Responses to Referee #1

Dear Reviewer,

We are very grateful for the constructive comments of Referee #1. We totally agree with all major and specific comments and recommendations. We propose to substantially modify the manuscript in order to respond to all points raised by Reviewer #1 especially by clarifying the presentation of the methodology used, by discussing the choices made for the classification procedure and by adding additional climate change RCM simulations.

In this letter, the comments of Referee #1 are given in black and our response in blue.

Kind regards,

Antoine Allam, Roger Moussa, Wajdi Najem, Claude Bocquillon

Overview

The manuscript of Allam et al. is introducing a novel regional climate classification for the Mediterranean region. About the style, the manuscript needs copy-editing for English language check, about the content, despite the scientific relevance of the topic I have two majors concerns that would require substantial modifications to the manuscript:

1- The classification methodology is not robust enough. They authors choose 5 classes without any justification. The authors should provide a robust evaluation of the classification proposed, with the different datasets available. The part about Decision Tree is not sufficiently explained (see specific comments below). The authors should also better highlight the novelty of their approach, by comparison to two recent papers, Barredo et al. 2019 in the reference list, and:

Koutroulis A., Dryland changes under different levels of global warming. Science of The Total Environment 655, DOI: 10.1016/j.scitotenv.2018.11.215

We thank Referee #1 for all his/her comments and agree that the classification methodology should be justified and detailed furthermore.

The methodology will be detailed so anyone could reproduce or apply the study on another database. The methodology will be expanded to include 3 additional subsections in Section 3 (which will have 7 in total):

3.1 Hydrology driven climatic indices

This subsection will be moved from section 4 Results to section 3 Methodology. It will be also expanded to justify the choice of these indices to highlight the hydrological specificity.

3.6 Verification methodology

This subsection will describe the grid-based and ground station classification verification steps within section 3 methodology

3.7 RCP Scenarios

This subsection will detail the procedure to assess the climate change impact on the classification. The delta change calculation and transposition to the WorldClim-2 grid cells using GIS.

Concerning the choice of 5 classes (See response to the comments on "Page 6, line 26"):

We chose 5 classes as we hoped for a classification that delimits the Mediterranean climate from North and South and divides the intermediate coastal zone. Therefore, one class would cover the southern desertic region, another class would cover the northern continental region and 3 classes to cover the intermediate coastal region. Thus, a distribution into 5 classes. A larger number would produce an uninterpretable fragmented classification. A detailed explanation and comparison with subdivisions with more or less 5 classes will be added in the text.

(Koutroulis A. et al., 2018) will be added to highlight the novelty of the work.

A copy-editing for English language check will be done.

2- On the climate change aspect, the use of one single regional climate model simulation is not enough to assess the uncertainties. I suggest either to remove this part or alternatively to strongly upgrade it.

The literature review on the topic is very weak and there is a need to include relevant references providing climate scenarios for the whole Mediterranean domain and its different sub-regions.

If the authors want to include a climate change study, they could use the ensemble of 50km simulations available in the MedCORDEX experiment.

When studying climate change impacts, it is very important to consider the uncertainties from different GCM and RCM simulations, in addition to the uncertainties stemming from the emission scenario.

We also agree that one single simulation is not enough to assess the uncertainties, therefore two additional simulations will be added, CCLM 4-8-19 and RegCM 4.3 for both RCP 4.5 and RCP 8.5 for the 2070-2100 period from the MEDCORDEX project and the discussion section will be expanded accordingly.

All the references mentioned by the referee will be added in their corresponding section, in addition other articles will be added to justify the approach and methodology and discuss the obtained results.

Breiman, L., J. Friedman, C. J. Stone and R. A. Olshen (1984). Classification and Regression Trees, Taylor & Francis.

Cramer Wolfgang, Guiot Joël, Fader Marianela, Joaquim Garrabou, Jean-Pierre Gattuso, Ana Iglesias, Manfred A. Lange, Piero Lionello, Maria Carmen Llasat, Shlomit Paz, Josep Peñuelas, Maria Snoussi, Andrea Toreti, Michael N. Tsimplis, Elena Xoplaki. Climate change and interconnected risks to sustainable development in the Mediterranean. Nature Climate Change, 2018; DOI: 10.1038/s41558-018-0299-2 http://www.medecc.org/climate-and-environmental-change-in-the-mediterraneanmain-facts/

Dell'Aquila, A., A. Mariotti, S. Bastin, S. Calmanti, L. Cavicchia, M. Deque, V. Djurdjevic, M. Dominguez, M. Gaertner and S. Gualdi (2018). "Evaluation of simulated decadal variations over the Euro-Mediterranean region from ENSEMBLES to Med-CORDEX." Climate dynamics 51(3): 857-876.

Diouf, O. C., Weihermüller, L., Ba, K., Faye, S. C., Faye, S., & Vereecken, H. (2016). Estimation of Turc reference evapotranspiration with limited data against the Penman-Monteith Formula in Senegal. Journal of Agriculture and Environment for International Development (JAEID), 110(1), 117-137.

Drobinski, P., N. D. Silva, G. Panthou, S. Bastin, C. Muller, B. Ahrens, M. Borga, D. Conte, G. Fosser, F. Giorgi, I. Güttler, V. Kotroni, L. Li, E. Morin, B. Önol, P. Quintana-Segui, R. Romera and C. Z. Torma (2018). "Scaling precipitation extremes with temperature in the Mediterranean: past climate assessment and projection in anthropogenic scenarios." Climate Dynamics 51(3): 1237-1257.

Giorgi, F. (2006). Regional climate modeling: Status and perspectives. Journal de Physique IV (Proceedings), EDP sciences.

Kotlarski, S., Keuler, K., Christensen, O. B., Colette, A., Déqué, M., Gobiet, A., Goergen, K., Jacob, D., Lüthi, D., van Meijgaard, E., Nikulin, G., Schär, C., Teichmann, C., Vautard, R., Warrach-Sagi, K., and Wulfmeyer, V.: Regional climate modeling on European scales: a joint standard evaluation of the EURO-CORDEX RCM ensemble, Geosci. Model Dev., 7, 1297–1333, https://doi.org/10.5194/gmd-7-1297-2014, 2014.

Koutroulis A., Dryland changes under different levels of global warming. Science of The Total Environment 655, DOI: 10.1016/j.scitotenv.2018.11.215

Lionello, P., and Scarascia, L.: The relation between climate change in the Mediterranean region and global warming, Reg. Env. Change, 18, 1481-1493, doi: 10.1007/s10113-018-1290-1, 2018.

Menne, M. J., I. Durre, B. Korzeniewski, S. McNeal, K. Thomas, X. Yin, S. Anthony, R. Ray, R. S. Vose and B. E. Gleason (2012). "Global historical climatology network-daily (GHCN-Daily), Version 3." NOAA National Climatic Data Center 10: V5D21VHZ.

Raymond, F., Ullmann, A., Camberlin, P., Drobinski, P., and Chateau Smith, C.: Extreme dry spell detection and climatology over the Mediterranean Basin during the wet season, Geophys. Res. Lett., 43, 7196–7204, https://doi.org/10.1002/2016GL069758, 2016.

Rivoire, P., Tramblay, Y., Neppel, L., Hertig, E., and Vicente-Serrano, S. M.: Impact of the dry-day definition on Mediterranean extreme dry-spell analysis, Nat. Hazards Earth Syst. Sci., 19, 1629–1638, https://doi.org/10.5194/nhess-19-1629-2019, 2019.

Romera R., Sánchez E., Domínguez M., Gaertner M.Á., Gallardo C. (2015) Evaluation of present-climate precipitation in 25 km resolution regional climate model simulations over Northwest Africa. Clim Res 66(2):125–139.

Ruti, P. M., S. Somot, F. Giorgi, C. Dubois, E. Flaounas, A. Obermann, A. Dell'Aquila, G. Pisacane, A. Harzallah and E. Lombardi (2016). "MED-CORDEX initiative for Mediterranean climate studies." Bulletin of the American Meteorological Society 97(7): 1187-1208. https://doi.org/10.1175/BAMS-D-14-00176.1

Tramblay, Y. and S. Somot (2018). "Future evolution of extreme precipitation in the Mediterranean." Climatic Change 151(2): 289-302.

Turc, L. (1961). "Estimation of irrigation water requirements, potential evapotranspiration: a simple climatic formula evolved up to date." Ann. Agron 12(1): 13-49.

Zittis, G. (2018). "Observed rainfall trends and precipitation uncertainty in the vicinity of the Mediterranean, Middle East and North Africa." Theoretical and applied climatology 134(3-4): 1207-1230. https://doi.org/10.1007/s00704-017-2333-0.

Specific comments

Page 1, first lines of introduction: Obviously these sentences are from a textbook. Please add the reference.

Ok. (Clerget, M., 1937). Les types de temps en Méditerranée. Paper presented at the Annales de géographie.

Page 2 line 11: add reference for MedCORDEX

Ok, reference (Ruti et al., 2016) added at page 2.

Ruti, P. M., S. Somot, F. Giorgi, C. Dubois, E. Flaounas, A. Obermann, A. Dell'Aquila, G. Pisacane, A. Harzallah and E. Lombardi (2016). "MED-CORDEX initiative for Mediterranean climate studies." Bulletin of the American Meteorological Society 97(7): 1187-1208. https://doi.org/10.1175/BAMS-D-14-00176.1

Page 2, line 15: this part should be moved to a data section later in the text to present the RCM simulations

Ok, we agree, it will be moved to section 2.3 climatic data.

Page 2, line 25: Ref Tramblay et al 2013 is only for a basin in Morocco. Please add references relevant for the whole Mediterranean.

Ok. Three references will be added:

Dell'Aquila et al. 2018;

Dell'Aquila, A., A. Mariotti, S. Bastin, S. Calmanti, L. Cavicchia, M. Deque, V. Djurdjevic, M. Dominguez, M. Gaertner and S. Gualdi (2018). "Evaluation of simulated decadal variations over the Euro-Mediterranean region from ENSEMBLES to Med-CORDEX." Climate dynamics 51(3): 857-876.

Drobinski et al., 2018;

Drobinski, P., N. D. Silva, G. Panthou, S. Bastin, C. Muller, B. Ahrens, M. Borga, D. Conte, G. Fosser, F. Giorgi, I. Güttler, V. Kotroni, L. Li, E. Morin, B. Önol, P. Quintana-Segui, R. Romera and C. Z. Torma (2018). "Scaling precipitation extremes with temperature in the Mediterranean: past climate assessment and projection in anthropogenic scenarios." Climate Dynamics 51(3): 1237-1257.

Tramblay et al., 2018

Tramblay, Y. and S. Somot (2018). "Future evolution of extreme precipitation in the Mediterranean." Climatic Change 151(2): 289-302.

Page 3, line 1, Rivoire et al 2019 also provided a Mediterranean classification based on P-PET computed from CRU database.

Rivoire, P., Tramblay, Y., Neppel, L., Hertig, E., and Vicente-Serrano, S. M.: Impact of the dry-day definition on Mediterranean extreme dry-spell analysis, Nat. Hazards Earth Syst. Sci., 19, 1629–1638, https://doi.org/10.5194/nhess-19-1629-2019, 2019.

Ok this reference will be added.

Page 3, line 32: "Practiced discipline"?

Ok. the expression will be modified to "field of practice"

Page 4 line 16: "to be treated in a personal way", strange wording.

Ok, the expression will be removed.

Page 4, section 2.2: Not clear what types of catchments are extracted. The authors should precise for which stream orders they extracted the catchment boundaries. Is it for all elementary catchments? Or is there a minimum basin size? For example, in the JRC data or HYDROSHED the Pfafstetter coding system is used (de Jager and Vogt, 2010, in the reference list).

Ok. the type of catchments will be precised in the text.

We extracted catchments at their outlets to Mediterranean Sea, and only those exceeding $1km^2$ were considered, hence a total of 3681 catchments all around the Mediterranean.

Page 4, section 2.3: it would be very useful to also provide a database as an output of this article, a map or GIS layer to have the climatic class for each catchment.

Ok. A GIS shapefile of the catchments climatic classes will be provided in supplementary material.

Page 4, section climatic data: The authors should provide a map with the number of stations used to build the WordClim database in the Mediterranean and the locations of the 144 weather stations.

Ok, this map is provided in figures S1 and S2 in the supporting information of Fick and Hijmans (2017) article.

However, we will add this information in the text:

The WorldClim-2 database was built over 23 regions with different coverage for each parameter. For the precipitation an overlap of 3 regions covered the Mediterranean area with a total of 10410 stations for the 3 regions (euw n= 3730; eue n = 3632; naf n = 3048). For average temperature, the Mediterranean was covered by one region (eu1) with number of stations n = 1760; n = 1627 for Maximum temperature and n = 1626 for Minimum temperature;

The location of the 144 stations is shown in figure 6 only, to avoid duplication.

Several authors have pointed out the strong variability of station density across the Mediterranean region, see:

Zittis G. (2017) Observed rainfall trends and precipitation uncertainty in the vicinity of the Mediterranean, Middle East and North Africa, Theoretical and Applied Climatology. https://doi.org/10.1007/s00704-017-2333-0.

Romera R., Sánchez E., Domínguez M., Gaertner M.Á., Gallardo C. (2015) Evaluation of present-climate precipitation in 25 km resolution regional climate model simulations over Northwest Africa. Clim Res 66(2):125–139.

Raymond, F., Ullmann, A., Camberlin, P., Drobinski, P., and Chateau Smith, C.: Extreme dry spell detection and climatology over the Mediterranean Basin during the wet season, Geophys. Res. Lett., 43, 7196–7204, https://doi.org/10.1002/2016GL069758, 2016.

Ok. these references and corresponding information will be added in the following text:

"The use of ground-based stations time series or gridded observational data is limited by several uncertainties mainly density and interpolation processing methods, especially in Mediterranean region where North African and Levantine countries are poorly covered (Zittis, 2017). Nevertheless,

the use of specific indices like seasonality and aridity, which are averaged on 30 years periods and based on monthly and annual values, while avoiding extreme event indices, reduces data quality uncertainties. On the other hand, several studies have revealed the uncertainties connected to the resolution of RCM simulated gridded data in the Mediterranean complex domain (Romera et al., 2015) hence the use high-resolution data like MEDCORDEX 12 km grids and WorldClim-2 1-km and overall, the regional aspect of this study makes it less sensitive to local errors.

In addition, the origin of this data is not provided. To which database do they belong? GHCN?

These stations belong to Global Historical Climatology Network GHCN (Menne et al., 2012) and recognized by the World Meteorological Organization (WMO), they are available for free access on the portal of the National Administration of Oceans and Atmosphere of the United States (NOAA). The average length of data series is 60 years and range between 30 and 120 years at monthly time step. The 1960 - 1990 period is common to all stations. The data quality was verified (i.e. ellipse of Bois, 1986) and only complete hydrological years were retained for indices calculation. Detailed information will be added in the manuscript.

Page 5, line 1: “5 and 3000” give locations/stations where these values are recorded

Ok. the following information will be added

“…reflecting the wide variability of mean annual precipitation ranging between 5 (“Jabal el Aswad desert in Libya”) and 3000 mm (Kobarid in Slovenia) and mean annual temperature ranging between -14°C (Mont Blanc, Alps, France) and +26°C (Karak, Jordan) where some catchments receive 50 times more than others the amount of precipitation while being 4 times colder.”

Page 5, line 1: Strange that the authors talk about taxonomy for a few lines later explain that it is not useful for climate classifications.

Ok, the paragraph about taxonomy will be removed.

Page 6, line 26: why choose a priori 5 classes? This is a major methodological problem since it is a subjective choice. Usually when performing classifications with kmeans, diagnostic tools such as the Scree plot or Silhouette plot are used to identify and choose the optimal number of clusters. The authors need to clarify and improve this point about the “optimal” number of clusters.

Ok, the following information will be added:

Figure 1 and text in page 5 line 30, shows that the Mediterranean hydrological boundary includes in addition to Csa and Csb climates, the desertic BWh and Bsk and continental Cf and Cs climates.

We chose 5 classes as we hoped for a classification that delimits the Mediterranean climate from North and South and divides the intermediate coastal zone. Therefore, one class would cover the southern desertic region, another class would cover the northern continental region and 3 classes to cover the intermediate coastal region. Thus, a distribution into 5 classes. A larger number would produce an uninterpretable fragmented classification.

Page 6, section 3.3: What is a Decision Tree? There are no bibliographic references in this section and this is clearly lacking. Do the authors refer to Classification and Regression Trees? (CART, Breiman 1984). How the method is applied is not clear. No need for this type of method to validate a k-means classification.

Ok, the following information will be added the subsection 3.4 decision tree

"A decision tree is a set of distance criteria or questions in the form of hierarchy that leads to an intended classification (Breiman 1984). To classify new points or stations, it suffices to define the distance criterion to the various kernels of the climatic classes by predicting values of a dependent variable based on values of predictor variables from a reference classification."

It is more a verification of K-means classification rather than a validation.

Page 7, section 3.4: No presentation of the RCM simulations is provided.

We will add a brief description of RCM as presented by Giorgi (2006)

Giorgi, F. (2006). Regional climate modeling: Status and perspectives. Journal de Physique IV (Proceedings), EDP sciences.

"RCM or Regional Climate Model was introduced in late 1980's as a nested technique into Global Climate Models GCM to consider regional scale climatic forcings caused by the complex physiographic features and small scale circulation features. (Giorgi, 2006). The primary application of RCM has been in the development of climate change scenarios of which we mention ALADIN RCM (Aire Limitée Adaptation dynamique Développement InterNational) developed by Météo France and applied for EURO-CORDEX and MED-CORDEX projects at 12-km spatial resolution (Tramblay et al., 2013)."

In addition, the use of a single simulation is not recommended to provide future scenarios, due to strong differences between different model simulations (Kotlarski et al 2014). This is for sure a weak point in the analysis presented.

See:

Kotlarski, S., Keuler, K., Christensen, O. B., Colette, A., Déqué, M., Gobiet, A., Goergen, K., Jacob, D., Lüthi, D., van Meijgaard, E., Nikulin, G., Schär, C., Teichmann, C., Vautard, R., Warrach-Sagi, K., and Wulfmeyer, V.: Regional climate modeling on European scales: a joint standard evaluation of the EURO-CORDEX RCM ensemble, Geosci. Model Dev., 7, 1297–1333, https://doi.org/10.5194/gmd-7-1297-2014, 2014.

We agree therefore at least two additional RCM scenarios will be added to the climate change section CCLM 4-8-19 and RegCM 4.3 for both RCP 4.5 and 8.5 scenarios.

Page 7, section 4.1: It is only in the table 3 that the reader can discover that potential evapotranspiration is computed from the Thornthwaite formula. This formula is most probably not adapted to the Mediterranean context, in particular for climate change scenarios. At least a discussion would be welcome to address this point.

See:

Beguería,S.,Vicente-Serrano,S.M.,Reig,F.,andLatorre,B.:Standardized precipitation evapotranspiration index (SPEI) revisited: parameter ïnˇA˛tting, evapotranspiration models, tools, datasets and drought monitoring, Int. J. Climatol., 34, 3001–3023, 2014.

McMahon, T. A., Peel, M. C., Lowe, L., Srikanthan, R., and McVicar, T. R.: Estimating actual, potential, reference crop and pan evaporation using standard meteorological data: a pragmatic synthesis, Hydrol. Earth Syst. Sci., 17, 1331-1363, https://doi.org/10.5194/hess-17-1331-2013, 2013.

Ok, this information will be corrected.

“The evapotranspiration was estimated according to Turc’s formula (Turc, 1961), chosen for its application simplicity and adequacy to Mediterranean areas as it was originally developed for southern France and North African countries (Diouf, 2016). Turc’s formula is mainly based on temperature and radiation, two stable parameters on the regional scale which reduces the uncertainties when using regionalized dataset such as WorldClim-2.”

Turc, L. (1961). "Estimation of irrigation water requirements, potential evapotranspiration: a simple climatic formula evolved up to date." Ann. Agron 12(1): 13-49.

Diouf, O. C., Weihermüller, L., Ba, K., Faye, S. C., Faye, S., & Vereecken, H. (2016). Estimation of Turc reference evapotranspiration with limited data against the Penman-Monteith Formula in Senegal. Journal of Agriculture and Environment for International Development (JAEID), 110(1), 117-137.

Page 8, line 24: “5 classes was the most suitable” this is a contradiction with the methodology described above, where the authors state Line 6, line 26 that they choose 5 classes.

Ok. In reference to the answer on the comment of Page 6 line 26, the following information will be added:

“We chose 5 classes as we hoped for a classification that delimits the Mediterranean climate from North and South and divides the intermediate coastal zone. Therefore, one class would cover the southern desertic region, another class would cover the northern continental region and 3 classes to cover the intermediate coastal region. Thus, a distribution into 5 classes. A larger number would produce an uninterpretable fragmented classification.”

Sentence corrected: “The K-Means classification shows in Figure 4 a distribution into 5 classes where”

Page 9, line 15: “a similar spatial distribution”, similar to what?

A spatial distribution similar to the catchment indices classification.

Page 9, section 4.4: Usually “validation” refer to the application of a model (or a classification) to data that has not been used for its calibration or training. This is not the case here.

We agree, it’s a verification of the results rather than a validation. It will be modified in the text.

Page 10, section 4.4.3: Again we don’t understand what is done here. A validation with a “decision tree”?

Ok. the word “Validation” will be removed, and the following information will be added.

“We generated a decision tree based on the distances to the clusters’ kernels obtained from the gridded indices classification. The aim of this decision tree is to easily reproduce the classification with same kernels rather than repeat the whole classification process which will modify the clusters and their kernels. In this way, the decision tree will permit to follow up the climate evolution and its impact on the classification under other scenarios.”

Page 10, line 16: “proximity analysis and spatial joint” are not statistical terms but rather obviously Geographic Information Systems (GIS) operations. Please explain clearly which method has been applied.

After the calculation of delta changes between baseline period 1970-2000 and projected period 2070-2100, MED-CORDEX grid was overlaid on WorldClim-2 grid and using spatial join algorithm, the attributes of the delta change grid cells were transposed to WorldClim-2 grid cells, to obtain the projected data on WorldClim-2. The indices were then recalculated using the projected values of monthly temperatures and precipitation.

Spatial join tool corresponds to joining attributes from a source feature to a target source based on the spatial relationship. The source feature is the calculated MED-CORDEX delta change grid and the target feature is the WorldClim-2 grid.

Proximity analysis corresponds to finding target features located within a buffer zone or a distance of a source feature. In our case. The MED-CORDEX grid is the source feature and the WorldClim-2 grid is the target feature. The features of MEDCORDEX grid cells were transposed to the nearest grid cells of WorldClim-2.

Page 11, line 3: The reference Colmet-Daage et al 2018 is about the Lez and Aude located in France, and Muga located in northeastern Spain. That is not representative of the whole Mediterranean basin. As mentioned before, the bibliography about climate change projections is rather weak and the authors should cite the relevant literature.

See for example (and the references herein): Lionello, P., and Scarascia, L.: The relation between climate change in the Mediterranean region and global warming, Reg. Env. Change, 18, 1481-1493, doi: 10.1007/s10113-018-1290-1, 2018.

Wolfgang Cramer, Joël Guiot, Marianela Fader, Joaquim Garrabou, Jean-Pierre Gattuso, Ana Iglesias, Manfred A. Lange, Piero Lionello, Maria Carmen Llasat, Shlomit Paz, Josep Peñuelas, Maria Snoussi, Andrea Toreti, Michael N. Tsimplis, Elena Xoplaki. Climate change and interconnected risks to sustainable development in the Mediterranean. Nature Climate Change, 2018; DOI: 10.1038/s41558-018-0299-2 http://www.medecc.org/climate-and-environmental-change-in-the-mediterraneanmain-facts/

Ok, we agree. The following references Lionello et al., 2018 and Cramer et al., 2018 will be added.

This section will be developed furthermore with to the two additional scenarios results.

Page 11, line 19: It is pretty obvious that “climate is continuous” and should not be mentioned in the conclusions.

Ok. this expression will be removed

Figure 1: Topographic boundaries should be replaced by hydrological boundaries, since what is shown on the map are catchment boundaries.

Ok, “topographic” will be replaced by “hydrological”.

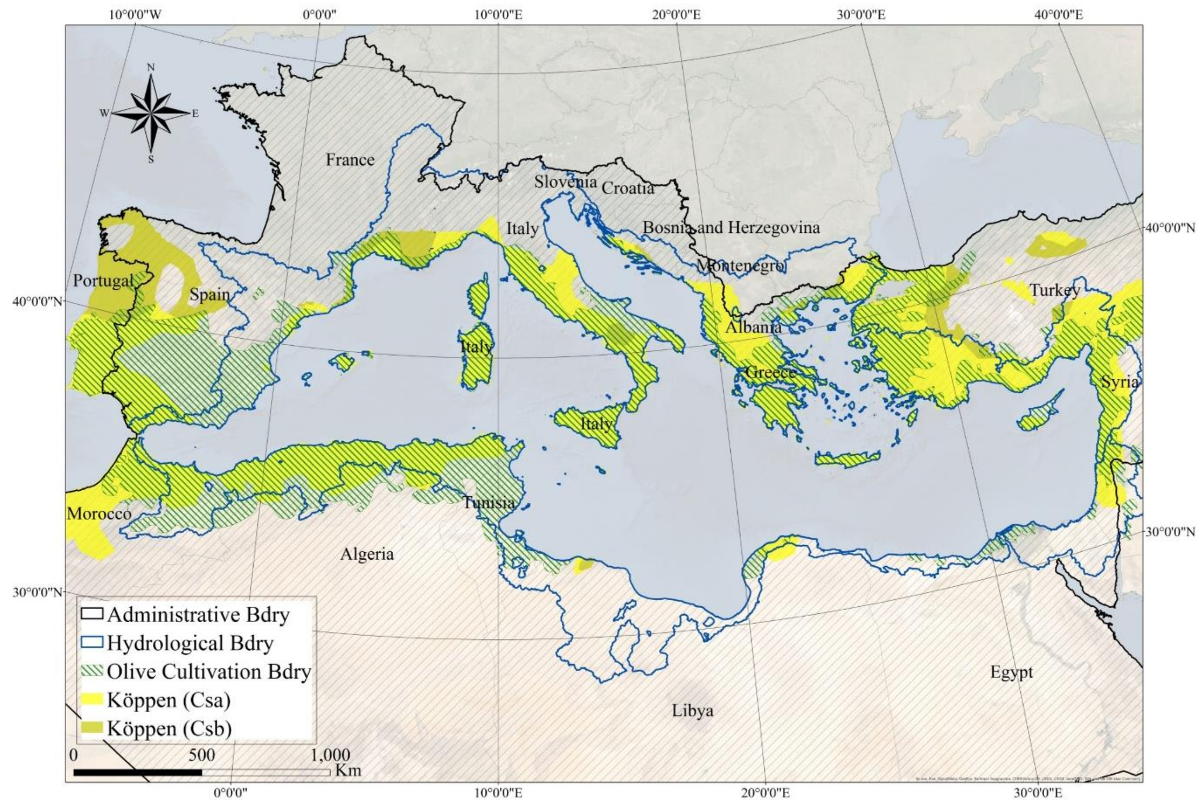

Figure 1 Four Mediterranean region boundaries (Bdry) (Merheb et al. 2016); first administrative, second hydrological (Milano 2013), third olive cultivation (Moreno 2014) and fourth climatic (Peel et al. 2007)

Figure 4: Green on green is hard to see (for olive boundaries)

The dark green colour was modified for a brighter green that should be seen clearly. All figures will be modified accordingly.

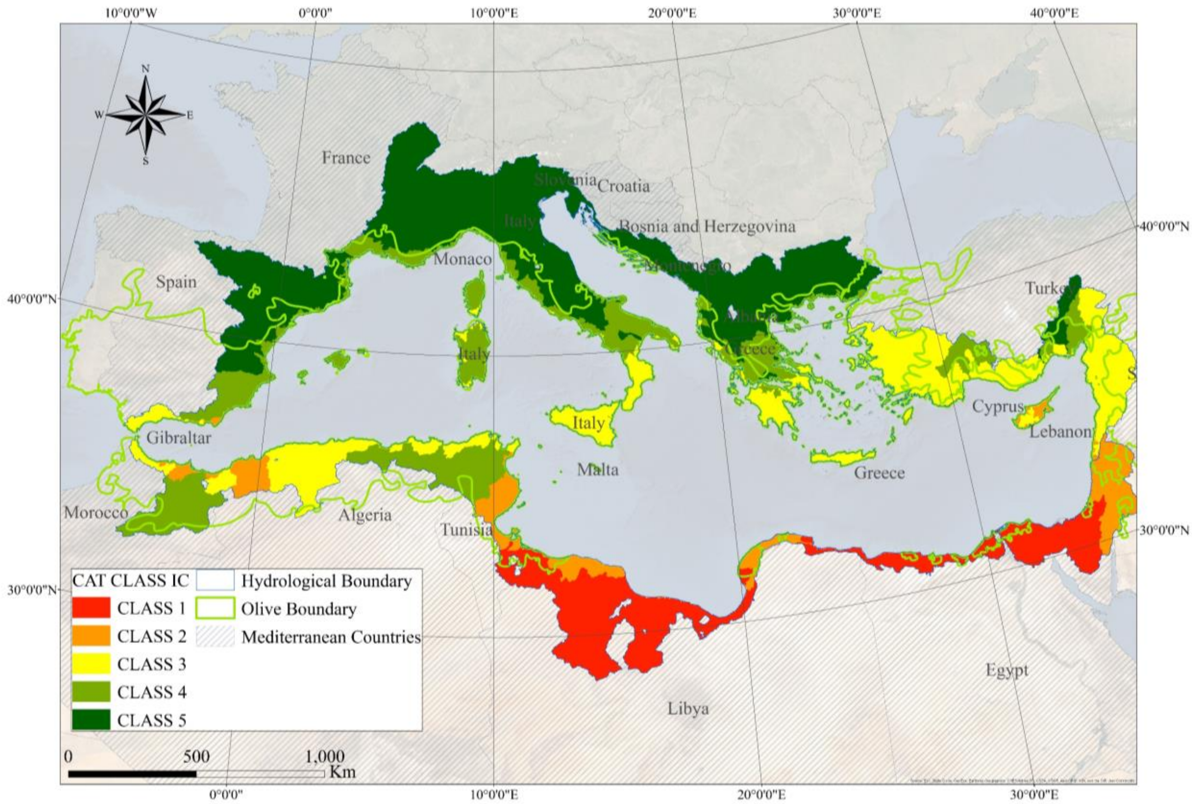

Figure 4. Geographical distribution of the Mediterranean climatic classes based on catchments average indices using WorldClim-2 monthly data.

Table 6 is very hard to understand

An example of how a rule could be applied was added to the legend. As an example, for class 1, if the distance to kernel 1 (D1) is below 3.5 and the distance to kernel 2 (D2) is above 2.2, then the grid cell belongs to class 1