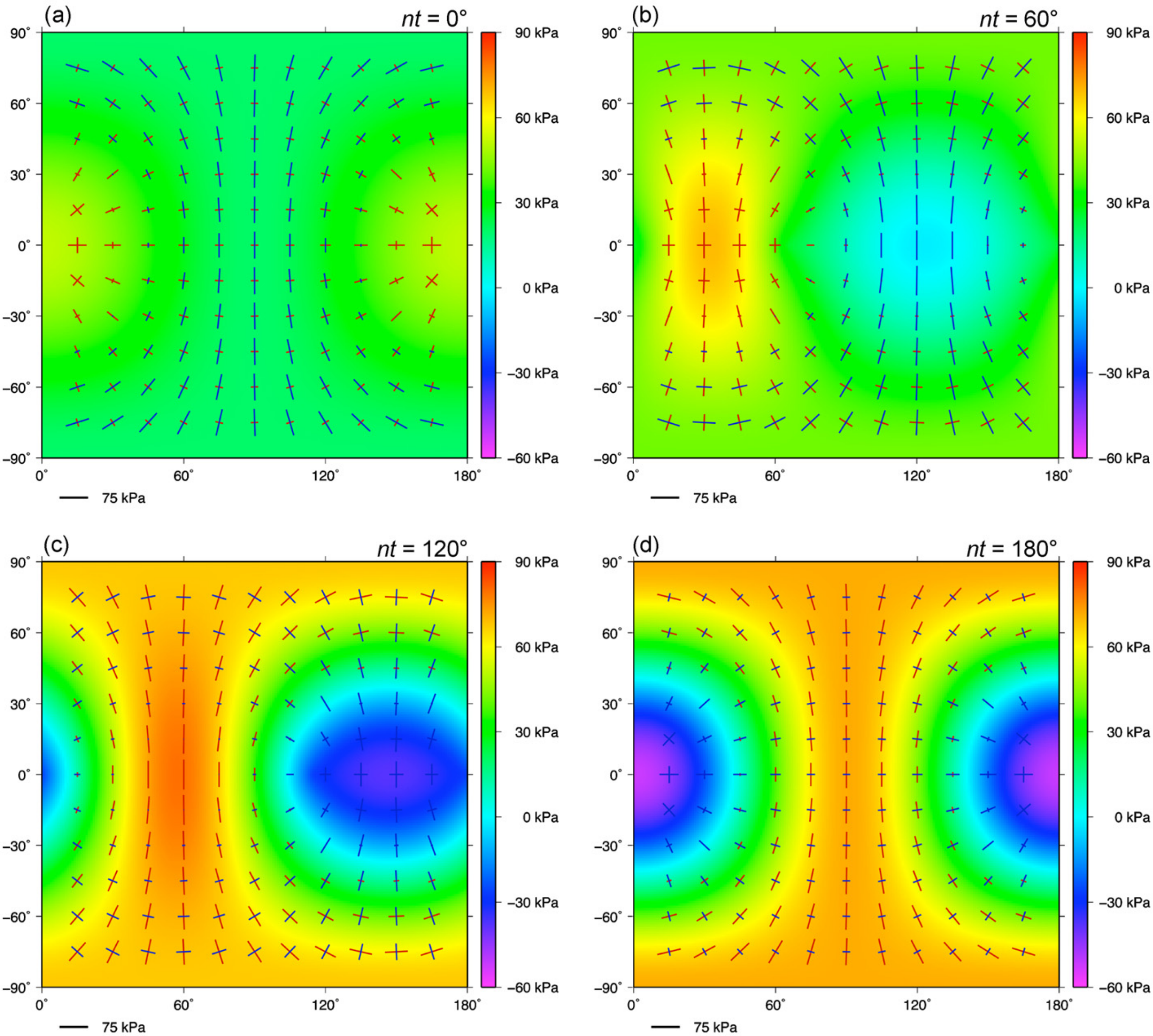

Fig. 3. Diurnal stress results for Europa from the viscoelastic model, at different orbital locations, measured from perijove (nt in Eqs. (29)–(31)), using parameters from Table 1. The sub-jovian point at perijove is at latitude (y-axis) 0°, longitude (ϕ, x-axis) 0°. East is taken as positive. Results for $180° < \phi < 360°$ are the same as those between 0° and 180°: $\tau(\phi) = \tau(\phi + 180°)$. Stresses in the second half of the orbit ($180° < nt < 360°$) are east–west reflections of those in the first half. Tic marks show the magnitude and orientation of the principal components of the stresses on the surface of the satellite. Compression (blue) is negative and tension (red) is positive. Background color shows the magnitude of the most tensile of the two principal components, as indicated by the color scales shown to the right of each panel.

sented as a sinusoidal function with a single frequency. For an NSR rate that varies with time, the stresses could be computed by expanding the NSR forcing as a sum of sinusoidal functions, using the model described in this paper to find the stresses caused by each of those sinusoidal functions, and then summing those stresses together. A change in NSR would cause changes in the stress that depend not only on the initial and final NSR rates, but also on how quickly the NSR evolved. If that change in rate happened quickly the induced stresses could be large during the transition even if the initial and final NSR rates were slow.

9. Comparison to previous methods

Results from the viscoelastic model described here can be used to assess the "flattening" model used in previous work to predict both diurnal and NSR stresses (Helfenstein and Parmentier, 1985; Leith and McKinnon, 1996; Hoppa, 1998; Greenberg et al., 1998; Hurford et al., 2007).

To estimate diurnal stresses, the flattening model computes the elastic response to the diurnal tidal potential terms, Eqs. (4) and (5). To estimate NSR stresses, the model takes the difference between two stress fields. Each field is the elastic stress pattern caused by the NSR potential Eq. (3), with one field rotated about the $\hat{z}$ axis relative to the other. In effect, one stress field is computed for $bt = 0$, and the other for $bt =$ some specified angle.

In both the diurnal and NSR cases, the flattening model relates the elastic stress field to the elastic Love number h; either explicitly (Hurford et al., 2007), or implicitly through a flattening parameter (Leith and McKinnon, 1996). Although the Love number ℓ does not occur explicitly in the flattening formalism, a comparison with our elastic results, Eqs. (12)–(14), shows that the flattening model