Rainfall Runoff Modeling

Using Doppler Weather Radar

For Adyar Watershed, Chennai

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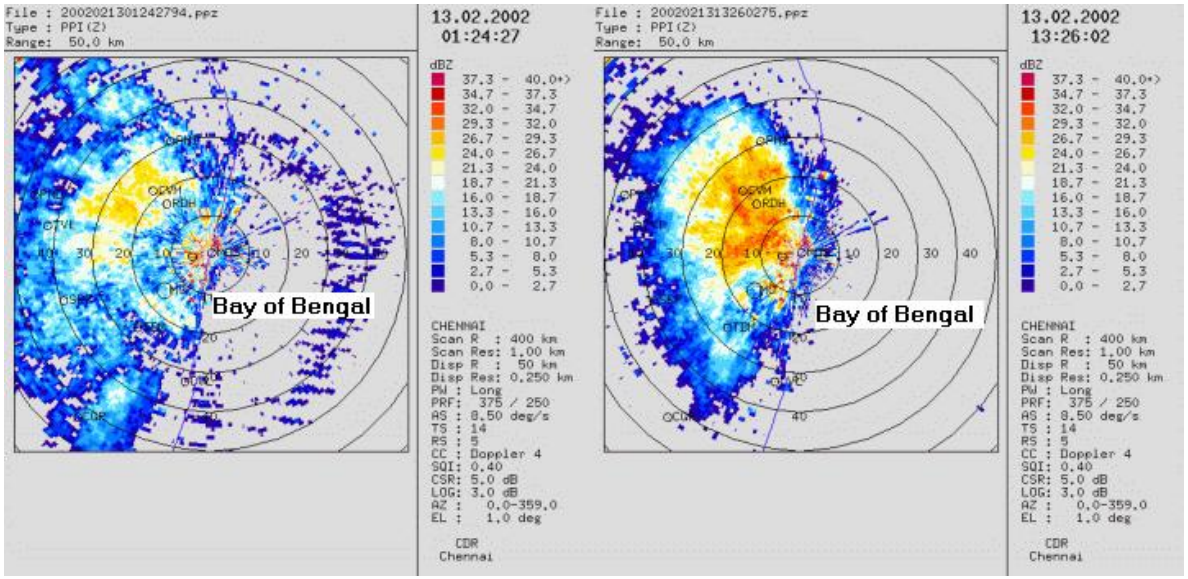
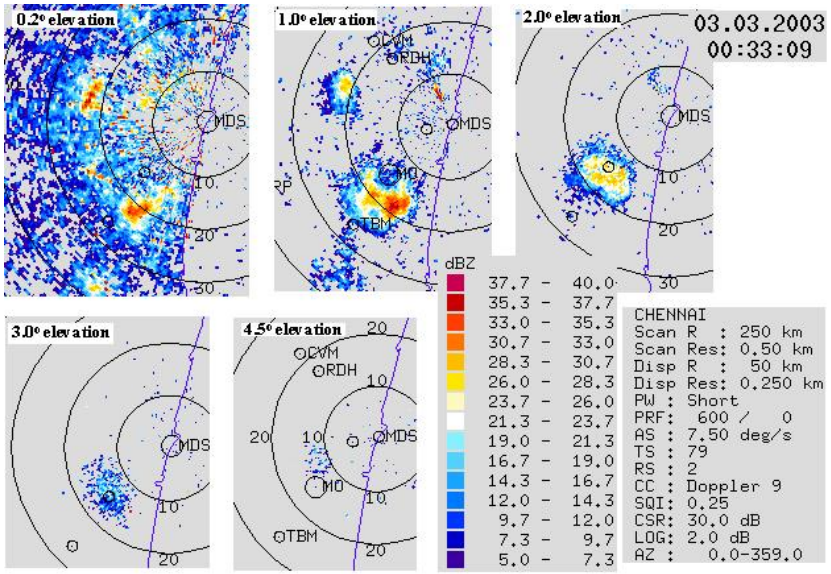
AGENDA

- Need For The Research
- Objectives
- Introduction
- DWR Products And Z-R Relationship
- Advantages And Disadvantages
- Methodology
- Study Area Selection
- HEC-HMS Model
- Results And Discussion
- Conclusion & Future Research Recommendations

NEED FOR THE RESEARCH





Was it raining around Chennai during December 2002-March 2003?

- **During late December 2002 – March 2003, reflectivity as high as 28-38 dBZ was observed around Chennai.**
- **It would have been as if 20-60cm rainfall received over an of about 600-1600 sq. km around Chennai during Jan – Mar2003.**

But there was no report of rainfall from Met. office/ public over these areas.

OBJECTIVES

- Simulate the rainfall-runoff process with HEC-HMS using conventional rain gauge data.
- Simulate the rainfall-runoff process with HEC-HMS using radar derived rainfall data.
- Compare the capability of the two different measurement systems in order to give correct input to derive rainfall-runoff model.

Data Collection:

- State Ground and Surface Water Resources Data Centre(PWD), and India Meteorological Department (IMD) for rain gauge data.
- Cyclone Deduction Radar Centre (CDR), Port Trust, Chennai for radar derived rainfall data.

INTRODUCTION

- Precipitation is a significant input for hydrological models; so, it needs to be quantified precisely.

- At present, the measurement of rainfall in a watershed is based solely on rain gauges network - assumption that it is uniform over the area - under or over estimation of runoff.

- There are numerous papers showing the improvements in flood estimation and flood forecasting using radar rainfall as the input data to the hydrological models.

- Limited studies are carried out in India to utilize the weather radar products for hydrological purposes.

- Utilization of DWR products for hydrological purposes similar to rainfall-runoff modeling, flood forecasting, flood zone mapping, and R&D activities.

DWR Products and Z-R Relationship

CDR provides continuous data on various meteorological parameters;

- Rainfall Data (SRI and PAC)
- Wind speed and Wind direction
- Temperature
- Humidity
- Air pressure
- Visibility

$$Z = A R^{b}$$

Z - Measured Radar Reflectivity in mm^6/m^3

R - Rain rate at ground level in mm/hr

A, b are constant and it varies from place to place, time to time and for different types of rainfall events.

Radar operating in the CDR, Chennai Port Trust has the following Z-R Relationship,

$$Z = 267 R^{1.345}$$

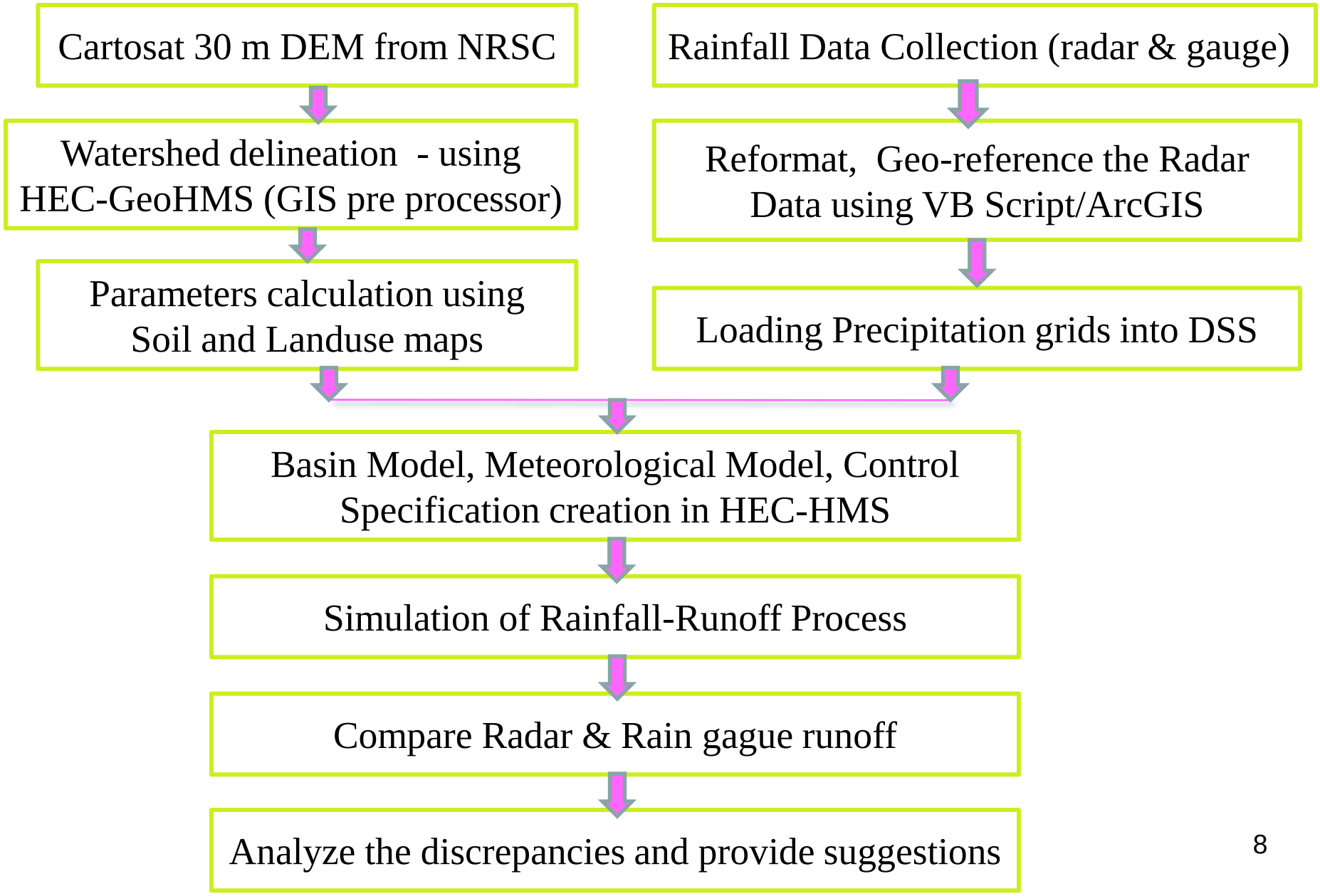
Error due to Ground clutter, Attenuation, Bright band and Vertical profile need to be corrected.

ADVANTAGES AND DISADVANTAGES

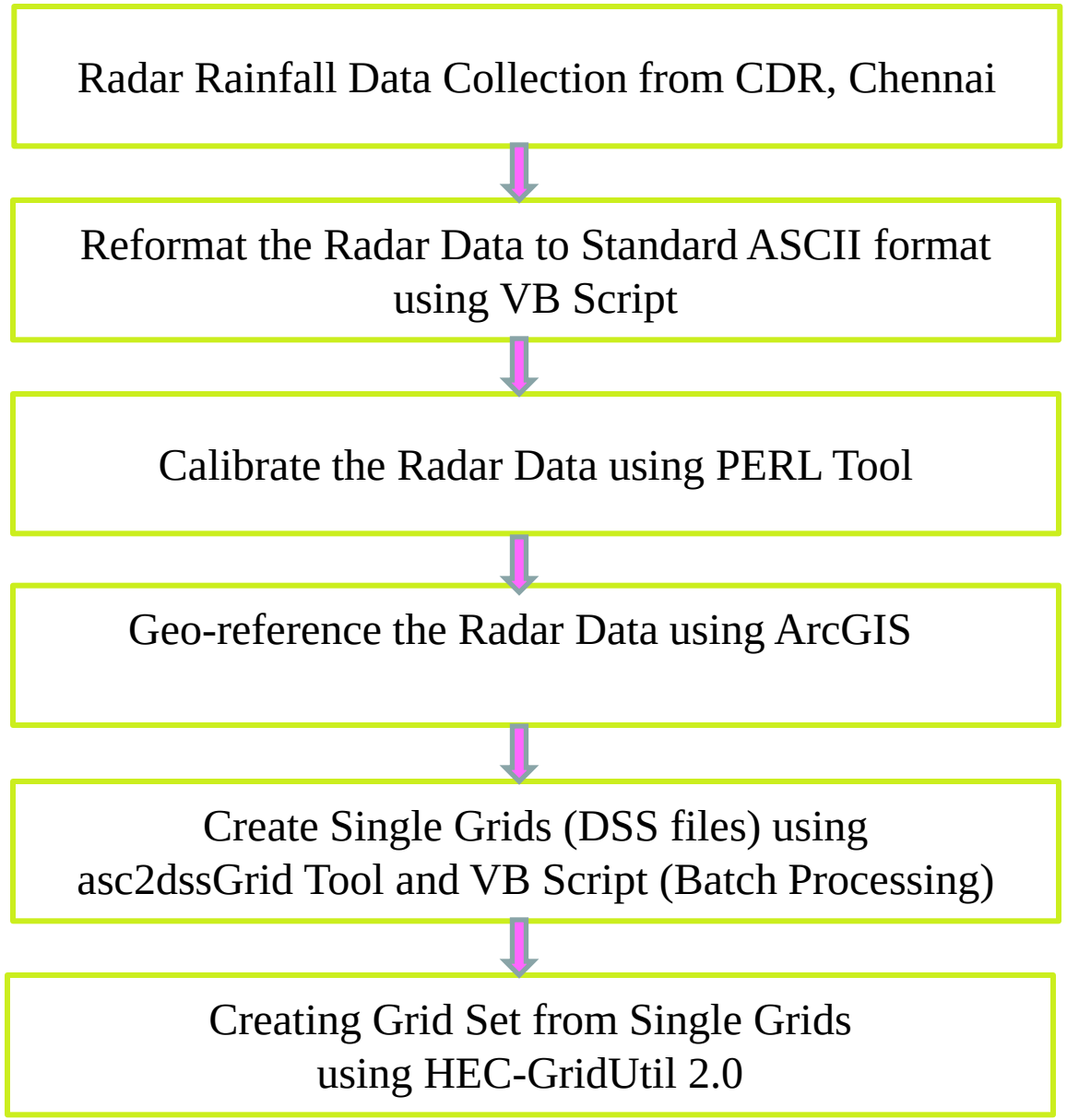
- The weather radar, which is a widely used basis for rainfall estimation at fine spatial and temporal resolutions, can better capture the spatial variation of rainfall fields than rain-gage rainfall data, in areas where rain-gages are distributed sparsely.
- Approaching storms can sometimes be observed before they reach the catchments of interest.
- It can be used as a forecasting tool for flash flooding and severe thunderstorm.
- It can supplement the existing rain-gages.
- It determines the intensity of precipitation.
- It helps to plan watershed management, based on the rain estimation over the catchments.

- The weather radar does not measure rainfall directly; algorithms are used to estimate the rainfall from radar observations. The radar data requires vigorous quality control before being converted into precipitation products that can be used as input to hydrologic models.

METHODOLOGY



METHODOLOGY – Radar Data Processing



Original Radar Data

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File Edit Format View Help

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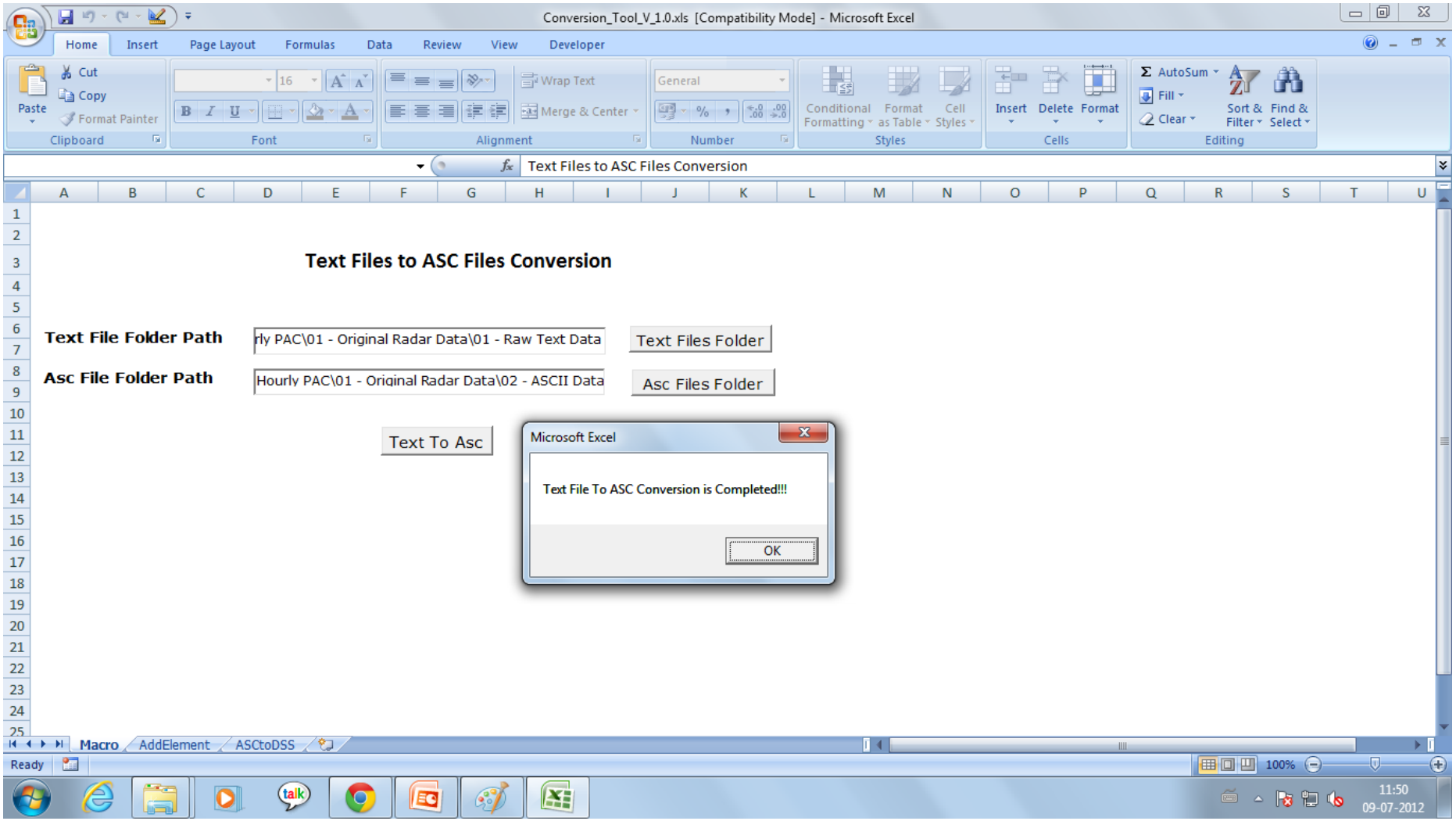
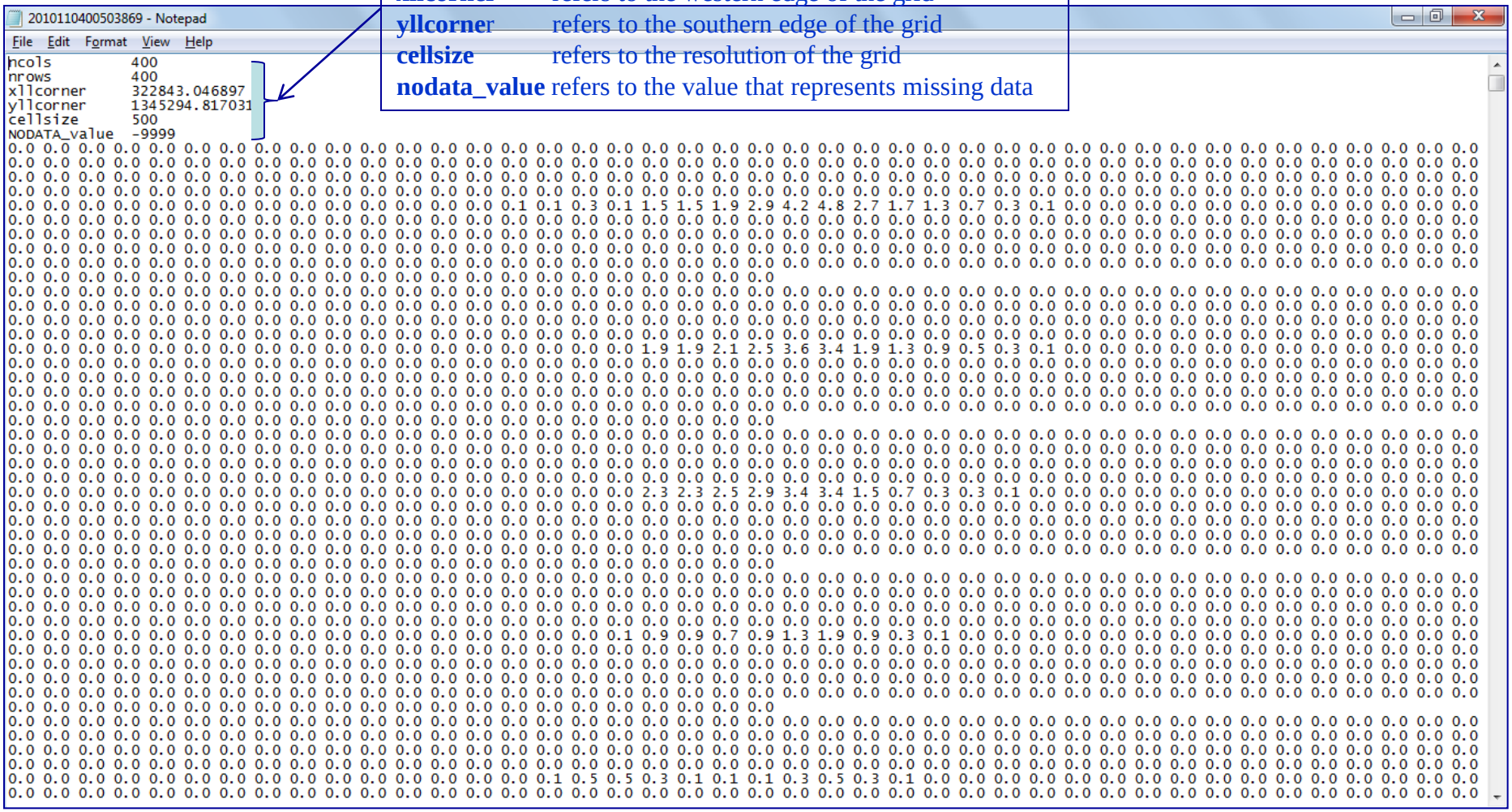
Text Files to ASCII Data Conversion

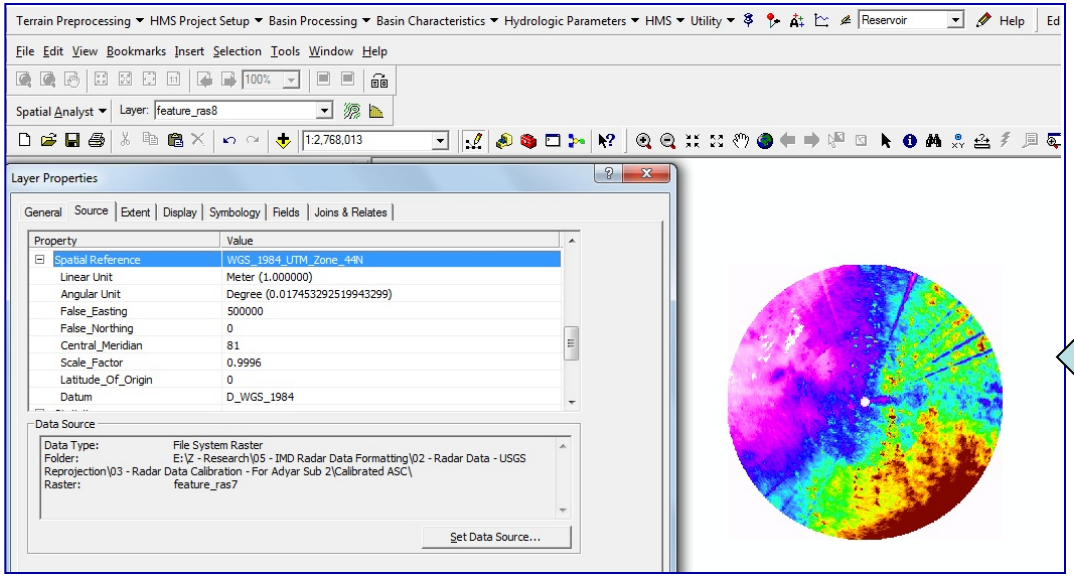


ASCII Radar Data

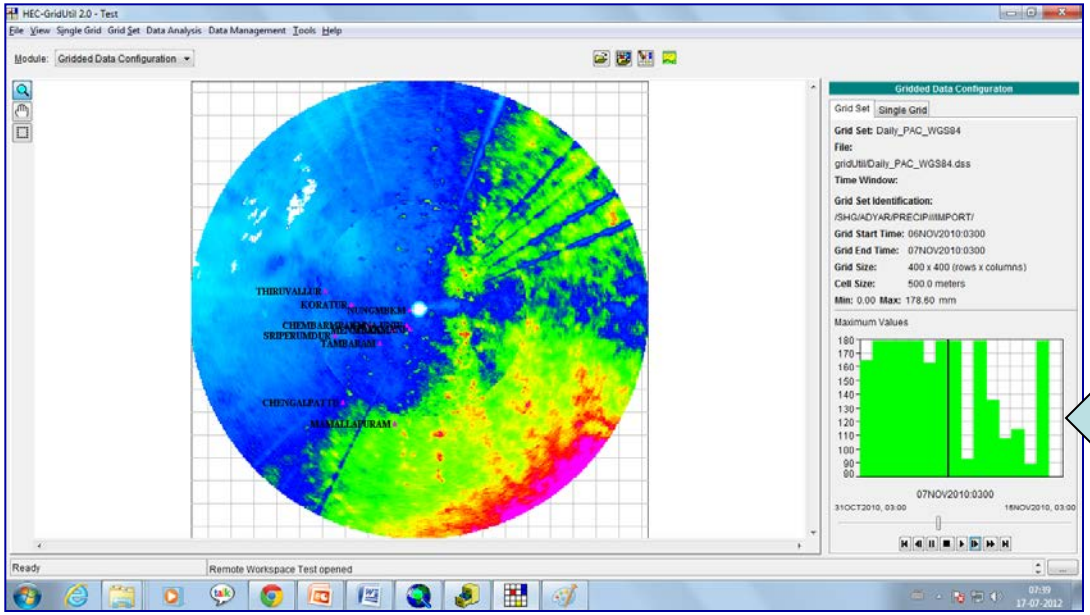
ncols	refers to the number of columns in the grid
nrows	refers to the number of rows in the grid
xllcorner	refers to the western edge of the grid
yllcorner	refers to the southern edge of the grid
cellsize	refers to the resolution of the grid
nodata_value	refers to the value that represents missing data



Radar Data – Projection

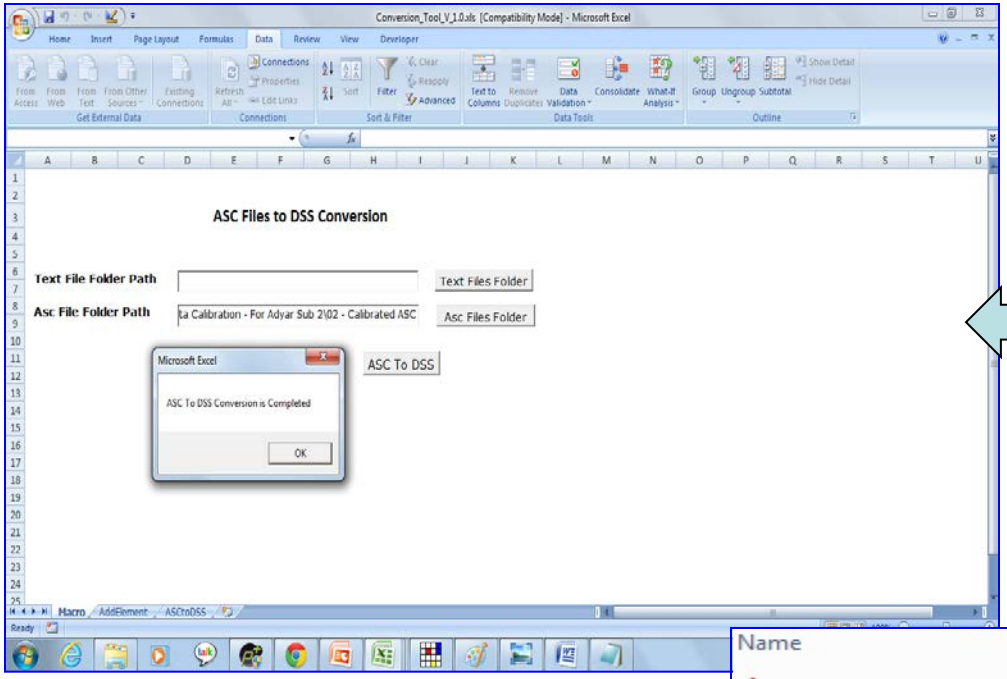


Radar Data Projection - ArcGIS



Radar Data Projection – HEC-GridUtil 2.0

ASCII Data to DSS(Single Grids) Conversion



Using asc2dssGrid Utility and VBScript (for Batch Processing)

Name	Date modified	Type	Size
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PACnov0304_01	09-07-2012 14:21	DSS File	102 KB
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PACnov0809_01	09-07-2012 14:22	DSS File	90 KB
PACnov0910_01	09-07-2012 14:22	DSS File	118 KB
PACnov1011_01	09-07-2012 14:22	DSS File	102 KB
PACnov1112_01	09-07-2012 14:22	DSS File	69 KB
PACnov1213_01	09-07-2012 14:22	DSS File	40 KB
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PACnov1415_01	09-07-2012 14:22	DSS File	98 KB
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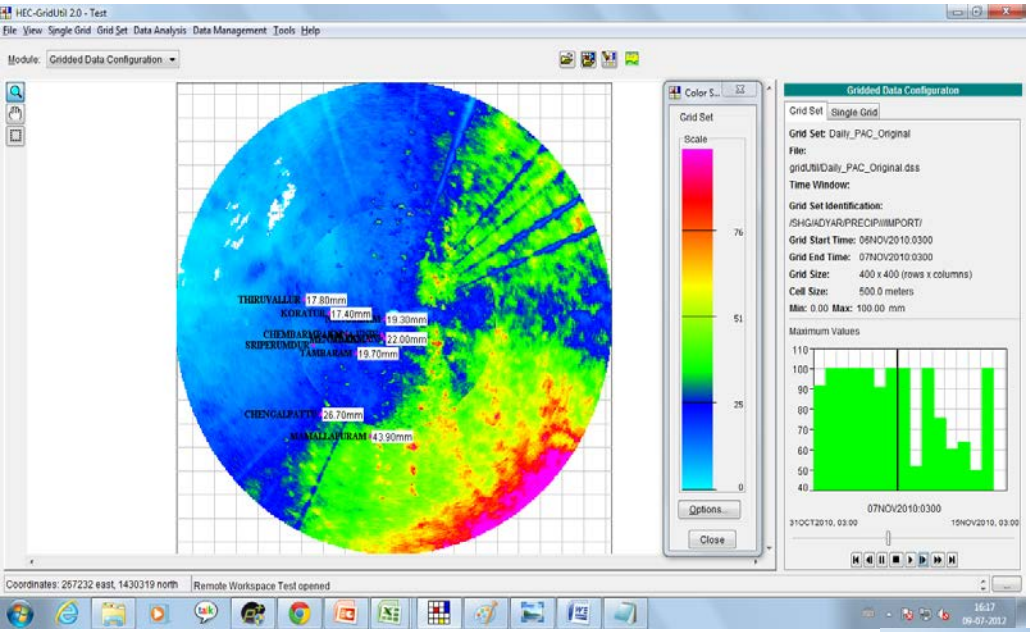
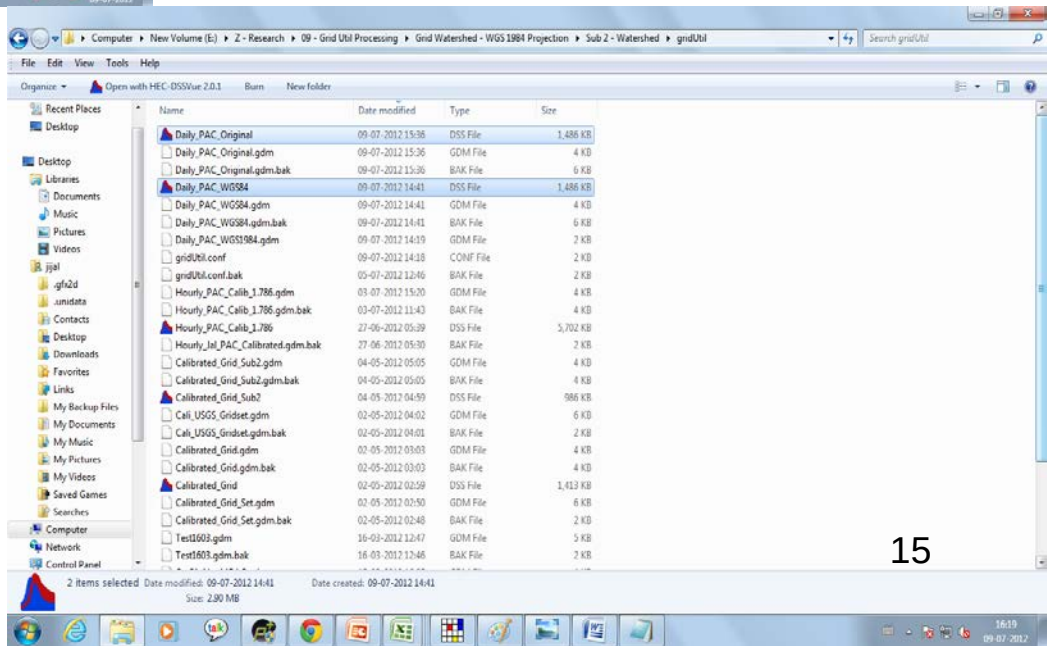
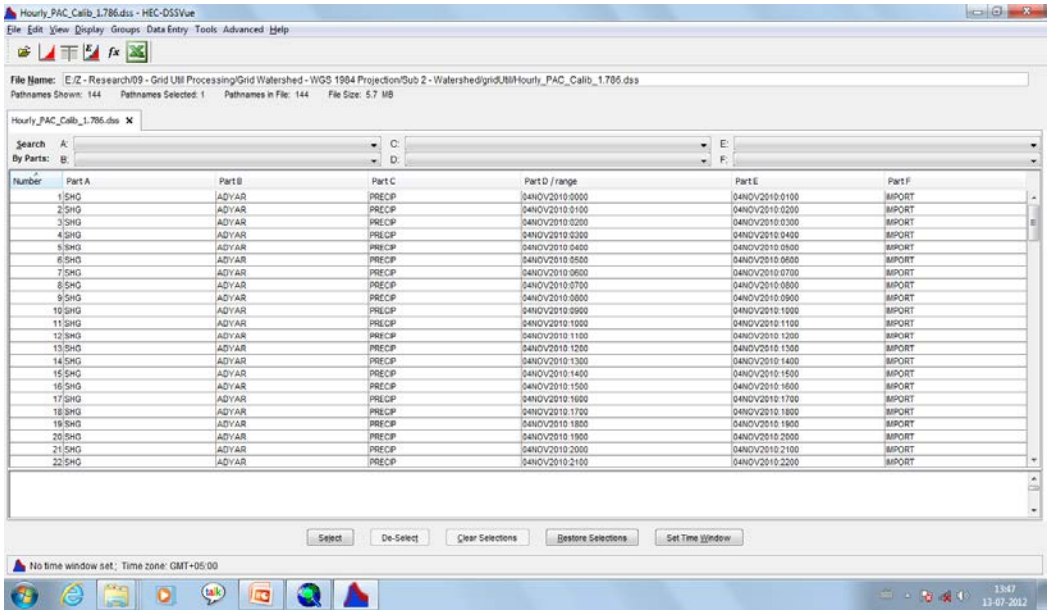
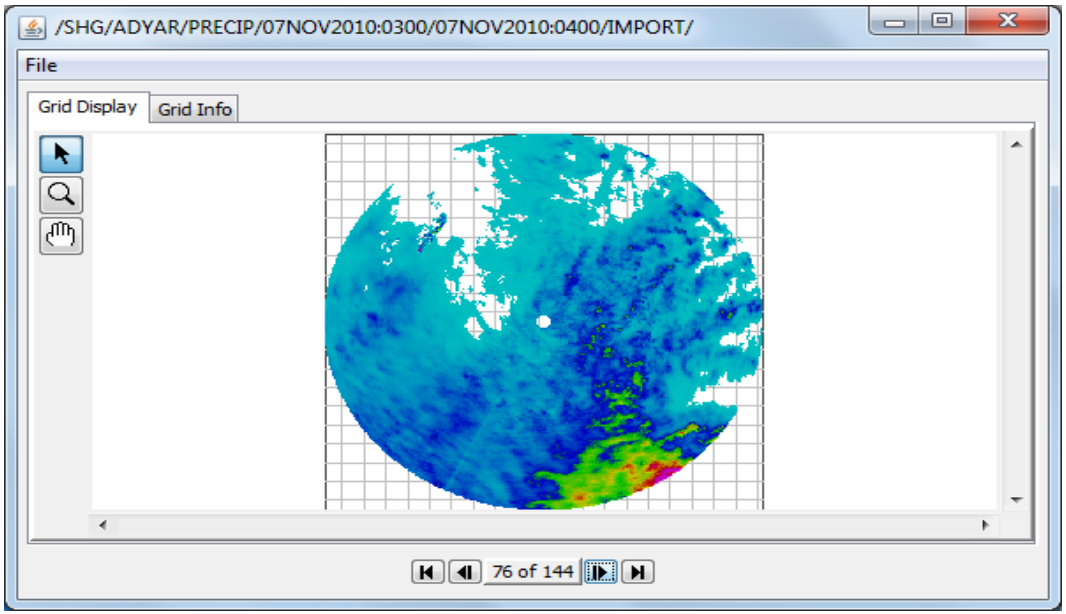
Grid Set(DSS) creation in HEC-GridUtil 2.0

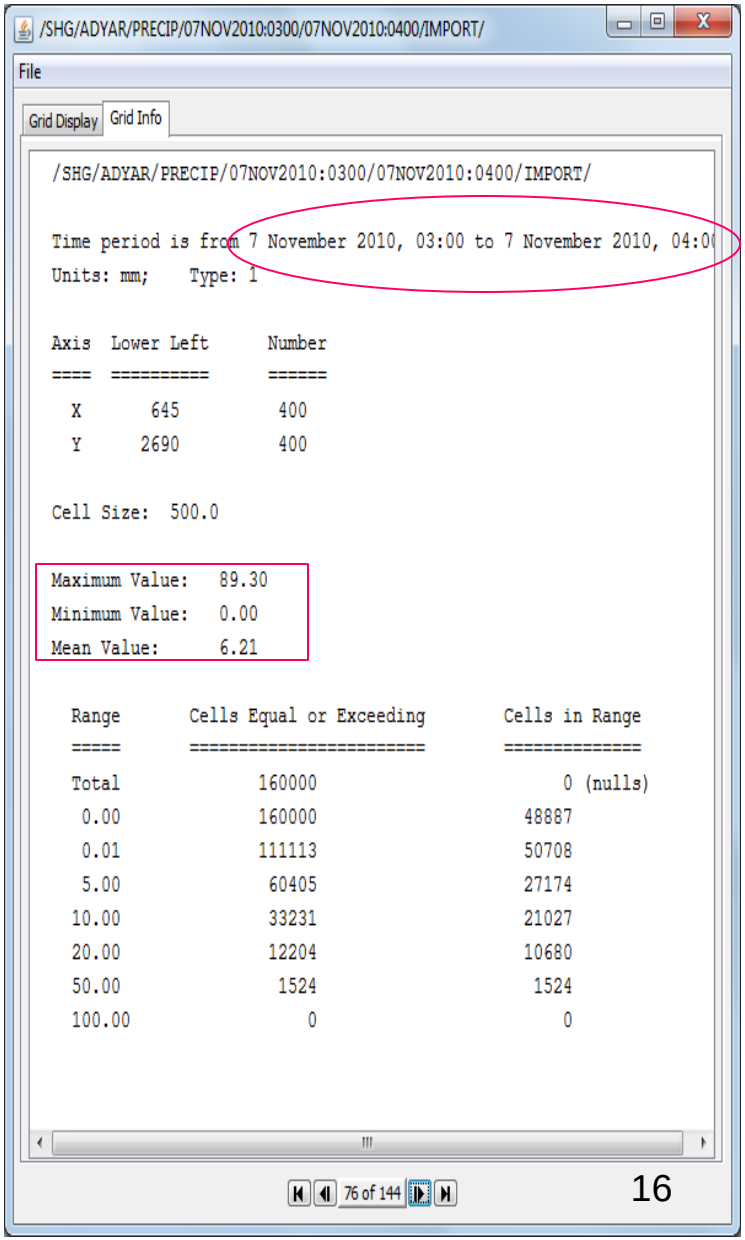




HEC-DSSVue Utility for DSS File Editing







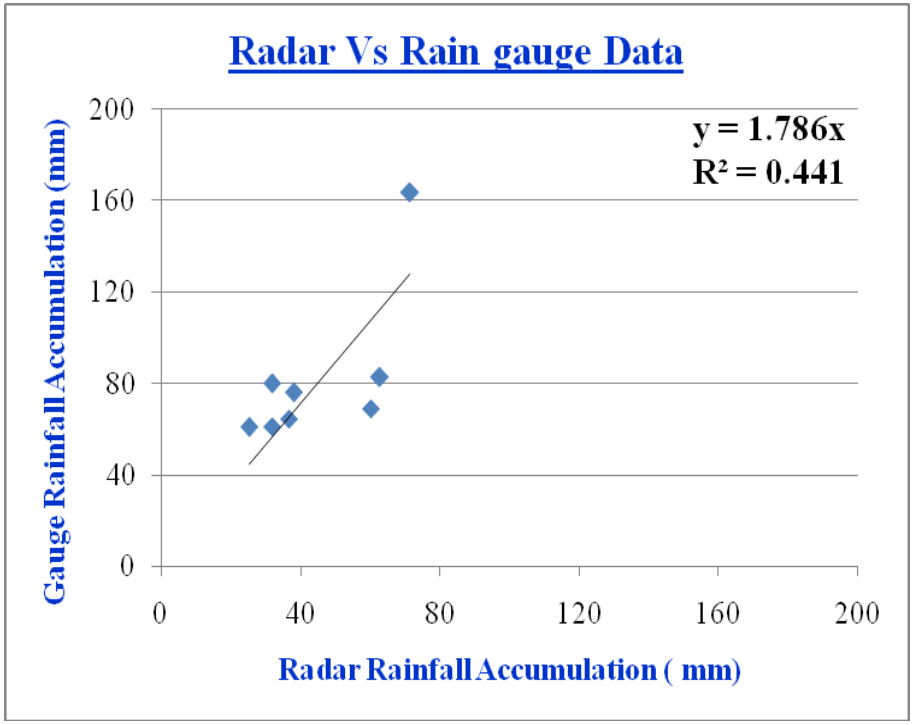
Radar Rainfall Information Extraction

C:\Users\acer\Desktop\session e4\Daily PAC - without Calibration

Radar – Rain Gauge Data comparison

Radar data (mm)								
Rain Gauge Stations	**Nungambakkam**	**Tharamani**	**Meenambakkam**	**Tambaram**	**Chembarambakkam**	**Korattur**	**Sriperumpudur**	**Chengalpattu**
04-Nov-10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90
05-Nov-10	0.00	0.00	1.00	1.00	0.00	1.00	0.00	0.00
06-Nov-10	2.90	2.20	10.00	2.60	16.60	0.00	1.00	2.20
07-Nov-10	19.30	20.90	17.00	19.70	14.30	17.40	11.90	26.70
08-Nov-10	9.60	13.50	10.00	36.90	31.80	6.80	18.90	37.59
Sum	**31.80**	**36.60**	**38.00**	**60.20**	**62.70**	**25.20**	**31.80**	**71.39**
Rain gauge data (mm)								
04-Nov-10	1.80	0.00	4.80	1.00	5.00	13.00	0.00	73.00
05-Nov-10	3.80	0.00	0.00	0.00	5.00	6.00	0.00	0.00
06-Nov-10	3.80	0.00	5.00	8.00	12.00	0.00	0.00	0.00
07-Nov-10	22.80	23.80	21.40	11.20	12.00	5.00	8.20	11.40
08-Nov-10	47.80	40.80	44.80	49.00	49.00	37.00	53.00	79.20
Sum	**80.00**	**64.60**	**76.00**	**69.20**	**83.00**	**61.00**	**61.20**	**163.60**

Calibration of Radar Data



Radar Rainfall Calibration Model (Original Values)

Radar rainfall calibration factor for the study area is identified as 1.786

Radar Rainfall Calibration – PERL Batch Program

ASCII Radar Data – Before Calibration

2010110702502543 - Notepad

File Edit Format View Help

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nrows         400
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yllcorner     1345294.817031
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19.7 20.5 20.9 19.3 18.9 19.3 18.5 17.8 17.8 17.4 17.8 20.9 25.2 25.9 25.6 27.1 26.7 23.2 20.9 19.7 19.7 21.3 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
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20.9 21.7 23.2 24.8 25.6 22.8 21.3 20.9 19.3 18.1 18.1 18.1 18.5 19.3 22.0 21.7 21.7 21.3 21.3 20.1 18.9 18.5 18.1 21.7 24.4 26.3 24.8 23.2 22.8 19.7 17.8 0.0 0.0 0.0
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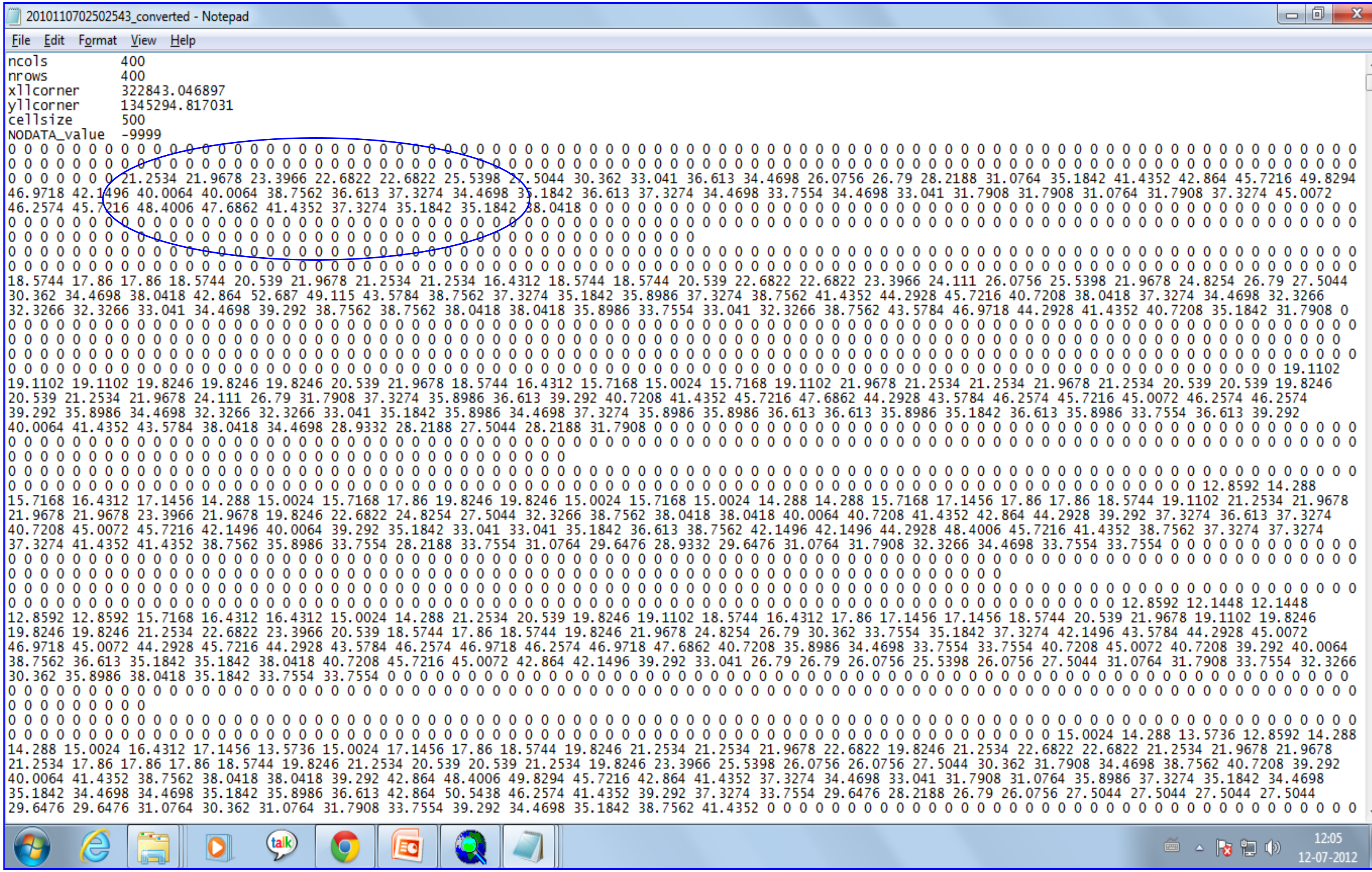
12:02

ASCII Radar Data – After Calibration

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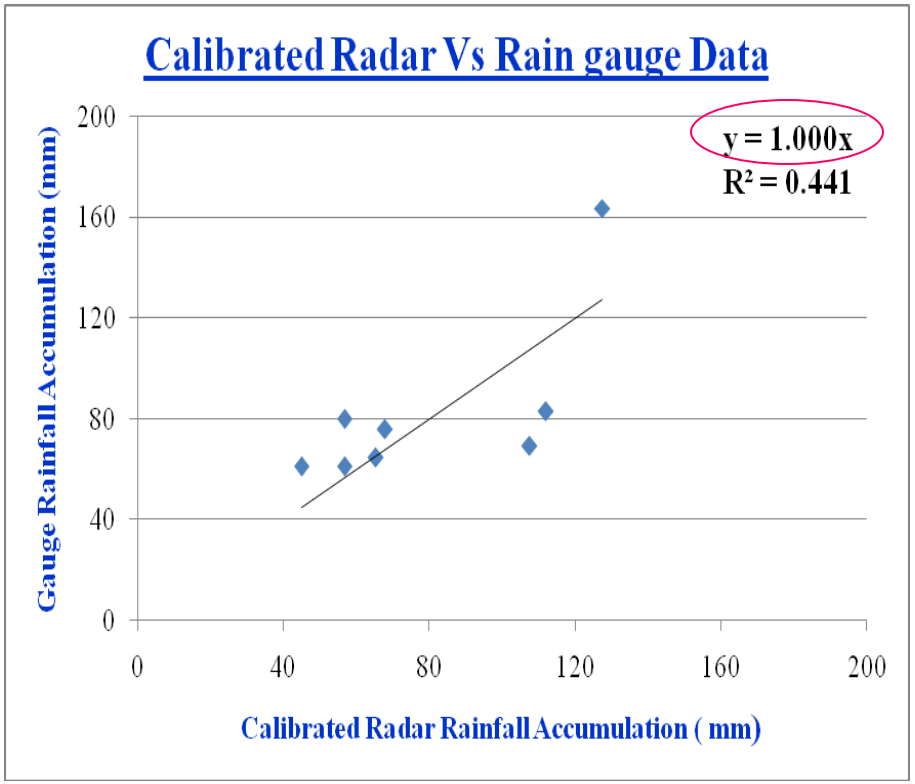
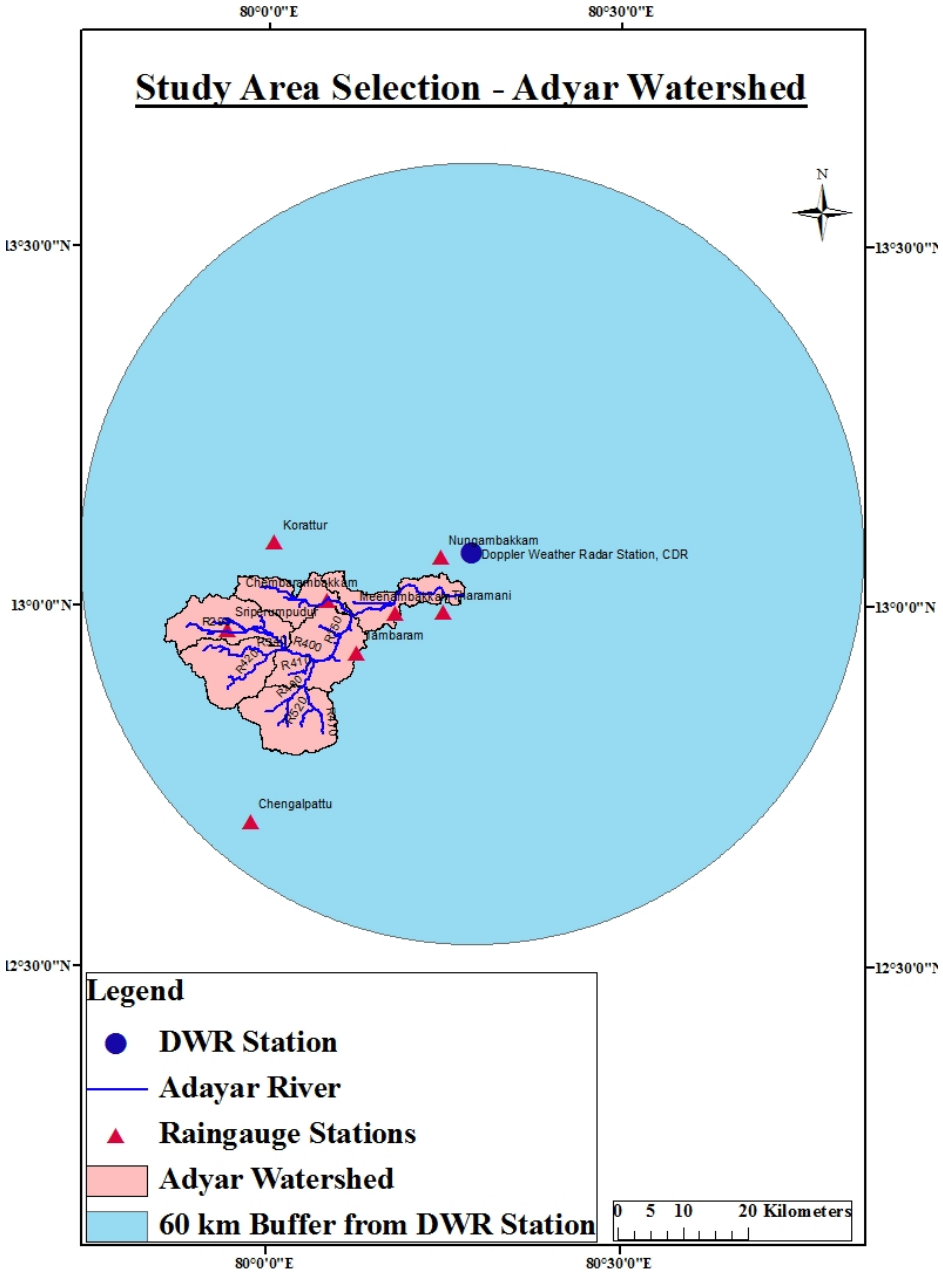
Radar Rainfall Calibration Model (Adjusted Values)



STUDY AREA SELECTION



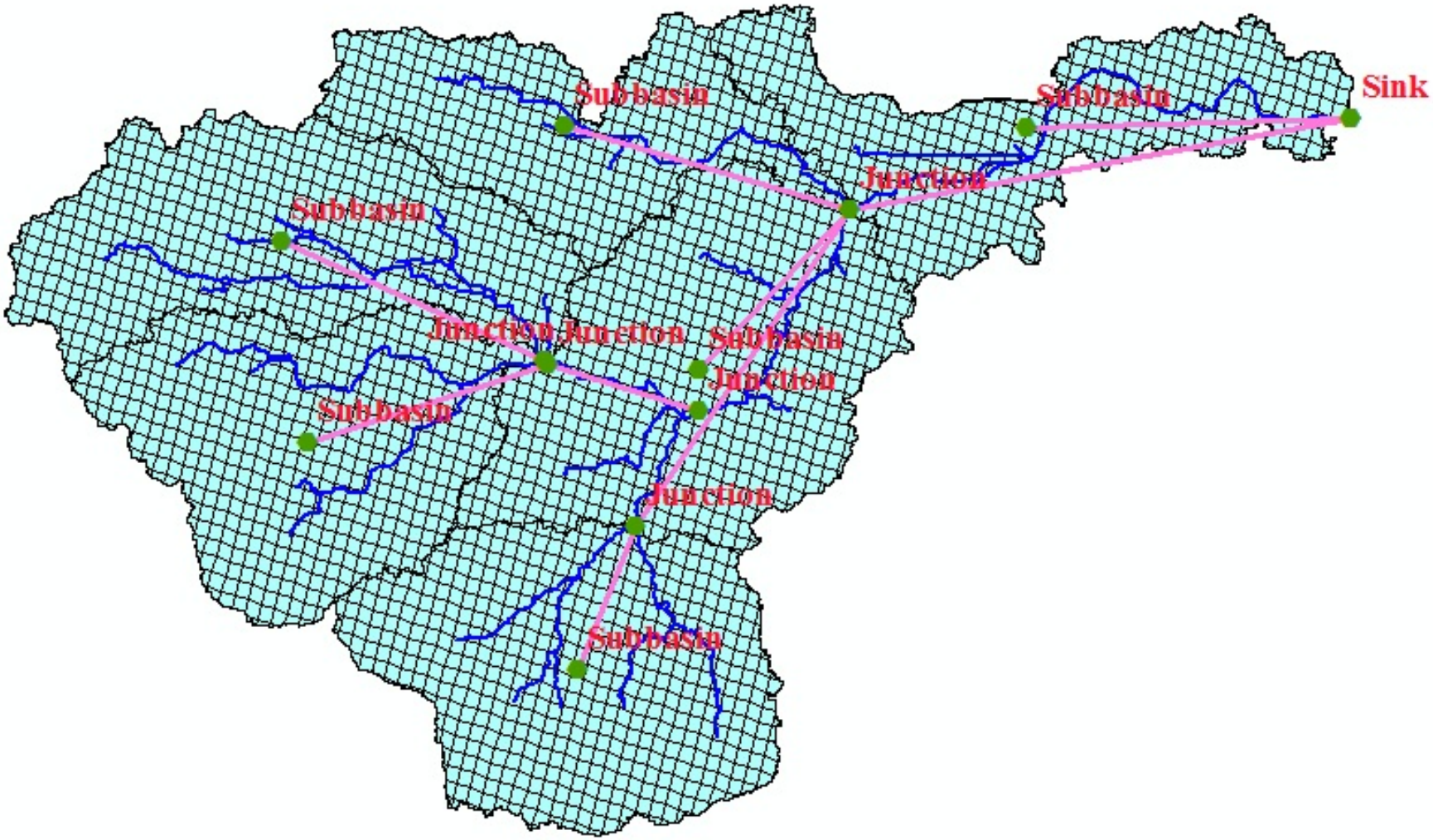
Area of the watershed: 632 km^2

Average Annual Rainfall: 1200 mm

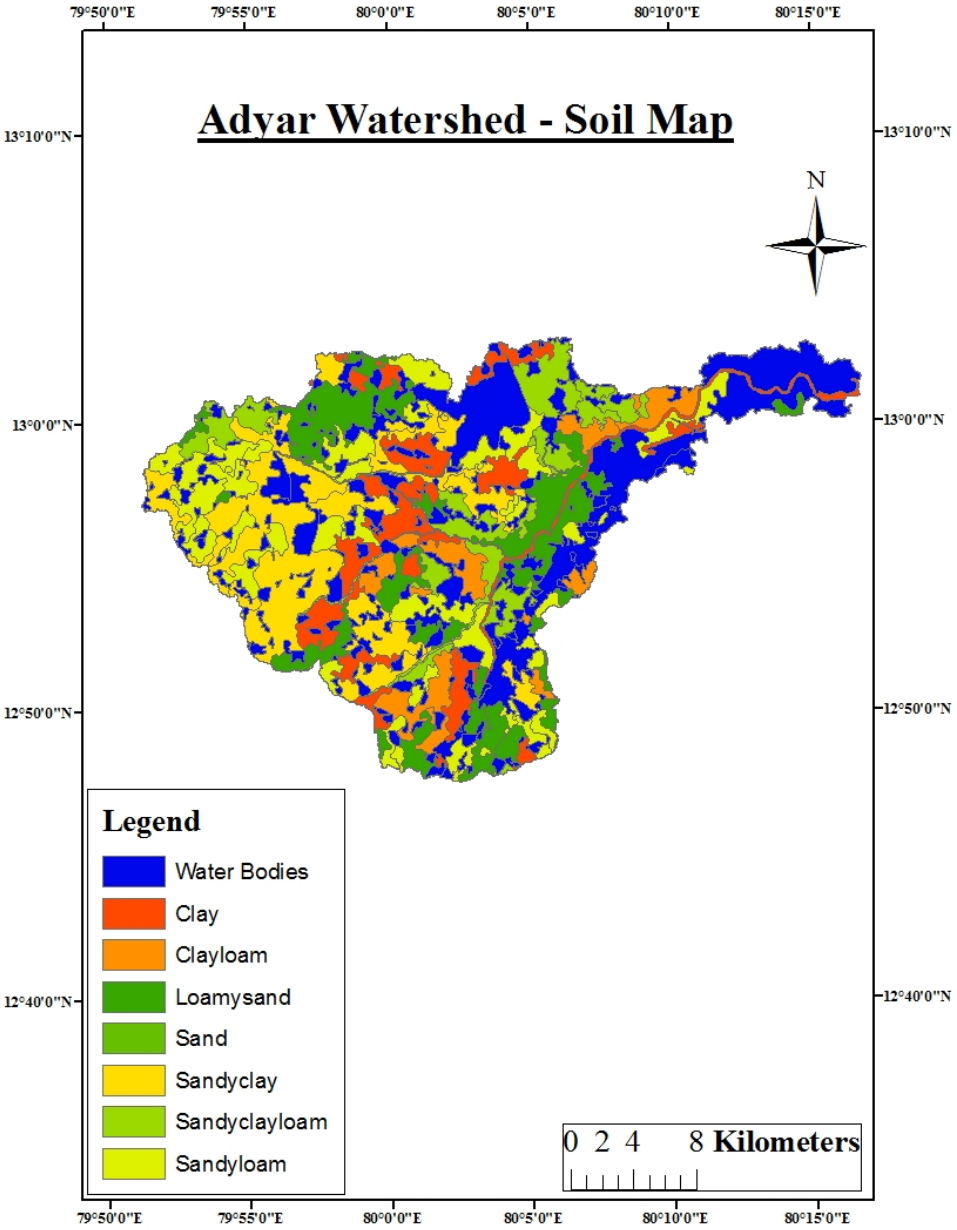
Average Monthly Minimum Temperature: 19º C

Average Monthly Maximum Temperature: 42º C

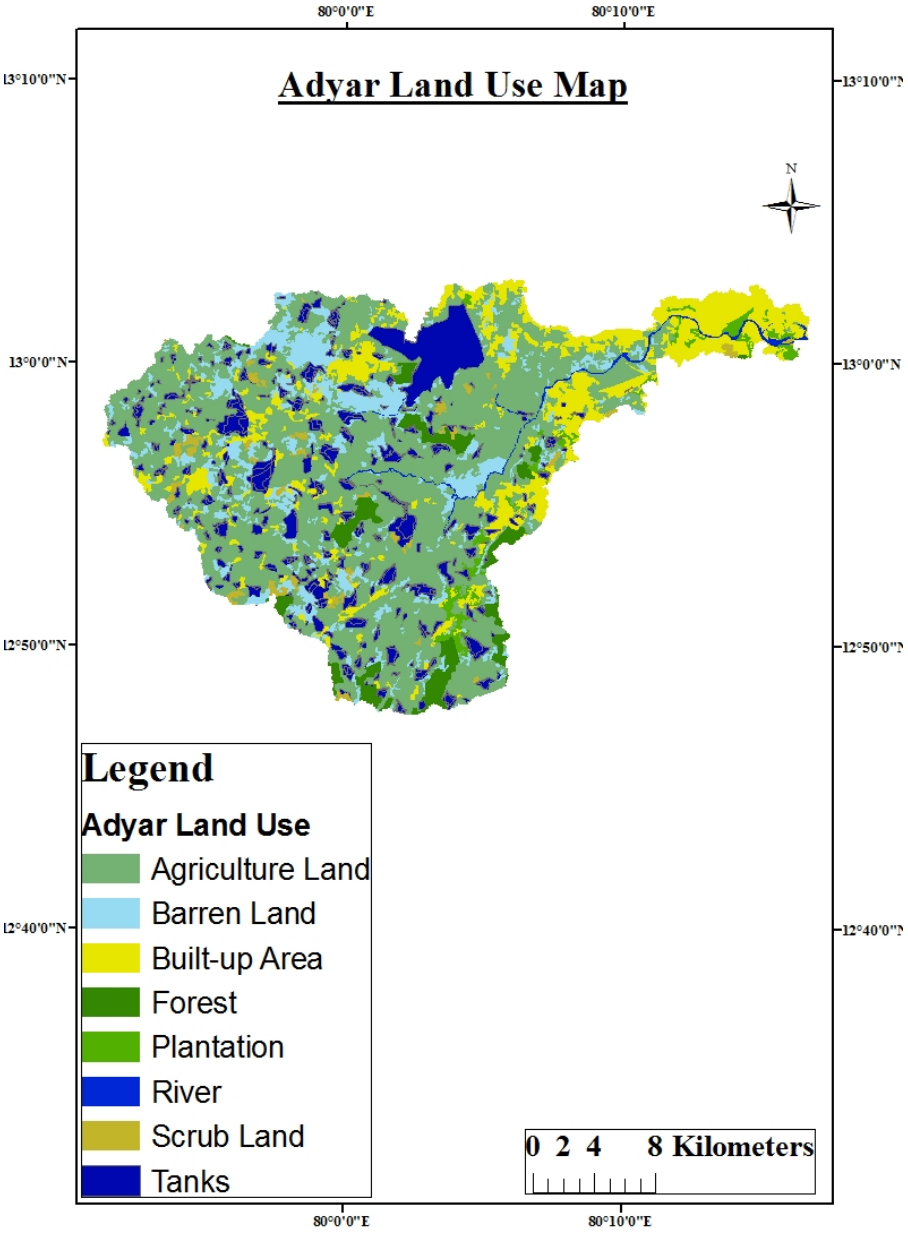
Basin Model – Grids with HMS nodes and Links



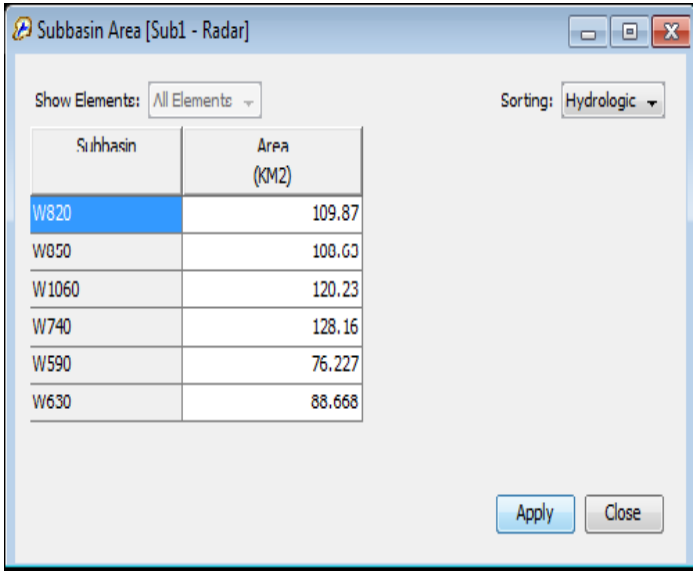
Adyar Soil Map

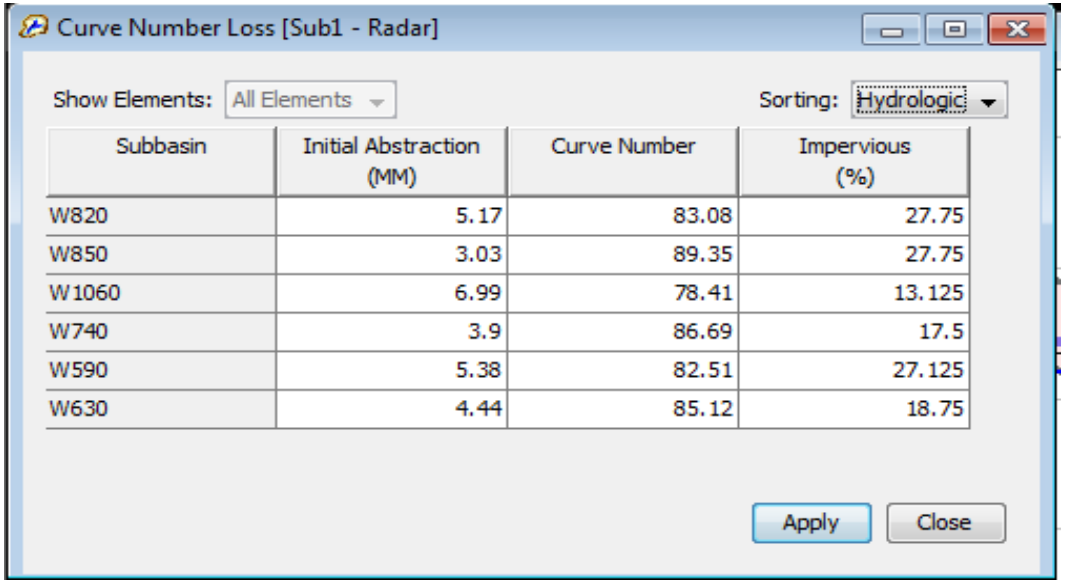


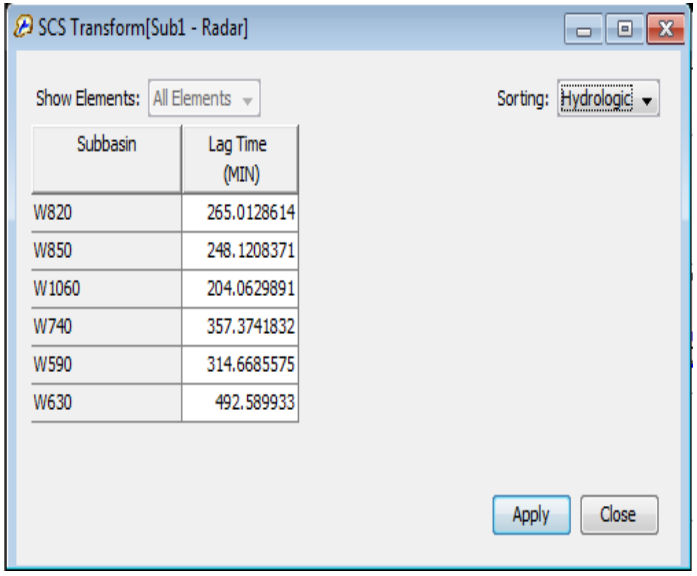
Adyar Landuse Map

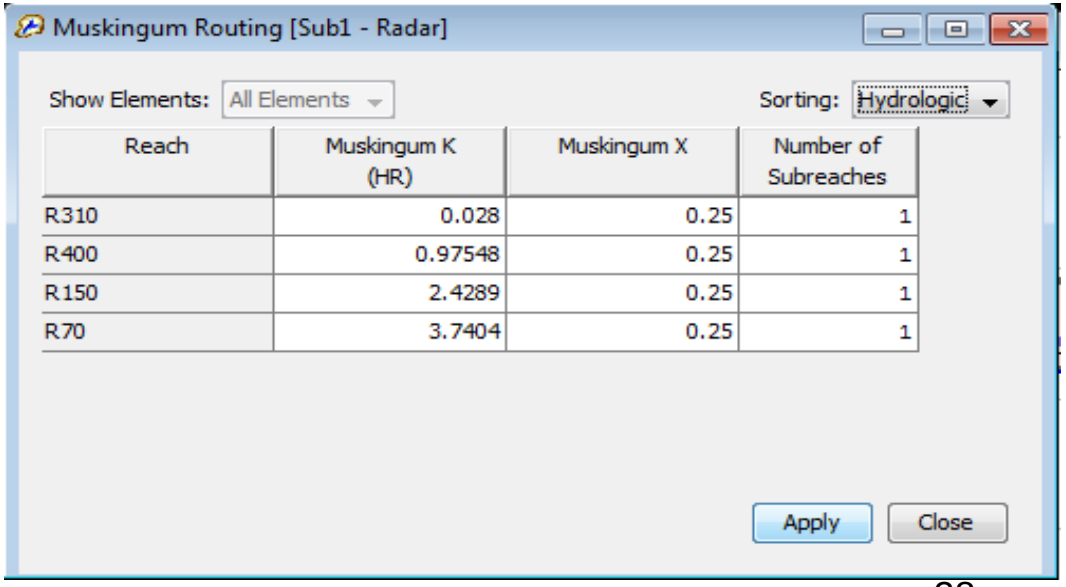


Basin Model – Parameters

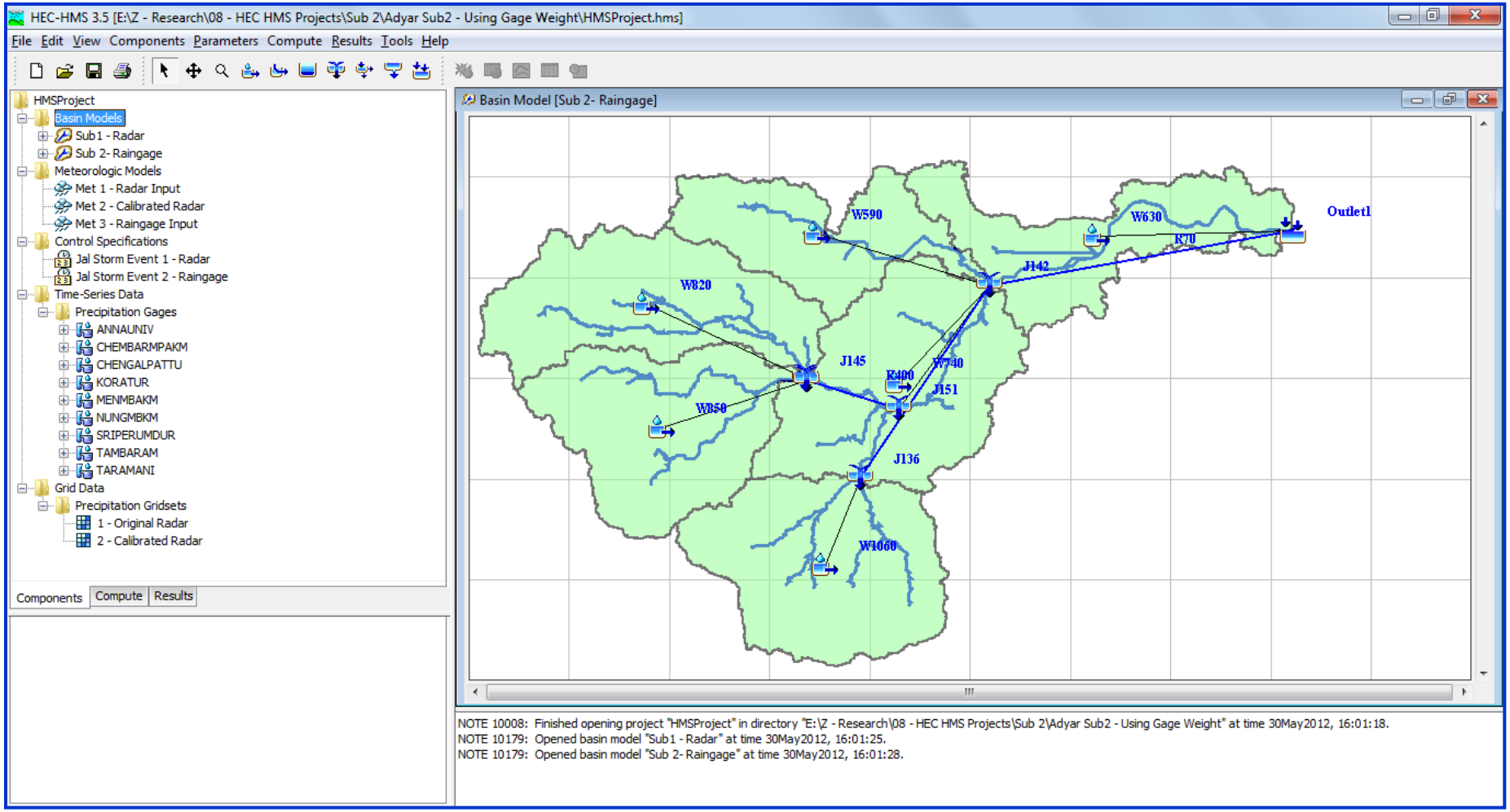




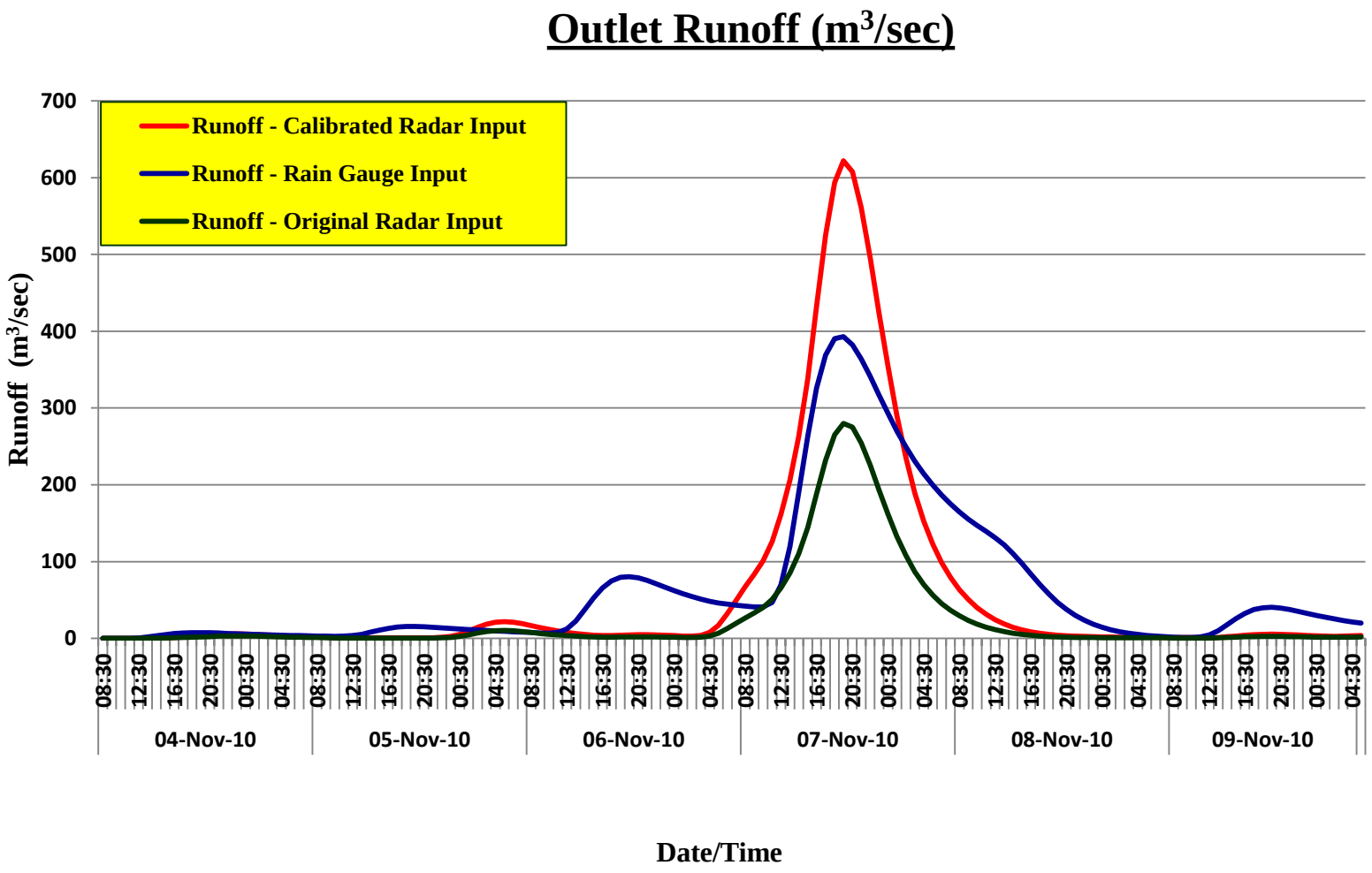




HEC-HMS Model



RESULTS AND DISCUSSION



RESULTS AND DISCUSSION

Watersheds	Sub1 - Nemam (Ungauged)		Sub2 - Adyar (Gauged)	
	Calibrated Radar Data	Rain Gauge Data	Calibrated Radar Data	Rain Gauge Data
Area(km ^{2})	110		632	
Peak Outflow(m^3/sec)	90.5	92.3	621.9	392.8
Date of Peak Outflow	07-Nov-10	07-Nov-10	07-Nov-10	07-Nov-10
Total Outflow(1000m^3)	3168.6	4574.8	28593.3	32572.9
Discrepancy		**30.74%**		**12.22%**

- Original Radar Rainfall data is quite low when compared to the rain gauge rainfall data, so it needs to be calibrated.

- Simulated values obtained from the model using Calibrated radar and rain gauge inputs are compared and difference in peak outflow is 12 % for Gauged watershed whereas it is 30 % for ungauged watersheds.

- The model prediction using radar data and field discharge are in fair agreement.

MEDIA INFORMATION

Severe Cyclonic Storm Jal near Chennai, Tamil Nadu,	
Formed	October 31, 2010
Dissipated	**November 8, 2010(Monday)**
Highest winds	3-minute sustained: 110 km/h (70 mph) 1-minute sustained: 100 km/h (65 mph)
Fatalities	at least 118 dead, 12 missing
Damage	$1.729 billion (2010 USD)
Areas affected	Malaysia, Malay Peninsula, Sri Lanka, **India**

Part of the 2010 Pacific typhoon season

&

2010 North Indian Ocean cyclone season

Severe Cyclonic Storm Jal near Chennai, Tamil Nadu, India, at peak intensity on November 7, 2010(Sunday)

Power outages occurred at many places in Tamil Nadu and Andhra Pradesh throughout Sunday.

One person was killed in Chennai,Tamil Nadu when a tree toppled.

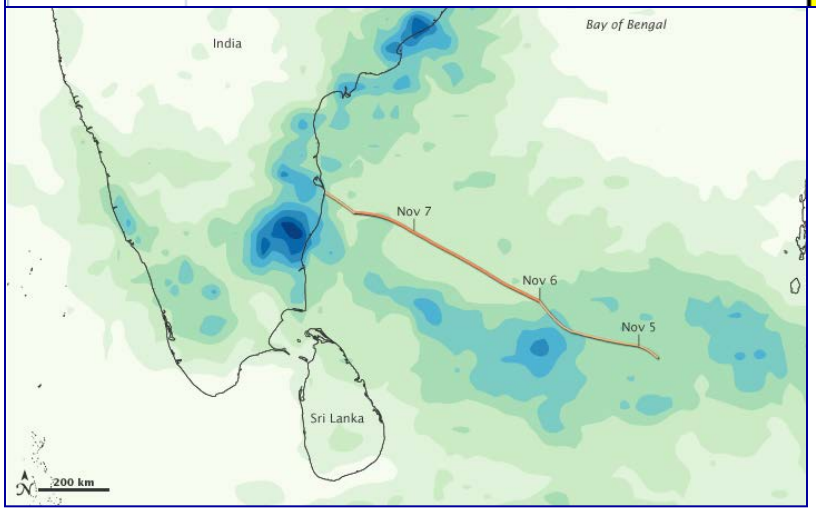
On November 9, The Andhra Pradesh chief minister Konijeti Rosaiahsaid that about 54 have died in India due to the storm.

Media news

'JAL' weakens into cyclonic storm PTI Nov 7, 2010, 06.32pm IST

CHENNAI: Severe cyclonic storm 'JAL' has weakened into a cyclonic storm and lay centred over southwest Bay of Bengal, about 250 km east-southeast of Chennai, today even as two persons died in rain-related incidents in Tamil Nadu.

Jal, which means water in Hindi, will bring thunderstorms.



CONCLUSION

- Research investigates the feasibility of using DWR rainfall data for hydrological purpose in Chennai watersheds.

- Radar outflow pattern matches the observed outflow.

- The research concludes that DWR products available at CDR, Chennai can be used for hydrological purposes such as runoff estimation, flood forecasting, flood zone mapping, and Research and Development activities because of the benefits of their spatial and temporal information content

FUTURE RESEARCH RECOMMENDATIONS

- DWR station is applying unique Z-R relationship, it may not be appropriate .

- Study area has inadequate automatic rain gauges, both recording as well as non recording rain gauges are considered.

- Research will be extended to simulate rainfall-runoff for the entire watersheds in Chennai basin to assist the policy and decision makers for better planning and development activities, especially in remote areas where rain gauges are sparse.

Thank you