Analysis of a Foreign Irradiance Estimation Model in the South African Climate in the pursuit of deriving a Humidity Estimation Model.

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***Abstract*—The following paper documents a study that was endeavoured in an effort to alleviate a gap in humidity data. An Irradiation model is deconstructed and a new humidity model is derived using said irradiation model. The model is then validated against empirical data and the results are presented along with conclusions regarding the efficacy of the model in question. In essence this paper shows that the irradiation model does produce feasible results in the South African climate and the humidity model produces usable results for the months January, June, September, October, November and December.**

***Index Terms*—Visualisation, Situational Awareness, humidity, Photo Voltaic, Irradiance.**

I. Introduction

Weather data is an enabling tool in predicting performance and status of the power grid and the equipment contained therein. The absence of any particular dataset poses significant challenges to a utility when attempting to model a power grid and the environment with which it interacts.

In an effort to fill gaps within datasets; humidity data is selected as a point of special interest and the following paper will attempt to answer whether it is feasible to use an irradiation estimation technique [1] to model the absent humidity data.

The technique to estimate solar radiation encompasses determining the position of the sun for a specific location at a specific point in time thus having a best case scenario of solar radiation. The atmospheric transmittance coefficient τ is hence established by estimating it based on the measured relative humidity. With τ the diffuse and horizontal beam radiation values can be calculated which when combined provides the total incident radiation. The reverse of this calculation could provide the missing humidity data.

II. Modelling Irradiation

Any given Photo Voltaic (PV) plant will typically record four parameters on an hourly basis. This may include relative humidity, temperature, irradiation and barometric pressure. According to [1], solar radiation is a function of the geographical location of the area of interest, humidity and temperature.

In [1], τ (capacity of the atmosphere to transmit electromagnetic energy) takes on only discrete values. This may have worked well in the area in which the model was developed, but an alternative method of estimating τ which involves a sigmoidal transfer function is used and compared in this paper. The sigmoidal transfer function to estimate τ is shown in Equation 1.

$$\tau = 0.6976 + \frac{(0.12287 - 0.6976)}{\left(1 + \left(\frac{RH}{67.367}\right)^{-5.1731}\right)}$$

Equation 1

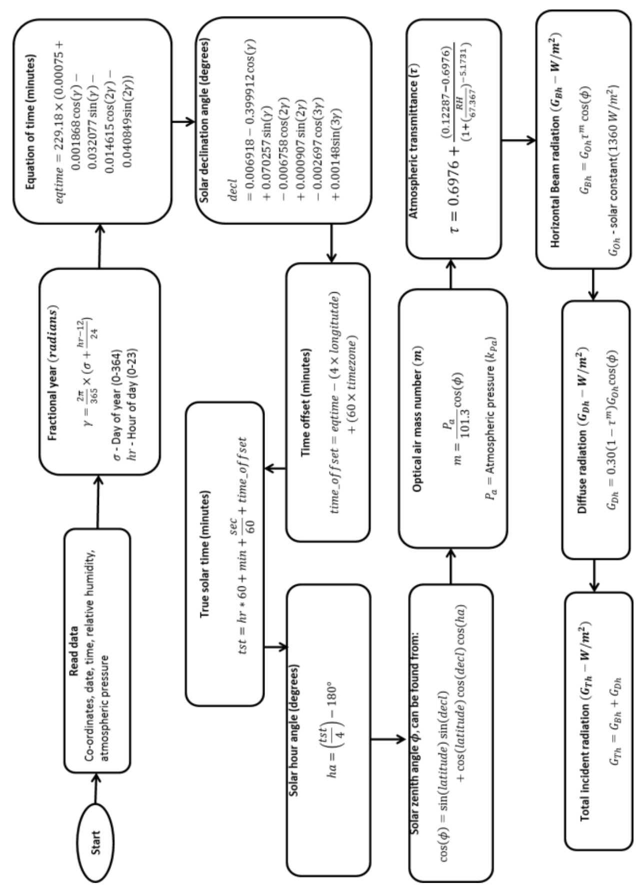

Figure 1 Solar Irradiation Estimation Block Diagram [1]

Figure 1 shows the process diagram of implementing the model mentioned in [1] but implements the developed sigmoid transfer function to establish τ rather than the original set of discreet values.

A. Results of using Solar Irradiance estimation model in South African climate

The results of the statistical analysis were used to validate the model to ensure a good enough building block for the forthcoming analysis. Table 1 was calculated using RMSE (Root Mean Square Error) and was presented in NRMSE (Normalized Root Mean Square Error).

Table 1 Statistical Analysis Results for Irradiation Model

Statistical Parameter		
RMSE	NRMSE	R^2
135.90	17%	0.81

The results show that the model can estimate the solar irradiance in a margin of 17% of the actual value. I.e. an estimation of 350W/m^2 implies that the actual solar irradiance lies between 320.25 W/m^2 and 370.95W/m^2.

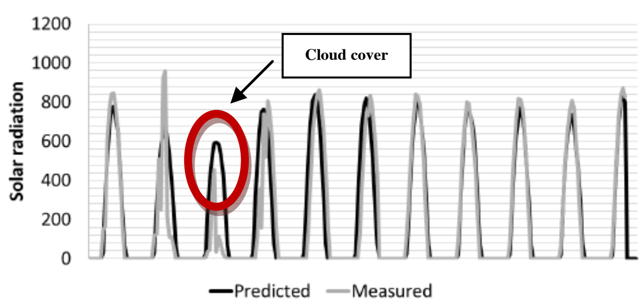

Figure 2 Graphical comparison of predicted and measured solar radiation on random dates

The line diagram above is a visual illustration of how the model is able to predict solar irradiance with only relative humidity as a parameter. Bearing in mind that since this model only takes humidity as an input parameter– it will not be able to predict whether there is cloud cover over the region of interest. An example of such an event is as illustrated with the red outline above where the maximum predicted solar irradiance value exceeds the measured value.

III. Modelling Humidity

Since the solar irradiance estimation model proved to produce favourable results using only humidity as an input parameter to predict solar irradiance – it was decided to attempt estimating humidity from the measured solar irradiance. The results of the said endeavour were unsuccessful so an alternative approach was undertaken to estimate humidity.

A complete dataset of weather data required to test the humidity model was collected for the following months; June, August, September, October, November, December and January (2015).

According to [1], night-time minimum temperature is approximately equal to the dew point temperature. Dew point temperature is closely linked with relative humidity.

The dew point temperature is the temperature at which the air must be cooled to become saturated with water vapour. If the temperature drops below dew point temperature, the water vapour will condense into water droplets.

Assuming the dew point temperature is constant throughout the day then $T_{min}=T_{dew}$ can be used to measure the average daily humidity. Figure 2 is the process diagram for estimating humidity that was derived from the work of [2].

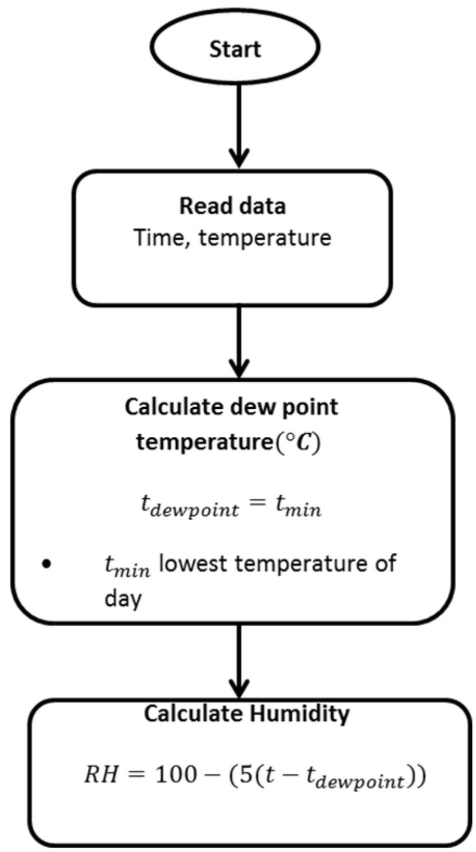

Figure 3 Humidity estimation block diagram

A. Results of Humidity Estimation model

As in the previous section of this paper the same statistical approach was used to validate the humidity model. Periods that have a higher average humidity, such as months of October, November and December and January are predicted notably more accurate than other months. The following figures depict these results.

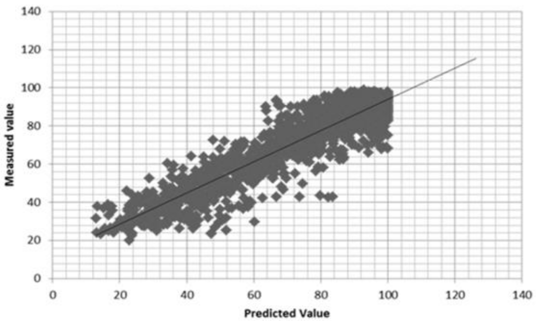

Figure 4 Scatter plot of estimated humidity vs measured humidity (Nov, Dec, Jan)

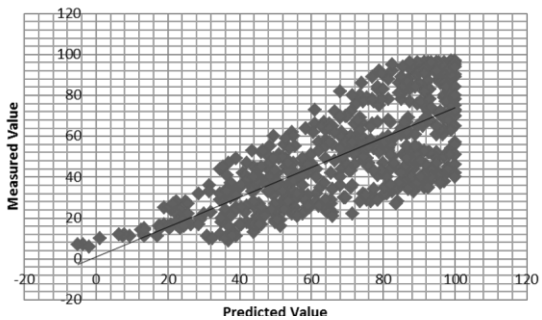

Figure 5 Scatter plot of estimated humidity vs measured humidity (Aug)

Table 2 Statistical analysis of humidity estimations

Months	Statistical Parameters		
	RMSE	NRMSE (%)	R^2
Jan, Jun, Sep, Oct, Nov, Dec	14.04	10.04	0.77
Jan, Dec, Nov	8.66	8.5	0.85
Jun, Sep, Oct	19.97	16.91	0.64

The analysis shows a higher error in the months of June, September and October. These months in general are drier than others periods of the year and have an average daily humidity of below 50.

In order to illustrate this point the following figures offer a visual confirmation of the previous statement.

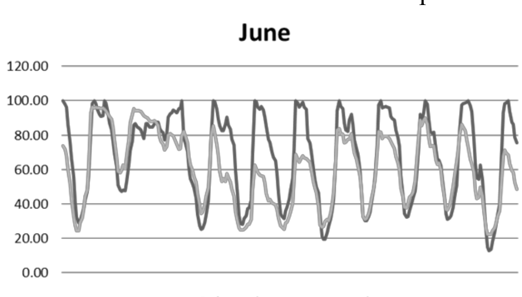

Figure 6a Comparison of estimated humidity and actual humidity for different months in the year

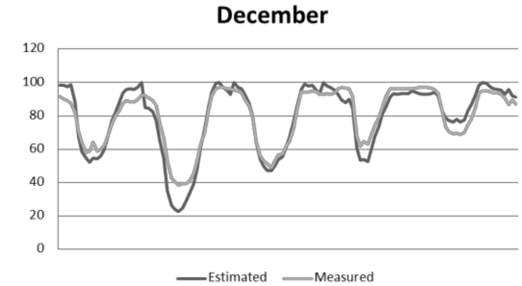

Figure 6b Comparison of estimated humidity and actual humidity for different months in the year

IV. Conclusion

A model for estimating solar radiation was tested and then analysed to verify that the model can be used on the South African climate. The analysis showed that the model attained a NRMSE of 17% which indicated that it may yield usable results for days that are not affected by cloud cover.

It was then attempted to develop a humidity model using the said irradiance model – this did not provide favorable results. Hence an alternative means of approximating humidity was developed and analysed. The model was tested through various times of the year. The results showed that the humidity model has a NRMSE of 8.5% in summer compared to a NRMSE of 16.91% in winter.

This result indicated that the model is less accurate during winter months. In essence the model is not usable during winter months, however in summer months the model does yield usable results.

V. Bibliography

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