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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "A method to estimate freezing rain climatology from ERA-Interim reanalysis over Europe" *by* Matti Kämäräinen et al.

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Referee comment on the paper "A method to estimate freezing rain climatology from ERA-Interim reanalysis over Europe" with authors M. Kämäräinen et al.

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General comments The paper describes a method for estimation of the freezing rain (FZRA) climatology from the ERA-Interim reanalysis. The method is based on an algorithm for determination of the precipitation type, which uses the vertical profiles of relative humidity and air temperature. The algorithm is briefly described and then the results from its evaluation and calibration with SYNOP weather station observations are presented. Finally, the method is applied on gridded data from the ERA-Interim reanalysis for estimation of some characteristics of the freezing rain events in Europe

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such as mean annual and monthly numbers, duration and spatial extent.

The paper is structured in 5 paragraphs as follow: a pertinent abstract with briefly and clearly summary of the work done; an introduction with brief description of the previous and related work in this field, the topicality of the problem and the data and methods used; a paragraph with description of these data and methods, followed by a paragraph with the results and the main body of the manuscript concludes with two paragraphs for discussion and conclusions. The availability of the data is given in paragraph 6 and the verification measures, used in paragraph 2, are presented in a separate annex.

The manuscript represents a substantial contribution to the climatology of freezing rains in Europe. As the authors correctly point out, despite the severe impact of this phenomenon, the publications on its climatology for the European region are quite few in contrast to these for North America. Thus the proposed publication is timely. The used approach for estimating of the FZRA climatology, based on the application of the proposed evaluated and calibrated method on gridded meteorological data, is appropriate and ensures spatial and temporal cohesion of the results, despite some uncertainties.

The description of the data and the methods used is sufficiently complete and accurate and allows reproduction.

The consideration of previous and related work is also sufficient and the cited references are appropriate.

The conducted research is sound and comprehensive and the achieved results are discussed in an appropriate and balanced way.

Specific comments

I would recommend the authors replace the references Rauber et al., 2000; Carrière et al., 2000 for the warm rain process (page 2) with (or add) the following two:

Bocchieri, J., 1980: The objective use of upper air soundings to specify precipitation

type. Mon. Wea. Rev., 108, 596–603. Huffman, G. J., and G. A. Norman Jr., 1988: The supercooled warm rain process and the specification of freezing precipitation. Mon. Wea. Rev., 116, 2172–2182.

I disagree with the decision of the authors to exclude most of the stations from eastern Europe. It seems that they have erroneously interpreted the explanations of Bezrukova et al. (2006) for the different definitions of FZRA events in these countries. Indeed, sometimes the icing due to supercooled clouds or fogs may deposit as glaze (wet growth process) and then the symbol for glaze is written down, but such a case will never be reported as freezing rain or freezing drizzle in the WMO weather codes. This ambiguity concerns mostly the local meteorological archives where additional control is needed to distinguish between both events. The weather codes 24, 56, 57, 66 and 67 are not affected at all. By this reason the authors (of Bezrukova et al., 2006) have decided to restrict only to the WMO codes.

The authors of the manuscript have also filtered the data outside the interval –30oC Ãů + 10oC, which seems to be too wide. Most often FZRA occur in the interval –10oC Ãů 0oC, so an appropriate interval for filtering, in my opinion, would be –15oC Ãů + 5oC. This would prevent to a certain extent from misclassification of ice pellets as FZRA or FZDR.

The finding that the altitude does not contribute to the explain variance is somehow surprising for me. One would expect that the number of FZRA and their duration would decrease with the altitude because of the decreasing of the depth of the near-surface cold layer and FZRA aloft should be even more rare event than the FZRA at the ground. However, mountain ranges mostly caused cold air damming which is difficult to be recognized in data sets with coarse resolution.

The vertical resolution of the FMINWP seems to be not very appropriate for detailed representation of the vertical profiles of the relative humidity and the air temperature, which would affect the correct estimation of the near-surface cold layer and the melting

layer above. It can be seen that an increasing of the resolution is foreseen as future work and this would be very helpful.

The minimum acceptable cold layer depth has been significantly increased by the calibration procedure – from 130 meters up to 400 meters. This seems very reasonable because of the large size of the investigated area and variable weather conditions. For example Bernstein reported values of the near-surface cold layer in USA between 100 and 1400 meters, the minimums being between 100 and 300 meters (Bernstein, B., 2000: Regional and local influences on freezing drizzle, freezing rain, and ice pellet events. Wea. Forecasting, 15, 485–508.).

The annual numbers of the FZRA events is indeed well reproduced by the algorithm (fig. 3), but its hit rate of 20% and the behaviour of its results for large number of events (fig. 4) are another indication for the need of future improvement of FMICLIM.

Both algorithms predict quite well the most typical duration of the FZRA events but overestimate the longer-lasting events as well as the events with large spatial extent.

Very interesting results are presented in the paragraph 3.3 Climatology of freezing rain in Europe. However, the finding for a maximum in the annual number of events over the Carpathian mountain sounds surprisingly for me. It would be useful if the altitude of these regions is given.

Technical comments I have encountered only two small misprints – on page 9, third row – the FMICLIM is written wrongly and on page 11, third row is written “The Carpathian . . .”.

Conclusions The paper addresses relevant scientific questions regarding the climatology of FZRA for the European region which are within the scope of NHESS.

The paper presents new data and new coherent results for FZRA occurrence in Europe and all these are up to international standards.

The scientific methods and assumptions are valid and outlined clearly and the results

are sufficient to support the interpretations and the conclusions.

The authors have reached substantial conclusions about the spatial and temporal distribution of the main characteristics of the FZRA in Europe – mean monthly and annual number of cases, duration of the FZRA events and their spatial extent.

The description of the used data and methods, as well as of the obtained results, is sufficiently complete and accurate and allows their reproduction by fellow scientists.

The title clearly and unambiguously reflects the contents of the paper.

The abstract provides a concise, complete and unambiguous summary of the work done and the results obtained.

The title and the abstract are pertinent, and easy to understand to a wide and diversified audience.

The mathematical formulae, symbols, abbreviations and units are correctly defined, described and used. The formulae, symbols and abbreviations are numerous and there is an appendix listing them.

The size, quality and readability of each figure is adequate to the type and quantity of data presented, except for figure 5 which could be a little bit larger.

The authors give proper credit to previous and related work with a small oversight of two references for the warm rain process.

The authors have indicated clearly their own contribution.

The number and quality of the references are appropriate taking into account the mentioned small oversight.

The references are accessible by fellow scientists.

The overall presentation is well structured, clear and easy to understand by a wide and general audience.

The length of the paper is adequate.

There is not any part of the paper (title, abstract, main text, formulae, symbols, figures and their captions, tables, list of references, appendixes) that needs to be clarified, reduced, added, combined, or eliminated. The authors should only take into account that they could use for future investigation the stations in eastern Europe with no restrictions, as far as they utilize the international weather WMO codes.

The technical language is precise and understandable by fellow scientists. The English language is of good quality, fluent, simple and easy to read and understand by a wide and diversified audience.

The amount and quality of supplementary material (one annex) is appropriate.

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