

**INTERCOMPARISON OF REAL-TIME
HIGHFLOW FORECASTING MODELS
FOR YAMUNA CATCHMENT**

by
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DEDICATED TO
DEAR NEERJA AND ROHINI

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CERTIFICATE

This is to certify that the thesis entitled, 'Intercomparison of Real-Time High-Flow Forecasting Models for Yamuna Catchment' being submitted by A.K.Gosain, to the Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy, is a record of bonafide research work carried out by him under my guidance and supervision. In my opinion, the thesis has reached the requisite standard fulfilling the requirements of the regulation relating to the said degree. The material contained in this thesis has not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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(iii)

SYNOPSIS

Real-time flood forecasting is an important non-structural method which can be utilized for reducing flood damages. Two important aspects of a forecast are its accuracy and its lead time. An accurate flood forecast well in advance can help the water managers in taking emergent actions to mitigate some of the adverse effects of flooding. The accuracy of the forecast depends mainly on the capability of the model to represent the system. On the other hand the forecast lead time depends primarily on the physiography of the catchment and on the telemetry of the input components essential for using the model. Therefore, the latter component, i.e., the forecast lead time, remains fixed for a catchment with a given hydrometeorologic/hydropetric system until and unless the system is updated to improve the information on input, e.g., the forecasted values of precipitation and/or runoff are used in the model.

The need for accurate and reliable forecasting has resulted in the development of variety of models. These models vary from very simple models based on simple correlation diagrams to the complex conceptual models of Stanford Watershed Type. Quite often, the availability of innumerable models for short-term forecasting creates difficulty for the user in choosing appropriate model.

This difficulty of the users was realised and the WMO proceeded with an evaluation and intercomparison of a specific category of models, viz., conceptual hydrological models used for short-term streamflow forecasting (WMO, 1975)). Besides conceptual models, there are many varieties of models used for the purpose of short-term streamflow forecasting. But, so far, no attempt has been made to carry out an intercomparison of these various categories of models. So it is decided to undertake such a study. In order to carry out this study three models, which belong to different categories and are commonly used, are selected. These being, a model based on unit hydrograph theory which is developed for the purpose of real time forecasting, an ARMAX (autoregressive moving average with exogeneous input) model and a conceptual model.

The first one, the UH (unit hydrograph) model, as name suggests, is based on unit hydrograph theory. Traditionally the unit hydrograph method required the availability of effective rainfall for its application. But in real time it is not feasible to fulfil this requirement. So, a procedure is developed whereby the total rainfall values and the current discharge information is used to compute the rainfall excess. The rainfall excess is convolved with the unit hydrograph to obtain the forecast hydrographs. The parameters of the model, i.e., the unit hydrograph ordinates,

remain fixed but the updating is done through changing the rainfall excess.

The second one, the ARMAX model is a stochastic model. The models of this category postulate that the future values of runoff at a point can be expressed in terms of some finite number of current and past values of runoff and rainfall. The data required for this model are the total rainfall, observed runoff and observed inflows (if required). The main features of this model are the simplicity in structure and the adaptability to upgrade the parameters.

The third model is a conceptual watershed model known as NWSRFS (National Weather Service River Forecast System) model. The model has many components but for this study only two of its components, i.e., the soil moisture accounting and runoff routing components have been used. The programme has been modified to run in real time forecasting mode. The soil moisture accounting portion of NWSRFS involves seventeen parameters. All these parameters have real physical significance and most of them can be evaluated from the past historical data whereas the others can be evaluated through calibration. As the model is deterministic the parameters are not supposed to change once calibrated but in this study, provision is made to account for the variability of rainfall by changing the time delay histogram.

The three models described above are used on an Indian catchment, namely, Yamuna catchment for the purpose of inter-comparison. The raw meteorological and hydrological data as available are not suitable for use as such in the models. The raw data have been processed, analysed and checked before it is utilized. This itself is an extensive project and is described adequately in the study. Once the data base as required collectively by these three models is ready, split sample procedure is used to divide the data into calibration and test data sets. The parameters of the models are determined using the calibration set. For example, the unit hydrograph required by the unit hydrograph model is derived, the order of the ARMAX model is determined, and the NWSRFS model is calibrated to evaluate the model parameters. The test set data is used to run the models in real-time forecasting mode.

The models belonging to different categories should be compared with respect to certain common criterion. In this study two criteria are used, one based on the accuracy of the forecasts and another based on the user's requirements of the model. With respect to the second criterion, Chander and Kumar (1982) have suggested certain attributes to assess different types of models used for real time highflow forecasting. The attributes suggested by them are:

1. The model should be able to formulate a forecast of the desired quality with maximum lead time.
2. It should have the ability to update the parameters on the basis of the observed errors in the earlier forecasts.
3. The model should preferably be capable of operation with interrupted data sequences as forecasts may be needed only at highflows.
4. The requirement of the model in terms of computer storage should be as minimum as possible as it is more likely that the small computer systems are only available at the forecast sites.
5. Development and operation of the model should be possible with limited hydrometric/hydrometeorologic data as very limited data becomes available in extreme situations.

The capability of a forecast model can best be judged by its ability to formulate an acceptable forecast with maximum lead time. The three models have been compared with respect to the graphical and numerical criteria. This comparison reveals that with this criteria all the models on the whole perform equally well.

A comparison is also made with respect to the attributes which a general user desire the model to possess. With respect to this criteria, the UH model fared the best

followed by the ARMAX model in which the model identification is a tedious job. The NWSRFS model has the disadvantage of being a complex model which needs lot more expertise for its calibration and requires comparatively larger computer storage and run time than the other two models.

It is concluded that the user should keep into consideration the attributes defined above while making the choice of the model. It is also observed that the simple models possess most of these attributes. Therefore an attempt should be made to identify a model fulfilling maximum of these attributes.

TABLE OF CONTENTS

	Page
CERTIFICATE	(i)
ACKNOWLEDGEMENT	(ii)
SYNOPSIS	(iii)
TABLE OF CONTENTS	(ix)
LIST OF TABLES	(xiv)
LIST OF ILLUSTRATIONS	(xvi)
CHAPTER 1	1
1. INTRODUCTION	2
1.1 General	2
1.2 Statement and Objectives of the Problem	2
1.3 Outline of the Study	3
CHAPTER 2	7
2. LITERATURE REVIEW OF RAINFALL-RUNOFF MODELLING AND SELECTION OF THE MODELS	8
2.1 Introduction	8
2.2 Rainfall-Runoff Modelling - A Literature Review	8
2.2.1 Physics Based Models	10
2.2.2 Input-Output or 'Black-box' Models	12
2.2.3 Water Balance Models	24
2.3 Selection of the Models for the Study	33
CHAPTER 3	35
3. THE YAMUNA CATCHMENT	36
3.1 Physical Hydrology	36
3.2 Hydrometric Network	38
3.3 Justification of Modelling the Upper Yamuna catchment only	40
3.4 The Need to Subdivide the Upper Yamuna Catchment	40

(x)

	Page
COLLECTION, QUALITY, VALIDATION AND PROCESSING OF DATA	56
4.1 Introduction	56
4.2 The Collection of Data	58
4.2.1 The Type of Data required for the Study	58
4.2.2 The Sources of the Collected Data	61
4.2.3 The Existence and Availability of Data	61
4.2.3.1 Length of Records	61
4.2.3.2 Discontinuous and Missing Data	62
4.2.4 The Form of the Collected Data	63
4.2.4.1 Rainfall Data	63
4.2.4.2 Runoff Data	63
4.2.4.3 Evapotranspiration Data	64
4.3 The Quality of the Data	65
4.3.1 Errors in Rainfall Data	65
4.3.2 Errors in Runoff Data	66
4.3.3 Representativeness of the Collected Data	67
4.4 The Validation of the Data	69
4.4.1 Rainfall Data	70
4.4.2 Runoff Data	71
4.5 Computer-based Data Processing	71
4.5.1 The Necessity of Computer-based Data Handling	71
4.5.2 Data Preparation for Input to the Computer	73
4.5.2 Processing of the Data	75

	Page
4.5.3.1 Infilling Missing Records of Rainfall Data	76
4.5.3.2 The Assessment of Mean Areal Rainfall	77
4.5.3.3 Derivation of Stage-Discharge Curves	78
4.5.3.4 Conversion of Stages to Discharges	79
CHAPTER 5	98
5. THE ANALYSIS OF DATA	99
5.1 Separation of the Data into Calibration Set and Test Set	99
5.2 Recognition of Typical Rainfall Patterns and Storm Movement	99
5.3 The Importance of Various Subcatchments for Flood Forecasting	101
5.3.1 The Giri to Dadahu	102
5.3.2 The Tons to Koti	103
5.3.3 The Yamuna to Lakhwar	103
5.3.4 The Catchment Between Dadahu, Koti, Lakhwar and Kalanaur	104
5.4 Flood Wave Travel Times	106
6. REAL-TIME FLOOD FORECASTING	135
6.1 Introduction	135
6.2 Real-time Field Conditions and Their Effect on Model Performance	136
6.2.1 Sampling Time Interval for Data Collection	136
6.2.2 Availability of Data at the Time of Forecast	137
6.2.3 Missing Data	138
6.2.4 Difficulty in Applying Quality Control to Data	138
6.2.5 Time Lost in Preparing the Forecast	138
6.2.6 Type of Forecast needed	139
6.2.7 Forecast Lead Time	140

	Page
6.3 The Simulation of Real-Time Conditions	140
7. CATCHMENT MODELLING	145
7.1 Unit Hydrograph (UH) Model	145
7.1.1 Theoretical Basis of UH Model	145
7.1.2 Technique of Calibrating the Model	147
7.1.3 Calibrating the Model on the Sub-catchment	150
7.1.4 Real-time Forecasting with Unit Hydrograph Model	152
7.1.5 Methods by Which Forecasts can be Improved	156
7.1.6 Scope of Revising the Test Data Set	158
7.1.7 Forecasting with Additional Test Events.	158
7.2 The ARMAX Model	180
7.2.1 Theoretical Basis of ARMAX Model	180
7.2.2 Model Identification and Parameter Estimation	180
7.2.3 Model Identification for the Sub-Catchment	183
7.2.4 Using the Model for Real-time Forecasting	184
7.2.5 Improvement of the Forecasts	187
7.2.6 Revising the Test Data Set and Forecasting with Additional Events	188
7.3 The NWSRFS Model	209
7.3.1 Basis of the NWSRFS Model	209
7.3.2 Structure of the NWSRFS Model	211
7.3.3 Model Calibration Procedure	215
7.3.4 Calibrating the Model on the Sub-Catchment	226
7.3.5 Using the Model for Real-Time Forecasting	229
7.3.6 Improving the Forecasts.	230

	Page
CHAPTER 8	255
8. COMPARISON OF THE MODELS AND CONCLUSIONS	255
8.1 Comparison of the Models	255
8.1.1 The Criteria for Comparing the Models	255
8.1.1.1 Criteria based on accuracy of the forecasts	256
8.1.1.2 Criteria based on requirements of the user	258
8.2 Discussion of Results	260
8.2.1 Evaluation on the Basis of 'Accuracy of the Forecast' criteria	260
8.2.1.1 Graphical criterion	261
8.2.1.2 Numerical Criteria	264
8.2.2 Evaluation on the basis of 'the User's Requirements' criterion	267
8.3 Summary of Conclusions	271
REFERENCES	304
APPENDIX	
'A' - Sample Input	317
'B' - Data Description	318

LIST OF TABLES

Table		Page
3.1	Mean monthly and annual values of rainfall (cms) (1951-58) on the Yamuna catchment	43
3.2	Theissen weights for different sub-catchments of Upper Yamuna catchment	44
4.1	Data sources	80
4.2	Availability of daily rainfall data for the Yamuna catchment (percentages)	81
4.3	Availability of hourly rainfall data at self-recording stations on the Yamuna catchment (percentages)	83
4.4	Availability of hourly gauge readings on the Yamuna catchment (percentages)	84
4.5	Form of runoff data collected for the Yamuna catchment	85
4.6	Potential evapotranspiration data available in Upper Yamuna catchment	86
4.7	Discrepancies between summed hourly values and daily totals given by check gauges (Yamuna catchment above Kalanaur)	87
4.8	Rainfall data-Input FORMAT	88
4.9	Runoff data - Input FORMAT	90
4.10	Procedure for interpolation of missing rainfall data	91
4.11	Procedure for the derivation of rating curve	93
5.1	The contribution of catchment upstream of Dadahu, Koti and Lakhwar to peak at Kalanaur (m ³ /sec)	107
7.1.1	Unit hydrograph (1mm, 3 hour) ordinates used for testing the model	160

LIST OF TABLES (contd....)

Table		Page
7.1.2	Improvement achieved in forecasts through proper choice of initial lag using UH model (only three hours ahead forecasts considered)	161
7.2.1	Comparison of sum of squares error using different order of ARMAX model using forecast lead time of six hours	190
7.2.2	Initial parameters and error covariance matrix of Event 19.8.76 used for forecasting (ARMAX(1,2,1))	191
7.2.3	Improvement achieved in forecasts through proper choice of initial lag using the ARMAX model	192
7.3.1	Model parameters and their description	232
7.3.2	Initial estimates of parameters and the final estimates after manual optimisation	234
7.3.3	Derivation of Time-delay-histogram for the subcatchment Dadahu, Koti, Lakhwar and Kalanaur	235
7.3.4	Improvement achieved in forecasts through proper choice of time-delay-histogram in the NWSRFS model	236
8.1	Comparison of UH, ARMAX and NESRFS models with respect to the numerical criteria using test events for different lead times (3,6,9 and 12 hours)	275
8.2	Comparison of the UH and ARMAX models with respect to the numerical criteria using additional test events.	276
8.3	Comparison of the UH, ARMAX and NWSRFS models with respect to the relative error between peak and time to peak of observed and computed discharges	277

LIST OF ILLUSTRATIONS

Figure	Page
3.1 Yamuna catchment to Delhi Hydrometric Network	46
3.2 Longitudinal section of Yamuna river and its tributaries	47
3.3 Tracks of some important depressions responsible for devastating floods in Yamuna river	48
3.4 Yamuna catchment to Kalanaur:- sub-catchments	49
3.5 Yamuna catchment to Kalanaur - Theissen Polygons	50
3.6 - Runoff Response at Kalanaur due to rainfall	51-
3.7 in Yamuna catchment	52
3.8- Yamuna catchment above Kalanaur Isohyets (mm)	53-
3.9	54
4.1 Stage-discharge curves at Dadahu for Monsoon seasons 1976 to 1977	95
4.2 Stage discharge curve at Lakhwar for Monsoon seasons 1976 to 1978	96
4.3 Stage discharge curve at Kalanaur for Monsoon season 1978	97
5.1 Yamuna catchment above Kalanaur Isohyets (mm) (Event 20.7.76)	108
5.2 Yamuna catchment above Kalanaur Isohyets (mm) (Event 26.7.76)	109
5.3 Yamuna catchment above Kalanaur Isohyets (mm) (Event 29.7.76)	110
5.4 Yamuna catchment above Kalanaur Isohyets (mm) (Event 26.7.77)	111
5.5 Yamuna catchment above Kalanaur Isohyets (mm) (Event 1.8.77)	112
5.6 Yamuna catchment above Kalanaur Isohyets (mm) (Event 8.9.77)	113
5.7- Yamuna catchment above Kalanaur	114-
5.14 Isohyets (mm) (Event 19.9.76)	121

Figure		Page
5.15-	Yamuna catchment above Kalanaur	122-
5.18	Isohyets (mm) (Event 23.7.77)	125
5.19	High flow event: R.Giri at Yashwant Nagar and Dadahu (Event 26.7.76)	126
5.20	High flow event: R.Giri at Yashwant Nagar and Dadahu (Event 19.8.76)	127
5.21	High flow events: R.Pabar at Tuini and R.Tons at Tuini and Koti	128
5.22	High flow events: Yamuna at Damta and Lakhwar	129
5.23	Upper catchment contribution to high flow events at Kalanaur (Events 20.7.76 and 26.7.76)	130
5.24	Upper catchment contribution to high flow events at Kalanaur (Event 19.8.76)	131
5.25	Upper catchment contribution to high flow events at Kalanaur (Events 1.8.77 and 4.8.77)	132
5.26	Upper catchment contribution to high flow events at Kalanaur (Event 13.9.77)	133
6.1	Schematic diagram showing typical sequence of events during flood forecasting situation	143
7.1	Unit hydrographs (1 Hour, 1mm) for Dadahu, Koti, Lakhwar to Kalanaur	162
7.2	Unit hydrographs (1 Hour, 1mm) for Dadahu, Koti, Lakhwar to Kalanaur	163
7.3	Derivation of mean unit hydrograph (1 mm, 1hr) by matching the peaks of unit hydrographs of the two cases for Dadahu, Koti, Lakhwar to Kalanaur	164

Figure		Page
7.4	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 9.7.78, initial lag = 6 hrs)	165
7.5	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 2.8.78, Initial lag = 6 hrs)	166
7.6	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 5.8.78, Initial lag = 6 hrs)	167
7.7	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 19.8.78, Initial lag = 6 hrs)	168
7.8	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 2.8.78, Initial lag = 3 hrs)	169
7.9	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 19.8.78, Initial lag = 3 hrs)	170
7.10	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 20.7.76, Initial lag = 6 hrs)	171
7.11	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 26.7.76, Initial lag = 6 hrs)	172
7.12	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 19.8.76, Initial lag = 6 hrs)	173
7.13	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 3.8.77, Initial lag = 6 hrs)	174
7.14	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 8.9.77, Initial lag = 6 hrs)	175
7.15	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 13.9.77, Initial lag = 6 hrs)	176

(xix)

Figure		Page
7.16	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 20.7.76, Initial lag = 3 hrs)	177
7.17	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 26.7.76, Initial lag = 3 hrs)	178
7.18	3,6,9 & 12 hours ahead forecasts at Kalanaur using UH model (Test event 8.9.77, Initial lag = 3 hrs)	179
7.19	Serial correlations of residuals using ARMAX (1,2,0) and ARMAX (1,2,1) on event 19.8.76	193
7.20	3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 9.7.78, Initial lag = 6 hrs)	194
7.21	3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 2.8.78, Initial lag = 6 hrs)	195
7.22	3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 5.8.78, Initial lag = 6 hrs)	196
7.23	3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 19.8.78, Initial lag = 6 hrs)	197
7.24	3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 2.8.78, Initial lag = 3 hrs)	198
7.25	3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 19.8.78, Initial lag = 3 hrs)	199
7.26	3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 20.7.76, Initial lag = 6 hrs)	200
7.27	3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 26.7.76, Initial lag = 6 hrs)	201

(xx)

Figure	Page
7.28 3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Calibration event 19.8.76, Initial lag = 6 hrs)	202
7.29 3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 3.8.77, Initial lag = 6 hrs)	203
7.30 3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 8.9.77, Initial lag = 6 hrs)	204
7.31 3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 13.9.77, Initial lag = 6 hrs)	205
7.32 3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 20.7.76, Initial lag = 3 hrs)	206
7.33 3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 26.7.76, Initial lag = 3 hrs)	207
7.34 3,6,9 & 12 hours ahead forecasts at Kalanaur using ARMAX model (Test event 8.9.77, Initial lag = 3 hrs)	208
7.35 Schematic diagram of NWSRFS catchment model (Sacramento) (after Peck, 1976)	237
7.36 Hydrograph for determination of LZTWM	238
7.37 Percolation representation (after Peck, 1976)	239
7.38 Calculation of primary parameters for Yashwant Nagar, a subcatchment of Yamuna	240
7.39 Calculation of supplemental parameters for Yashwant Nagar	241
7.40 Simulation at Kalanaur using NWSRFS Model (Calibration event 20.7.76)	242
7.41 Simulation at Kalanaur using NWSRFS Model (Calibration event 26.7.76)	243

Figure		Page
7.42	Simulation at Kalanaur using NWSRFS Model (Calibration event 19.8.76)	244
7.43	Simulation at Kalanaur using NWSRFS Model (Calibration event 3.8.77)	245
7.44	Simulation at Kalanaur using NWSRFS Model (Calibration event 8.9.77)	246
7.45	Simulation at Kalanaur using NWSRFS Model (Calibration event 13.2.77)	247
7.46	6 and 12 hours ahead forecasts at Kalanaur using NWSRFS model (Test event 9.7.78) TDH-0.049,0331,0.620	248
7.47	6 and 12 hours ahead forecasts at Kalanaur using NWSRFS model (Test event 2.8.78) TDH-0.049,0331,0620	249
7.48	6 and 12 hours ahead forecasts at Kalanaur using NWSRFS model (test event 5.8.78) TDH- 0.049,0331,0620	250
7.49	6 and 12 hours ahead forecasts at Kalanaur using NWSRFS model (Test event 19.8.78) TDH-0.049,0331,0620	251
7.50	6 and 12 hours ahead forecasts at Kalanaur using NWSRFS model (Test event 9.7.78) TDH-0.300,0673,0.027	252
7.51	6 and 12 hours ahead forecasts at Kalanaur using NWSRFS model (Test event 19.8.78) TDH-0.300,0.673,0.027	253
8.1	Scatter diagram of 6 hours ahead forecasts using UH model	278
8.2	Scatter diagram of 6 hours ahead forecasts using ARMAX model	279
8.3	Scatter diagram of 6 hours ahead forecasts using NWSRFS model	280
8.4	Scatter diagram of 12 hours ahead forecasts using UH model	281

Figure		Page
8.5	Scatter diagram of 12 hours ahead forecasts using ARMAX model	282
8.6	Scatter diagram of 12 hours ahead forecasts using NWSRFS model	283
8.6.1	Scatter diagram of 3 hours ahead forecasts using UH, ARMAX and NWSRFS Models (events 9.7.78, 2.8.78, 5.8.78, 19.8.78)	284
8.6.2	Scatter diagram of 6 hours ahead forecasts using UH, ARMAX and NWSRFS Models (events 9.7.78, 2.8.78, 5.8.78 and 19.8.78)	285
8.6.3	Scatter diagram of 9 hours ahead forecasts using UH, ARMAX, and NWSRFS Models (events 9.7.78, 2.8.78, 5.8.78, and 19.8.78)	286
8.6.4	Scatter diagram of 12 hours ahead forecasts using UH, ARMAX, and NWSRFS Models (events 9.7.78, 2.8.78, 5.8.78 and 19.8.78)	287
8.7	Scatter diagram of 3 hours ahead forecasts using UH model (Initial lag = 6 hrs)	288
8.8	Scatter diagram of 3 hours ahead forecasts using ARMAX model (initial lag = 6 hrs)	289
8.9	Scatter diagram of 6 hours ahead forecasts using UH model (Initial lag = 6 hrs)	290
8.10	Scatter diagram of 6 hours ahead forecasts using ARMAX model (Initial lag = 6 hrs)	291
8.11	Scatter diagram of 9 hours ahead forecasts using UH model (Initial lag = 6 hrs)	292
8.12	Scatter diagram of 9 hours ahead forecasts using ARMAX model (Initial lag = 6 hrs)	293
8.13	Scatter diagram of 12 hours ahead forecasts using UH model (Initial lag = 6 hrs)	294
8.14	Scatter diagram of 12 hours ahead forecasts using ARMAX model (Initial lag = 6 hrs)	295

Figure		Page
8.15	Scatter diagram of 3 hours ahead forecasts using UH model (Initial lag = 3 hrs)	296
8.16	Scatter diagram of 3 hours ahead forecasts using ARMAX model (initial lag = 3 hrs)	297
8.17	Scatter diagram of 6 hours ahead forecasts using UH model (Initial lag = 3 hrs)	298
8.18	Scatter diagram of 6 hours ahead forecasts using ARMAX model (Initial lag = 3 hrs)	299
8.19	Scatter diagram of 9 hours ahead forecasts using UH model (Initial lag = 3 hrs)	300
8.20	Scatter diagram of 9 hours ahead forecasts using ARMAX model (initial lag = 3 hrs)	301
8.21	Scatter diagram of 12 hours ahead forecasts using UH model (initial lag = 3 hrs)	302
8.22	Scatter diagram of 12 hours ahead forecasts using ARMAX model (initial lag = 3 hrs)	303