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Climate indicators for Italy: calculation and dissemination

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Abstract. In Italy, meteorological data necessary and useful for climate studies are collected, processed and archived by a wide range of national and regional institutions. As a result, the density of the stations, the length and frequency of the observations, the quality control procedures and the database structure vary from one dataset to another. In order to maximize the use of those data for climate knowledge and climate change assessments, a computerized system for the collection, quality control, calculation, regular update and rapid dissemination of climate indicators was developed. The products publicly available through a dedicated web site are described, as well as an example of climate trends estimates over Italy, based on the application of statistical models on climate indicators from quality-checked and homogenised time series.

1 Introduction

In the context of the United Nations Framework Convention on Climate Change (UNFCCC) and also at the level of European policies, great attention is given to the issue of climate change adaptation. The scientific community recognizes that measures for mitigating greenhouse gases must be accompanied by programs of adaptation in order to reduce the risks and, whenever possible, take advantage of present and future climate change effects. As outlined by the Fourth IPCC Assessment Report (IPCC, 2007), impacts due to global warming, and more generally to climate change, are already evident in many areas of the world. The Mediterranean region is considered a hot spot of climate change (Diffenbaugh et al., 2007; Giorgi, 2006). Due to the specific characteristics of this region, climate change may have wide-ranging impacts that affect socio-economic and production sectors (such as energy, transport, agriculture and tourism) and the environment (including mountainous areas and forests, ecosystems and biodiversity, water resources, coastal areas and marine environment) (e.g. IPCC, 2007; EEA, 2009; EEA-JRC-WHO, 2008). The impacts on human health are expected to be relevant as well (e.g. WHO, 2008). The implementation and evaluation of potential adaptation strategies require accurate knowledge of climate and its variations at the local scale; in addition, the survey of the impacts related to specific features and vulnerabilities of the territory, are needed. This state-of-the-art knowledge should also cover awareness of the uncertainties of the impact estimates, and be continuously updated and clearly communicated to the stakeholders. Instrumental data represent a primary source of information about climate. They are usually archived at daily or sub-daily scales by national and local meteorological networks. Several data sets, which cover different time periods, are useful for the characterization of the recent past climate and its changes over Italy. The identification and estimation of trends in climate time series relies on climate data that meet rigorous criteria of accuracy and temporal continuity. Climate trends may be responsible for different types of impact, already recognized or projected for the near future. Instrumental climate time series are also necessary for the assessment of climate model skill and consequently for tuning the adaptation strategies. In order to address these needs and to build a bridge between climate research and societal sectors involved in climate change impacts, the Italian National Institute for Environmental Protection and Research (ISPRA) has developed a computerized system called SCIA (www.scia.sinanet.apat.it). In the following sections, a description of this project and its related products is provided.

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Table 1. Main meteorological Italian networks and data sources.

Synoptic (GTS dissemination)		
Air Force Weather Service	from ′50s–′60s	~90 stations
ENAV-Italian Company for air navigation services	from ′80s	~40 stations
National Agrometeorological (Ministry of Agriculture)		
Automatic	from 1991	~40 stations
Observatories	from 1860	~30 stations
Regional		
Meteorological services	from ′90s	few tens/region
Hydrological/Civil Protection Network	from ′50s	few tens/region
Agrometeorological services	from ′90s	few tens/region

2 Data sources and climate indicators

In Italy, the meteorological data necessary and useful for climate evaluations are collected, processed and archived by a wide range of national and regional institutions (Table 1). They range from synoptic observations carried out by the national Air Force weather service and the civil aviation agency, to hourly measurements at automatic stations by regional meteorological, hydro-meteorological and agrometeorological networks. Therefore, the density of the stations, the length and the frequency of the observations, the quality control procedures and the database structure vary from one data source to another. The SCIA system has been developed in order to optimize the use of these data for climate knowledge and climate change assessments. It is dedicated to the collection, quality control, calculation, regular update and dissemination of climate indicators, which reflect the main statistical properties (mean values, intensity and date of occurrence of extreme events, standard deviation, etc.), at different time scales (i.e. 10-daily, monthly and yearly), of a wide range of meteorological variables: temperature, precipitation, humidity, wind, water balance, evapotranspiration, degree-days, cloud cover, sea level pressure and solar radiation. All climate indicators are freely available through the SCIA web site. Climatological values over 30-yr reference periods (e.g. 1961–1990) are calculated and available as well. Today, the SCIA system is fed and updated once a year in collaboration with (and with the data of) the national Air Force weather service, the automatic stations of the national agrometeorological network, the meteorological stations of the national Sea Service and twelve regional environmental protection and agrometeorological agencies. Visitors of SCIA can extract, download and plot: (a) the time series of each climate indicator for each single station; (b) the climate indicators for all the stations which are available in a selected time period; (c) the tables and/or the maps of climate normals over standard climatological 30-yr periods. Through SCIA, users can also access secondary products such as high resolution monthly temperature maps obtained by the application of spatial interpolation techniques (regression kriging). In order to guarantee the integration and comparison of indicators obtained from different data sources, all the indicators undergo a common set of quality controls. The general criteria adopted for the calculation of the indicators follow the recommendations of the World Meteorological Organization (WMO, 2010). Although the validity of input data is the responsibility of each data provider, two classes of formal controls are applied to input data before the calculation of the climate indicators. In the first (weak climatological controls), each value must fall within a range delimited by minimum and maximum thresholds, representing the limits for physically acceptable data. In the second (internal consistency controls), the values of different variables at the same time are checked for consistency; for example, air temperature and dew point temperature are checked in order to verify that the latter is not greater than the former.

3 Climate trends estimate

Climate statistics and indicators available through SCIA are used for climate trend recognition and estimation, which are needed for climate impact and vulnerability assessments over Italy, and represent a part of the climate state chapter of the national communications to the UNFCCC. In order to get reliable trends estimates, it is necessary to control and eliminate wrong values from the series and filter out (or at least reduce the influence of) eventual non-climatic signals (i.e. inhomogeneities), such as those due to station relocation or change of meteorological instrumentation. For this reason, time series undergo a number of suitable homogeneity statistical procedures and they are homogenised whenever one or more break points are identified (e.g. Aguilar et al., 2003; Kuglitsch et al., 2009). Then, the variation of climatic variables (in terms of differences or, in the case of

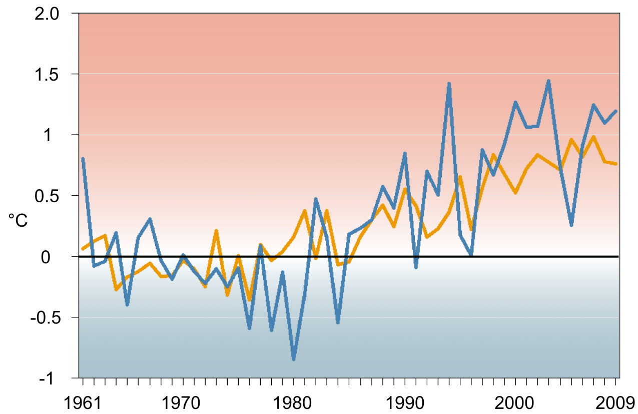

Figure 1. Mean temperature annual anomalies. Italian (blue line) and global land (orange line, data from NCDC/NOAA) series.

precipitation, percentage differences) are estimated through the application of statistical models for trend recognition and linear or piecewise-linear statistical models for trends estimate (e.g. Tomé and Miranda, 2004; Seidel and Lanzante, 2004). The estimation of mean temperature trends over Italy was obtained by averaging annual mean temperatures obtained from homogenised time series of 49 synoptic stations with uniform spatial distribution. The application of a sloped-steps trend model (Toreti and Desiato, 2008a) indicated a slightly negative variation of the mean temperature from 1961 to 1981 (−0.6 °C), followed by a positive trend from 1981 to 2008 with an increase of about 1.6 °C. The estimated net variation from 1961 to 2008 is about +1.0 °C. It is confirmed that the mean temperature increase recorded during recent decades in Italy, as in the Mediterranean basin, is higher than the global mean (see Fig. 1). In particular, in 2008 and 2009 the mean Italian temperature anomalies, with respect to 1961–1990, were 1.09 and 1.19 °C, respectively; while the global mean anomalies were about 0.78 and 0.76 °C, respectively. In Italy, 2009 was the 18th consecutive year with a positive anomaly, and its value is ranked 5th from 1961 until now. Besides average climate indicators, quality checked data series are also used for the estimate of indicators and trends of climate extremes. Regarding temperature extremes over Italy, three indices among those defined by the CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (Peterson, 2005) have been evaluated: the number of days per year with daily minimum temperature less than or equal to 0 °C (frost days); the number of days per year with daily minimum temperature greater than 20 °C (tropical nights); and the number of days per year with daily maximum temperature greater than 25 °C (summer days). Data processing and the results are described by Toreti and Desiato (2008b). Trend estimates are updated yearly, and recently heat wave indicators (number, duration and intensity) have also been evaluated.

4 Conclusions

Besides climate state and trend evaluation purposes, the indicators disseminated through SCIA may be used in several socio-economic contexts, such as energy consumption, water management, agriculture, tourism and health. At the moment, there are several gaps that must be addressed in the near future, in order to better meet the demands for information about the Italian climate. The main limitations concern: (a) the density and the irregular geographical distribution of the observations, which need to include more data sources; (b) the time resolution of climate indicators, which must be increased especially for the evaluation of climate extremes; (c) the frequency and timeliness of updating the climate indicators. Improvement of these aspects would enable better responses to be made to the increasing demand for reliable information on climate and its trends over Italy.

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