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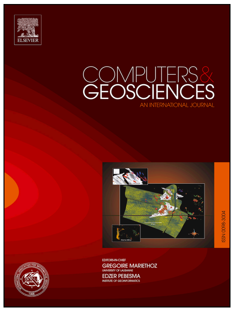

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Fibonacci lattices for the evaluation and optimization of map projections

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ABSTRACT

Latitude-longitude grids are frequently used in geosciences for global numerical modelling although they are remarkably inhomogeneous due to meridian convergence. In contrast, Fibonacci lattices are highly isotropic and homogeneous so that the area represented by each lattice point is virtually the same. In the present paper we show the higher performance of Fibonacci versus latitude-longitude lattices for evaluating distortion coefficients of map projections. In particular, we obtain first a typical distortion for the Lambert Conformal Conic projection with their currently defined parameters and geographic boundaries for Europe that has been adopted as standard by the INSPIRE directive. Further, we optimize the defining parameters of this projection, lower and upper standard parallel latitudes, so that the typical distortion for Europe is reduced a 10% when they are set to 36º and 61.5º, respectively. We also apply the optimization procedure to the determination of the best standard parallels for using this projection in Spain, whose values remained unspecified by the National decree that commanded its official adoption, and obtain optimum values of 37º and 42º and a resulting typical distortion of 828 ppm.

Keywords: Fibonacci lattices; Lambert Conformal Conic projection; standard parallels; optimization.

1. Introduction

The effective evaluation of scalar models for a particular area is an issue frequently encountered in geosciences. The standard approach is to use regular latitude-longitude lattices, which are conceptually simple and generally easy to implement in any software. They suffer, however, from fundamental problems especially associated with the meridian convergence, which often make them ineffective for the evaluation of the model in the geographic area under study.

In the last decades, some alternatives to latitude-longitude lattices have been proposed for global numerical modelling, which have some desirable properties such as higher geometrical regularity and isotropic spatial resolution as well as ease of parallelization (Purser 1999). They generally require a lower number of lattice points than standard latitude-longitude lattices to obtain results of the same quality. Among them, Fibonacci lattices have emerged as powerful tools to enhance numerical effectiveness due to their virtual uniformity and isotropic resolution (Swinbank and Purser, 2006).

While the regular hexagonal lattice provides optimal sampling for the plane (Conway and Sloane, 1998), it is impossible to arrange regularly more than 20 points on the sphere let alone on the ellipsoid. The usual latitude-longitude lattice is highly inhomogeneous and far from the desired situation where every point represents almost the same area, which can be virtually obtained with the use of a Fibonacci lattice, a mathematical idealization of natural patterns with optimal packing. González (2010) takes advantage of this feature and applies Fibonacci lattices to the problem of area determination by means of point counting, obtaining results with at least 40% error reduction when compared to the use of latitude-longitude lattices. Other applications of Fibonacci lattices can be found in disparate fields as shallow water modelling, climate models and three-dimensional numerical weather prediction (Swinbank and Purser, 2006) including tornado outbreak prediction

[1] Sergio Baselga is the sole author of this research