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The climate of the Venetian and North Adriatic region: Variability, trends and future change

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ABSTRACT

This editorial analyzes the evolution of the climate of the Venetian region on the basis of the contributions presented at a workshop that was organized in Venice (27–29 October 2008) by CORILA (COnsorzio RIcerche LAguna) and published in this special issue. The workshop considered past and future evolution of the regional climate, sea level, storminess, and allowed a wide discussion of important scientific results and the identification of existing gaps in the present knowledge. In the Venetian plane an unprecedented warming (3.2 °C/century) and a moderate decrease of annual precipitation (−3%/century) are expected at the end of the 21st century, with no analogy in the past 250 years during which there was no sustained centennial trend. The understanding of past sea level evolution is in part problematic. The analysis of the Venice tide gauge time series (and its comparison with that of Trieste) suggests a centennial trend of relative sea level rise (about 1.1 mm/year) comparable to, but smaller than, the global sea level trend. However, past relative sea level in Venice has been strongly affected by tectonic motions and isostatic adjustment. If their estimated effects are subtracted from the tide gauge observation, the sea surface height in Venice would show a centennial trend (0.3 mm/year) that is much smaller than the global mean value. Unless a physical explanation for this low value is found, estimates of vertical land motions for this century need to be reconsidered. Future evolution of sea level is uncertain. Glaciers and ice sheet melting, its regional implications, regional steric effects associated with changes of temperature and salinity are all expected to be important in the future and are not adequately known. A large future halosteric contribution is peculiar for the Mediterranean Sea, where future increased salinity and consequent contraction of the water column could compensate for water mass addition and thermosteric expansion. The time series of storminess is dominated by large interannual and interdecadal variability and there is no evidence of its past or future changes on centennial time scale. Relative sea level trends are very likely to be the main cause of future changes of flood frequency and height, which will, anyway, continue to be strongly affected by large interannual and interdecadal fluctuations.

1. Introduction

Venice and the environment of the Venetian lagoon are the result of a complex interaction between a peculiar morphology and human action. The natural landscape, which existed here in the Roman times has been at the same time preserved and modified by human action, which produced a peculiar civilization. The morphology of the lagoon presented a unique opportunity for the establishment of a unique city, which for its own preservation and safety controlled and maintained an environment that would have otherwise evolved differently over centuries and, eventually, disappeared. The Venetian lagoon is in fact the largest remnant of many similar water extensions that existed here during Roman times. Whether in the future it will be possible to maintain this situation and continue using the past management practice is not clear. The ongoing construction of the movable barriers closing the lagoon inlets shows that new strategies have been decided. The long (and still ongoing) debate on the optimal solutions shows clearly how difficult it is to identify an effective policy on multidecadal time scale. Difficulties arise from the changing environment and climate (particularly sea level), from new societal needs, and from the consequences of previous human induced changes. Climate change, which is a main focus of this extended editorial, is a new factor, whose action is necessary to take into account.

This special issue stemmed from the workshop "The climate in the Venetian and North Adriatic region: variability, trends and change" which was organized by CORILA (COnsorzio Ricerche Laguna) in Venice, 27–29 October 2008. The workshop aimed at understanding the factors that are important for the evolution of the Venetian environment and considered a wide set of topics: historical climatology and climate of the past, northern Adriatic sea level (its variability and trends, its extremes, land motions affecting it), storminess (cyclones, waves and storm surges), regional climate

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change. The presentations held during the workshop have evolved in the articles that are published in this special issue.

The analysis of future climate scenarios at regional scale and their comparison with past variability and trends are fundamental topics. It is important to separate natural variability, which has been active during the last centuries, from the trend that most records show in the last decades, and to produce reliable scenarios of climate future evolution. Essential climate variables, such as temperature and precipitation, have fundamental effects on the environment, e.g. on the hydrographic characteristics of the lagoon and on its ecosystem, and also influence sea level, because of their effect on water density. Section 2 contains a synthesis of the articles that are published in this special issue on the evolution of temperature and precipitation and summarizes the present knowledge for the Venetian region.

Relative sea level is a variable crucial for Venice, the lagoon and the whole flat coastline of the northern Adriatic. Relative sea level changes can be considered as the difference between vertical land motion (active at multiple space and time scales) and changes of sea surface height. Changes of sea surface height are associated with regional changes of mass and volume distribution of the water in the sea, which are caused by changes of sea circulation, temperature, salinity, and are, ultimately, due to the interaction with the atmosphere. The important (and negative) effect of past relative sea level rise is well known and shows how critical even small changes can be for a city whose pedestrian level is mostly about 1 m above mean sea level, with a tidal range from 50 cm (neap tide) to 100 cm (spring tide) on top of which storm surges frequently occur. A small increase of mean relative sea level would dramatically increase the frequency of floods and also change the speed of the erosion of the lagoon (see Section 4 and Plag et al., 2006). The ongoing global sea level increase and the expectation of its acceleration are causes of great concern and could imply a radical future change in the management of the lagoon. Section 3 contains a synthesis of articles that are published on this topic in this special issue and a short discussion of issues that are relevant for regional sea level evolution.

Marine storminess and storm surges are ultimately the causes of present floods of Venice and nowadays the main hazard to the city. Monitoring their evolution and analyzing their future evolution is important, because increase of their frequency or changes of their extreme intensity would have important consequences for the management and planning of coastal defenses. The articles published in this special issues on this topic and a discussion of Venice flood frequency in future climate scenarios are contained in Section 4.

General comments, discussion and a final synthesis are contained in Section 5.

2. Past and future evolution of temperature and precipitation

This special issues contains three manuscripts dealing with analysis of temperature and precipitation:

- Projecting North Eastern Italy temperature and precipitation secular records onto a high resolution grid (here referred to as Brunetti et al., 2010).
- Recovery of the Early Period of Long Instrumental Time Series of Air Temperature in Padua, Italy (1716–2007) (here refereed to as Camuffo and Bertolin, 2010).
- Regional Climate change in the northern Adriatic (here referred to as Zampieri et al., 2010).
- These papers consider different aspects related to the analysis of temperature and precipitation, and of their variation in space and time in the Venetian region.

Brunetti et al. (2010) discuss how to produce a sequence of high resolution (30-arc s) monthly temperature and precipitation fields for North Eastern Italy, by superimposing a highly resolved mean climate field to a coarse monthly anomaly. This resolution is much higher than that presently attainable by climate models and by model re-analysis. The background concept of this study is that the monthly anomaly fields have a spatial correlation scale sufficiently large that they can be estimated by a relatively coarse network of station data, while the fixed-in-time mean climate field (accounting for local morphological features such as level, slope, and distance from the sea) is computed using a dense network. The high resolution fields that are obtained provide information very useful for environmental applications.

Camuffo and Bertolin (2010) describe the results of an accurate reanalysis of a instrumental temperature time series that was recorded over almost three centuries (1716–2007) in Padua, in the Venetian plane, about 40 km from Venice. The authors obtain a time homogeneous record, removing the discontinuities produced by the change of instrumentation, its deterioration or change of observational practice. This is an example of the precious opportunities for accurate description of the past climate that this part of the world (where the longest instrumental time series exist) offers. This careful work, when combined with the reconstruction of precipitation (Camuffo et al., 2010), allows the reconstruction of past climate evolution over almost three centuries. The analysis is suggestive of some small periodic variability of the regional climate with time scales of 35.8 year and 23.9 year, whose presence represents an interesting problem of past climate dynamics.

Zampieri et al. (2010) describe a set of model experiments to examine the future evolution of regional climate conditions in a large area centered on the Venetian region. Multi-model and multi-scenario simulations are included allowing to discuss how the choice of the model affects the results and how climate change signal depends on the level of emission. These models, validated against the available information on the present climate, are the unique tool for analyzing the future evolution of climate that is caused by the increase of greenhouse gases. Results suggest a warming, which is larger in the A2 scenario (about 5.5 K in summer and 4 K in winter) than in the A1B (Nakicenovic et al., 2000). Precipitation is projected to have contrasting trends between winter and summer (positive, +0.5 mm/day and negative, −1 mm/day, over the Alps, respectively). The climate change signal is much stronger for temperature than for precipitation, and for scenario A1B in the period 2021–2050, it is significant for temperature, but not yet for precipitation.

Some further analysis is shown here on the basis of the data produced by Camuffo and Bertolin (2010) and Zampieri et al. (2010). Fig. 1a and b concern the capability of models to reproduce the observed annual mean temperature and total precipitation value in Padua for the period 1961–1990. In both panels the vertical thin red and blue[1] lines represent individual models of the ENSEMBLES (Hewitt and Griggs, 2004) and PRUDENCE (Christensen et al., 2007) projects, respectively. The thick black line represents the observed value. The ENSEMBLE (PRUDENCE) model results are interpolated using a Gaussian red (blue) curve in order to help visualizing their distribution with respect to the observed value, which is inside the spread of the models and not far from their mean value for both temperature and precipitation. Statistics are based on 11 simulations of the ENSEMBLES project and 27 simulations of the PRUDENCE project. Note that the Padua time series are well correlated (the value is larger than 0.8 for both annual temperature and total precipitation) with the average of the E-OBS observational dataset (Haylock et al.,

[1] For interpretation of color in Figs. 1–6, the reader is referred to the web version of this article.