THE CLIMATE CHANGE IN ALBANIA, ITS IMPACT ON HYDROGRAPHIC SYSTEM AND ADRIATIC COASTLINE

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Abstract

The general cascade impact of the climate change on Albanian Adriatic Littoral: decreasing country water resources, influence on the hydrographic regime of Adriatic Sea and on ecosystems are presented in the paper. The study is based on the results of inversion of 6 thermologs data for the ground surface temperature history in Albania, and climate change according to the multi annual meteorological data from different regions of Albania. The wells and the meteorological stations are located in Sedimentary Basin of Albania, at the field region in the west of Central Albania and in the ophiolitic belt in the mountainous region of the northeast Albania.

Based on inversion data at coastal plane western region of Albania, GST history presents a gradual cooling before a middle of the 19th century, followed by 0.6 K warming. Climate warming of 0.6 K in the 20th century is observed also in mountainous northwestern Albania. This warming mainly after the second half of the 20th century is presented also by meteorological data: temperature, rainfall, and wind regimes.

There are estimated continental water flow, created by atmospheric rainfalls. Impact on processes of the forming and circulation of the Adriatic Sea water mass has been analyzed by particularly attention, for wet and dry years are analyzed. Estimation of run-off discharges is carried out for two categories of river basins: first, for river systems, where run-off discharge is computed as a function of the altitude of water level river section. Second, for the water system of Scutary Lake-Drini River-Buna River, which is very complicated and is the single in Mediterranean Hydrography.

The warming impact on country climate, and ecosystems of Albania, thermal stress in the wetlands, lagoons and lakes have presented in the paper. Impact it is observed first of all on the biodiversity.

Keywords: Ground Surface Temperature, Climate Changes, Hydrology, Hydrographic System, Adriatic Sea, Environmental Impact.

1. Introduction

Processes of the forming and circulation of the Adriatic Sea water mass, as is well known, presents a discussible phenomenon of the Mediterranean oceanographic dynamics. One of the main factors, which have determined these processes, is water discharge from the Albanian Hydrographic System into Adriatic Sea. Analyze of the factors that conditioned water discharge and their impact on Adriatic Sea Hydrology are presented in the paper.

Climate, geomorphology, lithology and geographical situation of the Albanian Hydrographic Network Catchment, are caused their impact on the water discharge from Albania into Adriatic Sea. Its impact has been observed on some directions:

- Country climate change,
- Water systems and water resources changes. Impact of inland water resources changes on the hydrographic regime of the Adriatic Sea.
- Mechanism of the forming and circulation of the South Adriatic Sea water.

In the first part of the paper is presented detailed analyzes of the climate change in Albania. Albania lies in a subtropical zone. It is a Mediterranean country. Winter is relatively short and mild, humid near the seaside areas. Summer lasts very long and it is hot and dry. To the east, in the mountain areas, the climate is Mediterranean mountainous. The climate in Albania varies from a region to the other, according to the location compared with the seaside, to the seasons, years, and centuries. The ground temperatures are conditioned by geographical position of the area, area's geology, and ground lithology, dynamics of the underground waters, meteorological conditions, and season. The climate change studies, are based on geothermal inversion results and meteorological observation data.. There is analyzed the ground surface history (GSH) and paleoclimate change according to the temperature measurements in the different wells in Albania. Climate changes during the last half of the XX century has been analyzed also based on the meteorological data.

There are estimated continental water flow, created by atmospheric rainfalls and its impact on processes of the forming and circulation of the Adriatic Sea water mass has been analyzed.

According to the complicated nature of the Albanian Hydrographic System, in the second part of the paper, is presented the Albanian Adriatic Littoral hydrology, and geological setting. In the last part of the paper the observed integrated factors of the coastline evolution are analyzed.

2. Material and methods

Climate change are analyzed in two directions: firstly by temperature record in the deep wells and shallow boreholes, and secondly by the meteorological observations data. The ground surface temperature reconstruction for long period, about 5 centuries, has been performed by estimation of the ground surface temperature changes at the past, according to the present-day distribution of the temperature at the depth, recorded in the borehole. The study of geothermal field of Albania has been carried out based on the temperature logging in the wells and boreholes (Çermak, V. et al 1996, Dimitriev V. I. et al. 1997, Frashëri, A. and Čermak, V. et al. 1995, 1994, 2004,). Six thermoplots were used for inversion of the ground surface temperature history, which are located at the plain region in the west of Central Albania, and in the mountainous region of the northeast of the Albania.

Air and ground temperatures, total annual rainfall quantity, wind speed and wetness, which are analyzed by records in Meteorological Stations. These stations are located in different plane regions (Shkodra, Tirana, Kuçova and Fier) and in mountainous region of Albania (Kukes), where the investigated wells are situated (Albanian Climate, 1978, Boriçi, M. and Demiraj E. 1990, Gjoka, L. 1990, Mici, A. et al 1975, the data for 1985-2007 after Mustaqi V.).

Water potential of the Albanian Rivers System have been evaluated by a specific way, because this System is very complicated (Pano N. 1974, 1984, 1998, 2008). This network has a surface of 43 305 km^2, where 28 500 km^2 is inside the Albanian state territory, and water of the Albanian river system discharge into Adriatic and Ionian Sea. Albanian River System represents in general a mountainous hydrographic network, with an average altitude 785 m above the sea level. Part of Albanian Hydrographic Network are lake system, Prespa-Ohri, and Scutary with a surface from 270-365 km^2. A karstic phenomenon is very intensive in the limestone formation, which is extended in great surface of the country.

Water potential evaluation of the Albanian River Basin based on the multi annual archival data of the Albanian Hydrometeorological Institute of the Academy of Sciences. The monitoring network has more than 22 meteorological and hydrometric stations, during the observed period 20-100 years.

The methodology of the estimation of the water potential, have calculated the annual run-off discharge of the Albanian River System according to the corresponded types of the water supply, structure of the annual discharge distribution, and hydrogeographical types of the river catchment. Estimation of run-off discharge (Qi) are performed for two categories of river basins, with different hydrographical and hydraulical natural conditions:

a). Water system: Scutary Lake-Drini River-Buna River), where the run-off discharge Q_i is computed by $Q_i= F(H_i,Q_l)$, where Q_l represent the discharge of the lateral source..

b). Drini, Mati, Ishmi, Semani , Vjosa River systems, etc), where the run-off discharge Q_i is computed by Q_i-f(H_i), where H_i- level in the river $Q_i=f(H_i)$, where H_i is altitude of the water level river (i) section.

All modeling and calculations have been performed for the model of dry and wet characteristic years, to analyze the climate impact on Albanian Hydrographic System.

Processes of the forming and circulation of the Adriatic Sea water mass have analyzed based on hydrographic data and Results of Albanian Marine Expeditions "Saranda 1963", "Patosi 1964" for the wet years (Pano N. 1974), and Italian-Albanian Expeditions "Italica I and II, 2000 and 2001" for dry years.

Integrated geological-geophysical: onshore surveys of the Albanian littoral areas have begun since 1958. Offshore geological-geophysical surveys on the Albanian Adriatic shoal shelf have started from 1976 (Frashëri A. 1987, 1994, Frashëri et al. 1991, Geological Map of Albania 1983, Leci V. et al. 1986, Papa A. 1985).

3. Results and discussion

3.1. Climate change

The ground surface temperature reconstruction of the thermoplots of Kolonja-10 and Arza-31 deep wells, which are located at coastal plane region of western Albania, are shown in fig. 1. As it is seen in this figure, the GST history yielded by tighter inversion of Ko-10, presents a gradual cooling of 0.6 K, before a middle of the 19th century. Later followed by 0.6 K warming, with a gradient 5.4 mK/years, that seems quite reasonable and is consistent with generally accepted ideas about the climate of the last 2-3 centuries. On the contrary, the paleothermal history, obtained from Arza-31 well, presents a monotone warming of 1,7 K, by a gradient 5.7 mK/year, during the 17th and 19th centuries. This trend of the warming has only explanation caused by a deforestation of the area and presence of the paleo-swamp.

Fig. 2 shows a GST history of Vl-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes, which are located in the mountainous regions of Northeast Albania. Some changes are observed in these regions as to the cooling of 0.2 K during the 19th century. Later, the warming trend of 0.6 K during the 20th century, by a gradient 6.7 mK/year. Warming gradient increasing at mountainous regions, in comparison with coastal areas, is caused by intensive deforestation during the last half of 20th century.

Climate changes in Albania are observed also by the hydrometeorological studies. Fig. 3 presents graphics of yearly average temperature of the air in Tirana and Shkodra Meteorological Stations, for the period from 1931 to 2000. As well known, Tirana is located in Central Albania. In general, the end of first observes half 20th century, a warming of climate, about 1^{o}C. Thirty quarter of 20th century is characterized by a cooling of 0.6^{o}C, and later, up to present a warming of 1.2^{o}C. The same climate changes are observed also at Shkodra City, in northwestern plane area of Albania.

The cross correlation coefficient is C_c = 0.78 between variation curves of the average annual temperatures of both of these stations. Warming trend of maximum 1.2^{o}C, in particular after seventy years, is observed in all Albanian territory (Fig. 4).

There are good cross correlation between variation curves of the average annual temperatures of Shkodra, Tirana and Kukesi, respectively C_c = 0.78 and 0.79. Weak cross correlation C_c = 0.58-0.68 is observed between temperature variation of the Kuçova area and other northern regions.

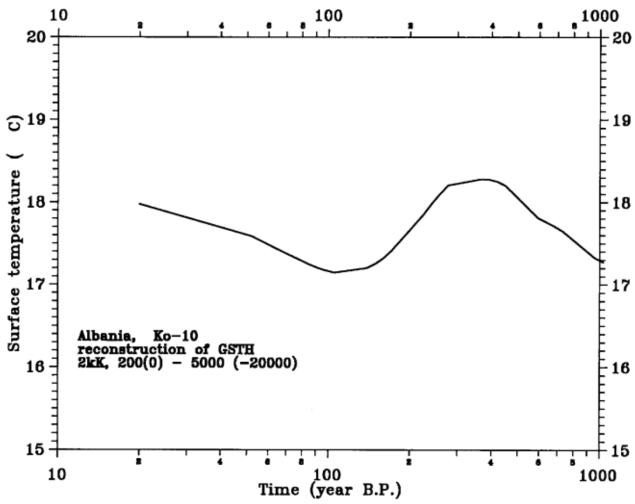


Figure 1. Ground surface temperature history according to thermoplot of Ko-10 and Arza-31 wells (According to the Šafanda, J. calculations).

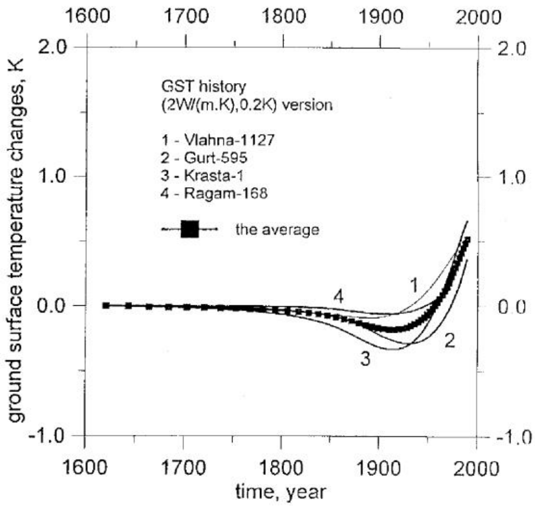


Figure. 2. Ground surface temperature history according to thermoplot of Vl.-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes (According to the Čermak, V. and Safanda, J. calculations).

This phenomenon presents the influence of the local character of the climate changes of Kuçova area. Warming of the soil is more intensive than air warming (Fig. 5).

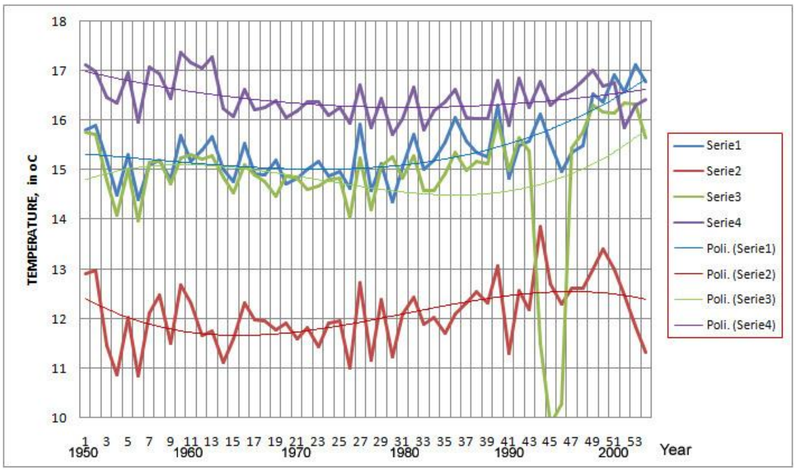


Figure 3. Air Average Annual Temperature Variation at Tirana and Shkodra Meteorological Stations (Period 1931-2004). 1- Tirana; 2- Kukesi; 3- Shkodra; 4- Vlora

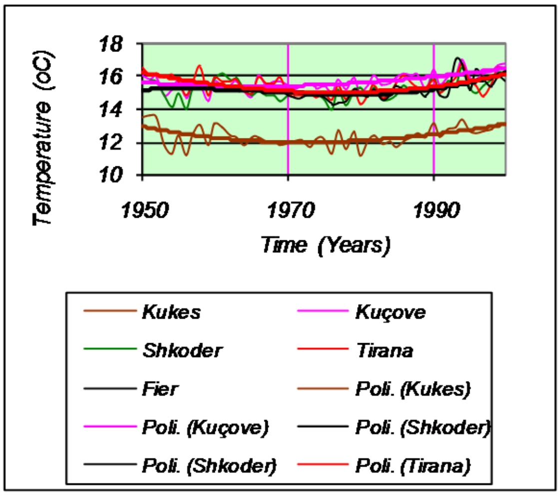


Figure 4. Cross-correlation of the Air Average Annual Temperature variations at Shkodra, Kukes, Tirana, Kuçova and Fier Meteorological Stations (Period 1950-2000).

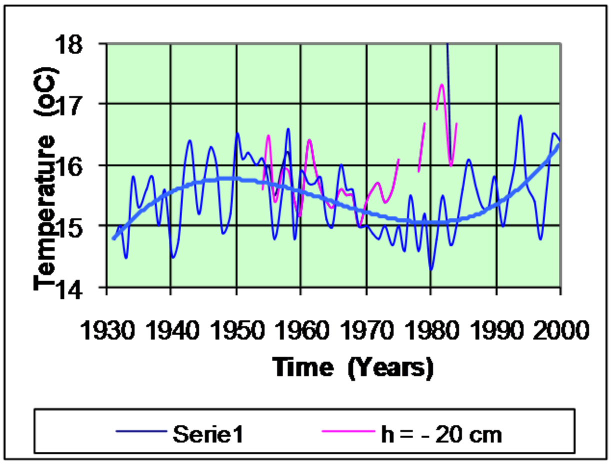
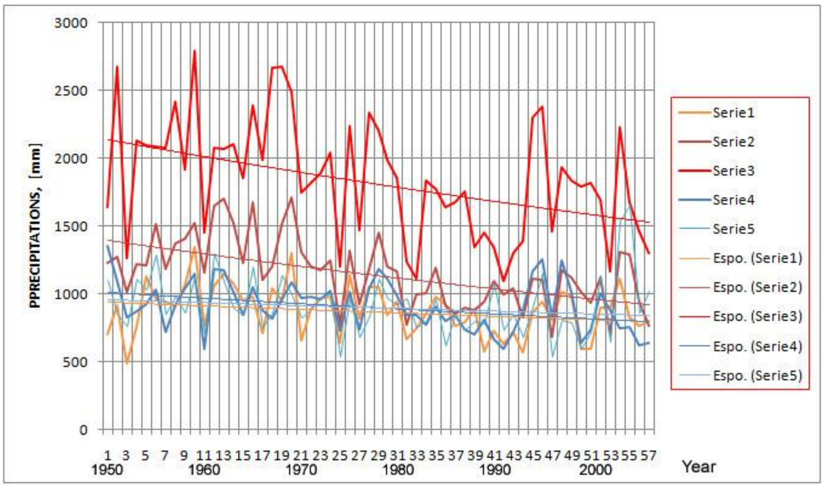


Figure 5. Air and Ground Average Annual Temperature Variation at Tirana Meteorological Station.

The meteorological data shows that the warming trend is not a monotone one. In short intervals are observed cooling and warming (Fig. 3, 4, 5). The meteorological studies have verified warming of the climate during the last quarter of the XXth century, too. It has been consisted that: "Around the 1980's a warming trend is observed" (Boriçi M., Demiraj E. 1990, Demiraj E. et al 1996).

The warming period in Albania is accompanied with changes of the rainfall regime., wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200-400 mm. (Fig. 6, 7,8).



1- Kukës; 2- Tirana; 3- Shkodra; 4- Erseka; 5- Vlora

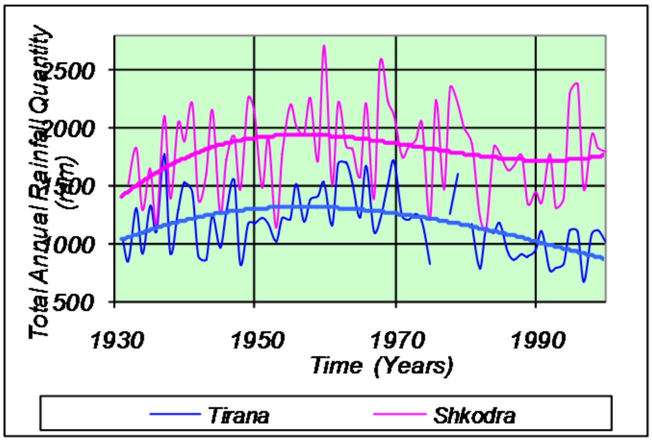


Figure 6. Total year rainfall quantity of the Tirana and Shkodra Meteorological Station (Period 1930-2007).

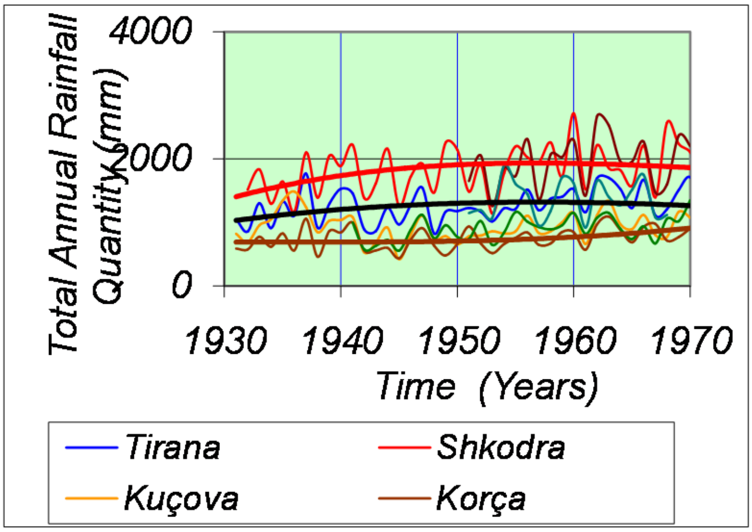


Figure 7. Cross correlation of the Total Year Rainfall Quantity of the Tirana, Shkodra, Kuçova, Korça, Kukesi, Gjirokaster, Vlora Meteorological Station (Period 1930-1970).

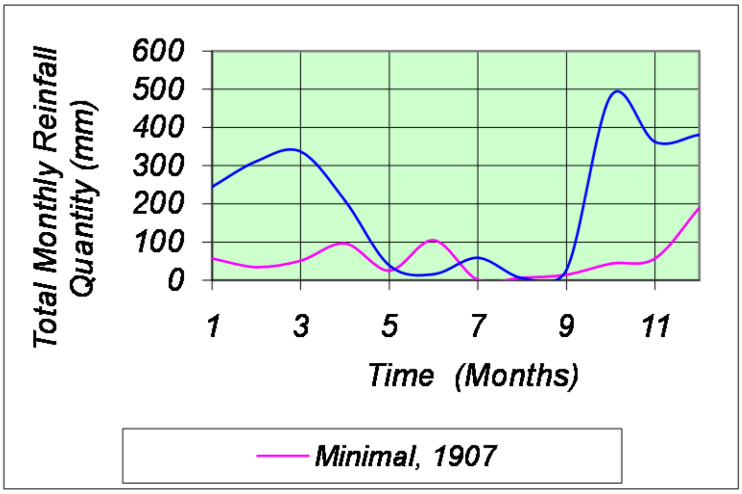


Figure 8. Total Year Rainfall Quantity in the most dry and wet year, respectively, of the Shkodra Meteorological Station (respectively 1907 and 1960 years).

In the dependence of the geographical location of the areas changes the cross correlation of the rainfall quantity: Tirana area with Shkodra area C_c=0.62, with Korça C_c=0.81, Kuçova C_c=0.66, Kukesi C_c=0.88, Gjirokaster C_c=0.88, Vlora C_c=0.53, during the period of 1930-1970. Fig. 8 is presented the difference of the total year rainfall quantity in the most dry and wet years, respectively 1907 and 1960. The warming have accompanied with decreasing of the wind speed about 1.5 m/sec and 5% increasing of the wetness, during the period of 1950-1994 (Fig. 9).

This warming is part of the global Earth warming during the second half of XX century. Its impact has been observed also on water systems and water resources. Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea, and particularly in the Albanian Adriatic Littoral (Frashëri A. & Pano N. 2003). Ecosystems, and biodiversity, in the particularly in the water's flora and fauna. Temperature augmenting has caused increasing of the evaporation in the water systems. Consequently in the river system, reservoirs, wetlands, lakes and lagoon system has been observed thermal stress. In very beautiful ecosystems of Albanian lagoon thermal stress has its impact, first of all on the biodiversity. This stress is extended also in the shallow coastal waters; consequently there are observed diminution of the fish quantity.

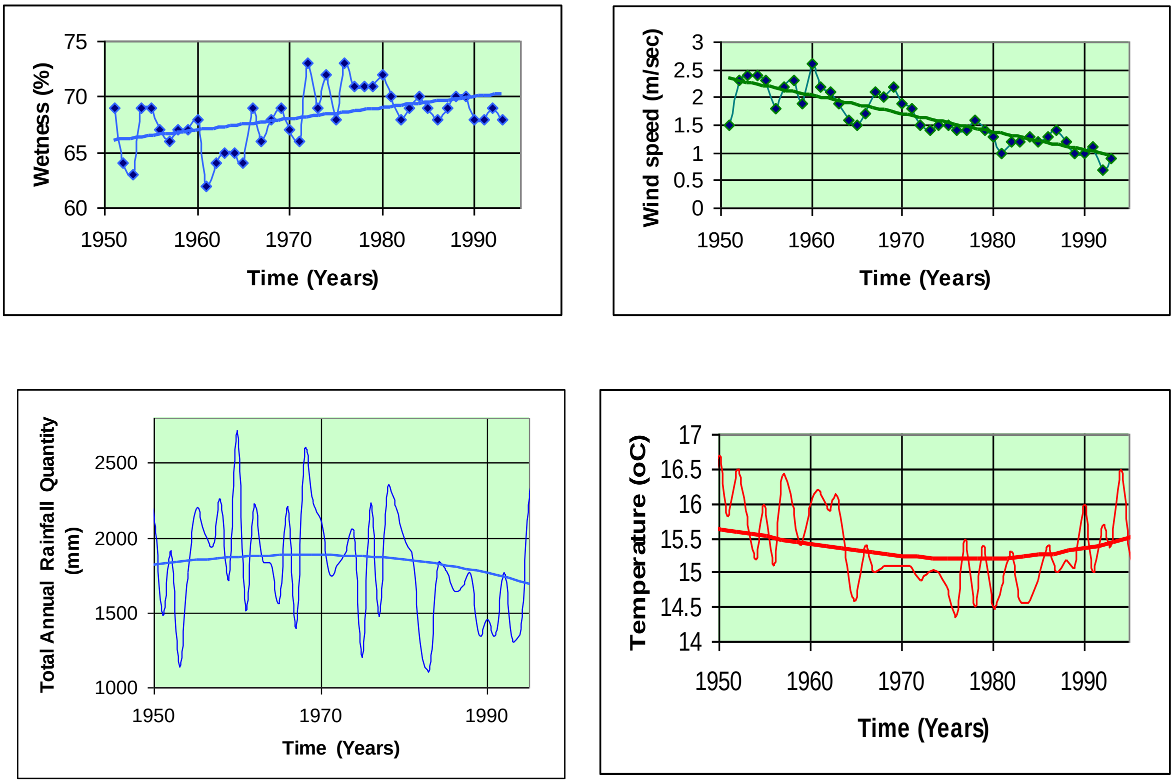


Figure 9. Air Average Annual Temperature, Total Year Rainfall Quantity, Wind Speed and Wetnees Variations, at Shkodra Meteorological Stations (Period 1950-1994).

3.2. Discussion about the climate change impact on the Albanian Adriatic Littoral

The Albanian coastal area lies from Velipoja to Vlora bays. Adriatic coastline is lies over the Neogene Peri-Adriatic Depression, covered by Quaternary deposits. Flattened accumulative coast is general characteristic of this coastline. There are also some hilly marine caps with cliffed coast. The caps are located in the sectors where the Neogene structure of the Peri-Adriatic Depression are abrupt by coastline and continues in the Adriatic Sea, old river deltas or mouths and submarine coastal bar. In fig. 10, 11, 12, and 13 are presented the geomophological evaluation and hydrographic regime of the different characteristics zones of Albanian Adriatic Littoral (Pano N. et al. 1974, 2003, 2004, 2006, 2008, Simeoni U. et al. 1999, Shuitsky Yu. D. et al. 1999).

1) Mouth of Buna River at the north to Rodoni Cap coastline. This unit has a length about 60 km and consists for almost 90% of beaches fed by fluvial imputes. The remaining 10% is clifts. Four rivers outflow within this area: from north to south Buna, Drini, Mati and Ishmi rivers (Pano N. 1998).

2) Rodoni Cap, Durrësi Bay up to Shkumbin River mouth coastline. Cape Pallës, Cape Selitës, Lalëzi Bay, Durrësi Bay and Shkumbini River mouth are main sectors of this littoral area. Lalëzi Bay has a length of coastal line of 32 km, and 65% consists of sandy beaches fed by the sediment load of Erzeni River. The remaining 35% consists of rocky cliffs. Durrësi Bay has a length of 35 km from Pallës Cap to the Selitës Cap. Main part of the bay littoral, about the 54% of their length, by sandy beaches is presented. Frequently, with dune ridges, vegetate by pine trees, there are extended.

3) Shkumbin-Seman-Vjosa rivers mouths up to Zvërneci hills coastline, is located in southern part of Central Albania, and have 40 km length. It expands in the western part of Ardenica and Divjaka hills. Karavasta Bay and Karavasta Lagoon are also part of this littoral area. From the geological viewpoint, this territory represents a new soil, constituted at the end of Pliocene and during Quaternary. The coastline in this region has a very intensive dynamics.

4) Vlora *Bay,* is represented southeastern edge of Otranto Strait. The *Upper* Cretaceous- Triassic limestone mountains are encircled southwestern and southeastern shores of the bay. In the north, the mountain chain is continued with Neogene's deposits hills.

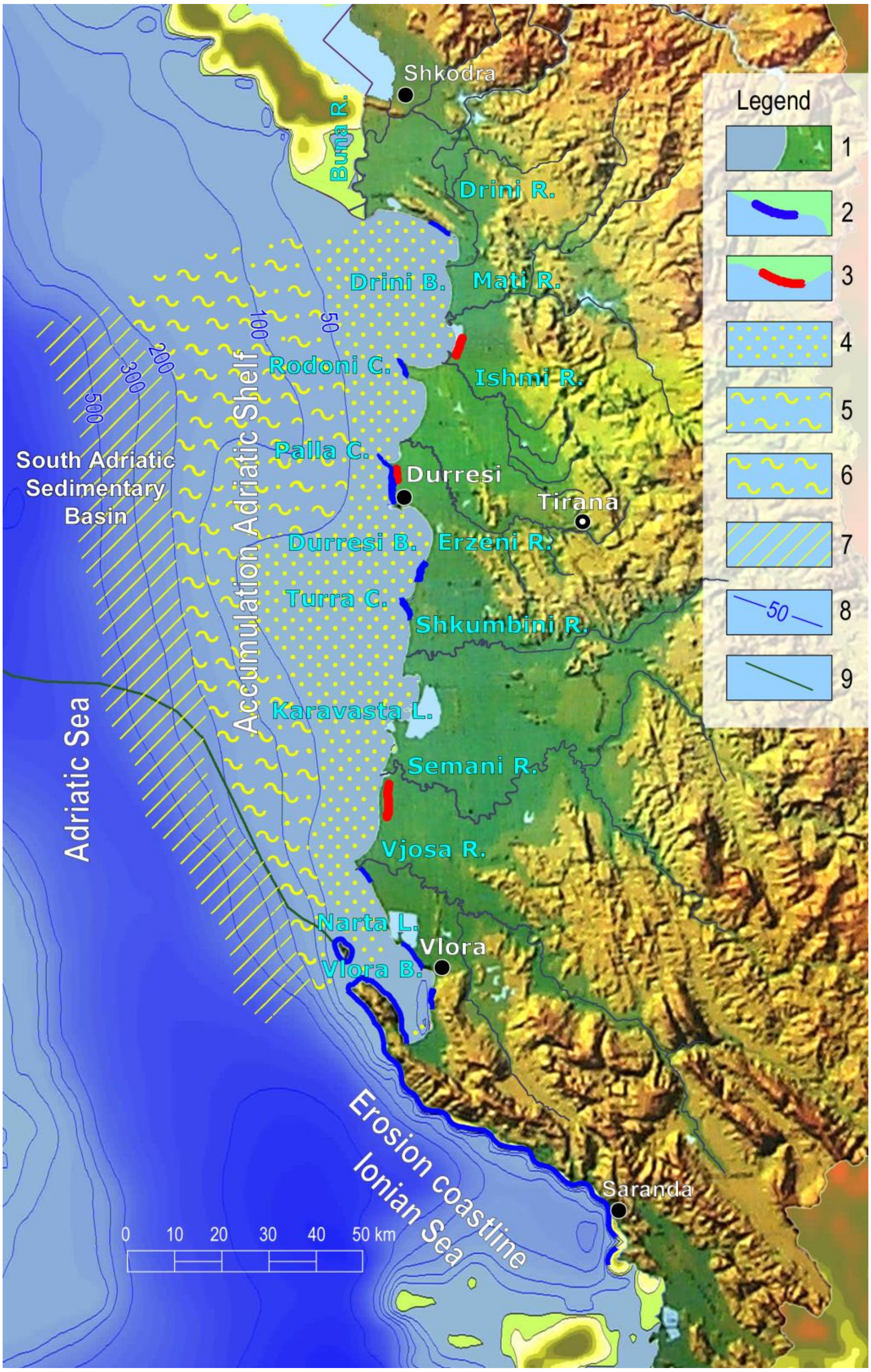


Fig. 10. Geomorphological Scheme of Albanian Adriatic and Ionian Seas coastline. (Digital Terrain Model, National Geophysical Data Center (NGDC), Geodas database, 2005.

1- Accumulative coastline; 2- Erosion coastline; 3- Submerged littoral zone; 4- Shoal shelf area with sand deposits; 5- Flat shelf area with sandy-silt deposits; 6- Inclined shelf area with muddy silt and deposits; 7- Continental slope with argillaceous sediments; 8- Isobaths; 9- Western flank of the South Adriatic Sedimentary Basin.

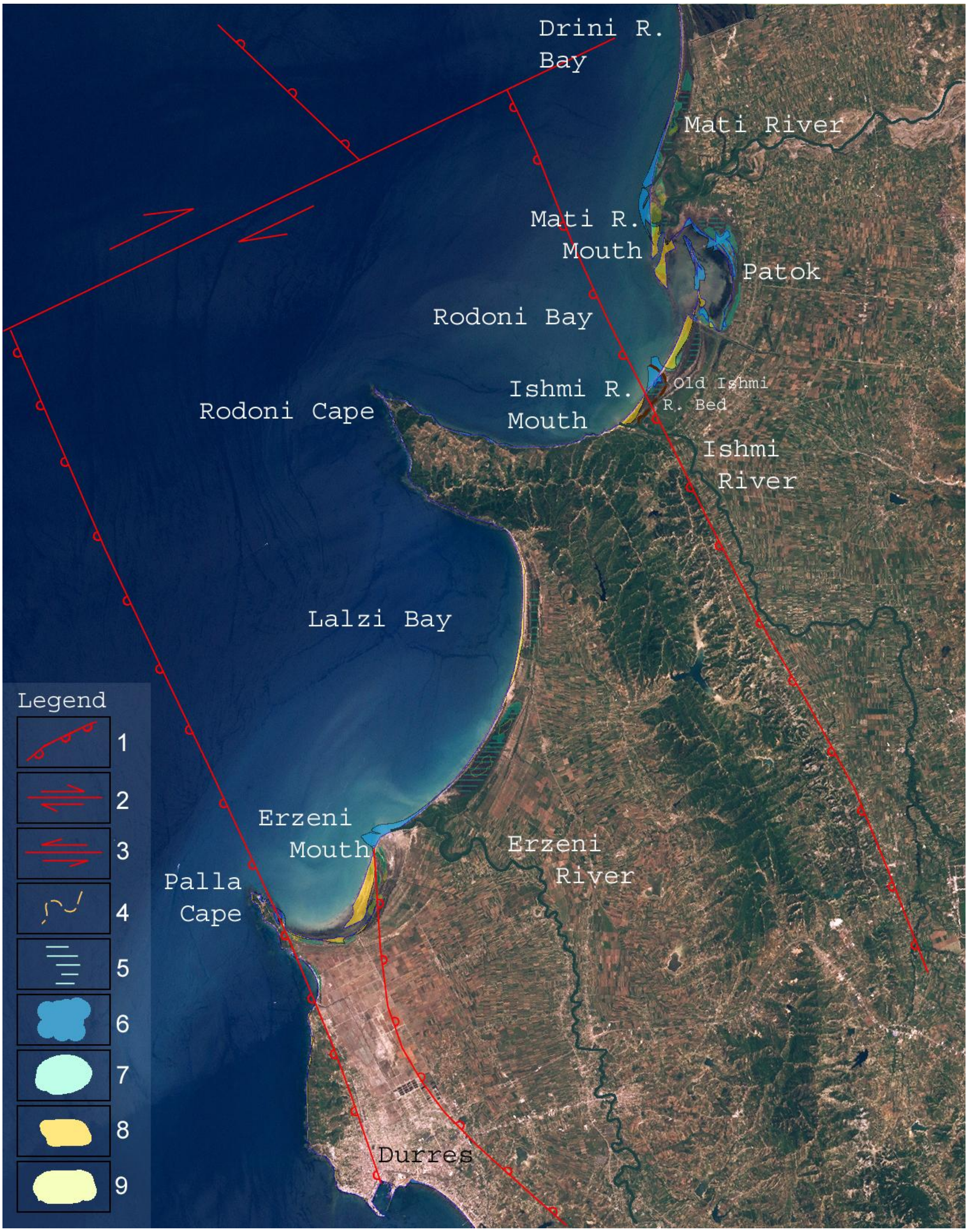


Fig. 11. Geomorphological Evolution view of the Drini Bay-Durrësi Bay coastline in the Albanian Adriatic Littoral after satellite images of the period summer 1977 & 2002 (Global Land Cover Facility Landsat, 2005; the neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).
1- Active reverse fault & thrust; 2- Dextral strike-slip; 3- Sinistral strike-slip; 4- Old Mati River bed; 5- Wetlands; 6- Erosion and marine ingression; 7- Lagoon extension; 8- Coastal deposition; 9- Lagoon surface diminishing.

Fig. 12. Geomorphologic view of Shkumbini River-Vjosa River mouths coastline after satellite images of the period August 1981 & July 1989 & October 2001 (Global Land Cover Facility Landsat, 2005; the neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).

1- Active reverse fault & thrust; 2- Dextral strike-slip; 3- Sinistral strike-slip; 4- Old Shkumbini River bed; 5- Coastal deposition with predecessor erosion; 6- Coastal deposition; 7- Coastal erosion; 8- Submerged littoral area.

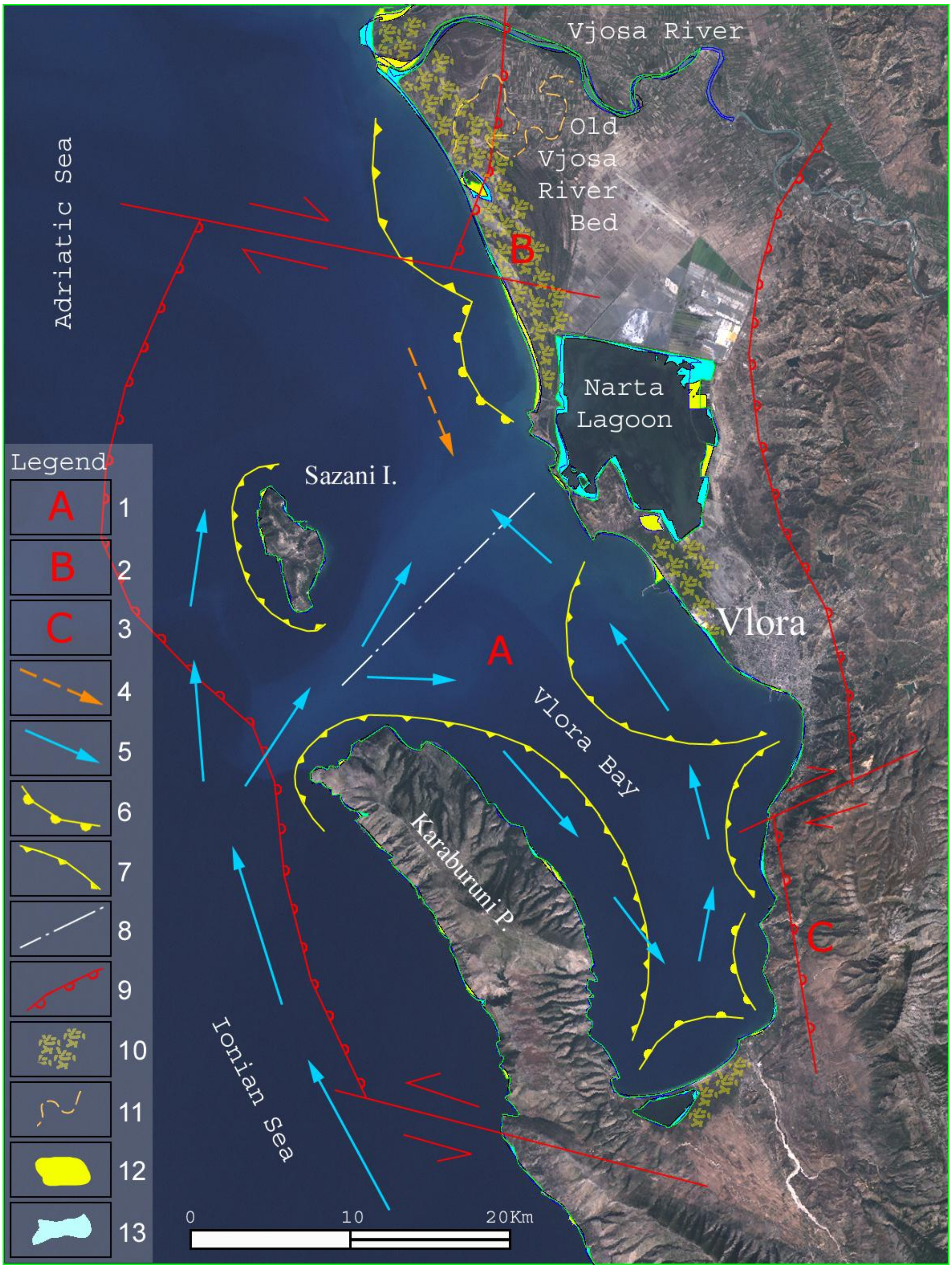


Fig. 13. General Evolution view of the Vlora Bay after satellite images of the period August 1981-July 1989-October 2001 (Global Land Cover Facility Landsat, 2005; Neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).

1- Marine shoal with sand deposits; 2- Littoral with sand beaches; 3- Rocky coastline; 4- Alluvium flow; 5- Marine current direction; 6- Accumulation area; 7- Erosion area; 8- Southern edge of the sediment replacement; 9- Active reverse fault & thrust; 10- Sand; 11- Old Vjosa River bed; 12- Filling coastline; 13- Erosion coastline.

The water potentials of Albanian rivers system is Wo = 41,249.10^9 m^3. The discharge of the Albanian rivers into the Adriatic Sea varies in very wide limits, from Q_o=700-850 m^3/s for the hydrological years of a lower precipitation to Q_o=1850 2150 m^3/s for the years of a higher precipitation (Pano N. 1974, 1984, 2008). The volume of suspended material, which is transported through river network, is 65,7. 10^6 ton/year, while the turbidity Q_o=1 260 g/m^3 (Pano N. 1984). The river suspended matter deposits itself the river mouth in the Adriatic Sea. This process is very dynamic, making the Albanian river's mouths very active. Many changes of the riverbeds position formation of the coastal lagoon, etc. are observed time after time in these mouths. The wind regimes, wave refraction, sea currents, littoral sediment transport, have determined the general dynamics of the change of the Albanian coastline (Pano N. 1994). The period with the wave height of H_1=(0,1-0,2)m represents about 80% of the general cases, while the height of H=(0.2-4.5)m about 20% of them for the average multi annual year. The highest waves have a direction from Northwest to West and a maximum wave height about h=3.5-4.5 meters near shore (Pano N. et al. 1974, Meçe B. 1978). Sea level has an average daily amplitude 0,30-0,40 meters and a multi annual maximal amplitude h=1,14-1,53 meters. The winds in the Adriatic Sea change their direction and speed during a year period as a result of the typical Mediterranean climate. Intensive winds with their maximal speed of 40 – 45m/s particular of NW, W and SW direction were observed in the coastal area. Winds with varying speed form 10 to 20 m/s, have a bigger frequency on waving process. The average annual temperature of the water varies from t=17,7°C in Shëngjini to 19,2°C in Saranda bays (Albanian Climate (Tables), 1978, Mici A. etc. 1975).

Adriatic coastal line from southern city Vlora up to Shëngjini Bay, in the north, have the marine accumulation flattened littoral, the marine erosion coast, and the submerged areas, where is observed marine ingression toward the mainland. In some areas there is cliffed coastline (Aliaj Sh. 1989, 1998, 2000, Aliaj Sh. et al. 2000, Frashëri A. 1987, 1994, Frashëri et al. 1991, Geological Map of Albania 1983, Leci V. et al. 1986, Papa A. 1985).. Evolution of Albanian Adriatic coastline has a very intensive dynamics. There is observed old and present shoreline migration up to 5-10 m/year, during the period from 1918 up to present (Boriçi S. 1981). According to submarine geological mapping and geoelectrical survey data, has been determined that marine deep erosion is developed in accumulation littoral of Adriatic shoal. The sandstone banks have been mapped in western submarine anticline limbs.

Accumulative areas that represent main part of the Albanian Adriatic Sea Littoral are extended over the edge of western Albanian plains (Fig. 10). This littoral is characterized by presence of the different Quaternary (Q) deposits genetic types (Aliaj Sh. 1989, Frashëri A. et al. 1991, Leci V. et al. 1986, Papa A. 1985, Leci V. et al. 1986, Ostrosi 1977). Marine Quaternary littoral deposits, presented by fine, medium, and coarse gray—white, gray-yellow sand, silty clay and mud interbeds present marine Quaternary littoral deposits. Interbeds thickness varies from 1-10-15 meters. Very beautiful sandy beaches are extended from Drini to Vlora Bay. At the present time the shore sand knolls have a length up to 4-5 km, width 35-80 m and some meters highs. At the northern bays, the coarse sand is predominated. Toward the southern part of Adriatic coastal line, fine and medium sand are predominated. This sand belt are composed by two or three parallel onshore dunes. Towards the flat shelf depression, up to –100m depths, the sandy-silt sediments are representative. In inclined shelf area, up to –200 m depths where are also some submarine hillocks, the muddy silt deposits are distributed. Continental slope by argillaceous sediments is characterized. Lithological changes from the shore to the continental slope area are gradually. There are observed some peculiarities, of river solid load distribution in shelf area, conditioned by marine currents. Filling process is intensive, generally, in river mouths. In these accumulative coastline areas there are some relatively small erosion sectors, which are located at the river mouths. In the shoal shelf zone, at the alluvial sea floor are observed the sandy splits. Marine deep erosion zones were developed over some sectors in accumulation littoral of Adriatic shoal. These zones are located in the uplifted side of the active reverse fault & thrust. The capes of the molasses bedrocks of the littoral anticlines of the Periadriatic Depressions have represented the erosion configurations of the Albanian Adriatic sea coastline (Fig. 10). In the Abanian Adriatic Littoral are observed some submerged areas, where is observed marine transgression toward the mainland (Fig. 10). Submerged process is caused by the neotectonics activity, consequently there are observed a marine transgression. Lagoons have a total surface of about 150 $km^{2,}$. Albanian lagoons represent crypto-depressions, with the floor under the level of the sea's bottom.

In the Albanian Adriatic Littoral are observed integrated factors of the coastline evolution: neotectonic's, erosion by marine currents and accumulation of the solid river discharge and eroded shore sediments that have directly an climate change impact. This factors complex has caused important changes on the coastline geomorphology, marine shoal and littoral landscape (Boçi S. 1981, Pano N. 1994, Simeoni U. et al. 1997, Shuitsky Yu. D. 1999). There we are analysed three most representative areas:

Drini Bay. Intensive change dynamics, Viluni Lagoon and Shëngjini portal town characterized this littoral area. The decreased sediment load of the Drini River, caused by its diversion into the Buna, has triggered coastal recession between Shëngjini and Tale, with greater intensity on the southern lobe of delta (Photo 1). Moving southwards, the coast becomes part of the sedimentary system of Mati River (Fig. 11). The coastal area between Tale and Patok can be considered as having a positive sediment budget (Pano N. 1998).

Photo 1. View of Mati River discharge in Adriatic Sea.

Karavasta Bay. The Seman and Shkumbini rivers are the main source of coastal sediments in Karavasta Bay. In ten last years, the coastline has advanced some hundred meters. Semani River mouth has changed in position in the last centuries six times and this displacements have covered on area of the littoral about 15-20 km long in a direction North-South; South-North during period 1870 to present days. In these conditions in the coast area there are two important sources of coastal sediments: the actual rivers mouth and the olds rivers mouths (Fig. 13).
Vjosa River Mouth-Vlora Bay. The general evolution map of coastline in fig. 14 is presented. Vjosa River Mouth has changed its position in the last century two times and these replacements have covered an area of the littoral about 10 km long in the northern direction (Pano N. 1994). The old mouth of this river is undergoing on important erosion process under the wave action. There are two sources of coastal sediments: first, the present Vjosa River Mouth, and second the old Vjosa River Mouth.

4. Conclusions

Based on the results of inversion of the thermologs data, recorded in deep wells and boreholes, for the evaluation of the ground surface temperature GST history and hydrometeorological data, we have arrived in following conclusions:

1. The climate at coastal plain region of Western of Albania was cooled of .6 K before of middle of 19th century. Later a warming of 0.6 K occurred, from last quarter of 19th until present-day.
2. Temperature records in northwestern mountainous region of Albania confirmed also a climate warming of 0.6 K during 20th century. At mountains regions, the warming has started about quarter of century later than at coastal plain area of western Albania.
3. Warming, mainly during the last quarter of the 20th century, is demonstrated also by meteorological data.
4. The rainfall regime changes have their consequences in the fresh water resources of the country, of surface's and underground waters.
5. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes of Albania. on the erosion processes, and on the hydrographic regime of the Adriatic Sea. Impact it is observed first of all on the biodiversity.Coastline has an intensive change and continuously modifying its shape.
7. It is necessary to continued realizing, by a new project, of the analytical integrated studies of environmental impact of the global warming in Albanian territory and its consequences.

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