Fundamental quantitative methods of land surface analysis

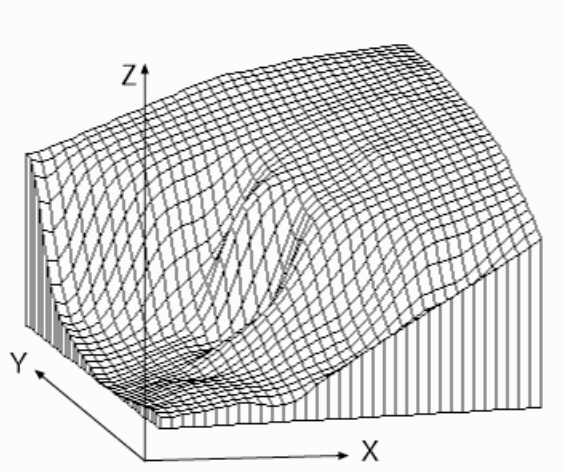
Peter A. Shary, Larisa S. Sharaya, Andrew V. Mitusov

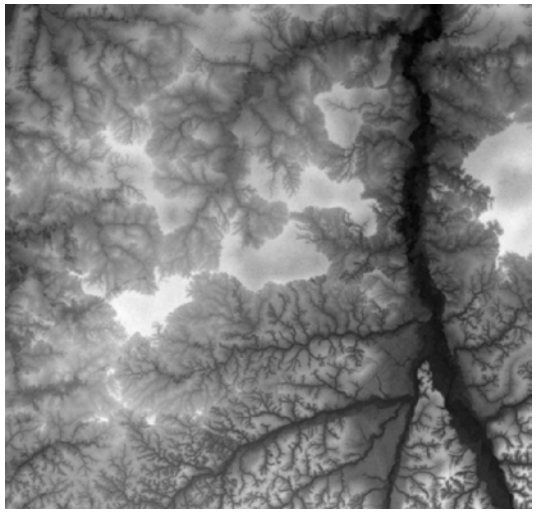
2002

Alexandre Copertino Jardim
Análise Espacial 2012

Modelo Numérico de Terreno

4.0	3.4	3.5	4.0
3.5	3.0	3.2	3.5
4.0	2.9	3.6	3.6
5.0	2.8	2.7	2.6
5.0	4.0	3.5	3.4





Motivação

- Conteúdo de água no solo e outras características hidrológicas.
- Distribuição do tamanho de partículas do solos.
- Profundidade do solo.
- Características da vegetação.

Variáveis Morfométricas

- Dependente de Escala
- Classificação
- Padronização

VM podem ser usadas para analisar

(i) formas geométricas da superfície da terra
(ii) escoamento superficial de materiais secos e líquidos
(iii) regime térmico de encostas
(iv) mudanças de temperatura e pressão atmosféricas

Continuação de outro trabalho

Land Surface in Gravity Points Classification by a Complete System of Curvatures (Shary, 1995)

(i) variáveis que são invariantes com relação à rotação de superfície em torno de qualquer eixo (para uma descrição forma geométrica)

(ii) variáveis isotrópicas que são invariantes com relação à rotação de superfície em torno do eixo vertical (por exemplo, para a descrição de escoamento superficial)

(iii) variáveis anisotrópicas que dependem de alguma orientação geográfica (por exemplo, insolação de encostas).

Classificação Geral

VM	Local	Regional
Dependente de Campo Vetorial	Classe A	Classe B
Independente de Campo Vetorial	Classe C	Classe D

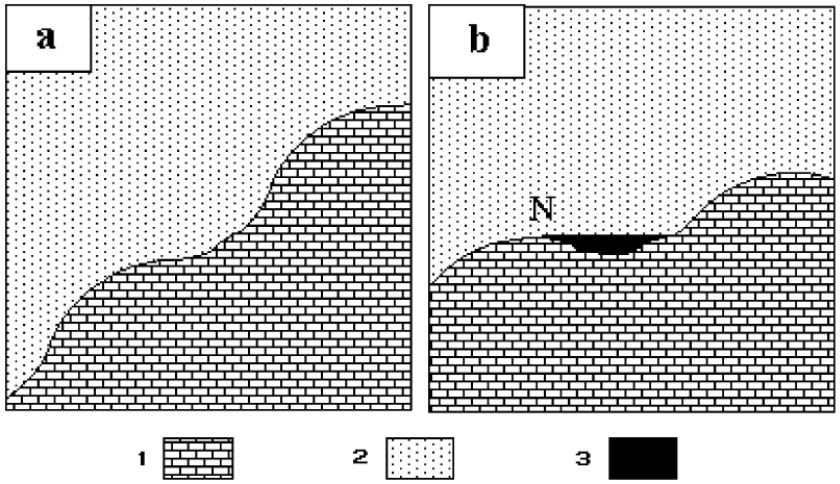


Fig. 1. On the concepts of D- and B-depressions (i.e., depressions of classes D and B). This is an example of two surfaces equal by form, but differently oriented in the gravitational field. 1— rocks, 2— air, 3 — water. The left is a D-depression (a broadly concave piece of land surface, it may have locally convex parts), right is a B-depression (a part of broadly concave land surface piece that is able to hold water).

Dependência de Escala

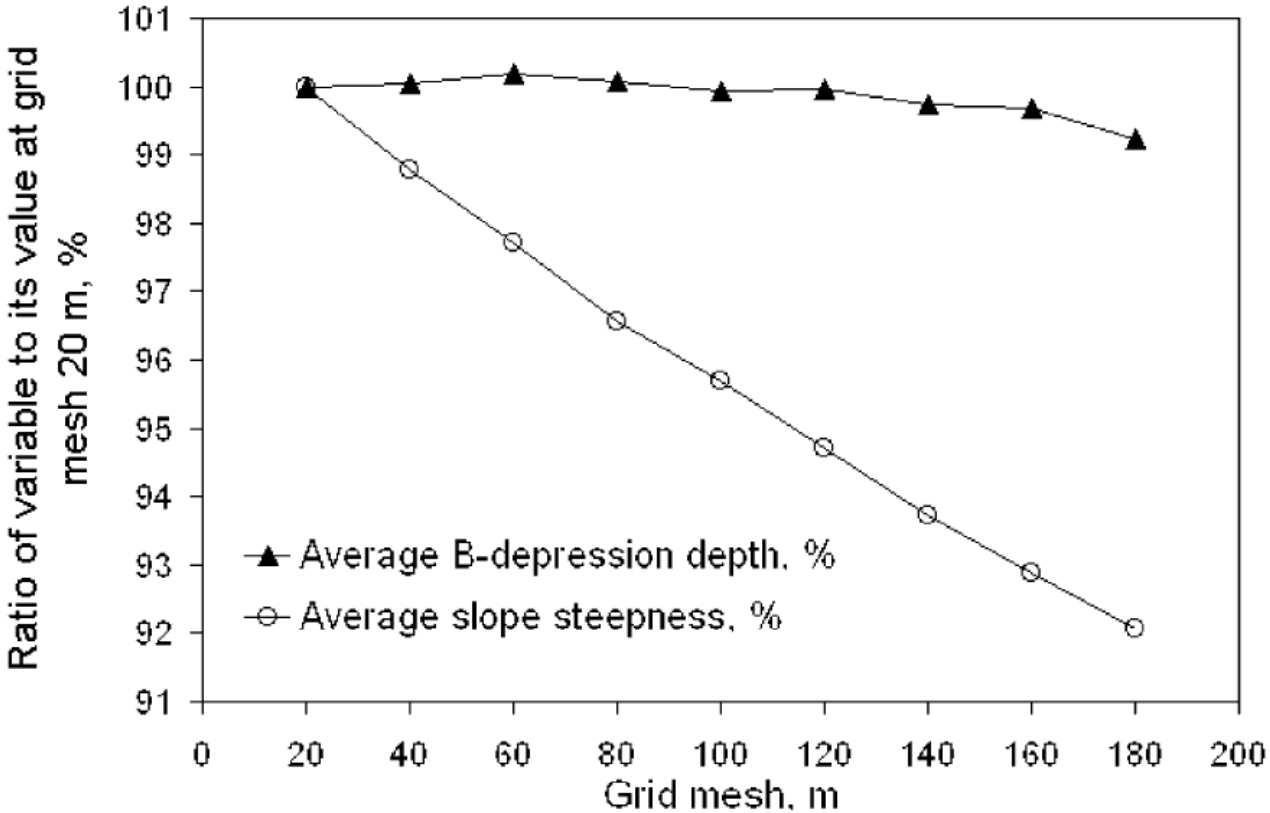


Fig. 2. The dependence of average depth of the lake Königssee in Germany and average slope steepness for the same terrain on grid mesh *w*. The scale of initial topographic map is 1:50,000 and it contains data on the lake bathymetry. For both the variables, their ratios (in %) to their initial value at grid mesh 20 m (6.23 m and 17.4°, respectively) are shown. It is seen that the average depth of the lake practically does not depend on *w*, while the average slope steepness essentially decreases with *w*.

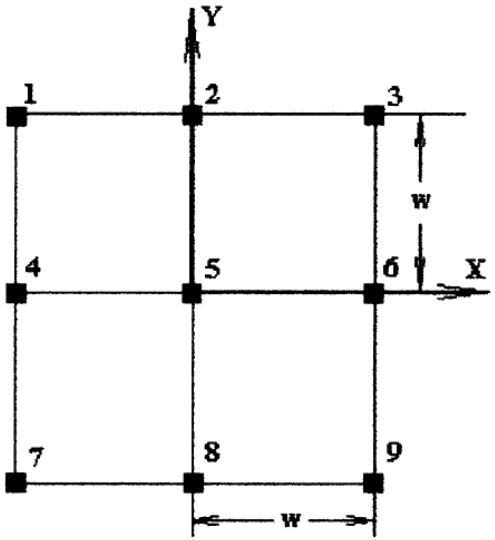
Formulae for calculation of local morphometric variables; in these formulae, $p=\partial z/\partial x$; $q=\partial z/\partial y$; $r=\partial^2 z/\partial x^2$, $s=\partial^2 z/\partial x\partial y$; $t=\partial^2 z/\partial y^2$ are designations for partial derivatives of the surface $z=z(x,y)$; the function sign(x) equals 1 for $x>0$, 0 for $x=0$, and -1 for $x<0$

Variable name	Class	Unit	Formula	Reference
Slope steepness	A	°	$\mathrm{GA}=\arctan(p^2+q^2)^{1/2}$	–
Slope gradient	A	–	$G=(p^2+q^2)^{1/2}$	–
Gradient factor	A	–	$\mathrm{GF}=(p^2+q^2)^{1/2}/[1+p^2+q^2]^{1/2}$	–
Slope direction (or aspect)	A	°	$A_0=-90[1-\mathrm{sign}(q)](1-\lvert\mathrm{sign}(p)\rvert)+180[1+\mathrm{sign}(p)]-180\mathrm{sign}(p)\arccos[-q/(p^2+q^2)^{1/2}]/\pi$	–
Mean curvature	C	1/m	$H=-[(1+q^2)r-2pqs+(1+p^2)t]/[2(1+p^2+q^2)^{3/2}]$	(Gauss, 1827)
Unsphericity	C	1/m	$M=[\{r[(1+q^2)/(1+p^2)]^{1/2}-t/[(1+q^2)/(1+p^2)]^{1/2}\}^2/(1+p^2+q^2)+\{pqr[(1+q^2)/(1+p^2)]^{1/2}-2[(1+q^2)(1+p^2)]^{1/2}s+pqt/[(1+q^2)/(1+p^2)]^{1/2}\}^2]^{1/2}/[2(1+p^2+q^2)^{3/2}]$	(Shary, 1995)
Difference curvature	A	1/m	$E=(q^2r-2pqs+p^2t)/[(p^2+q^2)(1+p^2+q^2)^{1/2}]-[(1+q^2)r-2pqs+(1+p^2)t]/[2(1+p^2+q^2)^{3/2}]$	(Shary, 1995)
Horizontal curvature	A	1/m	$\mathrm{kh}=-(q^2r-2pqs+p^2t)/[(p^2+q^2)(1+p^2+q^2)^{1/2}]$	(Krcho, 1983)
Plan curvature[a]	A	1/m	$\mathrm{kp}=-(q^2r-2pqs+p^2t)/(p^2+q^2)^{3/2}$	(Evans, 1972)
Vertical (=profile) curvature	A	1/m	$\mathrm{kv}=-(p^2r+2pqs+q^2t)/[(p^2+q^2)(1+p^2+q^2)^{3/2}]$	(Evans, 1972)
Rotor[a]	A	1/m	$\mathrm{rot}=[(p^2-q^2)s-pq(r-t)]/(p^2+q^2)^{3/2}$	(Shary, 1991)
Horizontal excess curvature	A	1/m	$\mathrm{khe}=M-E$	(Shary, 1995)
Vertical excess curvature	A	1/m	$\mathrm{kve}=M+E$	(Shary, 1995)
Minimal curvature	C	1/m	$\mathrm{kmin}=H-M$	–
Maximal curvature	C	1/m	$\mathrm{kmax}=H+M$	–
Total Gaussian curvature	C	$1/\mathrm{m}^2$	$K=(rt-s^2)/(1+p^2+q^2)^2$	(Gauss, 1827)
Total ring curvature	A	$1/\mathrm{m}^2$	$\mathrm{KR}=[(p^2-q^2)s-pq(r-t)]^2/[(p^2+q^2)^2(1+p^2+q^2)^2]$	(Shary, 1995)
Total accumulation curvature	A	$1/\mathrm{m}^2$	$\mathrm{KA}=H^2-E^2$	(Shary, 1995)
Slope insolation[b]	A	%	$F=50\{1+\mathrm{sign}[\cos a-\sin a*(p\sin b+q\cos b)]\}[\cos a-\sin a*(p\sin b+q\cos b)]/(1+p^2+q^2)$	(e.g., Onorati et al., 1992)

[a] These curvatures do not belong to the complete system of 12 curvatures (Shary, 1995).

[b] Here $90°-a$ is Sun vertical angle from horizon, b is Sun azimuth counted from northern direction clockwise.

The modified Evans-Young method



$$z_5' = (z_2 + z_4 + 41z_5 + z_6 + z_8)/45.$$

$$p = (z_3 + z_6 + z_9 - z_1 - z_4 - z_7)/6w,$$

$$q = (z_1 + z_2 + z_3 - z_7 - z_8 - z_9)/6w,$$

$$r = [z_1 + z_3 + z_4 + z_6 + z_7 + z_9 - 2(z_2 + z_5 + z_8)]/3w^2,$$

$$s = (-z_1 + z_3 - z_7 + z_9)/4w^2,$$

$$t = [z_1 + z_2 + z_3 + z_7 + z_8 + z_9 - 2(z_4 + z_5 + z_6)]/3w^2;$$

Variable name	Class	Unit	Formula
Slope steepness	A	°	$GA = \arctan(p^2 + q^2)^{1/2}$
Slope gradient	A	–	$G = (p^2 + q^2)^{1/2}$
Gradient factor	A	–	$GF = (p^2 + q^2)^{1/2}/[1 + p^2 +$
Slope direction (or aspect)	A	°	$A_0 = -90[1 - \mathrm{sign}(q)](1 -$
			$180\mathrm{sign}(p)\arccos[-q/(p^2$
Mean curvature	C	1/m	$H = -[(1 + q^2)r - 2pqs + ($
Unsphericity	C	1/m	$M = [\{r[(1 + q^2)/(1 + p^2)]^{1/}$
			$\{pqr[(1 + q^2)/(1 + p^2)]^{1/2} -$
			$(1 + p^2)]^{1/2}\}^2]^{1/2}/[2(1 + p^2$
Difference curvature	A	1/m	$E = (q^2r - 2pqs + p^2t)/[(p$
			$(1 + p^2)t]/[2(1 + p^2 + q^2)^{3/2}$
Horizontal curvature	A	1/m	$kh = -(q^2r - 2pqs + p^2t)/[$
Plan curvature[a]	A	1/m	$kp = -(q^2r - 2pqs + p^2t)/($
Vertical (= profile) curvature	A	1/m	$kv = -(p^2r + 2pqs + q^2t)/[$
Rotor[a]	A	1/m	$rot = [(p^2 - q^2)s - pq(r -$
Horizontal excess curvature	A	1/m	$khe = M - E$
Vertical excess curvature	A	1/m	$kve = M + E$
Minimal curvature	C	1/m	$kmin = H - M$
Maximal curvature	C	1/m	$kmax = H + M$
Total Gaussian curvature	C	$1/m^2$	$K = (rt - s^2)/(1 + p^2 + q^2)^2$
Total ring curvature	A	$1/m^2$	$KR = [(p^2 - q^2)s - pq(r -$
Total accumulation curvature	A	$1/m^2$	$KA = H^2 - E^2$
Slope insolation[b]	A	%	$F = 50\{1 + \mathrm{sign}[\cos a - si$
			$\sin a*(p\sin b + q\cos b)]/(1$

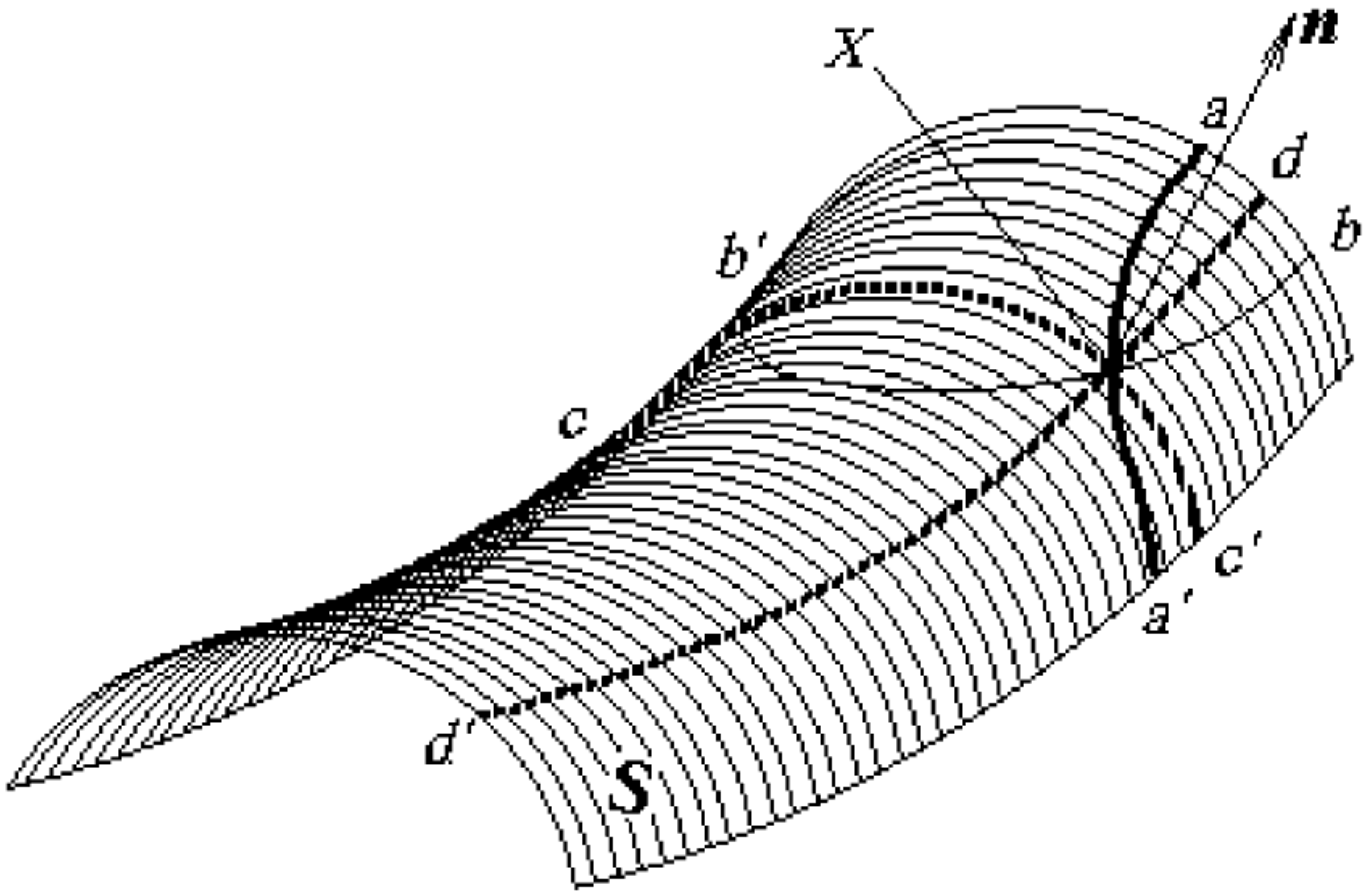


Fig. 6. The four directions naturally marked on the surface S. $\boldsymbol{n}$—normal vector to S at the point $\boldsymbol{X}$; aa′— gradient line; bb′— contour line; dd′, cc′— main normal sections.

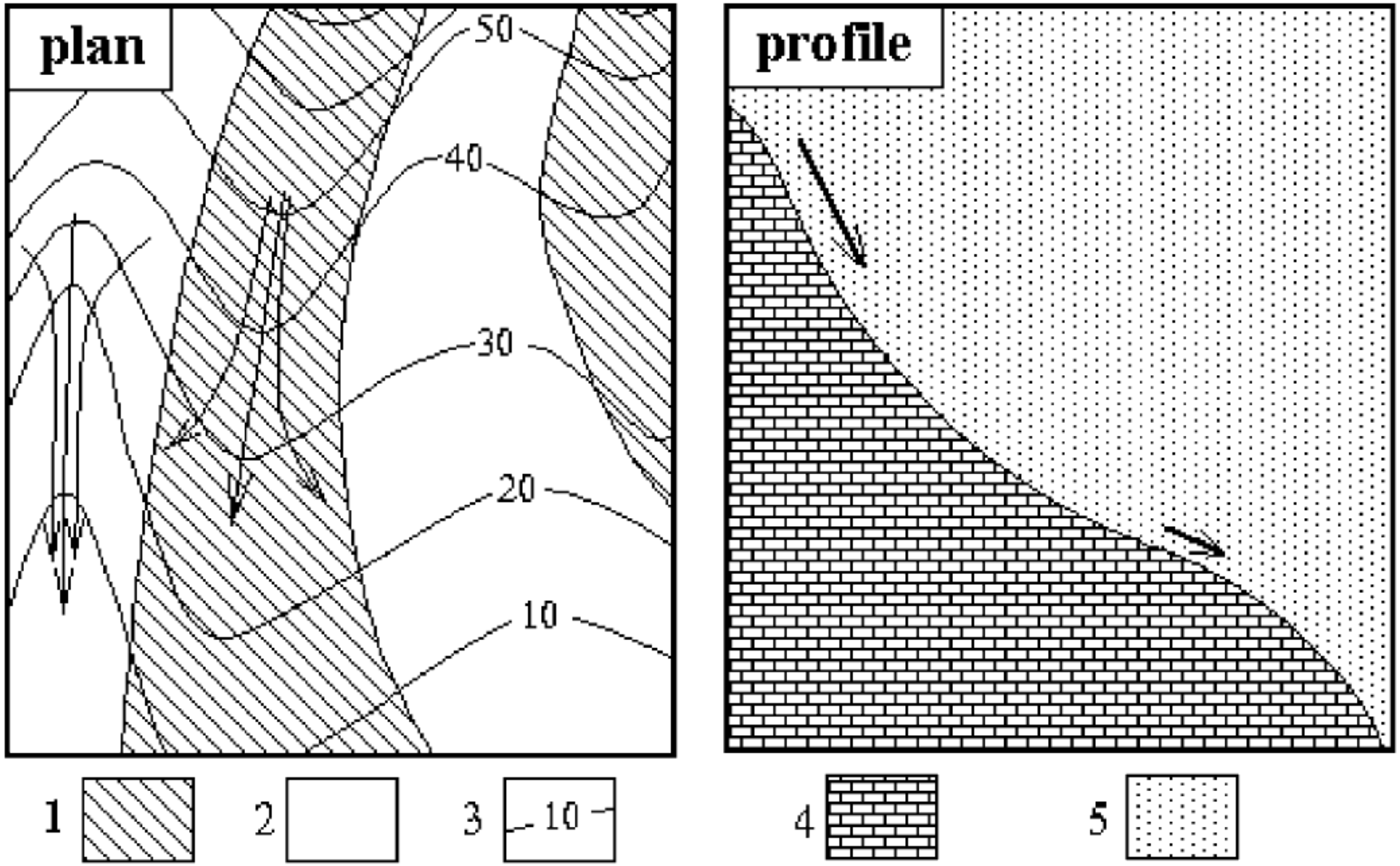
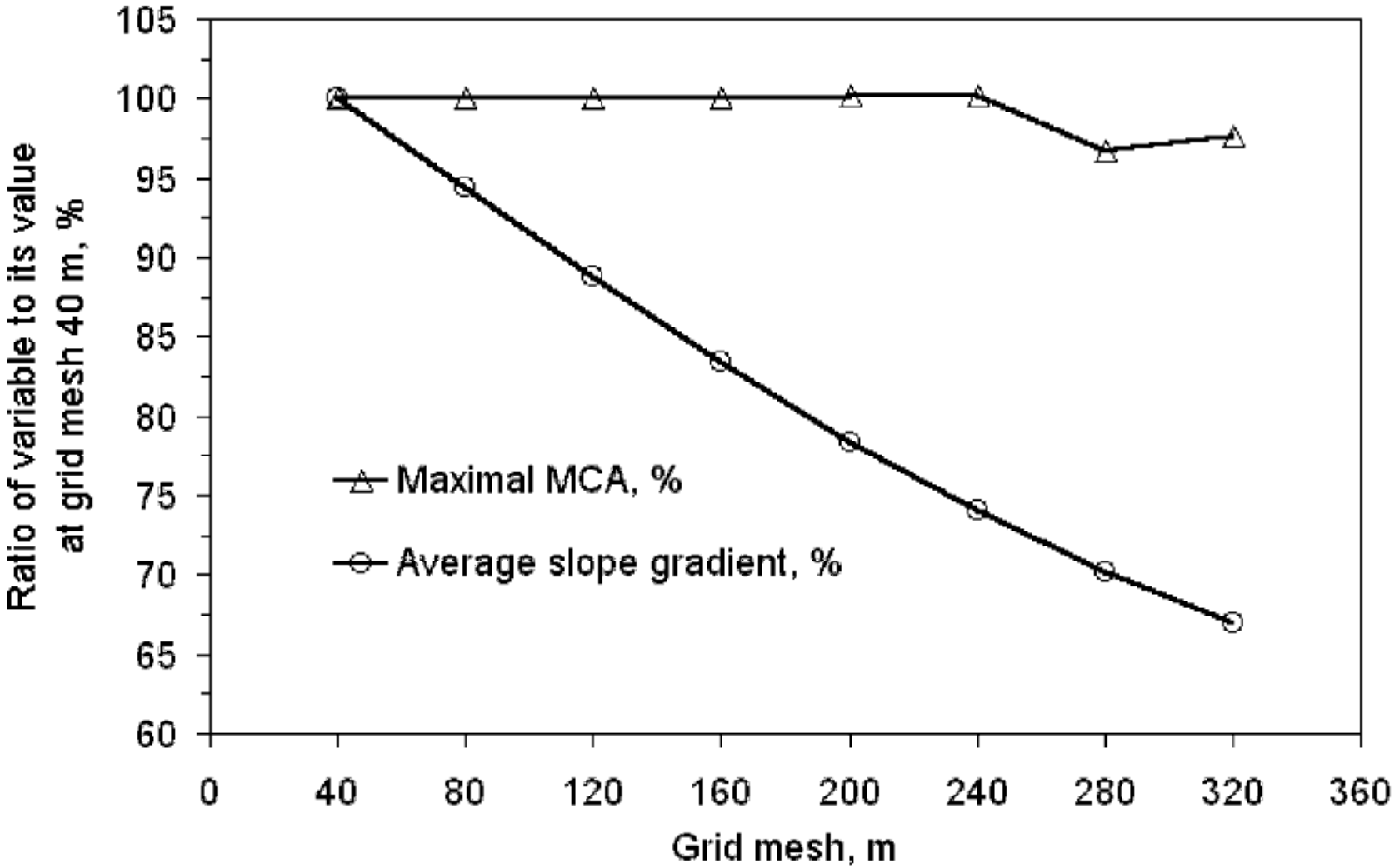
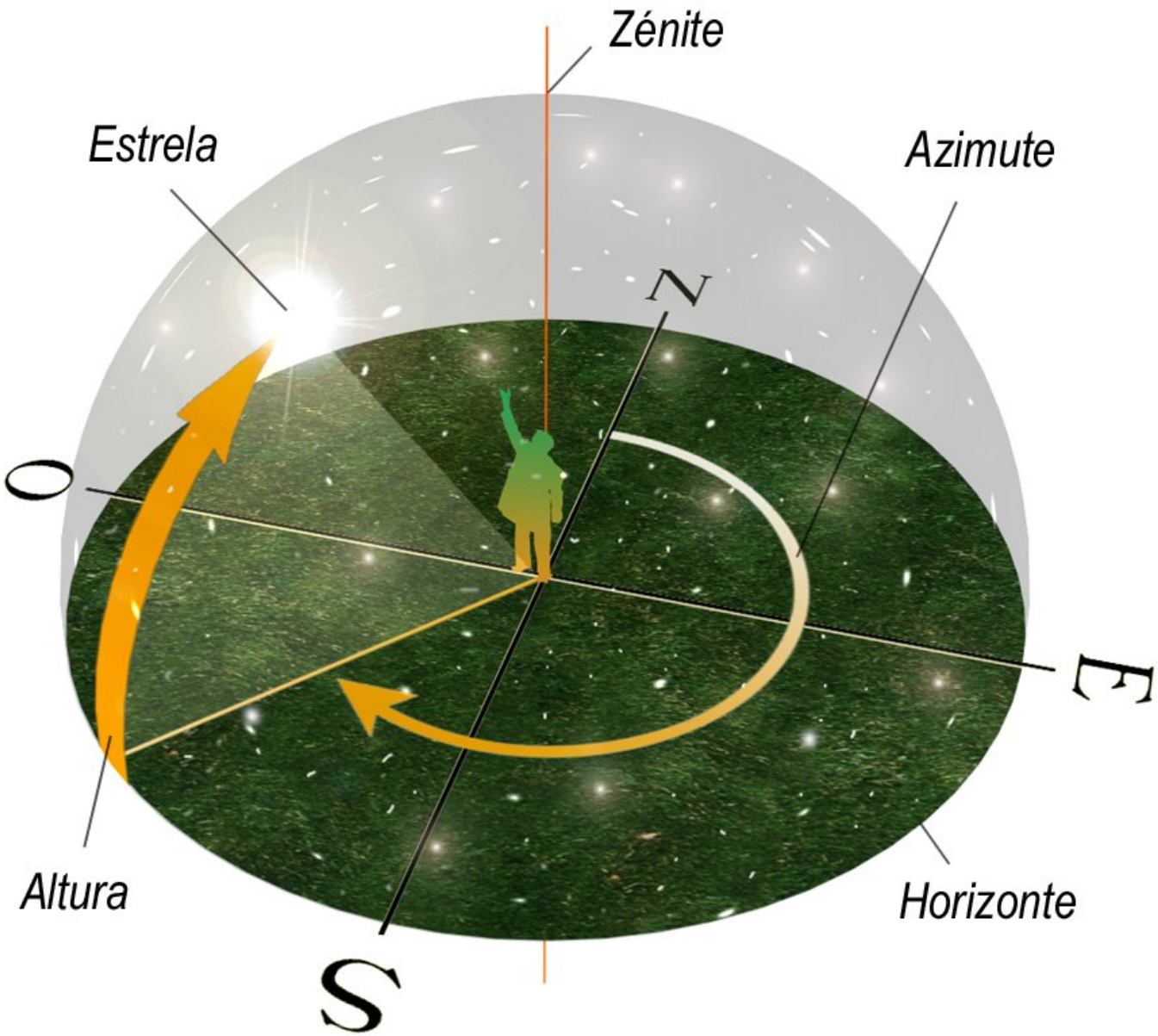


Fig. 4. Two accumulation mechanisms. Left — flow convergence/divergence, right — relative flow deceleration/acceleration. 1 — divergence areas, 2 — convergence areas, 3 — contour lines, 4 — rocks, 5 — air. See text for details.

Máxima Área de Contribuição



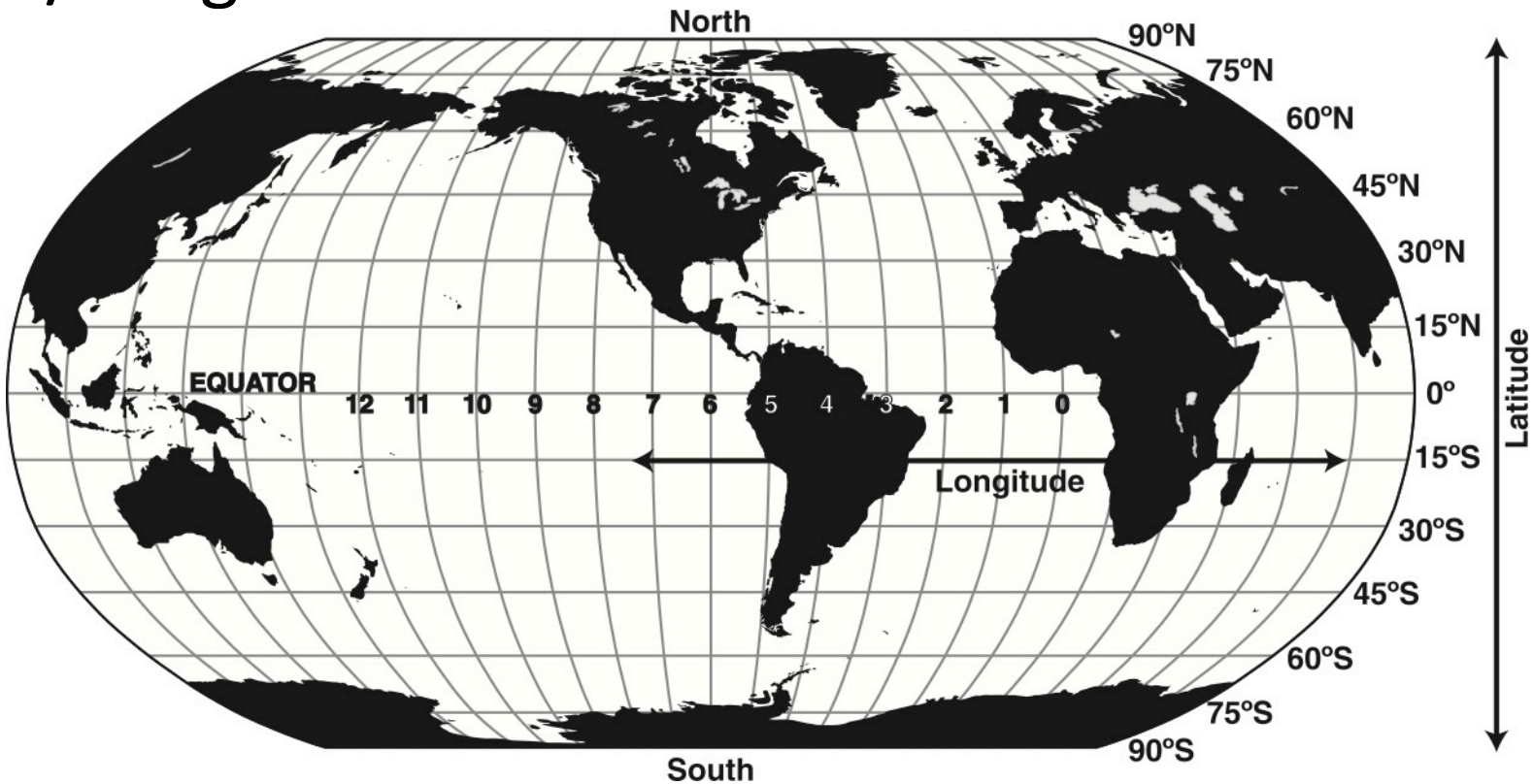


http://nautilus.fis.uc.pt/astro/hu/movi/azimute.html

Faltou

Detalhes de implementação

Lat/Long



http://www.planetarium-activities.org/activities/categories/navigation/latitude-and-longitude

Outras Publicações

citações 81 (scopus)

Land Surface in Gravity Points Classification by a
Complete System of Curvatures (Shary, 1995)

Citações 31 (scopus)

The problem of scale-specific and scale-free approaches in geomorphometry (2005)

Shary, P.A., Sharaya, L.S., Mitusov, A.V.

Citações 4 (scopus)

Landforms and landform elements in geomorphometry (2009)

MacMillan, R.A., Shary, P.A.

Citações 12 (scopus)