

CLIMATIC FEATURES OF PALAGRUŽA ISLAND, CROATIA

ŽIVKO TROŠIĆ
DRAŽEN JAŠIĆ
VINKO MARINKOVIĆ
College of Maritime Studies, Split
Visoka pomorska škola u Splitu

UDC: 551.582(497.5 Palagruža)
Review
Pregledni članak

Primljeno: 2003-04-07
Received:

The paper presents a brief review of contemporary research on climatic features of Palagruža Island, both in the pre-instrumental and instrumental period. The analysis was made upon climatic data provided by the meteorological station of Palagruža. For comparison purposes, data from the station in Split-Marjan was used, covering the standard climate period 1961-1990. The results show, among other things, that there is a decreasing trend of annual mean maximum air temperatures for 0.37 °C/30 years, average air temperature for 0.05 °C/30 years, and the mean minimum air temperature for 0.04 °C/30 years. There is a decreasing trend of annual mean of precipitation amount for 62 mm/30 years. Spearman rank statistic shows that neither of the trends noted above is statistically significant at 0.05 level (two-tailed t-test)

Key words: climate, Adriatic Sea, Palagruža Island, air temperature, precipitation

U radu se daje kratak pregled dosadašnjih istraživanja klimatskih obilježja Palagruže, u predinstrumentalnom i u instrumentalnom razdoblju. Analiza je izrađena na klimatskim podacima meteoroloških postaja Palagruža, a za usporedbu iskorišteni su i klimatski podatci postaje Split-Marjan, iz standardnoga klimatskog razdoblja 1961.-1990. godine. Rezultati rada, uz ostalo pokazuju trend smanjenja godišnje srednje maksimalne temperature zraka za -0,37 °C/30 godina, srednje za -0,05 °C/30 godina i srednje minimalne za -0,04 °C/30 godina. Trend smanjenja srednje godišnje količine oborina iznosi -62 mm/30 godina. Spearmanov rang test pokazuje da niti jedan od navedenih trendova nije statistički značajan na razini 0.05 (kritično područje na oba ruba t-razdiobe).

Ključne riječi: klima, Jadransko more, otok Palagruža, temperature zraka, oborine

Introduction

The weather and the climate have always had an effect on man and some of his activities, especially on outdoor activities. The land and the sea have a great and a multiple influence on the formation of climate. The climate on the Adriatic Sea is influenced by its location in relation to the Mediterranean Sea, the hinterland, the geographic latitude and the configuration of the coastline and its hinterland. According to

W. Köppen, the northern Adriatic Sea belongs to the Cfa type of climate (moderately warm and humid climate with hot summers) and the southern Adriatic Sea as include the Palagruža the Csa type of climate - Mediterranean climate with hot summers, (FILIPČIĆ, 1999).

The Adriatic area is under both land and maritime influences that create a climate with mild and rainy winters and warm and dry summers – with stronger continental influences in the northern part, and a predominantly Mediterranean influence in the middle and southern parts.

We can look at the climate of Palagruža Island during two periods: pre-instrumental and instrumental. Fish yield can be considered an indirect climatic indicator during the pre-instrumental period. A good yield of fish (sardines) was connected to periods of cold winter, while a poor yield corresponded with periods of warm winters. This means that the Palagruža Island winters were colder in the period 1430-1440. and especially in the first half of the 16th century, while they were warmer in the second half of the 16th century. Good yields dominated the 17th century, which should correspond to colder periods. Judging by sardine yields, the period 1730 – 1750. had warmer winters, followed by 30 years (1758 – 1788) of colder winters. The first half of the 19th century was also a cold period (PANDŽIĆ, SIJERKOVIĆ, 1996). The first known description of the climate on the island of Palagruža was published in the German magazine *Deutsche Rundschau für Geographie und Statistik* by the author M. Groller (1896).

During the instrumental period, Hann published the first processed results of climatic measurements conducted on the newly founded station (1894) on Palagruža Island. In 1899. the data was published in the Austrian Guide Through Dalmatia. In his overall review of Dalmatia, Marki (1924) states that Palagruža Island is an area with the least annual variations in temperature in all of Dalmatia and that during the cold part of the year.

Gavazzi (1925, 1929) published the first known climatic data on precipitation. The first extensive picture of the climate on Palagruža Island was given by Rubić (1929). Škreb et al. (1942) first analysed a series of data on the temperature of air and wind, while Mazzele (1918) published the first extensive analysis of wind on Palagruža Island. Band (1951) gives the annual wind chart, along with wind charts of other stations on the Adriatic Sea. Hann, Škreb and Rubić used the data on Palagruža Island in their other papers during the '40-ies and '50-ies. Golubić (1958) produces Walters climate diagram for Palagruža Island.

Among the new researches of Palagruža Island, explicitly or together with other areas, we can list these: a study called: *Režim vjetra na području Jadrana (RHMZ, 1978)*, Lončar (1980), Visković (1975), Penzar and Penzar (1982/83), Volarić and Lisac (1984), Pandžić and Pandžić (1988), Pandžić and Kisegi (1990). The greatest contribution to the multi-discipline research of the Palagruža area was given by a scientific symposium held in Split, June, 28-30, 1995. The results and all the papers were published under the title *Palagruža - the Adriatic Jewel (1996)*.

Data

By Palagruža, we mean a group of islands consisting of five islands (Velika Palagruža, Mala Palagruža, Kamik od tramuntane, Kamik od oštra and Galijula) and more

than 20 crevices and rocks. The total area of the islands is 0.40 km² and the largest island is Velika Palagruža with the area of 0.29 km² (BOGNAR, 1996). The Palagruža islands are located along the most frequent sea routes (along or across) on the Adriatic Sea. There have been a light-house on Velika Palagruža since 1875, and a meteorology station since 1894 ($\varphi = 42^{\circ} 24' N$ and $\lambda = 16^{\circ} 16' E$, $H = 98$ m).

Geographically speaking, Palagruža is located on the open sea, almost in the middle of the Adriatic Sea (Fig. 1). It is to be expected that the climate of Palagruža Island would be closely tied to the features of the Mediterranean climate.

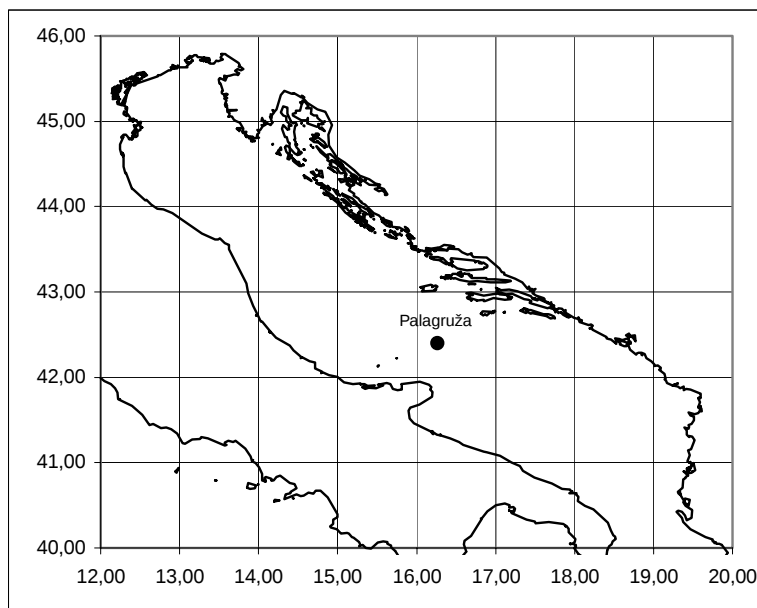


Fig. 1 The location of Palagruža Island in the Adriatic Sea.

Sl. 1. Položaj otoka Palagruže u Jadranskom moru.

A series of measurements and climatic data gathered at 7:00, 14:00, and 21:00 local time in the meteorological stations of Palagruža and Split-Marjan during the period 1961-1990, were used to illustrate the climatic features of Palagruža Island.

Methods of analysis and results

Due to interruptions numerous measurement data are missing, particularly those on precipitation. The missing data on monthly air temperature precipitation values were calculated by the authors on the basis of the adjacent Lastovo station data.

Time series of air temperatures and precipitation are graphically shown in the form of medium, mean maximum, and mean minimum annual air temperatures, annual precipitation and their linear trends.

To analyse the significance of a trend the Spearman's rank correlation test was used (MITCHELL ET AL., 1966).

Season and annual values of selected climatic parameters are given in Table 1. The mean temperature of air on Palagruža Island, which represents open sea, is 16.2 °C (Tab. 1), while the coastal area is 15.9 °C (Split).

Time series of the annual mean maximum (tmx), average (tav) and mean minimum (tmn) temperature of air and their trends are shown on Fig. 2. It shows that all time series of the annual trends on Palagruža Island (1961-1990) are negative. The decreasing trend of the mean maximum air temperature is 0.37 °C/30 years, the average 0.05 °C/30 years and the mean minimum is 0.04 °C/30 years.

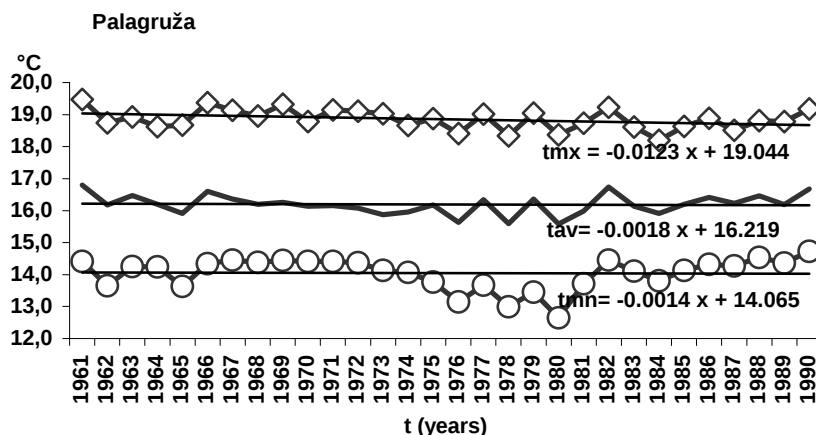


Fig. 2 Time series of the annual mean maximum (tmx), average (tav) and mean minimum (tmn) air temperature and their trends, Palagruža Island, 1961-1990.

Sl. 2. Vremenski niz godišnje srednje maksimalne (tmx), srednje (tav) i srednje minimalne (tmn) temperature zraka i njihove trendovi, otok Palagruža, 1961-1990.

The results, IPCC Data Distribution Centre (2003), show that there is an increasing trend of the global annual average temperature for +0.006/30 years, northern hemisphere 0.26 °C/30 years and southern hemisphere 0.37 °C/30 years.

It is plainly seen that the mean maximum air temperature has the greatest decreasing trend. Spearman rank statistic, Mitchell et al. (1966), shows that neither of the trends noted above is statistically significant at 0.05 level (two-tailed t-test).

The mean annual relative humidity on the open sea is 76%, and in the coastal area it is 58% (Split). The precipitation amount increases from the open sea (Palagruža Island) 304 mm, towards the coast (Split) 824 mm. Although there is a relatively high relative humidity of air throughout the year (seasonal values range from 74% to 77%), precipitation is very low and occurs within 65 days. The lack of precipitation is caused by Palagruža's location on the open sea, where clouds pass over it (55 cloudy days), but there are no obstacles that could cause the rain on the location. Time series of the annual amount of precipitation and the negative linear trend -62 mm/30 years (as compared to the global trend of increasing is +0.3/30 years) are shown on Fig. 3.

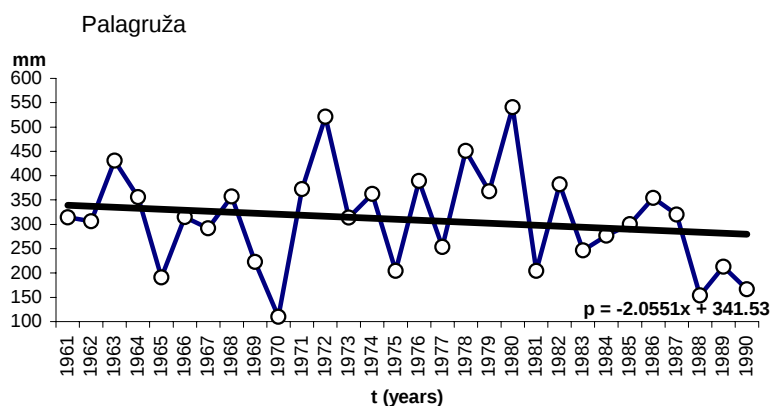


Fig. 3 Time series of the precipitation amount and linear trend (p), Palagruža Island, 1961-1990.

Sl. 3. Vremenski niz godišnje količine oborine i njen trend (p), otok Palagruža, 1961-1990.

The mean annual air pressure at the station level is 1003.3 hPa, and sunshine duration is among the longest on the Adriatic Sea; it is 2621.2 hours (2590.4 hours in Split). The average number of days when Palagruža Island has fog is 5 days, so that we can conclude that is not a significant occurrence.

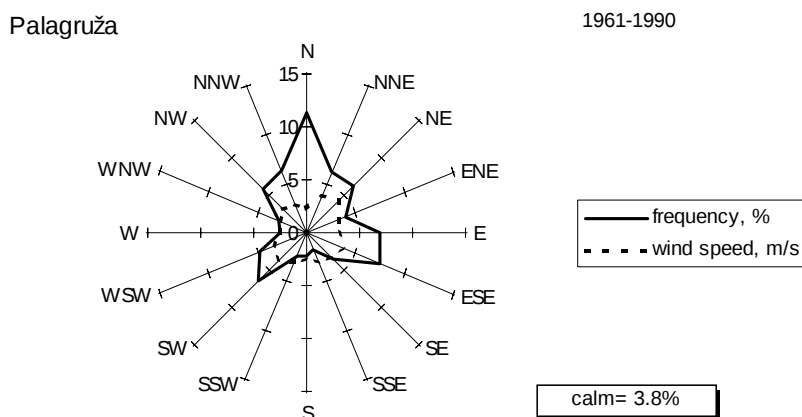


Fig. 4 Annual wind rose, Palagruža Island, 1961-1990

Sl. 4. Godišnja ruža vjetra, otok Palagruža, 1961-1990.

Weather conditions on the central Adriatic Sea are characterised by changes of low, which causes frequent exchanges of bora and sirocco, the dominant winds in the

winter period. Since the low's areas have the greatest persistence over the area of the Adriatic Sea and Aegean Sea during the cold part of the year, the frequency of strong to stormy wind blowing is the highest in that period. This means that winds from the south-east quadrant are possible in 28% days in a year, while the northwest quadrant winds are possible in 18% days in a year. Bora is more frequent than the scirocco on the northern Adriatic Sea, while jugo is more frequent than bura on the Southern Adriatic Sea, although the frequency of jugo is higher in the southern than in the Central Adriatic Sea.

Annually, Palagruža Island has 104 days with strong, and 21 days with stormy winds. There is a decreasing trend of annual mean amount of precipitation for 62 mm/30 years. Spearman range statistic shows that the trend of annual mean is not statistically significant at 0,05 level (two-tailed t-test).

Because of the influence of the Azorean high-pressure area from the west, and the Karachi depression from the east, summer conditions are characterised by etesian wind on open sea.

Tab. 1 Mean seasonal and annual values of climatic parameters, Palagruža Island, 1961-1990.

Tab. 1. Srednje sezonske i godišnje vrijednosti klimatskih parametara, otok Palagruža, 1961-1990.

WINTER	SPRING	SUMMER	FALL	ANNUAL
air temperature (°C)				
10.1	14.0	23.1	17.5	16.2
maximum air temperature, (°C)				
12.1	16.8	26.5	20.0	18.9
minimum air temperature (°C)				
8.4	11.8	20.4	15.7	14.1
relative humidity (%)				
75	77	74	76	76
amount of precipitation (mm)				
101	74	47	82	304
number of days with amount of precipitation (≥ 0.1 mm)				
23	17	9	16	65
air pressure (hPa)				
1003.5	1001.9	1003.0	1005.0	1003.3
cloudiness (in tenths)				
5.9	4.6	2.4	4.2	4.3
sunshine duration (hours)				
343.5	693.9	988.6	595.2	2621.2
number of clear days ($< 2/10$)				
11	23	49	27	110
number of cloudy days ($> 8/10$)				
24	16	3	12	55
number of days with fog or invisible sky				
1	2	1	1	5
wind force (Bf)				
4	3	3	3	3
number of days with strong wind (6 and 7 Bf)				
36	26	16	26	104
number of days with stormy wind (8 and more Bf)				
9	5	2	5	21

There is no need to point out the influence of wind on navigation and fishing not only around Palagruža Island, but even over a wider area, since the influence of winds has a bearing on the generating of waves, which in turn, can influence navigation even far from Palagruža Island.

Due to its central position in the Adriatic, Palagruža Island usually has the northwesterly winds and the scirocco (*jugo*), while the frequency of bora (*bura*) is lower. This is why this station is the best indicator of the winds and precipitation amount on the Adriatic high seas (Fig. 4).

Conclusions

If considering the warmth features, as expressed by the temperatures of air, Palagruža Island is the most maritime part of the Croatian Adriatic, as the result of the warmth influenced by the surrounding sea. According to measurements up to date, Palagruža Island has the lowest amount of precipitation in Croatia.

The results show, among other things, that there is a decreasing trend of annual mean maximum temperature of air for 0.37 °C/30 years, average for 0.05 °C/30 years, and mean minimum for 0.04 °C/30 years. A decreasing trend of annual mean of precipitation amount is 62 mm/30 years. Spearman rank statistic shows that neither of the trends noted above is statistically significant at 0.05 level (two-tailed t-test).

Finally, the Palagruža Island station represents a major indicator of weather, especially wind, waves and amount of precipitation on the open sea.

LITERATURE

- BAND, G. (1951): *Die Bora der Adria*, Geofisica pura e applicata, 19, 3-4.
- BOGNAR, A. (1996): *Geomorfološke značajke arhipelaga Palagruže*, Zbornik radova simpozija Palagruža - jadranski dragulj, Split, 28.-30. 06. 1995., 1.
- FILIPČIĆ, A. (1999): *Razgraničenje Köppenovih klimatskih tipova Cf i Cs u Hrvatskoj. Prilog geografskoj regionalizaciji Hrvatske*, Doktorski rad, Prirodoslovno-matematički fakultet Sveučilišta u Zagrebu, Zagreb.
- GAVAZZI, A. (1925): *Geografski raspored najveće in najmanje povprečne mesečne množine padavina na Balkanskom poluotoku*, Geografski vestnik, 1, Ljubljana, 1-7.
- GAVAZZI, A. (1929): *Horizontalni raspored najvećih i najmanjih prosječnih mjesečnih množina padalina na Balkanskom poluotoku*, Hrvatski geografski glasnik, 20, Ljubljana, 14-22.
- GOLUBIĆ, S. (1958): *Prilog poznavanja klime primorske regije Jugoslavije*, Geografski glasnik, 20, 139-148.
- GROLLER, M. (1896): *Die Inselgruppe Pelagosa im Adriatischen Meere*, Deutsche Rundschau für Geographie und Statistik, Leipzig, 159-171.
- HANN, J. (1898): *Ergebnisse meteorologischer Beobachtungen auf der Insel Pelagosa*, Meteorologische Zeitschrift, 15, 419-425.
- IPCC Data Distribution Centre (2003): <http://www.climatetrend.com/>
- HANN, J. (1911): *Handbuch der Klimatologie*, III/2. I.J. Engelhorn, Stuttgart, pp 444.
- JAŠIĆ, D. (1997): *Geografske i oceanografske značajke Palagruškog praga*, Magistarski rad, Prirodoslovno-matematički fakultet Sveučilišta u Zagrebu, Zagreb.

- LONČAR, E. (1980): *Tipovi gradijentskog strujanja na Jadranskom moru*, Zbornik meteoroloških i hiroloških radova, 6, Beograd, 443-479.
- MARKI, E. (1924): *Klimatske prilike Dalmacije*. Split, pp 24.
- MITCHELL, J. M. JR., DZERDZEEVSKII, B., FLOHN, H., HOFMEYER, W. L., LAMB, H. H., RAO, K. N., VALLÉN, C.C. (1966): *Climatic Change*, WMO, Tech. Note, 79, Geneva, pp 79.
- PANDŽIĆ, K., PANDŽIĆ, V. (1988): *Bora as katabatic wind*, Rasprave RHMZ, 23, 93-101.
- PANDŽIĆ, K., SIJERKOVIĆ, M. (1996.): *Dosadašnja istraživanja klime Palagruže*, Zbornik radova simpozija Palagruža - jadranski dragulj, Split, 28.-30. 06. 1995., 299-306.
- PANDŽIĆ, K., KISEGI, M. (1990): *Principal component analysis of a local temperature field within the global circulation*, Theor. Appl. Climatol., 41, 177-200.
- PENZAR, B., PENZAR, I. (1982/83.): *Prikaz godišnjeg hoda oborine u Hrvatskoj pomoću Köppenove sheme*, Geografski glasnik, 41, 28-48.
- PENZAR, B., MAKJANIĆ, B. (1978.): *Uvod u opću klimatologiju*, Zagreb, pp 206.
- RHMZ (1978): *Režim vjetra na području Jadranskog mora*, Zagreb, pp 64.
- RUBIĆ, I. (1929.): *Palagruža*, Hrvatski stražar, Split, 1-8.
- ŠKREB, S., LETNIK, J., OBULJEN, A., KOVAČEVIĆ, M., JURIČIĆ, H., MARGETIĆ, F. (1942.): *Klima Hrvatske*, Geofizički zavod, Zagreb, pp 139.
- VISKOVIĆ, S. (1975.): *Usporedba meteoroloških podataka kvadranta 17 (brodska motrenja) i stanice Palagruža*, VIJESTI 1/75, Split.
- VOLARIĆ, B., LISAC, I. (1984.): *Klimatska podjela Hrvatske prema značajkama godišnjeg hoda temperature zraka*, Radovi Geografskog odjela, 19, 3-11, Zagreb.

SAŽETAK

Živko Trošić, Dražen Jašić, Vinko Marinković: Klimatska obilježja otoka Palagruže, Hrvatska

Vrijeme i klima uvijek su djelovali na čovjeka i na njegove pojedine djelatnosti, osobito one na otvorenom prostoru. Palagruža se nalazi na otvorenom moru u sredini Jadranskog mora, idealno položena za proučavanje klime otvorenog dijela Jadrana. U radu se daje kratak pregled dosadašnjih istraživanja klimatskih obilježja Palagruže, u predinstrumentalnom i u instrumentalnom razdoblju.

Analiza je izrađena na klimatskim podacima meteoroloških postaja Palagruža iz standardnoga klimatskog razdoblja 1961.-1990. Nedostajući podatci mjesečnim temperaturama zraka i količini oborina izračunati su na osnovi podataka sa susjedne postaje Lastovo. Za usporedbu iskorišteni su klimatski podatci iz istog razdoblja s meteorološke postaje Split-Marjan.

U tab. 1 prikazane su sezonske i godišnje vrijednosti pojedinih klimatskih parametara. Prema W. Köppenu Palagruža, kao i cijeli južni Jadran, pripada klimatskom tipu Csa (sredozemna klima s vrućim ljetima). Vremenski niz godišnje srednje maksimalne (tmx), srednje (tav) i srednje minimalne (tmn) temperature zraka i njihovi trendovi prikazani su na sl. 2, a vremenski niz godišnje količine oborina i njezin trend (p) na sl. 3. Srednja godišnja količina oborine na Palagruži iz razdoblja 1961.-1990. iznosi svega 309,7 mm i sve padnu tijekom 64,9 dana u najvećem broju slučajeva kao kiša.

Rezultati rada pokazuju trend smanjenja godišnje srednje maksimalne temperature zraka za -0,37 °C/30 godina, srednje za -0,05 °C/30 godina i srednje minimalne za -0,04 °C/30 godina. Trend smanjenja srednje godišnje količine oborina iznosi -62 mm/30 godina. Međutim, Spearmanov rang test pokazuje da niti jedan od navedenih trendova nije statistički značajan na razini 0,05 (kritično područje na oba ruba t-razdiobe).