
Annick Douguédroit

Variations of mean annual minimum temperatures in the French Mediterranean region from 1951 to 2010

Annick DOUGUÉDROIT[1] and Sébastien BRIDIER[2]
[1, 2] *Aix-Marseille University, 8-29 Av. R. Schuman, 13621 Aix en Provence Cedex, France*
[1] *CNRS UMR7300 ESPACE, Annick.Douguedroit@ univ-amu.fr,*
[2] *CNRS UMR151 LPED, Sebastien.Bridier@univ-amu.fr*

dated : 15 May 2015

1. Abstract

This paper aims at comparing the evolution from 1950 to 2010 of the average annual minimum temperatures of 34 stations in the French Mediterranean region with the mean global average temperatures with a significant rise in temperatures between 1950 and 2012 divided into two periods, first a slowly descending one till the 70's followed by a second ascending up quickly till the end of the century (Stork et al., 2013). The environment of the French stations has been determined from georeferenced documents of different dates. Their linear evolution has been studied from a dual linear regression starting one at the beginning of the period, the other at the end with the aim of determining if it presented a succession of two periods with different evolution separated by a rupture.

2 Introduction

Changes in average annual global temperatures reveals a significant rise of 0.72°C (0.49°C to 0.89°C) between 1950 to 2012 in which the rapid development of Urban Heat Islands (UHI) and the changes of land use account for over 10% of the trend. It shows a change curve in 2 phases, the first slow down until the 70s was followed by a second ascending quickly especially until the end of the century (Stork et al., 2013). Mean annual minimum temperatures more sensitive than the maximum temperature to UHI development of a set of stations located in the French Mediterranean region is used here to study if the profile of temperature change at regional and local level is similar to the global profile.

3 Data and methods

The study is limited to a European temperate climate region, the French Mediterranean one whose spatial extent is determined by the classification Koeppen-Jaeger revised by Peel (2000). In this region 34 stations with standardized measures of Météo-France network have continuous series from 1950 to 2010, except for some slightly shorter ones (Fig. 1). Annual averages of minimum temperatures were calculated from the monthly averages. From their geographical coordinates contained in the metadata the station environments have been analyzed and determined from different georeferenced documents: satellite images, aerial photographs, topographic maps, CORINE LANDCOVER 2006.

The existence of two successive periods separated by a break has been found in all the trend analyzes of the temperature series studied until about 2012 (Stocker, TF et al., 2013) but, for a same series, the date of the break differs, depending on the technique used. The tests usually applied to the series relate to the passage of a statistical population to another (Test Mann-Kandall for example), which is different from the search for the starting date of a trend. A method based on the analysis of two linear trends, one of increasing duration beginning of the series in 1951, and a second with a decreasing length from 2010, since it is expected, according to the data figures, to find two successive series, has been developed by the authors (Douguédroit and Bridier, 2007). In each of the series of the two trends, the date of the strongest variance obtained by the highest determination coefficient was selected such as the rupture between the two trends.

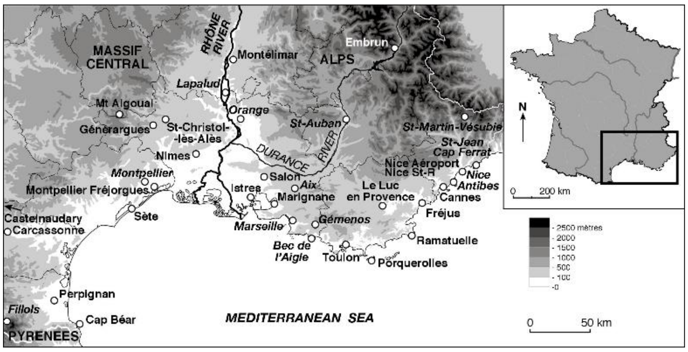

Fig. 1 Location of the stations in the French Mediterranean region

The analysis of the curve of each station includes an observation of the two trends with their slope failures (inflections of the evolution of the linear correlation between temperature and time in the trends).

Station profiles were put together according to the similarity of their trend evolution and associated with a type of environment. The 34 station profiles have been first divided into two main groups “Rural” and “Urban” according to the similarity of their trends associated with a type of environment (Steward and Oke, 2009, 2010). From the analysis of different sources on land use, with the localization error related to the coordinates of each station and the resolution of the various georeferenced documents used 6 environmental groups, each being subdivided into 3 subgroups, were determined: Isolated coastal Semaphores, Isolated inland airports and airfields and Inland Villages in the “Rural” Group, Coastal dense old urban center, Coastal urbanized outskirts and Inland urbanized Outskirts in the “Urban” Group. Some groups, such as urban inland centers, are missing in absence of representative stations. Temperature changing with longitudes at the same latitude, higher in the French Riviera than at the west of the region, stations of each group have similar evolutions of their temperature even if their temperatures are not identical. After curves have been simplified to develop a typical profile per subgroup. Then the profiles of the 6 subgroups have been compared with each other and with the profile of the annual mean average global between two periods placed between 1970 and 1980 as the curves of global and European annual mean temperatures between 1950 and 2012 (Stocker, TF et al., 2013).

4 “Rural” Group

4.1 Isolated coastal Semaphores

This group includes seven stations which spreads all along the French Mediterranean coast. Their curves of average annual minimum temperatures present two successive periods either side of a break around 1980. Before 1980 they present no statistically significant variations. After 1980, they increase significantly of 0.06-0.07°C/10 years up mid-90s or 2000 and then reach a kind of thermal plate (Fig.2: Bec de l'Aigle till 2008 when the station has been closed).

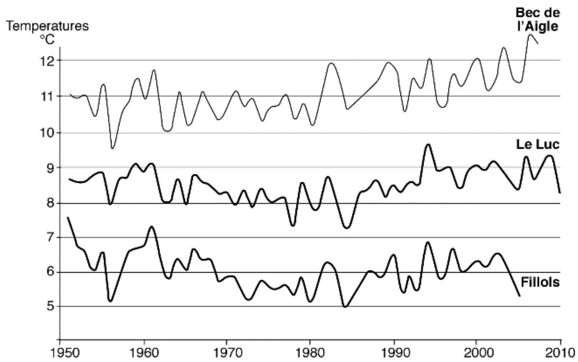

Fig.2. Annual average minimum temperatures in "rural" stations (1950-2010)

4.2 Isolated inland airports and airfields

These stations are installed in 5 airports and airfields remained far from any urbanization throughout the period 1950-2010. From 1951 to the late 70s the average annual minimum temperatures of these stations have a significantly decrease between 0.3°C and 0.34°C/10 years and are always lower than those of the stations of the nearest coastal semaphores. After 1980, their mean annual temperatures significantly increase of 0.06-0.07°C/over 10 years, before reaching a kind of thermal plate (Fig.2: Le Luc). Their evolution presents the succession of two periods with a significant evolution in opposite sense, first decreasing then increasing.

4.3 Inland villages

Some stations are located in villages without any important recent growth. They represent a kind of thermal background evolution which has not been influenced by any urban growth or change in the immediate environment. The only station representing this group in the French Mediterranean region is Fillols which has been closed in 2005 (Fig. 2). The evolution of its average annual minimum temperatures is also divided into 2 periods with a significant thermal decrease till the 70's followed by a significant increase.

5 "Urban" Group

The second great set of stations, the "urban" one, includes 2 main types of environment around the stations, first the dense centers of ancient cities which are represented only by the coastal city of Marseille and second the peripheral urban stations gained by an increasing urbanization in their environment.

5.1 The old dense urban center located on the coast: Marseille

Marseille-Observatory station belongs to a type placed in dense ancient center environment (Old Core according to Stewart and Oke, 2009, 2010) but on the coast. It was closed in 2002. From 1951 to 1979 the average annual minimum temperatures evolve statistically non significantly. Between 1980 and 2002 they increased by 0.8°C/10

(62 % of explained variance), while the warmest years seem reach a maximum in 1994. Over the entire period they rose by about 2°C (Fig. 3).

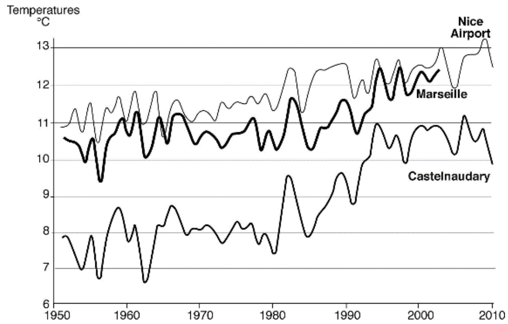

Fig.3. Annual average minimum temperatures in "urban" stations (1950-2010)

5.2 Urbanized coastal outskirts

The French Mediterranean region, including the Riviera, is characterized by strong urbanization spread along the coastline. There is therefore 6 meteorological stations in airports outside the nearest city in 1950 that were later gained by urbanization (Fig. 3: Nice airport). They present a non significant evolution during a first period till the 70's followed by a second period with a thermal increase significant but lower than in Marseille station.

5.3 Urbanized inland outskirts

The whole region has been reached by urbanization because of a strong demographic growth due to its attractiveness. This subgroup contains the largest share of stations, 14, scattered in small and medium cities throughout the region. All the stations have temperature values without significant variations till the 70's. Should we find here an effect of the HUI whose margin they all occupy? This plateau is followed after by a significant increase whose value varies from case to case: between 0.4 and 0.7°C/10 years and which continues until the end of the century and then gently. Castelnaudary station, adjoining the old city center and the edge of a developing industrial area approaches 3°C increase between the end of the 70s and the beginning of the 21st century (Fig. 3, 3) when it is rather less than 2°C in the outskirts of the other cities of the subgroup.

The relationship found in these cases with three phenomena, the general trend in average temperatures worldwide, the changing environment around the station related to local urban dynamism and the same location of the station with respect to the city.

6 Conclusion: 2 periods

The succession of two periods with variations different one from the other characterizes the evolution of the average annual minimum temperatures in the stations of the French Mediterranean region during the period 1950-2010. In each of the 6 subgroups of stations, each corresponding to a particular environment, the temperature profiles of the stations can be represented by a single one profile without temperature reference because all have a similar profile with different temperatures. 6 different profiles are obtained:

Isolated coastal semaphores: a first period of stable temperature followed by a period of increase (Fig. 4, 1)

Inland isolated airports and airfields: a first period of declining temperature followed by a temperature rise (Fig. 4, 2)

Inland village: a first period of temperature decline followed by a temperature rise (Fig. 4, 3)

Old dense urban center on the coast: period of thermal stability followed by a rapid temperature increase (Fig. 4, 4)

Coastal urbanized outskirts: period of thermal stability followed by a temperature increase (Fig. 4, 5)

Inland urbanized outskirts: a period of stability followed by a variable rise of the temperatures, according to the intensity of the urbanization (Fig. 4, 6).

The thermal profiles of 34 stations in the French Mediterranean region can be grouped into two types :

- a profile with a first period of stability followed by a second period with an increase of the temperature (Fig. 4:1,4,5,6)

- a profile with a first period of decline followed by a second period with an increase of the temperature (Fig. 4:2,3).

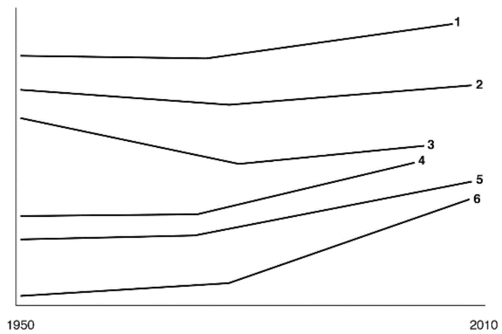

Fig.4. Temperature profiles of the 6 types of stations defined according to their environment

So at the stational and area scales can be drawn on one hand the existence of an increase of the average annual minimum temperatures in the French Mediterranean region either lower or higher than 0.72°C (0.49°C to 0.89°C) estimated from 1950 to 2012 for annual average global temperatures and secondly 2 successive periods defined over the same period as for the globe (Stork et al., 2013). Within these two successive periods, differences in trends between regional subgroups of stations according to their environment are revealed.

References

Douguédroit A. et Bridier S., 2007: Réchauffement climatique et évolution de l'environnement des stations en région méditerranéenne française (1951-2000), *Actes du XXè Colloque de l'Association Internationale de Climatologie*, Carthage, Tunisie, 3-8 septembre 2007, 204-209.

Douguédroit A. et Bridier S., 2008: Sur la détermination de la date du début de la tendance actuelle au réchauffement, *Actes du XXIème Colloque de l'Association Internationale de Climatologie « Climat et risques climatiques en Méditerranée»,* Montpellier, 9-13 septembre 2008, p.201-206.

Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.). IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Oke T. R. 1976: *Boundary layer climate*, Methuen, New-York.

Peel M. C., Finlayson B. L. and Mc Mahon T. P., 2007: Updated world map of the Köppen-Geiger climate classification, *Hydrol. Earth System*, **11**, 1633-1644.w

Stewart, I. and Oke, T. R., 2009: A New Classification System for Urban Climate Sites, *Bulletin of the American Meteorological Society*, **90**, (7), 922-923.

Stewart, I. and Oke, T. R., 2010: Newly developed "Thermal climate zones" for defining and measuring urban heat island magnitude in the canopy layer", Preprints*, T. R. Oke Symp. and Eighth Symp. on Urban Environment*, Phoenix, AZ, Amer. Meteor. Soc., J8.A.