CLIMATE CHANGE AND TOURISM POTENTIAL IN THE BLACK FOREST – A TOURISM AND CLIMATE APPROACH FOR FOREST AREAS

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ABSTRACT How the tourism potential in the low mountain ranges of Germany will change under modified climate conditions is analysed for the Black Forest. The tourism potential is mainly based on the attractiveness of natural parameters, e.g. landscape, flora and fauna. These parameters are highly sensitive to climate.

The A1B scenario, based on the regional model REMO from the Max-Planck-Institute for Meteorology in Hamburg, is used for climatic analyses of selected stations in the Black Forest. The high resolution data is available from 1950 until 2100. The following parameters are computed for the analysis of the climatic potential from 1961 until 2050, exclusively: thermal comfort, heat and cold stress, sunshine, fog, sultriness, precipitation, storm and ski potential. These analysed daily values refer to 14 CET, except for precipitation, which is the total daily precipitation amount. Using human-biometeorological, physical, thermal and aesthetic criteria, frequency classes and frequencies of extreme weather events are compiled based on 10-day-intervals. The derived results are presented in terms of the climate tourism information scheme (CTIS).

KEYWORDS: *Climate change, Black Forest, tourism, climate tourism information scheme*

INTRODUCTION

According to the IPCC (2007) the global surface temperature is raised by 0.74 degree. Climate is a dominant feature for tourist destinations. Global warming and extreme weather events, e.g. storms or heat waves, are related to climate change. Mountain areas are very sensitive to climatic change. Mountain regions offer a high biodiversity and attract people for recreation and sport activities, e.g. hiking in the summer and skiing in the winter season. Therefore, both flora/fauna and tourism are directly influenced. Besides, global warming exhibits a high risk and vulnerability for a slanted tourism towards snow and ski sports. Both lower and higher regions suitable for skiing are negatively affected. Less snow, a shorter ski season, an increase

of the snow line up to 1500 m and less income are the negative impacts of climate change on tourism (Beniston, 2003). The Black Forest belongs to the most favoured landscapes of Germany. Thereby, the southern part is most frequently visited. Since the 1950s, the arrivals of tourists have permanently risen (Statistisches Landesamt Baden-Württemberg, 2007). In general, the Black Forest is a very popular destination for winter sports. But in the future typical winter sport activities will only be possible in the highest elevated areas of the mountain ranges. In the Black Forest only the southern parts will be useable for such activities, e.g. Feldberg (1493 m asl).

METHODS

Study site

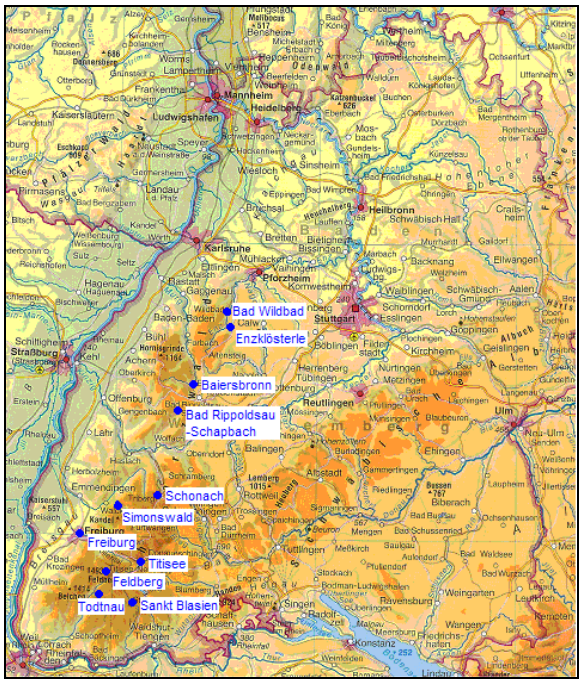

Figure 1: Topographical map of Baden-Württemberg, Germany. selected stations in the Black Forest

The Black Forest is a low mountain range in Baden-Württemberg in the southwest of Germany. It has a length of about 166 km and has a varying width of 30 km to 60 km. Its total area measures 6000 km². The averaged afforestation amounts to 66 per cent and is much higher than the average afforestation of Germany of 30 per cent (Wilmanns, 2001).

For the climatic analyses the following stations are selected: Bad Rippoldsau-Schapbach, Bad Wildbad, Baiersbronn, Enzklösterle, Feldberg, Freiburg, Schonach, Simonswald and Titisee (Fig. 1). These stations are representative for the whole Black Forest and relevant for tourism.

Meteorological data

For the computation of human-biometeorological, physical, thermal and aesthetic components the A1B scenario is used. The calculation is carried out by use of the regional climate model REMO from the Max-Planck-Institute of Meteorology in Hamburg with a spatial resolution of 10 km and data is available from 1950 until 2100. The period 1961-1990 is used as the reference period for future climate change. The climate projections are considered until 2050, exclusively (Jacob, 2001, Jacob et al., 2007).

The following climatic parameters relevant for tourism are chosen: thermal comfort, heat and cold stress, sunshine, fog, sultriness, precipitation, storm and ski potential. These analysed daily values refer to 14 CET, except for precipitation where the total annual precipitation amount is used. For the computation of thermal comfort and discomfort in terms of Physiologically Equivalent Temperature (PET) (Höppe, 1999) the model RayMan is used (Matzarakis et al., 2007). The parameters are based on particular thresholds (Matzarakis, 2007). To quantify the climatic tourism potential, frequency classes and frequencies of extreme weather events are generated based on 10-day-intervals. The derived results are presented using the climate tourism information scheme (CTIS).

RESULTS

The first results are shown for two stations of the Black Forest: Bad Rippoldsau-Schapbach (modelled height: 730 m) and Feldberg (modelled height: 1076 m). Bad Rippoldsau-Schapbach represents the most afforested area of the Black Forest and is located in the northern part. Feldberg is the highest mountain in this study site and belongs to the southern part of the Black Forest. Compared to urban areas their climatic conditions differ extremely. Figures 2 and 3 show the CTIS, Table 1 of Bad Rippoldsau-Schapbach for the periods 1961-1990 and 2021-2050, respectively. Figures 4 and 5 show the CTIS, Table 2 the trends for the selected parameters of Feldberg for the same periods.

In Bad Rippoldsau-Schapbach the average number of days with thermal comfort will be almost constant (72 days). On the other hand, the days with heat stress will definitely rise from 9 days during the period 1961-1990 to 13 days for 2021-2050. Sultry days will increase by about 14 days and will reach 36 days for the period 2021-2050. Due to the increase in air temperature, the days with cold stress will decrease by 14 days.

Table 1: Trends for Bad Rippoldsau-Schapbach (in days)

Parameter	1961-1990	2021-2050
Cold stress	103	89
Thermal comfort	72	73
Heat stress	9	13
Dry days	188	188
Wet days	97	98
Sultriness	22	36
Storm	18	20
Ski potential	16	11

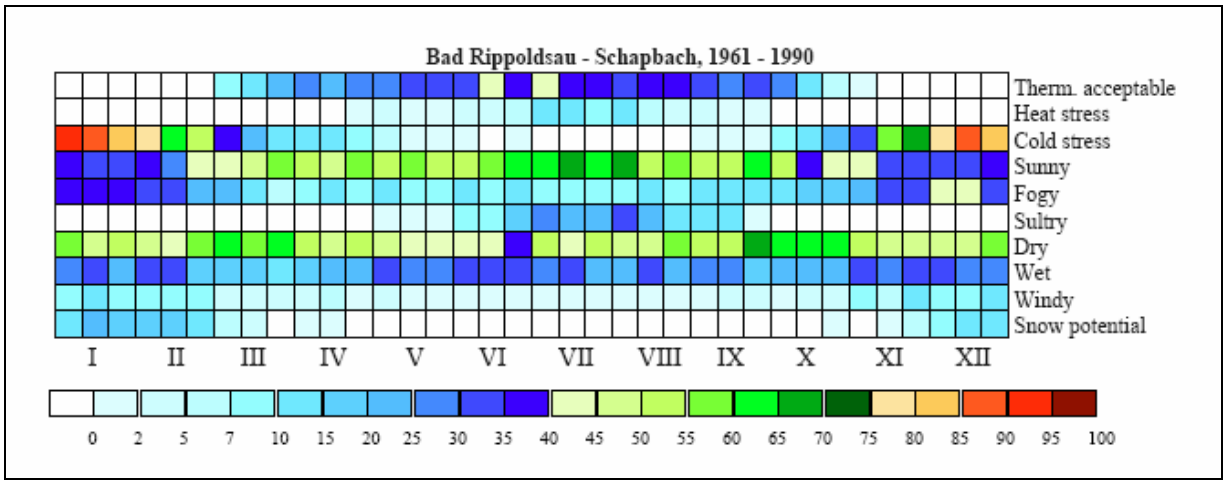

Figure 2: CTIS for Bad Rippoldsau-Schapbach for the period 1961-1990

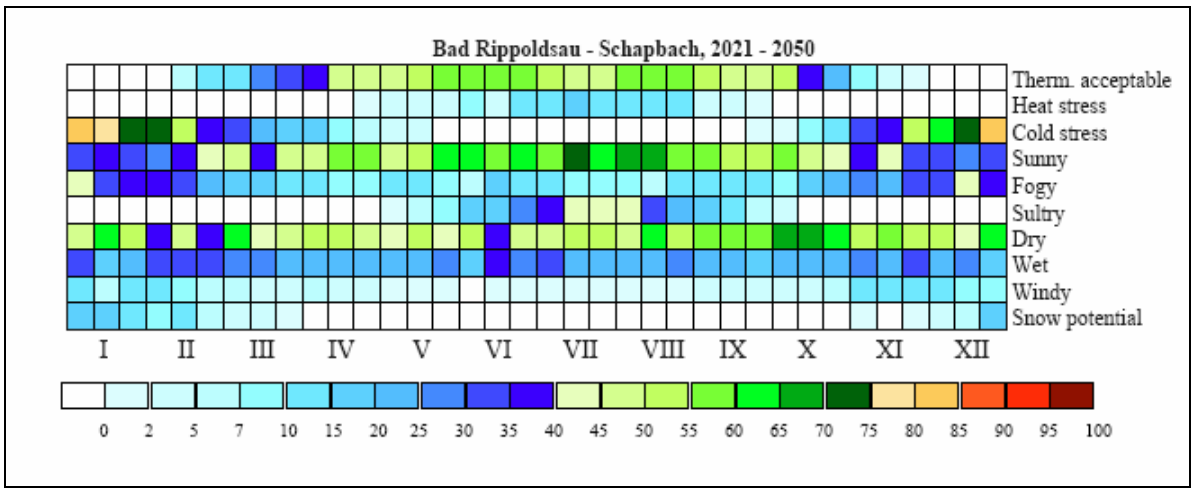

Figure 3: CTIS for Bad Rippoldsau-Schapbach for the period 2021-2050

Therefore, in Bad Rippoldsau-Schapbach there will be just 89 days of cold stress. The annual precipitation will change only marginally. But there will be a seasonal redistribution. The precipitation rate will decrease in summer and increase in winter. Due to the increase in air

temperature, the amount of rain will also increase, but not the amount of snow. Hence, the ski potential will decline by about 5 days (Tab. 1).

Figures 2 and 3 show that the thermal comfort range will expand from mid February to the end of November. The period of heat stress will also increase and the values are under 20 per cent. The cold stress period will shorten by 10-20 per cent. Fog is present all year, but at a higher rate in winter (35-40 per cent). The values for the summer season are 15 per cent. Sultry days will be most occur in July and August, with maximum frequencies of 45 per cent. Compared to 1961-1990, the sultry period will start in May and last until October, i.e. this period will increase in length. The precipitation in winter will increase. The frequency of wet days will decrease in the summer season. From this it follows that strong precipitation events will occur less often. Frequencies of decades of strong wind will occur especially in the winter months (November to February). In Bad Rippoldsau-Schapbach the beginning of the ski season will be delayed by one month. The ski potential will be reduced by about 5 per cent.

Table 2: Trends for Feldberg (in days)

Parameter	1961-1990	2021-2050
Cold stress	123	110
Thermal comfort	61	66
Heat stress	5	9
Dry days	190	190
Wet days	96	99
Sultriness	12	23
Storm	51	55
Ski potential	33	24

The days with thermal comfort at the Feldberg will rise by 5 days on average until 2021-2050 compared to 1961-1990. Both the days with heat stress and sultriness will almost double. Hence, the decades with cold stress will be reduced by 13 days to 110 per year. The trends of the annual precipitation and days with high precipitation are slightly positive. The average number of days without precipitation will be constant. The number of stormy days will increase as well. The ski potential will decrease by one decade from 33 days in 1961-1990 to 24 days in 2021-2050 (Tab. 2).

At the Feldberg the days with thermal comfort will begin one decade earlier and will end 20 days later in 2021-2050 compared to 1961-1990. Due to the higher altitude heat stress will not

occur in the future. The occurrence of annual heat stress will increase by about 5 per cent. climate changes will mainly cause a decrease in cold stress levels. A decrease by 20 per cent per year in the middle of the 21st century is expected.

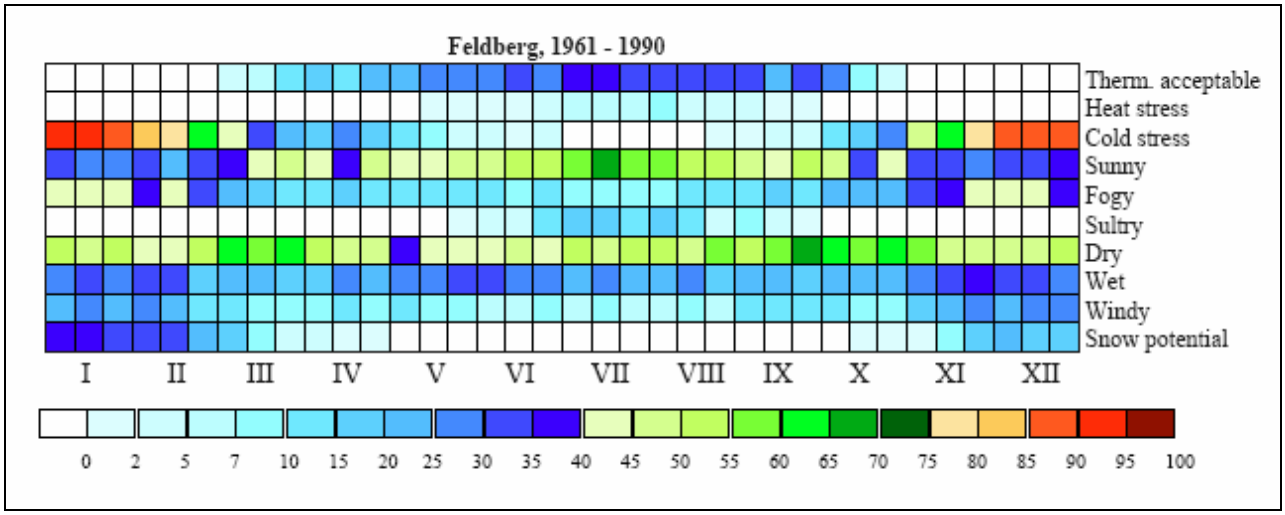

Figure 4: CTIS for Feldberg for the period 1961-1990

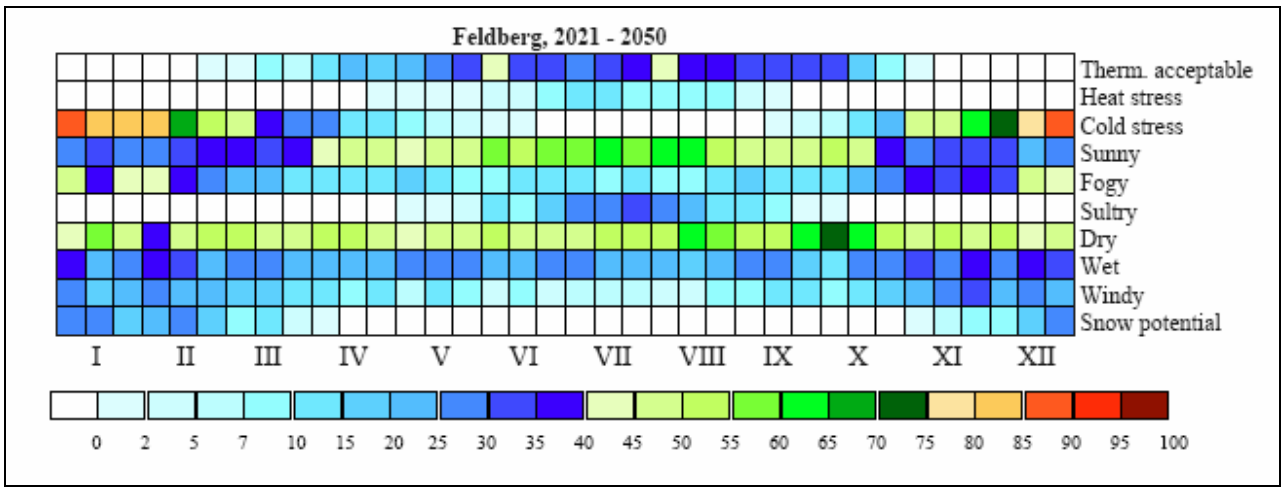

Figure 5: CTIS for Feldberg for the period 2021-2050

The occurrence of fog does not vary between seasons for both periods, 1961-1990 and 2021-2050. Thereby, the annual occurrences of fog will add up to between 10 per cent and 45 per cent with its maximum in winter. Sultriness will become more important for the Feldberg. The number of sultry days and their frequency will double, the time span will become longer. It will expand from the beginning of June to the middle of September in 2021-2050 compared to 1961-1990. In the reference period the time span of sultriness stretches from the end of June to the end of August. Precipitation will slightly increase, except in summer. The number of dry days during the summer months will increase fractionally. Autumn and winter are

characterized by a surge of strong wind events. The average ski potential will be markedly reduce by 10 to 15 per cent. Furthermore, in the 21st century the ski season will begin later.

DISCUSSION AND CONCLUSIONS

In consideration of the altitude of the selected stations, Bad Rippoldsau-Schapbach and Feldberg, the human-biometeorological trends are similar. The trend of variability in precipitation is not significant. Due to the increase in global warming, thermal comfort, heat stress, sultriness and storm events will increase, while cold stress and ski potentials will decrease. From this it follows that the typical character for ski sports will get lost in winter seasons whereas the summer seasons will gain in importance for tourism. The summers become dryer and warmer. Therefore, the opportunities for hiking or swimming in the Black Forest will become more attractive. Due to its climatic low mountain range character the Black Forest will continue to remain an interesting destination for tourism in the future. The question to what extend the tourism potential and the ecosystem in the low mountain ranges of Germany changes under modified climate conditions remains unclear. Also it is uncertain whether the biodiversity will be more affected by anthropogenic or natural parameters.

ACKNOWLEDGEMENT

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