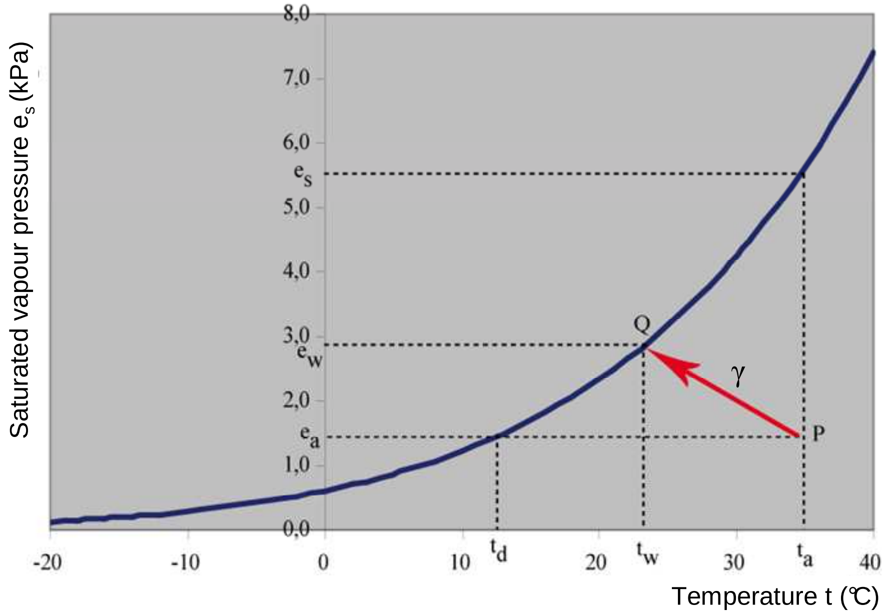
# ANSWERS Practical Day 1

## Exercise Humidity




In the figure above you see (an example of) the relation between vapour pressure and temperature. The curved line indicates the saturation vapour pressure as a function of temperature. The relation of the curved line is:

$$e_s(t) = 0.61\exp\left(\frac{17.3t}{237+t}\right)$$

With a psychrometer the actual vapour pressure $e_a(t_a)$ can be determined through the relation $e_a(t_a) - e_s(t_w) = -0.066(t_a - t_w)$. This relation is indicated by the arrow between point P and Q.

At a certain moment the following temperatures are measured with a psychrometer:
25° C and 17,5 °C

a) Say in words where $t_a$, $t_w$ en $t_d$ stand for.

b) What are the temperatures 25° C and 17,5 °C

c) How much is the saturation vapour pressure for 17,5 °C

d) Calculate on the basis of the psychrometer measurements the actual vapour pressure

e) What is the value of the psychrometer constant and what is its unit.

f) Give the definition of the relative humidity and calculate the relative humidity on the basis of the measurements.

Answers:

a) $t_a$ = actual temperature, $t_w$ = wet bulb temperature,   $t_d$ = dew point

b) 25° C  = $t_a$ = actual temperatuur
   17,5 °C = $t_w$ = temperatuur of the wet bulb

c) $e_s(17.5) = 0.61\exp\left(\frac{17.3*17.5}{237+17.5}\right) = 2.0$  [KPa]

d) $e_a(t_a) - e_s(t_w) = -0,066(t_a - t_w)$

$e_a(t_a) - 2.0 = -0,066(25 - 17.5)$

$e_a(t_a) = 1.51$ [kPa]

e) psychrometer constant = 0.066 [kPa/°C]

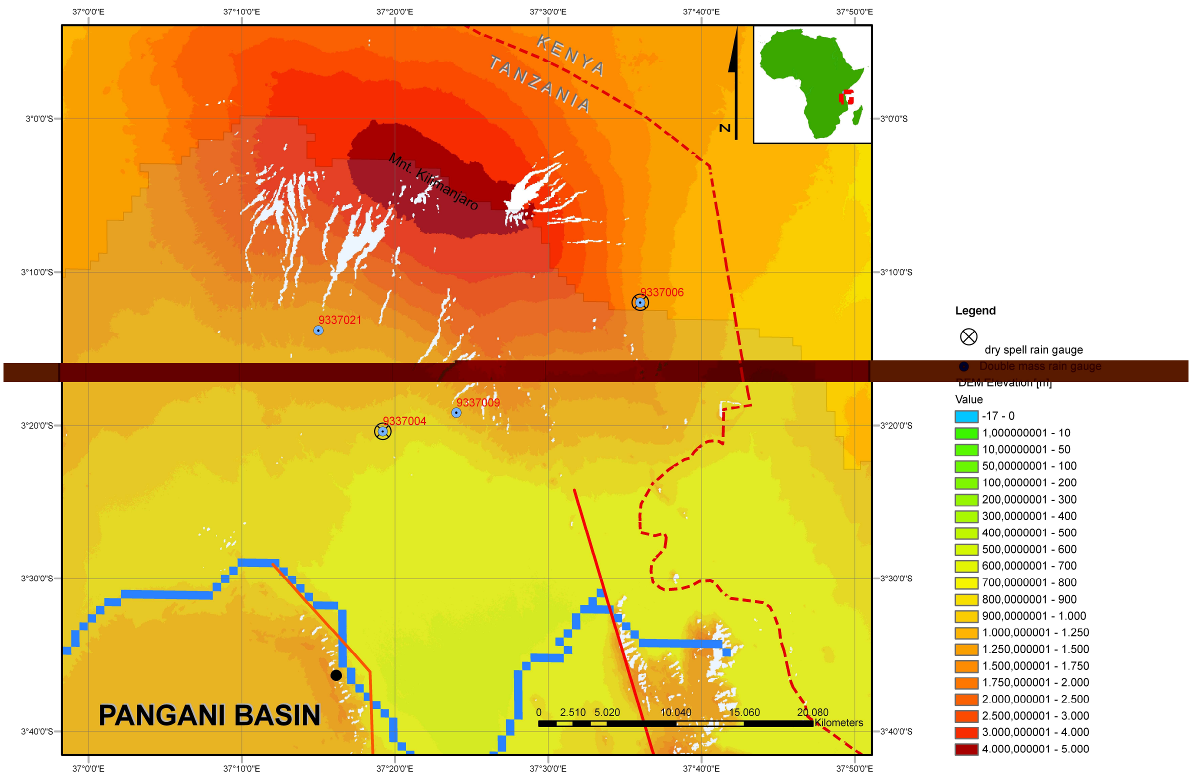
f) $h = \frac{e_a(t)}{e_s(t)}$

$e_s(25) = 0.61\exp\left(\frac{17.3*25}{237+25}\right) = 3.18$

$h = \frac{e_a(t)}{e_s(t)} = \frac{1.51}{3.18} = 0.475$ or 47.5%

**Exercise Data Screening**
**Double Mass**

The monthly rainfall data of the four stations coded 9337004, 9337006, 9337009 and 9337021 in the Pangani Basin, Tanzania over the period 1935-1990 are provided in a spreadsheet on blackboard. The map indicates the location of the stations.



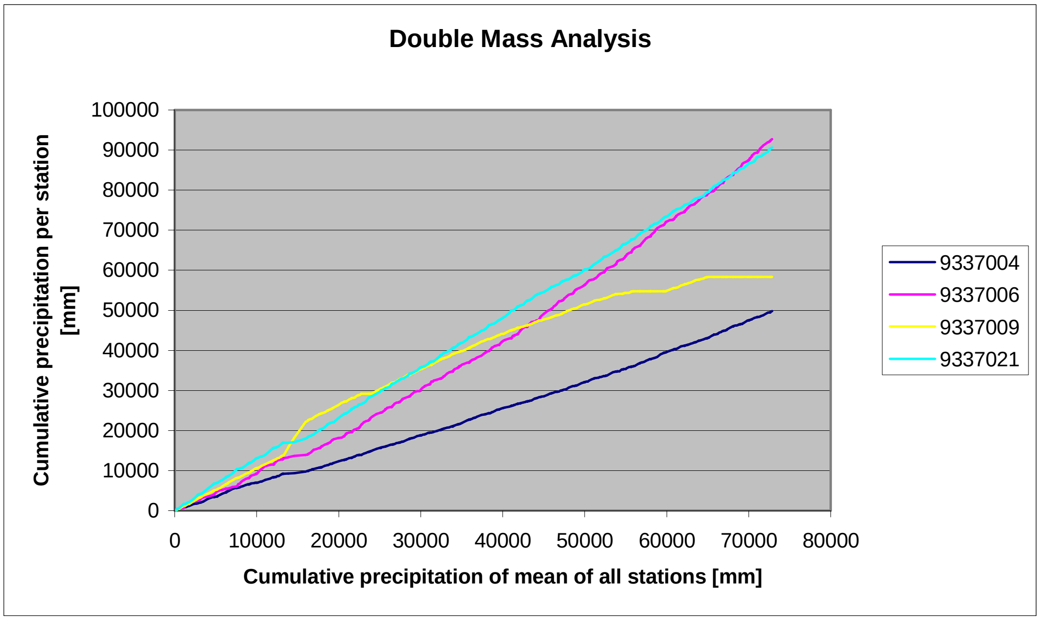

You are requested to investigate and explain irregularities in the stations data by comparing for each station the cumulative precipitation against the average cumulative precipitation of **all** four stations.

1) Compile these results in a graph with the so called double mass curves. Draw your conclusions.

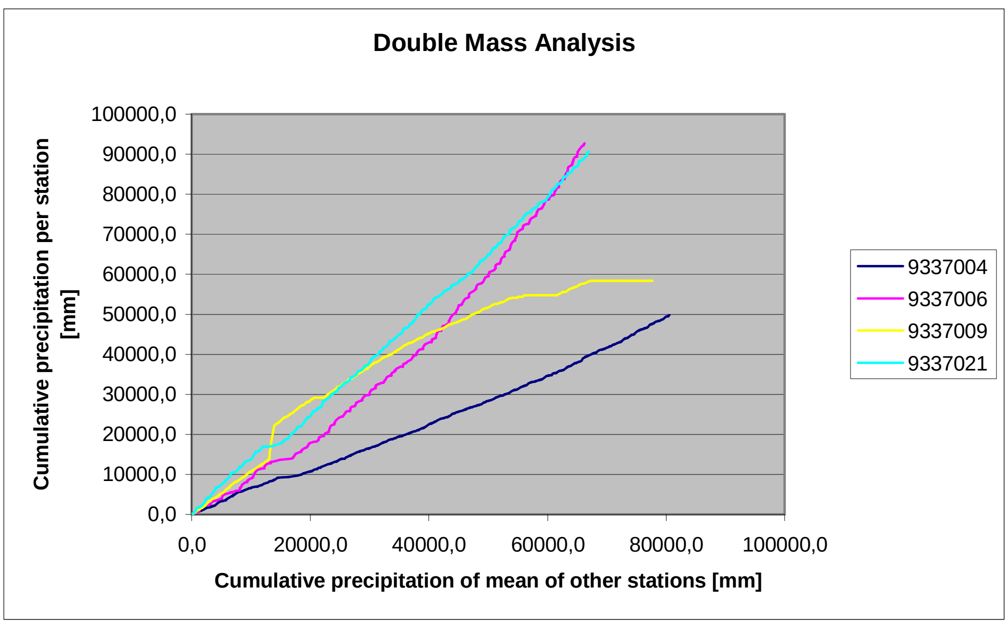
2) Compile again the double mass curves but now comparing for each station the cumulative precipitations against the average of the other three stations.
Explain the differences with the previous graph.

3) Remove any suspicious stations from the analysis and create new double mass graphs from the remaining stations.

1) Station 9337009 clearly deviates from a straight line




2) The deviation from a straight line of station 9337009 is even more obvious



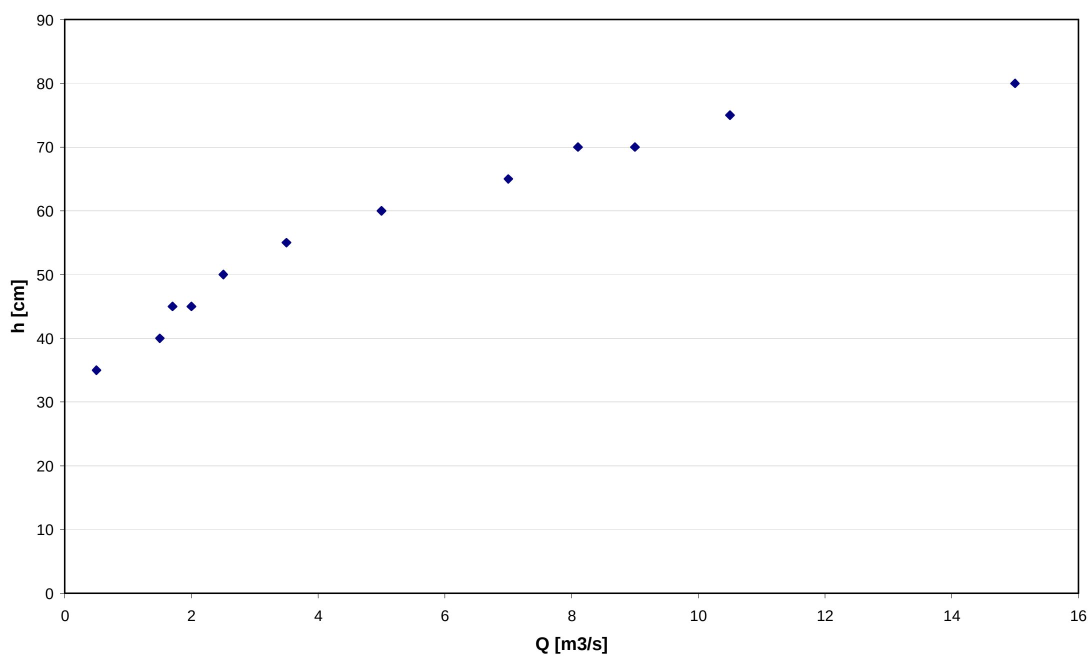
**Exercise Stage-discharge relationships**

Use all discharge measurements below to draw a stage-discharge curve.

| Measurement | Date | Staff gauge [cm] | Discharge [$m^3/s$] |
|---|---|---|---|
| 1 | 1-2-76 | 35 | 0.5 |
| 2 | 5-4-76 | 45 | 1.7 |
| 3 | 13-6-76 | 80 | 15.0 |
| 4 | 7-8-76 | 70 | 9.0 |
| 5 | 11-10-76 | 65 | 7.0 |
| 6 | 19-11-76 | 60 | 5.0 |
| 7 | 8-2-78 | 40 | 1.5 |
| 8 | 15-4-78 | 50 | 2.5 |
| 9 | 2-7-78 | 60 | 8.1 |
| 10 | 27-8-78 | 65 | 10.5 |
| 11 | 9-9-78 | 55 | 3.5 |
| 12 | 28-10-78 | 45 | 2.0 |

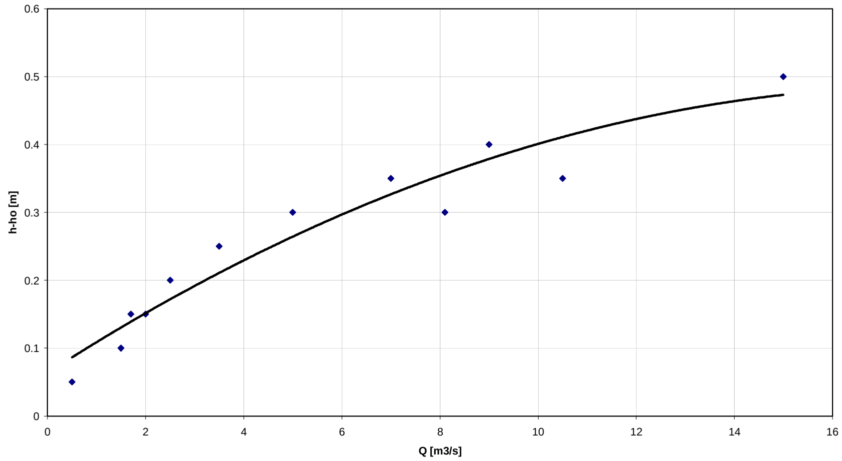
- Estimate $h_0$.
- Plot the Q-h-relationship logarithmically and hence determine the coefficients a and b in the equation.

$$Q = a*(h-h_0)^b$$




$H_0$ is ± 30 [cm]

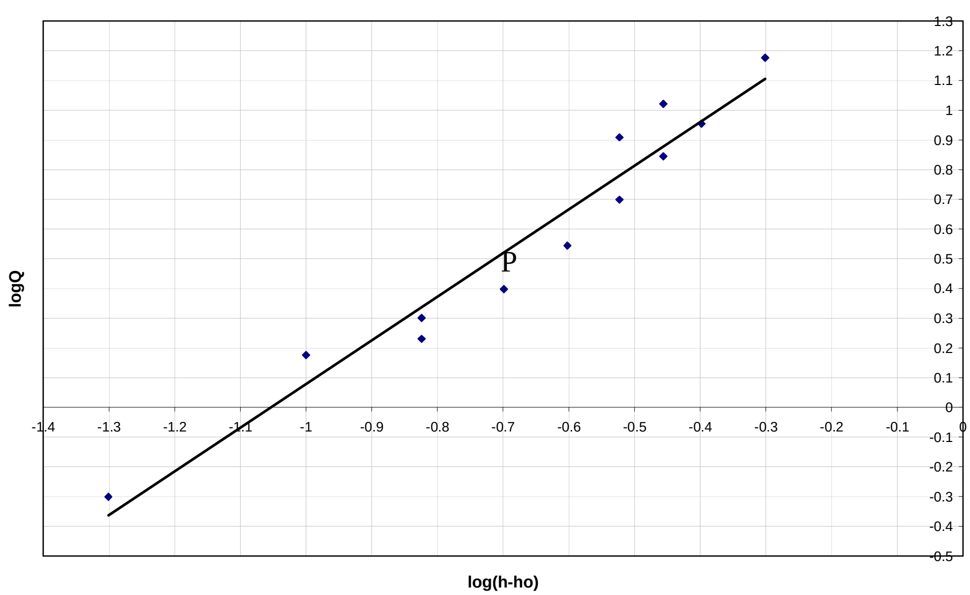
Q against ($h - h_0$) of 1976 and 1978




- 1976 and 1978 plotting logarithmically of Q against $(h\text{-}h_0)$

| $h\text{-}h_0$ | $\log(h\text{-}h_0)$ | Q | log(Q) |
|---|---|---|---|
| 0.05 | -1.30 | 0.5 | -0.30 |
| 0.15 | -0.82 | 1.7 | 0.23 |
| 0.5 | -0.30 | 15 | 1.18 |
| 0.4 | -0.40 | 9 | 0.95 |
| 0.35 | -0.46 | 7 | 0.85 |
| 0.3 | -0.52 | 5 | 0.70 |
| 0.1 | -1.00 | 1.50 | 0.18 |
| 0.2 | -0.70 | 2.50 | 0.40 |
| 0.3 | -0.52 | 8.10 | 0.91 |
| 0.35 | -0.46 | 10.50 | 1.02 |
| 0.25 | -0.60 | 3.50 | 0.54 |
| 0.15 | -0.82 | 2.00 | 0.30 |

$\log Q = \log a + b * \log(h\text{-}h_0)$
b = slope
a = intercept



Fill in two points at the line to solve a and b.

1. At the intersection with the y-axis:
   $\log(h-h_0) = 0$
   $\log Q = \log a = 1.5$
   $a = 31.6$

2. at P: $\log Q = \log a + b * \log(h-h_0)$
   $0.48 = 1.5 + b * (-0.7)$
   $-1.1 = b * (-0.7) \rightarrow b = 1.45$

So:

$$Q = 31.6 \cdot (h - h_0)^{1.5}$$

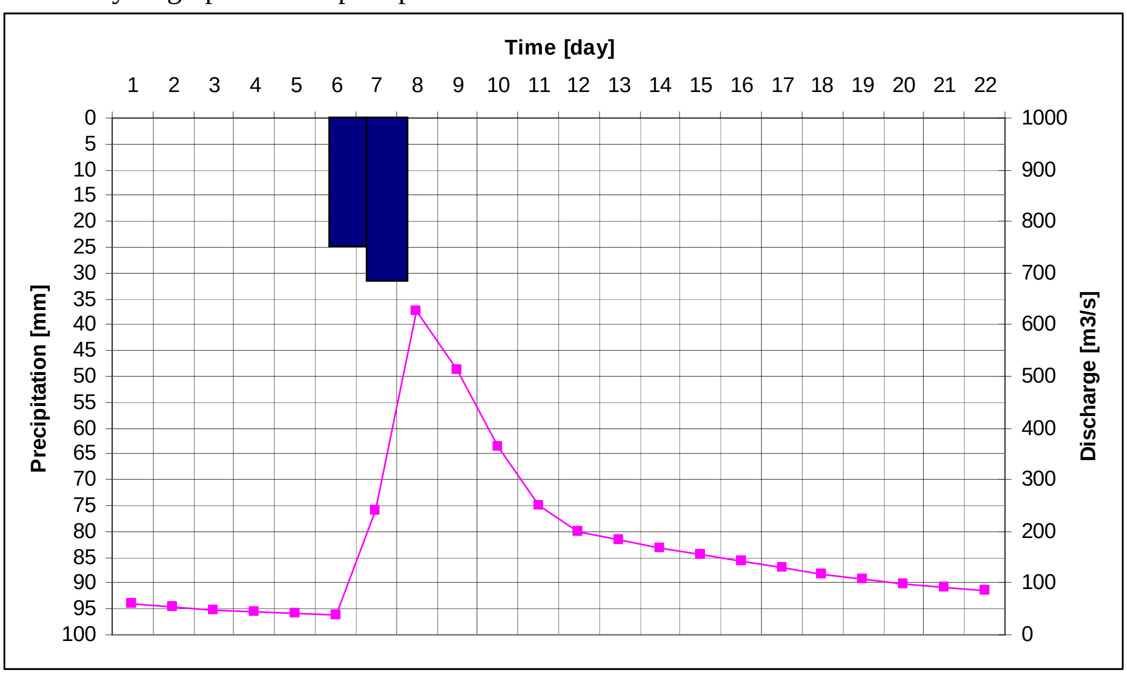
**Water balance from hydrograph**

Below you find the measured precipitation and the measured discharges of a catchment with a surface area of 8640 $km^2$.

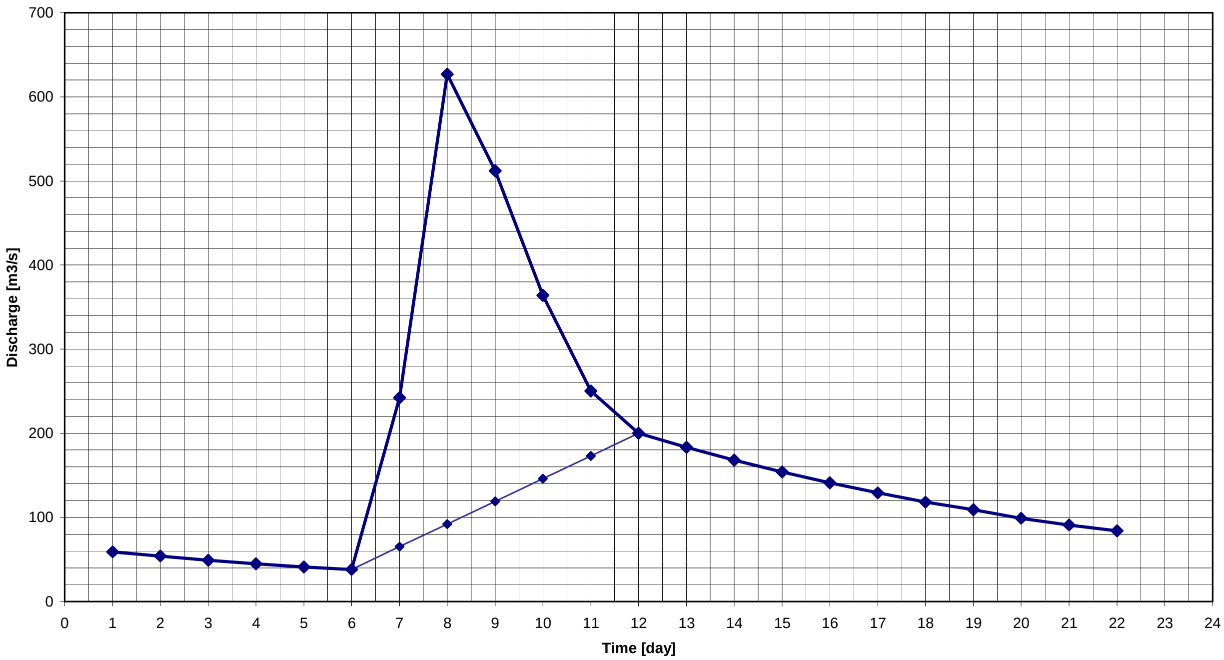
| Time [day] | Precipitation [mm] | Discharge [$m^3/s$] | Time [day] | Precipitation [mm] | Discharge [$m^3/s$] |
|---|---|---|---|---|---|
| 1 | | 59 | 12 | | 200 |
| 2 | | 54 | 13 | | 183 |
| 3 | | 49 | 14 | | 168 |
| 4 | | 45 | 15 | | 154 |
| 5 | | 41 | 16 | | 141 |
| 6 | | 38 | 17 | | 129 |
| 7 | 25 | 242 | 18 | | 118 |
| 8 | 32 | 627 | 19 | | 109 |
| 9 | | 512 | 20 | | 99 |
| 10 | | 364 | 21 | | 91 |
| 11 | | 250 | 22 | | 84 |

All measurements are instantaneous measurements at 08:00 hr AM. For the discharge it means it is the discharge at 08:00 hr AM. For precipitation it means it is the cumulative 24 hr rainfall of the 24 hrs before!

- Plot the hydrograph and the precipitation

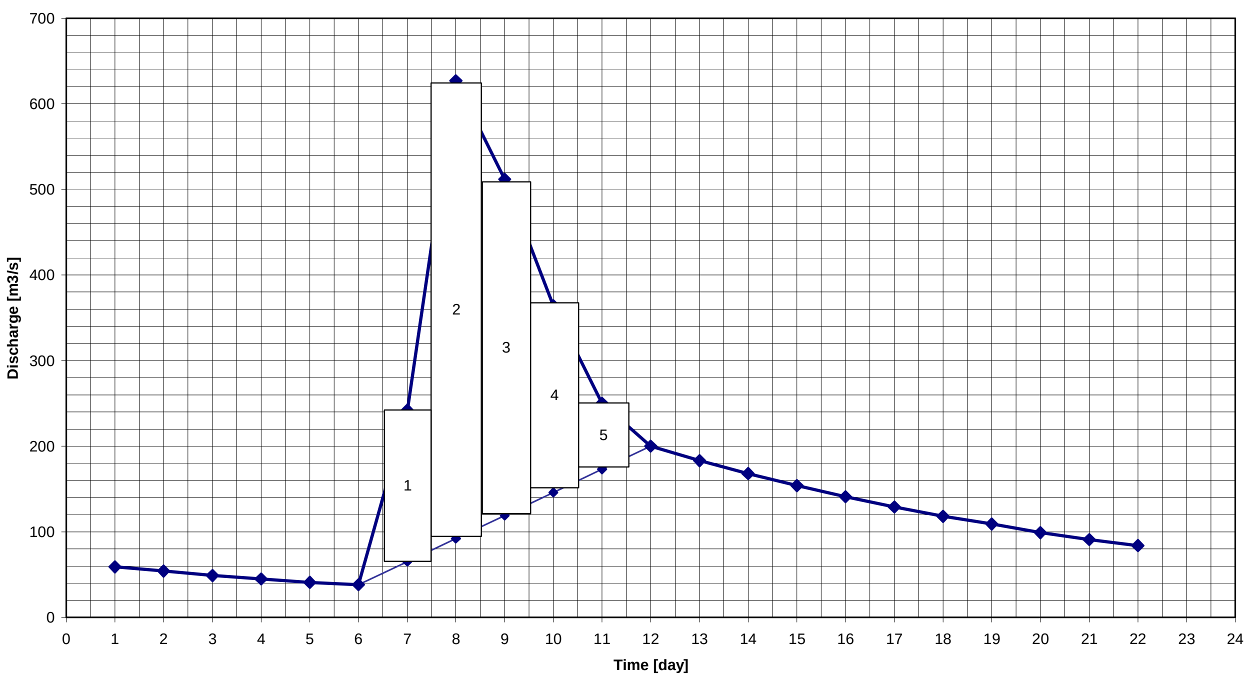


- Discharge has a baseflow and direct flow component. Direct flow ends at day 12. Apply the ‘straight line’ method to divide the base flow from the direct flow.

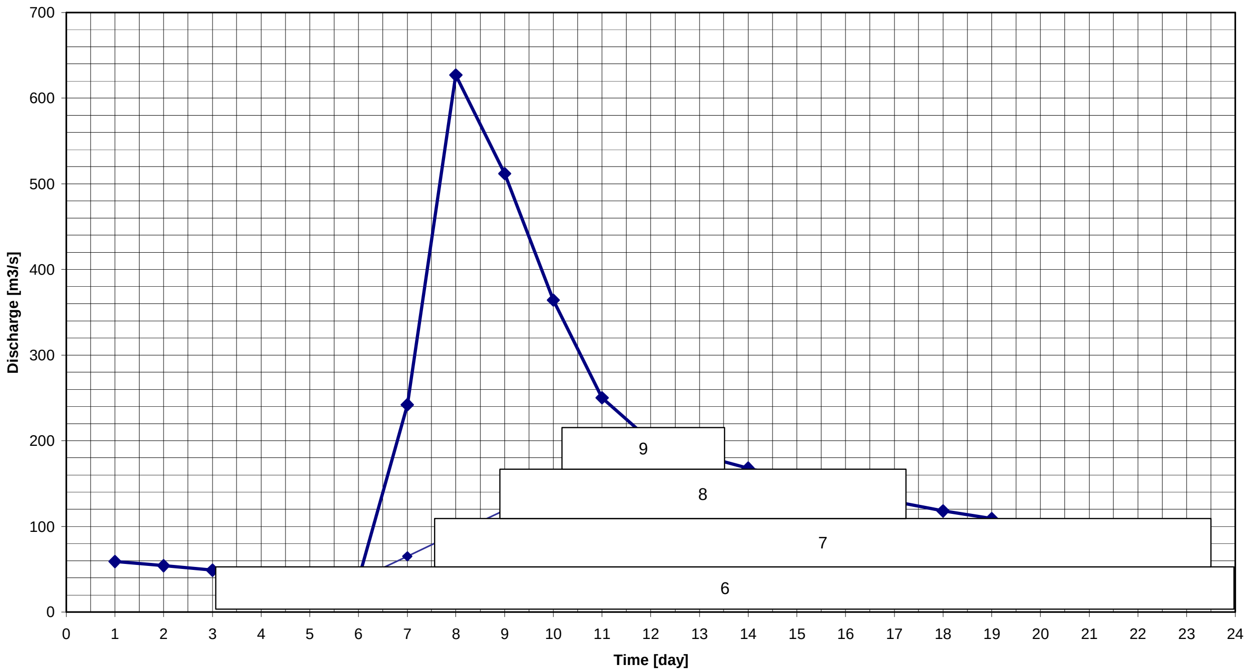



- Determine the percentage precipitation that leaves the catchment as ‘direct flow’.

“counting cells” (1 cell is 20 $m^3$/s x 0.5 day = 20 x 60 x 60 x 24 x 0.5 = 864000 $m^3$)



- Determine the percentage precipitation that leaves the catchment as ‘base flow’.




$(Q_{\text{direct}})$ = ±127 cells equals $1.1 \cdot 10^8$ [$m^3$]=

$$\frac{1.1 \cdot 10^8}{8640 \cdot 10^6} = 1.27 \cdot 10^{-2}[m] = 12.7[mm]$$

$$Q_{direct} = \frac{12.7}{25+32} = 22[\%]$$

$(Q_{\text{basis}})$ = ±308 cells equals $2.66 \cdot 10^8$ [$m^3$]=

$$\frac{2.66 \cdot 10^8}{8640 \cdot 10^6} = 3.08 \cdot 10^{-2}[m] = 30.8[mm]$$

$$Q_{basis} \frac{30.8}{57} = 54[\%]$$

NB. Loss P: 57 - (12.7 + 30.8) = 57 - 43.5 = 13.5 [mm]

**Rainfall Intensity Duration Curves.**

From a record of 50 years of daily rainfall data you have to establish the intensity-duration curve. The relation obviously depends on the return period. In a few systematic steps you will compile such a curve.

1) Occurrence in class intervals for various durations.
The occurrences of rain exceeding the lower limits of certain class intervals and certain duration is established from the daily rainfall data. The result for 10mm class intervals and durations of 1,2,5 and 10 days duration is provided in the table.

| Class interval (mm) | 1 | 2 | 5 | 10 |
|---|---|---|---|---|
| 0 | 18262 | 18261 | 18258 | 18253 |
| 10 | 384 | 432 | 730 | 2001 |
| 20 | 48 | 127 | 421 | 1539 |
| 30 | 5 | 52 | 243 | 713 |
| 40 | 1 | 12 | 158 | 493 |
| 50 | | 5 | 83 | 286 |
| 60 | | 2 | 49 | 221 |
| 70 | | | 25 | 170 |
| 80 | | | 16 | 96 |
| 90 | | | 9 | 76 |
| 100 | | | 5 | 49 |
| 110 | | | 3 | 31 |
| 120 | | | 1 | 22 |
| 130 | | | 1 | 16 |
| 140 | | | | 9 |
| 150 | | | | 7 |
| 160 | | | | 5 |
| 170 | | | | 4 |
| 180 | | | | 2 |
| 190 | | | | 2 |
| 200 | | | | 1 |

2)Cumulative frequency curves
In an excel sheet and graph establish for each duration (1,2,5, 10 days, 4 lines ) the relation between return period (vertical axis) for each bottom value of class interval (horizontal axis). We are not interested in return periods less than a year. Plot the return period on logarithmic scale.

3) Depth Duration Frequency Curve
For the specific return periods of 1, 10 and 100 years (3 lines) plot the duration in days (x-axis) against the (cumulative) rainfall depth in millimeters. This information follows directly from reading the previous plot. Make the same plot on a log-log scale.

4) Intensity Duration Frequency Curve.
Dividing the rainfall depths from the previous step by the duration yields the average intensity in [mm/day].
In this way make a Intensity Duration Frequence curve (3 lines) on both linear and double logarithmic scale

Results: See Lecture notes
Chapter 1.2.1 Frequency analysis, Fig 1.17, Fig 1.18, Fig 1.19