a sample size of about 1635 to 3270 values (year) and 818–1635 (half-year). Preliminary investigations have shown that the statistical estimations of the parameters were stable with these sample sizes (not shown here). The other GWL only have a frequency of occurrence between 2 % and 5 %. For these GWL, a stable estimation of the statistical parameters is not guaranteed and was used solely to check issues detected. These are ‘southwest, anticyclonic’ (SWA), ‘high Fennoskandia, anticyclonic’ (HFA), ‘high Northern Sea-Fennoskandia, anticyclonic’ (HNFA), ‘southeast, anticyclonic’ (SEA), and ‘south, anticyclonic’ (SA).

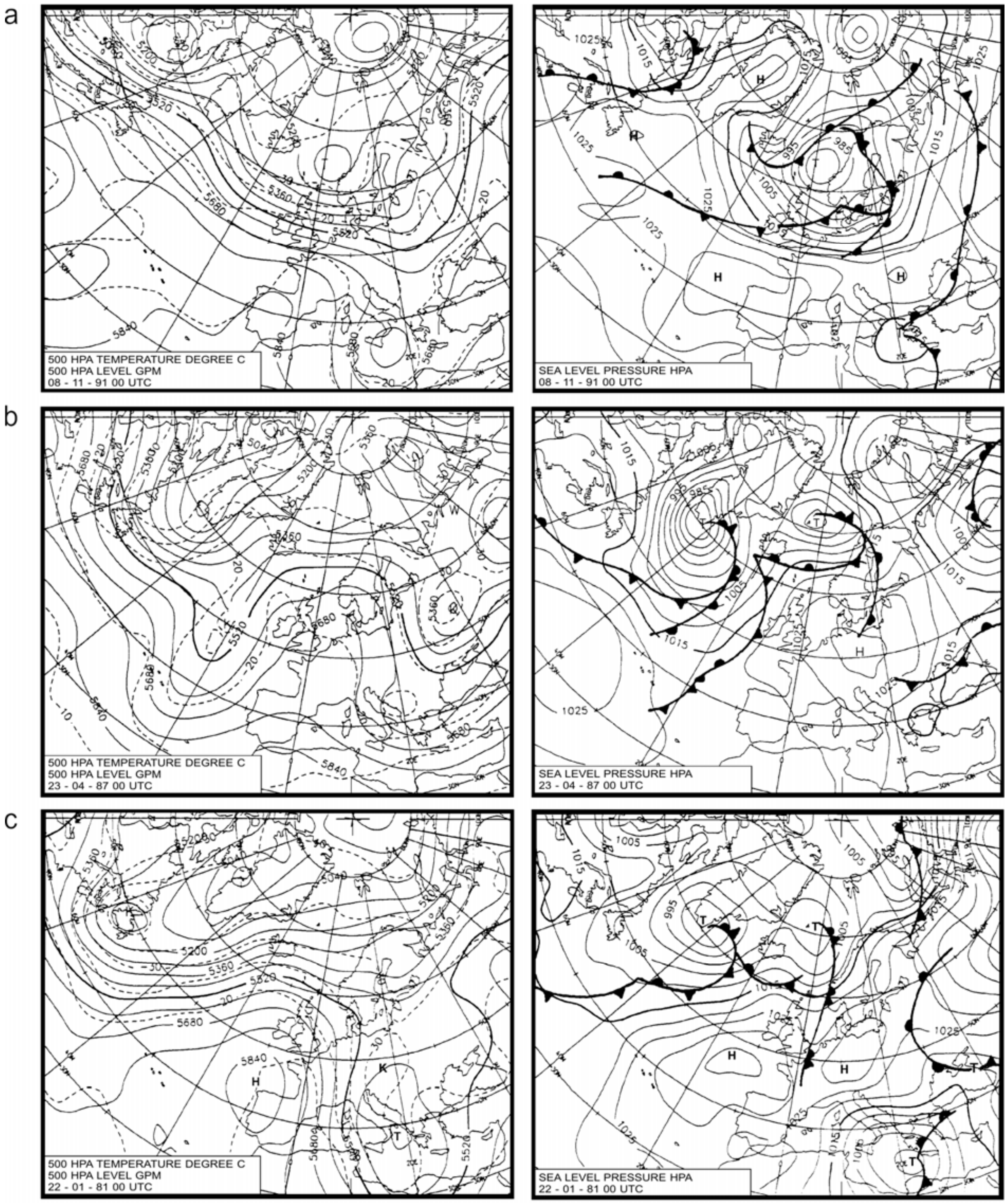

Figure 2: Circulation pattern of a) WZ, b) HM and c) BM

3 METHODS

Analyses were made for the hydrologic half-years (summer: May–October, winter: November–April) since GWL show a different weather behaviour in summer and winter (e.g., HM: very warm–very cold).

For the frequently occurring GWL WZ, HM, and BM, the variations of different meteorological parameters (daily mean and daily sums) between 1951 and 2006 were estimated. Since the variations in the frequency of the occurrence of different Großwetterlagen do not happen evenly within a year, anomalies from the daily value (value = mean [1951/2006]) were used for meteorological terms so that results were not 'distorted' by the annual course. There are two ways to calculate anomalies: either, one sums up the values of all years for every day, calculates the mean, and subtracts this from the current daily value, or one additionally streamlines the row of mean values. In the examination presented, the additional streamlining was considered. Figure 3 shows the changes in frequency of occurrences of HM. To derive this, the investigation period of 56 years was divided into periods of 28 years in order to calculate the differences between the two periods. In calculating the mean value related to GWL, one can easily see whether the parameter values for a particular GWL lie above or beneath the long-time overall mean.

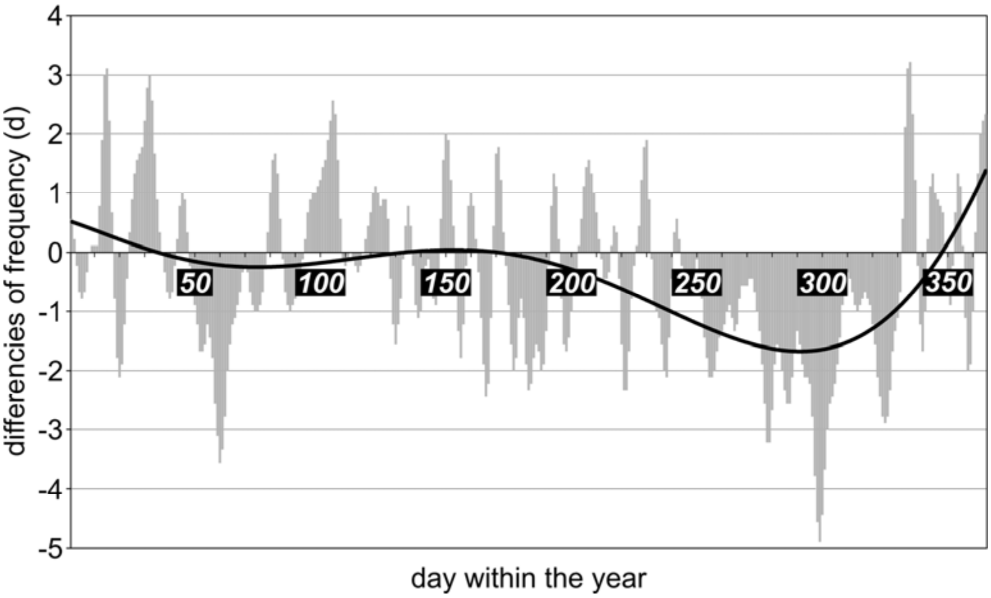

Figure 3: Differences (1979/2006 − 1951/1978) of the frequencies of HM in the course of the year (smoothed)

In the next step, anomalies and linear trends of the meteorological parameters related to selected GWL averaged for the investigation area were calculated. There is, of course, an inter-decadic variability within the time series. So the question arises if a trend within these time series can approximately be described by a linear adaptation. For this, a preliminary investigation was carried out, and its result is exemplarily depicted in Figures 4a and 4b. Here we see that the residues of linear and polynomial adaptations (polynomial of 3rd degree) differ only marginally. All examined trends of meteorologic values behave in a similar way. Hence, the employment of the linear trend is justified for this investigation. The statistical significance of the calculated trends was checked by Spearman's rank test (Kendall & Gibbons 1990). The results are discussed within section 4. For cases showing considerable variations, maps of Germany were generated both for mean conditions and for trends within the period 1951–2006. This latter statistical parameter was checked for significance using the Spearman rank correlation test (error probability 5 %). Both tables and figures indicate the alteration of the respective parameter with relation to the whole period (trend).

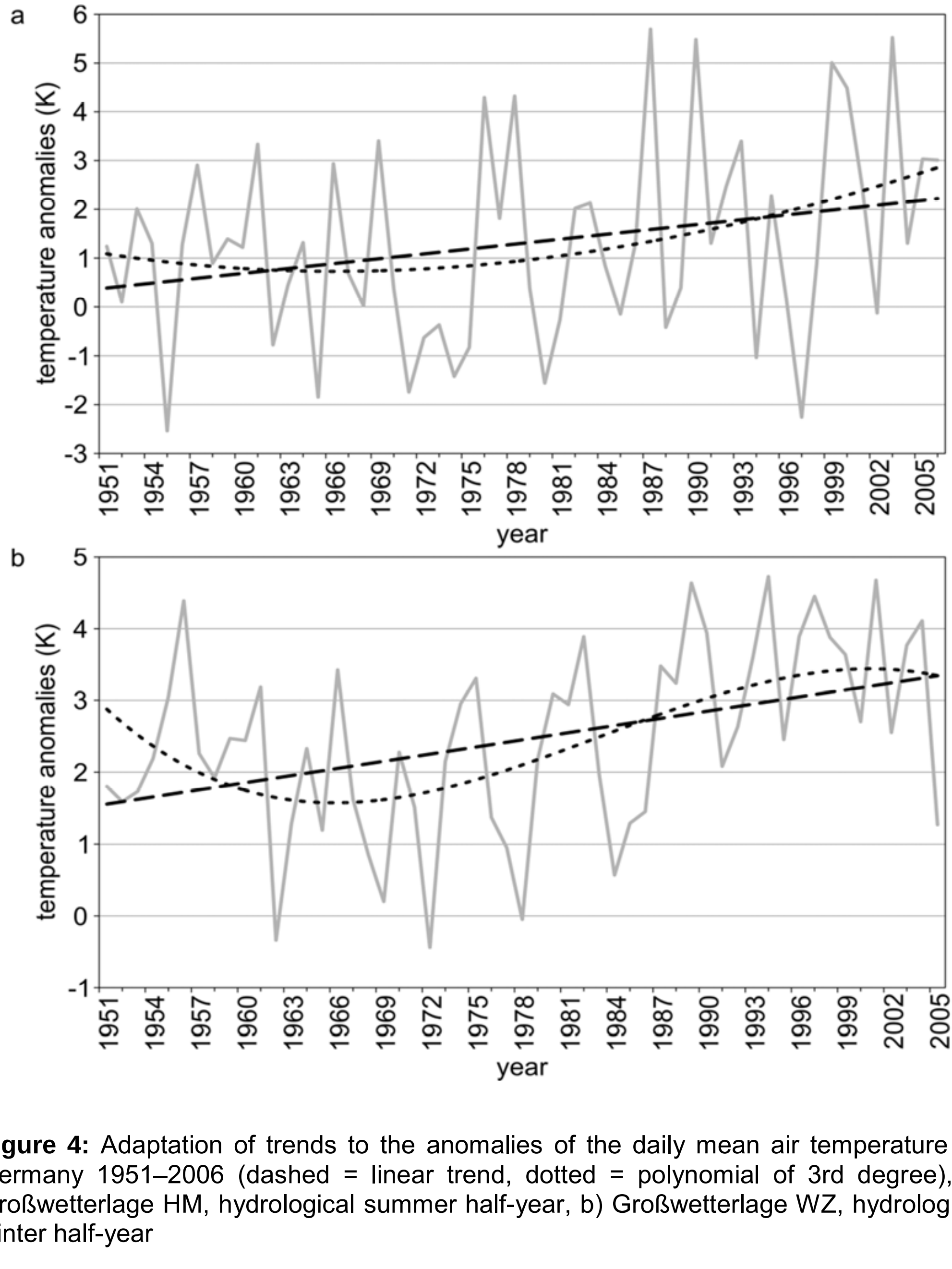

Figure 4: Adaptation of trends to the anomalies of the daily mean air temperature for Germany 1951–2006 (dashed = linear trend, dotted = polynomial of 3rd degree), a) Großwetterlage HM, hydrological summer half-year, b) Großwetterlage WZ, hydrological winter half-year

Moreover, spatial correlations between the meteorological parameters were determined according to half-year and GWL. For this, the four-fold test (Taubenheim 1969) was applied since it is independent of distribution. Only those stations were employed where the trends of both variables were significant.

The line of best fit for the demonstration of the correlation between two meteorological parameters within a GWL was calculated by means of a least-square estimation.

4 RESULTS

For reasons of a general view, the most important results were discussed in the following with the help of some selected examples. All results were summarized in tables which give a good survey of the overall development.

Table 1 clearly depicts how the three Großwetterlagen chosen represent themselves in weather terms. It contains the long-term annual means of anomalies. The GWL can be characterised as follows:

WZ is cooler in summer than normal, apart from tmin, since a higher portion of clouds diminishes radiation. In winter, the air temperature lies significantly above the mean value due to the presence of maritime air masses. WZ is moist, sparse in sunshine and hence in radiation, which lessens the daily amplitude altogether. Wind velocity is far above normal.

HM is the warmest GWL with the least precipitation and highest air pressure among the three GWL selected. But tmin is below normal and, hence, there is a large amplitude in daily temperatures. The reasons for this temperature behaviour are low air humidity, high radiation, sparse cloudiness, and low wind.

In winter, HM is colder than normal, only tmax lies a little above mean, due to high radiation. The other meteorological parameters behave as they do in summer, in terms of sign.

BM behaves similarly to HM but the magnitudes are mostly smaller in figures. Since there is a little more cloudiness than in HM, both half-years show a positive anomaly in tmin but a negative one in tmax in winter.

Table 1: Annual means of anomalies of several meteorological parameters in relation to the chosen Großwetterlage, averaged over the investigated area and the period 1951–2006

Parameter	WZ		HM		BM	
	Summer	Winter	Summer	Winter	Summer	Winter
tmax (°C)	−1.35	2.45	2.52	0.20	1.70	−0.77
tmean (°C)	−0.74	2.67	1.20	−1.00	1.14	−0.96
tmin (°C)	0.05	2.80	−0.65	−1.87	0.28	1.24
prec (mm)	1.15	1.89	−1.93	−1.80	−1.21	−1.37
rehu (%)	2.37	0.18	−6.43	−4.06	−2.74	−0.57
airp (hPa)	−2.49	−3.90	6.01	11.72	4.16	7.04
wvap (hPa)	−0.20	1.13	−0.13	−0.77	0.39	−0.49
sund (h)	−1.49	−0.67	3.35	2.07	1.48	0.64
cloa (eighths)	0.92	0.62	−2.05	−1.89	−0.86	−0.52
grad (J cm^{-2})	−178.41	−55.47	396.11	171.09	192.60	64.49
wind (m s^{-1})	2.80	3.87	−0.50	−0.88	−0.42	−0.73
tamp (°C)	−1.39	−0.35	3.16	2.07	1.41	0.47

The changes over time from 1951–2006, averaged over the investigation area for each major GWL as summarized in Table 2, are not marginal in many cases. For air temperature and thus often also for relative humidity, the trends are frequently considerable. Large increases in sunshine duration and global radiation in HM in summer are documented. In contrast, these values decrease in BM in this season. During this half-year, BM has become a little more moist (see prec) and cloudier (see cloa), causing a decrease of the daily amplitude of air temperature (tamp) as well. The differences in air pressure between these three GWL have diminished a little. In the low-pressure condition WZ, air pressure has increased, while in the high-pressure conditions HM and BM it has decreased.

Table 2: Linear trends of several meteorological parameters in relation to the chosen Großwetterlage, averaged over the investigated area and the period 1951–2006

Parameter	WZ		HM		BM	
	Summer	Winter	Summer	Winter	Summer	Winter
tmax (°C)	0.76	2.41	2.37	0.68	1.26	0.69
tmean (°C)	0.79	1.95	2.33	0.61	1.61	0.36
tmin (°C)	0.71	1.71	1.78	0.69	2.35	0.33
prec (mm)	0.05	0.33	−0.49	−0.06	0.60	0.31
rehu (%)	−0.40	−1.91	−5.27	−2.58	−1.63	−1.38
airp (hPa)	0.43	2.48	−0.04	−0.15	−1.02	−0.99
wvap (hPa)	0.34	0.75	0.41	−0.28	0.78	−0.09
sund (h)	−0.40	0.27	1.73	0.56	−0.70	0.29
cloa (eighths)	−0.03	−0.28	−0.58	−0.42	0.52	−0.11
grad (J cm^{-2})	−56.50	16.13	243.91	24.64	−79.29	16.91
wind (m s^{-1})	−0.31	−0.44	0.06	−0.12	0.26	−0.10
tamp (°C)	0.04	0.70	0.59	−0.01	−1.08	0.36

The extent of variation within the particular GWL can only be seen when considering the spatial component as well. The number (in %) of stations with significant trends (level of error probability not greater than 5 %) is depicted in Table 3. In air temperature, significant trends only occur area-wide in the case of WZ in winter, and they only occur for large parts of the area in the case of HM or BM in summer. In summer, a decrease in precipitation is quite common in HM, and an increase in BM, as well as a massive, widespread decrease in relative air humidity in HM, in general as a result of the temperature and precipitations trends. The proportion of stations indicating an increase in sunshine duration and global radiation in HM in summer is remarkable, as well as those showing an increase in water vapour pressure and the daily amplitude of air temperature, and a decrease of relative air humidity in WZ in winter.

Table 3: Number of stations (%) with significant trends of several meteorological parameters in relation to the chosen Großwetterlage, averaged over the investigated area and the period 1951–2006

Parameter	WZ		HM		BM	
	Summer	Winter	Summer	Winter	Summer	Winter
tmax (°C)	41.7	100.0	62.2	0.1	52.0	18.6
tmean (°C)	40.5	100.0	73.2	0.1	86.4	0.1
tmin (°C)	49.7	99.4	36.0	0.0	96.6	0.0
prec (mm)	4.5	10.5	47.2	9.6	52.9	27.7
rehu (%)	20.7	59.9	72.8	15.6	32.7	36.8
airp (hPa)	2.3	35.5	0.6	0.6	38.2	4.5
wvap (hPa)	19.7	98.8	0.3	1.4	34.0	0.2
sund (h)	21.8	26.4	87.3	15.0	23.9	25.7
cloa (eighths)	14.0	43.9	34.5	2.7	39.4	10.2
grad (J cm^{-2})	20.3	15.4	85.0	5.3	21.7	13.0
wind (m s^{-1})	47.7	40.9	34.2	28.3	50.8	26.7
tamp (°C)	7.3	60.3	13.8	2.0	47.4	17.4

A comparison of the results discussed here for radiation and cloudiness with the results published by Chiacchio & Wild (2010) for Europe shows a good correlation in winter, as regards trends. In summer, this only holds true for the Großwetterlage HM. The reason for this is, on the one hand, the strong influence of NAO in winter for Europe as a whole, whereas the influence of the autochton continental high-pressure weather can be noticed in summer. The spatial distribution of mean and trend values is exemplarily presented for the 270 German climate stations in Figures 5 to 10.

The mean anomaly of air temperature during WZ in the hydrological winter half-year (Figure 5a) generally shows positive values that turn out to be significantly higher in many parts of southern and south-eastern Germany compared to the western and northern areas. During the time frame 1951–2006, temperature (Figure 5b) rises from slightly above 0 K to as much as 4 K, mainly in the areas showing high anomalies already. The next example explores the spatial anomalies in daily maxima of air temperature in HM in summer (Figures 6a, b). Here, the distribution patterns are nearly inverse to the previous example. The highest anomalies and changes can be observed in the western areas of Germany. In another example for temperature, the daily minimum of air temperature in BM in summer (Figures 7a, b), the structure is completely different for some regions. In the north, mean anomalies oscillate around 0 K, whereas they are mainly positive in the south. Tmin increases area-wide, with the core area in southern Germany. If one compares the anomalies in relative air humidity in HM in summer (Figures 8a, b) to the anomalies in daily maximum of air temperature in the same GWL and season of year, the structural relations are reflected approximately. The most notable negative anomalies in mean values are located mainly in the western parts, with some in the southern parts of Germany, approximately where the largest trend decreases can be found as well. It is hard to decide whether the increases recorded at a few stations are measuring errors, or not. In HM in summer (Figures 9a, b), of course, the anomalies in global radiation are significantly positive, as anticipated, and they often amount to considerable mean values, which can also be observed in the trend increases. As an example having a minor spatial structure, the mean anomalies of the daily amplitude in air temperature in WZ in winter (Figure 10a) was chosen. However, more than 60 % of the stations show a significant trend (see Table 3) and these trends are spatially distinctive (Figure 10b).

As an example of a special local climate situation, the Rhön (small mountains in the middle of Germany) is considered. The climate of this area (800–900 m a.s.l.) can be compared with an alpine climate at a height of 1400 m (Beyer 1996). Because of this fact, this roughly triangular 'structure anomaly' in the Rhön area stands out frequently in the maps (Figures 5a, 6a, 7a, 7b, 8a, 9a and 10b).

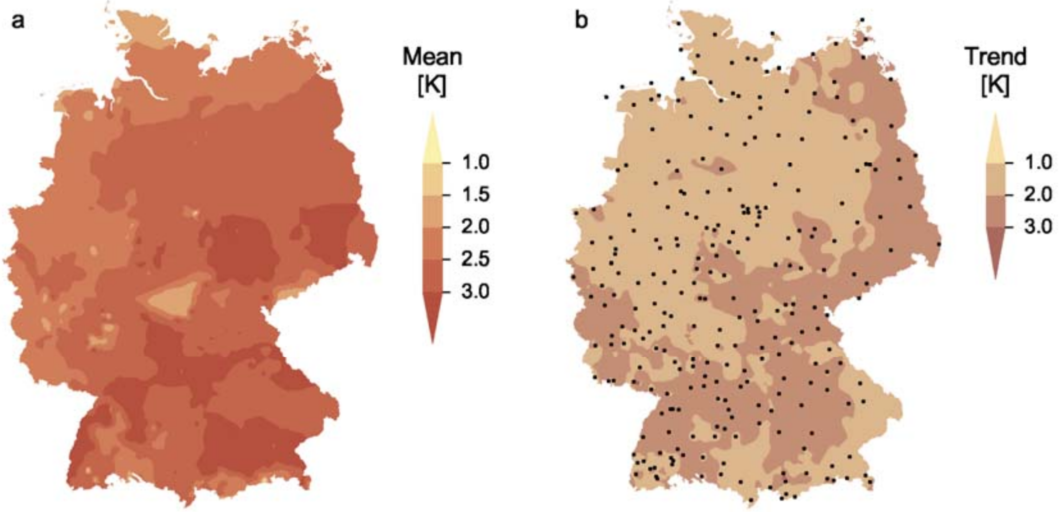

Figure 5: Anomalies of the air temperature during WZ in the hydrological winter half-year, 1951–2006, a) mean, b) trend (• significant trends with level of error probability not greater than 5 %)

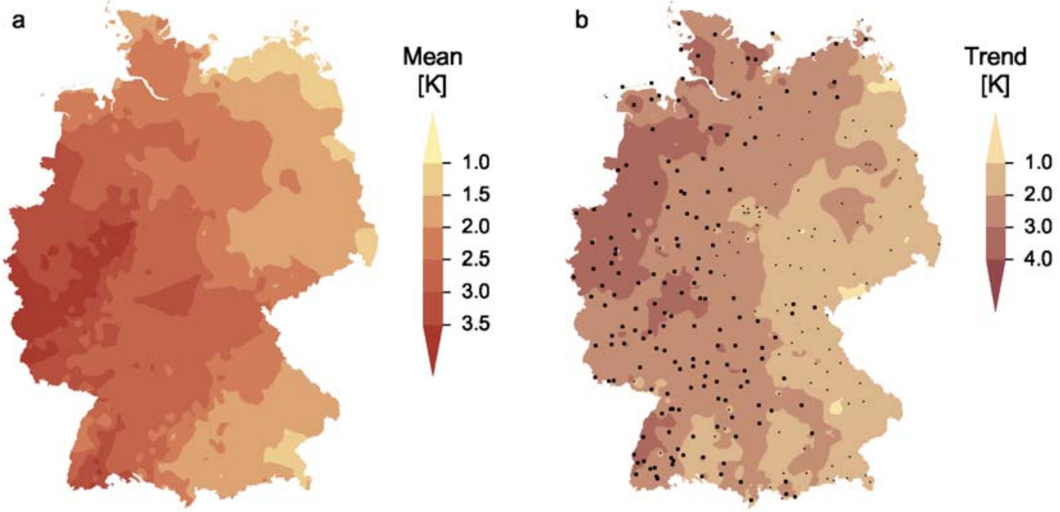

Figure 6: Anomalies of the daily maximum of air temperature during HM in the hydrological summer half-year, 1951–2006, a) mean, b) trend (• significant trends with level of error probability not greater than 5 %)

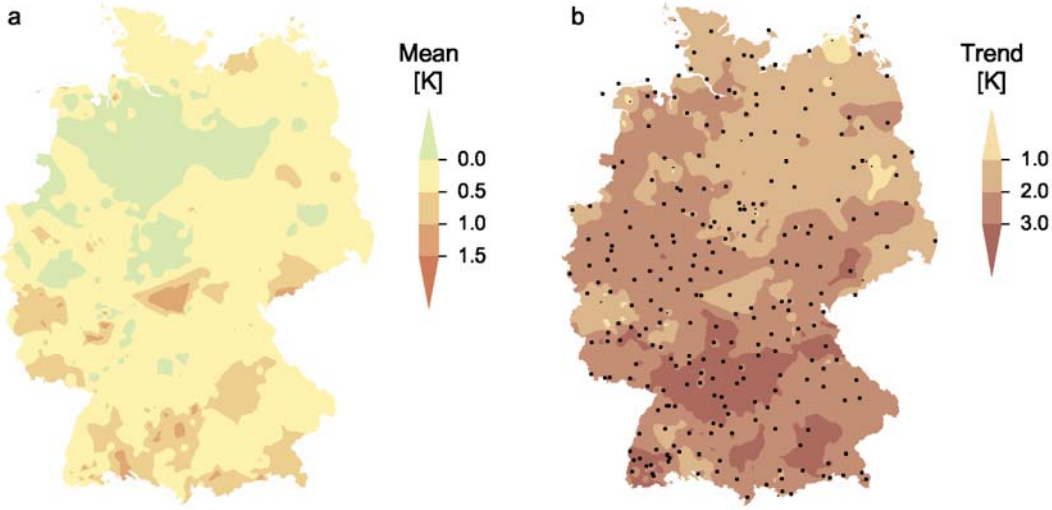

Figure 7: Anomalies of the daily minimum of air temperature during BM in the hydrological summer half-year, 1951–2006, a) mean, b) trend (• significant trends with level of error probability not greater than 5 %)

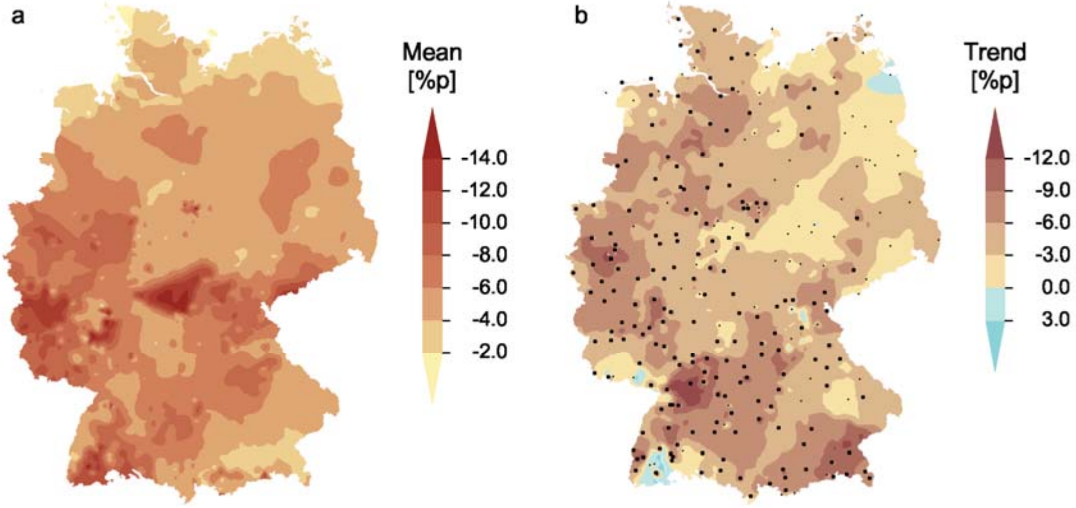

Figure 8: Anomalies of the relative humidity during HM in the hydrological summer half-year, 1951–2006, a) mean, b) trend (• significant trends with level of error probability not greater than 5 %)

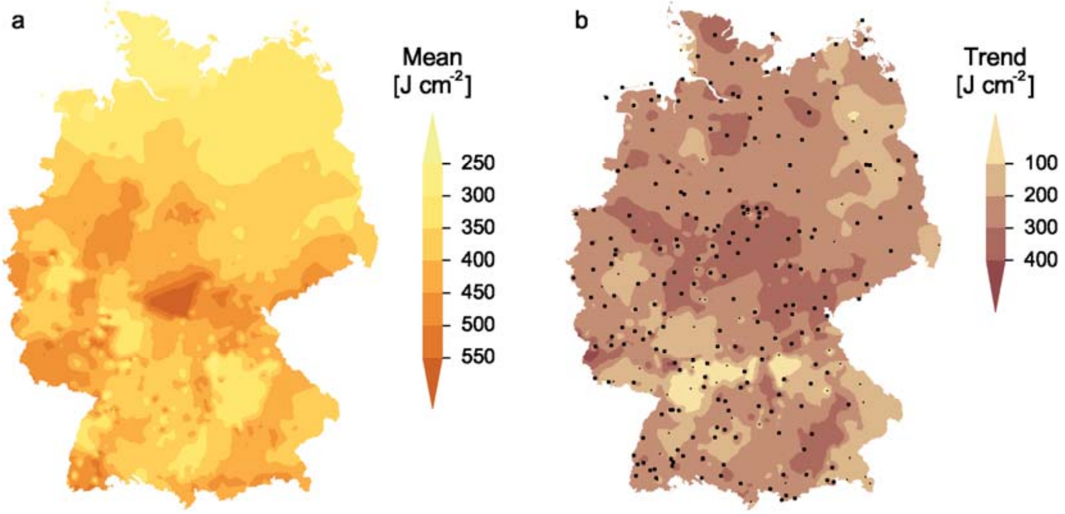

Figure 9: Anomalies of the daily sum of global radiation during HM in the hydrological summer half-year, 1951–2006, a) mean, b) trend (• significant trends with level of error probability not greater than 5 %)

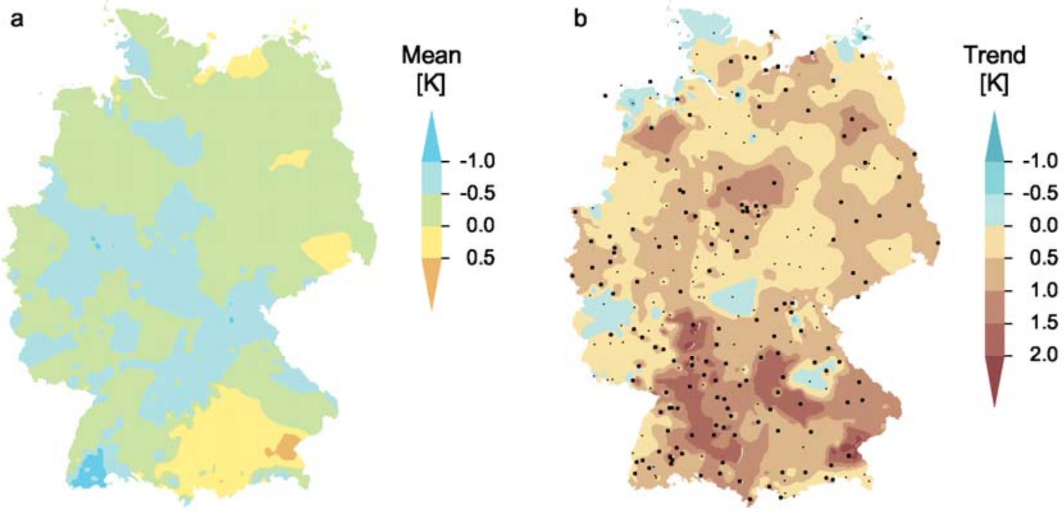

Figure 10: Anomalies of the daily range of air temperature during WZ in the hydrological winter half-year, 1951–2006, a) mean, b) trend (• significant trends with level of error probability not greater than 5 %)

The following investigations show that changes in different meteorological parameters do not occur independently of each other. For each combination of parameters, the trend values at the stations were related to each other, and the correlation was determined by the four-fold test. A prerequisite for this was a significance of trends at 100 stations at least. The values of significant correlations (5 % probability value) can be found in Table 4. One can state that there is no statistically trusted correlation between precipitation trends and the trends in other parameters. The reason for this is mainly the spatial and temporal stochastic character of precipitation. As expected, most of the 'distinct' correlations can be identified among the temperature parameters. The fewest correlations of this kind, but also for other parameter combinations, can be found in HM. This is certainly due to the fact that local influences act especially strongly under these atmospheric conditions. Further parameters correlating closely are sunshine duration, cloudiness, and global radiation. The decrease in relative air moisture in winter, interrelated to a decrease in air velocity and an increase in sunshine duration, is explainable by the fact that the maritime influence, apparently being low anyway, has decreased even more (see also decrease in precipitation, Table 2). A similar correlation can be seen in BM in winter for the combination rehu – wind. For the remaining combinations, explanations are not so obvious. Because of the strong correlations between the different meteorological parameters, the changes of weather patterns within a GWL occur more or less consistently (see also section 5).

Table 4: Significant correlations between the trends of several meteorological parameters in relation to the chosen Großwetterlage, averaged over the investigated area and the period 1951–2006

Parameter combination	WZ		HM		BM	
	Summer	Winter	Summer	Winter	Summer	Winter
tmax – wind	0.76					−0.90
tmax – tmean		0.65	0.58			
tmax – tamp		0.57				0.72
tmax – tmin			0.58			
tmean – tmin	0.92		0.70		0.76	
tmean – wind	0.55					
tmean – grad	0.64					
tmean – rehu		−0.56				
tmean – sund					−0.58	
tmin – tamp		−0.55			−0.65	
rehu – wvap	0.79					
rehu – grad	−0.62					
rehu – sund				−0.63		
rehu – wind				0.98		0.56
wvap – cloa		0.61				
wvap – wind					−0.72	
sund – cloa	−0.90					
sund – grad		0.56			0.74	0.91
cloa – grad	−0.74					
airp – grad					−0.69	
airp – tamp					−0.65	

In order to discover whether these are characteristic trends, five types of high-pressure conditions (SWA, HFA, HNFA, SEA, SA) which are warm in summer were selected, and trends in their meteorological parameters were calculated. Table 5 lists those mean trends where the particular trends are significant. One can recognize that there is a number of parameters where only few stations with a statistically trusted trend can be allocated to the referring circulation pattern. Example: tmax and HFA with a trend of 0.31 K and a station number of 0.7 % = 16 stations.

All of these Großwetterlagen showed large scale changes in the values of several different meteorological parameters. Hence, one can conclude that the value allocation for a GWL does not generally remain stable.

Note that in spite of a considerable increase in sunshine duration and global radiation, air temperature in HNFA decreased markedly (backed by recordings at less than a third of the stations, however). This is contrary to the general development of temperature.

The general trends of meteorological parameters in the several Großwetterlagen were lastly examined (Table 6).

Table 5: Linear trends of several meteorological parameters in relation to the chosen Großwetterlage and number of stations (%) with significant trends, averaged over the investigated area and the period 1951–2006

Parameter	SWA		HFA		HNFA		SEA		SA	
	Trend	Stat. %	Trend	Stat. %	Trend	Stat. %	Trend	Stat. %	Trend	Stat. %
tmax (°C)	2.93	100.0	0.31	0.7	−1.46	20.3	2.89	92.4	1.02	36.4
tmean (°C)	2.52	99.4	0.54	1.2	−1.55	14.9	3.18	100.0	1.54	76.5
tmin (°C)	2.19	96.1	0.62	3.9	−1.80	28.0	3.36	99.2	2.38	90.2
prec (mm)	0.25	10.2	0.26	12.2	−1.58	39.2	0.47	25.4	0.00	-
rehu (%)	−1.59	15.0	−3.52	38.1	−6.63	56.5	−1.07	3.3	−1.24	21.2
airp (hPa)	0.59	7.1	−3.16	96.2	4.03	97.2	0.86	1.3	0.62	2.6
wvap (hPa)	1.46	84.3	−0.39	7.2	−2.23	81.6	2.08	98.3	0.26	26.4
sund (h)	0.60	13.0	0.21	14.9	1.73	44.8	1.30	6.0	−0.69	26.8
cloa (eighths)	−0.20	8.0	−0.09	12.0	−1.34	63.2	−0.34	1.7	0.52	33.6
grad (J cm^{-2})	77.89	10.3	29.26	15.5	135.46	18.5	179.47	10.2	−86.47	32.8
wind (m s^{-1})	−0.18	29.1	0.24	41.8	0.29	64.7	0.21	39.0	0.23	42.2
tamp (°C)	0.74	28.4	−0.31	10.8	0.34	21.1	−0.47	3.1	−1.36	52.4

Table 6: Linear trends of several meteorological parameters and number of stations (%) with significant trends, averaged over the investigated area and the period 1951–2006

Parameter	Summer half-year		Winter half-year	
	Trend	Stat. %	Trend	Stat. %
tmax (°C)	1.49	99.9	1.36	98.1
tmean (°C)	1.43	100.0	1.29	99.7
tmin (°C)	1.38	100.0	1.34	95.6
prec (mm)	−0.02	4.8	0.20	64.0
rehu (%)	−1.99	54.6	−0.49	25.2
airp (hPa)	−0.05	2.4	1.72	69.4
wvap (hPa)	0.50	68.7	0.39	73.1
sund (h)	0.12	4.1	−0.01	10.9
cloa (eighths)	−0.08	12.1	0.04	8.8
grad (J cm^{-2})	21.08	9.8	−6.93	9.3
wind (m s^{-1})	−0.06	37.4	−0.09	36.7
tamp (°C)	0.11	13.8	0.02	21.4

Generally, the trend values and the number of significant trends show the same tendency as the ones assigned to individual GWL but frequently with smaller values. The following considerable differences occurred:

In summer, the temperature trends in HM (only partially in BM) are significantly higher, in WZ considerably lower. In winter, the situation is exactly the adverse as far as GWL are concerned. In HM, relative humidity decreases much stronger during both half-years than normally. The values for global precipitation are, in some cases, a magnitude higher in GWL.

Another interesting question arises from the classification of the so far gained results into the general large-scale development of circulation. For the investigation area chosen here, it is obviously the best to employ the NAO index (Hurrell & Deser 2009) in order to clarify the correlation. NAO values (NAO-Index 2010) for both the hydrologic summer and winter half have been evaluated in their temporal development between 1951 and 2006. If one compares the mean normalized NAO indices for the first ten and the last ten years of the investigation period summer, a decrease from 0.19 to −0.35 results. This test can be statistically backed by the Spearman test with a 5 % error probability. This development goes into reverse in winter, and the index rises from −0.09 to 0.25. This trend is trusted with a 5 % error probability as well. In the catalogue of Großwetterlagen according to Hess/Brezowsky (Werner & Gerstengarbe 2010), it was proved that both high-pressure conditions in summer and west-weather conditions in winter have increased in their frequency and duration. This corresponds well to the development of NAO index as discussed here. Hence, the alterations of meteorologic parameters which have been proved so far gain a special importance within weather conditions with respect to their hydrological impacts. Table 3 makes clear that a great number of the stations examined show a statistically tested positive trend in temperature. For precipitation, such a clear development cannot be proved. So, as an example, a negative development within the trend of the climatic water balance in summer is the result but this differs regionally. A proof of this development can be found, i.a., in investigations on the impact of climate changes on the water balance of the river Elbe (Wechsung et al. eds. 2008). Another proof can be found when considering Baur’s series, which is valid for Central Europe, for temperature and precipitation (Pelz et al. 2011). Within this series, temperature increases significantly both during the summer and the winter half (1 % error probability). The increase is 1.25 K (summer) resp. 1.12 K (winter). Concerning precipitation, significant trends cannot be proved in spite of an apparent decrease in precipitation in summer resp. an increase in winter. Relevant impacts are described, i.a., in Bárdossy & Caspary (1990), Bárdossy et al. (1999), Grabau (1985), Kyselý & Domonkos (2006), and Planchon et al. (2009).

Since the annual courses of meteorological parameters did not change uniformly throughout the year (see Figure 11), the handling of anomalies is still afflicted with errors. However, these errors will certainly not influence the overall conclusions on results.

5 CONCLUSIONS

Within a Großwetterlage, there are spatial structures for the particular meteorological parameters. The changes within GWL are not spatially uniform over time. The trends within the individual GWL examined here are mostly higher in terms of value than the trends for all GWL combined. Moreover, the changes differ according to GWL and season. On the basis of the changes found, one must conclude that the relations between large-scale air pressure and geopotential fields and small-scale fields (points or stations) are generally not stable. Hence, 'downscaling' methods are afflicted with errors that certainly cannot be neglected. This means that the predictors must be chosen in due consideration of instationarities (Schmith 2008). Carrying out simple bias corrections of single parameters in order to diminish such errors makes no sense because this would disturb the temporally relative consistency between the several parameters as was demonstrated previously. A better way to handle these problems is the consideration of the range of climate parameters within the circulation patterns, for instance as bias information in future climate scenario calculations. Additionally the so- called 'best practice method' involves the use of multiple predictor variables such as moisture content, lapse rates, vorticity, etc. to better describe the complexe relationship between regional forcing and local meteorology. But this statistical downscaling technique for present-day conditions does not necessarily imply legitimacy for changing climate conditions (Charles et al. 1999).

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LITERATURE

Bárdossy A, Caspary JJ (1990) Detection of climate change in Europe by analyzing European atmospheric circulation patterns 1881–1989. Theor Appl Climatol 42:155–167

Bárdossy A, Hartmann G, Giese H (1999) CC-HYDRO, Impact of Climate Change on River Basin Hydrology under Different Climatic Conditions. Final Report German Part, ENV4-CT95-0133, iwhw.boku.ac.at/forschung/-Part3_Germany.pdf

Beyer H (1996) Das erdgeschichtliche und historische Klima der Rhön. Rhön-Verlag Hünfeld

Bissolli P, Müller-Westermeier G (2005) The spatial distribution of precipitation in Germany for different weather types. Proceedings from the 5th annual meeting of the European Meteorological Society, Session AW8, Utrecht, 27–37

Charles SP, Bates BC, Whetton PH, Hughes JP (1999) Validation of downscaling models for changed climate conditions: case study of southwestern Australia. Clim Res 12:1–14

Chiacchio M, Wild M (2010) Influence of NAO and clouds on long-term seasonal variations of surface solar radiation in Europe. J Geophys Res 115:1–17

Comrie AC (1992) A procedure for removing the synoptic climate signal from environmental data. Int J Climatol 12:177–183

Fricke W (2002) Hängen vermehrte Starkniederschläge am Hohenpeißenberg mit veränderten Wetterlagen zusammen? Klimastatusbericht, DWD, 165–171

Gerstengarbe F-W, Werner PC (2005) Katalog der Großwetterlagen Europas (1881–2004) nach Paul Hess und Helmut Brezowsky, 6. verbesserte und ergänzte Auflage. PIK Report 100

Grabau J (1985) Klimaschwankungen und Großwetterlagen in Mitteleuropa seit 1881. Inaugural-Dissertation, Universität Paderborn

Hurrell JW, Deser C (2009) North Atlantic climate variability: The role of the North Atlantic Oscillation. J Mar Syst 78, 1:28–41

Huth R, Ustrnul Z, Dittmann E, Bissolli P, Pasqui M, James P (2005) Inventory of circulation classification methods and their applications in Europe within the COST 733 action. Proceedings from the 5th annual meeting of the European Meteorological Society, Utrecht, 9–16

Hay LE, Clark MP (2003) Use of statisticalla and dynamically downscale atmospheric model output for hydrologic simulations in three mountainous basins in the western United States. J Hydrology 282:56–75

IPCC (2007) AR 4, Working Group 1, Regional Climate projections

Kendall MG, Gibbons JD (1990) Rank correlation methods (5th ed.). Edward Arnold, London

Kyselý J, Domonkos P (2006) Recent increase in persistence of atmospheric circulation over Europe: comparison with long-term variations since 1881. Int J Climatol 26:461–483

Matulla C, Haas P (2003) Prediktorensensitives Downscaling gekoppelt mit Wettergeneratoren: saisonale und tägliche CC-Szenarien in complex strukturiertem Gelände. Berichte der GKSS 2003/24

Mauraun D, Wetterhall F, Ireson AM, Chandler RE, Kendon EJ, Widmann M, Brienen S, Rust HW, Sauter T, Themeßl M, Venema VKC, Chun KP, Goodess CM, Jones RG, Onof C, Vrac M, Thiele-Eich I (2010) Precipitation downscaling under climate change: Recent developments to bridge the gap between dynamical models and the end user. Rev Geophys 48:1–34

NAO-Index (2010). www.cgd.ucar.edu/cas/jhurrell/indices.data.html#naostatmon

Pelz J, Rüge U, Schlaak P (2011) Zur Fortführung der von F. Baur im Jahre 1975 veröffentlichten Temperaturreihe für Mitteleuropa ab 1761 und der Niederschlagsreihe für Deutschland westlich der Oder ab 1851. Beilage zur Berliner Wetterkarte, www.Berliner-Wetterkarte.de

Planchon O, Quénol H, Dupont N, Corgne S (2009) Application of the Hess-Brezowsky classification to the identification of weather patterns causing heavy winter rainfall in Brittany (France). Nat. Hazards Earth Syst. Sci. 9:1161–1173

Schmith T (2008) Stationarity of regression relationships: Application to empirical downscaling. J Climate 21:4529–4537

Stehlik J, Bárdossy A (2003) Statistical comparison of European circulation patterns and development of a continental scale classification. Theor Appl Climatol 76:31–46

Taubenheim J (1969) Statistische Auswertung geophysikalischer und meteorologischer Daten. Akademische Verlagsgesellschaft, Geest & Portig, Leipzig

van den Besselaar EJM, Klein Tank AMG, van der Schrier G (2010) Influence of circulation types on temperature extremes in Europe. Theor Appl Climatol 99, 3:431–439

Wechsung F, Kaden S, Behrendt H, Klöcking B eds. (2008) Integrated Analysis of the Impacts of Global Change on Environment and Society in the Elbe Basin. Weißenseeverlag, Berlin

Werner PC, Gerstengarbe F-W (2010) Katalog der Großwetterlagen Europas (1881–2009) nach Paul Hess und Helmut Brezowsky, 7. verbesserte und ergänzte Auflage. PIK Report No. 119

Wilby RL, Wigley TML (1997) Downscaling general circulation model output: a review of methods and limitations. Prog Phy Geogr 21:530–548

PIK Report-Reference:

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