Airports and climate change: identifying the risks and building resilience

Rachel Burbidge[a1]

[a]*EUROCONTROL, Brussels, Belgium*

Abstract

The impacts of climate change, such as sea level rise, higher temperatures and greater weather extremes, create both an operational and business risk for European aviation. Due to their fixed infrastructure and vulnerability to disruptive weather, airports are particularly at risk. New analysis from EUROCONTROL, the European Organisation for the Safety of Air Navigation, builds on the organisation's earlier work in this area to further clarify what the expected impacts might be, when they might be experienced and how they might be mitigated. The paper also presents the results of a consultation with European aviation stakeholders to determine whether the industry now considers adaptation actions are necessary, and what actions they are taking. The work was part of the Challenges of Growth 2013 (CG13) study.

Keywords: climate change; resilience; adaptation; extreme weather; sea level rise.

Résumé

Les impacts du changement climatique inclus l'élévation du niveau de la mer, des températures plus élevées et une augmentation de phénomènes météorologiques extrêmes. Cela crée à la fois un risque opérationnel et un risque économique pour l'aviation européenne. En raison de leur infrastructure fixe et leur vulnérabilité aux intempéries, les aéroports sont particulièrement à risque. Une nouvelle analyse de EUROCONTROL, l'organisation européenne pour la sécurité de la navigation aérienne, explique quels sont les impacts attendus, quand ils pourraient arriver et comment ils pourraient être reduit. Le document présente également les résultats d'une consultation avec les parties prenantes de l'aviation européennes afin de déterminer si l'industrie considère maintenant les mesures d'adaptation sont nécessaires, et les actions qu'ils prennent. Le travail fait partie de l'étude *Challenges of Growth 2013.*

Mots-clé: le changement climatique; la résilience; l'adaptation; les conditions météorologiques extrêmes; l'élévation du niveau de la mer.
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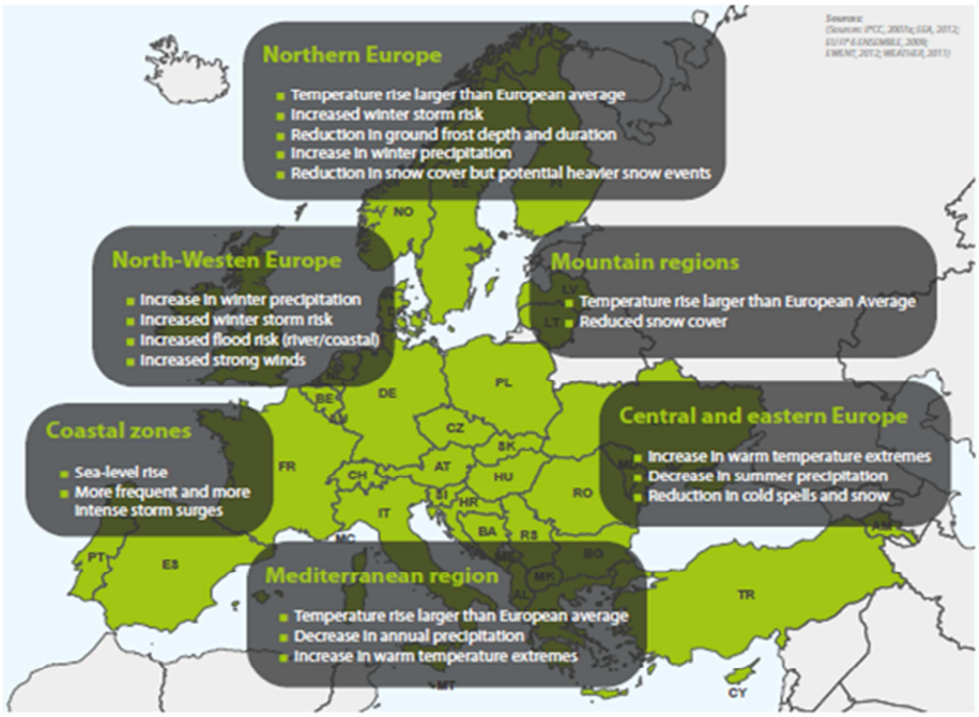
[1] Tel.: 32-2-7293451
E-mail address: rachel.burbidge@eurocontrol.int

1. Introduction

The potential impacts of climate change for the European region are now well-established (EEA, 2012). Although the specific risks vary according to climate zone, in general we can expect higher temperatures, greater weather extremes and inundation due to sea-level rise and flooding (Figure 1). This creates both an operational and business risk for European aviation. Due to their fixed infrastructure and vulnerability to disruptive weather, airports are particularly at risk.



Source: EUROCONTROL, Challenges of Growth, 2013

Figure 1 – climate impacts

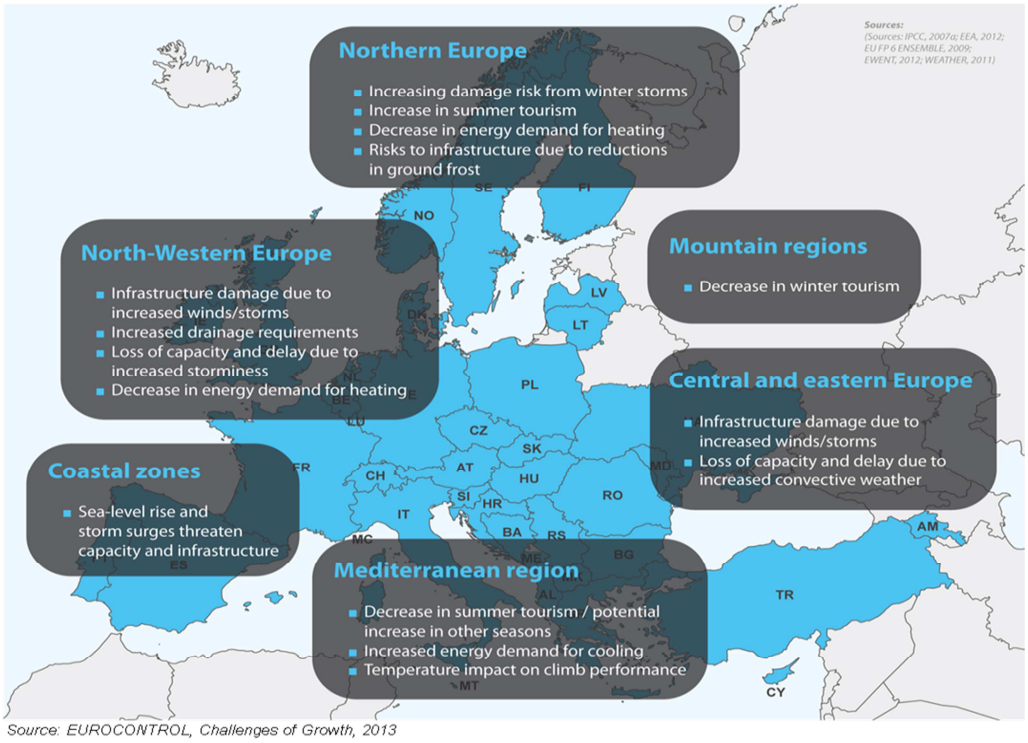
EUROCONTROL, the European Organisation for the Safety of Air Navigation, analysed climate change risk for European aviation as part of its Challenges of Growth 2013 (CG13) study[2]. The work had two objectives: to update and augment the organisation's earlier work in this area by further clarifying what the expected impacts might be, when they might be experienced and how they might be mitigated; and, to carry out a consultation with European aviation stakeholders to determine whether the industry now considers that climate adaptation will be necessary, and what actions they are taking.

This paper considers the results of the analysis which have particular relevance to airports. Section 2 will review the various climate change impacts which could affect airports and the risks which they entail. Section 3 considers the results of the stakeholder consultation before Section 4 examines some of the measures which airports can take to adapt to climate change impacts. Finally the paper concludes that the key to developing cost-effective mitigation of climate change risks is a combination of early action, on-going infrastructure and operational improvements and no-regrets measures which simultaneously address other issues such as capacity.

[2] *Challenges of Growth is a series of studies intended to provide decision-makers with the best-achievable set of information to support long-term planning decisions for aviation in Europe, with a particular focus on the capacity of the air transport network. Studies were completed in 2001, 2004, 2008 and 2013. They are available from http://www.eurocontrol.int/articles/challenges-growth.*

2. Expected impacts for airports

Although impacts will vary according to geographical location and scale of operation, there is now broad agreement as to the risks that climate change will entail for European aviation (Figure 2). Although, some of the risks, such as increased convective weather, will affect aircraft which are en-route, the majority of impacts will be centred on airports (Figure 3). In the shorter-term, increased frequency and intensity of storm systems and snow events is expected to disrupt operations, leading to temporary loss of capacity and increased delays. In the longer-term higher summer temperatures may impact demand patterns, whilst mean-sea level rise may threaten coastal airports. The following sections will discuss the key impacts in turn.



Source: EUROCONTROL, Challenges of Growth, 2013

Figure 2 – climate impacts for aviation by region

Source: EUROCONTROL, Challenges of Growth, 2013

Figure 3 – climate impacts for airports

2.1. Changes in precipitation

Southern Europe will experience a decrease in precipitation. However, in most of Europe heavy precipitation events are likely to become more frequent, particularly in Scandinavia in the winter and Northern and Eastern Central Europe in the summer (EEA, 2012).

Heavy precipitation events can require increased separation distances between aircraft; this impacts airport throughout. Current aerodrome surface drainage capacity may be insufficient to deal with more frequent and intense precipitation events, leading to increased risk of runway and taxiway flooding. Underground infrastructure such as electrical equipment may also be at risk of inundation.

Snowfall is generally expected to decrease, although there may be an increase in heavy snowfall days (over 10 cms) or snowfall in new areas (EEA, 2012). This implies that a much greater geographical area needs to be prepared for heavy winter weather.

2.2. Increased convective weather

Forecasts as to the frequency, location and intensity of storms are uncertain, although a number of studies predict that, in the longer term, the overall number of storms will decrease whilst the most powerful storms will be more intense (particularly in Northern and Western Europe) (EEA, 2012). Earlier work carried out for EUROCONTROL in 2010 forecasts an increase in convective weather systems with the potential to disrupt aircraft operations of around 3-4 days in the summer months by 2020; this equates to a doubling of the present impact (McCarthy and Budd, 2010).

Summer convective weather can have an exponential effect on weather delay due to the high seasonal traffic levels. Moreover, European continental areas may experience larger, meso-scale convective systems with the

potential to affect multiple hub airports in a region. This may reduce the choice of diversionary airports whilst those that are available may not have sufficient capacity for the traffic which they need to accommodate. Consequently, dynamic capacity-based flight planning may be required.

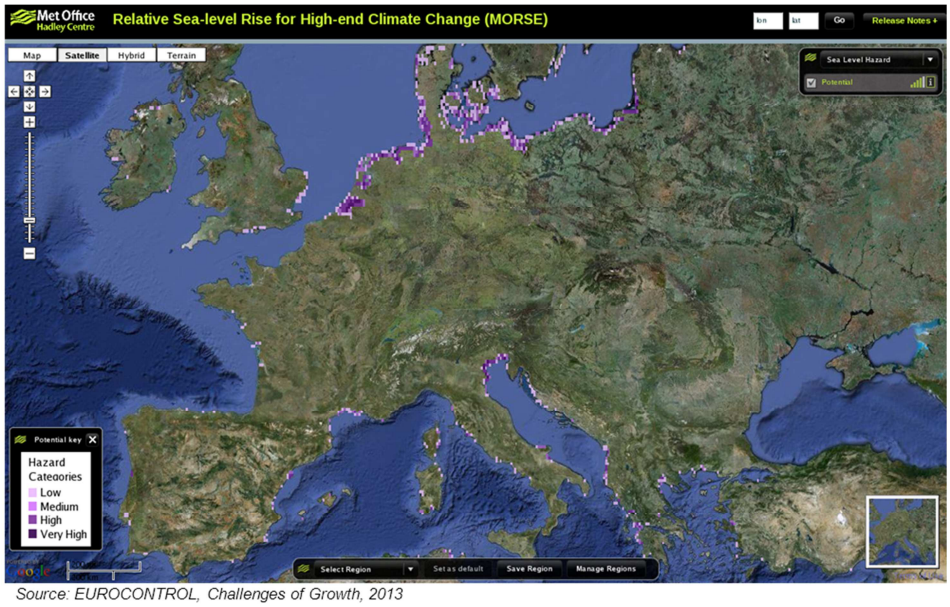
2.3. Changes in wind patterns

Although there are many uncertainties regarding projections, wind directions are expected to change as the position of the jet stream and storm tracks move polewards and upwards. Consequently, runways constructed along the locally prevailing wind direction may experience more cross-winds as the prevailing direction changes (Thomas et al, 2008). Crosswinds might be outside tolerance for some aircraft types or, if prevailing wind direction changes, an airport may have crosswinds but no crosswind runway. This may entail the need for a change in procedures and airspace redesign which, in turn, may incur an additional environmental risk due to the redistribution of noise impact around airports.

2.4. Sea-level rise and storm surges

Analysis carried out by the UK Met Office for EUROCONTROL in 2010, forecasts that more than 30 European airports will be at risk from mean-sea level rise and flooding by the end of the century (de Gusmão, 2010; figure 4). At some locations, ground transport links are also potentially at risk. However, such impacts will be experienced gradually, allowing for longer term planning which can be based on cost benefit analyses.

The impacts of an increase in storm surges may be experienced in the shorter term and could result in a temporary reduction in capacity and increase in delay. However, there are likely to be significant geographical differences in impact with some areas experiencing an increase in the number and height of storm surges and others a reduction in the frequency and magnitude (EEA, 2012).



Source: EUROCONTROL, Challenges of Growth, 2013

Figure 4 – Sea–level rise in Europe, mapping of potential sea level rise hazard in a high-end warming world based on a worst-case scenario of +4°C warming by 2099 (MORSE, +4°C)

2.5. Increased summer temperatures

In the longer-term increased summer heat and humidity in the Mediterranean Basin may impact the amount, location and temporal distribution of traffic demand. The Mediterranean region currently attracts around 100

million visitors from Northern Europe each year (Amelung and Moreno, 2009). Of course, not all of those tourists will choose to fly there. However, earlier work carried out for EUROCONTROL in 2010 estimated that 73% of tourist arrivals to Greece arrive by air (Dimitriou and Drew, 2010). Therefore, if a proportion of tourists who fly to the Mediterranean during the summer months decide to travel to alternative destinations, there may be significant changes in infrastructure and staffing requirements at both traditional and potential new destinations. However, whether and to what extent this is an issue is not yet well-understood. More positively, if tourists decide to visit traditional holiday destinations in the spring or autumn months instead of the customary summer season, this could ease congestion during the traditional peak season.

Increased temperatures may also impact infrastructure. Extreme summer temperatures may exceed design standards leading to heat damage to tarmac surfaces; tarmac runways or aprons may experience difficulties due to surface melting during peak heat periods. There will be a need for increased summer cooling of airport buildings with the attendant energy costs. Some buildings which were designed for cooler climates may not be able to maintain comfortable temperatures during very hot periods leading to overheating of equipment and health issues for staff (Thomas *et al*, 2008).

3. European Aviation stakeholder consultation

To establish whether the industry now considers it necessary to build resilience to these risks, a survey was sent to approximately 100 European aviation operational stakeholders. 35 valid responses were received, mainly from Air Navigation Service Providers and Airport Operators.

The survey identified that just over half of respondents consider that climate change will be a risk for their organisation between now and 2050 (N = 33, Figure 5a). The main climate change impacts which stakeholders expect to be affected by are more incidences of extreme weather such as storms, an increase in precipitation (both rain and snow) and higher temperatures. A potential change to predominant wind directions was also a recurring concern. Although just under half of respondents replied that their organisation does not yet have an official position, mainly as they have not yet assessed the risks or the issue is not yet on their long-term agenda, over 80% consider that resilience measures to adapt to climate change will be necessary now or in the future (N = 29, Figure 5b). This indicates that that even those organisations which do not yet have an official position consider that this is an issue which warrants attention. This is a shift in opinion from four years ago when very few organisations had begun to address the issue. For those that did not think it will be necessary to take action the main reasons were because they do not expect to experience significant impacts or because the risks have not yet been assessed.

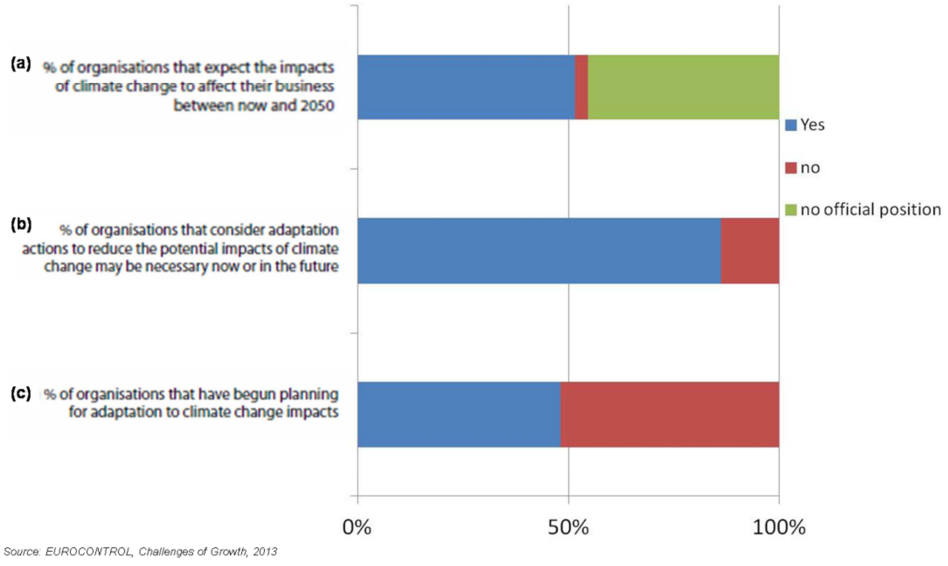


Figure 5 – Percentage of respondents who (a) expect to be impacted by climate change by 2050; (b) consider adaptation to climate change will be necessary (c) have begun adaptation planning

Yet, despite this growing awareness of potential impacts, less than half of organisations that responded have begun planning for adaptation (N = 25, Figure 5c). Some organisations feel it is too early whilst others feel they do not have enough information or resources. Of those that have begun planning, only four respondents had produced adaptation plans. Notably, they were all either airports or combined airport operator/ANSP organisations. When respondents were asked their opinion as to the current adaptation status of the European aviation industry 50% thought that some adaptation measures were in place but more needs to be done 25% thought that adaptation had been considered but nothing concrete had been done yet and another 25% thought that adaptation has not yet been considered (N = 16, Figure 5).

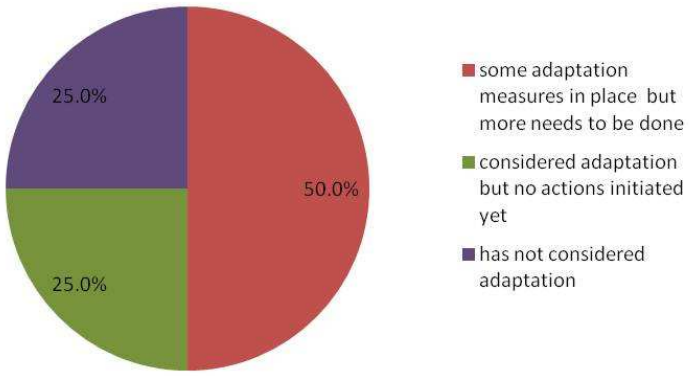


Figure 6 –*Stakeholder perception of level of preparedness for the potential impacts of climate change for the European Aviation Sector*

Overall, the results indicated that a growing number of organisations expect to need to take action to adapt to the potential impacts of climate change, but that this is still an emerging issue, with a perceived lack of information and guidance. However, the results may demonstrate a degree of self-selection; organisations that are already experiencing an increase in incidences of disruptive weather, or who are already implementing measures to adapt to climate change, may have been more likely to respond to the survey. In order to gain a more precise picture of the extent to which the European aviation industry is developing climate resilience, it would be necessary to carry out a more strategic state by state analysis of vulnerabilities, adaptation measures being implemented and action gaps.

The survey was followed by a one day workshop at EUROCONTROL Headquarters in Brussels. Participants represented 20 organisations including airport operators, air navigation service providers, the Single European Sky ATM Research programme (SESAR), industry associations, the academic community and European policy makers. Participants concluded that there is a growing need for climate change risk assessment and planning for adaptation measures. However, concerns were expressed about acquiring financial resources for something which may not be within immediate planning horizons. To address this issue it was proposed that no-regrets solutions, measures which are already being implemented to address other issues such as capacity but which also contribute to building climate resilience, and low-cost actions such as training should be identified. The next section will consider how these proposals can be translated into concrete action to build airport climate resilience.

4. Building airport resilience

Airports are the frontline of climate change adaptation. The measures which they implement will not only work to make their own operations resilient in the face of climate change impacts but will contribute to building overall network resilience; given the interconnectedness of the aviation network the introduction of resilience measures at both local and system-level will be required. It is pointless for one part of the global integrated transport system to become fully protected against this risk, if another vital part does not.

Therefore, as a first step to building this resilience, comprehensive climate change risk assessments need to be carried out at both local and network level. At an airport level, assessments should take account of regional climate forecasts, to the extent which they are available, and specific local characteristics such as geographical location and scale of operation. Following this the appropriate resilience measures can be identified and an adaptation programme can be developed. Indeed, some airports have already taken action; following the introduction of national legislation, the largest UK airports were mandated to produce climate adaptation plans, whilst Avinor, the Norwegian air navigation service provider and airport operator, and the French Directorate General for Civil Aviation are both carrying out risk assessments for their airports.

Of course, the particular measures to be implemented will vary according to local specificities. Coastal airports may need to consider a cost-benefit analysis to assess whether to allow a certain degree of inundation, to build or reinforce sea-defences, or to consider relocation. Airports which may be exposed to new or heavier snow conditions might want to consider innovative solutions to address unpredictable snow-clearing requirements; one European airport, rather than investing in snow ploughs, has bought snow plough shields which are then attached to tractors belonging to local farmers. At a network level, EUROCONTROL's Network Manager is implementing network-wide solutions which also contribute to local operational resilience. For example, an alert tool is being developed to warn airports when disruptive weather may impact capacity and strategies also being put in place to proactively manage demand when a severe weather event is considered highly probable.

However, whatever the specific impacts which may have to be dealt with, the most cost-effective solutions will be achieved by implementing resilience measures as part of on-going operational and infrastructure improvements. At airports which may be faced with higher temperatures this may involve improving resilience to potential heat damage to runways and taxiways, whilst at locations which may experience heavier precipitation events it may be advisable to improve drainage capacity or to protect electrical infrastructure locations. Other cost-effective responses include so-called no-regrets solutions, measures which are already being implemented to address other issues such as capacity but which also contribute to building climate resilience. For example, SESAR operational improvements which aim to improve airport capacity also provide climate resilience benefits as they decrease the overall vulnerability of the network to perturbation. To complement physical infrastructure and operational resilience measures, some of the cheapest and potentially most effective ways identified to build resilience are staff training, sharing of best practices, experiences and solutions, and the implementation of processes which facilitate collaborative responses to climate change challenges.

Finally, it must also be kept in mind that airports do not exist in isolation but are an intrinsic part of both the urban network and regional economy. This entails a need for holistic planning within regional adaptation frameworks which recognise both the specificities of airports' operational requirements and their strategic importance for the regional economy and mobility. Consequently, there is a need for greater collaborative planning between regional stakeholders such as government authorities, other transport modes and the business sector so as to both include airports in wider regional adaptation planning and to develop an effective intermodal policy which protects mobility during disruptive conditions (Jeandel *et* al, 2012; Doll *et al*, 2011).

5. Conclusions

The impacts of climate change for European airports will vary according to geographical location and scale of operation. However, at a high-level they include capacity reduction and delay due to increased precipitation or convective weather, inundation due to sea-level rise or flooding, changes in demand patterns or infrastructure damage due to higher temperatures and operational impacts due to changes in prevailing wind direction. The EUROCONTROL *Challenges of Growth* consultation suggests that although such risks are a growing concern for stakeholders, as yet relatively few organisations have begun to take action.

However, climate change is fundamentally an issue of risk management and early action is the key to cost-effective mitigation of those risks. This can be achieved by implementing measures gradually as part of on-going infrastructure and operational improvements, identifying no-regrets measures which address other issues,

such as capacity, and through softer measures such as training. Nevertheless, airport climate resilience should not be considered in isolation; adaptation measures at individual airports plays an intrinsic part in developing network-wide resilience, whilst an airport's essential contribution to a city region's economy and logistics dictates that it is considered as an integral part of wider adaptation planning.

References

Amelung, B. and Moreno, A. (2009) *Impacts of climate change in tourism in Europe. PESETA-Tourism study* (JRC Scientific and Technical Reports). European Commission — Joint Research Centre, Institute for Prospective Technological Studies [online] http://ftp.jrc.es/ EURdoc/JRC55392.pdf (accessed 07/01/2013)

de Gusmão, D. (2010) *Case-Study 2: European Airports and Sea Level Rise*, in Thomas, C. and Drew, A. J. (eds) (2010) *Challenges of Growth Environmental Update Study: Climate Adaptation Case Studies*, EUROCONTROL, Brussels

Dimitriou, D. and Drew, A. J. (2010) *Case-Study 1: Changes to Tourist Activity in Greece*, in EUROCONTROL (2010) *Challenges of Growth Environmental Update Study: Climate Adaptation Case Studies*, EUROCONTROL, Brussels

Doll, C., S. Klug, J. Köhler, I. Partzsch, R. Enei, V. Pelikan, N. Sedlacek, H. Maurer, L. Rudzikaite, A. Papanikolaou, V. Mitsakis (2011) Adaptation Strategies in the Transport Sector: Deliverable 4 of the research project WEATHER (Weather Extremes: Impacts on Transport Systems and Hazards for European Regions) funded under the 7th framework program of the European Commission. Project coordinator: Fraunhofer ISI, Karlsruhe

EUROCONTROL (2013) *Challenges of Growth 2013: Climate Change Risk and Resilience*, STATFOR, EUROCONTROL, Brussels

European Environment Agency (EEA) (2012) *Climate Change Impacts and Vulnerability in Europe 2012*, European Environment Agency, Copenhagen

Jeandel, A., Burbidge, R., Goldmann, D., Melrose, A., Schreiber, B. (2012) Base-line Environmental Risk Review – D03 of SESAR Project 160307, SESAR, Brussels

McCarthy, R. and Budd, L. (2010) *Case-Study 3: Potential Changes in Severe Convection in Maastricht Upper Area Airspace*, in EUROCONTROL (2010) *Challenges of Growth Environmental Update Study: Climate Adaptation Case Studies*, EUROCONTROL, Brussels

Thomas, C., McCarthy, R., Lewis, K., Boucher, O., Hayward, J., Owen, B., and Liggins, F (2009) *Challenges to Growth Environmental Update Study*, EUROCONTROL, Brussels