

## Refined heat shock response GCM:

$$\begin{aligned} [r_1] \text{ rhsf} \geq 2 \wedge \text{ hsf}_2 \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf} * \text{ rhsf} * k_1 : (\text{ rhsf}' = \text{ rhsf} - 2) \wedge (\text{ hsf}_2' = \text{ hsf}_2 + 1); \\ [r_2] \text{ rhsf} \geq 1 \wedge \text{ rhsf}^{(1)} \geq 1 \wedge \text{ rhsf}_2^{(1)} \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf} * \text{ rhsf}^{(1)} * k_1 : (\text{ rhsf}' = \text{ rhsf} - 1) \wedge (\text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} - 1) \wedge (\text{ rhsf}_2^{(1)'} = \text{ rhsf}_2^{(1)} + 1); \\ [r_3] \text{ rhsf}^{(1)} \geq 2 \wedge \text{ rhsf}_2^{(2)} \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf}^{(1)} * \text{ rhsf}^{(1)} * k_1 : (\text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} - 2) \wedge (\text{ rhsf}_2^{(2)'} = \text{ rhsf}_2^{(2)} + 1); \end{aligned}$$

$$\begin{aligned} [r_4] \text{ rhsf}_2 \geq 1 \wedge \text{ rhsf} \leq N_{\text{hsf}} - 2 \rightarrow \text{ rhsf}_2 * k_2 : (\text{ rhsf}_2' = \text{ rhsf}_2 - 1) \wedge (\text{ rhsf}' = \text{ rhsf} + 2); \\ [r_5] \text{ rhsf}_2^{(1)} \geq 1 \wedge \text{ rhsf} \leq N_{\text{hsf}} - 1 \wedge \text{ rhsf}^{(1)} \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf}_2^{(1)} * k_2 : (\text{ rhsf}_2^{(1)'} = \text{ rhsf}_2^{(1)} - 1) \wedge (\text{ rhsf}' = \text{ rhsf} + 1) \wedge (\text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} + 1); \\ [r_6] \text{ hsf}_2 \geq 1 \wedge \text{ rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow \text{ rhsf}_2^{(2)} * k_2 : (\text{ rhsf}_2^{(2)'} = \text{ rhsf}_2^{(2)} - 1) \wedge (\text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} + 2); \end{aligned}$$

$$\begin{aligned} [r_7] \text{ rhsf} \geq 1 \wedge \text{ rhsf}_2 \geq 1 \vee \text{ rhsf}_3 \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf} * \text{ rhsf}_2 * k_3 : (\text{ rhsf}_2' = \text{ rhsf}_2 - 1) \wedge (\text{ rhsf}' = \text{ rhsf} - 1) \wedge (\text{ rhsf}_3' = \text{ rhsf}_3 + 1); \\ [r_8] \text{ rhsf}^{(1)} \geq 1 \wedge \text{ rhsf}_2 \geq 1 \wedge \text{ rhsf}_3^{(1)} \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf}^{(1)} * \text{ rhsf}_2 * k_3 : (\text{ rhsf}_2' = \text{ rhsf}_2 - 1) \wedge \text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} - 1 \wedge (\text{ rhsf}_3^{(1)'} = \text{ rhsf}_3^{(1)} + 1); \\ [r_9] \text{ rhsf} \geq 1 \wedge \text{ rhsf}_2^{(1)} \geq 1 \wedge \text{ rhsf}_3^{(1)} \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf} * \text{ rhsf}_2^{(1)} * k_3 : (\text{ rhsf}_2^{(1)'} = \text{ rhsf}_2^{(1)} - 1) \wedge (\text{ rhsf}' = \text{ rhsf} - 1) \wedge (\text{ rhsf}_3^{(1)'} = \text{ rhsf}_3^{(1)} + 1); \\ [r_{10}] \text{ rhsf}^{(1)} \geq 1 \wedge \text{ rhsf}_2^{(1)} \geq 1 \wedge \text{ rhsf}_3^{(2)} \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf}^{(1)} * \text{ rhsf}_2^{(1)} * k_3 : (\text{ rhsf}_2^{(1)'} = \text{ rhsf}_2^{(1)} - 1) \wedge (\text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} - 1) \wedge (\text{ rhsf}_3^{(2)'} = \text{ rhsf}_3^{(2)} + 1); \\ [r_{11}] \text{ rhsf} \geq 1 \wedge \text{ rhsf}_2^{(2)} \geq 1 \wedge \text{ rhsf}_3^{(2)} \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf} * \text{ rhsf}_2^{(2)} * k_3 : (\text{ rhsf}_2^{(2)'} = \text{ rhsf}_2^{(2)} - 1) \wedge (\text{ rhsf}' = \text{ rhsf} - 1) \wedge (\text{ rhsf}_3^{(2)'} = \text{ rhsf}_3^{(2)} + 1); \\ [r_{12}] \text{ rhsf}^{(1)} \geq 1 \wedge \text{ rhsf}_2^{(2)} \geq 1 \wedge \text{ rhsf}_3^{(3)} \leq N_{\text{hsf}} - 1 \rightarrow \text{ rhsf}^{(1)} * \text{ rhsf}_2^{(2)} * k_3 : (\text{ rhsf}_2^{(2)'} = \text{ rhsf}_2^{(2)} - 1) \wedge (\text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} - 1) \wedge (\text{ rhsf}_3^{(3)'} = \text{ rhsf}_3^{(3)} + 1); \end{aligned}$$

$$\begin{aligned} [r_{13}] \text{ rhsf}_3 \geq 1 \wedge \text{ rhsf}_2 \leq N_{\text{hsf}} - 2 \wedge \text{ rhsf} \leq N_{\text{hsf}} - 2 \rightarrow \text{ rhsf}_3 * k_4 : (\text{ rhsf}_3' = \text{ rhsf}_3 - 1) \wedge (\text{ rhsf}_2' = \text{ rhsf}_2 + 1) \wedge (\text{ rhsf}' = \text{ rhsf} + 1); \\ [r_{14}] \text{ rhsf}_3^{(1)} \geq 1 \wedge \text{ rhsf}_2 \leq N_{\text{hsf}} - 2 \wedge \text{ rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow \text{ rhsf}_3^{(1)} * k_4 : (\text{ rhsf}_3^{(1)'} = \text{ rhsf}_3^{(1)} - 1) \wedge (\text{ rhsf}_2' = \text{ rhsf}_2 + 1) \wedge (\text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} + 1); \\ [r_{15}] \text{ rhsf}_3^{(1)} \geq 1 \wedge \text{ rhsf}_2^{(1)} \leq N_{\text{hsf}} - 2 \wedge \text{ rhsf} \leq N_{\text{hsf}} - 2 \rightarrow \text{ rhsf}_3^{(1)} * k_4 : (\text{ rhsf}_3^{(1)'} = \text{ rhsf}_3^{(1)} - 1) \wedge (\text{ rhsf}_2^{(1)'} = \text{ rhsf}_2^{(1)} + 1) \wedge (\text{ rhsf}' = \text{ rhsf} + 1); \\ [r_{16}] \text{ rhsf}_3^{(2)} \geq 1 \wedge \text{ rhsf}_2^{(1)} \leq N_{\text{hsf}} - 2 \wedge \text{ rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow \text{ rhsf}_3^{(2)} * k_4 : (\text{ rhsf}_3^{(2)'} = \text{ rhsf}_3^{(2)} - 1) \wedge (\text{ rhsf}_2^{(1)'} = \text{ rhsf}_2^{(1)} + 1) \wedge (\text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} + 1); \\ [r_{17}] \text{ rhsf}_3^{(2)} \geq 1 \wedge \text{ rhsf}_2^{(2)} \leq N_{\text{hsf}} - 2 \wedge \text{ rhsf} \leq N_{\text{hsf}} - 2 \rightarrow \text{ rhsf}_3^{(2)} * k_4 : (\text{ rhsf}_3^{(2)'} = \text{ rhsf}_3^{(2)} - 1) \wedge (\text{ rhsf}_2^{(2)'} = \text{ rhsf}_2^{(2)} + 1) \wedge (\text{ rhsf}' = \text{ rhsf} + 1); \\ [r_{18}] \text{ rhsf}_3^{(3)} \geq 1 \wedge \text{ rhsf}_2^{(2)} \leq N_{\text{hsf}} - 2 \wedge \text{ rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow \text{ rhsf}_3^{(3)} * k_4 : (\text{ rhsf}_3^{(3)'} = \text{ rhsf}_3^{(3)} - 1) \wedge (\text{ rhsf}_2^{(2)'} = \text{ rhsf}_2^{(2)} + 1) \wedge (\text{ rhsf}^{(1)'} = \text{ rhsf}^{(1)} + 1); \end{aligned}$$

$$\begin{aligned} [r_{19}] \text{ rhsf}_3 \geq 1 \wedge \text{ rhse} \geq 1 \wedge \text{ rhsf}_3 \text{ hse} \leq N_{\text{hsf}_3 \text{ hse}} - 1 \rightarrow \text{ rhsf}_3 * \text{ rhse} * k_5 : (\text{ rhsf}_3' = \text{ rhsf}_3 - 1) \wedge (\text{ rhse}' = \text{ rhse} - 1) \wedge (\text{ rhsf}_3 \text{ hse}' = \text{ rhsf}_3 \text{ hse} + 1); \\ [r_{20}] \text{ rhsf}_3^{(1)} \geq 1 \wedge \text{ rhse} \geq 1 \wedge \text{ rhsf}_3 \text{ hse}^{(1)} \leq N_{\text{hsf}_3 \text{ hse}} - 1 \rightarrow \text{ rhsf}_3^{(1)} * \text{ rhse} * k_5 : (\text{ rhsf}_3^{(1)'} = \text{ rhsf}_3^{(1)} - 1) \wedge (\text{ rhse}' = \text{ rhse} - 1) \wedge (\text{ rhsf}_3 \text{ hse}^{(1)'} = \text{ rhsf}_3 \text{ hse}^{(1)} + 1); \\ [r_{21}] \text{ rhsf}_3^{(2)} \geq 1 \wedge \text{ rhse} \geq 1 \wedge \text{ rhsf}_3 \text{ hse}^{(2)} \leq N_{\text{hsf}_3 \text{ hse}} - 1 \rightarrow \text{ rhsf}_3^{(2)} * \text{ rhse} * k_5 : (\text{ rhsf}_3^{(2)'} = \text{ rhsf}_3^{(2)} - 1) \wedge (\text{ rhse}' = \text{ rhse} - 1) \wedge (\text{ rhsf}_3 \text{ hse}^{(2)'} = \text{ rhsf}_3 \text{ hse}^{(2)} + 1); \\ [r_{22}] \text{ rhsf}_3^{(3)} \geq 1 \vee \text{ rhse} \geq 1 \wedge \text{ rhsf}_3 \text{ hse}^{(3)} \leq N_{\text{hsf}_3 \text{ hse}} - 1 \rightarrow \text{ rhsf}_3^{(3)} * \text{ rhse} * k_5 : (\text{ rhsf}_3^{(3)'} = \text{ rhsf}_3^{(3)} - 1) \wedge (\text{ rhse}' = \text{ rhse} - 1) \wedge (\text{ rhsf}_3 \text{ hse}^{(3)'} = \text{ rhsf}_3 \text{ hse}^{(3)} + 1); \end{aligned}$$



[r<sub>43</sub>]  $\text{rhsf}_3^{(2)} \geq 1 \wedge \text{rhsp} \geq 1 \wedge \text{rhsphsf}^{(1)} \leq N_{\text{hspshsf}} - 1 \wedge \text{rhsf} \leq N_{\text{hsf}} - 2 \wedge \text{rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow$   
 $\text{rhsf}_3^{(2)} * \text{rhsp} * k_{11} : (\text{rhsf}_3^{(2)' = \text{rhsf}_3^{(2)} - 1} \wedge (\text{rhsp}' = \text{rhsp} - 1) \wedge (\text{rhsphsf}^{(1)' = \text{rhsphsf}^{(1)} + 1} \wedge (\text{rhsf}^{(1)' =$   
 $\text{rhsf}^{(1)} + 1) \wedge (\text{rhsf}' = \text{rhsf} + 1);$

[r<sub>44</sub>]  $\text{rhsf}_3^{(3)} \geq 1 \wedge \text{rhsp} \geq 1 \wedge \text{rhsphsf}^{(1)} \leq N_{\text{hspshsf}} - 1 \wedge \text{rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow \text{rhsf}_3^{(3)} * \text{rhsp} * k_{11} : (\text{rhsf}_3^{(3)' =$   
 $\text{rhsf}_3^{(3)} - 1) \wedge (\text{rhsp}' = \text{rhsp} - 1) \wedge (\text{rhsphsf}^{(1)' = \text{rhsphsf}^{(1)} + 1} \wedge (\text{rhsf}^{(1)' = \text{rhsf}^{(1)} + 2);$

[r<sub>45</sub>]  $\text{rhsp} \geq 1 \wedge \text{rhsf}_3 \text{hse} \geq 1 \wedge \text{rhsphsf} \leq N_{\text{hspshsf}} - 1 \wedge \text{rhse} \leq N_{\text{hse}} - 1 \wedge \text{rhsf} \leq N_{\text{hsf}} - 2 \rightarrow$   
 $\text{rhsp} * \text{rhsf}_3 \text{hse} * k_{12} : (\text{rhsp}' = \text{rhsp} - 1) \wedge (\text{rhsf}_3 \text{hse}' = \text{rhsf}_3 \text{hse} - 1) \wedge (\text{rhsphsf}' = \text{rhsphsf} + 1) \wedge (\text{rhse}' = \text{rhse} + 1)$   
 $\wedge (\text{rhsf}' = \text{rhsf} + 2);$

[r<sub>46</sub>]  $\text{rhsp} \geq 1 \wedge \text{rhsf}_3 \text{hse}^{(1)} \geq 1 \wedge \text{rhsphsf}^{(1)} \leq N_{\text{hspshsf}} - 1 \wedge \text{rhse} \leq N_{\text{hse}} - 1 \wedge \text{rhsf} \leq N_{\text{hsf}} - 2 \rightarrow \text{rhsp} * \text{rhsf}_3 \text{hse}^{(1)} * k_{12} :$   
 $(\text{rhsp}' = \text{rhsp} - 1) \wedge (\text{rhsf}_3 \text{hse}^{(1)' = \text{rhsf}_3 \text{hse}^{(1)} - 1} \wedge (\text{rhsphsf}^{(1)' = \text{rhsphsf}^{(1)} + 1} \wedge$   
 $(\text{rhse}' = \text{rhse} + 1) \wedge (\text{rhsf}' = \text{rhsf} + 2);$

[r<sub>47</sub>]  $\text{rhsp} \geq 1 \wedge \text{rhsf}_3 \text{hse}^{(1)} \geq 1 \wedge \text{rhsphsf} \leq N_{\text{hspshsf}} - 1 \wedge \text{rhse} \leq N_{\text{hse}} - 1 \wedge \text{rhsf} \leq N_{\text{hsf}} - 2 \wedge \text{rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow$   
 $\text{rhsp} * \text{rhsf}_3 \text{hse}^{(1)} * k_{12} : (\text{rhsp}' = \text{rhsp} - 1) \wedge (\text{rhsf}_3 \text{hse}^{(1)' = \text{rhsf}_3 \text{hse}^{(1)} - 1} \wedge (\text{rhsphsf}' = \text{rhsphsf} + 1) \wedge$   
 $(\text{rhse}' = \text{rhse} + 1) \wedge (\text{rhsf}' = \text{rhsf} + 1) \wedge (\text{rhsf}^{(1)' = \text{rhsf}^{(1)} + 1);$

[r<sub>48</sub>]  $\text{rhsp} \geq 1 \wedge \text{rhsf}_3 \text{hse}^{(2)} \geq 1 \wedge \text{rhsphsf}^{(1)} \leq N_{\text{hspshsf}} - 1 \wedge \text{rhse} \leq N_{\text{hse}} - 1 \wedge \text{rhsf} \leq N_{\text{hsf}} - 2 \wedge \text{rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow$   
 $\text{rhsp} * \text{rhsf}_3 \text{hse}^{(2)} * k_{12} : (\text{rhsp}' = \text{rhsp} - 1) \wedge (\text{rhsf}_3 \text{hse}^{(2)' = \text{rhsf}_3 \text{hse}^{(2)} - 1} \wedge (\text{rhsphsf}^{(1)' =$   
 $\text{rhsphsf}^{(1)} + 1) \wedge (\text{rhse}' = \text{rhse} + 1) \wedge (\text{rhsf}' = \text{rhsf} + 1) \wedge (\text{rhsf}^{(1)' = \text{rhsf}^{(1)} + 1);$

[r<sub>49</sub>]  $\text{rhsp} \geq 1 \wedge \text{rhsf}_3 \text{hse}^{(2)} \geq 1 \wedge \text{rhsphsf} \leq N_{\text{hspshsf}} - 1 \wedge \text{rhse} \leq N_{\text{hse}} - 1 \wedge \text{rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow \text{rhsp} * \text{rhsf}_3 \text{hse}^{(2)} * k_{12} :$   
 $(\text{rhsp}' = \text{rhsp} - 1) \wedge (\text{rhsf}_3 \text{hse}^{(2)' = \text{rhsf}_3 \text{hse}^{(2)} - 1} \wedge (\text{rhsphsf}' = \text{rhsphsf} + 1) \wedge (\text{rhse}' = \text{rhse} + 1)$   
 $\wedge (\text{rhsf}^{(1)' = \text{rhsf}^{(1)} + 2);$

[r<sub>50</sub>]  $\text{rhsp} \geq 1 \wedge \text{rhsf}_3 \text{hse}^{(3)} \geq 1 \wedge \text{rhsphsf}^{(1)} \leq N_{\text{hspshsf}} - 1 \wedge \text{rhse} \leq N_{\text{hse}} - 1 \wedge \text{rhsf}^{(1)} \leq N_{\text{hsf}} - 2 \rightarrow \text{rhsp} * \text{rhsf}_3 \text{hse}^{(3)} * k_{12} :$   
 $(\text{rhsp}' = \text{rhsp} - 1) \wedge (\text{rhsf}_3 \text{hse}^{(3)' = \text{rhsf}_3 \text{hse}^{(3)} - 1} \wedge (\text{rhsphsf}^{(1)' = \text{rhsphsf}^{(1)} + 1} \wedge$   
 $(\text{rhse}' = \text{rhse} + 1) \wedge (\text{rhsf}^{(1)' = \text{rhsf}^{(1)} + 2);$

[r<sub>51</sub>]  $\text{rhsp} \geq 1 \rightarrow \text{rhsp} * k_{13} : (\text{rhsp}' = \text{rhsp} - 1);$

[r<sub>52</sub>]  $\text{rprot} \geq 1 \wedge \text{rmfp} \leq N_{\text{mf}} - 1 \rightarrow \text{rprot} * k_{14} : (\text{rprot}' = \text{rprot} - 1) \wedge (\text{rmfp}' = \text{rmfp} + 1);$

[r<sub>53</sub>]  $\text{rhsp} \geq 1 \wedge \text{rmfp} \geq 1 \wedge \text{rhspmf} \leq N_{\text{hspmf}} - 1 \rightarrow \text{rhsp} * \text{rmfp} * k_{15} : (\text{rhsp}' = \text{rhsp} - 1) \wedge (\text{rmfp}' = \text{rmfp} - 1) \wedge$   
 $(\text{rhspmf}' = \text{rhspmf} + 1);$

[r<sub>54</sub>]  $\text{rhspmf} \geq 1 \wedge \text{rhsp} \leq N_{\text{hsp}} - 1 \wedge \text{rmfp} \leq N_{\text{mf}} - 1 \rightarrow \text{rhspmf} * k_{16} : (\text{rhspmf}' = \text{rhspmf} - 1) \wedge$   
 $(\text{rhsp}' = \text{rhsp} + 1) \wedge (\text{rmfp}' = \text{rmfp} + 1);$

[r<sub>55</sub>]  $\text{rhspmf} \geq 1 \wedge \text{rhsp} \leq N_{\text{hsp}} - 1 \wedge \text{rprot} \leq N_{\text{prot}} - 1 \rightarrow \text{rhspmf} * k_{17} : (\text{rhspmf}' = \text{rhspmf} - 1) \wedge$   
 $(\text{rhsp}' = \text{rhsp} + 1) \wedge (\text{rprot}' = \text{rprot} + 1);$