ARTICLES

CLIMATE RESEARCH ON SLOVENIAN TERRITORY IN PRE-INSTRUMENTAL PERIOD: WEATHER AND CLIMATE IN THE 17TH CENTURY

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ABSTRACT
Climate research on Slovenian territory in pre-instrumental period: weather and climate in the 17th Century
Climate and weather conditions in the Slovenian lands from the time before regular and continuous meteorological measurements began are but poorly known. Investigations in this field began as late as the beginning of the 17th century; particularly the second half of this century, when the polymath Janez Vajkard (Johann Weichard) Valvasor and the Ljubljana chronicler Janez Gregor Dolničar (Thalnitscher) were active, is one of the periods which is sufficiently documented in historical sources as concerns the weather and the climate of the time. In spite of certain limitations in using these sources, by means of additional information it is possible to present satisfactorily the weather and the climate of that time and their effects in social environment.

KEY WORDS
climate in Holocene, climate in pre-instrumental period, Little Ice Age, Maunder minimum, weather disasters, Janez Vajkard (Johann Weichard) Valvasor, Janez Gregor Dolničar (Thalnitscher), Slovenia

IZVLEČEK
Raziskovanje podnebja v predinstrumentalnem obdobju na Slovenskem: vreme in podnebje v 17. stoletju
Podnebne in vremenske razmere na Slovenskem so pred začetkom rednih in kontinuiranih meteoroloških meritev slabo poznane. Raziskave na tem področju so šele v začetku. Sedemnajsto stoletje, še posebej njegova druga polovica, ko sta delovala Janez Vajkard Valvasor in ljubljanski kronist Janez Gregor Dolničar, je eno od obdobij, za katero imamo zadovoljivo pokritost z zgodovinskimi viri o tedanjem vremenu in podnebju. Kljub določenim omejitvam pri uporabi teh virov, lahko z uporabo dodatnih informacij zadovoljivo predstavimo tedanje vreme in podnebje ter njegove posledice v družbenem okolju.

KLJUČNE BESEDE
podnebje v holocenu, podnebje v pred instrumentalnem obdobju, mala ledena doba, Maunderjev minimum, vremenske ujme, Janez Vajkard Valvasor, Janez Gregor Dolničar, Slovenija

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1 Introduction

Climate changes on the Slovenian territory until the mid-19th century, when meteorological stations in Ljubljana and in the nearby cross-border areas – in Trieste and Zagreb – began to operate continuously, is poorly known, except for the general trends which apply whether to the Mediterranean and Central Europe or the whole of Europe (Ogrin 2005). Studies dealing with climate in Slovenia in pre-instrumental period are very few. Little is known about the weather and climate conditions and responses to them in natural and social environment in individual climate periods, e.g. in the medieval warm period or in the Little Ice Age. One of older studies in this field places the origin of the Triglav glacier in the time of one of the climaxes of the Little Ice Age (Šifrer 1963), and another is the presumption that towards the end of the medieval warm period, i.e. in the time of the secondary, high-altitude colonization of Slovenian territory, the highest-lying farms emerged in the mountainous world, of which many were later abandoned (Gams 1998, 117). The best explained are the circumstances in the southwest part of Slovenia which is under the influence of Mediterranean climate. A chronicle of exceptional weather and climate events for this part was made for the period from the 7th century until 1850 (Ogrin 1994; 1995), and analysed on its basis was the frequency of dry and wet years from the 14th through 19th centuries (Ogrin 2002), harsh winters, particularly those when damage was done to olives by frosts (Ogrin 2007b), and severe storms and their effects (Ogrin 2007a). In recent time some dendrochronological and dendroclimatological studies have also been made which can be helpful in the reconstruction of summer temperatures in particular and precipitations in Slovenian mountainous world (Levanič 2005; 2006; 2007; Levanič and Čufar 1998) and in southeast Slovenia (Čufar et al. 2008). Two diploma theses should also be mentioned, done by the students of departments of geography and history at the Faculty of Arts of the University of Ljubljana. One deals with the weather and climate in Carniola (Si. *Kranjska*; Ger. *Krain*) from the 14th to the 18th centuries with a special emphasis on the records in Janez Vajkard Valvasor's *The Glory of the Duchy of Carniola* (Levec 2009), and the other discusses the influence of the Little Ice Age on agrarian settling in the select cases in the valley of Upper Savinjska dolina (Zwitter 2010).

To study the climate of the past has several meanings. Outstanding among these is the enhancement of climate recollection, especially of those weather and climate events which reached the level of natural disasters. Namely, we are inclined to forget the events that are unpleasant for us. When they recur after a certain period of time we are naturally taken by surprise and tend to declare on such occasions that this is something extraordinary which has never happened in the past (»not even our oldest people can remember something like this«). But even a brief survey of climate and weather events of the past quickly reveals that this is not true and proves that our knowledge of weather and climate history is insufficient. This knowledge is also important in view of evaluating the currently changing climate and extraordinary weather events related to it. To make a proper assessment also of the human role in it, and in the making of climate projections for the following decades of the 21st century, it is necessary to know the past climate conditions as well, when human impact on the environment was essentially lower. Unfortunately, when doing so, we often have to face deficient data on weather and climate in the past, particularly for the period prior to regular and systematic measurements.

2 Methodology

The objective of this paper is to cast light by means of historical sources on weather and climate events on the Slovenian territory in the 17th century. In view of climate history this century belongs to the second half of the Little Ice Age, i.e. the rather cold period the beginning of which is mainly set in the mid-15th century and its end in the mid-19th century. The Little Ice Age was a regional climate change which spread over the northern hemisphere, mainly Europe and east parts of North America. As two

possible causes are stated: lower activity of the Sun and the increased frequency and intensity of volcanic eruptions. It was an unevenly cold period, with considerable climate variability and with uneven developments in different parts of Europe. It was less explicit south of the Alps, since the central ridge of the Alps hinders the intrusions of cold air masses from the north. In comparison with the mid-20th century, the average annual temperature in Europe were lower by 1 to 1.5 °C, winters were very cold and dry (January temperatures were lower by 2 to 4 °C), and precipitation amount was lower by up to 10%. There were three cooling climaxes: the first in the second half of the 16th century, the second (Maunder minimum) between 1645 and 1715, and the third from the mid-1730s to the mid-1780s. Because of long and harsh winters troubles in agriculture were frequent, alpine glaciers reached the lowest level after the last glaciation, rivers were frozen and also the sea in the English Channel (Le Manche) and along the coast of the Netherlands and water in Venetian lagunas (Flohn, Fantechi 1984; Shindell 2009, 520–522, 550–551).

The choice of the 17th century for the study of climate conditions was not made by chance. Paleoclimatic reconstructions of the last 500 years of pre-instrumental period, which ends in Europe mainly in the 18th or the 19th century, are based on the analysis of historical sources which directly or indirectly speak about the past weather and climate. These records are typical for their low resolution data as a rule and distributed thinly so that they do not provide for complete climate reconstructions. Belonging to direct sources are e.g. diverse descriptions of climate and weather in chorographies and records of exceptional weather events in various chronicles by means of which we can most often establish the frequency of individual events in a certain spell of time (e.g. frosts, draughts, severe storms, and the like). By mak-

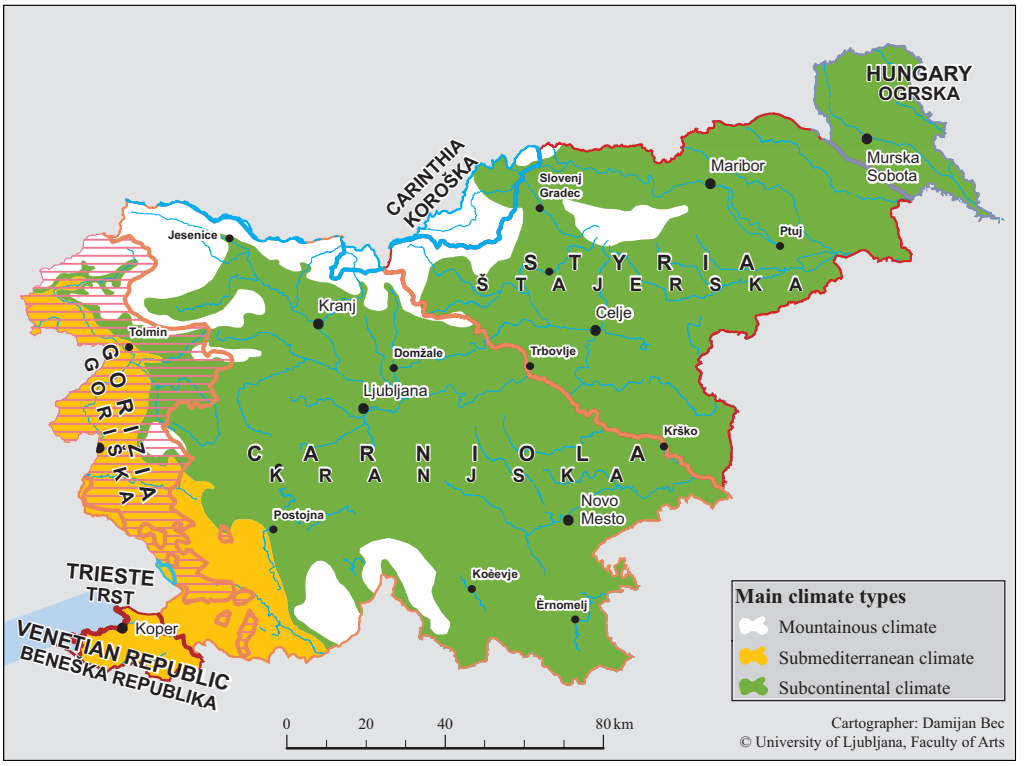

Figure 1: Borders of present-day Slovenia and of Carniola in the 17th century and climate division of Slovenia.

ing use of indirect sources we can make conclusions about the past weather and climate by means of their effects (phenological data, data on crops, fluctuation of prices of food products). We can also make use of the data on the fluctuation of glaciers, both from historical sources and from the reconstruction of the onetime state which can be obtained by means of analysing moraine material and investigating lichens. One of the more relevant methods is the dendroclimatological method, in which climate conditions are deduced from tree-ring series.

The trouble with historical sources to be used for the reconstruction of climate is that, in general, the farther to the past we go the fewer they are, they are less reliable and their verification is more difficult. The 17th century is one of the periods for which sufficient historical sources exist for the territory of present-day Slovenia, which renders possible a basic insight at least into the weather and climate events of that time. Towards the end of the 17th century *The Glory of the Duchy of Carniola* was published, a work by Janez Vajkard Valvasor (1641–1693), a Carniolan polymath (Valvasor 1689; partial translation to Slovenian: Valvasor 1984, Slovenian translation of entire Tomes 1 and 2: Valvasor 2009; 2010). Following the tradition of similar works of the time, the author gives a comprehensive description of Carniola, a historical province that stretched over the major, mainly central, part of Slovenia of today (Figure 1). At the beginning of Book three he describes general climate characteristics of Carniola, while in the continuation he pays greater attention to exceptional weather events, mainly those which had negative impact on agricultural products. Valvasor's description of exceptional weather events was used for establishing chronology of these events in the 17th century and at the beginning of the 18th century, i.e. to the end of the Maunder minimum. One of the basic sources for the chronology were also the weather data provided by the Ljubljana chronicler Janez Gregor Dolničar (1655–1719) for the 1660–1718 period (Pučnik 1980, 56–59). To complement the chronicle we made use of applicable data from the chronicle of exceptional weather and climate events for the sub-Mediterranean part of Slovenia (Ogrin 1994; 1995), from the church chronicle of the parish Rečica ob Savinji (Novak 1999, 111–112), from the chronicle of crops and natural disasters of Središče ob Dravi in (Slovenian) Styria (Si. *Štajerska*; Ger. *Steiermark*) (Kovačič 1910, reprint 1986), and from the history of poor crops, famines and high costs of living on the Dravsko polje plain (Slekovec 1885, 120–123). We are well aware that the chronicle is not perfect and that primary sources still exist which could further complement it. Nevertheless it offers an insight into the characteristics of occurrence of exceptional weather events of that time and their consequences.

3 Definitions of weather conditions and climate in 17th-century Carniola according to Valvasor

3.1 General designations of climate and characteristics of the four seasons

The present climate divisions of Slovenia (Ogrin 1996; Ogrin and Plut 2009, 88–91) point out to the contact between and interlacing of three types of climate on its territory: the mountainous, the Mediterranean and the continental (Figure 1). All three are characteristic for their atypicalness if compared to genuine mountainous, Mediterranean or continental climates, but the principal features of these three are combined in them, so they are often pre-fixed by »sub« (sub-Mediterranean, subcontinental). However, underlined are great spatial and temporal unsteadiness and variability of the climate elements' characteristics. In Valvasor's time, Carniola encompassed part of the Alpine world, practically the entire central and south-eastern part of present-day Slovenia, where subcontinental climate features prevail, and in its southwest, part of lands by the Maditerranean. Hence it is not surprising that in his description of general climate conditions in Carniola Valvasor pointed out both the variety of climate and its changeability: »*Although Carniola is not exactly a big country, it is possible to observe such great differences in its climate as nowhere else. The air is relatively mild but also rather changeable:*

it tends to change not only with time but also with place and landscape; therefore certain crops, particularly fruit, grow ripe much earlier in one place than in another, … although the distance between such places is often no longer than a day's or two days' walk« (Valvasor 1689, Book III, 306; Slovenian translation: Valvasor 2009).

In his description of the seasons' characteristics, Valvasor reports on winters that in the time when his work was written, i.e. in the second half of the 17th century, they were not harsh: *»The winter is not really harsh – on the contrary – it is rather mild and bearable. It is true that snowfall is frequent, but the snow does not lie long but melts soon«* (Valvasor 1689, Book III, 307; Slovenian translation: Valvasor 2009). He further mentions great differences between various parts of Carniola: *»However, as regards the cold there are considerable differences in Carniola, since in Highland Carniola (Oberkrain) it can still be freezing cold and snow can still lie deep, while in Lowland Carniola (Unterkrain) it melts and everything begins to bud, and in Istria and around the nature is already in bloom«* (Valvasor 1689, Book III, 307; Slovenian translation: Valvasor 2009).

From the present viewpoint, Valvasor's definition of winters as being mild and bearable does not agree with the general characteristics of the Little Ice Age, to which also the latter half of the 17th century belonged, and with the fact that between 1645 and 1715 the so-called Maunder minimum lasted, when cold years with harsh and long winters occurred. Valvasor's statement that 17th-century winters were not really severe may have resulted from the then prevailing comprehension of harsh winters as normal, since from around 1655 to around 1710 harsh winters were predominant in Central Europe (Pfister 1995). In spite of different regional unfolding of the Little Ice Age there is no evidence that winters in Slovenia in the latter half of the 17th century were milder than in the neighbouring countries. Just the opposite: it is evident from various chronological records (Table 1) that from the year 1645 until the publication of the Glory of the Duchy of Carniola there were at least five bitter winters with frosts (1648, 1653/54, 1660, 1683/84, and 1684/85). These were followed by a series of at least five harsh win-

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Figure 2: List of charges of the Krofič farm in 1698. The text bottom right says that the farm has become desolate due to repeated poor harvests, and the serf has incurred debt to the landlord (Zwitter 2010, 92; Source: Archives of the monastery at St. Paul in the valley Lavanttal, Austria; St. Paul HS 63/7, Provenienzgr. Eberndorf, Stiftregister 1696).

ters at the very beginning of the 18th century (1708/09, 1710/11, 1712/13, 1714/15, and 1715/16); as the harshest of them – even as one of the worst in the last 500 years in the bigger part of Europe (Xoplaki et al. 2001, 598) – the winter of 1708/09 is stated. It is rather unlikely as well that Valvasor's characterization of winters was influenced by the situation in the first half of the 17th century, which means before he was born, when according to Pfister (2004), winters in Central Europe were slightly milder between the years 1615 and 1655.

Unfavourable conditions in the colder half of the year are also corroborated by poor cereal harvests in Carniola during the Maunder minimum in the years 1675, 1677, 1685, 1695, 1696, 1708 and 1709 (Šorn 1950, 172; Valenčič 1977, 20–22, 122–124). Necessary for a good year of winter crops are a sufficiently wet autumn, a not too harsh and too long winter, sufficient precipitation in spring and not too wet weather during ripening and harvest time. In the case of spring cereals a long winter causes belated first sowing which results in late ripening at higher altitudes, or the cereals cannot ripen at all due to early colds. It is favourable for such altitudes that early autumn is dry and warm. Bad weather conditions and the resulting poor harvests and the constantly increasing taxes were, according to Šorn (1950), the main reasons for peasant uprisings in the early 18th century. At that time the economic situation of numerous peasants seriously aggravated due to a series of poor harvests; therefore many of them abandoned their lands and homes and went abroad (Šorn 1950). Zwitter (2010) also states that it is possible to detect influence – not great and not lasting – of the Early-Modern-Time Little Ice Age on agrarian settling in the case of farms at high altitudes in Solčavsko region in the eastern section of the Slovenian Alps. At the climax of the Maunder minimum climatic conditions were in many a place so unfavourable that several farms were abandoned (Figure 2).

It is evident from climate reconstructions for Central Europe that springs were mainly cool in the 17th and the first half of the 18th century, summers were changeable, rather cool in the early and late century and very cool in the first half of the 18th century. However, in the mid century a series of above-average hot summers occurred (Glaser 2001, 94). Pfister (1995, 92–117) mentions cool springs to have taken place particularly in the 1690s and the 1740s. Our chronicle reports as hot (and dry) summers only the summers of 1616 and 1644, as dry (at least in the Littoral) also the summer of 1660. Bad growing conditions at the beginning of the 18th century, that means below-average temperatures from May to August (and short vegetation period), are possibly indicated also by larch chronology for the upper forest line in the south-eastern Alps (Levanič 2005, 2007). In his description of summer climatic conditions Valvasor was obviously influenced by the middle of the century, when he says: »*In summertime Carniola enjoys cosy, temperate warmth*« (Valvasor 1689, Book III, 310; Slovenian translation: Valvasor 2009). But once again he points out great differences between the Alpine part of Carniola and the lower-lying lands on the south-east and in the vicinity of the sea: »*Highland Carniola (Oberkrain) has almost cool air early in the morning, because it lies high and snow-covered mountains rise above it. However, in the direction towards Croatia it is very warm or even hot. On the Kras (Karst) and in Istria the sun burns strongly and heats unbearably. Otherwise, rainfall and frequent hail considerably weaken and soothe the torridness; likewise, the snow-covered peaks play their role, because fresh and cool air or wind always breezes from them, which lessens the heat*« (Valvasor 1689, Book III, 307; Slovenian translation: Valvasor 2009).

3.2 Severe storms

Judging from attention that Valvasor pays to storms and accompanying phenomena, hail in particular, it is possible to assume that the main characteristic of the warm half of the year in his time was great frequency of storms and their resultant great damage. He mentions that hardly a day passes in Carniola without lightning and thunder, that the Littoral and the mountainous world receive more storms, and that in the neighbouring Carinthia and Styria there is likewise a lot of hail, yet less than in Carniola. He explains that this natural disaster affects zones of different width (from a shooting range to one mile) which can be more than seven miles long, which could mean over 50 kilometres (Vilfan 1954). But it

Table 1: Classification of weather hazards in the Slovenian lands in the 17th century and during the Maunder minimum based on chronicle records (Valvasor 1689; Slekovec 1885, 122; Kovačič 1910; Pučnik 1980, 56–59; Ogrin 1994, 1995; Novak 1999, 111–112; Levec 2009).

Harsh winters: 1608/09, 1634/35, 1648, 1653/54, 1660, 1683/84, 1684/85, 1708/09, 1710/11, 1712/13, 1714/15, 1715/16	**Mild winters:** 1627/28, 1681/82, 1702, 1704/05, 1707/08, 1709/10
Hot and dry summers: 1616, 1644, 1660, 1701, 1704, 1705, 1708	**Rainy years:** 1627, 1631, 1654, 1703, 1706, 1707, 1710, 1711, 1713, 1714, 1715
Severe storms (with hail, strong wind): 1613, 1622, 1628, 1636, 1637, 1644, 1650, 1654, 1657, 1665, 1672, 1677, 1683, 1685, 1686, 1688, 1691, 1693, 1698, 1700, 1701, 1708, 1710	**Locust invasions:** 1611, 1644
Floods: 1628, 1631, 1633, 1635, 1688, 1702, 1703, 1707, 1710, 1714	**Famines, high costs of living:** 1612, 1628, 1629, 1654, 1675, 1685, 1686, 1705, 1711

never ravages throughout the country. It happens that it devastates the one and the same zone two or three successive years, and it likewise affects the same areas several times a year. Sometimes the pellets that fall from the clouds are as big as a hazel, sometimes as big as a fist, »*sometimes the hail cover is three or four fingers thick and lies until the next day*« (Valvasor 1689, Book III, 311; Slovenian translation: Valvasor 2009).

Valvasor reports that storms cause great damage in Carniola. Hail ruins not only the crops but also trees and cattle: »*From time to time hail falls so intensely, ferociously and is accompanied by such fierce wind so that even the strongest trees, so to say, fall and lie all contorted by wind which blows in so powerful gusts and so ferociously. Carniola would possibly be a true core of happy and fertile lands if hail did not reduce its happiness so considerably: if we calculate the damage it causes, it is so great that usually a fifth of fruit trees and other plants are ruined every year, which certainly curtails the country for much more*« (Valvasor 1689, Book III, 311; Slovenian translation: Valvasor 2009). He observes that this does not entail price rise of agricultural products, because storms with hail usually affect only smaller areas. However, he points out the grim fate of poor people, because hail ruins the little they possess, particularly if this natural disaster strikes in two or more successive years: »*When a storm completely beats down winter crops, such as wheat, rye and the like, and then beats to the ground summer wheat, buckwheat, millet, beans, peas, lentils, and other crops, then poor peasants are in great distress and fall into poverty. … Whoever is struck feels it gravely, especially hardworking peasants who are thus driven into such distress and poverty that they suffer food shortage and together with their family they suffer misery. They expect with hope the next year. If these poor villagers … are stricken as badly and devastatingly again, … they are forced to grind tree bark to make bread of it*« (Valvasor 1689, Book III, 321; Slovenian translation: Valvasor 2009).

If Valvasor's reports on severe storms and records in chronicles are reliable, it is possible to assume that storm frequency in the 17th century (and similarly in the 18th century) was comparable to the present state, when higher rate of these weather extremes is mainly attributed to global warming of the atmosphere. Comparison between a record in the 17th-century weather chronicle (Table 1) and the chronicle for the 20th century composed by Trontelj (1997) and complemented for the final three years of the century in the journal Ujma (Šipec 1999; 2001) shows that in the second half of the 17th century eight major severe storms occurred in Ljubljana and its neighbourhood, while in the latter half of the 20th century there were nine. It is interesting that the styles of recording the damage and the consequences

of these weather hazards today and 200–300 years ago are very similar. It is also clear from the records that the storm characteristics and the kind of damage done have not essentially changed by now. Only the people's very existence is not jeopardized as much as it used to be once.

3.3 Other weather-related and climate characteristics

Other weather-related and climate characteristics of Carniola are given less attention in Valvasor's descriptions. As it is emphasized today, in his opinion, too, Carniola is sufficiently wet: »*Carniola is not thirsty for rain, because rainfall often gently waters the land, even when it is least expected*« (Valvasor 1689, Book III, 309; Slovenian translation: Valvasor 2009). He mentions sporadic periods of drought, when rain does not fall even for a fortnight, and heavy passing showers in summer and also in autumn which cause high water level of rivers. In his description of climatic characteristics floods are not extra mentioned. However, it is clear from chronicle records that in the 17th century there were at least five in central Slovenia (1628, 1631, 1633, 1635, 1688). In the case of snow he underlines its unreliability and the fact that snow cover is usually not thick and does not last long, while in the Littoral snow falls seldom and lies but for a short time. He presents the lower section of Ljubljana Basin, including the city of Ljubljana, as the foggiest part of Carniola. He believes that this fog is dangerous to health, because it causes cough and catarrh, but he quotes a certain physician who claims the opposite: »*that frequent and thick fog is a mild harm to the townspeople of Ljubljana because of a lot of fire and smoke, which purifies the air*« (Valvasor 1689, Book III, 309; Slovenian translation: Valvasor 2009). It is of course dif-

Figure 3: Valvasor's depiction of bora on Gabrk ridge as it knocks down a horse and a man (Valvasor 1984, 49).

ficult to agree with this statement nowadays. He says that Upper Carniola (Si. *Gorenjska*; Ger. *Oberkrain*) has but little fog while hoarfrost is more frequent there: »*Early in the morning, when there is hoarfrost, everything is white like a whitewashed wall. Hoarfrost often continues for three successive days, which harms seriously buckwheat in the field, so that the price of cereals goes up immediately. The inhabitants receive this pale visitor shaking their heads and watching anxiously, seeing in it a white shroud of the field*« (Valvasor 1689, Book III, 309; Slovenian translation: Rupel 1969).

In the case of windiness there are no essential differences between Valvasor's notes and the present state. Valvasor, too, ascertains that Carniola is not too heavily exposed to winds; that the winds are not constant but very changeable. As to Inner Carniola (Si. *Notranjska*; Ger. *Innerkrain*), he mentions that stronger and colder winds can blow from the east and that in summer gusty winds appear during storms. As the windiest areas he outlines the Kras (Karst), Pivka and Istria, where the winds are so cold, »*that they cut deep to the heart. … In Kras (Karst) and Pivka the wind blows extremely strongly especially in winter, when the east wind whistles and sweeps so fiercely that neither people nor animals can go forth when it strikes with all its might and blows out its anger from its fully puffed out cheeks. It can continue like this for two, three, four or five days or even more. Its gale force can knock a man or a horse to the ground; therefore those who want not to be knocked down or swept from the ground when the wind has been, so to say, unleashed should stay at home. Not only foliage is swept but also sand and stones; its whistling is so shrill that ears begin to ache. It is called bora and it comes approximately from the east. When it blows with all its might/… no man can resist it and it is then impossible to go on foot or on horseback across Gabrk ridge and through Senožeče to Trieste or from Trieste to Senožeče …*« (Valvasor 1689, Book III, 308; Valvasor 1689, Book IV; Slovenian translation: Valvasor 1984; 2009).

There was another pest related to weather and climate that troubled the inhabitants of Carniola but is unknown today in our country: invasions of migratory locusts (*Locusta migratoria*). Although in general the 17th century was not particularly favourable for locusts, due to the Little Ice Age, they infested the land at least twice, i.e. in 1611 and 1644. The last locust invasions on the present-day Slovenian territory were reported in the 18th century, reliably in the years 1720 (Ogrin 1995, 295) and 1782 (Slekovec 1885, 123). Valvasor noted on the locust invasion of 1611: »*It was a year of a particularly high yield of wine. But a disaster stroke again. Swarms of locusts came flying like clouds from the Croatian border. When they left, everything looked as if having been burnt and mown down*« (Valvasor 1689, Book XV, 551; Slovenian translation: Levec 2009). As concerns the invasion of locusts of 1644, we learn that it was related to hot and dry weather at the beginning of summer (Ogrin 1995, 290).

The locusts that repeatedly infested the territory of present-day Slovenia came from Asia Minor. In favourable weather they propagated immensely and evolved from the individual phase of life to the collective phase. In dry and sufficiently warm weather they spread in search for food along the Danube to the Pannonian Basin, from where they migrated to different parts of Europe, thus they also crossed the Dinaric passes on the present-day Slovenian territory and continued towards Italy. They usually came in summer, most often in August. Because their flying capacity is not exactly great, proper winds are required for their spreading (Camuffo and Enzi 1991). Because east winds are not particularly frequent in summer at our latitude nowadays and they do not blow for a longer spell at a time, it is possible to claim hypothetically that in the past, at least in the time of locust invasions, the wind-scheme was slightly different than it is today. A question arises whether, due to the anticipated warming of climate, prolonged warm half of the year and increased possibility of longer periods of drought, more favourable conditions for locust invasions in our lands will occur again in the 21st century.

4 Conclusion

It is a lucky coincidence that we have two sources from the 17th century, offering a lot of information about the weather and climate of the time on the Slovenian territory: Valvasor's »Glory of the Duchy

of Carniola« and Dolničar's Ljubljana chronicle. Valvasor's descriptions of weather and climate are not based on technical measurements and observations but just on occasional visual observations by the author and his informers. Certain explanations (and descriptions) are inadequate from the viewpoint of contemporary science, therefore we only took into consideration those which seemed acceptable to us. The two basic sources are not concordant in relation to all of the events. A certain degree of inaccuracy can be attributed to Valvasor which calls for additional precaution in the use of this source. Even though the two authors were contemporaries, they only rarely described the same events. This makes us conclude that there were possibly more events than just those about which the two chroniclers obtained information from the information sources of the time. In spite of all deficiencies we believe that – through a synthesis of all data, by elimination of those explanations which are non-professional, comparison with climate reconstructions made by means of other methods and reconstructions for neighbouring countries – we can establish a sufficiently reliable picture about the climate conditions of that time and their social consequences. It is possible to conclude on the basis of chronology of exceptional weather events that there were also periods of greater frequency of individual events. Between the years 1700 and 1720, springs and summers with lot of rain were frequent in the Slovenian lands, while in the middle of the century summers were warm, and winters were harsh between 1630 and 1650 and during the Maunder minimum period, 1680–1716. During that time, very mild winters also occurred in between harsh winters. Throughout the 17th century there were very many severe storms in the warm half of the year. In spite of the fact that the 17th century belongs to the second half of the Little Ice Age, it is evident from the sources that it was a rather varied period as to the climate and weather, with a great concentration of exceptional weather events which had significant impact on the life of the people of the time and their social circumstances.

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