Reply to the referee #1 comment of 13-March-2014

General comments

In my opinion since the project refers to the whole Mediterranean region, there was an unequal presentation of the results concerning western and eastern Mediterranean. In fact for the western Mediterranean the authors give a full report and analysis of the facts, episodes and results that were found, while for eastern Mediterranean the description is limited in 2 or 3 facts and episodes with a complete lack of the extreme events in eastern Mediterranean in the calendar (both of wind and rainfall). Similarly, in the analysis of literature there are plenty of references and analysis of previous studies regarding western Mediterranean while for the eastern part the references are very limited.

The first thing that needs to be highlighted is that this paper tries to be a review about the MEDEX activities and results only, not on research about cyclones and adverse weather in the Mediterranean in general. Nevertheless, we agree that the inclusion of some additional references to work done prior to MEDEX or beyond MEDEX is useful to the reader. Some references in this sense were already included in our initial manuscript, but we have added some other, mainly referred to the Eastern Mediterranean or coming from that part of the region, in order to improve the information and also to compensate a possible disequilibrium between East and West. In any case, we have to insist that in this paper we are not looking at all for exhaustiveness with regard to non-MEDEX research.
About MEDEX itself, it is true that this project refers to the whole Mediterranean region, but it is also true that it was mostly based on the voluntarism of the participant institutions. In this sense, the number of the participating institutions from the Western Mediterranean was not the same than from the Eastern part. On the other hand, for different reasons the degree of involvement of different institutions was not uniform. In particular, with regard to data collecting, the only data owner institution of the Eastern Mediterranean area that provided information was the Bulgarian meteorological service. A certain disequilibrium between East and West existed in MEDEX, therefore it is normal to appreciate it in an overview about MEDEX.

Specific comments

1. I was wondering the thresholds extremes (60mm/day for rainfall and 20 or 25m/sec for wind) are they results from a statistical analysis or statistical methodology or did the authors took them arbitrarily?

There are several options to define thresholds for heavy precipitation and strong wind, when thinking on calendars of events with potential social impact.
As known, the (negative) social impact of an intense meteorological event depends, not only on the intensity of the phenomenon, but also on the vulnerability. The vulnerability depends on the population density, degree of urbanisation, presence and condition of infrastructures and so on. But it also depends on the rarity or frequency of the phenomenon, that is, of the climatology, because there is a certain natural and human adaptation to frequent phenomena, even if they are very intense. Extreme options are to

determine different thresholds everywhere, by taking into account all the aforementioned factors (a really difficult task) or to adopt unique thresholds for the whole territory. An intermediate option is the pure climatological approach, through computing thresholds for every station, with reference to pre-defined percentiles or return periods; this is also complicate and needs complete climatological information. Note that MEDEX has used thousands of climatological stations.
The decision taken in MEDEX was to adopt a threshold system as simple as possible. There is only a very partial reference to climatology. The decision was taken by consensus within the MEDEX community and it was not contested by the WMO WWRP Steering Committee.
Regarding precipitation, it is assumed that accumulations of 60 mm per day can produce damages, mainly trough flash flooding, if they affect inhabited zones or headers of certain rivers or streams. Therefore, although in some areas 60 mm do not produce significant impact, this threshold was adopted for simplification by the MEDEX community for the whole Northern Mediterranean area. It was already used as a threshold for the Northern Mediterranean in the former WMO Mediterranean Cyclone Project (MCP). On the contrary, a threshold of 30 mm per day was adopted in MCP for the Southern Mediterranean. This climatological differentiation probably would also have been considered if data from the Southern Mediterranean were actually integrated in the MEDEX calendar. Note, for instance, that one of the most dramatic hydro meteorological events in the Mediterranean, the 1-2 November 1994 flooding in Egypt, with 500 human life looses (Obassi, 1997, Address, INM/WMO International Symposium on Cyclones and Hazardous Weather in the Mediterranean, Palma de Mallorca, Spain, April, pp. 21–25), occurred with relatively modest precipitations, under 20 mm according to direct measurements or up to 58 mm according to estimations (Krichak et al, 2000, Atmos. Res., 53, 45-62; Gheith and Sultan, 2002, Jour. of Hydrology, 263, 36-55).
Regarding wind and also thinking on impacts, sustained winds of 18 m/s or gusts of 25 m/s are considered to be dangerous in general, but not in the most windy locations or regions. On the other hand, in the most windy locations or regions the general threshold is so frequently overpassed that it would be inconvenient to retain so many events. For that reason, for some particular weather stations in Spain and for the whole French Mediterranean areas the thresholds were increased to 25 m/s for sustained wind and 33 m/s for gusts. From some farther work, it seems that, thinking on impacts, the adopted thresholds are quite representative (see, for instance, Amaro et al, 2010, or Papagiannaki et al., 2013).

To gain clarity, we propose to change the initial text in pg 546, lines 4-8,

“The threshold for precipitation is 60 mm/day. The thresholds for wind depend on the climatological characteristics of the station. The usual thresholds are 18 m/s for maximum sustained wind (ten minutes average) and 25 m/s for the maximum daily gust, but for the windiest stations the thresholds are increased to 25 m/s and 33 m/s respectively.”

by the following:

*"**The MEDEX community adopted a very simple threshold system for precipitation and wind. The threshold for precipitation is unique for the Northern Mediterranean, 60 mm/day. Note that the MEDEX calendar does not include data from the Southern Mediterranean, which is climatologically drier, what would demand a lower threshold. The thresholds for wind do depend on the climatological characteristics of the station or the region. The general thresholds are 18 m/s for maximum sustained wind (ten minutes average) and 25 m/s for the maximum daily gust, but for the windiest stations or windiest regions the thresholds are increased to 25 m/s and 33 m/s respectively.**"*

2. In the calendar of the extreme events countries as Bulgaria, Croatia, France, Italy, Spain are included while others like Greece, Turkey, Cyprus, Israel are not found. Especially for Greece there are numerous days with precipitation over the 60mm/day limit and also many days when extreme winds blow over the Aegean Sea making the sailing of the ships impossible.

The calendar of extreme events, which is included as part of the MEDEX Database, was exclusively constructed with data supplied by some of the participant institutions, which voluntarily acted as data providers. Of course, only the participant institutions that were data owners could act as data providers. Possibilities of obtaining (some) data from external sources existed, but it was decided not to use them and in fact data from external sources were not obtained and in consequence were not included. Unfortunately countries in the Eastern and Southern Mediterranean remained without data in the MEDEX calendar. Things cannot be changed later: a paper on MEDEX cannot give information about data that were not collected.
Following in certain way the example of MEDEX, additional databases have been created later, in other Mediterranean countries, for example, in Greece. To report on this we propose to add the following text at the end of section 3.1:

*"**Following the example of MEDEX various data bases of high impact weather events have been created later. Namely Papagiannaki et al. (2013) have recently presented a database that covers all the high-impact weather events that occurred over Greece during the period 2001-2011 (201 events in total), while it is continuously updated to provide systematic monitoring and the foundation for future long-term impact analysis."***

3. I agree with the authors comments that numerous extreme precipitation events can occur with shallow depressions. They presented analytical and persuasive examples for western Mediterranean while once again for eastern Mediterranean not even one example is presented (with extreme precipitation due to a shallow depression system). One classic example of this atmospheric circulation over the eastern Mediterranean is a combination of high surface pressure over central and eastern Europe and shallow low pressure to the south of Italy and Peloponnisos while in the upper levels low geopotential heights or a cut off low cover the southern Balkan Peninsula. This combination of the upper atmospheric circulation centers with the orography in the eastern parts of Greece (mountain Olympos, Ossa, Pilio and the mountains of Eubia)

have as a result the extreme rainfall totals even in the eastern regions of the aforementioned mountains. These precipitation heights may exceed 100mm/day or even 200mm/day. Thus in my opinion an updated project like MEDEX should have as a priority the examination of the dynamical and other causes of the extreme precipitation values.

Some papers on the relationship between cyclones and heavy precipitation in the Eastern Mediterranean were already included in the introductory part of our paper. Nevertheless, we recognize that there is disequilibrium between East and West regarding the detail in which this question is considered in each area. Although we find difficulties to find works in which heavy precipitation is explicitly related to a shallow depression in Eastern Mediterranean particular cases. On the contrary, there are studies concerning Eastern Mediterranean particular cases in which the orographic effect and the effect of a cold air surge are considered. We propose a modification of the text in pg. 538, lines 3-5, in order to improve the information.

Initial text:

"Regarding the Eastern Mediterranean, some studies also relate heavy rain with cyclonic presence (see Kotroni et al., 2005; Ziv et al., 2006; Houssos et al., 2008, among others)".

New text:

*"**Regarding the Eastern Mediterranean, some studies also relate heavy rain with cyclonic presence (see Xoplaki et al., 2000; Kotroni et al., 2005; Ziv et al., 2006; Houssos et al., 2006, 2008; Tolika et al., 2007; Lagouvardos et al., 2007; among others). Especially over Greece heavy precipitation amounts and / or heavy snowfall can be related with cold surges that are accompanied with the passage of a fast moving cold front from the north towards the south, gale force winds, especially in the gaps between mountains in northern Greece and over the Aegean Sea. A sharp temperature decrease over the whole country and a sharp pressure rise are also observed. In the frame of these cases heavy rainfall amounts may exceed 100 mm in 24 hours. The lifetime of these surges is normally from 1 to 3 days, extending up to 10 days in exceptional cases (Lagouvardos et al., 1998).***

***In other papers (Toreti et al., 2010; Reale and Lionello, 2013) the connection between cyclones and heavy precipitation is considered in general, for the whole Mediterranean region (East and West).**"*

The text modification supposes the inclusion of the following new references:

Houssos, E.E., and A. Bartzokas: Extreme precipitation events in NW Greece. Advances in Geosciences, 7, 91–96, 2006.

Lagouvardos K., V. Kotroni, and G. Kallos: An extreme cold surge over the Greek Peninsula. Quarterly Journal of Royal Meteorological Society, 124, 2299-2328, 1998.

Reale, M. and P. Lionello: Synoptic climatology of winter intense precipitation events along the Mediterranean coasts. Nat. Hazards Earth Syst. Sci., 13, 1707–1722, 2013, doi:10.5194/nhess-13-1707-2013

Tolika, K., Chr. Anagnostopoulou, P. Maheras and H. Kutiel: Extreme precipitation related to circulation types for four case studies over the Eastern Mediterranean. Adv. Geosci., 12, 87–93, 2007.

Toreti, A., E. Xoplaki, D. Maraun, F. G. Kuglitsch, H. Wanner and J. Luterbacher: Characterisation of extreme winter precipitation in Mediterranean coastal sites and associated anomalous atmospheric circulation patterns. Nat. Hazards Earth Syst. Sci., 10, 1037–1050, 2010.

Xoplaki, E., J. Luterbacher, R. Burkard, I. Patrikas and P. Maheras: Connection between the large-scale 500 hPa geopotential height fields and precipitation over Greece during wintertime. Climate Research, 14, 129-146, 2000.

4. Even though the authors in the literature analysis mention that they will not present a historical overview of the studies concerning the cyclones in the Mediterranean region, I believe that the present study lacks of several important studies regarding mainly authors from the eastern parts of the Mediterranean region as follows: a) The studies of the French meteorologist M Berenger are missing who for the period 1955-1963 analyzed the depressions in the Mediterranean. M. Berenger is the first to study systematically the depressions in the Mediterranean and the authors can find the literature in the library of Meteo-France. b) Also, recent important studies such as Flocas et al for the cyclones in the Mediterranean are missing (explosive cyclones, climatological aspects, vertical structure, tracks). c) Final the authors should add the studies of Kallos et al concerning the forecasting of explosive cyclones in the Mediterranean.

a) Unfortunately we have not been able to find the paper or to identify the exact reference in which M. Berenger analysed the 1955-1963 Mediterranean depressions, although the Météo-France Library has been consulted, as well as databases of bibliography and lists of references of classical papers on Mediterranean cyclones.

b and c) Although we have to insist that this paper deals with MEDEX and it is not a general overview on research about Mediterranean cyclones, some references have been added to the initial manuscript, in the following form:

A reference on explosive cyclones have been included in the introductory part, as an addition to the first paragraph, after the end of line 25, pg. 536:

*"**It is almost obvious that severe weather has to accompany explosive cyclones, which are not so rare in the Mediterranean (Kouroutzoglou et al., 2011)"***

In order to collect some non-MEDEX historical and recent work on Mediterranean cyclones climatology, an initial paragraph is proposed to be included at the beginning of Section 4.1 (pg. 549, line 15):

*“**Before MEDEX or simultaneously with it, although independently of this project, important work has been done concerning the climatology of the Mediterranean cyclones. Prior to describe the climatological work done within MEDEX, it is worthy to mention some of the more relevant non-MEDEX papers, published since 1990, : Alpert et al., 1990a, 1990b; Flocas and Karacostas, 1996; Trigo et al., 1999, 2002; Flocas et al., 2001, 2010; Maheras et al., 2001, 2002; Kouroutzoglou, 2011. It is also relevant and worthy to mention climatological MedCLIVAR work, partially done in collaboration with MEDEX (see Lionello et al., 2006, and Ulbrich et al., 2012, for a review).”***

Regarding dynamical processes, Section 4.2, the following has been added after “lee cyclogenesis”, in line 17, pg. 552:

“***Also Flocas (2000) had used the PV inversion to diagnose cyclogenetic processes***.”

At the end of Section 4.2 we propose to add:

“***Without direct connection with MEDEX, the processes involved in Mediterranean explosive cyclogenesis have been studied by Kouroutzoglou et al. (2012).”***

The former text modifications suppose the inclusion of the following new references:

Alpert, P., B.U. Neeman and Y. Shay-El: Intermonthly Variability of Cyclone Tracks in the Mediterranean. Journal of Climate, 3, 1474-1478, 1990b.

Flocas, H.A., and T.S. Karacostas: Cyclogenesis over the Aegean Sea: identifications and synoptic categories. Meteor Appl., 3, 53-61, 1996.

Flocas, H.A.: Diagnostics of Cyclogenesis Over the Aegean Sea Using Potential Vorticity Invesrion. Meteorol. Atmos. Phys., 73, 25-33, 2000.

Flocas H, Maheras P, Karacostas T, Patrikas I, Anagnostopoulou C.: A 40-year climatological study of relative vorticity distribution over the Mediterranean. International Journal of Climatology, 21(14): 1759–1778, 2001, DOI: 10.1002/joc.705.

Flocas, H.A., J. Simmonds, J. Kouroutzoglou, K. Keay, M. Hatzaki, V. Bricolas and D. Asimakopoulos: On Cyclonic Tracks over the Eastern Mediterranean, Journal of Climate, 23, 5243-5257, 2010.

Kouroutzoglou, J., H. A. Flocas, K. Keay, I. Simmonds and M. Hatzakia: Climatological aspects of explosive cyclones in the Mediterranean. Int. J. Climatol. 31: 1785–1802, 2011, DOI: 10.1002/joc.2203

Kouroutzoglou, J., H.A. Flocas, M. Hatzaki, K. Keay, and I. Simmonds: On the Dynamics of Mediterranean Explosive Cyclogenesi, in C.G. Helmis and P.T. Nastos (eds.), Advances in Meteorology, Climatology and Atmospheric Physics, Springer Atmospheric Sciences, DOI 10.1007/978-3-642-29172-2_80, # Springer-Verlag Berlin Heidelberg 2012

Lionello, P., Bhend, J., Buzzi, A., Della-Marta, P.M., Krichak, S., Jansa, A., Maheras, P., A. Sanna, A., Trigo, I.F. and Trigo, R.: Cyclones in the Mediterranean region: climatology and effects on the environment. in

Lionello, P., Malanotte-Rizzoli, P., Boscolo, R. (Eds.) Mediterranean Climate Variability. Elsevier, Amsterdam, The Netherlands, pp. 325-372, 2006

Maheras P, Flocas H, Patrikas I, Anagnostopoulou C. A 40 year objective climatology of surface cyclones in the Mediterranean region: spatial and temporal distribution. International Journal of Climatology 21(1): 109–130, 2001, DOI: 10.1002/joc.599.

Maheras P, Flocas H, Anagnostopoulou C, Patrikas I.: On the vertical structure of composite surface cyclones in the Mediterranean region. Theoretical and Applied Climatology 71(3–4): 199–217, 2002.

Trigo I, Davies T, Bigg G.: Objective climatology of cyclones in the Mediterranean region. Journal of Climate 12(6): 1685–1696, 1999

Trigo I, Bigg G, Davies T.: Climatology of cyclogenesis mechanisms in the Mediterranean. Monthly Weather Review 130(3): 549–569, 2002, DOI: 10.1007/s00382-005-0065-9.

Ulbrich, U., Lionello, P., Belusic, D., Jacobeit, J., Knippertz, P., Kuglitsch, F.G., Leckebusch, C., Lutebacher, J., Maugeri, M., Maheras, P., Nissen, K.M., Pavan, M., Pinto, J.G., Saaroni, H., Seubert, S., Toreti, A., Xoplaki, E., and Ziv, B.: Climate of the Mediterranean: Synoptic Patterns, Temperature, Precipitation, Winds, and Their Extremes. In Lionello, P. (Ed.), The Climate of the Mediterranean Region: from the Past to the Future. Elsevier, Amsterdam, The Netherlands, pp. 301-346, 2012

References to Kallos are already included in various papers by Kotroni et al. and Lagouvardos et al.

Technical Corrections:

- page 539, line 13: the authors should erase “due” which is written twice.

Made in the manuscript

- Page 545, line 18: they should close the parenthesis “)”

Made in the manuscript

- Page 550, line 13: it should be summer and not “summery”

Corrected in the manuscript

- Page 555, line 14: change “systenmatic” to “systematic”.

Corrected in the manuscript