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Climate change and winter tourism — A Pan-European perspective

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Abstract

This paper provides a detailed analysis of the *impact* of climate change on *winter sport tourism* in European regions. It draws on a European-wide study on 'climate change and territorial effects on regions and local economies' (ESPON Climate, 2011). The paper is based on a framework which considers 'impact' as the combined effects of exposure to climate change stimuli and economic sensitivity of the winter tourism sector. Using this framework, an innovative methodology is developed to identify regions whose winter sport tourism is likely to be significantly impacted by climate change.

1. Introduction

Climate change is one of the defining features of the twenty first century. Although the exact severity of its impacts is uncertain, there is no doubt that it affects many aspects of economy, society and environment in Europe. With regards to economy, the impact of climate change is threefold. Some sectors of the economy (such as the primary sectors, tourism, energy sector and infrastructure) are likely to be *directly* affected by climate change while others (such as manufacturing industries) will also be affected indirectly through complex supply and demand chains. Furthermore, climate change-related extreme weather events, such as flooding, can also affect major infrastructures and utilities which in turn may lead to significant disruption of economic activities and loss of capital and labour. One economic sector that is directly affected by climate change is tourism, defined by the United Nation World Tourism Organisation - in its 1991 Ottawa Conference on Travel and Tourism Statistics- as:

> "Activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited" (WTO, 1995:10).

Developing a deeper understanding of the relation between tourism and climate change has been the subject of a growing body of literature in recent years. While some studies (for example, Scott el al, 2004) have concentrated on the impact of climate change on particular tourist destinations, others have tried to build statistical models of behaviour focusing on how weather and climate shape the demands of particular types of tourists (for example, Maddison, 2001; Lise and Tol, 2002; Bigano et al, 2006). A third group of literature has focused on simulation models in order to investigate the relation between projected changes in tourism flows and the way in which climate change affects the attractiveness of a place relative to its competitors (Hamilton et al, 2005). However, to the best of our knowledge, there had been no European-wide research on the impact of climate change on tourism sector prior to a recently completed study on 'climate change and territorial effects on regions and local economies' (ESPON Climate, 2011) in which the present authors were involved. Drawing on that study, this paper provides a detailed analysis of the *impact* of climate change on *winter sport tourism* in European regions. The paper is structured under five main sections. After this introduction, section two provides an overview of tourism sector in Europe with a particular emphasis on winter sport tourism. Section three describes the framework for assessing vulnerability to climate change in general and the specific methodology used for assessing the impact of climate change on winter tourism. Section four discusses the outcome of the analyses and their visualisation on maps and section five concludes the paper by highlighting some of the emerging adaptation strategies.

2. Tourism in Europe

Tourism is a dynamic component of the service sectors and the third largest contributor (after the trade and distribution, and construction sectors) to the European economy. It generates more than 5 per cent of the European Union (EU) Gross Domestic Products (GDP) and provides employment for about 9.7 million people which accounts for approximately 5 per cent of the total workforce in Europe (ECORYS, 2009). When considering its close interrelationship with other sectors of the economy- such as distribution, construction, transport and cultural and creative industries – the contribution of the tourism sector to the EU economy rises to 10 per cent of its GDP and 12 per cent of its employments (CEC, 2010). The Mediterranean region alone is the world's most popular destination, attracting some 120 million visitors from northern Europe each year (Amelung and Moreno, 2009).

There is of course a high level of variations between European countries. For example, international tourism in countries around the Mediterranean Sea accounts for about 10 per cent of GDP and employment (OECD and

EEA, 2010; Magnan, et al., 2012). There are also large variations within each country. The share of GDP and employment in popular tourist regions in Greece, Spain, France, Italy and Portugal rises "far above these values (EEA, 2012:209). Furthermore, tourism in Europe is highly seasonal with its volume twice as high in the summer (July to September) than in the winter (October to March). The seasonal contrasts within Europe drive the bulk of the demands for summer vacations in Europe (Viner, 2006; Alcamo, et al, 2007).

Indeed, for most types of tourism, local weather is a major magnet in attracting potential tourists, leading to direct link between climate change and the viability of the tourist industry in a given location. While currently the predominant flows of tourists in summer are from north to south (EEA, 2012), Hamilton et al. (2005) suggest that, a climate change scenario of 1°C increase in mean temperature would lead to a gradual shift of tourist destinations to the north of Europe and making the mountainous areas of France, Italy and Spain more popular. The localities at higher altitude, such as the Alpine region of Europe, are therefore expected to become more attractive for summer tourism (Hamilton et al, 2005; Hamilton and Tol, 2007; Muller and weber, 2008). In addition to the changes to local weather, there may also be indirect impacts through, for example, climate induced loss of biodiversity, impacts on the natural and built environment, and on tourism-related infrastructure (OECD, 2012) which would reduce the attractiveness of places as tourist destinations.

2.1 Winter sport tourism

Across Europe, the winter sport industry attracts millions of tourists and with an annual turnover of 50 billion Euros, it contributes significantly to the economy (Abegg et al., 2007: 26). Winter tourism and particularly ski-related tourism is highly dependent on the amount and reliability of snow cover, or what is often termed 'snow security'. To be economically viable, a skiing area requires a minimum of 100 days with sufficient snow (Köning and Abegg, 1997; Elsasser and Bürki, 2002). In Europe, areas at altitudes higher than about 1300 meters, as in the Alpine regions, usually fulfil this criterion with some regional variation occurring due to inversion and wind. These regions have therefore been the main destinations for winter sport tourism in Europe. Indeed, after the Mediterranean coast, the Alps[i] are the second most popular tourist destination in Europe with more than 60 million overnight guests visiting the region (including its metropolitan areas) every year. This is four times the local population (EEA, 2003). The tourism sector generates some 10 to 12 per cent of jobs in Alps (Abegg et al., 2007: 26). While summer tourism has dwindled since the 1970s, winter tourism has flourished substantially with 85% of the 600 ski resorts and 10,000 ski installations located in France, Switzerland, Austria and Italy (WWF Italia, 2006; EEA, 2009). As noted in an Alpine case study (which was undertaken as part of the ESPON Climate project) by Kruse et al (2011:15), a distinction should be made between *city and rural tourism* at the foothill of the Alps or in lower altitudes and *high Alpine tourism* in higher altitudes with various dependencies on snow levels. Nevertheless, winter tourism is highly sensitive to climate change. While climate-induced factors such as warmer and drier summers may increase the attraction of Alps as summer tourist destination, they may also make them less attractive for winter tourism. According to the OECD Report (Agrawala, 2007), an increase of 1°C in the global mean air temperature will move up the snow line by 150 metres. This also means that some ten per cent of alpine ski resorts in Austria, Germany, Italy, France and Switzerland will not be considered snow-reliable. If the temperature increases to 2°C, the share of snow-unreliable resorts will rise to about 33 per cent (ibid.). The shortening of the winter season means that skiing will have to start later and finish earlier, reducing the viability of the industry. As will be discussed below, other adaptation strategies have emerged of which some have negative environmental effects. Other climate related factors such as glacier retreat and the melting of permafrost can also affect winter tourism in Alps. The latter increases the risk of landslide, rock falls and instability of mountain cableway stations. It also affects lifts masts and other buildings in permafrost soil (EEA, 2009). More localised studies have confirmed this general trend. For example, Hantel et al (2000) argue that an increase in mean temperatures of 1°C in the most sensitive elevations in the Austrian Alps will reduce skiing days by four weeks in winter time and by six weeks in spring. Similarly, Beniston et al (2003) estimate that a temperature increase of 2°C, and no change in precipitation, would shorten the seasonal snow cover at a Swiss Alpine sites by 50 days per year. Drawing on a number of studies (Agrawala, 2007; Steiger and Mayer, 2008; EEA, 2009) Kruse et al (2011:15) summarise the effects of the changing climatic stimuli on the following factors that are considered as most relevant to the economic viability of winter tourism:

- Decrease in *snow reliability* due to changes in winter precipitation and number of frost days. These affects the days of snow fall as well as the amount and number of days with snow cover.
- Retreat of *glaciers* due mainly to the number of frost days, changes in mean summer and winter temperature as well as winter precipitation. Expected impacts are a change in water run-off and a change in landscape scenery.

- Thawing *permafrost* due to the rise in mean temperature and number of summer days. Expected impacts are increasing insecurity of infrastructure in permafrost zones and a rising risk of landslides and rock falls.
- *Extreme events*, such as heat waves, droughts and flooding which may also affect infrastructure.

3. Methodology

In line with the framework developed by Füssel and Klein (2002) and adopted by the ESPON Climate project (Grieving et al., 2011) we consider the *impact* of climate change on specific regions as being the outcome of the interaction between two factors: a) the nature and level of their *exposure* to climate change; and, b) their distinct characteristics or *sensitivity*. The interface between these two factors and the capacity to respond to changes (i.e. the *adaptive capacity* of places) determines their *vulnerability* to climate change (see Figure 1). Sensitivity is defined as a multidimensional phenomenon including physical, environmental, social, cultural and economic elements. The focus of this paper is on economic sensitivity and more specifically on the economic sensitivity of winter tourism sector[ii]. Given the difficulties of quantifying the indirect economic impacts of climate change at the European scale (Hallegatte et al, 2008a&b), this sectoral approach has enabled us to better understand the regional economic impacts of climate change on winter tourism.

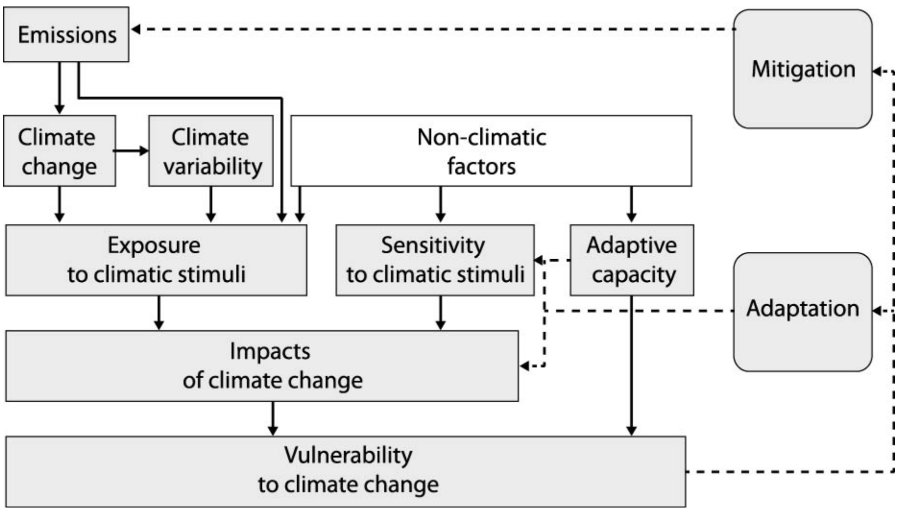

Figure 1: A Framework for assessing the impact of climate change

Source: Adapted from Füssel and Klein, 2002, P. 54

As mentioned above, a growing number of studies have attempted to measure the impacts of climate change on winter tourism. However, none has provided a methodology suitable for European-wide analysis which links the differentiated level of regional exposure to climate change to the level of sensitivity of winter tourism in different European regions. In other words, there is no pan-European study that makes a connection between socio-economic indicators and climatic indicators. In the ESPON Climate Project we attempted to do that by developing a novel methodology. This follows the conceptual framework of the project (as outlined in Figure 1) and consists of three stages.

In the first stage, we define the *exposure* of winter sport tourism to climatic changes. As it will be analysed below, climate change is related to a variety of climatic changes some of which can directly affect winter tourism. In the second stage, we present the *sensitivity* analysis which is a two-step process. The first step defines the spatial focus of the analysis by selecting the regions which have the potential to host winter sport tourism. The second step analyses the *economic dependency* of these regions on winter tourism. The third stage combines the analyses of the above two steps in order to quantify the *impacts* of climate change on winter sport tourism which in turn can be considered as proxy for the impact of climate change on the regional economies across Europe (given the high dependency of these economies of winter tourism). It should be stressed that the term quantification does not represent a monetary approach, but rather a relative scale, as will be explained below. Regarding the spatial resolution of our analysis, the focus is on European NUTS3[iii] regions, covering the entire 'ESPON Space' which includes all EU member states as well as Switzerland, Norway, Iceland and Liechtenstein (as shown in Figures 2-5).

3.1 The exposure analysis

As mentioned above, the exposure analysis focuses on climatic variable(s) which are the outcome of climatic changes and perform as *stimuli* to winter tourism activities. Such stimuli are based on climate change projections and climate variability which have been developed by the CCLM climate model[iv]. The CCLM model was selected because of its: fine spatial grid resolution (<20km), the Pan-European spatial coverage, the extended simulations period until 2100, the state-of-the art climate module, and the variety of climate variables (Grieving et al., 2011, p.12). The project used the Intergovernmental Panel on Climate Change (IPCC) emission scenario A1B[v] and aggregated data for two time periods (1961-1990 and 2071-2100) for eight different climate based stimuli. These include:

- change in annual mean temperature
- change in annual mean number of frost days
- change in annual mean number of summer days
- relative change in annual mean precipitation in winter months
- relative change in annual mean precipitation in summer months
- change in annual mean number of days with heavy rainfall
- relative change in annual mean evaporation
- change in annual mean number of days with snow cover

The change indicators relate the reference time frame (1961-1990) to the climate conditions within the projected periods as calculated by the CCLM model (2071-2100) and the A1B scenario. The absolute or relative difference between these two periods constitutes the projected change for each climate parameter" (ibid, p.2).

The analysis of the above climatic stimuli can result to a typology of climate change regions in Europe which is described and discussed in detail in the final report of the ESPOO Climate project (ibid). In summary, the CCLM based analysis shows a strong increase in annual mean temperature for three clusters (types) that are defined as: 'Northern Europe', 'Southern-central Europe' and 'Mediterranean region'. It also shows strong decrease in the number of frost days predominantly in the clusters of 'Northern-central Europe, 'Northern Europe' and 'Southern-central Europe'. Strong increases in annual mean number of summer days is projected for the clusters of 'Southern-central Europe' and 'Mediterranean region'. Change in precipitation in winter months in the 'Northern Europe' cluster shows particularly strong increases while strong decrease in summer months are in 'Southern-central Europe' and 'Mediterranean region' clusters. The variables of heavy rainfall and evaporation do not show very strong changes for any of the clusters, while days with snow cover are projected to decrease strongly in the 'Northern-central Europe' cluster (ibid).

The above provided an overview of the projected climatic changes in European regions. While all eight climate stimuli are potentially significant, they do not affect winter tourism in the same way. The most relevant stimulus for winter tourism is the change in the annual mean number of days with snow cover (see for example, EEA 2009). This along with the sensitivity analysis provides the basis for the calculation of the impact of climate change on winter tourism across the European regions.

3.2 The sensitivity analysis

The IPPC (2007) defines climate change sensitivity as the degree to which a system can be directly or indirectly affected, either adversely or beneficially, by climate related stimuli. As mentioned above, the impact of climate change on a particular European region depends not only on the nature and level of the regions' *exposure* to climate change, but also on its particular economic, environmental, cultural, physical and social *sensitivities* to climate stimuli. As the focus of this paper is primarily on economic impact of climate change on regional winter tourism and, hence, regional economies, the focus here turns on the economic sensitivity of European regions to climate change. In order to analyse the sensitivity we firstly identify the regions with potential to host winter sport tourism and secondly assess their economic dependency on this sector.

3.2.1. Identifying regions with potential to host winter sport tourism

The first step of the sensitivity analysis is to identify those regions which are capable of attracting winter sport tourism. In order to do so, we undertook spatial analysis by utilizing the information on the factors that are essential for developing and sustaining winter sport tourism (notably skiing). These are: annual mean number of days with snow cover during the period 1961-1990, and the typology of mountainous regions in Europe. Both of these factors are considered vital for winter sports. From a computational point of view, the first task is to calculate the annual mean number of snow-cover days for each NUTS3 region of Europe. The initial data provided by the CCLM is a point-based grid and the different climatic stimuli are estimated for these points.

There are two options for calculating the annual mean number of snow-cover days per NUTS3 region: a) to calculate the mean value of all the annual means of every grid point inside the NUTS3 regional borders; and b) to identify the maximum value of all the annual means of every grid point inside the NUTS3 regional borders and assign this value to each region. Although the former is simpler, the latter better serves the objective of the analysis as the winter tourism character of a region is reflected not in spatially averaged snow-cover values, but only in the few locations in a region with a great number of snow-cover days.

After testing different thresholds for the maximum snow-cover days for these selected mountainous regions, a threshold of at least 100 snow-cover days, as suggested by Elsasser and Bürki (2002) is adopted. The second task is to capture the mountainous regional character. This is accomplished by focusing on the regions which according to the typology developed by the ESPON Climate Project (see "'Typology Compilation"[vi]) have a predominantly or moderately mountain character. The former refers to regions where more than half of the population lives in mountainous municipalities and the while the latter refers to regions where more than a quarter of the population lives in such municipalities. Additionally, we use a number of other filters to further separate winter sport tourism from other touristic activities such as summer and urban tourism. As a result, the selected regions analysis excludes coastal Mediterranean regions and regions which host a city with population of more than 250,000 inhabitants. Although these regions may attract some forms of winter sport tourism it is reasonable to assume that in regions located by the Mediterranean coast the main tourism activities take place during summer. Similarly, the main activities in the regions with major cities can be assumed to be urban tourism.

To sum up, the regions which have the potential to host winter sport tourism are those which are: considered mountainous according to the EU typology, have at least one location with an annual average of 100 or more days of snow cover during the period 1961-1990, are not located by the Mediterranean coast, and do not include a city with more than 250,000 population. These are mapped in Figure 2.

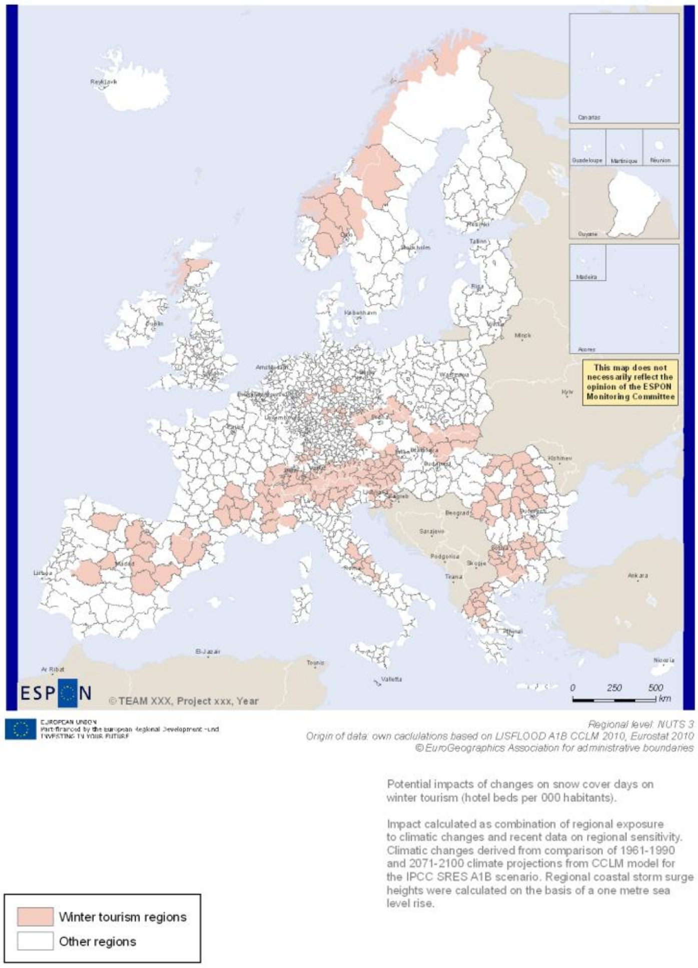

Figure 2: Regions with potential for hosting winter sport tourism

3.2.2 Analysing the economic dependency of the selected regions on winter tourism

Economic sensitivity to climate change is the result of two factors: the exposure of a region's economic sectors to climate stimuli (such as the exposure of winter tourism to changes in the annual snow-covered days) and the structure of the regional economy. Thus, the economy of a region that is highly *dependent* on a sector that is highly *sensitive* to climate stimuli will be affected by climate change more than a region which is less dependent on the same sector, even though it is exposed to the same climate stimuli. In other words, the impact of climate change on the economy of these two regions will not be the same. Hence, the economic sensitivity of European regions to climate change, as far as winter tourism is concerned, is also related to their level of dependency on winter tourism.

The widely used '*dependency*' indicators for measuring the relative significance of a particular sector to the overall regional economy are the share of GVA (Gross Value Added) and the share of employment. However, such data is not readily available at the regional (NUTS3) level. Neither are they always disaggregated into sub-sectors to distinguish between, for example, hotels, retail and restaurants. In addition, analysis for such a pan-European study can always face missing data problems due to the limited coordination of primary data collection by the national statistical authorities in different member states. Thus, in order to fill the gaps in data on employment or GVA of the tourism sector at the NUTS3 level, we identified proxies for regional dependency on tourism using data which is available for the whole Europe. After exploring secondary data sources, a variable indicating the *number of beds in hotel and similar establishments* (henceforth number of beds) appeared to be the most appropriate basis to build proxies for the dependency of regional economy on tourism. For the vast majority of the NUTS 3 regions data for the year 2008 was used. However, for some German and UK regions data for this year was not available at the time of analysis. Therefore, for 40 regions in these two countries, data for the latest available year was utilised. This exercise resulted in the full coverage of the ESPON space. As mentioned above, the economic dependency to winter tourism is calculated for those regions which fit the criteria for hosting winter sport tourism (so called mountainous regions as defined by the EU). Two different variables were initially built and tested in order to perform the dependency analysis: the absolute number of beds and the number of beds per thousand inhabitants. Both of these variables are used in the following analysis. While the former is used as an input for calculating the *absolute* impact of climate change on winter tourism and regional economy, the latter is used for the calculation of the *relative* impact of climate change.

3.3 The impact assessment

The final outcome of the analysis is the assessment of the potential impact of climate change on winter sport tourism and consequently the economy of those European regions that are highly dependent on this sector. We consider the potential impact as the outcome of the multiplication of sensitivity (i.e. the economic dependency of regions with potential to host winter sport tourism) and the exposure to climatic stimuli. For the multiplication process the normalised version of the economic dependency and climatic stimuli metrics are used. The results and their visualisation on maps are presented below.

4. Discussions

Figure 3 presents the climate stimulus for winter tourism (change in snow cover days) for the regions with potential to host winter sport tourism. Not surprisingly, the most drastic changes due to climate change can be observed in the Alps and the Nordic region. A large part of these areas will experience a decrease of more than 55 days of snow cover per year. This can generate significant impacts on snow reliability and consequently the length of the winter sport season.

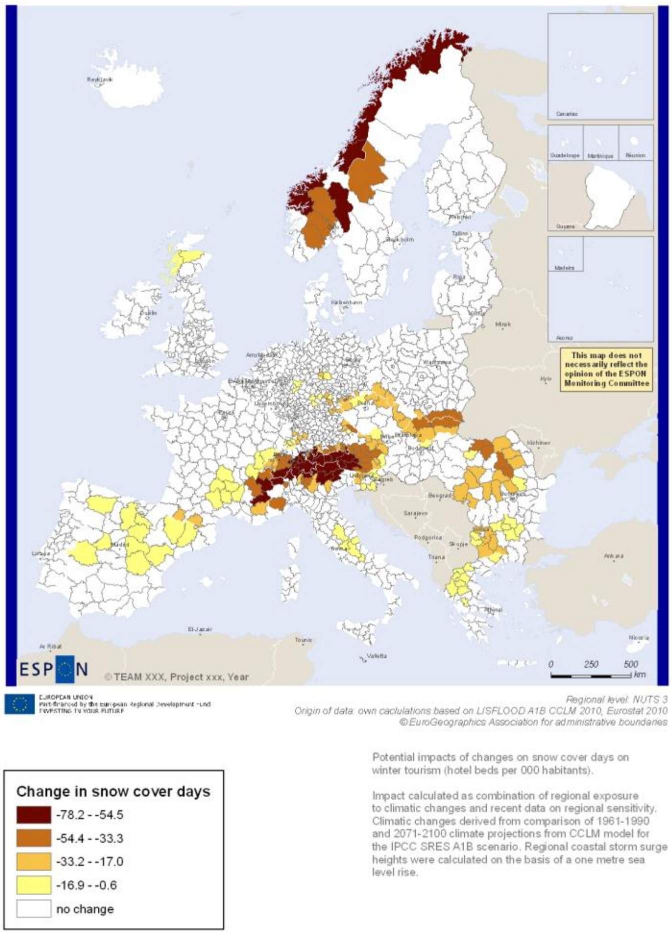

Figure 3: Climate stimulus: change in snow cover days in regions with potential to host winter sport tourism

However, if the region is not highly dependent on this sector, its economy cannot be considered sensitive to the effects of climate change. Thus, the analysis presented in Figure 3 is combined with the analysis of economic dependency presented in Figure 2 to assess the impact of climate change on the regional economy. This is mapped in Figures 4 and 5 at the level of NUTS regions. It is calculated both as an absolute and a relative measure. While the latter is based on the number of beds in hotel and similar establishments per 1000 inhabitants (Figure 4), the former is based on the absolute number of beds in a region (Figure 5). This methodological choice can address the problem of potential bias regarding urban agglomerations.

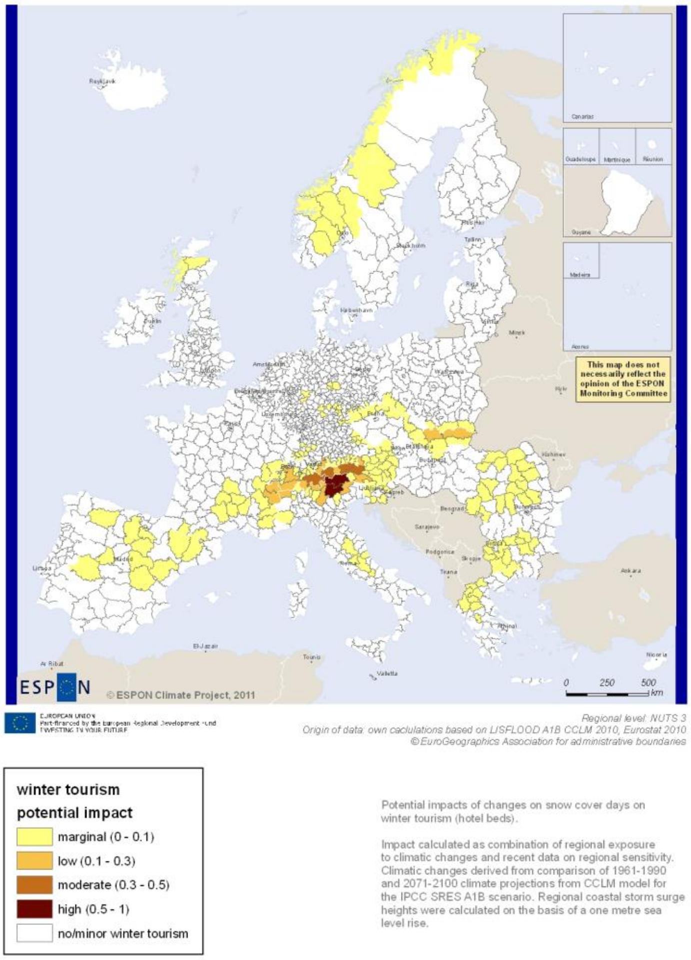

Figure 4: Potential impact of climate change on winter tourism (absolute)

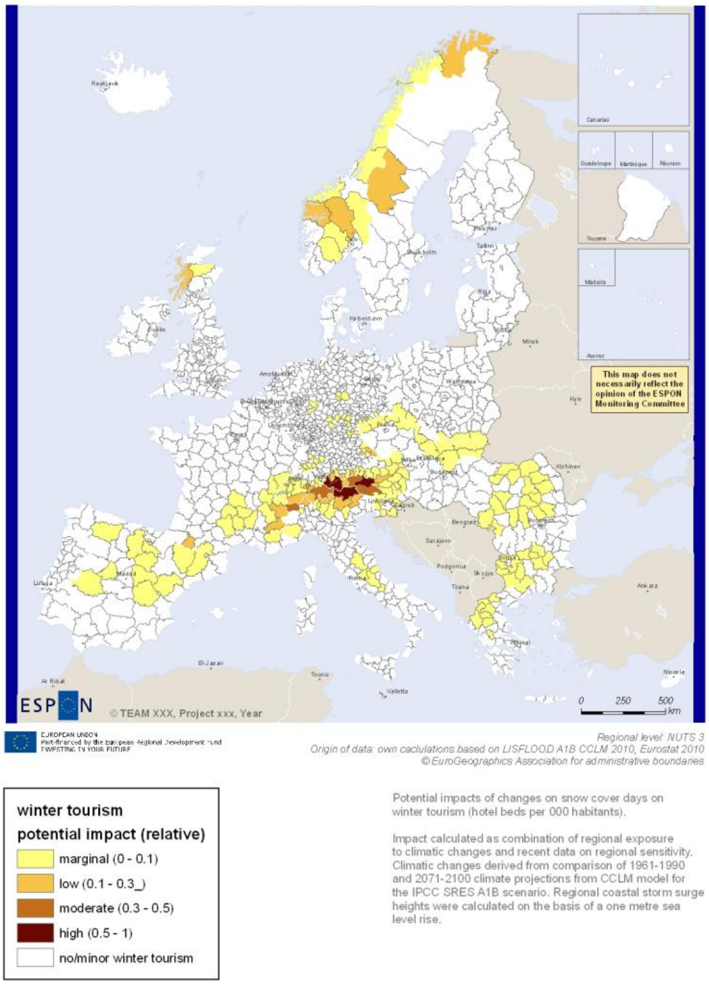

Figure 5: Potential impact of climate change on winter tourism (relative)

Despite some differences, both maps present a similar picture which indicates the concentration of the potential impact on winter tourism in the Alps region. Not surprisingly, the sensitivity of that region to winter tourism, as depicted on its economic dependency and the high stock of tourism infrastructure, in combination with the changes in average annual snow-covered days will potentially generate high impacts in this area. In comparative terms, the economies of the Alps region are likely to be affected more severely than the rest of Europe as a result of climate change. Although similar changes on average annual snow cover days are identified for the Nordic region, the impact in this area is much lower than in the Alps due to the lower economic dependency of the Nordic regions on winter sport tourism. Nonetheless, in some regions of Norway and Sweden the sector itself will be potentially affected by climate change. The same also applies to the regions in the northern part of Scotland; in Slovakia and the Balkan peninsular, including regions in Romania, Bulgaria and Greece; and, in the Pyrenees region. The latter is an interesting case because despite the economic dependency of these regions on winter tourism, the decrease in snow cover days will be less significant according to the CCLM model. Thus, the potential impact on tourism will be less severe for the regions in Pyrenees.

5. Concluding remarks

Winter tourism is highly dependent on the amount and reliability of snow which itself is sensitive to changes in the climate. The combination of sensitivity of the sector to climate stimuli (notably changes in snow cover day) and dependency of the regional economy on the sector can make European ski resorts highly vulnerable if appropriate adaptation strategies are not put in place. Related to the discussions in this paper, it is possible to distinguish between two main categories of adaptation options: the first one aims to tackle the problem of exposure to climatic stimuli (i.e. the problems of reduced number of snow cover days) and the second one aims to tackle the problem of economic dependency (i.e. the problem of over-dependency on skiing as the major source of revenue for winter tourism sector). With regard to the first category, Abegg et al. (2007) have shown that four technological adaptation options have already been tried in Alps involving: landscaping to reduce the depth of snow that is needed for skiing, moving to higher elevations and facing north where snow pack is likely to last longer, glacier skiing to bring forward the ski season and provide more certainty for snow availability, and artificial snowmaking which is currently the most common adaptation option (Rixen et al, 2011). All these options are faced with financial constraints and have environmental implications.

With regard to the second category, the adaptation option that is gaining currency is the diversification of winter tourism and the promotion of non-ski activities such as, hiking, tobogganing and snow shoeing which require less snow than skiing. Other tourist activities which require no snow (such as indoor sport, heath and business tourism, etc.) can also provide alternative adaptation options. However, although the latter activities are not dependent on snow, they are still dependent on the weather which due to climate change can become wetter and less attractive in these regions.

Finally, the adaptation measures mentioned above are largely undertaken autonomously by individual ski operators and in response to market forces. In order to increase the resilience of winter tourism economy in the European regions there needs to be coherent and concerted public policy involving governments at multiple levels. Such policy needs to focus not necessarily on maintaining the status quo but on seeking new economic opportunities which are more environmentally sustainable than some of the common adaptation practices.

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[i] The European Alps refers to an area (190,000 square kilometres) delineated by the Alpine Convention. It comprises eight countries (Austria 28.7%, Italy 27.2%, France 21.4%, Switzerland 13.2%, Germany 5.8%, Slovenia 3.6 %, the Principality of Liechtenstein 0.08%, and Monaco 0.001%.

[ii] Analysis of the non-economic sensitivity dimensions can be found in ESPON Climate Scientific Report (Greiving et al, 2011, Sections 3.2.5 and 3.3.3)

[iii] Nomenclature of territorial units (known as NUTS) are established by the European Union as a common classification of territorial units for statistics, to facilitate the collection, transmission and publication of harmonised regional statistics in the EU. NUTS3 has a minimum population of 150,000 and maximum population of 800,000.

[iv] This is a non-hydrostatic unified weather forecast and regional climate model developed by the COnsortium for SMall scale MOdelling (COSMO) and the Climate Limited-area Modelling Community (CLM) (for more details see Rockel, Will, and Hense, 2008, and the cited references).

[v] "The A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1FI), non-fossil energy resources (A1T) and a balance across all sources (A1B)" (IPCC, 2007:44).

[vi] The mountainous character of municipalities is based on altitude and slope criteria. For more details see http://www.espon.eu/export/sites/default/Documents/Projects/ScientificPlatform/TypologyCompilation/fir-090615.pdf