



# Analysis of the Climate Data (Earth Observation Stations and Space Stations) Through Geographic Information System

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**Abstract:** Earth observation stations' data on meteorological parameters is inadequate for several technical or financial reasons as well as data interpretation under different circumstances. This leads to misleading and inaccuracy for their results, so it was necessary to search for an alternative to achieve accuracy. The digital data of space station in climatic studies such as TIRS, NOAA, GOES, NIMBUS, ERS-1, METEOSAT-9 are the means to fill the shortage of data recorded by earth observation stations. The present study focused on space recordings with earth observations and tested its accuracy extent using the Pearson correlations coefficients, the results showed that there was a strong direct relationship between space and ground data ( $r=0.931-0.970$ ), proving the accuracy and convergence of its records with the ground data.

**Keyword:** Satellite data, Climate data, Weather forecasts, GIS, Accuracy

Researchers in the field of climate studies suffer from the problem of the lack of recorded data for the meteorological stations, both local and regional, to make their studies semi disabled and linked to the available data, so there was a need to adopt other sources to provide climate data, therefore there is need to adopt data provided by specialized satellite for climate studies (NOAA, TIRS, ERS-1, NIMBUS, GOES and METEOSAT-9) for climate data. But the key question remains whether it is possible to rely on these satellite data to replenish the shortage and inaccuracy of their recordings. The idea of current research aimed to make comparison between the results of a documented study that adopted the data of the meteorological ground stations with the results of the satellite data by adopting the same mechanism of work and the duration of the documented study. Pearson correlation coefficients were used to prove strength of the relationship between climatic data for Geo-meteorological stations and data provided by the global sites associated with satellites specialized in climate studies.

## MATERIAL AND METHODS

**Area study:** The spatial boundaries were confined to the political borders of Iraq, and between the longitudes  $38^{\circ} 45'-48^{\circ} 45'$  east and the latitudes  $29^{\circ} 5'-37^{\circ} 22'$  (Republic of Iraq, 2001). Twelve main space observation stations (Sulaymaniyah, Mosul, Kirkuk, Khanaqin, Rutbah, Baghdad, Al-Hayy, Najaf, Amarah, Nasiriyah and Basrah) were selected because they represent the different topographical area of Iraq with different directions (Table 1 and Map 1). The temporal boundaries of the study were the study period 1979-2000. The daily data were used for both temperature and

rainfall components).

The analytical approach with quantitative analysis method to description strength of the relationship between the accuracy of space data and its results with meteorological stations of the documented study, represent the results in the form of a cartographical statistical model (Tenget al 1993 and Lakshmi and Susskind 2000)

### The ground meteorological stations and their problems:

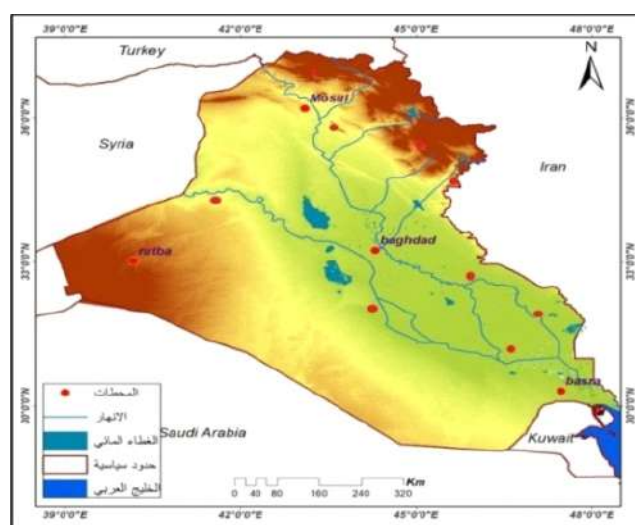
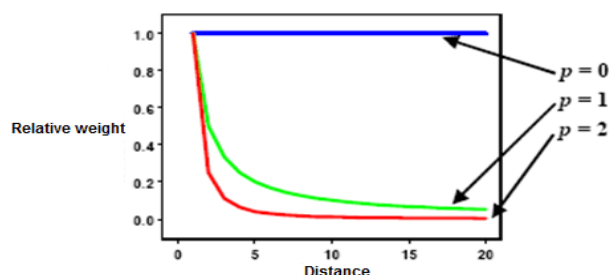
The government ground meteorological stations provide various climatic data for most of the climatic elements in their main stations, with limitation to some elements in the secondary stations (agricultural). These records date back to 1940s (monthly rates only), some of which date back to the beginning of the 20th century, such as Baghdad, Mosul and Basra so considering as a source for studies of climatic changes. Data are available with many measurements of the elements (hourly, daily, monthly, yearly), especially after the mid-eighties of the last century where access to it are easy, and measured/recorded by specialists at that time with high accuracy than it is in present conditions. The meteorological organization were tabulated and organized electronically from the last decade of the last century (Ji et al 2015, Tote et al 2015, Nash and Sutcliffe 1970. Wang et al 2011. Ahmed et al 2016).

The most important problems faced by researchers during the adoption of the data of ground stations are: the heterogeneity of their distribution, which does not provide overall coverage of all regions (Map 2), which gives a completeness in their recording and the increase in the percentage of missing observed elements so its recommended using of experimental criteria to replenish the

**Table 1.** Climatic stations included by the study

Station	Ground meteorological stations		Space meteorological stations	
	Latitude, North	Longitude, East	Latitude, North	Longitude, East
Sulemanea	35.438	45.3125	35.32	45.27
Mosel	36.3747	43.125	36.19	43.09
Kirkuk	35.438	44.375	35.28	44.24
Khanaqin	34.1891	45.3125	34.29	45.23
Rutba	32.9401	40.3125	33.03	40.17
Ana	34.5013	41.875	34.22	41.57
Baghdad	33.2524	44.375	33.18	44.24
Alhi	32.0035	45.9375	32.08	46.02
Najaf	32.0035	44.375	31.57	44.19
Omara	32.0035	47.1875	31.5	47.1
Nasirea	31.0668	46.25	31.01	46.14
Basra	30.4423	47.8125	30.31	47.47

Source (Iraq, Ministry of Transport, G.O.M), <https://globalweather.tamu.edu>

**Map 1.** Location of search stations**Fig. 2.** The decrease of weight with distance illustration

data deficit. The current positions of the observation stations are professionally ineligible for measurement due to the urban extension, which reduces the accuracy of the recorded data, as well as the personal inflection for the observers. Lately a problem has recently emerged, it's the high financial cost associated to obtain data by students and researchers.

**Climatic satellite stations and their problems:** The satellites specialized in climate studies provide data that their recording accuracy reaches to observation level for hourly, daily, monthly and annually for the climatic elements. They are easily obtained and not interrupted for a relatively long period of time, starting from 1970, to be used for climate studies and for pursuance of change. In addition, provides a wide coverage ratio compared to ground stations (Map 2) and with high accuracy observation, which reduces the loss of recording elements, not related to the privacy of the observers (Turab et al 2014, Barril et al 2015, Sumi et al 2013). Capabilities and accuracy in measuring and recording elements, as well as its electronic availability and ease of obtaining solve most of the problems faced by researchers.

The most important problems of satellite data are the weakness of communication between the concerned institutions and the research centers (universities and scientific centers), as well as the problem of the weakness of English language and the inability to use the sites provided by most researchers. The most important problem facing satellite data is measurements of climatic elements and connecting with the work of satellite sensors.

**Statistical processing:** The study was based on the selection of a documented scientific study that used the data of the government Meteorological Stations for the study of climate fluctuation and its effect on the limits of the climatic regions in Iraq. Depended on the data of the monthly averages of the ground stations for the period 1970-2000 were obtained for the two elements of temperature and rainfall (Katsanos et al 2016). Koppen classification (Peel et al 2007, Kottek et al 2006) were used as a criteria for determining climatic regions.

It is possible to compare the data recorded with the satellite data by adopting the same time period of the above study and follow the same steps in the work to achieve the results of the use of satellite data as an alternative to ground stations data. Compared the results of the documented study and using the Pearson correlation ( $R$ ) which were equal and associated with it and had a strong positive relationship either with the general climate classification or with the climate classification for years chosen from the period studied (Table 2).

The ArcGIS geostatistical analyst extension provides the capability for modeling using deterministic and

geostatistical methods. The idw method is adopted and uses the measured values surrounding the prediction location to predict a value for any un sampled location, based on the assumption that things that are close to one another are more alike than those that are farther apart. The points highlighted in the data view show the locations and the weights that will be used for predicting a location at the center of the ellipse (the location of the crosshair). The search neighborhood is limited to the interior of the ellipse. In the eastern sector, one point (brown) will be given a weight between 5 and 10 per cent, the rest of the points in the search neighborhood will receive lower weights.

The analysis of the climatic space stations data show similarity to the ground stations used in the study of Salman for different years and the application of the modified Koppen classification, which was based on satellite data, showed that there is an approach in results in most stations (Tables 3, 4, 5 and 6).

## RESULTS AND DISCUSSION

Through using the results of satellite data in draw maps

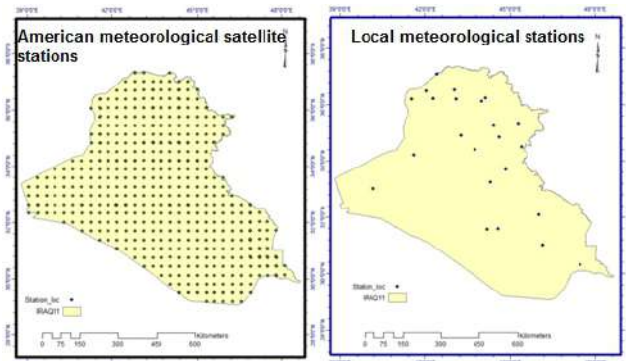
**Table 2.** Pearson correlation coefficient between the results of the satellite data and the data recorded for all studied stations

Classification years	1982-1981	1990-1989	2000-1999	2000-1970
Pearson correlation coefficient	0.93	0.94	0.97	0.95
Relationship type	Strong positive	Strong positive	Very Strong positive	Strong positive

**Table 3.** Results of the general classification of the Iraq climate for the period 1970-2000

Stations	Satellite climate stations		Ground climate stations	
	Region description	Station classification	Region description	Station classification
Nasireia	Dry	5.03	Very dry	3.8
Najaf	Very dry	4.34	Very dry	3.48
Alhi	Dry	5.94	Dry	5.59
Omara	Dry	7.36	dry	7.55
Rutba	Dry	6.2	dry	6.37
Khanaqin	Semi dry	13.87	dry	8.79
Ana	Dry	7.17	dry	7.32
Sulemanea	Humid	37.95	humid	45.4
Baghdad	Dry	5.69	Very dry	4.8
Basra	Dry	5.85	dry	5.52
Kirkuk	Semi dry	16.89	Semi dry	19.07
Mosel	Semi arid	18.52	humid	34.69

Source: Salman 2011; <https://globalweather.tamu.edu>



**Map 2.** Geographical distribution of ground observation stations and space stations.

Source: Iraqi, Ministry of Transport and Communications, 1981-2018 <https://globalweather.tamu.edu>

**Table 4.** Results of the general classification of the Iraq climate for the period 1981-1982

Stations	Satellite climate stations		Ground climate stations	
	Station classification	Region description	Station classification	Region description
Sulemanea	100.75	Humid	44.66	humid
Mosel	66.15	Humid	17.52	Semi arid
Kirkuk	34.26	Humid	15.61	Semi arid
Khanqin	11.74	Semi arid	14.34	Semi arid
Rutba	9.49	Dry	6.67	Dry
Ana	12.27	Semi arid	13.4	Semi arid
Baghdad	4.74	Very dry	3.42	Very dry
Alhi	5.01	Very dry	3.27	Very dry
Najaf	2.27	Very dry	4.77	Very dry
Omara	6.18	Dry	5.84	dry
Nasriea	2.27	Very dry	4.89	Very dry
Basra	3.74	Very dry	5.12	Dry

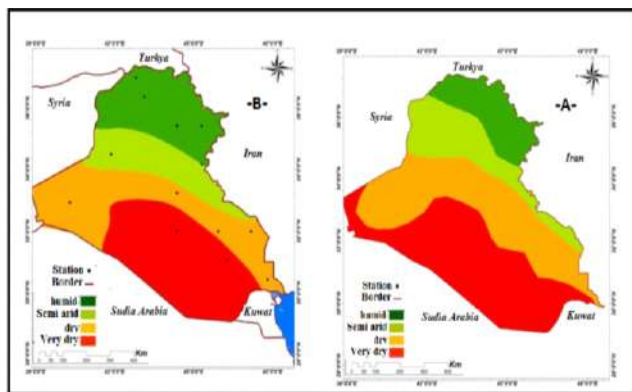
Source: Salman 2011; <https://globalweather.tamu.edu>

**Table 5.** Results of the general classification of the Iraq climate for the period 1989-1990

Stations	Satellite climate stations		Ground climate stations	
	Station classification	Region description	Station classification	Region description
Sulemanea	61.89	Humid	34.59	Humid
Mosel	33.95	Humid	16.52	Semi arid
Kirkuk	22.26	Humid	17.07	Semi arid
Khanqin	10.67	Semi arid	14.44	Semi arid
Rutba	4.03	Very dry	4.55	Very dry
Ana	2.64	Very dry	6.46	Dry
Baghdad	0.56	Very dry	6.23	Dry
Alhi	6.3	Dry	3.27	Very dry
Najaf	1.75	Very dry	1.63	Very dry
Omara	11.14	Semi arid	3.93	Very dry
Nasriea	5.54	Dry	3.89	Very dry
Basra	7.55	Dry	4.02	Very dry

Source: Salman 2011; <https://globalweather.tamu.edu>

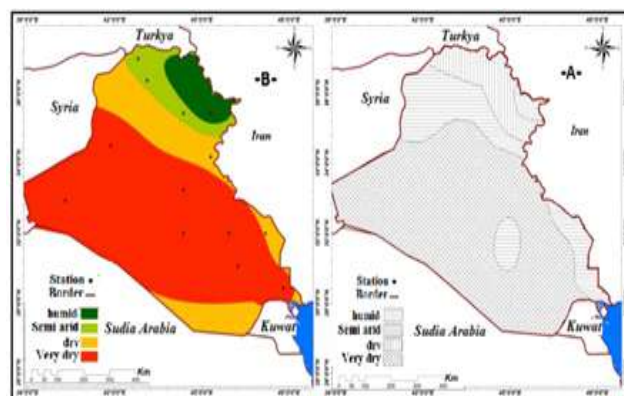




A. Results of ground station data B Results of satellite data

Source: Table 3

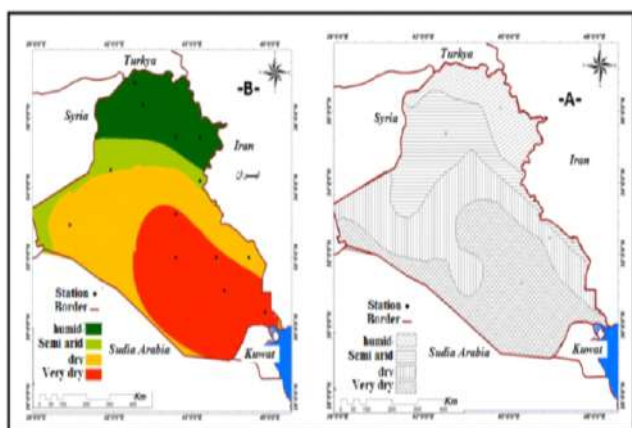
**Map 3.** Results of the comparative study of the general classification of Iraq for the period, 1970-2000



A. Results of ground station data B Results of satellite data

Source: Table 6

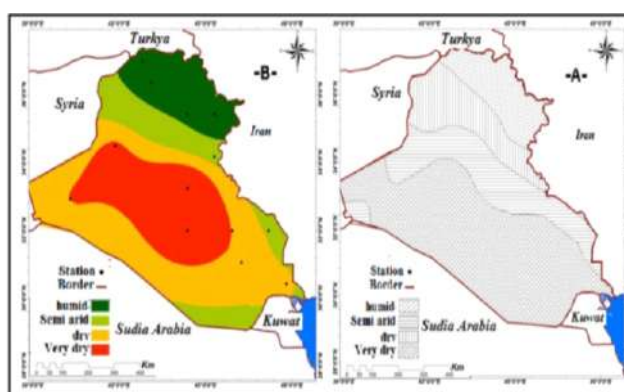
**Map 6.** Results of the comparative study of the general classification of Iraq for the period, 1999-2000



A. Results of ground station data B Results of satellite data

Source: Table 4

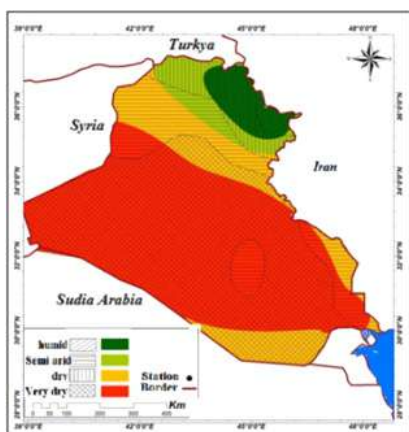
**Map 4.** Results of the comparative study of the general classification of Iraq for the period, 1981-1982



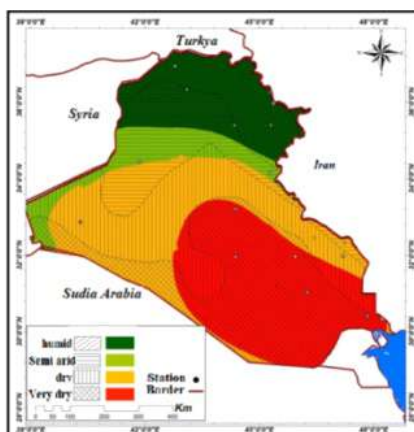
A. Results of ground station data B Results of satellite data

Source: Table 5

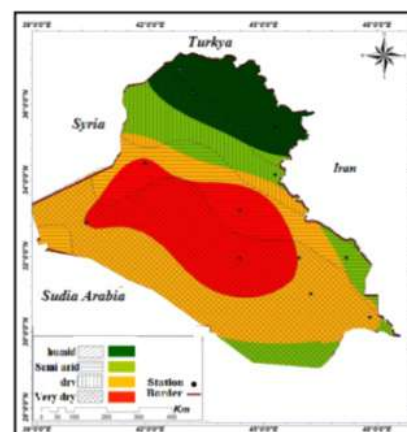
**Map 5.** Results of the comparative study of the general classification of Iraq for the period, 1989-1990



**Map 7.** Coincidence map of meteorological stations data with satellite data for the years 1981-1982; Source Map 4 .



**Map 8.** Coincidence map of meteorological stations data with satellite data for the years 1989-1990; Source Map 5 .

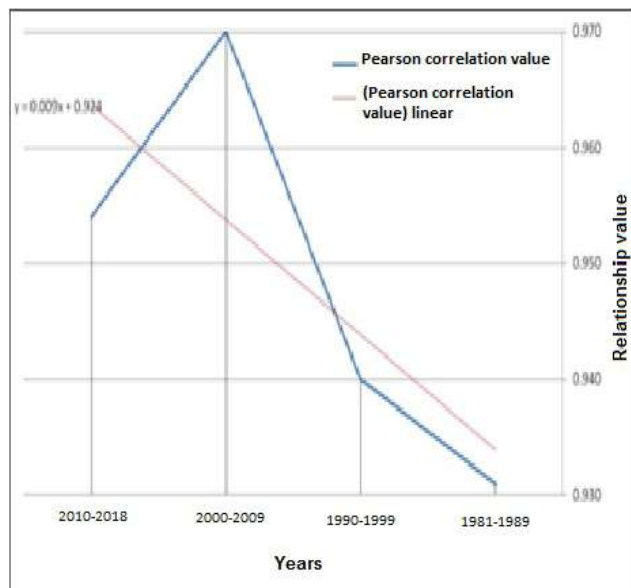


**Map 9.** Coincidence map of meteorological stations data with satellite data for the years 1999-2000; Source Map 6 .

**Table 6.** Results of the general classification of the Iraq climate for the period 1999-2000

Stations	Satellite climate stations		Ground climate stations	
	Station classification	Region description	Station classification	Region description
Sulemanea	40.97	Humid	19.53	Semi arid
Mosel	12.72	Semi arid	8.41	Dry
Kirkuk	10.25	Semi arid	7.57	Dry
Khanqin	6.01	Dry	4.36	Dry
Rutba	2.23	Very dry	2.74	Very dry
Ana	2.64	Very dry	4.25	Very dry
Baghdad	2.77	Very dry	2.67	Very dry
Alhi	3.78	Very dry	3.11	Very dry
Najaf	3.2	Very dry	1.26	Very dry
Omara	6.43	Dry	4.68	Very dry
Nasriea	4.93	Very dry	2.7	Very dry
Basra	4.64	Very dry	6.16	Dry

Source: Salman 2011; <https://globalweather.tamu.edu>



**Fig. 1.** The relationship between the results of the satellite data and the ground stations (Source: Based on Table 2)

of climatic regions classification and comparing them with regional classification maps based on meteorological data Maps (3, 4, 5, 6), found that there was a semi similarity within the regions borders for the Maps (7, 8, 9)

The variation in the representation of the above regions is due to the difference in the methods of representation, which depended on different statistical mechanisms as generalization, which represents the satellite data in each station based on similarity (the great probability). The study of

Salman does not know any method of representation adopted, the fact that the researcher did not mention it in the context of her thesis, but the basic stations, their representation was coincidence with a large proportion, which shows that maps and tables, while the divergent stations made the representation process is more generalization to show the difference clearly by the number and distribution of stations. It's possible to depending on climatic satellites data and can be used as an substitute or support data of ground stations to compensate the losses for any reason.

## CONCLUSIONS

The data of the ground stations (Government) despite their advantages, but suffers from several problems can be avoided by the adoption of data from the space stations as a support to them. There was a strong positive relationship between the satellite data and ground data (r value ranged between 0.931 - 0.970) proved accuracy.

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