

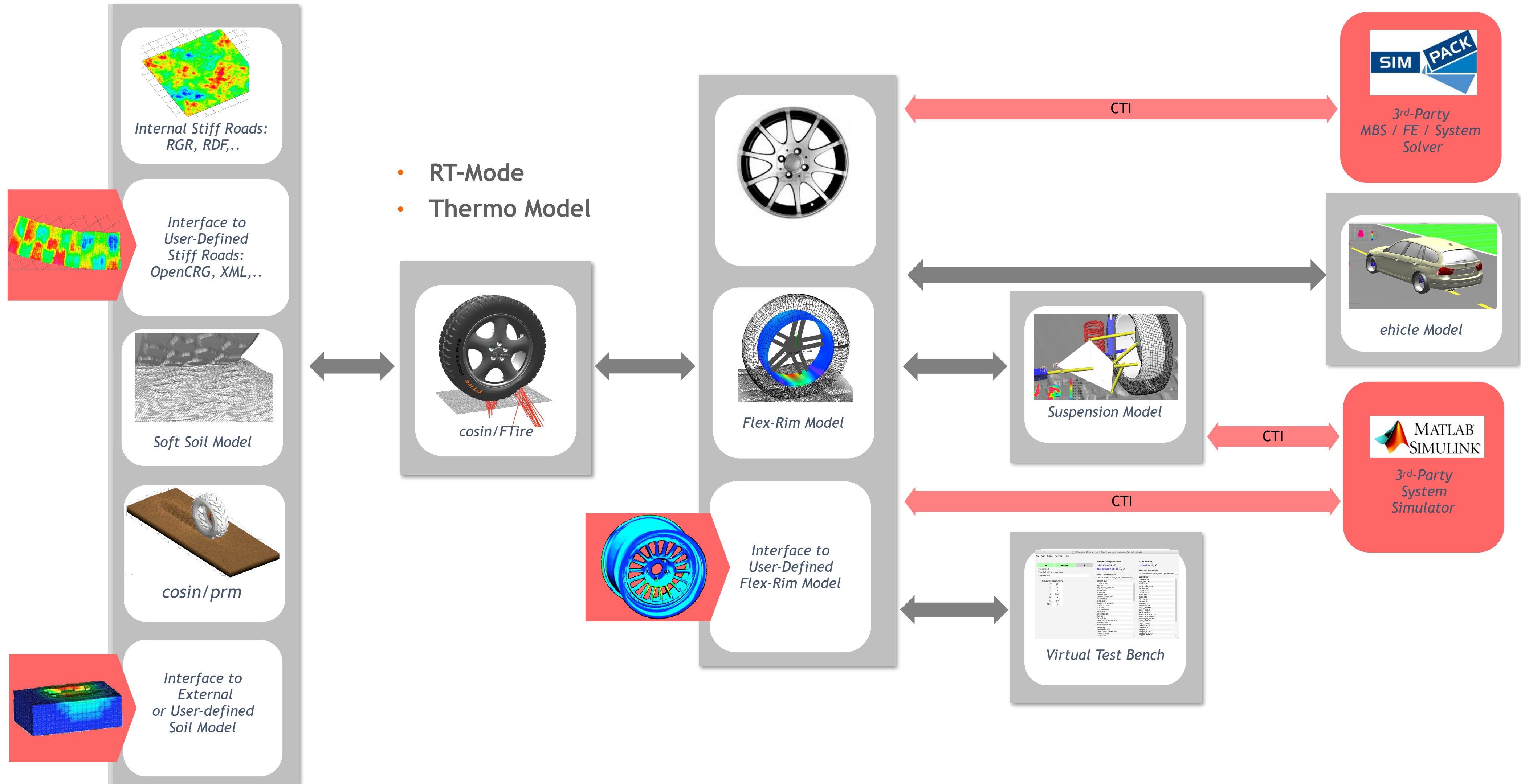
FTire

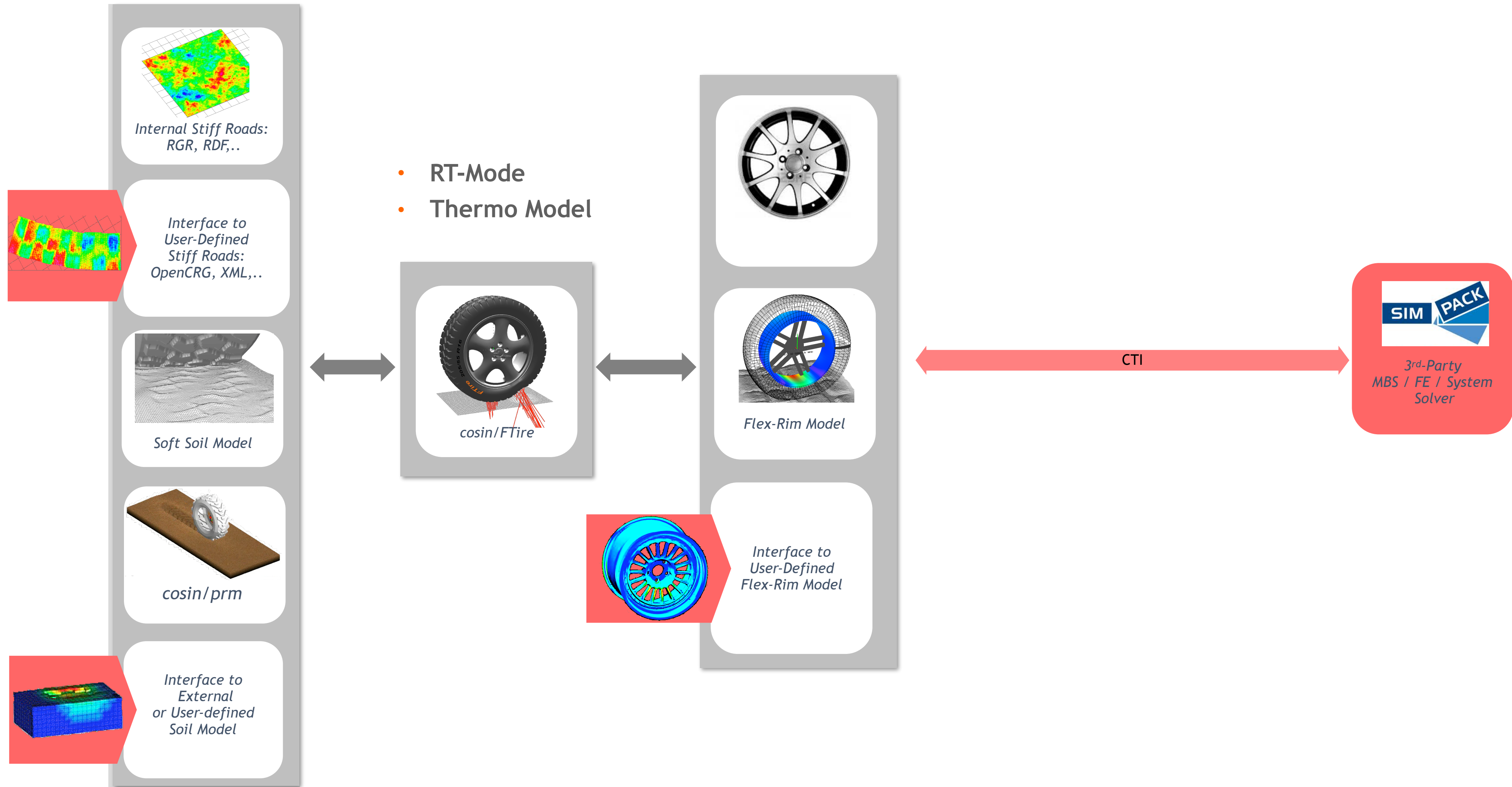
More Than Rubber and Cord

Thermal, Flexible Rim, and RealTime

Michael Gipser & Gerald Hofmann
cosin scientific software



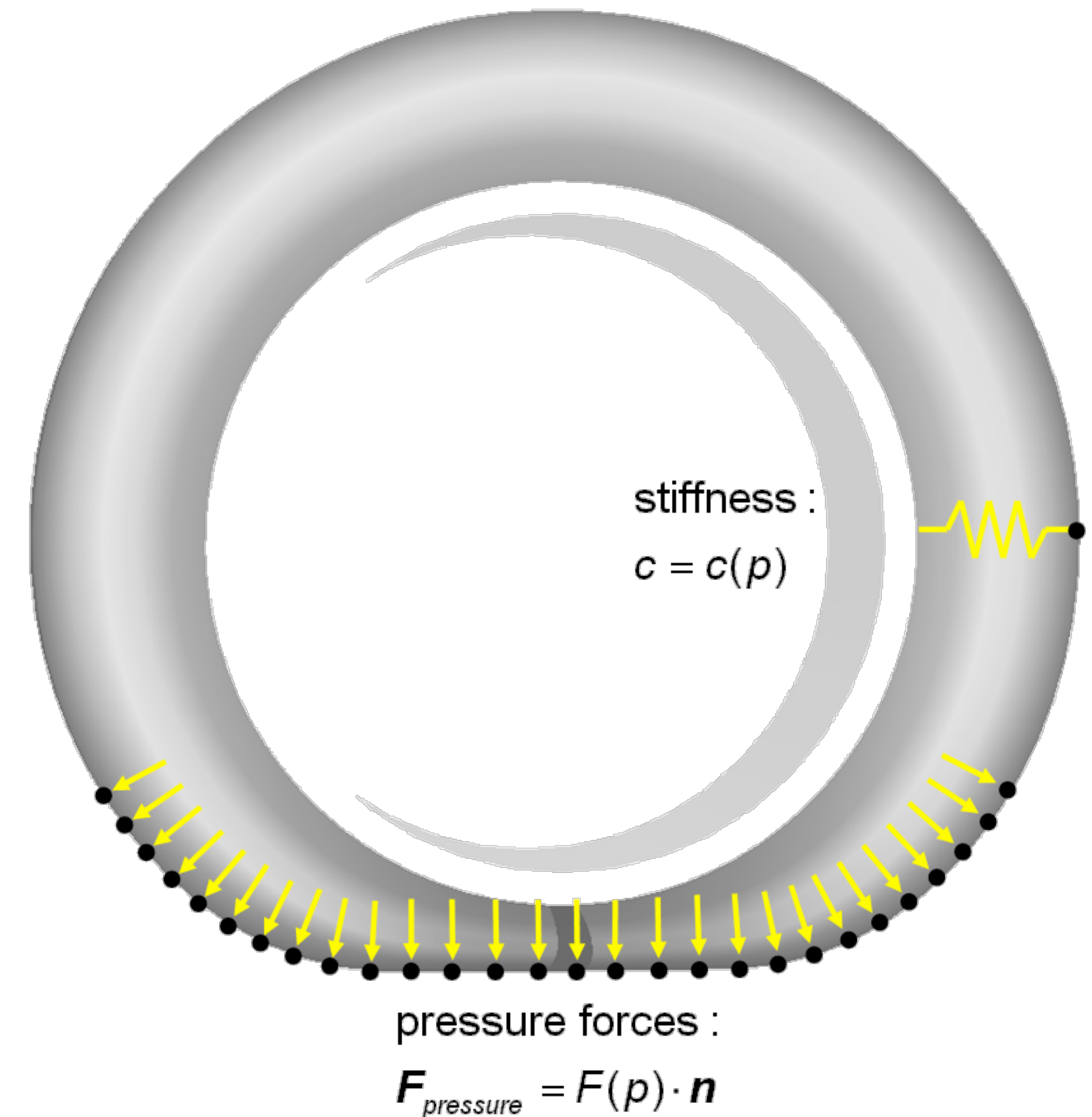






Thermal model: Impact on other model components

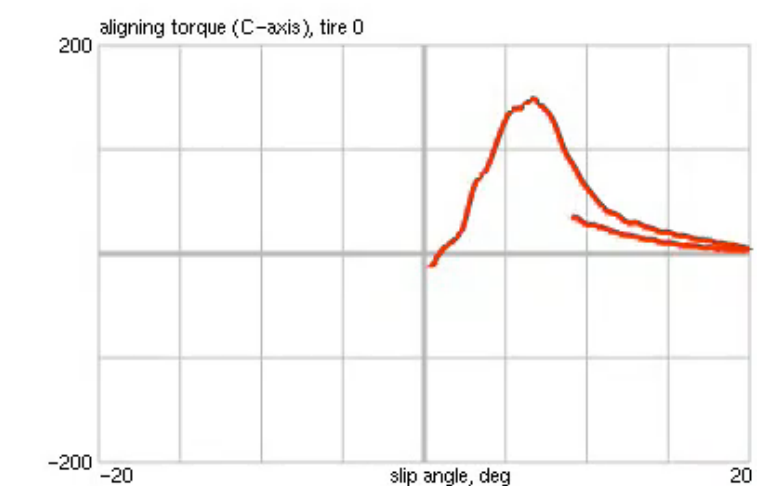
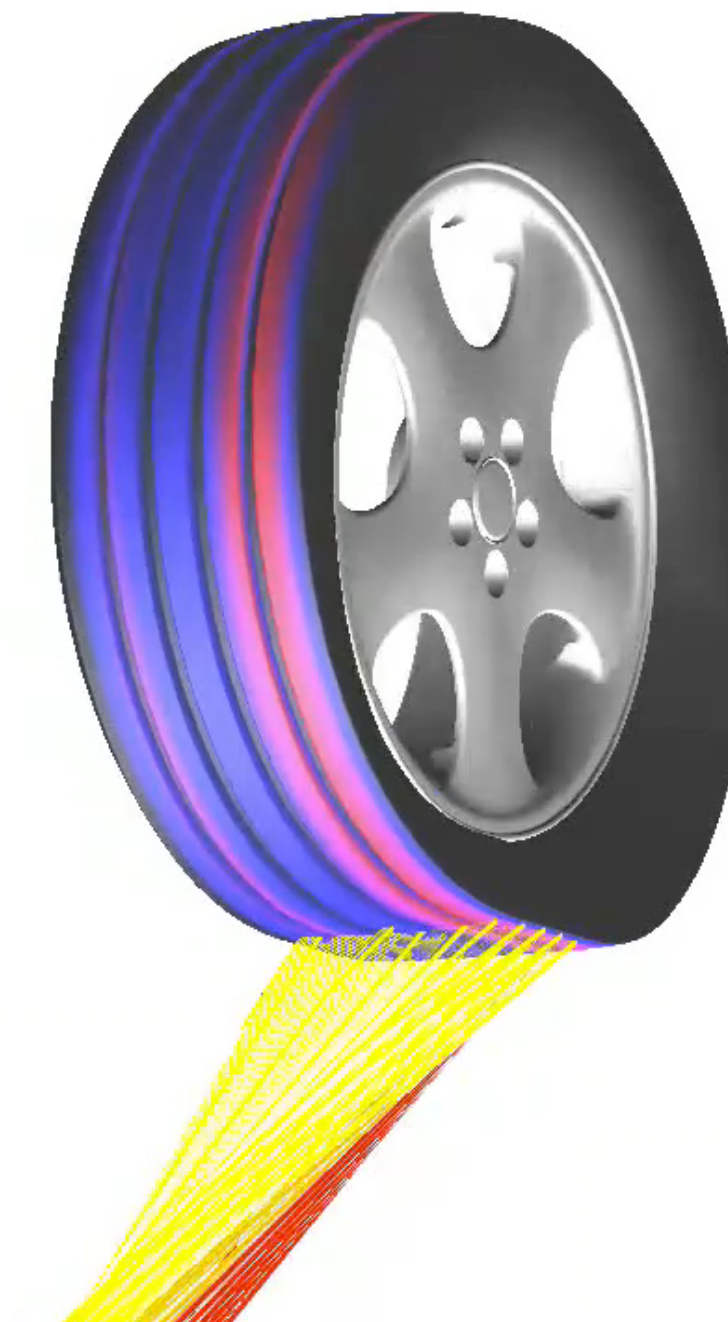
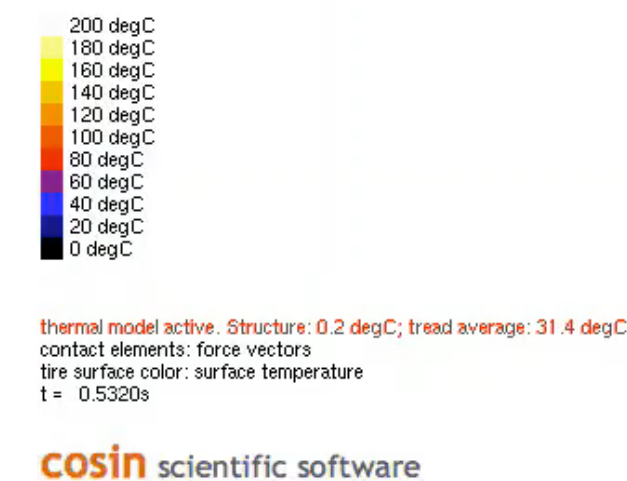
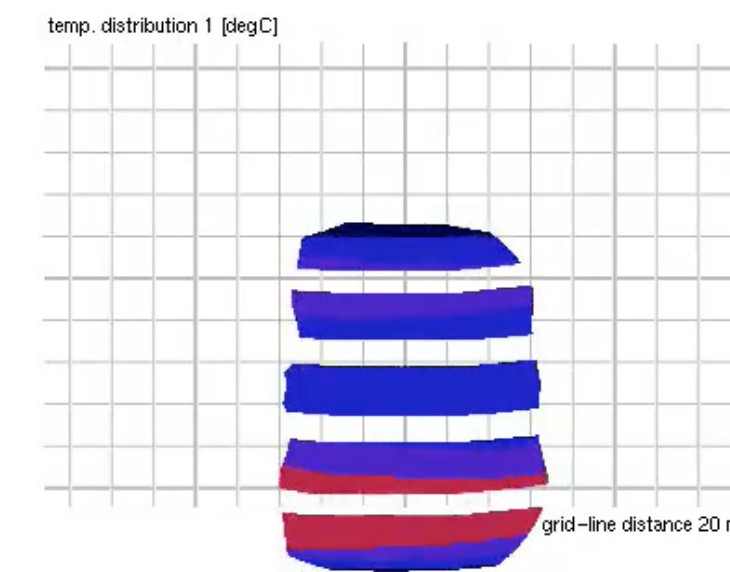
- Tire structure temperature influences
 - inflation pressure via $pV = kT$
 - indirectly tire stiffness
 - structural stiffness
- Distributed tread rubber temperature influences
 - road friction characteristic by temperature dependent modification factor
 - tread rubber compression and shear stiffness
 - tread wear rate





Thermal model: Heating, Cooling, Heat Transfer

- **Heating** by all dissipative elements
 - structural damping and hysteresis
 - polytropic state change of filling gas
 - tread rubber damping and hysteresis
 - friction in contact patch
- **Cooling** by
 - convection in sidewall and tread, depending on
 - rolling speed
 - ambient temperature
 - road surface temperature
 - radiation in sidewall and tread
- **Heat transfer**
 - between regions, determined by **heat transfer coefficients** and discretized **heat transfer equation**





Thermal model: Determination of heat transfer data

- **Heat conductivities**

- tread-tread
- tread-structure
- tread-road

- **Heat capacities**

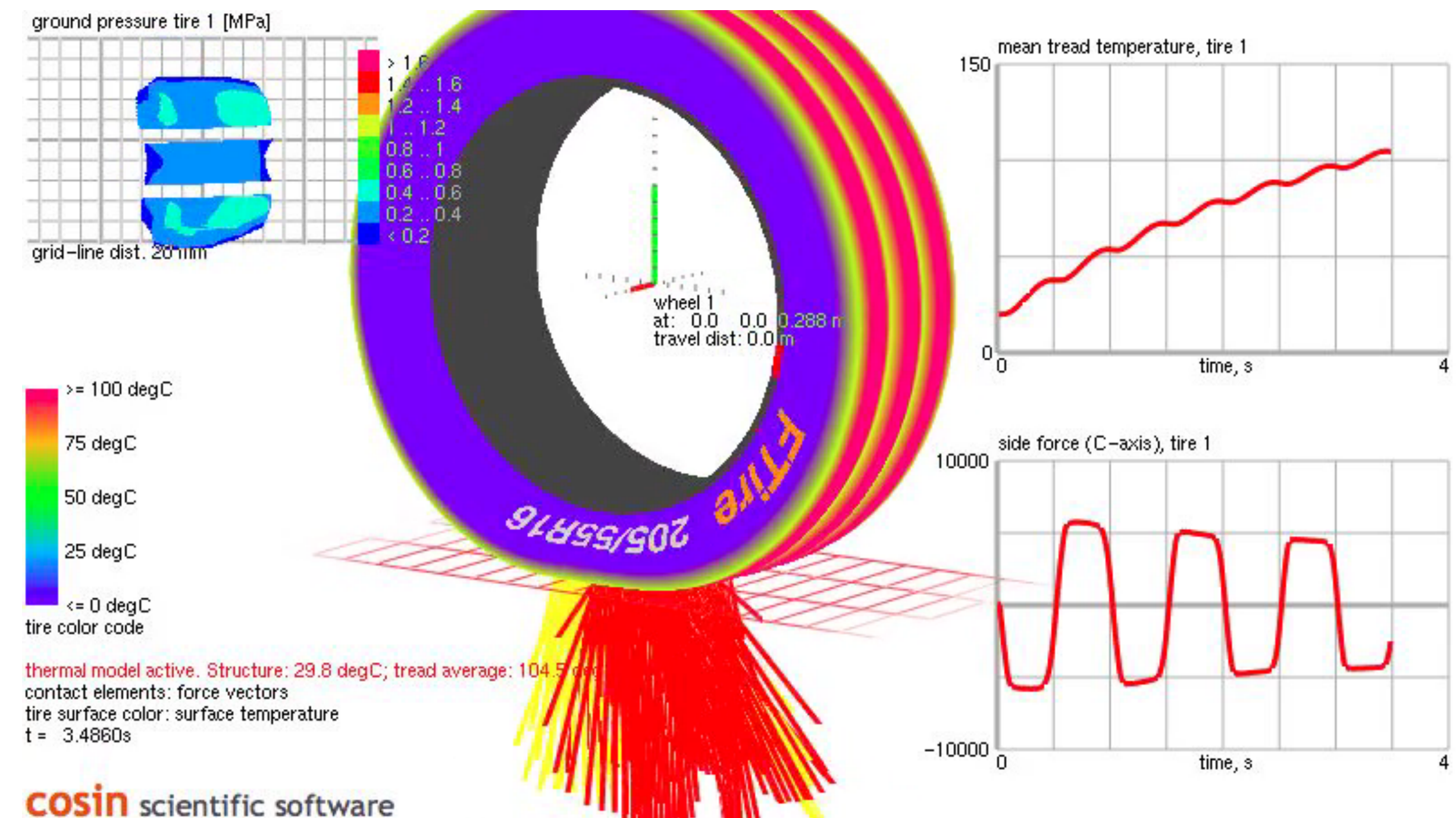
- tread
- structure

Parameters are simultaneously identified by using

- **Measured steady-state temperatures**

@ const. slip angle, temp. measured at spots near contact patch

- **Measured heating time constants**
slip angle or wheel slip step response





cosin/tools for Tires

File Edit Output Settings Help

thermal.tir

cosin scientific software

model type FTire
last access 2016/10/17 11:01:55
last modification 2016/10/17 00:00:47
compat. mode 2099/12/31
manufacturer n/a
brand n/a
size 205/55 R 16 91V 6.5J
inflation pressure 2.40 bar
pre-process for non-RT ☒ pre-process for RT and check real-time capability

edit analyze process post-process helpers

tire size & specification
geometry
carcass / belt mass & stiffn.
carcass / belt stiffn. (more)
carcass / belt damping
tread
friction
thermal & wear
air vibration
flexible / viscoplastic rim
TPMS

imperfections
numerics
data model conditions
operating conditions
animation
version control
open in text editor
polish data file
discard pre-processed data

Thermal and tread wear data: thermal.tir (autosave)

Output Help

thermal model

☒ activate ☐ deactivate

heating time constant of tire structure ? 50 s
heating time constant of tread ? 1.5 s
tire heating at reference slip and 25% vmax ? 50 degC
tread heating at reference slip and 25% vmax ? 70 degC
tread heating at reference slip and 50% vmax ? 75 degC
tread heating at reference slip and 100% vmax ? 80 degC
tread heating reference slip ? 8 %
% of friction power to heat tread ? 90 %

temperature influence

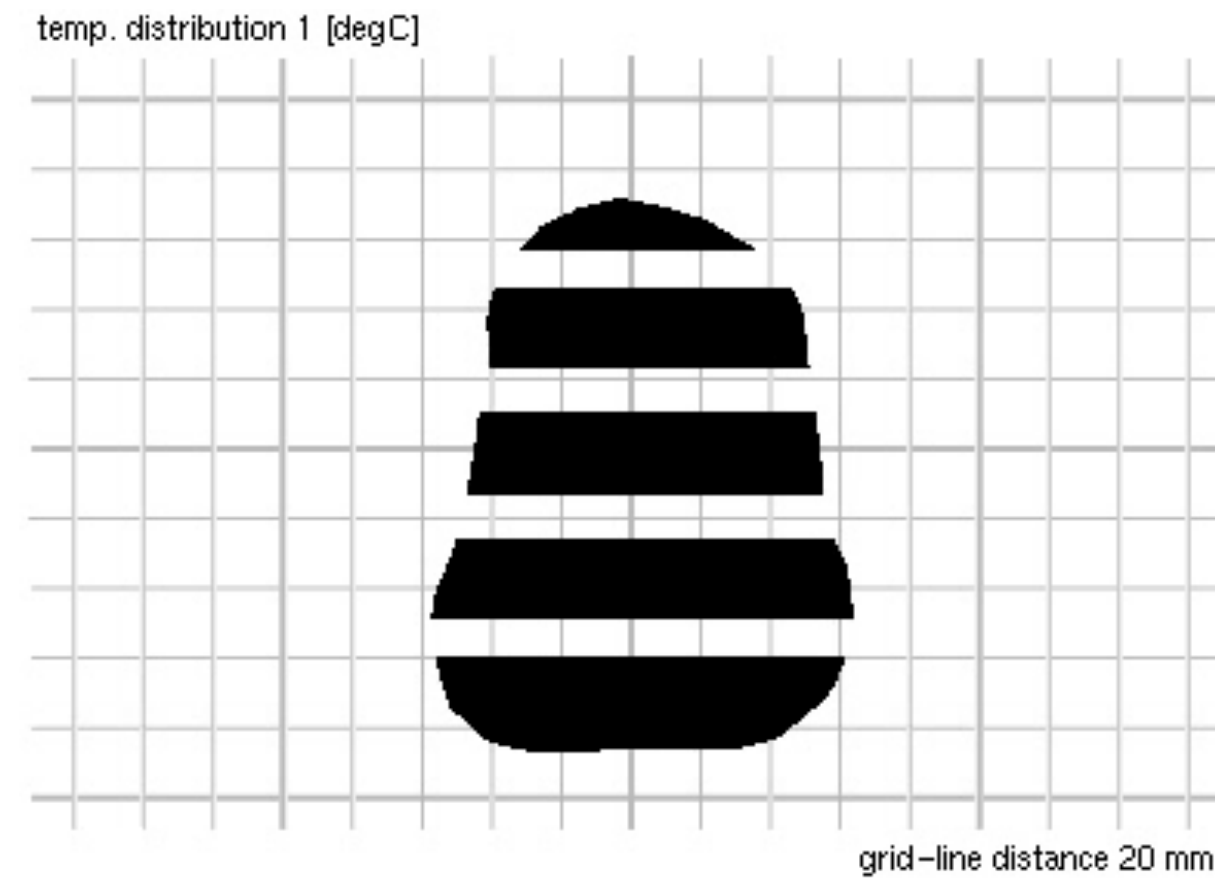
factor friction change vs. temp. ? ... ☐ lin ☒ spl
factor structural stiffn. change vs. temp. ? ... ☐ lin ☒ spl
factor tread stiffn. change vs. temp. ? ... ☐ lin ☒ spl

tread wear model

☐ activate ☐ activate, averaged ☐ only compute input ☒ deactivate

wear rate coefficient ? 0 -
wear rate exponent ? 1 -

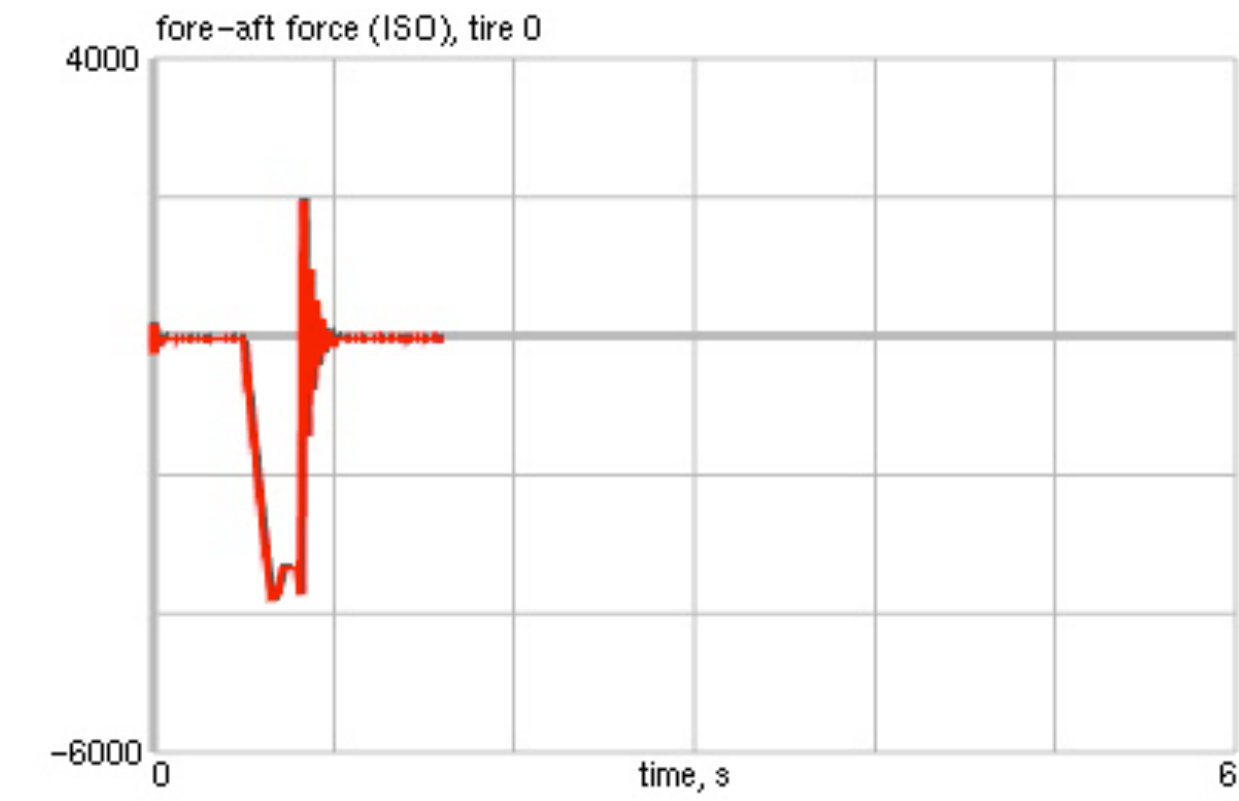
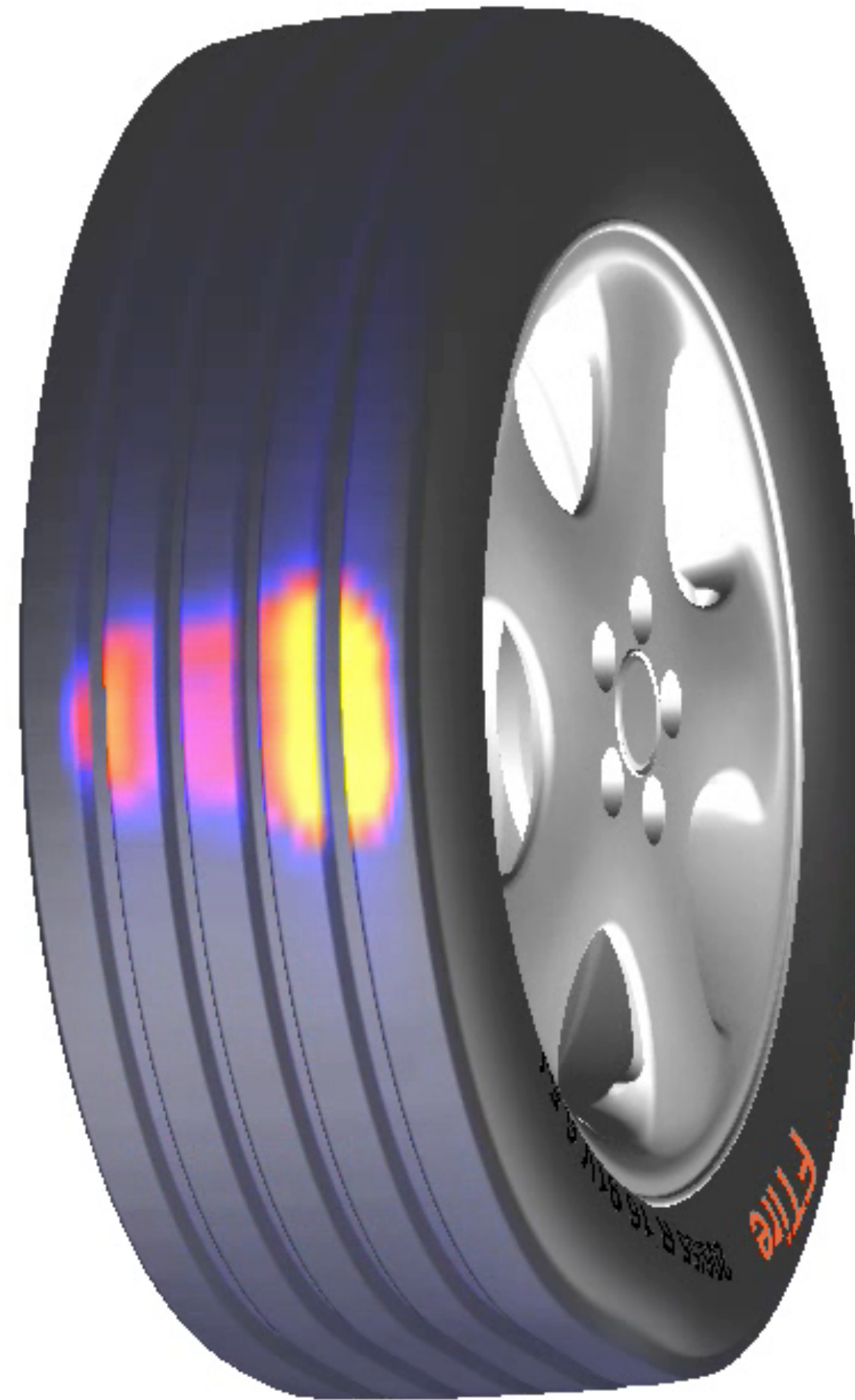
default fill ok cancel apply

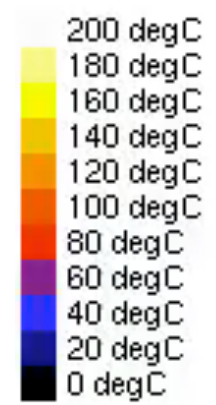
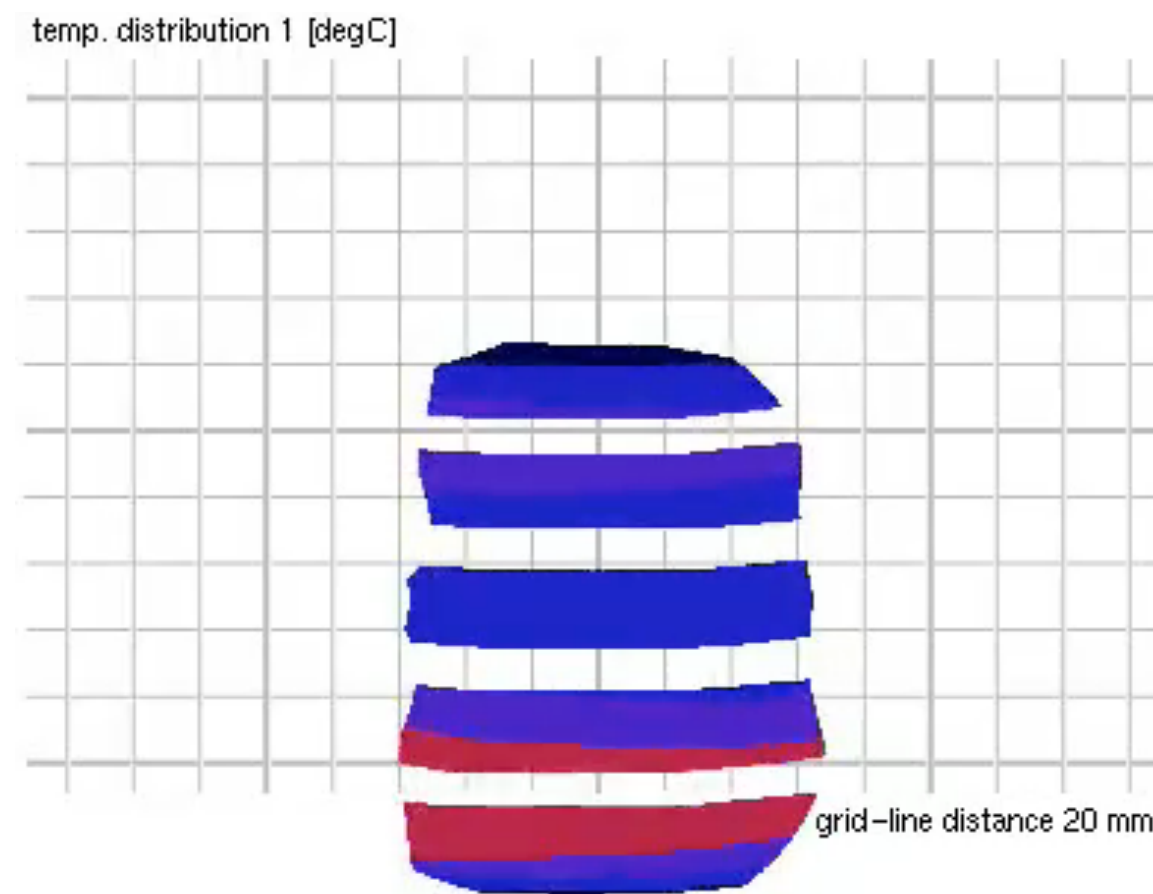


255 degC
225 degC
195 degC
165 degC
135 degC
105 degC
75 degC
45 degC
15 degC

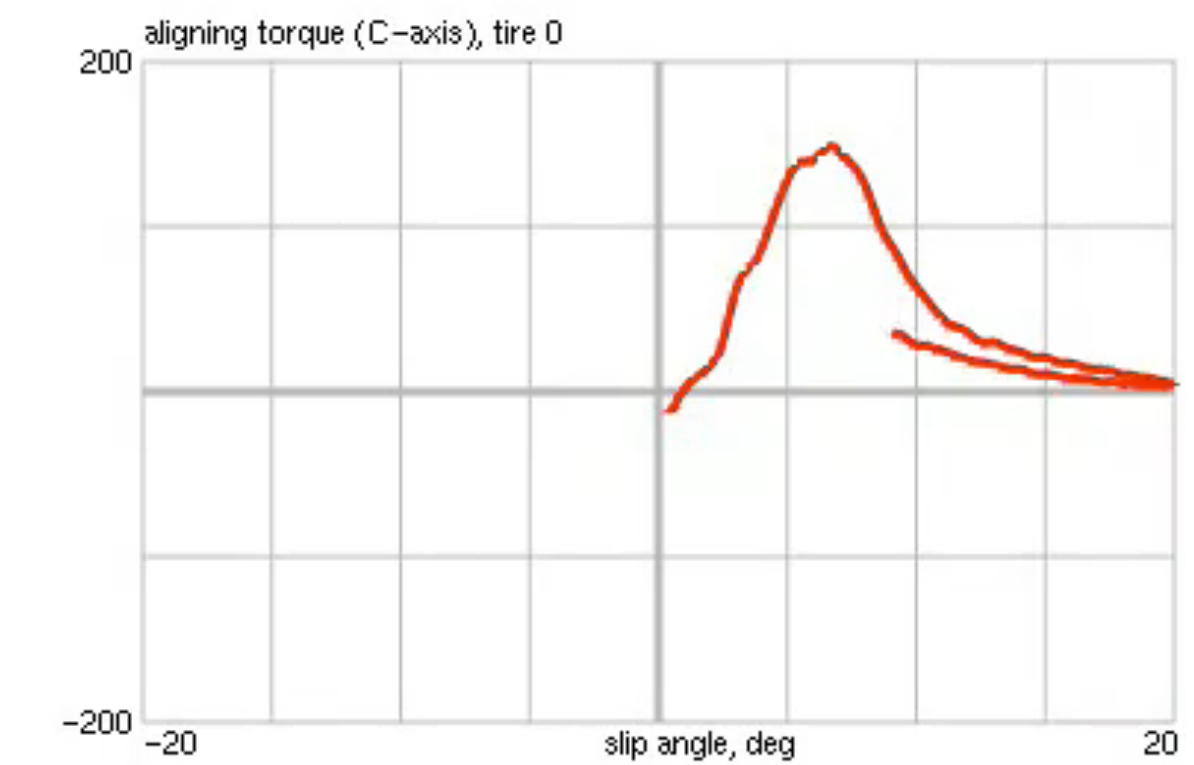
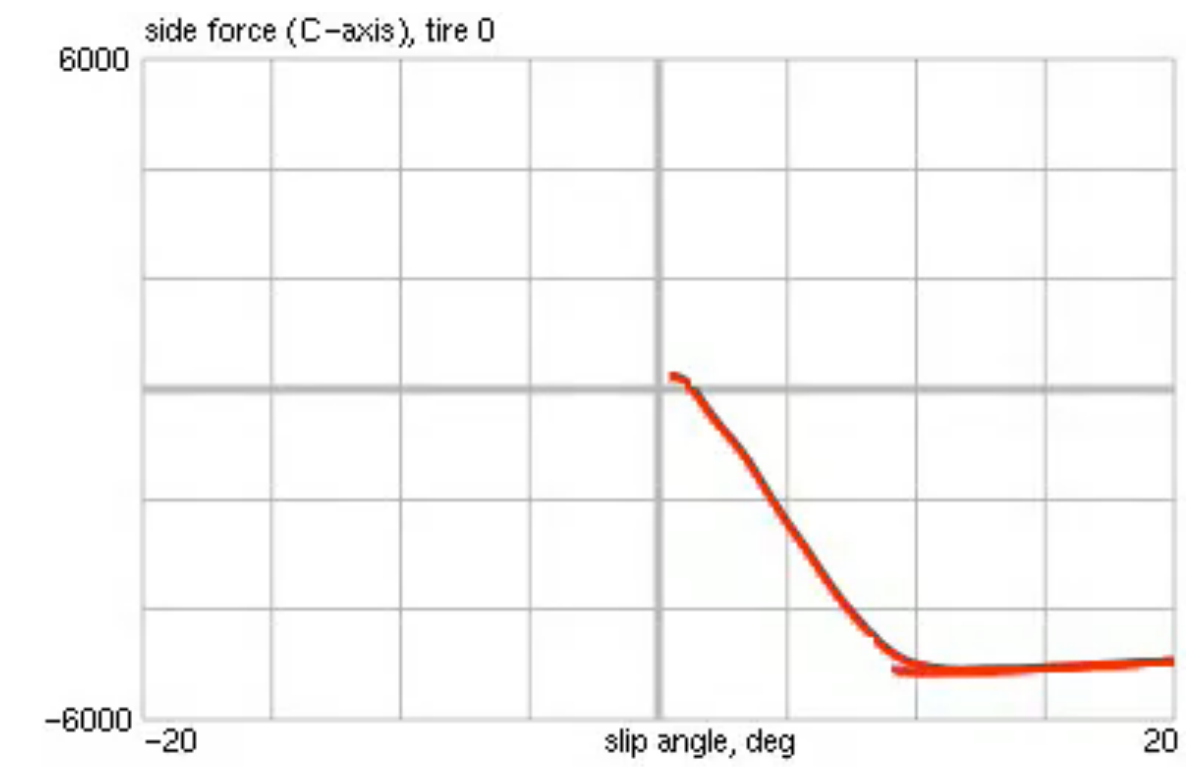
tire color code

thermal model active. Structure: 0.2 degC; tread average: 6.4 degC
tire surface color: surface temperature
t = 1.6100s





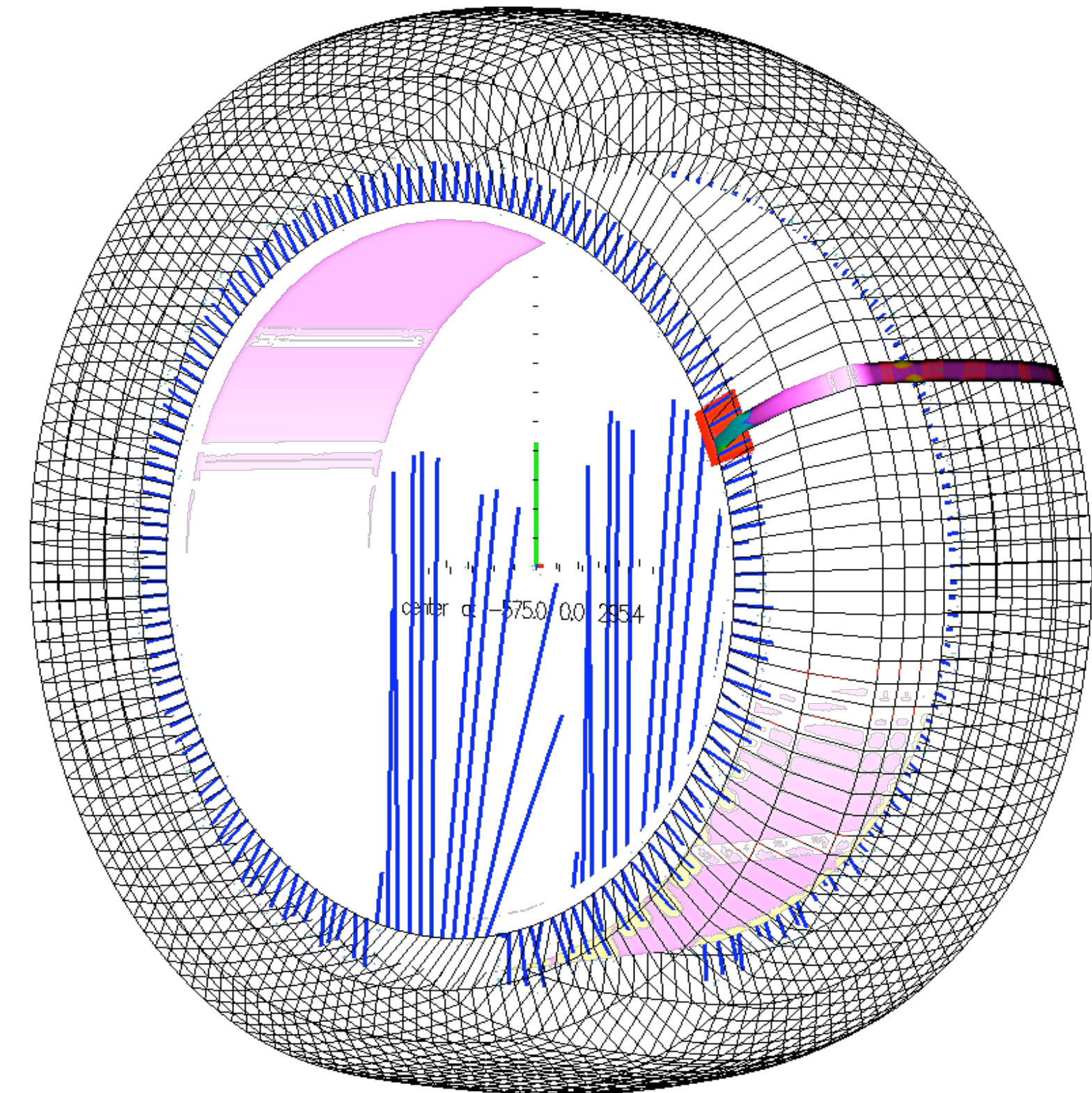
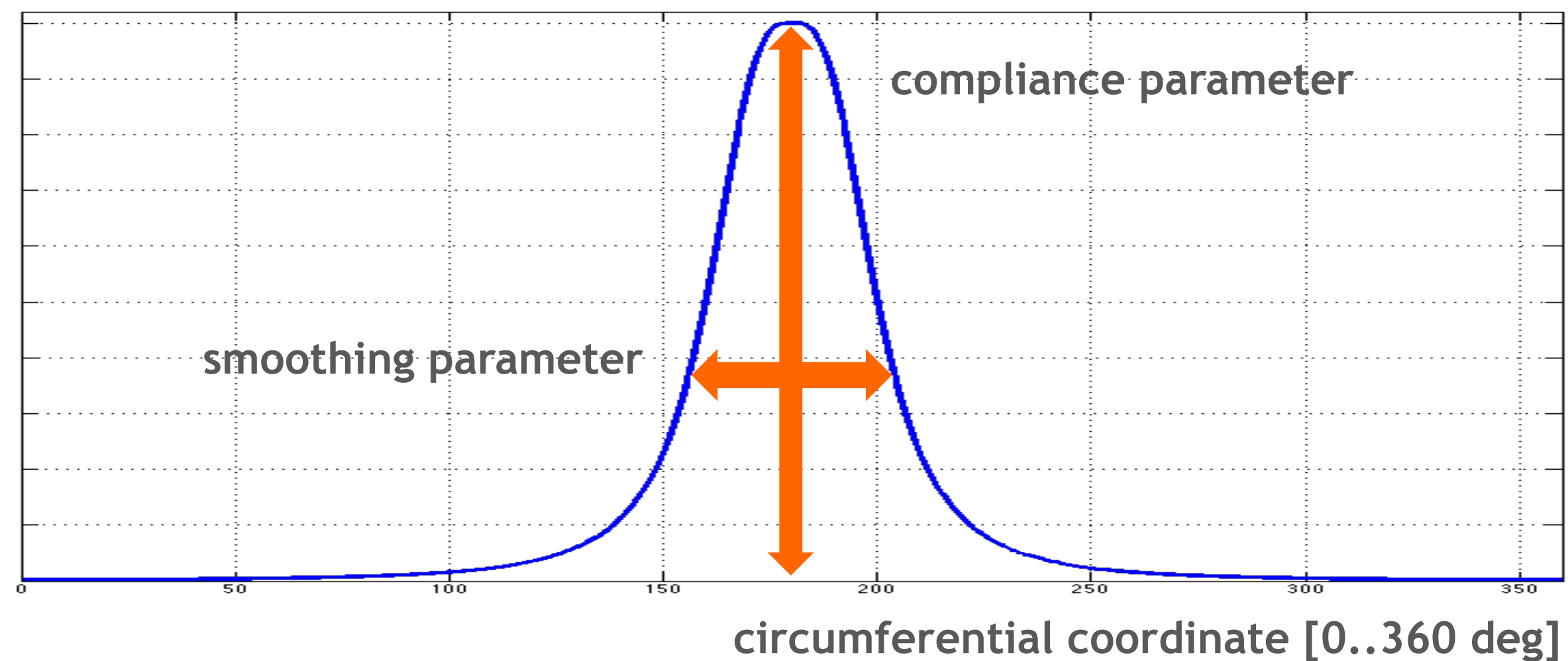
thermal model active. Structure: 0.2 degC; tread average: 31.4 degC
contact elements: force vectors
tire surface color: surface temperature
t = 0.5320s



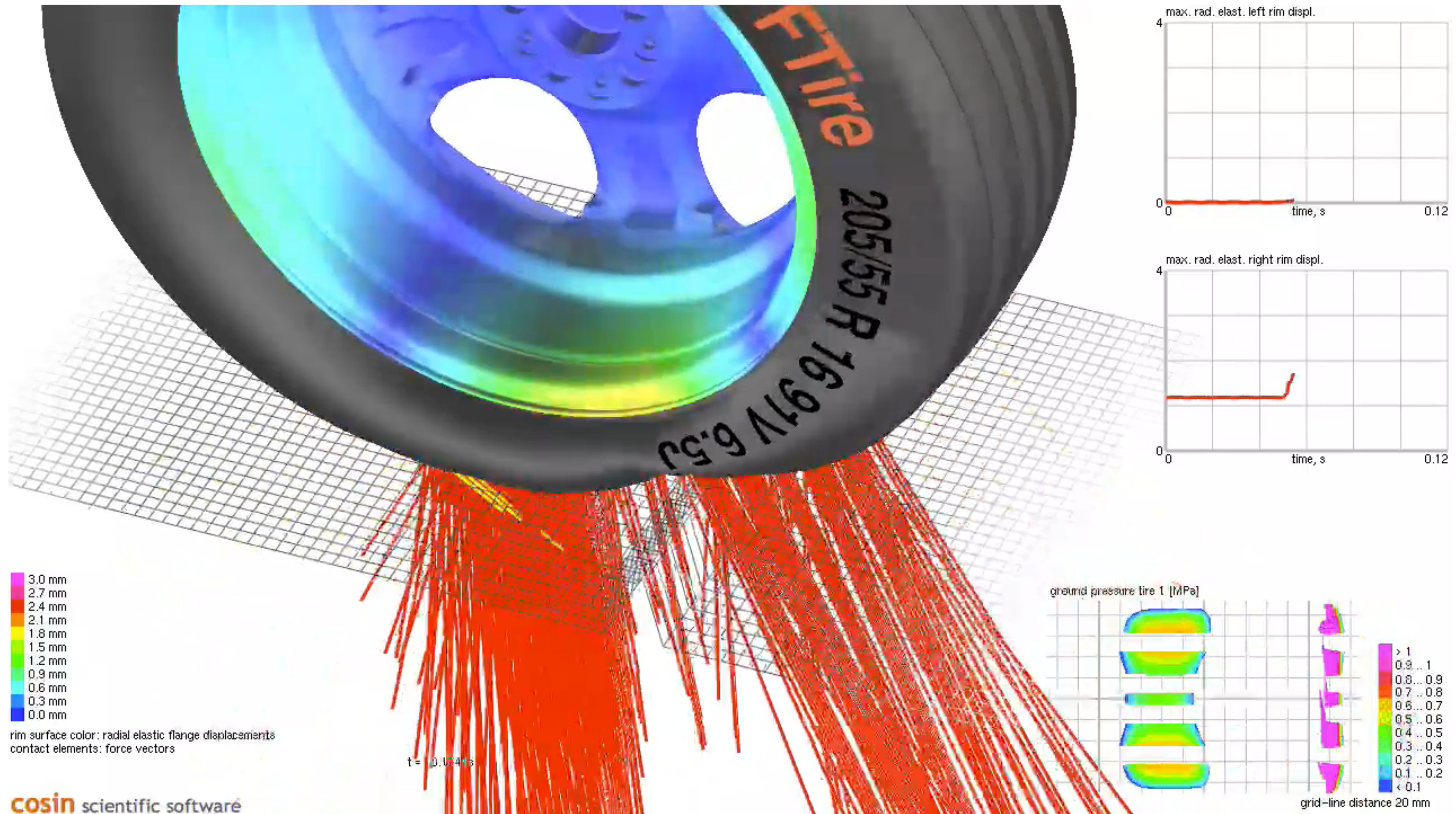


- radial and lateral compliance of rim flanges approximated by parameterized Green's function

Displacement caused by point load



- stiffness variation caused by spokes
- additional plastic deformation, if elastic displacement locally exceeds threshold value





cosin/tools for Tires

File Edit Output Settings Help

thermal.tir



cosin

scientific software

model type: FTire

last access: 2016/10/17 11:01:55

last modification: 2016/10/17 00:00:47

compat. mode: 2099/12/31

manufacturer: n/a

brand: n/a

size: 205/55 R 16 91V 6.5J

inflation pressure: 2.40 bar

pre-process for non-RT: ☒

pre-process for RT and check real-time capability: ☐

edit

analyze

process

post-process

helpers

tire size & specification

geometry

carcass / belt mass & stiffn.

carcass / belt stiffn. (more)

carcass / belt damping

tread

friction

thermal & wear

air vibration

flexible / viscoplastic rim

TPMS

imperfections

numerics

data meas. conditions

operating conditions

animation & sound

output

version control

open in text editor

polish data file

discard pre-processed data

Numerics data: _default.tir (autosave)

Output Help

run-time mode (* requires RT license)

standard ☐

accelerated, level ☐ 1 ☐ 2 ☐ 3* ☐ 4*

real-time, level ☐ 1* ☐ 2* ☐ 3* ☐ 4* ☒ 5*

pre-processing

run time

post-processing

numerical settings for accelerated and real-time mode

# belt segments in RT mode	?	60	-
# belt bending dofs in RT mode	?	3	-
# contact elem. per belt seg. in RT mode	?	15	-
# tread strips in RT mode	?	15	-
internal time step in RT mode	?	0.00025	s
BDF parameter	?	0.5	-
maximum angle increment in RT mode	?	1	deg
Jacobian update fraction in RT mode	?	0.5	-
contact processor bound in accel. mode	?	35	%

default

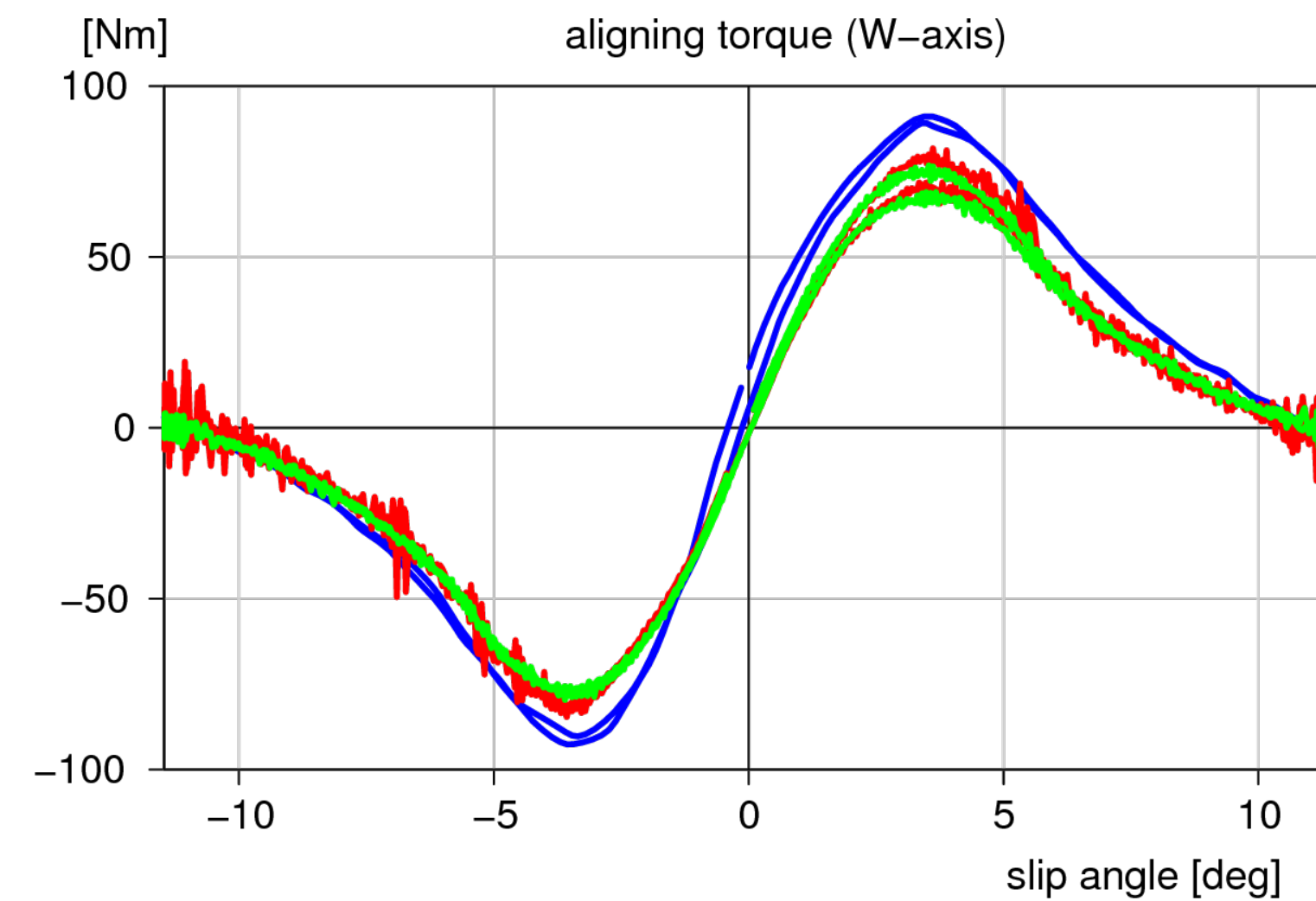
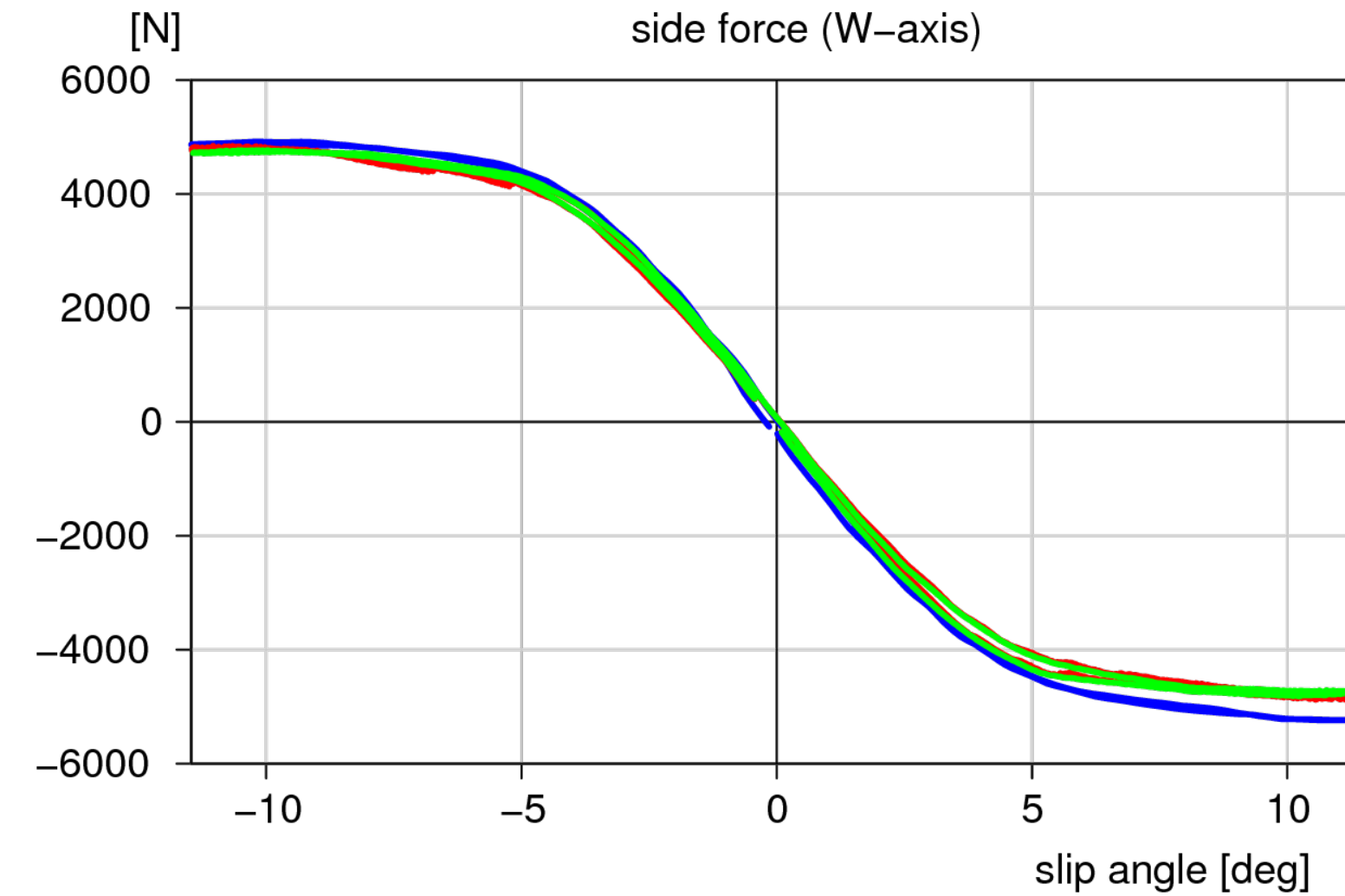
RTF?

ok

cancel

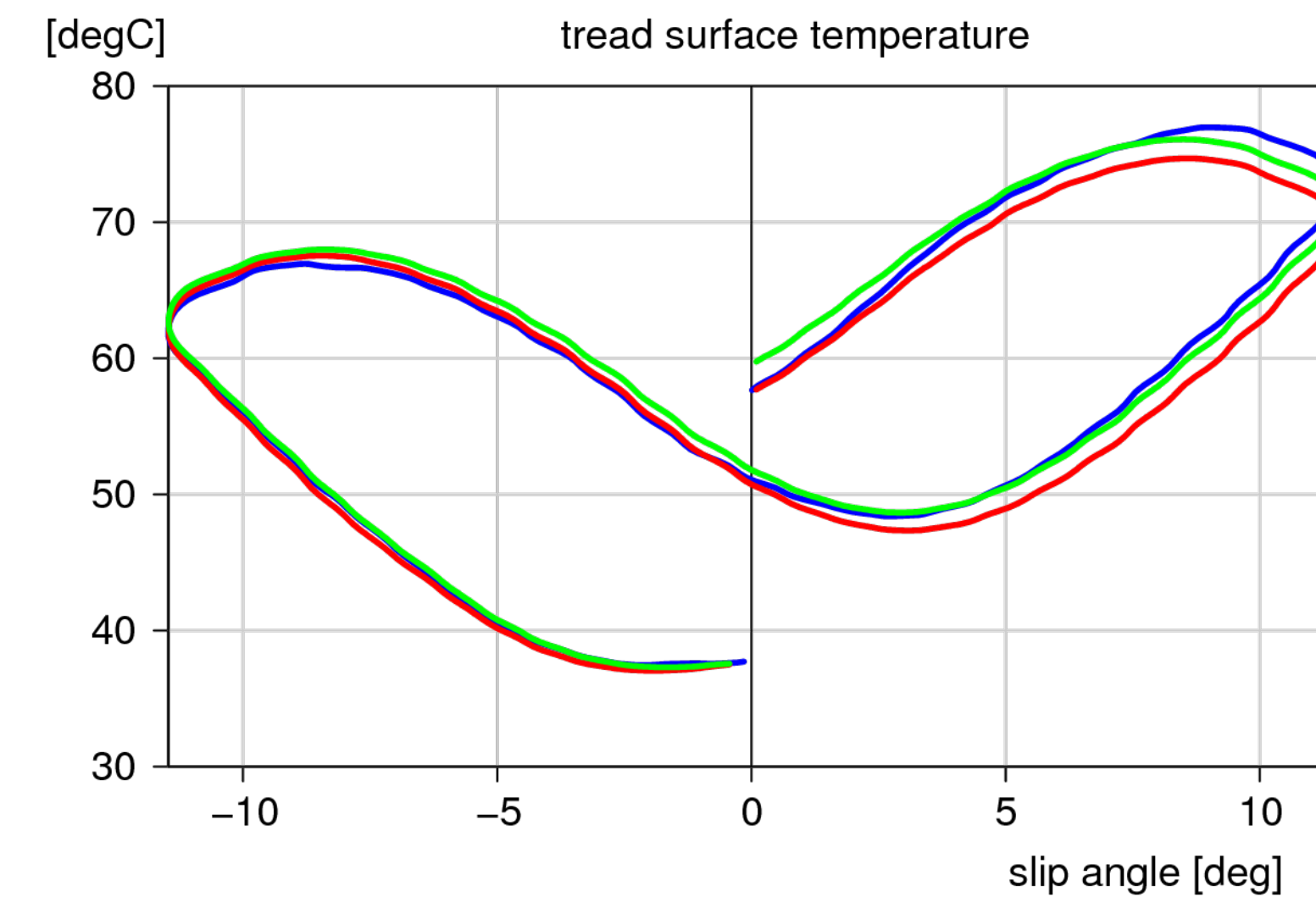
apply

(selected automatically in RT environments)



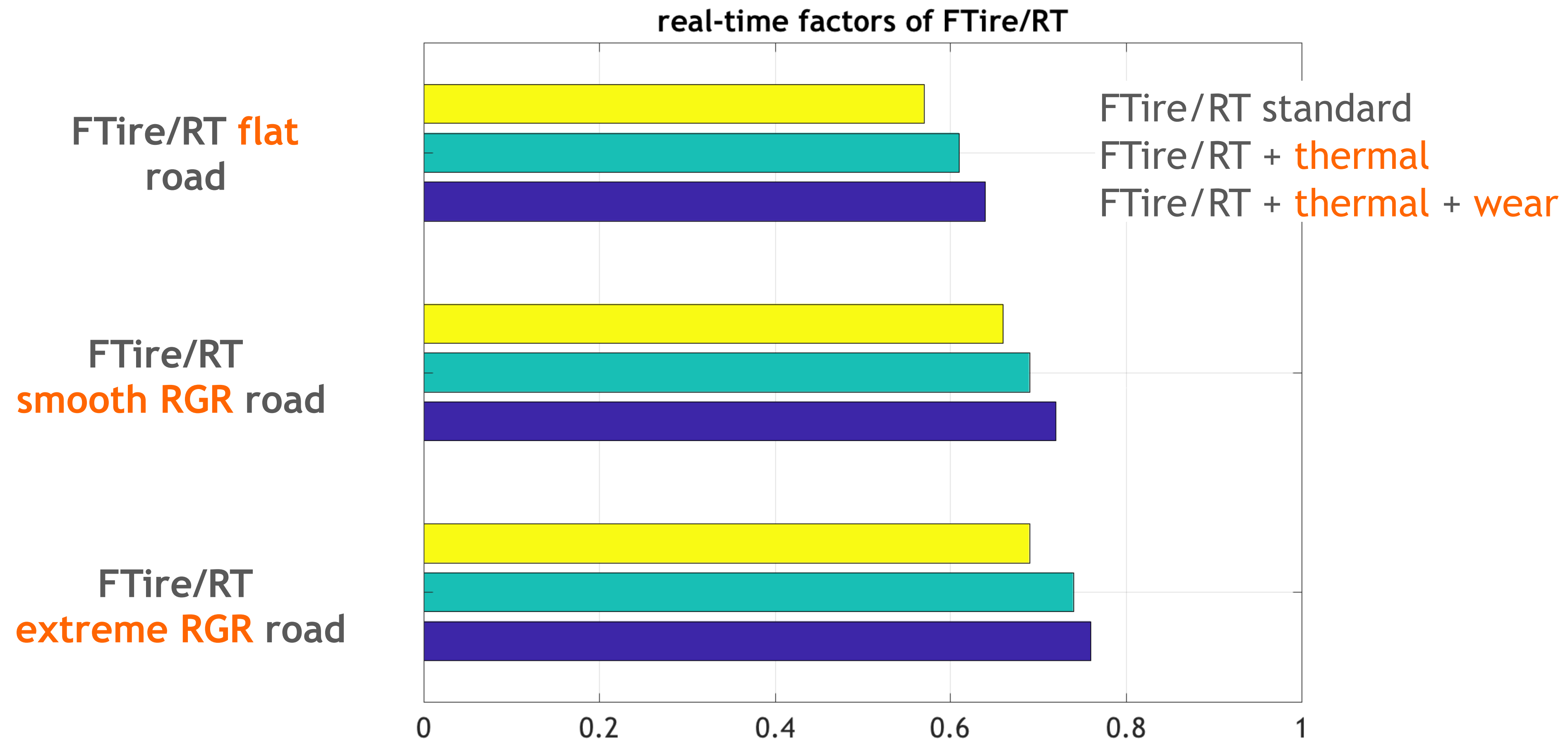
Example:
Surface temperature @ slip angle sweep (2 deg/s, 5 kN)

Measurement
FTire Real-Time
FTire standard





Road contact resolution **1.07 mm x 12.5 mm** = 900 contact elements; sample frequency **4.0 kHz**



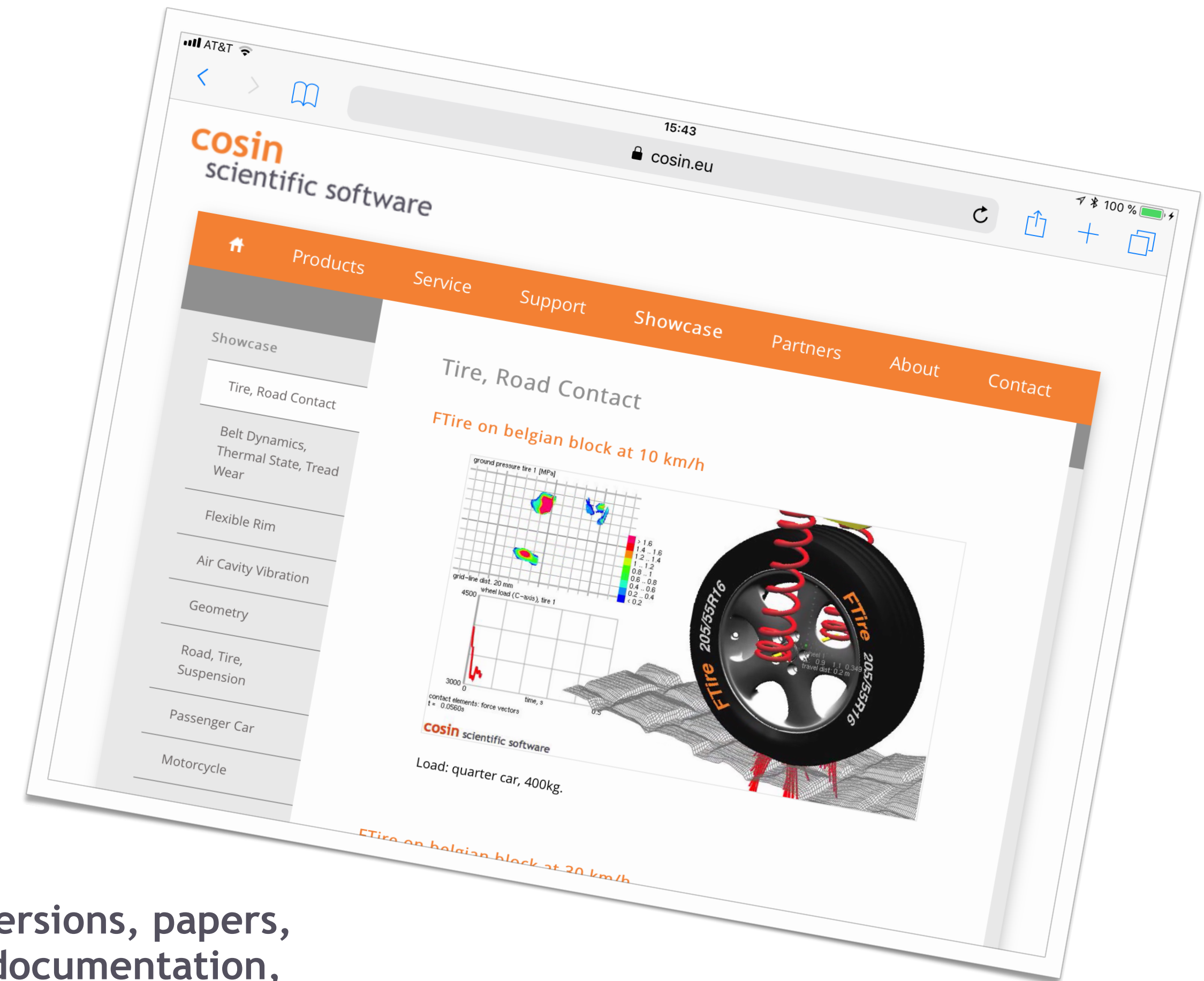


- FTire solver extensions available through CTI in Simpack and Abaqus environment
- FTire thermal model is available in RT mode
- Flexible rim input data can easily be derived from a complex FE rim model
- Thermal properties can easily be measured as part of the standard measurement procedure
- RT mode supported by Simpack RT
- FTire allows complex offline and RT/HIL application cases to be done by one single tire parameter set only



..thank you for your attention!

Q & A



FTire demo versions, papers,
animations, documentation,
version updates, and more: