Computer Practical: Saturn's Hexagon

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1 Overview

In this computer practical, a shallow water model on a rotating sphere, implemented in Fortran, is used to simulate Saturn's Hexagon.

2 Model formulation

The equations are largely the same as for the practical on Shallow Water Modelling; however, the circumference of the model domain now changes with latitude as it is mapped onto a sphere. In addition, the model can be split into sections and the equations in these sections can be solved on separate computer processors in parallel. This is key to how weather predictions are completed in time: the model is sped up by performing the calculations in parallel.

3 Downloading and compiling the code

Log into the server computer with an SSH window. Also, log into the server computer with an SFTP window. Space the windows out on your screen so that you can easily move between them.
If you have not done this already, download the code you will be using today from GitHub by typing the following:

```
git clone https://github.com/EnvModelling/shallow-water-model-on-sphere
```

this should download the code to your working directory.
In order to access the files you will need to change the working directory to where the files are. Type the following:
`cd shallow-water-model-on-`
followed by the `tab` key and the command should auto-complete. Then press the `enter` key.

Type `ls` followed by the `enter` key. The screen should list the files in this directory.
Finally, type `make` followed by the `enter` key. This will compile the FORTRAN code into machine code that the computer can run.

4 Viewing and Editing the code

We will use the `nano` text editor to view some files. In this practical there is an input file called `namelist.in`. To see what variables we can change, type:

```
nano -l namelist.in
```

the `-l` means to show line numbers. The code can be edited in the text editor and saved by typing `Ctrl-X` at the same time and pressing `Y` to save the file. The important variable is `u_jet` on line 11 of this file.

5 Running the model

After the code has been compiled (see Section 3), the procedure for running the model is to:

1. Edit the file `namelist.in` to configure the model.
2. Type `./run.sh` at the command line, followed by `enter` to run the model.

You will find that it takes way too long to run. Hold `Ctrl` and press c in the command window to break out of the model. We will run the model with more processing power.
On Saturn the Hexagon appears around 77° N. Scientists have been able to determine the average wind speed by tracking the motion of clouds over time. However, the speed of these features also includes the speed of the planet's rotation. How do we determine the planet's rotation when there is no solid ground? There are radio emissions that emanate from the core of Saturn. These radio waves have a periodic nature, which repeats every 10 and a half hours. This is usually taken to be the rotation period of Saturn.

After running the model a NetCDF file will be generated at the location `/tmp/<username>/output.nc`. You can then run a python script by typing:

```
python3 python/height_and_streamlines.py
```

and a plot of the model simulation will be shown in `/tmp/<username>/frame.png`, which you can download using SFTP by typing:

```
get /tmp/<username>/frame.png
```

Additionally, we can make an animation of the output by typing:

```
python3 python/animate_output.py
```

and a plot of the model simulation will be shown in `/tmp/<username>/animation.gif`, which you can download using SFTP by typing:

```
get /tmp/<username>/animation.gif
```

6 Experiments

You will notice that the model takes far too long to run on a single processor. for this reason we will run the model on 4 processors. To do this we will add an argument to the `./run.sh` command described in Section 5, which is the number of processors to run on as follows:

```
./run.sh 4
```

The simulations will take a while, maybe 7 minutes each.

6.1 Simulations to do

Simulations to do are to set the value `u_jet` to the following values:

1. 60 m s^{-1}
2. 90 m s^{-1}
3. 120 m s^{-1}
4. 200 m s^{-1}
5. 420 m s^{-1}

See Section 5 for details of how the run the model and generate the output (with the update in Section 6). Download the file and then explain what you see in the class (and upload the output for the rest of the class).

Exercise: Where do the cyclones and anticyclones form?

Exercise: What do you notice happens as the wind speed in the jet is increased?