Theoretical Global Seismology

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and

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14.1.5 Geographic versus geocentric colatitude

The location of a seismic station situated upon the Earth's surface is conventionally specified by giving its elevation e above the geoid, its longitude ϕ with respect to Greenwich, and its *geographical colatitude* θ', which is the angle between the normal $\hat{\mathbf{n}}$ to the reference ellipsoid and the normal $\hat{\mathbf{z}}$ to the equatorial plane. Prior to calculating a synthetic accelerogram or spectrum by mode summation, it is necessary to convert the geographic colatitude θ' to the corresponding *geocentric colatitude* θ, which is the angle between the radius vector $\hat{\mathbf{r}}$ and $\hat{\mathbf{z}}$. Correct to first order in the ellipticity, the two colatitudes are related by

$$\tan\theta \approx (1 + 2\varepsilon_{\mathrm{a}})\tan\theta'. \qquad (14.32)$$

Geometrically, the transformation $\theta' \to \theta$ projects a point on the reference ellipsoid to a point on the unperturbed sphere along a line through the origin. The original and projected points in Figure 14.2 are the feet of the unit normals $\hat{\mathbf{n}}$ and $\hat{\mathbf{r}}$, respectively. The hypocentral location of an earthquake source is likewise specified by giving its depth h beneath the geoid, its longitude ϕ_{s} and its geographical colatitude θ'_{s}. In calculating the real receiver and source vectors $r_k = \hat{\boldsymbol{\nu}} \cdot \mathbf{s}_k(\mathbf{x})$ and $s_k = \mathbf{M} : \boldsymbol{\varepsilon}_k(\mathbf{x}_{\mathrm{s}})$ we stipulate that

$$\mathbf{x} = (a, \theta, \phi), \qquad \mathbf{x}_{\mathrm{s}} = (a - h, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}). \qquad (14.33)$$

A similar geographic-to-geocentric coordinate transformation must precede the calculation of a spherical-Earth seismogram or spectrum, using equa-

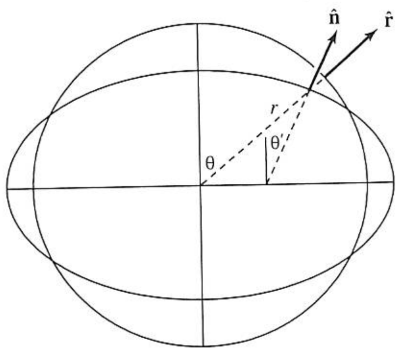

Figure 14.2. Cartoon illustrating the relation between the geographical colatitude θ and the geocentric colatitude θ'. The vectors $\hat{\mathbf{n}}$ and $\hat{\mathbf{r}}$ are the unit normals to the hydrostatic ellipsoid and the undeformed (equal-mass) sphere, respectively. Note that $\theta \geq \theta'$, with equality prevailing only at the poles and the equator.

tions (10.51)–(10.65). Station elevations e are generally ignored in normal-mode and long-period surface-wave seismology; however, they are routinely accounted for in short-period body-wave travel-time investigations.