



Optimal Interactive Rainfall Maps (Iraq) in Client Side and Google Earth

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ABSTRACT

Global environment change has become a worldwide concern in recent years. Rainfall is an important climatologically parameter, and knowledge of its temporal and spatial patterns is useful for researchers working in many disciplines, such as optimal management of agriculture, environment and related activities. Meteorological data coming from stations are the most reliable and used sources to assess the climate condition of an area. Historical records of monthly rainfall data for the time period 2003-2013 were acquired from the Iraqi Meteorological Organization and Seismology (IMOS). The long-term data were collected from 24 weather stations. To obtain optimal maps of rainfall we also used the Tropical Rainfall Measuring Mission (TRMM). In this paper we tried to explain the possibility of vector format KML and its properties for thematic mapping in Google Earth closer, which is used to display the resulting map outputs. Maps alone are compiled by the client using the Web site browser for transferring input variables to the server, where they are processed and map data is subsequently generated according to client requirements.

Keywords

Thematic Mapping, GIS Server, Google Earth, KML, Rainfall, TRMM, Iraq.

Academic Discipline And Sub-Disciplines

Computer science, Geographic Information System.

SUBJECT CLASSIFICATION

Optimal Interactive Maps, Predict Meteorological Disaster.

TYPE (METHOD/APPROACH)

Geostatistical interpolation, Kriging.

Council for Innovative Research

Peer Review Research Publishing System

Journal: INTERNATIONAL JOURNAL OF COMPUTERS & TECHNOLOGY

Vol 13, No. 1

editor@cirworld.com

www.cirworld.com, www.ijctonline.com

I. INTRODUCTION

A Geographical Information System (GIS) provides a powerful collection of tools for the management and visualization of Meteorological data. These tools can be even more powerful when they are integrated with methods for geostatistical interpolation techniques. Kriging is a technique of interpolation named after a South African mining engineer named D. G. Krige who developed the technique in an attempt to more accurately predict or reserves[1]. ArcGIS for Server allows to share geographic information system (GIS) resources across an enterprise as web services. GIS resources are the maps, globes, address locators, geodatabases, and tools that we want to share with others. It can host GIS resources on ArcGIS for Server system and allow client applications, such as web mapping applications and mobile devices, to use and interact with the resources. ArcGIS for Server also gives the capability to connect with and monitor real-time data streams from nearly any type of sensor[2]. Google Earth is a program that allows users to find places on the Earth, mark them, and show visual data. It is a program that is becoming compatible with many other programs. There are many programs on the internet that have the option of converting or mapping data into a Google Earth format. With a small amount of html coding, the user gains the ability to show images within description balloons and link to images or other files that are on the internet or the local computer[3].

II. Study Area

The republic of Iraq is located in the South - West of Asia, to the North - East of the Arab homeland, bounded on the North by Turkey, on the East by Iran, on the West by Syria, Jordan and Saudi Arabia, on the South by Arab Gulf, Kuwait and Saudi Arabia. Iraq lies between latitudes $29^{\circ} 5'$ and $37^{\circ} 22'$ North and between longitudes $38^{\circ} 45'$ and $48^{\circ} 45'$ East[4]. The area of Iraq covers 435052 Sq.Km (see Figure 1).

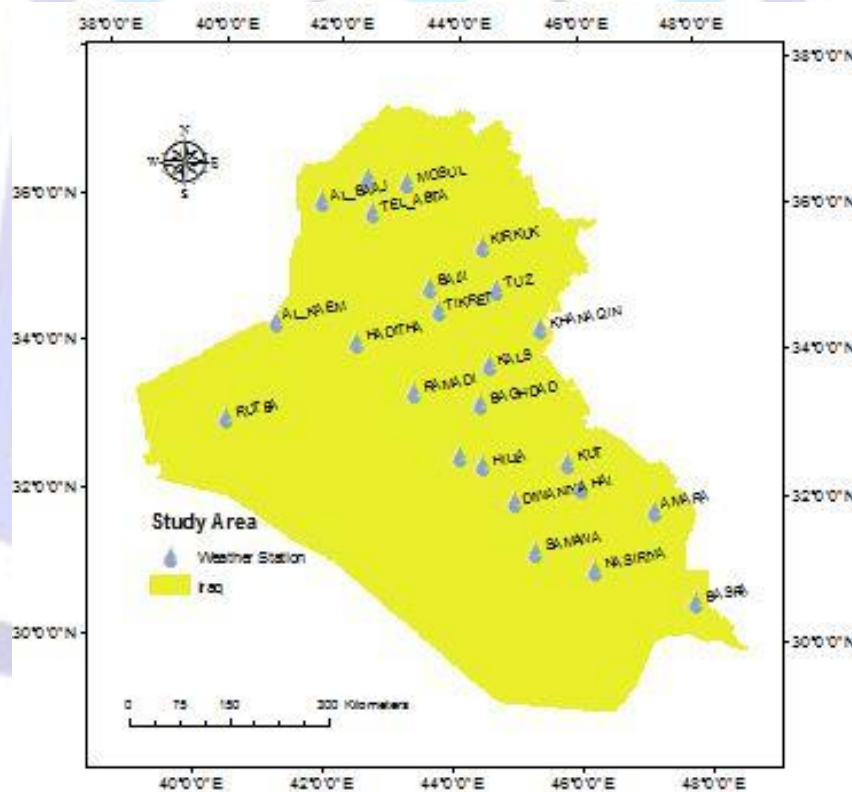


Fig. 1 : Weather stations distribution

III. MATERIALS

In the study, Meteorological stations data and TRMM data were used using geostatistical analyst in GIS to obtain optimal maps of rainfall in Iraq shown below:

A. Meteorological Data

Historical records of monthly rainfall data for the time period 2003-2013 were acquired from the Iraqi Meteorological Organization and Seismology (IMOS). The long-term data were collected from 24 weather stations, which included; Khanqin, Kirkuk, Mosul, Teleafer, Tuz, Amara, Baghdad, Basrah, Hadithah, Hai, AlBaa, Biji, Kahalis, Kut, Qaim,



Ramadi, TelAbta, Tikrit, Diwaniya, Hella, Kerbela, Nasiriya, Rutba and Samawa), located at different regions of the country. The database was digitally encoded into a GIS database .

B. TRMM Data

To obtain optimal maps of rainfall we also used the TRMM data products 2B43 V7 in this study. The TRMM dataset is obtainable via the NASA Goddard Earth Sciences Data and Information Services Center (GES DISK) Website (<http://disc2.nascom.nasa.gov>) with resolution

(0. 25×0.25).

IV. METHODOLOGY

Geostatistical Interpolation Techniques

Kriging are Geostatistical methods create surfaces incorporating the statistical properties of the measured data. Because geostatistics is based on statistics, these methods produce not only prediction surfaces but also error or uncertainty surfaces by cross validation , giving the user an indication of how good the predictions are[5].Kriging techniques are listed below:

- ◆ –Ordinary
- ◆ –Simple
- ◆ –Universal
- ◆ –Indicator
- ◆ –Probability
- ◆ –Disjunctive

Cross-validation

Cross-validation make an informed decision as to which model provides the best predictions. The calculated statistics serve as diagnostics that indicate whether the model and/or its associated parameter values are reasonable. Cross-validation and validation use the following idea—remove one or more data locations and then predict their associated data using the data at the rest of the locations. In this way, it can compare the predicted value to the observed value and obtain useful information about some of previous decisions on the Kriging model (for example, the semivariogram parameters and the searching neighborhood). Cross-validation uses all of the data to estimate the trend and autocorrelation models. It removes each data location, one at a time, and predicts the associated data value. Cross-validation omits a point and calculates the value of this location using the remaining points. The predicted and actual values at the location of the omitted point are compared. This procedure is repeated for a second point, and so on. For all points, cross-validation compares the measured and predicted values. . In a sense, cross-validation "cheats" a little by using all of the data to estimate the trend and autocorrelation models(see Figure 2).

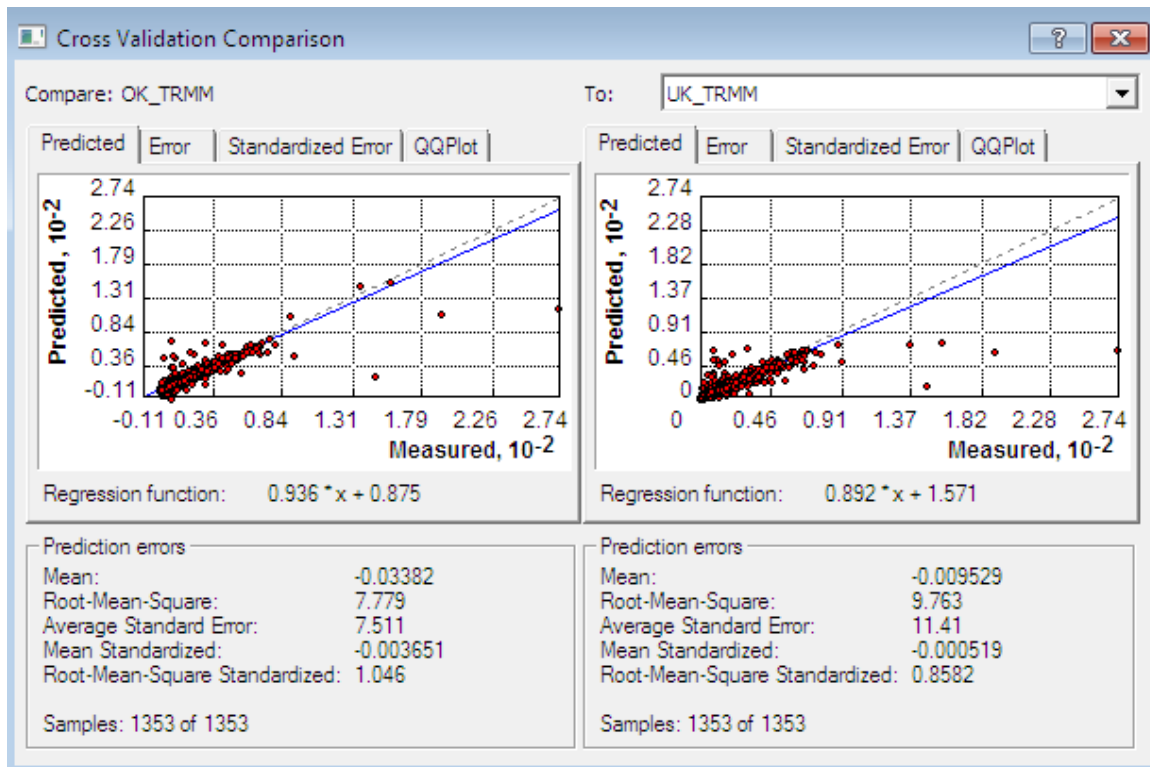


Fig. 2 : Cross validation in Geostatistical Interpolation

WebGIS Technology

Web GIS, one of most important direction of GIS which combined the technology of WWW and traditional Geographic Information System, has been widely used in many fields . Its essence is to achieve in the Internet space in the GIS site data sharing, information dissemination, production of thematic maps, as well as a variety of spatial search and spatial analysis. Mainly by the Web server, browser, page description language, Web interactive applications, GIS database manager and other parts[6].

ArcGIS Server Architecture

A WebGIS architecture which uses the ArcGIS Server is made up of some of the following components:

1) GIS Server

The GIS server hosts your GIS resources and exposes them as services to client applications. It is composed of two distinct parts: the server object manager (SOM) and server object containers (SOCs). As the name implies, the SOM manages the services running on the server. When a client application requests the use of a particular service, it's the SOM that actually gives one out for the client to use. There is only one SOM per GIS Server.

2) Web Server

The web server hosts web applications and web services that use the resources running on the GIS server.

3) Clients

Client applications are Web, mobile, and desktop applications that connect over HyperText Transfer Protocol (HTTP) to ArcGIS Server Internet services, or ArcGIS Server Local services over a LAN or WAN.

4) Data Server

The data server contains the GIS resources that have been published as services on the GIS server.

5) Manager and ArcCatalog administrators ArcGIS Server administrators can use either Manager or ArcCatalog to publish their GIS resources as services.

6) ArcGIS Desktop content authors:They author the GIS resources using ArcGIS Desktop applications[7](see Figure 3).

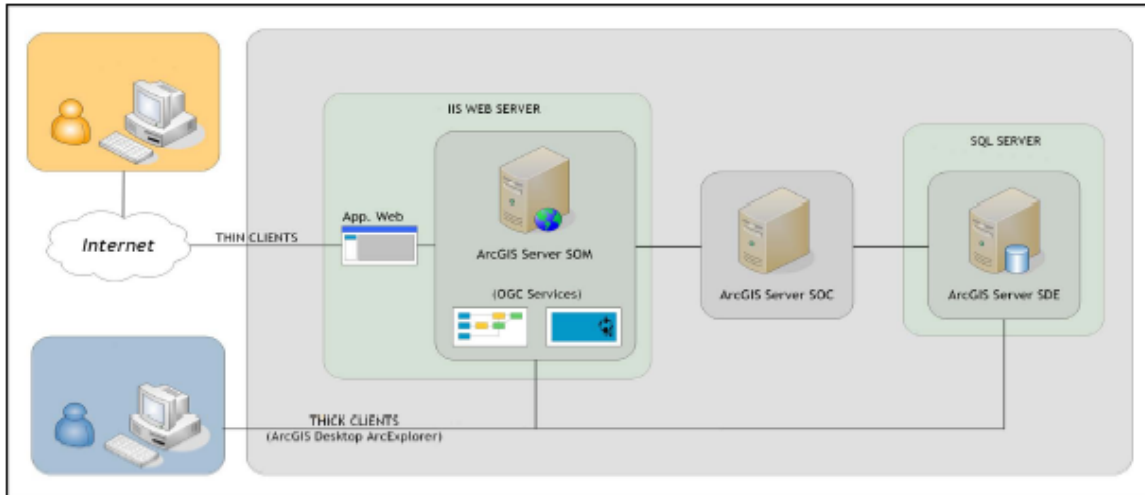


Fig.3 : ArcGIS server architecture[8]

TRMM Motivation

Global environment change has become a worldwide concern in recent years. Satellite remote sensing is recognized as a powerful and essential means for monitoring global change of earth environment. The Tropical Rainfall Measuring Mission (TRMM) is a joint mission between US and Japan, and it is the first satellite earth observation mission to monitor tropical rainfall, which closely influences to global climate and environment change[9]. TRMM cosponsored by the National Aeronautics and Space Administration (NASA) of the U.S.A. and the Japan Aerospace Exploration Agency (JAXA, previously known as the National Space Development Agency, or NASDA), has collected data since November 1997 [10]. TRMM is a long-term research program designed to study the Earth's land, oceans, air, ice, and life as a total system. Previous estimates of tropical precipitation were usually made on the basis of climate prediction models and the occasional inclusion of very sparse surface rain gauges and/or relatively few measurements from satellite sensors. The TRMM satellite allows these measurements to be made in a focused manner. TRMM is NASA's first mission dedicated to observing and understanding tropical rainfall and how it affects the global climate [11].

Google Earth

Google Earth is a 3D interface to the geography of the planet Earth, a browser with tremendous capabilities that allows users to view and navigate all kinds of data that can be represented on a map such as 2D or 3D models. Assuming that we have finished data analysis and generated all predictions, we can proceed with preparing the data for web-sharing. The most suitable option to share the results of a mapping project to a wider community is Google Earth. It is possible to use Google Earth without an internet connection, but functionality is limited to low resolution satellite imagery, imagery cached on the computer from recent use, and locally saved KML (Keyhole Markup Language) files[12].

Keyhole Markup Language

In the world of markup languages, there are many powerful tools that realize data managing, modeling, storing and displaying. Keyhole Markup language (KML) is one of those tools that realizes these services and allows users to get results in Google Earth (GE) based on selected geographic features. KML developed by Google Company, is a descriptive Markup Language based on the syntax and file format of XML for describing and storing geographical information such as point, line, surface, three-dimensional. The principles that how Google Earth works are similar to those used in Internet Explorer Browser, Google Earth can view any KML files on the internet and have capable of saving those KML files to local computer, but contents are the static instead of the dynamic. If it want to view KML as view HTML pages in browser, the Google Earth Browser is essential(see Figure 4)[13].

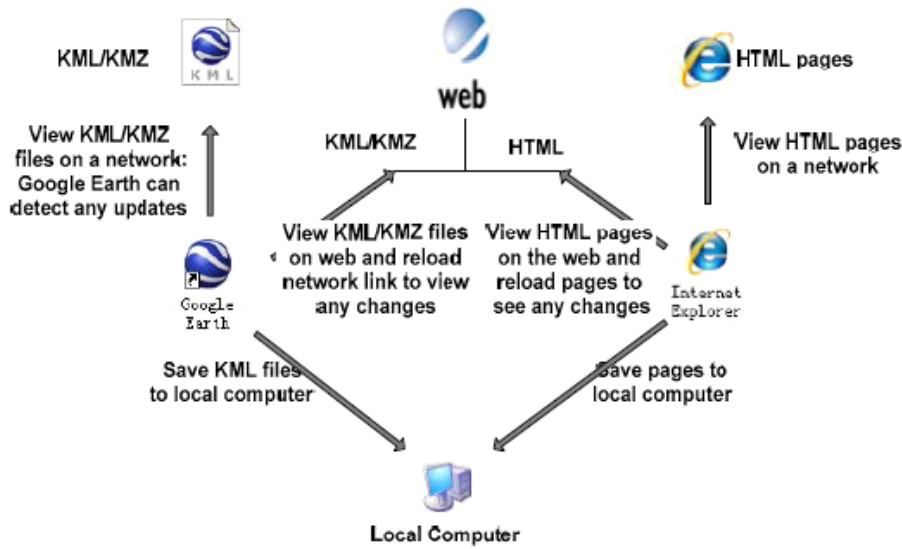


Fig.4 : Compare Google Earth Browser with Web Browser

V.Mathematical Model Implementation

Kriging is a special regression method for interpolation of spatially correlated data under variance minimization. The kriging Interpolator is best linear unbiased prediction to determine the intensity of a phenomenon at unsampled locations, Kriging minimizes the prediction variance[1], kriging formula below:

$$\hat{Z}(x_0) = \sum_{i=1}^N \lambda_i Z(x_i) \quad (1)$$

Where $\hat{Z}(x_0)$ is the kriging estimate at unsampled location x_0 , $Z(x_i)$ is samples value at location x_i , and λ_i is the weighting factor for $Z(x_i)$. The estimation error is

$$\hat{Z}(x_0) - Z(x_0) = R(x_0) = \sum_{i=1}^n \lambda Z(x_i) - Z(x_0) \quad (2)$$

Where $Z(x_0)$ is the unknown true value at x_0 and $R(x_0)$ is the estimation error for an unbiased estimator, the mean of the estimation error must equal zero. Therefore,

$$E\{R(x_0)\} = 0 \quad (3)$$

$$\sum_{i=1}^n \lambda_i = 1 \quad (4)$$

As best linear unbiased estimator technique, the estimator must also have minimum variance of estimation error. The minimization of the estimation error variance under the constraint of unbiasedness leads to a set of simultaneous linear algebraic equations for the weighting factors, which can be solved by an optimization routine and the method of Lagrange multipliers. A major step in any kriging method is the estimation of the semi-variogram model parameters such as correlation length, sill and nugget variance (see Figure 5). A semi-variogram represents the spatial dependence of the variable being interpolated. In this study, the semi-variogram was modeled as spherical type function.

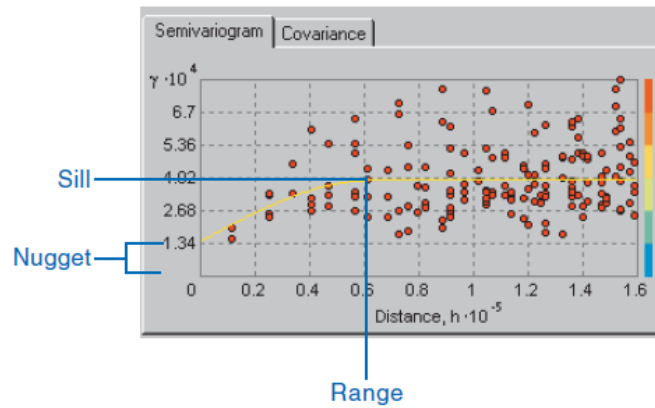


Fig.5 : Semivariogram depicting range, sill, and nugget effect

VI. Results and Outputs

The results and the outcome of the proposed work include :

Optimal map result from different kriging techniques for January /2013 such as example(see Figure 6). Prediction method is ordinary kriging because it gives least error for IMOS and TRMM data .

To made these optimal maps as interactive to user as client side in this paper we used GIS Server package to make maps available online in local area network(see Figure 7), and it open in google earth as KML format (see Figure8).

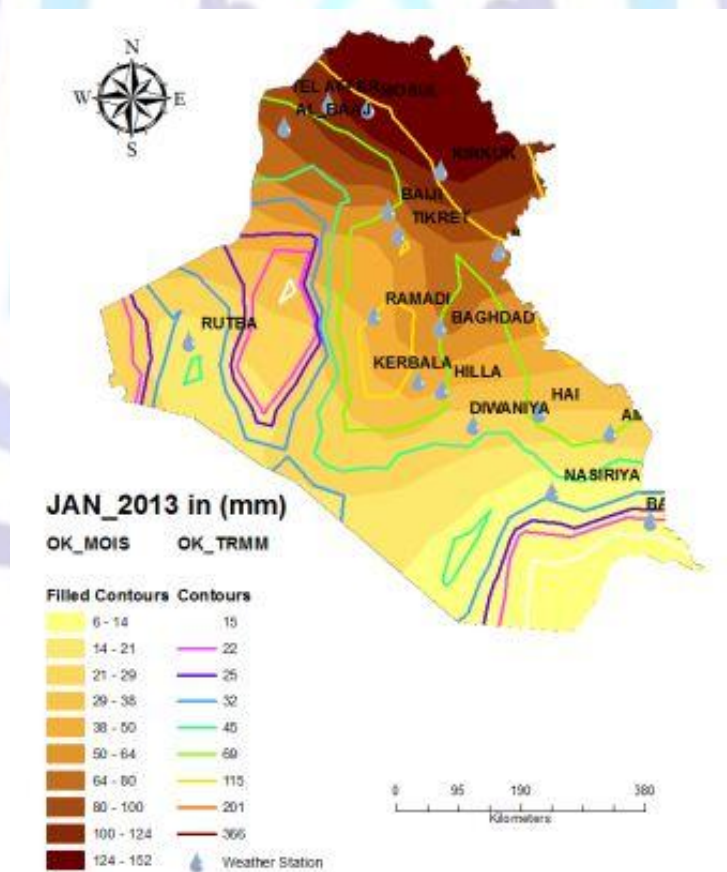


Fig.6 :Optimal map for January 2013

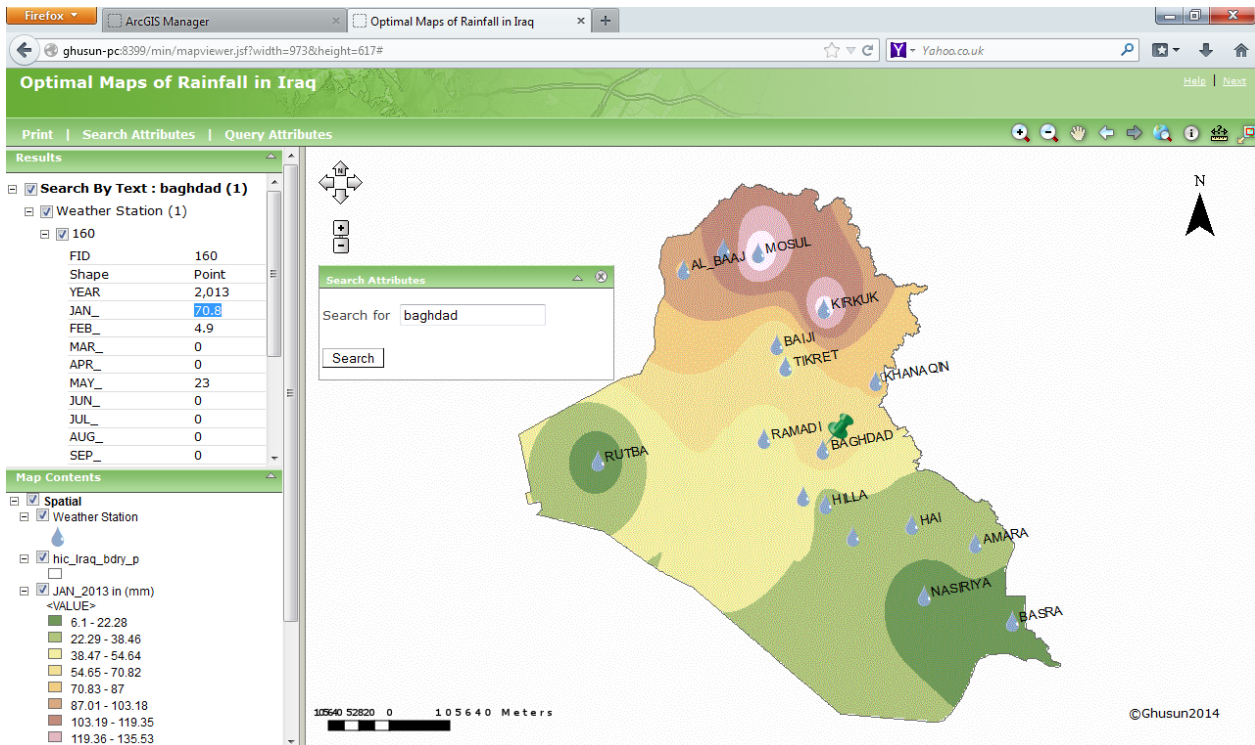


Fig.7 : Optimal map in client side

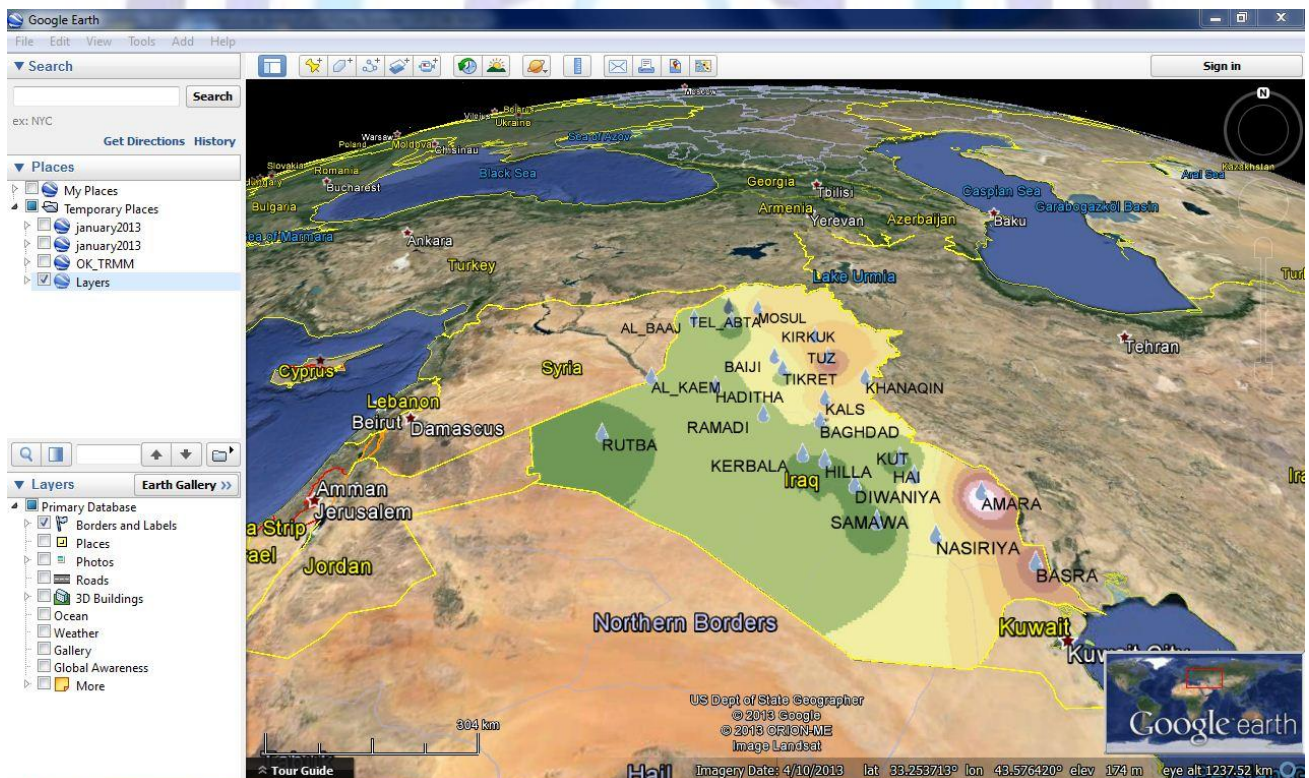


Fig.8 : Optimal map in google earth

VII. CONCLUSIONS

The essence of spatial interpolation is to estimate the values of unobserved points based on known sample data. Due to non-availability of abundant measurement points, reliable estimation of rainfall distribution poses a great challenge. Creation of digital grid maps makes it possible to obtain climatic information at any point, whether there is a weather station or not. Multiple factors condition the difficulty of map creation, such as the location of the site samples, spatial



density, spatial variability etc. The annual rainfall map developed can be useful for agricultural management in the region. Reliable calculation for agricultural management and improvement of climatic models at local scales can be obtained with increased efficiency. Rainfall data, as a climatic factor, is important parameters in environmental studies, such as climate modeling and hydrological modeling. It can be used to estimate runoff, predict meteorological disaster like rainstorm, drought and flood. Continuous precipitation data, as input, is essential for accurate modeling.

ACKNOWLEDGMENTS

.The authors wish to thank Dr.Yaseen K. Al-Timimi,(a Lecturer in the Atmospheric Sciences Department,Al-Mustansiriyah University, Iraq) for his constructive excellent suggestions that improved this manuscript.

REFERENCES

- [1] Ragab Elsayed Rabeiy,2010,"Spatial Modeling of Heavy Metal Pollution of Forest Soils in a Historical Mining Area Using Geostatistical Methods and Air Dispersion Modeling", Doctoral Thesis, Clausthal University of Technology ,Germany.
- [2] Janet Crossley,2008," Google Earth as a geospatial tool for development organizations: mapping climate change vulnerability", M.Sc. in Geographical Information Science by Research Dissertation, the University of Edinburgh.
- [3] Office of Educational Partnerships,2011," Tutorial Using Google Earth", Tutorial prepared for the Project-Based Global Climate Change Education Project, funded by NASA GCCE, Clarkson University, Potsdam NY.
- [4] Yaseen K. AL-Timimi, Monim H. AL-Jiboori, 2013,"Assessment of Spatial and Temporal Drought in Iraq During The period 1980-2010",International Journal of Energy And Environment, Volume 4, NO. 2, pp.291-302.
- [5] ESRI,2001, "ArcGIS™ Geostatistical Analyst: Statistical Tools for Data Exploration, Modeling, and Advanced Surface Generation".
- [6] Zhang Zhaoyu, Ren Yuan, Zhang Ni, 2011,"Study on Economic Early Warning System Based on Web GIS and Prosperity Index", Transcation in IEEE.
- [7] Han Lu, Wang Nihong, Wang Chang, Chi Yujia,2010 ," The Research on the WebGIS Application Based on the J2EE Framework and ArcGIS Server", International Conference on Intelligent Computation Technology and Automation,IEEE 978-0-7695-4077-1/10.
- [8] Fernández F., Velarde V., Puente A., Juanes J.A., Medina R.,2011,"Answering Environmental European Directives through Information Systems ",Transcation in IEEE.
- [9] Earth Observation Center , "TRMM Data Users Handbook ", National Space Development Agency of Japan,2001.
- [10] Kummerow,C.Simpson, J.Thiele,O.Barnes,W.Chang,A.T.C., Stocker, E ,2000, "The status of TRMM After Two Years in Orbit", Journal of Applied Meteorology, 39-1965-1982.
- [11] Wolff D.B., Marks D.A., Amitai E., Silberstein D.S., Fisher, B. L., Tokay A.,2005,"Ground Validation for the TRMM", Journal of Atmospheric and Oceanic Technology, 22,365–379.
- [12] Esri® White Paper,2013, "ArcGIS® 10.2 for Server Functionality Matrix", November, Printed in the United States of America.
- [13] DU Ying-jun,YU Chong-chong, Liu Jie,2009," A Study of GIS Development Based on KML and Google Earth",IEEE, Fifth International Joint Conference on INC, IMS and IDC.

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