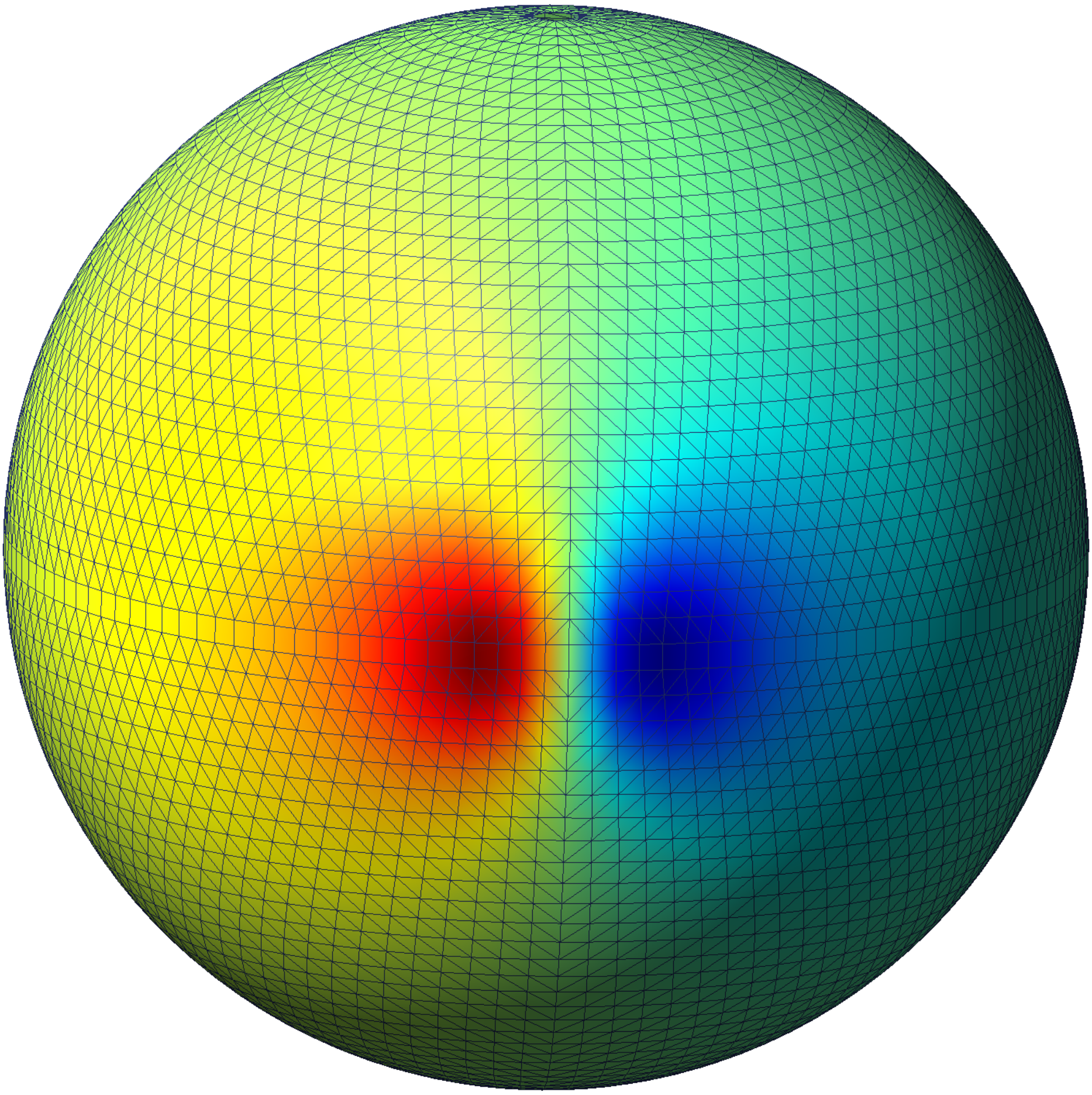
Elliptic Solver Dwarf

Hands-on exercises for the course
Advanced Numerical Methods



Introduction

We study in these exercises the three dimensional version of the elliptic solver dwarf. This code solves a potential flow over a Gaussian-shaped hill.

Configuration File

The following table gives a short explanation of the different parameters in the configuration file under the section "general":

name	description	default value
grid: { name : ? }	the letters at the beginning of this value determine the type of the mesh that is used for the simulation. Possible values are: "O" for octahedral mesh and "Slat" for longitude-latitude mesh. The number at the end of the value determines the resolution. This number gives the number of latitudes in one hemisphere. The default value "O32" for example uses an octahedral mesh with 32 latitudes in one hemisphere. This is approximately one quarter of the number of grid cells along the equator.	O32
nb_levels	number of levels in the vertical direction	51
dz	vertical resolution in meters	800
planet_radius	radius of the planet in meters	6.37122e+06
hill_radius	radius of the hill in meters	3.0e+06
hill_height	height of the hill in meters	4000
vstretch	0: no stretching (vertical resolution is constant), 1: with stretching (vertical resolution becomes finer towards the bottom. The parameter dz describes in this case the average vertical resolution)	1
vx0	wind speed in m/s of the ambient velocity field along the equator	20.0
nb_precon_iter	number of preconditioner iterations	3
eps0	iterative solution is stopped if the residuum is smaller than this tolerance eps0	1.0e-8
kord	order of the method	3
itmn	minimum number of iterations	1
itmx	maximum number of iterations	60

Exercises

1. Running the code

Open the Terminal on the virtual machine and go to the following folder with

```
cd /home/student/NMcourse/elliptic-solver
```

You can now run the code with the command

```
./run out
```

This command runs the code and writes the log messages that are shown on screen also to the file out.

The setup of the simulation can be changed by editing the file `config.yaml` inside this folder `ellipticSolver`. If you have no favourite editor we recommend to open the file with

```
mousepad config.yaml &
```

Please remember to save the file after making changes. You can plot the convergence stored in previously used output-files out1, out2, ... with

```
./plot_resid.py out1 out2 ...
```

The code writes different *.msh files while running:

filename	description
field_rho.msh	density
field_zcr.msh	vertical coordinate
field_terrain.msh	orography
field_solution.msh	resulting potential after computing the elliptic solver

If you use the virtual machine through X2Go you can plot these fields with one of the following two commands:

```
./plot mesh3d.msh field_solution.msh
```

This command creates a 3D sphere which you can rotate with the mouse. The other command is

```
./plot mesh2d.msh field_solution.msh
```

This creates a 2D lat-lon plot of the field.

This plot is created with a software called gmsh. This software does not work when accessing the virtual machine through ssh. You can still do the exercises by using the plot_resid.py script which should also work through ssh.

By default gmsh displays all height levels. You can hide them all by clicking on "Post-processing" in the left column. After this you can display one height level by clicking on one of the entries under the Post-processing section. The levels are ordered from bottom to the top.

Familiarise yourself with running the code, plotting the convergence and with the data that is shown on the screen while running the code.

2. Accuracy

Change the accuracy threshold "eps0" and see how it impacts the number of iterations required to converge to that threshold?

3. Hill height

Change the mountain height "hill_height" and see how it impacts convergence. What do you observe for a zero hill height?

4. Vertical resolution

How does the convergence change if you reduce the height of the atmosphere by reducing "dz"?

5. No preconditioner

Switch off the preconditioner by setting "nb_precond_iter" to 0. What do you observe?

6. Small planet

While keeping the preconditioner switched off and the vertical resolution at 800m, what do you observe if you reduce the radius of the planet down to ~50km (keep in mind that the mountain width needs to be adjusted accordingly)?

7. More information about the elliptic solver dwarf

More information about the elliptic solver dwarf can be found in Section 4.2 of the dwarf documentation which can be found at: http://goo.gl/s65ojl