GEO 428: Aspect and Curvature
October 4, 2012

Due Dates

Aspect – Utility
Aspect = direction of steepest slope
Key factor in solar insolation
Driver for many biophysical processes
Evapotranspiration, temp, energy rates
Applications
Site suitability: agriculture, solar power
Visibility analysis
Habitat modeling

Aspect on a Surface
Recall the formal definition of slope:
\[ S = \arctan \sqrt{p^2 + q^2} \]
where p is the west-east gradient
\[ p = f_x = \frac{\partial f}{\partial x} \]
And q is the north-south gradient
\[ q = f_y = \frac{\partial f}{\partial y} \]
Aspect is:
\[ A = 180^\circ - \arctan \left( \frac{q}{p} \right) + 90^\circ \left( \frac{p}{|p|} \right) \]

Measuring Aspect
In degrees, typically clockwise from north
Values range from 0 – 360
0 = 360 = North!
Typically code flat areas as -1
Ex: Aspect = 90 degrees
Maximum slope faces 90 degrees
East facing terrain

Aspect Data Type
Circular, continuous scale
Compare to other Data Types
Nominal, Ordinal, Interval, Ratio
Does the Identity relation hold?
Is 30 = 30?
Do ordinal relations hold?
Is 180 > 30 > 20?
Can you add aspects meaningfully?
270 + 180 = 460?
Are ratios meaningful?
Is 180 degrees twice 90 degrees?
What's wrong with gray-shading 0-255 for aspect degrees 0-360?
**Rescaling Aspect**  
Rescaling aspect for continuous 'circular' shading  
Shade = |Aspect – 180|  
  
- Asp = 5 or 355: shade = 175  
- Asp = 160 or 200: shade = 20

**DEM Example**  
In Grid, a raster called cach_asp  
nice_aspect = ABS(180 – cach_asp)

**GRASS Examples**  
Using existing GRASS aspect color ramps

**Hillshading**  
Cartographic tool for displaying terrain  
Also used for modeling reflectance  
  
- Remote sensing applications  
- Digital replacement for Shaded Relief Maps, Plaster Models, etc.  
- Employs slope and aspect to calculate reflectance  
  
- Relative to light source

**Hillshading Concept**  
Shine a light on the landscape  
  
- Azimuth (degrees from north)  
- Altitude (height above horizon)  
Identify angle at which light strikes the surface  
  
- Surface perpendicular to light source = bright  
- Surface parallel to light source = dark

**Hillshading and Angles**  
Reflectance from a light source  
Compare Terrain Angle – Sun Angle  
Which will be brightest?

**Reflection**  
Angles perpendicular are brightest  
Angles parallel are darkest

**Shadows**  
Light may not strike parts of surface

**Sun Angle Important**  
Hillshade depends on lighting position  
  
- Azimuth and altitude
Examples (Azimuth 315 deg.)

Examples (Altitude 45 deg.)

Caveats
Actual reflectance function of landcover, soil properties
May not account for shadows
'Inversion' can be a problem
  Visual system assumes light from above
  Shading with Southern azimuths = 'below'
    Our brains invert the intended image

Inversion
Harlan, KY: 180 degree Azimuth

Curvature
2nd derivative of terrain
  How is slope changing across landscape?
Profile
  Rate of change in vertical
  Slope increasing, decreasing
Plan
  Rate of change horizontally
  Slope converging, diverging

An 'Ideal' Slope

Applications
Critical for evaluating surface flow
Erosion / landslide risk
Soil Moisture, Organic content, Depth
Anything associated with those factors

Calculating Curvature
4th order polynomial function fit to 3x3 neighborhood
8 output parameters
Combination of these used to calculate:
  Slope (not the same as Horn!)
  Aspect
  Plan Curvature
  Profile Curvature
Examples (Harlan, KY)

**Curvature in the Landscape**
Which color lines are profile?
  - Increasing slopes?
  - Decreasing slopes?
Which are plan?
  - Divergent?
  - Convergent?
Concave?
Convex?

**Impact of Curvature**
Where is erosion occurring?
Where is deposition occurring?
Dampest soils?
Driest soils?

**Curvature ID & Impact II**

**Summary**
Measuring Aspect
  - Visualizing aspect
Hillshading
Curvature
  - Profile
  - Plan
Applications