EXAMPLES OF THE *BURA* WIND EFFECTS IN THE EASTERN ADRIATIC AREA ACCORDING TO CHRONICLES, TRAVELOGUES, AND MILITARY REPORTS (15TH CENTURY-18TH CENTURY)

DJELOVANJE *BURE* NA JADRANU PREMA ZAPISIMA KRONIČARA, PUTOPISACA I VOJNIKA (15.-18. ST.)

... what is bura, it is bura - it never does benefit, but only damage ... (1759) [1]

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Summary

The author analyzed excerpts from the chronicles, travelogues and reports mentioning bura and its effects. This wind became ill reputed primarily because of its ferocity and the cold it carries with it, but on the other hand it purified the air and brought clear weather. According to descriptive sources, bura has a negative impact on a range of human activities: movement and farming, warfare (land and maritime), transport, and construction as well. In a number of cases, this wind aided the defenders by dispersing enemy naval forces. Due to geographical location, surroundings of Senj, Pag, Klis, Makarska, and Kvarner Bay, also the Velebit and Brač channels, as well the Field of Sinj in the interior are particularly exposed to the stormy blowing of bura.

Keywords: the Adriatic Sea, the *bura* wind, navigation, warfare, narrative sources, the Little Ice Age

Ključne riječi: Ključne riječi: Malo ledeno doba, Jadransko more, bura, plovidba, kronike, izvješća, putopisi

1. INTRODUCTION

Bura is a dry, cold and gusty north-east wind (NNE-ENE directions) (Fig. 1). *During bura, there is an increased perception of coldness. (...) Bura is often preceded by a cold north (N) wind known as tramontana*.[2]

This concise definition of *bura* and its closest wind tramontana gives us the characteristics of those winds from the north and northeast quadrants that, through their effect on the lives of humans - both on land and at sea, gave occasion to writers to devote more or less space to them in the chronicles, diaries, reports, travelogues and other narrative sources dating from 1404 to 1783.[3] Since almost all of them

[1] Nikola GOJAK, Gojakov ljetopis, ed. Ante Bešlić, Josip Ante Soldo, in: *Makarski ljetopisi 17. i 18. stoljeća*, Split: Književni krug, 1993, 174. *... što (je) bura, bura (je), nikada ne čini koristi, ma sve štetu ...* (1759.)

[2] Višnja VUČETIĆ; Alica BAJIĆ, Vjetar / Wind, in: *Klimatski atlas Hrvatske / Climate atlas of Croatia 1961-1990., 1970-2000*., ed. Ksenija Zaninović, Zagreb: Državni hidrometeorološki zavod, 2008, 112-113.; Branko GELO, *Opća i pomorska meteorologija*, Zadar: Sveučilište u Zadru, 2010, 156-161. In this paper, there is no explicit need to emphasize the existence of the anticyclonal and cyclonal ("škura") bura.

[3] The criteria for selecting the documents were as follows: territorial coverage of the main occurrences of *bura*, presentation of the impact

originated in the period prior to the instrumental measurements, we can only rely on the witness' ability to observe and compare.[4]

However, for the sake of illustration, it is necessary to supplement it in the form of modern meteorological data. It is primarily gustiness, as a key, distinctive feature of the *bura* wind. Just here it is a need to supplement the gustiness feature by giving it an exact size - the speed of squall, to understand the all-times fear of its occurrence. In the last decades of the 20th century, *bura* reached velocities of: 35,0 ms^{-1} (126 kmh^{-1}) - Pula; 58,9 ms^{-1} (212 kmh^{-1}) - the bridge of Krk Island; 48,0 ms^{-1} (173 kmh^{-1}) - Senj; 65,2 ms^{-1} (235 kmh^{-1}) - the bridge of Pag Island; 69,0 ms^{-1} (248 kmh^{-1}) - the bridge of Maslenica; 41,0 ms^{-1} (148 kmh^{-1}) - the Šibenik surroundings; 48,5 ms^{-1} (175 kmh^{-1}) - the Split surroundings; 59,0 ms^{-1} (212 kmh^{-1}) - the Makarska surroundings; 44,3 ms^{-1} (160 kmh^{-1}) - the bridge of Dubrovnik (Fig. 2).[5]

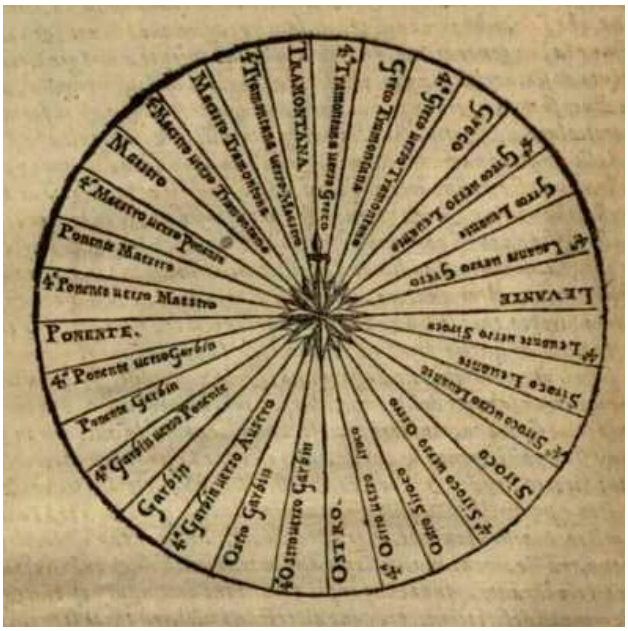

Figure 1: *The Rose of the Winds from the book »Anfiteatro di Europa«, by Giovanni Nicolò Doglioni, printed in Venice 1623. According to him bura (i.e. greco) blows from five directions - one main (NE) and two transitional to tramontana (N) and levante (E).*

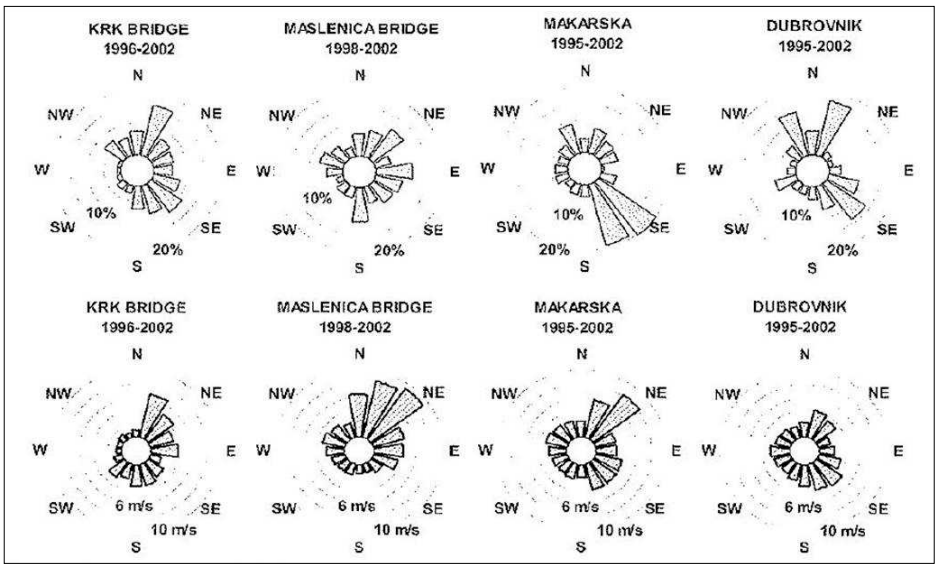

Figure 2: *Wind rose from locations: Krk bridge, Maslenica bridge, Makarska, Dubrovnik. Frequency of wind direction and average speed are shown. (From: A. BAJIĆ, B. PEROŠ, Meteorological basis for wind loads calculation in Croatia, Wind and Structures 8/6, 2005)*

of *bura* on a wide range of human activities and a uniform timeline of events within the selected period. Using this method landmarks and guidelines for further research in the archival collections of Adriatic cities were marked.

4 Rudolf BRAZDIL, Christian PFISTER, Heinz WANNER, Hans von STORCH, Jörg LUTERBACHER, Historical Climatology in Europe – the State of the Art, *Climatic Change* 70, Dordrecht-Boston 2005, 376-383.; Dario CAMUFFO, Chiara BERTOLIN, Alberto CRAIEVICH, et al., When the Lagoon was frozen over in Venice from A.D. 604 to 2012: evidence from written documentary sources, visual arts and instrumental readings, *Mèditerranèe* 125, 2015, 2.

5 VUČETIĆ, V., BAJIĆ, A., 2008, 113.; Alica BAJIĆ, Severe bora on the Northern Adriatic - Part I: Statistical analysis / Olujna bura na sjevernom Jadranu - dio I: statistička analiza, *Rasprave* 24, Zagreb 1989, 3, 5.; Višnja VUČETIĆ, Statistical analysis of Severe Adriatic bora / Statistička analiza olujne bure na Jadranu, *Hrvatski meteorološki časopis* 26, Zagreb 1991, 42-43, 48-50.

2. THE ORIGIN OF THE *BURA*

The conditions and processes from which the *bura* wind is produced as a final product are well known. All scientific analyses that as factors use the terms: air pressure and gradients, landform, channeling effect, hydraulic stream / jump, katabatic wind and many others, are relatively recent achievements. In other words, at the end of the 20th century, scientists, by persistent and systematic research, have overthrown previous explanations given and formulated by older generations of meteorologists.[6] However, the first interpretations of the origin and occurrence of the *bura* were recorded in times when meteorology did not have measuring instruments and when it did not exist as an independent science. Knowledge of the weather, primarily empirical, was vital to seamen sailing along the Adriatic [7], and the descriptions that they transmitted for the most part verbally prevailed upon travel writers, geographers, cosmographers and philosophers to take them into their own works. When we analyze them, we also discover the erudition of their authors, because in some interpretations the ancient foundations are recognized. When all is said and written, whatever the occasion is, it is definitely worth publishing these excerpts.

2.1. Old interpretations and explanations:

I. a

(Benedikt Kotruljević – before 1465)

... when it snows on the tops of mountains in Dalmatia in the winter, bura and tramontana tend to blow more...[8]

I. b

(Benedikt Kotruljević – before 1465)

... as much as windy the area by nature may be, and especially when the north winds blow, which have great power here. I saw in the territory of the Duke Stjepan, called Popovo and distant from Dubrovnik one day of walking, that there was a huge cave [9] *which, both in winter and in summer, it blows so great wind that it provides an astonishing spectacle from. ...*[10]

II.

(Palladio Fusco – 1508)

... In the hinterland of Senj there are some caves which there is no day without blowing a fierce wind from, and as it is characteristic of this city, it is called the Senj bura. ...[11]

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6 GELO, B., 2010, 159.; Vesna JURČEC, Severe Adriatic Bora Storms in Relation to Synoptic Developments, *Rasprave* 24, Zagreb 1989, 11-12.; VUČETIĆ, V., 1991, 41-42.; G. BEG-PAKLAR, A. BAJIĆ, V. DADIĆ, B. GRBEC, M. ORLIĆ, Bora-induced currents corresponding to different synoptic conditions above the Adriatic, *Annales Geophysicae* 23, 2005, 1083-1084.;

7 Benedikt KOTRULJEVIĆ, *De navigatione - O plovidbi*, Zagreb: Ex libris, 2005, 115, 155.; Radovan Vidović, Koine pomorskoga anemonimijskoga nazivlja, *Čakavska rič* XX/1, Split 1992, 57-59.; Krešimir KUŽIĆ, *Hrvatska obala u putopisima njemačkih hodočasnika XIV.-XVII. st.*, Split: Književni krug, 2013, 192, 216-217, 347, 388, 393, 466,

8 KOTRULJEVIĆ, 2005, 168-169. - *... quando nevechano soma le montagne de la Dalmaçia, soglono quel verno usare più greco et tramontana ...*

9 Vjetrenica Cave. See below.

10 KOTRULJEVIĆ, 2005, 82-83. - *... quantumque la regione de sui natura è ventosa, et potissime quando fiatano li venti septentrionali li quali pigliano multa potentia quivi. Et io ó visto nel territorio del duca Stephano, in loco distante da Ragusi una dieta dicto Popovo, dove è uno grandiximo specho lo qual al continuo, tanto de verne quanto de state, sputa tanto vento che è mirabile ad vedere ...*

11 Paladije FUSKO, *De situ orae Illyrici / Opis obale Ilirika*, trans. Bruna Kuntić-Makvić, Zagreb: Latina et graeca, 1990, 88-89. - *... A tergo autem Seniae sunt quidam specus unde nullo non die vehemens ventus perflat, quem loci peculiarem Boream Senensem nuncupant. ...*

III.

(Pedro Mexía – 1540)

... Ch. IX. (...) on the cave in Dalmatia ... Pliny writes in the second book [12] *about a very deep cave located in Dalmatia, from which, if a stone or other heavy thing is thrown into it, the air comes out with such fury and with such immense fierceness that it causes very great and terrible storms in the area. ...*[13]

IV.

(Jan Somer – 1591)

... It should be noted that the Gulf of Venice [14] *is very dangerous, with a northeast wind that makes it necessarily for people sailing in it to keep a man on the mast all the time. He does nothing but just watch out if any darkness or cloud appears from the northeast and then they get all the sails struck. The reason for this is: The Hungarian mountains* [15]*, which are very high, force the wind so fast that, if the shipman did not collect the sails in time, wind would capsize the ship, or strand it on the coast of Calabria* [16]*, where there is no port, ...*[17]

V.

(anonymous Italian – 1617)

... Above mountain of Sv. Juraj, in the place called Podgorje,[18] *there are some caves that, if one light a fire of straw or something else in it, and as long as thick smoke is created, get furiously, by some secret of nature, terrible winds sent out. The more the smoke gushes, the stronger the wind blows - in this way, a severe storm is created along these channels ...*[19]

VI.

(Andrea Argoli – 1653)

... The bura wind blowing from the north is cold and dry and healthy, parent of serenity and preserves everything from spoilage. Otherwise, because of the extreme coldness it is dangerous for trees and vines, and is called tramontana by many people. All north winds are cold. The northerly or the bura towards the summer (sunrise) site has the northeasterly: ... The northeasterly has these features: it is more healthy, cleans the air, producing sometimes snow, and hail: ... Saturn stirs the east winds, Jupiter the northern ones [20] *...*

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[12] PLINY, *Natural history*, Cambridge, London: Harvard University Press, Wiliam Heinemann, 1967, 256-257.

[13] Pedro MEXÍA, *Silva de varia lecion*, Sevilla: Juan Cromberger, 1540, 56rv; Silva de varia leccion, Madrid: Luis Sanchez, 1602, 94. - *... Cap. IX. (...) de la cueua de Dalmacia ... Plinio en el libro segundo escriue de una cueua muy honda que esta en Dalmacia, en la qual si echan una piedra o otra cosa pesada, sale luego tal furio so ayre della, con tan grandissimo impetu, que causa en la comarca muy temerosa y grande tempestad. ...*

[14] Venetian name for the Adriatic Sea. See: Mithad KOZLIČIĆ, *Kartografski spomenici hrvatskoga Jadrana*, Zagreb: AGM, 1995, 83, 86, 115, 173.; George SANDYS, *A Relation of a Iourney begun An. Dom. 1610. - Foure Bookes*, London 1615, 1-2. About Sandys' travelogue, see: Marina METELKO, Hrvatski krajevi u putopisima Georgesa Sandysa (1615) i Williama Lithgowa (1632), Nova croatica III/3, Zagreb 2009, 69-70, 86.

[15] As Kingdom of Croatia was in a personal union with Kingdom of Hungary, the author simplified territorial affiliation. The mentioned mountains are: Velebit (1758 and 1699 m asl), and Velika Kapela (1533 and 1428 m asl).

[16] The writer was wrong, and he should write *... on the coast of Puglia, ...*

[17] Jan SOMER, *Zee en Landt Reyse, Gedaen naer de Levante*, Amsterdam: Jacobus van der Bergh, 1661, 6v - *... Want men moet weten dat de Venetiansche Golf seer gevaerlijck is met een N. O. wint, daerom de Schippers die daet varen, hebben altijt een man erpressselijck tot dien eynde, in de mast, op dat hy anders niet doen en soude, als sijn ooghe hebben, wanneer eenighe donckerheydt ofte wolcken uptter N. O. op-komen, datmen terstondt alle zeylen marh strijcken. De oorsaecke hier van is, dat het Hongersche geberghte hoogh wesende den wint soo subytelijck afftupt, dat in dien de Schippers hare zeplen in tijts niet neer konnen krijgen, het Schip sin wert gesmeten of gedreven aen de kuste van Calabrien daer geen havenen zijn, ...*

[18] Sv. Juraj is a village, the "mountain" is Mount Velebit, Podgorje is its coastal slope exposed to the sun.

[19] Franjo RAČKI, Prilog za poviest hrvatskih uskoka, *Starine JAZU* IX., Zagreb 1877, 176, 225. - *... Sopra il monte di san Giorgio nell' luogo detto Spodgoria vi sono alcune caverne che accendendovi il fuoco dentro con paglia o altro, pur che facci fume grande, e per qualche segreto naturale o sotto empiendo quell' luogo lo fa con isdegno mandar fuora venti orribili, e quanto più crescie il fumo, tanto più crescie il vento - dove per quei canali fa fortuna crudele. ...*

[20] Andrea ARGOLI, Pandosion sphæericum, Padova: Paolo Frambotti, 1653, 24-27. - *... Boreas à septemtrione spirans est ventus frigidus, & siccus, saluberrimus, parens serenitatis, & à corruptione omnia præservans; ob nimiam alioqui frigiditatem arboribus, & recentibus vitibus perniciosus; vocatur multis Tramontana. ... Venti septemtrionales omnes sunt frigidi; Septemtrio seu Boreas versus ortum*

VII.

(Franz Ferdinand von Troilo – 1666)

... This gulf or sea bay is quite violent and subjected to storms, on that account all those who sailed on it will have to give me a certificate. This is because of the surrounding mountains, where strong and fierce winds pile up, and then they fall down so violently that they cause many shipwrecks. ...[21]

VIII.

(Ivan Lovrić – 1776)

... It is a popular opinion that this wind (bura) *comes out of the caves in our mountains, but this cannot be true. I was convinced by a lot of countrymen, that there are some caves in the mountains − and one in Mount of Prolog* [22] *− from which the wind downbursts with the greatest fierceness and during the greatest summer heat, and if a heavy thing is thrown by someone into the cave, the wind rejects it. In winter, the fury of this cave wind does not grow at all, and if the bura were in any way related to it, it would blow forever, and that doesn't happen. ...*[23]

IX.

(Petar Nutrizio Grisogono – 1780)

... The wind that generally upsets the sea of Dalmatia, has a constant relationship with the height of the mountains, breathing more vigorous wherever they are more eminent. The openings formed by the tops of two mountains, which cross each other, and the different valleys of the mountains themselves unleash especially the bura wind, which makes itself felt, and venerated more than any other. So it is that the mountains, which dominate the districts of Zadar, of Šibenik, Trogir, and Split, as less than those of Morlacha,[24] *and of others that go from Omiš to the borders of Dalmatia, make it more quiet waters, and easier navigation. The Naturalist* [25] *makes mention of a certain hole similar in property to the caves, which are praised on Mount Gamor* [26] *in Switzerland, where everything that is thrown produces a rainy wind. However, I have no traces, nor would be able to imagine where, and what was in his time this so windy tube. ...*[27]

Just within these texts it can be found the precursors of modern scientific terms. Using the phrase "pile up of winds", a German traveler von Troilo recognized and explained in plain words "air pressure" as a prerequisite for *bura*. "The form of the land", as one of the key factors was used by the native

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æstivum habet Aquilonem: ... Aquilo easdem habet qualitates; led est salubrior, aerem expurgat, nives, grandines aliquando etiam producens. ... Saturnus commovet ventos Orientales, Iuppiter Boreales ...; PLINY, 1967, 226-227, 248-249.

21 Franz Ferdinand von TROILO, *Orientalische Reise-Beschreibung*, Dresden: Melchior Bergens, 1676, 7. - *... Diser Golfus oder Meer-Busen ist gantz ungestüm, und dem Ungewitter unterworffen, dessen alle die jenigen, die darauff gefahren sind mir Zeugnüß werden geben müssen, und dieses von wegen der Umbliegenden Berge, auff denen die starcke und hefftige Winde sich häuffen, und dann so ungestüm herab fallen, daß viel Schiffbrüche dadurch verursachet werden ...*

22 Prolog is actually the name of the pass (1173 m asl) between the mountains of Dinara and Kamešnica.

23 Ivan LOVRIĆ, *Osservazioni di Giovanni Lovrich sopra diversi pezzi del Viaggio in Dalmazia del signor abate Alberto Fortis*, Venezia: Francesco Sansoni, 1776, 184-185. - *... È volgare opinione, che questo vento esca dalle Caverne de'monti, ma ciò non può essere vero assolutamente. Fui assicurato da moltissimi Morlacchi, che vi son alcune Caverne ne'Monti, ed una nella Montagna di Prologh, da cui con sommo impeto prorompe il vento incessamente, e nel più caldo bollor di State, se si getta in essa qualunque peso, il vento lo rispinge. Di Verno la furia del vento Cavernoso niente si accresce, e se Borea dovesse aver qualche relazione con esso, soffiarebbe perennemente, che non soffia. ...*; Ivan LOVRIĆ, *Bilješke o Putu po Dalmaciji opata Alberta Fortisa*, trans. Mihovil Kombol, Zagreb: Izdavački zavod Jugoslavenske akademije, 1948, 151.

24 Mount Velebit.

25 Gaius Plinius Secundus Maior. See: PLINY, 1967, 256-257.

26 It is a cave near Appenzell.

27 Petar NUTRIZIO GRISOGONO, *Notizie per servire alla storia naturale della Dalmazia*, Treviso: Giulio Trento, 1780, 21-22 - *... Il Vento che generalmente sconvolge il Mare della Dalmazia, hà un costante rapporto coll'altezza de' Monti, spirando più gagliardo là dove sono più eminenti. L'aperture formate dalle sommità di due Montagne, che si attraversano, ed i seni diversi de'monti stessi scatenano specialmente il vento Borea, che si fà sentire, e venerare più d'ogni altro. Quindi è che le Montagne, che signoreggiano i Contadi di Zara, di Sebenico, di Traù, e di Spalato, come men alte di quelle della Morlacha, e dell' altre che da Almissa camminano sino ai confini della Dalmazia, rendono più quiete quell'acque, e più facile la navigazione. Il Naturalista fà menzione di certa Spelonca simile nella proprietà alle Caverne, che si decantano del Monte Gamor nell'Elvezia, dove ogni cosa che si getta vi produce un vento piovoso. Io però non ho traccie, ne saprei figurarmi dove, e qual fosse a tempi suoi questo speco così burrascoso. ...*

Nutrizio very successfully in his claim, and indirectly, by Dutchman Somer long before him. "The channeling effect" was pointed out shrewdly by the anonymous Italian. Features of "the catabatic wind" can be recognized in the Dutch Somer's explanation; just as in the text of German von Troilo.

Earth cavities, caves as the start origin of the *bura* wind, natural or driven by human activity, are a special story. Kotruljević personally noticed the flow of air from a cave (it was Vjetrenica - literaly: Wind Cave in the hinterland of Dubrovnik), which led him to the wrong conclusion.[28] Fusco, as a longtime lecturer in the eastern Adriatic cities, records "wind-making caves" far more in the north (hinterland of Senj); Spaniard Mexía (who has never been in the Adriatic) is not precise and refers to Pliny, who places the cave somewhere in Dalmatia (Pliny is believed to have been deeming the aforementioned Vjetrenica); an anonymous Italian, a good connoisseur of local circumstances, adds smoke to an unnamed cave above Sv. Juraj (at the foot of northwestern Velebit), which is a variant of the story according to which the Senj's uskoks are the "instigators" of *bura*.[29] Lovrić, as a supporter of the Enlightenment, rejects traditional folk interpretation of the *bura*-making caves on Mount Prolog, and finally Nutrizio sarcastically dismisses the Pliny's ancient assertion of the cave source of storms in Dalmatia.

An astrological interpretation of the occurrence of meteorological phenomena is given to us by Argoli in his work "Pandosion sphæricum" from 1653 (the first edition 1644). There he claims that the planet Jupiter is the originator of *bura*.[30]

It took three centuries to dispel the inaccuracies of ancient authors, unquestioned authorities in the age of humanism, and then the stubborn misconceptions of the pseudoscience of astrology [31], and ultimately various forms of superstition.

3. IMPACTS OF *BURA*

If we were to stick to that hypothesis in the subtitle literally, there is no doubt that we would be wrong. However, such a qualification of *bura* is justified for all persons who came from rural areas or were part of maritime circles. Life in almost all parts of Europe depended on agriculture, quantity and quality of yield. Europe, at the time (14^{th}-18^{th} centuries), as Braudel rightly states, was a conglomerate of political entities based on the peasant layer of society, [32] and every crop failure, whether it be cereals, vines or olives, disrupted the normal functioning of the society, especially in the action of the top strata. Maritime affairs, as part of a transport network that facilitated the trade of goods but also naval warfare operations, was also extremely vulnerable to the weather conditions - storms and contrary winds.[33] The eastern coast of the Adriatic was an area belonging to four states (the Venetian Republic, the Holy Roman Empire, the Croatian Kingdom in union with the Hungarian Kingdom, and the Ottoman Empire, of which the first and fourth one showed serious aspirations for exclusive supremacy. The small but tough Republic of Dubrovnik acted in accordance with the political relations of these countries, with a constant reliance on important external political factors (Spain and the Holy See). Considering the overall period, war conflicts and fraudulent ceasefires were a permanent feature of the mutual relations of

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[28] Recent measurements have shown a flow velocity 5,1 do 9,8 m s^{-1} (18,4-35,3 kmh^{-1}), which explains Kotruljevic's cause of misinterpretation. Darko BAKŠIĆ, Dalibor PAAR, Nenad BUZJAK, Ivo LUČIĆ, Mikroklimatska opažanja u Vjetrenici / Microclimatic monitoring in Vjetrenica Cave, B&H, Međunarodni znanstveno-stručni skup "Čovjek i krš" 13.-16.10.2011. Bijakovići, Međugorje, Knjiga sažetaka, Sarajevo, Međugorje 2011, 13-14.

[29] Minuzzio MINUZZI, *Historia degli Uscochi*, Venezia 1602, 10-11.; Paolo SARPI, *Aggionta all'historia Degli Uscochi di Minucio Minucci*, Venezia 1613, 39. In the immediate vicinity of the town of Senj there are several caves, of which three half-caves are well visible from the sea, but their position also offers a view of the sea. From there, the uskok's sentry gave signs with smoke to the garrison down in the city in the case of approaching Venetian ships. Vlado BOŽIĆ, Špilje senjskih uskoka, Senjski zbornik 31, Senj 2004, 327, 330-332.

[30] ARGOLI, A., 1653, 37. ... *Saturnus commovet ventos Orientales, Iuppiter Boreales* ... It is far more important that he describes the operation of a thermoscope, a device for indicating the change of temperature and the precursor of a thermometer.

[31] Martin HILLE, Mensch und Klima in der frühen Neuzeit, *Archiv für Kulturgeschichte* 83/1, Köln, Wien 2001, 68, 71.

[32] Fernand BRAUDEL, *Strukture svakidašnjice – Materijalna civilizacija, ekonomija i kapitalizam od XV. do XVIII. stoljeća (Civilisation matérielle, économie et capitalisme, XV^e-XVIII^e siècle, tome 1, Les structures du quotidien: le possible et l'impossible)*, Zagreb 1992, 39, 67-70.

[33] Jacques LE GOFF, *Medieval Civilization 400-1500*, Oxford: Basil Blackwell, 1988, 137-138.

the first four mentioned states, but climatic characteristics, i. e. anomalies, were a factor that was inevitably imposed above all and which everyone had to respect and adapt to. Just *bura*, as one of the dominant winds in the Adriatic [34], has significantly influenced economic activities, war operations, but also other forms of human activity. They who did not respect the *bura* wind were suffering from it. Then, in their despair, the humans resorted to personification, so it was called *the enemy* and *the evil beast*. The writer Juraj Baraković (1548-1628) gave an extraordinary example of the consciousness of his helplessness.[35] The data in the introduction provide strong enough support for the claim that I will paraphrase in this occasion: ... *Bura shapes the theatre in which human existence ... takes place*, ...[36]

3.1. Living beings

Every wind, including *bura*, directly affects humans and animals in two ways - kinetic and thermal one. All following examples given in the chapter: 1, 6, 8, 9, 11, 18, 21, 22, 24, 26, 28, and 30 (Fig. 3) corroborate it, and besides them there are plenty of records that speak of it but are not listed for the space limitation. What must have been the speed of *bura* to throw a horseman with a horse or pedestrian to the ground, or prevent them from moving? The events from Senj and Kaštela (6, 8, 11, 19, 21) clearly speak of a fierce wind.[37] Using the Beaufort scale, only approximate results can be obtained, but they are much improved if we use modern research. [38] Accordingly, the minimum estimate refers to force 8-10, respectively: gale, strong gale or storm, that is, an average speed of 62 to 102 kmh^{-1}. If the method of

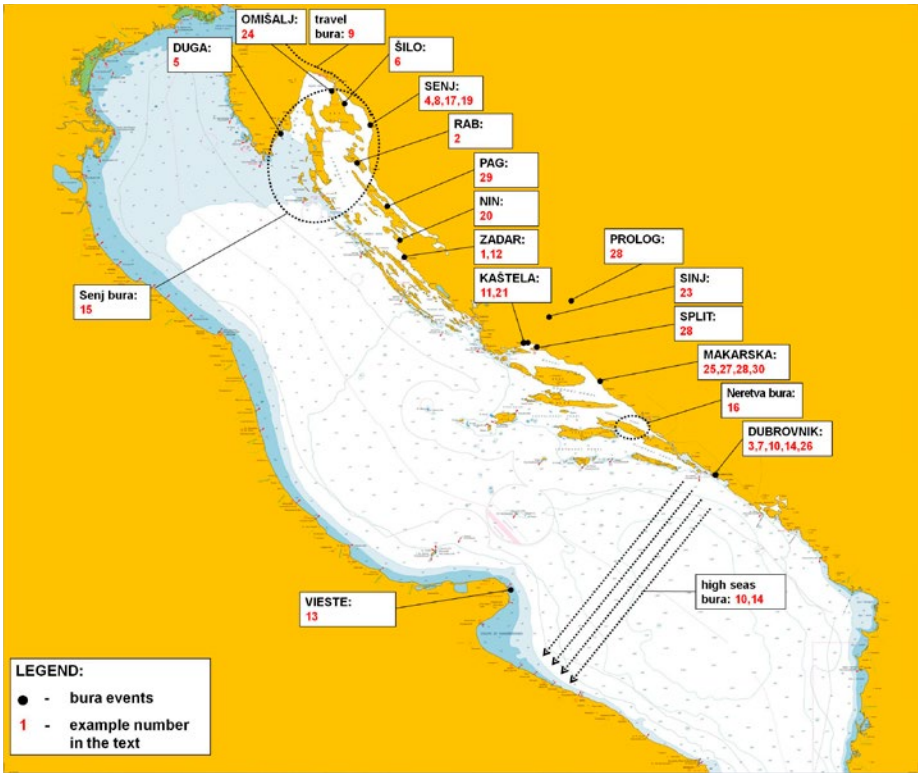

Figure 3: *Locations of all bura events on the coast and in the islands of the Adriatic Sea. The numbers are arranged in chronological order from the text.*

[34] Daniel BELUŠIĆ, Mario HRASTINSKI, Željko VEČENAJ, Branko GRISOGONO, Wind Regimes Associated with a Mountain Gap at the Northeastern Adriatic Coast, *Journal of Applied Meteorology and Climatology, September*, 2013, 2089.

[35] Juraj Baraković, *Djela, Stari pisci hrvatski XVII*, Zagreb: JAZU, 1889, 176-177. - *... sivera vitra zled odvrati i odren (...) Trepetat svit jame, kad bukne siver van (...) sivera vitra zloć odvrati od mora ...*

[36] BRAZDIL, R, PFISTER, CH., WANNER, H., STORCH, H. VON, LUTERBACHER, J., 2005, 402.

[37] Examples from Senj from the end of the 18th century. See: Alberto FORTIS, *Put po Dalmaciji*, trans. M. Maras, Zagreb: Globus, 1984, 274.

[38] Lidija CVITAN, Determining wind gusts using mean hourly wind speed, *Geofizika* 20, 2003, 64, 69-70.

calculating the gust speed of *bura* is applied, then the results figure out from 117 to 159 kmh^{-1}. It is clear that terrain characteristics have a big impact - gusts on a bridge or on a bare mountain slope are not the same as gusts between olive groves and vineyards, but the silhouette of a figure (enlarged by clothing as in the case of the woman on the drawbridge) also contributes to the impact strength.

The subjective feeling of cold has several elements that are related to lifestyle and quality of life - the rougher (outdoor) vocations (farmer, herder, sailor, soldier) raised the threshold of cold and unbearable cold, as opposed to the finer (indoor) professions (priest, notary, doctor, artist) who kept it low. Of course, clothing and footwear were an indicator of wealth, but types of food were even more - a lack of the former or the latter greatly influenced the feeling. Most chroniclers show some kind of sympathy when they describe the circumstances in view of the freezing of people - without regard to whether they are beggars, homeless people or poor travelers. This might have been caused by a sense of personal guilt about the community's failure and about lack of Christian mercy. Maybe the reason is that the records were done mostly by church persons. Hypothermia is a condition in which the body transmits more heat to the environment than it produces. We can distinguish three stages - from mild hypothermia in which the temperature drops to 35º C, over medium to severe in which the body temperature drops below 32º C. In the next step, the person falls into a coma, and death comes by freezing.[39] As an inevitable consequence of the *bura* blowing, in addition to a measurable, instrumentally recorded temperature, a subjective feeling of cold is created in a person exposed to their impact. Thus, at an air temperature of 0º C and a wind speed of 50 kmh^{-1}, the body has a temperature sensation of −8º C; at an air temperature of −5º C and a wind speed of 50 kmh^{-1}, the sensation is −15ºC; and with a temperature of −10º C and the same wind speed, the body feels like at −22º C.[40] Since those victims from Krk and Makarska were exposed to the icy *bura* for a long time and were poorly dressed, the only outcome could be death.

In addition to humans, *bura* caused the freezing of animals: sheep and horses (9, 28), and Pribojević claims that the wind also affected the movement of fish: *... storms with winds, which rage across the wide seas, Ionian, Apulian and Illyrian force fish against their will, to seek safer places. ...* (1525).[41] The sheep (with the goat) was the basis of animal husbandry in the Adriatic area, and the breed of *pramenka* was predominantly bred.[42] The farmers' reliance on extensive breeding meant that sheep stayed in mountain pastures for the most part of the year. *Pramenka* is not very sensitive to low temperatures to some extent, but in this case it was first caught in the rain, and then *bura* with its blowing caused hypothermia and eventually freezing. The horse hypothermia has similar symptoms as in the case of the human one, and the extremely negative effect of malnutrition and age of individuals is repeated.[43] It should be said that the Venetians praised horses from Croatia.[44] However, everything listed here belongs to a group of subjective factors that allow of wide ranges of the experienced temperature.

Therefore, some other phenomena should be taken in consideration as credible indicators of temperature, in the first place, the freezing of various liquids - from water to wine and grappa. Because these last two liquids (drinks) contain a lower or higher percentage of ethyl alcohol, their freezing point is much lower than water and its 0° C, which is a solid testimony to the considerable intensity of cold. The case of wine and grappa has been reported in Makarska (27), but its percentage of alcohol remained unknown. There is nothing for us but to draw simplified analogies with present wines and grappas. If the

[39] Dalen LEGOVIĆ, Gordan GULAN, Anton TUDOR et al., Tjelesna aktivnost u hladnim uvjetima okoline i prevencija hipotermije, *Hrvatski športskomedicinski vjesnik* 24/1, 2009, 39.; Marissa G. SPITZ, John W. CASTELLANI, Beau J. FREUND, Michael N. SAWKA, *Management of Heat and Cold Stress – Guidance to NATO Medical Personnel. USARIEM Technical Report T13-3*, Natick 2012, 19-20, 43.

[40] LEGOVIĆ, D. et al., 2009, 41.; SPITZ M. G., CASTELLANI J. W., FREUND B. J., SAWKA M. N., 2012, 28, 45.

[41] Vinko PRIBOJEVIĆ, *De origine successibusque Slavorum / O podrijetlu i zgodama Slavena*, trans. Veljko Gortan, Zagreb: JAZU, 1951, 96-97. - *... tum quia per late patentia aequora Ionicum Apulumque ac Illyricum saeuientes uentorum procellae uel inuitos pisces tutiora petere loca compellunt. ...* / 200.

[42] *Poljoprivredna enciklopedija* 2, Zagreb: JLZ, 1970, 419, 424, 426.

[43] Tomas GIMENEZ, *Accidental Hypothermia in the Horse - A Review for Emergency Responders**, Pendleton 2011, without pagination

[44] Šime LJUBIĆ, Commissiones et relationes Venetae II., *Monumenta spectantia historiam Slavorum meridionalium* 8, Zagreb: JAZU, 1877, 262.

iced wine contained 10-12% C_2H_5OH, then a temperature of about −5.5° C should be ruling. Regarding the frozen grappa, a possible amount of 20-30% ethyl alcohol gives a likely air temperature of −10 to −19° C.[45]

Water freezing events 1, 24, 26, 27 occurred at four different and distant locations on the Adriatic coast, and they also differ in that frozen sea water was noted in all four texts, but also in the second and fourth one it was freshwater - a stream. First of all, it is very useful to find possible correlations of these events with the freezing of the Venetian lagoon. This could point at the geographical extent of the meteorological extreme. So, the Zadar case should be connected with "the year of ice" that was misdated in 1407.[46] The event noted on the Island of Krk from the year 1709 belongs to the group of continental-scale anomalies, or, as Camuffo called them, "the great winters".[47] According to his division, the winter of 1755 also belonged to the same group, and the days of cold (in both Venice and Makarska) almost coincided in the days of beginning and ending.[48]

All cases on the Croatian coast have in common the long blowing of *bura*, the favorable shape of the coast (relatively shallow coves), and the mountain relief, as well. Only the origins of cold air mass are not stated anywhere (in accordance with the time!), but modern research has revealed it. In case 1, *bura* was allegedly blowing for 100 days and the coves were mentioned; in case 24 the blowing lasted 19 days (without precise location); in case 26 there is no duration information and the cove is indicated, and in case of 27 *bura* has blown for 29 days (the icing could be in Makarska port).[49] It should be noted that due to the salinity of seawater, which is around 38.5 ‰ in the Adriatic Sea, freezing occurs only when the temperature of the uppermost seawater layer drops below −1.9° C.[50] It is a threshold, which was probably crossed to a considerable extent in all cases. Also, it would be very useful to investigate possible differences in salinity, which may be influenced by general and local circumstances (near the mouth of a watercourse, or submarine spring). For example, at one point in the Velebit channel the salinity varies from 30.6 to 38.6 ‰.[51] Only when we consider some data from the intrumental period we become aware of the approximate magnitudes of the air temperature required to freeze the sea water in the past: Makarska: −8° C (until freezing, *bura* blew for 3 days), Senj: −13° C (blowing for 5 days), −16,6° C (blowing for 3 days), −18° C (blowing for 5 days).[52]

3.2. Warfare

Meteorological conditions have always been an important factor in planning and conducting military operations at all levels.[53] Once upon a time with the onset of autumn cold European armies used to be sent to winter quarters or be temporarily disbanded - the war usually began in spring, when the grass grew, and the main Sultan's army adhered to it.[54] But, in 1463, with the arrival of the turkish *akinjis* (or, akincis) and *martolos*, everything changed dramatically. They had, as ordinary cattle-lifters, plunderer, ravager, and last but not the least, slave raider,[55] chosen winter time for their actions because of three

[45] *Ethyl Alcohol Handbook*, Houston: Equistar, 2003, 61.
[46] CAMUFFO, D., BERTOLIN, C., CRAIEVICH, A., et al., 2015, 22. Among the cited examples there is no icing of the lagoon in 1498 recorded by Sanudo. It froze after just one day of the bura blowing. See: Marino SANUDO, I diarii I, Venezia 1879, 853-854.
[47] CAMUFFO, D., BERTOLIN, C., CRAIEVICH, A., et al., 2015, 12, 31.
[48] CAMUFFO, D., BERTOLIN, C., CRAIEVICH, A., et al., 2015, 32.
[49] Božena VOLARIĆ, Davor NIKOLIĆ, Zaleđivanje istočne obale Jadrana, *Hrvatski meteorološki časopis* 48/49, Zagreb 2013/14, 105.
[50] VOLARIĆ, B., Davor NIKOLIĆ, D., 2013/14, 94.
[51] Damir VILIČIĆ, Specifična oceanološka svojstva hrvatskog dijela Jadrana, *Hrvatske vode* 22, Zagreb 2014, 298-299.; Zlatimir BIĆANIĆ, Zvonko HELL, Dražen JAŠIĆ, Termohalinska svojstva morske vode u Paškom zaljevu i Velebitskom kanalu, *Geoadria* 3, Zadar 1998, 7-8, 10, 15.
[52] VOLARIĆ, B., Davor NIKOLIĆ, D., 2013/14, 94, 96-98, 101.
[53] Carl von CLAUSEWITZ, *Vom Kriege*, Berlin: Ullstein, 1998, 87, 113, 194, 315-316, 325, **401.** - *... der herannahende Winter einen sehr natürlichen Wendepunkt zu machen pflegt ...*, 612, 666.
[54] Emil LASZOWSKI, Monumenta habsburgica I, *Monumenta spectantia historiam Slavorum meridionalium 35*, Zagreb: JAZU, 1914, 89, 146, 148-149.
[55] Gábor ÁGOSTON, Bruce MASTERS, *Encyclopedia of the Ottoman Empire*, New York: Facts on File, 2009, 353, 593.

reasons: the harvest (was collected - ready-for-loot), the slaves - mostly peasantry (were at home - ready-for-taking away), the delaying of defender's reaction (due to snow or mud). Three centuries of soldiers in Croatian regions began.[56]

The neglect or respect of weather / *bura* indicators are recognized in the examples: 6, 13, 15, 18, 23 (Fig. 3). The catastrophic event 13 happened during the war between the Republic of St. Mark and Spain (1528-1529).[57] Several Venetian ships, among them three galleys and one fusta were lost after having been stranded. From the official report it can be reconstructed that the vessels left harbor during a stillness directing south (propelled by rowing), but in the night they were attacked by grego-levante (i.e. *bura*) surprisingly. The *sopracomito*, i. e. commander regretted for his move and well he might. Main navigation feature of the coast of Puglia is lack of the safe ports [58], therefore, when strong *bura* crosses the entire width of the Adriatic Sea, every ship near by this coast is inevitably wrecked. There is one curious coincidence more - in the same time one merchantman capsized in front of strait of Boka Kotorska - opposite the site of the accident.

The Ottoman fleet has threatened several times that it would sail to the unseized part of the Croatian coast and destroy resistance there. But, Hayreddin Barbarossa, as an experienced naval commander, who conquered Herceg-Novi in 1539 from the hands of the Spaniards, did not dare to sail more north-westerly, among the islands, within the *bura* range. The only plundering (not a conquering) raid was made by the Turks at the time just before the Battle of Lepanto in 1571. The target was the island of Hvar, while Korčula was saved just by the *bura* gusts.[59] The uskoks acted totally different. They were the only soldiers who systematically and deliberately turned all the negativities of *bura* in favor of their combat operations. In the passive sense, they waited until *bura* blew away the Venetian blockade ships, and in active mode they sailed under the strongest blows of the wind and attacked where no one expected them.[60]

Oarsmen, as the most numerous part of the galley-crew, because of ship's structural features, were extremely exposed to the weather, and *bura* was particularly harmful to their health. Cases of frostbites, amputations of parts of the hands and feet, as well as other diseases caused by hypothermia, were a regular occurrence, especially if naval operations were performed during the winter months. Admittedly, Venice used to pay galley-oarsmen, but their health care was rarely a priority.[61] Too often, they were boarding healthy and returning home sick. A man from the island of Cres wrote in 1662 that: ... *he was crippled on one leg because he lacked half a foot, which he lost due to the extreme cold on the galley,* ...[62] The galley has been an excellent ship for centuries we call the MWP - but for the LIA it has been dangerous to seamen, and most of them have lost health during winter engagements.

During the Venetian-Ottoman wars of 1645-1669 and 1684-1699, fierce conflicts were marked by bad weather. We see in the case 23 how the commander decided to avoid the perilous *bura* and cold having disbanded the units. In distinction from them general governor Foscolo, who was commander-in-chief of the expeditionary forces [63] that laid siege to the fortress of Klis in 1648, ran a hazard. It was

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[56] Geoffrey PARKER, *Global Crisis - War, Climate Change and Catastrophe in the Seventeenth Century*, New Haven, London: Yale University Press, 2012, 26.

[57] Giuseppe GULLINO, Le frontiere navale, *Storia di Venezia, IV Il Rinascimento – Politica e Cultura*, Roma, 1996, 96-100.

[58] SANDYS, G., 1615, 2.- ... *But more dreadfull are the Northerne, beating upon the harbourlesse shore.* ...; Alvise da MOSTO, *Il portolano del mare*, Venezia: Silvestro Gnoato, 1806, 30.; NUTRIZIO GRISOGONO, P., 1780, 5.; *Peljar Jadranskog mora*, Split: Hidrografski institut JRM, 1964, 351-352.

[59] Emil LASZOWSKI, Monumenta habsburgica II, *Monumenta spectantia historiam Slavorum meridionalium 38*, Zagreb 1916, 452.; Ivan KUKULJEVIĆ SAKCINSKI, Ljetopis nepoznatoga u talijanskom jeziku, *Arkiv za povjestnicu jugoslavensku* 4, Zagreb 1857. (B), 52, 54-55.; Francisco de LAIGLESIA, *Estudios históricos (1515-1555)*, Madrid 1908, 585-586.

[60] MINUZZI, M., 1602, 70.; Krešimir KUŽIĆ, Posljedice erupcije vulkana Huaynaputina godine 1600. na hrvatske zemlje, *Ekonomska i ekohistorija* 9, Zagreb 2013, 107.

[61] Danilo KLEN, *Šćavunska vesla - Galije i galijoti na istočnoj obali Jadrana*, Pula, Rijeka, 1986, 185-196.

[62] KLEN, D., 1986, 199-201.

[63] It was consisted of the following units: Croatian lancers, cuirassiers and militiamen, German mounted musketeers, and Venetian gunners and fusiliers. See: Krešimir KUŽIĆ, The impact of the "Little Ice Age" on operations during the liberation of Klis in 1648 (in the publication process).

March with extremely harsh, icy weather and severe *bura*. The cold was so great that a number of soldiers were frozen to death, and several horses perished as well. Though Foscolo was advised to raise the siege he didn't change object of effort, so thanks to the valor and endurance of his soldiers he achieved what he had set out to do. His soldiers were hurled and thwarted in marching by *bura*, just like those soldiers who were climbing and attacking castle of Šilo.[64] From this similarity it is difficult to conclude at what speed *bura* was blowing, however, according to the Beaufort scale, such a description of the effect of wind corresponds to the speed of at least 20.8 ms^{-1} (75 kmh^{-1}). Gusts probably reached speed of 37.6 ms^{-1} (135 kmh^{-1}).[65] The castle Šilo was located on the northwest coast of Krk, opposite Crikvenica, and was exposed to the direct blows of *bura*.

3.3. Agriculture

The cultivation of plants in the Adriatic area was strongly influenced by *bura*. Equally, cereals, or fruit trees, equally olive-trees or grapevine suffered from the aforementioned negative features of this wind. The only difference was the damage duration - annual plants, such as wheat and barley, would be destroyed for that year, but the perennial ones recovered for a long time, or would have to wait long for new plantation to bear fruit. Just like in humans, damage could be done by kinetic and thermal action. In the excerpts it is mentioned several types of fructiferous plants: olive-, fig-, pommegranates-tree, and vine. The type and degree of damage were partial (temporary) - breaking, or complete (permanent) - uprooting, which depended on the characteristics of the species, soil, position, and, of course, the speed of *bura*.

The olive-trees (*Olea europaea*) from the event 12 were completely destroyed, unlike the case of Makarska (25), when only branches were broken on the trees. According to the Beaufort scale, the breaking of large branches is a consequence of the 8 Bf (gale) *bura*, and the ability to uproot trees is a feature of the 10 Bf *bura*. Damages to olive-trees from the event 24 were a consequence of low temperatures, but it should be noted that the level of damage depends on the sort, the age of the tree and vegetation season. Since the olive is a xerophytic plant, the danger arises when the temperature drops below −8° C. It is also significant that less damage occurs from short-term lower temperatures of −12 to −15° C in dry weather than in high humidity and temperatures of −5 to −8° C.[66] Although the Franciscan Chronicles of Makarska abound in descriptions of the damage of olive trees due to *bura* in the 18th century, the most devastating disaster occurred in 1549, when all these trees in Istria and Dalmatia were destroyed.[67]

The fig-tree (*Ficus carica*) was a very widespread fruit and was grown mostly on the edges of arable land. It is sensitive to strong wind because it has fragile branches and is resistant to drought. If the air temperature drops below −10° C, its bark breaks causing the tree to decay.[68] In the same year, 1549, fig-trees were also destroyed throughout Dalmatia.[69]

Pomegranate-tree (*Punica granatum*) is a fruit grown as a side crop and also used as a hedge. Although the pomegranate withstands cold, it suffers if the temperature drops below −17° C.[70]

The vine (*Vitis vinifera*) was once the most represented agricultural crop in the entire Adriatic, both on the coast and on the islands, due to the lucrative wine production. This plant is highly adapted to local climatic conditions, but depending on the vegetation period, the *bura* can partially or completely destroy it. Some varieties are particularly sensitive to this wind. It can withstand temperatures up to −13° C.[71]

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[64] By all accounts, it was one of the episodes in the conflict among the brothers and relatives - the Counts of Frankopan. Probably between Ivan VII, who was the lord of the island of Krk and Ivan VIII, the lord of Brinje. See: Vjekoslav KLAIĆ, *Krčki knezovi Frankapani*, Zagreb: Matica hrvatska, 1901, 251-254.

[65] CVITAN, 2003, 64, 69-70.

[66] *Poljoprivredna enciklopedija* 2, Zagreb: JLZ, 1970, 143-144.

[67] LJUBIĆ, Š., 1877, 199, 206, 211, 215.;

[68] *Poljoprivredna enciklopedija* 3, Zagreb: JLZ, 1973, 162-163.

[69] LJUBIĆ, Š., 1877, 211, 215, 218, 223, 257.

[70] *Poljoprivredna enciklopedija* 3, Zagreb: JLZ, 1973, 294.

[71] *Poljoprivredna enciklopedija* 3, Zagreb: JLZ, 1973, 488.; Ivan SOKOLIĆ, *Veliki vinogradarsko vinarski leksikon*, Novi Vinodolski 2006, 455.

The chronicler did not give the name of the frozen grapevine, but it can be argued with a great deal of certainty that it was either Žlahtina - the most common variety on the island of Krk, or Ošljevina - an old, almost extinct variety.[72] On the island of Pag, the most exposed to *bura*, in the mid-16th century the vine could not survive at all, [73] but, it was recorded that the offshore island of Molat was also within reach of *bura*, which caused damage to the vineyards there.[74]

Did the lack (after having cut down) of forests, especially in the vicinity of Senj, have any effect on the strength of *bura*?[75] Judging by the sources, one cannot make such a general impression. Maybe at the micro level. *Bura* has been blowing wildly with and without forests.

3.4. Traffic and Transport

Bura had a negative impact on both land and maritime transport, as shown in the following examples: 4, 5, 8, 9, 10, 13, 14, 15, 16, 17, 19, 20, 21, 24 (Fig. 3). However, as soon as the sources are studied in more detail, a disproportion can be observed between the few records in which pedestrians and horsemen, therefore, land travelers, were struck by *bura* and the sheer abundance of records of the dangers and casualties experienced by sailors and passengers at sea. It is a popular saying that sailor's bread has seven crusts, so if we think about it, we cannot get rid of the impression that at least three crusts were dried and hardened by the *bura* wind. The experienced seafarers perceived that some parts of the Adriatic Sea were more perilous for ships due to *bura*.[76] As such there were bay of Trieste, bay of Rijeka, bay of Kvarner, sea areas of Senj, and Solin, cape Ploča, coves Vrulja, and Žuljana, and straits of Boka Kotorska. It was just Bay of Kvarner which was particularly ill-famed. Historically considered, justly.[77] The story is further illustrated by Baraković's poetic expression, part of which I mention here: ... *don't step over the door at night, lest the bura overwhelm you, if it blows through the Strait of Senj* ...[78] From the point of the long distance sailboat shipping of this period, Bay of Kvarner was an inevitable stretch of route from Venice, and towards Venice. All other points were of more or less local importance and were mostly traversed by coastal vessels. The most troublesome feature of crossing Kvarner was the collision of the ship's navigation directions with the direction of the *bura* blowing at an angle of 90 degrees (simplified NW/SE against NE). It was somewhat similar in the case of navigation near Cape Ploča (W/E against N), too. The main difference was that *bura* in Kvarner was channeled orographically, so it is justified to speak of its gusty jets (Fig. 4).[79] Speaking of Ploča it "leans" with one side to mainland.

The sailors of that time found a temporary break along the southern shores of the island of Hvar, described by the local man in words: ... *Between these islets and Hvar there is a channel ... where neither winds nor waves are raging. ... They have to go there, especially in winter, if they want to avoid the*

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72 Edi MALETIĆ, Jasminka KAROGLAN KONTIĆ, Ivan PEJIĆ, et. al., *Hrvatske izvorne sorte vinove loze*, Zagreb: DZZP, 2015, 40, 152, 194, 210, 332.

73 LJUBIĆ, Š., 1877, 260.

74 KUŽIĆ, 2013, 554.

75 Nataša ŠTEFANEC, Trgovina drvetom na Triplex confiniumu ili kako izvući novac iz senjskih šuma (1600-1630)?, in: *Triplex confinium (1500-1800): ekohistorija*, ed. Drago Roksandić, Ivan Mimica, Nataša Štefanec, Vinka Glunčić-Bužančić, Split, Zagreb: Književni krug, Zavod za hrvatsku povijest Filozofskog fakulteta Sveučilišta u Zagrebu, 2003, 340-345, 358-362.

76 Tome MARELIĆ, Utjecaj vjetra na organizaciju jedrenjačke plovidbe na hrvatskom dijelu Jadrana / Wind Influence on Sailing Ship Navigation Across Croatian Part of Adriatic Sea, *Geoadria* 21/2, Zadar 2016, 212, 216-217, 220.

77 KUŽIĆ, 2013, 311, 346, 347, 386, 390, 449, 466, 541.; Nikola ČOLAK, *Regesti maritimi croati III / Hrvatski pomorski regesti III*, ed. Zrinka Podhraški Čižmek, Split: Odsjek za povijest Filozofskog fakulteta u Splitu, 2017, 40. - ... *furiosa borrasca* ... (20.01.1766.), 56. - ... *furente borasca* ... (03.03.1769.); ... *gagliardo Greco Leuante* ... (18.03.1769); ... *crudele borasca* ... (?20.03. 1769, 57. - ... *Borasca* ... (08.05. 1769.), 62. - ... *furare di borasca da Greco Leuante* ... (17.04.1770.); 94. - ... *burasca* ... (?21.07.1782.), 96. - ... *furioso vento di greco levante* ... (09.01.1783.), 101. (?05.11.1783.)

78 BARAKOVIĆ, 1889, 360. - ... *ne hod obnoć priko vrata, / da te bura ne oslani, ako dunu Senjska vrata. / Često vitri smetu more, ko se ufa u tišinu, / Senjska vrata kad obore / staru svoju opačinu, / rasrdi se ča se more / nose vali u visinu, da priskaču Rabske gore / prik otoka u pučinu. ...*

79 BELUŠIĆ, D., HRASTINSKI, M., VEČENAJ, Ž., GRISOGONO, B, 2013, 2090.; Davide BONALDO, Edoardo BUCCHIGNANI, Antonio RICCHI and Sandro CARNIEL, Wind storminess in the Adriatic Sea in a climate change scenario, *Acta Adriatica* 58/2, 2017, 197.

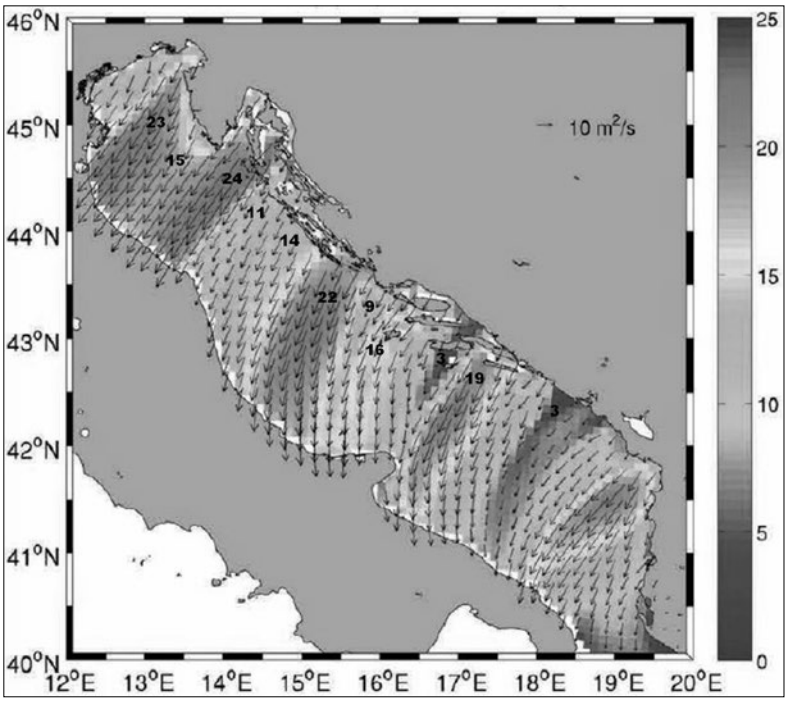

Figure 4: *Jets of bura blowing in the Adriatic. The following buras are recognizable: Trieste, Kvarner, Senj, Šibenik, Klis and Neretva (Pelješac) bura. (From: D. BONALDO, E. BUCCHIGNANI, A. RICCHI and S. CARNIEL, Wind storminess in the Adriatic Sea in a climate change scenario, Acta Adriatica 58/2, 2017.)*

greatest marine dangers, those who sail from Venice ... or who go to Venice. ... (1525).[80] To this beautified story, for the sake of truth, it should be added that the seafarers further south faced the northeasterly. That was in front of Ston and Zaton, where ... *the bura rage reigned* ... once again.[81] But, as you can see, the anxiety continued for this reason until Boka Kotorska, as evidenced by Ivan Bolica from Kotor and even more by that overturned ship (10,14).[82]

3.5. Construction

The destructive energy of *bura* is very clearly shown in examples 2, 3, 7, 12, 25 and 29 (Fig. 3). Knowing the constructors practices and techniques of that period it is perfectly clear that was to be expected. That is to say the mass of building material was the most important factor that helped resist to the *bura* gusts.[83] All mentioned buildings without exception were stone-built, but there are many striking differences among them.

Though city walls were to be generally considered as weighty and solid structures, the various appendages, like watch-houses, breastworks and battlements as well, attached to the city walls, were fairly sensitive. Actually, they were the thinnest sections of the fortifications, and, moreover, positioned on the top of the structure, on the spot/line where the impact of *bura* was the greatest. With regard to the three events: Rab, Dubrovnik and Zadar, it was a question of the old-fashioned, medieval walls, i. e. vertical ones, with no escarpments.[84] Finally, according to what the chronicles say, parts of the city walls that had been demolished by *bura* were at right angles to its blowing. In the Dubrovnik case, the demolition site was to the east, and the Zadar wall is known to have been tumbled down to the southwest, near the Franciscan monastery.[85] This means that the wind has struck it in the inner side. According to

[80] PRIBOJEVIĆ, V., 1951, 98-99. / 202.
[81] LJUBIĆ, Š., 1877, 223.
[82] Flaminio CORNER, *Catharus Dalmatiae civitas in ecclesiastico & civili statu historicis documentis illustrate*, Padova: Typis Seminarii, 1759, 105.
[83] John D. HOLMES, *Wind Loading of Structures, Second Edition*, London, New York: Taylor & Francis, 2007, 15.
[84] Lukša BERITIĆ, *Utvrđenja grada Dubrovnika*, Zagreb: JAZU, 1955, 66, 76, 246, Plan V., VI., VII.
[85] Tomislav RAUKAR, Ivo PETRICIOLI, Franjo ŠVELEC, Šime PERIČIĆ, *Zadar pod mletačkom upravom 1409-1797*, Zadar: Narodni list,

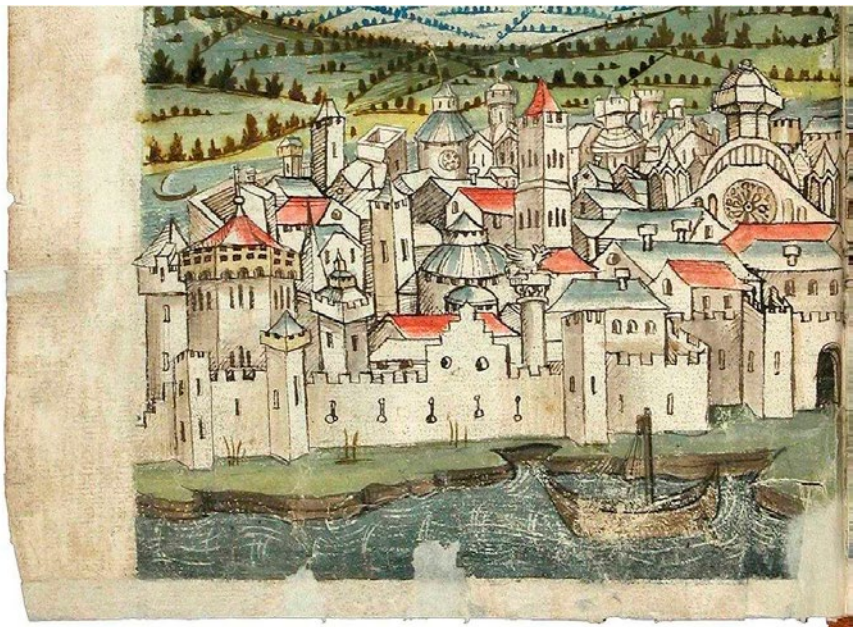

Figure 5: *Picture of Zadar from 1486 from the travelogue of Konrad von Grünemberg. View from the southwest. (From: Badische Landesbibliothek, Karlsruhe)*

the official report, the wall was quite high and had merlons at the top.[86] The whole story is confirmed by a unique drawing of the German pilgrim Konrad von Grünemberg who passed through Zadar in 1486. Despite some confusion, the most important detail (for this article) of Grünemberg's work, the south-western walls with merlons, are clearly shown (Fig. 5). Judging by this, the collapsed wall was located between the second and third tower (viewed from left).[87]

The Makarska event is something specific. First of all, it was a palace, consequently, a civil edifice, with thinner, delicate walls. The building was under construction what was the main unfavorableness for the fall resistance. Such unbound walls were easy prey of the mighty gusts of *bura*.

In short, it should be elaborated the wind unroofing, too. There were, in principle, three types of roofing materials in the Adriatic area. Public buildings and houses of richer town inhabitants were covered with pantiles - the thin limestone-plates were used by commoners. In the countryside the great majority of houses and sheds were thatched - the rest was limestone-plated. In order to protect their roofs people set up heavy stones, but nevertheless *bura* usually ripped the straw cover as mercilessly, as it did with the unbound limestone-plates. The city of Senj, the most famous for *bura*, never experienced such a kind of damages because its inhabitants learned to coexist with this wind. Is it possible to determine the approximate speed of these ancient *buras*? In order to answer this question, we have to rely on Valvasor's description. He states that the blowing of the Senj *bura* at his time (before 1682) caused the formation of foam and tiny droplets that the wind carried over the sea.[88] This results in an approximate speed of 118 kmh^{-1}.

Wind loading of buildings depends primarily on its shape, and the walls are classified as bluff bodies with elongated rectangular form. The geometry of roofs is more complicated, owing to their multifacetedness and steepness.[89] With regard to wind its speed, gustiness, and gust factor play very important role. Further, there is the angle of wind attack as an important factor - if the angle in both of planes is

Filozofski fakultete Zadar, 1987, 135.

86 Šime LJUBIĆ, Commissiones et relationes Venetae I., Monumenta spectantia historiam Slavorum meridionalium 6, Zagreb: JAZU, 1876, 171.; LJUBIĆ, Š., 1877, 11, 45.

87 Ivo PETRICIOLI, Prinove istraživanju srednjovjekovnog lika Zadra, *Radovi Filozofskog fakulteta u Zadru, Razdio povijesnih znanosti* 28(15), Zadar 1989, 147-149.; KUŽIĆ, 2013, 386.

88 Johann W. VALVASOR, *Die Ehre des Hertzogthums Crain IV., Zwölfftes Buch,* Nürnberg 1689, 79. - *... Diese* (Winds) *treiben die zu solcher Zeit schäumende Meereswellen so hoch auf, daß sie auch über den kurtz zuvor besagten Sabbae Thurn öffters zusammen schlagen. ...*

89 HOLMES, J.D., 2007, 82, 195, 202-203.

about 90°, the pressure is the strongest.[90] Impressive data of both basic (1428 N / m^2) and peak pressure (5712 N / m^2) at a basic wind speed of 172 kmh^{-1} were measured at the Maslenica Bridge in 2003.[91] The trouble is, such a *bura* can last for hours, and with shorter abatings, for days.

EXCERPTS FROM SOURCES AS EXAMPLES

1. 1404/1405, December the 13th 1404 - March the 23th 1405), city of Zadar and surroundings – The north winds had been blowing from St. Lucy's Day for the next 100 days. It was icy cold, snow fell, and the sea was frozen in the coves there.[92]
2. 1418/1419, before January the 17th, city of Rab – A stormy wind (*bura*?) blew down a part of the city wall in the length of several (?) Venetian fathoms [93] (7-14 m).[94]
3. 1434-1440, Dubrovnik – ... *The aforementioned bura, the enemy and the most powerful expeller of the* jugo *wind (sirocco), rules here and is so violent and furious that doors have to be closed with iron bolts and windows with double-shutters. ...*[95]
4. 1455, September the 12th, seaport-towns Rijeka and Senj – Traders [96] had been waiting for boreal weather to smuggle goods in sight of Venetian naval guards.[97]
5. 1464, June the 24th, cove Duga, Istria – Franciscans in the course of sailing from Ancona to Rijeka experience sudden gusts of *bura*.[98]
6. 1464, beginning of November, coast of the Krk island near castle *Šilo* – During a siege the sudden gusts of the wind knocked soldiers down the hillside and threw them into the sea.[99]
7. 1505, February the 22nd, Dubrovnik – A terrible *bura* was blowing which knocked down the breastworks at the gate of Ploče and also did a lot of damage around the city.[100]
8. 1516, from August the 21st to September 1st, city of Senj – The Venetian envoy Antonio Surian described a severe *bura* in Senj. The blowing lasted 11 days and was so strong that the wind carried horses with horsemen (Fig. 6).[101]
9. 1517, January the 15th to January the 22nd – The envoy of count Bernardin Frankopan speaks of the dreadful *bura* and the unbearable cold that he experienced being on the road from Ogulin

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90 HOLMES, J.D., 2007, 66, 86-91.

91 Alica BAJIĆ, Opterećenje građevinskih konstrukcija burom, *Hrvatski meteorološki časopis* 48/49, Zagreb 2013/2014, 4, 8, 13-14.

92 Ferdo ŠIŠIĆ, Ljetopis Pavla Pavlovića patricija zadarskoga, *Vjestnik kr. hrvatsko-slavonsko-dalmatinskog zemaljskog arhiva* 6/1-2, Zagreb 1904, 39. - ... *venti septentrionales a festo Sanctae Luciae de mense decembris quasi per dies centum cum asperrimis frigoribus et insuetis continuo viguerunt profundissimae nives, glacies grossissimae et latae in montibus et apud maritima, ita ut multi portus et littora satislarge congelata fuerunt per insulas nostraset iuxta civitatem, ...*

93 Zlatko HERKOV, Prinosi za upoznavanje naših starih mjera za dužinu i površinu, *Zbornik Historijskog zavoda JAZU* 8, Zagreb 1977, 147. - ... *1 passo di 5 piedi veneti = 1,7385 m ...* , 168.

94 Šime LJUBIĆ, Listine o odnošajih izmedju južnoga slavenstva i Mletačke Republike VII., *Monumenta spectantia historiam Slavorum meridionalium* 12, Zagreb 1882, 301. - ... *et exposito, quosdam passus muri illius nostre terre Arbi ob terribiles ventos ... cecidisse, ...*

95 Filip de DIVERSIS, *Opis slavnoga grada Dubrovnika*, trans. Z. Janeković-Römer, Zagreb: Dom i svijet, 2004, 41-42, 141. - ... *Hic Boreas Austri inimicus et expulsor potentissimus ibi regnat, et tanta vi flat furitque, ut vectibus ferreis claudi et duplicatis tabulis spectaculorum ianuas fieri oporteat; ...*

96 Sabine Florence FABIJANEC, Trgovački promet Kvarnera na Jadranu krajem srednjeg vijeka, *Zbornik Odsjeka za povijesne znanosti Zavoda za povijesne i društvene znanosti HAZU* 25, Zagreb 2007, 105, 107-109.

97 Šime LJUBIĆ, Listine o odnošajih izmedju južnoga slavenstva i Mletačke Republike X., *Monumenta spectantia historiam Slavorum meridionalium* 22, Zagreb: JAZU, 1891, 69. - ... *expectant tempora borearum ...*

98 Leonard LEMMENS, *B. Bernardini Aquilani Chronica fratrum minorum observantiae*, Roma: Typis Sallustianis, 1902, 97-98. - ... *transactisque promonturiis et canali Quarnarii jam sumpto, ut ad Flumen iremus, mala bestia borea contra nos mirabili furore surgente vix Portum Longum cum maximo labore capere potuimus; ...*

99 Giuseppe BRIZZOLARA, La cronaca di Cristoforo da Soldo, *Rerum italicarum scriptores* XXI/III, Bologna: Nicola Zanichelli, 1938, 147. - ... *E trovandosi sotto una corna de monte ... Si levò una altra fortuna mazora di la prima; e subito se zitò fora una quantitade de quelli guastadori; rampegando in suso per quelle corne a pena si potevano tenir com le mane e molti ne cascava in aqua e negavano; e ne scampò in quello modo da circa 60. E crescendo la fortuna, se ne zitò fora da circa cento, rampegando come quelli de prima. ...*

100 Natko NODILO, Notizie, aggiunte de mani ignote alle Croniche di Giovanni Gondola, *Monumenta spectantia historiam Slavorum meridionalium* 25, Zagreb: JAZU, 1893, 434.

101 Marino SANUDO, *I diarii XXIII*, Venezia 1888, 348. - ... *portava via li cavali con li homeni suso, ...*

(Croatia) to Venice. As a consequence his companion died by frost together with the horse on which he rode.[102]

10. 1521, December ?, Dubrovnik – The stormy *bura* overturned a large nave loaded with grain in the city port, and sank many ships on the high seas.[103]
11. 1523, December the 23rd - 24th, Kaštel Novi – Fire was blazed up in the village by stormy *bura*, and then a gust of the wind threw one woman into the sea as she crossed the drawbridge [104] at the gate of the castle (Fig. 7). Her body was never found.[105]
12. 1524, December the 16th, Zadar – The severe *bura* torn down the city walls on the southwest side in three places, for a total length of 25 fathoms (43-44 m) (Fig. 5).[106] It also uprooted the olive trees.[107]
13. 1528, December the 27th - 30th – The report of general governor Zuan Vitturi in which he detailed effects of the terrible grego-levante (east-northeast wind) that shattered the Venetian galleys on the Italian western Adriatic coast near the town of Vieste.[108]
14. 1545, January the 1st - 3rd, Dubrovnik and surroundings – The fierce *bura* fell on from the mountains, blew off 30 ships to the coast of Apulia and sank them, including three large naves.[109]
15. 1580 – Unknown reporter points out natural features of the Senj area, especially winds (tramontana, i. e. *bura*) and islands, that prevent the Ottoman fleet from attacking the city.[110]
16. 1589 – French nobleman Jacques de Villamont points out the intensity of the *bura* wind in front of the Neretva River mouth, and its impact on navigation.[111]
17. 1601, September - October the 7th – Due to the *bura* wind that blew continuously for 20 days, it was not possible to deliver food to Senj, so people were starving.[112]
18. 1615, March the 18th – Antonio Civran, Commander of the Adriatic Fleet, states that galley-oarsmen suffer from *bura* and cold on galleys deployed in Dalmatia.[113]

Figure 6: *Bura throwing riders and horses (From: J. W. VALVASOR, Die Ehre des Hertzogthums Crain IV., Zwölfftes Buch, Nürnberg 1689)*

[102] SANUDO, M.,1888, 508.

[103] Natko NODILO, Annales Ragusini anonymi item Nicolai de Ragnina, *Monumenta spectantia historiam Slavorum meridionalium* 14, Zagreb: JAZU, 1883, 277-278.

[104] Katja MARASOVIĆ, Kaštel Novi i kula Cippico, *Kaštelanski zbornik* 5, Kaštela 1996, 37-39, 42, 48. The castle was built in 1512 and was located on a sea cliff. To the mainland it was connected by about 30 m long stone bridge with a drawbridge in front of the gate.

[105] Marino SANUDO, *I diarii XXXV*, Venezia 1892, 335, 342.

[106] LJUBIĆ, Š., 1876, 171. - *... a mezza notte el vento di buora ruinò de la banda de garbin, che è verso el canal maistro, mure per longeza passa 25. ...*

[107] KUKULJEVIĆ SAKCINSKI, I., 1857 (A), 40 - *... Tada bura uvali na tri mesti zidi u zadru na donem muru, mnoge masline vrže, i naš lipi topo(l) ...*; RAUKAR, T., PETRICIOLI, I., ŠVELEC, F., PERIČIĆ, Š., 1987, 277.

[108] Marino SANUDO, *I diarii XLIX*, Venezia 1897, 353-356. - *... E partito a hore 5 di notte, ne assaltò una crudelissima fortuna da griego-levante, et qualche volta girava fin a la tramontana, ... La qual galia del Gritti andò in mille pezzi. ... perchè queste spiagie di Puia et Abruzo son cative di estate per li casi che ognor sucedono a queste spiagie, nonchè d'inverno ...*

[109] Natko NODILO, Annales Ragusini anonymi item Nicolai de Ragnina, *Monumenta spectantia historiam Slavorum meridionalium* 14, Zagreb: JAZU, 1883, 104.

[110] August THEINER, *Vetera monumenta Slavorum meridionalium historiam illustrantia II*, Zagreb: JAZU, 1875, 75. - *... La tramontana et gli altri venti, che in quel golfo (...) Quarnier chiamato, di continuo quasi regnano, sono i maggiori i presidii del luogo, altrimente la'armata del Turco giá guari l'havria occupata, se non dubitava di tal venti et de le isole ...*

[111] Jacques de VILLAMONT, *Les voyages du Sr. de Villamont, divisez ent trois livres*, Arras: Guillaume de la Riviere, 1606, 210. - *... Bref le passage de ce goulfe est perilleux, pource que la tempeste y est presque continuelle, à raison des montagnes qui sont à l'entour. Lors que nous le passames survint une borasque d'un vent nommé Grego qui contraignit caller du tout le voile de Cueba, et ...*

[112] Karlo HORVAT, Monumenta historiam uscocchorum illustrantia I, *Monumenta spectantia historiam Slavorum meridionalium* 32, Zagreb: JAZU, 1910, 376.

[113] Grga NOVAK, Commissiones et relationes Venetae VI, *Monumenta spectantia historiam Slavorum meridionalium* 49, Zagreb: JAZU, 1970, 230.

19. before 1617, Senj – an unknown Italian merchant writes that they couldn't leave the house in Senj because of *bura*.[114]
20. 1620, February the 20th, Nin – Governor of Zadar, Alvise Zorzi, recorded that *bura* was carrying sand that filled the port of Nin.[115]
21. 1632, in February, Kaštel Lukšić – Marco Molin, governor of Trogir, states that because of the *bura* gusts it was not possible to ride through the Kaštela Field.[116]
22. 1677, December the 10th – Alvise Foscari, commander of the Adriatic, showed compassion to the galley-oarsmen who were hit by cold, winds and rain.[117]
23. 1686, September, the 30th, Sinj – General governor Girolamo Cornaro and other military commanders of the Duke of Parma described the difficulties caused by the snow and the furious *bura*.[118]
24. 1709, January the 6th-25th, Omišalj – *... and it took rise a great cold from the bura wind, snow and ice. Every day bigger and bigger ... The cold has left a terrible reminiscence and damage to people, the harvest, the forest, the ships and the animals. People were found dead-frozen along roads and hills. The ships in the water were frozen along with people. The large streams were so frozen that the ice could not be cut through. Olive trees, fig trees, and pomegranates trees became frozen all over, all crops, both wheat and winter-corn devastated ...*[119]
25. 1741, March the 20th-21st, Makarska – The fierce *bura* unroofed houses, broke olive trees, razed to the ground walls from the side of *bura*, and smashed windows and doors of the new bishop's palace.[120]
26. 1752, January the 15th, Dubrovnik – The tempestuous *bura* was blowing, which brought the cold and as a result the sea in the Bay of Gruž was frozen.[121]

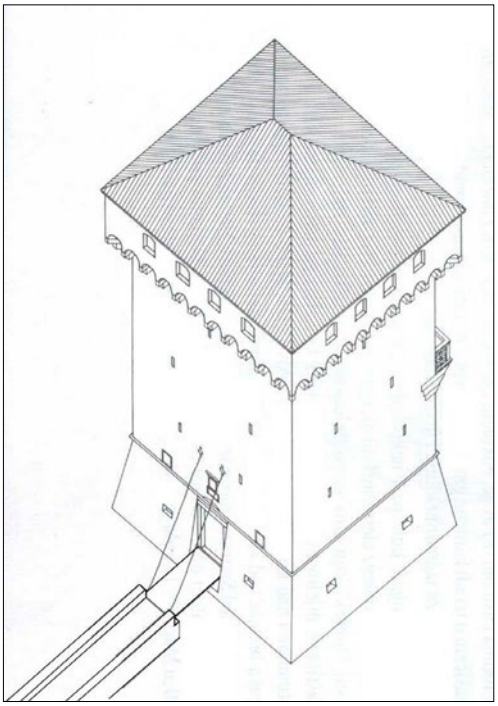

Figure 7: *The reconstructed appearance of the castle and the bridge from which bura threw the woman. (From: K. MARASOVIĆ, Kaštel Novi i kula Cippico, Kaštelanski zbornik 5, Kaštela 1996)*

[114] RAČKI, F., 1877, 176. - *... E mi sono ritrovato a Segna, quando soffiava questi venti non potevo uscire di casa ne io ne altri, se non con gran pericolo rispetti lo scoprimento de' tetti, che cascono nelle strade. ...*

[115] Grga NOVAK, Mletačka uputstva i izvještaji VIII, *Monumenta spectantia historiam Slavorum meridionalium* 51, Zagreb: JAZU, 1977, 94.

[116] NOVAK, G., 1977, 185. - *... ne i rigori di arrabbiate freddissime bore, et crudelissimi tempi, che non si poteva venir nelle proprie case, non che cavalcar la campagna ...* Vidi: VALVASOR, J.W., 1689, 7"9. - ... Zur Winters-Zeit gibt es allhier überaus starcke und so heftig tobende Winde, daß man, vor selbigen, nicht wol aus den Häusern gehen kann ... Vidi također: Marko VUČETIĆ, Vrijeme i klima Jadrana u antičkih pisaca / The Weather and climate of the Adriatic according to ancient writers, Hrvatski meteorološki časopis 46, 2011, 66.

[117] Alvise FOSCARI, *Capitano in Golfo 1676-1678 - Capitano estraordinario delle galeazze 1690-1692 – Dispacci*, a cura di Fausto Sartori, Venezia: La Malcontenta, 2009, 75.

[118] Boško DESNICA, Istorija kotarskih uskoka 1684-1749, sveska II, *Zbornik za istoriju, jezik i književnost srpskog naroda, treće odeljenje, knjiga* 13, SAN, Beograd 1951, 153. - *... incommodo delle nevi già cadute sopra i monti di Prologh, al vento di borra furioso* ... Lovrić described bura on Mount Dinara in another chapter (November 26th, 1758). See: LOVRIĆ, I., 1776, 235.; LOVRIĆ, I., 1948, 193.

[119] Vjekoslav ŠTEFANIĆ, *Glagoljski rukopisi Jugoslavenske akademije II*, Zagreb: JAZU, 1970, 154. - *... i učini se velika zima od duha bure i sniga i leda, vsaki dan veća i veća do obraćenie svetoga Pavla. ... zima velik spomin i škodu ludi, intradi, driv, brodi i živine e ostavila tako da ludi smeržneni mertvi po putih su se nahaĕli po gorah, brodi vu vodah tekućih se s ludmi smeržnivali, potoki veliki priko se premeržnivali da se ledi nisu mogli prosići. Ulikve, smokve i mograne pozebli vse sidbi pšenične i ozimčene poginuli ... ...*

[120] GOJAK, N., 1993, 117.

[121] Mirko DEANOVIĆ, Dnevnik Iva M. Matijaševića, *Anali historijskog instituta u Dubrovniku* 1, Dubrovnik 1952, 309.

Figure 8: *Prolog Pass between Dinara Mountain and Kamešnica Mountain with Sinjsko Polje on a map from 1785. (From: J. BAJAMONTI, Storia delle peste che regnò in Dalmazia negli anni 1783-1784, Venezia, 1786.)*

27. 1755, January the 5th - February the 3rd, Makarska – The terrible *bura* blew continuously for 29 days, with snow falling. The fierce cold caused the flowing waters, wine and even grappa to freeze. The seawater was also frozen.[122]
28. 1762, June the 23rd, Split and surroundings, Mount Prolog (Fig. 8) – *Bura* started to blow on June 23rd and caused a severe cold that killed many sheeps on the Mount Prolog.[123]
29. 1762, June the 23rd, Makarska and surroundings – *Bura* started to blow on June 23rd in the morning and lasted until the 24th; it snowed on Mount Biokovo.[124]
30. 1774, island of Pag – The impact of *bura* on the island's soil and vegetation cover as well as the construction of houses.[125]
31. 1783, March the 17th-25th, Makarska – Due to the great *bura* and cold that lasted nine days, many of the poor died.[126]

A few examples from Makarska are included in this list of the *bura* events, but this is only a small part, as there are several dozen cases of the fierce *bura* blowing in this city. They were recorded thanks to the diligent Franciscan chroniclers, who entered them relatively continuously. So far, these are the only continual weather series on this side of the Adriatic Sea recorded as first-hand information.[127]

[122] GOJAK, N., 1993, 158. - *... na 5. gjenara 1755. učini bura nevelika pak učini snig a na Vokarsće bi bura i snig i sve se smarze i bi velika studen i led (...) i tako slidi vas misec led veliki i bure continue a parvi veljače učini toliko žestok led da se i more smarze i vode žive i vino i rakija, niti je ovaki led bio nego li del 1709. ...*

[123] Kruno PRIJATELJ, Ljetopis nepoznatog Splićanina od g. 1756. do 1811., *Starine JAZU* 44, Zagreb 1952, 67. - *... Li 23 di mese Giugnio fece un temporale con pioggia e bora ...*

[124] GOJAK, N., 1993, 183.

[125] FORTIS, A., 1778, 500. - *... The winter is dredfully cold; and the summer scorching hot. The stormy sea beats furiously against the rocky coast of the island opposite to the mountain; and, on that side, the heights and sides of the hills are rendered desolate by the wind, so that neither wood, nor pasture, nor corn lands are found upon them. (...) The inhabitants of the city cannot go out of their houses during the violence of the wind; and are obliged to have the roofs defended all round by large stones. Those who have been there in the winter time, speak of it as a Siberia quite covered with snow and ice, and always exposed to the cold north wind; ...*; FORTIS, A., 1984, 266-267.

[126] Andrija IVIČEVIĆ, Makarski ljetopis, ed. Ante Bešlić, Gašpar Bujas, in: *Makarski ljetopisi 17. i 18. stoljeća*, Split: Književni krug, 1993, 310.

[127] Sam WHITE, Christian PFISTER, Franz MAUELSHAGEN (Ed.), *The Palgrave Handbook of Climate History*, London: Palgrave, MacMillan, 2018, 37, 40-41.

In this collection of *bura* effects, it is worth devoting a few lines to the thinking of people of that time about the health effects of *bura*. Their thoughts inevitably rested on ancient thinking about the connection between weather and health.[128] Diversis (in 1440) thinks positively about *bura*:

... therefore it should be known that in Dubrovnik mostly blow two mutually contrary winds, of course jugo (southeasterly) *and bura. The first one is warm and harmful to health, the second one, however, is very fresh and good for health. ...*[129]

His opinion is also shared by Massa (in 1550), who, although not active on the eastern Adriatic coast, points out the positive impact of *bura* during the plague epidemic.[130] Nutrizio (1780) also emphasizes that *bura* has a beneficial effect on humans.[131] In the end, Bajamonti's description of the plague epidemic in and around Split in 1783 is very valuable: *... The furious northern wind, which disrupting the rustic shelters of the fields, and making the people guarded there atrociously cold, ...* It shows the bad side of *bura* during the implementation of quarantine.[132]

GENERAL CLIMATIC CHARACTERISTICS

Climate is, to put it simply, the average weather in a given area.[133] This term originated in antiquity, but it took over two thousand years to make a systematic division applicable to all parts of the world. According to the Köppen's climatic classification the eastern Adriatic coast is characterized by Mediterranean climate with hot summer (Csa) from island of Lošinj southwards, from there northwards with narrow inland and Dalmatian hinterland it is the temperate humid climate with hot summer (Cfa) that rules. Only the highest mountains (Velebit, Dinara, Biokovo, etc.) have the t.h.c. with warm summer (Cfb) and the humid boreal climate (Df).[134]

The first preserved judgments about climate features on the Adriatic coast were written by learned and astute individuals inspired by humanism, and the geographical range went from (most often) their hometown, across the local district to the entire coast. The mentioned Fusko was one of these valuable scholars, who did not fail to describe the climate.

... The climate here is so temperate that in the summer there is no excessive heat because gentle winds blow ... In the winter, moreover, it does not feel cold, except when bura blows ... (1508).[135]

Pribojević, a Dominican from Hvar, was the second full-scale erudite.

... Indeed, this entire coast is neither exposed to the drought of excessive heat nor chilly and desolate from excessive cold, but retains a medium temperature, so it is always green ... (1525).[136]

The question is, where and how they both received information from which they sublimated the Adriatic climate. The answer, on the one hand, lies in the studied literature, and on the other, in com-

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128 BRAZDIL, R, PFISTER, CH., WANNER, H., STORCH, H. VON, LUTERBACHER, J., 2005, 373.

129 DIVERSIS, 2004, 41, 141.

130 Nicolo MASSA, *Ragionamento dello Eccellentiss. M. Nicolo Massa sopra le infermità, che vengono dall'aere pestilentiale del presente Anno MDLV*, Venezia 1556, 4rv .

131 NUTRIZIO GRISOGONO, P., 1780, 148.

132 Julije BAJAMONTI, *Storia delle peste che regnò in Dalmazia negli anni 1783-1784*, Venezia: Vincenzio Formalloni, 1786, 113. - *... Il successivo progresso di tale miglioramento non fu meno felice del suo principio , ad onta di molte gravissime difficoltà, che vi si opponevano. Il furioso vento boreale, che scompaginando i rustici ricoveri de' campi , e facendo provare alle genti colà custodite un atroce freddo, le concitava ai più furibondi effetti della disperazione, per calmare i quali niente meno ci volea , che la presenza del provveditore; le piogge e le nevi , che oltre a venti, rendevano intransitabile il fiume, ed impedivano anche per terra il trasporto de' giornalieri necessari soccorsi , non che le gite degl' ispezionati in siti alpestri, e lontani; ...*

133 WHITE, S., PFISTER, Ch., MAUELSHAGEN, F., 2018, 641.

134 Anita FILIPČIĆ, Klimatska regionalizacija Hrvatske po W. Köppenu za standardno razdoblje 1961.-1990. u odnosu na razdoblje 1931.-1960, *Acta Geographica Croatica* 33, Zagreb 1998, 9-12.; Marjana GAJIĆ-ČAPKA, Ksenija ZANINOVIĆ, Klima Hrvatske, in: *Klimatski atlas Hrvatske / Climate atlas of Croatia 1961-1990., 1970-2000*., ed. Ksenija Zaninović, Zagreb: Državni hidrometeorološki zavod, 2008, 16-17.

135 FUSKO, P., 1990, 86-87. - *... Sed ad oram redeo, in qua ea est aeris temperies, ut per aestatem ventis leniter flantibus, nullus ingens calor; per hyemem vero nullum frigus, nisi spiret aquilo, sentiatur. ...*

136 PRIBOJEVIĆ, V., 1951, 81. / 185. - *... Nam tota haec ora neque nimiis caloribus exuriter neque superfluo frigore aspera est aut horrida, sed inter utrunque manens semper uiret ...*

munication with the numerous seafarers and travelers who came to the cities where these two lived and served. In their time, shipping lines of Venetian, Dubrovnik and local shipowners reached the coasts of Africa, the Levant, Great Britain and Scandinavia.[137] The data that Fusko and Pribojević collected in this way was an excellent base for creating a comparative picture of the climate. There is a little shadow of suspicion with Pribojević, as his work is a kind of pan-Slavic panegyric.

THE *BURA* WIND AND THE LITTLE ICE AGE

The Little Ice Age has caused controversy among scientists since the inception of this term, and concerning the duration limits the greatest disagreements have been about its beginning.[138] In view of this topic, I accept the argumentation of scholars who set it at the beginning of the 15th century. Therefore, the selected samples start with the year 1404. As much as increase of the weather extremes has been slow, we would say stealthily, yet more aware contemporaries of these developments have noticed these LIA changes. Long before the famous early modern Swiss weather observer Renward Cysat, Petar Zoranić (1508-1543?), a nobleman and a writer from Zadar, gave a pith of the matter:... *the winter winds are suffocating, everywhere the waters are freezing (...) Jupiter does not create like in the old days, ...*[139]

Air flowings (with all secondary features) are just one element of the climate [140], and so it was during the Little Ice Age. The question is whether the frequency and severity of the *bura* wind in some parts of the eastern Adriatic coast had increased so much that they forced the population to permanently leave their settlements? Or, in the milder variant, to change the basic economic activity? Surely one fierce *bura* would not discourage them, but a series of consecutive extreme northeasterlies within one generation probably would! [141] There are two debatable and very speculative cases. The first one is the settlement and fort of Korintija on the southeast side of the island of Krk (Fig. 3). Recent archaeological research has confirmed the existence of secular and sacral structures.[142] Since the mid-6th century there has been a community whose extinction has not been dated because the sources are silent. It is the fact that Korintija was opposite the direction of the blowing of the Senj *bura* which indicates the climatic reasons for an abandonment of the town. It is likely that the inhabitants yielded in this unequal battle with the fierce and icy wind and found a more secure location elsewhere for further life. The lucid judgement from the late 18th century directly supports this hypothesis: ... *For what cause, or what time it was abandoned or destroyed, is not easy to ascertain; but if the inhabitants voluntarily abandoned the place, it is probable they did so on account of the fury of the wind, which would interrupt their communication with the rest of the island, ruin their plantations, and even carry away their cultivable land from the sides of the hills* ...[143] Another victim of *bura*, according to some, may be the town of Pag on the island

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137 PRIBOJEVIĆ, V., 1951, 81. / 185.; Bernard DOUMERC, Il dominio del mare, in: *Storia di Venezia, IV Il Rinascimento – Politica e Cultura* (a cura di Alberto Tenenti e Ugo Tucci), Roma 1996, 113-114, 163.

138 Raymond S. BRADLEY, Philip D. JONES, When was "the Little Ice Age"?, *Proceedings of the International Symposium on the Little Ice Age Climate*, ed. T. Mikami, Tokyo Metropolitan University, 1992, 1, 3.; John A. MATTHEWS, Keith R. BRIFFA, The 'Little Ice Age': Re-evaluation of an Evolving Concept, *Geografiska Annaler* 87/1 A, Stockholm 2005, 17-18, 24, 32.; BRAZDIL, R, PFISTER, CH., WANNER, H., STORCH, H. VON, LUTERBACHER, J., 2005, 388-392.; WHITE, S., PFISTER, Ch., MAUELSHAGEN, F., 2018, 643.

139 Krešimir KUŽIĆ, Zabilježbe o "malom ledenom dobu" i njegovim posljedicama u hrvatskim krajevima / Notes on "The Little Ice Age" and its consequences for the Croatian lands, *Prilozi* 18, Zagreb 1999, 374.; Christian PFISTER, "The Monster Swallows You". Disaster Memory and Risk Culture in Western Europe, 1500-2000, *RCC Perspectives* 1, München 2011, 8.; PARKER, G., 2012, 3.

140 Ivan ČAČIĆ, Predgovor / Foreword, in: *Klimatski atlas Hrvatske / Climate atlas of Croatia 1961-1990., 1970-2000.*, ed. Ksenija Zaninović, Zagreb: Državni hidrometeorološki zavod, 2008, 6.; Dirk MEIER, Entwicklung von Klima, Natur und Umwelt im hohen und späten Mittelalter zwischen Klimaoptimum und Kleiner Eiszeit, in: *Adel und Bauern in der Gesellschaft des Mittelalters*, ed. Carola Fey, Steffen Krieb, Affalterbach: Didymos Verlag, 2012, 16.

141 BRAZDIL, R, PFISTER, CH., WANNER, H., STORCH, H. VON, LUTERBACHER, J., 2005, 396.

142 Zdenko BRUSIĆ, Kasnoantička utvrđenja na otocima Rabu i Krku, *Izdanja HAD* 13, Zagreb 1989, 112-113.; Željko TOMIČIĆ, Auf der Spur der Reconquista Iustiniana: spätantike Befestigungsanlagen an der Nordküste Kroatiens, *Prilozi Instituta za arheologiju* 10, Zagreb 1996, 111-112.

143 FORTIS, A., 1778, 535-536.; FORTIS, A., 1984, 283-284. - *... Zbog kojega je uzroka i u koje vrijeme mjesto napušteno ili uništeno, nije lako reći; ali ako su ga stanovnici dobrovoljno napustili, vjerojatno su to učinili zbog siline vjetra koji bi im prekidao veze s ostatkom otoka, uništavao nasade, pa i odnosio obradivu zemlju s brdskih padina.* ... PFISTER, Ch., 2011, 13-14.

of the same name, to be more exact - the Stari grad (Old Town) of Pag (Fig. 3). This abandoned settlement is located on the northeastern slopes of central island ridge, and is directly affected by the *bura* strokes. Its existence ended in 1443, when it was decided to build a new city from the ground up - today's Pag.[144] The southwest slope of the northern island ridge was chosen for its location, eliminating the direct impact of *bura*. The countless *bura* events of the medieval period, especially those of the first decades of the 15th century, as well as political changes, prompted this difficult decision. In some parts of Europe, this period was remembered for its severe colds and other disturbances.[145] If we accept the results of the study on future climate change, according to which the intensity, number and duration of events will decrease, that is, *bura* will be weakening, [146] then we can safely accept the assumption that *bura* in the past (LIA) was proportionally stronger and more frequent at all places of occurrences. Let us return to the two recorded speeds: at Maslenica Bridge - 69.0 ms^{-1} (248 kmh^{-1}), and in the vicinity of Makarska - 59.0 ms^{-1} (212 kmh^{-1}). According to previous research, this should mean that the former *bura* blowings in these positions exceeded these sizes, by themselves impressive. It is relatively simple to determine the number and duration of events by analyzing descriptive sources alone, but unfortunately the intensity of *bura* remains unavailable. Knocking down the wall and capsizing of the ship seem like good starting points for the calculation, but other related unknowns prevent access to the result. Valvasor's information about sea foam and the throwing of horsemen and pedestrians can help us here.

Let us set agriculture and warfare between 1400 and 1800 opposite each other. Can there be talk of humanization of environment and degradation of landscape? In a sea of chronicler records and commentaries, especially from the data-rich 18th century, we rarely find arrogant behavior of the state, interest groups, or individuals. We find almost exclusively the struggle to survive and secure existence. The state of war is something else completely, because it sets different criteria and the conflicting parties mercilessly exploit natural resources in order to win. But we will agree, defense is a positive form of human action, and destructive aggression and related degradation of landscape is certainly not. Being under attack the humanization of the environment was forced into the high, choking city walls and the narrow arable belt which it was to live of. The example from the island of Pag is more than convincing. In the period of 25 years, about 400 people have been killed trying to get firewood on land opposite the island. That coast and the mountain slopes were no man's land where the *akinjis* and *martolos* made predatory excursions capturing these woodmen. *Bura* was the second cause of their suffering.[147] When the enemy was finally removed from the Adriatic coast, the forceful *bura* remained. Due to the inability to withstand the elemental forces, in this case our *dry, cold and gusty north-east wind*, the individual constantly repaired the damage it caused, adjusted his activities skilfully by believing in his own power. Thus, the society on the eastern Adriatic coast, and first of all the humans from the areas with exceptional *bura* blowing, survived the LIA and lived to see today's climate change. They had come to be the anemographic people. [148]

CONCLUSION

The comprehensiveness achieved by the authors, led by Brázdil for the Czech countries [149], is unattainable at this stage of the research, but it is an excellent example of a possible broader coverage of the topic. *Bura* is ideal for analysis for several reasons. First of all, it was not a phenomenon of short duration. It was real challenge for some senses (hearing, temperature, and balance), it was recognizable, so

[144] Cvito FISKOVIĆ, Bilješke o paškim spomenicima, *Ljetopis JAZU* 57, Zagreb 1953, 53, 56, 62.
[145] Chantal KAMENISCH, *Endlose Kälte - Witterungsverlauf und Getreidepreise in den Burgundischen Niederlanden im 15. Jahrhundert*, Basel: Schwabe Verlag, 2015, 164-179, 189-194.
[146] Miroslava PASARIĆ, Mirko ORLIĆ, Meteorological forcing of the Adriatic: present vs. projected climate conditions, *Geofizika* 21, Zagreb 2004, 81.
[147] LJUBIĆ, Š., 1877, 259-260.
[148] PFISTER, Ch., 2011, 5.
[149] Rudolf BRÁZDIL, Petr DOBROVOLNÝ, Josef ŠTEKL, Oldřich KOTYZA, Hubert VALÁŠEK, Jaroslav JEŽ, *History of Weather and Climate in the Czech Lands VI: Strong Winds*, Brno: Masaryk University, 2004, 7.

all kinds of creators of narrative sources couldn't help but notice it. Second, it is interesting because of its direct and indirect multiple impact on human activity. Third, each of the more extensive narrative records, especially at sea and on the coast, can be estimated for its intensity, which makes it easier to give numerical magnitudes. It is difficult to say who will draw more motivation from this to make analyzes, but historians of climatology are certainly the first to be called for this. According to the theory of Fernand Braudel one of the time dimensions of the environmental history is time of events (*temps del'évenement*). Using them, we also discover a link to the next dimension - time of trade-cycle (*temps des conjunctures*) and we stop here because serious analysis would require much more extensive and comprehensive engagement. The relationship with astrophysics as well as volcanology is similar. At this stage of research, even if the link between Maunder Minimum and the *bura* frequency is not visible, it cannot be completely discarded because of the low number of registered events. Additional descriptive records should be found in the future to test this assumption. Volcanic eruptions, such as the 1600 Huaynaputina case, offer possible indirect links to the *bura* blowing.

I agree that climate history becomes more and more the vanguard of consilient history, but I would dare to take it a step further and assert: climate history becomes a counsellor of great history. Great history is known to be existentially dependent on firmly proven data. Maybe it is, in certain cases, not so hard to find ... *direct documentary connection between climate and human events* ...[150] This paper has demostrated that the *bura* wind played a prominent role in several aspects of the history of eastern Adriatic, ranging from economy and everyday life to architecture and even political history. If we focus only on the data from the Imperial Offices, we will probably pass without a catch, but if we descend into the Governor's offices or the ships 'captain's cabins, we will discover the full wealth of documents. Finally, written sources, as proxy data, in any case confirm *bura* as an important factor that has influenced human activity in the Adriatic for centuries.

SAŽETAK

U radu su analizirana pisana vrela: kronike, putopisi, vojna izvješća i kozmografije u kojima se spominje bura i njezino djelovanje. Ovaj vjetar došao je na zao glas prvenstveno zbog svoje silovitosti i hladnoće koju nosi sa sobom, no s druge strane pročišćavao je zrak i donosio vedro vrijeme. Prema deskriptivnim izvorima negativan utjecaj bura ostvaruje na niz čovjekovih aktivnosti: kretanje i poljodjelstvo, ratovanje (kopneno i pomorsko), promet i prijevoz, kao i graditeljstvo. U nizu slučajeva bura je braniteljima pomagala razbijajući neprijateljske pomorske snage. S obzirom na geografski smještaj olujno puhanje bure glavno je obilježje okolice Senja, Paga, Klisa, Makarske te Kvarnerskog zaljeva, Velebitskog i Bračkog kanala, a u unutrašnjosti Sinjskog polja. Uz pomoć adekvatnih meteoroloških analiza rekonstruirane su najveće brzine vjetra (najmanje 159 kmh^{-1}), kao i najniže temperature (najmanje −19° C). Isto tako pretpostavljamo kako je tijekom malog ledenog doba bura imala veću frekvenciju puhanja i dulje trajanje intervala.

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[150] WHITE, S., PFISTER, Ch., MAUELSHAGEN, F., 2018, 635.

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