AVHRR Pathfinder OCEANS

# Equal-area gridding scheme proposed for Pathfinder/SeaWiFS ocean products

## Introduction

This document describes the equal-area gridding scheme proposed by the University of Miami's Rosenstiel School Remote Sensing Group for the binned sea surface temperature fields produced by the AVHRR Pathfinder Oceans project. The same approach is being adopted for SeaWiFS binned ocean color products. The gridding scheme is based on that adopted by the International Satellite Cloud Climatology Project (ISSCP).

This document does not motivate the need for an equal area grid for SeaWiFS or other oceanographic products. Such motivation can be found in a paper by W. Rossow and L. Gardner (Selection of a map grid for data analysis and archival, *Journal of Climate and Applied Meteorology*, 1984, 23:1253-1257). Furthermore, this document describes only the design of the proposed equal-area grid, and does not discuss other related topics such as rules for spatially or temporally combining observations into the equal-area bins.

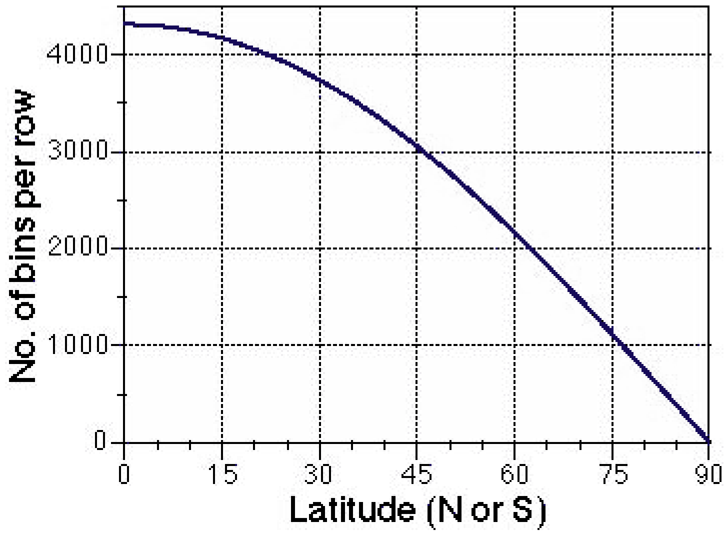
## Overview

The gridding scheme proposed consists of rectangular bins or tiles, arranged in zonal rows. A compromise between data processing and storage capabilities, on one side, and the potential geophysical applications of satellite data, on the other side, suggest that a suitable minimum bin size would be approximately 8-10 km on a side.

In the scheme proposed here, the tiles are approximately 9.28 km on a side. This size (9.28 km) was chosen because (a) it has approximately the desired minimum resolution, and (b) it results in 2160 zonal rows of tiles from pole to pole (i.e., 1080 in each hemisphere). This particular number of rows (2160) has some advantages which will be discussed in more detail below. Because the total number of rows is even, the bins will never straddle the Equator (i.e., there will be an equal number of rows above and below the Equator). This avoids possible situations where the Coriolis factor is zero, a characteristic that numerical modellers expect from any gridding scheme adopted.

The total number of approximately 9-km bins is 5,940,422. The bins or tiles are arranged in a series of zonal rows; the number of tiles per row varies. The rows immediately above and below the Equator have 4320 tiles. This number is derived by dividing the perimeter of the Earth at the Equator by the standard tile size (i.e., 2 *pi* $R_e$ /9.28), where $R_e$ is the equatorial radius of the Earth ($R_e$ = 6378.145 km). The number of tiles per row decreases approximately as a cosine function as the rows get closer to each pole (rigorously, there should be an adjustment for ellipticity of the Earth, as the equatorial radius decreases progressively to the smaller polar radius; this adjustment is not applied in the current implementation). At the poles, the number of tiles is always three. This special situation will be discussed in detail below. The number of tiles per row as a function of latitude is shown on Figure 1.

**Figure 1.** Number of 9.28 km tiles per zonal row as a function of latitude (North or South). The number of tiles is 4320 at the Equator and decreases to 3 at the poles.




The number of bins in each zonal row is always an integer. To ensure an integer number of bins, the width of each bin (the size of a bin along a parallel, or x-length) must vary slightly from row to row. The bins, however, are always 9.28 km long along the meridians. That is, only one of the bin dimensions changes. The size of the bins at each zonal row is established in the following manner. First, a preliminary value for the number of tiles ($N_p$) at a given latitude (L) is computed as

$$N_p = 2\ pi\ r / X,$$

where X is the x-size of a bin at the Equator (9.28 km) and r is the radius of the circle produced by slicing the Earth with a plane parallel to the Equator at latitude L. The radius r can be calculated as

$$r = R_e \cos(L),$$

where $R_e$ is the equatorial radius of the Earth. If the fractional part of $N_p$ is greater or equal than 0.5, then $N_p$ is rounded up to the nearest integer (i.e., the final number of tiles will be the integer portion of $N_p$ plus one), otherwise $N_p$ is rounded down (the final number of tiles is the integer portion of Np. Once the final integer number of tiles along a row is calculated, the X-size of the tiles must be adjusted. This is done by dividing the perimeter of the row (2 *pi* r) by the integer number of tiles. The result is the x-length of a tile (width) for a given row.

Because the x-length of the tiles is adjusted to ensure an integer number at each row, the "equal area" characteristics of this binning scheme are not rigorously preserved. However, variations in tile size are negligible throughout most of the globe, and only become relevant at very high latitudes, where there are fewer tiles per row and, thus, any adjustments are more noticeable. As soon as the number of tiles increases with distance from the poles, the difference between tile sizes rapidly becomes practically unnoticeable. To provide an idea of the magnitude of the fluctuations in tile size, the worst possible case occurs when half a tile remains "uncovered" after filling a zonal row with an integer number of tiles. Once a row has 100 bins (approximately 16 rows, or 148 km from the poles), the worst possible difference between the actual tile x-length and the standard x-length is of the order of 0.5% (i.e., half a tile's length redistributed among about 100 tiles). For a tile of about 9 km a side, this represents a difference in the x-length of about 45 m. Through a similar calculation, a row with 50 bins (about 80 km away from the poles) has a 1% variation with respect to the standard bin size.

The gridding scheme described here has an extremely useful feature: the number of 9.28 km tiles in each hemisphere (1080) is divisible by many numbers (e.g., 2,3,4,5,6) and therefore it is extremely easy to generate an integer number of rows at many useful spatial resolutions. For instance, 12 rows of 9.28 km tiles can be combined to generate zonal bands of approximately one degree (one degree of latitude is equal to 111.12 km; 12 bins would form a band 111.20 km wide). Another example is the use of 30 rows of to generate zonal bands of approximately 2.5° (a typical output resolution of atmospheric circulation models).

## The poles

Both the North and South poles are special cases in the gridding scheme presented here. The pole areas are always covered by three tiles, shaped like pie sectors. While the meridional size of the polar bins (the y-length) will be the usual 9.28 km, the length of the bins along the arc of the sectors will be slightly larger. Neglecting sphericity, the area encompassed by the last row of tiles is *pi* $X^2$, where X = 9.28 km. If we express the area of the circle as a rectangle of height X, the remaining dimension is *pi* X. If we divide the perimeter by three (to yield three tiles), each tile will have dimensions X by *pi* X/3 (approximately 1.05X). That is, the bases of the triangular polar tiles are about 5% larger than the x-length of the equatorial tiles.

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