Spectral method to compute mesoscale mass-consistent wind fields on a complex terrain

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One of the main physical constraints the that wind field has to satisfy, is the conservation of mass [1,2]. Several methods have been proposed to get mass-consistent wind fields from a data set provided by a meteorological network of numerical solutions of the hydrodynamic equations. These methods go from a simple interpolation to the numerical solution of primitive-equation models in 3D or 4D data-assimilation schemes [3]. Variational Mass consistent models (VMCM's) of the wind field, is a class a class of diagnostic models that is intermediate in sophistication between interpolated and primitive-equation models and attempts to satisfy the continuity equation [4-7]. Several studies give evidence that this models appear to suitable for several applications, since they introduce a fewer number of arbitrary parameters [5-7]. VMCM's have been applied to modeling the transport, diffusion and dispersion of atmospheric pollutants and as input of prognostic models [5-11], a review of these models is given in Refs. [5,6]. The simplicity of VMCM's has motivated the development of new computational algorithms [11-14] and applications for air quality modeling and climatological studies [15,16] over the last decades.

The main aim of this work is to propose a scheme to compute VMCM's. The scheme has the following features: (i) The formulation uses a functional in the space of contravariant vector fields that leads to an elliptic equation which can be solved explicitly by means of trigonometric Fourier series, independently of the complexity of the terrain. This reduces the computational problem to the use of 2D and 3D Fast Fourier Algorithm, for which there are highly efficient computational routines. (ii) The scheme yields an explicit expression of the accuracy of the wind field to satisfy the continuity equation, expression that requires only the estimation of a three-dimensional Fourier Series. (iii) The boundary conditions are easy to use and improve in several orders of magnitude the accuracy with which velocity field satisfies the continuity equation. The method is illustrated by means of analytic and numerical examples to estimate the error produces by the estimation of Fourier coefficients with the Fast Fourier Transform algorithm.

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