KMI – IRM

Koninklijk Meteorologisch Instituut

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ENSEMBLE FORECAST IMPLEMENTATION IN THE RMI ROAD WEATHER FORECASTING SYSTEM

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Introduction

Forecasting the condition of roads and highways is important for **traffic safety** and **road maintenance**. The Royal Meteorological Institute of Belgium (RMI) performs this task for regional road and traffic agencies in Flanders and Wallonia: Agentschap Wegen & Verkeer (AWV) and MéteoRoutes.

RMI collaborated with the Royal Netherlands Meteorological Institute (KNMI) to develop the **Belgian forecasting system GMS** ("Gladheidsmeetsysteem" in Dutch). It is operational since 2018.

The system is based on a physical **road weather model** (RWM), making use of **meteorological forcing** from various available numerical weather prediction models (NWP) and **1D energy balance** at the road surface.

Outline

1. RMI Road Weather Model
2. Operational GMS system
3. Ensemble road weather forecasting
4. Future developments
5. Conclusions

KMI road weather model

NWP Input

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

RWM Output

- Road surface temperature (RST)
- Road surface condition (RSC)
  Dry, wet, snow, ice, melting snow, …
- Amount of liquid water and ice on road

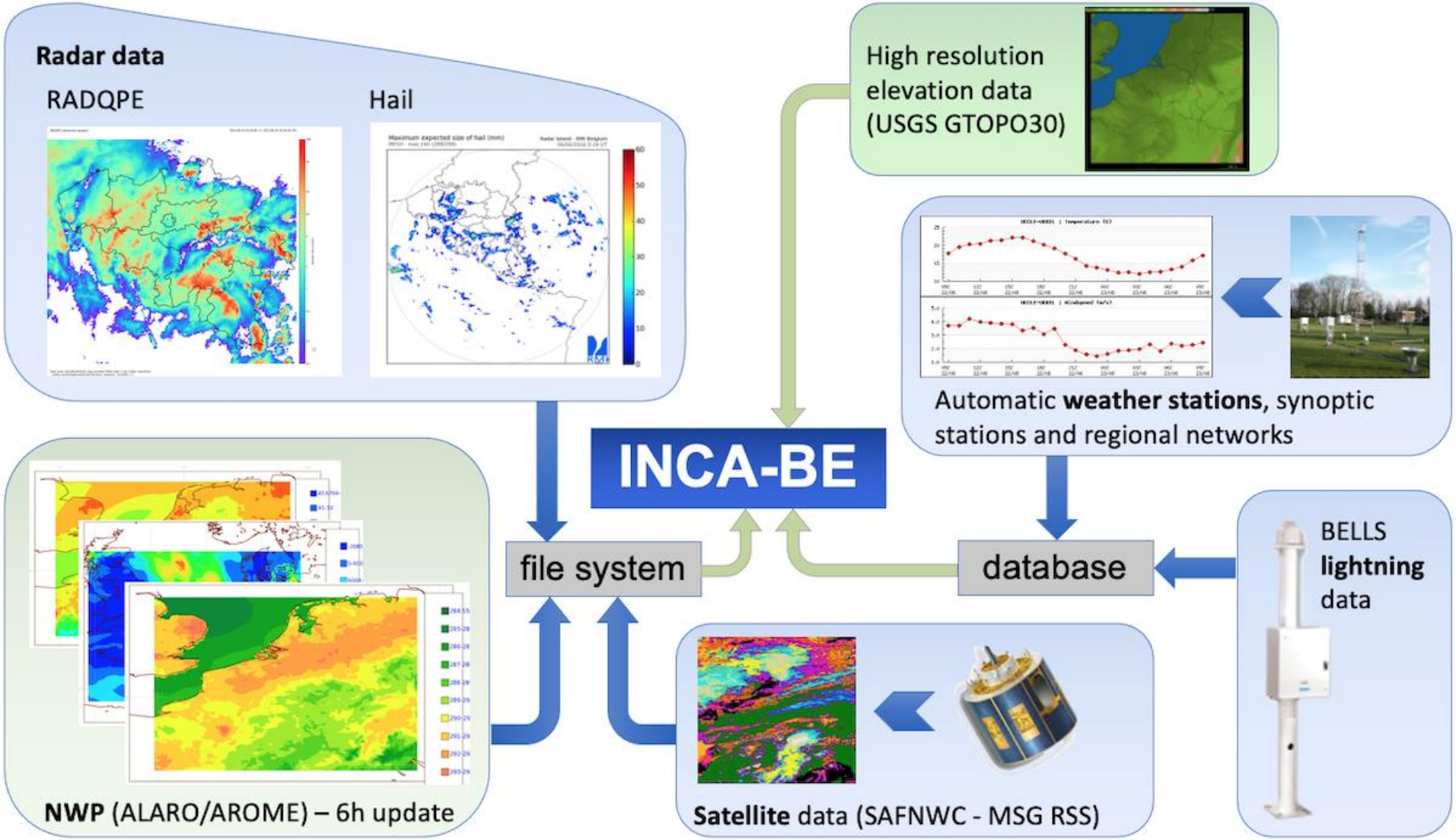
KMI road weather model

- Output for **point locations**, can be coupled to different NWP models.
- Twenty vertical model layers, about 30cm thickness. Short spin-up time.
- Assimilation of road surface temperature, and correction of air temperature and dewpoint temperature from **road weather station (RWS) observations**.
- **Radiation correction** based on errors during past hours.
- Use of **observed road surface condition and snow depth** from RWS, and information on the presence of salt on the road to correct initial water and ice amounts on road.

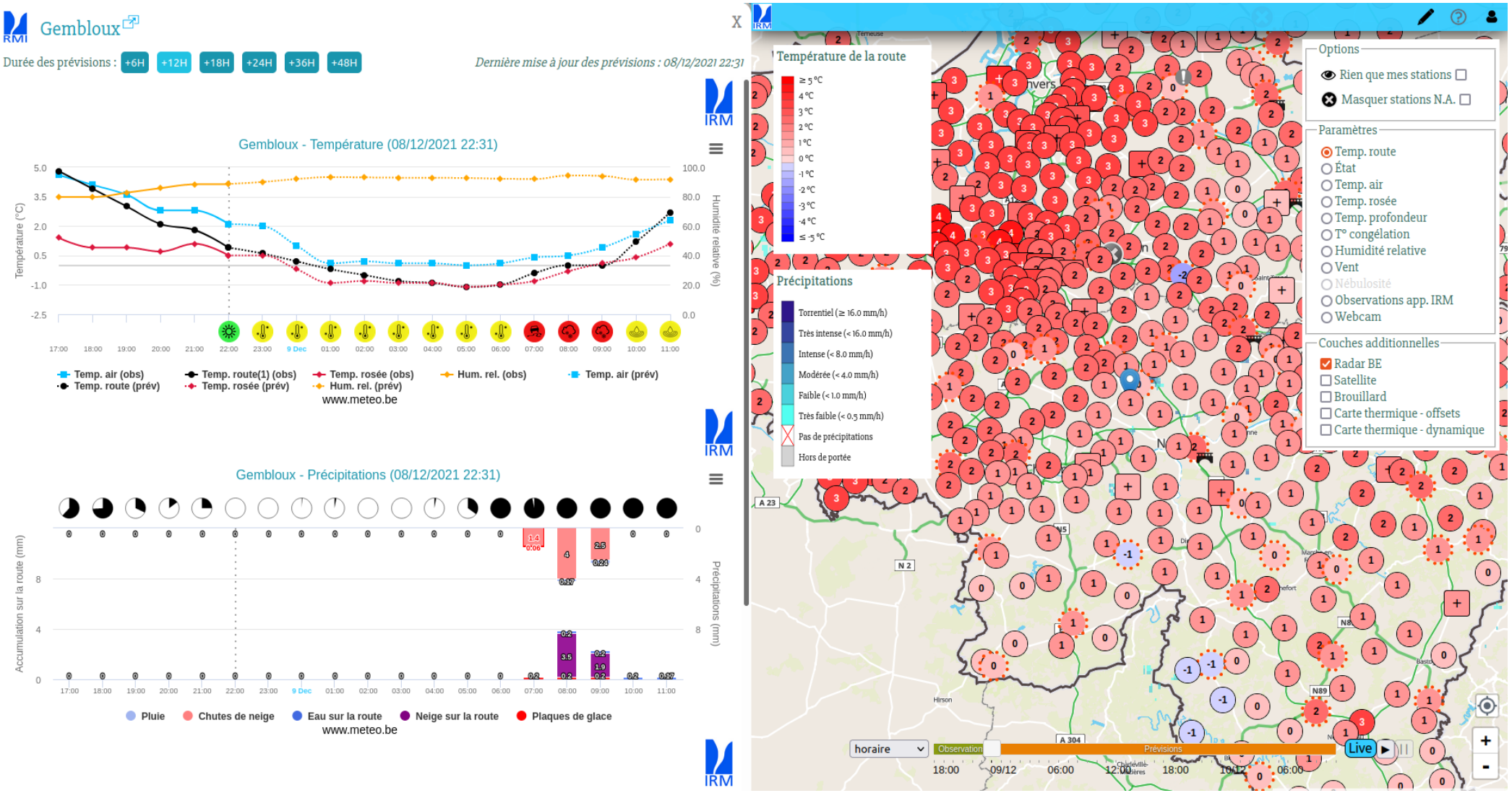
Operational GMS: “Gladheidsmeetsystem”

- Operational GMS over Belgium, with **dynamically chosen NWP model + INCA-BE nowcast** input.
- Output at RWS locations:
  - 55 stations in Wallonia (MéteoRoutes)
  - 90 stations in Flanders (AWV)
- One RWM run per hour, assimilating the latest observations from RWS, updated every 10 minutes.
- Visualized through GIS platform, accessible to end users.

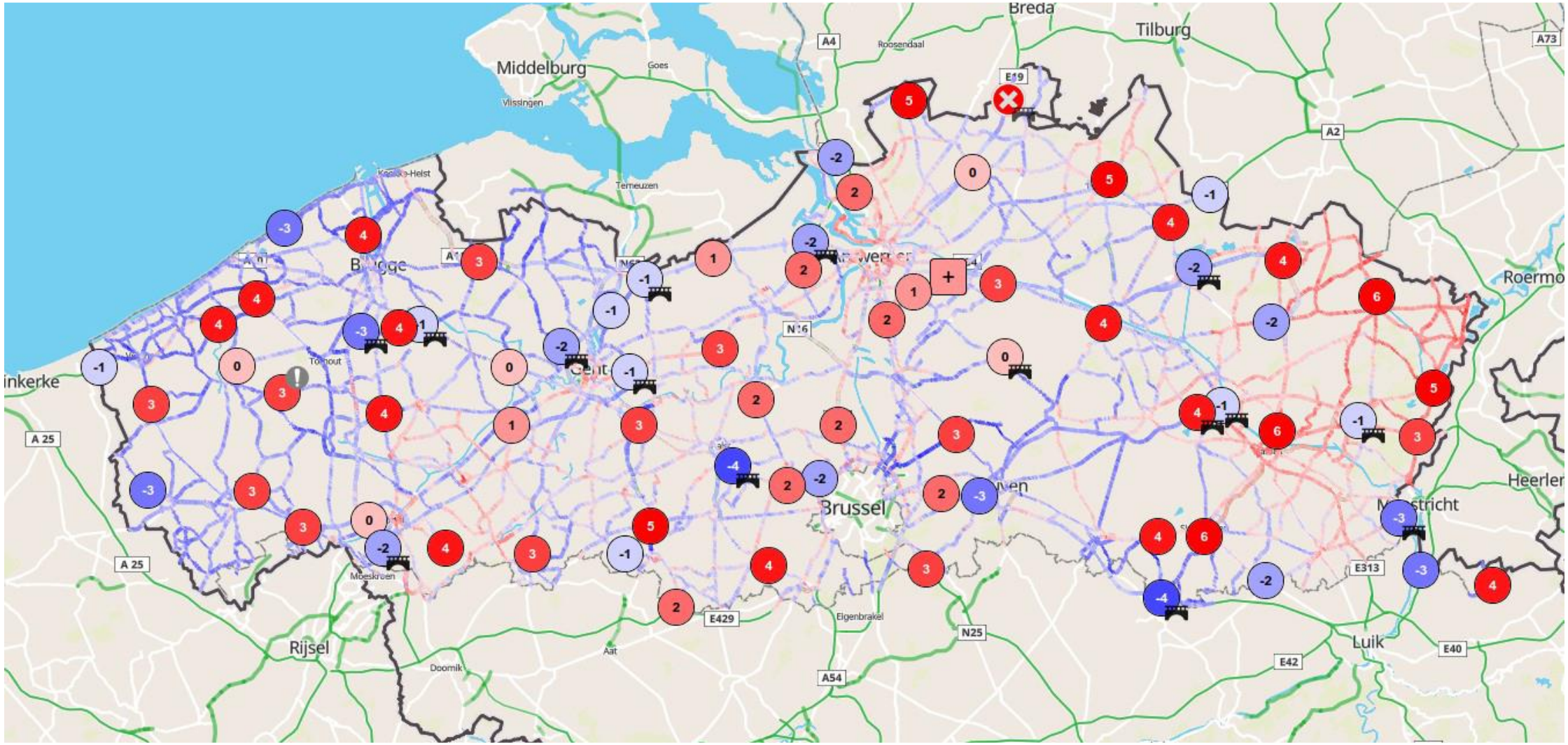
INCA-BE nowcast input for first 3 hours



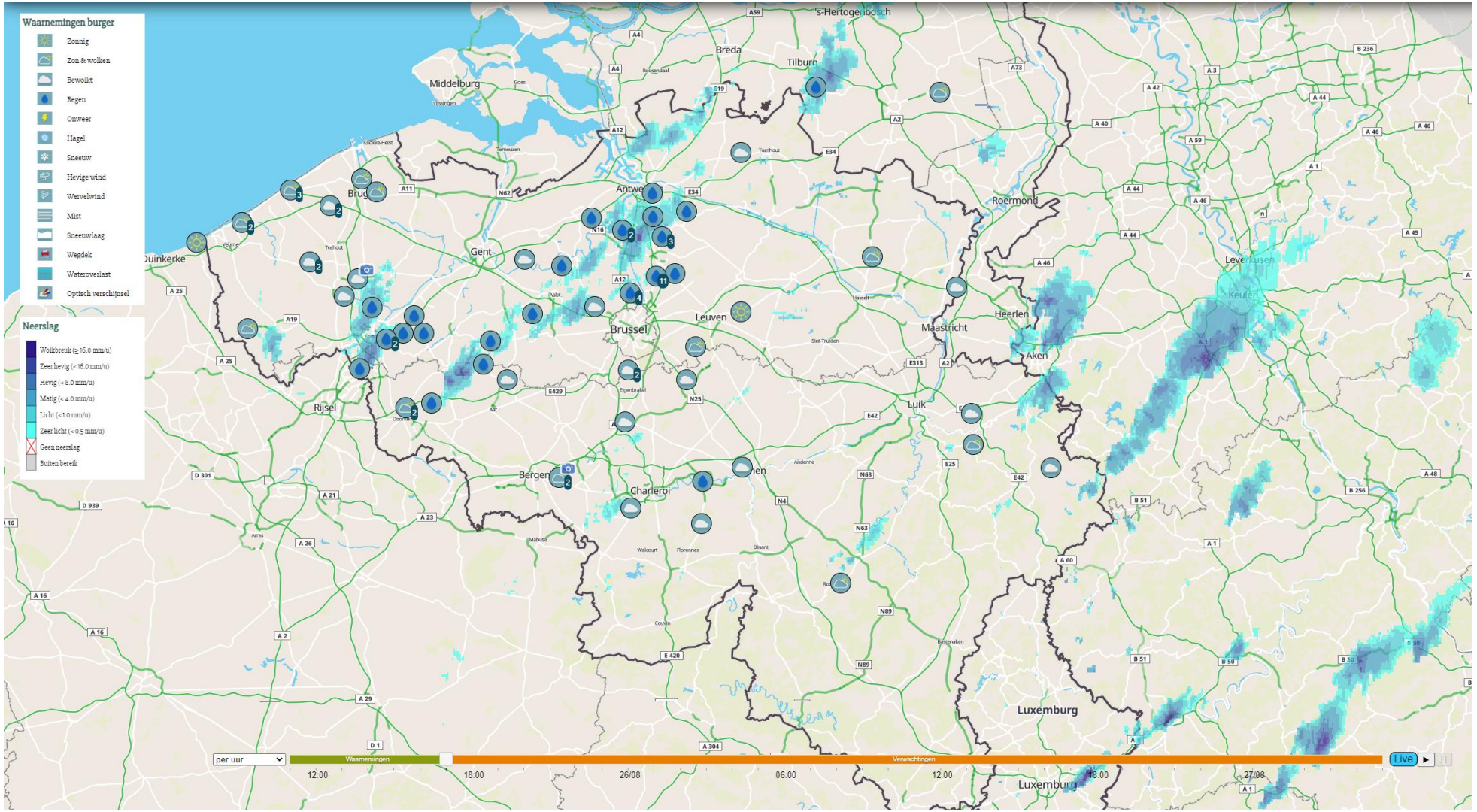
GMS GIS interface



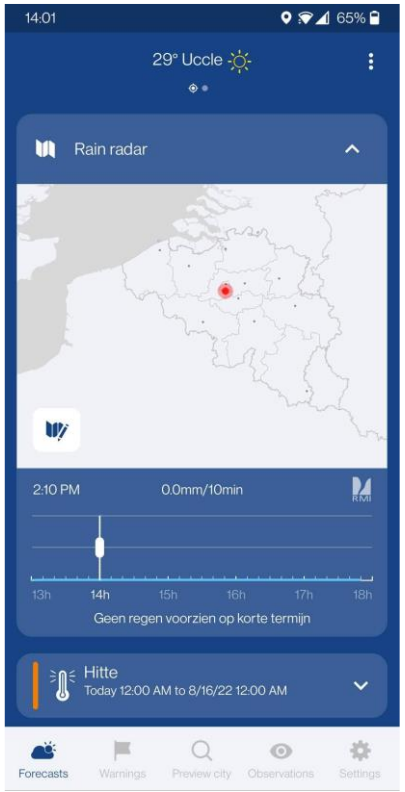
Thermal mapping

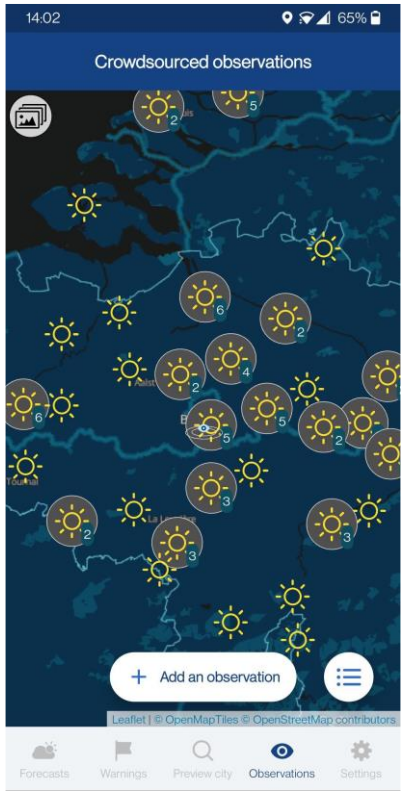


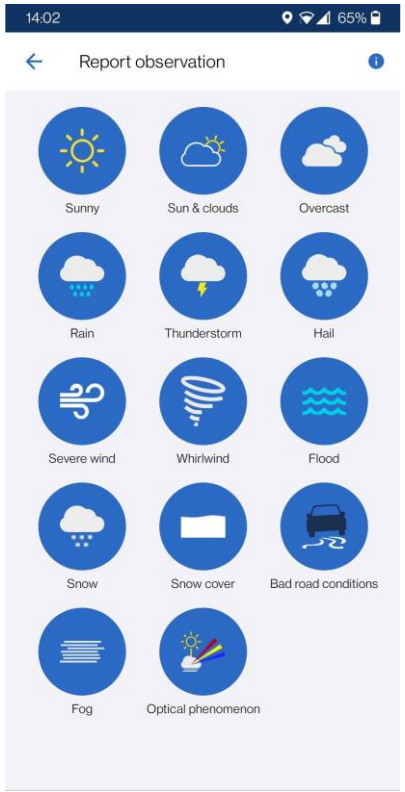
Radar image layer and geolocated citizen reports



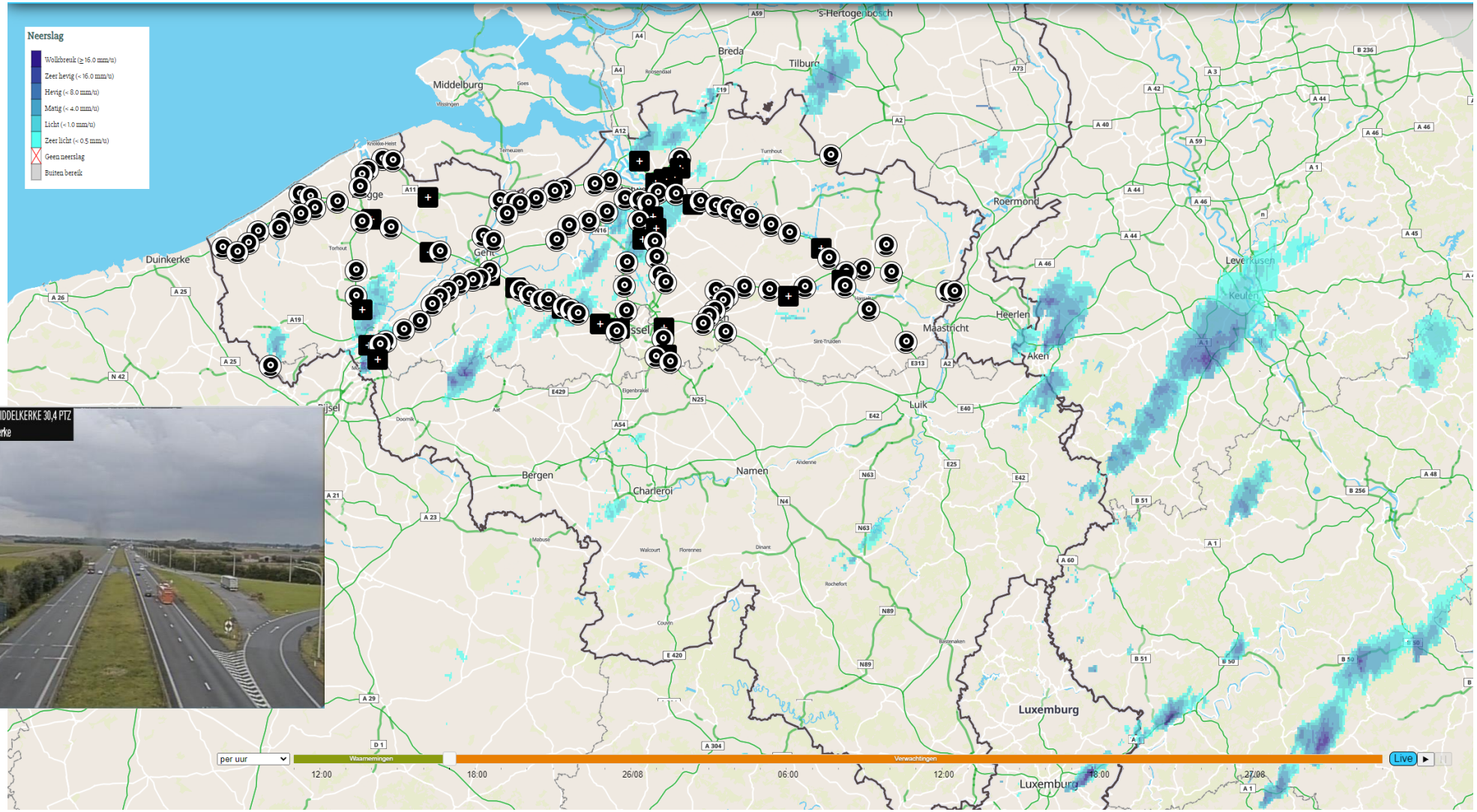
Geolocated citizen reports (work of M. Reyniers)







AWV webcams in Flanders

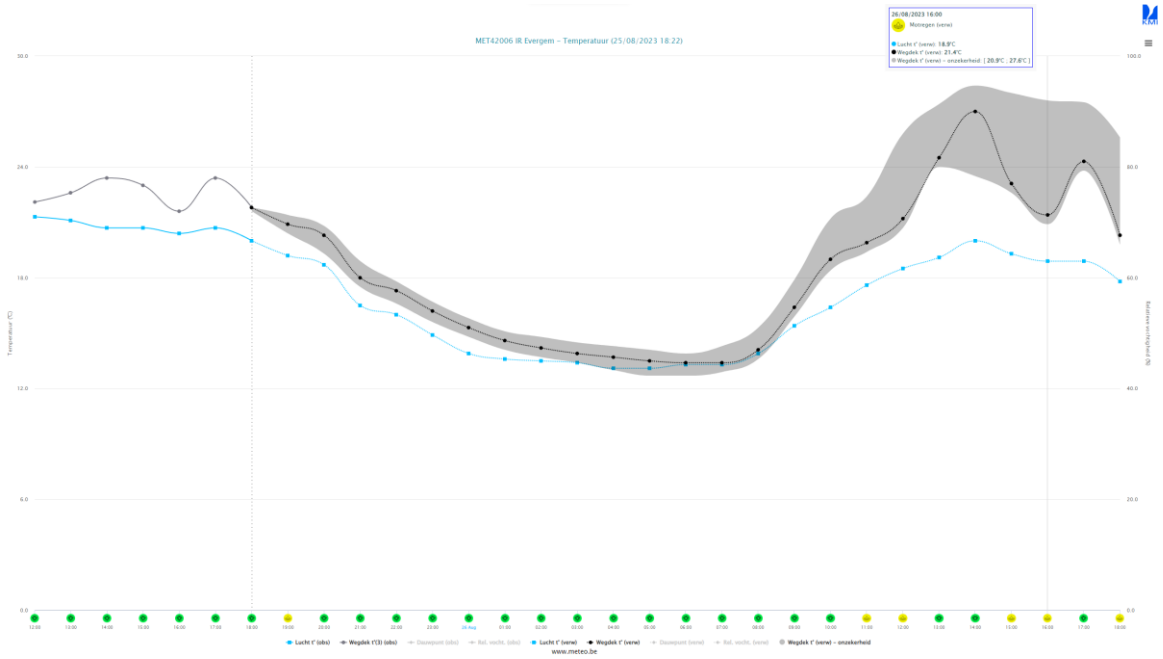


GMS validation

- **Automatic verification** system: monthly KPI for minimum RST during night: RMSE, bias, probability of frost contingency, percentage of errors < 1°C. Evolution of monthly scores, accessible through GMS interface.
- **Ongoing collaboration with end users**, who report problematic cases. Monthly meetings with AWV during winter season.
- **Most difficult weather situation** with large RST forecast errors: cases with forecasted **low clouds and fog vs. clear sky** observation and vice versa.

Ensemble forecasts

- RWM forced with “mini-ensemble” of NWP models since 2022:
  - Alaro 1.3 km
  - Arome 1.3 km
  - ECMWF HIRES (9km)
  - UKMO UM Global (10km)
  - “Model best” (chosen by forecasters)
- Used operationally to generate uncertainty plume for RST forecasts.
- Ensemble forecasts for all variables archived.
- Positive user feedback!

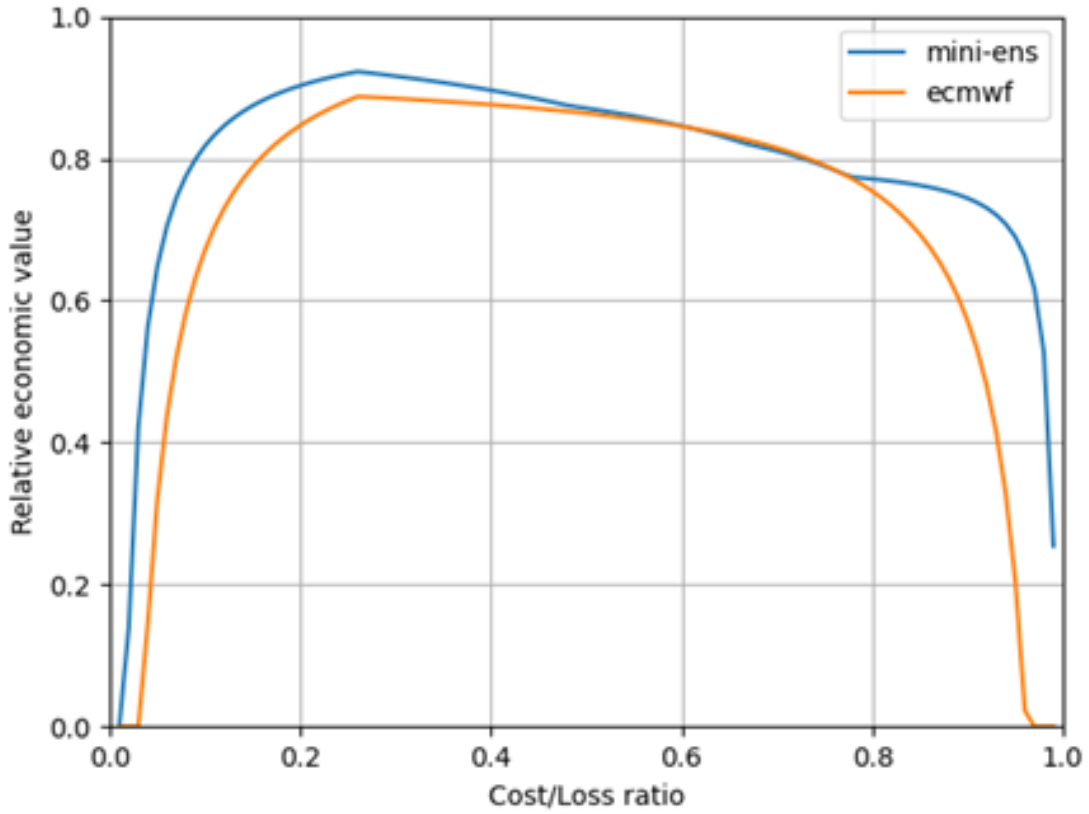


Ensemble validation winter 2023-2024

Nightly minimum RST, 18 UTC forecast.

Model	RMSE (°C)
Ensemble mean	0.87
Alaro (1.3km)	1.15
Arome (1.3km)	1.02
ECMWF HIRES	1.00
UKMO UM Global	1.11
MBG	0.94

Model	CRPS (°C)
Ensemble	0.52



Ongoing developments

- Ensemble forecasts:
  - Inclusion of DWD model.
  - Extended verification study on probabilistic forecast of dangerous road conditions.
  - Investigation of additional user applications: challenge is presenting probabilistic information while keeping the visualization clear and intuitive.
- Installation of pyranometers at selected AWV stations: collecting data since October 2023.
- Road weather forecasts for bicycle lanes and bicycle bridges since winter 2023-2024.

Conclusions

- Operational road weather forecasting system “GMS” predicts road weather conditions for Belgian roads and highways since 2018, resulting from collaboration between RMI and KNMI.
- GIS interface with forecasts and extra layers such as radar image, thermal mapping and crowdsourced citizen reports.
- Operational mini-ensemble forces the RWM with additional NWP models, used to generate uncertainty plume for RST forecasts. More applications under investigation.
- First validation results are encouraging. Additional verification underway for probabilistic forecasts of dangerous road conditions.

THANK YOU

The Royal Meteorological Institute

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