Figure S1a. Summary map showing location of analyzed channels presented in Figs. S1b and S3. Deep blue catchments contain 1 trunk stream, Lighter blue catchments contain more than 1 major channel.

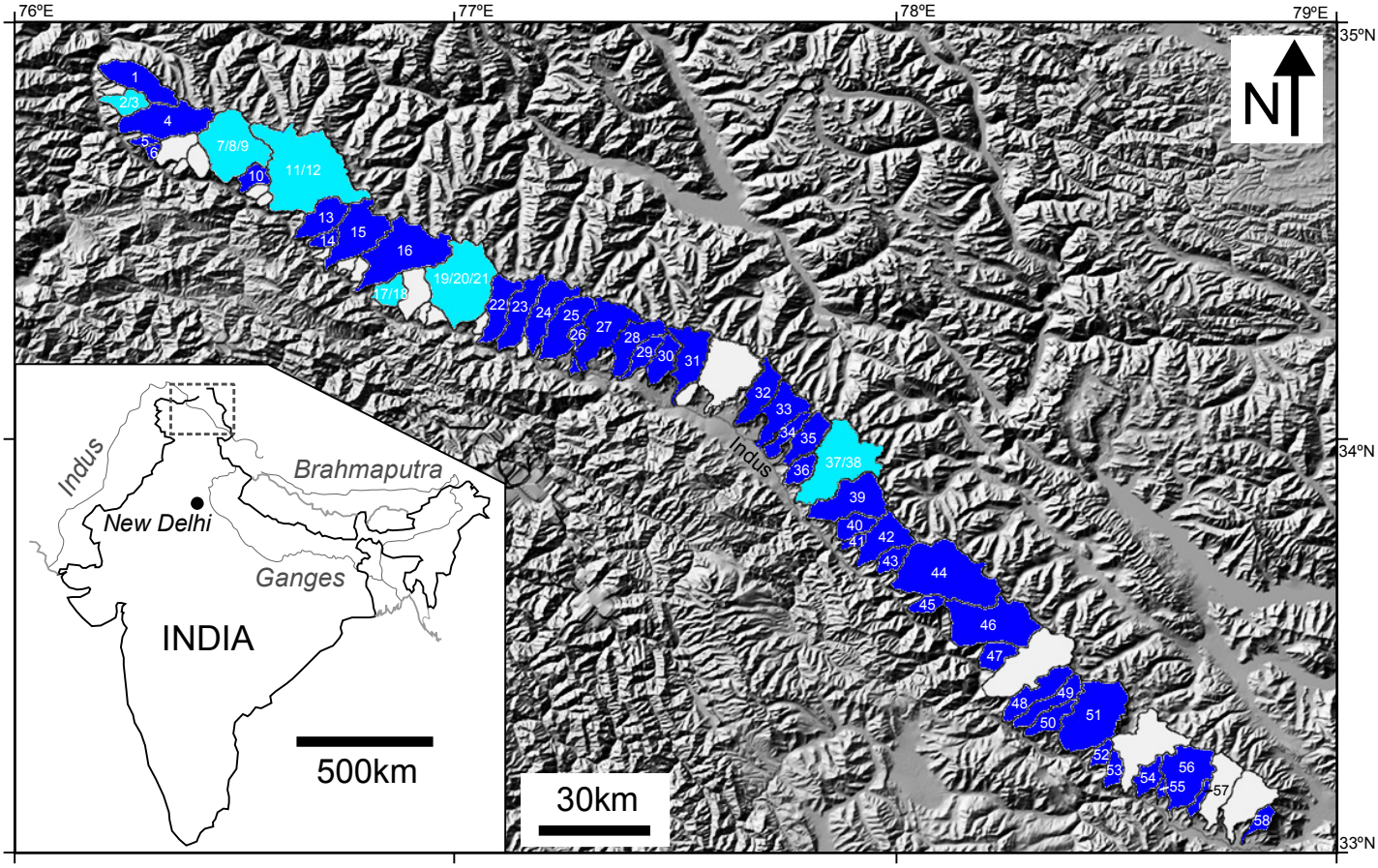
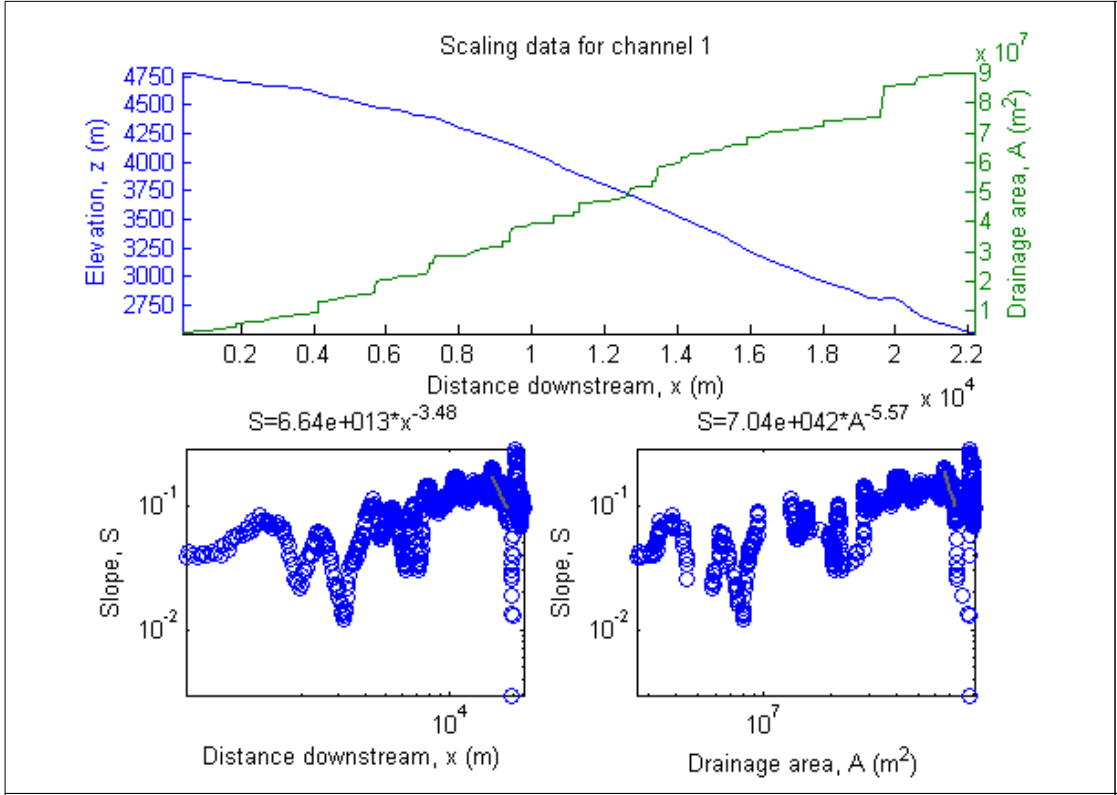
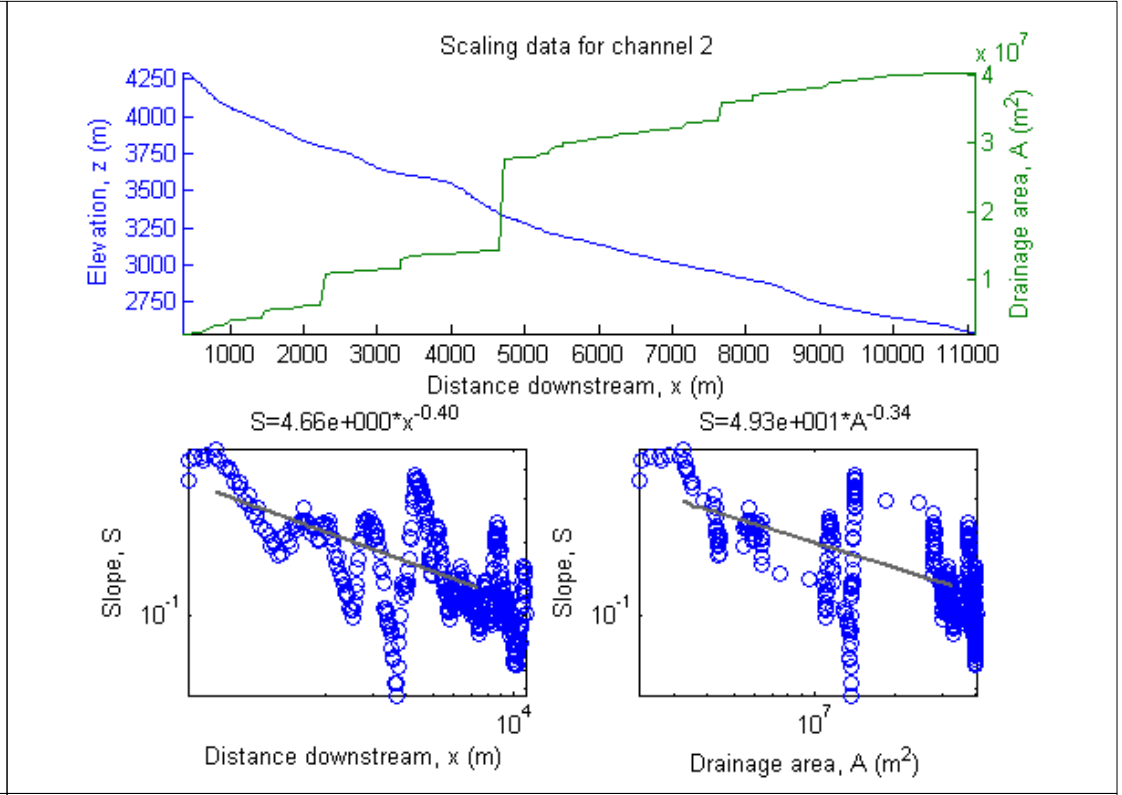
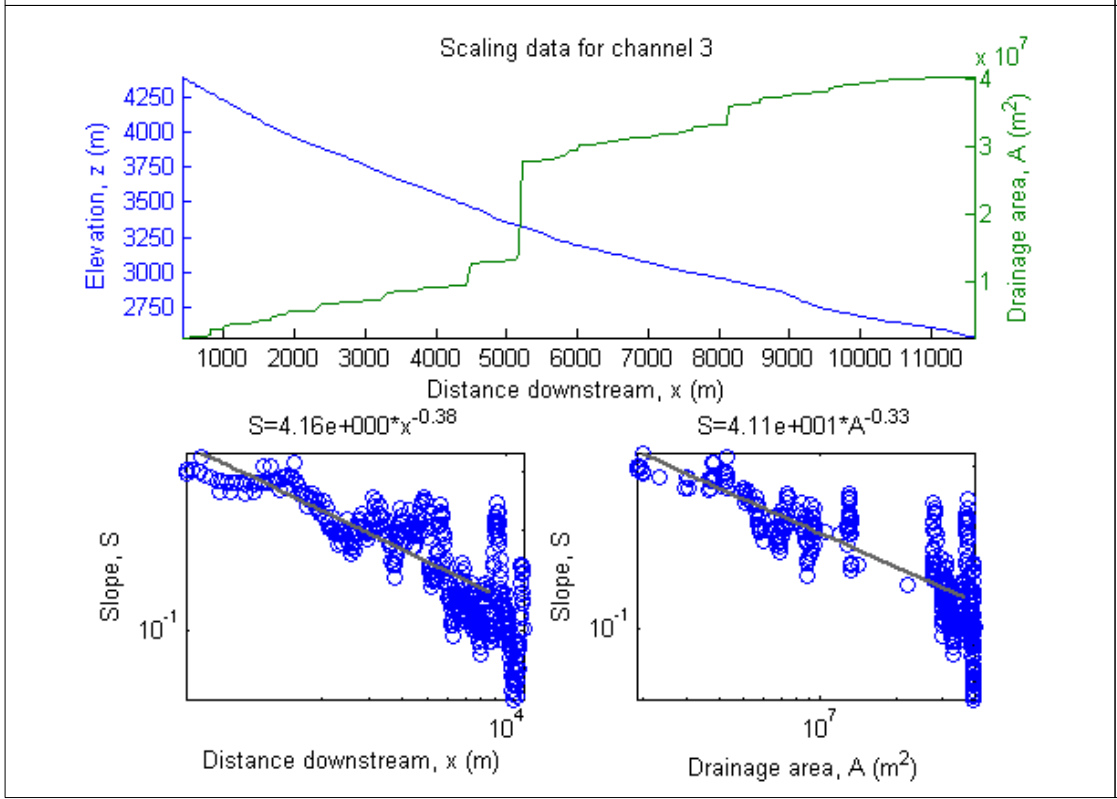
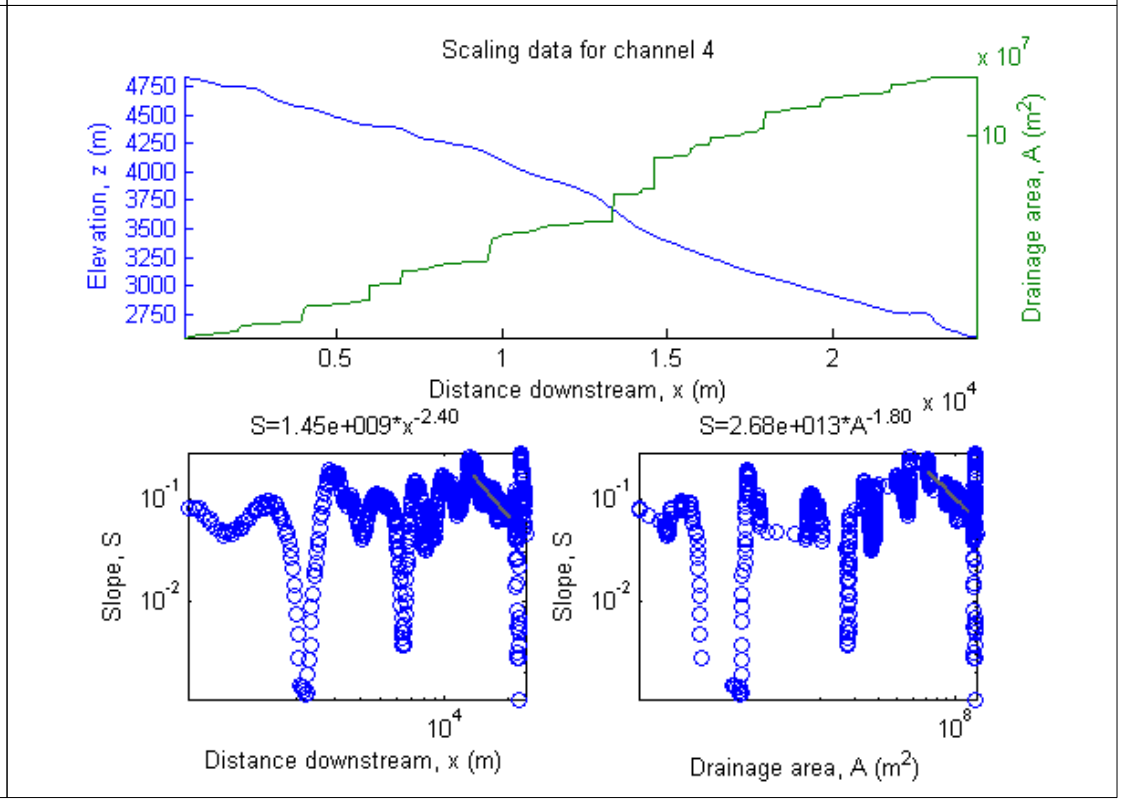


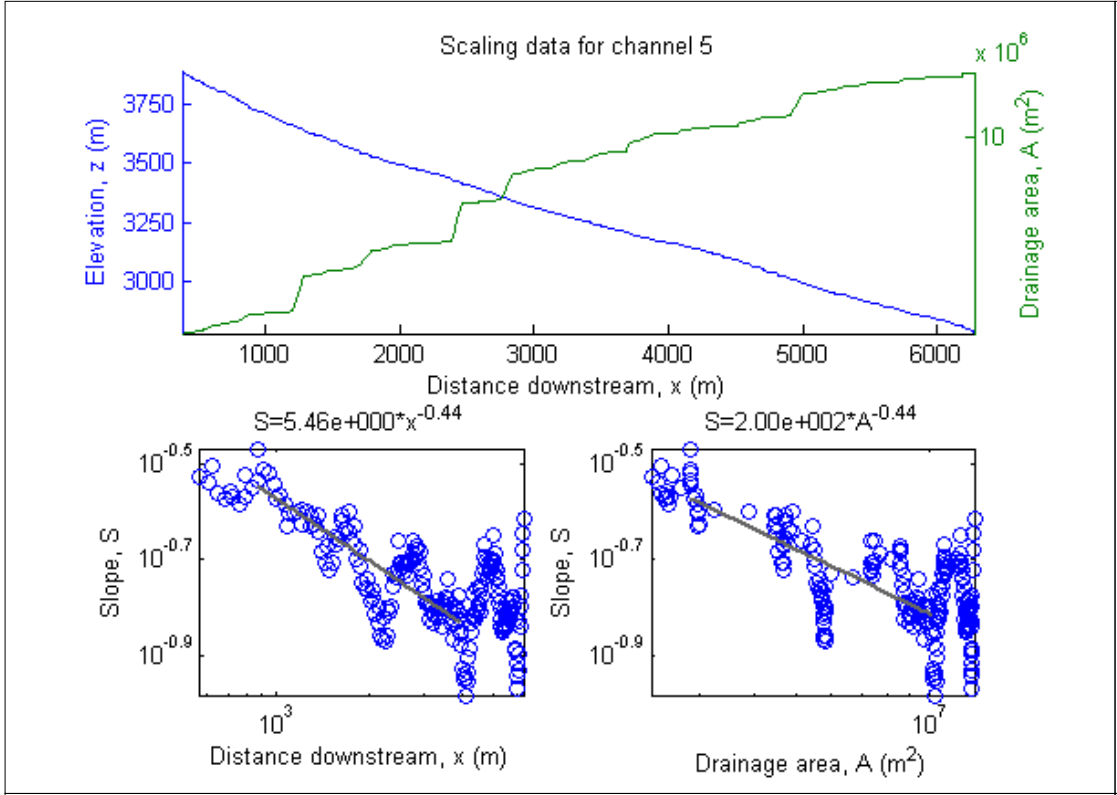
Figure S1b. Plots of long profile (z-x) and drainage structure (A-x) of each analyzed channel, along with associated slope plots S-x and S-A, plotted on logarithmic axes. Greyscale lines show slope scaling relations fitted to these latter two plots by the method described in the main text, and the range of values over which the fit is made. The associated equations are also shown above the figures.

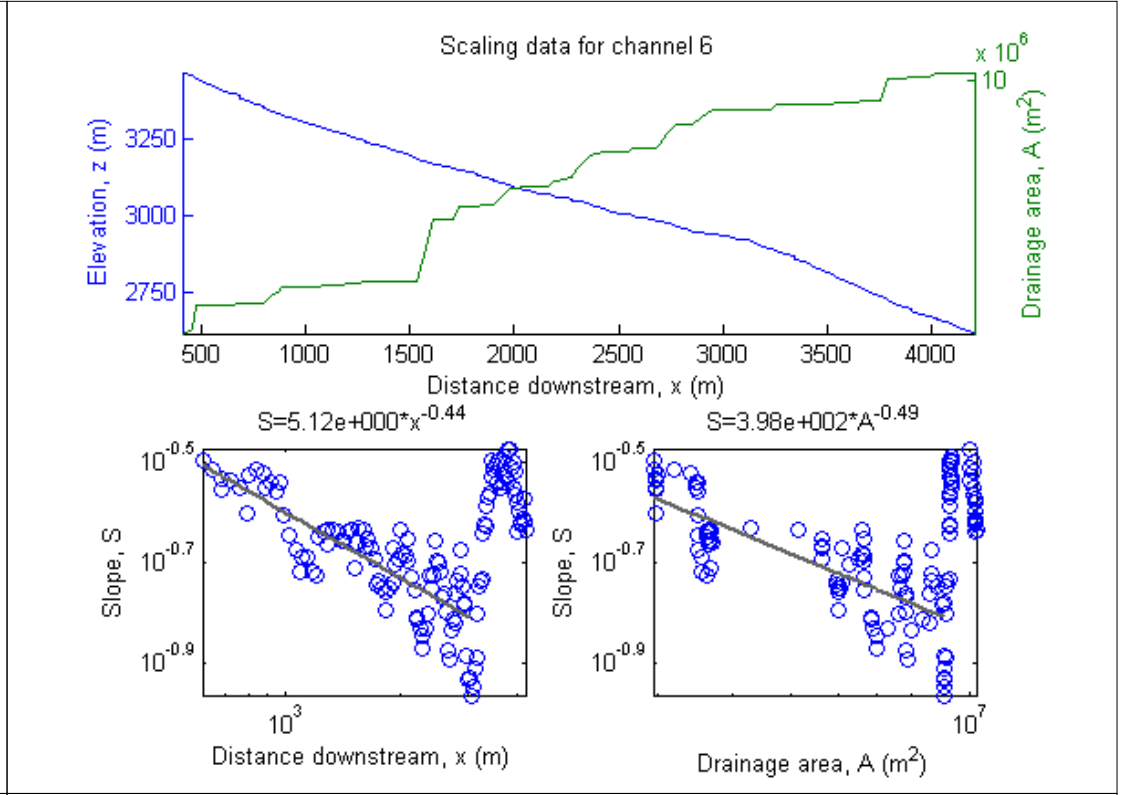

Scaling data for channel 1
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=6.64e+013*x^-3.48
S=7.04e+042*A^-5.57
x 10⁴
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

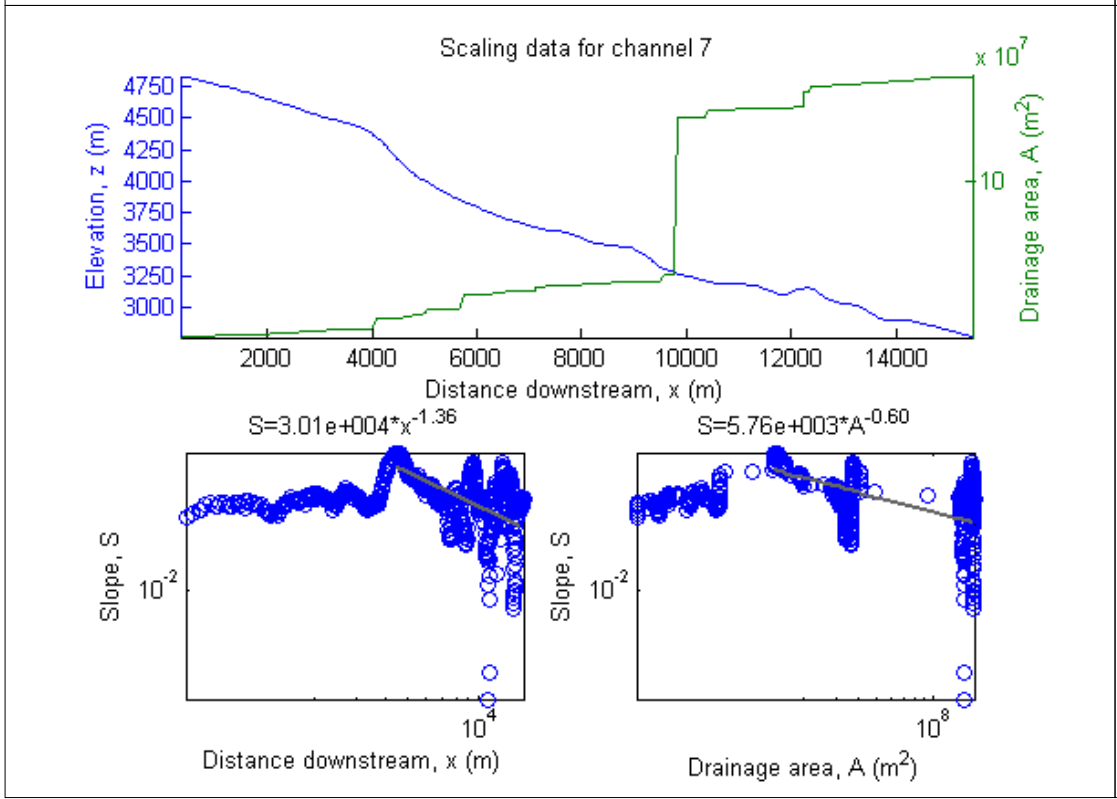

Scaling data for channel 2
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=4.66e+000*x^-0.40
S=4.93e+001*A^-0.34
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

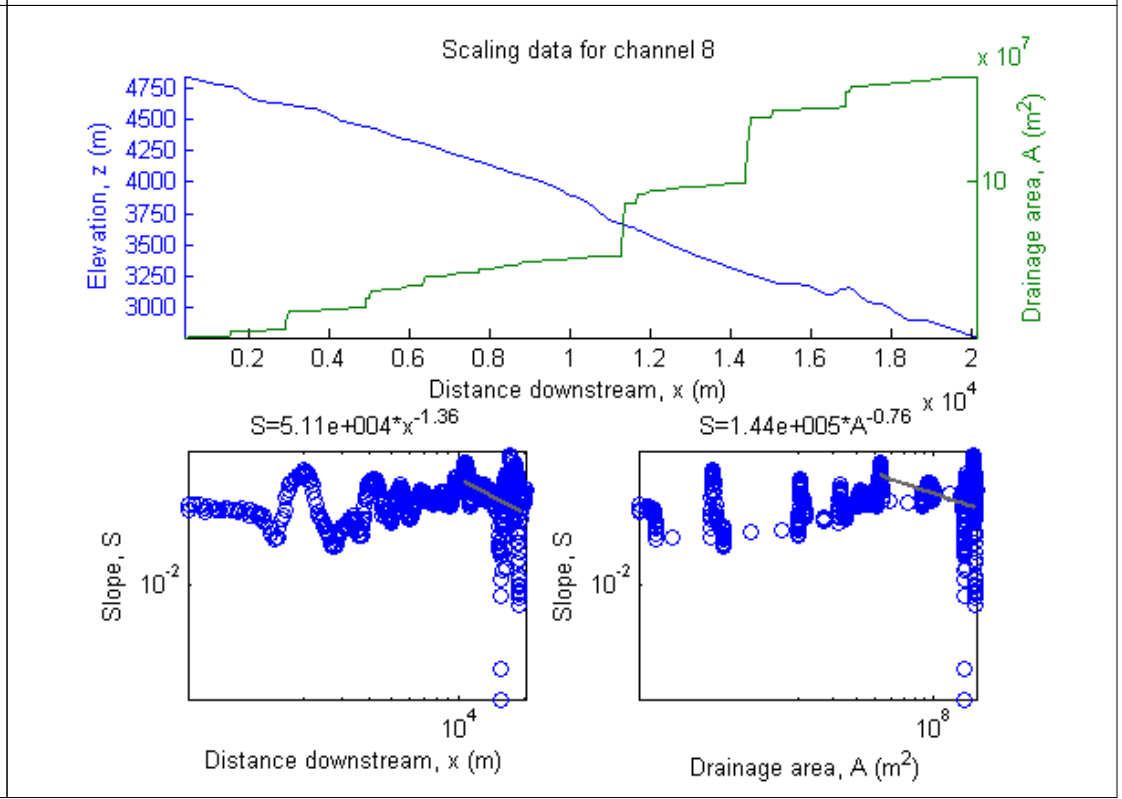

Scaling data for channel 3
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=4.16e+000*x^-0.38
S=4.11e+001*A^-0.33
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

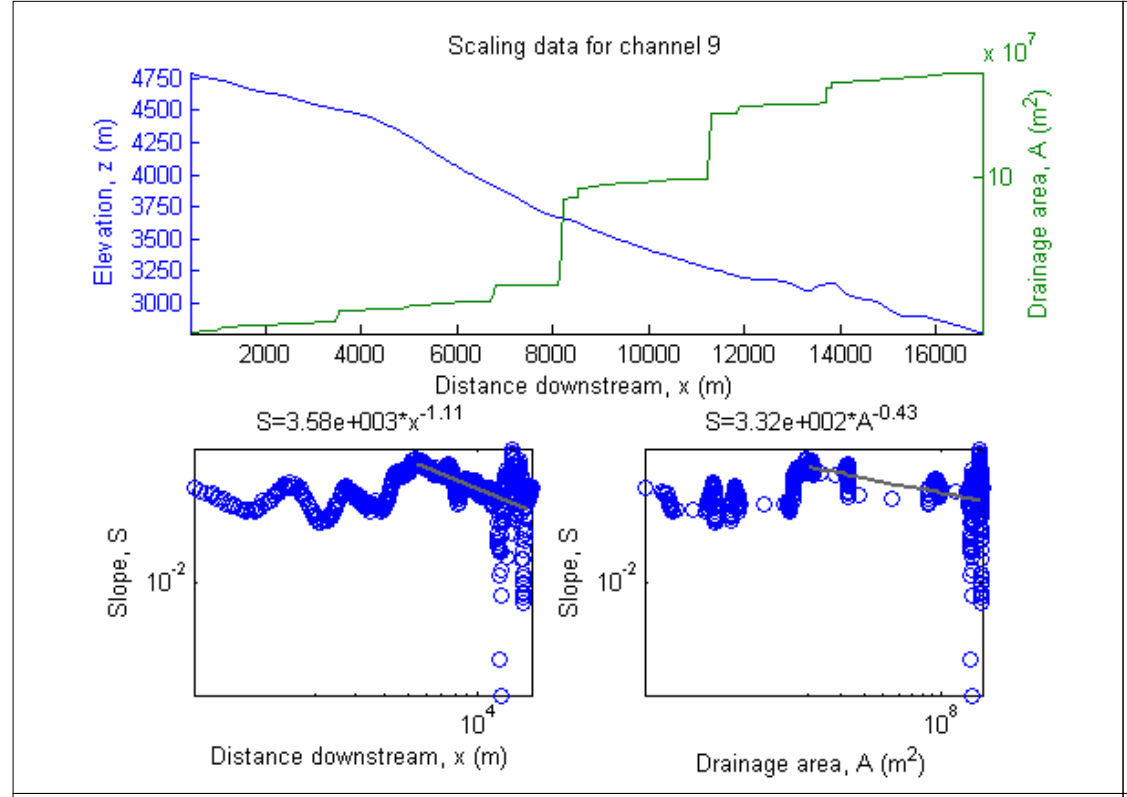

Scaling data for channel 4
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=1.45e+009*x^-2.40
S=2.68e+013*A^-1.80
x 10⁴
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

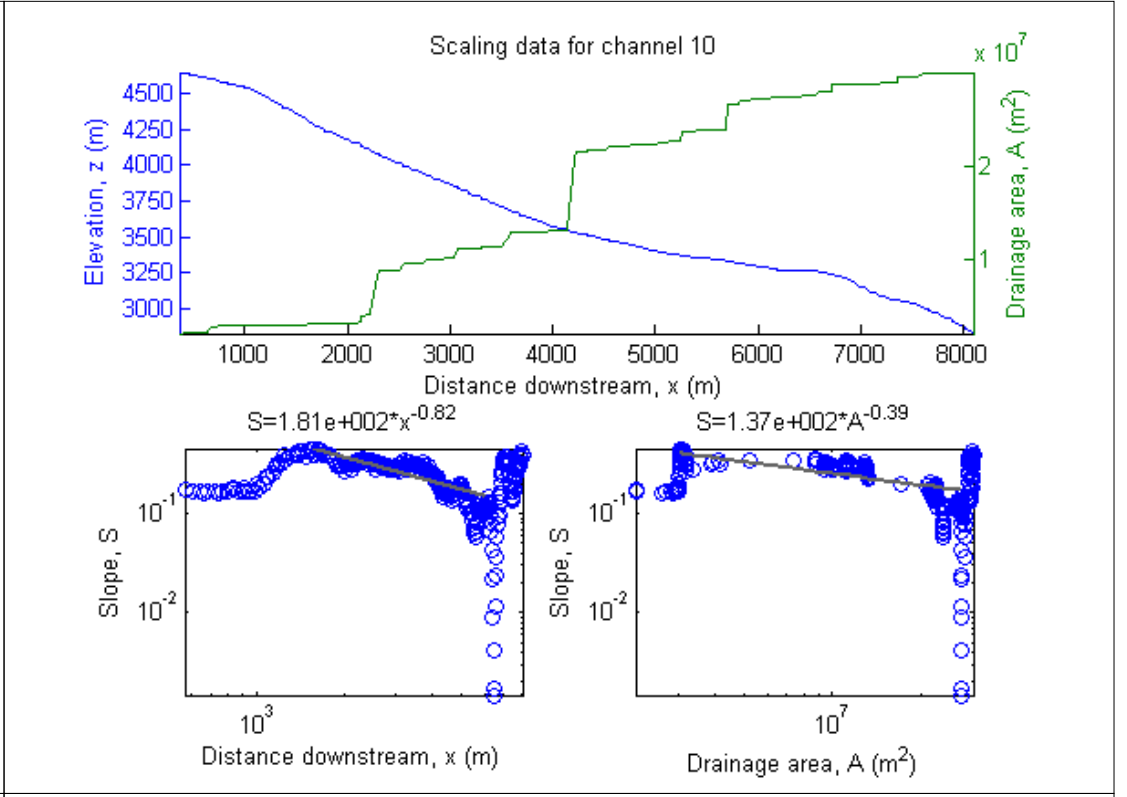

Scaling data for channel 5
Elevation, z (m)
Drainage area, A (m²)
x 10⁶
Distance downstream, x (m)
S=5.46e+000*x^-0.44
S=2.00e+002*A^-0.44
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

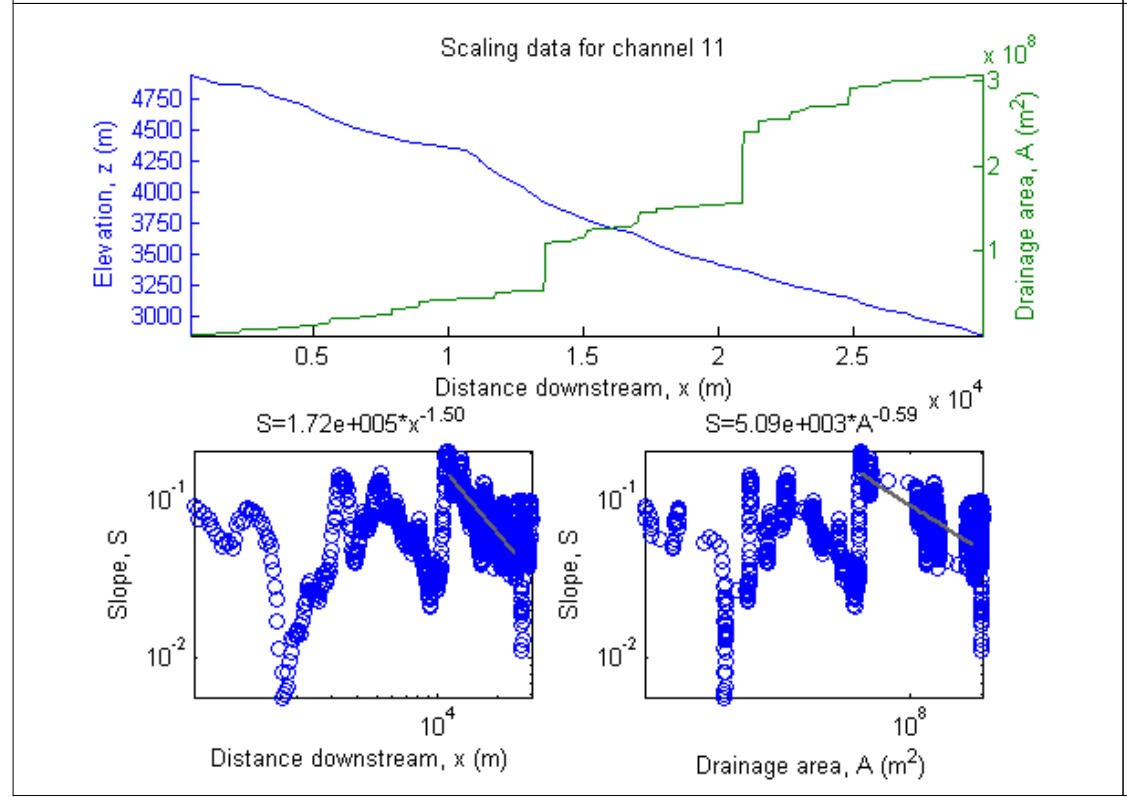

Scaling data for channel 6
Elevation, z (m)
Drainage area, A (m²)
x 10⁶
Distance downstream, x (m)
S=5.12e+000*x^-0.44
S=3.98e+002*A^-0.49
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

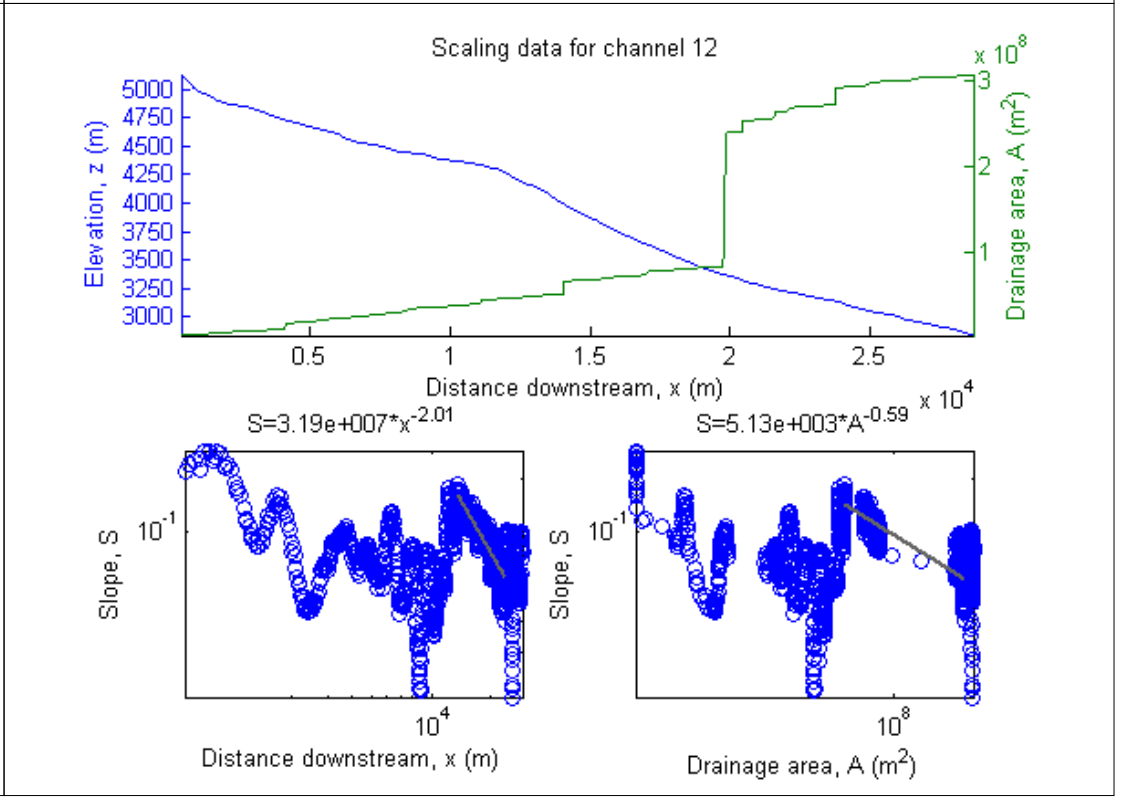

Scaling data for channel 7
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=3.01e+004*x^-1.36
S=5.76e+003*A^-0.60
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

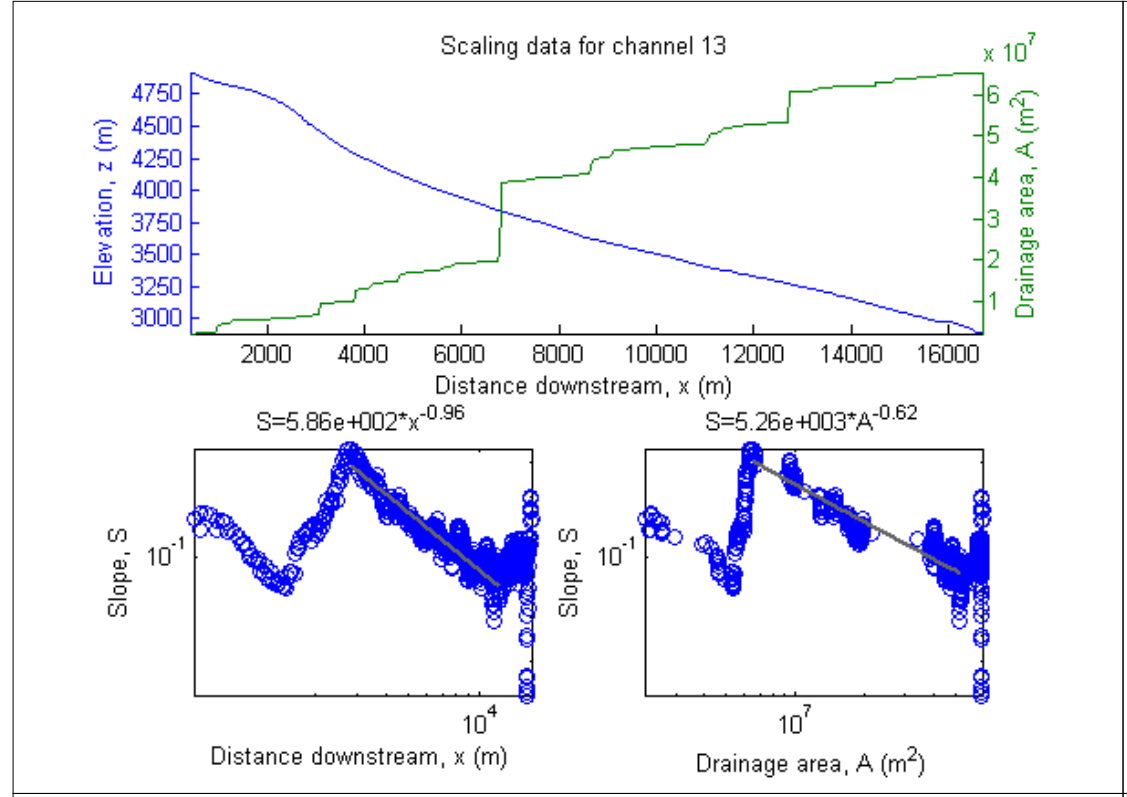

Scaling data for channel 8
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
x 10⁴
Distance downstream, x (m)
S=5.11e+004*x^-1.36
S=1.44e+005*A^-0.76
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

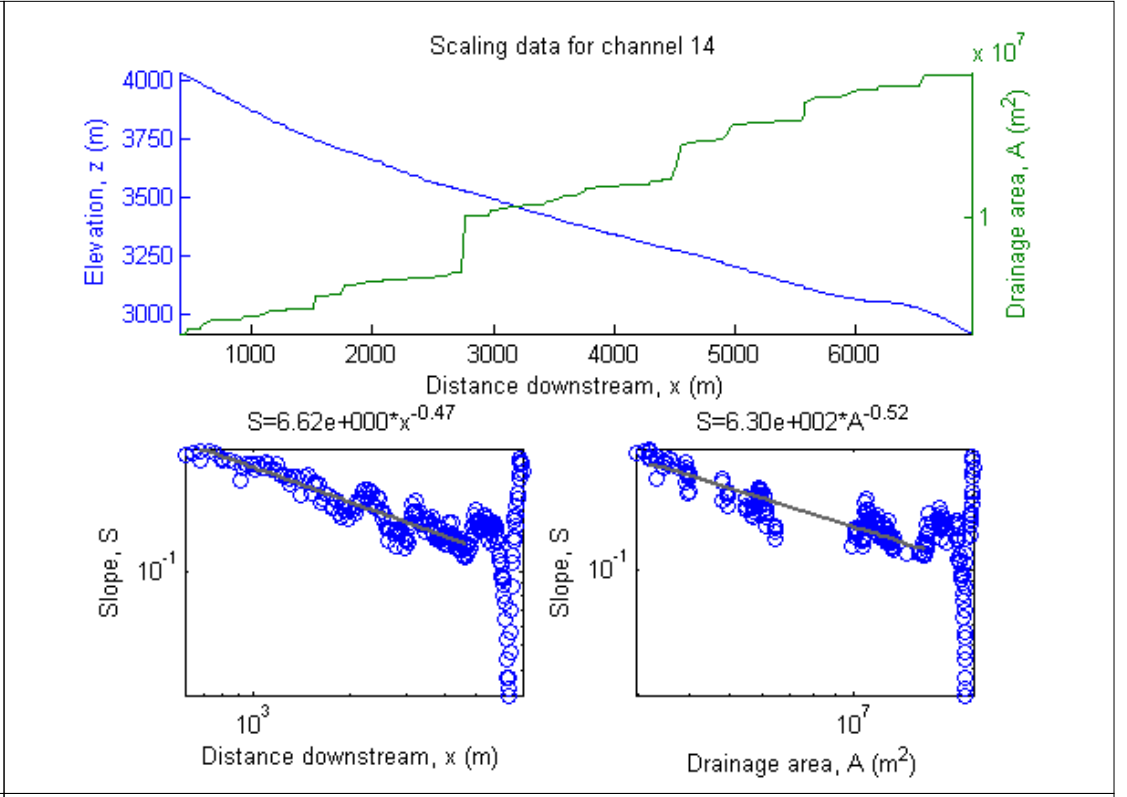

Scaling data for channel 9
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=3.58e+003*x^-1.11
S=3.32e+002*A^-0.43
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

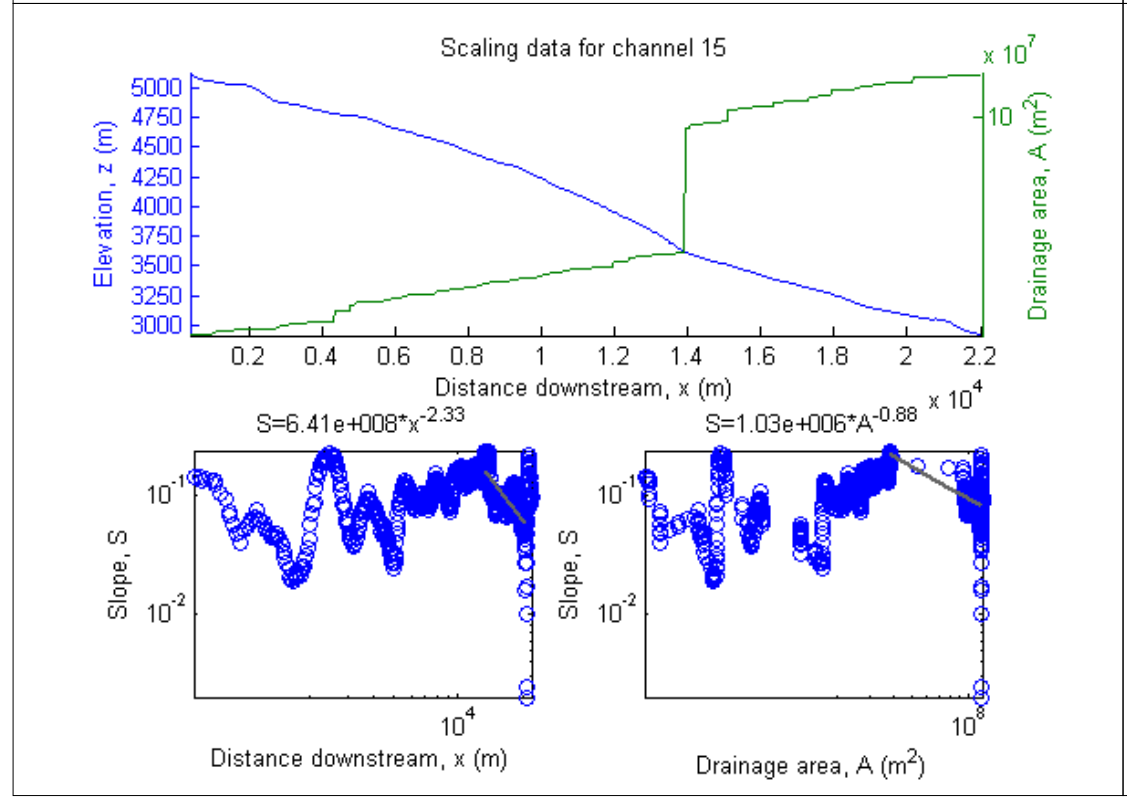

Scaling data for channel 10
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=1.81e+002*x^-0.82
S=1.37e+002*A^-0.39
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

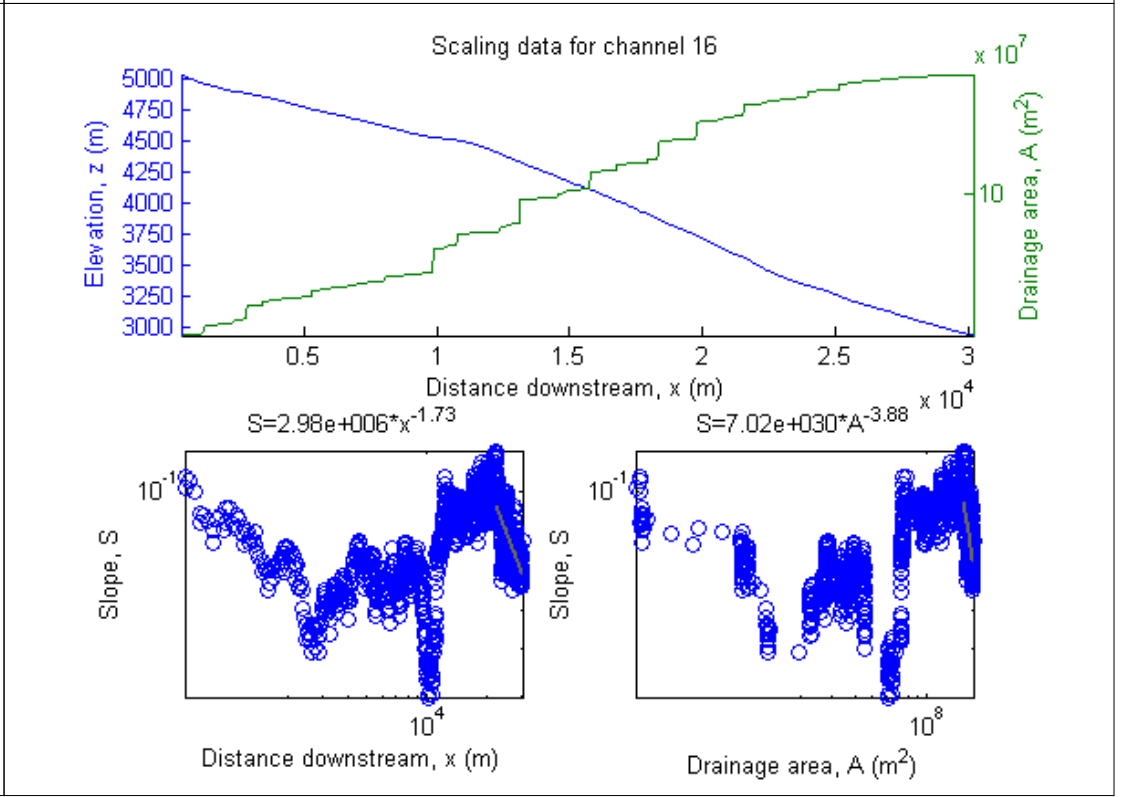

Scaling data for channel 11
Elevation, z (m)
Drainage area, A (m²)
x 10⁸
Distance downstream, x (m)
S=1.72e+005*x^-1.50
S=5.09e+003*A^-0.59
x 10⁴
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

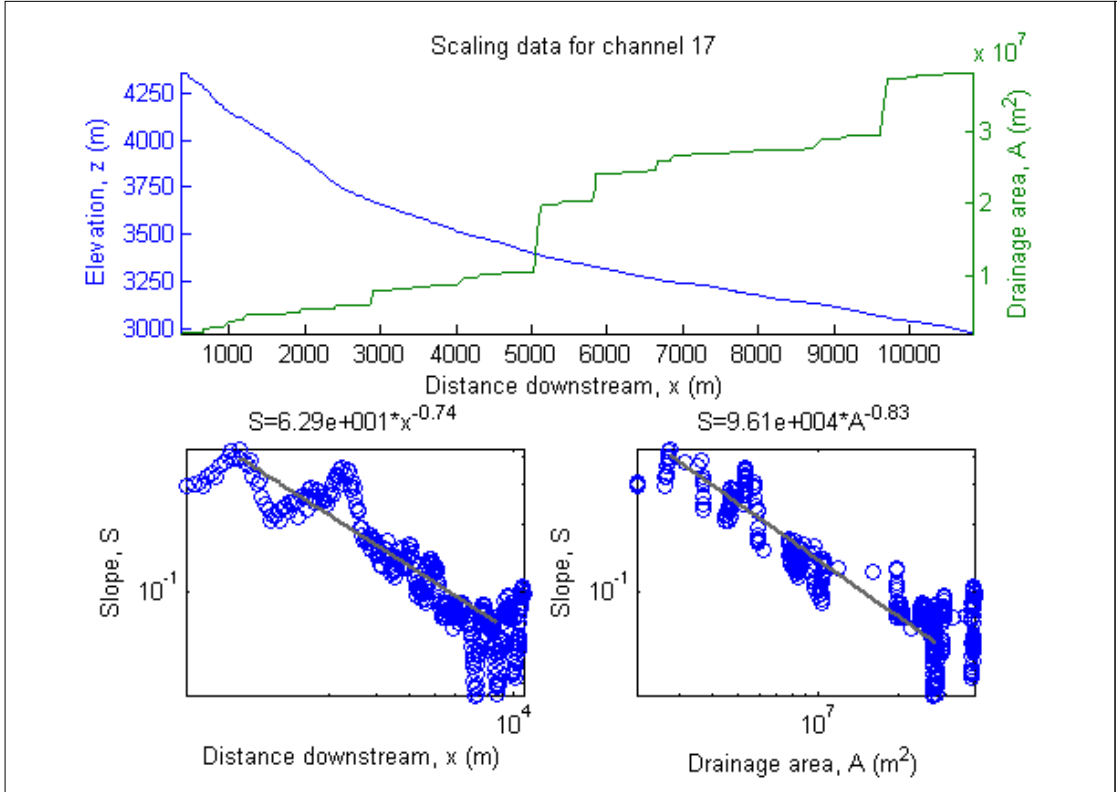

Scaling data for channel 12
Elevation, z (m)
Drainage area, A (m²)
x 10⁸
Distance downstream, x (m)
S=3.19e+007*x^-2.01
S=5.13e+003*A^-0.59
x 10⁴
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

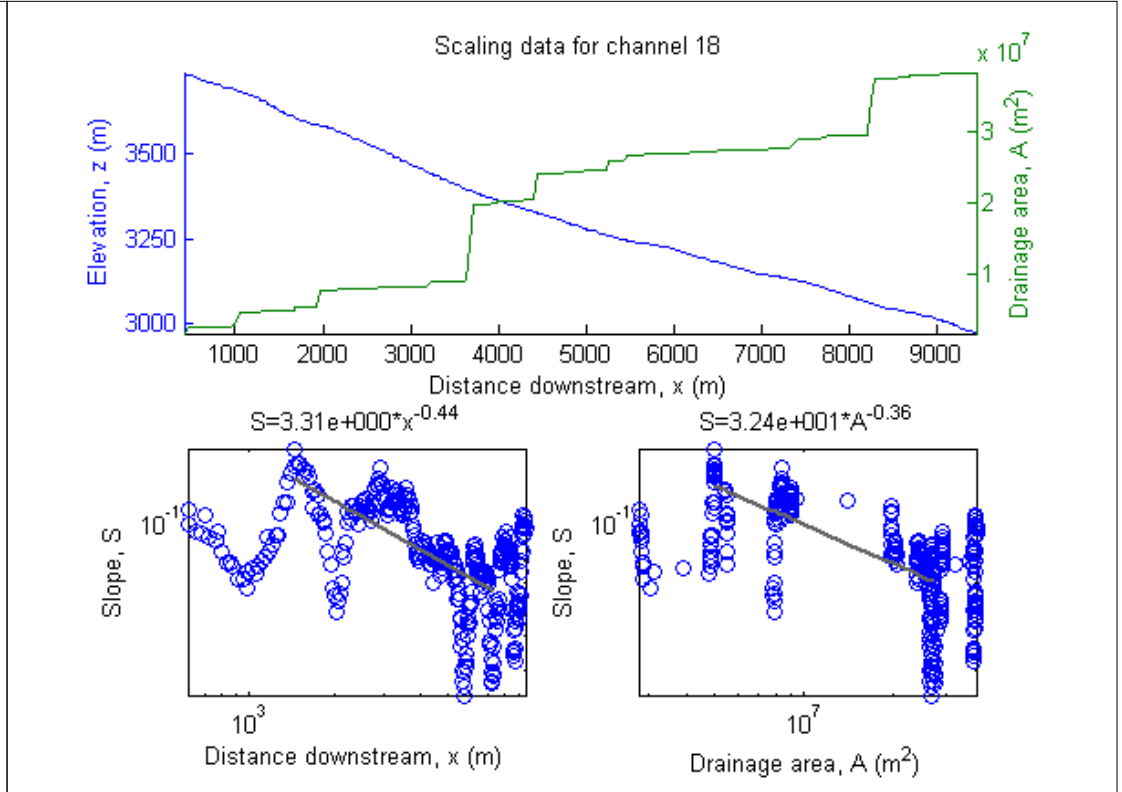

Scaling data for channel 13
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=5.86e+002*x^-0.96
S=5.26e+003*A^-0.62
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

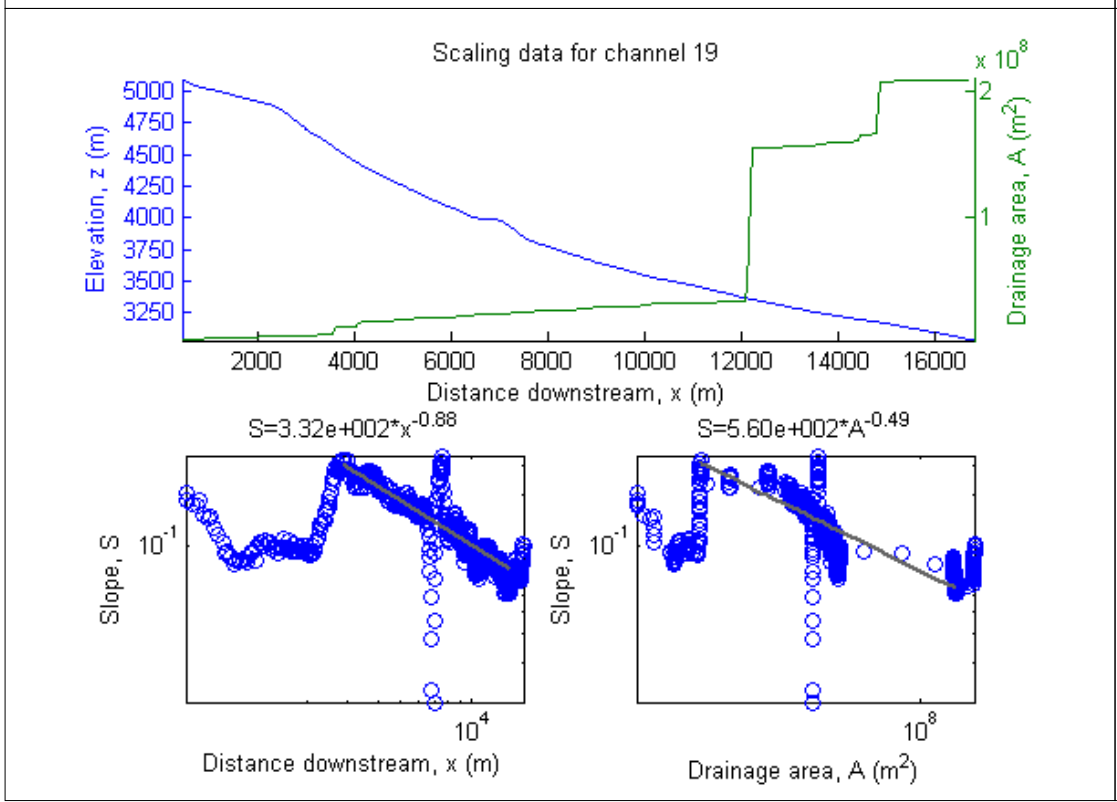

Scaling data for channel 14
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=6.62e+000*x^-0.47
S=6.30e+002*A^-0.52
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

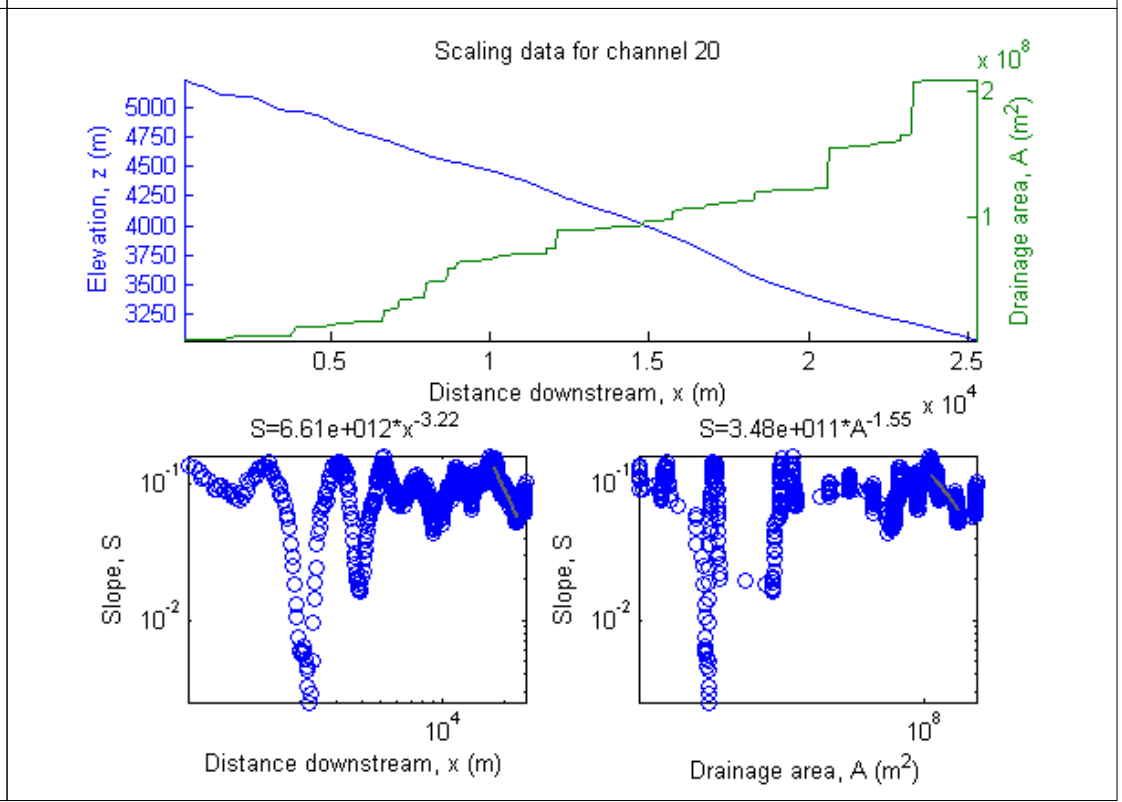

Scaling data for channel 15
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
x 10⁴
Distance downstream, x (m)
S=6.41e+008*x^-2.33
S=1.03e+006*A^-0.88
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

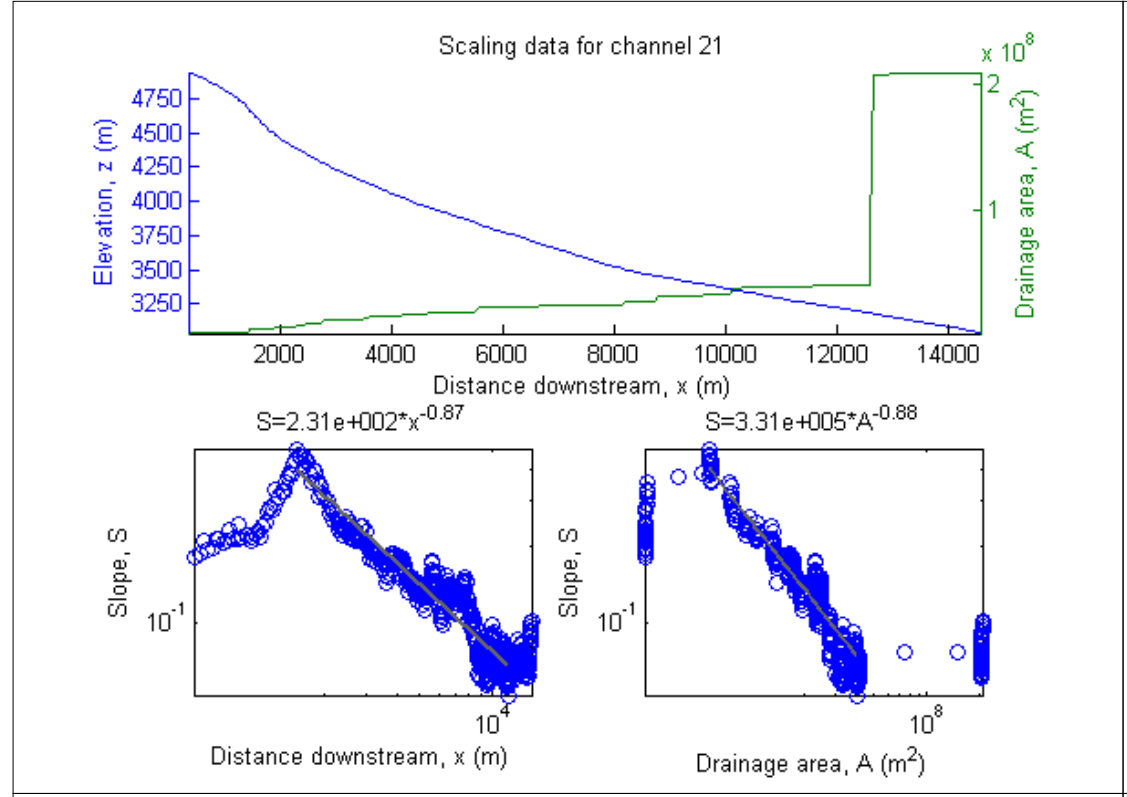

Scaling data for channel 16
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
x 10⁴
Distance downstream, x (m)
S=2.98e+006*x^-1.73
S=7.02e+030*A^-3.88
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

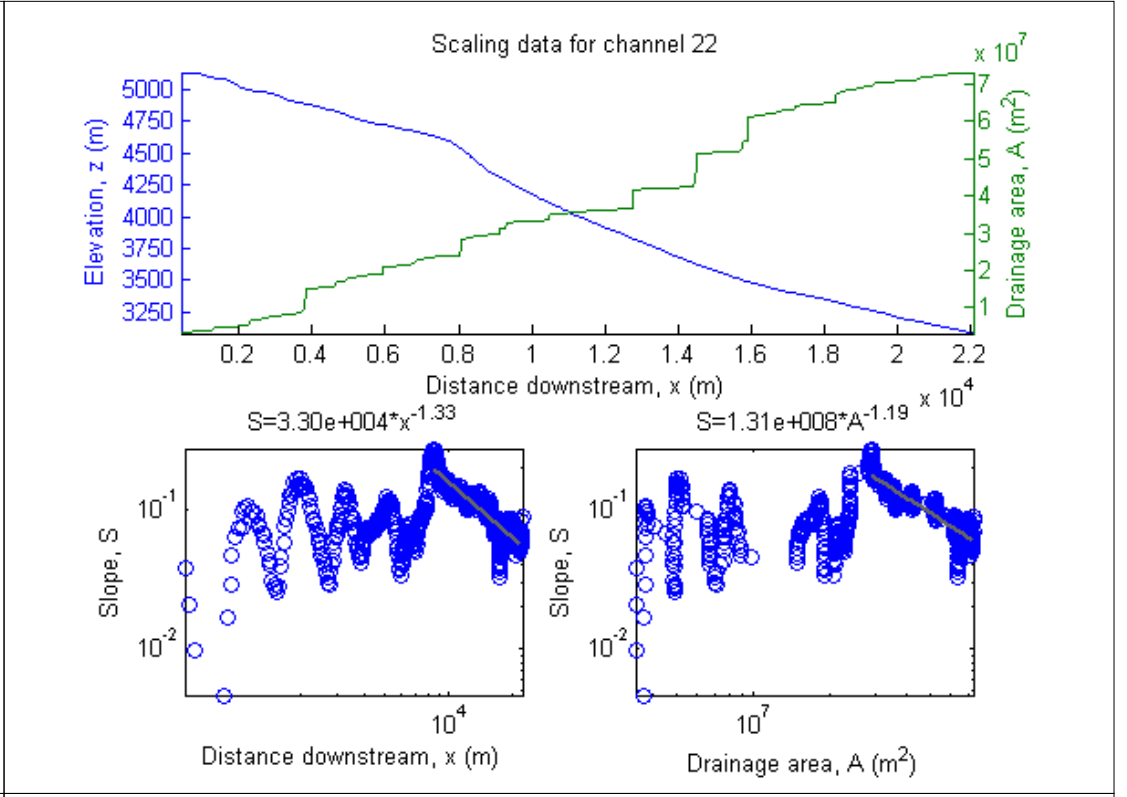

Scaling data for channel 17
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=6.29e+001*x^-0.74
S=9.61e+004*A^-0.83
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

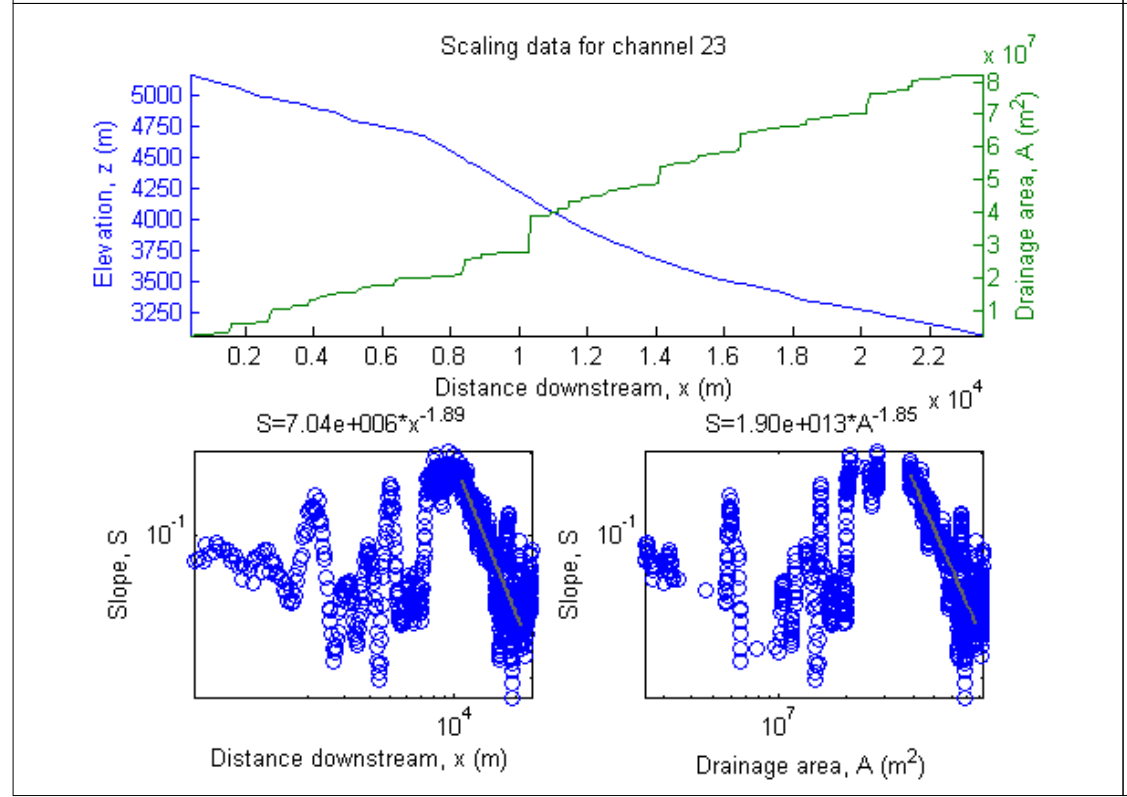

Scaling data for channel 18
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=3.31e+000*x^-0.44
S=3.24e+001*A^-0.36
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

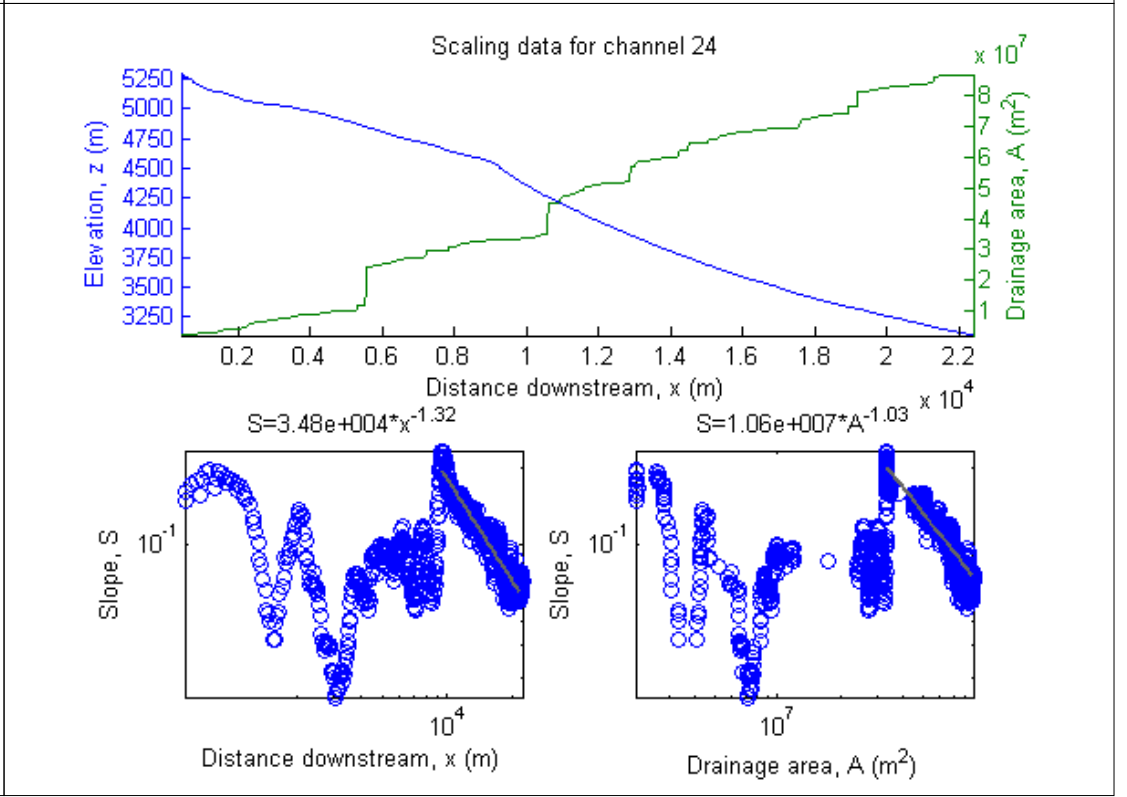

Scaling data for channel 19
Elevation, z (m)
Drainage area, A (m²)
x 10⁸
Distance downstream, x (m)
S=3.32e+002*x^-0.88
S=5.60e+002*A^-0.49
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

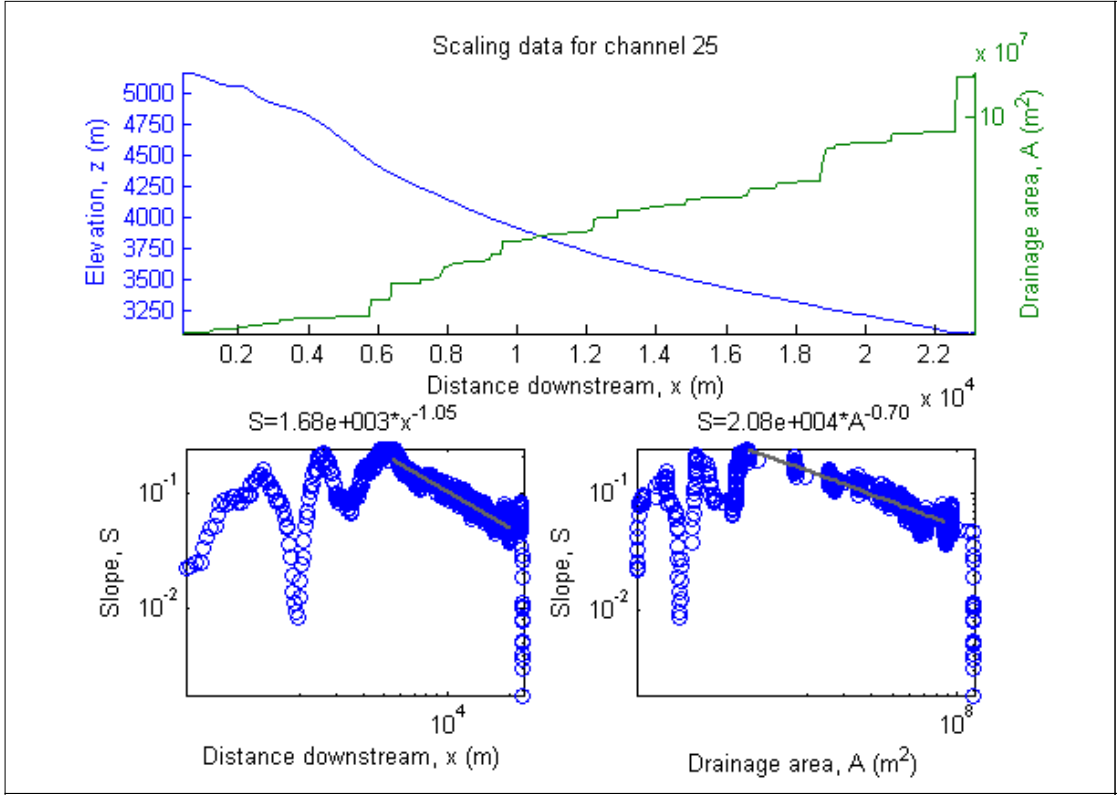

Scaling data for channel 20
Elevation, z (m)
Drainage area, A (m²)
x 10⁸
Distance downstream, x (m)
x 10⁴
S=6.61e+012*x^-3.22
S=3.48e+011*A^-1.55
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

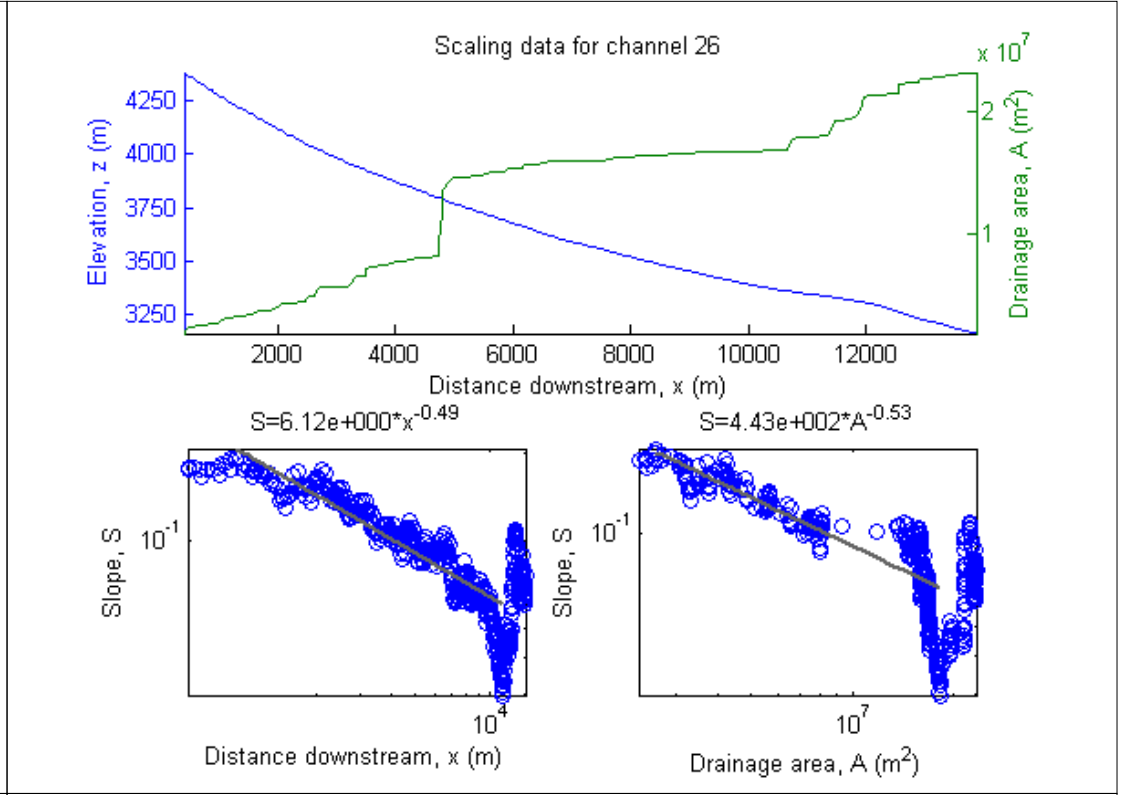

Scaling data for channel 21
Elevation, z (m)
Drainage area, A (m²)
x 10⁸
Distance downstream, x (m)
S=2.31e+002*x^-0.87
S=3.31e+005*A^-0.88
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

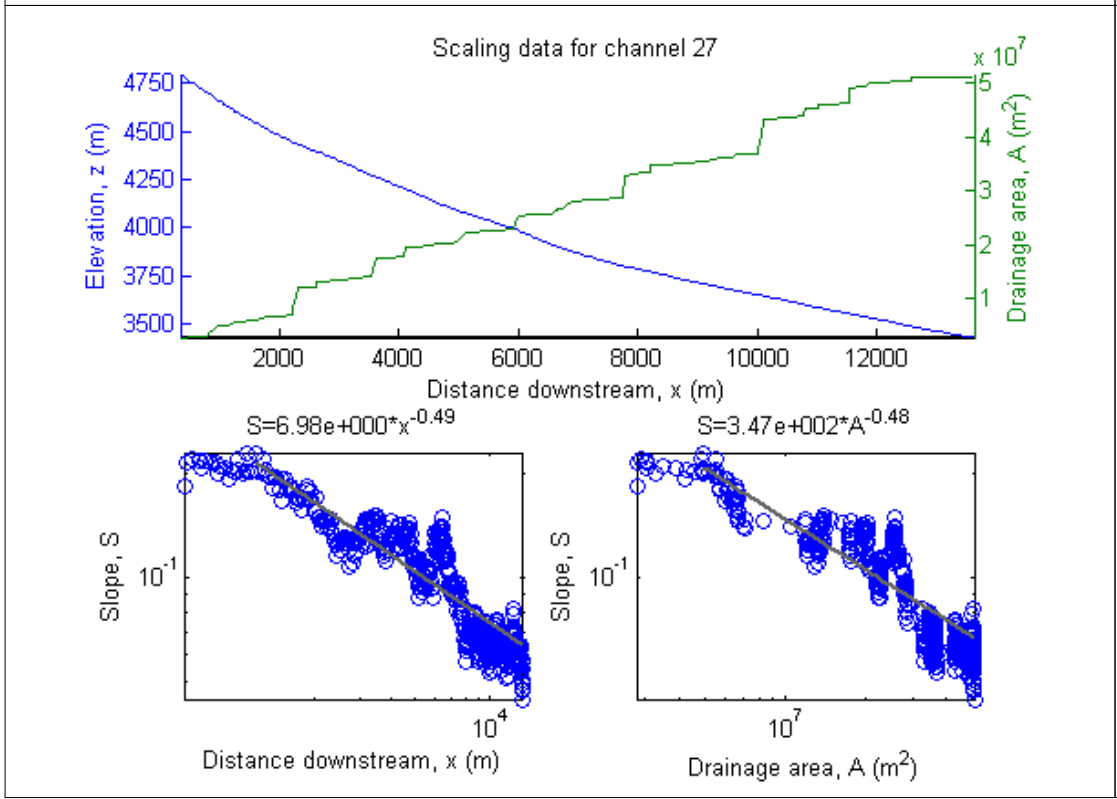

Scaling data for channel 22
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
x 10⁴
S=3.30e+004*x^-1.33
S=1.31e+008*A^-1.19
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

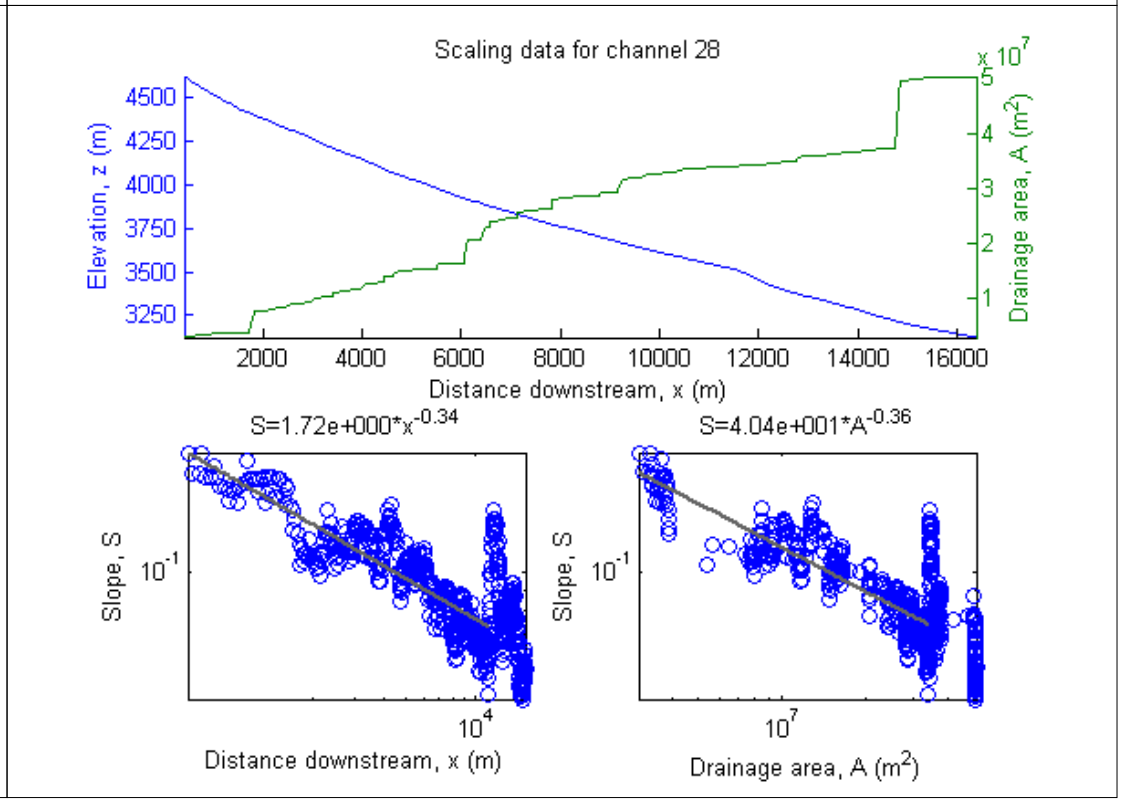

Scaling data for channel 23
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
x 10⁴
S=7.04e+006*x^-1.89
S=1.90e+013*A^-1.85
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

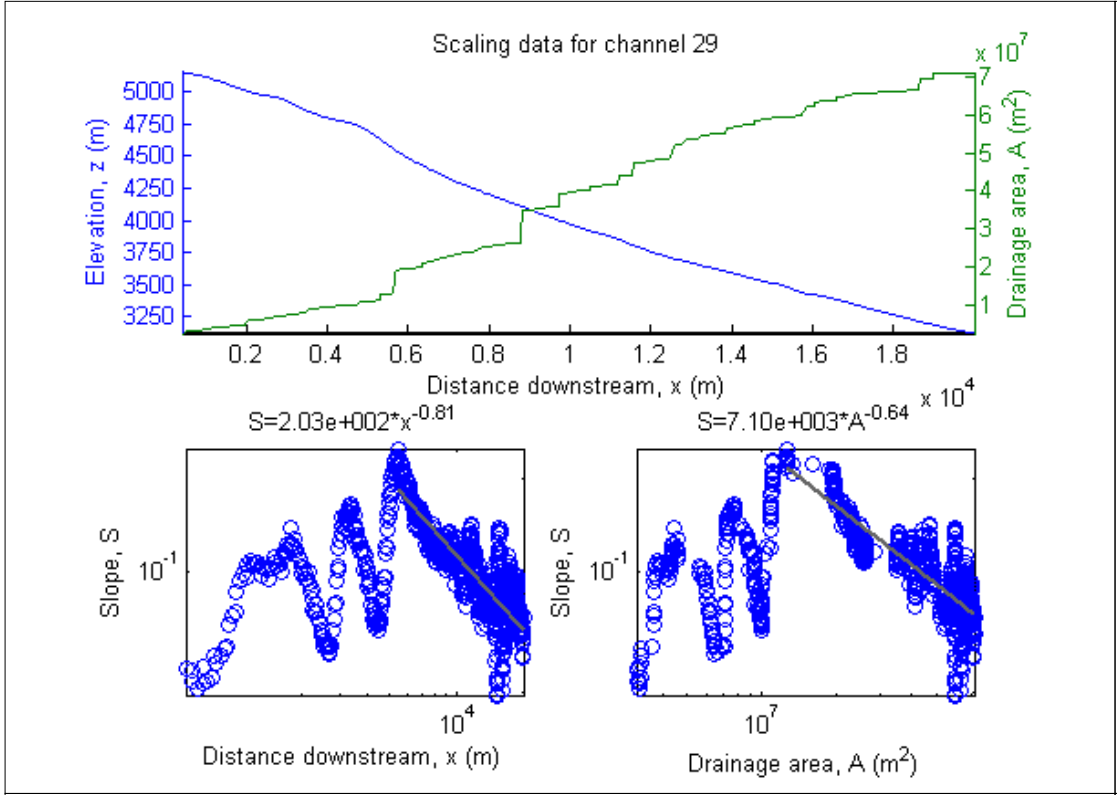

Scaling data for channel 24
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
x 10⁴
S=3.48e+004*x^-1.32
S=1.06e+007*A^-1.03
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

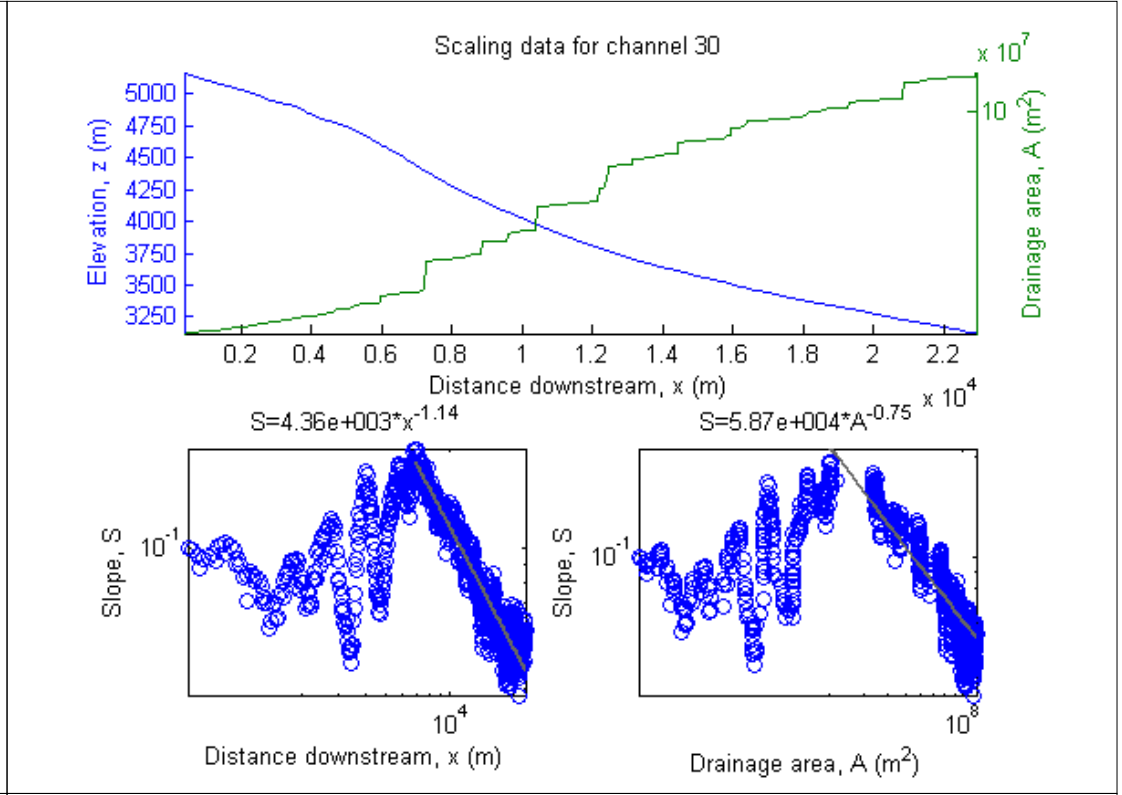

Scaling data for channel 25
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=1.68e+003*x^-1.05
S=2.08e+004*A^-0.70
x 10⁴
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

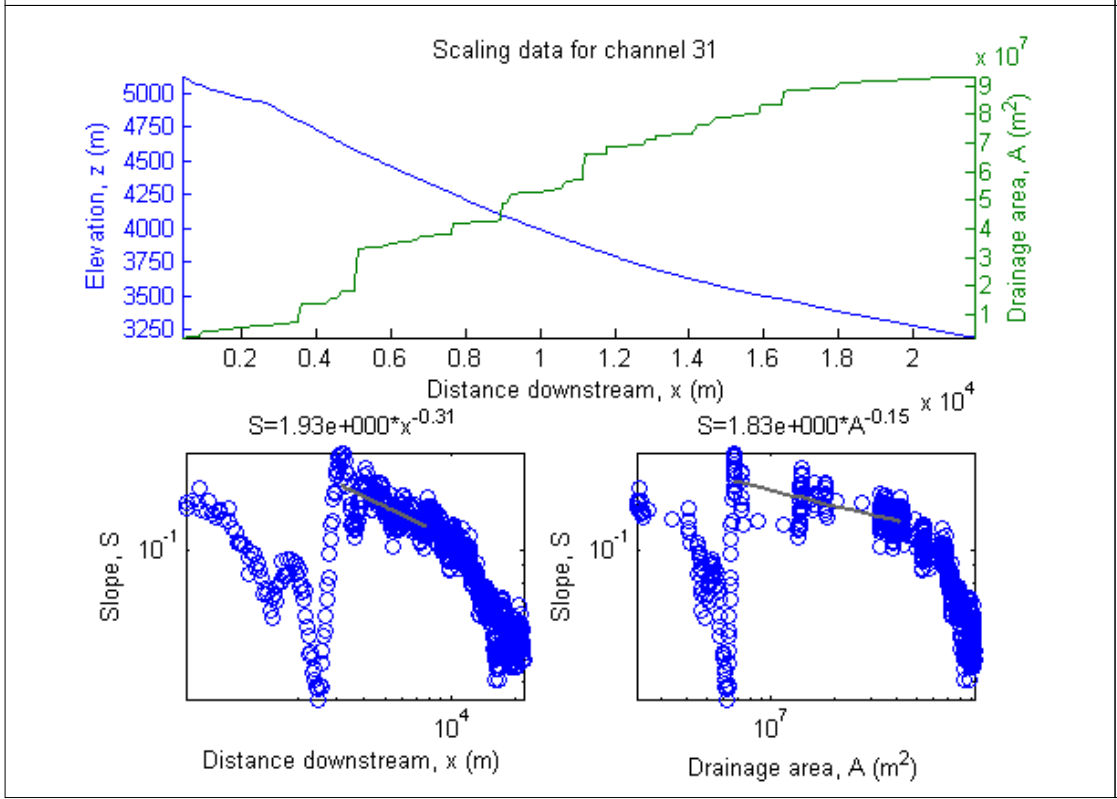

Scaling data for channel 26
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=6.12e+000*x^-0.49
S=4.43e+002*A^-0.53
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

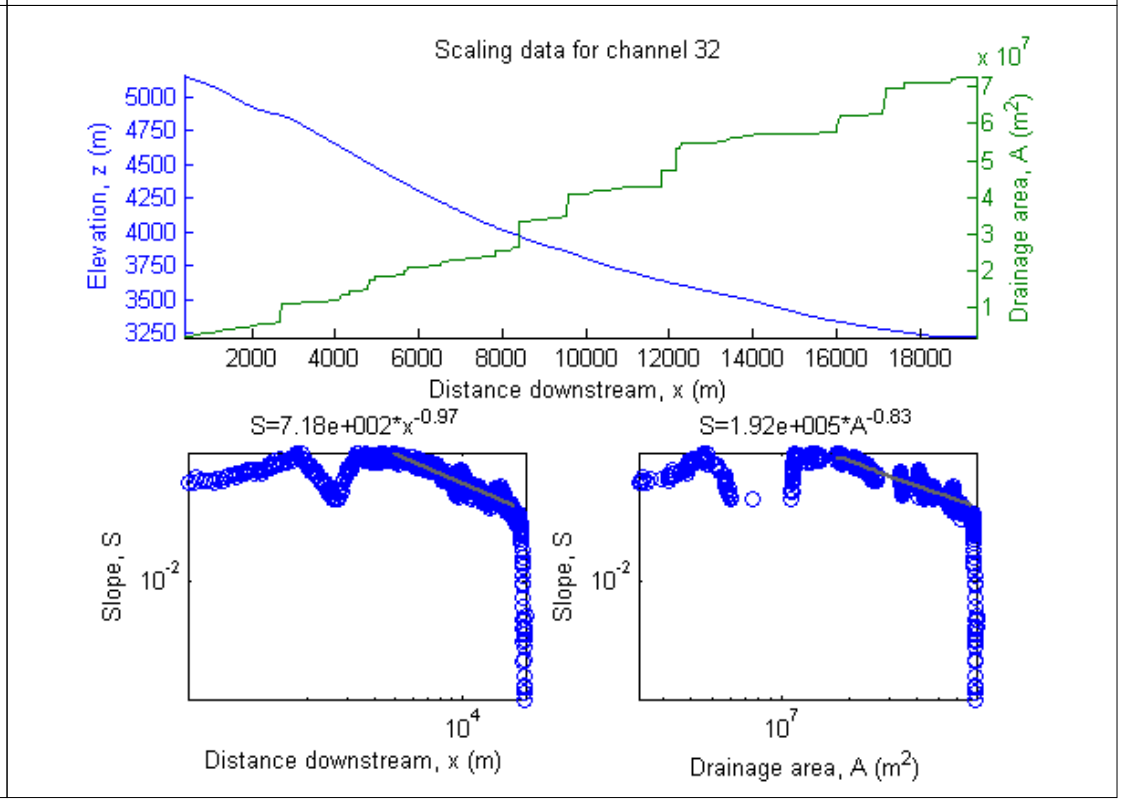

Scaling data for channel 27
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=6.98e+000*x^-0.49
S=3.47e+002*A^-0.48
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

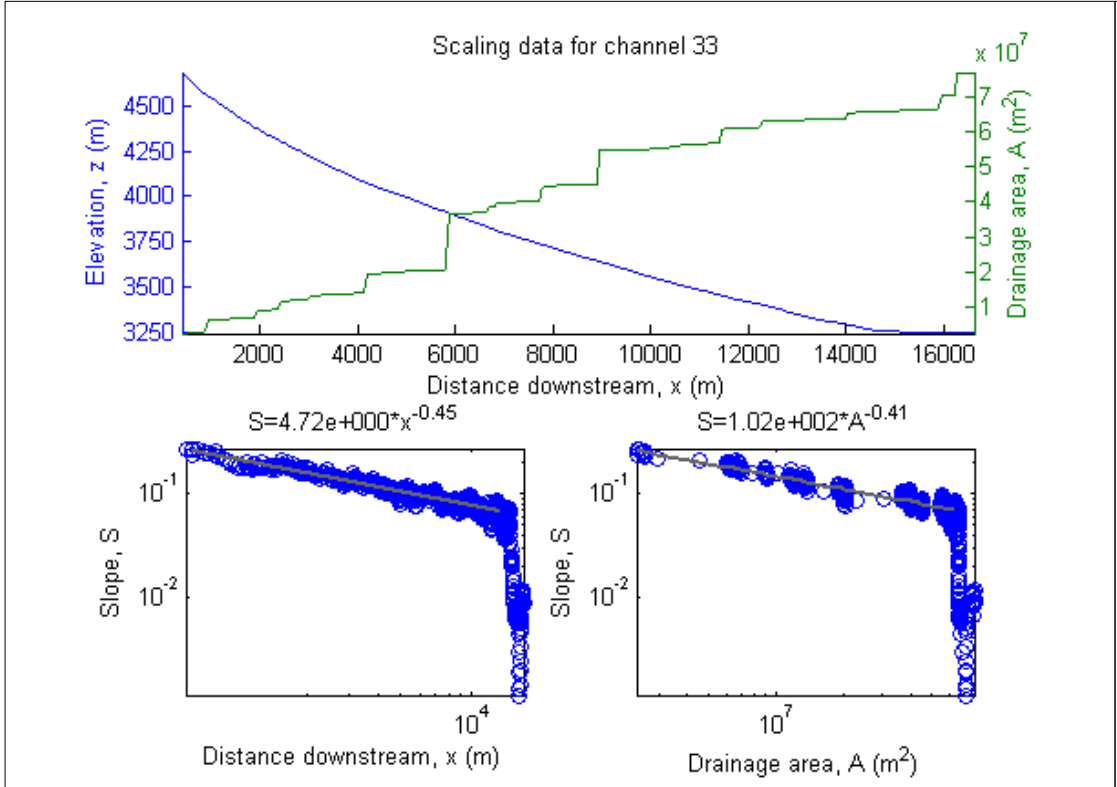

Scaling data for channel 28
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=1.72e+000*x^-0.34
S=4.04e+001*A^-0.36
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

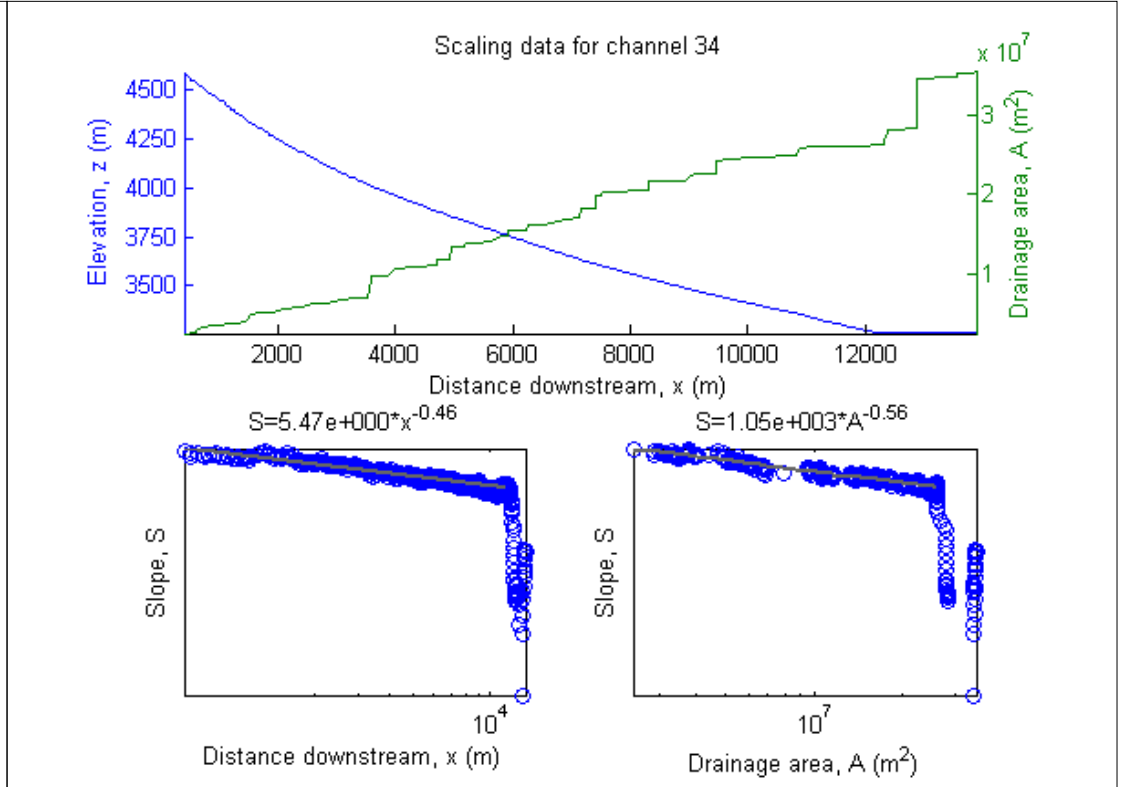

Scaling data for channel 29
Elevation, z (m)
Drainage area, A (m²)
Distance downstream, x (m)
S=2.03e+002*x^-0.81
S=7.10e+003*A^-0.64
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

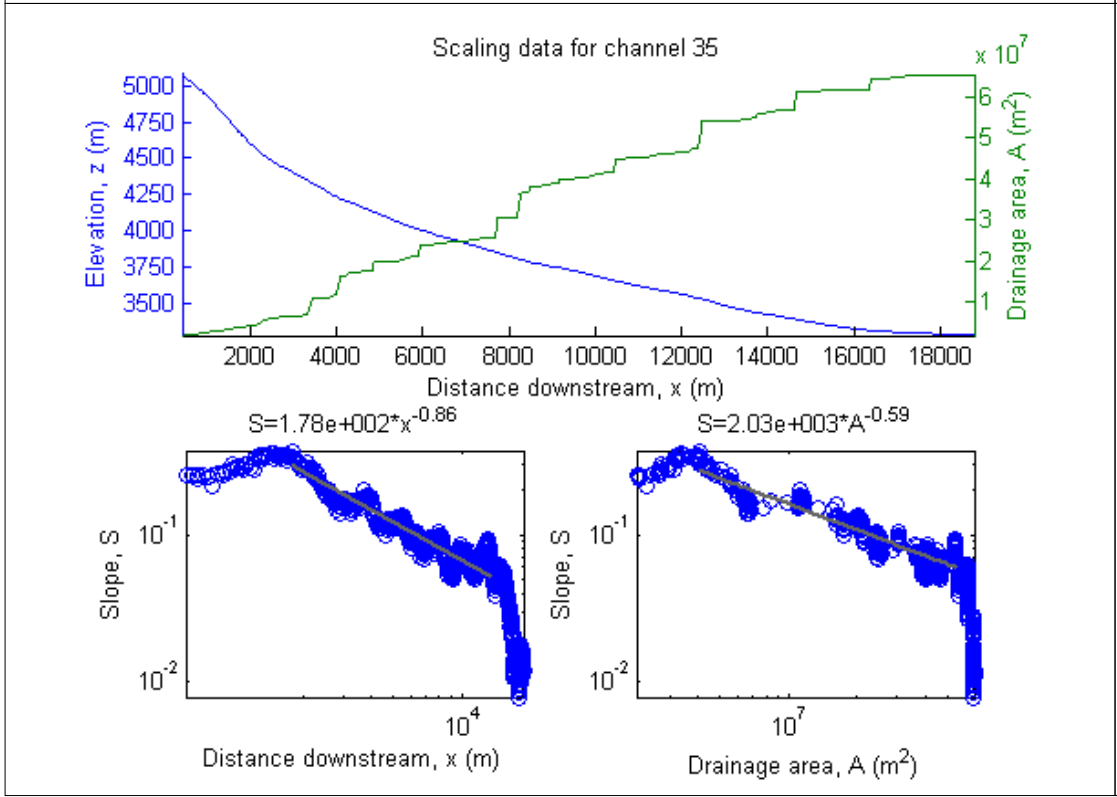

Scaling data for channel 30
Elevation, z (m)
Drainage area, A (m²)
Distance downstream, x (m)
S=4.36e+003*x^-1.14
S=5.87e+004*A^-0.75
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

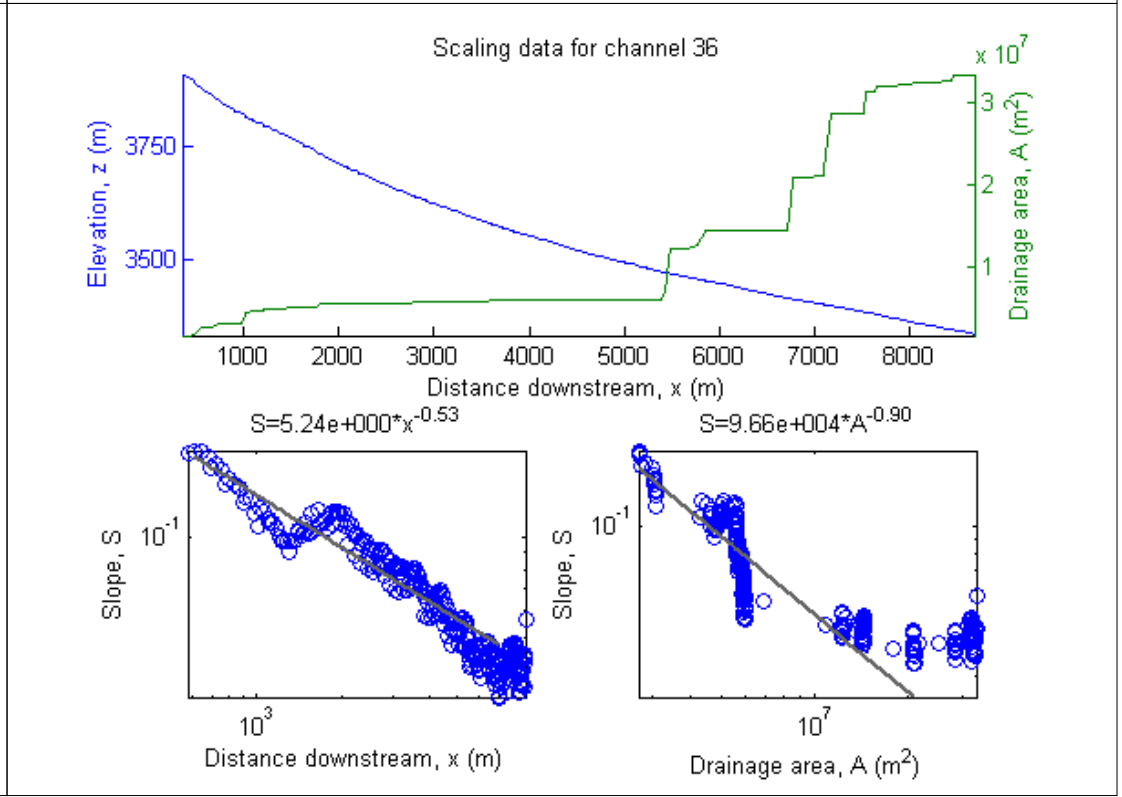

Scaling data for channel 31
Elevation, z (m)
Drainage area, A (m²)
Distance downstream, x (m)
S=1.93e+000*x^-0.31
S=1.83e+000*A^-0.15
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

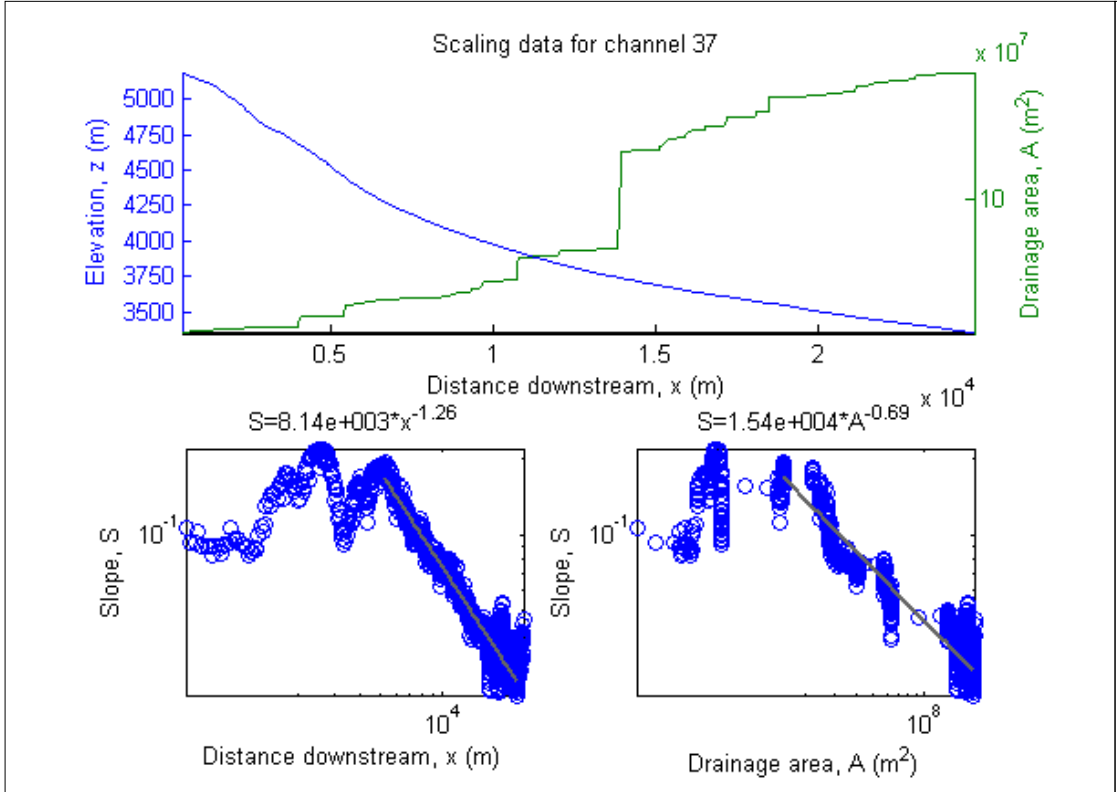

Scaling data for channel 32
Elevation, z (m)
Drainage area, A (m²)
Distance downstream, x (m)
S=7.18e+002*x^-0.97
S=1.92e+005*A^-0.83
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

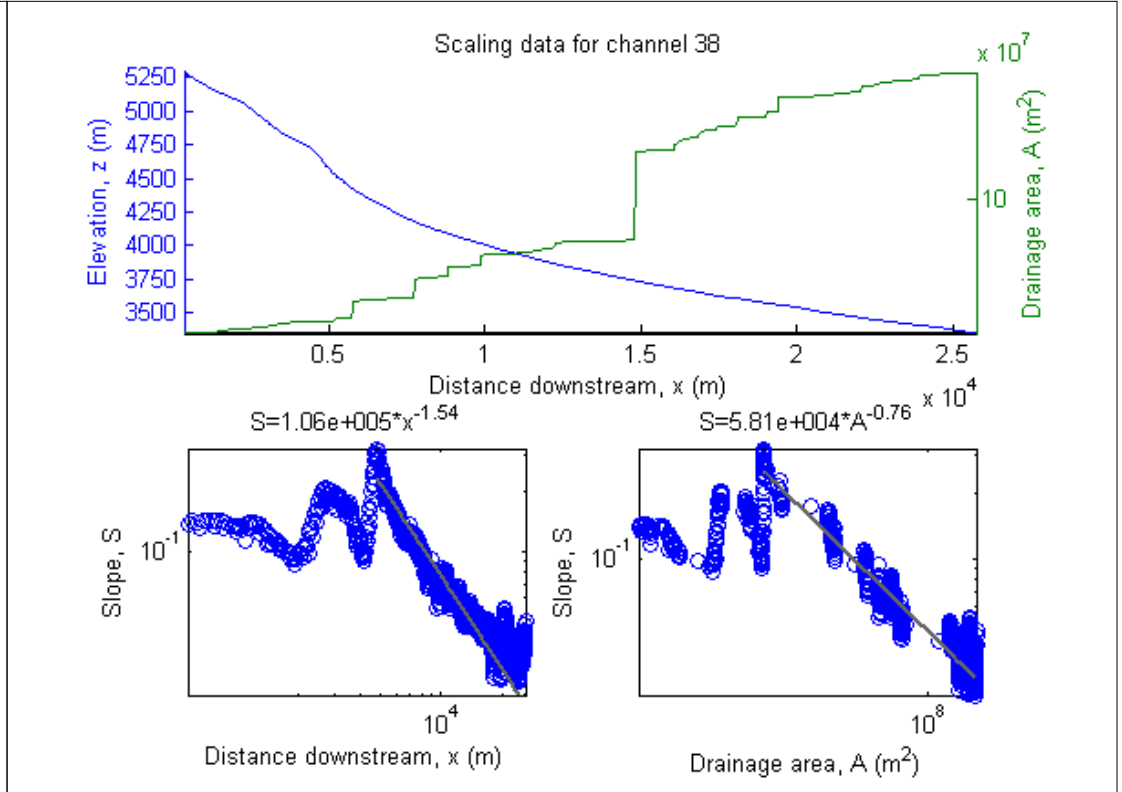

Scaling data for channel 33
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=4.72e+000*x^-0.45
S=1.02e+002*A^-0.41
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

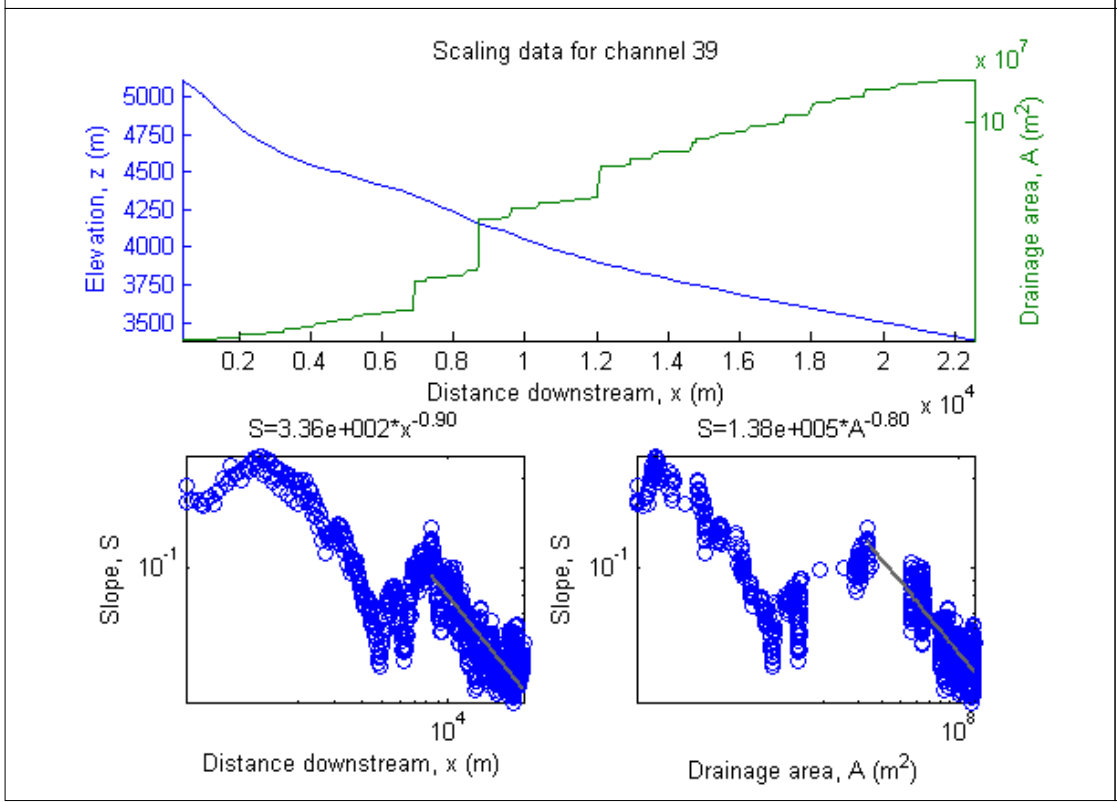

Scaling data for channel 34
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=5.47e+000*x^-0.46
S=1.05e+003*A^-0.56
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

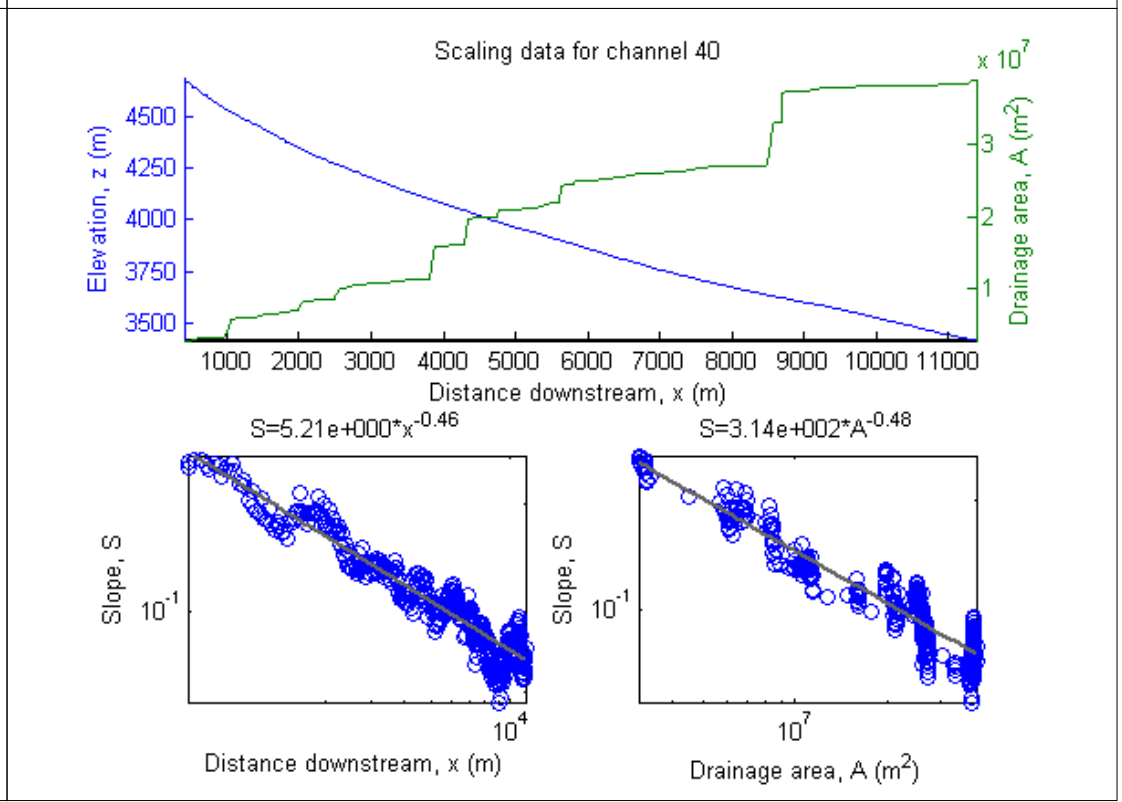

Scaling data for channel 35
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=1.78e+002*x^-0.86
S=2.03e+003*A^-0.59
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

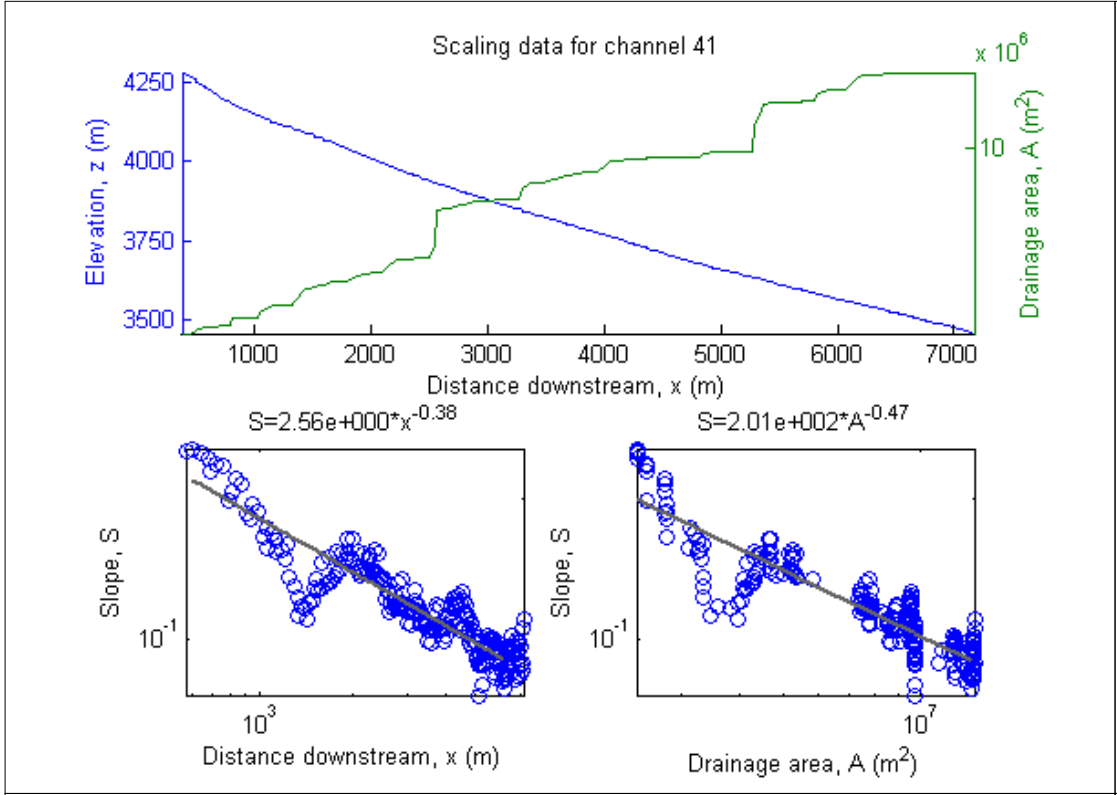

Scaling data for channel 36
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=5.24e+000*x^-0.53
S=9.66e+004*A^-0.90
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

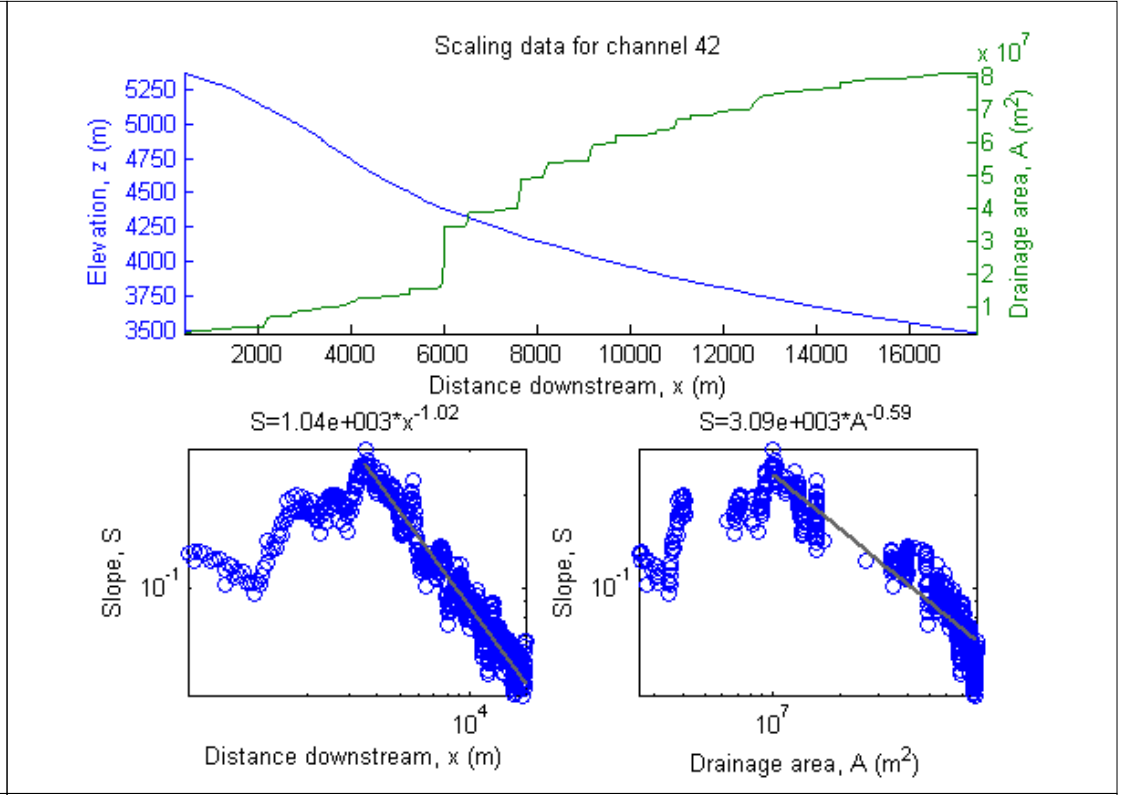

Scaling data for channel 37
Elevation, z (m)
Drainage area, A (m²)
Distance downstream, x (m)
S=8.14e+003*x^-1.26
S=1.54e+004*A^-0.69
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

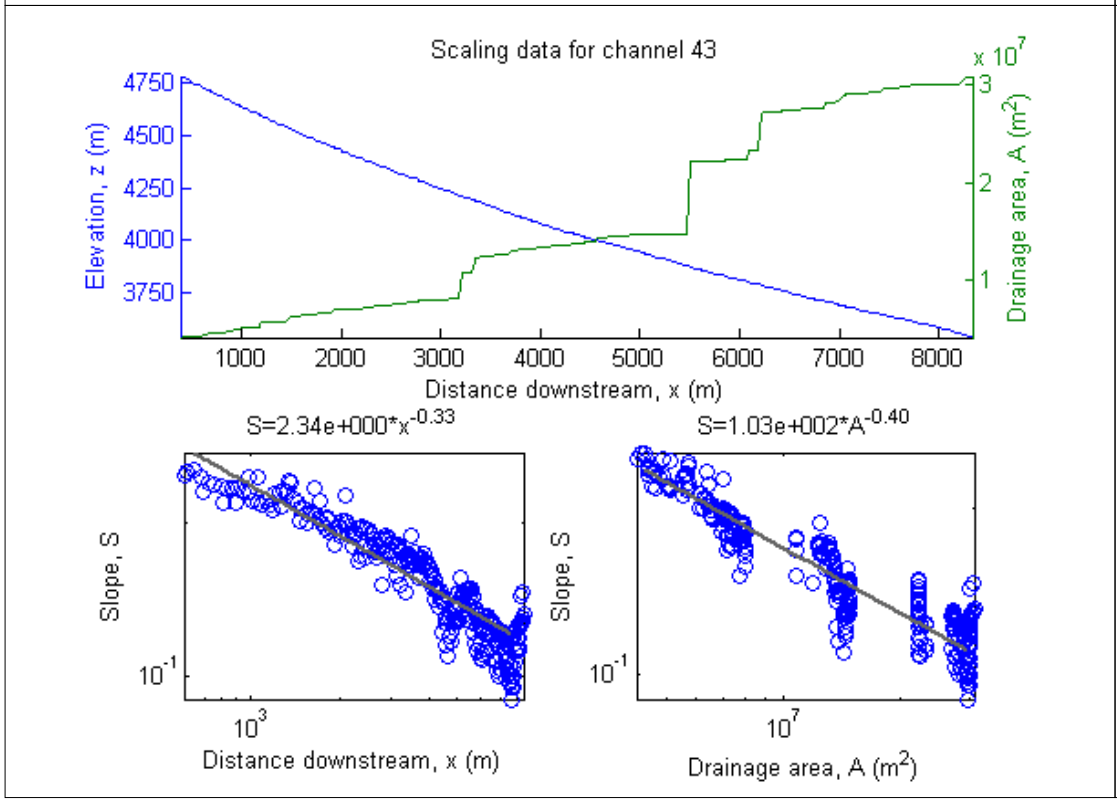

Scaling data for channel 38
Elevation, z (m)
Drainage area, A (m²)
Distance downstream, x (m)
S=1.06e+005*x^-1.54
S=5.81e+004*A^-0.76
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

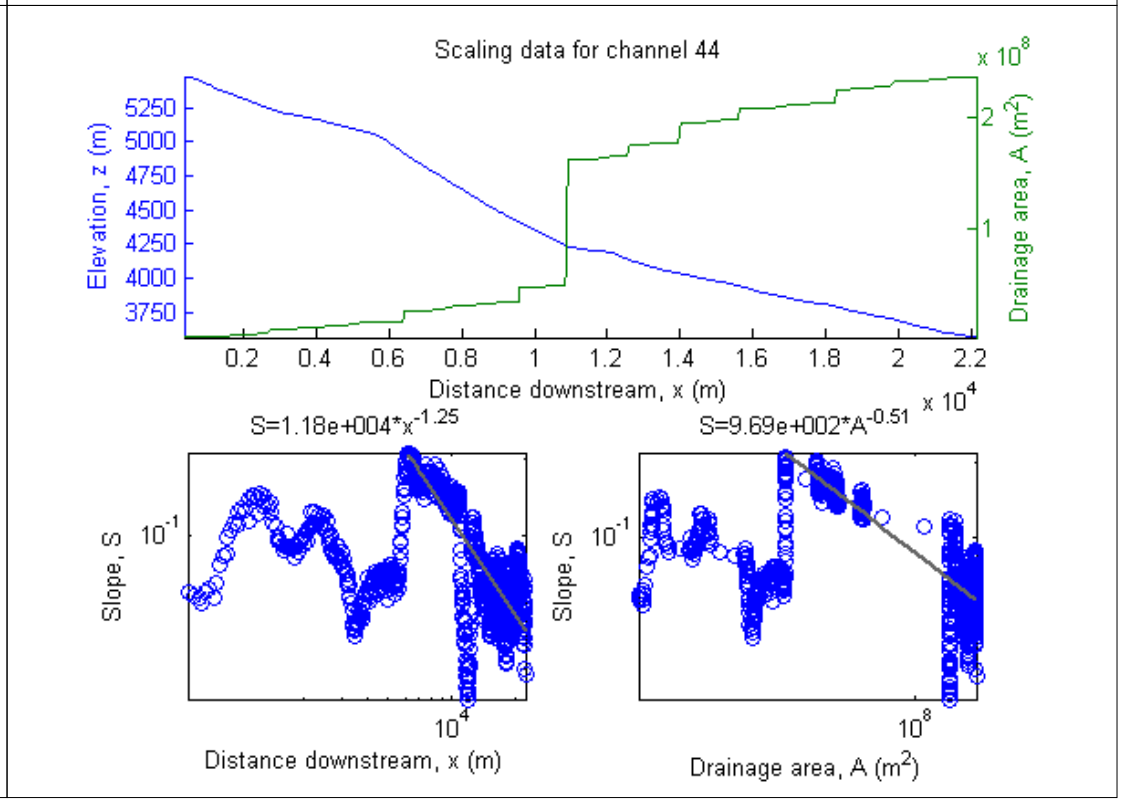

Scaling data for channel 39
Elevation, z (m)
Drainage area, A (m²)
Distance downstream, x (m)
S=3.36e+002*x^-0.90
S=1.38e+005*A^-0.80
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

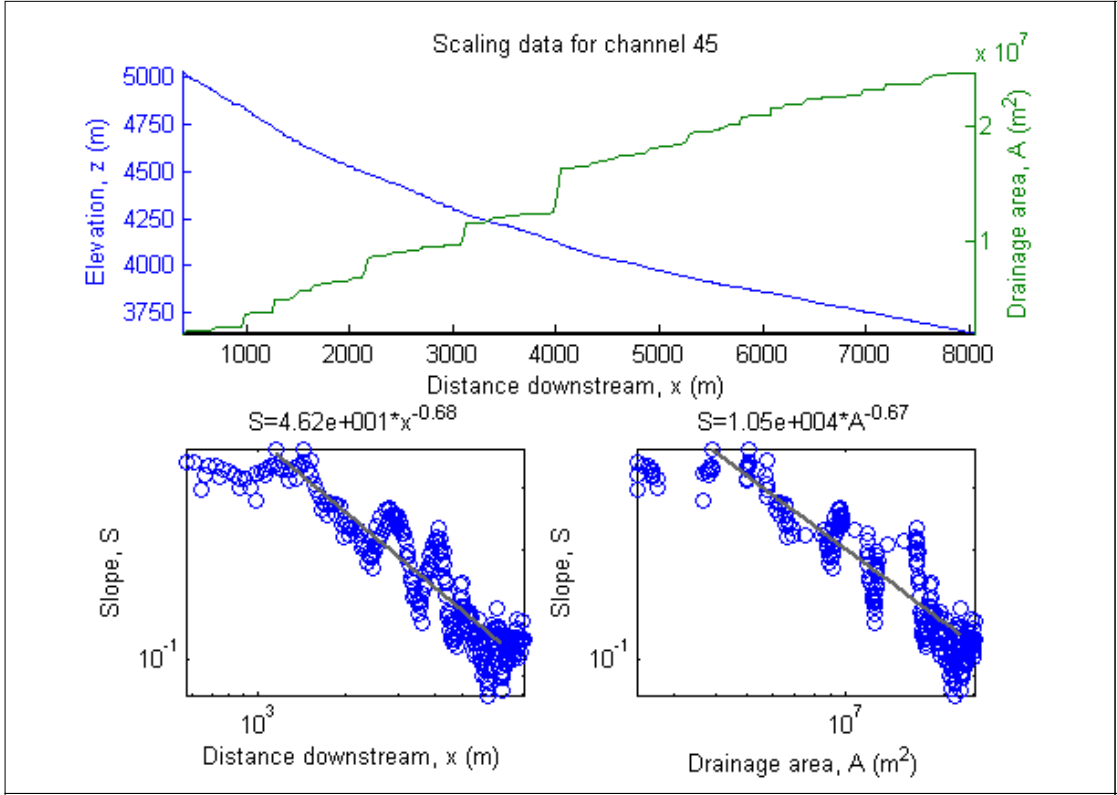

Scaling data for channel 40
Elevation, z (m)
Drainage area, A (m²)
Distance downstream, x (m)
S=5.21e+000*x^-0.46
S=3.14e+002*A^-0.48
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

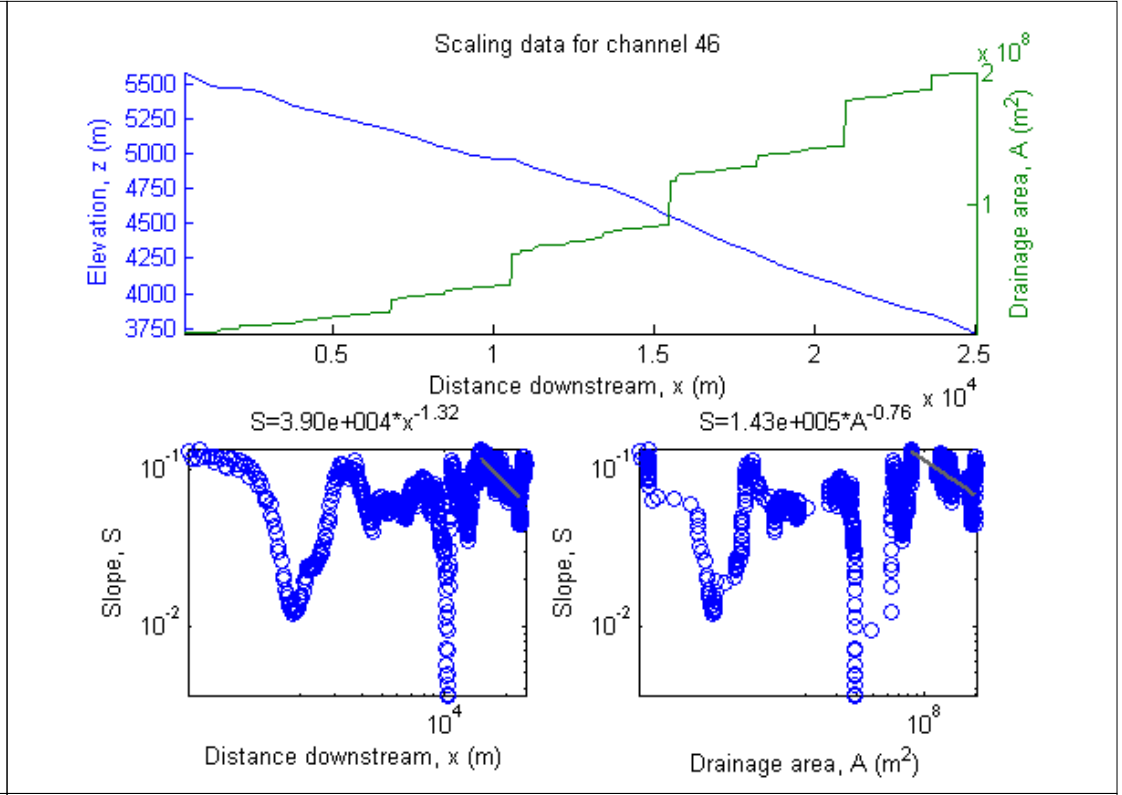

Scaling data for channel 41
Elevation, z (m)
Drainage area, A (m²)
x 10⁶
Distance downstream, x (m)
S=2.56e+000*x^-0.38
S=2.01e+002*A^-0.47
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

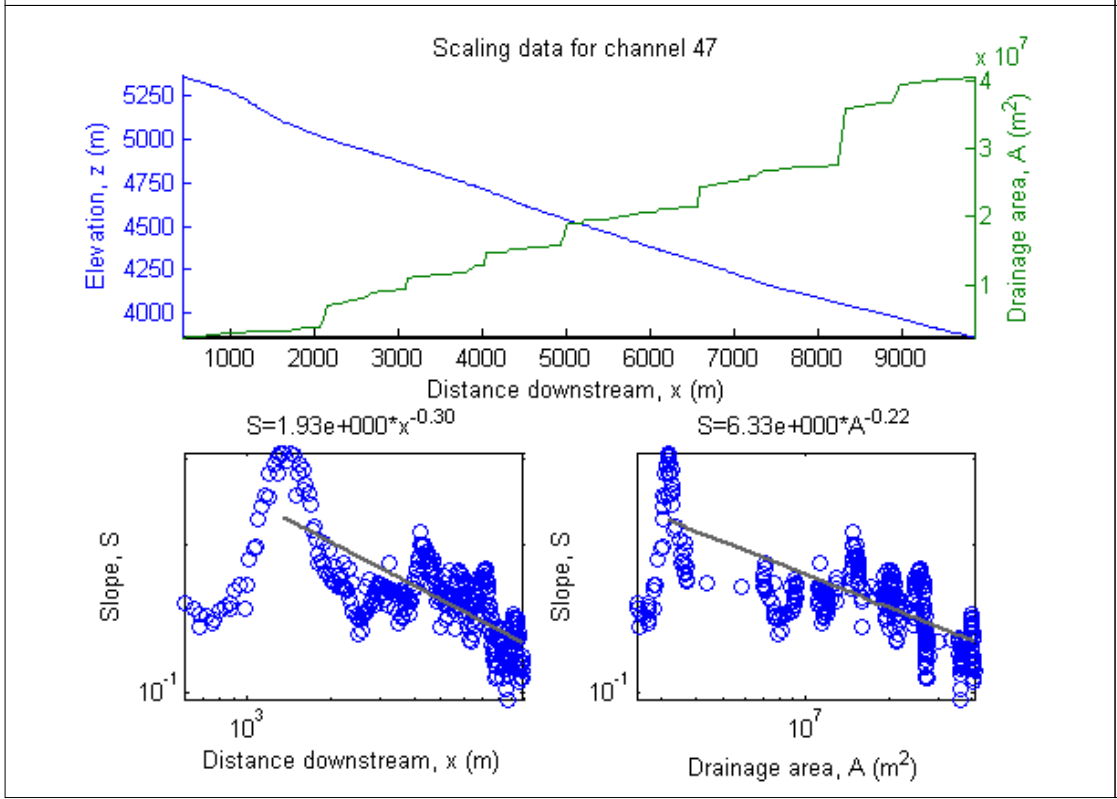

Scaling data for channel 42
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=1.04e+003*x^-1.02
S=3.09e+003*A^-0.59
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

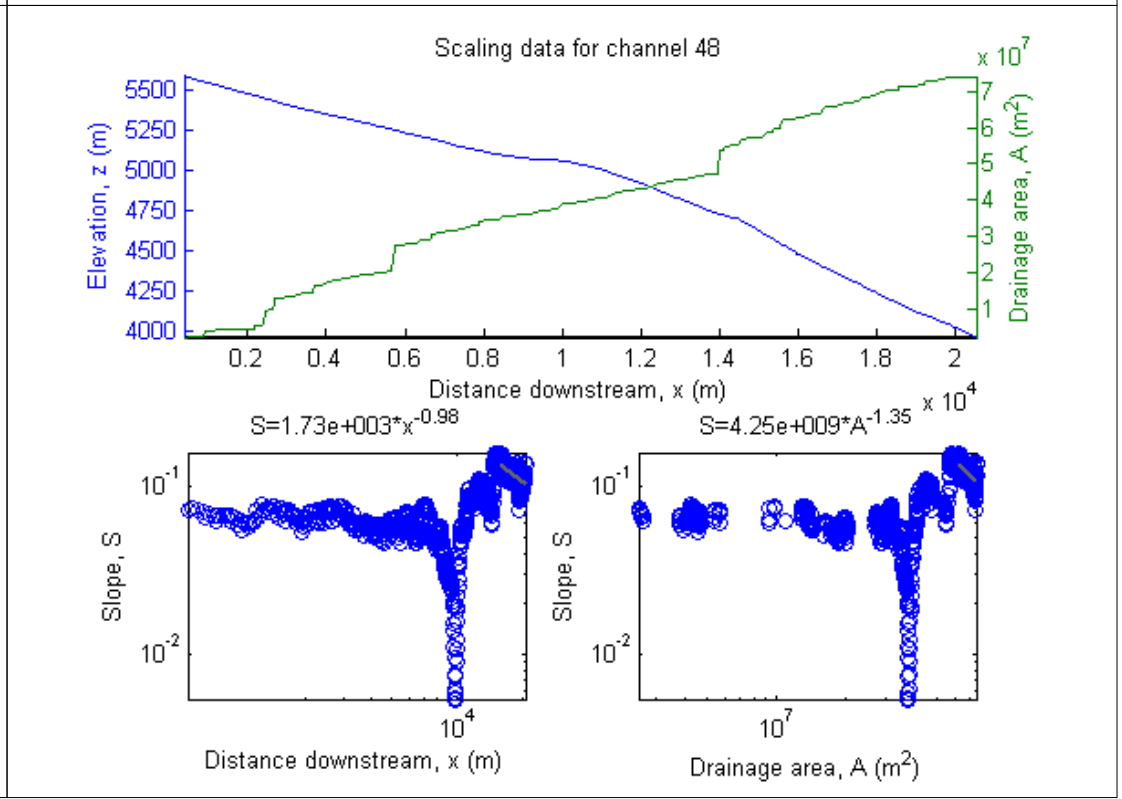

Scaling data for channel 43
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=2.34e+000*x^-0.33
S=1.03e+002*A^-0.40
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

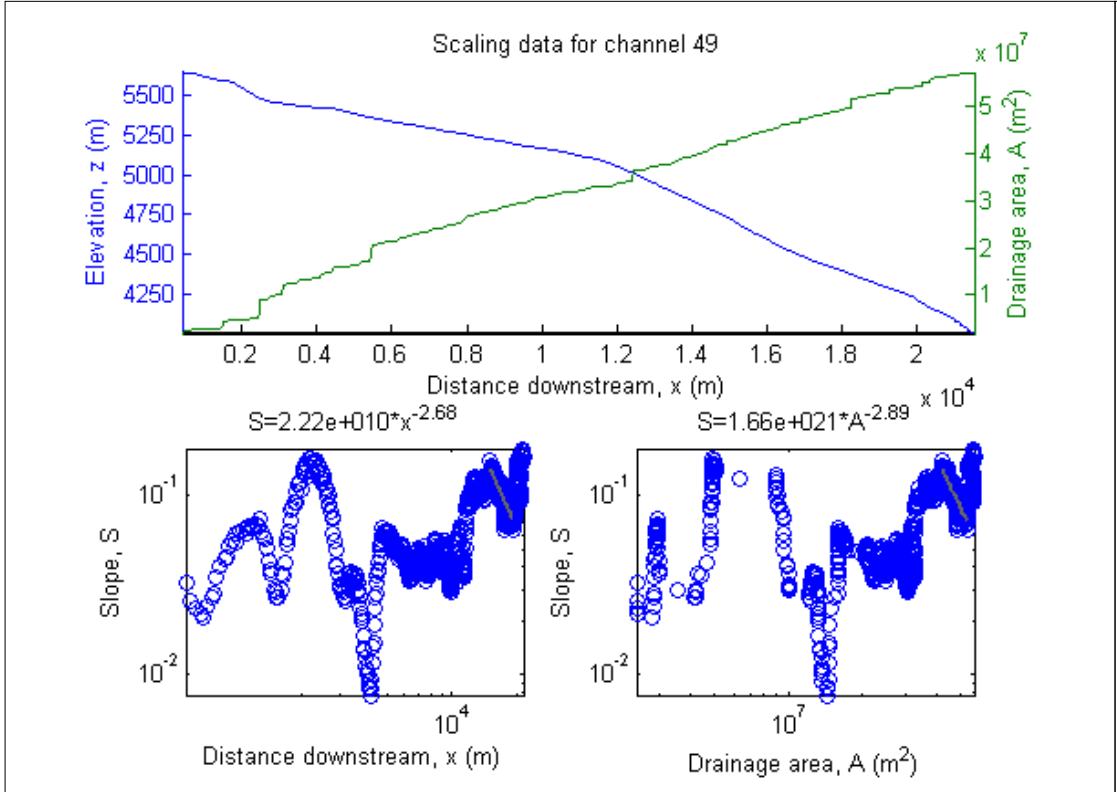

Scaling data for channel 44
Elevation, z (m)
Drainage area, A (m²)
x 10⁸
Distance downstream, x (m)
x 10⁴
S=1.18e+004*x^-1.25
S=9.69e+002*A^-0.51
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

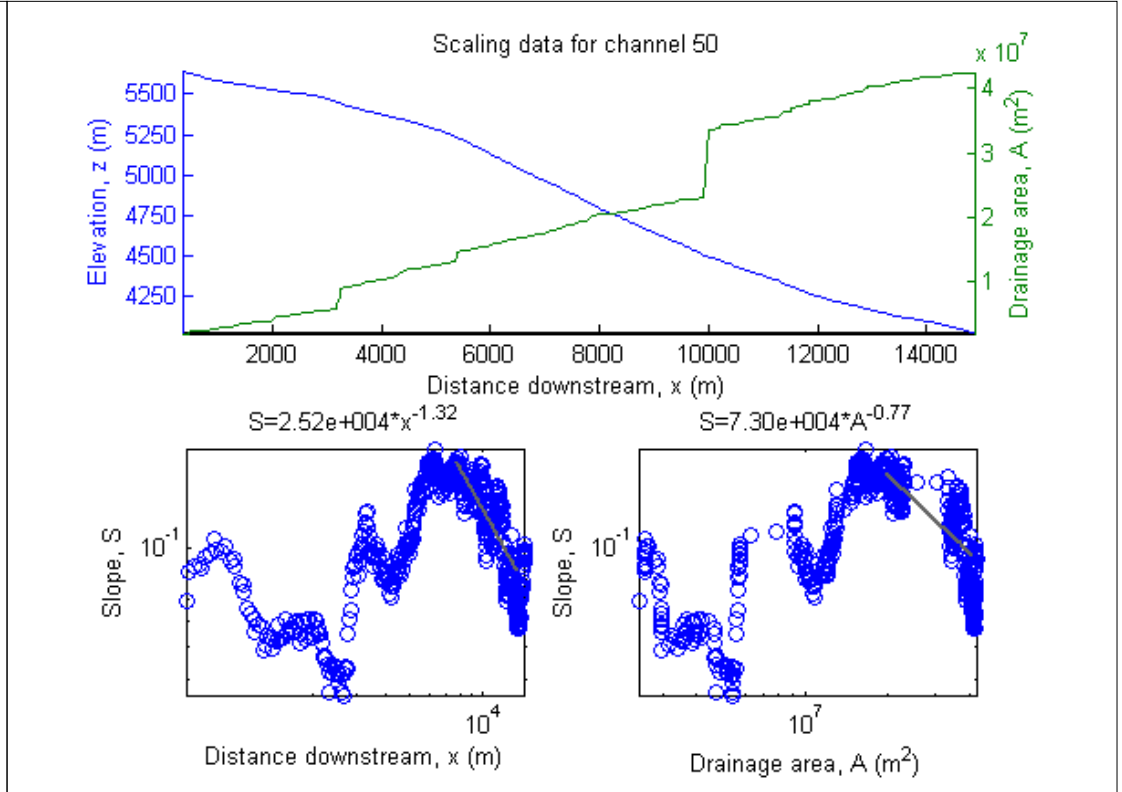

Scaling data for channel 45
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=4.62e+001*x^-0.68
S=1.05e+004*A^-0.67
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

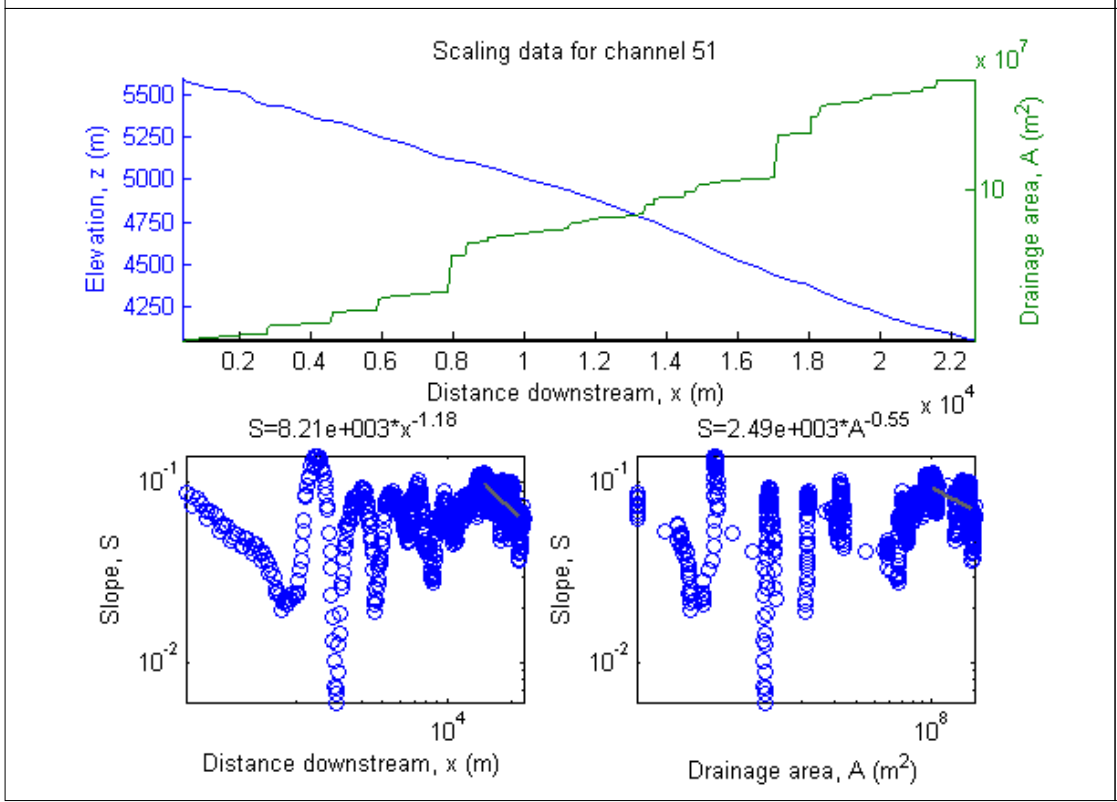

Scaling data for channel 46
Elevation, z (m)
Drainage area, A (m²)
x 10⁸
x 10⁴
Distance downstream, x (m)
S=3.90e+004*x^-1.32
S=1.43e+005*A^-0.76
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

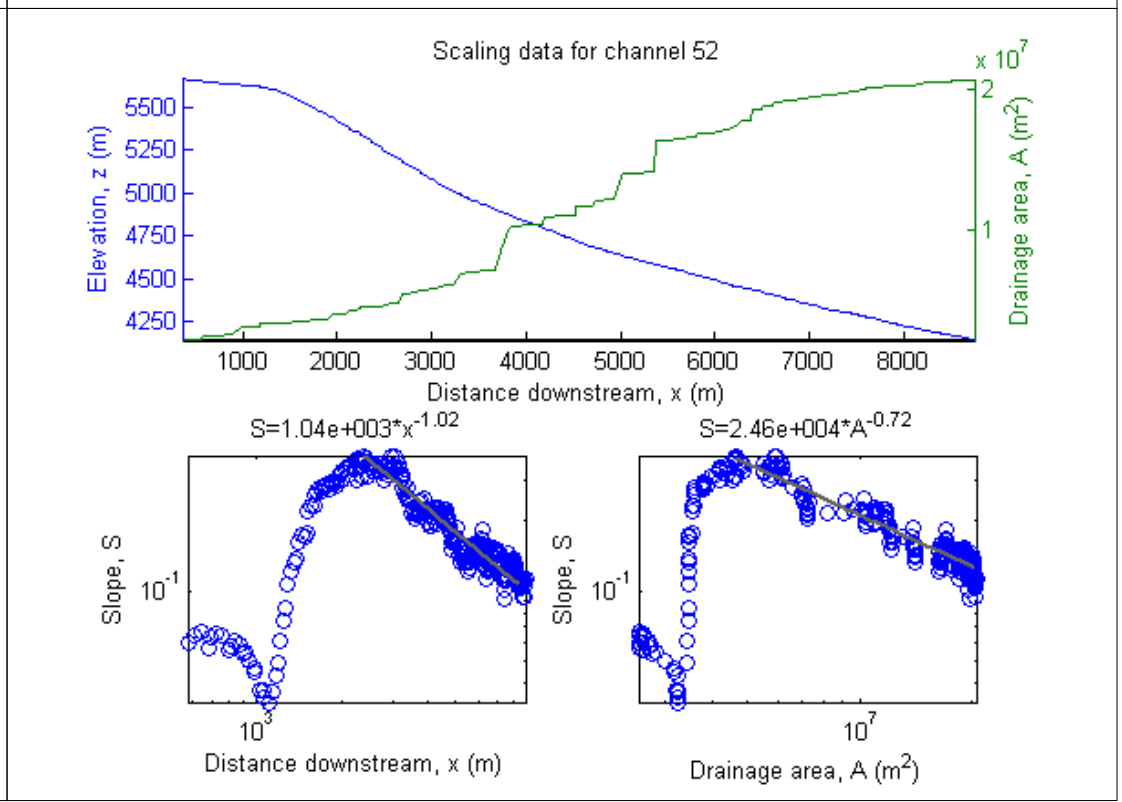

Scaling data for channel 47
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=1.93e+000*x^-0.30
S=6.33e+000*A^-0.22
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

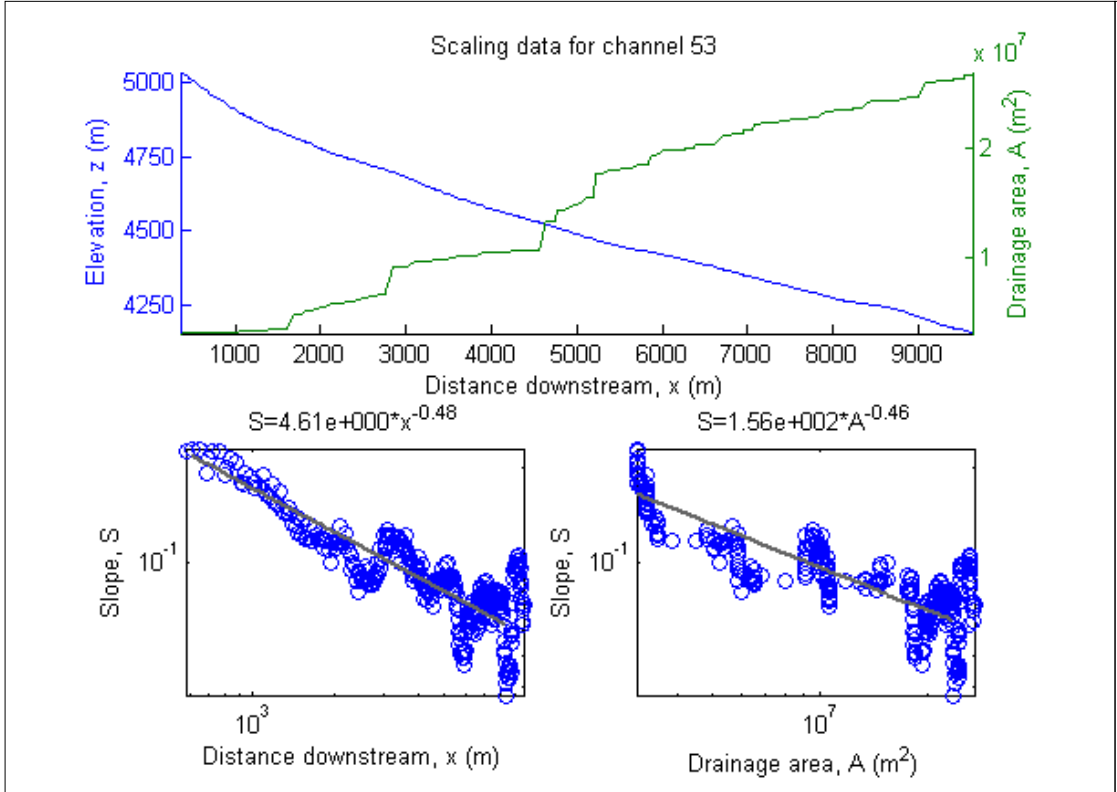

Scaling data for channel 48
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
x 10⁴
Distance downstream, x (m)
S=1.73e+003*x^-0.98
S=4.25e+009*A^-1.35
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

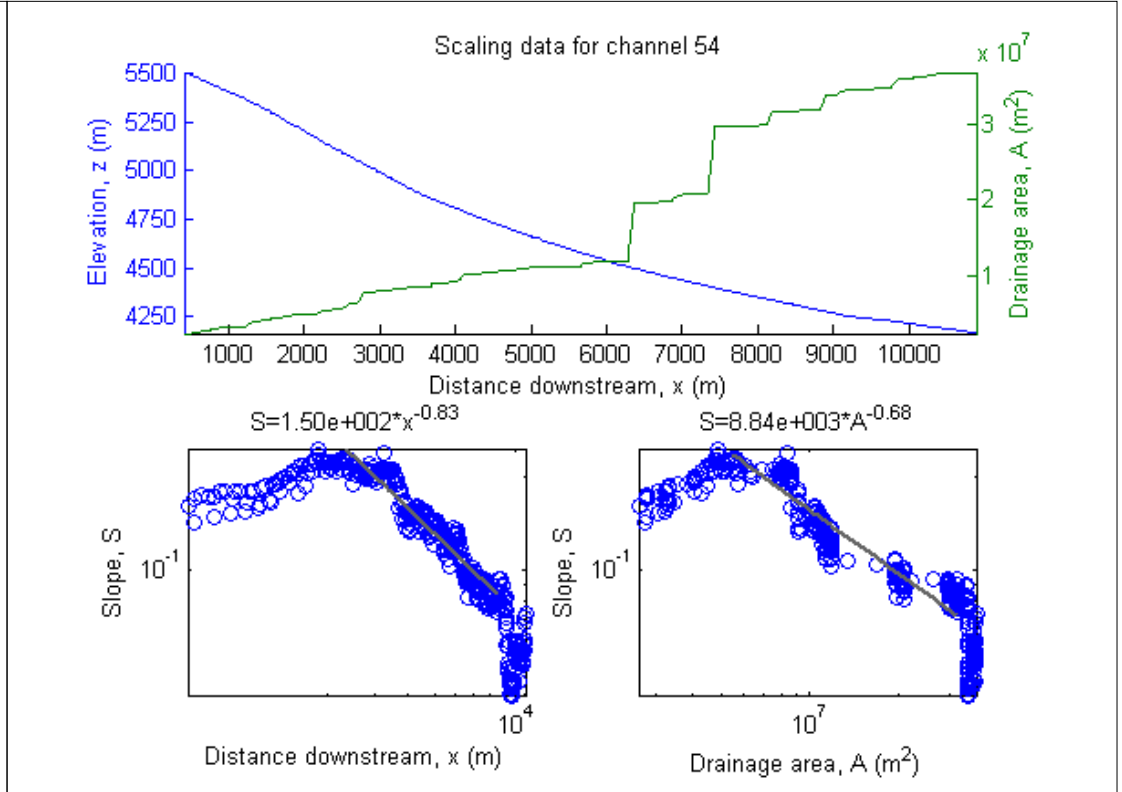

Scaling data for channel 49
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=2.22e+010*x^-2.68
S=1.66e+021*A^-2.89
x 10⁴
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

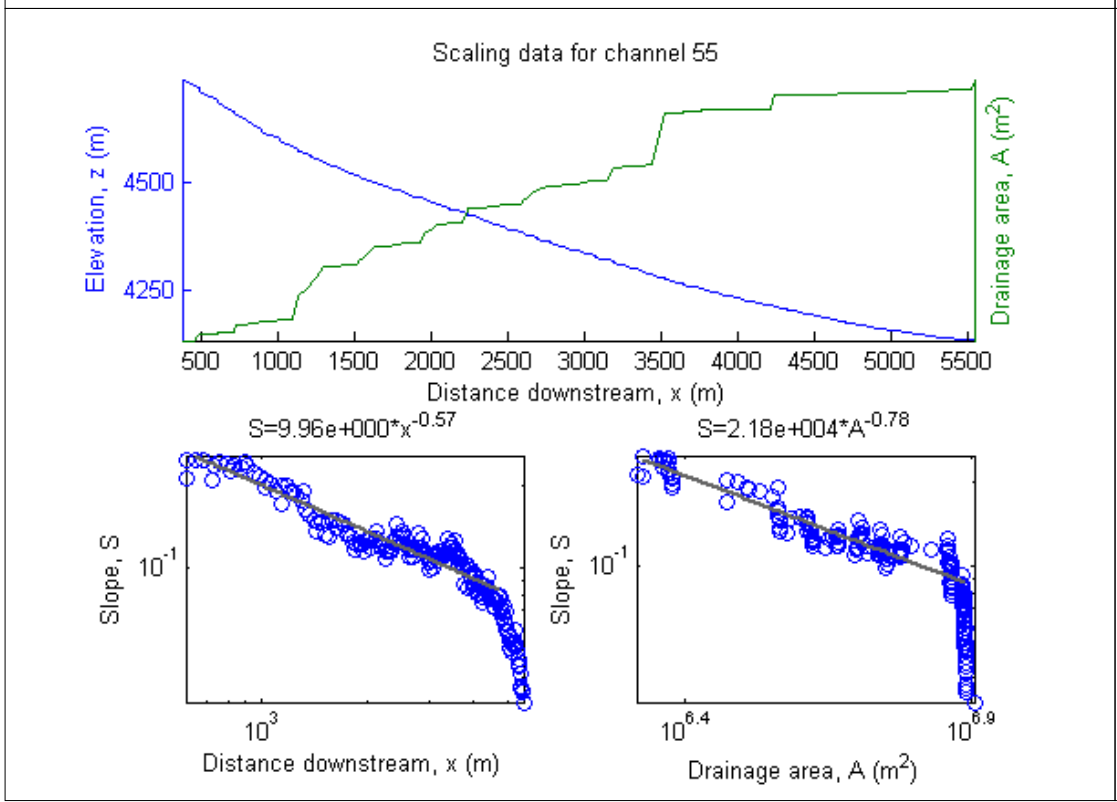

Scaling data for channel 50
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=2.52e+004*x^-1.32
S=7.30e+004*A^-0.77
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

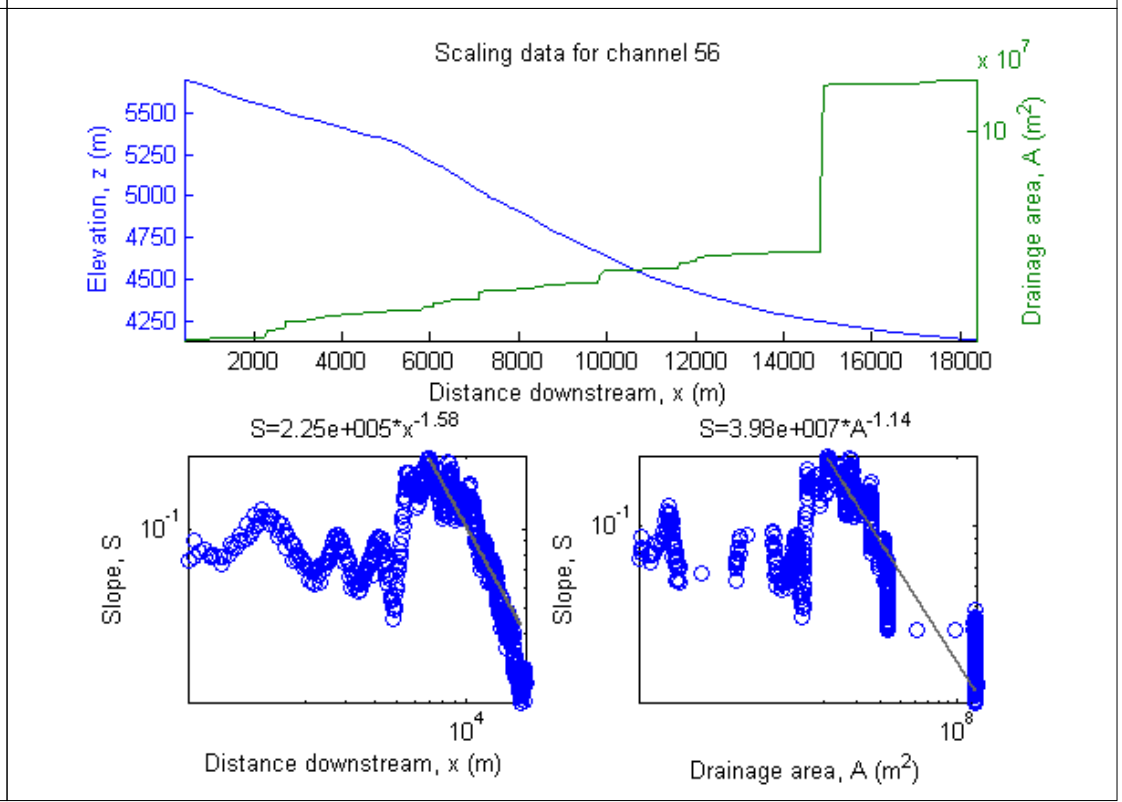

Scaling data for channel 51
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=8.21e+003*x^-1.18
S=2.49e+003*A^-0.55
x 10⁴
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)

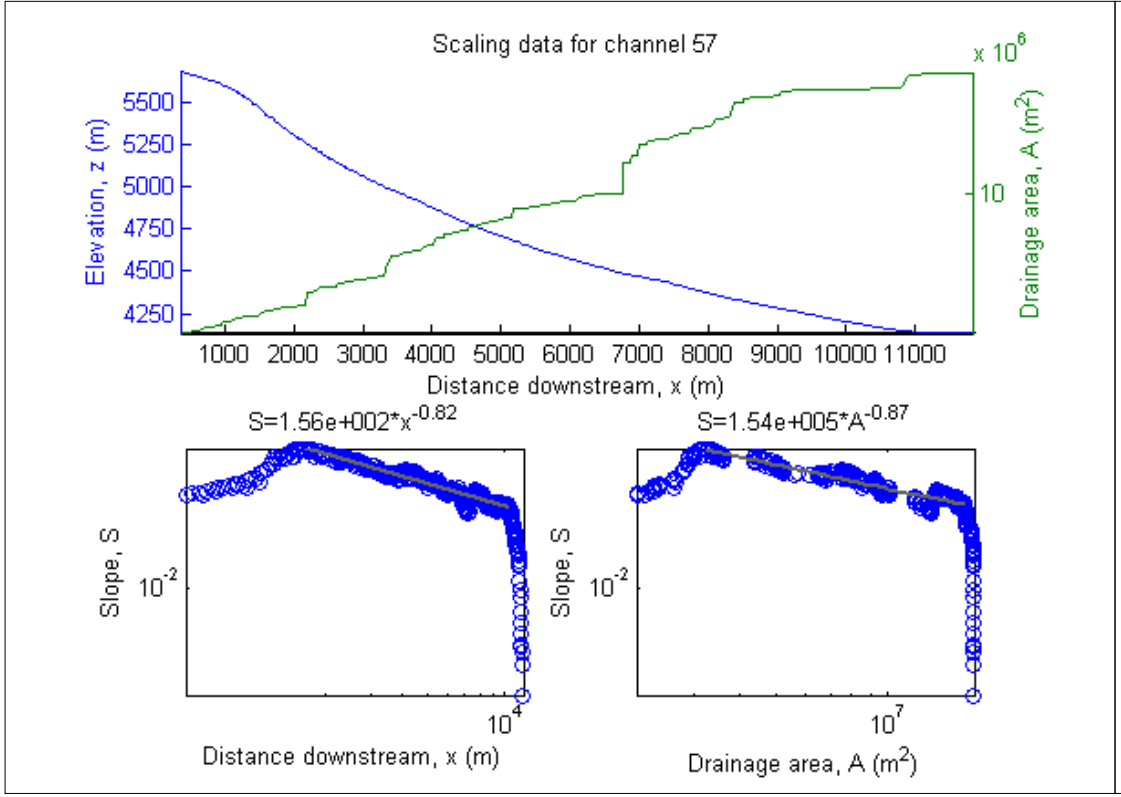

Scaling data for channel 52
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=1.04e+003*x^-1.02
S=2.46e+004*A^-0.72
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)


Scaling data for channel 53
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=4.61e+000*x^-0.48
S=1.56e+002*A^-0.46
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)


Scaling data for channel 54
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=1.50e+002*x^-0.83
S=8.84e+003*A^-0.68
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)


Scaling data for channel 55
Elevation, z (m)
Drainage area, A (m²)
Distance downstream, x (m)
S=9.96e+000*x^-0.57
S=2.18e+004*A^-0.78
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)


Scaling data for channel 56
Elevation, z (m)
Drainage area, A (m²)
x 10⁷
Distance downstream, x (m)
S=2.25e+005*x^-1.58
S=3.98e+007*A^-1.14
Slope, S
Distance downstream, x (m)
Drainage area, A (m²)


Scaling data for channel 57
x 10^6
Elevation, z (m)
Drainage area, A (m^2)
Distance downstream, x (m)
S=1.56e+002*x^-0.82
S=1.54e+005*A^-0.87
Slope, S
Distance downstream, x (m)
Drainage area, A (m^2)

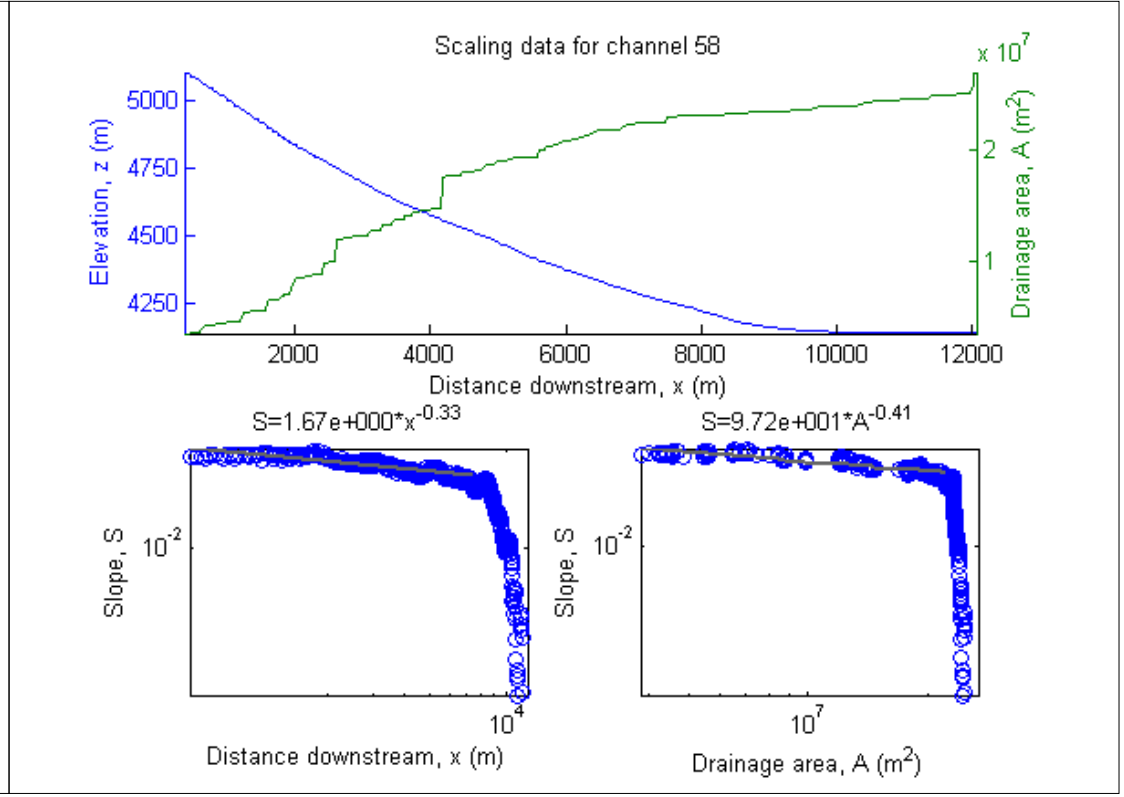

Scaling data for channel 58
x 10^7
Elevation, z (m)
Drainage area, A (m^2)
Distance downstream, x (m)
S=1.67e+000*x^-0.33
S=9.72e+001*A^-0.41
Slope, S
Distance downstream, x (m)
Drainage area, A (m^2)

Figure S2a. Comparison of field (black squares) and DEM (grey circles) derived slopes as measured downstream for (i) Basgo valley and (ii) Leh

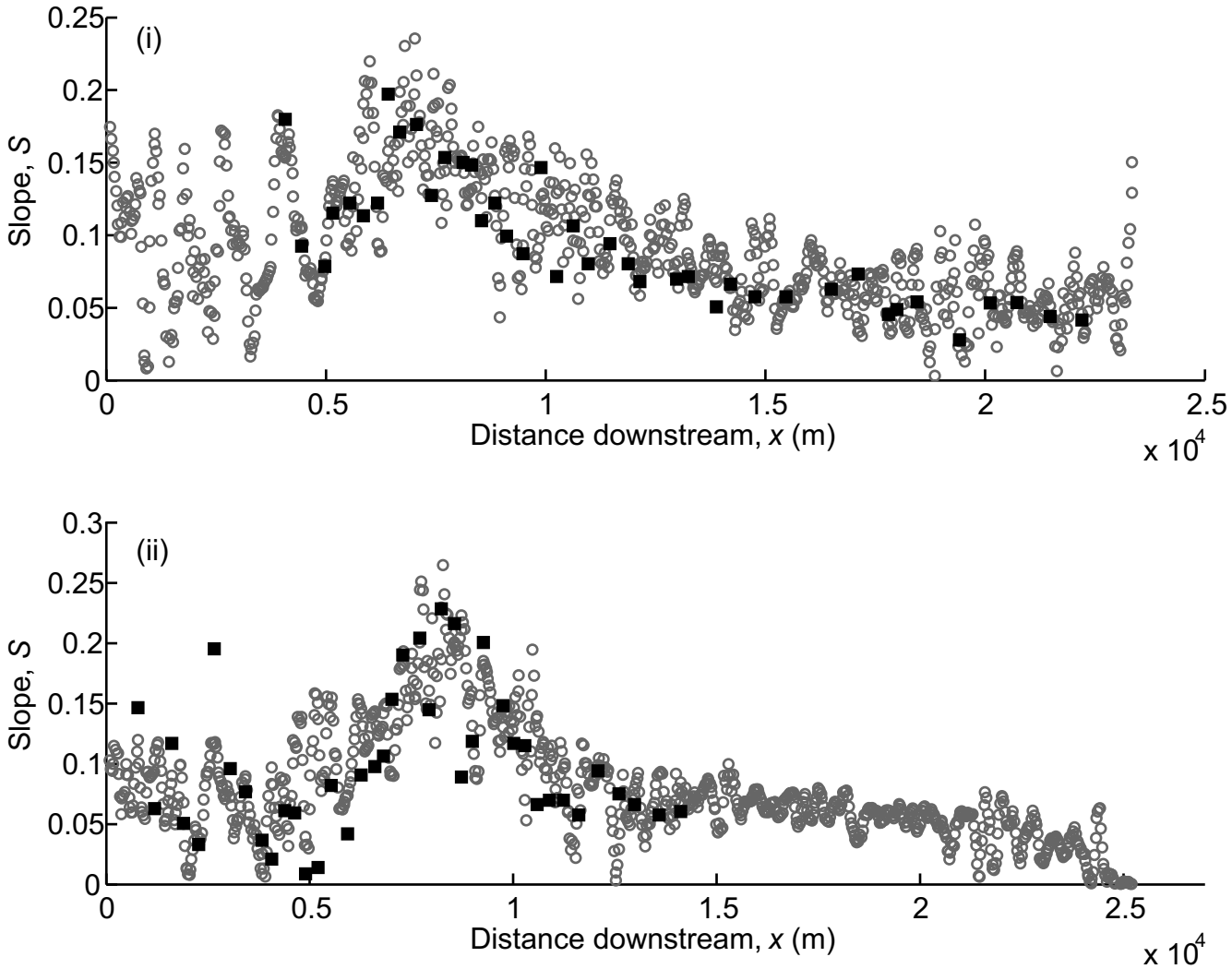


Figure S2b. Field slopes versus DEM slopes for two catchments, (i) Basgo valley, (ii) Leh valley

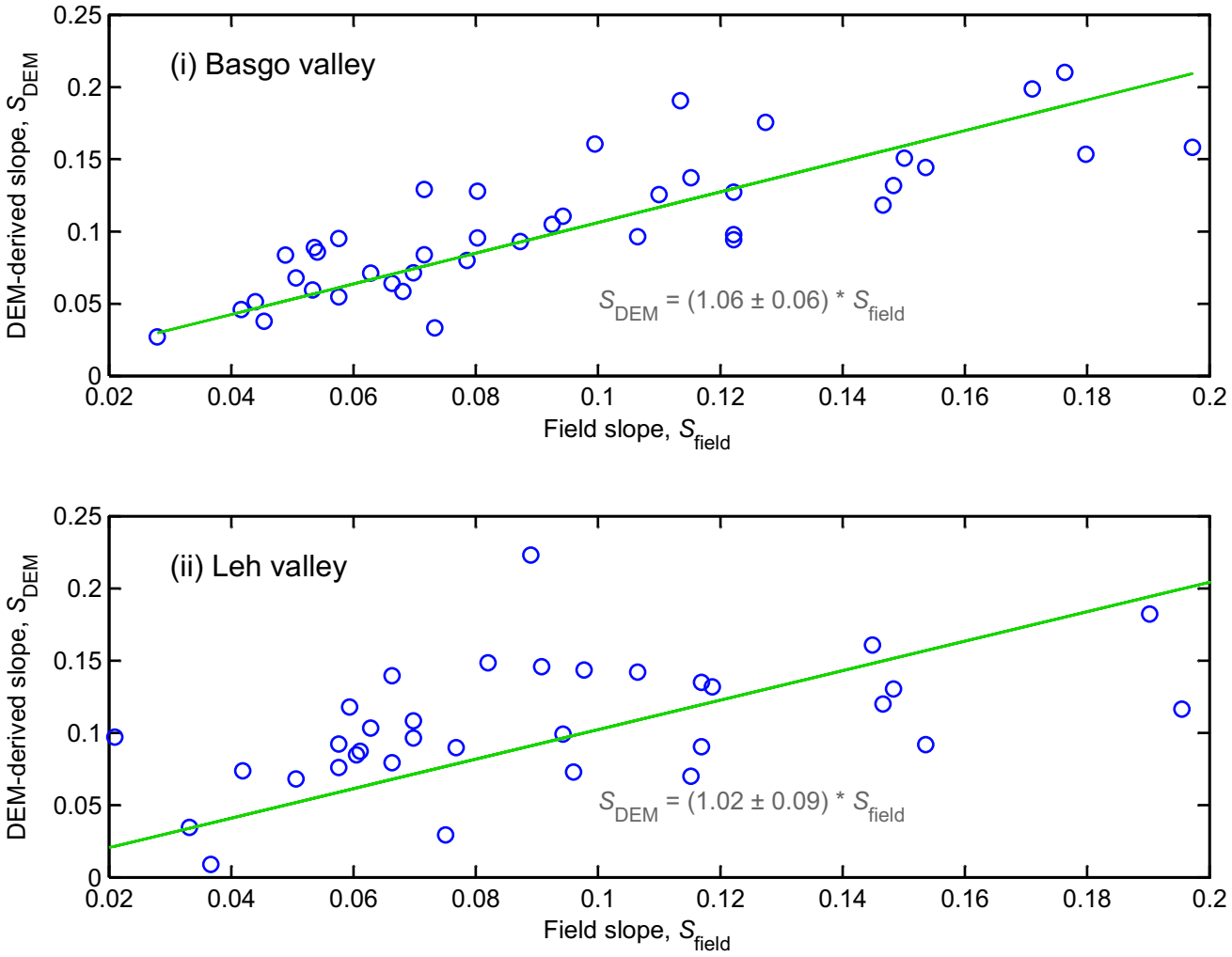
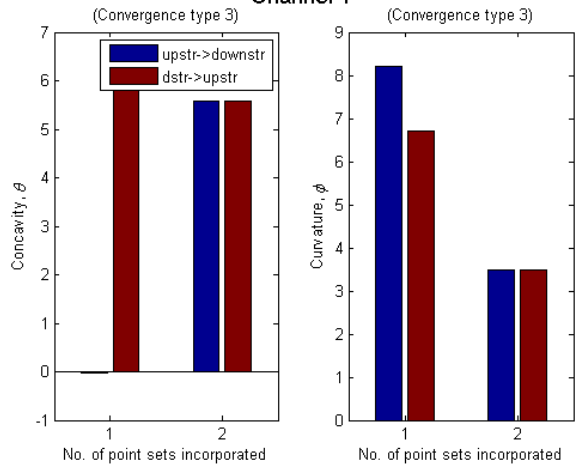
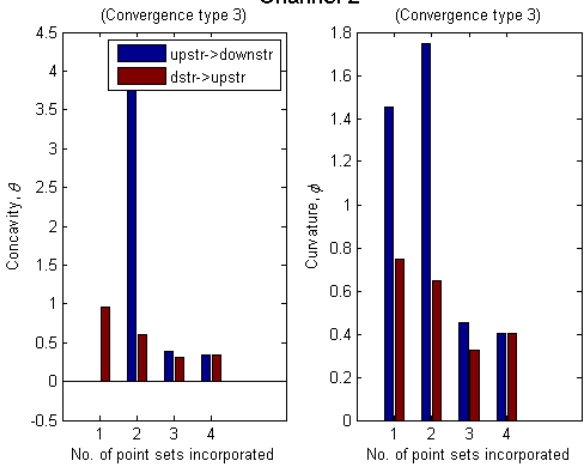


Figure S3. Plots of calculated concavity and curvature values for each catchment, subdividing the data to investigate possible variations in the values downstream. Data is plotted incorporating different numbers of sets of 50 data points, working both from upstream to downstream (blue) and downstream to upstream (red). The pattern of convergence as described in the accompanying supporting text is noted above each graph. See accompanying text for full explanation.

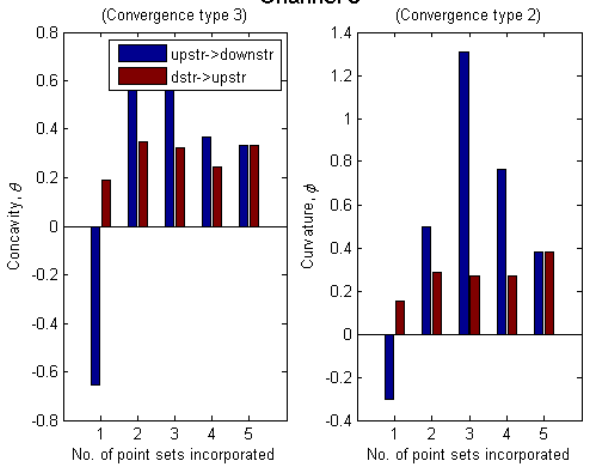
Channel 1



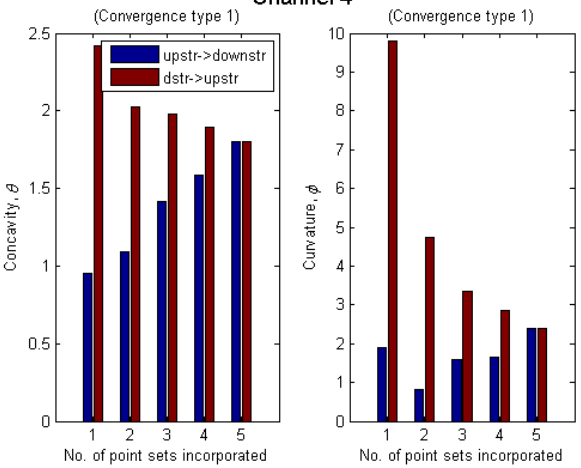
Channel 2



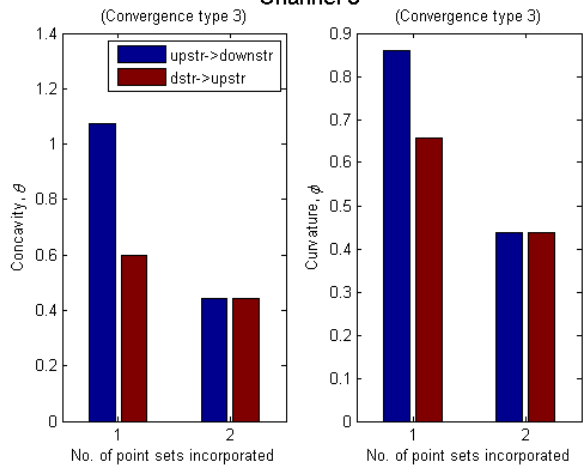
Channel 3



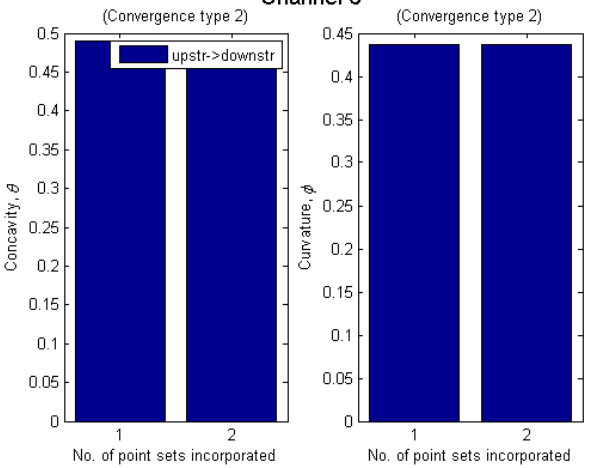
Channel 4



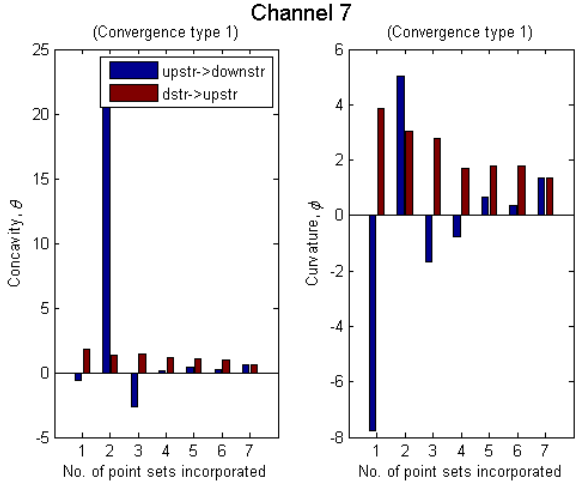
Channel 5



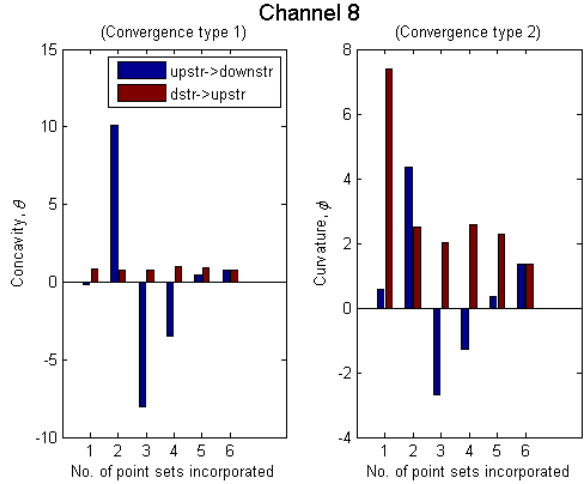
Channel 6



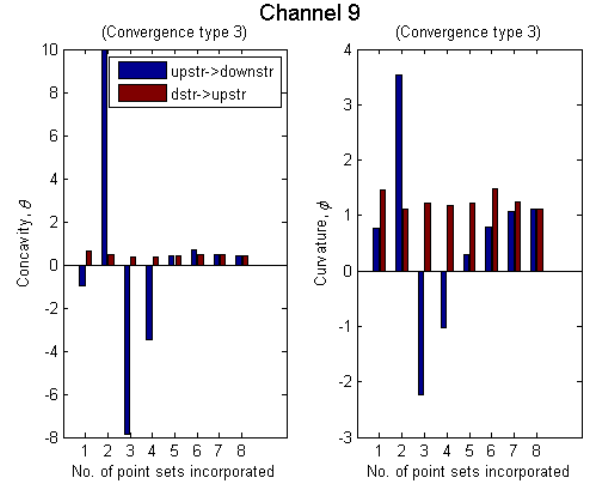
Channel 7

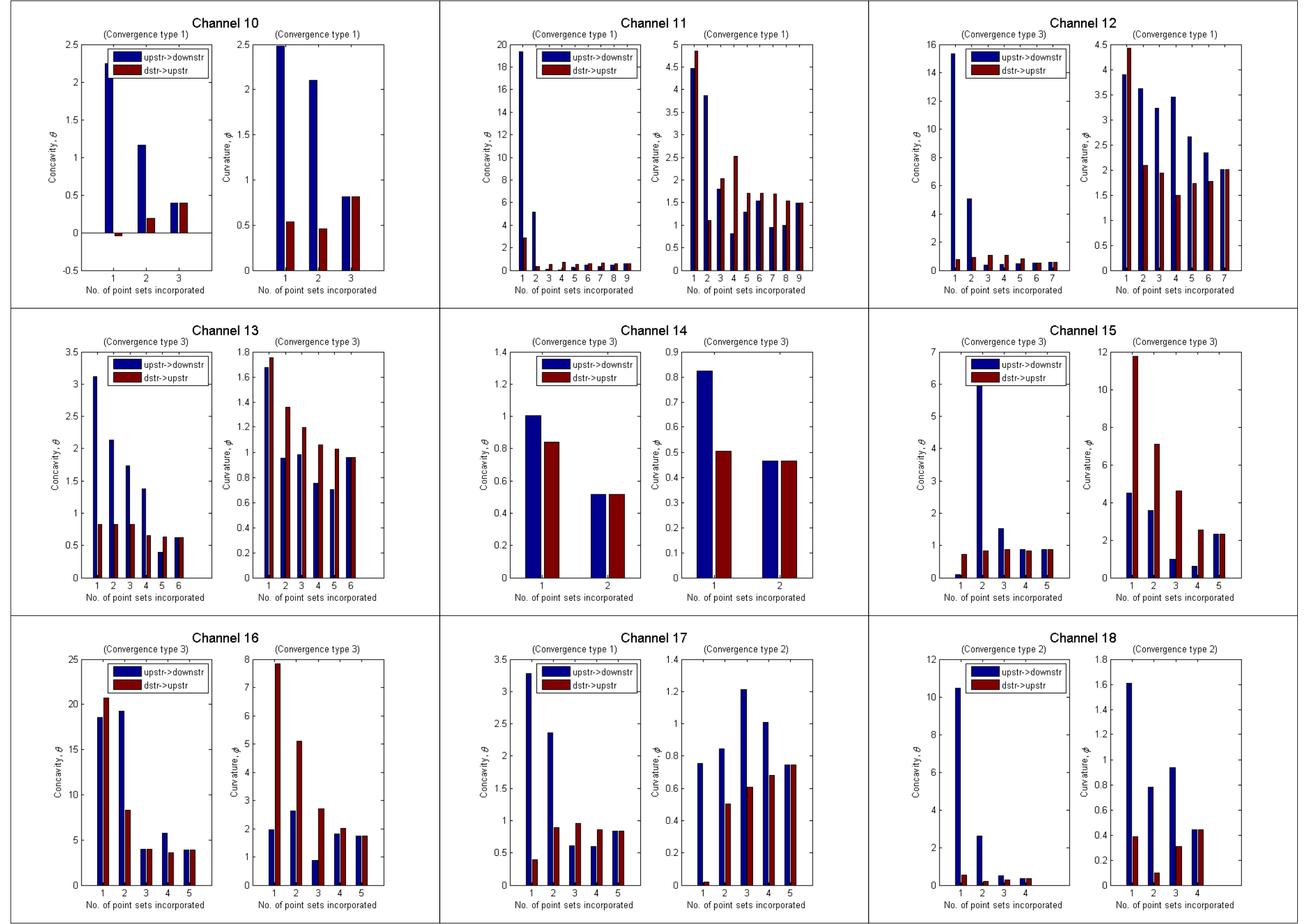


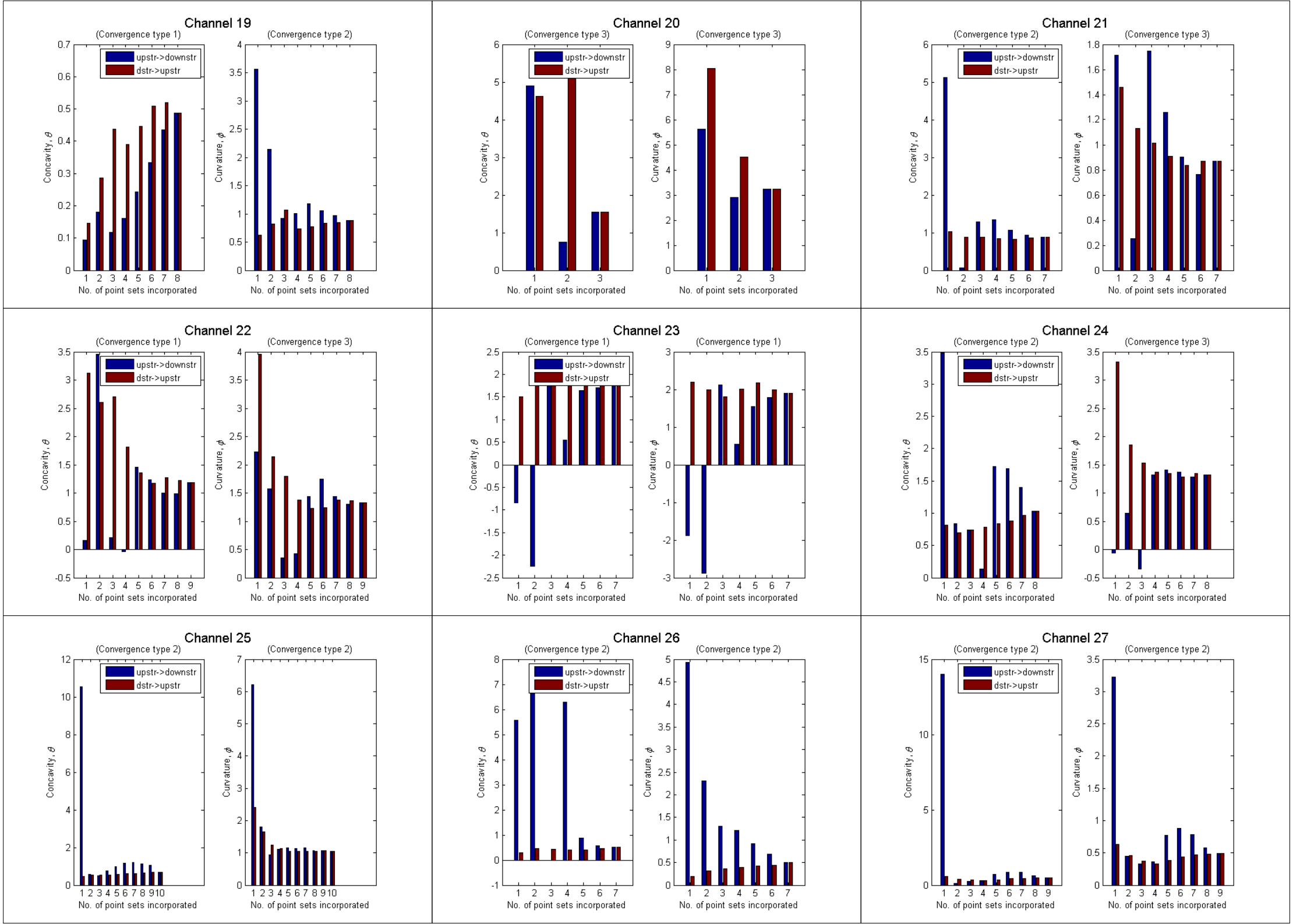
Channel 8

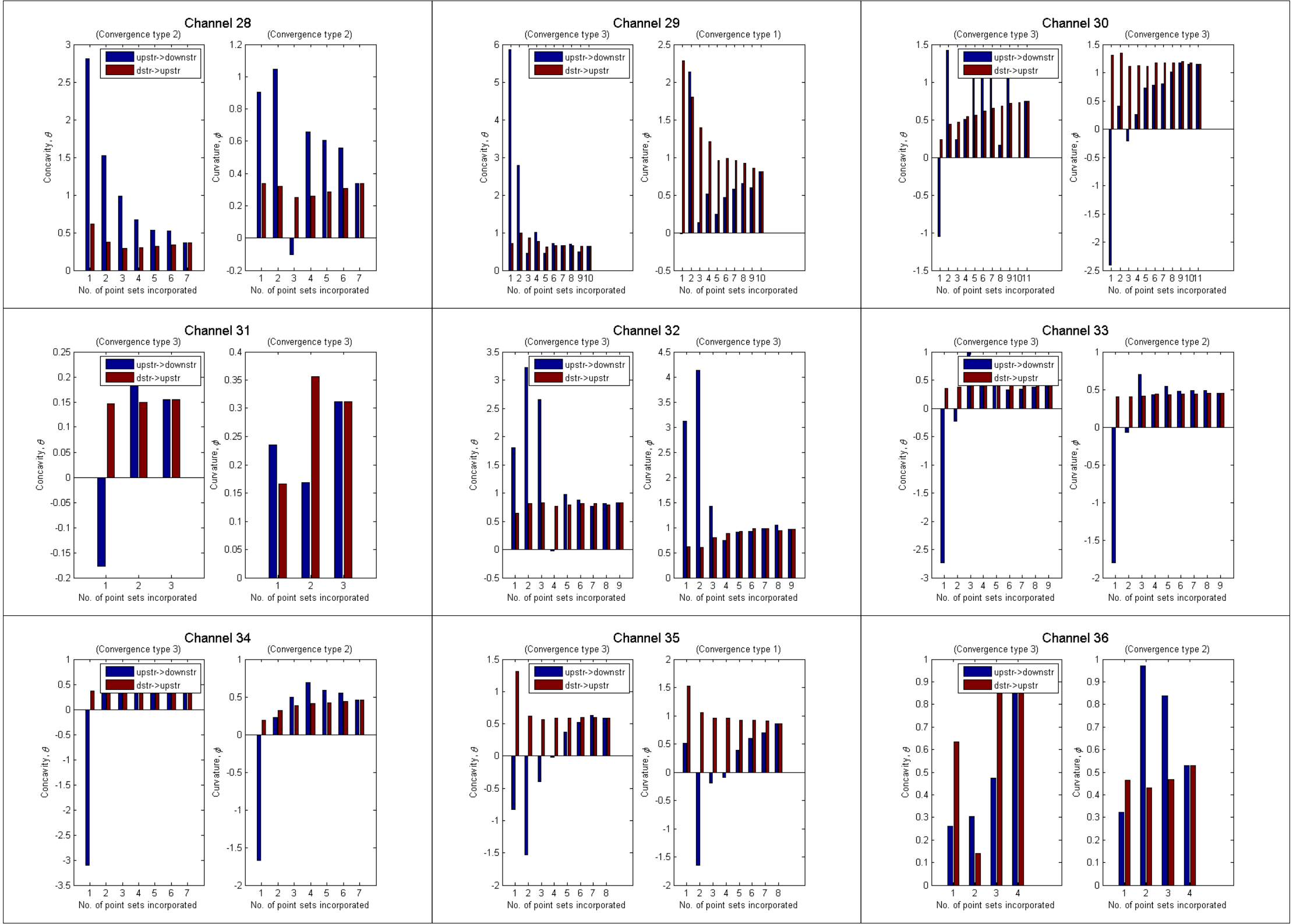


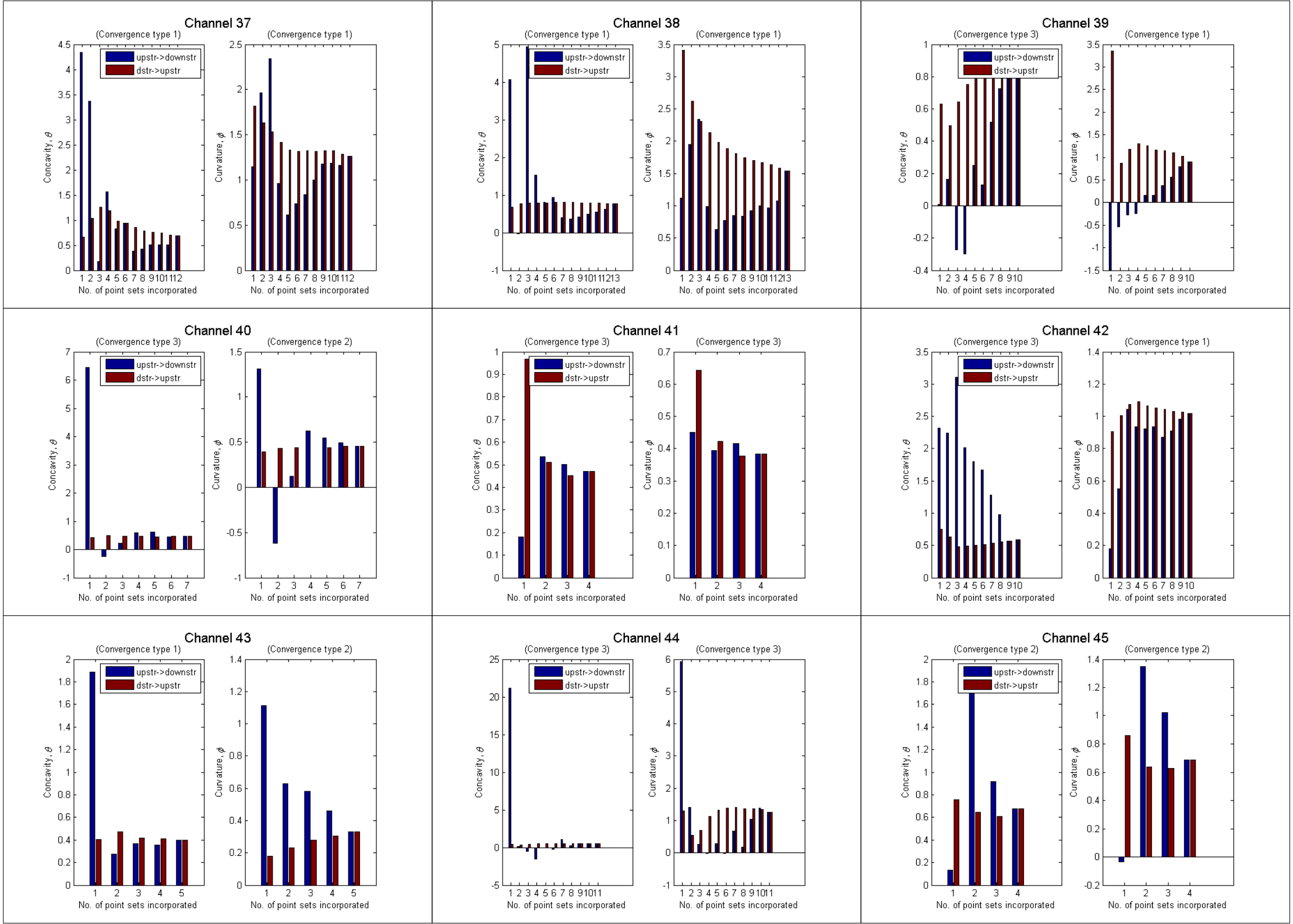
Channel 9

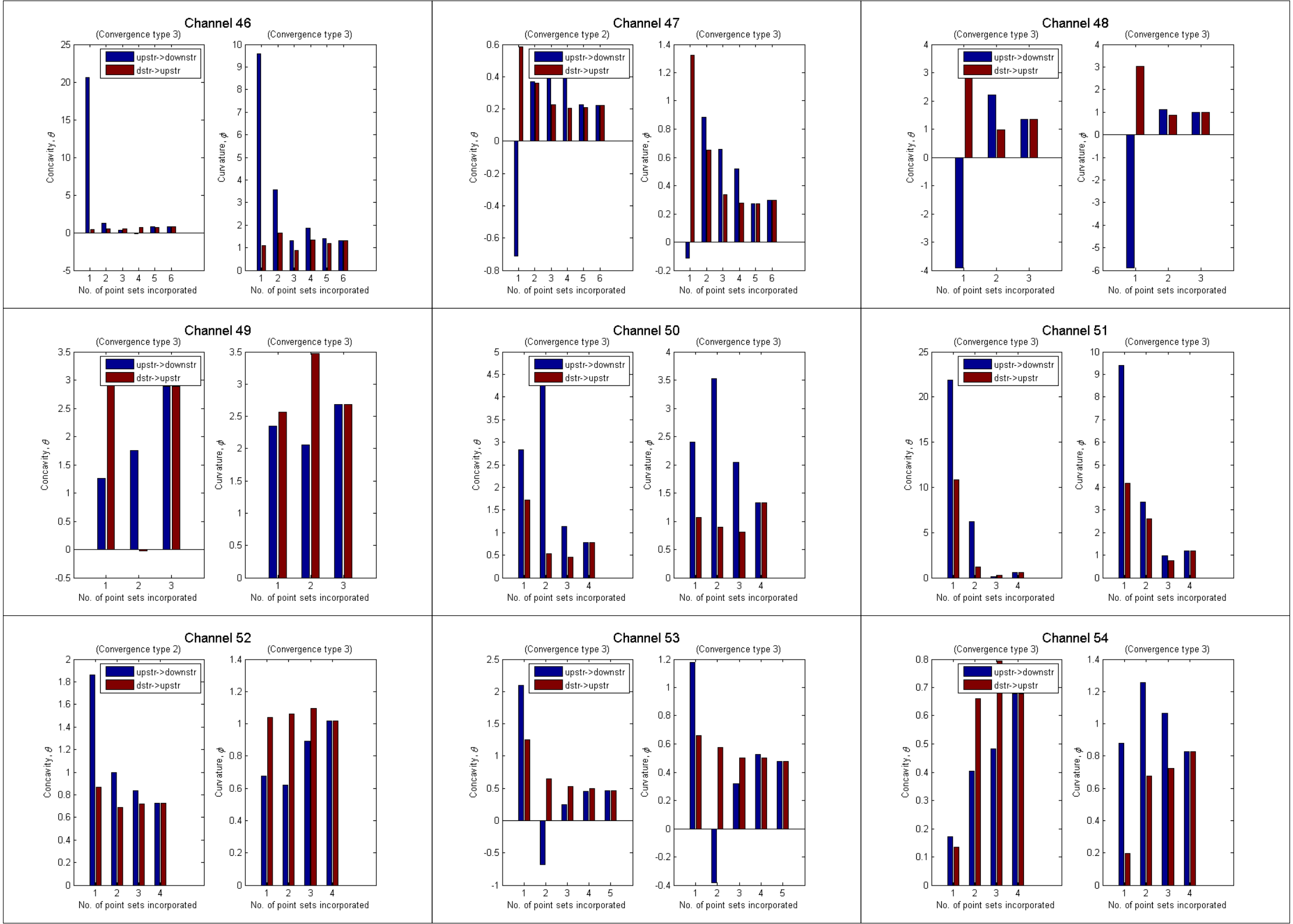


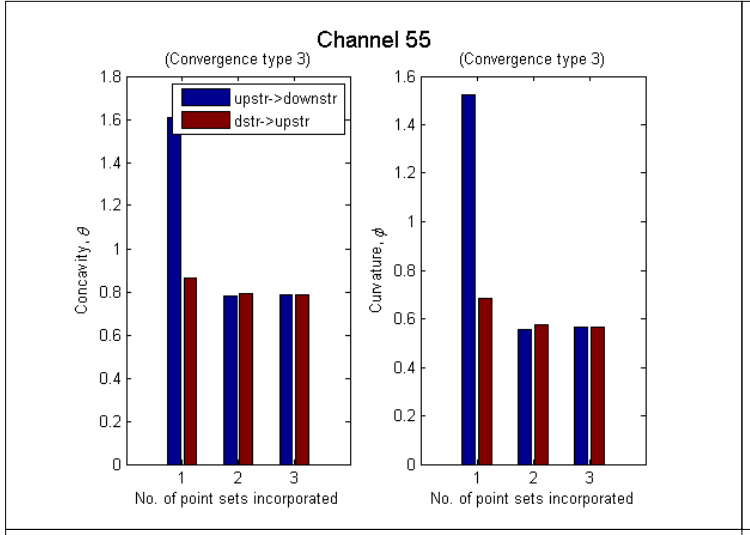

Channel 10
(Convergence type 1)
(Convergence type 1)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 11
(Convergence type 1)
(Convergence type 1)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 12
(Convergence type 3)
(Convergence type 1)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 13
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 14
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 15
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 16
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 17
(Convergence type 1)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 18
(Convergence type 2)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated

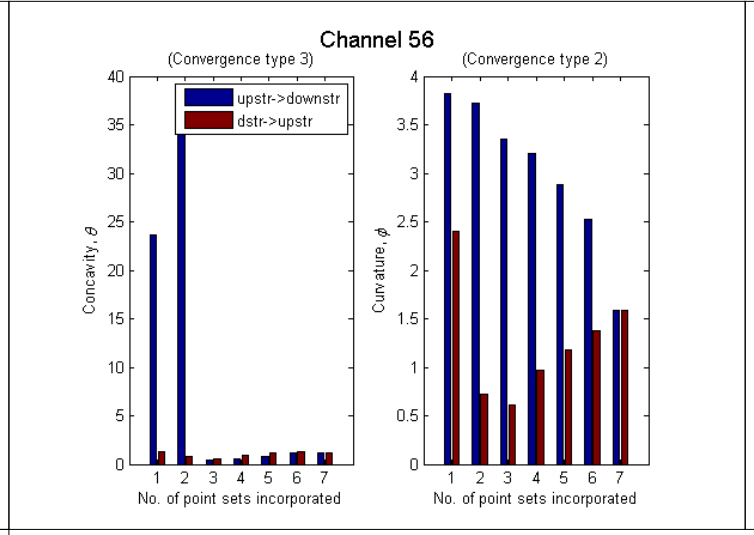

Channel 19
(Convergence type 1)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
Channel 20
(Convergence type 3)
(Convergence type 3)
Channel 21
(Convergence type 2)
(Convergence type 3)
Channel 22
(Convergence type 1)
(Convergence type 3)
Channel 23
(Convergence type 1)
(Convergence type 1)
Channel 24
(Convergence type 2)
(Convergence type 3)
Channel 25
(Convergence type 2)
(Convergence type 2)
Channel 26
(Convergence type 2)
(Convergence type 2)
Channel 27
(Convergence type 2)
(Convergence type 2)

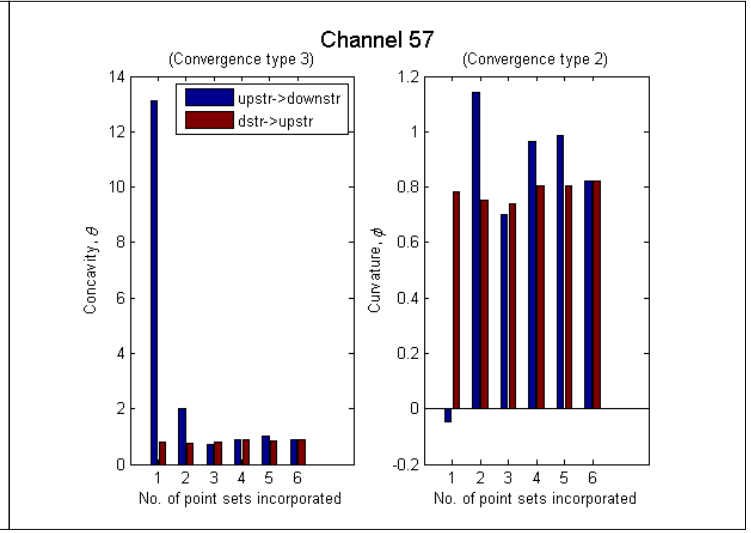

Channel 28
(Convergence type 2)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 29
(Convergence type 3)
(Convergence type 1)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 30
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 31
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 32
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 33
(Convergence type 3)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 34
(Convergence type 3)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 35
(Convergence type 3)
(Convergence type 1)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 36
(Convergence type 3)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated


Channel 37
(Convergence type 1)
(Convergence type 1)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
Channel 38
(Convergence type 1)
(Convergence type 1)
Channel 39
(Convergence type 3)
(Convergence type 1)
Channel 40
(Convergence type 3)
(Convergence type 2)
Channel 41
(Convergence type 3)
(Convergence type 3)
Channel 42
(Convergence type 3)
(Convergence type 1)
Channel 43
(Convergence type 1)
(Convergence type 2)
Channel 44
(Convergence type 3)
(Convergence type 3)
Channel 45
(Convergence type 2)
(Convergence type 2)


Channel 46
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 47
(Convergence type 2)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 48
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 49
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 50
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 51
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 52
(Convergence type 2)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 53
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated
Channel 54
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated


Channel 55
(Convergence type 3)
(Convergence type 3)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated


Channel 56
(Convergence type 3)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated


Channel 57
(Convergence type 3)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated

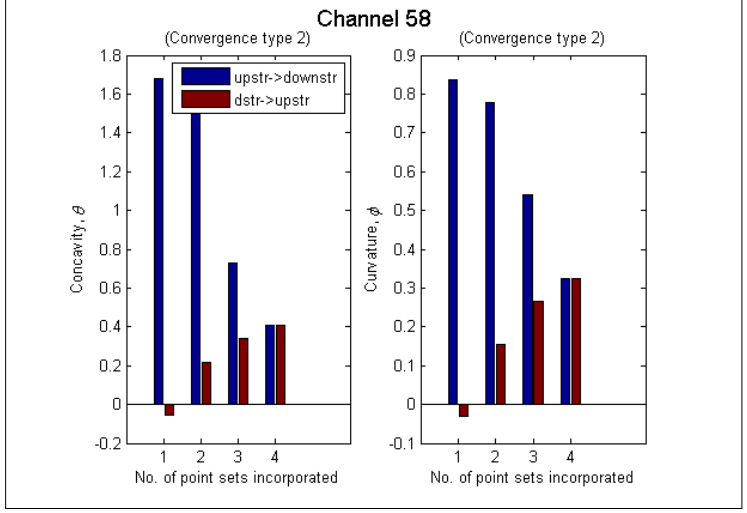

Channel 58
(Convergence type 2)
(Convergence type 2)
upstr->downstr
dstr->upstr
Concavity, θ
Curvature, ϕ
No. of point sets incorporated
No. of point sets incorporated

TABLE S1. DATA EXTRACTED FROM DEM FOR REACHES DOWNSTREAM OF KNICKZONES

Channel number	Area upstream of knickzone, A_{PC} (m^2)	Total area, A_{tot} (m^2)	Downstream distance of knickzone, x_{PC} (m)	Total channel length, x_{tot} (m)	A_{PC}/A_{tot}	x_{PC}/x_{tot}	k_θ	θ	Error on θ	k_ϕ	ϕ	Error on ϕ
1	6.60E+07	7.44E+07	15749	18633	0.887	0.845	7.04E+42	5.57	0.76	6.64E+13	3.48	0.52
2	3.26E+06	3.32E+07	779	7451	0.098	0.105	4.93E+01	0.34	0.07	4.66E+00	0.40	0.08
3	1.99E+06	3.73E+07	695	8804	0.053	0.079	4.11E+01	0.33	0.02	4.16E+00	0.38	0.03
4	7.17E+07	1.19E+08	13852	20710	0.600	0.669	2.68E+13	1.80	0.11	1.45E+09	2.40	0.17
5	2.88E+06	1.02E+07	878	3947	0.283	0.223	2.00E+02	0.44	0.07	5.46E+00	0.44	0.05
6	2.94E+06	9.07E+06	607	3036	0.325	0.200	3.98E+02	0.49	0.08	5.12E+00	0.44	0.06
7	1.41E+07	1.66E+08	4478	15142	0.085	0.296	5.76E+03	0.60	0.05	3.01E+04	1.36	0.13
8	5.33E+07	1.65E+08	10767	19692	0.322	0.547	1.44E+05	0.76	0.12	5.11E+04	1.36	0.22
9	2.05E+07	1.65E+08	5503	16546	0.124	0.333	3.32E+02	0.43	0.04	3.58E+03	1.11	0.08
10	3.06E+06	2.71E+07	1556	6024	0.113	0.258	1.37E+02	0.39	0.07	1.81E+02	0.82	0.11
11	4.63E+07	2.72E+08	11423	24730	0.170	0.462	5.09E+03	0.59	0.04	1.72E+05	1.50	0.10
12	5.01E+07	2.71E+08	13600	23642	0.185	0.575	5.13E+03	0.59	0.03	3.19E+07	2.01	0.11
13	6.51E+06	5.30E+07	2846	12300	0.123	0.231	5.26E+03	0.62	0.03	5.86E+02	0.96	0.04
14	3.20E+06	1.49E+07	683	4668	0.215	0.146	6.30E+02	0.52	0.04	6.62E+00	0.47	0.03
15	3.86E+07	1.18E+08	13411	20417	0.327	0.657	1.03E+06	0.88	0.09	6.41E+08	2.33	0.25
16	1.63E+08	1.83E+08	22297	30193	0.891	0.738	7.02E+30	3.88	0.53	2.98E+06	1.73	0.22
17	2.77E+06	2.75E+07	913	8629	0.101	0.106	9.61E+04	0.83	0.04	6.29E+01	0.74	0.05
18	4.98E+06	2.75E+07	1442	7324	0.181	0.197	3.24E+01	0.36	0.05	3.31E+00	0.44	0.07
19	4.67E+06	1.65E+08	2894	14724	0.028	0.197	5.60E+02	0.49	0.05	3.32E+02	0.88	0.10
20	1.12E+08	1.65E+08	17836	23187	0.676	0.769	3.48E+11	1.55	0.14	6.61E+12	3.22	0.17
21	5.73E+06	4.00E+07	1538	11648	0.143	0.132	3.31E+05	0.88	0.03	2.31E+02	0.87	0.03
22	2.91E+07	7.28E+07	8501	21593	0.399	0.394	1.31E+08	1.19	0.05	3.30E+04	1.33	0.05
23	3.90E+07	7.74E+07	10854	21138	0.503	0.513	1.90E+13	1.85	0.13	7.04E+06	1.89	0.13
24	3.35E+07	8.67E+07	9525	21821	0.386	0.437	1.06E+07	1.03	0.05	3.48E+04	1.32	0.04
25	1.08E+07	8.84E+07	5503	20265	0.122	0.272	2.08E+04	0.70	0.03	1.68E+03	1.05	0.03
26	2.62E+06	1.82E+07	949	11309	0.144	0.084	4.43E+02	0.53	0.04	6.12E+00	0.49	0.03
27	4.96E+06	5.13E+07	1152	13624	0.097	0.085	3.47E+02	0.48	0.02	6.98E+00	0.49	0.02
28	3.04E+06	3.40E+07	576	11451	0.089	0.050	4.04E+01	0.36	0.02	1.72E+00	0.34	0.02
29	1.25E+07	7.12E+07	5503	19999	0.176	0.275	7.10E+03	0.64	0.04	2.03E+02	0.81	0.05
30	2.00E+07	1.17E+08	6831	22921	0.171	0.298	5.87E+04	0.75	0.03	4.36E+03	1.14	0.03
31	6.73E+06	4.19E+07	3188	7780	0.161	0.410	1.83E+00	0.15	0.03	1.93E+00	0.31	0.06
32	1.78E+07	6.96E+07	4858	17457	0.255	0.278	1.92E+05	0.83	0.03	7.18E+02	0.97	0.03
33	2.40E+06	6.37E+07	646	13206	0.038	0.049	1.02E+02	0.41	0.01	4.72E+00	0.45	0.01
34	2.45E+06	2.61E+07	607	11613	0.094	0.052	1.05E+03	0.56	0.01	5.47E+00	0.46	0.01
35	4.04E+06	5.48E+07	1784	13624	0.074	0.131	2.03E+03	0.59	0.02	1.78E+02	0.86	0.03
36	2.71E+06	2.09E+07	607	6983	0.130	0.087	9.66E+04	0.90	0.06	5.24E+00	0.53	0.03
37	1.50E+07	1.92E+08	5313	23070	0.078	0.230	1.54E+04	0.69	0.02	8.14E+03	1.26	0.03
38	1.05E+07	1.91E+08	4802	23984	0.055	0.200	5.81E+04	0.76	0.02	1.06E+05	1.54	0.04
39	3.34E+07	1.19E+08	8368	22542	0.280	0.371	1.38E+05	0.80	0.05	3.36E+02	0.90	0.05
40	3.09E+06	3.91E+07	645	11385	0.079	0.057	3.14E+02	0.48	0.02	5.21E+00	0.46	0.01
41	2.38E+06	1.30E+07	607	6186	0.183	0.098	2.01E+02	0.47	0.03	2.56E+00	0.38	0.02
42	1.01E+07	8.12E+07	3545	17419	0.124	0.204	3.09E+03	0.59	0.02	1.04E+03	1.02	0.02
43	4.39E+06	2.99E+07	645	7623	0.147	0.085	1.03E+02	0.40	0.02	2.34E+00	0.33	0.02
44	1.62E+07	2.36E+08	6224	22119	0.069	0.281	9.69E+02	0.51	0.03	1.18E+04	1.25	0.08
45	3.89E+06	2.26E+07	1152	6777	0.172	0.170	1.05E+04	0.67	0.05	4.62E+01	0.68	0.05
46	8.36E+07	1.98E+08	15066	23632	0.422	0.638	1.43E+05	0.76	0.09	3.90E+04	1.32	0.12
47	3.17E+06	4.06E+07	1366	9863	0.078	0.139	6.33E+00	0.22	0.02	1.93E+00	0.30	0.03
48	6.24E+07	7.42E+07	15787	20531	0.842	0.769	4.25E+09	1.35	0.31	1.73E+03	0.98	0.23
49	4.27E+07	5.36E+07	15104	19274	0.797	0.784	1.67E+21	2.89	0.30	2.22E+10	2.68	0.25
50	1.97E+07	4.14E+07	7780	13890	0.476	0.560	7.30E+04	0.77	0.09	2.52E+04	1.32	0.13
51	1.04E+08	1.66E+08	14914	21441	0.627	0.696	2.49E+03	0.55	0.15	8.21E+03	1.18	0.24
52	4.64E+06	2.05E+07	2391	8349	0.226	0.286	2.46E+04	0.72	0.03	1.04E+03	1.02	0.04
53	3.06E+06	2.36E+07	607	8349	0.129	0.073	1.56E+02	0.46	0.03	4.61E+00	0.48	0.03
54	5.51E+06	3.18E+07	2353	8652	0.173	0.272	8.84E+03	0.68	0.03	1.50E+02	0.83	0.03
55	2.13E+06	7.70E+06	645	4744	0.276	0.136	2.18E+04	0.78	0.04	9.96E+00	0.57	0.03
56	2.12E+07	1.25E+08	6831	17571	0.170	0.389	3.98E+07	1.14	0.05	2.25E+05	1.58	0.09
57	3.27E+06	1.61E+07	1670	10552	0.203	0.158	1.54E+05	0.87	0.03	1.56E+02	0.82	0.02
58	3.80E+06	2.23E+07	576	7438	0.170	0.077	9.72E+01	0.41	0.03	1.67E+00	0.33	0.02

DR2010074

Text supporting supplementary material for the paper: "Processes, rates and timescales of fluvial response in an ancient post-glacial landscape of the northwest Indian Himalaya", *GSA Bulletin*

Daniel E. J. Hobley – Email dan.hobley@ed.ac.uk

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This document provides additional text supporting data which was too substantial to be included concisely within the print version of the manuscript. This comprises: -

1. Details of methodology for processing of the raw DEM data.
2. Text supporting presentation of all remotely sensed stream long profiles and scaling data used to derive the data shown in Figs. 7 and 8 in the main manuscript, and associated location information (Figs. S1a,b).
3. Text supporting figures showing a comparison of channel slopes derived from the DEM versus known field measurements of slope for two catchments on the batholith (Figs. S2a,b).
4. Text supporting figures (Fig. S3) illustrating values of concavity and curvature calculated for separate segments of each stream, used to investigate whether the measured values are systematically different for the lower part of domain 2 compared to domain 3.

This follows below.

1. METHODOLOGY FOR ACQUISITION AND TREATMENT OF DEM

We have taken three arc-second resolution data freely available from NASA (ftp://e0srp01u.ecs.nasa.gov/srtm/version2/SRTM3/), derived from the Shuttle Radar Topography Mission (SRTM). Raw data was converted to ARCinfo GRID format for processing using IMAGEGRID.aml, developed by the United States Geological Survey (ftp://e0srp01u.ecs.nasa.gov/srtm/version2/Documentation/Notes_for_ARCInfo_users.pdf). The data used here comprises one degree by one degree squares N33E077, N33E078, N34E076, N34E077 and N34E078 (see Fig. 1). The data for this region is in fact well suited to DEM analysis, since the glaciers have widened and flattened the valley floors over much of the rivers' courses, meaning artifacts produced by the satellite's footprint catching the valley sides as well as the channel in the valley centre are much reduced. Minor holes in the data (<2% of pixels in analyzed catchments, and rarely impinging on valley bottoms) were patched by converting the whole dataset into a point dataset then using ARCinfo to interpolate back into GRID form using a cubic spline algorithm. This process provided the base DEM on which subsequent analysis was carried out.

The base DEM was first filled to remove artificial internally draining patches – the affected area comprises <1% of the total surface, almost entirely confined to regions of the Indus valley itself and not significantly changing the profiles of the tributaries. The drainage network was then predicted from a flow accumulation threshold of 200

pixels (a drainage area of approximately 1.4×10^6 m^2). This relatively high value was chosen to avoid the prediction of channels beneath the existing glaciers and recent moraine successions in the highest elevations of the catchments, and creates a channel network that agrees well with the known channel forms seen in satellite imagery. The trunk streams for each of the 70 independent basins draining southwards into the Indus were then selected, taking more than one profile per valley if a major bifurcation of the trunk stream was present, and elevation, z, upstream drainage area, A, and distance downstream, x, data extracted for each pixel along the course of each trunk stream. MATLAB was then used first to smooth out high frequency noise in the elevation data with a low-pass filter on z, then to construct a value of channel slope, S, on a reach length scale of 500 m. Both these methods act to damp local (< 500 m) variation in channel slope, whether an artifact of the DEM or due to fine scale river responses. This scaling is appropriate since we only sampled local slope and channel form in the field once every 300 – 500 m, and variability on a finer scale than this will not be revealed by the data. These methods and smoothing techniques correspond broadly to those chosen by Snyder et al. (2003a) and recommended by Wobus et al. (2006), though with different absolute values chosen appropriate to the coarser resolution of our DEM data.

2. LONG PROFILES AND SCALING PLOTS FOR ALL ANALYZED CATCHMENTS (FIGS. S1a,b)

An altered version of Fig. 1 is presented as Fig. S1a in order to illustrate which catchments provide acceptable slope-distance (curvature) and slope-area (concavity)

regressions, as described in the Remotely Sensed Data section of the main manuscript. Those which do are colored blue. Channels are numbered consecutively as they appear along the batholith going from west to east. Note that several catchments have more than one trunk stream, and these channels are each allocated their own number. The channels in question are 2/3, 7/8/9, 11/12, 17/18, 19/20/21 and 37/38, and the associated catchments are shown in a lighter blue in the Figure. Fig. S1b illustrates the long profile (z-x) and drainage structure (A-x) of each of these channels, along with associated slope plots S-x and S-A, plotted on logarithmic axes. The grayscale lines show the slope scaling relations fitted to these latter two plots by the method described in the main text, and the range of values over which the fit is made. The associated equations are also shown above these figures. The file TableS1.pdf collates all of these data, and is the source for Figs. 7 and 8 in the main text.

3. FIELD-DEM SLOPE COMPARISONS (FIGS. S2a,b)

Figure S2a shows plots of channel slope, S, versus distance downstream, x, for the valleys Basgo (i) and Leh (ii). DEM-derived slopes (see section 1 of this document) are shown as grey open circles and direct field measurements over 30 m intervals, every c. 500 m are shown as black closed squares. Figure S2b displays this same data as a direct comparison for each catchment. Quoted errors on the lines of best fit are 95% confidence intervals, assuming direct linear correlation. Note that neither gradient is distinguishable from 1, but that there is a tendency for the DEM values to be slightly higher. This is probably an artifact of the different scales over which the gradient is averaged (500 m vs 30 m), especially in domain 1, where slope can be

highly variable on a scale less than 500 m. This is particularly clear in Fig. S2a. For the same reason, we note that the fit for Leh is poorer, since a larger proportion of these data points come from within domain 1.

4. VARIATION OF SCALING METRICS BETWEEN DOMAINS (FIG. S3)

As noted in the main text, the data presented here does not extend across enough variation in drainage area to conclusively calculate the scaling metrics of concavity and curvature for the bottom of domain 2 and domain 3 separately. However, in order to investigate this issue further, we present here a semi-quantitative method examining the convergence towards the whole channel values as progressively larger proportions of the channel are included. We plot calculated concavity and curvature values for each channel over the first 50, 100, 150, 200, etc. points downstream of the knickzone up to the end of the whole analyzed segment, then similarly plot the data in sections 50, 100, 150, etc. points long going from the downstream end of the channel up to the knickzone. This data is then displayed graphically on the same chart, where the fits established for the first 50 points (upper- and lower-most stream sections of the channel) are displayed to the left and the fits incorporating all of the data to the right. We then examine the manner in which the data converges to the right-hand side of the graph. The measured values are clearly quite variable where fewer data points are used, but as more data is incorporated, the variability in the values tends to stabilize. We recognize three patterns in these tails as the final elements of data are incorporated: -

1. Magnitude of concavity (or curvature) becomes gradually greater as data is incorporated towards the downstream end of the channel (blue bars), and gradually smaller as data is incorporated towards the upstream end of the channel (red bars). This suggests that the scaling exponents are uniformly lower in the upstream reaches of the channel than in the downstream reaches.
2. Magnitude of concavity (or curvature) becomes gradually lesser as data is incorporated towards the downstream end of the channel (blue), and gradually greater as data is incorporated towards the upstream end of the channel (red). This suggests that the scaling exponents are uniformly greater in the upstream reaches of the channel than in downstream reaches.
3. Neither of the above is the case, with no trends in the scaling metrics, or with trends in the same direction incorporating data going both upstream and downstream in the catchment. This category also includes catchments with few points in total (<200). We interpret this to indicate that there is no demonstrable systematic difference in concavity (or curvature) in the upstream reaches versus the downstream reaches of the channel as a whole.

The pattern we assign for the concavity and curvature of each channel is noted above each graph as 1, 2 or 3. Note that we ignore the first three data points (50-150 data points) entirely, where random noise will certainly overwhelm any signal. This method is, at best, limited, but provides at least some indication of the variability of the scaling values quoted in the main text, and also avoids having to pre-allocate domain boundaries for all of the catchments, which are not always easy to accurately fix from the satellite imagery.

We find that for both the concavity and curvature, very many channels (34 out of 58 for θ; 27 out of 58 for ϕ) show no uniform tendency for a changing value downstream. The remainder are split between a tendency for increase and a tendency for decrease downstream for both metrics (12 type 1, 12 type 2 for θ; 12 type 1, 19 type 2 for ϕ). We interpret this to mean that there is no tendency for upstream reaches to have uniformly higher or lower scaling exponents to downstream reaches, including across the boundary of domain 2 into domain 3, as discussed in the main text.