Atmospheric Research 122 (2013) 16–31

Contents lists available at SciVerse ScienceDirect

Atmospheric Research

journal homepage: www.elsevier.com/locate/atmos

Changes in temperature and precipitation extremes observed in Modena, Italy

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ARTICLE INFO

Article history:
Received 13 February 2012
Received in revised form 12 October 2012
Accepted 14 October 2012

Keywords:
Temperature
Precipitation
Trends
Climate indices
Time series

ABSTRACT

Climate changes has become one of the most analysed subjects from researchers community, mainly because of the numerous extreme events that hit the globe. To have a better view of climate changes and trends, long observations time series are needed.

During last decade a lot of Italian time series, concerning several surface meteorological variables, have been analysed and published. No one of them includes one of the longest record in Italy, the time series of the Geophysical Observatory of the University of Modena and Reggio Emilia. Measurements, collected since early 19th century, always in the same position, except for some months during the second world war, embrace daily temperature, precipitation amount, relative humidity, pressure, cloudiness and other variables.

In this work we concentrated on the analysis of yearly and seasonal trends and climate extremes of temperature, both minimum and maximum, and precipitation time series, for the periods 1861–2010 and 1831–2010 respectively, in which continuous measurements are available.

In general, our results confirm quite well those reported by IPCC and in many other studies over Mediterranean area. In particular, we found that minimum temperature has a non significant positive trend of +0.1 °C per decade considering all the period, the value increases to 0.9 °C per decade for 1981–2010. For maximum temperature we observed a non significant +0.1 °C trend for all the period, while +0.8 °C for the last thirty years.

On the other hand precipitation is decreasing, -6.3 mm per decade, considering all the analysed period, while the last thirty years are characterised by a great increment of 74.8 mm per decade. For both variables several climate indices have been analysed and they confirm what has been found for minimum and maximum temperatures and precipitation. In particular, during last 30 years frost days and ice days are decreasing, whereas summer days are increasing. During the last 30-year tropical nights and warm spell duration indices are characterised by a particular strong increment, if compared to the ones of the entire period.

Finally, a cursory comparison between winter precipitation and NAO index was done, showing a high anti-correlation, especially since the second half of 20th century.

1. Introduction

The subject of climate changes has become more and more important, due to the numerous extreme events, such as hurricanes, droughts, floods and so on, that increasingly hit the globe. The study of these events and their frequency is very important in order to understand why they happen and if there are some signs or particular periodicities. Moreover this kind of researches are fundamental in order, first of all, to save human beings, but also to avert or to limit damages done by these extreme events.

In 2007 IPCC published its Fourth Assessment Report (IPCC, 2007), where numerous results, obtained by studies

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http://dx.doi.org/10.1016/j.atmosres.2012.10.022

done all over the globe from different instruments observations (both from singular stations, satellites and models), are collected, to give a global view of climate changes and of the anthropogenic effects on the Earth system; it reported also some projection models results and the potential impacts on the life of human beings.

IPCC described that during the last one hundred years (1906–2005) the global mean surface temperature increased by almost +0.74 °C, particularly during two periods: between 1910 and 1945 and between 1970 and 2005. In the last analysed 50 years the warming rate is equal to +0.13 °C per decade, almost double the one over the last 100 years (+0.07 °C per decade). Moreover it said that, for the northern Hemisphere, the second half of the 20th century was warmer than any other 50-year period in the last 500 years, with the greatest warming during winter and spring. It reported a reduction of daily cold extremes and cold nights, while an increase of warm extremes and warm nights. Finally, diurnal temperature range (DTR) has decreased of about −0.07 °C per decade in the second half of the 20th century, even if in the last decades the change has been smaller.

On the other hand, IPCC underlined the difficulty to give a general global trend for precipitation, because its changes are more spatially and seasonally variable than temperature ones. It reported that, in the considered period, it has become wetter in northern Europe, while drier in the Mediterranean. Moreover an increase of heavy precipitation for many land areas has been found, also for regions where the total amount of precipitation is decreasing. These interannual and interseasonal precipitation variations could be caused by the influence of different atmospheric oscillations, as for example the North Atlantic Oscillation, which influences precipitation over Europe.

To better analyse long-term climate changes, in addition to variations of minimum, maximum and mean temperatures and precipitation, several studies have defined some climate indices to underline the variation of intensity of extreme events (e.g. Klein Tank and Können, 2003; Frich et al., 2002; Moberg et al., 2006; Ramos et al., 2011). Different groups of indices have been created, using thresholds, percentiles and in general values tied with the low or high probability that certain events occur. One of the most used is the group of indices of the Expert Team on Climate Change Detection and Indices (ETCCDI), sponsored by the Commission for Climatology (CCI) of the World Meteorological Organization (WMO), the JCOMM (Joint Commission for Oceanography and Marine Meteorology) and by the CLIVAR (Climate Variability and Predictability) project.

For the investigation of climate changes and trends long time series are fundamental. Italy has a significant historical role in meteorological observations and their improvement, underlined by the creation of several important meteorological instruments and by the development of the “rete of Cimento”, the first observations network in the world (Brunetti et al., 2006b). Several long-term time series are available, thanks to the numerous observatories and institutes in the Italian area; few started to collect data since the 18th century, other since the 19th one. Several climatological works have been done taking into account these stations: studies on minimum, maximum or mean temperatures (Maugeri and Nanni, 1998; Brunetti et al., 2000b), on precipitation (Buffoni et al., 1999; Brunetti et al., 2000a; Piervitali and Colacino, 2003; Pavan et al., 2008), but also on other meteorological variables, as for example pressure (Maugeri et al., 2004). Brunetti et al. (2006b) recently improved their previous studies and they analysed several mean, minimum and maximum temperatures and precipitation time series that almost cover all Italian territory. Another important work has been done by Auer et al. (2007), in which they took into account the HISTALP database and they homogenised and analysed temperature, precipitation, pressure, sunshine and cloudiness records. They reported an increasing trend of about +1 °C per century all over Italy for mean temperature, higher for minimum temperature than for maximum one. On the other hand precipitation is decreasing of about −5% per century, but trends are low and rarely significant.

So far, none of these cited works took into account the relatively long temperature and precipitation time series of Geophysical Observatory of Modena (GOMO) located in the Italian Po Plain, and that have been studied in the present paper. GOMO dataset includes different meteorological variables (temperature, precipitation, pressure, humidity, wind, snow, cloudiness, fog and solar radiation), but in this work only daily maximum and minimum temperatures, during the period between 1861 and 2010, and daily accumulated precipitation, for the period between 1831 and 2010, have been analysed. Data before 1861 for temperature and before 1831 for precipitation also exist but they represent sparse observations, so it was decided to not considered them in this analysis.

These time series have already been studied and published since the early years of the establishment of Geophysical Observatory. However, do not exist recent international climatological studies that analyse the GOMO time series. Among the less old, it could be cited for example Marseguerra et al. (1979), in which daily temperature for the period 1869–1977 has been analysed, estimating minimum, mean and maximum temperature trends equal to +0.14, +0.08 and −0.05 °C per decade respectively, or Aprilesi et al. (1977), in which the stochastic behaviour of daily temperatures during 1892–1975 was studied. Recently, a collection of several information about GOMO history, dataset from all its time series and meteorological events, can be found in Lombroso and Quattrocchi (2008).

The main aim of this work is to analyse temperature and precipitation trends and the time variability of their climate extremes since the beginning of Modena time series, to understand if the climate of this area has changed.

The paper starts with a brief history of Geophysical Observatory of Modena and the description of dataset, its reconstruction and its homogenisation. Thereafter, both minimum (TN) and maximum (TX) temperatures extreme indices are given. Following the analogous analysis for precipitation (PRCP) time series is reported. At the end the conclusions, in which obtained results are summarised.

2. History, description of data and methodology

2.1. History of Geophysical Observatory

On 14th January 1826 in the east tower of the Ducal Palace of Modena (Italy), an astronomic observatory was set