

# Intro to ECCO datasets for ATOC 5051: Introduction to Physical Oceanography or, Notions for the Motions of the Oceans

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## 1 Contacts

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The ECCO (Estimating the Circulation and Climate of the Ocean) consortium is a group of scientists who are using the same framework to assimilate data (satellite, ship observations, buoys, etc.) through a data-assimilating model. The model being used is the MITgcm (<http://mitgcm.org>), and the data assimilation takes place by an *adjoint* method.

The adjoint method is the way the model is adjusted to match the data, and it is somewhat complex (see the websites for more info). The essential idea for our purposes is that the model is run over and over again with a smart method for adjusting parameters and forcing (within errorbars) of the model so that the data is matched (to within errorbars). Each iteration of the model is fully consistent physically, though, so no ‘nudging’ of the physics occurs during the simulation. Thus, closing budgets or calculating the momentum equation should work just like the model was an ordinary solution of the equations of motion.

## 2 The Variables

The variables you will use most commonly are the ‘state’ variables: U, V, W, eta (hydrostatic pressure), S, theta (potential temperature). Many other variables (surface heat or salt forcing–recall virtual salt flux, advective and diffusive fluxes in different directions, etc. are available for download).

## 3 The Grid

The variables are arranged on a staggered grid.

The velocities and fluxes of properties are considered to lie on the faces of each finite volume, while the conserved properties are considered at the center of each volume. Thus, if one wants to calculate the advection of salinity:  $uS$ , one needs to average the salinities onto the locations of the u-grid, and then multiply. in Matlab this could be done quickly via:

```
>> U(:,:,,2:11).*(S(:,:,,1:10)+S(:,:,,2:11))*0.5
```

Note that the variables are in t,z,y,x order. Also note that we assume that U is larger than S in the x direction. Some care is needed with this. usually, the ECCO datasets will contain an ‘X’ variable which is

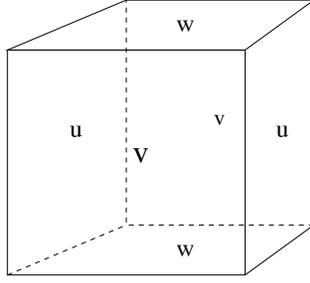


Figure 2.9: Three dimensional staggering of velocity components. This facilitates the natural discretization of the continuity and tracer equations.

Figure 1: The MITgcm staggered grid. The velocities are arranged on the faces of each finite volume, while the conserved properties (S, T,  $\rho$ , p) are represented at the center of each volume.

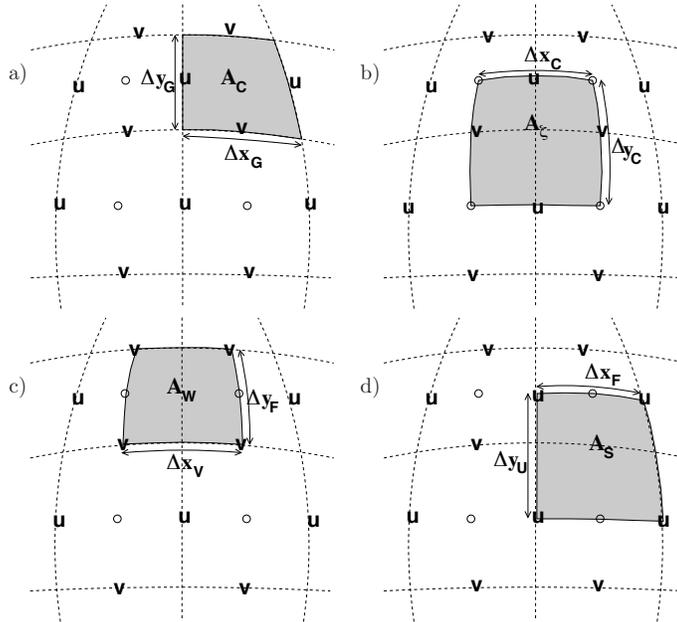


Figure 2.10: Staggering of horizontal grid descriptors (lengths and areas). The grid lines indicate the tracer cell boundaries and are the reference grid for all panels. a) The area of a tracer cell,  $A_c$ , is bordered by the lengths  $\Delta x_g$  and  $\Delta y_g$ . b) The area of a vorticity cell,  $A_\zeta$ , is bordered by the lengths  $\Delta x_c$  and  $\Delta y_c$ . c) The area of a u cell,  $A_w$ , is bordered by the lengths  $\Delta x_v$  and  $\Delta y_f$ . d) The area of a v cell,  $A_s$ , is bordered by the lengths  $\Delta x_f$  and  $\Delta y_u$ .

Figure 2: The MITgcm staggered grid. Different areas are arranged on the faces of the finite volumes to aid in calculating fluxes through the volume faces.

the longitude location of S, theta, etc., and an 'Xp1' variable, which is the location of the U. By making sure that you intend for your fluxes to 'live' on the Xp1 grid, you will average correctly.

You can also download the meridional and zonal advective and diffusive fluxes directly. They should also 'live' on the 'Xp1' and 'Yp1' grids. They *will not* equal the product of U and S above generally, for two important reasons;

1. They are time-averaged after multiplication, and  $\bar{u} \bar{S} \neq \overline{uS}$ . (Or, if you prefer to think in terms of eddy fluxes, the eddy fluxes are included in one version but not in the other)
2. They are the volume\*property flux. That is, they include the cross-sectional area of the finite volume face through which they are flowing, and their units are  $[units]m^3/s$  where  $[units]$  might be  $g/kg$  for salinity, or  $degC$  for theta, etc.

## 4 Virtual Salt Flux and Net Heating

The ECCO model is forced by a combination of heating/cooling effects at the surface, but what is readily downloaded is only the net heat flux. For your budgets, you can use these net fluxes, and if you want to distinguish between them, use another data source like the NOCS dataset ([link on webpage](#)).