Supporting multiple dynamical cores:
UM development

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Contents:

- Historical UM review; the grids and dynamical cores
- Can we support multiple grids within current UM?
- Can we support multiple dynamical cores within current UM?
- Implications for the future; scalability and hires global modelling?

Decades ago…

- Late 1980's separate models for climate and operational NWP
- Separate code and control routines.
- Significant effort to port both to new PLATFORMs.

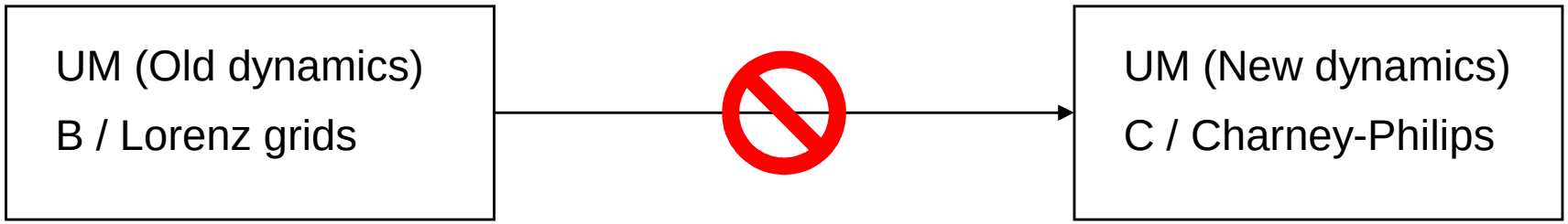
- In response the UM is born, including the strategic aims….
  - **Share a common control and file structure for all types of models**
  - Model set-up would be achieved via a graphical user interface
  - **Separate choices of scientific schemes would be readily available from the user interface, and different physics schemes would be `plug compatible'**
- The UM went operational 1991

UM grid staggering history in a single slide

UM Versions Hydro/Non-hydro	Horizontal grid staggering on lat/long grid (polar points)	Vertical grid staggering
UM2.0-4.5 Hydrostatic (1990-1998)	Arakawa B grid (Scalars at poles)	Lorenz Hybrid Pressure
UM5.0– onwards Non-Hydrostatic (1999→)	Arakawa C grid (Scalars and u winds at poles)	Charney-Phillips Hybrid Height
UM8.? Non Hydrostatic (2012→	Arakawa C grid (v winds at poles)	Charney-Phillips Hybrid Height

UM step change or multiple support.

UM control code is directly linked to the dynamical core and its grid staggering.



When New dynamics was introduced it implied a ‘replacement’ of much of the UM control code and updated physics coupling within the ‘atm_step’.

Migration of work which led to OD→ND conversion support but not vice versa of model runs.

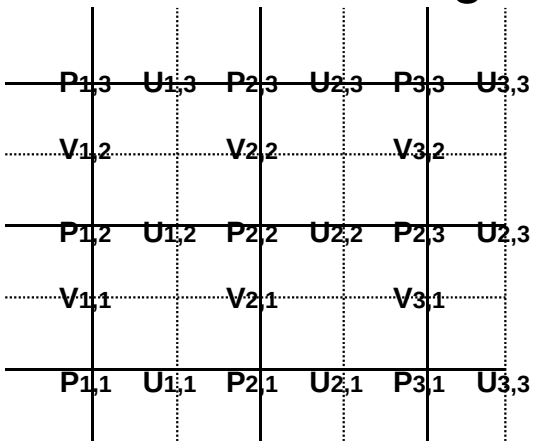
UM step change or multiple support.

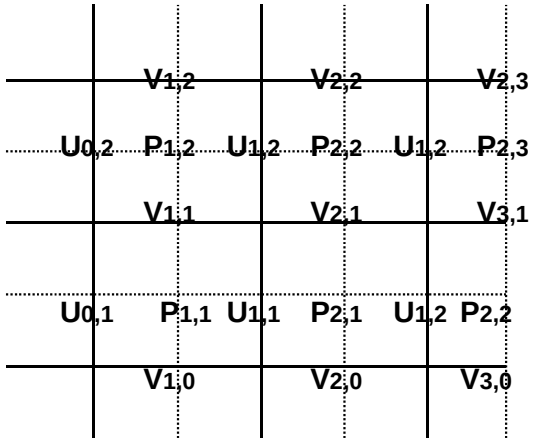
What if we are only making minor changes to the grid staggering?

Can we support both within the UM?

UM step change or multiple support.

Comparison of grids: highlights need to support alternate array bounds when switching between grids.





Simple 3x3 C grid u at the poles (N/S boundaries)

Scalar (row length, rows) = (3,3)

u wind (row_length, rows) = (3,3)

v wind (row_length, n_rows) = (3,2)

n_rows=rows-1

Simple 3x3 C grid v at the poles (N/S boundaries)

Scalar (row length, rows) = (3,2)

u wind (row_length, rows) = (3,2)

v wind (row_length, n_rows) = (3,3)

n_rows=rows+1

UM step change or multiple support.

- Aim to make underlying grid change ‘transparent’ to physics coupling and much of UM control code.
- Abstract array bounds out of explicit um code into modules
- Historically UM code hard-coded the array bounds for loops.

```
REAL ::  uwind (row_length,rows,model_levels)

DO j = 1, rows
    DO i = 1, row_length
    uwind(i,j) = stuff…..
    END DO
END DO
```

MODULE array_bounds

using TYPES to build up array structures…

Compile time option to select v or u at poles to define the the actual array bounds

eg: vdims%jend = n_rows-1

```
REAL ::  uwind (udims%istart:udims%iend, udims%jstart:udims%jend,model_levels)

DO j = udims%jstart, udims%jend
    DO i = udims%istart,udims%iend
    uwind(i,j) = stuff…..
    END DO
END DO
```

A significant re-coding effort.

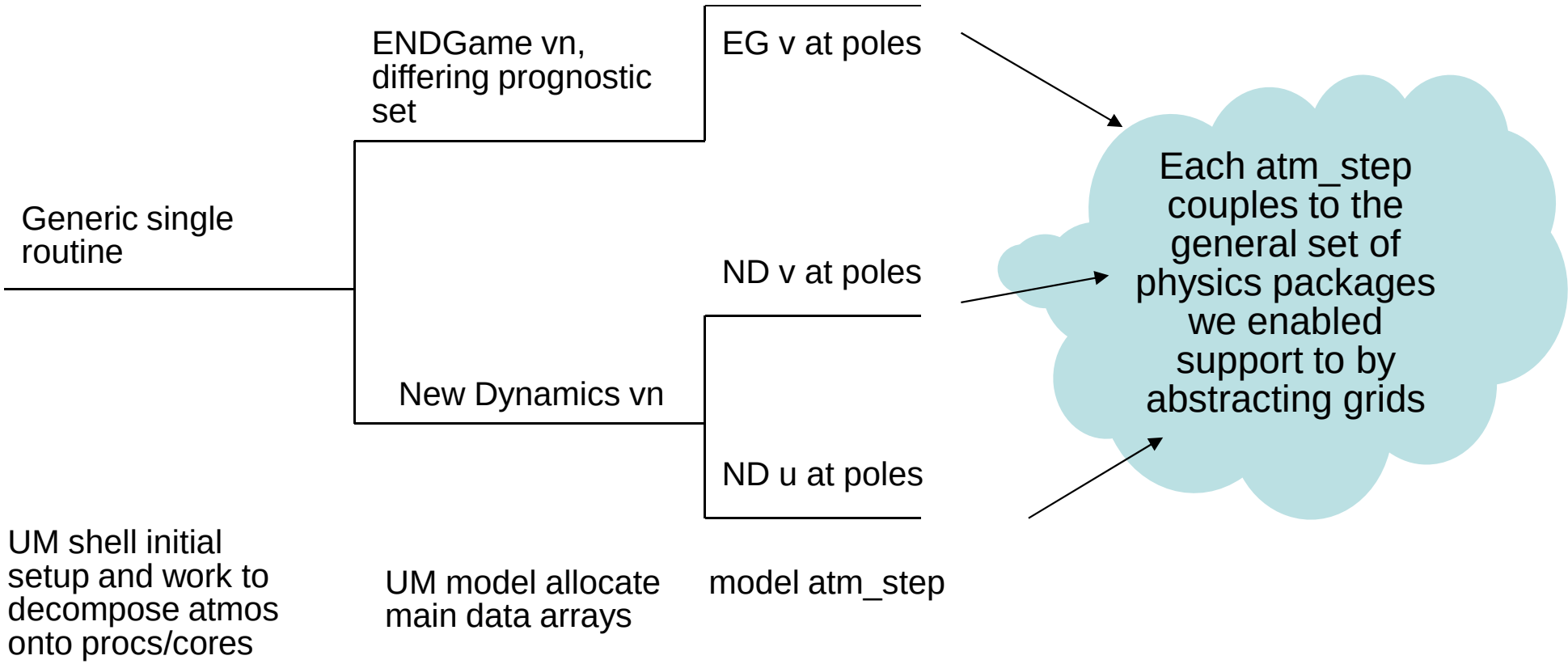
UM step change or multiple support.

What if we are making minor changes to the grid staggering **and updates to dynamical core**?

Can we support both within the UM?

UM step change or multiple support.

UM control routines define how the UM timesteps through the dynamics and physics coupling.



UM step change or multiple support.

- The selection of dynamical core now also implies a selection of control code at compile time.
- Some routines are now triplicated, many more duplicated, to support the three alternative dynamical cores
  - Headache for maintenance and development.
  - Testing overheads

- The original UM strategic aim was to '**support different physics schemes**'. Experience thus far implies that this does not hold for the dynamics. (Prefer step change to bolted support.) We now have a **divergence of control code** again which led to the birth of the UM.

- UM control structure (framework) in need of redesign!

Future UM grids

Lat Long grid suffers from the convergence of the grid at the poles.

Impact of this worsens rapidly as resolution increases.

Big impact on model scalability.

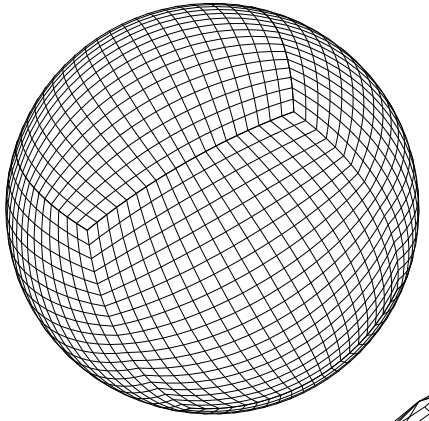
The UM needs to consider an alternative underlying horizontal model grid and hence dynamical core.

GUNGHO dynamical core project:
Globally Uniform,Next Generation, Highly Optimized

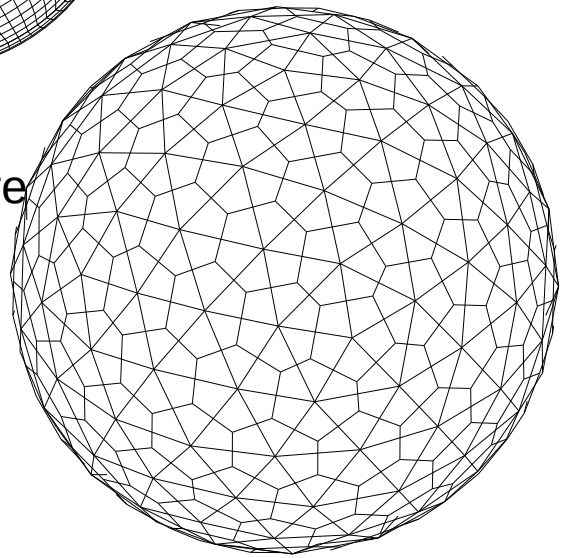
Implies a **step change** for the UM as its design currently assumes lat/long.

An opportunity to deliver a new UM control code/framework.

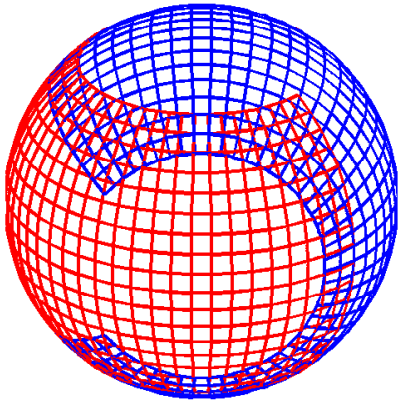
Exotic Grids being considered for the future



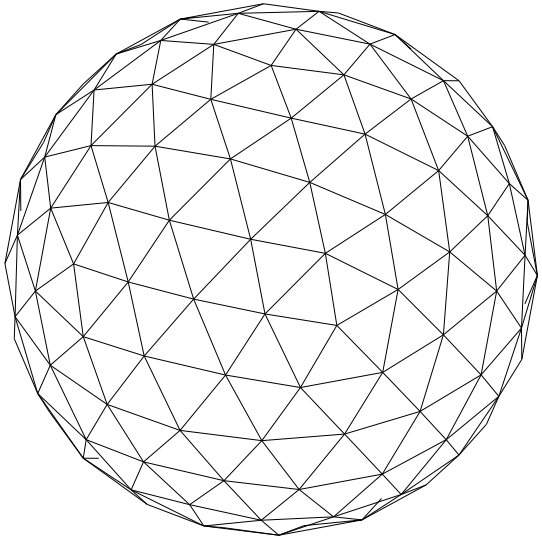
Cubicsphere



Kites



YinYang



Icosahedral

Future UM design

Can we abstract the grid away so to enable better support for alternative grids in future?

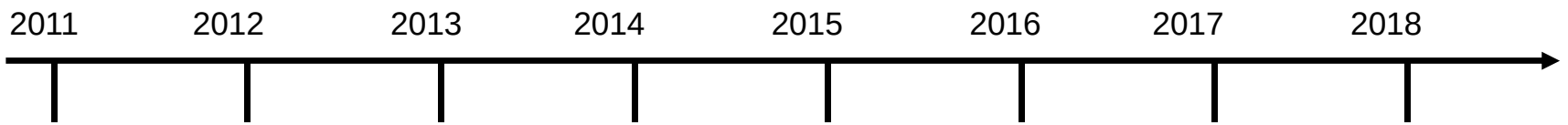
Can we abstract away the dynamical core so to readily support alternative dynamical cores?

In theory both these aspirations are possible and would enhance model development/maintenance.

But at what expense? The code must be efficient and if the framework itself adds significantly to model cost it is not a viable solution.

It will be a number of years before we can say whether the above aspirations are achievable or not in a Met Office operational model.

Outline future UM timeline



GUNHGO

Science Led

Decide upon horiz grid

Explicit or implicit scheme

Vertical grid and development of dynamical core

NGWCP UM FRAMEWORK

Review other related model designs to determine best practise

Deliver new UM framework/control code ready for GUNGHO core

Software design led

?

Window when majority UM dev work switches from UM to NGWCP

Contents revisited:

- Can we support multiple grids within current UM?
  - *Yes* but only if they are very similar.
- Can we support multiple dynamical cores within current UM?
  - *Yes* but this adds significantly to control code complexity and again assumes similar underlying grid staggerings

- The UM control framework is to be rewritten but may still not resolve the above aspirations.
- Questions?