Influence of water transpired and irrigation on maize yields for future climate scenarios using Regional Model

Charveline F. Donfack¹ | Brice B. S. Wandjie² | Eric Efon³ | Andre Lenouo² | David Monkam² | Clement Tchawoua¹

¹Department of Physics, Faculty of Science, University of Yaoundé 1, Yaoundé, Cameroon
²Department of Physics, Faculty of Science, University of Douala, Douala, Cameroon
³Department of Physics, Faculty of Science, University of Bamenda, Bamenda, Cameroon

Abstract
Over northern Cameroon, limited water resources and drought conditions continue to hinder maize production. In this study, the result of the downscaling of the global climate model MPI-ESM-LR by the regional climate model REMO under the high-emission Representative Concentration Pathway 8.5 scenario is used to force the agricultural model AquaCrop. The main goal of the study is to assess the climate change impact on maize yield production throughout the 21st century in this region. The model is first calibrated, and then validated, observed in situ precipitation, temperature, and yield data over the period 2005–2018. The results showed that if the amount of water increase over a period of 1 year by 27 mm, maize yield will increase by 0.415 ton/ha, which corresponds to more than 8% over the entire study area. These findings can be used for decision-making by Cameroonian farmers, particularly in optimizing maize production under climate change scenarios. Irrigation potentially minimizes the impact of climate change. The result also reveals that, for a better yield of corn, the quantity of water necessary for irrigation would be less than 80 mm in 2099 in northern Cameroon.

KEYWORDS
AquaCrop, climate change, irrigation, maize yields, semi-arid region, water transpired

1 INTRODUCTION

Climate change is a cause of concern for all countries and its consequences significantly threaten the achievement of the Millennium Development Goals and the growth in terms of economic impact over Africa (FPA 201, Inoussa 2010). Future climate trends show that large areas, including the Sahel, the Horn of Africa, and parts of central and southern Africa, could be warmed by up to 3 to 6°C by 2100, with a mean of 4.5°C (IPCC, 2013). It is also expected that rainfall patterns will also be affected and maybe reduced by 20% to 30% relative to the World Meteorological Organization (WMO) baseline for 1961–1990 (Bigot, 1997). Recent studies documented a large-scale drying and warming trend across Africa (Hua et al., 2016; Jiang et al., 2019). These changes may seriously alter the agricultural sector, which is the main economic provider for the countries of the sub-region (Nonki et al., 2021; Smith et al., 2019). For example, studies carried out in Senegal (Seck & Moussa, 2005) and Niger (Salack et al., 2006) showed that agricultural yields will experiencing drastic deficits due to the adverse
effects of climate change in horizon 2050. Therefore, understanding the impacts of climate change is critically needed for an efficient program in related sectors.

Maize (Zea mays L.) is among a diverse array of arable crops that are cultivated in Cameroon and has been reported as having high irrigation requirements (Rhoads et al., 1990; Stone et al., 2009). The availability of water anywhere is important for maize growth and development. Low precipitation and associated moisture stress have been mentioned as the major limitations to optimal growth and development of maize (Lobell et al., 2011). Bergamaschi et al. (2007) attributed global maize yield losses of 47% between 1961 and 1980 to changes in temperature in Brazil. For a reference crop, ETo represents the processes of evaporation and transpiration from the vegetation surface. Giannakopoulou and Toumi (2012) suggested that agricultural use increases the water demand by enhancing potential evapotranspiration (ETP). Wandjie et al. (2020) studied the impact of potential ETP on maize yield using the AquaCrop model and reported that maize yield increases with potential ETP.

Traoré et al. (2011) conducted agronomic trials on-farm surveys to adapt the SARRAH (Système d’Analyse Regionale des Risques Agroclimatiques, version H) crop simulation model, and also evaluated it in farmers’ field conditions in West Africa. AquaCrop developed by Food and Agriculture Organization (FAO) is a fairly simpler model, which can simulate maize yield. It differs from other models in its ability to balance precision, simplicity, and robustness. It focuses on water, the use of standardized water productivity values for evaporative demands, and CO₂ concentrations, it also gives high extrapolation of capacities for various locations, seasons, and climates. The model can be applied to various agricultural systems in different parts of the world. Moreover, it has been successfully used for a better performance of cotton crops in Syria and Spain (Farahani et al., 2009; Garcia-Vila et al., 2009), maize in Zimbabwe (Mhiza, 2010), wheat in the winter (Salemi et al., 2009), and cabbages in the Keiyo Highlands in Kenya (Kiptum et al., 2013). Data from six cropping seasons, collected from experimental plots in Davis, California, were initially used to calibrate and validate the model (Hsiao et al., 2009). The model was able to separate evaporation and transpiration of culture and to give the water needed to have good yields of this culture. For example, it has been used to determine the water requirements in northern Cameroon for good yields of maize during the dry season (Donfack et al., 2018).

The goal of this study is to assess the possibility of coupling the crop model with weather and climate forecasts. Hence, we planned to predict future maize yield production in northern Cameroon using the AquaCrop model and to observe the impact of transpiration and irrigation on the production. Section 2 presents data used, study locations, and methods; while Section 3 presents results and discussions, and Section 4 presents the conclusion.

2 | DATA AND METHODOLOGY

Three locations were selected in northern Cameroon: Garoua (9°18’N–13°24’E), Kaélé (10°05’N–14°26’E), and Maroua (10°35’N–14°19’E). They are all characterized by Sudanian and Sudano-Sahelian climates. The selected locations have one dry season and one rainy season (Figure 1) as founded by Jiang et al. (2019). These three locations were selected for the calibration period of 2005–2018. To evaluate the performance of the Regional Model (REMO) in simulating seasonal rainfall over Central Africa, we compared their results with those of the ensemble mean of four gridded observation products over a common time period across models and observation (2005–2018). The Central African domain was defined between 15°S and 15°N latitude, and 5°E and 25°E longitude, which have a complex and heterogeneous topography with extensive mountains, coasts, lakes, and rivers (Fotso-Nguemo et al., 2018). More information on the characteristics of the different observations used is summarized in Table 1. These observations, which are archived and freely accessible (Beck et al., 2017; Funk et al., 2015; Harris et al., 2014; Novella & Thiaw, 2013), were built spatially and temporally by interpolating ground-based and satellite data records. It should be mentioned that, despite the fact that these observations may have some uncertainties due to either ground-based measurement or satellite measurement bias, they have recently shown a remarkable performance over Africa where daily rain gauge data sets are rare and very scarce if they exist (Nikulin et al., 2012; Sylla et al., 2013).

For the calibration and validation results of AquaCrop model, the present study analyzes the December–February (DJF), March–May (MAM), June–August (JJA), and September–November (SON) seasonal means of rainfall for 0-, 3-, and 6-month lead-times (lead-0, lead-3, and lead-6). The agreement between simulated and observed seasonal rainfall was evaluated using the Taylor diagram (Taylor, 2001), which quantifies the similarity between simulations and observations in terms of pattern correlation coefficient (PCC), centered root mean square error (RMSE), and amplitude of variability (SD). The highly performing models were chosen based on two criteria (i) the PCC should be greater than 0.8; and (ii) the SD (i.e., the ratio of the standard deviation of simulated and observed fields) should be between 1.00 ± 0.5.
Simulated data series used in the present study include monthly precipitation, minimum and maximum air temperature for the period of 2010–2099 in the three study areas. These regions have the greatest potential for maize production and productivity due to their high solar radiation, low incidence of pests and diseases (Oyekunle & Badu-Apraku, 2014). Future projection, data were obtained from the REMO forced with the global model Max Planck Institute Earth System Model (MPI-ESM) and the Representative Concentration Pathway 8.5 (RCP 8.5) scenario. The REMO regional climate model, which is suitable for estimating future climate and weather forecasting, was developed as an atmospheric component of the coupled atmosphere-hydrology model system. The different data used to initialize the model in this article was the MPI-ESM re-analyzes (Stevens et al., 2013), for the reference period (1950–2005) and the future period (2020–2099) under the RCP 8.5 emission scenario. The REMO was integrated over a continuous period of 151 years, from January 1950 to December 2100 with 31 vertical levels and a horizontal resolution of 50 km (0.44°). This model was chosen because of its performance in simulating the climate of Central Africa in general (Fotso-Nguemo et al., 2017) and North Cameroon in particular (Nonki et al., 2019). During the period (1980–2005), the spatial rainfall distribution was simulated with an annual spatial PCC of 0.76 for REMO driven
by EC-Earth and 0.74 for REMO driven by MPI-ESM, respectively, when compared to in situ measurements. In terms of temperature, the annual PCC was 0.93 for the two REMO outputs. The seasonal displacement of the Intertropical Convergence Zone (ITCZ) and negative biases of rainfall reproduced by this model as represented in this study, were consistent with those documented in previous studies using either the REMO model (Paeth et al., 2005), the MM5 model (Vizy & Cook, 2002), or the RegCM2 model (Jenkins, 1997).

Water availability is generally the most important natural factor limiting the expansion and development of agriculture in arid and semi-arid regions (Abu-Awwad, 1999). Figure 2a gives an idea of the quantity of rainfall projected for every year from 2010 to 2099. Rainfall was projected to decrease over the Central African region according to all RCP scenarios. As suggested by Van-Vuuren et al. (2011), the RCPs are the products of an innovative collaboration between integrated assessment modelers, climate modelers, terrestrial ecosystem modelers, and emission inventory experts. The resulting product forms a comprehensive data set with high spatial and temporal resolutions for the period extending to 2100. Temperature over Central Africa will rise in a more or less uniform manner in response to various scenarios (Fotso-Nguemo et al., 2017) as shown in Figure 2b by the trend of the average temperature during this period.

The phenological data of maize crops were obtained from the Institute of Agriculture Research for Development (IARD). This maize variety (CMS9015) is used in the three studied areas since it is usually cultivated in these regions, and according to IARD, good yields are obtained (Donfack et al., 2020; Wandjie et al., 2020).

The AquaCrop crop growth model was developed by FAO and assesses the effect of the environment and management on crop production. AquaCrop simulates the yield response of herbaceous crops to water and is particularly well suited to conditions in which water is a key limiting factor in crop production (Raes et al., 2009). As inputs into the model, four variables are used: climate, plant, soil, and irrigation for the considered regions. The calculation scheme of AquaCrop with an indication of the four steps and the processes affected by water stress and temperature stress, green canopy cover, reference ETP, etc. are shown in Figure 3.

Climate parameters include maximum and minimum temperatures, rainfall, and reference ETP. The potential ETP was used as a reference ETP calculated by the following relation (Riou, 1976):

\[
ETP = 0.30T_{\text{max}} - 5.9
\]

where \(T_{\text{max}}\) is maximum temperature. The analysis of data required for the calculation of the ETO followed the method and procedure given in Chapter 3 of the FAO paper 56 (Allen et al., 1998). The trend of mean values for different years (from 2010 to 2099) is shown in Figure 4. Clay soil was taken as a soil profile with all characteristics in AquaCrop. The 15th of June was considered the day after sowing and 17 September was the day of maturity for each year. This period falls within the rainy season in the different sites.

3 | RESULTS AND DISCUSSIONS

3.1 | REMO and AquaCrop models evaluation results

Figure 5 shows the spatial pattern of correlation between the DJF, MAM, JJA, and SON mean rainfall anomalies
observed (left panel), and REMO (right panel) at lead-0 over Central Africa (15°S–15°N, 5°E–35°E) during the period 2005–2018. The observed data set used here is the mean of the four gridded observation rainfall products listed in Table 1. In DJF, correlation is negative in the west of Central Africa and in the east, it is positive. The REMO model appropriately represents this teleconnection but with a slightly more pronounced positive correlation. The PCC = 0.65 confirms this good representation of teleconnection in DJF. In MAM, the observed correlations were significantly positive over the north of the domain near the equator and significantly negative over the south of the Central African domain. The REMO model accurately represents this teleconnection in MAM (PCC = 0.90). In JJA, teleconnection is not well represented by the REMO (PCC = 0.42). The observed correlations were negative over almost the entire domain. The REMO model shows strong positive correlations over southern Cameroon, northern Gabon, and eastern Central African Republic, and strong negative correlations over northern and southern of the domain. In SON, the correlations observed were extremely weak and the teleconnection, although nonexistent, is very poorly represented by the REMO model (PCC = 0.02). At lead-3 (figure not shown), PCC = 0.29 in DJF, PCC = 0.90 in MAM, PCC = 0.37 in JJA, and PCC = 0.07 in SON. At
lead-6 (figure not shown), PCC = 0.48 in DJF, PCC = 0.88 in MAM, PCC = 0.44 in JJA, and PCC = 0.07 in SON.

The calibration and validation of AquaCrop model were done using in situ data and observed the yields for the period 2005 to 2018. The following statistical indicators: the coefficient of determination ($R^2$) of linear adjustment, the root mean square error (RMSE), the square root of the normalized mean square error (nRMSE), and Willmott’s agreement index ($d$) were used to evaluate the relationship between observed and simulated data (Figure 6). The values of $R^2 = 0.93$ for Garoua and $R^2 = 0.85$ for Maroua were obtained by comparing simulated yields with the observed ones. These values:
$R^2$, RMSE, nRMSE, and $d$ are much close to ideal values for perfect calibration of crop yields; therefore, the relationship between the observed and simulated yields was good. This implies that the model is capable of simulating maize yields in the study area.

Simulating the DJF, MAM, JJA, and SON means of rainfall at lead-0, lead-3, and lead-6 averaged at Garoua, Kaélé, and Maroua is shown in Figure 7. In DJF, at all leads, precipitation at Garoua has a significant skill (>0.8) with a normalized SD very close to observations. The precipitation at Kaélé also presented a significant skill (>0.7) at all the lead time. The strongest skills were recorded for the precipitation at Maroua (skill > 0.95). In MAM, the scores were low compared to those of DJF. The precipitation at Garoua and at Maroua had skills >0.8 and precipitation at Maroua has a skill >0.6. For the JJA and SON seasons, and for all the lead times, the skill was >0.9. However, we noted that the normalized SDs were closer to the observations for precipitation at Maroua and Kaélé.

Simulations were carried out to determine the impact of the future climate on agricultural yields and determine the quantities of water needed to compensate for the shortcomings: (i) The first consisted in simulating the yields of maize plants from 2020 to 2099 and then comparing the values obtained with those of the reference period 1987–2004 (Garoua and Maroua) and 1970–1985 (Kaélé) in order to assess the impact of future climate on maize yields in each study area. (ii) The second consisted in estimating yields when irrigation is done from 2020 to 2099 in the three study areas. During this second simulation, we also determined the quantities of water needed for irrigation in order to develop strategies for adapting and mitigating the impacts of these future climates.

### 3.2 Simulation of maize yields and transpiration

Transpiration occurs because plants take in more water than they actually need at a given time. When water is removed from the plant, it can easily access the carbon dioxide that it needs for photosynthesis. In addition, plants can use transpiration as a method of cooling themselves. It should be noted that the rate of transpiration can be higher during dry spells.

Maize productions in Garoua, Kaélé, and Maroua from 2010 to 2099 are shown in Table 2. We found that Garoua has the greatest maize plant transpiration (156 mm) implying greater average yield (3.72 ton/ha) than other areas. The crop yield per water transpired here was 0.023.8 ton/ha/mm. Shorter maize growth cycle is likely to occur in the future, thus reducing seasonal water supply, crop transpiration, and water demand (Islam et al., 2012; Meza et al., 2008). Conversely, a longer growth cycle is likely to produce larger and deeper root systems that allow extracting more soil moisture and maximizing crop water uptake (Blum, 2009; Debaeke & Aboudrare, 2004). Based on different results shown in Table 2, transpiration can be regarded as an important parameter in maize yield. In fact, the effectiveness of AquaCrop to separate soil evaporation and plant transpiration enables us to have the best insight on transpiration effect. According to the predictions, a higher rate of transpiration from 1 year to another is generally followed by an increase in yield. For example, transpiration will increase from 225 mm for 6.346 ton/ha in 2044 to 226 mm for 6.487 ton/ha in 2045 at Garoua, from 162 mm for 3.612 ton/ha in 2044 to 103 mm for 1.826 ton/ha in 2045 at Kaélé, and from 218 mm for

---

**Figure 6** Relationship between observed and simulated grain yield per hectare at 95th percentile confidence for (a) the city of Garoua and (b) the city of Maroua
5.423 ton/ha in 2044 to 205 mm for 5.029 ton/ha in 2045 at Maroua. The inverse phenomenon was observed when transpiration decreases. Similar results were obtained by Wandjie et al. (2020), which compared the results on two stations by using five formulations of potential ETP.

Kang et al. (2015) analyzed climate change impacts on water productivity of cropping systems in the Murray Darling Basin (Australia) and the results pointed out that for rainfall and irrigated maize, the crop yield, the potential, and actual ETP will increase by 3–32, 3–12, 30–45 and 32%–45, 3%–15, 6%–15% under both scenarios in the future during the maize growth period compared with the baseline, respectively. Similar results were highlighted by Donfack et al. (2018) where rainfall maize yields were significant than driest maize yields. The simulated results in the present study showed a global decrease of maize yield with the decrease of rain, for example, in Maroua, 3.358 ton/ha for 509 mm of rain in 2090 and 1.836 ton/ha for 312 mm of rain in 2091.

**TABLE 2** Average yields and average plant transpiration for simulation period (from 2010 to 2099)

| Location | Average yield (ton/ha) | Average plant transpiration (mm) | Crop yield per unit water transpired (ton/ha/mm) |
|----------|------------------------|---------------------------------|-----------------------------------------------|
| Garoua   | 3.72                   | 156.0                           | 0.0238                                        |
| Kaélé    | 2.23                   | 116.9                           | 0.0190                                        |
| Maroua   | 2.53                   | 127.7                           | 0.0198                                        |
So, although the fact that maize needs water to grow and to produce, the water transpired by maize during the growth period plays an important role in maize yield.

4 CONCLUSION

Considering the semi-arid climate particularly in northern Cameroon, with limited water resources, and the role of agriculture and economic impact of maize yield in Cameroon in general, the evaluation of the effects of climate change on water resources and water supplies for agriculture in future is of great importance. The aim of this study was to determine the climate projections obtained from the REMO forced with the global MPI-ESM model of the RCP 8.5 scenario over the period 2010 to 2099 in three localities in northern Cameroon. These data were used to calibrate the AquaCrop model in order to simulate future corn yields. The AquaCrop model requires minimum and maximum temperatures, precipitation, and ETP.

The results showed that maize yields will decrease with future climate change in the three zones of study, and according to the water send away into the atmosphere (evaporation and transpiration) we found that maize yields will increase significantly with transpiration. In fact, the transpiration of the plant during the growing cycle will affect the crop yield more than the soil evaporation; for example, a decrease of transpiration from 162 to 103 mm will induce a decrease of maize yield from 3.612 to 1.826 ton/ha in Garoua and the same trend will be observed in other areas. In general, a reduction in the rate of transpiration will decrease maize production. The results of field experiments and on-farm surveys allowed adapting the AquaCrop model, which can be used to simulate the growth and development of a large spectrum of local and improved crop varieties in semi-arid agro-climatic conditions.

Implementing the adaptation scenarios to the potential effects of climate change should be among the main strategies to enhance the reliability of the water supply system in the future. Knowing the impact of transpiration on crop yields is recommended for better water resources management in the studied area. Similarly, measures such as increasing transpiration and irrigation can be taken into account to enhance crop yields and to manage their vulnerability under the possible consequences of climate change. In perspective, we plan to evaluate the effect of different irrigation dynamics on yield and water consumption through the application of deficit irrigation.

ACKNOWLEDGEMENTS

The authors thank Dr. Fotso-Nguemo who provided the simulation of the data obtained from the Regional Model forced with the global model MPI-ESM of the RCP 8.5 scenario. The phonological data of maize crops were obtained from the Institute of Agriculture Research for Development and AquaCrop model a software developed by an expert group of Food and Agriculture Organization, we acknowledge these two teams. Anonymous reviewer’s comments helped to improve the earlier version of this manuscript.
AUTHOR CONTRIBUTIONS
Charveline Francine Donfack: Conceptualization; data curation; formal analysis; investigation; methodology; resources; software; validation; writing – original draft; writing – review and editing. Brice B. S. Wandjie: Data curation; methodology; writing – original draft; writing – review and editing. Efon Eric: Data curation; methodology; writing – original draft; writing – review and editing. Andre Lenouo: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; supervision; validation; writing – original draft; writing – review and editing. Monkam David: Project administration; resources; writing – original draft. Clement Tchawoua: Project administration; resources; supervision; writing – original draft.

ORCID
Andre Lenouo https://orcid.org/0000-0003-4745-8476

REFERENCES
Abu-Awwad, A.M. (1999) Irrigation water management for efficient water use in mulched onion. Journal of Agronomy and Crop Science, 183, 1–7.
Allen, R.G., Pereira, L.S., Raes, D. & Smith, M. (1998) Crop evapotranspiration: guidelines for computing crop water requirements. In: FAO irrigation and drainage paper 56. Rome: FAO.
Beck, H.E., Van Dijk, A.I., Levizzani, V., Schellekens, J., Gonzalez Miralles, D., Martens, B. et al. (2017) MSWEP: 3-hourly 0.25 global gridded precipitation (1979-2015) by merging gauge, satellite, and reanalysis data. Hydrology and Earth System Sciences, 21(1), 589–615.
Bergamaschi, P., Frankenberg, C., Meirink, J.F., Krol, M., Dentener, F., Wagner, T. et al. (2007) Satellite chartography of atmospheric methane from SCIAMACHY on board ENVISAT: 2. Evaluation based on inverse model simulations. JGR-Atmospheres, 112, D2. https://doi.org/10.1029/2005JD006235
Bigot, S. (1997) Les précipitations et la convection profonde en Afrique centrale: cycle saisonnier, variabilité interannuelle et impact sur la végétation. Thèse de doctorat, Université de Bourgogne, Centre de Recherches de Climatologie, Dijon, p. 289.
Blum, A. (2009) Effective use of water (EUW) and not water-use efficiency (WUE) is the target of crop yield improvement under drought stress. Field Crops Research, 112, 119–123.
Debaeke, P. & Aboudrar, A. (2004) Adaptation of crop management to water-limited environments. European Journal of Agronomy, 21, 433–446.
Donfack, F.C., Lenouo, A. & Tchawoua, C. (2018) Water requirements for corn yields in the northern regions of Cameroon using aquacrop model. Journal of Agriculture and Ecology Research International, 16, 1–11.
Donfack, F.C., Wandjie, B.B.S., Lenouo, A., Monkam, D. & Tchawoua, C. (2020) Irrigation requirements and yields of maize crop under future climate in some cities of Northern Cameroon. Journal of Agricultural Science, 12(8), 226–244. https://doi.org/10.5539/jas.v12n8p226
Lobell, D.B., Schlenker, W. & Costa-Roberts, J. (2011) Climate trends and global crop production since 1980. *Science*, 333(6042), 616–620.

Meza, F.J., Silva, D. & Vigil, H. (2008) Climate change impacts on irrigated maize in Mediterranean climates: evaluation of double cropping as an emerging adaptation alternative. *Agricultural Systems*, 98, 21–30.

Mhiza, T. (2010) *Increase of yield stability by staggering the sowing dates of different varieties of Rainfed Maize in Zimbabwe*. Thesis, D.Phil. Catholic University, Leuven, p. 43.

Nikulin, G., Jones, C., Samuelsson, P., Giorgi, F., Asrar, G., Bchnner, M., Cerez-Mota, R., Christensen, O.B., Déqué, M., Fernandez, J., Hansler, A., van Mejigaard, E., Sylla, M.B., & Sushima, L. (2012). Precipitation climatology in an ensemble of CORDEX-Africa regional climate simulations. *Journal of Climate*, 25, 6057–6078. https://doi.org/10.1175/JCLI-D-11-00375.1.

Nonki, R.M., Lenouo, A., Lennard, C.J. & Tchawoua, C. (2019) Assessing climate change impacts on water resources in the Benue river basin, northern Cameroon. *Environmental Earth Sciences*, 78, 606.

Nonki, R.M., Lenouo, A., Tchawoua, C., Lennard, C.J. & Amoussou, E. (2021) Impact of climate change on hydropower potential of the Lagdo dam, Benue River Basin, northern Cameroon. *Proceedings of the International Association of Hydrological Sciences*, 98, 1–6. https://doi.org/10.5194/pihs-98-1-2021 (in press).

Novella, N.S. & Thiaw, W.M. (2013) African rainfall climatology version 2 for famine early warning systems. *Journal of Applied Meteorology and Climatology*, 52(3), 588–606.

Oyekunle, M. & Badu-Apraku, B. (2014) Genetic analysis of grain yield and other traits of early-maturing maize Inbreds under drought and well-watered conditions. *Journal of Agronomy and Crop Science*, 200, 92–107.

Paeth, H., Born, K., Podzun, R. & Jacob, D. (2005) Regional dynamical downscaling over West Africa: model evaluation and comparison of wet and dry years. *Meteorologische Zeitschrift*, 14, 349–367.

Raes, D., Seduto, P., Hsiao, T.C. & Fereres, E. (2009) AquaCrop: the FAO crop model to simulate yield response to water: II. Main algorithms and software description. *Agronomy Journal*, 101, 438–447.

Rhoads, F.M., Bennett, J.M., Corn Stewart, B.A. & Nielsen, D.R. (1990) Irrigation of agricultural crops. 569–596 ASA, CSSA, and SSSA Madison, WI Agronomy Monogr. 30.

Riou, C. (1976) *Les relations entre le rayonnement solaire et la température*. O.R.S.T.O.M. collection de référence n°8170 Hydr.

Salack, S., Traoré, B.S. & Sarr, B. (2006) *Synthèse sur la collecte, la mise en forme et le stockage des données climatologiques des pays du CLISS, et Étude d’impacts des changements climatiques sur la production agricole au Sahel*. Rapport de stage, Centre Régional AGRHYMET, p. 95.

Salemi, H., Soom, M.A.M., Lee, T.S., Mousavi, S.F., Ganji, A. & Yusoff, M.K. (2011) Application of AquaCrop model in deficit irrigation management of winter wheat in arid region. *African Journal of Agricultural Research*, 610, 2204–2215.

Seck, M. & Moussa, N.A. (2005) *Adaptation aux Changements Climatiques*. L’étude de cas des systèmes de production agricoles de Sébikotane (Sénégal) Linking Climate Adaptation Project, 33 p.

Smith, E., Baxter, C., Schaeffer, M., Baarsch, F. & Granadillos, J.R. (2019) *Climate change impacts on Africa’s economic growth*. Germany: African Development Bank, Potsdam Institute for Climate Impact Research, p. 169.

Stevens, B., Giorgetta, M., Esch, M., Mauritsen, T., Crueger, T., Rast, S. et al. (2013) The atmospheric component of the MPI-M earth system model: ECHAM6. *Journal of Advances in Modeling Earth Systems*, 5, 146–172.

Stone, D.A., Allen, M.R., Stott, P.A., Pall, P., Min, S.K., Nozawa, T. et al. (2009) The detection and attribution of human influence on climate. *Annual Review of Environment and Resources*, 34, 1–16.

Sylla, M.B., Diallo, I., & Pal, J.S. 2013. West African monsoon in state-of-the-art regional climate models. In: Climate Variability Regional and Thematic Patterns, Aondover Tarhule, IntechOpen, https://doi.org/10.5772/55140

Taylor, K.E. (2001) Summarizing multiple aspects of model performance in a single diagram. *Journal of Geophysical Research-Atmospheres*, 106(D7), 7183–7192.

Traoré, S.B., Alhassane, A., Muller, B., Kouressy, M., Somé, L., Sultan, B. et al. (2011) Characterizing and modeling the diversity of cropping situations under climatic constraints in West Africa. *Atmospheric Science Letters*, 12, 89–95. https://doi.org/10.1002/asl.295

Van-Vuuren, D.P., Edmonds, J.A., Kainuma, M., Riahi, K. & Weyant, J. (2011) The representative concentration pathways: an overview. *Climate Change*, 199, 1–4.

Vizy, E. & Cook, K. (2002) Development and application of a meso-scale climate model for the tropics: influence of sea surface temperature anomalies on the West African monsoon. *Journal of Geophysical Research Atmospheres*, 107(D3), 4023. https://doi.org/10.1029/2001JD000686

Wandjie, B.B.S., Lenouo, A. & Monkam, D. (2020) Impact of potential evapotranspiration on maize yields in northern Cameroon using AquaCrop model. *International Journal of Hydrology Science and Technology*, 10(1), 17–37.

How to cite this article: Donfack, C. F., Wandjie, B. B. S., Efon, E., Lenouo, A., Monkam, D., & Tchawoua, C. (2022). Influence of water transpired and irrigation on maize yields for future climate scenarios using Regional Model. *Atmospheric Science Letters*, 23(3), e1075. https://doi.org/10.1002/asl.1075