Dear Editor

Dear Reviewer

Authors answers to reviewer 2

We thank the reviewer for his valuable comments and suggestions. We hereafter reply and/or clarify the comments raised by the Reviewer point by point.

Referee comment

General Comments

The study presented a method for analysis of uncertainty in SWAT model parameters regionalization in Mediterranean catchments. An extensive analysis is done in the study. The study aimed to address very important issue in hydrological modelling. The study is recommended with the moderate revision.

Authors answers

We thank the reviewer for this comment

Referee comment

1. Lines 10-12, Page 4954, Can you please add reference?

Statistical approaches were deeply criticized due to the assumption that most statistical models consider linearity between CAs and optimized Mps

Authors answers

1. Lines 10-12, Page 4954

The following references are added to the text. (Merz and Blöschl, 2004 ; Parajka et al., 2005; McIntyre et al., 2005).

Referee comment

2. Lines 4-8, page 4955. Can you please further look into these lines. First it is mentioned that similarity based regionalization approach outperformed the regression approach. Further, the best performance is obtained by the kriging method which is also a regression method.

Parajka et al. (2005) showed also that similarity based regionalization approach outperformed as compared to the regression approach. But, they concluded that the best performing regionalization method was a kriging method based on nearest neighbor interpolation, followed by the similarity approach based on similarity of CAs between the donor and the receptor catchment.

Authors answers

2. Lines 4-8, page 4955.

Thank you for this valuable comment. We completely agree with the referee that the text is little bit confusing. Thus, the text is re-formulated as follow: "*Parajka et al. (2005) have used 4 groups of regionalization approaches. The first group is based on spatial averaging of calibrated model*

parameters, the second is based on spatial proximity (spatial distance) between the catchments, the third uses multiple regression between catchments attributes and model parameters and the last group is based on similarity between catchment attributes. They have found that regionalization methods based on spatial proximity and catchment attributes similarity performed better than multiple regression and spatial averaging methods.

Referee comment

3. Lines 1-3, page 4955. PMD, GR4 and TOMPO are not defined anywhere nor any references are provided for these models. Please add what PMD…. Stands for and also provide the appropriate references of these models in the text.

the statistical regression approach using a five parameters version of the PDM model, applied on 127 UK catchments. Similar conclusions were drawn by Oudin et al. (2008) using two conceptual rainfall-runoff models, GR4J and TOPMO, in 913 French catchments.

Authors answers

3. Lines 1-3, page 4955.

PDM stands for Probability Distribution Model (Moore, 1985), GR4J stands for modèle du Génie Rural à 4 paramètres Journalier (Perrin et al., 2003) and TOPMO is six free parameters rainfall-runoff model inspired by TOPMODEL (Beven and Kirkby, 1979).

Acronyms of PDM, GR4J and TOPMO as well as their appropriate references are added in the text and in the references list.

Referee comment

4. Lines 8-9, page 4955. Other studies reported……., but only one reference is given. Can you add some more reference?

Other studies have reported that even nearby catchments can be hydrologically different (Beven, 2000).

Authors answers

4. Lines 8-9, page 4955.

Thank you for this comment.

Refernces (Ourda et al., 2001; Shu and Burn (2003) ; McIntyre et al., 2005; Beven, 2000) are added in the text and in the reference list.

Referee comment

5. Line 22-25, page 4957. The statement looks confusing. What is the total number of rain-gauges in the study area? Sète rain gage is having only data of 2007-2009 or also having from 1990-1999? What Fig. 1 is referring for? Can you please include the location of rain-gauges in the Fig. 1? Further, the ten catchment boundaries are not clearly visible in Fig. 1

Daily precipitation data (from 1990 to 1999) are provided by five rain gauge stations located within the study area but only the Sète rain gage (French national meteorological station of Météo France) has daily precipitation data that covers the 2007–2009 period (Fig. 1).

Authors answers

5. Line 22-25, page 4957

We agree with the reviewer that the statement looks confusing. In fact, the total number of rain-gauges in the study including the Sète rain gauge is 5. However, daily precipitation recorded at the Sète station cover the period from 1990 to 2009 while the remaining rain gauge stations provide daily precipitation values from 1990 to 1999.
New fig.1 is uploaded showing the geographic location of the Thau catchment, the 5 rain gauge stations within the catchment and the sub-catchment boundaries (Fig.1 in attachment).

To clarify the text and avoid confusing, the statement is changed as follow: "*Daily precipitation data (from 1990 to 1999) are provided by five rain gauge stations located within the study area (Fig.1) but only the Sète rain gauge (French national meteorological station of Météo France) has daily precipitation data from 1990 to 2009.*

Referee comment

6. Lines 1-19, page 4958. The text is quite confusing to understand regarding the available data for each catchment. It is suggested to present this information in tabular form rather in text form.

Authors answers

6. Lines 1-19, page 4958

We thank the reviewer for his suggestion. We follow the reviewer suggestion and we change the text into a Table.

Referee comment

7. Line 16, page 4959. Replace SWt with SWo.

Authors answers

7. Line 16, page 4959

As has been suggested by Referee 1, the equation (1) is changed and, thus, the SWt and SW0 do not exist anymore.

Equation (1) is changed and added to the text as follow:

$$\frac{\partial SW}{\partial t} = P_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw} \qquad (1)$$

where SW is the soil water content (mm), P_{day} is precipitation rate (mm/day), Q_{surf} is the surface runoff rate (mm/day), E_a is evapotranspiration rate (mm/day), W_{seep} is the water percolation rate from the soil profile (mm/day), and Q_{gw} is the groundwater flow rate (mm/day).

Referee comment

8. Line 4, page 4960. Use “Manning’s Kinematic Equation” instead of only “Manning’s formula”.

Authors answers

8. Line 4, page 4960.

Thank you for the suggestion. “Manning’s Kinematic Equation” is used instead of “Manning’s formula”.

Referee comment

9. Lines 13-19, page 4960. It would be better to delete terms GW_DELAY, GWQMN, GW_REVAP as they may be not of interest for the readers.

Authors answers

9. Lines 13-19, page 4960.

The terms GW_DELAY, GWQMN, GW_REVAP are deleted.

Referee comment

10. Line 1-3, page 4961. Why 4 years out of total of 7 years data is selected as the warming up period?

The SWAT simulations are conducted on the gauged catchments from 1990 to 1996 with 4 yr (1990–1993) as a warming-up period to minimize the effects of the initial state of SWAT variables on river flow

Authors answers

10. Line 1-3, page 4961. This is a valuable comment from the reviewer, Thank you.

The warm-up period was set to 4 years due to the karstic nature of the study area. This periode of time was assumed to be sufficient to minimize the effect of the initial SWAT state variables. Warm-up period of 4 years for SWAT model was also used by Li et al.(2010). Other example, Chahinian et al. (2011) has applied the SWAT model on the Vène catchment with 10 years as warm-up period for model calibration and validation period of 5 years.

Referee comment

11. Lines 22, page 4961. It would be better to include all the 17 SWAT model parameters in Table 2. A rank of zero may be assigned to 7 model parameters which were found insignificant.

Authors answers

11. Lines 22, page 4961. All the 17 parameters are included in Table 2 following the suggestion of the reviewer.

Referee comment

12. Line 20, page 4966. Define FDC before using it.

Besides these CAs, others authors have used flow indices or characteristics using FDC (Masih et al., 2010)…

Authors answers

12. Line 20, page 4966. Thank you.

Besides these CAs, others authors have used flow indices or characteristics using flow duration curve (FDC) such as (Masih et al., 2010)…

Referee comment

13. Line 25, page 4966. It would be better to use “Occurring” instead of “accruing” on the objective of the regionalization procedure and on the knowledge about the key hydrological processes accruing within the catchment…

Authors answers

13. Line 25, page 4966. Thank you

“Occurring” is used instead of “accruing”.

“…the objective of the regionalization procedure and on the knowledge about the key hydrological processes occurring within the catchment…

Referee comment

14. Line 28, page 4966. Replace “theses” with “those”.

Model parameters, especially theses of physically based model such as SWAT,

Authors answers

14. Line 28, page 4966. “theses” is replaced with “those”.

Model parameters, especially those of physically based model such as SWAT,

Referee comment

15. Line 16-17, page 4972. Use “due to” instead of “due”

In addition, this difference can also be due the subjectivity involved within the GLUE procedure for selecting the threshold value,

Authors answers

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In addition, this difference can also be due to the subjectivity involved within the GLUE procedure for selecting the threshold value,

Referee comment

16. Section 5.2.1, pages 4975 & 4976. What is the impact of percentage of the transferred Mps on the performance? Further, why only 16.6% Mps are transferred for Negues-Vacques catchment. This small percentage is not coherent with the other 7 catchments in Table 3.

Authors answers

16. Section 5.2.1, pages 4975 & 4976. Thank you for the comment.

According to our approach, as the percentage of the transferred Mps from the donor to the receptor catchment increases, the prediction uncertainty interval at the ungauged catchment increases. Figure 7 shows that a relationship between the percentage of the transferred Mps and the width of the prediction uncertainty interval at the ungauged catchment exists. However, as we have cited in the text, it is not pretended that uncertainty in the transferred parameter sets is the only one contribution source for model prediction uncertainty at the ungauged catchment. As it was demonstrated by the results, although the relationship between the transferred model parameters uncertainty and model prediction uncertainty at the ungauged catchments exists, this relationship is far to be linear due to the non-linearity of the hydrological model, to the possible correlation between the parameters, to the equifinality problem, to the non-identifiable parameters and to other sources of uncertainty (e.g. model structure, inputs uncertainty) that are difficult to be simultaneously taken into account.

Table 3 shows the catchments cluster, the degree of similarity and the corresponding percentage of transferred Mps from the donor to the receptor catchment. The Negues-Vacques catchment is the one that resembles the most to the donor catchment of Pallas with a similarity value of 0.88. By introducing the latter value in Eq .(3), the Thresh value calculated is 0.66, meaning that only Mps that lead to model simulations with Nash (NS) $\geq$ 0.66 at the Pallas catchment should be transferred to the Negues-Vacques catchment. These Mps correspond to only 16.60% of the total Mps at the Pallas catchment.

Referee comment

17. Lines 5-11, page 4981. NS values of -0.131, -0.144, 0.169 and 0.518 are obtained for the four un-gauged catchments. Out of these only 0.518 for Joncas catchment can be considered as the good performance, while others three are having poor performance. How these NS values can justify the results. Comment please.

Authors answers

17. Lines 5-11, page 4981. This is a very nice comment from the reviewer, thank you.

We fully agree that the NS values for these three ungauged catchments are poor and cannot justify the results. However, as we have mentioned in the text, when evaluating the regionalization performances in ungauged catchments, other criteria such as fit to reality and fit to geography should be used besides the statistical criteria such as NS. The reason is that NS is very sensitive to the length and quality of the observation data. The streamflow records of these catchments are either missing or have gaps and, thus, are not reliable to allow a sufficient and solid statistical evaluation. For instance, daily discharge at the Aygues_Vacques and Joncas catchments covers only 80 days while the Soupie and Fontanilles catchments have streamflow of 500 daily records. In addition to the NS index we have used other statistical criterion which is the percentage of the observation data bracketed in the prediction uncertainty interval (P_factor). Although the NS values are poor for these ungauged catchments, the

P_factor indicates that more than 65%, except for Aygues_Vacques catchment, of the observation data are with the modelling uncertainty interval reflecting “acceptable” results (Table 5).

As we have cited and discussed in the paper any available observation data, field knowledge and/or previous work conducted in the area of interest can be precious and helpful to check the performances of the regionalization method when dealing with ungauged catchment. Therefore, more transparent assessment of the regionalization technique performance should not only be based on statistical criteria alone but in combination with other criteria such as fit to reality and fit to geography.

Referee comment

18. The following two statements are contradicting.

Lines 24-27, page 4986

The assumptions behind the developed methodology were that similar catchments (similar in their physical attributes) are hydrologically similar and that model prediction uncertainty **increases as the dissimilarity between the donor and the receptor catchment decreases.**

Line 9-13, page 4988

We think also that the speculation behinds the developed methodology such as **model prediction uncertainty at the ungauged catchments increases as the dissimilarity between the donor and the receptor catchment increases is appealing**, reasonable and provides more reliable prediction uncertainty at the ungauged catchment than the traditional approach

Authors answers

18. Thank you very much for this comment.

We have corrected the statement.

Lines 24-27, page 4986

The assumptions behind the developed methodology were that similar catchments (similar in their physical attributes) are hydrologically similar and that model prediction uncertainty increases as the dissimilarity between the donor and the receptor catchment **increases.**

Line 9-13, page 4988

We think also that the speculation behinds the developed methodology such as **model prediction uncertainty at the ungauged catchments increases as the dissimilarity between the donor and the receptor catchment increases is appealing**, reasonable and provides more reliable prediction uncertainty at the ungauged catchment than the traditional approach

Referee comment

19. There are many sentences in the paper which are unnecessarily long. It is suggested to revise the whole paper and use small sentences instead of long sentences.

Authors answers

19. We will revise all the paper. Unnecessarily sentences will be removed and long sentences will be shortened.

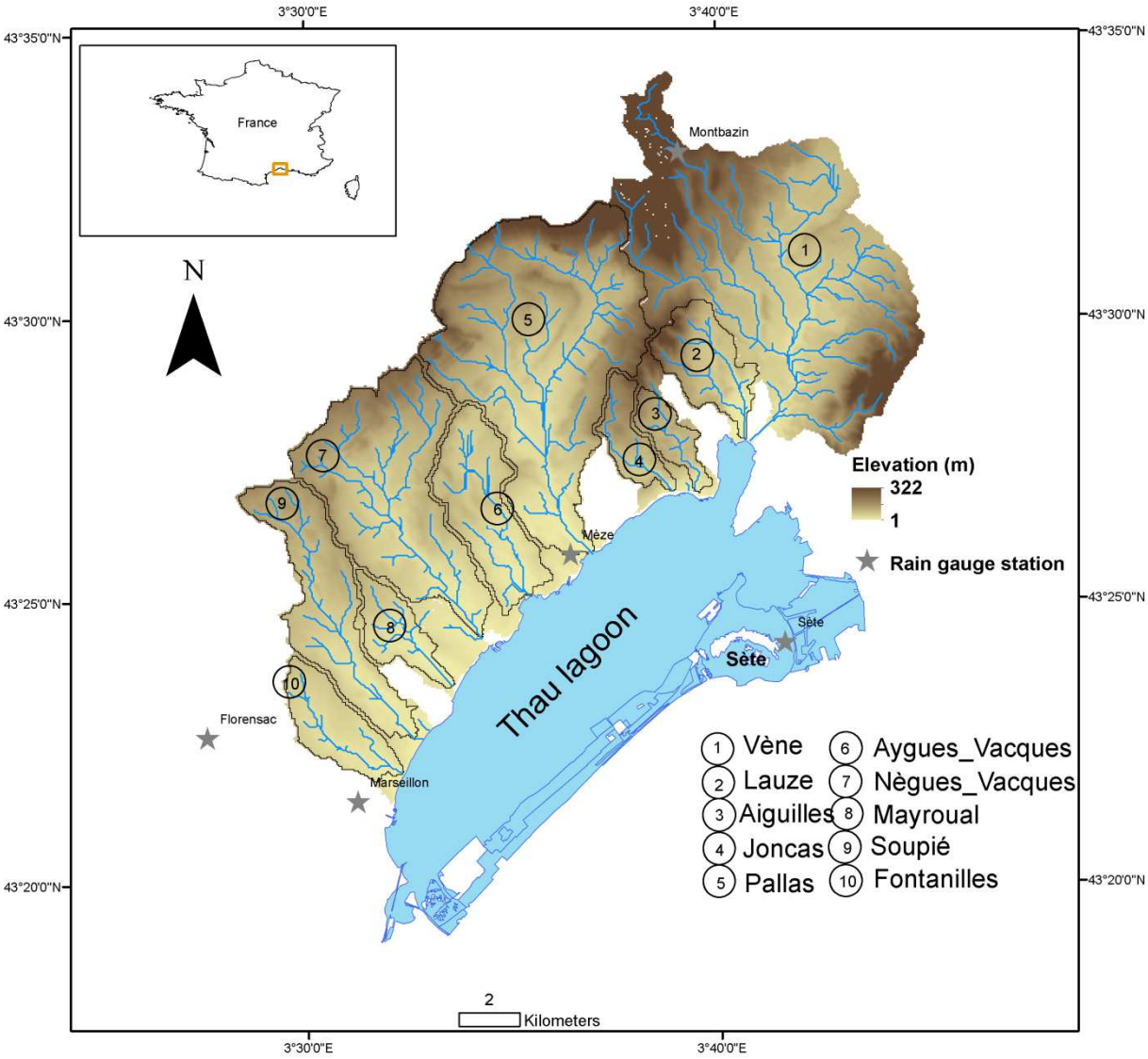

Fig.1 Location of the study site, topography, sub-catchments boundaries and rain gauge stations