

Reply to Professor Hussain's Note on Analysis of Solar Insolation over Karachi – Pakistan

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I am thankful to Prof. Hussain for his comments and useful suggestions to improve further the above study. I agree that the sum of coefficients a and b must not exceed unity. While in the study under discussion it does for the months of July and August. The overcast sky and clear sky conditions of $H/H_0 = a$ and $H/H_0 = a + b$, respectively also seem to be violated and the results show inconsistency in some instances. On the basis of the recent scrutiny of the daily data of the sunshine hours, it is believed that the poor correspondence between the coefficients a and b and the data is due to the type of the sunshine recorder used and the human practice in obtaining the data. Campbell-Stokes recorders are used in all observatories. The instruments suffer from the drawback that the card does not burn until the insolation intensity reaches a certain critical value. Hay [1] suggested a 5 degree (sunset and sunrise) correction to the daylength to correct for this. However we have applied a 4 degree correction on the basis of having clear mornings and evenings. It is found that the bright sunshine duration (in hours) exceeds the actual daylength for certain days (human error). The number of such unusual cases are around 10%, when a 4 degree corrected daylength is considered. In our study we have used the actual measured data, which possibly might have led to the discrepancies. However, our results are not unique. Iqbal [2] reported for Resolute $a = 0.319$ and $b = 0.683$, where the sum $a + b > 1$. I intend to revise our study with daily values after reconstructing the data.

Prof. Hussain suggested the inclusion of seasonal effects, particularly monsoons. Pakistan receives only the tail end of monsoons. Thus the monsoon season is neither as prolonged nor as wet as that in India [3] and Bangladesh. Therefore, it will not affect the results considerably. Also one of the basic advantages of using the Ångström relation is that the variations of climate appear in the regression coefficients themselves [4]. The coefficients thus obtained using annual mean data or seasonal data or the daily data, would account for the climatic variations within that specific period. It is understood that the climatic variations are less within a month than in the season or in the year as a whole. Therefore the seasonal coefficients could not produce better results than those of monthly. Prof. Hussain obtained the seasonal values of the coefficients a and b using only three data points. Statistically this is not appropriate. However, we intend to carry out the analysis on a seasonal/daily basis, using daily data. This will provide a reasonable and statistically appropriate number of data points for the regression analyses. The annual mean regression analyses have already been done [5,6]. The values obtained are:

$$\begin{aligned} a &= 0.327 && \text{with sunshine record 1951-87} \\ b &= 0.368 && \text{and insolation record 1957-61} \\ r &= 0.98 && \text{and 1966-87} \end{aligned}$$

and

$$\begin{aligned} a &= 0.324 && \text{with sunshine record 1969-85} \\ b &= 0.384 && \text{and insolation record 1957-61} \\ r &= 0.98 && \text{and 1966-84} \end{aligned}$$

These results agree with Prof. Hussain's analysis, except for the correlation coefficient.

REFERENCES

1. Hay, J.E. (1979), Calculation of Monthly Mean Solar Radiation for Horizontal and Inclined Surfaces, *Solar Energy*, Vol. 23, No.4, pp.301-307.
2. Iqbal, M. (1983), *An Introduction to Solar Radiation*, Academic Press, Canada.
3. Fazle Karim, M. (1984), *Pakistan: An Economic Geography*, Sir Sayyed Academy, Karachi, Pakistan.
4. Page, J.K. (1964), The Estimation of Monthly Mean Values of the Daily Total Short Wave Radiation on Vertical and Inclined Surfaces from Sunshine Records for Latitudes 40 °N-40°S, *Proceedings of the UN Conference on New Sources of Energy*, Vol.4, Paper No. S/98, pp.378-387.
5. Raja, I.A. and J.W. Twidell, Iso-Sunshine Maps and Correlations for Predicting Global Insolation for Pakistan, *RERIC International Energy Journal*, submitted.
6. Raja, I.A., S.B.H. Abidi and J.W. Twidell (1989), Correlation for the Prediction of Monthly Average Daily Global and Diffuse Radiation over Karachi, Pakistan, *9th Miami International Conference on Alternative Energy Sources*, 11-13 December 1989, Miami Beach, Florida, USA.