Here I document series of conformal grids covering the sphere that are available to carry global simulations. They are of three grid classes: cube, lat-lon cap (llc), lat-lon pillow case (llpc). The grid design, and the codes that were used to generate them, largely follow from the earlier efforts of Chris Hill and Ed Hill. In particular, llc and llpc were designed so that the grid singularities ('poles') where grid points converge are located on land (see section 2), to allow for larger time steps. All grids ought to comply with the exch2/cube MITgcm architecture. MITgcm grid input files can be found under '/raid3/gforget/grids/gridCompleted/' for each grid and resolution. Those files have names such as 'cube*.bin', and they are in float64 big-endian format.

For each grid class, a fine mesh was first generated for which the nominal resolution is $1/48°$ (or 2km). It was then sub-sampled to generate coarser grids. While global runs at $1/48°$ are hardly computationally feasible right now, we can anticipate that they will be of common practice a few years from now. The coarser grids are of most immediate application, and they were generated for a set of different (nominal) resolutions: $4°$, $2°$, $1°$, $1/3°$, $1/6°$, $1/12°$, and $1/24°$. As each of the coarser grids is obtained as a subset of a high resolution grid, it will be easy to switch the resolution of gridded fields.

Choices of grid class will depend on the type of run, and are up to the user. Each grid class arguably has advantages and drawbacks. In general, the rationale that led to the design of llc/llpc grids is that gridded fields (let alone the cap part of llc grids) would be easier to manipulate and analyze than for cube grids. A couple remarks to held guide user choices:

- Cubes may be most suited for atmospheric/coupled runs. Grids of the other two classes indeed show a stronger convergence of grid points at their poles (see Fig.9) that cannot be masked out in atmosphere runs. Conversely lat-lon cap and pillow-case grids may be most suited to global ocean runs, especially at high resolution, because all of their poles are located on land (which is not possible for cube grids).

- llc and llpc grids mostly differ in the Arctic. llc has more grid points in the Arctic, where it is also more isotropic and symmetric. An argument in favor of llc is that it is most original, whereas llpc resembles the tri-polar grid used by the european NEMO modeling group. An argument in favor of llpc however is that global gridded fields may be easier to manipulate and analyze, as they can be put in the form of simple two dimensional arrays.

Hereafter I provide a series of graphs to illustrate the grids structure and properties. The 1° grids are mostly used for this illustration.

Gael Forget

1 grids structure

Figs.1-3 simply show the mesh for the three grid classes, looking from one side of the sphere. A different color is used for each face. The cube has 6 faces, the llc has 5 faces, the llpc has 4 faces. The section 2 graphs will show the sphere from above (looking at the Arctic) and from below (looking at Antarctica).

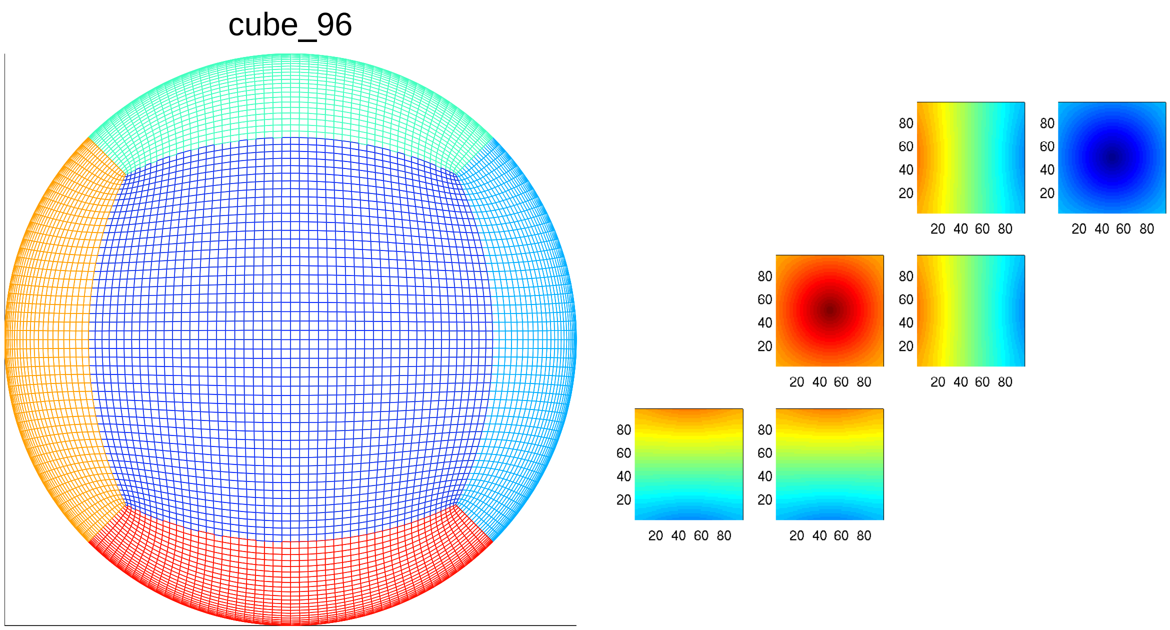

Figure 1: Left: cube 96, looking at the Equator. Only half the grid lines are shown. Right: latitude array for each face.

2 distances, isotropy and isometry

Figs.4-8 show the extent to which the grids satisfy isometry and isotropy. Figs.4-6 (resp. Figs.7-8) show the northern (resp. southern) Hemisphere.

Top left panels show, for each grid cell, the grid point spacing normalized by it's global maximum value. Top right panels show the same ratio, but a land mask is applied. The minimum

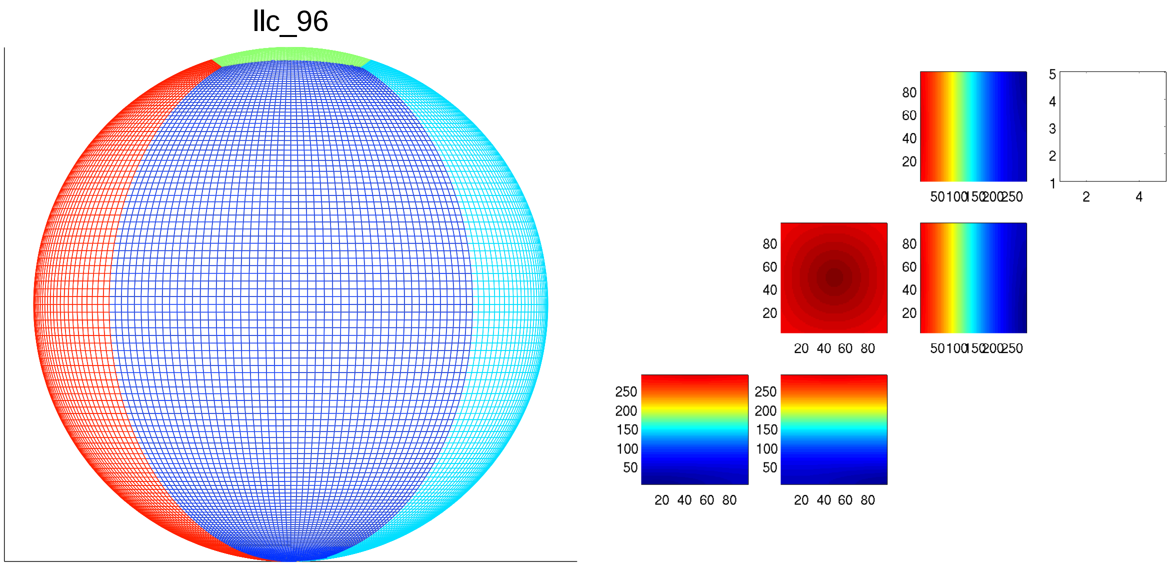

Figure 2: Same as Fig.1 but for llc 96.

ratio over un-masked points (reported in the panel title) should determine the minimum time step that is required to satisfy CFL criteria of stability. Except for the cube, that minimum ratio is virtually independent of the grid resolution. For the cube, an issue is that the minimum ratio decreases as the resolution increases, because some poles are not land points.

In the perspective of global model runs resolving ice shelves, the Antarctica poles are located away from the Ronnes and Weddell ice shelves. In Fig.8 un-masked regions are added (reaching 86°S) that roughly represent these two widespread ice shelves. The llc/llpc 1° grids show a minimum grid spacing of $\approx$ 16km there. For comparison, simply extending the lat-lon grid to 86°S would lead to a minimum grid spacing of $\approx$ 8km.

Finally, the bottom left panel of Figs.4-8 shows, for each grid cell, the ratio of the small side length to the large side length. Values close to one indicate that the grid spacing is near isotropic. To provide context, the bottom right panel simply shows the ocean bottom depth, and a subset of the mesh is super-imposed in blue lines in all panels.

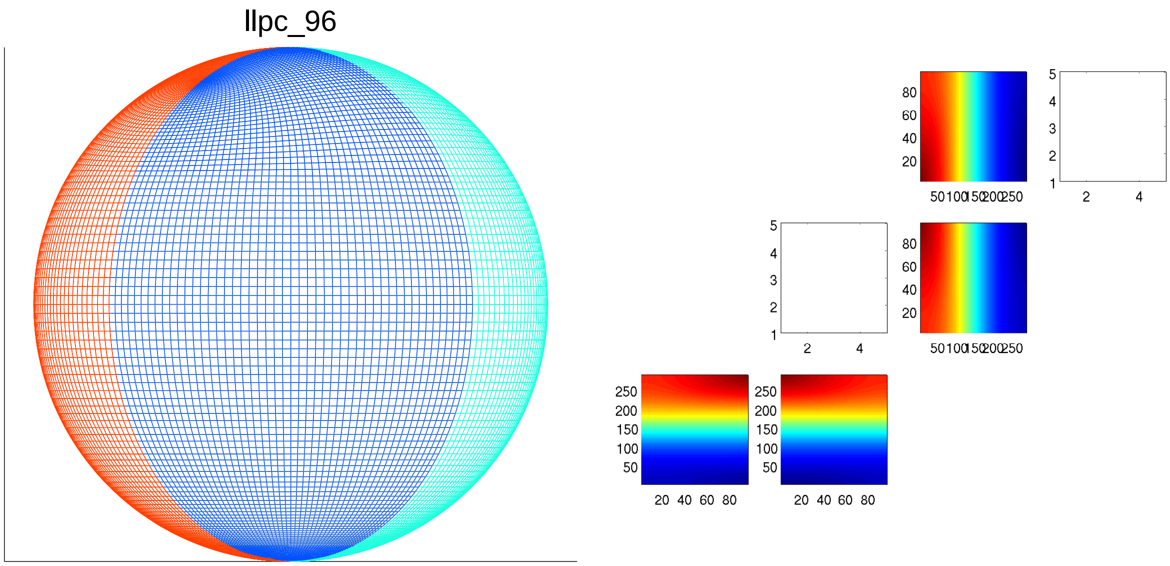

Figure 3: Same as Fig.1 but for llpc 96.

3 refined resolution in the tropics

The red lines in Fig.9 illustrate the grid spacing for additional grids, where the resolution was increased in the tropics. The top two panels show grids that could be used for the ECCO version 4 setup, where an increased resolution should allow a better representation of the zonal current/wave system near the equator. The nominal resolution of 1° was increased to 1/3° in the tropics. This was done by displacing/adding grid points in the lat-lon part of the high resolution grid. The bottom right panel shows a grid that could be used in coupled simulations, where it should allow for ENSO-like signals. The nominal resolution of 2° was increased to 2/3° in the tropics. This was done simply by subsampling the high resolution cube grid. The resulting grid has 72 in the meridional direction of side faces, and 48 points otherwise.

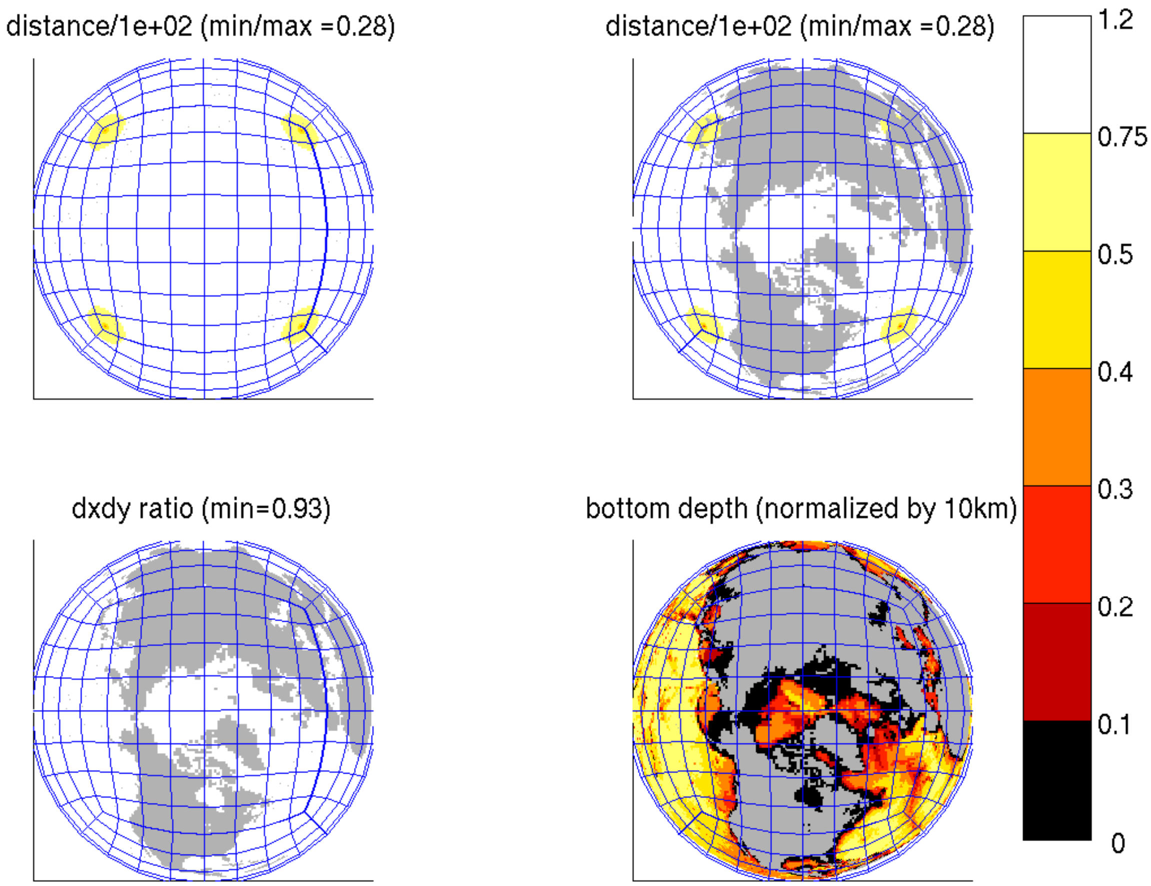

Figure 4: cube 96, looking at the Arctic.

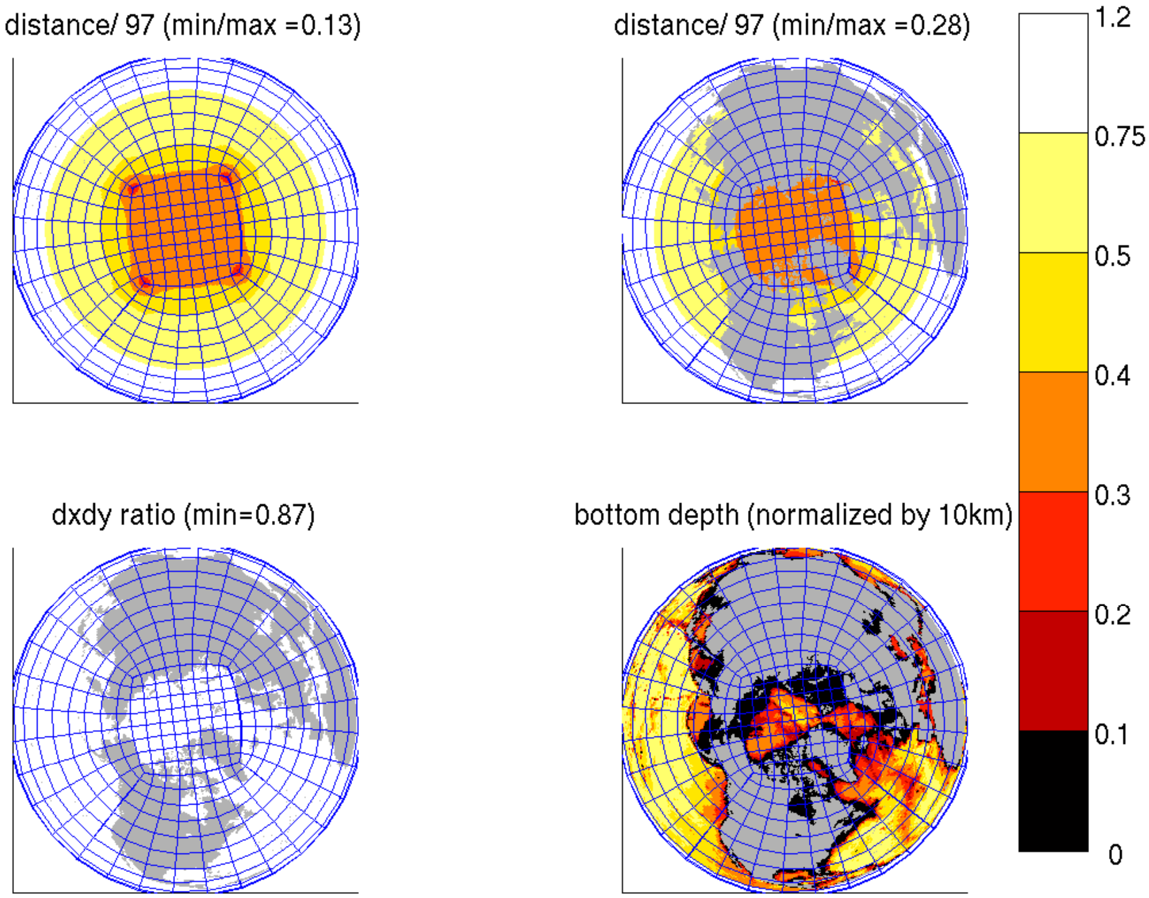

Figure 5: llc 96, looking at the Arctic.

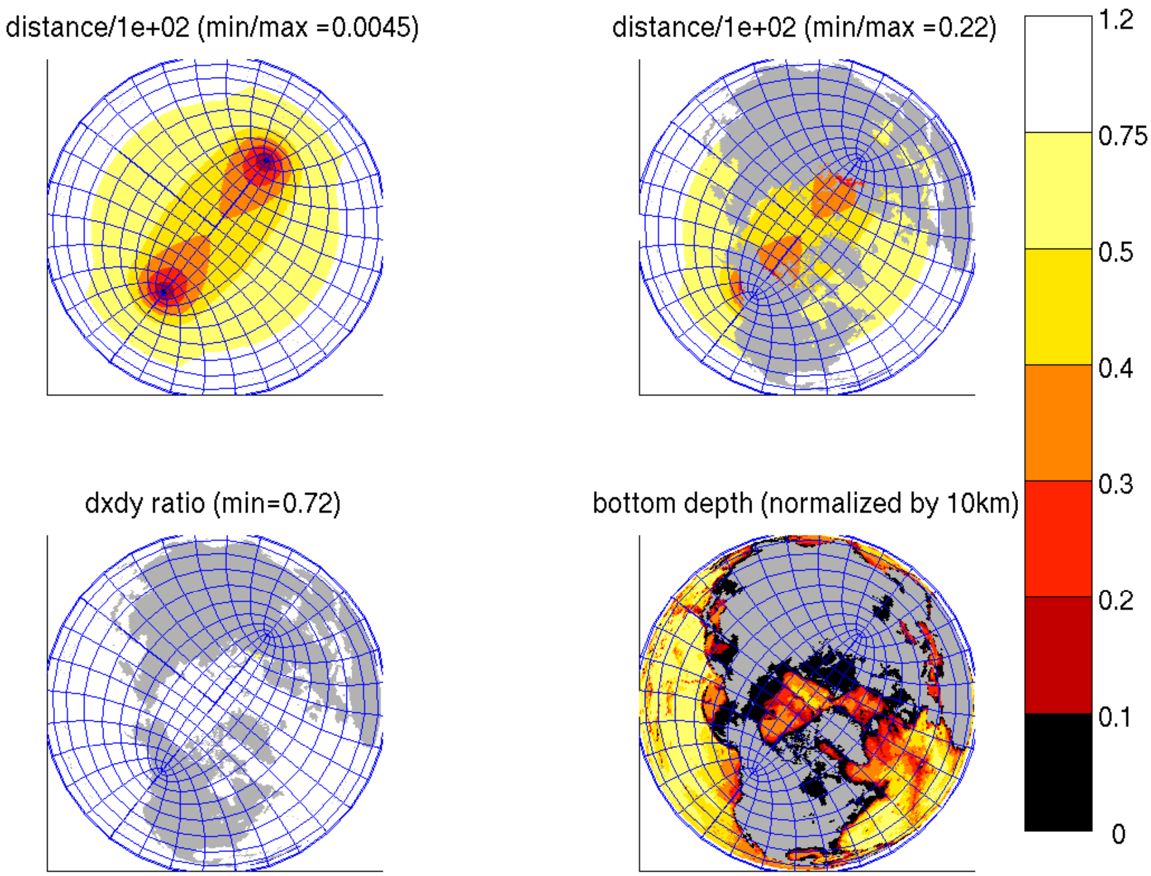

Figure 6: llpc 96, looking at the Arctic.

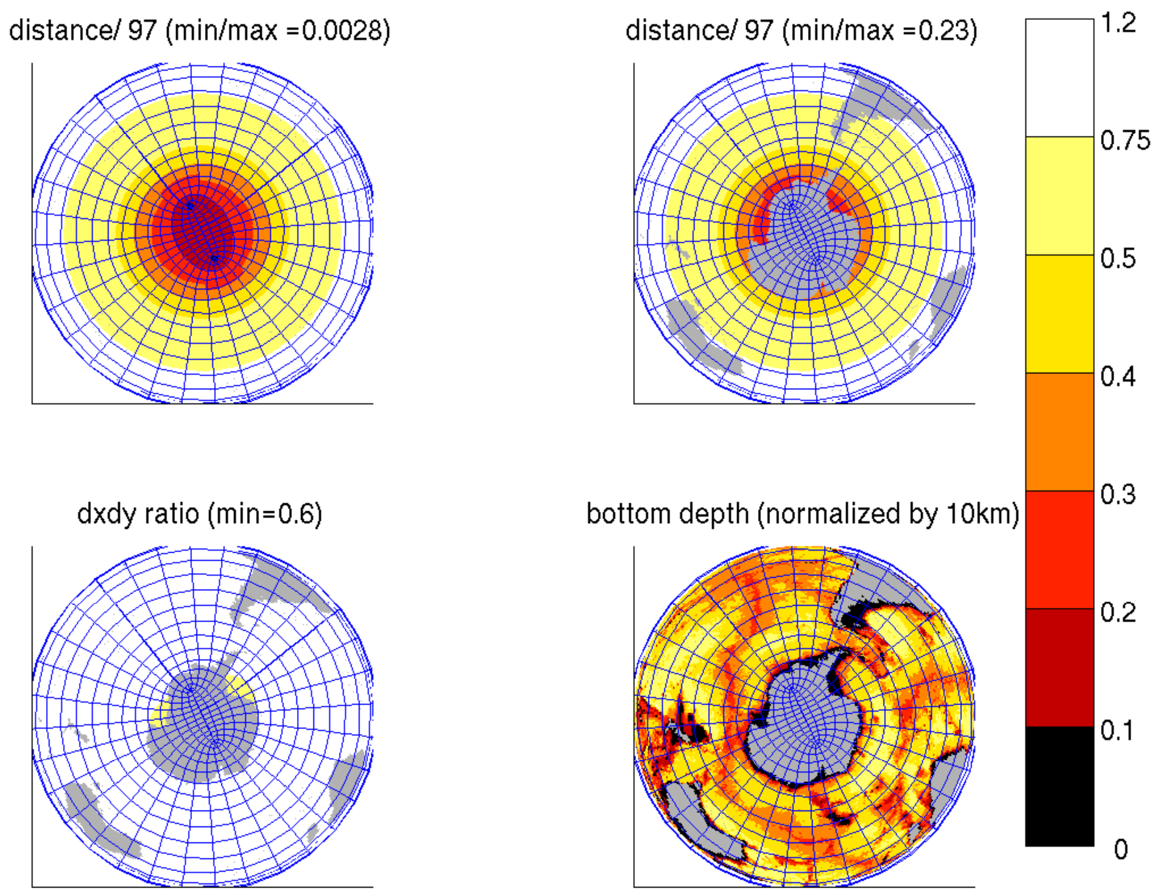

Figure 7: llc 96, looking at Antarctica.

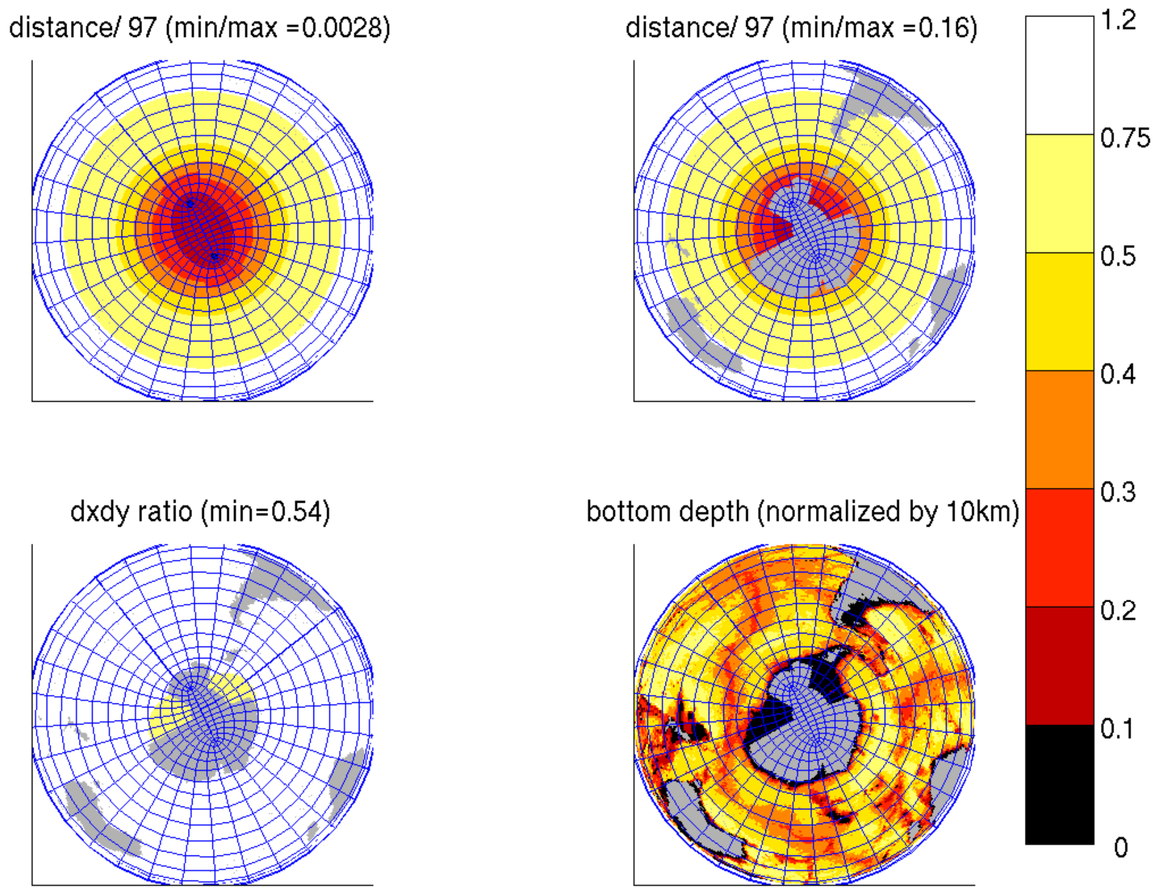

Figure 8: Same as Fig.7 but adding un-masked regions (reaching 86°S) that roughly represent the Ronnes and Weddell ice shelves.

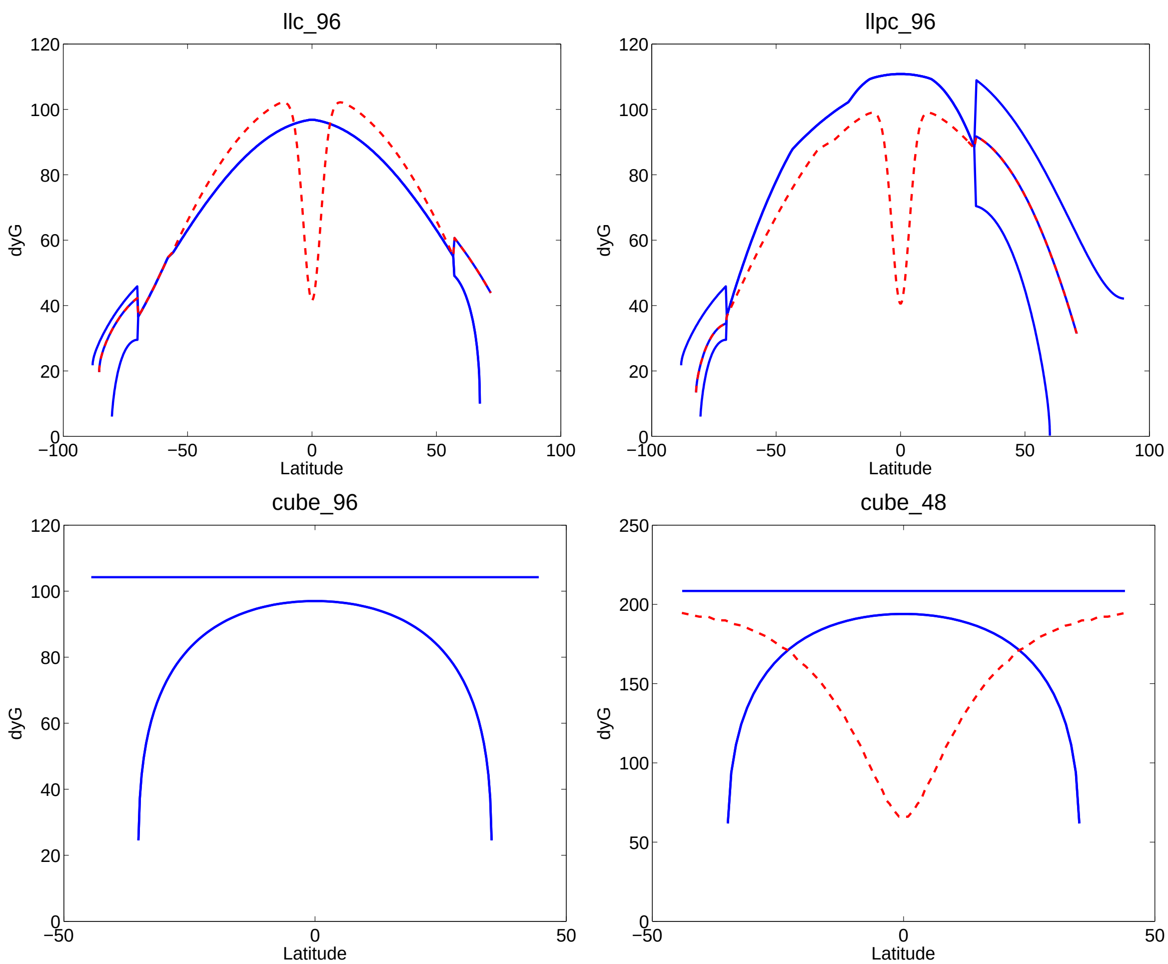

Figure 9: Grid point spacing for a side face of each grid. The bottom right panel is for the 2° cube, whereas the other panels are for the various 1° grid. In each panel three blue curves follow three grid lines of the standard grid (east edge, west edge, and middle line). Grid convergence is evident at curves ends, corresponding to grid singularities ('poles'). Except for cubes, those poles are located on land (see section 2). The dashed red curve is the middle line for a grid with increased resolution in the tropics (see section 3).