Geosci. Model Dev. Discuss., 7, C676–C679, 2014
www.geosci-model-dev-discuss.net/7/C676/2014/

Geoscientific Model Development Discussions
Open Access

Interactive comment on "IL-GLOBO (1.0) – integrated Lagrangian particle model and Eulerian general circulation model GLOBO: development of the vertical diffusion module" *by* D. Rossi and A. Maurizi

Anonymous Referee #1

Received and published: 28 May 2014

General comments:

This paper presents a carefully thought out approach to integrating a diffusive Lagrangian dispersion model within an Eulerian global numerical weather prediction model. While the basic ideas are not especially new, the fully integrated approach and the careful investigation of coordinate-system, time-step and interpolation issues mean that the paper is of significant interest. The code is not however yet fully integrated with the NWP model (p2815, line 10: 'The vertical diffusion model is now ready to be implemented within ...'). There is also I think a significant mathematical error in

Eq (11) which will need resolving. There are also a number of aspects which could be clarified a little.

Specific comments:

1) Because the model has not yet been implemented within the NWP model, I think it would be useful to give a little more detail on exactly what code is being made available at the web address on p2815. E.g. is this just for 1-D test cases (with no horizontal interpolation code or 3-D concentration output)? Perhaps it's also worth mentioning the computer language used.

2) There is an error in Eq (11). It's not dimensionally correct. The middle two terms in square brackets and the random term are dimensionally correct if K is the σ-space diffusivity K_σ (i.e. K in (8) times $(\partial\sigma/\partial z)^2$) while the last term in the square brackets is dimensionally correct if K is the K in (8). It's not clear what is intended here. Although there is no discussion of transforming K or $\langle\rho\rangle$, the equation seems to make most sense if they are both σ-space versions (so K means K_σ and $\langle\rho\rangle$ means $\langle\rho\rangle_\sigma$, i.e. $\langle\rho\rangle$ in (8) times $\partial z/\partial\sigma$ – see p2810, line 4). Using the (Ito) chain rule I calculate (omitting $\langle\rangle$ and any mean velocity)

$$d\Sigma = \frac{\partial\sigma}{\partial z}\left(\frac{1}{\rho}\frac{\partial\rho K}{\partial z}\right)dt + \frac{\partial\sigma}{\partial z}\sqrt{2K}\,dW + \frac{\partial^2\sigma}{\partial z^2}K\,dt$$

$$= \frac{\rho}{\rho_\sigma}\left(\frac{1}{\rho}\frac{\partial\rho K}{\partial z}\right)dt + \frac{\rho}{\rho_\sigma}\sqrt{2K}\,dW + \frac{\partial\rho/\rho_\sigma}{\partial z}K\,dt \text{ (using } \partial\sigma/\partial z = \rho/\rho_\sigma\text{)}$$

$$= \frac{\rho}{\rho_\sigma^2}\frac{\partial(\rho_\sigma^2/\rho)K_\sigma}{\partial\sigma}dt + \sqrt{2K_\sigma}\,dW + \frac{\rho_\sigma}{\rho}\frac{\partial\rho/\rho_\sigma}{\partial\sigma}K_\sigma\,dt \text{ (converting to } K_\sigma \text{ and } \partial/\partial\sigma\text{)}$$

$$= \frac{\rho}{\rho_\sigma^2}\frac{\partial(\rho_\sigma/\rho)(\rho_\sigma K_\sigma)}{\partial\sigma}dt + \sqrt{2K_\sigma}\,dW - \frac{\rho}{\rho_\sigma}\frac{\partial\rho_\sigma/\rho}{\partial\sigma}K_\sigma\,dt$$

$$= \frac{1}{\rho_\sigma}\frac{\partial\rho_\sigma K_\sigma}{\partial\sigma}dt + \sqrt{2K_\sigma}\,dW$$

which clearly satisfies a σ-coordinate version of the well-mixed condition but omits the last term in square brackets in (11). Eq (11) needs correcting which probably will require some new simulations.

3) p2802, Eq (7): This can't be derived using only the well mixed condition, e.g. could replace $\overline{u}_i$ by any other velocity field satisfying (5) (for the specified $\langle\rho\rangle$) and still satisfy the well mixed condition. Need to also require that the tracer flux in the well-mixed state is correct (or work in 1-D and impose boundary conditions). This is probably discussed by Venkatram (1993) and Thomson (1995).

4) p2803, line 20: Perhaps should explain that the α restriction arises from requiring $\partial\sigma/\partial P \geq 0$ (if it does). Also need $\alpha > 1$ to ensure σ approaches P/P_0 high up. Perhaps should also clarify that z and Z refer to height above ground (not strictly a Cartesian coordinate) and that Σ (line 23) is the Lagrangian coordinate corresponding to σ (there are many possibly choices of Lagrangian coordinate).

5) p2805-6: It would be useful to clarify which of the two Akima splines are used, whether K_{NLEV+1} is zero or e.g. depends on the roughness length, and whether the linear profile near the ground can be matched smoothly to the Akima splines.

6) p2809-10, Eqs (21) and (22): These are presented as just function fits, but look like hydrostatic/perfect-gas approximations (at least with no orography) with R_d being the gas constant. This should be explained.

7) Although not necessary, I thought it would be useful to consider some actual profiles from the NWP model as well as the idealised fits (21-24). These may be less smooth and be a stronger test of the numerics. In addition, with the second derivative term dropped in (11) (see point (2) above), one could try the much simpler approach of linearly interpolating K and calculating $\partial K/\partial\sigma$ consistently. $\partial K/\partial\sigma$ will jump in value at the grid points, but this doesn't matter if the second derivatives aren't needed. This would make choosing the time step more complex (or at least different), but one could e.g. ensure change in position is less than about a grid box or consider $\partial K/\partial\sigma$ in

neighbouring grid boxes to estimate a finite difference second derivative.

Technical comments:

1) p2800, line 5: typo 'water 0'. 2) p2801, line 10-11: It should be $b_{ik}b_{jk}/2$ I think. Also, while many different probabilistic notations are used in the literature, it would be more usual to write $p(x^{(0)}, ..., x^{(M)}, t)$. It is the pdf of the random variables $X^{(0)}...X^{(M)}$ but is a function of $x^{(0)}...x^{(M)}$ (unless one wants to evaluate it at the random location of a particular trajectory). Eqs (3) and (4) make more sense this way. 3) p2802: Having a new paragraph at the start of this page doesn't feel right. 3) p2802, line 11: 'density weighted mean velocity'. 4) p2804, line 22: 'Σ being a continuous coordinate'. 5) p2807, Eq (18): '$|\partial K/\partial\sigma|^{-1}$'. 6) p2810, line 12-16: K in (24) doesn't actually vanish so 'tend to zero near the boundary layer top' might be better. Units should be given for u_*, A and B. 7) p2811, §4.1: It wasn't clear to me whether this used a grid of K values computed from (24) or if the analytic function was used directly. Also is the 3 standard deviations value based on the theoretical statistical error or computed from the simulation results? 8) Fig 1 would be clearer if the dotted line were removed (or replaced by a vertical dotted line).

Interactive comment on Geosci. Model Dev. Discuss., 7, 2797, 2014.