GEO INFORMATION

Methods in Spatial Analysis
PS | LV.Nr. 856.141

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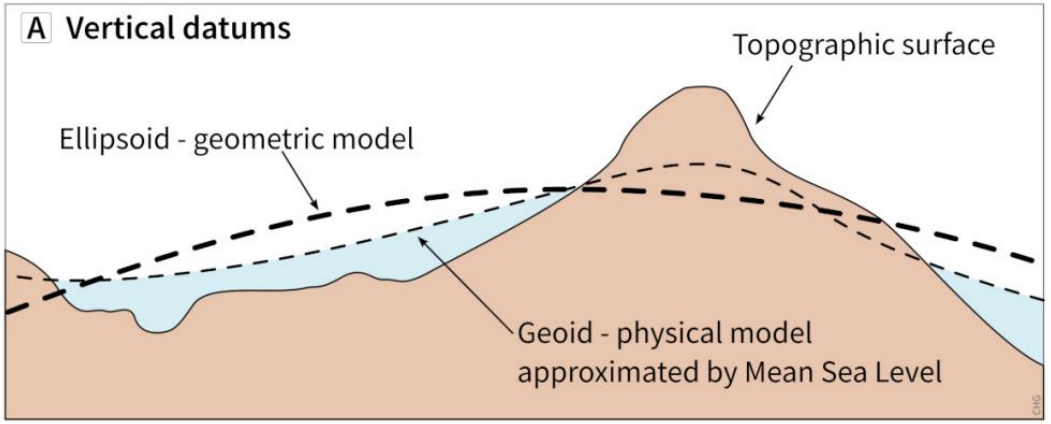
Analyzing Surfaces

Introduction

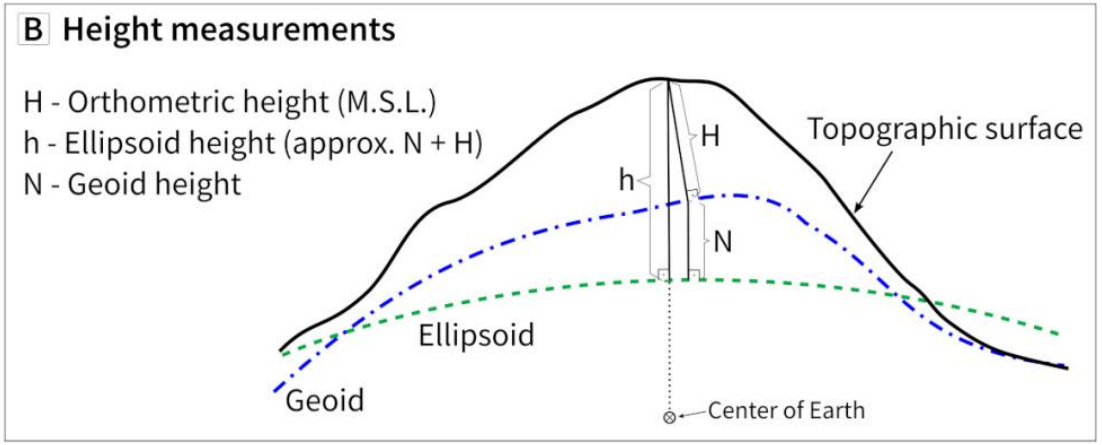
- Spatial analysis techniques to determine (estimate) the following terrain parameter:
  - Elevation (mostly the base dataset)
  - Slope
  - Aspect
  - Profile Curvature
  - Plan Curvature

Basic Info

- Vertical Datums:

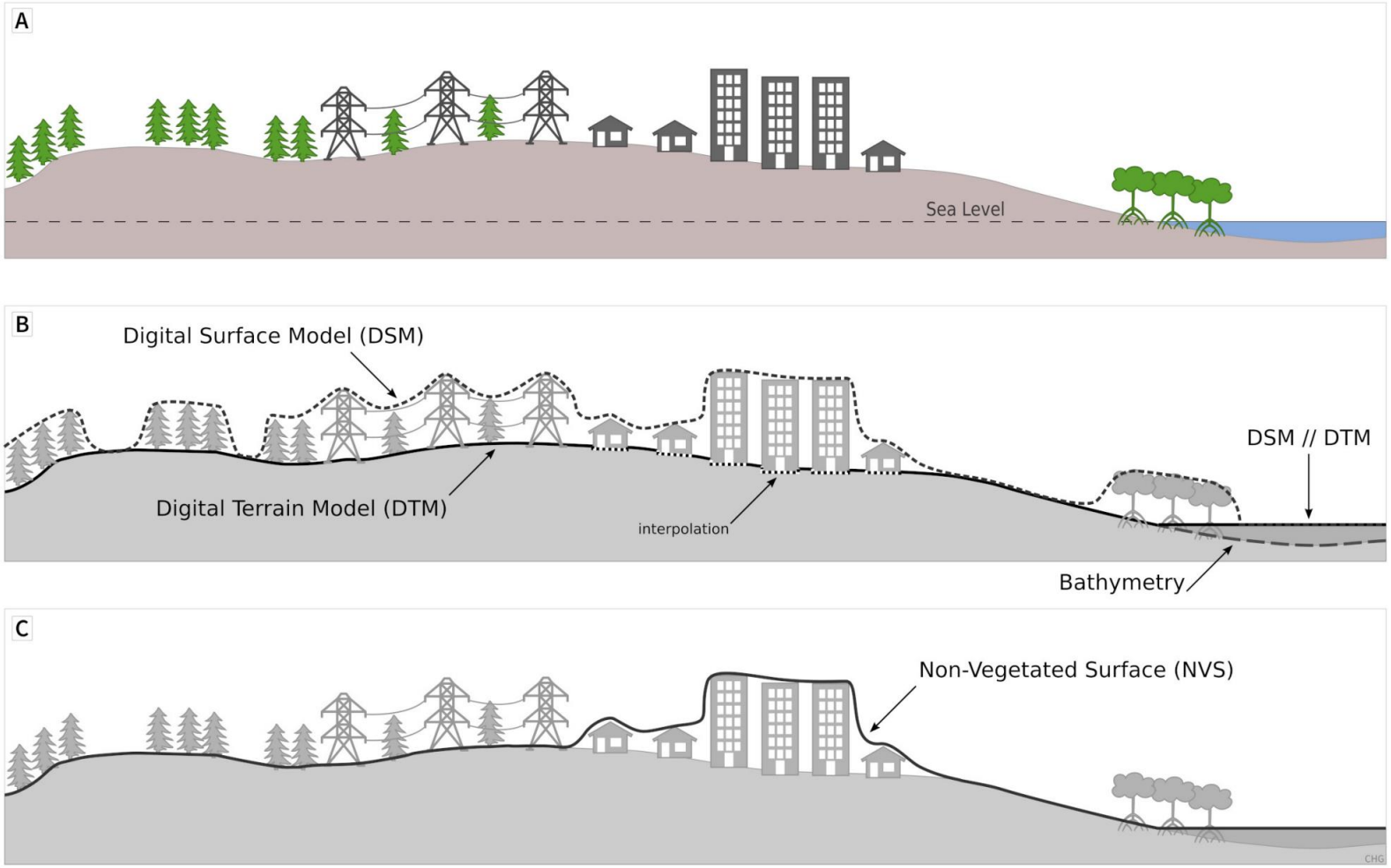


- Height measurements

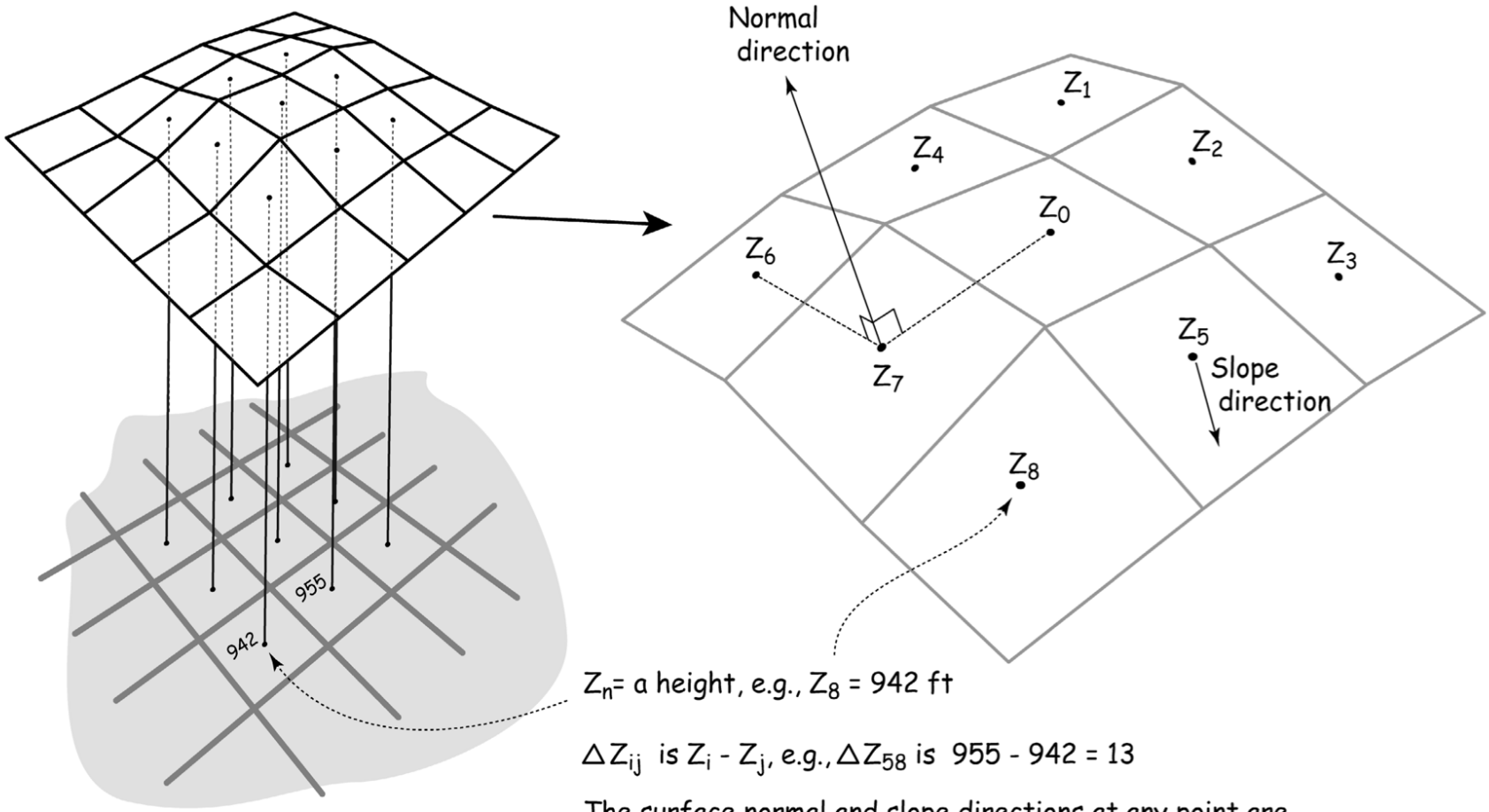


Basic Info (DSM – DTM)

Different types of Digital Elevation Models (DEMs)



Basic Info



Z_n= a height, e.g., Z_8 = 942 ft

ΔZ_{ij} is $Z_i - Z_j$, e.g., ΔZ_{58} is 955 - 942 = 13

The surface normal and slope directions at any point are calculated from various ΔZ_{ij}

Slope

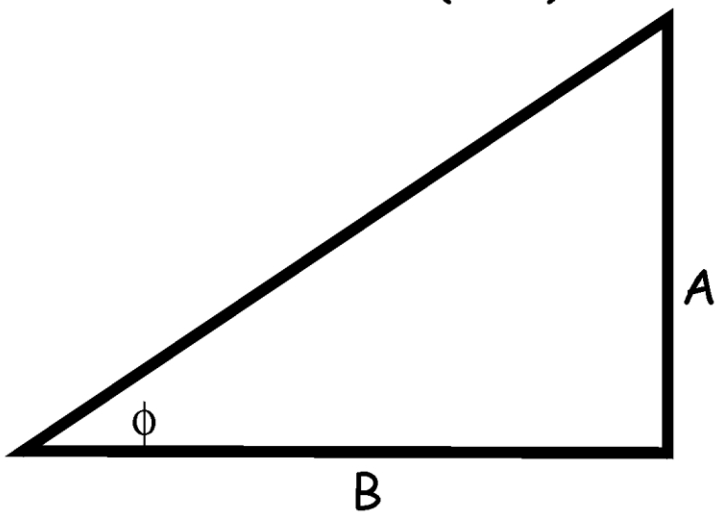
- Calculation:

$$\text{Slope as percent} = \frac{\text{rise}}{\text{run}} * 100$$

$$= A/B * 100$$

$$\text{Slope as degrees} = \phi$$

$$= \tan^{-1}(A/B)$$



Slope Calculation (Zevenbergen & Thorne 1987)

Four nearest cells
elevation values

42	45	47
40	44	49
44	48	52

← C = 10 →

kernel for dZ/dx

Z_1 0	Z_2 0	Z_3 0
Z_4 -1	Z_0 0	Z_5 1
Z_6 0	Z_7 0	Z_8 0

$dZ/dx = (Z_5 - Z_4)/2C$

$dZ/dx = (49 - 40)/20 = 0.45$

kernel for dZ/dy

Z_1 0	Z_2 1	Z_3 0
Z_4 0	Z_0 0	Z_5 0
Z_6 0	Z_7 -1	Z_8 0

$dZ/dy = (Z_2 - Z_1)/2C$

$dZ/dy = (45 - 48)/20 = -0.15$

$$\text{slope} = \text{atan}\left[(0.45)^2 + (-0.15)^2\right]^{0.5} = 25.3^\circ$$

Slope Calculation (Horn 1981)

3rd-order finite difference

elevation values

42	45	47
40	44	49
44	48	52

◄C = 10►

kernel for dZ/dx

Z_1 -1	Z_2 0	Z_3 1
Z_4 -2	Z_0 0	Z_5 2
Z_6 -1	Z_7 0	Z_8 1

$$dZ/dx = [(Z_3 - Z_1) + 2(Z_5 - Z_4) + (Z_8 - Z_6)]/8C$$

$$dZ/dx = [\ (47 - 42) + 2\,(49 - 40) + (52 - 44)\ ]/80 = 0.39$$

kernel for dZ/dy

Z_1 1	Z_2 2	Z_3 1
Z_4 0	Z_0 0	Z_5 0
Z_6 -1	Z_7 -2	Z_8 -1

$$dZ/dx = [(Z_1 - Z_6) + 2(Z_2 - Z_7) + (Z_3 - Z_8)]/8C$$

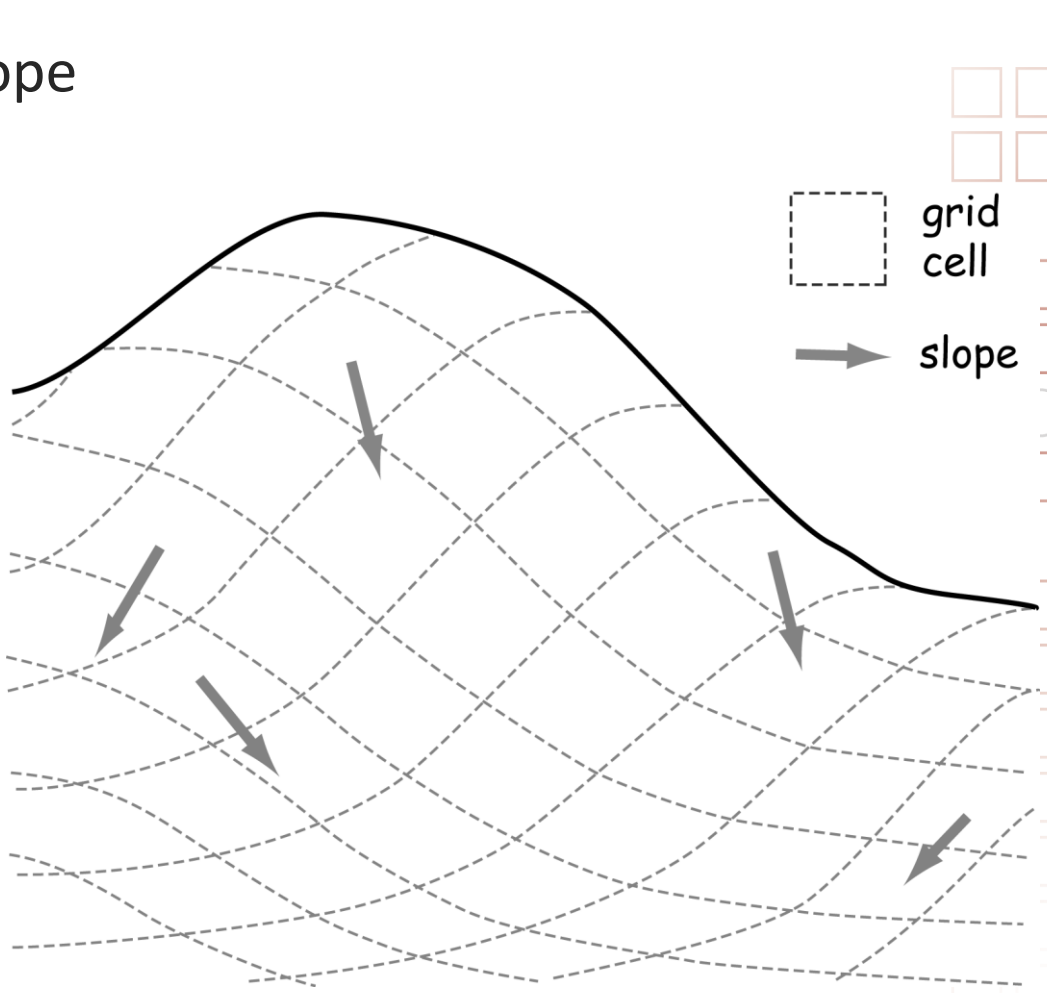
$$dZ/dy = [\ (47 - 52) + 2\,(45 - 48) + (42 - 44)\ ]/80 = -0.16$$

$$\text{slope} = \text{atan}\left[(0.39)^2 + (-0.16)^2\right]^{0.5} = 22.9^\circ$$

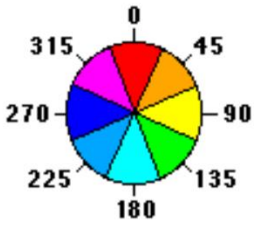
Aspect

- Direction of max. slope
  - 0° >> N
  - 90° >> O
  - 180° >> S
  - 270° >> W

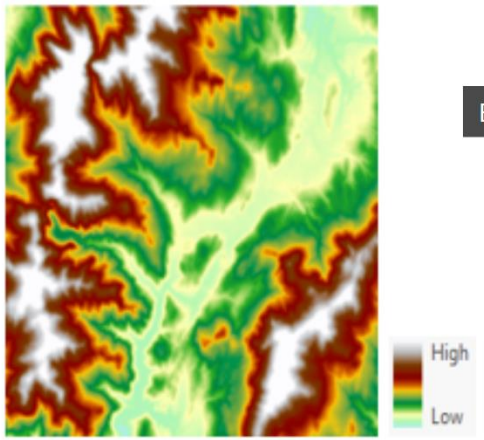
- Important for hydrological analyses!



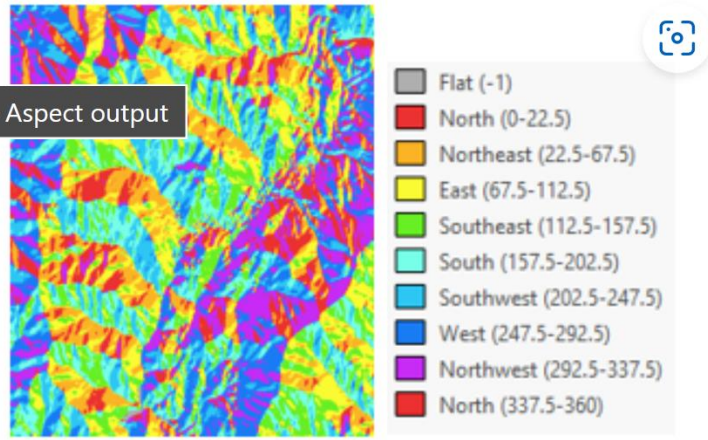
Aspect



The following images show an input elevation dataset and the output aspect raster.



Input elevation raster



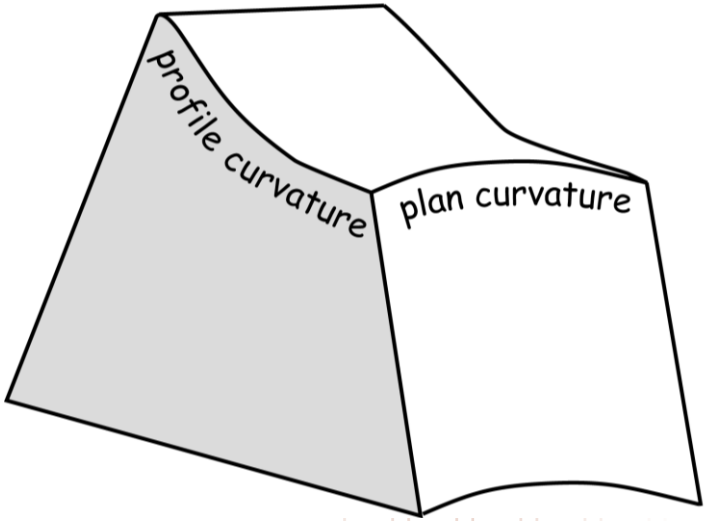
Output aspect raster

Profile & Plan Curvature

- Characterisation of the land forms
- Used to estimate soil wetness, rain runoff, vegetation conditions, …

- Profile Curvature: parallel to the direction of the maximum slope

- Plan Curvature: perpendicular to the direction of the maximum slope



Profile & Plan Curvature

Z_1	Z_2	Z_3
Z_4	Z_0	Z_5
Z_6	Z_7	Z_8

← C →

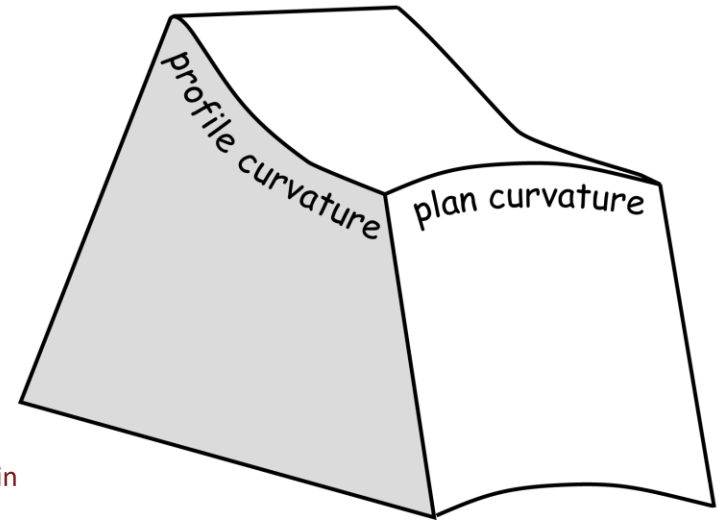
$$D = [(Z_4 + Z_5)/2 - Z_0] / C^2$$

$$E = [(Z_2 + Z_7)/2 - Z_0] / C^2$$

$$F = (Z_3 - Z_1 + Z_6 - Z_8) / 4C^2$$

$$G = (Z_5 - Z_4) / 2C$$

$$H = (Z_2 - Z_7) / 2C$$



plan curvature

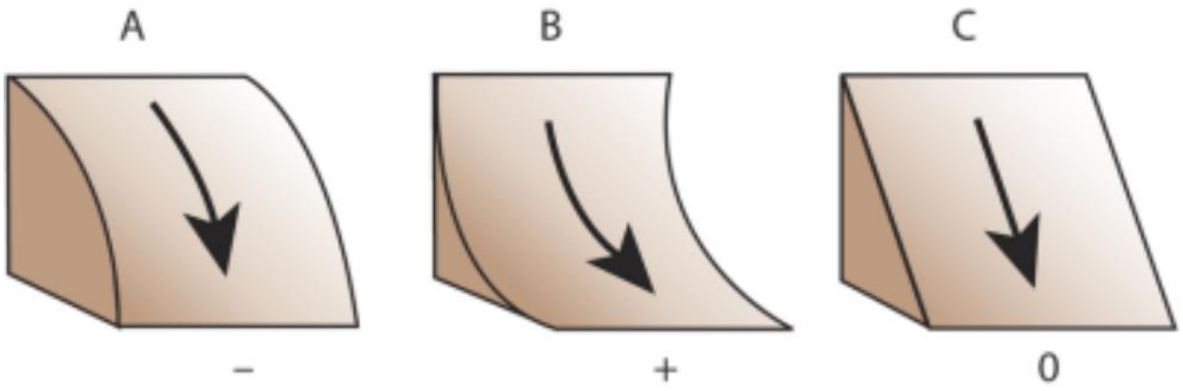
$$\frac{2 (DH^2 + EG^2 - FGH)}{G^2 + H^2}$$

profile curvature

$$\frac{-2 (DG^2 + EH^2 + FGH)}{G^2 + H^2}$$

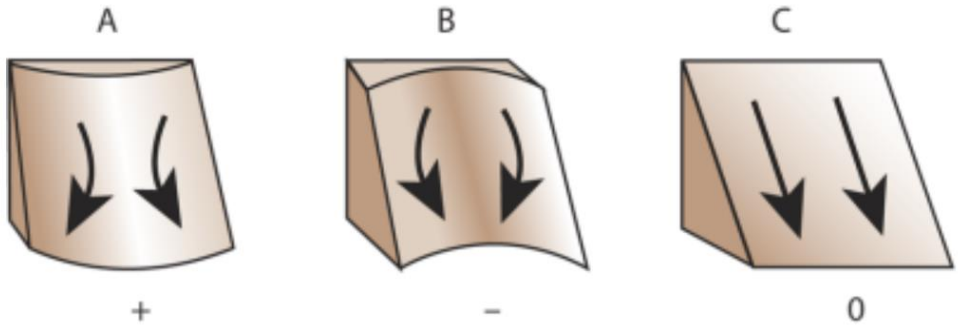
Profile Curvature

- A negative value (figure A) indicates that the surface is upwardly convex at that cell.
- A positive profile (figure B) indicates that the surface is upwardly concave at that cell.
- A value of zero indicates that the surface is linear (figure C)
- Profile curvature affects the acceleration or deceleration of flow across the surface.



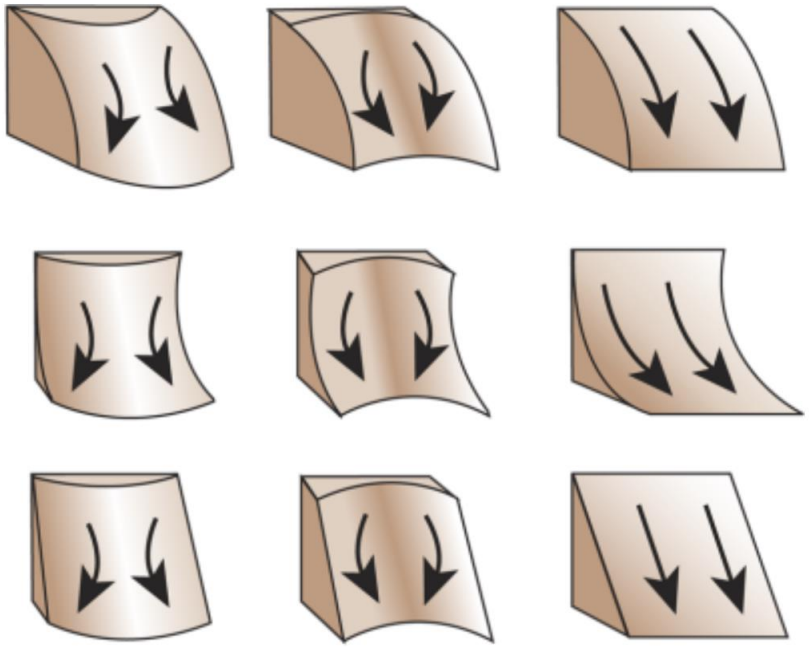
Plan Curvature

- A positive value (figure A) indicates the surface is sidewardly convex at that cell.
- A negative plan (figure B) indicates the surface is sidewardly concave at that cell.
- A value of zero indicates the surface is linear (figure C)
- Profile curvature relates to the convergence and divergence of flow across a surface.



Combinations

- The slope affects the overall rate of movement downslope.
- Aspect defines the direction of flow.
- The profile curvature affects the acceleration and deceleration of flow and, therefore, influences erosion and deposition.
- The plan curvature influences convergence and divergence of flow.
- Considering both plan and profile curvature together allows us to understand more accurately the flow across a surface.



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