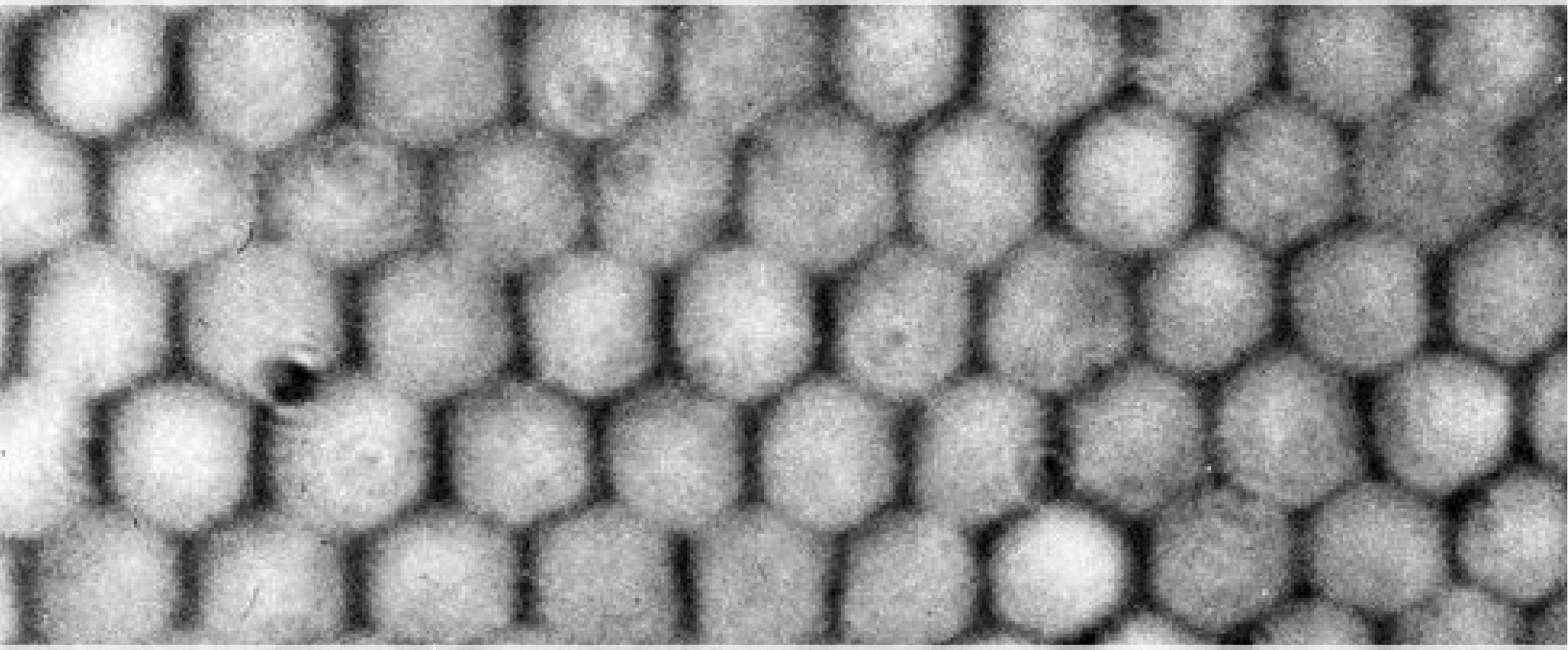
Discrete Global Grids

what they are – how to use them



Richard Barnes

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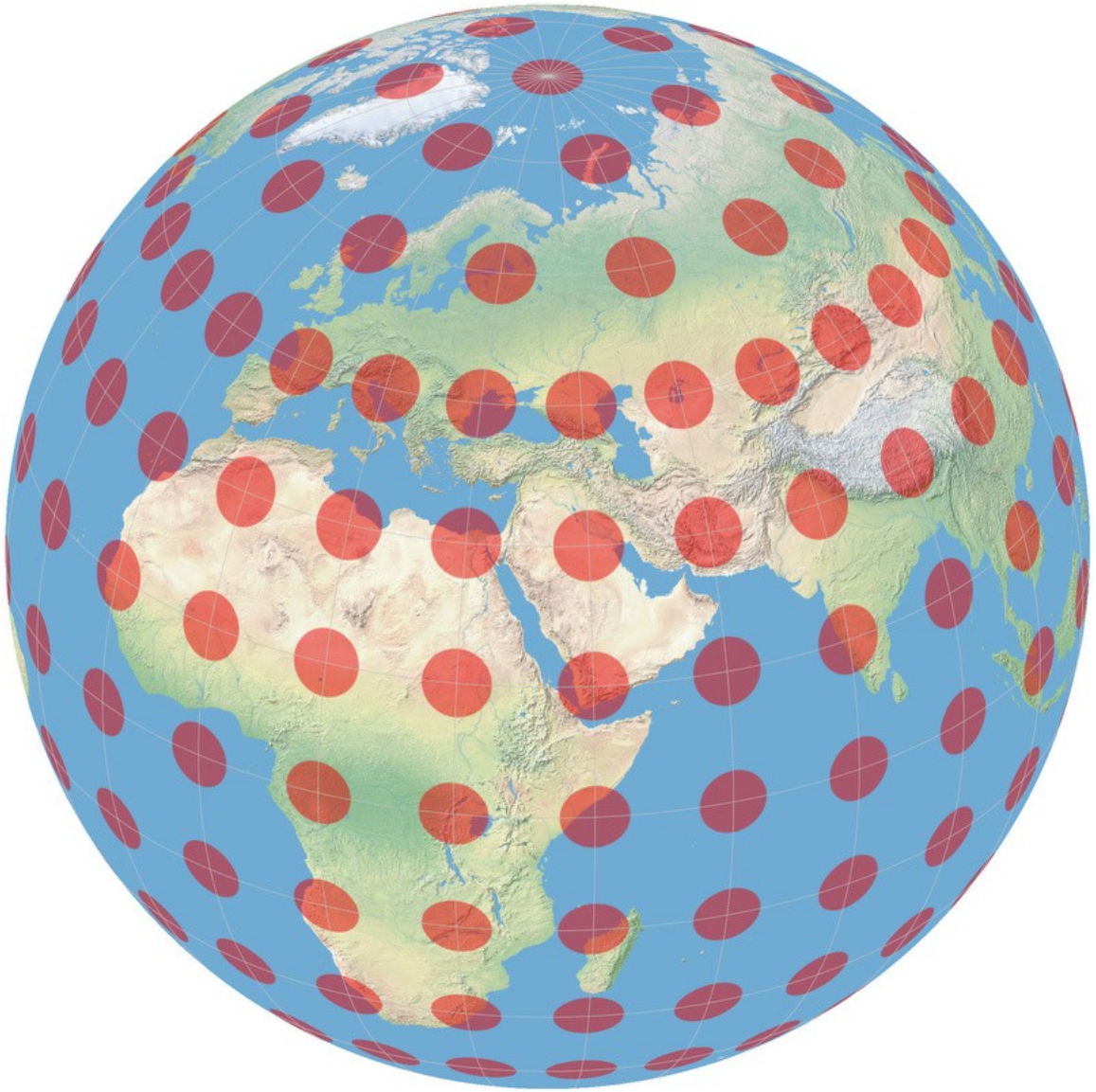
Not to worry about projections

Equal-sized cells/bins for stats

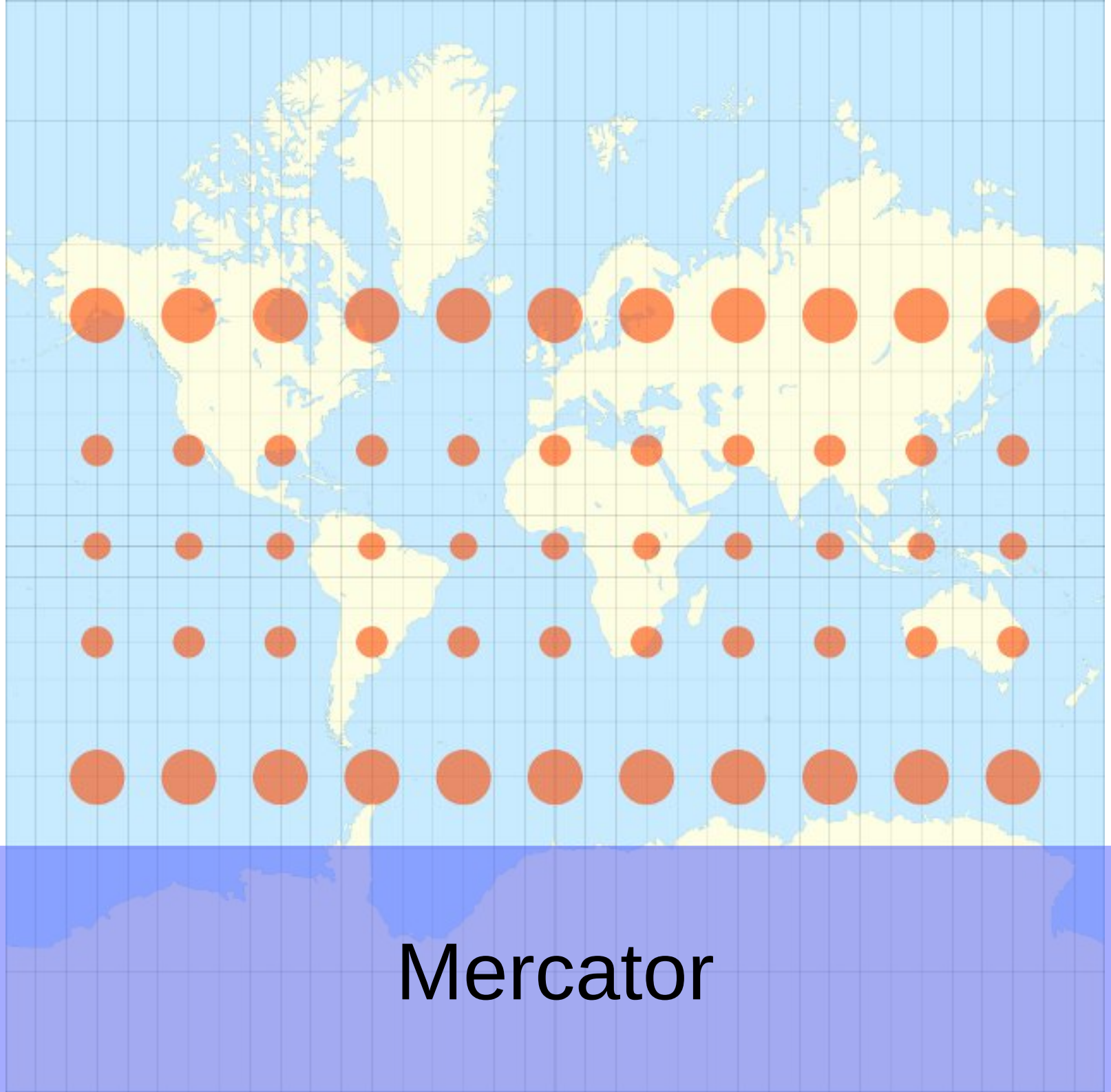
Fast neighbour-cell addressing

(Anything you might use geohashing for)

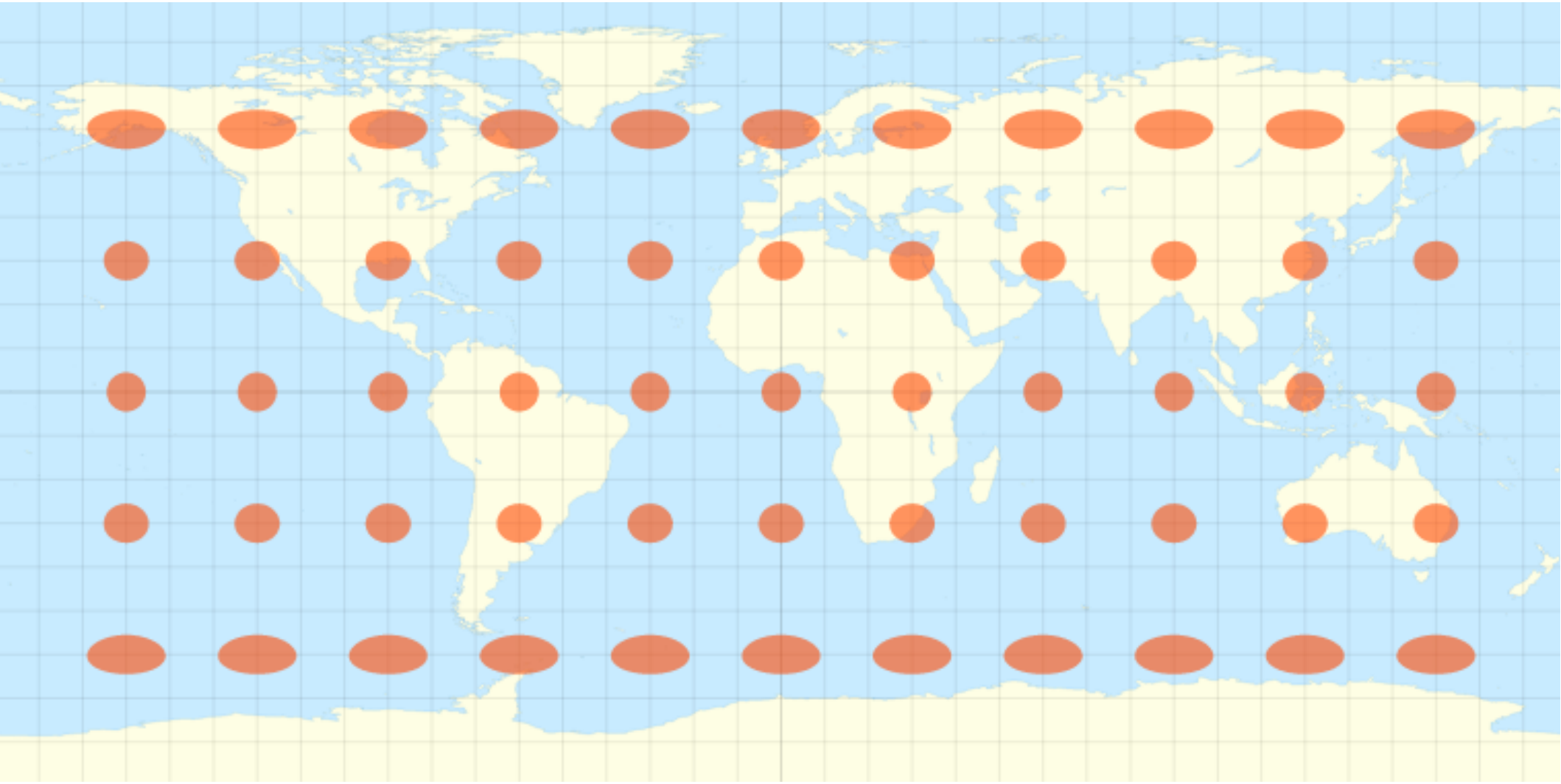
What do we want?



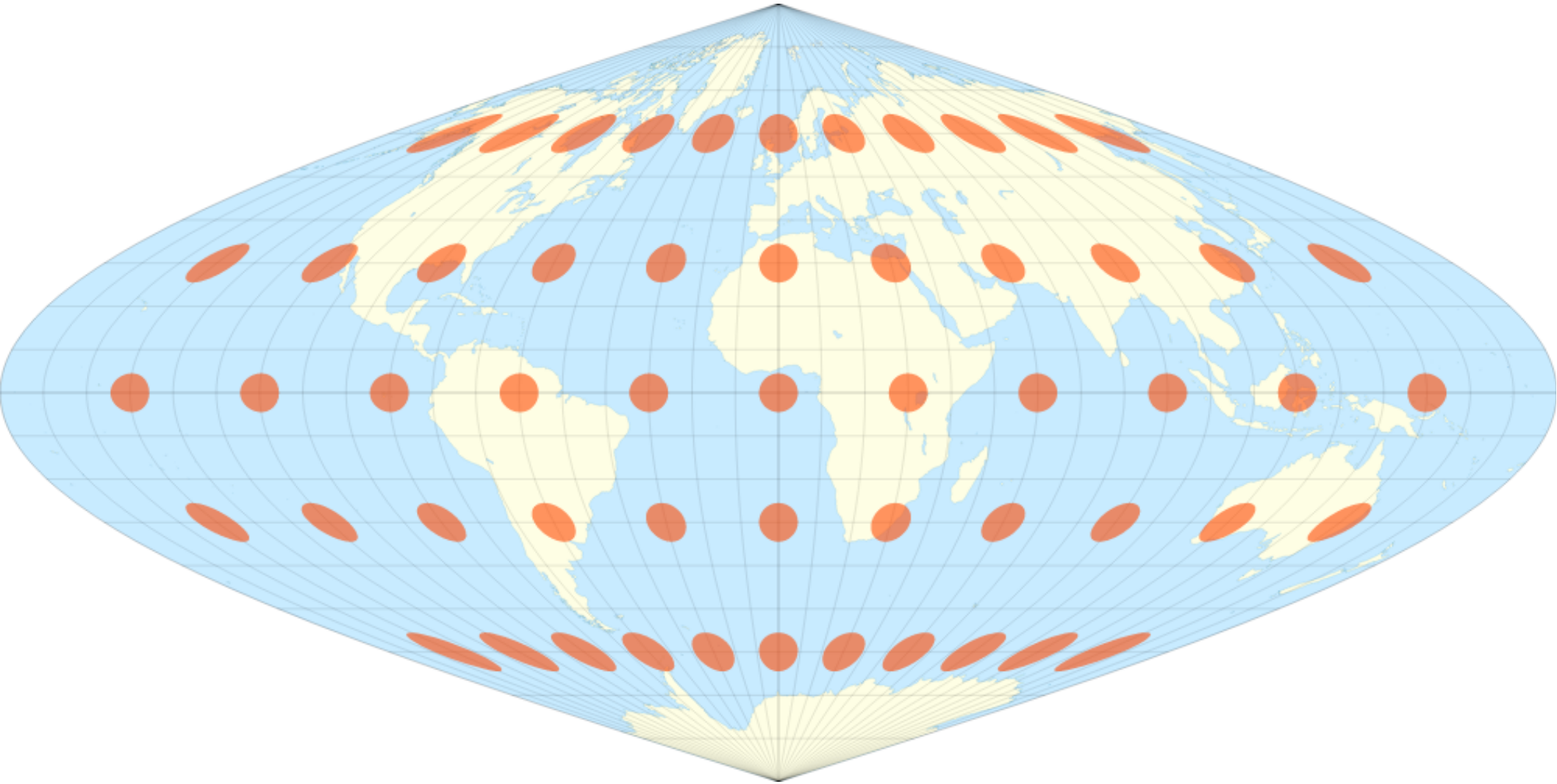
Distortion: Tissot’s Indicatrix



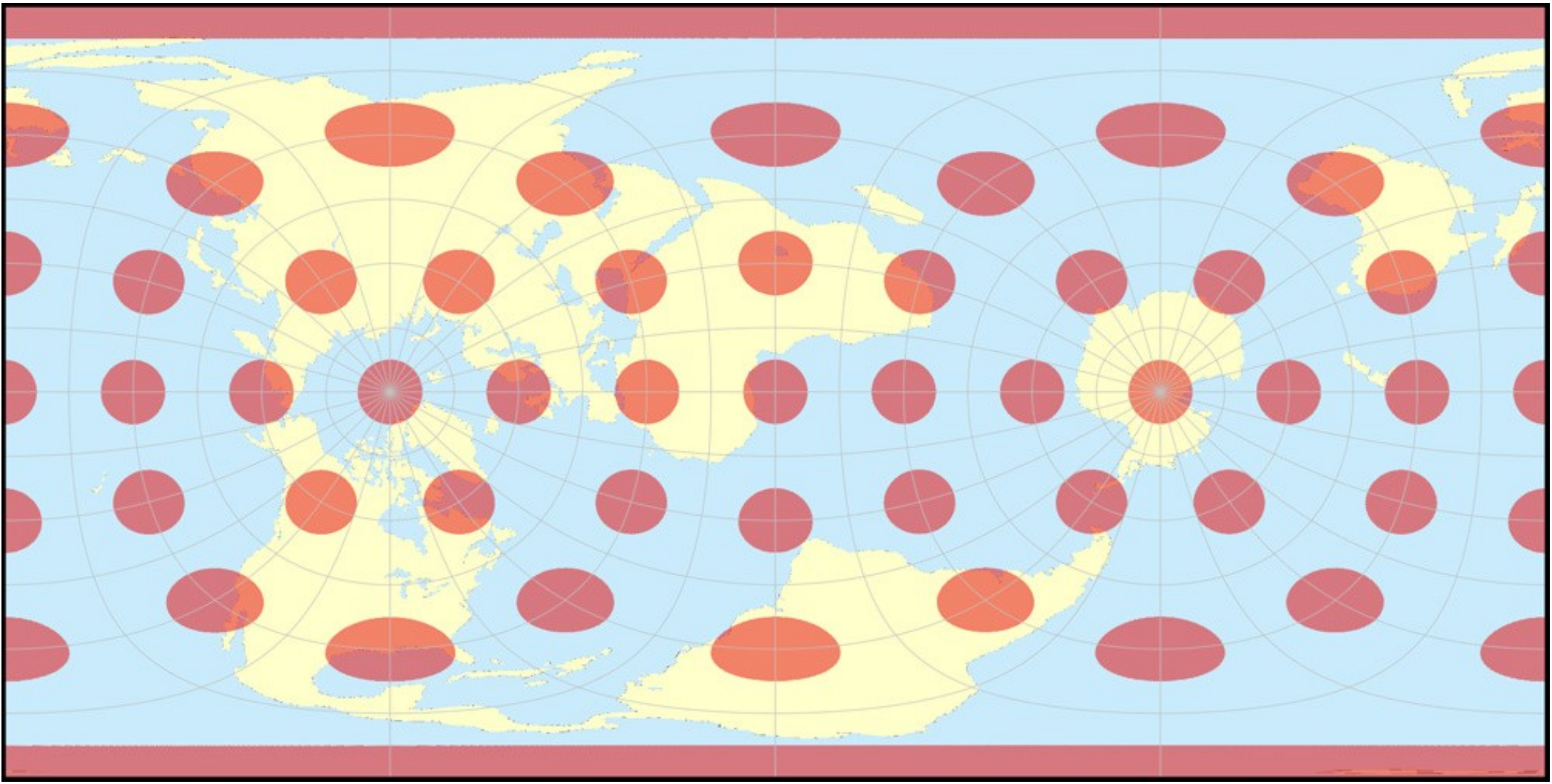
Mercator



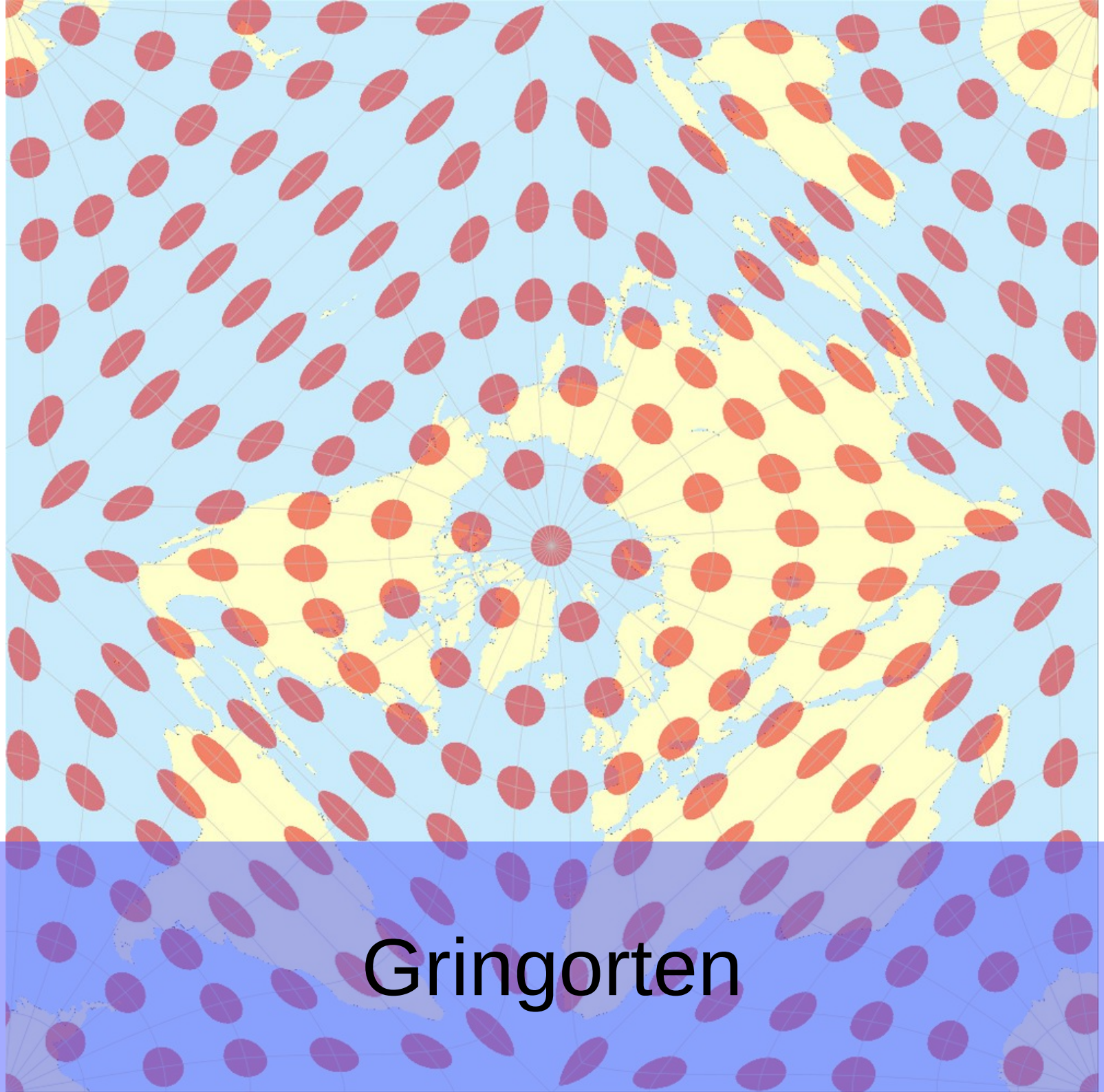
Equirectangular

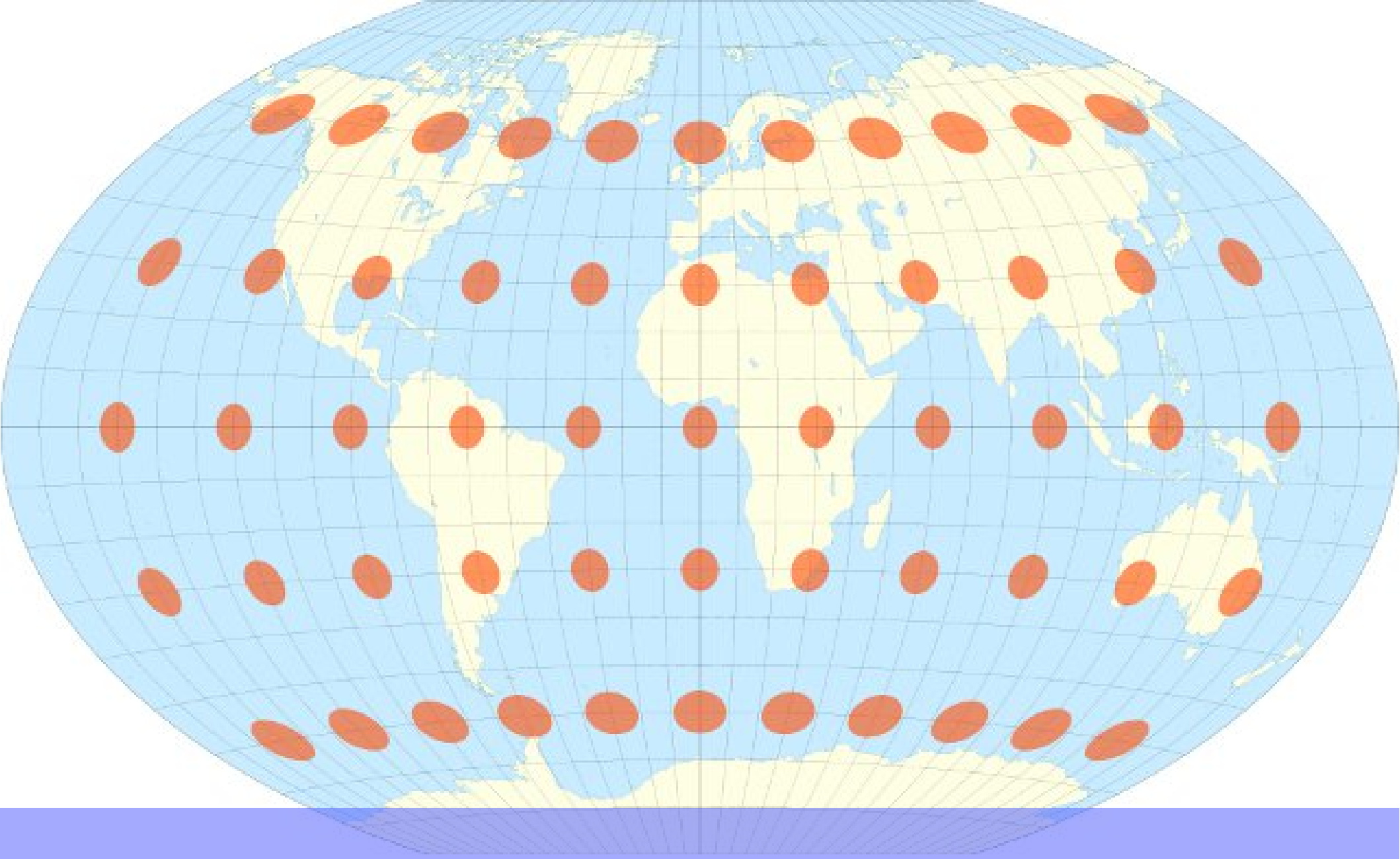


Sinusoidal

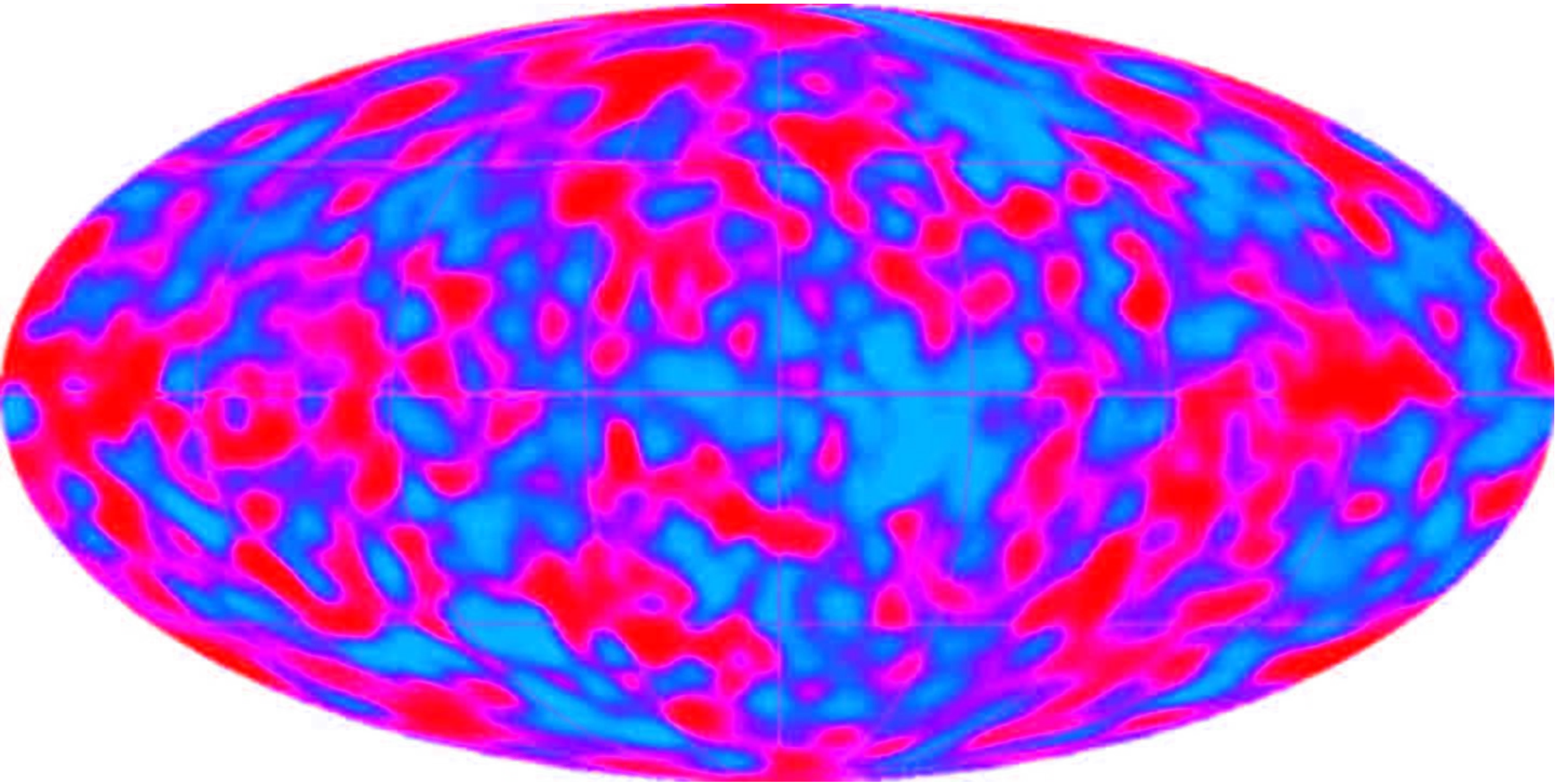


Cassini

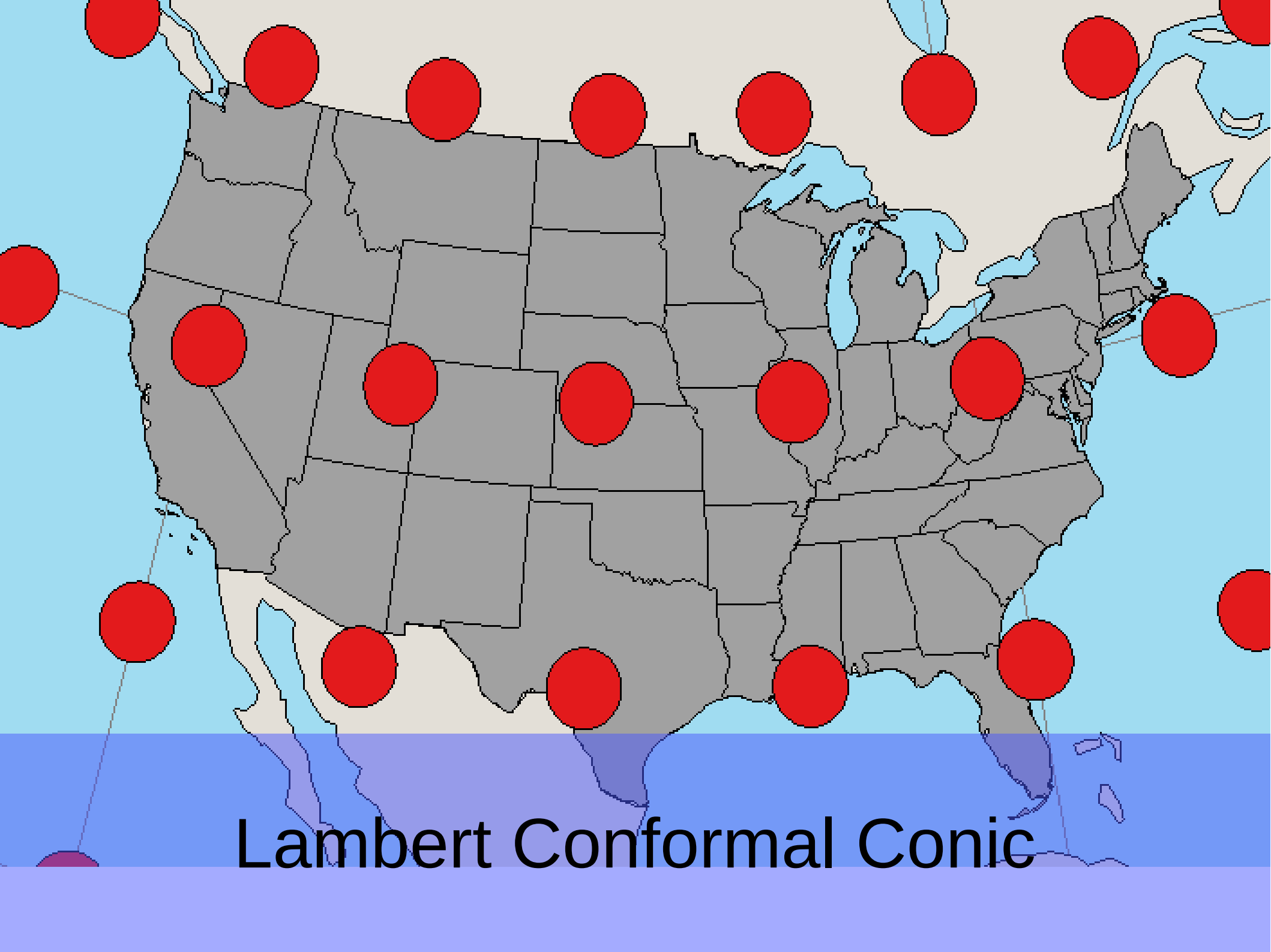

Gringorten

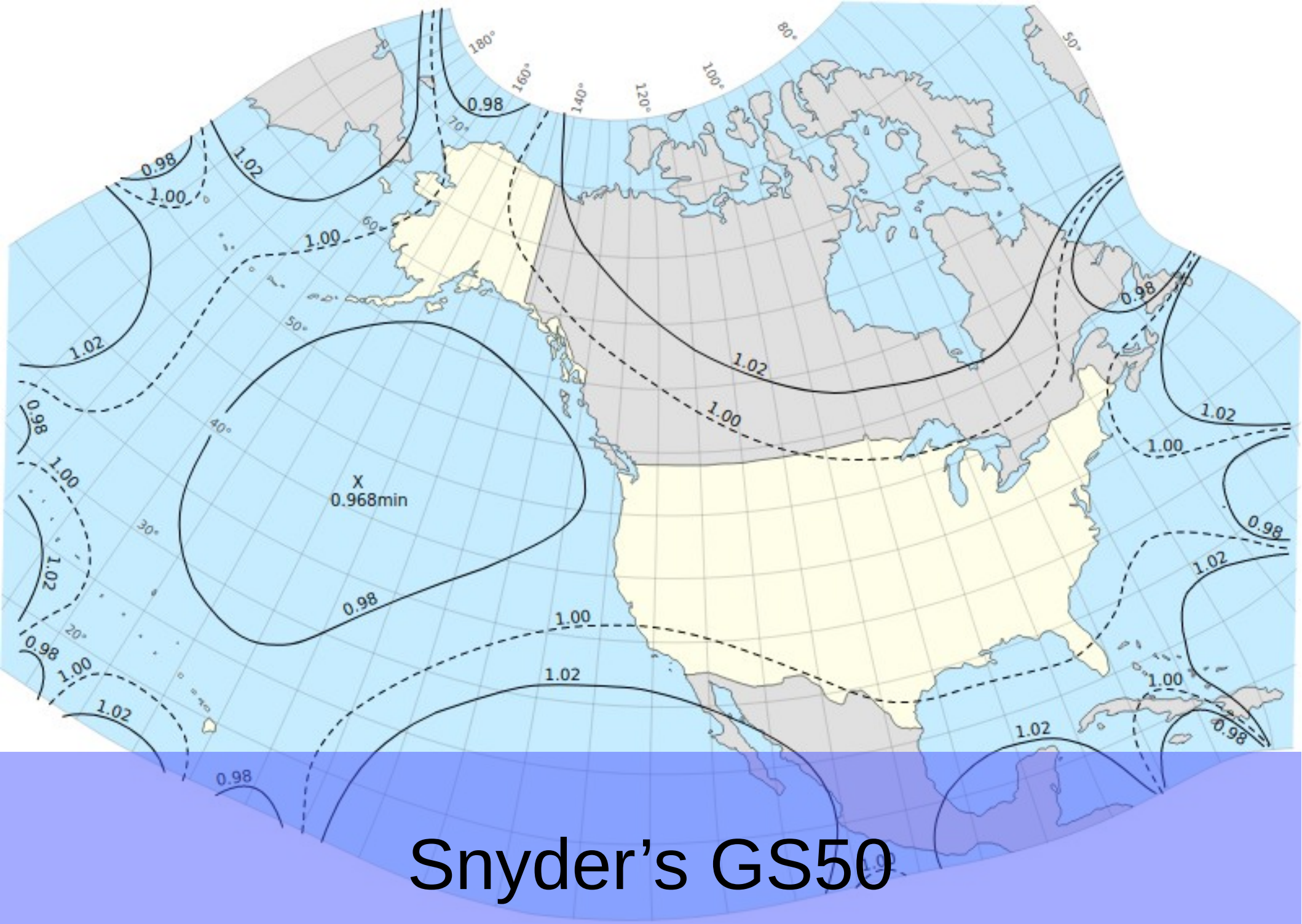


Winkel III

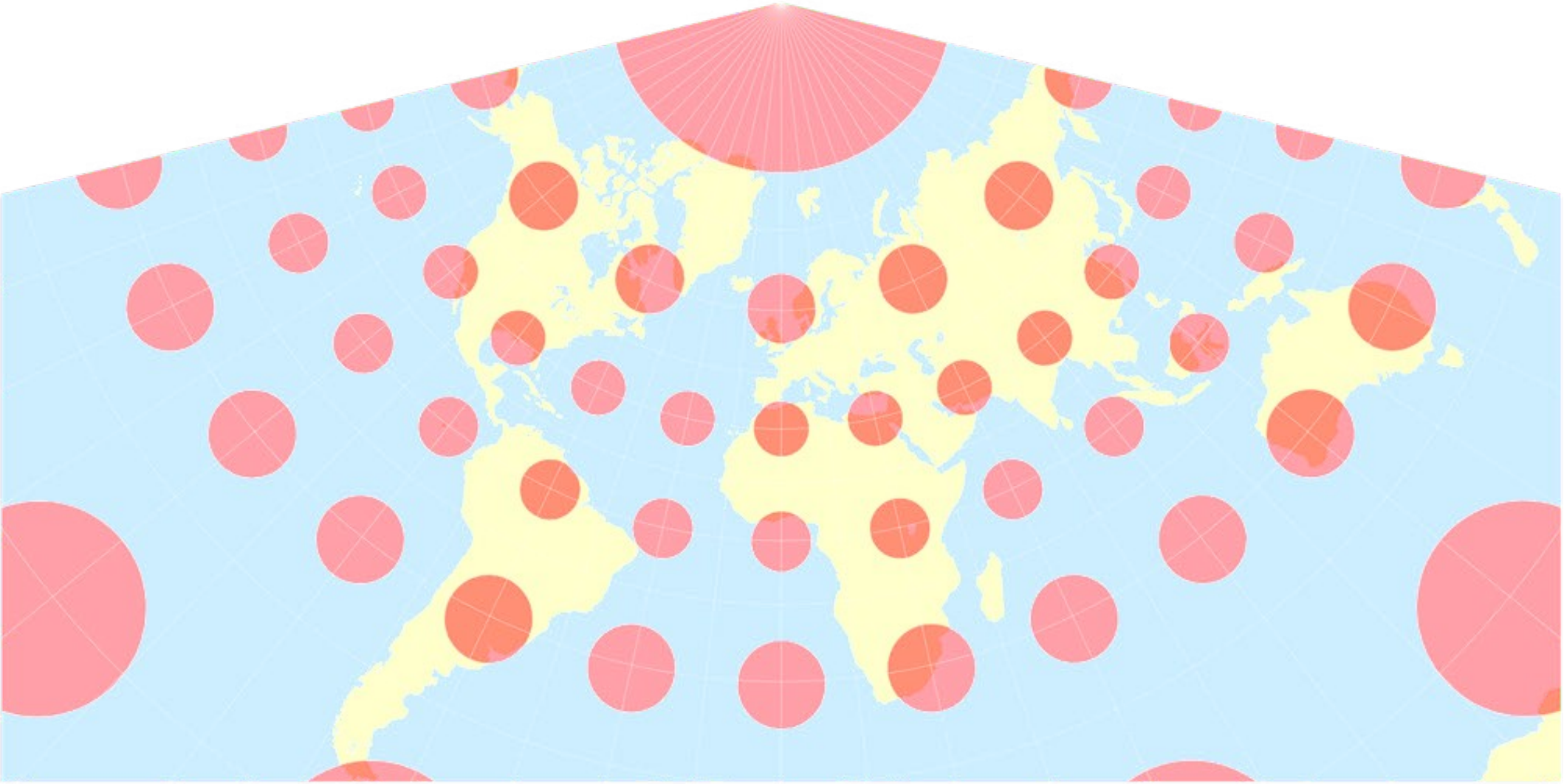


“CMB” Projection

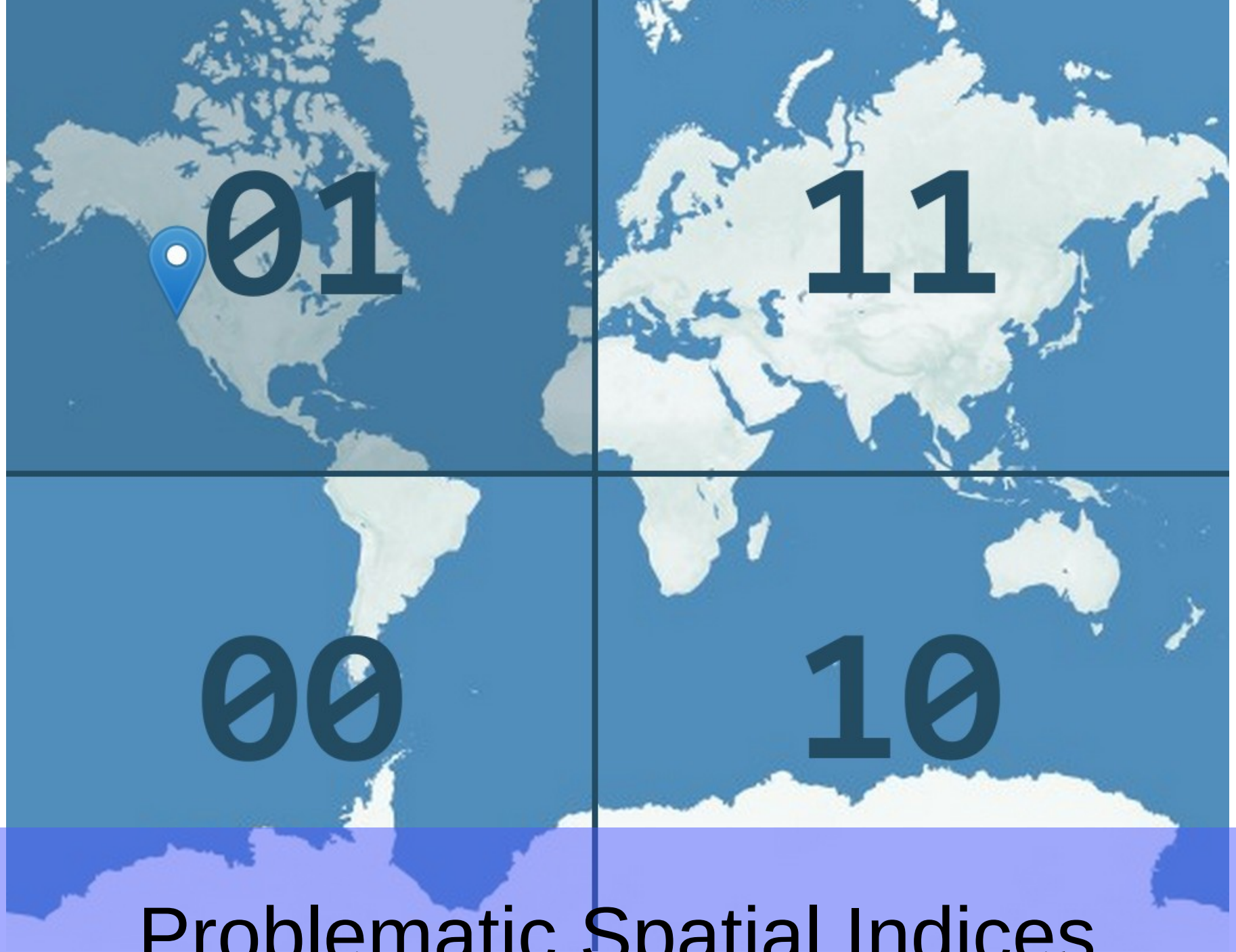

Lambert Conformal Conic



Snyder’s GS50



Lambert Conformal Conic



Problematic Spatial Indices

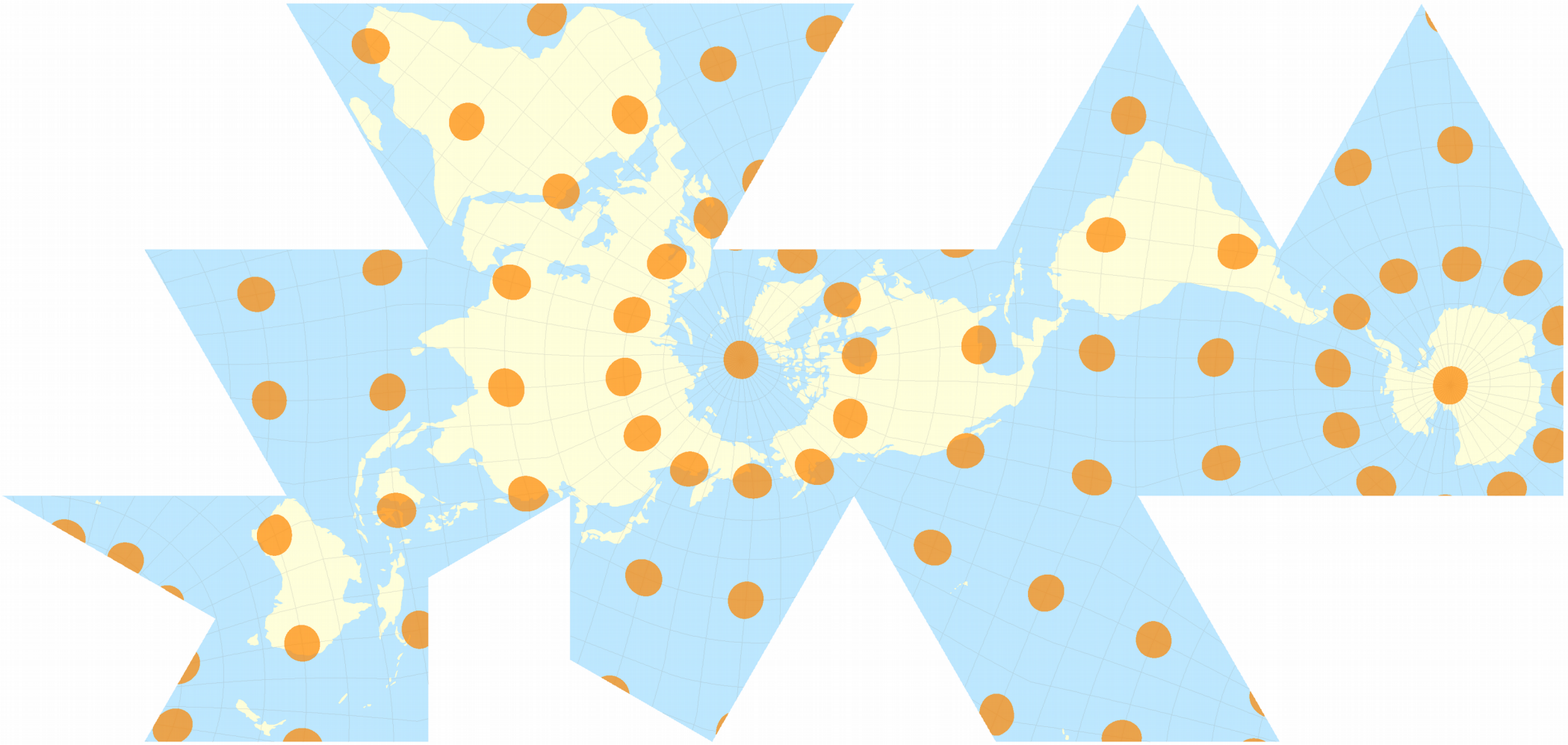
(Mapzen.com)

Discrete global grid system evaluation criteria as proposed by Goodchild (1994) and modified by Kimerling et al. (1999)

1. Areal cells constitute a complete tiling of the globe, exhaustively covering the globe without overlapping
2. Areal cells have equal areas
3. Areal cells have the same topology
4. Areal cells have the same shape
5. Areal cells are compact
6. Edges of cells are straight in a projection
7. The midpoint of an arc connecting two adjacent cells coincides with the midpoint of the edge between the two cells
8. 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
9. A single areal cell contains only one grid reference point
10. Grid reference points are maximally central within areal cells
11. Grid reference points are equidistant from their neighbors
12. Grid reference points and areal cells display regularities and other properties which allow them to be addressed in an efficient manner
13. The grid system has a simple relationship to the latitude and longitude graticule
14. The grid system contains grids of any arbitrary defined spatial resolution

Design Goals

(Goodchild 1994 & Kimerling et al 1999)



Fuller

Polyhedra

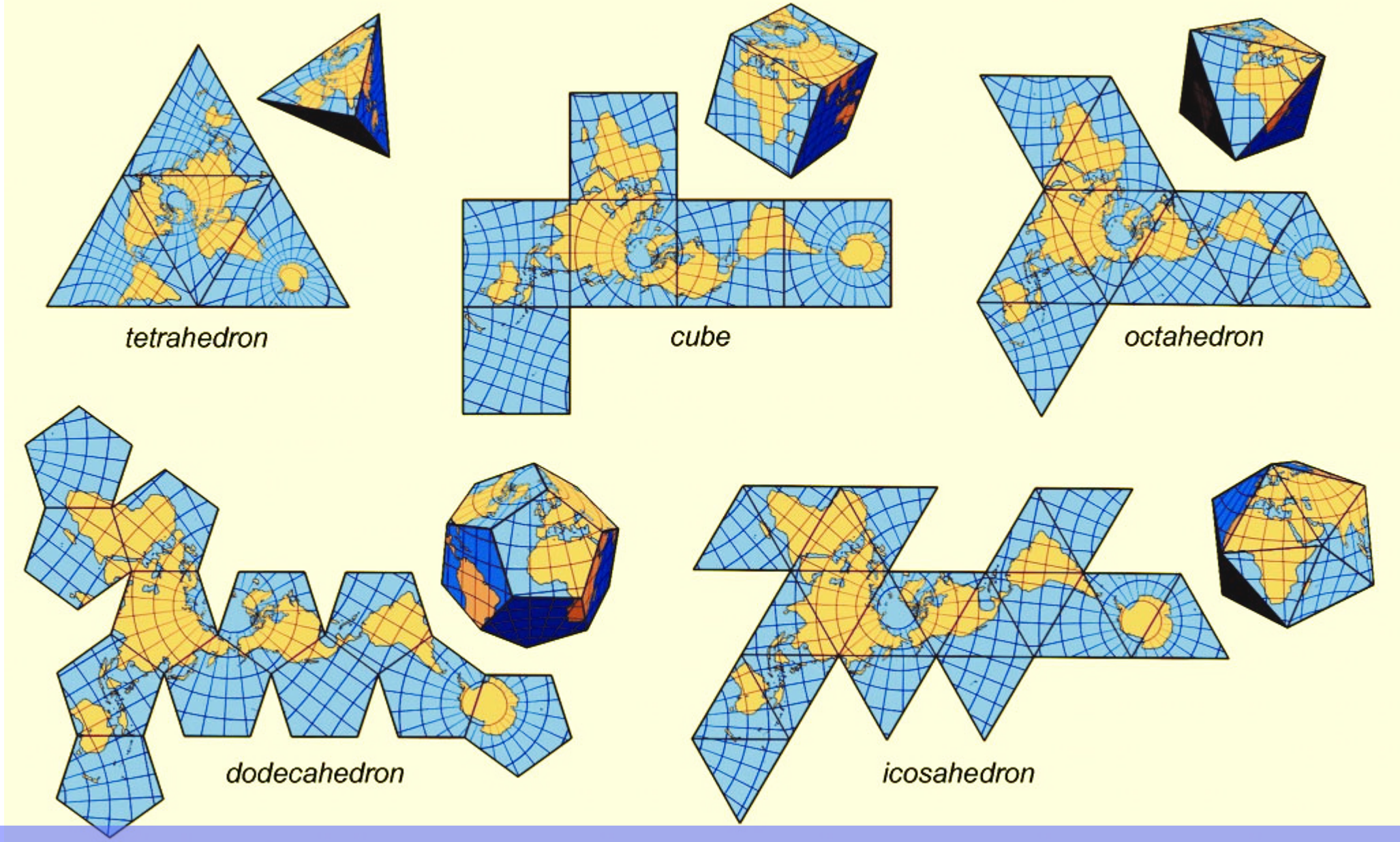
Orientation

Partitioning

Transformation

Design Choices

GOURMET POPCORN

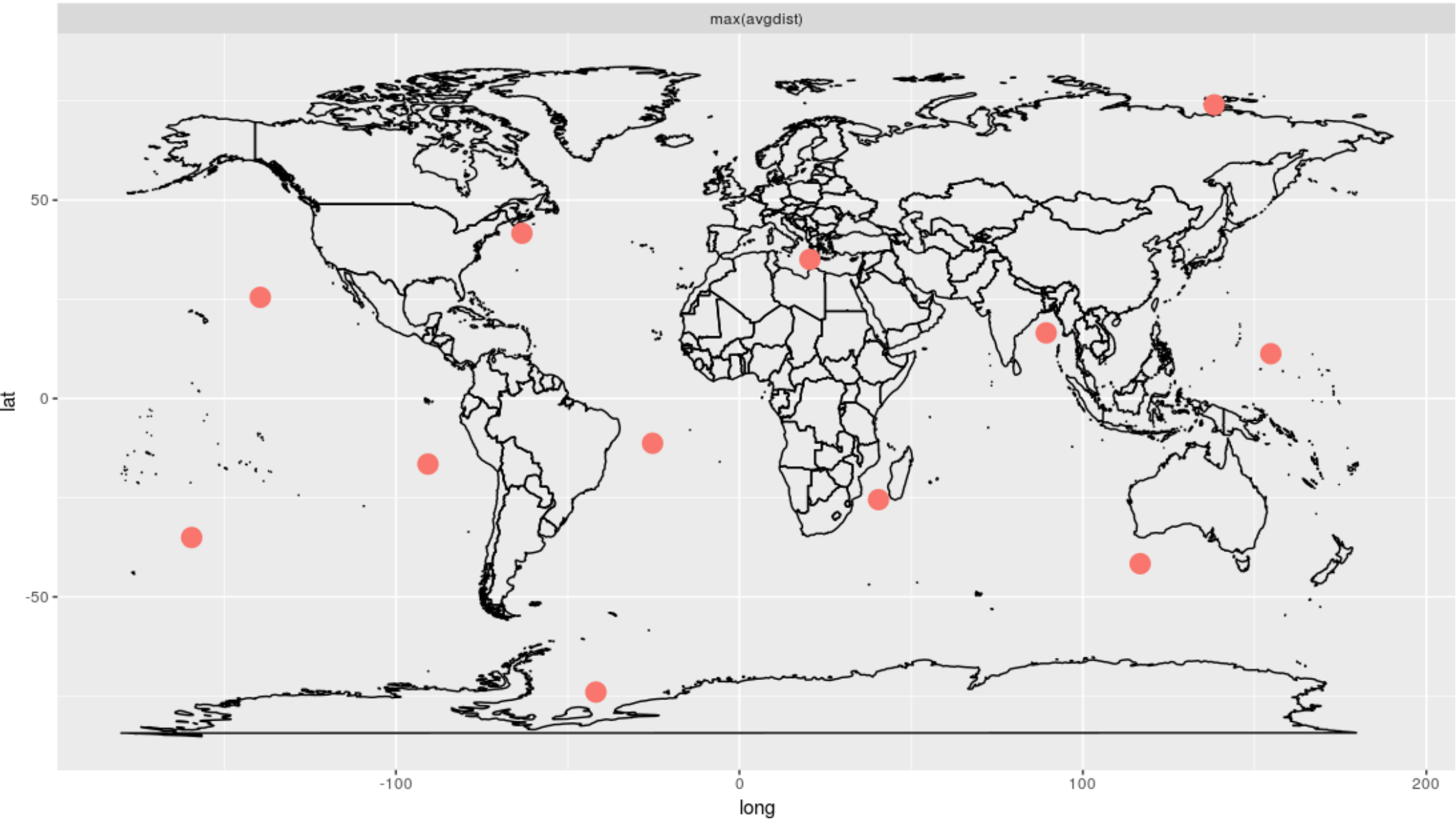


Design Choice: Polyhedra

(van Wijk 2008)

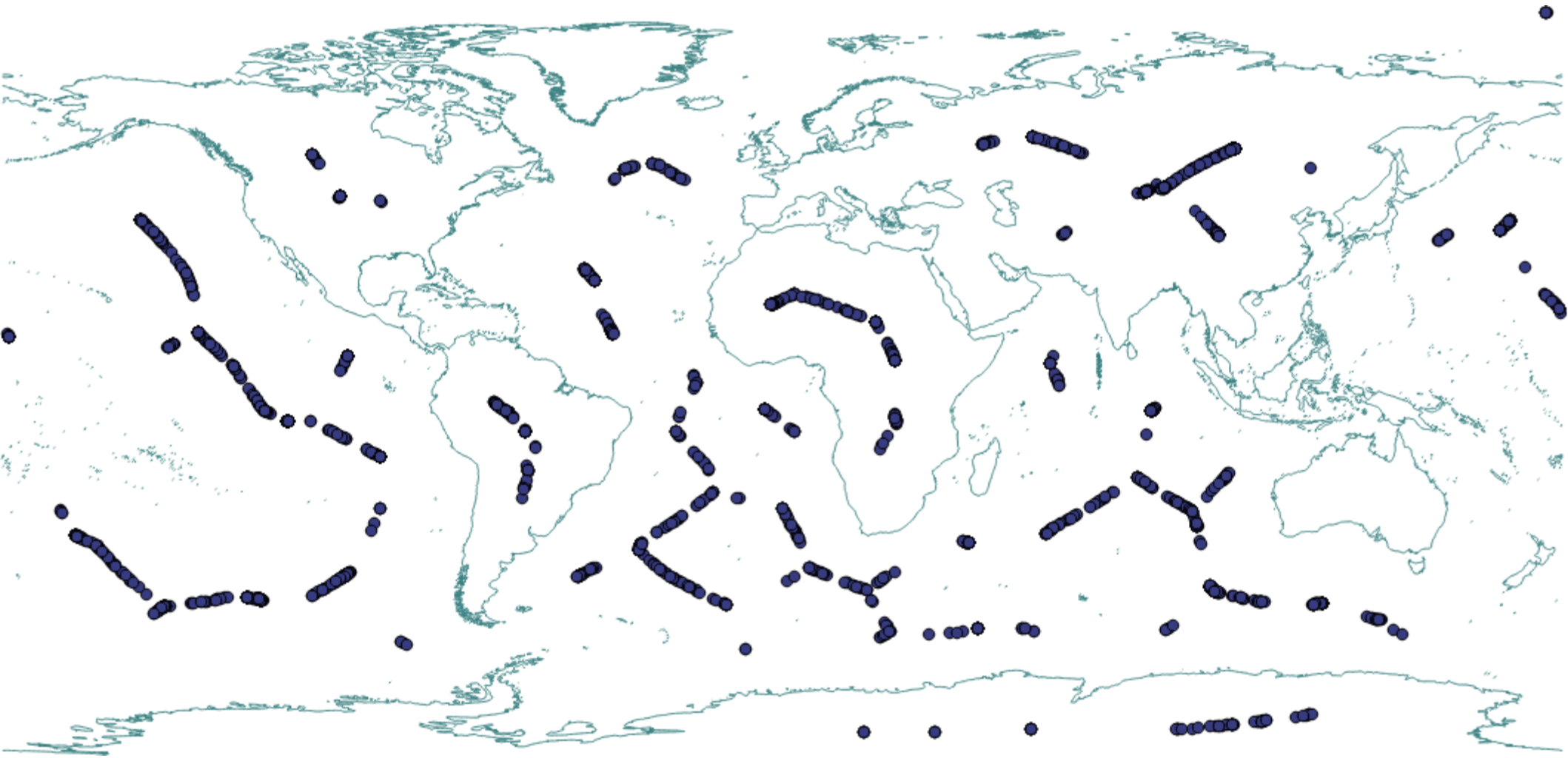
Design Choice: Polyhedra

(Hafner and Zitko)



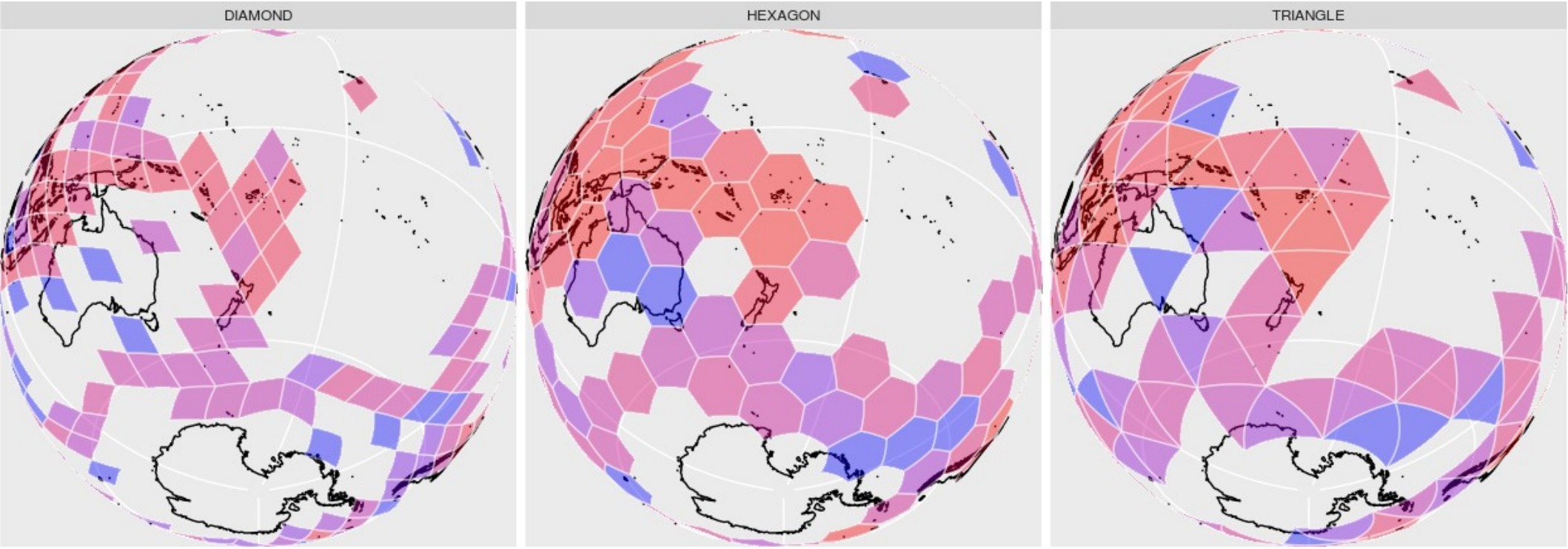
Design Choice: Orientation

(Barnes, in-progress – almost done!)



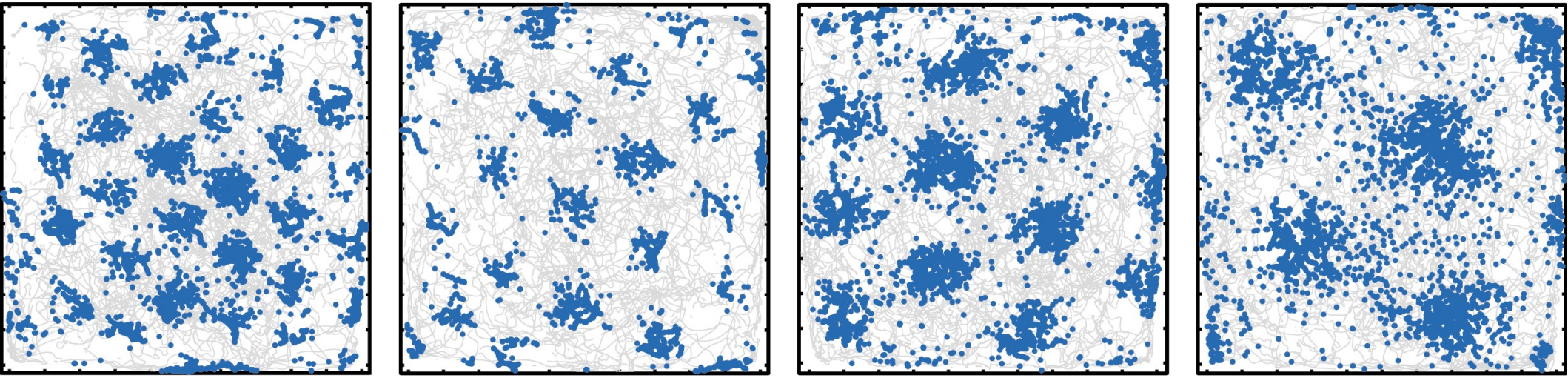
Design Choice: Orientation

(Barnes, in-progress – almost done!)



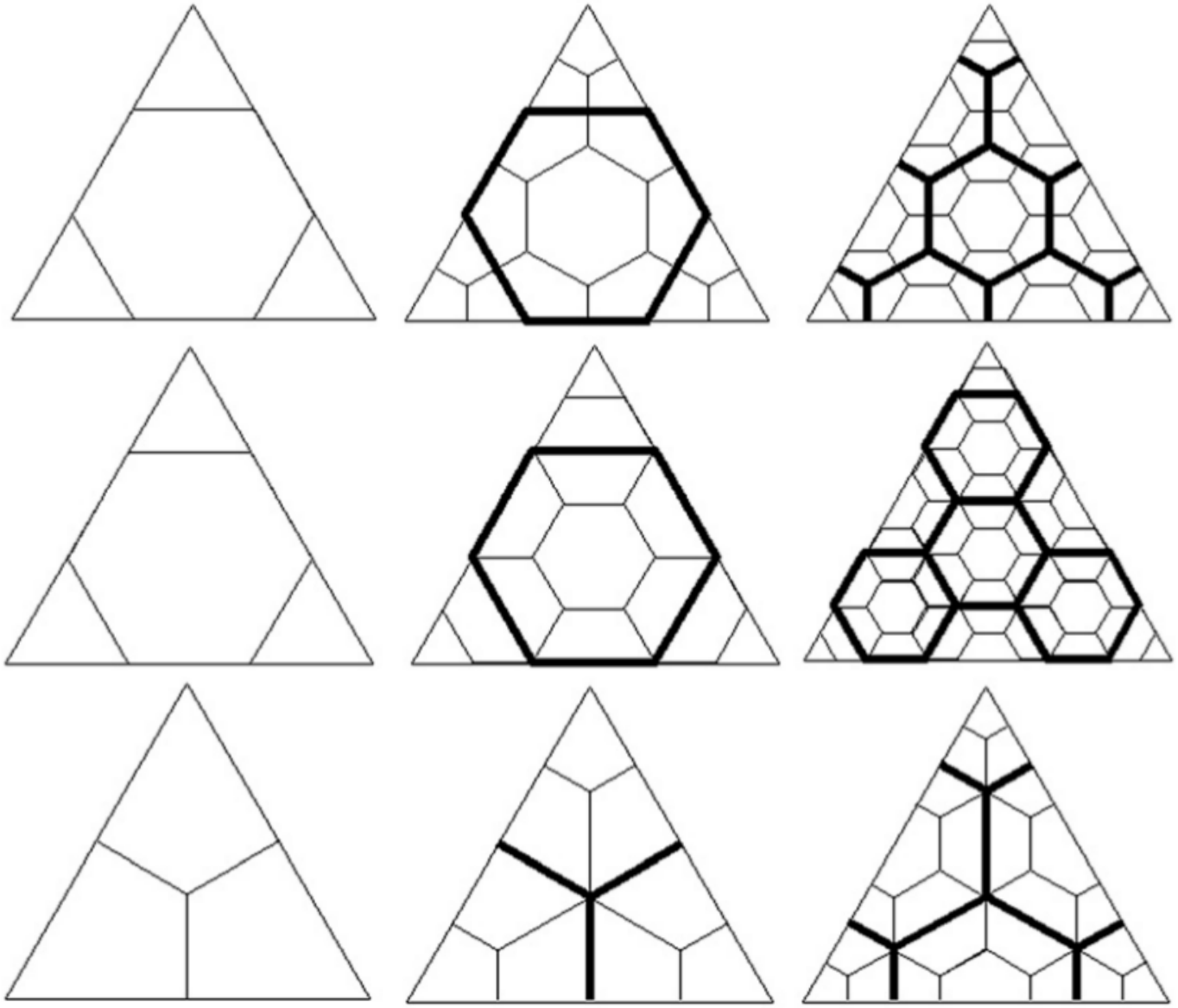
Design Choice: Partition

(Barnes)



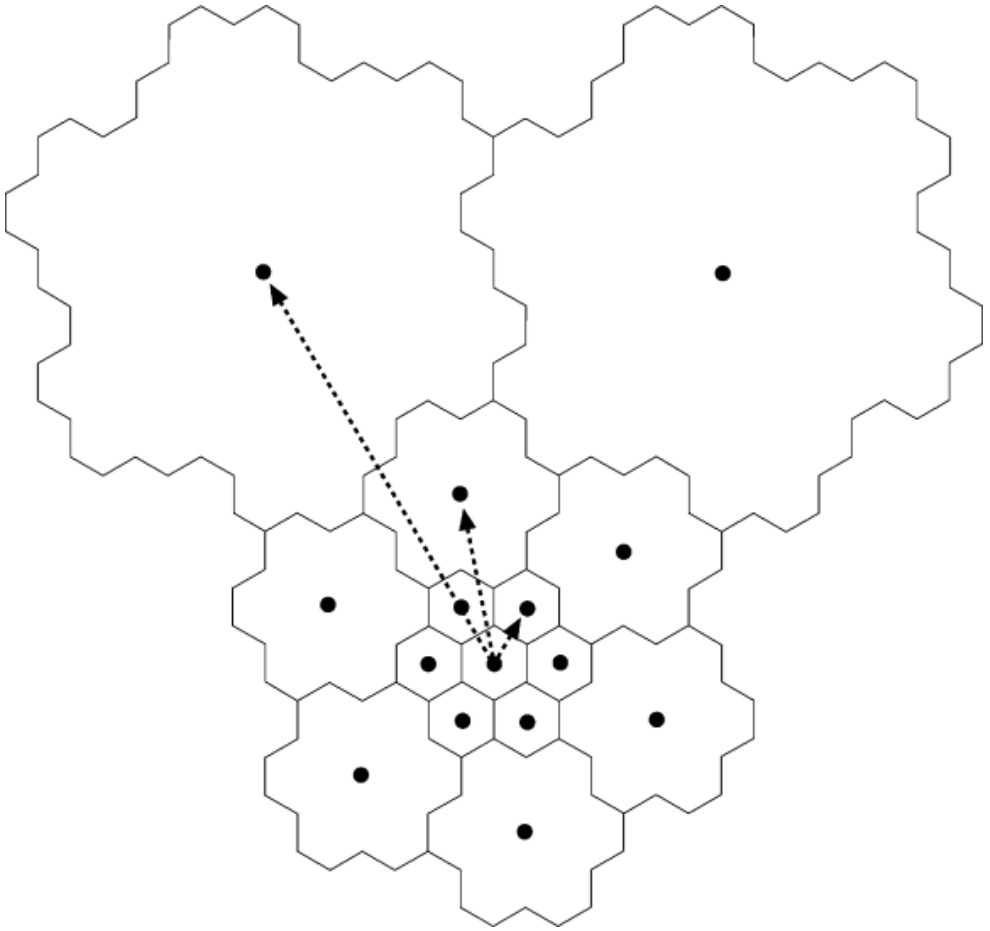
Design Choice: Partition

(Tor Stensola, CBM/Kavli Institute)



Design Choice: Partition

(Sahr et al 2003)

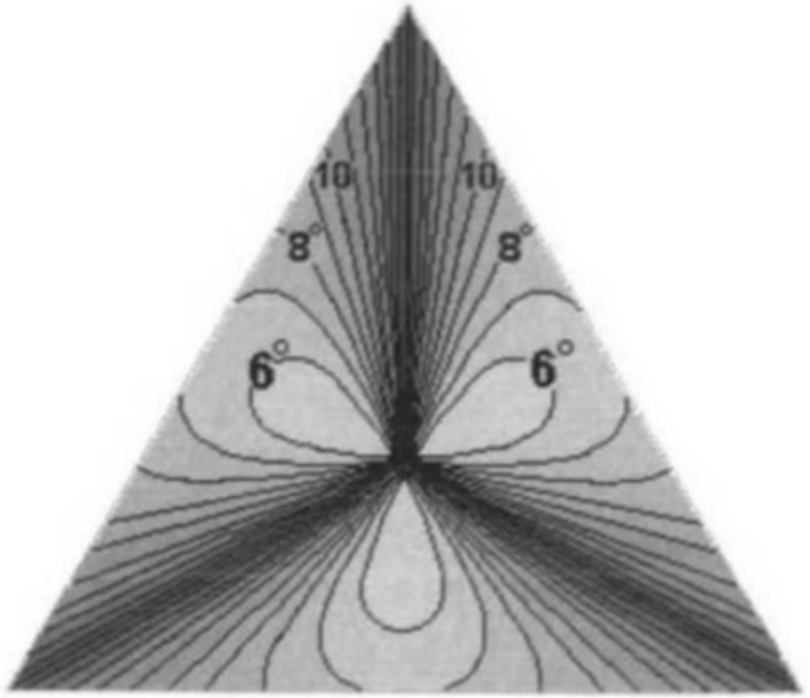


Work needed: Partitioning/Addressing

(Oom et al 2004)

SNYDER MAP PROJECTION

Icosahedron Face



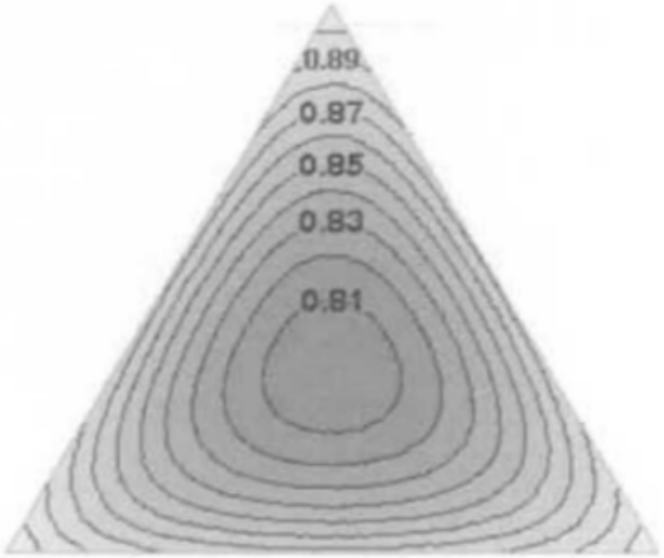
Tissot Angular Deformation

Design Choice: Transformation

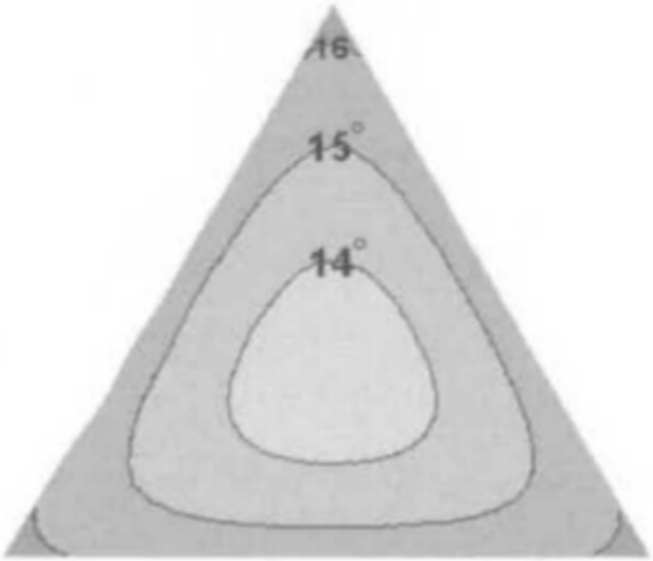
(Kimerling 1999)

Fuller–Grey map projection

Icosahedron Face



Area Distortion

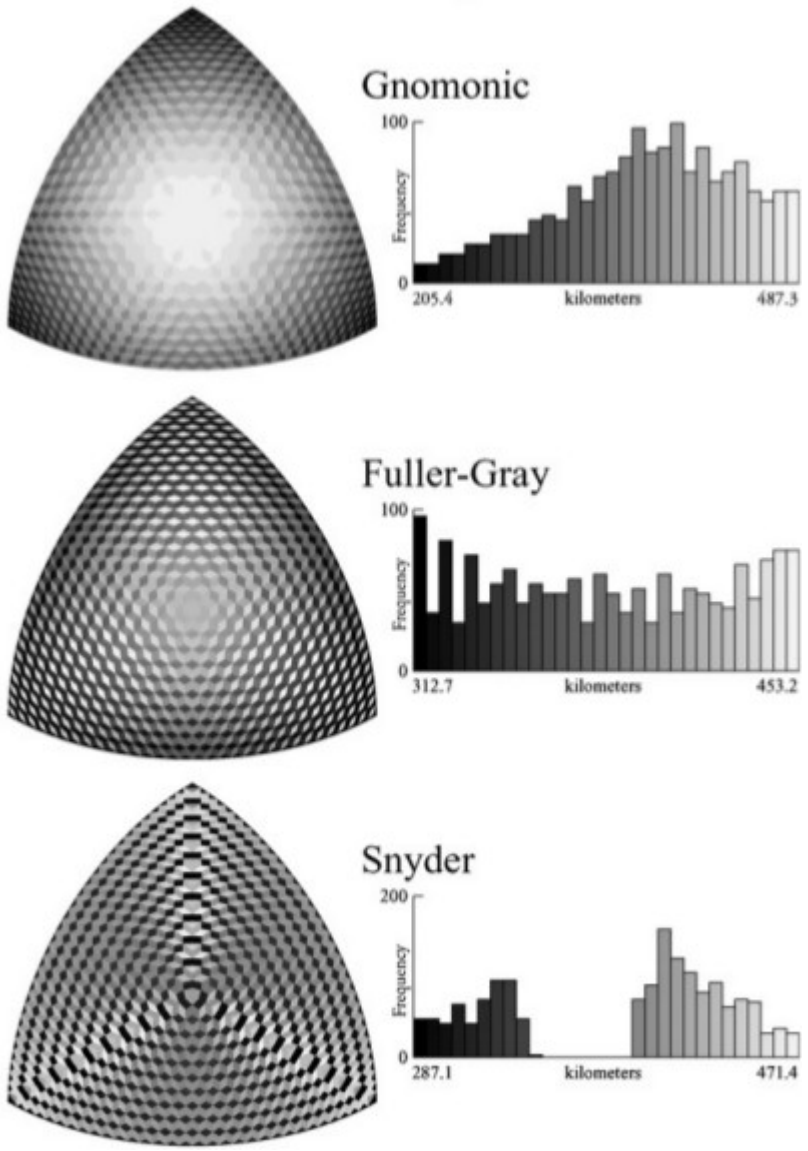


Angular Deformation

Tissot distortion analysis

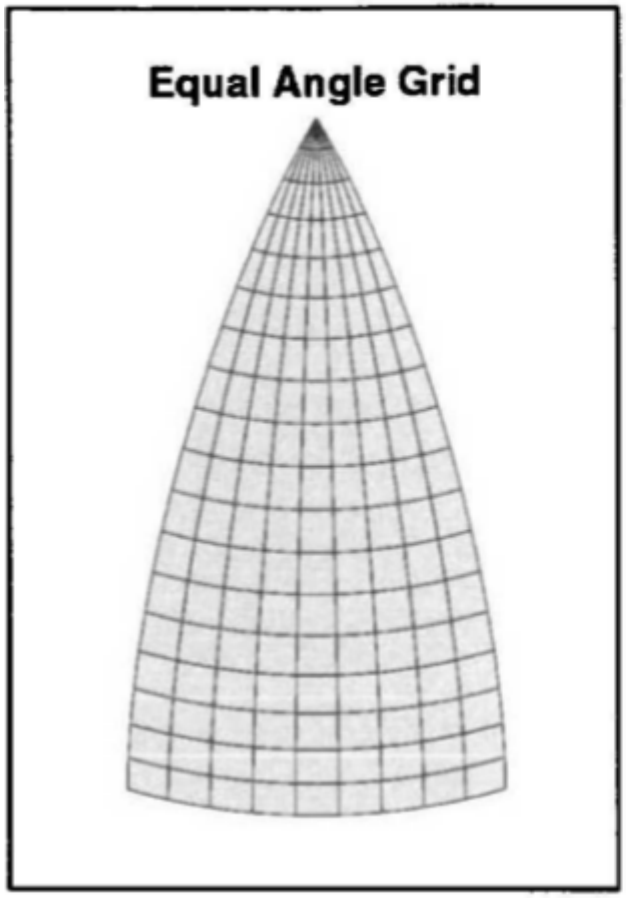
Design Choice: Transformation

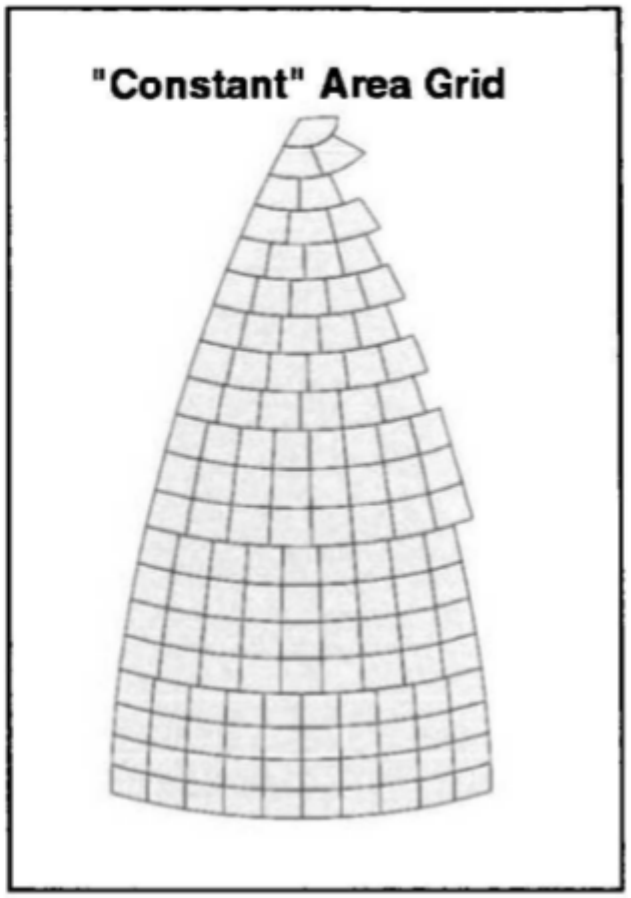
(Kimerling 1999)



Design Choice: Transformation

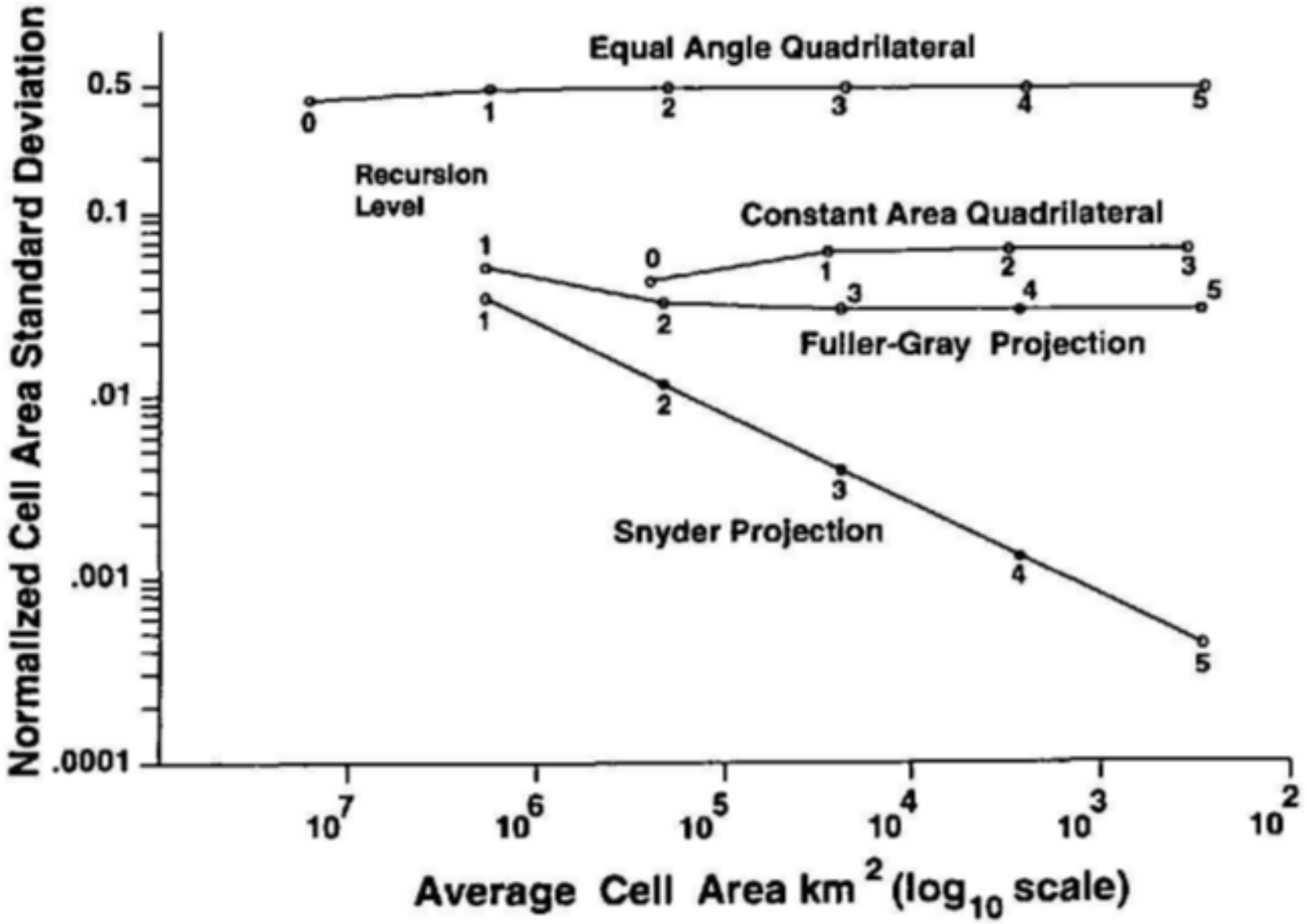
(Kimerling 1999)





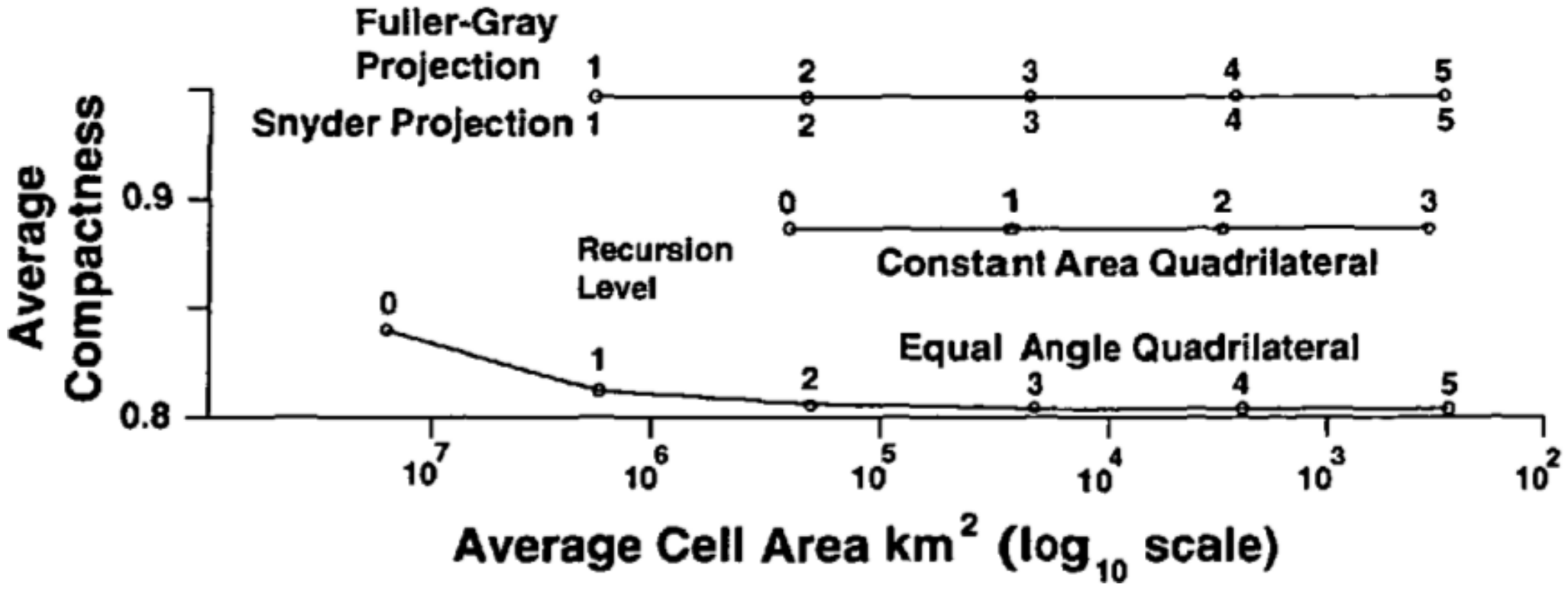
An Alternative Grid Idea

(Kimerling 1999)



Design Choice: Transformation

(Kimerling 1999)



Design Choice: Transformation

(Kimerling 1999)

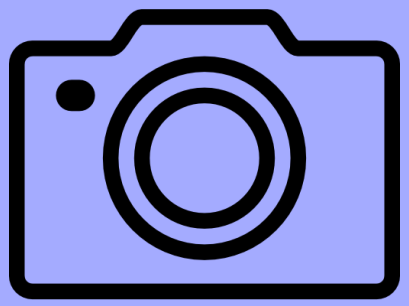
ISEA3H

Icosahedral

Snyder Equal Area

Aperture-3

Hexagonal



Design Decision

```r
#Include libraries
library(dggridR)
library(dplyr)

#Construct a global grid with cells approximately 1000 miles across
dggs          <- dgconstruct(spacing=1000, metric=FALSE, resround='down')

#Load included test data set
data(dgquakes)

#Get the corresponding grid cells for each earthquake epicenter (lat-long pair)
dgquakes$cell <- dgGEO_to_SEQNUM(dggs,dgquakes$lon,dgquakes$lat)$seqnum

#Get the number of earthquakes in each cell
quakecounts   <- dgquakes %>% group_by(cell) %>% summarise(count=n())

#Get the grid cell boundaries for cells which had quakes
grid          <- dgcellstogrid(dggs,quakecounts$cell,frame=TRUE,wrapcells=TRUE)
```

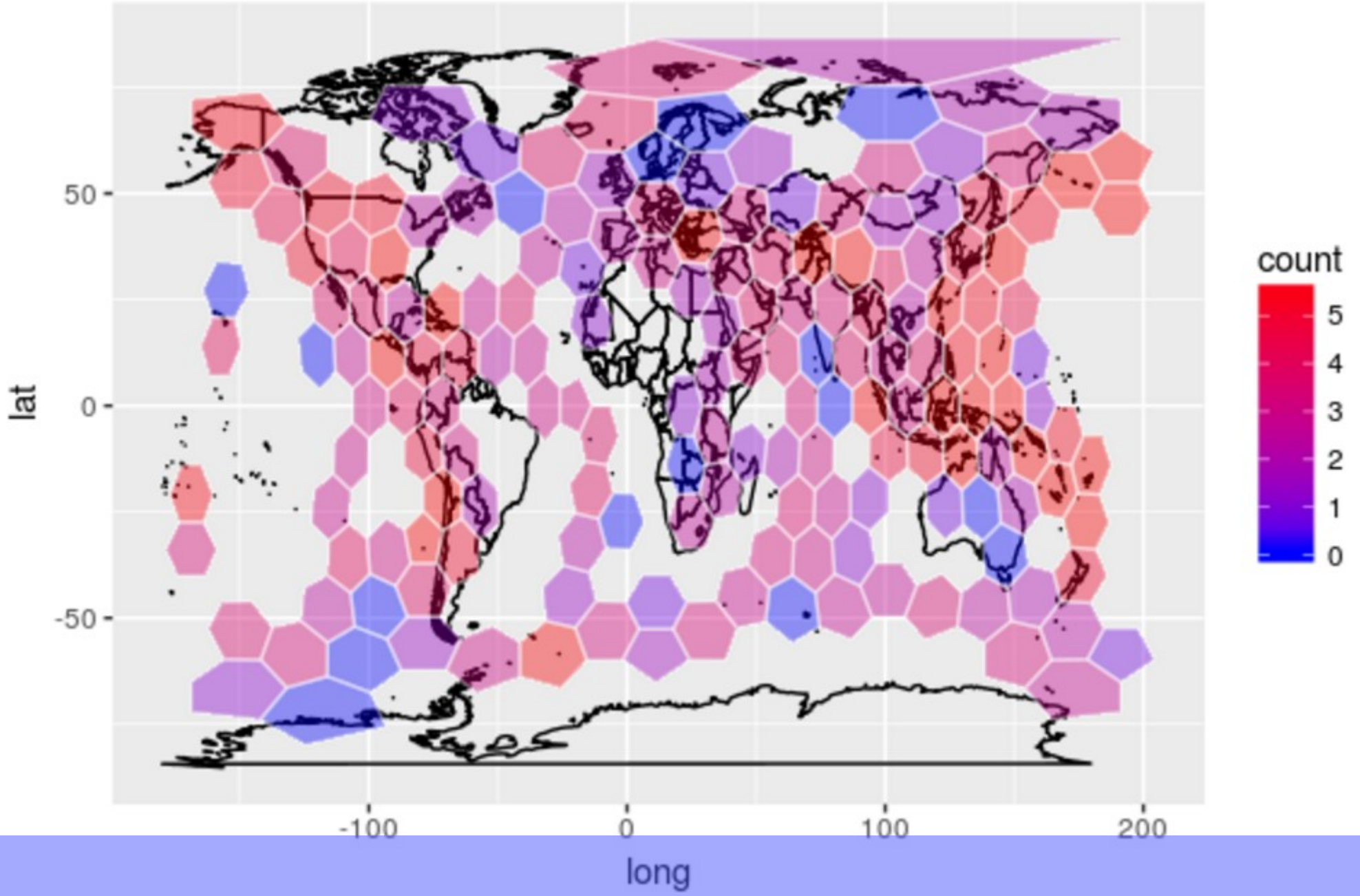
dggridR: Using a DGG

```r
#Update the grid cells' properties to include the number of earthquakes
#in each cell
grid          <- merge(grid,quakecounts,by.x="cell",by.y="cell")

#Make adjustments so the output is more visually interesting
grid$count    <- log(grid$count)
cutoff        <- quantile(grid$count,0.9)
grid          <- grid %>% mutate(count=ifelse(count>cutoff,cutoff,count))

#Get polygons for each country of the world
countries <- map_data("world")
```

dggridR: Using a DGG

```
#Plot everything on a flat map
p<- ggplot() +
    geom_polygon(data=countries, aes(x=long, y=lat, group=group), fill=NA, color="black")   +
    geom_polygon(data=grid,      aes(x=long, y=lat, group=group, fill=count), alpha=0.4)    +
    geom_path   (data=grid,      aes(x=long, y=lat, group=group), alpha=0.4, color="white") +
    scale_fill_gradient(low="blue", high="red")
p
```

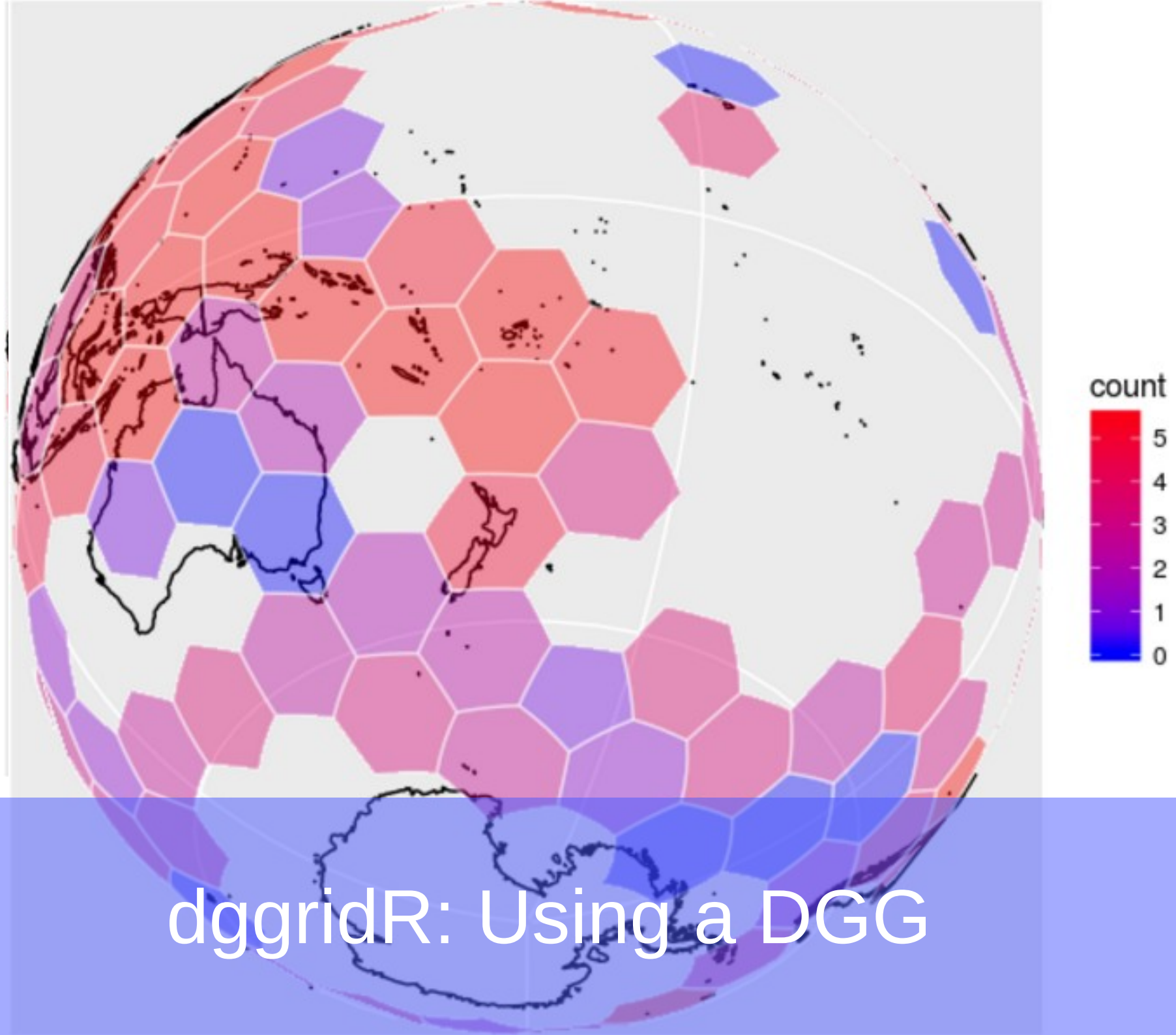
dggridR: Using a DGG



dggridR: Using a DGG

```r
#Replot on a spherical projection
p+coord_map("ortho", orientation = c(-38.49831, -179.9223, 0))+
  xlab('')+ylab('')+
  theme(axis.ticks.x=element_blank())+
  theme(axis.ticks.y=element_blank())+
  theme(axis.text.x=element_blank())+
  theme(axis.text.y=element_blank())+
  ggtitle('Your data could look like this')
```

dggridR: Using a DGG

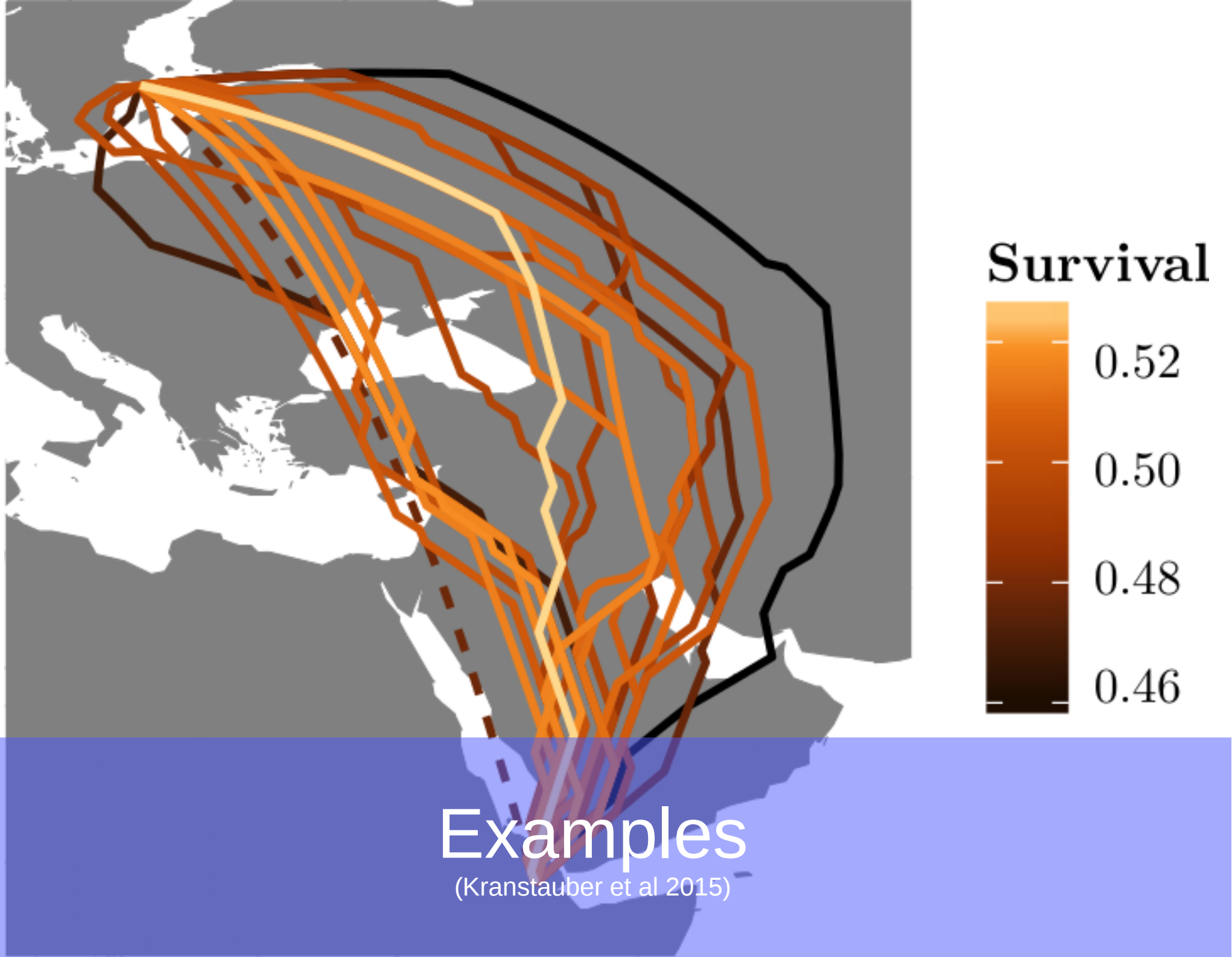


dggridR: Using a DGG

```
library(webglobe)

#Construct a webglobe
wg            <- webglobe(immediate=FALSE)
wg            <- wg + wgpolygondf(grid, alpha=0.6)
wg
```

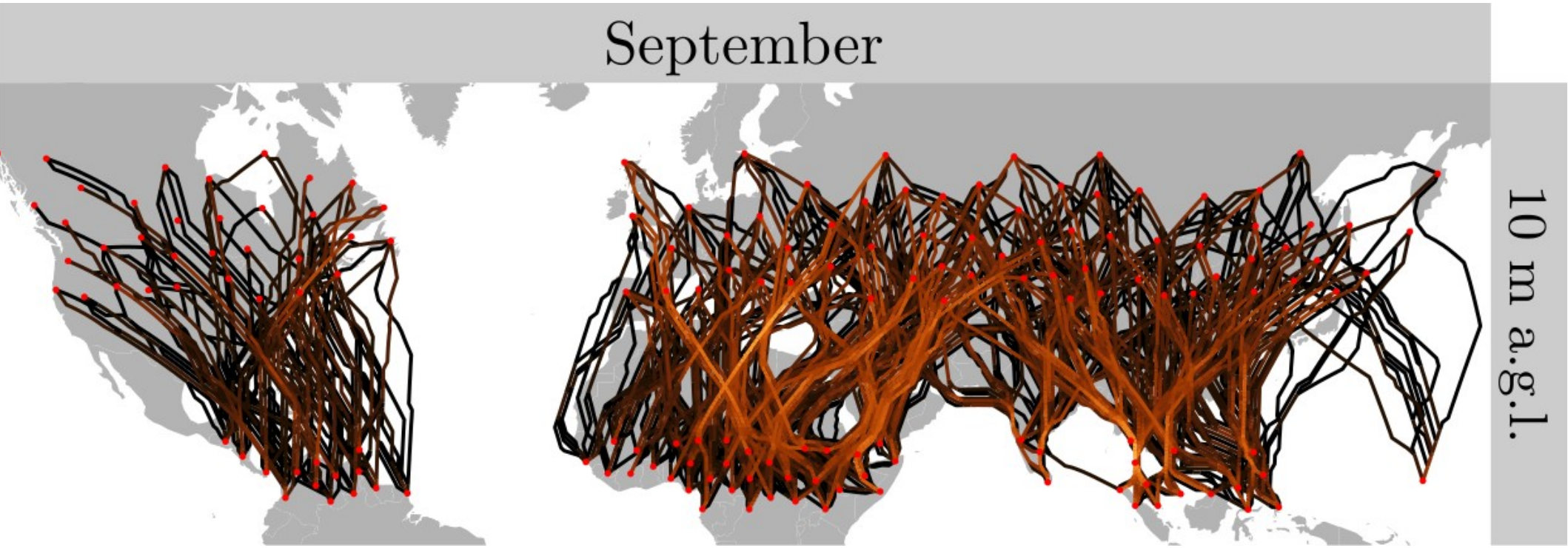
webglobe: Using a DGG

webglobe: Using a DGG



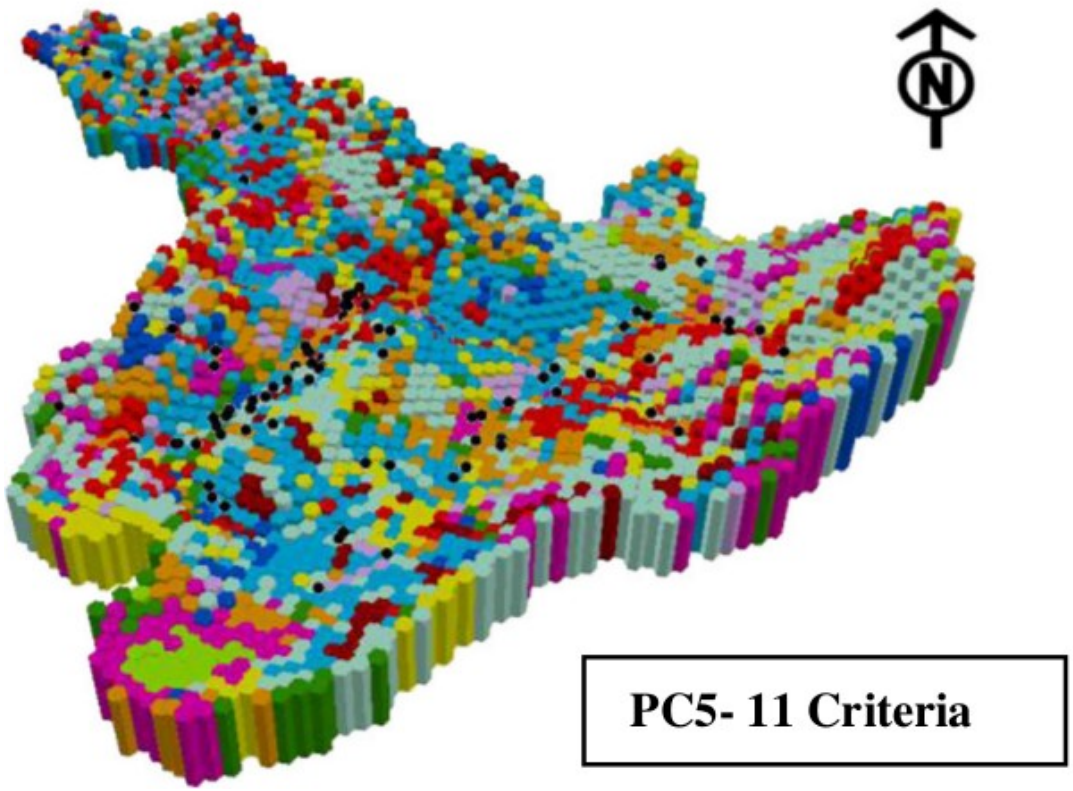
Examples

(Kranstauber et al 2015)



Examples

(Kranstauber et al 2015)



Landslide Related Variables (Components)

- Aspect
- Elevation
- Fault
- Geology
- Rain
- River
- Road
- Slope
- Soil
- Vegetation
- Village
- Landslides

Examples

(Sabokbar et al 2014)

Crider, J.E., 2008. Exact Equations for Fuller's Map Projection and Inverse. Cartographica: The International Journal for Geographic Information and Geovisualization 43, 67–72. doi:10.3138/carto.43.1.67

Gray, R.W., 1995. Exact transformation equations for Fuller's world map. Cartographica: The International Journal for Geographic Information and Geovisualization 32, 17–25.

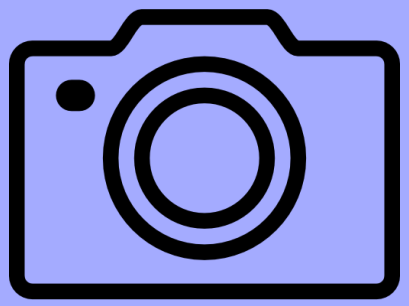
Kimerling, J.A., Sahr, K., White, D., Song, L., 1999. Comparing geometrical properties of global grids. Cartography and Geographic Information Science 26, 271–288.

Sahr, K., White, D., Kimerling, A.J., 2003. Geodesic discrete global grid systems. Cartography and Geographic Information Science 30, 121–134.

Snyder, J.P., 1992. An equal-area map projection for polyhedral globes. Cartographica: The International Journal for Geographic Information and Geovisualization 29, 10–21. doi:10.3138/27H7-8K88-4882-1752

van Wijk, J.J., 2008. Unfolding the Earth: Myriahedral Projections. The Cartographic Journal 45, 32–42. doi:10.1179/000870408X276594

White, D., Kimerling, A.J., Sahr, K., Song, L., 1998. Comparing area and shape distortion on polyhedral-based recursive partitions of the sphere. International Journal of Geographical Information Science 12, 805–827. doi:10.1080/136588198241518



Bibliography

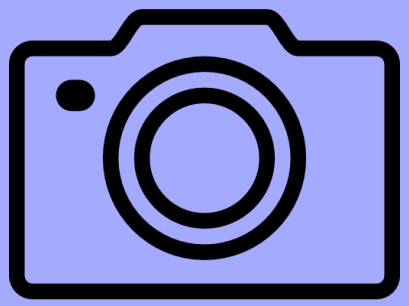
github.com/r-barnes/dggridR

github.com/r-barnes/webglobe

www.discreteglobalgrids.org

healpix.sourceforge.net

www.pyxisinnovation.com



Software

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ERG
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DOE CSGF