Ocean Science Discussions

Ocean Sci. Discuss., author comment AC6
https://doi.org/10.5194/os-2022-12-AC6, 2022

Reply on RC6

Peter Chu

Author comment on "Gravity disturbance driven ocean circulation" by Peter C. Chu, Ocean Sci. Discuss., https://doi.org/10.5194/os-2022-12-AC6, 2022

Thank you very much for your quick response to my reply.

Response to the 'Geoid Surface Represents the True Horizontal'

"*In his reply to my review, the author states that 'Oceanographers have used the geoid for several decades, but almost no one recognizes that the geoid surface represents the true horizontal'. On this important point I disagree. For independent evidence, I refer the author to the book "Ocean Dynamics" by Olbers, Willebrand and Eden and published by Springer. Their Figure 2.9 corresponds exactly to the author's Figure 1a, showing that they are aware of the geoid*."

My statement 'Oceanographers have used the geoid for several decades, but almost no one recognizes that the geoid surface represents the true horizontal' has two components: (1) oceanographers have used the geoid for several decades, (2) the geoid surface represents the true horizontal.

It is not surprised that Fig. 2.9 in the book "Ocean Dynamics" by Olbers, Willebrand and Eden (2012) corresponds exactly to Fig.1a in my manuscript. Because similar figures about geoid were published by oceanographers earlier such as 'Fig. 5 EGM96 geoid height *N* …' in the paper:

Wunsch C., and D. Stammer (1998), Satellite altimetry, the marine geoid, and the oceanic general circulation. Annu. Rev., Earth. Planet. Sci., 26, 219-253.

The geoid surface is treated as a reference surface, but not a true horizontal surface.

Response to the Geopotential

"*It is hence very convenient and useful to use a coordinate system which has phi = constant as one coordinate surface (phi is the geopotential). For orthogonal coordinates, gravity must thus coincide exactly with one coordinate direction, i.e.* ***g*** *= (0,0, -g). The geopotential is then dependent on the vertical coordinate z. Referring the potential to the mean surface, i.e. phi(z = 0) = 0, we have phi (z) = gz. The geopotential is thus the work which must be applied to lift a unit mass from z = 0 to height z*."

I disagree. Because this statement is valid only for the effective gravity, not for the true gravity.

In the book "Ocean Dynamics" by Olbers, Willebrand and Eden (2012), and any other similar books such as "Principles of Large Scale Numerical Weather Prediction, by Phillips in "Dynamic Meteorology" (1973 edited by Morel) pages 2-7, "Geophysical Fluid Dynamics" (1986) by Pedlosky pages 17-19, "Atmosphere-Ocean Dynamics" by Gill (1982) pages 73-74, and "Atmospheric and Oceanic Fluid Dynamics" by Vallis (2006) pages 54-57, the effective gravity $\mathbf{g}_{\text{eff}}$ (or called the normal gravity in geodesy) is used with the corresponding effective-geopotential Φ_{eff}, and effective-geopotential coordinate (coincidence with the Earth ellipsoidal surface).

However, the true gravity $\mathbf{g}$ is the summation of the effective gravity $\mathbf{g}_{\text{eff}}$ and the gravity disturbance $\delta\mathbf{g}$, $\mathbf{g} = \mathbf{g}_{\text{eff}} + \delta\mathbf{g}$, with the corresponding true geopotential, $\Phi = \Phi_{\text{eff}} - T$. Here, T is the gravity disturbance potential.

Response to the Sverdrup/Stommel/Munk Problem

"*Regarding the Sverdrup/Stommel/Munk problem, the issue is the direction that is used for the vertical. In the coordinate system used by the author, this is not the same as in the coordinate system I describe above, or as used in the standard Sverdrup/Stommel/Munk problem. In the latter, there is no horizontal component of gravity. The different vertical directions lead to different torque balances in the vertical direction*."

I agree.

Response to the Recommendation

"*I am afraid I stand by my original review. The mistake being made by the author is to work in spherical coordinates from the beginning, whereas the coordinate system used by modellers and observationalists is an orthogonal, curvilinear coordinate system in which the vertical direction is perpendicular to geopotential surfaces. As such, I cannot recommend publication of the manuscript. The author could, nevertheless, make a very useful contribution by writing an authoritative manuscript dealing with these issues. But the author needs to be clear about what coordinate system is being used by modelers and observationalists. It is not the coordinate system he uses in his submitted manuscript*."

Thank you very much for your critics and recommendation. I will revise the manuscript thoroughly according to the critics of yours and the other two reviewers.