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# BEGINNING OF MODERN METEOROLOGICAL MEASUREMENTS IN FIUME (RIJEKA)

# POČETAK MODERNIH METEOROLOŠKIH MJERENJA U RIJECI (FIUME)

**Ana Alebić-Juretić***

Summary

*When reporting on extreme weather conditions in the city of Rijeka (former Fiume), it is often specified „ ... since the beginning of measurements in 1948". In reality the modern meteorological measurements in Fiume had started already in 1868, when the Austrian Imperial Academy of Science established the meteorological station. The station was operating at the Naval Academy, under the supervision of prof. dr. Emil Stahlberger, the first university professor of physics in Fiume (Rijeka). The following year the station was equipped with mareograph (marigraph/tide gauge). Based on three years measurements, prof. Stahlberger published the first book on tides in the Rijeka bay* (Ueber die Ebbe und Flut in der Rhede von Fiume). *After his sudden death, Prof. Peter Salcher, his succesor at the Physics chair at the Naval academy, took charge of the Meteorological station. In 1884. He published the book entitled Climate in Rijeka and Opatija* (Das Klima von Fiume und Abbazia). *The meteorological data in the book are presented in the very same way as it is done today, and therefore these data can be used for comparative purposes regarding climate variations/ changes.*

***Key words:*** *history of meteorology, climate, Peter Salcher, Fiume-Rijeka*

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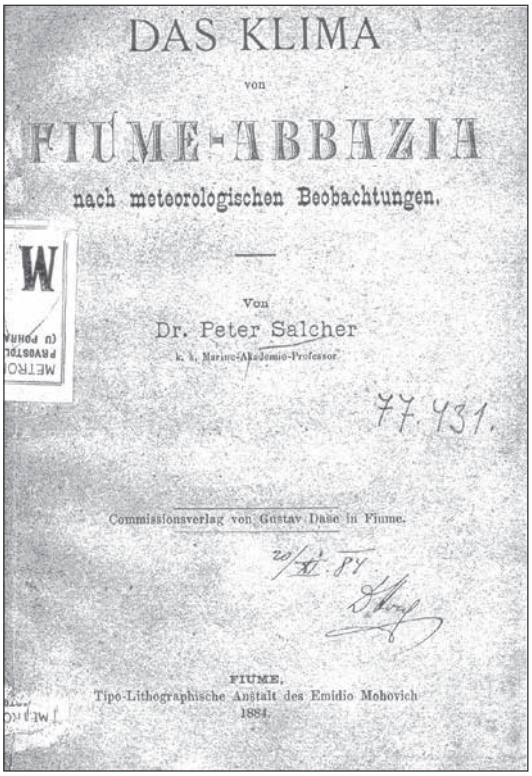
## Introduction

Historically, many initiatives taken by the City of Rijeka (Fiume) were not carried to complete fruition because of the changes in rulers. This is what happened to the recording of meteorological data. In fact, currently when extreme weather conditions are reported they are usually presented with the understanding that they are the highest (or the lowest) values observed „... since the beginning of measurements in 1948." In fact, the first modern meteorological measurements in Fiume started 80 years earlier, though some meteorological observations were done already in 1842 by municipal physician Nicola Tiller (Katušin, 1978). The Adriatic Commision (Adria Commission) of the Austrian Imperial Academy of Science (keis. Academie der Wissensshaften) established the first modern meteorological station in Rijeka (Fiume) in November 1868 (Salcher, 1902). The head of the station was prof. dr. Emil Stahlberger, the first university professor of physics in Rijeka (Fiume). The station was also equipped with a mareograph (marigraph/tide gauge) with pencil recorder for continous monitoring of sea level variations. A three years set of data enabled prof Stahlberger to write a book on high and low tide in the Rijeka bay (*Ueber die Ebbe und Flut in der Rhede von Fiume*), where he explained all factors and circumstances affecting the sea levels and leading to extreme high tides: season, Moon phase, air pressure, wind speed, waves from the open Adriatic sea (Stahlberger, 1874). Similar analyses on high tide occurence in the Adriatic sea were done only recently (Orlić et al., 2010), and it would be very desirable to compare these two studies.

The activity of the meteorological station was quickly extended to include chemical and physical analyses of sea water: temperature depth profile, salt and gas content. For this purpose in 1873 Stahlberger invented a device called Stahlberger rheobarometer, that was used to measure depth, sea currents and take samples of deep water. A specimen of this device is kept in the Oceanographic museum in Monaco.

After prof. Stahlberger's sudden death in 1875, prof. Peter Salcher, his successor in the Chair of Physics, took charge of the meteorological station. After the disolution of Adriatic Commission in 1880, the station was attached to the Physical laboratory of the Naval Academy. In 1884 prof Salcher published the first book on Climate of Rijeka and Opatija *(Das Klima von Fiume und Abbazia,* Figure 1), that gives us the first insight in meteorological observations in Fiume (Rijeka).


DAS KLIMA

von

FIUME-ABBAZIA

nach meteorologischen Beobachtungen.

Von

Dr. Peter Salcher

k. k. Marine-Akademie-Professor

77.431.

Commissionsverlag von Gustav Dase in Fiume.

FIUME.
Tipo-Lithographische Anstalt des Emidio Mohovich
1884.

Figure 1 - Cover page of the book Das Klima von Fiume und Abbazia

*Slika 1. Naslovnica knjige Klima Rijeke i Opatije*

## Location of the meteorological station

There is still some confusion regarding the location of the meteorological station. In a book published in the occasion of the 50th anniversary of the Naval Acedemy, the meteorologocal station was located in the park surrounding the Academy (Salcher, 1902). On the other hand, Stahlberger in his book stated that the mareograph (tide gauge) should have been transferred to Fiumara, a channel on the eastern border of the town, because of the building of a new railroad in front of the Academy port (Stahlberger, 1874). According to the literature (Katušin, 1978) other equipment remained in the Academy's park. In favour of this location is prof Salcher critical analyses of the first temperature data obtained in Abbazia (Opatija) that were compared with those from Fiume, that means, the both stations had similar environment, i.e. the park area.

On the other hand, in his book about climate in Fiume and Abbazia, Salcher (1884) gave the coordinates of the station as: 45° 19' N 14° 27' E , that is obviously eastern from the location of the Academy building measured today: 45° 19' N 14° 25' E, and falls to the east of Fiumara (as Stahlberger cited) into the sea in front of the river Rječina flow. This location is quite unlikely, since it was outside of the „corpus separatum" area. In this respect the location at Fiumara seems to be more likely. Checking out the Fiumara channel banks, there is a single place that could accomodate the mareograph (tide gauge): a particularly shaped stone (Figure 2). On the other hand, bollard errected in the vicinity is against this location, though, by its outlook, it belongs to later generations.

If there were some doubts about location, details on the equipments' setting are precise. The barometer was located at 4.9 m a.s.l. (that would be in favour of Academy's park area), a thermometer at 2 m and a pluviometer 3.2 m above ground. Pluviometer measured the precipitation above 0.5 mm, while today this limit is lowered to >0,1 mm. After 1903, the measurements were extended to insolation.

## Early description of climate in Fiume/Abbazia

In the first book about climate in Fiume/Abbazia (Rijeka/Opatija), Salcher (1884) gathered and analysed 15 year data (1869-1884) from Fiume

Figure 2 - Possible location of the mareograph/tide gauge at Fiumara

*Slika 2. Moguća lokacija mareografa na Fiumari*

(Rijeka), according to the principles defined in 1873 during the first congress of International Meteorological Organization, that are still valid today, and for that reason could be used for comparative purposes.

The Salcher's description of the climate in Fiume states that: "On the average, the coolest month is January (5,6°C), while the warmest is July (24°C). The average temperature in April (13°C) and October (14,6°C) are closest to the annual average (14.1°C). The difference between the coolest and the warmest month (18.4°C), classifies the climate in Fiume /Rijeka as changeble." (Salcher, 1884). Comparing these with corresponding values obtained for the climate normal (1961-1990) and the last two decades (1991-2010): both January minimum (5,3°C in both periods) and July maximum (22,8°C and 23,3 °C, respectively) are somewhat lower. The multiyear average for the warmest last two decades (1991-2010) is exactly the same as those for the period 1869-1884 (14,1°C), but is higher than the climate normal (13,6°C). That means, although the average temperatures in the last two decades are higher than the climate normal (1961-1990), these values fall within the range already measured in the second half of the 19th century (Alebić-Juretić, 2012), prior to high industrial emissions, that might have caused the global warming.

The same stands for the multiyear average of precipitation: 1580 mm for the period 1869-1884, but the same levels are observed for the climate normal and two last decades (1561 and 1557 mm respecticvely). The dryest month was July, while the wettest October (Salcher, 1884). In the recent multiyear periods November is slightly exceeding the October as the wettest month. The average number of rainy days was 122 (range: 98-151) that coincides with the corresponding values in the period 1977-2010 (Alebić-Juretić, 2012). Snow was very rare, once a year, mostly in December and January. It was more often at elevation above 200 m asl (Salcher, 1884).

The further description of climate is as following: "Due to maritime influence winters are mild, so that plants like laurel can grow. The disadvantage of the Fiume's climate is sudden change of weather conditions, with big variations of temperature and humidity, the latter being more difficult to bear. One of the characteristic of the Fiume's climate is big climatic differences in the small area. As the area east from Fiume is exposed to bora *(a northern to north-eastern wind on the east Adriatic coast that blows in gusts up to 150-200 km/h, mostly in winter, author's remark)*, the areas on the west have milder climate. On the Kvarner Bay coast climatic differences are not caused by temperature or humidity but by the occurrence of wind. Abbazia (Opatija) is

situated only 10 km away from Fiume, but within location protected from south and north wind exposures. Because of similar temperatures and precipitation, vegetation is also similar *(in both locations, author's remark.)*. Similar climate as from Abbazia is possible to find in Fiume only on locations protected from winds, like the park area in Mlaka." (Salcher, 1884).

It is worth mentioning that the meteorological measurements in Abbazia started in 1883, and Salcher was involved in starting up the monitoring station. As he observed the big difference in daily summer temperature (up to 3°C) relative to Fiume, the thermometer was adjusted properly afterwards, so that the official measurements started only in 1885 (Salcher, 1884). This is another proof of his sharp mind.

## Multiyear monthly profiles

Except in the book on climate in Fiume and Abbazia (Salcher, 1884), that contained multiyear monthly means of meteorological paramaters: temperature, relative humidity, precipitation depth and number of rainy days for the period 1868-1884 (Figure 3 ), the same parameters for 1869-1892 (Figure 4) are given in Mittheilungen (1896). Another historical multiyear monthly averages was calculated from yearly mateorological data for the period 1899-1904 published in Mittheilungen (1900-1904). Comparing these historical data for temperature with the climate normal (1961-1990) and multiyear monthly profiles for the last two decades (1991-2010) that were claimed to be the warmest ever, it is evident that these profiles differ only by July and August multiyear monthly averages (Figure 5 ). Though the July and August values obtained for 1991-2010 are higher than the corresponding values in climate normal (1961-1990), these values are still lower than those from the historical data.

Similar results are obtained for the precipitation data (Alebic-Juretic, 2012), showing the commom feature with minimum in July and maximum in October-November.

## Annual weather report

As already mentioned, the first meteorological congress held in 1873. defined the methodology for meteorological data evaluatuion and interpretation that are still in current use. Therefore, it is possible to compare the recent data, with the historical ones. As an example, the report of weather conditions in 1902 states:

## Die durchschnittlichen Temperaturverhältnisse.

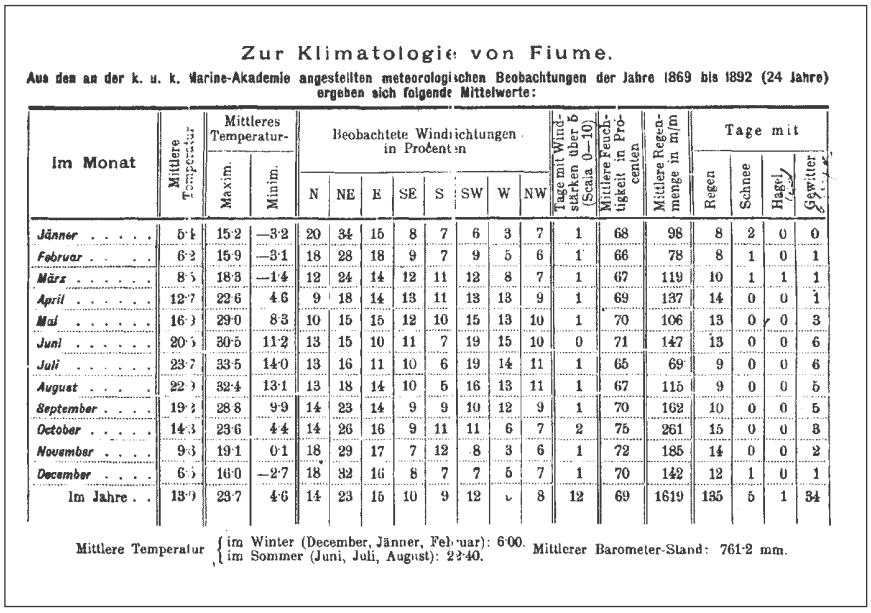
(Die Temperaturangaben beziehen sich durchwegs auf die Celsius-Scala).

| Zeitraum | Temperatur | | | | Tägl. Schwank. 2) | Veränderlichkeit der Tagestemp. 3) | Häufigkeit einer Temperaturänderung 4) | | | Mittleres | | Schwankung 6) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7h | 2h | 9h | Mittel 1) | | | 2-4° | 4-6° | 6-8° | Maximum | Minimum 5) | |
| December | 6·2 | 8·7 | 6·4 | 6·9 | 6·9 | 1·5 | 6·4 | 1·2 | 0·2 | 17·3 | —0·5 | 17·8 |
| Jänner | 4·5 | 7·8 | 5·0 | 5·6 | 7·8 | 1·5 | 6·9 | 1·4 | 0·3 | 16·1 | —2·4 | 18·5 |
| Februar | 5·3 | 9·2 | 6·2 | 6·9 | 8·9 | 1·3 | 5·1 | 0·4 | 0·1 | 17·4 | —2·4 | 19·8 |
| März | 7·1 | 11·3 | 8·1 | 8·6 | 7·9 | 1·4 | 5·9 | 1·2 | 0·2 | 19·5 | 0·1 | 19·4 |
| April | 11·8 | 15·7 | 12·3 | 13·0 | 8·5 | 1·2 | 4·3 | 0·6 | 0·2 | 22·7 | 5·5 | 17·2 |
| Mai | 15·5 | 19·3 | 15·7 | 16·5 | 8·5 | 1·4 | 5·5 | 1·1 | 0·2 | 29·5 | 8·8 | 20·7 |
| Juni | 20·0 | 23·2 | 19·7 | 20·6 | 8·3 | 1·3 | 5·7 | 0·5 | 0·1 | 30·0 | 10·9 | 19·1 |
| Juli | 23·1 | 26·8 | 23·0 | 24·0 | 9·4 | 1·1 | 3·9 | 0·5 | 0·1 | 33·1 | 14·5 | 18·6 |
| August | 22·0 | 25·7 | 22·4 | 23·1 | 8·6 | 1·3 | 5·0 | 0·8 | 0·1 | 31·3 | 13·4 | 17·9 |
| September | 17·8 | 21·9 | 18·5 | 19·2 | 7·8 | 1·1 | 3·5 | 0·7 | 0·0 | 27·5 | 10·7 | 16·8 |
| October | 13·5 | 17·0 | 14·0 | 14·6 | 6·1 | 1·2 | 4·0 | 0·7 | 0·0 | 23·7 | 5·7 | 18·0 |
| November | 8·8 | 11·9 | 9·4 | 9·9 | 7·4 | 1·4 | 6·8 | 1·0 | 0·4 | 20·5 | 2·6 | 17·9 |
| Winter 7) | 5·3 | 8·6 | 5·9 | 6·5 | 7·9 | 1·4 | 6·1 | 1·0 | 0·2 | 18·3 | —3·7 | 22·0 |
| Sommer | 21·7 | 25·2 | 21·7 | 22·6 | 8·8 | 1·2 | 4·9 | 0·6 | 0·1 | 33·2 | 10·7 | 22·5 |
| Jahr | 13·0 | 16·5 | 13·4 | 14·1 | 8·0 | 1·3 | 5·1 | 0·8 | 0·2 | 33·4 | —4·0 | 37·4 |

Figure 3 - Average temperatures for the period 1868 – 1884 (Salcher, 1884)

*Slika 3. Prosječne temperature za razdoblje 1868. – 1884. (Salcher, 1884.)*

"Comparing the results for the year 1902 with the corresponding more than 30 years averages, the following conclusions could be drawn: The usually coolest month January was by 1,3°C, and February by 1,7°C warmer than the multiyear average. On the other hand, May was unusually cold, by 0.7°C colder than the preceeding month April, and even by 3.5°C lower that the (multiyear) average. Unusually cold were also November and December, with 2.1°C and 1.3°C lower than the multiyear average, respectively. December was the coldest month of the year, and on December 23rd the minimum yearly temperature (-3.3°C) was recorded.



Zur Klimatologie von Fiume.

Aus den an der k. u. k. Marine-Akademie angestellten meteorologischen Beobachtungen der Jahre 1869 bis 1892 (24 Jahre) ergeben sich folgende Mittelwerte:

| Im Monat | Mittlere Temperatur | Mittleres Temperatur- Maxim. | Mittleres Temperatur- Minim. | Beobachtete Windrichtungen in Procenten N | NE | E | SE | S | SW | W | NW | Tage mit Windstärken über 5 (Scala 0—10) | Mittlere Feuchtigkeit in Procenten | Mittlere Regenmenge in m/m | Tage mit Regen | Schnee | Hagel | Gewitter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jänner | 5·1 | 15·2 | —3·2 | 20 | 34 | 15 | 8 | 7 | 6 | 3 | 7 | 1 | 68 | 98 | 8 | 2 | 0 | 0 |
| Februar | 6·2 | 15·9 | —3·1 | 18 | 28 | 18 | 9 | 7 | 9 | 5 | 6 | 1 | 66 | 78 | 8 | 1 | 0 | 1 |
| März | 8·5 | 18·3 | —1·4 | 12 | 24 | 14 | 12 | 11 | 12 | 8 | 7 | 1 | 67 | 119 | 10 | 1 | 1 | 1 |
| April | 12·7 | 22·6 | 4·6 | 9 | 18 | 14 | 13 | 11 | 13 | 13 | 9 | 1 | 69 | 137 | 14 | 0 | 0 | 1 |
| Mai | 16·0 | 29·0 | 8·3 | 10 | 15 | 15 | 12 | 10 | 15 | 13 | 10 | 1 | 70 | 106 | 13 | 0 | 0 | 3 |
| Juni | 20·5 | 30·5 | 11·2 | 13 | 15 | 10 | 11 | 7 | 19 | 15 | 10 | 0 | 71 | 147 | 13 | 0 | 0 | 6 |
| Juli | 23·7 | 33·5 | 14·0 | 13 | 16 | 11 | 10 | 6 | 19 | 14 | 11 | 1 | 65 | 69 | 9 | 0 | 0 | 6 |
| August | 22·9 | 32·4 | 13·1 | 13 | 18 | 14 | 10 | 5 | 16 | 13 | 11 | 1 | 67 | 115 | 9 | 0 | 0 | 5 |
| September | 19·2 | 28·8 | 9·9 | 14 | 23 | 14 | 9 | 9 | 10 | 12 | 9 | 1 | 70 | 162 | 10 | 0 | 0 | 5 |
| October | 14·3 | 23·6 | 4·4 | 14 | 26 | 16 | 9 | 11 | 11 | 6 | 7 | 2 | 75 | 261 | 15 | 0 | 0 | 3 |
| November | 9·3 | 19·1 | 0·1 | 18 | 29 | 17 | 7 | 12 | 8 | 3 | 6 | 1 | 72 | 185 | 14 | 0 | 0 | 2 |
| December | 6·5 | 16·0 | —2·7 | 18 | 32 | 16 | 8 | 7 | 7 | 5 | 7 | 1 | 70 | 142 | 12 | 1 | 0 | 1 |
| Im Jahre | 13·9 | 23·7 | 4·6 | 14 | 23 | 15 | 10 | 9 | 12 | 9 | 8 | 12 | 69 | 1619 | 135 | 5 | 1 | 34 |

Mittlere Temperatur { im Winter (December, Jänner, Februar): 6·00. im Sommer (Juni, Juli, August): 22·40.

Mittlerer Barometer-Stand: 761·2 mm.

Figure 4 - Average of meteorological parameters for the period 1869 – 1892 (Mittheilungen, 1896)

*Slika 4. Prosječne vrijednosti meteoroloških parametara za razdoblje 1869. – 1892.*

The warmest months were July and August, with the same mean temperature. Usually warmest month July was by 0.9°C cooler that the (multiyear) average. The highest daily temperature was measured on August 6th (32.7°C).

The yearly temperature was 0.3°C lower than the normal (average).

Total precipitation depth for the whole year was normal, but there were 25 rainy days less than the average. There was unusual distribution of precipitation: the usually wettest month October shared this position with February, whose precipitation depth was four times the normal. For that reason, January, September, November and December were unusually dry.

It is interesting that until 1887 the wettest month was November, and then taken of by October. In this year the month of February took over as the wettest month *(320.4 mm vs. 315.4 mm in October, authors remark).*

It was snowing for a single day in January and 2 days in February and November. Mist was observed for 7 days, and thunderstorms for 25 days.

The prevailing winds were from north-east, the least frequent from west. Windspeed over 5 (in the scale 1-10) were registered during 6 days."(Mittheinungen, 1903)

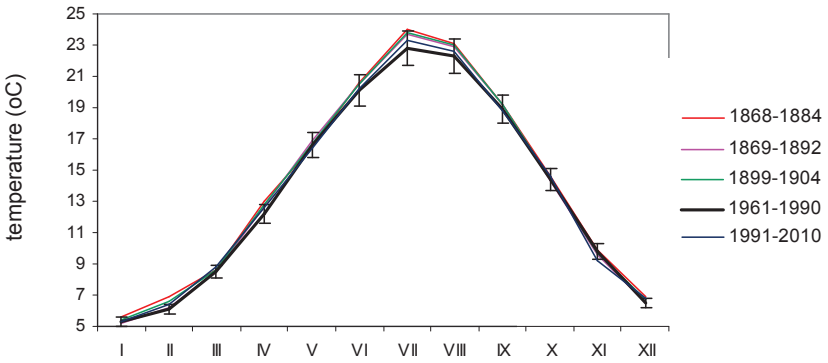



Figure 5 - Multiyear monthly profiles for temperature with respect to climate normal (1961 – 1990)

*Slika 5. Višegodišnji mjesečni profili temperature u odnosu na klimatsku normalu (1961. – 1990.)*

Such a report could describe the weather condition in Rijeka today. The only doubtful detail regards the missing unit of the wind speed (Bofour or something else ?).

The meteorological station ceased its activity within the Naval academy in 1918. From 1918 to 1943 the meteorological station was active in the new location, close to the lighthouse in the Mlaka area. After te WorldWar II the meteorological station was mooved severel times within the harbour area (port authorities). In 1954 the station was transferred first to the eastern slopes of the Kozala hill and than in 1977 to the present location on the southern slopes of Kozala (Katušin, 1978).

## Conclusion

Although the historical meteorological data available from the literature as multiyear averages with few annual results, are scarce and covering the last decades of the 19$^{th}$ century, they enable the comparison with recent data (since 1977). In spite of the big gap in the time series, the similarity of historical multiyear monthly profiles with climate normal (1961-1990) and the last two decades (1991-2010) for temperature and precipitation indicate that in the Rijeka area similar warm periods were recorded in the seventies and eighties of the 19$^{th}$ century, suggesting the occurence of climate variation in this area, not climate change. In fact, the highest annual temperature of 15,5$^{o}$C recorded in 1873 has not been reached yet, while the precipirtation depth of 2027 mm in 2010 approached that from 1882 (2100 mm).

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## Sažetak


*U medijima se često može čuti o ekstremnim vremenskim uvjetima u Rijeci od početka mjerenja 1948. godine. No meteorološka mjerenja u Rijeci imaju puno dužu povijest, barem do 1868. godine kada je Bečka akademija znanosti u ovom gradu osnovala meteorološku stanicu. Meteorološka je stanica djelovala u sklopu Mornaričke akademije, a njezin prvi voditelj bio je prof. Emil Stahlberger, ujedno prvi akademski profesor fizike u Rijeci. U sklopu meteorološke stanice instaliran je 1869. i mareograf te je prof. Stahlberger 1874., na osnovi trogodišnjih rezultata mjerenja, objavio knjigu o plimi i oseki u Riječkom zaljevu (Ueber die Ebbe und Flut in der Rhede von Fiume). Nakon njegove smrti, voditelj meteorološke stanice postao je već dobro znani prof. Peter Salcher koji 1884. objavljuje knjigu o klimi u Rijeci i Opatiji (Das Klima von Fiume und Abbazia). U toj je knjizi, i na danas važeći način, obradio i interpretirao meteorološke podatke koji mogu poslužiti za usporedbu današnjih vrijednosti u svrhu praćenja promjene/varijacije klime.*



***Ključne riječi:*** *povijest meteorologije, klima, Peter Salcher, Fiume-Rijeka*



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