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## Examples of Scale Factors for a Semi-Empirical Tire-Model

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# Examples of Scale Factors for a Semi-Empirical Tire-Model

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May 2006



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<i>Title and subtitle</i> Examples of Scale Factors for a Semi-Empirical Tire-Model		
<i>Abstract</i> <p>This report shows examples of the scale factors used in a previously published semi-empirical tire-model, developed at the Department of Automatic Control in Lund. The scale factors are plotted as 3d surface diagrams depending on the longitudinal and lateral slip for a few different camber angles and velocities.</p>		
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## 2. Introduction

This report is written as a complement and refers to a semi-empirical tire model previously described in [2, 5, 7, 6, 4, 3, 8, 9, 10]. The combined slip forces and torque are, in the model, formed from the pure slip forces and torque as

$$\hat{F}_x(\lambda, \alpha, \gamma) = G_{ax}(\lambda, \alpha, \gamma)\hat{F}_{0x}(\lambda_{0a}) + G_{sx}(\lambda, \alpha, \gamma, v)\hat{F}_{0x}(\lambda_{0s}) \quad (1a)$$

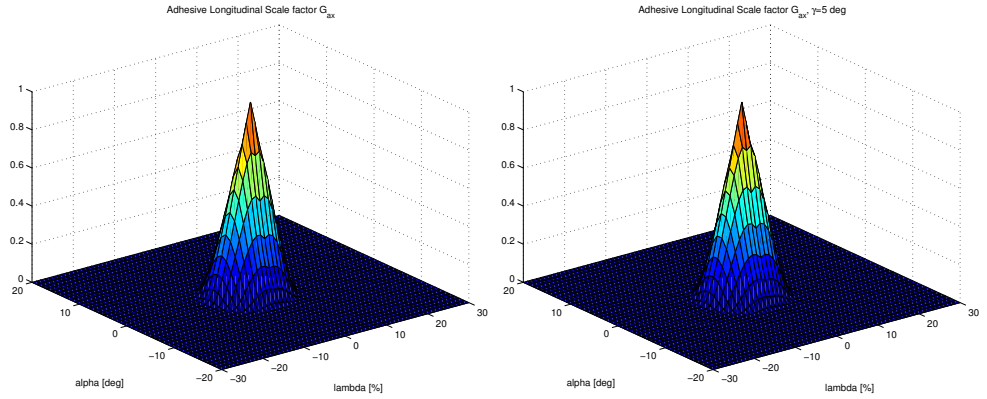
$$\begin{aligned} \hat{F}_y(\lambda, \alpha, \gamma) &= G_{ay}(\lambda, \alpha, \gamma)\hat{F}_{0y}(\alpha_{0a}) + G_{sy}(\lambda, \alpha, \gamma, v)\hat{F}_{0y}(\alpha_{0s}) \quad (1b) \\ &+ G_{camy}(\lambda, \alpha, \gamma)\hat{F}_{0cam}(\gamma) \end{aligned}$$

$$\begin{aligned} M_z(\lambda, \alpha, \gamma) &= G_{fz}(\lambda, \alpha, \gamma)\hat{F}_{0y}(\alpha_{0r}) + G_{mz}(\lambda, \alpha, \gamma)\hat{M}_{0z}(\alpha_{0r}) \quad (2) \\ &+ G_{camz}(\lambda, \alpha, \gamma)\hat{F}_{0cam}(\gamma) \end{aligned}$$

The aim of report is to visualize how the scale factors  $G$  from (1) – (2), further explained in [3, 8, 9, 10], depend on different input signals.

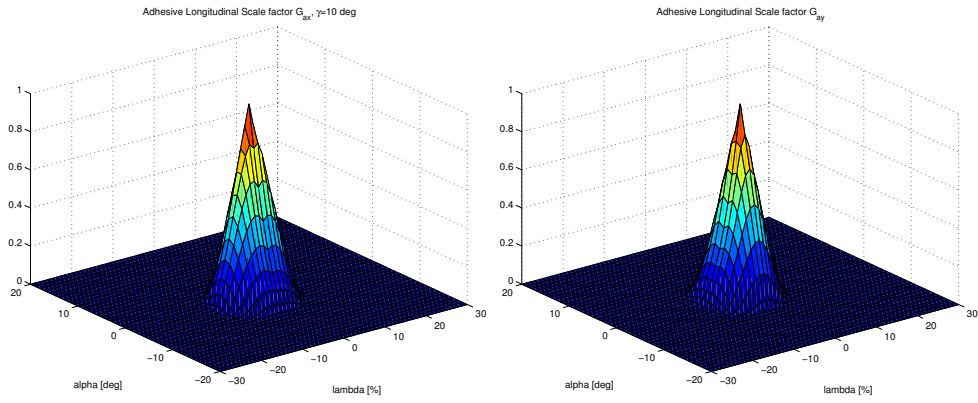
Respective scale factor is shown for sweeps of the longitudinal slip  $\lambda$  and sweeps of the slip angle  $\alpha$  and for  $\gamma = [0 \ 5 \ 10]$  [deg]. The sliding force scale factors,  $G_{sx}$  and  $G_{sy}$  are also shown for  $v = [0.5 \ 1 \ 2] \cdot v_0$ . The pure slip tire models used for the computation of the limit slips,  $\lambda^\circ$  and  $\alpha^\circ$  and the sliding force angle  $\beta'$  are Magic formula parameterizations presented with parameters in [1] for  $f_z = 4$  kN.

## 3. Plots of Scale Factors

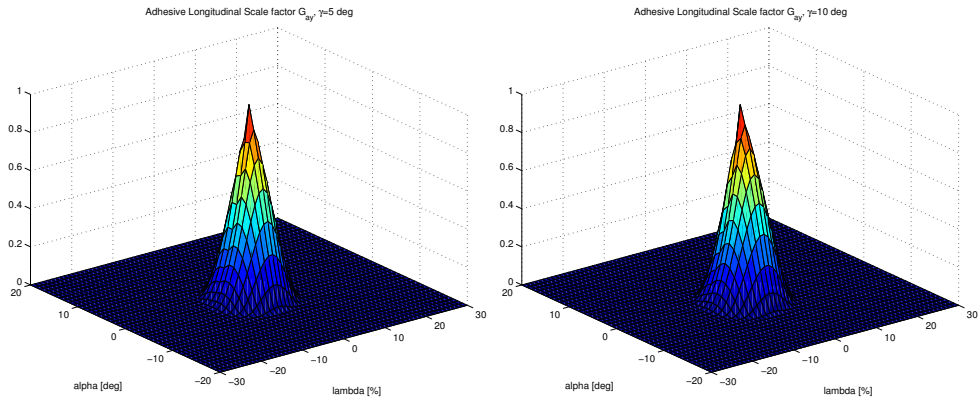


**Figure 1** Longitudinal adhesive scale factors. To the right with camber,  $\gamma=5$  [deg].

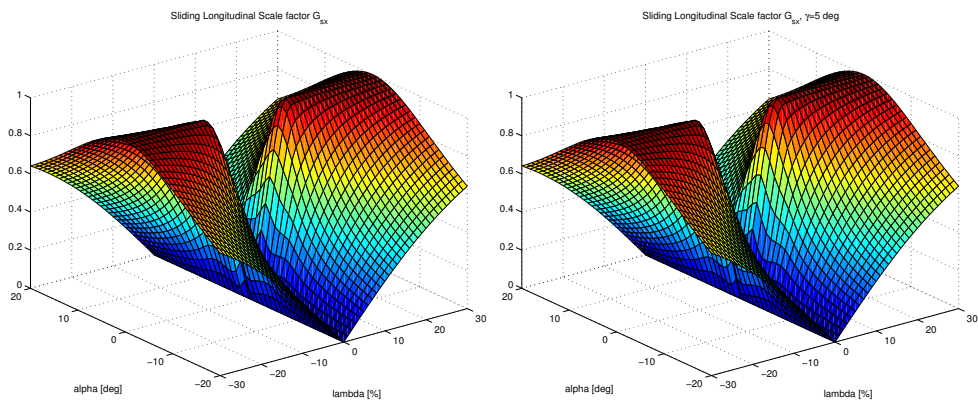




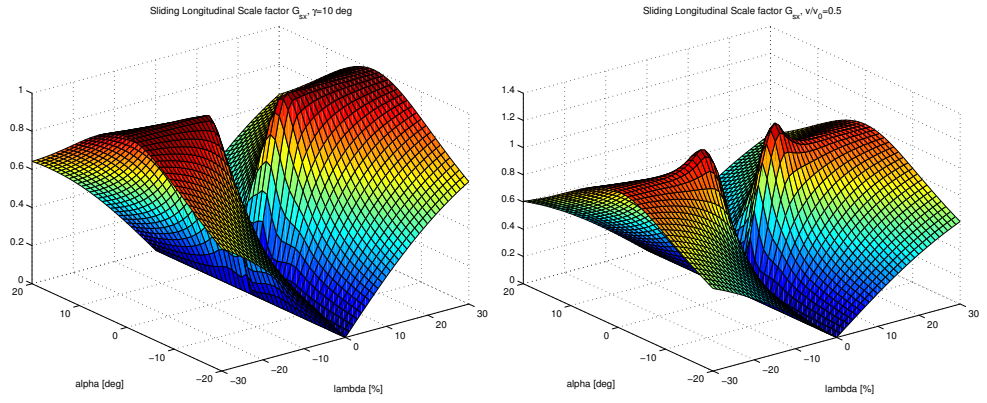
**Figure 2** To the left: Longitudinal adhesive scale factor with camber,  $\gamma=10$  [deg]. To the right: Lateral adhesive scale factor.



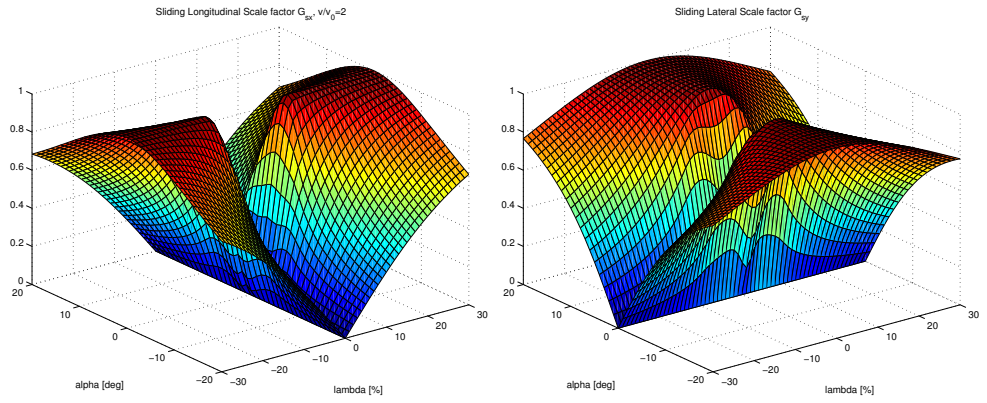
**Figure 3** Lateral adhesive scale factors with camber. To the left:  $\gamma=5$  [deg] and to the right:  $\gamma=10$  [deg].



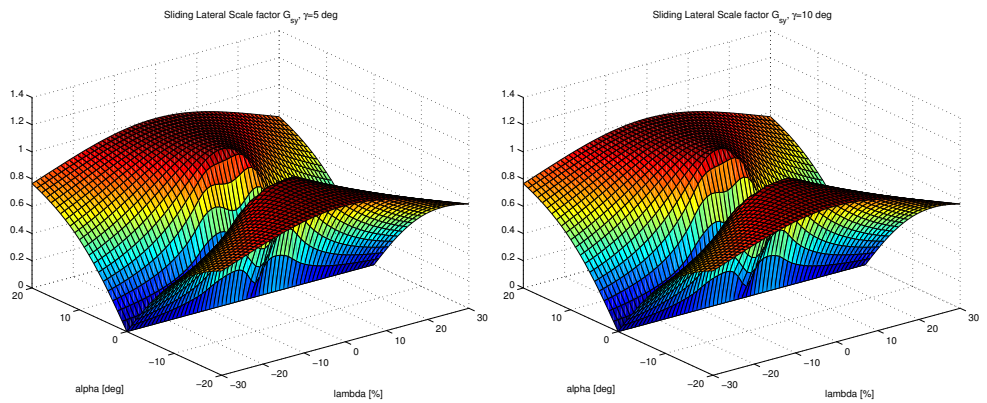
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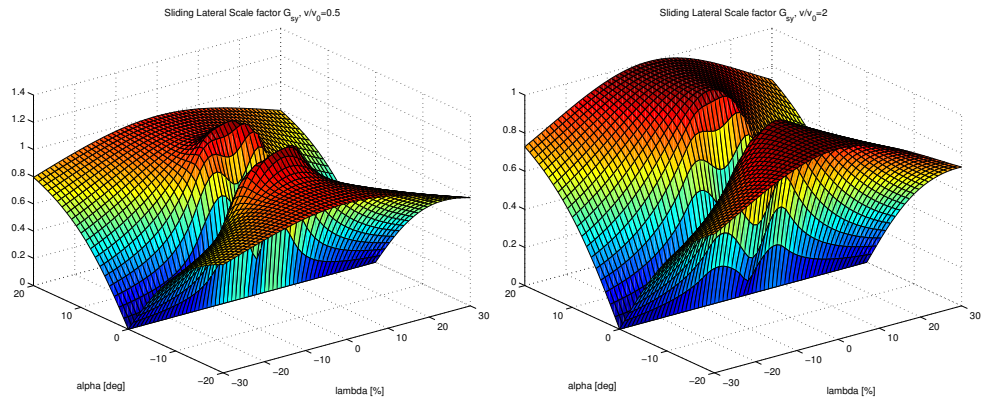
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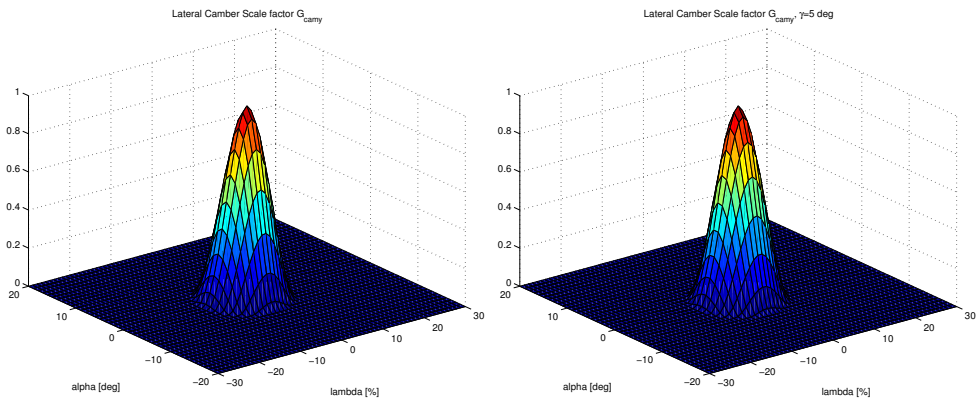
**Figure 6** To the left: Longitudinal sliding scale factor,  $v/v_0 = 2$ . To the right: Lateral sliding scale factor.



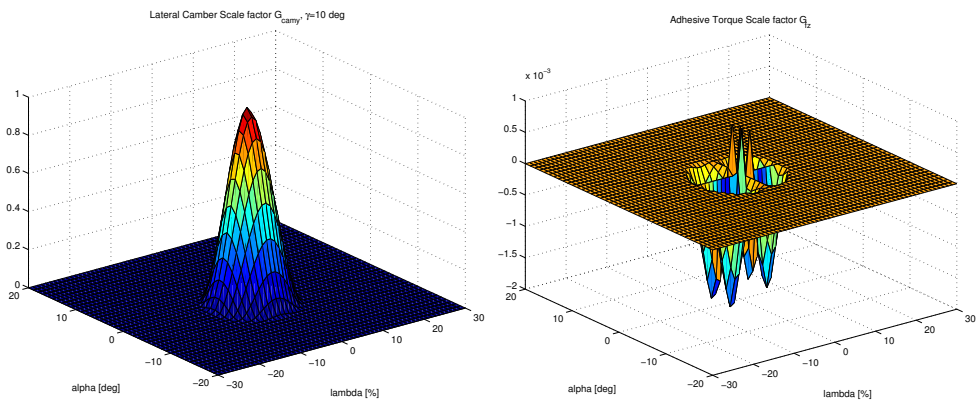
**Figure 7** Lateral sliding scale factors with camber. To the left:  $\gamma=5$  [deg] and to the right:  $\gamma=10$  [deg].



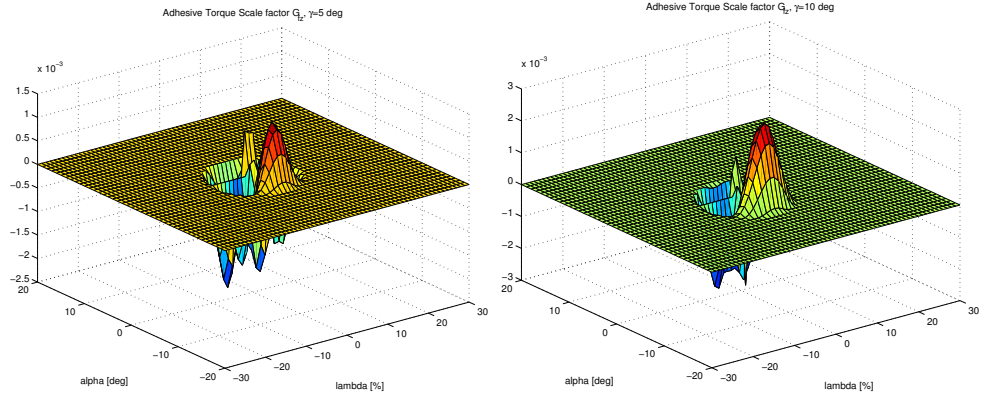
**Figure 8** Lateral sliding scale factors with velocity dependence. To the left:  $v/v_0 = 0.5$  and to the right:  $v/v_0 = 2$ .



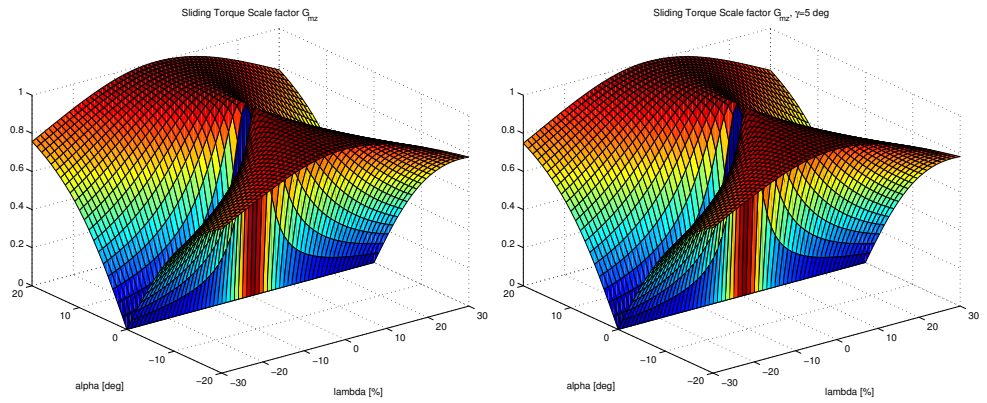
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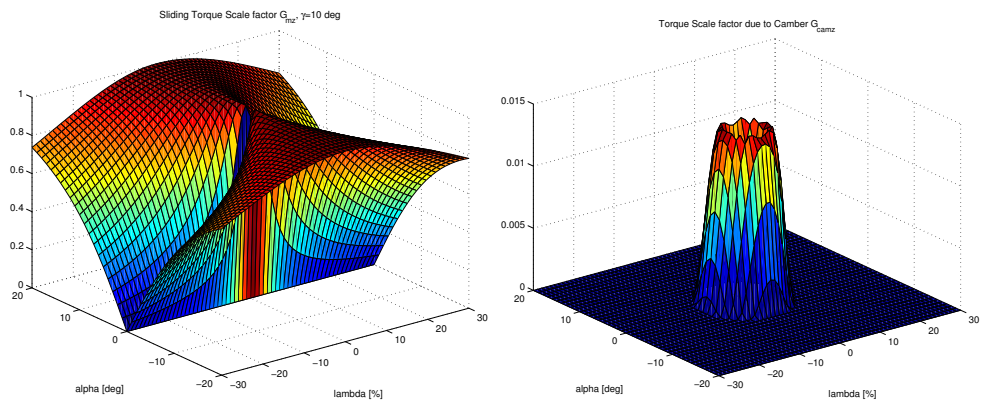
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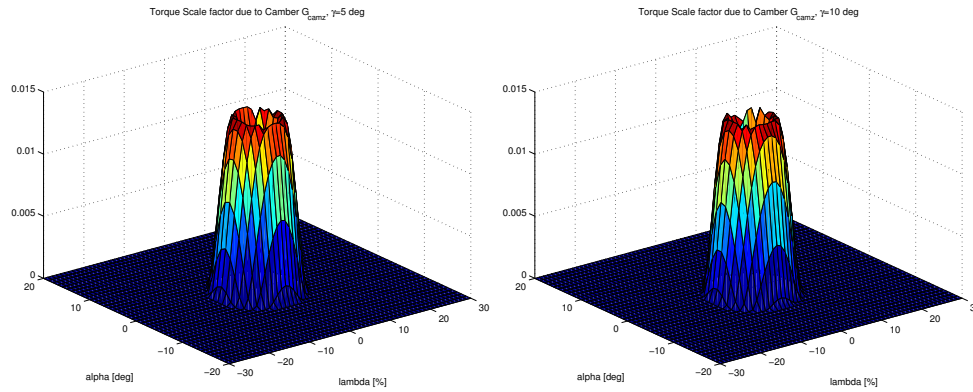


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**Figure 14** Self-aligning torque camber scale-factors with camber. To the left:  $\gamma=5$  [deg] and to the right:  $\gamma=10$  [deg].

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