Geographic Information System and its Application in Hydro-Meteorology – Exercises using SavGIS

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COPY DATABASE FOLDER "BHUTAN" in to "SAVBASE" FOLDER. Open Savateca and click Register and define Bhutan folder and click ok. Then only you will be able to work with the database.

Exercise 1: Getting started with GIS

To get familiar about spatial and surface analysis functions in SAVGIS. At the end of the exercise, users must be familiar with displaying relations, overlaying layers, attribute classification, spatial queries and making map layouts.

A. Display relations using Map explorer in SAVANE

- **Savane** →Base→Bhutan→ Click **"Map Explorer"** →Select the relation **"Country, District, Sub district"** under "objects from database" (Double click the relation or single click the relation and click the Draw Icon) to display in the frame.
- Click "Map Explorer" →Select the relation **"Rainfall Station"** under "objects from database" (Double click)
- Click "Map Explorer" →Select the relation **"SRTMElevation90m"** under "objects from database" (Double click) →Select attribute "**Altitude**" under mosaic →Enable **Color gradation** and click **">>"** → Click "**Auto**" →Click "**Colors**" and choose →Click **Apply**→Click **Ok** and click **Display all** tab in Map Explorer.
- Click "**properties**" tab and edit the properties of each layer to display in different colour, symbol properties

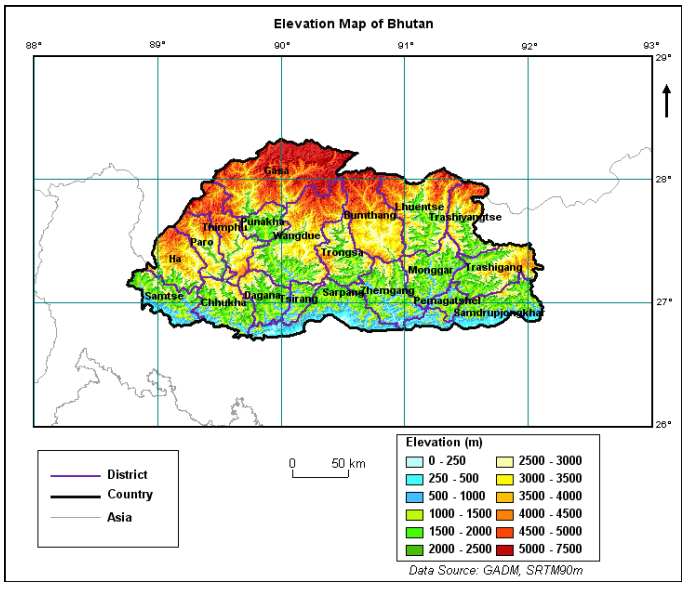


Figure 1: Administrative boundaries and Topography Map of Bhutan

- Click "**Frame**" →Select "**Legend**" →Edit legend properties →**Pencil icon** will appear, left click inside the frame to place the legend.
- Click Text Editor Icon "**A**" , Type text and left click in the frame to place the text.
- Click "**Frame**" →Click **North Arrow** & **Graphical Scale** →**Pencil icon** will appear, left click inside the frame to place the north arrow and graphical scale.
- Select "**Frame**" →Right click and select "**Screen Capture**" →Define the directory and file name.

B. Import Population data from Excel file

- Select **"Frame"** → **Import attributes** →From an **Excel file** →Define the directory for the population file "**District_population**" in Data folder → Select relation **"District"** and select the attribute **"Name"** →**Next** →select the tables under **"Tables to integrate with"** and click **"Name"** under the column **"Join with"** → Finish

C. Compute Population density by district

- Click **"Compute"** → select **"Area"** menu →select the relation **"District"** → Select unit **"square kilometer"** and enable **"Maximum accuracy"** and click **"ok"**. It will create a new attribute called **"Area"** in the relation **District.**

- Click **"Compute"** → select **"Numerical Calculations"** menu → **"Formula"** → Select the relation **"District"**. Type the formula "**v[population]/v[Area**]"→ then click next → Give name for the new attribute **"Density"** and click **"Finish"**

D. Manual classification of Population attribute

- Click **"Class"** → select **"user delimited intervals"** menu → Select the relation **"District"** →Select attribute **"Density"** → then **define the interval and give the name "DensityRC"**

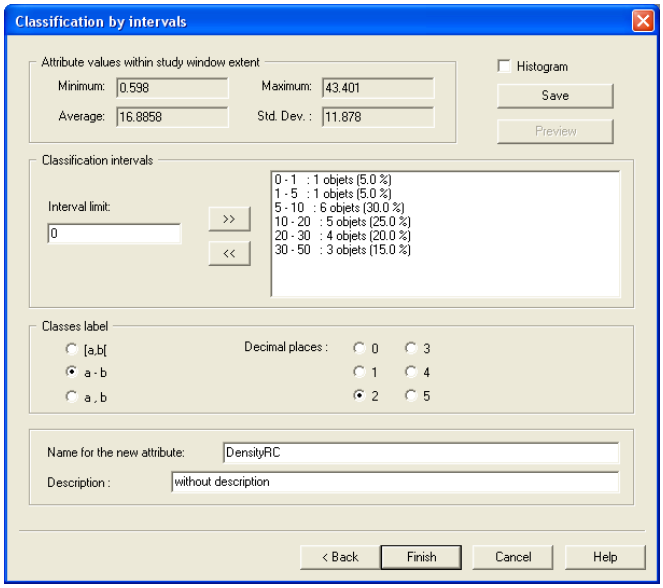


Figure 2: Screen capture of Reclassifying classes using "User Delimited interval function"

- Click **"Map Explorer"** →Select the relation **"District"** under **"objects to display"** →**"Properties"** →Zone → "Fill zones according to one attribute" → Select **"DensityRC"** → click **>>** next to the **colors and patterns** →Define colour for each class and Click OK.
- Click **"Frame"** →Select **"Legend"** →Edit legend properties →Pencil icon will appear, left click inside the frame to place the legend.
- Click Text Editor Icon "**A**", Type text and left click in the frame to place the text.
- Click "**Frame"** →Click **North Arrow** & **Graphical Scale** →**Pencil icon** will appear, left click inside the frame to place the north arrow and graphical scale.
- Select "**Frame**" →Right click and select "**Screen Capture**" →Define the directory and file name.

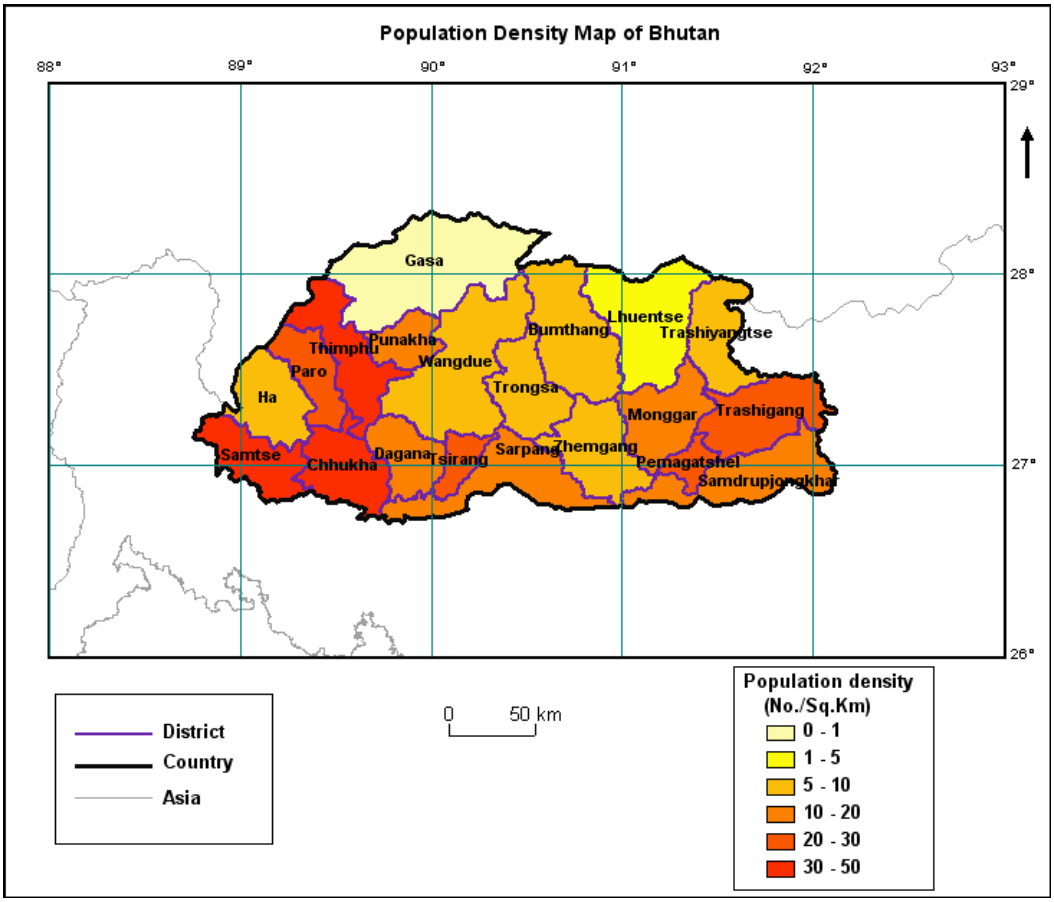


Figure 3: Population Density Map of Bhutan by district

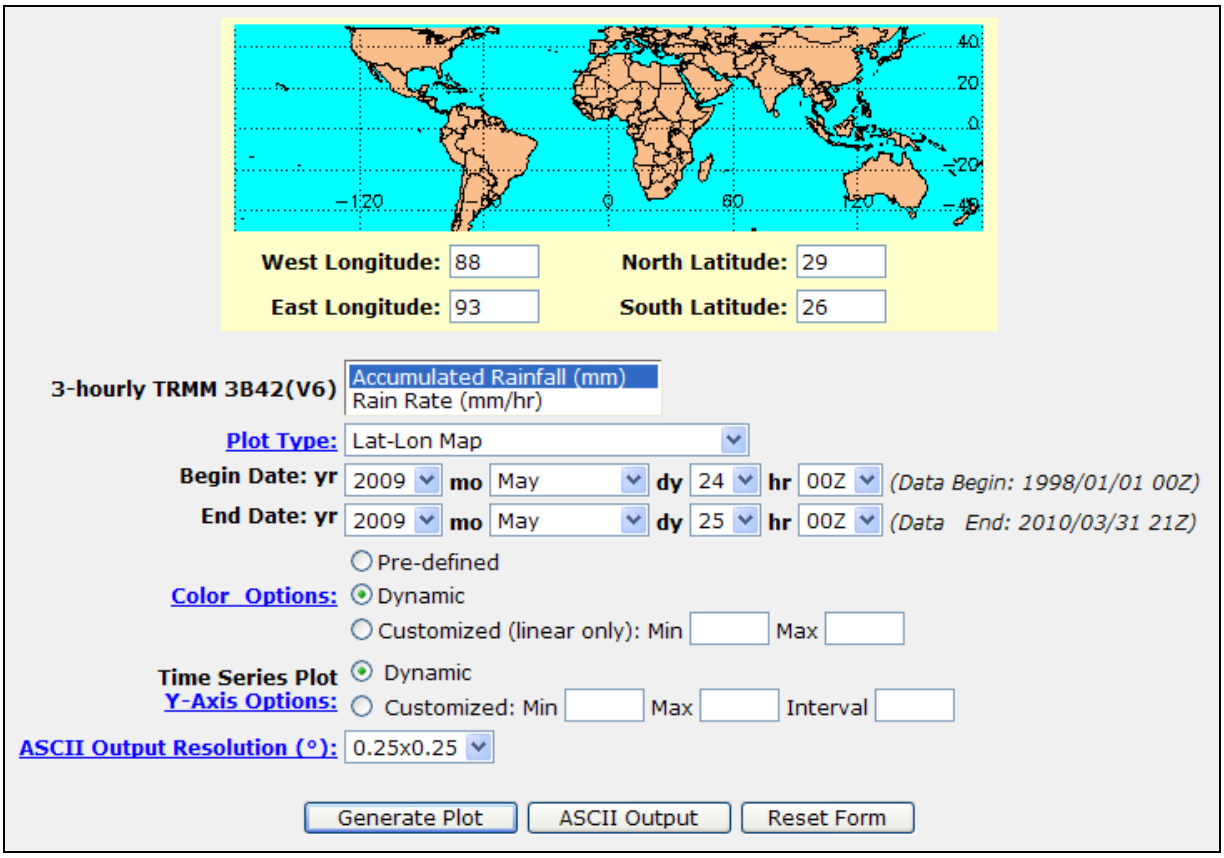
Question: Where can you use this method? Give two examples or situation where it is more applicable?

Exercise 2: Surface Analysis of TRMM rainfall data

To get familiar about handling TRMM rainfall grid datasets in GIS.

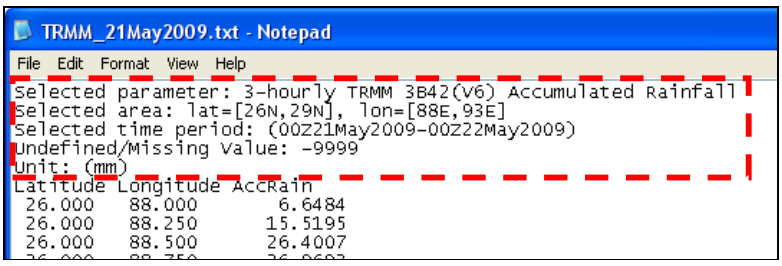
Description of the Exercise

A. Three hourly or Daily or Monthly data in ASCII format is easily available in the following link http://disc2.nascom.nasa.gov/Giovanni/tovas/TRMM_V6.3B42.2.shtml



Users can define their geographical extent and download the data for required period by clicking Ascii format in the webpage. New webpage will pop-up with ascii data set. Save the popup web page as text file to your computer.

Open the text file and delete first five lines, so that the file should have Latitude, Longitude, AccRain at first line and data follows. Import these monthly rainfall data as column in Excel file and have one excel file for one year to integrate into GIS.



Data Sample

Example file is available in the following path **\Data\TRMM_Obs\TRMM_24May2009.txt**

Creating a Relation and Attribute

- Open **SAVATECA** → Click **Base** → Select **Bhutan** and Click OK→ Click the menu **Scheme** → Select **Relations** under Scheme →Click the **Create** Button in the Relation Manager window → Assign the name of the relation "**TRMM24May09"** and Choose the Type "**Point"** and Click **OK**

- Click the menu **Scheme** → Select **Attributes** → Select the relation **TRMM24May09** → Click **Add** button → Assign the name of the attribute "**Rainfall"** and Choose the Type **Numeric** →Click **>>** and Click **OK**

Modify External View

- Click **External views** →Click Modify →Choose "**view**" →Click OK → Select the relation "**TRMM24May09**" and click "**Add relations**" or Double click the relation under "**TRMM24May09**", it will appear under "Visible relations"

Data Integration from Text file

- **Integrate** → **Location-based objects** → **Points with id only (ASCII format)** → Points integration window will popup, Select the **relation** name (**TRMM24May09**) where you want to integrate → Select the **attribute** (**Rainfall**) →Click **Next** →Define the path where the ASCII file is stored "**\Data\TRMM_Obs\TRMM_24May2009.txt"** and select the file →Select the document under **"Available documents"** → Select the delimiter type (<tab> for our exercise) →if first row in data is description, then enable the Field headers →Click **Next** →Assign the Longitude (2) and latitude (1) field no. and click Next →Select the attribute "Rainfall" and assign the field no. (4) in "field in external file" →Click **>>** →Click **Test** →Click **Finish.**

Data Visualization in SAVANE

- Open **Savane** → Base → **Bhutan** →**Babel** → **Interpolation** → Select the relation **TRMM21May09** → Define the attribute which you want to interpolate (**Rainfall**) → Define the name for the new attribute "**RF24May** or any" and then Click Next → Choose the interpolation method "**Barycentric over Neighbors – Two Steps**" to make the process fast → Click Next and Finish the process.

- **Class** → **User delimited interval** → Select the relation **RASTER** and attribute **RF24May** (interpolated attribute) → Type the numbers from lower limit to upper limit one by one 1,10,25,50, 100,200,300 and the give a new name (**RF24MayRC**) for this attribute and Finish the process.

- **Map Explorer** → Double click the layer **Raster** and select the attribute **RF24MayRC** to display in the screen → Change the "**color gradation**" → Place north arrow, scale bar, legends, grid lines, and boundaries.

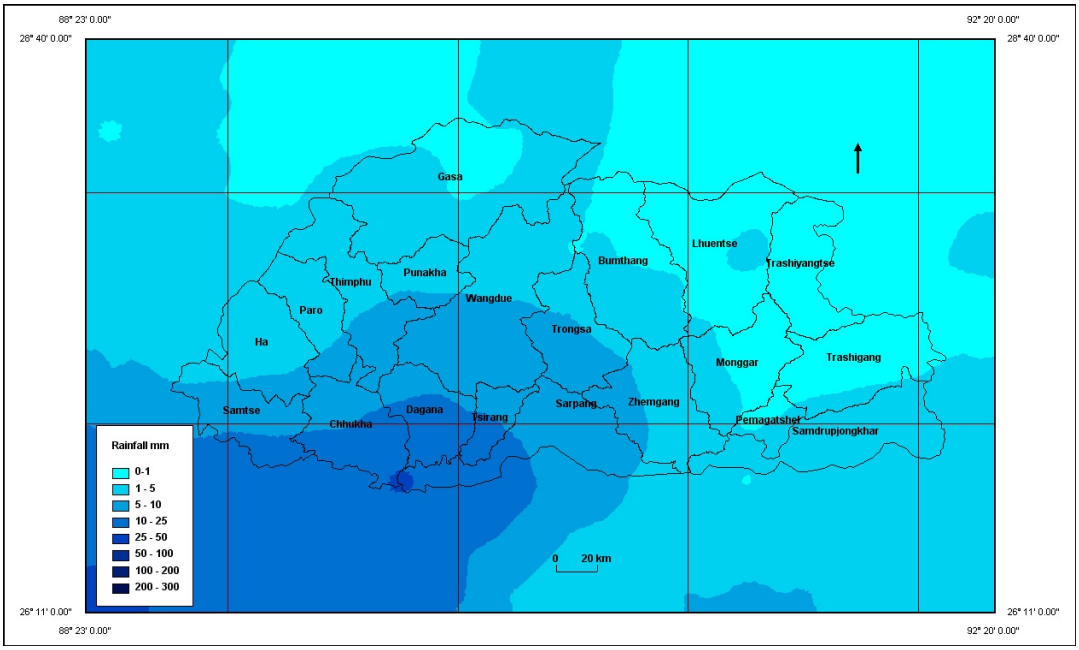


Figure 4: TRMM Rainfall surface map of Bhutan – 24May2009

Exercise for Practice:

Do the same procedures for plotting the rest of the TRMM data file in the following path "**\Data\TRMM_Obs*.May2009.txt"**

Multiple Data Integration from Excel File

User can import five days rainfall data as attributes in a single relation. Import these daily rainfall data files as column in Excel file and have one excel file for one year to integrate into GIS.

Step1: Import text files one by one into EXCEL file
Lat|Lon|AccRain|Lat|Lon|AccRain|Lat|Lon|AccRain|Lat|Lon|AccRain|Lat|Lon|AccRain

Step2: Rename the column names with respective dates
Lat|Lon|21May09|Lat|Lon|22May09|Lat|Lon|23May09|Lat|Lon|24May09|Lat|Lon|25May09

Step3: Keep the first Lat|Lon and remove all other Lat|Lon columns in the file
Lat|Lon|21May09| 22May09 |23May09| 24May09| 25May09

Step4: Save the Excel file

Step5: Savateca →Base →Bhutan →Create a new relation RFTRMM →Add attributes from 21May, 22May, 23May, 24May, 25May (5 attributes). Integrate →Location based objects →Points with id and other attributes (Excel format) →Browse and select your excel file and define Lat. (1) Lon(2) position and projection details(Geographic) →Define attribute position in Excel file, for example 21May09 as 3, 22May09 as 4, 23May09 as 5, 24May09 as 6, 25May09 as 7 → Click Finish to end the process → External views →Modify → Double click the relation RFTRMM to make it visible.

Step6: Open Savane → Interpolate and make Map layout using SAVANE as explained for previous exercise.

Exercise 3: Surface Observatory rainfall data

To get familiar about handling observatory rainfall datasets in GIS.

Integrate New Data

Data can be separated with columns in Excel file

"Name Lat Lon May2009"

Column1: Name of station
Column2: Latitude
Column3: Longitude
Column4: May2009

Savateca →Base →Bhutan →Create a new relation "RFOBS" →Add attributes Name (Nominal), May2009 (Numeric). Integrate →Location based objects →Points with id and other attributes (Excel format) →Browse and select your excel file and define Lat. (2) Lon(3) position and projection details(Geographic) →Define attribute position in Excel file, for example Name as 1, May09 as 4, → Click Finish to end the process → External views →Modify → Double click the relation RFTRMM to make it visible.

Open Savane → Interpolate and make Map layout using SAVANE as explained for previous exercise.

Adding Temporal Data to Existing Station in GIS database (PERMANENT)

Create one Excel file and add columns for every month or day or year and save it.

"Name June2009 July2009 Aug2009 Sep2009 etc…"

Savateca →Base →Bhutan → Values using a Join →Excel Sheet →Select the relation "RFOBS" and attribute "Name" →Define the path of the Excel file which you saved →Select the sheet under "Select table to integrate" → select the key attribute "Name" under "Attribute to integrate with" → Browse and select your excel file and define attribute position in Excel file, for example June2009 as 2, July2009 as 3, Aug2009 as 4 etc.,→ Click Finish to end the process → External views →Modify → Double click the relation RFOBS and select the newly created attributes to make it visible.

Adding Temporal Data to Existing Station in GIS database (TEMPORARY)

Create one Excel file and add columns for every month or day or year and save it.

"Name June2009 July2009 Aug2009 Sep2009 etc…"

Savane →Import attributes→From an Excel file → Define the path of the Excel file which you saved and click Open → Select the relation "RFOBS" and attribute "Name" → Select the sheet under "Select table to integrate" → select the key attribute "Name" under "Attribute to integrate with" → Click Finish to end the process

Data Visualization in SAVANE

- Open **Savane** → **Base** → **Bhutan** →**Babel** → **Interpolation** → Select the relation **RFOBS** → Define the attribute which you want to interpolate (**May2009**) → Define the name for the new attribute "**May09obs** or any" and then Click Next → Choose the interpolation method "**Barycentric over Neighbors – Two Steps**" to make the process fast → Click Next and Finish the process.

- **Class** → **User delimited interval** → Select the relation **RASTER** and attribute **May09Obs**(interpolated attribute) → Type the numbers from lower limit to upper limit one by one 1,10,25,50, 100,200,300 and the give a new name (**May09obsRC**) for this attribute and Finish the process.

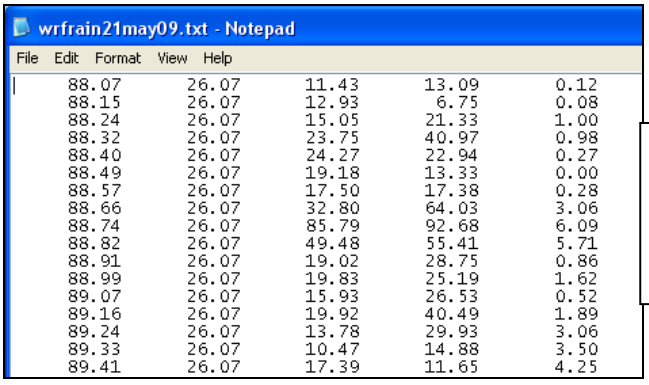
- **Map Explorer** → Double click the layer **Raster** and select the attribute **21day1fcstRC** to display in the screen → Change the "**color gradation**" → Display District boundaries with names, Place north arrow, scale bar, legends, grid lines, and boundaries.

Exercise 4: RIMES WRF Forecast Plot in GIS

To get familiar about handling WRF forecast data in GIS. All Grid data can be imported into a GIS database if it has geographic coordinates. FORTRAN Program enables us to write the WRF model output data into GIS compatible format.

Data Sample

Example file is available in the following path **\Data\RIMES_WRF\wrfrain21may09.txt**



Column 1: Longitude
Column 2: Latitude
Column 3: Rainday1forecast
Column 4: Rainday2forecast
Column 5: Rainday3forecast

Initial condition for the file wrfrain21may09 is 21May2009 12UTC. Following are the day1, day2 and day3 forecasts.

- Rainday1forecast (22May2009 00UTC to 23May2009 00UTC)
- Rainday2forecast (23May2009 00UTC to 24May2009 00UTC)
- Rainday3forecast (24May2009 00UTC to 25May2009 00UTC)

Creating a Relation and Attribute

- Open **SAVATECA** → Click **Base** → Select **Bhutan** and Click OK→ Click the menu **Scheme** → Select **Relations** under Scheme →Click the **Create** Button in the Relation Manager window → Assign the name of the relation "**wrfrain21may09"** and Choose the Type "**Point"** and Click **OK**

- Click the menu **Scheme** → Select **Attributes** → Select the relation **wrfrain21may09** → Click **Add** button → Assign the name of the attribute "**Day1fcst, Day2fcst, Day3fcst"** and Choose the Type **Numeric** →Click **>>** and Click **OK**

Modify External View

- Click **External views** →Click Modify →Choose "**view**" →Click OK → Select the relation "**wrfrain21may09**" and click "**Add relations**" or Double click the relation under "**wrfrain21may09**", it will appear under "Visible relations"

Data Integration from Text file

- **Integrate** → **Location-based objects** → **Points with id only (ASCII format)** → Points integration window will popup, Select the **relation** name (**wrfrain21may09**) where you want to integrate → Select the **attribute** (**Rainfall**) →Click **Next** →Define the path where the ASCII file is stored "**\Data\RIMES_WRF\wrfrain21may09.txt"** and select the file →Select the document under **"Available documents"** → Select the delimiter type (<tab> for our exercise) →if first row in data is description, then enable the Field headers →Click **Next** →Assign the Longitude (1) and latitude (2) field no. and click Next →Select the attribute "Day1fcst" and assign the field no. (4) in "field in external file" and similarly for the attribute "Day2fcst" – field no(5) and for the attribute "Day3fcst" –field no. (6) →Click **>>** →Click **Test** →Click **Finish.**

Data Visualization in SAVANE

- Open **Savane** → **Base** → **Bhutan** →**Babel** → **Interpolation** → Select the relation **wrfrain21may09** → Define the attribute which you want to interpolate (**Day1fcst**) → Define the name for the new attribute "**21day1fcst** or any" and then Click Next → Choose the interpolation method "**Barycentric over Neighbors – Two Steps**" to make the process fast → Click Next and Finish the process.

- **Class** → **User delimited interval** → Select the relation **RASTER** and attribute **RF24May** (interpolated attribute) → Type the numbers from lower limit to upper limit one by one 1,10,25,50, 100,200,300 and the give a new name (**21day1fcstRC**) for this attribute and Finish the process.

- **Map Explorer** → Double click the layer **Raster** and select the attribute **21day1fcstRC** to display in the screen → Change the "**color gradation**" → Display District boundaries with names, Place north arrow, scale bar, legends, grid lines, and boundaries.

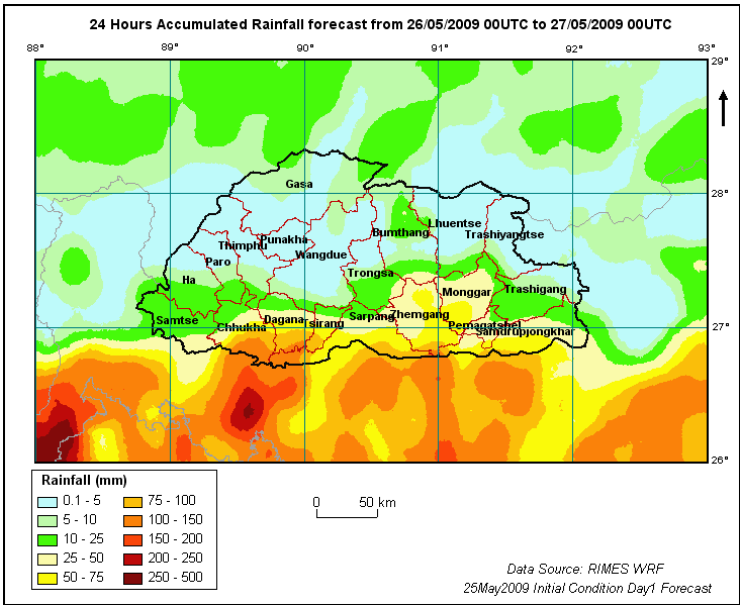


Figure 5 Map showing RIMES WRF forecast map(25May2009 Day1 fcst) for Bhutan region.

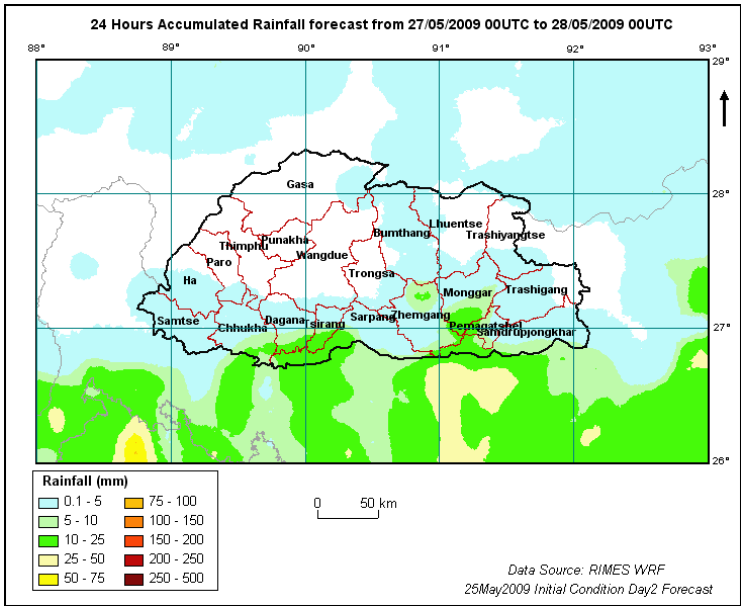


Figure 6: Map showing RIMES WRF forecast map(25May2009 Day2 fcst) for Bhutan region.

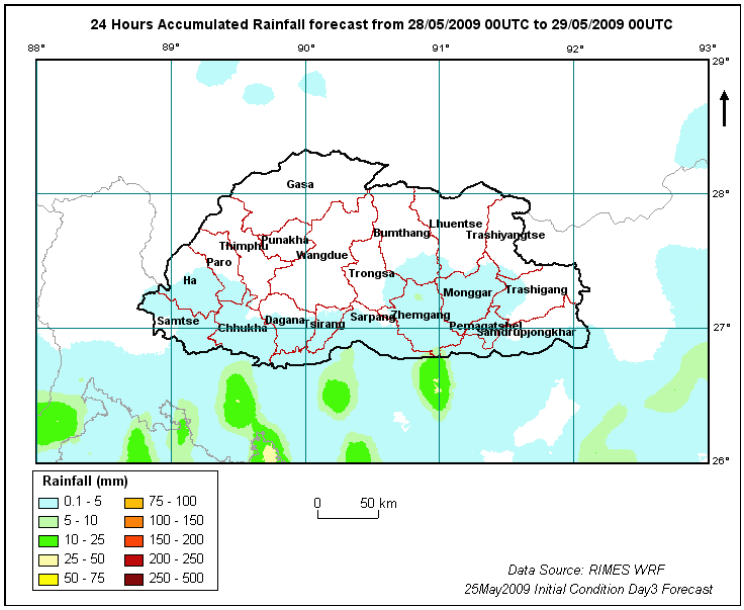
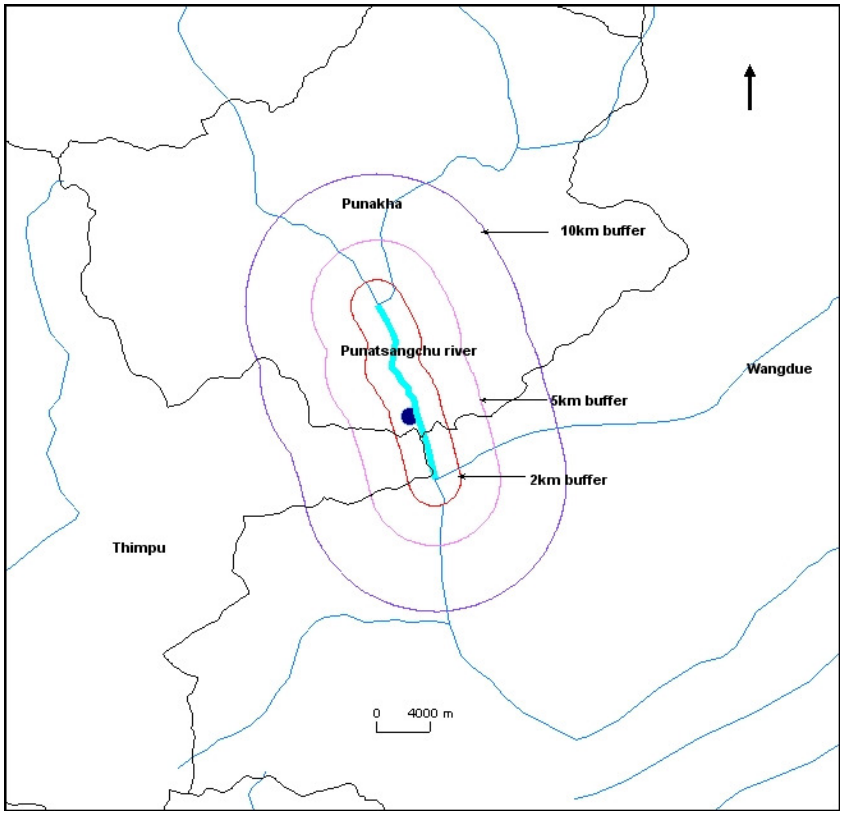


Figure 7: Map showing RIMES WRF forecast map (25May2009 Day3 fcst) for Bhutan region.

Exercise 5: Exposure Assessment

A sample case study is assumed for Bhutan based on Aila Cylone Impact. It is known that Punatsangchu river is flooded during 25May2009. So



Visualizing elements at risk in Flood Hazard prone area

- Open **Savane** → **Base** → **Bhutan** →**Mask** → **Create** → **Around Objects** →Select the relation "**Floodriver"** → Assign width around objects "2000" m and save as 2kmbuffer . Repeat the same by assigning 5000m and 10000m and save as 5kmbuffer, 10kmbuffer respectively.

- **Mask** → **Integrate** → Select **"2kmbuffer"** and enable **"Zone** and assign name **"HighHZ".** Repeat the same by selecting **"5kmbuffer,10kmbuffer"** and save as **"MedHZ, LowHZ" respectively**

- **Map Explorer** → Display relations one by one "**Floodriver**", **District boundary, HighHZ, MedHZ, LowHZ, PopulationGRUMP"** → Edit the properties to display in different colour.

Spatial Queries to know elements at risk in 10km buffer region

Query → **Restriction** →**Using a Mask** →Select the relation **Subdistrict** → Click **Next** →Select the mask **"10kmbuffer"** →Enable **"Select the intersection"** → click **Finish**

Query → **List Values** → Select the relation **Subdistrict** → Click **Next** → Select the attribute "**Name**" → Click **Finish**

Query → **Restriction** →**Using a Mask** →**Select the relation "PopulationGRUMP"** → Click **Next** →Select the mask **"10kmbuffer** →Enable **"Select the intersection"** → click **Finish**

Stat → **Explorer** → **Select the relation "PopulationGRUMP" .**Check the Sum value of population in the popup window

Repeat the same for 5kmbuffer and 2km buffer. Tabulate the results

Exercise 6: Hydrological Station Location Plot

Integrate New Data

Data can be separated with columns in Excel file

Column1: ID
Column2: StationNo.
Column3: StationName
Column4: Latitude
Column5: Longitude

Savateca →Base →Bhutan →Create a new relation "Hydrologystation" →Add attributes ID, StationName (Nominal), StationNo (Numeric). Integrate →Location based objects →Points with id and other attributes (Excel format) →Browse and select your excel file and define Lat. (4) Lon(5) position and projection details(Geographic) →Define attribute position in Excel file, for example ID as 1 and station No as 2 and StationName as 3 → Click Finish to end the process → External views →Modify → Double click the relation RFTRMM to make it visible.

Adding Temporal Data to Existing Station in GIS database (PERMANENT)

Create one Excel file and add columns for every month or day or year and save it.

"ID StationNo. StationName Lat Lon Hmax10May09 Hmax11May09 etc.,"

Savateca →Base →Bhutan → Values using a Join →Excel Sheet →Select the relation "Hydrologystation" and attribute "Name" →Define the path of the Excel file which you saved →Select the sheet under "Select table to integrate" → select the key attribute "ID" under "Attribute to integrate with" → define attribute position in Excel file, for example Hmax10May09 as 6, Hmax11May09 as 7 etc.,→ Click Finish to end the process → External views →Modify → Double click the relation Hydrologystation and select the newly created attributes to make it visible.

Adding Temporal Data to Existing Station in GIS database (TEMPORARY)

Create one Excel file and add columns for every month or day or year and save it.

"ID StationNo. StationName Lat Lon Hmax10May09 Hmax11May09 etc.,"

Savane →Import attributes→From an Excel file → Define the path of the Excel file which you saved and click Open → Select the relation "Hydrologystation" and attribute "ID" → Select the sheet under "Select table to integrate" → select the key attribute "Name" under "Attribute to integrate with" → Click Finish to end the process