Geosci. Model Dev. Discuss., 6, C1263–C1266, 2013
www.geosci-model-dev-discuss.net/6/C1263/2013/

Geoscientific Model Development Discussions
Open Access

GMDD
6, C1263–C1266, 2013

Interactive Comment

Interactive comment on "Automating the solution of PDEs on the sphere and other manifolds in FEniCS 1.2" *by* M. E. Rognes et al.

Anonymous Referee #2

Received and published: 19 August 2013

The paper describes the extension of FEniCS, a software for automated generation of efficient solutions of differential equations with finite element methods, to handle immersed manifolds, such as the sphere in three dimensional space for modeling atmosphere and ocean. It provides the mathematical basis, an introduction on how the software is used, and presents test cases that cover different complexities going all the way up to the non-linear shallow water equations on the sphere for several types of finite elements. The paper is highly relevant for GMD, since FEniCS could allow to build up efficient finite element models for geophysical applications with minimal effort and concise code. The paper is written at a high scientific standard.

However, the presentation should be improved. It is hard to identify to which extend the projection technique has been adapted from other publications and the design of the plots should be improved. I recommend minor revisions to address the points listed below.

General comments:

1. p 3558: 'The impact of this approach is dramatic: models which require tens to hundreds of thousands of lines of C++ or Fortran, and which take months or years to develop can be written in tens to hundreds of lines of high level code and developed in days to weeks.' I think this statement is too strong and should be changed. The authors probably refer to a full 3D model for atmosphere or ocean when talking about 'hundreds of thousands of lines'. I can see that a vast reduction of code is possible for the dynamical core, but I do not see that the same is true for example for parametrisation schemes of the atmosphere. These would need much more than hundreds of lines of code.

2. The presentation of the mathematical formulation is detailed and on a very high level, although lengthy. It is hard to understand the motivation for some parts in section 2 when reading the paper for the first time. Maybe section 2 and 3 should be combined tighter, or merged.

3. I am surprised that computational efficiency is not evaluated for the presented test cases. Parallelisation is not at all mentioned within the paper, although I though it would be a major topic within the FEniCS project. The whole approach looses much of its attractiveness if the code is not able to work on parallel architectures and very efficient. Most of the finite element libraries can do this.

4. What is the difference between the projection methods used in this paper and the projection method used in Bernard et al. 2009? In case there is no difference, the paper should be cited. The different possibilities to work with finite element methods on a sphere should be mentioned in the introduction, and set into context to the method used in this paper.

GMDD
6, C1263–C1266, 2013

5. In which space is the energy conservation in equation (56) evaluated, I guess it is the physical space? Can the authors give the absolute value of the error in energy conservation at day ten in Figure 10? It might be useful to give information on mass conservation for the test in section 5.4 as well.

6. What happens if parts that are needed for the implementation of a specific problem are not supported yet (for example the UFL operator for curl and rot for m<n). Is the user stuck with the bits and pieces he has? I am sure there are other fundamental parts that are still missing. These should be mentioned in section 6 in more detail.

7. Figure 6: The code should be connected closer to Formula (23). Where does G and A fit into the formula? Where is the integral solved in the Code?

8. The labels of the axes in Figure 7, 8, 10 and 12 are insufficient (either too small, or missing).

9. Figure 15: The initial fields are not very helpful. The plot of velocity should be replaced by a longitude/latitude plot of vorticity, which is typically shown for this test case.

10. What is just-in-time compilation?

11. p 3573: 'As a consequence, mixed elements for which different components are defined over different cells are not supported.' Can you give the one or two most prominent examples for these elements?

Technical corrections:

12. p 3585: 'These are given by: find the depth of the shallow water layer...' should be rephrased.

13. p 3585: 'in in Sect. 51'

14. p 3585: '...these solutions represent the large scale balanced flow that slowly evolves in the nonlinear solution, giving rise to “weather”.' should be rephrased.

GMDD

6, C1263–C1266, 2013

Interactive Comment

P.-E. Bernard, J.-F. Remacle, R. Comblen, V. Legat, K. Hillewaert: High-order discontinuous Galerkin schemes on general 2D manifolds applied to the shallow water equations, 2009

Interactive comment on Geosci. Model Dev. Discuss., 6, 3557, 2013.

GMDD

6, C1263–C1266, 2013

Interactive Comment