Road Weather Forecasting in Belgium

Joris Van den Bergh & Sylvain Watelet

Collaboration with S. Dekeyzer, D. Dehenauw , M. Reyniers, J. Schmitz, P. Termonia (RMI), and S. Tijm (KNMI)

Outline

- Introduction
- KMI Road Weather Model
- Operational GMS system
- Validation
- Future Development
- SARWS project

February 2012 – More than 1200 km of traffic jams in Belgium due to snow event!

Mission of the Royal Meteorological Institute (RMI) - Royal Decree 1986

To produce **permanent services**:

In order to ensure the security and the information of the population, of the socio-economical and scientific communities and to support the political authorities.

- Hydrometeorology
- Climatology
- Geophysics

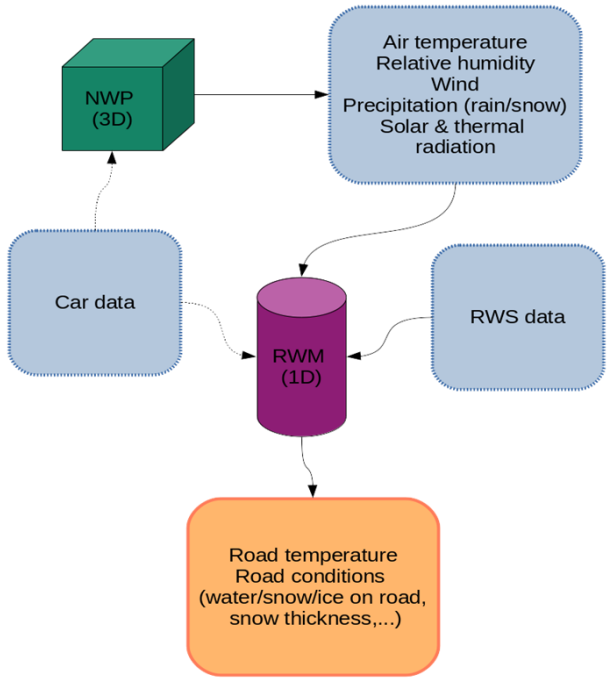
… since this year: **Road Weather Forecasts** as service to regional road and traffic management agencies.

Introduction

- Forecasting the condition of roads and highways is important for **traffic safety** and **road maintenance** (salting, clearing snow, ...).
- Most used forecasting method: **Road Weather Models** (RWM). These make use of **meteorological forcing** from weather models, and **1D heat balance** balance equations at the road surface.
  - RoadSurf (FMHI, Kangas et al, 2015, Karsisto et al, 2016).
  - KNMI model (Karsisto, Tijm, en Nurmi, 2017).
- RMI **collaborated with KNMI** (Netherlands) to adapt their RWM for Belgium: system operational since winter 2018 – 2019.

KMI RWM Physical Processes

- Incoming thermal and solar radiation, ground heat flux into road surface, latent and sensible heat fluxes.
- Precipitation (rain & snow.)
- Freezing & melting, evaporation & condensation, and accumulation of water and ice on the road.
- Road surface characteristics: presence of bridges, sky-view factor.



KMI RWM

Input

- Air temperature
- Relative humidity
- Rain, Snow, Graupel
- Wind speed
- Solar & thermal radiation

Output

- Road surface temperature
- Condition road surface:
  - Dry, wet, snow, ice, melting snow, …

KMI RWM, Features

- Output for **point locations**, can be coupled to different numerical weather prediction models (NWP).
- Twenty vertical model layers, about 30cm thickness. Short ‘’spin-up’’ time, deeper soil layers not modeled.
- Fast computation (< 1 second per point).
- **Correction** of forecasts performed using assimilation of **observed** road surface temperatures, air temperature and dewpoint temperature from road weather information stations (RWIS).
- Use of **observed snow depth** from AWV IR stations, and information on the presence of salt on the road to correct the modeled depth of ice and snow on the road.

Operational status, December 2019
GMS: “Gladheidsmeetsystem”

- Operational GMS over Belgium, with **dynamically chosen NWP model + INCA-BE nowcast** input. Output at RWIS locations:
  - 55 stations in Wallonia, MeteoRoutes,
  - 90 stations in Flanders, Agentschap Wegen & Verkeer (AWV).
- One RWM run per hour, assimilating the latest observations from RWIS (real time transmission, update every 10 minutes).
- New NWP forecast every 6 hours (00, 06, 12, 18 UTC).
- New nowcast every hour (first 2 hours of input).
- Visualized through GIS interface, access through login for AWV and MeteoRoutes users, and the RMI Weather Office.

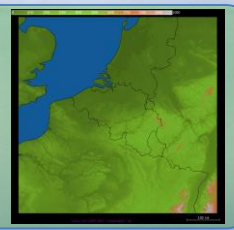
INCA-BE summary (Maarten Reyniers)

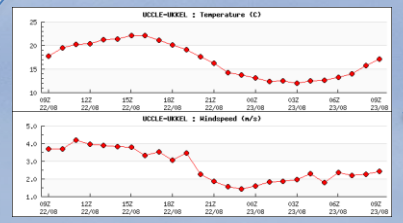
- INCA = Integrated Nowcasting through Comprehensive Analysis
- **Nowcasting system** of several meteorological fields:
  temperature, humidity, wind, cloudiness, precipitation, precipitation type
  and some derived fields (e.g. wind chill, height of freezing level, visibility)
- **High resolution**: 1 km
- Developed by national meteorological institute of Austria (ZAMG)
- **INCA-BE**: implementation of INCA in Belgium, with own developments

INCA-BE input

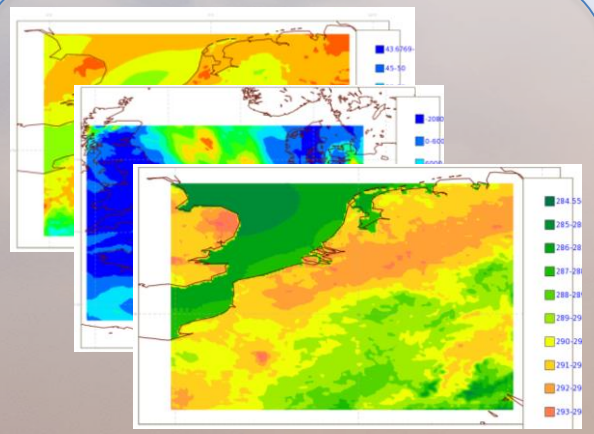
Radar
(Wideumont, Zaventem, Avesnois, Jabbeke)

High resolution elevation data (USGS GTOPO30)



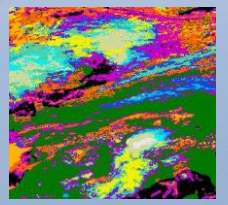


Automatic weather stations, synop stations and regional gauge networks



NWP (ALARO-4km) – 6h update

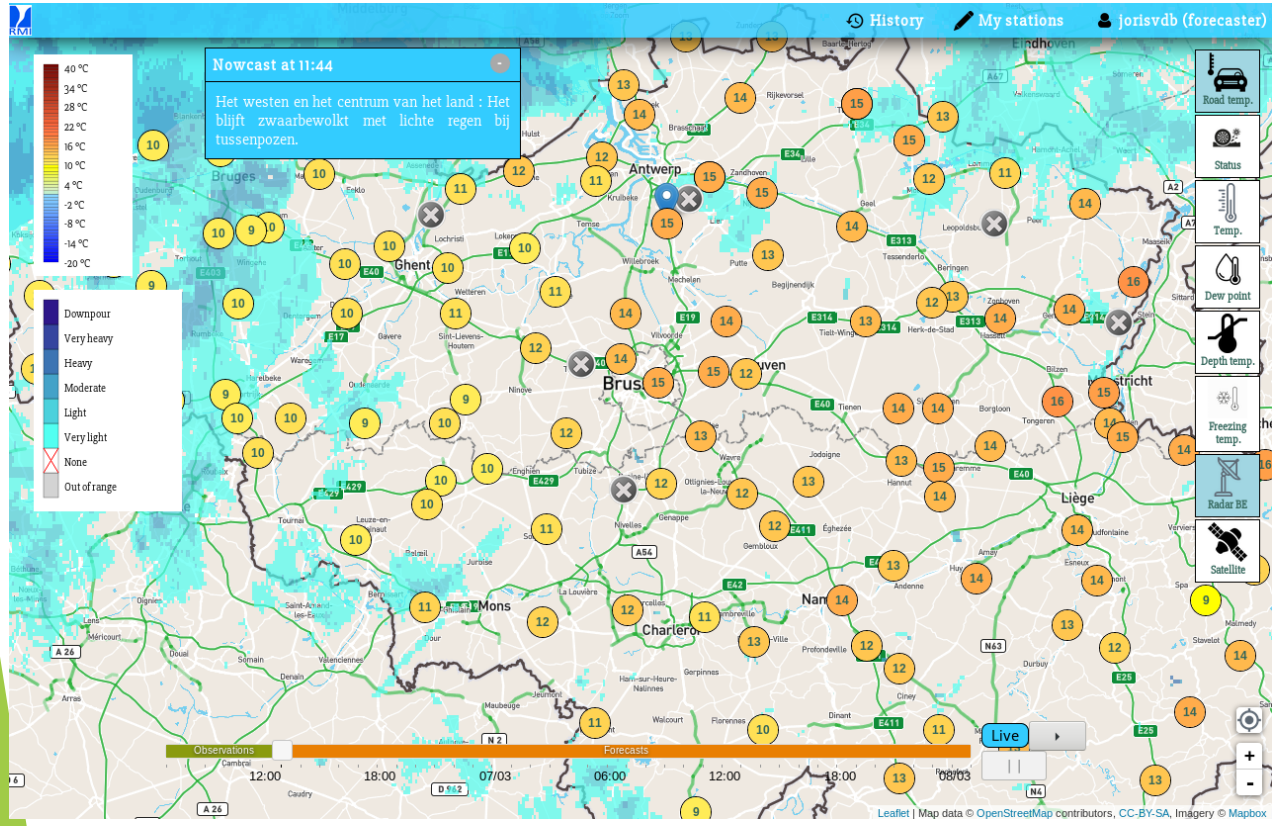
INCA-BE

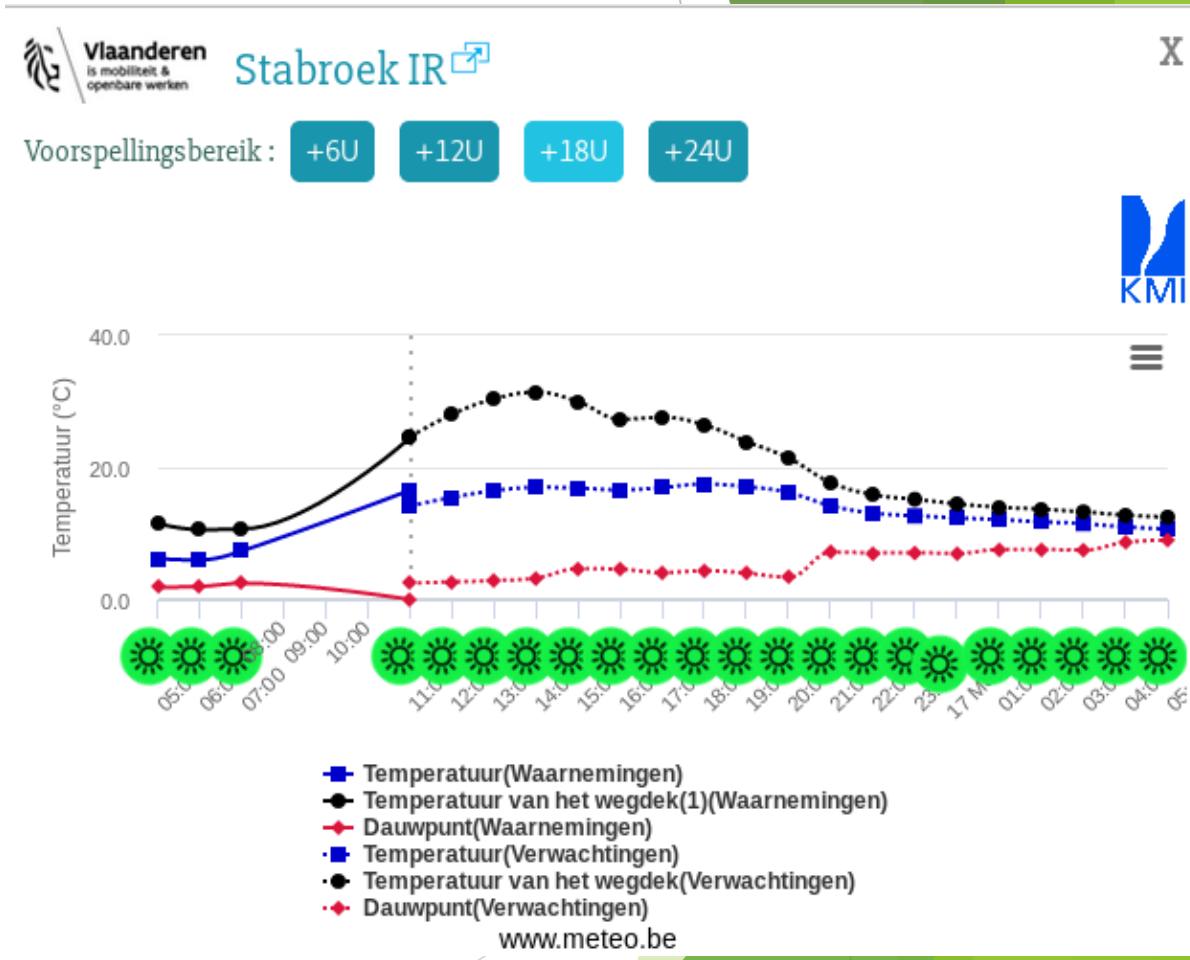


Satellite data (MSG RSS - SAFNWC)

BELLS light-ning data

GMS GIS interface





Operational status GMS & GIS interface

- Forecasting system runs in a Docker environment on the RMI production server:
  - RWM: Fortran code
  - Data handling, I/O, interaction with Oracle db: Python code
- **RMI Weather Office** can influence forecasts
  - Choice of NWP model input
  - Temperature corrections & precipitation switch rain/snow
  - Telephone support
- Web interface: https://rmipro.meteo.be/roadmonitoring/live/

Validation

- RWM run with historical Alaro forecasts for past winters.
- Main validation period: winter 2017 – 2018.
- For Flanders, a representative set of 8 stations was chosen, in collaboration with AWV, for which forecasts were compared with the historical MeteoWing forecasts.
- This data set was used to improve the RWM by retuning it, to give comparatively better forecasts.
- For Wallonia, validation is ongoing, in collaboration with MeteoRoutes.

MeteoWing vs untuned RWM first validation for eight AWV stations, Nov 2017 – March 2018

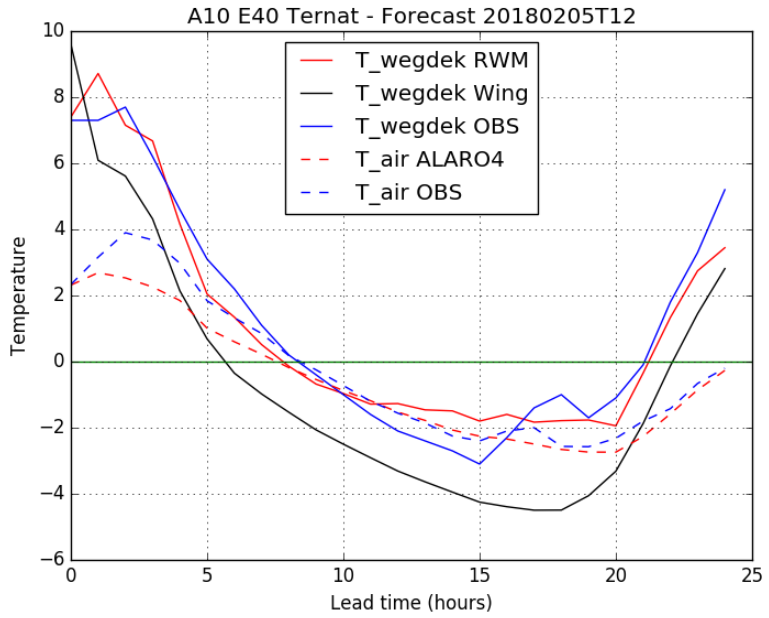
- Metrics: bias and RMSE for minimum temperature, probability of frost (proportion correct), percentage errors < 1C, ‘’time of crossing’’ error (timing of freezing moment), and same scores for ‘’marginal cases’’ (-1 < T < 3).
- Main conclusions were:
  - Positive bias for RWM, negative bias for Wing (our model forecasts too warm temperatures, vs too cold for Wing).
  - RWM: more ‘misses’ for frost, Wing: more ‘false alarms’ for frost.
  - Our RWM had too slow cooling and warming overall.
- Solution: **retuning of RWM** through physical parameters.

RWM Retuning for Flanders

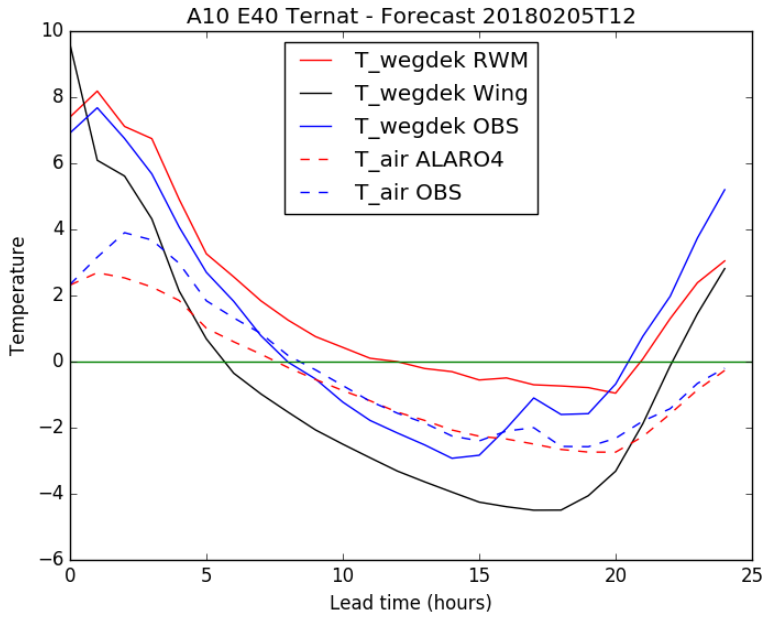
- "**Grid search**" of parameter combinations was performed: reaction speed of asphalt, which determines cooling and warming speed (C, K, ϱ), plus sky-view factor at night, albedo during day: 9 model runs per station for Nov 2017 – March 2018
- Combination of parameters with **best average scores** over all stations for minimum road surface temperature RMSE and "time of crossing" was chosen.
- Individual finetuning per station ongoing for locations that perform less well.

“Too slow cooling and warming issue”: largely solved by new tuning.

Cooling after retuning



Cooling: old result



Work in progress and future Development

- **Finetuning** to take local effects into account at specific locations.
- Test **input of ensemble** weather prediction models to better capture uncertainty, **probabilistic forecasts**.
- More **advanced error correction** techniques: machine learning & statistical postprocessing, Kalman filter, …
- **SARWS project**: vehicle sensor data for new locations, and validation of existing stations (see below).

Conclusions

- KMI RWM + GIS interface operational for Flanders & Wallonia since winter 2018-2019.
- Collaboration is ongoing with AWV en MeteoRoutes.
- For Flanders, validation and retuning of the model gave good results in comparison with the old forecasting system. Further finetuning needed here and there.
- For Wallonia, the same development is ongoing, preliminary results look promising.

SARWS project: “Accurate Location-Aware Road Weather Services Composed from Multi-Modal Data”

Sylvain Watelet, Joris Van den Bergh, Maarten Reyniers

SARWS

Weather data applications

BEMOBILE smart mobility

bpost

imec

inuits OPEN SOURCE INNOVATORS

RMI

VERHAERT

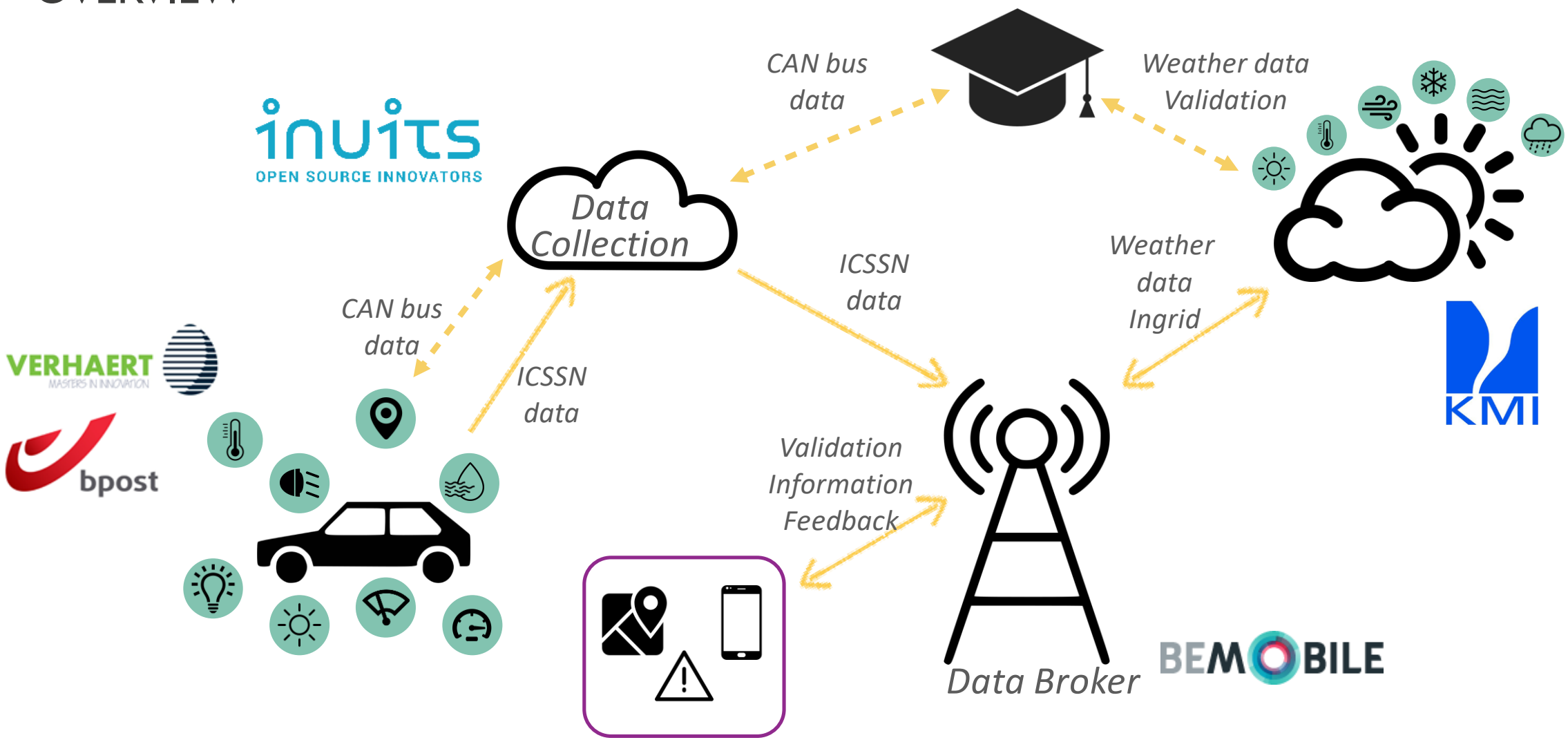
FLANDERS INNOVATION & ENTREPRENEURSHIP

Flanders State of the Art

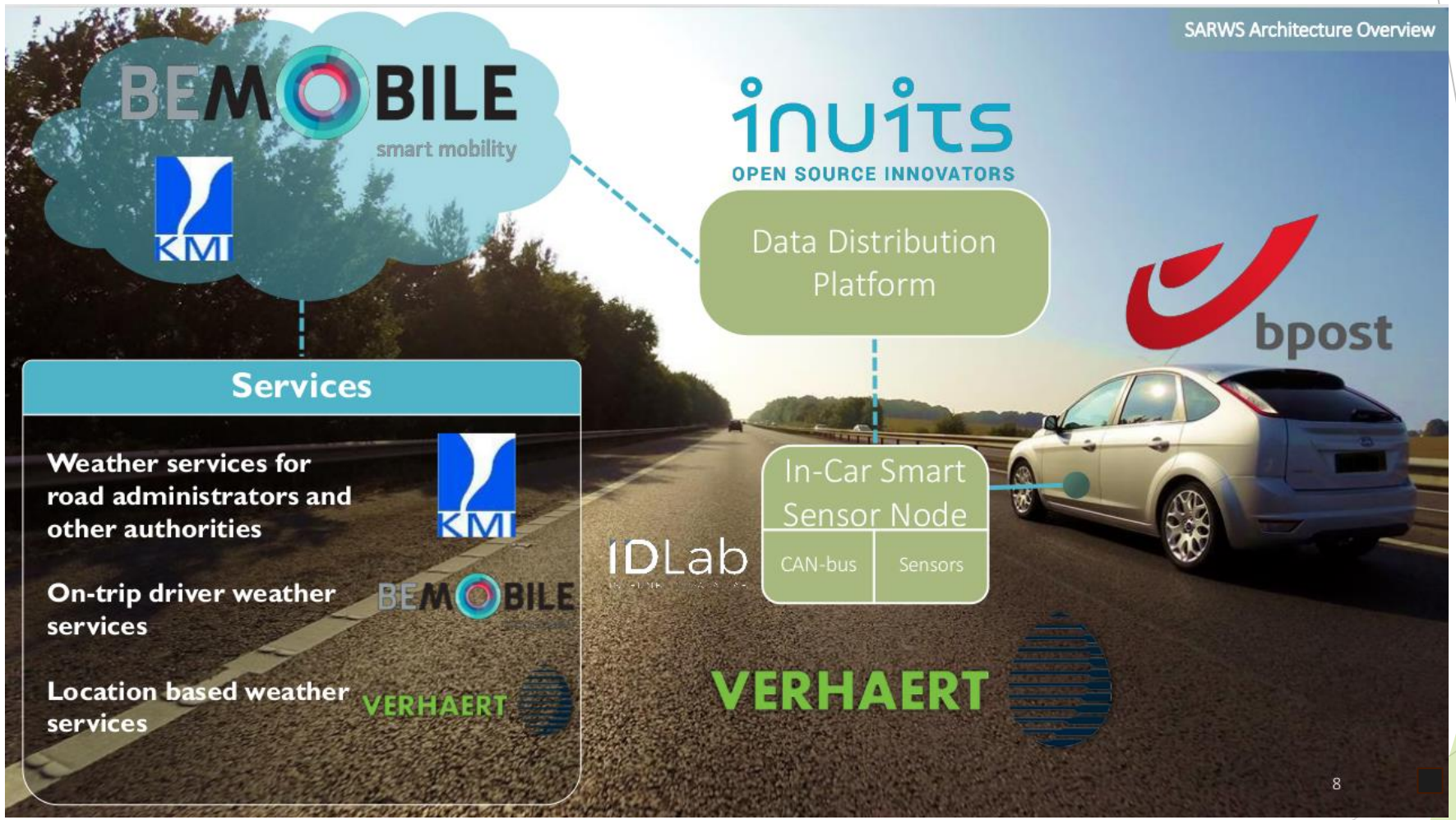
SARWS in a nutshell

- Stands for “Secure and Accurate Road Weather Services”
- Objective: provide real-time weather services from crowd-sourced vehicle
- data (2 => 30 => 6500 bpost cars)
- November 2018 – October 2021
- 5 Belgian partners: IMEC-IDLab, VPS-Verhaert, Be-Mobile, Inuits, RMI
- Funded by VLAIO (~2 M€)
- Part of the European consortium Celtic-Plus

FLEMISH CONSORTIUM
OVERVIEW

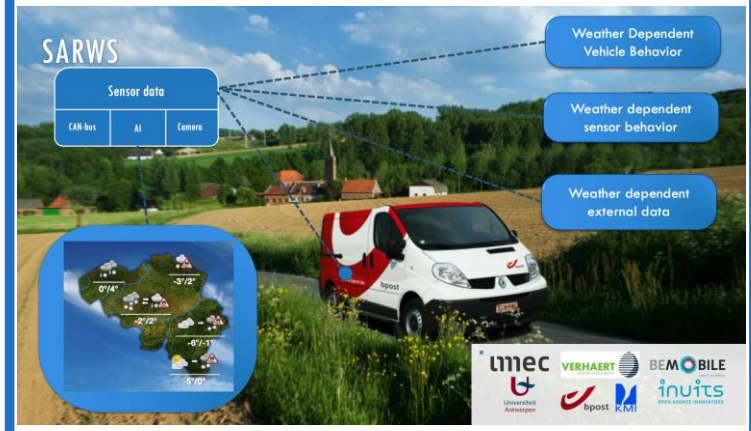


SARWS architecture



SARWS status

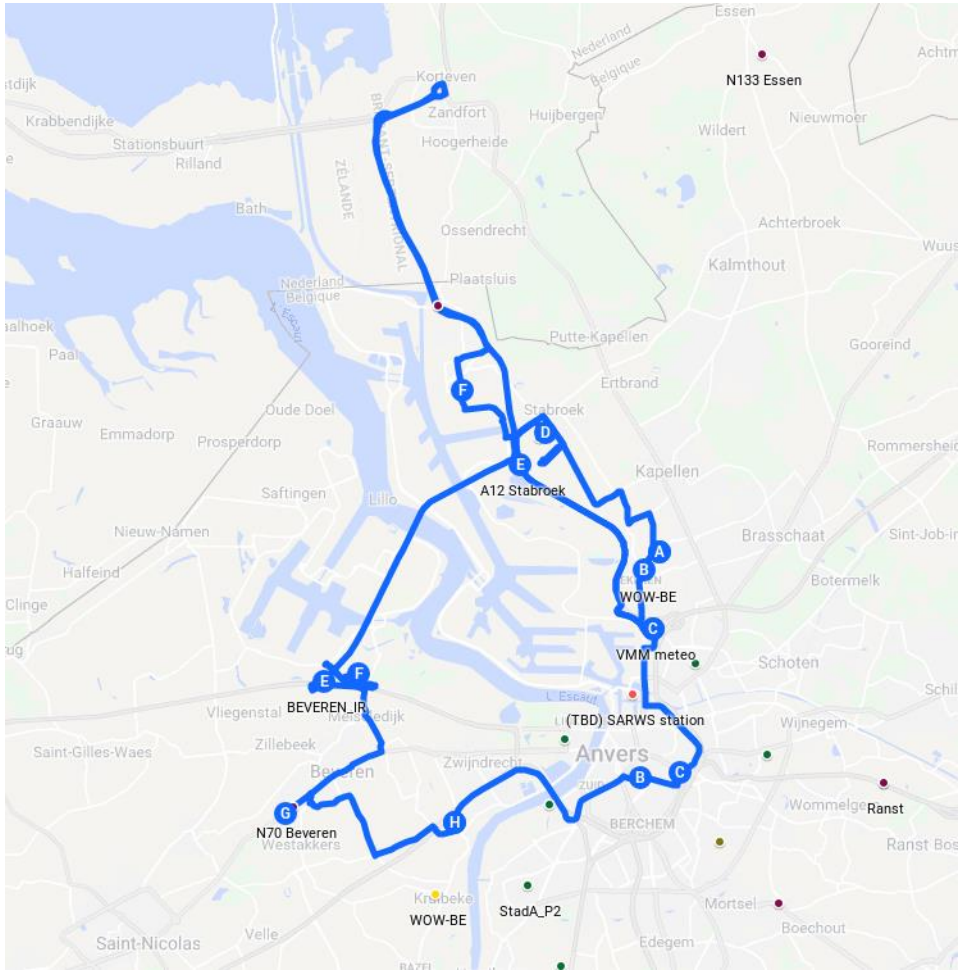
- ✓ First field test in June 2019
- ✓ Region of Antwerp-North
- ✓ Focus on precipitation (wipers speed), temperature, fog (lights or optical sensor)

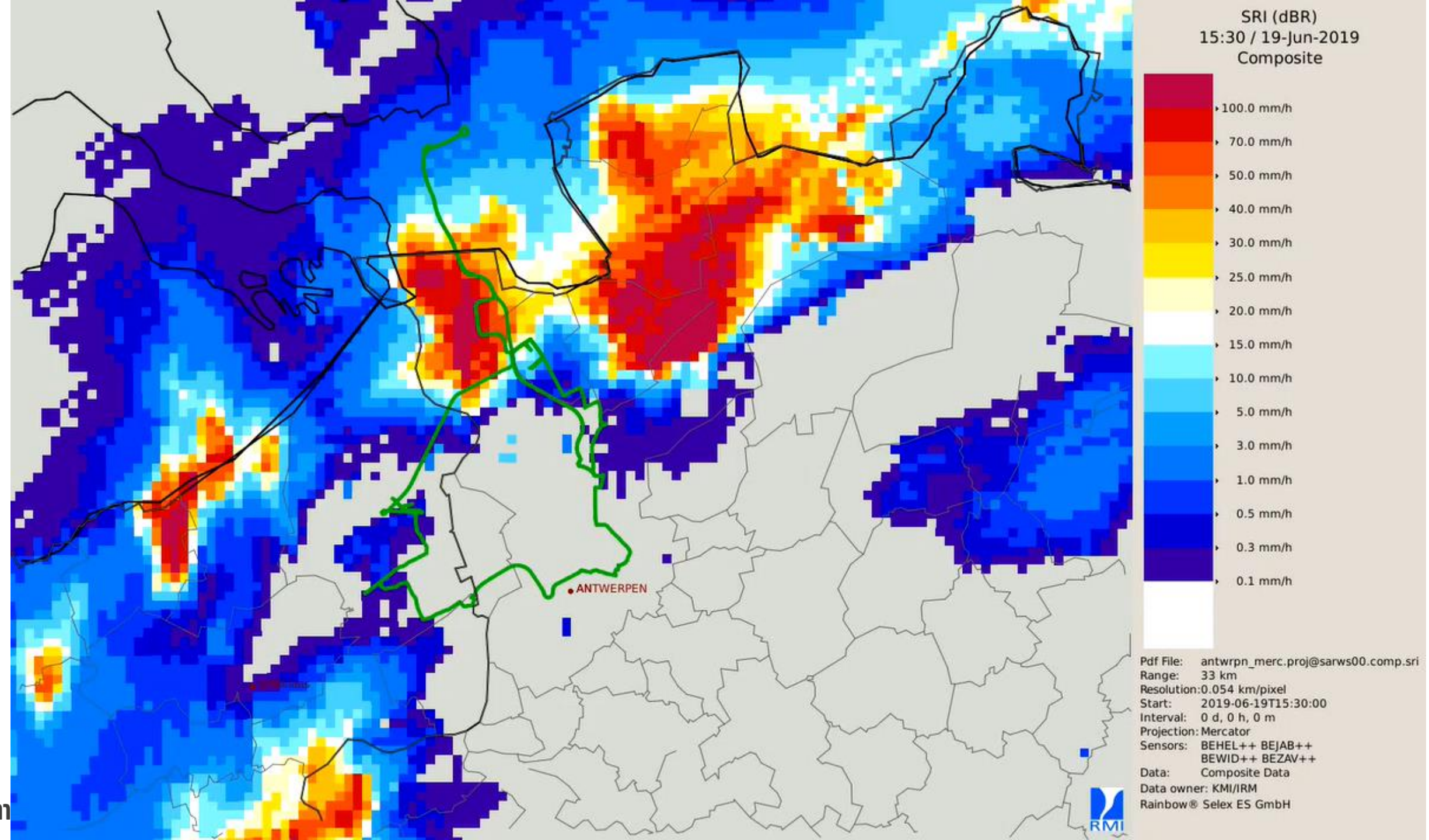


Ongoing RMI actions

- Collect field test data
- Compare with AWS & RWM/NWP outputs
- Use of mobile data to improve RWM

Field test itinerary

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40.0 mm/h
30.0 mm/h
25.0 mm/h
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0.5 mm/h
0.3 mm/h
0.1 mm/h
ANTWERPEN
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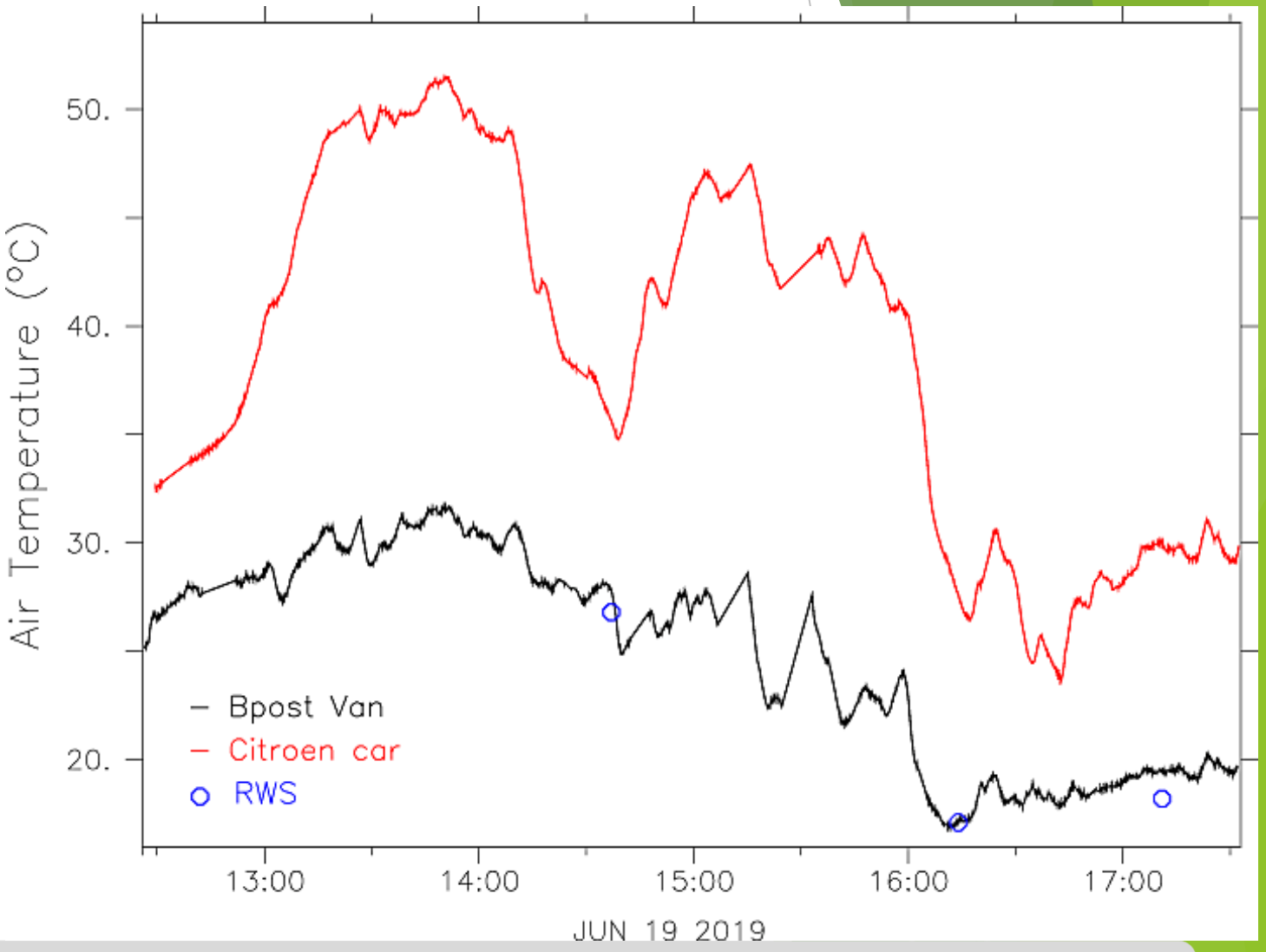
Resolution: 0.054 km/pixel
Start: 2019-06-19T15:30:00
Interval: 0 d, 0 h, 0 m
Projection: Mercator
Sensors: BEHEL++ BEJAB++ BEWID++ BEZAV++
Data: Composite Data
Data owner: KMI/IRM
Rainbow® Selex ES GmbH
RMI

Sensor data allocation for road weather modelling

Field	Format
Timestamp	Time of measurement (Epoch standard time)
Coordinates	Longitude and latitude
Car speed	km/h
Wiper status	0 = off; 1 = auto; 2 = interval; 3 = continuous
Wiper interval	ms
Wiper speed	0-100%
Front fog light	0 = off; 1 = on
Rear fog light	0 = off; 1 = on
Temperature	°C
Humidity	%



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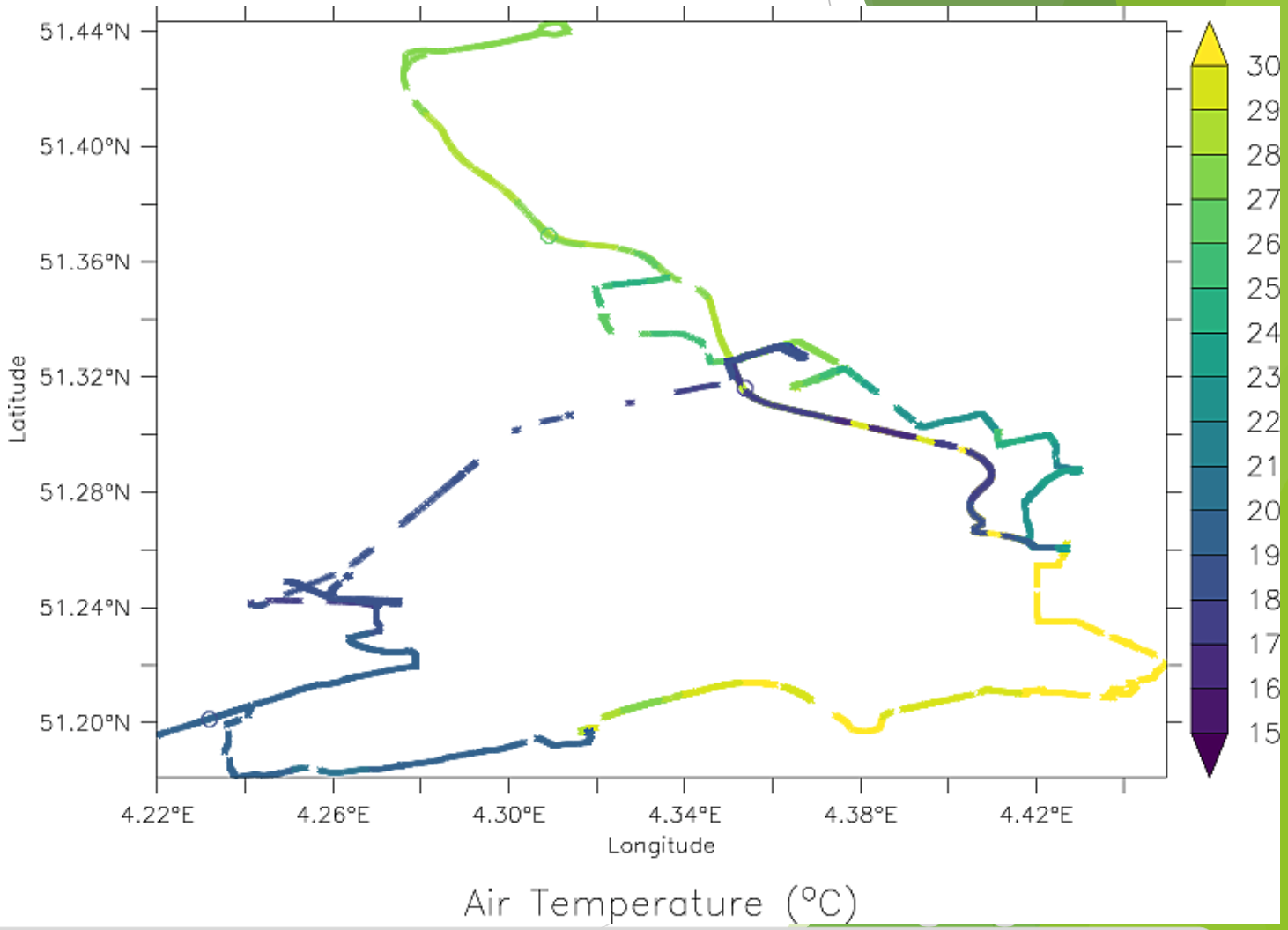

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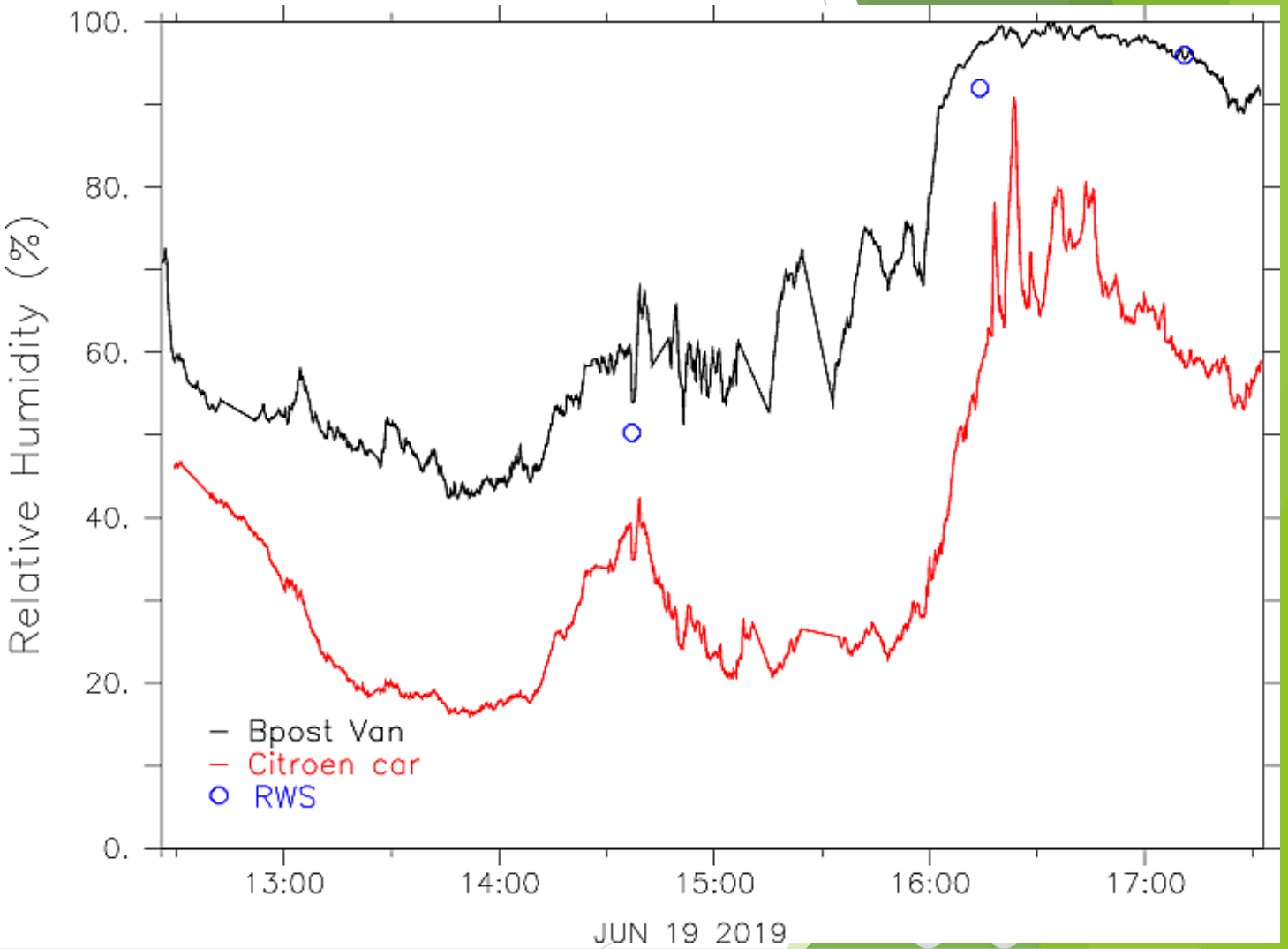

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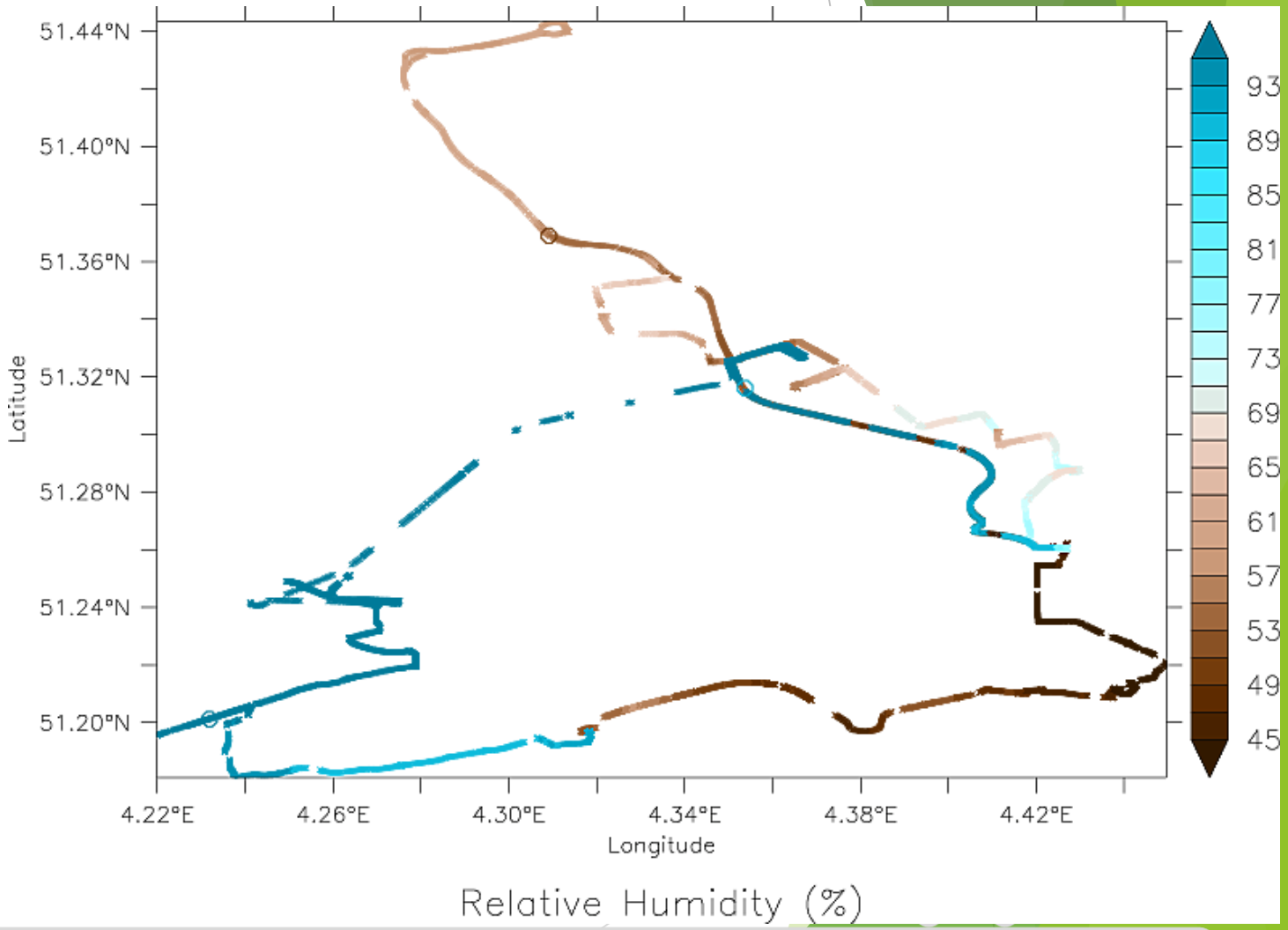

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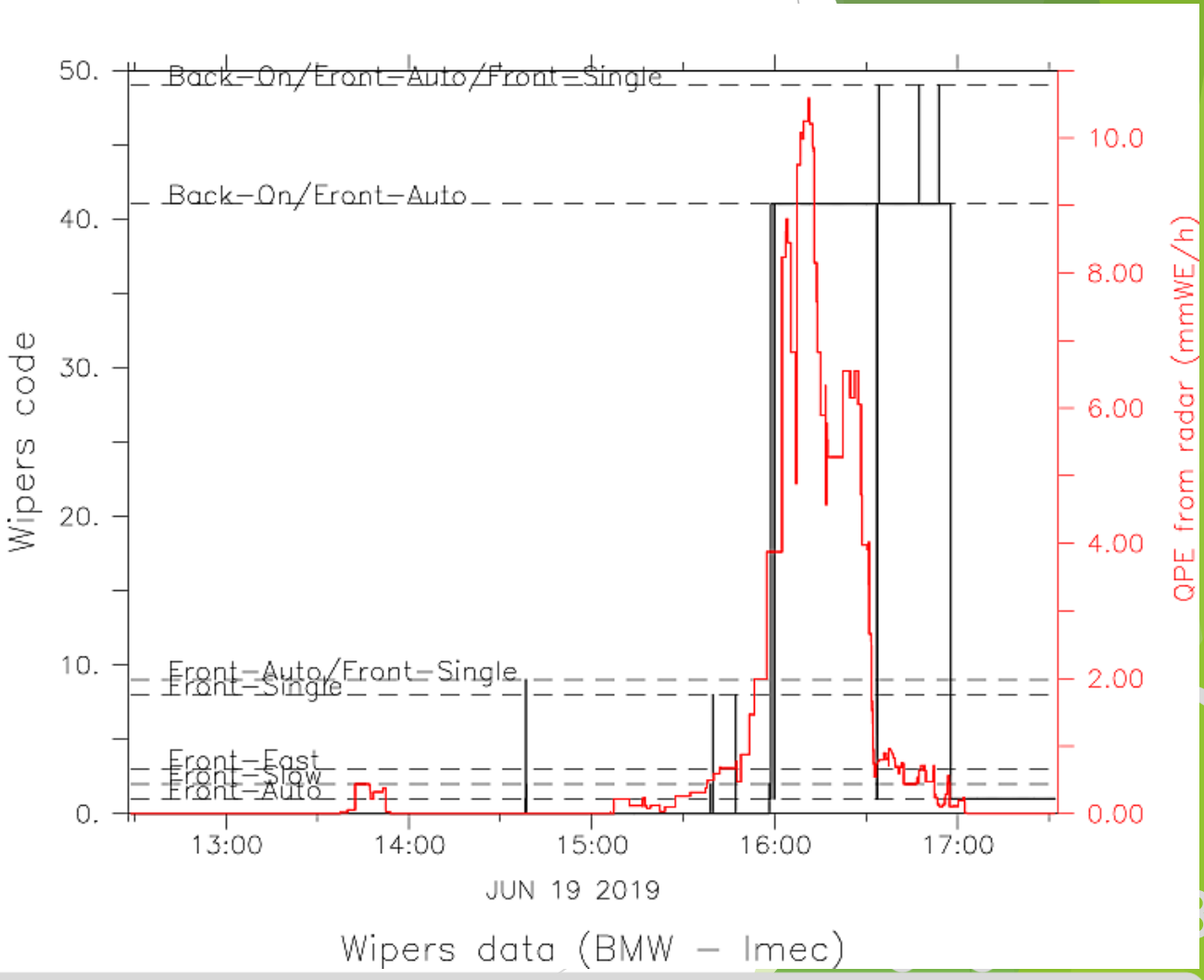
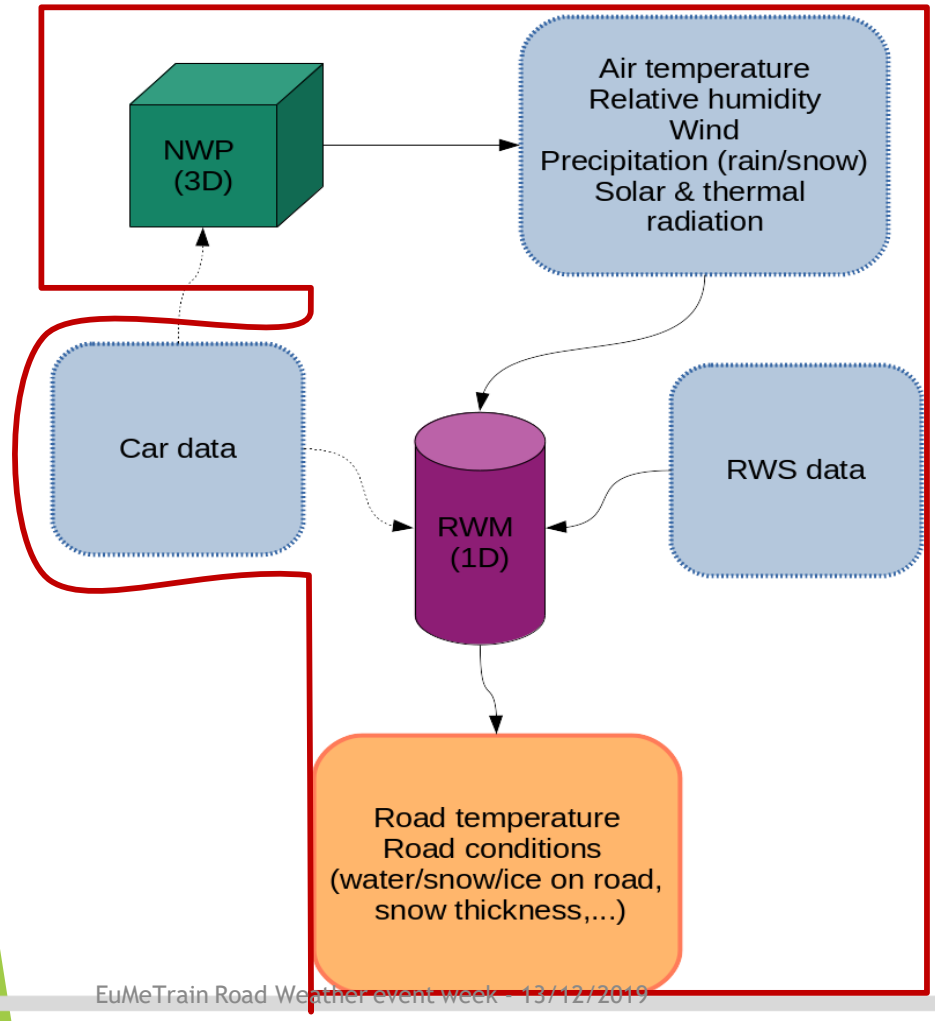


RWM enhancement with SARWS data

Preparing the classic RWM for SARWS car data



- Forking of the current RWM to start the design of a fully independent SARWS-RWM → will run for each 250 m road segments
- First field test results (June 2019) introduced in a database to be used by SARWS-RWM (in progress)

Questions?