Hydrological Modelling

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PCRASTER DYNAMIC MODEL

- A **dynamic model** represents the behaviour of an object over time.
- Representing simplified hydrological runoff model of hilly catchment.
- Model is used for analysis of rainfall-*runoff* with time-step.
- ILWIS software for producing input maps for PCRaster.

TERMINOLOGIES

- Raster - A raster consists of a matrix (data-structure) of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing geographic data, such as temperature or rainfall etc.
- A **hydraulic model** is a mathematical **model** of a water/sewer/storm system and is used to analyse the system's **hydraulic** behaviour.

Runoff Model

- The catchment area considered contains 3 raingauges installed.
- The rainfall data is available for all 3 raingauges over a period of 168 hours.
- It is divided into 28 time-steps with each time-step of duration 6 hours.
- The catchment area consists of three types of soil i.e. sandy, loam and clay.
- The DEM (Digital Elevation Model) map of the area is taken.
- The model is a runoff model in hilly catchment.

EQUATIONS

Curve number is a runoff curve number depends on land use and land cover and soil type found in the region concerned and other factors affecting runoff and retention in a watershed. curve number is a dimensionless number defined such that $0 \leq CN \leq 100$. For impervious and water surface $CN=100$.

Potential Maximum retention depends on Curve Number

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$

where,

$Q = runoff (inch)$

$P = rainfall \ (inch)$

$I_a =$ Initial abstraction (surface storage, interception, and infilteration, inch)

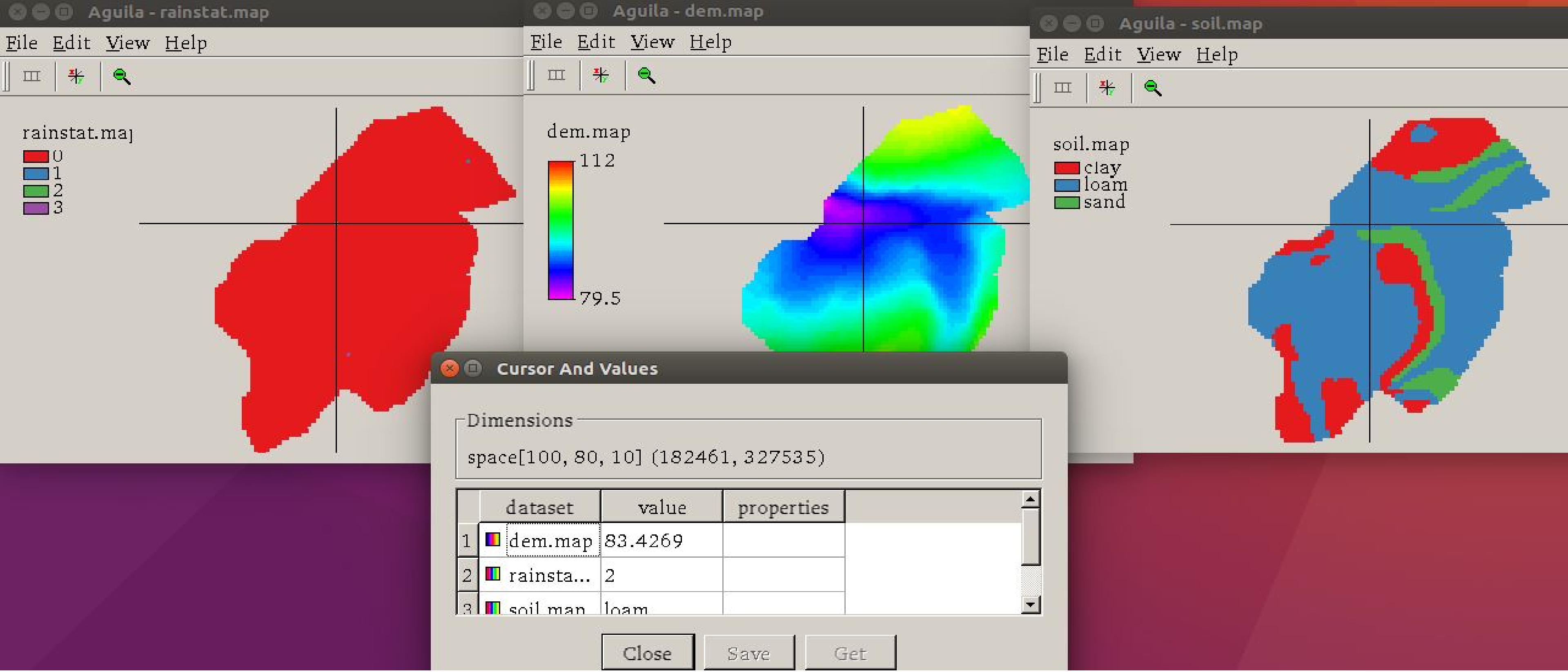
$S =$ potential maximum retention (inch)

$I_a = 0.2S$

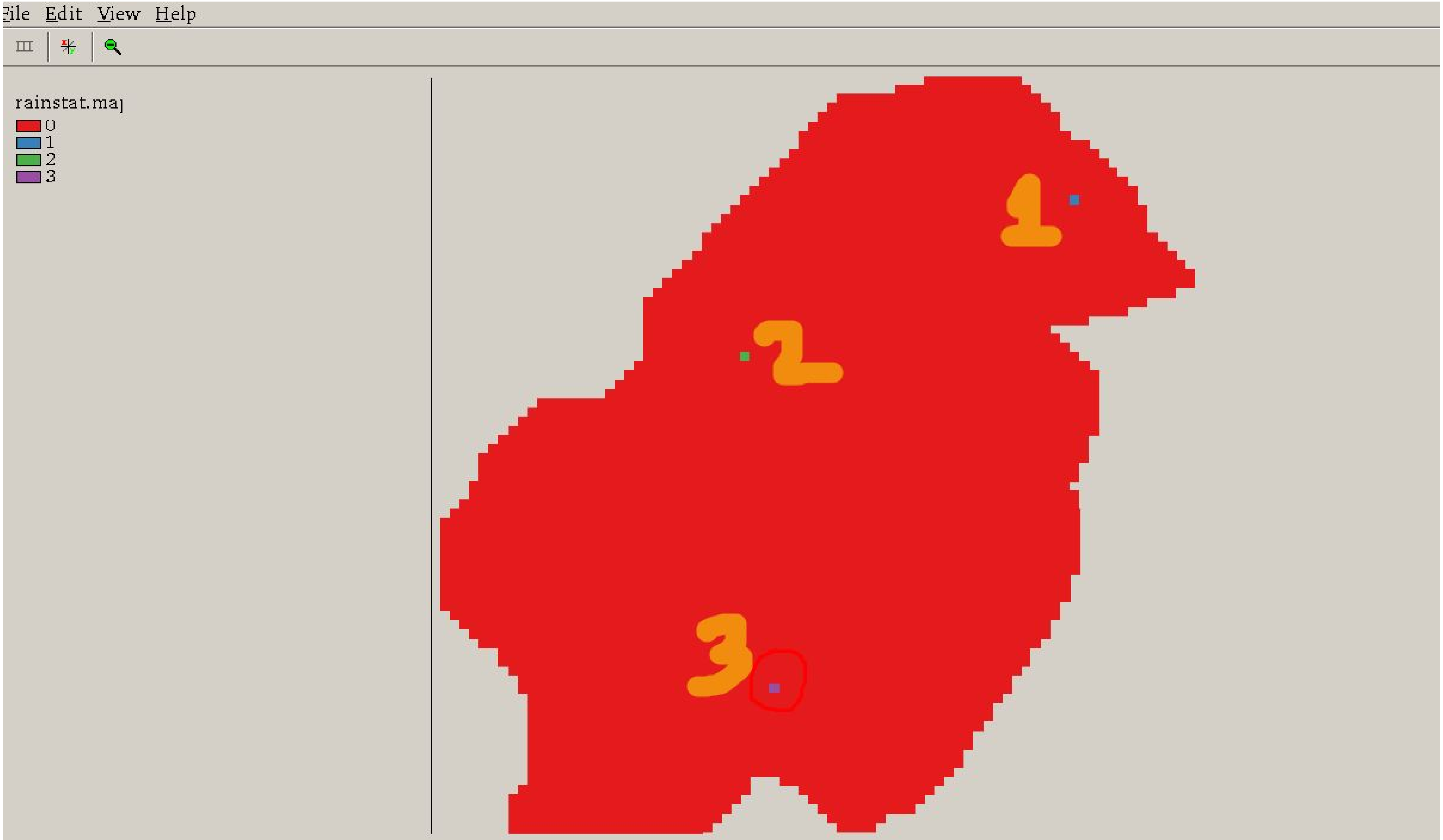
$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Curve number is used to determine S:

$$S = \frac{100}{CN} - 10$$



- dem.map: a Digital Elevation Map (DEM) of the study area, in metres above sea level.
- rainstat.map: map with the location of three rainfall measurement stations.
- soil.map: map of soil types occurring in the study area.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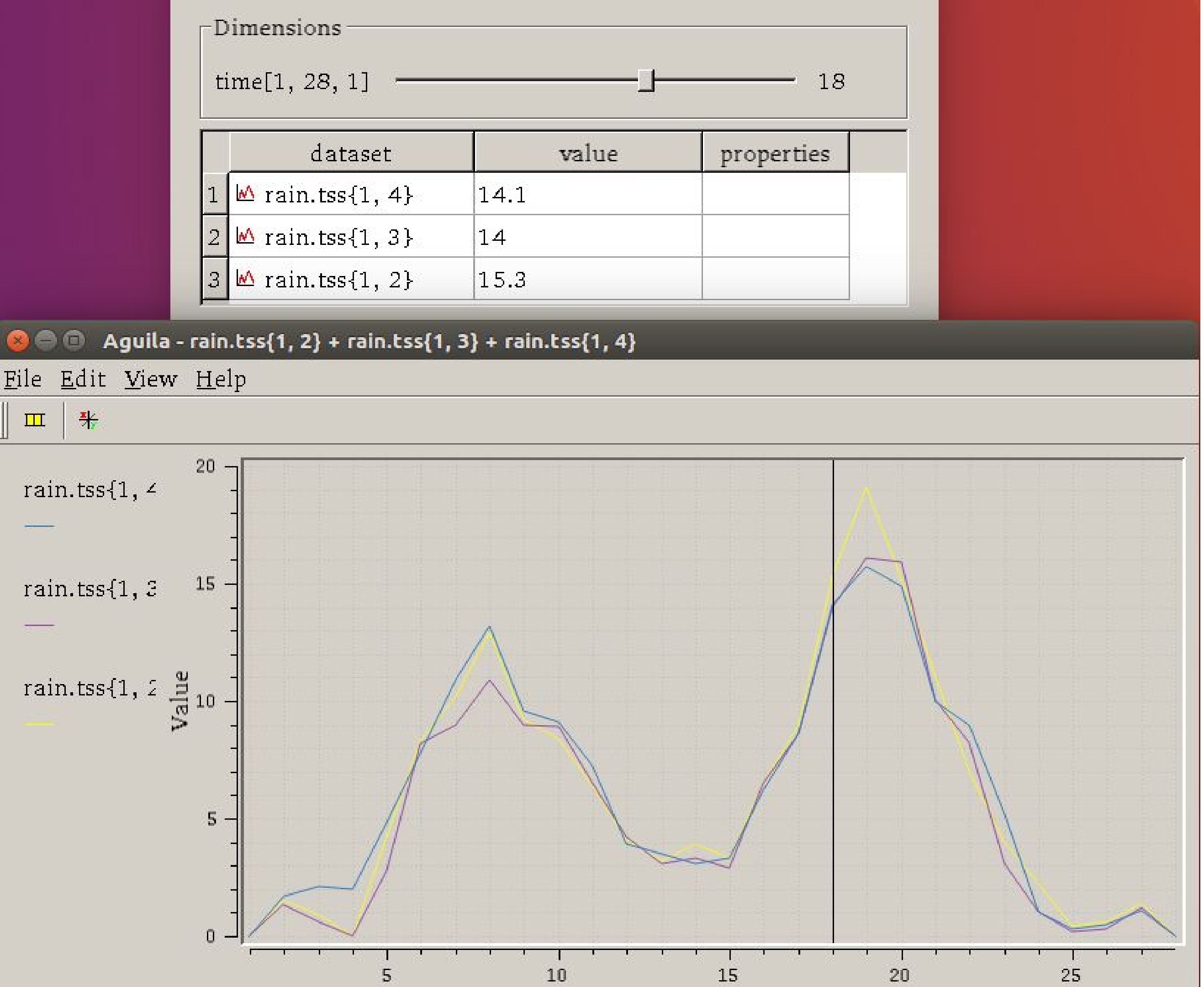
rainstat.maj
0
1
2
3
1
2
3

```
precipitation at 3 rainstations, mm/6 hours
4
timesteps
rainstation 1
rainstation 2
rainstation 3
1       0.0     0.0     0.0
2       1.5     1.3     1.7
3       0.9     0.6     2.1
4       0.0     0.0     2.0
5       4.2     2.8     4.8
6       8.3     8.2     7.8
7      10.2     9.0    10.9
8      12.9    10.9    13.2
9       9.2     9.0     9.6
10      8.4     8.9     9.1
11      6.4     6.5     7.2
12      4.1     4.2     3.9
13      3.2     3.1     3.5
14      3.9     3.3     3.1
15      3.3     2.9     3.3
16      6.5     6.5     6.2
17      9.0     8.6     8.6
18     15.3    14.0    14.1
19     19.1    16.1    15.7
20     15.2    15.9    14.9
21     11.0    10.0    10.0
22      7.0     8.2     9.0
23      4.0     3.1     5.2
24      2.2     1.0     1.0
25      0.4     0.2     0.3
26      0.6     0.3     0.5
27      1.4     1.2     1.1
28      0.0     0.0     0.0
```

- Precipitation (mm) at three rain-station at different timestamps taken at an interval of 6 hrs.

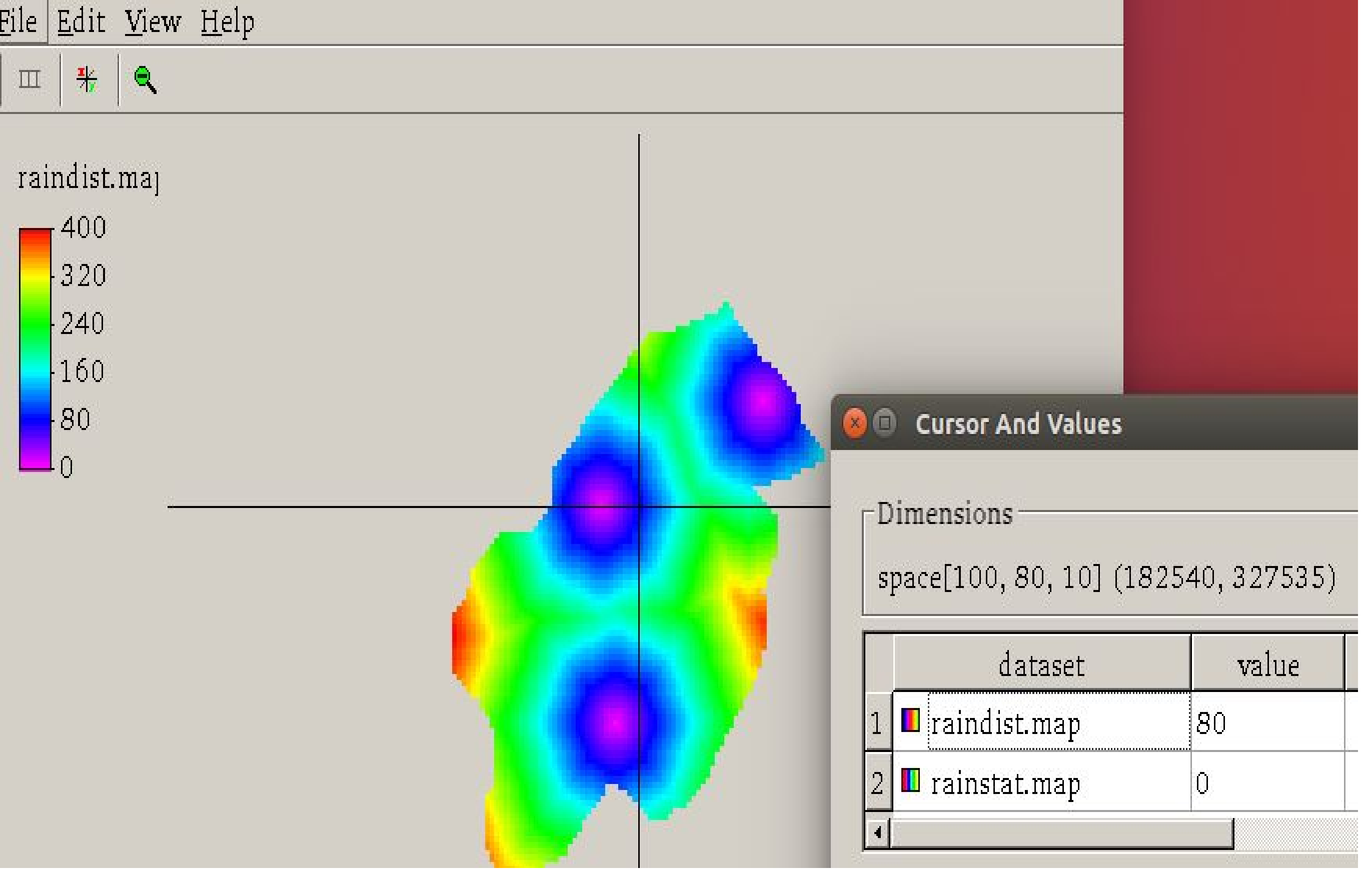


- The precipitation values shown are for different station at time-stamp 18.
- Yellow gives the variation of rainfall at station 1 red at 2 and blue at 3.
- The peak values of rainfall(mm) for various stations are:

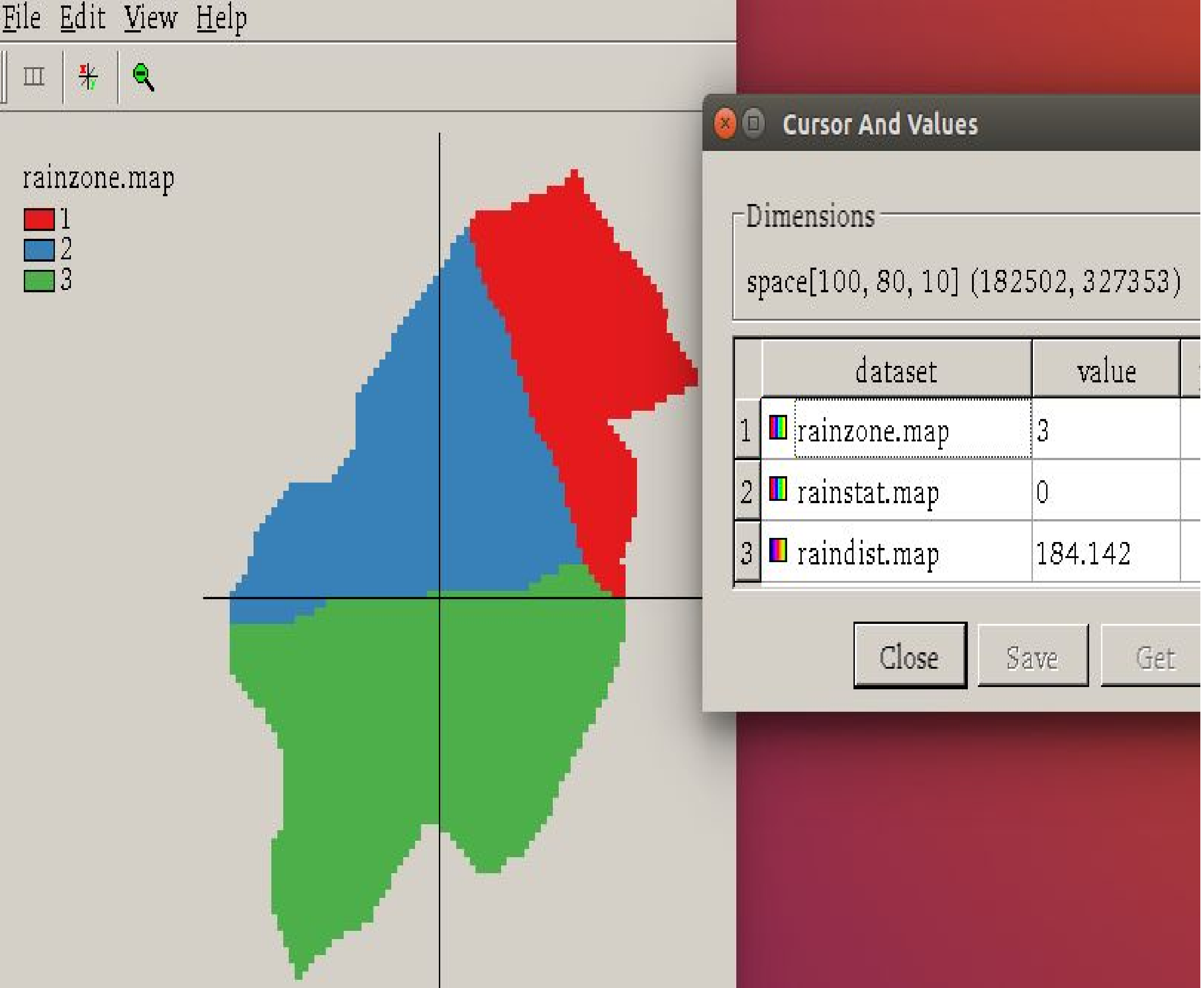
19.1 for station 1

16.1 for station 2

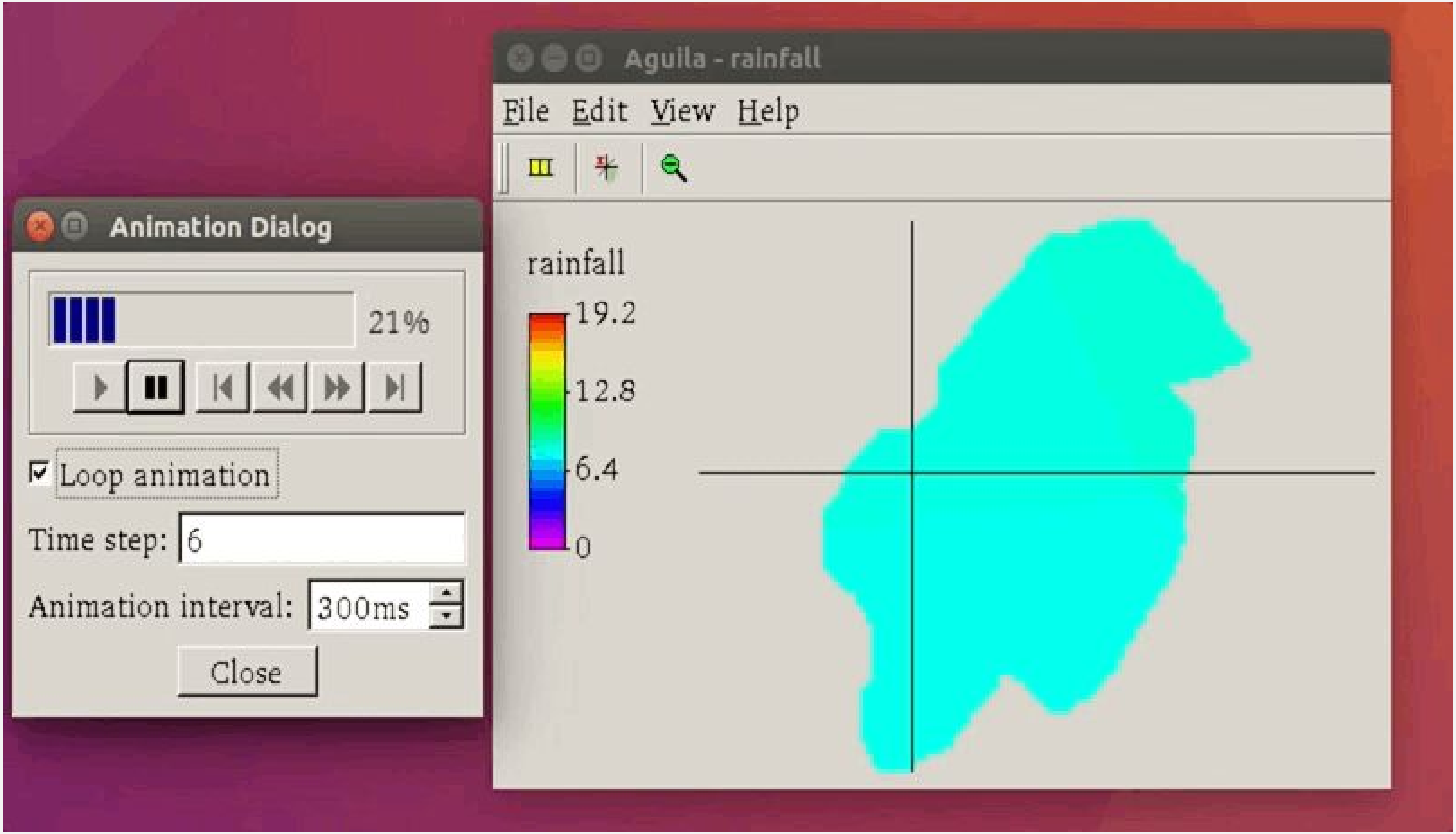
15.7 for station 3



- Map is showing distance of zero points from nearest non zero points.
- Regions with dark blue are closest from their nearest non-zero point.
- This is a relative distance plot. Red marked regions are far from their closest non-zero points as compared to other regions.



- Rain-zones is allocated to each zero points.
- Zoning is done based on the distance of zero points and nearest non-zero points.
- Region marked blue is under zone2(Rainstation-2).


Animation Dialog
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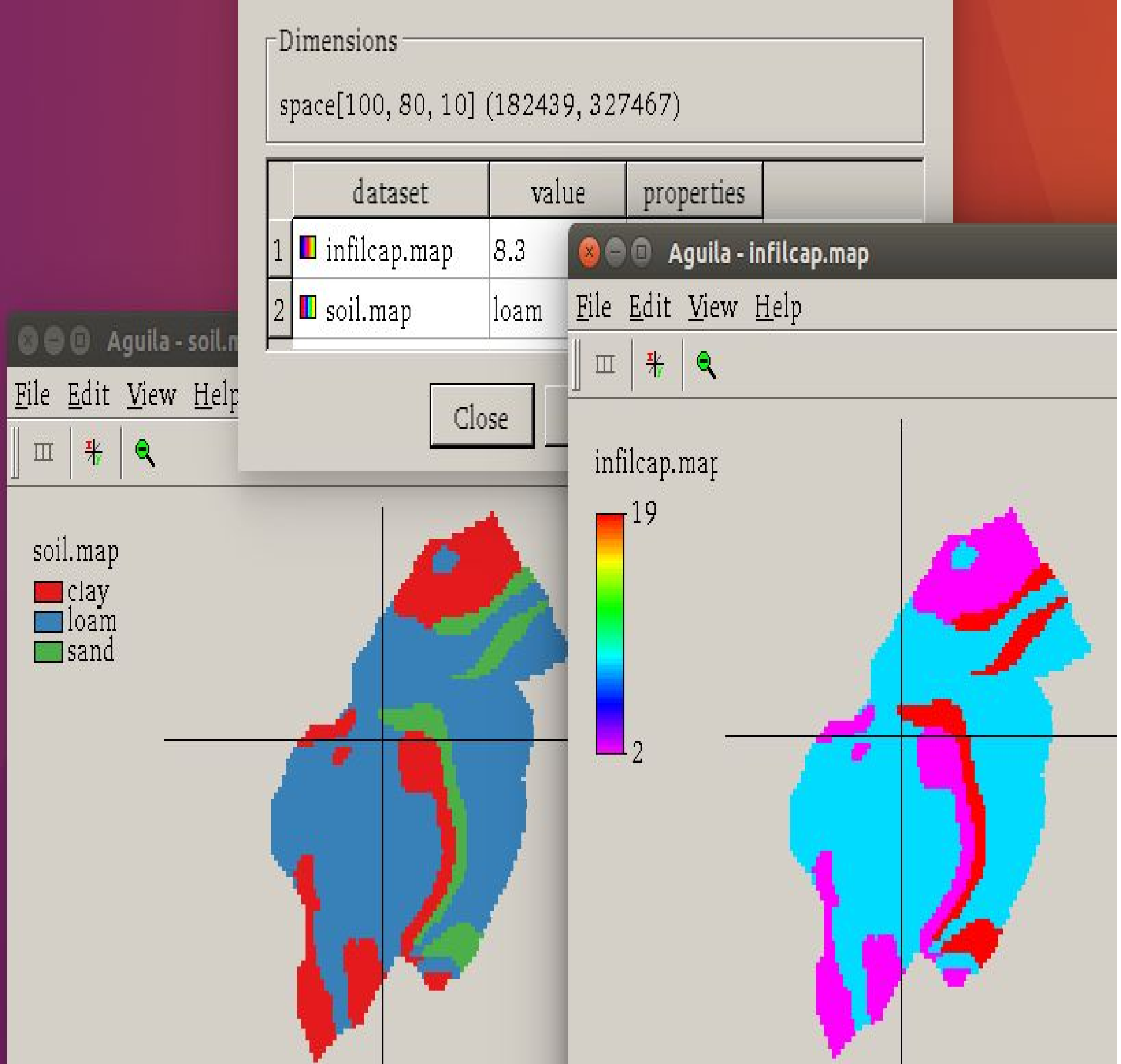
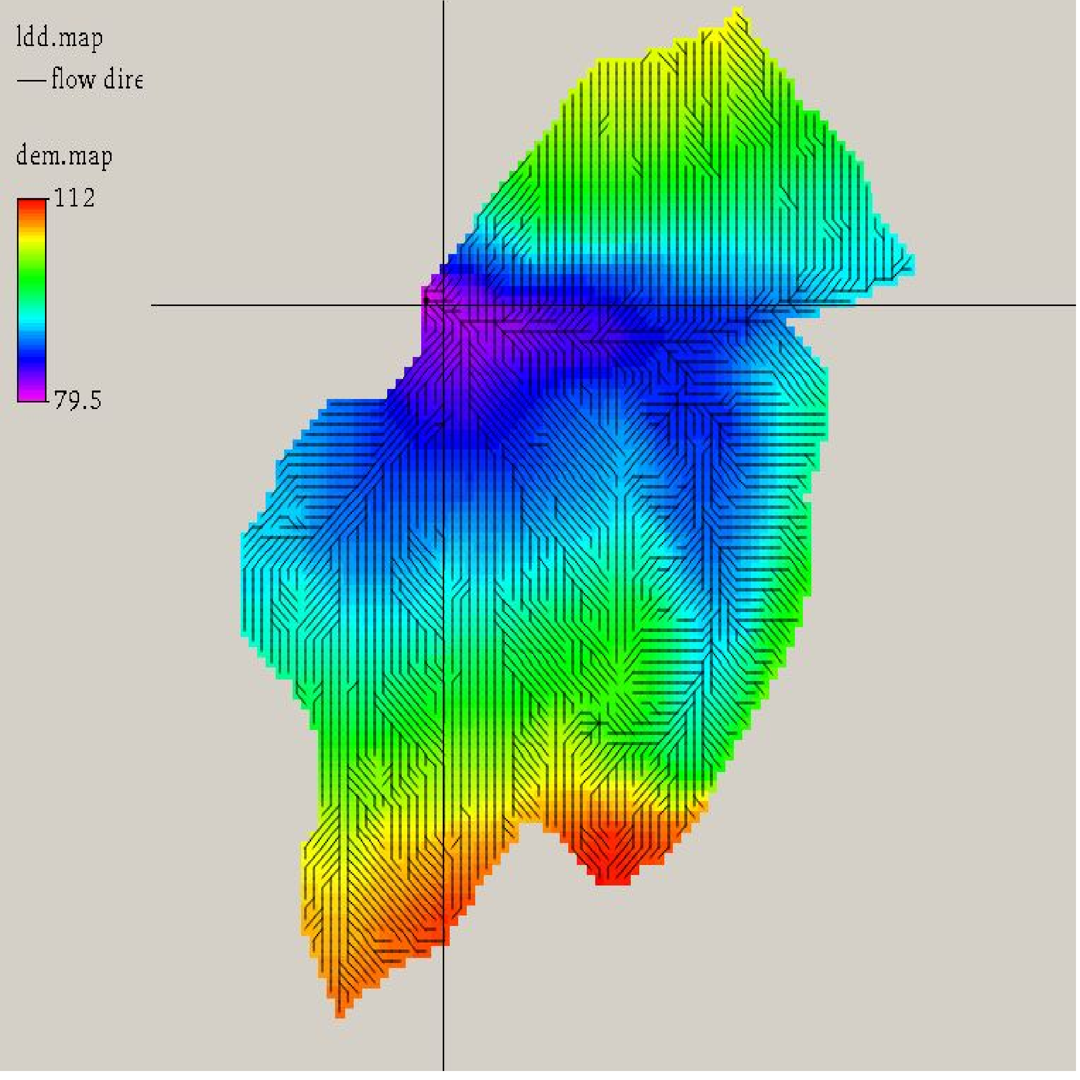
rainfall
19.2
12.8
6.4
0



- Soil map showing the different soil types in the catchment area.
- The infiltration capacity (the maximum amount of water that can infiltrate during one timestep of 6 hours, mm/6 hours) is different for each soil type.

- Clay has a very low infiltration capacity, sand a high capacity and loam a medium capacity.

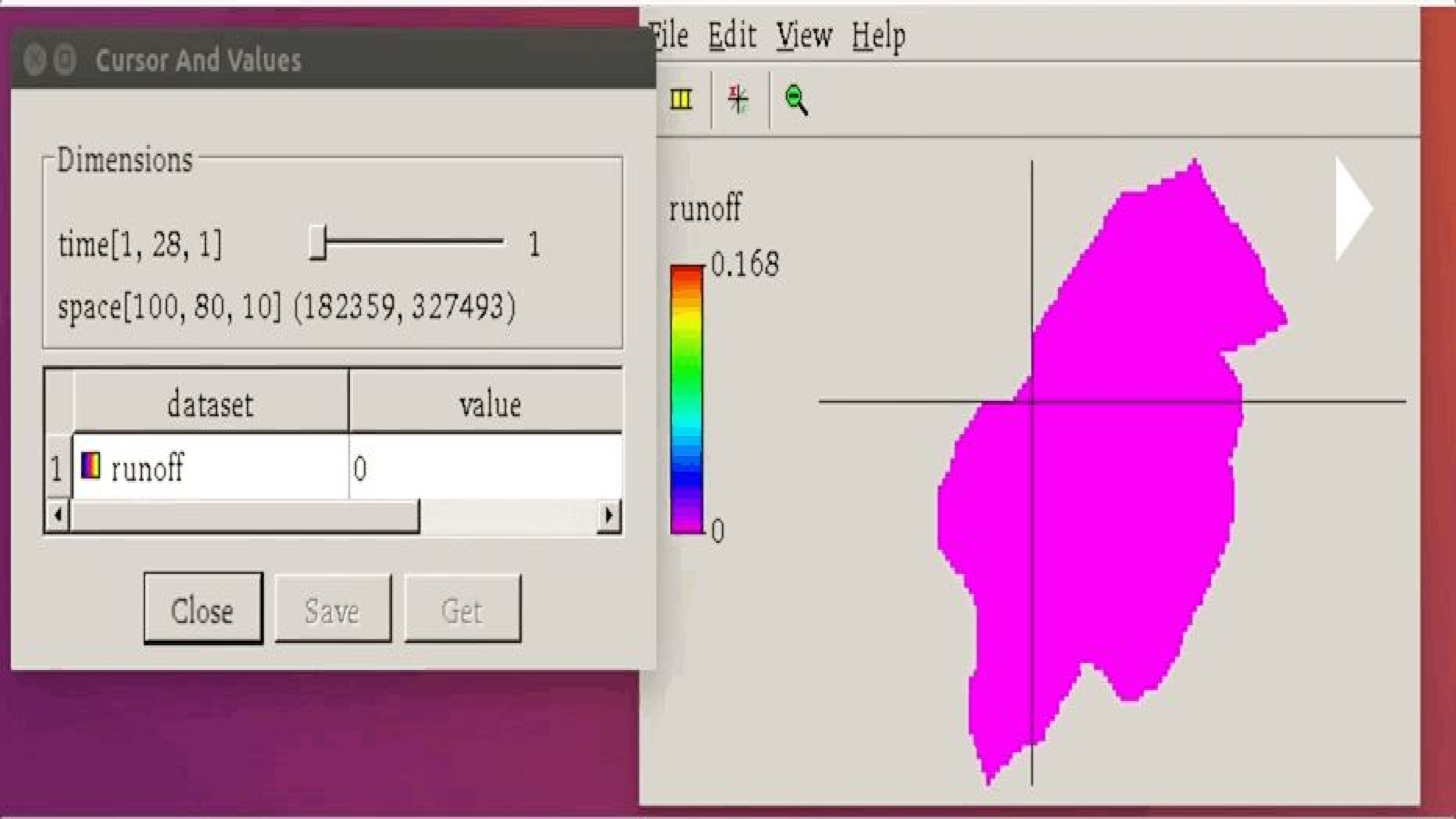
- The infiltration capacity of sand is 19.3, for loam it is 8.3 and for clay it is 2.1.



- The map shows the elevation of regions. The region with lowest elevation is marked with purple.
- Less the elevation of the region more will be runoff.
- In most areas the infiltration capacity is exceeded and runoff of excessive water occurs.
- If soil reaches its saturated point, if infilteration capacity is exceede than .

INFILTRATION, RUNOFF, PRECIPITATION

- **As infiltration capacity is exceeded(saturation of soil) , runoff of excessive water occur.**
- The sandy soils have an infiltration capacity of 19 mm while the amount of rain nowhere exceeds 15.3 mm. So at the sandy soils runoff will only occur when a great amount of water is supplied from upstream areas with lower infiltration capacities.
- Sandy soil at the top of a hill does not have upstream areas that supply water. As a result the infiltration capacity is not exceeded here and no runoff occurs.
- **Actual infiltration of soil at particular timestamp will always be less than equal infiltration capacity.**


Cursor And Values
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dataset
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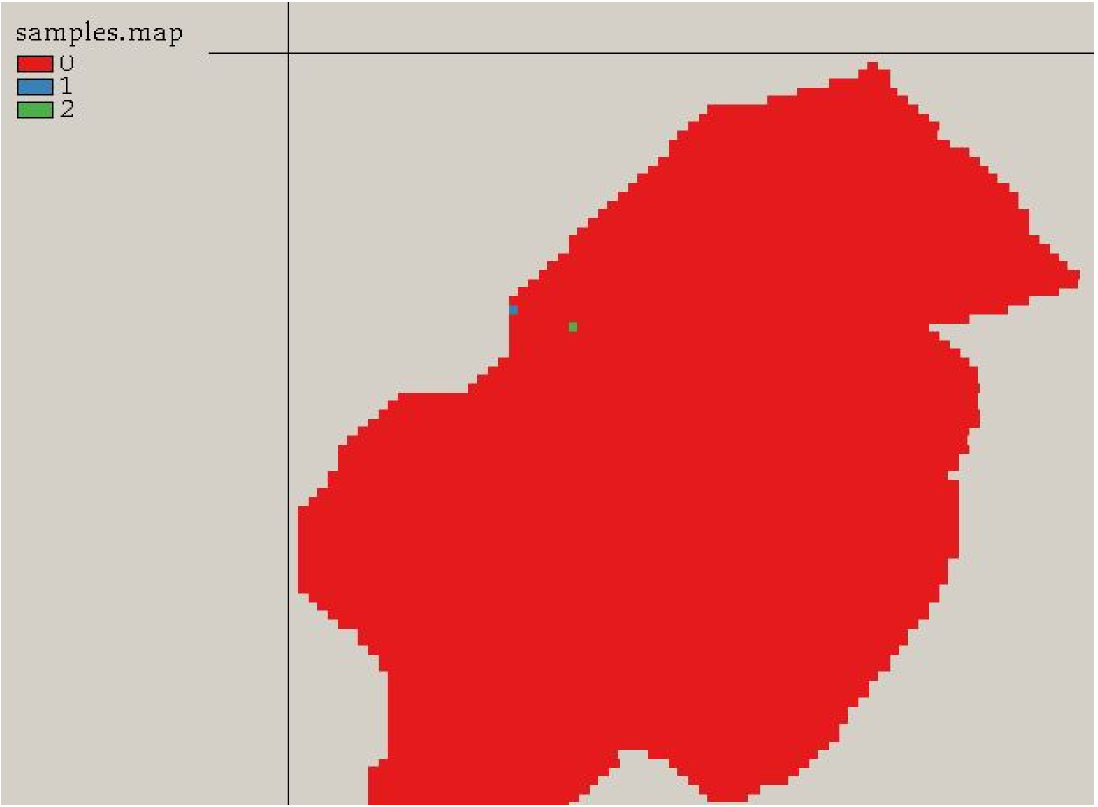
RUNOFF CALCULATION SAMPLE POINTS



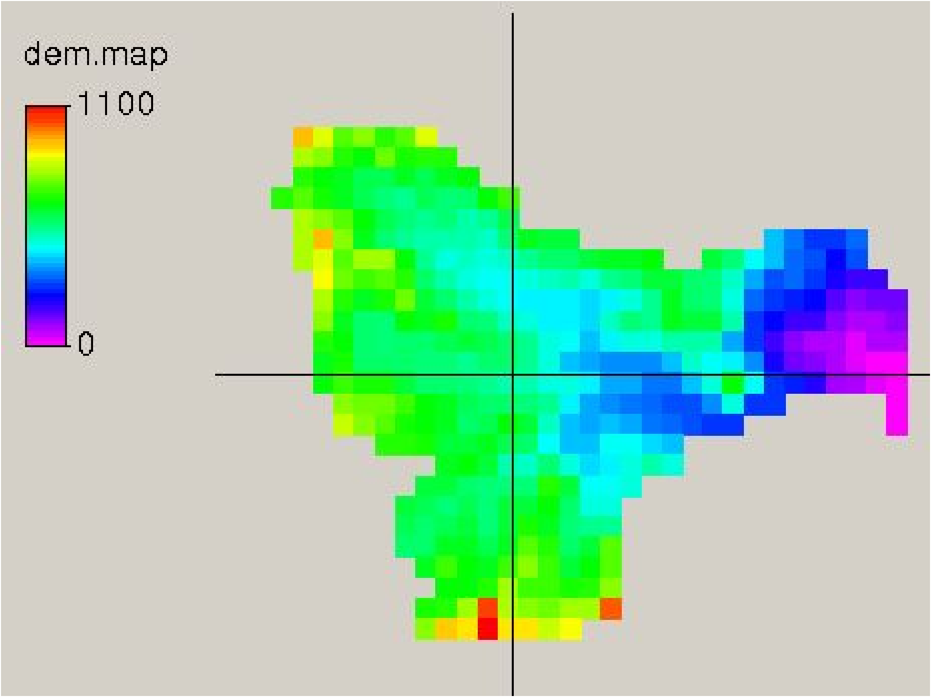
- For calculating runoff, two sample points are selected.
- These points are lowest elevation points where runoff is maximum at each timestamp. Water will move from higher elevation points to these lower elevation points.

RUNOFF AND RAINFALL AT DIFFERENT TIMESTEPS

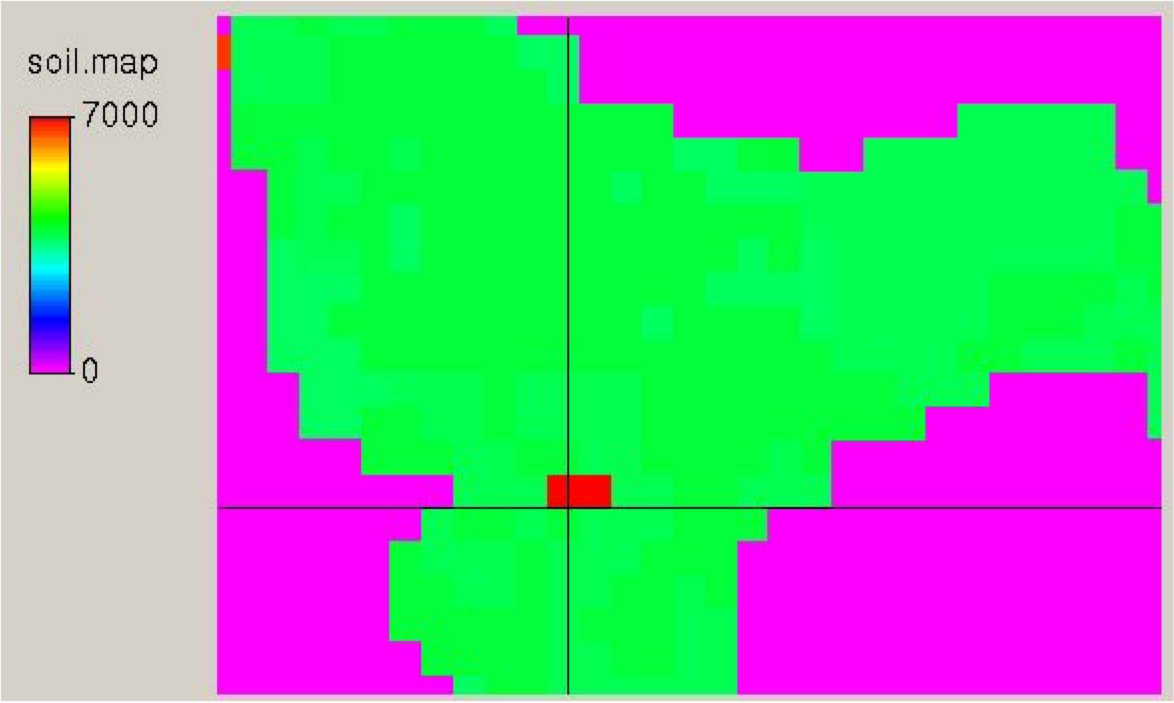
- Video
- Value of run-off of two sampling location for different timestamp and rainfall is shown in the video.
- Helps us to:-
    - Analyze the rain-runoff and infiltration at hilly catchment.
    - Different factors responsible for runoff and infiltration like soil type, elevation etc.

CASE STUDY KRISHNA RIVER BASIN of Year 2015

DEM MAP:-

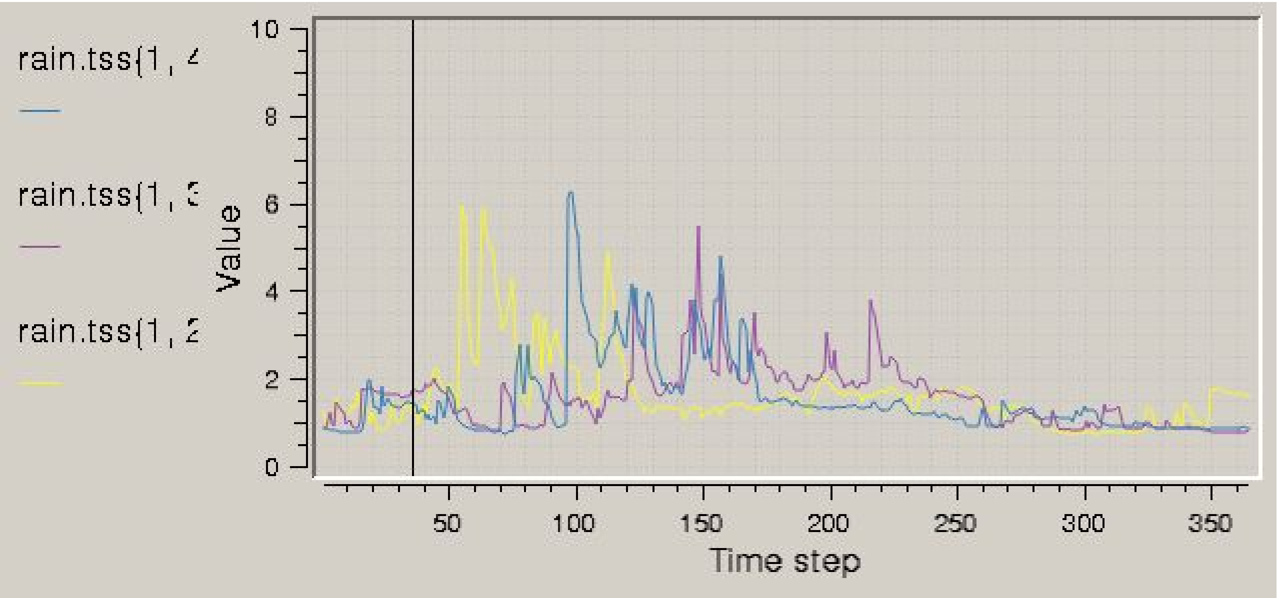


SOIL MAP



Rainfall

Precipitation at various rainstations vs time step



Rain fall video/ Infiltration values

Considered 5 infiltration values

0

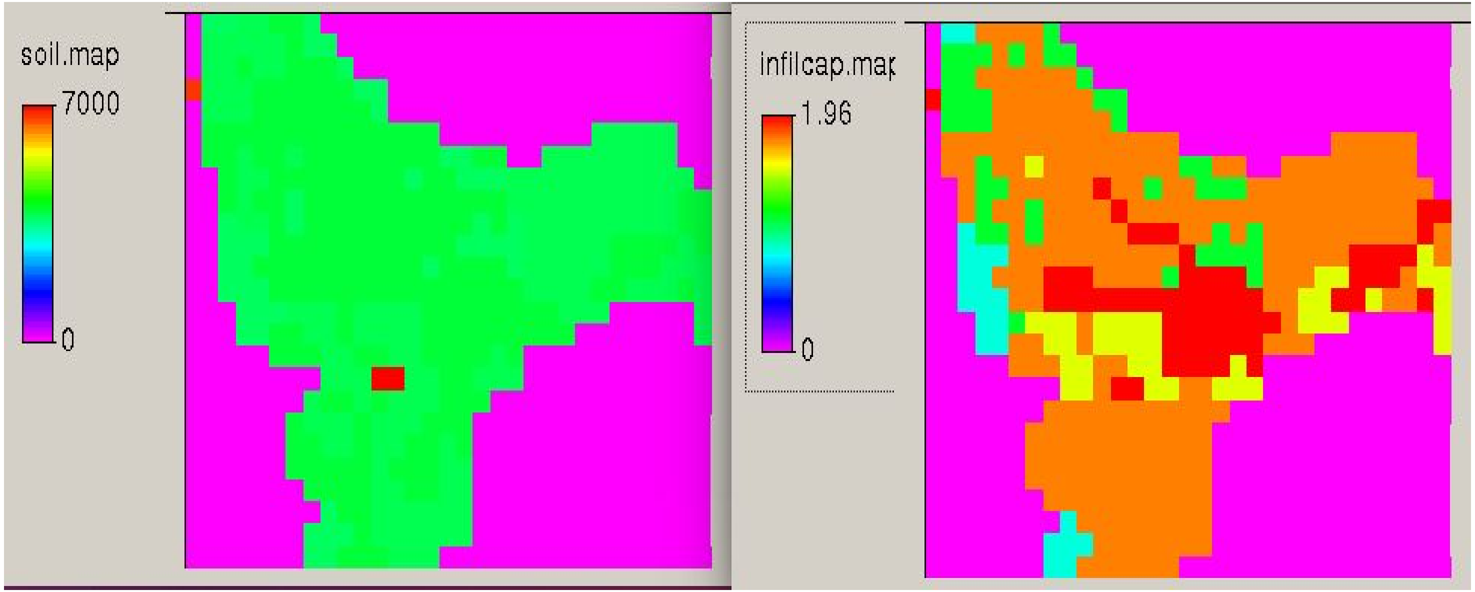
0.83

1.10

1.50

1.75

1.95


soil.map
7000
0
infilcap.ma
1.96
0

REFERENCES

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- http://pcraster.geo.uu.nl/quick-start-guide/
- https://books.google.co.in/books?id=z1qignvz7YkC&pg=PA311&lpg=PA311&dq=some+good+modelling+softwares+like+pc+raster&source=bl&ots=7Xxmm-XuEC&sig=mO_DnfW28pNldUeyMikaYjc81Qs&hl=en&sa=X&ved=0ahUKEwiXyuGyv7PWAhXKMY8KHefVDXIQ6AEIQjAG#v=onepage&q=PC-Raster&f=false
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THANK-YOU