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Spatial and Temporal Analysis of Precipitation and Mapping using Terra Climate data in southern Uzbekistan

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ABSTRACT: Climate parameters such as temperature and precipitation are of high importance in irrigated agriculture to understand frequency of changes over time and make decisions based on the results of spatially distributed maps. Economy of Central Asian States are highly dependent on irrigated agriculture where there is a need for accurate measurement of climate parameters get better understanding of how much precipitation is available and what are the time series changes. Climate engine provides long term cloud data on various climate related parameters. This study conducted analysis of precipitation from Terra Climate (Huntington, et al., 2017)with 4 km grid data. Terra climate provides datasets on climate and climate water balance datasets for terrestrial surface based on WorldClim and CRU Ts4.0 and JRA55. Time span of the datasets are starting form 1958 up to present time. Precipitation maps downloaded directly from Climate Engine platform and calibration has been done using available historical data to get more accurate information for the study area. The calibration method has been successfully compared with the observed full datasets and the results were prepared as spatial maps.

KEY WORDS: Climate Engine, Precipitation, Calibration, Mapping

I. INTRODUCTION

The expansion of irrigated areas in Kashkadarya province of the Amudarya river Basin is becoming more challenging to the available water resources. Climate change is affecting both the crop water requirement and water availability in the region. In the past century, air temperature in the region has increased by 0.1˚C - 0.2˚C each decade [UNEP]. Increasing temperatures are affecting to increase evapotranspiration rates and reduced water availability in the region will continue to increase the pressure on the scarce water with possible negative impacts on irrigated agriculture. To mitigate these negative impacts, there is a need expand research activities to study each single parameters of climate and natural resources and develop an optimal methods to better understand the climatic parameters. Global warming is already affecting depletion of glaciers and snow melting in the region (Aizen et al., 2009, Savoskul et al., 2013). Increasing temperature and changing precipitation patterns has an effect on soil water storage. Therefore, these challenges will require new methodologies and approaches and adaptation strategies in the region. Optimal studies of spatial and temporal assessment of precipitation in Central Asia are poorly understood and quantified. The quantification of this can provide to the more information of spatial distribution of rainfall amount across the province. This will help decision makers and research communities to implement new ways of generating spatial maps which can be useful for accurate measurement and implement sustainable management of existing natural resources.

II.STUDY AREA AND DATA

A. STUDY AREA

Kashkadarya region is located in southern part of Uzbekistan. The area of the Kashkadarya region is 28 570 km2(fig.2.1). The western part of the basin is occupied by vast desert spaces.(Sands of Sundukli), eastern foothills and mountains. In the northeastern part the pool is bounded by the Zarafshan ridge, in the east and southeast of the basin the spurs of the Gissar Range-Baysuntau and Kugitangtau are located (Irrigation in Uzbekistan, Volume 3) (Fig. 1). The climate in the study area especially temperature is very high or summer is hot and long, but winter is short and cold, spring is relatively wet. The climate is changing asmoving from the desert lowlands to the mountains. The amount of

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positive temperatures reach 4900-5000 °, the sum of effective - 2519-2980 °.Maximum temperature in these territory reaches up to 47-50 °. Annual precipitation is 144-534 mm during the growing season, 40-140 mm with evaporation from the water surface. As a result, there is a large moisture deficit,which in the growing season reaches 970-1540 mm(Miroshnichenko, 1981).

Fig.1. Study area (Wikipedia).

B. DATA USED IN THIS STUDY

Precipitation from Terra climate was used which is collected from climate engine platform. This platform provides good amount of datasets both climate and remote sensing information (fig.2). In addition to this it was possible to collect historical observed data from local hydro meteorological service Center. Data were collected are starting from 1993 up to present time. This data was used for calibration and bias correction of spatial map of Terra Climate. Below we can see interface of climate engine platform.

Fig.2. Interface of climate engine platform.

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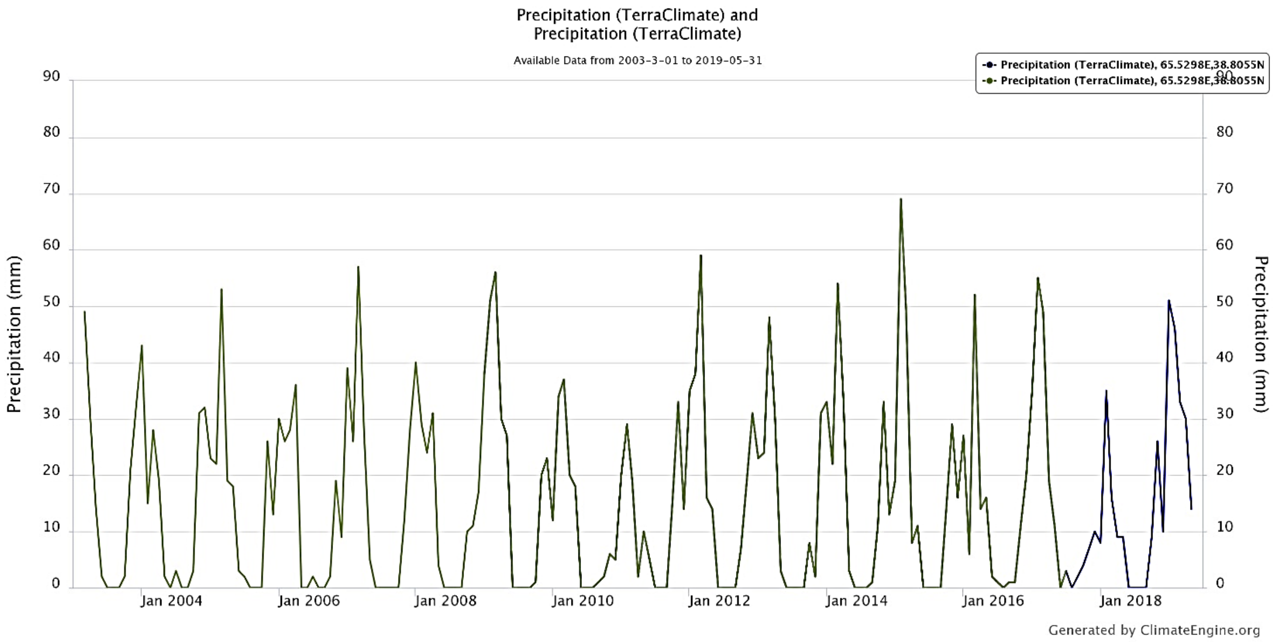

Fig.3. Time series trend of precipitation from TerraClimate.

III. METHODOLOGY

Although Terra Climate data is the result of interventions of like many other numerical global climate models regional analysis of these data still requires verification of accuracy using meteorological data by comparison with those observed at weather stations in history. Evaluation and Correction this dataset for the study area were made by comparing terra climate results with observed meteorological data which was done according to meteorological stations in the study area.

The datasets of terra climate were adjusted and calibrated taking into account discrepancies resulting from the interpolation procedure in nodesregular grid at the nearest meteorological stations and terra climate results according to the formulas:

$$\overline{\Delta}_m = \frac{1}{\mathrm{L}}\sum_{\mathrm{k}=1}^{\mathrm{L}}\frac{1}{\mathrm{N}}\sum_{i=1}^{N}\left(f_{m_i}^{mod} - f_{m_i}^{int}\right)_{k},$$

$$\hat{f}_m = f_m^{mod} + \overline{\Delta}_m,$$

Where $f_{m_i}^{mod}$ is mean monthly climate variable whereas $f_{m_i}^{int}$ is an observed datasets. Weather data from 1993 to 2011 were used for calibration and weather data from 1993 and 2011 were used for validation of the model. Thereafter, the calculated bias correction factors for each month were considered in correction of precipitation data of Terra Climate. In fig. below shows the annual trend of precipitation, generated according to model calculations, observed data on weather stations and adjusted model precipitation curve giving much closer results of the terra climate data compared to observed data.

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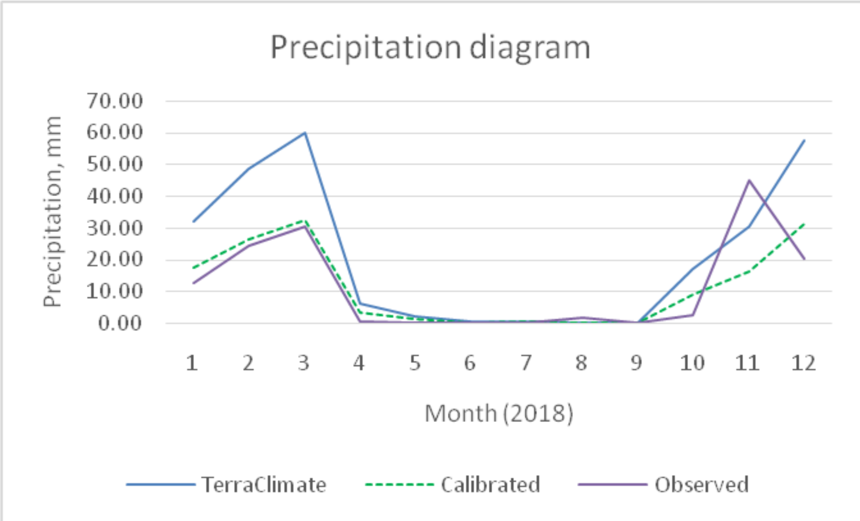

Fig.4. Monthly calibration graph.

The distribution of the curves shown in the figure, it is easy to see that the model curve carries a systematic error with various shifts. The reason for this feature of the annual course systematic error is unclear and requires an in-depth analysis of the Terra Climate data. It is most likely that the change of sign of systematic error from one to another is associated with the response of climate models toregional climatic features, more precisely, not taking into account these features.

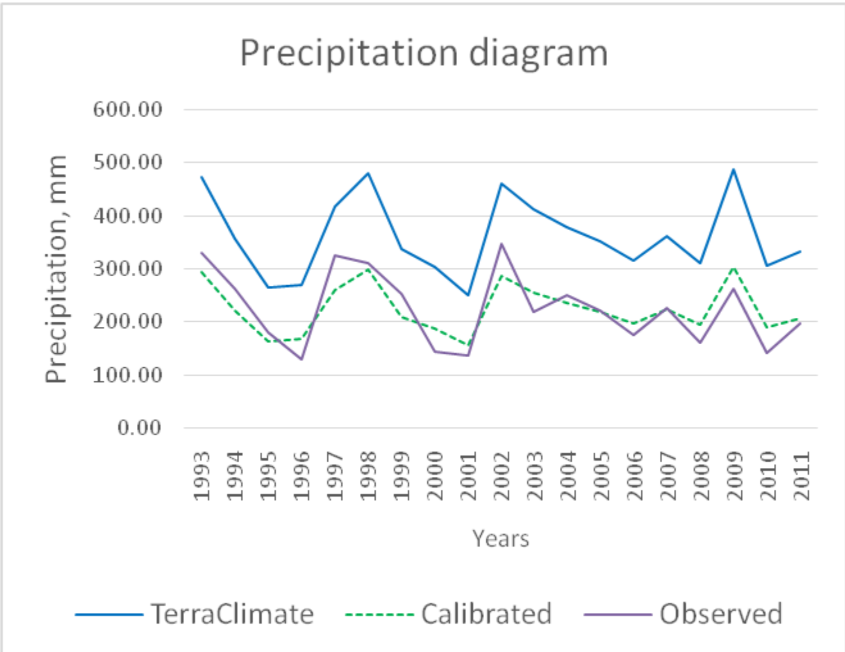

Fig.5. Annual calibration graph.

Correction factor was obtained using the formula suggested by Teutschbeina and Seiberta (2012). The formula calculates the bias correction factor divides mean monthly precipitation obtained from the Terra climate by mean monthly precipitation obtained from the observation datasets. The pixel data of geographical location of the observation meteorological station were identified and pixel data extracted from the climate engine interface as excel file. This way all corresponding data to the same locations were analysed and calibrated.

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IV. EXPERIMENTAL RESULTS

Once correction factor identified and used in excel form to correct datasets, we then used this factor in raster calculator tool in ArcGIS to apply the correction values for the images that is obtained from Terra Climate. The result is shown as spatial map where one can

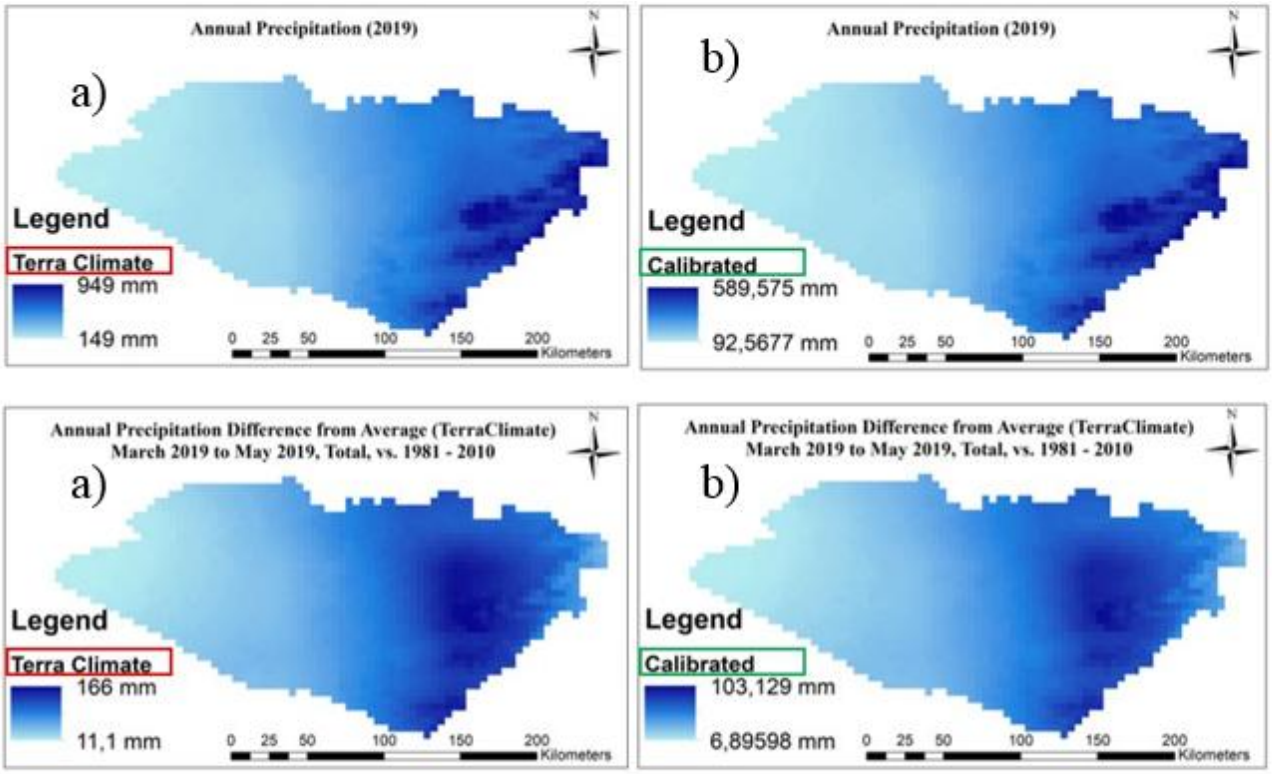

Fig.6. Spatial map of precipitation a) before correction b) after correction

Terra climate datasets raw data shown above before calibration has overestimates on precipitation. After calibration and correction the values has decreased and is similar to the observed data.

V.CONCLUSION AND FUTURE WORK

Based on the results, the correction equation is providing more realistic results which is also shown in the figure 4 that it is suitable using this equation to get more accurate results in arid continental climate of Kashkadarya region in southern Uzbekistan. Since data on Terra Climate is developed regional wise, and the information is not as close to the observed data it is possible to modify and correct using the methods mentioned above and get more accurately calculate information. Measuring and assessing precipitation is highly important for understanding of available water resources and water cycle of natural systems. This types of assessments are necessary to get more accurate information so that the results can be used in other research activities especially in the water balance of like large scale irrigated areas. This is important for such area where water resources have to be managed rationally. So reliable and consistent information on precipitation can be accessed with less time, temporal and spatial estimation at low cost, it can be used for other activities to analyse the performance of various devise better management resources.. Additionally, the findings suggest that the methods used in this paper can be applied in data limited regions to get spatial distribution of precipitation, as well as to inform decision making and develop more effective agricultural practices on water management, irrigation scheduling and crop production.

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