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Znanstveni časopis *Hrvatski meteorološki časopis* nastavak je znanstvenog časopisa *Rasprave* koji redovito izlazi od 1982. godine do kada je časopis bio stručni pod nazivom *Rasprave i prikazi* (osnovan 1957.). U časopisu se objavljuju znanstveni i stručni radovi iz područja meteorologije i srodnih znanosti. Objavom rada u Hrvatskom meteorološkom časopisu autori se slažu da se rad objavi na internetskim portalima znanstvenih časopisa, uz poštivanje autorskih prava.

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Hrvatski meteorološki časopis – Croatian Meteorological Journal, 53, 2018., 43–54

Preliminary contribution
Prethodno priopćenje

HOMOGENIZATION OF THE HELLENIC CLOUD COVER TIME SERIES - PRELIMINARY RESULTS

Homogenizacija vremenskih nizova podataka naoblake u Grčkoj - preliminarni rezultati

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Abstract: Cloud cover is an important meteorological parameter because it affects the radiative energy balance of the Earth and precipitation and plays a major role in the hydrological cycle. Impact of clouds on the radiative balance is twofold: cloud cover modifies the albedo of the Earth and the atmospheric long wave radiative exchange. Long records of cloud cover data are the result of human estimations made during the synoptic observation hours at each meteorological station. Currently the quantification of cloud cover has been automated due to the advent of modern remote sensing space (e.g. satellites) and ground sky monitoring techniques (e.g. sky cameras). All weather time series records may suffer from inhomogeneities; their use in climatology requires homogenization. In this work we attempt a preliminary homogenization of the cloud cover time series of the Hellenic National Weather Service (HNMS) network. Data come from 36 meteorological stations, and cover the period from 1975 to 2004. Raw data comprise (synoptic) hourly cloud cover observations which we subjected to quality control before producing daily and then monthly average cloud cover time series. For this homogenization exercise we used the HOMER software tool.

Key words: cloud cover, homogenization, remote sensing

Sažetak: Naoblaka je važan meteorološki parametar koji utječe na ravnotežu radijacijske energije Zemlje i oborinu te ima ključnu ulogu u hidrološkom ciklusu. Utjecaj naoblake na radijacijsku ravnotežu je dvostruk: naoblaka mijenja albedo Zemlje i utječe na atmosfersko dugovalno zračenje.
Dugogodišnji nizovi podataka naoblake rezultat su motrenja u sinoptičkim terminima na meteorološkim postajama. U novije doba određivanje naoblake je automatizirano upotrebom daljinskih mjerenja sa satelita i kamera na zemlji koje snimaju cijelo vidljivo nebo. Svi vremenski nizovi motrenja meteoroloških pojava, pa tako i naoblake, podliježu nehomogenosti, pa ih za potrebe klimatologije treba homogenizirati.
U radu su prikazani preliminarni rezultati homogenizacije vremenskih nizova podataka naoblake dobivenih u mreži postaja Grčkog državnog meteorološkog zavoda (HNMS), s 36 postaja, za razdoblje od 1975. do 2004. Osnovni podaci su satne vrijednosti naoblake u sinoptičkim terminima. Oni su podvrgnuti kontroli kvalitete nakon čega su računati dnevni i mjesečni srednjaci. Za homogenizaciju je korišten programski alat HOMER.

Ključne riječi: naoblaka, homogenizacija, daljinska mjerenja

1. INTRODUCTION

Clouds play a pivotal role in our climate system. The amount of clouds in the sky vault, officially termed to as cloud cover, determines the albedo of Earth; the more and brighter clouds, the more short wave solar radiation is reflected back to space. Due to the high absorptivity of the H_2O molecule in the long wave range of the electromagnetic spectrum, clouds affect the net long wave radiative balance of Earth. Clouds also affect precipitation and snowfall. Clouds are directly related to the energy sector, since they impact e.g. the energy consumption of buildings and the yield of solar power plants, thermal or photovoltaic.

Due to the importance of clouds, their amount in the sky became part of the routine meteorological observations very early. The amount of clouds, termed to as cloud cover, refers to the fraction of the sky obscured by clouds when observed from a particular location; okta is the usual unit of measurement of the cloud cover. In the recent years, cloud cover is also being measured automatically with the advent of modern remote sensing space technology and other automated sky monitoring techniques. Cloud observations via satellite remote sensing also has the advantage of a larger observation coverage. However, measured cloud cover time series are available only for the recent years, limiting their use for climatological studies, especially for climate change studies.

Climatological and especially climate change studies require long records of cloud cover observations and measurements. These time series are the result of human observations made during the synoptic observation hours at each meteorological station, which may be completed by cloud cover time series resulting from automatic stations.

All weather records may suffer from inhomogeneities. This is even more true for cloud cover time series since, in addition to the usual causes of inhomogeneities (station relocations, instrumentation changes, measurement practices, changes in the surrounding environment, transition to automatic weather stations, etc.), a) the value attributed to it is the subjective result of an evaluation of the observer and b) the time series may be completed by measurements from automatic systems, also having homogeneity issues of their own; changes in the viewing angle (Evan et al., 2007), satellite calibration differences and orbital drifts (Jacobowitz et al., 2003) may introduce artificial shifts in cloud cover time series (Free and Sun, 2013). It is therefore necessary to have homogenized cloud cover time series.

This paper presents the results of the first attempt to homogenize and analyze the cloud cover time series of Greece, of the only national meteorological network measuring this parameter that belongs to the Hellenic National Weather Service (HNMS). This network is part of the World Meteorological Organization observing network. Data were homogenized using the HOMER software (Mestre et al., 2013).

2. DATA

Synoptic cloud cover observations for thirty years (1975–2004) come from the 36 WMO meteorological stations of the HNMS listed in Table 1.

The station types are characterised as:

- AG: agrometeorological – 4 or 5 observations made at the synoptic time 00:00, 06:00, 12:00, 18:00 UTC and occasionally at few intermediate synoptic hours of 03:00, 09:00, 15:00, 21:00 UTC;
- AN: aeronautical – 4 to 8 observations, at synoptic times 00:00, 06:00, 12:00, 18:00 UTC and occasionally at the intermediate synoptic hours 03:00, 09:00, 15:00, 21:00 UTC;
- AUX: auxiliary climatological – 3 observations 06:00, 12:00, 18:00 UTC;
- GOS: part of the global observing system;
- CS: climatological – 4 or 5 observations made at the synoptic time 00:00, 06:00, 12:00, 18:00 UTC and occasionally at few intermediate synoptic hours of 03:00, 09:00, 15:00, 21:00 UTC;
- MS: main synoptic – 8 observations at the synoptic times 00:00, 06:00, 12:00, 18:00 UTC and at the intermediate synoptic hours of 03:00, 09:00, 15:00, 21:00 UTC;

Table 1. HNMS meteorological stations observing cloud cover.

Tablica 1. Postaje Grčke nacionalne meteorološke službe na kojima se motri naoblaka.

WMO code	Location	Lat (°)	Lon (°)	Alt (m)	Period	No years	Type
16606	Serres	41.06	23.53	34.5	1975-2004	30	AG, GOS
16610	Komotini	41.12	25.04	30.0	1975-1983	9	AUX
16614	Kastoria	40.45	21.28	660.9	1980-2004	25	MS
16619	Trikala Imathias	40.60	22.55	0.8	1980-2004	25	AG
16622	Macedonia	40.53	22.99	1.68	1975-2004	30	MS, GOS
16624	Chryssoupoli	40.92	24.62	4.20	1985-2004	21	MS, GOS
16627	Alexandroupoli	40.85	25.95	3.52	1975-2004	25	CS
16628	Konitsa	40.05	20.75	542.0	1980-2004	25	CS
16638	Potidaia	40.19	23.33	5.0	1977-1993	17	SS
16641	Corfu	39.61	19.91	4.0	1975-2004	30	MS, GOS
16642	Ioannina	39.70	20.81	484.0	1975-2004	30	SS, GOS
16648	Larisa	39.65	22.45	73.6	1975-2004	30	MS, GOS
16650	Limnos	39.91	25.23	3.3	1975-2004	30	MS, GOS
16654	Arta (Filothei)	39.16	21.00	10.5	1976-2004	29	AM
16665	Agxialos	39.22	22.80	15.3	1976-2004	29	MS, GOS
16667	Mytilini	39.07	26.60	4.0	1975-2004	30	MS, GOS
16685	Argostoli	38.11	20.50	22.0	1975-2004	30	SS, GOS
16701	Nea Filadelfia	38.05	23.73	138.0	1975-2004	30	MS, GOS
16706	Chios	38.35	26.13	4.3	1975-2004	30	MS, GOS
16716	Elliniko	37.90	23.73	15.0	1975-2004	30	MS, GOS
16719	Zakynthos	37.75	20.88	1.0	1982-2004	23	SS, GOS
16721	Samos (city)	37.75	26.97	7.0	1975-1978	4	SS
16723	Samos (airport)	37.68	26.91	7.3	1978-2004	27	SS, GOS
16730	Syros (city)	37.44	24.94	23.0	1975-1976	2	AN
16732	Naxos	37.10	25.36	9.8	1975-2004	30	MS, GOS
16741	Spata (Athens Intl. Airport)	37.95	23.95	80	1982-2004	23	SS
16743	Kythira	36.15	22.98	166.8	1975-2004	30	MS, GOS
16744	Thira	36.40	25.48	33.6	1981-2004	24	SS, GOS

Table 1. - continued

Tablica 1. - nastavak.

16746	Souda	35.55	24.11	151.6	1975-2004	30	MS, GOS
16749	Rhodos	36.40	28.08	11.5	1975-2004	30	MS, GOS
16754	Heraklio	35.33	25.18	39.3	1975-2004	30	MS, GOS
16756	Ierapetra	35.01	25.73	10.0	1975-2004	30	AG
16757	Siteia	35.26	26.10	115.5	1975-2004	30	SS, GOS
16759	Tymbaki	35.056	24.76	6.7	1975-2004	30	SS, GOS
16760	Kastelli	35.21	25.33	335.6	1976-2004	29	SS, GOS
16766	Paros (Airport)	37.02	25.13	33.5	1987-2004	18	AN

SS: secondary synoptic – 4 to 8 observations, at synoptic times 00:00, 06:00, 12:00, 18:00 UTC and occasionally at the intermediate synoptic hours 03:00, 09:00, 15:00, 21:00 UTC.

Figure 1 shows the lack of stations in central continental Greece and in the Peloponnese peninsula.

Figure 2 shows the total available number of time series.

2.1. Quality control

The HNMS has applied quality control on raw synoptic cloud cover data up to 2004, which is the limiting year of our study. From the synoptic data and according to the World Meteorological Organization (2011), we calculated daily average cloud cover values as the arithmetic mean of the synoptic observations of the day, provided that (i) at least 3 synoptic observations within the day exist and (ii) the time difference between the first and last synoptic observation equals 12 hours. Then we calculated monthly averages as the arithmetic mean of the daily average values of the month, provided that there are no more than (i) three consecutive missing daily average values and (ii) five in total missing daily average values in the month.

Monthly cloud cover time series from stations 16610, 16638, 16701, 16721, 16730, 16741 and 16766 were excluded from further analysis because their length revealed to be limited or they had many missing monthly values. Also, the time series of stations 16721 of Samos city center and 16723

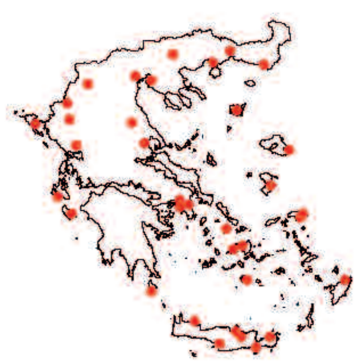


Figure 1. Location of the HNMS meteorological stations observing cloud cover.

Slika 1. Položaj postaja Grčke nacionalne meteorološke službe na kojima se motri naoblaka.

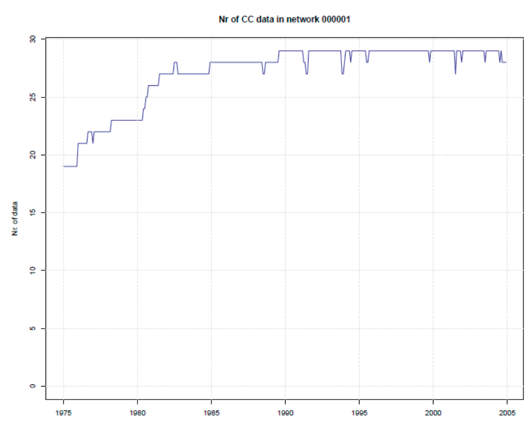


Figure 2. Total number of time series available.

Slika 2. Ukupni broj dostupnih nizova podataka.

of the airport of Samos were merged into one (under code 16723) because they come from the same station relocated from the city to the airport (a distance of about 8.7 km) in April 1978. This process produced monthly cloud cover time series for 28 of the weather stations.

The monthly cloud cover time series were also subjected to quality control using the tools built in HOMER, namely CLIMATOL and PRODIGE that were derived from previously developed software suites. CLIMATOL allows a visual inspection of the station network and the raw data via correlograms, histograms, box plots and cluster analysis. PRODIGE detects outliers. HOMER provides a graphical output of the difference between candidate and best neighbor time series per month. The quality control tests identified 25 values as outliers and we excluded them from further processing.

3. HOMOGENIZATION

HOMER was developed in the frame of the COST Action ES0601 (Mestre et al., 2013). HOMER combines the following homogenization methods: PRODIGE (Causinus and Mestre, 2004), ACMANT (Domonkos, 2011; Domonkos et al., 2011) and CLIMATOL (Guijarro, 2011).

3.1. Model selection

A basic step when applying a homogenization method is to select the appropriate stochastic model describing the cloud cover time series. If the variable of interest represents an intensity (e.g. temperature, pressure, etc.) and the absolute difference of the values is of importance, then additive model and the normal distribution are used. If the process is described by an additive model, the seasonal pattern remains relatively constant as the time series shifts to higher or lower levels. The additive model assumes that the difference between two monthly values of a series remains the same every year. Also the residuals have about the same magnitude throughout the series (they are a random component that adds on to other components in the same way everywhere in the series). Additive models assume that the different components affect additively the time series.

If the variables have a natural zero and reflect an accumulation (e.g. precipitation or snowfall) then percentage changes rather than differences between values are more important (Tian et al., 2013). Therefore the multiplicative model and the quasi-log normal distribution (Causinus and Mestre, 2004; Domonkos et al., 2011; Picard et al., 2011; Guijarro, 2011) or the inverse Gaussian distribution (Dunn and Smyth, 2005) are more suitable for the description of these variables.

In an additive model, the original time series O_t is expressed as follows (Harhoff, 2005):

$$O_t = TC_t + S_t + I_t \tag{1}$$

where TC_t is the trend cycle, S_t the seasonal effect and I_t the irregular effects component.

The seasonality adjusted data SA_t are:

$$SA_t = O_t - S_t \tag{2}$$

According to the multiplicative model, the original time series is (Harhoff, 2005):

$$O_t = TC_t \times S_t \times I_t, \tag{3}$$

and

$$SA_t = O_t / S_t \tag{4}$$

In current literature, additive models are applied when homogenizing temperature time series and other weather variables that follow closely the normal distribution. Multiplicative models are suggested when homogenizing biased variables with a natural zero, such as precipitation, that follows an L-shaped distribution (Hanson and Vogel, 2008) or wind speed, that follows the Weibull distribution (Seguro and Lambert, 2000). However, it is not always clear which is the most appropriate model to use (Guijarro, 2016).

In this study we tested the applicability of both the additive and the multiplicative model on the cloud cover time series. For this reason we randomly picked the data

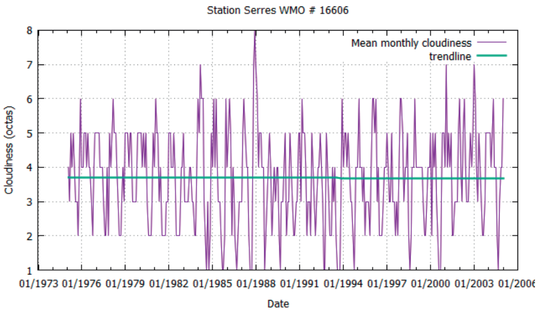


Figure 3. Time series of monthly mean cloudiness for Serres station and the corresponding trend line.

Slika 3. Vremenski niz srednje mjesečne naoblake za postaju Serres i pripadni trend.

from station 16606, Serres, in Northeastern Greece. This is a 30-year (1975 to 2004) mean monthly cloud cover time series with no missing values (Fig. 3); seasonality is clearly manifested but random fluctuations in the time series seem to be relatively constant in magnitude over time. The practically zero value of the slope of the trend line (Fig. 3) indicates stationarity.

In order to further assess this property, we applied a unit root test to our time series, namely the augmented Dickey-Fuller (ADF) test (Box et al., 2015). Unit root tests determine how strongly a time series is defined by a trend; the null hypothesis of the test is that the time series can be represented by a unit root, that it is not stationary, i.e. it has some time-dependent structure. The alternate hypothesis is that the time series is stationary. The ADF statistic is a negative number; the more negative the statistic, the stronger the rejection of the null hypothesis. If this value is lower than a critical value corresponding to a certain percentage, we have a strong indication that our time series is stationary. Also, we check the p-value from the test: a p-value below a threshold (e.g. 5% or 1%) suggests we reject the null hypothesis at the corresponding level. The results of the ADF test for the Serres cloud cover time series are given in Table 2.

The test statistic in this case is lower than the 1% critical value, and the p-value is very low, so the null hypothesis can be rejected with a significance level of less than 1%.

Table 2. Augmented Dickey-Fuller test results for the Serres cloud cover time series.

Tablica 2. Rezultati ADF testa za vremenski niz podataka naoblake postaje Serres.

test statistic	-1.006787
p-value No	$1.281976 \cdot 10^{-17}$
of lags	1
No of observations	358
Critical Value (1%)	-3.448749
Critical Value (5%)	-2.869647
Critical Value (10%)	-2.571089

This is a strong indication that our cloud cover time series is stationary.

The histogram of the Serres cloud cover time series is shown in Figure 4.

Figure 5 illustrates the logarithmically transformed cloud cover time series of Serres. It can be seen that the seasonal variation does not become more constant. That suggests that a multiplicative model might not be appropriate, since logarithmic transformation often eliminates or reduces growing seasonal variation and heteroscedasticity in seasonal time series (Lee, 2010).

In addition to the above qualitative assessment, we investigated the suitability of either the additive or the multiplicative model on the cloud cover time series, by applying the Holt-Winters exponential method (Hyndman et al., 2008; Hyndman

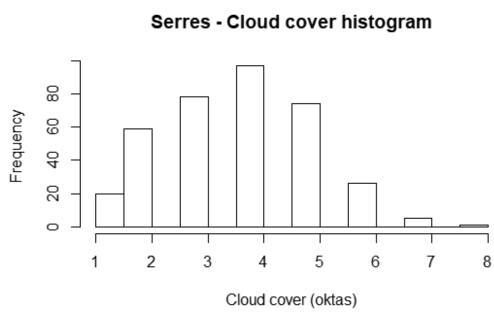


Figure 4. The Serres station cloud cover time series histogram.

Slika 4. Histogram vremenskog niza podataka naoblake za postaju Serres.

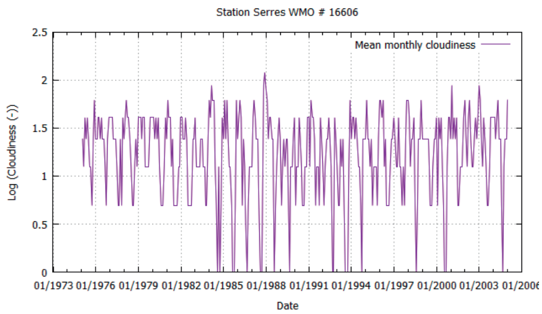


Figure 5. Logarithmically transformed Serres station cloud cover time series.

Slika 5. Logaritamski transformiran vremenski niz podataka naoblake s postaje Serres.

Table 4. Performance statistics of the additive and multiplicative Holt-Winters model on cloud cover data.

Tablica 4. Statističke značajke aditivnog i multiplikativnog Holt-Winters modela primijenjenog na podatke naoblake.

Method	ME	RMSE	MAE	MAPE	SSE
Additive	-0.05	1.07	0.8	29	398
Multiplicative	-0.08	1.08	0.9	30	409

and Athanasopoulos, 2018). The Holt-Winters seasonal method comprises the forecast equation and three smoothing equations for the level l_t, trend b_t, and seasonal component s_t respectively, with smoothing parameters α, β^* and γ selected to minimize the sum of the squared one-step-ahead prediction errors. Their values range between 0 and 1; values close to 0 mean that relatively little weight is placed on the most recent observations when making forecasts of future values. The period of the seasonality, m, defines the number of seasons in a year, e.g. $m = 4$ for quarterly data, $m = 12$ for monthly data. There are two variations to this method: (i) the additive method, preferred when the seasonal variations are roughly constant through the series and (ii) the multiplicative method, when the seasonal variations are changing proportionally to the level of the series.

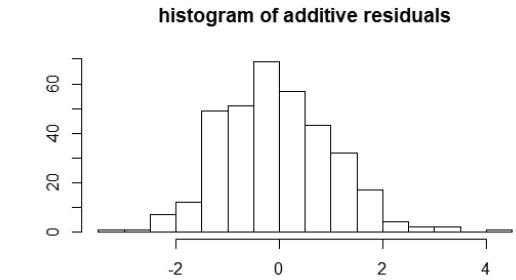
Here we applied both the additive and multiplicative Holt-Winters exponential methods on the Serres cloud cover time series. The obtained smoothing parameters are shown in Table 3.

Table 3. Estimated α, β^* and γ parameters.

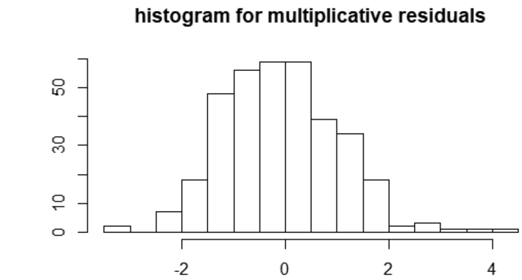
Tablica 3. Procijenjeni parametri α, β^* i γ.

Method	α	β^*	γ
Additive	0.054	0.014	0.139
Multiplicative	0.03	0.018	0.15

Based on the above results, we calculated the forecasted cloud cover time series with both the additive and multiplicative methods and the corresponding residuals between the forecasted and the measured values. We compared the performance of these methods using as statistics: mean (ME), root mean square (RMSE), mean absolute (MAE), mean absolute percentage (MAPE) and sum of squared errors of the residuals (SSE). The values of these statistics are provided in Table 4.



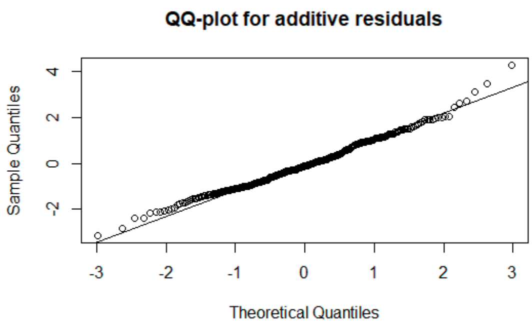
(a) Additive model / Aditivni model.



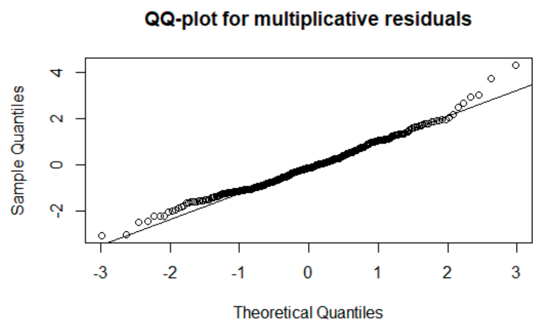
(b) Multiplicative model /Multiplikativni model.

Figure 6. Histogram of residuals.

Slika 6. Histogram reziduala.



(a) Additive model / Aditivni model.



(b) Multiplicative model / Multiplikativni model.

Figure 7. Q-Q plots versus a normal distribution.

Slika 7. Q-Q prikaz za normalnu razdiobu.

All statistics are of the same order of magnitude, but slightly lower for the additive model.

The histograms of the residuals of the additive (Fig. 6a) and of the multiplicative (Fig. 6b) model show that additive model residuals are much closer to the normal distribution; this also suggests that the additive model is more appropriate to describe the cloud cover time series. However, when testing the normality of the two time series using the Shapiro-Wilk test, we get that W = 0.9894 (p-value = 0.01 < 0.05) for the additive model and W = 0.98671 (p-value = 0.003 < 0.05) for the multiplicative model. We, therefore, conclude that the null hypothesis that the residuals are normally distributed is rejected at the 5% level, both for the additive and the multiplicative model.

Figures 7a) and 7b) show the quantile - quantile plots of the residuals of the additive and of the multiplicative model respectively. Both plots do not deviate significantly from normality and are very close to each other.

In summary, we found that: (i) the statistics on the residuals of the additive and of the multiplicative model are quite similar, but those of the former are slightly better; (ii) although the Shapiro-Wilk test rejects the normality hypothesis for the residuals of both models, visual inspection of the corresponding histograms and Q-Q plots reveals that the residuals of the additive model are slightly closer to the normal distribution; (iii) analyzing cloud cover from a physical point of view, it takes discrete values and is more related to an intensity (since it affects solar irradiance) rather to an accumulation (like precipitation). These are indications that the additive model is more suitable for the homogenization of the cloud cover time series.

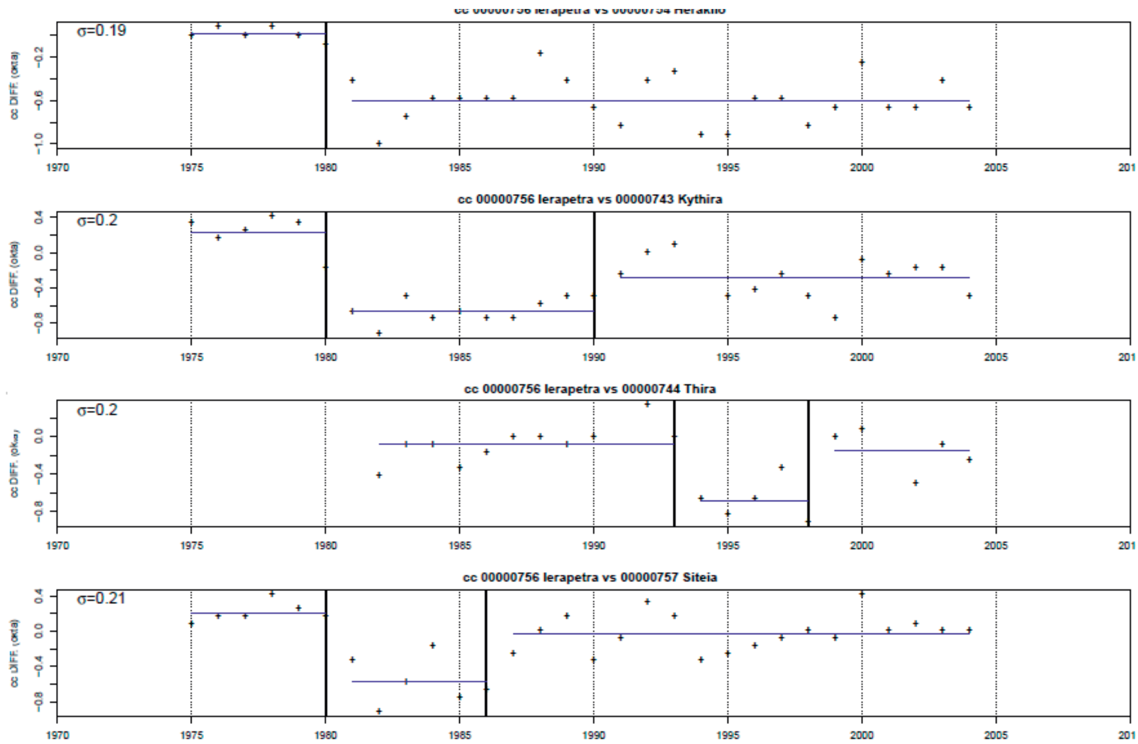


Figure 8. Pairwise comparisons between the Ierapetra station with its neighboring stations; bold vertical lines denote the year of probable break point, σ is the standard deviation of the noise.

Slika 8. Usporedba parova nizova podataka za postaju Ierapetra i susjednih postaja; podebljane vertikalne linije označavaju godine vjerojatnog prekida, σ je standardna devijacija šuma.

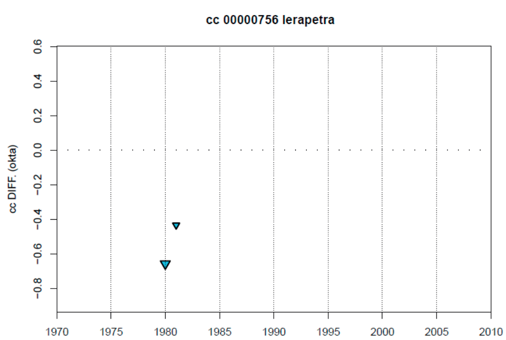


Figure 9. Average magnitude and sign (+ or -) of the probable break points detected by pairwise comparison of the Ierapetra station with its neighboring stations

Slika 9. Srednji iznos i predznak (+ ili -) vjerojatnih točki prekida detektiranih usporedbom parova nizova podataka postaje Ierapetra i susjednih postaja.

3.2. Application of HOMER

For this preliminary homogenization exercise, we applied the pairwise detection feature of HOMER provided by PRODIGE to all the 28 data sets that passed the quality control tests. In the pairwise detection a time series is compared to all other series by producing a series of differences between the target series and the others. These different series are then tested for change points; if the same (i.e. concerning the time of occurrence) is detected in all comparisons between the candidate series and its neighbors, this can be a break point attributed to the candidate series. However, in the case of simultaneous break points between candidate and neighbor series or in the case of weak break amplitude, pairwise detection may lead to false detection or to no detection at all. Therefore in those cases meta-data is very useful (Mamara et al., 2014).

Greece is classified into seven climate zones (Mamara et al., 2013). In order to take into

Table 5. Detected break points (years). Time series start after the relocation date in stations 16719 and 16744.

Tablica 5. Pronađene točke prekida (godine). Niz podataka s postaja 16719 i 16744 počinje nakon datuma premještaja.

WMO code	Location	Breakpoint years	Relocation
16606	Serres	none	
16614	Kastoria	none	
16619	Trikala Imathias	1996	
16622	Macedonia	1996	
16624	Chryssoupoli	none	
16627	Alexandroupoli	none	
16628	Konitsa	1992	
16641	Corfu	1983, 1993	
16642	Ioannina	none	
16648	Larisa	none	
16650	Limnos	1993	
16654	Arta (Filothei)	none	
16665	Agxialos	none	
16667	Mytilini	none	
16685	Argostoli	none	
16706	Chios	none	
16716	Elliniko	none	
16719	Zakynthos	none	6/1982
16723	Samos (airport merged)	1978	Apr-78
16732	Naxos	none	
16743	Kythira	1989	
16744	Thira	none	Apr-81
16746	Souda	none	
16749	Rhodos	none	Jul-77
16754	Heraklio	none	Between 1976-1977
16756	Ierapetra	1980	
16757	Siteia	1988	Between 1984-1986
16759	Tymbaki	1981	
16760	Kastelli	none	

account the climatological differences between the various regions of Greece (differences in cloudiness between Northern and Southern Greece and also between the western (more rainy) and eastern parts, along the Pindos mountain chain), we applied the pairwise detection method on annual and seasonal cloud cover time series, with geographic inter-comparison neighborhood, with a maximum distance of 200 km and a minimum of 5 neighbors.

Because of the ambiguity whether the additive or multiplicative model describes better the cloud cover time series, we tested both approaches. It came out that using the additive model, more breaks were detected. Due to this result and also taking into account the findings reported in subsection 3.1, we decided to opt for the additive model. An example of graphical output of pairwise detection is provided in Figure 8; a break point in 1980 is evident for the cloud cover time series of Ierapetra.

This is also clear in Figure 9 depicting the average magnitude and sign of the probable break points.

The total number of possible break points of all time series are listed in Table 5.

4. CONCLUSIONS

In this paper we presented the preliminary results of the homogenization of the cloud cover time series in Greece. Emphasis was given to the model selection, additive or multiplicative, that is more appropriate for this type of meteorological time series. Despite the fact that cloud cover takes a natural zero value (under clear sky conditions), this parameter has a physical meaning closer to intensity rather than to accumulation. Also, the various tests indicated a slightly better performance of the additive model. Also, taking into account physical considerations, we concluded that the additive model is more suitable and applied it during our homogenization exercise.

For the homogenization we applied the pairwise detection on cloud cover time series coming from 29 stations. Each station was compared with its neighbors, defined after climatological considerations. Out of the 25 cloud cover time series, 19 were found with no possible break points, 9 with one possible break point and 1 with two possible break points. Only one of these break points is confirmed by the available meta data, the relocation of station 16723, Samos.

One of the side effects of the additive model would have been the appearance of values without physical meaning (e.g. higher than 9). However, we did not observe such values in the homogenized series.

Our future work will focus on break point detection of this data using additional homogenization methods, in order to cross validate the results reported above, correct the time series of cloud cover by removing the break points and study the cloud cover amount trend over Greece.

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