Lab 4 - Part IV: Vorticity Inversion Lab

Objectives:
- Gain further experience in finite differencing
- Further investigate the influence of boundary conditions
- Investigate the superposition principle for vortices

Overview:
1) Copy over a new version of the inversion code to your home directory. The file can be copied from ~dnnelson/311lab/newvort_311.m
2) Modify the code to calculate the $u$ and $v$ components of the wind by adding the finite difference expressions for $u(j,i)$ and $v(j,i)$ from:
$$ u = -\frac{\partial \psi}{\partial y} \quad \text{and} \quad v = \frac{\partial \psi}{\partial x} $$
3) This modified version of the code should be very similar to your code from Lab 4 part III. The new code has $nx=ny=51$ points, $dx=dy=1$, and uses point sources of vorticity instead of a Gaussian shaped distribution. This code uses Dirichlet boundary conditions on all four boundaries (streamfunction set to zero).
4) As a reminder, we will have group meetings to discuss all aspects of the vorticity labs. Be sure you understand the basics behind finite differencing, coding in Matlab, how to perform an inversion, and how point vortices interact.

Assignment:
1) Derive the finite difference expression for $u$ and $v$, and turn it in with your lab write-up.
2) Place a point vortex with magnitude of 5 in the middle of the domain ($i=26, j=26$). Solve for the streamfunction and winds. Is the result of the inversion consistent with what you would expect?
3) Now place a point vortex of magnitude -5 in the middle of the domain, and solve for the streamfunction and winds. How does the result change? Explain.
4) Describe how the structure of the solution changes as the point vortex is moved toward the southern boundary. Explain why this is the case.
5) Place two like-signed vortices symmetrically in the domain. Describe how the solution changes as they are brought closer together. Explain.
6) Place two opposite-signed vortices as in the previous step. How does the solution change? Explain.
7) Perform the inversion using four point vortices, in any configuration, of any sign, and any magnitude. Was the result you obtained expected? Explain the interaction of the point vortices.

Write-up/Figures due Friday, 24 April 2009