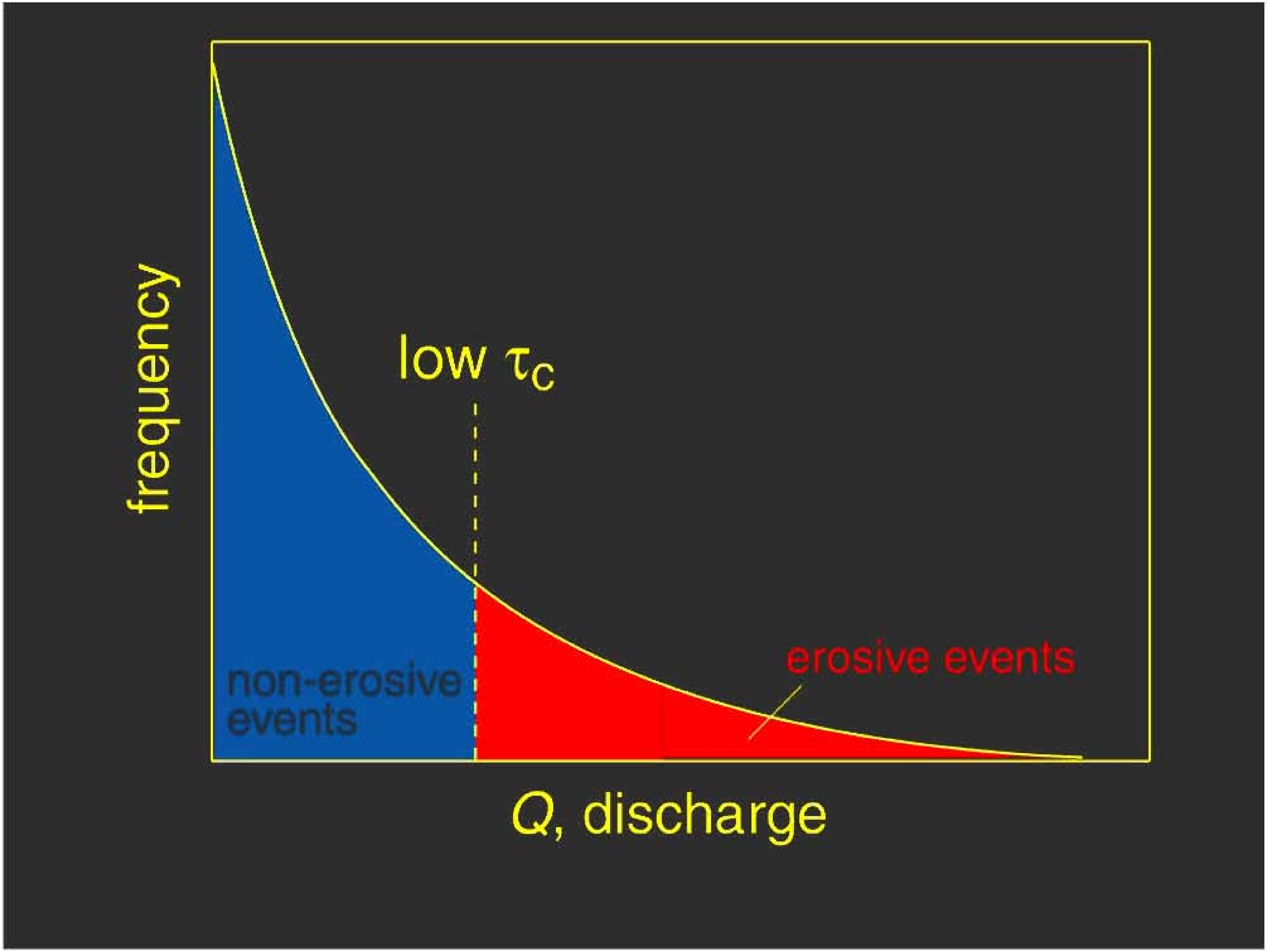
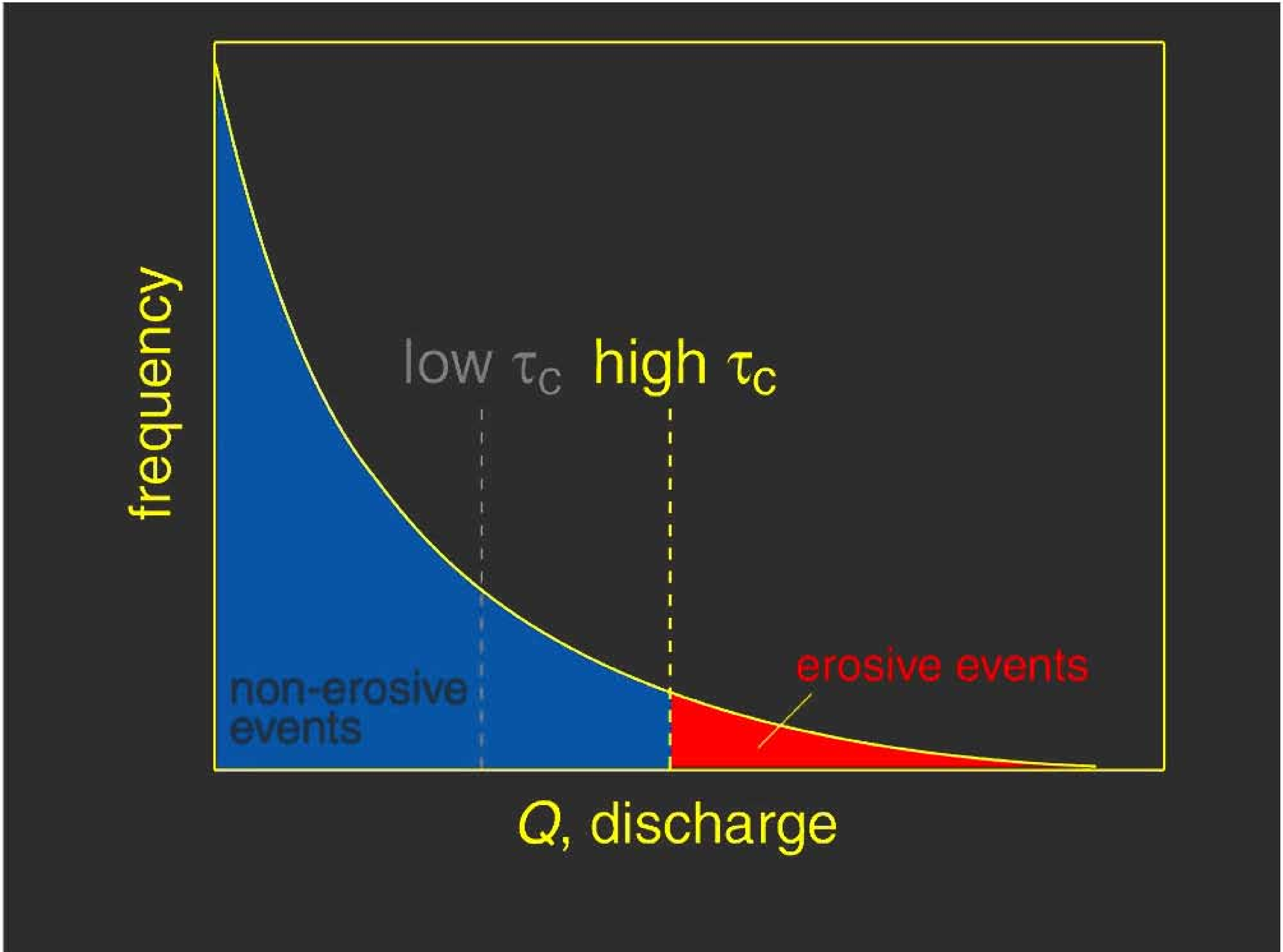
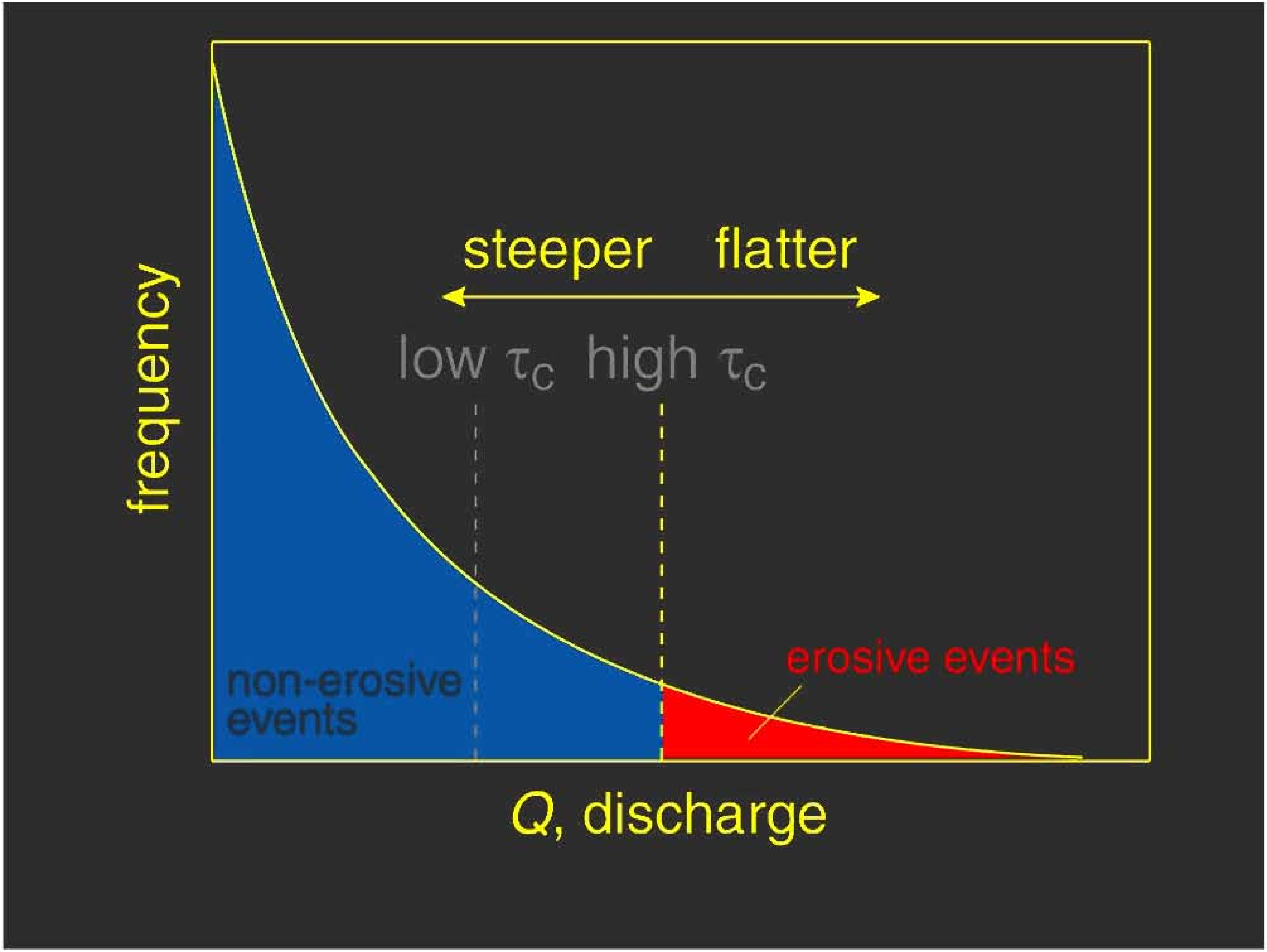
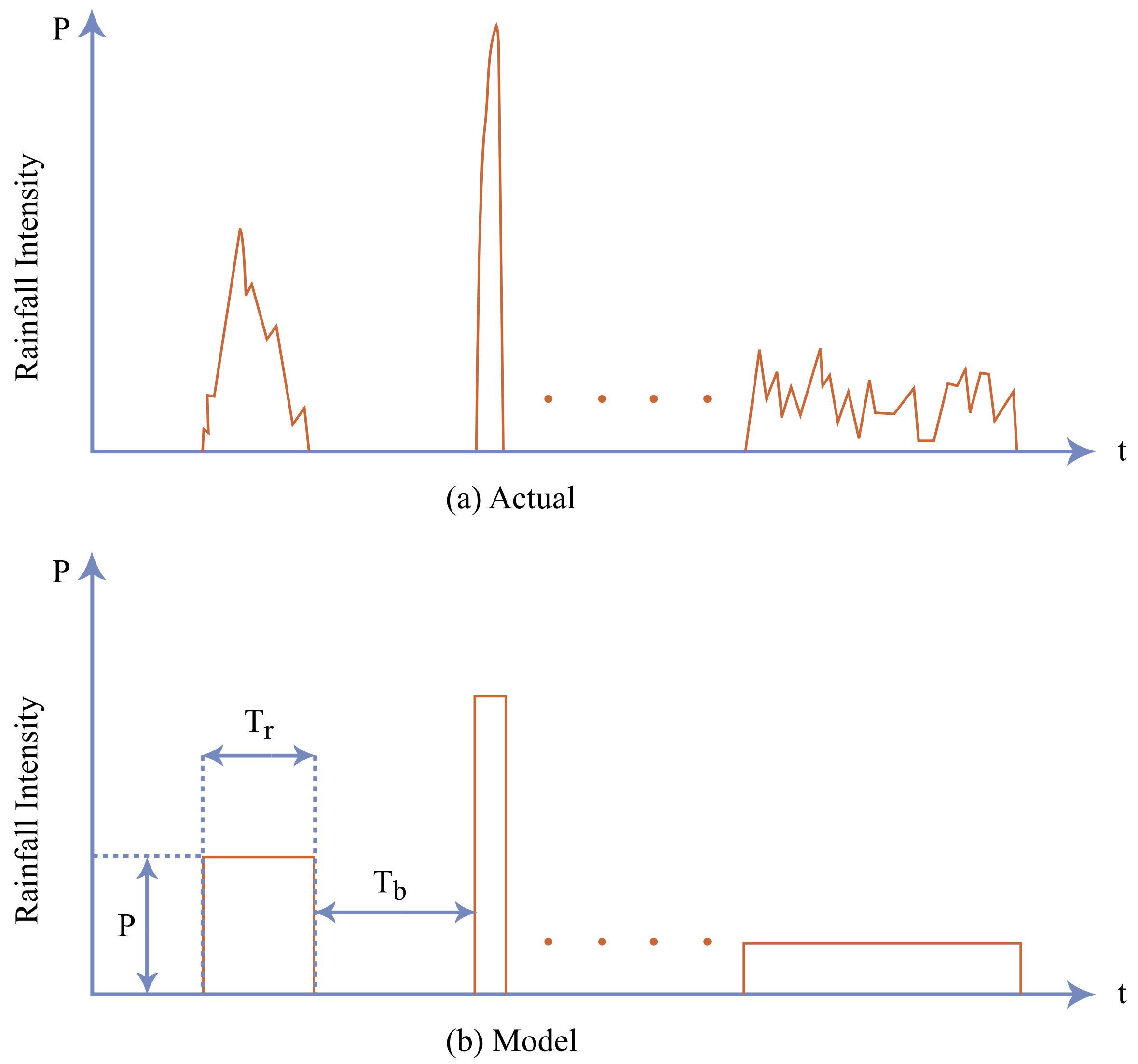

frequency
low τ_c
non-erosive
events
erosive events
Q, discharge



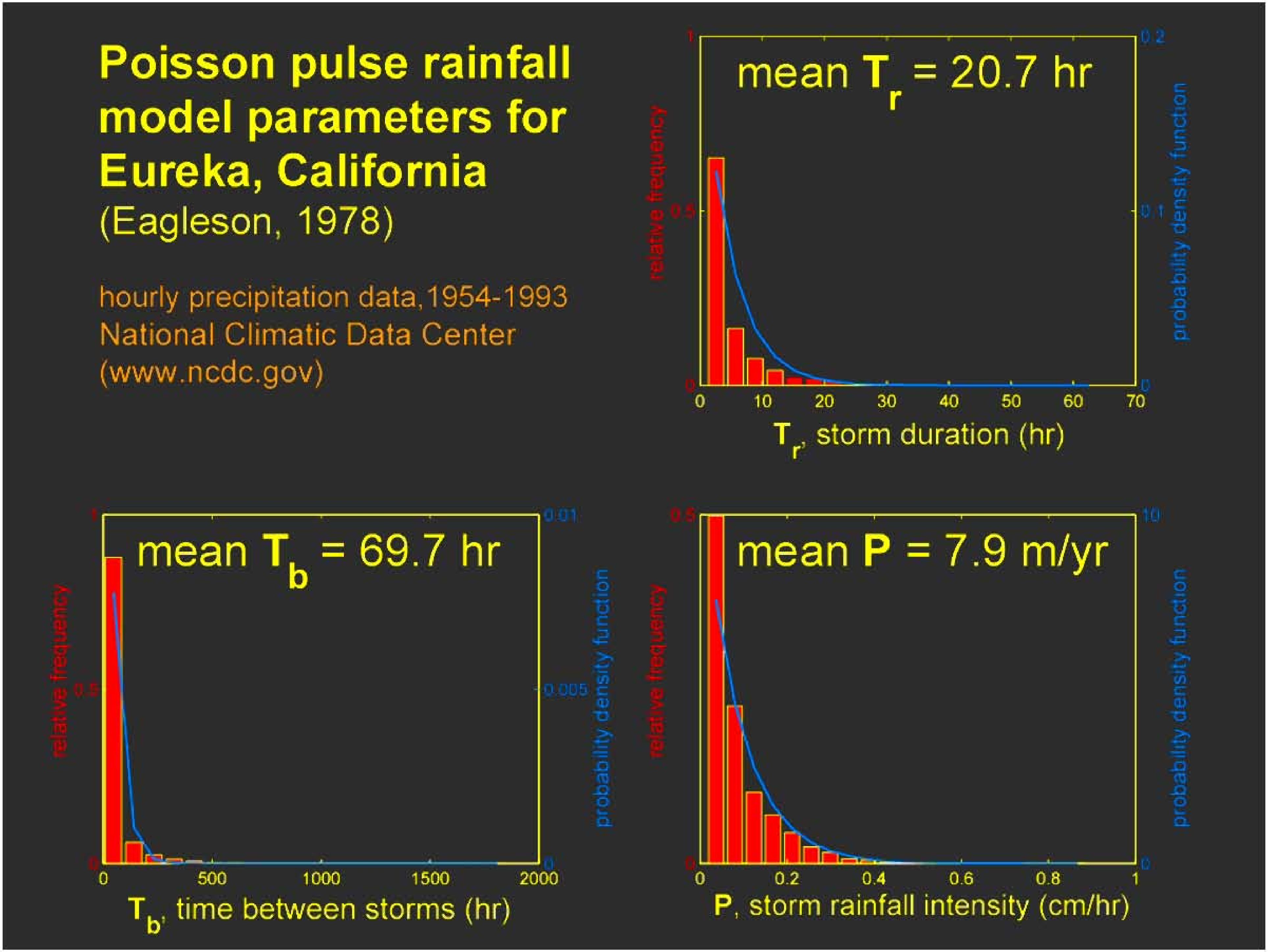
frequency
low τ_c
high τ_c
non-erosive events
erosive events
Q, discharge



steeper
flatter
low τ_c
high τ_c
frequency
non-erosive events
erosive events
Q, discharge



Schematic Illustration of Poisson Rectangular Pulse Rainfall Model



- Tucker & Bras used the Poisson pulse rainfall model of Eagleson (1978).
- Parameterizes climate using exponential distributions of storm duration, interstorm duration, and rainfall intensity.
- This distributions can be derived from hourly precipitation data, a resource readily downloaded for hundreds of stations in the U.S. from the NCDC website.

Stochastic-threshold incision model

(Tucker & Bras, 2000)

$$\mathbf{E = K_R K_C K_{\tau c} A^m S^n}$$

- $\mathbf{K_R}$=$\mathbf{K_R}$(physical parameters, ρ, **g**, $\mathbf{k_e}$, width, lithology)
- $\mathbf{K_C}$=$\mathbf{K_C}$ (climate parameters, **P**, $\mathbf{T_r}$, $\mathbf{T_b}$)
- $\mathbf{K_{\tau c}}$=$\mathbf{K_{\tau c}}$ ($\mathbf{R_c}$/**P**$\propto\tau_c$/**P**, **A**, **S**; varies from 0 to 1)
- Key unknown parameters: τ_c, $\mathbf{k_e}$, and **a** (or **n**)
  - From the basic postulate, $\mathbf{E=k_e(\tau_b^a-\tau_c^a)}$

The Tucker & Bras approach can be simplified to this form. Incision rate set by area and slope, and three coefficients.

- KR, typical parameters
- KC, the climate parameters from the Eagleson model.
- Ktc, A critical runoff set by the Tc/P and also dependent on A and S in a complicated way.

Bedrock Channel Incision Models

Basic Postulate

$$E = k_e\left(\tau - \tau_{cr}\right)^a \quad \text{or} \quad E = k_e\left(\tau^a - \tau_{cr}^a\right)$$

$$E = K_{eff} A^m S^n$$

$$K_{eff} = K_r K_c \beta_{\tau_{cr}} \;:\; n = \frac{2}{3}a \;:\; m = \frac{2}{3}ac\left(1-b\right)$$

Stream Power Model

$$K_r = k_e k_w^{-2a/3} k_t^a$$

$$K_c = k_q^{2a/3(1-b)}$$

$$\beta_{\tau_{cr}} = 1$$

Empirical Relations

$$k_t = C_f^{1/3} \rho g^{2/3}$$

$$Q_r = k_q A^c$$

$$w_{bf} = k_w Q_{bf}^b$$

$$\left(w/w_{bf}\right) = \left(Q/Q_{bf}\right)^s$$

Stochastic Model (Tucker and Bras)

$$K_r = k_e k_w^{-2a/3} k_t^a$$

$$K_c = \langle P\rangle^{\gamma_b - \varepsilon_b} F_{var}^{\gamma_b - 1} \exp\left(-I/\langle P\rangle F_{var}\right)\Gamma\left(\gamma_b + 1\right)$$

$$\beta_{\tau_{cr}} = \frac{\left[\Gamma\left(\gamma_b + 1, R_c/P\right) - \left(R_c/P\right)^{\gamma_b} \exp\left(-R_c/P\right)\right]}{\Gamma\left(\gamma_b + 1\right)}$$

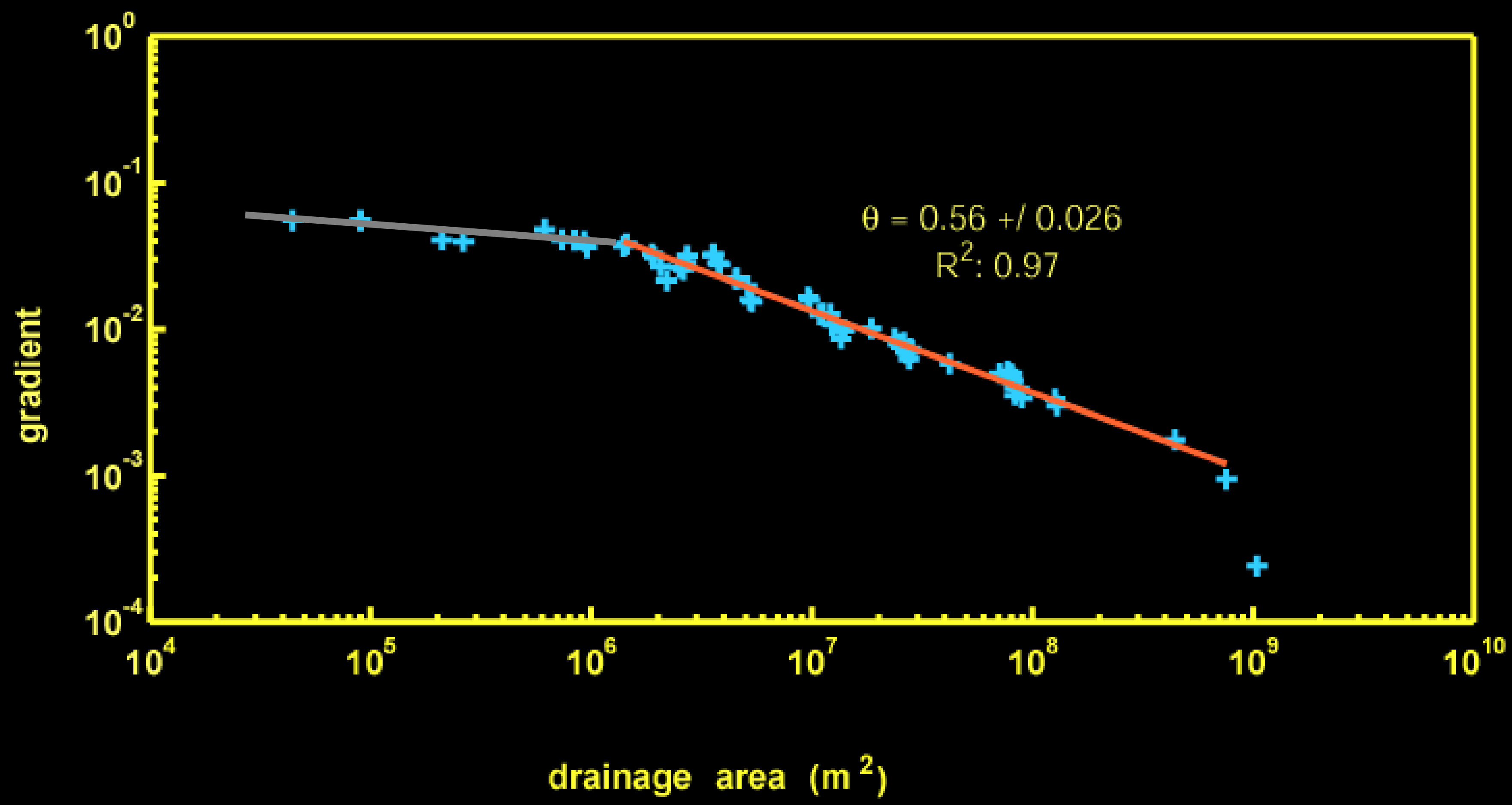
Exponents (Stochastic Model)

$$c = 1$$

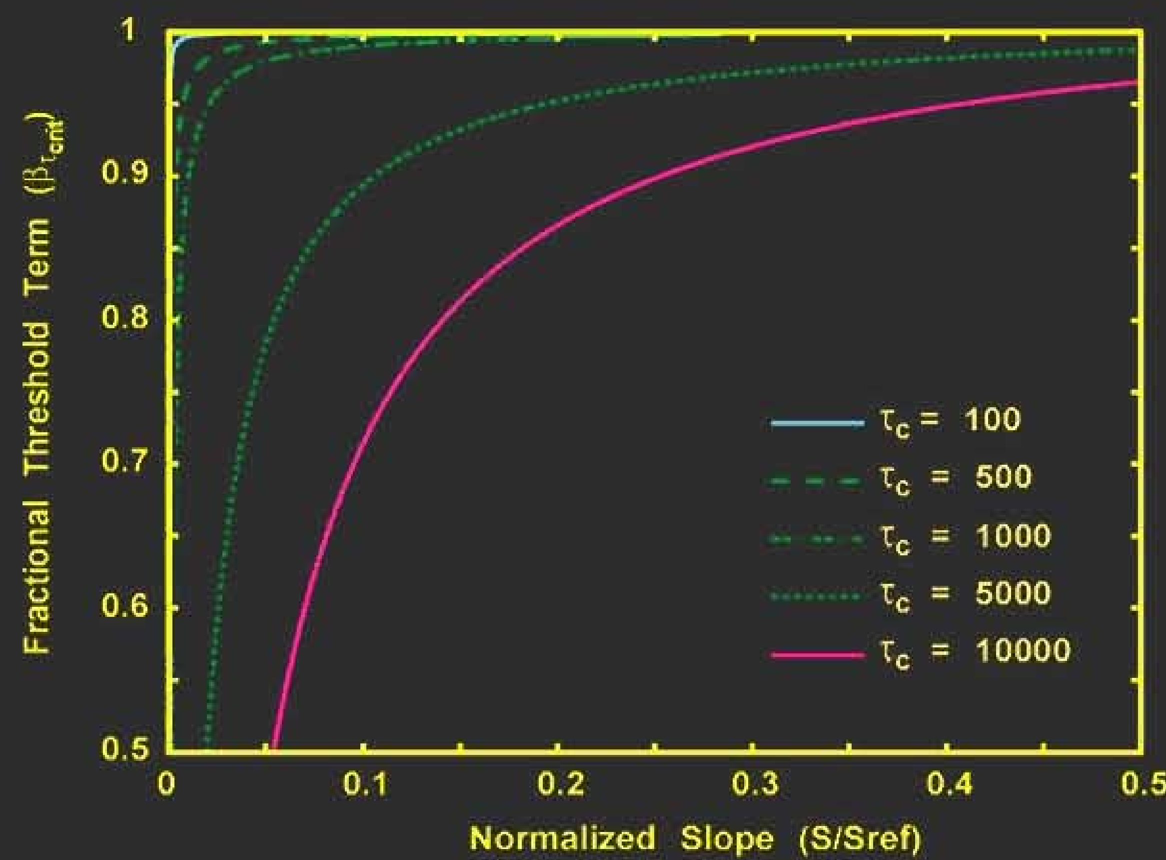
$$\gamma_b = 2a\left(1-s\right)/3$$

$$\varepsilon_b = 2a\left(b-s\right)/3$$

Mixed Bedrock-Alluvial Stream (Appalachians, VA)

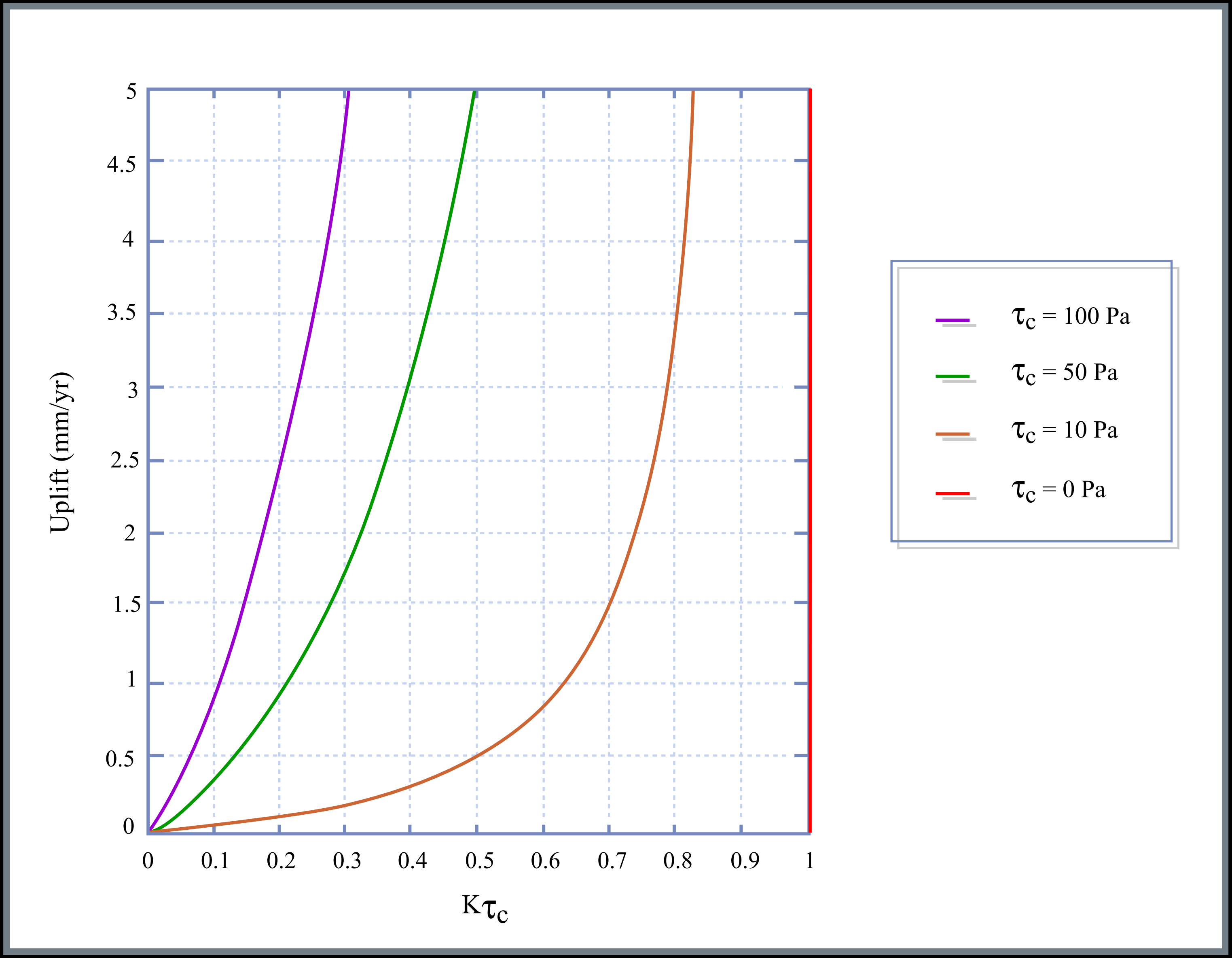


Concavity Index indistinguishable from detachment-limited bedrock channels



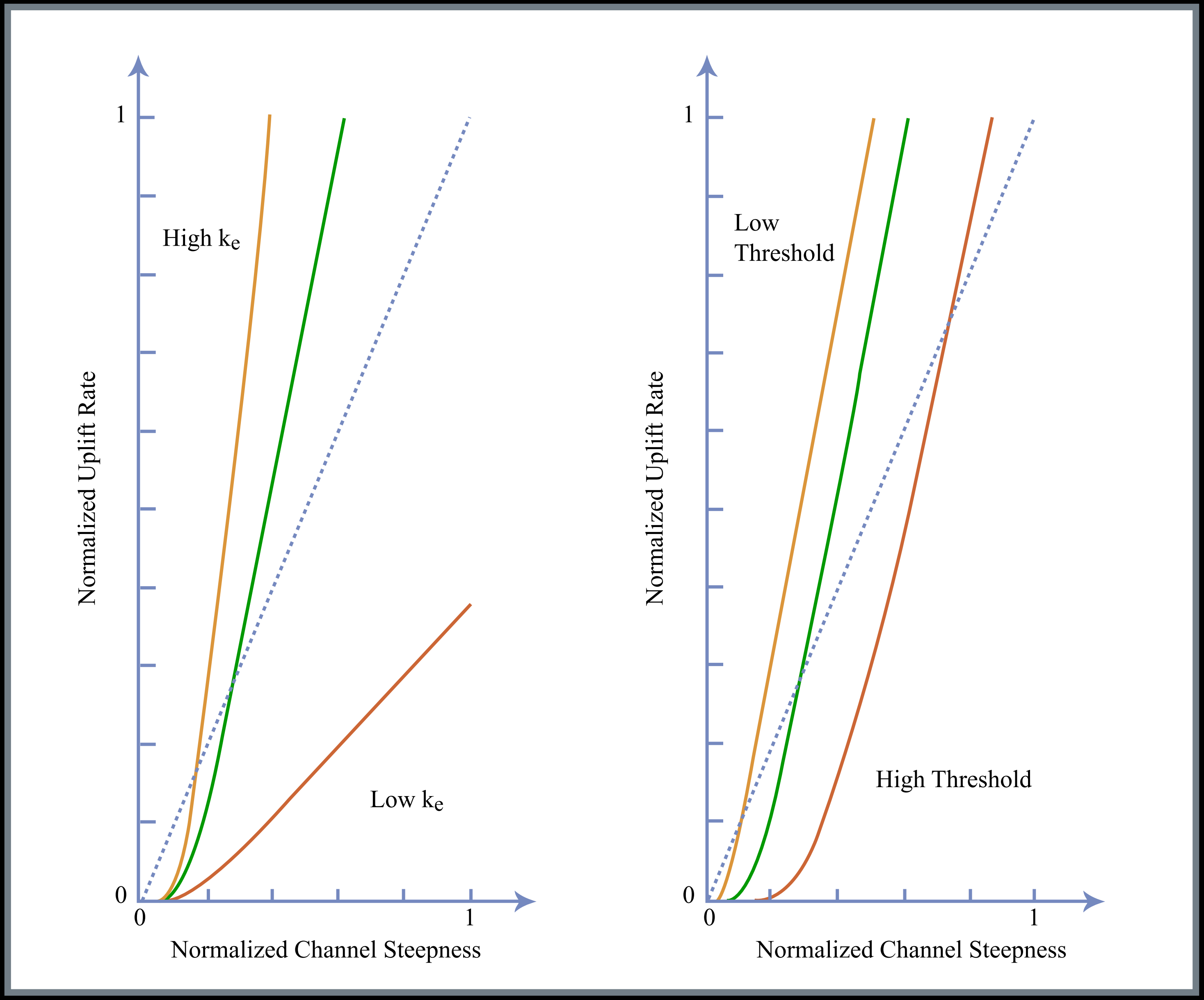
Fractional Threshold Term ($\beta_{\tau_{crit}}$)
Normalized Slope (S/Sref)
0.5
0.6
0.7
0.8
0.9
1
0
0.1
0.2
0.3
0.4
0.5
τ_c = 100
τ_c = 500
τ_c = 1000
τ_c = 5000
τ_c = 10000

$K_{\tau c}$ at steady state



Ktc varies between 0 and 1. For the no-threshold case, simply equals 1. For other cases, in steady-state streams it's constant downstream and varies with uplift rate.

Model effect on relief-uplift rate relation



But, the important point is heuristic. Thresholds fundamentally change the predicted relationship between relief and U.

- n=1
- Simple model is dashed line-- linear relation between slope and uplift rate for ss channels.
- Top plot varies ke, shear stress-erosion rate coefficient. Low ke (hard rocks) stronger relationship btw U and S. High ke (weak rocks, fast E), weaker relation at high U. Small changes in S yield large changes in E because more events exceed the threshold.
- Effect of the Tc is less prononouced. Simply the presence of the Tc is important. Of course Tc and ke will covary in lithologies.