Koninklijk Meteorologisch Instituut

Institut Royal Météorologique

Königliches Meteorologisches Institut

Royal Meteorological Institute

KMI – IRM

Advancing severe weather alerts in Belgium with radar-based convective gust warnings in the INCA-BE system

Maarten Reyniers

European Nowcasting and Weather Forecasting Conference ENWFC-2024, Oslo, Norway

Convective gust warnings

**1.
INCA-BE
system**

**2.
Severe weather
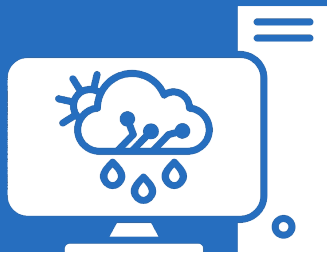notifications**

**3.
Feature detection
in radar data**

Convective gust warning generation

Two cases as illustration

Convective gust warnings

1. INCA-BE system

INCA-BE nowcasting system

- INCA = Integrated Nowcasting through Comprehensive Analysis
- **Nowcasting system** for
  temperature, humidity, wind, cloudiness, precipitation, precipitation type
- **High resolution**: 1 km
- **Base code** from GeoSphere, Austria
- Implemented at RMI since 2012 and
  heavily **adapted/improved** since then
- **Reference** (technical report) :
  https://zenodo.org/record/5798952

Koninklijk Meteorologisch Instituut van België

Institut Royal Météorologique de Belgique

Royal Meteorological Institute of Belgium

The INCA-BE system: ten years of operational nowcasting and its applications at the national meteorological service of Belgium
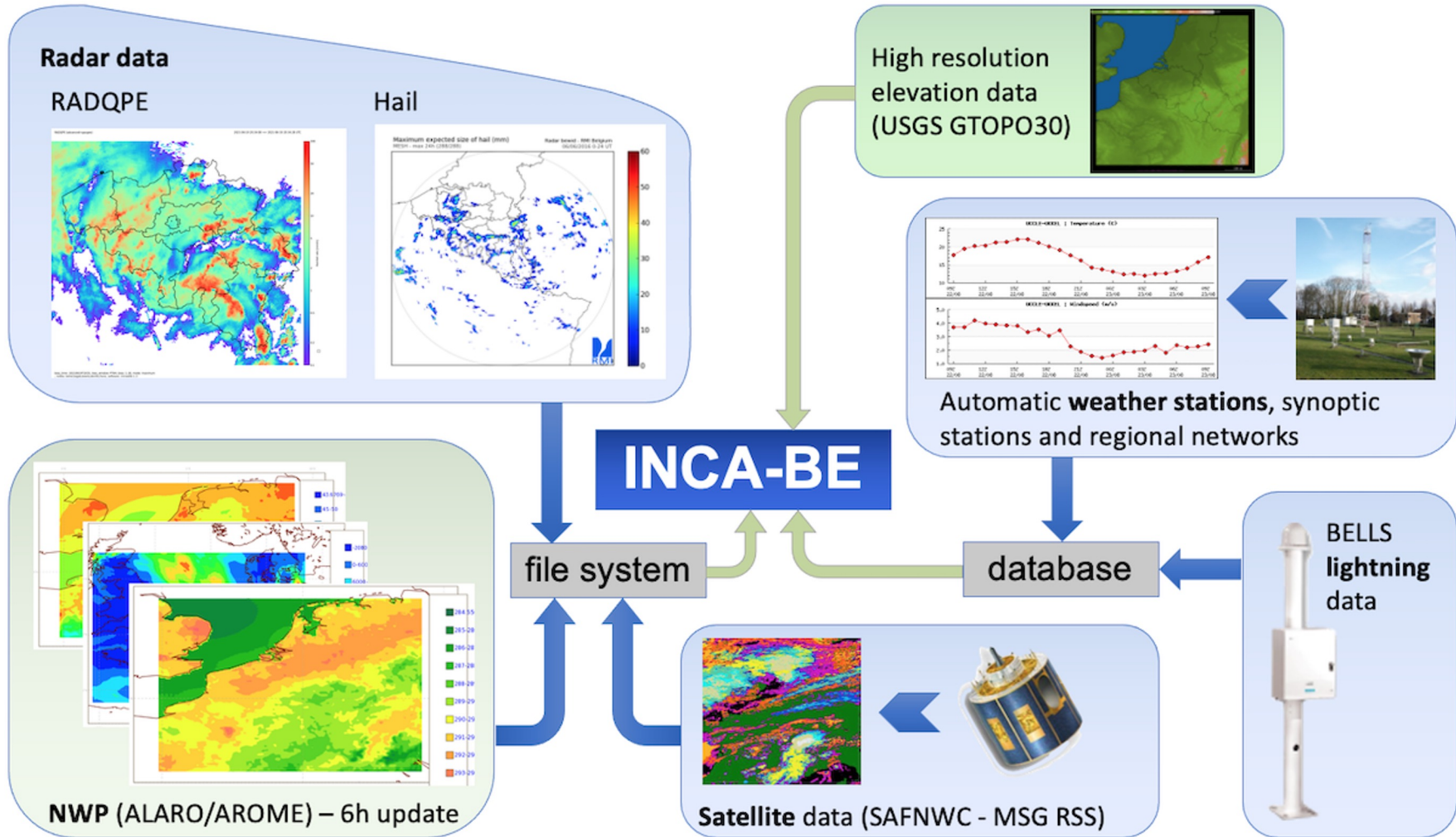
Maarten Reyniers[1],
André Simon[2], Laurent Delobbe[1],
Alex Deckmyn[1], Edouard Goudenhoofdt[1]
[1]Royal Meteorological Institute of Belgium
[2]Hungarian Meteorological Service

Radar data
RADQPE
Hail

High resolution elevation data (USGS GTOPO30)

Automatic **weather stations**, synoptic stations and regional networks

INCA-BE

file system

database

BELLS **lightning** data

NWP (ALARO/AROME) – 6h update

Satellite data (SAFNWC - MSG RSS)

5

INCA-BE nowcasting system: output

Basic fields
forecast up to **+12h, 1h** step

Temperature, dewpoint, relative humidity, snowfall level, freezing level, wind, wind gust speed, wind chill, ground temperature

Precipitation fields
forecast up to **+4h, 10'** step

Precipitation, precipitation type, lightning, severe weather index

Cloudiness fields
forecast up to **+2h, 10'** step
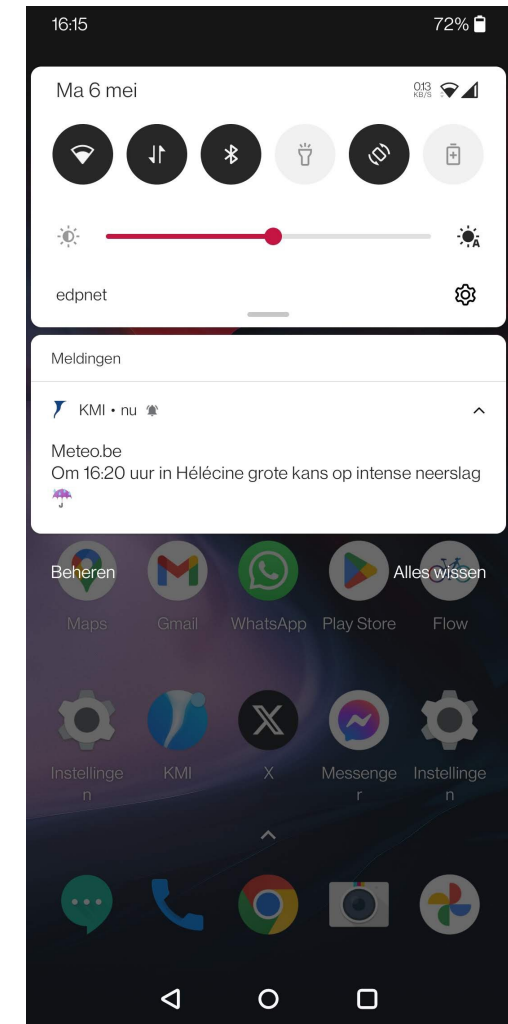
Cloudiness, visibility
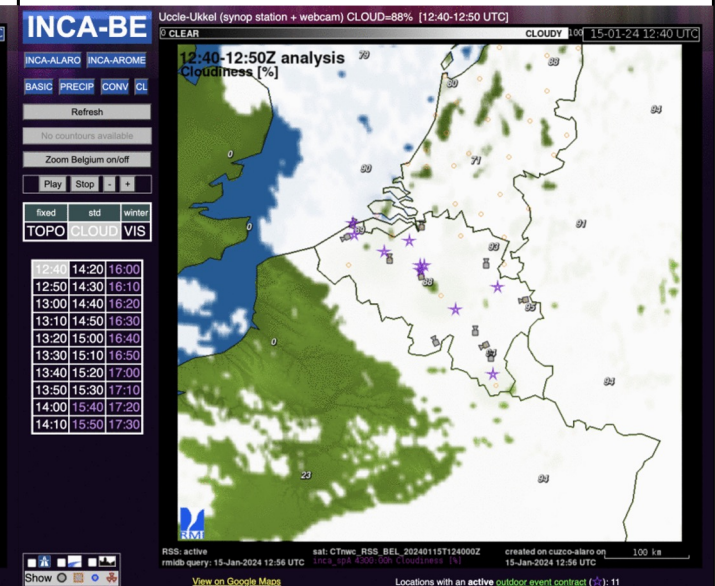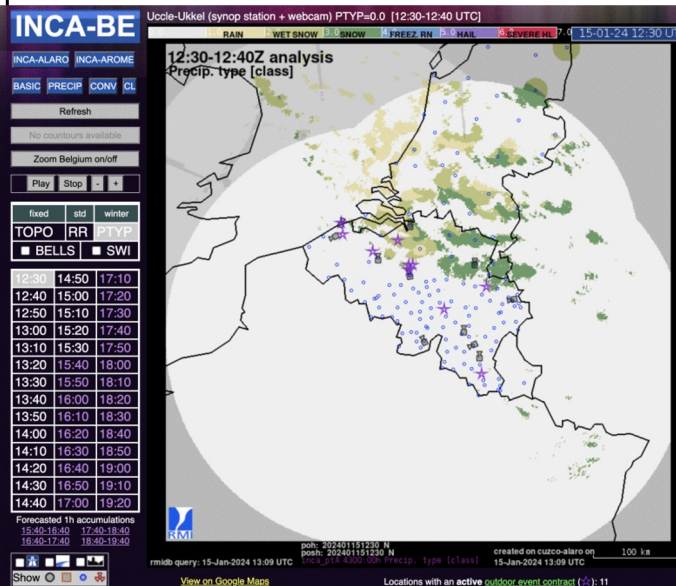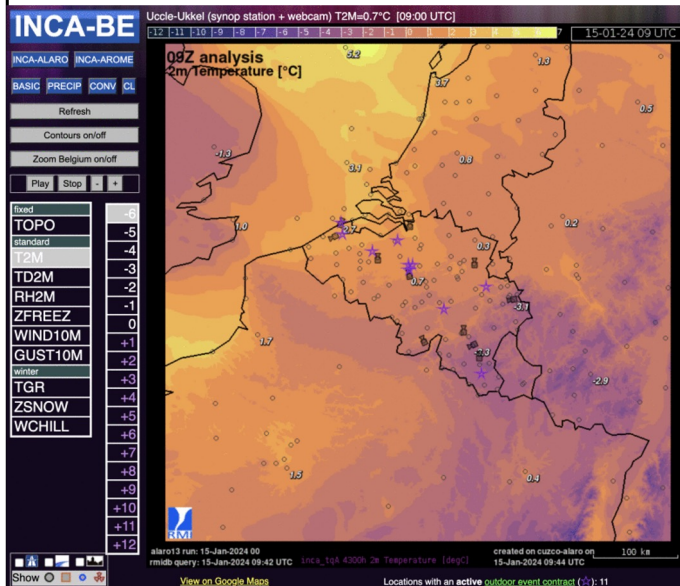
Convective gust warnings

2. Severe weather notifications

Severe weather notifications RMI app

- **Push notifications : "flashes"**
- Distinction between
  - *Near real-time*: 0-20 minutes ahead
  - *Short-term*: 20-80 minutes ahead
- **Spatial scale**: municipality
- Currently **four types** of flashes:
  - **Heavy rain** with additional tags for **lightning** and **hail**
  - **Snowfall**
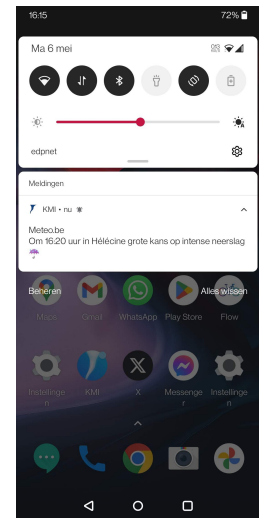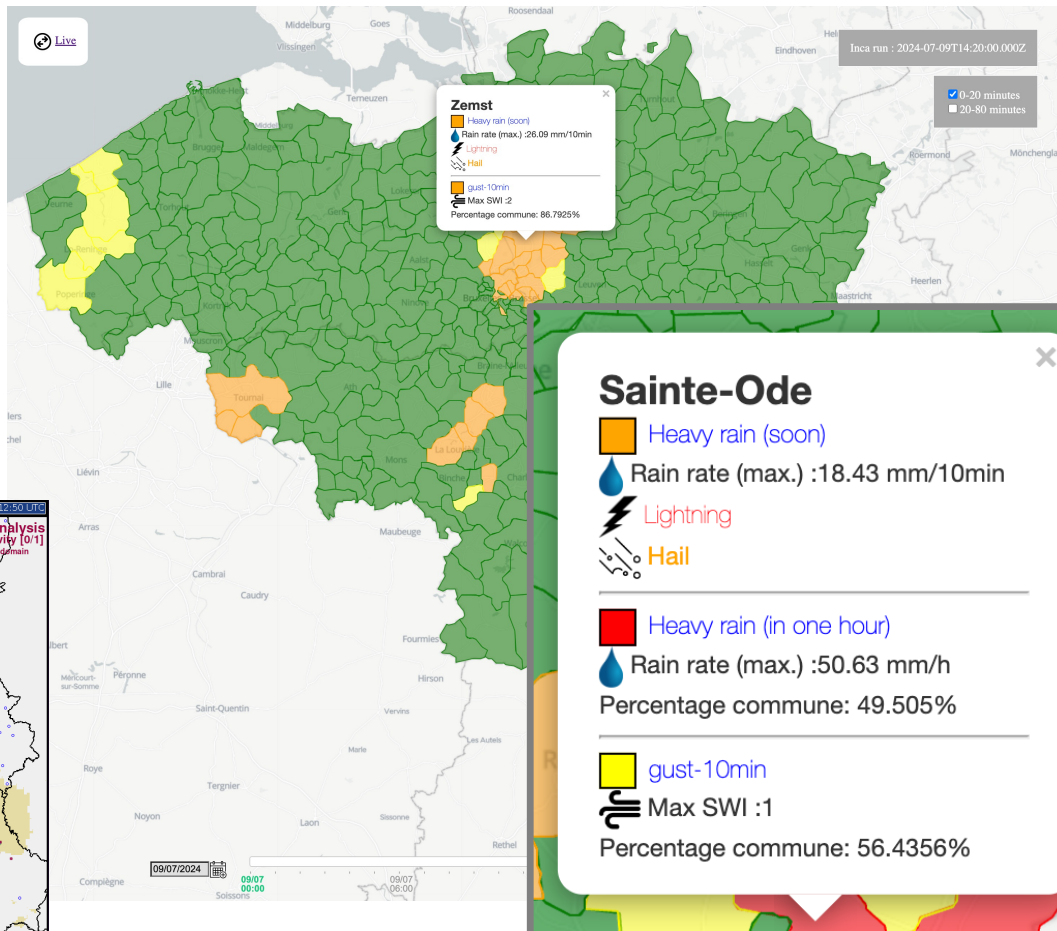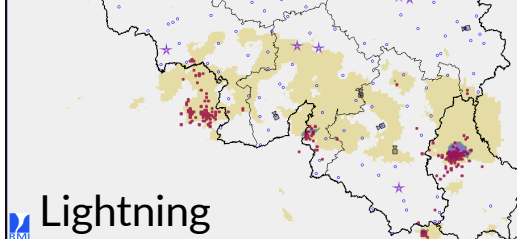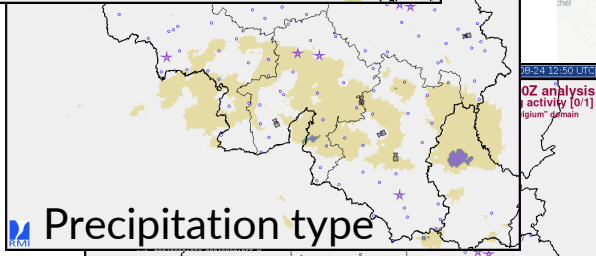 - **Freezing precipitation**
  - **Convective gusts** *(this talk)*

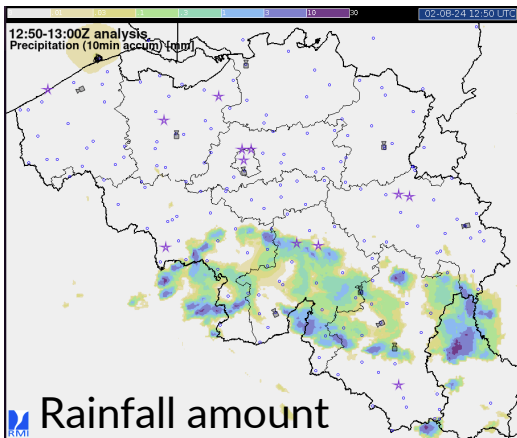# Severe weather notifications RMI app

INCA-BE → Aggregation + thresholding → RMI app


Rainfall amount

Precipitation type

Lightning

Zemst
- Heavy rain (soon)
- Rain rate (max.) :26.09 mm/10min
- Lightning
- Hail
- gust-10min
- Max SWI :2
- Percentage commune: 86.7925%

Sainte-Ode
- Heavy rain (soon)
- Rain rate (max.) :18.43 mm/10min
- Lightning
- Hail

- Heavy rain (in one hour)
- Rain rate (max.) :50.63 mm/h
- Percentage commune: 49.505%

- gust-10min
- Max SWI :1
- Percentage commune: 56.4356%

Severe weather notifications RMI app

- Popular weather app in Belgium:
  >1mio installation on population of 11 mio
- 570,000 app users receive push notifications
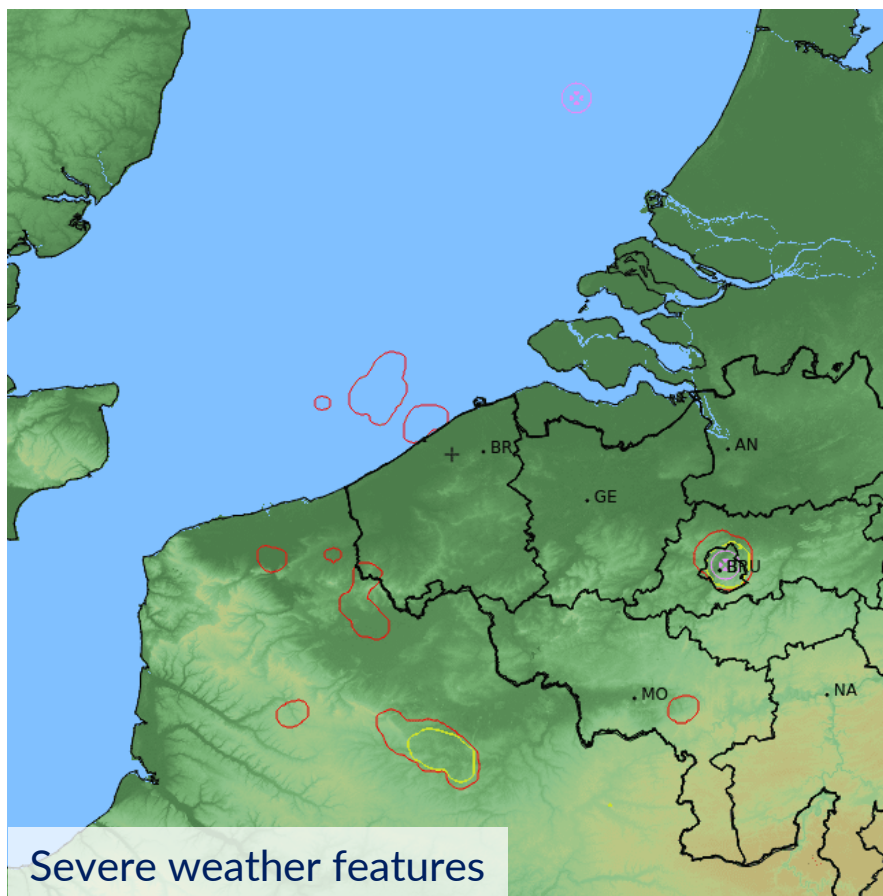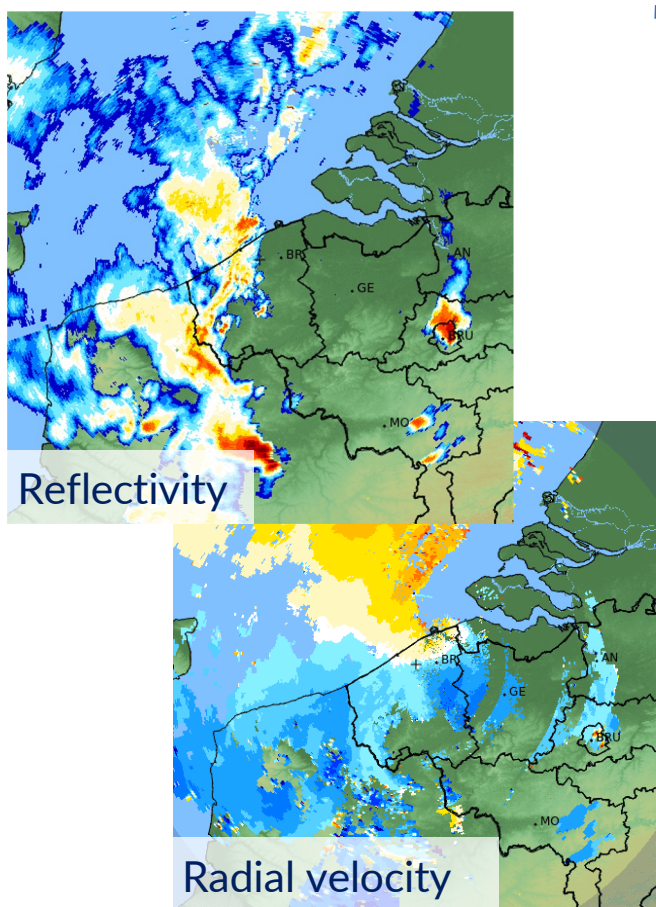
iPhone
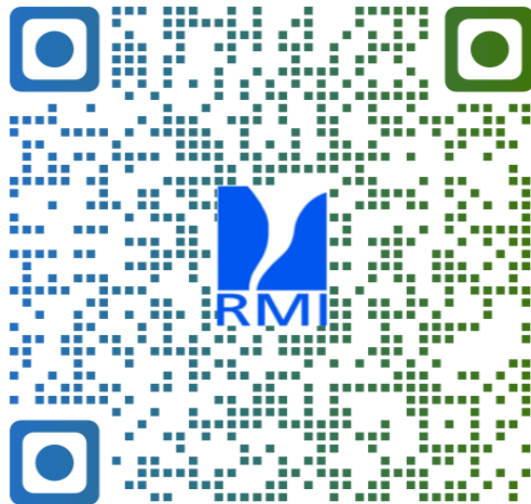
Android
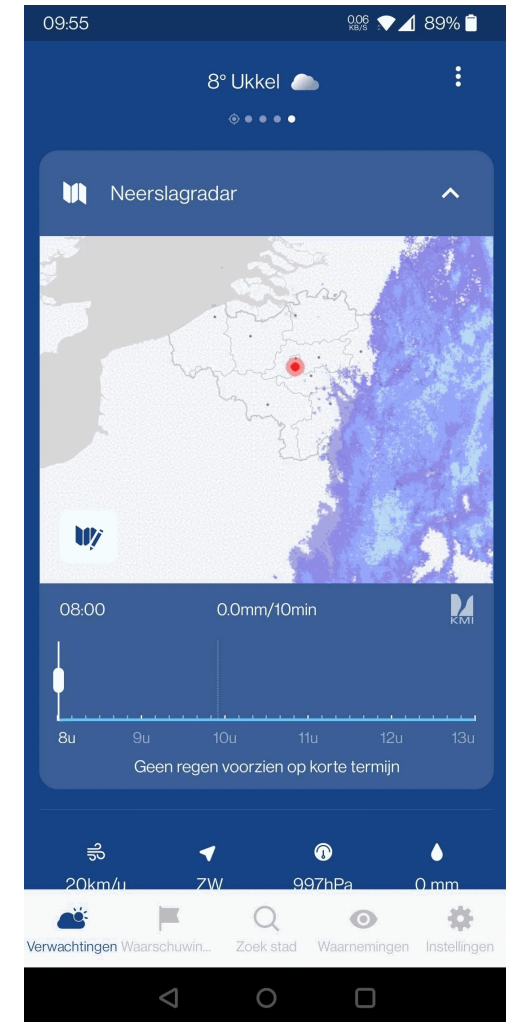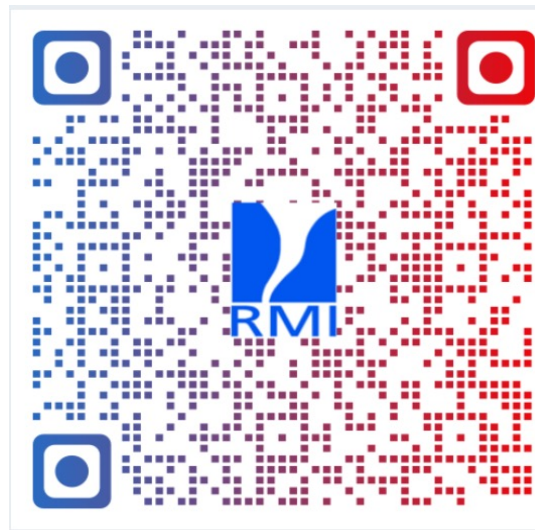
Convective gust warnings

3.
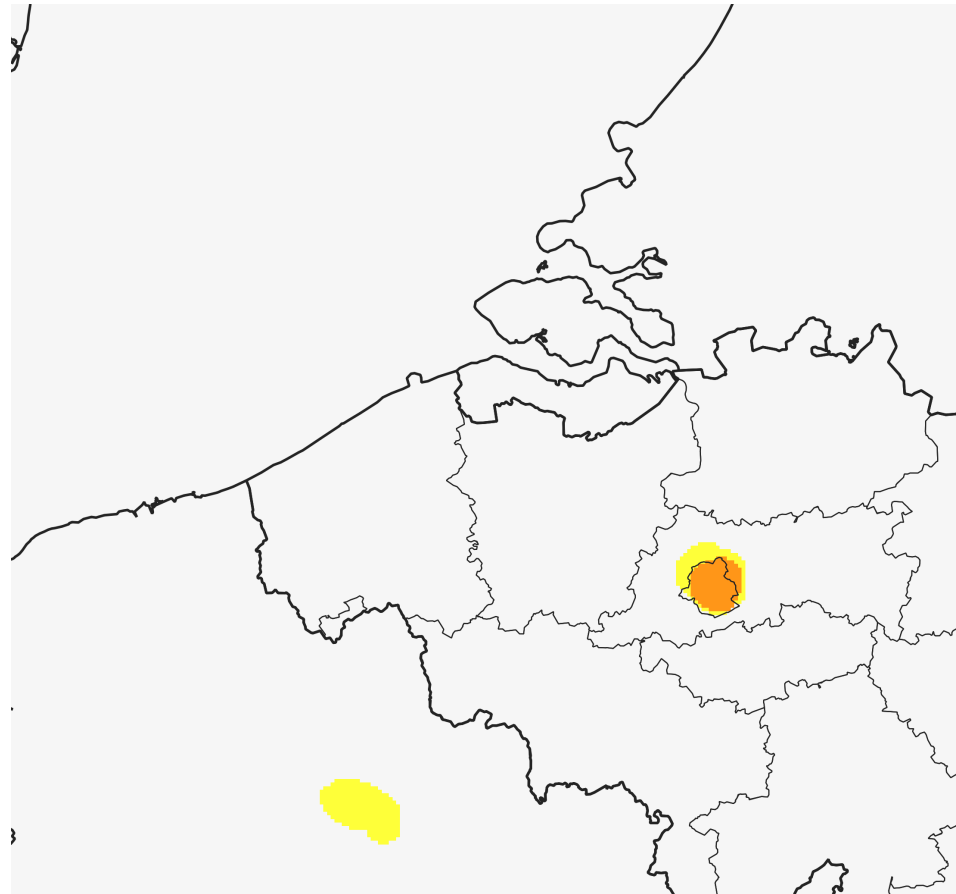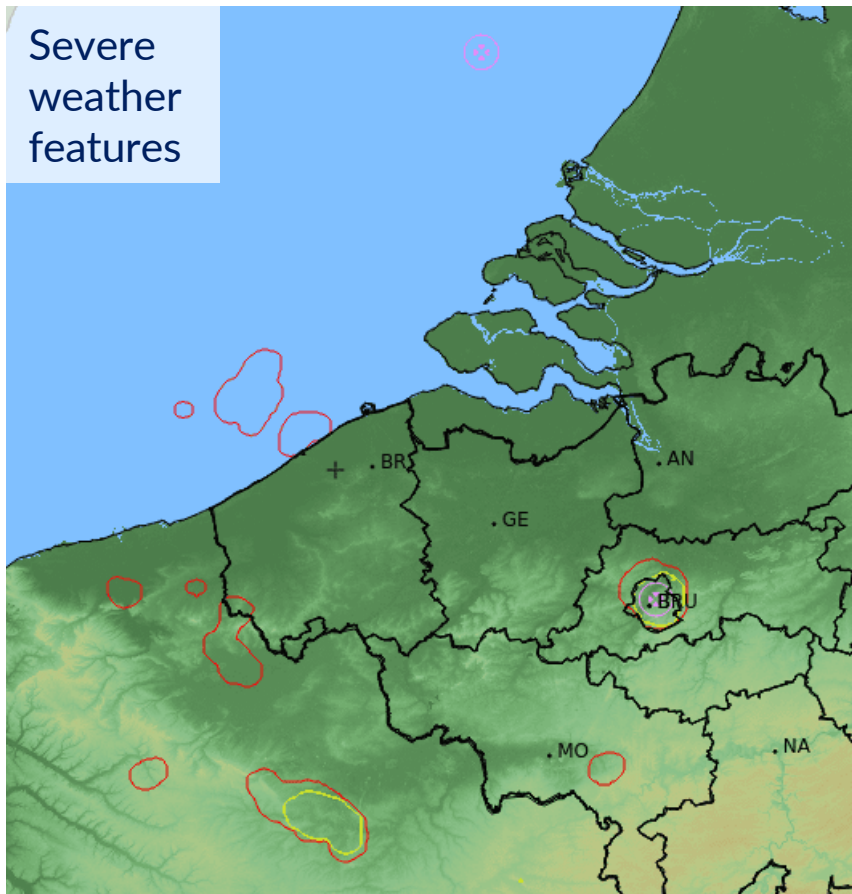**Feature detection in radar data**

Feature detection in radar data

Leonardo Rainbow®5 **severe weather feature** detection

Reflectivity

Radial velocity

Severe weather features

🔴	Storm
🟡	Storm core
🔵	Mesocyclone
⊗	Convergence
⊕	Divergence

Feature detection in radar data
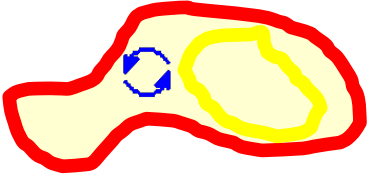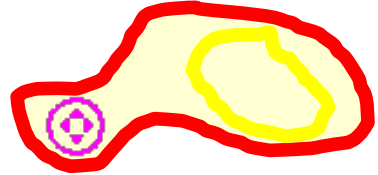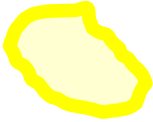
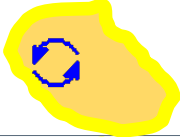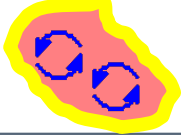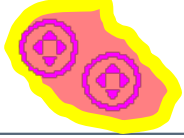Aggregation of features into **Severe Weather Index** (SWI) raster product with 3 levels

Feature detection in radar data

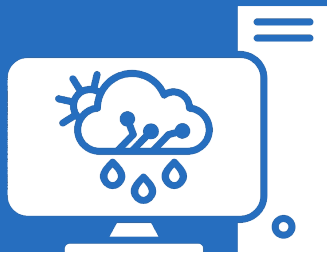Aggregation of features into **Severe Weather Index** (SWI) raster product with 3 levels

SWI	Description	Looks like
1	*Storm* intersection with areas of ≥7 m/s average wind. The intersection must include at least 1 div/conv or 1 rotation.	Avg. wind > 7m/s ... or ... Avg. wind > 7m/s
1	Entire *storm* area that contains at least 1 storm core and includes at least 1 div/conv or 1 rotation.	... or ...
1	The entire area of a *storm core*.	
2	The entire area of a *storm core* with at least 1 div/conv or 1 rotation.	... or ...
3	The entire area of a *storm core* with at least 2 div/convs or 2 rotations.	... or ...

Convective gust warnings

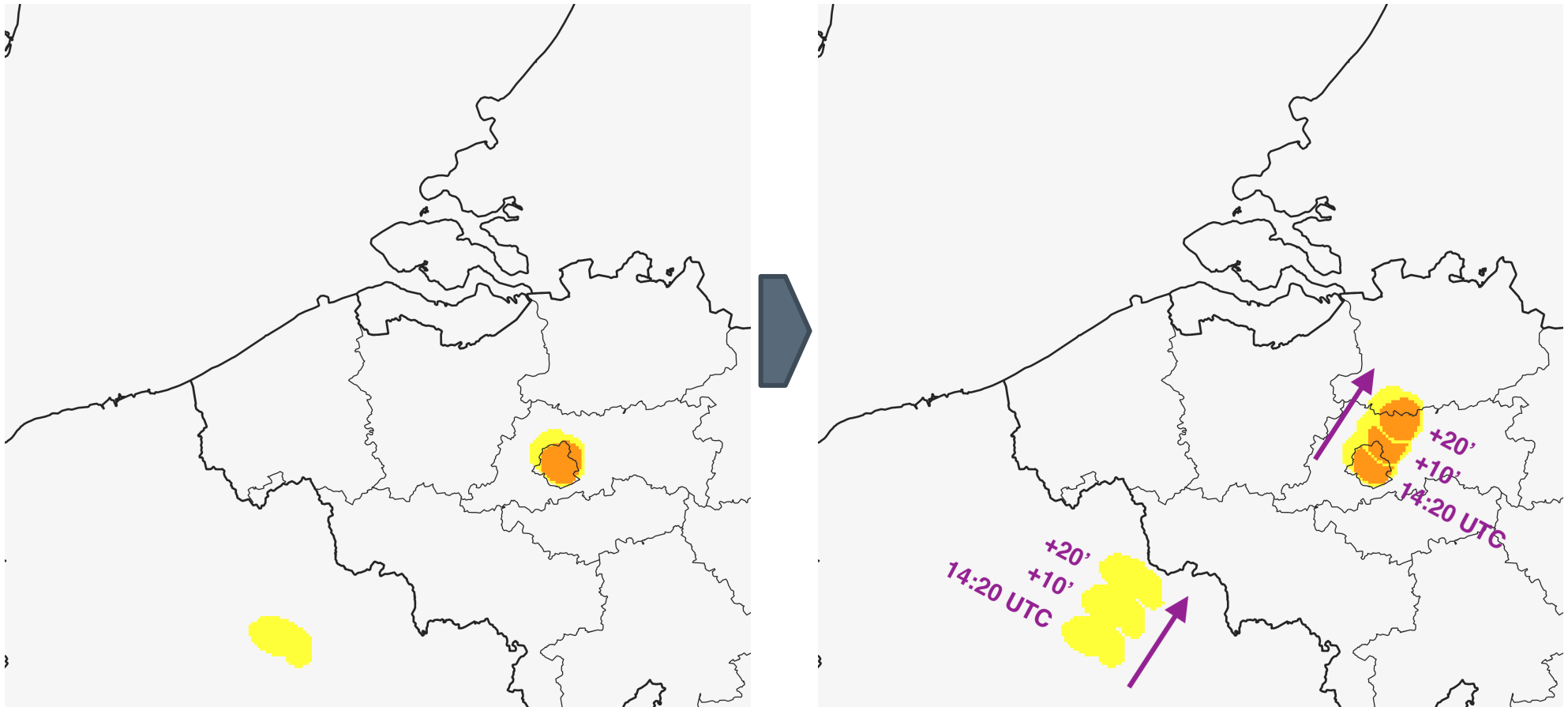| 1. INCA-BE system | 2. Severe weather notifications | 3. Feature detection in radar data |

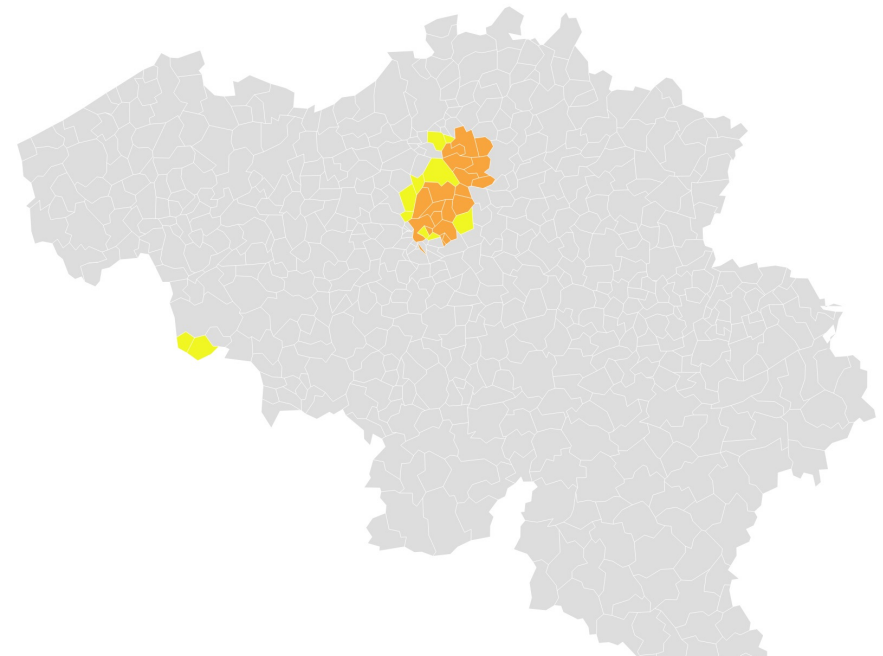**Convective gust warning generation**
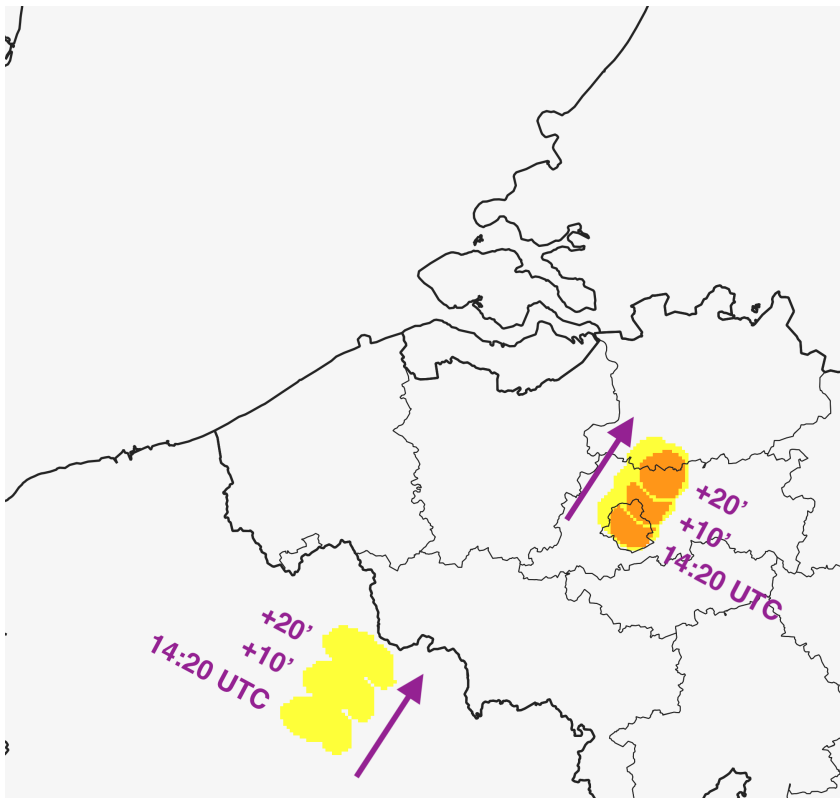
Convective gust warning generation

Advection Severe Weather Index field in INCA-BE along with precipitation vectors

Convective gust warning generation

A ▮▮▮ flash on municipal level is triggered if at least 1/3 of the INCA-BE grid cells within the municipality reach 1|2|3 SWI level.

Convective gust warnings

1.
INCA-BE system

2.
Severe weather notifications
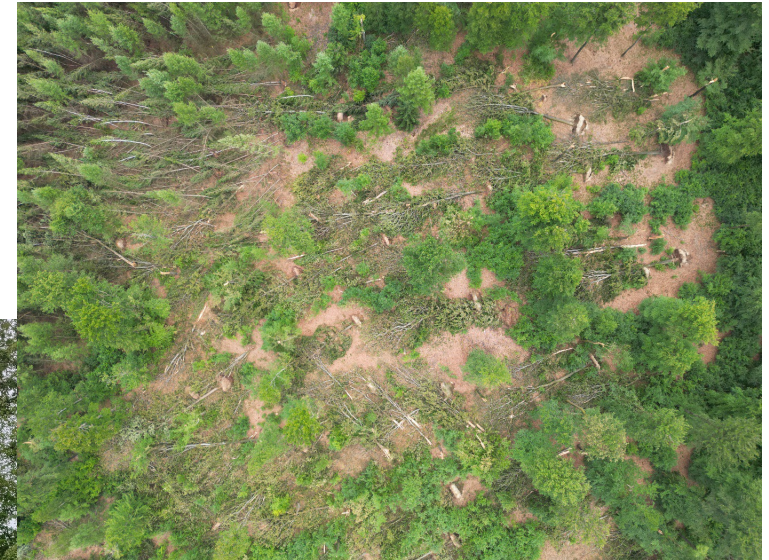
3.
Feature detection in radar data

Convective gust warning generation

Two cases as illustration

Case 1: tornado Bouillon 22-Jun-2023

- Tornado in unpopulated area (forest)
- Radar images show **bookend vortex**
- Tornado touchdown between 12:40 and 12:45 UTC
- 1,400-meter damage path with **684 trees damaged**
- "small" EF2, implying wind velocities up to 200 km/h

12:30

SWI analysis 12:30

Severe weather features
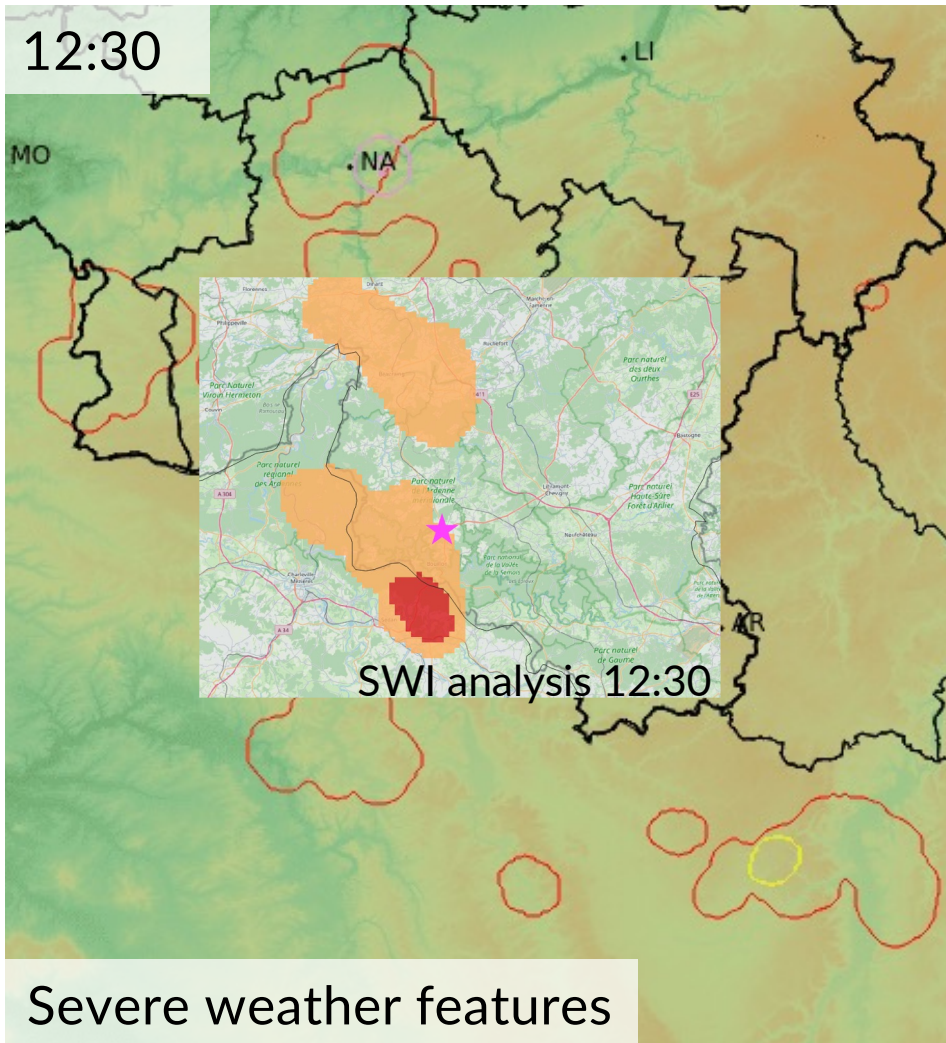
★ = tornado location (12:40 - 12:45 UTC)

INCA-BE nowcast **+10'**
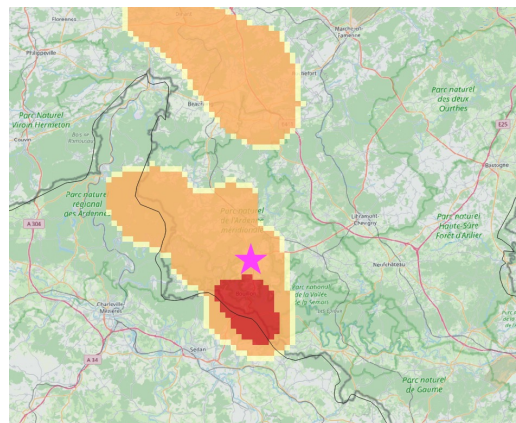
INCA-BE nowcast **+20'**
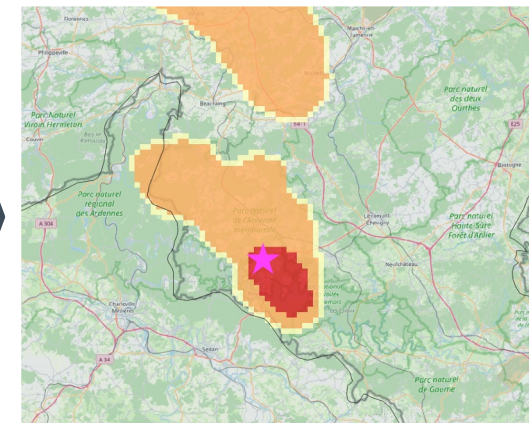
Successful signal of potential severe wind event 10 to 20 minutes ahead.

Case 2: downburst Mechelen 09-Jul-2024

- Doppler images **do not show** evidence of **rotation**
- Downburst from ~15:45 to ~16:00 UTC
- Wind gusts estimated >150 km/h
- Damage: - toppled power poles, church tower blown off
          - damage to ~20,000 private homes

Downburst from ~15:45 to ~16:00 UTC in impacted region (circle).
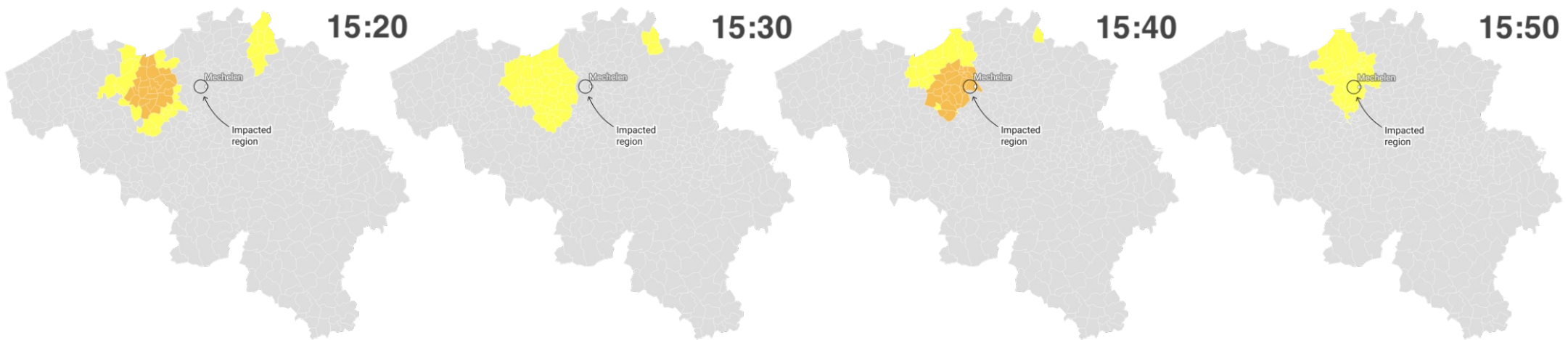
Flashes for convective gusts along NE moving squall line. Impacted region notified **5 minutes ahead** with **orange flashes**.

Earlier orange flashes at 15:20 were however **too alarming** (no damage reported in that region).

Convective gust warnings

- Method to generate nowcast warnings ("flashes") for convective gusts
- Pragmatic approach by combining existing ingredients
- Performance on past cases encouraging
- Validity critically depends on severe weather feature detection in radar manufacturer's software
- False alarms to be studied further

Thank you!

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