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Effects of screening and sky view factor on road surface temperature forecasts

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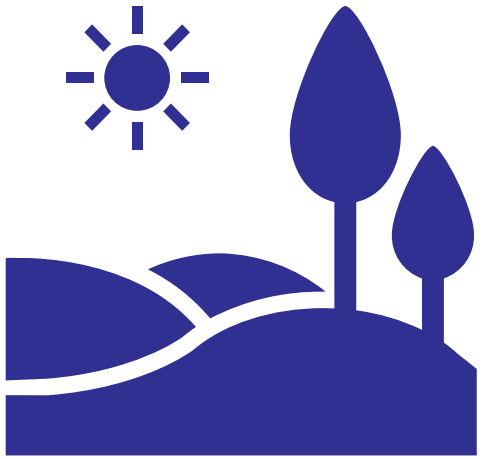
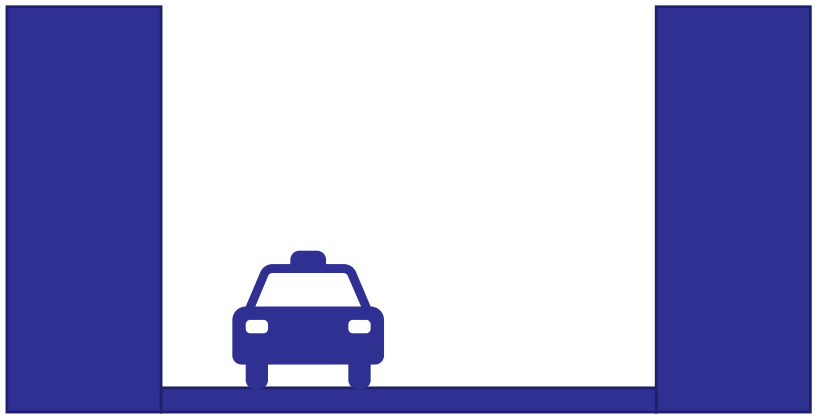
Virve Karsisto and Matti Horttanainen
virve.karsisto@fmi.fi

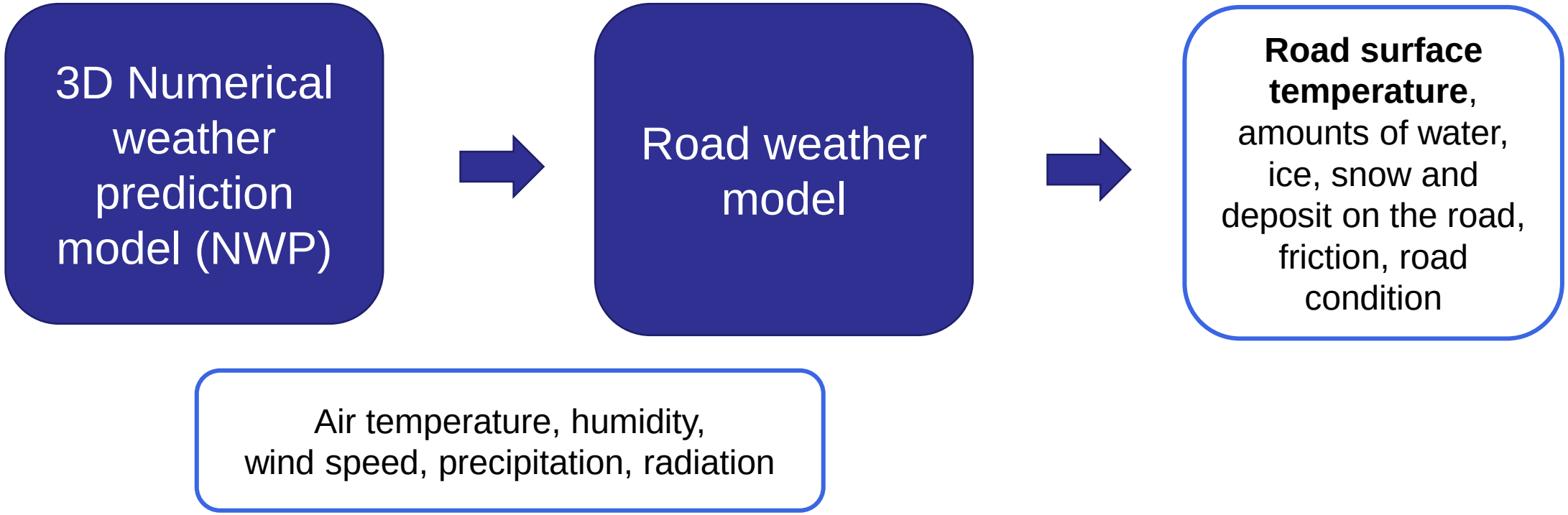
Introduction

- Road surroundings affect road surface temperature
- Shadowed locations can be several degrees colder than locations exposed to the sun
- Obscured locations can remain warmer on clear nights





Key elements of road weather forecast



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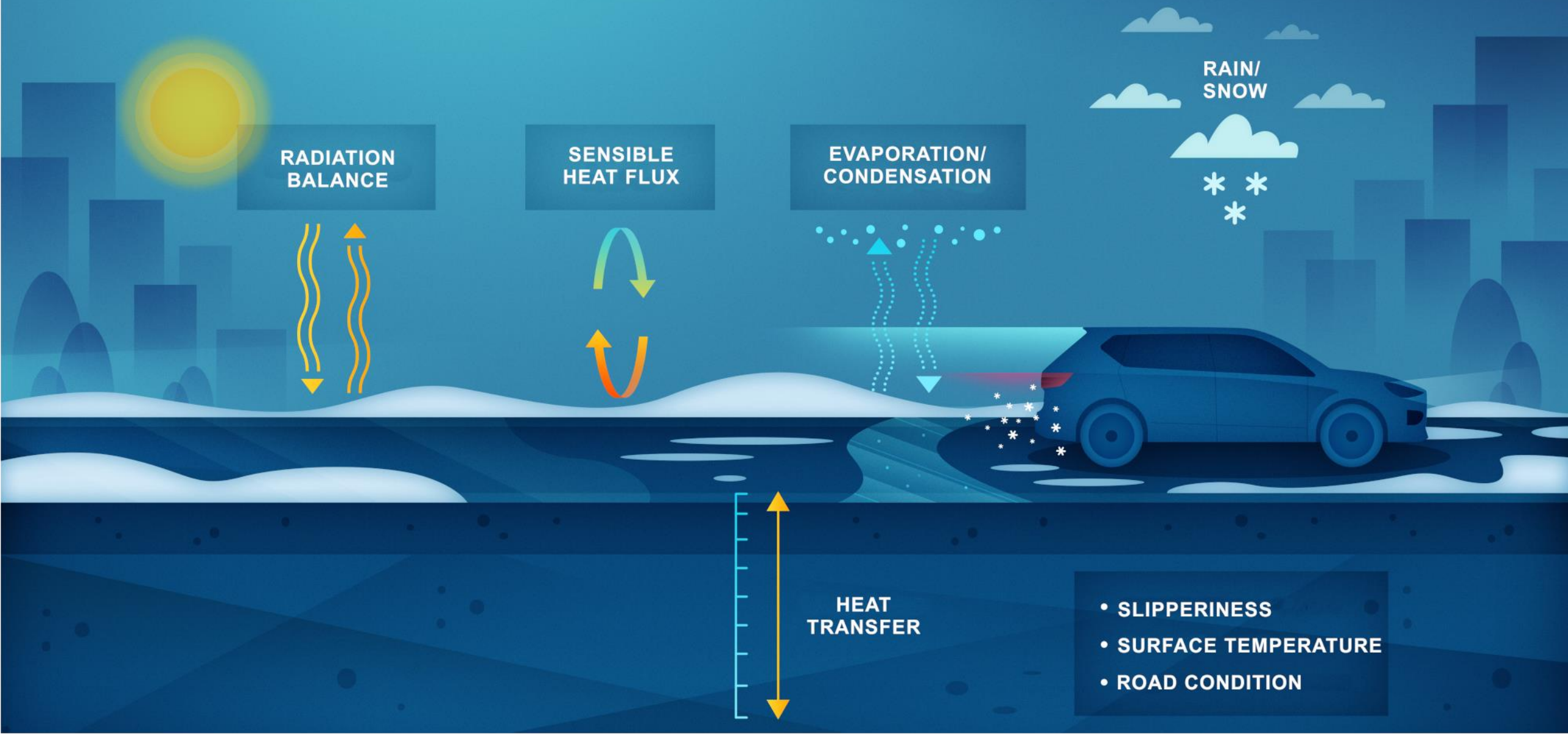
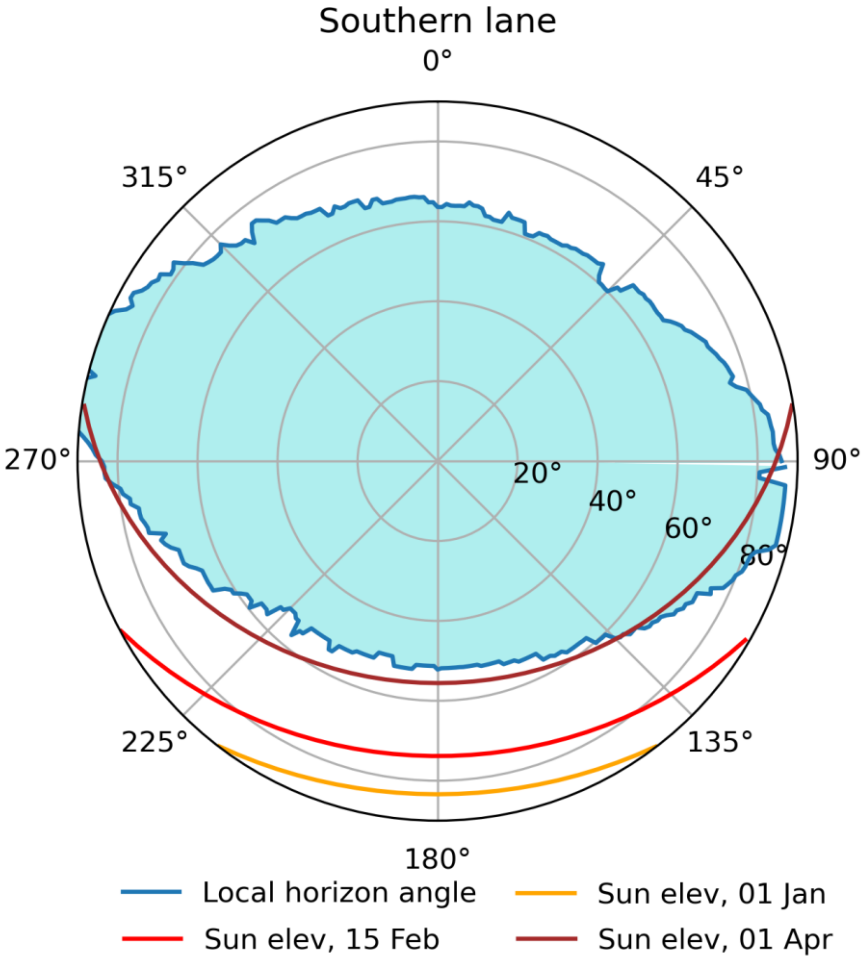
Road weather model

- One-dimensional heat balance model



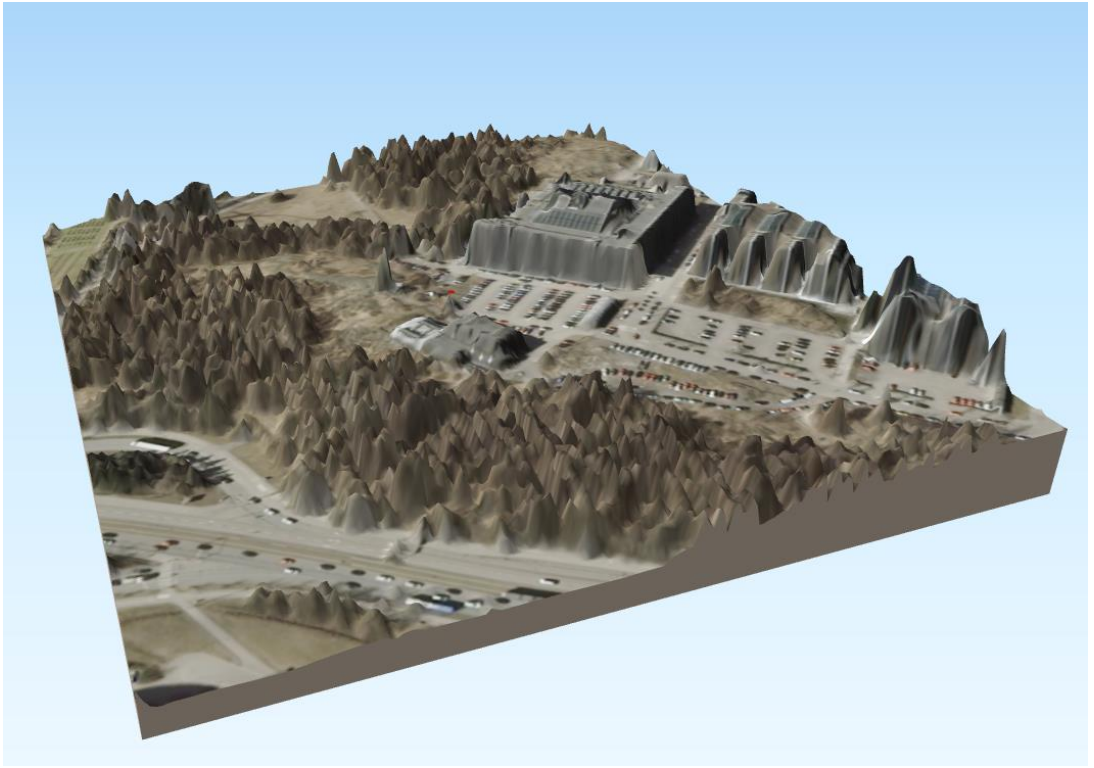
Sky view factor and shading added to the FMI Road weather model

- Sky view factor (SVF) means the ratio of sky hemisphere visible from the ground
  - Affects to the incoming radiation
- Shading is determined using local horizon angles
  - Point is in shadow if the sun elevation is lower than the horizon angle in the sun direction
  - Direct solar radiation is set to zero when the point is in shadow



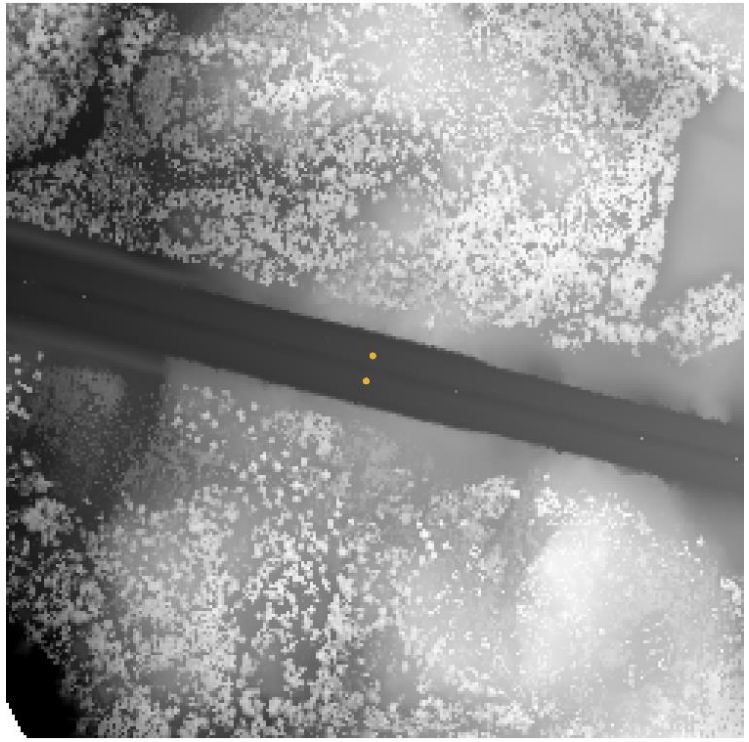
Determination of SVF

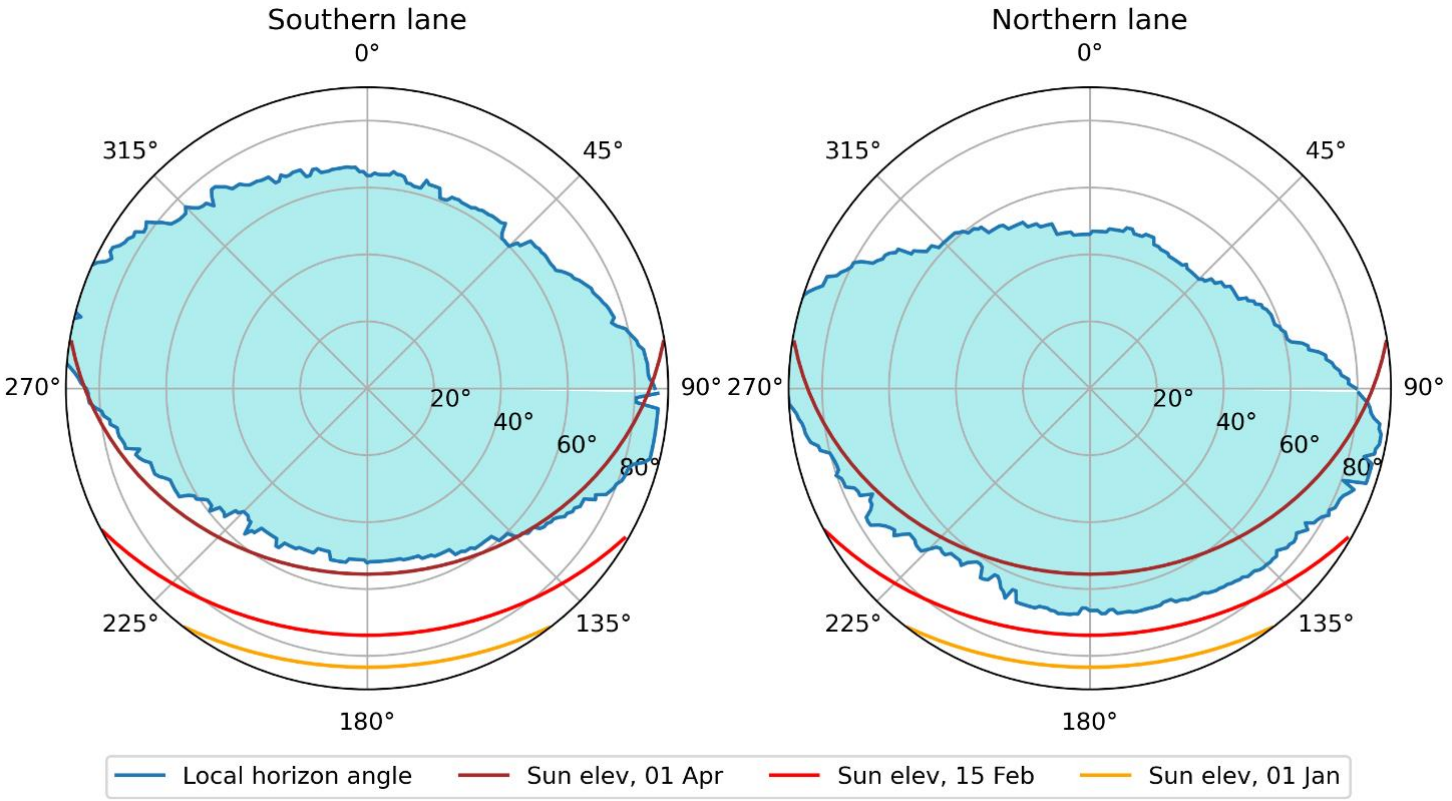
- Local horizon angels were calculated from digital surface model
  - Generated from laser scanning data available for whole Finland (provided by National Land Survey of Finland)
    - Resolution 0.5 points per square meter
- SVF was calculated from the local horizon angles



Digital surface model for Kumpula, Helsinki

- Differences between roadways, Salo Lakiamäki, Helsinki-Turku motorway

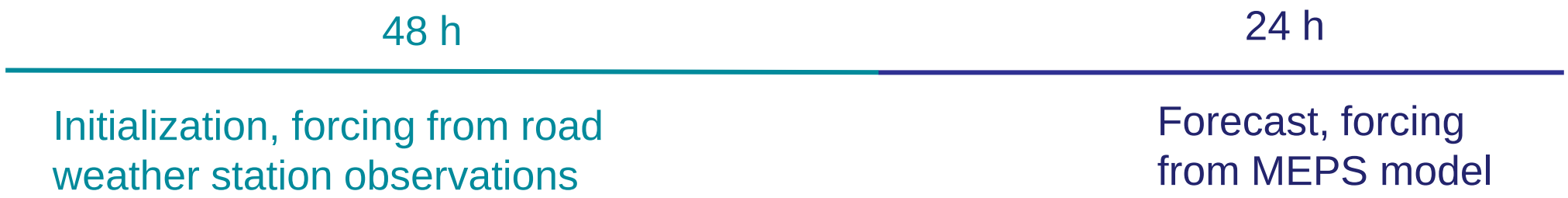




Model using SVF and shading was tested at several locations

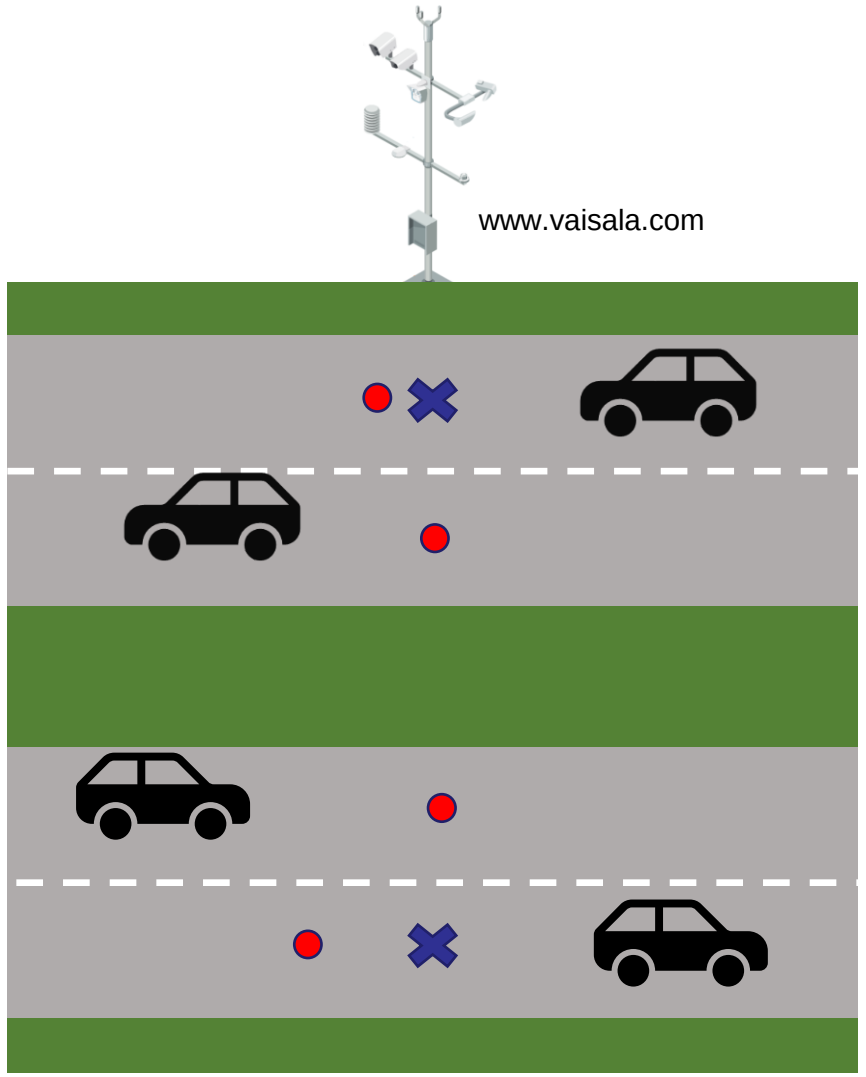
- Test included three winter periods (October -March): 2018-2019, 2019-2020, 2020-2021
- Model runs consisted of 48 h initialization and 24 h forecast

- Four forecasts started each day
- Driving forecast from MEPS model
- 23 Locations in different parts of Finland
  - SVFs varied between 0.72 and 0.98



Forecast points

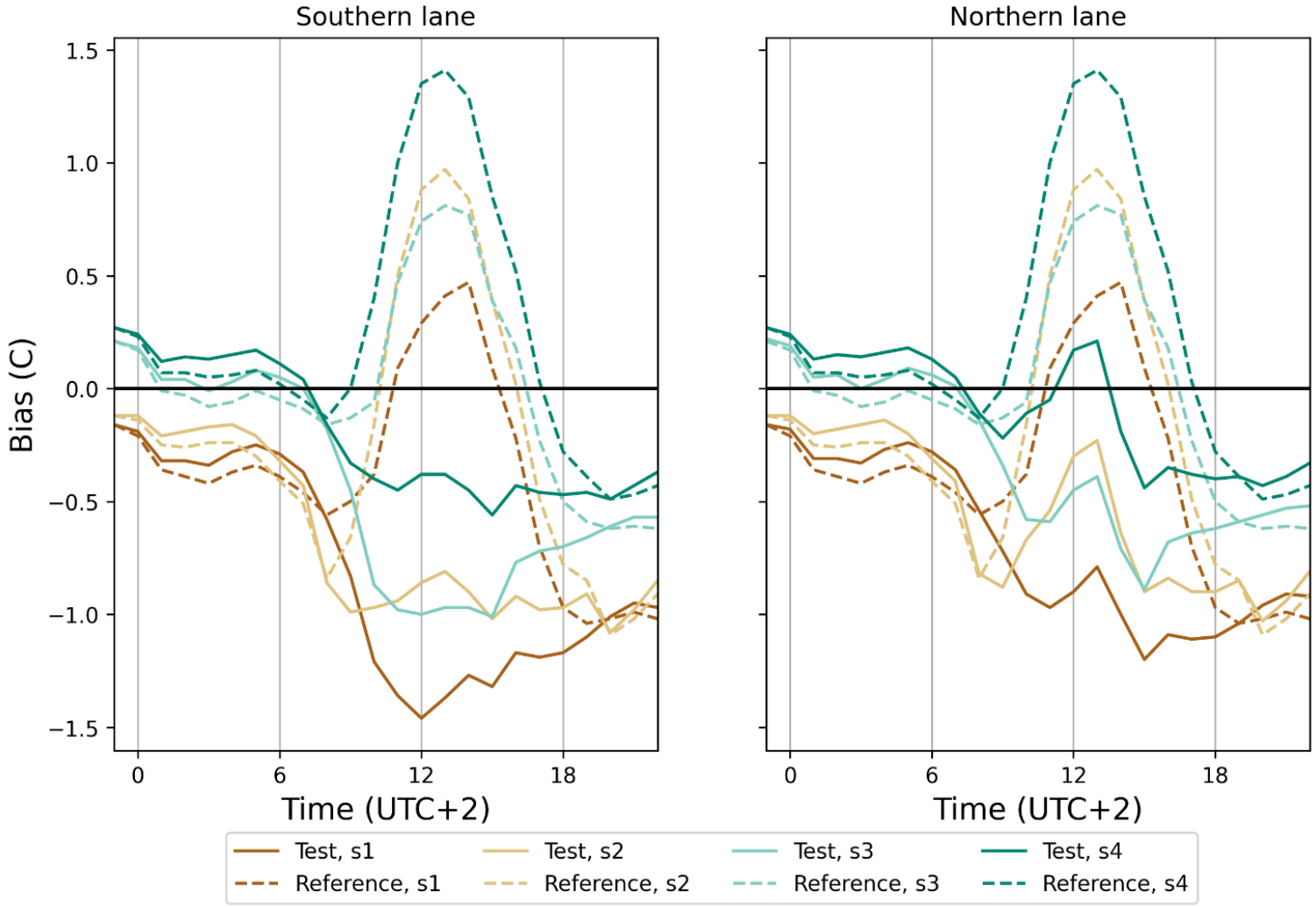
- Many road weather stations had multiple surface temperature sensors
  - Exact locations were not known
  - Forecasts were done multiple times using each sensor's data separately as forcing
- Two forecast points on different lanes/roadways
  - SVFs were calculated separately
  - Separate forecasts for both
- For example, on station with 4 sensors ->8 separate forecasts



Results

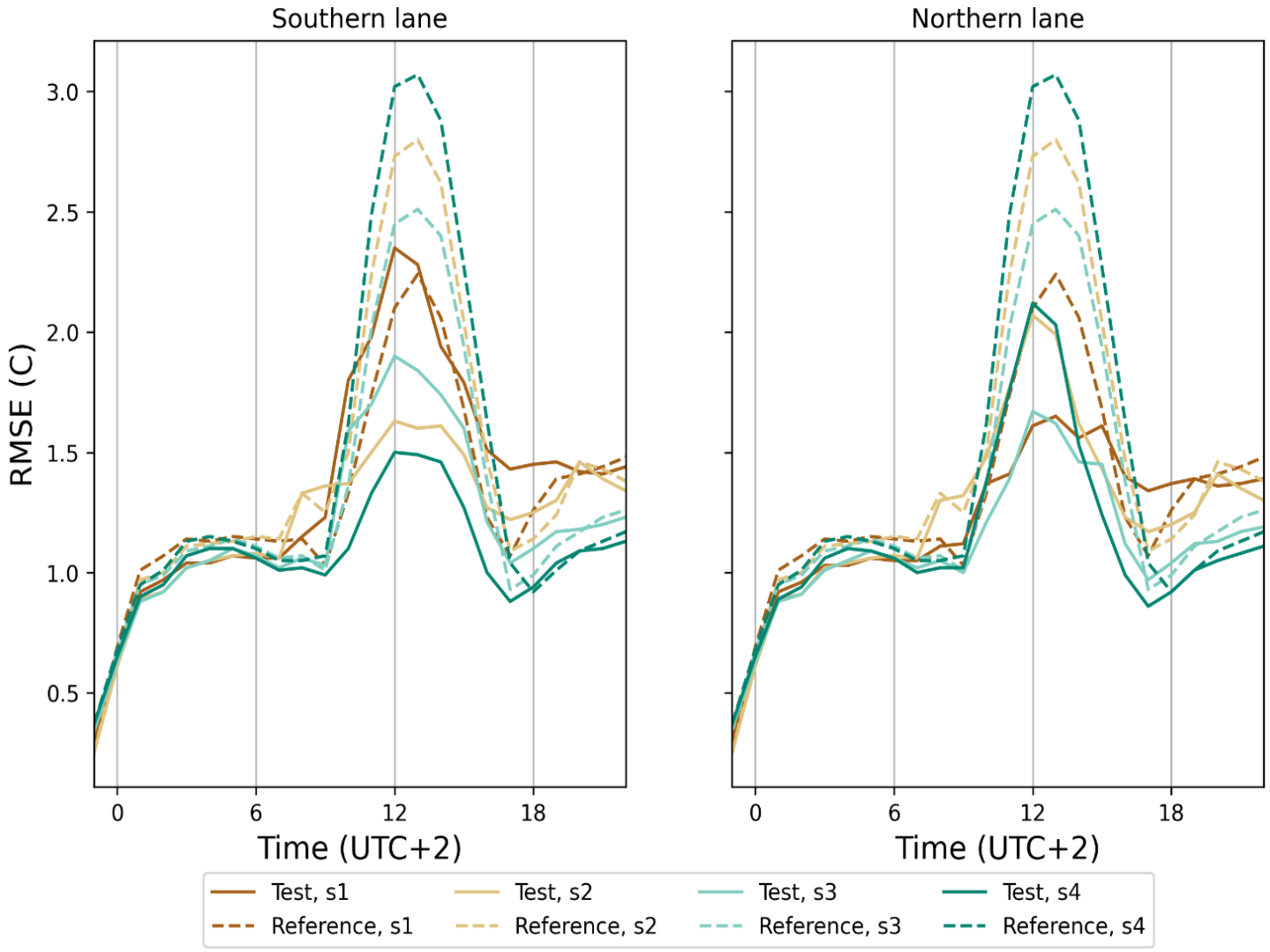
- **Test**: SVFs and shading included
- **Reference**: no SVFs and shading
- Verification is done using the same sensor's data as used in initialization
- Results dependent on both the roadway and the sensor
- Reference simulations have warm bias during the day

Surface temperature bias, Salo Lakiamäki, Octobers 2018, 2019, 2020, forecast start time 21 UTC

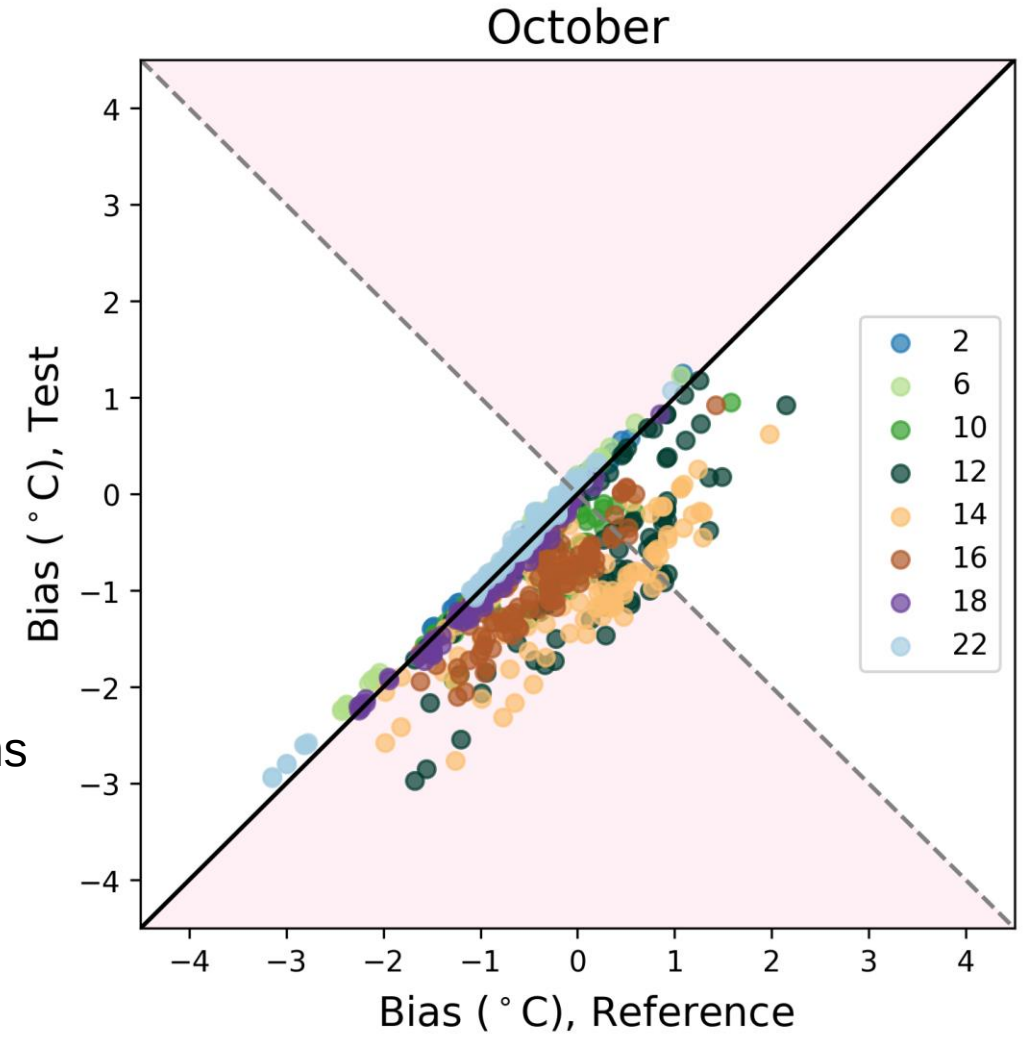


- Using SVFs and shading decreases the daytime RMSE
- Best daytime results for sensors 2 &4 on southern roadway and for sensors 1 & 3 on northern roadway

Surface temperature RMSE, Salo Lakiamäki, Octobers 2018, 2019, 2020, forecast start time 21 UTC



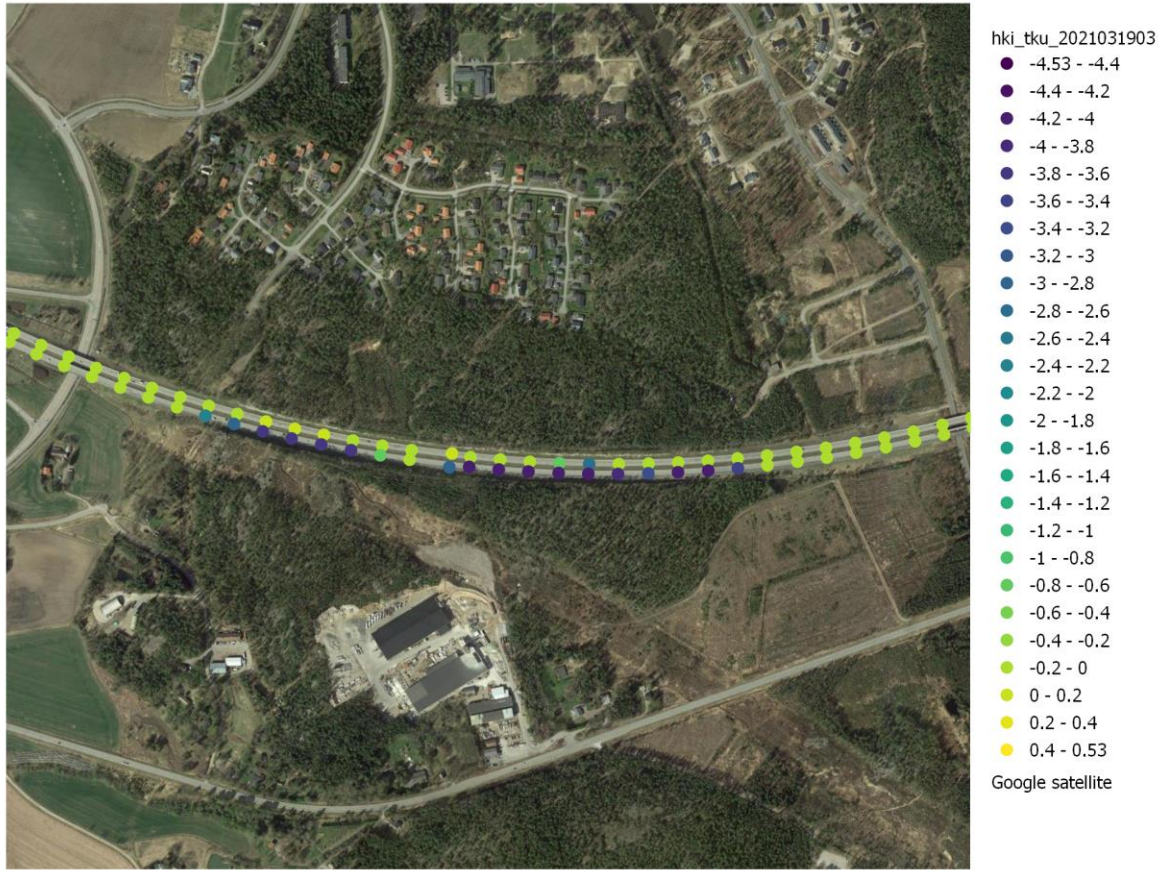
- At many stations, shading made already too cold forecast even colder during the day
- During the night, radiation from surroundings made simulations using SVF a little warmer



All forecast station-sensor-lane combinations
Octobers 2018, 2019 and 2020
Forecast start time: 21 UTC
Different colors represent different times, given in Finnish wintertime (UTC+2)

Test ongoing on Helsinki-Turku motorway

- Forecast points located every 50 meters on both roadways
- Figure shows example road surface temperature forecast for 19th March 2021
  - The southern roadway is shadowed by forest, causing lower temperatures in the morning



Conclusions

- At best shading considerably decreases the RMSE during the day
- In many cases, shading increases the already negative bias
- The effects of shading and SVFs vary greatly depending on the studied location, even between roadways

➡ Separate forecasts should be made for roadways going in each direction