Can be changes of solar radiation and climate associated to landscape drainage?

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Introduction

Human had modified the hydrological cycle and continues in doing so. It is quite distinct, that territories of many ancient civilizations are a (semi-)desert now. Desertification, local only in the past, has turned into a permanent challenge all over the world now. Rain forests are destroyed in tropics, deforestation continues in the temperate and boreal zones too, a drought increase in Europe can be observed. The man-caused drainage of landscape, decline up to loss of vegetation cover and dewatering are to be observed everywhere and can cause the disturbances in the short water cycle.

It is the Sun's energy that drives the water cycle, plant production and other processes, which cause equilibrium shifts in the biosphere and which enable its development. The amounth of incoming solar energy reaching the Earth surface changes (Kovářová and Pokorný, 2010). These changes are necessary to search in the Earth climatic system as the incoming solar energy is very stable at the top of the atmosphere.

From the five main component of the Earth climatic system it is the atmosphere and its chemical compound, namely carbon dioxid, which is the most overestimated cause of climate change in recent studies. As the cryosphere and the lithosphere could be assumed almost stable or let us say can be of random influence in a case of vulcanism there are the hydrosphere and mainly the biosphere namely with its vegetation part strongly underestimated as a cause of climate change.

Water plays a cardinal role in the climate of the Earth. Temperature on the Earth is relatively stable due to water. Evaporation of water has a principal function in the dissipation of solar energy by transforming it into latent heat. If there is not enough water in the land then more of solar energy is transformed into sensible heat instead of latent heat from evaporated water.

The role of vegetation in the Earth climate system is even bigger than that of water. Vegetation can handle very effectively with water as this enables to hold stable and adequate environment for its life (Pokorný et al., 2010).

The European long term temperature and precipitation data, the solar radiation data and the land cover data are analysed to show the interaction and dependence of local climate at vegetation and water.

Data and Methods

We have analyzed data of more than 50 solar radiation stations for the period 1988-2007 where the records of global and diffuse solar radiation are available and data of almost 200 climatic stations from the years 1800 – 2009 from Europe and neighborhood (North Africa, Arabia, Caucasus too).

The stations are classified through the prevailing landscape occurrence to the classes according to Corine land cover classification 2000. Wetlands are classified according to the Ramsar List of Wetlands of International Importance too. There was a large number of climatic stations accessible in the European Climate Assessment & Dataset database in 2009, the preferably chosen ones were the stations with long and continual series of records reaching up to date so that a more or less uniform coverage of the observed area was secured. We have set limits in the final analysis to the years 1961 – 2009 because of better overall comparability as the longstanding records are available mostly for a landscape type urban area.

The stations were classified into 8 groups according to landscape type: urban area, agricultural land, forest, wetland, polar, desert, low mountain (800 to 1600 meters) and high mountain (1800 to 3300 meters). Because we are interested in effects of vegetation and water on climate, we have halved a year time period into a vegetation period (April to September) and a non vegetation period (October to March). Data were evaluated with conventional statistical techniques.

Results

Direct and diffuse solar radiation

The increase of direct solar radiation accompanied by a decrease of diffuse solar radiation was observed at almost all station in Europe during the periods 1988–1997 and 1998–2007. The rise in ratio of direct to diffuse solar radiation was significant on about 70% of evaluated stations; the remaining stations had only an insignificant or zero growth. The partition of solar radiation into direct and diffuse components on the selected stations in the vegetation periods for the years 1988 – 2007 is illustrated on Fig. 1.

Air temperature

The highest maximum air temperature in vegetation period in the years 1961 – 2009 with regard to latitude has been reached on station of the desert type and it is statistically significantly higher than this temperature regarding to latitude on other types of landscape. This difference amounts 4°C to 8°C on average. A statistically significant difference can be observed between urban area and agricultural land station types on one hand and forest and wetland types on the other hand. As we assumed, forest and wetland are having the maximum air temperature regarding to latitude circa 2°C lower. The air temperature values in highland correspond to the temperature decline as consistent with an altitude (Fig. 2).

The minimum air temperature at desert station type achieves lower values than vice versa the minimum air temperature in the other landscape station types. The minimum air temperature in vegetation season in the period 1961 – 2009 in wetland and forest landscape types is according to latitude higher than in urban area and agricultural land (Fig. 3).

Daily as well as yearly temperature range according to landscape types corresponds to behaviour of maximum and minimum air temperature.

Monthly mean maximum and mean minimum air temperature have increased over the decades, but there is a differential rate of a temperature rise among the landscape types. We observed the largest increase of maximum air temperature in vegetation season in wetland and forest stations and the smallest in desert stations (Fig. 4).

Figure

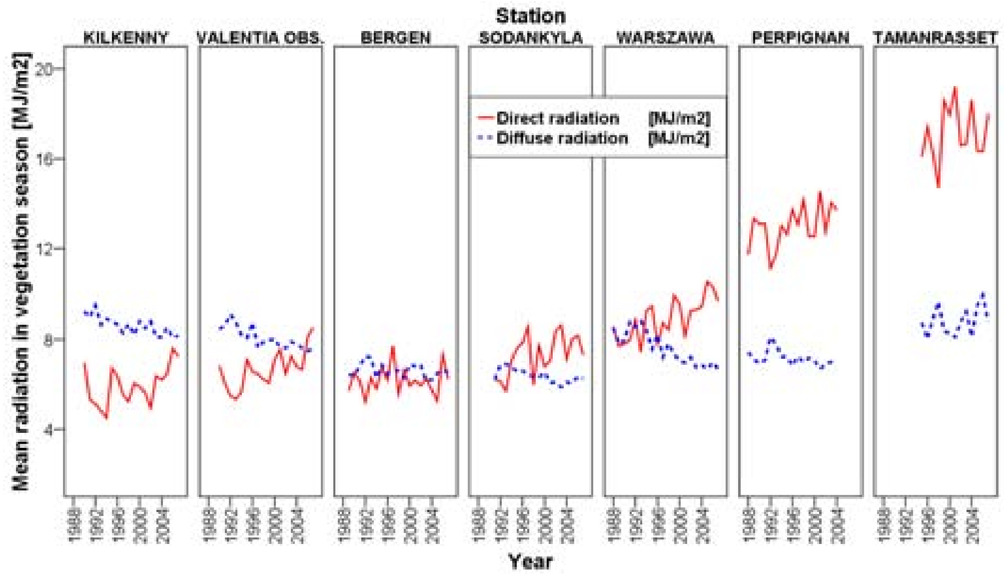

Fig. 1. Direct and diffuse solar radiation in chosen European stations and at the station Taramrasset (Algeria, Sahara) in vegetation season in years 1988-2007 [MJ/m2].

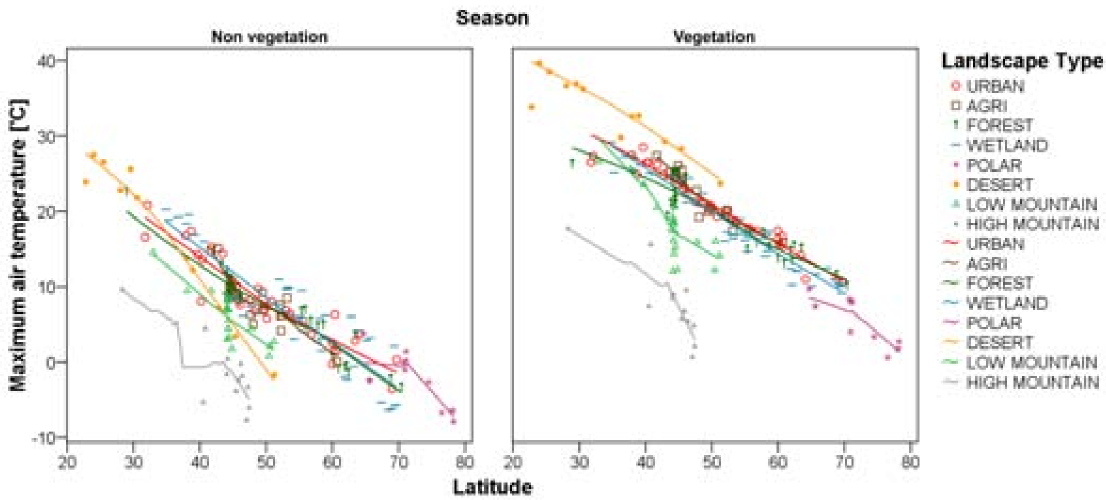

Fig.2. Maximum air temperature according to latitude and a landscape type in non vegetation and vegetation season in the years 1961-2009 [°C].

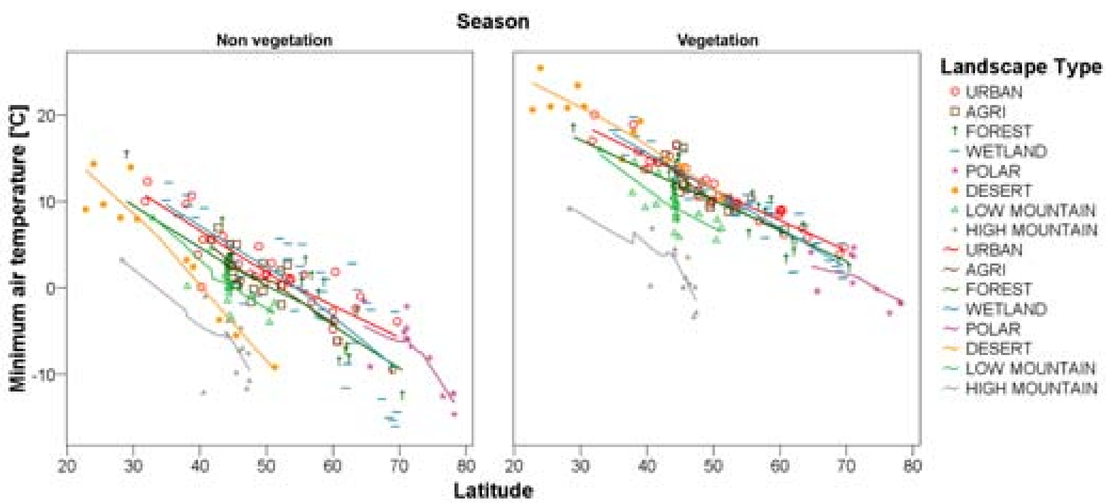

Fig. 3. Minimum air temperature according to latitude and a landscape type in non vegetation and vegetation season in the years 1961-2009 [°C].

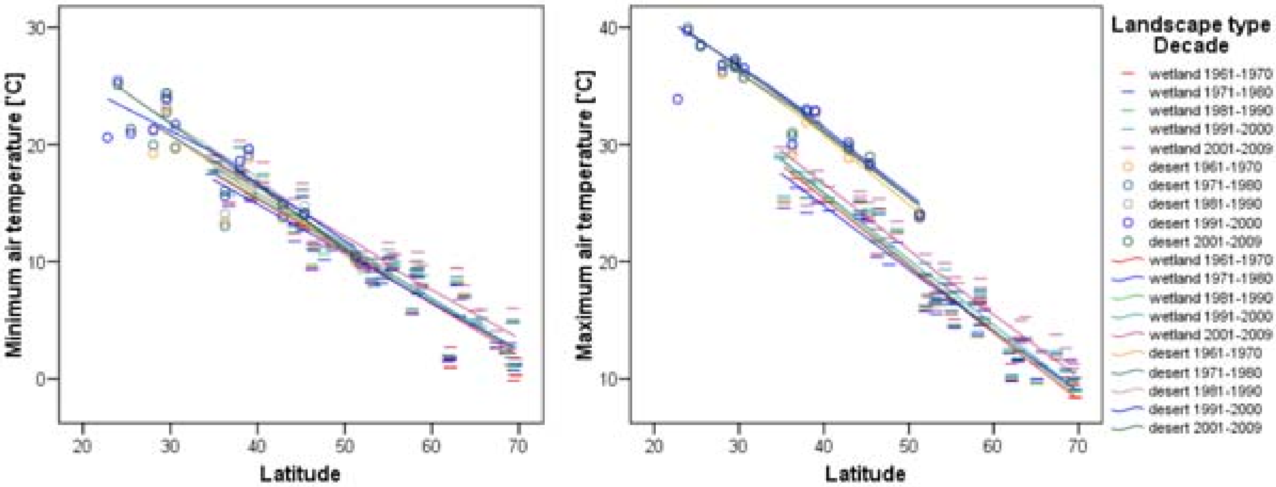

Fig.4. Minimum and maximum air temperature in desert and wetland in vegetation season in decades 1961-1970, 1971-1980, 1981-1990, 1991-2000, 2001-2009 [°C].

Discussion

The original Köppen classification of climatic zones considers geographical position, altitude, water and vegetation to be the main factors determining a type of climate (Köppen, 1936) The proportion of direct and diffuse solar radiation corresponds the availability of water and vegetation and can be on certain conditions regarded as a measurement of a landscape drainage. Although e.g. in India or China a decrease at solar radiation caused by air pollution can be observed, the impact of air pollution is not so significant here in Europe. A stable and high ratio of direct to diffuse solar radiation can be observed in African and Australian deserts. A considerable rise of direct solar radiation accompanied by a concurrent decline of diffuse solar radiation at almost all station can be observed over all Europe.

Maximum air temperature in vegetation season at desert is about 4 to 8 °C higher than a mean maximum air temperature according to its Earth latitude as well as maximum air temperature in vegetation season at wetland, which is 1 to 2°C lower (Fig. 2). It is easy to show that draining of an area causes an increase of maximum air temperature there (Pokorný et al., 2010; Hesslerová and Pokorný, 2010). Minimum air temperature in vegetation season is lower at desert and on the contrary higher at wetland in comparison with mean minimum air temperature according to its Earth latitude (Fig. 3). These both changes cohere with the property of water to dissipate the solar energy (Pokorný et al., 2010). However, draining of an area could cause an increase of temperature not only in the surroundings but even in remote areas (Kovářová and Pokorný, 2010).

Comparison of temperature changes in time in dependence on landscape type (desert and wetland) demonstrates the largest rise of temperature in wetland (Fig. 4, Kovářová and Pokorný, 2010) whereas temperature on desert is relatively stable in long terms. A lowering of evapotranspiration from the Earth surface increases surface temperature (Hayden, 1998). Land use changes on a large scale may modify local climatic conditions (Shaver et al., 2000; McPhearson, 2007). Water and land usage are shifting, they are the fundamentals of climatic changes.

Every change in any component of climatic system is intermediately manifested in a location by a change of local climate. Aristoteles (Meteorologica, 350 BC) has refereed, that shifts in a land usage are coming in too slow for people to observe them, so that a retreat in cultivatable acreage in Nil's delta can be unobserved. The important influence of water and vegetation on climate was noticed also in Middle Ages (Maiestas Carolina, 1353; Colón, 1960). Controversy was held in connection with a plough land expansion in Russia (Moon, 2010). The usage of land has changed since the first agrarian cultures beyond imagination. These changes are taking place far more quickly nowadays owing to the advanced industrialization and more globally too, however they are not included in the meteorological records and it is difficult to include them in the statistical analyses. That could be a cause for underestimating the influence of vegetation and water on climate.

Conclusion

The decrease of available water is manifested almost everywhere in Europe by an increased ratio of direct to diffuse solar radiation, by a decreased number of precipitation days and by an increased period without precipitation.

The comparison of air temperature according to landscapes types shows an unsurprising fact that the maximum air temperature and daily as well as yearly temperature range at desert is higher than that at the other places whereas this temperature is at wetlands and forest lower. Everywhere where a process of a desertification could be followed in temperature data we are able to observe a corresponding temperature rise. The air temperature increases at areas where a decline of available water occurs and latent heat of evapotranspiration shifts to sensible heat. However, the air temperature rises also at areas with good water availability because of a heat transport from the overheated areas.

Water in every state is important to terrestrial climate system. Draining of water from land through deforestation, agriculture and urbanization contributes to climate change. Vegetation cover and water recovery in landscapes are the key measure to mitigate the impacts of climate change.

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RÉSUMÉ (ABSTRACT)

The Intergovernmental Panel on Climate Change has supplied evidence of global climate change, which manifests itself through drought and floods, low predictability of weather, extremes in temperature and precipitation, destructive winds frequently reported in formerly calm areas. Human had modified the hydrological cycle and continues in doing so. It is quite distinct that territories of many ancient civilizations are a (semi-)desert now. Desertification, local only in the past, has turned into a permanent challenge all over the world. Rain forests are destroyed in tropics, deforestation continues in the temperate and boreal zones too, a drought increase in Europe can be observed. The man-caused drainage of landscape, decline up to loss of vegetation cover and dewatering are to be observed everywhere and can cause the disturbances in the short water cycle.

Water and vegetation play an essential role in the climate of the Earth. Air temperature is relatively stable due to water and an evaporation of water plays a principal function in the dissipation of solar energy by transforming it more into latent instead of sensible heat. Changes in land usages and land overgrowth affect biophysical surface fluxes. If there is not enough water in the land, then more of solar energy is transformed into sensible heat instead of latent heat from evaporated water. Huge amount of sensible heat is added here due to new landscape drainage, urban expansion and deforestation every year.

Water in its every state is important for terrestrial climate system. Draining of water from land through deforestation, agriculture and urbanization is contributing to climate change. Vegetation cover and waters recovery in landscapes are the key measure to mitigate the impacts of climate change. Better understanding of natural processes, in order to increase our ability to sustainable manage them, is crucial if that one of the main climate change causes is anthropogenic activity.

An evaluation of selected European climatological and land cover data showing an interaction of water, vegetation and climate will be presented.

Key words: water, vegetation, landscape drainige, temperature