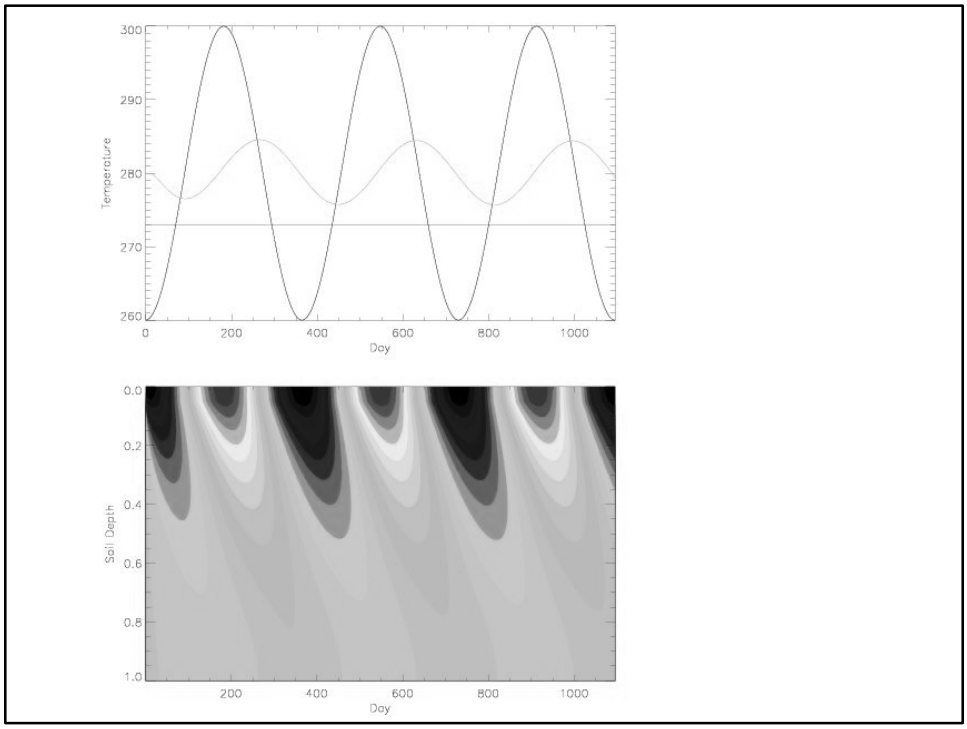
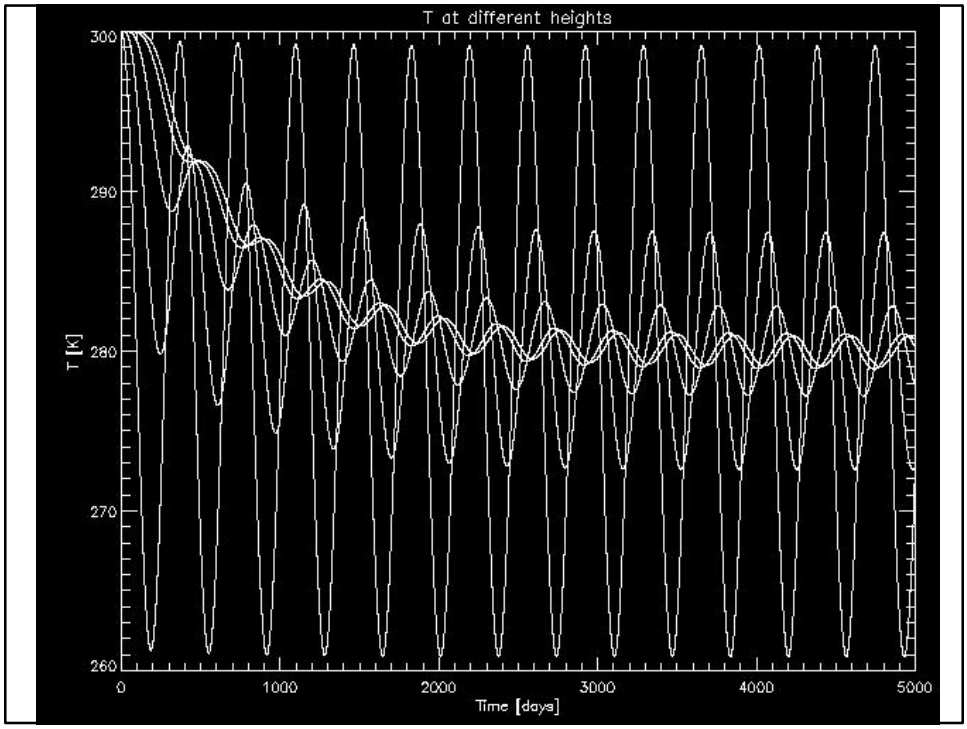
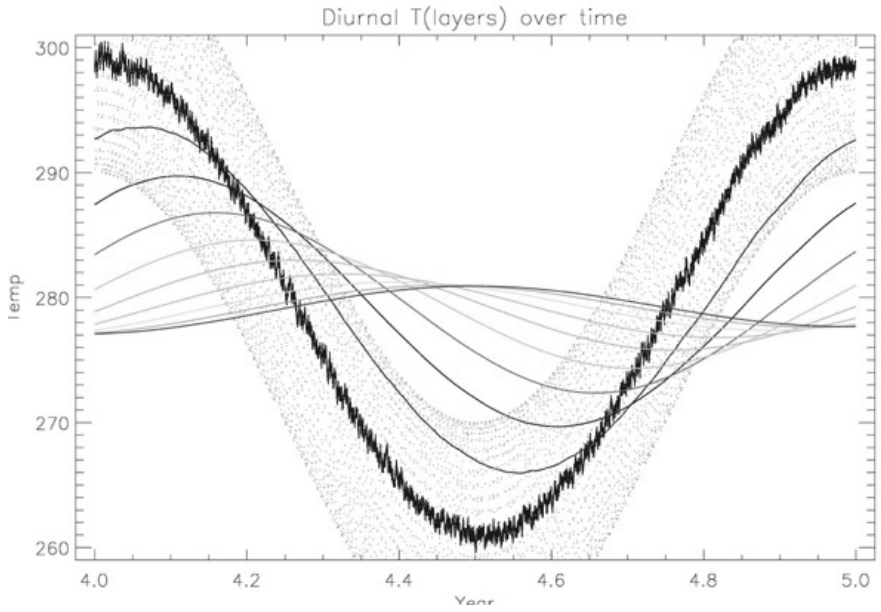
Vorticity and streamfunction

- How does the result change if I aim to plant on the other side of the yard where the soil is clay rich?
- How does the result change if we include a diurnal cycle (Ad = 5K)?
- What is the time mean soil temperature?
- Is the result the same for all time steps?
- Does the scheme conserve mass?
- Does the scheme conserve variance?
- Is the system positive definite?
- Is the phase and amplitude of the seasonal cycle the same at all depths?
- What is the role of the surface heat flux (and the magnitude of D) in the result?
- Do your predictions match the date given by the Farmers Almanac?

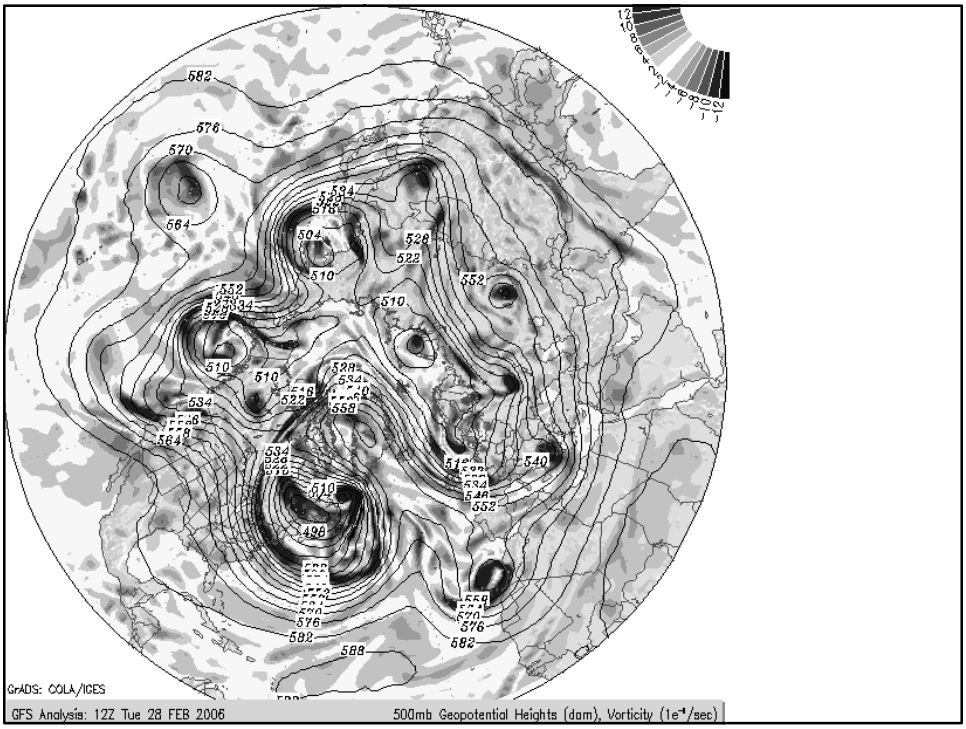

Temperature
300
290
280
270
260
0
200
400
600
800
1000
Day
Soil Depth
0.0
0.2
0.4
0.6
0.8
1.0
200
400
600
800
1000
Day

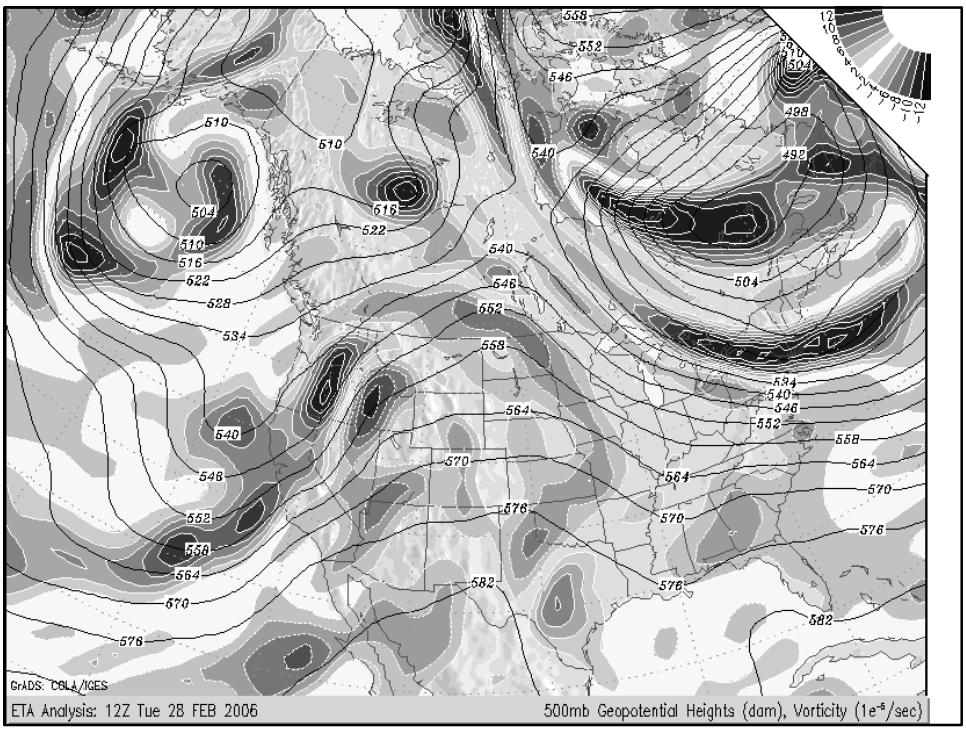

T at different heights
T [K]
300
290
280
270
260
0
1000
2000
3000
4000
5000
Time [days]



The 2d realm

- Advection in 2d?
- Diffusion in 2d?
- Can it be done with finite differences?


GrADS: COLA/IGES
GFS Analysis: 12Z Tue 28 FEB 2006
500mb Geopotential Heights (dam), Vorticity (1e-5/sec)


GrADS: COLA/IGES
ETA Analysis: 12Z Tue 28 FEB 2006
500mb Geopotential Heights (dam), Vorticity (1e-5/sec)

Vorticity advection

(absolute vorticity conserved)

$$h = z + f \qquad z = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \qquad f = 2\Omega \sin q \approx f_0 + by$$

$$\frac{dh}{dt} = 0 \qquad \frac{\partial z}{\partial t} = -u\frac{\partial z}{\partial x} - v\frac{\partial z}{\partial y} - vb$$

$$\frac{\partial z}{\partial t} = -\frac{\partial}{\partial x}\left[u(z + f)\right] - \frac{\partial}{\partial y}\left[v(z + f)\right]$$

Vorticity and stream function

- Stream function
  (flow along contours)
- For geostrophic flow (and QG), we can thus deduce streamfunction from geopotential height
- Vorticity is the Laplacian of the streamfunction
  (Thus streamfunction looks like a smooth or diffused version of vorticity)

$$u = -\frac{\partial y}{\partial y}$$

$$v = \frac{\partial y}{\partial x}$$

$$y = \frac{g}{f_0}\Phi$$

$$z = \nabla^2 y$$

Assignment

- What will the weather be next Tuesday?
  Make a 5-day weather forecast from Thursday using the non-divergent barotropic vorticity equation on a beta plane.

- Initialize with observed 500 hPa geopotential height
- Output predicted geopotential height, vorticity and u and v wind components.

- Choose a grid of nlon=64 and nlat = 16, with a 500 km spacing and a time step of 1 hour.
- Domain is cyclic in longitude, and bounded (v = 0) on the north and south boundaries.
- Choose boundary condition ψ=mean at N and S edges.

Coding challenges

- Calculate streamfunction from geopotential
- Calculate vorticity from for streamfunction

1. Given vorticity, obtain streamfunction
2. Calculate u and v wind from streamfunction
3. Predict evolution of vorticity (1 hour time step)
4. Loop for 5 days

Code elements (suggested subroutines):

- Finite difference X and Y derivatives
- Finite difference Laplacian
- Finite difference Poisson solver (invert Laplacian)