Wide Area Grid Development for Creating HF Radar Total Vector Solutions

Mark Otero
January 27, 2006

Coastal Observing Research & Development Center
Scripps Institution of Oceanography
motero@mpl.ucsd.edu
www.cordc.ucsd.edu

1. Motivation

Coastal grids need to be developed around the United States in order to seamlessly integrate radial HF-Radar data for total vector production on a nationwide scale. Four grids are currently planned to cover the following regions in order to meet this need:

- U.S. West Coast
- U.S. East & Gulf Coast
- Alaska
- Hawaii

Due to the large spatial extent of these regions (alongcoast distances up to 3000 km) and relatively high resolution of HF-Radar data (1 – 5 km), careful consideration must be given to the advantages and disadvantages of potential grid generation methodologies. The adopted grid should preserve data integrity as well as provide a practical format for data dissemination.

Present standard practices are based upon the geometric combination of radial data from limited number of sites using a grid defined by fixed latitudinal and longitudinal resolution. These grids are typically established in an ad-hoc manner over limited spatial extents which do not need to consider projection errors.

2. Coastline Definition

Coastline masks are used to define valid over-water grid cells. We have adopted the use of World Vector Shoreline data collected by the National Geospatial-Intelligence Agency and made available through the National Geophysical Data Center (http://rimmer.ngdc.noaa.gov/mgg/coast/getcoast.html). These data, consisting of latitude and longitude pairs arranged in segments of coastline, were further manipulated to produce continuous, non-repeating segments of coastline for the U.S. East and West coast as well as polygons for the United States, North America (between 20N and 55.5N), Cuba (north of 20N), and all associated coastal islands (coastline for Hawaii and Alaska have not been extracted yet). These segments and polygons provide the data needed to mask grid points falling on or near land or beyond a given offshore limit.

3. Grid generation

3.1 Masking

Our general approach to grid generation is to first develop a 'blank' grid of latitude and longitude with the desired resolution covering the region of interest. The resulting grid blank only contains only a fraction of relevant grid cells, requiring the removal, or masking of the un-needed cells.

Since the national grid development effort results in approximately 3 million latitude and longitude pairs within the blank, masking is performed in a successively refined manner. This approach was found to significantly reduce computer processing time. Masking subroutines were developed according to the following criteria and are applied in the order shown:

a) Grid cells falling over the mainland United States.
b) Grid cells falling outside the 300 km offshore boundary.
c) Grid cells falling over islands.
d) Grid cells falling within 0.5 km of land.

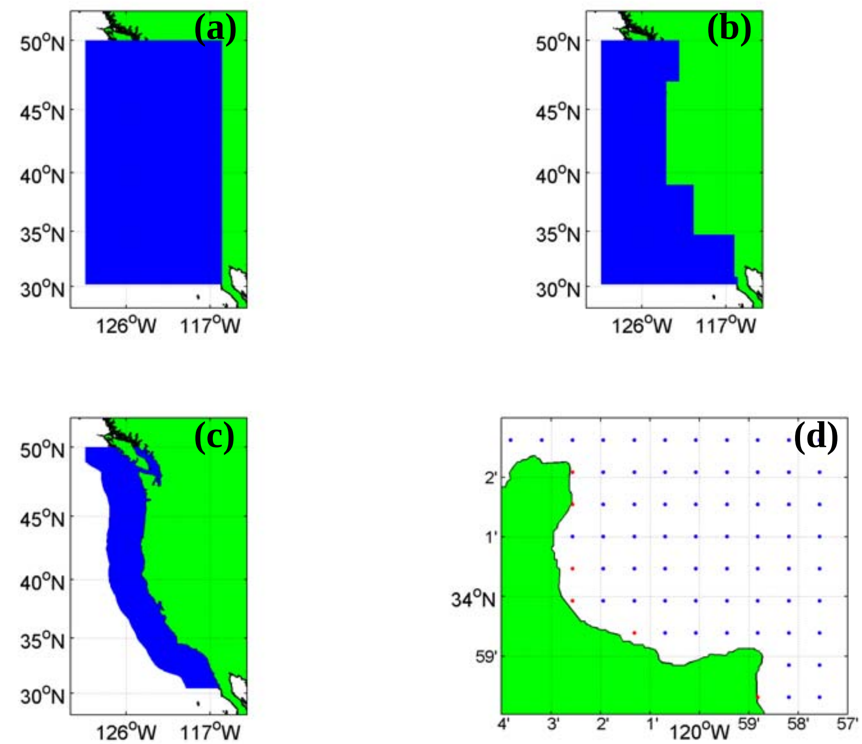

Figure 1. The Equidistant cylindrical grid blank for the U.S. West Coast is shown in panel (a). The same grid, after initial gross point elimination is shown in panel (b). Panel (c) shows the grid after points falling over land and outside of the 300km boundary have been removed. Grid points shown in red in panel (d) indicate points that were eliminated from the northeast region of Santa Rosa Island due to their close proximity to land (within 0.5 km).

Landmasking, while seemingly straightforward, is a complicated process because of the large number of points in both the grid and coastline database. Code developed for this effort is grid independent to allow for its application to any blank grid of variable resolution.

3.2 Equal Area Grid

Initial grid development was conducted for the U.S. West Coast using algorithms developed in MATLAB. The grid 'blank' was generated for a region extending from 31 to 50 North latitude and -130.4 to -110.7 East longitude at a resolution of 1 km in both latitude and longitude. Masking was done for all points falling over land, points falling outside of a 300 km offshore boundary, and points falling within 0.5 km of land. Resolution and distances were computed based on the WGS84 ellipsoid.

The resulting U.S. West Coast grid is equal area and constant resolution. However, the grid is not orthogonal throughout. It forms 1 km squares around the central longitude but forms parallelograms with increasing tilt as distance from the central longitude increases. While properties of equal area and constant resolution retain the native resolution of data throughout the grid, it complicates data dissemination. Dissemination is mainly complicated by the fact that the grid's latitude and longitude pairs are based on a stepwise approach of converting distances based on the WGS84 ellipsoid to latitude and longitude pairs making it difficult for users to modify, re-create or interpolate the grid. Ease of interpolation is an important factor for dissemination of spatial velocity data since products will likely be based upon interpolations of the data. For example, since the eastward (u) and northward (v) components of the total vector will be co-located on the grid ("A grid") interpolation onto a staggered grid ("C grid") may be done for calculating geophysical parameters such as vorticity and divergence. Other examples include interpolation onto various grid types for model ingestion.

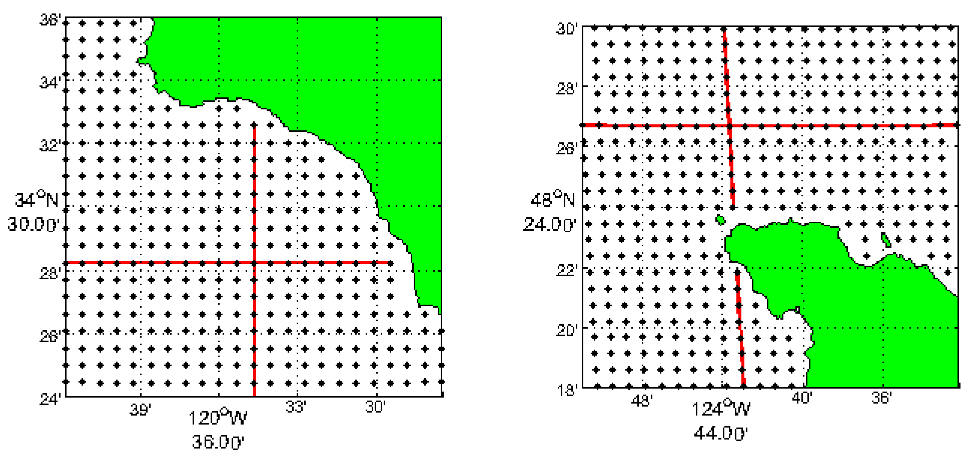

Figure 2. Images from regions near the central longitude (left) and far from the central longitude (right) show how grid cells change in shape from squares to parallelograms. The image on the left is between Point Conception and Point Arguello, CA. Along lines of latitude, grid points have constant values. However, along lines of longitude, grid points only have constant values along the central line of longitude. The grid points along the central longitude and an arbitrary latitude are highlighted on the left. The image on the right is from the region around Cape Flattery, WA, approximately four degrees away from the central longitude. A pair of arbitrary grid lines along latitude and longitude are highlighted to show their non-orthogonal nature.

3.3 Equal Latitude/Longitude Spacing

The issues present with equal area grid cells are also found within the ocean modeling community who have adopted approaches which can be used for developing wide area HF radar grids. The most common approach is to develop a grid based upon constant latitude and longitude spacing using an equidistant cylindrical projection. The resulting grid will have variable resolution in longitude that increases poleward, but constant resolution in latitude. In return for sacrificing constant resolution and equal area, orthogonality is gained in addition to a grid with very simple construction and interpolation. Grid metrics (data about vertical and horizontal grid spacing and grid areas) will also be provided based on the WGS84 ellipsoid, the same ellipsoid used by CODAR processing software for producing radial measurements.

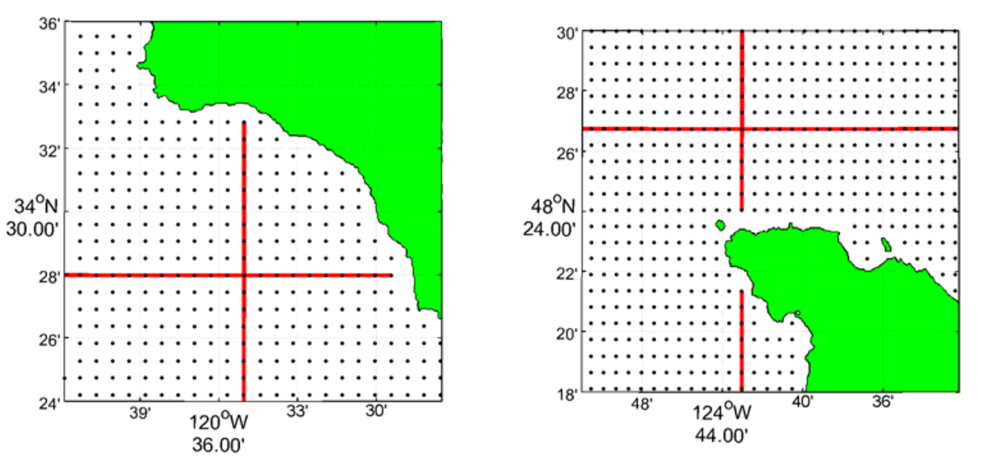

Figure 3. Images of the same region show in Figure 1 for the US West coast grid based on an equidistant cylindrical projection. Vertical resolution is constant throughout the grid at 1 km while horizontal resolution increases from 1 km at the southernmost latitude (30.25^{o} N) to 0.75 km at the northernmost latitude (50^{o} N). Arbitrary grid lines highlighted in red show orthogonality is preserved throughout the grid.

The nominal resolution of HF-Radar data should be made clear upon dissemination of total vectors calculated on the equidistant cylindrical grid. Grid resolution above the nominal resolution of the data should be interpreted as oversampled data while grid resolutions below the nominal resolution should be interpreted as undersampled data.