Derivatives used in the Mapping Matrix in the PASP Paper “Refinement of the Spitzer Telescope Pointing History Based on image Registration Corrections from Multiple Data Channels”, Howard L. McCallon, John W. Fowler, Russ R. Laher, Frank J. Masci, Mehrdad Moshir

Notation:	PASP Paper	Herein
	α_M	α
	δ_M	δ
	γ_M	γ

$\frac{\partial \alpha_B}{\partial \alpha}$:

$$
\begin{aligned}
&((\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha - (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) \\
&(\cos\gamma \sin\delta \cos\alpha - \sin\gamma \sin\alpha) - (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) \\
&(-\sin\gamma \sin\delta \cos\alpha - \cos\gamma \sin\alpha))/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha \\
&+ (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)(-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) \\
&+ (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)(\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha)) \\
&- (\cos\theta_1 \cos\theta_2 \cos\delta \sin\alpha - (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) \\
&(\cos\gamma \sin\delta \sin\alpha + \sin\gamma \cos\alpha) - (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) \\
&(-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha))(-\cos\theta_1 \cos\theta_2 \cos\delta \sin\alpha \\
&+ (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)(\cos\gamma \sin\delta \sin\alpha + \sin\gamma \cos\alpha) \\
&+ (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)(-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha)) \\
&/ (\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha + (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) \\
&(-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) \\
&(\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))^2)/(1 + (\cos\theta_1 \cos\theta_2 \cos\delta \sin\alpha \\
&- (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)(\cos\gamma \sin\delta \sin\alpha + \sin\gamma \cos\alpha) \\
&- (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)(-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha))^2 \\
&/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha + (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) \\
&(-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) \\
&(\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))^2)
\end{aligned}
$$

$\frac{\partial \alpha_B}{\partial \delta}$:

$((-\cos\theta_1 \cos\theta_2 \sin\delta \sin\alpha - (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta \sin\alpha$
$+ (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) \sin\gamma \cos\delta \sin\alpha)/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha$
$+ (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) (-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \cos\gamma_I) (\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha)) - (\cos\theta_1 \cos\theta_2 \cos\delta \sin\alpha$
$- (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) (\cos\gamma \sin\delta \sin\alpha + \sin\gamma \cos\alpha) - (\sin\theta_1 \sin\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \cos\gamma_I) (-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha)) (-\cos\theta_1 \cos\theta_2 \sin\delta \cos\alpha$
$- (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta \cos\alpha + (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2$
$\cos\gamma_I) \sin\gamma \cos\delta \cos\alpha)/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha + (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2$
$\sin\gamma_I) (-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)$
$(\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))^2)/(1 + (\cos\theta_1 \cos\theta_2 \cos\delta \sin\alpha - (-\sin\theta_1 \cos\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \sin\gamma_I) (\cos\gamma \sin\delta \sin\alpha + \sin\gamma \cos\alpha) - (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2$
$\cos\gamma_I) (-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha))^2/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha + (-\sin\theta_1 \cos\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \sin\gamma_I) (-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2$
$\cos\gamma_I) (\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))^2)$

$\frac{\partial \alpha_B}{\partial \gamma}$:

$((-(-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) (-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha)$
$- (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) (-\cos\gamma \sin\delta \sin\alpha - \sin\gamma \cos\alpha))$
$/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha + (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) (-\cos\gamma \sin\delta \cos\alpha$
$+ \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) (\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))$
$- (\cos\theta_1 \cos\theta_2 \cos\delta \sin\alpha - (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) (\cos\gamma \sin\delta \sin\alpha$
$+ \sin\gamma \cos\alpha) - (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) (-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha))$
$((-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) (\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \cos\gamma_I) (\cos\gamma \sin\delta \cos\alpha - \sin\gamma \sin\alpha))/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha$
$+ (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) (-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \cos\gamma_I) (\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))^2)/(1 + (\cos\theta_1 \cos\theta_2 \cos\delta \sin\alpha$
$- (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) (\cos\gamma \sin\delta \sin\alpha + \sin\gamma \cos\alpha) - (\sin\theta_1 \sin\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \cos\gamma_I) (-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha))^2/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha$
$+ (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) (-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \cos\gamma_I) (\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))^2)$

$$\frac{\partial \alpha_B}{\partial \theta_1}:$$

$$((-\sin\theta_1\ \cos\theta_2\ \cos\delta\ \sin\alpha\ - (-\cos\theta_1\ \cos\gamma_I\ - \sin\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (\cos\gamma\ \sin\delta\ \sin\alpha$$
$$+ \sin\gamma\ \cos\alpha) - (\cos\theta_1\ \sin\gamma_I\ - \sin\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (-\sin\gamma\ \sin\delta\ \sin\alpha\ + \cos\gamma\ \cos\alpha))$$
$$/(\cos\theta_1\ \cos\theta_2\ \cos\delta\ \cos\alpha\ + (-\sin\theta_1\ \cos\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (-\cos\gamma\ \sin\delta\ \cos\alpha$$
$$+ \sin\gamma\ \sin\alpha) + (\sin\theta_1\ \sin\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (\sin\gamma\ \sin\delta\ \cos\alpha\ + \cos\gamma\ \sin\alpha))$$
$$- (\cos\theta_1\ \cos\theta_2\ \cos\delta\ \sin\alpha\ - (-\sin\theta_1\ \cos\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (\cos\gamma\ \sin\delta\ \sin\alpha$$
$$+ \sin\gamma\ \cos\alpha) - (\sin\theta_1\ \sin\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (-\sin\gamma\ \sin\delta\ \sin\alpha\ + \cos\gamma\ \cos\alpha))$$
$$(-\sin\theta_1\ \cos\theta_2\ \cos\delta\ \cos\alpha\ + (-\cos\theta_1\ \cos\gamma_I\ - \sin\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (-\cos\gamma\ \sin\delta\ \cos\alpha$$
$$+ \sin\gamma\ \sin\alpha) + (\cos\theta_1\ \sin\gamma_I\ - \sin\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (\sin\gamma\ \sin\delta\ \cos\alpha\ + \cos\gamma\ \sin\alpha))$$
$$/(\cos\theta_1\ \cos\theta_2\ \cos\delta\ \cos\alpha\ + (-\sin\theta_1\ \cos\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (-\cos\gamma\ \sin\delta\ \cos\alpha$$
$$+ \sin\gamma\ \sin\alpha) + (\sin\theta_1\ \sin\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (\sin\gamma\ \sin\delta\ \cos\alpha\ + \cos\gamma\ \sin\alpha))^2)$$
$$/(1 + (\cos\theta_1\ \cos\theta_2\ \cos\delta\ \sin\alpha\ - (-\sin\theta_1\ \cos\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (\cos\gamma\ \sin\delta\ \sin\alpha$$
$$+ \sin\gamma\ \cos\alpha) - (\sin\theta_1\ \sin\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (-\sin\gamma\ \sin\delta\ \sin\alpha\ + \cos\gamma\ \cos\alpha))^2$$
$$/(\cos\theta_1\ \cos\theta_2\ \cos\delta\ \cos\alpha\ + (-\sin\theta_1\ \cos\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (-\cos\gamma\ \sin\delta\ \cos\alpha$$
$$+ \sin\gamma\ \sin\alpha) + (\sin\theta_1\ \sin\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (\sin\gamma\ \sin\delta\ \cos\alpha\ + \cos\gamma\ \sin\alpha))^2)$$

$$\frac{\partial \alpha_B}{\partial \theta_2}:$$

$$((-\cos\theta_1\ \sin\theta_2\ \cos\delta\ \sin\alpha\ - \cos\theta_1\ \cos\theta_2\ \sin\gamma_I\ (\cos\gamma\ \sin\delta\ \sin\alpha\ + \sin\gamma\ \cos\alpha)$$
$$- \cos\theta_1\ \cos\theta_2\ \cos\gamma_I\ (-\sin\gamma\ \sin\delta\ \sin\alpha\ + \cos\gamma\ \cos\alpha))/(\cos\theta_1\ \cos\theta_2\ \cos\delta\ \cos\alpha$$
$$+ (-\sin\theta_1\ \cos\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (-\cos\gamma\ \sin\delta\ \cos\alpha\ + \sin\gamma\ \sin\alpha) + (\sin\theta_1\ \sin\gamma_I$$
$$+ \cos\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (\sin\gamma\ \sin\delta\ \cos\alpha\ + \cos\gamma\ \sin\alpha)) - (\cos\theta_1\ \cos\theta_2\ \cos\delta\ \sin\alpha$$
$$- (-\sin\theta_1\ \cos\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (\cos\gamma\ \sin\delta\ \sin\alpha\ + \sin\gamma\ \cos\alpha) - (\sin\theta_1\ \sin\gamma_I$$
$$+ \cos\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (-\sin\gamma\ \sin\delta\ \sin\alpha\ + \cos\gamma\ \cos\alpha))\ (-\cos\theta_1\ \sin\theta_2\ \cos\delta\ \cos\alpha$$
$$+ \cos\theta_1\ \cos\theta_2\ \sin\gamma_I\ (-\cos\gamma\ \sin\delta\ \cos\alpha\ + \sin\gamma\ \sin\alpha) + \cos\theta_1\ \cos\theta_2\ \cos\gamma_I$$
$$(\sin\gamma\ \sin\delta\ \cos\alpha\ + \cos\gamma\ \sin\alpha))/(\cos\theta_1\ \cos\theta_2\ \cos\delta\ \cos\alpha\ + (-\sin\theta_1\ \cos\gamma_I$$
$$+ \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (-\cos\gamma\ \sin\delta\ \cos\alpha\ + \sin\gamma\ \sin\alpha) + (\sin\theta_1\ \sin\gamma_I\ + \cos\theta_1\ \sin\theta_2$$
$$\cos\gamma_I)\ (\sin\gamma\ \sin\delta\ \cos\alpha\ + \cos\gamma\ \sin\alpha))^2)/(1 + (\cos\theta_1\ \cos\theta_2\ \cos\delta\ \sin\alpha$$
$$- (-\sin\theta_1\ \cos\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (\cos\gamma\ \sin\delta\ \sin\alpha\ + \sin\gamma\ \cos\alpha) - (\sin\theta_1\ \sin\gamma_I$$
$$+ \cos\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (-\sin\gamma\ \sin\delta\ \sin\alpha\ + \cos\gamma\ \cos\alpha))^2/(\cos\theta_1\ \cos\theta_2\ \cos\delta\ \cos\alpha$$
$$+ (-\sin\theta_1\ \cos\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \sin\gamma_I)\ (-\cos\gamma\ \sin\delta\ \cos\alpha\ + \sin\gamma\ \sin\alpha)$$
$$+ (\sin\theta_1\ \sin\gamma_I\ + \cos\theta_1\ \sin\theta_2\ \cos\gamma_I)\ (\sin\gamma\ \sin\delta\ \cos\alpha\ + \cos\gamma\ \sin\alpha))^2)$$

$\frac{\partial \alpha_B}{\partial \gamma_I}$:

$((-(\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)(\cos\gamma \sin\delta \sin\alpha + \sin\gamma \cos\alpha)$
$- (\sin\theta_1 \cos\gamma_I - \cos\theta_1 \sin\theta_2 \sin\gamma_I)(-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha))$
$/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha + (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)(-\cos\gamma \sin\delta \cos\alpha$
$+ \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)(\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))$
$- (\cos\theta_1 \cos\theta_2 \cos\delta \sin\alpha - (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)(\cos\gamma \sin\delta \sin\alpha$
$+ \sin\gamma \cos\alpha) - (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)(-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha))$
$((\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)(-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) + (\sin\theta_1 \cos\gamma_I$
$- \cos\theta_1 \sin\theta_2 \sin\gamma_I)(\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha$
$+ (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)(-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha) + (\sin\theta_1 \sin\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \cos\gamma_I)(\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))^2)/(1 + (\cos\theta_1 \cos\theta_2 \cos\delta \sin\alpha$
$- (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)(\cos\gamma \sin\delta \sin\alpha + \sin\gamma \cos\alpha) - (\sin\theta_1 \sin\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \cos\gamma_I)(-\sin\gamma \sin\delta \sin\alpha + \cos\gamma \cos\alpha))^2/(\cos\theta_1 \cos\theta_2 \cos\delta \cos\alpha$
$+ (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)(-\cos\gamma \sin\delta \cos\alpha + \sin\gamma \sin\alpha)$
$+ (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)(\sin\gamma \sin\delta \cos\alpha + \cos\gamma \sin\alpha))^2)$

$\frac{\partial \delta_B}{\partial \alpha}$: 0

$\frac{\partial \delta_B}{\partial \delta}$:

$(\cos\theta_1 \cos\theta_2 \cos\delta - (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \sin\delta + (\sin\theta_1 \sin\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \sin\delta)/(1 - (\cos\theta_1 \cos\theta_2 \sin\delta + (-\sin\theta_1 \cos\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)^2)^{1/2}$

$\frac{\partial \delta_B}{\partial \gamma}$:

$(-(-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)\sin\gamma \cos\delta - (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)$
$\cos\gamma \cos\delta)/(1 - (\cos\theta_1 \cos\theta_2 \sin\delta + (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta$
$- (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)^2)^{1/2}$

$\frac{\partial \delta_B}{\partial \theta_1}$:

$(-\sin\theta_1 \cos\theta_2 \sin\delta + (-\cos\theta_1 \cos\gamma_I - \sin\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (\cos\theta_1 \sin\gamma_I$
$- \sin\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)/(1 - (\cos\theta_1 \cos\theta_2 \sin\delta + (-\sin\theta_1 \cos\gamma_I$
$+ \cos\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)^2)^{1/2}$

$$\frac{\partial \delta_B}{\partial \theta_2}:$$

$$(-\cos\theta_1 \sin\theta_2 \sin\delta + \cos\theta_1 \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta - \cos\theta_1 \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)$$
$$/(1 - (\cos\theta_1 \cos\theta_2 \sin\delta + (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta$$
$$- (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) \sin\gamma \cos\delta)^2)^{1/2}$$

$$\frac{\partial \delta_B}{\partial \gamma_I}:$$

$$((\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) \cos\gamma \cos\delta - (\sin\theta_1 \cos\gamma_I - \cos\theta_1 \sin\theta_2 \sin\gamma_I)$$
$$\sin\gamma \cos\delta)/(1 - (\cos\theta_1 \cos\theta_2 \sin\delta + (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta$$
$$- (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I) \sin\gamma \cos\delta)^2)^{1/2}$$

$$\frac{\partial \gamma_B}{\partial \alpha}: 0$$

$$\frac{\partial \gamma_B}{\partial \delta}:$$

$$((\sin\theta_2 \cos\delta + \cos\theta_2 \sin\gamma_I \cos\gamma \sin\delta - \cos\theta_2 \cos\gamma_I \sin\gamma \sin\delta)$$
$$/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta$$
$$- (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I) \sin\gamma \cos\delta) - (\sin\theta_2 \sin\delta$$
$$- \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta) (\sin\theta_1 \cos\theta_2 \cos\delta$$
$$- (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \sin\delta + (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)$$
$$\sin\gamma \sin\delta)/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta$$
$$- (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I) \sin\gamma \cos\delta)^2)/(1 + (\sin\theta_2 \sin\delta$$
$$- \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)^2/(\sin\theta_1 \cos\theta_2 \sin\delta$$
$$+ (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I$$
$$+ \sin\theta_1 \sin\theta_2 \cos\gamma_I) \sin\gamma \cos\delta)^2)$$

$$\frac{\partial \gamma_B}{\partial \gamma}:$$

$$((\cos\theta_2 \sin\gamma_I \sin\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \cos\gamma \cos\delta)/(\sin\theta_1 \cos\theta_2 \sin\delta$$
$$+ (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)$$
$$\sin\gamma \cos\delta) - (\sin\theta_2 \sin\delta - \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)$$
$$(-(\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I) \sin\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)$$
$$\cos\gamma \cos\delta)/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta$$
$$- (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I) \sin\gamma \cos\delta)^2)/(1 + (\sin\theta_2 \sin\delta$$
$$- \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)^2/(\sin\theta_1 \cos\theta_2 \sin\delta$$
$$+ (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I) \cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)$$
$$\sin\gamma \cos\delta)^2)$$

$\frac{\partial\gamma_B}{\partial\theta_1}$:

$-(\sin\theta_2 \sin\delta - \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)(\cos\theta_1 \cos\theta_2 \sin\delta + (-\sin\theta_1 \cos\gamma_I + \cos\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (\sin\theta_1 \sin\gamma_I + \cos\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)/((\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)^2 (1 + (\sin\theta_2 \sin\delta - \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)^2/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)^2))$

$\frac{\partial\gamma_B}{\partial\theta_2}$:

$((\cos\theta_2 \sin\delta + \sin\theta_2 \sin\gamma_I \cos\gamma \cos\delta - \sin\theta_2 \cos\gamma_I \sin\gamma \cos\delta)/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta) - (\sin\theta_2 \sin\delta - \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)(-\sin\theta_1 \sin\theta_2 \sin\delta + \sin\theta_1 \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta - \sin\theta_1 \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)^2)/(1 + (\sin\theta_2 \sin\delta - \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)^2/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)^2)$

$\frac{\partial\gamma_B}{\partial\gamma_I}$:

$((-\cos\theta_2 \cos\gamma_I \cos\gamma \cos\delta - \cos\theta_2 \sin\gamma_I \sin\gamma \cos\delta)/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta) - (\sin\theta_2 \sin\delta - \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)((-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)\cos\gamma \cos\delta - (-\cos\theta_1 \cos\gamma_I - \sin\theta_1 \sin\theta_2 \sin\gamma_I)\sin\gamma \cos\delta)/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)^2)/(1 + (\sin\theta_2 \sin\delta - \cos\theta_2 \sin\gamma_I \cos\gamma \cos\delta + \cos\theta_2 \cos\gamma_I \sin\gamma \cos\delta)^2/(\sin\theta_1 \cos\theta_2 \sin\delta + (\cos\theta_1 \cos\gamma_I + \sin\theta_1 \sin\theta_2 \sin\gamma_I)\cos\gamma \cos\delta - (-\cos\theta_1 \sin\gamma_I + \sin\theta_1 \sin\theta_2 \cos\gamma_I)\sin\gamma \cos\delta)^2)$