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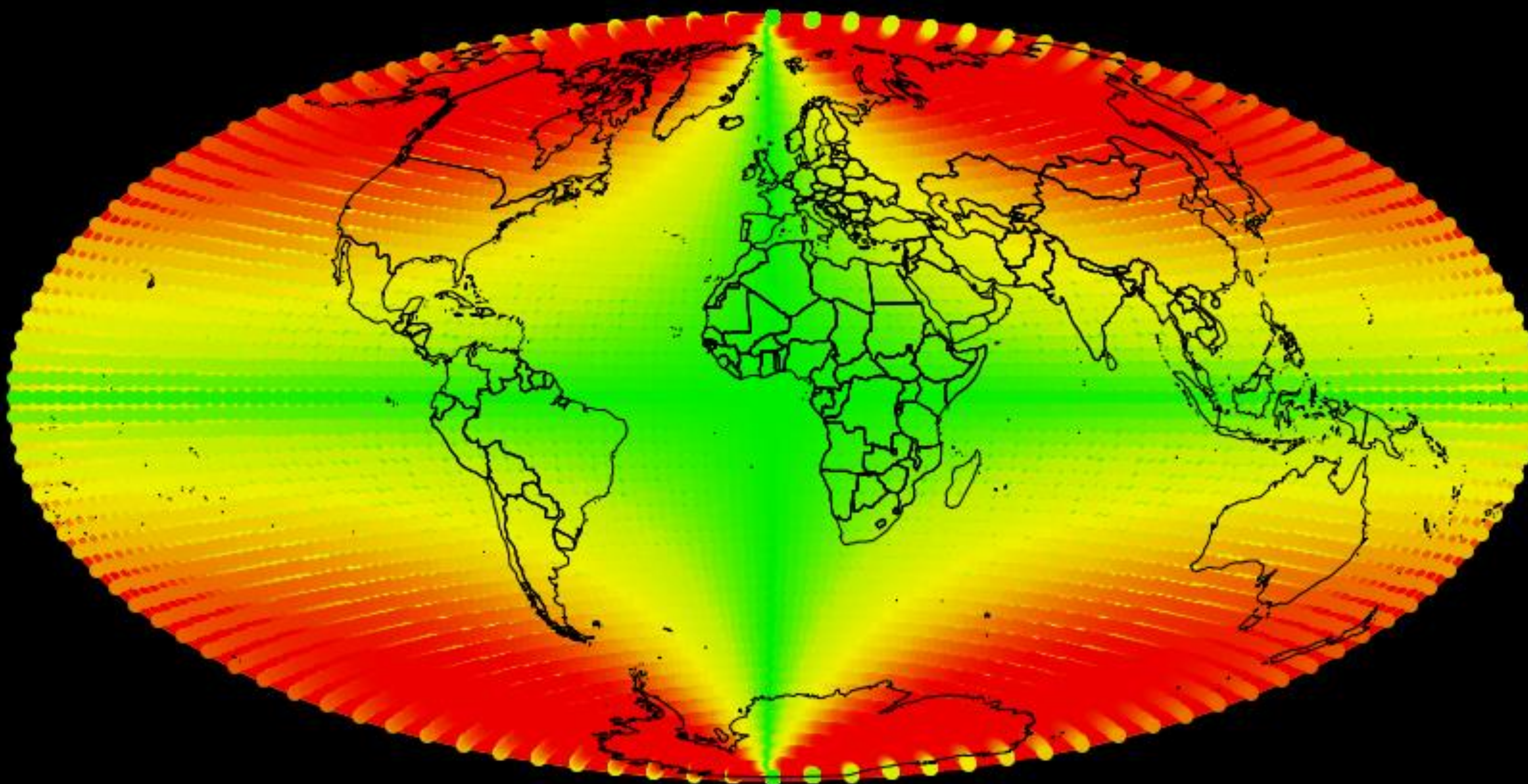
VISUALIZATIONS OF UNCERTAINTY IN PROJECTIONS

DR. JAMES GRAHAM & CHRIS MUHL · HUMBOLDT STATE UNIVERSITY · DEPARTMENT OF GEOSPATIAL ANALYSIS



Dr. Jim Graham and Chris Muhl
Humboldt State University, 2014

The Need

- Error varies greatly between projections and their settings
- Computing error in projections can be time-consuming
- Projections can be difficult for students to appreciate

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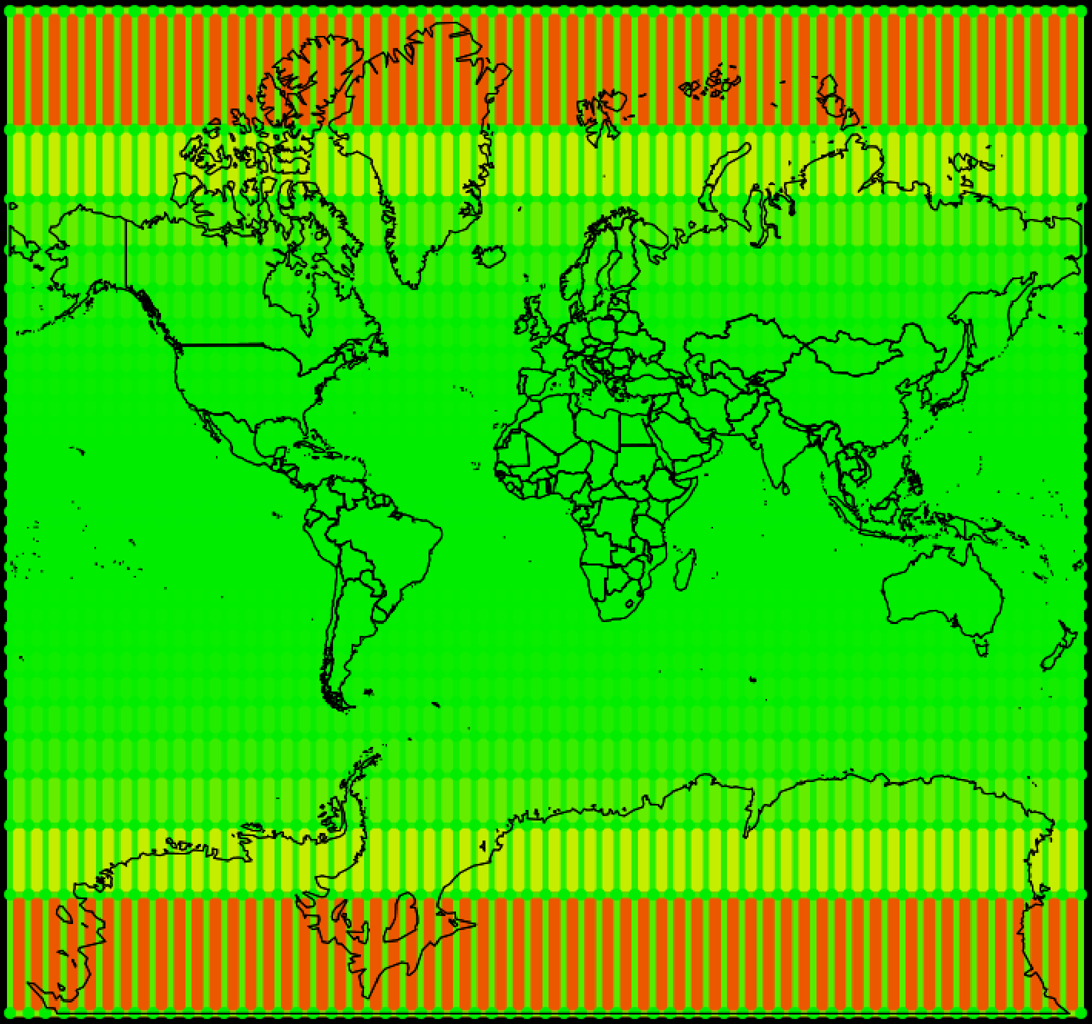
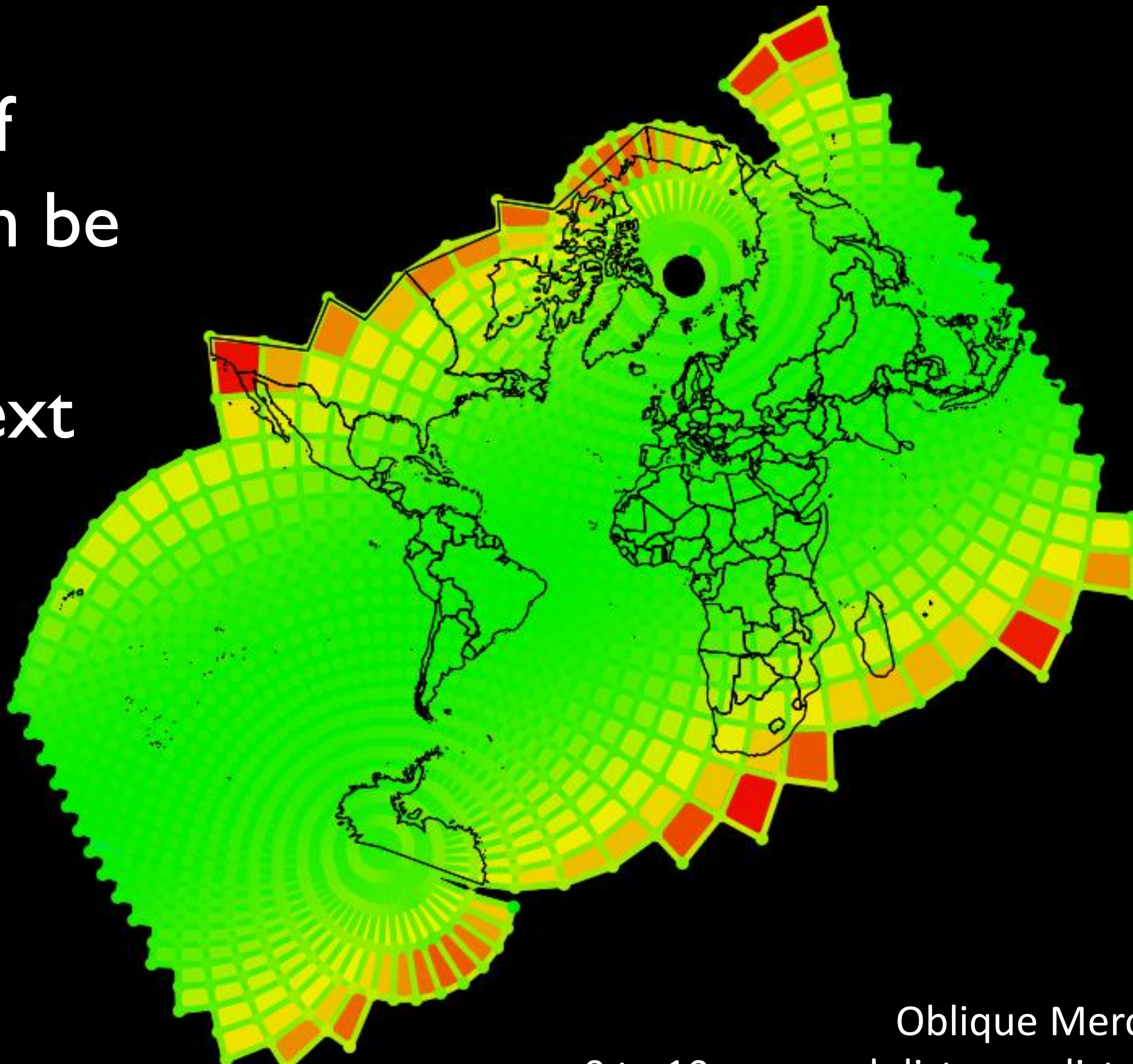
- Projections greatly distort area, distance, and/or shape (form)



Mercator
0 to 50 area and distance distortion

- The nature of distortion can be difficult to describe in text



Oblique Mercator
0 to 10 area and distance distortion

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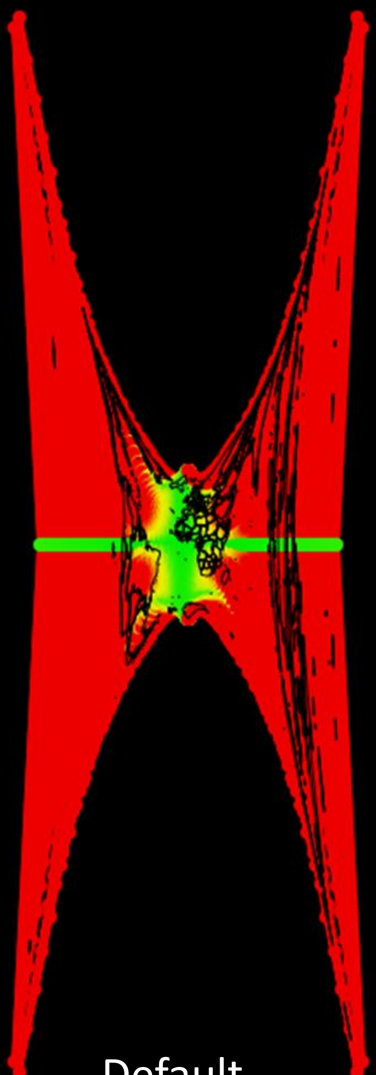
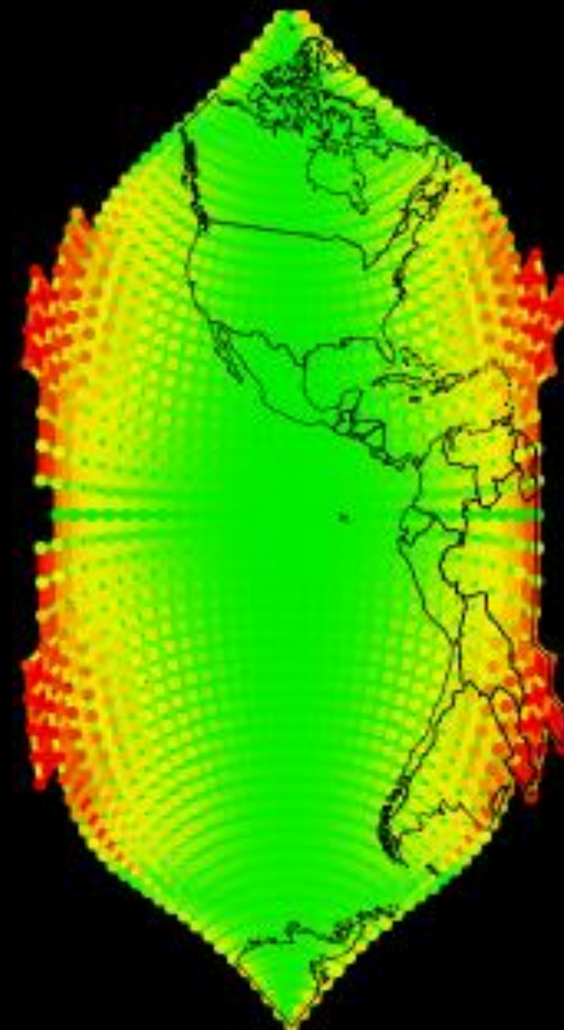


Default

Clipping bounds are also needed

Cassini
Soldner
Projection



Limited to 0 to 2x distance distortion

Previously, to Compute Area Distortion

- Create "Fishnet" of polygons
- Project to equal-area projection
- Compute "Exact" areas
- Project to desired projection
- Compute projected areas
- Divide the exact by projected area values
  - <1: area was made much smaller than expected
  - >1: area was made larger than expected

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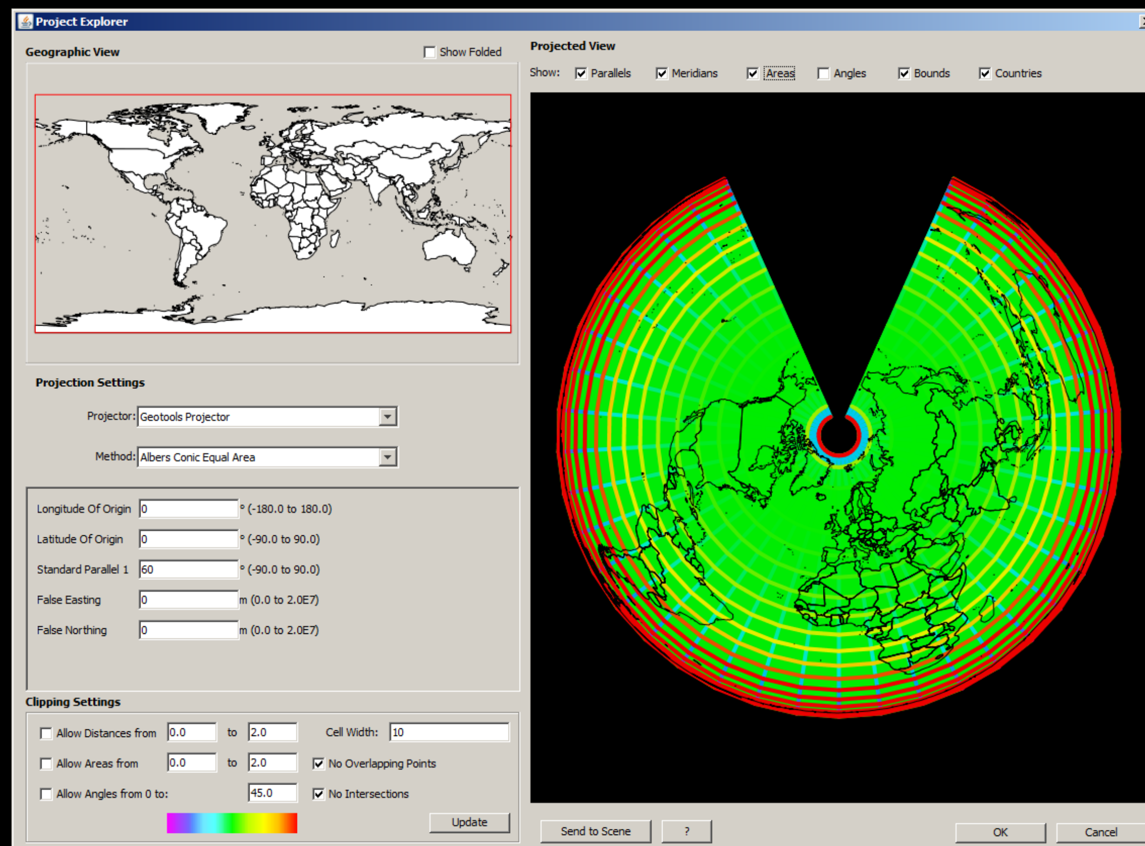
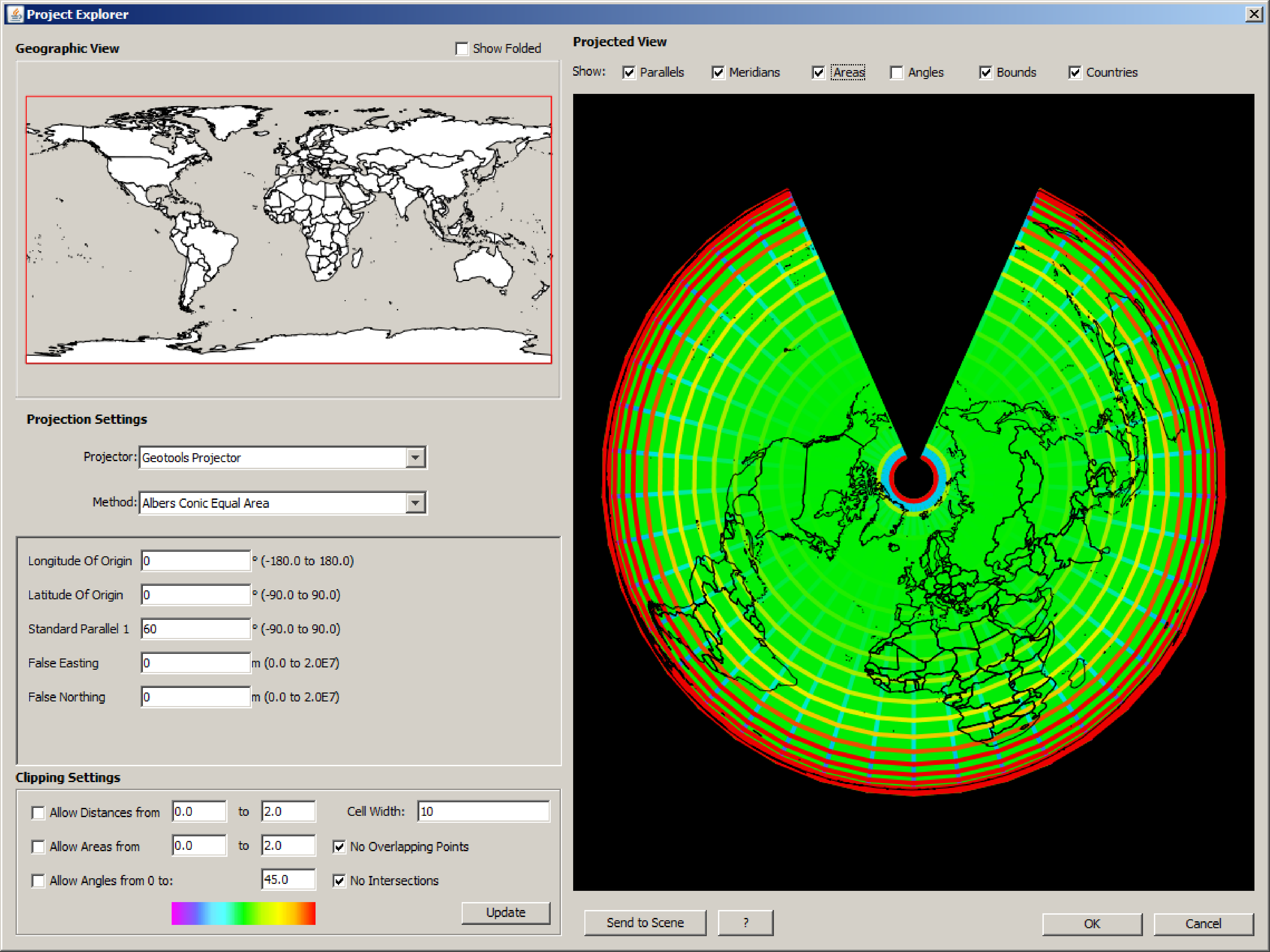
Today:

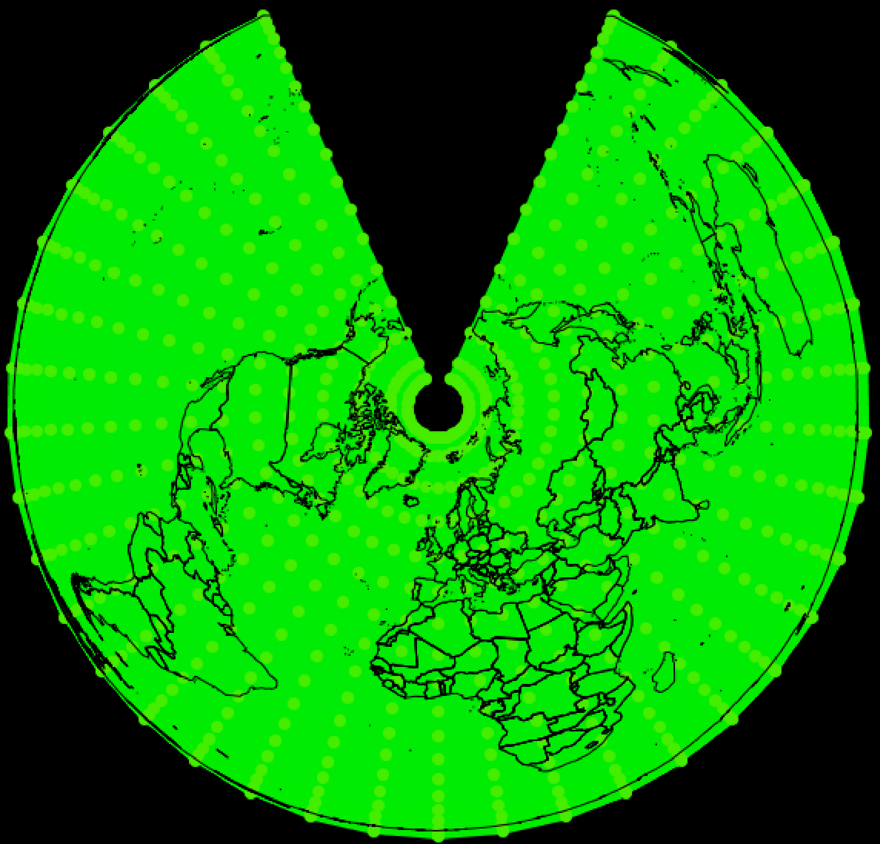
- Selection projection
- Enter desired settings
- Press “Update”
- “OK” to add layers



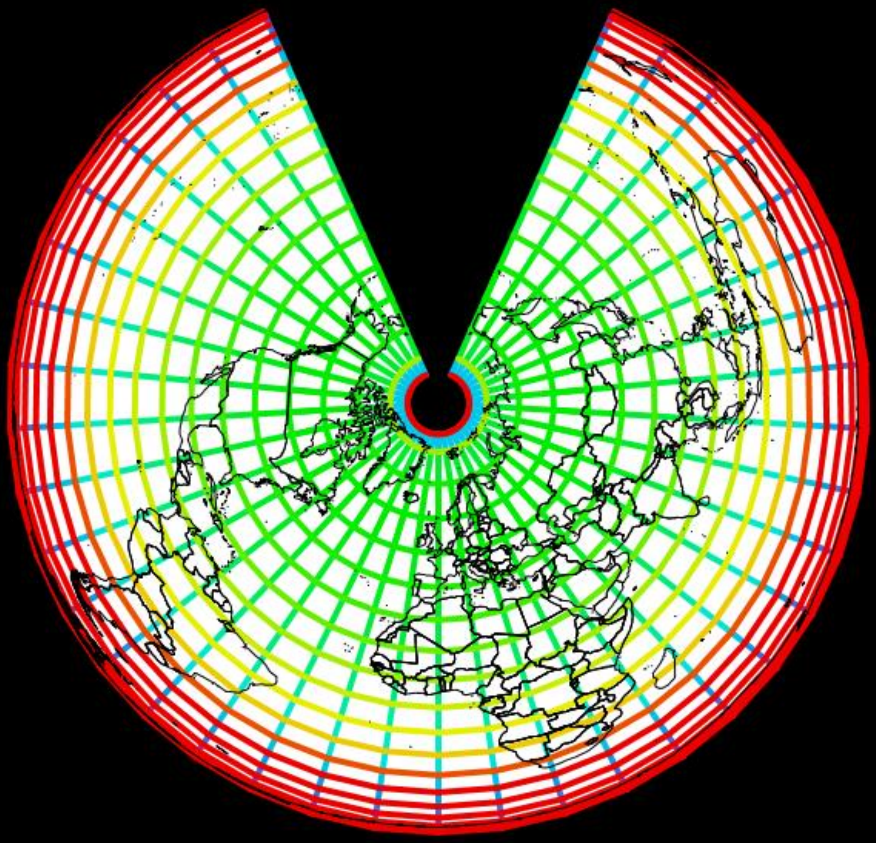

Project Explorer
Geographic View
Show Folded
Projected View
Show:
Parallels
Meridians
Areas
Angles
Bounds
Countries
Projection Settings
Projector:
Geotools Projector
Method:
Albers Conic Equal Area
Longitude Of Origin
0
° (-180.0 to 180.0)
Latitude Of Origin
0
° (-90.0 to 90.0)
Standard Parallel 1
60
° (-90.0 to 90.0)
False Easting
0
m (0.0 to 2.0E7)
False Northing
0
m (0.0 to 2.0E7)
Clipping Settings
Allow Distances from
0.0
to
2.0
Cell Width:
10
Allow Areas from
0.0
to
2.0
No Overlapping Points
Allow Angles from 0 to:
45.0
No Intersections
Update
Send to Scene
?
OK
Cancel

Albers Equal Area Conic

Preserves Area and Form



Distorts Distance



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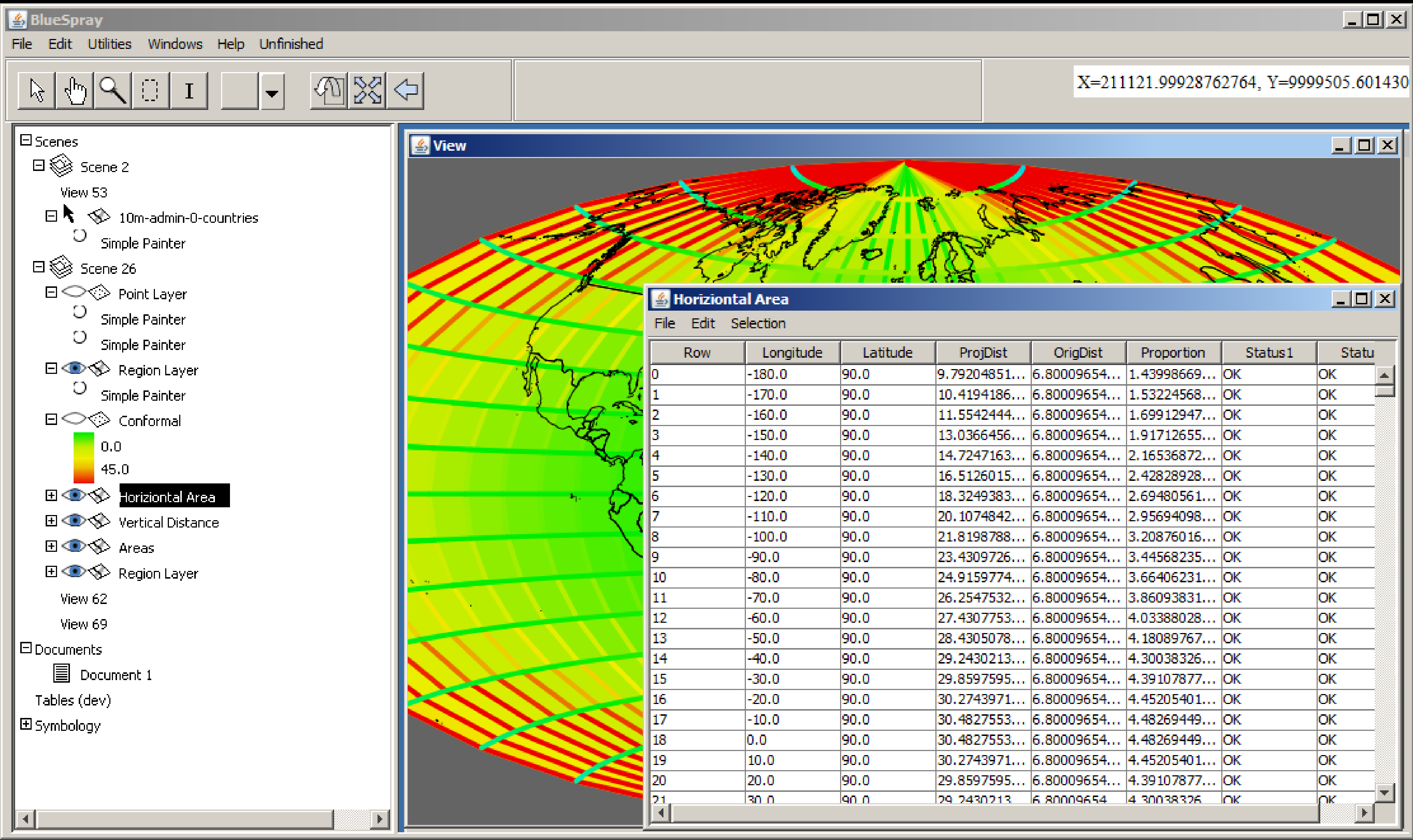

Row	Longitude	Latitude	ProjDist	OrigDist	Proportion	Status1	Statu
0	-180.0	90.0	9.79204851...	6.80009654...	1.43998669...	OK	OK
1	-170.0	90.0	10.4194186...	6.80009654...	1.53224568...	OK	OK
2	-160.0	90.0	11.5542444...	6.80009654...	1.69912947...	OK	OK
3	-150.0	90.0	13.0366456...	6.80009654...	1.91712655...	OK	OK
4	-140.0	90.0	14.7247163...	6.80009654...	2.16536872...	OK	OK
5	-130.0	90.0	16.5126015...	6.80009654...	2.42828928...	OK	OK
6	-120.0	90.0	18.3249383...	6.80009654...	2.69480561...	OK	OK
7	-110.0	90.0	20.1074842...	6.80009654...	2.95694098...	OK	OK
8	-100.0	90.0	21.8198788...	6.80009654...	3.20876016...	OK	OK
9	-90.0	90.0	23.4309726...	6.80009654...	3.44568235...	OK	OK
10	-80.0	90.0	24.9159774...	6.80009654...	3.66406231...	OK	OK
11	-70.0	90.0	26.2547532...	6.80009654...	3.86093831...	OK	OK
12	-60.0	90.0	27.4307753...	6.80009654...	4.03388028...	OK	OK
13	-50.0	90.0	28.4305078...	6.80009654...	4.18089767...	OK	OK
14	-40.0	90.0	29.2430213...	6.80009654...	4.30038326...	OK	OK
15	-30.0	90.0	29.8597595...	6.80009654...	4.39107877...	OK	OK
16	-20.0	90.0	30.2743971...	6.80009654...	4.45205401...	OK	OK
17	-10.0	90.0	30.4827553...	6.80009654...	4.48269449...	OK	OK
18	0.0	90.0	30.4827553...	6.80009654...	4.48269449...	OK	OK
19	10.0	90.0	30.2743971...	6.80009654...	4.45205401...	OK	OK
20	20.0	90.0	29.8597595...	6.80009654...	4.39107877...	OK	OK
21	30.0	90.0	29.2430213	6.80009654	4.30038326	OK	OK

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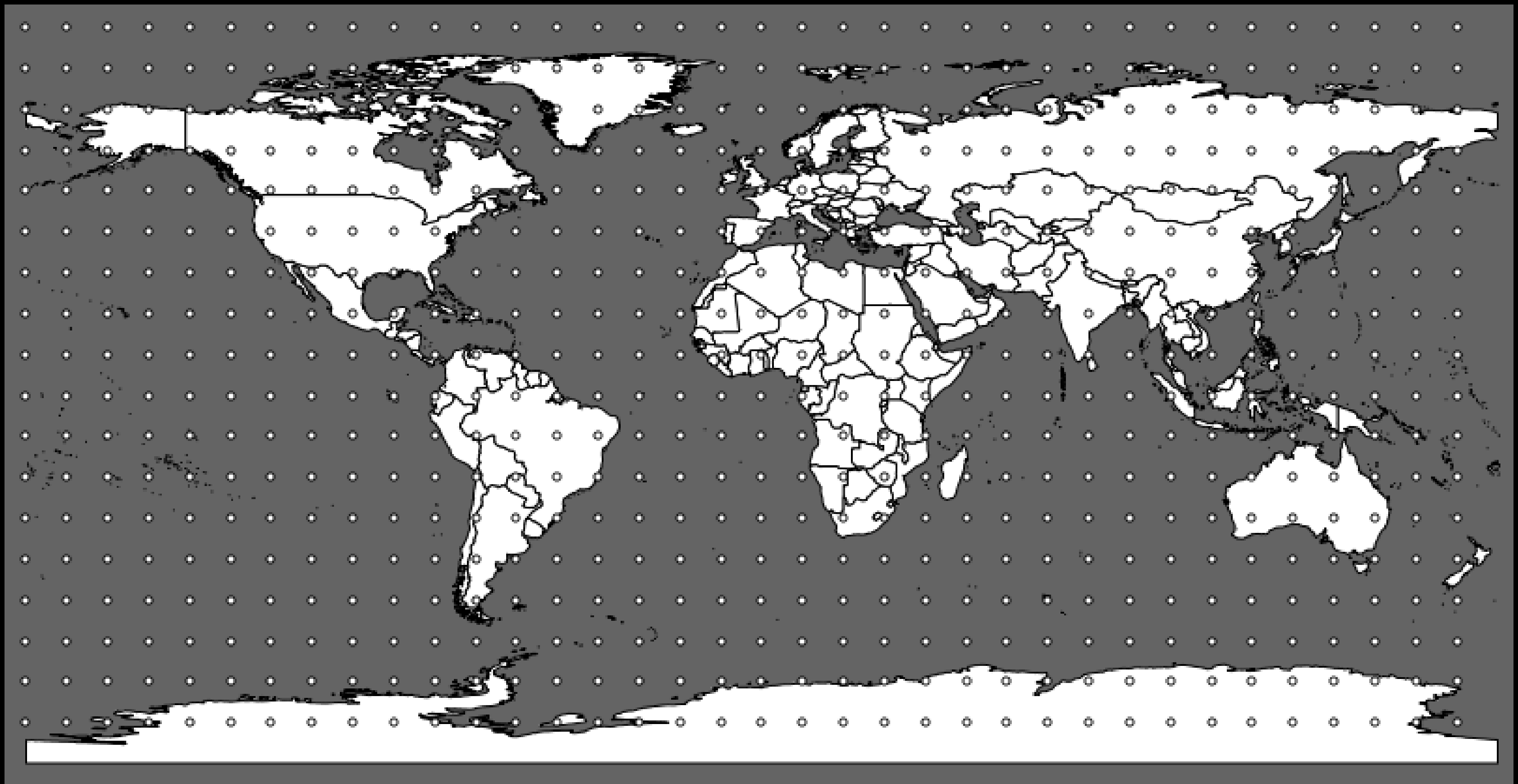
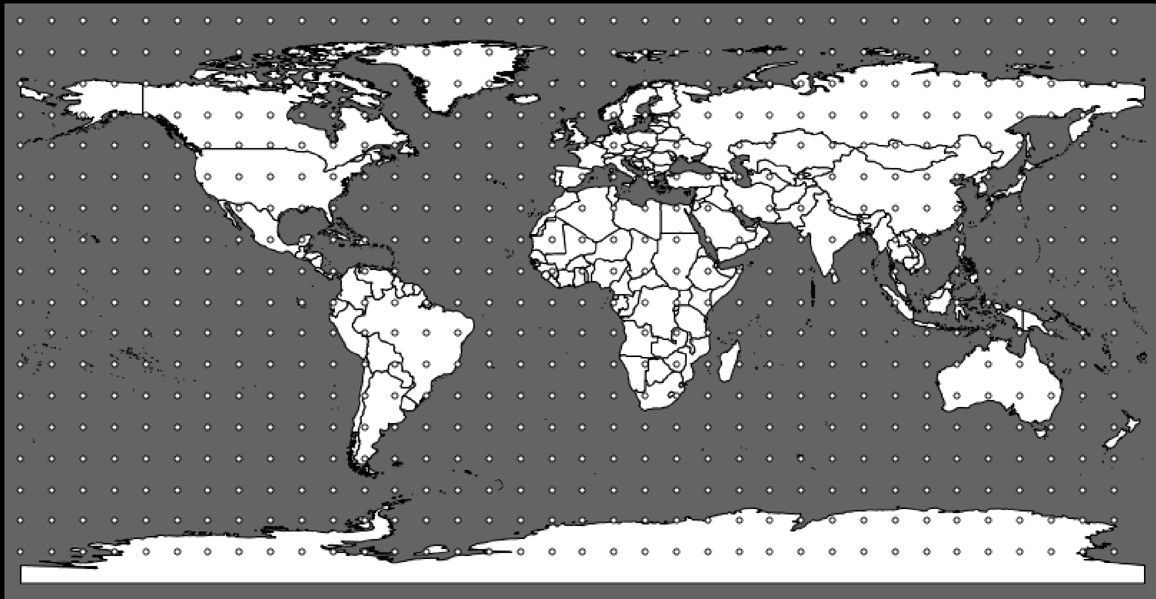
The Approach

- BlueSpray
  - Created by SchoonerTurtles, Inc.
  - Provided free under a beta testing agreement
- GDAL, GeoTools
  - Open source projection engines
- Also:
  - Java from Oracle
  - Java Topology Suite
  - NetBeans

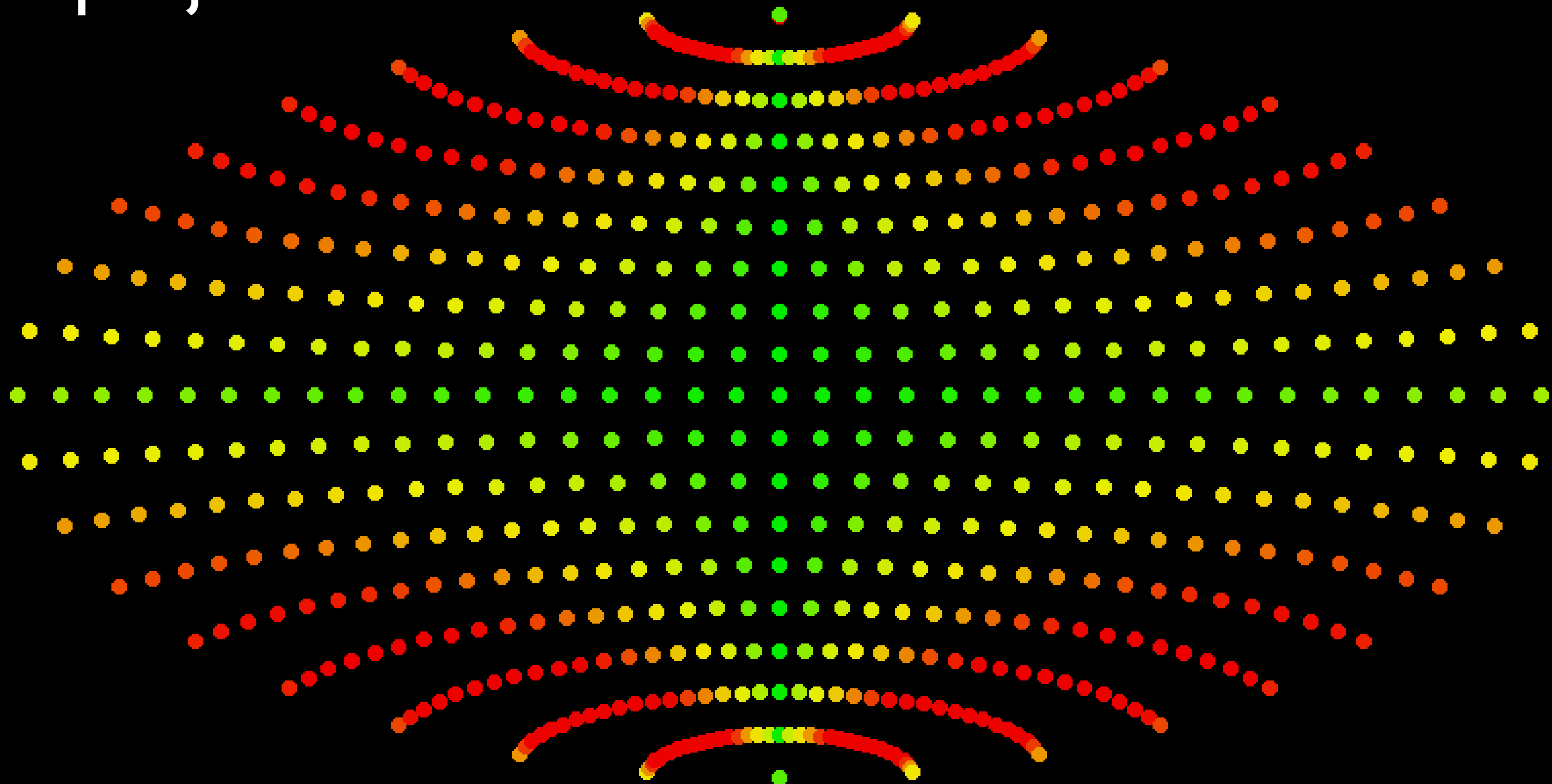
- Create grid of points along lines of latitude and longitude (parallels and meridians)



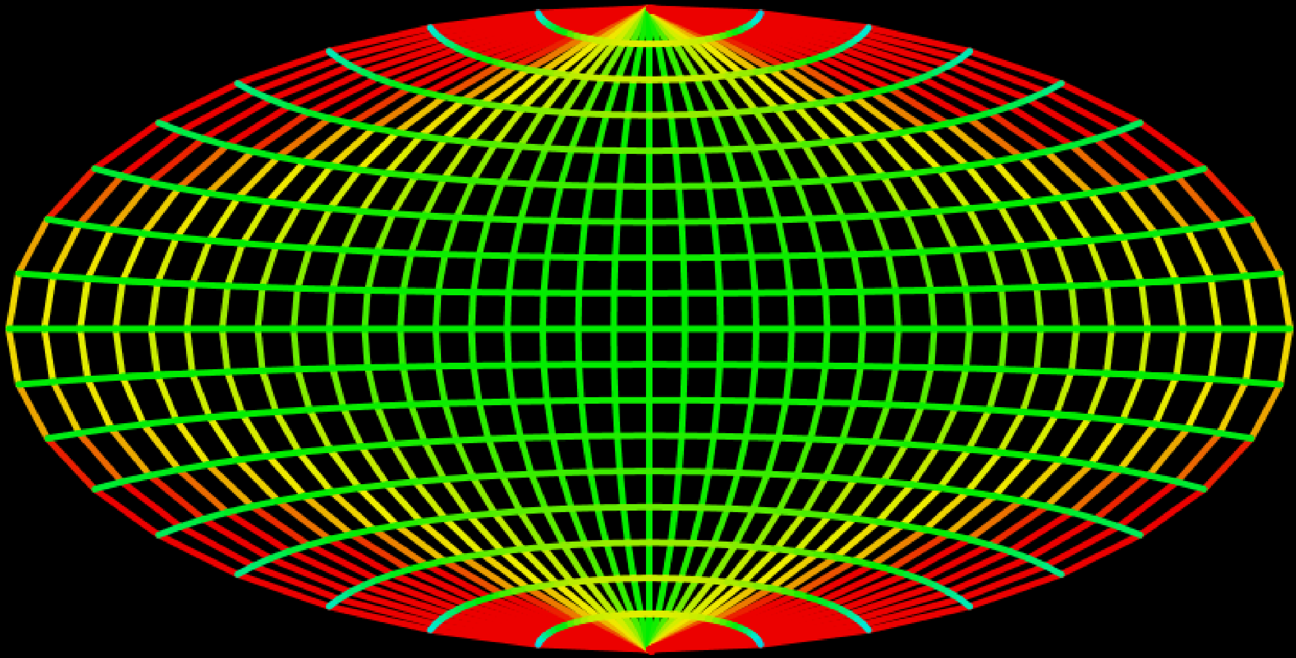
- Compute:
  - Great circle area
  - Great circle distances (along meridians and parallels)
  - Angles are at intersections are 90 degrees except for the poles



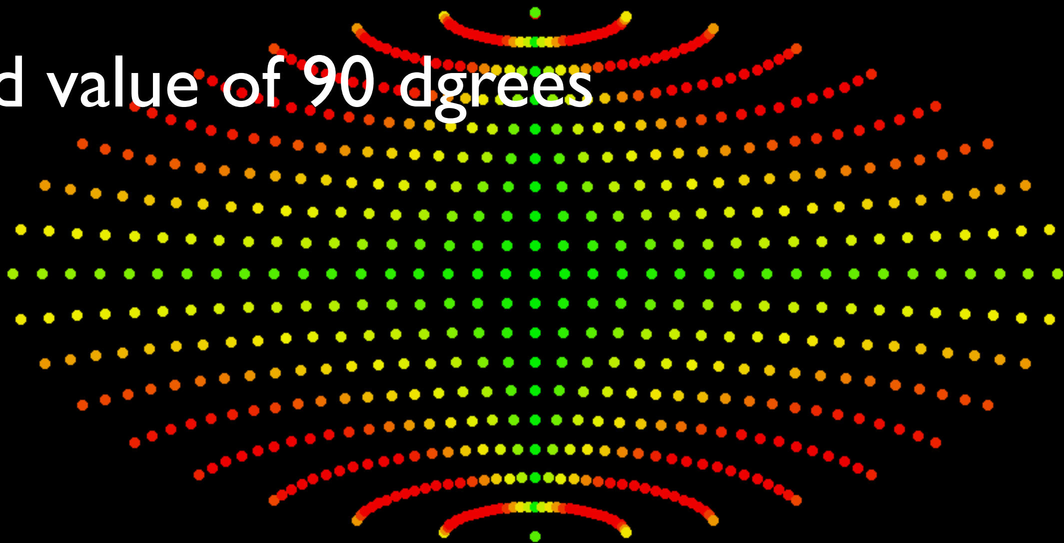
- Project the grid of points to desired projection



- Compute area of "cells" between points
- Divide by expected area
- Compute the length of each line segment
- Divide by expected length



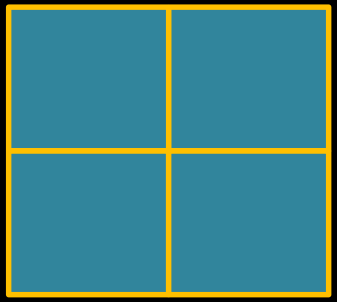
- Compute the average change in angle at each point
  - Sum the angle between all the line segments at each point
  - Divide by the number of angles to find the average angle
  - Divide by expected value of 90 dgrees



Finding the bounds

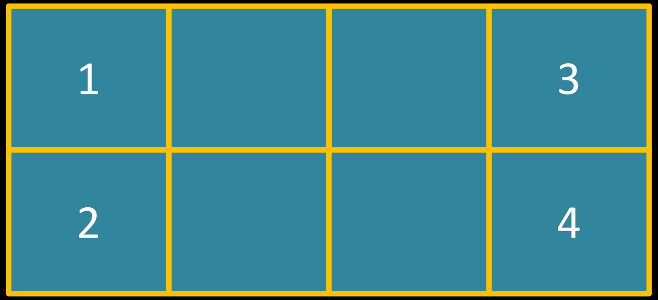
- Start at the center (0,0)
- Moving left and right two cells then up and down one cell:
  - Add cells that are within the specified tolerances
  - Check for overlapping points
  - Check for intersecting lines

Adding "Cells"



Assumed the first four cells were within tolerances

Adding “Cells”



Add cells to left and right that are within tolerance

Adding "Cells"

5	1			3	7
6	2			4	8

Add additional cells to the left and right since the world is twice as wide as it is call (with Geographic data)

Adding "Cells"

11	10	9	12	13	14
5	1			3	7
6	2			4	8
17	16	15	18	19	20

Add cells along the top and bottom.
Keep repeating the cycle until no more cells are added

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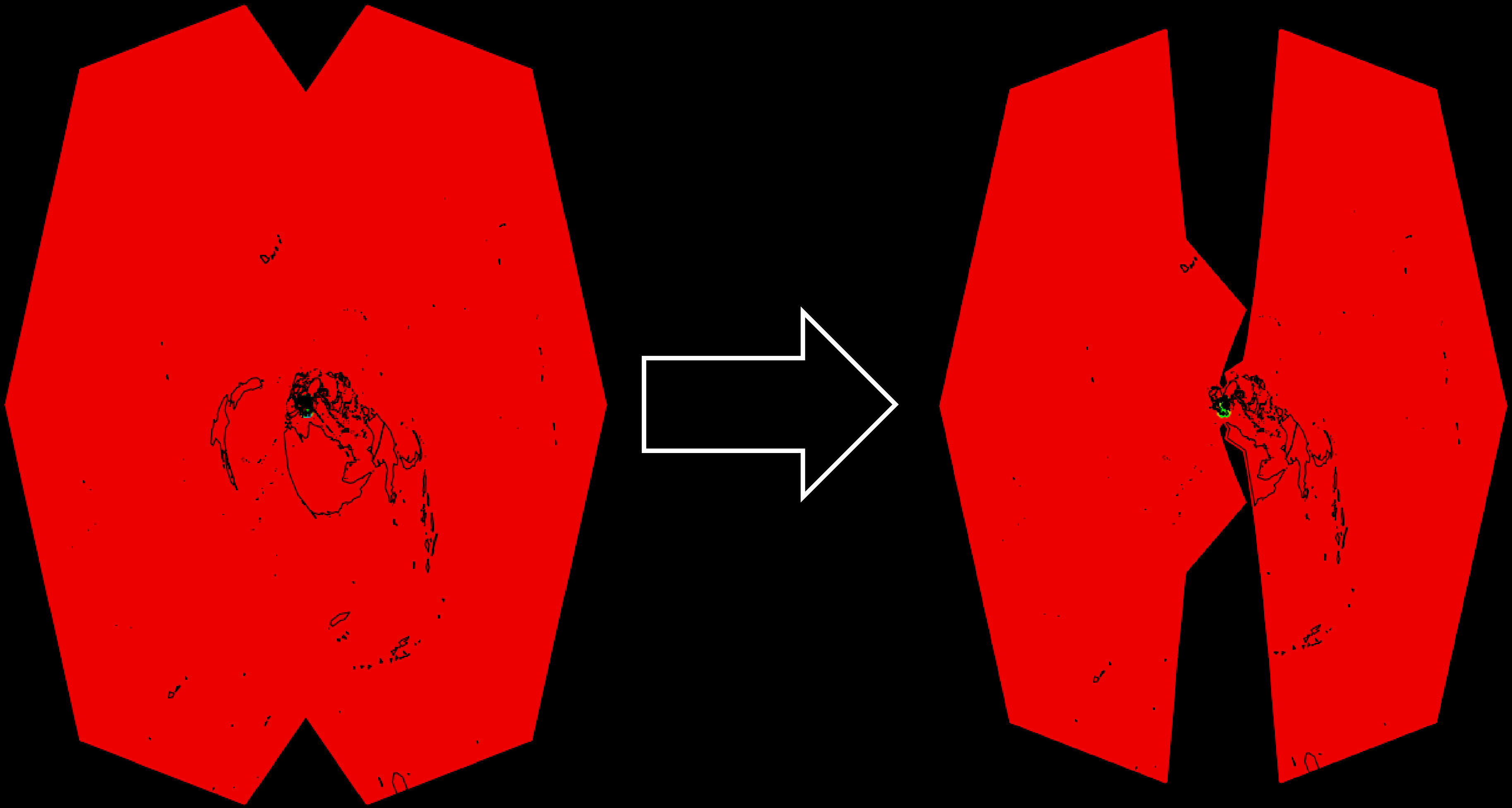
Disallow Intersections and Overlaps



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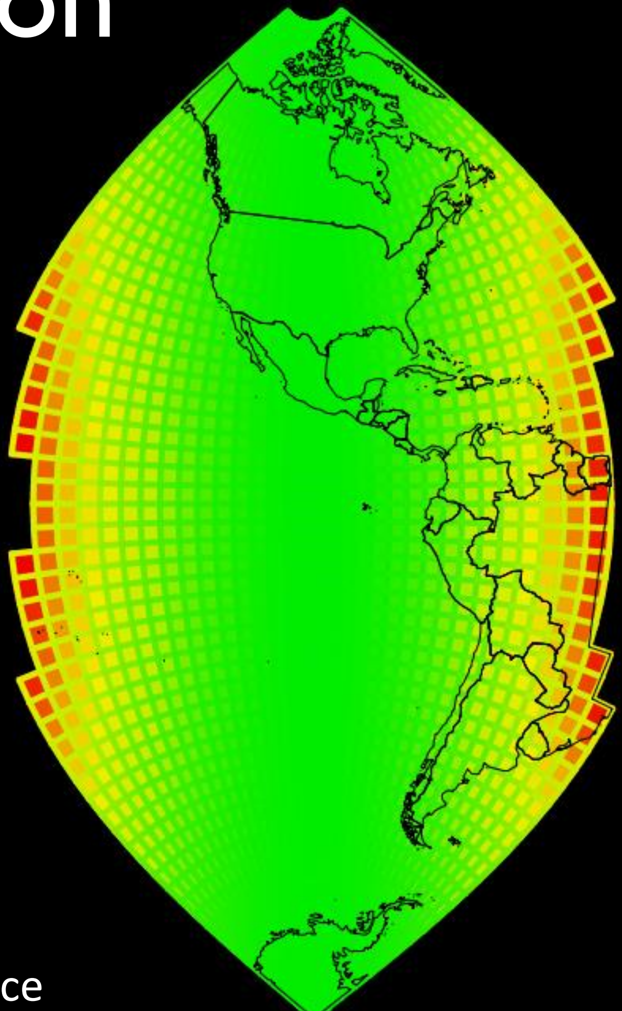
Limit Distortion



0 to 2x on area and distance

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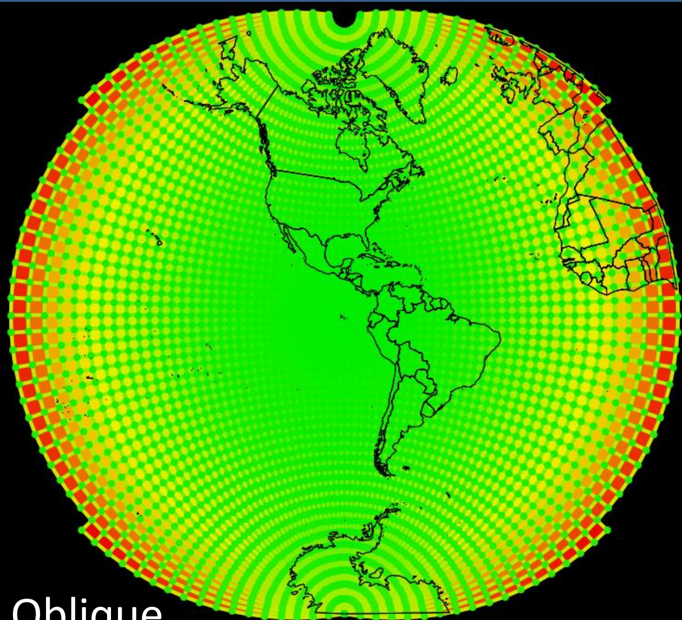
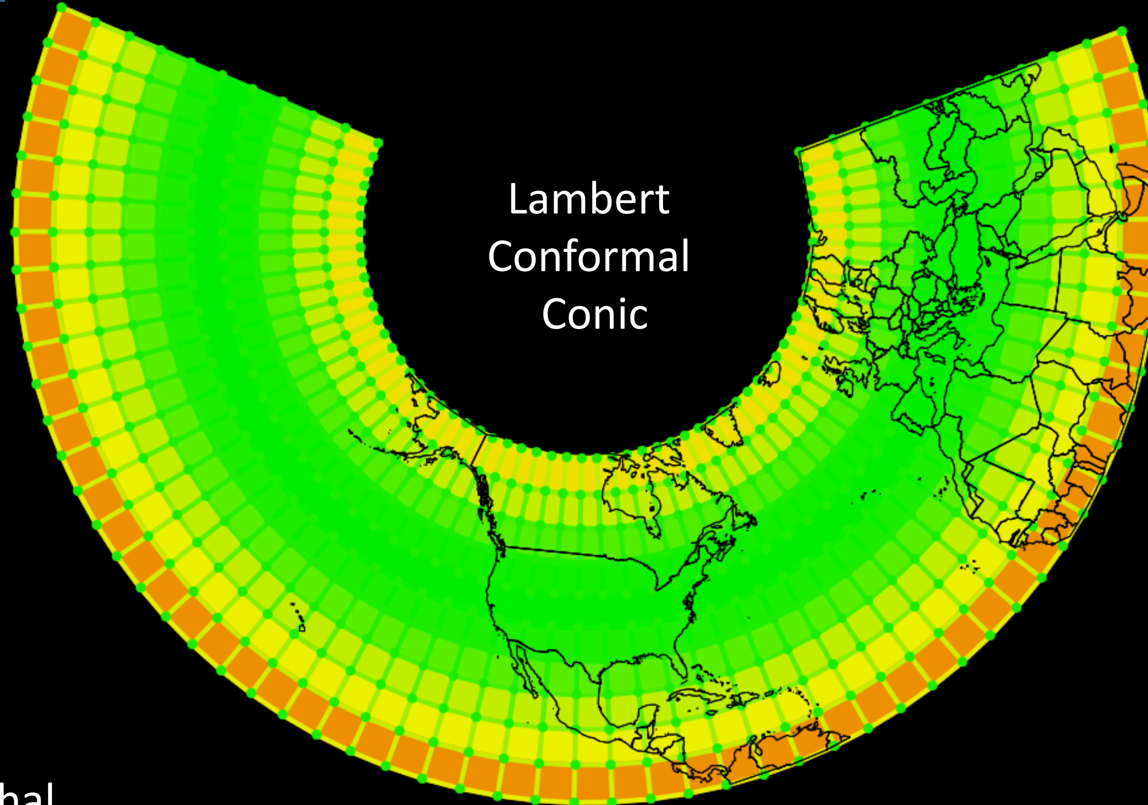
Details

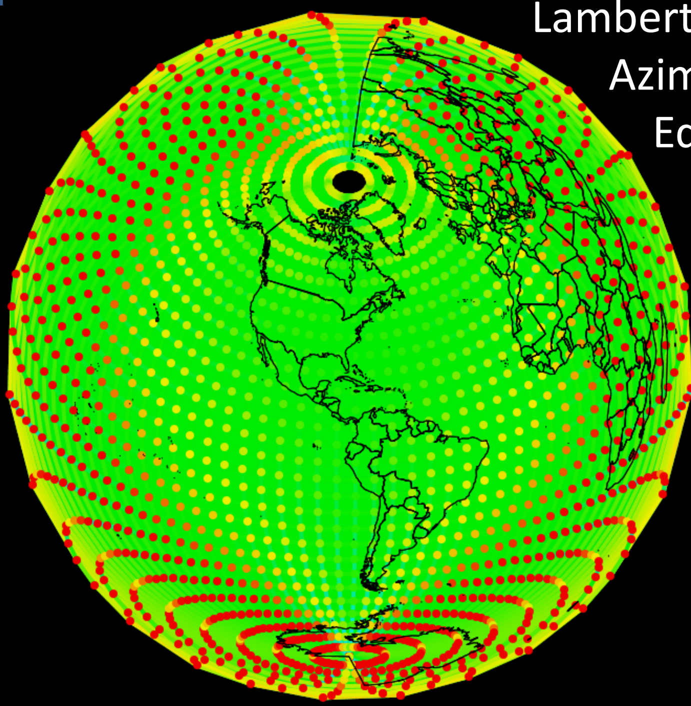
- Accessing vector data from an applet
  - Used BlueSprays "stx" format
- Java Topology Suite is very picky
- Projected Systems can extend beyond +-180 to +-90 degrees
  - Used a 360*3, 180*3 sized grid for analysis



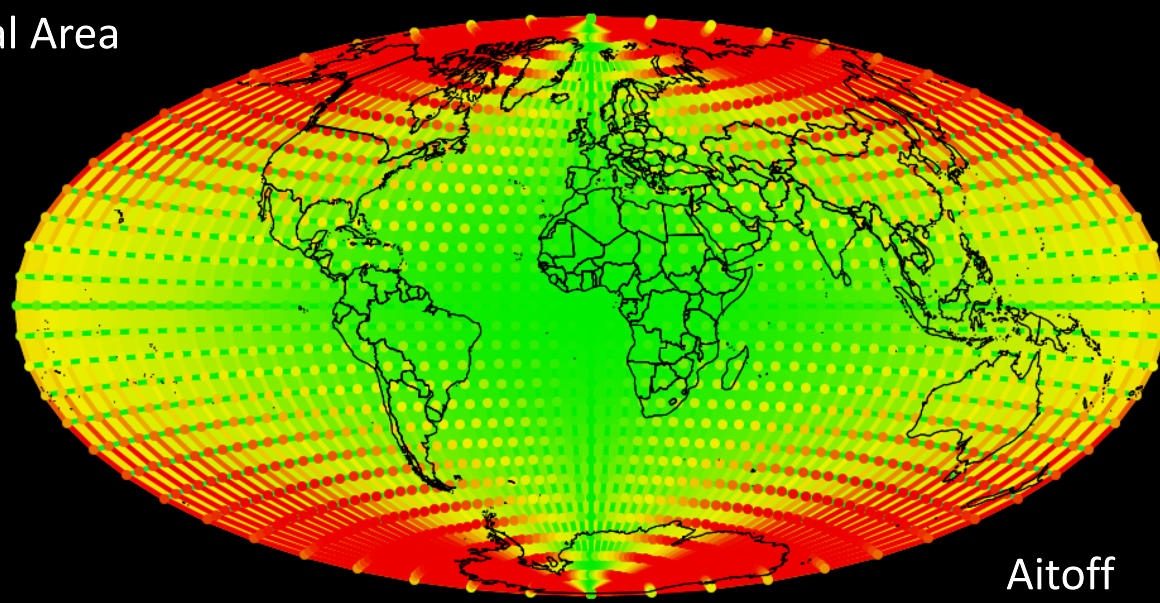
Oblique Stereographic



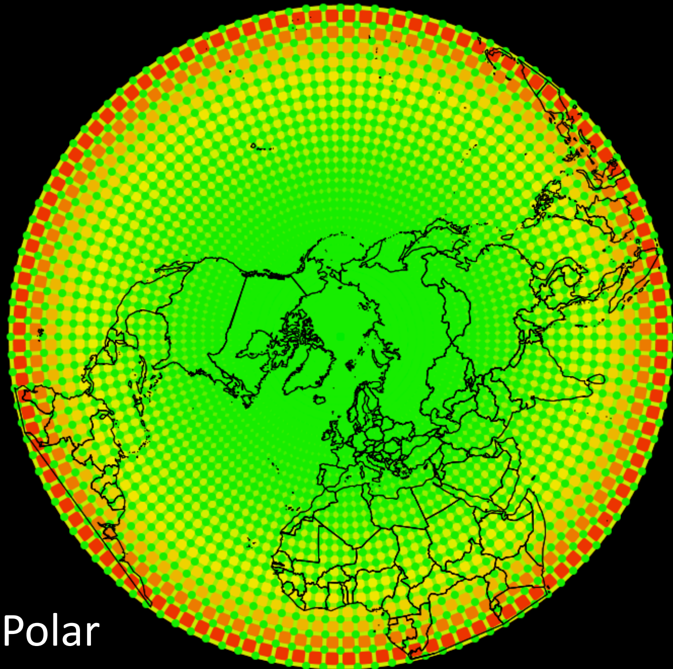
Lambert Conformal Conic



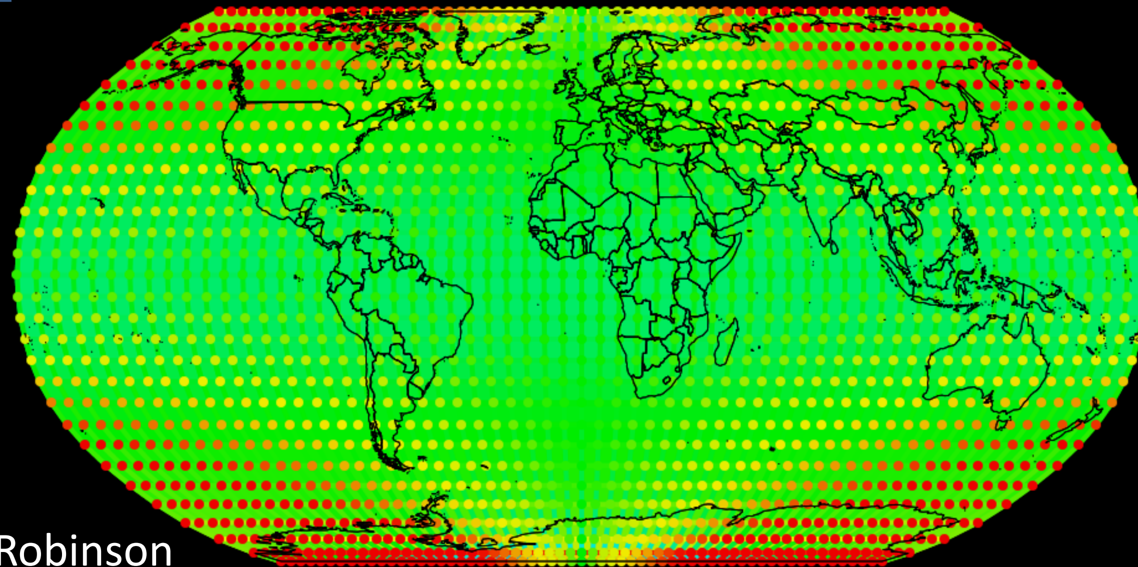
Lambert Azimuthal Equal Area



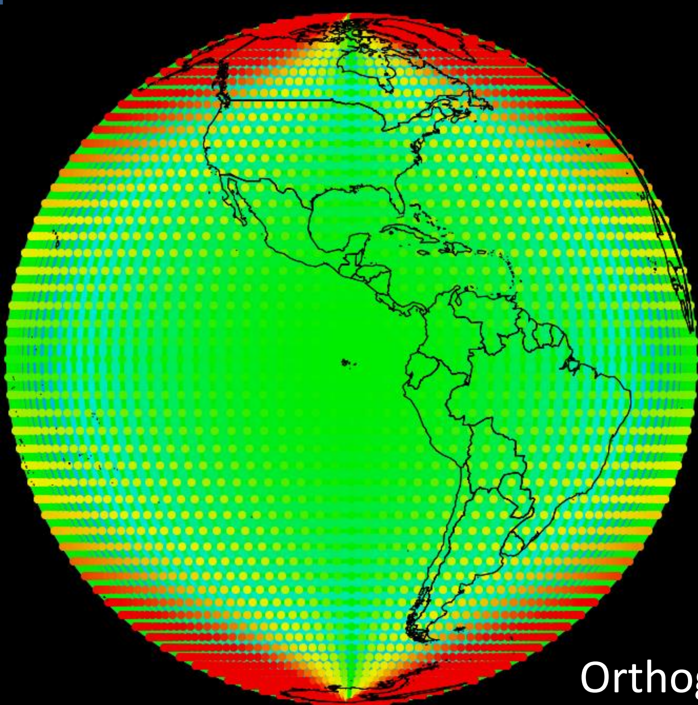
Aitoff



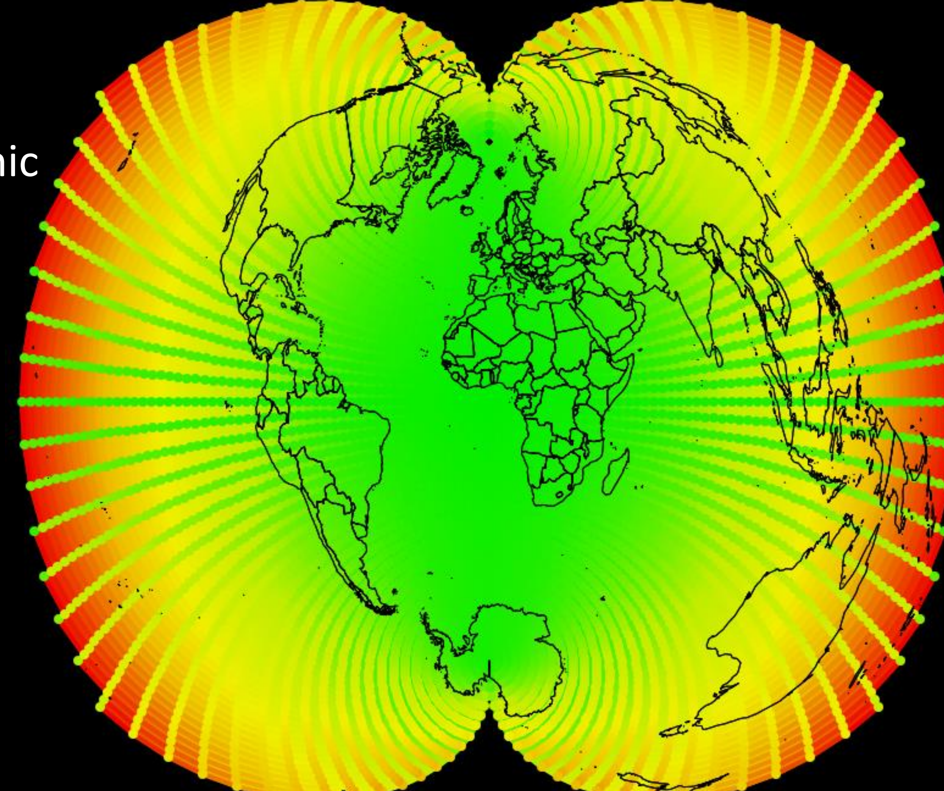
Polar Stereographic



Robinson



Orthographic



Polyconic

Available At:

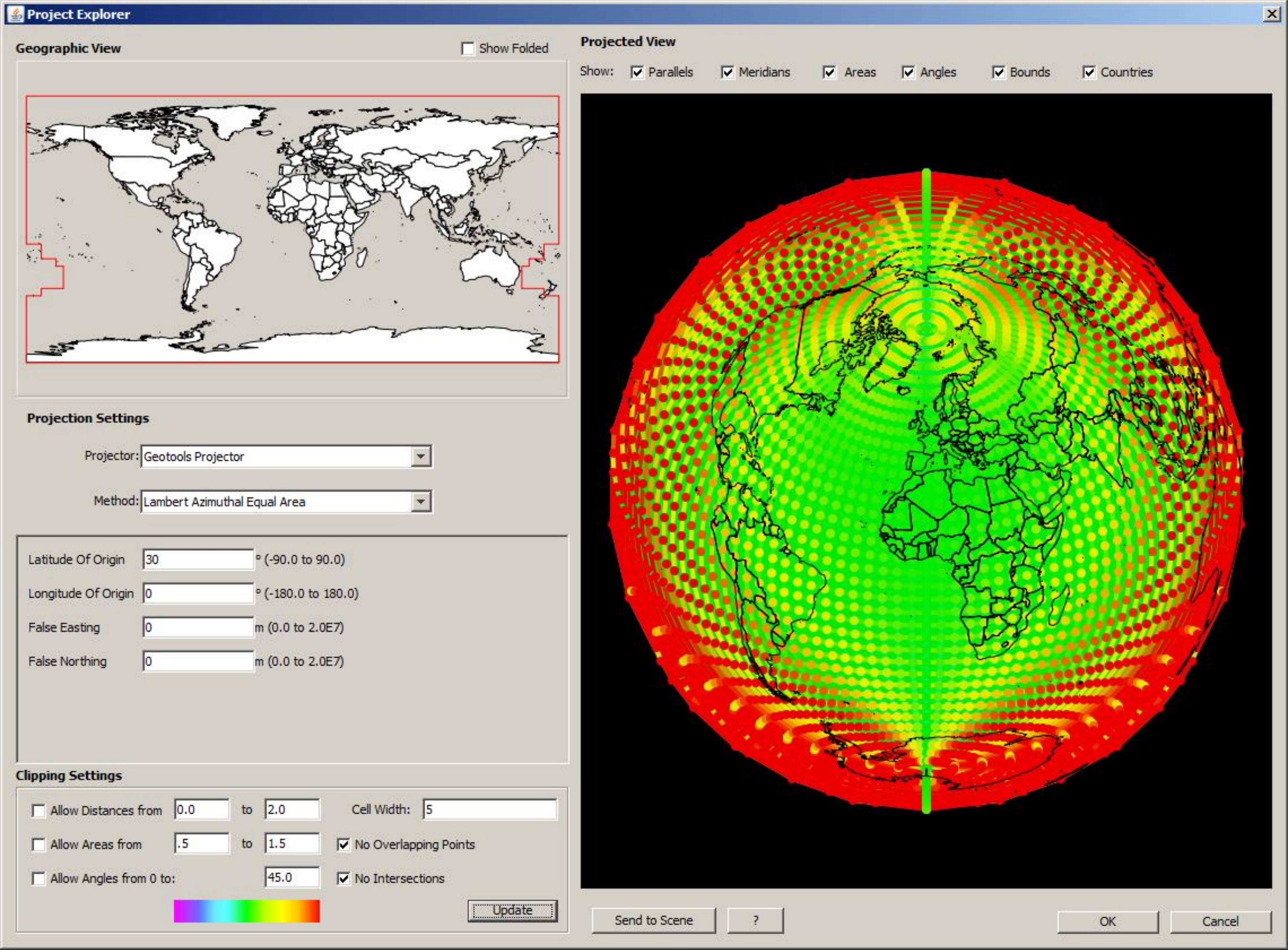
- Applet:
  - HSU Geospatial Web Site
  - www.humboldt.edu/gsp -> Links
- BlueSpray:
  - SchoonerTurtles web site:
  - www.schoonerturtles.com

Future Steps

- Add the ability to project from any layer
  - Not just the globe
- Finish projection engine within BlueSpray
  - Uses the Projection Explorer to set the bounds

Acknowledgments

- Jake Nelson, Dr. Bernhard Jenny at Oregon State University
- Nick Ramirez at Humboldt State University
- Greg Newman at Colorado State University
- All the folks that support open source GIS software: GDAL, GeoTools, Proj4, JTS, NetBeans, etc.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Clipping Settings
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Cell Width:
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Allow Areas from
.5
to
1.5
No Overlapping Points
Allow Angles from 0 to:
45.0
No Intersections
Update
Send to Scene
?
OK
Cancel