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Variability modes of precipitation along a Central Mediterranean area and their relations with ENSO, NAO, and other climatic patterns

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ABSTRACT

This study analyses a century-long set of precipitation time series in the Central Mediterranean (encompassing the Greek Ionian and the Italian Puglia regions) and investigates the statistically significant modes of the interannual precipitation variability using efficient methods of spectral decomposition. The statistical relations and the possible physical couplings between the detected modes and the global or hemispheric patterns of climatic variability (the El Niño Southern Oscillation or ENSO, the North Atlantic Oscillation or NAO, the East Atlantic or EA, the Scandinavian or SCAND, and others) were examined in the time-frequency domain and low-order synchronization events were sought.

Significant modes of precipitation variability were detected in the Taranto Gulf and the southern part of the Greek Ionian region at the *sub-decadal* scales (mostly driven by the SCAND pattern) and particularly at the *decadal* and *quasi-decadal* scales, where strong relations found with the ENSO activity (under complex implications of EA and NAO) prior to the 1930s or after the early-1970s. The precipitation variations in the Adriatic stations of Puglia are dominated by significant *bi-decadal* modes which found to be coherent with the ENSO activity and also weakly related with the Atlantic Ocean sea surface temperature intrinsic variability. Additionally, important discontinuities characterize the evolution of precipitation in certain stations of the Taranto Gulf and the Greek Ionian region during the early-1960s and particularly during the early-1970s, followed by significant reductions in the mean annual precipitation. These discontinuities seem to be associated with regional effects of NAO and SCAND, probably combined with the impact of the 1970s climatic shift in the Pacific and the ENSO variability.

1. Introduction

Precipitation is a fundamental parameter in the research of climate dynamics whose extreme spatial variability often enforces its study on a regional and/or sub-regional scale, as have been also suggested by the Intergovernmental Panel on Climate Change for regions located in transitional climate areas (Solomon et al., 2007; Trenberth et al., 2007). The Mediterranean basin consists of an area, whose climate conditions are principally controlled by the descending branch of the Hadley circulation (during the summer and early autumn) and the Westerlies zonal flow during the winter season, both of them being major constituents of the general circulation (e.g., Bolle, 2003). The alternation between these fundamental flow systems couples the Mediterranean precipitation with anomalous pressure distribution patterns of the North Hemisphere, mainly with the North Atlantic Oscillation or NAO (Hurrell et al., 2003; Marshall et al., 2001; Wanner et al., 2001; Polonskii et al., 2004), the East Atlantic or EA (Wallace and Gutzler, 1981; Barnston and Livezey, 1987), the Scandinavian or SCAND (Bueh and Nakamura, 2007), the East Atlantic - West Russian or EA-WR (Ionita, 2014), the Indian Monsoon, and probably with even more distant patterns of global-scale climatic fluctuations, such as the El Niño Southern Oscillation or ENSO (e.g., Allan, 2000; Brönnimann, 2007). The Mediterranean cyclogenesis, which is influenced by NAO, SCAND, and the EA-WR variations (Nissen et al., 2010) along with the sea-atmosphere mass and heat flows, are two extra factors that induce further variability in the regional precipitation.

An anomalous climatic event that was recently affecting the entire Mediterranean basin is the significant decline of precipitation between

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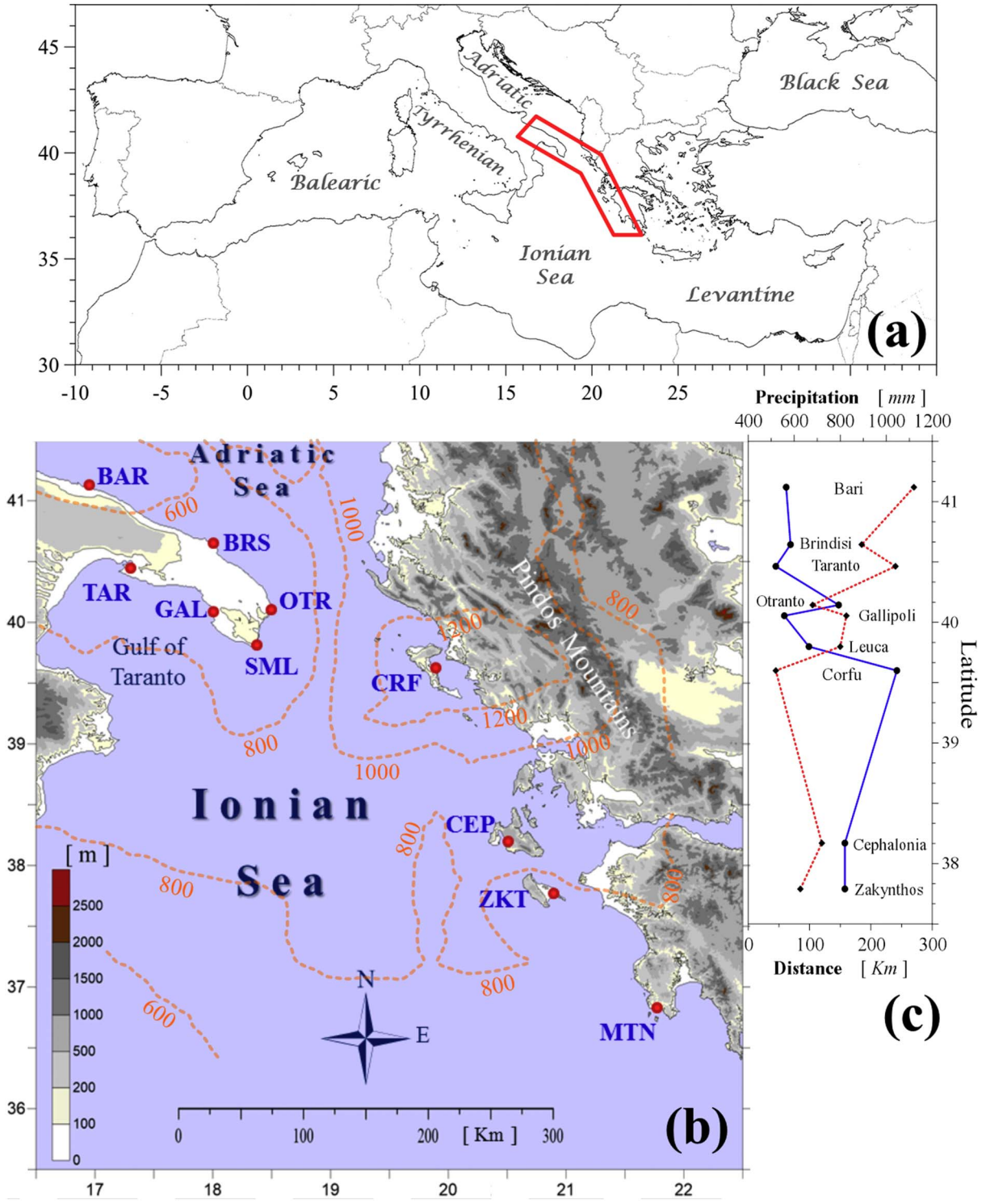

Fig. 1. (a): The location of the studied area in the Mediterranean basin (red polygon).
(b): Geophysical map of the studied area. The position of the ground stations used in this study is indicated by the red dots. The meaning of the acronyms is: Bari (BAR), Brindisi (BRS), Taranto (TAR), Otranto (OTR), Gallipoli (GAL), Santa Maria di Leuca (SML), Corfu (CRF), Cephalonia (CEP), Zakynthos (ZKT), Methoni (MTN). The *annual* precipitation height field curves (in mm) implied by the TRMM over the period 1998–2012, are shown by the orange dashed lines.
(c): Variation of the mean annual precipitation height (over the period 1921–2010) in respect to the latitudinal position of the indicated stations (blue line, scale at the top). The corresponding distance of each rain gauge from the main orography (height ≥ 1 km) of the Balkans coastline is also shown by the red line (scale at the bottom). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

the early 1970s and 2000. This event is caused by a persisting NAO positive phase (initiated at an epoch where protracted El Niño events and strong inter-decadal activity developed in ENSO) under the enhancing effects of SCAND and EA-WR (e.g., Krichak et al., 2002; Krichak and Alpert, 2005). Then, dryness became more evident in parts of the Central and Eastern Mediterranean, particularly in the Italy–Greece region (Norrant and Douguédroit, 2005). This area, which is actually comprised by the Ionian Sea (Fig.1a), is one of the least-studied