EGU General Assembly 2007

An analytical model of the effects of catchment hypsography on the flood frequency distribution

P. Allamano, P. Claps & F. Laio
Department of Hydraulics - Politecnico di Torino

15-20 April 2007
Vienna

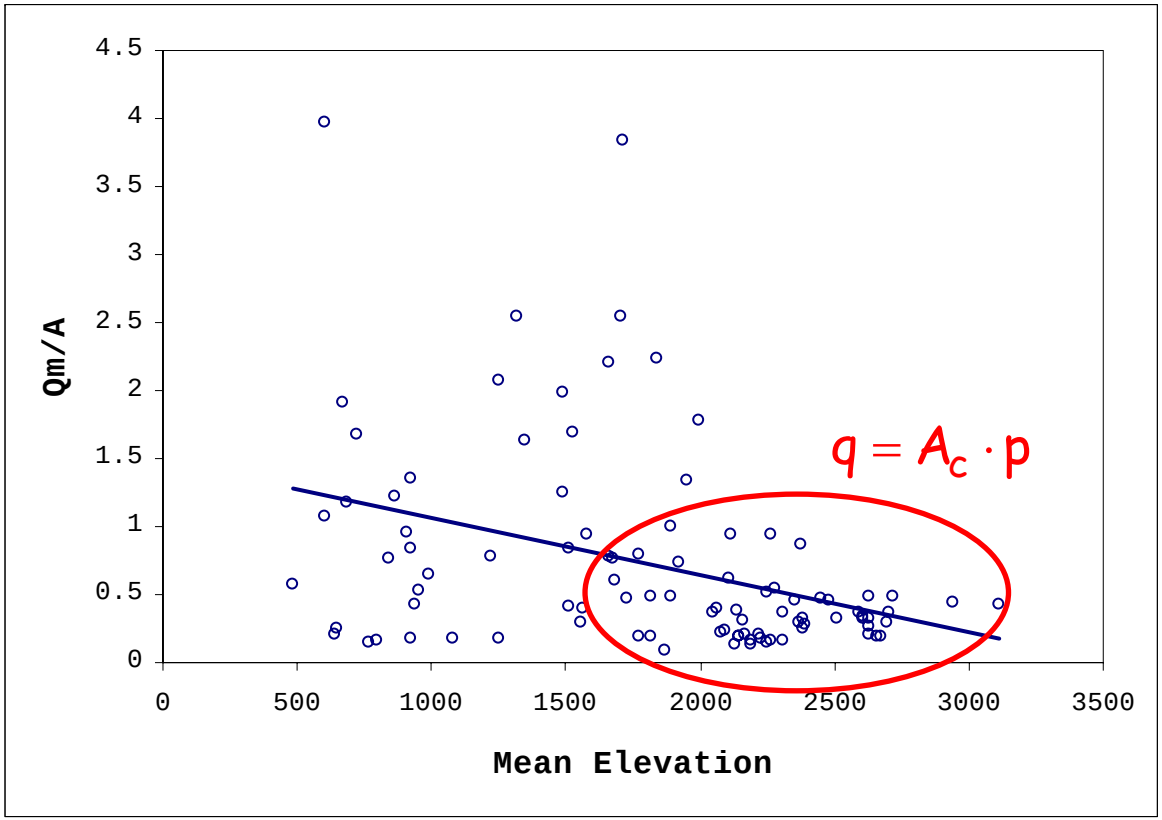
Framework

- Context: ALPINE regions
- Difficulty to describe processes from observed hydrologic series
- High reliability of altimetric info

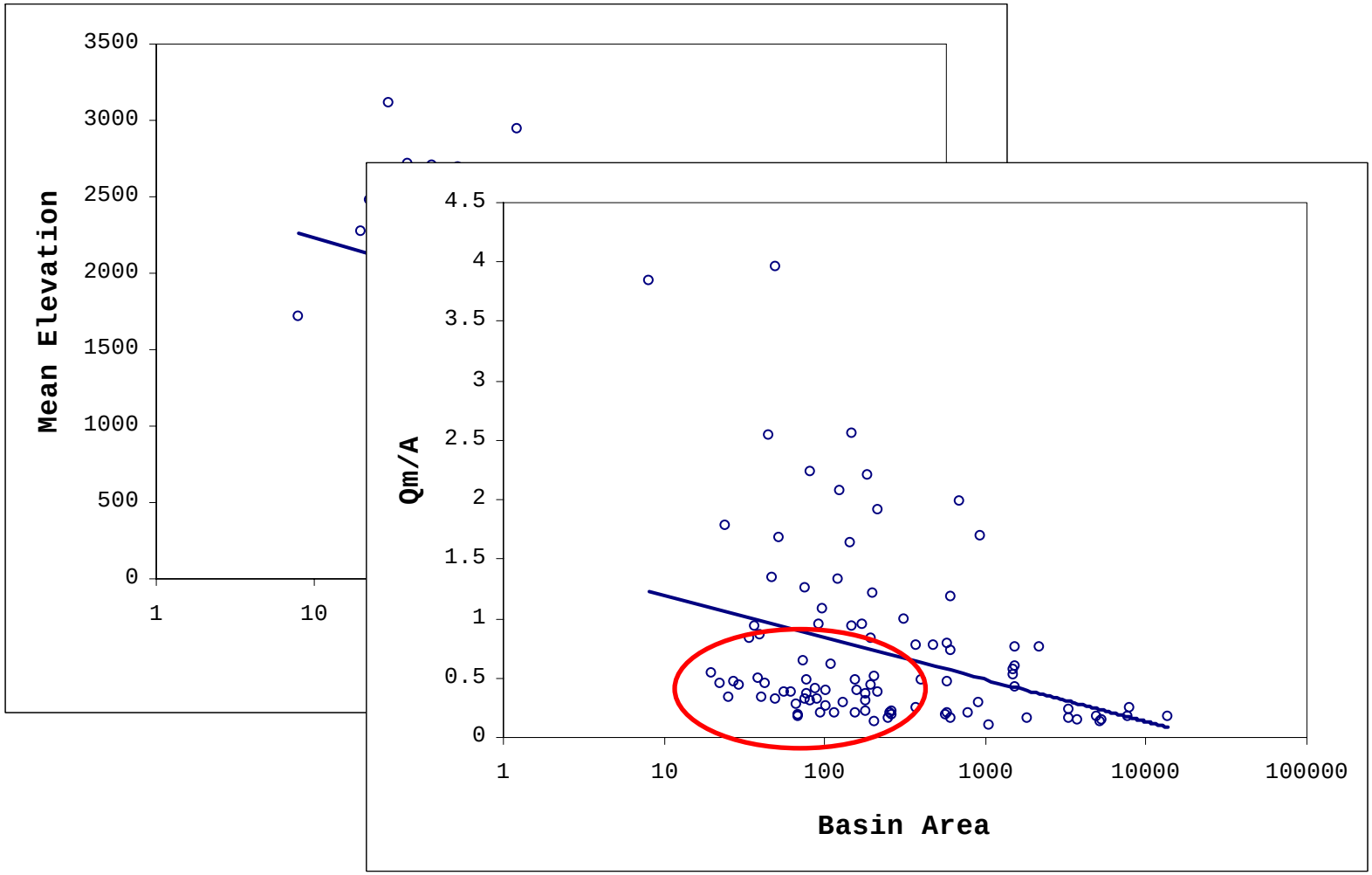
➔ Need to find a parsimonious representation of hydrologic processes in mountainous areas

Experimental evidence

Subtractive mechanism on streamflow formation (Contributing Area):

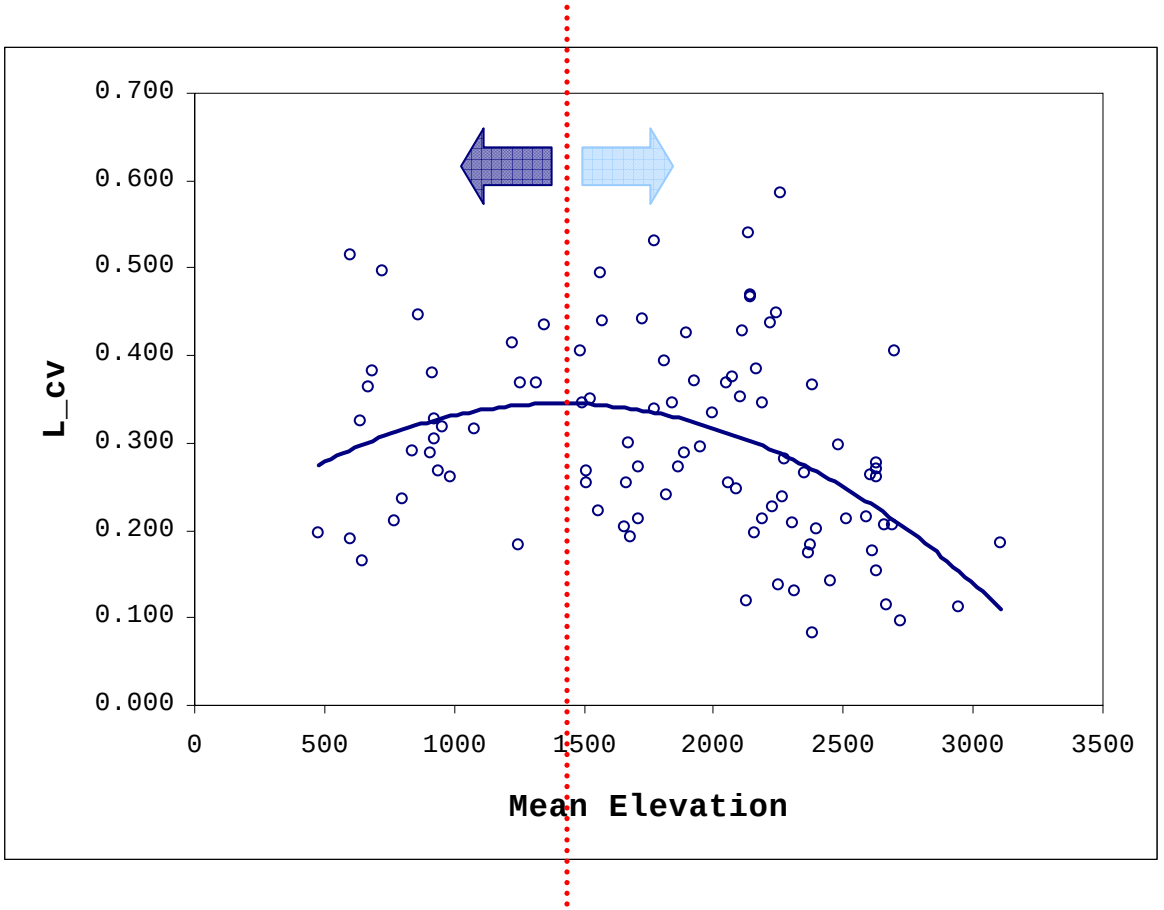


Experimental evidence

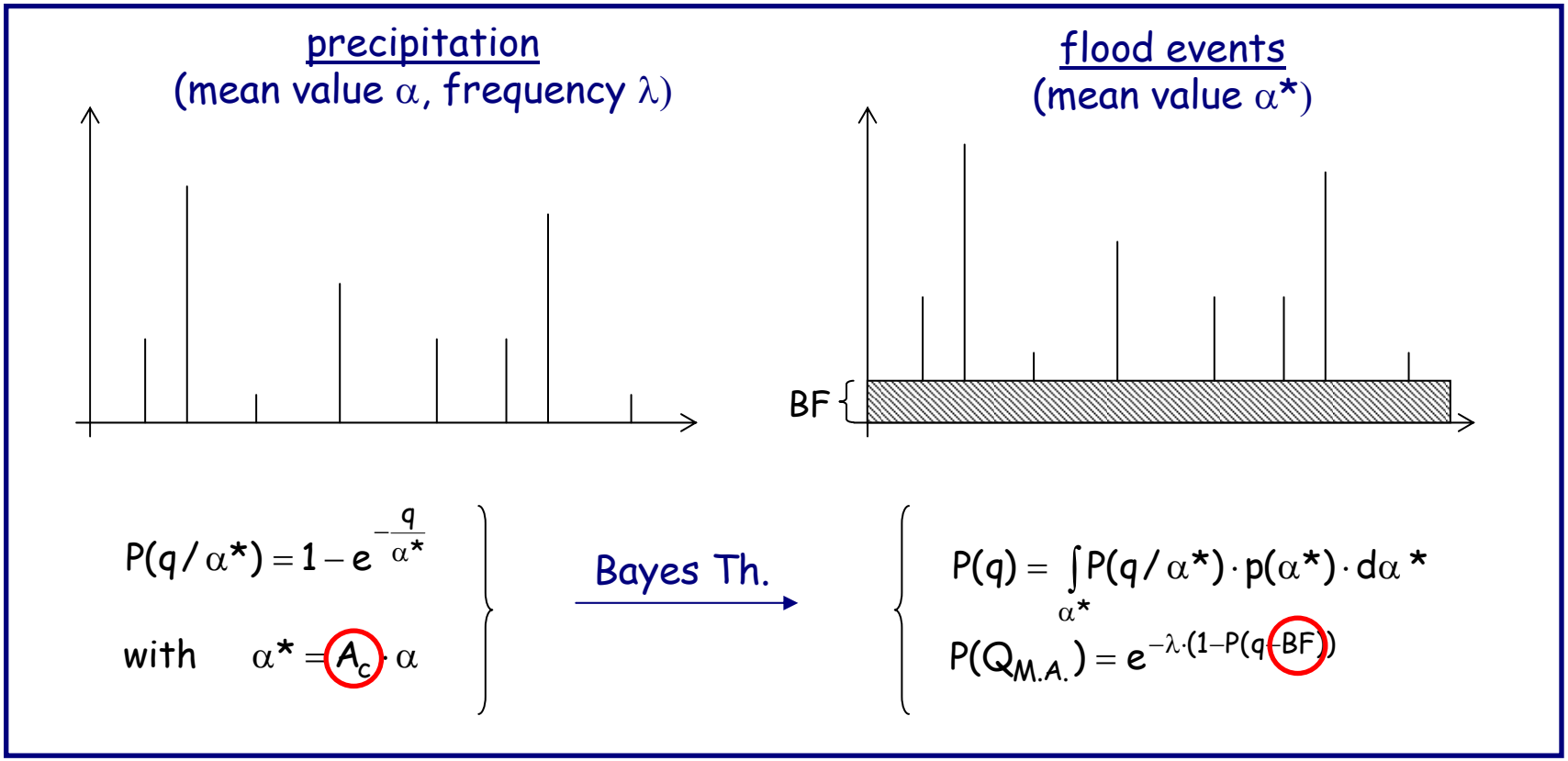


Experimental evidence

"Contradictory" information from CV:



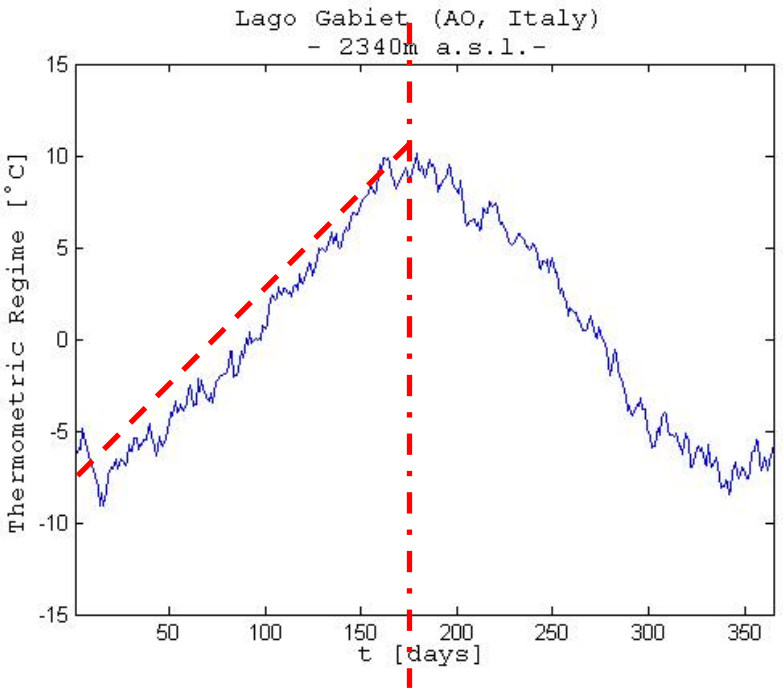
Model Structure



Contributing Area Ac → Snow Accumulation Effects
Base Flow BF → Snowmelt Effects

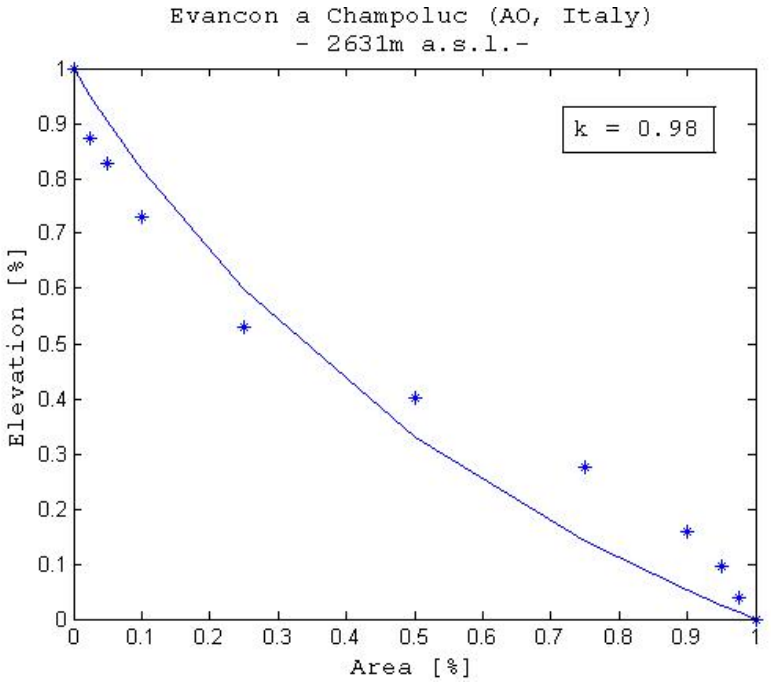
Hypotheses:

Thermometric Regime



- Linear
- Symmetric

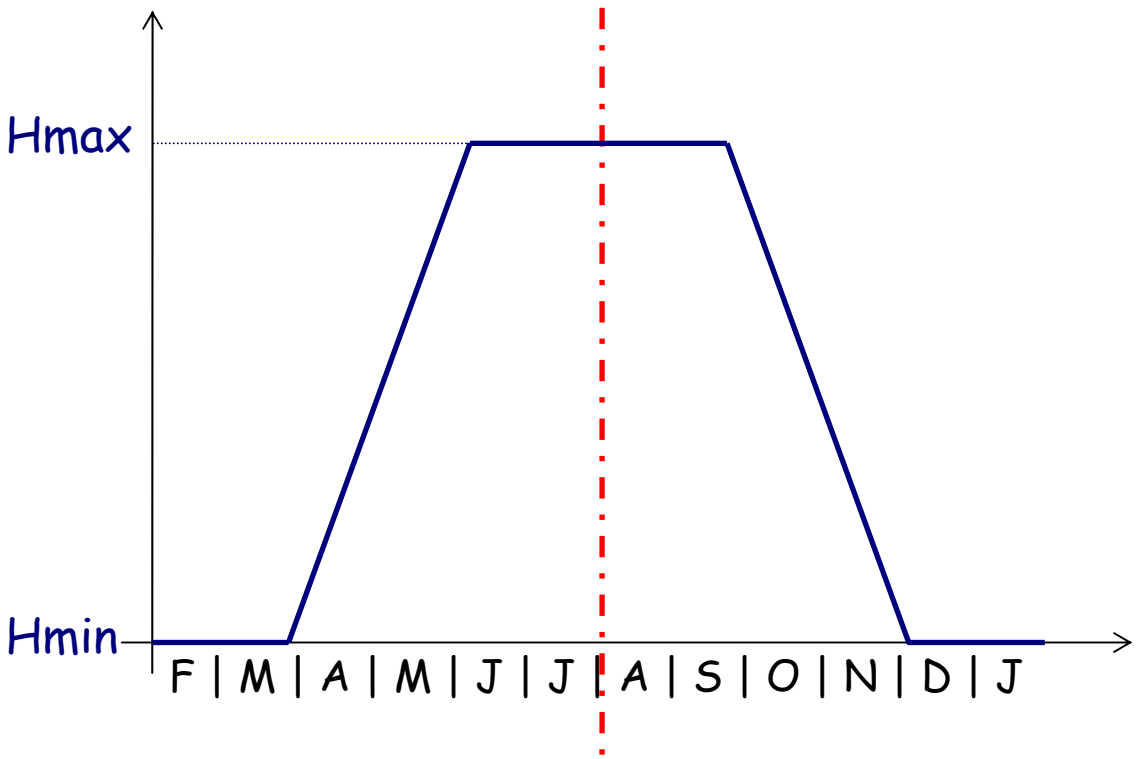
Hypsographic Curve



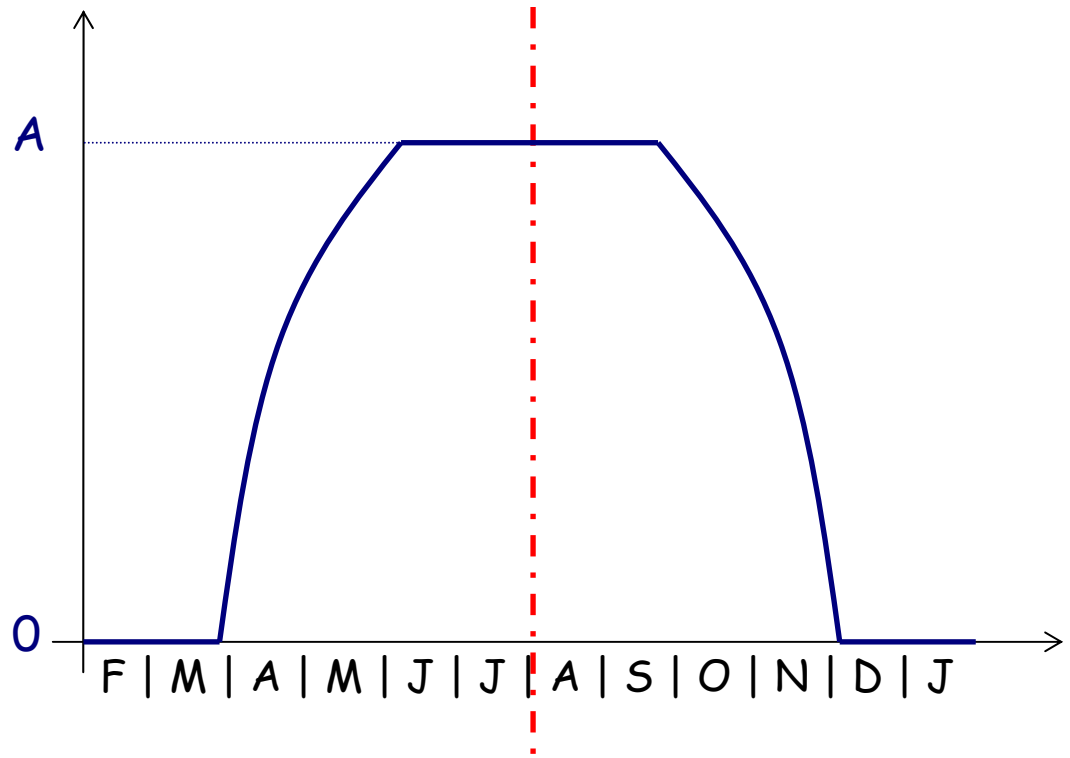
$$z = \frac{k \cdot (1 - A)}{A + k}$$

Seasonal Snow Line

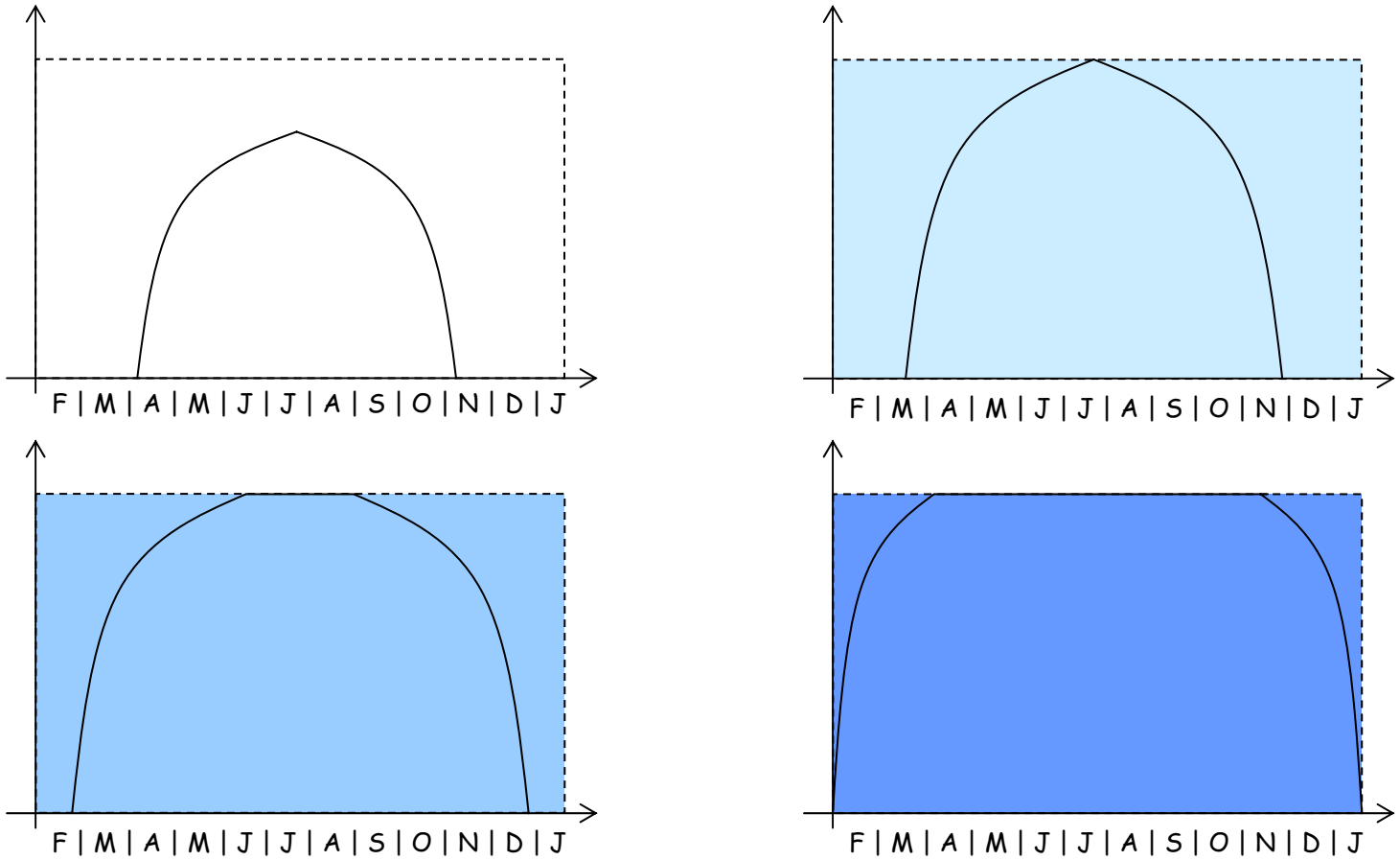
according to standard lapse rate $= \frac{6.5°C}{1000m}$



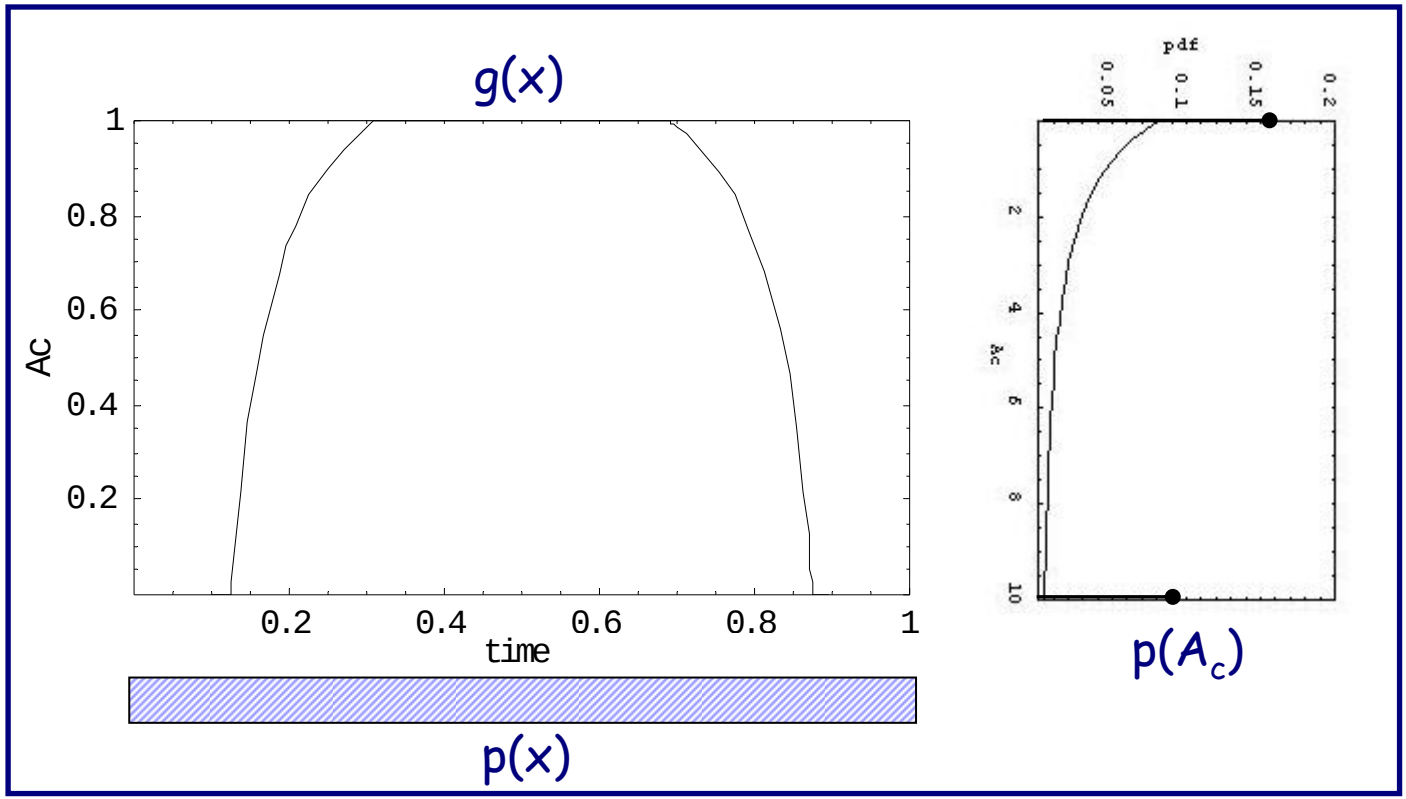
Contributing Area



Contributing Area sensitivity



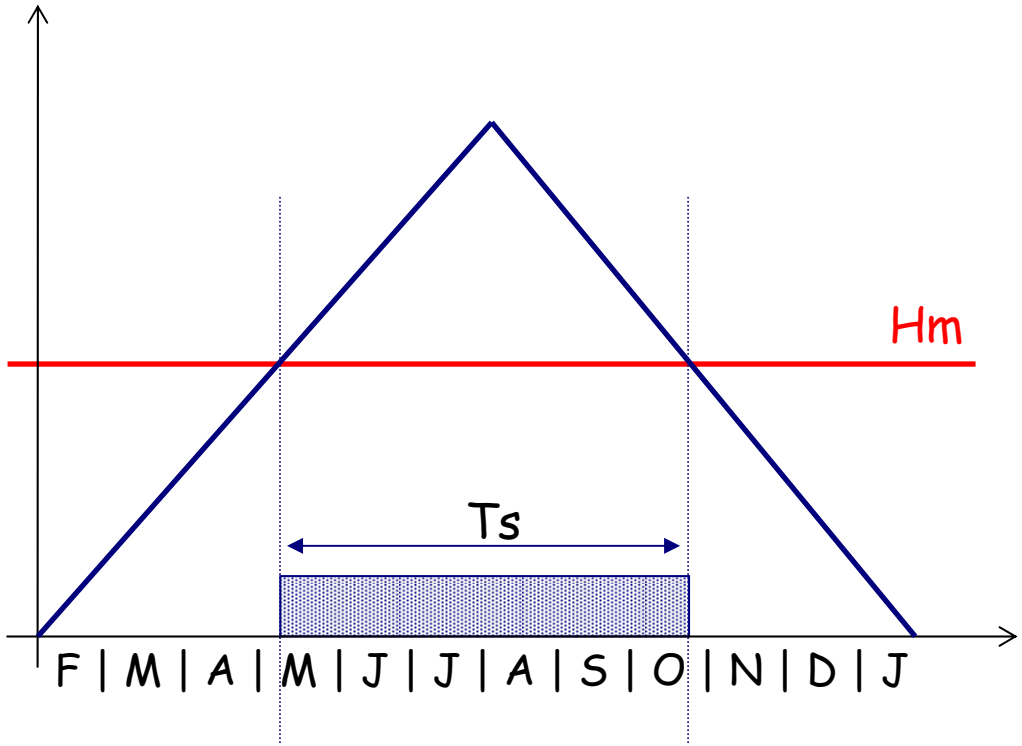
Derived Distribution for A_c



$$p(A_c) = \int_x Delta(x - g(x)) \cdot p(x) \cdot dx$$

BASE FLOW modeling

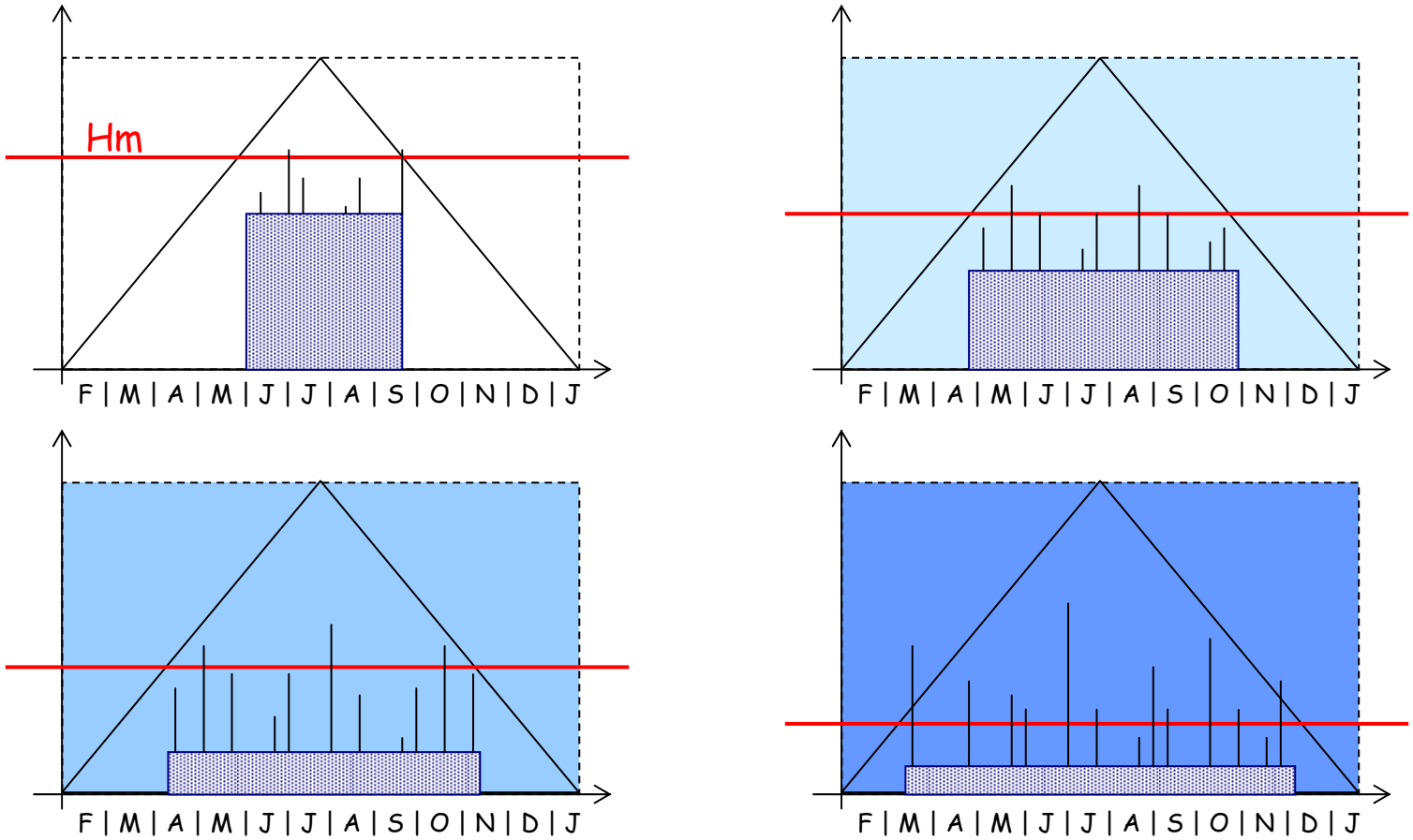
snowmelt amount over the period 'Ts' is constant:



Base Flow increases with basin elevation because:

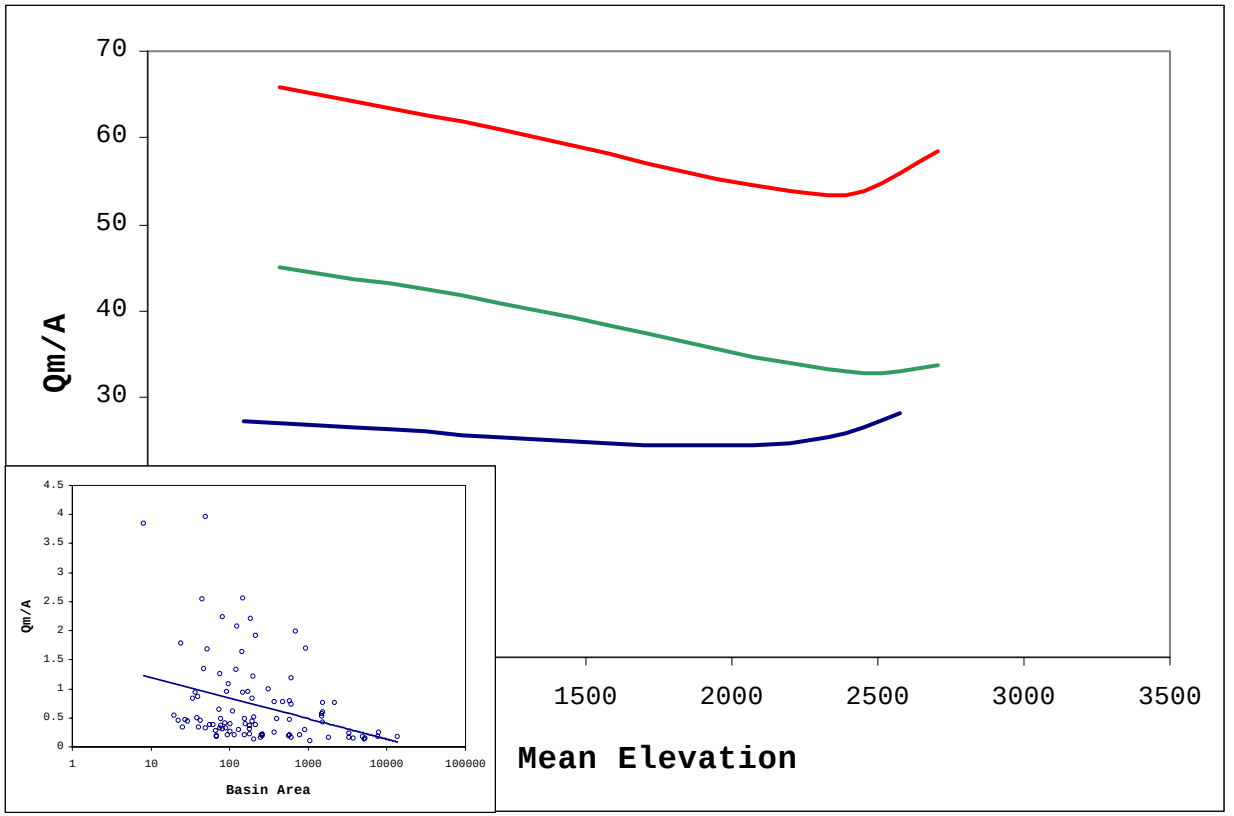
- snow accumulation rises
- the time interval Ts shortens

Base Flow sensitivity

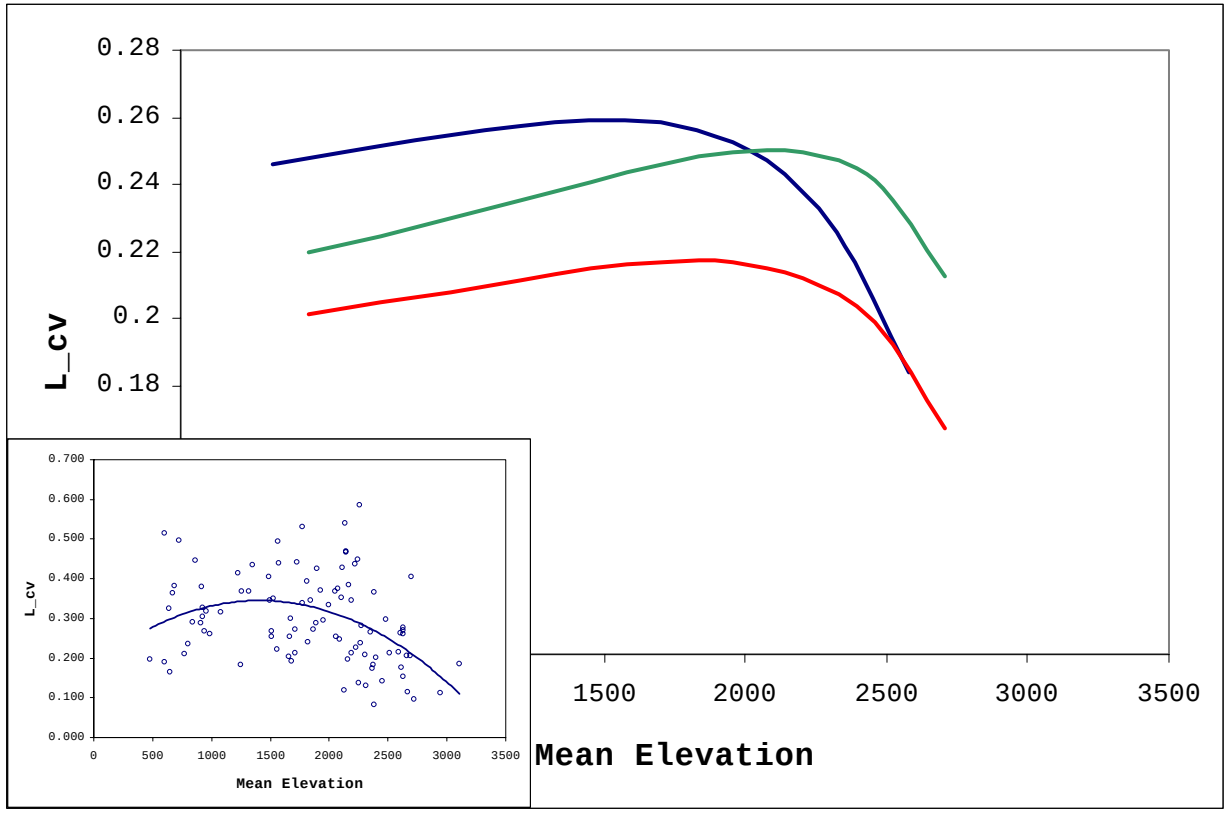


Mean Elevation

Results


70
60
50
40
30
Qm/A
1500
2000
2500
3000
3500
Mean Elevation
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Qm/A
1
10
100
1000
10000
100000
Basin Area

Results


0.28
0.26
0.24
0.22
0.2
0.18
L_CV
1500
2000
2500
3000
3500
Mean Elevation
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
L_CV
0
500
1000
1500
2000
2500
3000
3500
Mean Elevation

Conclusions

- Flood Frequency Distribution in alpine basins is determined by the superimposition of the precipitation and temperature regimes
- Deviations from undisturbed (no snow effect) Flood Frequency Distribution are particularly relevant when the two regimes are in phase and low return periods are considered
- We obtain reasonable representations of the relations between L-moments and mean basin elevation
- Results can be relevant in Regional Analysis (descriptors evaluation) and Climate Change studies