Flow Separation

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1 Initializing the MITgcm

1.1 Test files

A standard 2D grid of dimensions 100×1km was introduced in the x-z plane. Hyperbolic tangent topography was generated which had an extent of 50m in depth in the west to 1000m of depth in the east. A linear temperature profile was introduced; the surface was fixed at 14°C, and the lowest layer was fixed at 2°C. Boundary conditions were set on the west side for an inflow of $U(x = 0, z, t) = 1$m/s, $T(x = 0, z, t) = 14$°C. The flow of 1m/s would typically reach the shelf break after 1 day.

1.2 Adjusting the `data` parameters for numerical stability

The MITgcm was run serially on Snapper at varying resolutions on a 2D grid. The data file was initially stripped to the bare essentials and then modified to determine which lines were necessary. Initially, the file consisted simply of:

```
# Model parameters
# Continuous equation parameters
 &PARM01
 tRef=14.,
 sRef=30.,
 no_slip_sides=.TRUE.,
 no_slip_bottom=.TRUE.,
 viscAh=1E-2,
 viscAz=1E-2,
 f0=1E-4,
 beta=0.E-11,
 tAlpha=2.E-4,
 sBeta=7.4E-4,
 gravity=9.81,
 readBinaryPrec=64,
 nonHydrostatic=.FALSE.,
 &
# Elliptic solver parameters
 &PARM02
 &
# Time stepping parameters
 &PARM03
 nIter0=0,
 nTimeSteps=19440,
 deltaT=40,
 dumpFreq=86400.0,
# Gridding parameters
 &PARM04
 delXfile='delX_Nx_256.bin',
```

```
delY=100.,
delZ=64*15.625,
&
PARM05
bathyFile='Bathy_profile_Nx_256_Nz_64.bin',
hydrogThetaFile='T_profile_Nx_256_Nz_64.bin',
uVelInitFile=,
&
```

However on a 256×64 grid (in x and z respectively) the numerics were unstable and grid-scale oscillations developed in the u field, causing the final solutions to be `Inf` or `NaN`. The first attempt to remedy this was to change the lateral eddy viscosity line (denoted by `viscAh`), and use *Jamart wet points* [Jamart and Ozer, 1986]:

```
viscAh=1E0,
useJamartWetPoints=.TRUE.,
```

Jamart wet points force the code to calculate averages excluding boundary points. This change was insufficient; the output continued to show grid-scale oscillations in the u field. Subsequently, three lines were added:

```
viscAhGridMin=0.01,
viscAhGridMax=1.0,
viscAhReMax=10.0,
```

These lines were imported from Karina's MITgcm data initialization file. However, the grid-scale oscillations continued and the output eventually blew-up.

Smagorinsky eddy viscosity was added as the next attempt.

```
viscC2Smag=2.2,
```

The inclusion of this Smagorinsky eddy viscosity seemed to remedy the issues of grid-scale oscillations and unstable output. To determine which parameters could be disposed of, the previous set of `viscAh*` settings were reverted to the initial file settings, however the Jamart wet points flag was kept on. The code blew up again, and so the `viscAh` flag was reverted back to `viscAh=1E0`. This run still blew-up and so the grid min/max and remax viscAh lines were reintroduced.

The state of the file which yields stable output for 9 days is:

```
# Model parameters
# Continuous equation parameters
 &PARM01
 tRef=14.,
 sRef=30.,
 no_slip_sides=.TRUE.,
 no_slip_bottom=.TRUE.,
 viscAh=1E-2,
 viscAz=1E-2,
 viscAhGridMin=0.01,
 viscAhGridMax=1.0,
 viscAhReMax=10.0,
 viscC2Smag=2.2,
 f0=1E-4,
 beta=0.E-11,
 tAlpha=2.E-4,
 sBeta=7.4E-4,
 gravity=9.81,
 readBinaryPrec=64,
 nonHydrostatic=.FALSE.,
 useJamartWetPoints=.TRUE.,
```

```
 &
# Elliptic solver parameters
 &PARM02
 &
# Time stepping parameters
 &PARM03
 nIter0=0,
 nTimeSteps=19440,
 deltaT=40,
 dumpFreq=86400.0,
# Gridding parameters
 &PARM04
 delXfile='delX_Nx_256.bin',
 delY=100.,
 delZ=64*15.625,
 &
 PARM05
 bathyFile='Bathy_profile_Nx_256_Nz_64.bin',
 hydrogThetaFile='T_profile_Nx_256_Nz_64.bin',
 uVelInitFile=,
 &
```

1.3 Selecting parameters

Now to investigate the effects of numerical parameters on flow separation, an initial profile must be chosen which is representative of previous studies done where early flow separation was seen. A similar profile to the one in [Cummins, 2000] will be used. In particular, a domain of 10km×200m will be used.

References

[Cummins, 2000] Cummins, P. (2000). Stratified flow over topography: time-dependent comparisons between model solutions and observations. Dynamics of Atmospheres and Oceans.

[Jamart and Ozer, 1986] Jamart, B. and Ozer, J. (1986). Numerical boundary layers and spurious residual flows. Journal of Geophys. Research.