The SURFEX/TEB new road model with traffic effects: Validation and operational plans

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PLAN

- **Introduction**
  - Represent cold conditions in an urban model for multiple purposes

- **Natural process modeling**
  - **Method :** Ice and snow modeling in TEB
  - **Experiment and results :** Col de Porte in France

- **Anthropic process modeling**
  - **Method :** Traffic modeling in TEB
  - **Experiment and results :** Nupuri road weather station in Finland

- **To go further**

Represent cold conditions in an urban model for multiple purposes

- Physiographic parameters (Countryside, urban...

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- Road or runaway parameters

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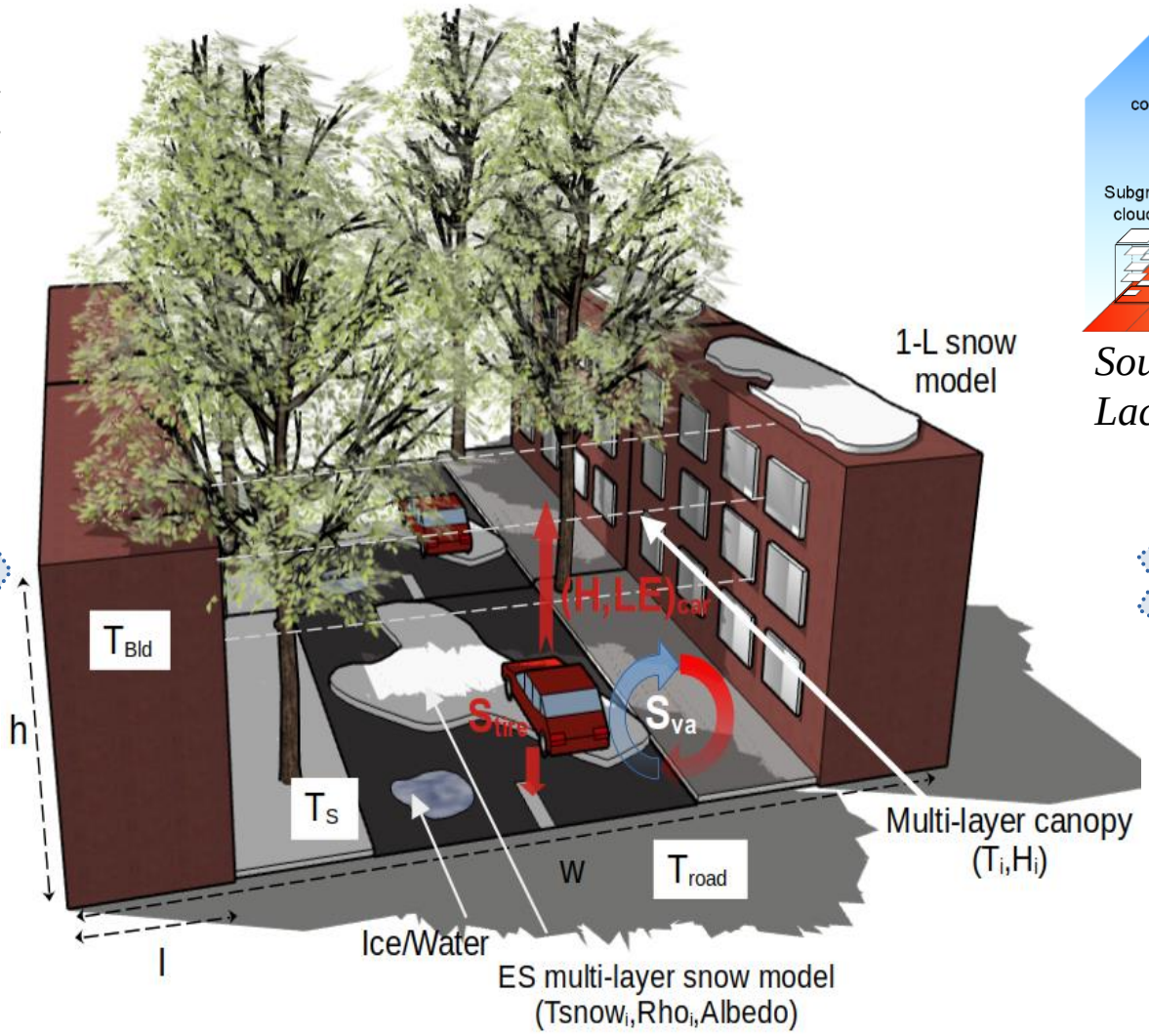
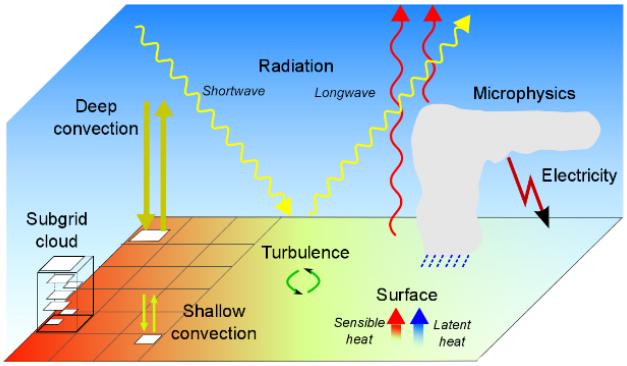
- Atmospheric and traffic conditions

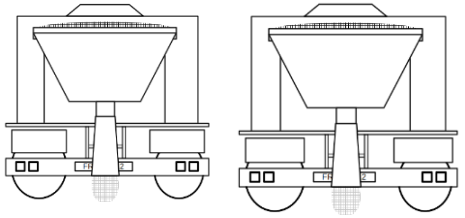


Improved SURFEX-TEB v9.0 model with a multi-layer snow model, ice and traffic

Urban behavior / Better flux modeling



Source : Meso_nh, extracted from Lac et al 2018.



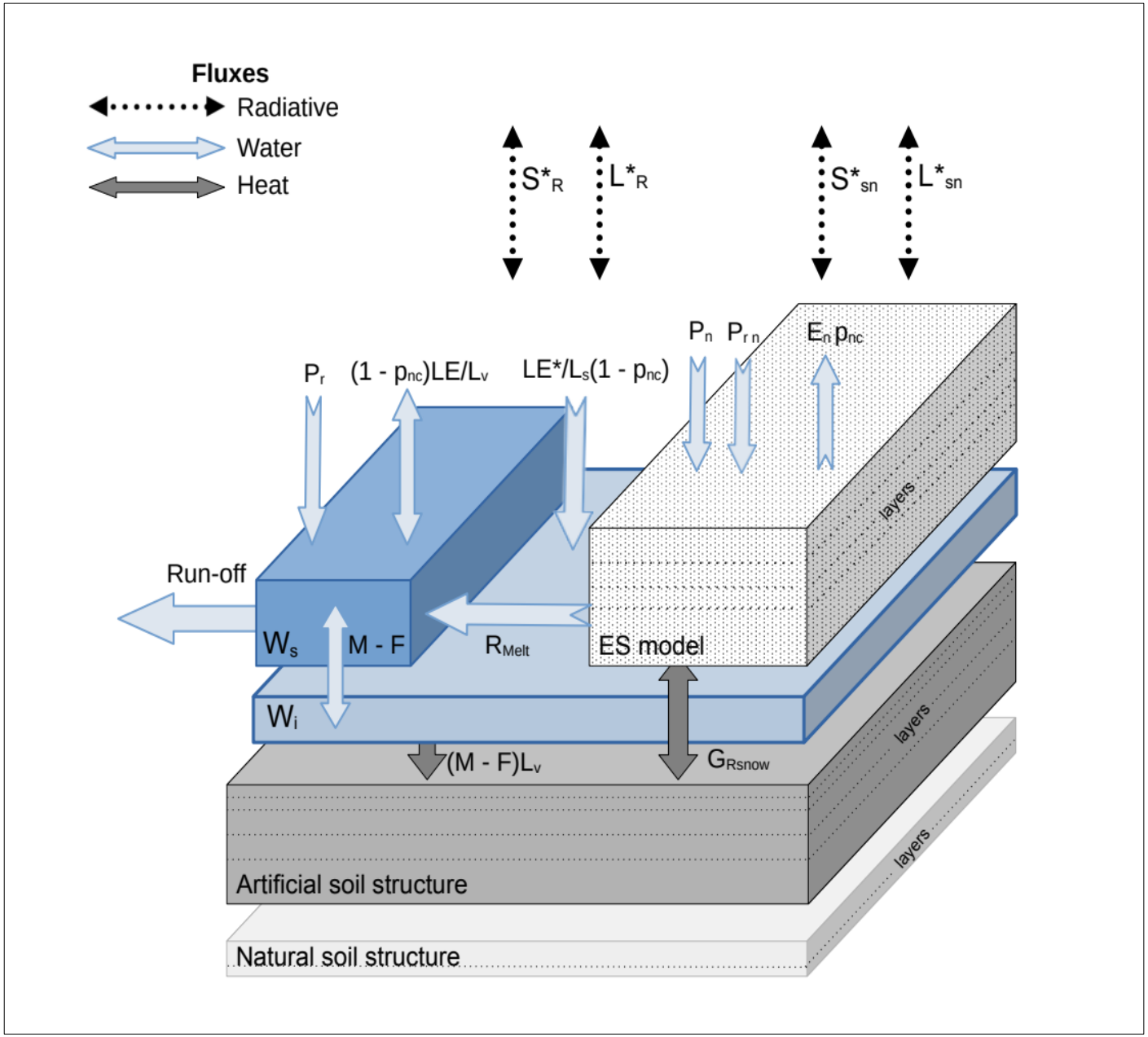
Road weather system

Ice and snow process implementation in TEB (TEB-ES)

Ice and snow implementation

- **Add ice content Wi**
- **(in light blue) on the road**
- **to represent icy conditions**
  - Interaction with the water
  - content Ws (in blue)
  - with melt and freeze
  - processes and its impact on
  - road energy budget, and
  - atmosphere

- **Coupling the road with an**
- **explicit multi-layer model**
- **scheme (ES-Model in white)**
  - Water balance with
  - Ws and energy
  - balance with the road
  - and atmosphere



Schematic implementation of the ice content Wi in light blue, the ES model in white and their interactions. Extracted from colas et al. 2024 (under review)

Evaluation at the Col de Porte site with the GELCRO campagin measurements (1998-1999)

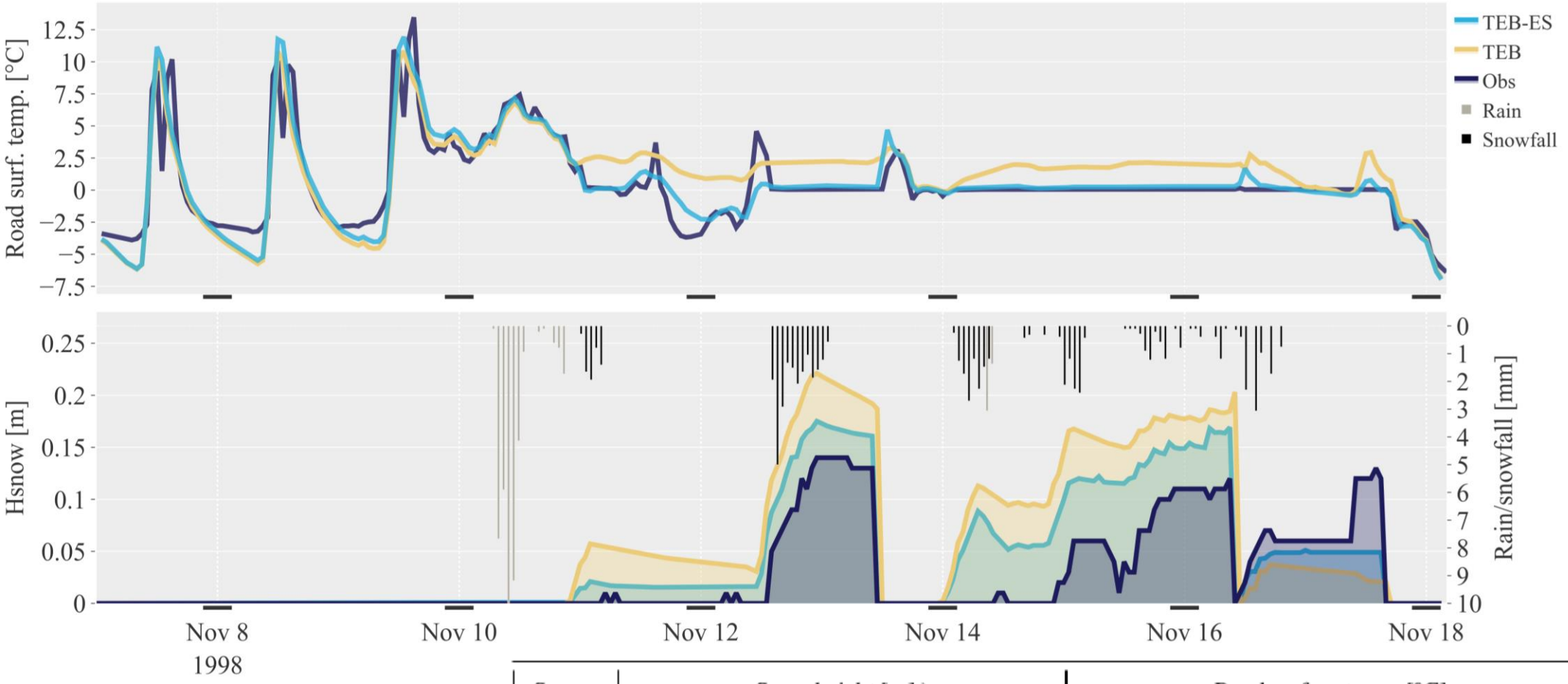
Experimental set-up

- Observations and validation data from the
- 1998/1999 campaign :
  - Forcing from weather station CDP :
  - (Rain/snow intensity,
  - LW, SW, Air temperature,
  - HUmidity)
  - Evaluation with snow height and
  - surface temperature from the campaign

- Hand snow removal
- Building from TEB removed for clear-road
- evaluation
- Comparison with french road
- weather model (ISBA-ROUTE)

Col de porte experimental artificial soil during the GELCRO campaign. Extracted from Bouilloud and Martin 2006

Results : TEB-ES and TEB simulations compared with Col de Porte observations



Scores	Snow height [m])			Road surface temp. [°C]			
Models	TEB	TEB-ES	ISBA-Route/CROCUS	TEB	TEB-ES	ISBA-Route/CROCUS	MLR
RMSE	0.19	0.13	0.14	2.82	2.05	2.53	3.64
MAE	0.12	0.08	0.09	2.10	1.33	1.40	2.45
R^2	0.54	0.84	0.80	0.82	0.89	0.83	0.57

- Snow height better modeled with TEB-ES than TEB.
- Significant improvement of road surface temperature under snowy conditions.

TEB, TEB-ES, ISBA-ROUTE and MLR results compared to the Col de Porte observations during winter 1998. Extracted from Colas et al. 2024 (under review)

Traffic modelling in TEB (TEB-CAR Option)

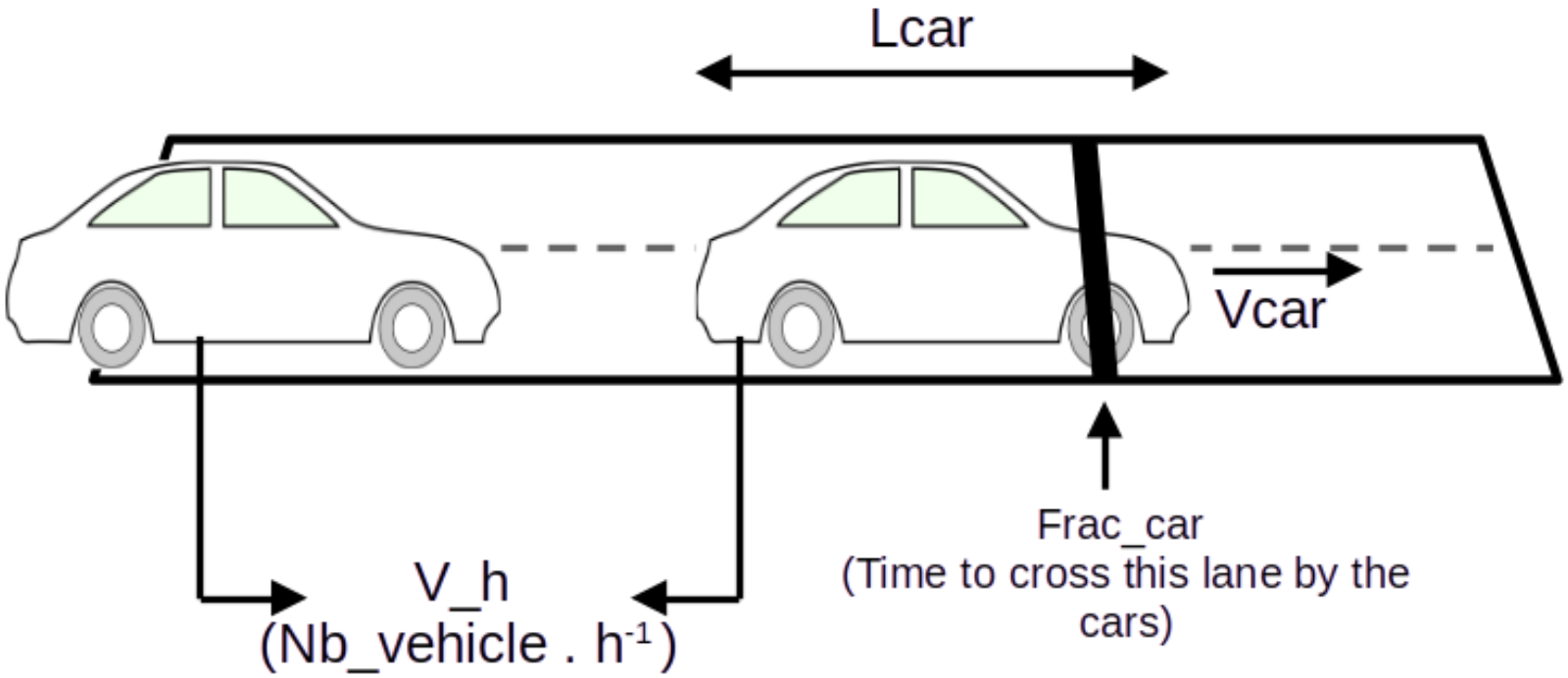
Compute number of vehicle per hour (V/h)

$$V_h = V_{moy} V_{mod} \quad (1)$$

Number vehicle per hour (V/h)

Mean Number vehicle per hour (V/h)

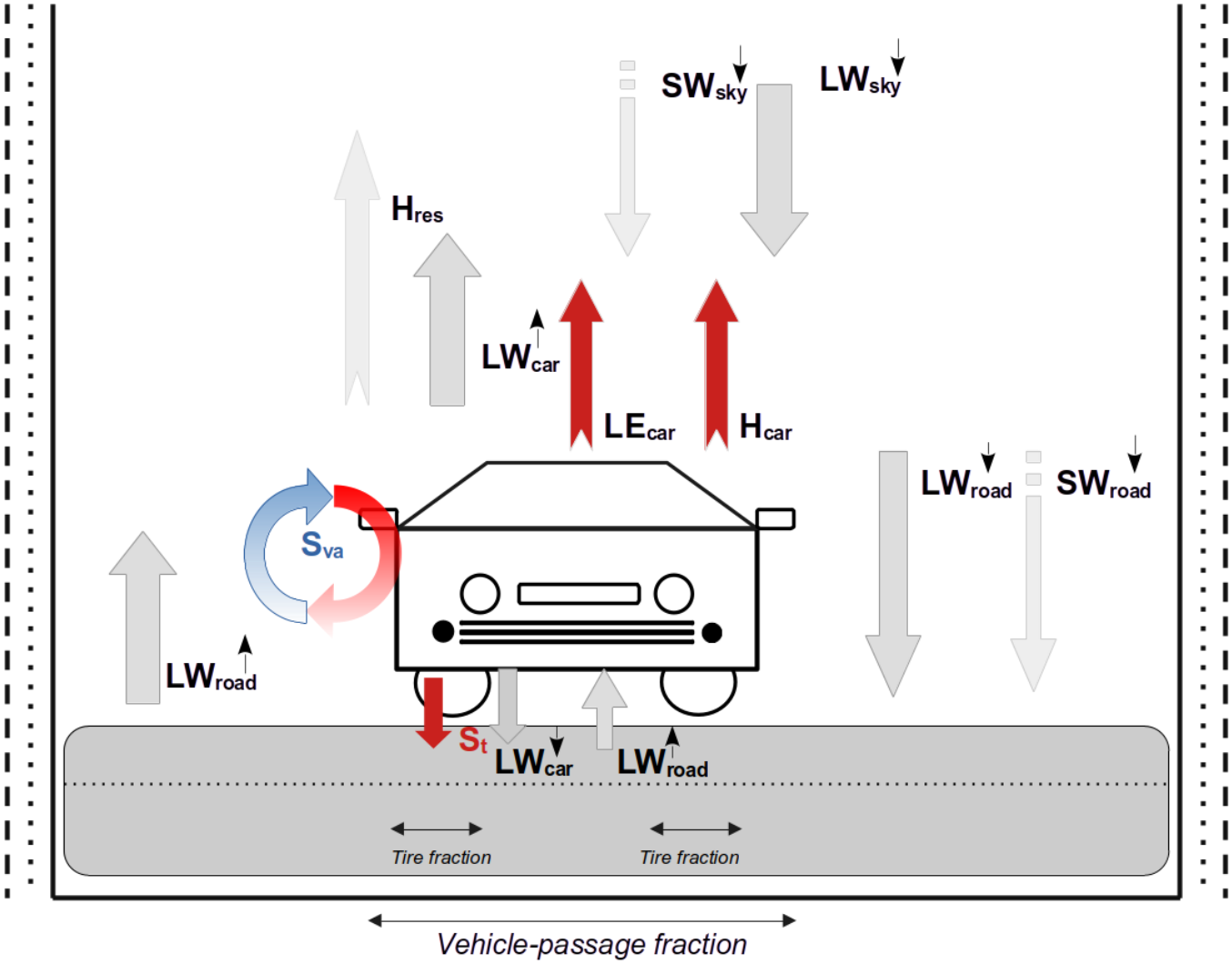
V_mod (Value/24h) = Mean Number vehicle per hour modulation



Traffic modelling in TEB (TEB-CAR Option)

- **Model the vehicles process inside the urban canyon :**

- Car shadowing and radiation impact on road and canyon surface components (window, walls).
-
- Tire friction heat on the road : S_t
- Turbulent heat change between the road and the canyon with passing vehicle : S_{va}
- Explicit sensible and latent heat from internal car energy (36kW) *Prusa et al. 2002 :* H_{car} LE_{car}



Energy balance scheme of a car, its impact on the road and the atmosphere

Evaluation in Finland road weather stations

Salo Hajala road weather station (2021) Street View

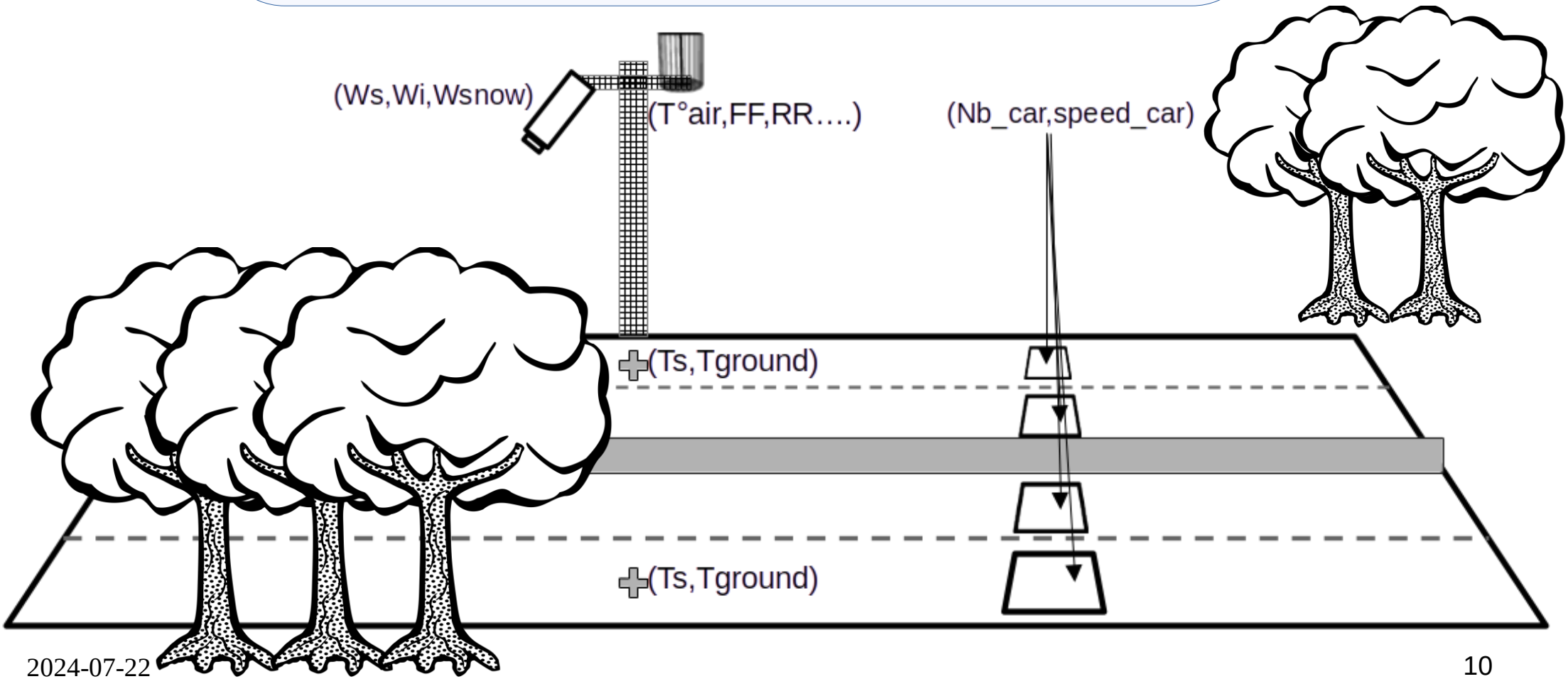
Simulations

- Location : Nupuri / Palojarvi / Lemijarvi
- Simulations :
  - Reference simulation without trafic
  - Simulation direction Helsinki
  - Simulation direction Turku

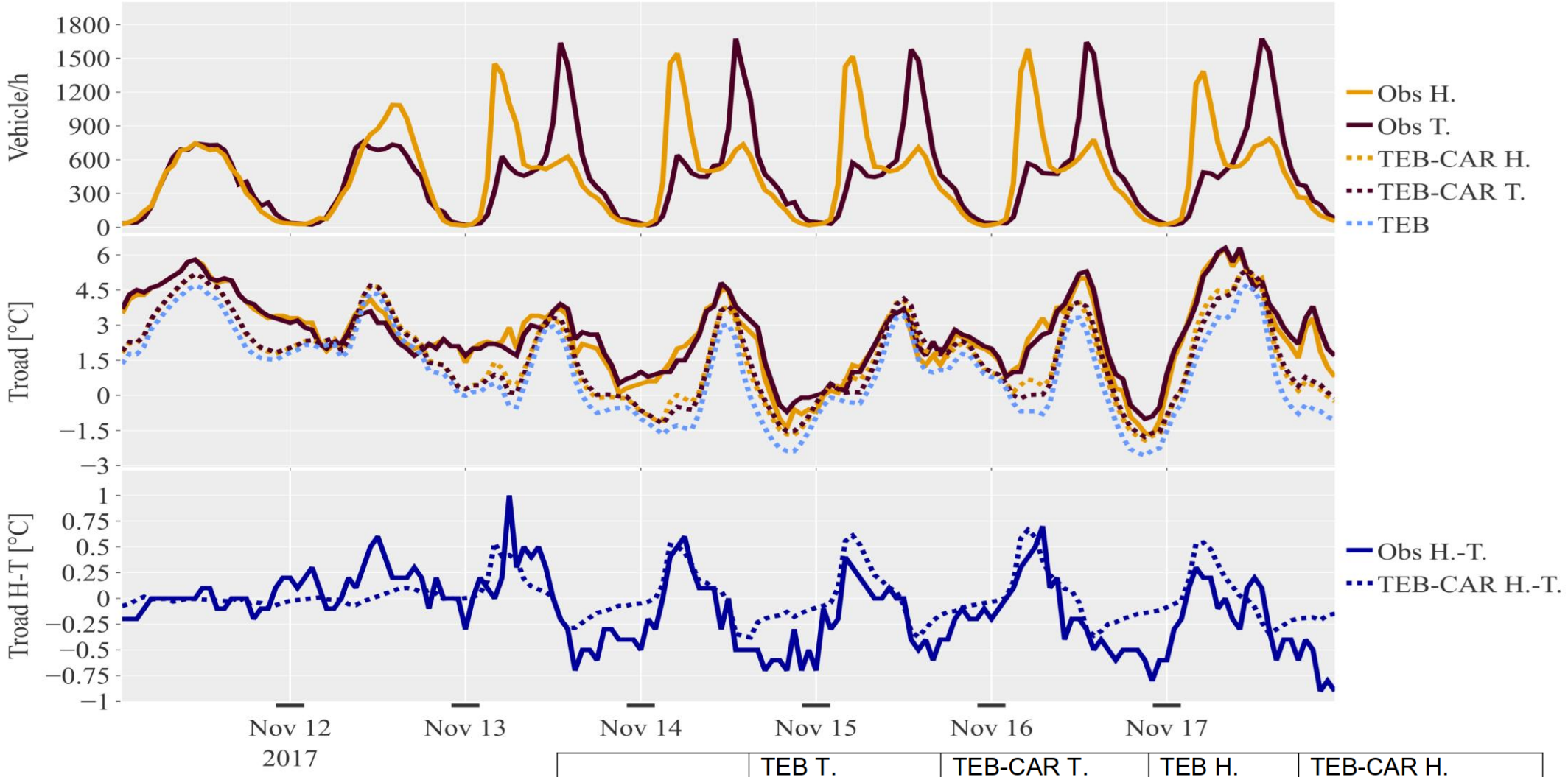
Evaluation in Finland road weather stations

Experimental set-up

- Observations : Road weather stations June 2017 – May 2018
  - and traffic
- Forcings : Snow/Rain intensity, Air temp, Humidity,
  - radiation data from ERA5 (SW et LW)
- Validation : Tsurf, Content Water/Ice/Snow
- Anthropic effects : Salting and traffic effects



Results : Comparison between TEB and TEB-CAR simulations at Nupuri Location

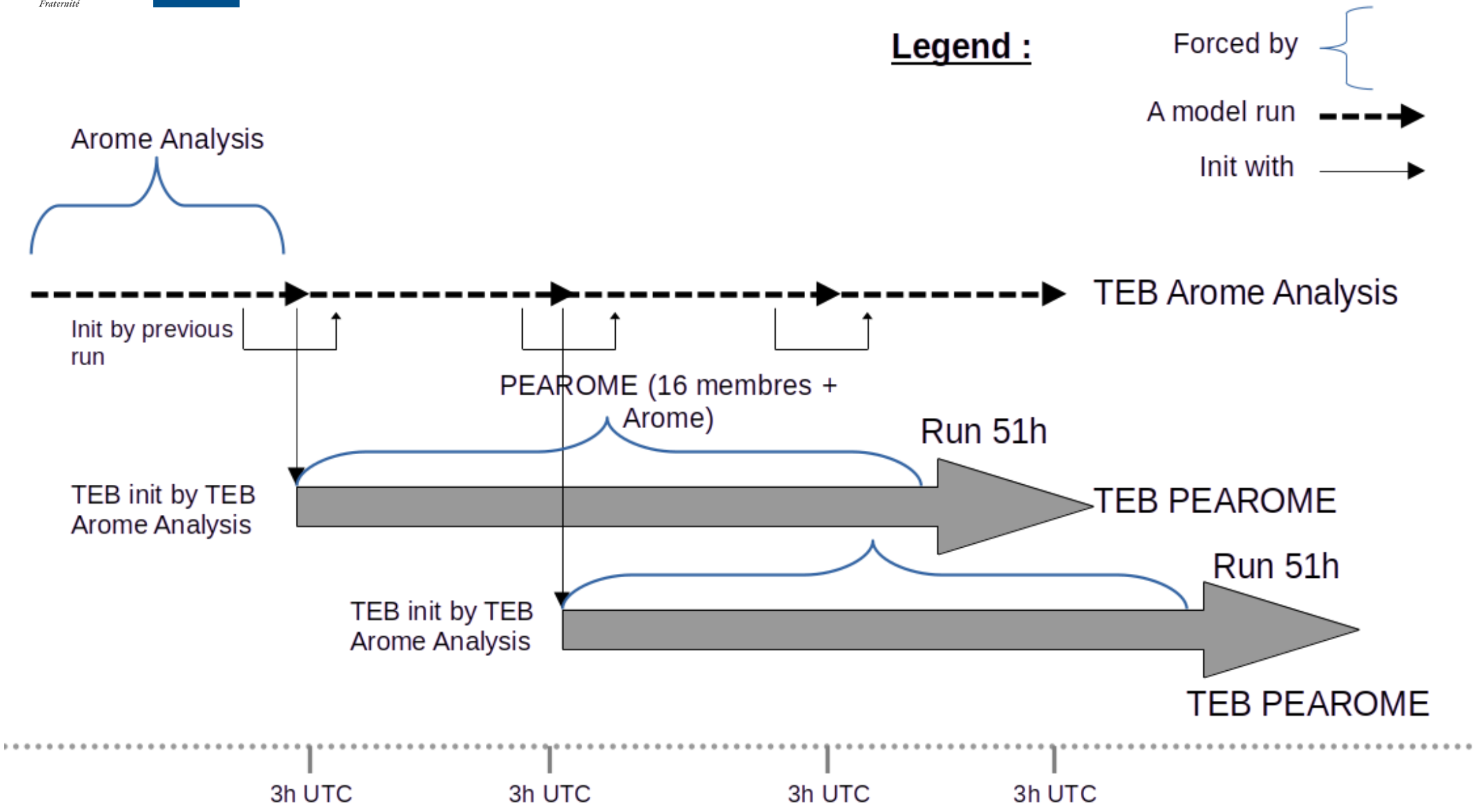


- Significant improvement of road surface temperature
- Consistent traffic impact with the observations

	TEB T.	TEB-CAR T.	TEB H.	TEB-CAR H.
RMSE	3.56	1.83	3.49	1.82
MAE	1.55	1.07	1.53	1.05
BIAS	-1.14	-0.66	-1.0	-0.51

Comparison of the road surface temperature simulations of TEB and TEB-CAR with the measurements on the lanes towards Turku (T.) and Helsinki (H.)

To go further : Ensemble forecast with TEB for operational purpose



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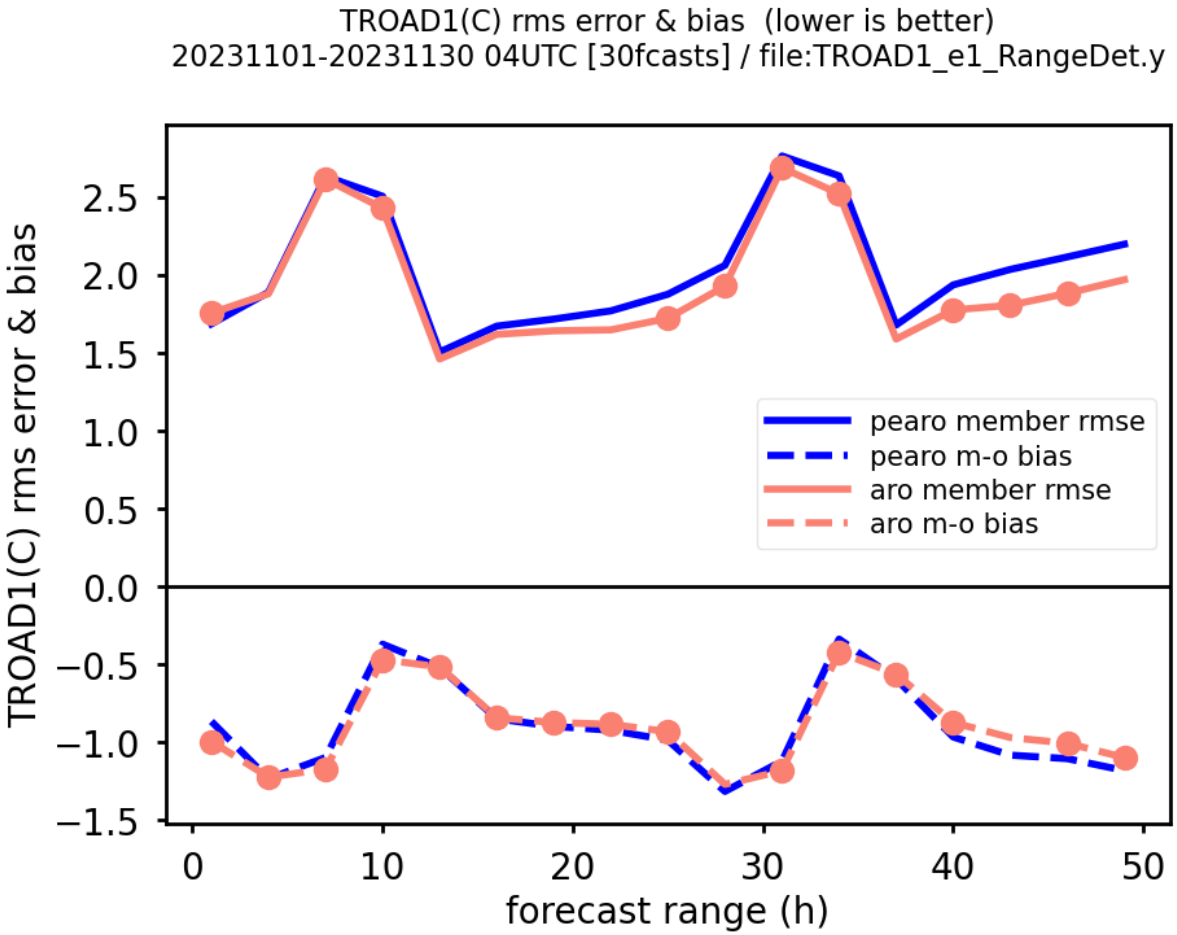
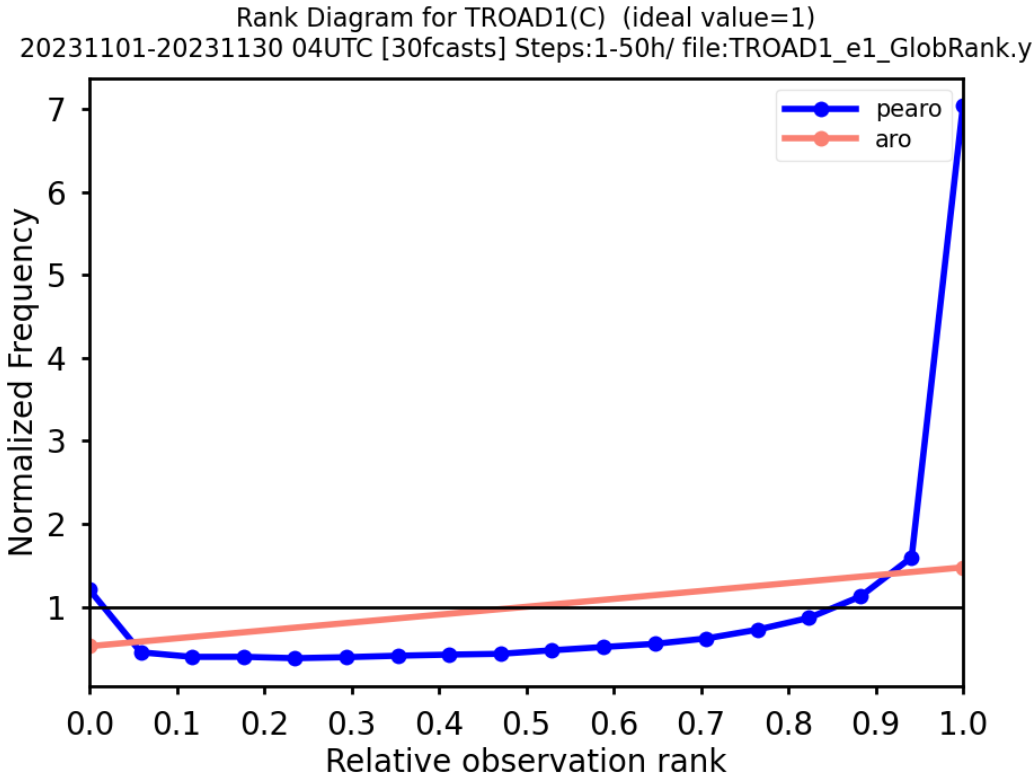


RMSE and Bias of road surface temperature with the road weather stations observations at France location for Arome and PE-Arome on November 2023



Rank Diagram of road surface temperature with the road weather stations observations at France location for Arome and PE-Arome on November 2023

Calibration is needed