Climatic conditions of the delta of the PiniosRiver (Thessaly, Greece), based on in situ meteorological measurements

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The microclimatic conditions of the deltaic plain of the Pinios River are studied, within the framework of the THALES-DAPHNE research project. Three meteorological stations were installed at Stomio, Palaiopyrgos and Mesagkala and the recorded time series were intercompared to monitor meteorological conditions and their variation in the deltaic plain. Climatic data for the area were obtained from the analysis of multi-year data from two monitoring stations at Karitsa (1978-1996) and Pyrgetos (1960-1993) and of ERA-interim data. During 2013 the Stomio area received more rain than the Palaiopyrgos area by 9-54%, with the exception of July and August, when Palaiopyrgos received 85% and 593% more rain respectively. Both areas received significantly less precipitation (from -28% to -96%) than the multi-year mean monthly values of Karitsa and Pyrgetos, with the exception of February (+ 32-95%) and July (+ 110-300%). Air temperature at Palaiopyrgos was 1-2 °C higher than at Stomio during the winter months and about equal during the rest of the year. Both areas are slightly warmer (7-14%) than Karitsa during the summer and much warmer during the winter (57-69%). The above differences are attributed to the effects of orography and vegetation on the microclimate of each installation area.

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1 Introduction and study area

River deltas are among the most sensitive coastal ecosystems, characterized by immense biological diversity and conflicting human activities (e.g. agricultural, touristic). Changes in climatic conditions and weather patterns could affect both agriculture and tourism on local and regional scale (Becken 2010, Matzarakis and Nastos 2011). Furthermore, coastal ecosystems, such as river deltas, are very sensitive to temperature and rainfall changes, which could affect important ecological processes and species interactions. The trends and variability of the air temperature for the wider area of Greece and for several time periods have been studied in recent studies (e.g. Nastos and Matzarakis 2008, Philandras et al. 2008; Nastos et al. 2011). Research on precipitation over Greece has been carried out on local and regional scale (e.g. Feidas et al. 2007, Nastos and Zerefos 2008).

A significant part of the Thales-DAPHNE project of the University of Athens is to expand the current knowledge of the local climatic conditions in the area of the Pinios River delta, by monitoring and analysing the temporal variability of important meteorological parameters, and to assist stakeholders in planning necessary interventions and in developing compatible rural and touristic activities.

The delta of Pinios River is located on the western coast of south Thermaikos Gulf (Fig. 1).The deltaic plain (approximately 69 km^2) extends between the Lower Mount Olympus to the N and Mount Ossa to the S, has elevations up to 10 m and is under "Special Protection" according to the Directive 79/409/EEC, NATURA 2000 (GR1420002).

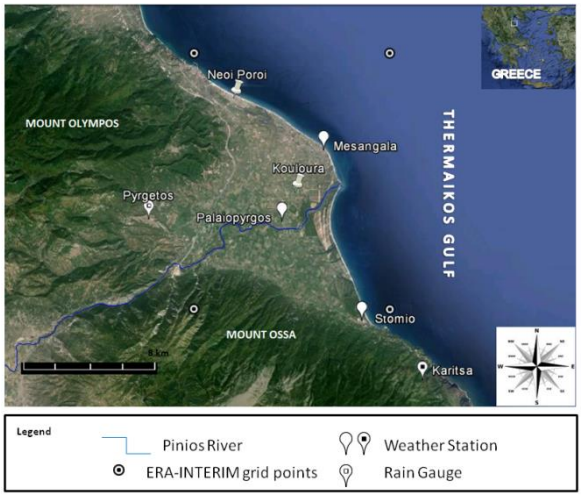

Fig. 1. Location map of the study areashowing the PiniosRiver delta, the locations of the weather stations and the ECMWF ERA-Interim grid used in this study.

The delta is generally considered to have a “Mediterranean” type climate, even though its central area is closer to the “continental” type with less rainfall and larger seasonal variations of air temperature (Foutrakis et al. 2007). Mean annual precipitation ranges from 400 mm near the delta to nearly 1600 mm in the surrounding mountainous area. Mean annual temperature is about 17°C (Gaki-Papanastassiou et al. 2010).

The objective of this work is to analyze the climatic regime of the Pinios River delta based on the ERA-interim reanalysis dataset (ECMWF) and on long-term ground-based observations and to present the preliminary results of the study of the micro-meteorological conditions of the deltaic plain, based on in situ observations.

2 Data and Methodology

Climatic data over the deltaic plain of Pinios for the period 1979-2013 were obtained from the ERA-interim reanalysis dataset (ECMWF). These data consist of 6-hourly estimates of mean sea level pressure, temperature at 2m, zonal and meridional wind vectors, with a grid analysis of 0.125°x0.125°. Historical data from the Pyrgetos rainfall gauge station (altitude: 34 m) and the Karitsa weather station (altitude: 380 m), covering the periods 1960-1993 (Pyrgetos) and 1978-1996 (Karitsa) (Panagopoulos et al. 2001) were used for the investigation of recent climate trends.

In order to study the micro-meteorological conditions of the deltaic plain, two meteorological stations (Davis Vantage Pro2 Plus) were installed at Stomio (in June 2011) and Palaiopyrgos (in January 2013) (see Fig. 1), at altitudes of 9 and 6.5 m respectively, to record the barometric pressure, air temperature, relative humidity, rainfall, wind speed and direction, solar radiation and UV radiation. In November 2013 a third weather station was installed close to the shoreline at Mesagkala to monitor wind speed and direction, barometric pressure, air temperature and relative humidity. The time series for each parameter, recorded at 5 min intervals by the three weather stations, were used to examine the annual variability and to investigate the cross-correlations between the datasets. The same analyses were performed on the data from the Pyrgetos and Karitsa stations in order to extract climatological information for the general area of the Pinios river delta.

For the ERA-interim dataset, the four points of the grid nearest to the weather stations were used to compute the weighted distance average value of each parameter at the location of each weather station. The resulting time series were converted to monthly mean values and were used for the extraction of information on the climatic conditions in the delta area over the past 35 years.

3 Results

3.1 Climatic characteristics of the delta area

According to the analysis of the ERA-interim data set, during the last 35 years the mean monthly air temperatures range from 6°C (in January) to 26°C (in July). Stomio appears to be consistently warmer (1-2°C) than Palaiopyrgos (Fig. 2a,c), with the higher differences occurring during the colder months (October to March). Mean monthly wind speeds range from 2.2 to 3.7 m/s with the highest speeds occurring in February and December and the lowest in July and August (Fig. 2b). Mean monthly wind speeds at Stomio are consistently higher (12–20%) than at Palaiopyrgos, with the difference increasing as the wind speed increases (Fig. 2d). The above differences are attributed to the fact that Stomio is located close to the sea and to the influence of the nearby mountainous region of Ossa.

From the analysis of the rainfall data, recorded by the Pyrgetos and Karitsa stations, it is concluded that the area of Karitsa receives significantly more rainfall than the area of Pyrgetos. During the summer months both areas receive approximately the same amount of rain, but from October to April the amount of rainfall at Karitsa is almost double the amount recorded at Pyrgetos (Table 1).

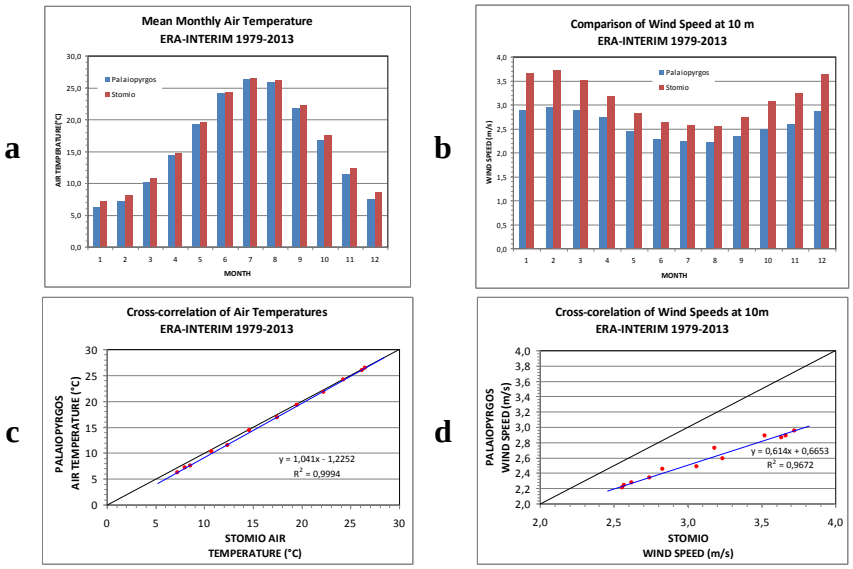

Fig. 2. Comparison of ERA-interim climatic data (1979-2013) for the areas around Stomio and Palaiopyrgos.

Table 1. Monthly rainfall (in mm) in the area of the PiniosRiver delta.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Climatic data													
Karitsa (1978-1996)	168.2	127.4	128.3	105.5	52.0	39.1	19.9	25.3	58.8	196.6	191.4	200.9	1313.4
Pyrgetos (1969-1993)	105.3	66.6	89.2	60.7	57.4	38.5	19.4	23.1	49.7	94.4	88.2	103.1	795.6
Recent data													
Stomio (2011-2013)	60.20	201.14	90.21	23.47	91.67	21.87	14.07	10.10	32.59	85.51	225.50	200.78	1131.07
Palaiopyrgos (2013)	26.80	130.20	29.40	21.80	40.40	26.80	77.60	5.20	16.00	52.40	62.80	91.20	580.60

3.2 Current conditions and trends

Recent micro-meteorological data (2011-2013) show that Palaiopyrgos is slightly warmer (1-2°C) than Stomio during November, January and February (Fig. 3a, c). Both Stomio and Palaiopyrgos have received significantly less rainfall (from -28% to -96%) than the climatic monthly means of Karitsa and Pyrgetos. However, five severe storms (February and July 2013 at Palaiopyrgos and February, May, November and December 2012 and February 2013 at Stomio) have resulted in monthly precipitation higher than the corresponding climatic means. Year 2012 was exceptionally wet. In 2013 Stomio received approximately twice the amount of rainfall of Palaiopyrgos (see Table 1 and Fig. 3b,d). Monthly rainfall values at Stomio were 1.5 to 3.6 times higher than the corresponding values at Palaiopyrgos with the exception of April and June, when values were similar, and July, when the severe storm that hit the area of the delta produced 5.5 times more precipitation at Palaiopyrgos than at Stomio (Table 1).

From April to December the mean monthly wind speeds at Stomio were slightly higher than the wind speeds at Palaiopyrgos, whereas they were approximately equal during the rest of the year (Fig. 3e, f). During the two months of operation of the weather station at Mesagkala (November and December 2013), mean monthly wind speeds at Mesagkala were approximately three times the wind speeds at Stomio and Palaiopyrgos (Fig. 3e). This is attributed to the sea breeze that minimizes calm periods, but it has to be seen if this trend persists throughout the year.

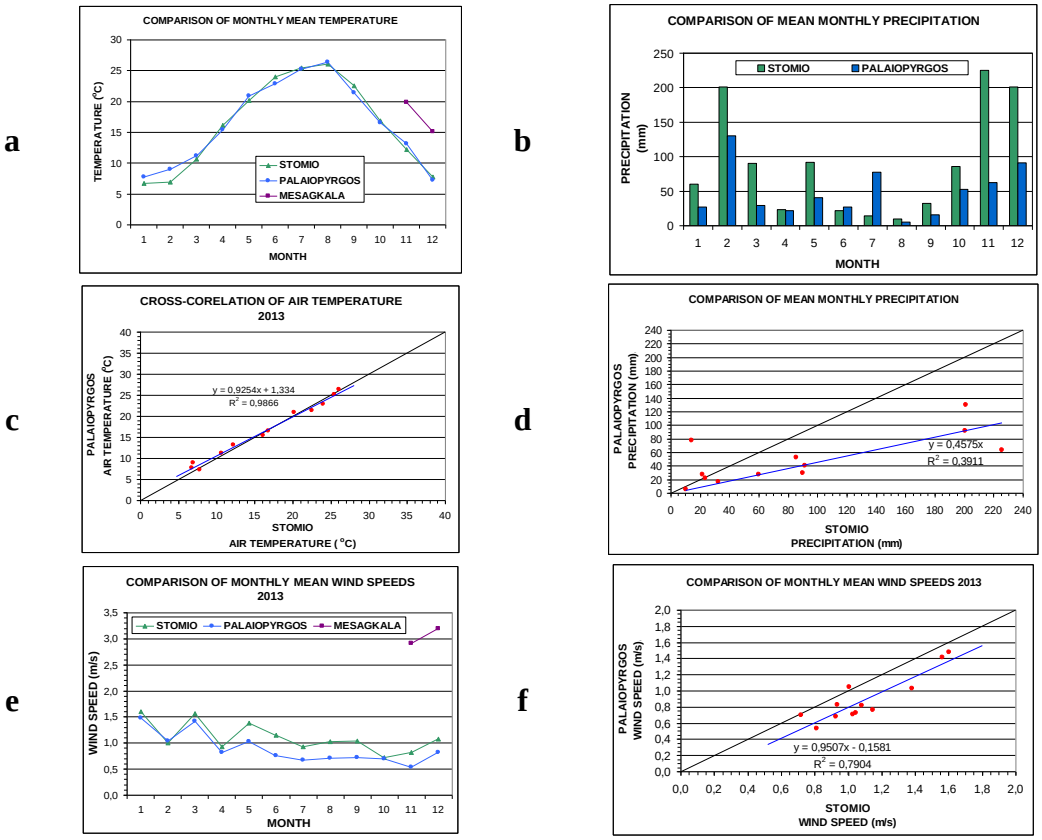

Fig. 3. Comparison of recent (2011-2013) mean monthly temperature, precipitation and wind speeds data from the Stomio, Palaiopyrgos and Mesagkala weather stations.

4 Conclusions

The preliminary results reveal micro-meteorological anomalies within the Pinios river delta, which can be attributed to the effects of the local orography and to the distance from the shoreline. Thus, Stomio shows higher temperatures and wind speeds than Palaiopyrgos, both in climatic means and in recent data, while recent data from both stations show higher temperatures and lower precipitation, compared to the climatic means for the region.

Acknowledgments This work is supported by the research program THALES-DAPHNE (MIS: 375908) that is funded by the Operational Programme "Education and lifelong learning, 2007-2013" of the Ministry of Education and Religious Affairs, Culture and Sports.

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