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Weather and Climate Information for Tourism

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Abstract

The tourism sector is one of the largest and fastest growing global industries and is a significant contributor to national and local economies around the world. The interface between climate and tourism is multifaceted and complex, as climate represents both a vital resource to be exploited and an important limiting factor that poses risks to be managed by the tourism industry and tourists alike. All tourism destinations and operators are climate-sensitive to a degree and climate is a key influence on travel planning and the travel experience. This chapter provides a synopsis of the capacities and needs for climate services in the tourism sector, including current and emerging applications of climate services by diverse tourism end-users, and a discussion of key knowledge gaps, research and capacity-building needs and partnerships that are required to accelerate the application of climate information to manage risks to climate variability and facilitate successful adaptation to climate change.

Keywords: tourism, outdoor recreation, sustainability, adaptation, climate services, climate sensitivity

1. Introduction

The tourism sector is one of the largest and fastest growing global industries and is a significant contributor to national and local economies around the world. Tourism represents far more than just travel for leisure and holidays. Tourism encompasses travel for education, health, religion, conventions and conferences, general business travel and visiting friends and relatives. The United Nations World Tourism Organization [1] defines tourism as including: "… the 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." According to the UNWTO [2], international tourist arrivals have grown from just over 200 million in 1980 to 922 million in 2008. International travel is also forecast to almost double to 1.6 billion arrivals by 2020 [3]. The economic importance of the sector worldwide is demonstrated by World Travel and Tourism Council [4] estimates that in 2008 the global travel and tourism industry, contributed 9.6 per cent of global Gross Domestic Product (GDP) and 7.9 per cent of world-wide employment.

While the majority of international tourism currently occurs in developed countries, the sector is a vital contributor to the economy of many developing countries. Between 1995 and 2007, it is estimated that international tourism in emerging and developing markets grew at twice the rate of industrialized countries – by 11 per cent for Least Developed Countries and 9 per cent for other low and lower-middle income economies [5]. Visitor spending represented more than 10 per cent of national GDP in 36 developing countries in 2006 [6]. The UNWTO [7] also estimates that tourism is a primary source of foreign exchange earnings in 46 out of 50 of the world's LDCs. With the growth of tourism in developing countries, international tourism is increasingly promoted by development organizations and many governments as having an important role in contributing to the United Nations Millennium Development Goals, particularly the alleviation of poverty in LDCs, gender equality and environmental sustainability.

While comparable global statistical data on domestic tourism are not available, its volume was estimated at around 8 billion trips worldwide in 2005, of which 4 billion were estimated to be from same-day visitors and 4 billion from overnight tourists. The shorter-term nature of much domestic tourism, particularly day trips or weekend holidays, increases the importance and relevance of nowcast and short-term forecast information for decision-making by tourists. Consequently, domestic tourism is an important consideration of this review.

The tourism sector is characterized by considerable diversity and a fragmented structure. While varied conceptualizations of the subsectors that comprise the tourism sector are used in academia and by international organizations, major components include: transportation (air lines, cruise ships, rail lines, ground coaches and taxies, for example), accommodation (hotels, apartments, youth hostels, for example), food and hospitality services (restaurants, bars and pubs, for example), travel agents and tour service operators, visitor attractions (cultural or sporting events, casinos, parks, museums, for example) and tourist focused retail or service providers (insurance, conventions, tourist equipment rentals, for example). Tourism operators differ in terms of ownership (government, non-government organizations, private businesses), size (there is a predominance of small and medium-sized enterprises in the sector, but also many international conglomerates) and purpose (for-profit or non-profit, as well as conservation, education, community development mandates). Tourism operators have also adapted to provide tourism services in every climatic zone on the planet from

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deserts and high mountains to the tropics and polar regions. As a consequence of this heterogeneity, there are extensive differences in the nature of climate sensitivities and abilities of tourism operators worldwide to incorporate climate services into decision-making.

Equally as diverse are the motivations and characteristics of domestic and international travellers. Major global tourism market segments include: sun and beach tourism, sports tourism, adventure tourism, nature-based tourism, cultural tourism, urban tourism, health and wellness tourism, cruises, theme parks, visiting friends and relatives and meetings and conferences. The disparate climate requirements and preferences of tourists within these major market segments, as well as between groups within each major market segment (golf, ski, and windsurfing segments of sports tourism, for example), create very different demand-side climate sensitivities within the tourism sector.

The interface between climate and tourism is multifaceted and highly complex. Figure 1 outlines the temporal scales (extreme events, seasonality, interannual variability, climate change) at which climate influences different subsectors of tourism, either directly (blue lines) or indirectly (black and red lines). Importantly, climate is but one macroscale influencing factor on the tourism system and interacts with other macroscale factors as well. The selected media headlines in Table 1 provide illustrative examples of the varied climate sensitivities in tourism supply (tourism destinations and tourism operators) and demand (tourism arrivals and travel patterns) around the world.

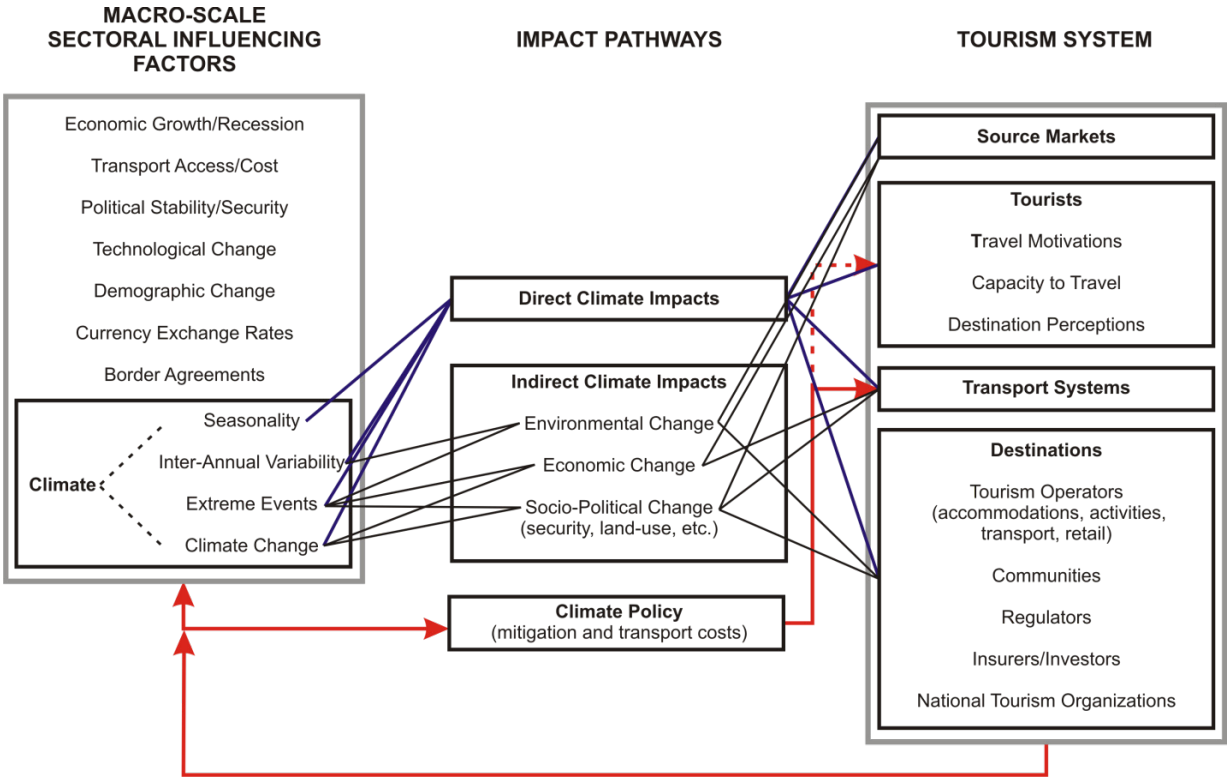


Figure 1. Climate influences on the tourism sector

Tourism destinations and tourism operators are affected by climate variability and change in a number of ways. All tourism destinations are climate-sensitive to a degree, in that they are influenced by natural seasonality in demand, are affected positively or negatively by interannual climate variability that brings heatwaves, unseasonable cold, drought or storms and heavy rain, which can affect not only tourist comfort and safety (and thereby satisfaction), but also the products that attract tourists (snow cover, coral reefs, wildlife, for example). Climate variability also influences various facets of tourism operations (water supply and quality, heating–cooling costs, snowmaking requirements, irrigation needs, pest management, and evacuations and temporary closures, for example). An international survey of 66 national tourism and meteorological organizations found that a large majority (81 per cent) felt weather and climate were major determinants of tourism in their nation [8]. Indeed some argue that climate is among the most dominant factors affecting global tourist flows [9][10].

There is a general consensus that destination image is a key determinant in destination choice (among other macroscale influencing factors, such as travel distance, time, holiday cost, and travel motivation and those set out in Figure 1) [11] and that climate is dominant attribute of destination image along with scenery and cost [12]. A review of destination image studies found that natural beauty and climate were of universal importance in defining destination attractiveness [13]. Some tourism destinations can be considered climate-dependent, in that climate is the principal resource on which tourism to the destination is predicated (for example, many Small Island Developing States).

In the same way that climate affects the destination choice of travellers it highly influences the timing of travel. Seasonal demand is one of the main defining characteristics of global tourism, and is comprised of two elements – natural and institutional seasonality [14]. Seasonal climate fluctuations at tourism destinations and at major outbound markets, particularly at high latitudes, are a key driver of tourism demand at global (Figure 2) and regional scales. When climatic resources are no longer suitable for certain tourism markets, such as ski or beach holidays, tourism operators can be forced to close seasonally (Figure 3).

Table 1. Recent media headlines of weather/climate impacts on the tourism sector

Africa	"Cape Town heat wave fans fires ahead of tourism season" (*Agence France Presse*, 9 December 2008)
	"Soggy weather proves bad month for tourists" (*Africa News*, October 2008)
	"Mozambique tourist resorts struggle to recover from cyclone" (Agence France Presse, 18 March 2008)
Americas	"Snow joke -- Ski hills are sweating, but the golf courses are rolling in green with this wacky weather" (*The Toronto Sun*, 30 November 2009)
	"A race to get snow in time for Olympic Games; Backup plan activated after warm temperatures plague Cypress Mountain" (*The International Herald Tribune*, 23 January 2010)
	"California tourism fighting fires, too" (*USA Today*, 10 July 2008)
	"Hurricane Ike tosses Caribbean tourism for a loop" (*Miami Herald*, 10 September 2008)
	"Officials try to lure tourists back to the storm-raked Caribbean" (*USA Today*, 16 September 2008)
	"Tourism's winter of discontent: warm weather has seasonal industries feeling the heat" (*Globe and Mail*, 4 June 2005)
	"Wilma deals $800 million blow to Mexican travel industry" (CNN, 27 October 2005)
Europe	"July rainfall takes toll on tourism industry" (*Irish Times*, 2 August 2008)
	"Weather puts a damper on tourism" (*Daily Mail*, 15 September 2007)
	"Devon gloomy weather forecasts keep away visitors" (*Telegraph*, 31 July 2008)
	"Ski resorts sweat in warm weather" (BBC News, 4 December 2006)
	"Tourism fears as heatwave sparks fires across Greece" (*The Guardian*, 26 July 2007)
	"Forget Summer: washout will wreck Brits' fun" (Daily Star, 10 May 2010)
Asia and South/East Asia	"A snow-less Srinagar disappoints tourists on New Year" (Asian News Int'l, 31 December 2007)
	"Snow storms costs China's tourism sector nearly one billion U.S. dollars" (Xinhua General News Service, 21 February 2008)
	"Freezing weather dampens during Spring Festival holiday" (BBC, 9 February 2008)
	"Andaman tourism dampened by tropical storm" (*The Nation*, 4 May 2007)
Oceania	"Queensland tourism hit by wild weather" (ABC Premium News, 12 February 2008)
	"Ongoing rain keeps Sun Coast tourists away" (ABC Regional News, 27 February 2008)
	"Storms battle coastal tourism" (*The Courier Mail*, 3 January 2008)
	"Cooling weather brings visitor lull" (*The Press*, 12 April 2008)
	"Weather thwarts tourism operators" (*The Press*, New Zealand, 25 January 2010)
	"Cyclone slams Queensland tourism operators" (*Australian Financial Review*, 24 March 2010)

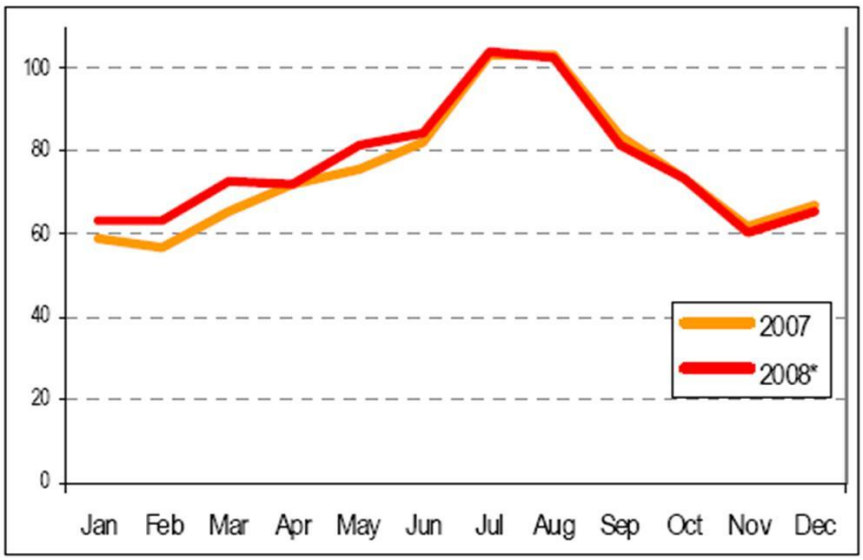


Figure 2. Monthly international tourist arrivals (millions) (Source: UNWTO [2])

Figure 3. Seasonal closure of major resorts in Greece (Photo: Daniel Scott)

Climate also has an important influence on environmental conditions that can deter tourists, including infectious disease, wildfires, insect or water-borne pests (for example, jellyfish and algae blooms) and extreme events such as tropical cyclones. In Greece, after the devastating fires of summer 2000, more than 50 per cent of all bookings from tourists for 2001 were cancelled [15]. Drought in the state of Colorado (United States) during the spring and summer of 2002 created dangerous wildfire conditions and the media coverage of major fires in some parts of the state had a significant impact on summer tourism. Visitor numbers declined by 40 per cent in some areas of Colorado and reservations in state park campgrounds dropped 30 per cent [16]. The drought also affected fishing and river-rafting tourism in the state. Anglers were restricted from fishing in many rivers because fish populations were highly stressed by low water levels and high water temperatures. Low water levels also shortened the river-rafting season substantially. Some river-rafting outfitter companies lost 40 per cent of their normal business and economic losses in the state's river rafting industry alone exceeded US$ 50 million [17][18].

Extreme weather events routinely influence tourism operators and travel decisions in regions such as the Gulf of Mexico. The economic impact of hurricanes on tourism in this region is often substantial. In the Florida Keys, the ten-day closure and clean-up following *Hurricane Georges* in 1998 resulted in tourism revenue losses of approximately US$ 32 million [19]. The economic impact of the four hurricanes that struck the state of Florida in 2004 was estimated to be several times larger, as the storms caused thousands of cancellations as travellers went elsewhere, and a marketing survey found that 25 per cent were also less likely to visit Florida during hurricane season in the future [20][21]. Importantly, these same extreme events in one destination had a positive impact on other parts of the tourism system, as destinations such as Arizona and California benefited from the transfer of large numbers of visitors and convention business [22]. That same year, the government of Mexico estimated that as a result of the late season *Hurricane Wilma* and media coverage of damage and stranded tourists, it would lose US$ 800 million in tourism revenue between October and December [23]. With 26 tropical storms and 14 hurricanes, the 2005 hurricane season was one of the most active and destructive in history, spawning three of the most intense North Atlantic storms on record, including *Hurricane Katrina* which caused extensive damage to the tourism infrastructure in New Orleans and coastal Mississippi, where impacts on convention business and gambling are expected for years, perhaps decades, to come [24].

The effects of the 2003 summer heatwave on tourism are also illustrative of the complexities of the climate and tourism interface. The 2003 heatwave in western Europe was exceptional by its temperatures and also its length. Tourism establishments in the Spanish beach destination of Costa Brava reportedly lost an estimated 10 per cent of guest nights during the summer season, with decreased stays at campsites most pronounced, while visitation to inland mountain destinations increased as travellers sought comfortable climatic conditions [25]. Similar shifts in tourist patterns were documented in France, with increased occupancies in destinations in northern and north-western shores and central mountains, and decreases in urban centres and southern regions. Activities, accommodations and consumption patterns were also modified, as access to some forests with high fire risk was blocked, fishing restricted, and camping and accommodations without adequate space-cooling systems became uncomfortable, while demand for accommodations with pools increased and sales of beverages and ice cream increased substantially [26].

Tourism operators in certain market segments are also profoundly affected by interannual climate variability and extremes. Climate defines the length and quality of multibillion dollar tourism seasons in different regions. Winter sports tourism, for example, is highly climate-sensitive. Figure 4 demonstrates the impact of interannual climate variability on the length of ski seasons in the ski regions of the United States. The marginal snow conditions during the record warm winter of 2001/02 (Figure 5) in North-east, South-east and Midwest regions had important impacts on skier visits (7–11 per cent lower than in the previous climatically average winter) and operating profits (33 per cent lower than during a climatically average winter) [27][28]. In the state of Washington (Pacific west region) skier visits declined 78 per cent in 2004/05 because of warm temperatures and frequent rain. The highly reduced season length caused some resorts to honour 2004/05 season passes again for the 2005/06 season in order to maintain customer loyalty [29]. Others were forced to forego investment plans, including repairs to a chair lift, indicating they would be in recovery mode for several years because of this one poor snow season [29].

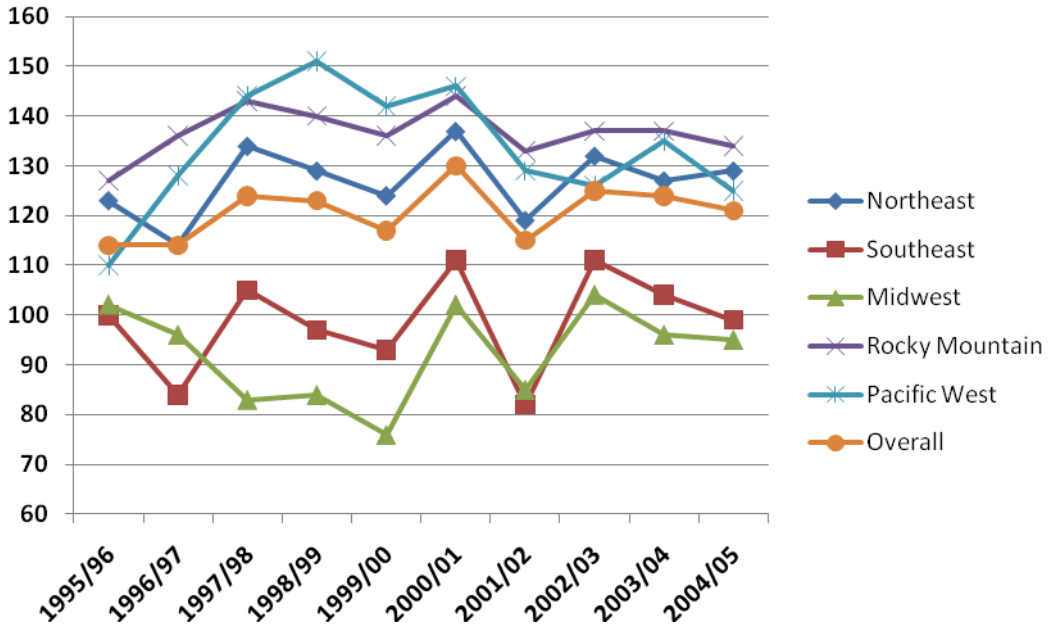


Figure 4. Annual ski season length (days open) by United States ski region (Source: National Ski Areas Association [30][31][32])

Figure 5. Marginal ski conditions during holiday season (Photo: Jackie Dawson)

The golf industry similarly attributes a considerable share of its annual economic success to climate. According to a number of golf industry reports, the single most important factor impacting season length and rounds played each year (both positively and negatively) is the weather. These same reports also identify climate as a primary determinant of irrigation needs and pest management, which represent major operating costs for most courses.

Weather and climate also play an important role in the planning, financial success and quality of visitor experience at special events that take place in outdoor venues, for example, music concerts, cultural festivals, sporting events – football, golf, auto racing [33]. Many outdoor events are held at certain times of the year in order to take advantage of certain climatic conditions or reduce climate risk. For example, the annual Albuquerque International Balloon Fiesta is held in October because of calm winds in the morning and limited severe weather. The Canadian Tulip Festival is held in May, coinciding with the maturate stage of the flowers. Climate conditions have forced organizers to undertake measures such as planting tulips bulbs in shady locations or irrigating flowers beds to delay bulb maturation to adapt the mismatch of tulip phenology and event schedule [34]. Climatic conditions can affect special events on a short-term basis (for example, short rain storm) or for the entire event (multiday rain or high winds, for example). A study of the reasons for the failure of special events through members of the International Festival and Events Association, found that weather was ranked first among eight external factors [35]. Of the full 30 factors considered in the study, weather was identified as the second most important factor contributing to event failure, only after a lack of corporate sponsorship.

> "The golf industry's significant sensitivity to weather will make it one of the first to feel the impacts of increasing weather uncertainty due to climate change. As a result, we anticipate the industry to be impacted in the near-term as the old paradigm of business and financial planning around predictable and cyclical weather patterns may be disrupted by an increasingly volatile climate… certain geographic markets are already facing these challenges…"
>
> WeatherBill Inc. (2007) [36]

Climate is also a salient influence on tourist decision-making and the travel experience. Climate is a key factor considered by tourists, consciously or implicitly during travel planning, and represents both a push and pull factor for tourists. Weather and climate are an intrinsic component of the vacation experience and have been found to be a central motivator for travel. General travel surveys conducted in Germany, the United Kingdom and Canada, have all found that weather and climate were a primary travel motivation for the majority of travellers [37][38][39]. Other traveller surveys, conducted in a number of countries have also revealed the importance of climate in the selection of a holiday destination and the timing of holiday travel [38][40][41][42][43]. Importantly, travel patterns are often related to the weather and climate conditions at the point of origin and not just the destination. For example, despite the global economic recession in 2008–2009 and expectation of reduced travel demand, the very rainy weather throughout much of the early summer in the United Kingdom was credited by the Association of British Travel Agents for the increase in foreign holiday bookings over the previous year [44].

Climate variability has been found to influence travel patterns (proportion of domestic and international holidays) and tourism expenditures in some nations. Studies of tourism demand in the United Kingdom have found that outbound and inbound visitor movements were responsive to weather (temperature and rainfall) during the current year as well as from the previous year [45][46][47][48]. Similar correlations between monthly accommodations demand (bed-nights) and summer temperatures (both current year and the previous summer) were found in Italy [49]. Demand for summertime inclusive tour charters by Norwegians, most of which (greater than 75 per cent) are to sunshine destinations, has been found to be influenced by weather conditions in the previous summer [50]. The influence of past seasons is understandable, for an individual that has experienced a negative impact on holiday satisfaction or perceived loss of holiday in the past due to weather, is likely to be wary of this potential when contemplating current holiday options. However, there is some evidence from tourist surveys that suggests the decision to return to a destination is largely unaffected by past experiences of poor weather [38][43]. A 1°C warmer than average summer season was found to increase domestic tourism expenditures in Canada by 4 per cent [51]. A number of sector or destination specific studies have also shown significant relationships between climatic conditions (daily to weekly timescales) and a range of tourism indicators – ski lift tickets,

golf rounds, park attendance, special event attendance [52][53][54][55][56][57][58]. Importantly, climate information is embedded in a matrix with other information relevant to travel decision-making (cost, time, attractions, holiday commitment, motivations, for example) and these factors bound the use of climate information in travel decisions [59]. (See also Figure 1.)

There is also evidence that the weather conditions experienced at the destination have important influence on travel and holiday satisfaction (Figure 6). Visitor surveys by the Scottish Tourist Board show that 20 per cent of overseas visitors identify weather as the main cause of dissatisfaction [60]. Poor weather has similar impacts at sunshine destinations, where cool and windy conditions, such as those shown at a winter getaway resort in the Caribbean, have a highly negative impact on holiday satisfaction and are thought to adversely affect the likelihood of repeat visitation to the destination. The importance of snow conditions to skier satisfaction has been documented in several countries [27][61][62][63] and influences the satisfaction of visitors to winter resorts to an extent that it must be controlled for in surveying to avoid contamination of holiday satisfaction and destination evaluations [64]. Poor snow conditions have also been linked to negative impacts on personal safety of tourists. During the poor snow conditions of the 1990/1991 ski season in the Swiss and Austrian Alps, accident insurance claims by British skiers were almost double average levels, with approximately half listing accidents caused by exposed rocks and congestion on the slopes [60].

Figure 6. Reduced holiday satisfaction due to unseasonal cool and windy conditions (Photo: Daniel Scott)

The preceding lines of evidence demonstrate the climate sensitivity of the tourism sector. For the tourism industry and tourists alike, climate represents both a vital resource to be exploited and an important limiting factor that poses risks to be managed. Consequently, it is expected that the integrated effects of climate change (both shifts in climatic means and extremes) will have profound impacts on tourism businesses and destinations. Furthermore, because climate, the natural environment, personal safety and travel cost are primary factors in travel decisions, and each are projected to be significantly impacted by global climate change, far-reaching shifts in consumer travel demand may also occur. Accumulating evidence indicates that climate change, particularly high emission scenarios, could therefore fundamentally transform aspects of the global tourism sector in the decades ahead [27][65][66][67][68]. The demands for accurate and increasingly detailed climate information are therefore anticipated to increase substantially in order to allow tourism businesses and destinations to minimize associated risks and capitalize upon new opportunities posed by climate change, in an economically, socially and environmentally sustainable manner. WMO defines ”climate information” as including: historical data, analyses and assessments based on these data, forecasts, predictions, outlooks, advisories, warnings, model outputs, model data, climate projections and scenarios, climate monitoring products, etc.

> “Climate change will constitute an increasing risk for tourism operators in many destinations. With many tourism activities heavily dependent on the climate and insurance policies increasingly affected by natural hazards, accurate weather information and forecasting of extreme climatic events are becoming ever more important for tourism businesses.”
>
> UNWTO Secretary-General Francesco Frangialli
> Beijing, November 2005

Despite the growing global economic importance of the tourism sector and the multiple, complex interactions between climate and tourism, there have been very limited evaluations of the use of climate information or assessments of the climate services needs within the sector [27][69][70][71]. This report provides a synopsis of the scientific and government literature and expert opinion (see list of experts consulted) on the capacities and needs for climate services in the tourism sector and was commissioned by the WMO and UNWTO to provide background information for the parallel working session on Climate Information for Adaptation and Risk Management in the Transportation and Tourism Sector at the 3rd World Climate Conference in Geneva, Switzerland.

The remainder of the report focuses on current and emerging applications of climate services in the tourism sector starting with an overview of climate information providers and various delivery pathways of climate information to the end-users within the tourism sector. The varied roles of different providers, types of existing collaborations and examples of best practice of communication and specialized climate products are identified. The next section summarizes the wide range of current and potential uses of climate information by the diverse tourism sector end-users, and key entry points into user decision-making. This summary is followed by a

discussion of key knowledge gaps, research and capacity-building needs and partnerships that are required to accelerate the application of climate information to manage risks to climate variability and facilitate successful adaptation to climate change.

2. Applications of weather and climate information in the tourism sector

There has been a proliferation of climate information providers and communication technologies over the past two decades. The types of information available to tourism end-users from major providers vary considerably. While national meteorological services are primarily concerned with the production of climate information that benefits society at large in the public interest (for example, minimizing damage and enhancing human well-being), other government agencies and most private sector providers tailor their products specifically for use by special end-users and pay-for-service customers [72]. The relative availability of basic and specialized climate information, the types of providers and the delivery pathways (communication channels) vary substantially from nation to nation and even within nations. Figure 7 provides a conceptual framework of the supply of climate information and services to end-users in the tourism sector. WMO defines the following: "Basic services" are those services provided by a National Meteorological or Hydrometeorological Service in discharging its government's sovereign responsibilities to protect the life and property of its citizens, to contribute to their general welfare and quality of their environment, and to meet its international obligations under the Convention of the WMO and other relevant international treaties. "Specialized services" are those beyond basic service, which may include the provision of special data and products, their interpretation, distribution and dissemination and consultative advice

Sources of primary climate data typically include government agencies (NMSs, for example) and private meteorological companies (for example, The Weather Network®-Canada; The Weather Channel®-United States, United Kingdom, and Australia; BBC© Weather-United Kingdom), but can also include universities, non-governmental organizations (NGOs), and tourism operators that operate their own meteorological data collection station(s) (a ski operator, for example). Climate information is delivered to tourism end-users by many types of providers and communication media, ranging from tourism marketing and guide books, the Internet, television (including several all-weather channels in a number of developed countries), radio, newspapers and hand-held devices (BlackBerry® and iPhone™, for example). A brief overview of the objectives and capacities of each major type of climate information provider with respect to the tourism sector is provided in Section 2.1. Section 2.2 then provides a comprehensive, though not exhaustive, inventory of current and emerging applications of climate information in decision-making by major end-users within the tourism sector.

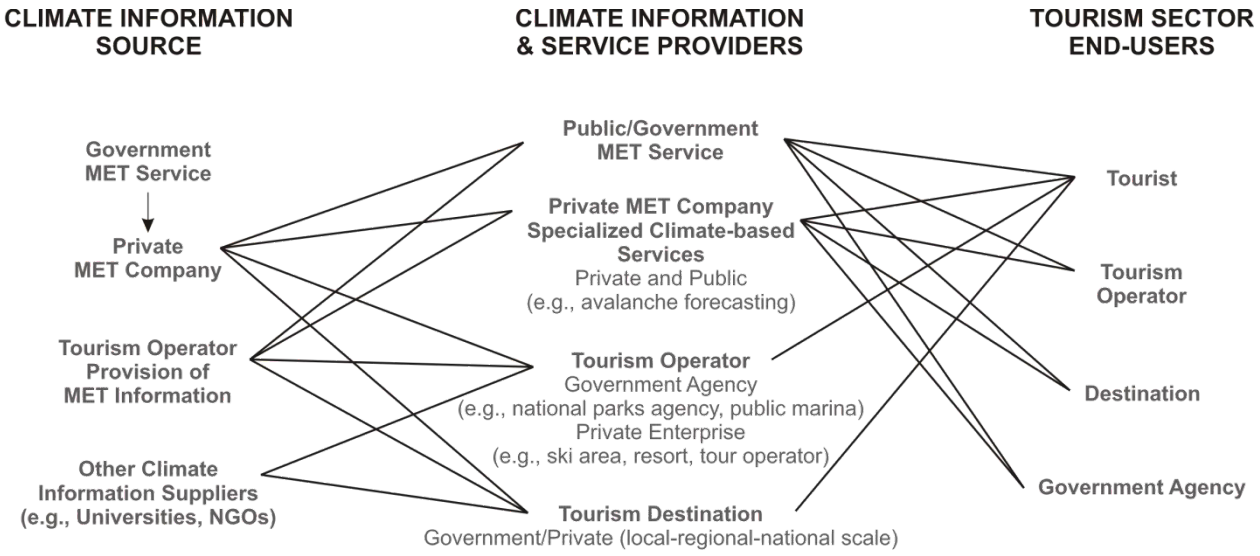


Figure 7. Conceptual framework of climate information in the tourism industry

2.1 Climate information and service providers

2.1.1 National Meteorological Services and other government agencies

Governments play an important role in the provision of climate information and this provision is sometimes dominated by legal requirements and constitutional provisions. Because basic weather and climate information is perceived as an economic public good, all 187 Member States and Territories of the World Meteorological Organization have established some form of national meteorological service to develop and operate the essential observation and data processing infrastructure needed to support the provision of climate services relevant to minimize the impact of climate-induced natural hazards (protect life and property of citizens), maintain the quality of environmental systems, enhance the economic performance of climate-sensitive sectors and meet other obligations under the Convention of the WMO and other international treaties. The NMSs may be organized in many different ways according to national circumstances and the major user communities they are required to serve, and have a high level of awareness within their respective countries [72].

For the tourism sector, NMS climate information can generally be grouped under four main categories: basic weather services (observations/nowcasting and short- to medium-range forecasts, for example); warnings to the public, aviation and marine transport weather services; specialized services for tourism end-users; and more recently climate change projections to facilitate successful adaptation. A detailed discussion of the provision of climate information for aviation and marine transport is provided in the

Transport Sector paper in this proceedings.Like with all climate-sensitive economic sectors, the maintenance and enhancement of the global climate monitoring network that provides basic weather services are of vital interest to the tourism sector. Certain key tourism environments are underserviced by the global meteorological observation system (mountains and small islands) and would benefit from system improvements. The improved accuracy of basic weather forecasts is also important for tourism operators, as these forecasts inform operational decisions and because inaccurate forecasts can be detrimental to the tourist experience and tourism demand (see previous section). Improved accuracy (or skill) of forecasts (short- to medium-term and seasonal) has been identified at workshops in the United States, Spain, Jamaica, Bahamas, Fiji and Greece, by several of the experts consulted for this report and by Altalo and Hale [71] and Gamble and Leonard [73] as a requirement for increased use in operational decision-making in the tourism sector.

> "Accurate, geographically specific meteorological information is essential for tourism operations. General forecasts, though meteorologically accurate, often have a negative impact on tourism operations because tourist destinations, such as beaches, coastal areas and mountains are often regions with unique and better than average microclimates. … (climatic conditions) which would attract tourists, may differ substantially from prevailing regional conditions."
>
> Final Communiqué
> Secure and Sustainable Living –
> Social and Economic Benefits of Weather, Climate and Water Services
> Madrid. 19-22 March 2007

Issuing weather watches, warnings, and advisories is a key function of NMSs. These enable appropriate action to be taken to prepare and protect travellers against the dangers of all forms of meteorological hazards (evacuation of people, deploying security personnel, reallocation of resources, or closing down operations, for example). Table 2 illustrates select countries and legislative responsibilities with respect to the issuance of meteorological warnings and advisories according to a recent World Meteorological Organization survey. While the survey revealed a number of NMSs to be directly responsible for the provision of meteorological information to users (Bahamas, Germany, New Zealand, for example), others are not legally responsible (Australia, parts of the Caribbean, for example) or the extent of legislative responsibilities is unknown.

In most nations in the Caribbean, the ministries of tourism work very closely with the NMS to monitor hurricane forecasts and are integral members of national emergency management agencies or task groups that coordinate hurricane preparedness. For example, in the Bahamas the Ministry of Tourism, along with other major government agencies and the International Committee of the Red Cross, is a member of the active hurricane committee that operates within the National Emergency Management Agency. The Ministry of Tourism has its own plan of operation, which includes contacting hotel operators directly by phone or e-mail as soon as a storm threat is forecast and providing hour-by-hour updates and evacuation plans as necessary.

While the quantity and diversity of specialized climate services provided by NMSs to the tourism sector is currently limited, however, some of the joint government and WMO demonstration projects of nowcasting systems and applications have focuses on major sporting and tourism events (the Summer Olympic Games in Sydney, Australia, and Beijing, China). The NMSs have a critical role in supplying much of the climate information to the mass media and other tourism specific outlets (tourist guides, marketing brochures, travel planning Web sites, for example) and provide the essential historical, current, and forecast information that allow other providers to develop specialized climate products for the tourism sector. The climate change modelling and scenario communication capacity remain limited in some developing nations. The application of climate change projections for adaptation has also been found to be quite limited thus far within the tourism sector [68][74].

Table 2. Select countries and legislated responsibilities for the issuance of meteorological information to the public

Country	*Legislated Responsibility for Issuing Meteorological Information*
Bahamas	Meteorological Service is the exclusive agent for issuing warnings on hurricanes, tropical storms and other weather conditions that are likely to give rise to floods, surges and wind damage.
China	The law provides exclusive powers to China Meteorological Association: "The state applies a unified system for the issuance of public meteorological forecasts and severe weather warnings. Meteorological stations subordinate to the competent meteorological departments at different levels shall, in compliance with their functions and duties, issue to the community, public meteorological forecasts and severe weather warnings … No other organization or individual may issue to the community such forecasts and warning."
Germany	Under 'Duties and Competences', the Deutscher Wetterdienst is mandated with "issuance of official warnings of weather occurrences that could become a danger for public safety and order, especially concerning the impending danger of floods." No express provision for exclusive rights to the Met Service to issue forecasts and/or warnings.
New Zealand	The Minister of Transport who, under Meteorological Services Act 1990, is responsible for ensuring the provision of meteorological warnings and forecasts for New Zealand and the collection of data to support these services. Furthermore, the Minister is required to designate an organization that shall provide the authorized warning service in New Zealand.
South Africa	In Act No. 8 of 2001, under functions of the Weather Service, "Only the Weather Service may issue severe weather-related warnings over South Africa in order to ensure that there is single authoritative voice in this regard."
United Kingdom	The UK Met Office has no direct legislated responsibility. The Civil Contingencies Act (CCA) 2004 sets out the roles and responsibilities for UK Authorities who are required to respond to incidents (including weather-related incidents). A piece of secondary legislation (Statutory Instrument 2042/2005) states that respondents to the CCA should not seek to duplicate information provided by the Met Office.
United States	An Act of Congress provides that NOAA, as an Agency, shall not, except where specifically authorized by statute: establish an exclusive, restricted, or other distribution arrangement that interferes with timely and equitable availability of public information to the public; restrict or regulate the use, resale, or re-dissemination of public information by the public.
Australia	No express provision for exclusive rights to the Met Service to issue forecasts and/or warnings.
The Caribbean	No express provision for exclusive rights to the Met Service to issue forecasts and/or warnings.

Source: World Meteorological Organization, 2009 [75]

In addition to NMSs, in some nations, other government departments or agencies maintain basic or specialized climate observation systems that provide climate information relevant to tourism end-users. The Great Barrier Reef Marine Park Authority's (GBRMPA) Climate Change Response Programme is an exemplary case of partnerships to utilize climate data and other monitoring information for both management decision-making and communication to tourism stakeholders. The Great Barrier Reef has experienced several mass coral bleaching events in the past decade (1998, 2002, 2006), with 60 per cent of the reef being bleached during the largest event in 2002 [76]. The Response Plan has three main components: Early Warning System; Assessment and Monitoring; and Communication [77]. The Early Warning System uses climate forecasts, remote-sensing data, sea temperature monitoring, BleachWatch reports and site inspections to monitor conditions and provide early warnings of major bleaching events. Based on an emerging understanding of the relationship between weather and sea temperatures for the Great Barrier Reef, current and forecast weather conditions are used to indicate whether conditions conducive to bleaching are likely. The programme produces tools, such as ReefTemp (a Google™ Earth application), for the monitoring of environmental conditions conducive to coral bleaching or the early signs of bleaching. BleachWatch assists managers to collect data across a wide spatial distribution and is also used to communicate and increase the understanding of broader climate change impacts to the public, tourists and tourism operators. A survey of tourists in Cairns (North Queensland, Australia) asked if they would visit the region if they knew that there had been a recent bleaching event – 29 per cent were uncertain and 35 per cent indicated they would not.

2.1.2 Private sector climate service providers

Private sector climate service providers have, to a great extent, embraced the rapid technological advancements that have occurred over the past decade with respect to meteorological observation, remote sensing and model development, as well as in communication and delivery systems (advances in cable television, the Internet, and more recently wireless hand-held devices such as RIM's® BlackBerry® and Apple's® iPhone™), in order to provide more user-friendly access and formats of climate information than provided by NMSs and other government agencies, as well as to develop specialized, value-added climate information products for the tourism sector. As a result, private sector climate service providers tend to provide a greater variety of climate information and applications that are of interest to tourism end-users.

Private sector climate service providers have led in terms of innovation of specialized climate services tailored to specific tourism destinations, individual tourist activities and subsectors. The major private climate service provider in the United States (The Weather Channel®) exemplifies best practice in this area of innovation. It should be noted that other private meteorological companies in the United States (such as *Accuweather*) and in Europe (such as *WeatherNet*) also offer a range of forecast products tailored to recreation and tourism sector operations (skiing/snowmaking, golf turf management, marine forecasts, pool management, incident reports, business revenue/visitor analyses, weather risk insurance assessments) and traveler decision-making. The Weather Channel® provides access to specialized weather reports for the following tourism activities, events and destinations: golfing, ski and snowboarding, snowmobiling, special events and major sporting events (Major League Baseball and Professional Golf Association events, for example. The Weather Channel® is the "official supplier" of weather information to Major League Baseball and the Professional Golf Association.), weather sensitive travel routes (airport weather and highway construction, for example), coastal beach destinations, international sunshine destinations and potential wedding and honeymoon locations. In some situations, what

private meteorological companies identify as activity/destination specific forecasts, are no more than renamed local forecasts for nearby cities and provide little or no added value for tourist decision-making. The Weather Channel® has also developed several climate indices relevant to the individual tourist and to various tourism subsectors. The Spectator Index (Figure 8) provides tourists a rating of how comfortable they will feel while watching a sporting event. A variety of weather factors are used to calculate the index, including temperature, probability of precipitation, humidity, wind speed and cloud cover. A Spectator Index value of 1 signifies poor conditions while a 10 signifies ideal conditions for watching an event. The Weather Channel® states that the best index values result from short-sleeve temperatures, minimal chances of precipitation, low humidity, light winds and fair skies. Conversely, cold and stormy conditions will result in the lower values.

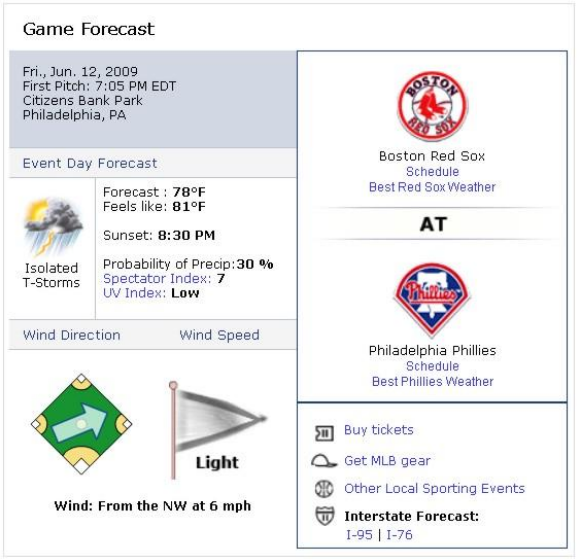


Figure 8. The Weather Channel® Spectator Index (Source: The Weather Channel® *[78])*

Other unique multivariable indices developed by the Weather Channel®, include the Ski Index (Figure 9), Golf Index (Figure 10) and the Fishing Index (Figure 10). While the weather parameters used to calculate the ski index are not entirely known, a number of parameters are acknowledged specifically as being used to calculate the rating: surface snow conditions, average snow depth, new snow accumulation, temperature, precipitation and wind speed. The Ski Index is based on a 1 to 10 scale, where a 10 signifies ideal ski conditions and 1 signifies dangerous conditions. Unpleasant weather conditions, such as thunderstorms, wind speeds at or greater than 35 mph and freezing rain will automatically set the Ski Index value to 1. A Ski Index will not be calculated for temperatures greater than 60 degrees Fahrenheit. To ensure the upmost accuracy, the Ski Index is only available for the current day and next two days and is updated frequently. The forecast Ski Index is not calculated after 4 p.m. since the lowest temperatures tend to occur at night and would therefore unfavourably skew results. The weather parameters used to calculate the Golf Index are also not known; however, parameters known to be included in the rating are: extreme temperatures, high dew points, low visibilities, thunderstorm risk, high winds and precipitation. The Golf Index is based on a 0 to 10 scale, where 0 is an unfavourable golfing day, and 10 is an excellent golfing day. The Fishing Index differs in that it only includes three rating classifications (excellent, good, fair). Variables used to calculate this index include time of day, solar influence, lunar influence, weather and wildlife charts and declination and diurnal inequality.

The Weather Channel® also provides users with current and forecast weather conditions for most national and state parks in the United States. A unique application developed by the Weather Channel® for its parks reports is the Mosquito Activity Forecast, which predicts how active mosquitoes in a particular park will be based on a variety of environmental factors, including temperature, wind, humidity values and time of day and year. The levels of mosquito activity ranges from none (conditions not favourable for mosquitoes) to very high (light winds and ideal temperatures make it perfect for mosquitoes). The Mosquito Activity Forecast cannot predict how many mosquitoes will be in a particular area (a campground, for example) or bite frequency. Mosquito populations and concentrations of species with different behaviours can vary considerably in short distances and are not taken into account in the forecast.

The development of such indices and user-friendly tools, such as the ability to conduct climate comparisons between two potential tourism destinations, has done much to increase overall brand awareness of private climate service providers in some nations. Moreover, because weather and climate data provided by private Met services can be accessed more readily via a number of different media (Internet, TV, desktop applications, mobile phones, RSS feeds and wireless handheld devices such as SmartPhones, for example), end-users are constantly reminded of who is providing them with weather and climate-related information and the types of services offered.

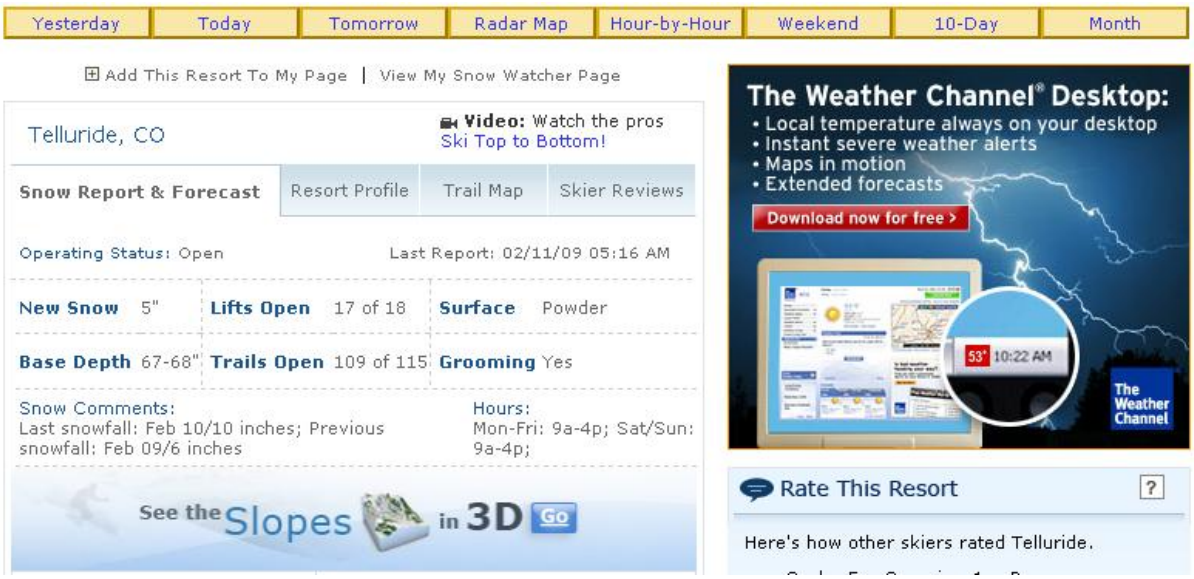


Figure 9. The Weather Channel® Ski Index (Source: The Weather Channel® *[79])*

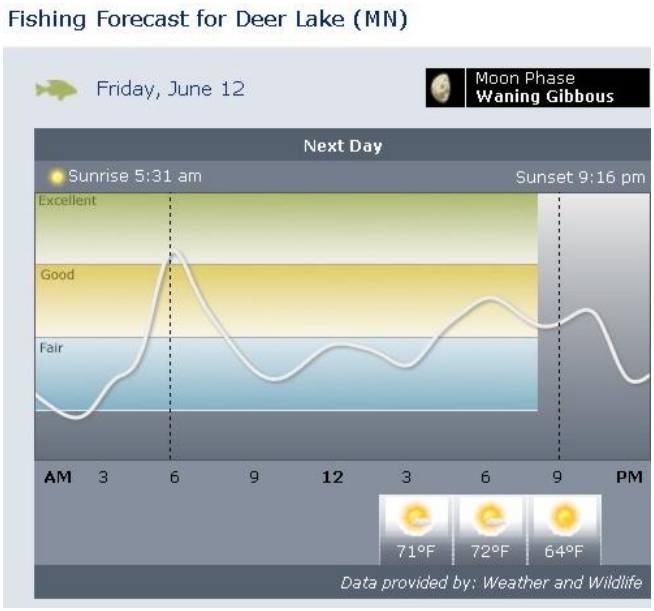


Figure 10. The Weather Channel® Golf Index and Fishing Indices (Source: The Weather Channel® *[80][81])*

Other private sector climate service providers concentrate on specialized climate information to tourists within a single tourism subsector. For example, SnowForecast.com provides climate information for over 2 200 ski locations around the world. (See Table 3 for coverage by nation.) It applies topographical corrections to basic NMS data to produce "more accurate" snow forecasts for mountain resort destinations, including snow conditions and forecasts for top-, mid-, and bottom-lifts (Figure 11). Users can access historical weather data, current weather conditions (for up to five weather stations located closest to the resort) and six-day weather forecasts (including morning, midday, and night forecasts for each day) free-of-charge. SnowForecast.com also provides access to more detailed two-day and nine-day forecasts for a subscription fee. In addition to static maps, SnowForecast.com provides access to interactive maps that allow users to select from a number of climatic variables (temperature, snowfall and wind, for example) and animate projected changes for up to a six-day period for a given region. The Website also provides other tourism relevant information to end-users, including ski trail maps, resort reviews, and links to current conditions Webcams that could be used in the destination and activity choice decision-making process. The Website also provides visitors with the opportunity to register for Snow

Alerts that are delivered regularly via e-mail. Such information and functionality is virtually never provided by government agencies and rarely provided by even the largest and most prominent private weather service providers.

Table 3. National coverage of mountain/snow forecasts by SnowForecast.com

Andorra	9	Germany	80	Pakistan	4
Argentina	12	Greece	14	Peru	1
Armenia	2	Greenland	2	Poland	11
Australia	17	Hungary	4	Portugal	1
Austria	215	Iceland	4	The former Yugoslav Republic of Macedonia	6
Plurinational State of Bolivia	1	India	11	Réunion	1
Bosnia and Herzegovina	6	Indonesia	1	Romania	30
Bulgaria	6	Islamic Republic of Iran	8	Russian Federation	11
Canada	108	Israel	1	South Africa	2
Chile	17	Italy	193	Serbia/Montenegro	5
China	6	Japan	311	Slovakia	35
Colombia	1	Kazakhstan	1	Slovenia	25
Croatia	4	Kenya	1	Spain	30
Cyprus	1	Lebanon	4	Sweden	31
Czech Republic	37	Lesotho	1	Switzerland	204
Ecuador	1	Liechtenstein	2	Taiwan, Province of China	1
Egypt	1	Mexico - Puebla	1	United Republic of Tanzania	1
Ethiopia	1	Morocco	2	Turkey	15
Finland	5	Myanmar	1	Uganda	1
France	174	Nepal	2	Ukraine	12
France - Corsica	1	New Zealand	40	United Kingdom	16
Georgia	1	Norway	37	United States	408

A similar product has been developed by Surf-Forecast.com for surfers, kite surfers, sea kayakers and other water sport enthusiasts. The NMS weather data are used to develop coastal weather and swell projections for over 8 000 surfing locations around the globe. (See Table 4 for coverage by nation.) Surf-Forecast.com uses a star rating scale to rate the quality of surf conditions at a particular location. The scale is based on swell size and character (the bigger the swell and longer the period, the higher the rating). However, if the wind is onshore, the star rating drops in proportion to the wind speed (Figure 12). A rating of 10 is considered to be the best surf with classic conditions and light offshore winds. Flat conditions, blown out waves, onshore winds or very strong winds in any direction result in a star rating of 0. Other additional tourism information that is provided by Surf-Forecast.com includes swell and wind maps, surf cams, tide tables and surf-site-specific user ratings.

Avalanches are of high importance to winter sports tourism, as many popular destinations, such as renowned ski resorts, parks and climbing areas in the European Alps, Rocky Mountains and Himalayas are in avalanche-prone locations. Approximately 150 avalanche fatalities occur each year within the 17 countries that are members of the International Commission for Alpine Rescue [84] and the majority of victims are skiers, snowboarders and winter climbers [84][85]. The mandate for avalanche prediction and communication varies by nation.

In Canada, a broad coalition of federal, provincial, private and not-for-profit sector stakeholders established the Canadian Avalanche Centre (CAC) as a not-for-profit corporation to provide public avalanche safety warnings, coordinate public avalanche safety programming and provide professional snow science and avalanche training. The CAC uses a combination of available weather and climate information, technology and science to develop their avalanche forecasts (Figure 13). Weather and climate information is primarily provided by Environment Canada or directly by local agencies or tourism operators, and satellite and remote-sensing data are provided by the University of Washington.

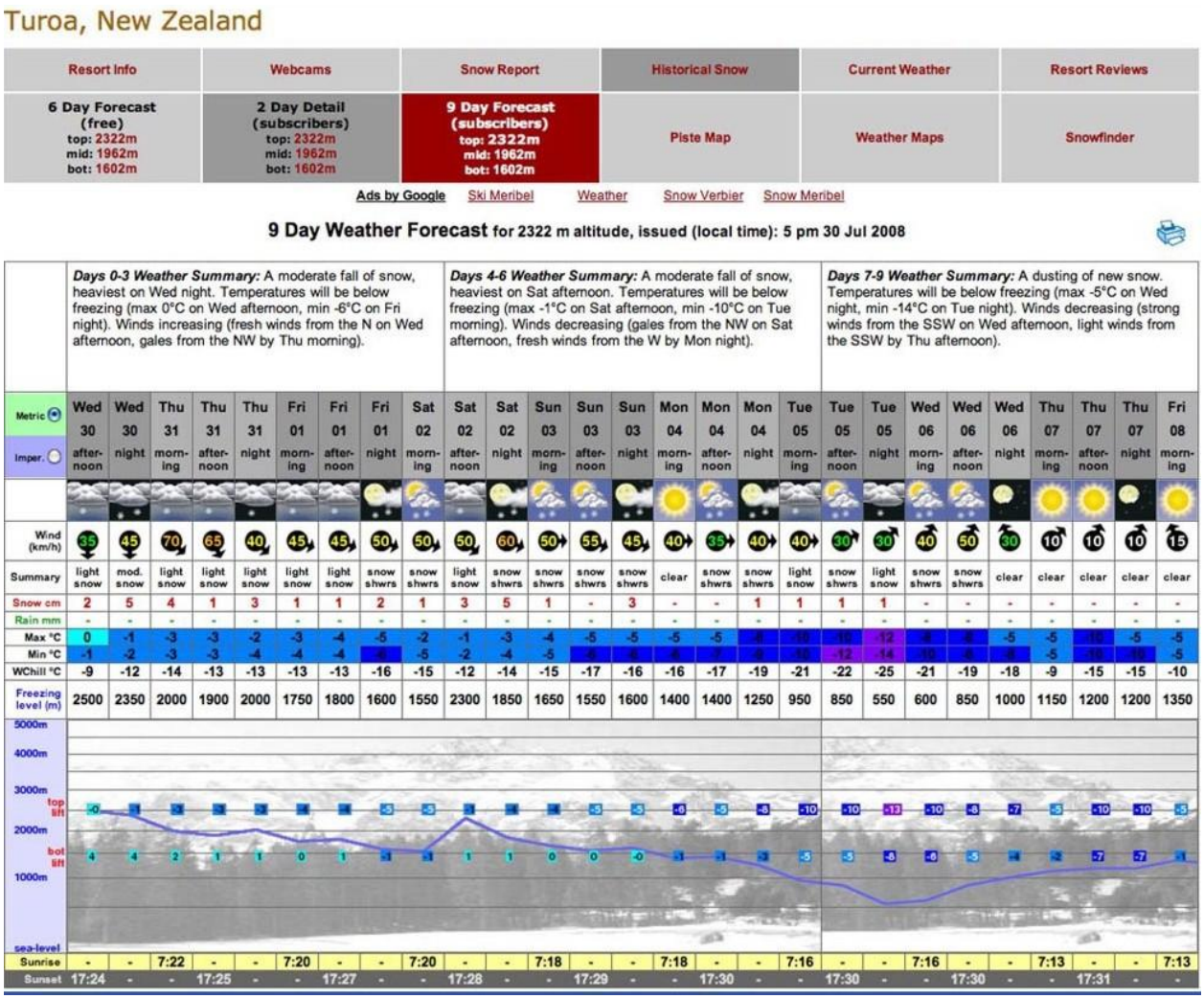
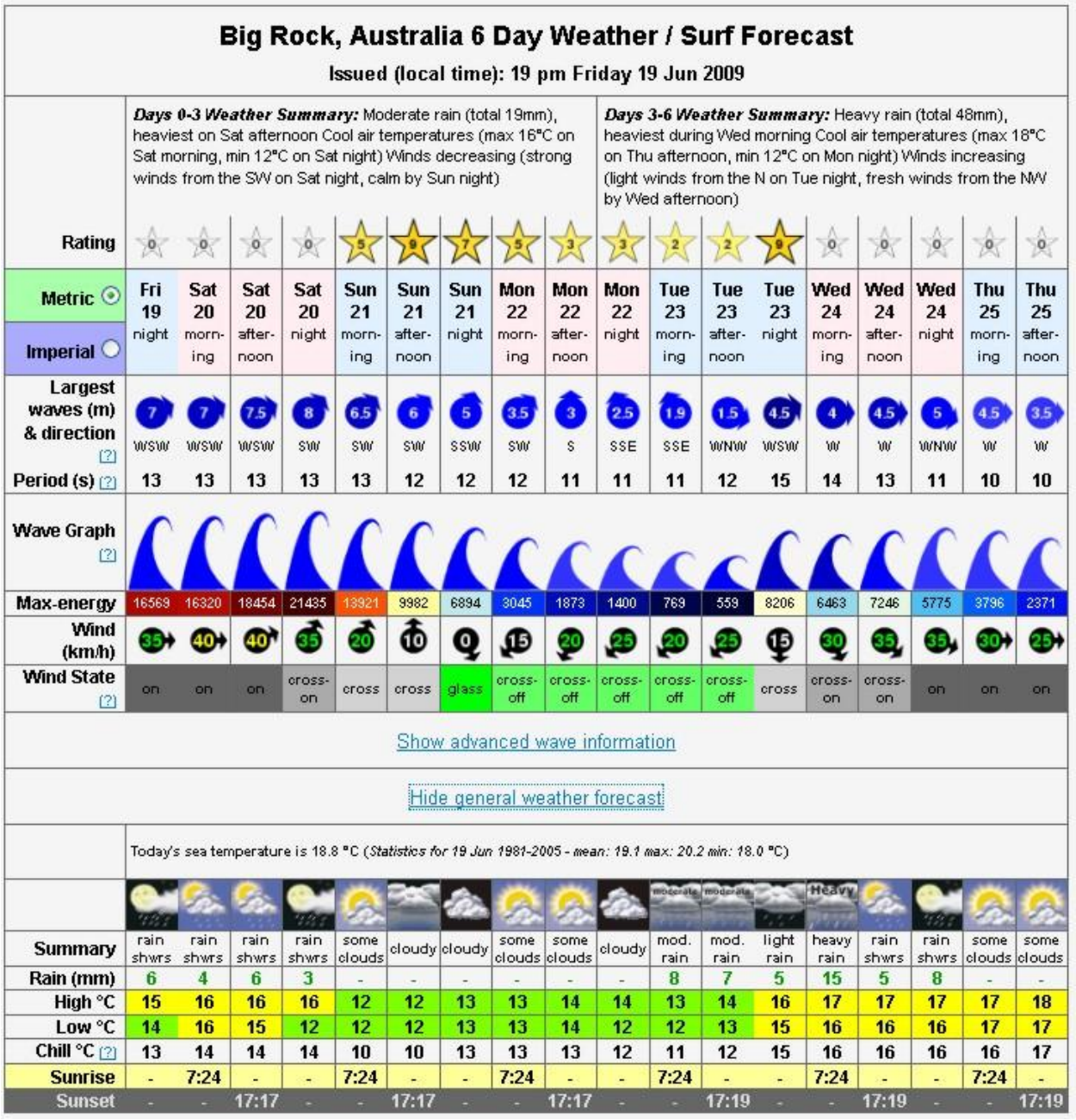


Figure 11. SnowForecast.com weather forecast for Turoa ski resort, New Zealand (Source: SnowForecast.com [82])

Table 4. National coverage of surf forecasts by Surf-Forecast.com

American Samoa	19	Ghana	17	Papua New Guinea	18
Angola	7	Guadeloupe	24	Peru	82
Argentina	17	Guam	13	Philippines	45
Australia	623	Guatemala	15	Portugal	124
Bahamas	16	India	8	Puerto Rico	16
Barbados	33	Indonesia	146	Réunion	1
Belgium	7	Ireland	87	Réunion	25
Bermuda	9	Israel	6	Samoa	16
Brazil	377	Italy	40	Senegal	11
British Virgin Islands	19	Japan	113	Seychelles	11
Canada	48	Madagascar	18	Solomon Islands	9
Cape Verde	10	Maldives	23	South Africa	256
Chile	71	Martinique	14	Spain	222
China	9	Mauritius	15	Spain	77
Colombia	9	Mexico	234	Sri Lanka	23
Cook Islands	7	Montserrat	16	Sweden	13
Costa Rica	70	Morocco	55	Taiwan, Province of China	12
Côte d'Ivoire	8	Mozambique	8	Tonga	7
Denmark	8	Namibia	12	Trinidad and Tobago	14
Dominican Republic	44	Netherlands	20	United Kingdom	436
Ecuador	54	Netherlands Antilles	7	United States	898
El Salvador	16	New Caledonia	4	Uruguay	52
Fiji	22	New Zealand	356	Vanuatu	31
France	197	Nicaragua	27	Bolivarian Republic of Venezuela	33
French Polynesia	40	Oman	10	Viet Nam	7
Gabon	10	Pakistan	10		
Germany	15	Panama	37		



Big Rock, Australia 6 Day Weather / Surf Forecast

Issued (local time): 19 pm Friday 19 Jun 2009

Days 0-3 Weather Summary: Moderate rain (total 19mm), heaviest on Sat afternoon Cool air temperatures (max 16°C on Sat morning, min 12°C on Sat night) Winds decreasing (strong winds from the SW on Sat night, calm by Sun night)

Days 3-6 Weather Summary: Heavy rain (total 48mm), heaviest during Wed morning Cool air temperatures (max 18°C on Thu afternoon, min 12°C on Mon night) Winds increasing (light winds from the N on Tue night, fresh winds from the NW by Wed afternoon)

	Fri 19 night	Sat 20 morning	Sat 20 afternoon	Sat 20 night	Sun 21 morning	Sun 21 afternoon	Sun 21 night	Mon 22 morning	Mon 22 afternoon	Mon 22 night	Tue 23 morning	Tue 23 afternoon	Tue 23 night	Wed 24 morning	Wed 24 afternoon	Wed 24 night	Thu 25 morning	Thu 25 afternoon
Rating	0	0	0	0	5	9	7	5	3	3	2	2	9	0	0	0	0	0
Largest waves (m) & direction	7 WSW	7 WSW	7.5 WSW	8 SW	6.5 SW	6 SW	5 SSW	3.5 SW	3 S	2.5 SSE	1.9 SSE	1.5 WNW	4.5 WSW	4 W	4.5 W	5 WNW	4.5 W	3.5 W
Period (s)	13	13	13	13	13	12	12	12	11	11	11	12	15	14	13	11	10	10
Max-energy	16569	16320	18454	21435	13921	9982	6894	3045	1873	1400	769	559	8206	6463	7246	5775	3796	2371
Wind (km/h)	35	40	40	35	20	10	0	15	20	25	20	25	15	30	35	35	30	25
Wind State	on	on	on	cross-on	cross	cross	glass	cross-off	cross-off	cross-off	cross-off	cross-off	cross	cross-on	cross-on	on	on	on

Show advanced wave information

Hide general weather forecast

Today's sea temperature is 18.8 °C (*Statistics for 19 Jun 1981-2005 - mean: 19.1 max: 20.2 min: 18.0 °C*)

	Fri 19 night	Sat 20 morning	Sat 20 afternoon	Sat 20 night	Sun 21 morning	Sun 21 afternoon	Sun 21 night	Mon 22 morning	Mon 22 afternoon	Mon 22 night	Tue 23 morning	Tue 23 afternoon	Tue 23 night	Wed 24 morning	Wed 24 afternoon	Wed 24 night	Thu 25 morning	Thu 25 afternoon
Summary	rain shwrs	rain shwrs	rain shwrs	rain shwrs	some clouds	cloudy	cloudy	some clouds	some clouds	cloudy	mod. rain	mod. rain	light rain	heavy rain	rain shwrs	rain shwrs	some clouds	some clouds
Rain (mm)	6	4	6	3	-	-	-	-	-	-	8	7	5	15	5	8	-	-
High °C	15	16	16	16	12	12	13	13	14	14	13	14	16	17	17	17	17	18
Low °C	14	16	15	12	12	12	13	13	14	12	12	13	15	16	16	16	17	17
Chill °C	13	14	14	14	10	10	13	13	13	12	11	12	15	16	16	16	16	17
Sunrise	-	7:24	-	-	7:24	-	-	7:24	-	-	7:24	-	-	7:24	-	-	7:24	-
Sunset	-	-	17:17	-	-	17:17	-	-	17:17	-	-	17:19	-	-	17:19	-	-	17:19

Figure 12. Surf-Forecast.com surf forecast for Big Rock, Australia (Source: Surf-Forecast.com [83])

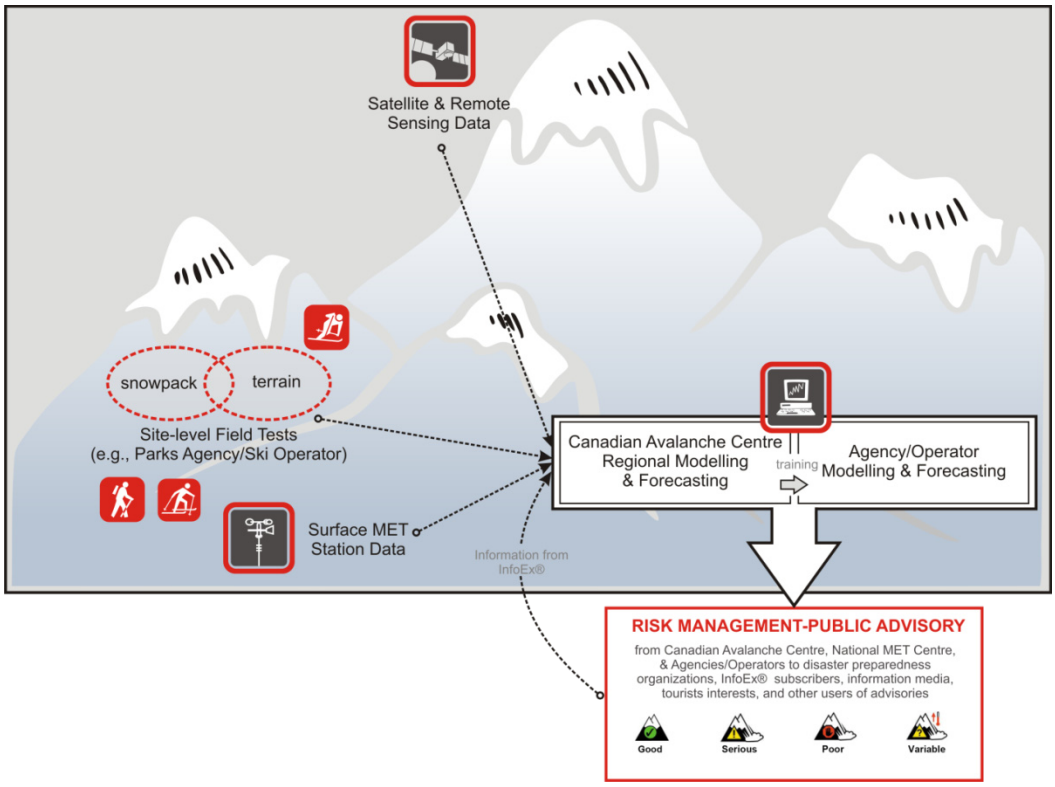


Figure 13. The use of weather and climate information in Canadian avalanche public advisories and the risk management communication chain

The CAC produces a daily Backcountry Avalanche Advisory, Public Avalanche Forecasts three times a week and weekly Public Avalanche Information Reports for very specific mountain regions and specific destinations (national parks and major ski resorts, for example). Advisories are posted on the CAC Website, the Canadian Meteorological Service Website (Environment Canada), agency and operator Websites, and are forwarded to the information media and other users of advisories (Figure 14). All areas are rated on the avalanche danger scale, which provides travel and activity recommendations for users. The Canadian Avalanche Association (CAA), a subsidiary of the CAC, also offers subscription-based mountain weather forecast services for tourism organizations and individuals who are involved in avalanche-related work via its Industry Information Exchange (InfoEx®) program. The more than 450 organizations that currently subscribe to InfoEx® are all Professional Members and actively manage avalanche hazards – backcountry and heli-skiing companies, mountain parks, resorts and lodges and road maintenance departments, for example [86]. The fee for service options include specialized forecasts for a distinct geographic location and one-on-one consultation services.

	Danger level	Snowpack stability	Avalanche triggering probability	Consequences for transportation routes and settlements / recommendations	Consequences for persons outside secured zones / recommendations
1		The snowpack is generally well bonded and stable.	Triggering is generally possible only with high additional loads** on very few extreme slopes. Only natural sluffs and small avalanches are possible.	No danger	Generally safe conditions
2		The snowpack is only moderately well bonded on some steep slopes*, otherwise it is generally well bonded.	Triggering is possible, particularly through high additional loads**, mainly on steep slopes indicated in the bulletin. Large natural avalanches are not expected.	Low danger of natural avalanches.	Mostly favourable conditions. Careful route selection, especially on steep slopes of indicated aspects and altitude zones.
3		The snowpack is moderately to weakly bonded on many steep slopes*.	Triggering is possible, even through low additional loads** mainly on steep slopes indicated in the bulletin. In certain conditions, some medium and occasionally large natural avalanches are possible.	Isolated exposed sectors are endangered. Some safety measures recommended in those places.	Partially unfavourable conditions. Experience in the assessment of avalanche danger is required. Steep slopes of indicated aspects and altitude zones should be avoided if possible.
4		The snowpack is weakly bonded on most steep slopes*.	Triggering is probable even through low additional loads** on many steep slopes. In certain conditions, many medium and multiple large natural avalanches are expected.	Many exposed sectors are endangered. Safety measures recommended in those places.	Unfavourable conditions. Extensive experience in the assessment of avalanche danger is required. Remain in moderately steep terrain / heed avalanche run out zones.
5		The snowpack is generally weakly bonded and largely unstable.	Many large natural avalanches are expected, even in moderately steep terrain.	Acute danger. Comprehensive safety measures.	Highly unfavourable conditions. Avoid open terrain.

Figure 14. European avalanche danger rating scale for recreation and travel (Source: Swiss Federal Institute for Forest, Snow and Landscape Research [87])

In Europe, the WSL Institute for Snow and Avalanche Research SLF (Switzerland) has been publishing public Avalanche Bulletins since the 1940s and the standardized Avalanche Danger Scale shown in Figure 15 has been in use throughout Europe since 1993. National and Regional Avalanche Bulletins are broadcast to the public on several media (television, radio, newspapers, Websites) as well as through mobile communications (SMS, MMS).

The Weather Network (Canada) application for the RIM® BlackBerry® Bold™ and Storm™.

Oakley® The Snow Report iPod Touch™ and iPhone™ application.

The North Face® Snow Report iPod Touch™ and iPhone™ application.

Fishing Calendar iPod Touch™ and iPhone™ application.

Figure 15. Select examples of RIM® BlackBerry® and Apple® iPhone™ and iPod Touch™ weather-related applications available to tourism and recreation end-users

Private sector climate service providers have been innovators in the use of emerging communications technologies to deliver specialized climate information to tourists and other tourism sector end-users. In the last two years, there has been a tremendous increase in the use of mobile phones to search the Internet, and a proliferation in the development of climate-related applications made available to tourism end-users through wireless hand-held devices. Apple's® iPod Touch™ and iPhone™ and Research in Motion's (RIM®) BlackBerry® products offer a diverse range of both free and pay weather-related information applications, with Apple's® App Store™ alone providing 245 weather-related products to consumers. The BlackBerry® App World™ also provides end-users with the opportunity to personalize their BlackBerry® Smartphone with several weather-related applications. With the number of mobile phones expected to exceed 4 billion in 2010, these specialized applications are likely to further revolutionize how travellers receive and utilize weather and climate information over the next decade.

The Weather Channel® 2.0 (United States) for the iPhone™, iPod Touch™, BlackBerry® Bold™ and Storm™, for example, provides users with real-time (current) conditions, hourly and 10-day forecasts, severe weather warnings and other fully interactive applications, including in-motion radar maps and traffic cameras (for select markets). The original free, ad-based version of The Weather Channel® application for iPhone™ and iPod Touch™ has received more than 3.8 million downloads (as of 26 May 2009) since its November 2008 launch [88], and is the second most downloaded weather-related application available in the Apple® App Store, illustrating the demand for climate information from the general public. For a small fee (US$ 3.99), consumers can also download a premium version of software. The Weather Channel® Max provides ad-free and more specialized weather information, such as in-motion future radar imagery projected on a map. The availability of radar information and warnings on Smartphones represent a powerful new information source for tourist activity planning and safety. Where Smartphone communications exist, tourists can be informed of adverse or hazardous weather and revise activities or avoid imminent danger. Other features of the premium application include additional severe weather coverage, an enhanced video centre, tropical updates and a Boat and Beach Forecast that provides marine coastal forecasts, local tide information and wind and surf conditions for coastal locations around the globe.

Both the Apple® App Store™ and the BlackBerry® App World™ provide a number of more specialized weather applications tailored to specific tourism-related activities. The Apple® App Store™ contains applications developed specifically for alpine skiing (iSki App, The North Face® Snow Report, SkiResort and SnoCountry, for example), boating (TideApp, for example), sailing, windsurfing and kitesurfing (iWind Italia Light, for example), surfing (Oakely® Surf Report, for example) and fishing (Fishing Calendar, for example). (See Figure 15 for screen captures.) The North Face® SnowReport is a free iPhone™ application that provides skiers and snowboarders with up-to-date weather and map information about winter resorts across the globe. The application provides resort-based snow conditions with current and expected snowfall, detailed daily forecasts and wind direction and speed information. Users can access their favourite resorts and navigate around them once they arrive through Google™ Maps and can also utilize the Trail Maps function to view a detailed lay of the land through high-resolution images. Additional information through links to the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center, as well as resort-specific Websites, can be accessed via the application.

Overall, while the number of weather- and tourism-related applications available to users is burgeoning, there is still a great opportunity for the wireless hand-held device and Smartphone programming communities to further develop and tailor specific weather and climate-related applications for tourism and recreation end-users.

2.1.3 Tourism operators

Reviews of tourism marketing materials and Websites have indicated that most tourism operators provide limited climate information to potential travellers; the most common practice is to provide only average monthly temperatures [60][89][90][91]. De Freitas [92] argues that such averages have limited value for tourists and that the tourism community should instead focus on communicating the probability of experiencing certain conditions known to be important to travellers (for example, temperatures above a certain threshold, sunshine) during specific periods (monthly or bi-weekly). Some tourism operators, especially those in more dynamic tourism environments where weather conditions can pose a health risk to tourists (for example, mountains, deserts, marine-coastal zones), provide more comprehensive climate information to their potential visitors so that they can properly prepare for their travels, including the best time climatically for travel and what to pack to ensure a safe and comfortable travel experience. Resorts and other tourism operators also frequently provide climate information to their guests to assist them with planning holiday activities once they have arrived, and as a marketing tool to reinforce the value of the holiday (Figure 16).

Figure 16. Tourism operator on-site marketing with climate information (Photo: Daniel Scott)

In most cases, tourism operators obtain primary climate information from NMSs or private meteorological companies and relay this information to tourists who are planning to utilize their travel services or who are already travelling. An example of a creative new private sector partnership began in 2009 between Husa Hotels and Cham Palaces and Hotels (Jordan) and Weather Decision Technologies to provide weather content for each hotel in the two chains (including more than 125 cities) as a value-added service for their customers. Some tourism operators provide multiple sources of climate information to travellers and a limited number also maintain climate monitoring stations and data processing capabilities at the site level. For example, Whistler-Blackcomb ski resort in Canada provides multiple types of climate information (Figure 17) and has implemented its own climate monitoring network in order to communicate more accurate local conditions to end-users and to utilize real-time information in operations decision-making (as input into its snow production management system, for example). More detailed climate information, including conditions at different altitudes (base, middle and top if there are chair lifts on each mountain) are provided to more accurately communicate the diverse climatic conditions that can be experienced by visitors and to provide greater accuracy of current conditions than NMSs and private meteorological services. Although such detailed climate information may not be needed by general tourists, it is desired by activity specialists (expert skiers in this case) who have more advanced climate information needs.

2.1.4 Destinations

Like tourism operators, organizations that promote tourism to specific destinations typically provide climate information with two purposes: to market the destination, and to assist travellers to prepare for safe and comfortable travel experiences. The studies that have examined the way in which climate is used in the advertising of destinations have consistently found that weather and climate are used in a high percentage of brochures [90][91][93][94][95][96]. According to Besancenot (1991), “The iconographic analysis of tourist brochures and the careful reading of the accompanying text only confirm the obsessive presence of references, direct or indirect, to the climate.”

Figure 17. Sources of climate information provided for Whistler-Blackcomb (Canada) ski resort

The sophistication of climate information within destination marketing communications (brochures, TV, Websites, for example) ranges widely and depends on the prominence of climate within the brand image of the destination. At one end of the spectrum are marketing communications that provide absolutely no climate information on the destination, but display a very obvious blue sky bias in all photography of the destination [90][91][97]. Often, even basic climate information (monthly mean temperature and precipitation) and advice on what to wear and health-related issues (insect repellent, UV index and sunscreen, for example) are not provided. More detailed climate information on sunshine hours, water temperatures, elevational differences in temperature and climate-related hazards remains the exception. At the other end of the spectrum are destinations that provide detailed climate information that is tailored to the types of tourists who visit and to the activities they typically undertake.

In destinations where seasonal weather is not highly conducive to tourism, climate is sometimes downplayed in marketing communications (Iceland's "more solar than polar", for example) or is omitted altogether. Marketing is also used to specifically address unfavourable perceptions about a destination's climate. For example, a tourism brochure for Brittany, France, informs tourists that "Common misconceptions and prejudices have portrayed Brittany as a rainy region when in fact its maritime climate is mild and bracing … [and its] iodine-rich sea air is unique and just to breathe it in is to enjoy its health-giving properties." In contrast, other destinations have cultivated a destination image and marketing strategy around certain activities or experiences that are largely based on the local climate. The Cayman Islands promotes its "perpetual summer", while Florida brands itself as "the sunshine state" (Figure 18). In an effort to differentiate its climate-based destination image, the Barbados Tourism Authority began offering its perfect weather guarantee in 2009. (See Table 3.) Similar money-back sunshine guarantees have begun to be offered for destinations in the south of France by travel agents in France in cooperation with the insurance company Aon France [98].

Other destinations use what would typically be considered adverse weather conditions to develop distinct tourism products. Historically, tourism has not been an important activity to the local economy of Tarifa, Spain, as the frequent high winds were not suitable for conventional sun, sand, sea tourism development. However, the high winds of Tarifa are a very valuable resource for water sports such as windsurfing and kitesurfing, and the community now markets itself as the "windsurfing capital of Europe" or the "Costa de la Luz y el Viento" ("the Coast of Light and Wind"). Vancouver Island (British Columbia, Canada) promotes a Storm Watching product on its Pacific Ocean coast during the fall and winter months and encourages visitors to take advantage of the special conditions created during La Niña phase of Pacific Ocean Southern Oscillation.

> "…experience the raw power of the mighty Pacific Ocean as ferocious waves roll in from Japan and pound the shores of the rugged west coast - nature in all its fierce majesty! … Watch as a smooth sandy beach is transformed when hundreds of pieces of driftwood are pitched up onto its sandy shore. Likewise, the Gulf Islands experience some stunning electrical storms that can only be viewed out over the water… When the storm has passed, you'll be rewarded with peaceful strolls along cool, deserted beaches – a good time for beachcombing for washed-up treasures. Make the best of these *La Nina* seasons by creating opportunities to witness some spectacular weather."
>
> Storm Watching Accommodation and Tours
> (Source: BritishColumbia.com)

2.2 Climate service users

The potential use of climate information within tourism is tremendous given the diversity of end-users in the sector. The full temporal scale of climate information, from nowcasting (up to 1 hour), to short- and medium-range forecasts (1 and 7–10 days), to multi-decadal climate change projections is utilized within the tourism sector and examples of applications are outlined for each major end-user below. However, to date, there has been no systematic assessment of the extent of climate information use in tourism decision-making in any region or subsector or of whether the information needs of specific tourism user groups are being met regionally or nationally. User awareness and capacity to use climate products and services also remain largely unknown. All remain important areas for future research and capacity-building.

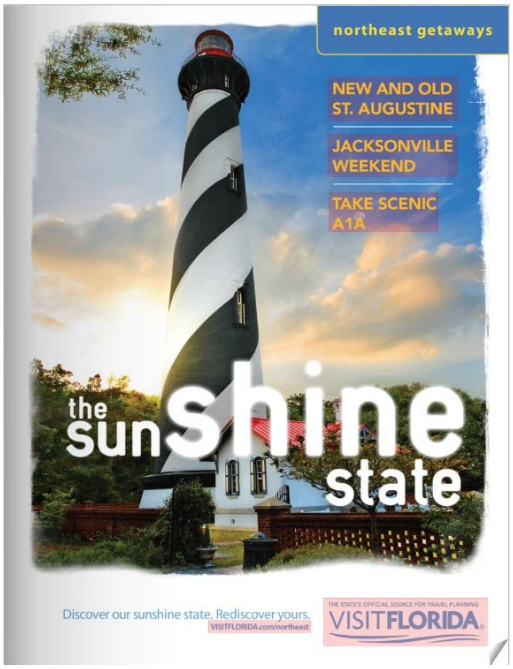


Figure 18. “The Sunshine State” tourism marketing for north-east Florida (Source: VisitFlorida.com)

2.2.1 Tourists

As indicated, weather and climate have broad significance to tourist decision-making and the vacation experience. Climate is of universal importance in defining destination attractiveness and a central motivator in the selection of a holiday destination and the timing of holiday travel. Climate influences travel patterns (proportion of domestic and international holidays), tourism expenditures and overall holiday satisfaction. Travellers are interested in the climate and weather at their intended destination as well as the weather along the way (travel phase). Business travellers are particularly cognizant of how weather causes delays and diversions, and utilize forecasts in routing decisions. Figure 19 conceptualizes the influence of different types of climate information (historic, forecasts, nowcasts) on tourist decision-making.

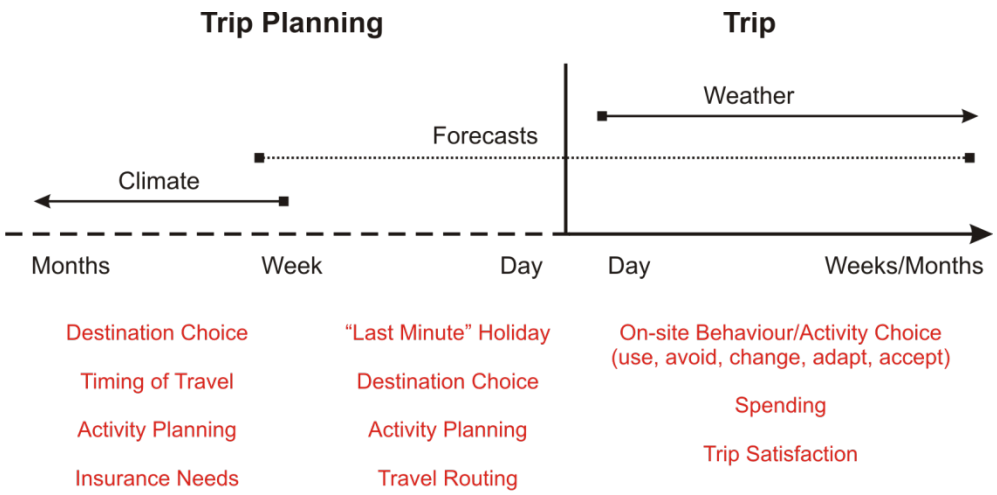


Figure 19. Weather-climate information for leisure tourist decision-making (Adapted from Scott [99])

The limited studies that have examined the use of climate information by travellers reveal widespread use in holiday planning. Tourism and recreation users were shown to generate the largest demand from automated telephone weather services in Scotland and

Britain [100]. A survey of German outbound tourists found 73 per cent informed themselves about the climate of their destination and 42 per cent informed themselves about the climate before booking their travel [41]. A similar survey of Northern European travellers to the Mediterranean region found 86 per cent would obtain information on their destination's climate, with 81 per cent doing so before making any travel reservations [101].

Interestingly, consideration of current weather conditions or near-term forecasts (next 1–4 days) has been found to be the most important factor in last minute domestic leisure tourism [102]. With the trend toward shorter timeframes for travel planning, especially discounted last minute bookings made in the week (or day) prior to departure, the value of short- and medium-term forecasts for travel planning is likely to increase. In the same way, the influence of media stories about unfavourable weather for tourism and extreme events may also increase. For example, when northern European travellers were asked if media stories about heatwaves in the Mediterranean would affect their travel plans to a destination in the region, 51 per cent said they would alter their travel plans in some way and a further 15 per cent said they would seek additional information before deciding [101]. This finding was consistent with earlier research that found travellers interpreted weather forecasts differently, depending on the relative level of commitment to holiday travel [59].

Tourist decision-making is a highly complex process, incorporating multiple influencing factors. The place of weather and climate information in the psychological process of travel planning remains an important area for further research.

2.2.2 Tourism developers, operators and destinations

Weather and climate information provide input into a several decision-making contexts for tourism developers, operators and destinations (Figure 20). Historic climate information can be used for strategic planning of tourism infrastructure, including location analysis for new resorts, architectural and landscape design and construction scheduling in remote locations. Altalo and Hale [71] found that weather and climate were not usually cited as reasons for development (or not) of new resorts and accommodations, nor critically to influence site selection decisions relative to other macrolevel factors like transportation access, source markets, land ownership and coastal access. Climate information was utilized more extensively in engineering, construction planning, property design and maintenance and other post-build decisions (insurance, heating–cooling budgeting, staffing). The limited availability of historic climate information in many developing nations and remote locations (for example, smaller islands and mountainous areas) at the scale relevant to tourism developers has been a significant barrier in the past [103][104] and the limited availability of electronically archived historic climate data from many stations continues to be a barrier in regions such as the Caribbean.

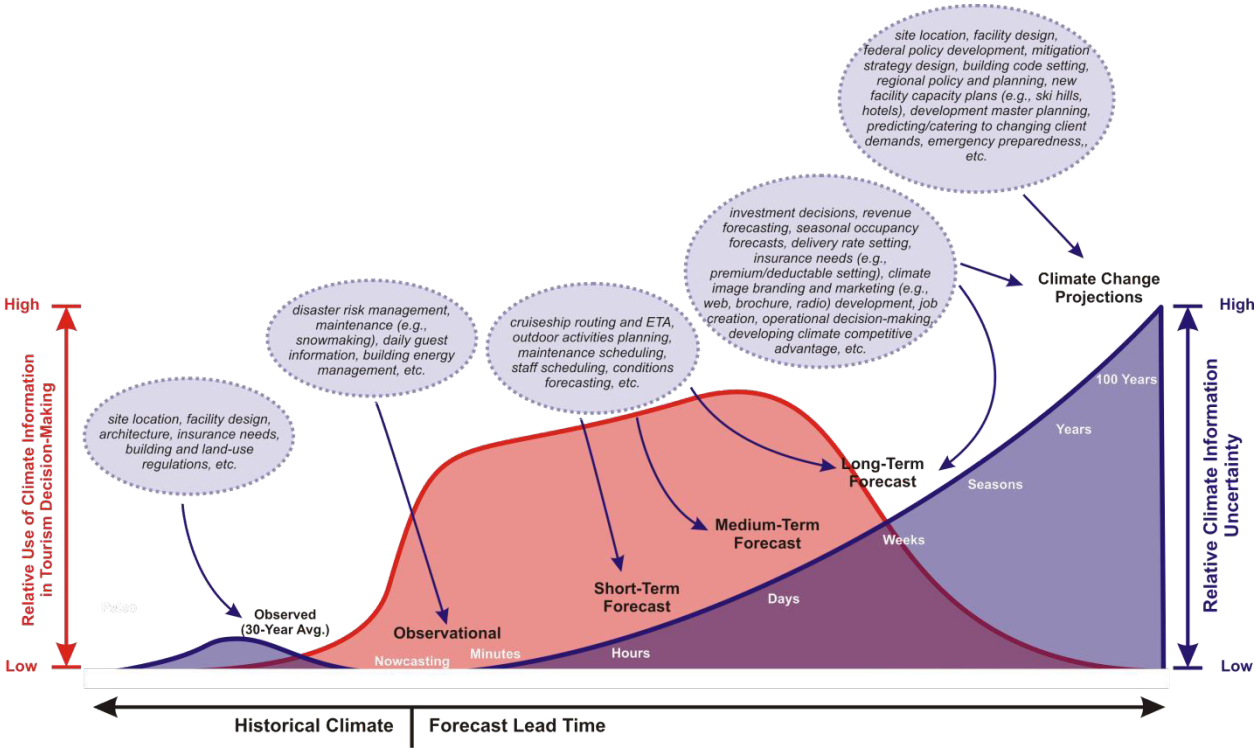


Figure 20. Potential uses of weather and climate information by tourism operators and destinations

In the same way that historic climate information has been used for strategic planning of future tourism developments, climate change projections are now also being utilized to anticipate and adapt to market risks and opportunities at the business, destination and national level. Since climate change is likely to increase the occurrence of extreme weather events [105], there is a need for a long-term integrated response. Real estate and tourism developers have begun a billion dollar investment in a giant new ski area near the remote mountain town of Revelstoke (British Columbia, Canada), because they believe the astounding snowfall in the area (an average of 15 meters annually) will become a major market advantage as snow conditions at major ski areas in more southern locations of the United States and the European Alps are projected to continue to decline in the decades ahead [106]. At the destination scale, both the internationally renowned mountain tourism community of Aspen, Colorado, [107] and Tourism Australia are using climate change scenarios in the development of climate change adaptation plans. While the use of climate change

information by tourism developers, operators and destinations remains isolated to date [68][74], its necessity for successful climate change adaptation is anticipated to increase substantially in the decades ahead (Figure 20).

Historic climate data are also the foundation for the growing application of innovative weather derivatives and index insurance products to reduce weather risk in the tourism sector. Weather derivatives are financial instruments that emerged in the late 1990s to protect against weather-related loss of revenue in the energy and agriculture sectors and differ fundamentally from weather insurance commonly held by tourism operators [108]. Weather index insurance is a financial risk transfer product that operates on similar principles. Insurance policies against infrastructure damage or business interruption from wind, floods or other extreme events pay out only in the event of an actual economic loss and reimburse only the actual amount of loss via established claim procedures. In contrast, weather derivative contracts and weather index insurance pay a fixed amount based on observed weather conditions regardless of the extent of losses experienced or whether actual damages can be demonstrated.

One of the key advantages of weather derivatives and weather index insurance is that the scalability of the product can range from individual businesses to national governments (Table 5). This feature is particularly suited to small and medium sized enterprises that dominate the tourism sector. The flexibility of designing contracts and insurance based on weather at any climate station is also uniquely suited to the tourism sector, where impacts in revenues can be attributed to weather conditions in source markets that are hundreds or thousands of kilometres from the destination where the impacts occur. Since their inception in the late 1990s, the number of companies that offer weather derivatives and the countries in which they are offered has grown substantially. In 2007–2008, the total market value of weather derivatives was estimated at US$ 32 billion [109].

Participation of the tourism sector in the weather derivatives market has remained rather limited. Knowledge of just how dependent different tourism subsectors and specific businesses are on the weather is still relatively unexplored and is hampering development within the tourism sector. Nonetheless, as the examples of tourism applications of weather derivatives in Table 5 illustrate, there is tremendous potential to develop innovative partnerships with the financial services sector to develop highly customized contracts to reduce weather-related revenue loss and create new destination marketing strategies that deliver a competitive advantage regardless of actual weather conditions. For example, the company WeatherBill now provides specialized consultations for ski resorts, sports venues (golf, water and theme parks), events (sports or entertainment) and for the travel sector in order to stabilize income, control costs, improve marketing and public relations and protect special events.

Climate information, particularly real-time observations and short-term forecasts, are used extensively by tourism operators. Recent weather observations are important inputs into a range of decision-support tools, including: automated turf management systems used by golf courses and other sports facilities, snow production systems used by ski areas, cruise ship and aviation routing, fire and avalanche rating and warning systems and energy management (heating–cooling) systems used by accommodations providers. A study examining the enhancement of swimming pool management decisions with forecast information found the potential for large annual savings related to staffing. The study also recommended that the pool management company consider using value-added, short-term weather forecasts, produced by private sector meteorologists, in their decisions [112]. However, as Altalo and Hale [71] point out, despite the acceptance of seasonal and weather influences on tourist flows by the accommodation and hospitality subsectors, there are no widely applied business forecast or revenue models allowing for climate or weather data input.

Real-time observations and near-term forecasts are also used by tourism operators for marketing purposes. Tourism operators provide current observations (including Webcams) and short-term forecasts to promote their location or event to tourists. Other innovative marketing strategies that utilize forecast information to tailor marketing messages or target certain markets have emerged recently. For example, a major golf course operator in South Carolina monitors forecasts in nearby regional markets and when poor conditions are forecast, target-markets those locations via prearranged Internet marketing arrangements with two-day specials for weekend golf and pleasant weather [113].

The extent to which climate information is used by tourism operators for strategic, operational or marketing purposes has not been evaluated sufficiently to determine its economic value or the degree to which user needs are being met. One exception was a study of the use and need for coastal climatology information in North Carolina [73]. This study revealed that almost all the interviewees responded that marine and weather information are important in their decision-making processes, but that few managers used climatological information for longer timescales (month or longer) and that tailored products would serve as an important education resource for teaching coastal managers the utility of the long-term perspective in climatology.

2.2.3 Government agencies

Government agencies, while primarily climate information suppliers, are also tourism end-users of climate information. Government agencies are often directly responsible for marketing their nation and specific destinations or do so in partnership with the tourism industry. Governments are also operators of tourist attractions (national parks, for example) and other key tourism infrastructure (airports and marinas, for example). Some governments are also assisting their tourism sectors to assess the risk posed by the impacts of global climate change (Australia's Tourism Action Plan on Climate Change, for example – see Government of Australia, 2008 [114]). In these capacities, governments utilize climate information in the same ways that were previously outlined for private sector operators and destinations.

Table 5. Applications of weather derivative contracts in the tourism sector

Tourism Operator-Destination	*Derivative Contract Details*
Island of Barbados	Weather-related Challenge: low temperatures or heavy rain Weather Derivative Protection: The Barbados Perfect Weather Guarantee, gives travellers money back when daytime temperatures do not reach 26°C or when there is more than 5 mm of rain, is a recent weather derivative backed marketing campaign to promote perfect holiday weather on the island.
City of Victoria (Canada)	Weather-related Challenge: reputation for seasonal rainy conditions Weather Derivative Protection: Offers a 'Sunshine Guarantee' that will refund travellers a set amount if they experience more than 1.25 cm of rain in one day during their holiday.
Bombardier Motor Corp (Montreal)	Weather-related Challenge: limited snowfall Weather Derivative Protection: Promised buyers of new snowmobiles that if snowfall in their area was less than 50 per cent of a three-year average, they would receive a set payment.
Corney & Barrow (Wine Bar Chain, London) (Similar contracts were arranged by Massive Ltd which operates 26 Pubs and Restaurants in London)	Weather-related Challenge: low temperatures Weather Derivative Protection: Contract paid the company for every Thursday and Friday that temperatures did not reach over 24°C. The lower the temperature, the greater the payout.
Flagstaff Nordic Center Guaranteed Season Passes (Arizona)	Weather-related Challenge: lack of snow or cold temperatures required for snowmaking Weather Derivative Protection: Purchase of seasonal weather protection for season pass holders and weekend protection for special events against inadequate precipitation (less than two inches of liquid precipitation, approximately two feet of snow) between 23 November and 23March.
PGA Championship: Greater Hickory Classic at Rock Barn, North Carolina	Weather-related Challenge: rain interruption of special event Weather Derivative Protection: Purchase of derivative protection against rain event. Payment for rain accumulation over ¾ inches during the tournament.
Taste of Antwerp (Belgium)	Weather-related Challenge: rain interruption of festival with no advance booking of tickets available Weather Derivative Protection: Organizers will receive a payment should rainfall during the event exceed 9.7 mm.
Priceline.com "Sunshine Guaranteed" Vacation	Weather-related Challenge: rain during holiday tour Weather Derivative Protection: Priceline.com offered consumers a "Sunshine Guarantee" that refunded travellers if it rained Europe (>0.50 inches per day) during half or more of their vacation days at over 100 destinations in the U.S., the Caribbean, Canada and Europe.
Itravel2000.com "Let it Snow!" Weather Promotion	Weather-related Challenge: snow related travel delay Weather Derivative Protection: itravel.2000 offered consumers a refund for travel if it snowed 5 inches or more at Calgary, Halifax, Montreal or Toronto airports on New Year's Day, 1 January 2008.

Source: WeatherBill [110]; Speedwell Weather Derivatives [111]; Weather2000.com, 2001

The regulatory function of government and its central role in emergency preparedness and disaster planning also have important requirements for climate information. A number of regulatory frameworks that are relevant to tourism utilized historic climate information as well as near-term and occasionally seasonal forecasts: coastal management plans and setback requirements; building design standards (for heating and cooling or hurricane force winds, for example; emergency management (tourist warning systems, evacuation plans, for example); environmental impact assessments (influencing property developments as well as operations like snowmaking and desalination plants, for example); wildlife management (fish and game quotas, for example); water quality standards (swimming bans, for example); and wildfire management (open fire bans in parks and campgrounds, for example).

2.3 Knowledge gaps and needs assessment

Although climate information is increasingly available to tourism users in most countries in a number of forms, there has been little systematic assessment of the extent to which climate information is used within the tourism sector at regional, national or global scales or with any specific tourism subsector or tourist market segment. Altalo and Hale [71] and Gamble and Leonard [73] are the only known studies that have explored the climate information needs of specific tourism users; these studies provide the basis for further work in the sector.Although decision-makers in the tourism sector are increasingly aware of climate risks, no doubt in large measure due to increased concerns over global climate change, tourism operators and authorities appear generally ill-equipped to make effective use of available climate information. This review has identified major knowledge gaps with respect to: the level of

end-user awareness of different types of climate information and services, exactly what climate information (basic or specialized) is being utilized by tourism end-users, how this information is being integrated into the specific decision-making processes of tourists or the tourism industry and whether there are climate information needs for end-user decision-making that are not being met with existing climate information. There also exists a tremendous need to evaluate the value of climate information for decision-making in the tourism sector both for tourists and business-destination planning, marketing and operations. This review found the following limitations in the provision of weather and climate related services to hinder the effective use of climate information in the tourism sector.

2.4 Climate information availability and resolution

Effective decision-making requires the right climate information not only in terms of the quality of the data, but in terms of its applicability to tourism operators and specific activities pursued while travelling. As discussed in Section 2.1, historical climate information has often been unavailable for tourism planning because meteorological networks are not present (or have lacked electronic archiving) or do not adequately represent the climatic conditions in specific tourism destinations. Climate information in regions with spatially coarse meteorological networks can have reduced applicability to decision-making in the tourism sector, because activity patterns and tourism operations are highly localized, often in microclimate conditions (for example, mountain valleys, high elevations, coasts or small islands). In this review of the types of climate information provided by destinations or tourism operators, it was observed in a number of cases that the climate station operators or destination promoters used were more than 100 km away from the destination. Weather information being communicated to potential users may therefore differ substantially from the prevailing local conditions.

Recommendation: Investment is necessary to strengthen climate monitoring networks in areas where the tourism sector is vital to local economies, specifically rural areas and many developing countries (particularly Small Island Developing States), in order to improve climate risk management and climate change adaptation in the tourism sector.

Recommendation: With the risk in developing countries of permanent loss of historical climate data, which has potentially high value for managing climate risk and informing climate change adaptation, action is urgently needed establish a coordinated international data rescue initiative.

Issues of availability and representativeness of climate data for tourism destinations are likely to encumber climate change adaptation and the further development of weather-linked securities within the tourism sector. It is almost impossible to develop an effective climate change adaptation strategy without knowledge of past climate and how this baseline is projected to change in the future. The pricing of weather derivative contracts and the right of a customer to receive payment are based on weather statistics and observations at individual weather stations with a high quality historical record, and are not contingent upon conditions at a specific business location (for example, ski area, golf course) or event (for example, music concert). The more coarse the meteorological network, the less representative the conditions at the nearest weather station may be, depending on distance and local geography. The lack of sufficient weather stations and availability of adequate data reduces the potential application for weather-risk reduction through weather derivatives and weather index insurance. These issues are particularly acute in rural areas and some developing nations where tourism is a major part of the economy and that could benefit significantly from weather risk management products.

In situations where multiple sources of climate information were available for a destination (NMSs, private meteorological company, tourism operators), inconsistent information was sometime being provided to tourists. Current conditions more than 10°C to 15°C apart were occasionally reported, as were very different forecasts for temperature, rain and winds. Such varied reporting of climate conditions and forecasts is likely to raise questions about the validity of the source among tourists and will impact tourist decision-making for short-term visits (day trips and weekend travel especially) and highlights the importance of forecast accuracy for some segments of the tourism sector.

Recommendation: Strengthening of climate monitoring networks is necessary to support the development and access to innovative financial products (weather derivatives and index insurance) to manage climate risk in the tourism sector.

Climate information represents a double-edged sword for the tourism sector. While accurate climate information can be invaluable to the tourism industry, inaccurate climate information that deters visitation is a lament heard often by all of the experts consulted in this review and has been the subject of several workshop discussions and media stories. For example, at the Climate, Weather, and Tourism Workshop in North Carolina [115], multiple tourism stakeholders voiced frustration with media reporting of weather and how it unnecessarily affected tourism. Wineries in the region saw visitation decline for an entire season after inaccurate reports that spring frost had wiped out that year's crop [116]. Similar concerns about forecast skill and media coverage of weather forecasts were expressed by other tourism operators and tourism authorities in the region, especially the typical margin of error in early hurricane track forecasts (7–10 forecasts) that have been observed to be very damaging to the tourism economies of regions at the low probability edges of the forecast track [117]. The accuracy of early forecasts of extreme events was also an important topic of discussion at the Secure and Sustainable Living – Social and Economic Benefits of Weather, Climate and Water Services Conference in 2007 (see statement below). Seasonal forecasts have also recently been shown to have adversely affected travel decisions in the United Kingdom. In 2009, travel agents and tour operators observed that following the NMS long-range summer forecast of "unusually warm, dry weather with heatwaves up to 30°C", demand for foreign holidays declined substantially [44]. After a very rainy month of July and a revised forecast for "wet weather until September", the Association of British Travel Agents reported an increase in travel bookings of up to 40 per cent and a diminished supply of package holidays to sunshine destinations [44].

> "…the very early warning of extreme weather events, such as tropical cyclones, can unwittingly put off tourists from destinations unlikely to be affected by the event or if impacted, well outside the time that the tourist would be in the destination. Thus there is a need for the industry and forecasters to work closely together to resolve the issues that arise from lack of specificity in forecasts, while ensuring public safety."
>
> Final Communiqué
> Secure and Sustainable Living –
> Social and Economic Benefits of Weather, Climate and Water Services
> Madrid, 19-22 March 2007

The article "Gold Coast Businesses Unhappy with Weather Forecasting" (Nolan, 2001) describes the concerns of several tourism operators in Queensland, Australia, about the accuracy rate of the local forecasts and the financial impact on their businesses. Some tourism operators have indicated that one of the reasons they included additional sources of localized climate information and live Webcams on their Website, was to overcome perceived limitations in forecasts and biased reporting by mass media, who, in their words, were often "looking for a story" about a storm or poor travel conditions. As the statement below indicates clearly, tourism businesses affected by weather and forecasts have an economic stake in the quality of the climate information.

> "It's a fair assumption to suggest that the weather and the weather forecast – however derived – is a very important part of the (tourist) decision making process. … I think we both (NMS and tourism industry) want accuracy, but also at the same time, we want it balanced, with a situation where the travelers are not deterred because the off chance of a shower is portrayed as if it was a certainty."
>
> Daniel G-Schwind
> Chief Executive, Queensland Tourism Industry Corporation
> (in Nolan, 2001)

Unsubstantiated speculation about the impacts of climate change on tourism destinations is likewise problematic and may adversely affect investment and eventually visitation needlessly. A number of media stories have foretold the major threat that increased future summer temperatures pose for tourism in the Mediterranean. Indeed some have gone so far as to state that, "The likelihood [is] that Mediterranean summers may be too hot for tourists after 2020" (Guardian, 2006 - based on Amelung and Viner [118]) and that "by 2030, the traditional British package holiday to a Mediterranean beach resort may be consigned to the 'scrapheap of history'" [119]. Such pronouncements have been shown to be unfounded scientifically (see Scott et al., [74] and Rutty and Scott, [101]). Similar speculation about the demise of winter sports tourism in the European Alps, North America, and other ski regions is also widespread, with some stories going as far as identifying specific ski areas expected to be lost and "where not to buy ski properties" (real estate investment).

Unfortunately, such misinformation continues to be perpetuated by other travel writers even years after the initial stories have been published (see Osborne, [120]; Munns, [121]; *The Independent*, [122]; Couttswoman, [123]; Newsom, 2007) and will continue to negatively impact the reputation of certain destinations. This type of speculation diminishes the credibility of all other climate change assessments designed to help the tourism sector and destination communities adapt to future climate change. In the same way accurate forecasts are in the best interest of the tourism sector, so too are accurate representations of the risks posed by climate change. The tourism sector, particularly destinations, need to work closely with informed scientists to accurately understand the risks and opportunities posed by climate change and ensure that the misrepresentations of climate change vulnerability in the media do not go unanswered.

Recommendation: The development of regionally and locally specific climate change scenarios is necessary to facilitate effective climate change adaptation by the tourism industry and tourism-dependent communities. The refinement of near-term climate change predictions (covering the next 25–30 years) that are most relevant to business investment and government policy timeframes are particularly encouraged.

2.5 Influence of climate information on decision-making

Knowledge about the process of how tourism end-users integrate weather and climate information into specific decisions remains very limited. Key knowledge gaps remain regarding the decisiveness of weather and climate as a factor in decision-making and when end-users require climate information in different decision-making processes. The proportion of tourists travelling primarily for climate-related motivations or to engage in climate-sensitive activities remains unknown and central to understanding the relative climate sensitivity of destinations. Describing the decision-making process requires, at a minimum, describing the key decision-makers, their goals and the context in which they operate (the decision-making environment), the information they use to make decisions, the alternative actions available to them, and the important decision points [124][125]. Climate information is typically embedded in a matrix with other relevant information [27][59][70][124] and disentangling the role of climate and its relationship to other situational factors in major decision-making processes in tourism remains an important objective for future research.

Tourists experience and respond to the integrated effects of the weather elements – thermal, physical, aesthetic [70] that comprise climate [70][126][127][128]; however, there remains a very incomplete understanding of the relative importance of different climate parameters to tourists, the range of climate preferences among tourists in terms of the optimal conditions and thresholds of unacceptability for certain variables, how preferences differ for specific tourism environments or destinations and whether significant cultural, regional or market segment differences exist in climate preferences [43][95][128]. The complexities of tourist climate

preferences are only beginning to be examined. For example, recent survey research in temperate regions of North America, Europe and New Zealand [38][43][101][128] has found that the importance of key climate variables as well as perceptions of optimal conditions and thresholds for unacceptable conditions differed substantially among tourists and in specific tourism environments (Table 6 and Figures 21 and 22). More research is required to understand whether similar climate preferences exist among tourists from other climatic regions of the world as well as to understand the specific climate sensitivity of specific tourism activities.

Table 6. Importance of weather variables in different tourism environments

Importance Rank	*Beach*	*Mean* (1–7)	*Urban*	*Mean* (1–7)	*Mountain*	*Mean* (1–7)
1	Sun	6.14	Temp	5.98	Rain	6.04
2	Temp	6.11	Rain	5.77	Temp	5.84
3	Rain	5.87	Sun	5.14	Sun	5.55
4	Wind	5.13	Wind	4.75	Wind	5.41

Source: Scott et al. [128]

Temp = "comfortable temperature"; Rain = "absence of rain"; Wind = "absence of strong wind"; Sunshine = "presence of sunshine"

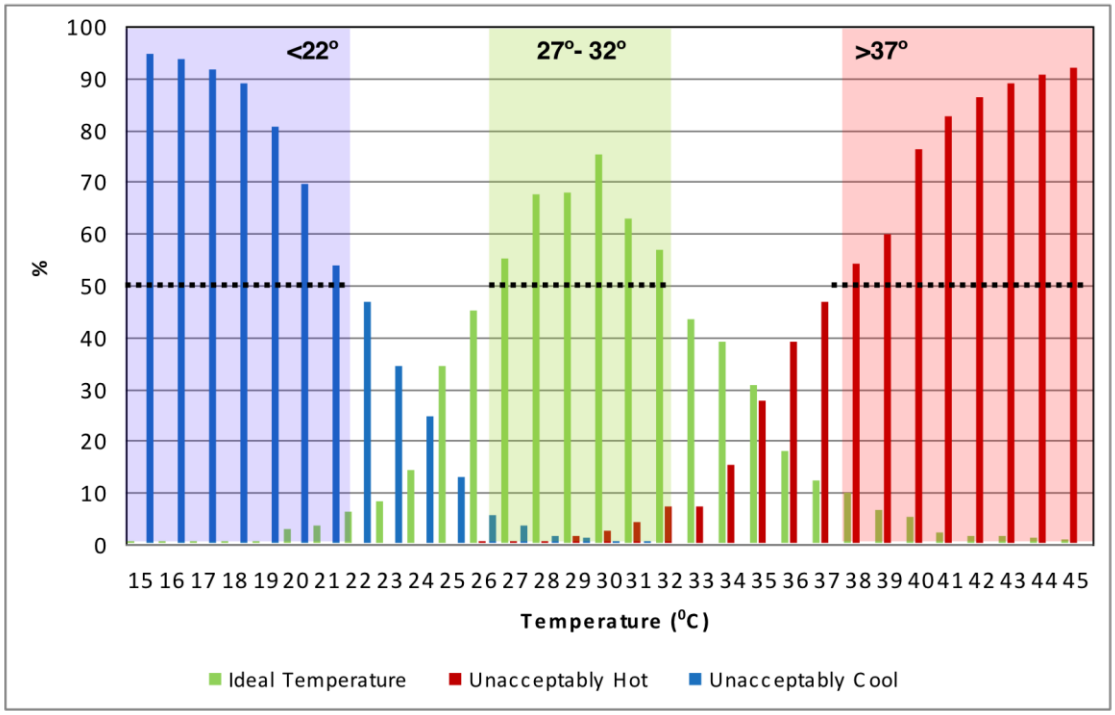


Figure 21. Tourist rating of temperatures for beach holidays (Source: Rutty and Scott [101])

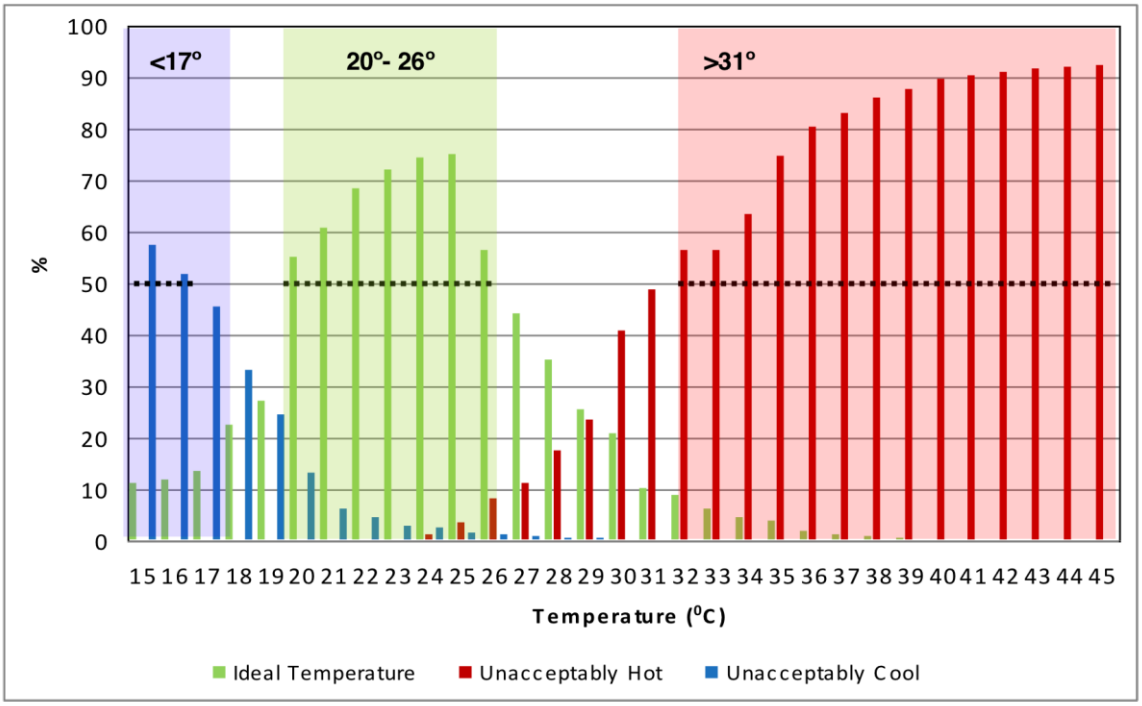


Figure 22. Tourist rating of temperatures for urban holidays (Source: Rutty and Scott [101])

Recommendation: Support is necessary for the fundamental multidisciplinary research needed to understand the salience of climate (both in source markets [push factor] and destinations [pull factor]) in different travel decision-making contexts, cross-cultural climate preferences for major destination types, the effect of weather on holiday satisfaction and future travel choices and the climate sensitivity of major tourism activities.

Fundamental knowledge of climate conditions that strongly influence destination choice and activity satisfaction is a prerequisite to the development of specialized climate products for the tourism sector. Without it, the validity of existing indices, and those utilized in the research literature (the Tourism Climate Index by Mieczkowski [126], for example) remain uncertain. Unfortunately, most of the newly developed specialized products from private meteorological companies lack transparency in the methods and data sources to properly evaluate their application to either domestic or international travellers. Many specialized products will serve to inform destination and activity choices, and their design must be transparent to the consumer to allow objective destination comparisons and marketing claims in a global tourism marketplace. The “Heat Wave Vacation” story in the *Wall Street Journal* [129] illustrates how some travellers feel misled by travel operators and destination marketers about the climate of destinations and how they would benefit from a tool to compare climatic conditions of destinations they are considering. Some specialized products

will also affect decisions that have implications for the personal safety of travellers and therefore the design and data inputs should be transparent to tourism professionals that might use them as well as to the travellers themselves.

Recommendation: Developers of specialized climate products for the tourism sector, whether the private sector, universities or governments, are encouraged to disclose the scientific methodology or market testing results to demonstrate validation in the tourism marketplace.

Recommendation: The tourism sector, in collaboration with NMSs, private meteorological companies and university researchers, are encouraged to develop accepted standards for specialized climate products, to ensure consistent and accurate communication of climate information to international travellers and to facilitate objective destination comparisons and marketing claims in a global tourism marketplace.

The availability of climate information has not been the sole barrier to understanding the interface of climate and tourism sufficiently to develop specialized climate services, facilitate greater involvement in the emerging weather derivatives and index insurance market or determine the weather and climate information for tourism decision-making. Access to tourism data has been a frequently noted impediment to research and the development of specialized climate services and climate change assessments [41][42][45][130][131][132][133] and a common frustration of many of the experts consulted for this review. For this partnership to move forward and succeed, the tourism community must be an active contributor. Furthermore, the importance of collecting accurate and consistent domestic and international tourism data to advance scientific understanding of the climate–tourism interface and the implications of climate change cannot be overemphasized. Past recommendations of the UNWTO [5][134] and the broader tourism research community [135] for continued efforts to maintain and enhance monitoring of tourism performance indicators are echoed here.

Recommendation: Collaboration between governments, universities, communities and the private sector (tourism businesses, meteorological service companies, financial services), must be strengthened to drive innovation that connects climate information to the needs of the tourism sector and tourism-dependent communities.

Recommendation: The active collaboration of the tourism industry is necessary to support the development of climate services to improve outcomes for the sector, and the industry is strongly encouraged to provide increased access to sectoral data, consult on specific climate information needs and constraints to its use, provide expert review of specialized products and create effective strategies to communicate weather and climate information to tourists.

2.6 Socio-economic benefits of weather and climate information for tourism

Effective use of climate information has the potential for avoiding injury and death, averting property and environmental damage and a wide range of other societal benefits [124]. There is a growing literature on the economic value of climate information and forecasts [136] as well as techniques to valuate non-market benefits. The tourism sector is virtually absent from this literature, although Altalo and Hale [71] contend that the financial benefits of weather and climate information for the sector are likely to be very substantial. One of the few attempts to evaluate the specific financial benefits of improved weather and climate information for the tourism sector was a NOAA study of the multisector benefits of new observational equipment [137][138]. Specific to the tourism sector, the study found that weather information and hurricane forecasts from the new satellite imager and sounder would create US$ 196 million per year in socio-economic benefits through improved golf safety, irrigation efficiency, grounds maintenance, tournament and personal golf planning [138] as well as US$ 31 million per year in economic benefits, from damage avoidance in recreational boating, amusement and recreation services [137][139].

Moreover, there are no studies of the financial or non-market benefits of specialized products for tourism or the willingness to pay for climate information among tourists and tourism operators. Consequently, the value of climate information to tourists and the tourism industry remains unknown. Hypothetically, if tourists were willing to pay 1 Euro for weather and climate information needed for trip planning for each of the estimated 900 million international and 8 billion domestic trips, then the global value of climate services would be very significant even without consideration of its value for supply-side operations and marketing. Based on the success of studies that have applied techniques for economic and social valuation of climate services (market prices, normative market models, descriptive behavioural response studies and contingent valuation studies, for example) in other economic sectors, it is clear that uncovering the potential value for the tourism sector and determining how to fully realize that potential remain critical areas for future inquiry.

Recommendation: An interdisciplinary initiative should be established to evaluate the economic and non-market societal value of climate information for decision-making by tourists and tourism operators.

2.7 Communicating weather and climate information to the tourism sector

The production of climate information alone is not sufficient for travel or business planning and decision-making. Information must be delivered to end-users in a form that is relevant to them and that they have the capability to interpret. As identified in Section 2.1, there are a range of communication channels for the delivery of climate information to tourists and the tourism sector. How climate information is communicated to tourists and tourism subsectors is largely unexplored and communication channels, especially related to warnings of abrupt and dangerous weather events, are not widely documented within the tourism sector. There has been almost no evaluation of what sources of climate information tourist or tourism operators utilize, nor the effectiveness of different communication pathways and formats.

Gamble and Leonard's [73] study is the only known attempt to identify Web-based tourist preferences for climate information. Examining the communication of coastal climatology information, the authors found that simple sites were perceived by tourists to

be most effective and included: (a) a limited amount of information presented on the Website; (b) efficient and clear Web navigation features; (c) limited use of scientific jargon and graphics; and (d) limited use of colours and flashy graphics. Also of note was the identified need for more local data and the annoyance with the need to purchase or download software to further assess climate data. Overall, the authors found that a more organic, bottom-up Website design that reflects the needs of users and locals was beneficial. There is a clear need to test these findings for universal applicability across the breadth of tourism-related climate information products available to end-users.

Most weather forecasts today still contain little uncertainty information. Without this information, forecasts can easily be misinterpreted and potentially misused in decision-making. This can have potentially negative social and economic consequences (especially with respect to hazardous weather events). Although this challenge is recognized by many NMSs and private meteorological companies, overall the meteorological community has a limited understanding of how to communicate weather forecast uncertainty effectively to users with diverse technical and intellectual capabilities [140]. Interdisciplinary research on tourist and tourism sector perceptions of uncertainty within forecasts, preferences for uncertainty communication formats and a better understanding of the decision stakes related to uncertainty across a wide set of weather and climate information end-users is needed.

Recommendation: Greater effort should be made to consult with major tourism end-users about their needs for climate information. This consultation must be done regionally in order to adequately represent specific information needs and the capabilities of regional providers.

The responsibility for ensuring that the natural hazard information is communicated to the public rests squarely with government agencies. Ensuring adequate community response requires a close partnership and well established and regularly tested working arrangements and channels of communication. However, understanding how weather forecasters and emergency managers use climate information and how this information is communicated to the tourism sector is currently limited.

Social science research conducted during the last decade has highlighted the difficulty in preparing visitors to effectively respond to warning messages [141][142][143][144]. Tourists can be particularly vulnerable to natural hazards because they often visit highly dynamic environments, can have limited familiarity with the places they are visiting and with common meteorological hazards and remote locations can lack communication channels for public warnings of impending hazards. The tornado that struck the Pine Lake, Alberta, (Canada) campground in July 1999, killing nine and injuring over 100, is one such example. Although the Meteorological Service of Canada had issued a tornado warning well in advance of the event, there was a communication breakdown, and virtually all of the tourists at the campground were unaware of the warning of imminent severe weather and there was no on-site emergency warning system available (a siren system used in urban areas, for example). Furthermore, because tourists can be unfamiliar with the local language and are less likely to utilize local media information sources (either purposively or unintentionally), tourists are less apt to receive hazard warnings when they are issued, and prompt communication with them of imminent climatic hazards poses a particular challenge [85].

Recommendation: An interdisciplinary evaluation of best practices for communication of climate information, particularly specialized products and forecast uncertainty, to tourism end-users is encouraged.

3. Conclusions

The past decades have seen tremendous advances in climate science and knowledge of how the global climate is likely to change over the twenty-first century as a result of anthropogenic greenhouse gas emissions and feedbacks in the global climate system. The revolution in communication technology, particularly the Internet and more recently mobile personal data devices (Smartphones, for example) has also revolutionized the climate information available to tourists and the tourism industry. Although interest in the climate–tourism interface has also increased markedly during the past decade, as evidenced by a doubling in the number of scientific publications on tourism and climate between 1996–2000 and 2001–2005 [145], the research community has yet to evaluate how the revolution in climate information and information communication technologies has translated into improved decision-making in the tourism sector.

This review has documented the many sources of climate information now available to the tourism sector and the continuing development of specialized climate products for tourists and tourism operators. It also revealed that there has been no systematic evaluation of the extent and nature of climate information use in any tourism subsector or specific destination region. There is very little insight into the role of climate information in specific decision processes within the tourism sector (either demand or supply-side), the economic and non-market value of climate information and related service to end-users and society or the most effective ways to communicate climate information to diverse tourism end-users. Addressing these key knowledge gaps and others identified throughout this review would provide significant opportunities to enhance decision-making and reduce climate risk in the sector.

Critically, accumulating evidence indicates that climate change, particularly high emission scenarios, will be a pivotal issue affecting the medium- and long-term future of tourism development and management [27][66][67][68]. Consequently, it is recognized that the need for climate services will increase throughout the twenty-first century as the magnitude of climate change increases and the ability to rely on previous experience diminishes. As the statements from the Secretaries-General of the WMO and UNWTO indicate, both organizations recognize that improving the use of climate information is an important strategy to facilitate sustainable development of tourism that contributes to the United Nations Millennium Development Goals.

> "Given that climate change is expected to pose an increasing threat to tourism operations in many destinations . . ., WMO urges governments and the private sector to increasingly use climate information . . ., and to take additional steps towards incorporating climate considerations in tourism policies, development and management plans."
>
> WMO Secretary-General M. Michel Jarraud (2007)

> "Climate change will constitute an increasing risk for tourism operators in many destinations. With many tourism activities heavily dependent on the climate and insurance policies increasingly affected by natural hazards, accurate weather information and forecasting of extreme climatic events are becoming ever more important for tourism businesses."
>
> UNWTO Secretary-General Francesco Frangialli (2005)

Improving the use of climate information in the tourism sector is a challenge that will require closer collaboration among the climate and tourism research communities (both physical and social scientists), NMSs, government tourism authorities and the tourism industry. Over a decade ago Smith [60] argued that the limited research on the complex interactions of climate and tourism was in large measure because, "… meteorologists and leisure specialists rarely communicate with each other." With substantial opportunities to more effectively deliver climate services that are of immediate and recognizable value to tourists and the tourism industry and the imperative of adapting to climate change in the decades ahead, the time has come for the conversation between climate service providers and tourism end-users to begin in earnest. Positively, a number of key new partnerships have emerged in recent years that provide a solid foundation for necessary future collaboration. The collaboration between the WMO and UNWTO to establish an Expert Team on Climate and Tourism in 2005 is a critical initiative at an international level. New partnerships have also developed between meteorological institutions and tourism stakeholders [146]. This cooperation has taken multiple forms, from new forecasts for tourism destinations, improved media training and cooperation to deliver forecasts related to tourism, to specific contracts between meteorological services and destinations, tour operators and other stakeholders.

What is now most needed is a strategic initiative that will encourage direct interaction and catalyse regional and local partnerships among climate service providers, governments, universities and the diverse user groups within the tourism sector. It is recommended that a series of multi-objective, capacity-building workshops be undertaken over the next five years in major tourism regions with diverse climate sensitivities. The regional workshops would build capacity in both the climate services and tourism sectors. The workshops would stimulate interest in the impacts of climate variability and change, increase awareness of existing basic and specialized climate services among tourism professionals, determine specific needs for climate forecasts and information by tourism subsectors and provide educational sessions in the use of probability-based products, decision support tools and weather risk markets and weather derivative/index insurance products.

Despite visibly increased attention to the challenge of climate change by the UNWTO over the last five years, a number of studies of climate change awareness and adaptation practice for the UNWTO, the United Nations Environment Programme (UNEP) and WMO [74] and a recent multisectoral comparison by KPMG [147] consistently found low awareness of climate change risk and little evidence of strategic planning within the tourism industry. Developing awareness of the regional, tourism-specific implications of climate change, with the aim of improving adaptation, would therefore be a second major objective of the capacity-building workshops. Climate services professionals would be provided with feedback on the diverse information needs of specific tourism stakeholders in their region, the potential development of specialized products and how to improve communications to enhance the utility of climate information.

The lessons learned from Regional Climate Outlook Forum workshops undertaken by WMO, the Awareness and Preparedness for Emergencies at the Local Level (APELL) workshops for tourism destinations coordinated by UNEP, and other recent climate and tourism specific workshops (Caribsave in the Bahamas and Jamaica, GEF and UNWTO in Fiji, NOAA and East Carolina University in the United States), would inform the themes and structure of the workshops. In addition to establishing key regional partnerships, these workshops would build a pool of professionals qualified to transfer advances in climate science and climate prediction to climate-related decision frameworks and develop decision-support tools for the tourism sector. By adopting a regional approach, the capacity-building workshops would also overcome some of the major regional knowledge gaps on the sensitivity of tourism to climate variability and change in developing nations, notably Africa, South-East Asia and Latin America [74][148].

Recommendation: A series of multi-objective, capacity-building workshops should be initiated in major tourism regions around the world, in order to foster the direct interactions and partnerships between climate service providers and tourism user groups needed to make significant progress in the application of climate information in the tourism sector.

Recommendation: Training the next generation of tourism professionals to utilize climate information to reduce climate risks and adapt to climatic change in the decades ahead is a priority, and it is urged that a Climate Risk Management training module be created for use by tourism and hospitality schools around the world.

As an important contributor to national and local economies around the world, tourism is also highly interlinked with other major sectors for which white papers are being produced, such as health (tropical disease outbreaks and dispersion by travellers, for

example), urban (heat warnings, for example) and biodiversity (involvement in coral reef monitoring programs, for example). Consequently, common interests and recommendations are probable, providing a basis for multisectoral collaboration on the improvement of global climate services that foster sustainable development.

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