Impacts of Map Projections on Geophysical Data Calculations

PolarWatch Sea Ice Training Course
October 21, 2024

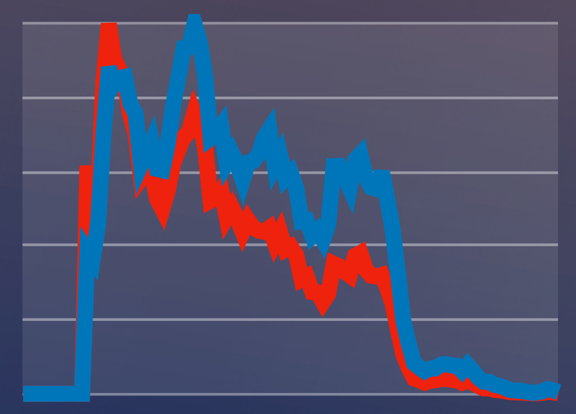
Peter Hollemans, CoastWatch Central Operations

Data analysis results can change when the map projection changes.

Statistical results

$$\bar{x} = \frac{\sum x_n}{N}$$

Histogram shapes



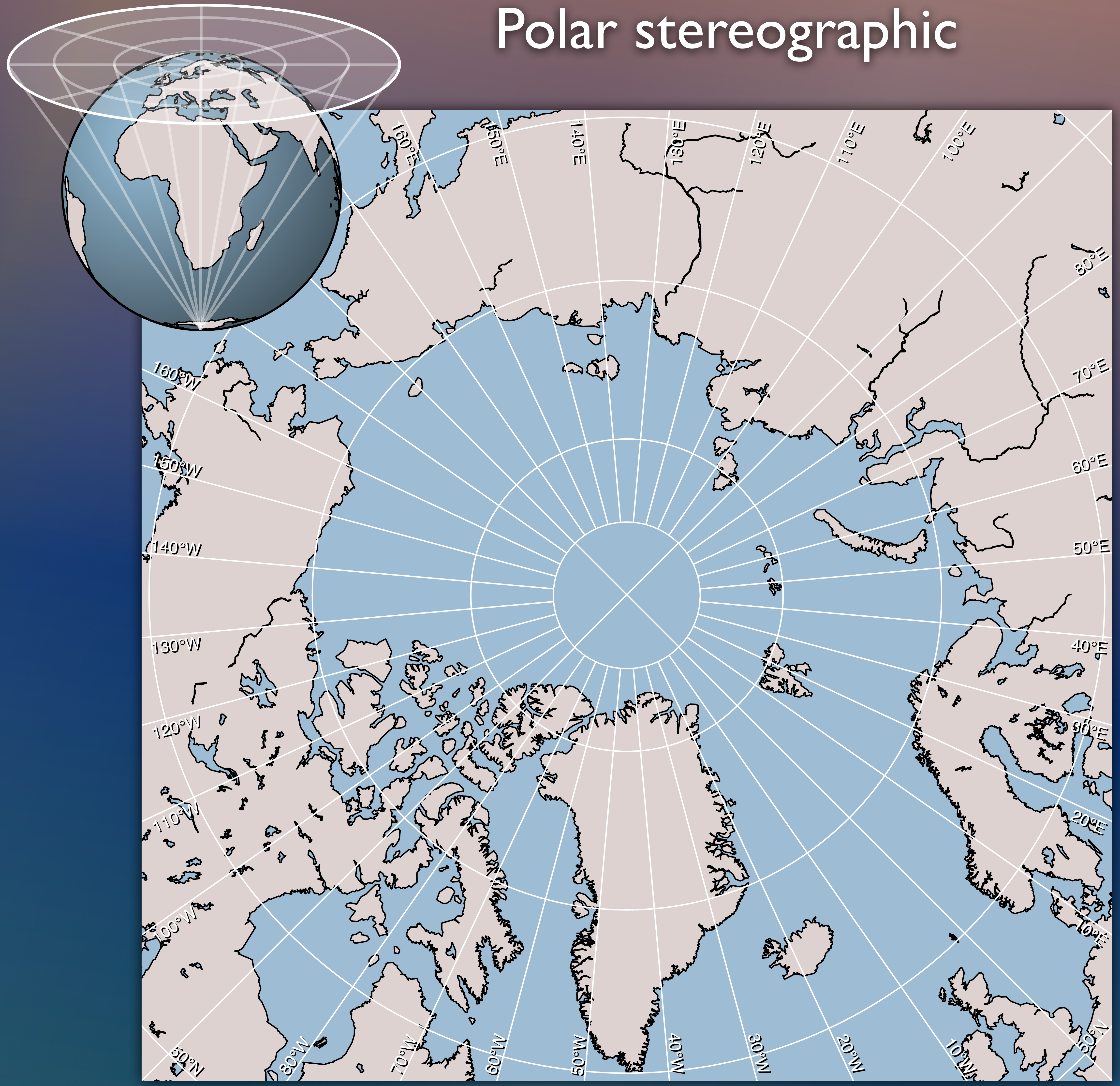
Areal extents

Line surveys

Cylindrical and planar map projections distort physical areas in different ways.

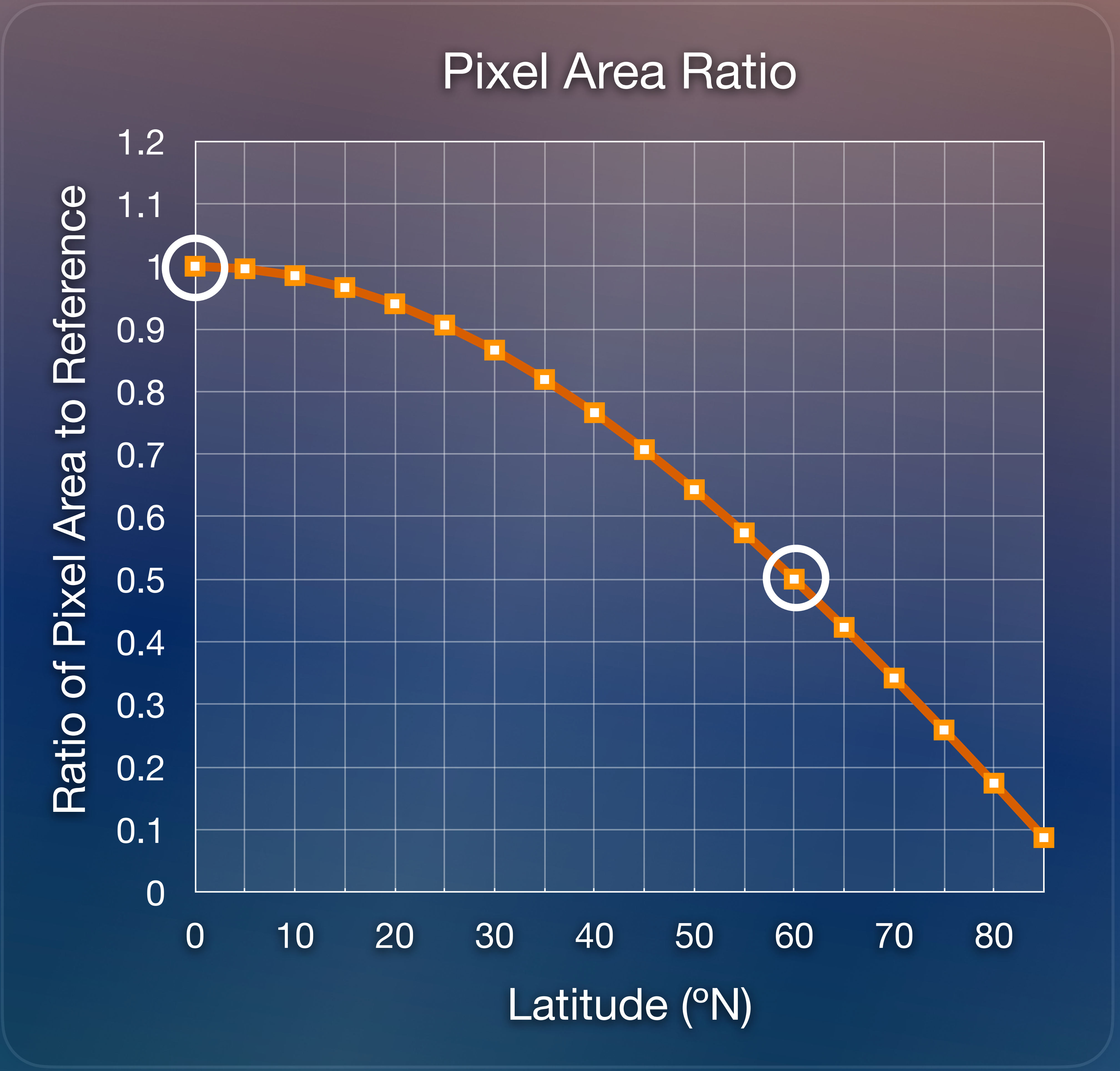
Geographic

Polar stereographic

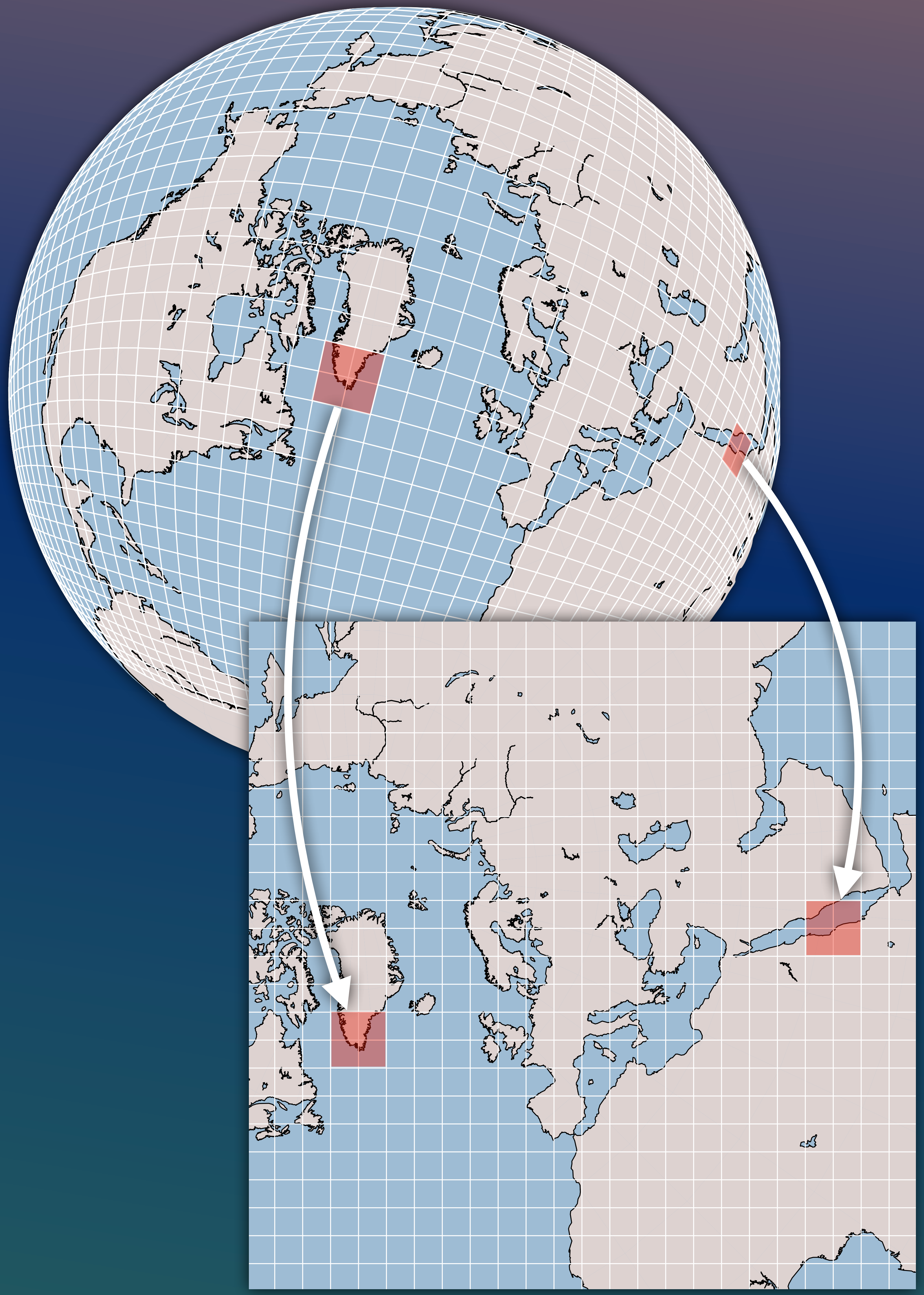


A geographic map projection has the least distortion near the equator, and the greatest towards the poles.

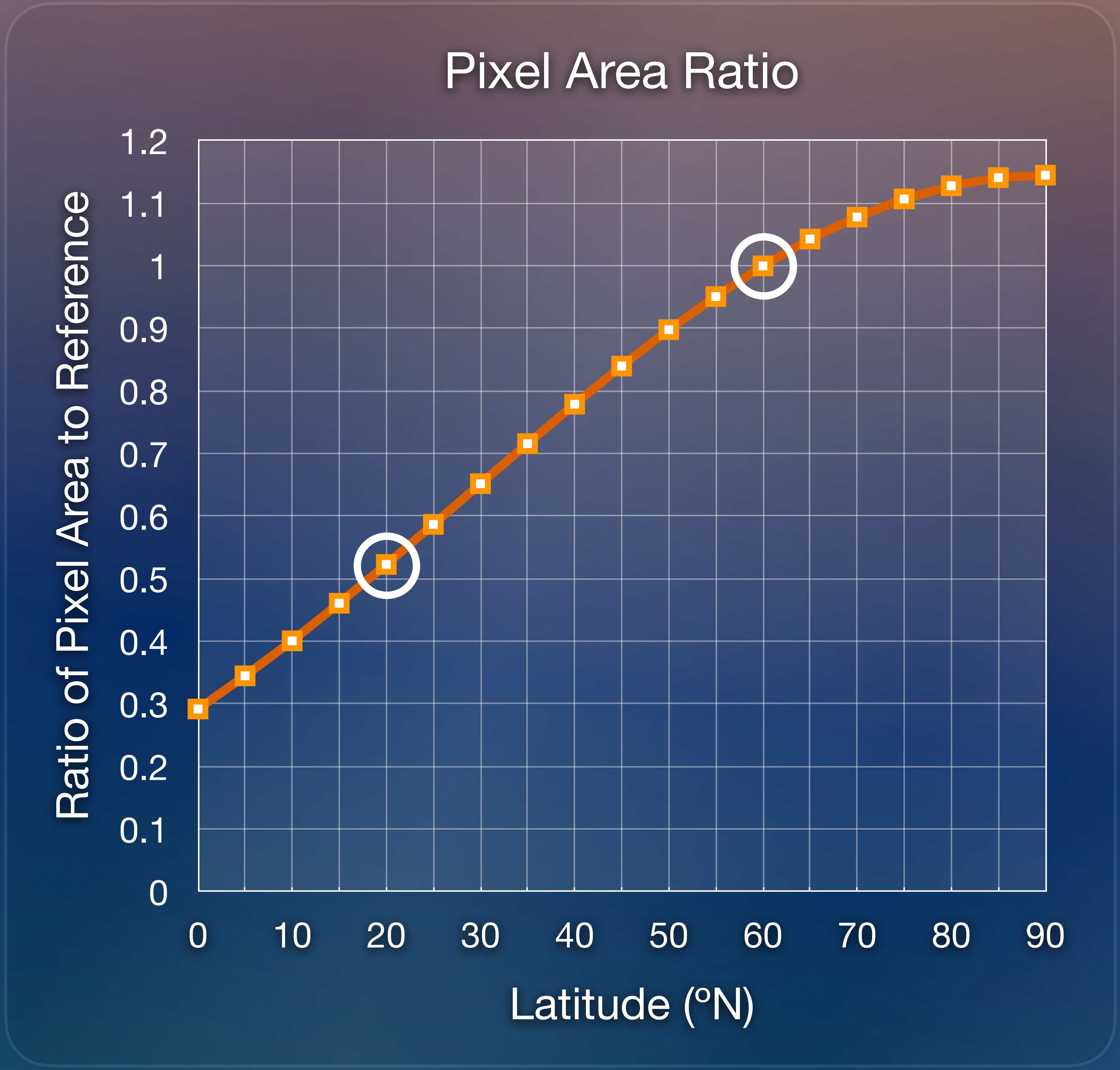
Lat (ºN)	Area Ratio
0	1.000
5	0.996
10	0.985
15	0.966
20	0.940
25	0.906
30	0.866
35	0.819
40	0.766
45	0.707
50	0.643
55	0.574
60	0.500
65	0.423
70	0.342
75	0.259
80	0.174
85	0.087



A polar stereographic map projection has the least distortion near the pole, and the greatest towards the equator.

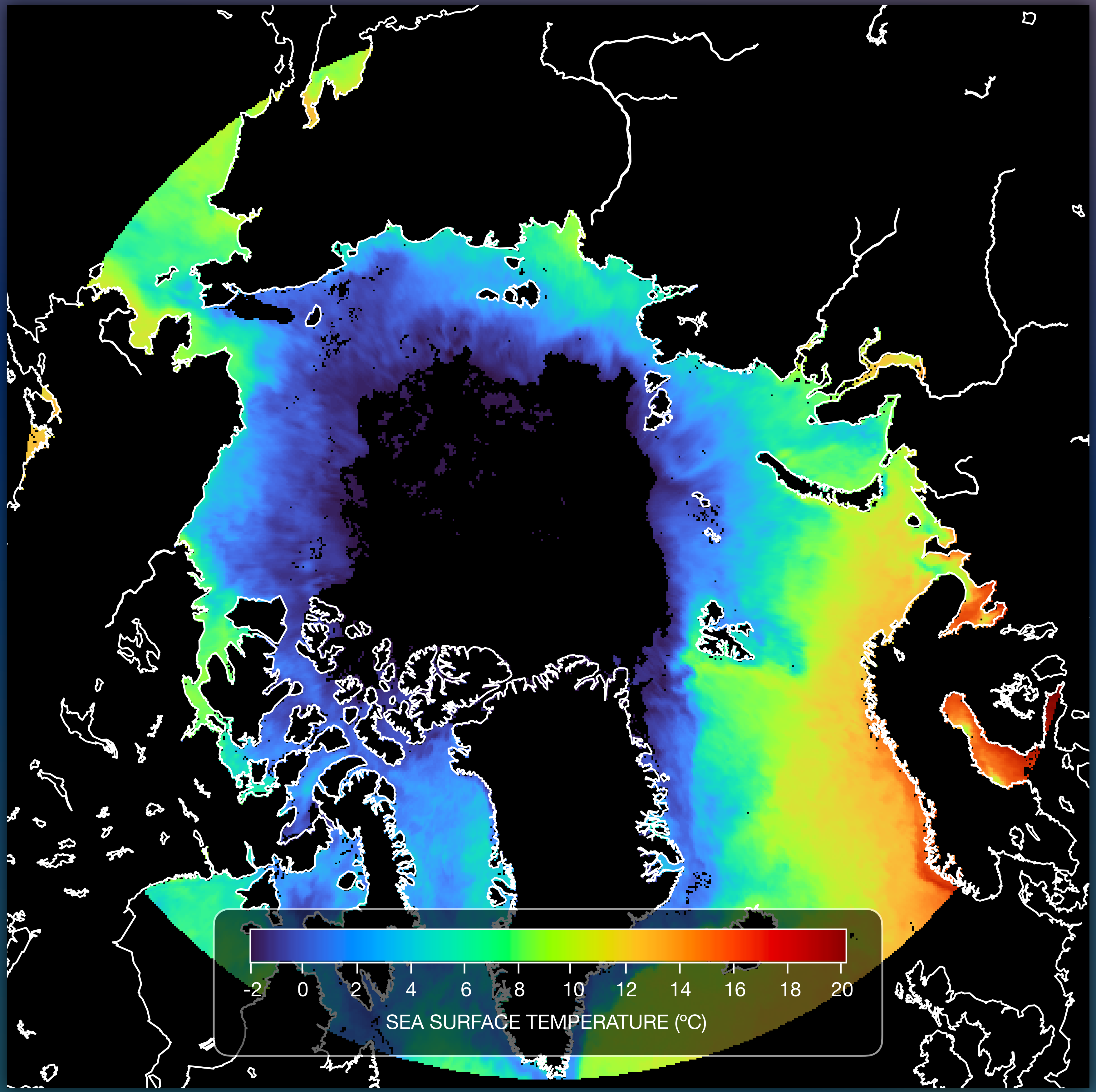


Lat (°N)	Area Ratio
0	0.292
5	0.345
10	0.401
15	0.461
20	0.523
25	0.587
30	0.652
35	0.716
40	0.779
45	0.840
50	0.898
55	0.951
60	1.000
65	1.043
70	1.078
75	1.107
80	1.128
85	1.141
90	1.145

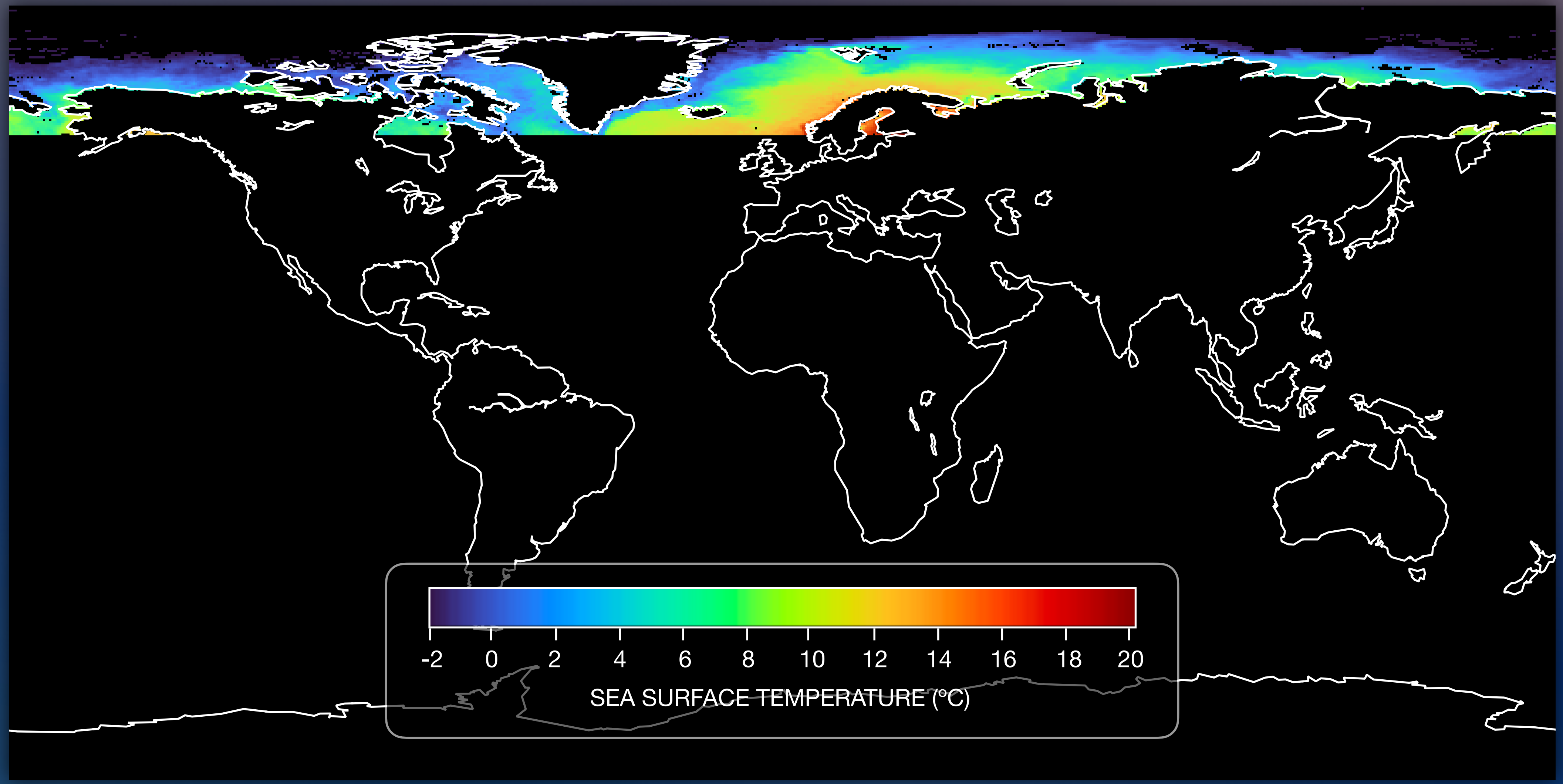


The mean pixel value computed for a geophysical variable varies depending on which projection is used for the calculation.

Mean sea surface temperature value = 5.10°C

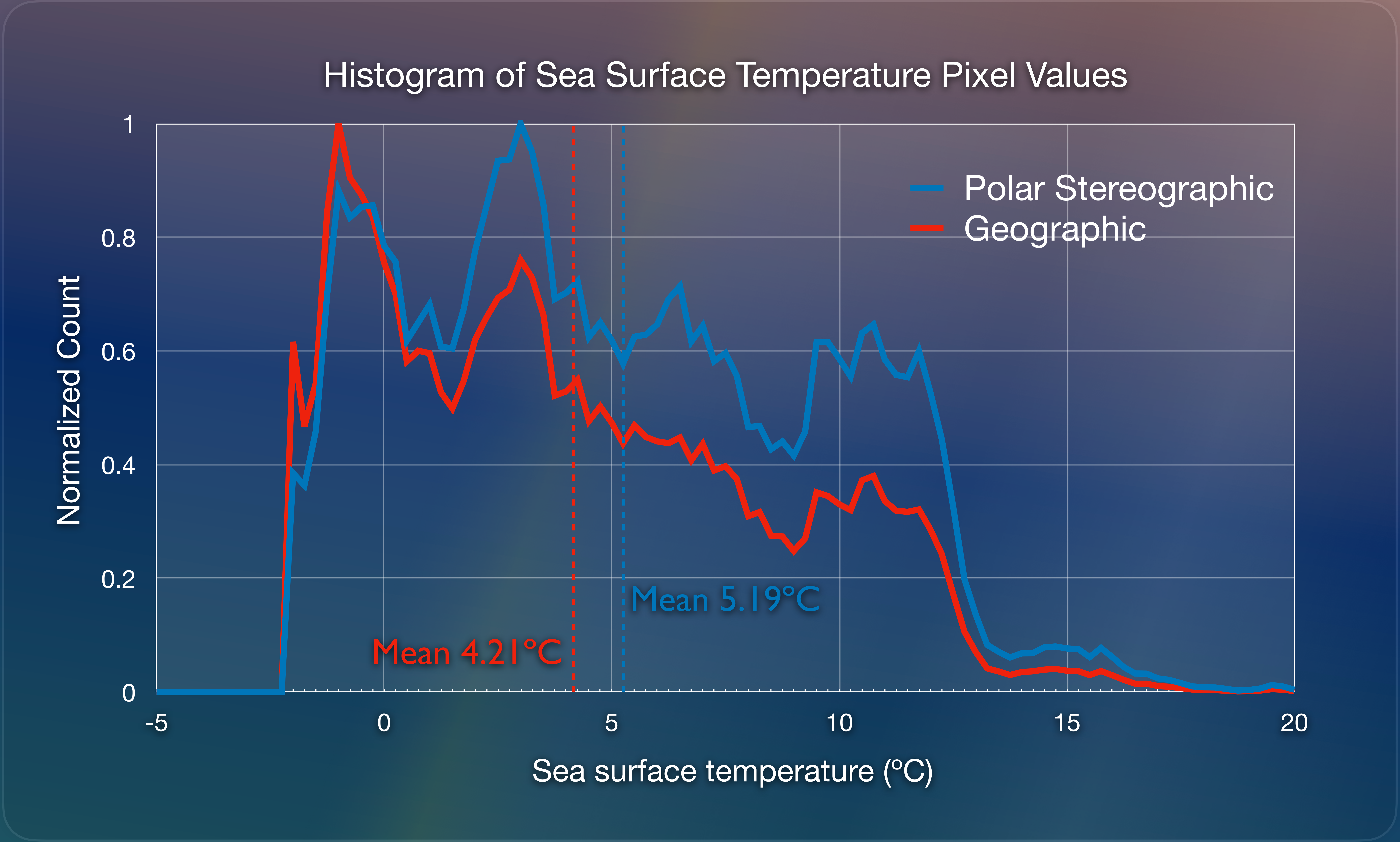


Mean SST pixel value = 5.19°C



Mean SST pixel value = 4.21°C

The histograms of pixel values reveal why the statistics are different.



A solution is to take into account the different pixel areas when computing statistics.

Pixel value mean:

$$\frac{\sum_{n=1}^{N} SST_n}{N}$$

```
double sum = 0;
int values = 0;
while (iter.hasNext()) {
  loc = iter.next();
  value = varObject.getValue (loc);
  if (!Double.isNaN (value)) {
    sum += value;
    values++;
  } // if
} // while

mean = sum/values;
System.out.println ("Mean = " + mean);
```

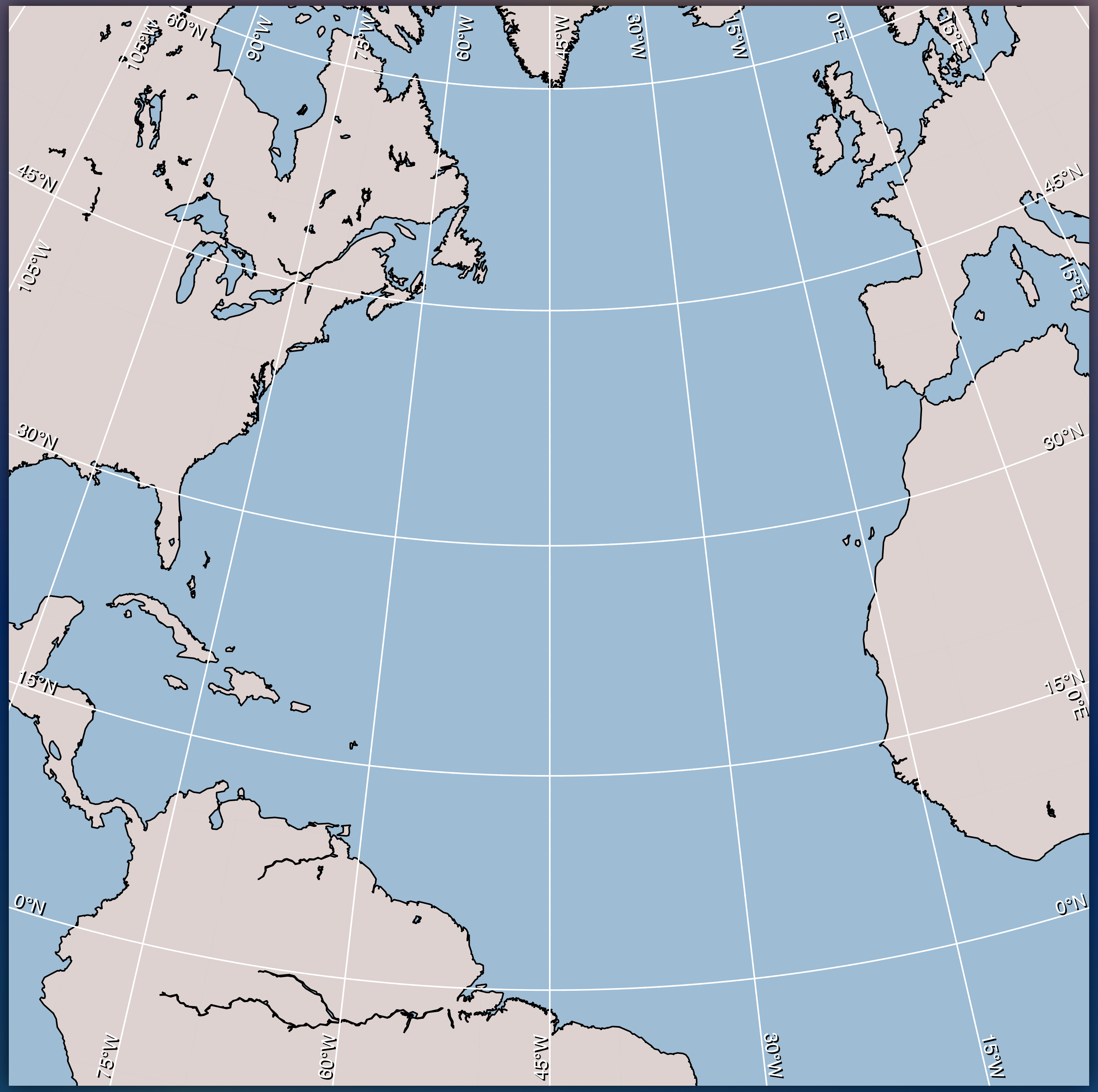
Area weighted mean:

$$\left(\sum_{n=1}^{N} SST_n \cdot A_n\right) \Big/ \sum_{n=1}^{N} A_n$$

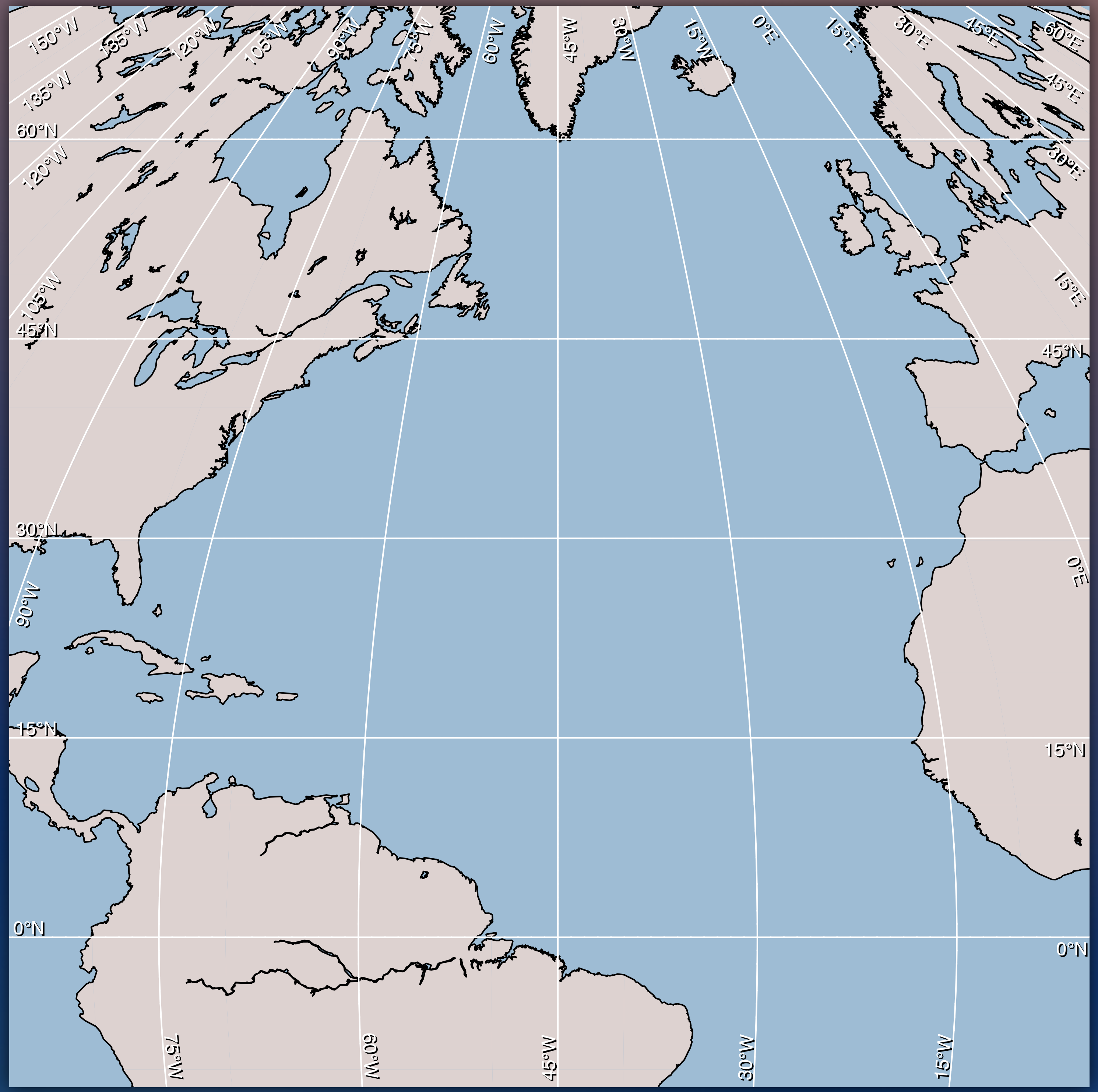
```
double weightedSum = 0;
double areaSum = 0;
while (iter.hasNext()) {
  loc = iter.next();
  value = varObject.getValue (loc);
  if (!Double.isNaN (value)) {
    res = transform.getResolution (loc);
    area = res[Grid.ROW] * res[Grid.COL];
    weightedSum += area*value;
    areaSum += area;
  } // if
} // while

weightedMean = weightedSum/areaSum;
System.out.println ("Area weighted mean = " + weightedMean);
```

Another solution is to compute statistics using an equal area projection.

Lambert azimuthal
equal area



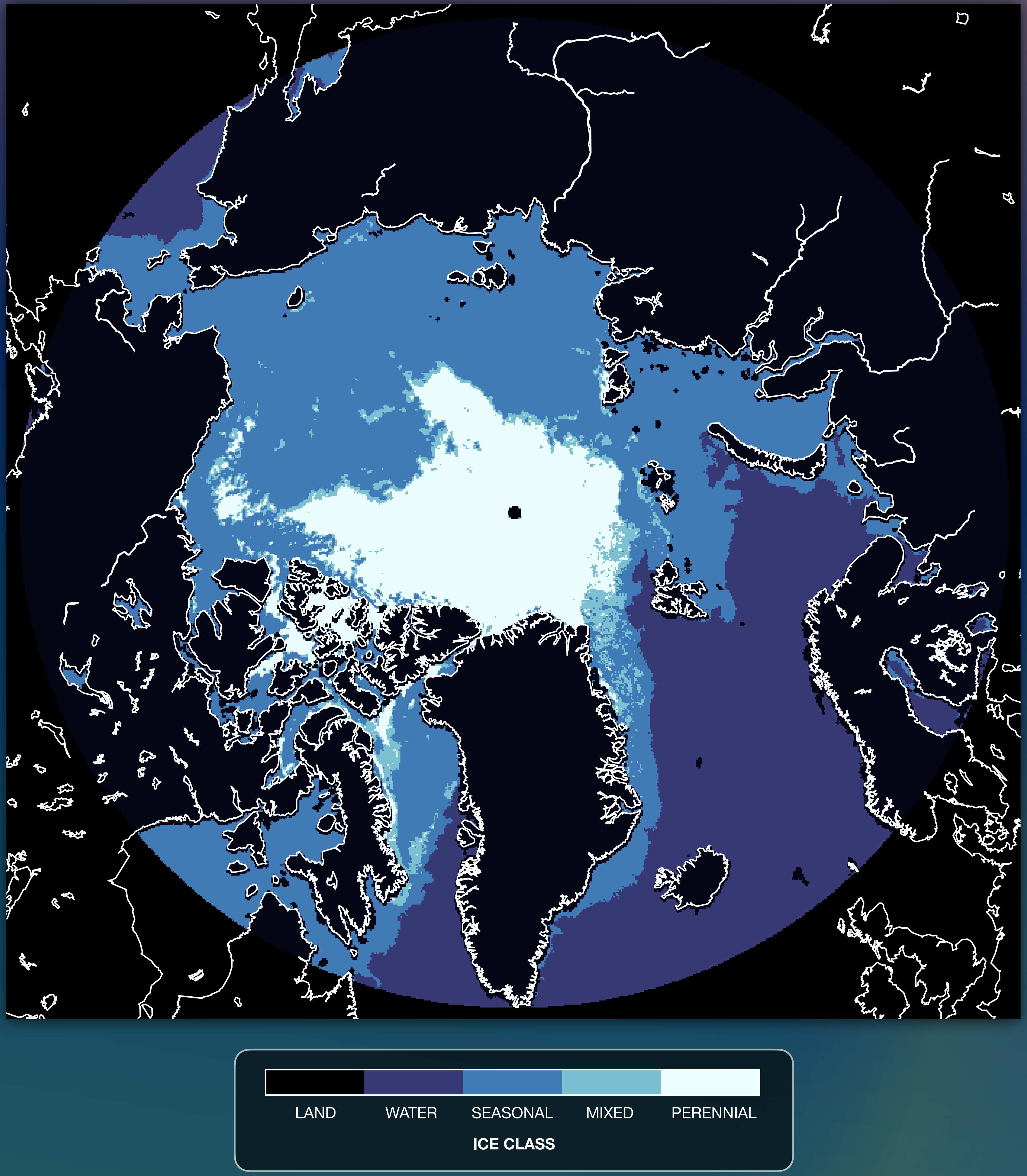
Albers conical
equal area

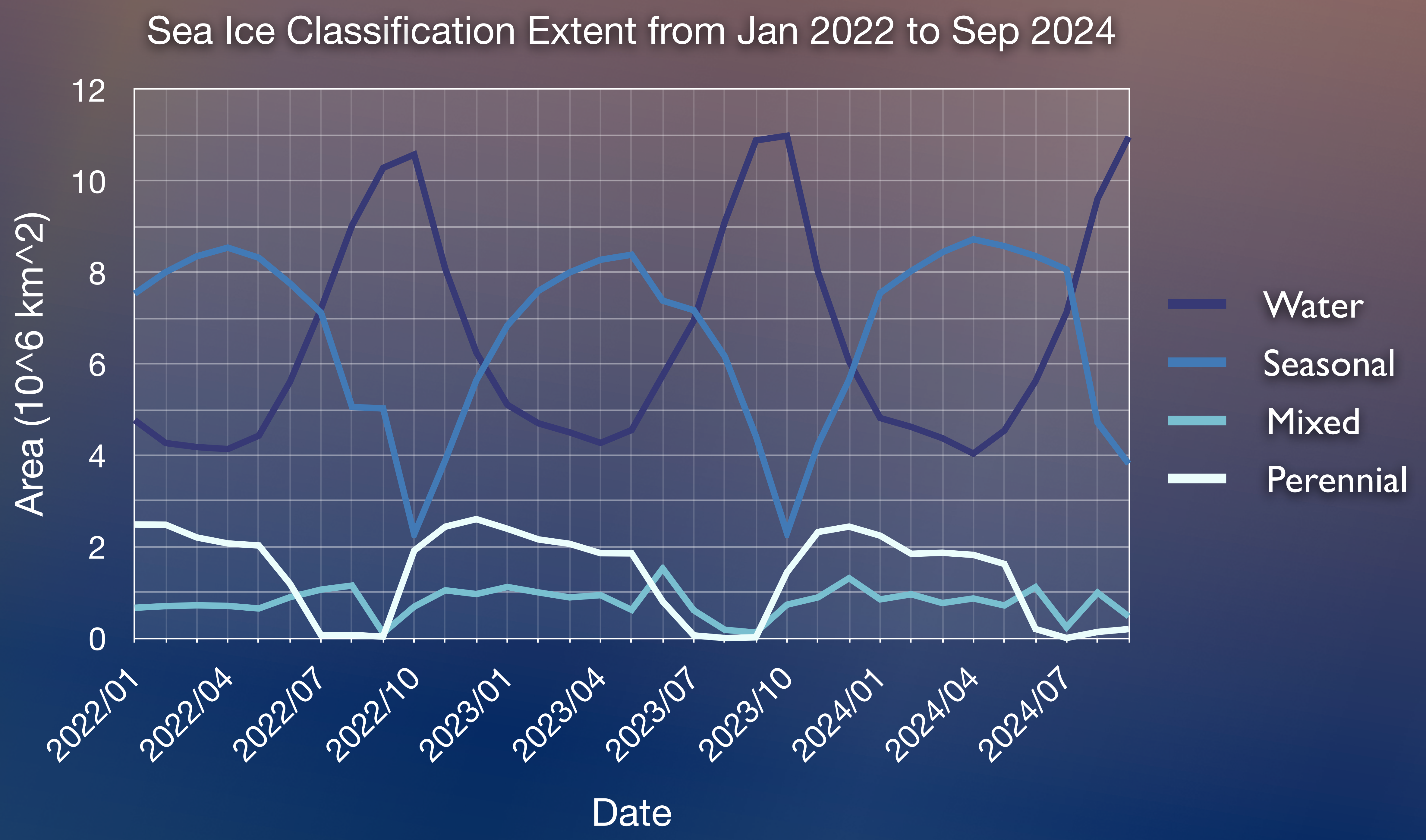


Sinusoidal

Geophysical variable extent calculations also need to account for pixel areas.

Metop-C ASCAT Ice Classification

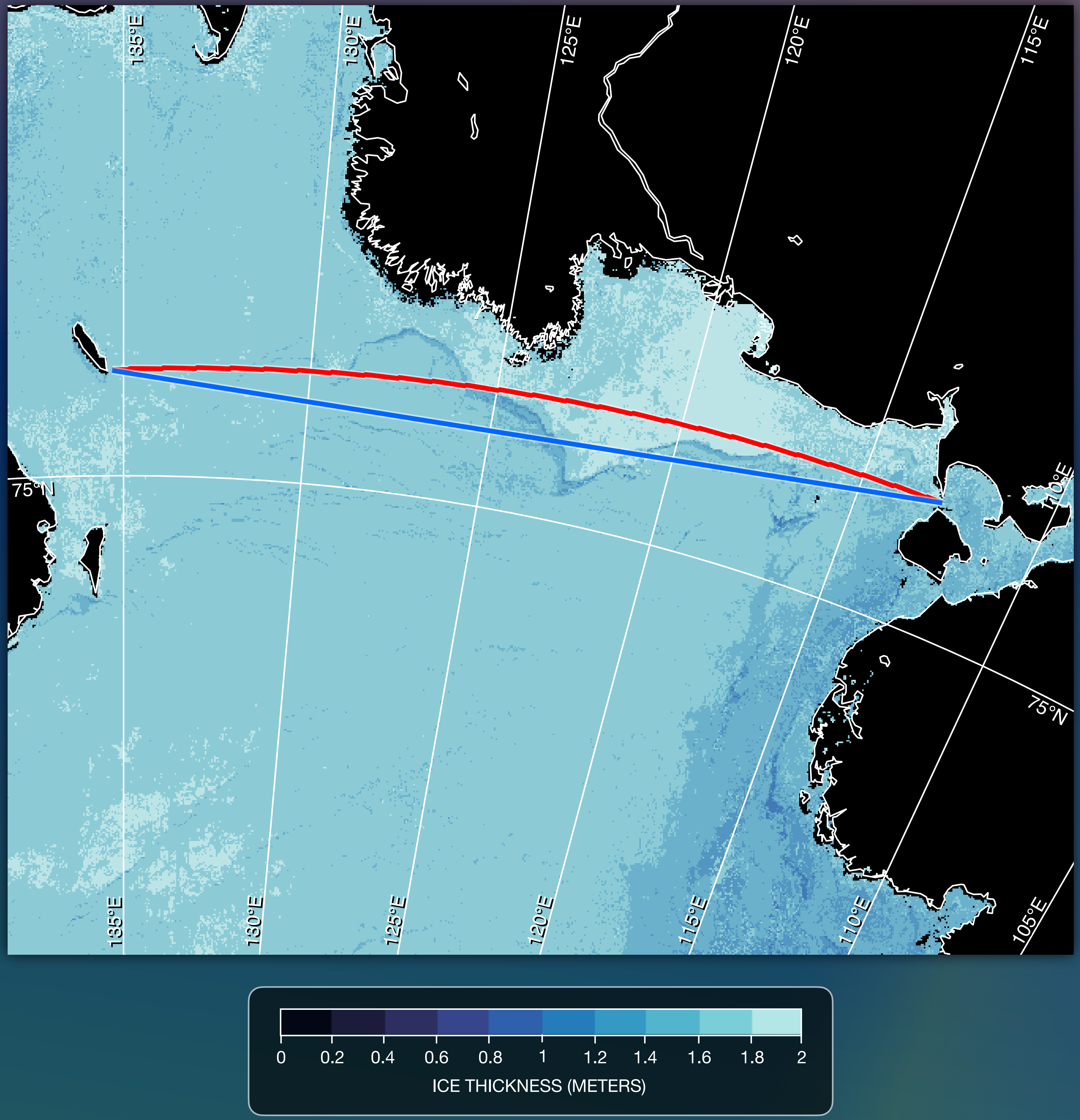


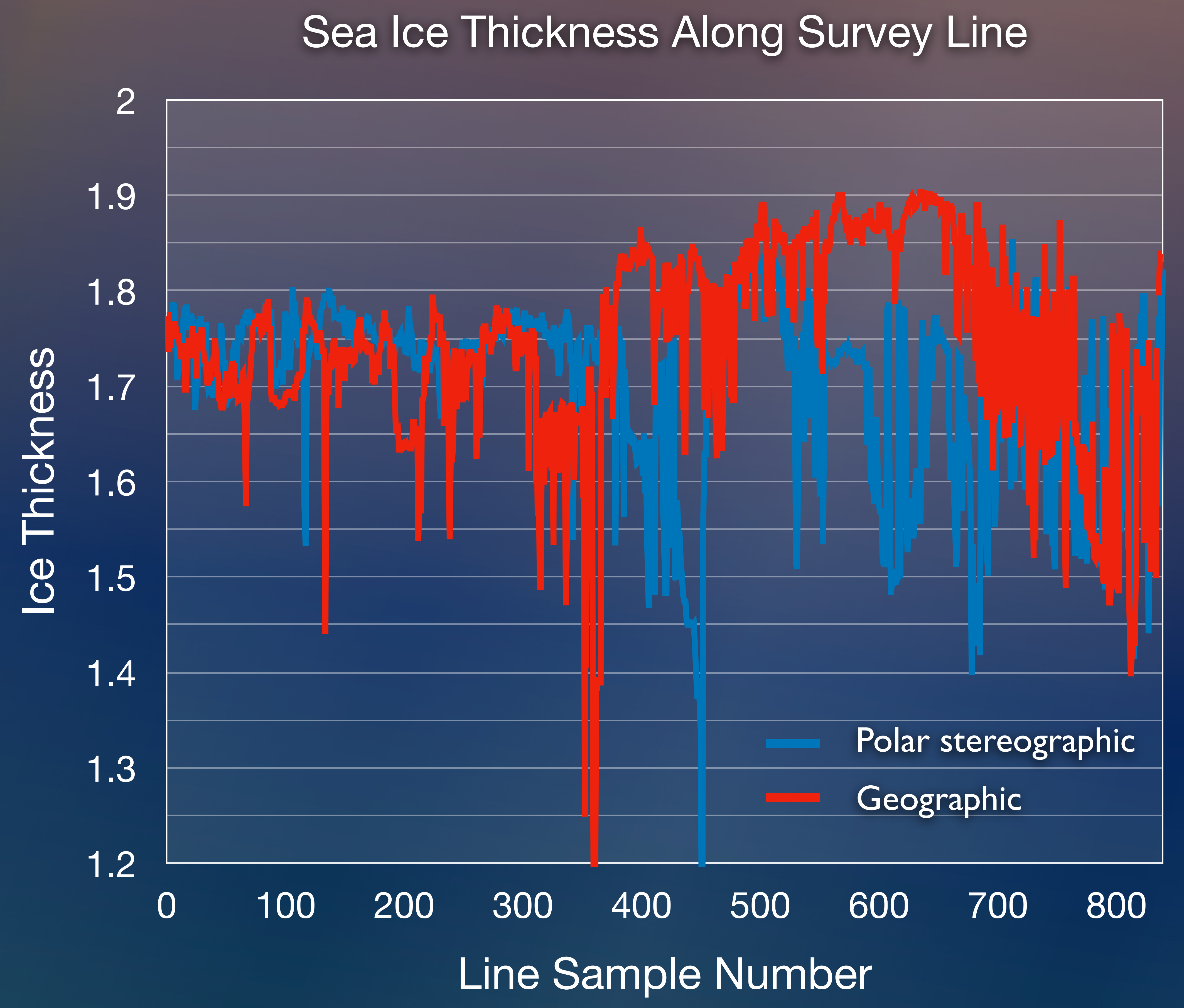



```
double areaSum = 0;
while (iter.hasNext()) {
  loc = iter.next();
  value = varObject.getValue (loc);
  if (((int) Math.round (value)) == iceValue) {
    res = transform.getResolution (loc);
    area = res[Grid.ROW] * res[Grid.COL];
    areaSum += area;
  } // if
} // while

print ("Ice extent = " + (areaSum*1e-6) + " x 10^6 km^2");
```

Line survey data depends on the map projection used.

NOAA-20 VIIRS Ice Thickness





Resources

Course page:
https://coastwatch-training.github.io/CoastWatch-Workshops/courses/seaice24.html

Sea surface temperature data:
https://polarwatch.noaa.gov/erddap/griddap/nesdisGeoPolarSSTN5NRT
Sea ice classification data:
https://polarwatch.noaa.gov/erddap/griddap/noaacwSARciceclassnpoleDaily
Ice thickness data:
https://polarwatch.noaa.gov/erddap/griddap/noaacwVIIRSn20icethickNP06Daily4Day

Code snippets:
http://terrenus.ca/download/courses/seaice_oct21_2024/code