Data structure of the icosahedral grid atmospheric circulation model at the earth simulator

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1.Introduction

The massively parallel super-computer, which is called the earth simulator (hereinafter, ES) will be available in March of 2002.This computer will have the highest-speed in the world at the time.

It is designed so that the peak processing speed is 40TFLOPS and the execution processing speed is 5TFLOPS.The total amount of main memory is about 10TB.ES consists of 640 computational nodes, each of which has 8 vector-processors.

Therefore, all the numbers of the processors are 5120.Theses nodes are connected by crossbar network.

ES is used for the research of the global scale phenomena such as the global warming.

At present, most of today's atmospheric general circulation models employ the spectral method rather than the grid method. However, there are several difficulties such as the inefficiency and extensive communication of the Legendre transformation.

So, it is pointed out that the spectral method is not suitable for high-resolution calculation. Grid method is a good alternative of spectral method. When the simple latitude-longitude grid is used, another problem, so-called the pole problem, occurs.

The grid spacing near the poles becomes very small as the resolution becomes high. It is needed to use other types of grid, which are distributed as homogeneous as possible on the sphere.

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2. Grid generation method

The grid generation method of icosahedral grid is explained as follows.

Each side of the icosahedron whose vertices are on a unit sphere is projected onto the sphere. This grid is called ``glevel-0''(Fig.1(a)).

By connecting the midpoints of the geodesic arcs, four sub-triangles are generated from each of the glevel 0 triangles (Fig.1 (b)).

By iterating this process n-th times, a grid structure of glevel-n is obtained.

The grid structure with glevel-4 is shown in Fig.1(c).

3. Area divisions and the parallelization

When the sphere surface is divided into appropriate areas, it is efficient that the length of boundary line is minimum. So, the best shape of area is the square.

Our method of area division in the icosahedral grid system is as follows.

First, it makes 10 rectangular areas that are constructed by connecting two triangles.

This division is called rlevel0 (Fig.2 (a)). By the similar way of grid generation, each of rectangles is divided into four rectangles by linking these opposite sides.

This division is called rlevel1 (Fig.2 (b)). This process is repeated.

The number of process is determined by considering the available number of processors and the vector-length.

For example, if the computation in rlevel-0 is performed by 10 processes, each process manages one region. In practice, because it is needed to consider the load imbalance, we design that any process can manage any number of areas.

This method of area division has an advantage for the vectorization of computation.

In general, the vectorization on the structured-grid is easier than that on the unstructured-grid.

Because the shape of grid element of the icosahedral grid system is triangle, the grid seems to be unstructured. However, each of areas itself is structured, so that we can handle it as the structured grid.

4. Future plan

Because ES has 5120 processors, all processors output massive data.

We now consider how to handle such a massive data.

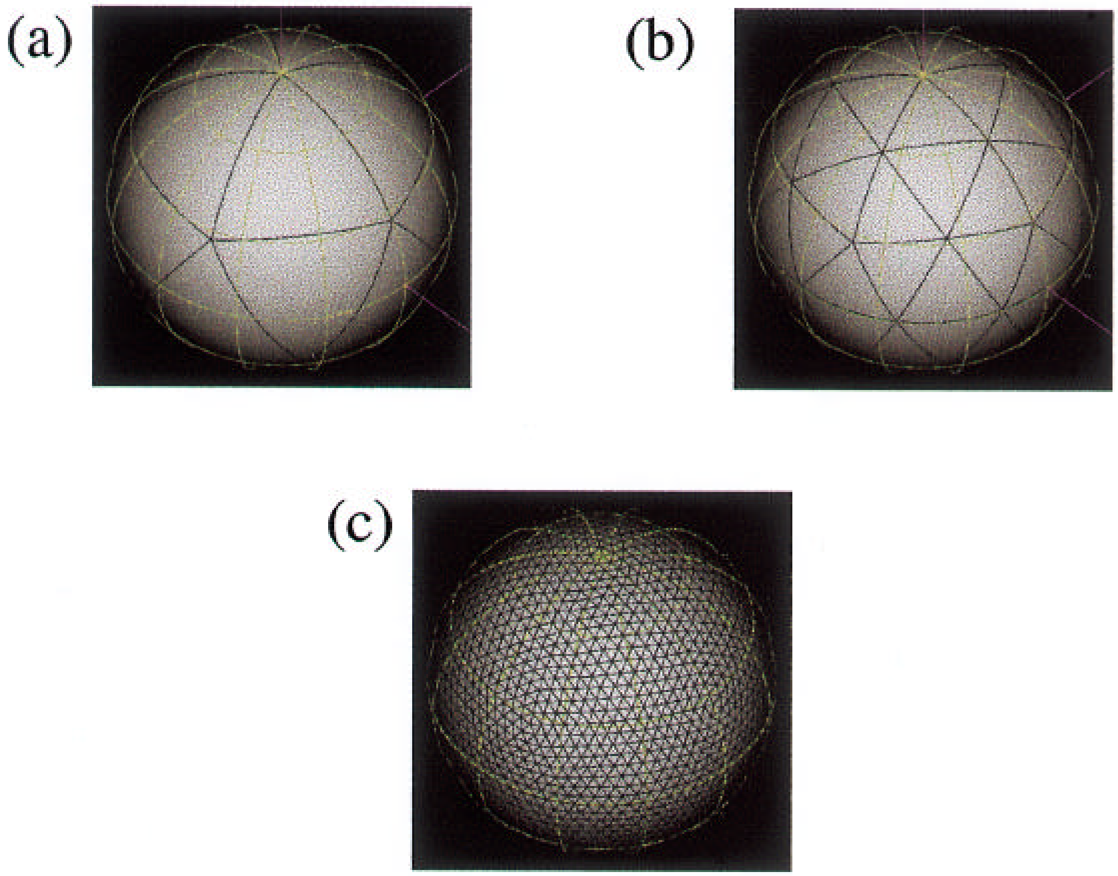

Fig.1: Schematic figure of grid structure. (a)grid division level 0, (b)grid division level 1 and (c)grid division level 4

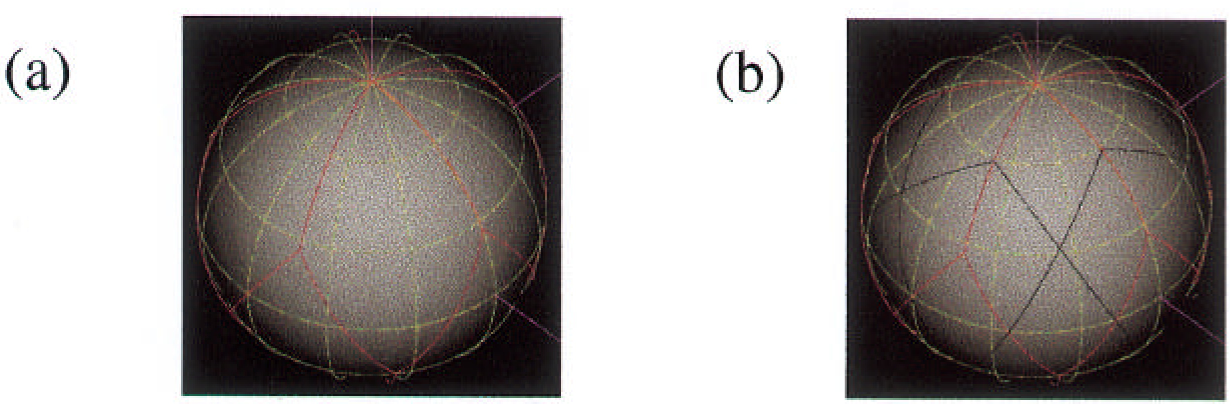

Fig.2: Schematic figure of region structure. (a)region division level 0 and (b)region division level 1.