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CLIMATE CHANGE IMPACTS ON TOURISM

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1 Aim of the Working Paper

The working paper at hand constitutes research material that was generated within the project "Adaptation to Climate Change in Austria (ADAPT.AT)", founded by the Austrian Climate Research Programme (ACRP), but deserves separate exposition. It aims at modeling a tourism impact function of changes in meteorological parameters for each tourism region/type identified by the cluster analysis outlined in Köberl et al. (2010)¹ and using this function to quantify the potential impacts of climate change on tourism demand under the assumption of no additional adaptation measures. The paper consists of two parts. Part one (chapter 2) deals with quantifying the weather sensitivity of tourism demand by means of multiple regression analysis and results in the mentioned tourism impact functions. Part two (chapter 3), on the other hand, describes the application of these tourism impact functions on meteorological scenario data that are generated by four different regional climate models and cover a time horizon until 2050. Comparing the resulting climate change scenarios to a baseline scenario indicates the potential impacts of climate change on tourism demand.

2 Impact functions

Direction and extent of climate change impacts on tourism demand in a particular region depend on two factors: (i) the weather sensitivity of tourism demand in the considered region described by the impact function and (ii) the region's exposure to changes in the climate. The present chapter deals with the first of these two factors by using historical observational data to analyze the weather sensitivity of tourism demand for the four tourism regions identified by cluster analysis. The following subsections describe methods and data employed to determine these weather sensitivities and outline the results of the analyses.

2.1 Methods

Weather sensitive tourism forms related to the winter season (e.g. skiing tourism) generally require and benefit from completely different weather and climatic conditions than weather sensitive tourism forms related to the summer season (e.g. lake tourism). Thus, it makes sense to analyze the weather sensitivity of tourism demand for winter and summer season separately. As we do not expect the weather sensitivity of tourism demand to vary

¹ Regarding the labeling of the four tourism regions identified by cluster analysis in Köberl et al. (2010), throughout the paper at hand "urban" is used as short form for *urban and thermal spa tourism*, "mixed" as abbreviation for *mixed portfolio of lower intensity tourism*, "focus summer" as short form for *focus on summer tourism* and "focus winter" as abbreviation for *focus on winter tourism*.



considerably between the single months of the winter season - i.e. November to April - analyses concerning the winter half year are carried out on a seasonal basis. On the contrary, investigations related to the summer season – i.e. May to October – are done for each month separately since in this case it seems likely that there are considerable differences between the single months. Despite the different temporal resolution, the models applied to quantify the weather sensitivity of tourism demand are the same for the winter season as well as the single summer months.

In order to determine the weather sensitivity of tourism demand in a particular tourism region we make use of partial adjustment models, a special form of the general Autoregressive Distributed Lag (ADL) model, where the dependent variable is explained by lagged endogenous variables, i.e. autoregressive terms, as well as simultaneous exogenous variables. Within tourism demand modeling, models including dynamic effects are generally preferred to static models since the latter tend to show highly autocorrelated error terms, which indicate the possibility of spurious demand relationships that are characterized by invalid inference statistics and inconsistent parameter estimates (Song and Witt, 2000). The introduction of dynamic effects, such as lagged values of the endogenous variable, has the potential to reduce the amount of spurious regression. In addition, the inclusion of lagged dependent variables also makes sense from a theoretical point of view as it allows considering tourist expectations and habit persistence (Witt, 1980).

Within the analyses at hand the dependent variable is represented by the natural logarithm of overnight stays in one of the four tourism regions during the winter season or a particular summer month, whereas one of the weather indices listed in Table 2-5 enters the model as independent variable.² We choose overnight stays instead of arrivals as tourism demand indicator since they also encompass the length of the trips. In fact, weather conditions frequently cause tourists to depart earlier or spontaneously extend their holidays, whereas the terms of cancellation most often encourage tourists to set out on a trip, even if bad weather is anticipated. As mentioned above, overnight stays are additionally transformed to logarithms. This procedure is quite common within tourism demand modeling since it generates time series with more or less constant variance over time.

For each of the four tourism regions, each of the separately considered times of the year (i.e. the winter season and the single summer months) and each of the weather indices taken into account various model specifications are tested, which differ in the number of considered lags of the dependent variable (between one and three periods) as well as the inclusion of a trend variable. Table 2-1 summarizes all model specifications tested within the analyses at hand, where ln(*nights*_{it}) describes the natural logarithm of the overnight stays in tourism

² Snow indices serve for analyzing the weather sensitivity of tourism demand during the winter season whereas temperature and precipitation indices are applied for quantifying the weather sensitivity of tourism demand during the single summer months.



region *i* at time *t*, WI_{it} /sd(WI_i) denotes the considered weather index in tourism region *i* at time *t* divided by its standard deviation (i.e. the standardized weather index), β_{i0} , β_{i1} , ϕ_{i1} , ϕ_{i2} , ϕ_{i3} , and γ_{i1} represent the parameters for tourism region *i*, which are estimated by means of ordinary least squares³ (OLS), and ε_{it} indicates the error term. As shown in Table 2-1, all tested model specifications are of semi-logarithmic form, thus the coefficient of the standardized weather index can be interpreted as semi-elasticity each time.

| Model No. | Model specification |
|-----------|--|
| 1.1 | $\ln(nights_{it}) = \beta_{i0} + \phi_{i1} \ln(nights_{it-1}) + \beta_{i1}WI_{it} / sd(WI_i) + \varepsilon_{it}$ |
| 1.2 | $\ln(nights_{it}) = \beta_{i0} + \sum_{j=1}^{2} \phi_{ij} \ln(nights_{it-j}) + \beta_{i1}WI_{it} / sd(WI_i) + \varepsilon_{it}$ |
| 1.3 | $\ln(nights_{it}) = \beta_{i0} + \sum_{j=1}^{3} \phi_{ij} \ln(nights_{it-j}) + \beta_{i1}WI_{it} / sd(WI_i) + \varepsilon_{it}$ |
| 2.1 | $\ln(nights_{it}) = \beta_{i0} + \phi_{i1} \ln(nights_{it-1}) + \gamma_{i1}trend + \beta_{i1}WI_{it} / sd(WI_i) + \varepsilon_{it}$ |
| 2.2 | $\ln(nights_{it}) = \beta_{i0} + \sum_{j=1}^{2} \phi_{ij} \ln(nights_{it-j}) + \gamma_{i1}trend + \beta_{i1}WI_{it} / sd(WI_i) + \varepsilon_{it}$ |
| 2.3 | $\ln(nights_{it}) = \beta_{i0} + \sum_{j=1}^{3} \phi_{ij} \ln(nights_{it-j}) + \gamma_{i1}trend + \beta_{i1}WI_{it} / sd(WI_i) + \varepsilon_{it}$ |

| Table 2-1: | Overview | of the | tested | model | specifications |
|------------|----------|--------|--------|-------|----------------|
|------------|----------|--------|--------|-------|----------------|

In order to prevent multicollinearity, only one weather index enters the regression model at a time. This holds for both, the analyses of the winter season and the analyses of the single summer months. With six different model specifications and three different snow indices, 18 model estimations are carried out for each tourism region within the winter season analyses, whereas the application of four different temperature and precipitation indices within the summer season analyses leads to 24 model estimations per tourism region and summer month. Thus, some kind of selection procedure is needed to end up with the most adequate model specification and the most appropriate weather index for quantifying the weather sensitivity of tourism demand in a particular tourism region and for a particular time of the year⁴. For reasons of clarity, the selection procedure is divided into two steps:

⁴ Besides allowing the finally selected model specification and weather index to vary from tourism region to tourism region, also more restrictive selection approaches are imaginable in principle, such as choosing the most adequate model specification and weather index on condition that all tourism regions end up with one and the same model specification and/or with one and the same weather



³ Note, that from a theoretical point of view the parameter estimates resulting from using OLS are biased and inconsistent, since the lagged dependent variables, which are by nature correlated to the error term, lead to an endogeneity problem (see e.g. Verbeek 2008). However, we accept this bias in order to avoid the problems related to static models.

<u>STEP 1:</u> Selection of the most appropriate model specification per considered weather index

Regarding the selection of the most adequate model specification out of those at choice (see Table 2-1) the following two selection criteria are applied:

- 1. Criterion The considered model passes diagnostic checking and thus can be considered as statistically acceptable
 Each model is tested for the absence of residual autocorrelation by means of the Breusch-Godfrey test (Breusch 1978; Godfrey 1978), for the absence of heteroscedasticity by use of the Breusch-Pagan test (Breusch and Pagan 1979), for the normal distribution of the residuals by means of both the Lilliefors test (Lilliefors 1969) and the Jarque-Bera test (Jarque and Bera 1980), and for the absence of functional form misspecification employing Ramsey's (1969) RESET test. Each of these tests is carried out at the 5 percent level of significance. Those models that pass all tests mentioned above form the subsample to which the second selection criterion is applied.
- 2. Criterion The considered model shows the smallest BIC-value of all tested models that fulfill the first criterion

The Bayesian information criterion (BIC)⁵ is then used to choose between those model specifications that pass the first selection criterion.

STEP 2: Selection of the most appropriate weather index

The first step of the selection procedure results in a particular model specification for each of the considered weather indices. In order to select the most adequate weather index we again make use of the BIC-criterion by choosing the model with the smallest BIC-value. With this second step, the selection procedure results in a unique season-specific impact function for each of the four tourism regions identified by cluster analysis.

2.2 **Data**

Having outlined the methods employed to model region- and season -specific impact functions we now present the data used for the calibration of these impact functions. Starting

index for each analyzed season. However, we aim at selecting the most appropriate model specification and most adequate weather index for each tourism region and thus do not apply such kind of restrictions.

⁵ $BIC = \log \frac{1}{n} \sum_{i=1}^{N} e_i^2 + \frac{k}{n} \log n$, where *n* denotes the number of observations, e_i indicates the residual

and k describes the number of parameters.



with an overview of the base data, the main steps of data preparation are described hereafter.

2.2.1 Overview of base data

Table 2-2 gives an overview of the base data that is used to calibrate the impact functions and thus to determine the weather sensitivity of tourism demand in the identified tourism regions. Data on overnight stays are available at district level on a monthly base as well as at the municipal level on a seasonal base, where the former does not encompass all accommodation facilities but only overnight stays in hotels and similar establishments. Meteorological data are given on a monthly scale either at grid cell level (snow indices) or at the municipal level (temperature and precipitation indices).

Table 2-2: Overview of the base data used for examining the weather sensitivity of tourism demand

| Data set | Time horizon | Temporal resolution | Regional resolution | Source |
|---|-----------------|----------------------|---------------------|-------------------------------|
| Overnight stays (hotels and similar establishments) | 1977-2009 | monthly | district | Statistics Austria (2010a) |
| Overnight stays (all accommodation facilities) | 1973-2007 | seasonal (winter) | municipality | Statistics Austria (2008) |
| Meteorological data (snow) | 1948-2006 | monthly | 1 × 1 km grid | ZAMG (2009a) |
| Meteorological data (temperature, precipitation) | 1948-2006 | monthly | municipality | ZAMG (2009b) |

As appears from Table 2-2, the available data sets encompass different time horizons and partly do not show the temporal and/or regional resolution required for the methods outlined in chapter 2.1. Thus, before using the data within our econometric analyses some preparations are needed. Data used within the winter season analyses is needed at tourism region level and on a seasonal base, whereas data employed within the summer season analyses is required at tourism region level and on a monthly base. The auxiliary data employed for the purpose of data preparation is outlined in Table 2-3.

| Table | 2-3: | Overview | of | auxiliary | data |
|-------|------|----------|----|-----------|------|
|-------|------|----------|----|-----------|------|

| Data set | Time horizon | Temporal resolution | Regional resolution | Source |
|--|-----------------|---------------------|---------------------|-------------------------------|
| Overnight stays (all accommodation facilities) | 2000-2005 | seasonal | municipality | Statistics Austria (2007) |
| Overnight stays (all accommodation facilities) | 1990-2009 | seasonal | NUTS 3 | Statistics Austria (2010b) |

2.2.2 Data preparation – overnight stays

As already mentioned in chapter 2.1, winter and summer season are analyzed separately, with the weather impacts on regional winter overnight stays being studied on a seasonal basis. Thus, for the analyses of the winter half year seasonal data on overnight stays is



required for each tourism region. Starting from seasonal data on winter overnight stays at the municipal level (Statistics Austria 2008), simple aggregation from the municipal to the tourism region level translates the data into the desired form⁶. A graphical illustration of the resulting time series is given in Figure 2-1, where the upper image shows the evolution of winter overnight stays per tourism region between 1973 and 2006, which represents the time horizon for regression analyses.

Contrary to the winter season analyses, weather impacts on regional summer overnight stays are studied for each month of the summer season separately. Thus, the analyses of the summer half year require monthly data on overnight stays for each tourism region. The longest time series concerning overnight stays on a monthly basis is only available at district level (Statistics Austria 2010a). However, translating data from district level to tourism region level is not as trivial as translating data from the municipal to the tourism region level, since some districts refer to more than one NUTS 3 region and also to more than one tourism region⁷. Overnight stays of those districts have to be allocated to the respective tourism regions according to some allotment formula. In order to derive such an allotment formula for each district that refers to more than one tourism region we make use of the fact that districts consist of communities that are in turn clearly assigned to one tourism region. Thus, the overnight stays of a district that refers to more than one tourism region are allocated to the respective tourism regions according to the distribution at communal level as reported for the tourism year 2000 (Statistics Austria 2007). A graphical illustration of the resulting time series is given in Figure 2-2, where the evolution of overnight stays per tourism region is presented for each month of the summer season from 1977 to 2006, which represents the time horizon for regression analyses. Since the original data set only comprises overnight stays in hotels and similar establishments, the time series illustrated in Figure 2-2 are grossed up to all accommodation facilities using the region-specific shares of 2006 (see Table 2-4) in order to make their dimension comparable to the data on winter overnight stays. In addition to these monthly illustrations, the lower graphic in Figure 2-1 shows the evolution of overnight stays for the summer season as a whole.

⁷ There are six districts that refer to more than one NUTS 3 region (Baden, Bregenz, Gänserndorf, Mistelbach, Urfahr-Umgebung, and Wien Umgebung) and four districts that refer to more than one tourism region (Baden, Bregenz, Urfahr-Umgebung and Wien Umgebung).



⁶ Each tourism region consists of 6 to 14 NUTS 3 regions (see Working Paper "Identification of Tourism Types"). Since each municipality is clearly assigned to one NUTS 3 region and each NUTS 3 region is in turn clearly assigned to one tourism region, no problems occur in transforming overnight stays from the municipal to the tourism region level.

| Tourism region | Region-specific share [%] | | | | |
|----------------|-----------------------------------|--|--|--|--|
| Urban | 78.86 | | | | |
| Mixed | 56.75 | | | | |
| Focus Summer | 51.14 | | | | |
| Focus Winter | 64.26 | | | | |
| Source: | Statistics Austria (2010a: 2010b) | | | | |

 Table 2-4: Summer overnights stays – Region-specific shares of hotels and similar establishments in all accommodation facilities (2006)

As illustrated in the upper graphic of Figure 2-1, each of the four tourism regions identified by cluster analysis recorded increases in their winter overnight stays between 1973 and 2006, ranging from a gain of 50 % in the "mixed" tourism region to a rise of almost 160 % in the "focus winter" tourism region. Summer overnight stays, on the contrary, only increased in the "urban" tourism region, where a gain of about 40 % was registered between 1977 and 2006 (see the lower graphic of Figure 2-1). The remaining tourism regions, by contrast, faced losses ranging from -4 % ("focus winter") to -35 % ("focus summer").

Winter overnight stays



Summer overnight stays



Figure 2-1: Evolution of winter overnight stays (top) and summer overnights stays (bottom) per tourism region/type



Looking at the summer season in a higher temporal resolution identifies July and August as those months with the highest number of overnight stays per tourism region (see Figure 2-2). However, except for the "urban" tourism region, overnight stays in both months showed a decreasing tendency throughout the observation period.



Figure 2-2: Evolution of overnight stays per tourism region/type for each month of the summer season (May-October)

2.2.3 Data preparation – weather indices

Within winter season analyses the weather sensitivity of winter overnight stays in a particular tourism region is quantified by employing data on the natural snow conditions in ski areas



located within the region under consideration. Thus, snow data on Austria's ski areas⁸ is required. Since longer time series of consistent snow measurements are only available for a limited number of measurement stations, data from a snow cover model developed by the Austrian Central Institute for Meteorology and Geodynamics is used (ZAMG 2009a). This model reconstructs historic snow conditions on a daily base by using temperature and precipitation data. Several snow indices calculated for 550 selected ski area coordinates⁹ (1×1 km grid cells) and aggregated on a monthly base by ZAMG are available within the project at hand. These include the mean depth of natural snow (S_{mean}), the number of days with at least 1 cm depth of natural snow (S_{day1}), and the number of days with at least 30 cm depth of natural snow (S_{day30}).

To translate the original snow data from grid cell level to tourism region level and from a monthly to a seasonal base we proceed in three steps. The first step comprises the translation from grid cell level to ski area level by averaging snow data from coordinates belonging to the same ski area¹⁰. Within the second step, the snow data is aggregated from ski area level to tourism region level¹¹ by forming the weighted average, where overnight stays in communities with a ski resort averaged over the winter seasons 2000 to 2005 (Statistics Austria 2007) serve as weighting factor. In a third step, the monthly snow data at tourism region level is summed (in case of the snow indices S_{day1} and S_{day30}) or averaged (in case of snow index S_{mean}) over the months of the winter season.

Within summer season analyses temperature and precipitation indices are employed to quantify the weather sensitivity of overnight stays in a particular tourism region during a particular summer month. The weather indices for the summer season analyses include mean temperature (T_{mean}), the number of days with at least 1 mm precipitation (R_{day1}), the number of days with at least 10 mm precipitation (R_{day10}), and the sum of precipitation (R_{sum}). The original data are given on a monthly scale and at the municipal level (see Table 2-2), which means that the meteorological conditions are reported for the centers of the communities, or in other words for those points, where the bulk of economic activities takes place. The aggregation of the original data from the municipal to the tourism region level is

¹¹ In this case, tourism region level means "all considered ski resorts within a tourism region".



⁸ The classification of ski areas applied within the paper at hand follows that of Töglhofer (2011, p. 54-56), who takes all areas with more than five transport facilities or at least one cable car into account and results in a total of 202 ski areas.

⁹ For further details on the selection procedure of the 550 ski area coordinates see Töglhofer (2011, p. 55f).

¹⁰ Snow data from up to five coordinates are potentially available per ski area. However, if the mean grid altitude of a particular coordinate deviates significantly from the altitude of the respective ski area, snow data from this coordinate is excluded from averaging. For further details see again Töglhofer (2011, p. 57f).

done by forming the weighted average, where the communal overnight stays averaged over the summer seasons 2000 to 2005 serve as weighting factor.

Table 2-5 once more summarizes the weather indices that are used to quantify the weather sensitivity of tourism demand by means of the methods outlined in chapter 2.1.

| Abbreviation | Explanation | Time horizon | Temporal Resolution | Regional Resolution |
|---------------------|--|-----------------|------------------------|------------------------|
| S _{mean} | Mean depth of natural snow (in ski areas) [cm] | 1973-2006 | seasonal | tourism region |
| S _{day1} | Number of days with at least 1 cm depth of natural snow (in ski areas) [days/winter season] | 1973-2006 | seasonal | tourism region |
| S _{day30} | Number of days with at least 30 cm depth of natural snow (in ski areas) [days/winter season] | 1973-2006 | seasonal | tourism region |
| T _{mean} | Average of the near-grounded temperature (2 m above the ground) [°C] | 1977-2006 | monthly | tourism region |
| R _{days1} | Number of days with at least 1 mm precipitation [days/month] | 1977-2006 | monthly | tourism region |
| R _{days10} | Number of days with at least 10 mm precipitation [days/month] | 1977-2006 | monthly | tourism region |
| R _{sum} | Sum of precipitation [mm/month] | 1977-2006 | monthly | tourism region |

2.3 **Results**

Having outlined methods and data employed to model and calibrate region- and seasonspecific impact functions we now turn to the presentation of the resulting outcomes. Thereby, the focus is on the weather sensitivity of tourism demand, i.e. the relationship between overnight stays and the considered weather index. Thus, parameter estimates of control variables (lagged dependent variables and trend variable) are not pointed out explicitly.

2.3.1 Winter season analysis

Table 2-6 presents the snow sensitivities of the tourism regions' winter overnight stays depending on the snow index chosen for representing the natural snow conditions in the regions' ski areas. It results from the first step of the selection procedure, where for each tourism region and each snow index the most adequate model specification was selected out of those outlined in Table 2-1. The values presented in Table 2-6 indicate the percentage change in the winter overnight stays of the considered tourism region due to an increase in the employed snow index by its standard deviation. Regarding the "focus summer" tourism region none of the six tested model specifications passes diagnostic checking when using S_{day1} as snow index. Apart from that, more or less the same picture evolves regardless of the snow index chosen, namely that neither the winter overnight stays in the "urban" tourism region nor the winter overnight stays in the "mixed" tourism region show a statistically significant snow dependency and that winter overnight stays in the "focus summer" tourism region are more sensitive to the natural snow conditions in the region's ski areas than winter



overnight stays in the "focus winter" tourism region. This result is quite intuitive. Measured in terms of transport capacity per winter overnight stay, the "focus summer" tourism region shows the highest relative importance of skiing tourism for winter overnight stays closely followed by the "focus winter" tourism region. In addition, the ski areas of the "focus summer" tourism region are on average located at a lower altitude than the ski areas of the "focus winter" tourism region.

| | S _{mean} | S _{day1} | S _{day30} |
|--------------|-------------------|-------------------|--------------------|
| Urban | 0.70 | 0.38 | 0.67 |
| Mixed | 0.61 | 0.50 | 0.56 |
| Focus Summer | 2.82*** | - | 1.91* |
| Focus Winter | 1.60*** | 1.58** | 1.43** |

| | e | | | | |
|---------------------------|---------------|-----------------|-----------|---------------|------------|
| able 2-6: Snow sensitivit | v of winter o | vernights stays | depending | on the chosen | snow index |

Significance codes: *** ... 0.01, ** ... 0.05, * ... 0.1

Table 2-7 summarizes the most important characteristics of the model finally selected for representing the impact function of a particular tourism region. The first column contains the snow sensitivity of winter overnight stays (i.e. the coefficient of the considered standardized snow index multiplied by 100), indicating the percentage change in winter overnight stays resulting from an increase in the considered snow index by its standard deviation. In addition, the statistical significance of the snow index coefficient is pointed out. The second column indicates whether the estimated snow index coefficient shows the expected sign. Column three presents the 95 % confidence interval corresponding to the point estimate outlined in column one. The fourth column contains the name of the finally selected snow index, column five outlines the number of the finally selected model specification and column six shows the adjusted R².

| | Snow coefficient (× 100) | Expected sign | 95% confidence interval | Snow index | Model | Adj. R² |
|--------------|-----------------------------|---------------|----------------------------|-------------------|-------|---------|
| Urban | 0.70 | \checkmark | -0.30 - 1.70 | S _{mean} | 2.1 | 0.982 |
| Mixed | 0.61 | \checkmark | -0.25 - 1.47 | S _{mean} | 1.1 | 0.900 |
| Focus Summer | 2.82*** | \checkmark | 1.08 - 4.56 | S _{mean} | 1.1 | 0.972 |
| Focus Winter | 1.60** | \checkmark | 0.42 - 2.78 | S _{mean} | 1.1 | 0.980 |

Table 2-7: Attributes and results of the finally selected models (winter season)

Significance codes: *** ... 0.01, ** ... 0.05, * ... 0.1

As outlined in the fifth column of Table 2-7 each of the finally selected model specifications includes a one period lag of the dependent variable, whereas the model chosen for the "urban" tourism region additionally contains a trend variable. Furthermore, each of the finally selected models employs snow index S_{mean} for indicating the snow conditions in the region's ski resorts. As reported by the second column of Table 2-7 each snow coefficient shows the expected (positive) sign – the better the natural snow conditions in a region's ski resorts



during a winter season the higher the number of winter overnight stays. As already mentioned above, results suggest that winter overnight stays in the "focus summer" tourism region show the highest dependency on the natural snow conditions in the region's ski resorts followed by winter overnights stays in the "focus winter" tourism region. No statistically significant dependency of the region's winter overnight stays on the natural snow conditions in the region's ski resorts is found for the "urban" and the "mixed" tourism region at the 10 % level of significance.

2.3.2 Summer season analysis

Since within summer season analyses each month was studied separately, for reasons of clarity only the results of the finally chosen models are outlined in the following. Tables with the weather sensitivities resulting from the first step of the selection procedure, where for each tourism region and each weather index the most adequate model specification was chosen, are however given in the appendix (see Table 5-1 to Table 5-6).

Table 2-8 presents the most important attributes and results of the models finally selected for representing the regional impact functions of month May. The first column contains the weather sensitivity of overnight stays (i.e. the coefficient of the considered standardized weather index multiplied by 100), indicating the percentage change in overnight stays during May due to a one standard deviation increase in the considered weather index. Additionally, the statistical significance of the weather index coefficient is pointed out. The second column again indicates whether the estimated weather index coefficient shows the expected sign, whereas column three shows the 95 % significance interval corresponding to the point estimate outlined in column one. Column four presents the name of the finally selected weather index and column five the number of the finally selected model specification. The last column outlines the value of the adjusted R^2 .

| | Weather coefficient (× 100) | Expected sign | 95% confidence interval | Weather index | Model | Adj. R² |
|--------------|--------------------------------|---------------|----------------------------|--------------------|-------|---------|
| Urban | -2.00** | × | -3.52 – -0.48 | T _{mean} | 2.1 | 0.917 |
| Mixed | -1.07 | × | -3.29 – 1.15 | T_{mean} | 2.1 | 0.351 |
| Focus Summer | -2.65 | \checkmark | -6.68 - 1.38 | R _{day10} | 1.1 | 0.024 |
| Focus Winter | -2.33 | × | -7.26 - 2.60 | T_{mean} | 1.1 | 0.020 |

| Table | 2-8: | Attributes | and result | s of the | finally | selected | models | (May) |
|-------|------|------------|------------|----------|---------|----------|--------|------------------|
| | | | | | | | | (···· J) |

Significance codes: *** ... 0.01, ** ... 0.05, * ... 0.1

As reported in the fifth column of Table 2-8 each of the finally selected model specifications includes a one period lag of the dependent variable. The models chosen for the "urban" and the "mixed" tourism region additionally contain a trend variable. T_{mean} is selected by the BIC-criterion as the most appropriate weather index, except for the "summer" tourism region where R_{day10} represents the chosen weather index. However, apart from the "urban" tourism region, none of the finally selected weather indices is found to show a statistically significant



influence on regional overnight stays in May. Moreover, the sign of the only statistically significant weather index coefficient seems somewhat unexpected at first sight as it states that higher temperatures during May cause overnight stays in the "urban" tourism region to decrease. However, a possible explanation for the negative sign arises by Table 2-9 that indicates the "urban" tourism region's temperature index to be highly positively correlated to the other regions' temperature indices. This means that if the mean May temperatures in the "urban" tourism region decrease from one year to the next, the other tourism regions are also very likely to report a decline in their mean May temperatures. As we expect vacations in the "urban" tourism region to become more attractive relative to the other tourism regions when mean temperatures are decreasing in all regions, the negative sign seems somewhat intuitive.

| | | io tourioin rogio | | mean (may) |
|------------------|-------|-------------------|--------------|--------------|
| Pearson\Spearman | Urban | Mixed | Focus Summer | Focus Winter |
| Urban | 1.000 | 0.984 | 0.965 | 0.979 |
| Mixed | 0.994 | 1.000 | 0.953 | 0.962 |
| Focus Summer | 0.983 | 0.973 | 1.000 | 0.960 |
| Focus Winter | 0.977 | 0.966 | 0.970 | 1.000 |

Table 2-9: Correlation between the tourism regions' weather indices $T_{\mbox{\scriptsize mean}}$ (May)

Note that measured by means of the adjusted R^2 (see the last column in Table 2-8) the performances of the finally selected models for the "focus summer" and the "focus winter" tourism region are rather poor. This is also reflected in the comparatively large 95 % confidence intervals of the respective weather index coefficients.

Table 2-10 shows the main characteristics of the models finally selected for representing the regional impact functions of month June. As outlined in column five, all finally selected model specifications contain a one period lag of the dependent variable and, except for the "mixed" tourism region, a trend variable. Apart from the "summer" tourism region, one of the precipitation indices is selected by the BIC-criterion as the most adequate weather index.

| | Weather coefficient (× 100) | Expected sign | 95% confidence interval | Weather index | Model | Adj. R² |
|--------------|--------------------------------|---------------|----------------------------|--------------------|-------|---------|
| Urban | 2.20** | × | 0.12 - 4.28 | R _{day1} | 2.1 | 0.599 |
| Mixed | 1.37 | × | -0.56 - 3.30 | R _{day10} | 1.1 | 0.237 |
| Focus Summer | 1.01 | \checkmark | -2.51 – 4.53 | T _{mean} | 2.1 | 0.803 |
| Focus Winter | 2.14 | × | -0.76 - 5.04 | R _{day10} | 2.1 | 0.417 |

| Table 2-10: Attributes a | and results | of the finally | v selected | models | (June) |
|--------------------------|-------------|----------------|------------|--------|--------|
| | | | | | ··· |

Significance codes: *** ... 0.01, ** ... 0.05, * ... 0.1

In accordance with the analysis of month May a statistically significant weather index coefficient is only reported for the "urban" tourism region. Again the sign of the only significant weather index coefficient seems somewhat unexpected at first sight as it indicates



that a higher number of days with more than 1 mm precipitation during June causes overnight stays in the "urban" tourism region to increase. However, as indicated in Table 2-11 the number of days with at least 1 mm precipitation in the "urban" tourism region is positively correlated to the number of days with at least 1 mm precipitation in the other tourism regions. As we expect vacations in the "urban" tourism region to become more attractive relative to the other tourism regions when the number of days with at least 1 mm precipitation is increasing in all regions, the positive sign seems fairly intuitive.

| Pearson\Spearman | Urban | Mixed | Focus Summer | Focus Winter |
|------------------|-------|-------|--------------|--------------|
| Urban | 1.000 | 0.900 | 0.663 | 0.816 |
| Mixed | 0.941 | 1.000 | 0.713 | 0.834 |
| Focus Summer | 0.667 | 0.705 | 1.000 | 0.794 |
| Focus Winter | 0.819 | 0.831 | 0.816 | 1.000 |

Table 2-11: Correlation between the tourism regions' weather indices R_{day1} (June)

The main attributes and outcomes of the final models for July are summarized in Table 2-12. Contrary to the other tourism regions, the model specification finally chosen for the "mixed" tourism region not only includes a one but also a two period lag of the dependent variable. Furthermore, a trend variable is considered within the finally selected model specifications of the "mixed" and the "focus summer" tourism region. Again, with the "focus summer" tourism region being the only exception, one of the precipitation indices is selected by the BIC-criterion as most appropriate weather index. However, this time none of the chosen weather indices shows a statistically significant influence on regional overnight stays in July.

| | Weather coefficient (× 100) | Expected sign | 95% confidence interval | Weather index | Model | Adj. R² |
|--------------|--------------------------------|---------------|----------------------------|--------------------|-------|---------|
| Urban | -1.09 | \checkmark | -2.86 - 0.68 | R _{day10} | 1.1 | 0.288 |
| Mixed | 0.33 | × | -0.77 – 1.43 | R _{day10} | 2.2 | 0.952 |
| Focus Summer | 0.58 | \checkmark | -1.83 – 2.99 | T_{mean} | 2.1 | 0.966 |
| Focus Winter | 1.30 | × | -0.57 – 3.17 | R _{day1} | 1.1 | 0.882 |

Table 2-12: Attributes and results of the finally selected models (July)

Significance codes: *** ... 0.01, ** ... 0.05, * ... 0.1

Table 2-13 outlines the main characteristics of the models finally selected for representing the regional impact functions of month August. As reported in the fifth column of the table, the finally chosen model specifications for the "mixed" and the "focus summer" tourism region include a one period lag of the dependent variable, whereas the models for the "urban" and the "focus winter" tourism region additionally consider a two period lag. Furthermore, three out of four selected model specifications take a trend variable into account. Apart from the "urban" tourism region, the finally chosen weather index - each time represented by one of the precipitation indices - shows a statistically significant influence on regional overnight



stays in August. Moreover, the statistically significant weather index coefficients all exhibit the expected sign.

| | Weather coefficient (× 100) | Expected sign | 95% confidence interval | Weather index | Model | Adj. R² |
|--------------|--------------------------------|---------------|----------------------------|--------------------|-------|---------|
| Urban | -0.58 | \checkmark | -1.94 – 0.78 | R _{day1} | 1.2 | 0.714 |
| Mixed | -2.01*** | \checkmark | -3.33 – -0.69 | R _{day10} | 2.1 | 0.906 |
| Focus Summer | -1.88* | \checkmark | -3.80 - 0.03 | R _{day1} | 2.1 | 0.955 |
| Focus Winter | -2.99*** | \checkmark | -5.060.92 | R _{day10} | 2.2 | 0.811 |

Table 2-13: Attributes and results of the finally selected models (August)

Significance codes: *** ... 0.01, ** ... 0.05, * ... 0.1

The main attributes and results of the final models for month September are summarized in Table 2-14. As outlined in column five, the finally chosen model specifications for the "mixed" and the "focus winter" tourism region not only include a one but also a two period lag of the dependent variable, whereas a trend variable is additionally considered within the models of the "mixed" and the "focus summer" tourism region. Moreover, the BIC-criterion each time suggests one of the precipitation indices to be the most appropriate weather index. However, apart from the "mixed" tourism region, no statistically significant influence of the weather index on regional overnight stays in September is found.

| | Weather coefficient (× 100) | Expected sign | 95% confidence interval | Weather index | Model | Adj. R² |
|--------------|--------------------------------|---------------|----------------------------|--------------------|-------|---------|
| Urban | -1.06 | \checkmark | -2.54 - 0.42 | R _{day10} | 1.1 | 0.767 |
| Mixed | -1.35** | \checkmark | -2.650.05 | R _{day1} | 2.2 | 0.857 |
| Focus Summer | -1.20 | \checkmark | -3.18 - 0.78 | R_{sum} | 2.1 | 0.933 |
| Focus Winter | -1.44 | \checkmark | -3.19 – 0.31 | R _{day10} | 1.2 | 0.793 |

Significance codes: *** ... 0.01, ** ... 0.05, * ... 0.1

Table 2-15 represents the main characteristics of the models finally selected for representing the regional impact functions of month October. As reported in column five each of the finally chosen model specifications includes a one period lag of the dependent variable, whereas the model selected for the "urban" tourism region additionally involves a trend variable. Apart from the "focus winter" tourism region, one of the precipitation indices is finally chosen for quantifying the weather sensitivity of a tourism region's overnight stays during October. As outlined in column one results suggest that both, overnight stays in the "mixed" and in the "focus summer" tourism region show a statistically significant sensitivity towards precipitation. Moreover, both statistically significant weather index coefficients exhibit the expected sign.



| | Weather coefficient (× 100) | Expected sign | 95% confidence interval | Weather index | Model | Adj. R ² |
|--------------|--------------------------------|---------------|----------------------------|--------------------|-------|---------------------|
| Urban | -0.96 | \checkmark | -2.55 - 0.63 | R _{day1} | 2.1 | 0.956 |
| Mixed | -2.25*** | \checkmark | -3.54 – -0.96 | R _{day10} | 1.1 | 0.935 |
| Focus Summer | -2.41* | \checkmark | -4.90 - 0.08 | R _{sum} | 1.1 | 0.863 |
| Focus Winter | 1.60 | \checkmark | -0.85 - 4.05 | T_{mean} | 1.1 | 0.937 |

Table 2-15: Attributes and results of the finally selected models (October)

Significance codes: *** ... 0.01, ** ... 0.05, * ... 0.1

To give a better overview, Table 2-16 once more summarizes the weather indices finally employed for quantifying the weather sensitivities of the regional overnight stays on a monthly basis. As reported in the table in 25 % of cases the BIC-criterion selects the temperature index for quantifying the weather impacts on regional overnight stays, whereas in 75 % of cases one of the precipitation indices is chosen. An overview of the quantified weather sensitivities corresponding to the indices outlined in Table 2-16 is presented in Table 2-17.

| | Мау | June | July | August | September | October |
|--------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Urban | T _{mean} | R _{day1} | R _{day10} | R _{day1} | R _{day10} | R _{day1} |
| Mixed | T _{mean} | R _{day10} | R _{day10} | R _{day10} | R _{day1} | R _{day10} |
| Focus Summer | R _{day10} | T _{mean} | T _{mean} | R _{day1} | R _{sum} | R _{sum} |
| Focus Winter | T _{mean} | R _{day10} | R _{day1} | R _{day10} | R _{day10} | T _{mean} |

Table 2-16: Overview of the finally selected weather indices

Measured in terms of the number of regional impact functions that exhibit statistically significant weather index coefficients, results suggest overnight stays to be most weather sensitive during August, followed by October. No statistically significant weather dependency at all is found for overnight stays during July.

| | | | | loo of rogional (| , vornight otayo | |
|--------------|-----------------|----------|---------|--------------------|------------------|--------------------|
| | Мау | June | July | August | September | October |
| Urban | -2.00** × | 2.20** × | -1.09 √ | -0.58 √ | -1.06 √ | -0.96 √ |
| Mixed | -1.07 × | 1.37 × | 0.33 × | -2.01 *** √ | -1.35** √ | -2.25 *** √ |
| Focus Summer | - 2.65 √ | 1.01 √ | 0.58 √ | -1.88 * √ | -1.20 √ | -2.41 * √ |
| Focus Winter | -2.33 × | 2.14 × | 1.30 × | -2.99*** √ | -1.44 √ | 1.60 √ |

| Table 2-17: Overview of the weather s | sensitivities of regional | overnight stays |
|---------------------------------------|---------------------------|-----------------|
|---------------------------------------|---------------------------|-----------------|

Finally, it is important to note that, based on the initial data being available for summer season analyses, the weather impacts quantified for each summer month strictly speaking only refer to overnight stays in hotels and similar establishments. Nevertheless, for the analyses presented in chapter 3 we assume the estimated impact functions to be also



representative for overnight stays in other accommodation facilities than hotels and similar establishments.

2.3.3 Concluding remarks

Using observational data¹² of the periods 1973 to 2006 (winter season analysis) and 1977 to 2006 (summer season analysis) respectively, we calibrated region- and season-specific impact functions of changes in a particular weather index on overnight stays. Except for the occasional one, the finally selected models all show an acceptable to high adjusted R². Note that the historical weather sensitivities derived from the calibrated impact functions already consider some degree of adaptation, namely the average level observed within the calibration period.

3 Impact scenarios

Chapter 2 focused on the region- and season-specific weather sensitivity of tourism demand, which represents one of the two factors that determine the direction and extent of climate change impacts on tourism demand. The present chapter on the one hand deals with the second factor – the region- and season-specific exposure to changes in the climate – and on the other hand merges both factors in order to quantify the potential impacts of climate change on tourism demand. The following subsections describe methods and data employed as well as the results.

3.1 Methods

In order to quantify the potential impacts of climate change on tourism demand under the assumption of no additional adaptation measures - i.e. under the assumption of the same adaptation level as in the calibration period - we proceed in three steps:

STEP 1: Generation of region- and season-specific baseline scenarios

In a first step, the calibrated region- and season-specific impact functions outlined in chapter 2 are used to simulate how overnight stays could potentially evolve until 2050 if the climatic conditions remained the same as in the recent past. For this purpose, some sort of climate baseline scenario, which exhibits the same climatic mean and variability as observed in the climate normal period 1971-2000, is simulated for the scenario period 2007 to 2050 for each weather index finally selected to enter one of the impact functions. This is done by randomly drawing (without replacement) 44 times from the set of weather-index-specific observational

¹² Actually, the data on snow employed for calibrating the impact functions represents data generated by a snow model. However, since observed temperature and precipitation data enter this model, the snow indices are referred to as observational data.



data points used for calibrating the respective impact function. Mean and standard deviation of the resulting time series are adjusted to the ones observed for the period 1971-2000. Note that this method of generating climate baseline scenarios would not work properly

- if more than one weather index was considered in a region- and season-specific impact function at once, as the method ignores correlations between different weather indices,
- or if the analysis was carried out at a higher temporal resolution (e.g. on a daily instead of a seasonal or monthly base).

It is further important to state that, contrary to actually observed time series of the considered weather indices, a climate baseline scenario generated by the above mentioned approach does not exhibit any autocorrelation. Moreover, since our approach involves some randomness in generating a climate baseline scenario, the sensitivity of the final results with respect to different simulations of the climate baseline scenario will be investigated in chapter 3.4.

Note that, besides the meteorological data representing the climatic conditions of the recent past, the simulations of region- and season-specific overnight stays are solely based on the functional relationships and evolutions observed within the calibration period and describe one of a countless number of possible developments. It is also important to mention that our prior interest does not refer to the evolution of the overnight stays itself, but to the difference between the development described by the baseline scenario and the development described by several climate change scenarios, i.e. the result of STEP 3.

STEP 2: Generation of region- and season-specific climate change scenarios

In a second step, again the calibrated region- and season-specific impact functions outlined in chapter 2 are applied to simulate how overnight stays could potentially evolve until 2050. But this time instead of using meteorological data representing the climatic conditions of the recent past, meteorological scenario data, generated by four different regional climate models, are employed. By the way, the difference between the climate as simulated for the baseline scenario and the climate as simulated for the climate change scenarios represents the exposure to potential changes in the climate.

STEP 3: Generation of region- and season-specific impact scenarios

In a final step, the deviation of each climate change scenario from the baseline scenario is calculated, which results in the region- and season-specific impact scenarios.

3.2 **Data**

Having outlined the methods employed to quantify the potential impacts of climate change on tourism demand, the present chapter presents the meteorological data used to generate the baseline as well as the climate change scenarios.



3.2.1 Meteorological data for the baseline scenario

For each of the weather indices finally selected to enter one of the region- and seasonspecific impact functions a time series consisting of 44 data points and exhibiting the climatic mean and variability as observed during the climate normal period 1971-2000 needs to be simulated in order to generate region- and season-specific baseline scenarios for the period 2007 to 2050. As already mentioned, we construct each of these time series by randomly drawing (without replacement) from the set of weather-index-specific observational data points used for calibrating the respective impact function. In order to ensure that the statistical key figures (mean and standard deviation) of the meteorological time series simulated for the baseline scenarios coincide with that observed during the climate normal period 1971-2000, some adjustments need to be taken. First of all, each data point of a simulated time series is multiplied by a constant factor that causes the standard deviation of the respective simulated time series to adjust to the standard deviation observed during the climate normal period. In a second step, a positive or negative constant is added to each data point of the already partly adjusted time series in order to adapt its mean to that observed during the climate normal period. The whole procedure, ranging from the simulation of the time series to its mean and variability adjustment, is carried out for each weather index finally selected to enter one of the region- and season-specific impact functions.

3.2.2 Meteorological data for the climate change scenarios

For the climate change scenarios, error corrected meteorological data for four different scenarios generated by the regional climate models CNRM-RM4.5, ETHZ-CLM, ICTP-REGCM3, and SMHI-RCA on the basis of IPCC's A1B emission scenario are provided by our project partner WegC-RELOCLIM for each of the weather indices listed in Table 2-5. The time horizon of these meteorological scenario data comprises 1951 to 2050, whereas their temporal and regional resolution coincides with the original temporal and regional resolution of the observational meteorological data used for calibrating the impact functions. Thus, meteorological scenario data on snow indices are given at grid cell level on a monthly basis, whereas meteorological scenario data on temperature and precipitation indices from a monthly to a seasonal basis and from grid cell to tourism region level, the same data preparation steps as described in chapter 2.2.3 are carried out. The same holds true for transforming the temperature and precipitation indices from a precipitation indices from a monthly to the tourism region level. However, for reasons explained below, further data preparation steps need to be taken.

Remember that observational meteorological data has been used in order to calibrate the impact functions outlined in chapter 2. However, there might be some kind of gap when switching from actually observed meteorological data to meteorological scenario data generated by a climate model, since the latter does not necessarily reproduce the exactly same climatic conditions (represented by the climatological mean and variability) as actually observed in the past. To eliminate this gap and ensure that the weather index coefficients of



the impact functions, which were estimated by using observational data, can be applied to the meteorological scenario data, the latter need some adjustment. Thus, in a first step, each data point of a particular scenario time series encompassing the period 1951 to 2050 is multiplied by a constant factor that causes the time series' standard deviation during the climate normal period 1971-2000 to coincide with the actually observed one. In a second step, a positive or negative constant is added to each data point of the already partly adjusted time series such that its mean during the climate normal period is adjusted to that of the actually observed data. This adjustment procedure is applied on each of the four scenarios given for those weather indices that are finally selected to enter one of the regionand season-specific impact functions. As an example, Figure 3-1 illustrates this adjustment for scenario data (generated by the climate model CNRM-RM4.5) on weather index R_{day10} in the "focus summer" tourism region during May.



Figure 3-1: Adjustment of the scenario data using the example of weather index R_{day10} in the "focus summer" tourism region during May

3.3 Results

Having described methods and data applied to quantify the potential impacts of climate change on tourism demand the following subsections outline the resulting outcomes. Besides the separate presentation of the results for the winter season and the summer season, outcomes are also aggregated and outlined for the whole tourism year.



3.3.1 Winter season

Before presenting the results regarding the potential climate change impacts on tourism demand, Figure 3-2 to Figure 3-5 show each region's exposure to changes in the snow index that enters the respective regional impact function. More precisely, the difference between the evolution of the considered weather index as simulated by one of the climate models and the evolution of the considered weather index as simulated for the baseline scenario is illustrated. Since the difference observed in one particular winter season is somewhat random and does not allow conclusions about changes in the climate, the dotted lines additionally represent 20-year-averages (2011 to 2030 and 2031 to 2050) of the illustrated differences. According to these 20-year-averages, all four climate change scenarios indicate a decrease in each of the considered regional snow indices compared to the baseline.



Figure 3-2: Exposure of winter overnight stays in the "urban" tourism region to changes in the finally selected snow index (S_{mean})





Figure 3-3: Exposure of winter overnight stays in the "mixed" tourism region to changes in the finally selected snow index (S_{mean})



Figure 3-4: Exposure of winter overnight stays in the "focus summer" tourism region to changes in the finally selected snow index (S_{mean})





Figure 3-5: Exposure of winter overnight stays in the "focus winter" tourism region to changes in the finally selected snow index (S_{mean})

Having illustrated the regions' exposure to changes in the considered snow index, we now turn to the presentation of the potential climate change impacts on tourism demand as indicated by the results of our analyses. Figure 3-6 shows the outcomes of the first two steps of the procedure that is employed to quantify the potential climate change impacts on tourism demand (see chapter 3.1), namely the regional evolution of winter overnight stays as simulated by the baseline and the four climate change scenarios.



Urban and Thermal Spa tourism region







Focus Summer tourism region







Figure 3-6: Baseline and climate change scenarios for the winter season



On the left-hand side of the dotted vertical line, each of the plots in Figure 3-6 outlines the historical evolution of the regional overnight stays as observed for the respective tourism region in the period 1973 to 2006. On the right-hand side of the dotted line, potential evolutions of the overnight stays until 2050 are illustrated. As outlined in chapter 3.1, these were simulated by inserting five different meteorological scenario data sets – representing a baseline scenario and four climate change scenarios – into the calibrated regional impact functions.

Remember that our primary interest is not the evolution of the overnight stays itself, but the deviation of the climate change scenarios to the baseline scenario, which represents the potential impacts of climate change on overnight stays. As mentioned above, the exposure observed in one particular winter season is somewhat random. The same holds true for the potential impacts, since the exposure forms one of the factors they depend on. Thus, long-term averages are calculated again. Besides the 20-year-averages for the periods 2011 to 2030 and 2031 to 2050, also 40-year-averages that encompass the period 2011 to 2050 are pointed out (see Table 3-1 to Table 3-3 and Figure 3-7).

Table 3-1: Average seasonal deviation from baseline overnight stays between 2011 and 2050 (winterseason)

| | | Absolute | e [in 1.000] | | Relative [in %] | | | |
|--------------|--------|----------|--------------|--------|-----------------|--------|--------|--------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban | -314 | -374 | -329 | -544 | -1.45 | -1.69 | -1.55 | -2.54 |
| Mixed | -127 | -106 | -140 | -159 | -2.07 | -1.72 | -2.28 | -2.58 |
| Focus Summer | -1,741 | -1,443 | -1,207 | -2,057 | -27.82 | -21.78 | -18.71 | -33.21 |
| Focus Winter | -2,373 | -2,375 | -2,441 | -3,370 | -6.40 | -6.41 | -6.60 | -9.11 |

Table 3-2: Average seasonal deviation from baseline overnight stays between 2011 and 2030 (winterseason)

| | | Absolute | e [in 1.000] | | Relative [in %] | | | |
|--------------|--------|----------|--------------|--------|-----------------|-------|-------|--------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban | -223 | -240 | -245 | -404 | -1.30 | -1.38 | -1.43 | -2.37 |
| Mixed | -127 | -77 | -112 | -160 | -2.06 | -1.24 | -1.82 | -2.59 |
| Focus Summer | -886 | -319 | -386 | -1,178 | -16.06 | -4.53 | -6.54 | -21.61 |
| Focus Winter | -1,827 | -1,627 | -1,716 | -2,753 | -4.88 | -4.30 | -4.60 | -7.34 |



| | | | | season) | | | | | |
|--------------|--------|---------------------|--------|---------|--------|-----------------|--------|--------|--|
| | | Absolute [in 1.000] | | | | Relative [in %] | | | |
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | |
| Urban | -404 | -508 | -413 | -684 | -1.61 | -1.99 | -1.68 | -2.72 | |
| Mixed | -127 | -135 | -167 | -157 | -2.08 | -2.21 | -2.74 | -2.58 | |
| Focus Summer | -2,595 | -2,568 | -2,027 | -2,936 | -39.57 | -39.03 | -30.89 | -44.81 | |
| Focus Winter | -2,919 | -3,124 | -3,165 | -3,987 | -7.93 | -8.52 | -8.60 | -10.88 | |

Table 3-3: Average seasonal deviation from baseline overnight stays between 2031 and 2050 (winterseason)





Figure 3-7: Average seasonal deviation from baseline overnight stays between a) 2011 and 2050, b) 2011 and 2031, c) 2031 and 2050 (winter season)

As outlined in Table 3-1 to Table 3-3 and Figure 3-7 all four climate change scenarios indicate negative climatic effects on winter tourism demand in all four tourism regions. The results further suggest that the average negative climatic effects increase over time (compare Table 3-2 and Table 3-3 or plots b) and c) in Figure 3-7). Measured in relative terms, winter overnight stays in the "focus summer" tourism region show the highest reductions due to potential climate change, whereas absolute decreases are the highest in the "focus winter" tourism region.



3.3.2 Summer season

In fact, results regarding the summer season are available on a monthly basis. However, for reasons of clarity, figures and tables relating to these monthly results are outlined in the Appendix. The following presentations, by contrast, refer to the summer season as a whole and represent the aggregated monthly results.

Figure 3-8 outlines the regional evolution of summer overnight stays as simulated by the baseline and the climate change scenarios, whereas Table 3-4 to Table 3-6 as well as Figure 3-9 present the potential impacts of climate change on summer overnight stays. Compared to the winter season, results suggest the extent of the climate change impacts to be smaller (both, in absolute and relative terms). Regarding the impact direction, outcomes are by far less clear than in case of the winter season, as in many cases the direction depends on the regional climate model employed to generate the scenario data used for the simulation.



Urban and Thermal Spa tourism region



Mixed Portfolio of Lower Intensity tourism region



Focus Summer tourism region





Figure 3-8: Baseline and climate change scenarios for the summer season



| | | | | season) | | | | | |
|--------------|------|---------------------|------|---------|-------|-----------------|-------|-------|--|
| | | Absolute [in 1.000] | | | | Relative [in %] | | | |
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | |
| Urban | -173 | -110 | -189 | -53 | -0.84 | -0.51 | -0.92 | -0.22 | |
| Mixed | -67 | -3 | -132 | -30 | -0.82 | -0.06 | -1.56 | -0.37 | |
| Focus Summer | -52 | 52 | -60 | 64 | -0.80 | 0.83 | -1.13 | 1.11 | |
| Focus Winter | 856 | 270 | -285 | -145 | 4.12 | 1.29 | -1.35 | -0.69 | |

Table 3-4: Average seasonal deviation from baseline overnight stays between 2011 and 2050 (summerseason)

Table 3-5: Average seasonal deviation from baseline overnight stays between 2011 and 2030 (summerseason)

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|--------------|---------------------|------|------|------|-----------------|-------|-------|------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban | -130 | -30 | -142 | 35 | -0.70 | -0.16 | -0.77 | 0.19 |
| Mixed | 23 | 57 | -85 | 65 | 0.25 | 0.63 | -0.96 | 0.74 |
| Focus Summer | -65 | 48 | -33 | 59 | -0.81 | 0.61 | -0.55 | 0.87 |
| Focus Winter | 986 | 385 | -287 | 44 | 4.68 | 1.83 | -1.35 | 0.23 |

Table 3-6: Average seasonal deviation from baseline overnight stays between 2031 and 2050 (summerseason)

| | | Absolute | [in 1.000] | | Relative [in %] | | | |
|--------------|------|----------|------------|------|-----------------|-------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban | -217 | -190 | -237 | -141 | -0.98 | -0.86 | -1.08 | -0.64 |
| Mixed | -157 | -62 | -179 | -124 | -1.89 | -0.75 | -2.15 | -1.49 |
| Focus Summer | -40 | 56 | -87 | 69 | -0.80 | 1.05 | -1.71 | 1.35 |
| Focus Winter | 726 | 156 | -283 | -334 | 3.55 | 0.76 | -1.36 | -1.61 |







Figure 3-9: Average seasonal deviation from baseline overnight stays between a) 2011 and 2050, b) 2011 and 2031, c) 2031-2050 (summer season)

3.3.3 Tourism year

Aggregating the outcomes of the winter and summer season gives the results for the whole tourism year, which are presented in Figure 3-10, Table 3-7 to Table 3-9 and Figure 3-11. As shown in the tables, the potential climate change impacts outlined for the whole tourism year are largely dominated by the winter season. Thus, results indicate negative climatic effects on each region's tourism demand regardless of the considered climate change scenario, with decreases found to be highest in the "focus summer" tourism region.



Urban and Thermal Spa tourism region







Focus Summer tourism region





Figure 3-10: Baseline and climate change scenarios for the tourism year



| | | Absolute | e [in 1.000] | | Relative [in %] | | | |
|--------------|--------|----------|--------------|--------|-----------------|--------|--------|--------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban | -487 | -484 | -519 | -597 | -1.15 | -1.11 | -1.24 | -1.39 |
| Mixed | -194 | -108 | -272 | -188 | -1.34 | -0.75 | -1.86 | -1.29 |
| Focus Summer | -1,793 | -1,391 | -1,267 | -1,993 | -14.92 | -11.84 | -10.64 | -16.55 |
| Focus Winter | -1,517 | -2,105 | -2,726 | -3,515 | -2.63 | -3.65 | -4.73 | -6.10 |

Table 3-7: Average annual deviation from baseline overnight stays between 2011 and 2050 (tourism year)

Table 3-8: Average annual deviation from baseline overnight stays between 2011 and 2030 (tourism year)

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|--------------|---------------------|--------|--------|--------|-----------------|-------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban | -353 | -270 | -386 | -369 | -0.99 | -0.75 | -1.08 | -1.03 |
| Mixed | -105 | -20 | -197 | -95 | -0.70 | -0.14 | -1.32 | -0.63 |
| Focus Summer | -951 | -271 | -419 | -1,119 | -7.42 | -2.23 | -3.30 | -8.72 |
| Focus Winter | -840 | -1,242 | -2,003 | -2,709 | -1.43 | -2.11 | -3.43 | -4.63 |

| Table 3-9: Average annual deviation | rom baseline overnight stays between | 2031 and 2050 (tourism year) |
|-------------------------------------|--------------------------------------|------------------------------|
|-------------------------------------|--------------------------------------|------------------------------|

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|--------------|---------------------|--------|--------|--------|-----------------|--------|--------|--------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban | -621 | -698 | -651 | -825 | -1.32 | -1.47 | -1.40 | -1.75 |
| Mixed | -284 | -197 | -346 | -282 | -1.97 | -1.37 | -2.41 | -1.96 |
| Focus Summer | -2,635 | -2,511 | -2,115 | -2,867 | -22.41 | -21.45 | -17.99 | -24.38 |
| Focus Winter | -2,193 | -2,969 | -3,448 | -4,321 | -3.83 | -5.20 | -6.02 | -7.57 |







Figure 3-11: Average annual deviation from baseline overnight stays between a) 2011 and 2050, b) 2011 and 2031, c) 2031-2050 (tourism year)

3.4 Sensitivity analysis

As mentioned in chapter 3.1, our approach of generating climate baseline scenarios involves some randomness. Thus, within this section the sensitivity of the final results with respect to different simulations of the climate baseline scenario is investigated. For this purpose, simulating a climate baseline scenario for each of the weather indices finally selected to enter one of the region- and season-specific impact functions is repeated 1,000 times, resulting in 1,000 different simulations of the climate baseline scenario per considered weather index. Then, for each considered tourism region and season the three-step-



procedure for quantifying the potential impacts of climate change on tourism demand as described in chapter 3.1 is carried out 1,000 times, using each time another simulation of the climate baseline scenario. This results in 1,000 different estimations of the potential impacts of climate change on tourism demand per considered tourism region and season. Figure 3-12 (winter season), Figure 3-13 (summer season) and Figure 3-14 (tourism year) illustrate the range in the resulting quantified potential climate change impacts on tourism demand by reporting for each considered tourism region and each applied climate change scenario the upper (a) and lower (c) bound of the 1,000 estimations on the average deviation from baseline overnight stays between 2011 and 2050. For reasons of comparison, the result reported in chapter 3.3, which lies somewhere between the upper and lower bound, is illustrated as well (b).







Figure 3-12: Range in the average seasonal deviation from baseline overnight stays between 2011 and 2050 with 1,000 baseline simulations (winter season)







Figure 3-13: Range in the average seasonal deviation from baseline overnight stays between 2011 and 2050 with 1,000 baseline simulations (summer season)







Figure 3-14: Range in the average annual deviation from baseline overnight stays between 2011 and 2050 with 1,000 baseline simulations (tourism year)



4 References

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5 Appendix

Table 5-1: Weather sensitivity of overnights stays in May depending on the chosen weather index

| | T _{mean} | R _{day1} | R _{day10} | R_{sum} |
|--------------|-------------------|-------------------|--------------------|-----------|
| Urban | -2.00** | -0.37 | -0.28 | 0.00 |
| Mixed | -1.07 | 0.13 | -0.62 | -0.10 |
| Focus Summer | -0.33 | -2.32 | -2.65 | -3.63* |
| Focus Winter | -2.33 | -1.09 | -1.89 | -1.50 |

Table 5-2: Weather sensitivity of overnights stays in June depending on the chosen weather index

| | T _{mean} | R _{day1} | R _{day10} | R _{sum} |
|--------------|-------------------|-------------------|--------------------|------------------|
| Urban | -1.10 | 2.20** | 0.68 | 1.13 |
| Mixed | 0.17 | 1.01 | 1.37 | 1.05 |
| Focus Summer | 1.01 | -0.29 | -0.11 | -0.42 |
| Focus Winter | 1.43 | 1.18 | 2.14 | 1.75 |

Table 5-3: Weather sensitivity of overnights stays in July depending on the chosen weather index

| | T _{mean} | R _{day1} | R _{day10} | R _{sum} |
|--------------|-------------------|-------------------|--------------------|------------------|
| Urban | -0.11 | 0.33 | -1.09 | -1.02 |
| Mixed | 0.10 | 0.23 | 0.33 | 0.06 |
| Focus Summer | 0.58 | -0.19 | -0.44 | -0.49 |
| Focus Winter | -0.83 | 1.30 | 0.56 | 0.51 |

Table 5-4: Weather sensitivity of overnights stays in August depending on the chosen weather index

| | T _{mean} | R _{day1} | R _{day10} | R _{sum} |
|--------------|-------------------|-------------------|--------------------|------------------|
| Urban | 0.15 | -0.58 | -0.58 | -0.40 |
| Mixed | 1.07 | -1.7** | -2.01*** | -1.78** |
| Focus Summer | 1.96* | -1.88* | -1.61 | -1.76 |
| Focus Winter | 0.95 | -1.80* | -2.99*** | -2.37** |

Table 5-5: Weather sensitivity of overnights stays in September depending on the chosen weather index

| | T _{mean} | R _{day1} | R _{day10} | R _{sum} |
|--------------|-------------------|-------------------|--------------------|------------------|
| Urban | 0.71 | -0.78 | -1.06 | -0.72 |
| Mixed | 1.10 | -1.35** | -1.06 | -1.30* |
| Focus Summer | - | -2.04** | -1.09 | -1.20 |
| Focus Winter | 0.72 | -1.39 | -1.44 | -1.30 |



| Tabla E 6: Waathar concitivit | v of overnighte ote | wa in Aatabar danandina | , on the chocon | woothor indox |
|--------------------------------|---------------------|--------------------------|-----------------|---------------|
| i abie 5-0. Weather Sensitivit | v or overmunits sta | ivs in October debending | a on the chosen | weather muex |
| | | | | |

| | T _{mean} | R _{day1} | R _{day10} | R _{sum} |
|--------------|-------------------|-------------------|--------------------|------------------|
| Urban | -0.73 | -0.96 | -0.74 | -0.82 |
| Mixed | 1.19 | -2.13*** | -2.25*** | -2.22*** |
| Focus Summer | 0.19 | -2.25* | -2.30* | -2.41* |
| Focus Winter | 1.60 | -1.17 | -0.75 | -0.91 |



Figure 5-1: Exposure of May overnight stays in the "urban" tourism region to changes in the finally selected weather index (T_{mean})



Figure 5-2: Exposure of May overnight stays in the "mixed" tourism region to changes in the finally selected weather index (T_{mean})





Figure 5-3: Exposure of May overnight stays in the "focus summer" tourism region to changes in the finally selected weather index (R_{day10})



Figure 5-4: Exposure of May overnight stays in the "focus winter" tourism region to changes in the finally selected weather index (T_{mean})





Figure 5-5: Exposure of June overnight stays in the "urban" tourism region to changes in the finally selected weather index (R_{day1})



Figure 5-6: Exposure of June overnight stays in the "mixed" tourism region to changes in the finally selected weather index (R_{day10})





Figure 5-7: Exposure of June overnight stays in the "focus summer" tourism region to changes in the finally selected weather index (T_{mean})



Figure 5-8: Exposure of June overnight stays in the "focus winter" tourism region to changes in the finally selected weather index (R_{day10})





Figure 5-9: Exposure of July overnight stays in the "urban" tourism region to changes in the finally selected weather index (R_{day10})



Figure 5-10: Exposure of July overnight stays in the "mixed" tourism region to changes in the finally selected weather index (R_{day10})





Figure 5-11: Exposure of July overnight stays in the "focus summer" tourism region to changes in the finally selected weather index (T_{mean})



Figure 5-12: Exposure of July overnight stays in the "focus winter" tourism region to changes in the finally selected weather index (R_{day1})





Figure 5-13: Exposure of August overnight stays in the "urban" tourism region to changes in the finally selected weather index (R_{day1})



Figure 5-14: Exposure of August overnight stays in the "mixed" tourism region to changes in the finally selected weather index (R_{day10})





Figure 5-15: Exposure of August overnight stays in the "focus summer" tourism region to changes in the finally selected weather index (R_{day1})



Figure 5-16: Exposure of August overnight stays in the "focus winter" tourism region to changes in the finally selected weather index (R_{day10})





Figure 5-17: Exposure of September overnight stays in the "urban" tourism region to changes in the finally selected weather index (R_{day10})



Figure 5-18: Exposure of September overnight stays in the "mixed" tourism region to changes in the finally selected weather index (R_{day1})





Figure 5-19: Exposure of September overnight stays in the "focus summer" tourism region to changes in the finally selected weather index (R_{sum})



Figure 5-20: Exposure of September overnight stays in the "focus winter" tourism region to changes in the finally selected weather index (R_{day10})





Figure 5-21: Exposure of October overnight stays in the "urban" tourism region to changes in the finally selected weather index (R_{day1})



Figure 5-22: Exposure of October overnight stays in the "mixed" tourism region to changes in the finally selected weather index (R_{day10})





Figure 5-23: Exposure of October overnight stays in the "focus summer" tourism region to changes in the finally selected weather index (R_{sum})



Figure 5-24: Exposure of October overnight stays in the "focus winter" tourism region to changes in the finally selected weather index (T_{mean})



Urban and Thermal Spa tourism region







Focus Summer tourism region





Figure 5-25: Baseline and climate change scenarios for month May



| between 2011 and 2050 | | | | | | | | | |
|------------------------------|------|---------------------|------|------|-------|-----------------|-------|-------|--|
| | | Absolute [in 1.000] | | | | Relative [in %] | | | |
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | |
| Urban ^{b)} | -94 | -79 | -117 | -67 | -2.25 | -1.91 | -2.94 | -1.65 | |
| Mixed ^{a,b)} | -12 | -10 | -13 | -9 | -0.78 | -0.66 | -0.92 | -0.61 | |
| Focus Summer | -14 | 10 | 10 | -8 | -1.11 | 0.98 | 0.95 | -0.55 | |
| Focus Winter ^{a,b)} | -42 | -43 | -52 | -31 | -2.20 | -2.24 | -2.70 | -1.62 | |

Table 5-7: Difference to the baseline scenario regarding the average monthly overnight stays (May)

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-8: Difference to the baseline scenario regarding the average monthly overnight stays (May)between 2011 and 2030

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|-----------------------|---------------------|------|------|------|-----------------|-------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{b)} | -49 | -25 | -59 | -41 | -1.46 | -0.78 | -1.87 | -1.26 |
| Mixed ^{a,b)} | -7 | -4 | -8 | -7 | -0.49 | -0.29 | -0.63 | -0.50 |
| Focus Summer | -25 | -6 | -6 | -24 | -1.98 | -0.41 | -0.47 | -1.96 |
| Focus Winter a,b) | -14 | -15 | -27 | -17 | -0.71 | -0.77 | -1.42 | -0.89 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level) ^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-9: Difference to the baseline scenario regarding the average monthly overnight stays (May) between 2031 and 2050

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|-----------------------|---------------------|------|------|------|-----------------|-------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{b)} | -139 | -132 | -175 | -93 | -3.04 | -3.05 | -4.01 | -2.05 |
| Mixed ^{a,b)} | -16 | -15 | -18 | -11 | -1.06 | -1.02 | -1.21 | -0.71 |
| Focus Summer | -3 | 27 | 27 | 9 | -0.25 | 2.36 | 2.36 | 0.86 |
| Focus Winter a,b) | -71 | -71 | -77 | -45 | -3.70 | -3.71 | -3.98 | -2.34 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign



Urban and Thermal Spa tourism region







Focus Summer tourism region





Figure 5-26: Baseline and climate change scenarios for month June



| between 2011 and 2050 | | | | | | | | | |
|----------------------------|------|---------------------|------|------|------|-----------------|-------|-------|--|
| | | Absolute [in 1.000] | | | | Relative [in %] | | | |
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | |
| Urban ^{b)} | 41 | -21 | -5 | -14 | 1.34 | -0.61 | -0.16 | -0.32 | |
| Mixed ^{a,b)} | 31 | 5 | 1 | -8 | 2.06 | 0.38 | 0.07 | -0.51 | |
| Focus Summer ^{a)} | 8 | 15 | 8 | 14 | 0.84 | 1.52 | 0.72 | 1.43 | |
| Focus Winter a,b) | 63 | 2 | -11 | 3 | 2.41 | 0.04 | -0.36 | 0.10 | |

Table 5-10: Difference to the baseline scenario regarding the average monthly overnight stays (June)

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-11: Difference to the baseline scenario regarding the average monthly overnight stays (June)between 2011 and 2030

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|----------------------------|---------------------|------|------|------|-----------------|-------|-------|------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{b)} | 28 | -4 | -12 | 2 | 1.01 | -0.10 | -0.45 | 0.11 |
| Mixed ^{a,b)} | 27 | 21 | 7 | 8 | 1.80 | 1.41 | 0.51 | 0.55 |
| Focus Summer ^{a)} | 9 | 12 | 7 | 13 | 0.77 | 1.01 | 0.50 | 1.06 |
| Focus Winter a,b) | 78 | 45 | 8 | 43 | 2.83 | 1.63 | 0.35 | 1.59 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level) ^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-12: Difference to the baseline scenario regarding the average monthly overnight stays (June) between 2031 and 2050

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|----------------------------|---------------------|------|------|------|-----------------|-------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{b)} | 54 | -39 | 2 | -29 | 1.68 | -1.11 | 0.14 | -0.75 |
| Mixed ^{a,b)} | 35 | -10 | -6 | -24 | 2.33 | -0.66 | -0.36 | -1.57 |
| Focus Summer ^{a)} | 8 | 18 | 8 | 15 | 0.92 | 2.04 | 0.94 | 1.80 |
| Focus Winter a,b) | 48 | -41 | -29 | -37 | 1.98 | -1.55 | -1.06 | -1.39 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign



Urban and Thermal Spa tourism region







Focus Summer tourism region





Figure 5-27: Baseline and climate change scenarios for month July



| | between 2011 and 2050 | | | | | | | | | | | |
|------------------------------|-----------------------|----------|------------|------|-----------------|-------|-------|-------|--|--|--|--|
| | | Absolute | [in 1.000] | | Relative [in %] | | | | | | | |
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | | | | |
| Urban ^{b)} | -16 | 20 | 12 | 16 | -0.56 | 0.75 | 0.44 | 0.58 | | | | |
| Mixed ^{a,b)} | 5 | -3 | -3 | -4 | 0.33 | -0.23 | -0.24 | -0.24 | | | | |
| Focus Summer ^{a)} | 34 | 24 | 24 | 11 | 3.35 | 2.51 | 2.19 | 1.19 | | | | |
| Focus Winter ^{a,b)} | 596 | -9 | -229 | -123 | 12.70 | -0.06 | -4.78 | -2.58 | | | | |

Table 5-13: Difference to the baseline scenario regarding the average monthly overnight stays (July)

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-14: Difference to the baseline scenario regarding the average monthly overnight stays (July)between 2011 and 2030

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|----------------------------|---------------------|------|------|------|-----------------|------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{b)} | -30 | 5 | 8 | 22 | -1.05 | 0.20 | 0.28 | 0.79 |
| Mixed ^{a,b)} | 9 | 0 | -3 | -8 | 0.57 | 0.01 | -0.24 | -0.56 |
| Focus Summer ^{a)} | 43 | 27 | 33 | 12 | 3.06 | 1.98 | 2.23 | 0.91 |
| Focus Winter a,b) | 651 | 171 | -146 | -32 | 14.07 | 3.69 | -3.14 | -0.69 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level) ^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-15: Difference to the baseline scenario regarding the average monthly overnight stays (July) between 2031 and 2050

| | 1 | Absolute | [in 1.000] | | Relative [in %] | | | | |
|----------------------------|------|----------|------------|------|-----------------|-------|-------|-------|--|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | |
| Urban ^{b)} | -2 | 35 | 16 | 10 | -0.07 | 1.29 | 0.60 | 0.38 | |
| Mixed ^{a,b)} | 1 | -6 | -4 | 1 | 0.09 | -0.46 | -0.24 | 0.09 | |
| Focus Summer ^{a)} | 25 | 20 | 14 | 10 | 3.63 | 3.03 | 2.15 | 1.46 | |
| Focus Winter a,b) | 541 | -189 | -312 | -215 | 11.33 | -3.81 | -6.41 | -4.47 | |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign



Urban and Thermal Spa tourism region







Focus Summer tourism region





Figure 5-28: Baseline and climate change scenarios for month August



Table 5-16: Difference to the baseline scenario regarding the average monthly overnight stays (August) between 2011 and 2050

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|---------------------|---------------------|------|------|------|-----------------|------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{b)} | -3 | 24 | 12 | -3 | -0.10 | 0.75 | 0.36 | -0.09 |
| Mixed | -6 | 19 | -15 | -16 | -0.38 | 1.16 | -0.73 | -0.77 |
| Focus Summer | -30 | 29 | 1 | -7 | -1.56 | 2.04 | -0.24 | 0.18 |
| Focus Winter | 14 | 77 | 23 | -18 | 0.31 | 1.61 | 0.67 | -0.12 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-17: Difference to the baseline scenario regarding the average monthly overnight stays (August)between 2011 and 2030

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|---------------------|---------------------|------|------|------|-----------------|------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{b)} | 17 | 16 | 12 | -3 | 0.52 | 0.50 | 0.36 | -0.09 |
| Mixed | 14 | 10 | -23 | -18 | 0.90 | 0.61 | -1.08 | -0.66 |
| Focus Summer | -41 | 22 | 18 | -30 | -1.55 | 1.18 | 0.62 | -0.83 |
| Focus Winter | 121 | 57 | -33 | -22 | 2.46 | 1.17 | -0.39 | -0.05 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level) ^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-18: Difference to the baseline scenario regarding the average monthly overnight stays (August) between 2031 and 2050

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|---------------------|---------------------|------|------|------|-----------------|------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{b)} | -23 | 33 | 12 | -3 | -0.71 | 0.99 | 0.37 | -0.09 |
| Mixed | -27 | 27 | -7 | -15 | -1.65 | 1.71 | -0.38 | -0.87 |
| Focus Summer | -19 | 35 | -16 | 15 | -1.57 | 2.90 | -1.09 | 1.18 |
| Focus Winter | -94 | 97 | 78 | -15 | -1.83 | 2.05 | 1.73 | -0.20 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign



Urban and Thermal Spa tourism region







Focus Summer tourism region





Figure 5-29: Baseline and climate change scenarios for month September



| (September) between 2011 and 2050 | | | | | | | | | | | |
|-----------------------------------|------|----------|------------|------|-----------------|-------|-------|-------|--|--|--|
| | | Absolute | [in 1.000] | | Relative [in %] | | | | | | |
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | | | |
| Urban ^{a)} | -54 | -21 | -55 | -10 | -1.94 | -0.75 | -1.99 | -0.36 | | | |
| Mixed | -13 | -8 | -12 | -17 | -0.99 | -0.55 | -0.85 | -1.25 | | | |
| Focus Summer ^{a)} | -19 | -1 | -26 | -4 | -2.38 | -0.02 | -3.11 | -0.63 | | | |
| Focus Winter ^{a)} | -105 | -33 | -94 | -57 | -2.45 | -0.72 | -2.18 | -1.30 | | | |

Table 5-19: Difference to the baseline scenario regarding the average monthly overnight stays

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-20: Difference to the baseline scenario regarding the average monthly overnight stays(September) between 2011 and 2030

| | | Absolute | [in 1.000] | | Relative [in %] | | | | |
|----------------------------|------|----------|------------|------|-----------------|-------|-------|-------|--|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | |
| Urban ^{a)} | -69 | -32 | -54 | 14 | -2.50 | -1.15 | -1.97 | 0.53 | |
| Mixed | 1 | -5 | -9 | -4 | 0.07 | -0.35 | -0.69 | -0.25 | |
| Focus Summer ^{a)} | -26 | -5 | -35 | -1 | -2.47 | -0.41 | -3.40 | 0.05 | |
| Focus Winter ^{a)} | -169 | -25 | -104 | -32 | -4.05 | -0.54 | -2.46 | -0.77 | |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level) ^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-21: Difference to the baseline scenario regarding the average monthly overnight stays (September) between 2031 and 2050

| | Absolute [in 1.000] | | | | Relative [in %] | | | | |
|----------------------------|---------------------|------|------|------|-----------------|-------|-------|-------|--|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | |
| Urban ^{a)} | -38 | -10 | -56 | -35 | -1.38 | -0.34 | -2.01 | -1.25 | |
| Mixed | -27 | -10 | -14 | -30 | -2.05 | -0.76 | -1.01 | -2.25 | |
| Focus Summer ^{a)} | -13 | 2 | -18 | -8 | -2.29 | 0.37 | -2.82 | -1.32 | |
| Focus Winter ^{a)} | -41 | -41 | -84 | -81 | -0.86 | -0.91 | -1.91 | -1.83 | |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign



Urban and Thermal Spa tourism region







Focus Summer tourism region





Focus Winter tourism region

Figure 5-30: Baseline and climate change scenarios for month October



Table 5-22: Difference to the baseline scenario regarding the average monthly overnight stays (October) between 2011 and 2050

| | Absolute [in 1.000] | | | | Relative [in %] | | | | |
|----------------------------|---------------------|------|------|------|-----------------|-------|--------|------|--|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI | |
| Urban ^{a,b)} | -48 | -34 | -36 | 26 | -0.96 | -0.53 | -0.71 | 0.70 | |
| Mixed | -72 | -7 | -89 | 24 | -5.86 | -0.36 | -7.26 | 2.20 | |
| Focus Summer | -32 | -25 | -76 | 58 | -4.22 | -3.25 | -10.28 | 8.03 | |
| Focus Winter ^{a)} | 331 | 276 | 78 | 82 | 15.45 | 12.84 | 3.66 | 3.87 | |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-23: Difference to the baseline scenario regarding the average monthly overnight stays (October) between 2011 and 2030

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|----------------------------|---------------------|------|------|------|-----------------|-------|-------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{a,b)} | -28 | 9 | -36 | 41 | -0.62 | 0.43 | -0.79 | 1.37 |
| Mixed | -22 | 34 | -48 | 93 | -1.66 | 3.17 | -3.84 | 8.06 |
| Focus Summer | -26 | -3 | -50 | 88 | -3.30 | -0.23 | -6.74 | 12.28 |
| Focus Winter ^{a)} | 319 | 152 | 15 | 104 | 15.00 | 7.10 | 0.81 | 5.01 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level) ^{b)} The weather coefficient of the underlying model shows a not expected sign

Table 5-24: Difference to the baseline scenario regarding the average monthly overnight stays (October) between 2031 and 2050

| | Absolute [in 1.000] | | | | Relative [in %] | | | |
|----------------------------|---------------------|------|------|------|-----------------|-------|--------|-------|
| | CNRM | ETHZ | ICTP | SMHI | CNRM | ETHZ | ICTP | SMHI |
| Urban ^{a,b)} | -68 | -77 | -36 | 10 | -1.30 | -1.50 | -0.62 | 0.04 |
| Mixed | -123 | -48 | -131 | -45 | -10.06 | -3.89 | -10.68 | -3.67 |
| Focus Summer | -38 | -46 | -102 | 27 | -5.14 | -6.27 | -13.82 | 3.78 |
| Focus Winter ^{a)} | 343 | 401 | 140 | 59 | 15.89 | 18.58 | 6.51 | 2.74 |

^{a)} The weather coefficient of the underlying model is not significant (at a 10% level)

^{b)} The weather coefficient of the underlying model shows a not expected sign

