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Design a Model to Predict Visibility for Aviation over Trivandrum Using MATLAB

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A B S T R A C T

Visibility plays a significant role in flight accidents and aviation safety. Many flight accidents are happened due to less visibility and bad weather. In this study, the authors attempted to develop a functional relationship to predict the visibility over Trivandrum using the meteorological parameter. The authors have used relative humidity to predict visibility. The relative humidity is a direct relation to the visibility and fog. The authors have obtained the relative humidity data from the IGRA website. They have used eight years of data (2012-2020) to develop a functional relationship between relative humidity and visibility. The developed functional relationship has been validated with the radiosonde date. The authors have used two years of data for validation (January 2021-December 2022). The estimated visibility matches well with the visibility retrieved from the radiosonde data

KEYWORD: Visibility, Relative humidity, Trivandrum, Radiosonde, Curve estimation

1. INTRODUCTION

The prime factors for flight accidents are ceiling height (CH) and visibility (V). In Instrument Meteorological Conditions (IMC), the CH is below 1000 feet, and the V is 3 miles. In Marginal Visual Flight Rules (MVFR), the CH is between 1000-3000 feet, and the V is 3-5 miles, and in Visual Flight Rules Meteorological Conditions (VMC), the CH is above 3000 feet, and V is > 5 miles.

RH is readily available everywhere, so the authors attempted to find a functional relationship between RH and visibility. The proposed functional relationship has been validated against the data fetched from the IGRA.

A study by Singh et al. (2018) shows that the number of fights diverts in Northern India due to visibility and fog. Gupta (11987) reveal that the study of fog prediction needs to be more detailed using numerical models. Zhou and Du (2010) used liquid water content and relative humidity to predict fog.

Curve estimation tool has been used for many applications such as medical image processing (Thirumala Lakshmi et al., 2019), thunders on Prediction (Litta et al., 2013), precipitation prediction (Bodri& Cermak 2000), flood prediction (Luk et al., 2000), and image classification (Thirumala Lakshmi & Devi 2016)to find the correlation between the parameters.

2. DATA AND METHODOLOGY

The visibility (V) and relative humidity (RH) data have been taken from the IGRA over Trivandrum (8.47 N, 76.95 E). The IGRA station ID of Trivandrum is INM00043371. Figure1 shows the visibility and RH of Trivandrum on 20th December 2022 at 00 hr. The authors downloaded the visibility and RH data from April 2012-December 2022.

Observations for THIRUVANANTHAPURAM, India (VOTV)

Location: 8.47N 76.95E 8 meters

Observation time: 20 Dec 2022 00:00 UTC

Altimeter Setting	1007.0 hPa
Station Pressure	1006.0 hPa
Temperature	26 C
Dew Point	24 C
Relative Humidity	89 %
Wind Speed	0 m/s
Visibility	3.0 km
Clouds	Scattered at 370 meters
	Broken at 2440 meters
Weather	fog
Air Density	1.158 kg/m3

Fig. 1– Visibility and relative humidity over Trivandrum from IGRA

Using the curve estimation technique, the authors developed a functional relationship between RH and visibility. The data are fitted into the nine models: cubic, power, sigmoid, logarithmic, quadratic, linear, exponential, compound, inverse, growth, and logistic. The model which shows less significance (<0.005) and error (<1) has been chosen as the best model.To develop a model, the authors have used 2012-2020 data. The model has been validated using 2021-2022 data.

The authors also wish to know the number of IMC, MVFR, and VMC cases during 2012-2022 over Trivandrum. For this purpose, they have classified the visibility cases as follows:

Case I: V<3 miles (IMC)

Case II: 3>V<5 miles (MVFR)

Case III: V>5 miles (VMC)

3. RESULTS AND DISCUSSIONS

3.1. Functional Relationship between RH and Visibility

The data are fitted into the curve estimation technique to establish a correlation between the RH and visibility. The model with less significance, high R^2, and less error has been chosen as a fit model.

Figure 2 shows the curve estimation tool for model development. The authors have checked the ANOVA table for analysis. At first, the data are entered into the tool. They have entered the relative humidity as an independent parameter. Then they checked the nine model's R^2, significance, and error.

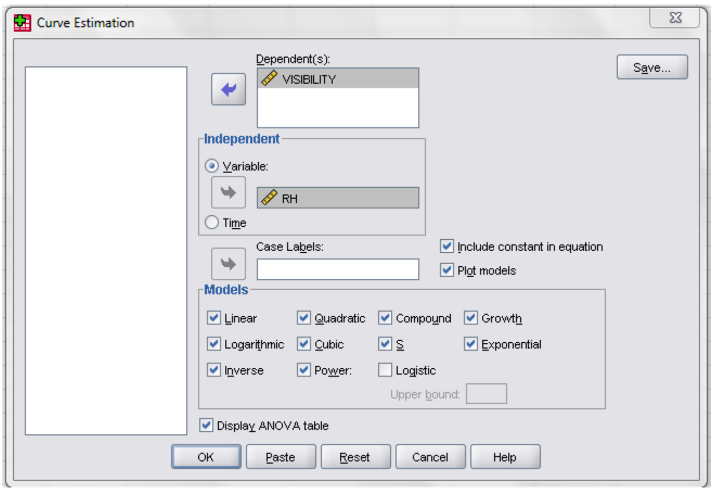

Fig. 2. Curve estimation tool

When the data from April 2012 to December 2020 are entered into the curve estimation technique, a linear relationship has been seen between them. Figure 3 shows the established functional relationship between visibility and relative humidity. The developed functional relationship has been validated over Trivandrum for January 2021-December 2022 data.

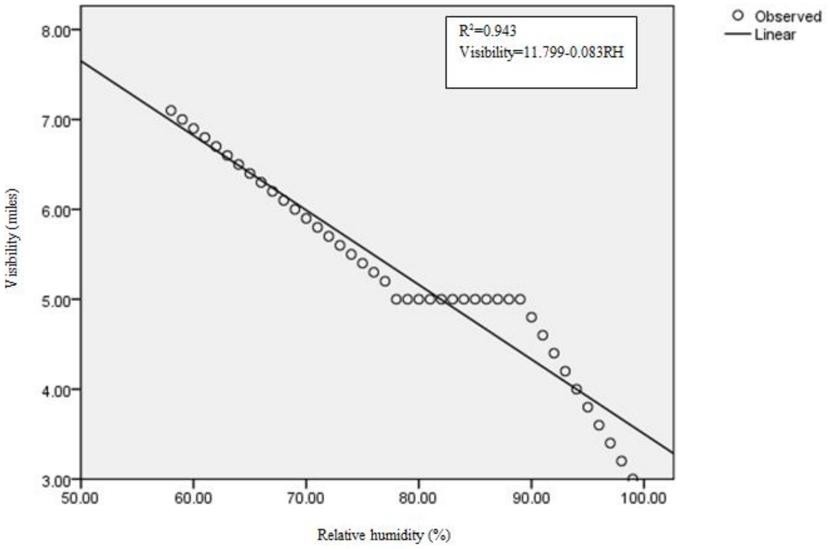

Fig. 3 Functional relationship between visibility and relative humidity over Trivandrum

The authors have validated the developed functional relationship between visibility and RH. Figure 4 shows the validation result for August 2021. The developed model has been matched well with the data obtained from the IGRA. The percentage error between these two is <2 %. Thus the authors have suggested the proposed model predicts visibility from RH, which will be helpful for the pilots and stop flight accidents.

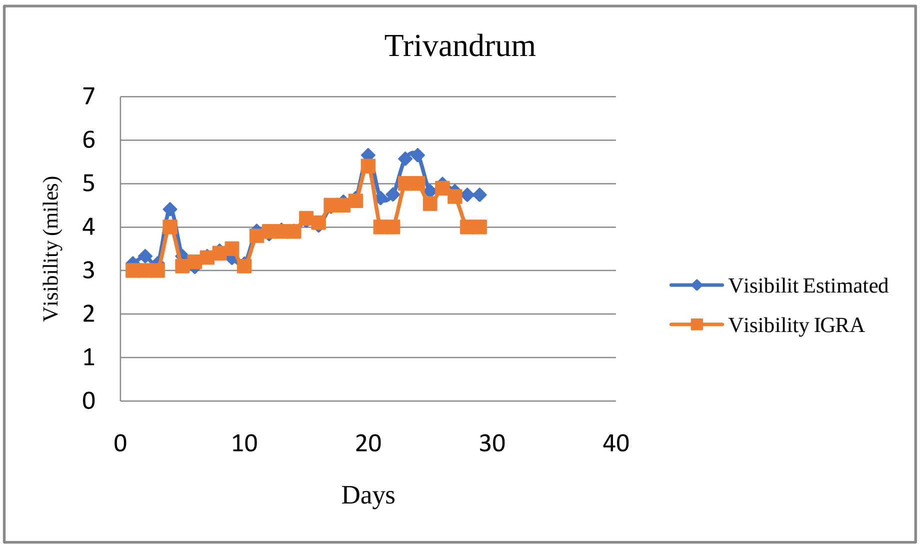

Fig. 4 Validation of visibility estimated from the proposed model and visibility retrieved from the IGRA over Trivandrum

To validate the result, the root mean square error (RMSE) and scatter index (SI) have been calculated over Trivandrum. The RMSE estimates the error between the visibility estimated from the proposed model and the visibility retrieved from the radiosonde, whereas the term SI judges the value of RMSE, i.e., it tells whether the developed model is efficient estimating the visibility or not. If the value of SI is less than 1, then the model is fit to evaluate the visibility. The RMSE and SI are obtained from (The Analysis factor, 2023).The RMSE of the established functional relationship is 0.56 miles.

Table 1 shows the percentage visibility cases under IMC, VMFR, and VMC over Trivandrum. The investigation shows that during 2012-2022, in Trivandrum, in 63.58 % of cases, the visibility is < 3 miles, in 29.8 % of cases, it is between 3-5 miles, and in 6.62 % of cases, it is above 5 miles.

Table 1 Percentage cases of visibility under IMC, MVFR, and VMC

IMC	MVFR	VMC
63.58 %	29.8 %	6.62 %

4. Conclusion

The functional relationship between visibility and relative humidity has been established over Trivandrum. The established functional relationship has been validated over Trivandrum from the IGRA data for 2021-2022. The visibility IGRA shows a good match with the visibility predicted from the proposed functional relationship. The percentage of error obtained between the visibility estimated from the proposed model and that obtained from the IGRA is less than 2 %. The RMSE of the established functional relationship is 0.56 miles. Thus the authors suggest using this functional relationship where the measurement is unavailable. This will help pilots to prevent flight accidents and aviation safety.

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