Numerical methods in geophysics **2001**

You have three F90 programs which allow you to calculate the derivative of a function on a 2D grid. These programs use matrix-matrix multiplication to calculate these derivatives. The following exercise should make you familiar with this technique and provide you with routines to generate the differentiation matrices with the methods:

- dmfd.f (Finite difference method)
- dmfo.f (Fourier method)
- dmch.f (Chebyshev method)

Try to compile the above programs using the command

F90 dmfd.f –o dmfd.x

The screen output of the programs shows you a comparison of the analytical and the numerical derivative for a Gauss function.

$$f(x) = e^{-1/a^2((x-x_0)^2+(y-y_0)^2)}$$

The programs allow you to vary the constant *a* which influences the half-width of the function (and thus the number of grid points per wavelength).

1. Vary the constant *a* and observe its influence on the accuracy of the numerical derivative.
2. Output the differential matrices and visualize them using Matlab
3. Output the original funtion and the analytical and numerical derivatives and visualize them with Matlab. Visualize also the error of the derivative (Difference between analytical and numerical derivative).
4. Often it is useful to use harmonic functions to evaluate the accuracy of numerical derivatives. Replace the Gauss function by a sin(kx) or sin(ky), where $k=2\pi/\lambda$ and test the accuracy as a function of grid points per wavelength.