Consultancy to Develop Climate Products and Services for the Caribbean Tourism Industry (Feasibility Study)

Final Report

December 13, 2019

ESSA

Prepared for the Caribbean Tourism Organization (CTO) and the Caribbean Development Bank (CDB)

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Executive Summary

The purpose of this consultancy was to explore how weather information could be used to inform decision-making that minimizes risk and maximize opportunities in the Caribbean Tourism industry. The Caribbean Tourism Organization (CTO) and its partner the Caribbean Institute for Meteorology and Hydrology (CIMH), have the long-term vision of developing specific, spatially and temporally-explicit climate information products to support public and private decision-makers in the region's tourism sector. This assignment investigates the empirical relationship between climate and tourist arrivals, with the goal of determining the feasibility of developing a climate-data driven approach to forecasting tourism arrivals.

The finalized scope of work included:

1. A comprehensive literature review on the previous applications of Tourism Climate indices (TCIs) and other composite indicators of tourism climate resources. Additionally, we reviewed publications where climate information had been used in some way to predict or account for tourism demand. Since stakeholders identified extreme events as the main meteorological driver of demand, we reviewed literature review on this subject, focusing on cyclonic activity. Section 2 outlines the findings of the **Literature Review**.

2. A stakeholder online survey and focal group exercise to identify perceptions about the main tourism demand drivers (and the perceived relative importance of climate/weather) as well as to learn about how stakeholders in the region currently use climate information products and how they might use such products if developed. This task and the main findings are described in Section 3 (**Potential for Uptake**).

3. An empirical investigation of the historic arrivals data for select Caribbean destinations and corresponding weather data to identify whether there were intra-regional and/or extra-regional weather-response signals in the arrivals data. The investigation included characterization of the destinations (arrivals data) as well as analyses of correlations between sub-national demand markets in Canada and the USA. It was assumed that if a moderately strong correlation existed between any of the weather variables and arrivals, this could be used as a basis to determine the statistical feasibility of using weather variables to forecast tourism outlooks from these source markets. This task is discussed in Section 4 (**Empirical Investigation).**

4. Section 5 (**Institutional Capacity to Co-Develop and Co-Deliver Climate Information Products for Caribbean Tourism**) discusses strengths, weaknesses, opportunities and threats with respect to the evolving climate services in support of adaptation of the Caribbean tourism sector. The institutional capacity assessment focuses on three regional entities that directly and indirectly contribute to the sector's sustainability: the Caribbean Institute for Meteorology and Hydrology, the Caribbean Tourism Organization and the Caribbean Hotel and Tourism Association.

5. The final section of this report (Section 6 **Recommendations**) provides recommendations for (a) next steps for understanding the drivers of tourism demand in the Caribbean, and the relative importance of weather (b) climate information products and (c) longer-term climate-tourism demand analyses than those focused on by this study.

The main findings of the report include:

- TCIs generally serve to characterize the suitability of a destination's climate for tourism in a given month. Above 30° N TCIs are more variable both within the year and by latitude. This suggests that the TCI may be less relevant as a discriminator in geographic areas where the TCI annual distribution rarely deviates from a near optimal range. Explaining or predicting tourism arrivals are not among the documented uses of TCIs and related indices. The empirical investigation confirmed that the use of TCIs for Caribbean destinations showed only weak correlation with arrivals from source markets.
- Indices that do not take into account weather at the source markets (the weather "push factor") are missing a major driver of demand in the Caribbean and other 'sunshine' tourism markets. This was consistent with stakeholder reports that weather influenced demand in the source country.
- Studies found that non-climate factors were relatively important influences on arrivals. Stakeholders ranked non-climate factors higher in accounting for intra-regional spatial variability (e.g. marketing, products, websites, airlift and security) of tourism arrival.
- The occurrence of extreme events has also been shown to adversely impact tourist arrivals to the region. Stakeholders reported that extreme events and the associated risk to vacationers were the main intra-regional meteorological factors that influenced the spatial and temporal variability in arrivals.
- Stakeholders indicated a belief that last-minute buyers are most likely to be influenced by 5- to 10-day weather forecasts and the role the internet plays in facilitating quick and direct decision making needs to be taken into account in designing relevant and useful information products.
- Short-term weather forecasts (both intra and extra-regional) are used strategically by the majority of target stakeholders. Use of historic weather data and longer-term predictions was reportedly low.
- It was confirmed that there was a low level of uptake of climate information products by tourism stakeholders.

Recommendations

- Focus attention on source market weather. This recommendation is based on the mild to moderate correlations found between in-country/destination weather variables and arrivals.
- Consider alternative at-destination weather parameters (drought indicators used by the CRCC/CIMH). No further effort should be spent on developing TCIs to predict demand. An alternative optimized winter severity index is proposed to be developed for source market characterization of the 'climate push' that influences seasonal demand.
- Pilot test a winter market demand outlook. The literature review found that the strongest weather signals (temperature in particular) in arrivals were related to the difference between source market climate and destination climate. This is consistent with the findings of this study that weather signals in the arrivals data were strongest in winter, when the difference in temperature was greatest.
- In terms of source market weather indicators, the strongest correlation was between arrivals and temperatures in the Canadian source market; related indicators like number of days below zero (freezing days) and number of snow days were also found to have relatively stronger correlations. This correlation pertains to specifically to the winter season, with relatively strong correlations seen with the 1-year lag for temperatures and the shorter 1-month lag for number of freezing days. For future work, it is recommended that the analysis of time lags be expanded to include the 3-month and 6-month lags. It is also recommended that further exploration of a **weather-driven tourism demand model focus on the winter season temperatures in Canada** and possibly other markets located above the 40th parallel (including the more northerly markets in the US and Europe).

- Develop and validate an optimized index of individual weather variables for the Canadian market – a “winter push index”—with improved explanatory power. Work on the Ontario winter market should be continued to determine the potential for a climate information product.
- Produce a single outlook for the Caribbean region as a whole using temperature data from Canadian source markets (AB and BC in the west and ON and QC in the east) from the previous year (i.e., 12-month lag) as well as the seasonal forecasts.
- Given the lack of available destination specific data at this time, one option may be to use one of the six countries for which data is easily available as a reference country. Other CTO members can track the demand outlooks for the reference country as a guide as to how their own demand might vary from norms. Of the destinations for which we had data, Barbados was likely the most representative in the spread of its quarterly arrivals with a distinct winter peak.
- Steps should be taken to improve data management and interoperability between destinations.
- Explore using a multi-factor analysis for source markets with weaker climate signals. It is recognized that the US is by the more important of the two North American markets (accounting for 76.5% of all North American tourists travelling to the six destination countries between 2008 and 2017). This study found that correlations between the US source markets weather parameters and arrivals from those source markets were generally weak to moderate. It is unlikely that a robust weather-driven arrivals model could be developed on this basis, and it is therefore recommended that a US-based tourism demand model should take into account non-climate factors. **Multi-variate analyses of tourism demand that includes but is not restricted to climate factors may be the most feasible approach to explaining regional tourism demand in the Caribbean**.
- Improve understanding of how extreme weather and related disruptions affect arrivals. Explore the impacts (immediate and lagged by different intervals) of direct landfall and ‘near neighbour’ (which would have been in forecast/warning zones) investigate intra-regional ‘deflections’ to other destination countries. A robust analysis should look at landfall / land impact, magnitude of these storms and tourism responses. Our hypothesis is that category 1-3 storms create disruptions to tourism and recovery can occur within weeks, with impact on arrivals limited to the month of the storm and month after and to countries in and near the actual and forecast storm track. Conversely, more intense storms are likely to affect arrivals in that season and, in some cases, multiple seasons afterward.
- Important questions remain about tourists’ perceptions about the spatial extent of hurricanes, and geographic transfers of demand during, immediately after and long term (intra- and inter-regional). Stakeholders felt that in the event of disasters impacting one or two islands, the One-Caribbean branding strategy works against the region, as buyers potentially view Caribbean as uniform even when only one island (or part of a country, as in the recent Bahamas experience) is impacted.
- Perhaps a more useful concept to consider in developing climate information products is the idea of a holiday risk, and what factors influence travellers’ behaviour in respect of reducing the risk of losing their holiday or having a bad holiday as a result of weather variables.
- To improve uptake of the TCB, it is important to identify and remove barriers to uptake and to ensure that information products suit the needs of the users. This may include tailoring the products to better suit needs of the stakeholders and increasing awareness of availability.
- Consider alternatives to the TCB: consider adapting the FEWER app or developing a platform like the Copernicus Tourism-climate service that uses shorter timeframes, user forums, and social media to convey short-term forecasts.
- Improve understanding of how climate change may impact tourism demand from source markets: e.g. changes in the length, timing and intensity of the winter season. How changes in climate (both at destination and source markets) interacts with other climate change impacts on Caribbean

tourism assets and infrastructure as well as other major drivers of tourism in the region remains an important area of future research.

1. Introduction

1.1 Project Rationale

The tourism sector is critical to the Caribbean's economy, enabling the transition of agricultural economies to those that capitalize on the region's natural beauty, rich cultural heritage, proximity and accessibility to major markets, political stability and the global perception of a highly desirable and salubrious climate. The Caribbean is on the front lines of climate change, being particularly vulnerable to extreme events, shifts in precipitation regimes, and sea-level rise. Actors in the sector are exploring how to use increasingly available climate information to inform decision-making that minimizes risk and maximize opportunities.

In September 2018, the Caribbean Tourism Organization (CTO) signed a contract with ESSA Technologies Ltd. (ESSA) for delivery of a research project aimed at supporting the design and application of climate-smart products and services for the use and benefit of the Caribbean tourism sector. The CTO, and its partner the Caribbean Institute for Meteorology and Hydrology (CIMH), have the long-term vision of developing specific, spatially and temporally-explicit climate information products to support public and private decision-makers in the region's tourism sector. This assignment is a first step in delivering on this vision. This *Consultancy to Develop Climate Products and Services for the Caribbean Tourism Industry (Feasibility Study)* investigates the empirical relationship between climate and tourist arrivals, with the goal of determining the feasibility of developing a climate-data driven approach to forecasting tourism arrivals.

The specific objectives of the research are as follows:

Objective a:	Conduct an empirical investigation of the historical relationship between intra- and extra-regional climate and Caribbean tourist arrivals.
Objective b:	Assess climate and tourism modelling capacity, including but not limited to data availability, accessibility and quality; modelling software availability; as well as key skill sets for climate tourism modelling at regional and national levels.
Objective c:	Validate an approach for intra- and extra-regional tourism-climate modelling for the Caribbean through the development and/or recommendation and application of a tourism-climate index/indices.
Objective d:	Enhance knowledge on the availability, management and use of climate information, tools and services to enhance Caribbean tourism performance.

1.1 Scope and Approach

The scope of work to achieve these objectives was defined by the following tasks:

a) *Conduct a feasibility study on the need for and the potential benefits regarding the development and use of operational tourism-climate productivity index/indices that explains the effect of intra- and extra- regional climate on Caribbean tourism arrivals, estimating the long-term value of the intra- and extra- regional tourism-climate productivity index/indices to the Caribbean*;

b) *Conduct an empirical investigation of the historical relationship between intra- and extra-regional climate and Caribbean tourist arrivals;*

c) *Validate an approach for intra- and extra-regional tourism-climate modelling for the Caribbean through the development and/or recommendation and application of a tourism-climate index (or indices) that estimates the* *influence of (1) intra-regional climatic conditions on tourist arrivals to the Caribbean; and (2) climatic conditions in the Caribbean's main tourist-generating regions on tourist arrivals.*

d) Evaluate regional institutional capacity (CTO, CIMH, CHTA) to manage and use the tourism-climate index/indices for the long-term sustainability needs of the Caribbean tourism sector;

e) Make recommendations for integrating outputs of the research into the CTO-CHTA-CIMH Caribbean Tourism-Climatic Bulletin, illustrating on an operational level, the opportunities and options to enhance the content of this communication tool.

Figure 1 below illustrates the flow of tasks undertaken and underlying assumptions for successful progress in each step.

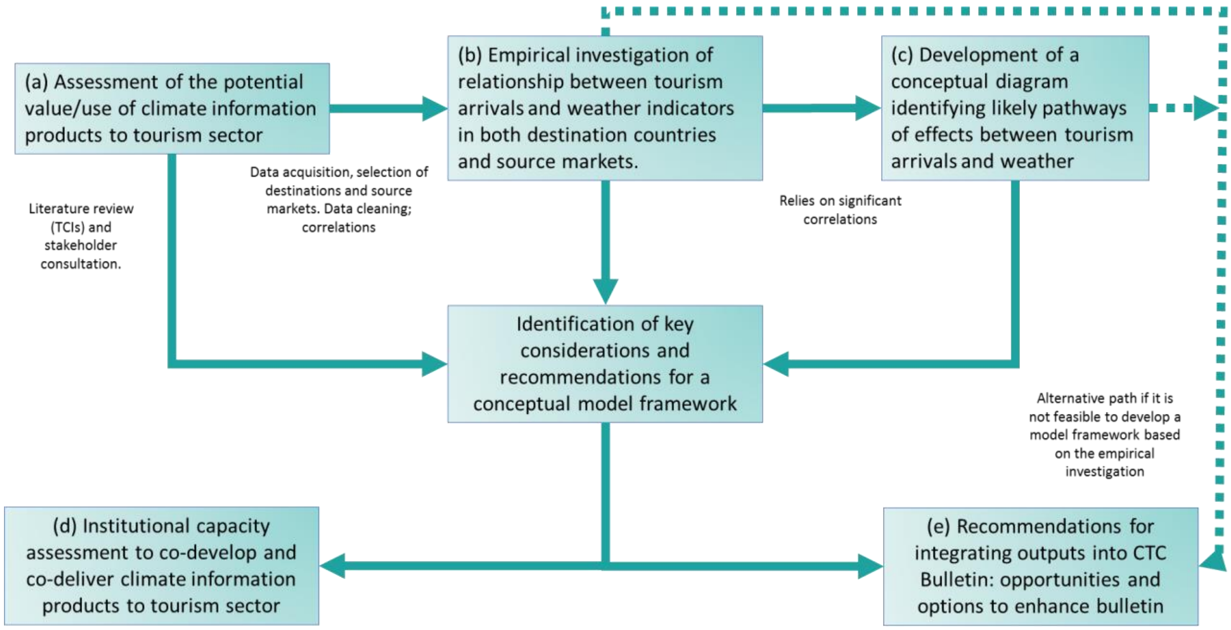

Figure 1 Task flow Diagram

The levels of effort assigned to each task were adjusted during the course of the consultancy, with significant upward adjustments in the time invested in the empirical investigation. The main reason for this shift was the effort involved in obtaining and processing the data sets (both Caribbean and source market climate data) in preparation for statistical analyses, which was not foreseeable at the onset of the research. Consequently, the tasks that were completed included:

6. A comprehensive literature review on the previous applications of Tourism Climate indices (TCIs) and other composite indicators of tourism climate resources. Additionally, we reviewed publications where climate information had been used in some way to predict or account for tourism demand. Since stakeholders identified extreme events as the main meteorological driver of demand, we also reviewed literature review on this subject, focusing on cyclonic activity. Section 2 outlines the findings of the **Literature Review**.

7. Following presentations from team members on the project and climate information services in general, we conducted a stakeholder online survey and focal group exercise at the CTO's October 2019 "State of Tourism Conference" in the Bahamas. These stakeholders represented high-level tourism planning agencies and associations (national and regional), many of whom (particularly from the private sector associations) also worked in the sector at an operational level. The objectives of the stakeholder exercises were to identify perceptions about the main tourism demand drivers (and the perceived relative importance of climate/weather) as well as to learn about how stakeholders in the region

currently use climate information products and how they might use such products if developed. This task and the main findings are described in Section 3 (**Potential for Uptake**).

8. An empirical investigation of the historic arrivals data for select Caribbean destinations and corresponding weather data to identify whether there were intra-regional and/or extra-regional weather-response signals in the arrivals data. The investigation included characterization of the destinations (arrivals data) as well as analyses of correlations between sub-national demand markets in Canada and the USA. It was assumed that if a moderately strong correlation existed between any of the weather variables and arrivals, this could be used as a basis to determine the statistical feasibility of using weather variables to forecast tourism outlooks from these source markets. This task is discussed in Section 4 (**Empirical Investigation**), which outlines the methodology, the relationships between (a) destination arrivals and corresponding destination weather variables (including composite indicators), and (b) sub-national markets and the corresponding source market weather variables. Statistical/technical feasibility was a pre-requisite for the development of any possible weather/climate driven tourism outlook model. The actual development of the model was outside of the scope of work of the assignment.

9. Consequently, the assessment of institutional capacity was less targeted and more broadly-based. Section 5 (**Institutional Capacity to Co-Develop and Co-Deliver Climate Information Products for Caribbean Tourism**) discusses strengths, weaknesses, opportunities and threats with respect to the evolving climate services in support of adaptation of the Caribbean tourism sector. The institutional capacity assessment focuses on three regional entities that directly and indirectly contribute to the sector's sustainability: the Caribbean Institute for Meteorology and Hydrology, the Caribbean Tourism Organization and the Caribbean Hotel and Tourism Association.

10. The final section of this report (Section 6 **Recommendations**) provides recommendations for (a) next steps for understanding the drivers of tourism demand in the Caribbean, and the relative importance of weather (b) climate information products and (c) longer-term climate-tourism demand analyses than those focused on by this study.

2. Literature Review

2.1 Overview

An extensive literature review was a first step in determining the applicability of Tourism Climate Indices (TCIs) as an integral part of a tourism arrivals outlook model driven by climate/weather data. TCIs reflect the influence of annual climate distributions at a given location, showing periods of peak climatic conditions, as desired by tourists. The TCI concept, therefore, seeks to explain the influence of climate on visitor satisfaction/experience at the destination. They were not designed for modelling tourism demand (arrivals or other performance indicators) and do not generate quantitative predictions about tourism arrivals to specific destinations. Some studies show a positive correlation between TCIs and tourism arrivals (e.g., Kubokawa *et al.* 2014; Li *et al.* 2017). However, data-driven models or software applications that generate quantitative tourism demand outlooks based on TCIs do not currently exist.

The TCI concept was developed by Mieczkowski (1985) as a composite index to evaluate the suitability of a climate for tourism activities. The Mieczkowski equation is given as TCI = 2 x (4CID + CIA + 2P +2S + W), where CID is the daytime comfort index (combination of the maximum daily temperature and minimum daily relative humidity); CIA is the daily comfort index (combination of mean daily temperature and mean daily relative humidity); P is precipitation (mm) and S is sunshine (hours) and W is wind (m/s). The weights (multipliers) included in the equation were subjectively determined and not based on either tourists' stated climate preferences or tourism data. This equation was established for general sightseeing and not for specific tourism segments (e.g., beach/coastal tourism) and performs best in comparing sites where there is significant variability in the parameters used (temperature, humidity, rainfall, sunshine hours and windspeeds). Applications of the Mieczkowski TCI include quantification of tourism resources at specific locations and comparative analysis of tourism resources at different locations or at different points in time (Scott et al. 2003; Amelung and Viner, 2007; Tang, 2013; Fang and Yin, 2015; Robinson 2016). Scott *et al* (2003) were the first to apply the TCI concept beyond its 'design purpose', using it characterize the possible change in tourism climate resources that could arise from climate change.

2.2 Limitations of the TCI Concept

Mieczkowski's seminal paper showed the January global TCI map and the distribution of favourable and unfavourable tourism resources. The global TCI map showed four classes of TCIs: excellent, very good/good, acceptable and unfavourable. Areas within 10 and 30 degrees north of the equator were classified as excellent to very good/good and areas with latitudes above this showed a decline from acceptable to unfavourable with increasing latitude. However, subsequent studies have revealed several theoretical weaknesses that constrain the general use of TCIs as an indicator of suitability of a given climate given tourists' preferences (Scott *et al.* 2016; Tang 2013). These weaknesses have the potential to create biases in the research, and include the following:

- An emphasis on thermal comfort and exclusion of risks of extreme conditions, climatic non-stationarity and variability.
- TCIs focus on the climate resource at the destination. Using TCIs in a tourism-demand model implies that pull factors may be more important in tourism decisions, thus skewing the research.

- The perception of optimal tourism resource may vary with market shifts and changes in consumer preferences.

According to Scott *et al.* (2016) the central weakness of Mieczkowski's TCI is that the rating and weighting scheme is based on Mieczkowski's opinion and was not empirically tested with tourists or tourism data. One specific concern is the overemphasis on thermal comfort, when, in fact, some evidence suggest low precipitation may be of greater importance to many tourists than temperature. This might be especially valid for the Caribbean's Sun, Sea and Sand (3S) tourism, where spatial and annual variability of air temperature is less pronounced than at higher latitudes.

Moreover, TCIs, as currently used, do not consider factors that affect destination choice such as (real and perceived) risks associated with the region's record of extreme conditions (e.g., tropical storms, heavy rain, or wind) and their year-to-year and spatial variability. The use of TCIs also does not allow for consideration of localized adaptations that may change the climate resource and thus alter visitor comfort levels (e.g., higher air temperatures can be off-set by air-conditioning, building design, landscaping designed to create shade, increased availability of misters and water-based recreational opportunities). Other theoretical issues with the TCI concept include its lack of responsiveness to seasonal atmospheric teleconnections.

A fundamental limitation of the TCI as a predictive tool for arrivals in this feasibility study is that it is usually applied to assess the pull factors or weather conditions at the destination, rather than climate-push factors at the source markets. Very little research uses TCIs at source markets to understand how climate-push factors might drive arrivals to a destination that is climatically different. Theoretically, a low TCI at source area (reflecting an assumed push) can be used in an analysis of arrivals from that source to a particular destination. Li *et al* 2017 used a relative TCI, which measures the climatic comfort of a destination relative to that of the traveler's origin. The effects of the relative climate index on seasonal tourism demand was tested using quarterly panel data of arrivals from Hong Kong to 13 Chinese cities. They found that the effect of relative climate on seasonal variability in tourism arrivals was more important where there was a significant difference in climate between the source market and the destination. The study found that decisions to travel by tourists were "*mainly determined by the relative intra-annual seasonality*", suggesting that seasonal variability was also important. They noted that deviations from long-term norms did not particularly impact arrival numbers. This would suggest that seasonal forecasts are less likely to affect arrivals than established perceptions of the climate at the destination in comparison to the climate at the source market.

Tourists' weather preferences are complex. For example, tourists from temperate countries with relatively cool summers may well prefer cooler temperatures in general. The Rutty & Scott (2014) survey of 3S tourists in the Caribbean showed variability in climate preferences depending whether tourists were from temperate or tropical countries. Tourists from temperate countries found ideal temperatures to be in the range of 27˚C to 30˚C, with conditions being unacceptably hot over 30˚C. Thermal preferences may change, as summer temperatures increase in temperate countries (arising from urban heat island effects and climate change) and temperate tourists acclimatize to higher temperatures. Other research (Scott *et al.* 2008; Rutty and Scott, 2016) also demonstrates that climate preferences vary with activity: "too hot" may be different on the beach compared to city sightseeing/shopping for example.

2.3 Other Climatic Indices

Aside from the Mieczkowski's TCI numerous climate indices of relevance to tourism exist. According to Amiranshivili *et al*. (2015) over 2,000 climate indices are documented in applied climatology and human biometeorology studies. Many of these bio-climatic indicators were not specifically developed for tourism applications. They tend to focus heavily on thermal comfort and less so on physical and aesthetic dimensions of climate resources for tourism. For tourism climatology, Amiranshivili *et al*. (2015) note that the Physiological Equivalent Temperature (PET, e.g., Lin and Matzarakis, 2008) is "*one of the most popular physiological thermal indices".* The PET captures a combination of daily air temperature, relative humidity, wind velocity, mean cloud cover and other variables. Other indices mentioned in Amiranshivili *et al*. (2015) include Air Equivalent-Effective Temperature (EET- air temperature, relative humidity and wind velocity) and Air Radiation Equivalent-Effective Temperature (REET- combination of air temperature, relative humidity, wind velocity and solar radiation intensity). Many of the limitations that apply to the Mieczkowski's TCI also apply to PET, EET and REET. Because these indices are not specifically designed for tourism, they also do not reflect the specific needs and preferences of travellers and people on specific types of holidays (i.e., that beach tourists may seek very warm conditions that are classified as uncomfortably or dangerously hot by such thermal indices). Data limitations in the Caribbean are an additional barrier to their potential application (e.g., the need for high resolution and comprehensive time series of cloud cover and solar radiation/insolation data).

Since the development of the original TCI concept, new indices that are better aligned with 3S tourism have emerged. These include the Beach Climate Index (BCI) (Morgan *et al.*, 2000) and the Climate Index for Tourism (CIT), which rates the climate resource for activities that are weather/climate sensitive (de Freitas *et al* 2008). Castro and Soler (2012) adapted the TCI to produce a Mean Historical Climate (MHC) Index for Cuba (*loc cit,* Mendez-Lazaro et al 2014*)*. Yu *et al.* (2009) developed the Modified CIT (MCIT), which used multivariate climate parameters (humidity, temperature, wind, significant weather, visibility) and high temporal resolution (hourly data) for Alaska and Florida. That study produced a graph showing the frequency of occurrence of ideal and unsuitable conditions over time, illustrating temporal fluctuations in the climate resource.

Introduction of the Holiday Climate Index (HCI) is also noteworthy. The HCI (Scott *et al.* 2016) addresses several of the limitations of Mieczkowski's TCI, basing variable rating and weighting on tourist climatic preferences obtained from surveys. Temperature preference and perceived optimal thermal comfort level appear to be variable across individuals and groups. The European-based Copernicus Climate Change Services (C3S) has begun providing country-level HCIs to estimate the probability of weather conditions (ranging from preferred to unacceptable) to facilitate strategic tourism marketing and investment planning, as well as improved climate change assessment.[1] Aside from allowing tourism-sector planners to plan for visitor comfort levels, comparisons across countries are also possible.

2.4 The Influence of Climate on Tourism Demand

The relationship between climate and tourism demand is widely discussed (Becken 2010; Scott & Lemieux 2010, Scott *et al.* 2011). However, few studies use climate data to explain or model tourism arrivals. Agnew and Palutikof (2006, as cited in, Li *et al.* 2017) found that the UK's outbound tourism demand was sensitive to climate variability of the preceding year, whereas the domestic demand was more sensitive to climate variability within the travel year. Alvarez-Diaz et al. (2010) examined annual Northern Atlantic Oscillation (NAO) influences on tourism demand in the Balearic archipelago, and concluded that there was a statistical

[1] https://destinet.eu/News/2018/8/copernicus-climate-data-boosts-europe-s-tourism-sector

relationship between these variables on an annual timeframe. For China, Li *et al.* (2017b) found that outbound tourism demand increased with a decrease in home climate comfort, and that outbound tourism demand decreased with increased home climate comfort. An economic gravity equation developed to examine tourism demand in the Caribbean (Lorde *et al*. 2015) found that there was "*highly significant effect as a result of the distance (difference) in climatic conditions between home and destination countries". ***This finding has implications for the research of this consultancy, highlighting the importance of investigating climate differences between source countries and destinations.**

Kulendran and Dwyer (2012) modelled seasonal variation in arrivals in Australia (1975 and 2009) using disaggregated climate variables such as maximum temperature, humidity and hours of sunshine. They found that maximum temperature was the most important determinant of arrivals. Maddison (2001) examined the climate as a major factor in the choice of destination and timing of trips for British tourists, and concluded that that quarterly climate variables were able to account for differences in flows of tourists, and that "*British tourists were attracted to climates which deviate little from an average daytime maximum of 29˚C". ***These two studies suggest that warmer temperatures relative to the source location are important.**

In the Caribbean, Ridderstaat *et al.* (2014) studied seasonal push and pull climate elements (rainfall, temperature, wind and cloud cover) on demand fluctuations from the United States and Venezuela to Aruba. They concluded that climate push factors in the United States ***were most important*** (rainfall, temperature and wind). These authors notably did not use a comprehensive index approach, but rather individual climate variables. A second Caribbean-based study of the effect of climate on arrivals was done for Puerto Rico (Mendez-Lazaro et al, 2014). These authors calculated monthly TCIs (per Mieczkowski's design) for Puerto Rico and compared the monthly changes in TCIs with monthly hotel occupancy rates. Puerto Rico has relatively high occupancy rates throughout the year (with an average annual low of ~65% in September) so it was relatively difficult to determine whether climate did affect occupancy rates. Indeed, separating the effects of marketing and seasonal pricing efforts to offset less favourable climate conditions is difficult. A study (Lorde *et al*. 2015) modelling tourism demand for 18 destinations in the Caribbean using historic data (1980-2008) found that the gap between climate conditions at the source market and destination was a determinant, but the primary drivers were non-climatic (habit persistence, income, destination population, cost of transportation and tourism price). **This consultancy focuses on the importance of climate and Caribbean tourism flows. Examining the relative importance of non-climate drivers is outside the scope of this assignment.**

Studies from other regions also point to the importance of non-climate drivers in tourism decisions. Pokharel *et al* (2017) used regression analysis of both climate and non-climate drivers of tourism demand in Nepal, and found that the former were less important to tourism flows than non-climate factors; this is not surprising as climate is unlikely to be a major tourism draw in that country, except during the small window of time when mountain climbing is feasible. Zhang and Kulendran (2017) developed a tourism demand dynamic model that included climate and economic factors as well as calendar events, concluding that while climate variables "*played a dominant role in shaping season variation*" in tourism, economic factors such as price and income were also important. **The findings of these studies suggest that a multi-variate analysis that includes but is not restricted to climate factors may be the most accurate approach to explain demand for regional tourism in the Caribbean.**

Perceptions of holiday risk caused by weather forecasts at the destination may also influence tourism demand. However much of the research on holiday risk has been done in relation to climate change and the ski industry in higher latitudes (e.g. Steiger *et al.* 2019). Those authors looked at switching destinations or timing when there was a high risk to the vacation posed by weather at a particular place. 3S tourists may display similar risk avoidance behaviour to ensure their vacation is not affected by heavy rain and overcast conditions The capacity of tourism concepts such as substitution, specialization, and destination loyalty to enhance our understanding of climate-induced behavior change have not been adequately explored. Despite this, the concept of holiday risk is a potential way to link economic influences of a holiday (e.g., source market income, destination prices) to the risk represented by weather at the destination (or conversely the reliability or lack of variability of weather). Using a standardized econometric indicator (the one-week beach holiday price), a study by the International Monetary Fund found that the cost Caribbean beach holiday was higher than other beach destinations around the world (Laframboise *et al.* 2014). Consequently, the risk could be expected to be higher if the holiday was ruined by 'bad' weather.

Climate disasters in the Caribbean can cause disruptions to tourism services and damage to basic infrastructure functioning and tourism products. While disaster recovery unfolds, destinations can experience a loss of arrivals that can be on the order of several months to years (e.g., WTTC, 2018; Hsiang, 2010). Although there is general information to support the view that arrivals decline after the occurrence of higher-magnitude storms (e.g., Leframboise *et al.* 2014), quantitative analysis on the nature of the correlation between the frequency of cyclonic activity (and/or storm intensity) and declines in arrivals after the incidence of the storm activity is lacking. Important questions remain about the spatial extent of impacts from hurricanes (i.e., to landfall and nearby neighbours or region wide) and geographic transfers of demand during, immediately after and long term (intra- and inter-regional). Other research suggests that media coverage in the wake of extreme events can negatively influence tourism arrivals (e.g., Scott and Lemieux, 2010).

A fundamental challenge with an approach focused on tourism-arrival outlooks that draws purely on the statistical relationship between weather data (or composite indicators) and arrivals data is the failure to account for other factors that influence tourism decisions. These include access to information, strategies to influence perceptions (i.e., marketing and pricing), media framing (including social media and news reports) as well as non-climate factors. In particular, the Internet has revolutionized the industry in the past 20 years, not only in terms of providing information for holiday risk assessment and decision-making, but also shortening the booking lead times and facilitating direct/retail booking. This can lead to last-minute decisions based on weather forecast information (Scott and Lemieux, 2010). The use of Internet searches to assess the tourism *interest* in a particular destination is an emerging area of study, which leverages tools such as Google Trends[2] (e.g., Rossello and Waqas, 2016; Rodriguez 2017). Availability and use of information on both demand and supply sides of the tourism equation are important to consider.

2.5 Summary

TCIs generally serve to characterize the suitability of a destination's climate for tourism in a given month. Above 30° N TCIs are more variable both within the year and by latitude. This suggests that the TCI may be less relevant as a discriminator in geographic areas where the TCI annual distribution rarely deviates from a near optimal range. Mieczkowski's seminal research concluded that places lying within 10 – 30˚N of the equator generally had the best year-round climates for tourism: Caribbean latitudes occur between ~1°N (southern Guyana) and ~27°N (the Bahamas). Importantly for understanding demand, indices that use destination weather data and do not take into account weather at the source markets (the weather "push factor") are missing a major driver of demand in the Caribbean and other 'sunshine' tourism markets.

[2] https://trends.google.com

Explaining or predicting tourism arrivals are not among the documented uses of TCIs and related indices. Although a few studies examined the effects of individual climate elements (particularly temperature) on tourism arrivals, these studies also found that other non-climate factors were relatively important influences on arrivals. For example, the risk associated with a holiday (time and investment) is increased by weather variability and forecasts of poor conditions or cyclones. The occurrence of extreme events has also been shown to adversely impact tourist arrivals to the region. Furthermore, pricing and marketing strategies are specifically designed to reduce climate-related seasonality and thus mask the climate signal on tourist arrivals.

3. Potential for Uptake

3.1 Tourism Stakeholder Survey Approach

This consultancy seeks to support the development of climate information products for the Caribbean tourism sector. To explore the potential demand for these products we investigated whether and how a climate information product in the way of a demand (arrivals) outlook would be used by stakeholders in the sector. We also elicited stakeholders' views on whether and how climate and weather shaped tourism demand. Target stakeholders included national-level bodies involved in strategy (government agencies/ministries, tourism planning board and private sector associations) and regional planners (such as the Caribbean Hotel and Tourism Association and the Caribbean Tourism Organization).

An online survey was deployed at the CTO's workshop for regional and national tourism sector planners in the Bahamas in October 2018. The main objective of the survey was to understand whether and how weather information factors into tourism decision-making as well as current use of weather/climate information in the sector. We achieved a good response rate (25/29 or 86% of workshop participants) to the survey, and, since the workshop attracted participants from across the region we were able to gather views from sectoral representatives from Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, Saint Lucia, Saint Martin, St. Vincent and the Grenadines, and Trinidad and Tobago. Half of the respondents (13) were affiliated with tourism ministries or other government authorities with mandates for tourism planning and promotion, the rest represented tourism industry associations (11) as well as private companies (2). Less than a quarter of survey respondents had participated in CTO/CIMH activities pertaining to climate information products and services. Only 4 of 21 survey respondents had attended regional workshops organized by CIMH and 6 out of 17 reported that they or their organizations had participated in survey and interview research undertaken by CIMH in 2016. This means that responses to the ESSA online survey and outputs from focus group discussions described below shed new light on the needs and perceptions of tourism stakeholders and validate previous findings from social science research undertaken by CIMH. It is recognized that while our survey was aimed at high-level strategic planners as opposed to *operational level* stakeholders, many of the strategic planners who participated also played a role at the operational levels of the tourism sector, and may have responded from that perspective.

Additionally, delegates were engaged in a focus-group discussion during a designated session at the workshop. The group of workshop delegates was split into five groups of five. Each group was asked to discuss five questions, but report to plenary on a particular one. After each group reported, other groups were invited to contribute any additional points that had not been mentioned previously. The focus group discussions provided rich information on destination planners' perceptions of the relative importance of weather/climate in tourism decision-making and on other factors of equal or more importance.

3.2 Findings

3.2.1 Perceptions about the Relative Importance of Weather/Climate as an Influence on Tourism Demand

To gain insights from stakeholders on (climatic and non-climatic) drivers that might account for variability in arrivals within the region the focus group discussion included a question on **whether participants thought there were significant intra-regional differences in the factors that explain arrivals statistics**. Climate was one of the key drivers of arrivals that were identified by the destination planners, and in general, climate as perceived within the context of extreme events was discussed.

The other (higher ranked) non-climate drivers that could account for intra-regional differences in arrivals included:

- Marketing budgets to draw tourists to the destination.
- Types of offerings/products e.g., hotel types, niche markets.
- User-friendly and accessible websites.
- Airlift logistics: direct flights, travel time.
- Crime levels at destination.
- Competitiveness: price, travel taxes and levies; travel requirements (e.g., visas).

Participants were asked to **rank the 3 most important drivers of tourism arrivals overall**. Climate/weather on its own was not specifically mentioned as an option. The top-named drivers were:

1. The 3 A's – Access, Airlift and Awareness (promotions/reputation).
2. The economy at source (ripple effect and whether buyers had the funds to spend). There was also mention of the perceived value for money (impact of exchange rates; value of the source country currency at the destination) and the competitiveness of the offerings.
3. The environment (including issues like solid waste), which included the quality of the experience (the 3-S market), climate enjoyment and perceptions about disaster proneness (risk of having their vacation ruined).
4. Safety and security (crime levels).

Via the online survey we also inquired about stakeholders' perspectives on key drivers of tourism arrivals in the region. Asking stakeholders in both formats was a way to ensure every participant's perspective was captured since small group discussions can be dominated by a vocal few, even with the most highly-trained facilitators guiding the process. As is apparent from the series of tables below (Table 1 to Table 4) climate is among drivers of arrivals, but it is not reported as the most important one.

Destination airlift and access to destinations is by far the most important driver of tourism arrivals, from the perspective of the stakeholders we surveyed. A number of issues tied to economics are second in importance; these issues include the source country's economy, value for money of destination and exchange rates. Awareness is third in importance and this include issues of marketing, promotions and reputation (e.g., marketing budget, marketing of destinations in source countries). This stakeholder feedback is important as it highlights the potentially limited explanatory power climate indicators will have on their own in explaining historic arrivals in the region and capacity to forecast future arrivals.

Factors influencing arrivals (overall)	Count
Destination airlift / access	19
Economics	17
Awareness (marketing & promotions)	12
Safety and security	11
Product offerings	8
Environment (weather, climate)	7

Table 1: What are the three most important factors that influence visitor arrivals / hotel occupancy rates from major tourism-generating markets outside of the Caribbean (e.g., countries in North America, Europe)? (Coded responses from 25 surveys – factors overall)

Factors influencing arrivals (mentioned 1st)	Count
Destination airlift / access	15
Safety and security	4
Awareness (marketing & promotions)	3
Economics	2
Environment (weather, climate)	1
Product offerings	

Table 2: What are the three most important factors that influence visitor arrivals / hotel occupancy rates from major tourism-generating markets outside of the Caribbean (e.g., countries in North America, Europe)? (Coded responses from 25 surveys – factors mentioned first)

Factors influencing arrivals (mentioned 2nd)	Count
Economics	10
Product offerings	5
Destination airlift / access	3
Awareness (marketing & promotions)	3
Safety and security	2
Environment (weather, climate)	1

Table 3: What are the three most important factors that influence visitor arrivals / hotel occupancy rates from major tourism-generating markets outside of the Caribbean (e.g., countries in North America, Europe)? (Coded responses from 25 surveys – factors mentioned second)

Factors influencing arrivals (mentioned 3rd)	Count
Awareness (marketing & promotions)	6
Safety and security	5
Economics	5
Environment (weather, climate)	5
Product offerings	3
Destination airlift / access	1

Table 4: What are the three most important factors that influence visitor arrivals / hotel occupancy rates from major tourism-generating markets outside of the Caribbean (e.g., countries in North America, Europe)? (Coded responses from 25 surveys – factors mentioned third)

Notwithstanding the perceived importance of non-climate drivers of tourism arrivals, stakeholders acknowledge that climate does affect tourism demand. As part of focus group discussions, participants were asked **whether they thought that climate/weather affected tourism demand**, considering their knowledge of the sector, industry experience and observations. Key points that the stakeholders raised included:

- Variability in arrivals from year to year was attributed to climate/weather variability in the source markets.
- The risk of extreme event-based hazards, such as hurricanes, at destinations is a factor that is likely to be considered by tourists, particularly if disasters have occurred recently and have made the news. If there are several years of disasters, there is likely to be increased awareness. The CTO markets the "*One Caribbean*" brand. Participants felt that in the event of disasters impacting one or two islands, this branding strategy works against the region, as buyers potentially view Caribbean as uniform even when only one island is impacted. CTO indicated they do try to offset this by providing detailed situation updates through the Caribbean travel website[3] identifying which countries are affected and providing credible information about the percentage recovery rate. In addition, CTO offices in the US and UK and the CTO's public relations agency serve as clearinghouses for information. The effect of visitors avoiding a place impacted by an extreme event may also be exacerbated by the influence of tour operators, who may divert to travellers to similar areas with remaining capacity.

[3] https://www.caribbeantravel.com/the-rhythm-never-stops

- To combat the disincentive of hurricane risk some destinations are offering insurance products such as weather guarantees, for example St Lucia and Antigua offer a hurricane guarantee.[4]

- The availability of climate risk information from vacation sellers is considered important, since it enters into travellers' calculation of holiday risk. For example, travel agents may be part of the problem if they have generalized information or insufficient information to guide buyers. It was noted by stakeholders that the US is a "retail market" compared to Canada (a "wholesale market"): in that in the US travellers may be relying less on travel agents and vacation packages, and may be doing more research themselves and making their own vacations purchases. Either way, these sources often do not have enough climate risk information.

Another question that was posed during focus group discussion was **whether they were able to identify any specific relationships between climate/weather and tourism arrivals**. The rationale behind this question was to get at possible testable hypotheses given the empirical datasets. The responses are summarized below.

- The Caribbean has all-year pull (favorable tropical climate), which keeps up a base level of year-round arrivals. There is an increase in arrivals when there is a stronger push from the source countries, such as a cold-weather escape. Our analysis of the total arrivals data (2001-2017, all markets) for five Caribbean destinations (Belize, Cayman, Jamaica, Barbados, and St Lucia) supports this stakeholder perception, with the lowest season (September, October, November) having an average of 20% of the total annual arrivals, and this was only 7% less than the 'high seasons'.
- Arrivals decline when the Caribbean faces extreme weather and climate events. This perception is consistent with the observations of the IMF (Laframboise *et al*. 2014).
- Good weather in source markets causes buyers to opt for "staycations". This is however also seen as an economic choice as staycations can be less expensive than travel. Consequently, it was suggested that pricing might offset source market inertia. This response does not necessarily consider alternative non-economic or non-climate reasons for staycations, for example, buyers' preferences may be based on seeking different experiences from ones they have had in the past for example. Another factor that may influence decisions to avoid air travel relates to individuals' desire to reduce their carbon footprints.
- Stakeholders noted that advanced bookings were common, with hotels being booked up several months ahead of time. It is uncertain whether buyers take long-range (seasonal) forecasts into account more than other factors (e.g., scheduled calendar events) in these advanced bookings, which may be more than 3 months ahead of time. In comparison, buyers that are "on the fence" look for last minute deals being offered to incentivize certain destinations. These last-minute deal seekers are more likely to take near-term weather forecasts into consideration (expected to range between medium-range to extended range weather forecasting as defined by the WMO (Appendix 1).
- Some buyers are interested in climate change mitigation, and air travel is an emissions-intensive activity. It was noted that there is a niche market for tourists interested in offsetting greenhouse gas (GHG) emissions through their vacation choices. A clear marketing strategy has to be developed to

[4] https://www.caribbeantravel.com/blog/hot-news/antigua-and-barbuda-introduce-hurricane-insurance-guarantee

demonstrate how GHGs emissions associated with travel to the destination may be offset by options available at the destination.

Results from the online survey reinforced messages on the climate-tourism link from focus group discussions. Figure 2 below shows summary responses to a close-ended question on the influences of weather / climate on tourist arrivals in the region. Clearly, stakeholders perceive the region's climate as a key draw for tourists and that the threat or actual occurrence of weather extremes in the region affects arrivals and visitor experience (thereby potentially affecting future choices). Stakeholders registered a level of disagreement on the importance of shifts in climate conditions occurring in source countries as affecting the realities of Caribbean tourism.

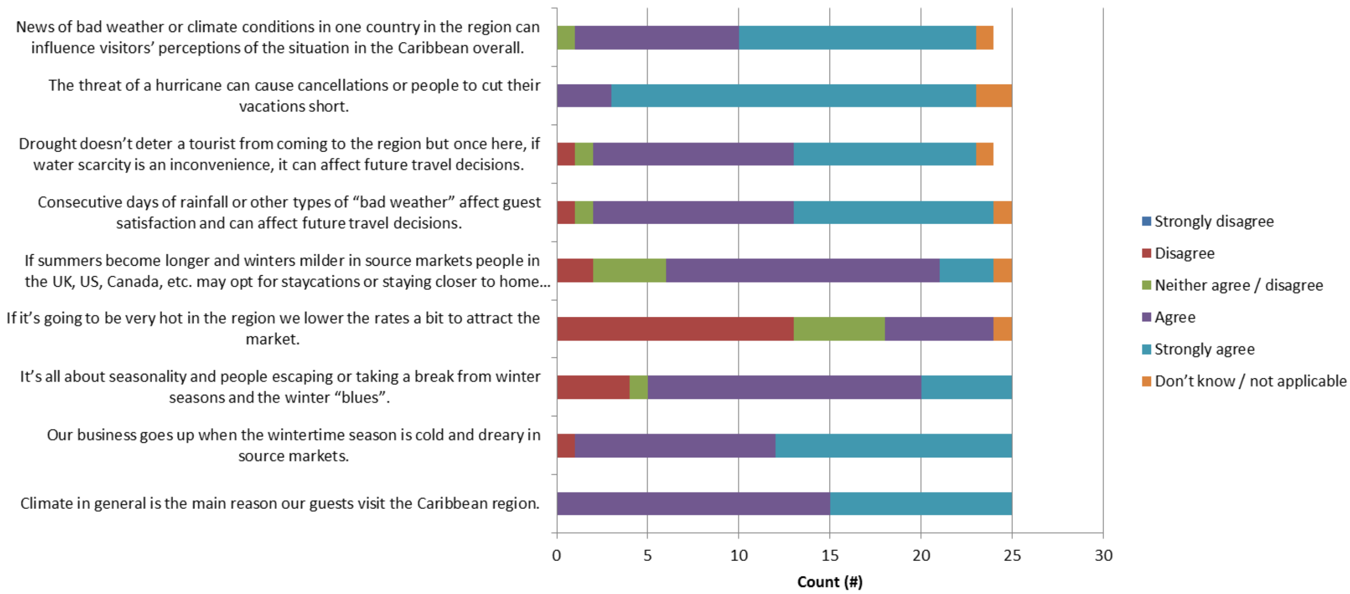

Figure 2: How do weather and climate influence visitor arrivals / hotel occupancy rates from major tourism-generating markets outside of the Caribbean (e.g., countries in North America, Europe)? (Rate your level of agreement with the statements below.) (25 responses)

3.2.2 Current Use of Climate Information Products & Services

Preliminary indications are that the level of uptake of the Tourism Climatic Bulletin (TCB) by stakeholders is very low. We reviewed results of the 2018 survey of Caribbean Tourism industry stakeholders (Edwards, 2018) in which 192 stakeholders were asked about their use of a range of information tools and products. We assume this survey included both destination planners and private-sector operators. The information products and services profiled by the Edwards' survey included the TCB and eight other online offerings; they ranged in format from one-way dissemination of information (e.g., a newsletter, manual/guidelines, a short online course) to more interactive tools (e.g., CCORAL, THIS, CARCEP, SIDS x SDG toolkit). The Edwards' survey results suggest that uptake of all formats is very low, with a significant number (42% to 60%) of respondents not using any available tools. The TCB was reportedly one of the most used tools, although use was generally not high, with only ~12.5 % reporting high or very high utilization of the tool, and 69% reporting low or no usage.

Low usage of the TCB does not mean that tourism stakeholders ignore weather/climate information. The interview research undertaken by CIMH in 2016 suggests some use of weather forecasts from source markets and the region by tourism stakeholders. We reviewed the transcripts of 16 interviews with public sector tourism stakeholders and hoteliers. Based on responses to the questions concerning use of weather / climate information when making operational and / or strategic decisions we surmise the following:

- Representatives of the tourism sector consult weather forecasts, some on a daily basis, others with less frequency, in an effort to anticipate extreme weather conditions either in the region or in source markets. National weather services are key sources of information, as are online sources like The Weather Channel and the BBC.
- Representatives of the tourism sector consult weather and seasonal forecasts for at least four reasons: (1) to inform marketing strategy (seasonal campaign) and tactics (timing of marketing blasts); (2) to prepare for expected surges in demand due to cold weather in source markets; (3) to provide information to tourists so they stay safe during extreme events; (4) to satisfy guests' inquiries on daily weather conditions (e.g., Is it going to be sunny tomorrow?).
- Consideration of climate information influences operational decisions among some tourism stakeholders, for example:
    - The choice of marketing messaging, tone and target audience, such as creating feelings of envy or using creative approaches to downplay exceptionally hot conditions;
    - Crisis communications to limit losses linked to perceived adverse conditions at a destination (e.g., sharing images of clear beaches and educating people about *Sargassum* seaweed);
    - Rate adjustments (pricing) in anticipation of increased/decreased demand if, for example, a blizzard is predicted in the eastern seaboard; and
    - Deployment of emergency response measures in the case of a hurricane or tropical storm (e.g., crisis communications, inter-agency coordination and actions to support visitor safety).

We explored current use of weather / climate information as well as barriers to their use through questions in the online survey. According to our survey results, 5 out of 24 (~1 in 5 or 20%) do not consult weather or climate information to guide strategic or operational decisions (see Figure 3). This means that the majority (19/24) do use weather/climate information as inputs into decision-making. More often than not (13 out of 24) tourism stakeholders look to weather / climate information from both the region and source markets. Fewer stakeholders claim to just consult information for just one geographic area (regional versus source).

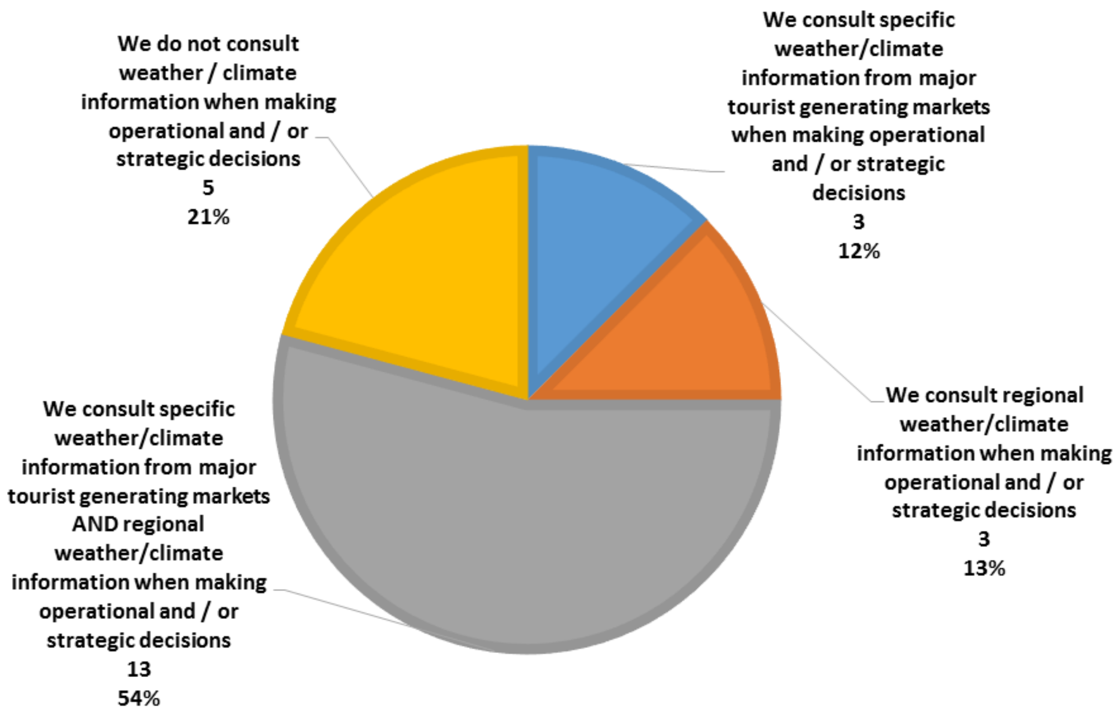

Figure 3: Do you consult and/or use any weather/climate information when making operational and/or strategic decisions? (24 responses)

As for types of weather/climate information used, stakeholders predominantly consult weather forecasts (up to 2 weeks out) (17 out of 20 respondents) and long-range (seasonal) forecasts (11 out of 20 respondents) (see Table 5). Stakeholders' reported use of historical climate data, inter-annual climate predictions and long-term climate scenarios is low. This suggests that these tourism stakeholders' use of climate information for design or climate risk assessment or other types of quantitiave analysis to inform longer-term planning is likely low.

Type of weather / climate information	Count
Weather forecasts (forecasts from hours up to 2 weeks into the future)	17
Seasonal climate forecasts (forecasts for next month up to a year into the future)	11
Past weather data (such as historical weather observations)	5
Past climate data (such as historical climate averages)	5
Targeted outlooks (e.g., Caribbean drought outlook, wet days outlook)	5
Inter-annual climate predictions (predictions for next year up to 10 years into the future)	1
Climate change projections (30 years and beyond)	1

Table 5: What types of weather/climate information do you consult and/or use most frequently? (Select all that apply) (20 responses)

We asked stakeholders about the purpose of using weather / climate information at present. Figure 4 below summarizes the responses received by using a word cloud. Responses suggest that a main reason to consult weather/climate information currently is as an input into marketing decisions. This is an example from one respondent: *"[…] if it is forecasted to be very cold in the winter in Canada, we would have specific campaigns running showing that there is sunshine in the destination.*[5]*"* Emergency preparedness and response and water planning are other reported uses of weather / climate information, although these uses are less frequently mentioned than marketing.

Figure 4: Word cloud summarizing responses to the question: How do you use weather / climate information? For what purpose (e.g., marketing campaigns, water / food / energy management, health and safety planning)? (20 responses)

Factors shaping stakeholders' ability / wilingness to integrate weather / climate information into tourism decisions relate to both supply and demand-side issues (Figure 5). Challenges that stand out as having a lot of influence or that somewhat influence are the following:

- the information available does not suit the needs of decision-makers,
- low capacity to use the information,
- limitations in awareness of what information is available in the first place.

These challenges are not surprising. The Climate Knowledge Brokers Manifesto higlights "*hidden information*" and "*untailored information*" as two core issues to grapple with to ensure decision-makers do not struggle to find and integrate what they need to make more robust decisions (CKB, 2015). Survey responses also suggest the need to pay attention to variability in users' levels of capacity for uptake: *"[t]he larger hotels have departments that consult this information but most of the smaller hotels don't have the resources to do so.*[6]*"* Insights from ESSA's online survey on challenges to weather / climate information use and uptake align with findings in Edwards (2018) as well. This latter work emphasized, among other factors, the importance of building awarenss of climate information offerings at the national level and ensuring language is not a barrier.

[5] ESSA online survey, Ministry of Tourism and Investment, Antigua and Barbuda

[6] ESSA online survey, Jamaica Hotel and Tourist Association, Jamaica

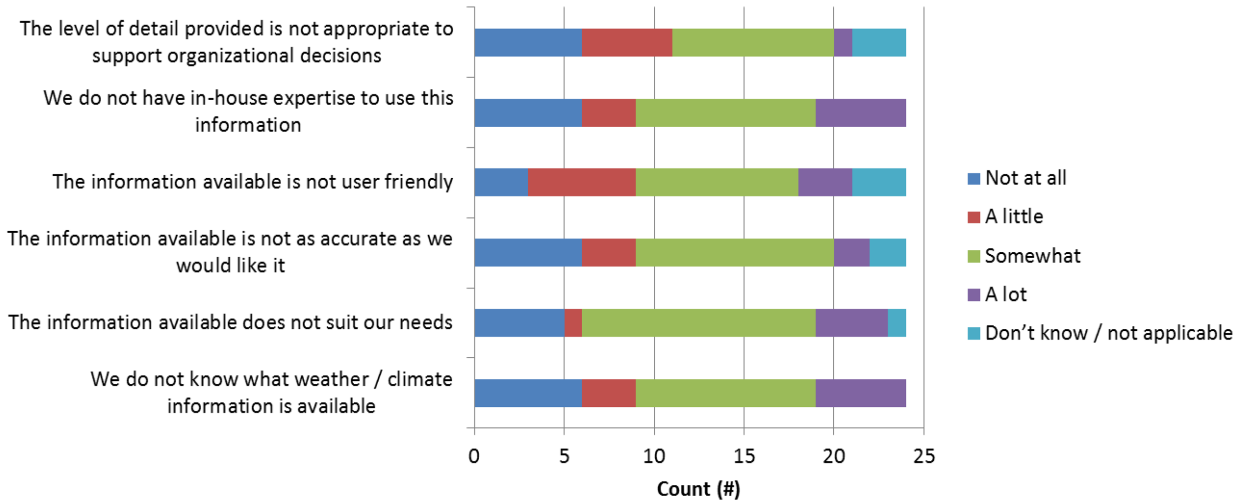

Figure 5: Please rate the following challenges and their potential influence on your ability / willingness to integrate weather / climate information when making operational and / or strategic decisions. (24 responses)

3.2.3 Potential Uses of Existing and New Products and Services

Responses to the ESSA online survey and focus group discussions also shed light on potential uses of climate information products, including the type of outlook linking climate and arrivals being contemplated by CTO/CIMH. Figure 6 summarizes stakeholders' views on the potential usefulness of a range of climate information products. The survey was administered to the group after they had received information about the research project and an overview of TCIs. Therefore, the group had a common foundation of knowledge on climate products being contemplated.

Survey results indicated a slightly more positive regard for a climate information product that forecasts tourism arrivals in the region compared to other products. An information product that forecasts arrivals in the region as a function of weather conditions in the source market, and an information product that gives a quarterly forecast of weather-related deviations in arrivals relative to a norm are a close second. Noteworthy is the apparent preference of information products that forecast out quarterly as opposed to monthly. One stakeholder noted that language and format were important to get right regardless of the type of climate product: "[the] *information should be presented in layman's language though and not technical climate terms….* [extent of use] *would depend on how user friendly it is and also how accessible - will there be an app?"*[7].

[7] ESSA online survey, Ministry of Tourism and International Transport, Barbados

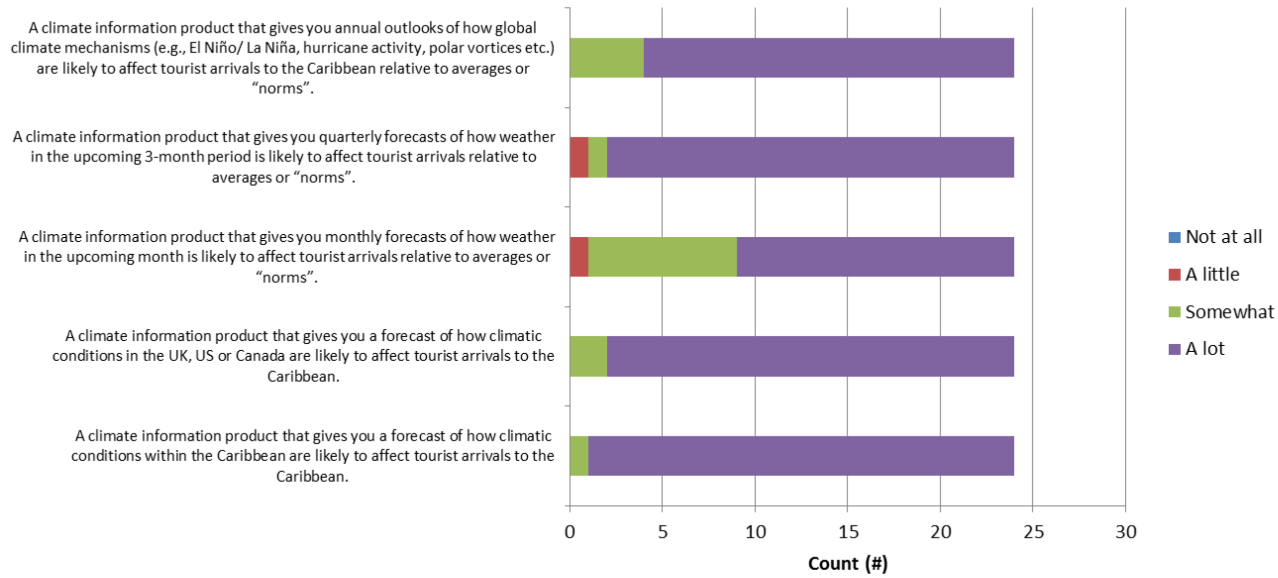

Figure 6: How useful would the following climate information products be for making operational and / or strategic decisions? (Rate each product) (24 responses)

Tourism operators provided examples of how they would use the hypothetical climate information products profiled in the online survey (Table 6). These examples related to marketing, airlift, capacity & pricing and safety & preparedness. Within these responses was an acknowledgement by one stakeholder that it was insufficient to simply know when the hurricane season would be in full force, for example. The perspective of this stakeholder was that the industry needed to improve understanding and use of travel trends that surround climate.

Marketing	Airlift	Capacity & pricing	Safety & preparedness
• To guide destination marketing efforts, target market to go after • To set/rollout marketing in activities in target markets, to increase activities in those slower markets • To increase efforts in domestic markets when regular markets fall off • To create specific marketing ads, schedule staff, promotions and form ideas for activities that match the climate • To determine marketing changes by source markets, human resource optimization, closures for maintenance, promoting domestic tourism	• To negotiate airlift • To mitigate and reroute trips or plan for trips in other places.	• To set pricing strategies (for accommodation options) • To make informed decisions re refurbishments, upgrades / additions • To determine level of investment in business • For preparing infrastructure • To forecast occupancy, rates and plan for changes in capacity • Plan for increase or decrease in numbers by increasing or reducing resources	• For disaster and weather preparedness • They could use it for safety plans • It would also be useful in ensuring that we plan for visitor safety during bad weather • To ensure safety of locals and guests

Table 6: Examples of responses provided to the open-ended question on how tourism operators might use the climate information products listed previously

Focus group discussions specifically focused on the potential for a quarterly outlook of tourism arrivals linked to climate. **Delegates were asked how they would use quarterly tourism arrivals outlooks**. In reporting back to plenary, the group tasked with summarizing feedback on this question considered the potential use of both positive (higher than normal arrivals) and negative (lower than normal arrivals) seasonal outlooks:

1. The main market. In the event of a positive outlook (higher than average arrivals), stakeholders suggested that they would examine options for deeper segmentation of the market. In a negative outlook (lower than average arrivals), they would apply out-of-the-box marketing (for example, by increasing traditional markets and exploring new markets). Some destinations have important intra-regional markets that may be responsive to localized and shorter-term climate differentials. Other considerations for what was referred to as '*off-season*' and '*shoulder-seasons*' included discount incentives for airlift, rooms and tours.
2. Niche and events (destination weddings and sporting events) marketing. In the event of a positive outlook, they would ensure maximum capacity (e.g., room stock), and look for / promote new products. In the case of a negative outlook, they would enhance public relations and communication of updates. They might also engage in maintenance activities.
3. Repeat business. In the case of positive outlooks, planners would encourage adding activities. With a negative outlook (referred to as '*lean times*') for main markets, it was suggested that planners might recommend changing the mix of markets, possibly increasing outreach to domestic and niche markets. They would also recommend cost-cutting (e.g., downsizing staff).
4. Domestic business (intra-regional). With a positive outlook, planners would focus more on value-added amenities to improve the quality of visitors' experience. In the case of a negative outlook, the following strategies were recommended: price drops, staff training and facilities maintenance.

   Although climate-derivative products like holiday/hurricane guarantees were mentioned in other contexts, these were not mentioned specifically in the context of how tourism-arrivals-climate information would be used. Moreover, stakeholders did not include any climate-specific adaptations or marketing strategies that could offset low arrivals caused by predictions of unfavorable climatic conditions at either the destination or source.

The more tailored a climate information product is to industry needs, the harder it is for the public sector to justify providing it for free, especially if climate information solutions emerge privately. Therefore, it is conceivable that industry-specific climate information products may be developed and delivered by public institutions (or through a partnered approach) on a cost-recovery basis. In the online survey we asked stakeholders for their perspective on tourism operators' willingness to pay for climate information products that forecast arrivals in the region as a function of weather / climate. Three quarters of respondents (18 out of 24) suggested tourism operators would be willing to pay for such products (Table 7). However, several stakeholders noted that willingness-to-pay was subject to the following caveats:

Willingness to pay by tourism operators	Count
Yes	18
No	6

Table 7: Do you think tourism operators would be willing to pay for climate information products that forecast tourist arrivals to the Caribbean as a function of weather / climatic conditions? (24 responses)

- It depends on pricing and whether it is viewed as having value for money;
- Individual operators might be reluctant to buy the tools, but special pricing considerations (or complimentary access) could be given to national associations and provide aggregate or summary data sets to entice purchasing of the full-range climate information product;

- It depends on the size of the establishment and the pricing strategy should reflect this;
- It depends on the perceived accuracy and relevance (tied to value for money);

Even if the value for money is proven, operators may still believe that the information should be provided by the government at no cost and may not see obtaining and using this information as a priority.

3.3 Summary

Climate is a major tourism resource and a primary reason why visitors choose the Caribbean for vacations. However, qualitative research undertaken as part of this consultancy shed light on nuances to this assertion. Stakeholders ranked non-climate factors higher in accounting for intra-regional spatial variability (e.g. marketing, products, websites, airlift and security) of tourism arrival. Stakeholders reported that the occurrence of extreme events and the associated risk to vacationers were the main intra-regional meteorological factors that influenced the spatial and temporal variability in arrivals. Stakeholders also suggest that extreme events occurring in one country shape perceptions about the regional vacation risk from extreme events.

Weather was also thought to influence demand in the source country, in that good winter weather in source market areas resulted in lower demand for Caribbean tourism. Bad winter or shoulder season weather was thought to result in increased demand. Additionally, it was noted that the source markets appeared divided between those who bought months in advance and last-minute shoppers looking for quick getaways. Weather information could conceivably be of greater influence on the decisions of the latter group than of the former. Although stakeholders indicated a preference for quarterly information as opposed to shorter-term outputs, the belief that last-minute buyers are most likely to be influenced by 5- to 10-day weather forecasts and the role the internet plays in facilitating quick and direct decision making needs to be taken into account in designing relevant and useful information products.

In terms of the use of climate information products, the survey and focus group investigations suggested that short-term weather forecasts (both intra and extra-regional) are used strategically by the majority of target stakeholders. Use of historic weather data and longer-term predictions was reportedly low. This research also indicated that there is a need for quarterly outputs that are specifically tailored to the needs and capacity of the users. This is consistent with recent research in the Fijian tourism sector (Nalau *et al* 2017), which found that products that best support stakeholder needs are designed through an understanding of what they consider useful given their needs, and capacity to access, use and evaluate the validity of the information. It is emphasised that the stakeholder capacity to access and use information is different from the institutional capacity to produce and deliver information products.

In both this study and the Edwards' survey, it was generally found that there was a low level of uptake of climate information products. The relatively low utilization for this kind of product was attributed to the information possibly not being tailored enough, low capacity to access and use the information, and a lack of awareness about the availability of information. Caribbean actors are not unique in this regard. A study of the market for climate services in the European tourism sector found that there was "*no major market demand for climate services in the sector at the moment*" (Damm *et al* 2019) and suggested that that the main barriers to using climate services included low levels of risk awareness, risk denial and a lack of sense of urgency (in relation to climate variability and change). They also found that lack of awareness of the availability of the services and their potential benefits and applications also played a role in low uptake.

4. Empirical Investigation

4.1 Research Approach

4.1.1 Selection of Arrivals Data (Destinations)

The selection of datasets was contingent on the availability of (1) continuous and disaggregated (monthly) time series of arrivals data that (2) matched destinations/source market (sub-national for the United States and Canada) and timeframes of interest. Based on these selection criteria, two sub-groups were identified: Group 1 and Group 2 (see Figure 7).

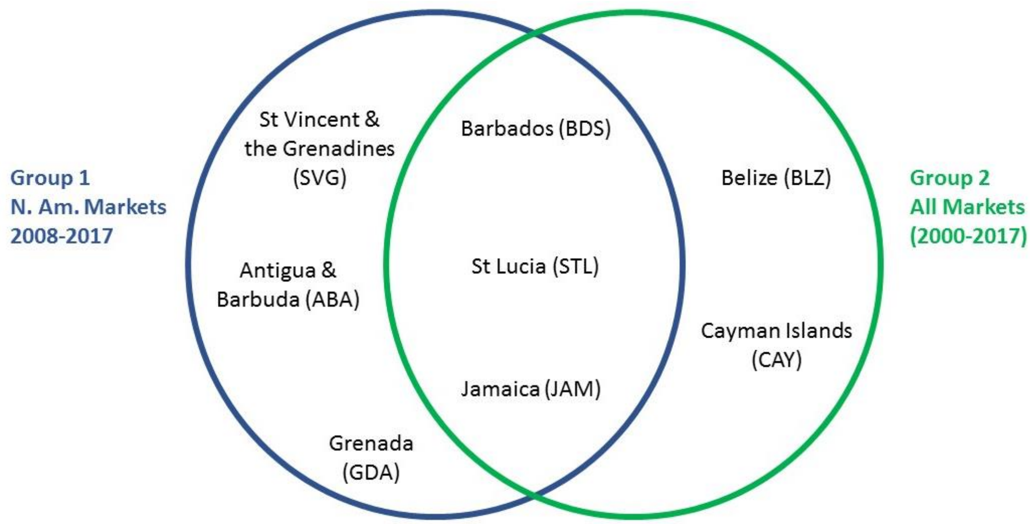

Figure 7: Schematic of two groups of countries characterized by arrivals data

Key:

Antigua & Barbuda	ABA	Grenada	GDA
Barbados	BDS	Jamaica	JAM
Belize	BLZ	St Vincent & the Grenadines	SVG
Cayman Islands	CAY		

Group 1 comprised a group of six countries for which subnational North American (N. Am. = Canada and the United States) markets arrivals data were available for a ten-year period (2008-2017) with no data gaps. Countries in this group comprised five Eastern Caribbean states (SVG, STL, GDA, BDS and ABA) and Jamaica in the western Caribbean, with JAM and ABA being the most northerly islands. Group 2 included five countries for which complete monthly arrivals datasets were available (for all source markets) for a longer period (2000 -2017): BDS, JAM, STL, BLZ and CAY. Datasets for Barbados, St. Lucia and Jamaica correspond to both Group 1 and 2. Appendix 2 contains summary statistics and trends of tourism arrivals over 2008 and 2017. SVG is the only country that has seen a contraction in tourism arrivals from US and Canadian markets over the study period.

4.1.2 United States Source Market Selection

Tourists from the United States account for 76.5 % of North American tourist arrivals in the six Group 1 Caribbean nations between 2008 and 2017. For the purposes of this climate analysis, **seven U.S. States** out of the top ten with the highest number of tourist departures were selected, based on the availability of weather data and to ensure a representative geographical cross section of continental United States (see Appendix 3). In the south, Texas (610,338 departures) and Florida (1,760,701 departures) were chosen and California (650,906 departures) was selected to represent the west coast of the United States. For central U.S., Illinois (608,717 departures) was chosen and in the northeast; New York (2,439,847 departures), New Jersey (789,685 departures), and Pennsylvania (788,332 departures). These three last states are in close geographic proximity to one another, but they are all in the top four of highest departures overall and thus were included.

4.1.3 Canada Source Market Selection

Canadians accounted for 23.5% of North American tourists travelling to the six Group 1 Caribbean nations (Appendix 3) between 2008 and 2017. For the purpose of this report, Manitoba and Saskatchewan were combined to form the Prairie Region (218,804 departures), and the eastern Maritime provinces (Prince Edward Island, Nova Scotia, New Brunswick and Newfoundland & Labrador) were combined to form the Atlantic region (246,983 departures). Ontario (3,068,096), Quebec (667,595), Alberta (358,520), and British Columbia (177,305) are all assessed as individual provinces.

4.1.4 Tourism Climate Indices Calculations

Three main tourism climate indices are calculated for Caribbean destinations. These three indices were calculated on a daily level in the study period (2008-2017) and then correlated with monthly arrivals to destinations. As noted in Section 2.1, the first Tourism Climate Index (TCI) was developed in the mid-1980s by Mieczkowski (1985), who created the TCI as a means of integrating climatic conditions at a destination into a single numeric value. Mieczkowski (1985) used mean monthly values to calculate the TCI, which ranges from scores of -30 to 100.

The calculation for the **TCI** is provided as: ***TCI = 4CID + CIA + 2P +2S + W***, where:

> **CID** (daytime comfort index) is the maximum daily temperature and accounts for 40% of the index;
> **CIA** (daily comfort index - combination of mean daily temperature and mean daily relative humidity) is used for evening comfort and accounts for 10%;
> **P** is precipitation (mm) and accounts for 20%;
> **S** is sunshine (hours) and accounts for 20%;
> **W** is wind (m/s), accounting for 10%.

For the purposes of this study, and because beach tourism is a daytime activity and the availability of air conditioning (critical for comfortable sleeping conditions) has become virtually universal since the early 1980s when the original TCI was developed, evening temperatures are not included as a separate component and the calculation used is *TCI = 5CID + 2P +2S +W.* Additionally, because sunshine hours were not provided by CIMH, the daily percent cloud cover variable was converted to sunshine hours.

Similar to the Mieczkowski TCI, the **HCI: urban** is based on five weather variables that are used to calculate three sub-indices based on the work of de Freitas (2003): thermal comfort, aesthetic, and physical dimensions of climate for tourism (Scott *et al.* 2016). The calculation for the HCI: urban specification is derived from Scott *et al.* (2016) and is represented as: *HCI: urban = 4 (TC) + 2(A) + (3(P) + W),* where:

> **TC** is the thermal comfort sub-index (daily maximum) and accounts for 40% of the index;

A represents the aesthetic sub-index and is based on the daily per cent of cloud cover and accounts for 20% of the index;

The physical sub-index is a combination of **P** (precipitation) and **W** (wind speed), which represent 30 % and 10% respectively.

Similar to the HCI: urban, the **HCI: beach** is based on five weather variables that are used to calculate three sub-indices based on the work of de Freitas (2003): thermal comfort, aesthetic, and physical dimensions of climate for tourism. The calculation for the HCI: beach specification is modified from the HCI:urban (Scott *et al.* 2016) for this study to represent 3S tourism and is represented as: *HCI: beach = 2 (TC) + 4(A) + (3(P) + W),* where:

TC is the thermal comfort sub-index (daily maximum temperature) and accounts for 20% of the index;

A represents the aesthetic sub-index and is based on the daily per cent of cloud cover and accounting for 40%;

the physical sub-index is a combination of **P (precipitation)** and **W (wind speed),** which represent 30% and 10% respectively.

Overall, the TCI, HCI: urban and HCI: beach utilize an additive approach whereby each of the sub-indices is weighted to represent the proportional impact of each climatic variable (Table 8). Mieczkowski (1985) used expert judgment to derive weights and the HCI: beach and HCI: urban uses responses from tourists' stated preferences.

Table 8 Beach weather components and calculation

Index component	Weather variable	TCI weight (%)	HCI: beach weight (%)	HCI: urban weight (%)
Thermal comfort (TC)	Temperature (C)	50%*	20%	40%
Aesthetic (A)	Cloud cover (%)	20%	40%	20%
Precipitation (P)	Total precipitation (mm)	20%	30%	30%
Wind (W)	Mean wind speeds (km/hr)	10%	10%	10%
Overall index score range		-30 to 100	-33 to 100	-13 to 100

* In Mieczkowski's (1985) original index, the Daytime comfort index was weighted as 40% of the index and evening comfort was weighted as 10% of the index. Beach tourism is predominately a daytime activity and evening temperatures are not included as a separate component in this study.

Thermal comfort facet: The TCI, HCI: urban, and the HCI: beach use three different rating schemes for the thermal comfort facet (Appendix 4). The thermal comfort rating scheme for the TCI assigns days to 23 different temperature ranges and assigns a score from minus six for 'very undesirable' temperatures to plus ten for 'ideal' temperatures. The HCI: beach is similarly designed with 20 different temperature ranges and associated scores ranging from minus ten for 'very undesirable' temperatures to plus ten for 'ideal' temperatures. The HCI: urban has 17 temperature ranges and is also scored on a plus ten to 0 scheme. It should be noted that while the TCI, HCI: urban, and HCI: beach were designed to use a combination of daily temperatures and relative humidity for the thermal comfort components, this study only uses maximum ambient air temperature due to data limitations.

Aesthetic facet: The TCI, HCI: urban, and the HCI: beach use three different rating schemes for the aesthetic facet (Appendix 4). The original TCI uses the number of sunshine hours in a day for the aesthetic factor. In contrast, the HCI: urban and the HCI: beach indices use the percentage of cloud cover for calculating the aesthetic facet. In their work on the HCI: urban, Scott *et al.* (2016) selected cloud cover data due to the absence of sunshine data from many meteorological stations and this decision was extended to the development of the HCI: beach. The rating scheme developed for the HCI: beach aesthetic facet assigns the highest score to days with 15 percent to 25 percent cloud cover instead of on days with completely clear skies (zero percent cloud cover) as this was revealed to be the ideal preference for tourists from studies on revealed climate preferences of tourists (*e.g.,* Rutty & Scott 2010, 2014, 2015).

Physical facet-precipitation: The TCI, the HCI: urban, and the HCI: beach use three different rating schemes for the precipitation component of the index (Appendix 4). The TCI has ten evenly-sized ranges with one point being removed for each additional 0.50 mm of precipitation. Any day that received more than 4.99 mm of precipitation is assigned a score of zero. The HCI: urban has seven categories, and only after 12 mm of precipitation is a zero assigned. An additional difference is the inclusion of a -1-penalty function in the HCI: beach that is assigned on days with more than 25 mm of precipitation. The HCI: beach is very similar to the HCI: urban with the exception of the ratings for moderate precipitation amounts.

Physical facet-wind: The original TCI has four different rating schemes for wind (Appendix 4). Each of these four schemes, 'normal', 'trade wind', 'hot climate', and 'wind chill' has a unique rating system and the selection of which rating scheme to use is based on daily maximum temperatures. In Mieczkowski's (1985) TCI the wind chill rating system is only used when the wind speed is faster than 8 km/hr and the daily maximum temperature is below 15.0°C. Given that the purpose of this study is to assess beach tourism, the fourth wind speed rating system (wind chill) is excluded. The HCI: urban and HCI: beach both acknowledge that temperature and aesthetics are already accounted for in other sub-indices and thus omit the inclusion of another temperature constraint in the wind component (Scott *et al.* 2016). As such, the HCI: beach and HCI: urban include one rating scheme with eight wind speed categories, but slightly different rating schemes.

4.1.5 Weather Data

Weather data were extracted from the National Oceanic and Atmospheric Administration's (NOAA) land-based station portal for the seven US source market areas (Appendix 5). Average daily weather parameters were calculated per month to account for the differential number of days in a month. Similarly, mean daily departures for a month are used instead of total monthly departures because February has three fewer days than December and January and thus departures would be expected to be lower. As such, mean daily values per month are calculated to ensure consistency between months.

Weather data for six Canadian source market regions were also obtained from the Meteorological Service of Canada. All Meteorological Service of Canada climate stations with central proximity to each of the Canadian provinces and regions were examined to determine the completeness of the climate elements of interest (*i.e.,* daily temperature, precipitation, wind, relative humidity, sunshine hours and cloud cover). The Meteorological Service of Canada stations are given in Appendix 5. Weather variables were downloaded at the hourly level (temperatures, wind speed, and cloud cover) from which the daily-level values were computed. The precipitation data were downloaded at the daily level (rainfall and snowfall).

Destination weather data (daily) for the eight countries were provided by the CIMH.

4.1.6 Statistical Analyses

We used the R-squared (R^2) coefficient to test the relative strength of relationships between variables. R^2 is defined as the proportion of the variation seen in the response variable that is explained by a linear model (i.e. the mathematical model expressed by the regression line).[8] R^2 values are expressed herein as values between 0.00 and 1.0. An R^2 value of 0.0 indicates that none of the variability in the data around its mean is explained by the linear model, whereas a value closer to 1.0 indicates that the variability in the data can be fully explained by the model. The results of the regression analysis (R^2 values) indicate the relative strength of the relationship between two variables. For the purposes of this research, we use a simple classification scheme to describe the relative strength of the consider R^2 values between 0.0 and 0.2 to be weak, and values between 0.2 and 0.4 to be indicative of a modest relationship, whereas values between 0.4 and 0.6 may be considered moderate. Values between 0.6 and 0.8 can be considered moderately strong, and values above 0.8 can be considered strong. Another way of saying this, for example is that an R^2 value of 0.2 between arrivals to a particular destination and mean monthly temperatures at the destination is relatively weak, with only 20% of the variance in one variable (arrivals) explained by the influence of the other variable (e.g., temperature).

Key: Classification of R^2 values (correlation strength)

Range	**Correlation strength**	**Colour Code**
< 0.200	Weak	No color
0.200 to 0.399	Mild	
0.400 to 0.599	Moderate	
0.600 to 0.799	Moderately strong	
> 0.800	Strong	

The R^2 essentially tells us the percent of the explanatory variable (weather variable or index) that accounts for the response variable (flows/ #visits)[9]. So, an R^2 of 0.345 means that the weather variable under consideration can be expected to explain 34.5% of the variation in arrivals flows. It also suggests that other factors and randomness explain the rest. Weather variability in the destination countries had limited explanatory power e.g., for rainfall in the 6 destination countries, R^2 for arrivals from the selected US and Canadian regional ranged between 0.000 to 0.199. In other words, less than 2% of the variability in arrivals to these destinations can be explained by weather.

4.2 Characterization of Destinations based on Arrivals Data

4.2.1 Relative Importance of Tourism in the National Economies

Table 9 highlights some basic characteristics of the selected destination countries tourism markets. Key observations from the data presented in the table are as follows:

[8] https://blog.minitab.com/blog/adventures-in-statistics-2/regression-analysis-how-do-i-interpret-r-squared-and-assess-the-goodness-of-fit

[9] For more information: https://statisticsbyjim.com/regression/interpret-r-squared-regression/

- As measured by contributions of tourism to gross domestic product (GDP), tourism is less important to **SVG** than to other countries (<6% of the national GDP). Another indicator of the relative importance of tourism to a country's economy is the total number of international tourism arrivals expressed as percentage of the total population. At 69% SVG had the lowest value for this indicator.
- Tourism accounts for 7% of **GDA's** national GDP, but appears to be relatively more important when the arrivals/population percentage is considered, standing at 156% in 2017. GDA has also shown the most rapid increase in annual North American arrivals for the period 2008-2017, increasing by 147%.
- **JAM** has by far the largest tourism industry of the group, with total international tourism arrivals in 2017 being 84% of its 2017 population. The North American stopover market is a critical market for JAM, accounting for 75.5% of the total tourism market. JAM experienced a 40% increase in North American stopovers between 2008 and 2017; tourism in general directly generates just over 10% of the national GDP.
- Although **ABA** has the smallest population, tourism contributions to the national economy are among the highest in the group, generating 13% of the GDP and having annual international tourism arrivals more than 2.5 times size of its population in 2017. The growth in North American arrivals was 24% for the period 2008-2017.
- For **BDS**, tourism also generates 13% the national GDP, with total international tourism arrivals in 2017 also being more than twice the size of its population (2.3 times). The rate of growth in North American arrivals for the period 2008-2017 was significant, at 44%.
- In general **stopover**[10] guests from the Canada represented ~22% of the total number of North American stopovers to these six countries in 2017, and therefore represents the smaller source market of the two North American markets. The Canadian source market is smallest for GDA and ABA and largest for Barbados.
- Of the six Group 1 countries, the tourism sector is the most important to **STL** in terms of GDP contribution (at 15%). Total international tourism arrivals were also double the island's total population in 2017. STL has also shown relatively significant growth (52%) in North American stopovers over the period.
- No sub-national N. Am data were available for BLZ and CAY (Group 2 countries). Although tourism accounted for less than 10% the national GDP, international visitors account from more than 6 times the total **CAY** population. This is due to the very small population of CAY and the relatively high earnings from banking services compared to tourism.
- Tourism is relatively more important to the **BLZ** economy, earning 15% of the national GDP, with total international arrivals in 2017 exceeding its population size.

[10] Stopover visitors are defined as visitors staying more than 24-hours.

Table 9: General information about the selected destination countries

Column 1	Column 2	Column 3	Column 4	Column 5		Column 6		Column 7	
Countries	[a] Total Pop (2017)	[c] Latitude (°N)	[d] % GDP in 2017	Total International Tourism Arrivals in 2017 (World Bank)[11]		Winter 2016/17 to Fall 2017 (CTO Data)		% Change Arrivals	
				Total	% of 2017 Population	US Arrivals	Canada Arrivals	N. Am. Markets 2008-2017	All Markets 2001-2017
SVG	109,894	13.2	5.90%	76,000	69%	14,298	4,784	-7	
GDA	107,850	12.1	7.00%	168,000	156%	53,517	11,533	147%	
JAM	2,813,284	18.2	10.30%	2,353,000	84%	1,394,560	382,072	40%	32%
ABA	93,659	17.1	13.00%	247,000	264%	95,130	20,447	24%	
BDS	285,744	13.2	13.00%	664,000	232%	187,078	84,489	44%	15%
STL	187,768	13.9	15.00%	386,000	206%	166,680	41,880	52%	31%
CAY	[b]61,560	19.3	8.10%	418,400	680%	No data	No data	No data	34%
BLZ	374,651	17.5	15.00%	427,076	114%	276,566	26,084	No data	70%

[a]Source: https://www.populationpyramid.net/

[b]Source: https://en.wikipedia.org/wiki/Cayman_Islands

[c]Source: Google Earth

[d]Source: This indicates the Direct Contribution of Travel & Tourism as estimated by the World Travel & Tourism Council. Travel and Tourism Economic Impact – Country Reports 2018

Note: Total International Tourism Arrivals (Column 5) are assumed to include all international visitors including both those staying overnight (tourists) and cruise passengers (excursionists), per definitions included in the 2008 International Recommendations for Tourism Statistics[12]. Data obtained from CTO member countries for this study, which are included in Column 6, specifically exclude cruise-ship arrivals data.

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[11] https://data.worldbank.org/indicator/ST.INT.ARVL

[12] https://unstats.un.org/unsd/statcom/doc08/BG-TourismStats.pdf

4.2.2 Seasonality of Arrivals – North American Markets (Group 1)

Figure 8 compares average seasonal contributions of **stopover** arrivals from the North American market for each of 6 Group 1 countries.

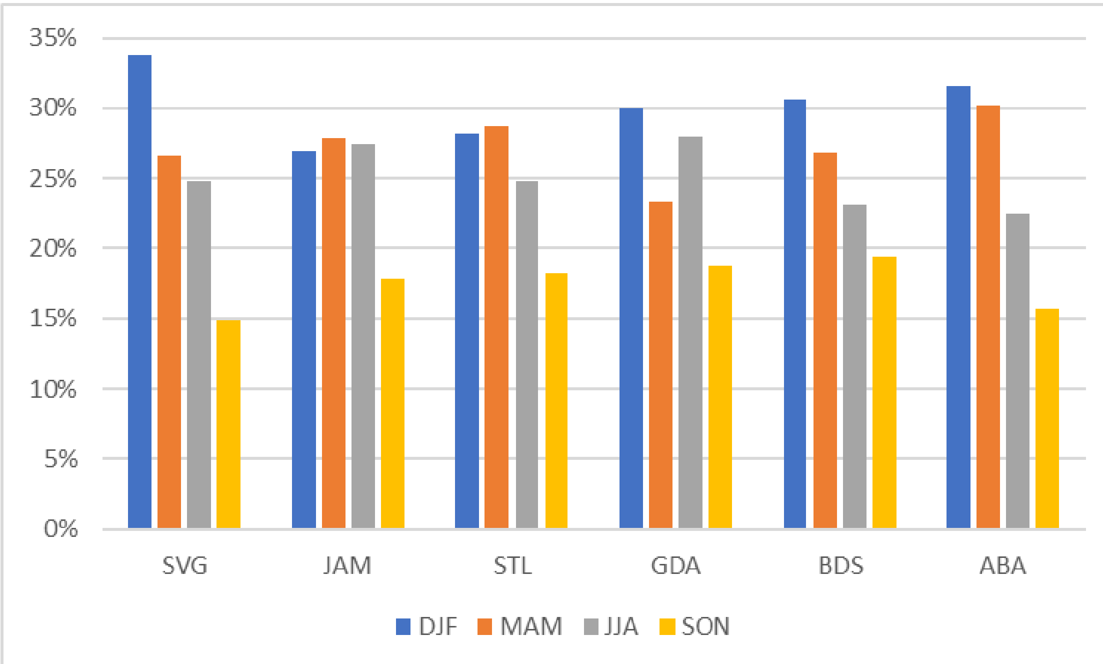

Figure 8: Comparison of % Seasonal Contributions to Arrivals in the 6 Group 1 countries

Key observations are as follows:

- The winter season (December-January-February or DJF) is the peak season for SVG, GDA, BDS and ABA, and it is a very important shoulder season for JAM and STL, where the spring season (March-April-May or MAM) is the peak.
- Summer (June-July-August or JJA) is relatively more important in GDA than spring or fall. For JAM, summer, spring and winter are roughly on par.
- All 6 countries all experience a notable Fall low season (September October November or SON) for the available data.

Appendix 2 shows trends for each country by year, disaggregated by quarters, and shows average quarterly distributions.

4.3 Destination Weather and Arrivals

4.3.1 Mean Monthly Temperatures & Precipitation

Daily temperature and precipitation data were provided by CIMH for all six of the Group 1 destinations. As is evident in Figure 9 the distribution of annual temperatures is highly consistent among the six Group 1 nations and there is less than a 2°C difference in mean monthly temperatures among the Group 1 destinations at any time throughout the year, with the maximum difference in mean monthly temperature for any of the countries over the year at about 2.5°C.

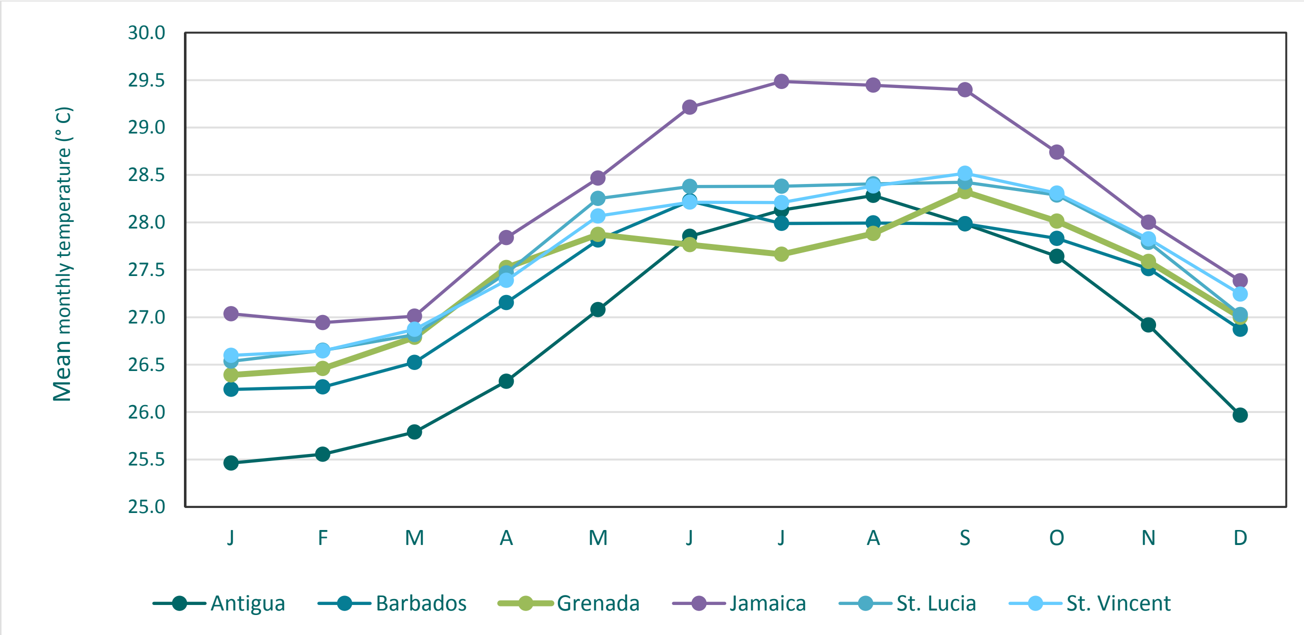

Figure 9: Mean monthly temperatures (°C) in six Caribbean countries

The annual distribution of precipitation shows larger differences in mean monthly precipitation (Figure 10), compared to temperature. Of the six Group 1 countries, SVG experiences the most annual precipitation, and Jamaica and Antigua & Barbuda experience the least.

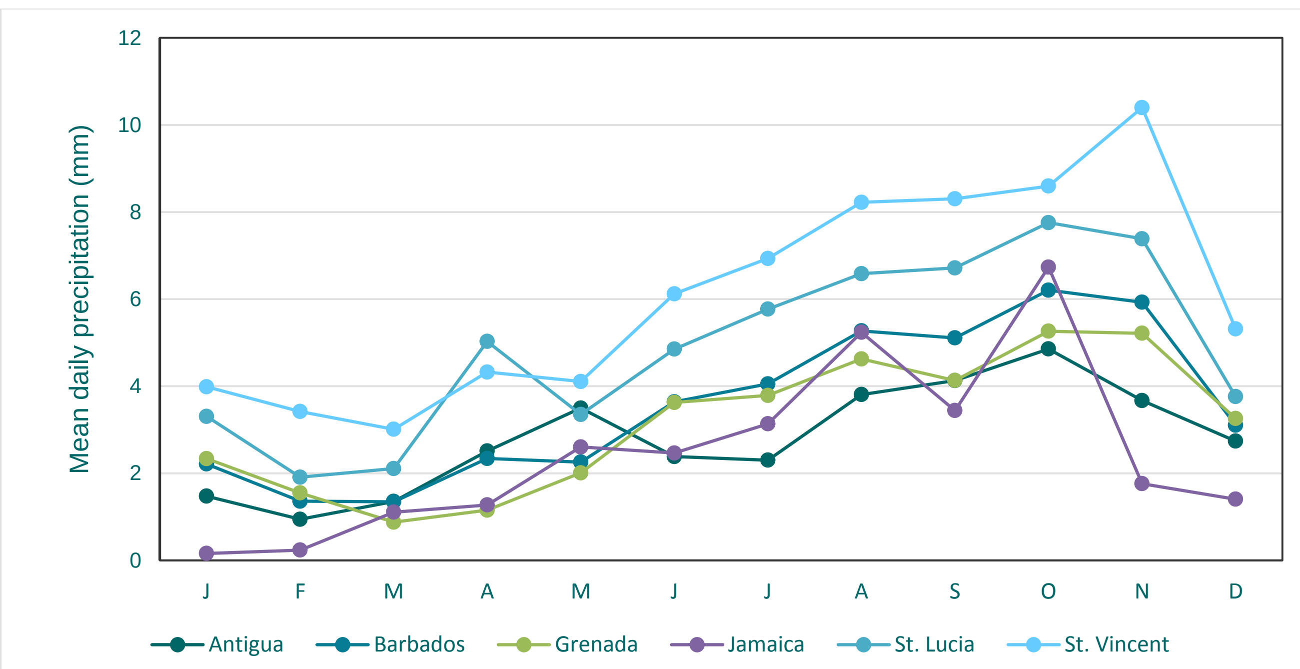

Figure 10: Mean daily precipitation (mm) in six Caribbean countries

Regression analysis revealed a mild to moderate inverse relationship between the destination monthly mean temperatures (°C) at the destinations and total monthly arrivals from many Canadian regions (Table 10).

Table 10 Relationship (R^2) between destination monthly mean temperatures (°C) and arrivals at 6 Caribbean nations from 2008-2017 (N=120 months for each destination*)

	BDS	ABA	STL	JAM	SVG	GDA
British Columbia	0.394	0.458	0.452	0.668	0.298	0.227
Quebec	0.491	0.353	0.367	0.574	0.122	0.078
The Prairies	0.505	0.402	0.403	0.622	0.215	0.242
Ontario	0.423	0.563	0.593	0.514	0.467	0.310
Alberta	0.360	0.423	0.456	0.663	0.204	0.255
Atlantic Provinces	0.247	0.464	0.208	0.258	0.345	0.103
Canada Total	**0.574**	**0.551**	**0.583**	**0.631**	**0.524**	**0.330**
California	0.007	0.026	0.136	0.233	0.076	0.004
Texas	0.015	0.099	0.189	0.250	0.006	0.038
Illinois	0.203	0.432	0.070	0.217	0.227	0.068
Pennsylvania	0.003	0.268	0.015	0.000	0.210	0.010
New York	0.001	0.235	0.017	0.008	0.102	0.002
New Jersey	0.020	0.240	0.011	0.047	0.210	0.016
Florida	0.043	0.049	0.008	0.122	0.046	0.008
USA Total	**0.021**	**0.304**	**0.001**	**0.002**	**0.319**	**0.002**
Grand Total (USA and CAN)	**0.300**	**0.462**	**0.166**	**0.115**	**0.408**	**0.042**

* The data for SVG and Barbados end in December 2016 and N=108 months

This inverse relationship indicates that as temperatures in the destinations decrease, arrivals increase. For Canadian arrivals as a whole, the relationship between destination temperatures and arrivals is strongest for Jamaica and weakest for Grenada. The modest-moderate correlations suggest that destination temperatures played a statistically significant role in influencing arrivals from those source markets, but other factors were relatively more important. This pattern also reflects the availability of summer temperatures in these source markets, and is not likely related to the slightly warmer temperatures in the Caribbean destinations.

Interestingly, this relationship is not at all evident in arrivals from US source markets with the exception of US arrivals to ABA (R^2 = 0.462) and SVG (R^2 = 0.408). The highest individual correlation is with ABA temperatures and arrivals to ABA from Illinois (R^2 = 0.432).

Table 11 shows the correlations values for precipitation at the destinations and North American arrivals to the 6 destination countries. The maximum average R^2 values found was less than 0.2, indicating that there is no discernable relationship between arrivals and rainfall at the monthly level.

Table 11 Relationship (R^2) between daily mean precipitation (mm) and arrivals at six Caribbean nations from 2008-2017 (N=120 months for each destination*)

	BDS	ABA	STL	JAM	SVG	GDA
British Columbia	0.051	0.107	0.078	0.113	0.007	0.003
Quebec	0.105	0.113	0.141	0.133	0.031	0.003
The Prairies	0.087	0.123	0.126	0.119	0.006	0.065
Ontario	0.093	0.170	0.161	0.148	0.183	0.056
Alberta	0.050	0.125	0.112	0.154	0.048	0.027
The Atlantic Provinces	0.112	0.124	0.108	0.047	0.017	0.062
Canada Total	**0.114**	**0.166**	**0.166**	**0.155**	**0.166**	**0.054**
California	0.000	0.039	0.003	0.004	0.076	0.000

	BDS	ABA	STL	JAM	SVG	GDA
Texas	0.002	0.004	0.005	0.002	0.000	0.023
Illinois	0.092	0.199	0.064	0.112	0.172	0.000
Pennsylvania	0.028	0.190	0.052	0.020	0.114	0.001
New York	0.000	0.158	0.029	0.011	0.069	0.000
New Jersey	0.023	0.147	0.000	0.004	0.081	0.000
Florida	0.005	0.062	0.000	0.001	0.051	0.011
United States Total	**0.022**	**0.196**	**0.031**	**0.023**	**0.169**	**0.000**
Grand Total (USA and CAN)	**0.085**	**0.222**	**0.112**	**0.095**	**0.182**	**0.004**

* The data for SVG and Barbados end in December 2016 and N=108 months

4.3.2 Other Weather Variables

In addition to the daily temperature and precipitation data provided by the CIMH for the six destinations, daily **wind speed** (km/hr) and **cloud cover** (%) data were provided for BDS, STL, and ABA. These additional variables allowed for the calculation of the multi-dimensional tourism climate indices for these three destinations. The general lack of data needed to calculate TCIs for all destination countries for which arrivals data were available, indicates that it this would be an important constraint to the widespread development and use of TCIs in the Caribbean.

In terms of the annual variability for wind speed and cloud cover, there is very little variability both within a year and among the three nations. Mean monthly cloud cover is consistently around 40% to 60% at all three destinations with BDS experiencing marginally more cloudy days than ABA (Figure 11). Similarly, there is very little annual variability in wind speeds, with mean monthly wind speeds consistently around 10 km/hr (Figure 12). Wind speeds observed on ABA are consistently lower, though marginally, than the wind speeds observed in BDS and STL.

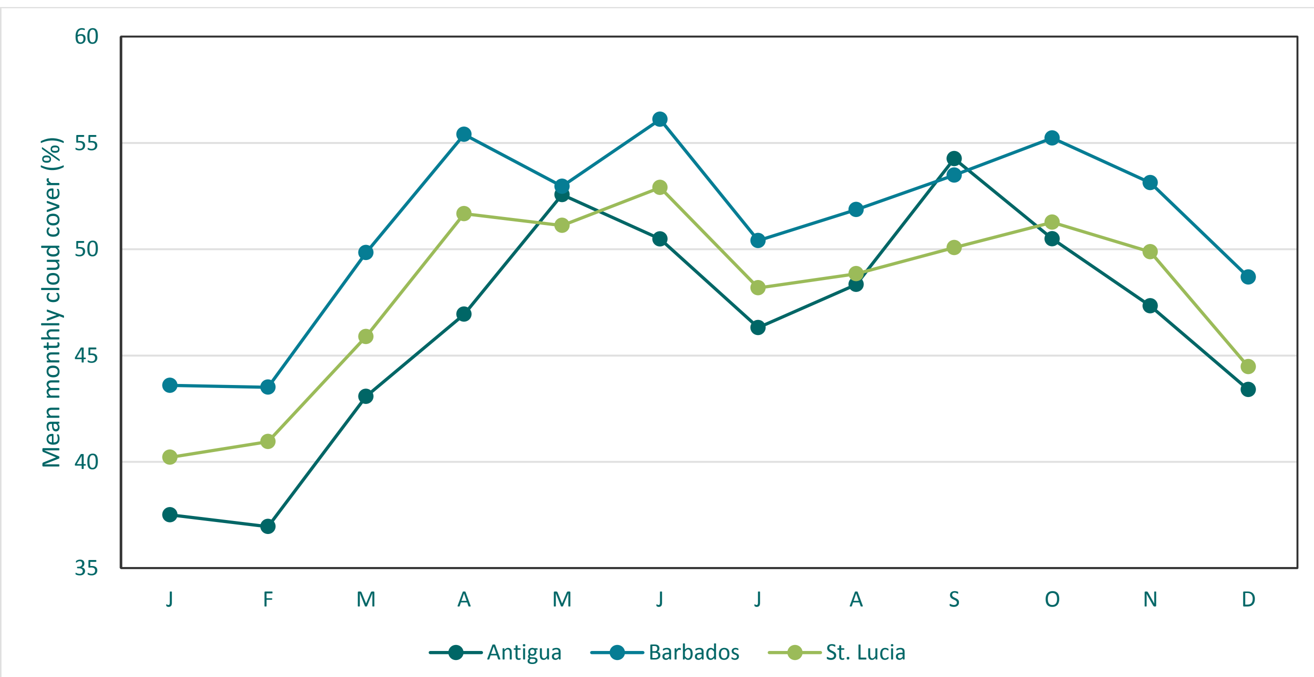

Figure 11: Mean monthly cloud cover (%) for three Caribbean destinations

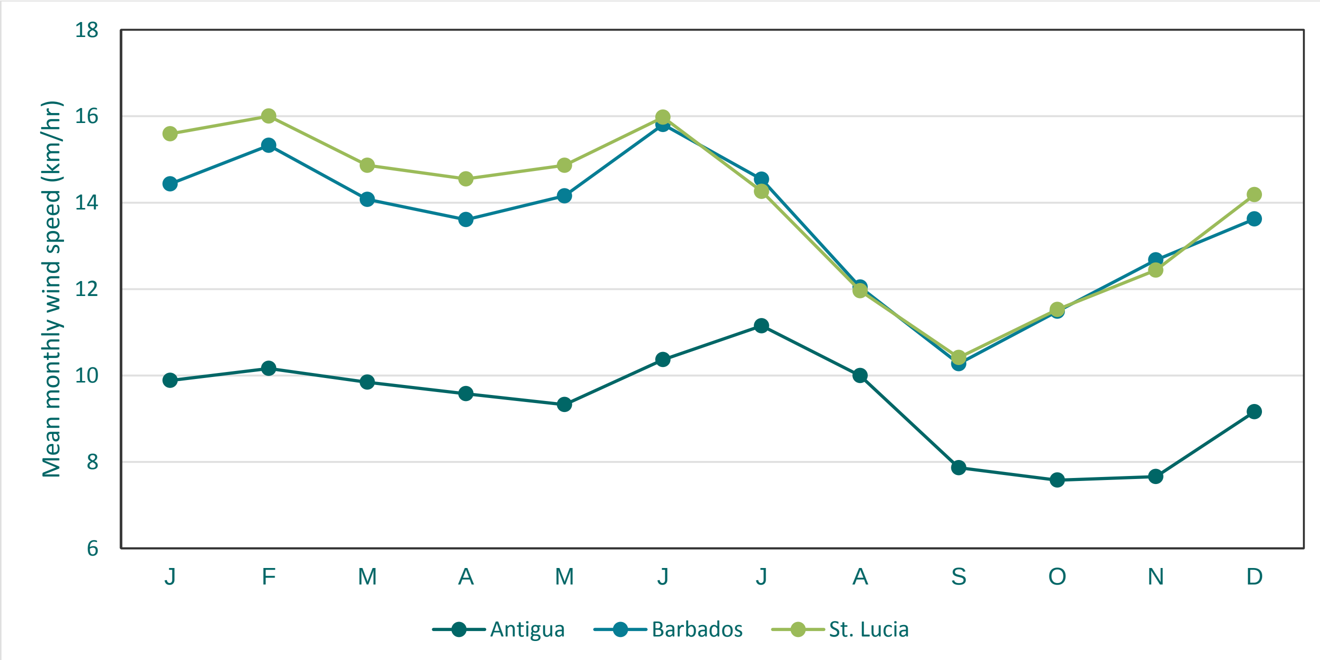

Figure 12: Mean monthly wind speeds (km/hr) for three Caribbean destinations

In terms of the relationships between cloud cover and wind speed and arrivals at these three destinations, the regression analysis reveals that there is a mild relationship between cloud cover in the noted Caribbean countries and arrivals from Canada to these destinations. The months with the highest sunshine also correlate with the coldest months in this market and the greatest difference in temperature between source markets and destinations. Only weak or no correlations were found with cloud cover at destination and arrivals from the US. Even weaker correlations are noted with destination wind speeds and arrivals to that destination from various North American source markets (Table 12).

Table 12: Relationship (R^2) between (a) monthly mean cloud cover (%) and arrivals and (b) monthly mean wind speeds (km/hr) and arrivals at six Caribbean nations from 2008-2017 (N=120 months for each destination*)

	(a) Cloud Cover & Arrivals				(b) Wind Speeds & Arrivals		
	BDS	ABA	STL		BDS	ABA	STL
British Columbia	0.154	0.165	0.220		0.005	0.043	0.106
Quebec	0.263	0.246	0.296		0.061	0.001	0.169
The Prairies	0.307	0.356	0.354		0.051	0.001	0.169
Ontario	0.252	0.325	0.325		0.037	0.004	0.195
Alberta	0.112	0.230	0.225		0.003	0.030	0.142
The Atlantic Provinces	0.076	0.161	0.082		0.038	0.009	0.144
Canada Total	**0.247**	**0.323**	**0.344**		**0.085**	**0.004**	**0.210**
California	0.005	0.000	0.136		0.028	0.000	0.037
Texas	0.091	0.066	0.095		0.002	0.015	0.076
Illinois	0.115	0.193	0.017		0.030	0.001	0.160
Pennsylvania	0.104	0.167	0.015		0.053	0.067	0.278
New York	0.018	0.184	0.062		0.063	0.062	0.181
New Jersey	0.022	0.122	0.000		0.100	0.021	0.092

	(a) Cloud Cover & Arrivals				(b) Wind Speeds & Arrivals		
	BDS	ABA	STL		BDS	ABA	STL
Florida	0.001	0.032	0.071		0.117	0.093	0.154
United States Total	**0.041**	**0.168**	**0.000**		**0.178**	**0.048**	**0.276**
Grand Total (US and CAN)	**0.177**	**0.263**	**0.099**		**0.177**	**0.016**	**0.401**

* The data for SVG and Barbados end in December 2016 and N=108 months

4.3.3 Tourism Climate Index Scores for Three Destinations and Arrivals

The TCI, HCI: urban, and HCI: beach index scores were calculated for each day in the 10-year study period for St. Lucia, Barbados, and Antigua & Barbuda to assess the empirical relationship between index scores and arrivals. For each country, the monthly index value is the mean of daily scores. As is evident in Figure 13, there is very little annual variability in scores for all three indices, with all months having TCI scores over 70, which is considered to be very good. There are consistently high index scores for all three countries for all months of the year indicating that these destinations have excellent climatic resources for tourism throughout the year (Scott *et al.* 2016). It is noteworthy that slightly lower TCI scores occur between July and October for these three countries, which is related to the higher temperatures that are not considered optimum for sightseeing tourism in the TCI, and because the TCI is highly weighted to temperature.

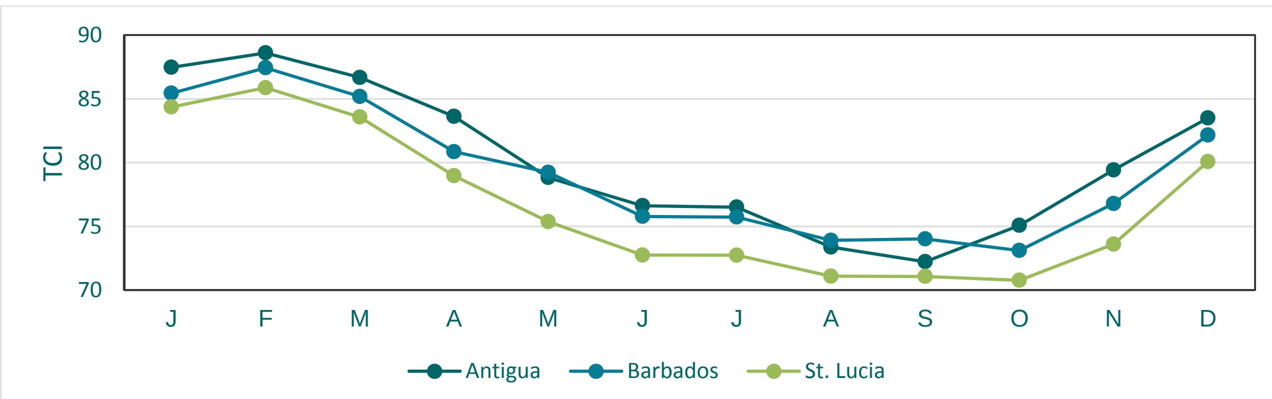

Figure 13: Mean monthly TCI scores for three Caribbean destinations

Figure 14 and Figure 15 show the HCI scores (HCI: urban and HCI: beach, respectively) for the three countries. As in the case of the TCI scores, all three countries showed limited seasonal variability, with scores staying above 75 for all months of the year. The HCI:urban shows a decline between May and November, reflecting higher temperatures in the summer months, which while less desireable for sightseening, shopping and other urban activities are more desireable for beach activities. HCI:beach shows a different seasonal pattern, with higher summer temperatures limiting the range to within approximately 75 to 85 year round.

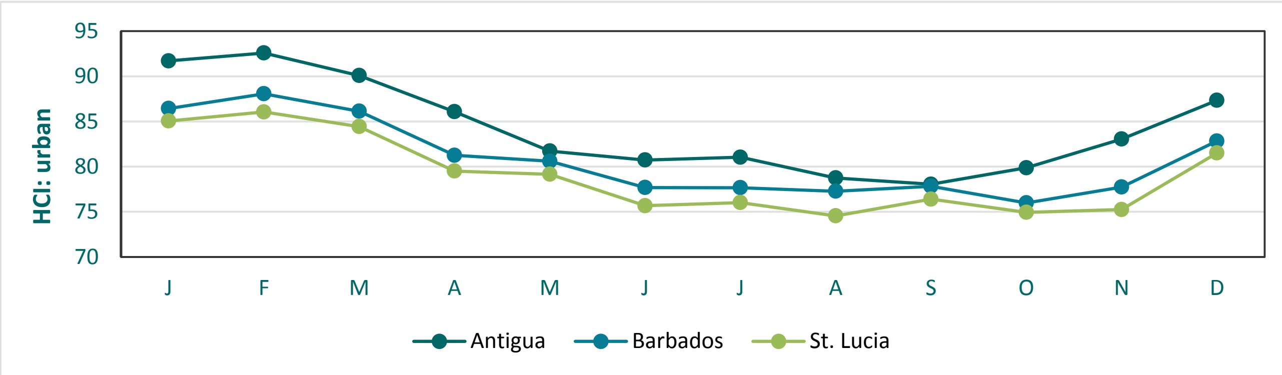

Figure 14: Mean monthly HCI: urban scores for three Caribbean destinations

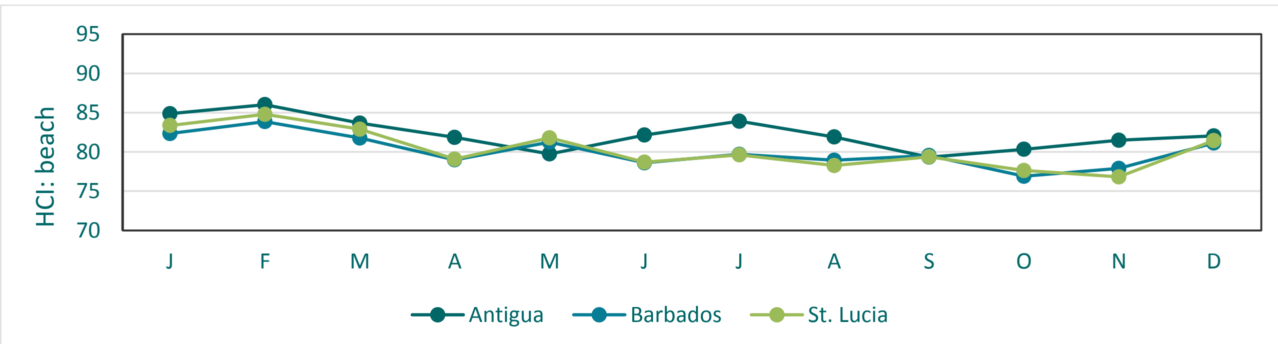

Figure 15: Mean monthly HCI: beach scores for three Caribbean destinations

While the mean monthly index values indicate that on average, the climatic conditions are excellent for tourism at these three destinations it is also important to look at the daily distribution of scores for each of the three indices in each of the three destinations. Figure 16 shows that the daily distributions of scores are also largely consistent between destinations and across the three indices.

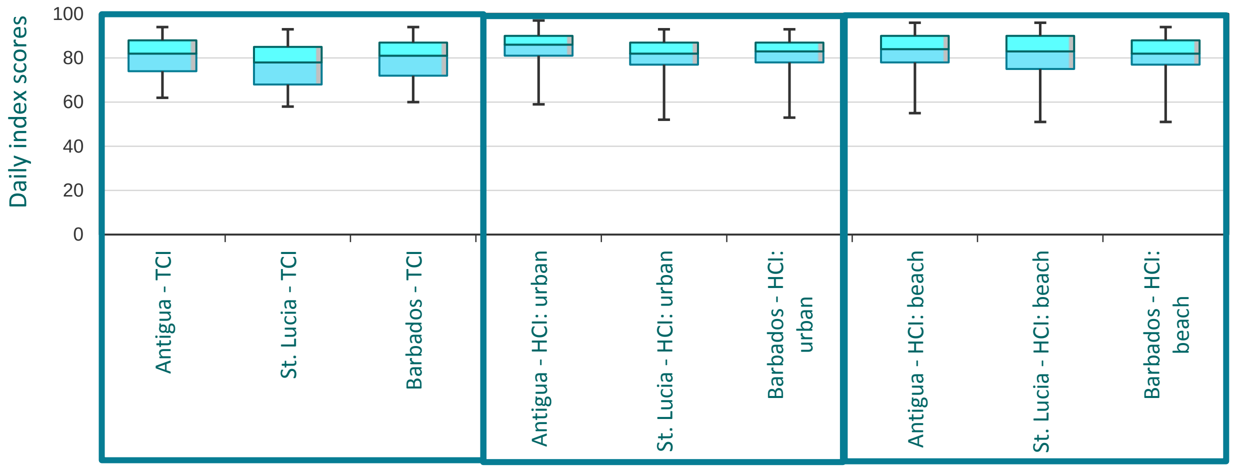

Figure 16: Boxplot showing the interquartile range (25% to 75%) for the number of days with different index scores in three Caribbean countries. The whiskers represent the 5th and 95th percentiles.

The results of the regression analysis (Table 13) indicate that there are mild to moderate fits at the monthly level for arrivals from Canadian source markets with the destination TCI and HCI: urban scores, but virtually no fit with the HCI: beach index. This is because the year-round climate suitability for beach tourism does not match the seasonality of arrivals (which is largely influenced by seasonal weather in the Canadian market). For Canadian arrivals as a whole, a moderately strong relationship is found between the TCI for STL and arrivals to St. Lucia (R^2 = 0.653). Relatively high moderate correlations are noted for the other two countries (BDS and ABA).

Table 13: Relationship (R^2) between monthly mean index scores and total monthly arrivals at three Caribbean nations from various North American source markets (2008-2017; N=120 months for each destination*)

	TCI				HCI: urban				HCI: beach		
	BDS	ABA	STL		BDS	ABA	STL		BDS	ABA	STL
British Columbia	0.313	0.377	0.433		0.285	0.398	0.298		0.055	0.055	0.081
Quebec	0.469	0.364	0.476		0.441	0.382	0.375		0.116	0.094	0.181
The Prairies	0.431	0.419	0.486		0.447	0.470	0.400		0.112	0.138	0.191
Ontario	0.410	0.536	0.634		0.401	0.580	0.521		0.117	0.116	0.184
Alberta	0.279	0.404	0.516		0.261	0.431	0.365		0.042	0.088	0.121
The Atlantic Provinces	0.288	0.449	0.303		0.250	0.448	0.216		0.059	0.058	0.087
Canada Total	**0.531**	**0.533**	**0 653**		**0.494**	**0.570**	**0.524**		**0.109**	**0.118**	**0.197**
California	0.007	0.031	0.109		0.000	0.024	0.109		0.000	0.000	0.025
Texas	0.052	0.037	0.122		0.061	0.049	0.139		0.071	0.002	0.026
Illinois	0.204	0.461	0.067		0.230	0.456	0.059		0.069	0.087	0.025
Pennsylvania	0.040	0.375	0.039		0.040	0.332	0.031		0.071	0.104	0.029
New York	0.004	0.289	0.045		0.000	0.294	0.020		0.005	0.087	0.032
New Jersey	0.048	0.296	0.001		0.026	0.266	0.012		0.013	0.064	0.000
Florida	0.010	0.073	0.013		0.024	0.042	0.038		0.001	0.014	0.035
United States Total	**0.057**	**0.382**	**0.014**		**0.033**	**0.356**	**0.003**		**0.020**	**0.088**	**0.008**
Grand Total (US and CAN)	**0.340**	**0.523**	**0.255**		**0.287**	**0.515**	**0.171**		**0.080**	**0.119**	**0.087**

* The data for Barbados end in December 2016 and N=108 months

There are also generally very weak relationships between the indices for the US source markets. The one exception is a moderate correlation between arrivals to ABA from Illinois, which is the most northerly of the US source markets. Mild correlations between TCI and HCI: urban are noted with ABA arrivals from Pennsylvania, New York and New Jersey. Overall, the original TCI performed best, and this is likely due to its high weighting and lower thresholds for 'too hot' temperatures, which drive down summer scores and match the lower seasonal pattern of arrivals.

4.4 US Source Market Weather and Arrivals

4.4.1 Temperature and Departures from the United States

As is evident in Figure 17, although the distribution of seasonal temperatures shows a similar pattern for US source markets, the absolute temperatures differ markedly among the seven states with nearly a 20°C difference in mean monthly temperatures throughout the year. The warmest temperatures are in Texas and the coldest are in Illinois.

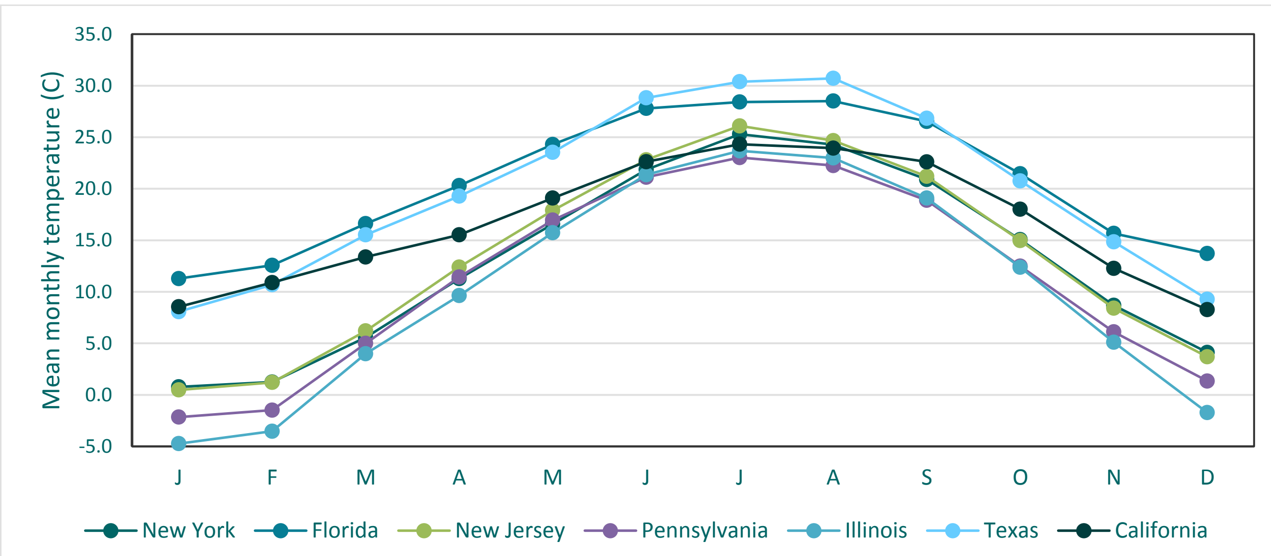

Figure 17: Mean monthly temperatures (°C) in seven American source markets (2008 – 2017)

The R^2 values indicating the strength of the relationship between mean monthly temperatures (MMTs) and departures from the selected US cities were below 0.2 (Table 14), with a few exceptions. This indicated a weak relationship between temperatures at source and departures from that source to the destination countries. The strongest correlation between MMTs and departures is noted in respect of Illinois and Texas, both of which are still relatively modest (between 0.2 and 0.4).

Table 14: Relationship (R^2) between monthly mean temperatures (°C) and departures from seven US source markets (2008-2017) with NO TIME LAG

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	0.002	0.121	0.003	0.247	0.147	0.161	0.156
Texas	0.217	0.100	0.055	0.349	0.310	0.002	0.339
Illinois	0.325	0.284	0.092	0.148	0.050	0.199	0.172
Pennsylvania	0.124	0.037	0.015	0.062	0.002	0.114	0.029

New York	0.143	0.008	0.035	0.044	0.006	0.025	0.013
New Jersey	0.122	0.010	0.029	0.136	0.027	0.112	0.055
Florida	0.006	0.022	0.021	0.240	0.092	0.003	0.204

When a 12-month time lag is applied there is no significant difference in the relationship between source temperatures and arrivals to the destination compared to no-time lag (Table 15).

Table 15: Relationship (R^2) between monthly mean temperatures (°C) and departures from seven US source markets with a 12 MONTH TIME LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures	Difference with No lag
California	0.003	0.120	0.001	0.250	0.143	0.194	0.157	**0.001**
Texas	0.240	0.076	0.043	0.349	0.319	0.000	0.339	**0.000**
Illinois	0.355	0.299	0.130	0.119	0.077	0.207	0.151	**-0.021**
Pennsylvania	0.157	0.061	0.024	0.070	0.000	0.160	0.029	**0.000**
New York	0.155	0.003	0.053	0.049	0.009	0.032	0.013	**0.000**
New Jersey	0.160	0.018	0.047	0.157	0.018	0.130	0.058	**0.003**
Florida	0.011	0.033	0.030	0.265	0.092	0.000	0.227	**0.023**

With a one-month time lag applied, the correlations with source market temperatures and departures from those areas to Antigua increase slightly, with a stronger relationship indicated (Table 16) between the states that have colder winters (Illinois, Pennsylvania, New Jersey and New York) compared to the states with milder winters (California, Texas and Florida). It is interesting also that the correlation also increases slightly between Illinois temperatures and departures from Illinois to Jamaica with the one-month time lag.

Table 16: Relationship (R^2) between monthly mean temperatures (°C) and departures from seven American source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures	Difference with No lag
California	0.052	0.114	0.003	0.129	0.024	0.173	0.061	**-0.095**
Texas	0.052	0.023	0.032	0.154	0.112	0.015	0.141	**-0.198**
Illinois	0.551	0.362	0.076	0.321	0.166	0.259	0.355	**0.183**
Pennsylvania	0.429	0.069	0.027	0.012	0.044	0.276	0.036	**0.007**
New York	0.323	0.002	0.029	0.001	0.057	0.087	0.012	**-0.001**
New Jersey	0.386	0.073	0.032	0.014	0.001	0.262	0.001	**-0.054**
Florida	0.071	0.007	0.019	0.080	0.004	0.030	0.062	**-0.142**

This would tend to support the hypothesis that nearer term bookings are likely more influenced by weather forecasts than climate normals.

4.4.1 Number of Freezing Days and Departures from the United States

We explored whether the temperature signal with departures was actually related to the number of freezing days rather than the mean monthly temperatures. As such, a new variable, percent of days in a month with freezing temperatures (Tmax <0°C) was calculated and the annual distribution of freezing days is presented in Figure 18. This option focuses on the winter months November to March, and did not apply to source states like Florida and California. Illinois and Pennsylvania have the most freezing days in general.

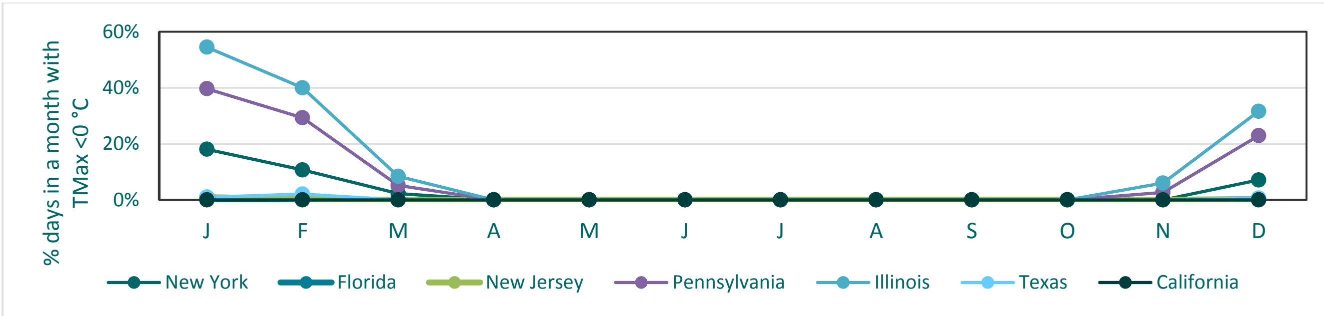

Figure 18: Mean monthly percent of days with max daily temperature <0°C cm in 7 US source markets (2008 – 2017)

As seen in Table 17, there is no meaningful relationship between the percentage of freezing days and departures from the US source markets. The application of 12-month and 1-month time lags (Tables 18 and 19 respectively) do not change the correlations significantly. A very slight increase in correlation of % freezing days and departures from corresponding source areas for departures to Antigua and Barbuda is noted with a 1-month time lag, but these relationships are still considered statistically weak to mild/modest.

Table 17: Relationship (R^2) between mean monthly percent of days with maximum daily temperature <0°C and departures from six US source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	NA	NA	NA	NA	NA	NA	NA
Texas	0.041	0.001	0.009	0.032	0.032	0.003	0.031
Illinois	0.144	0.106	0.097	0.086	0.025	0.143	0.096
Pennsylvania	0.049	0.047	0.006	0.022	0.006	0.078	0.007
New York	0.045	0.003	0.004	0.003	0.015	0.015	0.000
New Jersey	0.024	0.000	0.030	0.059	0.006	0.029	0.028
Florida	NA	NA	NA	NA	NA	NA	NA

Table 18: Relationship (R^2) between mean monthly percent of days with maximum daily temperature <0°C and departures from six US source markets with a 12 MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	NA	NA	NA	NA	NA	NA	NA
Texas	0.025	0.008	0.000	0.020	0.032	0.001	0.018
Illinois	0.172	0.145	0.150	0.065	0.036	0.180	0.082
Pennsylvania	0.081	0.061	0.029	0.018	0.024	0.150	0.003
New York	0.066	0.001	0.010	0.002	0.023	0.012	0.000
New Jersey	0.052	0.007	0.096	0.049	0.001	0.053	0.015
Florida	NA	NA	NA	NA	NA	NA	NA

Table 19: Relationship (R^2) between mean monthly percent of days with maximum daily temperature <0°C and departures from six US source markets with a ONE MONTH lag (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures

California	NA	NA	NA	NA	NA	NA	NA
Texas	0.000	0.006	0.002	0.010	0.008	0.004	0.008
Illinois	0.269	0.166	0.055	0.138	0.074	0.088	0.155
Pennsylvania	0.243	0.050	0.022	0.003	0.057	0.168	0.016
New York	0.118	0.001	0.001	0.004	0.035	0.016	0.009
New Jersey	0.115	0.002	0.087	0.019	0.001	0.077	0.001
Florida	NA	NA	NA	NA	NA	NA	NA

4.4.2 Precipitation and Departures from the United States

In terms of precipitation, there is considerable variability in the amount of monthly precipitation for each of the seven US source markets (Figure 19). Most states receive their highest precipitation in the winter months; for New York, New Jersey, Illinois and Pennsylvania, this would be mixed rain and snowfall.

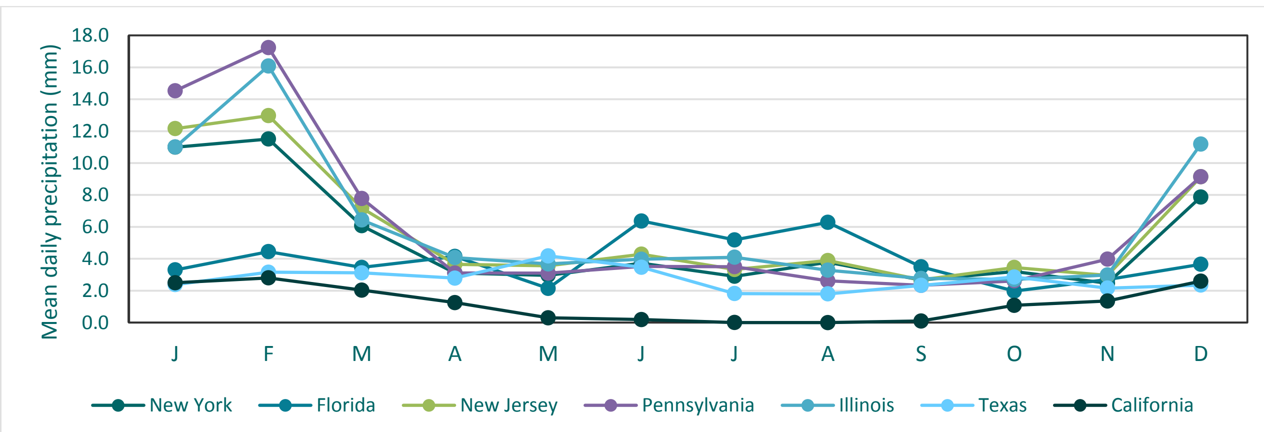

Figure 19: Mean daily precipitation (mm) in seven American source markets (2008 – 2017)

Statistical analysis of the precipitation amount (mm) and departures from each of the seven states, (Table 20), indicates that there are weak relationships (i.e., $R^2<0.2$) between precipitation and departures from those source areas to the Caribbean. The best correlation (which is borderline weak to mild) is with Pennsylvania, which experiences the heaviest snowfall of the selected states. The correlations do not significantly improve with either the 12-month or 1-month time lags (Tables 21 and 22), although the latter does show a very marginal increase in departures to Antigua & Barbuda, particularly from Pennsylvania.

Table 20: Relationship (R^2) between daily mean precipitation (mm) and departures from six US source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	0.003	0.067	0.017	0.096	0.083	0.037	0.059
Texas	0.000	0.008	0.008	0.000	0.000	0.000	0.000
Illinois	0.087	0.095	0.038	0.074	0.028	0.163	0.082
Pennsylvania	0.116	0.107	0.005	0.001	0.028	0.207	0.002
New York	0.058	0.001	0.002	0.001	0.027	0.038	0.005
New Jersey	0.027	0.005	0.016	0.029	0.005	0.075	0.011
Florida	0.012	0.006	0.010	0.063	0.016	0.078	0.056

Table 21: Relationship (R^2) between daily mean precipitation (mm) and departures from six US source markets with a 12 MONTH TIME LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	0.001	0.080	0.001	0.082	0.033	0.085	0.046
Texas	0.006	0.003	0.000	0.004	0.001	0.004	0.003
Illinois	0.138	0.147	0.090	0.073	0.053	0.142	0.088
Pennsylvania	0.137	0.030	0.016	0.005	0.039	0.125	0.000
New York	0.074	0.006	0.007	0.001	0.039	0.038	0.007
New Jersey	0.044	0.011	0.038	0.030	0.001	0.045	0.008
Florida	0.005	0.005	0.013	0.084	0.013	0.050	0.071

Table 22: Relationship (R^2) between daily mean precipitation (mm) and departures from six US source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	0.022	0.060	0.005	0.073	0.010	0.032	0.036
Texas	0.040	0.019	0.040	0.029	0.046	0.038	0.034
Illinois	0.152	0.119	0.036	0.089	0.038	0.051	0.099
Pennsylvania	0.296	0.088	0.010	0.032	0.055	0.175	0.058
New York	0.126	0.004	0.009	0.010	0.045	0.012	0.017
New Jersey	0.122	0.014	0.033	0.002	0.005	0.082	0.002
Florida	0.012	0.007	0.000	0.003	0.002	0.027	0.001

4.4.3 Snowfall and Departures from the United States

We further explored snowfall (Figure 20) in isolation from other forms of precipitation and the results reveal that there is no relationship between snowfall and departures from the US source markets. The annual distribution of total precipitation versus snowfall is quite different: Pennsylvania and Illinois are the snowiest whereas the southern states do not experience snowfall with any regularity.

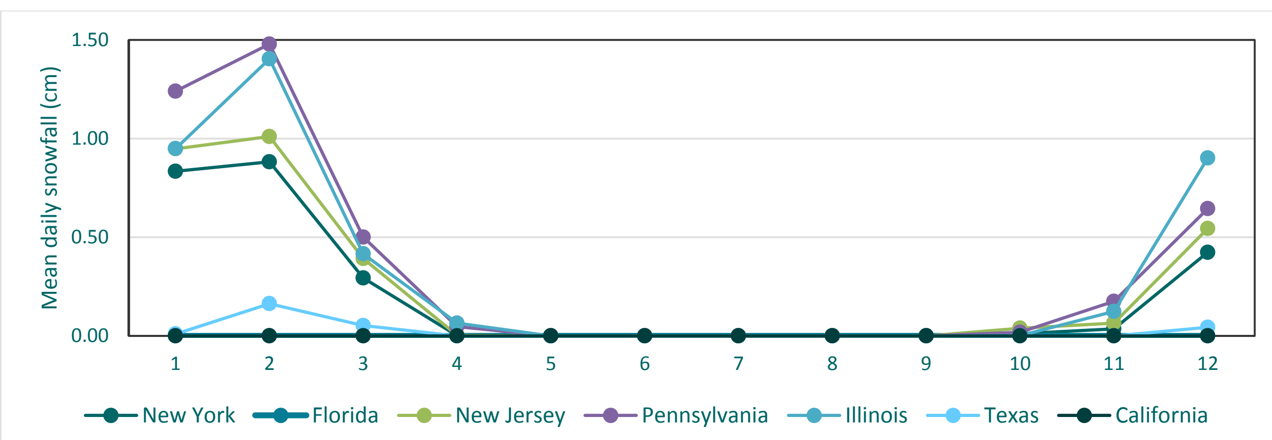

Figure 20: Mean daily snowfall (cm) in seven American source markets (2008 – 2017)

Interestingly, when snowfall is explored in isolation from total precipitation, there is no improvement in fit, as measured by R^2 (Table 23). A marginal increase in the relationship was noted with the one-month lag (Table 25) and departures to Antigua & Barbuda from Illinois and Pennsylvania.

Table 23: Relationship (R^2) between monthly snowfall (cm) and departures from seven US source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	NA	NA	NA	NA	NA	NA	NA
Texas	0.028	0.007	0.017	0.030	0.036	0.004	0.031
Illinois	0.124	0.121	0.052	0.086	0.025	0.184	0.095
Pennsylvania	0.106	0.098	0.003	0.007	0.014	0.197	0.000
New York	0.070	0.002	0.001	0.000	0.035	0.029	0.004
New Jersey	0.035	0.008	0.025	0.044	0.004	0.068	0.016
Florida	NA	NA	NA	NA	NA	NA	NA

Table 24: Relationship (R^2) between monthly snowfall (cm) and departures from seven US source markets with a 12 MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	NA	NA	NA	NA	NA	NA	NA
Texas	0.032	0.011	0.007	0.025	0.043	0.000	0.023
Illinois	0.174	0.182	0.122	0.082	0.056	0.166	0.101
Pennsylvania	0.131	0.029	0.019	0.012	0.034	0.125	0.001
New York	0.097	0.008	0.008	0.000	0.045	0.032	0.005
New Jersey	0.055	0.018	0.058	0.039	0.001	0.051	0.010
Florida	NA	NA	NA	NA	NA	NA	NA

Table 25: Relationship (R^2) between monthly snowfall (cm) and departures from seven US source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	NA	NA	NA	NA	NA	NA	NA
Texas	0.008	0.002	0.001	0.011	0.006	0.000	0.010
Illinois	0.223	0.177	0.050	0.113	0.055	0.075	0.129
Pennsylvania	0.303	0.083	0.009	0.019	0.045	0.184	0.042
New York	0.176	0.006	0.004	0.014	0.066	0.025	0.026
New Jersey	0.153	0.014	0.047	0.005	0.003	0.101	0.001
Florida	NA	NA	NA	NA	NA	NA	NA

4.4.4 Wind speed and Departures from the United States

In terms of wind speed, there is some variability among the seven US source markets (Figure 21). California and New Jersey (both coastal states) experience the greatest wind speeds, with a notable spring peak for California.

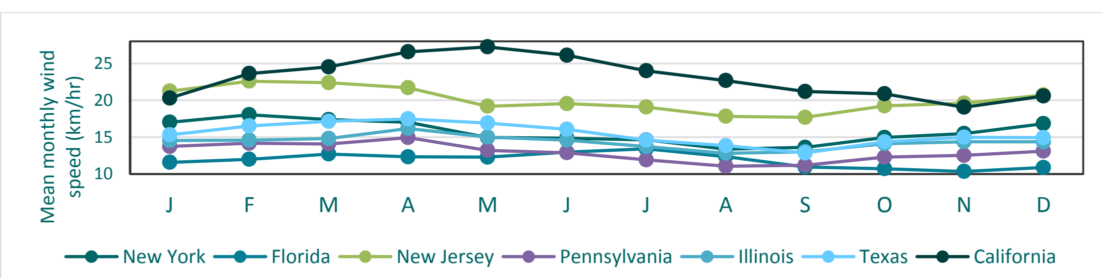

Figure 21: Mean monthly wind speeds (km/hr) in seven American source markets (2008 – 2017)

Tables 26 through 28 show the relationships (R^2 values) calculated for wind speeds and departures from those source areas directly, with a 12-month lag and a one-month lag respectively. Overall wind speeds at the source market state have a weak (<0.2) to modest relationships (0.2 to 0.4) with departures. The strongest relationship was with wind speeds in Pennsylvania with a one-month lag with departures from Pennsylvania to Antigua & Barbuda.

Table 26: Relationship (R^2) between monthly mean wind speeds (km/hr) and departures from seven US source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	0.055	0.021	0.002	0.083	0.139	0.011	0.092
Texas	0.010	0.007	0.009	0.002	0.000	0.055	0.000
Illinois	0.112	0.033	0.044	0.092	0.052	0.060	0.096
Pennsylvania	0.309	0.009	0.046	0.042	0.072	0.110	0.065
New York	0.277	0.021	0.020	0.006	0.056	0.090	0.022
New Jersey	0.270	0.111	0.040	0.000	0.004	0.217	0.013
Florida	0.131	0.090	0.046	0.238	0.190	0.138	0.241

Table 27: Relationship (R^2) between monthly mean wind speeds (km/hr) and departures from seven US source markets with a 12 MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	0.063	0.002	0.000	0.085	0.202	0.015	0.094
Texas	0.025	0.008	0.012	0.003	0.004	0.040	0.001
Illinois	0.127	0.032	0.036	0.083	0.043	0.040	0.087
Pennsylvania	0.228	0.066	0.029	0.032	0.033	0.126	0.053
New York	0.238	0.014	0.016	0.001	0.044	0.095	0.013
New Jersey	0.256	0.071	0.035	0.004	0.001	0.169	0.004
Florida	0.104	0.069	0.011	0.283	0.144	0.155	0.268

Table 28: Relationship (R^2) between monthly mean wind speeds (km/hr) and departures from seven US source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
California	0.034	0.000	0.003	0.239	0.234	0.000	0.207
Texas	0.150	0.123	0.000	0.082	0.096	0.142	0.094
Illinois	0.120	0.022	0.025	0.158	0.077	0.100	0.155
Pennsylvania	0.358	0.027	0.040	0.234	0.198	0.099	0.266
New York	0.248	0.009	0.014	0.039	0.083	0.050	0.050
New Jersey	0.274	0.079	0.010	0.037	0.042	0.149	0.075
Florida	0.002	0.032	0.019	0.096	0.034	0.006	0.087

4.5 Canadian Source Market Weather and Arrivals

4.5.1 Temperature and Departures from Canada

The average of 24-hourly temperature readings for each station were computed for the daily mean temperature variable, which were then averaged to the monthly level and correlated with tourist departures from each source market area. As is evident in Figure 22, while the distribution of seasonal temperatures shows a similar pattern across the six regional markets in Canada, the absolute temperatures are rather different, with an over 20°C difference in mean monthly temperatures during winter months.

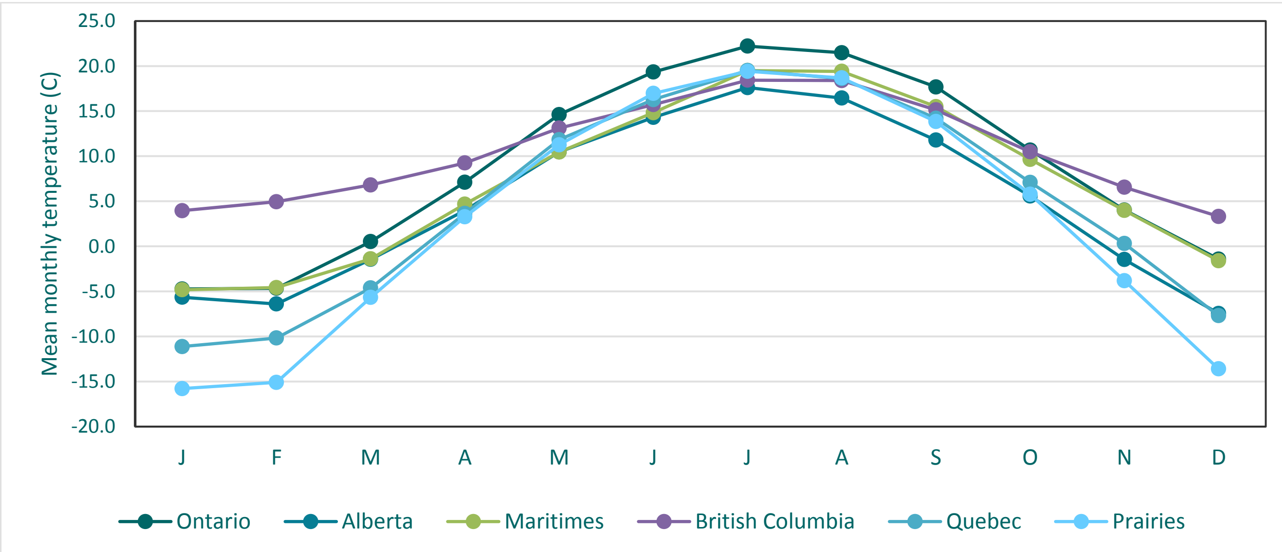

Figure 22: Mean monthly temperatures (°C) in six Canadian source markets (2008 – 2017)

Tables 29 through 31 show the relationships (R^2 values) calculated for mean monthly temperatures (MMTs) and departures from Canadian sub-national source markets, with a 12-month lag and a one-month lag respectively. An inverse relationship with regards to the MMTs (°C) and total monthly departures is evident from many Canadian regions. This inverse relationship indicates that as temperatures in the source markets decrease, departures increase. Moderate to moderately strong correlations between temperature and departures from the same source market have been noted for BDS, JAM, STL and ABA from all major source markets in Canada. The application of the 12-month time lag does not result in a significantly improved correlation, while the application of the 1-month time lag actually results in a slight decline.

The relationship between the at-source temperatures and arrivals to select destinations from that source appears to be relatively lower in GDA (between 0.180 and 0.331). SVG also have relatively lower correlations (between 0.172 and 0.479) with stronger signals from Ontario and the Atlantic Provinces. A potential explanation for this difference is the availability of vacations packages/ hotel rooms in these destinations may be saturated throughout the year whereas the larger availability in other destinations allows for a stronger climate signal. There is no significant change in these with time lags applied.

Table 29: Relationship (R^2) between monthly mean temperatures (°C) and departures from six Canadian source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.480	0.699	0.331	0.629	0.548	0.309	**0.734**
Quebec	0.424	0.707	0.180	0.643	0.510	0.127	**0.680**
The Prairies	0.517	0.630	0.325	0.683	0.551	0.236	**0.688**
Ontario	0.662	0.637	0.298	0.567	0.707	0.479	**0.652**
Alberta	0.431	0.580	0.274	0.678	0.594	0.172	**0.707**
Atlantic Provinces	0.514	0.395	0.279	0.230	0.399	0.397	0.313

The Atlantic Provinces show a much lower correlation between arrivals and source temperatures than the other Canadian source markets. A closer examination of the data shows that there is spring peak in departures to the 6 Caribbean destinations with relatively higher departures in February, March and April compared to the other months. Our hypothesis is that this spring peak is driven by economic reasons, including availability of low-cost packages and the imminent onset of the commercial fishing season, an important source of income in this Canadian region.

Table 30: Relationship (R^2) between monthly mean temperatures (°C) and departures from six Canadian source markets with a 12 MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.486	0.692	0.322	0.624	0.523	0.273	**0.731**
Quebec	0.443	0.745	0.229	0.635	0.571	0.130	**0.693**
The Prairies	0.618	0.654	0.399	0.705	0.594	0.289	**0.715**
Ontario	0.636	0.693	0.296	0.620	0.717	0.476	**0.695**
Alberta	0.430	0.563	0.251	0.727	0.637	0.188	**0.749**
Atlantic Provinces	0.538	0.415	0.306	0.228	0.402	0.355	0.316

Table 31: Relationship (R^2) between monthly mean temperatures (°C) and departures from six Canadian source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.506	0.628	0.273	0.589	0.517	0.307	**0.686**
Quebec	0.418	0.620	0.110	0.578	0.478	0.107	**0.614**
The Prairies	0.499	0.568	0.324	0.644	0.517	0.238	**0.648**
Ontario	0.603	0.562	0.289	0.552	0.687	0.460	**0.621**
Alberta	0.456	0.588	0.233	0.704	0.640	0.237	**0.735**
Atlantic Provinces	0.590	0.453	0.272	0.501	0.459	0.387	0.591

4.5.2 Number of Freezing Days and Departures from Canada

As before with the US data, we also examined the correlation of departures to specific destinations with number of **freezing days** at the source marker as an alternative to mean monthly temperatures. The annual distribution of freezing days by source market is presented in Figure 23. The Tmax value for each day was computed as the maximum hourly temperature for any given day (°C). British Columbia has the fewest freezing days and the Prairies and Quebec are the coldest with the highest percentage of days below freezing.

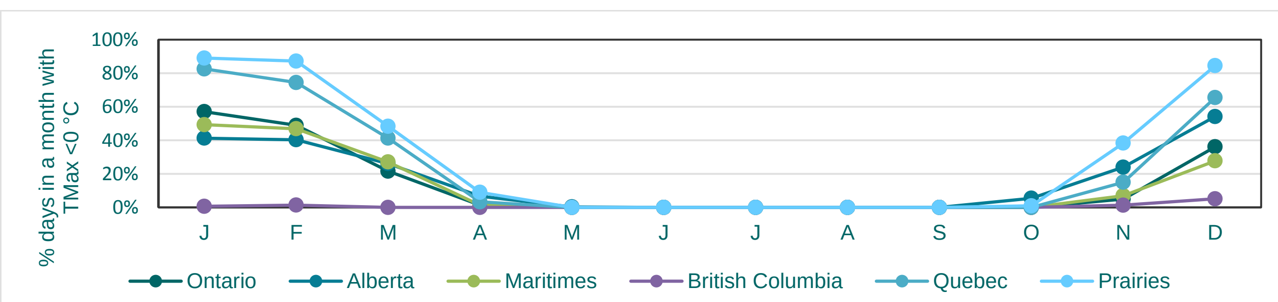

Figure 23: Mean monthly percent of days with maximum daily temperature <0°C cm in six Canadian source markets (2008 – 2017)

Tables 32 through 34 show the relationships (R^2 values) calculated for number of freezing days and departures from Canadian sub-national source markets directly, with a 12-month lag and a one-month lag respectively. The results of the regression analysis reveal that for departures to JAM, the number of freezing days show slightly better correlation with departures from Quebec and the Prairies than due to temperature (Table 29). In general, departures to JAM, BDS, STL and ABA show stronger correlations with freezing days at the source markets compared to the smaller nations of GDA and SVG.

The Prairie Region shows the strongest overall relationship between the freezing days and departures with an R^2 of 0.741, this is followed by Quebec (R^2 = 0.715) and Alberta (R^2= 0.537). The weakest relationship is found in the coastal regions: Atlantic Provinces (R^2= 0.095) and British Columbia (R^2= 0.068).

Table 32: Relationship (R^2) between mean monthly percent of days with maximum daily temperature <0°C and departures from six Canadian (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.030	0.067	0.006	0.065	0.025	0.018	**0.068**
Quebec	0.416	0.683	0.201	0.695	0.520	0.212	**0.715**
The Prairies	0.568	0.674	0.349	0.734	0.602	0.232	**0.741**
Ontario	0.511	0.433	0.368	0.415	0.579	0.452	**0.488**
Alberta	0.296	0.431	0.324	0.516	0.431	0.188	**0.537**
Atlantic Provinces	0.323	0.255	0.260	0.049	0.279	0.288	**0.095**

With the one-month lag applied, the relationships with Quebec and the Prairies between freezing days and departures from these sources show a general weakening (Table 33). A slight improvement in the correlation is seen when the 12-month time lag is applied (Table 34). Table 35 summarizes the correlations for total arrivals from each of the Canadian regions with no lag, 1-month and 12-month lags.

Table 33: Relationship (R^2) between mean monthly percent of days with maximum daily temperature <0°C and departures from six Canadian with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.025	0.088	0.101	0.125	0.045	0.087	0.123
Quebec	0.422	0.513	0.108	0.603	0.488	0.117	0.620
The Prairies	0.519	0.580	0.381	0.666	0.544	0.278	0.670
Ontario	0.430	0.304	0.306	0.347	0.594	0.261	0.406
Alberta	0.354	0.410	0.216	0.549	0.494	0.246	0.568
Atlantic Provinces	0.463	0.381	0.312	0.457	0.458	0.359	0.534

Table 34 Relationship (R^2) between mean monthly percent of days with maximum daily temperature <0°C and departures from six Canadian with a 12- MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.017	0.091	0.009	0.040	0.025	0.006	0.051
Quebec	0.448	0.743	0.246	0.689	0.614	0.211	**0.739**
The Prairies	0.677	0.677	0.425	0.740	0.633	0.321	**0.751**
Ontario	0.439	0.530	0.266	0.446	0.569	0.426	0.513
Alberta	0.246	0.390	0.217	0.555	0.435	0.138	0.559
Atlantic Provinces	0.284	0.301	0.257	0.035	0.210	0.274	0.078

Table 35: Comparison of Relationship (R^2) between mean monthly percent of days with maximum daily temperature <0°C and Arrivals with no lag, a one-month lag and a 12-month lag applied (2008-2017)

	No Lag	1-Month Lag	12-Month Lag
British Columbia	0.068	0.123	0.051
Quebec	0.715	0.620	0.739
The Prairies	0.741	0.670	0.751
Ontario	0.488	0.406	0.513
Alberta	0.537	0.568	0.559
Atlantic Provinces	0.095	0.534	0.078

4.5.3 Precipitation and Departures from Canada

In terms of precipitation, there is considerable variability in the amount of monthly precipitation for each of the six regions in Canada (Figure 24). As expected, the coastal regions of British Columbia and the Atlantic Provinces experience the most precipitation, especially during the winter months. Alberta and the Prairies are the driest regions in Canada and there is much variability throughout the year.

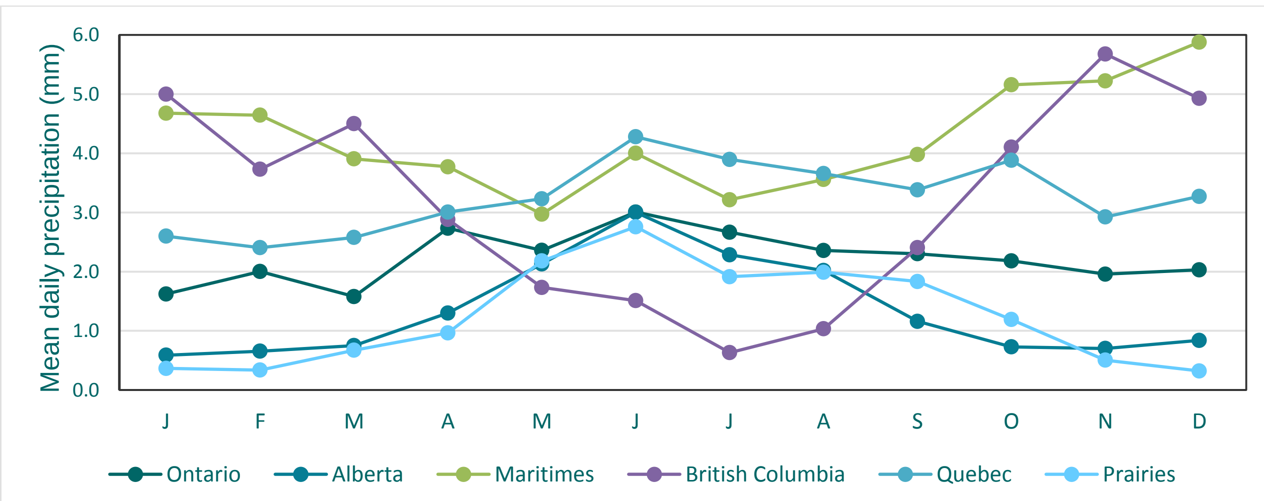

Figure 24: Mean daily precipitation (mm) in six Canadian source markets (2008 – 2017)

Tables 36 through 38 show the results of the statistical analysis of correlations (R^2) between precipitation in the source markets and departures from the source markets to each of the six Caribbean destinations, with no lag, one-month and 12-month lags applied respectively. There are weak (<0.2) to modest (0.2 to 0.4) relationships between precipitation and departures. While the correlation is still weak, British Columbia shows the strongest relationship between departures and precipitation (R^2 = 0.340); this relationship increases to moderate (0.423) with a one-month lag.

Table 36: Relationship (R^2) between daily mean precipitation (mm) and departures from six Canadian source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.295	0.355	0.209	0.269	0.299	0.147	**0.340**
Quebec	0.078	0.096	0.001	0.116	0.058	0.007	**0.111**
The Prairies	0.199	0.278	0.165	0.282	0.257	0.118	**0.288**
Ontario	0.102	0.057	0.044	0.123	0.087	0.042	**0.114**

Alberta	0.128	0.147	0.131	0.196	0.158	0.025	**0.202**
The Atlantic Provinces	0.003	0.009	0.034	0.011	0.012	0.004	0.005

Table 37: Relationship (R^2) between daily mean precipitation (mm) and departures from six Canadian source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.468	0.451	0.228	0.329	0.345	0.184	**0.423**
Quebec	0.033	0.038	0.000	0.049	0.031	0.000	**0.047**
The Prairies	0.242	0.251	0.169	0.294	0.258	0.077	**0.296**
Ontario	0.098	0.084	0.028	0.115	0.096	0.072	**0.114**
Alberta	0.177	0.215	0.107	0.264	0.208	0.015	**0.272**
The Atlantic Provinces	0.043	0.049	0.071	0.001	0.067	0.072	**0.007**

Table 38: Relationship (R^2) between daily mean precipitation (mm) and departures from six Canadian source markets with a 12 MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.232	0.293	0.161	0.229	0.236	0.216	**0.288**
Quebec	0.147	0.098	0.017	0.121	0.067	0.035	**0.126**
The Prairies	0.254	0.289	0.147	0.294	0.262	0.204	**0.300**
Ontario	0.112	0.069	0.074	0.123	0.098	0.042	**0.119**
Alberta	0.130	0.175	0.080	0.182	0.192	0.057	**0.195**
The Atlantic Provinces	0.001	0.018	0.013	0.019	0.008	0.000	**0.010**

4.5.4 Mean Snowfall and Departures from the Canada

As was done in the case of US departures, we explored snowfall in isolation from other forms of precipitation. Figure 25 below shows the annual distribution of snowfall for the six source market regions in Canada. British Columbia, the Prairie, Ontario and Alberta receive considerably less snow than the Atlantic Provinces and Quebec.

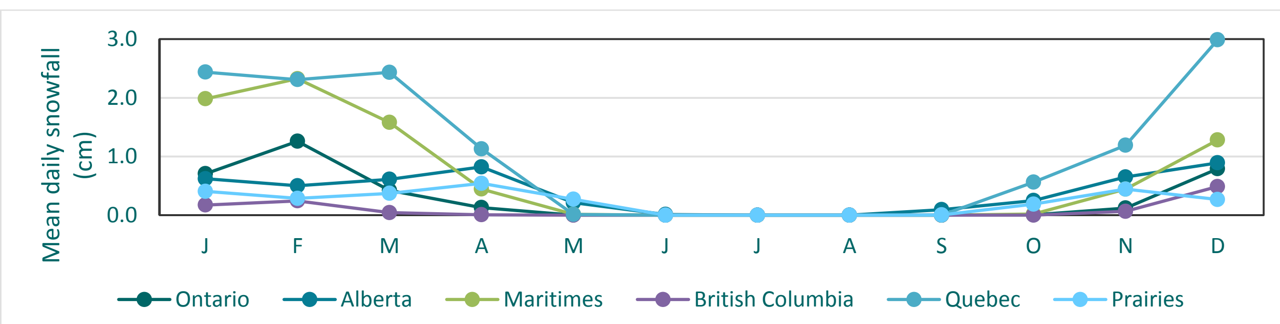

Figure 25: Mean daily snowfall (cm) in six Canadian source markets (2008 – 2017)

In terms of the relationship between departures to Caribbean destinations, monthly snowfall in Quebec was found to have a moderate relationship (R^2 = 0.479), followed by modest relationships of this parameter with snowfall in Ontario and Alberta (Table 39). Application of the one-month time lag did not improve the correlations generally, but application of the 12-month did improve the correlation for Ontario in particular, suggesting the influence of longer-term planning by travelers in this source market; the correlation did not change for Quebec.

Table 39: Relationship (R^2) between monthly snowfall (cm) and departures from six Canadian source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.066	0.091	0.020	0.087	0.078	0.023	**0.099**
Quebec	0.264	0.565	0.208	0.443	0.364	0.204	**0.479**
The Prairies	0.088	0.104	0.012	0.124	0.054	0.026	**0.120**
Ontario	0.396	0.357	0.265	0.293	0.422	0.420	**0.358**
Alberta	0.190	0.235	0.046	0.300	0.223	0.052	**0.304**
The Atlantic Provinces	0.272	0.235	0.271	0.081	0.309	0.246	0.129

Table 40: Relationship (R^2) between monthly snowfall (cm) and departures from six Canadian source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.042	0.075	0.079	0.137	0.080	0.099	**0.135**
Quebec	0.289	0.433	0.094	0.374	0.342	0.071	**0.410**
The Prairies	0.052	0.100	0.021	0.095	0.053	0.043	**0.094**
Ontario	0.268	0.192	0.176	0.203	0.370	0.185	**0.243**
Alberta	0.131	0.186	0.036	0.215	0.242	0.087	**0.227**
The Atlantic Provinces	0.356	0.311	0.306	0.367	0.451	0.313	**0.433**

Table 41: Relationship (R^2) between monthly snowfall (cm) and departures from six Canadian source markets with a 12 MONTH TIME LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.014	0.102	0.014	0.075	0.027	0.011	**0.080**
Quebec	0.241	0.545	0.164	0.444	0.416	0.090	**0.479**
The Prairies	0.117	0.129	0.028	0.123	0.088	0.008	**0.124**
Ontario	0.355	0.432	0.238	0.351	0.483	0.438	**0.413**
Alberta	0.165	0.306	0.066	0.329	0.278	0.028	**0.340**
The Atlantic Provinces	0.257	0.345	0.282	0.053	0.253	0.164	**0.104**

4.5.5 Percentage Snowfall Days in a Month and Departures from the Canada

It is evident that mean daily snowfall for a month has a stronger correlation with departures to the Caribbean than overall precipitation. We explored whether climate signal would be stronger if the analysis was narrowed to the number of days with snowfall rather than the total snowfall accumulation. As such, a new variable, *percent of days in a month with snowfall* was calculated and the annual distribution of snowfall days is presented in Figure 26. Quebec and the Atlantic Provinces have the highest percentage of snow days. Alberta, Ontario and the Prairies form middle group, while British Columbia, as expected, as the lowest percentage of snow days.

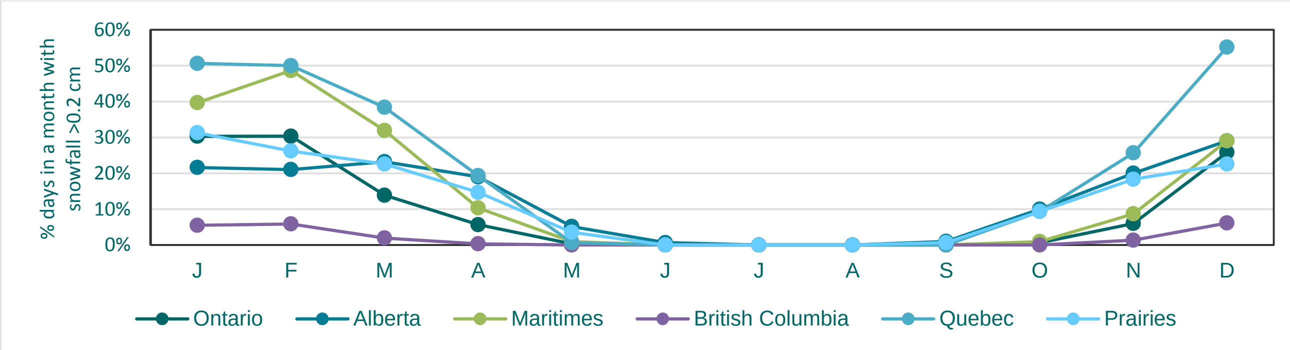

Figure 26: Mean monthly percent of days with snowfall >0.2 cm in six Canadian source markets (2008 – 2017)

The results of the regression analysis reveal that the percentage of snowfall days in a month is more strongly correlated with departures than total snowfall amounts. Quebec shows the strongest relationship between the percentage of snowfall days and departures with an R^2 = 0.668, this is followed by Ontario (R^2 = 0.544) and the Prairie Provinces (R^2= 0.524). The weakest relationship is found in the coastal regions with the Atlantic Provinces (R^2= 0.195) and British Columbia (R^2= 0.190). It is also interesting that the relationships with the two relatively smaller tourist destinations (Grenada and St Vincent and the Grenadines) are relatively weaker than for the other four destinations.

Whilst the one-month lag (Table 42) shows a slight decrease in the correlations, there appears to be a very slight strengthening of the correlation with the application of the 12-month lag.

Table 42: Relationship (R^2) between monthly percent of days with snowfall >0.2cm and departures from six Canadian source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.078	0.164	0.102	0.170	0.156	0.078	**0.190**
Quebec	0.357	0.728	0.212	0.648	0.443	0.203	**0.668**
The Prairies	0.305	0.543	0.107	0.529	0.277	0.168	**0.524**
Ontario	0.562	0.520	0.349	0.468	0.567	0.551	**0.544**
Alberta	0.218	0.399	0.177	0.453	0.376	0.109	**0.468**
Atlantic Provinces	0.381	0.301	0.248	0.133	0.307	0.350	**0.195**

Table 43: Relationship (R^2) between monthly percent of days with snowfall >0.2cm and departures from six Canadian source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.071	0.144	0.130	0.175	0.146	0.162	**0.190**
Quebec	0.407	0.590	0.115	0.577	0.447	0.108	**0.604**
The Prairies	0.233	0.468	0.081	0.457	0.252	0.176	**0.452**
Ontario	0.463	0.354	0.280	0.372	0.554	0.300	**0.431**
Alberta	0.203	0.366	0.124	0.389	0.380	0.155	**0.409**
Atlantic Provinces	0.452	0.358	0.223	0.513	0.405	0.355	**0.579**

Table 44: Relationship (R2) between monthly percent of days with snowfall >0.2cm and departures from six Canadian source markets with a 12 MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total Departures with 12-month lag	Total Departures with NO lag
British Columbia	0.044	0.217	0.043	0.216	0.075	0.035	**0.219**	**0.190**
Quebec	0.436	0.749	0.198	0.630	0.507	0.167	**0.678**	**0.668**
The Prairies	0.468	0.555	0.114	0.540	0.401	0.158	**0.545**	**0.524**
Ontario	0.547	0.595	0.364	0.527	0.653	0.550	**0.604**	**0.544**
Alberta	0.238	0.517	0.131	0.463	0.391	0.081	**0.489**	**0.468**
Atlantic Provinces	0.356	0.380	0.238	0.112	0.284	0.250	**0.179**	**0.195**

4.5.6 Cloud Cover and Departures from Canada

According to the Environment and Climate Change Canada (2019), the following terms are used to record the amount of cloud covering the sky: clear (0 tenths), mostly clear (1-4 tenths), mostly cloudy (5-9 tenths), and cloudy (10 tenths). For the purposes of calculating the percentage of cloud cover, the mid-point of these ranges is converted to percentages so that clear (0%), mostly clear (25%), mostly cloudy (75%), and cloudy (100%), and all other weather such as rain or hail (100%) is assigned a percentage value for that hour. The average of the 11 hours between 6am and 4pm is then calculated.

As illustrated in Figure 27 there is considerable variability for monthly levels of cloud cover. Overall, British Columbia is the cloudiest in the winter (Figure 20) and the Prairie Region is the least cloudy. The annual variability in cloud cover is low, with the summer months experiencing slightly less cloud cover than the winter months; this distribution is most pronounced for British Columbia.

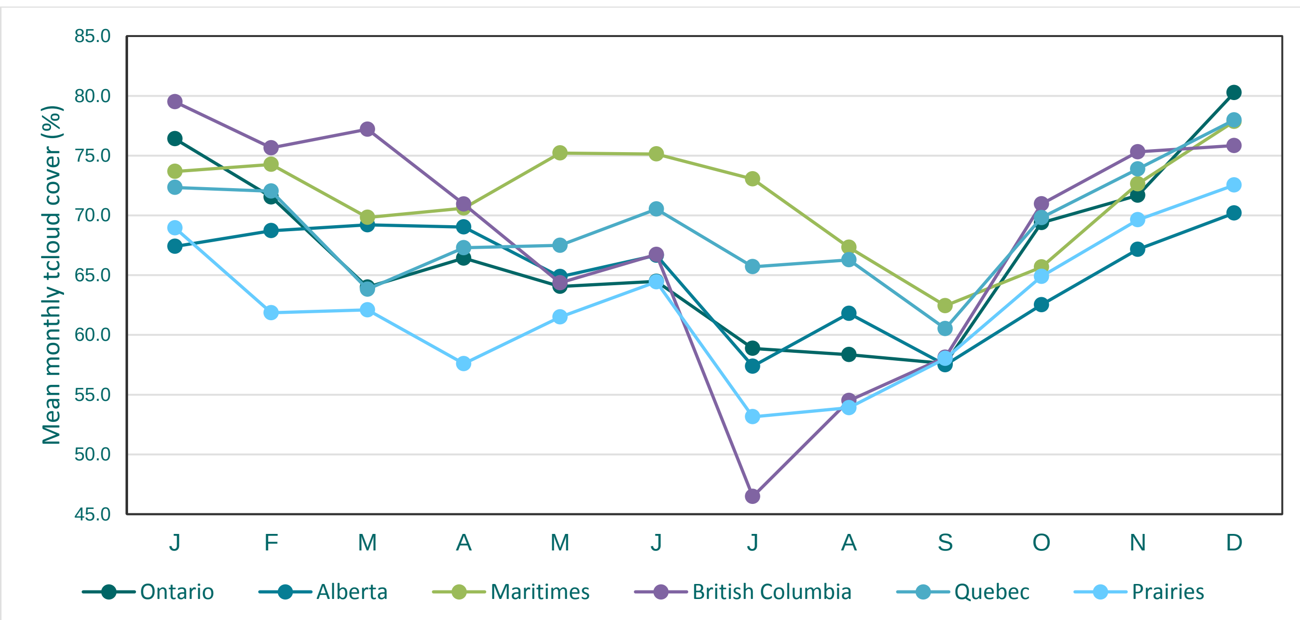

Figure 27: Mean monthly cloud cover (%) in six Canadian source markets (2008 – 2017)

Overall, cloud cover has a limited relationship with departures from the six Canadian regions. The regression analysis reveals that there is little relationship between cloud cover and departures, with mild correlations with British Columbia and Ontario datasets. The highest R^2 values were obtained for departures from Ontario and cloud cover in Ontario to the six destinations (0.444) with a one-month time lag.

Table 45: Relationship (R^2) between monthly mean cloud cover (%) and departures from six Canadian source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.343	0.400	0.169	0.323	0.310	0.163	**0.395**
Quebec	0.023	0.084	0.165	0.043	0.078	0.014	**0.056**
The Prairies	0.163	0.087	0.114	0.113	0.168	0.044	**0.118**
Ontario	0.279	0.226	0.163	0.274	0.219	0.222	**0.285**
Alberta	0.183	0.050	0.079	0.177	0.188	0.089	**0.177**
Atlantic Provinces	0.058	0.002	0.088	0.002	0.048	0.033	**0.004**

Table 46: Relationship (R^2) between monthly mean cloud cover (%) and departures from six Canadian source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.356	0.346	0.140	0.296	0.296	0.150	**0.361**
Quebec	0.065	0.143	0.154	0.142	0.194	0.069	**0.158**
The Prairies	0.268	0.226	0.223	0.257	0.337	0.167	**0.268**
Ontario	0.468	0.359	0.366	0.405	0.402	0.358	**0.444**
Alberta	0.159	0.031	0.069	0.116	0.123	0.056	**0.117**
The Atlantic Provinces	0.062	0.001	0.055	0.004	0.067	0.034	**0.006**

Table 47: Relationship (R^2) between monthly mean cloud cover (%) and departures from six Canadian source markets with a ONE YEAR LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.346	0.335	0.183	0.281	0.295	0.140	**0.351**
Quebec	0.001	0.081	0.121	0.031	0.040	0.009	**0.037**
The Prairies	0.088	0.071	0.181	0.089	0.125	0.055	**0.093**
Ontario	0.226	0.191	0.143	0.240	0.199	0.235	**0.248**
Alberta	0.158	0.050	0.102	0.158	0.120	0.021	**0.155**
Atlantic Provinces	0.016	0.000	0.082	0.002	0.035	0.013	**0.000**

4.5.7 Wind Speed and Departures from Canada

Wind speed is computed as the average of the 24-hour readings for each day at each station. As shown in Figure 28, there is very little annual variability in monthly wind speeds and thus the likelihood of a meaningful relationship between this climate element and departures from the six Canadian regions is low. Interestingly, British Columbia is the least windy and the Atlantic region is most windy. The annual variability in wind speeds is small, with the summer months experiencing slightly slower wind speeds than the winter months, except for in Quebec and British Columbia where the wind speeds are highest during the summer months.

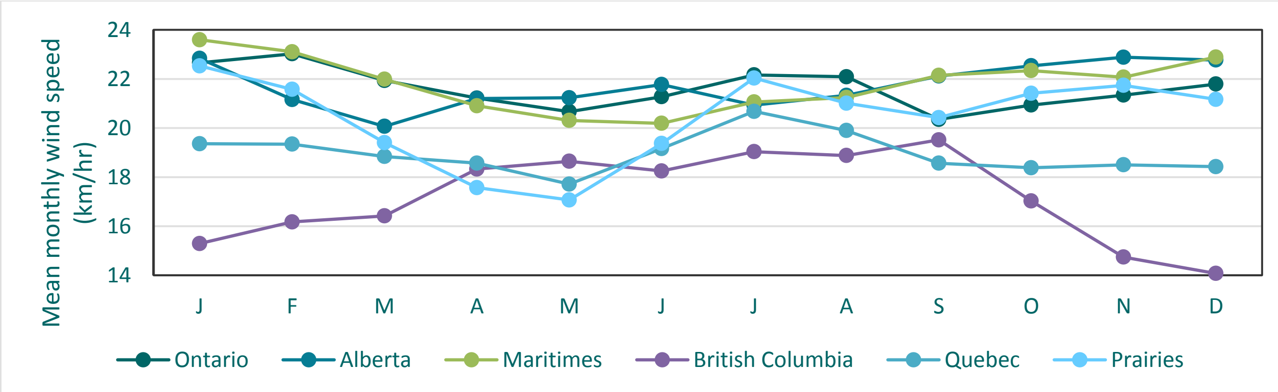

Figure 28: Mean monthly wind speeds (km/hr) in six Canadian source markets (2008 – 2017)

The regression analyses (Table 48) indicated that there is generally little relationship between wind speeds and departures. The highest R^2 values are for British Columbia (R^2= 0.346), with the strongest correlation with departures to BDS and British Columbia wind speeds with a one-month time lag (0.537).

Table 48: Relationship (R^2) between monthly mean wind speeds (km/hr) and departures from six Canadian six Canadian source markets (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.231	0.428	0.161	0.273	0.252	0.254	**0.346**
Quebec	0.001	0.000	0.000	0.005	0.002	0.012	**0.002**
The Prairies	0.060	0.069	0.054	0.067	0.073	0.050	**0.069**
Ontario	0.059	0.058	0.111	0.080	0.098	0.087	**0.086**
Alberta	0.000	0.000	0.001	0.000	0.001	0.013	**0.000**
The Atlantic Provinces	0.052	0.067	0.044	0.001	0.033	0.054	**0.007**

Table 49: Relationship (R^2) between monthly mean wind speeds (km/hr) and departures from six Canadian six Canadian source markets with a ONE MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.392	0.537	0.274	0.385	0.334	0.219	**0.480**
Quebec	0.003	0.009	0.002	0.000	0.009	0.003	**0.001**
The Prairies	0.111	0.129	0.084	0.155	0.130	0.042	**0.155**
Ontario	0.043	0.028	0.042	0.039	0.084	0.039	**0.046**
Alberta	0.037	0.068	0.038	0.065	0.062	0.039	**0.070**
The Atlantic Provinces	0.135	0.176	0.070	0.117	0.139	0.110	**0.148**

Table 50: Relationship (R^2) between monthly mean wind speeds (km/hr) and departures from six Canadian six Canadian source markets with A 12 MONTH LAG (2008-2017)

	ABA	BDS	GDA	JAM	STL	SVG	Total departures
British Columbia	0.229	0.372	0.165	0.286	0.261	0.186	**0.350**
Quebec	0.003	0.000	0.008	0.002	0.001	0.008	**0.002**
The Prairies	0.077	0.055	0.062	0.055	0.072	0.064	**0.058**
Ontario	0.102	0.101	0.075	0.100	0.086	0.079	**0.108**
Alberta	0.007	0.001	0.003	0.000	0.004	0.002	**0.000**
The Atlantic Provinces	0.051	0.047	0.030	0.002	0.021	0.050	**0.008**

4.6 Extreme Events – Tropical Cyclones

This feasibility study focused on the identification of the potential influence of TCIs and weather elements (both intra and extra-regional) on destination arrivals. However, the stakeholder survey undertaken early in the study and other sources (e.g., Laframboise *et al.,* 2014) identified extreme weather events as influential in shaping tourism arrivals. Time and budget constraints did not permit an in-depth statistical examination of the influence of extreme events on arrivals, but some preliminary observations are noted.

The National Ocean and Air Administration (NOAA) developed an annual index that characterizes the net intensity/activity (both frequency and intensity) of the entire North Atlantic hurricane season for any given year. The index is called the Accumulated Cyclone Energy (ACE) index, and NOAA has calculated ACE index values for the period 1948 to 2018 using its Atlantic hurricane database (HURDAT). The ACE index is described by NOAA as: "*an index that combines the numbers of systems, how long they existed and how intense they became. It is calculated by squaring the maximum sustained surface wind in the system every six hours that the cyclone is a Named Storm and summing it up for the season. It is expressed in 104* kt^2 [knots squared]." [13]

The ACE index is potentially useful for determining the influence of extreme events in the region on arrivals. A preliminary examination of the 2001 to 2017 annual arrivals data (total stopovers from all markets) for the Group 2 countries did not reveal any significant influence of extreme events on arrivals to Caribbean destinations (either directly or with a one-year time lag), the best association between total arrivals and the ACE was still weak (for BDS, $R^2 = 0.146$). Isolating the individual seasons (DJF, MAM, JJA, SON), the strongest correlation was found between arrivals in the summer months (JJA) and BDS ($R^2 = 0.276$). The fact that there was a mild association with the summer arrivals data is not surprising as the North Atlantic Hurricane Season starts June 1. The usefulness of the ACE as a potential driver for regional or annual arrivals is likely to have its limitations, particularly as it is calculated after the year, and time lags investigated did not improve the association.

It should also be emphasised that this analysis did not examine specific storm events impacting specific destinations. It is likely that direct effects of individual storms on specific destinations would have more direct effects on arrivals. It has been documented that individual storms or consecutive cyclonic events in any given year can have devastating effects on the destinations that are directly impacted. For the entire region, the WTTC (2018) estimated a loss of 826,100 visitors to the Caribbean (compared to pre-hurricane forecasts) in 2017 as a result of the 2017 hurricane season (in which there were two major hurricanes, Irma and Maria), and further indicated that "*recovery to previous levels could take up to four years…"*. As expected, the estimated impact on arrivals was greatest on countries that were directly impacted by these hurricane systems.

Granvorka and Strobl (2013) developed a Hurricane Destruction index to estimate the historic impact on individual Caribbean destination's tourism arrivals using econometric techniques. Those authors found that average hurricanes resulted in a 2% loss in arrivals, while as much as 20% decline in arrivals was attributed to larger events that directly impacted specific destinations. In its examination of the impact of the 2017 hurricane season on Caribbean tourism, the WTTC (2018) estimated a loss of 0.826 million

[13] https://www.aoml.noaa.gov/hrd/tcfaq/E11.html

arrivals to the region as whole and attributed it to a combination of loss of availability (in directly impacted destinations) as well as indirect losses (in destinations not impacted) by the markets' misconception that the entire region was affected.

Extreme events could also be a function of teleconnections. However, the limited capacity to forecast occurrence and strength these teleconnections and associated weather systems represents a critical information gap for the feasibility of provision of relevant weather information products for the tourism sector (Nalau *et al*, 2017). El Niño is the warm phase of the El Niño Southern Oscillation (ENSO), caused by warmer tropical Pacific Ocean temperatures. Stronger El Niño years are linked to calmer hurricane seasons and the suppression of cyclonic activity in the tropical North Atlantic (Krishnamurthy, 2016; Steptoe et al, 2018). The relative weakness of El Niño is one of the factors used by NOAA to predict the intensity of the hurricane season.[14] The La Niña (cold phase) tends to be associated with conditions more favourable with cyclone development. Similarly, it has been suggested that the warm phase of the Atlantic Multi-Decadal Oscillation (AMO) results in conditions that are more conducive to cyclone development. It has also been discussed (Steptoe et al 2018) that the North Atlantic Oscillation (NAO) has a "*weak, but significant relationship with North Atlantic tropical cyclones"*, impacting conditions conducive to cyclone development in its negative phase.

Teleconnection-driven extreme weather systems may also increase the effect of weather-related push factors in the source country: Saverimuttu and Varua (2014) found that there was an increase in US tourist arrivals to the Philippines when La Niña-like weather conditions prevailed in the US (cold phase); Alvarez-Diaz et al (2010) found that there was a statistical relationship between NAO and tourism demand in the Balearic Islands (from the UK and German market). In the Caribbean, Oduber and Ridderstadt (2016) empirically examined the effect of teleconnections on tourism demand in Aruba, and concluded that ENSO and NAO were likely to account for some variation in arrivals from the US market in particular. These preliminary findings suggest that further examination of the influence of teleconnections on tourism demand may be useful.

4.7 Summary

With the exception of Illinois, at-destination weather variables and TCIs had very mild to weak correlations with arrivals from the US source markets. The associations with at-source (extra-regional) weather for US source markets were also found to be weak to mild. It is likely that non-climate factors play a much more important role in driving arrivals to the Caribbean from the US (see Laframboise *et al.* 2014).

Although arrivals from Canada represent less than a third of the US arrivals for the six Caribbean destinations, the weather signal in the arrivals data from Canada seems to have the most potential for generating arrivals outlooks: associations between Canadian arrivals and temperatures (both at source and at destination) were considerably stronger than the US associations. Excluding the Atlantic Provinces and British Columbia (Table 51), the strongest associations found were between Canadian arrivals with at-source temperatures and with percent freezing days (maximum temperature below 0^oC).

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[14] https://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml

It was also found that there was a moderate to moderately strong correlation between snow days with a 12-month time lag and arrivals from Canadian source markets excluding British Columbia (ranging between 0.468 in Alberta and 0.668 in Quebec). In these three cases the correlation improved with the application of a 12-month lag, suggesting that weather data from the previous year (source countries) could be applied to forecast variability in arrivals.

Table 51: Relationship (R^2) between Arrivals and (a) Mean Monthly Temperatures and (b) Freezing Days

	R^2 between Arrivals and Mean Monthly Temperatures				R^2 between Arrivals and % Days with max Temp <0°C		
	No Lag	1-Month Lag	12-Month Lag		No Lag	1-Month Lag	12-Month Lag
British Columbia	0.734	0.686	0.731		0.068	0.123	0.051
Quebec	0.680	0.614	**0.693**		0.715	0.620	**0.739**
The Prairies	0.688	0.648	**0.715**		0.741	0.670	**0.751**
Ontario	0.652	0.621	**0.695**		0.488	0.406	**0.513**
Alberta	0.707	0.735	**0.749**		0.537	0.568	**0.559**
Atlantic Provinces	0.313	0.591	**0.316**		0.095	0.534	0.078

The at-destination temperature correlations with Canadian arrivals were not as strong and ranged between 0.524 (SVG) and 0.631 (JAM). Reflecting the at-destination temperature signal, the association between destination TCIs (subgroup of 3 countries) and arrivals ranged between 0.431 (BDS) and 0.653 (STL).

The main challenges with the widespread application of any tourism climate index as a basis for projecting arrivals include:

- Data issues: data needed for the calculation of TCIs are not widely available; the sample of 3 countries is not sufficient data on which to evaluate the potential feasibility of building a TCI-based arrivals model.
- Based on the available data, there is unlikely to be sufficient variability in destination annual TCI distributions to account for variances in the distribution of arrivals.
- The strength of the climate signal: The strength of the correlations for Canada and Illinois found with the TCI and arrivals are generally below 0.65, which suggests non-climate factors (and possible climate factors not included in the TCI calculation) are also important. These can be accounted for in year to year forecasts.
- Accurate interpretation of compound index values. It is likely that the better correlations with TCI and HCI:urban reflect temperature as a driver of arrivals not the specific index formulation. This view is supported by the fact that temperature had a higher weighting for TCIs (50%) and HCI: urban (40%), compared to HCI: beach (where temperature was only weighted at 20%).

5. Institutional Capacity for Development and Delivery of Climate Services for the Tourism Sector

This section explores broad aspects of regional capacity to serve the climate information needs of tourism stakeholders. It focuses on the three institutional partners working together to develop the Caribbean Tourism-Climatic Bulletin as part of a wider consortium of sectoral Early Warning Information Systems Across Climate Timescales (EWISACT): CIMH, CTO and the Caribbean Hotel and Tourism Association (CHTA). Four semi-structured interviews were undertaken between November 12 and 20, 2019 with a total of five representatives from these institutions (two from CTO and CIMH, respectively, and one from CHTA). Lines of inquiry included governance, climate data, tourism data, co-development of climate information products and services and user needs and preferences. The interview guide appears in Appendix 7.

The ESSA team used a Strengths-Weaknesses-Opportunities-Threats framework (see Table 52) to organize and analyze the qualitative information compiled from stakeholder interviews. In this case, strengths and weaknesses refer to institutional factors such as human resources, finances, organizational structures and culture, decision making processes, data management and information flows that shape the effective use of climate information in regional tourism decisions. Opportunities and threats refer to factors that could shape the development, delivery and use of climate information in the future, including political, social, cultural and financial features.

Strengths	**Weaknesses**
• What is going well, with respect to: ○ Governance (clarity of roles and responsibilities, vertical integration) ○ Data management and sharing ○ Co-development ○ Knowledge exchange and uptake • What human, technical and financial resources are successfully drawn upon? • What are the strengths?	• What could be improved, with respect to: ○ Governance (clarity of roles and responsibilities, vertical integration) ○ Data management and sharing ○ Co-development ○ Knowledge exchange and uptake • What are others outside CIMH, CTO and CHTA likely to see as a weakness?
Opportunities	**Threats**
• What opportunities are open to CIMH, CTO and CHTA to further develop tourism-focused climate products and services? • What trends could be taken advantage of? • How can institutions' strengths turn into opportunities?	• What threats could derail the evolution of climate products and services for the tourism sector? • What is the source of threats?

Table 52: S-W-O-T analysis framework

Results of this analysis appear in the following sections.

5.1 Strengths

Strengths include strong leadership by CIMH, formal partnerships, effective engagement mechanisms and activity at the national level.

The CIMH has the institutional mandate to lead development of climate services in the region. The CARICOM Council for Trade and Economic Development (COTED) formally endorsed the Global Framework for Climate Services (GFCS) of the World Meteorological Organization (WMO) in 2015. Building on work within the Applied Meteorology and Hydrology Section of CIMH, including training and capacity development on several aspects of meteorology, hydrology and climatology; data collection; technical analyses on weather/water/climate and data product development, this section of CIMH has become the Caribbean Regional Climate Change Centre – the main institutional node to advance implementation of the GFCS in the Caribbean. As such, CIMH's Applied Meteorology and Hydrology Section has staff fully dedicated to climate services. About twelve technical staff engaged in climate services, with functions that include developing data products, as well as archiving climate data and making climate data available for use in research. Both CTO and CHTA recognize that the drive and impetus for establishing closer relationships between climate information providers and the tourism sector has come from CIMH.

CIMH's capacity in climatology, in generating derived indices (extreme heatwave spells from raw temperature data) and seasonal forecasts has improved significantly since 2012. It is apparent that the CIMH has the capacity to utilize the available databases with the main findings of our empirical study to generate qualitative outlooks for arrivals. Based on our preliminary assessment of other outputs of the CIMH, we are confident that CIMH has the necessary capacity to access and utilize weather data of Canadian source markets. Initial set-up assistance may be required to identify relevant weather stations in the Canadian weather databases and to determine the confidence levels based on the historic strength of the temperature signals in the arrivals database.

CIMH's approach to supporting the development of climate services is collaborative, strategic and based on evidence. Developing early-warning information to help stakeholders in climate-sensitive sectors anticipate and respond to climate-related risks and opportunities has been a core initiative for CIMH since 2015. CIMH pursues this in collaboration with its network of National Meteorological and Hydrological Services and a consortium of agencies responsible for six climate-sensitive sectors, of which tourism is one (i.e., consortium of Sectoral Early Warning Information Systems Across Climate Timescales (EWISACTs)). The consortium, which engages both CTO and CHTA, serves both governance and operational objectives. Among its strategic activities, CIMH and consortium partners have developed a roadmap and action plan (2020-2030) in support of climate services in Caribbean, as guided by GFCS. This roadmap and action plan is one example that demonstrates CIMH's systematic approach to identifying shared needs and priorities. This process of developing regional climate services has also benefitted from CIMH's investment in baseline research, such that priorities and activity design are evidence based. For example, in 2015 CIMH led a study to assess the capacity of national meteorological and hydrological services to develop/deliver climate information across key pillars of GFCS (Figure 29).

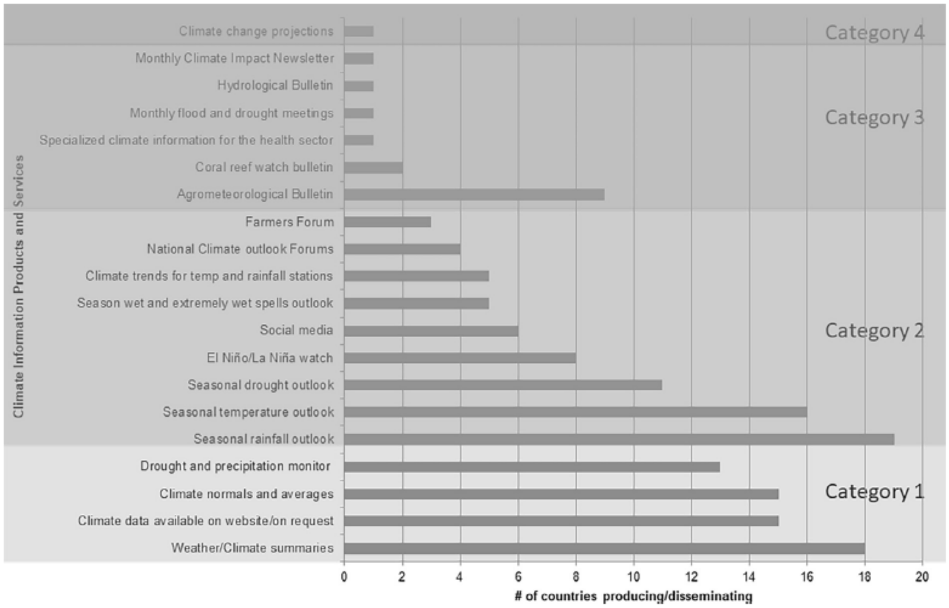

Figure 29: Climate information products and services generated by national meteorological services in the Caribbean region (source: Mahon et al. 2019)

Formal agreements among consortium partners pave the way for fluid collaboration. Institutional partners (CIMH, CTO and CHTA) support partnership models as a way to pool resources and access networks and opportunities otherwise unavailable if acting alone. For example, CTO recognized there were gaps in the tourism sector's knowledge and awareness of the risks of climate change and variability and saw collaboration with CIMH as an avenue to close those gaps. Formal agreements, in the way of letters of agreement, endorsed by heads of institutions have facilitated the process of co-development of climate products and services. By spelling out fundamental expectations of the collaborative effort (e.g., commitments and expected results) as well as specific operational supports (e.g., provisions for sharing of historic and current data) these formal agreements are key tools to facilitate productive engagement across institutions, particularly in cases that require forging new working relationships. CTO and CHTA have a long history of working together, so in this case the novelty was in the relationship between CIMH and regional tourism institutions. The tourism sector was not one of the CIMH's original test beds for climate product and service development and is not a priority sector at the global level (under the WMO's GFCS). Nevertheless, the tourism sector became a target for engagement by CIMH due to its climate sensitivity, socio-economic and cultural standing in the region. From the perspective of CIMH, the working relationship is "easier than originally anticipated".

The Caribbean Climate Outlook Forum (CariCOF) and the Tourism Climate Bulletin (TCB) are mechanisms that contribute to bringing the climate and tourism sectors closer together. CIMH coordinates seasonal climate forecasting activities through CariCOF. CariCOF involves training to climate forecasters from the region, production of climate outlooks and joint interpretation of climate outlooks through bi-annual events at the beginning of the wet and dry seasons, respectively. Engagement with user communities in climate-sensitive sectors is core to the bi-annual CariCOF events. Although not involved in designing or planning CariCOF events, representatives from CTO and CHTA participate and, in so doing, boost their own awareness of existing or planned products and disseminate the information to their stakeholders. CIMH integrates qualitative data collection in CariCOF events, using them as opportunities to understand user needs and preferences (e.g., focus group discussions on how sectors report climate impacts currently). Interviews with CIMH representatives indicate a genuine willingness to and interest in understanding of sector-specific breaking points and impacts, what are the characteristics of extreme wet spells or drought conditions that cause severe impact in the tourism sector.

The Tourism Climate Bulletin is one of the information products generated by the CIMH's wider consortium of regional agencies representing climate-sensitive sectors. The TCB is produced quarterly and is currently less than 10 pages long. It includes a review of the last quarter and brief climate advisories and outlooks for the Caribbean and source markets. The Caribbean climate advisory contains qualitative information about hurricane monitoring websites, as well as the normal range of wet and dry days/spells; the outlook for drought, temperatures, the UV index and coral bleaching are also briefly described. Actual forecast numbers, probabilities, graphics or maps are not included at present. Possible impacts of the climatic phenomena (e.g., increased demand for cooling/hydration) are suggested, and examples of measures that tourism stakeholders could take (e.g., precautionary conservation practices in the case of drought) are provided. Although several improvements to the TCB as a product are possible (see Section 6.3 of this report), interviews suggest that the process by with CTO, CHTA and CIMH work together to generate it is effective. Translation of the science and technical information into plain language (e.g., rainfall instead of precipitation) and simple messages for non-technical audiences is a critical process that enhances the salience and usability of the product.

National climate services are in development and capacity to provide tourism-specific messages in seasonal bulletins in increasing. Capacity of national meteorological and hydrological services is critical to the integration of climate information at local scales. In this regard, awareness and interest at the national level in building capacity for climate services is also a strength. National versions of CariCOF are emerging as national committees for climate services. Some national services are investing in additional training in climate forecasting, either by paying for an additional person to participate in regional events or by paying for CIMH to deliver training in country. A few examples also exist of national services transitioning from offering generic monthly bulletins, to producing bulletins with sections that deal specifically with tourism and other sectors. Grenada, St. Lucia, Dominica and St. Vincent and the Grenadines currently include tourism-specific messages in their climate bulletins. The regional Tourism Climate Bulletin is a model; national representatives from meteorological services directly use the contents of the TCB and adapt it to their own context and needs.

5.2 Weaknesses

Weaknesses include a short history of engagement between climate and tourism communities, partial understanding of the needs and preferences of tourism stakeholders and gaps in data collection / standardization and modelling capacity.

Globally, tourism is not a priority sector for climate services. Although tourism is not among the five priority climate-sensitive sectors under WMO's Global Framework for Climate Services, the sector is a priority in the Caribbean. By virtue of serving the tourism sector, the Caribbean has the potential to become a global model of how to develop and deliver tourism-relevant climate services. However, at the same time, the sector will not benefit from research, networking and best practices developed and shared through global initiatives. Within the region itself, representatives from the institutions interviewed recognize that historical ties between the weather / climate community have been greater with agriculture, water and disaster risk management and weaker with the tourism sector. Therefore, the willingness and openness to collaborate on climate services manifested by CIMH, CTO, CHTA and others in the tourism sector may take time to translate into tangible benefits, as the two communities undergo a period of discovery.

There is an incomplete understanding of the information needs and preferences of tourism-sector stakeholders. Relative to other climate-sensitive sectors dialogue between weather / climate professionals and decision makers in the tourism sector is in early stages. Therefore it is reasonable to expect that climate information providers might not yet have a solid grasp of the decision-making needs and communication preferences of tourism stakeholders and that tourism stakeholders are unlikely to be fully aware of the range of existing weather and climate information and its value. CTO and CHTA representatives assert that tourism stakeholders care more about weather (including extreme events) than climate, suggesting that information products that helped with preparedness and response are more relevant than climate products that inform long-term planning and decision-making. However, informal requests for information and advice received by CIMH from tourism operators indicate that there is also an unmet need for climate information to support adaptation. During the drought in 2010 CIMH received calls from hoteliers asking whether investing in desalination plants was a wise decision under future climate.

Awareness-raising on both sides of the climate services equation is necessary on a number of fronts. The demand side (i.e., tourism stakeholders) exhibits low awareness of the range of weather and climate information products already available. The low uptake of the TCB is partly due to low awareness of its existence, which indicates gaps in targeted dissemination. As well, the CIMH (through CariCOF) currently produces quarterly temperature outlooks for the region[15], which could be leveraged as a climate information product for the tourism sector. Additionally, CTO and CHTA representatives indicate a need to boost awareness of foundational aspects of climate products and services, such that users interpret the information and related uncertainty accurately. For example, one representative suggested that their members lacked understanding of what a forecast is.

On the supply side (i.e., climate information and service provider) efforts to understand and triage what climate products and tools would be most relevant and usable by tourism stakeholders are in early stages. As one CTO representative stated, *"ultimately for the tourism sector, at the private-sector level and minister of tourism sector-level, they want heads in beds and bums in seats. It's that concept of having more arrivals."* The TCB, although useful, does not provide information directly linked to tourism performance (arrivals, revenue, expenditures, foregone revenue) and so tourism stakeholders may fail to see the tangible value and benefit of this climate information product. This feasibility study, of course, represents a concrete effort to investigate options for climate-driven tourism demand modelling. Indeed, CIMH recognizes the need to identify climate thresholds and sector-specific impact indicators as key inputs into the development of a next generation of climate information products.

One additional aspect of discovery is deciding on target audiences within the broad audience of "tourism stakeholders". In its current form, the TCB is intended to have mass appeal, which is likely appropriate at this early stage of climate service development. Over time there may be value in audience segmentation (e.g., destination planners, tourism operators, international tourists) to improve the fit of products developed and efficiencies in engagement.

Finally, mobilization of and engagement with tourism stakeholders could be improved. At present, there is a heavy reliance on CTO and CHTA to perform knowledge translation and dissemination to their networks, and on individual technocrats participating in CariCOF events to share knowledge and insights

[15] https://rcc.cimh.edu.bb/temperature-outlook-july-august-september-2019/

with peers and policy/decision-makers. Although these channels are important and should be strengthened, achieving mutual understanding between climate and tourism communities will require more frequent and sustained contact between national tourism stakeholders and meteorologists / climatologists.

Some gaps in data and modelling capacity are evident. Climate and tourism data standardization (across nations, to regional level) is an ongoing challenge and one the consulting team became familiar with during this research project. Section 6.2.4 in this report includes recommendations to improve data standardization and interoperability, as a way of facilitating data analysis. From interview, we understand that a plan is in place for CTO to become data warehouse (i.e., single repository for all tourist statistics in the region). Although an initiative such as this would be beneficial it requires significant funding and so implementation may be slow.

Further, the lack of tourism data may be a constraint to the development of tourism-relevant climate products. CTO currently does not collect data on the impact of extreme weather / climate events on tourism operations. Tourism operators would be reluctant to share financial information, which would be necessary to generate tools linking climate and tourism business outcomes. In terms of barriers for tourism demand forecasting, CTO already has challenges in assembling timely data on tourism arrivals so use of this indicator to determine / characterize the health of tourism industry is a key consideration in scoping out such a modelling effort.

Regional capacity for forecasting climate variables at the sub-seasonal timescale (from two weeks to one month out) needs enhancement. All evidence indicates that this timescale is potentially beneficial to tourism stakeholders and so gaps in this regard may cause delays in engaging this sector. On the climate science side, CIMH is already working with the US National Oceanographic and Atmospheric Administration through CariCOF to strengthen sub-seasonal forecasting capacity.

5.3 Opportunities

Opportunities to continue making progress on developing climate products and services tailored to the tourism sector stem from (1) policy support and investments in capacity building, (2) the use of existing platforms to deepen understand across weather / climate and tourism communities and (3) learning from behavioural change initiatives in tourism.

Actions of individual champions are important in driving new initiatives but policy and other institutional supports, are necessary to sustain and grow these initiatives. It is clear from interviews with representatives from CIMH, CTO and CHTA that individuals are committed to working in an interdisciplinary way to support sustainable development of tourism through climate services. **The strong policy support for regional climate services development, including the development of the 2020-2030 roadmap, is clearly important to sustain research and engagement.** As mentioned previously and emphasized in Section 6 on Conclusions and Recommendations, co-developing sector-specific climate information products and services that deliver actionable information about the climate will require additional scientific research. As mentioned by a CIMH representative, "*being sector-specific means we have to be able to say things that are more directly targeting them and this has a lot has to do with understanding the links between climate and tourism, for example, is there a threshold in temperature, or other conditions, that would cause a tourist to leave Canada to go to Caribbean.*" A CHTA representative similarly emphasized that outlooks and forecasts need to credibly and convincingly reflect pathways of impact between climate and business outcomes. Research such as that undertaken through this feasibility study is necessary to explore those questions. The formation of consortium of lead technical agencies responsible for each of six climate-sensitive sectors, backed by 2020-2030 regional strategy can enable joint proposals looking for joint funding.

Funding is also necessary to build capacity and two current opportunities relate to a regional climate initiative and national budget allocations. At a global level funding to support capacity building for climate services has increased substantially over the past decade (WMO 2019). In the Caribbean and outside of annual CARICOM activities, the Pilot Program for Climate Resilience (PPCR) is funding activities to increase capacity in seasonal climate forecasting at a country level. This includes five days of training on the entire suite of suite of tools necessary from climate data management, to monitoring and seasonal forecasts for the country. It also includes two days of national consultations to initiate dialogue and priorities to set sector-specific climate services, demonstrating to national meteorological service staff the progress made at a regional level. CIMH has delivered these PPCR-funded activities in five countries (Dominica, Grenada, Jamaica, St. Lucia and St. Vincent and the Grenadines). Additionally, the importance of climate services is becoming recognized as a necessary investment from national budgets. In the last two years, representatives from CIMH have observed increased interest in and effort to start providing climate information to tourism. One concrete example is Guyana, which invited CIMH to have an exploratory discussion on climate services for tourism and health sectors.

Current engagement mechanisms can be further leveraged to bridge relationships between weather/climate and tourism communities. According to CIMH representatives the Tourism Climate Bulletin as a product and the process by which it is developed have been successful at catalyzing dialogue on how to better serve the tourism sector at the national level. This is a classic example of a "boundary object", a common point of reference that promotes communication among participants through the shared concepts and ideas embedded within (Lynch et al., 2008). Further use of the TCB is, therefore, an opportunity to create a shared language and conceptual framing around climate information to serve tourism adaptation needs. CariCOF meetings and spin-offs at the national level are also opportunities to continue to build relationships and familiarity between tourism stakeholders and regional and national climate representatives, for mutual discovery of what is possible to supply and what is of interest. Interests highlighted by CIMH, CTO and CHTA representatives include the following:

- How to capitalize on the demand from tourism stakeholders for information on the impact of Sargassum (hotel closures, arrivals, revenue), hurricanes and drought conditions. For example, on the issue of Sargassum, CHTA looking to work with University of South Florida's Sargassum Watch Systems and identify ways to make it more user friendly for tourism decision-makers.
- What weather / climate products and services (e.g., alerts) to leverage aimed at improving the tourism experience once in the region.
- How to expand tailoring of Coral reef watch and link it to the tourism experience.
- What climate indices (extreme cold, grey) in source markets (North America, Europe) CIMH should focus on and how to alert the tourist sector in the Caribbean to increase / target marketing efforts.

There are opportunities to learn from successes in improving sustainable practices in the tourism sector. Several sustainability initiatives have been implemented by the Caribbean tourism sector on a partnered basis, with donor funding. The regional climate consortium could build on some of the lessons learned in terms of cultivating partnerships across disciplines / sectors, demonstrating a value proposition, strategic communications and messaging and linking funding sources toward shared goals. Two specific initiatives mentioned during the interviews were in reference to uptake of energy efficiency measures in the hotel sector and managing crisis communications in the industry. CTO and CHTA representatives emphasized the critical importance of linking new practices (even consideration of different types of information) to the bottom line.

5.4 Threats

Threats that could derail progress made on developing climate products and services tailored to the tourism sector stem from (1) project-based finance; (2) weaknesses in knowledge translation / science communications; and (3) under-engagement by tourism decision-makers.

Lack of sustained funding for research and human resources limits agility and relevance of climate product development. Although there are signals of increased access to finance for development of climate services in the region, sources for the most part are tied to donor, project-based funding. A decreased ability to plan for the long term in light of potential interruptions in funding in turn means, for example, that CIMH is constrained in its capacity to hire and retain staff specialized in developing climate products; staff must work on multiple things. This reality detracts from the ability to tailor products through agile feedback cycles and demonstrate tangible progress in a short amount of time. Lack of donor coordination is another threat worth mentioning. Donor enthusiasm over building capacity in climate services is welcome. However, support organizations like CTO and CHTA can find themselves responding to requests to work on similar projects and to facilitate access to their memberships and networks. Duplication in efforts, in turn, represents a drain on resources, dilutes the message and the opportunity to mobilize attention and can lead to disappointment and unmet expectations if stakeholders' inclination to participate and engage wanes.

Fostering successful co-development of climate products between information producers and users presents several challenges (Climateurope, 2017). If left unaddressed, relevance and uptake of these products is at risk. In later sections of this report we provide recommendations on leveraging existing CariCOF products to cater to the information needs of tourism stakeholders. We also surmise that the contents in the Tourism Climate Bulletin be more detailed that what is currently offered. In contrast, a representative from CHTA emphasized that *"detailed technical information will not work; tourism operators need quick, concise information that speaks to the matter from their point of view."* Stakeholder engagement via an initial workshop and the limited number of interviews undertaken suggests that there is work to be done to identify the different user groups within the tourism sector, understand the nature and scope of their various information requirements and clarify appropriate modes of engagement (see Figure 30). CTO and CHTA fulfill a knowledge translation function as part of the co-development process in crafting editions of Tourism Climate Bulletins but as interest in climate information increases in the sector this centralized role could become too onerous to sustain.

Although tourism is a climate-sensitive sector engagement by tourism decision makers on climate risk management and resilience remains in early stages. Demand-driven efforts may take a while to materialize, and likely triggered by loss and damage incurred through climate-related disasters or climate change impacts. Interviews with CTO and CHTA indicate that the demand for climate information from private-sector tourism stakeholders is low. It may be somewhat higher for public-sector stakeholders given their mandate to promote the public good. Absent greater levels of engagement by sectoral stakeholders and practitioners the success of efforts such as the development of a quantitative demand forecasting model that considers climate alongside non-climate attributes as explanatory variables is not assured.

Figure 30: Three broad categories of engagement between users and providers of climate services (source: Hewitt et al., 2017).

6. Conclusions and Recommendations

6.1 Overview

This study contributes to CTO and CIMH's long-term vision of developing tailored climate-information products to support public and private decision-makers in the region's tourism sector. The TORs highlight that tourism is a climate-sensitive sector and that seasonal climate forecasts (SCFs) have the potential to help tourism stakeholders manage risks and exploit opportunities associated with weather-related fluctuations in demand (arrivals).

The study aimed at determining whether seasonal weather forecasts could be used to better predict tourism demand. The feasibility of this is contingent upon several factors, which were investigated:

- The potential for stakeholder uptake of a custom information product, which may be integrated into the existing TCB. To evaluate this, the research team reviewed previous work on uptake of climate information products by the sector, consulted stakeholders in a workshop setting and deployed an online questionnaire.
- The extent to which fluctuations in tourism arrivals (demand) could be accounted for by climate variability at either the tourism destination or source market. This involved (a) literature reviews on the application of TCIs and on the influence of weather on tourism arrivals; and (b) an analysis of historical relationship between arrivals for Caribbean destinations and weather variables (and TCIs) at destination and source markets (where suitable tourism data were available).
- Regional institutional capacity (CTO, CIMH and CHTA) to co-develop tourism-weather/climate information products to support the *long-term sustainability needs of the Caribbean tourism sector*.

We used the main findings of the study to explore the feasibility of developing a weather-driven tourism demand information tool. The construction of a tourism demand model was not within the scope of the assignment. The Feasibility Study can serve to guide further exploration of the potential for such a model. We have also highlighted feasible alternatives that could serve the more fundamental purpose of providing stakeholders with information about tourism demand and weather interactions that they could use to reduce risk and optimize performance and responsiveness of the sector to opportunities that may arise.

6.2 Suggested Next Steps

6.2.1 Focus on Source Markets

The recommendation to focus attention on source market weather is based in part that only mild to moderate correlations were found between in-country/destination weather variables and arrivals. Slightly stronger inverse correlations were found in respect of the Canadian markets and temperature at destination. This was reflected in the aggregate indices that were calculated (TCIs and HCIs), which also reflect the relative importance of temperature. It is likely that this inverse correlation coincides with and more accurately reflects increases in arrivals influenced by temperature at the source market. It is therefore recommended that further work use weather outlooks/seasonal forecasts at the source markets rather than those in-country.

At the final stakeholder presentation, it was suggested that market characterization by segment could yield optimized correlations with weather data at source. For example, it was pointed out that seniors versus young families may make decisions based on consideration of weather in different ways. Families are limited to certain holiday times and so are more influenced by institutional seasonality than seniors and retirees in particular. The differences in thermal comfort and 'unacceptable' conditions may also differ by age cohorts or other socio-demographic characteristics. Seniors may have a lower threshold for cold (cold intolerant) and lower threshold for heat (high heat risk). Families with young kids may also have lower high heat thresholds. Additionally, niche groups like surfers may also have different planning horizons and weather sensitivities.

Characterizing the market by segment may allow for greater optimization. However, key considerations for investing in this research direction include whether and how data for these segments can be routinely obtained, and whether the hypotheses about various segments can be tested. It should also be considered that the point of climate services is to devise a tool that would provide insight into the mass market and any changes that climate variability might cause, rather than advising the industry on micro-market segments, particularly with the data challenges in analyzing even the mass-markets.

6.2.2 Consider Alternative at-Destination Weather Parameters

The general lack of daily data needed to calculate TCIs for all destination countries for which arrivals data were available, indicates that it this would be an important constraint to the widespread development and use of TCIs in the Caribbean. An index-based approach, even if a strong relationship was found, is not feasible with current levels of data availability. Given the limitations of the TCI for arrivals predictions, particularly driven by source market weather, strong signals found with source market temperature and the lack of available data to construct TCIs for the more than 3 of the CTO member states, it is recommended that no further effort be spent on developing TCIs to predict demand. An alternative optimized winter severity index is proposed to be developed for source market characterization of the 'climate push' that influences seasonal demand.

It has been suggested by the CIMH that the relationship between arrivals and derived climate indices used by the Caribbean Regional Climate Centre /CIMH be explored (e.g., drought using SPI-6 and SPI-12 and of excessive rain using SPI-1, SPI-3 and SPI-6). It is recommended that this be included in a second phase of the research. However, generally speaking, awareness of drought / rain conditions by international tourists is likely low and influenced by media prominence (e.g., the prolonged drought in California or in Cape Town) or social media stories highlighting negative impacts on tourism experiences (e.g., shortages of water supplies at resorts). Indices such as the SPI can be tested, but we surmise that they are unlikely to have predictive value in terms of arrivals based on tourist decisions, choices and preferences.

6.2.3 Pilot Test a Winter Market Demand Outlook

The literature review found that the strongest weather signals (temperature in particular) in arrivals were related to the difference between source market climate and destination climate. This is consistent with the findings of this study, in which weather signals in the arrivals data were strongest in winter when the difference in temperature was greatest.

In terms of indicators of source market weather, the strongest correlation was between arrivals from and temperatures in Canadian source market; related indicators like number of days below zero (freezing days) and number of snow days were also found to have relatively strong correlations (Table 52). This correlation pertains to specifically to the winter season, with relatively strong correlations seen with the 1-year lag for temperatures and the shorter 1-month lag for number of freezing days.

Table 53 Summary of Significant Correlations between Barbados Arrivals and Selected Weather Variables (at Source Market)

	Mean Monthly Temperature				Number of Freezing Days		
Source Markets	No lag	12-mth	1-mth		No lag	12-mth	1-mth
British Columbia	0.699	0.692	0.628		0.067	0.088	0.091
Quebec	0.707	**0.745**	0.620		0.683	0.513	0.743
The Prairies	0.630	0.654	0.568		0.674	0.580	0.677
Ontario	0.637	0.693	0.562		0.433	0.304	0.530
Alberta	0.580	0.563	0.588		0.431	0.410	0.390
Atlantic Provinces	0.395	0.415	0.453		0.255	0.381	0.301

For future work, it is recommended that the analysis of time lags be expanded to include the 3-month and 6-month lags. It is also recommended that further exploration of a weather-driven tourism demand model focus on winter season temperatures in Canada and possibly other markets located above the 40^{th} parallel (including the more northerly markets in the US and Europe). Based on the strength of the results of correlations between source temperature and arrivals data we recommended to pilot a seasonal arrivals outlook for Canadian winter source markets. An extension to this model is to develop and validate an optimized index of individual weather variables for the Canadian market – a "winter push index"—with improved explanatory power. The research team initiated conceptualization of such an optimized index but its completion was beyond the time and budget available for this consultancy. Preliminary results for Ontario (for arrivals to all six destinations) suggest that arrivals correlate most strongly with source-market weather temperature data. The analysis for the Ontario market is consistent with the hypothesis and past work (Scott, personal communication) exploring the relative influence of climate from source markets on Jamaica and Barbados arrivals (i.e., R^2 increased from Gulf states, mid to northern States, highest in Canada). It is recommended that this work on the Ontario winter market be continued as an important next step to determine potential for climate information services. Climate information services could provide an advisory for future pricing. We recommend producing one outlook for the Caribbean region as a whole using temperature data from Canadian source markets (AB and BC in the west and ON and QC in the east) from the previous year (i.e., 12-month lag) as well as the seasonal forecasts.

It is noted that the number of sunshine hours per day at the source market may be another winter parameter that could be investigated in terms of potential correlation with tourism demand and flows to Caribbean destinations. For example, Barbados has a winter solstice (shortest day of the year) with 11 hours and 21 minutes of daylight compared to less than 8 hours of daylight on this day in many northern locations; moreover, the amount of actual bright vitamin-D generating sunshine during the winter daylight hours may be severely constrained by cloudiness. It is possible that lower levels of sunlight as well as shorter days could also influence tourism demand, with vacation at lower latitudes being a consideration to offset Seasonal Affective Disorder (SAD). It is also noted that there may be less variability in these parameters than with temperature so it is unlikely that there would be a specific signature in the data that a climate service could forecast. The extent to which SAD or these sunlight parameters are drivers of Caribbean tourism demand will require additional data to be collected and more attention to research design.

6.2.4 Use of a Reference Country

Historic data and analyses were done for 6 of the CTO's 30 member states where suitable tourism data was available. A keen observation raised at the final stakeholder presentation was the fact that the 6 destinations for which empirical analyses were done were not representative of the geographic spread of CTO members states, with five of these being from the Eastern Caribbean (Grenada, St Lucia, Barbados, St Vincent & the Grenadines and Antigua & Barbuda) and the other being Jamaica in the northern Caribbean. It was noted that different statistical relationships between weather and tourism demand may be obtained for mainland countries like Belize and Guyana.

How can the findings of this study be useful to the broader CTO membership? Given the lack of available destination specific data at this time, one option may be to use one of the six countries for which data is easily available as a reference country. Other CTO members can track the demand outlooks for the reference country as a guide as to how their own demand might vary from norms. Jamaica had the largest tourism industry of all the 6 countries examined, accounting for 72% of all arrivals from the North American markets to the 6 countries that were studied (Figure 29). However, in determining a representative reference country, it may be important to consider the relative importance of source markets as the North American market is much more important to Jamaica than it may be to other smaller destinations.

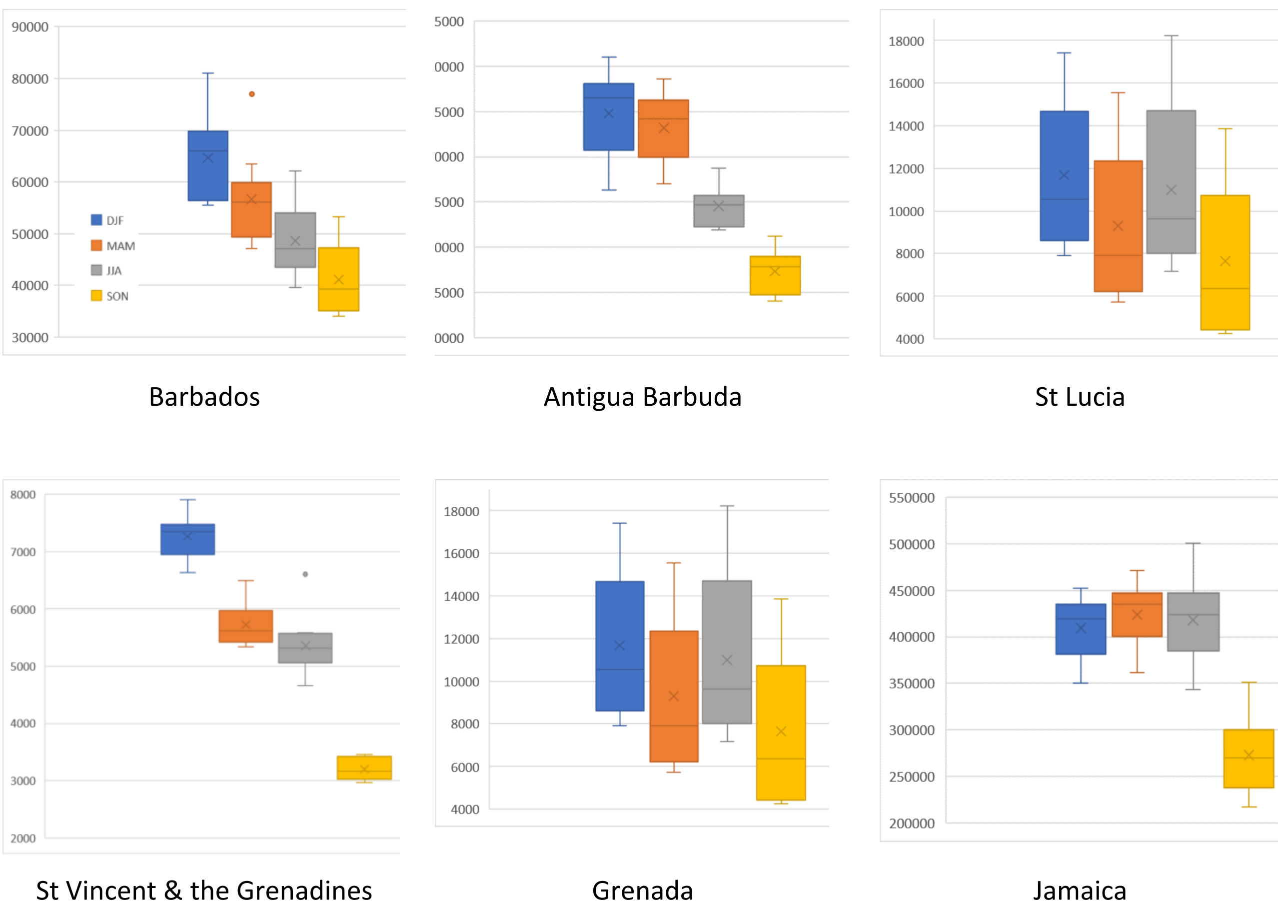

Figure 31 Comparison of Seasonality in Arrivals in the 6 destination countries

Jamaica also differed from the 5 other countries as it had a summer tourism peak, which was close to spring and winter seasons, and a notably lower fall low season. The remaining 5 destinations were all

English-speaking Eastern Caribbean states. Of these, Barbados had the largest tourist sector, with 40% of all arrivals to these 5 countries. Barbados was also fairly representative in the spread of its quarterly arrivals with a distinct winter peak. Barbados may therefore arguably be a better reference country for predicting tourism outlooks.

Should the CTO/CIMH wish to explore the option of having each member country have its own quarterly outlook, we strongly recommend that steps be taken to improve data management and interoperability, for example:

1. Provision of a 'data dictionary' that outlines explicitly what each file contains. For example, it was not always clear what each file contained or whether the values were inclusive of expats or not.
2. Development of a consistent template for storing and sharing both the tourism data and the climate data. Each data file from each country was slightly (or significantly) different from one another. CTO members should be encouraged to adopt common arrivals data collection procedures that would facilitate this work, but likely many other forms of tourism research.
3. More routine updating of summary files and collation of country level data sets. i.e., to the monthly level or to the regional level.
4. Development of an inventory for data completeness/incompleteness and the reason, dates, and significance of data gaps. This will save time in the future so individuals do not spend their time looking for data that do not exist.

6.2.5 Phase 1 Publications

We recommend that the following papers can be collaboratively drafted for publication based on the outcomes of this study:

1. A paper related to the stakeholder surveys on climate services perceptions, needs and uses, which would be targeted to Climate Services.
2. An empirical paper should focus the strongest analysis and contribution to the scientific and professional literature, which is the ongoing analysis of the Ontario market. This paper would also outline the comparisons of the different indices constructed and the optimization analysis, the latter is a continuation of this feasibility study. Possible journals include journals focused on climate services or tourism management. Key messages could be the differential role of destination/source market climate (for 3S driven markets) and varied geographical influence, inter-comparison of indices, resulting caution of previous studies using indices for climate change studies, additional work needed to develop climate service applications (i.e., refer to optimization approach and other promising approaches) and possible application for understanding impact of climate change on future demand to the region.

6.2.6 Explore using a multi-factor analysis for source markets with weaker climate signals

Several studies exploring climate-weather signals in tourism demand concluded that non-climate drivers were very important (e.g., Pokharel *et al* 2017; Zhang and Kulendran 2017). This is also consistent with the feedback we received from the stakeholder workshop. It is recognized that the US is by the more important of the two North American markets (accounting for 76.5% of all N. Am tourists travelling to the six destination countries between 2008 and 2017). This study found that correlations between the US source markets weather parameters and arrivals from those source markets were generally weak to moderate. New York accounted for 15.3% of all arrivals to the six destinations between 2008 and 2017, and Florida (with a climate very similar to the Caribbean) accounted for the second largest single source market in the US (11.1%). Each of the remaining states accounted for less than 5% of the total US arrivals. It is unlikely that a robust weather-driven arrivals model could be developed on this basis, and it is therefore recommended that a US-based tourism demand model should take into account non-climate factors such as:

- At source market: population size, distance from destination, income, calendar events.
- At destination: security, substitutability (competitive advantage), airlift availability; destination loyalty, marketing, products.

With the exception of the Canadian winter market, this study confirms stakeholder feedback that non-climate factors are more important drivers of inter-annual tourism demand than weather variables. The findings of these studies suggest that a multi-variate analysis that includes but is not restricted to climate factors may be the most feasible approach to explaining regional tourism demand in the Caribbean.

Additionally, we recommend further exploring two hypotheses. First, we hypothesize that a change in trip planning occurred in the mid- to late-2000s, which is influencing sensitivity to climate variation in arrivals data. Last-minute bookings are likely more influenced by weather conditions at source markets and this may explain weaker than expected climate signals in arrivals data from northern US sources. In addition to changes in online booking options, changes in visa/passport requirements may have also contributed to this observed change. Second, we hypothesize that business models of Caribbean tourism operators have decreased the seasonality of arrivals to the region. This includes adopting pricing strategies that bring more people to Caribbean destinations in the summer (traditionally “off peak”). This has been a strategy of some operators/countries and has also occurred in the Mediterranean, where resorts that used to close in the winter are now year-round operations. Disentangling the masking impact of pricing on arrivals data requires analysis of historical climate and pricing information.

A point of caution is the fact that arrivals patterns, like climate data, are non-stationary. Although the Canadian market showed a relatively strong weather signal for the period 2008-2017, other factors are likely to exert significant influences on trip planning and destination choice in the future, and the strength of the correlation may weaken or strengthen. It is also important to take into account the fact that tourism operators adjust prices to forecast demand, and this practice in part masks the demand signal of climate variability. To fully understand the impact of climate variability on tourism demand, data on price adjustments would be needed along with the arrivals data.

6.2.7 Improve understanding of how extreme weather and related disruptions affect arrivals

Our review of the literature and stakeholder feedback suggests that the disruptions associated with extreme weather events (both at source market and destination) may represent the strongest weather signal in arrivals data. Although Accumulated Cyclone Energy (ACE) has potential as an indicator that could be correlated with arrivals data, it does not take into account the impacts of the net storm energy. Therefore, a year with several Category 4 and 5 storms that largely stay out in the Atlantic would have a high ACE, but impact on tourism demand would be next to zero if there was no Caribbean landfall (or forecast landfall). Another limitation on the potential usefulness of the ACE is that it is calculated after the year is over so a one-year time lag would automatically apply. It is possible that the effects of extreme events are lagged by periods of less than 6-months, after which there may be substantive recovery. It should also be emphasized that the ACE does not examine specific storm events impacting specific destinations.

It is likely that direct effects of individual storms on specific destinations would have more direct effects on arrivals. We recommend examination of impacts (immediate and lagged by different intervals) of direct landfall and 'near neighbour' (which would have been in forecast/warning zones) as well as investigation of intra-regional 'deflections' to other destination countries. It would be most useful to obtain arrivals data for 2000 to 2019, given recent major storms and because more recent years include the influence of social media and newer post-event communications strategies. It would also be valuable to undertake a case study of tourism recovery and resilience in countries directly impacted during this period. A robust analysis needs to look at landfall / land impact, magnitude of these storms and tourism responses. Our hypothesis is that category 1-3 storms create disruptions to tourism and recovery can occur within weeks, with impact on arrivals limited to the month of the storm and month after and to countries in and near the actual and forecast storm track. Conversely, more intense storms are likely to affect arrivals in that season and, in some cases, multiple seasons afterward.

Important questions remain about tourists' perceptions about the spatial extent of hurricanes, and geographic transfers of demand during, immediately after and long term (intra- and inter-regional). Stakeholders felt that in the event of disasters impacting one or two islands, the One-Caribbean branding strategy works against the region, as buyers potentially view Caribbean as uniform even when only one island (or part of a country, as in the recent Bahamas experience) is impacted. Where markets are characterized by the use of travel agent services, there may be intentional diversion of demand by travel agents to areas with capacity or unaffected areas. Other research suggests that media coverage in the wake of extreme events can negatively influence tourism arrivals (e.g., Scott and Lemieux. 2010).

Perhaps a more useful concept to consider in developing climate information products is the idea of a holiday risk, and what factors influence travellers' behaviour in respect of reducing the risk of losing their holiday or having a bad holiday as a result of weather variables. According to Laframboise *et al.* (2014), a Caribbean holiday is considered to be a relatively expensive one, and the risk is therefore higher, particularly when this is coupled by the perceived probability of an extreme event adversely impacting the holiday. Very clear strategic responses (including information on insurance options) can be developed by tourism planners to guarantee holidays or compensation for weather-impacted holidays.

6.3 Climate Information Products

Although there is evidence of a low level of uptake of climate information products (Appendix 6 includes a list of information products included in the survey by Edwards, 2018), stakeholders have reported that they do use weather information in various ways for strategic planning and risk reduction. Based on stakeholder feedback and literature, we recommend two main pathways to improving delivery of climate information to the tourism sector in the region. One is to identify and remove barriers to uptake. The second is to ensure that information products suit the needs of the users.

6.3.1 Improving Uptake

Low demand for climate-information products by tourism planners and operators is not unique to the Caribbean. Low levels of risk awareness, a lack of sense of urgency (in relation to climate variability and change) and limited understanding of the tools available characterize the tourism sector in Europe (Damm et al., 2019), for example. Stakeholders reported consulting forecast information from hours to 2 weeks in the future. They also reported relying on information about weather conditions in both source markets and from within the region. It should be noted that the latter may be consulted to plan for supply-side actions (tourism product investment and development oriented) as opposed to demand-side planning (more marketing oriented) and this was not differentiated in the study.

Awareness of what information products are available is a key determinant of uptake in the Caribbean. If a new product is launched it will be important to demonstrate it to the stakeholders at regional meetings and to include additional information in sectoral websites, newsletters and twitter feeds. Increasing awareness of this study's findings that high latitude winter markets (Canada) are likely to be more influenced by weather related factors also need to be effectively communicated so that stakeholders understand the risks and opportunities involved.

Another reason for lack of use of the available information product may be that the product itself is not perceived as suitable to the needs of the users, which would be related to the secondary point of ensuring that products are industry-tailored. This is a common limitation in climate services across economic sectors and is further discussed in the following section.

6.3.2 Tailoring the TCB

The main climate information product in the Caribbean is the Tourism Climatic Bulletin (TCB) which is jointly authored by the CTO and CIMH. Although TCB was reportedly one of the most used tools in the Edwards (2018) survey, more than two thirds of survey respondents indicated low or no usage. However, low usage of the TCB does not mean that tourism stakeholders ignore weather/climate information.

The current TCB is broadly scoped to encompass potential information needs of destination planners and tourism operators. This "sector wide" approach may be less effective than specifically designing the information product to align with the decision needs of more targeted users. Moving toward a tailored approach includes consideration of business planning cycles (seasonal versus day-to-day operations) and required levels of sophistication in the information, interpretation and advice provided. This study revealed that tourism stakeholders *are* using weather / climate information already; therefore, the opportunity exists to deepen understanding of who uses what, how, why and for what segment of users could the TCB could make the most difference. For example, it is possible that tourism stakeholders savvy enough to use an intra or extra-regional seasonal forecast can find it themselves already through publicly-available portals[16] and will not switch to the TCB unless it provides added value in the way of additional interpretation and actionable advice, for example.

This research also indicated that there is a need for quarterly outputs that are specifically tailored to the needs and capacity of the users. This is consistent with recent research in the Fijian tourism sector (Nalau *et al* 2017), which found that products that best support stakeholder needs are designed through an understanding of **what they consider useful** given their needs, and **capacity to access, use and evaluate** the validity of the information. It is emphasised that the **stakeholder capacity** to access and use information is different from the institutional capacity to produce and deliver information products. A related recommendation is to explore the information communication technology (ICT) skills / capacity of the target group is required to ensure information is suitably tailored to be useful.

In the case of the Caribbean, it is hypothesized (based on stakeholder feedback) that operational level stakeholders would value:

[16] See, for example: https://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/

- Information that affects the last-minute weather-influenced buyers. This information would allow stakeholders to offer deals to these buyers.
- Actionable advice. Most stakeholders likely know where to get weather information on source markets. What would be considered valuable would be less generic measures that could be implemented based on outlooks for the upcoming winter season.

A preliminary list of action items that can be included in the TCB is given below (Table 53), with the assumption that a more severe winter in source markets will result in a higher than normal winter tourism demand throughout the region, and a milder winter will produce a lower than normal winter tourism demand. It is expected with optimization and further development of a winter market tourism demand model this relationship can become more refined. It should also take into account that based on historic trends, there is an annual average growth in the number of arrivals to the region.

Table 54 Preliminary List of Responses to Winter Market Forecasts

	More Severe	Milder
Pricing adjustments	• Higher prices based on demand pressure at affected source • Reduce availability quotas to other source areas	• Maybe lower prices to be more competitive.
Airlift negotiations	• May need to increase number of flights between key sources and destinations. • *Plan for delays and cancellations due to severe weather at airport hubs • Ensure adequate airport and transfer capacity	
Marketing & Advertising campaigns	• Stronger marketing in affected geographies – higher latitudes • Advertising should be more climate-focused enhancing weather difference between the destination and market	• Focus on less climate-driven source markets such as lower latitude US / Europe and regional markets • Focus less on weather related advertising – non-climate push and pull factors – e.g. destination events, experiences, tours etc.
Holiday risk offerings	• *It may be necessary to encourage airline flight risk insurance for delayed or cancelled flights due to storms at source or along flight paths	• Emphasize value propositions – discounts, 'free tours', special packages etc. • Satisfaction guarantees • Carbon off-setting to alleviate 'climate guilt' – this can include arrangements with airlines that offer carbon offsetting as well as mitigation programs at the destination and within the hotel
Supply-side adjustments	• Optimize staffing and resources • Ensure maximum capacity for accommodations and other offerings • Spill-over arrangements	

**Winter storms may be forecasted within a matter of days and may occur even when milder winters are predicted. They may also be related to negative Arctic Oscillation (AO) phases, which are associated with frigid air (commonly called polar vortices) and storms*.

The current study supports further development of a weather-driven Canadian winter market outlook, which likely represents less than a quarter of the North American market for most destinations. Other destinations may be more focused on the European winter market so expansion of the study to include the higher latitude European destinations would also be important to some.

The TCB currently advises users to monitor hurricane advisory websites and provides brief descriptions of the UV index and coral bleaching. CTO/CIMH should consider mining information resources available on the US National Oceanic and Atmospheric Administration's (NOAA) Climate Prediction Center and other credible sources[17] to provide summaries of outlooks and value-added discussion of implications of the formation of major weather systems in the region or in source markets and other biophysical phenomena likely to affect tourism markets in the region. The Government of Canada houses extensive temperature datasets of historic and forecast climate data, which can be downloaded for different provinces.[18] Users have different data and information needs and, therefore, the outlook should be provided in various formats (e.g., maps, tabular data or graphics based on post-processed information).

We recognize that regional tourism stakeholders may already be accessing outlooks and warnings from international sources but there is value in the TCB being a "one-stop shop". Outlooks for cyclonic activity and *Sargassum* blooms (which are referred to in the TCB) should also be discussed with clear advice on what can be done to offset negative media framing and other influences on travellers' decisions to choose the Caribbean.

6.3.3 Alternatives to the TCB

The TCB's current publication frequency may not serve the needs of tourism operators who opt for higher-frequency information sources. Therefore, CTO/CIMH should also consider whether and how to deliver weather alerts and early warnings to tourism operators / marketers for the shorter term (less than 90-day outlooks). Regional and national initiatives with the University of the West Indies regarding climate information services and early warning have been helpful in developing emergency response tools for the fisheries sector and crowdsourcing citizen science for community resilience. Specifically, the FEWER App, which was commissioned by the Caribbean Regional Fisheries Mechanism, may provide a useful platform on which to build, particularly for tourism activities occurring in coastal and marine environments. This can potentially be considered as a next step in the development and delivery of relevant climate information products.

The European Tourism-Climate Service Copernicus[19] provides a valuable case study in the delivery of higher frequency information services. Copernicus tweets on a daily basis and offers an emailed newsletter subscription (fortnightly), providing users with valuable current indicators information. There are also user forums that encourage strategy and information sharing amongst stakeholders. Copernicus specifically uses the HCI in relation to climate change projections about how tourism suitability will likely change. It is intended to help with seasonal marketing and longer-term (> 2 years) investment strategies.

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[17] For example, the *Sargassum* Watch System: https://optics.marine.usf.edu/projects/SaWS.html

[18] http://climate.weather.gc.ca/prods_servs/cdn_climate_summary_e.html
https://weather.gc.ca/saisons/prob_e.html

[19] https://climate.copernicus.eu/european-tourism

6.4 Longer-Term Analyses – Climate Change

The TORs for this assignment noted that Caribbean tourism is considered a climate-sensitive sector, and that there is a need for the sector's strategic planners to engage in climate-risk management. It is envisaged that climate information could be used to reduce the risks associated with weather variability. Although the TORs did speak to the broader issue of climate change and variability, the research focused on *weather* forecasting (monthly, quarterly and up to one-year) and did not extend to *climate* forecasting, which would extend beyond 2-years (see Appendix 1 for WMO forecasting definitions). Thus, climate change and variability were not included in the analysis of tourism arrivals. It is also important to note that increased climate variability and the occurrence of extreme hydrometeorological events beyond normal or historic magnitudes and frequencies are projected impacts of climate change in the region. It may be useful to offer planners climate information products that relate to climate change impacts on specific destinations and the likely effect of these impacts on tourism arrivals to the region.

It is important to note that climate change may cause changes in the length, timing and intensity of the winter season. For example, there might be heavy snow fall or snow storms and lower temperatures or ice storms occurring earlier in the Fall or Spring or more frequently in the winter months. Or it may be that winter may milder and shorter in more years, which could result in a lower winter season demand in the Caribbean. Projections of the expected changes in each season are available and this information can be linked to existing forecasting and tourism demand outlooks, particularly for the winter season when there is a stronger push for travellers. How changes in climate (both at destination and source markets) interact with climate impacts on Caribbean tourism assets and infrastructure as well as other major drivers of tourism in the region remains an important area of future research that is recognized by major tourism organizations including CTO[20], UNWTO[21], WTTC[22] as well as the scientific literature (e.g. Layne, 2017 and Scott et al 2011).

[20] https://www.onecaribbean.org/content/files/DavosReportOverviewDanScott.pdf

[21] UNWTO 2018. Regional Seminar on Climate Change, Biodiversity and Sustainable Tourism Development. Final Report. Fiji. 2018. https://www.e-unwto.org/doi/pdf/10.18111/9789284420155

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Appendix 1: Definitions of Meteorological Forecasting Ranges

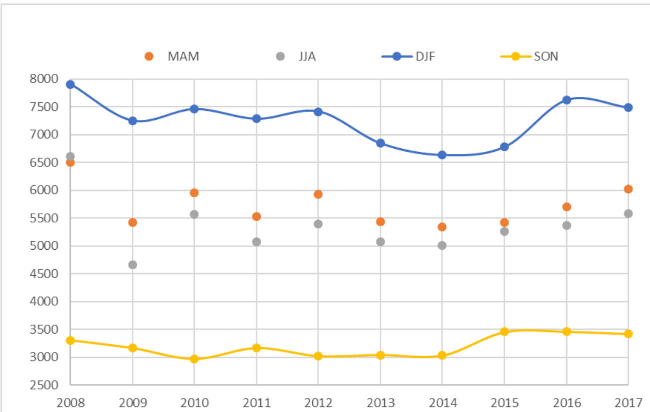
1	Nowcasting	A description of current weather parameters and 0 -2 hours description of forecasted weather parameters
2	Very short-range weather forecasting	Up to 12 hours description of weather parameters
3	Short-range weather forecasting	Beyond 12 hours and up to 72 hours description of weather parameters
4	Medium-range weather forecasting	Beyond 72 hours and up to 240 hours description of weather parameters
5	Extended-range weather forecasting	Beyond 10 days and up to 30 days description of weather parameters, usually averaged and expressed as a departure from climate values for that period.
6	**Long-range forecasting**	**From 30 days up to two years**
6.1	Monthly outlook	Description of averaged weather parameters expressed as a departure (deviation, variation, anomaly) from climate values for that month (not necessarily the coming month).
6.2	Three month or 90 day outlook	Description of averaged weather parameters expressed as a departure from climate values for that 90 day period (not necessarily the coming 90 day period).
6.3	Seasonal outlook	Description of averaged weather parameters expressed as a departure from climate values for that season.
7	Climate forecasting	Beyond two years
7.1	Climate variability prediction	Description of the expected climate parameters associated with the variation of inter-annual, decadal and multi-decadal climate anomalies.
7.2	Climate prediction	Description of expected future climate including the effects of both natural and human influences.

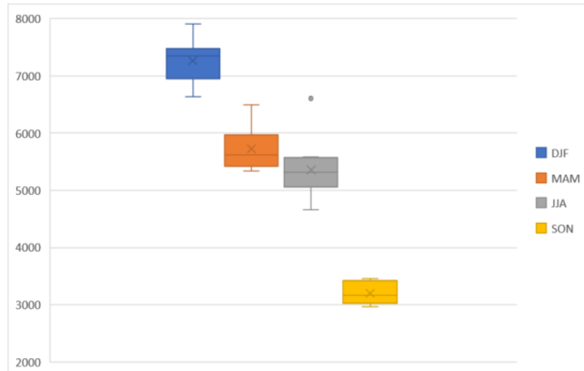
Notes: ***(1)*** ***In some countries, long-range forecasts are considered to be climate products***

(2) ***Season has been loosely defined as Dec/Jan/Feb = Winter; Mar/Apr/May = Spring; etc…in the northern hemisphere. In the tropical areas, seasons may have different durations. Outlooks spanning several months such as multi-seasonal outlooks or tropical rainy season outlooks may be provided.***

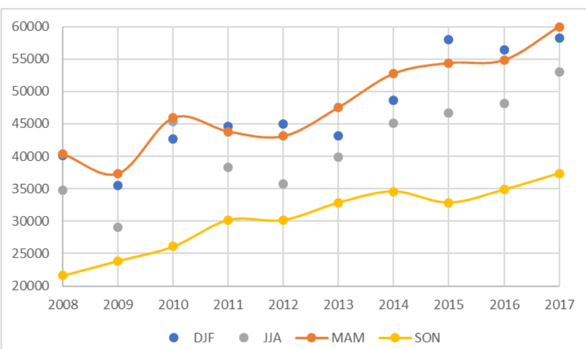
Source: World Meteorological Organization. https://www.wmo.int/pages/prog/www/DPS/GDPS-Supplement5-AppI-4.html

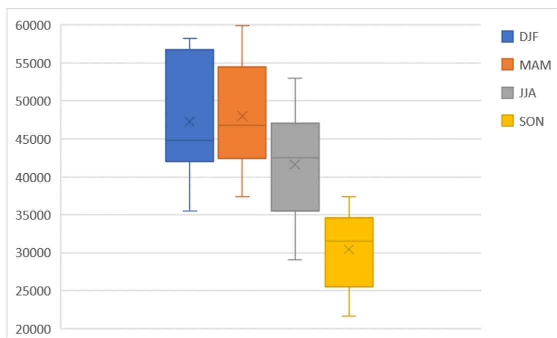
Appendix 2: Characterization of North American Arrivals to Destinations (Quarterly Trends 2008-2017)



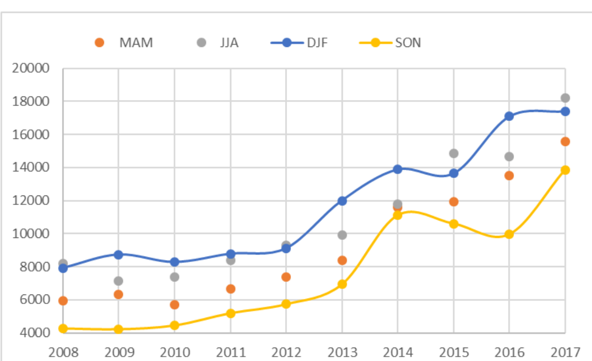


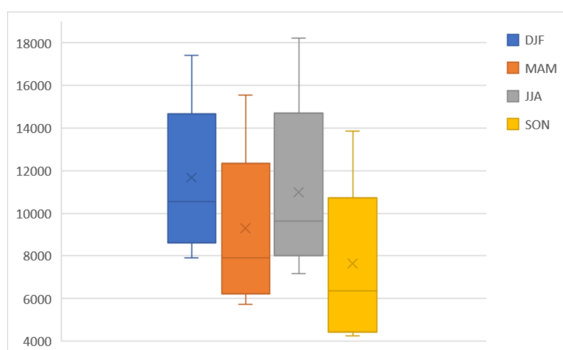
SVG (a) Quarterly Trends (2008-2017) and (b) Quarterly Distributions



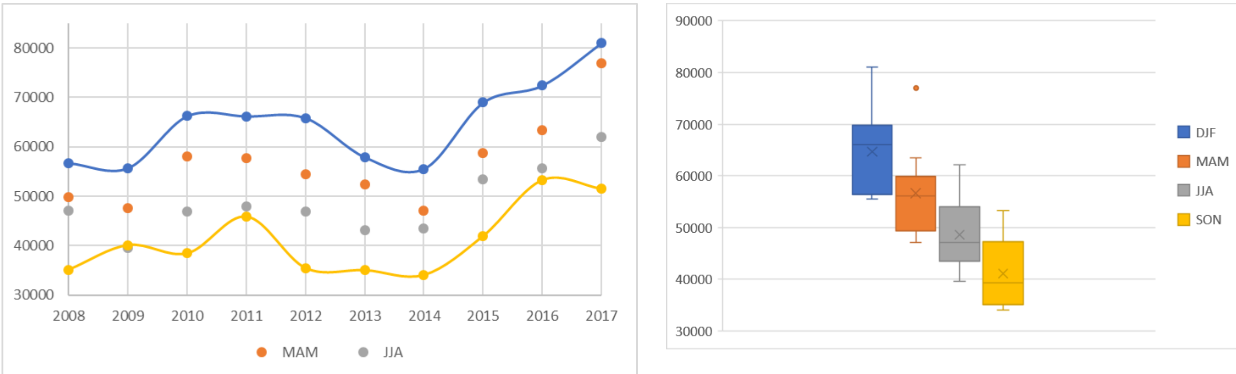


STL (a) Quarterly Trends (2008-2017) and (b) Quarterly Distributions

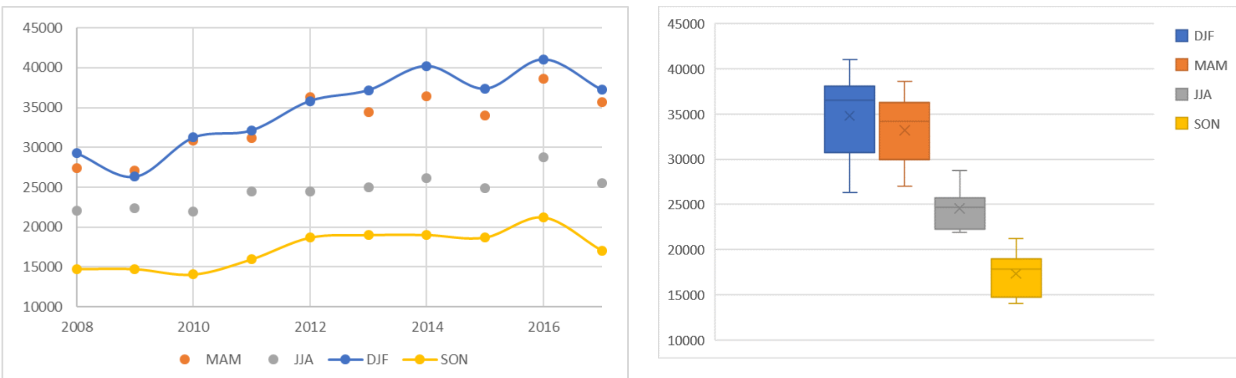




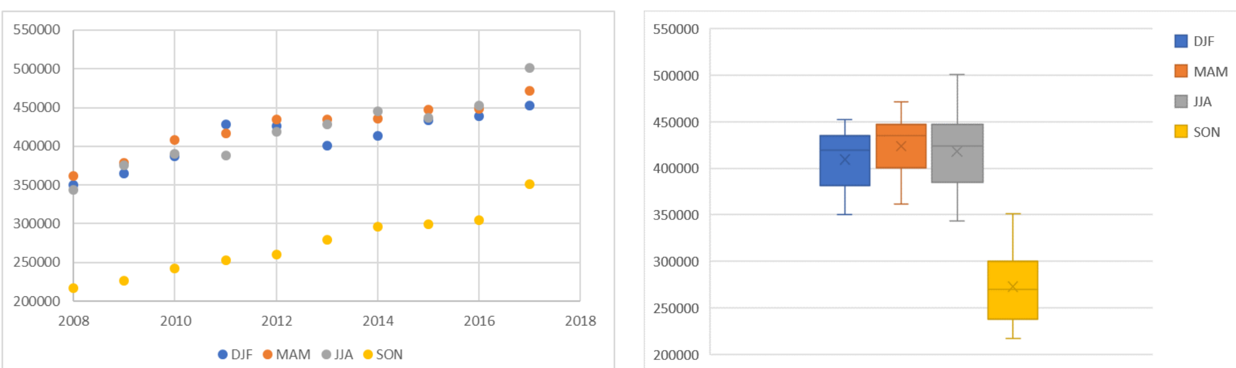
GDA (a) Quarterly Trends (2008-2017) and (b) Quarterly Distributions



BDS (a) Quarterly Trends (2008-2017) and (b) Quarterly Distributions



ABA (a) Quarterly Trends (2008-2017) and (b) Quarterly Distributions



JAM (a) Quarterly Trends (2008-2017) and (b) Quarterly Distributions

Appendix 3: Source Market Selection

Total tourism departures from each American State from 2008 – 2017

State	Total Departures		% NA tourists	State	Total Departures	% NA tourists
USA TOTAL	**15,931,478**		76.5%	OREGON	132,475	0.6%
NEW YORK*	2,439,847		11.7%	MAINE	119,723	0.6%
FLORIDA*	1,760,701		8.5%	ALABAMA	118,444	0.6%
NEW JERSEY*	789,685		3.8%	LOUISIANA	117,803	0.6%
PENNSYLVANIA*	788,332		3.8%	KENTUCKY	110,541	0.5%
NEW MEXICO	679,690		3.3%	ARIZONA	107,858	0.5%
CALIFORNIA*	650,906		3.1%	VERMONT	102,146	0.5%
MARYLAND	645,561		3.1%	WASHINGTON	94,882	0.5%
TEXAS*	610,338		2.9%	KANSAS	94,626	0.5%
GEORGIA	609,321		2.9%	NEBRASKA	85,215	0.4%
ILLINOIS*	608,717		2.9%	OKLAHOMA	83,853	0.4%
MASSACHUSETTS	434,386		2.1%	DELAWARE	76,251	0.4%
CONNECTICUT	412,010		2.0%	RHODE ISLAND	66,770	0.3%
VIRGINIA	393,788		1.9%	IDAHO	63,634	0.3%
OHIO	341,877		1.6%	NORTH DAKOTA	62,811	0.3%
MICHIGAN	339,218		1.6%	MISSISSIPI	62,191	0.3%
NORTH CAROLINA	329,390		1.6%	NEVADA	59,511	0.3%
TENNESSEE	290,692		1.4%	ARKANSAS	53,604	0.3%
WISCONSIN	289,862		1.4%	SOUTH DAKOTA	50,718	0.2%
D.O. COLUMBIA	287,939		1.4%	UTAH	41,398	0.2%
NEW HAMPSHIRE	241,194		1.2%	WEST VIRGINIA	38,800	0.2%
MINNESOTA	226,895		1.1%	MONTANA	17,418	0.1%
INDIANA	209,865		1.0%	WYOMING	12,063	0.1%
MISSOURI	206,688		1.0%	ALASKA	7,161	0.0%
COLORADO	159,451		0.8%	HAWAII	6,756	0.0%
SOUTH CAROLINA	146,009		0.7%	OTHER	389	0.0%
IOWA	137,741		0.7%			

* Selected State for analysis

Total tourism departures from each Canadian province from 2008 – 2017

Province	Total Departures	% NA tourists		Province	Total Departures	% NA tourists
CANADA TOTAL	**4,893,797**	**23.5%**		NOVA SCOTIA	115,273	0.6%
ONTARIO	3,068,096	14.7%		PEI	11,373	0.1%
QUEBEC	667,595	3.2%		NEW BRUNSWICK	63,838	0.3%
ALBERTA	358,520	1.7%		NEWFOUNDLAND	56,499	0.3%
B.COLUMBIA	177,305	0.9%				
				SASKATCHEWAN	109,696	0.5%
OTHER (NT/NU/YT)	6,199	0.0%		MANITOBA	109,108	0.5%
NOT STATED	27	0.0%				

Appendix 4: Facet Rating Schemes

Thermal comfort Facet Rating Schemes

TCI		**HCI: Beach**		**HCI: Urban**	
Rating	Daily Temperature (°C)		Rating	Temperature (°C)	Rating
0	≥36.0	≥39.0	0	≥39.0	0
		38.0 - 38.9	2	37.0 - 38.9	2
1	35.0 - 35.9	37.0 - 37.9	4		
2	34.0 - 34.9	36.0 - 36.9	5	35.0 - 36.9	4
3	33.0 - 33.9	35.0 - 35.9	6		
4	32.0 - 32.9	34.0 - 34.9	7	33.0 - 34.9	5
5	31.0 - 31.9	33.0 - 33.9	8	31.0 - 32.9	6
6	30.0 - 30.9	31.0 - 32.9	9	29.0 - 30.9	7
7	29.0 - 29.9	28.0 - 30.9	10	27.0 - 28.9	8
8	28.0 - 28.9	26.0 - 27.9	9	26.0 - 26.9	9
9	27.0 - 27.9	23.0 - 25.9	7	23.0 - 25.9	10
10	20.0 - 26.9	22.0 - 22.9	6	20.0 - 22.9	9
9	19.0 - 19.9	21.0 - 21.9	5		
8	18.0 - 18.9	20.0 - 20.9	4	18.0 - 19.9	7
7	17.0 - 17.9	19.0 - 19.9	3	15.0 - 17.9	6
6	16.0 - 16.9			11.0 - 14.9	5
5	10.0 - 15.9	18.0 - 18.9	2	7.0 - 10.9	4
4	5.0 - 9.9	17.0 - 17.9	1	0 - 6.9	3
3	0.0 - 4.9	15.0 - 16.9	0		
2	−0.1 - −5.9	10.0 - 14.9	-5	−0.1 - −5.9	2
0	−6.0 - −10.9	≤9.9	-10	≤−6.0	1
−1	−11.0 - −15.9				
−2	−16.0 - −20.9				
−6	≤−21.0				

Aesthetic facet rating schemes for cloud cover

TCI			**HCI: Beach**		**HCI: Urban**	
Rating	S-hours	CC (%)*	CC (%)	Rating	CC (%)	Rating
10	10	0.0-16.6%	0-0.9%	8	0.0-0.9%	8
9	9	16.7-24.9%	1.0-14.9%	9	1.0-9.9%	9
8	8	25.0-33.2%	15.0-25.9%	10	11.0-20.9%	10
7	7	33.3-41.6%	26.0-35.9%	9	21.0-30.9%	9
6	6	41.7-49.9%	36.0-45.9%	8	31.0-40.9%	8
5	5	50.0-58.2%	46.0-55.9%	7	41.0-50.9%	7
4	4	58.3-66.6%	56.0-65.9%	6	51.0-60.9%	6
3	3	66.7-74.9%	66.0-75.9%	5	61.0-70.9%	5
2	2	75.0-83.2%	76.0-85.9%	4	71.0-80.9%	4
1	1	83.3-91.6%	86.0-95.9%	3	81.0-90.9%	3
0	0	≥91.7%	≥96.0%	2	91.0-99.9%	2
					100.0%	1

*S-hours=sunshine hours; CC%= percentage of cloud cover. Sunshine hours were not available so the CC% were transformed to hours of sunshine

Physical facet: precipitation rating schemes

<table>
<tr><th colspan="2">TCI</th><th colspan="2">HCI: Beach</th><th colspan="2">HCI: Urban</th></tr>
<tr><td>Rating</td><td colspan="2">Precipitation (mm)</td><td>Rating</td><td>Precipitation (mm)</td><td>Rating</td></tr>
<tr><td>10</td><td>0.00-0.49</td><td>0</td><td>10</td><td>0</td><td>10</td></tr>
<tr><td>9</td><td>0.50-0.99</td><td rowspan="5">0.01-2.99</td><td rowspan="5">9</td><td rowspan="5">0.01-2.99</td><td rowspan="5">9</td></tr>
<tr><td>8</td><td>1.00-1.49</td></tr>
<tr><td>7</td><td>1.50-1.99</td></tr>
<tr><td>6</td><td>2.00-2.49</td></tr>
<tr><td>5</td><td>2.50-2.99</td></tr>
<tr><td>4</td><td>3.00-3.49</td><td rowspan="4">3.00-5.99</td><td rowspan="4">8</td><td rowspan="4">3.00-5.99</td><td rowspan="4">8</td></tr>
<tr><td>3</td><td>3.50-3.99</td></tr>
<tr><td>2</td><td>4.00-4.49</td></tr>
<tr><td>1</td><td>4.50-4.99</td></tr>
<tr><td rowspan="4">0</td><td rowspan="4">≥5.00</td><td>6.00-8.99</td><td>6</td><td>6.00-8.99</td><td>5</td></tr>
<tr><td>9.00-11.99</td><td>4</td><td>9.00-11.99</td><td>2</td></tr>
<tr><td>12.00-24.99</td><td>0</td><td>12.00-24.99</td><td>0</td></tr>
<tr><td>≥25.00</td><td>-1</td><td>≥25.00</td><td>-1</td></tr>
</table>

Physical facet: wind rating schemes

<table>
<tr><th colspan="4">TCI</th><th colspan="2">HCI: Beach</th><th colspan="2">HCI: Urban</th></tr>
<tr><td>Wind (km/hr)</td><td>Normal
(<-23.9 °C)</td><td>Trade wind
(24-32.9 °C)</td><td>Hot climate
(≥33 °C)</td><td>Wind
(km/hr)</td><td>Rating</td><td>Wind (km/hr)</td><td>Rating</td></tr>
<tr><td></td><td></td><td></td><td></td><td rowspan="2">0-0.5</td><td rowspan="2">8</td><td rowspan="2">= 0</td><td rowspan="2">8</td></tr>
<tr><td>≤2.88</td><td>10</td><td>4</td><td>4</td></tr>
<tr><td>2.89-5.75</td><td>9</td><td>5</td><td>3</td><td rowspan="2">0.6-9.9</td><td rowspan="2">10</td><td rowspan="2">0.1 – 9.9</td><td rowspan="2">10</td></tr>
<tr><td>5.76-9.03</td><td>8</td><td>6</td><td>2</td></tr>
<tr><td>9.04-12.23</td><td>7</td><td>8</td><td>1</td><td rowspan="2">10.0-19.9</td><td rowspan="2">9</td><td rowspan="2">10.0 – 19.9</td><td rowspan="2">9</td></tr>
<tr><td>12.24-19.79</td><td>6</td><td>10</td><td>0</td></tr>
<tr><td>19.80-24.29</td><td>5</td><td>8</td><td>0</td><td rowspan="3">20.0-29.9</td><td rowspan="3">8</td><td>20.0 - 29.9</td><td rowspan="3">8</td></tr>
<tr><td>24.30-28.79</td><td>4</td><td>6</td><td>0</td><td></td></tr>
<tr><td>28.80-38.51</td><td>3</td><td>4</td><td>0</td><td></td></tr>
<tr><td>≥38.52</td><td>0</td><td>0</td><td>0</td><td>30.0-39.9</td><td>6</td><td>30.0 - 39.9</td><td>6</td></tr>
<tr><td colspan="4" rowspan="3"></td><td>40.0-49.9</td><td>3</td><td>40.0-49.9</td><td>3</td></tr>
<tr><td>50.0-69.9</td><td>0</td><td>50.0-69.9</td><td>0</td></tr>
<tr><td>≥70.0</td><td>-10</td><td>≥70.0</td><td>-10</td></tr>
</table>

Appendix 5: Weather Stations for Regional Source Markets (2008-2018)

United States

State	Station	Name	Latitude	Longitude	Elevation
New York	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	40.6386	-73.7622	3.4
Illinois	USW00094846	CHICAGO OHARE INTERNATIONAL AIRPORT, IL US	41.995	-87.9336	201.8
California	USW00023232	SACRAMENTO EXECUTIVE AIRPORT, CA US	38.5069	-121.495	4.6
Florida	USW00093805	TALLAHASSEE REGIONAL AIRPORT, FL US	30.3930	-84.3533	16.8
Texas	USW00003927	DAL FTW WSCMO AIRPORT, TX US	32.8978	-97.0189	170.7
Pennsylvania	USW00094823	PITTSBURGH ASOS, PA US	40.4846	-80.2144	366.7
New Jersey	USW00014734	NEWARK LIBERTY INTERNATIONAL AIRPORT, NJ US	40.6825	-74.1694	2.1

Canada

Province	Station Name	Date range	Latitude	Longitude	Elevation
Alberta	CALGARY INTL A	2012-2018	51.12	-114.01	1099.1
Alberta	CALGARY INT'L A	2008-2012	51.11	-114.02	1084.1
Ontario	TORONTO LESTER B. PEARSON INT'L A	2008-2013	43.68	-79.63	173.4
Ontario	TORONTO INTL A	2013-2018	43.68	-79.63	173.4
Quebec	QUEBEC/JEAN LESAGE INTL A	2008-2013	46.8	-71.38	74.4
Quebec	QUEBEC INTL A	2013-2018	46.79	-71.39	74.4
British Columbia	VANCOUVER INT'L A	2008-2013	49.2	-123.18	4.3
British Columbia	VANCOUVER INTL A	2013-2018	49.19	-123.18	4.3
Maritime Region	HALIFAX INTL A	2012-2018	44.88	-63.51	145.4
Maritime Region	HALIFAX STANFIELD INT'L A	2008-2012	44.88	-63.5	145.4
Prairie Region	WINNIPEG RICHARDSON INT'L A	2008-2013	49.92	-97.23	238.7
Prairie Region	WINNIPEG INTL A	2013-2018	49.91	-97.24	238.7

Appendix 6 List of Information Products and Services Available to the Caribbean Tourism Industry

Information Product/Service	Description
1. The Caribbean Tourism Climatic Bulletin	Quarterly online bulletin that seeks to summary outlooks of climate conditions and implications up to 6 months in advance. https://www.flipsnack.com/CTOSUSTAINABLETOURISMDIVISION/ CTO/CIMH
2. CCORAL (Caribbean Climate Online Risk and Adaptation Tool)	Online decision-making tool for climate resilience (risk and adaptation). http://ccoral.caribbeanclimate.bz/ CARICOM and Caribbean Community Climate Change Centre.
3. Multi-Hazard Contingency Planning Manual for the Caribbean Tourism Sector	Online information resource - (CDERA) https://www.onecaribbean.org/content/files/OASDisasterManual2009final.pdf
4. Tourism and Health Information Surveillance System (THIS).	Online early warning and response system - http://this.carpha.org/ Caribbean Public Health Agency (CARPHA)
5. Sustainable Energy for SIDS	Free online course for policy makers – University of New Hamburg Germany and UNDP Aruba Centre of Excellence. https://dl4sd.org/
6. CARCEP Benchmarking Tool-Caribbean Clean Energy Program	Web-based benchmarking tool to allow hotel owners to compare their operations with others in the region and understand how to increase energy efficiency. http://cbt-dev.carcep.org/ USAID
7. The SIDS x SDGs Toolkit	Provides information resources for implementing measures to achieve SDGs. (UNDP Centre for Excellence for Sustainable Development of SIDS – Aruba)- https://www.sidstoolkit.org/
8. Regional Guidelines for response to Travel related Public Health Illness in Stay over and Sea Arrivals	CARPHA
9. SIDS Letter	UNDP Centre for Excellence for Sustainable Development of SIDS – Aruba

Appendix 7: Interview Guide

Climate services involve the direct provision of knowledge and information to specific decision makers. They generally involve tools, products, websites, or bulletins (Vaughan and Dessai, 2014). Climate services are distinct from weather services in that they convey information about average weather, using the analysis of time series data to estimate trends, departures from average conditions and low probability events on timescales from seasons to centuries. Climate services are also distinct from research and observations since they focus on serving users' adaptation needs.

The following interview questions build on methods and findings in the sources listed below. As well, interview questions integrate results of qualitative research to understand the potential value of climate information products for Caribbean tourism. This latter research was undertaken in the context of the Consultancy to Develop Climate Products and Services for the Caribbean Tourism Industry.

Koeberl, J., Damm, A., and Jimenez Alonso, E. 2018. Market Research for a Climate Services Observatory – Case Study 9 Report: Tourism.

Lemos, M.C., Kirchoff, C.J., and Ramprasad, V. 2012. Narrowing the climate information usability gap. Nature Climate Change, volume 2, November 2012.

Moore, W.R. 2010. The impact of climate change on Caribbean tourism demand, Current Issues in Tourism, 13:5, 495-505, DOI: 10.1080/13683500903576045

Stewart-Ibarra AM, Romero M, Hinds AQJ, Lowe R, Mahon R, Van Meerbeeck CJ, et al. (2019) Co-developing climate services for public health: Stakeholder needs and perceptions for the prevention and control of Aedes-transmitted diseases in the Caribbean. PLoS Negl Trop Dis 13(10). https://doi.org/10.1371/journal

United Republic of Tanzania. 2018. National Framework for Climate Services (2018-2025).

Vaughan, C. and Dessai, S. 2014. Climate services for society: origins, institutional arrangements, and design elements for an evaluation framework. WIREs Clim Change 2014, 5:587–603. doi: 10.1002/wcc.290

Theme and question	(1
Background	
1. What is the principal function of your department/office in your institution?	
2. What is the approximate number of technical staff in your department? Are there people with expertise in GIS (ArcGIS, QGIS, Google Earth), statistical (R, SPSS, SAS), programming (Python), or database (Microsoft Access, SQL) software?	
Governance	
3. Does your institution have a mandate to support regional (Caribbean) climate risk management in tourism via the development of climate information services and products? How does your work on tourism-climate services fit within your institutional priorities; is it guided by a law, regulation, policy, plan or program of your institution?	
4. Does your institution currently use weather or climate information to support, plan or implement sector interventions that may benefit or lead to climate risk management among public and private decision-makers in the region?	
5. Are there data sharing agreements between the tourism sector and other agencies, such as the Caribbean Institute of Meteorology and Hydrology and National Meteorological Agencies?	
Climate Data	
6. Who generates weather forecasts, seasonal forecasts, climate change projections? 7. How does your institution distribute climate information? 8. How do CIMH and the National Met Services interact to support the forecast operations of the Caribbean Outlook Forum? 9. What are your plans to standardize your data holdings? 10. What climate variables (besides temp and rainfall) do you make available and at what spatial and temporal resolutions? 11. What are the barriers/limitations and resources available for forecasting?	
Tourism Data	
12. Who generates economic, demographic & tourism-related data and forecasts? How do you work with industry stakeholders to access operational and financial data? 13. How does your institution distribute tourism performance and outlook information? 14. How does your institution support the forecast operations of the Caribbean Outlook Forum? 15. What are your plans to standardize your data holdings? 16. What tourism variables (besides arrivals and cruise tourism arrivals) do you collect and analyze and at what spatial and temporal resolutions? Examples of variables: tourist arrivals, cost of travel (between destination and source market, prices relative to source markets, prices relative to competitors, use of water and electricity, financial viability indicators. 17. What are the barriers/limitations and resources available for tourism demand forecasting?	
Co-Development of Climate Information Products and Services	
18. What factors limit or enable your department to work more closely with the climate / tourism sector? - Modeling capacity: human capacity, software, hardware - Trained personnel and technical capacity - Evidence of knowledge about the climate-tourism nexus - Prior experience with early warning systems or other climate services - Availability of financial resources - Efficiency in the management and distribution of financial resources - Coordination for cross cutting interventions for tourism climate risk management - Mobilization and coordination with tourism operators - Strong leadership (vision) - Organizational structure	
19. What strategies would improve the collaborations between institutions working in the areas of climate and tourism?	
User Needs and Preferences	

Theme and question	(1
20. Three kinds of capacity limit the ability of tourism stakeholders to benefit from climate services: financial capacity (which relates to their ability and willingness to pay for climate services), the capacity to use or interpret climate data and the capacity to provide business/region-specific data (this latter issue also relates to trust). [Note: In our project research tourism stakeholders' top two challenges in ability / willingness to integrate weather / climate information in decision making relate to in-house expertise and low levels of awareness of the information that exists.] What strategies are in place or planned to overcome these capacity challenges?	
21. According to our project research, tourism stakeholders predominantly consult short-term weather forecasts (up to 2 weeks out) and seasonal climate forecasts (forecasts for next month up to a year into the future). What opportunities do you see to build on existing preferences in supplying appropriate and timely climate information for tourism stakeholders across the region?	
22. According to our project research destination planners' and tourism policymakers' key information needs relate to (1) improving marketing decisions, (2) right-sizing capacity, installations to forecasted demand and (3) safety planning & emergency preparedness. What opportunities do you see to build on existing needs in supplying appropriate and timely climate information for tourism stakeholders across the region?	
23. According to our project research, there is strong interest by tourism stakeholders in quarterly outlooks of arrivals, as influenced by climate at both source and destination. What factors limit or enable your institution to work with others to meet these emerging information needs?	
24. According to our project research, early warning systems (tropical storms, Sargassum strandings, vector-food-water-borne disease outbreaks) tailored to tourism stakeholders could support targeted marketing and products to offset "negative" information. What factors limit or enable your institution to work with others to meet these emerging information needs?	