INLINE
Integrated pan-European rainfall and floods impact forecasts for cooperation in emergency management

Co-funded by the European Union

WP2
Improved precipitation estimation over Europe

Shinju Park, Jordi Capdevila, Víctor Gonzales and Marc Berenguer

CRAHI-UPC

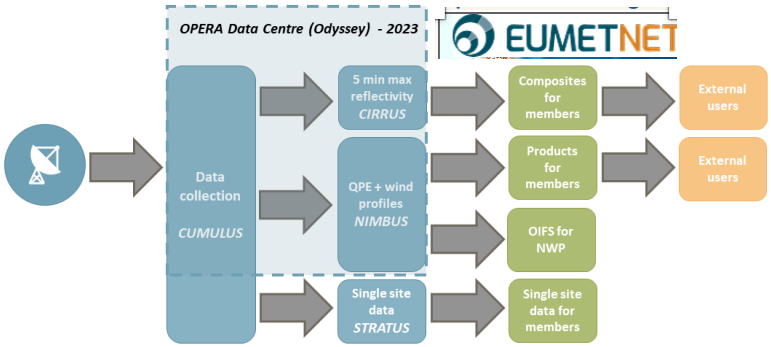
24 February 2026

Centre de Recerca Aplicada en Hidrometeorologia
UNIVERSITAT POLITÈCNICA DE CATALUNYA
ECMWF
ILMATIETEEN LAITOS METEOROLOGISKA INSTITUTET FINNISH METEOROLOGICAL INSTITUTE
AEMet Agencia Estatal de Meteorología
IPMA Instituto Português do Mar e da Atmosfera
EMA Agencia de Emergencias de Andalucía
Junta de Andalucía
GOBIERNO DE ESPAÑA MINISTERIO DEL INTERIOR
DIRECCIÓN GENERAL DE PROTECCIÓN CIVIL Y EMERGENCIAS
EMERGÊNCIA E PROTEÇÃO CIVIL AUTORIDADE NACIONAL

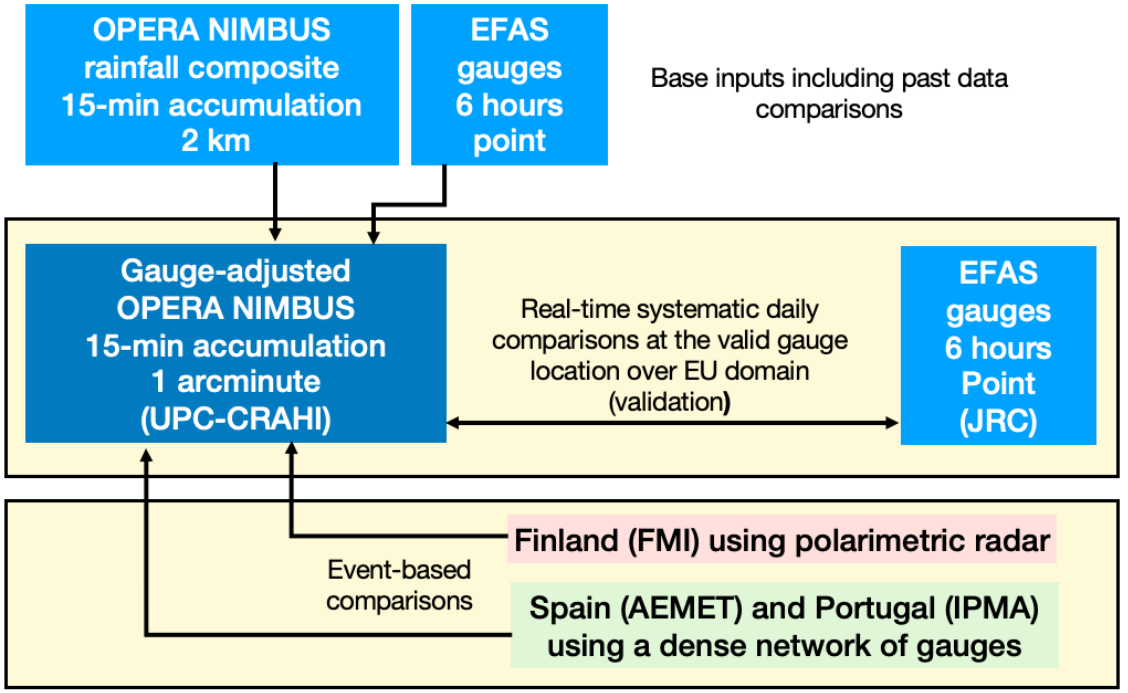
WP2

- Continuous assessment of the quality of OPERA radar-based gridded precipitation estimates over Europe.

T2.1 - Continuous evaluation of OPERA precipitation estimates
(lead: **UPC**; participants: FMI, AEMET, IPMA)



European radar network from EUMETNET OPERA - NIMBUS Rain rate composites (15 min, 2 km)



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WP2

- Evaluation of the effect of using OPERA radar-based gridded precipitation estimates to improve EFAS initial conditions.
- Analysis of the viability of initialising EFAS hydrological forecasts with radar-based QPE.

T2.2 - Improved precipitation estimation for EFAS initial conditions
(lead: **UPC**; participants: ECMWF)

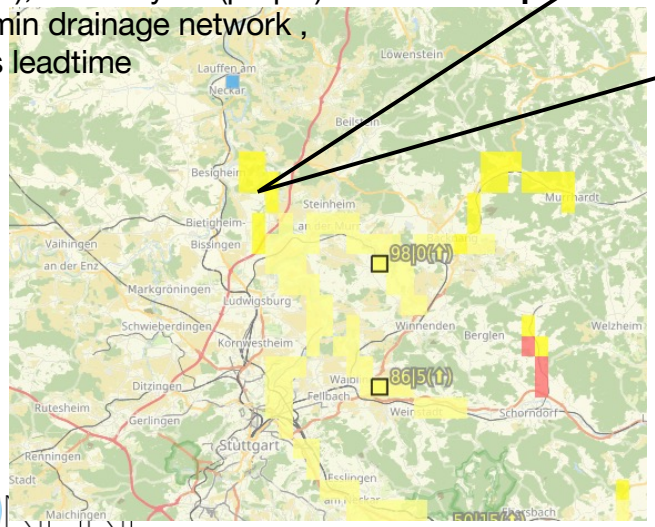
T2.3 -Hydrological assessment of improved precipitation estimates for EFAS initial conditions
(lead: **ECMWF**; participants: UPC)

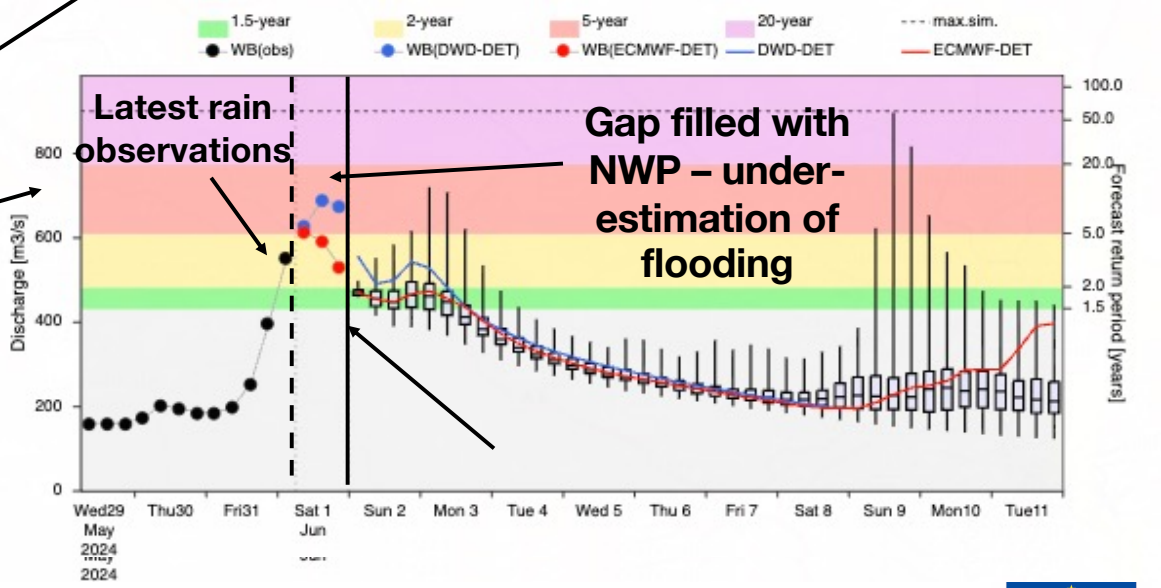


Flooding at Marbach am Neckar 3rd June 2024

By Mussklprozz - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=149046851

The probabilities of exceeding the 2-year (yellow), 5-year (red), and 20-year (purple) **EFAS return periods** @1 arcmin drainage network , 10 days leadtime





EFAS discharge forecasts

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EFAS gauges (EMO1 gridded gauge data at 1 arcmin by JRC)

+ Historic data:

6 hourly, 24 hourly (2013-2023 from JRC),

6 hourly only (Feb 2024 – 15 May from ECMWF)

+ Realtime data:

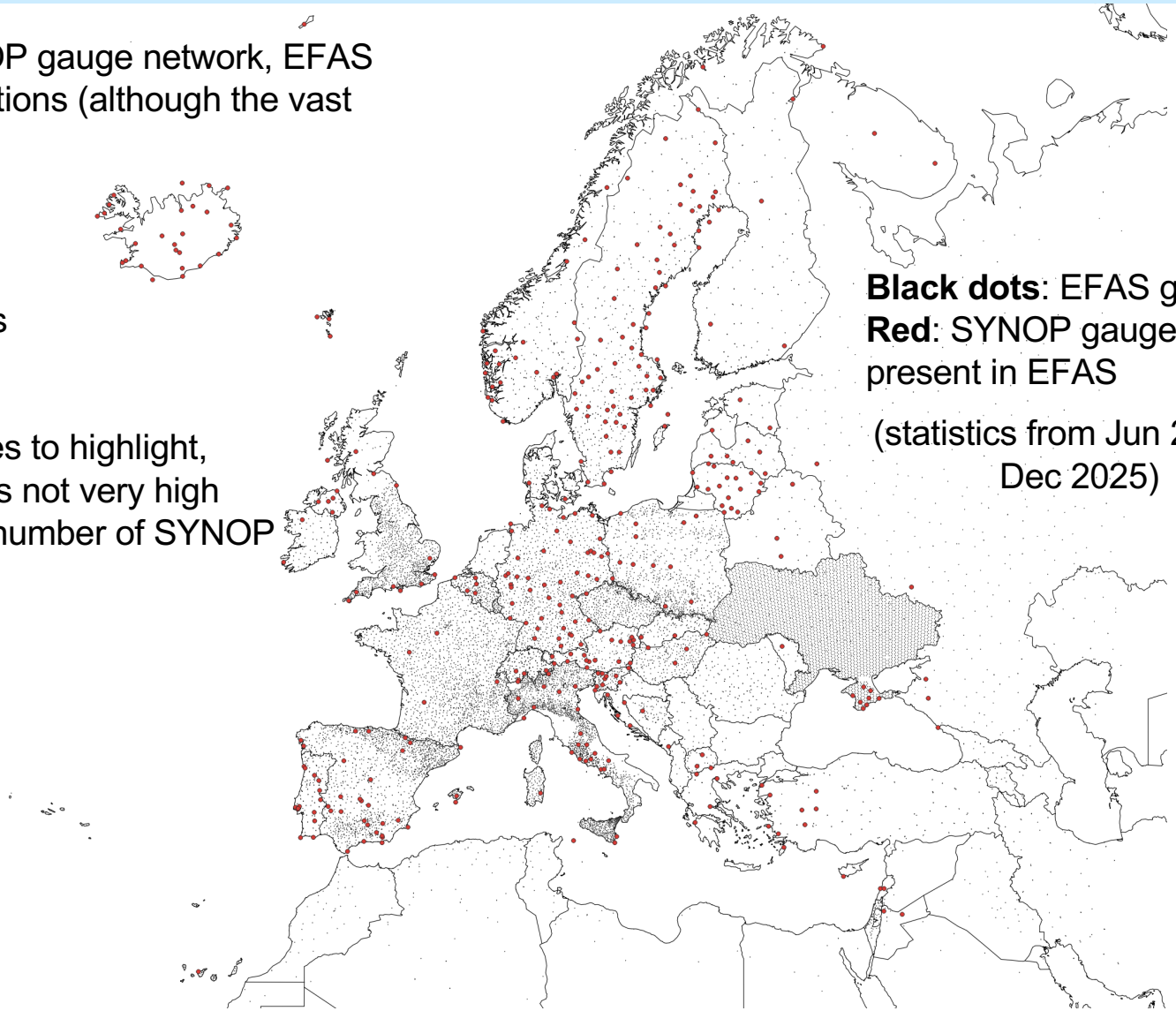
6 hourly, 24 hourly (15 May 2025 – present from JRC

Compared with the SYNOP gauge network, EFAS doesn't include all the stations (although the vast majority).

In general, the EFAS network has a greater density which makes this problem irrelevant.

There are only a few cases to highlight, where the EFAS density is not very high and there is a significant number of SYNOP stations:

- Iceland
- Baltic Republics



Black dots: EFAS gauges
Red: SYNOP gauges not present in EFAS

(statistics from Jun 2025 to Dec 2025)

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Correcting radar with EFAS gauges

+ Historic data:

6 hourly, 24 hourly (2013-2023 from JRC),

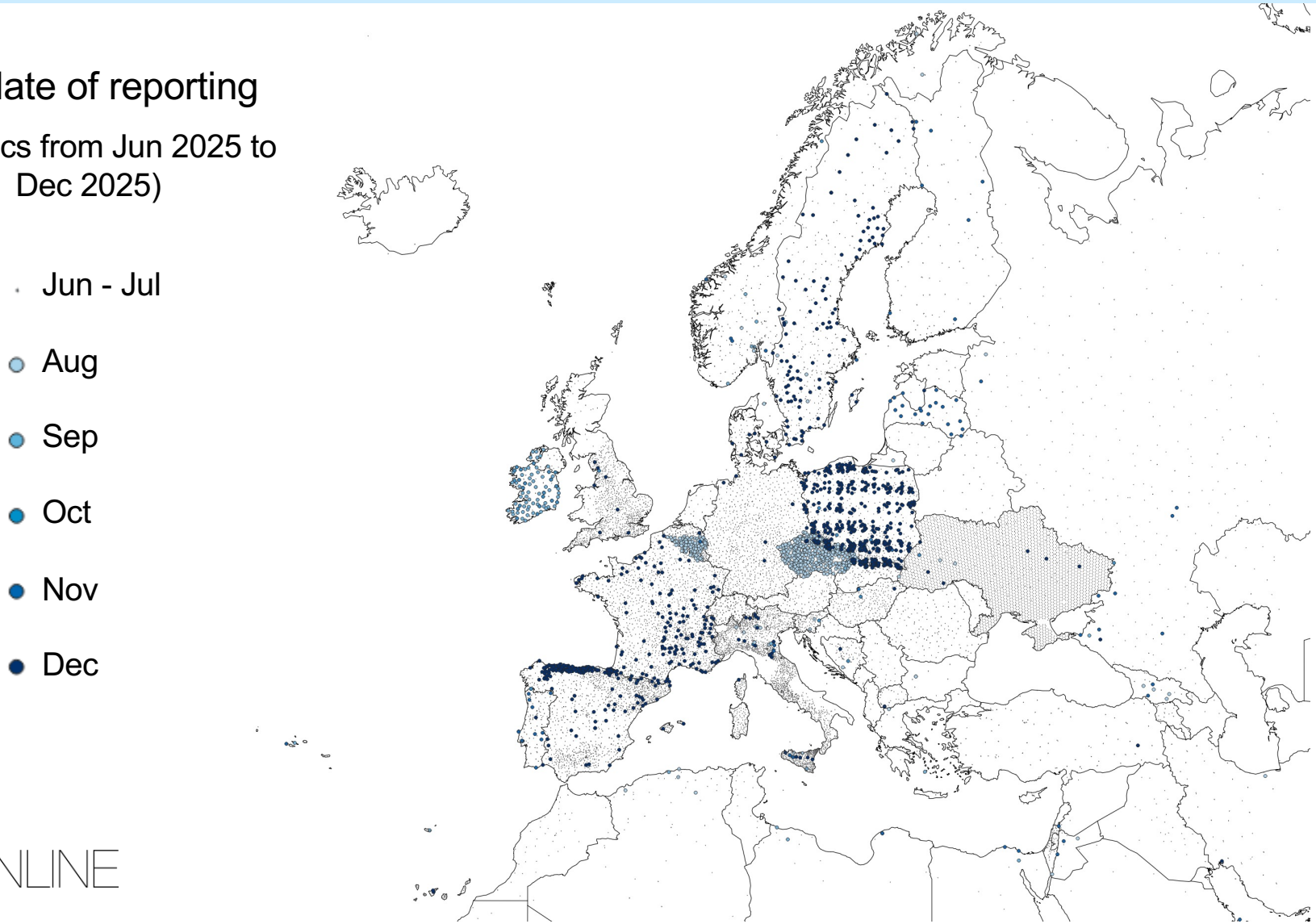
6 hourly only (Feb 2024 – 15 May from ECMWF)

+ Realtime data:

6 hourly, 24 hourly (15 May 2025 – present from JRC

First date of reporting

(statistics from Jun 2025 to Dec 2025)



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EFAS gauges (EMO1 gridded gauge data at 1 arcmin by JRC)

+ Historic data:

6 hourly, 24 hourly (2013-2023 from JRC),

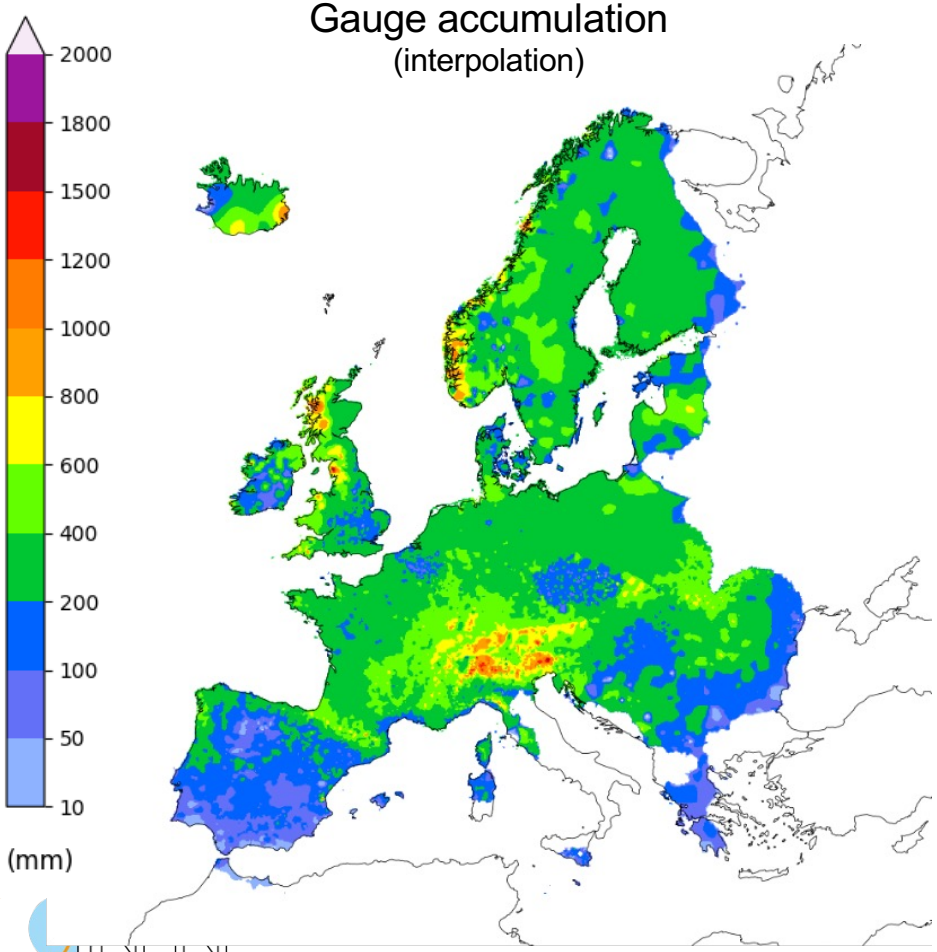
6 hourly only (Feb 2024 – 15 May from ECMWF)

+ Realtime data:

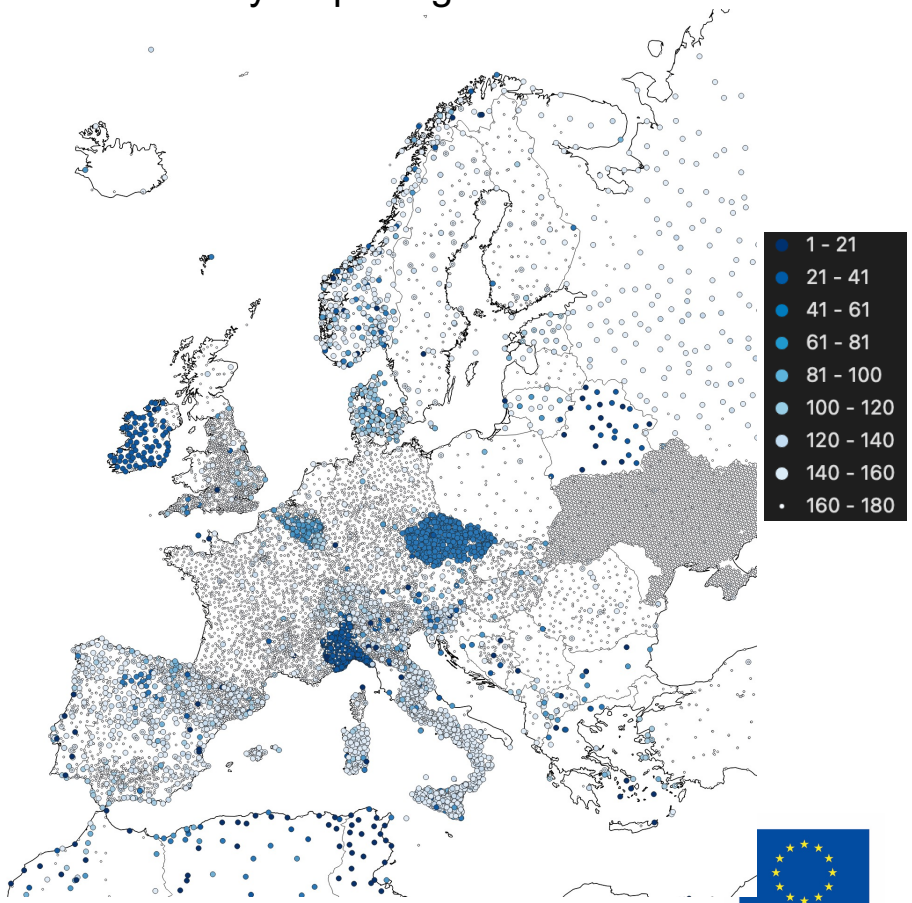
6 hourly, 24 hourly (15 May 2025 – present from JRC

Apr - Sep 2025 period (6 months)

Gauge accumulation
(interpolation)



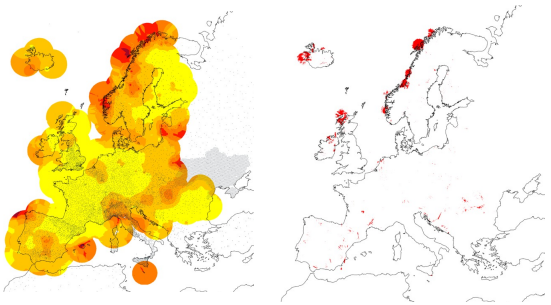
Number of days reporting accumulations



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EFAS gauges

Daily updated correction factor and clutter mask maps

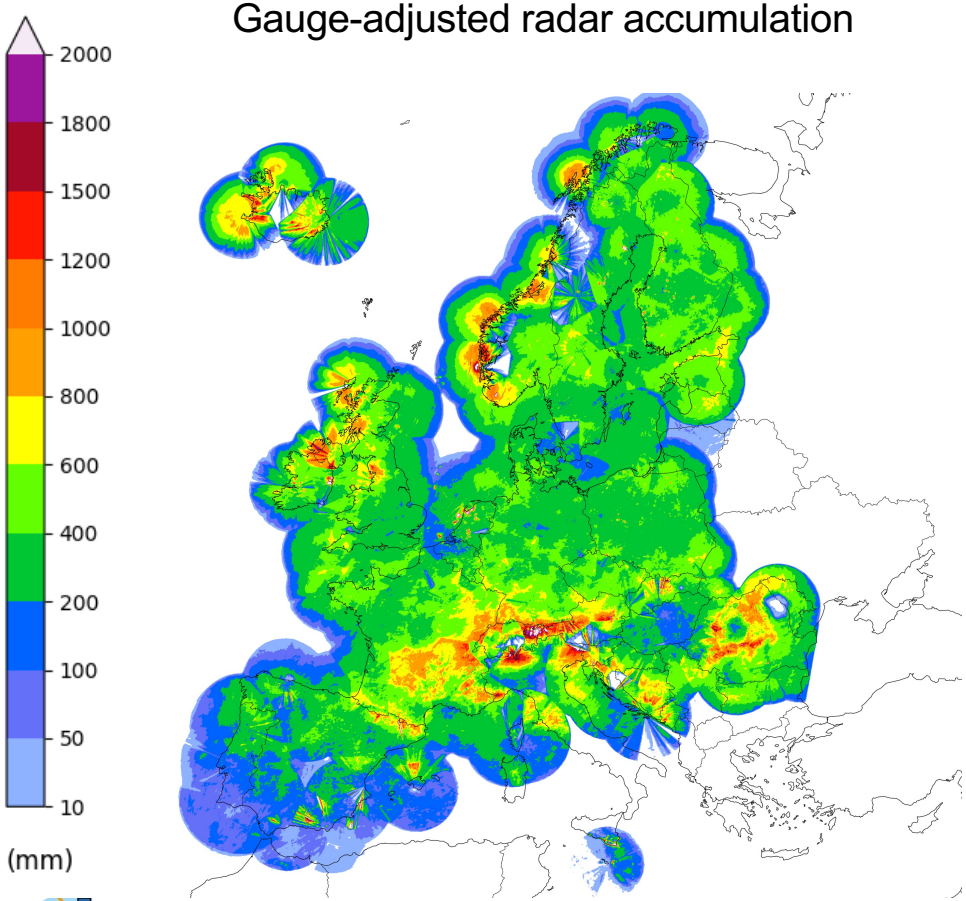


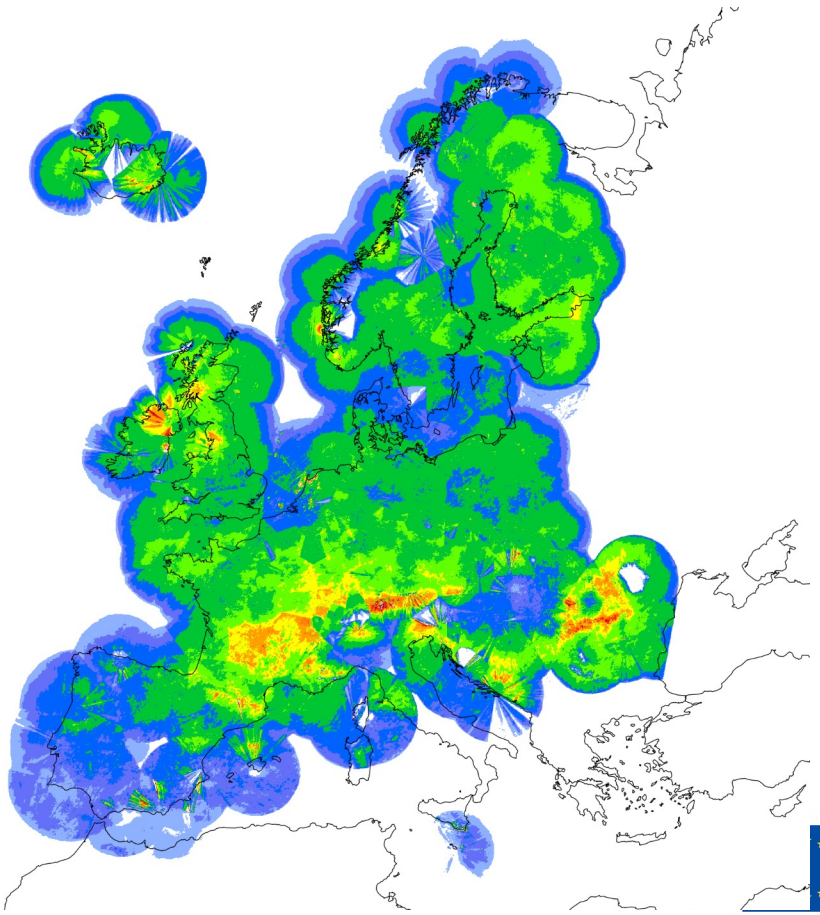
(Park et al. 2019; 2024)

Apr - Sep 2025 period (6 months)

Gauge-adjusted radar accumulation

nc-radar accumulation





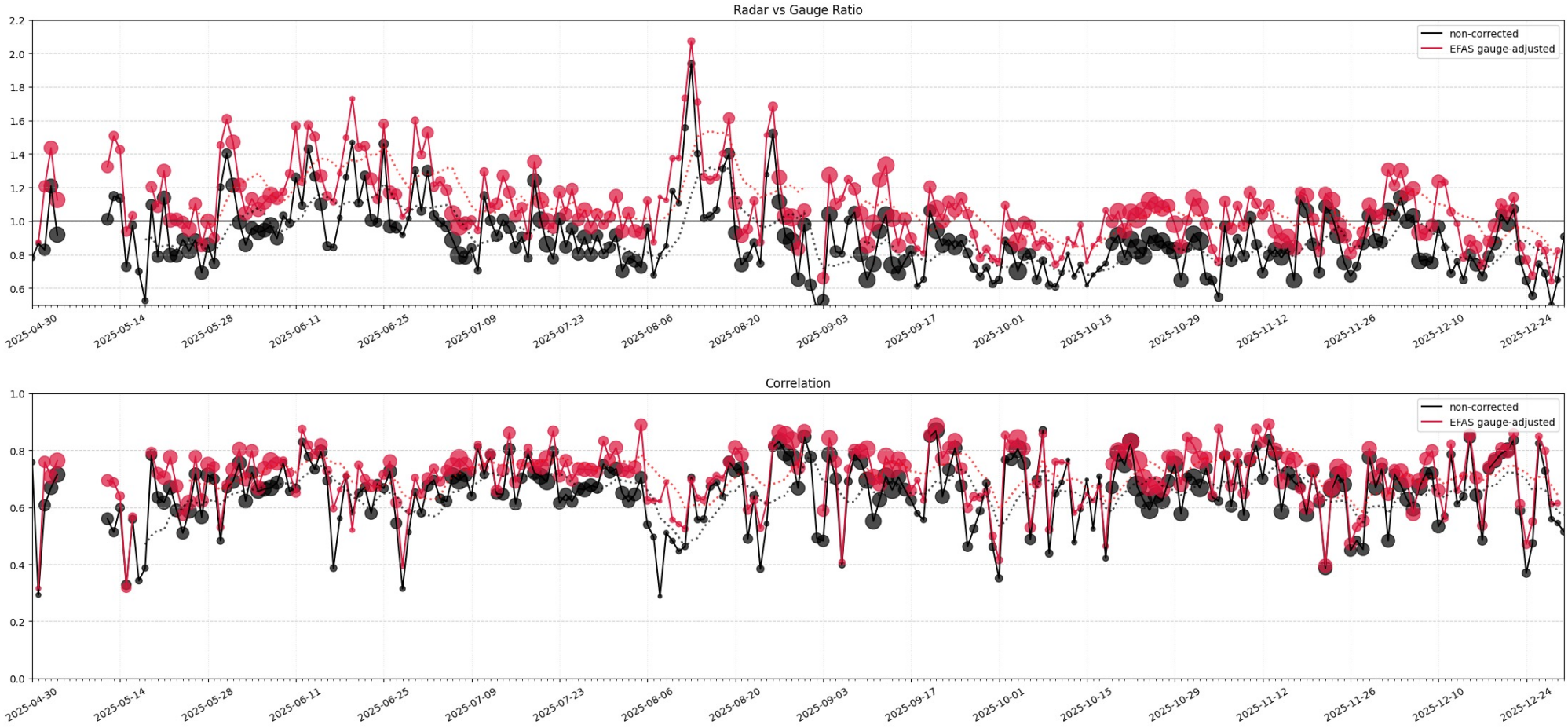
Co-funded by the European Union

Daily rain accumulation over EU coverage: OPERA vs gauge adjusted

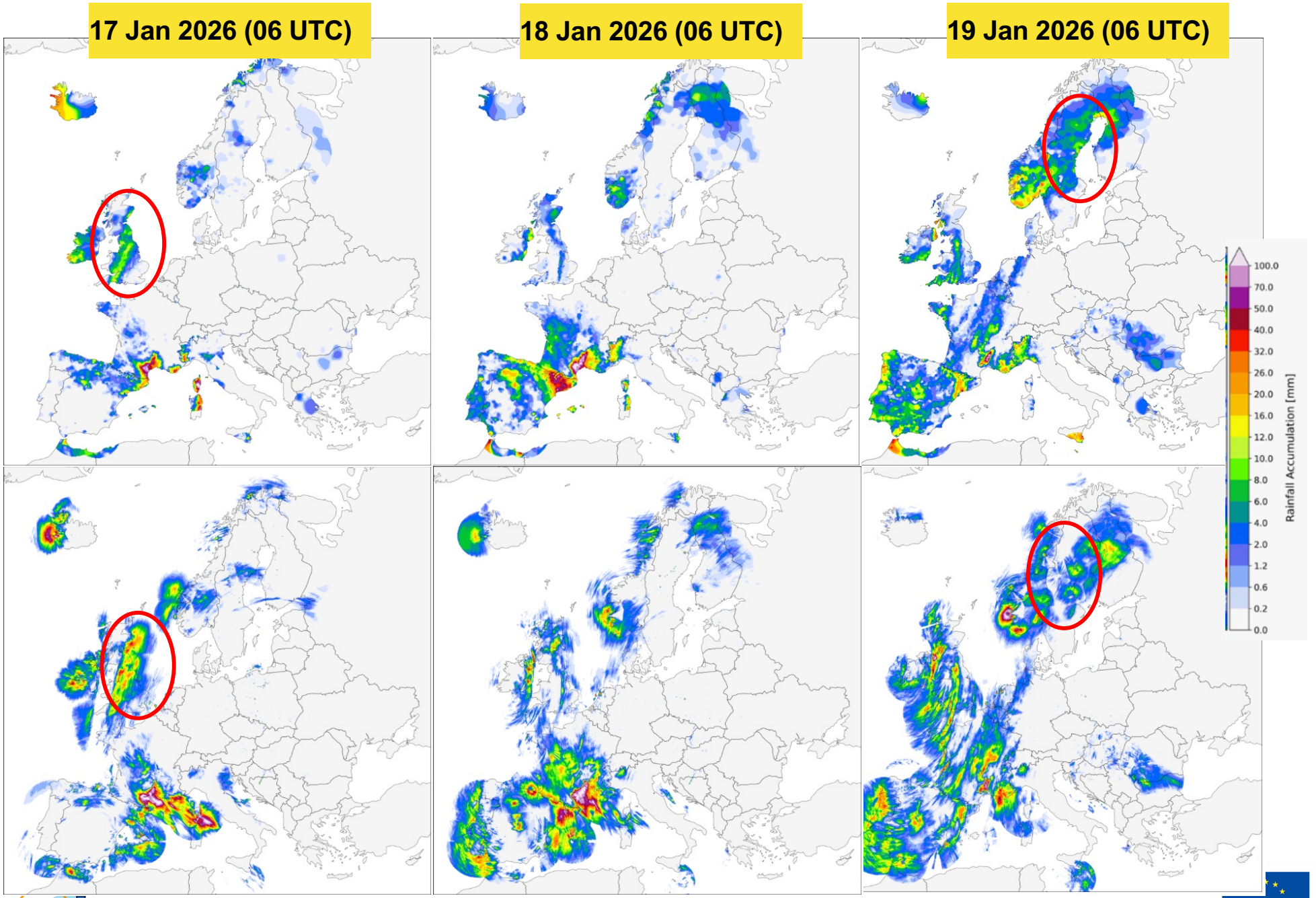
(April – December 2025)

Criteria to choose valid gauge-radar pairs:

- More than 1mm of rain in both records
- Less than 300mm of rain in both records
- Less than 25mm of difference between gauge and radar records
- Gauges in non-cluttering areas



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OPERA Plans 2026

OPERA 6 (2024-2028)

- Improve the quality of the OPERA products through the implementation of software algorithms to the production lines (dealiasing, satellite filter, dual-pol quality algorithms)
  - Dealiasing algorithm adopting torus mapping developed in SMHI and modified in ARSO
  - Satellite filter recoded and using Cloud Type product
- Roadmap and development for coexistence/merging ODIM and FM301
  - Converter development together with xradar and WMO
  - Survey of user needs and requests
- Production line development tasks
  - Surplus funding received to improve the NIMBUS compositing algorithm
- A new statement for wind turbine assessments (previous one 2010)
  - Surplus funding received to make an impact study of WTI and with this outcome update the wind turbine recommendations

Source: Klaus Stephan Chair of OUG and Annakaisa von Lerber, OPERA PM

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Improved precipitation estimation for EFAS initial conditions (T2.2)

2025/07/22 06:00 to 2025/12/19 06:00

Overview of the products

OPERA NIMBUS
raw accumulation files

(every 15 minutes, OPERA grid 2km)

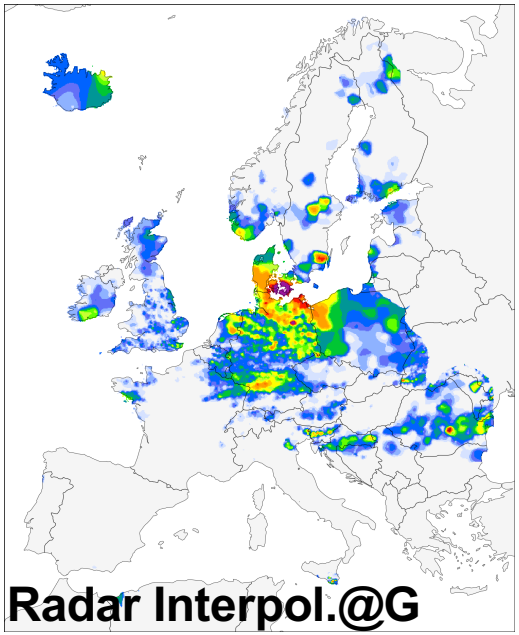
Radar preprocessing

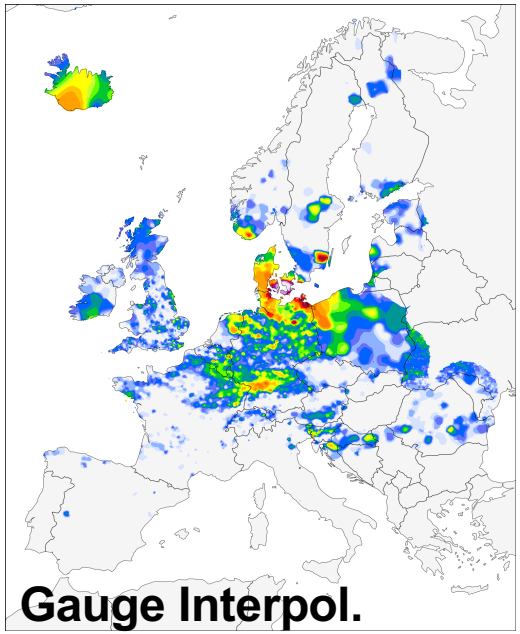
Radar adjustment

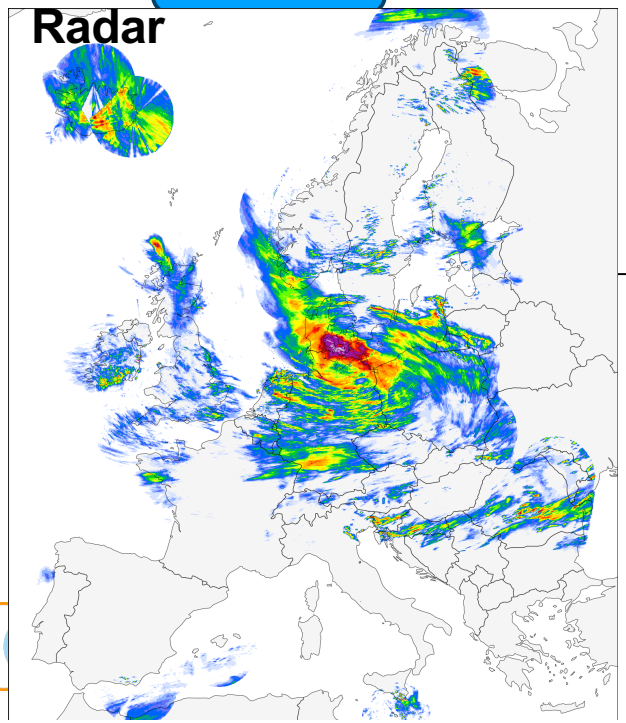
Gauge-adjusted accumulation

every 6 hours,

daily (06-06UTC+1day)







Filter locations with cluttering

only locations

EFAS gauge values

(every 6h and 24h)

Interpolation

Interpolation

Radar interpolation (at gauge locations)

Gauge interpolation

(EFAS grid 1arcmin)

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Clutter areas....

2025/12/18 06:00 to 2025/12/19 06:00

Overview of the products

OPERA NIMBUS
raw accumulation files

(every 15 minutes, OPERA grid 2km)

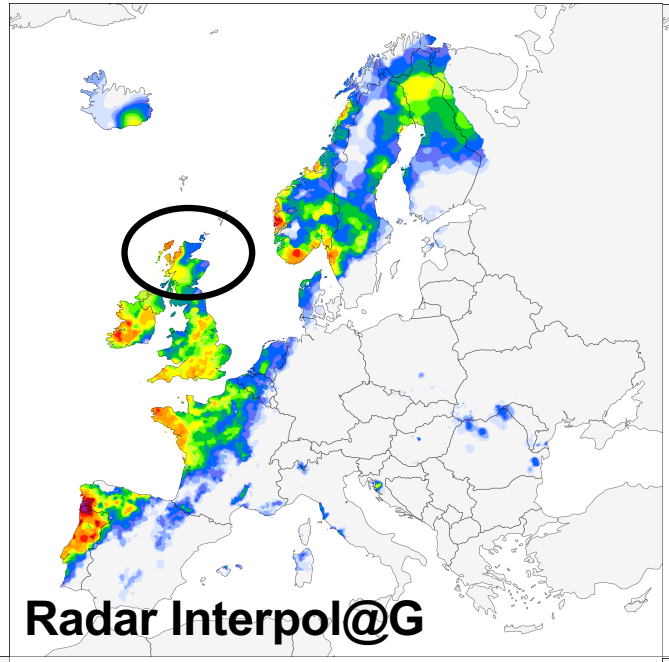
Radar preprocessing

Radar adjustment

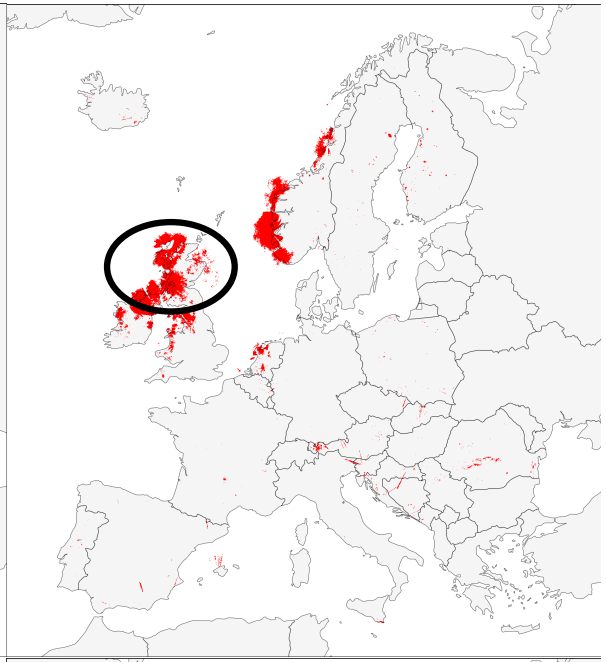
Gauge-adjusted accumulation

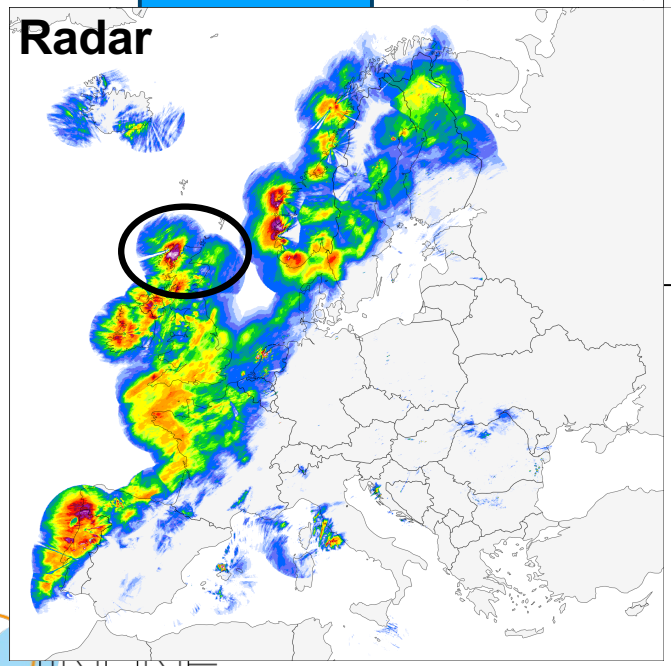
every 6 hours,

daily (06-06UTC+1day)



Radar Interpol@G





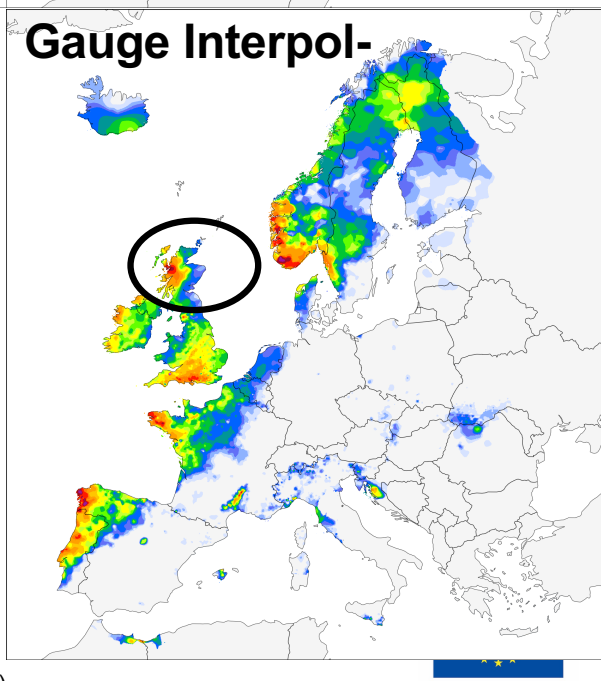
Radar

Filter locations with cluttering

only locations

Interpolation

Radar interpolation (at gauge locations)



Gauge Interpol-

(EFAS grid 1arcmin)

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Correcting radar with EFAS gauges

Clutter mask revision

Based on the rain statistics observed in these last months (see last presentation), the thresholds related with the clutter mask and correction factor have been updated with new values.

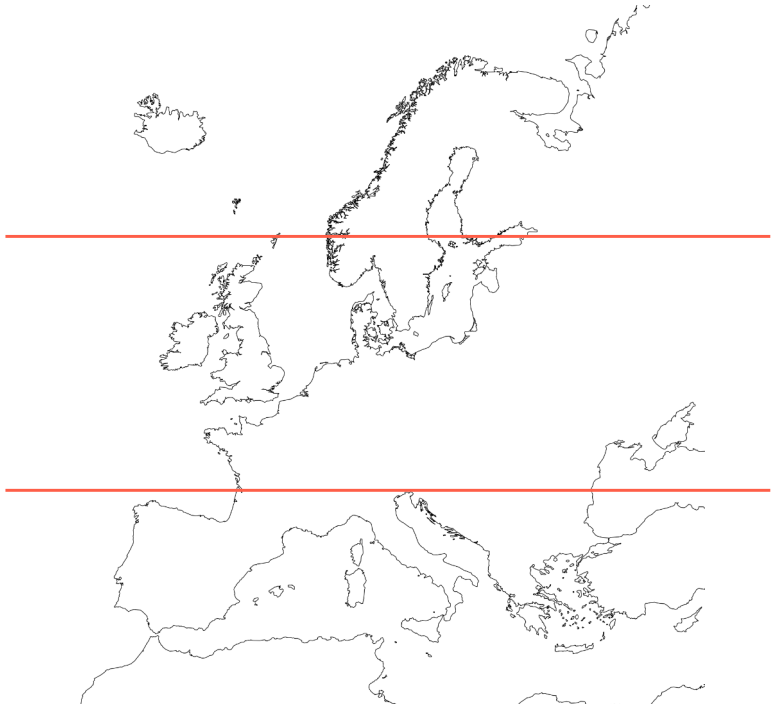
In our case, also making them customizable for different regions in Europe. For the moment, dividing Europe in three parts (north, center, south), as shown in the image (it could be more granular if necessary).

New clutter mask thresholds

- 6-month rain accumulation: 900 mm
- 6-month rainy days: 90

- 6-month rain accumulation: 1000 mm
- 6-month rainy days: 85

- 6-month rain accumulation: 1200 mm
- 6-month rainy days: 80



Former values for all the domain:

- *6-month rain accumulation: 1200 mm*
- *6-month rainy days: 90*

Any point that exceeds any of the thresholds is considered as clutter.

Clutter mask is then used within the correction factor calculation

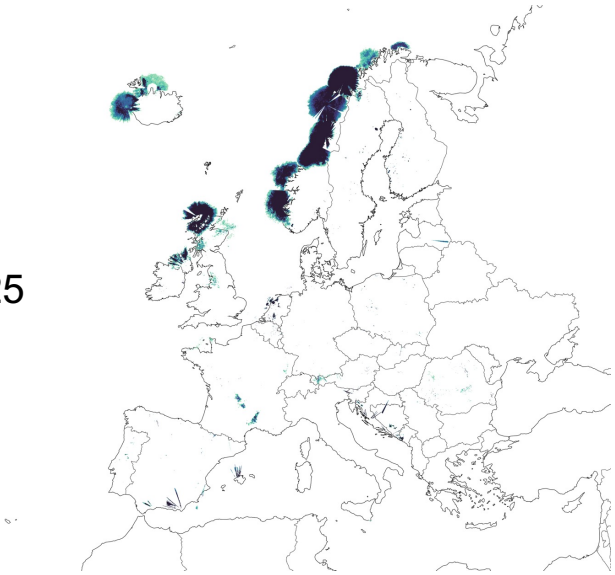
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Improved precipitation estimation for EFAS initial conditions (T2.2)

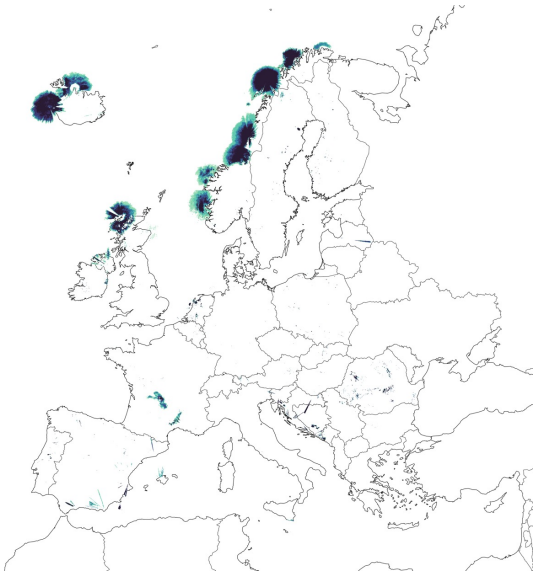
Radar statistics

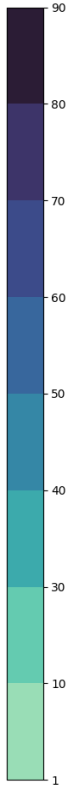
Number of days with clutter presence

Jan - Mar 2025

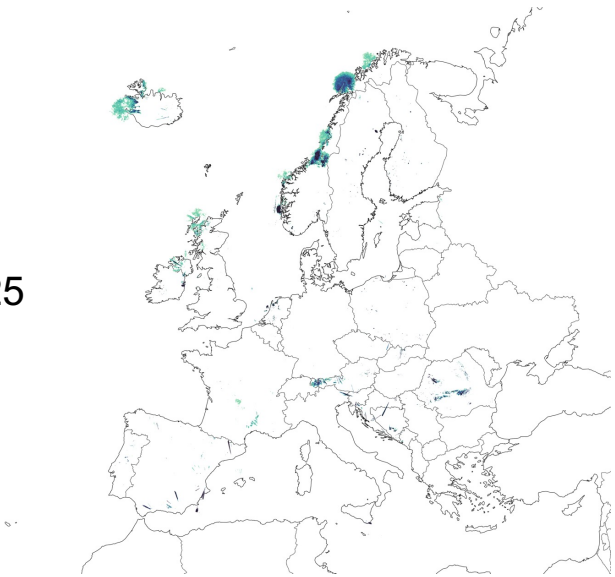


Apr - Jun 2025

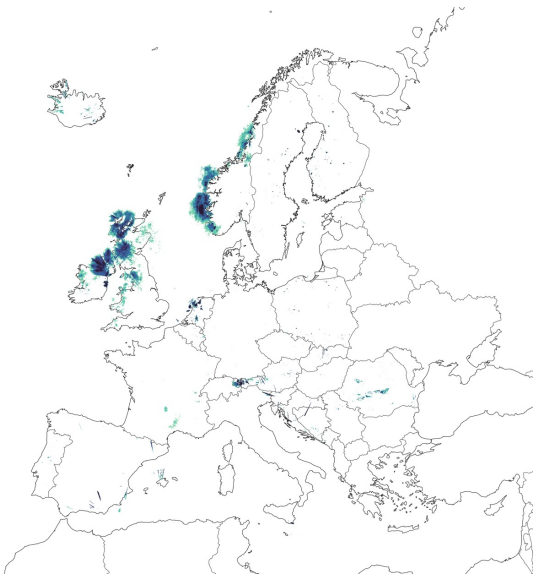




Jul - Sep 2025



Oct - Dec 2025



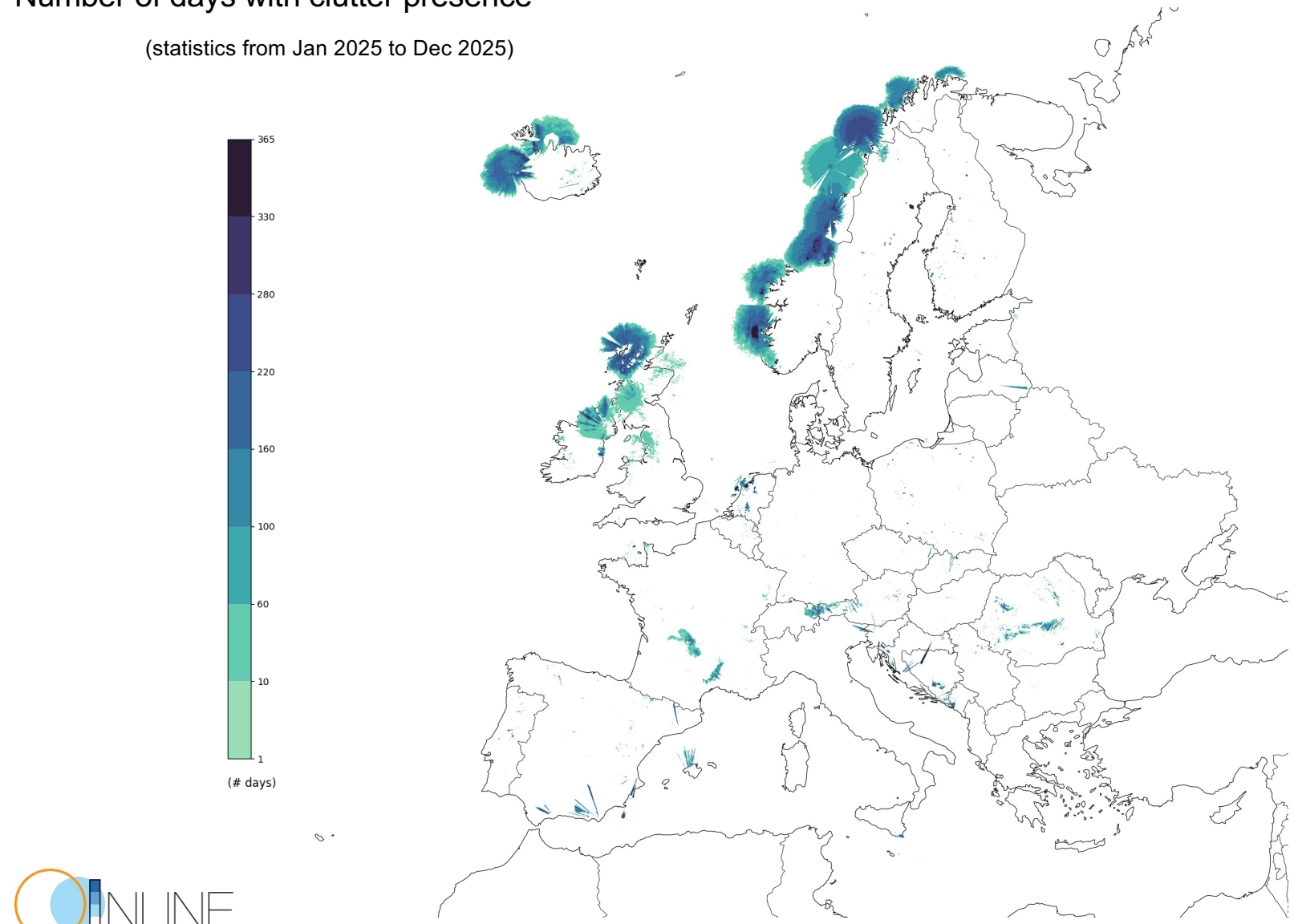
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Improved precipitation estimation for EFAS initial conditions (T2.2)

Radar statistics

Number of days with clutter presence

(statistics from Jan 2025 to Dec 2025)

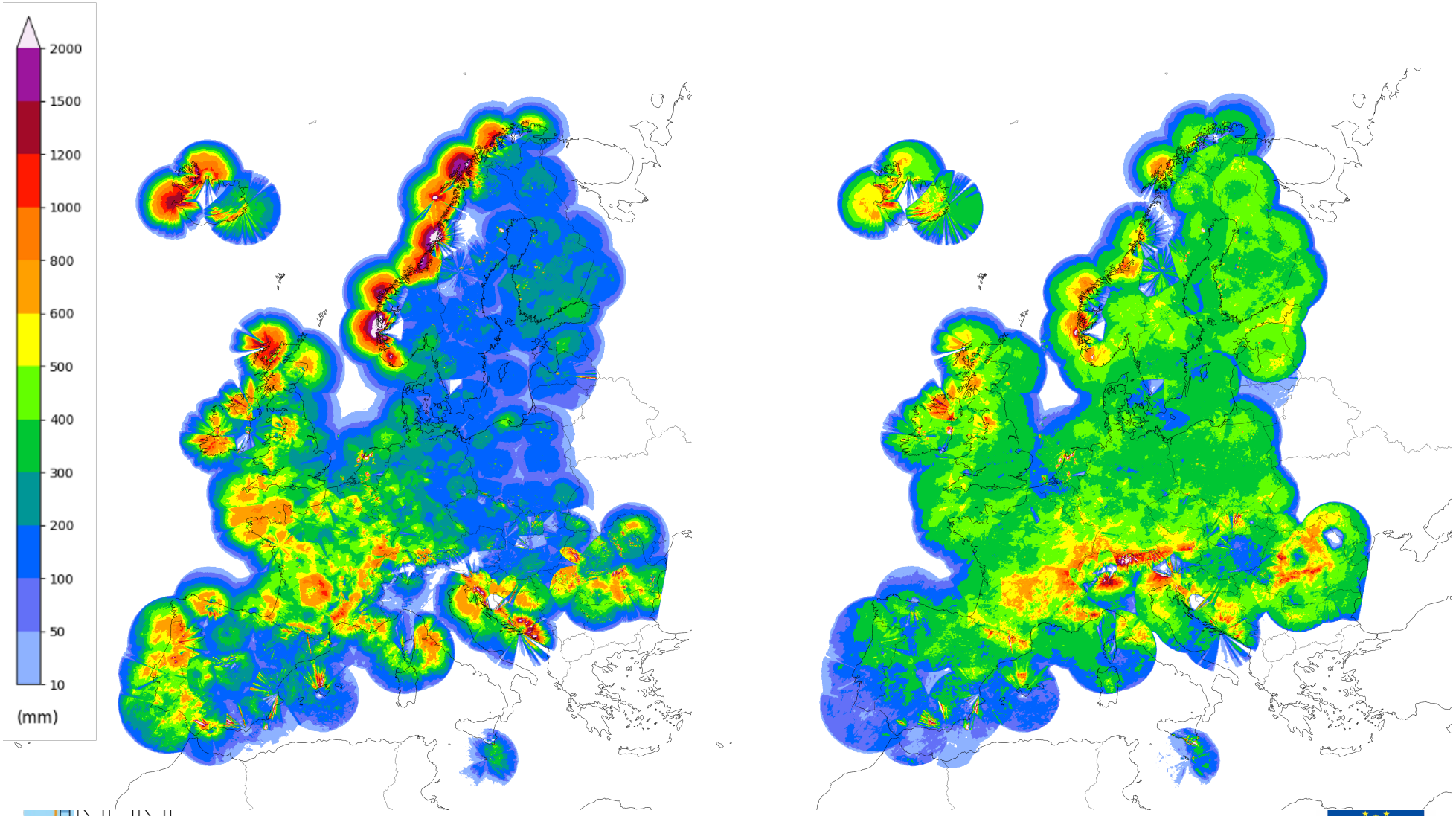


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Gauge-adjusted OPERA NIMBUS radar accumulation

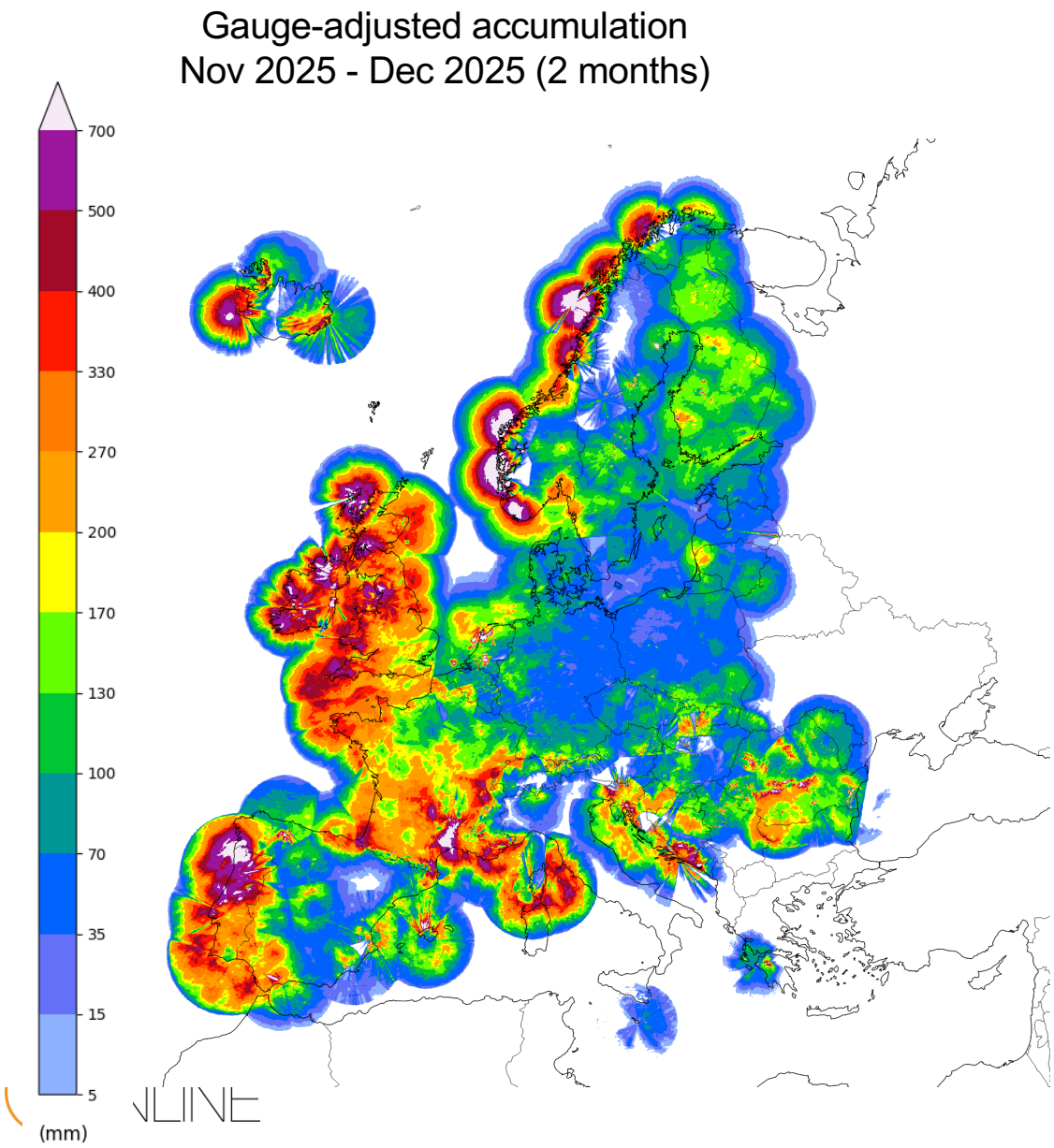
Oct 2024 - Mar 2025 period (6 months)

Apr 2025 - Sep 2025 period (6 months)



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Gauge-adjusted OPERA NIMBUS radar accumulation



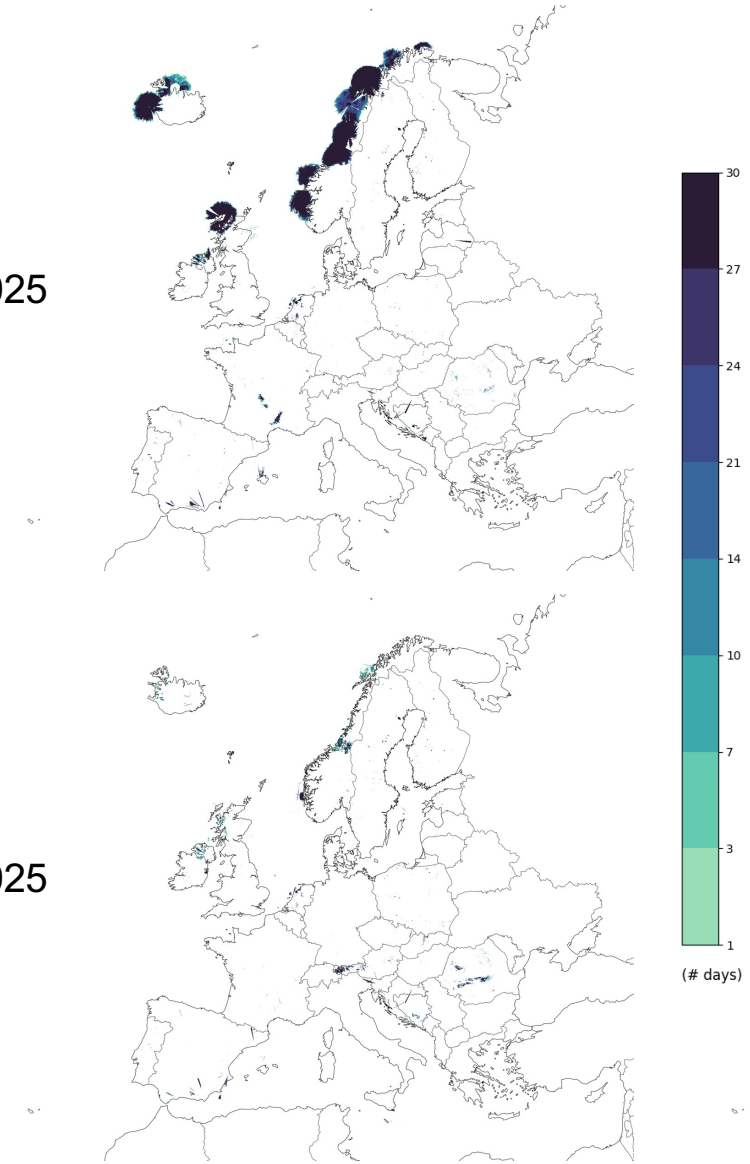
Co-funded by
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Correcting radar with EFAS gauges

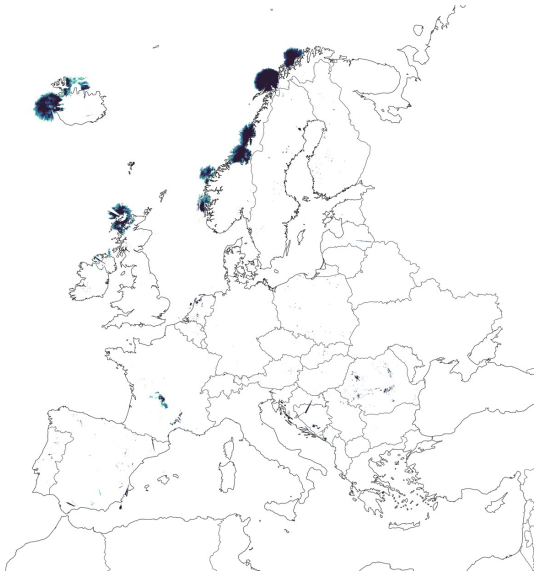
Clutter statistics

Number of days with clutter presence

Mar 2025

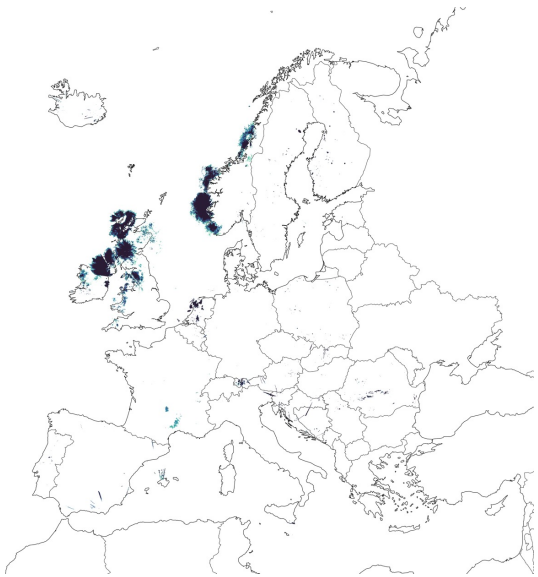


Jun 2025



Sep 2025

Dec 2025

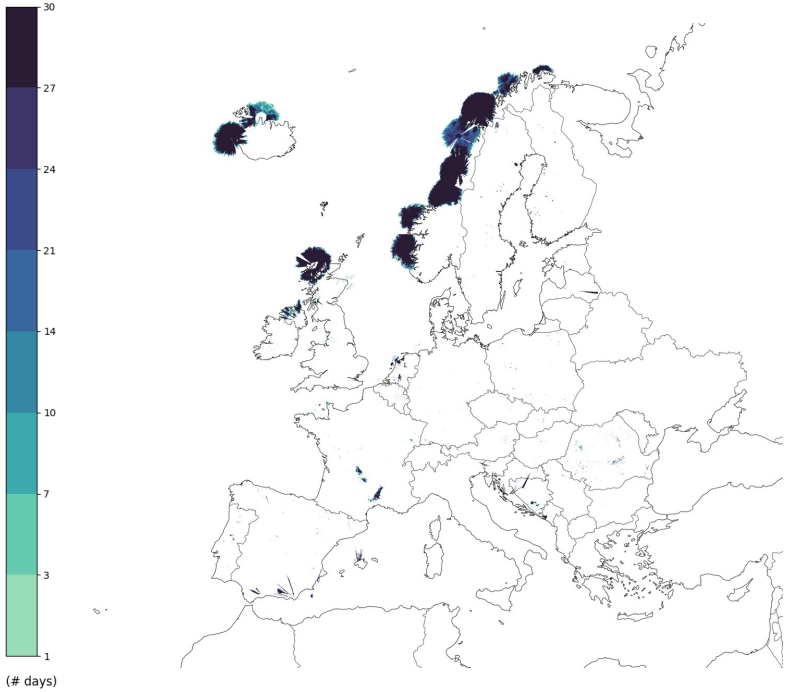


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Correcting radar with EFAS gauges

Clutter statistics

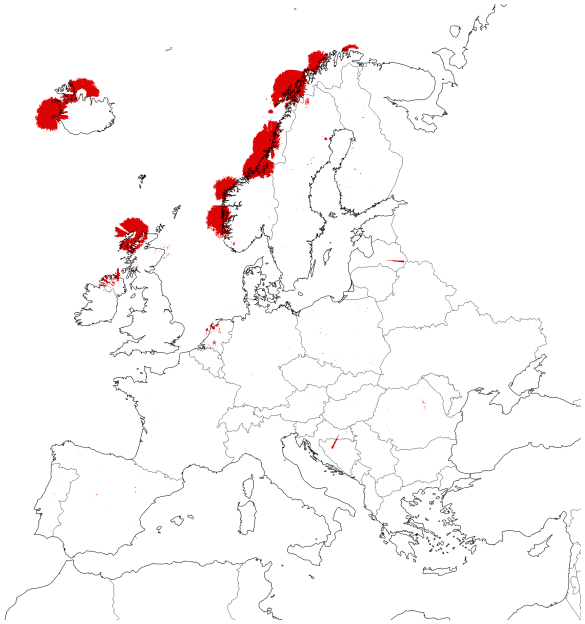
Understanding why the clutter is detected



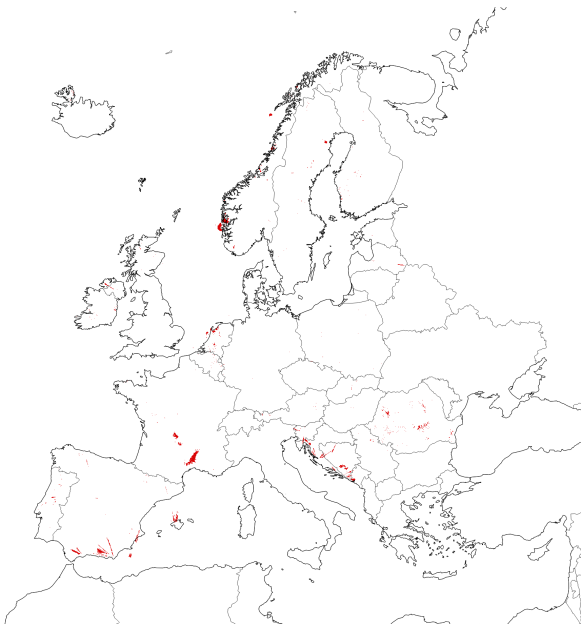
Clutter presence
(Mar 2025)

Clutter mask calculated
from Oct 2024 to Mar 2025

(autumn + winter period)



Number of days with rain
(> 90)



Total rainfall
accumulation
(> 1200 mm)

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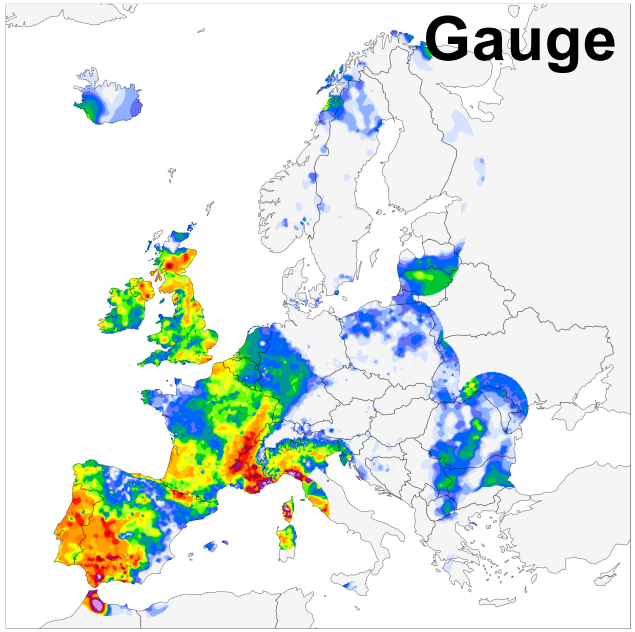
Correcting radar with EFAS gauges

Double-checking clutter

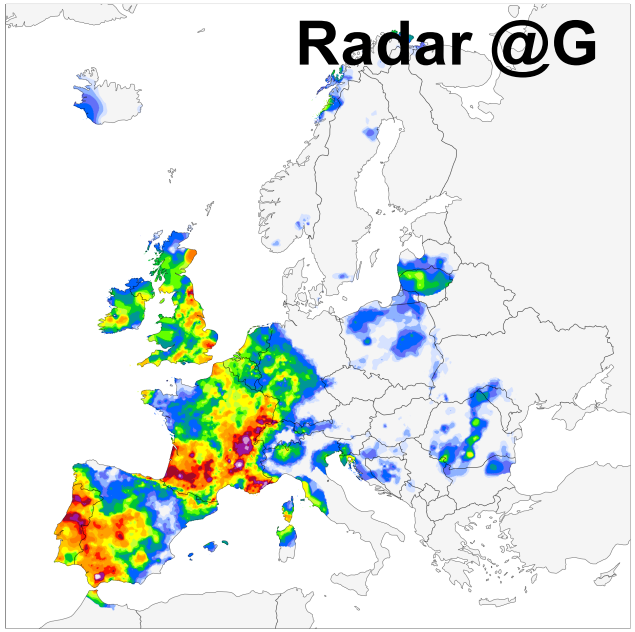
Concrete examples comparing the current implementation and the new proposal.

Storm Kristin (Portugal) Storm Chandra (N. Ireland, UK)

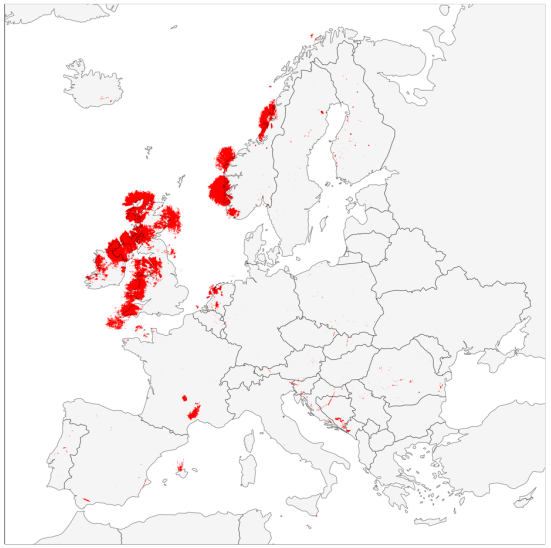
2026/01/27 06:00 to 2026/01/28 06:00
(impact over Scotland, Wales & North Ireland)



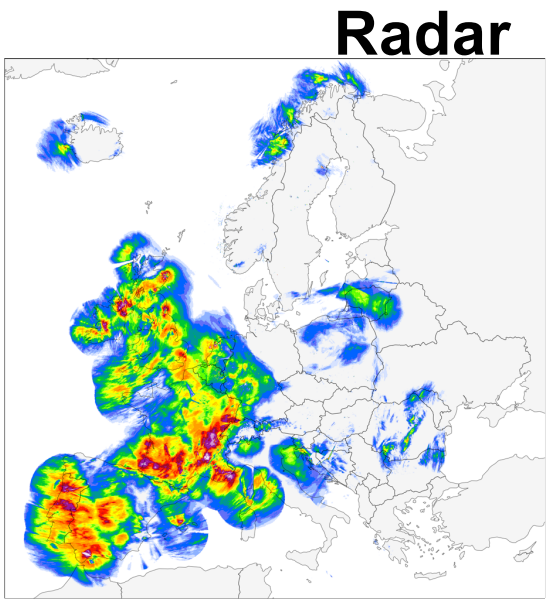
Gauge interpolation



Radar interpolation at gauge locations
(current implementation, without double-checking)



Clutter mask



Gauge-adjusted accumulation

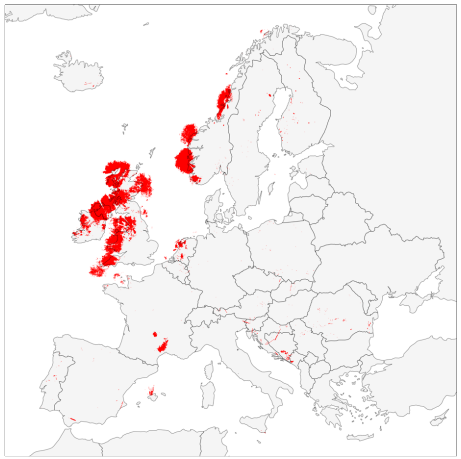
Co-funded by
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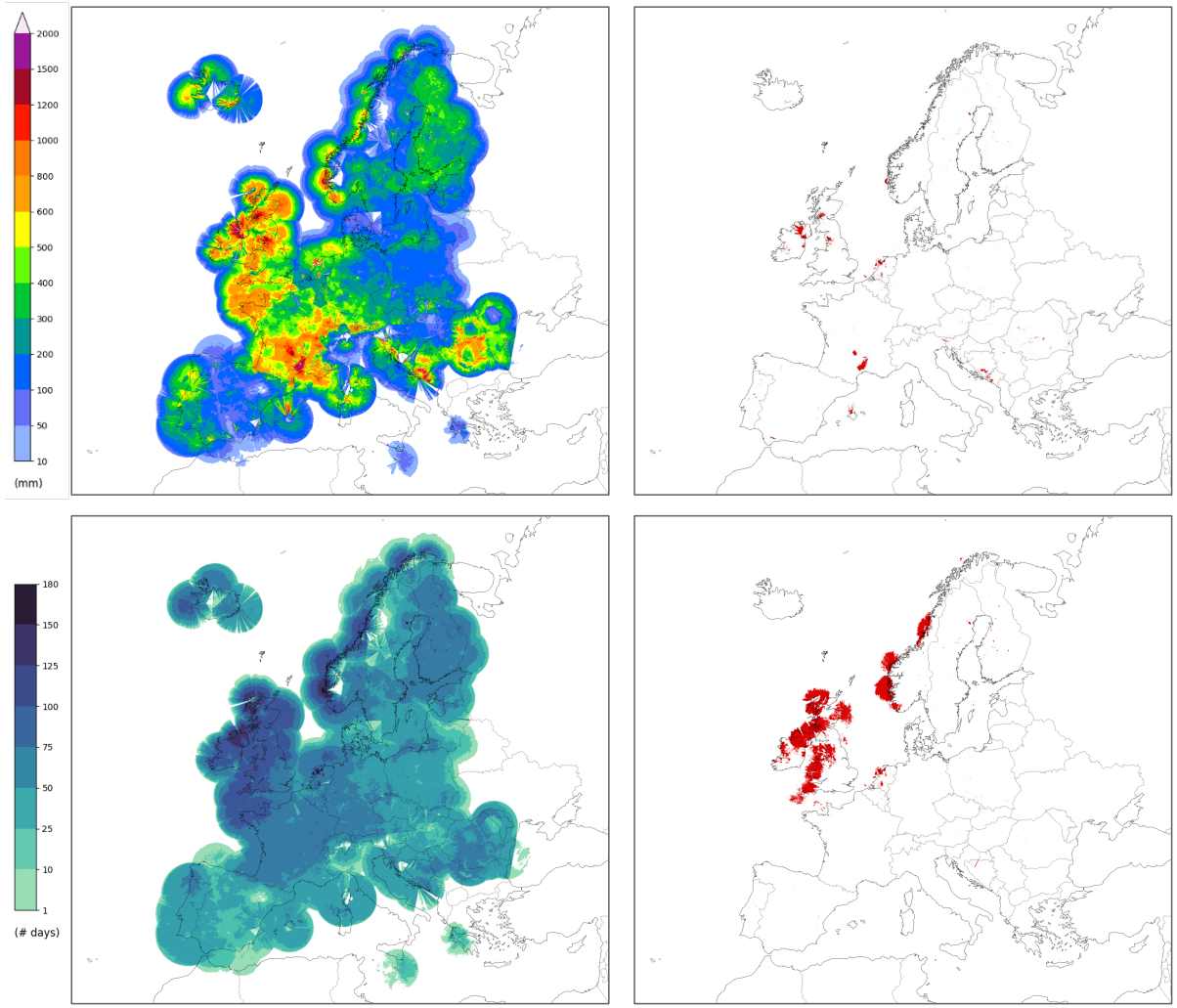
Correcting radar with EFAS gauges

Double-checking clutter

Where the clutter mask comes from:

2026/01/27 06:00
to 2026/01/28 06:00





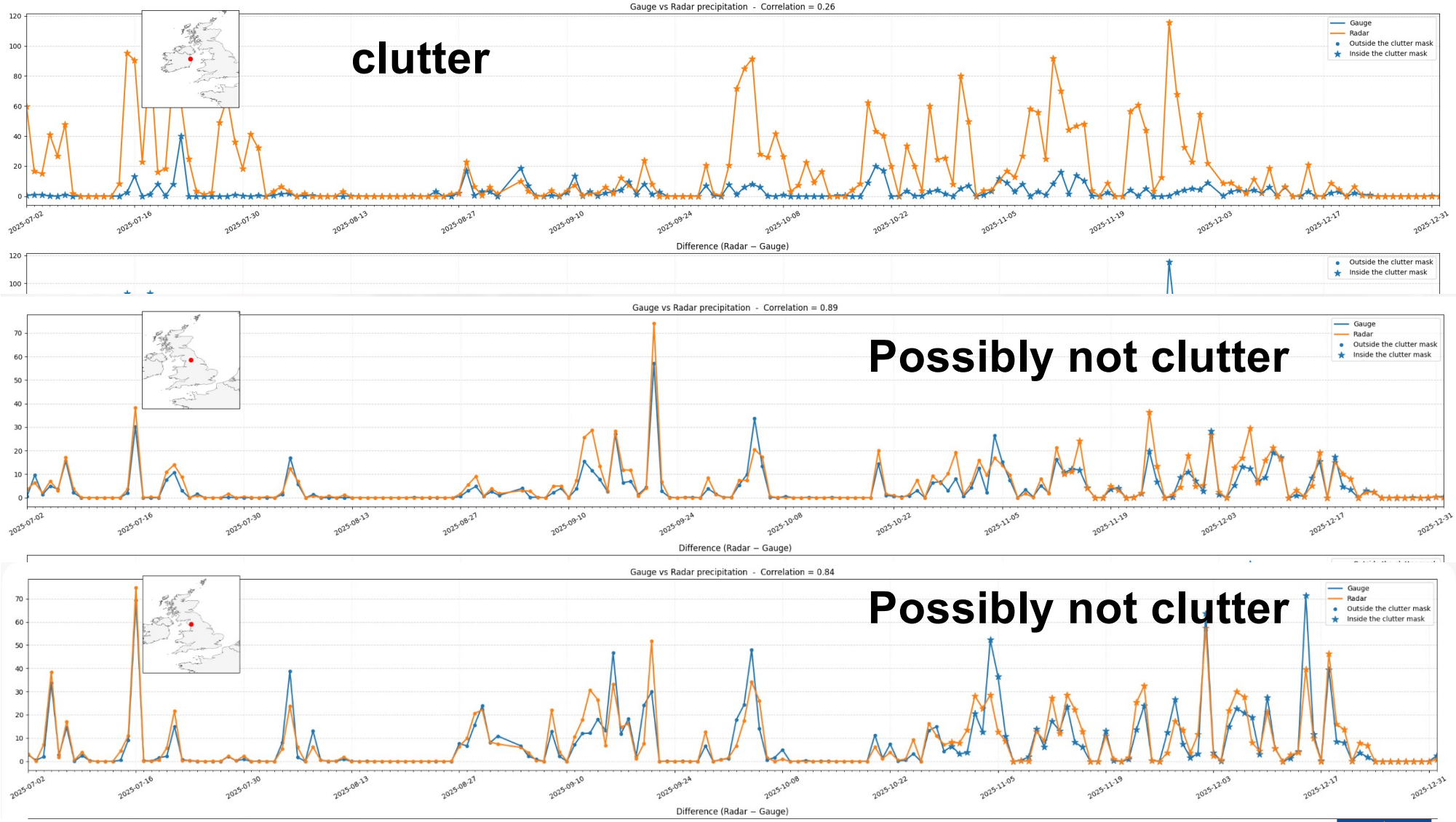
Rainfall accumulation
(previous 6 months)

Number of days with rain
(previous 6 months)

Co-funded by the European Union

Correcting radar with EFAS gauges

Double-checking clutter

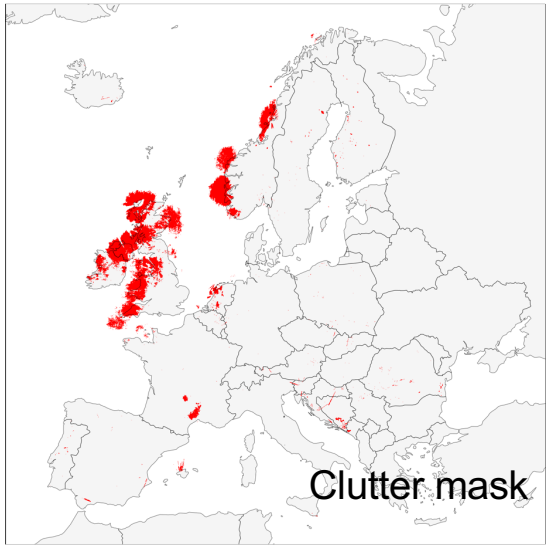


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Correcting radar with EFAS gauges

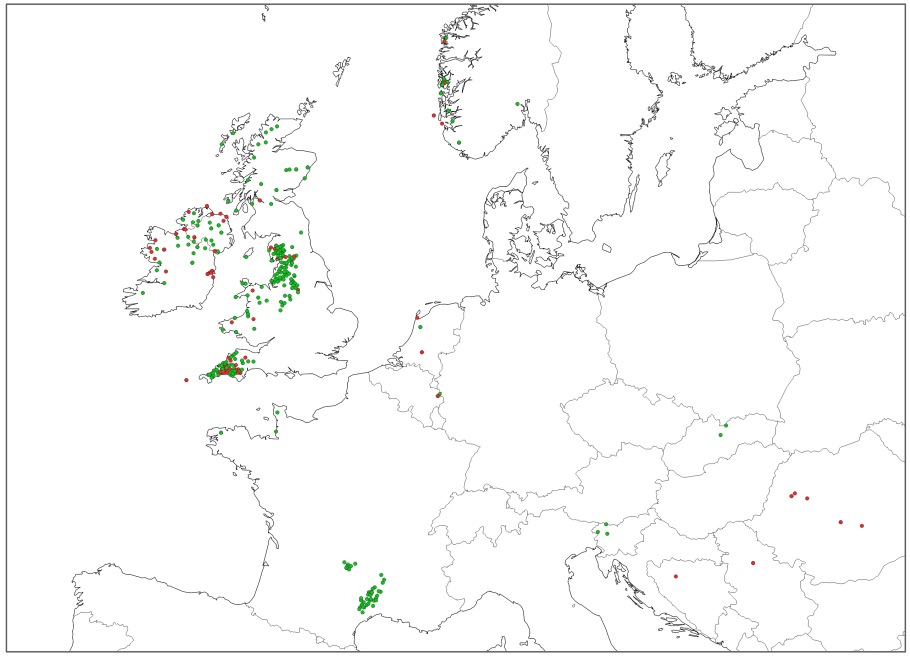
Double-checking clutter

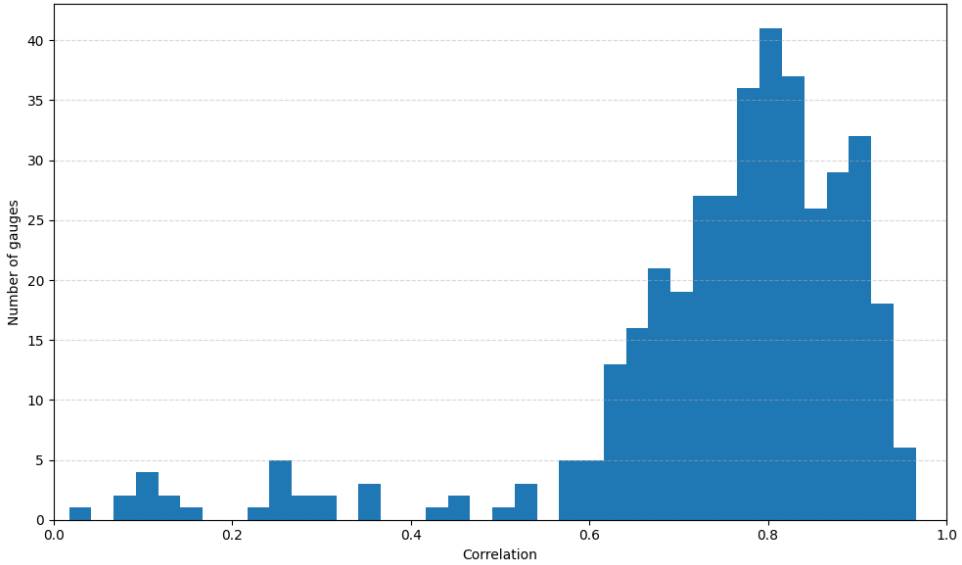
With the aforementioned criteria, we check how many gauge locations in the clutter area will be reevaluated.



2026/01/27 06:00 to 2026/01/28 06:00

In green, gauge locations with a correlation >= 0.7 with their radar values
In red, gauge locations with a correlation < 0.7





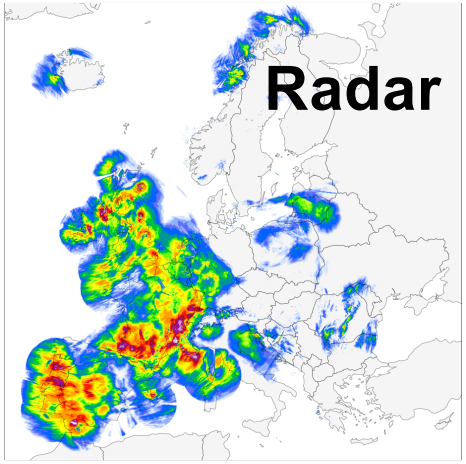
INLINE

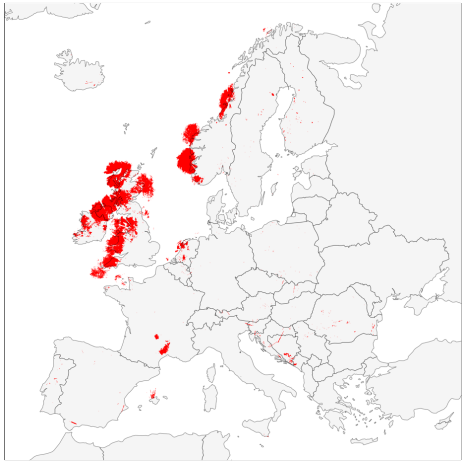
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Correcting radar with EFAS gauges

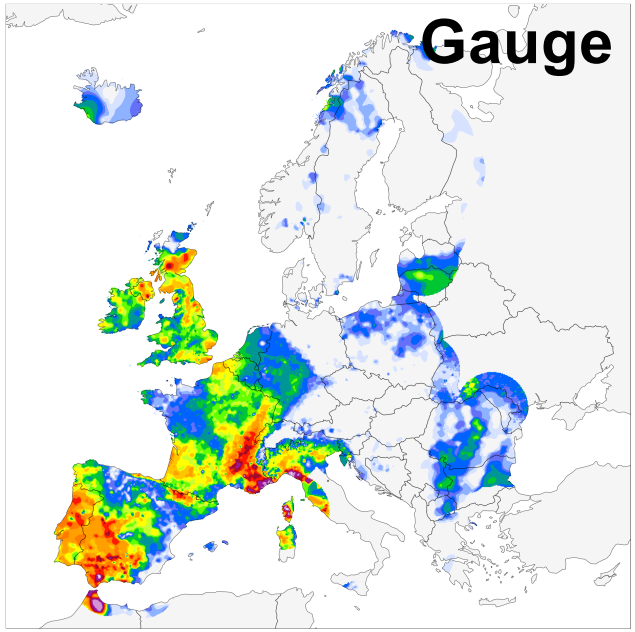
Double-checking clutter

Assessing the result of the double-verification proposal.

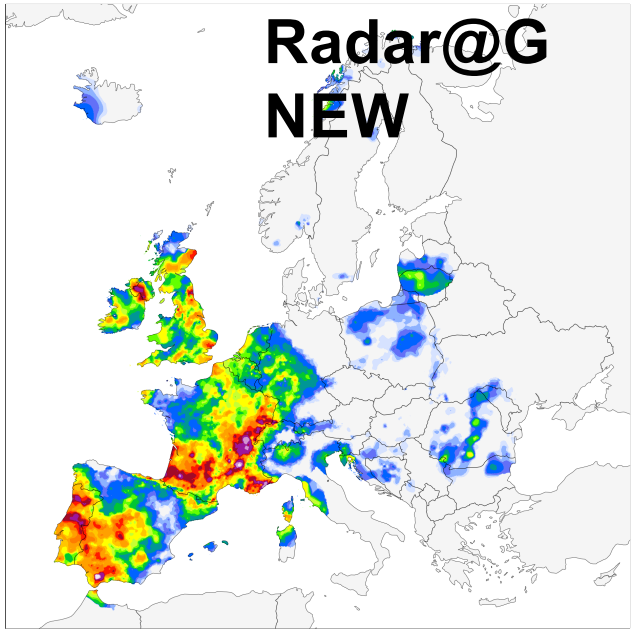




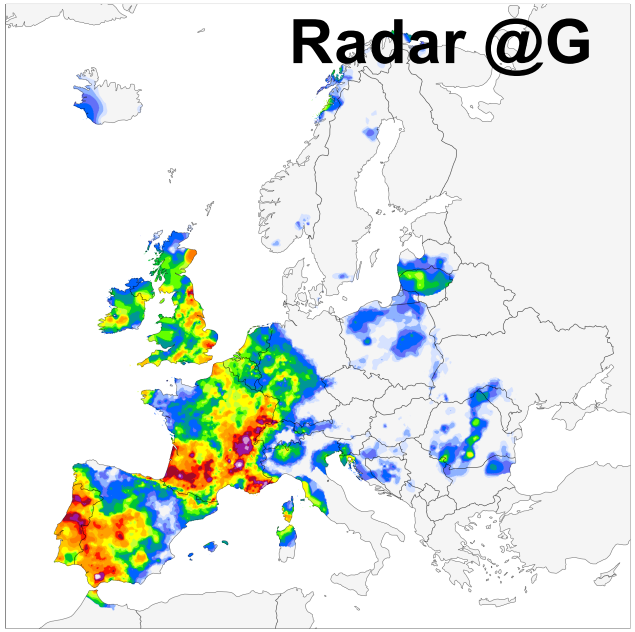
2026/01/27 06:00 to 2026/01/28 06:00
(impact over Scotland, Wales & North Ireland)



Gauge interpolation



Radar interpolation at gauge locations
(with double-checking)



Radar interpolation at gauge locations
(without double-checking)

INLINE

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Improved precipitation estimation for EFAS initial conditions (T2.2)

Progress and plan

- Preliminary results were sent to ECMWF for T2.3
  - ✓ Gauge adjusted radar and Radar interpolated rainfall accumulations (6h, 24h)
  - ✓ Nov 1st 2024 to Dec 31st 2025
- Regenerate gauge-adjusted radar interpolated accumulation at the gauge locations with double-checking the clutter mask (using a correlation threshold)
- Generate long-term datasets

Co-funded by the European Union

References

Park, S., M. Berenguer, and D. Sempere-Torres, and A. von Lerber, 2024. The EUMETNET OPERA Radar Network – European-Wide Precipitation Composites Supporting Rainfall- Induced Flash Flood Emergency Management. Chapter 5 in D. Sempere-Torres, A. Karakostas, C. Rossi, & P. Quevauviller (Eds.), Responding to Extreme Weather Events. John Wiley & Sons Ltd. 105-118. ISBN:9781119741589

Park, S., M. Berenguer, and D. Sempere-Torres. 2019. Long-term analysis of gauge-adjusted radar rainfall accumulations at European scale, J. of Hydrology, 573, 768-777. 10.1016/j.jhydrol.2019.03.093