Notes from Webex call on 30 May 2018 to discuss z-tilde and ALE coordinates

Attendees: Mike Bell, Jerome Chanut, Gurvan Madec, Alex Megann, Andrew Shao, Julien le Sommer

1. Alex's presentation (circulated by him before the meeting)

Alex explained the motivation for reducing numerical mixing due to flow across coordinate surfaces.

The drift in the mean temperature profile illustrated in his slide 9 was discussed. Julien mentioned that the Drakkar team had explored this drift and that some of it was attributed to misrepresentation of the strength of the bowl-shaped gyres. Andrew noted that the MOM6 team have found that they can reduce this drift by using ALE coordinates (see his email below and the attached slide).
Alex recalled that Lee et al. (JPO, 2002) found that the mixing was much stronger when the model was driven by 6-hourly winds.

Gibson et al (OM, 119, 2017) investigates the horizontal and vertical contributions to mixing in MOM6 in a suite of test cases (similar to that of Ilicak et al OM, 2012).

Sjoerd Groeskamp: https://www.sjoerdgroeskamp.com/about is working on a scheme to calculate gradients on neutral surfaces (rather than sigma_2 surfaces)

2. Jerome's presentation (circulated by him before the meeting)

Jerome talked through the z-tilde scheme and its implementation within NEMO. Gurvan explained that the motivation for staying with explicit vertical advection was connected with the desire to retain conservation of energy (and mass?) but that this could be re-visited. The advection choice relates to the issues with vanishing layers. In HYCOM the vanishing layer issue pervades all the dynamics routines. Andrew noted that vanishing layers are naturally handled by implicit remapping schemes (there is nothing to re-map).

Jerome has got an ORCA configuration (ORCA025) running with z-tilde but z-tilde is not working fully at version 3.6; z-tilde was introduced prior to the split-explicit free surface. Jerome has used z-tilde with z rather than s-coordinates; Gurvan noted that in principle s-coordinates could be used. Jerome has not used the z-tilde coordinate near the bottom - because it is hard to maintain non-zero thicknesses near bathymetry [?]

There was some discussion of the re-gridding term (R in Jerome's first term ?); whether R has to be applied every time-step (no it doesn't) and how Shchepetkin's adaptive vertical advection scheme could be used as a CFL limiter for very thin layers.

The choice of the blending of z* and isopycnal coordinates is tricky: for example waters of similar density convect to 1000 m in the North Atlantic and are present at 200 m in sub-Antarctic modes waters. Andrew thinks that the HYCOM choice is the only one that is published.

Jerome's final slide is a still from a movie loop showing the impressive reduction achieved by z-tilde in the mixing induced by internal waves generated by an idealized super-critical continental slope. As part of COMMODO, this test case has been run also in HYCOM and ROMS. Andrew in liaison with Julien will ask Angus Gibson if he would be interested to run this test case with MOM6 (see Andrew's email below).

3. Plans for the future

Alex has some project money to investigate the effect of tides on mixing in ORCA025 and try to remedy it using z-tilde coordinates.

Jerome is working with Alex to get z-tilde working at vn3.6_stable. He is also working with Bryan Arbic to investigate a 1/12 ORCA with a small number of vertical layers driven by tides.

Andrew has moved to Victoria University in Canada. He would like to implement the ideas on neutral diffusion he has developed in MOM6 within NEMO, using the rotated coordinate and Griffies triad approaches. He would also like to compare results [for z-tilde?] obtained using [implicit] remapping methods with those from [explicit] vertical advection methods

ACTION: Julien will discuss with the NEMO System Team manager (Claire Levy) how the NEMO System Team can best support Andrew's work (e.g. so that his developments can be brought into the trunk).

Subject: MOM6 Sensitivity to Vertical Coordinate: Temperature Drift

Hi all,

I very much enjoyed meeting with those of you in attendance at today's telecon and I look forward to working with all of you.

One topic that came up was a question about the role of the vertical coordinate in inducing spurious diapycnal mixing as diagnosed from temperature drift (Slide 9 of Alex's talk). I've attached a slide from a talk that Bob Hallberg gave in Australia in 2017 that shows the results from two coupled model experiments that are identical except that the ocean component (MOM6) in case uses a z* (50 levels) vertical coordinate and the other uses a HYCOM-like coordinate (75 levels). In GFDL's case, the z* case had a near-surface cool bias and a far to warm thermocline.
The hybrid-coordinate case shows a similar pattern but the drift is reduced by about a half.

I also did email Angus Gibson to see if he was interested in using MOM6 to mimic the idealized tidal wave test case that Jerome presented in the context of the z-tilde coordinate. I'll let you know what he says.

Please let me know if you have any questions about MOM6, my neutral diffusion work and/or experiences with ALE, or anything related to the CCCma's NEMO 3.4 configuration or GFDL's MOM6. I have a weekly meeting with all the MOM6 folk and would be happy to pass along any questions.

Best,
Andrew