Richardson forecast factory

Teams and instructions

The Richardson forecast factory activity will introduce students to the idea that weather and climate forecasts are generated using the equations of atmospheric motion, discretized on a grid which represents the atmosphere. We will be solving a simple advection equation as:

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = 0$$

The finite difference form of the equation that we will use is:

$$T_{future} = T - \left(\frac{\Delta t}{\Delta x} \times \left\{ \left(u \times \left[T - T_{west} \right] \right) + \left(v \times \left[T_{north} - T \right] \right) \right\} \right)$$

Don't worry if either of these expressions aren't familiar to you. The basic point is that we can predict the temperature in the future (T_{future}) by substituting numbers into the right hand side of the equation. You will be given a sheet with boxes which can be filled in with the appropriate numbers to help you with the calculation. The terms on the right hand side represent:

Terms which are fixed (the same at each step)

Δt – the time-step (time between predictions)

Δx – the grid-spacing (distance between points on the grid)

u & v – the east-west and north-south component of the windspeed

Terms which change each time

T – the current temperature at your grid-point

T_{north} - the temperature in the grid box to your north

T_{west} – the temperature in the grid box to your west

You will need to get the values of T_{north} and T_{west} from the person on the desk to your left and ahead of you. If you are on one of the boundaries, you will be given a piece of paper which shows the boundary condition that you should use.

Procedure for computing a time-step

1. Get student to collect information needed for each calculation. Your initial temperature, and the u and v wind speeds (the same u and v will be used for all timesteps) are on green paper. If you are at the far north or west boundary, you will need the temperature information on pink paper.
2. Fill in the information on your sheet.
3. Complete the calculation, remember to check it for a reasonable value.
4. Once you have finished your step, ask the student to come and write their answer in the correct grid cell on the board.
5. We will plot the answers on the computer screen before telling you to start the next time-step. At this point you will need to use your answer to the last step as the current value of temperature.

Important information to communicate to the students
The most important part of your task is to talk the student about the abstract activity you are engaged in and explain to them as you make the calculation what is going on. Some key points you might want to try and get across are:

- Weather forecasts are made by solving the laws of motion (physics) using mathematical techniques.
- To make forecasts, we divide the Earth's surface into grid-point which represent a certain area. These are typically big (of the order kilometres) because of the limitations of computing power.
- Changes in temperature at a grid-point depend most strongly on the local wind speed and the temperatures 'up-stream' i.e. if its colder to the north and the wind is blowing from the north then temperatures are likely to decrease.
- Small errors introduced into the calculations can lead to large errors everywhere because of the dependence of each grid-point on several others.
- Digital computers can do the kinds of calculations we do in the exercise in a fraction of the time that even the most talented mathematician can.

Groups
On the day there will be three student groups of approximately 16 students each. The forecast factory will run 3 times over the day. There will be two sessions in the morning (10:40 – 11:20 & 11:30 – 12:10) and one in the afternoon (13:00 – 13:50). We would like you to take part in either the morning or the afternoon. Our groups are:

Morning (10:40 – 11:20 & 11:30 – 12:10)	*Afternoon (13:00 – 13:50)*
1. Laura Baker 2. Pete Inness 3. Ross Reynolds 4. Chris Holloway 5. Keith Shine 6. Claire Bartholomew 7. Ciaran Brennan 8. Simon Rogerson	1. Ben Powrie 2. Matt Hawcroft 3. Katie McLean 4. Lorna Mitchell 5. Judith McConnell 6. Nicola Pounder 7. Dawn Turner 8. Richard Allan

On the day – Please bring a calculator!