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An assessment of the climatic suitability of Afriski Mountain Resort for outdoor tourism using the Tourism Climate Index (TCI)

Kirsten NOOME https://orcid.org/0000-0002-6114-9410; e-mail: 726461@students.wits.ac.za

Jennifer M. FITCHETT* https://orcid.org/0000-0002-0854-1720; e-mail: Jennifer.Fitchett@wits.ac.za

** Corresponding author*

School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg 2050, South Africa

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Abstract: Tourism Climatic Indices (TCIs) are widely used in the global North to quantify the climatic suitability of a destination for tourism. Only one such study has been conducted in southern Africa to date. It is in a chronic shortage of research on tourism and climate change in the southern hemisphere. This study presents the application of the TCI in Lesotho, calculated for the eastern Lesotho Highlands. The region has an emerging tourism sector, which primarily comprises outdoor activities. These include hiking, horse-riding, music festivals, mountain biking, cultural visits, sightseeing, and at the Afriski lodge, skiing and snowboarding. These activities are reliant on climatic conditions that are conducive to the activity taking place, prolonged periods outdoors, and tourist satisfaction of the activity. Climate is a major determinant of both the length of season for these activities and the timing of peak tourist arrivals. Rising temperatures and changes in relative humidity and precipitation pose real threats to hiking, sightseeing and snow tourism at Afriski. The reliance of tourism in the region on specific climatic conditions for successful tourism prompted the use of the TCI. TCI results classify the eastern Lesotho Highlands as having 'good' climatic conditions with an overall TCI score of 64 for the period 2012-2017. Monthly TCI scores for the eastern Lesotho reveal a bimodal-shoulder, meaning the peak climatic conditions are in the regional summer months (December to February). This conflicts with the peak tourist seasons of summer and winter, which align with South African school holidays, and the timing of the most profitable tourism activity (skiing) which occurs during the winter months of June, July and August. Lesotho is landlocked by South Africa. TCI analysis for South Africa reveals more suitable climatic conditions for tourism than Lesotho, with significantly higher scores of 80-89.

Keywords: Climate; Tourism Climatic Index (TCI); Lesotho Highlands; Outdoor tourism; Snow tourism

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Introduction

Tourism contributes a significant proportion to the global economic sector (Samimi et al. 2017). Currently, the bulk of the international tourism revenue is attracted by countries of the global North, and in particular European cities. Although many countries of the global South are growing in the global tourism market there is an uneven growth among the developing economies (Yfantidou and Matarazzo 2017). Developing economies regarding the economic boom tourism brings as salient for development, as it reduces poverty through foreign investment and increased development of infrastructure and technology (Giaoutzi 2017). Southern Africa, in particular, uses tourism as a building block for expansion within the economy through business developments and entrepreneurship which leads to increased job creation and economic security (Rogerson 2018). This holds true for the economy of the Kingdom of Lesotho, a small land-locked country surrounded by South Africa (Rogerson and Letsie 2013; Yiu et al. 2015).

Climate is a key resource for tourism (Scott et al. 2004). Although not the focal point of travel, weather conditions are a decisive factor for specific tourist activities (Amelung et al. 2007). Climate has been found to affect the seasonality of tourism, the choice of destination and the satisfaction of the vacation (cf. Scott et al, 2004; Amelung et al. 2007; Gössling et al. 2012; Giddy et al. 2017; Hoogendoorn and Fitchett, 2018). Winter sport tourism relies on cold conditions that are suitable for snow tourist activities, while summer tourism satisfaction often relies on "beach" weather conditions of warm temperatures with ample sunshine (Perch-Nielsen et al. 2010; Fitchett et al. 2016). Regions that rely predominantly on outdoor tourism offerings, including nature-based tourism, adventure tourism and sightseeing, require temperatures within human comfort levels, a large daily average sunshine hours, and limited days (Preston-Whyte and Watson 2005). Changes to the climate have potentially severe impacts on the tourism sector (Scott et al. 2004). Rising air and sea-surface temperatures, sea level rise, and changes to wind and precipitation patterns are likely to impact the selection process of the travel destination as certain climates will no longer be suitable to the tourists needs or satisfaction (Scott et al. 2012; Hoogendoorn and Fitchett 2018). This may have subsequent impacts on the economy of the travel destination on both a local and national level as many people and businesses rely on tourism for revenue (Turpie et al. 2002; Hoogendoorn et al. 2016).

Outdoor tourism is highly climate-sensitive as tourists are directly exposed to any adverse weather during the course of the activities that have attracted them to the destination (Becken 2010). However, the ideal climatic conditions depend on the nature of the primary attraction and activities on offer. For beach tourism, clear skies and warm temperatures would result in an ideal vacation (Fitchett et al. 2016). For safaris, cooler temperatures improve animal sightings, and rainfall during the late afternoon is seldom problematic (Preston-Whyte and Watson 2005). For snow tourism, cold temperatures and precipitation in the form of snow is better suited (Stockigt et al. 2018). Changes in weather and climatic conditions, such as extreme weather events, at these travel destinations will cause the locations to become unappealing for tourists, thus negatively impacting the tourism potential of that destination (Aylen et al. 2014; Wilkins et al. 2018). Therefore, the threats of climate change will significantly impact the level of tourist satisfaction and the way in which tourists will experience their destination (Dubois et al. 2016). Understanding tourist perceptions and behaviour toward changes to the climate at the travel destinations can be an effective tool in assisting the stakeholders and relevant organisations in designing and implementing adaptation measures to address the effects of climate change (Mearns 2016; Bunakov et al. 2018).

There has been an underwhelming focus on tourism and climate change in the tourism literature for countries of the global South (Scott et al. 2012; Hoogendoorn et al. 2018). Improvement in adaptive and mitigative action towards climate change for the tourism sector in countries of the global South is often hindered by competing commitments that require more immediate attention, such as infrastructural development (Mohan and Morton 2009). It is argued that there is a discrepancy between the perceptions of the tourism sector regarding climate change risk and the message portrayed by the media (Steiger et al. 2017). Long-term adaptive and mitigative strategies are often perceived as unnecessary due to the delay in climate change consequences and are often met with the belief that action should be taken when the effects of climate change are apparent (Hoogendoorn et al. 2016). Tourism-climate indices are an option for assessing climate change impacts on tourism and are useful for management planning regarding climate change impacts on tourism (Perch-Nielsen et al. 2010). The tourism-climate indices are used to assess the suitability of the climate for tourism, climate being an influential factor in travel destination satisfaction (Mieczkowski 1985; Fitchett et al. 2016). Marketing 'off peak' season visitation is a strategy used to avoid economic loss through reducing tourism dissatisfaction (Scott et al. 2012). Tourism planners can better assess existing infrastructure, development standards and climate change adaptability by examining the rating scale of the tourist satisfaction level with the climate of the region or destination (Scott et al. 2012). If the infrastructure, facilities or services improve to more efficiently withstand climate change impacts the level of tourist satisfaction will increase (Fitchett et al. 2016).

Research into the tourism sector in Lesotho has mainly focused on understanding the role of the informal sector (Rogerson and Letsie 2013), assessing the tourism resources of Lesotho and exploring mechanisms to improve the sustainability of the tourism sector in the country (Mearns 2011; Yiu et al. 2015). The research includes assessing the effects both local and foreign tourism have on the domestic, informal and formal tourism sectors as well as the consequences inadequate tourism management have on the local communities' income, tourism is often the sole income for these communities (Rogerson and Letsie 2013; Yiu et al. 2015). Outdoor tourism in Lesotho has received some attention in academic research (cf. Mearns 2011) but the research is eclipsed by its neighbouring country, South Africa, which is considered to have the best developed adventure tourism in southern Africa (McKay 2018). Outdoor recreational activities and natural attractions are a key drawcard for tourism in eastern Lesotho, as the business tourism offerings are concentrated in the city of Maseru in western Lesotho (Rogerson and Letsie 2013). These attractions include pony trekking (Mearns 2011), fishing, hiking, trail running, mountain cycling, quad biking and motorcycling, 4x4 trails, nature tours, trail runs, canoeing, fly-fishing, looking at dinosaur footprints in Leribe, climbing and mountaineering (Yiu et al. 2015) However, these attractions are highly vulnerable to climatic conditions (Hoogendoorn et al. 2016). Therefore, climate change has the potential to alter the popularity of tourism destinations since weather patterns play a key role in tourists' decisions on where and when to travel (Aylen et al. 2014; Wilkins et al. 2018). Afriski Mountain resort, a snow dependent resort located in the north-eastern region of the Kingdom of Lesotho in southern Africa, is one of two places that offers the unique skiing experience in southern Africa, it is rivalled by Tiffendell (Stockigt et al. 2018). Given the contemporary marginal temperatures required for snow-based tourism, and the wide range of destinations that can offer the more generic outdoor attractions, climate change poses a significant threat to long-term sustainable tourism at Afriski (Stockigt et al. 2018). Literature on climate change and tourism in Lesotho is limited to one study which qualitatively explores the threats to snow tourism through analysing TripAdvisor reviews for the ski lodge Afriski (Stockigt et al. 2018).

The Tourism Climate Index (TCI) is one of the most cited tourism-climate indices for assessing the tourist satisfaction level with the climate of a destination (Scott et al. 2019). Developed in the Global North, the use of the index is largely confined to northern hemisphere destinations with only a handful of studies in the Global South (Fitchett et al. 2016, 2017). This hinders efforts towards a global scale comparison of the climatic suitability of tourist destinations (Amelung et al. 2007; Hoogendoorn and Fitchett 2018). Mieczkowski (1985) developed the index to quantify the tourism-climate by combining tourism-related climatic factors into a single formula, this is the foundation of the TCI (Scott and Mc Boyle 2001). The variables in this formula are weighted according to the "average" comfort of tourists at a location and given time (Scott and Mc Boyle 2001). However, there are limitations to the TCI (Amelung et al. 2007; de Freitas et al. 2008; Li et al. 2018). It is argued that the weighing of the climatic variables is subjective and requires empirical testing (Perch-Nielsen et al. 2010). The TCI also applies only to general forms of tourism and tourism activity (Amelung et al. 2007). The TCI is most effective for outdoor tourism activities such as sight-seeing, adventure or nature-based tourism, it should not be used for tourism activities that impose different climatic requirements; including: skiing and surfing (Perch-Nielsen et al. 2010). Therefore, adaptions to the TCI may need attention or the implementation of an index that caters to the specific climatic conditions for non-generalised tourism activity (Perch-Nielsen et al. 2010). The TCI cannot predict the arrivals of tourists, nor does it take into account the quality of the infrastructure, crime rates or socio-economic background of the destination (Amelung et al. 2007). This may lead to cases where regions have a high TCI scores but do not have high arrivals of tourists; as mentioned tourist activity is influenced by a variety of factors not solely climatic conditions (Amelung et al. 2007). Mieczkowski (1985) was aware of the limitations of the index yet argued that it is not necessary for the final score of the TCI to be mathematically precise, rather it is a plausible approximation. Despite the limitations of the TCI, the index is still considered effective in that it can be applied to a wide range of destinations (Scott and Mc Boyle 2001; Li et al. 2018). When compared with other indices which focuses only on one specific type of tourism the TCI is still one of the most recognised tourism-climate indices (Scott and Mc Boyle 2001; Li et al. 2018). The TCI has been applied to 19 locations in South Africa, the neighbouring country to the study site of this research (Fitchett et al. 2016, 2017). South Africa has been shown to have 'excellent' climatic conditions for tourism in a number of locations throughout the country (Fitchett et al. 2017).

This paper uses the TCI to quantify the climatic suitability of the eastern Lesotho highlands for tourism. The index has already been applied to South Africa but has not yet been applied to Lesotho (Fitchett et al. 2017). Climatic data are sourced from Afriski lodge, where temperature, precipitation and humidity are recorded at fifteen-minute intervals for use in snow making. The objectives of this research are to: classify the climatic suitability of eastern Lesotho for tourism using the TCI, to compare the suitability output to the primary climatic requirements for the tourism attractions, and finally to critically analyse the appropriateness of the index for snow tourism at Afriski Mountain Resort as this is the strongest tourism operation in the region and the point source of the climate data. There is urgent need for tourism-climate research in Lesotho, given the dominance of the outdoor tourism in the Lesotho tourism sector. The quantification of the climatic suitability of the eastern Lesotho highlands in this pilot study is crucial for adaptive and mitigative action by both the Kingdom of Lesotho, and the tourism operators including Afriski under the threat of climate change.

1 Methods and Study Site

1.1 Study site

The Kingdom of Lesotho is located in southern Africa, landlocked by South Africa (Grab and Linde 2014). The country is situated between the longitudes 27°00'E and 29°30'E and the latitudes of 28°30'S and 30°40'S, covering an area of 30,335 km² (Figure 1; Grab and Linde 2014). Ruled as a kingdom, Lesotho is divided into ten districts with Maseru designated as the capital city (Faturiyele et al. 2018). Lesotho is a low-income nation with a population of approximately 2.2 million people in 2017 (Baral et al. 2011; Faturiyele et al. 2018). Lesotho is characterised by high levels of poverty and income inequality; it is estimated that only 27% of the population live in urban areas (World Bank 2016; Faturiyele et al. 2018). In 2016, the country had a gross GDP per capita of US$ 2808.20, the economy relies on income generated mainly from tourism and migrant labourers who find employment in the neighbouring countries (Baral et al. 2011; Faturiyele et al. 2018). In general, direct contribution to the tourism sector includes visitor expenditure at accommodation establishments, the use of transportation, engaging in the tourist cultural, sport and recreational attractions, retail, and investment (Rogerson 2009; WTTC 2018). Investment and tourist attractions in Lesotho are primarily based on two basic infrastructural factors: mobility and accommodation (Yiu et al. 2015). Tourism in Lesotho is marketed predominantly for outdoor activities, including nature-based attractions, adventure tourism offerings, and cultural and heritage tourism. The Maloti-Drakensberg Park, which borders eastern Lesotho and South Africa, for example, is one of eight World Heritage Sites in South Africa and the only one in Lesotho (Grab and Nüsser 2001; UNESCO 2018). The Maloti-Drakensberg Park is a mixed heritage site, incorporating both cultural and natural aspects (UNESCO 2018). Other outdoor tourism attractions in Lesotho include: quad biking cycling, and motorcycling trails, canoeing, fly-fishing, looking at dinosaur footprints, hiking, horse-riding, rock climbing and mountaineering (Yiu et al. 2015; Afriski 2018).

This paper focuses on a highly vulnerable yet emerging tourism destination in Lesotho for the first application of Miezckowski's (1985) TCI: the eastern Lesotho Highlands. This region is marked by rugged topography, limiting tourism access. The topography also limits the potential for agriculture, leaving much of the population highly vulnerable under a changing climate. Climate data were sourced from Afriski, a ski-resort located in the north-eastern part of Lesotho (Stockigt et al. 2018) which records meteorological data at high temporal resolution for snow making purposes. The lodge is located 28°49'22"S and 28°43'41"E in the eastern Lesotho Highlands, adjoining the Drakensberg Mountain Range (Figure 1; Grab and Nash 2010). It is considered the only alpine setting in southern Africa with elevation ranges from 1,400-3,482 m asl (Grab and Linde 2014). The highest peak of 3,482 m asl is at Thaba Ntlenyana in eastern Lesotho, adjoining the Drakensburg Mountain Range (Grab et al. 2009). Afriski is rivalled by Tiffendell, the only other resort that offers skiing and snow-based tourism activities in southern Africa. Afriski offers a wide range of outdoor tourist activities in both winter and summer, including pony-trekking, mountain cycling, 4×4 trails, hiking, nature-tours, trail runs, a zipline and ski activities (Stockigt et al. 2018).

The climate of Lesotho is influenced primarily by altitude (Grab and Linde 2014; Hughes et al. 2018). Lesotho and its neighbouring South-African interior regions are characterised by a semi-arid to sub-arid climate (Grab and Nash 2010). The effects of continentality and latitude contribute to the wet, warm summers and dry, cold winters experienced in Lesotho (Grab and Simpson 2000; Grab and Nash 2010). In Lesotho, the typical 'rainy' season spans October to April (Grab and Nash 2010). It is estimated that 80% of the annual precipitation, from thunderstorms and showers, fall within December, January and February. Winters are dominated by the high-pressure systems resulting

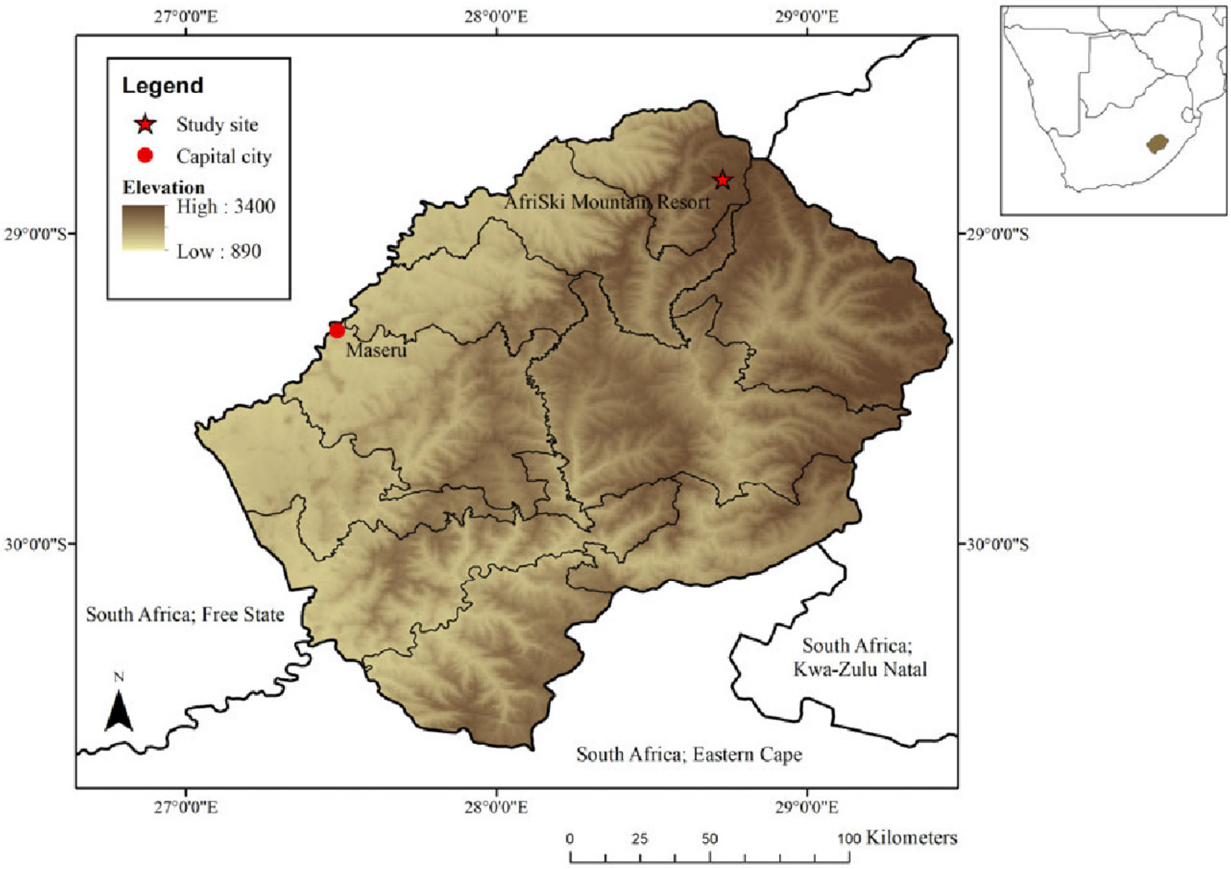

Figure 1 Location of the study site, Afriski Mountain Resort, in Lesotho.

in cool, dry conditions with minimal rainfall between June and July.

The eastern Lesotho Highlands experience mean rainfall of ~600mm per annum predominantly during the summer months, amounting to 70% of the annual precipitation. Winter months account for only 10% of the annual precipitation, often in the form of snow. This forms a key attraction for southern African sightseeing tourists who seldom encounter snow (Grab and Linde 2014). Snowfall occurs around eight times a year in the highlands, and intermittently in the lowlands following southerly polar cyclone passage approximately once every two years (Grab and Nash 2010; Nash and Grab 2010). Understanding the controls on the climate is an important factor in studying the tourism-climate relationship in the eastern Lesotho highlands for a TCI (Karmalkar et al. 2012). Key vulnerabilities for winter tourism have been identified with respect to climate change (Campos Rodrigues et al. 2018; Demiroglu et al. 2018). Climate projected suggest intensified warming from 2030, in the range of a low ~0.8°C to a high of ~1.2°C increase above the historic pre-industrial levels (IPCC 2018). This has serious implications for future snowfall and snow reliability for the snow tourism sector at Afriski. Simultaneous changes to the summer climate, including the incidence of droughts (Stockigt et al. 2018) further compromises the year-round and summer season tourism offerings in the region.

1.2 Methods

Afriski has an onsite Davis VantagePro weather station collecting and logging data at 15-minute intervals, from which the climatic data for this research was retrieved. The data included total rainfall, minimum and maximum temperatures, relative humidity and wind speed. This represents the most comprehensive and highest temporally resolved climate record for the region that spans more than two calendar years. A large portion of the data was missing and required additional data capturing and sorting. Sunshine and cloud cover data, for example, were not recorded. The data was recovered from weather archives on websites and satellite imagery. Sunshine data was obtained from online meteorological archives. This provided the mean monthly daylight hours for each month of the study period. However, for the calculation the mean monthly average sunshine hours (S) are required (Perch-Nielsen et al. 2010; Fitchett et al. 2017). To achieve this, mean monthly cloud cover hours were captured from satellite imagery (Sat24 2018). The mean monthly sunshine hours were calculated by subtracting the mean monthly cloud cover from the mean monthly daylight hours (Amelung and Viner 2006; Perch-Nielsen et al. 2010).

For comparability with TCI outputs for the global North, this research uses the adapted TCI version by Perch-Nielsen et al. (2010), based on the original TCI formula by Mieczkowski (1985):

$$TCI = 2(4CD - CA + 2R + 2S + W)$$

The calculation of the TCI using this formula has been used in several recent studies with successful outputs (Roshan et al. 2016; Fitchett et al. 2017). The calculation includes five components that are essential for tourism satisfaction regarding the outdoor climate of a travel destination: daytime thermal comfort CD, average thermal comfort CA, monthly average sunshine hours S, total monthly rainfall R, and monthly average wind speed W. These five variables are assigned weights in the calculation according to their perceived importance to tourist satisfaction (Roshan et al. 2016). Mean TCI scores and classifications for each month were calculated for the period 2012-2017. The scores were averaged to provide an annual TCI score and classification, followed by the calculation of an overall TCI score and classification by averaging the six annual TCI scores. Scott and McBoyle (2001) developed six tourism-climatic typologies to determine the distribution climatic conditions favourable for tourism within the year. The mean monthly TCI scores for Afriski were plotted to determine the tourism-climate typology for Afriski.

2 Results

2.1 Climate in the Eastern Lesotho Highlands

Data were primarily captured by the onsite weather monitoring station at Afriski for the months of priority for the winter tourist attraction (Table 1), namely June, July and August. The collection of data from winter months takes precedence as it provides climatic information that could be used for snow tourism schemes by Afriski. Year-round data collection would not yield climatic information as valued as the months of June, July and August. This is evident as three full year datasets are available (for the years 2013, 2014 and 2015) after which only the aforementioned months contain data (2012, 2016 and 2017; Table 1).

The warmest month throughout the six years is February, with the mean monthly maximum temperature of 17.3°C. February is considered the last month of the summer season in southern Africa. The coldest month is July, a winter month in southern Africa, across the six-year study period, with a mean monthly minimum temperature of -9.6°C. The overall temperature of Afriski is depicted as moderate, with very cool winters and relatively warm summers. Afriski experiences higher mean monthly total rainfall in the months where there are higher mean monthly temperatures. Although, December has a low mean monthly rainfall, the high maximum temperatures and relative humidity exceed the thresholds to facilitate rainfall. The winter months have low mean monthly rainfall due to the dominant anticyclone over the central-southern interior of southern Africa. The greatest mean cloud cover is recorded for the month of February, resulting in a decrease in the mean monthly sunshine hours. The mean monthly temperatures and mean monthly total rainfall rise from September in the spring and continues in to December, which is the start of the summer months in southern Africa. Mean monthly relative humidity for Afriski over the period 2012-2017 follows the pattern of the mean monthly maximum and minimum temperatures, whereby the mean monthly relative humidity readings are higher in the summer months and lower in the winter months. According to the data, September is the most suitable time of year for tourism in the eastern Lesotho highlands to avoid high relative humidity. The largest numbers of sunshine hours are experienced spanning late spring to mid-summer in the months of January, November, and December, with mean monthly sunshine hours per day of 9.0, 10.1, and 10.5, respectively. January, November and December are considered good times of the year to visit the region based on the favourable hours of sunshine (Table 2).

The eastern Lesotho highlands experience higher rainfall and temperatures in the spring and summer months, with the autumn and winter months experiencing lower rainfall and temperatures. Following the seasonal pattern of southern Africa, the mean monthly temperatures start to decrease (from 10°C to 0°C), along with rainfall (from 138.7 to 4mm), from February until August, temperature and rainfall begin to rise from September (Figure 2).

2.2 Mean annual TCI score

Only three years have full datasets in the six-year study period (Tables 3 and 4), 2013, 2014, 2015. The data captured at Afriski predominantly focuses on the winter months of June, July and August. For these months, the TCI scores are 64.7 'good', 65 'good' and 64.8 'good', respectively (Table 3). However, there is not a large variability

Table 1 Months of the year with recorded climatic data at Afriski for the period 2012-2017.

	2012	2013	2014	2015	2016	2017
Jan.		✓	✓	✓		
Feb.		✓	✓	✓		
Mar.		✓	✓	✓	✓	
Apr.		✓	✓	✓	✓	
May		✓	✓	✓	✓	✓
Jun.		✓	✓	✓	✓	✓
July		✓	✓	✓		✓
Aug.	✓	✓	✓	✓	✓	✓
Sep.		✓	✓	✓		
Oct.		✓	✓	✓		
Nov.		✓	✓	✓		
Dec.	✓	✓	✓	✓		

Table 2 Mean monthly climatic variables for Afriski for the period 2012-2017

	T_{max}	T_{min}	Rainfall (mm)	WS (km/h)	RH (%)	TSH
Jan.	16.8°C	3.2°C	143.6	15.5	67.2	9
Feb.	17.3°C	2.7°C	138.7	15.7	68.2	7.3
Mar.	15.1°C	1.6°C	51.1	15.5	61.9	8.8
Apr.	13.4°C	-3.3°C	30.8	16.9	56.5	8.5
May	12.7°C	-4.7°C	11.8	14.3	53.4	8.2
Jun.	11.3°C	-9.1°C	1.4	16.9	52.5	8.8
July	10.5°C	-9.6°C	9.3	17.4	51.9	8.9
Aug.	9.4 °C	-9.4°C	4	20.4	53.0	9.9
Sep.	14.0°C	-5.2°C	61	18	47.8	9.9
Oct.	16.7°C	-4.6°C	50.4	19.7	57.7	9.8
Nov.	16.5°C	-4.4°C	80.3	20.5	58.3	10.1
Dec.	16.4°C	2.7°C	43.3	16.7	68.6	10.5

Notes: WS= Wind speed; RH= Relative humidity; TSH= Total sunshine hours.

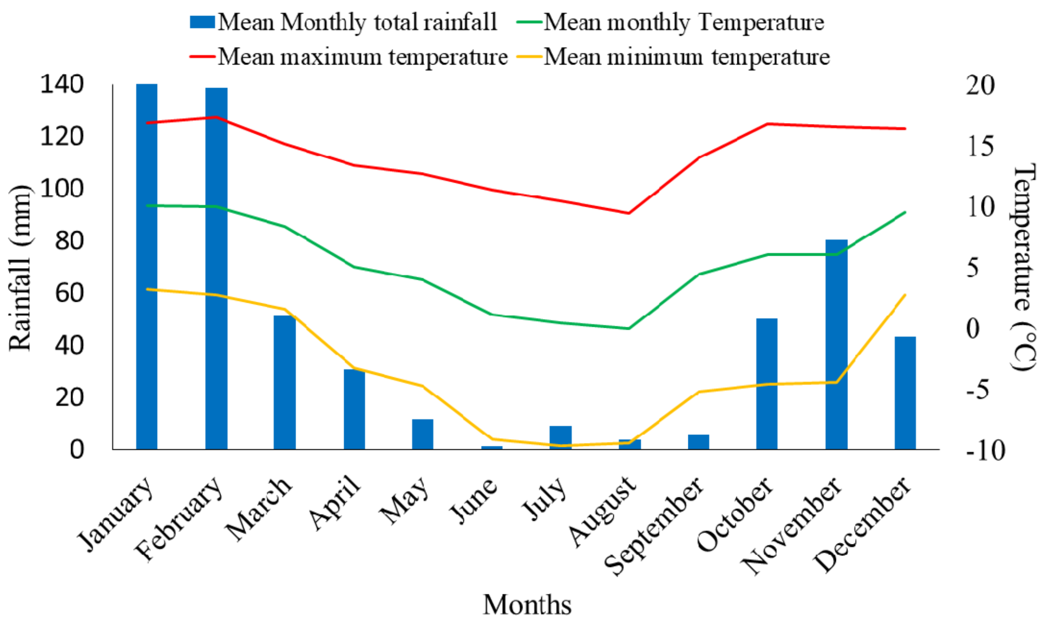

Figure 2 Mean monthly maximum and minimum temperature, mean temperature and mean total rainfall for Afriski 2012-2017.

Table 3 Three-year full Tourism Climate Index (TCI) scores for winter months compared to the complete dataset.

	Months	3-year full TCI	Classification	Complete dataset	Classification
Winter Months	June TCI	64.7	Good	65.6	Good
	July TCI	65	Good	65.8	Good
	August TCI	64.8	Good	65.7	Good
Summer Months	January TCI	57.3	Acceptable	57.3	Acceptable
	February TCI	63.3	Good	63.3	Good
	December TCI	74.3	Very Good	70.5	Very Good

in the scores from the full datasets compared to the complete datasets, this proves that the data is representational of the average climatic conditions in the eastern Lesotho highlands region for the study period (Tables 3 and 4). Of the complete June dataset and the three-year full TCI there is a low difference of 0.9. July and August have similarly low differences between the three-year full TCI and the complete dataset, of 0.8 and 0.9. Thus, there is confidence in the representational use of the data for the climate of Afriski.

Summer months of January and February have similar TCI scores for the 3-year full TCI and the complete dataset, with TCI scores of 57.3 ‘acceptable’ and 63.3 ‘good’. The full TCI years of 2013, 2014, and 2015 are the only years that have climatic data for the summer months, except for 2012 which includes December. TCI scores vary between the 3-year full TCI and the complete dataset in December, with the three-year full TCI having a score of 74.3 ‘very good’ and the complete dataset score of 70.5 ‘very good’. There is a range of 4.2 units between the scores. Nevertheless, a general idea of the climate in the summer months in the eastern Lesotho highlands is provided (Table 3).

The annual TCI scores for each year of the study period all fell within the same category of ‘good’ climatic conditions for tourism, except for 2012 which had only ‘acceptable’ climatic conditions. The overall mean TCI score for the climatic conditions of the eastern Lesotho highlands for tourism is classified as ‘good’, with a score of 64 (Table 4).

Summer months revealed seasonal variability in climatic conditions with TCI scores ranging from ‘acceptable’, ‘good’ and ‘very good’. TCI scores in winter months are considerably more consistent and are classified as having ‘good’ climatic conditions for tourism. The mean monthly TCI scores for the period 2012-2017 were predominantly between 60 and 69, which classify the region as having mainly ‘good’ climatic conditions for tourism throughout the given year. The months with the lowest scores were January and March, classifying these months as an acceptable time of year for tourism, with scores of 59 and 57, respectively. The most suitable month for tourism in the eastern Lesotho highlands according to the TCI is December, with a TCI score of 70.5 and a rating of ‘very good’. This aligns with increases in tourism numbers due to the school holidays in southern Africa and Visiting Friends and Relatives (VFR) tourism over Christmas but does not conform with the peak tourist season of Afriski itself; which due to the requirement of snow, spans the winter months of June, July and August. The months during the peak tourist season at Afriski mutually received a score of ‘good’ for the suitability of climatic conditions for tourism (Table 5).

2.3 Seasonal variation

The distribution of the annual TCI scores reveals that there is low seasonal variability in the winter months for the period 2012-2017 (Figure 3). The small range in the scores suggests that the climatic phenomena are relatively consistent within the winter months, as they do not have major outliers in the mean monthly TCI scores. The summer months have greater mean monthly TCI score variability, noted especially in the summer months of 2015. The variability may be a result of the effects of the El Niño event experienced in Southern Africa in 2015. Climatic typologies differ between the northern and southern hemisphere, the summer and winter season peaks are inverted. The distribution within the mean monthly TCI scores of the eastern Lesotho highlands for 2012-2017 depicts a bimodal-shoulder peak in the months of February and September. The bimodal-shoulder peaks are observed for summer and spring months, not the typical spring and winter months of the northern hemisphere. February and September are equally rated ‘good’ by the TCI. Notably, these months do not correspond with the peak visitor season of Afriski. As a winter attraction, the TCI promoting summer and spring months as the most suitable time of the year in terms of climate for tourism may be problematic for the ski resort. It is, however, promising for the wider variety of outdoor tourism attractions offered both in the region and at the Lodge itself, which are promoted in the off-season for snow tourism.

Table 4 Tourism Climate Index (TCI) scores for Afriski

Year	Annual TCI Score	Classification
2012	58	Acceptable
2013	62	Good
2014	63	Good
2015	69	Good
2016	66	Good
2017	66	Good
Overall TCI score	64	Good

Table 5 Mean monthly Tourism Climate Index (TCI) score for Afriski

Month	Mean monthly TCI Score	Classification
January	57.3	Acceptable
February	63.3	Good
March	59.8	Acceptable
April	64.3	Good
May	65.6	Good
June	64.4	Good
July	64.3	Good
August	64.7	Good
September	68.7	Good
October	68.0	Good
November	67.3	Good
December	70.5	Very good

2.4 Factors that Influence the TCI

The climatic phenomena that influence the TCI are sunshine, wind speed, rainfall, and temperature. The effect of negative climatic factors such as rain and unfavourable (cold) thermal comfort are the major factors bringing down the TCI scores. However, combined differently, each factor has the potential to increase or decrease the TCI score for a location. The most frequent highest rated factors influencing the annual TCI score are sunshine and rainfall (Table 6). Sunshine raises the TCI score, while rainfall and wind decrease the TCI score. Sunshine hours of 9 or >10 receive scores of 4 and 5. This increases the TCI score. Rainfall between 0.0mm-14.9mm receives a TCI score of 5, increasing the overall TCI. This means that the sunshine rating will be high as there is little to no rainfall. The lower rating of rainfall (high rainfall) will bring down the sunshine score. Thus, a pattern is apparent, as the amount of rainfall decreases the sunshine score increases. Rainfall, sunshine and wind are the most frequent factors determining the TCI score, but in 2015 CD influenced the TCI score,

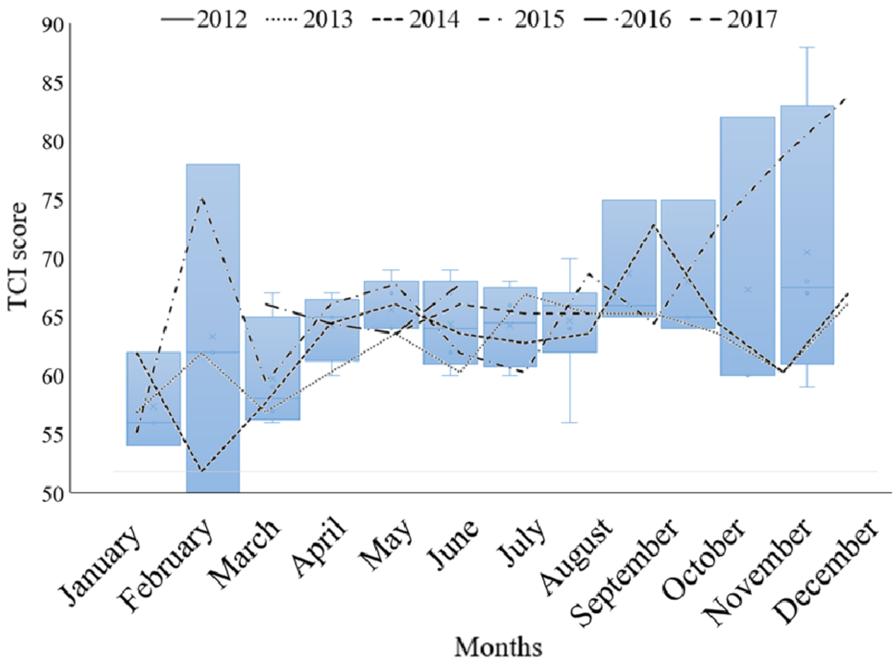

Figure 3 Mean monthly Tourism Climate Index (TCI) scores demonstrate a bimodal-shoulder peak seasonal variability within the study period from 2012-2017.

Table 6 Factors increasing and decreasing the Tourism Climate Index (TCI) scores. CD = daytime thermal comfort, CA = average thermal comfort, S = monthly average sunshine hours, R = total monthly rainfall, W = monthly average wind speed

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Increasing	2012	-	-	-	-	-	-	-	R, S	-	-	-	S
	2013	S	CD, S, W	S, W	R, S, W	R, S	R, S	R, S	R, S	R, S	S	S	R,S
	2014	S	S, W	S, W	R, S	R, S	R, S	R, S	R, S	R, S	S	S	S
	2015	S	R, S	S, W	R, S	R, S	R, S	R, S	R, S	R, S	R, S	CD, R, S	CD, R, S
	2016	-	-	R, S	R, S	R	R, S, W	-	R, S, W	-	-	-	-
	2017	-	-	-	-	R,W	R, S, W	R, S	R, S	-	-	-	-
Decreasing	2012	-	-	-	-	-	-	-	W	-	-	-	R
	2013	R	CA,R	R	CA	CA	CA	CA	CA	CA, CD	CA, R	R	CA, CD
	2014	CA, R	R	CD, R	CA,CD	CA,CD	CA	CA	CA	CA	CA	CA, CD, R	CA
	2015	R	CA	CA, CD	CA, CD	CA,CD	CA, CD	CA	CA	CA, CD	CA	CA	CA
	2016	-	-	CA, CD	CA, CD	CA	CA	-	CA	-	-	-	-
	2017	-	-	-	-	CA	CA	CA	CA, CD	-	-	-	-

for that year alone, indicating the severity of the thermal comfort conditions. The sunshine or rainfall scores did not decrease, rather there was a sudden rise in the CD scores in November and December—with scores of 4 and 5, which combined to raise the TCI score. Thus, it is evident that sunshine is the greatest influencer of a higher TCI score at Afriski, followed by low monthly total rainfall.

The factors that compromise the TCI scores are rainfall (R), wind (W), average thermal comfort (CA) and daytime thermal comfort (CD). Table 6 also depicts the months that received the lowest scores, between 0 and 2.5. CA is the most frequent factor that negatively affects the TCI score. The highest CA score is 2.5 and the lowest is 1. High wind speed decreases the TCI score. Wind speeds of >38.52 receive a score of 0. Wind was the lowest rated factor, most influencing the TCI score in August 2012, with a score of 0. High precipitation significantly reduced the sunshine hours, yet sunshine is not the most detrimental factor (Table 6), the minimum sunshine hour TCI score was 3.5, for February 2013 and 2014, and May 2016 and 2017. It is inferred that the CA is responsible for the increase in precipitation and the decrease in the rainfall TCI score, which decreases the sunshine hours as a result.

3 Discussion

3.1 TCI inferred climatic suitability of the eastern Lesotho Highlands

The aim of the study was to assess the climatic suitability for tourism in the eastern Lesotho highlands with data from Afriski, a skiing resort in the eastern Lesotho highlands, using a modified version of Mieczkowski's (1985) TCI. Mieczkowski (1985) used the TCI to produce a map that broadly categorised regions based on the suitability of their climate for tourism. This research is the first to apply the TCI directly to Lesotho, and one of the first to use the TCI in Africa. The TCI scores for the eastern Lesotho highlands can now be compared with the TCI scores from countries around the world through this study. Lesotho fell within the excellent range of southern Africa, according to Mieczkowski's (1985) map. Afriski has an overall mean TCI score of 64, which classifies the eastern Lesotho highlands as having 'good' climatic conditions for tourism. As this study is the first TCI that utilises meteorological data for Lesotho, the classification for Lesotho by Mieczkowski (1985) becomes questionable. The method of extrapolating data from neighbouring regions, a method used by Mieczkowski (1985), to produce a generalised account of the climate of a location is not appropriate for this study.

Comparing the TCI scores of this study to the results of its neighbour South Africa; geographically the two closest locations that have TCI calculations are Bethlehem and Ladysmith, both with scores of 80-89, classifying the climatic conditions of the regions as excellent (Fitchett et al. 2017). These scores are two ratings higher than the mean annual TCI classification for the eastern Lesotho highlands. The differences can be attributed to forces that affect the climate of the area; including: elevation, latitude (distance from equator), direction of prevailing winds, and amount of rainfall (Steiger and Mayer 2008). Ladysmith is situated approximately 1,015 m asl, in the foothills of the Drakensberg Mountain Range, and experiences mean annual rainfall of approximately 740 mm, and mean annual temperature of 16.5°C. For Ladysmith, the dominant positive factor was daytime thermal comfort (Fitchett et al. 2017). Bethlehem, on the other hand, is located near the northern part of the South Africa-Lesotho border, with an elevation of 1,636 m asl, a mean annual rainfall of ~690mm, mean annual T_{min} of 15°C and mean annual T_{max} of 26.2°C. Day time thermal comfort is the main positive influence on the TCI scores for Bethlehem (Fitchett et al. 2017). The South African locations that have TCI scores most similar to this study were Belfast, East London and Port Nolloth which each received scores between 70 and 79. The climatic conditions for the remaining regions were classified as very good (Fitchett et al. 2017). As a result of the markedly different topography and an altitude of ~3,200 m asl, the eastern Lesotho highlands have more climatic factors that actively decrease the TCI scores compared to the South African locations, including rainfall, wind, daytime and average thermal comfort.

A comparison of the TCI scores for the eastern Lesotho highlands to other locations that have TCI research is now possible. It is expected that areas of similar tourism activities, similar altitude and latitudinal aspects together with parallel seasonal and interannual variability, which creates parameters that are specific to the climate regime (Amelung and Moreno 2009), will have similar outputs for the TCI scores as they will rely on similar physical features and climatic conditions (Becken 2010; Perch-Nielsen et al. 2010). Beach tourism, for example, relies on copious amounts of sunshine, no precipitation and low wind speeds for successful tourism (Becken 2010). South eastern Australia has similar physical features to Afriski, such as the main tourist destination Mt Perisher, approximately 2,054 m asl (Grab and Linde 2014; Hughes et al. 2018). New South Wales and Victoria in Australia are likely to have similar TCI scores to eastern Lesotho Highlands as they have comparable climatic conditions (Hughes et al. 2018).

Climatic factors affect the TCI scores by either increasing or decreasing the resultant output TCI score and classification (Yu et al. 2009). In turn, this affects tourism as many outdoor and adventure tourism activities rely directly on specific climatic conditions, including sunshine, low incidents or high volumes of rain, low or high wind speeds, moderate humidity or a range in temperatures for tourist satisfaction (Martín 2005; Stockigt et al. 2018). The positive effect of high sunshine hours on the TCI scores is echoed in other regions where the TCI has been applied (Perch-Nielsen et al. 2010). In South Africa, the mean annual TCI scores are positively influenced by ample sunshine, especially in coastal regions for beach tourism (Fitchett et al. 2017). However, the lack of sufficient sunshine and cloud cover data from weather stations proves challenging for the application of the TCI in many southern African regions (Fitchett et al. 2016, 2017). Decreases in TCI scores for the eastern Lesotho highlands are driven by cold temperatures (average thermal comfort) and high year-round rainfall. These components are critical for determining peak season for tourism in the region, as they control the suitability of outdoor tourism for tourist satisfaction (Fitchett et al. 2016). However, noting the importance of snow tourism in Lesotho, the impact of increasing minimum temperatures on snow production and cover in the winter season poses threats that are not contemplated by the TCI (Wikle 2015; Demiroglu et al. 2018; Stockigt et al. 2018). Thus, the TCI coding of climatic suitability for a region in which snow tourism forms a key economic contributor for winter seasons may be considered problematic as the climatic factors that are needed are deemed negative factors for tourism satisfaction, in this instance.

Online commentary on weather phenomenon at Afriski provides evidence of tourist climatic sensitivity (Stockigt et al. 2018). According to the TCI, the most suitable climate for outdoor tourism is December. However, July has the highest visitor numbers due to the alignment of adventure sport tourism, skiing competitions and school holidays, coupled with the possibility of a unique experience of snow (Vanat 2018; McKay 2018; Mihăilă and Bistricean 2018; Stockigt et al. 2018). The disjuncture between the expected climatic conditions from a high TCI score and the physical conditions experienced may impact the tourists' satisfaction with Afriski and can deter future visitation (Yiu et al. 2015; Stockigt et al. 2018).

3.2 Reliability and appropriateness of the TCI for the eastern Lesotho Highlands

The ability to use the TCI for the Afriski Mountain Resort context was hindered, to an extent, by the availability and quality of the weather data captured by the weather station at Afriski. Most of the months were classified as having good climatic conditions. While this is a positive classification by tourism rating standards it decreases the ability of a seasonal comparison within the study. A seasonal comparison within the year for deciding which month would be the most gainful in terms of tourism experience is important (Scott and McBoyle 2001). For general outdoor tourism activities, which include activities such as mountain and quad biking, hiking, fishing the eastern Lesotho highlands are climatically suitable for general tourism.

Further research is important regarding prolonged temporal periods of low to absent rainfall to identify the effect of cyclic patterns, such as El Niño Southern Oscillation (ENSO), on threshold climatic conditions (Lakhraj-Govender and Grab 2018). A triggering factor for the rise in temperature, aside from climate change, is the El Niño event (Pomposi et al. 2018). Southern Africa experienced the effects of an El Niño event during the austral summer (October-March) over 2015 and 2016 (Lakhraj-Govender and Grab 2018). This particular ENSO event was considered one of the strongest recorded (Blamey et al. 2018; Pomposi et al. 2018). Rainfall decreased considerably from 2014 to 2015, from 71.4 mm to 14.4 mm. This interannual variability in temperature and rainfall coincides with the shift in the TCI scores (Yu et al. 2009). The extreme decrease in total rainfall as well as the spike in minimum and maximum temperatures influenced the TCI rating of the climatic conditions of tourism at Afriski (Fitchett et al. 2016; Stockigt et al. 2018). The highest overall TCI score for Afriski was in 2015, coinciding with the onset of the El Niño event in southern Africa, with a score of 69 classifying the climatic conditions of Afriski as 'good' (Blamey et al. 2018). However, the TCI model does not distinguish extreme climatic conditions from the meteorological data, classifying a drought-stricken region as having favourable tourism conditions is highly problematic as there may be water stresses, thus affecting the tourism experience depending on the time of arrival—in winter there would not be natural snow and likely limited artificial snow if there is a water crisis, the tourism would decline despite favourable climatic conditions of high total sunshine hours and no rainfall (Yu et al. 2009).

The TCI was developed with the aim to have high visibility to spend time outdoors (Mieczkowski 1985; Perch-Nielsen et al. 2010). Commercially popular snow tourism destinations are mainly found in the United States, the alps, western and eastern Europe and Asia; while Lesotho falls within a number of smaller destinations include Greece, Iran, Australia, New Zealand, and Turkey (Vanat 2016; Hughes et al. 2018). Furthermore, the effort towards creating specifically winter-based indices is needed to provide a baseline for tourist destination selection in choosing a winter tourism destination, as well as informing on the construction of winter resorts and providing the spatial layout of the winter tourism sector (Scott and Lemieux 2010).

The study by Cai et al. (2019) aims to guide winter tourism destination development and the spatial layout of winter tourism resources. They analysed the temporal and spatial distribution of winter tourism resources in northeast China. They used daily maximum temperature, mean wind speed, relative humidity and visibility to establish the Meteorological Suitability Index (MSI), while they used snow depth and duration to establish the Snow Abundance Index (SAI). These two indices were coupled with the copula function to analyse the degree of suitability for winter tourism. This approach could be useful for assessing the resources of Afriski as a winter tourism destination. Since ski and snow tourism destinations can operate with a snow depth of more than 30cm, but the temperature may not exceed 10°C for more than two consecutive days and there must be minimal rainfall (Scott et al. 2006; Becken 2010). The weather conditions that are promoting the high TCI scores are not appropriate for snow tourism at Afriski. Further research on the potential impact on the suitability of winter tourist destinations and the development of the winter tourism sector is required on a global scale (Stockigt et al. 2018). Therefore, the reliability and availability of the meteorological data for studying snow tourism is of high importance (Scott and Lemieux 2010). The CVIT may provide a more comprehensive framework to achieve this, as snow onset dates are one of the factors included (Scott et al. 2019).

The rising surface temperatures in the twenty-first century have the potential to shorten the ski season and unreliability of snow may cause tourists seeking the specific environmental conditions and activities to leave the snow resort earlier (Becken 2010; Campos Rodrigues et al. 2018; Stockigt et al. 2018). Ticket sales for ski tourism attractions have been empirically related to the snow depth, wind chill and the minimum and maximum climatic conditions of the region (Shih et al. 2009). Aside from artificial snow making (see Figure 4), there does not appear to be meaningful action towards an adaptive strategy by the snow resort, as there is limited research into the climate change consequences on snow tourism at Afriski (Stockigt et al. 2018). Poor snow conditions result in the exposure of rocks, which pose a safety risk to the skiers (Becken 2010). Thus, the TCI is a more appropriate index for nature, cultural or beach tourism where ample sunshine hours, little to no rainfall and wind are considered positive components of the TCI (Scott et al. 2008; Becken 2010; Stockigt et al. 2018).

Figure 4 Photograph of the Afriski ski-slope during the process of snow-making in the first week of June 2019 prior to natural snowfall on the site.

The TCI serves primarily as the first climate tourism index to be conducted in Lesotho. The TCI has been adapted to various regions around the world, but the results were derived from biometeorology literature and the subjective opinion of Mieczkowski (1985), without empirical testing with tourists (Perch-Nielsen et al. 2010). However, it is still widely favoured for its comprehensive metrics and integration of all three facets of climate namely, thermal comfort; aesthetic and physical components (Scott et al. 2004, 2016; de Freitas et al. 2008; Perch-Nielsen et al. 2010). This research may be useful for Afriski to improve the reliability of the seasonal results by matching tourist visitation peaks (Scott et al. 2016). The CIT developed by de Freitas et al. (2008) offers a more flexibility to the potential application than the TCI in that the index incorporates thermal sensation using the ASHRAE scale and recognises the overriding effect of certain weather conditions on thermal and aesthetic aspects (de Freitas et al. 2008). The CIT may be a more suitable index for ski tourism in Lesotho than the TCI, but is limited by the availability of input data. Another new index has recently been proposed that is arguably appropriate for all types of tourism (Li et al. 2018). The results suggest that there is a positive intra-annual effect on the tourist arrivals, while the climatic interannual effects express a non-significant correlation between tourist arrivals based on long-term relative TCI scores (Li et al. 2018). However, none of these indices are entirely appropriate for snow tourism, through some many come close to copiously representing a true classification. When considering the low temporal resolution of many of the tourism climate indices the integration of climatic factors in the index becomes encumbered (Perch-Nielsen et al. 2010).

3.3 Future outlook

The intricate relationship between tourism and climate change will be affected through changes in precipitation, temperature and humidity as well as sea level rise (Hoogendoorn and Fitchett 2018). Travel destinations will experience a redistribution of climatic resources; creating tourism destination "winners" and "losers" under climate change (Perch-Nielsen et al. 2010). Projections for the subarctic demonstrate that under increasing temperatures of climate change the TCI score will increase compared to southern regions (for example Colorado, USA) by 2050 (Scott 2003). Therefore, the need for thorough, location-specific and community-level research into climate change and tourism is of high importance (Hoogendoorn and Fitchett 2018). There has been a substantial effort toward this matter over recent decades for the global North, however, in the Global South (Africa in particular) there has been limited research concerning climate change impacts on tourism (Hoogendoorn and Fitchett 2018; Stockigt et al. 2018). Southern Africa has seen a rise in the diversity of the research locations (Hoogendoorn and Fitchett 2018). Due to the under-development and low-resolution warning systems for extreme climatic events, the Global South is more susceptible to climate change that the Global North (Hoogendoorn and Fitchett 2018). The socio-economics, political situation, capital and firstly meeting the basic human rights of the country significantly influences the degree to which long-term planning and adaptation can be implemented (Campos Rodrigues et al. 2018). Adaptation strategies are crucial for combating climate change in tourism locations (Elasser and Bürki 2002; Campos Rodrigues et al. 2018). Thus, the development of strategic research to assess the relationship between tourism and climate change and the implications climate change will have on sustainable tourism (Scott 2003). Increased collaboration between the scientists on climate change, government officials, stakeholders, and relevant parties becomes imperative for the tourism sector to raise awareness of the long-term decreasing trends in TCI scores for certain destinations as it can inform on the locations that will not be (financially) viable for tourism in the future due to climatic unsuitability (Roshan et al. 2016).

4 Conclusion

Building on the initial work of Mieczkowski (1985), this pilot study explores how tourism climate resources will be affected by projected global climate change, specifically in Lesotho. Weather and climate are significant controls on the types of tourism that can be offered at a location. The application of the indices to quantify the climatic suitability for tourism in the Global South has been sparse. This research presents the first application of the TCI in Lesotho, to assess the climatic suitability of the eastern Lesotho highlands for outdoor tourism, specifically at Afriski. A comparison is now possible between this region and other travel destinations that have TCI outputs. Snow tourism at Afriski is heavily reliant on specific climate conditions for skiing, which is a central tourism activity offered at the resort. Climate change threats of increasing temperatures and changes to the wind and precipitation patterns are of particular concern for snow tourism regions. With the projected future temperature increases predicted to alter snow reliability, immediate and effective planning for adaptive strategies and action is required. The TCI produced an overall score of 'good' for the climatic conditions for tourism at Afriski. The resultant output of the TCI does not coincide with the peak tourist season (winter) and the peak climatic time of the year for tourism. The TCI was designed for more favourable climatic conditions, more as a sightseeing tourism index than an extreme tourism index. This might be a key reason for the mismatch between the current tourism flows to Afriski and the TCI distribution. This suggests that a different index may be more appropriate for studying the relationship between tourism and the suitability of climatic conditions for snow tourism destinations. Further research incorporating a range of indices for Afriski is needed to ensure the most suitable tourism-climate index is chosen to represent the threatened tourism sector.

This research does not assert that climate is the single most influential factor for the selection of tourist destinations. Regions with a high TCI score may experience low tourism attraction based on socio-economic or political factors, including crime, war and political instability; or limited infrastructure that would support the desired tourism. Adaptions to the model to compensate for the difficulties in data acquisition allows for the conduction of a regional index more suitable for the African context. Further research and improved comprehensive meteorological recording are vital for calculating accurate indices and studies on the climatic suitability for snow tourism under the predicted climate change consequences in the future.

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References

Afriski (2018) Tourist attractions. https://www.afriski.net/tourist-attractions/, accessed 20 October 2018.

Amelung B, Viner D (2006) Mediterranean Tourism: exploring the future with the Tourism Climatic Index. Journal of Sustainable Tourism 14(4): 349-366. https://doi.org/10.2167/jost549.0

Amelung B, Nicholls S, Viner D (2007) Implications of Global Climate Change for Tourism Flows and Seasonality. Journal of Travel Research 45(3): 285-296. https://doi.org/10.1177/0047287506295937

Aylen J, Albertson K, Cavan G (2014) The impact of weather and climate on tourist demand: the case of Chester Zoo. Climatic Change 127(2): 183-197. https://doi.org/10.1007/s10584-014-1261-6

Baral S, Adams D, Lebona J, et al. (2011) A cross-sectional assessment of population demographics, HIV risks and human rights contexts among men who have sex with men in Lesotho. Journal of the International AIDS Society 14(1): 36-44. https://doi.org/10.1186/1758-2652-14-36

Becken S (2010) The importance of climate and weather for tourism: literature review. LEAP, New Zealand. https://doi.org/10182/2920

Blamey RC, Kolusu SR, Mahlalela P, et al. (2018) The role of regional circulation features in regulating El Niño climate impacts over southern Africa: A comparison of the 2015/2016 drought with previous events. International Journal of Climatology 38(11): 4276-4295. https://doi.org/10.1002/joc.5668

Bunakov OA, Zaitseva NA, Larionova AA, et al. (2018) Development Perspectives of" Last Chance Tourism" as One of the Directions of Ecological Tourism. Ekoloji Dergisi, 106. https://doi.org/106156/505-s-18

Cai W, Di H, Liu X (2019) Estimation of the Spatial Suitability of Winter Tourism Destinations Based on Copula Functions. International Journal of Environmental Research and Public Health 16(2): 186. https://doi.org/1660-4601/16/2/186

Campos Rodrigues L, Freire-González J, González Puig A, Puig-Ventosa I (2018) Climate Change Adaptation of Alpine Ski Tourism in Spain. Climate 6(2): 29-41. https://doi.org/2225-1154/6/2/29

Chi C, Qu H (2008) Examining the structural relationships of destination image, tourist satisfaction and destination loyalty: An integrated approach. Tourism Management 29(4): 624-636. https://doi.org/S0261517707001525

de Freitas CR, Scott D, McBoyle G (2008) A second-generation Climate Index for Tourism (CIT): specification and verification. International Journal of Biometeorology 52(5): 399-407. https://doi.org/10.1007/s00484-007-0134-3

Demiroglu OC, Dannevig H, Aall C (2018) Climate change acknowledgement and responses of summer (glacier) ski visitors in Norway. Scandinavian Journal of Hospitality and Tourism 18(4): 419-438. https://doi.org/10.1080/15022250.2018.1522721

Dubois G, Ceron J, Gössling S, Hall C (2016) Weather preferences of French tourists: lessons for climate change impact assessment. Climatic Change 136(2): 339-351. https://doi.org/10.1007/s10584-016-1620-6

Elsasser H, Bürki R (2002) Climate change as a threat to tourism in the Alps. Climate Research 20(3): 253-257. https://doi.org/10.3354/cr020253
Faturiyele I, Karletsos D, Ntene-Sealiete K, et al. (2018) Access to HIV care and treatment for migrants between Lesotho and South Africa: a mixed methods study. Public Health 18(1): 668-678. https://doi.org/10.1186/s12889-018-5594-3
Fitchett JM, Grant B, Hoogendoorn G (2016) Climate change threats to two low-lying South African coastal towns: Risks and perceptions. South African Journal of Science 112(5-6): 86-94. https://doi.org/10.17159/sajs.2016/20150262
Fitchett JM, Robinson D, Hoogendoorn G (2017) Climate suitability for tourism in South Africa. Journal of Sustainable Tourism 25(6): 851-867. https://doi.org//10.1080/09669582.2016.1251933
Giaoutzi M (2017) Tourism and regional development: New pathways. Routledge. New York. ISBN: 9781315235967
Giddy JK (2016) Environmental Values and Behaviours of Adventure Tourism Operators: The case of the Tsitsikamma, South Africa. African Journal of Hospitality, Tourism and Leisure 5(4): 1-19. ISSN: 2223-814X
Giddy JK, Webb NL (2018) Environmental attitudes and adventure tourism motivations. GeoJournal 83(2): 275-287. https://doi.org/10.1007/s10708-017-9768-9
Giddy JK, Fitchett JM, Hoogendoorn G (2017) Insight into American tourists' experiences with weather in South Africa. Bulletin of Geography. Socio-Economic Series 38: 57-71. https://doi.org/10.1515/bog-2017-0034
Gössling S, Scott D, Hall CM, et al. (2012) Consumer behaviour and demand response of tourists to climate change. Annals of Tourism Research 39(1): 36-58. https://doi.org/10.1016/j.annals.2011.11.002
Grab SW, Simpson AJ (2000) Climatic and environmental impacts of cold fronts over KwaZulu-Natal and the adjacent interior of southern Africa. South African Journal of Science 96(1): 602-608. https://doi.org/sajsci/96/11-12/AJA00382353_8933
Grab S, Nüsser N (2001) Towards an integrated research approach for the Drakensberg and Lesotho mountain environments: a case study from the Sani plateau region. South African Geographical Journal 83(1): 64-68. https://doi.org//10.1080/03736245.2001.9713720
Grab SW, Nash DJ (2010) Documentary evidence of climate variability during cold seasons in Lesotho, southern Africa, 1833–1900. Climate Dynamics 34(4): 473-499. https://doi.org/10.1007/s00382-009-0598-4
Grab SW, Linde JH (2014) Mapping exposure to snow in a developing African context: implications for human and livestock vulnerability in Lesotho. Natural Hazards 71(3): 1537-1560. https://doi.org/10.1007/s11069-013-0964-8
Grab SW, Mulder NA, Mills SC (2009) Spatial associations between longest - lasting winter snow cover and cold region landforms in the high Drakensberg, southern Africa. Geografiska Annaler: Series A 91(2): 83-97. https://doi.org/10.1111/j.1468-0459.2009.00356.x
Hall C (1992) Adventure, sport and health tourism. In: Hall CM and Weiler B (eds.), Special Interest Tourism. London: Belhaven Press. ISBN: 1852930721
Hoogendoorn G, Fitchett J (2018b) Tourism and climate change: a review of threats and adaptation strategies for Africa. Current Issues in Tourism 21(7): 742-759. https://doi.org/10.1080/13683500.2016.1188893
Hoogendoorn G, Grant B, Fitchett JM (2016) Disjunct perceptions? Climate change threats in two-low lying South African coastal towns. Bulletin of Geography. Socio-economic Series 31: 59-71. https://doi.org/10.1515/bog-2016-0005
Hughes L, Stock P, Brailsford L, Alexander D (2018) Icons at risk: Climate Change threatening Australian tourism. Climate Council of Australia, Australia. ISBN : 9781925573480
Intergovernmental Panel on Climate Change (IPCC) (2018) Summary for Policymakers. In: Masson-Delmotte V, Zhai P, Pörtner HO, et al. (eds.), Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. World Meteorological Organization. Switzerland.
Kaján E, Saarinen J (2013) Tourism, climate change and adaptation: a review. Current Issues in Tourism 16(2): 167-195. https://doi.org/10.1080/13683500.2013.774323
Karmalkar A, McSweeney C, New A, Lizcano G (2012) UNDP climate change country profiles: South Africa. http://www.geog.ox.ac.uk/research/climate/projects/undpcp/?country=SouthAfrica&d1=Reports, accessed October 2018.
Lakhraj-Govender R, Grab SW (2018) Assessing the impact of El Niño–Southern Oscillation on South African temperatures during austral summer. International Journal of Climatology 39(1): 143-156. https://doi.org/10.1002/5791
Li H, Goh C, Hung K, Chen JL (2018) Relative climate index and its effect on seasonal tourism demand Journal of Travel Research 57(2): 178-192. https://doi.org/10.1177/0047287516687409
Martín MBG (2005) Weather, climate and tourism a geographical perspective. Annals of Tourism Research 32(3): 571-591. https://doi.org/10.1016/j.annals.2004.08.004
McKay T (2018) An analysis of the South African adventure tourism industry. Anatolia 29(4): 529-539. https://doi.org/10.1080/13032917.2018.1455151
Mearns K (2011) Using sustainable tourism indicators to measure the sustainability of a community-based ecotourism venture: Malealea Lodge and Pony Trek Centre, Lesotho. Tourism Review International 15(1-2): 135-147. https://doi.org/10.3727/154427211X13139345020499
Mearns K (2016) Climate change and tourism: some industry responses to mitigate tourism" s contribution to climate change. African Journal of Hospitality, Tourism and Leisure 5(2): 2-9. ISSN: 2223-814X
Mieczkowski Z (1985) The tourism climatic index: a method of evaluating world climates for tourism. Canadian Geographer 29(3): 220-233. https://doi.org/10.1111/j.1541-0064.1985.tb00365.x
Mihăilă D, Bistricean PI (2018) The suitability of Moldova Climate for Balneary-Climatic Tourism and Outdoor Activities – A Study Based on the Tourism Climate Index. Present Environment and Sustainable Development 12(1): 263-282. https://doi.org/10.2478/pesd-2018-0021
Mohan S, Morton B (2009) The Future of Development Cooperation in a Changing Climate. Proceedings of Rethinking Development in a Carbon-Constrained World Development Cooperation and Climate Change, Finland. ISBN 978-951-724-742-9
Morgan R, Gatell E, Junyent R, et al. (2000) An improved user-based beach climate index. Journal of Coastal Conservation 6(1): 41-50. https://doi.org/10.1007/BF02730466
Nash DJ, Grab SW (2010) "A sky of brass and burning winds": documentary evidence of rainfall variability in the Kingdom of Lesotho, Southern Africa, 1824-1900. Climatic Change 101(3-4): 617-653. https://doi.org/10.1007/s10584-009-9707-y
Pandy WR, Rogerson CM (2018) Tourism and climate change: Stakeholder perceptions of at-risk tourism segments in South Africa. EuroEconomica 37(2): 4553-4568. ISSN: 1582-8859
Perch-Nielsen SL, Amelung B, Knutti R (2010) Future climate resources for tourism in Europe based on the daily Tourism Climatic Index. Climatic Change 103(3-4): 363-381. https://doi.org/10.1007/s10584-009-9772-2
Preston-Whyte RA, Watson HK (2005) Nature tourism and climatic change in Southern Africa. Tourism, Recreation and Climate Change 130-142. ISBN: 1845410033
Pomposi C, Funk C, Shukla S, et al. (2018) Distinguishing southern Africa precipitation response by strength of El Niño events and implications for decision-making. Environmental Research Letters 13(7). https://doi.org/10.1088/1748-9326
Rogerson CM (2009) Tourism development in Southern Africa:

patterns, issues and constraints. In: Saarinen J, Becker F, Manwa H, Wilson D (eds.), Sustainable tourism in Southern Africa: Local communities and natural resources in transition. Channel View, Bristol. pp 20-44.
Rogerson CM, Letsie T (2013) Informal sector business tourism in the global South: Evidence from Maseru, Lesotho. Urban Forum 24(4):485-502. https://doi.org/10.1007/s12132-013-9196-y
Rogerson C (2018) Local Economic Development in the Changing World: The Experience of Southern Africa. Routledge. New York. ISBN 9781351322607.x
Rogerson C, Visser G (2011) African tourism geographies: existing paths and new directions. Tijdschrift Voor Economische en Sociale Geografie 102(3): 251-259. https://doi.org/10.1111/j.1467-9663.2011.00661
Roshan G, Yousefi R, Fitchett JM (2016) Long-term trends in Tourism Climate Index scores for 40 stations across Iran: the role of climate change and influence on tourism sustainability. International Journal of Biometeorology 60(1): 33-52. https://doi.org/10.1007/s00484-015-1003-0
Saarinen J, Hambira WL, Atlhopheng J, Manwa H (2012) Perceived impacts and adaptation strategies of the tourism industry to climate change in Kgalagadi South District, Botswana. Development Southern Africa 29(2): 273-285.
Samimi AJ, Sadeghi S, Sadeghi S (2017) The relationship between foreign direct investment and tourism development: evidence from developing countries. Institutions and Economies 5(2): 59-68. ISSN 2232-1349
Sat24 (2018) http://www2.sat24.com/history.aspx?culture=en, accessed 2 June 2018.
Scott D, McBoyle G (2001) Using a 'Tourism Climate Index' to examine the implications of climate change for climate as a tourism resource. In: Matzarakis A, de Freitas CR (eds.), Proceedings of the first international workshop on climate, tourism and recreation, International Society of Biometeorology, Commission on Climate, Tourism and Recreation Freiburg, Germany. pp 69-88.
Scott D (2003) Climate change and tourism in the mountain regions of North America. 1st International Conference on Climate Change and Tourism.
Scott D, McBoyle G, Schwartzentruber M (2004) Climate change and the distribution of climatic resources for tourism in North America. Climate Research 27(2): 105-117. https://doi.org/10.3354/cr027105
Scott D, Jones B, Konopek J (2008) Exploring the impact of climate-induced environmental changes on future visitation to Canada's Rocky Mountain National Parks. Tourism Review International 12(1): 43-56. https://doi.org/10.3727/154427208785899939
Scott D, Lemieux C (2010) Weather and climate information for tourism. Procedia Environmental Sciences 1: 146-183. https://doi.org/10.1016/j.proenv.2010.09.011
Scott D, Gössling S, Hall CM (2012) International tourism and climate change. Climatic Change 3(3): 213-232. https://doi.org//10.1002/wcc.165
Scott D, Rutty M, Amelung B, Tang M (2016) An inter-comparison of the Holiday Climate Index (HCI) and the Tourism Climate Index (TCI) in Europe. Atmosphere 7(6): 80-97. https://doi.org/10.3390/atmos7060080
Scott D, Hall CM, Gössling S (2019) Global tourism vulnerability to climate change. Annals of Tourism Research 77: 49-61. https://doi.org/10.1016/j.annals.2019.05.007
Shih C, Nicholls S, Holecek D (2009) Impact of weather on downhill ski lift ticket sales. Journal of Travel Research 47(3): 359-37. https://doi.org/10.1177/0047287508321207
Steiger R, Mayer M (2008) Snowmaking and climate change: Future options for snow production in Tyrolean ski resorts. Mountain Research and Development 28(3): 292-298. https://doi.org/10.1659/mrd.0978
Steiger R, Scott D, Abegg B, et al. (2017) A critical review of climate change risk for ski tourism. Current Issues in Tourism. https://doi.org/10.1080/13683500.2017.1410110
Strobl A, Teichmann K, Peters M (2015). Do mountain tourists demand ecotourism? Examining moderating influences in an Alpine tourism context. Tourism 63(3): 383-398. ISSN 383-398
Stockigt L, Hoogendoorn G, Fitchett JM, Saarinen J (2018) Climatic sensitivity and snow-based tourism in Africa: an investigation of TripAdvisor reviews on Afriski, Lesotho. Proceedings of Biennial Conference of the Society of South African Geographers, Bloemfontein.
Turpie J, Winkler H, Spalding-Fecher R, Midgley G (2002) Economic impacts of climate change in South Africa: a preliminary analysis of unmitigated damage costs. Unpublished report. University of Cape Town.
UNESCO (2018) South Africa. https://whc.unesco.org/en/statesparties/za, accessed on 30th October 2018.
Vanat L (2016) 2016 International Report on Snow & Mountain Tourism. Overview of the key industry figures for ski resorts. http://www.isiaski.org/download/20160408_RM_World_Report_2016.pdf, accessed on 8 September 2018.
Vanat L (2018) 2018 International Report on Snow & Mountain Tourism. Overview of the key industry figures for ski resorts. https://www.vanat.ch/RM-world-report-2018.pdf, accessed 2 November 2018.
Wikle TA (2015) Subsistence farming and economic hardship in Lesotho, Africa's mountain kingdom. Focus on Geography 58(2): 79-90.
Wilkins E, de Urioste-Stone S, Weiskittel A, Gabe T (2018) Effects of weather conditions on tourism spending: implications for future trends under climate change. Journal of Travel Research 57(8): 1042-1053. https://doi.org/10.1177/0047287517728591
World Bank (2016) Lesotho water security and climate change assessment. http://documents.worldbank.org/curated/en/446521472206603986/Lesotho-water-security-and-climate-change-assessment, accessed 12 October 2018.
WTTC (2017) Travel and tourism economic impact 2017 world. https://www.wttc.org/-/media/files/reports/economic-impact-research/regions-2017/world2017.pdf, accessed on 9 May 2018.
WTTC (2018) Travel and tourism economic impact 2018 world. https://www.wttc.org/-/media/files/reports/economic-impact-research/regions-2018/world2018.pdf, accessed 22 October 2018.
Yfantidou G, Matarazzo M (2017) The future of sustainable tourism in developing countries. Sustainable Development 5(6): 459-466. https://doi.org/10.1002/sd.1655
Yiu L, Saner R, Lee MR (2015) Lesotho, a tourism destination: an analysis of Lesotho's current tourism products and potential for growth. In: Camillo A (ed.), Handbook of Research on Global Hospitality and Tourism Management, IGI Global, Pennsylvania. pp 312-331. https://doi.org/10.4018/978-1-4666-8606-9.ch017
Yu G, Schwartz Z, Walsh JE (2009) A weather-resolving index for assessing the impact of climate change on tourism related climate resources. Climatic Change 95(3-4): 551-573. https://doi.org/10.1007/s10584-009-9565-7