EVALUATION OF ECMWF DATA FOR IRAN'S CLIMATIC CONDITIONS

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In this study, the validity of the European Centre for Medium-Range Weather Forecasts (ECMWF) for providing temperature parameters (minimum and maximum, mean and dew point temperature) and precipitation prediction in different regions of Iran between 2015 and 2017 with a spatial resolution of 0.5 * 0.5 degrees has been evaluated. In order to compare and evaluate ERA-Interim data, minimum and maximum, average, dew point temperature and monthly precipitation of five stations over Iran representing different climate zones have been used. The results showed that the ERA-Interim model predicted generally monthly scale better than the daily scales. For precipitation, the coefficient of determination at all stations were high and, in most stations, it was more than 0.6 and up to 0.99. The values of R^2 for the average values of temperature, minimum temperature, and maximum temperature of all stations were close to one, which indicated that the observed values explained the changes in the predicted values of the model. In general, the standard error of all temperature variables was low and acceptable on a monthly scale, which indicated that the model values were with a small distance from observations. Nash–Sutcliffe model efficiency coefficient varied between -2.4 and 0.9 at stations and variables. A correlation coefficient of average and maximum temperature was about 1 at all stations, which indicated a strong relationship between the observed values and the model. The equally assumption for the minimum temperature and the dew point was not true. In general, the model could well simulate the process of time variation of different variables at selected stations, and the accuracy of the model was acceptable.

Keywords: Reanalysis; ERA-Interim, statistical analysis, Iran, Gridded data.

1. Introduction

Precise monitoring of climate factors such as precipitation and temperature is important in various fields of hydrology, agriculture, and industry. The spatial variation of the meteorological stations has led to the lack of access to various climatic data in the non-stationed areas. Today, the development of centers for forecasting and modeling of climatic data has provided access to time-consuming data. The reanalyzed data is used in conjunction with station data, or sometimes in non-data locations, which have been investigated in various studies of the validity of these data such as the European Centre for Medium-Range Weather Forecasts (ECMWF) in Iran (Sharifi et al, 2016; Raziei and Sotoudeh, 2017; Darand and Zand Karimi, 2015). ERA-Interim is produced by ECMWF, which describes the forecast model, data assimilation method, and input datasets (Dee et al, 2011). ERA-Interim also provided an opportunity to improve the technical base for reanalysis production at ECMWF. This includes checking of input observations, methods for quality control, and bias correction of the observations, as well as providing the tool for monitoring the data assimilation system and its all over efficiency. Each of these features has affected the quality of the reanalysis. Berrisford et al. (2009) prepared a detailed description of the ERA-Interim product archive. Near-real-time updates of various climate indicators derived from ERA-Interim data, can be found at http://www.ecmwf.int/research/era.

Reanalysis origins in the exploitation of meteorological data collected for the FGGE in 1979. These models assemble the data from meteorological stations around the globe (satellite stations, buoys, and upper air observing stations). The results obtained from international aviation and shipping lines and also taking into account the physical-dynamic relationship between the atmosphere and the ocean and the effect of the complex topography of the planet, and the distribution of seas, oceans and forests on it, predicts atmospheric movements and various variables such as pressure and wind. For production of reanalysis data, observational data combines with predictive models. Model predictions are derived from the input data into the model and the mathematical relation defined for the model (Dee et al., 2011; Balsamo et al., 2010). These data take into account the role and effect of observational data, and over time, the forecast errors will be less compared to observational data. (Dee et al., 2011).

The ECMWF first has been looking at atmospheric data since 1979 with high resolution power and for 31 levels (15-ERA). The second inspection of the center was referred to as 40-ERA and carried out during the period 2002-1957. for60 levels with the maximum use of satellite data. On the basis of the network, the data and predictions associated with ozone conditions and the state of the waves in the oceans are available. The data replication system used to generate ERA-Interim is based on the 2006 IFS version (Cy31r2). This system includes the analysis of 4D variations of the 4D-VAR with a 12-hour analysis window. The spatial resolution of the data set is about 80 km (T255 spectrum) at 60 vertical levels from the surface to 0.1 HPA. This database contains real-time rainfall data and its monthly data archives are updated every month.

Various researchers have studied on reanalysis data databases such as NCEP/NCAR, CRU, ECMWF, etc. in different regions and for different climate variables. Poli et al. (2010) described the details of using these data in the ERA-Interim version of the ECMWF database. Balsamo et al. (2010) evaluated the accuracy of estimated rainfall values of the ERA-Interim version on the United States at the daily, monthly, seasonal, and annual basis. The results of their research showed that there is an appropriate coordination between the estimated rainfall values and the precipitation of the GPCP v2.1 databases on the region mapped in the annual time scales. Belo Pereira et al (2011) evaluated global precipitation data sets over the Iberian Peninsula using ERA-Interim and ERA-40 versions of rainfall data and GPCC and CRU bases and compared the data with the values of the national base of IBO2 (Spanish and Portuguese national data). The results showed that estimated rainfall values of the ECMWF base were the best data for understanding the precipitation characteristics of this area. The results of MCEVOY et al. (2014) studies on 4 network databases with observations showed that the type of climate variable and the spatial resolution of network data has an impact on the results of statistical comparisons. Wang and Zeng (2012) compared observational rainfall data with the ECMWF analysis data on the Tibetan plateau (China), and found that there is a high correlation between these data. Pena-Arancibia et al. (2013) studied on precipitation data of NCEP / DOE, ERA-Interim and JRA-

25, and three remote sensing databases (TRMM, CMORPH, PERSIANN) in Australia and South East Asia. They found that ERA- Interim has the most accuracy for estimating precipitation in these areas. Kishore et al. (2015) examined the precipitation data of four databases with India's national data from 1989 to 2007, and found that ERA-Interim data was better than other databases. In another study, the precipitation values of eight databases were investigated with 46 in situ stations in the Sind River basin and Hindu Kush-Karakoram-Himalaya at different altitudes, which are more similar to those of the NCEP / NCAR and ERA-Interim bases compared to other land databases (Khan et al. 2015). A high correlation was found between the ERA-Interim rainfall data and observational data on monthly and daily scales in England and Wales (DeLeeuw et al., 2014). In addition, the potential of ERA-Interim was evaluated in predicting extreme precipitation characteristics for 1 to 7 days in England and Wales, and the results showed a very strong correlation between observational daily precipitation and ERA-Interim estimations (Rhodes et al. 2015). Szczypta et al. (2008) evaluated the data of precipitation, temperature, humidity, irradiance, and wind speed of the ERA-Interim version with the values of the national database of France and obtained a very good correlation between these two bases.

Iran with an area of 1,640,195 square kilometers is located in the southern half of the temperate northern region between 03 °, 25 ° and 47 °, 39 ° north latitude from the equator and 14 °, 44 ° and 20 °, 63 °the eastern part of the Greenwich Meridian. In Iran, researchers have studied the accuracy of ECMWF reanalysis database. Darand and Zand Karimi (2015), evaluated the spatial-temporal accuracy of precipitation of ECMWF over Iran. The results showed that not only the time coordination, but also the amount, are very similar between estimated values of ECMWF precipitation database and observed values of rainfall. Raziei and Sotoudeh (2017) studied on the error rate of the ECMWF in predicting rainfall in different regions of Iran, The results showed that ERA-Interim has a very high accuracy in prediction of rainfall in many parts of the country and its error rate is negligible. Sodoudi et al. (2010) compared the daily precipitation predicted by ECMWF with the daily precipitation of Iran's rainwater grid for the base year 2010. The results showed that the ECMWF provides reliable forecasts of daily rainfall throughout the country. Considering the expansive use of reanalysis data in different areas, and more need for further consideration to use it, this study evaluates the accuracy of the (ERA-Interim) reanalysis data for estimating precipitation and temperature in regions with diverse climates in Iran.

2. Method and Materials

a. ERA-Interim Data:

The daily rainfall data and average temperature, maximum and minimum daily temperature, and dew point temperature from the ERA-Interim ECMWF database with synoptic station data at corresponding geographic locations for 3 years from 1 January 2015 through 31 December 2017 was used and compared with a spatial resolution of 0.5 * 0.5 degrees. The ERA-Interim data were downloaded in February 2018 from the ECMWF Public Datasets web interface (http://apps.ecmwf.int/datasets/data/interim-full-daily/levtype=sfc/). Collection activities, quality control, selection, unification, and display of network data from various sources have been done. ERA-Interim products typically appear once a month with a two-month delay to ensure quality and to improve the technical issues of production.

Since there are variations in climatic conditions and topography in Iran, the study areas were selected in such a way that they could have a comprehensive coverage of climatic and topographic diversity. As shown in Fig. 1, according to the proposal of Sharifi et al. 2016, the Synoptic Station of Kermanshah (Zone 5), Synoptic Station of Rasht (Zone 8), Synoptic Station of Bushehr (Zone 4), Synoptic Station of Mashhad (Zone 2), and The synoptic station of Birjand (Zone 1) has been investigated. Table (1) presents the geographic and climatic characteristics of the stations mentioned above and their elevations.

Figure 1.
Spatial distribution of rainfall variation in Iran Reference Modarres 2006

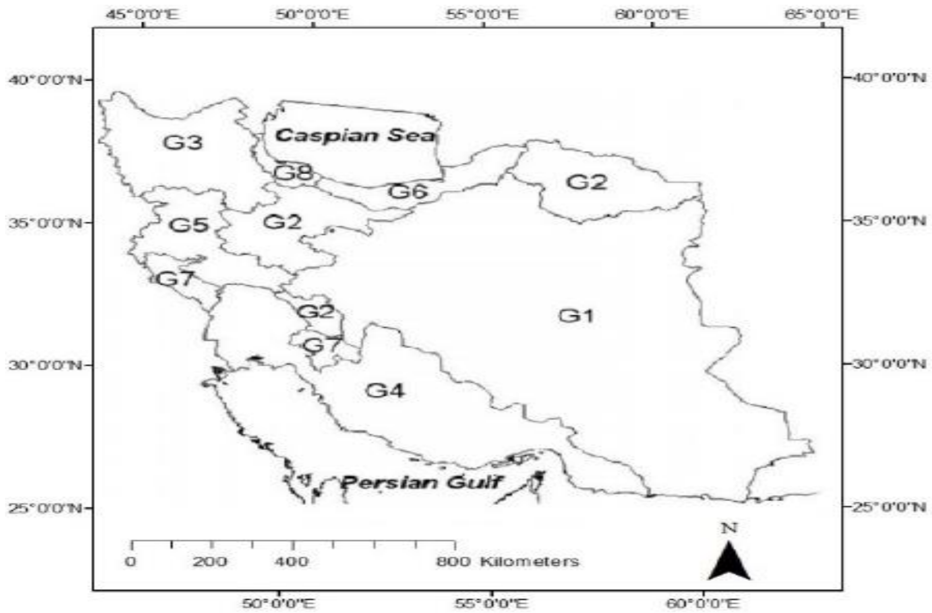


Table 1.
Specifications of synoptic stations studied

Synoptic Station	Longitude	Latitude	Elevation (m)	Climatic zone	Climatic Properties	Area of Iran (%)
Mashhad	59 38	36 16	999.2	Eastern climber	Moderate-mild precipitation, dry	17.1
Kermanshah	47 9	34 21	1318.6	Highlands	Cold good precipitation, dry	15.2
Bushehr	50 49	28 58	9	The climate of the Omani coast	Very hot, low rainfall, very wet	7.7
Rasht	49 37	37 19	-8.6	The Caspian Sea Region	Moderate, well rainfall, wet weather	1.5
Birjand	59 12	32 52	1491	Eastern Shelf Climate	Warm, very low rainfall, dry	39.7

Ref: Masoudian, 2012

For comparison, the correlation coefficients (R^2), RMSE and NRMSE, the mean bias error (MBE), Nash–Sutcliffe model efficiency coefficient (N_S) and residual coefficient (CRM) were used. The normalized root mean squared error (NRMSE) is used to evaluate the accuracy of model predictions against observations and compare them in different regions as shown by equation no.1.

$$NRMSE = \frac{RMSE}{O\ max - Omin} = \frac{\sqrt{\frac{\sum_{i=1}^{N}(Oi - Pi)^2}{N}}}{O\ max - Omin} \tag{1}$$

The N_S is used to compare the predictive power of a model with observational values and to describe the output accuracy of the model in accordance to equation no.2.

$$EF = 1 - \frac{\sum_{i=1}^{N}(Oi - Pi)^2}{\sum_{i=1}^{N}\left(Oi - \underline{O}\right)^2} \tag{2}$$

$$MBE = \frac{1}{N}\sum_{i=1}^{N}(Pi - Oi) \tag{3}$$

$$CRM = \frac{\sum_{i=i}^{N} Oi - \sum_{i=1}^{N} Pi}{\sum_{i=1}^{N} Oi} \tag{4}$$

In which, Pi and Oi values represent predicted and observable values, and N is the number of data or time series lengths and $\bar{O}i$ is the average of observational data. O_{max} and O_{min} are the maximum and the minimum of observations, respectively.

3. Results

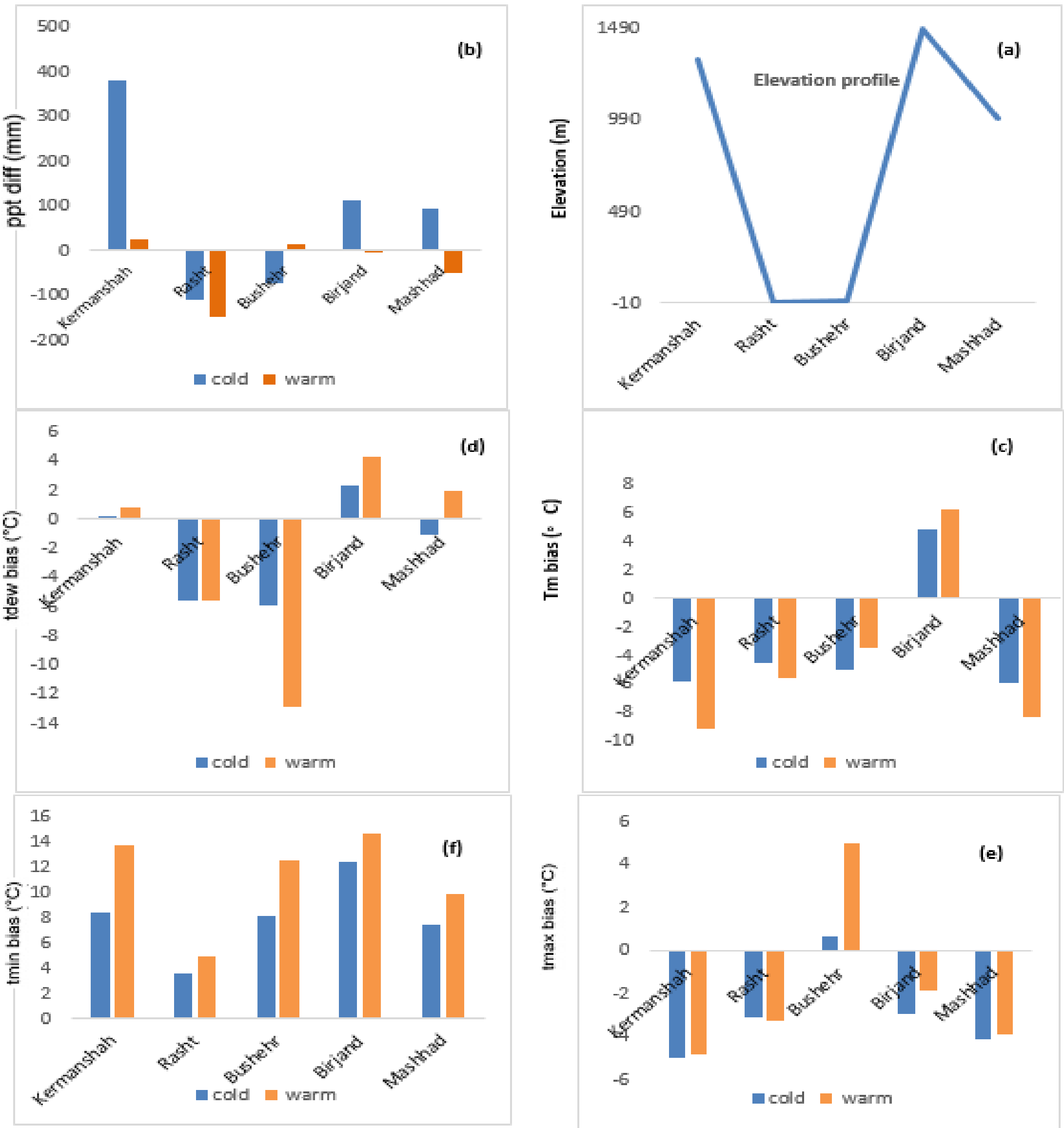
One of the important dimensions in comparative studies between measured and predicted data is the knowledge of the status of measured data. In addition to climatic factors, station location, altitude, vegetation around the station, exposure to wind and prevailing wind direction, and type of rain gauges were utilized at each station (Sieck et al., 2007). They may also affect measured climatic variables. These factors make it possible to record different measurement values from a rain event and cause uncertainty in the observations. These factors make it possible to obtain more uncertainties in the evaluation of observational data with a model such as ERA-Interim.

On a monthly scale, the elevation range of the stations and the bias comparison between the cumulative/average cold and warm season with the observations in the studied period are shown in Fig. 2. The difference between the sum of rainfall of different months (January, February, etc.) from model with observations in years 2015 to 2017 are demonstrated in Fig. 2. In the case of temperature variables, it is different from the average monthly temperature (January, February etc.) of the model with observations. In the Fig. (2b) during the cold season (autumn and winter), the bias range of precipitation is positive for stations in Kermanshah, Birjand, and Mashhad. The most difference between model and observed values is at Kermanshah station, which is due to model prediction in December. In Rasht and Bushehr, this difference is negative (model minus observation). The lowest difference in the cold season is at Bushehr station (-72 mm), which shows the total difference in cold seasons (18 months of cold) between model and observations. The difference in elevation between stations does not reflect the difference in rainfall, which indicates that the model's performance is not uniform in some regions with specific climatic and geographical conditions. The average temperature difference (Fig. 2c) is negative for the four stations in Kermanshah, Rasht, Bushehr, and Mashhad in the cold and warm seasons, and is positive only for the Birjand station, which has the highest elevation. In other words, the model predicts a higher average temperature (+4°C) for a warm, dry, and high climate region. The largest difference is negative (cooler than observations) at the stations of Mashhad and Kermanshah. The dew point temperature bias (Fig. 2d) is positive for warm and cold seasons for stations in Kermanshah and Birjand and is negative for Rasht and Bushehr. At Mashhad station, it is negative in cold season and positive in warm season. In general, many of these biases can be attributed to the network point and station location. At cold and warm seasons, the maximum temperature bias (Fig. 2e) is negative for 4 stations and only positive for the Bushehr station, which is in the range of 0.67 to -5 ° C. The minimum temperature difference (Fig. 2f) is positive for all stations in the cold and warm seasons. The minimum temperature difference changed in the range of 3.5 (Rasht) to 12.3 ° C (Birjand) in the cool season and 4.8 (Rasht) to 14.6 ° C (Birjand) in the warm season.

The dew point temperature of the model is calculated using the specific humidity parameters and surface pressure, and in the case of temperature below the minimum at 2 meters, the dew point temperature is assumed to be minimum temperature at 2 meters (Tmin = Tdew) (IFS documentation). Dew point temperature at Rasht and Bushehr stations with low altitude is negative in warm and cold seasons and is high in other stations that are located in high altitude, while the dew point temperature decreases at high elevation.

Figure 2.

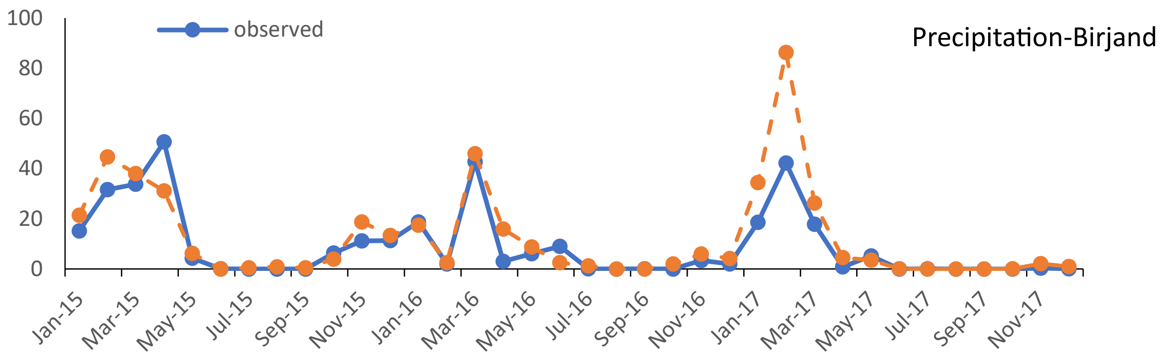
The elevation profile of the stations (A), the biases (model minus observations) at warm and cold season, (B) the precipitation bias, (C) the average temperature bias, (D) the dew point temperature bias, and (E) the maximum temperature bias in the 2015-2017.

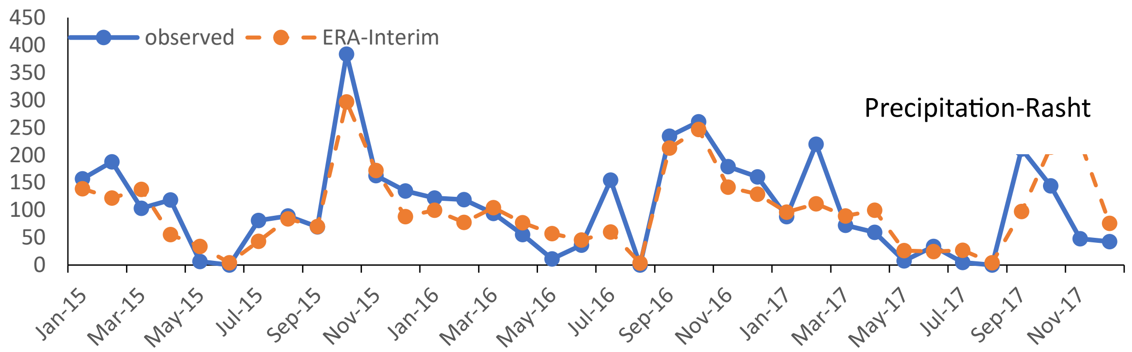


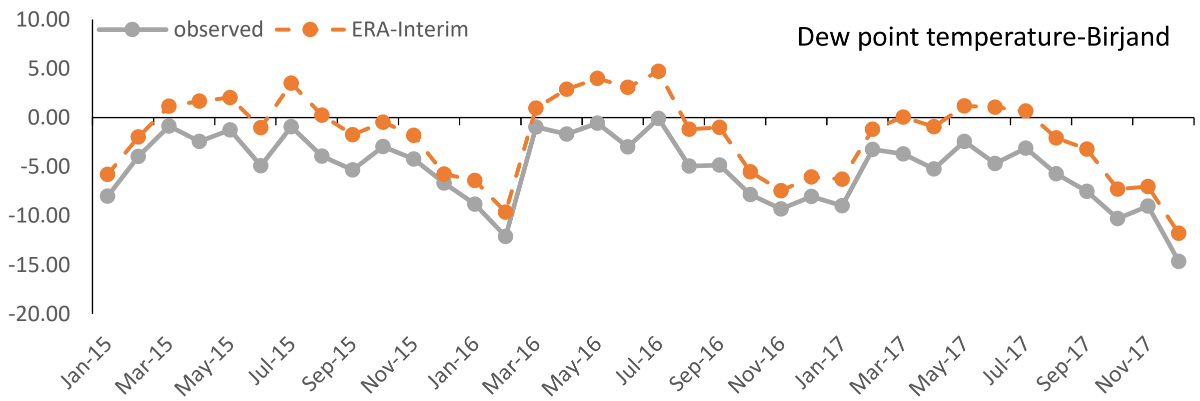
In order to evaluate the ability of the ERA-interim model to predict weather variables in special atmospheric conditions in different regions of the country, comparison between precipitation and dew point temperature values from model for Birjand and Rasht stations are done monthly. The choice of the two stations was based on the lowest and the highest rainfall rates among the selected stations. The model was able to predict rainfall on most months studied in Birjand and was only over-estimated in February of 2015 and 2017, and has been under-estimated in April 2015. The model's ability to predict Rasht precipitation is also shown in Fig. 3. The model has been over-estimated the moderate dew point temperature in Birjand (+3.27 ° C) and has been under-estimated at -5.6 °C in Rasht station for all months.

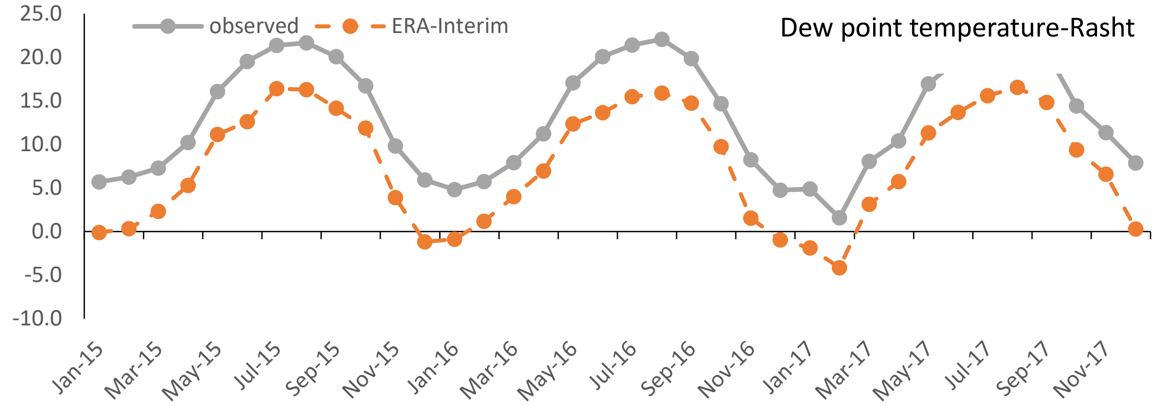
Figure 3.

Rainfall and dew point temperature comparison between model and observed in Birjand and Rasht stations monthly









The difference between model and observed data from monthly mean temperature sum of rainfall are presented in Table (2). The model overestimated in Mashhad, Kermanshah and Birjand and underestimated in Bushehr and Rasht in precipitation. These conditions also apply for dew point temperature of these stations. The minimum temperature overestimated at all stations, ranging from 4 to 13.5 ° C, with the least positive difference in Rasht and the highest positive difference in Birjand. The model underestimated maximum temperature in 80 percent of stations, which varied from -2.4 to -4.9 ° C that observed in Birjand and Kermanshah, respectively.

Table 2.

Differences of monthly average of model predictive values with observational variables

Station	Kermanshah	Rasht	Bushehr	Birjand	Mashhad
Precipitation	11	-7	-1.63	3	1.2
Average temperature	-7.5	-5.1	-4.2	5.6	-7.1
Dew point temperature	0.5	-5.6	-9.4	3.3	0.5
Minimum temperature	11	4.2	10.3	13.5	8.6
Maximum temperature	-4.9	-3.2	2.8	-2.4	-4

Determination coefficient and standard error for prediction values of model with observational values of the variables studied has shown in Table (3). The explanation or detection coefficient (R^2) indicates the ratio of the dispersion expressed from the regression model to the total dispersion. R^2 specifies that, according to the regression model, what proportion of the variation or dispersion of the model's prediction is related to the observed values. The closer the R^2 is to one, the more reliable a model can be. R^2 values are high (0.6 and up to 0.99) at all stations. The values of R^2 for mean temperature, minimum temperature and maximum temperature of all stations are close to one, which indicates that the observed values explain the changes in the predicted values of the model. In addition, the range of R^2 is for the maximum daily temperature variables and the average temperature is over 90% at daily scale. The coefficient of precipitation determination in the studied stations varies from 16 to 51 percent, of which the lowest is Bushehr station. Also, at Rasht station, 85% of variation and dispersion in dew point temperature variable predicted by ERA-interim model depend on observational values. On the other hand, it is observed that this coefficient for dew point temperature at Kermanshah station is less than 10 percent, but exceptionally low at high altitudes.

In general, the standard error of all temperature variables is low and acceptable on a monthly scale. The standard error of estimation specifies that, according to the regression model, the predicted value of the (ERA-interim) model is, on average, as far as the actual (observable). On a daily scale, on average, the lowest and highest standard errors of precipitation prediction are at Birjand and Rasht, respectively. On average, it seems that model to have less error in estimating average temperature and maximum temperature.

Table 3.

Determination coefficient and standard error for prediction values of model with observational values of the variables studied at relevant stations on the monthly scale during the period of 2017-2015

Parameter	Statistic	Kermanshah	Rasht	Bushehr	Birjand	Mashhad
Precipitation	R^2	0.74	0.62	0.44	0.99	0.85
	(std. E. E)	23.63	44.47	20.93	0.80	9.30
Average temperature	R^2	0.99	0.99	0.97	0.99	0.99
	(std. E. E)	19.99	0.71	1.26	0.80	0.61
Dew point temperature	R^2	0.17	0.98	0.48	0.93	0.82
	(std. E. E)	2.94	0.84	2.17	1.10	1.97
Minimum temperature	R^2	0.97	0.97	0.99	0.95	0.98
	(std. E. E)	1.90	1.43	1.11	1.94	1.36
Maximum temperature	R^2	1.00	0.99	0.98	1.00	1.00
	(std. E. E)	0.71	0.85	1.21	0.37	0.57

In Table 4, the results of the ERA-interim prediction accuracy against observed values are presented using RMSE and NRMSE statistics for selected stations at monthly scale. The higher the magnitude of this statistic is closer to zero, the less model error is in the prediction of the observed values. The RMSE range of precipitation in selected stations is 9.44 to 53.7 mm.The higher number is value at Rasht station due to the higher precipitation rate. The range of RMSE for mean temperature is 4.41 to 7.8 which are related to Bushehr stations and Kermanshah, respectively. The lowest RMSE of dew point temperature is for Mashhad station and the highest RMSE of dew point is for Bushehr station. In general, RMSE of maximum temperature of all stations are less than their minimum temperature. Comparison of standardized root mean square error by intervals of observational values between different stations shows that the model accuracy in precipitation forecast in all stations is high and error rates range from 5 to 10 percent. On a daily scale, the RMSE range of precipitation is at the selected stations is 7.3-4.1 mm. The higher amount at Rasht station is due to higher amount of precipitation at this station. Among the temperature variables, the lowest and highest RMSE values are for dew point temperature and minimum temperature at stations in Mashhad and Birjand, respectively. By looking at the NRMSE values of the various variables in the stations, the lowest NRMSE values are for the minimum temperature prediction at the Birjand station and precipitation at Mashhad station. The low values of NRMSE indicate model deviation of precipitation is less than one and represents an acceptable estimation of the model in all regions. Generally, NRMSE values in all precipitation and temperature variables are lower than 0.63 in all stations and is 1.11 in only one case. The highest NRMSE value is for the minimum temperature prediction at the Birjand station. The low NRMSE values indicate that precipitation model deviation is less than 1 and represents an acceptable model estimate in all areas. At this comparative level, the NRMSE model has been associated with a greater error in estimating the minimum temperature than other temperature variables. In general, the NRMSE values for all temperature and precipitation variables and at all stations are less than 0.4. On a daily scale, the highest NRMSE value is for the minimum temperature prediction at the Birjand station. The low NRMSE values indicate that precipitation model deviation is less than 1 and represents an acceptable model estimate in all areas. At this comparative level, the NRMSE model has been associated with a greater error in estimating the minimum temperature than other temperature variables. In general, the NRMSE values for all temperature and precipitation variables and at all stations are less than 0.4.

Table 4.

Root mean Square Error (RMSE) and Standardized (NRMSE) Model predictive values with observational values of the studied variables at relevant stations at monthly scale

Parameter	Statistic	Kermanshah	Rasht	Bushehr	Birjand	Mashhad
Precipitation	RMSE	25.97	53.69	24.00	9.43	9.44
	NRMSE	0.16	0.14	0.19	0.19	0.10
Average temperature	RMSE	7.80	5.17	4.41	5.67	7.27
	NRMSE	0.27	0.21	0.22	0.25	0.27
Dew point temperature	RMSE	4.48	5.62	10.45	3.48	2.05
	NRMSE	0.23	0.27	0.54	0.24	1.11
Minimum temperature	RMSE	11.58	4.45	10.61	13.68	8.85
	NRMSE	0.63	0.19	0.53	0.56	0.36
Maximum temperature	RMSE	4.95	4.45	3.75	2.49	4.02
	NRMSE	0.16	0.18	0.18	0.10	0.14

Table 5 shows the N_S between observational values and model prediction. N_S can vary from infinity to 1. EF = 1 means that the model has a perfect match with the observations. EF = 0 shows that the model predictions are accurately the mean of observational data, while the efficiency coefficient is less than zero, indicating that the average of the observations is better than the model and the accuracy of the model is very low. The range of N_S and variables at stations varies between -2.4 and 0.9. In comparison, the model has a low accuracy of dew point temperature in Birjand and Bushehr. The model also has a low accuracy of minimum temperatures in Mashhad, Birjand, Bushehr, and

Kermanshah stations. On the other hand, model have been high in predicting maximum temperature at all stations, as well as the rainfall and dew point temperature in Mashhad. The model in Birjand's dew point temperature estimate has operated with the average of observations and the efficiency coefficient is zero. On a daily scale, N_S changes at stations and various variables are between -0.3 and 0.9. The model underestimated the forecast of Bushehr precipitation, the minimum temperature in Mashhad, Birjand, Bushehr, and Kermanshah, and the maximum temperature at Kermanshah station. On the other hand, the dew point temperature in Mashhad, maximum temperature in Birjand, Rasht, and Mashhad were high.

The estimation of the mean bias error in this study shows that the model overestimated precipitation in Mashhad and Birjand stations, and underestimated rainfall of Bushehr, Rasht, and Kermanshah. Also, the model underestimated average temperature and overestimated the minimum temperature in most stations. On a daily scale, the mean bias error in this study shows that the model well done for forecasting rainfall in Mashhad station. The model underestimated the average temperature and overestimated the minimum temperature. Positive values of biases were shown for dew point temperature in Mashhad, Birjand and Kermanshah and its negative values were in Bushehr and Rasht. The positive values of biases for maximum temperature in Bushehr and Kermanshah and its negative values were seen in Mashhad, Birjand, and Rasht.

Table 5.

Nash–Sutcliffe model efficiency coefficient and mean bias error of the predicted model with the observed values of the variables studied at the stations in the monthly scale

Parameter	Statistic	Kermanshah	Rasht	Bushehr	Birjand	Mashhad
Precipitation	EF	0.6	0.6	0.4	0.5	0.8
	bias	11.2	-7.2	-1.6	3.0	1.2
Average temperature	EF	0.3	0.5	0.6	0.4	0.3
	bias	-7.5	-5.1	-4.2	5.6	-7.1
Dew point temperature	EF	0.1	0.2	-1.9	0.0	0.7
	bias	0.5	-5.6	-9.4	3.3	0.5
Minimum temperature	EF	-1.5	0.6	-1.5	-2.4	-0.3
	bias	11.0	4.2	10.3	13.5	8.6
Maximum temperature	EF	0.8	0.7	0.7	0.9	0.8
	bias	-4.9	4.2	2.8	-2.4	-4.0

The mean bias error (MBE) is the average of the model's tendency for over-estimating (positive values) or underestimating (negative values) of the model relative to the observed values (Table 6). The zero value of the statistic indicates the good ability of the model in predicting observational values. The study of the mean bias error in this study shows that the model predicted the observed values well for dew point temperature of Mashhad and Kermanshah stations. The bias error of the model in the prediction of minimum temperature in Birjand is the most overestimated and Bushehr dew point temperature is the least underestimated. The Coefficient of Residual Mass (CRM) also confirms MBE results. In an ideal model, CRM is zero. In the case where the residual coefficient is positive, the model's tendency to estimate predictive values is less than observational values, and if the residual coefficient is negative, then the prediction values of the model are larger than observational values.

Table 6.

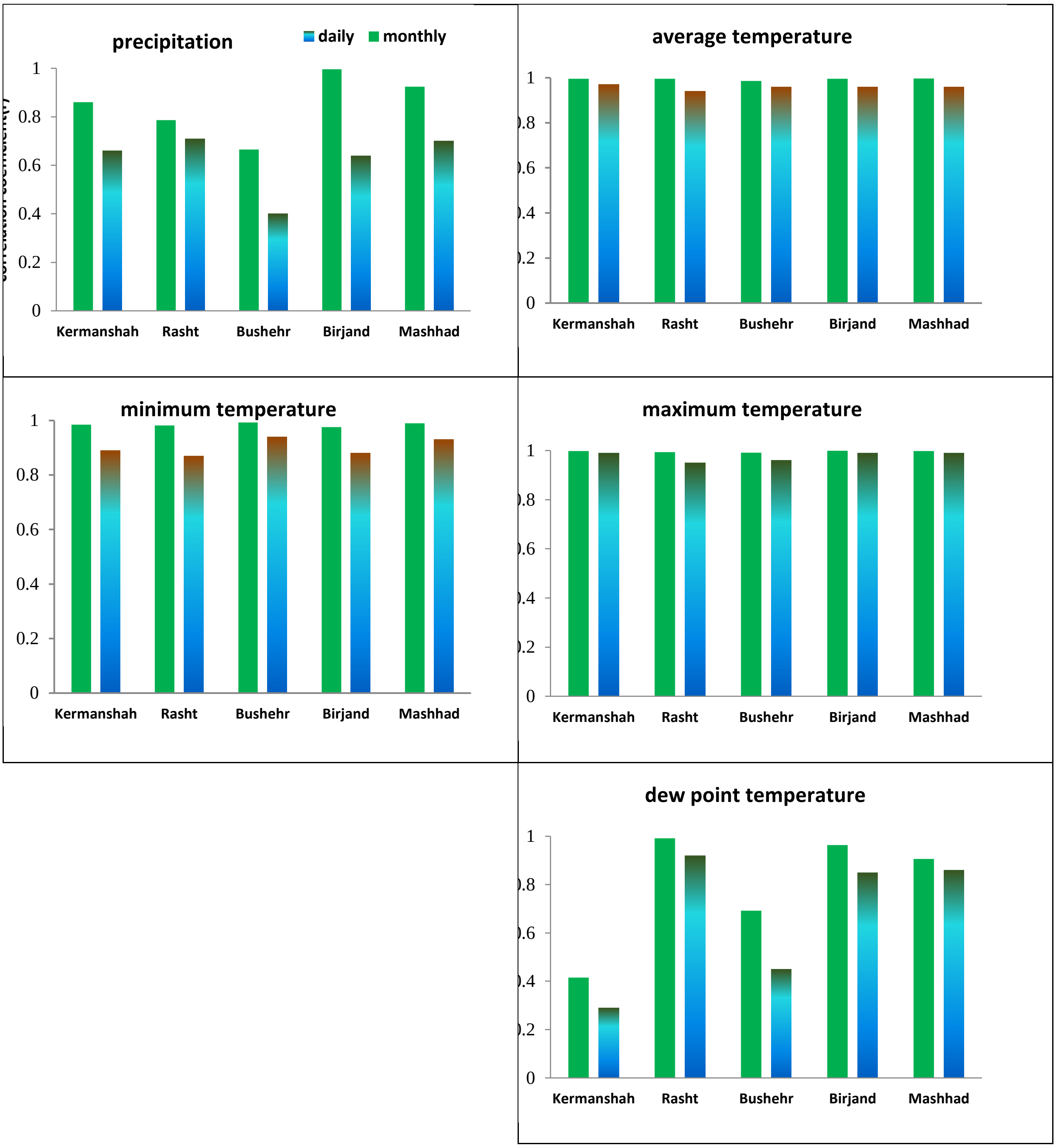
MBE and CRM of the predicted model with the observed values of the variables studied at the stations in the monthly scale

Parameter	Statistic	Kermanshah	Rasht	Bushehr	Birjand	Mashhad
Precipitation	MBE	11.2	-7.2	-1.6	3.0	1.2
	CRM	-0.3	0.1	0.1	-0.3	-0.1
Average temperature	MBE	-7.5	-5.1	-4.2	5.6	-7.1
	CRM	0.5	0.3	0.2	-0.5	0.4
Dew point temperature	MBE	0.5	-5.6	-9.4	3.3	0.5
	CRM	1.1	0.4	0.5	0.6	-0.4
Minimum temperature	MBE	11.0	4.2	10.3	13.5	8.6
	CRM	-1.5	-0.3	-0.5	-1.5	-0.9
Maximum temperature	MBE	-4.9	4.2	2.8	-2.4	-4.0
	CRM	0.2	0.1	-0.1	0.1	0.2

Figure 4 shows the correlation coefficient between the daily and monthly values of the studied variables in selected stations in the 2015-2017 period. The value of r on average temperature and maximum temperature is near 1 at all stations on monthly scale, which indicates a strong relationship between the observed values and the model. Thus, the model can be used to predict this climatic variables more successful in monthly scale and is consistent with Darand and Karimi (2015), Raziee and Sotoudeh (2016) and Sharifi et al, 2016. On a daily scale. pearson correlation coefficients vary from 0.7 to 0.99 and indicate a strong positive linear relationship between observational values and the ERA-interim model in various variables.

Figure 4.

Correlation Coefficients (r) Daily and monthly values of the studied variables at selected stations in 2015-2017



Conclusion

Due to the spatial and temporal constraints of in situ data, it is important to use grid data consist of a variety of ground databases, radars, and satellites in conducting hydrology, climate and, agricultural research. In this study, the accuracy of monthly values of temperature and precipitation variables of the ERA-interim model from the ECMWF base with five synoptic stations in different climatic regions of the country during 2015-2017 with a spatial resolution of 0.5 * 0.5 degrees has been evaluated. Notable achievements in modelling and data assimilation actualized at ECMWF in recent years. The results showed that the variability of the studied variables in the model with the observational data has a very high time synchronization. Due to the spatial distribution of selected stations, there is a strong and significant daily time series correlation between observational and model prediction in all variables. The ERA-Interim model predicts monthly data better than daily scale. In accordance to the N_S efficiency coefficient, the model predicted maximum temperature, mean temperature, and precipitation better than dew point and minimum temperature. The assumption of the model that the dew point temperature average equals the minimum temperature at daily scale is not true. In general, the model can well simulate the process of time variation for different variables at selected stations, with and acceptable accuracy. According to the results of this research, the data of this model can be used along with the station data.

Network data users should be aware of the existence of larger uncertainties in less density station areas. Observed difference may be due to factors such as the accuracy of the databases used in the model, the model's resolution, and the methods for interpolating the model in the corresponding coordinates of the stations. Also, the density of the terrestrial data network in the region and the study of the dynamics and physical relations governing the model, run steps etc. in predicting rainfall and dew point temperature and other temperature variables are the factors that should be considered in the application of models.

This study highlights the importance of conducting spatial analysis of observations and potential measurement errors in order to obtain an understanding of the potential deviations of network data before being used in hydro-climatic applications.

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