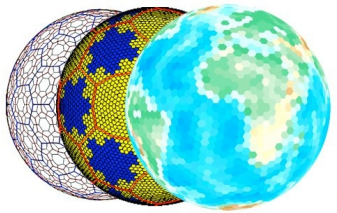
So You're Thinking of Trying a Hex DGGS…

Kevin Sahr
Southern Oregon University
NuDimensions, LLC



SOUTHERN
TERRA
COGNITA
LABORATORY

Our Use Case

- lots of geospatially referenced point data
- want to grid for analysis, visualization, etc.

Discrete Global Grid System (DGGS)

- Discrete Global Grid (DGG):
  - ✦ regular grid that covers the globe
  - ✦ facilitates comparison with other datasets anywhere on earth
- Discrete Global Grid System (DGGS):
  - ✦ multiple DGG resolutions

Cell Shape

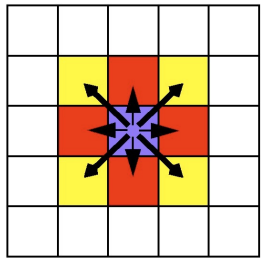
- square grid cells are the most common choice on the plane
- could choose a square-based DGGS…
  - ✦ examples: rHEALPix, Google S2

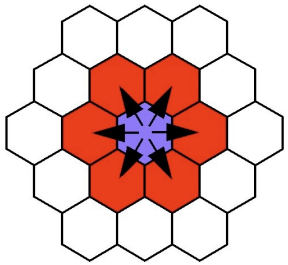
Why Hexagons?

- recall use case: each grid cell represents a set of data points
  - ✦ points near each other most likely to have similar values
  - ✦ compact cells minimize distance between represented points
  - ✦ **hexagons** are the most compact regular polygon that tiles the plane
- tiling requires 13% fewer hexes vs. same resolution squares

Why Hexagons?

- hexagonal neighborhoods are more “circular”
  - ✦ unambiguous neighbors, all same distance from center





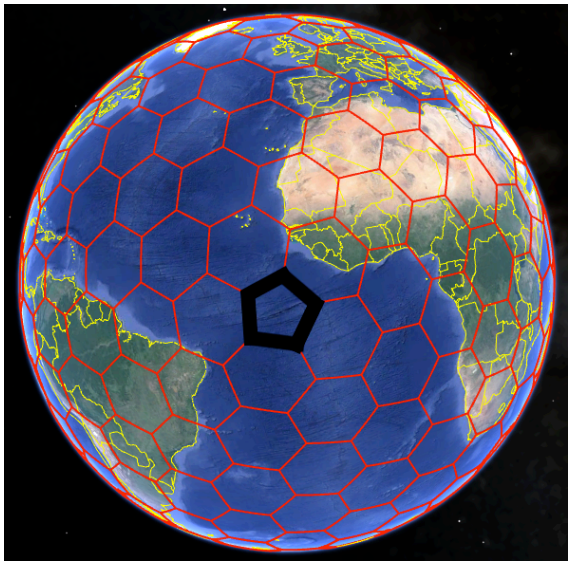
  - ✦ hex grid distance better approximates cartesian distance
- superior angular resolution

Why Hexagons?

- common processing algorithms 25% to 50% more efficient
- raster images less “blocky”/more aesthetically pleasing
- hexagonal grids are nature’s choice:
  - ✦ arrangement of photoreceptors in human eye
  - ✦ internal representation of space in human brain

Pentagons

- NOTE: hexagons can not tile a sphere; some other polygon is required
- common hex DGGS have 12 pentagons at every resolution

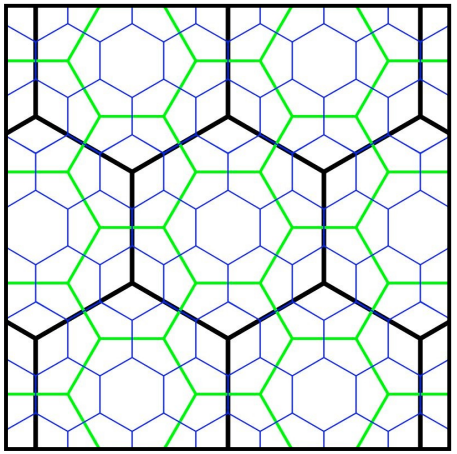


Finer Resolutions

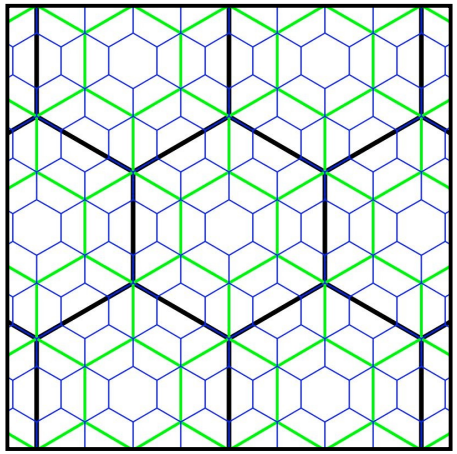
- finer resolution grids created from existing resolution with cells 1/3, 1/4, or 1/7 the area

  ✦ “aperture” of 3, 4, or 7 respectively

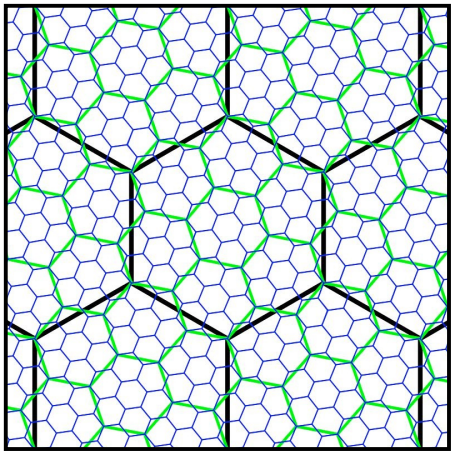
aperture 3



aperture 4



aperture 7



Finer Resolutions

- DGGS can use same aperture for all resolutions
- or different apertures for different resolutions
  - ✦ “mixed aperture” DGGS

Why NOT Hexagons?

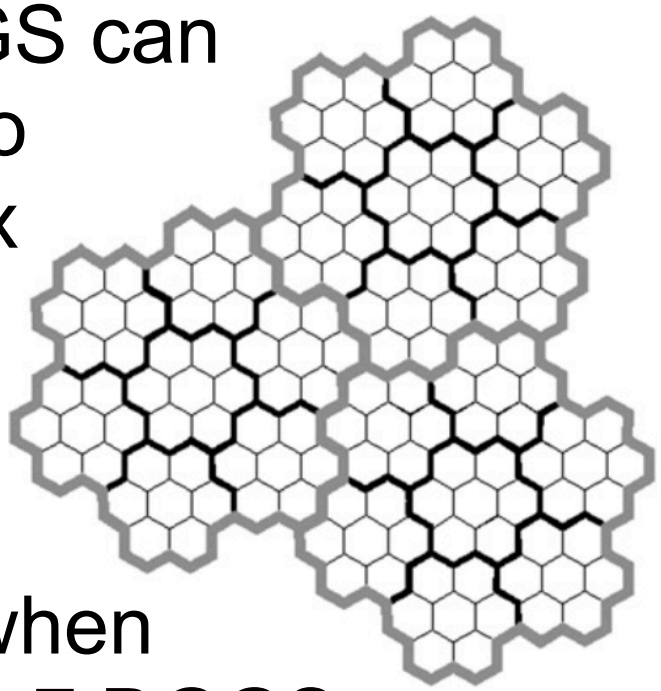
- hexagons don’t “nest” like squares do
  - ✦ can’t create a big hex from smaller hexes
  - ✦ potential problem if you want to build coarser grids from a fine grid

Alternative Approaches

- in our use case we have access to the original point data
  - ✦ bin data directly into each desired grid resolution
  - ✦ can reduce grid artifacts vs. multi-resolution square grids
    - ✤ example: Modifiable areal unit problem (MAUP)

Alternative Approach

- what if we only have access to single resolution gridded data?
  - ✦ cells in an aperture 7 DGGS can be recursively grouped into pseudo-hexagons with hex topology



  - ✦ Uber uses this approach when working with their aperture 7 DGGS **H3**

Why NOT Hexagons?

- lack of tools for working with DGGS (not just hexagonal!)
  - ✦ traditional GIS and geospatial databases treat DGGS cells as arbitrary polygons
  - ✦ no “grid advantage”

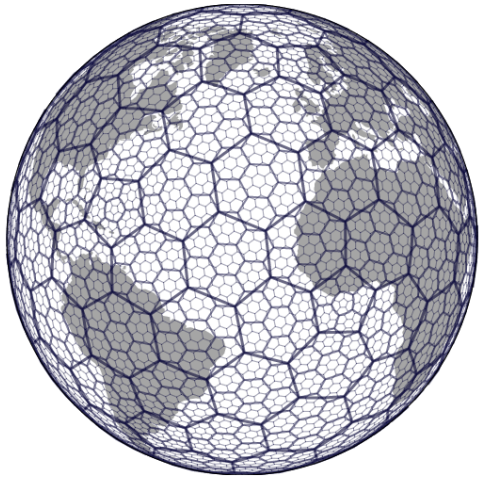
Good Enough

- BUT we can still complete our use case
- GFGS Project FairHair
  - ✦ demonstrated using DGGS cells with existing tools to visualize population data

Hex DGGS Choices

- two most widely used systems:
  - ✦ Uber **H3**
  - ✦ **DGGRID**
- both are open source

H3 Hex DGGS



- aperture 7 DGGS
- open source C library
  - ✦ github.com/uber/h3
  - ✦ developed by Uber for their needs (with help from Kevin)
  - ✦ bindings for Python, JavaScript, and Java

H3 Hex DGGS

- 15 resolutions
  - ✦ finest cells are .9 m^2
- cells are *not* equal area
  - ✦ area varies ~60% over the globe
  - ✦ varies gradually over small areas

Using H3

- **H3** easily integrates into any programming work flow
- lots of user examples available on the web

Using H3

- can experiment with **H3** using **Unfolded Studio** (www.unfolded.ai)
  - ✦ commercial cloud-based geospatial visualization with free tier
  - ✦ built by ex-Uber engineers using Uber open source technologies

DGGRID Software

- open source command-line C++ program for generating and manipulating DGGS
  - ✦ github.com/sahrk/DGGRID
  - ✦ originally developed by Kevin for US EPA

DGGRID Software

- generates many different DGGS, including hex DGGS using:
  - ✦ aperture 3, 4, or 7
  - ✦ any mixed aperture sequence
  - ✦ equal area cells using ISEA projection
- over 100 different resolution grids possible

Using DGGRID

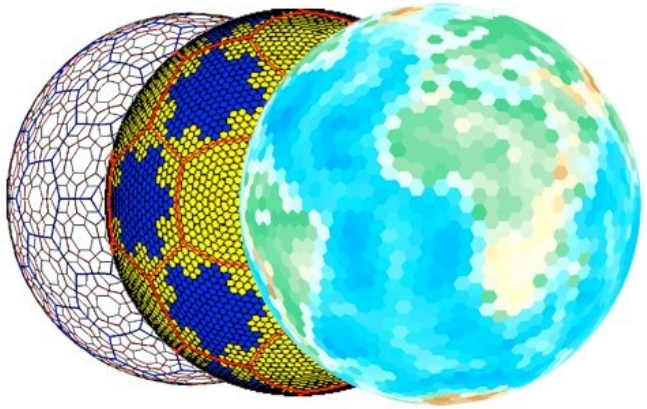
- build/use **DGGRID** from command line
  - ✦ steep learning curve
- often used via **dggridR**
  - ✦ **R** wrapper for **DGGRID** functionality by Richard Barnes
  - ✦ allows grid generation, visualization, etc. in **R**
  - ✦ github.com/r-barnes/dggridR

An Offer

- want to experiment with hex DGGS without dealing with **DGGRID**?
  - ✦ Kevin will generate ISEA grid shapefiles for ~5 randomly selected participants
  - ✦ in return we ask that you prepare a slide on your experience using hex DGGS for a future Coffee Talk

Offer Details

- to participate, email sahrk@sou.edu with:
  - ✦ desired study area
  - ✦ approximate finest desired cell area
  - ✦ brief description of intended use/data set
- participants will be randomly selected from amongst emails received by Thursday, May 6, 2021



SOUTHERN
TERRA
COGNITA
LABORATORY

www.discreteglobalgrids.org