Potential impacts of climate change on groundwater resources in five small plains of a semi-arid region: uncertainty quantification using a nonparametric method

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- Method
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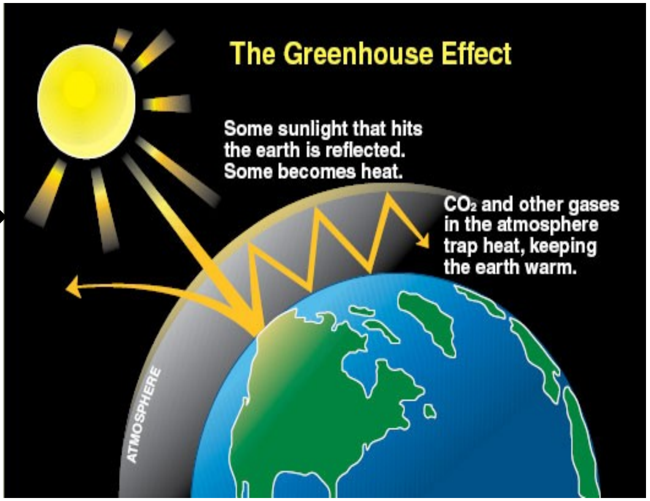
Climate Change:

The greenhouse gases concentration is expected to rise during the present century by global economic development. The impact of rising greenhouse gases concentration on climate variables such as temperature and precipitation is inevitable.



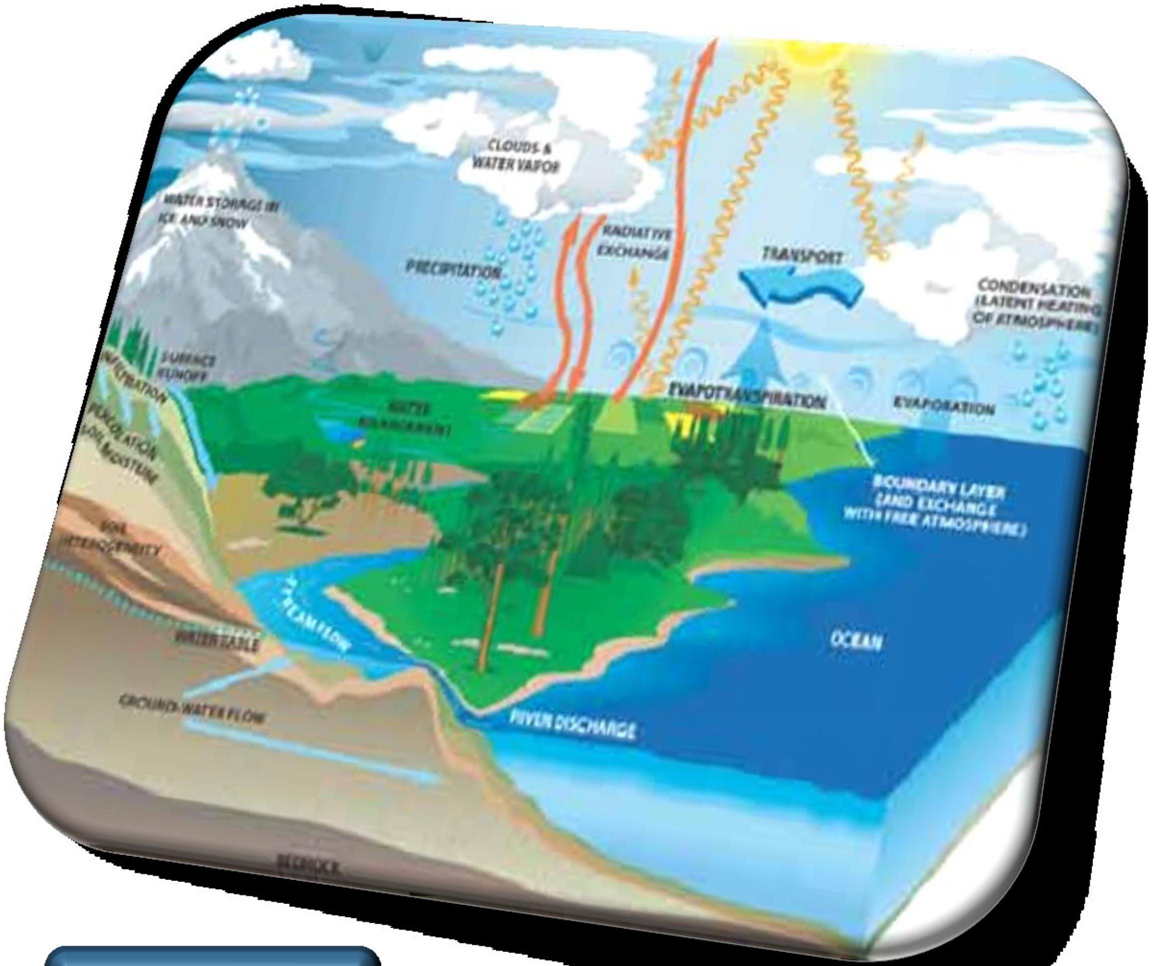
The trend of rising global warming will continue for decades even if the present greenhouse gasses concentration decreases at the global scale.

Climate Change:

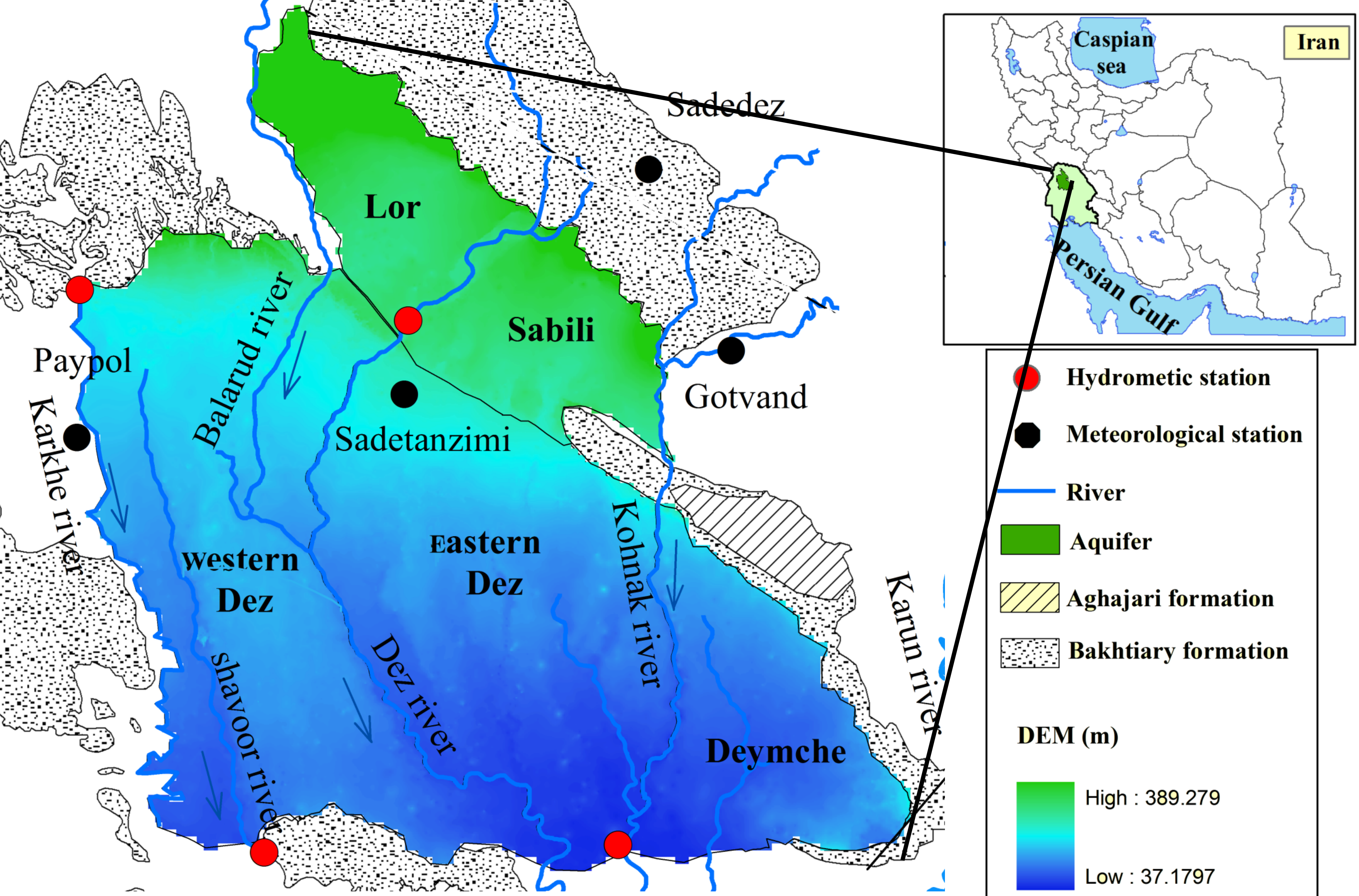
There are several methods for simulating present and future climate variables, which the most reliable tools are three-dimensional general circulation models (GCMs). However, there are high level of uncertainties associated with these models that rises from the parameters and the model structure that can lead to errors in forecasting and planning. Minville et al., 2008 indicated that the largest uncertainty in climate impact studies is due to GCMs rather than downscaling methods, or hydrological models. Many other studies suggested using more than one GCM in climate impact studies.

Climate Change:

Groundwater:

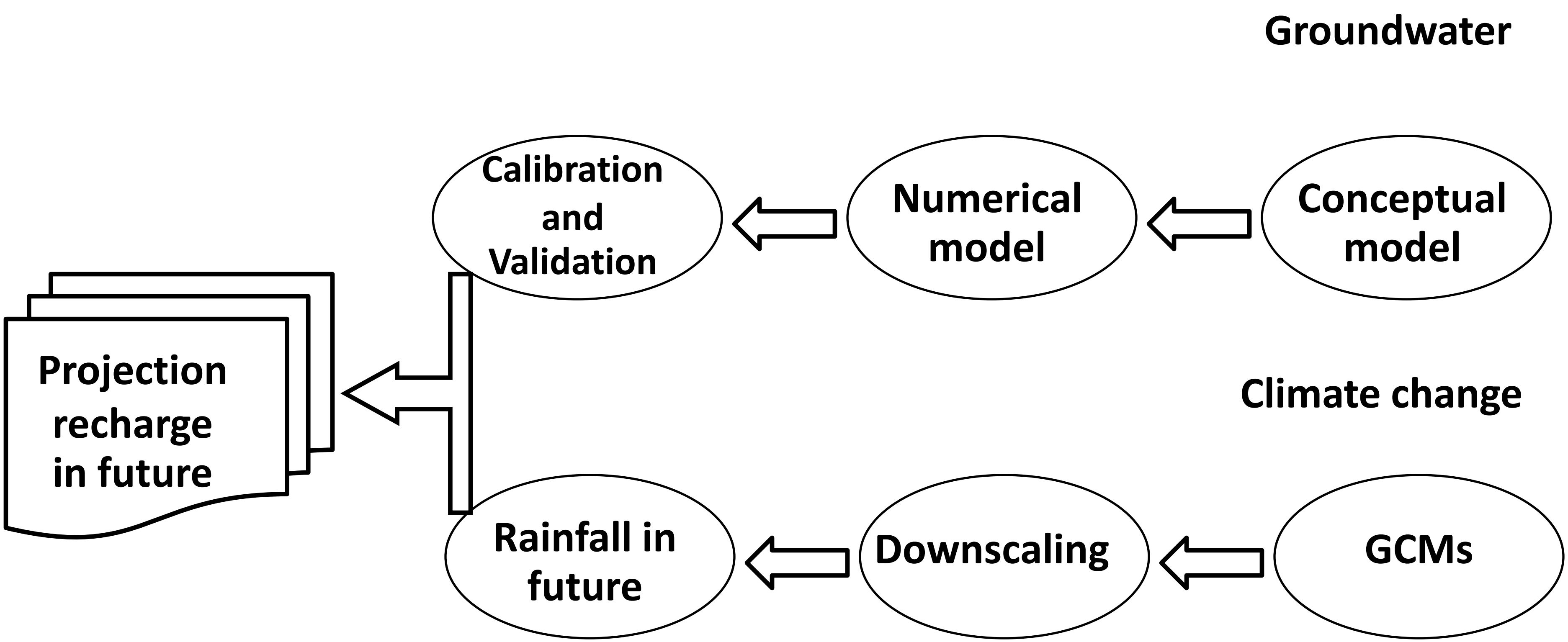


The numerical models are one of the best methods of assessing the quantity and quality of groundwater. These models are difficult and time consuming. However, in the recent decades research that uses simulation models have been developed due to the improvement of high-speed computers. The groundwater models actually are a simplified sample of reality.



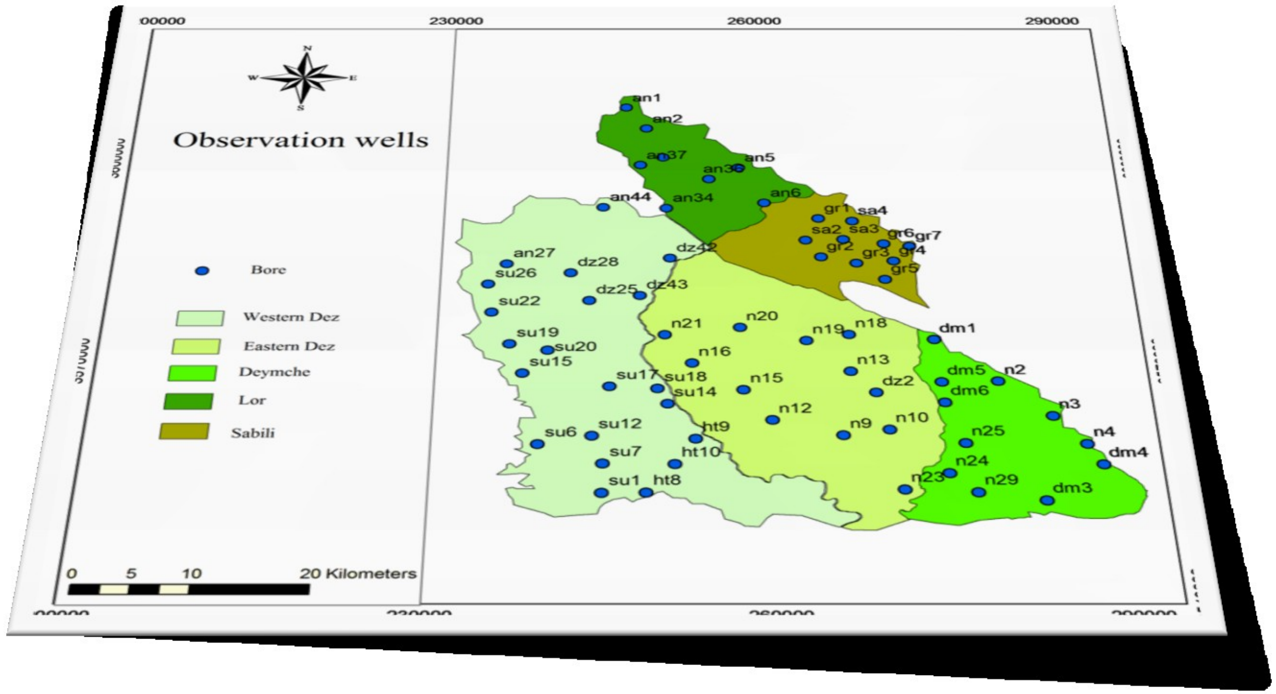
Caspian sea
Iran
Persian Gulf
Sadedez
Lor
Sabili
Paypol
Balarud river
Gotvand
Sadetanzimi
Karkhe river
Western Dez
Eastern Dez
Kohnak river
Karun river
shavoor river
Dez river
Deymche
Hydrometic station
Meteorological station
River
Aquifer
Aghajari formation
Bakhtiary formation
DEM (m)
High : 389.279
Low : 37.1797

Methodology Framework:



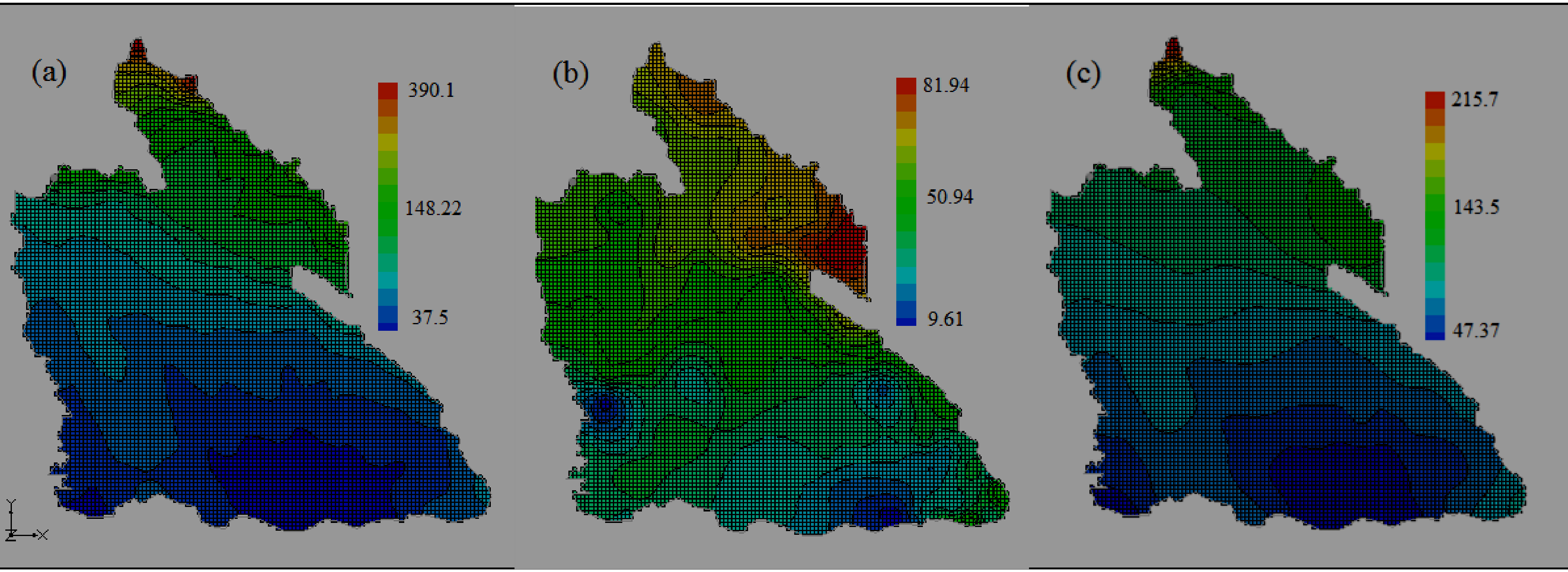
Groundwater model

Conceptual model :



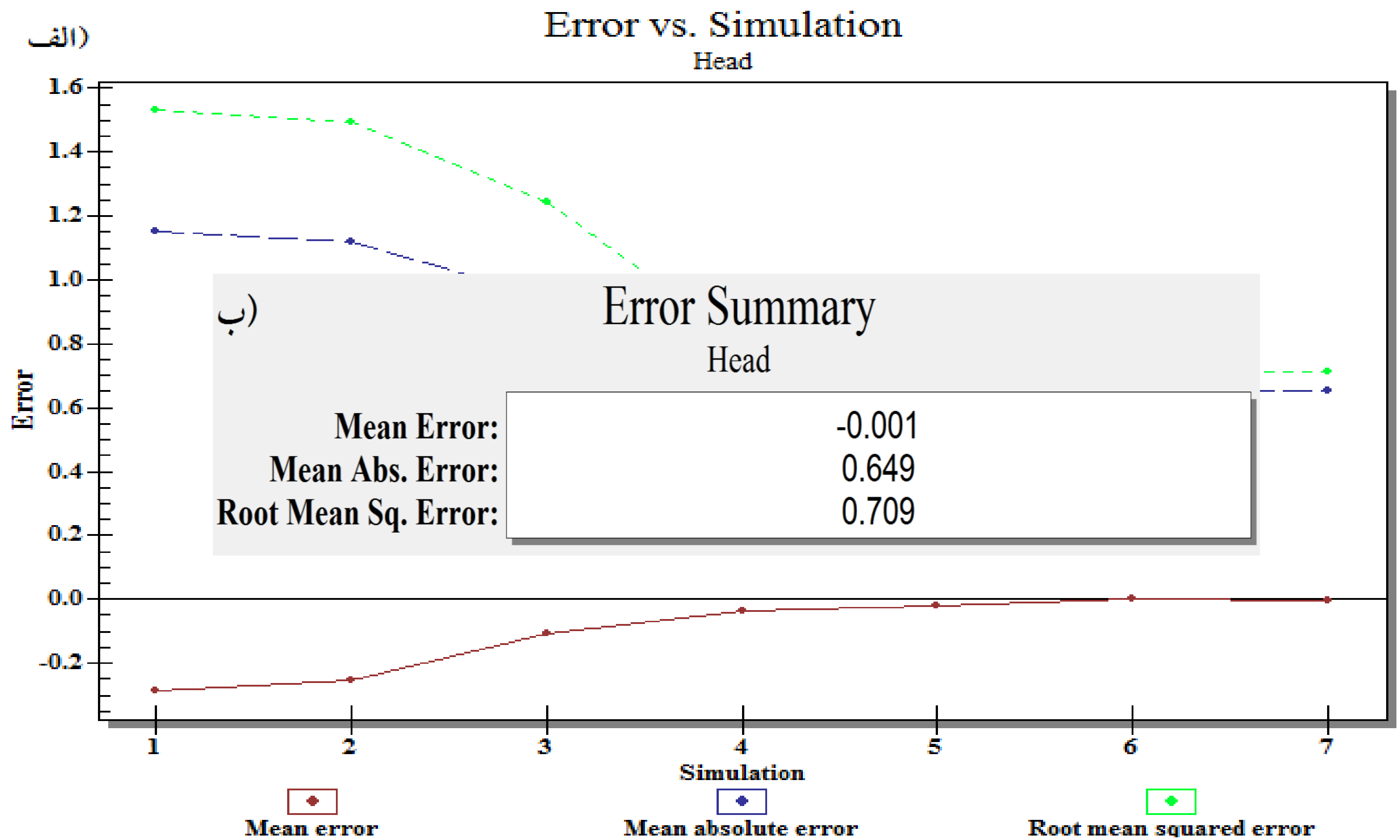
Groundwater Model

Numerical Model :



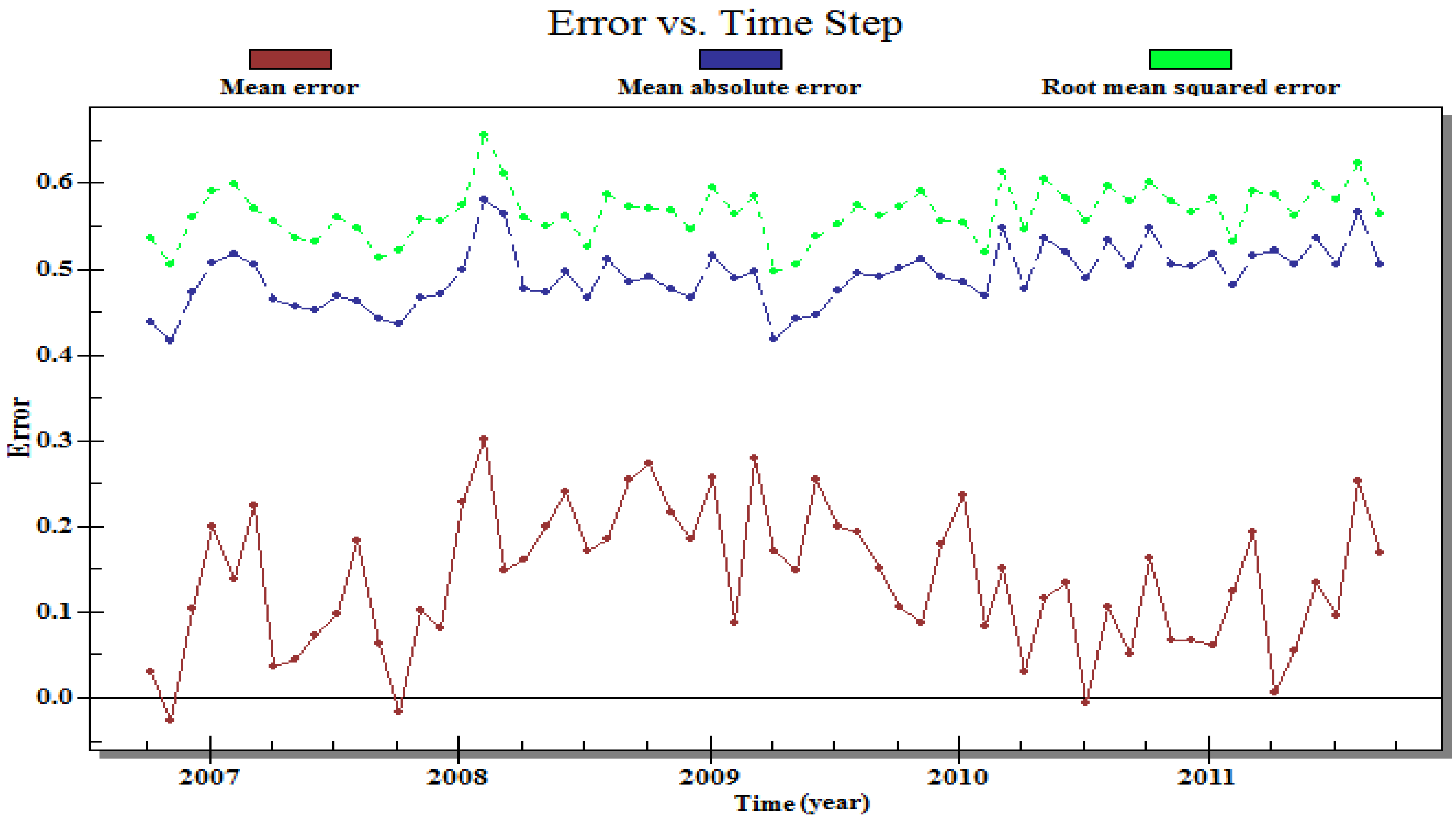
Groundwater Model

Calibration :



Groundwater model

Calibration：



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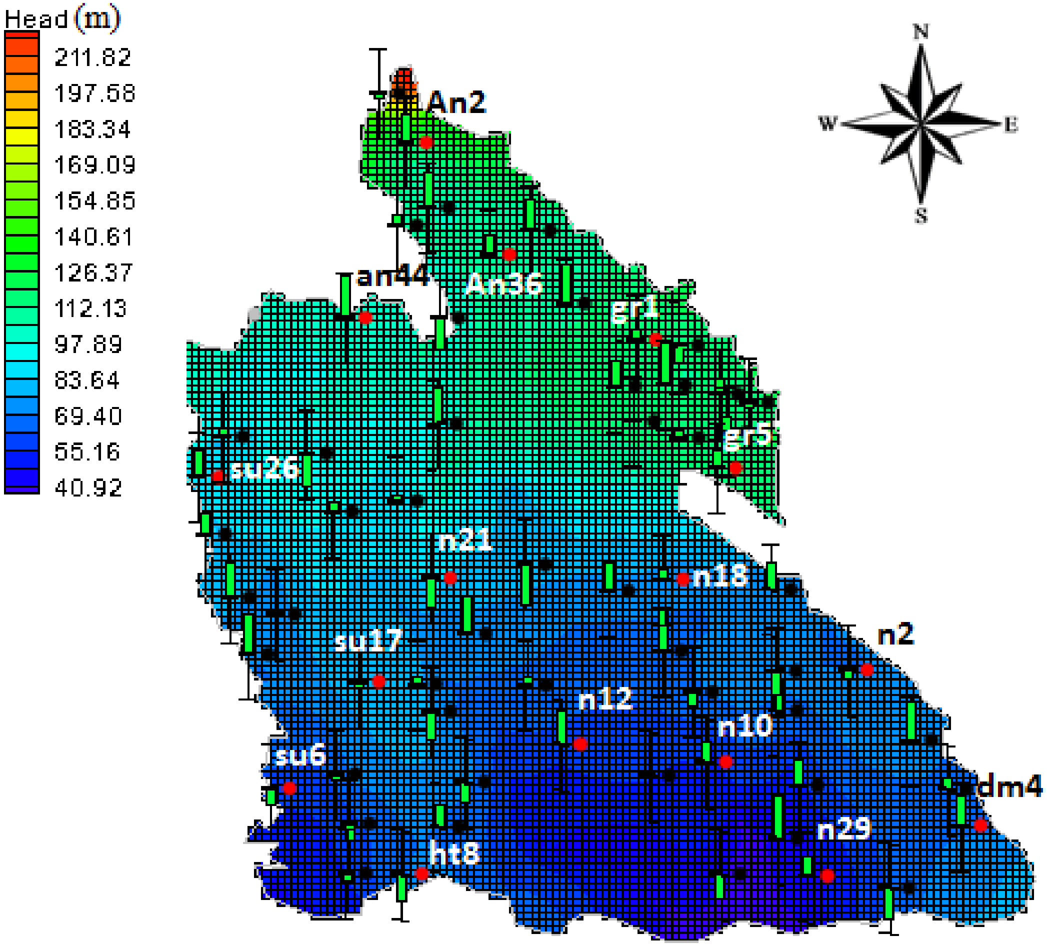
Groundwater model

Validation :



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Climate Change:

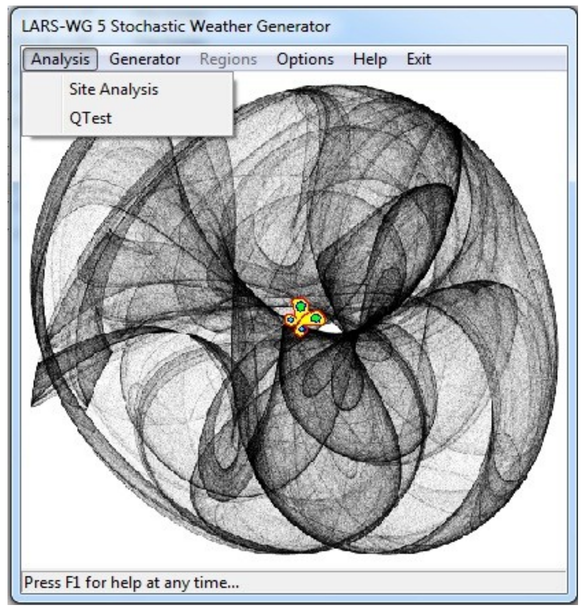
Number	Model	Emission scenarios	Organizer
1	CGCM3T47	A1B, A2, B1	Canadian Centre for Climate Modelling and Analysis (CCCma, Canada)
2	CNRMCM3	A1B, A2, B1	Center National Weather Research (CNRM, France)
3	CSIROMk3.5	A1B, A2, B1	Commonwealth Scientific and Industrial Research Organisation(CSIRO, Australia)
4	ECHAM5	A1B, A2, B1	Max Planck Institute for Meteorology (Germany)
5	ECHO-G	A1B, A2, B1	Meteorological Institute of the University of Bonn (Germany)
6	FGOALS-g1	A1B, B1	Institute of Atmospheric Physics (IAP, China)
7	GFDMCL2.1	A1B, A2, B1	Geophysical Fluid Dynamics Laboratory(GFDL, USA)
8	GISS-ER	A1B, A2, B1	Goddard Institute for Space Studies(GISS, USA)
9	HadCm3	A1B, A2, B1	Hadley Centre (United Kingdom)
10	HadGEM1	A1B, A2	Hadley Centre (United Kingdom)
11	INGV-SXG	A1B, A2	Istituto Nazionale di Geofisica e Vulcanologia (NIGV, Italy)
12	INMCM3	A1B, A2, B1	Institute of Numerical Mathematics (INM, Russia)
13	MIROC3.2	A1B, A2, B1	National Institute for Environmental Studies (NIES, Japan)
14	MRI CGCM2.3	A1B, A2, B1	Meteorological Research Institute, Japan Meteorological Agency
15	NCARPCM	A1B, A2, B1	National Center for Atmospheric Research (NCAR, USA)

Climate Change:

LARS-WG

GCMs

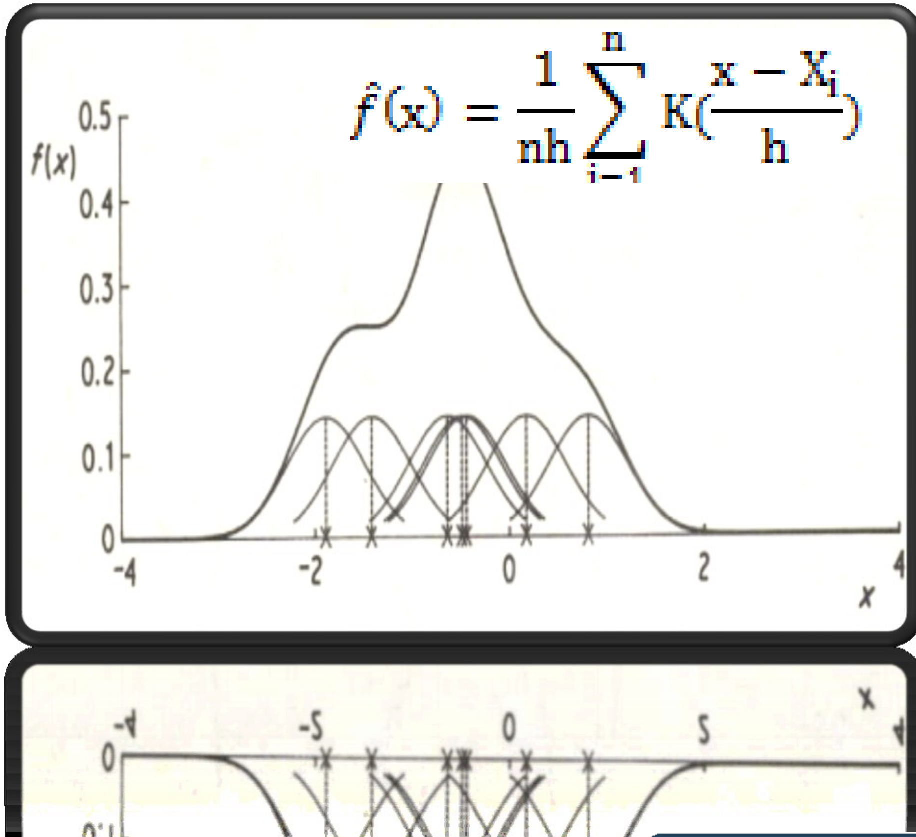
Rainfall and temperature in 2020-2044 =



+

Uncertainty :

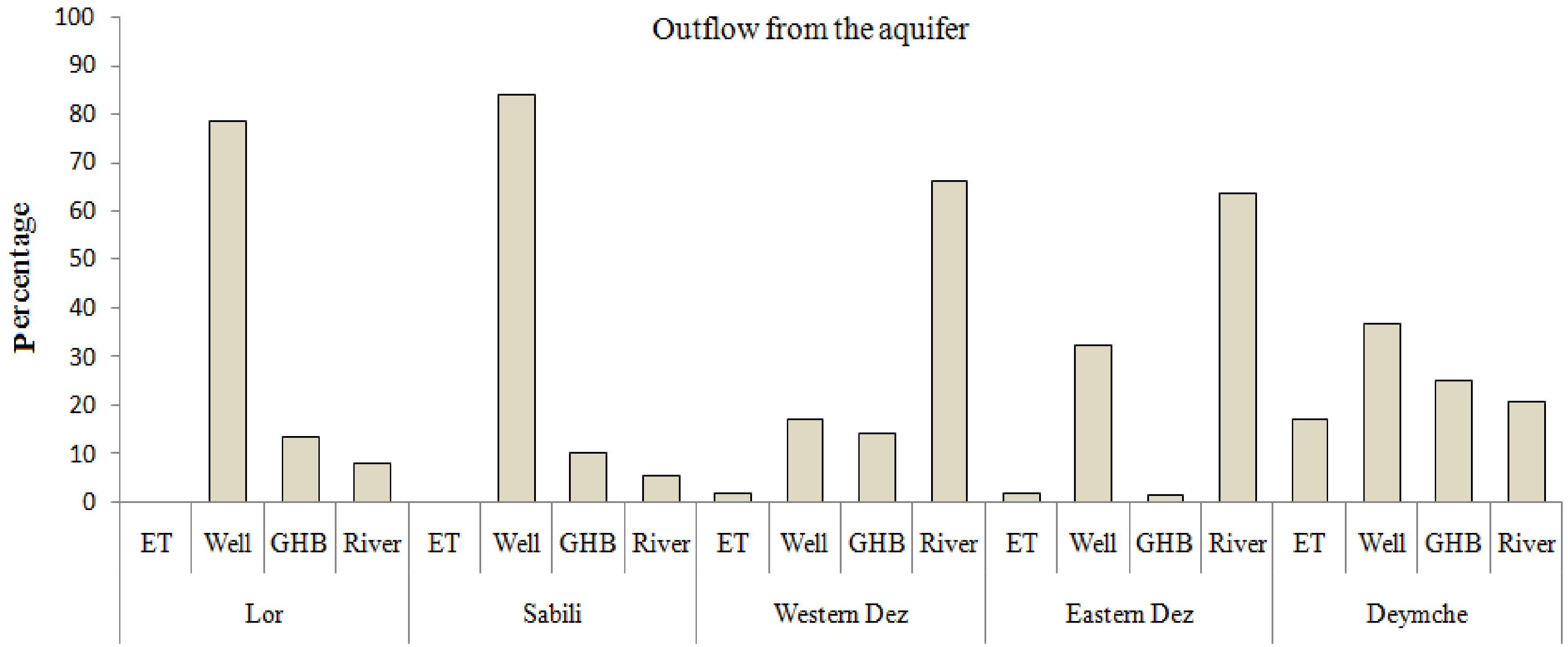
$$\hat{f}(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - X_i}{h}\right)$$



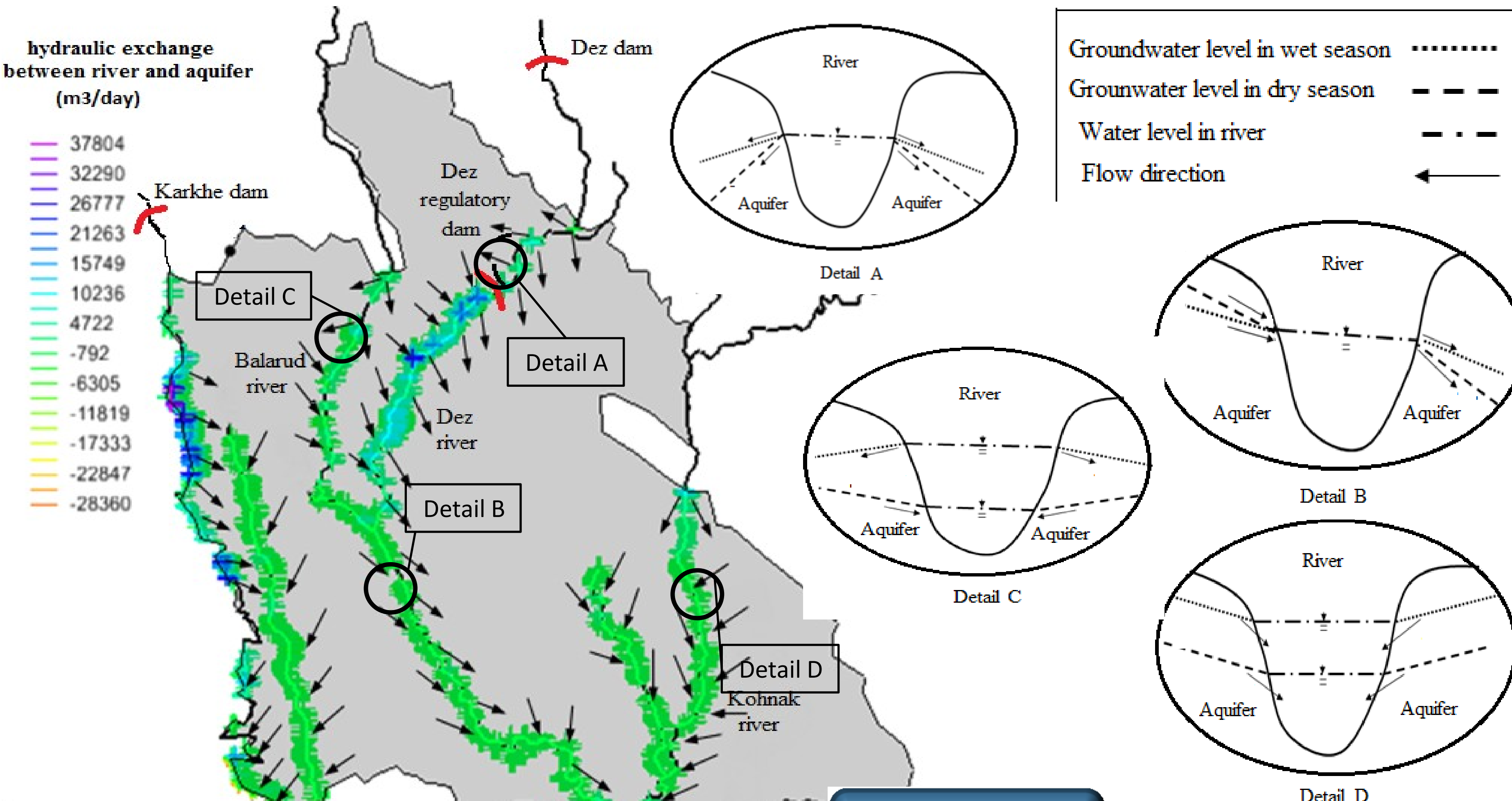
This method estimates a PDF function for climate variables obtained from GCMs output, such as precipitation and temperature. In the non-parametric method, the density function (f) is unknown and should be determined using statistical analysis.

The Kernel estimator with center K which is a symmetric density function such as Gaussian density.

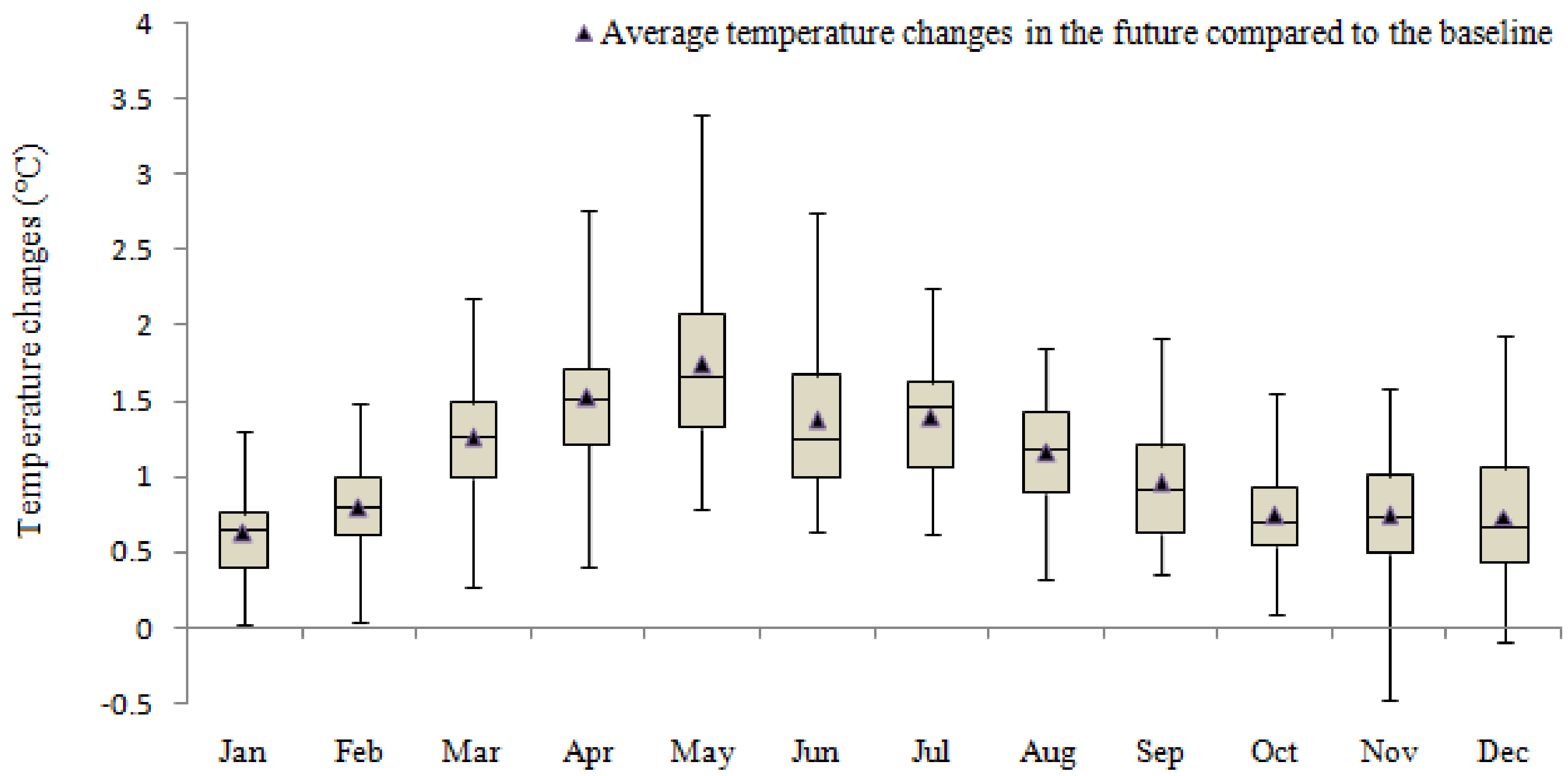
Groundwater Balance :



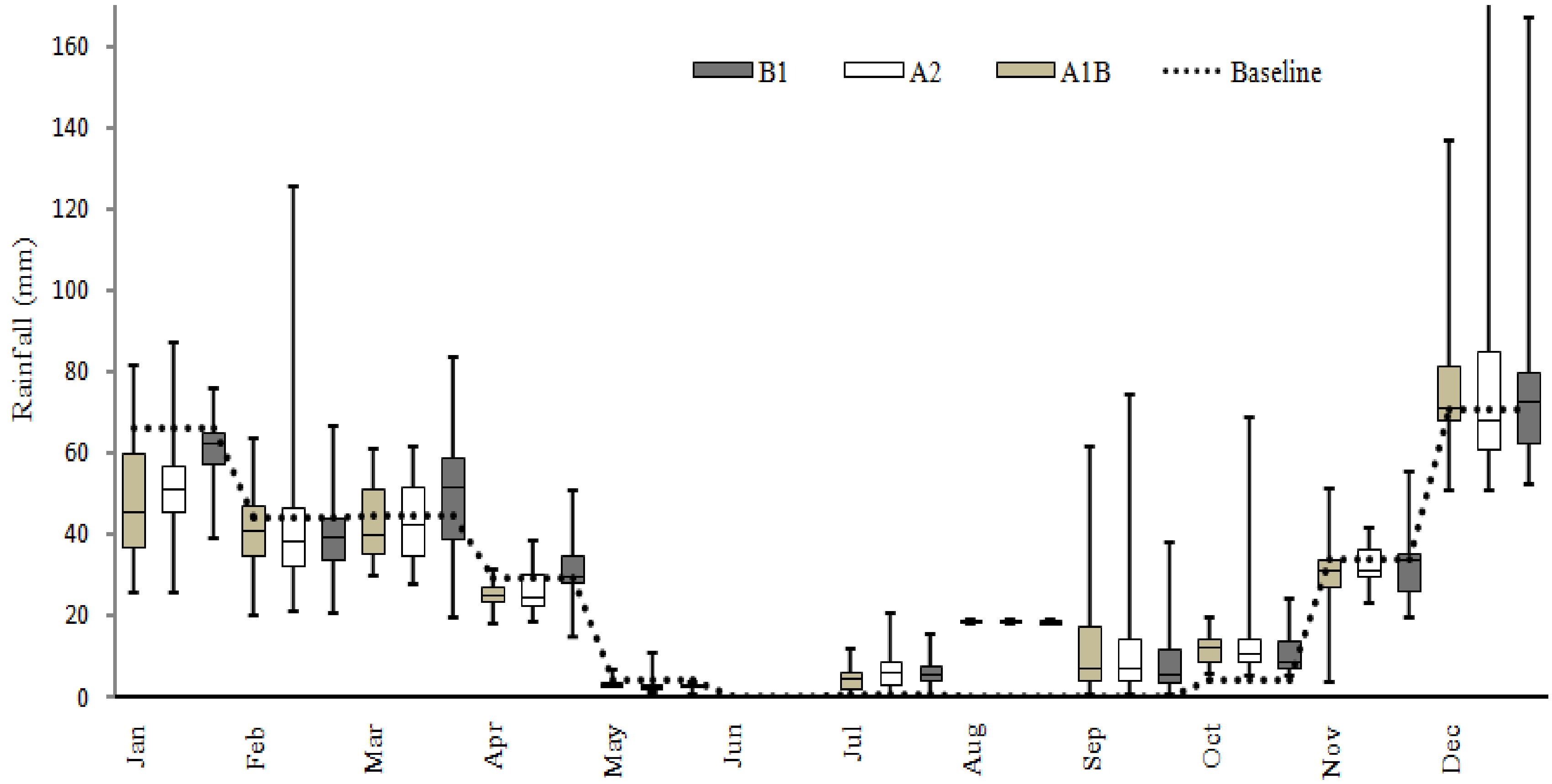
Interactions of groundwater and surface water :



Climate Change Impact on Temperature :



Climate change impact on precipitation :



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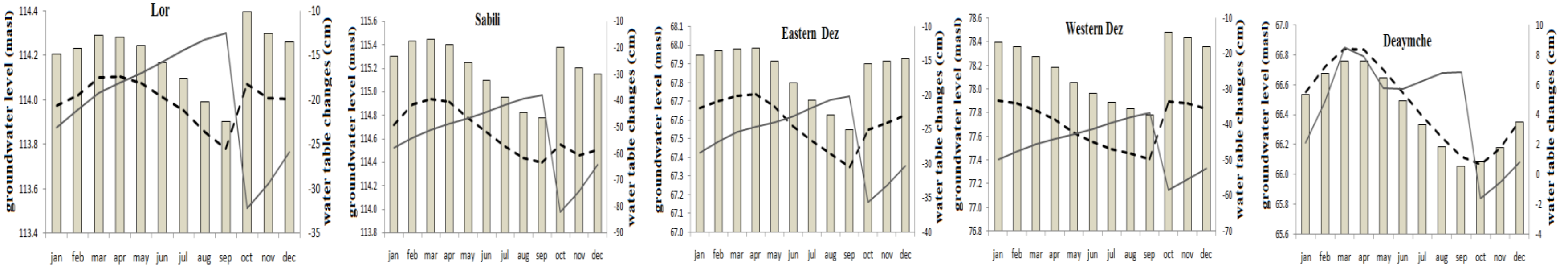
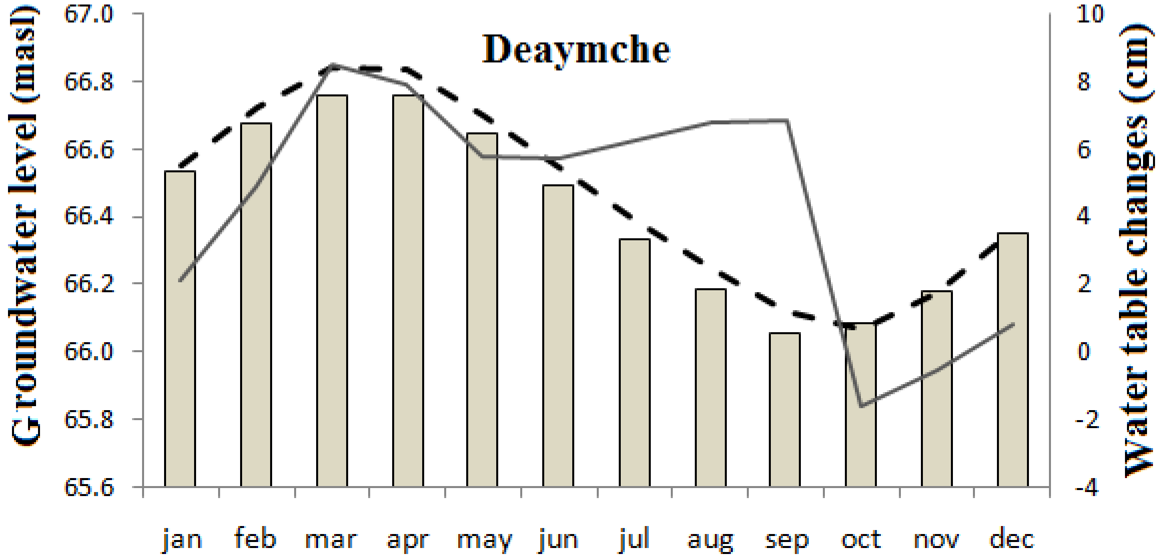
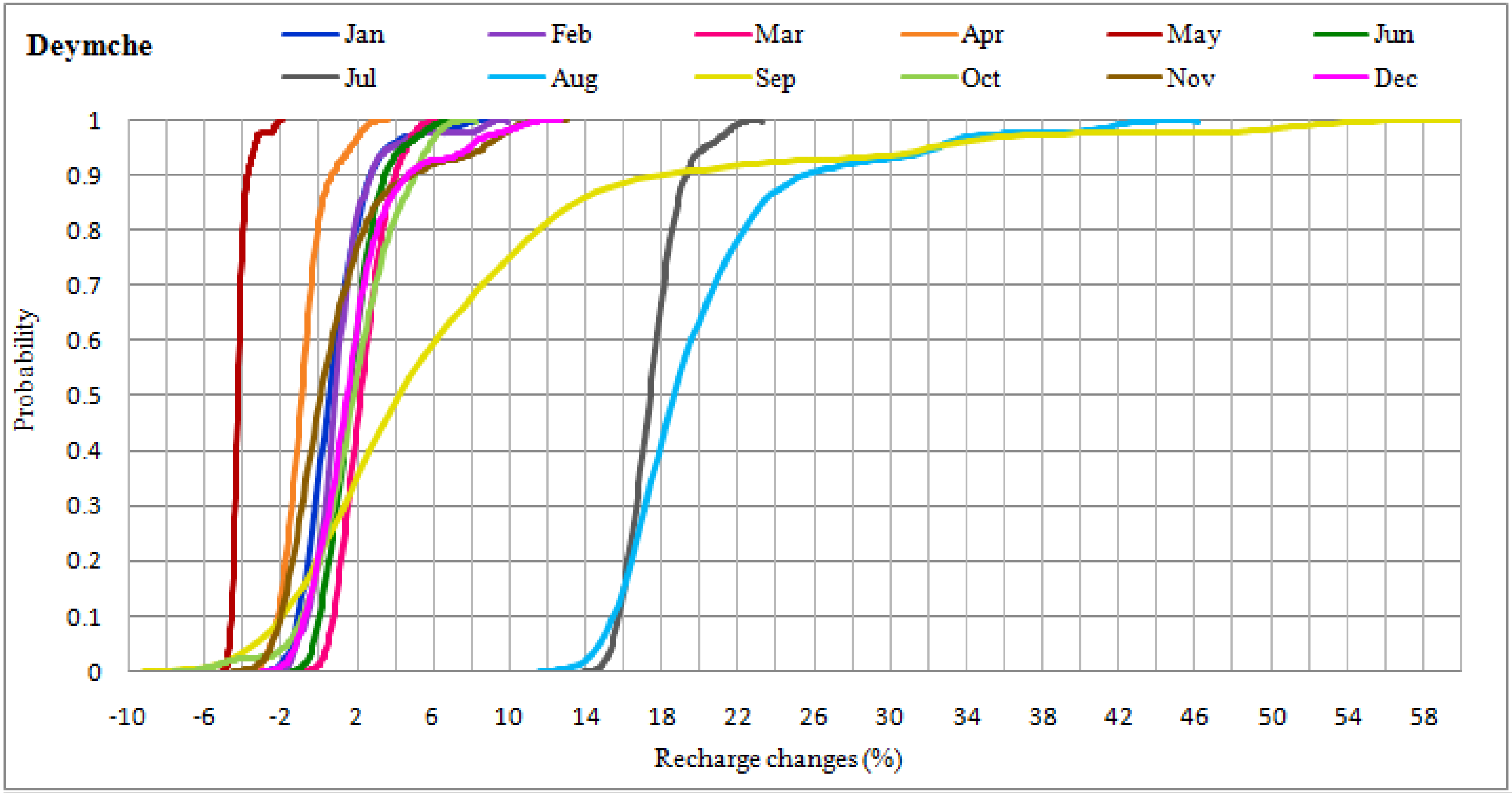
Climate change impact on groundwater :





Assessment of Uncertainty :



Conclusion :

Results revealed that the largest increase in temperature occurs in May while the largest decline occurs in January and October. In other words, the rise in temperature is more pronounced in the wet season compared to the dry season. There is a shift in precipitation from fall to the late summer. The largest change in precipitation occurs in August.

The pattern of change in recharge follows the precipitation pattern of change. There is a decrease in recharge in April, May, June, and October. The largest of change in recharge occurs by %40 in the late summer whereas the most pronounced changes occurs in the Lore plain.

The largest uncertainty in simulation of recharge under GCM scenarios was determined in August, September, and December. The range of changes in recharge were determined between -%10 and +%13 in the Sabili plain, -%6 and +%10 in the Deymche plain, -%4 and +%10 in the western-Dez plain, and -%6 and +%26 in the eastern-Dez plain. The largest decline in groundwater level occurs in the Sabili plain in September.

References

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