CHAPTER 7

SUMMARY AND CONCLUSION

7.1 SUMMARY

Statistical cyclone intensity prediction models tend to provide accurate predictions of tropical cyclone intensity compared to numerical weather prediction models. Though many such models have been developed for various ocean basins, the Indian Ocean has very few such models. Hence in this thesis an attempt has been made to develop a statistical prediction model using multiple linear regression technique to predict cyclone intensity up to 72 hours and increase prediction accuracy. Also a detailed study has been carried out to study the behaviour of each and every parameter with regard to cyclone intensity.

Application of the multiple linear regression formulae to the respective dataset of all the 41 cyclones (35 cyclones for formulation of model and 6 cyclones for testing) has resulted in intensity predictions whose summary is presented below.

The probable predictors such as SST, SMS, ISL, VWS, V850, D200, RH, TCHP and $\Sigma IC$ were subjected to best subset regression technique to select the potential predictors. Since TCHP did not influence the cyclone intensity directly and it only helped ocean to maintain its SST the same was not considered for model development. It was found in best subset regression that all other parameters were influencing cyclone intensity at some point of time or other. Based on the eight potential predictors multiple linear
regression model was developed for different prediction intervals, 12 hrs, 24hrs, 36hrs, 48hrs, 60 hrs and 72 hrs whose R² values are 46.9%, 39.7%, 51.4%, 71%, 92.1% and 97.2% respectively.

The AAE is ranging from 3 to 9 knots and 3 to 6 knots for the intensity prediction up to 36 hours for the dependent and independent cyclones respectively. The range varies from 11 to 18 knots for the higher prediction intervals. The RMSE value is ranging from 4 to 22 knots for the 35 dependent cyclones and 3 to 21 knots for the 6 independent cyclones.

7.2 CONCLUSION

The following conclusions are arrived based on the development of a statistical cyclone intensity prediction model for the Bay of Bengal region.

- The parameters, SMS, SST, ISL, VWS, V850, D200, RH and periodic intensity changes were found to be significantly affecting the final cyclone intensity on performing best subset regression, as indicated by the final intensity prediction equations.
- Among all eight parameters, considered for the model development $\Sigma IC$ is the prime contributing parameter influencing cyclone intensity.
- SST and D200 were highest contributing parameters in 12 hours (Table 5.1).
- ISL and D200 had significant impact on cyclone intensity in 24 hours (Table 5.2).
- V850 and D200 and $\Sigma IC$ play predominant role in influencing cyclone intensity in 36 hours (Table 5.3 and 6.3)
- SMS, VWS, D200, ISL, RH and $\Sigma IC$ are governing parameters in 48 hours (Table 5.4 and 6.4)
- D200, ISL, SST, VWS and $\sum$IC contribute to cyclone intensity in 60 hours (Table 5.5 and 6.5).
- SST, D200, ISL and $\sum$IC are deterministic parameters in influencing cyclone intensity in 72 hours (Table 5.6 and 6.6).
- The model (regression equations) so developed, is found to be quite robust at 36 hours and beyond, as confirmed by the $R^2$ values of the respective equations.
- The overall variance explained ($R^2$) for each multiple linear regression equation at different prediction intervals are 0-12 hrs ($R^2=46.9\%$), 0-24 hrs ($R^2=39.7\%$), 0-36 hrs ($R^2=51.4\%$), 0-48 hrs ($R^2=71\%$), 0-60 hrs ($R^2=92.1\%$) and 0-72 hrs ($R^2=97.2\%$).
- Percentage compliance of the predicted vs actual intensities of the dependent cyclones have improved significantly with a mean of among the approximately 106% (Table 6.11). The uniformity of percentage values around the said mean confirms that model is quite robust in its prediction.
- The range of percentage contribution by each parameters, up to 72 hrs are: SMS - 16 to 60%, SST - 3 to 21%, ISL - 19 to 42%, VWS - 0 to 13%, V850 - 0 to 20%, D200 - 23 to 43%, RH- 1 to 28% and $\sum$IC- 27 to 63%.
- Since this model is based on reanalysis data sets, with the improvement in resolution of the numerical weather prediction models in future, prediction accuracy can be improved.
- The model appears to be promising for operational applications in the Bay of Bengal.
- The influence of SMS on cyclone intensity is significant from 48 hours onwards.
- The ISL is positively correlated to intensity. This is so because the progressive latitudes determine influence of coriolis force on the storm.
• VWS less than 8 ms\(^{-1}\) helped cyclones to reach CS and VSCS stages. The model was tested with both NCEP and ECMWF ERA interim data sets and ERA interim was found to be reliable. However the same VWS tends to aid dissipation of the cyclone when the value reaches beyond 12 m/s.

• The influence of SST and D200 on cyclone intensity is high on higher prediction intervals (60 and 72 hours).

• Intensity tendencies are related to variations in TCHP, albeit not proportionally but negatively and indirectly. However, it is quite important that SST is maintained for the storm intensity build up.

• TCHP is positively correlated to SST for high (more than 60 KJ/cm\(^2\)) and low (less than 60 KJ/cm\(^2\)) conditions. However TCHP’ effective bandwidth lies between 30-80 KJ/cm\(^2\) for a corresponding SST bandwidth of 27-29.5 °C. This means, heat is absorbed by the storm from SST which in turn is rapidly fed by TCHP.

This study and research work was undertaken with the intention of finding a simple yet deterministic statistical forecasting methodology for prediction of cyclone intensity in BoB. In doing so, various influencing parameters and their behaviours were studied; data collected and analysed, to formulate a conclusive model for prediction. The statistical intensity prediction models developed for predicting cyclone intensity for progressive periodic intervals, have come closer in terms of their accuracy measurements and are also amenable for further research and improvements. This study has focused movements of cyclone in BoB sea region after cyclo-genesis and assumes prediction based on live datasets obtained from various satellites based applications, and ignores cyclones behavioural changes when it nears or crosses landmass. This study is considered as being a success because it has met its preset objectives.
7.3 SCOPE FOR FUTURE WORK

Following may be considered as future scope of work:

i) As brought out in conclusion, the effect of cyclone passing over landmass and hence its effect on intensity changes need to be studied, in relation to land parameters.

ii) These statistical models (equations) were developed taking into account 41 cyclones which had a reasonable life on sea i.e. beyond 24 hours. All these cyclones occurred over a period of 20 years, belonging to both pre-monsoon and post monsoon seasons. The availability of full and meaningful dataset of all related parameters, for all the cyclones proved to be a restricting factor. Prediction accuracy may improve if the same is analysed separately with more data for further periods.

iii) Reasons behind existence of a set of environmental conditions that lead to warmest SSTs in some locations need to be explored. Further their commonality or difference during pre and post monsoon periods need to be studied.