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Discrete Global Grid Systems – A Framework for the Next Era in Big Earth Data

A New OGC Standard Digital Earth Spatial Reference System

OGC DGGS Standards Working Group
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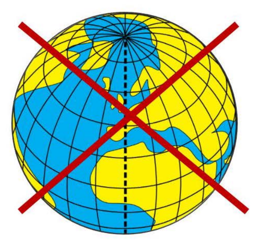
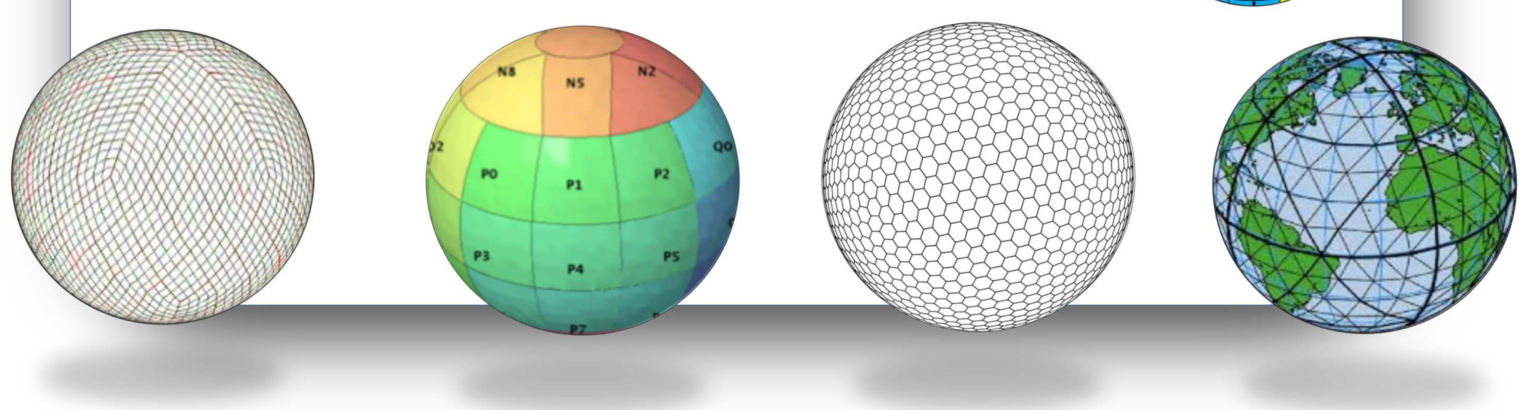
What is a Discrete Global Grid System?

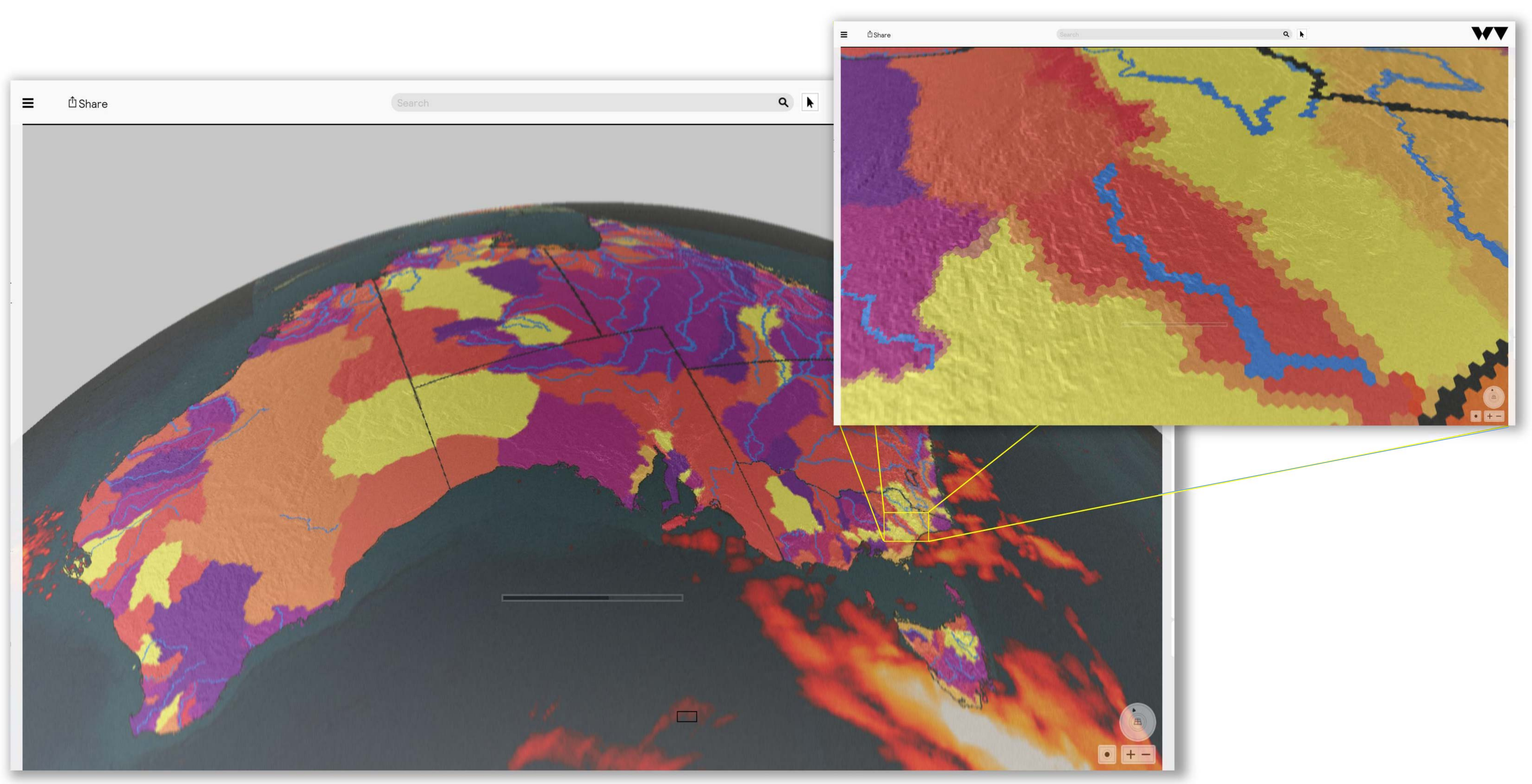
A Discrete Global Grid System (DGGS) is a spatial reference system that uses a hierarchical tessellation of equal area cells to partition and address the globe.

A DGGS is characterized by the properties of its:

- **Cell structure,**
- **Geo-encoding,**
- **Quantization strategy, and**
- **Associated mathematical functions.**

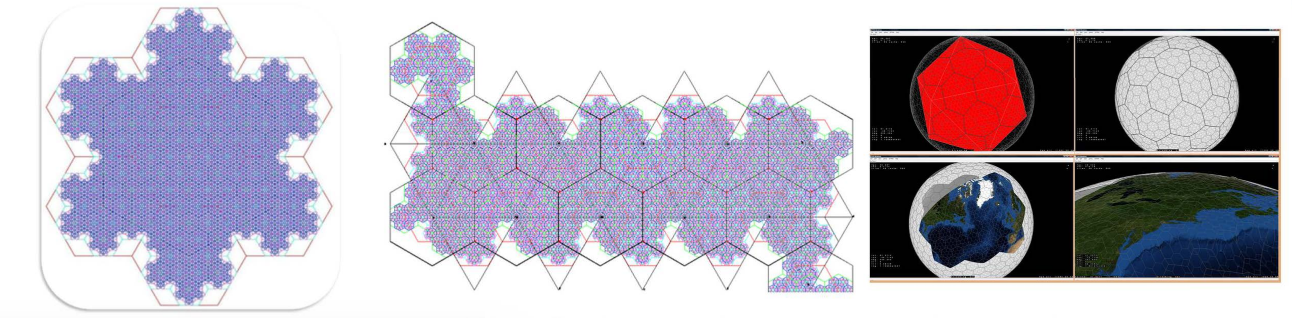






Data Values are Stored in Infinitesimal Cells

See DGGS in Action



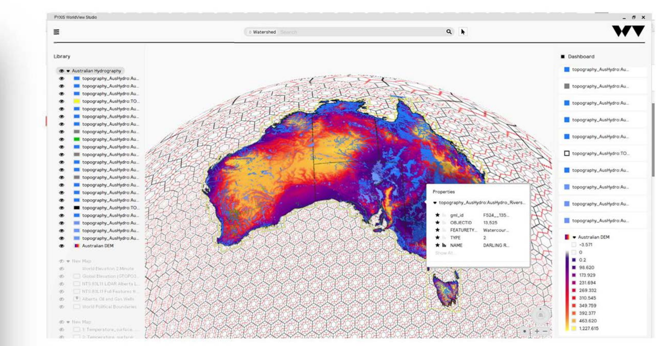


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Table 1: Criteria for DGGS characteristics have been proposed by both Goodchild and Kimerling, al. la Keith Clarke 2000.

DGGS Criteria in Goodchild (Goodchild, 1994)	
G1.	Each area contains one point
G2.	Areas are equal in size
G3.	Areas exhaustively cover the domain
G4.	Areas are equal in shape
G5.	Points form a hierarchy preserving some (undefined) property for m < n points
G6.	Areas form a hierarchy preserving some (undefined) property for m < n areas
G7.	The domain is the globe (sphere, spheroid)
G8.	Edges of areas are straight on some projection
G9.	Areas have the same number of edges
G10.	Areas are compact
G11.	Points are maximally central within areas
G12.	Points are equidistant
G13.	Edges are areas of equal length
G14.	Addresses of points and areas are regular and reflect other properties
DGGS Criteria in Kimerling. (Kimerling, Sahr, White, & Song, 1999) Goodchild's Numbers given in parentheses	
K1.	Areal cells constitute a complete tiling of the globe, exhaustively covering the globe without overlapping. (G3,G7)
K2.	Areal cells have equal areas. This minimizes the confounding effects of area variation in analysis, and provides equal probabilities for sampling designs. (G2)
K3.	Areal cells have the same topology (same number of edges and vertices). (G9, G14)
K4.	Areal cells have the same shape. Ideally a regular spherical polygon with edges that are great circles. (G4)
K5.	Areal cells are compact. (G10)
K6.	Edges of cells are straight in a projection. (G8)
K7.	The midpoint of an arc connecting two adjacent cells coincides with the midpoint of the edge between the two cells.
K8.	The points and areal cells of the various resolution grids which constitute the grid system form a hierarchy which displays a high degree of regularity. (G5,G6)
K9.	A single areal cell contains only one grid reference point.(G1)
K10.	Grid reference points are maximally central within areal cells. (G11)
K11.	Grid reference points are equidistant from their neighbors. (G12)
K12.	Grid reference points and areal cells display regularities and other properties which allow them to be addressed in an efficient manner.
K13.	The grid system has a simple relationship to latitude and longitude.
K14.	The grid system contains grids of any arbitrary defined spatial resolution. (G5,G6)

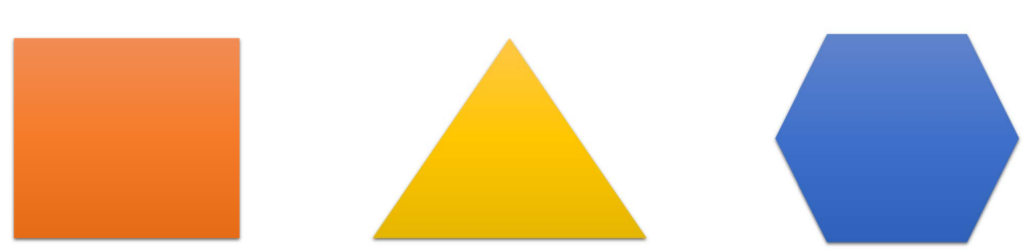
Notable Criterion

Choice of Cells

There are **many possible DGGS**, each with their own advantages and disadvantages.

Criteria for choosing an appropriate tessellation include properties of **shape, adjacency, connectivity, orientation, self-similarity, decomposability, and packing properties.**

There are only three shapes that provide regular tiling of the plane: **quadrilateral, triangle, and hexagon.**



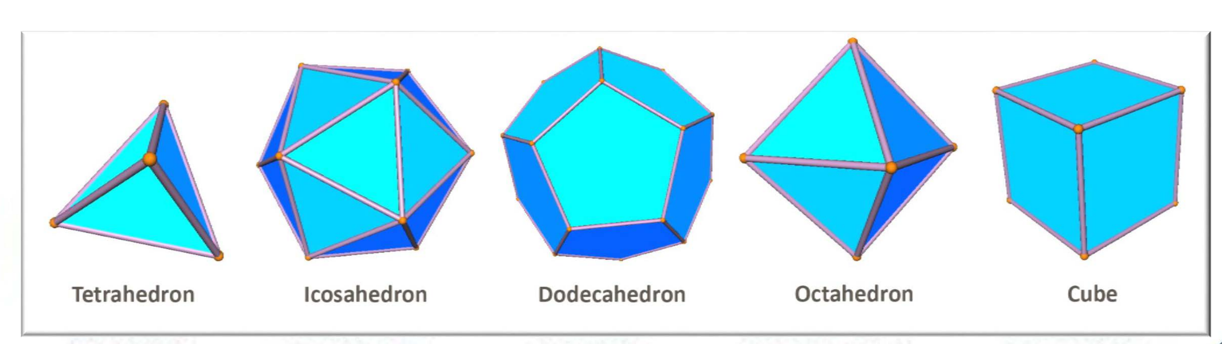
Essentially, squares are familiar, triangles are fast, and hexagons the finest fit.

Equal Area Partitioning the Earth

The generation of a tessellation over a representation of the Earth is mathematically intensive.

Most methods start with regular **polyhedron** and then **project** the cells to the sphere.

Preservation of cell area is an essential trait when a DGGS is intended to represent information consistently across the entire globe at the same resolution.



Uniquely Index Each Cell

Each cell must have a unique identifier.

Hierarchy-based, space-filling curves, and axes methods of indexing have been used to uniquely address cells.

Indexing that provides **nearest neighbour, fast linear ordering, and parent-child relationships** are the most common.

Indexing types can generally be transformed from one to the other.