



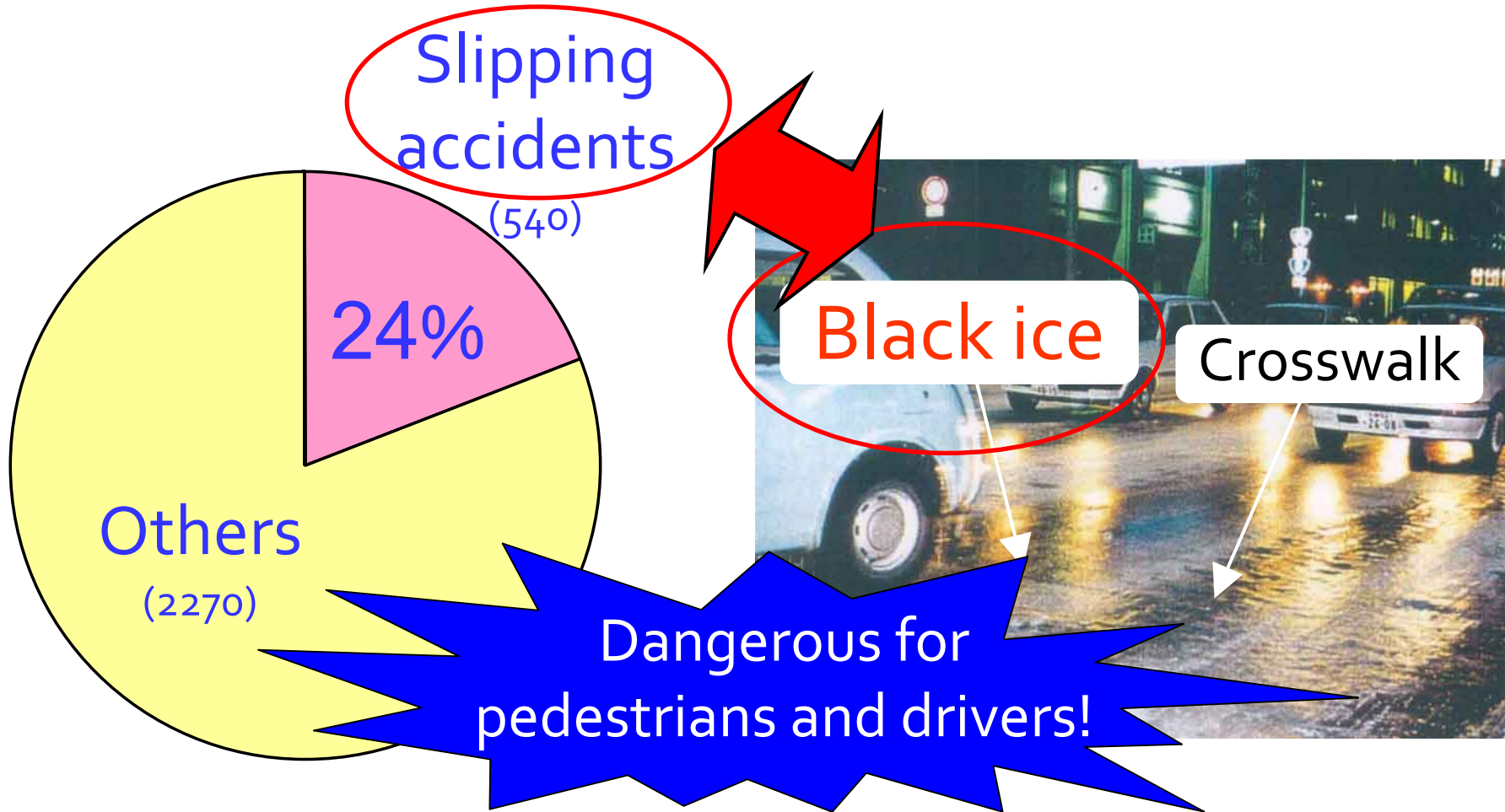
UNIVERSITY OF FUKUI

Effects of Vehicle Heat on Road Surface Temperature of Dry Condition

Standing International Road WEather Conference
Prague, May 2008

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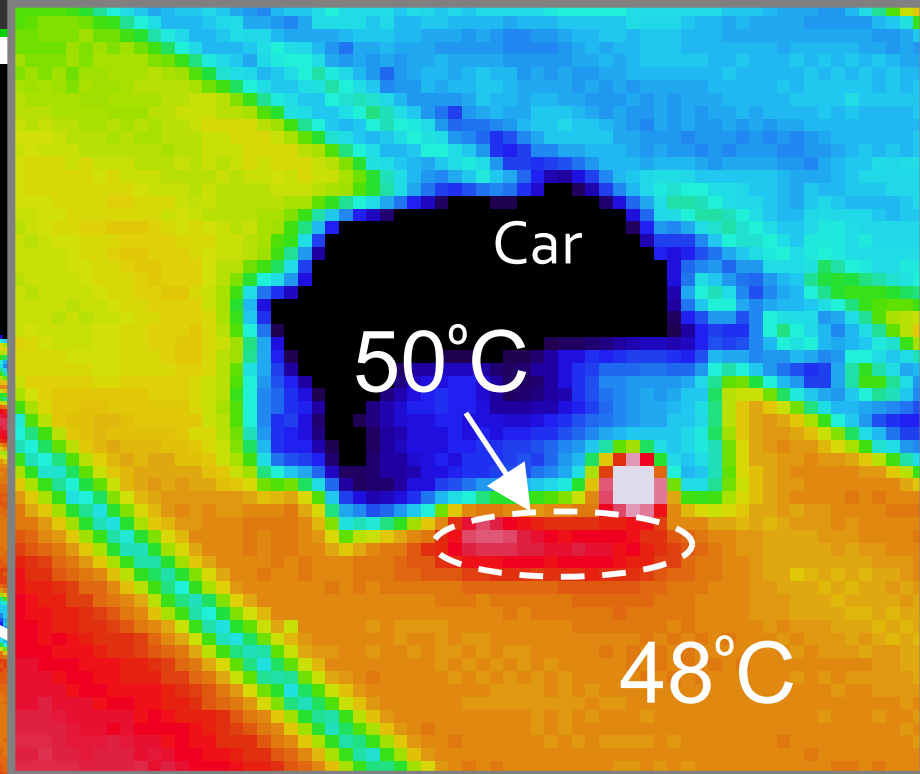
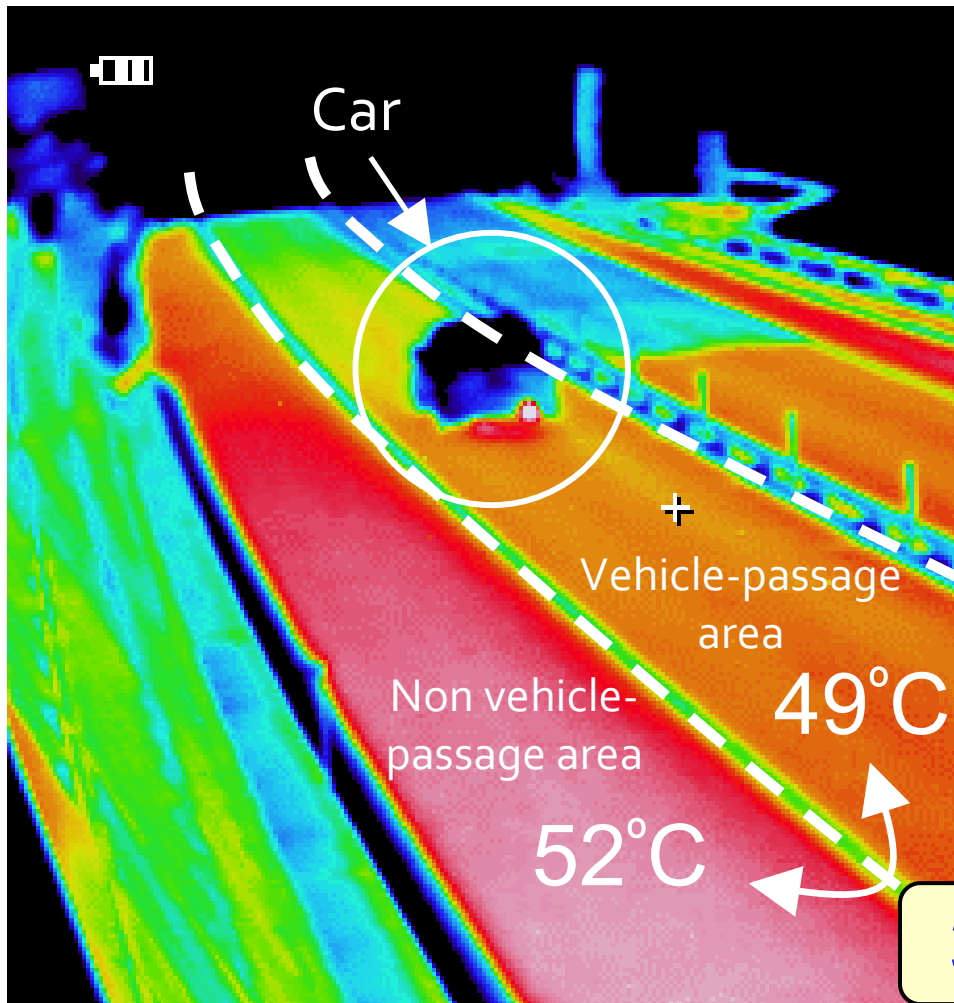
◆ Background



Number of traffic accidents
(Winter period, Hokkaido, Japan)

Road covered with black ice
at an intersection

◆ Effect of vehicle heat on road



◆ Purpose



1 Diagnosis of vehicle heats



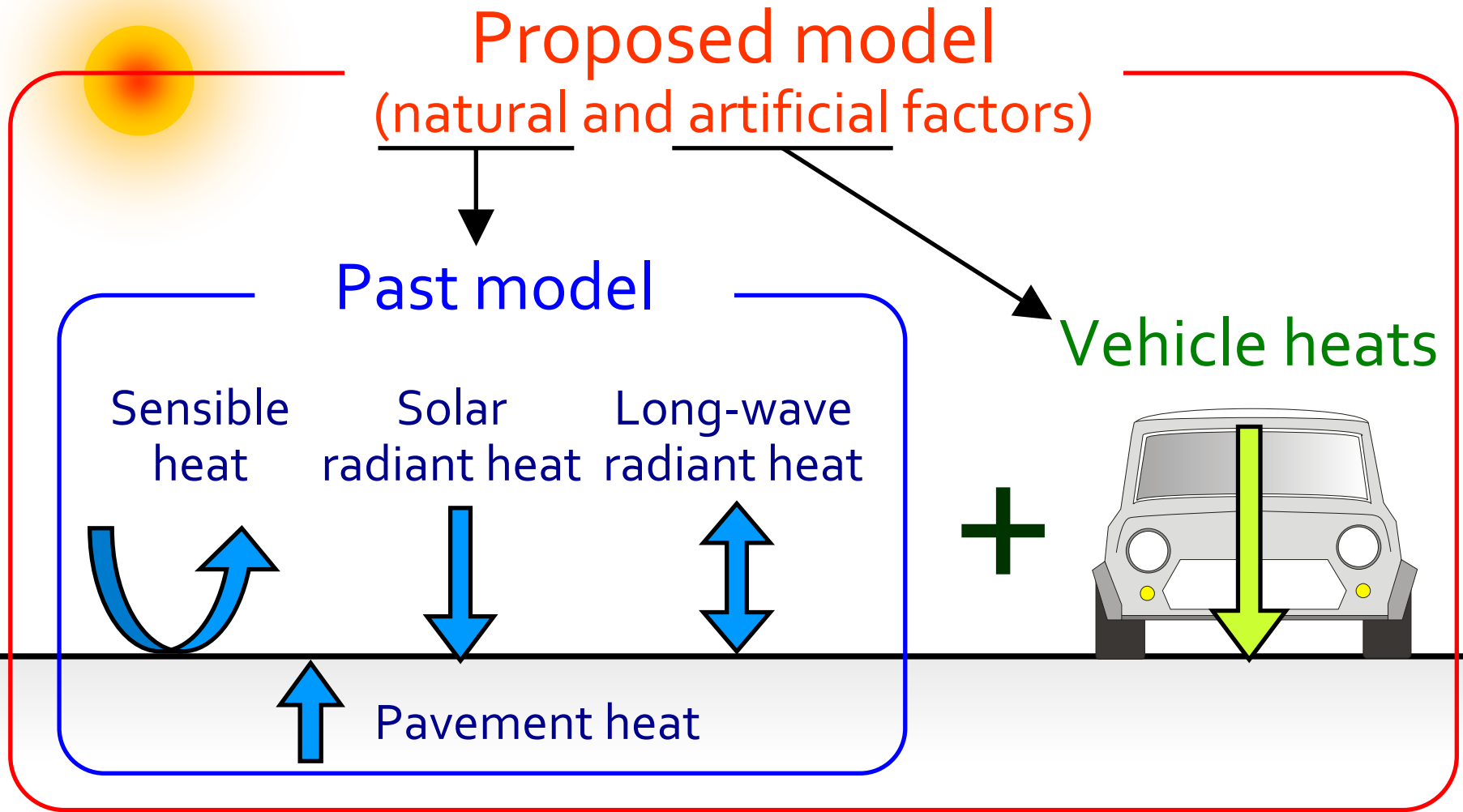
2 Development of Road Surface
Temperature (RST) prediction model



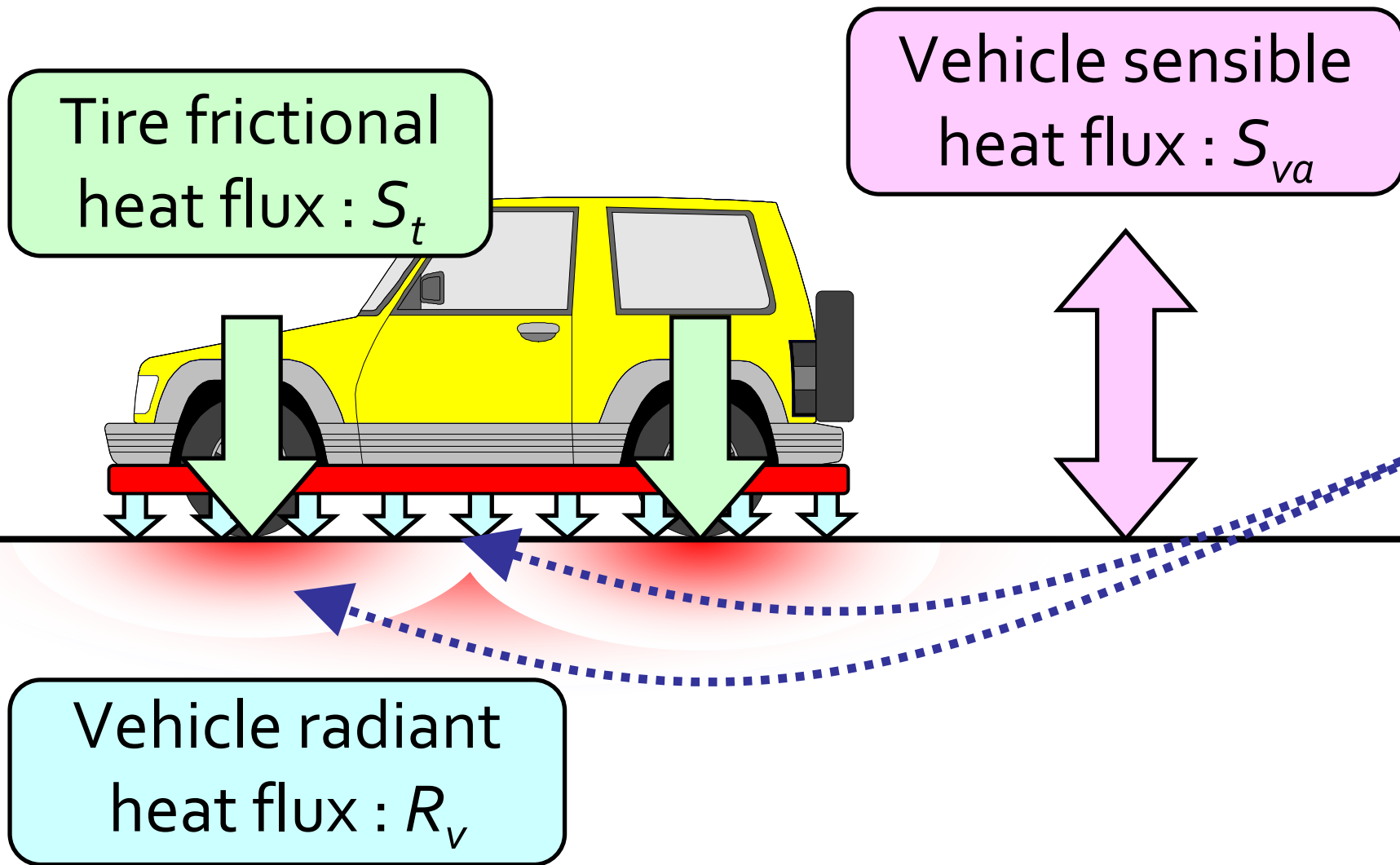
3 Examination of effects of vehicle heats
on RST

◆ RST prediction model

RST prediction model using a heat balance method



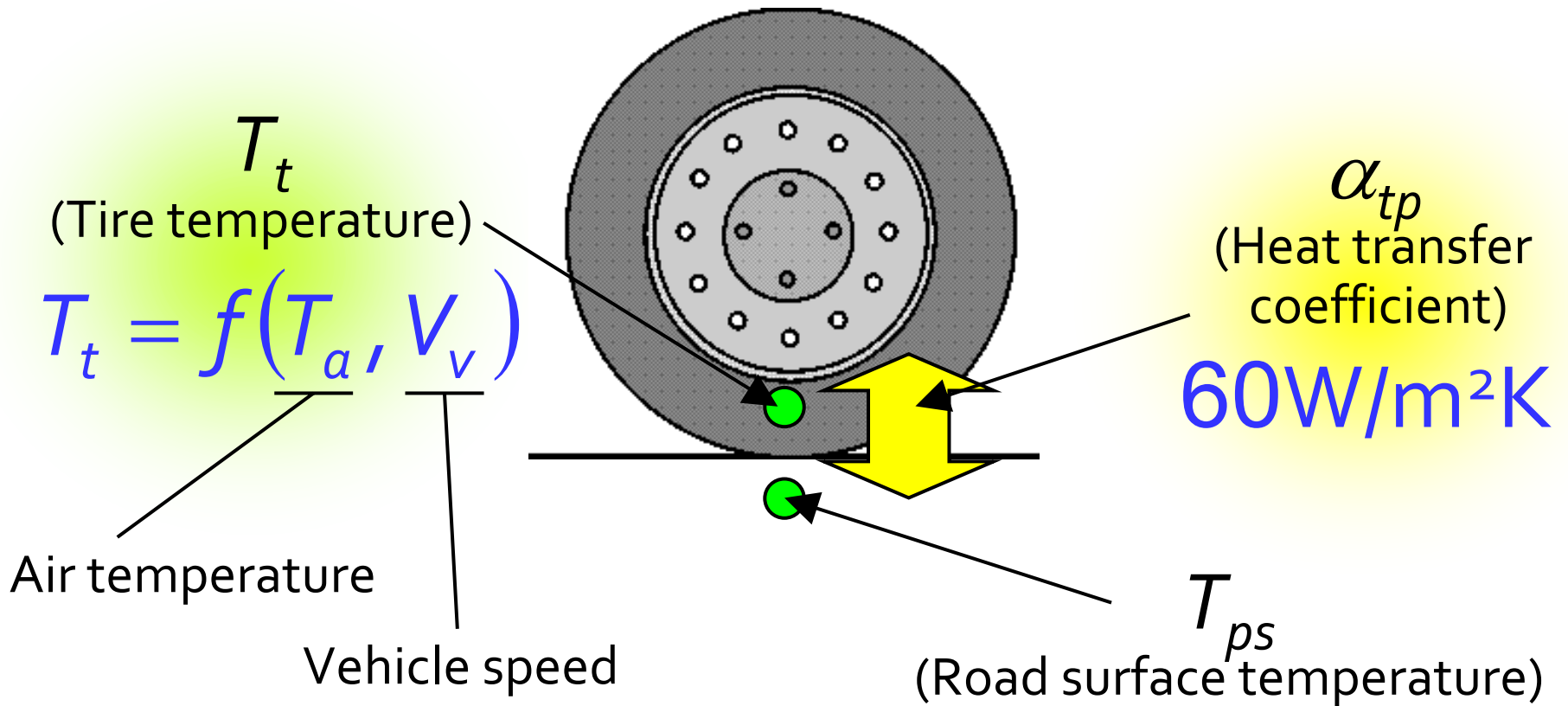
◆ Vehicle heats



◆ Tire frictional heat

Newton's law of cooling

$$S_t = \alpha_{tp} (T_t - T_{ps})$$



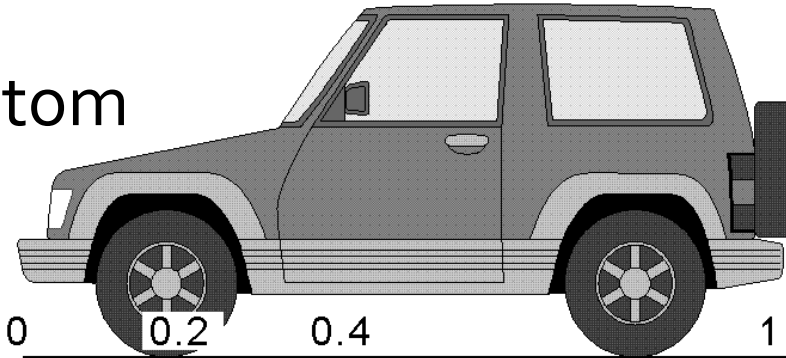
◆ Vehicle radiant heat

Stefan-Boltzmann law

$$R_v = \varepsilon_v \sigma (T_v + 273.15)^4$$

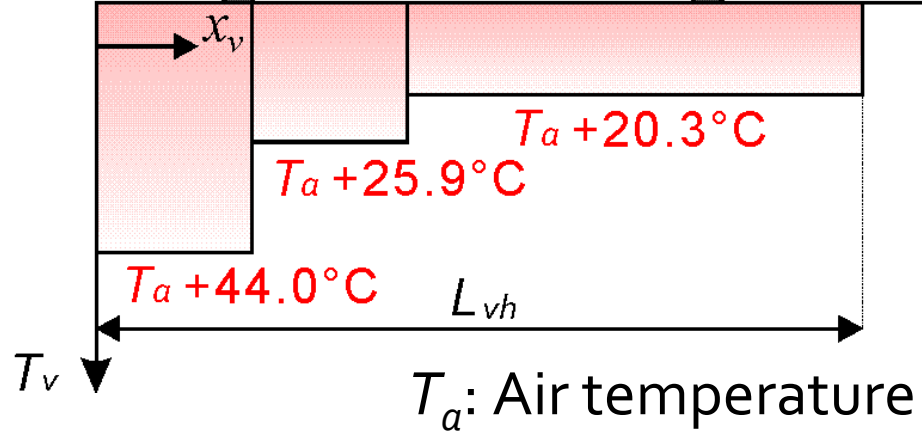
ε_v : Emissivity of vehicle

T_v : Temperature on bottom of vehicle



Temperature on the bottom of vehicle

$$T_v = f(T_a)$$



◆ Vehicle sensible heat



Newton's law of cooling

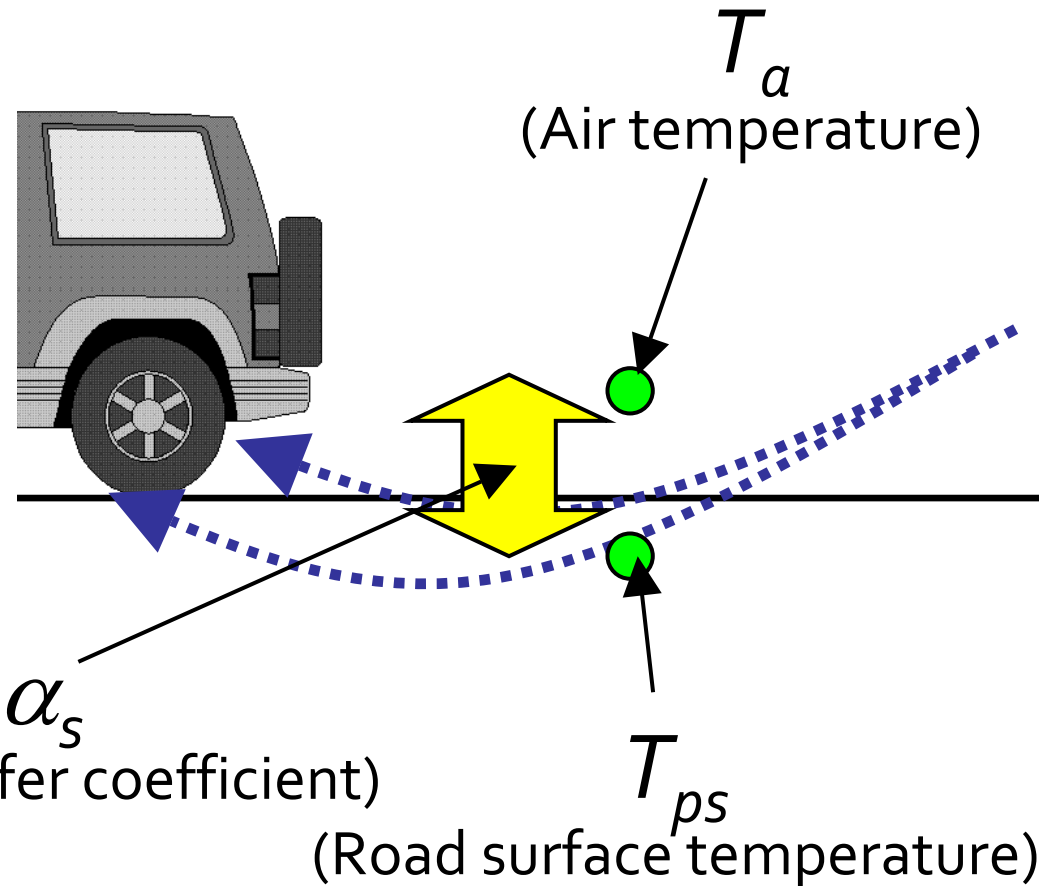
$$S_{va} = \alpha_s (T_a - T_{ps})$$

$$\alpha_s = 10.4V_w^{0.7} + 2.2$$

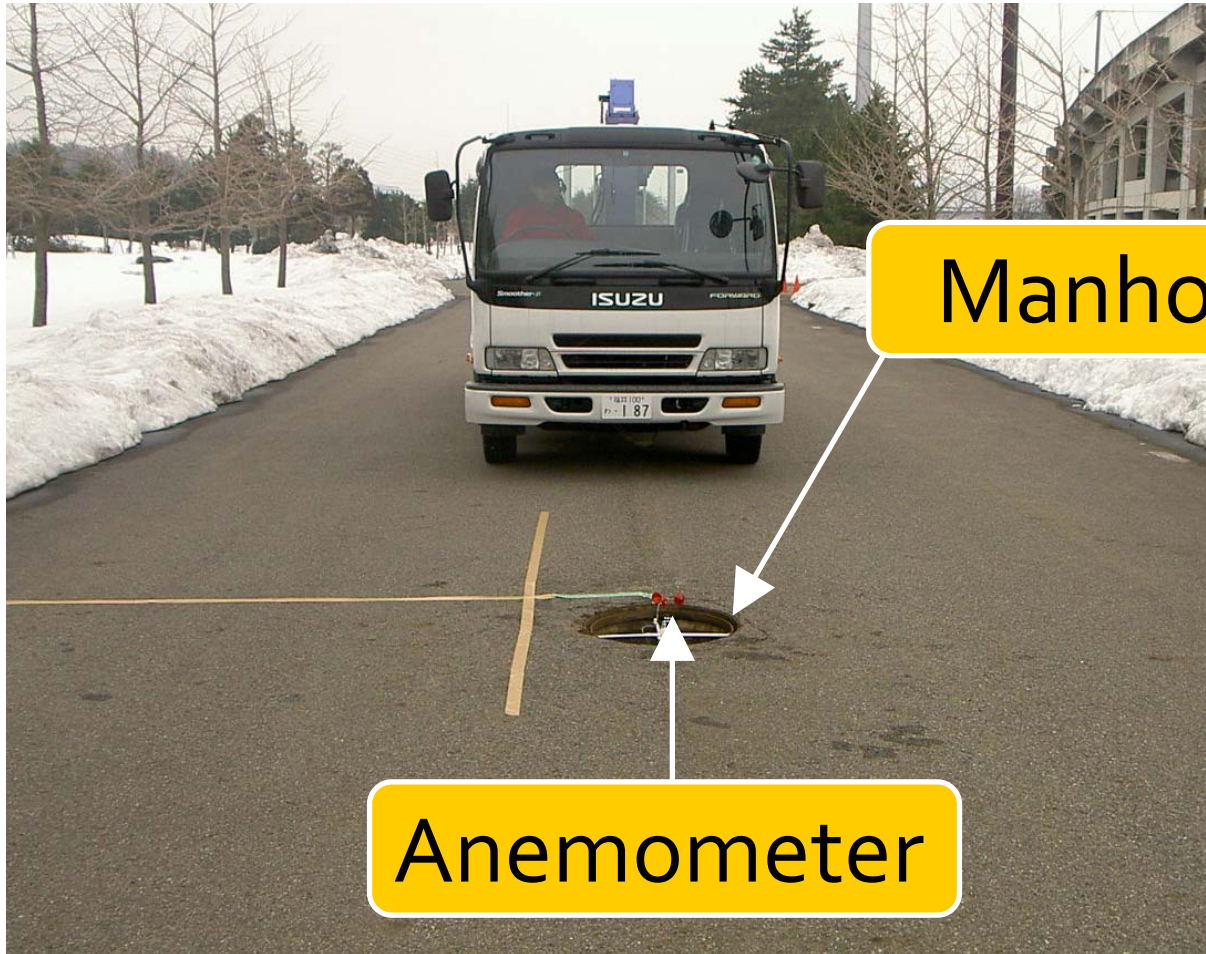
Vehicle induced
wind velocity

(Heat transfer coefficient)

(Road surface temperature)



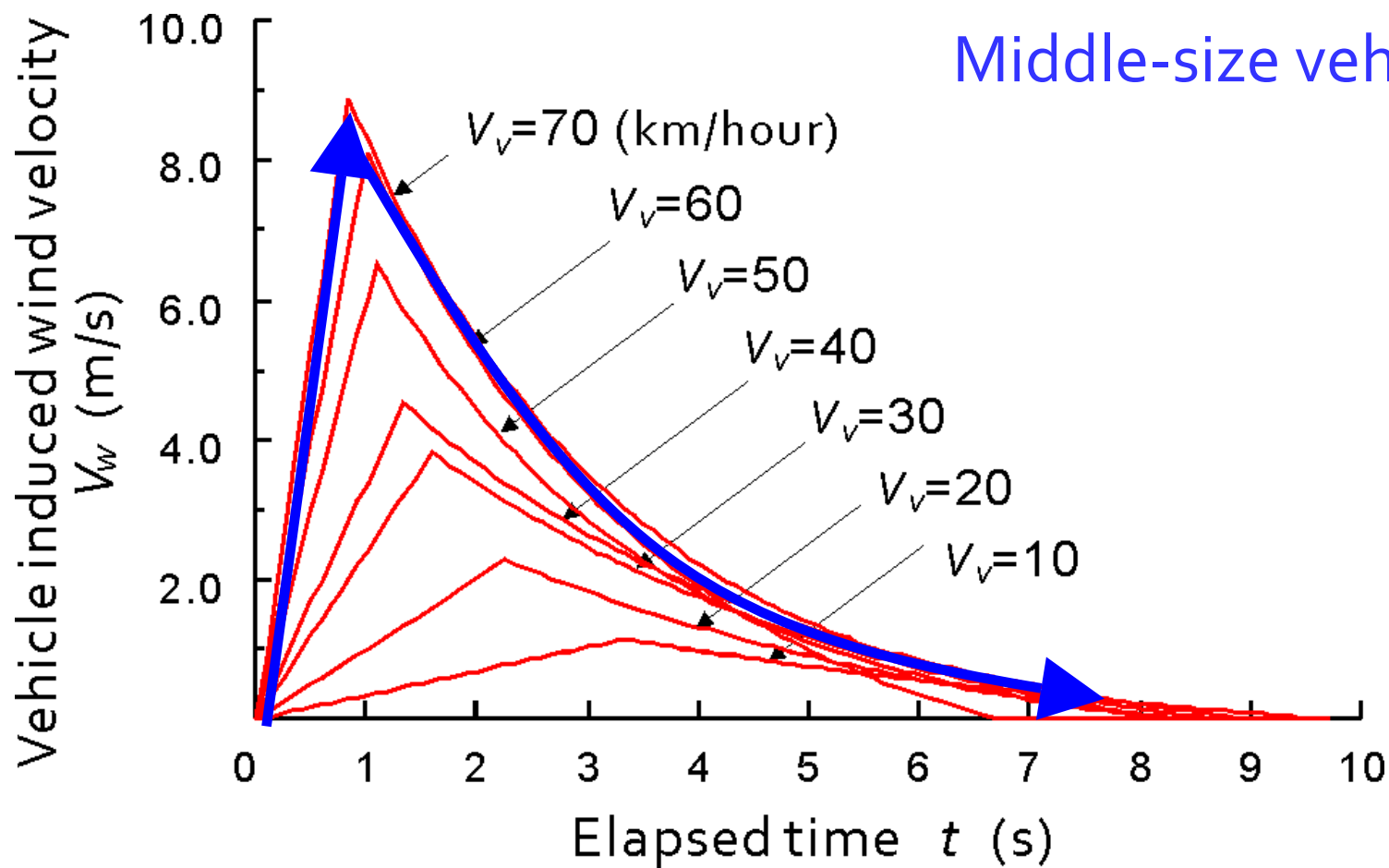
◆ Vehicle induced wind



◆ Vehicle induced wind

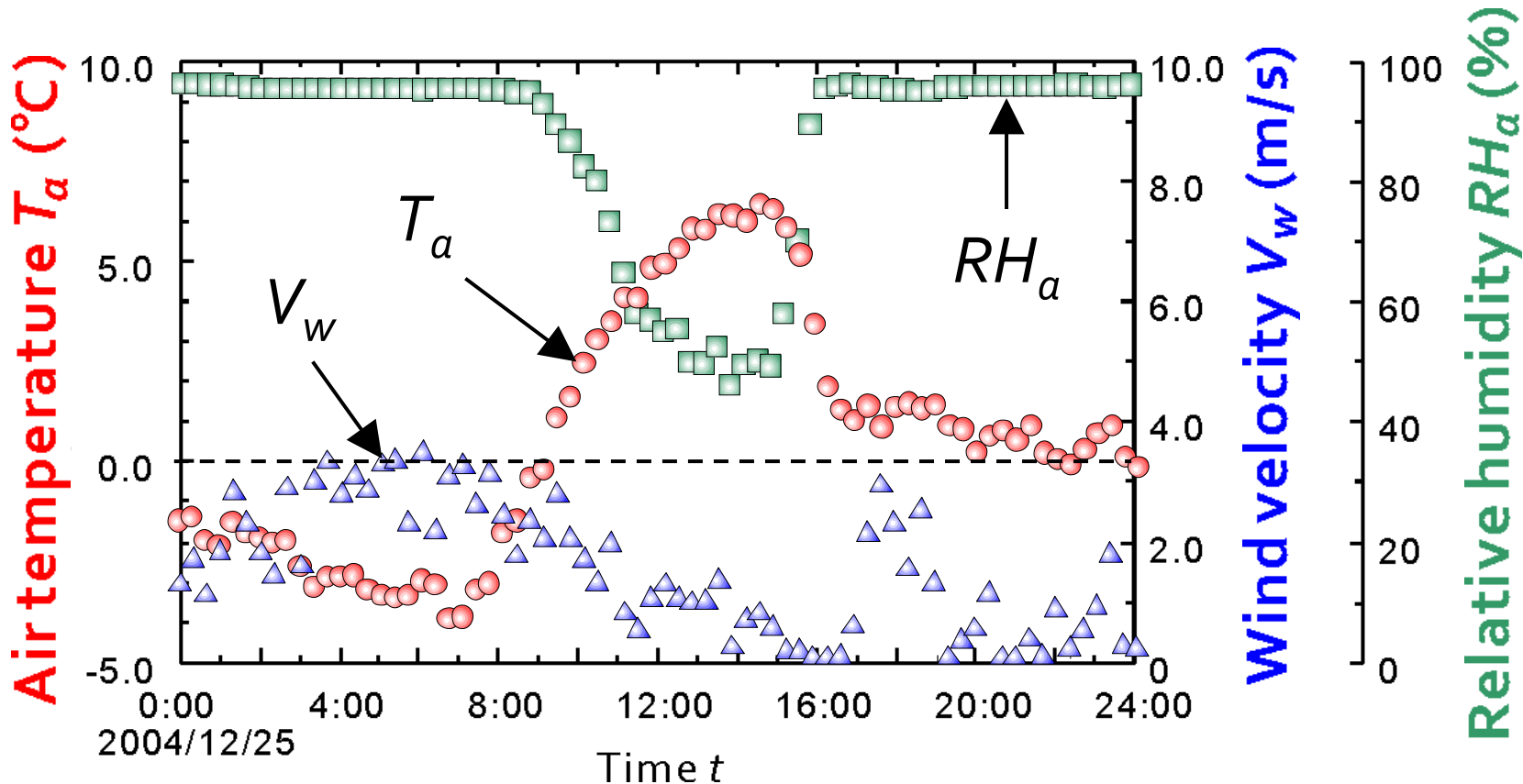


Middle-size vehicle

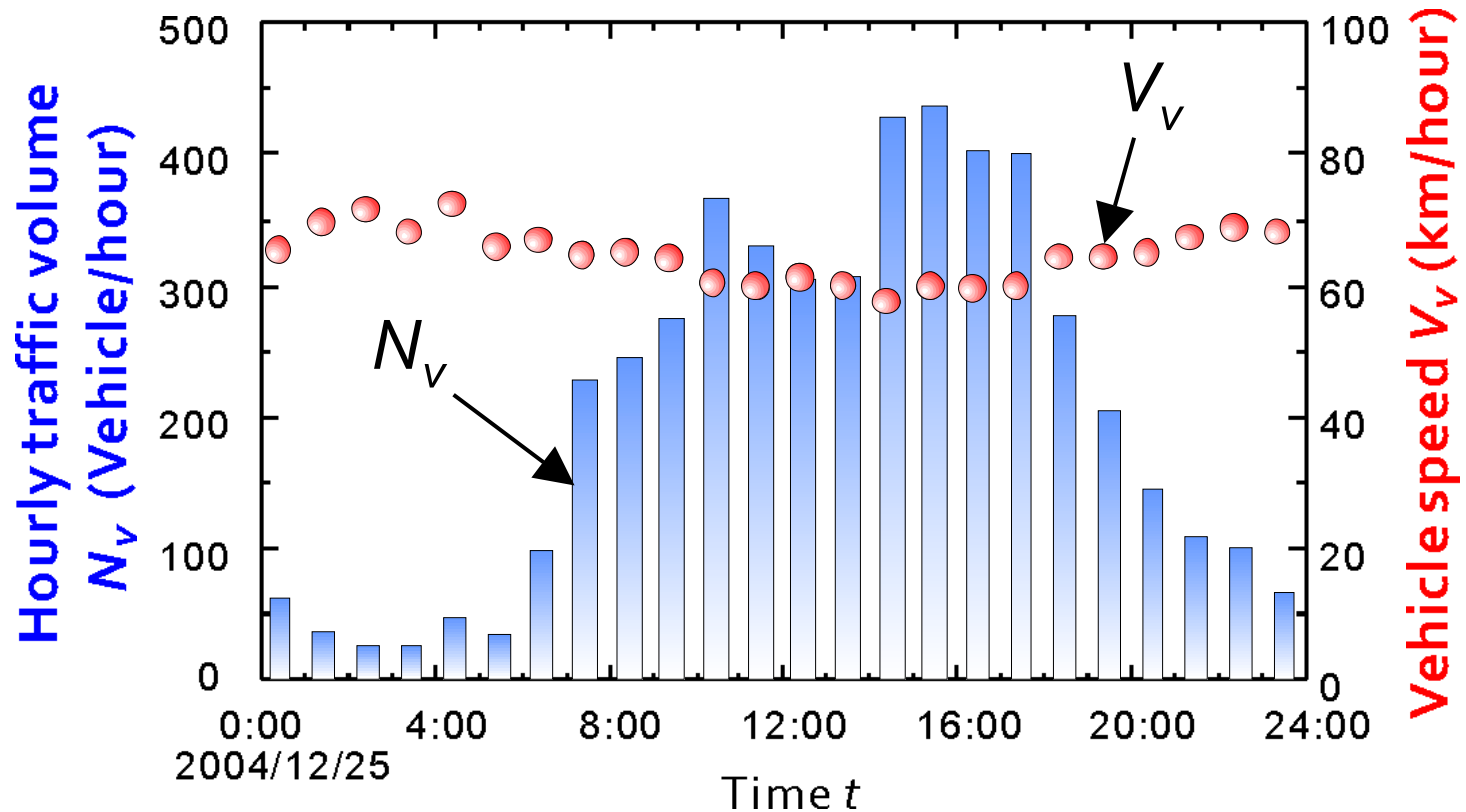


V_v : Vehicle speed

◆ Weather conditions for numerical simulation



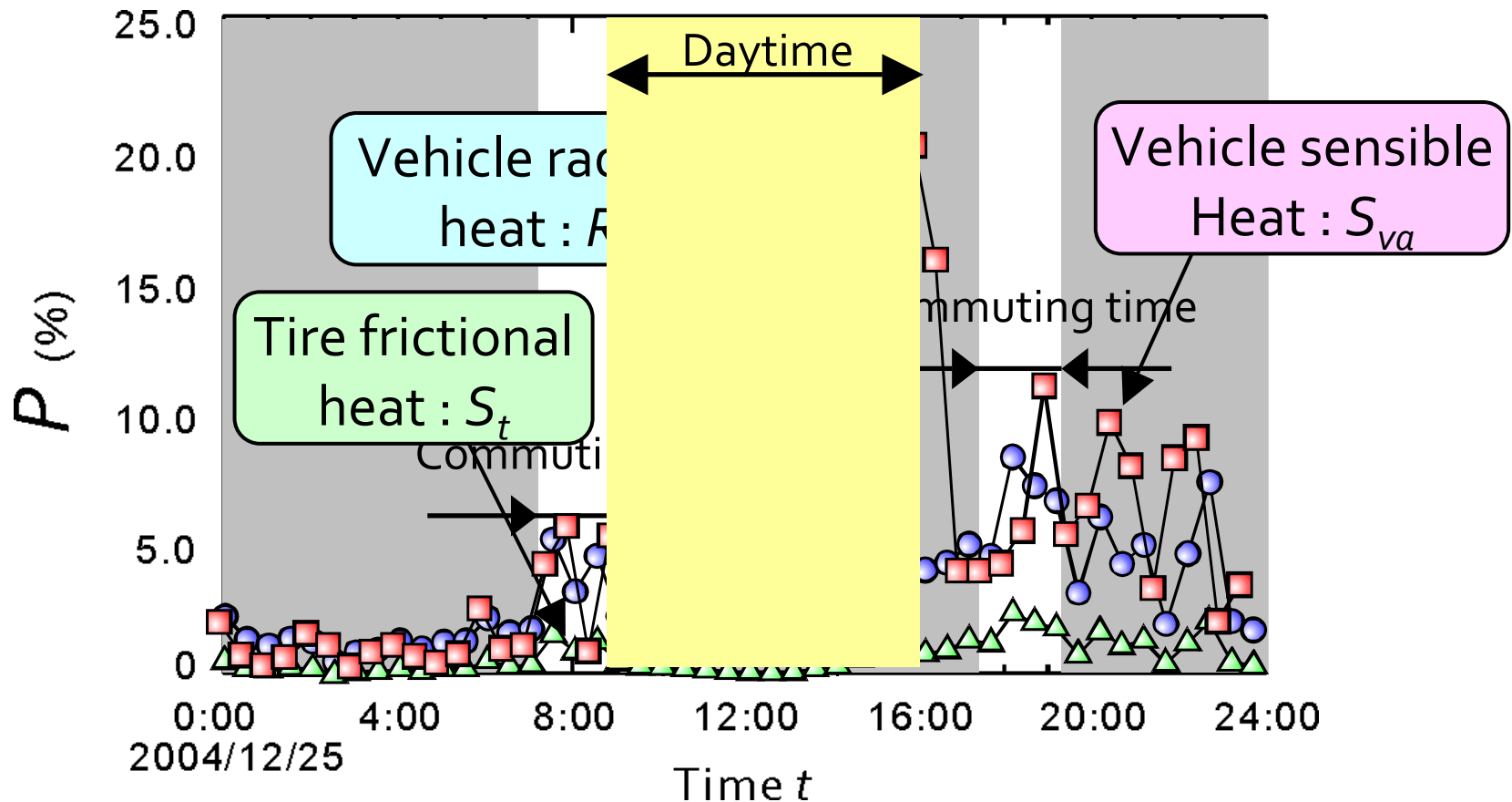
◆ Traffic conditions for numerical simulation



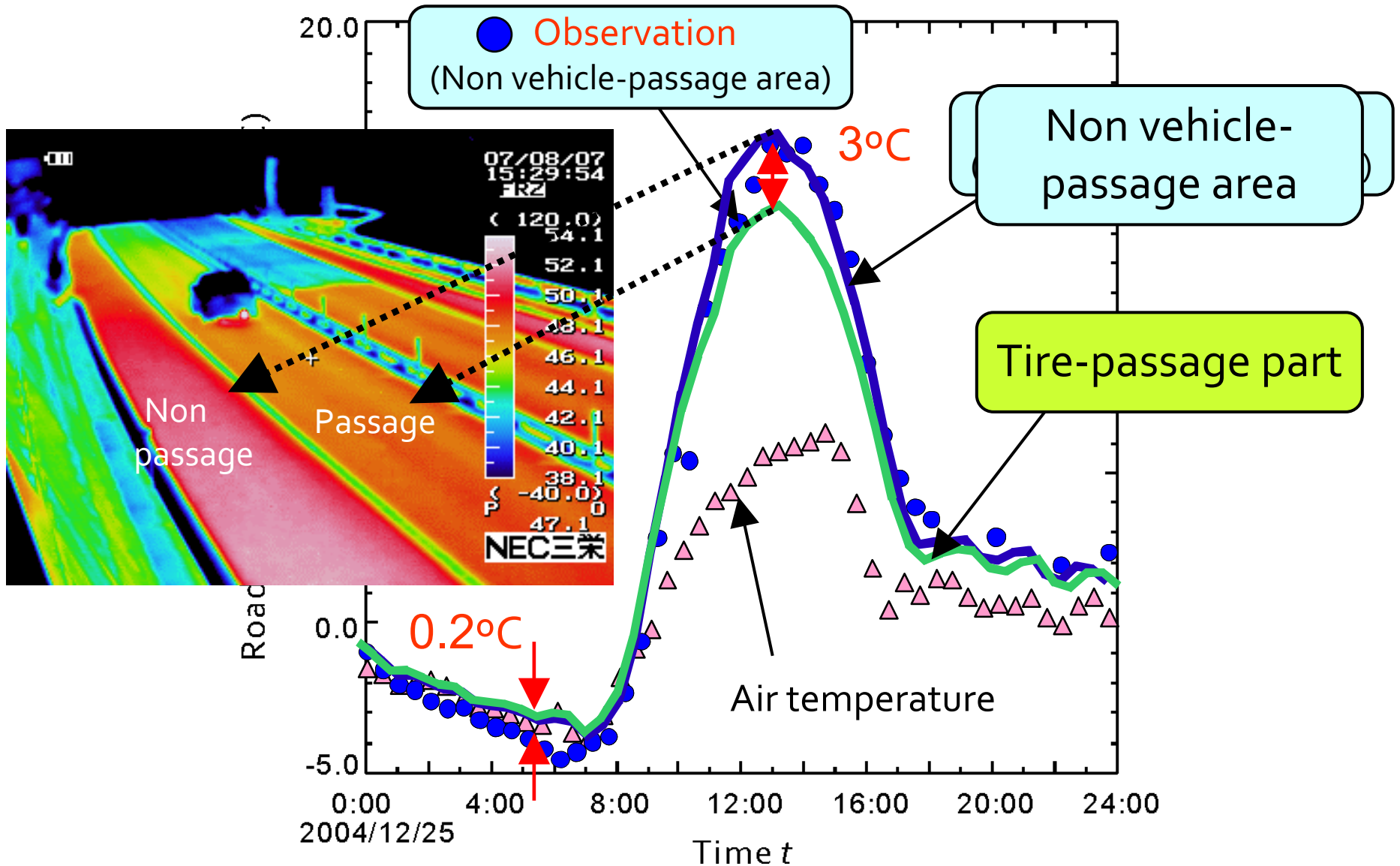
◆ Thermal effects of vehicles



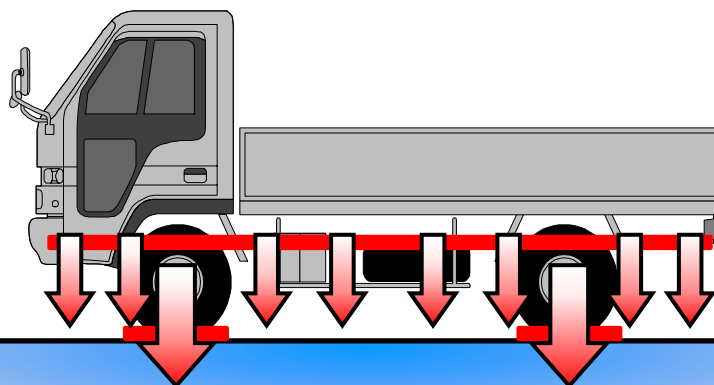
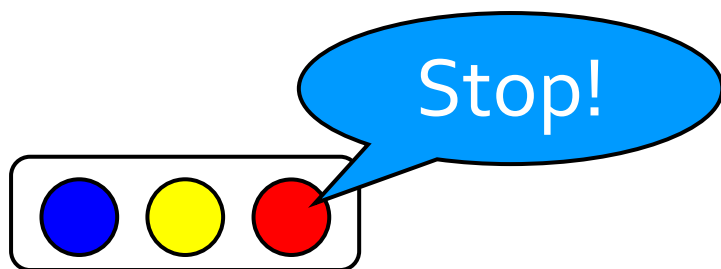
$$P = \frac{\text{Vehicle heat } (S_t \text{ or } R_v \text{ or } S_{va})}{\text{Total heat}}$$



◆ Road surface temperature



◆ Effect of vehicle heats on snowy road



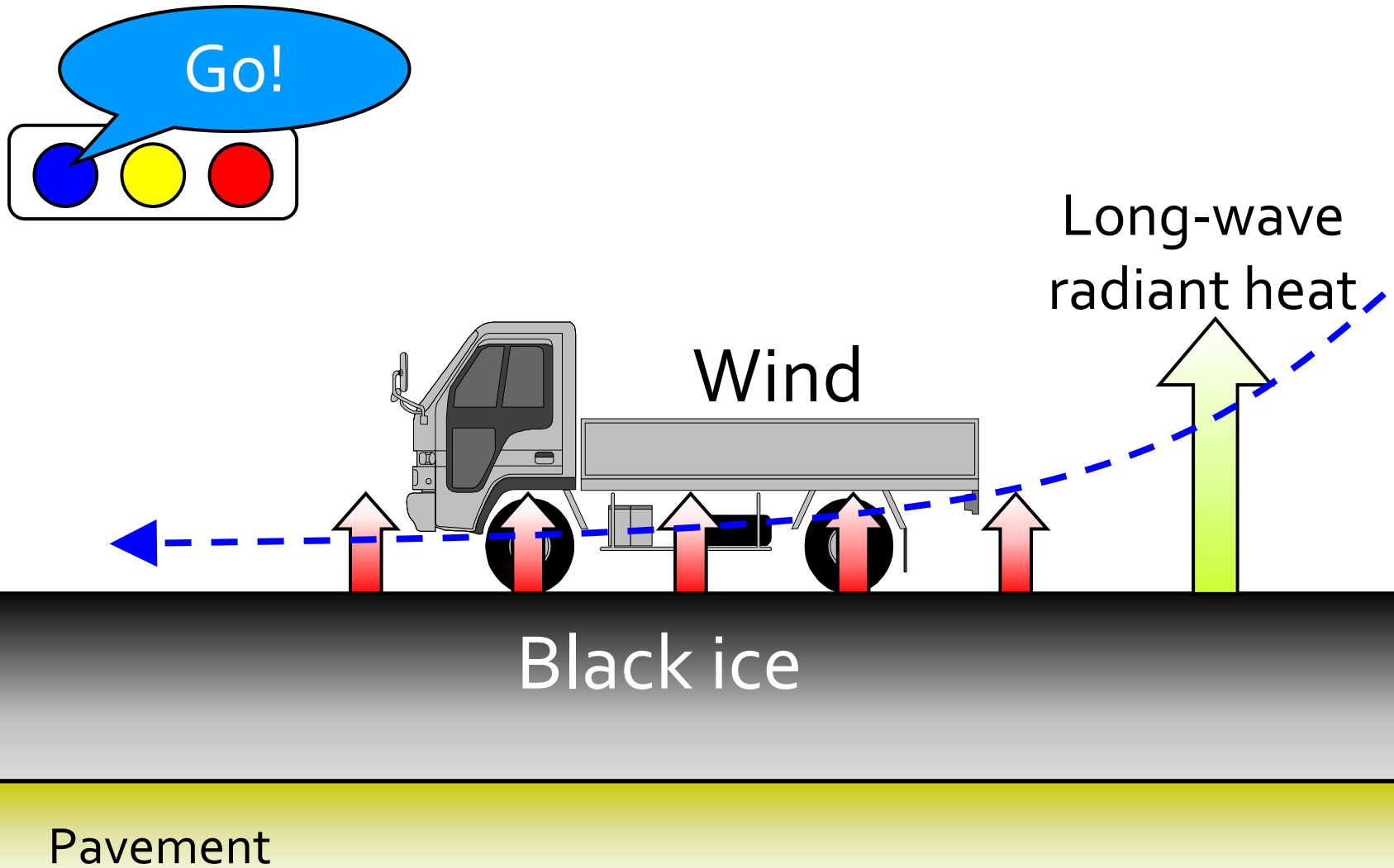
Dry snow

Melting

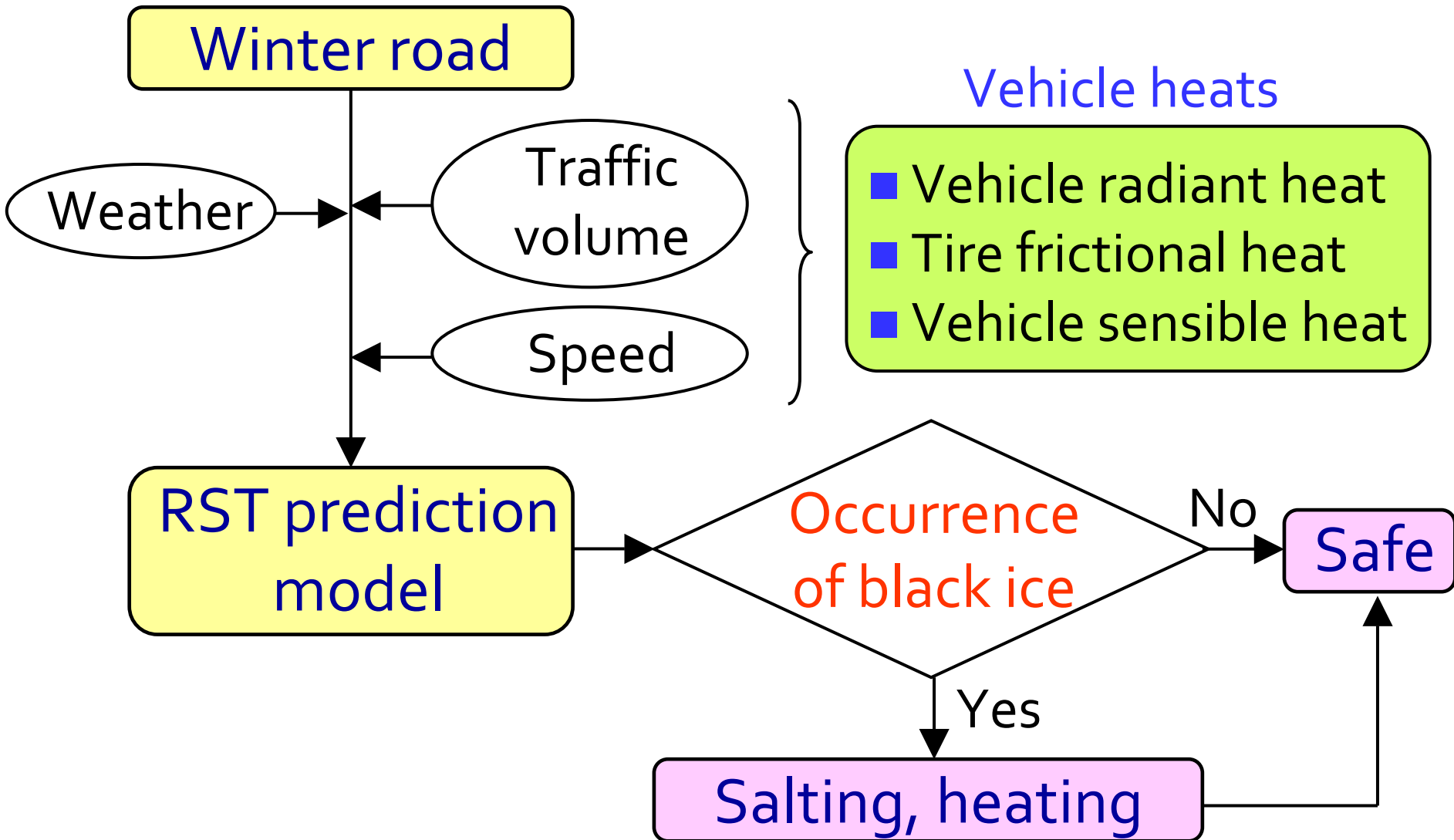
Heat gain

Pavement

◆ Effect of vehicle heats on snowy road



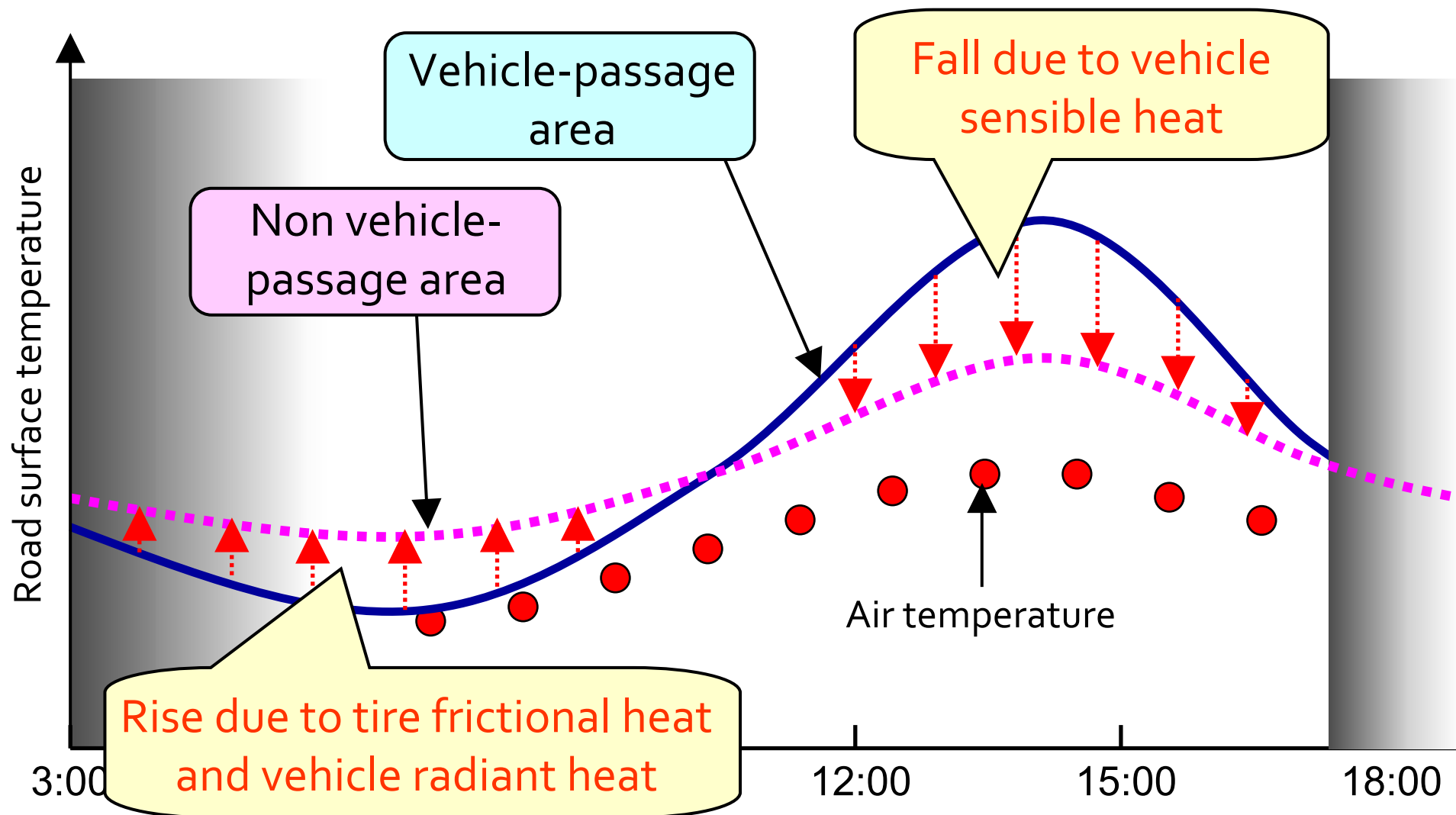
◆ Conclusions and future perspectives





Thank you very much
for your kind attention.

◆ Typical example of thermal effect of vehicle



◆ Heat balance



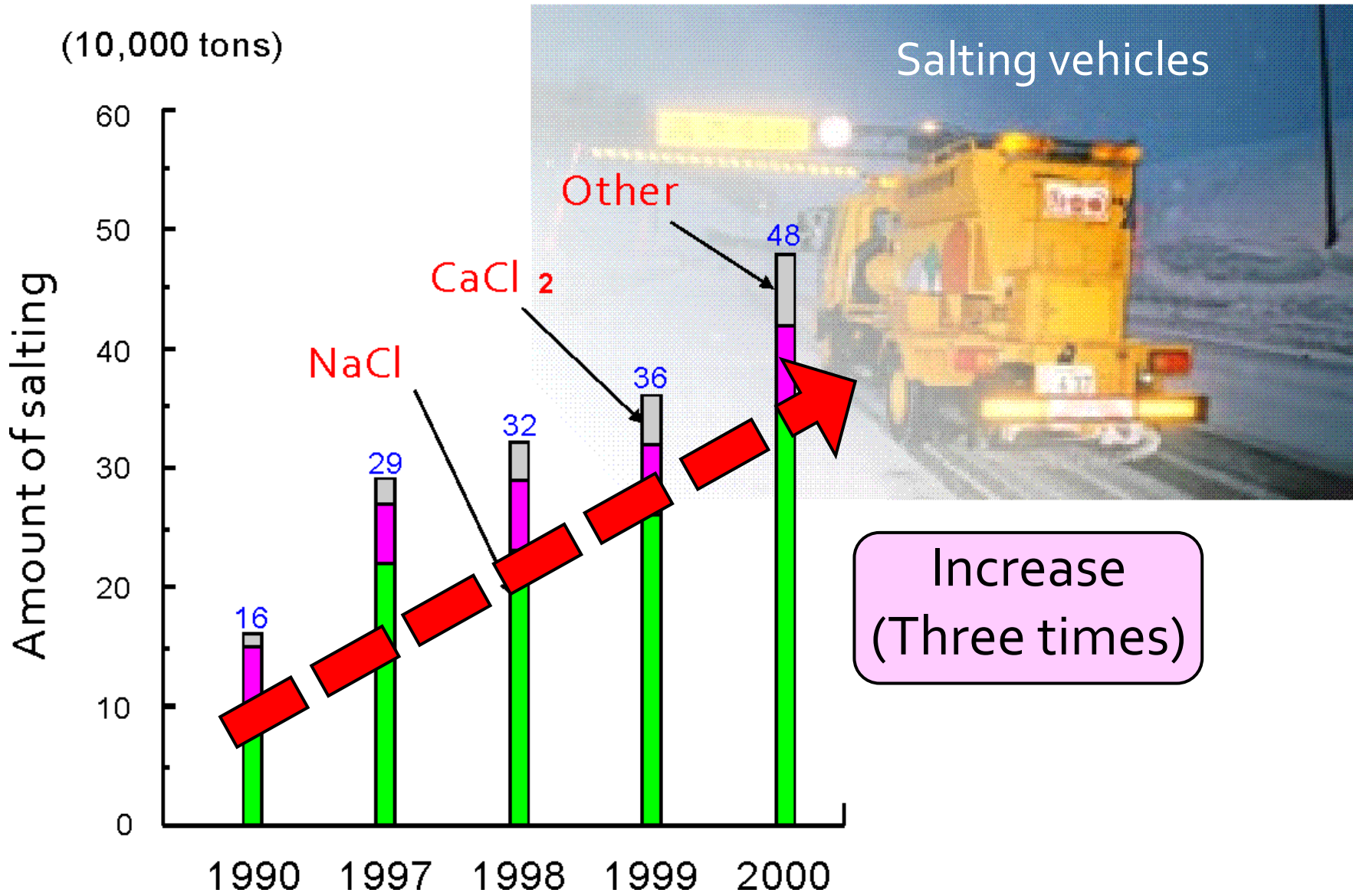
$$\underbrace{(\rho c)_p \frac{\partial T_{ps}}{\partial t} \Delta z_s}_{\text{Internal energy}} = \underbrace{G + R_{nl} + R_{ns} + S_a + L}_{\text{Natural factors}} + \underbrace{+Q_v}_{\text{Vehicle heat}}$$

Internal energy

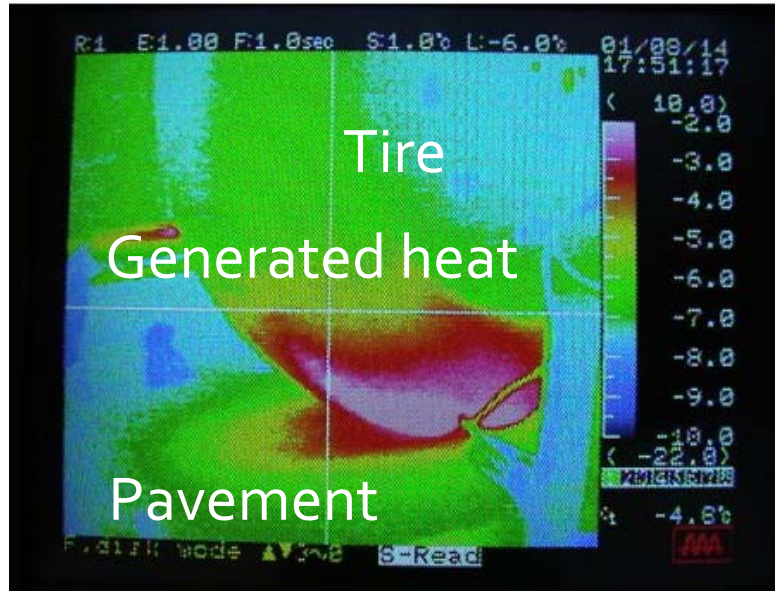
Natural factors

Vehicle heat

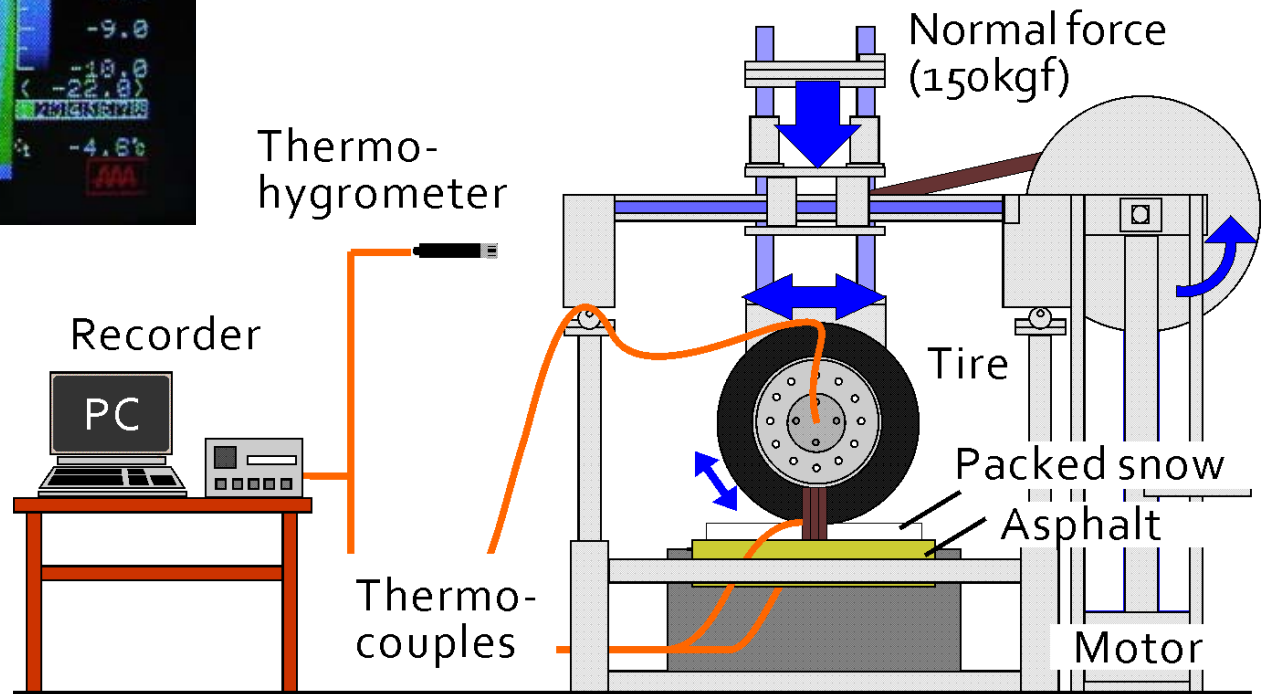
◆ Amount of salting



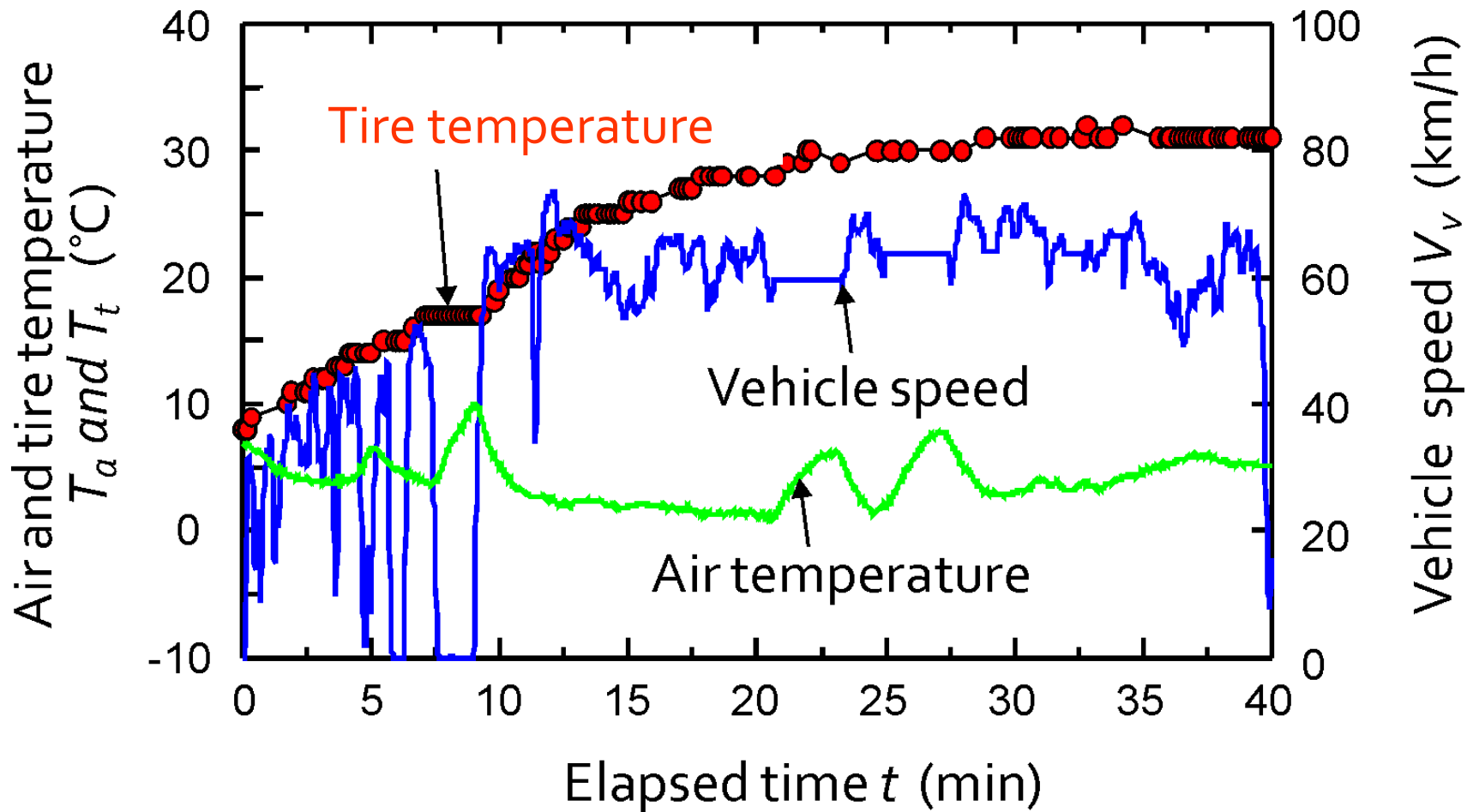
◆ Heat transfer coefficient between tire and road



Constant temperature room



◆ Tire temperature



$$T_t = f(T_a, V_v)$$

$$V_w = V_{wmax} \exp\{-b(t_v - t_{vmax})\} - c(t_v - t_{vmax}) \quad (t_{vmax} \leq t_v \leq t_{v0})$$

◆ Quantification of vehicle induced wind

