OCES 2003 midterms, Spring 2021

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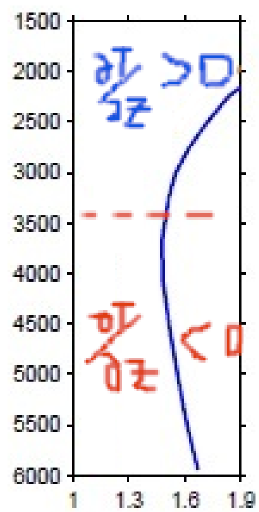
Set on: Tue 16th Mar; due: Tue 16th Mar

Model solutions and mark scheme

Problems

1. (a) It should be in-situ temperature because the temperature increase with depth is indicative of pressure contributions to in-situ temperature.
   (1 mark for in-situ temperature)



(b)

   (0.5 marks for each of the $\partial T/\partial z$)

   (c) The linear EOS with zero haline coefficient implies $\rho = \rho_0(1 - \alpha T_a)$ with $\alpha > 0$. As T_a increases, ρ decreases, so we have lighter water below denser water at depth, and the state is unstable and should overturn.
   (0.5 marks for noting the assumptions imply we don't care about salinity, and 0.5 marks for noting we have overturns)

   (d) Recalling that the $\kappa \sim L^2/T$, we have

$$T \sim \frac{L^2}{\kappa} = \frac{3000^2}{10^{-5}} = 9 \times 10^{11} \text{ s} \approx 30,000 \text{ years}$$

   with the conversion factor of 1 yr = $3600 \times 24 \times 365$ s

   (e) Note that $\kappa = 10^{-4}\ \text{km}^2\ \text{s}^{-1} = 100\ \text{m}^2\ \text{s}^{-1}$, so

$$T \sim \frac{L^2}{\kappa} = \frac{3000^2}{10^2} = 9 \times 10^4 \text{ s} \approx 1 \text{ day}$$

   with the conversion factor of 1 day = 3600×24 s

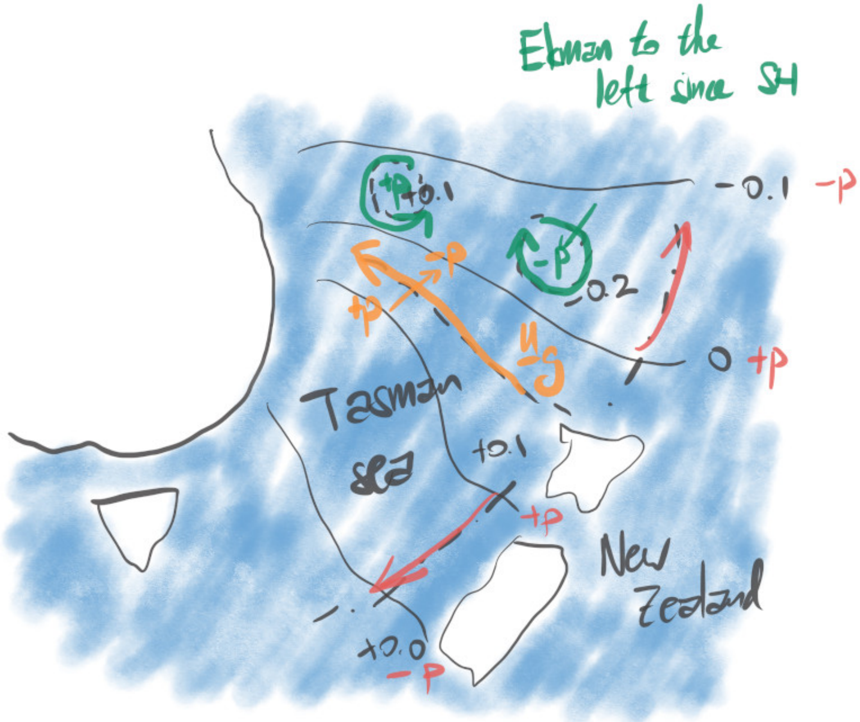
(3 marks in total for the last two parts. If answer is wrong but working is essentially right, then give maximum of two marks in total. For each part, 0.5 marks off for not giving it in the right units and/or not in the required degree of accuracy.)

2. As in the diagram below:

   (a) (red lines) isobars are related to SSH so $-\nabla p$ points towards the edge of the drawing

   (b) (green lines) geostrophic transport is to the left since we are in the southern hemisphere, so the +0.1 eddy is a high-pressure, while the -0.2 is a low pressure since we are in the region where the background SSH is between 0 and 0.1, so the associated flow is clockwise and anti-clockwise respectively.

   (c) (orange lines) within the +0.1 and 0 contour, $-\nabla p$ is pointing north, so since the geostrophic flow is to the left, the geostrophic flow is pointing into Australia (in reality the flow should of course be the other way round, but my SSH contours are completely artificial).



Conclusions doesn't hold if Ro is not small since we don't have geostrophic balance. The flow should then go in the direction of $-\nabla p$.

The Earth rotating around the Sun a different way makes no difference because the Coriolis effect arises from the rotation of Earth about its own axis. From an equation point of view, the rotation axis $\mathbf{\Omega}$ or the Coriolis effect parameter f doesn't care about the Earth's orbit around the Sun.

(5 marks for the drawing of the arrows, but only if the justification is correct. 1 mark each for the Ro and rotating around the Sun bit.)

3. There is no β, therefore no Sverdrup balance, no western intensification, and the resulting symmetric gyre rotates in the same sense as the wind stress curl.

   - On a flat Earth there is no β because there is no mismatch of the rotation axis $\mathbf{\Omega}$ with the local depth co-ordinate vector $\boldsymbol{e}_z$, i.e. $f = f_0$ = constant

- If there is no β then you can't have Sverdrup balance, so wind has to be balanced by friction
- There is no Sverdrup interior, so no need or reason for western intensification, and the flow should be symmetric
- Since there is no asymmetry, the flow should be in the same orientation as the wind from e.g. energy and/or vorticity considerations

(1 mark for each of noting that there is: no β; no Sverdurp balance; no western intensification; gyre in the same sense as wind forcing. 3 marks available for attempts at related explanations.)