Assessment of climate for tourism purposes in Germany

Christina Endler, Andreas Matzarakis

Meteorological Institute, Albert-Ludwigs-University of Freiburg, Germany

Abstract

The topic of climate and tourism is increasingly of high relevance due to the ongoing discussion about climate change. The close relationship between climate and tourism is confirmed by many studies. In the context of climate change adaptation to a changing climate becomes significant. The general objective of the BMBF joint research project CAST was both an analysis of climate, especially for tourism purposes and development of possible and potential adaptation strategies, in two climatic sensitive regions in Germany: the North Sea and the Black Forest.

1. Introduction

Due to the high relevance of climate and weather in industrial sectors such as tourism an adequate, easy understandable and complete assessment is required. Current climate conditions and weather thereby control, limit, and favour demand and supply in tourism and can affect decisively the motivation for travelling (UNWTO, 2008). Small changes in climate conditions can already result in huge losses in revenues. Higham and Hall (2005) identify climate change as the new challenge and determinant in tourism. It can be seen both as chance or risk and as chance and risk, especially in mountainous and coastal regions. Independent of the dimension of climate change a tourism industry without adaptation is faced with risks in many places. In order to estimate climatic, changes for tourism and recreation an integral assessment is required that is defined in the next section.

2. Method and Data

2.1. An integral assessment of climate

The assessment of climate for tourism and recreation is based on the climate facets introduced by de Freitas (2003): aesthetical, physical, and thermal. In this context, the thermal facet is regarded as the most important (Matzarakis et al., 2009).

Humans are exposed to and affected by the thermal environment. Büttner already stated 1938 that if one wants to assess the influence of climate on the human organism in the widest sense, it is necessary to evaluate the effects not only of a *single* parameter but of *all thermal components*. This leads to the necessity of modeling the human heat balance.

The Physiologically Equivalent Temperature (PET) is one thermal index based on the human energy balance and considering all relevant thermal components, especially short- and long wave radiation fluxes (Höppe, 1999).

From this it follows, that not only air temperature and precipitation ought to be included in the quantification of climate, which are the most common parameters in meteorology and climatology, but also parameters such as wind, snow, cloud cover, and a kind of perceived temperature, e.g. PET (Fig. 1). Furthermore, frequencies ("*number of days with*") of parameters considered in an analysis are more appropriate than mean values.

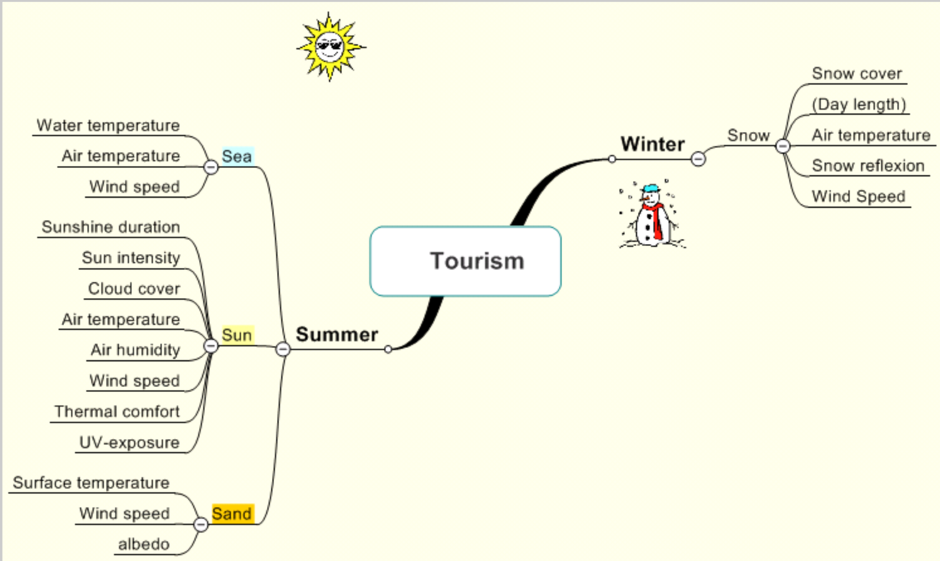

Fig. 1: Overview of the "*Quadruple S*" defined in tourism and corresponding parameters (Matzarakis, 2006)

2.2. Regional climate simulations

In order to reveal and assess the magnitude of vulnerabilities due to climate change climate simulations of two regional climate models (RCM) are used: REMO and CLM. The analysis considers the following parameters:

- Thermal acceptance:	18 °C < PET < 29 °C
- Cold stress:	PET < 0 °C
- Heat stress:	PET > 35 °C
- Humid-warm ("sultry")	conditions: vapour pressure > 18 hPa
- Sunny day:	cloud cover < 4 eights
- Fog:	relative humidity > 93 %
- Dry day:	precipitation ≤ 1 mm
- Wet day:	precipitation > 5 mm
- Stormy day:	wind velocity > 8 ms^{-1}
- Ski potential:	snow cover > 30 cm

Regional climate simulations used in this study have a spatial resolution of 0.088° (~10 km) for REMO (Jacob et al. 2001) and 0.167° (~18 km) for CLM (Steppeler et al. 2003). Both RCMs are driven by EHCAM5-MPI-OM (Roeckner et al., 2003, Marsland et al., 2003).
Future climate conditions are analysed for 2021-2050 compared to the reference 1971-2000. Two SRES scenarios, A1B and B1, are considered.

3. Results

3.1. North Sea

Till 2050, an increase in air temperature of about 1 °C is expected in the North Sea region. In this context, winter and autumn will stronger warm compared to summer and spring resulting in strong decrease in cold stress. Additionally, major changes are referred to humid-warm conditions up to 5-15 days (Fig. 2, Table 1).

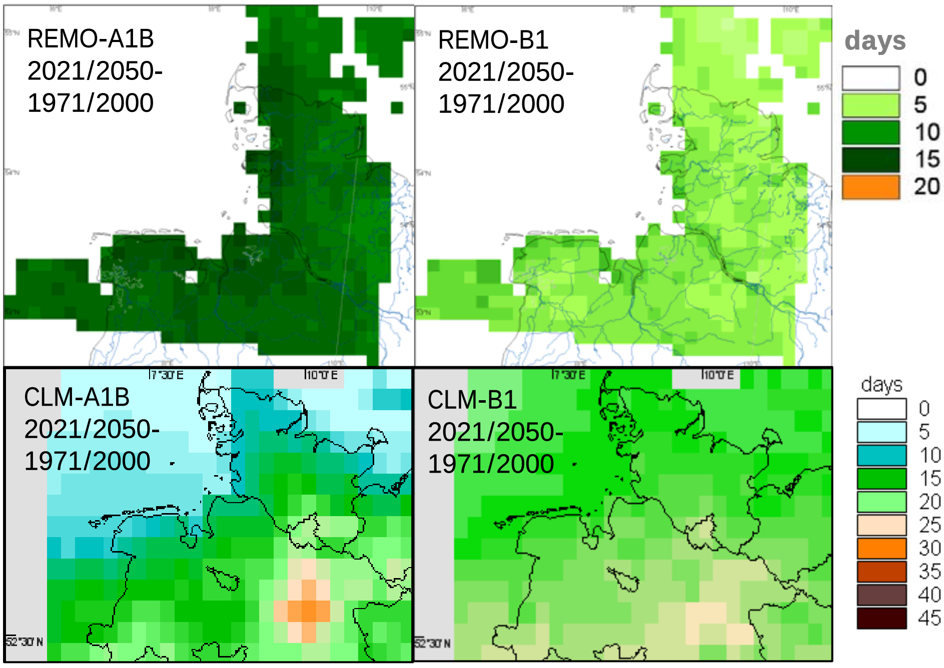

Fig: 2: Changes in humid-warm conditions for the North Sea region for 2021/2050 vs. 1971/2000 for both REMO (*upper panel*) and CLM (*lower panel*)

Thermal comfort will slightly increase. Due to the vicinity of the offshore, thermal and heat stress will not play any role in future.

Table 1: A qualitative summary of parameters analysed for the North Sea region based on the two regional climate models CLM and REMO. The notation "--/++" defines a moderate decrease/increase, "-/+" a slight decrease/increase, "0" no changes in the model, and "n. s." not specified due to huge variations between the scenarios A1B and B1

Parameter	**CLM**	**REMO**
Thermal acceptance	+	+
Cold stress	--	--
Heat stress	0	0
Humid-warm („sultry“) conditions	+	++
Sunny day	-	n. s.
Dry day	--	n. s.
Wet day	+	+
Fog	n. s.	n. s.
Stormy day	+	n. s.

Annual changes in precipitation might be not expected but redistribution throughout the year. In this context, winter precipitation will increase while summer precipitation will decrease. This pattern is also reflected by changes in dry or wet days, respectively.

Changes in sunny and stormy days as well as fog are not significant (Table 1).

3.2. Black Forest

The strong winter warming will have also an impact on changes in cold stress as well as on snow depth and ski potential decreasing about 15-20 days. These both parameters and humid-warm conditions show largest changes.

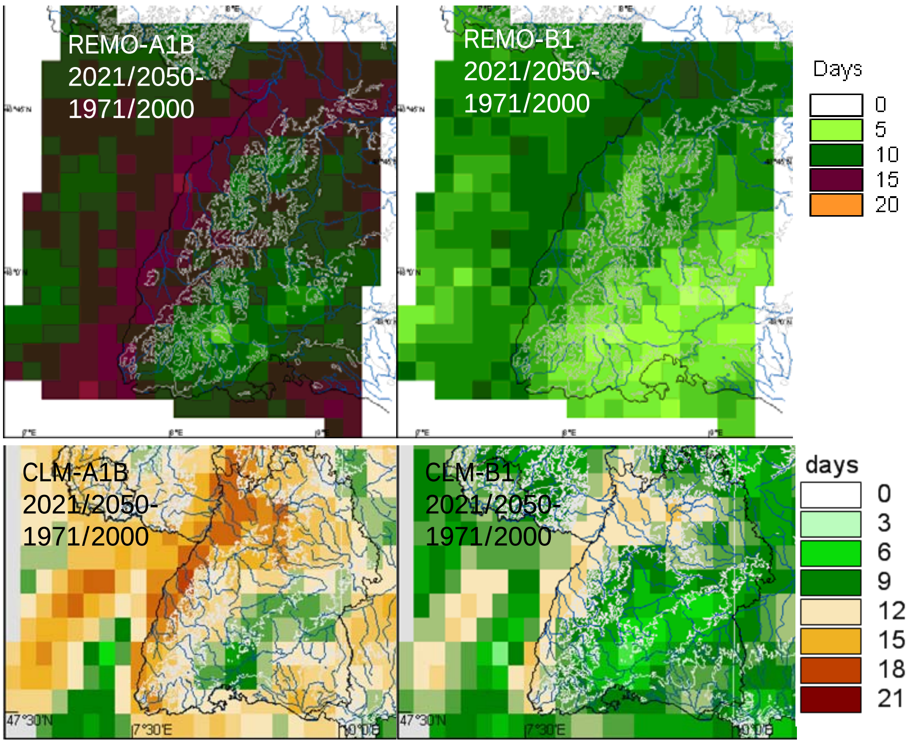

Fig: 3: Changes in humid-warm conditions for the Black Forest region for 2021/2050 vs. 1971/2000 for both REMO (*upper panel*) and CLM (*lower panel*)

Both cold stress and snow days (ski potential) will decrease about 15-20 days, whereby lower regions are more affected. In contrast, humid-warm conditions will only increase during summer by about 5-15 days (Fig. 3). In this context, higher regions are hardly affected.

Changes in precipitation are slightly more pronounced compared to the average of Germany due to processes induced by orography in the Black Forest affecting the hydrological cycle.

Changes in wind and cloud cover are hardly visible due to the challenge of modelling, among other (Table 2).

Table 1: A qualitative summary of parameters analysed for the Black Forest region based on the two regional climate models CLM and REMO. The notation "--/++" defines a moderate decrease/increase, "-/+" a slight decrease/increase, "0" no changes in the model, and "n. s." not specified due to huge variations between the scenarios A1B and B1

Parameter	CLM	REMO
Thermal acceptance	+	-
Cold stress	--	--
Heat stress	+	n. s.
Humid-warm („sultry") conditions	++	++
Sunny day	-	n. s.
Dry day	-	n. s.
Wet day	+	+
Fog	n. s.	n. s.
Stormy day	0	0
Ski potential	--	--

4. Conclusion

Model results for the North Sea and the Black Forest show that climatic changes are not so pronounced until 2050 compared to the end of the 21st century. In general, changes in B1 are somewhat lower compared to A1B.

Both models show generally same tendencies but differing in their magnitudes. One exception is the thermal acceptance in the Black Forest. While it increases in CLM, it will decrease in REMO.

Moreover, REMO indicates a wider range of the possible development of climate between A1B and B1. Although the evolution of emissions and GHG concentration is rather homogenous until 2040 and both RCMs are driven by the same general circulation model, differences can be due to RCM formulation and parameterization.

Main changes are referred to the thermal component, in particular cold stress and humid-warm conditions, and to snow. Altogether they tend to affect both summer and winter tourism. Hence, adaptation strategies, especially in the Black Forest are essential.

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Authors' address:

Dipl.-Met. Christina Endler (christina.endler@meteo.uni-freiburg.de)
Prof. Dr. Andreas Matzarakis (andreas.matzarakis@meteo.uni-freiburg.de)
Meteorological Institute, Albert-Ludwigs-University of Freiburg
Werthmannstr. 10, D-79085 Freiburg, Germany