Climate Modeling Homework 5, Due Tuesday May 13th

In this homework assignment, you will be running an idealized Atlantic model using the MOM4 code built at GFDL.

MOM4 – instructions
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%cd /home/disk/eos11/$LOGNAME

(i) Make a directory for the MOM4 runs.

%mkdir momruns
%cd momruns

(i) get code and run script from /home/disk/eos11/luanne

% cp /home/disk/eos11/luanne/code/mom4.tar .
% cp /home/disk/eos11/luanne/code/tmom.job .
code is mom4.tar
run script is tmom.job

(ii) unpack the code
Un-tar code in a directory of your choice - on olympus
this will normally be /home/disk/eos11/$LOGNAME/momruns

% tar xvf mom4.tar

Keep mom4.tar around just in case the files get messed up. I am giving you a compiled version, so you don't have to compile it. You will be changing run time parameters only.

(iii) edit tmom.job

change the line beginning "cd" to reflect your directory structure
In my script is says
cd /home/disk/eos11/luanne/code/mom4/exp/test1/workdir

Yours will probably be
cd /home/disk/eos11/$LOGNAME/momruns/mom4/exp
/test1/workdir

change the line #PBS -N test1-300yr if you want to give it a name that reflects your run

change the email address to your email address

(iv) change run-time parameters:

There are two files that you will be playing with, input.nml, and data_table, both in /workdir. You may also want to modify diag_table at your discretion. input.nml contains run time parameters that sets the length of the run and other parameters that some of you will be modifying. data_table sets the source of input files. In this case, some of you will be modifying the wind-stress input file. Both files are found in workdir.

% cd /home/disk/eos11/$LOGNAME/test1/workdir
edit the file input.nml to set the length of the run (and many other options)

Set the diffusivity parameter.

Edit the file data_table. The control simulation uses tau.nc for wind stress. Change the file to the one specified in the table below.

(v) submit job to batch system

cd to wherever you have the tmom.job script

%qsub tmom.job

monitor job "%qstat -a" or wait until you receive email from batch system

(vi) After the run is done, you have to recombine the output files. MOM4 has each processor output individually, so you need to combine the files together by running a script and then tars the output files that you can easily transfer.

%cd /home/disk/eos11/$USERNAME/mom4/exp/test1/
(note that this is one level above workdir where the model is being run)

This next command sets the stack size to unlimited so that you can combine the files
% unlimit
Run the script
% ./nccom

You will get a tar file out, so you will need to unpack it using the command tar xvf *.tar and you will get netcdf files that you can read into matlab. Using the commands that were given in Homework 1 to set up matlab on Olympus. Copy my matlab script /home/disk/eso11/luanne/plotmom.m to your directory.

Now for what you will do with the model. This is a very small model ocean, just a sector North Atlantic (it doesn't have real coastlines or geometry and has uniform depth of 4000m). It has only constant in time zonal wind-stress, and the buoyancy forcing is relaxation of temperature to a zonally uniform steady temperature. In the following

exercise, I want you to look at the meridional heat transport by the ocean as a function of wind-stress and vertical mixing. There are two aspects of the circulation in this model that are important for this exercise,
The meridional overturning circulation (MOC). This is the zonally averaged top to bottom circulation.
The barotropic circulation that brings warm water to the North in the western boundary current, and south in the ocean interior.

I want you to examine both aspects of the circulation. Make figures of the following quantities at the end of the run (look at the matlab script for an example of how to make the plots)

1. The barotropic (horizontal) circulation (lat-lon contoured)
2. The MOC (depth-lat contoured)
3. The meridional heat transport (lat plot)
4. The meridional heat transport can be divided into two components. We define the vertically averaged circulation by

$$\overline{V} = \frac{1}{H}\int_{z=-H}^{0} v dz$$

$$\overline{T} = \frac{1}{H}\int_{z=-H}^{0} T dz$$

and

$$v' = v - \overline{V}$$

$$T' = T - \overline{T}$$

The transport will be given by

$$\int_{x=0}^{x=x_e} dx \int_{z=-H}^{0} dz vT = \int_{x=0}^{x=x_e} dx \int_{z=-H}^{0} dz \overline{V}\overline{T} + \overline{v'T'}$$

So first calculation $\int_{x=0}^{x=x_e} dx \int_{z=-H}^{0} dz \overline{V}\overline{T}$

And then take the difference between this and the total heat transport to find

$$\int_{x=0}^{x=x_e} dx \int_{z=-H}^{0} dz \overline{v'T'}$$

Plot both of these results up. Let me know if you get stuck in matlab, but I will set you free to get this going. You can put your scripts up on the wiki to help the students who don’t have as much experience with matlab get going.

5. Make an entry in the table on the wiki of each of the quantities
    a) Maximum MOC
    b) Maximum barotropic circulation
    c) Maximum MHT
    d) Maximum barolinic MHT
    e) Maximum barotropic MHT

6. There are other variables in the data set. Look at the matlab script to see what each of them is, and what their units are. Make a plot of one more quantity and describe what you learned about the circulation from that quantity. Some things that you can look at include
surface heat flux
ideal age
MOC as a function of time
MHT as a function of time
Temperature as a function of time
Boundary current structure
Etc.

Put each figure up on the web page.

Each person will perform one simulation, make the length of the simulation 300 years. This will not be quite enough time to totally spinup the circulation, but will take about 6 hours. The control wind-stress is in tau.nc, while the diffusivity is 5.e-5.

Run number/Person	Wind-stress file (for data_table)	Diffusivity (for input.nml)
Kevin	tau.nc	5e-5
Kyle	tau.nc	1e-4
Stuart	tau.nc	5e-4
Kai-Chieh	tau100.nc	5e-5
Rei	tau100.nc	1e-4
Silje	tau100.nc	5e-4
Steve	tau1000.nc	5e-5
Kelly	tau1000.nc	1e-4
Paul	tau1000.nc	5e-4
Ty	tau10000.nc	5e-5
Justin	tau10000.nc	1e-4
Ed	tau10000.nc	5e-4

Instructions on modifying the input files

To modify input.nml to change the length of the run, modify line 2 to give the number of months of the run

months = 3600

To change the diffusivity modify the lines starting with 106. Modify the first two diffusivity kappa_h and diff_cbt_limit to the values for your run

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&ocean_vert_mix_coeff_const_nml
    kappa_h=5.e-5
    diff_cbt_limit=5.e-5
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kappa_m=5.e-4 /

To change the wind-stress input, modify data_table, changing the name of the wind-stress file from tau.nc to your wind-stress.

7) In one page, discuss your results, both the structure of the MOC, its magnitude, and compare the MHT to that in the lecture figures from Trenberth and Caron. Discuss the relative roles of the overturning circulation and the barotropic circulation to the meridional heat transport. Discuss the relative sizes of the two circulations and the relationship of those sizes to the the strength of the wind and the strength of the diffusivity. You can compare your results to results of the other model runs as they become available.

8) Upload your matlab scripts to the wiki after you make the plots. My matlab script can be found at

/home/disk/eos11/luanne/code/readmom.m

remember to set your paths as in the instructions for the earlier homeworks.

Feel free to e-mail me, Cecilia, or David Darr (darr@ocean.washington.edu) with questions or if the model crashes.