

Case Study 1: Atmospheric Model

Conservation of momentum:

$$\frac{du}{dt} - \left(f + u \frac{\tan \phi}{a} \right) v = - \frac{1}{a \cos \phi} \frac{1}{\rho} \frac{\partial p}{\partial \lambda} + F_\lambda$$

$$\frac{dv}{dt} + \left(f + u \frac{\tan \phi}{a} \right) u = - \frac{1}{\rho a} \frac{\partial p}{\partial \phi} + F_\phi$$

Solution in two horizontal directions, latitude and longitude

Hydrostatic approximation:

$$g = - \frac{1}{\rho} \frac{\partial p}{\partial z}$$

Coupling in vertical direction

Conservation of mass:

$$\frac{\partial \rho}{\partial t} = - \frac{1}{a \cos \phi} \left(\frac{\partial}{\partial \lambda} (\rho u) + \frac{\partial}{\partial \phi} (\rho v \cos \phi) \right) - \frac{\partial}{\partial z} (\rho w)$$

Horizontal and vertical gradients

Conservation of energy:

$$C_p \frac{dT}{dt} - \frac{1}{\rho} \frac{dp}{dt} = Q$$

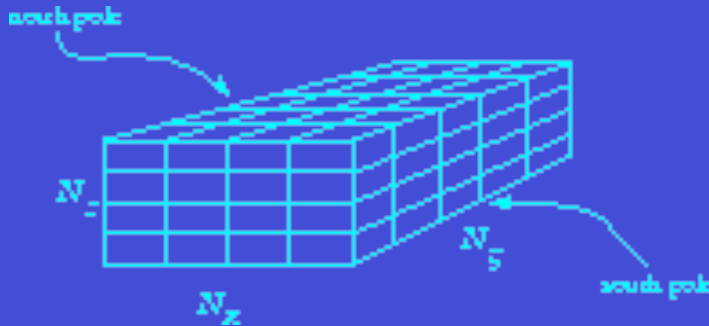
Connections between variables

State equation (atmosphere):

$$p = \rho R T$$

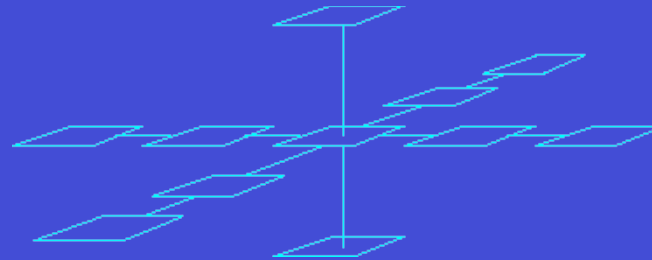
Case Study 1: Atmospheric Model (cont)

“Atmosphere in a box”:



Derivatives grid stencil:

- ✓ 9 points in horizontal
- ✓ 3 points in vertical



Other necessary operations:

$$Total\ Mass = \sum_{i=0}^{N_x-1} \sum_{j=0}^{N_y-1} \sum_{k=0}^{N_z-1} M_{ijk}$$

Other processes (“extra physics”=precipitation, clouds, radiation):

SAY, LOTS OF THEM AND LOTS OF COMPUTATION

Complicated accumulations of all z levels only, no x dependence

$$\begin{aligned} TCS_k &= \prod_{i=1}^k (1 - cld_i) TCS_1 \\ &= TCS_{k-1} (1 - cld_k), \end{aligned}$$

Student’s task:

Go through algorithmic design process (PCAM) for this problem ...

Case Study 2: Chip Real Estate

Arranging electronic components on a chip.

Real estate is a big issue=> Minimise total area

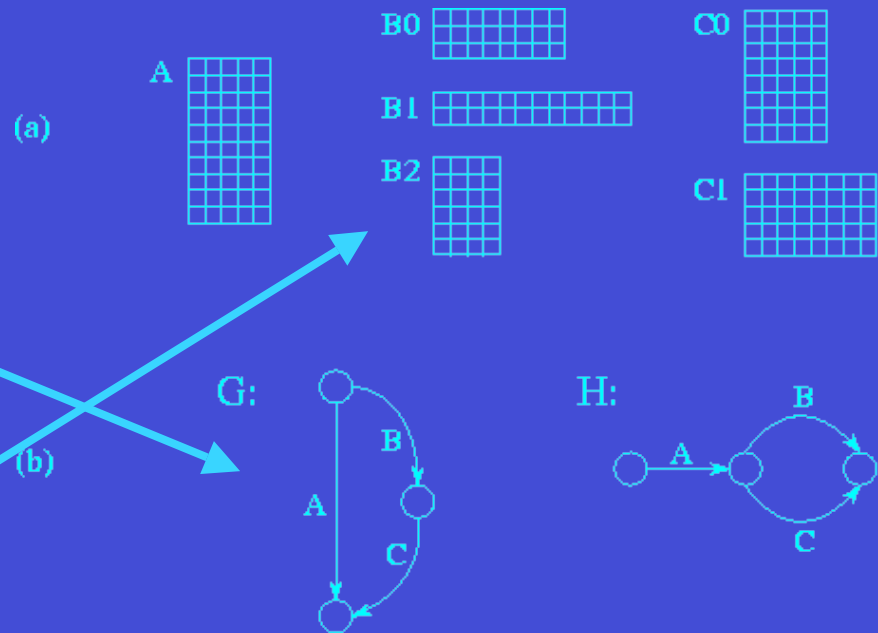
Components have to be in certain order (to connect, heat etc; e.g. above and to left of ...)

But might be able to have various configurations

Treat as “cells” of specific volume, various allowable configurations, order specified

=> Search through set of all possible solutions to minimise the total area

First convince yourself that this is a search algorithm by finding the answer by hand



(This means A has to be to the left of B and C and B has to be above C – read the arrows not the circles for the topology!)

HOMWORK:

First convince yourself that this is a tree search algorithm by finding the answer by hand.

Bear in mind that the exhaustive search can be considerably improved by “pruning” i.e. in this “depth-first” algorithm, stop if branch has no chance of providing min area (area already greater than best solution so far)

Convince yourself that the pseudo-code for “branch-and-bound” algorithm on the next page is what you are actually doing.

Consider how to design a parallel algorithm for this problem (PCAM).

Case Study 2: Chip Real Estate (cont)

Logic:

```
procedure b&b_search(A )
begin
   $A_{min} = \infty$ 
  b&b_search_1(A )
end

procedure b&b_search_1(A )
begin
  score = eval(A )
  if(score <  $A_{min}$ ) then
    if (leaf(A )) then
       $A_{min} = \text{score}$ 
      report solution and score
    else
      foreach child  $A_i$  of A
        b&b_search_1( $A_i$ )
      endfor
    endif
  endif
end
```

Students: Discuss PCAM for this problem ...