Hydrol. Earth Syst. Sci. Discuss., 10, C1058–C1071, 2013
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Hydrology and Earth System Sciences Discussions

Interactive comment on "Simulation of a persistent medium-term precipitation event over the Western Iberian Peninsula" *by* S. C. Pereira et al.

S. C. Pereira et al.

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Dear Reviewer,

We appreciate the constructive and knowledgeable comments of the Reviewer.

During the review process some Table and Figures were removed, others redone and others included. The reordered Figures and Tables are attached in the form of supplement to clarify the reading.

Anonymous referee #1:

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Interactive Discussion

Discussion Paper

Major comments:

C1. Is the model configuration first used for that region and period? If yes, the evaluation of control experiment (i.e., RunRef) should precede before elaborate analysis in terms of precipitation. In addition to the D03 (1 km) domain, D01 (25 km) and D02 (5km) domains need to be evaluated in terms of synoptic feature as well as precipitation, compared to the reanalysis and satellite-derived precipitation data. Please refer to Koo and Hong (2010). Regarding synoptic feature, the author stated "The heavy to extreme rainfall periods were caused by several low surface pressure systems associated with frontal surfaces." in Abstract, but this conclusion was not addressed in the manuscript at all. This can be confirmed by synoptic analysis from both observation and simulation.

A1: The physical parameterization schemes used in this work resulted from a previous study made by Ferreira et al. (2008), as mentioned in the manuscript (L18-C1430). The section 3.1 was changed according to the given indications and now starts with the evaluation of the control experiment.

A new section, under section 3 was introduced with an overview of the synoptic features during the 2009 December month and the evaluation of the control experiment. With the addition of the new section some paragraphs were added to the "Materials and Data" section, now renamed as "Methods and Data", to describe two observed datasets and a new measure (pattern correlation coefficient) was introduced in section "Assessment of model performance".

Thus, the new text is as follows:

" 2.4 Rainfall measurements and Observations from Gridded Data (...) In addition to the rainfall data described in the previous section two additional datasets were used. For the temperature, relative humidity, sea level pressure and winds were used the ERA-Interim (ERA) Reanalysis project from the European Centre for Medium-Range Weather Forecasts (ECMWF, http://www.ecmwf.int/). For precipitation the E-OBS grid-

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ded data set (EOBS) from the European Climate Assessment and Dataset project (ECAD, http://eca.knmi.nl/) was used. The ERA dataset is a reanalysis project of the global atmosphere covering the period starting at 1979 until present day. The dataset consists in a variety of meteorological variables with different resolutions and time steps for the several vertical pressure levels and surface. A full description of the forecast model, data assimilation method, and input datasets used to produce the ERA data, as well as, the performance of the system can be found in Dee et al. (2008). A detailed description of the ERA product archive can be found at Berrisford et al. (2009). For this study the ERA data were chosen with a horizontal resolution of 0.25° x 0.25° and 6 hourly time step and with 3 hourly time step for the sea level pressure. The EOBS dataset consists in a set of gridded daily observations for precipitation. The dataset covers the period starting at 01-01-1950 and ending up at 30-06-2012 covering the spatial region of Europe. A full description of the dataset can be found at Haylock et al. (2008). For this study it has been used the EOBS version 7 with a regular horizontal resolution of 0.25° x 0.25°. The chosen spatial coverage for both datasets extends from latitude 34° N to 49°N and for longitudes starting at -20° W to 0.5° E. Thereby the observational grids matched the WRF coarser grid (D01 domain)."

A new paragraph was added to L13- C1434 as follows:

"2.5 Assessment of model performance (. . .) To validate the capability of the model in reproducing the synoptic patterns and the precipitation it was used the continuous measures MD and the RMSE. The pattern correlation coefficient (PC) was used to measure the overall agreement between the simulations and the observations grid patterns, which is expressed as:

(Equation inserted as figure 1)

In this case the statistics were calculated for each grid point and the summations were performed for the entire grid; N stands for the total of grid points and the bar denotes spatial averaging over the grid."

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"Section 3.1 Observed and Simulated Synoptic features In this section are described the synoptic patterns over the 2009 December month over the region of analysis. The analysis follows closely the one presented by to Koo and Hong (2010). The circulation patterns were obtained from the ERA data and the precipitation from the EOBS data. Instead of analysing the mean state of the atmospheric circulation, during the time period of analysis, a variety of circulation weather types were used. These weather types describe the atmospheric circulation regime and are characteristics of a given location. The ones used in this study were produced and described by Santos et al (2005). For Portugal, five weather types were identified plus a six one derived from one of the regimes. The cyclone regime(C) associated with a high density of cyclonic features, the Westerly (W) associated with westerly and north-westerly winds (NW), the R regime linked with the negative phase of the North Atlantic Oscillation (NAO), the AA regime linked with positive phase of NAO and the Easterly regime associated with a high pressure system over the western European basin. In this study each daily circulation pattern that occurred in 2009 December was classified with five weather types plus a six one derived from one of the regimes (Table 5).

The most frequent regime was the cyclonic type (C) and the north-westerly (NW). In these two regimes the precipitation is linked with travelling frontal systems that extend to south covering Portugal (Fig. 5). Although the C-regime is not the most frequent it can occasionally be the dominant feature, as in the case, and can produce well-above-average rainfall probabilities throughout Portugal (Santos et al., 2005). The 2009 December observed anomalies from the mean December precipitation (PP) averaged for the time period of 1950 to 2012 show the above normal precipitation values that characterized this month (Fig. 6a).

The ERA mean 500 hPa geopotencial field represent a trough locate over sea west of Portugal indicating typical conditions for heavy induced precipitation (Fig. 6b). The mean sea level pressure pattern (Fig. 6c) is consistent with the geopotencial height: showing a low pressure region northwest of Portugal with a north south gradient. These

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conditions are favourable for the occurrence of precipitation as humidity advection due to south-westerly winds from North Atlantic (Fig. 6d) and along the south band of the cyclonic system which have a higher moisture content.

The simulated synoptic features reproduce well the mean atmospheric conditions (Fig. 7 and Table 6) for the analysed time period. The WRF model increased the 1000-500 hPa layer (Fig. 8b) but showed a negative bias in simulating the sea level pressure, the humidity content and temperature (Fig. 7c, Fig 7d and Fig. 7f), throughout the entire domain. The highest bias values are located over land but for the central and eastern part of Iberia rather than for Portugal.

The model precipitation was overestimated mainly over the ocean and underestimated over land, with some exceptions near the north-western and south coast of Portugal. This positive bias is located in northern region and covers the area defined for the finer grid domain (Fig. 1). The excess of model precipitation can be caused by the enhanced 500 hPa geopotencial height that tends to increase the trough locate west of Portugal which are the typical conditions

The 200hPa winds pattern simulated by the WRF (Fig. 7e) model show a positive bias close to the borders of the domain possible caused by the interpolation to the observations grid. Overall, the upper troposphere winds are weaker than the observed. In contrast the near surface winds are zonally stronger than the observed ones (Table 6).

Overall, the WRF higher deviations from the observations (Table 6) are related to the 500 hPa geopotencial height and with the 200 hPa winds with a low pattern association."

With the new text the respective references added to "Reference" section are:

Berrisford P, Dee DP, Fielding K, Fuentes M, Kållberg P, Kobayashi S, Uppala SM. 2009. 'The ERA-Interim Archive'. ERA Report Series, No. 1. ECMWF: Reading, UK.

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Dee, D. P., Uppala, S. M., Simmons, A. J., Berrisford, P., Poli, P., Kobayashi, S., Andrae, U., Balmaseda, M. A., Balsamo, G., Bauer, P., Bechtold, P., Beljaars, A. C. M., van de Berg, L., Bidlot, J., Bormann, N., Delsol, C., Dragani, R., Fuentes, M., Geer, A. J., Haimberger, L., Healy, S. B., Hersbach, H., Hólm, E. V., Isaksen, L., Kållberg, P., Köhler, M., Matricardi, M., McNally, A. P., Monge-Sanz, B. M., Morcrette, J.-J., Park, B.-K., Peubey, C., de Rosnay, P., Tavolato, C., Thépaut, J.-N. and Vitart, F. (2011), The ERA-Interim reanalysis: configuration and performance of the data assimilation system. Q.J.R. Meteorol. Soc., 137: 553–597. doi:10.1002/qj.828

Haylock, M.R., N. Hofstra, A.M.G. Klein Tank, E.J. Klok, P.D. Jones, M. New. A European daily high-resolution gridded dataset of surface temperature and precipitation. J. Geophys. Res (Atmospheres), 113, D20119, doi:10.1029/2008JD10201 (2008)

Koo, MyungâĂŘSeo, and SongâĂŘYou Hong. "Diurnal variations of simulated precipitation over East Asia in two regional climate models." Journal of Geophysical Research: Atmospheres (1984–2012), 115.D5, (2010).

Santos, J. A., J. CorteâĂŘReal, and S. M. Leite. "Weather regimes and their connection to the winter rainfall in Portugal."International Journal of Climatology,25.1 (2005): 33-50.

C2. Throughout the manuscript, Figures and Tables provide excess information. For example, Figs. 6 and 7 exhibit statistics for ALL stations but average value of classes would be enough to identify altitude dependency of model simulation if outliers are eliminated (S27MOSC2, S02BCBC2 and S25CASC3). Moreover, line plot or vertical bar chart would be better to compare the results than Table.

A2: The figures were changed according to the given indications. Figure 6 and Figure 7 are now displayed in a bar plot as Figure 8 and Figure 9

C3. In categorical measures of Table 9 (B, PC, POD, F and ETC), skill scores seem to be almost the same among three experiments. Is it meaningful to describe them in

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Table 9? I think that, in Section 3.2, the statement ". . ., the RunGridN experiment slight outperforms ... with increasing threshold value." is misleading as written.

A3: Since one of the goals, in this study, was to evaluate the model performance with different nudging schemes, a Table with the results summarized allows a quick overview over the major findings. The sentence was rephrased to "For the categorical verification the RunGridN results perform better for the 0.1 mm/h thresholds."

C4. Is cumulus parameterization (CP) scheme (in this study, Grell Devenyi ensemble convective parameterization scheme) used for D03 domain, i.e. 1 km horizontal resolution, as well (P1430L29)? As the author mentioned in Introduction, CP may be avoided for better model performance in terms of precipitation when horizontal resolution is less than 3 km. Therefore, sensitivity of precipitation simulation to CP should be checked for D03 domain.

A4. The sensitivity of the model performance regarding the turn on /off the cumulus option was tested. There is no significant difference among results.

A new paragraph was added to the end section 2.2, as follows:

"A sensitivity test regarding the cumulus parameterisation in domain D03 was made to the RunRef simulation, in which the Grell-Deveny parameterisation was tested against an explicit precipitation computation simulation. The mean error, mean square error and the root mean square error of both simulations were compared for the precipitation thresholds of 0.1, 1, 2 and 3 mmh-1. The results are similar with these metrics giving advantage to the Grell-Devenyi parameterisation scheme simulation. Thus all numerical experiments used the Grell-Devenyi parameterisation scheme in domain D03."

The introduction was rewritten in order to make clear that several studies point out that although model resolution would permit to sub-grid phenomena explicitly; choosing explicit methods not always give better model results. For example, Luna et al (2011) pointed out that, for a 1-km domain horizontal resolution, the precipitation amounts

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were not dependent on the cumulus schemes parameterisations for grid cells resolutions when compared to the results where precipitation was explicitly.

C5. (P1436L14) How was the model output on regular grid interpolated onto station location? Typical method is to average four grid-point values neighbouring a station location (see Koo et al., 2009), which may be different from the nearest grid-point value. Please exhibit their difference.

In this study two approaches were tested prior to the analysis. One method was to perform a linear interpolation with 4 grid point to station location and the other to choose the nearest grid point to station location. The two methods were applied to the RunRef run for the 1-km domain (D03) with no different results. The mean absolute deviation (MD) between the interpolated WRF and observations was 0.57 mmh-1 and for the nearest grid point was of 0.58 mmh-1.

The text (L13-C1436) was changed according to the given indications as follows:

"No difference was found between the averaged MD value calculated using the interpolated series and (MAD=0.57 mmh-1) and the nearest grid point to observations (MAD=0.58 mmh-1)."

C6. (P1437L4) Does the spatial correlation between a station value and model output at different location have any particular significance? I think that spatial correlation may be low even between station values estimated at different location. Moreover, is the correlation value of 0.018 really significant? (Fig. 2)

A6. With the inclusion of a new section and the introduction of the pattern correlation anomaly (please, see major comment C2) the authors choose to remove the correlation analysis from the manuscript. (L3-12-C1438).

A6. With the inclusion of a new section and the introduction of the pattern correlation anomaly (please, see major comment C2) the authors choose to remove the correlation analysis from the manuscript. (L3-12-C1438).

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C7. (P1437L17) In Table 9, categorical verification measures (B, PC, POD, F and ETS) are almost same among three experiments irrespective of threshold. Are the statistics valid for evaluating them? How about the thresholds above 3 mm per hour that provides information for heavy rainfall?

A7. One of the hypothesis being tested in this study was to inquire if there are any significant changes between a run with no nudging (less computationally expense and less time consuming) and others with nudging (common belief to produce better results). To evaluate those differences the authors chose to use a common metric: the basic statistics measurements widely used in the reference literature. We reassessed the differences and add a line in the conclusions mention "The runs have similar performances but the slight improvement of RunGridN, regarding the other two experiments, does not justify its use due to computational effort". We have computed the same error measures for precipitation thresholds of 4, 5, 10, 15 and 20 mm/day. However, for high thresholds these measures are based on very few data (very low values of a, b, c and d, in eqs 7 to 10, and its robustness may be questionable and are, therefore, not shown.

Minor comments:

C1 - Please specify full name when abbreviation is first used - P1428L25: IDF - P1429L18: MM5 - P1438L8: IQR - P1442L3: HIRLAM (in P1441L3) - Table 1: PP (its full name should be described in caption)

A1: The text was changed according to the given indications. PP was included in the title of the Figure.

Specific comments

C2 - P1424L2: numerical weather model -> numerical weather prediction model

A2: The text was changed according to the given indications.

C3 - P1424L5: what is the basis of “the heavy to extreme rainfall periods were caused

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by several low surface pressure systems associated with frontal surfaces"? I couldn't find any relevant discussion throughout the manuscript.

A3: Please, see comment major comment C2.

C4 - P1424 L16: Is root-mean-squared error (RMSE) be the only representative of the model accuracy.

A4: According to Wilks (2006) the term accuracy refers to the average correspondence between the model result and the paired observation. The accuracy measures summarized, in a single number, the overall quality of a set of simulations products. Apart RMSE, and looking into the categorical measures, the proportion corrected (PC, also known as Hit Rate) is also a measure of accuracy. Regarding the continuous measures the mean square error (MSE) is a measure of accuracy but not the mean error (ME).

C5 - P1425 L28: numerical weather prediction -> NWP

A5: The text was changed according to the given indications.

C6 - P1426 L7: domain horizontal resolution?

A6: the sentence was rephrased. The authors expected that it is clearer now.

C7 - P1426 L8: remove "and"

A7: The text was changed according to the given indications.

C8 - P1426 L8: domain what?

A8: the sentence was rephrased. The authors expected that it is clearer now.

C9 - P1426 L19: who are the same authors? Luna et al. (2011)? Or heikkila et al., (2011) and Luna et al., (2011)?

A9: the sentence was rephrased. The authors expected that it is clearer now.

C10 - P1428 L5: what is the criterion of exceptional amount?

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A10: It was considered exceptional base on the percentiles for that month and region. Comparing the monthly means and maximum daily rainfall with the long-term observed data (Table 1), half of the stations show daily maxima's higher than 90% percentile and seven stations monthly means higher than the 70% percentile.

C11 - P1428 L13: S and E part -> southern and eastern parts

A11: The text was changed according to the given indications.

C12 - P1428 L17: S and SE -> south and southeast

A12: The text was changed according to the given indications.

C13 - P1428 L21: NW -> northwest.

A13: The text was changed according to the given indications.

C14 - P1429 L26: (NW) -> i.e northwestern region.

A14: The text was changed according to the given indications.

C15 - P1430 L22: WRF single Moment 6 class scheme microphysics - > WRF Single Moment 6 (WSM6) microphysics scheme.

A15: The text was changed according to the given indications.

C16 - P1430 L25: remove ";"

A16: The text was changed according to the given indications.

C17 - P1430 L26: change reference "Noha et al., 2003" to "Hong et al., 2006".

A17: The text was changed according to the given indications.

C18 - P1432 L22: the station location -> the i-th station location.

A18: The text was changed according to the given indications.

C19 - P1436 L21: mean absolute error (MD) -> MD

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A19: The text was changed according to the given indications.

C20 - P1436 L22: “The results among experiments are identical” is not correct. The results among RunRef, RunObsN and RunGridN are different one another in Table 4.

A20: This short sentence was removed from the text.

C21 - P1436 L23: 0.31 -> 0.31 (S17PARC3)

A21: The text was changed according to the given indications.

C22 - P1436 L24: for S25CASC3 in Table 4, MD is not 1.49 but 1.50 mm h-1.

A22: The text was changed according to the given indications.

C23 - P1437 L7: lag -> time lag

A23: The text was changed according to the given indications.

C24 - P1437 L11-12: This statement is different from the results of table 5-7, Moreover, line plot would be better to compare one another than Table 5-7

A24: It was a mistake, it is corrected. Tables were replaced by bar graphs (Figure 8 and Figure 9).

C25 - P1437 L13-17: is table 8 positively necessary? In this statement, median and mode are not described.

A25: The table was removed.

C26 - P1437 L26: as well -> as well as A26: The text was changed according to the given indications.

C27 - P1439 L27: This paragraph is not quantitative but qualitative. How small (large) is the mean error (MSE and RMSE) compared to what?

A27. The sentence was removed.

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C28 - P1440 L3: In Fig. 7, specify the statistic's name at the top of the table. A28: statistic's names were introduced as end note in the end of the table.

C29 - P1442 L3: RUNGridN -> RunGridN

A29: The text was changed according to the given indications.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C1058/2013/hessd-10-C1058-2013-supplement.pdf

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$$PC = \frac{\sum_{n=1}^{N}\left(y_i - \bar{y}_i\right)(o_i - \bar{o}_i)}{\left[\sum_{i=1}^{N}(y_i - \bar{y}_i)\sum_{i=1}^{N}(o_i - \bar{o}_i)\right]^{1/2}}$$

Fig. 1. Eq 1

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