6
Case study of IMD Jodhpur Radiation Database

6.1 INTRODUCTION

Solar radiation database of IMD-Jodhpur consisting of one year (2015) raw data and meteorological database are analyzed here. Cloud analysis and quality control guidelines are applied to this dataset. Moreover, for each test, a code system is assigned, which helps in error identification and correction. After that gap filling approaches are applied to the identified gaps and comparison is done on the basis of daily averaged values of raw and corrected radiation database. Finally monthly and yearly averages are calculated for solar resource potential of Jodhpur.

6.2 QUALITY CONTROL OBSERVATIONS OF IMD STATION

In the initial phase of site selection available solar maps are used. Here the site selected is IMD-Jodhpur and corresponding historical radiation database is purchased (10-min averaged, year-2015) from IMD. It's time-step analysis and climatic studies are done by each day's transmittance plots. After that for the selected database, detailed data quality control procedure is carried out and data found erroneous is flagged accordingly. After erroneous data type (single, double or triple missing data) is done, these gaps are filled accordingly. For a better understanding of this procedure, a code system is applied. All quality control tests, climate conditions and errors occurred in individual radiation components measurements, codes are provided in Table 6.1. By comparing these codes, and databases individual data analysis and correction is performed. In addition, a coherence factor is also included in this data correction analysis, which helps in determining the measurement quality. These efforts help in solar resource assessment of Jodhpur site.

6.2.1 Parameter selection

Model parameters which are used during the detailed analysis and are helpful in analyzing the database are discussed here. For each parameter a code is provided, so during the detailed analysis its comparison becomes easy. For characterizing the climate present on each day, "k_t-k_n" and measured-calculated GHI results are compared with Maxwell *et al.,* (1993) plots (see codes for different cloud conditions in Table 6.1). Similarly, from data quality control tests, each error identified during the process is assigned a code (see Table 6.1). Results obtained from comparing cloud conditions, quality control and other visual tests, some additional codes are shown in Table 6.1. These help in identifying errors in individual radiation instruments.

6.2.2 Daily Climate Analysis

For doing one-year radiation database analysis, first each day's local climate condition is to be identified. Different cloud conditions can be identified using "k_t-k_n" and "measured-calculated GHI" plots [Khavrus and Apple, 2012] as explained in chapter 3. In addition, data from nearby radiation measuring station and meteorological data,

Table 6.1: Various Codes used for Data Identification and Correction

Quality Control Code	Cloud Condition Code	Instrument Error Code
M – Data missing MX– Maximum physical limit MN– Minimum physical limit CH- Coherence error DE- Diffused error TE- Tracking error	CS- Clear sky LC- Light cloud MC- Medium cloud HC- Heavy cloud Haze- Uniform cloud cover	S- Soil or dust I- Instrument sensitivity C- Calibration T- Instrument tracking SS- Station Shutdown

also help in cloud identification. Two radiation databases (SRRA-Jodhpur & IMD-Jodhpur) are also compared. As both stations are close to each other, both station's measured radiation pattern is found to be similar. However, some variation is seen during monsoon days, due to cloud motion and distance between the two stations. Other differences show measurement error in measured radiation values.

Using cloud condition guidelines discussed in "chapter 3", each identified day is assigned a code (provided in Table 6.1). But during cloud condition analysis, it is seen that cloud presence doesn't remain the same throughout the day (see Table (6.1) to (6.13)). For identification of clear-sky days from the available database, each day is compared with the "ASHRAE" clear-sky model equation. During analysis, one finds that clear sky days with "< 10 %" cloud presence are identified, for only 30-35 days (during the March, April, May, October, November and December months). After that, maximum number of days (around 280 days) is light clouded days, which are identified with the presence of small variation in measured values, due to 20% to 30% cloud cover or haze presence. The remaining 50-60 days, fall in medium and heavily clouded condition days, showing the presence of varying density clouds and another cloud like conditions present in the sky. Further classification such as rainy conditions, sandstorm and other cloud conditions also fall under this category.

6.2.3 Daily Quality Control Test Analysis

One year radiation database available from two ground-based measurement stations (IMD-Jodhpur and C-WET Jodhpur), are checked for their quality. Guidelines discussed in "chapter 4", and various error flags provided there for these radiation databases are carefully noted for each interval of the day. Each month's quality control results are shown in Table 6.2 to 6.13 and Fig. 6.2 (c, d, e) to Fig. (c, d, e). By comparing the results provided by these plots and quality tests results, it is identified that both stations perform unsatisfactorily in these tests. For few months "SRRA" data passes all quality tests, but it needs correction in other months. Similarly for "IMD" radiation database, data only passes the quality test during 2-3 months and for remaining duration, during sunshine hours no data passes quality control tests. Also during, the presence of different cloud conditions the data on majority of days appear to fail in tracking and coherence error tests. But after analysis, it is identified that error is due to irregular maintenance practices. Hence daily cleaning of sensors is recommended, where GHI component being most sensitive to dust. This problem is identified by Pape *et al.,* [2009], which discusses soil impact on thermopile and rotating shadow band pyranometer solar radiation sensors. Here energy loss between raw and corrected radiation databases will be discussed at the end.

From Table 6.1, each quality control code is discussed here with their occurrence in each day's quality control results. When studying the total database, the "Data Missing" is the most common error in the database. This is occurring due to original data failed to store in the database. In our database, this error is present in almost all months and gap filling is suggested. Next error listed is "maximum and minimum physical limits", which occurs due to storing of non-possible theoretical radiation values. Here few intervals during 3 months are identified with this error and it occurs during the movement of medium or heavy clouds. Next is "diffuse error", and it is identified only during heavy cloud condition days and in our database its occurrence is only seen for 1-2 intervals during the January month. For "maximum and minimum physical test" and "diffuse error" data failing interval, correction is done by comparing it with clear sky model values. Finally, "coherence and tracking error" tests are done. The climate condition also affects the error identification on individual radiation component values. For the final quality control results, see Table 6.2 to 6.13, which are compared with plots shown in Fig. 6.2 (c, d, e) to Fig. (c, d, e).

6.2.4 Data Passed in Quality Control Tests for Two Radiation Databases

For each month data passing in quality control tests is provided in Figure 6.1 (f) to Figure 6.12 (f). For IMD-Jodhpur database, for each month, the total data passing the quality control tests are 60, 60, 60, 55, 70, 70, 80, 70, 60, 60, 60 and 60 (all in percentage). Similarly for SRRA-Jodhpur, values passing in quality control test are 80, 60, 60, 80, 60, 70, 90, 90, 80, 70, 90 and 90 (all in percentage). This result shows that the "SRRA" database is found to be slightly better than IMD database. But conclusions derived after the quality tests show that both databases can't be used in the raw form for solar resource assessment. As from discussed results, 70 percent data contributes to night values, and if 20-30 percent data each day (sunshine duration data) is failing in quality test, then its reliability is questioned. Hence data gap filling is a must for further analysis.

6.2.5 Corrections in Measured Radiation Components

Here the radiation database available (IMD-Jodhpur) for the year "2015" is analyzed. By using instruments' error codes (provided in Table 6.1) each day of the radiation dataset is coded. Now error present in each radiation component is evaluated and final results are provided in Table 6.2 to Table 6.13.

In January, some data is failing in "coherence" and "tracking" error test, which after analysis shows the presence of maintenance issues (identified for the whole month) and tracking error for some identified intervals. In February, all days are identified with coherence and tracking error test, with some days having cases of data missing. In fact, for the starting half month, tracking error in DHI radiation component is identified. Hence, maintenance and instrument correction are required in this database. Next in March, April and May month database, similar response is seen. Hence station maintenance and tracking error in DHI and DNI value are identified. After that in June, July and August month database (monsoon period), the quality control result show data failure due to coherence and tracking error test. But after analysis, only presence of maintenance issues is identified for all measured radiation components. Next in September, October, November and December month database, data is failing due to coherence and tracking error test with some interval of station shutdown also. Here, the error is due to maintenance issues, tracking error in DHI and DNI, and data missing error for some duration. In conclusion for the whole year, soiling error is seen throughout the year in GHI measurement. For other two instruments (used for measuring DNI and DHI component) some intermediate days show the presence of soiling error. Hence station is not cleaned every day, due to which this GHI error is seen. Other instruments are also getting affected, but in the majority of cases, error is found within the acceptable range. All identified disturbing events and other types of error identified, during the detailed error identification process are listed in Table 6.1. For each day comprehensive results are shown in Tables 6.2 to 6.13 and Figures (6.1(a) to 6.12(a)).

6.2.6 Coherence Factor for Measured Radiation Quality

Coherence error test is used for checking the measured radiation component values. By this test, one can check the measurement relationship between radiation components: GHI, DHI, DNI and solar zenith angle. The correlation used here, is the same quality control test condition (see Eq. 4.10 and Eq. 4.11) discussed in "chapter 4". Where the output ratio "1" means clear sky day with no error in the measurement process, and less than "1" means the presence of some clouds and errors, which restricts the radiation to fall directly on the radiation measurement sensors. However, greater than "1" means error with overestimated radiation values, also shows the presence of instrument based error.

For a well maintained radiation measurement station, where all data passes each quality test, the coherence ratio, at available measured interval, should have minimal variation (decision only valid for sunshine duration period). However, if instruments' measurement ability degrades or instrument is not cleaned regularly, then this calculated factor will keep on reducing. Also, if this factor is tracked for complete radiation database, one finds that each station coherence factor varies slightly throughout the year (if no instruments are changed and the station is maintained regularly). Hence using this ratio, any stations' instrument health can be identified.

The coherence factor range provided in literature is "±8 %", but during the analysis one finds that, for any day the calculated coherence factor shows consistent values with small variation. For each interval of the day, coherence factor is calculated. Data which passes the quality control is selected for evaluation of that day's coherence value. For doing daily analysis of these coherence factors, all identified values of each day are averaged and results are provided in Table 6.2 to 6.13. The ratio calculated for the complete database is in the range of "0.92" to "0.97" for the whole year. For the majority of days, the ratio is around 0.95 and for medium and heavy cloud condition days, the ratio increases some times to 0.97. Hence by using this information, it can be suggested that, the averaged coherence factor for the whole year is 0.95. This value indicates (according to the provided literature) the presence of sand or soil layer floating over the sky or presence on the sensor top. This filter slightly restricts the radiation falling at the radiation measurement sensor. Moreover, the presence of un-identified artificial cloud like structure, also reduces this coherence factor value with increasing the location temperature.

6.3 DAILY AVERAGED RADIATION RESULTS

Using time-step analysis and quality control results (see Table 6.2 to Table 6.13 and Fig. 6.1(a, c, d, e) to Fig. 6.12(a, c, d, e)), the data missing intervals are identified in solar radiation components. Now according to the suggested gap-filling approach (discussed in "chapter 5"), one-year radiation database is gap filled. After correction of the database, the radiation components are plotted in Fig. 6.1(b) to Fig. 6.12(b), which are now free from all identified errors. Moreover, for verification of these modified corrected values, for each day of the month, the measured data is also compared with another station database (SRRA-Jodhpur). Intervals, for which data is passing the quality tests, are only selected in the corrected database. For these intervals (where both databases are passing the quality tests) one finds that both databases are found comparable with each other. Moreover, the same co-relation is seen between the coherence factors of both measurement locations. Hence, this makes the correction procedure valid for the location and now this database can be used for any solar energy-related assessment.

Here the per interval calculated values are identified, and the difference between the IMD-Jodhpur (raw and modified) database is provided in Fig. 6.1 (g, h, i) to Fig. 6.12 (g, h, i). Now, for each months maximum and minimum difference changes identified for GHI, DHI and

DNI radiation (10-minute interval database) component values are provided here: January (GHI: -100, 100; DHI: -75, 3; DNI: 0, 36), February (GHI: -74, 437; DHI: -734, 109; DNI: 0, 44), March (GHI: -122, 978; DHI: -843, 410; DNI: 0, 862), April (GHI: -48, 789; DHI: -773, 334; DNI: -220, 578), May (GHI: -76, 786; DHI: -400, 450; DNI: -34, 809), June (GHI: -77, 92; DHI: -41, 9; DNI: 0, 177), July (GHI: -88, 803; DHI: 0, 557; DNI: -1, 437), August (GHI: -80, 681; DHI: -642, 396; DNI: 0, 274), September (GHI: -38, 666; DHI: -758, 268; DNI: -68, 768), October (GHI: -17, 790; DHI: 0, 413; DNI: 0, 850), November (GHI: -49, 696; DHI: 0, 280; DNI: -16, 760) and December (GHI: -38, 114; DHI: 0, 26; DNI: 0, 834) (here all values are in W/m^2). The high variation identified above is due to tracking error present in that month. Finally in conclusion it is seen that maximum difference is present in GHI radiation component, and due to tracking and maintenance issue some error is also identified in DHI and DNI components.

In detailed analysis of this database, its averages are also calculated. From available 10-min interval (raw and corrected) radiation database, their daily averages and RMSE is calculated and results are plotted for each month (see Fig 6.1 (j, k, l) to Fig 6.12 (j, k, l)). By using these plots, total radiation energy received by each radiation component on each month is calculated and results are compared. For each month, daily average, minimum and maximum values are calculated and presented in Table 6.14. From which each month's total radiation energy receiving at the surface is calculated. Now for the complete year, difference between raw and corrected energy received at the location is: January (GHI= 615 kW, DHI= -2 kW and DNI = 114 kW), February (GHI= 775 kW, DHI= -2389 kW and DNI = 48 kW), March (GHI= 799 kW, DHI= -3314 kW and DNI = 312 kW), April (GHI= 363 kW, DHI= -541 kW and DNI = 61 kW), May (GHI= 235 kW, DHI= -134 kW and DNI = 510 kW), June (GHI= 77 kW, DHI= -51 kW and DNI = 56 kW), July (GHI= 59 kW, DHI= 59 kW and DNI = 20 kW), August (GHI= 878 kW, DHI= -610 kW and DNI = 3 kW), September (GHI= 197 kW, DHI= -1605 kW and DNI = 2679 kW), October (GHI= 2371 kW, DHI= 770 kW and DNI = 2508 kW), November (GHI= 1064 kW, DHI= 182 kW and DNI = 1264 kW) and December (GHI= 798 kW, DHI= 0 kW and DNI = 574 kW). Here the high DNI difference shown above is due to the presence of tracking errors. Similarly, the negative DHI value also shows tracking error, due to which this DHI instrument measures GHI values. In direct conclusion it is said, about 2-10% of GHI and 2-5% of DNI respectively (of total energy loss) is identified in each months average values. Finally monthly and annual averages values are calculated from this corrected radiation database.

By using corrected radiation database, the average values of each month are calculated: January (GHI= 152 W/m^2, DHI= 59 W/m^2 and DNI = 186 W/m^2), February (GHI= 194 W/m^2, DHI= 69 W/m^2 and DNI = 222 W/m^2), March (GHI= 223 W/m^2, DHI= 84 W/m^2 and DNI = 224 W/m^2), April (GHI= 248 W/m^2, DHI= 109 W/m^2 and DNI = 208 W/m^2), May (GHI= 268 W/m^2, DHI= 109 W/m^2 and DNI = 226 W/m^2), June (GHI= 235 W/m^2, DHI= 120 W/m^2 and DNI = 166 W/m^2), July (GHI= 183 W/m^2, DHI= 130 W/m^2 and DNI = 78 W/m^2), August (GHI= 202 W/m^2, DHI= 130 W/m^2 and DNI = 109 W/m^2), September (GHI= 217 W/m^2, DHI= 85 W/m^2 and DNI = 200 W/m^2), October (GHI= 201 W/m^2, DHI= 61 W/m^2 and DNI = 234 W/m^2), November (GHI= 158 W/m^2, DHI= 64 W/m^2 and DNI = 176 W/m^2) and December (GHI= 152 W/m^2, DHI= 49 W/m^2 and DNI = 207 W/m^2). The yearly averages values are also calculated, which are as follows: (GHI= 203 W/m^2, DHI= 89 W/m^2 and DNI = 186 W/m^2).

Similarly for monthly average sum values of each months are calculated: January (GHI= 3.6 $kWh/m^2/day$, DHI= 1.4 $kWh/m^2/day$ and DNI = 4.4 $kWh/m^2/day$), February (GHI= 4.6 $kWh/m^2/day$, DHI= 1.6 $kWh/m^2/day$ and DNI = 5.3 $kWh/m^2/day$), March (GHI= 5.3 $kWh/m^2/day$, DHI= 2.0 $kWh/m^2/day$ and DNI = 5.3 $kWh/m^2/day$), April (GHI= 5.9 $kWh/m^2/day$, DHI= 2.5 $kWh/m^2/day$ and DNI = 5.0 $kWh/m^2/day$), May (GHI= 6.4 $kWh/m^2/day$, DHI= 2.6 $kWh/m^2/day$ and DNI = 5.4 $kWh/m^2/day$), June (GHI= 5.6 $kWh/m^2/day$, DHI= 2.8 $kWh/m^2/day$ and DNI = 3.9 $kWh/m^2/day$), July (GHI= 4.4 $kWh/m^2/day$, DHI= 3.1 $kWh/m^2/day$ and DNI = 1.8 $kWh/m^2/day$), August (GHI= 4.5

kWh/m^2/day, DHI= 3.1 kWh/m^2/day and DNI = 2.6 kWh/m^2/day), September (GHI= 5.2 kWh/m^2/day, DHI= 2.0 kWh/m^2/day and DNI = 4.8 kWh/m^2/day), October (GHI= 4.8 kWh/m^2/day, DHI= 1.4 kWh/m^2/day and DNI = 5.6 kWh/m^2/day), November (GHI= 3.7 kWh/m^2/day, DHI= 1.5 kWh/m^2/day and DNI = 4.2 kWh/m^2/day) and December (GHI= 3.6 kWh/m^2/day, DHI= 1.1 kWh/m^2/day and DNI = 4.9 kWh/m^2/day). The yearly averages sum values are also calculated, which are shown as: (GHI= 4.8 kWh/m^2/day, DHI= 2.09 kWh/m^2/day and DNI = 4.43 kWh/m^2/day). In the next section, comparison is done with other available databases (currently used in literature for designing solar based energy installations).

6.4 COMPARISION OF DATA FROM DIFFERENT SOURCES

Some of the available radiation data sources are: NASA (daily), NREL (monthly), SAM (hourly) and MNRE solar radiation handbook (monthly). For correct solar potential estimation and for determining variation between these available databases, their daily and monthly averages are calculated. However, here all data sources do not provide all radiation values, but GHI value is available in all radiation databases. Now in daily averaged GHI radiation component analysis, databases available are from NREL-SAM (TMY database), NASA (satellite radiation database) and IMD-Jodhpur (ground-based). For annual and monthly average radiation values, data from NREL (Satellite-based), NASA (Satellite-based), SAM (TMY database), MNRE Solar Radiation Handbook (Ground and Satellite-based) and IMD-Jodhpur (ground-based) are used.

Before making any comparison of each database, first its data measurement system is identified, as it helps in deriving conclusions during data comparisons. Hence, for the selected year 2015, available satellite databases (NASA and NREL) are operating at a resolution of "½ x ½"degrees. This database is identified as having higher recorded values when compared with other databases. As these values are extracted from satellite images (taken from the top) and there is no disturbance (dust and maintenance) present at that location. Another database is provided by "MNRE", which is created by taking a long-term average of historical hourly averaged radiation database, available for Indian locations (database created using satellite and ground-based databases). Now in the modification of this database, SAM creates TMY (typical meteorological year) values by using previous 10-years hourly average radiation values and according to the suggested guidelines, months are selected. This database is created by NREL and is available globally for solar resource estimation. From these databases, the values available are averaged. But data measured at ground-based measurement station is considered to provide the most accurate values. This dataset will act as a standard database for making a comparison with other databases. Hence accordingly, all other radiation databases are compared with available ground measured (IMD) values. Comparison is done for each radiation component and concluded results are discussed below.

Daily averaged GHI data is plotted by using the available database (NREL, NASA and IMD) in Fig 6.13. Now during the analysis, the trend identified by database (provided by NASA) and data measured at the ground level by IMD database is found to be the same, with some uniform difference in measurement values. For some interval, high step is seen between the NASA and IMD databases, which after the analysis is identified as disturbing events occurring at the measurement station (instrument and operation based errors). Also during the cloud condition day, high variation is seen between these three databases, which is occurring due to averaging issues. However, for some identified duration, SAM data is less than ground measured values; hence SAM (TMY) database requires some modification.

After analyzing daily averaged values from each radiation source, the values of their monthly averages are calculated. Here GHI component is available from all radiation databases, but some databases do not provide other radiation components (DHI and DNI). In Fig 6.14 (a, c and e), one can see individual radiation components, monthly averaged radiation values. However, for comparing this database with ground values, all databases are plotted as bar charts and IMD is with a line. Moreover, for better understanding, a percentage difference table is also provided, which compares each database averaged value with ground-measured values (see Fig 6.14 (b, c and f). The averaged percentage difference identified in GHI component is (20.78, 15.55, 17.69 and 11.6 (all in percentage)) from NREL, MNRE, SAM and NASA monthly averaged radiation databases respectively. Similarly, the averaged difference identified in DNI component is (33.7 and 21.8 (all in percentage)) from NREL and SAM monthly averaged radiation database. Finally, averaged difference identified in DHI component, mixed results are obtained from MNRE and SAM monthly averaged radiation database. Now it is a plant designer's decision to choose appropriate radiation database for the solar plant analysis.

Finally, the calculation of annual averages obtained from all these approaches are discussed here. The GHI annual average estimated from databases: NREL, MNRE Handbook, SAM (TMY), NASA and IMD are 5.78, 5.54, 5.6, 5.34 and 4.8 ($kWh/m^2/day$). The DNI annual average estimated from databases: NREL, MNRE, SAM (TMY) and IMD are 5.63, 5.1 and 5.34 ($kWh/m^2/day$). Last DHI annual average estimated from databases: MNRE, SAM (TMY) and IMD are 1.98, 2.1 and 2.09 ($kWh/m^2/day$). DHI and DNI averaged databases and ground-based averaged values are acceptable, but in GHI the difference is seen. Also, according to "SolarMap" provided from MNRE, C-WET, the long-term averages of GHI and DNI identified for Jodhpur station are 5 and 5.34 ($kWh/m^2/day$) respectively. This shows similarity in historical averaged satellite data and station measured averaged data. Hence for broad estimation, the values provided in "SolarMap" and other daily and monthly averages can be used. But if one needs, per minute radiation database for solar thermal applications, the ground-based radiation database can only provide the required quality data.

The corrected radiation database is error-free and can be used for resource assessment. This directly helps in design of any solar energy based plant installation (PV, thermal, building design, etc.). Here the information collected from the quality control error flag report, transmittance ratio plot and instrument response are combined. In addition, installed instrument health is also tracked by using this information (by keeping eye on coherence and tracking error results). Moreover, additional results can be generated, if 2-3 years ground-based and 10 years historical radiation (quality control and corrected) database is available. Hence, location specific good quality TMY can be generated and measured radiation database trend can be studied using long term analysis (helpful in determining forecasting results). In addition, if available database is well-measured, quality tested and corrected, then forecasting models can be accurate.

6.5 SUMMARY

IMD-Jodhpur one year (2015) solar radiation database is analyzed in detail, and its solar energy potential is calculated. During this journey, first environmental study is done by information provided in the literature. The broad radiation potential is studied by using solar maps provided by MNRE (see Annexure A1). After that, all radiation and other helpful databases available for Jodhpur are collected. By using time-step analysis, all intervals for which data is missing in the database are identified. Now for each day climatic study is done, which uses transmittance component and calculated-measured GHI plots. Now this database is checked with standard quality control guidelines and additional tests, which provides information about error present in the measured values. Here results are in terms of quality flags, which help find errors in individual radiation components. Moreover, for better understanding of all these procedures, a code system is applied, which helps in inter-comparison between them. However, the final decision of error present in any data interval is decided on the basis of instrument maintenance schedule, near day's station performance and selected days cloud condition. For identified gaps, by using suggested gap-filling approach, all gaps present at different intervals of the database are filled. After correction, a new radiation database is created, which is free from all errors. Now for validation of its correctness, this database is compared with available SRRA-Jodhpur, radiation database for the same year. Only data which passed the quality control tests are used in this process. However in comparison, both stations show considerable similarity in clear sky and light clouded sky conditions, but for heavy and medium clouded condition days the variation is seen due to averaging issues. In addition database analysis, using the coherence ratio (correlating radiation component and solar zenith angle) for each interval values is calculated and it helps in identifying and correcting the radiation database.

Daily, monthly and yearly averages are also calculated. Using available raw and corrected radiation databases, their maximum and minimum variation seen over all months is discussed. Here for each month maximum change is seen in GHI corrected values (due to soil presence on the sensor), and for few days in DHI and DNI components (error occurring due to cleaning and tracking issues). Next the daily averages of all radiation components are calculated for each month with corresponding RMSE calculations. This RMSE are calculated by comparing the measured and predicted values, over the whole day and final value shows the total error incurred during the measurement. In addition, using the daily average values, the total energy lost due to above-identified errors for each month is also computed, where the daily loss of 2-10% in GHI component and 2-5% in DNI is seen. Moreover, monthly and yearly average values are calculated from the corrected radiation dataset. In addition, other radiation databases (NASA, NREL, MNRE and SAM) providing hourly, daily and monthly database are used for comparing this corrected radiation database. Their averages are plotted and the difference is calculated between ground-based measurement values with other databases. Here each database provides a different result and now it's designer's decision to select the radiation database based on the application.

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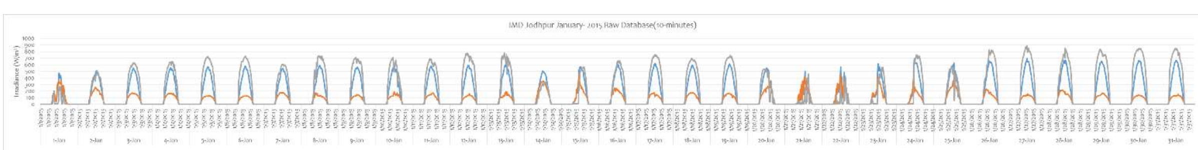
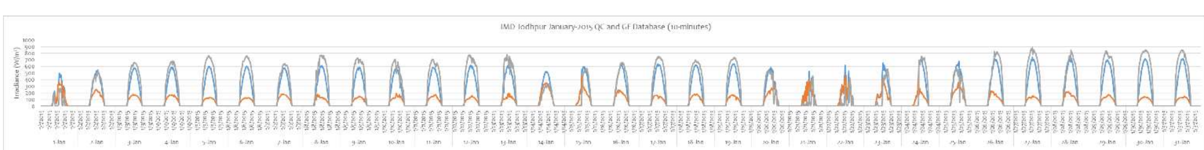
Table 6.2: January 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

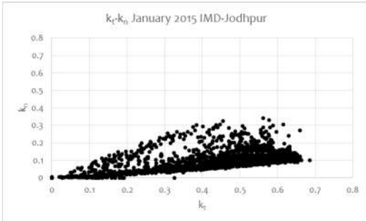
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
1/1/2015	HC	CH,TE,DE,MN	S	T		0.94
1/2/2015	MC	CH	S		S	0.93
1/3/2015	LC, HAZE	M,CH	S		S	0.93
1/4/2015	LC, HAZE	CH	S		S	0.93
1/5/2015	LC, HAZE	CH	S		S	0.92
1/6/2015	LC, HAZE	CH	S		S	0.92
1/7/2015	LC, HAZE	CH	S		S	0.93
1/8/2015	LC, HAZE	CH	S		S	0.92
1/9/2015	LC, HAZE	CH	S		S	0.92
1/10/2015	LC, HAZE	CH	S			0.92
1/11/2015	LC, HAZE	M, CH	S			0.92
1/12/2015	LC, HAZE	CH	S	S		0.92
1/13/2015	LC, HAZE	CH,TE	S	S		0.92
1/14/2015	MC	CH	S			0.92
1/15/2015	LC, HAZE	CH,DE,MN	S	T		0.92
1/16/2015	LC, HAZE	CH	S			0.92
1/17/2015	LC, HAZE	CH	S			0.95
1/18/2015	LC, HAZE	CH	S			0.93
1/19/2015	LC, HAZE	CH	S			0.93
1/20/2015	MC	CH,DE,TE	S			0.93
1/21/2015	HC	CH,TE,DE,MN	S			0.93
1/22/2015	HC	CH,TE,DE,MN	S			0.93
1/23/2015	MC	CH,TE,DE	S			0.93
1/24/2015	MC	CH,TE,DE	S			0.93
1/25/2015	MC	CH	S			0.93
1/26/2015	LC	CH,TE	S			0.93
1/27/2015	LC	CH,TE	S			0.93
1/28/2015	LC	CH,TE	S			0.93
1/29/2015	LC	CH,TE	S			0.92
1/30/2015	LC	CH,TE	S			0.92
1/31/2015	LC	CH,TE	S			0.93



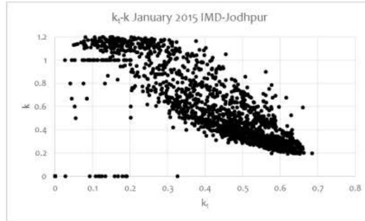
(a)



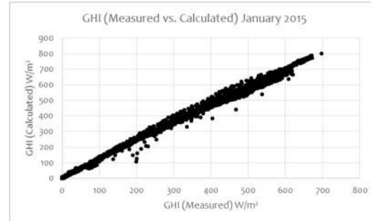
(b)


k_t-k_n January 2015 IMD-Jodhpur
k_n
k_t

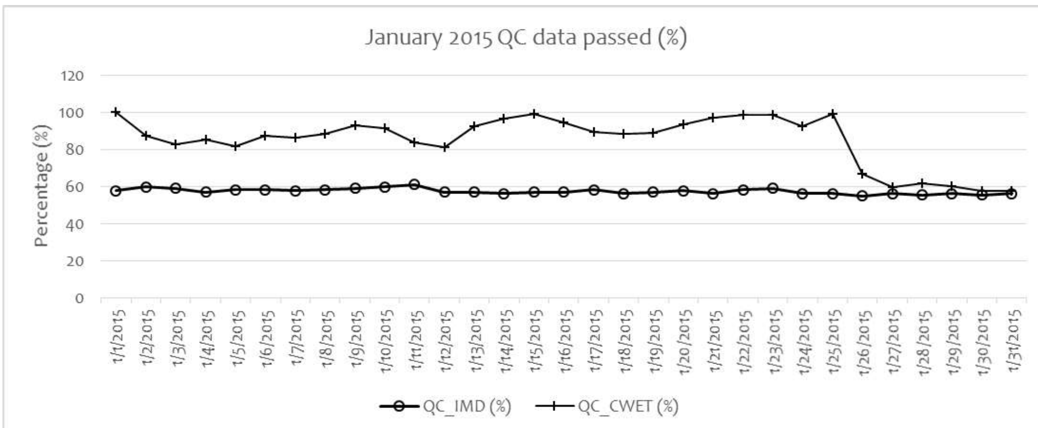
(c)


k_t-k January 2015 IMD-Jodhpur
k
k_t

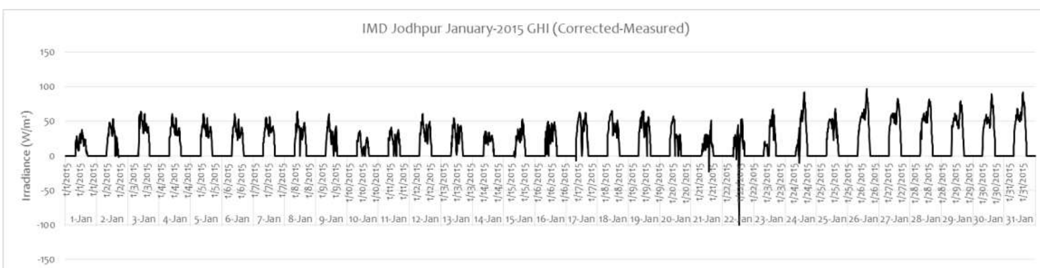
(d)


GHI (Measured vs. Calculated) January 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

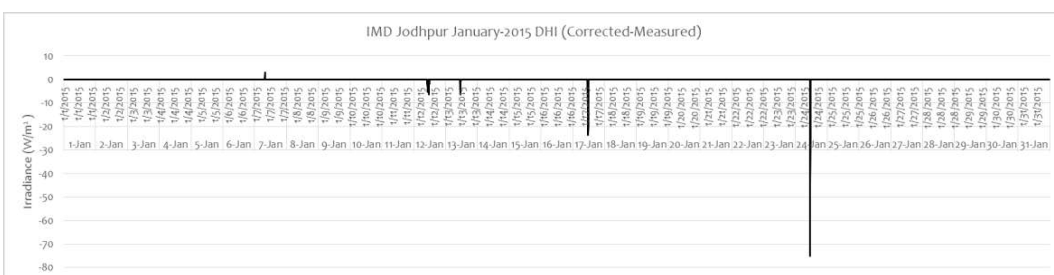
(e)


January 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

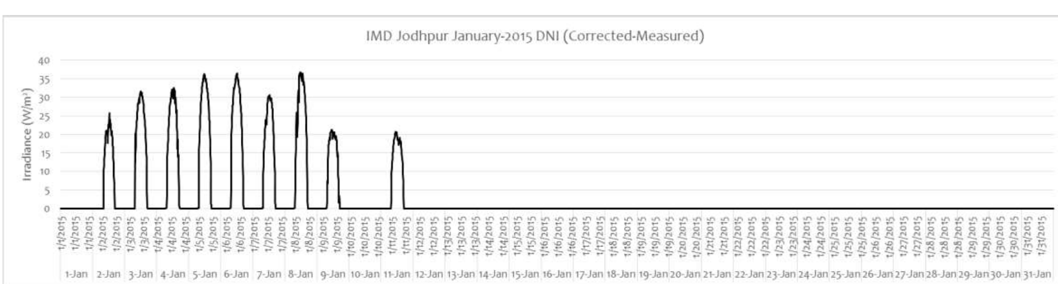
(f)


IMD Jodhpur January-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

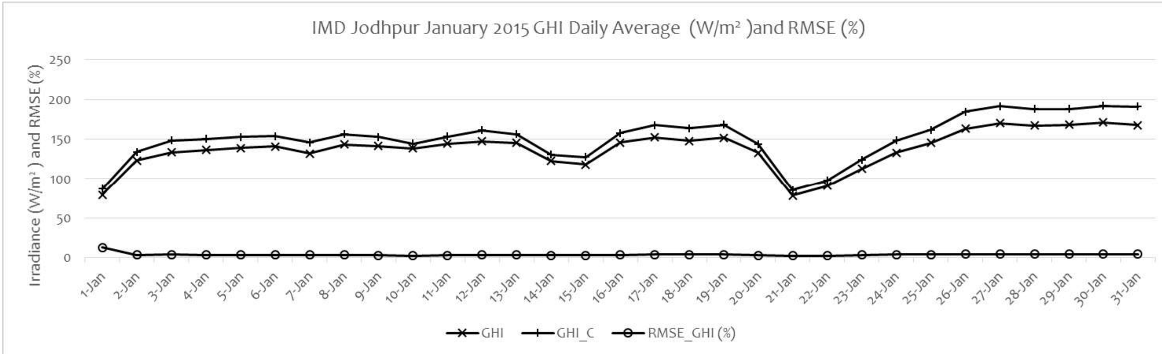
(g)


IMD Jodhpur January-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

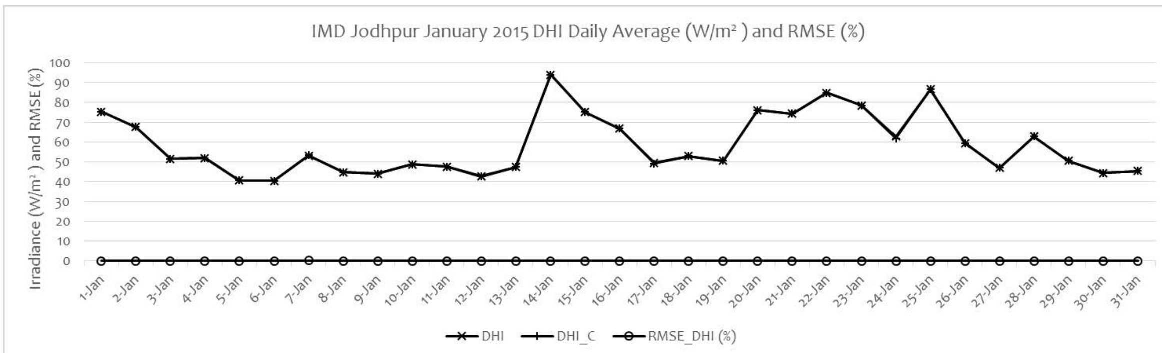
(h)


IMD Jodhpur January-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

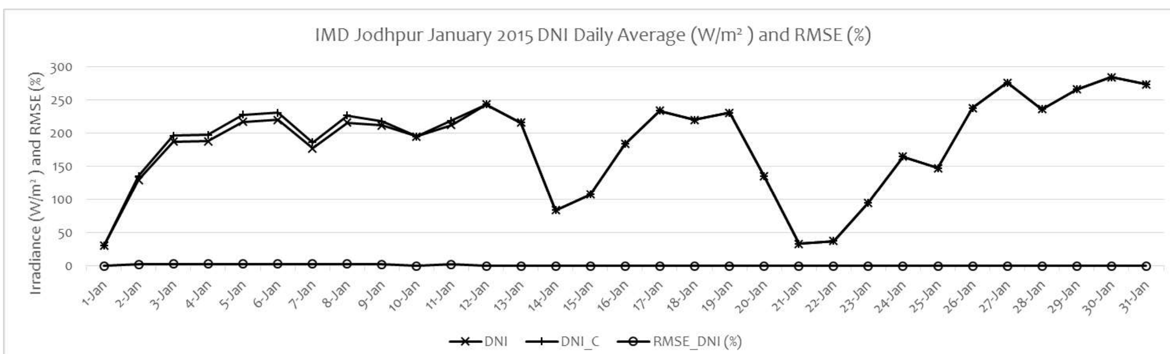
(i)



(j)



(k)

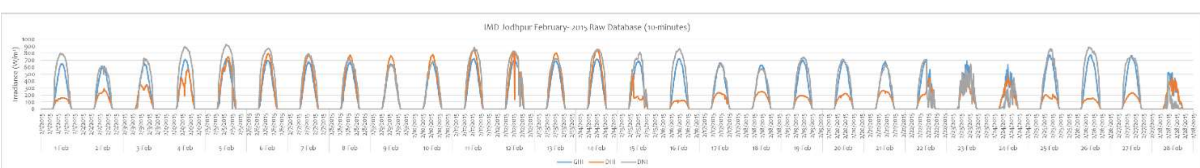


(l)

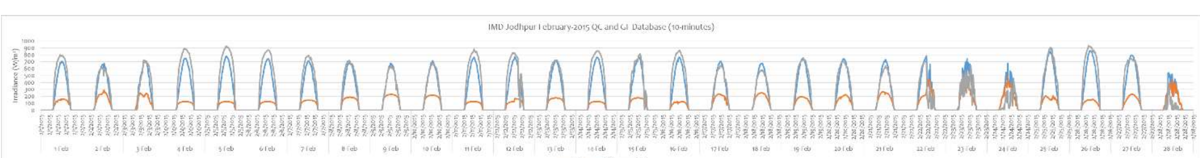
Figure 6.1: 2015 January month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.3: February 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

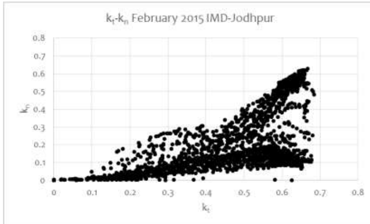
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
2/1/2015	LC	CH,TE	S	S		0.93
2/2/2015	MC	CH,TE	S	S		0.93
2/3/2015	MC	CH,TE	S	T		0.93
2/4/2015	CS	CH,TE	S	T		0.93
2/5/2015	CS	M, CH,TE	S	T	S	0.93
2/6/2015	CS	CH,TE	S	T		0.93
2/7/2015	LC	CH,TE	S	T		0.95
2/8/2015	MC	CH,TE	S	T		0.95
2/9/2015	MC	CH,TE	S	T		0.95
2/10/2015	MC	CH,TE	S	T		0.95
2/11/2015	CS	CH,TE	S	T		0.95
2/12/2015	LC,MC	CH,TE	S	T		0.95
2/13/2015	MC	CH,TE	S	T		0.95
2/14/2015	CS	CH,TE	S	T		0.94
2/15/2015	MC	CH,TE	S	T		0.94
2/16/2015	CS	CH	S			0.94
2/17/2015	MC	CH	S			0.94
2/18/2015	MC	M, CH	S			0.94
2/19/2015	MC	CH,TE	S			0.97
2/20/2015	MC	CH	S			0.95
2/21/2015	MC	CH	S			0.95
2/22/2015	MC,LC	CH,TE	S			0.95
2/23/2015	MC	CH,TE	S			0.95
2/24/2015	HC	CH,TE	S			0.94
2/25/2015	LC	CH,TE	S		S	0.94
2/26/2015	LC	CH,TE	S		S	0.94
2/27/2015	LC	CH	S			0.94
2/28/2015	HC	CH	S	S		0.94

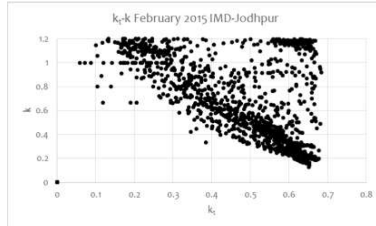


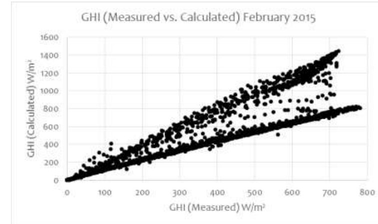
(a)

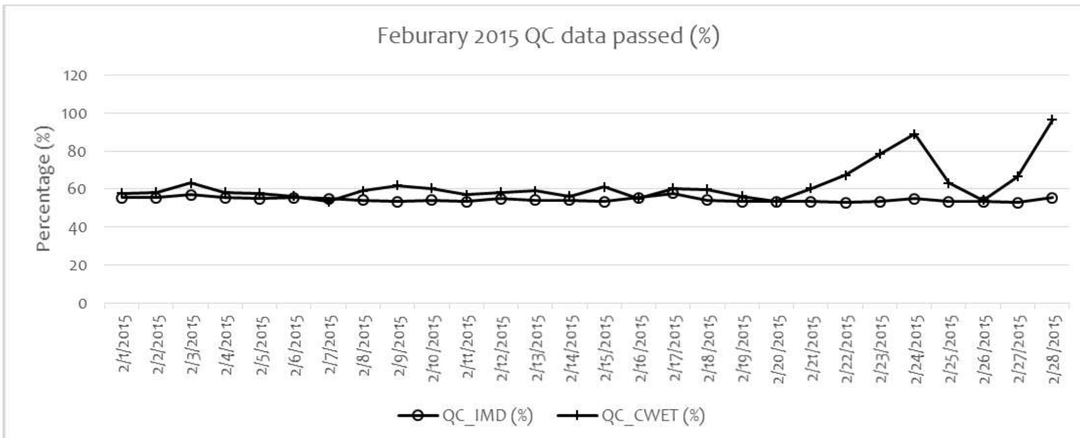


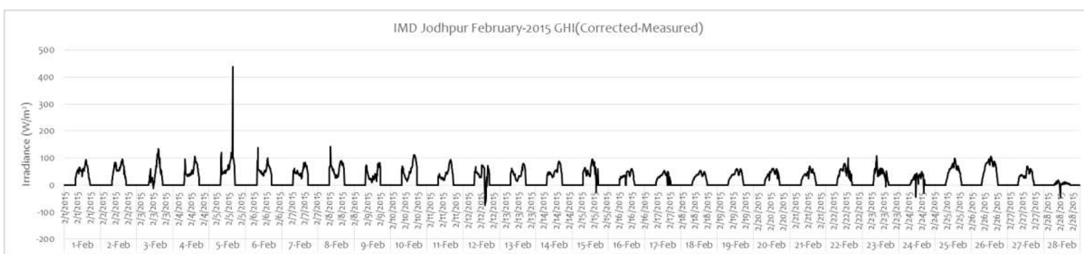
(b)

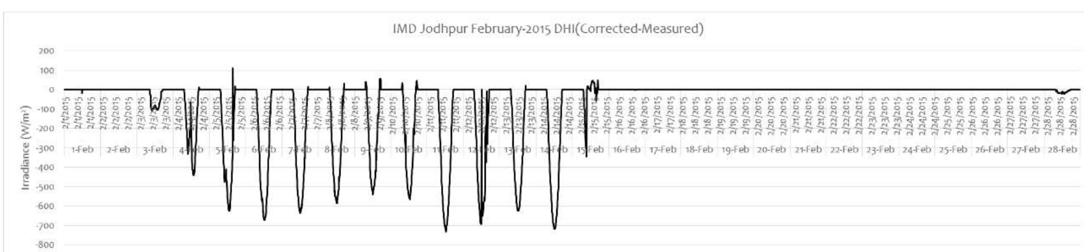

kt-kn February 2015 IMD-Jodhpur
kn
kt
(c)

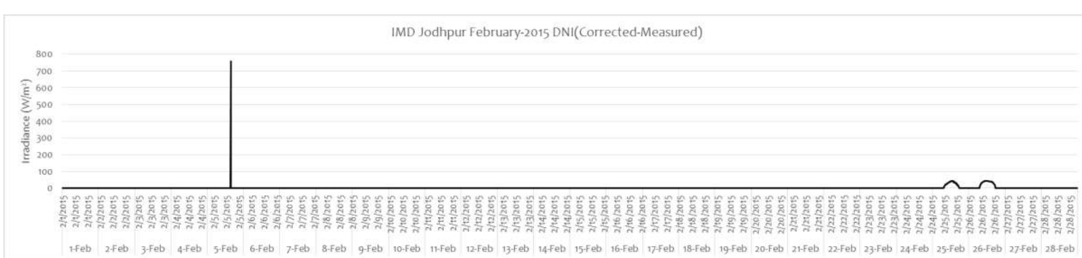

kt-k February 2015 IMD-Jodhpur
k
kt
(d)

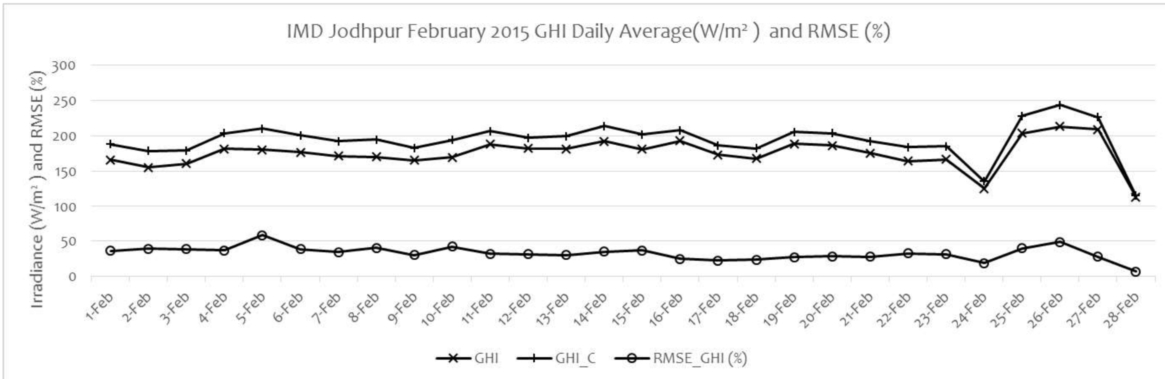

GHI (Measured vs. Calculated) February 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²
(e)


Feburary 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)
(f)

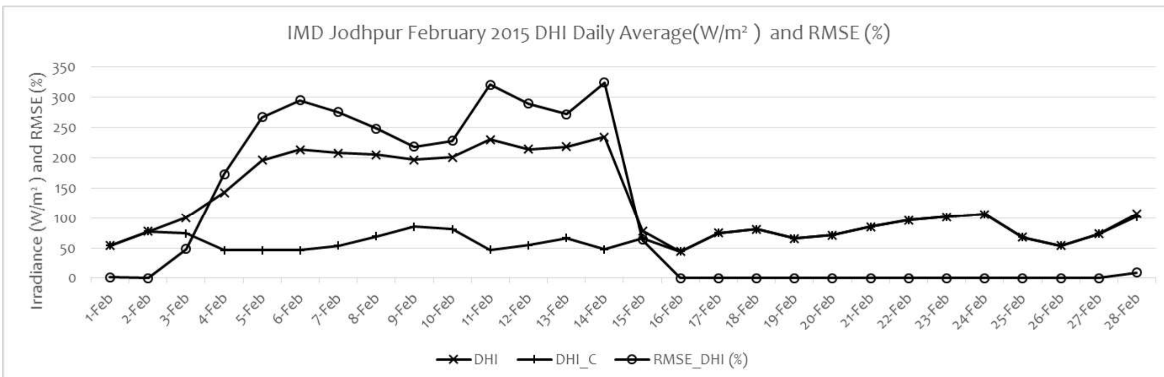

IMD Jodhpur February-2015 GHI(Corrected-Measured)
Irradiance (W/m²)
(g)


IMD Jodhpur February-2015 DHI(Corrected-Measured)
Irradiance (W/m²)
(h)

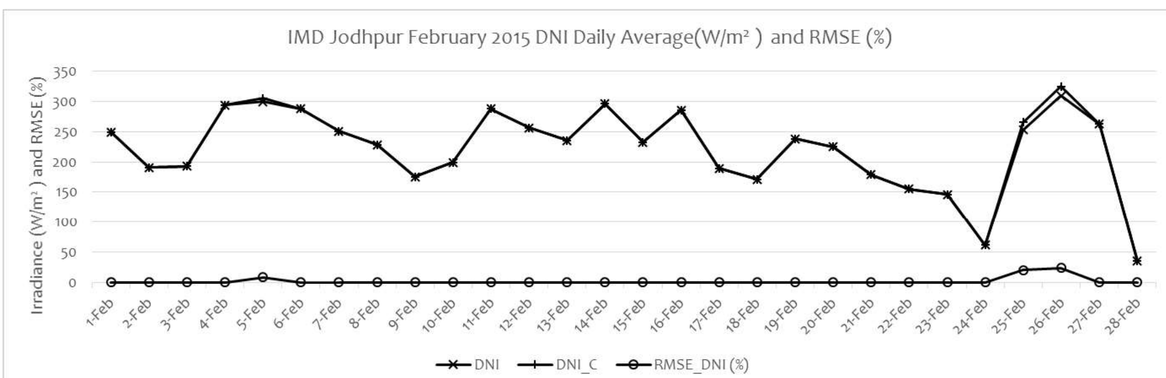

IMD Jodhpur February-2015 DNI(Corrected-Measured)
Irradiance (W/m²)
(i)



(j)



(k)

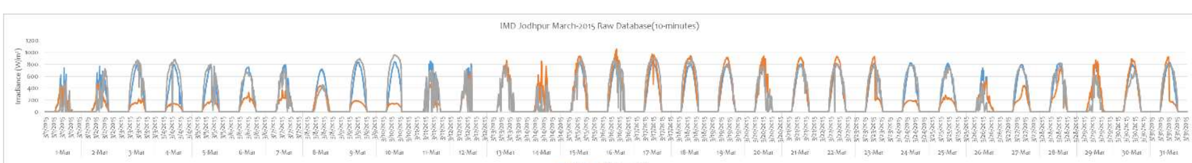


(l)

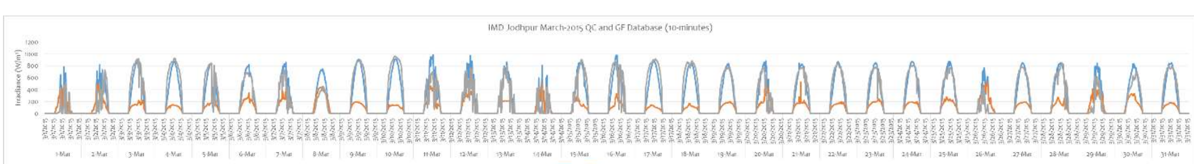
Figure 6.2: 2015 February month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.4: March 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

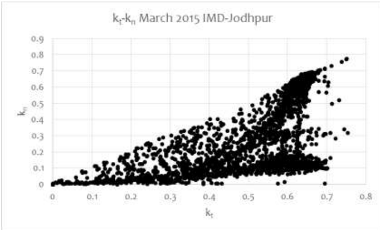
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
3/1/2015	HC	CH,TE	S			0.94
3/2/2015	HC,MC	CH,TE	S			0.93
3/3/2015	LC,MC	CH,TE	S			0.94
3/4/2015	LC	M, CH,TE	S	S		0.94
3/5/2015	LC,MC	CH,TE	S	S		0.93
3/6/2015	MC	CH,TE	S	S	S	0.93
3/7/2015	MC	CH,TE	S	S		0.93
3/8/2015	HC	CH,TE	S	S	S	0.93
3/9/2015	LC	CH,TE	S	S		0.93
3/10/2015	CS	M, CH,TE	S			0.93
3/11/2015	MC	M, CH,TE	S			0.93
3/12/2015	MC	M, CH,TE	S	T	S	0.93
3/13/2015	MC	CH,TE	S	T		0.93
3/14/2015	HC	M, CH,TE	S	T		0.93
3/15/2015	MC,LC	M, CH,TE	S	T		0.93
3/16/2015	LC,MC	CH,TE	S	T		0.93
3/17/2015	LC	CH,TE	S	T		0.93
3/18/2015	LC	CH,TE	S	T		0.93
3/19/2015	MC	CH,TE	S	T		0.93
3/20/2015	MC,HC	CH,TE	S	T		0.93
3/21/2015	LC	CH,TE	S	T		0.93
3/22/2015	LC	M, CH,TE	S	T	S	0.93
3/23/2015	LC	CH,TE	S	T		0.93
3/24/2015	LC,MC	CH,TE	S			0.93
3/25/2015	MC	CH,TE	S		S	0.93
3/26/2015	HC	CH,TE	S			0.93
3/27/2015	LC	CH,TE	S	T	S	0.93
3/28/2015	LC,MC	CH,TE	S	T	S	0.93
3/29/2015	HC,MC	CH,TE	S	T		0.93
3/30/2015	MC	CH,TE	S	T		0.93
3/31/2015	LC,MC	M, CH,TE	S	T		0.93



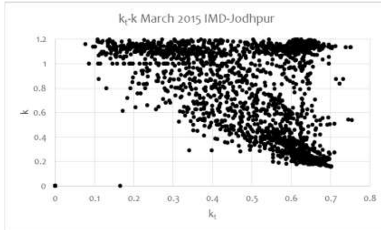
(a)



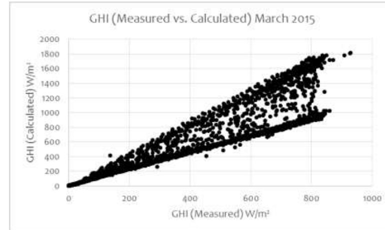
(b)


k_t-k_n March 2015 IMD-Jodhpur
k_n
k_t

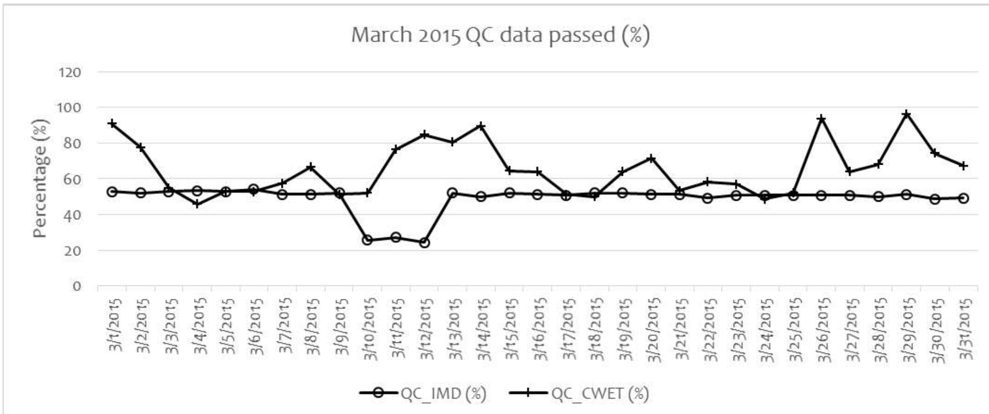
(c)


k_t-k March 2015 IMD-Jodhpur
k
k_t

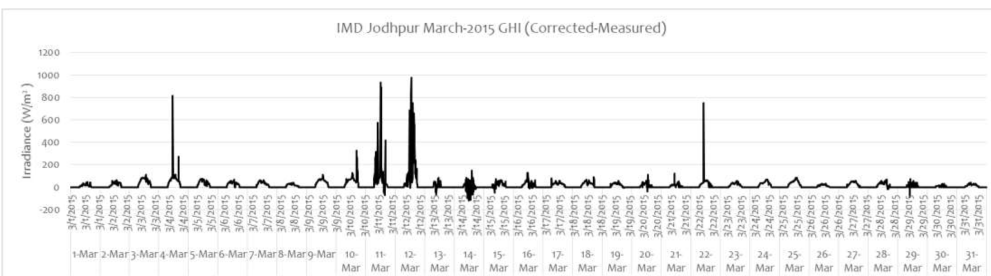
(d)


GHI (Measured vs. Calculated) March 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

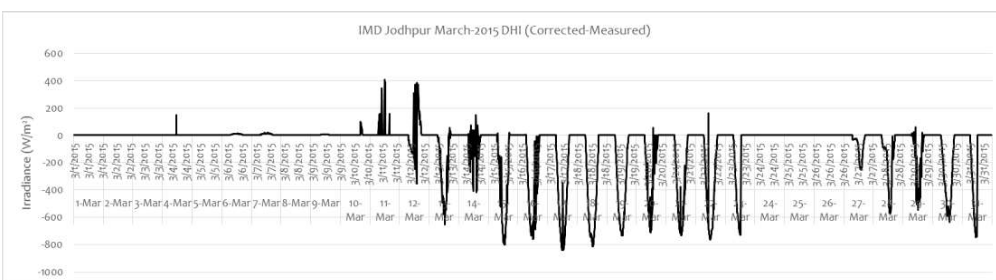
(e)


March 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

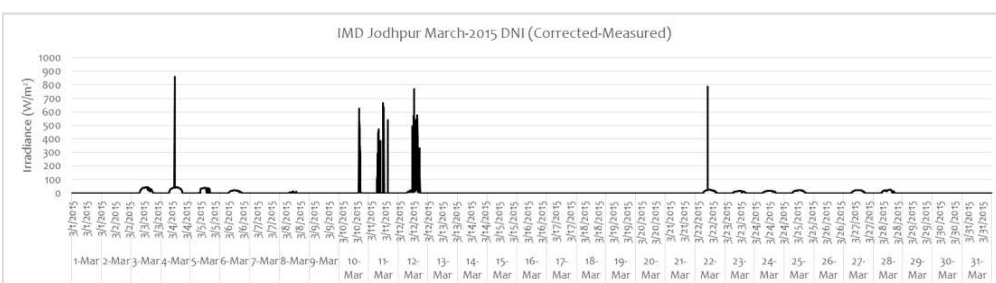
(f)


IMD Jodhpur March-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

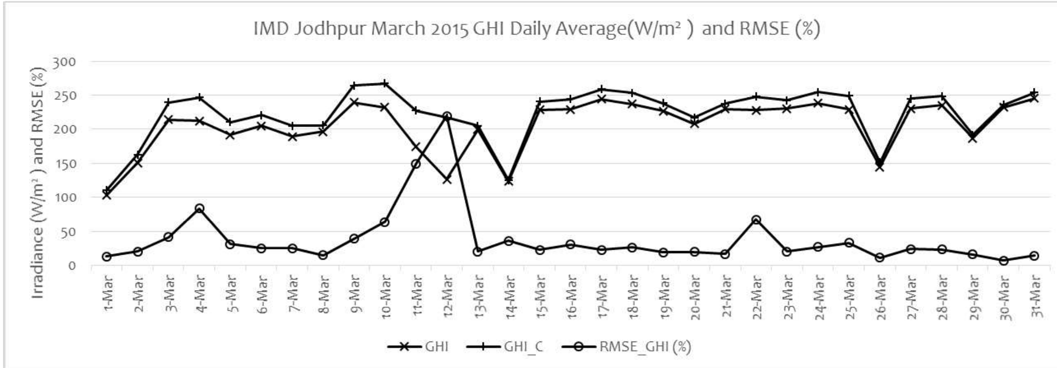
(g)


IMD Jodhpur March-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

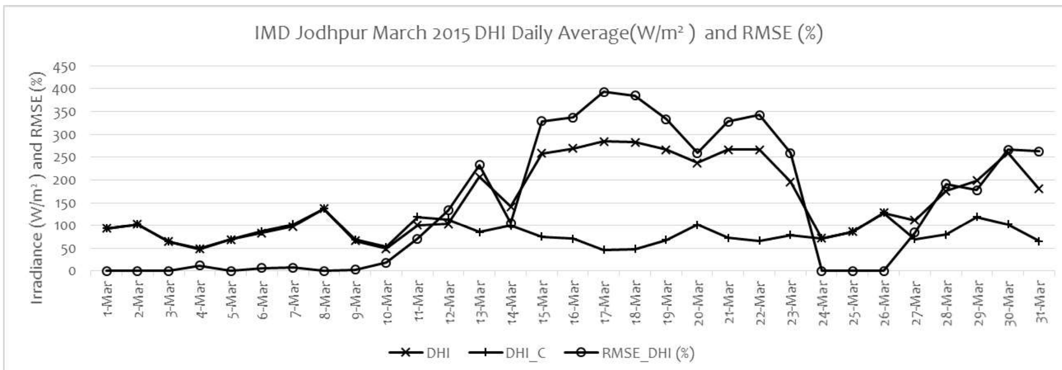
(h)


IMD Jodhpur March-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

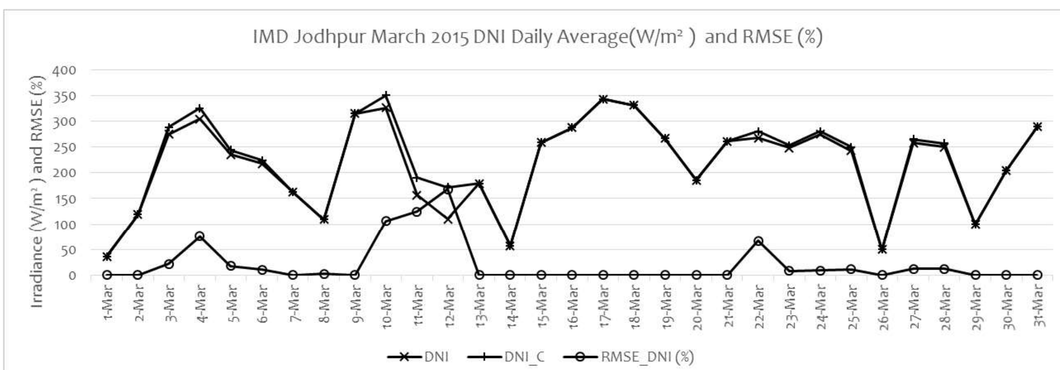
(i)



(j)



(k)

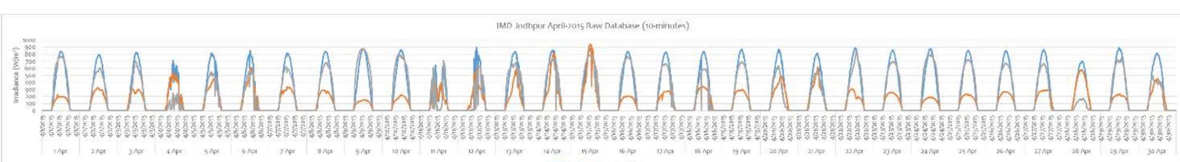


(l)

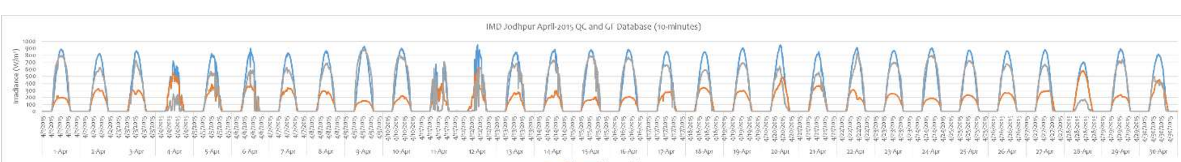
Figure 6.3: 2015 March month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.5: April 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

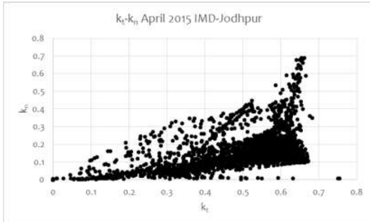
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
4/1/2015	LC	CH,TE	S			0.93
4/2/2015	MC	CH,TE	S		S	0.93
4/3/2015	MC	CH,TE	S		S	0.93
4/4/2015	HC	CH,TE	S			0.93
4/5/2015	MC,LC	CH,TE	S	T	S	0.93
4/6/2015	MC,LC	CH,TE	S	T	S	0.93
4/7/2015	MC,LC	CH,TE	S			0.93
4/8/2015	MC,LC	CH,TE	S	S		0.93
4/9/2015	CS	CH,TE	S			0.93
4/10/2015	LC	M, CH,TE	S			0.93
4/11/2015	MC,HC	CH,TE	S			0.93
4/12/2015	HC	CH,TE	S			0.93
4/13/2015	MC	CH,TE	S	T		0.93
4/14/2015	MC	M, CH,TE	S	T	S	0.93
4/15/2015	MC	CH,TE	S	T		0.93
4/16/2015	MC	M, CH,TE	S			0.93
4/17/2015	MC	M, CH,TE	S			0.93
4/18/2015	MC	M, CH,TE	S		S	0.93
4/19/2015	MC	M, CH,TE	S			0.93
4/20/2015	MC	CH,TE	S			0.93
4/21/2015	MC	CH,TE	S	S		0.93
4/22/2015	LC,MC	CH,TE	S			0.93
4/23/2015	LC,MC	CH,TE	S	S		0.93
4/24/2015	LC,MC	CH,TE	S			0.93
4/25/2015	LC,MC	M, CH,TE	S			0.93
4/26/2015	LC,MC	CH,TE	S			0.93
4/27/2015	LC,MC	CH,TE	S			0.93
4/28/2015	HC	CH,TE	S			0.93
4/29/2015	MC,LC	CH,TE	S			0.93
4/30/2015	MC,LC	CH,TE	S			0.93



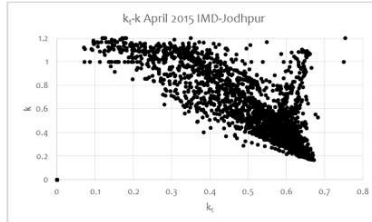
(a)



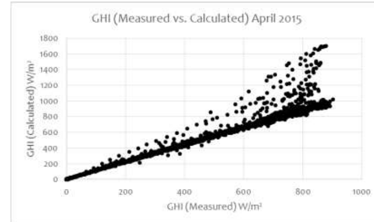
(b)


kt-kn April 2015 IMD-Jodhpur
kn
kt

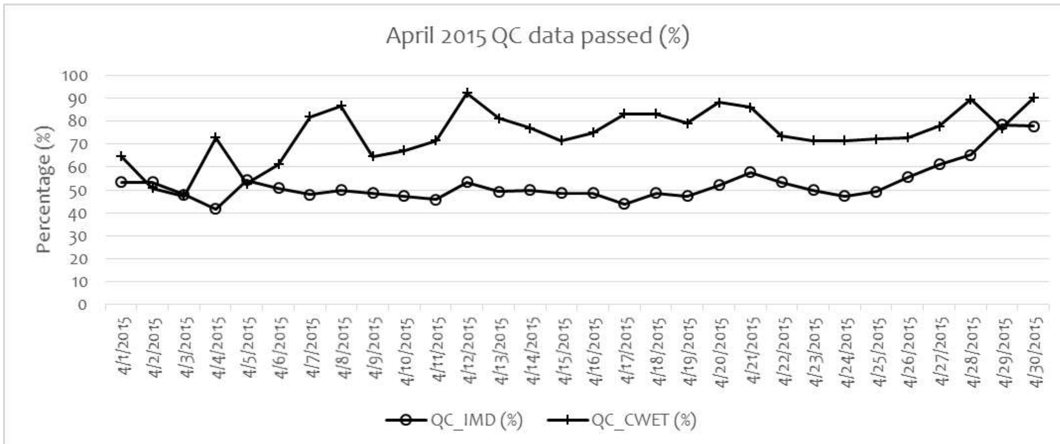
(c)


kt-k April 2015 IMD-Jodhpur
k
kt

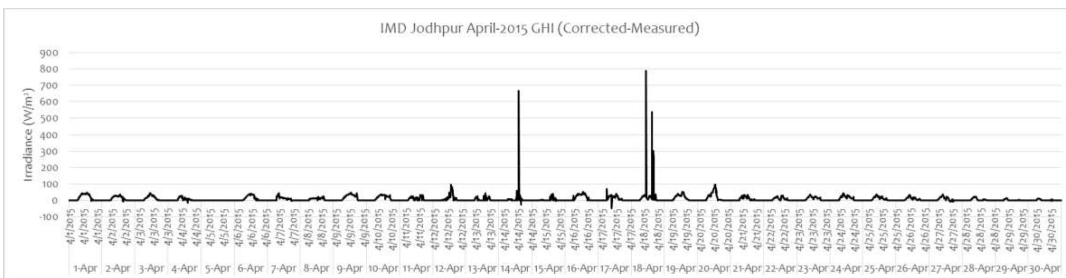
(d)


GHI (Measured vs. Calculated) April 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

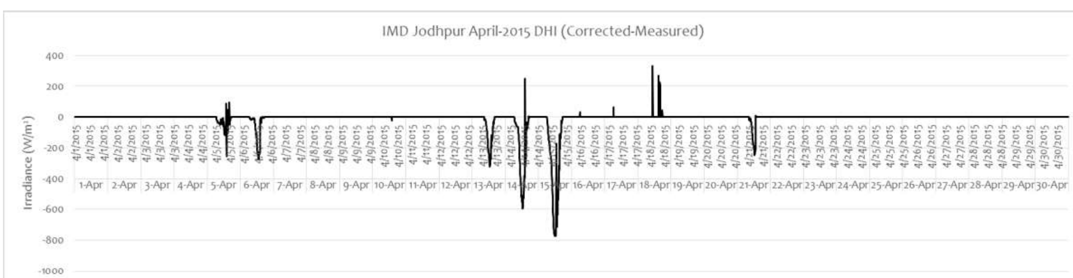
(e)


April 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

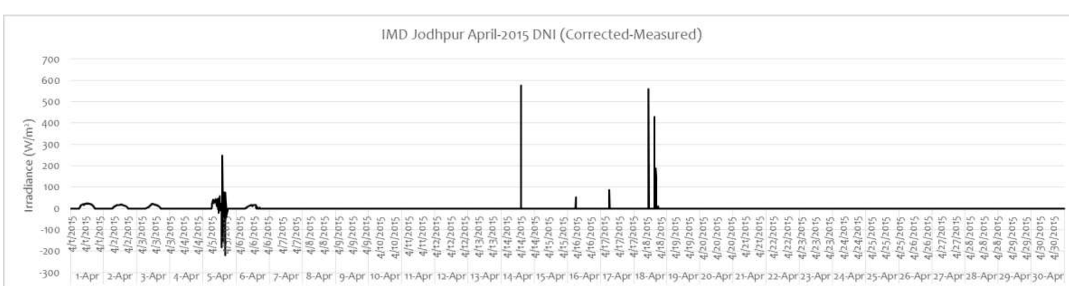
(f)


IMD Jodhpur April-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

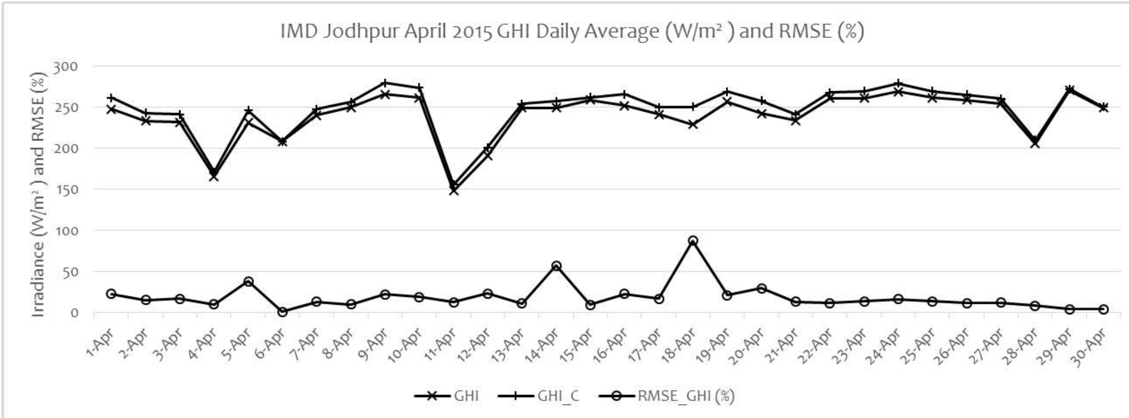
(g)


IMD Jodhpur April-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

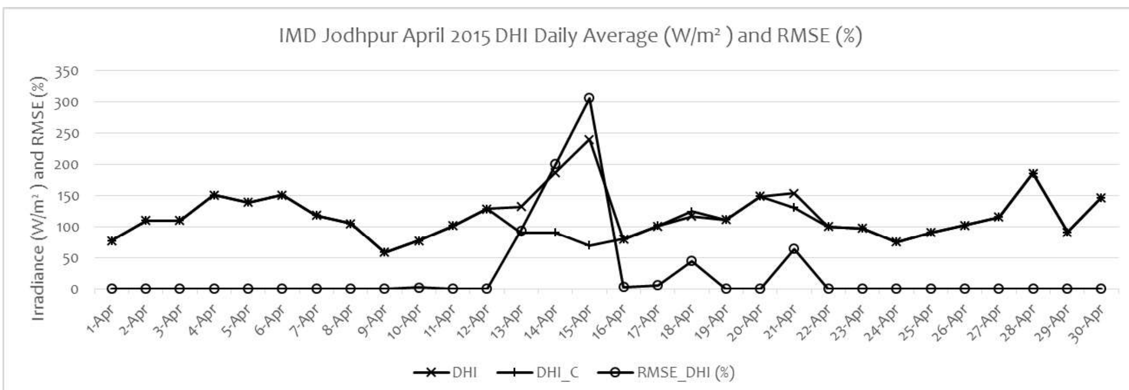
(h)


IMD Jodhpur April-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

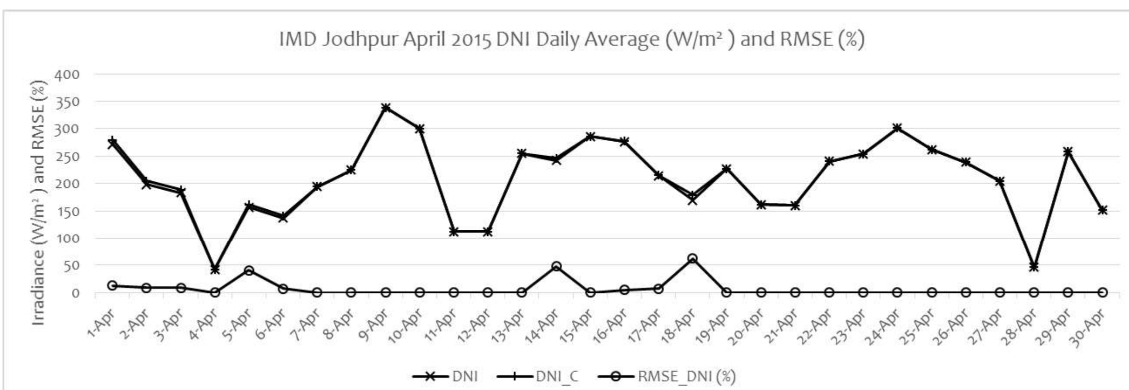
(i)



(j)



(k)

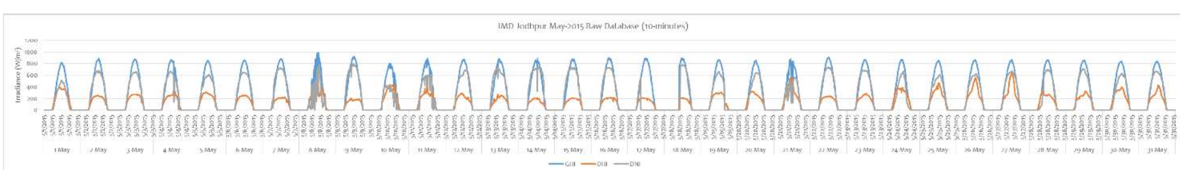


(l)

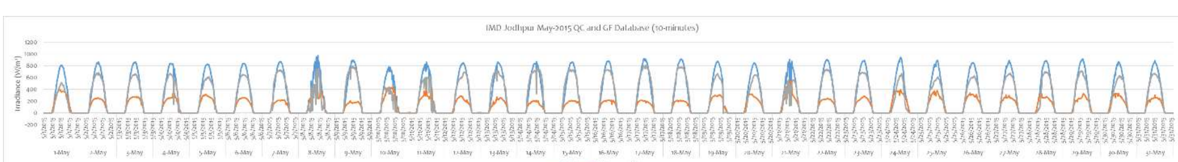
Figure 6.4: 2015 April month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.6: May 2015 (IMD Jodhpur) (Climate condition, QC Results Instrument Error and Coherence Factor)

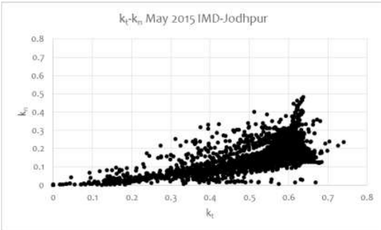
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
5/1/2015	MC	CH,TE	S			0.94
5/2/2015	LC,MC	CH,TE	S			0.94
5/3/2015	LC,MC	CH,TE	S			0.94
5/4/2015	LC,MC	CH,TE	S			0.93
5/5/2015	LC,MC	CH,TE	S			0.94
5/6/2015	LC,MC	CH,TE	S			0.94
5/7/2015	LC,MC	CH,TE	S			0.94
5/8/2015	MC	M, CH,TE	S	S		0.94
5/9/2015	LC,MC	CH,TE	S			0.94
5/10/2015	MC	CH,TE	S			0.94
5/11/2015	MC,LC	M, CH,TE	S	S		0.94
5/12/2015	LC	CH,TE	S			0.94
5/13/2015	LC	CH,TE	S			0.93
5/14/2015	LC	CH,TE	S			0.93
5/15/2015	LC	CH,TE	S			0.93
5/16/2015	LC	CH,TE	S			0.93
5/17/2015	LC	CH,TE	S		T	0.93
5/18/2015	LC,MC	M, CH,TE	S	S	T	0.93
5/19/2015	LC,MC	CH,TE	S			0.93
5/20/2015	LC,MC	CH,TE	S			0.93
5/21/2015	MC	CH,TE	S			0.93
5/22/2015	LC,MC	CH,TE	S			0.93
5/23/2015	LC,MC	M, CH,TE	S			0.93
5/24/2015	MC	CH,TE	S			0.93
5/25/2015	MC	CH,TE	S	T		0.93
5/26/2015	MC	CH,TE	S	T		0.93
5/27/2015	MC	CH,TE	S	T		0.93
5/28/2015	MC	CH,TE	S			0.93
5/29/2015	MC	CH,TE	S			0.93
5/30/2015	MC	CH,TE	S	T		0.93
5/31/2015	MC	CH,TE	S	T		0.93



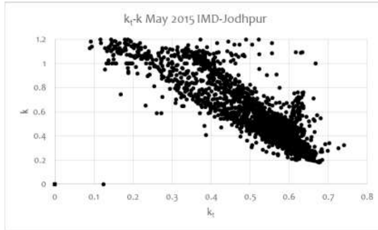
(a)



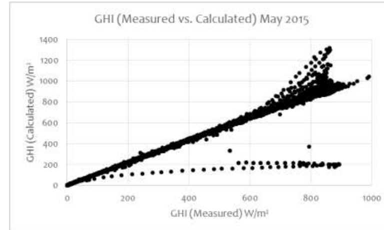
(b)


k_t-k_n May 2015 IMD-Jodhpur
k_n
k_t

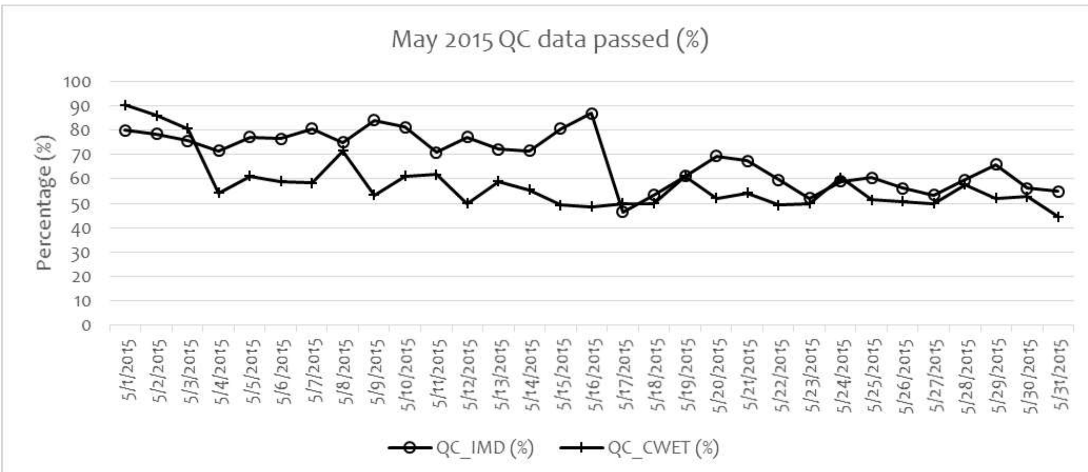
(c)


k_t-k May 2015 IMD-Jodhpur
k
k_t

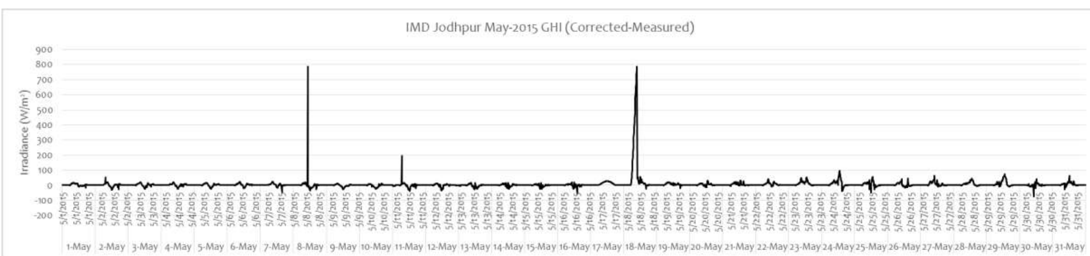
(d)


GHI (Measured vs. Calculated) May 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

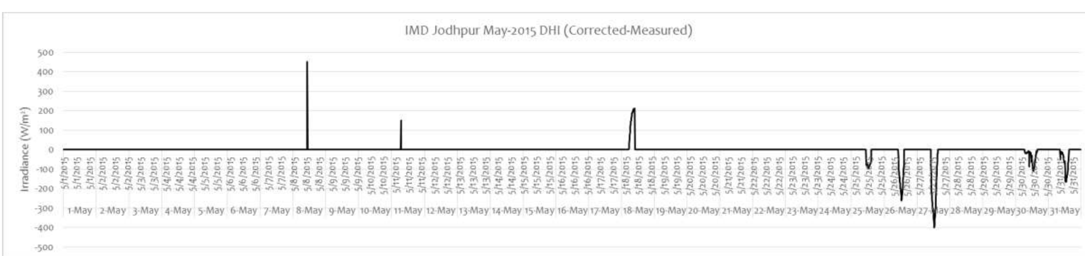
(e)


May 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

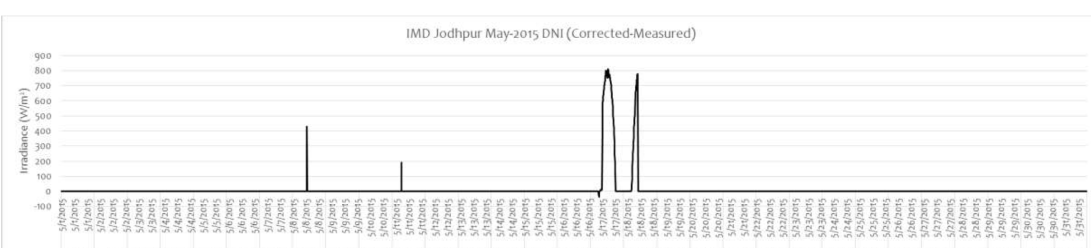
(f)


IMD Jodhpur May-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

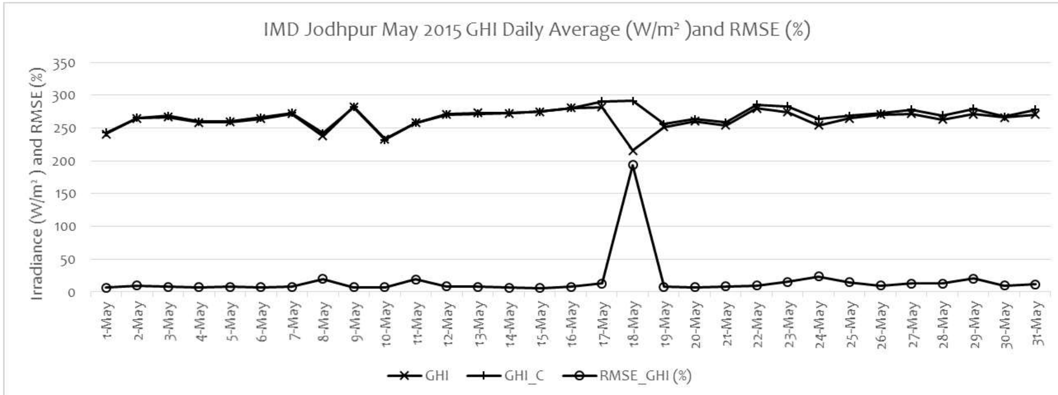
(g)


IMD Jodhpur May-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

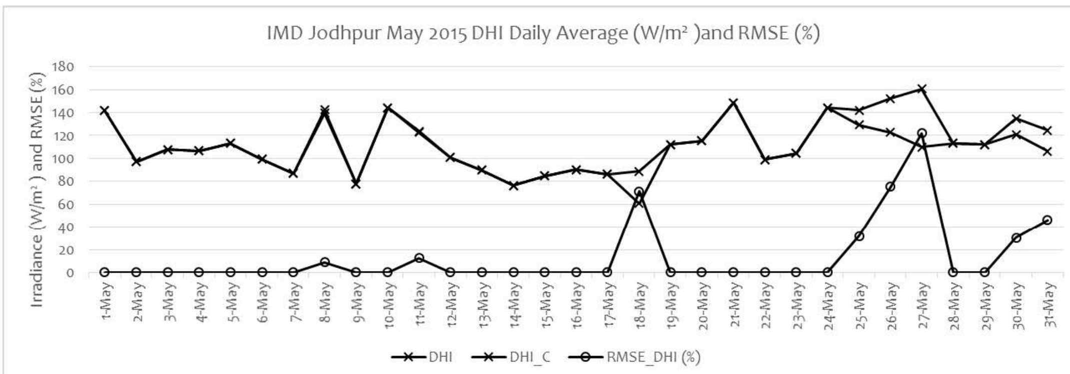
(h)


IMD Jodhpur May-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

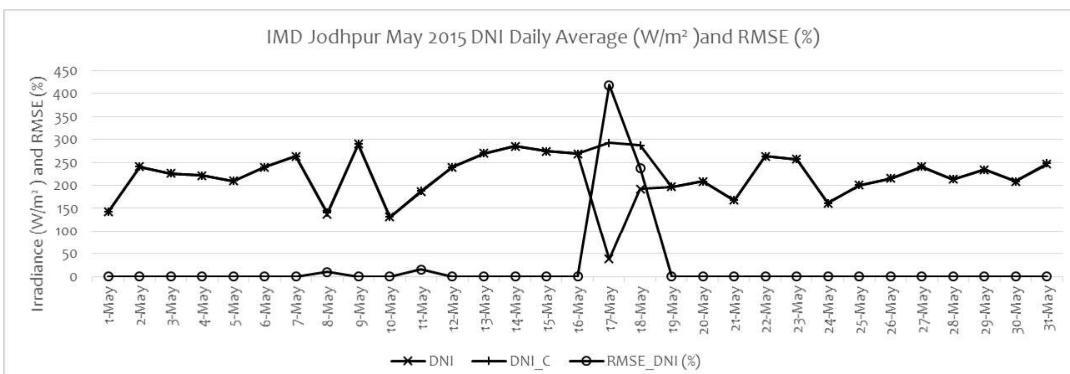
(i)



(j)



(k)

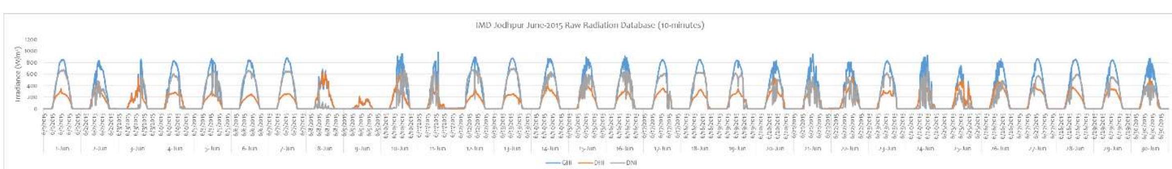


(l)

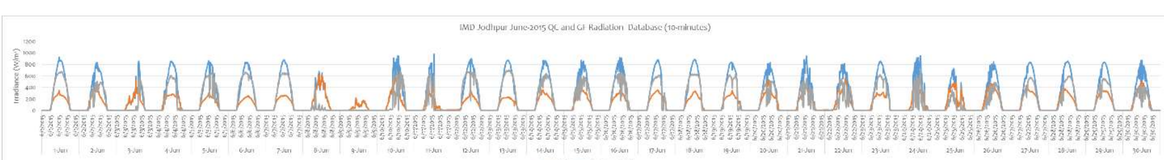
Figure 6.5: 2015 May month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.7: June 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

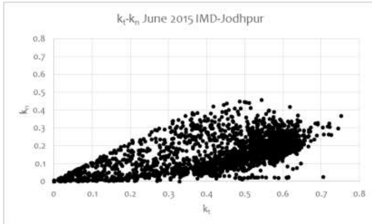
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
6/1/2015	LC	CH,TE	S			0.93
6/2/2015	MC,HC	CH,TE	S	S	S	0.93
6/3/2015	HC,MC	CH,TE	S	S		0.93
6/4/2015	MC	CH,TE	S			0.93
6/5/2015	MC	M, TE	S			0.93
6/6/2015	MC	M, TE	S			0.93
6/7/2015	MC	CH,TE	S			0.93
6/8/2015	HC	CH,TE	S			0.93
6/9/2015	HC	CH,TE	S			0.93
6/10/2015	MC	CH,TE	S			0.93
6/11/2015	MC	CH,TE	S			0.93
6/12/2015	LC	CH,TE	S	S		0.93
6/13/2015	LC	CH,TE	S	S		0.93
6/14/2015	MC	CH,TE	S	S		0.93
6/15/2015	MC	CH,TE	S	S		0.93
6/16/2015	MC	CH,TE	S			0.93
6/17/2015	MC	CH,TE	S			0.93
6/18/2015	MC	CH,TE	S			0.93
6/19/2015	MC	CH,TE	S			0.93
6/20/2015	MC,HC	CH,TE	S			0.93
6/21/2015	MC,HC	CH,TE	S			0.93
6/22/2015	MC,HC	M, CH,TE	S			0.93
6/23/2015	MC,HC	CH,TE	S			0.93
6/24/2015	MC,HC	CH,TE	S			0.93
6/25/2015	HC	M, CH,TE	S			0.93
6/26/2015	MC,HC	CH,TE	S			0.93
6/27/2015	MC,HC	CH,TE	S			0.93
6/28/2015	MC,HC	CH,TE	S	S		0.93
6/29/2015	MC,HC	CH,TE	S			0.93
6/30/2015	HC	CH,TE	S			0.93



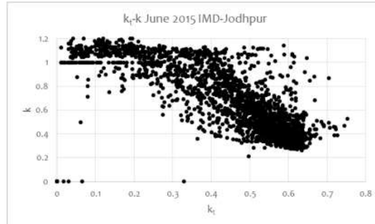
(a)



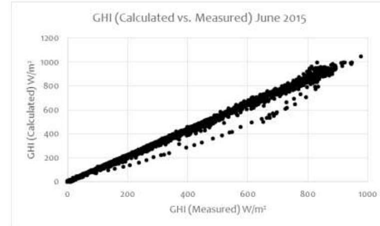
(b)


k_t-k_n June 2015 IMD-Jodhpur
k_n
k_t

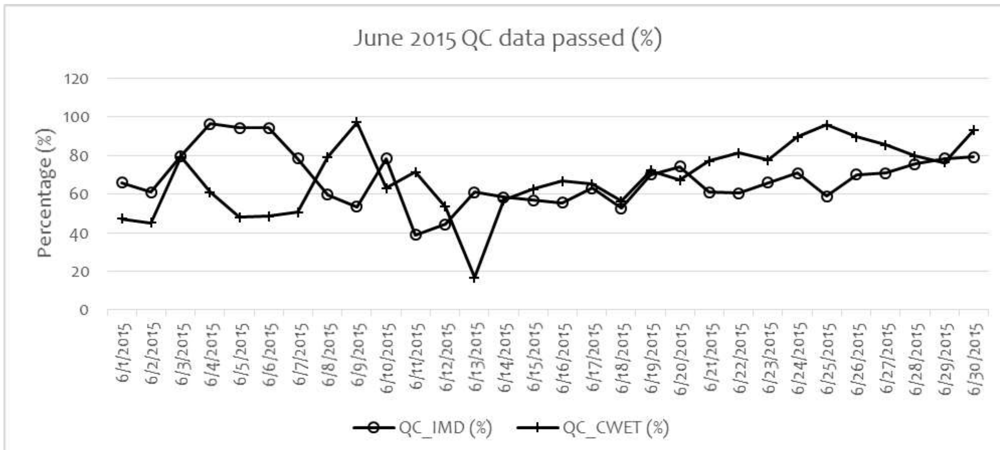
(c)


k_t-k June 2015 IMD-Jodhpur
k
k_t

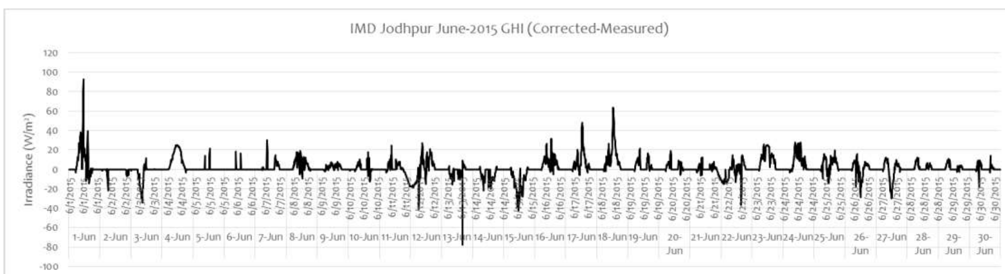
(d)


GHI (Calculated vs. Measured) June 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

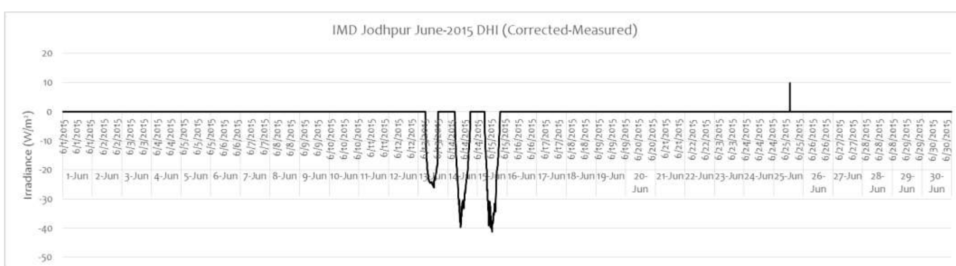
(e)


June 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

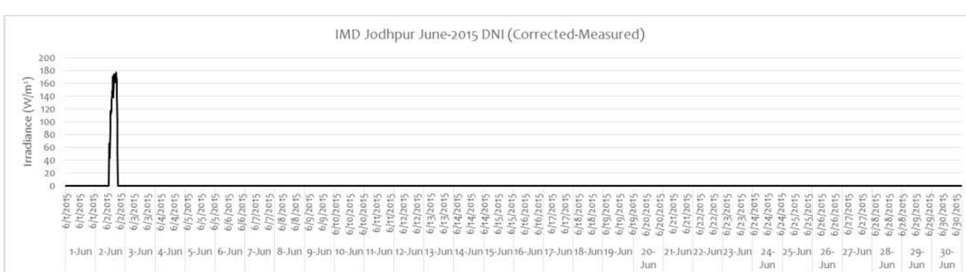
(f)


IMD Jodhpur June-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

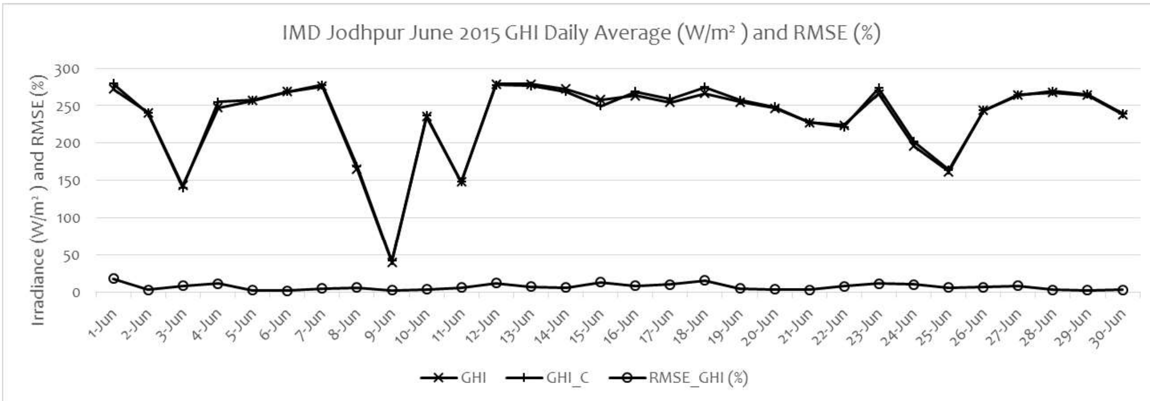
(g)


IMD Jodhpur June-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

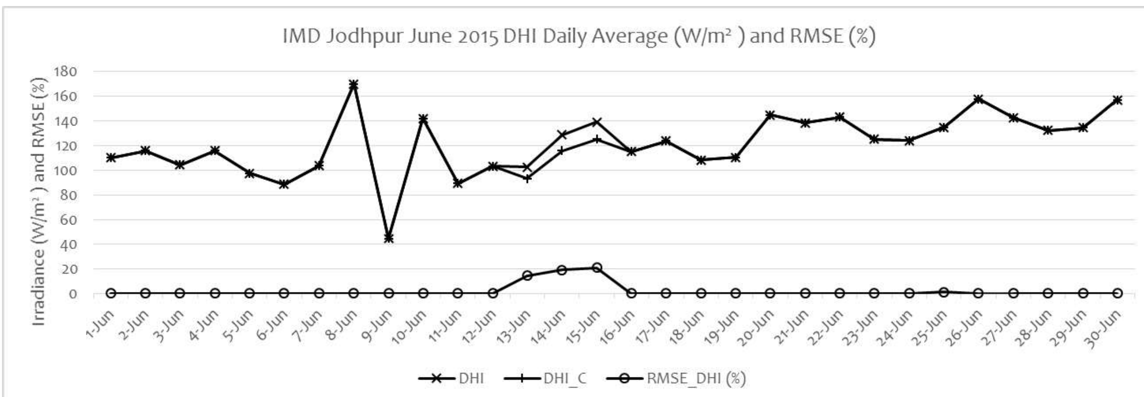
(h)


IMD Jodhpur June-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

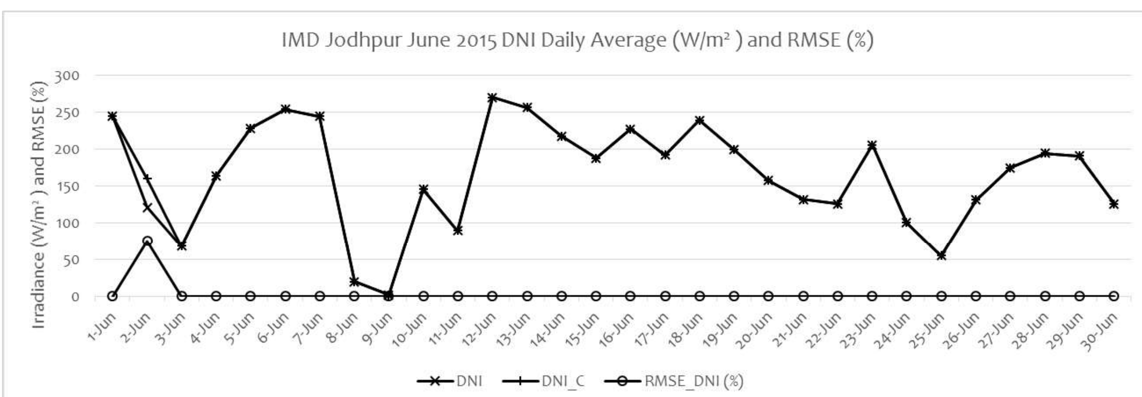
(i)



(j)



(k)

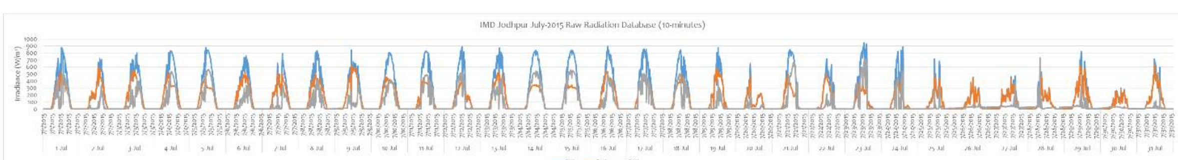


(l)

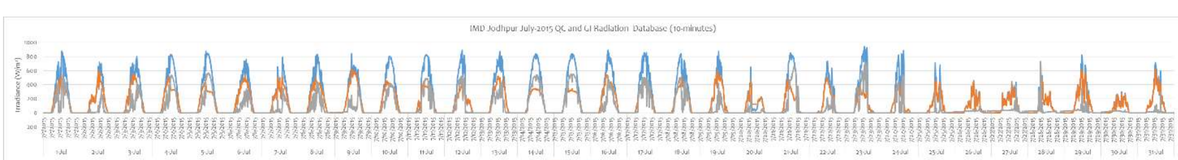
Figure 6.6: 2015 June month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.8: July 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

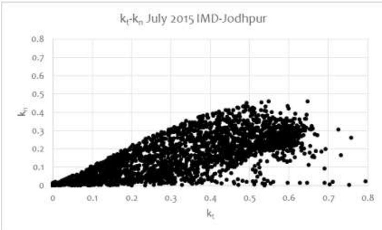
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
7/1/2015	LC,MC	CH,TE	S			0.93
7/2/2015	HC	CH,TE	S			0.93
7/3/2015	HC,MC	CH,TE	S	S		0.93
7/4/2015	HC,MC	CH,TE	S			0.93
7/5/2015	HC,MC	TE	S			0.93
7/6/2015	HC	CH,TE	S	S	S	0.93
7/7/2015	HC	CH,TE	S			0.93
7/8/2015	HC	CH,TE	S			0.93
7/9/2015	HC	M, CH,TE	S	S	S	0.93
7/10/2015	HC,MC	CH,TE	S			0.93
7/11/2015	HC,MC	CH,TE	S			0.93
7/12/2015	HC,MC	M, CH,TE	S			0.93
7/13/2015	HC,MC	M, CH,TE	S	S	S	0.93
7/14/2015	LC	M, CH,TE	S			0.93
7/15/2015	LC,MC	M, CH,TE	S	S		0.93
7/16/2015	MC	M, CH,TE	S	S		0.93
7/17/2015	MC,HC	M, CH,TE	S	S	S	0.93
7/18/2015	MC,HC	M, CH,TE	S	S	S	0.93
7/19/2015	HC	M, CH,TE	S	S		0.93
7/20/2015	HC	M, CH,TE, MN	S	S		0.93
7/21/2015	LC	CH,TE	S			0.93
7/22/2015	MC,HC	M, CH,TE	S	S		0.93
7/23/2015	LC	M, TE	S	S	S	0.93
7/24/2015	MC	M, TE	S	S	S	0.93
7/25/2015	MC	M, CH,TE	S			0.93
7/26/2015	MC	M, CH,TE	S	S		0.93
7/27/2015	MC	CH,TE	S			0.93
7/28/2015	MC	M, CH,TE	S			0.93
7/29/2015	HC	CH,TE	S			0.93
7/30/2015	LC	CH,TE	S			0.93
7/31/2015	HC	TE	S			0.93



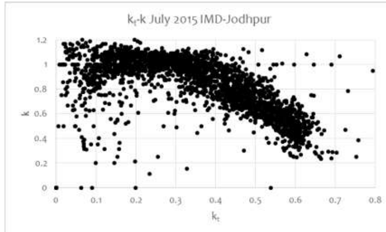
(a)



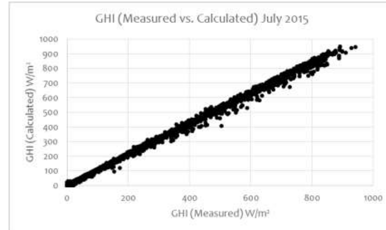
(b)


k_t-k_n July 2015 IMD-Jodhpur
k_n
k_t

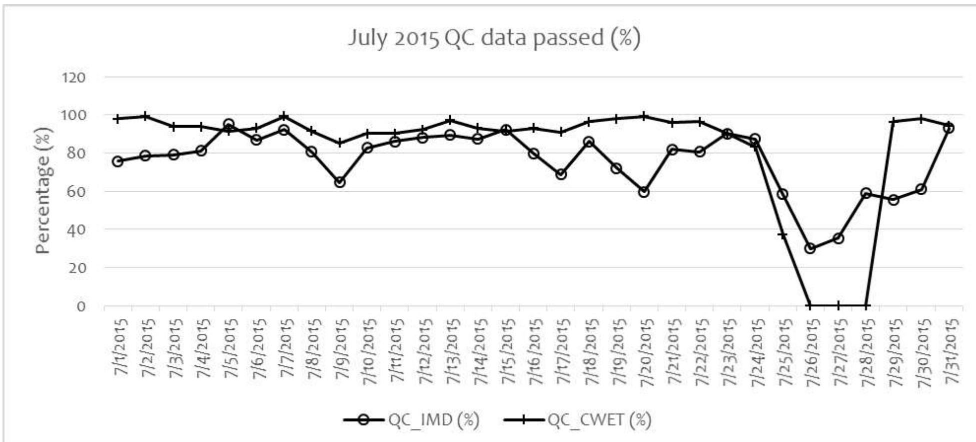
(c)


k_t-k July 2015 IMD-Jodhpur
k
k_t

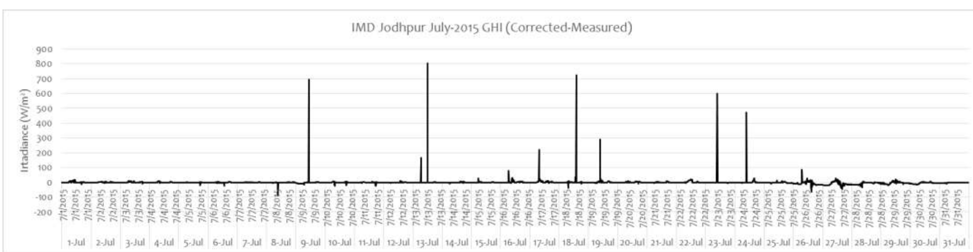
(d)


GHI (Measured vs. Calculated) July 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

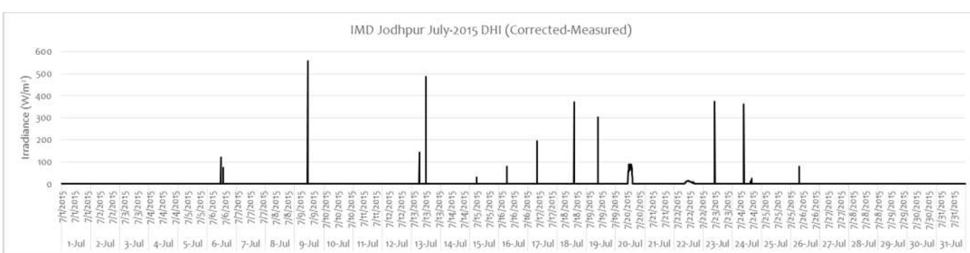
(e)


July 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

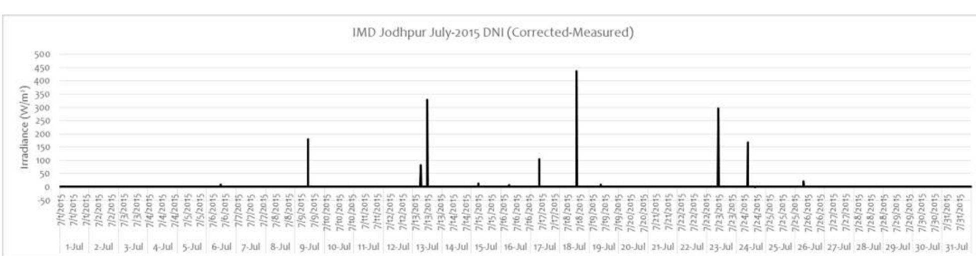
(f)


IMD Jodhpur July-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

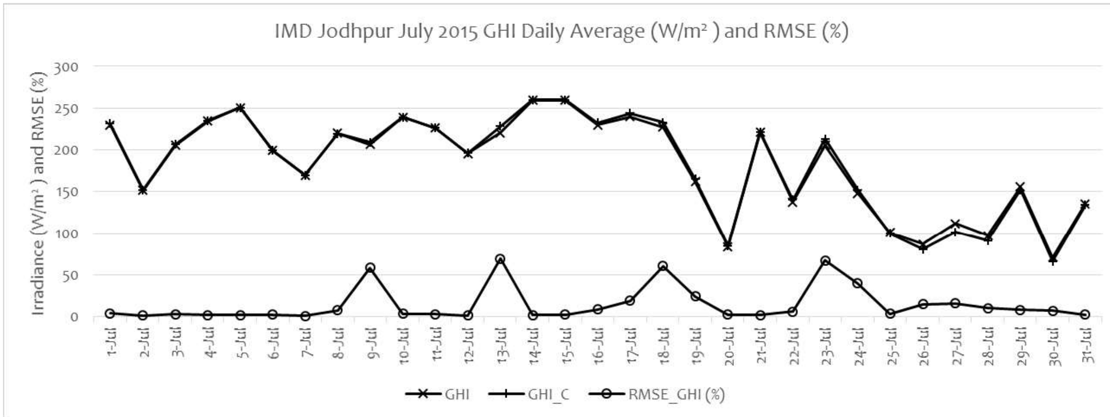
(g)


IMD Jodhpur July-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

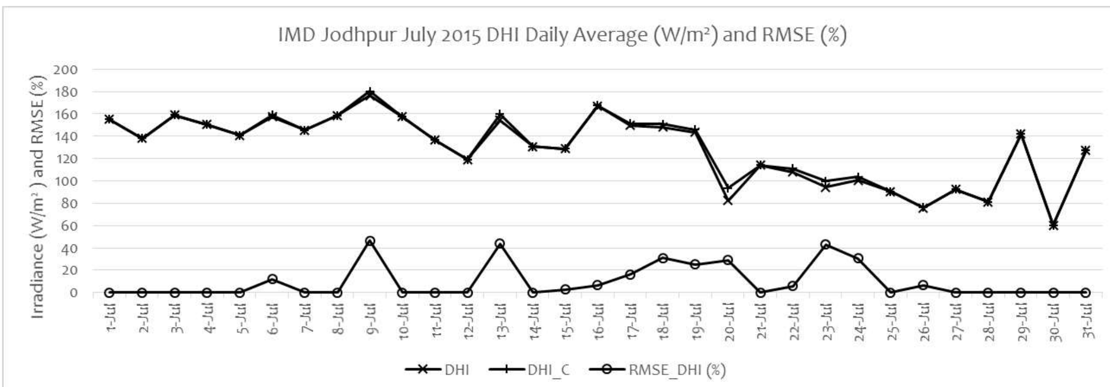
(h)


IMD Jodhpur July-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

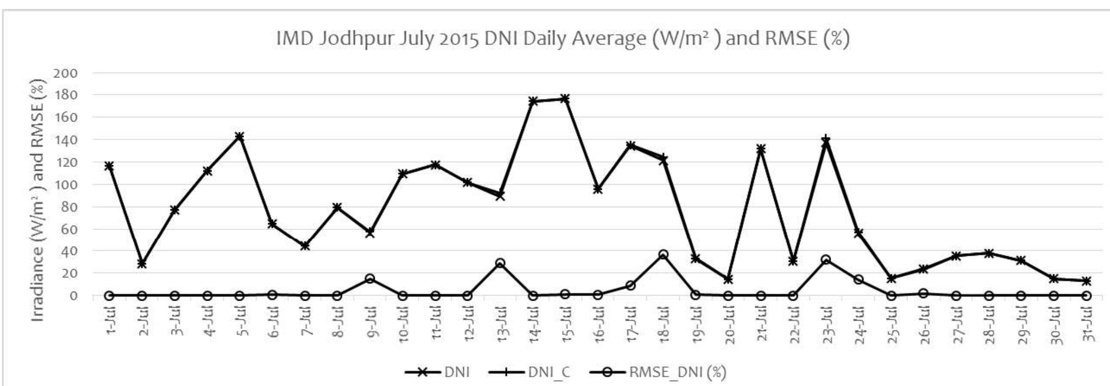
(i)



(j)



(k)

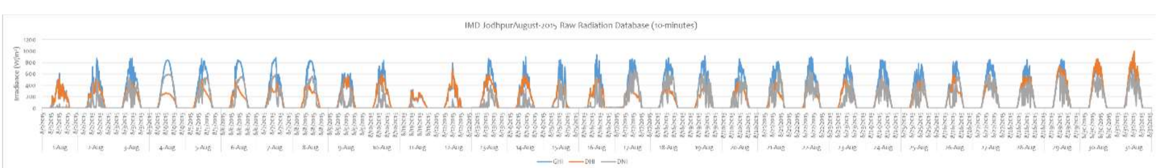


(l)

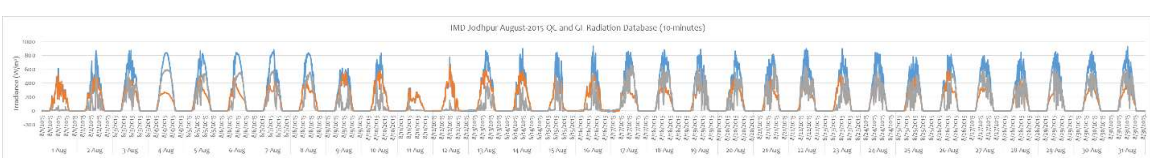
Figure 6.7: 2015 July month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.9: August 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

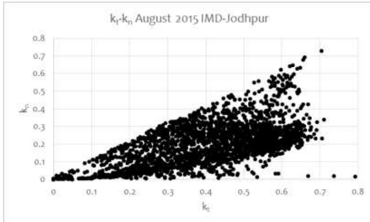
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
8/1/2015	HC	CH,TE	S			0.93
8/2/2015	MC,HC	CH,TE	S			0.93
8/3/2015	MC,HC	M, CH,TE	S	S	S	0.93
8/4/2015	MC,HC	CH,TE	S			0.93
8/5/2015	MC,HC	CH,TE	S	S		0.93
8/6/2015	MC,HC	M, CH,TE	S		S	0.93
8/7/2015	MC,HC	CH,TE,MN	S			0.93
8/8/2015	MC,HC	CH,TE	S	S		0.93
8/9/2015	MC,HC	CH,TE	S			0.93
8/10/2015	MC,HC	CH,TE	S			0.93
8/11/2015	HC	CH,TE	S			0.93
8/12/2015	MC,HC	CH,TE	S	S		0.93
8/13/2015	MC	CH,TE	S			0.93
8/14/2015	MC	CH,TE	S			0.93
8/15/2015	MC	CH,TE	S	S		0.93
8/16/2015	MC	CH,TE	S	S		0.93
8/17/2015	MC,LC	CH,TE	S	S		0.93
8/18/2015	MC,LC	CH,TE	S			0.93
8/19/2015	MC,LC	CH,TE	S	S		0.93
8/20/2015	MC,LC	M, CH,TE	S			0.93
8/21/2015	MC,LC	CH,TE	S	S		0.93
8/22/2015	MC,LC	CH,TE	S	S		0.93
8/23/2015	MC,LC	CH,TE	S			0.93
8/24/2015	MC,LC	CH,TE	S	S		0.93
8/25/2015	MC,LC	CH,TE	S			0.93
8/26/2015	MC,LC	CH,TE	S			0.93
8/27/2015	MC,LC	CH,TE	S	T		0.93
8/28/2015	MC,LC	CH,TE	S	T		0.93
8/29/2015	MC,LC	CH,TE	S	T		0.93
8/30/2015	MC,LC	CH,TE	S	T		0.93
8/31/2015	MC,LC	CH,TE	S	T		0.93



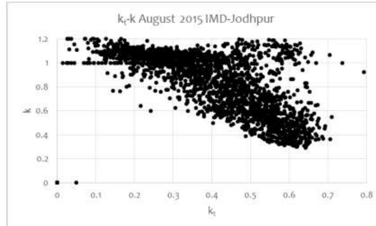
(a)



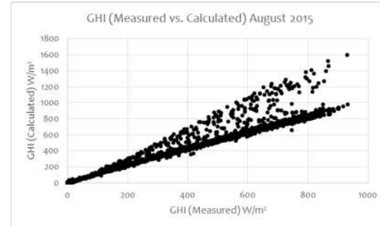
(b)


kt-kn August 2015 IMD-Jodhpur
kn
kt

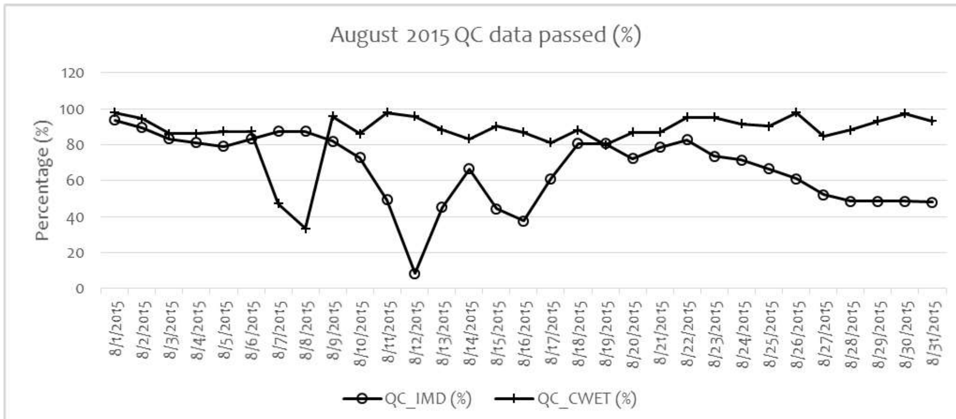
(c)


kt-k August 2015 IMD-Jodhpur
k
kt

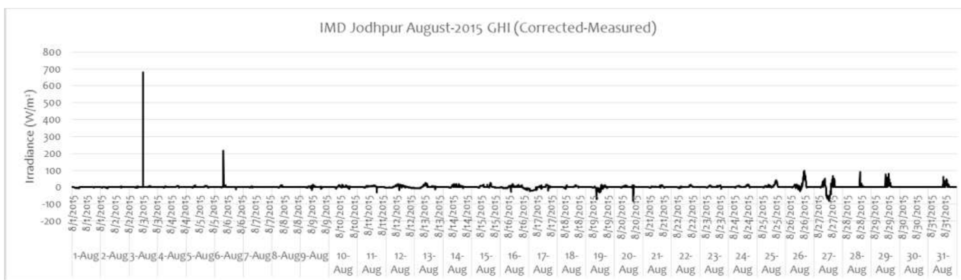
(d)


GHI (Measured vs. Calculated) August 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

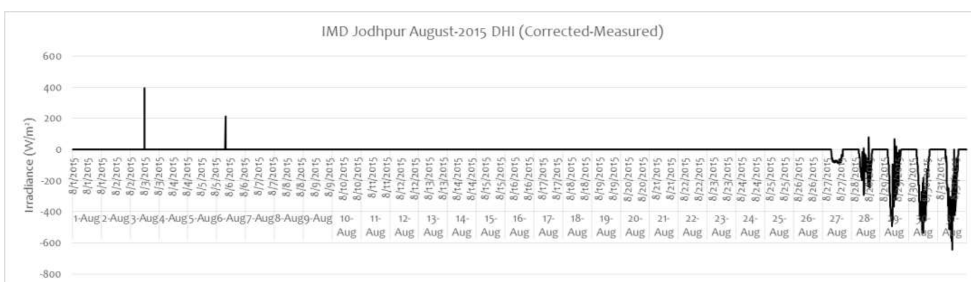
(e)


August 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

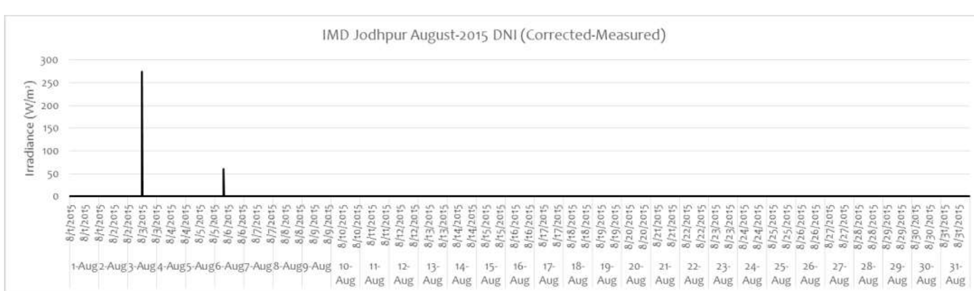
(f)


IMD Jodhpur August-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

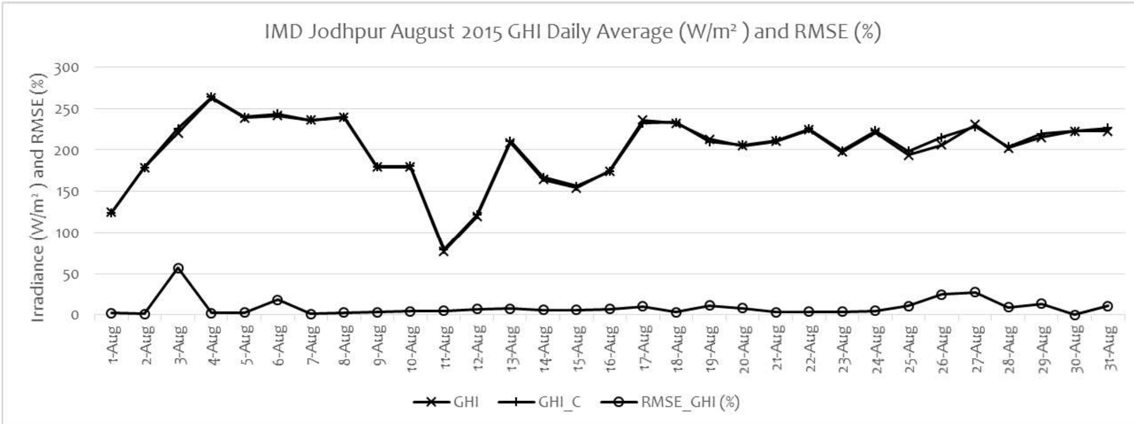
(g)


IMD Jodhpur August-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

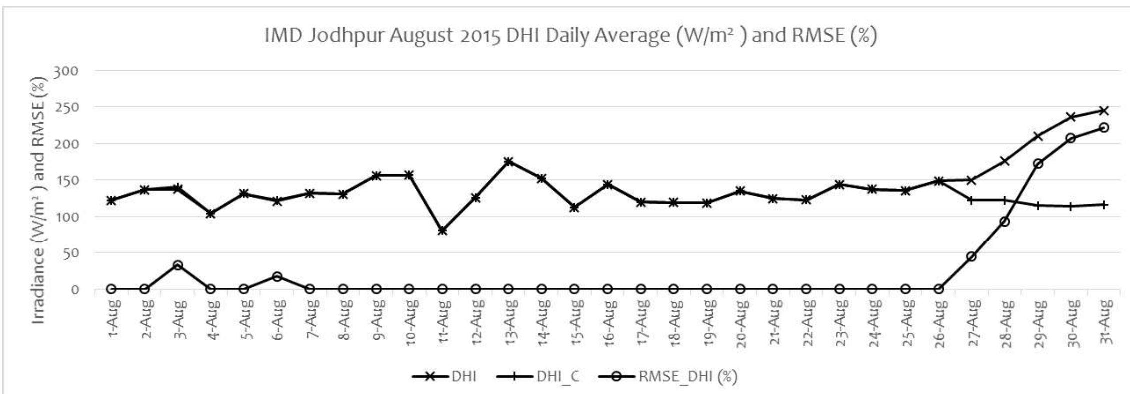
(h)


IMD Jodhpur August-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

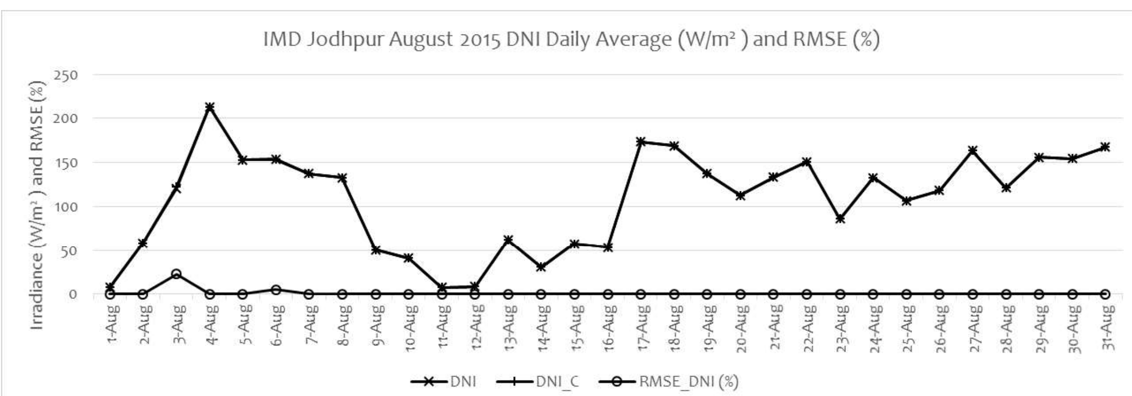
(i)



(j)



(k)

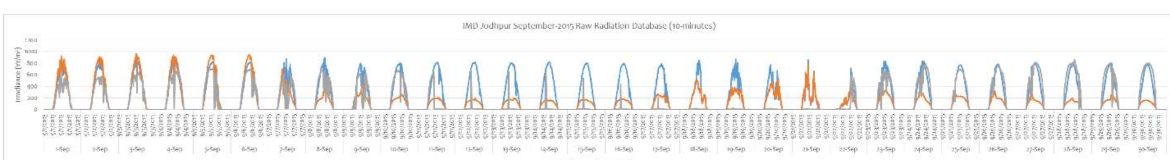


(l)

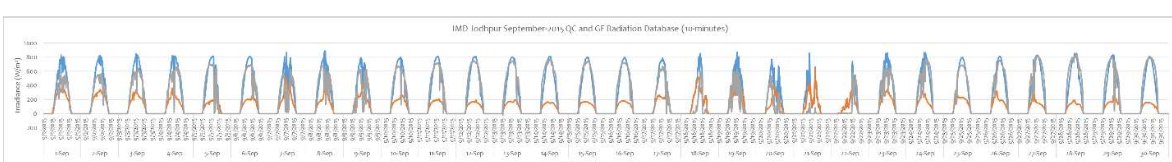
Figure 6.8: 2015 August month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.10: September 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

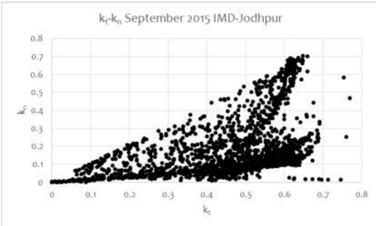
	Climate	QC Test	GHI correction	DHI correction	DNI correction	Coherence factor
9/1/2015	MC,HC	CH,TE	S	T		0.93
9/2/2015	MC,HC	M, CH,TE	S	T		0.93
9/3/2015	MC,HC	CH,TE	S	T		0.93
9/4/2015	MC,HC	CH,TE	S	T		0.93
9/5/2015	MC,LC	CH,TE	S	T		0.93
9/6/2015	MC,LC	CH,TE	S	T		0.93
9/7/2015	MC,LC	CH,TE	S	T		0.93
9/8/2015	MC,LC	CH,TE	S			0.93
9/9/2015	MC,LC	CH,TE	S			0.93
9/10/2015	MC,LC	CH,TE	S			0.93
9/11/2015	LC,CS	CH,TE			T	0.93
9/12/2015	LC	CH,TE			T	0.93
9/13/2015	LC	CH,TE			T	0.93
9/14/2015	LC	M, CH,TE	S	S	T	0.93
9/15/2015	LC	M, CH,TE			T	0.93
9/16/2015	LC	M, CH,TE	S		T	0.93
9/17/2015	LC,CS	CH,TE			T	0.93
9/18/2015	HC	CH,TE			T	0.93
9/19/2015	HC,MC	CH,TE			T	0.93
9/20/2015	HC	CH,TE		T	T	0.93
9/21/2015	HC	CH,TE		T	T	0.93
9/22/2015	HC,MC	CH,TE	S			0.93
9/23/2015	LC,MC	M, CH,TE	S	S	S	0.93
9/24/2015	LC,MC	CH,TE	S			0.93
9/25/2015	LC,MC	CH,TE	S			0.93
9/26/2015	LC,MC	CH,TE	S			0.93
9/27/2015	LC,MC	CH,TE	S			0.93
9/28/2015	CS	M, CH,TE	S	S	S	0.93
9/29/2015	CS,LC	CH,TE	S			0.93
9/30/2015	CS	CH,TE	S			0.93



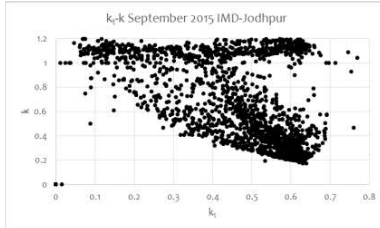
(a)



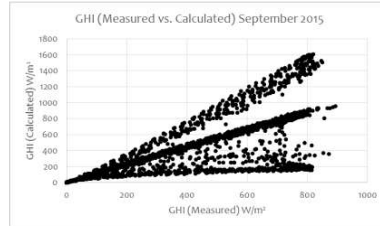
(b)


kt-kn September 2015 IMD-Jodhpur
kn
kt

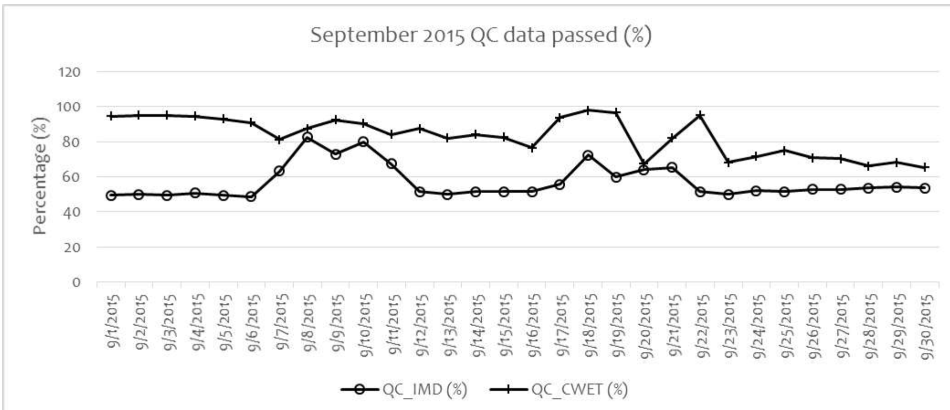
(c)


kt-k September 2015 IMD-Jodhpur
k
kt

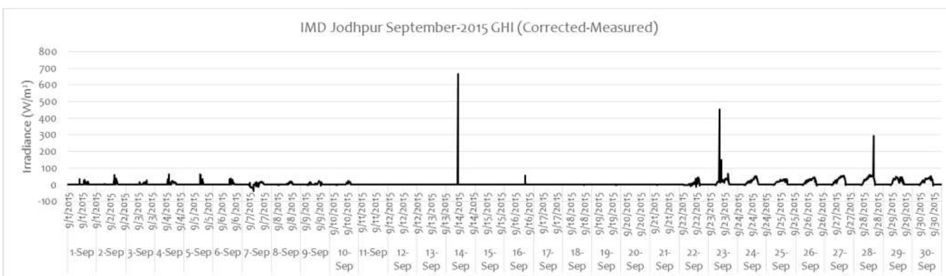
(d)


GHI (Measured vs. Calculated) September 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

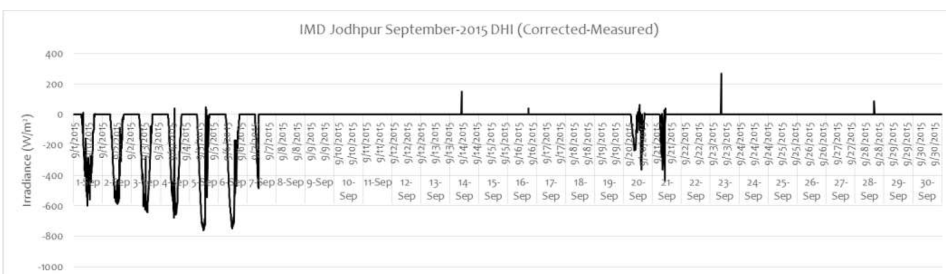
(e)


September 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

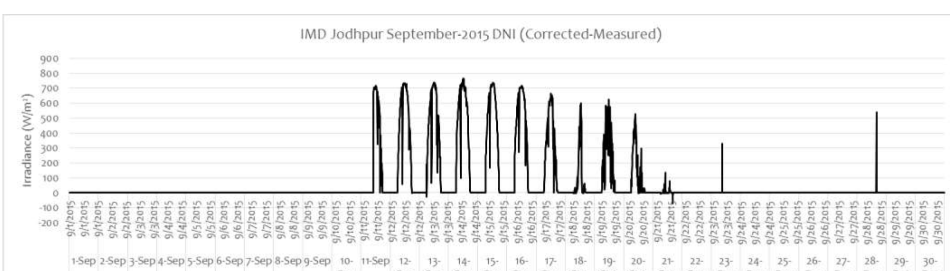
(f)


IMD Jodhpur September-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

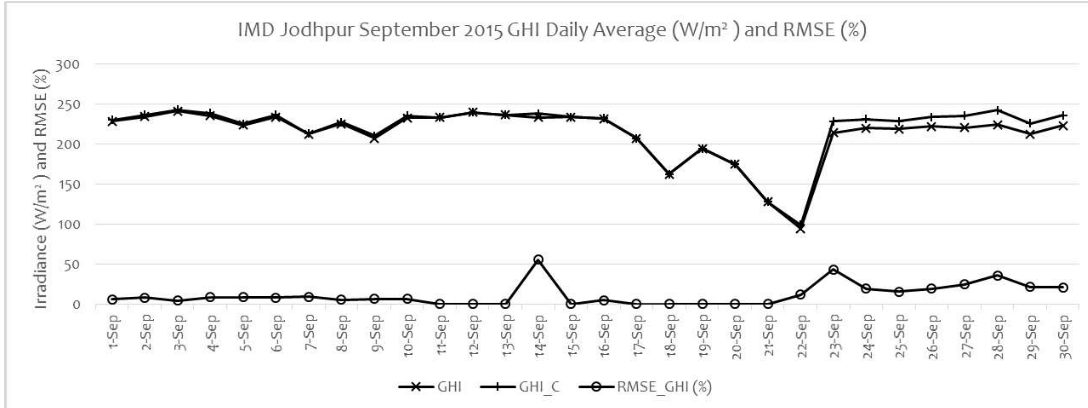
(g)


IMD Jodhpur September-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

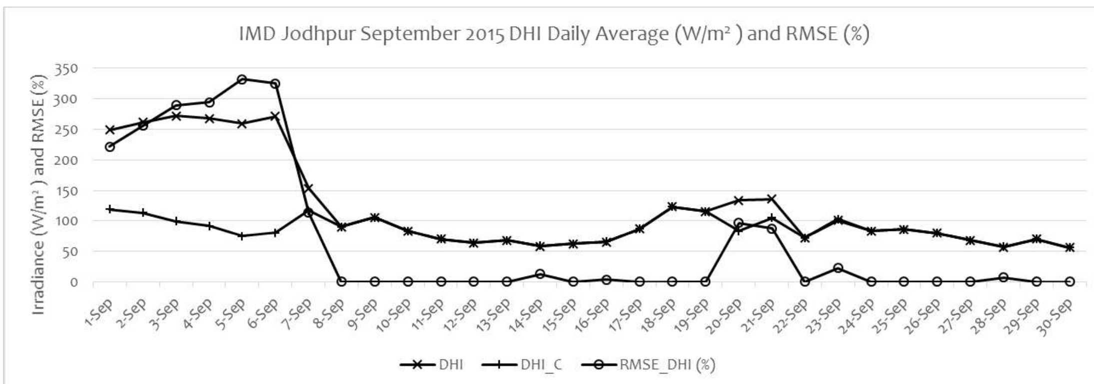
(h)


IMD Jodhpur September-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

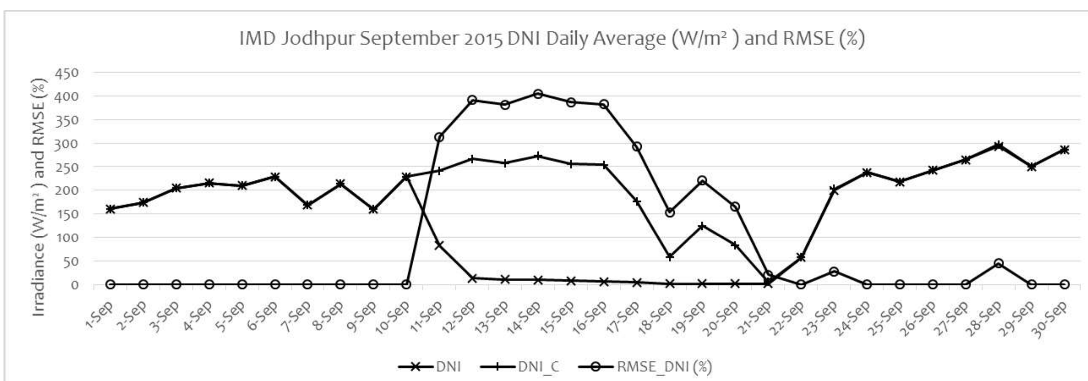
(i)



(j)



(k)

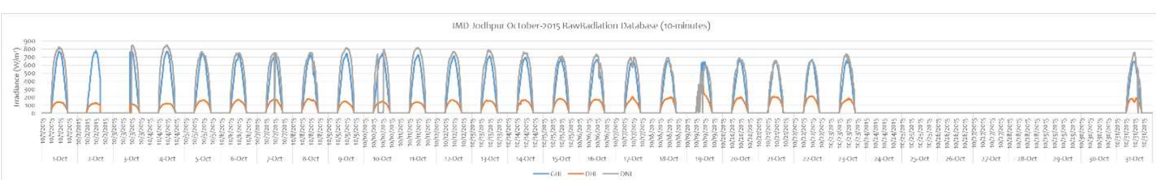


(l)

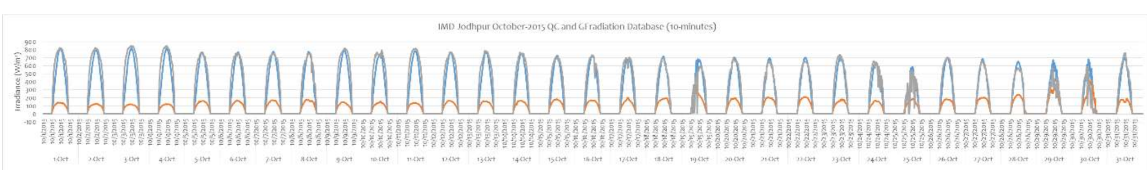
Figure 6.9: 2015 September month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.11: October 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

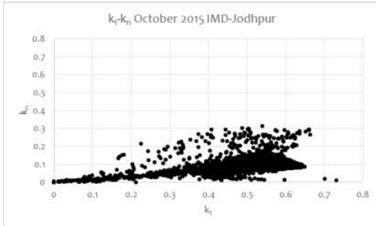
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
10/1/2015	CS	CH,TE	S			0.93
10/2/2015	CS	M, CH,TE	S	T	T	0.93
10/3/2015	CS	M, CH,TE	S	T	T	0.93
10/4/2015	CS	CH,TE	S			0.93
10/5/2015	CS,LC	CH,TE	S			0.93
10/6/2015	CS,LC	CH,TE	S			0.93
10/7/2015	CS,LC	M, CH,TE	S	S		0.93
10/8/2015	CS,LC	CH,TE	S			0.93
10/9/2015	CS,LC	CH,TE	S			0.93
10/10/2015	CS,LC	CH,TE	S		T	0.93
10/11/2015	CS,LC	CH,TE	S			0.93
10/12/2015	CS,LC	CH,TE	S			0.93
10/13/2015	CS,LC	CH,TE	S			0.93
10/14/2015	CS,LC	CH,TE	S			0.93
10/15/2015	CS,LC	CH,TE	S			0.93
10/16/2015	CS,LC	CH,TE	S			0.93
10/17/2015	CS,LC	CH,TE	S			0.93
10/18/2015	CS,LC	CH,TE	S			0.93
10/19/2015	LC,MC	CH,TE	S			0.93
10/20/2015	LC	M, CH,TE	S			0.93
10/21/2015	LC	CH,TE	S			0.93
10/22/2015	LC	CH,TE	S			0.93
10/23/2015	LC	M, CH,TE	S			0.93
10/24/2015	LC,MC	M	SS	SS	SS	0.93
10/25/2015	LC,MC	M	SS	SS	SS	0.93
10/26/2015	LC	M	SS	SS	SS	0.93
10/27/2015	MC	M	SS	SS	SS	0.93
10/28/2015	LC,MC	M	SS	SS	SS	0.93
10/29/2015	LC,MC	M	SS	SS	SS	0.93
10/30/2015	LC,MC	M	SS	SS	SS	0.93
10/31/2015	LC,CS	M, CH,TE	S	S	S	0.93



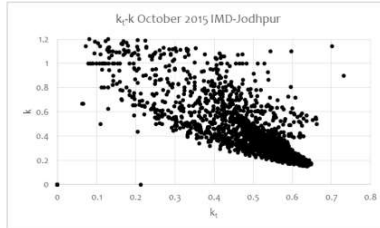
(a)



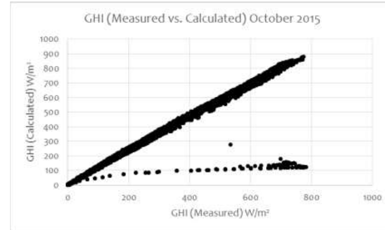
(b)


k_t-k_n October 2015 IMD-Jodhpur
k_n
k_t

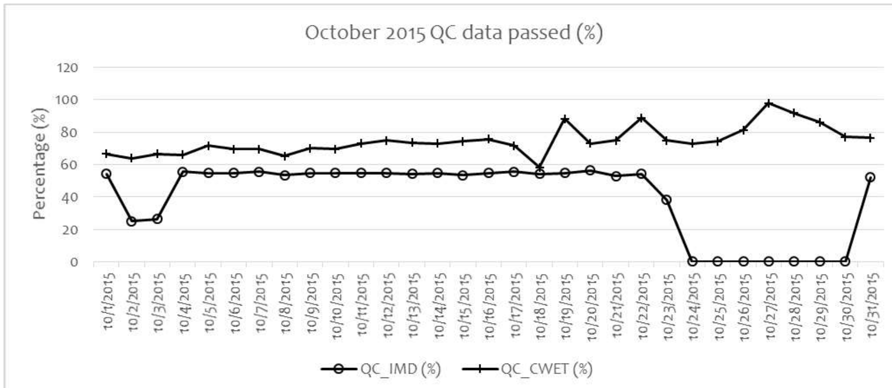
(c)


k_t-k October 2015 IMD-Jodhpur
k
k_t

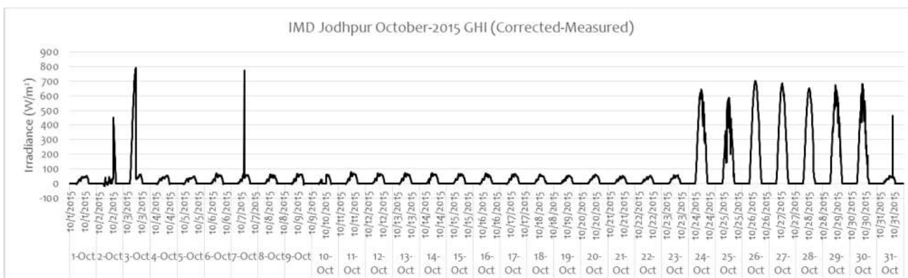
(d)


GHI (Measured vs. Calculated) October 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

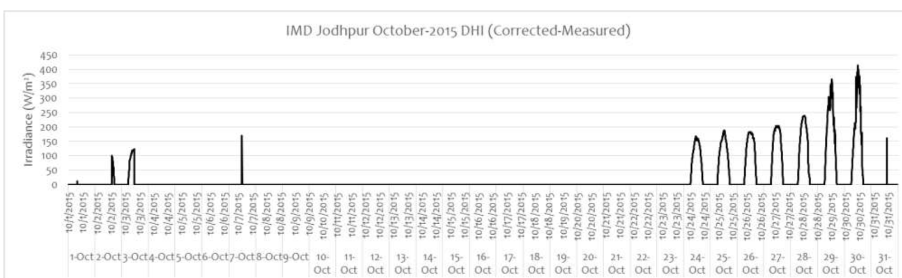
(e)


October 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

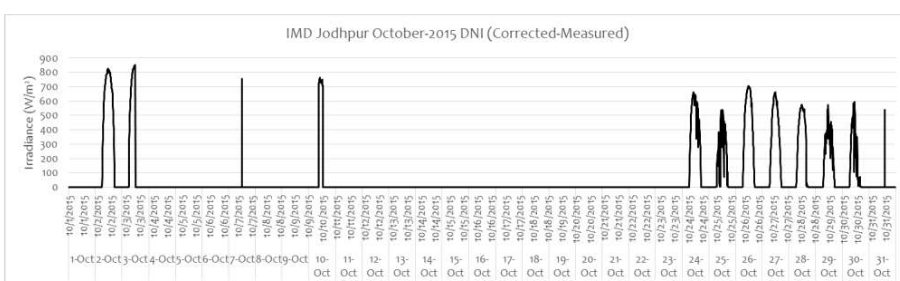
(f)


IMD Jodhpur October-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

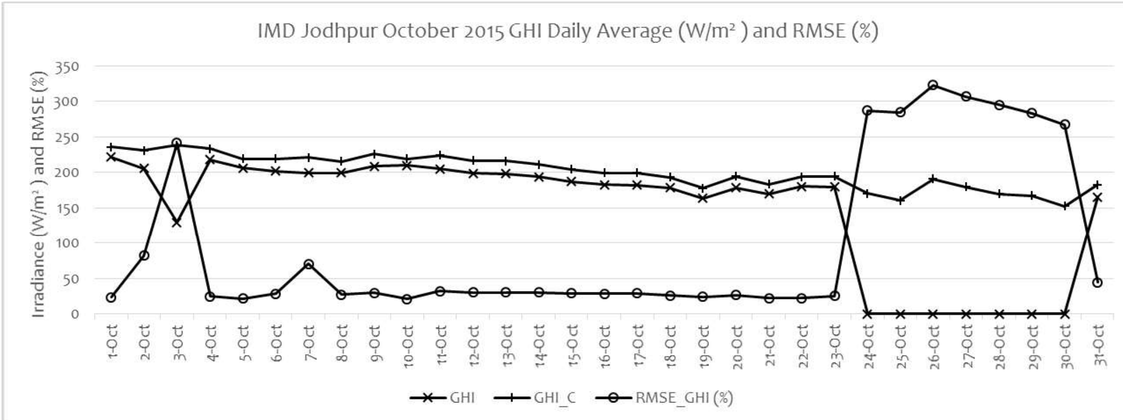
(g)


IMD Jodhpur October-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

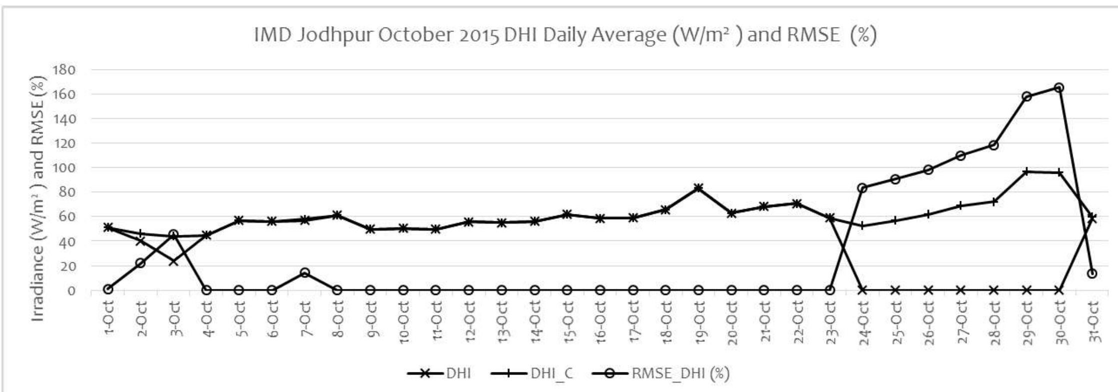
(h)


IMD Jodhpur October-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

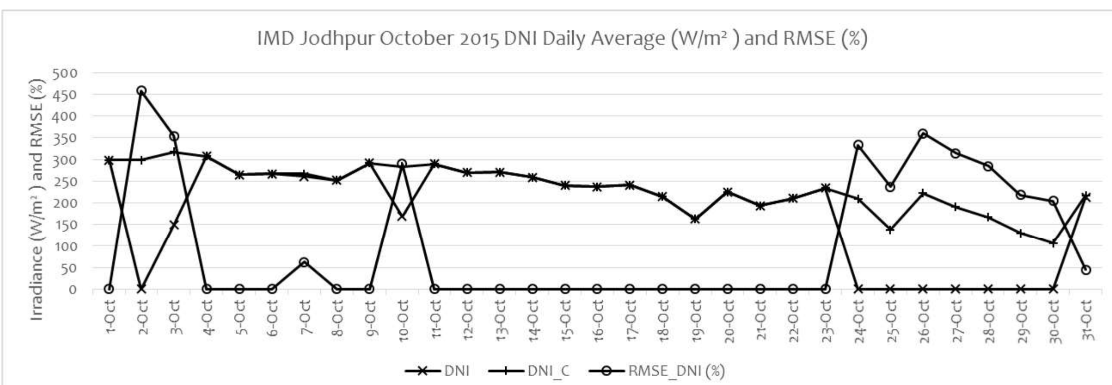
(i)



(j)



(k)

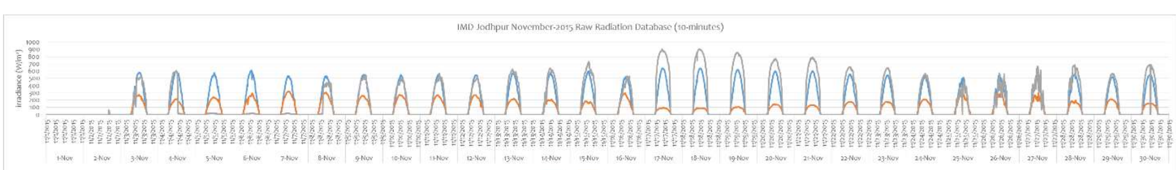


(l)

Figure 6.10: 2015 October month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.12: November 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

	Climate	QC Test	GHI correction	DHI correction	DNI correction	Coherence factor
11/1/2015	LC	M	SS	SS	SS	0.93
11/2/2015	LC	M, CH,TE	S	S	S	0.93
11/3/2015	MC	M, CH	S			0.93
11/4/2015	MC	CH,TE	S		T	0.93
11/5/2015	MC	M, CH,TE	S		T	0.93
11/6/2015	MC	CH,TE	S		T	0.93
11/7/2015	MC	CH,TE	S		T	0.93
11/8/2015	MC	CH,TE	S		T	0.93
11/9/2015	MC	CH	S			0.93
11/10/2015	MC	CH	S			0.93
11/11/2015	MC	CH	S			0.93
11/12/2015	MC	CH	S			0.93
11/13/2015	MC,LC	M, CH,TE	S			0.93
11/14/2015	MC,LC	CH,TE	S			0.93
11/15/2015	LC	CH,TE	S			0.93
11/16/2015	MC	CH	S			0.93
11/17/2015	CS	CH,TE	S			0.93
11/18/2015	CS	CH,TE	S			0.93
11/19/2015	CS,LC	CH,TE	S			0.93
11/20/2015	LC	CH,TE	S			0.93
11/21/2015	LC	CH,TE	S			0.93
11/22/2015	MC,LC	CH,TE	S	S		0.93
11/23/2015	MC,LC	CH	S			0.93
11/24/2015	MC	CH	S			0.93
11/25/2015	MC	M, CH	S		T	0.93
11/26/2015	MC	CH,TE	S			0.93
11/27/2015	MC,HC	CH,TE	S			0.93
11/28/2015	MC	CH,TE	S			0.93
11/29/2015	MC	CH,TE	S			0.93
11/30/2015	MC	M, CH,TE	S	S	T	0.93



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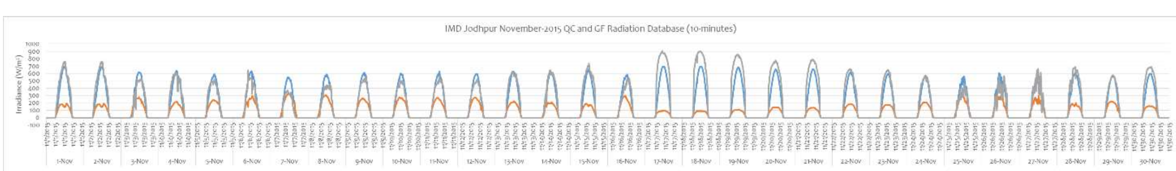

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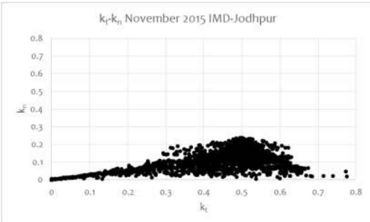
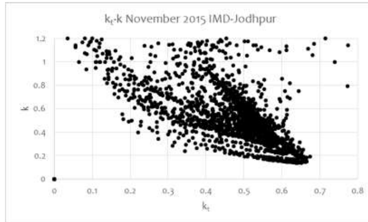
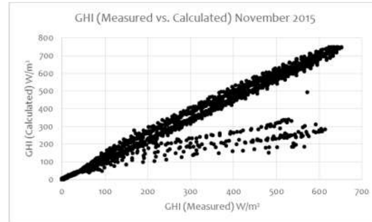

k_t-k_n November 2015 IMD-Jodhpur

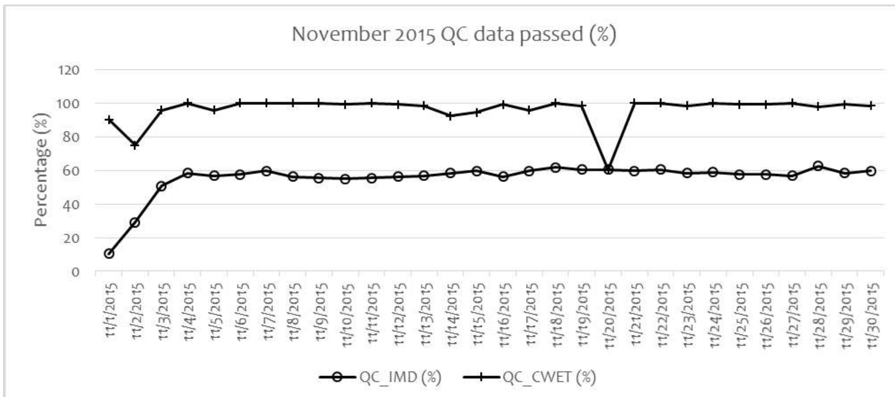
(c)


k_t-k November 2015 IMD-Jodhpur

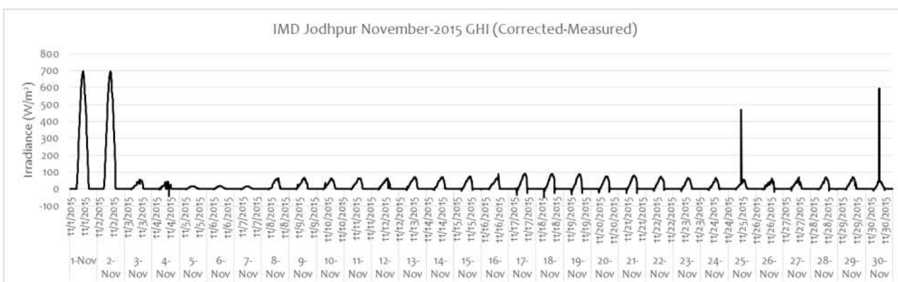
(d)


GHI (Measured vs. Calculated) November 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

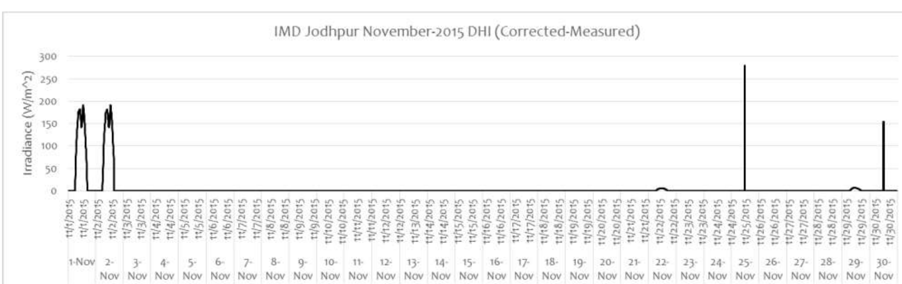
(e)


November 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

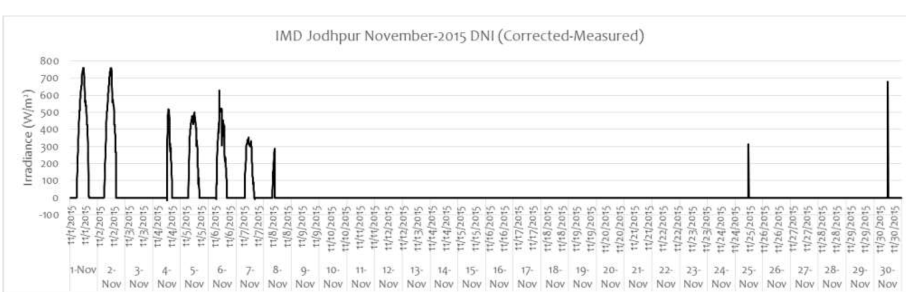
(f)


IMD Jodhpur November-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

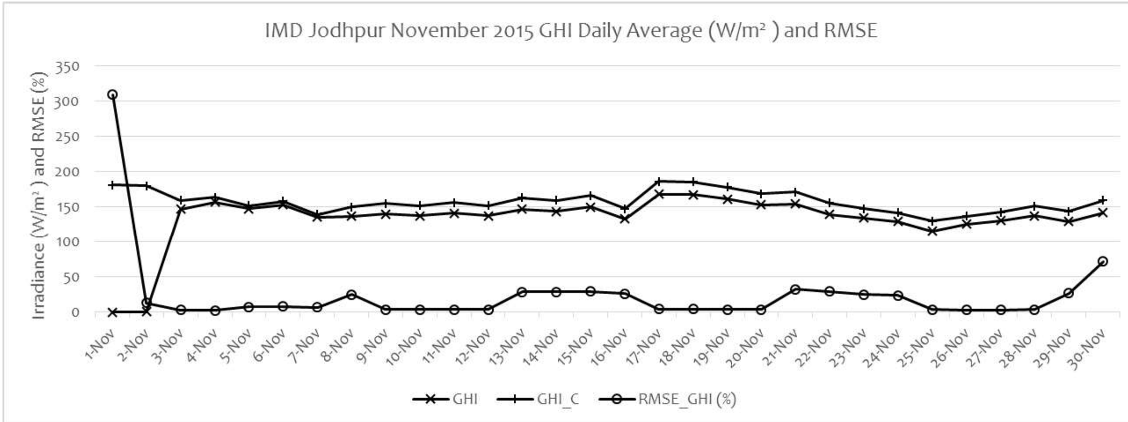
(g)


IMD Jodhpur November-2015 DHI (Corrected-Measured)
Irradiance (W/m^2)

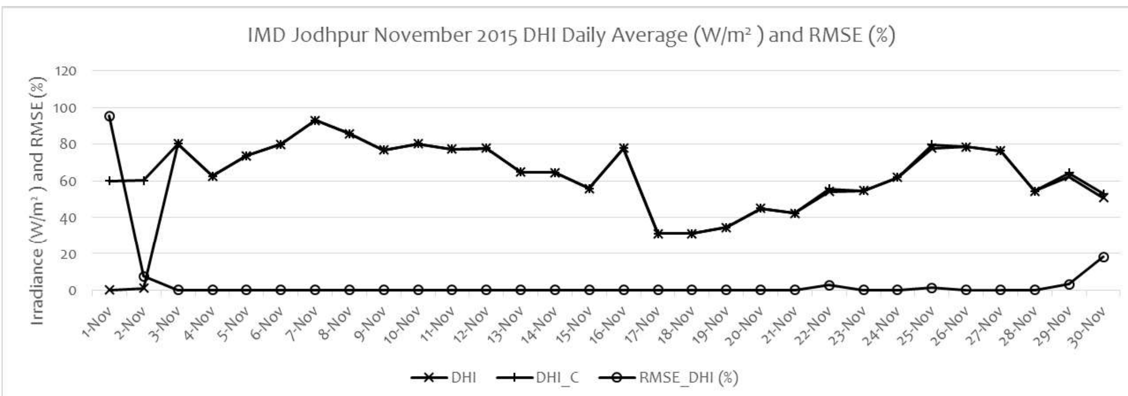
(h)


IMD Jodhpur November-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

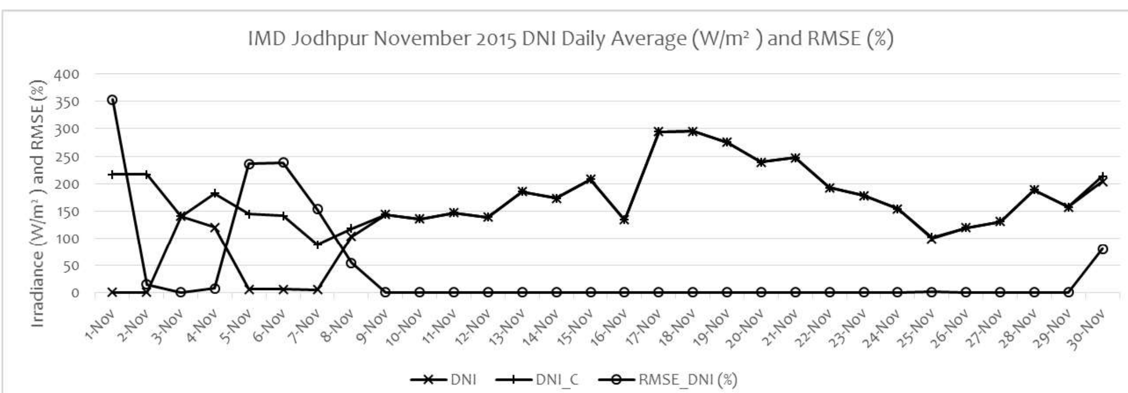
(i)



(j)



(k)

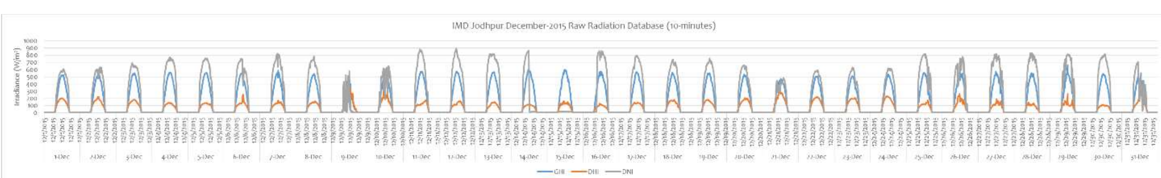


(l)

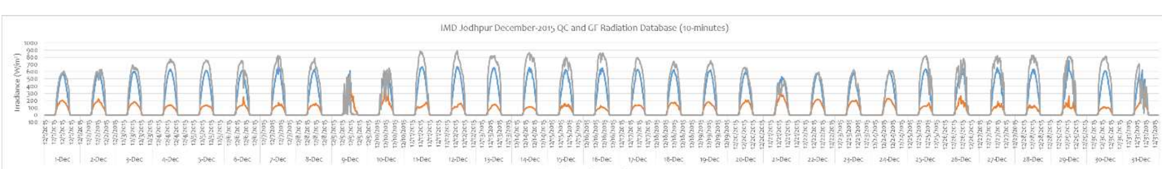
Figure 6.11: 2015 November month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.13: December 2015 (IMD Jodhpur) (Climate condition, QC Results, Instrument Error and Coherence Factor)

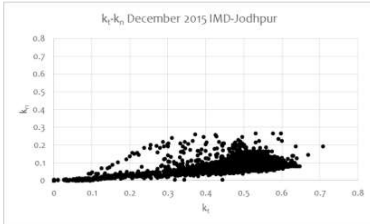
	Climate	*QC Test*	*GHI correction*	*DHI correction*	*DNI correction*	*Coherence factor*
12/1/2015	LC,MC	CH	S			0.93
12/2/2015	LC,MC	CH	S			0.93
12/3/2015	LC	CH,TE	S			0.93
12/4/2015	LC	CH,TE	S			0.94
12/5/2015	LC	CH,TE	S			0.94
12/6/2015	LC,MC	CH,TE	S			0.93
12/7/2015	CS,LC	CH,TE	S			0.93
12/8/2015	CS,LC	M, CH,TE	S	S	S	0.93
12/9/2015	HC	CH,TE	S			0.93
12/10/2015	HC,MC	CH,TE	S	S		0.93
12/11/2015	CS,LC	CH,TE	S			0.93
12/12/2015	CS,LC	CH,TE	S	S		0.93
12/13/2015	CS	CH,TE	S			0.93
12/14/2015	CS	CH,TE	S		T	0.93
12/15/2015	CS	CH,TE	S		T	0.93
12/16/2015	CS	CH,TE	S		T	0.93
12/17/2015	LC	CH,TE	S			0.93
12/18/2015	LC	CH,TE	S	S		0.93
12/19/2015	LC	M, CH,TE	S	S		0.93
12/20/2015	MC,LC	CH,TE	S			0.93
12/21/2015	MC	CH	S			0.93
12/22/2015	MC	CH,TE	S			0.93
12/23/2015	MC	CH,TE	S			0.93
12/24/2015	MC	CH,TE	S			0.93
12/25/2015	MC	CH,TE	S			0.93
12/26/2015	LC	CH,TE	S			0.93
12/27/2015	LC	CH,TE	S			0.93
12/28/2015	LC	CH,TE	S	S		0.93
12/29/2015	LC	CH,TE	S			0.93
12/30/2015	LC	CH,TE	S			0.93
12/31/2015	HC,MC	CH,TE	S			0.93



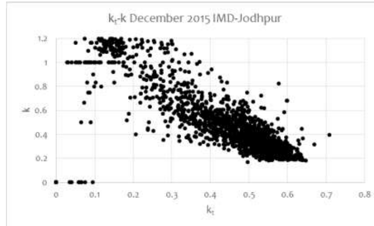
(a)



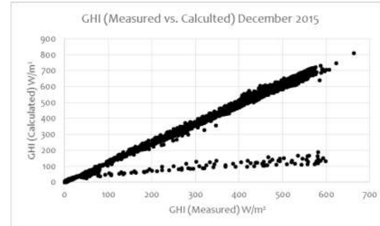
(b)


kt-kn December 2015 IMD-Jodhpur
kn
kt

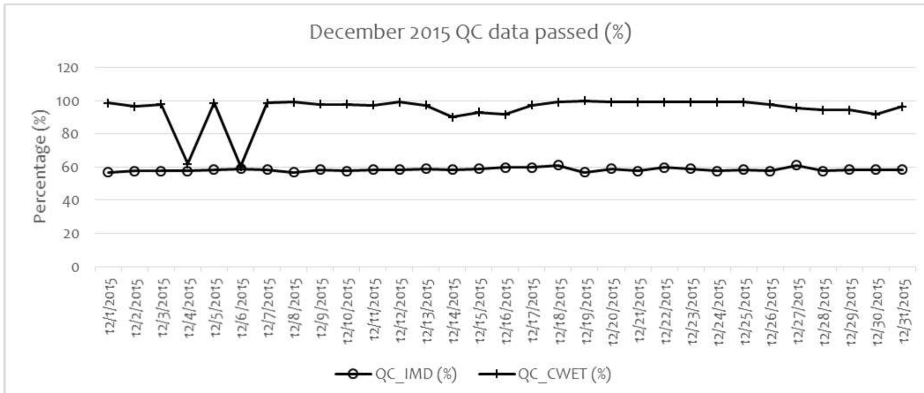
(c)


kt-k December 2015 IMD-Jodhpur
k
kt

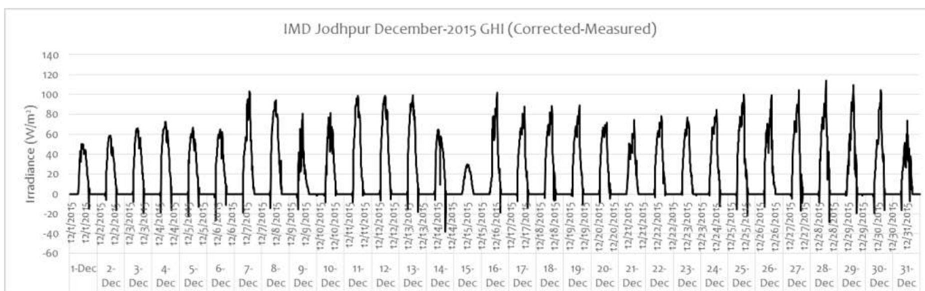
(d)


GHI (Measured vs. Calculted) December 2015
GHI (Calculated) W/m²
GHI (Measured) W/m²

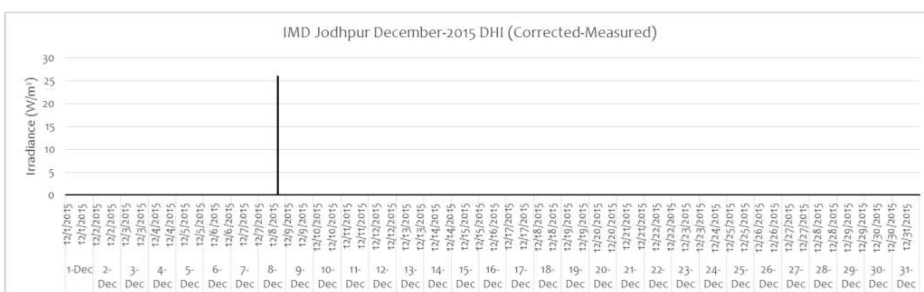
(e)


December 2015 QC data passed (%)
Percentage (%)
QC_IMD (%)
QC_CWET (%)

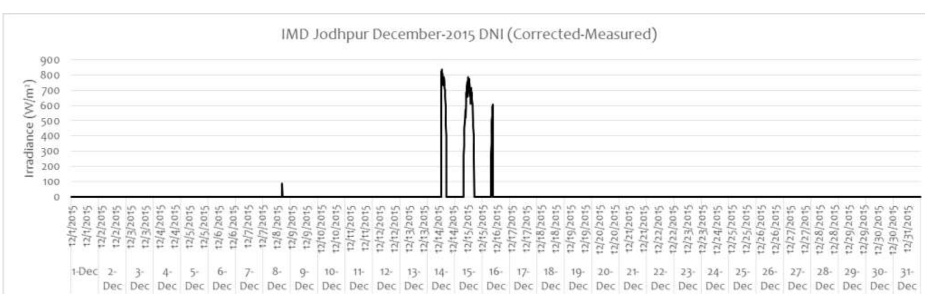
(f)


IMD Jodhpur December-2015 GHI (Corrected-Measured)
Irradiance (W/m²)

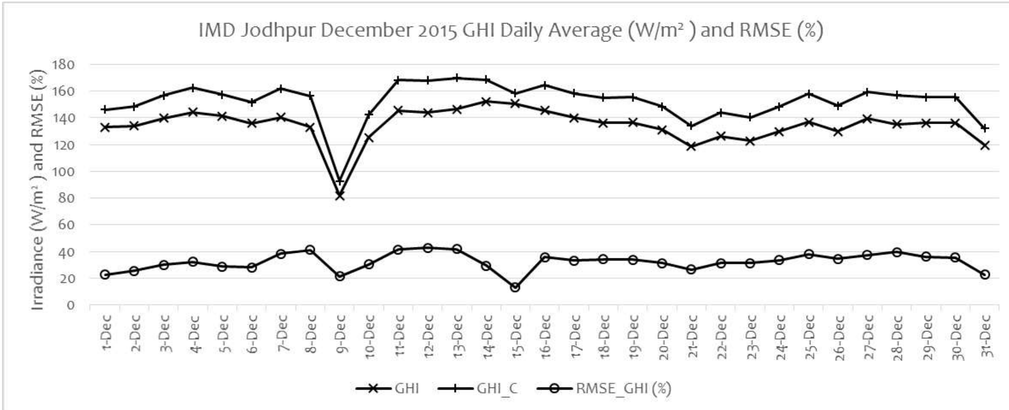
(g)


IMD Jodhpur December-2015 DHI (Corrected-Measured)
Irradiance (W/m²)

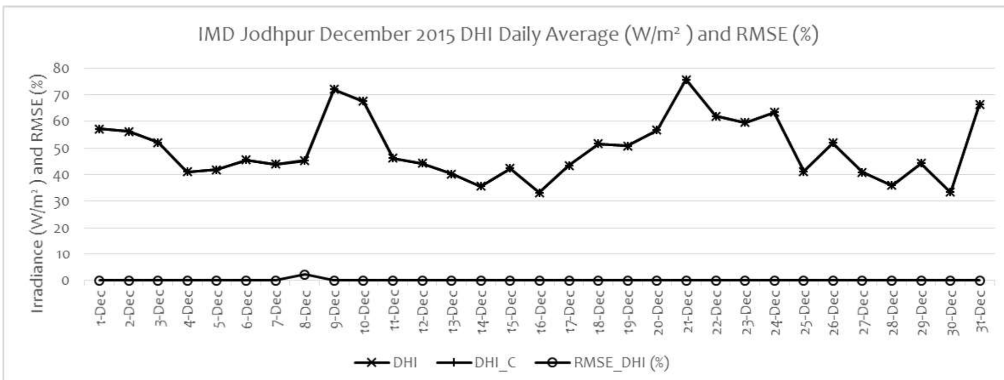
(h)


IMD Jodhpur December-2015 DNI (Corrected-Measured)
Irradiance (W/m²)

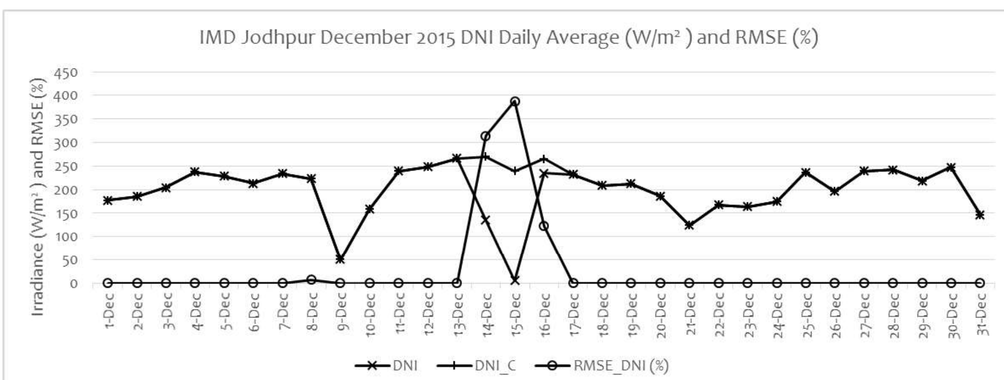
(i)



(j)



(k)



(l)

Figure 6.12: 2015 December month: (a) Raw solar radiation database (GHI, DHI and DNI); (b) Corrected solar radiation database (GHI, DHI and DNI), after applying detailed QC and GF approach; (c) k_t-k_n plot; (d) k_t-k plot; (e) GHI (Measured vs. Calculated); (f) Data missing from original database and data missing determined after detailed QC process; (g) Difference between corrected and original GHI radiation component; (h) Difference between corrected and original DHI radiation component; (i) Difference between corrected and original DNI radiation component; (j) Daily average of raw and corrected database and RMSE calculated between them for GHI; (k) Daily average of raw and corrected database and RMSE calculated between them for DHI; (l) Daily average of raw and corrected database and RMSE calculated between them for DNI.

Table 6.14: 2015 (IMD Jodhpur) (Sum/Average/Minimum/Maximum Daily Averaged Radiation Values)

January	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	3.60	151.8	4.4	186.3	1.4	58.6
Minimum	2.05	0	0.73	0	1.02	0
Maximum	4.60	743.9	6.8	888.3	2.25	466.6

(a)

February	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	4.6	194.3	5.3	222.0	1.6	69.2
Minimum	2.7	0	0.8	0	1.2	0
Maximum	5.4	860.2	7.7	931.0	2.5	485.0

(b)

March	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	5.3	223.2	5.3	224.0	2.0	83.8
Minimum	2.5	0	0.8	0	1.1	0
Maximum	6.4	989.7	7.7	961.6	3.2	531.6

(c)

April	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	5.9	247.9	5.0	208.8	2.5	107.3
Minimum	3.7	0	1.1	0	1.3	0
Maximum	6.7	950.1	8.1	880.0	4.4	610.0

(d)

May	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	6.4	268.5	5.4	226.6	2.6	109.5
Minimum	5.5	0	3.1	0	1.8	0
Maximum	6.9	971.5	7.0	809.9	3.5	553.0

(e)

June	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	5.6	235.6	3.9	166.4	2.8	120.2
Minimum	1.0	0	0.04	0	1.0	0
Maximum	6.7	978.3	6.4	701.6	4.0	623.3

(f)

Table 6.14 (Cont.) : 2015 (IMD Jodhpur) (Sum/Average/Minimum/Maximum Daily Averaged Radiation Values)

July	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	4.4	183.7	1.8	78.3	3.1	129.9
Minimum	1.5	0	0.3	0	1.4	0
Maximum	6.2	943.3	4.2	731.6	4.3	628.3

(g)

August	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	4.5	202.5	2.6	108.8	3.1	129.8
Minimum	1.9	0	0.1	0	2.5	0
Maximum	6.3	933.3	5.1	670.0	4.2	686.6

(h)

September	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	5.2	217.6	4.8	200.6	2.0	85.2
Minimum	2.3	0	0.1	0	1.2	0
Maximum	5.8	893.3	7.1	860.0	2.9	641.6

(i)

October	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	4.8	200.3	5.6	234.3	1.4	61.0
Minimum	3.0	0	2.5	0	1.1	0
Maximum	5.7	817.3	7.6	850	2.3	413.3

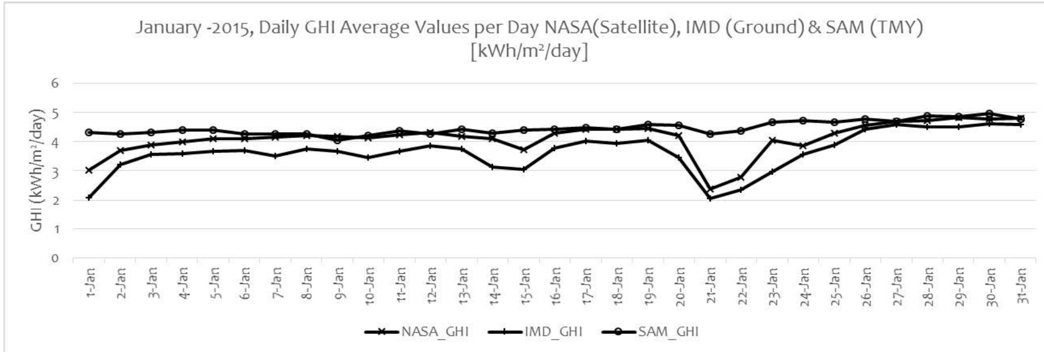
(j)

November	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	3.7	157.9	4.2	176.6	1.5	64.4
Minimum	3.1	0	2.1	0	0.7	0
Maximum	4.4	696.6	7.0	905.6	2.0	325

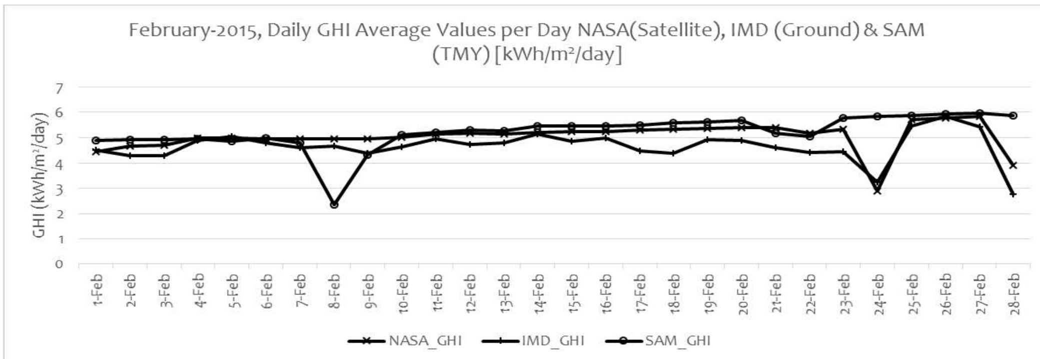
(k)

December	*GHI* (kWh/m²/day)*	*GHI (W/m²)*	*DNI* (kWh/m²/day)*	*DNI (W/m²)*	*DHI* (kWh/m²/day)*	*DHI (W/m²)*
Average	3.6	152.2	4.9	207.6	1.1	49.6
Minimum	2.2	0	1.2	0	0.7	0
Maximum	4.0	753.6	6.4	891.6	1.8	361

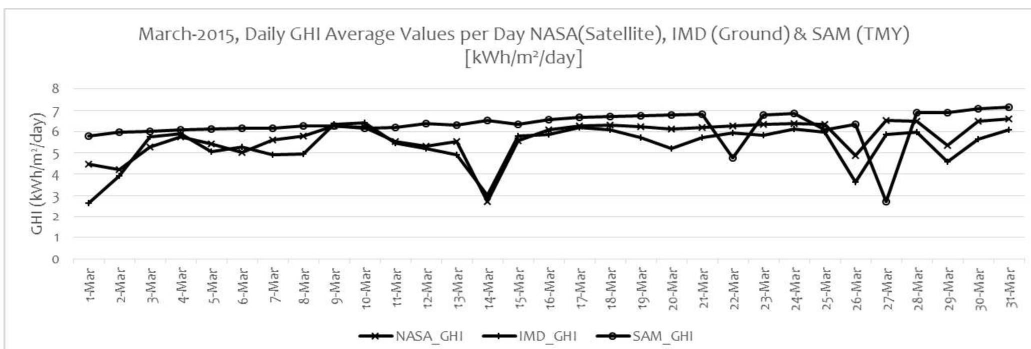
(l)


January -2015, Daily GHI Average Values per Day NASA(Satellite), IMD (Ground) & SAM (TMY) [kWh/m²/day]
GHI (kWh/m²/day)
NASA_GHI
IMD_GHI
SAM_GHI

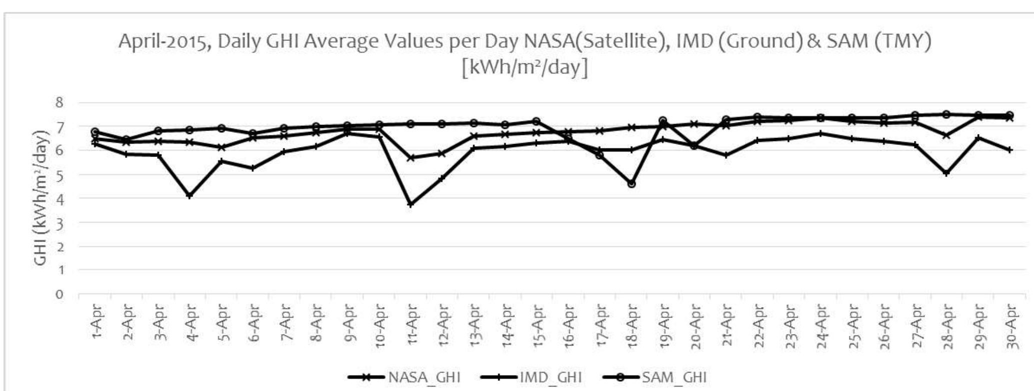
(a)


February-2015, Daily GHI Average Values per Day NASA(Satellite), IMD (Ground) & SAM (TMY) [kWh/m²/day]
GHI (kWh/m²/day)
NASA_GHI
IMD_GHI
SAM_GHI

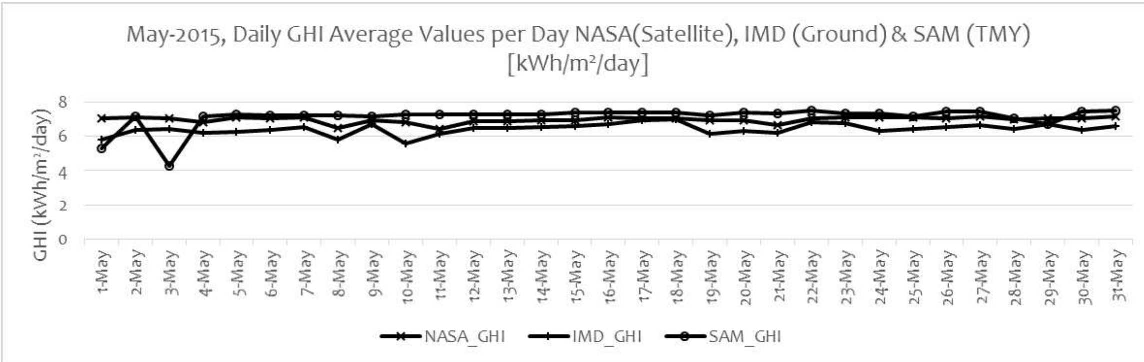
(b)


March-2015, Daily GHI Average Values per Day NASA(Satellite), IMD (Ground) & SAM (TMY) [kWh/m²/day]
GHI (kWh/m²/day)
NASA_GHI
IMD_GHI
SAM_GHI

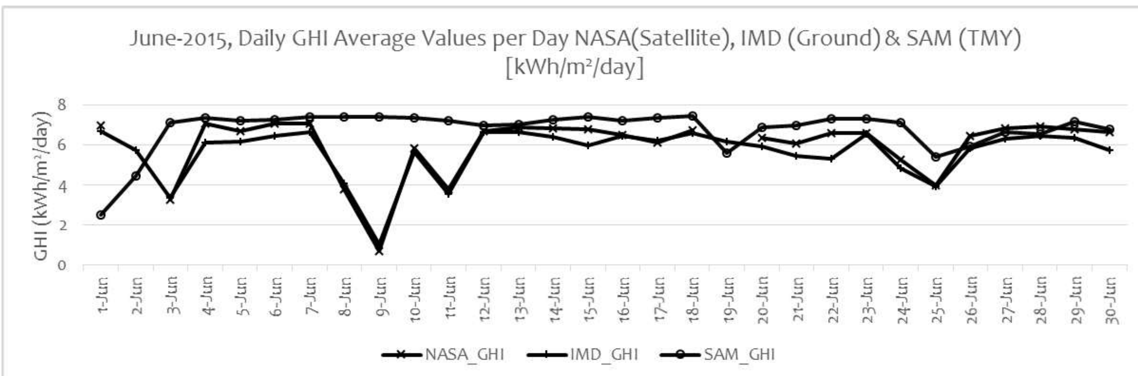
(c)


April-2015, Daily GHI Average Values per Day NASA(Satellite), IMD (Ground) & SAM (TMY) [kWh/m²/day]
GHI (kWh/m²/day)
NASA_GHI
IMD_GHI
SAM_GHI

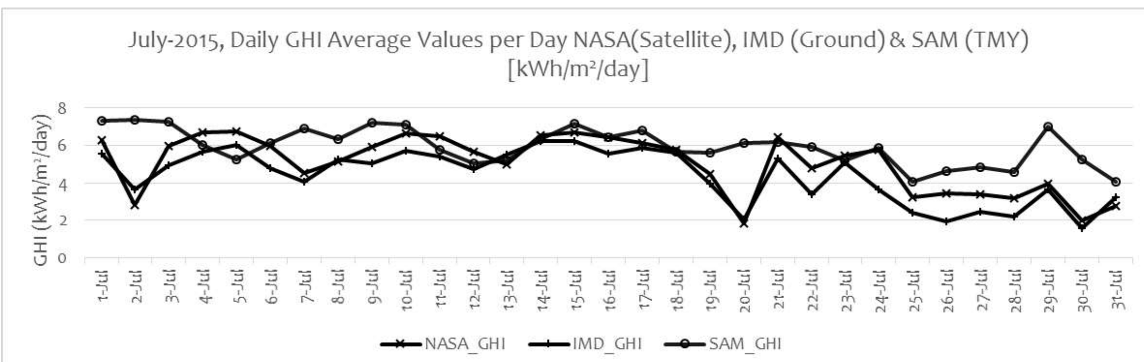
(d)


May-2015, Daily GHI Average Values per Day NASA(Satellite), IMD (Ground) & SAM (TMY) [kWh/m²/day]
GHI (kWh/m²/day)
NASA_GHI
IMD_GHI
SAM_GHI

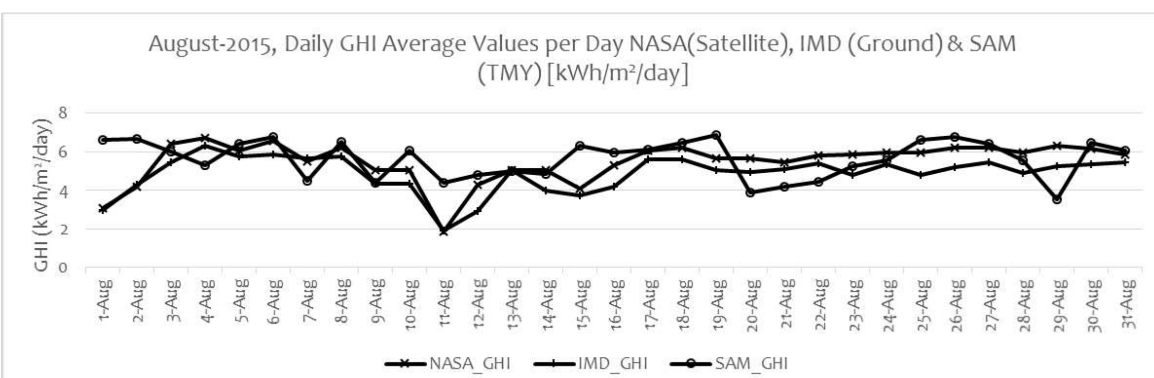
(e)


June-2015, Daily GHI Average Values per Day NASA(Satellite), IMD (Ground) & SAM (TMY) [kWh/m²/day]
GHI (kWh/m²/day)
NASA_GHI
IMD_GHI
SAM_GHI

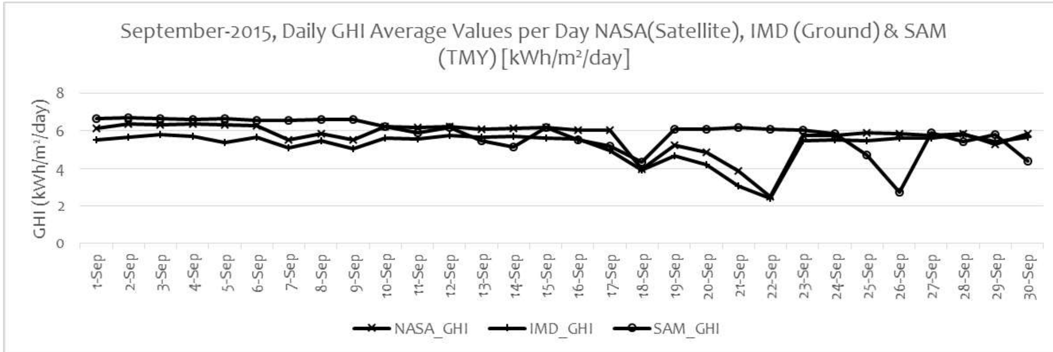
(f)


July-2015, Daily GHI Average Values per Day NASA(Satellite), IMD (Ground) & SAM (TMY) [kWh/m²/day]
GHI (kWh/m²/day)
NASA_GHI
IMD_GHI
SAM_GHI

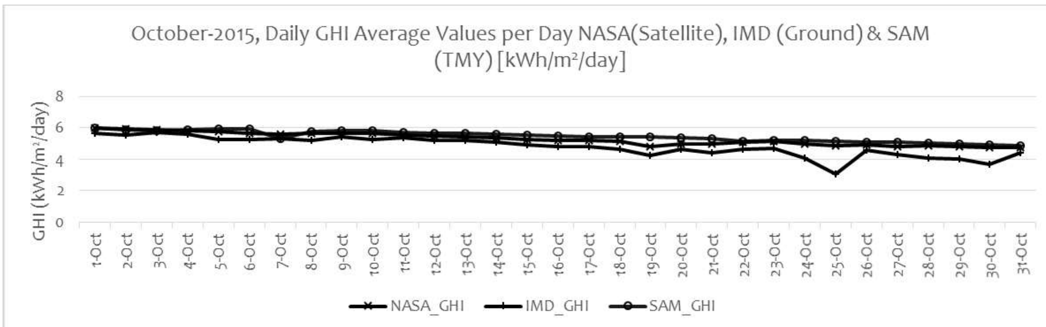
(g)


August-2015, Daily GHI Average Values per Day NASA(Satellite), IMD (Ground) & SAM (TMY) [kWh/m²/day]
GHI (kWh/m²/day)
NASA_GHI
IMD_GHI
SAM_GHI

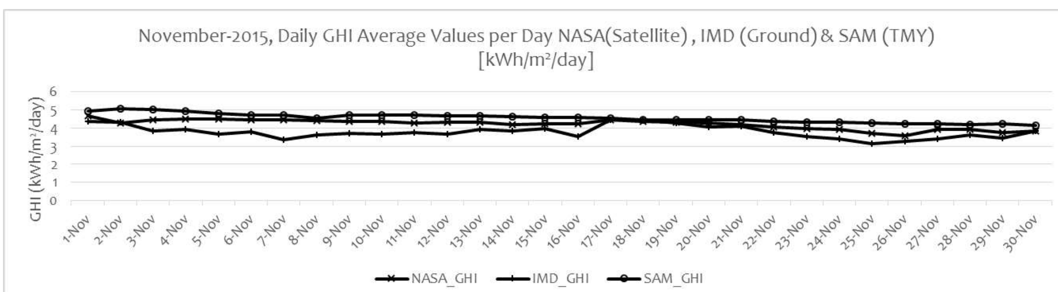
(h)



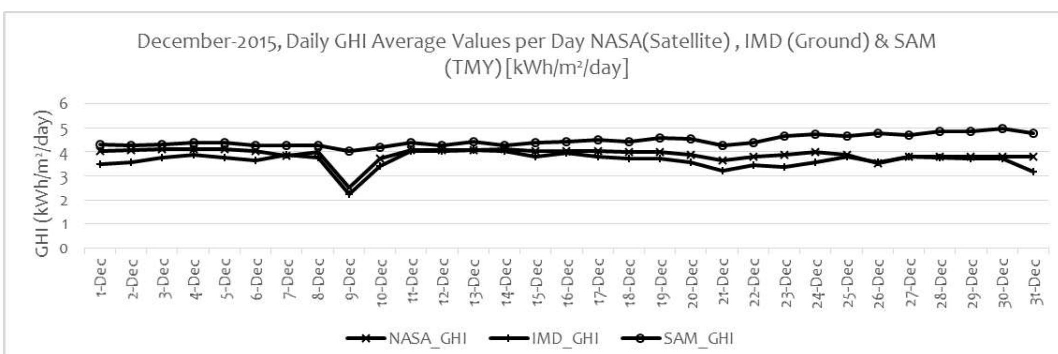
(i)



(j)

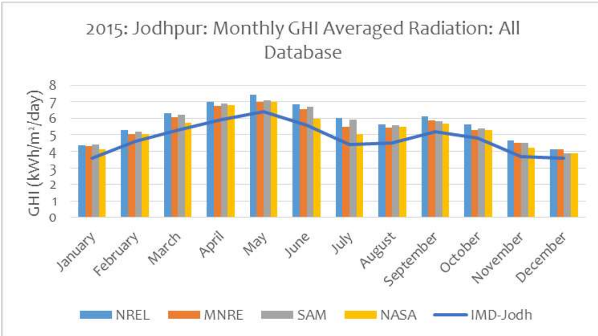


(k)



(l)

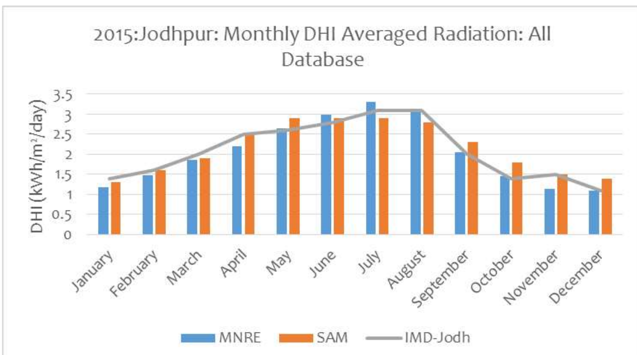
Figure 6.13: 2015 Jodhpur Daily Averaged Values: NASA (Satellite), IMD (Ground) & SAM (TMY): (a) January; (b) February; (c) March; (d) April; (e) May; (f) June; (g) July; (h) August; (i) September; (j) October; (k) November; (l) December



(a)

	NREL (%)	MNRE (%)	SAM (%)	NASA (%)
January	20.83	19.72	22.22	14.16
February	15.21	9.78	13.04	9.56
March	18.86	13.96	16.98	8.11
April	18.30	14.06	16.94	14.74
May	16.40	8.90	10.93	9.21
June	22.5	16.96	19.64	6.96
July	36.81	24.09	34.09	14.31
August	25.33	20.44	24.44	21.55
September	17.30	12.5	11.53	9.03
October	17.5	10.41	12.5	10
November	26.21	21.35	21.62	13.78
December	14.16	14.44	8.33	7.77

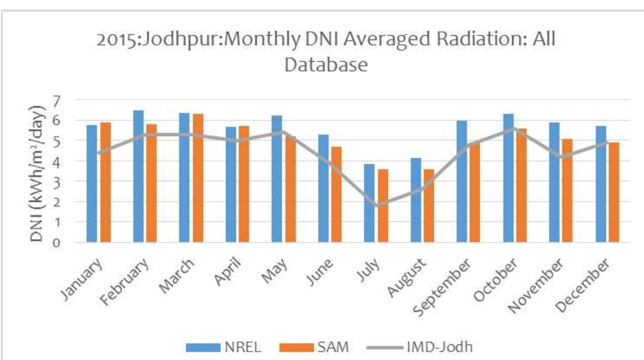
(b)



(c)

	MNRE (%)	SAM (%)
January	16.42	7.14
February	7.5	0
March	7.5	5
April	11.6	0
May	1.92	11.53
June	6.78	3.54
July	6.45	6.45
August	1.61	9.67
September	3	15
October	3.57	28.57
November	24	0
December	0	27.27

(d)



(e)

	NREL (%)	SAM (%)
January	31.36	34.09
February	22.26	9.43
March	19.81	18.86
April	13.8	14
May	15.18	3.7
June	35.89	20.5
July	113.3	100
August	59.2	38.46
September	24.58	2.08
October	12.5	0
November	40	21.4
December	16.73	0

(f)

Figure 6.14: 2015 Jodhpur Monthly Averaged Values: (a) GHI Averaged Radiation Value: All Database; (b) Percentage Difference: Daily GHI Averaged Radiation Value: All Database compare with IMD; (c) DHI Averaged Radiation Value: All Database; (d) Percentage Difference: DHI Averaged Radiation Value: All Database compare with IMD; (e) DNI Averaged Radiation Value: All Database and (f) Percentage Difference: DNI Averaged Radiation Value: All Database compare with IMD.