GEOMORPHIC CHANGE DETECTION

MANAGING RASTER DATA
TOPICS

I. Definitions
II. Problem with Ignoring
III. What ArcGIS does
IV. Why is it so hard to fix? The crux of the problem
V. What GCD requires and why?
VI. Good practice & Workarounds
RASTER TERMINOLOGY

- All rasters have the following primary properties:
  - Number of columns & rows (must be integers)
  - Cell resolution (grid size)
  - Type (integer, floating point precision)
  - Lower left coordinates (x,y) or upper left, upper right, or lower right

- From which the following secondary properties can be derived:
  - Width & Height
ORTHOGONALITY

• Orthogonal rasters must:
  – Share exact same grid resolution
  – Share the exact same grid centers (i.e. aligned in both easting and northing)
CONCURRENCY

• Grids are orthogonal and:
  – Share *exact* same extents
DIMENSIONAL DIVISIBILITY

• Are width & height evenly divisible by cell resolution?

• If not:
  – Does cell resolution or number of rows and columns take the hit?
INTERNAL DIVISIBILITY CONSISTENCY

• The corner coordinates must be evenly divisible by the cell resolution.

• More restrictive than dimensional divisibility, but gives rise to nice rounded extents

• Who cares?
MASKED (NODATA) EXTENTS

- Rasters that have the same masked extents, simply have the same nodata cells
- The mask can be derived from a polygon or a raster
- A concurrent raster mask is the most accurate!
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TO DO MAP ALGEBRA, RASTERS NEED TO BE COMPATIBLE (i.e. Concurrent)

- Compatibility defined by orientation, origin and resolution
SAME NUMBERS & ROWS, BUT...

Same resolution, **different orientation, different origin & extents** (but same width & height)

Same resolution, same orientation, **different origin & extents**

**NOT CONCURRENT**

Different resolution, same orientation, same origin
EVER SEEN SOMETHING LIKE THIS?

- The consistent horizontal and vertical bands are systematic errors!
- They are minor enough, most people ignore them, but they are unnecessary
- They are artifacts of resampling a raster to extents that were not orthogonal to the original raster
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If you give ArcGIS two overlapping but non-orthogonal rasters, it just lets you do the raster algebra...

It does this by a combination of using
- **Environment settings** to select extents and a grid resolution; &
- **Resampling** to make concurrent grids so raster algebra can be done

The result is the geoprocessing tool usually works... and the user has no idea what it did behind the scenes.
THOSE ENVIRONMENT SETTING DEFAULTS...

- For extents, it tends to take the intersection as default...

- For cell size, it tends to take Maximum of inputs:
RESAMPLING... VOODOO

• How?

- Nearest Neighbor
- Bilinear Interpolation
- Cubic Convolution

Distance weighted average of four nearest cell centers
RASTER CREATION

• Let's look at an example...
EXERCISE E – PART 1: FIND PROBLEM

1. Start a New Map Document
2. Load that TIN we just created from TIN3
3. Rerun the TIN to DEM conversion tool with same settings as before
4. Display Properties and inspect extents
   1. What’s wrong?
      1. Concurrency? Orthogonality? Dimensional Divisibility?
5. Open up the `ConcurrencyCalculator.xltx` and enter in extents and find a ‘fix’
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WHERE PROBLEMS COMES FROM

• Most people derive rasters from precise vector data, which introduces unnecessarily specific

• ArcGIS is inconsistent in raster geoprocessing tasks whether it gives priority to grid resolution or numbers of rows and columns
  – If priority is given to grid resolution you’ll often get one extra or one less row or column
  – If priority is given to rows and columns, you will get rounding errors in grid resolution
1. Using Results, open up your Tin to Raster Conversion
2. Manipulate environment settings to impose extents figured out in your XLS worksheet
3. Re-run TIN to Raster (saving new DEM) with correct extents...

If you have the original data... this is the solution desirable.
THE BASTARDIZED COORDINATES

- What’s wrong with that?
MANUALLY FIX...

- Put the spreadsheet numbers in the processing extent:
EXERCISE E – PART 3: TOOL FIX RASTER

1. Using GCD Toolbar, load the ‘Clean Raster’ tool
2. Load the original unfixed DEM...
3. Save new DEM...

Careful with Raster to Raster interpolation... negligible shift okay... change in cell resolution can be problematic.
CLEAN RASTER TOOL

- If you don’t have original raw XYZ data or TIN
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WHAT GCD REQUIRES

- All rasters must have internal divisible consistency
- All DEM Surveys must be orthogonal
- All associated surfaces & error surfaces must be concurrent with parent survey
- Clipped to concurrent intersection for GCD
WHY WE REQUIRE CONCURRENCY?

• No need to introduce further interpolation errors from resampling that the user is unaware of.
• Our underlying code (C++ library) is set up to require this as an input (we don’t use Arc’s geoprocessing for change detection).
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WHAT DO I REALLY NEED?

• Orthogonality?
  – Yes, because if not what cell values do I use?

• Concurrency?
  – Helps, but if some cells only exist within extents of one raster, then no calculation is possible

• All cells have a value (i.e. same masked extents)?
  – Sort of... can only do MOST calculations (e.g. subtraction) when all rasters have a value
  – Some operations (e.g. max) may still be possible
SOME GOOD PRACTICE

• Use even integers wherever possible for extents to simplify orthogonality problems
• NEVER use cell resolutions that are not evenly divisible into width or height of a raster
• ALWAYS, exert explicit control over extents and grid resolution when creating rasters from TINs or Terrains
• Once you get one raster defined, match its extents & cell size in environment settings for all other rasters
• Avoid resampling if at all possible
• If you must resample, be careful not to introduce systematic interpolation errors
TWO EXAMPLE WORKAROUNDS

• Best thing to do is exert explicit control over cell size selection and raster extents at stage of Raster creation from TIN or Terrain, to ensure that raster width and height are evenly divisible by cell size

• That’s not always possible

• Here’s two common problems:
  1. Two non-concurrent DEMs
  2. Two apparently concurrent DEMs, but....