and the tidal potential Eq. (1), to find τ at the outer surface as follows.

As noted in Section 4, $\tau_{rr} = \tau_{\theta r} = \tau_{\phi r} = \tau_{r\theta} = \tau_{r\phi} = 0$ at the outer surface. Writing $[\nabla\vec{s} + (\nabla\vec{s})^T]$ and $\nabla \cdot \vec{s}$ in spherical coordinates, as given by Eqs. (A139) and (A140) of Dahlen and Tromp (2001), we find that:

$$\tau_{rr} = \frac{\lambda}{R_s}\left[R_s\partial_r s_r + 2s_r + \partial_\theta s_\theta + s_\theta \cot\theta + \frac{\partial_\phi s_\phi}{\sin\theta}\right] + 2\mu\partial_r s_r = 0. \quad \text{(B.5)}$$

This implies that at the outer surface (where $\tau_{rr} = 0$):

$$\partial_r s_r = \frac{-\lambda}{R_s(\lambda + 2\mu)}\left[2s_r + \partial_\theta s_\theta + s_\theta \cot\theta + \frac{\partial_\phi s_\phi}{\sin\theta}\right], \quad \text{(B.6)}$$

so that (using Eq. (B.6) in Eq. (A140) of Dahlen and Tromp, 2001):

$$\nabla \cdot \vec{s} = \frac{2\mu}{R_s(\lambda + 2\mu)}\left[2s_r + \partial_\theta s_\theta + s_\theta \cot\theta + \frac{\partial_\phi s_\phi}{\sin\theta}\right]. \quad \text{(B.7)}$$

The only non-zero stress components at the outer surface are $\tau_{\theta\theta}$, $\tau_{\theta\phi} = \tau_{\phi\theta}$ and $\tau_{\phi\phi}$. Using the spherical components of $[\nabla\vec{s} + (\nabla\vec{s})^T]$ given by Eq. (A139) in Dahlen and Tromp (2001), and using Eq. (B.7) for $\nabla \cdot \vec{s}$, gives:

$$\tau_{\theta\theta} = \frac{2\mu}{R_s(\lambda + 2\mu)}\Bigg[(3\lambda + 2\mu)s_r + 2(\lambda + \mu)\partial_\theta s_\theta + \lambda\left(\frac{\partial_\phi s_\phi}{\sin\theta} + s_\theta \cot\theta\right)\Bigg], \quad \text{(B.8)}$$

$$\tau_{\phi\phi} = \frac{2\mu}{R_s(\lambda + 2\mu)}\Bigg[(3\lambda + 2\mu)s_r + \lambda\partial_\theta s_\theta + 2(\lambda + \mu)\left(\frac{\partial_\phi s_\phi}{\sin\theta} + s_\theta \cot\theta\right)\Bigg], \quad \text{(B.9)}$$

$$\tau_{\phi\theta} = \tau_{\theta\phi} = \frac{\mu}{R_s}\left[\partial_\theta s_\phi + \frac{\partial_\phi s_\theta}{\sin\theta} - s_\phi \cot\theta\right]. \quad \text{(B.10)}$$

At the outer surface, the displacements s_r, s_θ, and s_ϕ can be related to the tidal potential, $V_T|_{R_s}$, evaluated at the outer surface, using the Love numbers h and ℓ as described in (B.2)–(B.4). Using those results in Eqs. (B.8)–(B.10), gives:

$$\tau_{\theta\theta} = \frac{2\mu}{gR_s(\lambda + 2\mu)}\Bigg[h\big((3\lambda + 2\mu)V_T|_{R_s}\big) + \ell\left(\frac{\lambda}{\sin^2\theta}\partial_\phi^2 V_T|_{R_s} + \lambda\cot\theta\,\partial_\theta V_T|_{R_s} + 2(\lambda + \mu)\partial_\theta^2 V_T|_{R_s}\right)\Bigg], \quad \text{(B.11)}$$

$$\tau_{\phi\phi} = \frac{2\mu}{gR_s(\lambda + 2\mu)}\Bigg[h\big((3\lambda + 2\mu)V_T|_{R_s}\big) + \ell\left(\frac{2(\lambda + \mu)}{\sin^2\theta}\partial_\phi^2 V_T|_{R_s} + 2(\lambda + \mu)\cot\theta\,\partial_\theta V_T|_{R_s} + \lambda\partial_\theta^2 V_T|_{R_s}\right)\Bigg], \quad \text{(B.12)}$$

$$\tau_{\phi\theta} = \tau_{\theta\phi} = \frac{2\mu\ell}{gR_s\sin\theta}\left[\partial_{\theta\phi}^2 V_T|_{R_s} - \cot\theta\,\partial_\phi V_T|_{R_s}\right]. \quad \text{(B.13)}$$

Finally, using Eq. (1) to find $V_T|_{R_s}$ gives the results shown in Eqs. (12)–(14) of the main text:

$$\tau_{\theta\theta} = \frac{Z}{2gR_s}\Bigg[-\frac{1}{3}\big(\beta_1 + 3\gamma_1\cos(2\theta)\big) + \big(\beta_1 - \gamma_1\cos(2\theta)\big)\cos(2\phi + 2bt) + 3\epsilon\big(\beta_1 - \gamma_1\cos(2\theta)\big)\cos(nt)\cos(2\phi) - \epsilon\big(\beta_1 + 3\gamma_1\cos(2\theta)\big)\cos(nt) + 4\epsilon\big(\beta_1 - \gamma_1\cos(2\theta)\big)\sin(nt)\sin(2\phi)\Bigg], \quad \text{(B.14)}$$

$$\tau_{\phi\phi} = \frac{Z}{2gR_s}\Bigg[-\frac{1}{3}\big(\beta_2 + 3\gamma_2\cos(2\theta)\big) + \big(\beta_2 - \gamma_2\cos(2\theta)\big)\cos(2\phi + 2bt) + 3\epsilon\big(\beta_2 - \gamma_2\cos(2\theta)\big)\cos(nt)\cos(2\phi) - \epsilon\big(\beta_2 + 3\gamma_2\cos(2\theta)\big)\cos(nt) + 4\epsilon\big(\beta_2 - \gamma_2\cos(2\theta)\big)\sin(nt)\sin(2\phi)\Bigg], \quad \text{(B.15)}$$

$$\tau_{\phi\theta} = \tau_{\theta\phi} = \frac{2\ell Z\mu}{gR_s}\big[-\cos\theta\sin(2\phi + 2bt) + 4\epsilon\sin(nt)\cos\theta\cos(2\phi) - 3\epsilon\cos(nt)\cos\theta\sin(2\phi)\big]. \quad \text{(B.16)}$$

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