Diffusion and implicit solutions

Lab assignment

In Boulder the ground is frozen during winter, and plants can not grow in frozen soil. During spring, the soil thaws.

1. When should I plant tomatoes?
2. When will the tomatoes die (from the first frost)?

Build a model of the top meter of soil. Assume growing can start when the top 50 cm of soil thaws.

Heat flux through soil can be written proportional to the temperature gradient, such that local temperature change (convergence of flux is written:

$$\frac{\partial T}{\partial t} = K\frac{\partial^2 T}{\partial z^2} + D(T_a - T_1)$$

Solve for T(t,z) with appropriate value of the diffusivity K, and a solution scheme.

The air temperature T_a can be taken as mean of 280K of with an annual cycle of with an amplitude of 20 k, and the surface heat exchange coefficient can be taken as 1./86400 seconds.

Implementation considerations

- What are the state variables?
- How does time stepping work?
- How do you include the surface heat flux?
- What output do you need?

IDL task: make a *contour* plot of T as a function of depth and time.

- If you're feeling daring/finished early, what about an explicit scheme? What about a spectral scheme?

Tridiagonal solver

- Solves matrix system of equations:

$$T^n = A\ T^{n+1} \quad \text{so } T^{n+1} = A^{-1}\ T^n$$

A is a tridiagonal matrix, which has a well known efficiently calculated solution.

See ~dcn/ATOC7500/week06/tridiag.f90
and ~dcn/ATOC7500/week06/tdstub.f90

To compile: f90 tdstub.f90 tridiag.f90

Remember the mid-term assignment

- Models of the advection/diffusion equation

$$\frac{\partial q}{\partial t} = -u\frac{\partial q}{\partial x} + K\frac{\partial^2 q}{\partial x^2}$$