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A Comparison of the Tourist Potential of the Climates of the Coastal Resort at Odesa and the Inland Resort by Lake Svityaz

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Abstract: The aim of this study is to evaluate and compare the human-biometeorological conditions at two resorts in Ukraine: a coastal resort located at Odesa in southern Ukraine and an inland resort situated by the lake at Svityaz situated in northwest Ukraine. The results of this study can facilitate the assessment of the tourist potentials of both locations by the tourism industry, tour operators, and tourists. The evaluation is based on an analysis of the Physiologically Equivalent Temperature (PET) and parameters presented through the Climate–Tourism/Transfer–Information Scheme (CTIS) for the period 1991–2020. The CTIS data reveal that better conditions in terms of thermal comfort can be found during the warm period from May to September at both sites. The results show that the highest frequency of all grades of heat stress are observed in the last 10-day period of July and in the first 10-day period of August at both stations, but at Odesa, the frequency of heat stress of any grade is approximately 10% higher than at Svityaz. The frequency of moderate, strong and extreme heat stress during the daytime in July and in the first two 10-day periods of August at Odesa ranged from 51.3% to 66.5%, and at Svityaz it ranged between 40.2 and 54.6%. Human-biometeorological conditions during heat waves are more strenuous at Odesa. The frequency of days with extreme heat stress at 12 UTC during summer heat waves is 48.4% at Odesa and 35.6% at Svityaz. The results show a higher frequency of thermal stress at Odesa, which makes this resort less comfortable for people vulnerable to heat stress.

Keywords: physiologically equivalent temperature; Climate–Transfer/Tourism–Information Scheme; tourism potential; human thermal comfort; Odesa; Svityaz

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1. Introduction

Tourism represents one of the most important and fastest growing sectors of the economy. Key factors for sustainable tourism development include both the current and future regional climate conditions that may support or adversely impact tourist activities [1].

Tourism is underpinned not only by travel for leisure and holidays, but also by travel for other purposes, such as travel for health and well-being [2]. Recreation and wellness tourism development are very sensitive to climate conditions, especially to thermal comfort conditions, and tourists, as well as health tourism operators, should pay particular attention to thermal stress in warm periods to avoid adverse consequences for health resort visitors [3]. Sensitivity to heat stress varies according to many aspects, such as age, health, lifestyle, poverty levels, etc. [4]. People with respiratory and cardiovascular diseases, diabetes, or chronic mental illnesses; patients taking specific drugs or medications that affect perception or regulation of heat in the body; and young children and older people, whose capacity to adapt may no longer be sufficient, are found to be particularly vulnerable to temperature extremes [5–7]. Therefore, it is very important to incorporate a detailed analysis of climatic conditions into the assessment of the suitability of a region for recreational or health tourism and to the sensitivity that tourists of different ages and with different health conditions may have in regard to heat stress.

The most popular places for tourism and recreation are “places of triple S” (Sea, Sand and Sun) [8]. There are many climate-related factors which tourists use to make decisions in relation to planning their recreational activities. Among the most important criteria is the thermal component of the climate, which plays a particularly important role for summer tourism [9]. During warm periods, “places of triple S” may be characterized by high frequencies of thermal stress. Health problems may occur as a result of recreation in such locations (e.g., caused by heat stress, over-exposure to UV radiation or heat stroke). Additional risks associated with recreation in “places of triple S” are associated with summer heat wave events and associated high air temperature during these events. Heat waves always influence human thermal comfort conditions and can lead to marked short-term increases in the rates of morbidity and mortality [10,11]. During the last decades, the number of heat wave events has increased worldwide [12], and climate projections show that the frequency of heat wave events, their intensity and their duration will increase into the future.

Thus, “places of triple S” are not suitable for all categories of tourists. In contrast to this, resorts situated in mountains or inland forest areas or near lakes or rivers can have milder climates with lower risks of heat load. Such resorts can be alternative places for tourism and recreational activities because of the surrounding natural beauty, unique geography, low levels of air pollution, etc. They may not be places for mineral baths based on seawater, sea bathing and curative mud (like “places of triple S”), but they have a rich potential and can provide alternative tourism and recreation opportunities, attracting tourists from both near and far-away regions. Thus, resorts situated in mountains or in inland forests or near lakes or rivers are potentially more appropriate for tourists vulnerable to heat and who want to indulge in recreational and wellness activities. For the promotion of tourism, the recreational potential and the fast development of the tourism industry in these regions, it is important that materials used for promoting climate conditions and recreation potential are easily understood and user friendly, as well as reliable and scientifically based [8]. Incorrect, outdated or selective climate information may give the tourist the wrong impression of their destination [13].

Until now, there are no universal criteria, based on human-biometeorological climatological studies, that are used to determine the recreational potential of a region and/or whether it is fit for particular kinds of tourism. Generally, the broad climatic conditions of such regions are considered to be evidence, and a separate promotion (utilizing more specific climate or environmental information) is not seen to be needed [14]. However, in support of tourism, there are climate indices that can be utilized to identify the climatic conditions of a destination for all kinds of users. The tourism-relevant climate indices can be classified into three categories: (1) elementary indices are synthetic values that do not have any thermo-physiological relevance and are generally unproven (the Climate Index by Davies, etc.); (2) the bioclimatic indices such as the Predicted Mean Vote (PMV), the Physiologically Equivalent Temperature (PET); and (3) combined tourism climate indices such as the Tourism Climate Index (TCI) [15]. The bioclimatic indices have an advantage, as they can be used for the assessment of thermal comfort conditions as well as climate tourism potential of the territory. A comprehensive review of approaches and methods to ascertain outdoor human thermal perception, conducted by Potchter et al. [16], showed that PET is the most widely used bioclimatic index. An analysis of the frequency of the thermal indices that were used in the reviewed studies shows that the Physiologically Equivalent Temperature was used in 30.2% of the case studies [16]. In order to visualize and provide detailed climate information that can be used by tourists to anticipate thermal comfort, aesthetic and physical conditions for planning their vacations, the Climate–

Tourism/Transfer–Information Scheme (CTIS) has been developed [17]. CTIS has been successfully used in many studies of thermal bioclimate and climate tourism analysis worldwide [3,8,18–23].

In Ukraine, the most well-known tourist and recreational resorts are located on the southern coastal regions of the country. The coasts are a very attractive recreational factor, which provides the conditions for thalassotherapy. Odesa is one of the most popular places for recreation and tourism in Ukraine, as it has natural resources as well as historical and cultural attractions that support ongoing development of a regional tourism industry. Odesa is also one of the biggest cities in Ukraine, with a population of more than 1 million inhabitants. However, in big cities, recreational activities may not be fully realized because of the building structures, the lack of suitable open space and higher air temperatures due to urban heat island effects [24]. Additionally, the big-city lifestyle is more appropriate for younger tourists but may be less suitable for the recreational pursuits and the mental health improvements of elderly people and vacationers with children.

Svityaz is situated in the northwestern border region of Ukraine. The lake at Svityaz is the second largest lake in Ukraine (with an area of 27.5 km^2) and represents one of the greatest environmental attractions of the country. It belongs to a group of thirty Shatski lakes in the region surrounded by forests. This place is characterized by lower air temperature in summer compared to the coastal resorts of the southern region. Svityaz resort is suitable for different types of recreation, but this place is not as popular as the "resorts of triple S". For the promotion and further development of Svityaz resort, it is necessary to make detailed and scientifically based analyses of the thermal bioclimate and climate for tourism purposes.

Therefore, the aim of this study is to explore and compare the human-biometeorological conditions of Odesa and Svityaz, which can be used to facilitate decision making by the tourism industry, tour operators and tourists.

2. Materials and Methods

Odesa (46°25′ N, 30°45′ E, 40 m a.s.l.) is in the south-western part of Ukraine, on the northwestern shore of the Black Sea (Figure 1). It is the third most populous city in the country. The city's administrative boundaries cover a total terrestrial area of approximately 162.4 km^2. The population of the city is 1.015 million (not including non-permanent residents).

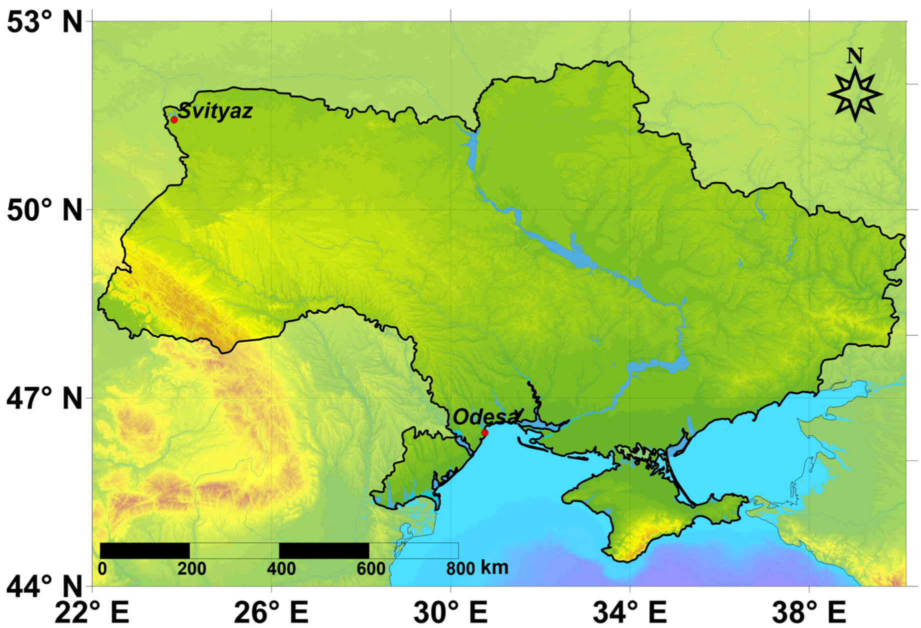


Figure 1. Odesa and Svityaz location.

According to Köppen-Geiger's climate classification [25], Odesa has a warm, temperate climate (Cfb) and is fully humid with warm summers. The annual average sunshine duration is 2308 h. The annual average air temperature is 10.3 °C. The total annual precipitation amount is 461 mm.

In the city and its vicinity and west towards the Dnieper River along the Black Sea coast, there are balneological, thalassotherapeutic and climatic resorts of high national and increasing international importance. The Odesa region has resources such as curative mud and brine estuaries. It is a favorable place for sea water-based marine and artificial mineral baths, sea bathing and sun and air baths (heliotherapy) [18].

Svityaz (51°26′ N, 23°50′ E, 164 m a.s.l.) is located in the northwest of Ukraine near the borders with Belarus and Poland (Figure 1). It is a small village (with less than 2000 thousand inhabitants) situated on the beach of Svityaz lake. According to Köppen-Geiger's climate classification [25], Svityaz has a warm-summer and a humid, continental (Dfb) climate. The annual average air temperature is 7.4 °C. Total annual precipitation amount is 567 mm.

The climatic and bioclimatic conditions of Odesa and Svityaz were analyzed using daily data available at 00:00, 03:00, 06:00, 09:00, 12:00, 15:00, 18:00 and 21:00 UTC, collected over the period of 1991 to 2020. The data are from the weather stations of the Ukrainian Hydrometeorological Center.

The Physiologically Equivalent Temperature (PET) is used in this study to determine the thermal bioclimate at Odesa and Svityaz for the assessment of their climate recreation potential. This thermal index is defined as the air temperature at which, in a typical indoor setting (without wind and solar radiation), the energy balance of the human body is balanced with the same core and skin temperature as under the complex outdoor conditions to be assessed [26,27]. PET is derived from the MEMI heat balance model [26]. The MEMI model is based on the energy balance equation of the human body and some of the parameters of the Gagge two-node model [26]. The individual heat flows in the equation are directly dependent on the meteorological parameters air temperature and humidity, air velocity (wind speed) and mean radiant temperature (T_{mrt}). A comprehensive analysis of the frequency of the thermal indices that have been used in past studies shows that PET is amongst the four most widely used human thermal indices [16]. PET values between 18.1 °C and 23.0 °C can be characterized as comfortable (Table 1).

Table 1. Ranges of the Physiologically Equivalent Temperature and associated grades of thermal perception by human beings and physiological stress on human beings [28].

PET, °C	Thermal Perception	Grade of Physiological Stress
<4	Very cold	Extreme cold stress
4.1–8.0	Cold	Strong cold stress
8.1–13.0	Cool	Moderate cold stress
13.1–18.0	Slightly cool	Slight cold stress
18.1–23.0	Comfortable	No thermal stress
23.1–29.0	Slightly warm	Slight heat stress
29.1–35.0	Warm	Moderate heat stress
35.1–41.0	Hot	Strong heat stress
>41.1	Very hot	Extreme heat stress

The calculation of PET and mean radiant temperature is performed utilizing the RayMan model, which is a micro-scale model developed to calculate radiation fluxes in simple and complex environments [29]. The RayMan model has been broadly applied worldwide (including in Ukraine) in different investigations on human biometeorology [18,30–35]. The mean radiant temperature (T_{mrt}) is one of the most important input meteorological parameters governing human energy balance [36]. The validation results of T_{mrt} have an effect on the accuracy of thermal indexes (including PET) simulated by RayMan. Validation of the accuracy of the mean radiant temperature simulated by the RayMan model was conducted by Matzarakis et al. [36,37], Krüger et al. [38], Thorsson et al. [39] and Andrade and Alcoforado [40]. Krüger et al. [38] compared four different methods for T_{mrt} calculations using the RayMan model. Results showed that all methods overestimate T_{mrt} compared to ISO calculations, with a significant effect of globe diameter, which can result in large errors also under controlled conditions at the laboratory scale [41] and outdoors [42]. However, correlations were found to be significant for the first method using input data consisting exclusively of data measured at urban sites. Andrade and Alcoforado [40] found that the linear correlation coefficient between the T_{mrt} estimated with RayMan and that calculated from radiation field measurement for Lisbon was 0.96.

In the present research, calculation of PET values is based on air temperature, relative humidity, wind speed and cloud cover data. It is necessary for all the meteorological parameters used in the calculation of PET to be recorded at a human-biometeorologically significant height, for example, 1.1 m above ground level (the average height of a standing person's center of gravity in Europe). Wind speed was not available at a height of 1.1 m, so it was calculated based on a power-law profile approach, e.g., applied by Kuttler through application of the following formula [43]:

$$WS_{1.1} = WS_h (1.1/h)^{\alpha} \alpha = 0.12 \times z_0 + 0.18 \tag{1}$$

where WS_h is the wind speed (m s^{-1}) at a height of h (10 m), α is an empirical exponent, depending on the surface roughness, and z_0 is the roughness length.

The values of the other parameters were obtained at a height of 2 m and were used without altitude correction because the error is negligible.

In this study, a heat wave (HW) is defined as a period of more than 5 consecutive days with the daily $T_{a,max} \geq 5$ °C above the mean daily maximum temperature $T_{a,max}$ for the normal climatic period 1961–1990 (definition of heat waves recommended by IPCC) [44,45]. CTIS can be used to display frequency and probability information for different bioclimatic and tourism-related climate data. Tourists can utilize this information to anticipate thermal comfort and plan their recreational activities. The authorities can incorporate this information into their planning for music festivals, national and international sports competitions and other events, as well as for the establishment of a Heat Health Warning System (HHWS) [46].

CTIS shows all-year frequency classes and the frequency of extreme weather conditions. This information can be presented in terms of months or decades (10-day periods), depending on the meteorological data resolution. CTIS can combine thermal components (such as PET ranges and thresholds) with aesthetic components (like cloudiness and fog) and physical components (such as wind speed, precipitation and vapor pressure) [15]. However, the factors which are included in CTIS can differ from climate regions and in different research. Therefore, the selection of thresholds is based on literature references and can be adjusted for different researched locations [46].

The CTIS was used to display frequency information (expressed as a percentage) for each parameter averaged over a 10-day 'window' period. The following threshold criteria were selected: thermal comfort (13 °C < PET ≤ 29 °C); heat stress (PET > 35 °C); cold stress (PET < 4 °C); sunny days (<5 octas); foggy days (RH > 93%); rainy days (daily sum of precipitation > 5 mm); dry days (daily sum of precipitation ≤ 1 mm); sultriness (vapor pressure > 18 hPa); and stormy days (wind speed > 8 m s^{-1}).

Within the CTIS, the probabilistic information can be classified further into grades. A seven-scale grading system is used, with probability intervals of 14% for each grade. Higher probabilities indicate less comfortable conditions in relation to heat and cold stress, fog, warm humid, wet day and stormy day, and they indicate more comfortable conditions in thermal comfort, cloudiness and dry day parameters [3].

3. Results

The thermal conditions in Odesa and Svityaz throughout the year are based on the thermal index PET to provide the thermal comfort and stress conditions. Three-hourly PET values were averaged over a decades (10-day periods) for the last 30 years (1991–2020). These values were subsequently used to create decadal averages of PET for each month. PET values simulated by RayMan for the research period varied extensively throughout the year (Figure 2). The winter months (December to February) are dominated by values of PET < 4 °C, indicating extreme cold stress at both sites. The frequency of extreme cold stress in these months at Svityaz varied from 92.5% to 99.3% and was slightly lower in Odesa, ranging from 88.4% to 96.7%. All grades of heat stress (PET > 23 °C) in Svityaz were observed to occur from the second 10-day period of April through to the second 10-day period of October. In the last 10-day period of July and in the first 10-day period of August, the highest frequency of all grades of heat stress were found to be slightly greater than 40%. The highest frequencies of strong and extreme heat stress (PET > 35 °C) were 11.8% and 12.3%, respectively. In Odesa, heat stress was found to occur from the last 10-day period of April and observed until the second 10-day period of October. The highest frequency of all grades of heat stress was recorded during the last 10-day period of July and the first 10-day period of August, reaching a value of nearly 50%. The highest frequency of strong and extreme heat stress occurred in the last 10-day period of July (14.2%) and in the first 10-day period of August (15.9%).

It is well-known that the daily variation of air temperature values on sunny days during the warm period in Ukraine can reach 15 °C and even more. During a typical sunny, summer day, high air temperatures observed during the daytime typically decrease at night as part of the normal diurnal cycle. PET values depend (in part) on air temperature; thus, higher air temperature values during the daytime are correlated with higher thermal stress. In order to investigate more about thermal stress at Odesa and Svityaz, PET values during daytime (09:00, 12:00, 15:00 and 18:00 UTC) were calculated and analyzed for the period of March–November (Figure 3). The higher frequency of all grades of heat stress in daytime was found at Odesa and ranged from 58.3% to 89.6% in the summer months. The frequency of moderate, strong and extreme heat stress (more than 29.0 °C) in July and in the first two 10-day periods of August in Odesa was higher than 51.3%, and in the last 10-day period of July and the first 10-day period of August, it reached about 66%. In Svityaz, the frequency of daytime heat stress ranged from 56.9% to 78.8% in summer months, and the frequency of moderate, strong and extreme heat stress in July and in the first two 10-day periods of August ranged from 40.2 to 54.6%.

Summertime heat waves top the list of extreme climate and weather events [47] and are known to have a negative effect on the human body. During the period 1 June 1991–31 August 2019, the number of heat wave cases identified at both Odesa and Svityaz and their total duration are similar (Table 2). However, the thermal conditions during HWs at Odesa and Svityaz are quite different. The mean maximum air temperature for all HW events in Odesa is 1.5 °C higher than in Svityaz. The frequency of days with maximum daily air temperature >30 °C during HWs is 67.1% in Svityaz and 85.1% in Odesa. The frequency of days with extreme heat stress at 12 UTC reached 35.6% in Svityaz and 48.4% in Odesa.

The annual mean precipitation in Odesa for the period 1991–2020 is approximately 464 mm. No significant distinction can be made between a wet and dry season in this city. Similar amounts of precipitation are observed throughout the seasons; winter (114 mm), spring (100 mm) and autumn (117 mm). Higher rainfall values (132 mm) occurring in summer are associated with intense, convective air-mass events [18]. The least precipitation occurs in April, at 28 mm; the most rain falls in June, at 47 mm, and July, at about 45 mm. Days without rain at Odesa were most often observed in the period from the second 10-day period of July to the first 10-day period of October (the frequency of such days varied from 78.2% to 85.3%) and in the last 10-day period of April (78.7%) (Figure 4). The highest probability of days with light rain (0.1–1.0 mm) occurred from the last 10-day period of December to the second 10-day period of February, with values ranging from 14.9% to

17.3%. The frequency of heavy rain (>10.0 mm) events was quite low, and the highest value reached 5.2–6.3% and occurred in some 10-day periods of February, June, August, October and November.

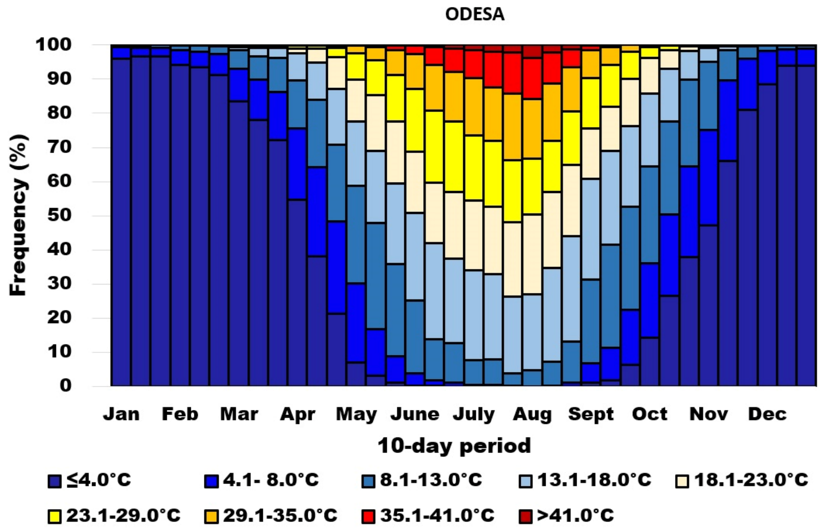


Figure 2. Frequency diagram depicting the average occurrence of the Physiologically Equivalent Temperature classes for Odesa and Svityaz for each 10-day period (column) of the year for the period 1991–2020 (based on three-hourly resolution data). The reference height for the results is 1.1 m. The thermal perception classes are defined in Table 1.

Table 2. Characteristics of summertime HWs events in Odesa and in Svityaz for the period 1991–2019.

Characteristics	Odesa	Svityaz
Number of heat wave events	18	17
Total duration of HWs, Days	153	146
Maximum duration of a HW event, Days (year of occurrence)	16 (2019)	16 (1994)
Mean maximum air temperature during HWs (°C)	32.6	31.1
Frequency of days with maximum air temperature > 30 °C during HWs	85.1%	67.1%
Frequency of days with PET > 41 °C at 12 UTC	48.4%	35.6%

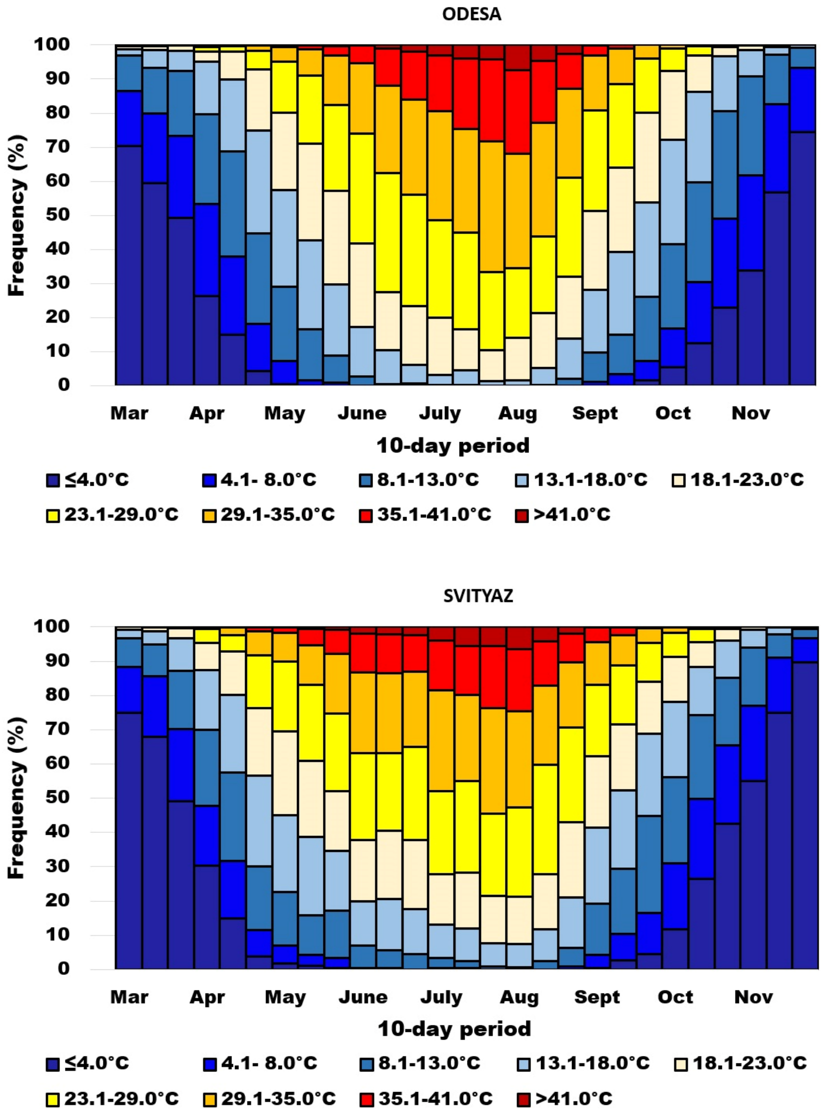


Figure 3. Frequency diagram depicting the average occurrence of the Physiologically Equivalent Temperature classes for Odesa and Svityaz during daytime (09:00, 12:00, 15:00 and 18:00 UTC) for each 10-day period (column) of the year for the period 1991–2020. The reference height for the results is 1.1 m. The thermal sensation classes are defined in Table 1.

Svityaz is generally characterized by greater annual amounts of precipitation and is in another climate regime when compared to Odesa. The annual mean precipitation for the 1991–2020 period is approximately 600 mm. The wet season persists from May to September, with mean monthly precipitation ranging from 59.1 mm to 77.1 mm. During the dry season, mean monthly precipitation varies between 33.3 and 43.6 mm. The frequency of days without rain is generally much lower at Svityaz than at Odesa. Such days are most often observed in August, where the probability of days with no precipitation is approximately 67% (Figure 4). Days with the highest probability of light rain occur from the second 10-day period of December through to the first 10-day period of January (with values ranging from 20.7% to 27.7%), in the last 10-day period of January (21.5%), in the second 10-day period of February (26%) and in the first 10-day period of March (24.3%). The frequency of heavy rain events was higher in warm season, and in some 10-day periods, reached nearly 10%.

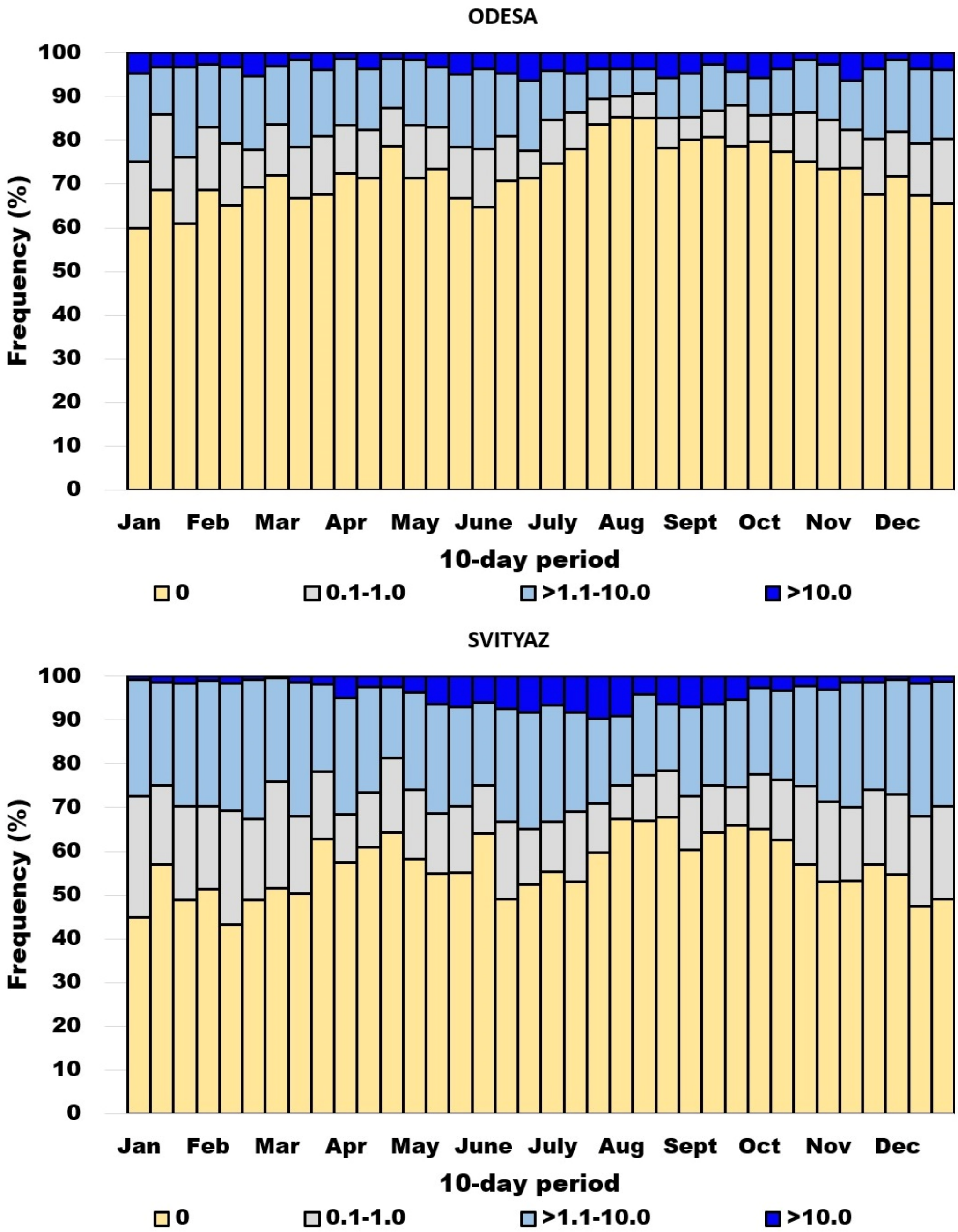
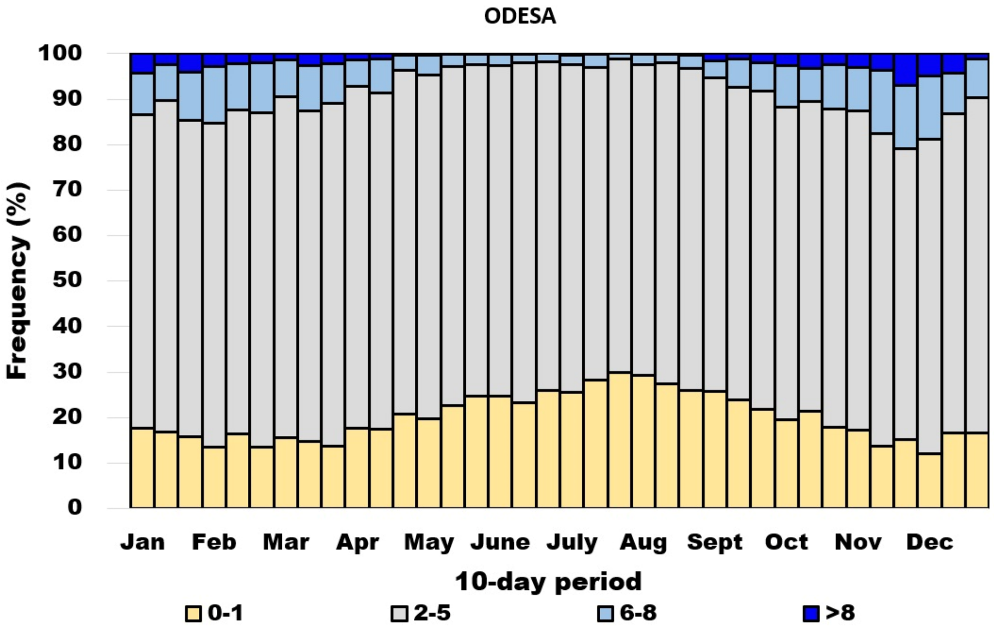


Figure 4. Frequency distribution of precipitation classes (in mm) for Odesa and Svityaz 1991–2020.

Frequency distributions of wind speed ranges for each month show that values of less than 6 m s^{-1} prevail at both Odesa and Svityaz through the year (Figure 5), with values ranging from 87.1% to 97.3% at Svityaz and from 79.0% to 98.8% at Odesa. A significant difference was found in the frequencies of wind speed in the range 2–5 m s^{-1} and 0–1 m s^{-1}, however. The frequency of wind speed in the range 0–1 m s^{-1} at Odesa varied within 12.0–30.0% and varied from 30.4 to 64.3% at Svityaz, with higher frequency values occurring over the summer period compared to in the other months.



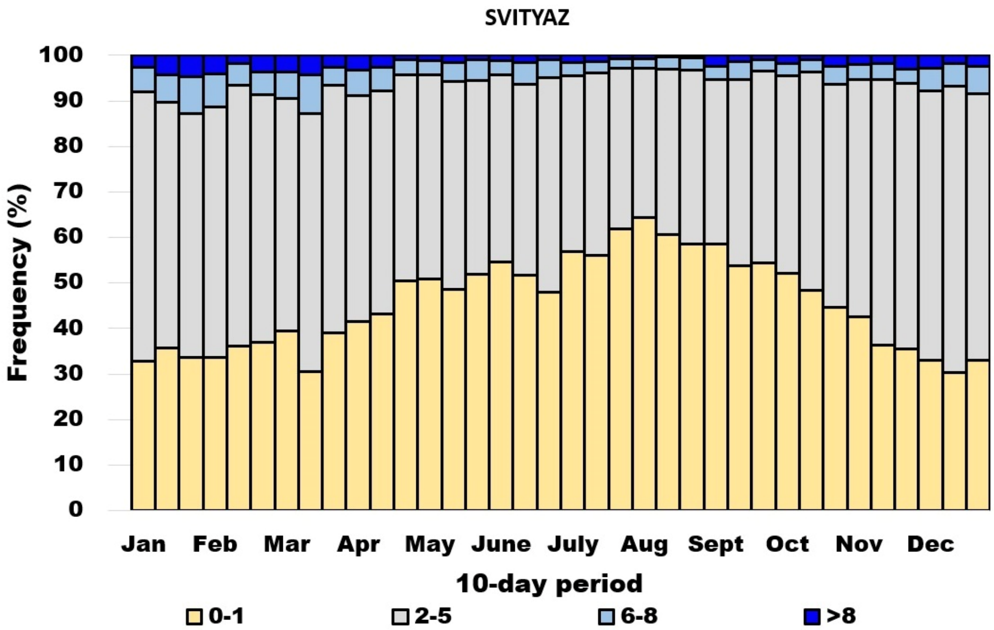


Figure 5. Frequency distribution of wind speed (m s^{-1}) for Odesa and Svityaz 1991–2020.

Higher frequencies of cloudiness are generally observed during the colder months at Odesa and Svityaz (Figure 6). Between April and October, the overcast conditions decrease, reaching a minimum in the last 10-day period of July and in the first 10-day period of August at both locations. It should be noted that at Odesa, the frequency of occurrence of sky cover with less than 5 octas of cloud is higher and reached a maximum value of 60.2% in this period, while in Svityaz, it reached the maximum value at 52.7%.

Figures 7 and 8 show the Climate–Tourism/Transfer–Information Schemes for Odesa and Svityaz, which include several parameters of climate that are relevant for tourism. The data are presented in a manner to make the results clear for non-experts. The CTIS reveals that better thermal comfort conditions can be found during the warm period from May to September at both sites. The winter month conditions are uncomfortable, because cold stress occurs frequently from October to May, while sunny conditions are rare.

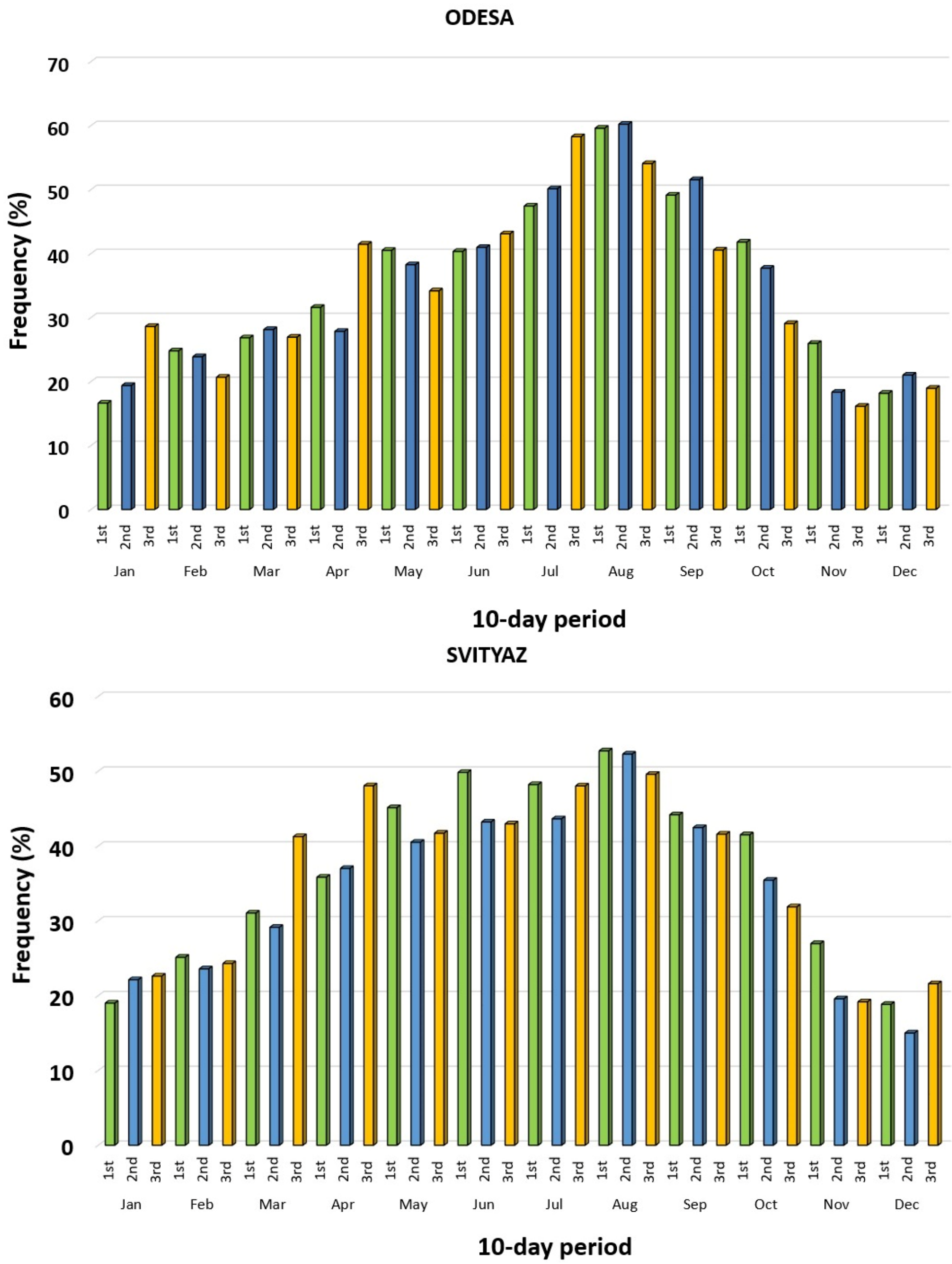


Figure 6. The probability of occurrence of sky cover less than 5 octas in Odesa and in Svityaz, 1991–2020.

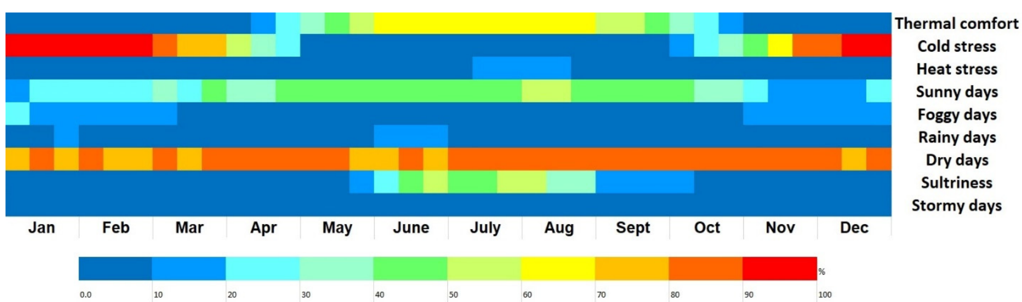


Figure 7. Climate–Tourism/Transfer–Information Scheme (CTIS), exhibiting the average frequency classes for several relevant parameters in Odesa for the period 1991–2020.

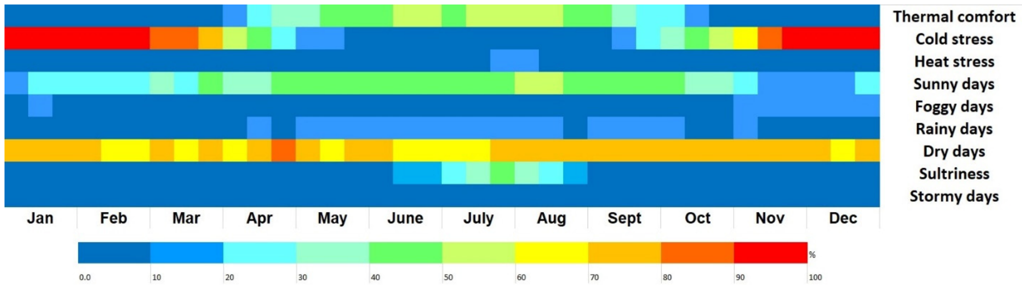


Figure 8. Climate–Tourism/Transfer–Information Scheme (CTIS), exhibiting the average frequency classes for several relevant parameters in Svityaz for the period 1991–2020.

Heat stress (PET values higher than 35 °C) during the summer months is not very frequent (the highest probability of occurrence is less than 20%). However, it should be noted that the frequency of heat stress within the range of 10–20% at Svityaz occurs over two 10-days periods, while at Odesa over four 10-day periods. Stormy days are rare (less than 10%) throughout the year at both Odesa and in Svityaz. Foggy days are rare, but more often during the cold period, and the frequency of such days are higher in Odesa than in Svityaz. Days with sultriness have been found more often in Odesa. The highest frequency of such days was nearly 60% in this city, while in Svityaz it was about 40%. The probability of dry days was high during the year at both sites and varied between 65–81.3% at Svityaz and 75–90.7% at Odesa.

4. Discussion

The results obtained in this research show that the winter months are totally uncomfortable both in Odesa and in Svityaz, with the frequency of extreme cold stress being higher than 88% during this period. Based on the three-hourly resolution data, it was found that the highest frequency of all grades of heat stress in Odesa reached nearly 50% and slightly higher than 40% in Svityaz in summer months. During a typical sunny, summer day, daily variation of air temperature is very high and leads to the formation of a diurnal cycle of PET with minimum values in the early morning and maximum in the afternoon [34,48,49]. Due to daily variation, even during mega-heat waves, PET values before sunrise and in the morning are categorized as comfortable conditions and conditions with slight cold stress, while during the daytime, strong and extreme heat stress prevails [34]. Therefore, for more detailed research of thermal comfort conditions for tourism purposes, it is necessary to analyze the variation of PET values during daytime (09:00, 12:00, 15:00 and 18:00 UTC). The more strenuous human-biometeorological conditions during the day are found in Odesa. The frequency of all grades of heat stress ranged from 58.3% to 89.6% there in summer months, while in Svityaz, values ranged from 56.9% to 78.8%.

In Svityaz, comfortable conditions (PET values within the range 18.1–23.0 °C) at 12:00 UTC are observed most often from the last 10-day period of April to the second 10-day period of May and from the second 10-day period of September to the first 10-day period of October. The frequency of comfortable conditions in these periods varies from 19.7 to 23.3%. The highest frequency of comfortable conditions in Odesa was found at nearly the same periods, but each of them is longer than one 10-day period, and the frequency of comfortable conditions is higher (25.7–36.0%). It may provide a useful point of comparison to also reference the biometeorological conditions of other tourist destinations. For example, the highest probability of the occurrence of weather with no thermal stress in Kyiv is found from the last 10-day period of April to the end of June and from the last 10-day period of August to the end of September and is lower than in Odesa (21–28%) [50]. However, during the summer months (from the second 10-day period of June), the higher frequency of comfortable conditions at 12:00 UTC is found in Svityaz than in Odesa. The differences in summer month comfortable condition frequencies between the two sites for some 10-day periods was higher than 10%. PET values corresponding to no thermal stress varied between 0.3% (in the first 10-day period of August) and 7.0% (the second 10-day period of

June) in Odesa. As a comparison, Crete Island (Greece), which is one of the most popular places for Ukrainian tourists, is characterized by significantly higher PET values than Odesa and Svityaz due to its more southern location. The probability of thermally comfortable conditions of Heraklion (Crete) from the second 10-day period of June to the end of August was lower than 10% and reached just a few percent in some 10-day periods [30]. Croatia is also a popular tourist destination. This small country, characterized by several climates, is suitable for a variety of tourism and recreation activities. Hvar (Croatia) is an island in the middle of the Adriatic Sea and is a typical “triple S” resort, slightly reminiscent of Odesa, but it is situated further south. A favorable characteristic of the Hvar bioclimate is that the sensation of hot and very hot are felt nearly exclusively during the afternoon hours, and the evenings are mostly comfortable. The frequency of PET values associated with no thermal stress in Hvar at 2 p.m. is lowest from the last 10-day period of June to the second 10-day period of August and reached only a few percent [51]. While for the coastal resorts thermal stress is associated with high air temperature, cold stress can be found at the resorts in mountain regions even during the hottest summer period [52]. The probability of cold stress and its intensity depend on the altitude at the resort location.

For the period of study (1991–2020), a similar number of heat wave cases were analyzed at Odesa and at Svityaz, although the thermal comfort conditions during these events in Odesa and in Svityaz were quite different. The frequency of days with extreme heat stress at 12 UTC during summer heat waves reached 35.6% in Svityaz and 48.4% in Odesa. Mean PET values during HW events for Ukraine during the period of 1961–2015 ranged from the west to the south and south-east, and the lowest mean PET values were found at the stations of the western region where Svityaz is situated; the PET values at Svityaz are about 2 °C lower than in Odesa [35].

Global climate change has been observed all over the world and in Ukraine during the last a few decades [53,54]. The most evident of these changes include changes in air temperature and associated phenomena (for example, the frequency of occurrence of hot days, tropical nights (TN20) and heat wave cases, and displacement of climatic seasons and their duration, etc.), as well as thermal comfort conditions. Comparison of the frequency of days with extreme heat stress in Kyiv across two time periods (1961–1990 and 1991–2015) show that those days repeat now three times more often than in the normal climatic period [50]. Long-term analysis of thermal comfort conditions of Kłodzko Land (Poland) also showed that heat-stress frequency has significantly risen over the last decades and will likely intensify in the following years [55]. Thus, the regions currently with a high frequency of thermal stress will likely become even less comfortable in the very near future.

The resort at Svityaz can potentially be promoted through the creation of a leaflet summarizing the pertinent climatological and bioclimatological data presented in this study and by emphasizing the natural characteristics of the region [3]. Additionally, the results of the assessment of the human thermal comfort conditions at Odesa and Svityaz can be used for choosing appropriate activities during recreation, as well as for guiding strategic decisions in relation to regional tourism development. Local authorities can use the study findings for the establishment of the Heat Health Warning System (HHWS) and adaptation measures to heat stress [50].

5. Conclusions

This study utilizes a climatology of human-biometeorological conditions to compare the tourist potentials of two resorts in Ukraine: a coastal resort at Odesa in southern Ukraine and the inland resort by Lake Svityaz, located in northwest Ukraine. Despite the geographic separation of the resorts, heat stress is found to occur at similar periods of the year at both locations. The highest frequency of heat stress at any level is found in the last 10-day period of July and in the first 10-day period of August at both locations during the study period (1991–2020); however, at Odesa, heat stress occurs about 10% more frequently than at Svityaz. The frequency of strong and extreme heat stress is higher at Odesa by only a few percent; however, the frequency of moderate, strong and extreme heat stress during daytime hours in July and in the first two 10-day periods of August at Odesa ranged from 51.3% to 66.5% and, at Svityaz, between 40.2% and 54.6%. A similar number of have wave cases are found to have occurred at Odesa and Svityaz during the study period; however, the frequency of days with extreme heat stress at 12 UTC during summer heat wave events reached 35.6% in Svityaz and 48.4% in Odesa. The frequency of days with maximum air temperature greater than 30 °C during heat waves is higher at Odesa and reached 85.1%, compared to 67.1% at Svityaz. The frequency of light wind speed (0–1 m s^{-1}) in Svityaz varied from 30.4 to 64.3%, while in Odesa, wind speed of 2–5 m s^{-1} prevailed through the year. Between April and October, the frequency of occurrence of sky cover of less than 5 octas ranged from 58.3 to 60.2% at Odesa, while in Svityaz, it ranged from 48.0 to 52.7%.

The findings obtained in this study show that during summer months, more comfortable conditions are observed at Svityaz, and it is therefore more suitable for recreational activities for tourists who may have a greater level of vulnerability to heat stress. Coastal resorts that are so-called "places of triple S" (Sea, Sand and Sun), such as Odesa, are mostly associated with a higher frequency of thermal stress, and such regions will likely become less comfortable and less suitable for recreation for tourists more vulnerable to heat stress in the near future due to climate change.

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