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Using car observations in road weather forecasting

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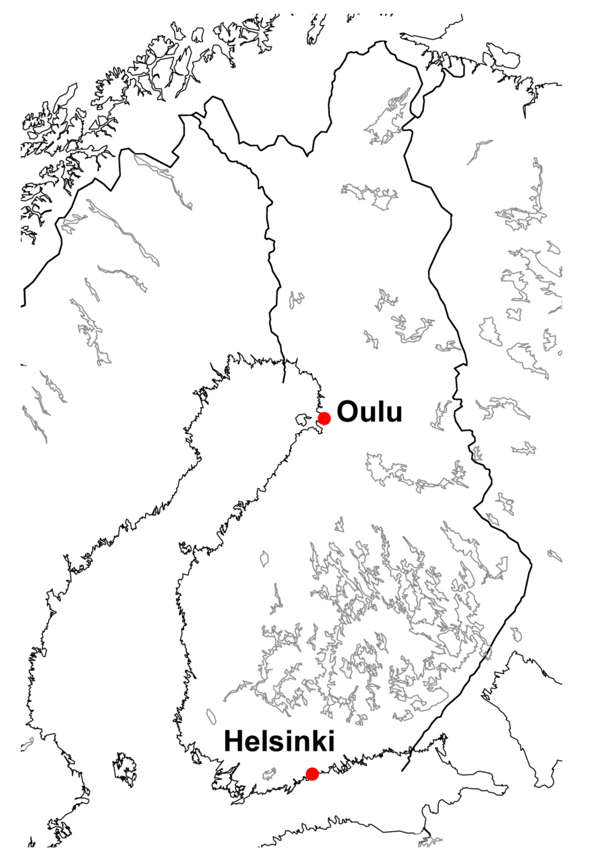


Figure 1. Map of Finland showing the cities of Oulu and Helsinki.

✓ Road condition measurements with an instrument attached to a commuter bus operating in the city of Oulu

✓ Mobile measurements used in the initialization of the Finnish Meteorological Institute (FMI) road weather model

- Goal : More detailed road condition forecasts

1. Introduction

- Road weather stations too sparsely located
  - Cannot provide sufficient input information for precise forecasts
- Observations from mobile sources to be used to obtain essential information

2. FMI road weather model (RWM)

- 1-D energy balance model [1]
- Forecast output: Road surface temperature and road condition
- Requires weather data as forcing

3. Data

3.1 Mobile observations

- *Teconer RCM411* instrument attached to a commuter bus to determine road surface temperature, friction and water layer thickness
- Measurement period: 1-22 December 2015
- 15 km route in the city of Oulu (Figure 1), with measurement examples in Figure 2
- 18 runs during an optimum day
- Measurements every second

3.1 Kriging data

- Used in the RWM **initialization**
- Observations from weather stations and radar measurements interpolated to a 1 km x 1 km grid using the kriging method [2]

3.3 HARMONIE forecasts

- 3-D NWP model used as forcing in the **forecast** phase of the RWM
- Horizontal resolution 2.5 km
- 12 UTC (14:00 local time) forecasts

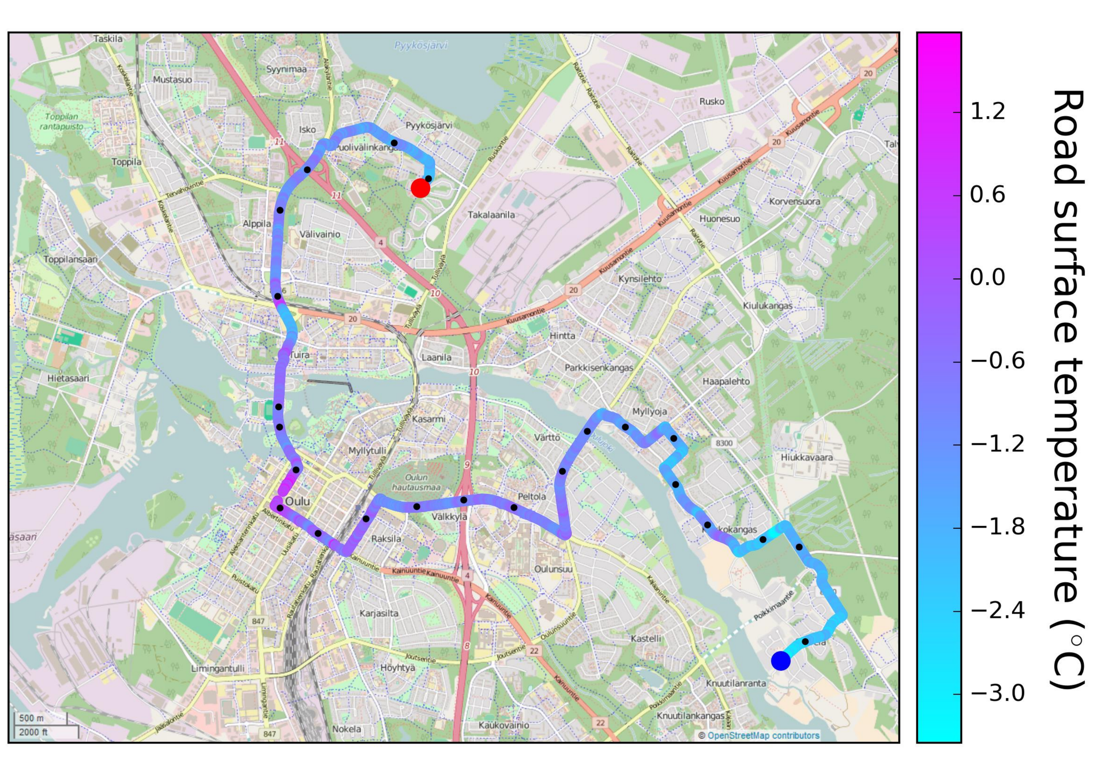


Figure 2. Road surface temperature along the bus route on 8th December 2015, 16:16-16:57 local time. The red and blue dots show the start and end points, respectively, of the route. The black dots indicate the selected forecast points.

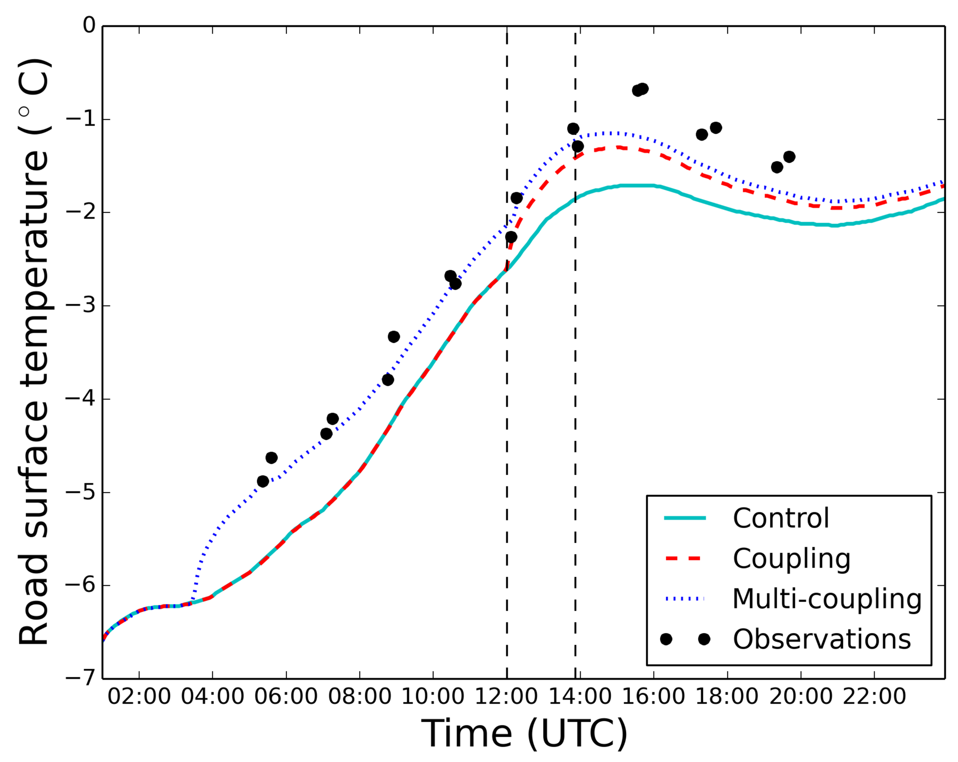
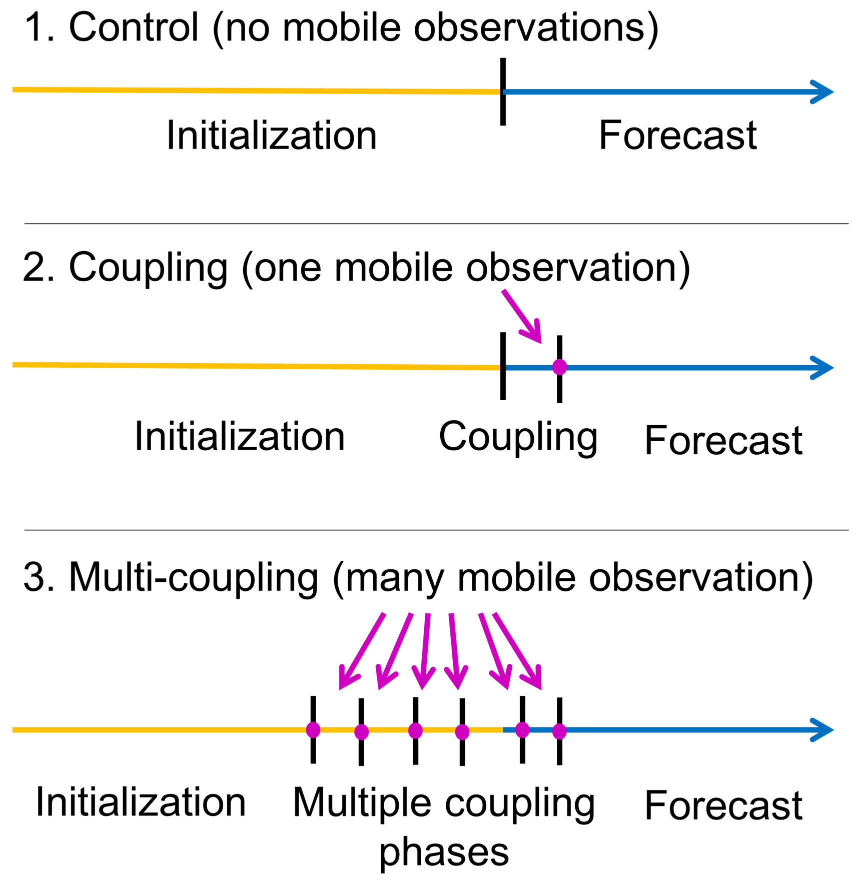


Figure 3. Surface temperatures for 18th December 2015 forecast runs for point nearest the red start point of Figure 2. The control run is shown in cyan continuous line, the run with simple coupling in red dashed line, and the multi-coupling run in blue dotted line. Black dots are mobile observations. The left vertical line at 12:00 noon shows the start of HARMONIE forecast, and the right one the end of the last coupling period of the multi-coupling model run.

4. Methods

- 23 forecast points selected along the route shown in Figure 2
- Average taken from surface temperature measurements with a 25 m radius around the forecast points
- Combination of data from different runs
  - Time-series of observations at forecast points
- Each model run included a two-day initialization and a one-day forecast period

Three model versions:



Initialization: Observation data used as forcing
Forecast: HARMONIE data used as forcing
Coupling: Modifying radiation flux in the model so that the forecasted road surface temperature matches the observation [3]

5. Results

- Example of results for surface temperature shown in Figure 3:
  - **Control** and **coupling** runs have a cold bias during the initialization phase
  - **Multi-coupling** run has also a cold bias after the start of the real forecast, but much smaller than the **control** run
  - **Coupling** run produces similar results as **multi-coupling** after the start of the forecast
- Bus observations made after 15 UTC were used for verification
- Root mean square error (RMSE) for different lead times from the start of the HARMONIE forecast in Table below
  - Calculations covered all available observations at all 23 forecast points
  - Model versions using **coupling** and **multi-coupling** produce considerably lower RMSE values

Model version	3-5 h	5-7 h	7-9 h
Control	1.10	1.18	1.22
Coupling	0.61	0.77	0.92
Multi-coupling	0.59	0.76	0.91

Root mean square error (RMSE, °C) of surface temperature forecasts of the different model versions. The three vertical columns show forecast errors with lead times 3-5 hrs, 5-7 hrs and 7-9 hrs, respectively, from the HARMONIE run start time.

6. Conclusions

Mobile observations have great potential to improve road weather forecasts and, when becoming more widely available, possess great potential to bringing road weather forecasting to the next level …

References

[1] Kangas M, Heikinheimo M, Hippi M. 2015: RoadSurf – a modelling system for predicting road weather and road surface conditions. *Meteorol. Appl.* **22**: 544-533

[2] Aalto J, Pirinen P and Heikkinen J, 2013: Spatial interpolation of monthly climate data for Finland: comparing the performance of kriging and generalized additive models. *Theor. Appl. Climatol.* **112**:99-111

[3] Karsisto V, Nurmi P, Kangas M, Hippi M, Fortelius C, Niemelä S and Järvinen H. 2016. Improving road weather model forecasts by adjusting the radiation input. *Meteorol. Appl.* In Press