

Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

Deltares

Seamless forecasting

*Recent advances in rainfall nowcasting
and forecasting for flood prediction in
small basins*

Klaas-Jan van Heeringen

Ruben Imhoff

02-07-2026

About the speakers

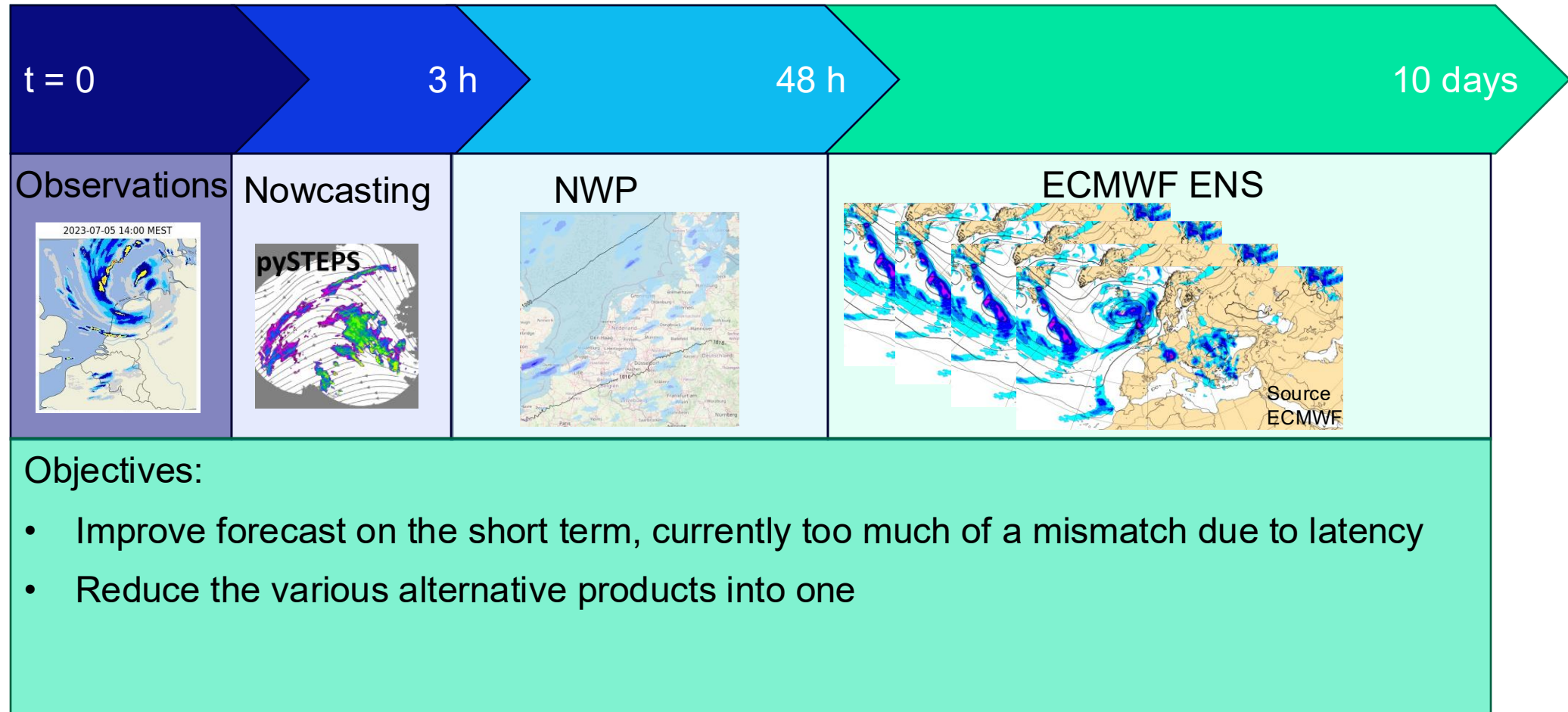


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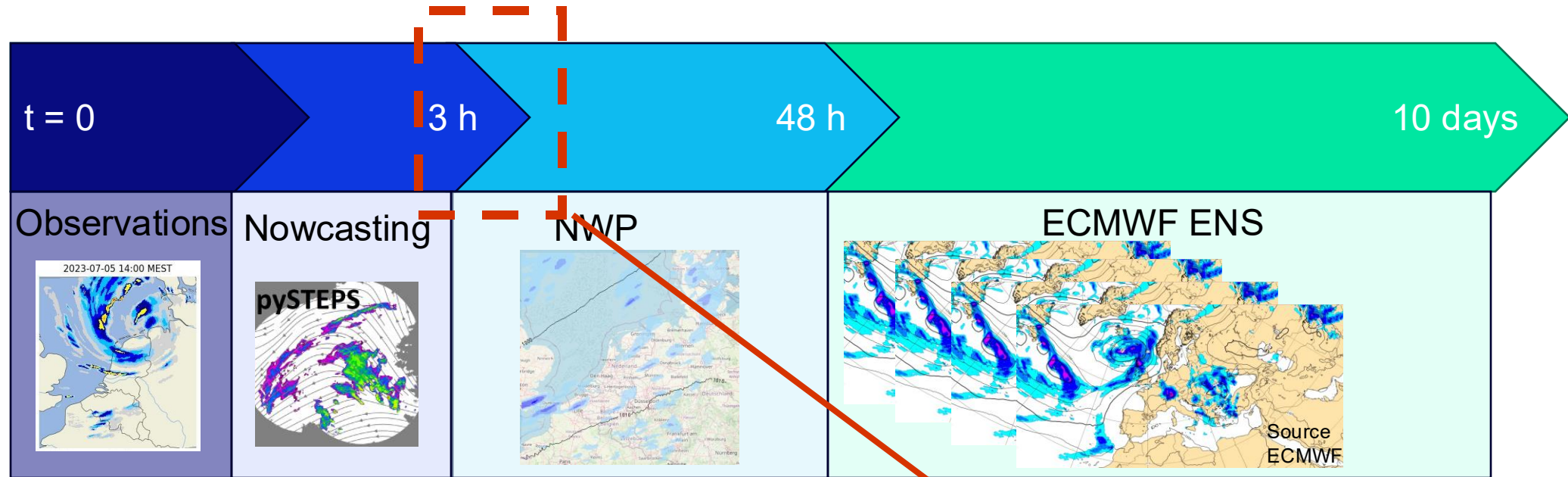


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Introduction – why a need for seamless NWP products



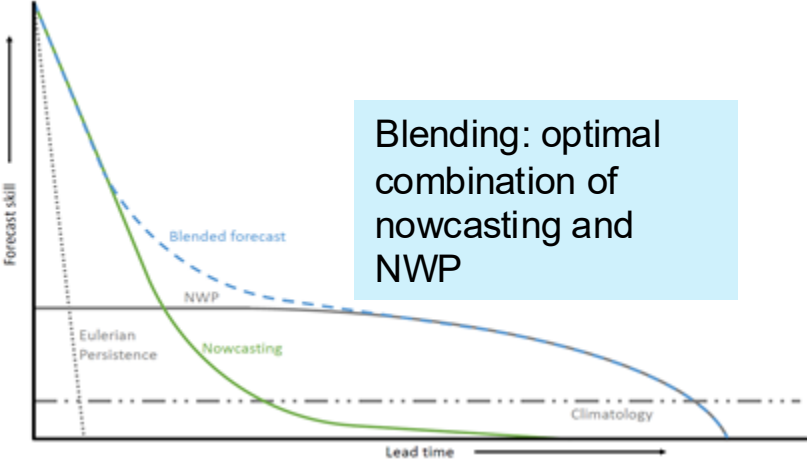
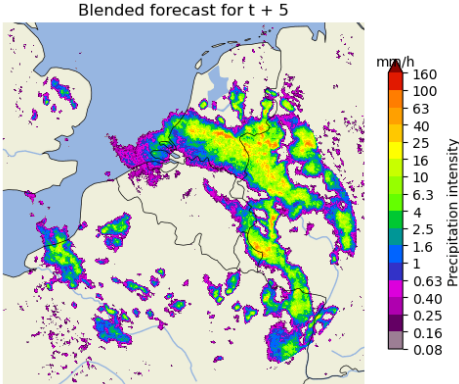
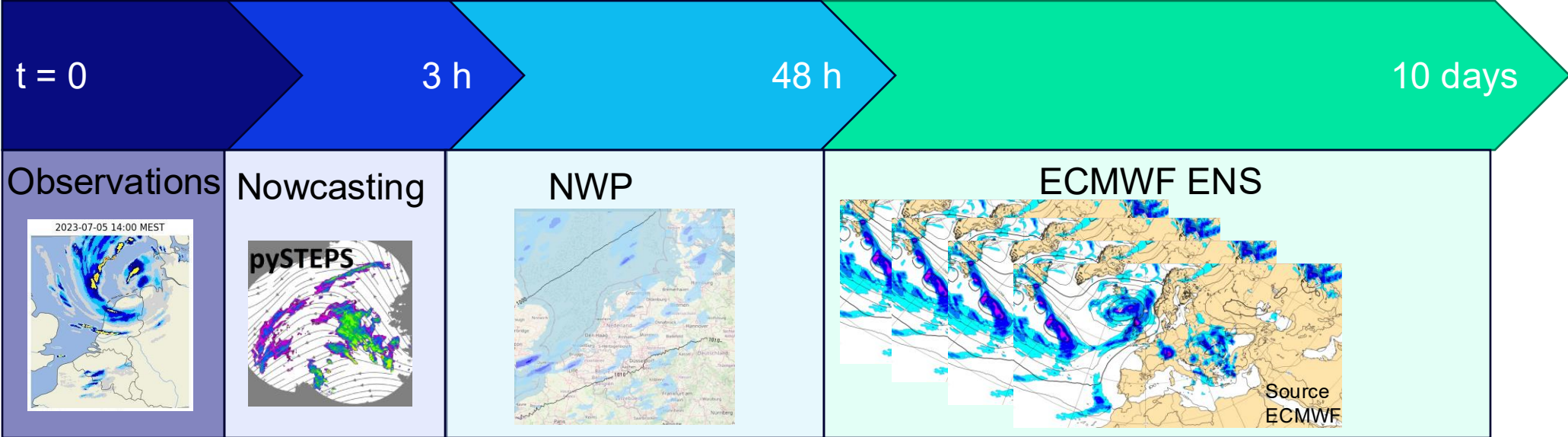
Introduction – why a need for seamless NWP products



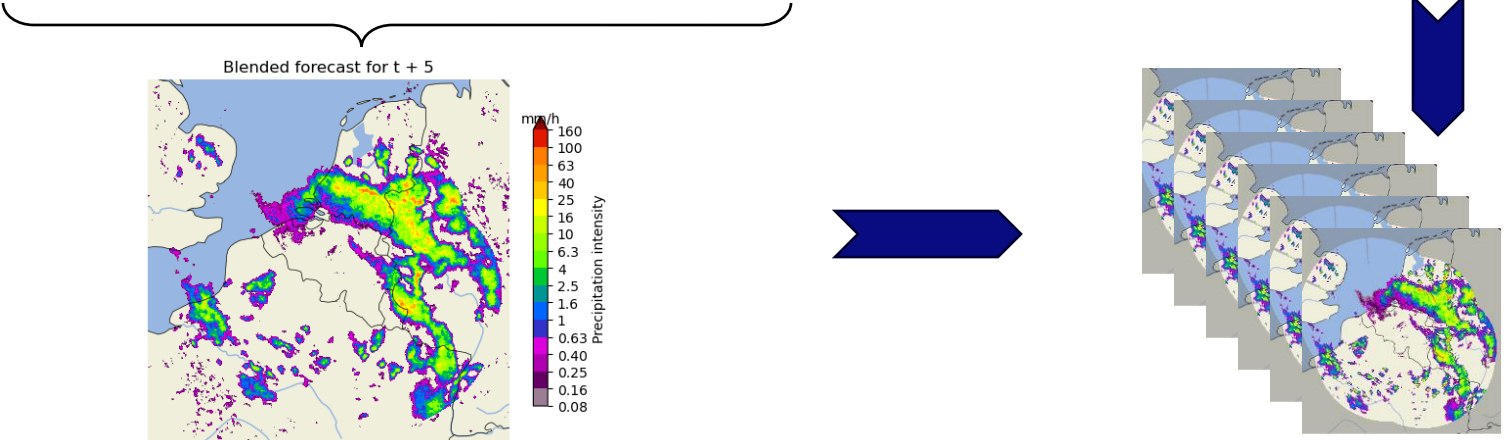
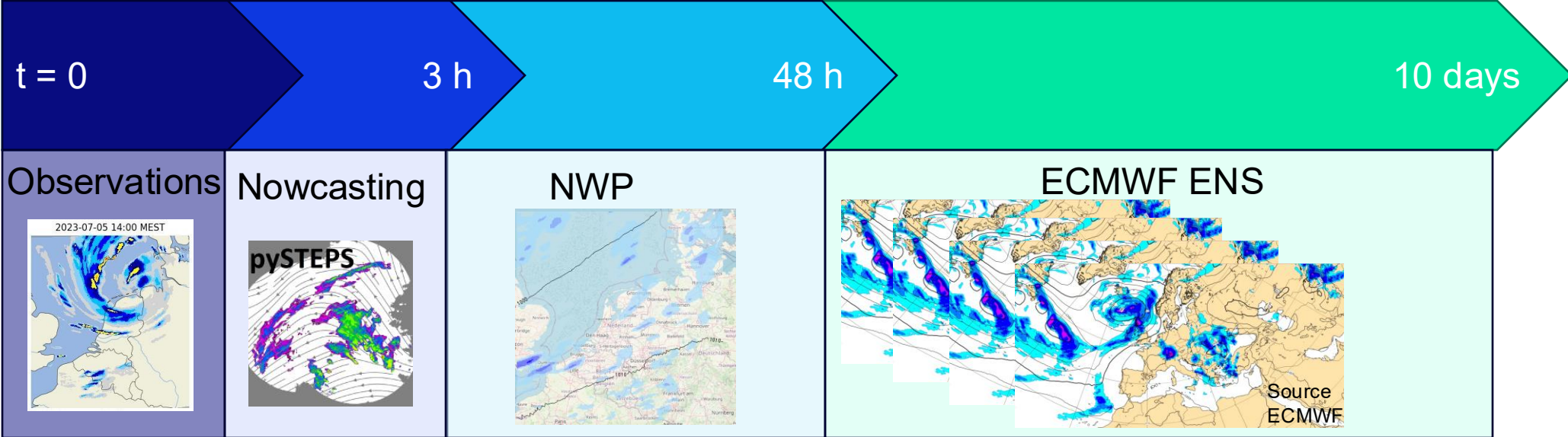
Forecast horizon to respond to urban and flash flooding is typically < 12 hours.
New products helpful, but we have multiple products to cover this short timeframe now...

Still suboptimal skill for these lead times..

Introduction – why a need for seamless NWP products



Introduction – why a need for seamless NWP products

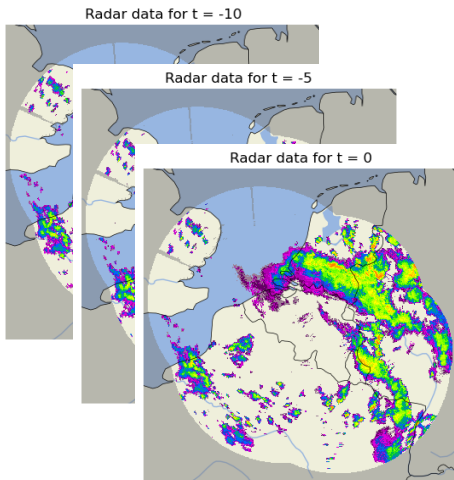


How do we make a nowcast?

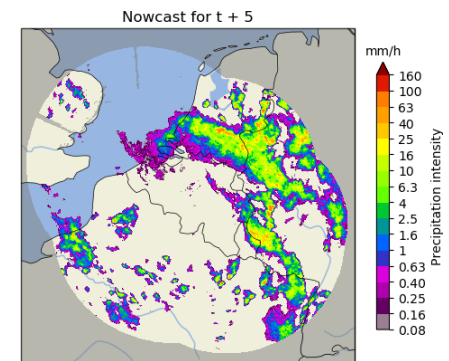
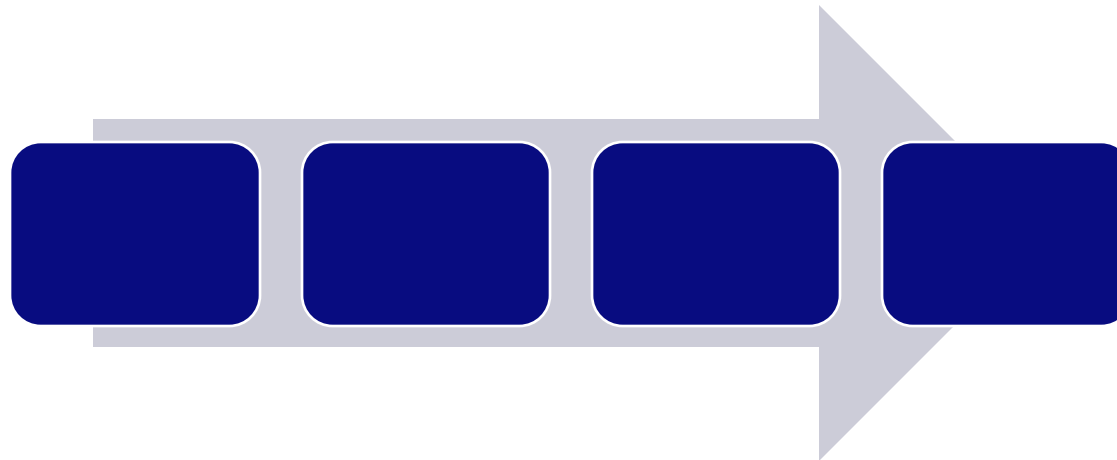
Statistical extrapolation

Fast!

But no physics involved..



From most recent weather radar observations



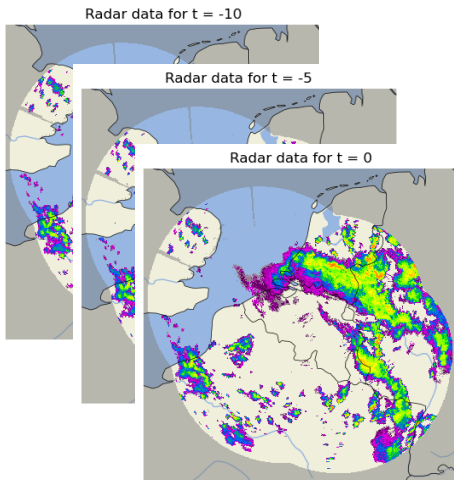
To rainfall forecast up to max. 6 hr ahead

How do we make a nowcast?

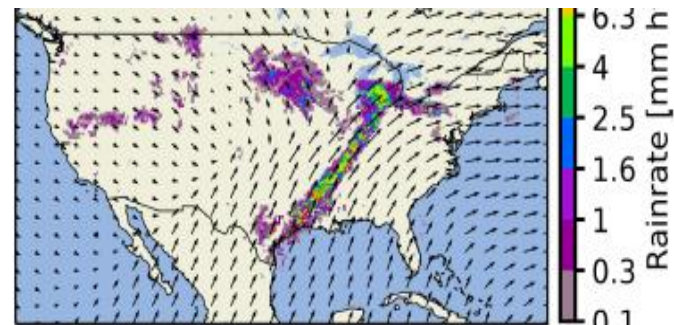
Statistical extrapolation

Fast!

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Determine movement of rainfall fields



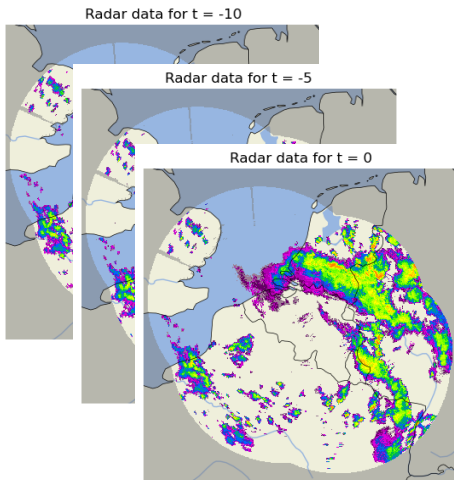
Source: Pulkkinen et al., Geosci. Model. Dev., 2019

How do we make a nowcast?

Statistical extrapolation

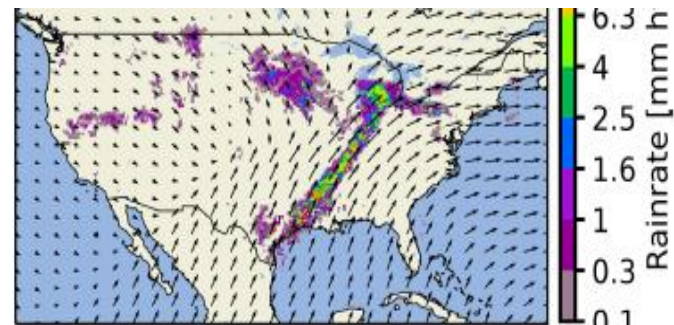
Fast!

But no physics involved..

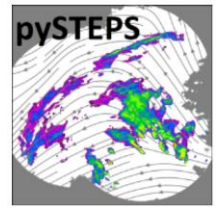


Determine movement of rainfall fields

Rainfall field evolution



Source: Pulkkinen et al., Geosci. Model. Dev., 2019

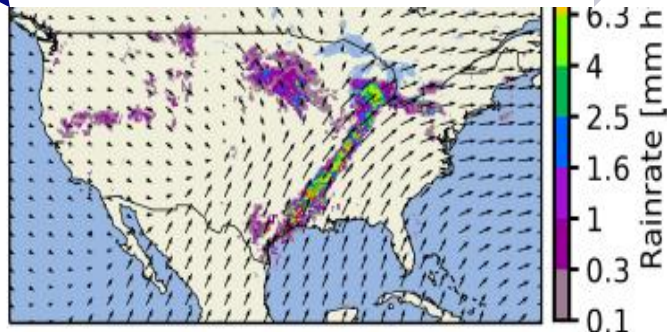
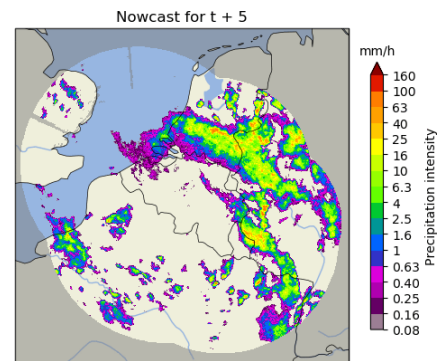
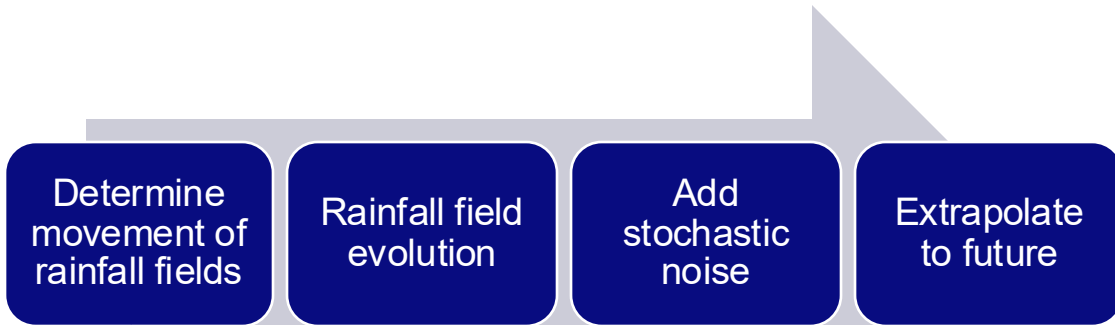
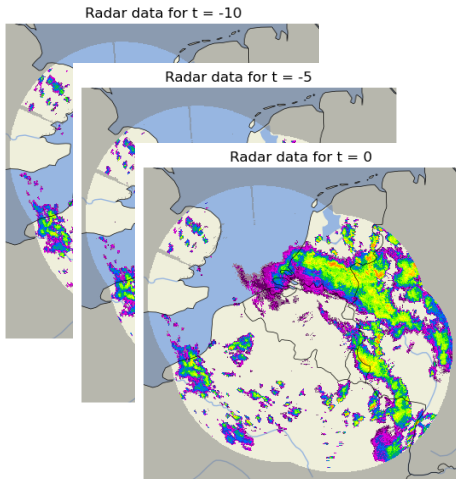


How do we make a nowcast?

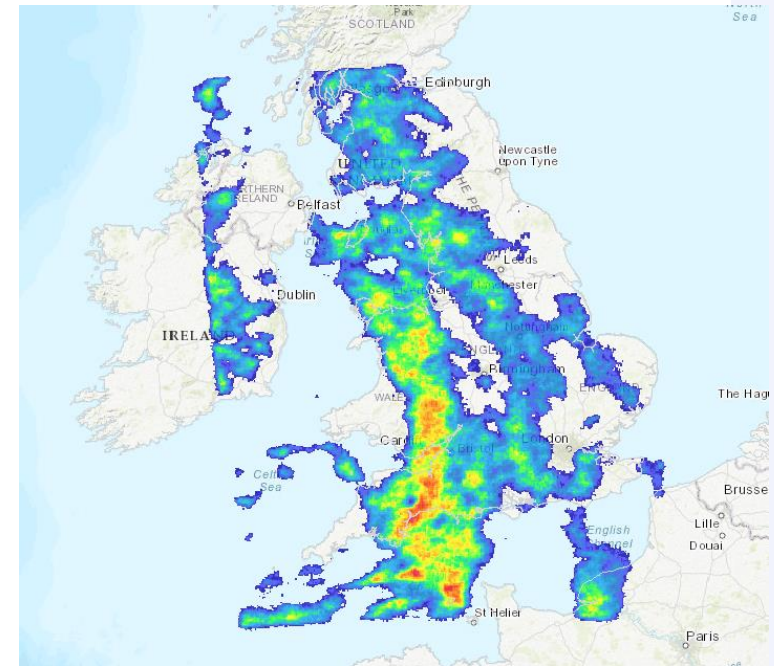
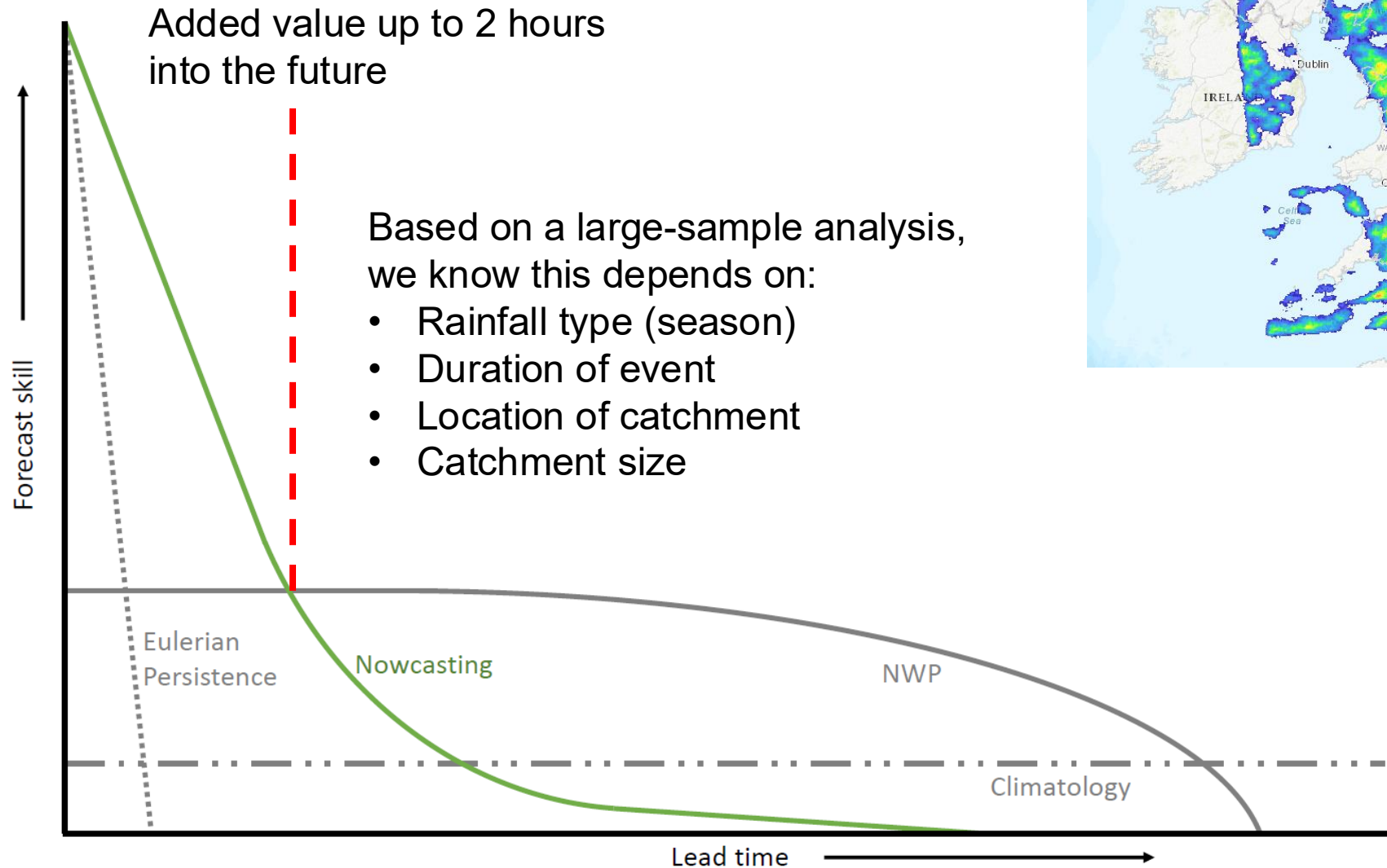
Statistical extrapolation

Fast!

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The skill of nowcasting

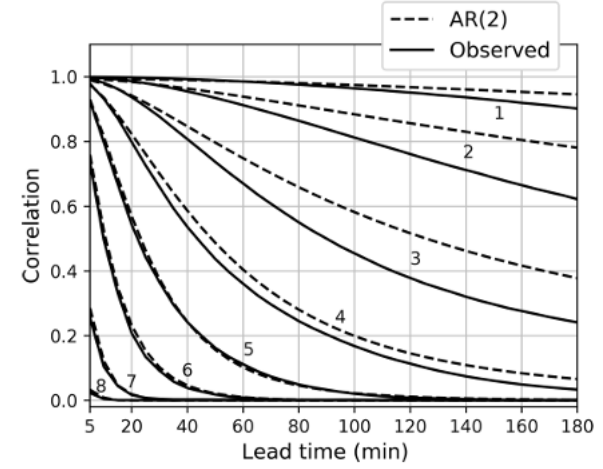
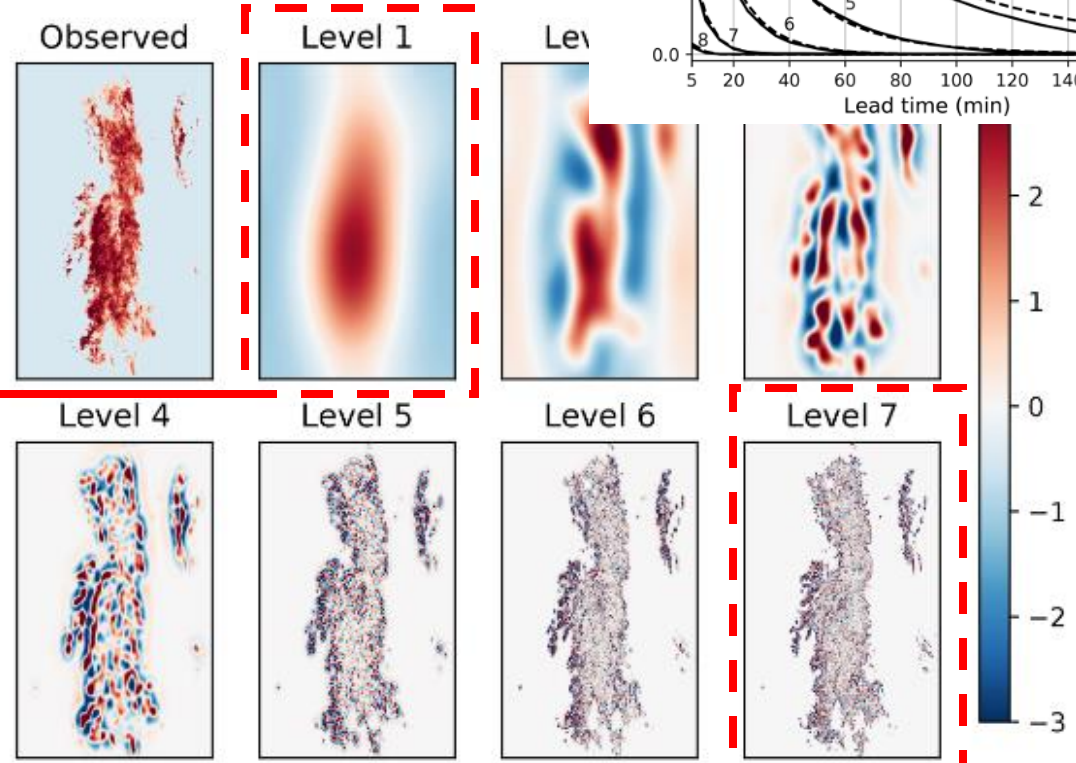


The STEPS algorithm in pysteps

- Past research has shown that the lifetime of rainfall fields relates to its spatial scale (e.g., Venugopal et al., 1999, *J. Geophys. Res.-Atmos.*)
- STEPS takes this into account by decomposing the rainfall fields in spatial cascades with a fast Fourier transform.

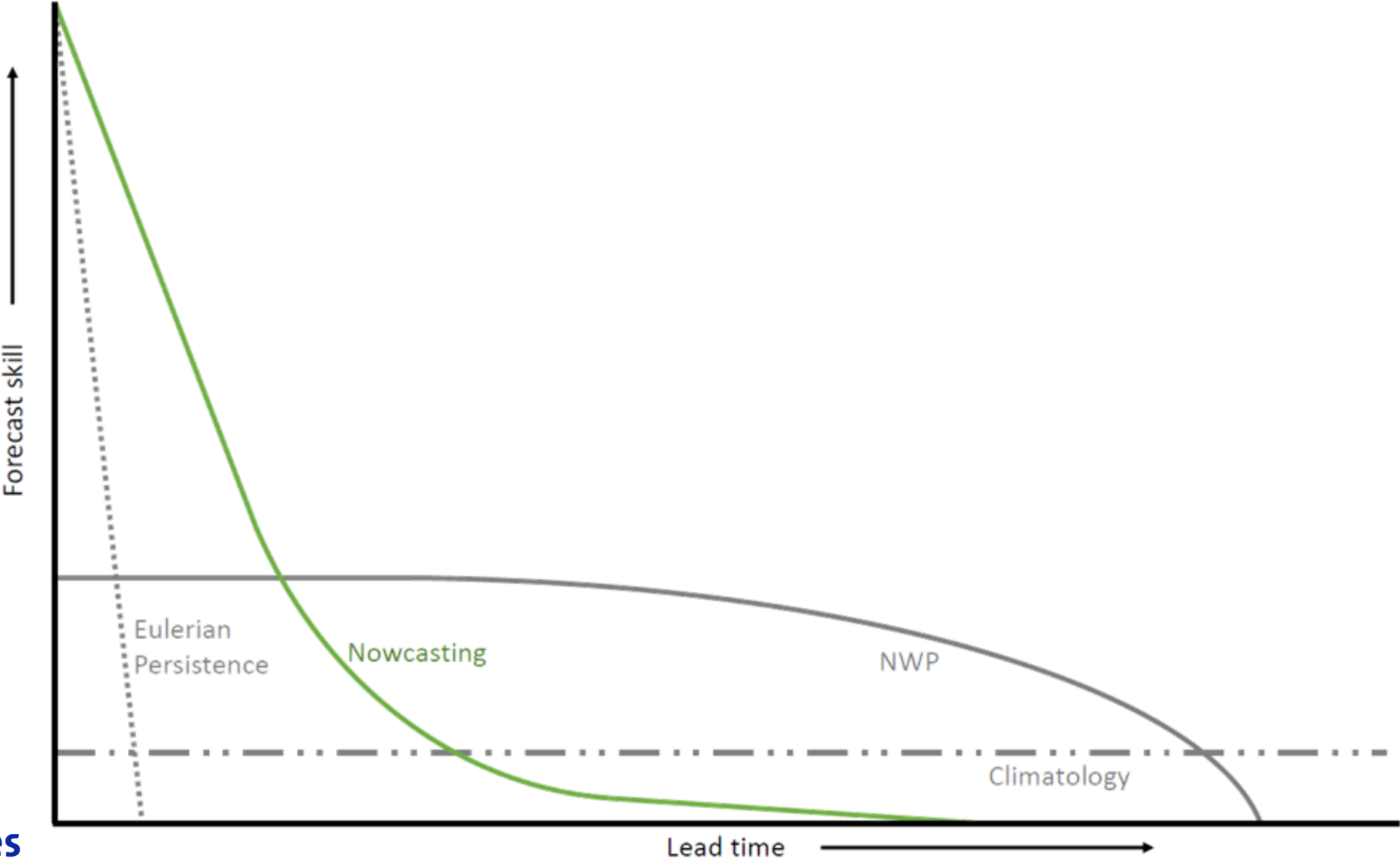
Largest spatial scale: **long lifetime**, advects (moves) without much growth and dissipation

Smallest spatial scale: **short lifetime**, advects (moves) and changes with a combination of **autoregression** and **stochastic perturbations (to model growth and dissipation)** using spatially correlated Gaussian noise.



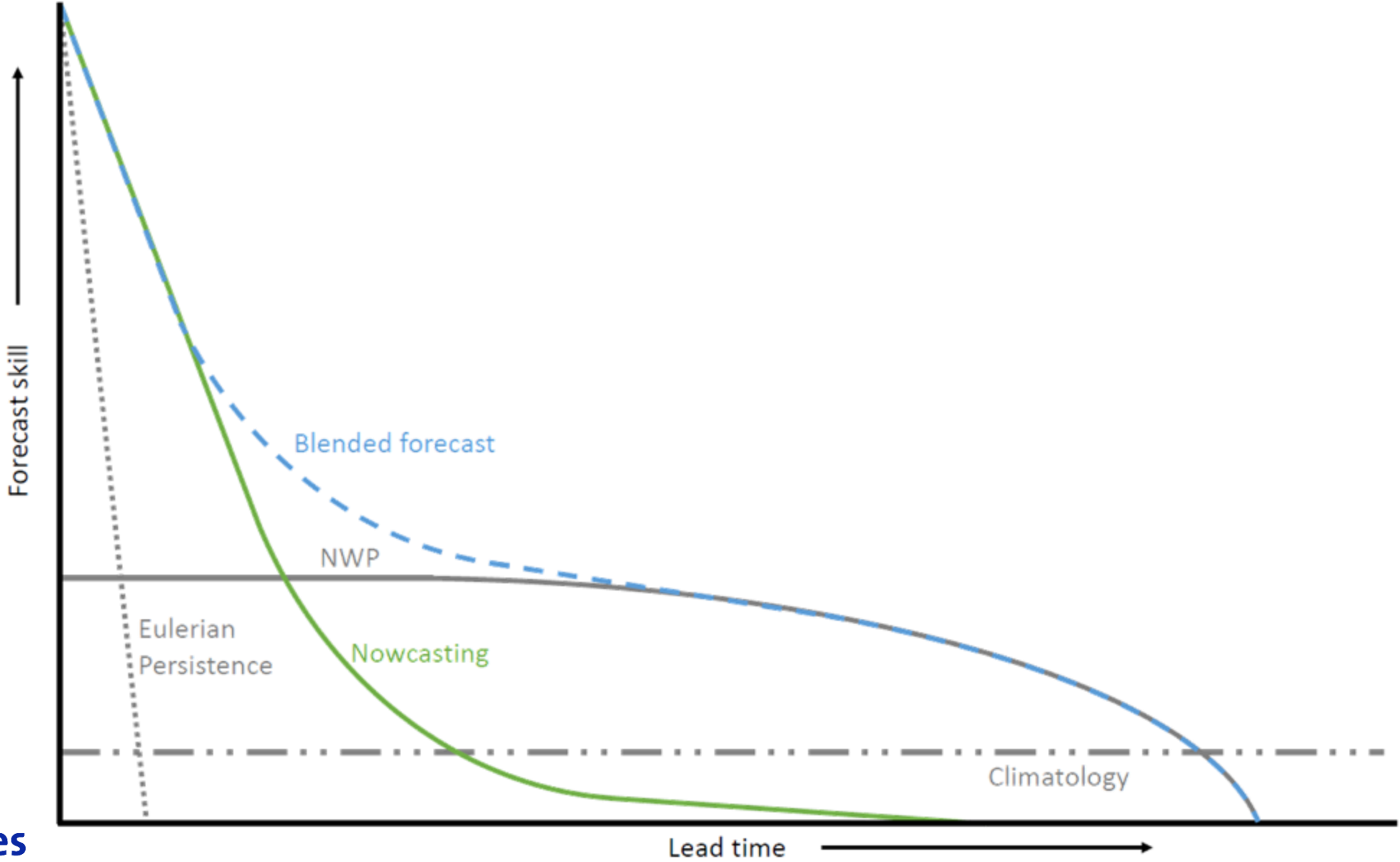
Source: Pulkkinen et al., 2019, GMD

Seamless forecasting: a better combined forecast



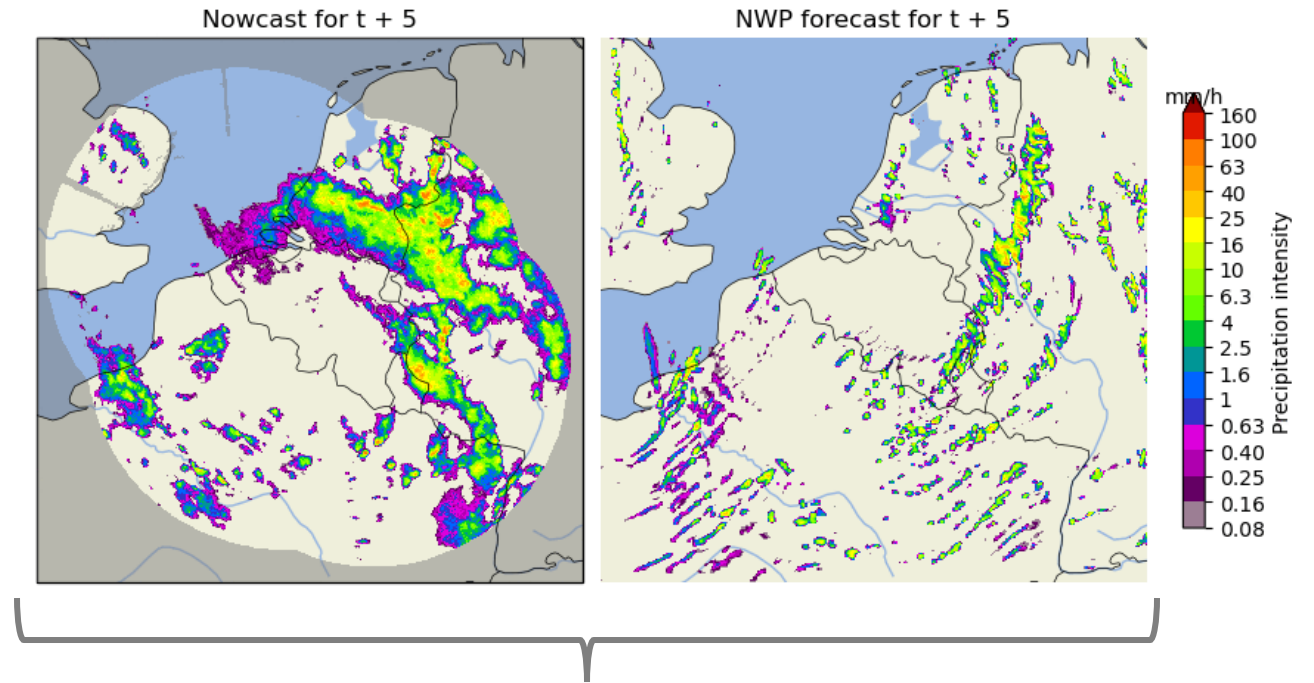
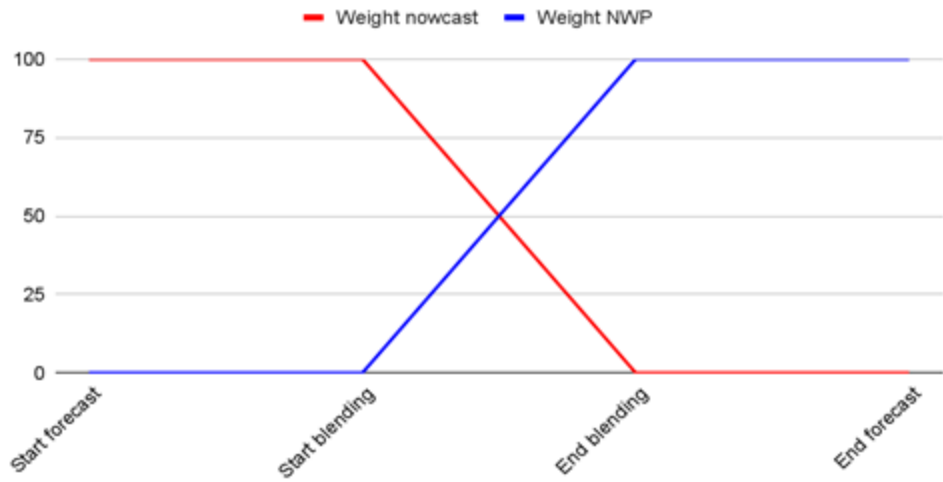
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Seamless forecasting: a better combined forecast



Simple linear blending?

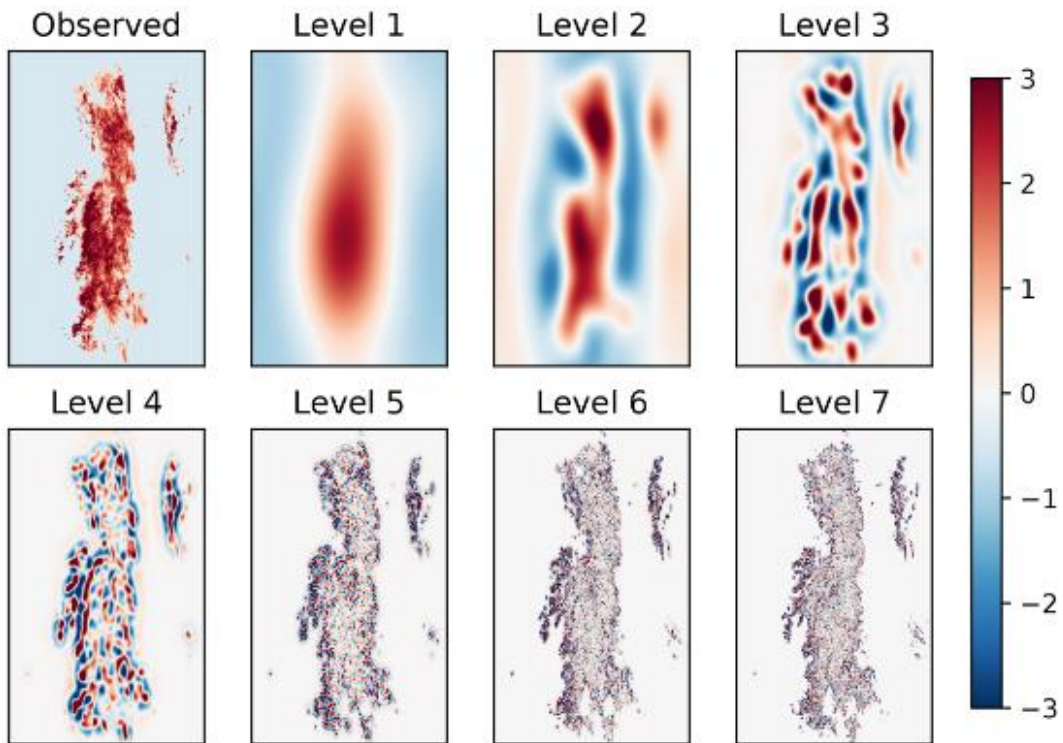
Linear blending weights



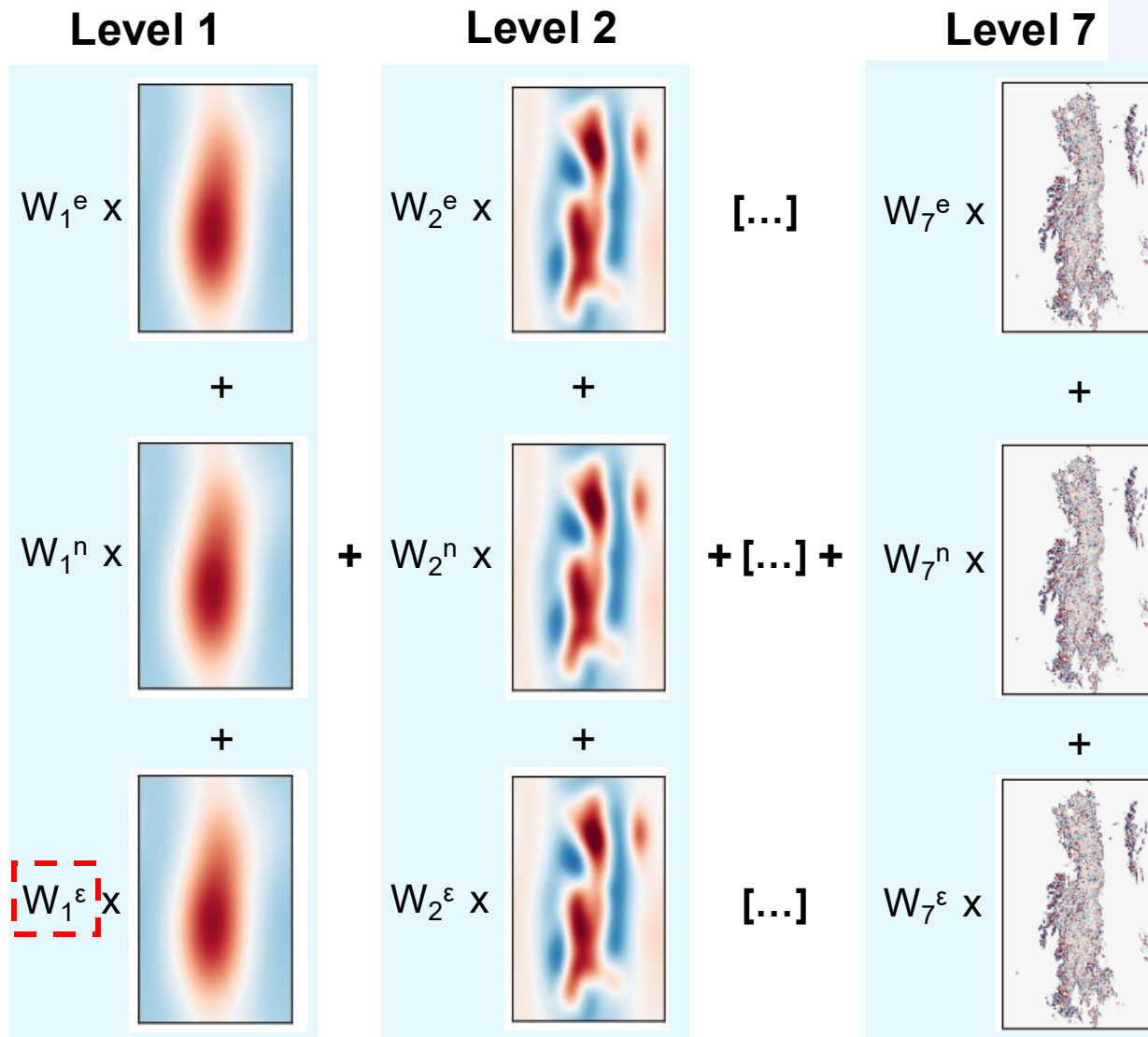
How to combine
a case like this?

An advanced blending method (STEPS) – included in the open-source pysteps framework

Blending per spatial scale:



Per ensemble member:

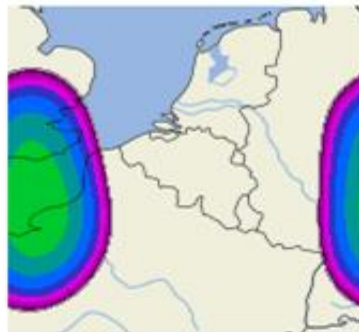


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NWC cascade level 0
2022-05-20 08:00 UTC + 5 min



NWP cascade level 0
2022-05-20 00:00 UTC + 485 min



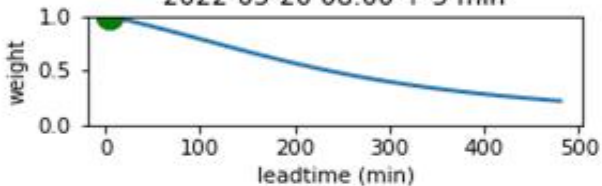
Noise cascade level 0
2022-05-20 08:00 UTC + 5 min



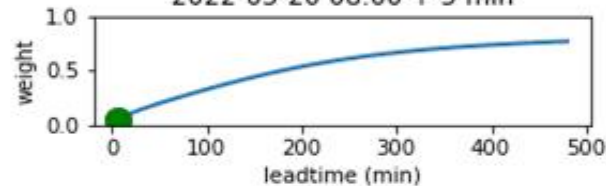
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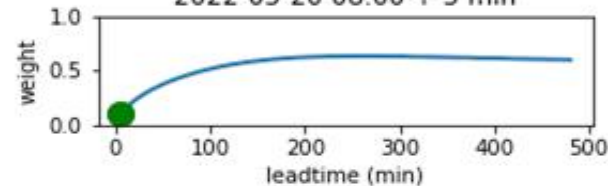
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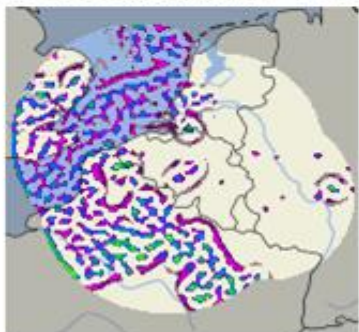
NWP weight cascade level 0
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Noise weight cascade level 0
2022-05-20 08:00 + 5 min



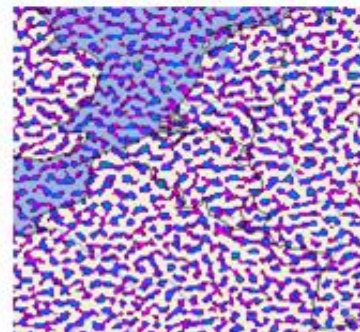
NWC cascade level 4
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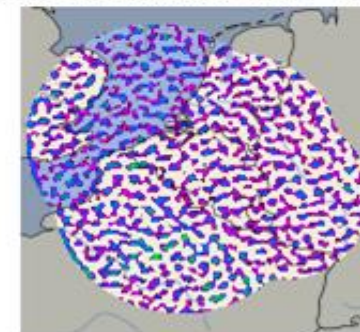
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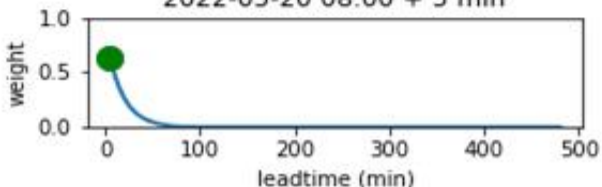
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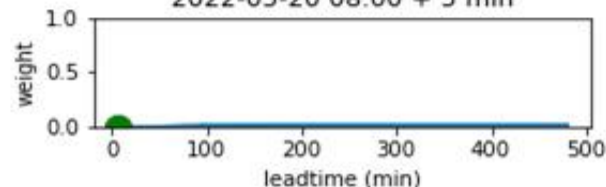
Blended cascade level 4
2022-05-20 08:00 UTC + 5 min



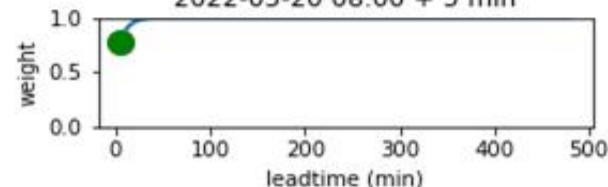
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2022-05-20 08:00 + 5 min



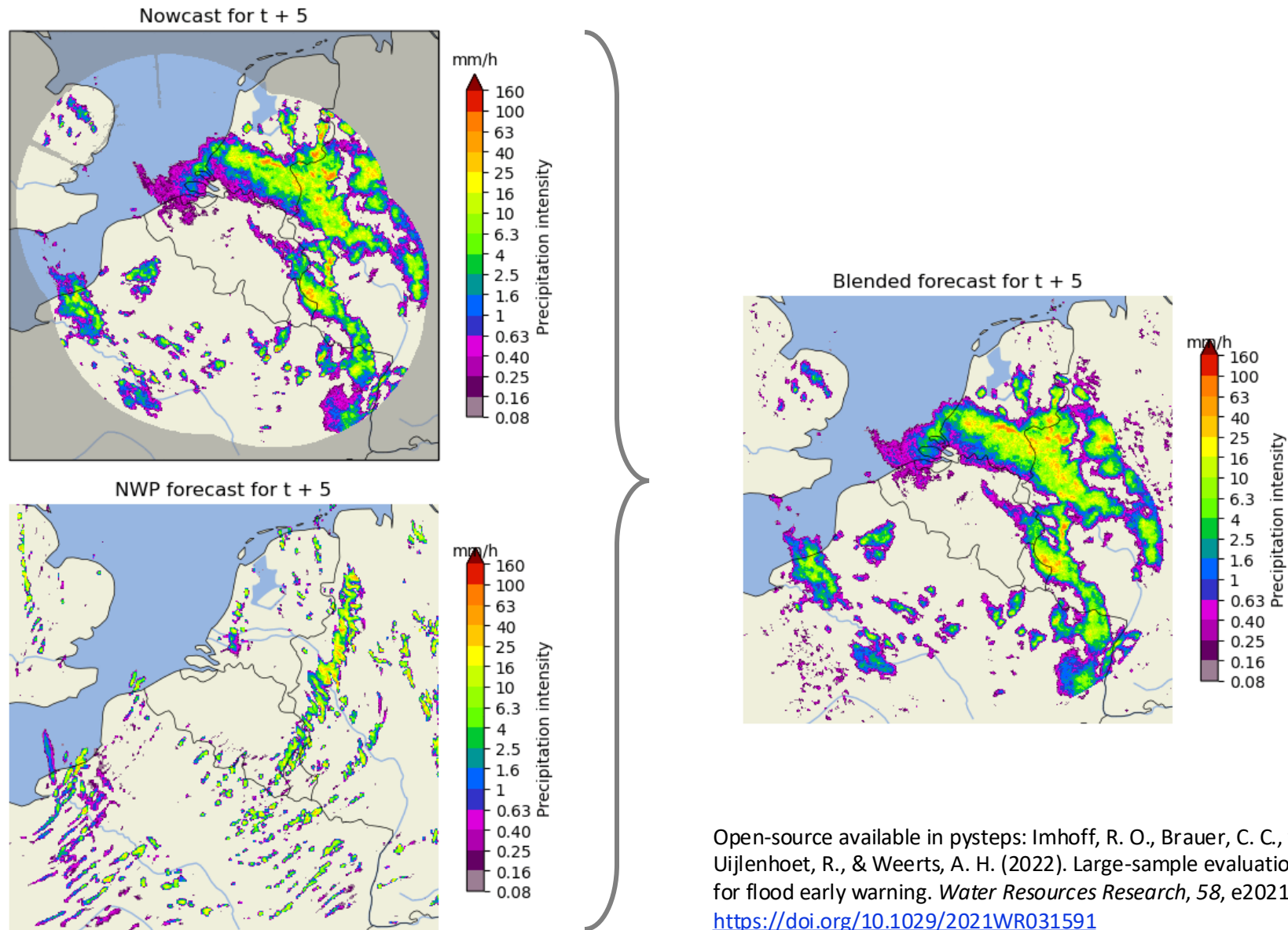
NWP weight cascade level 4
2022-05-20 08:00 + 5 min



Noise weight cascade level 4
2022-05-20 08:00 + 5 min



An advanced blending method



Example of the seamless product for the Netherlands

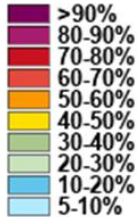
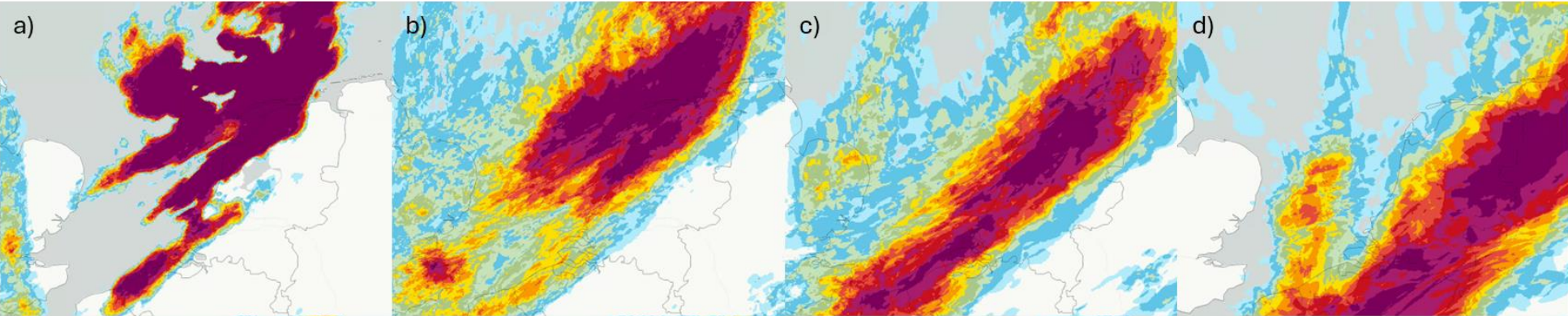
+1 hour

+3 hours

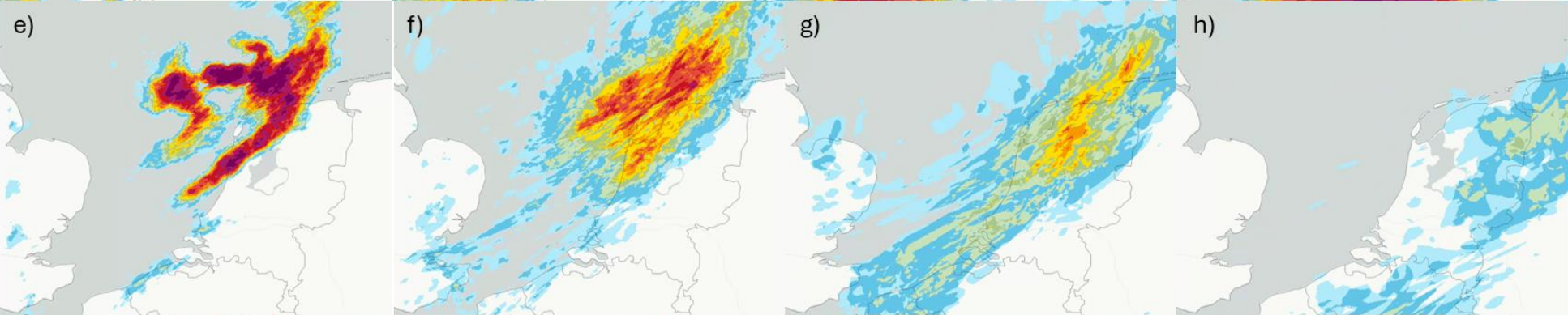
+6 hours

+10 hours

>0.3 mm/h

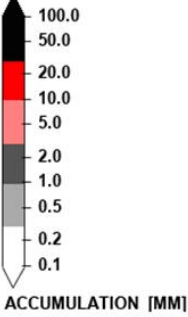
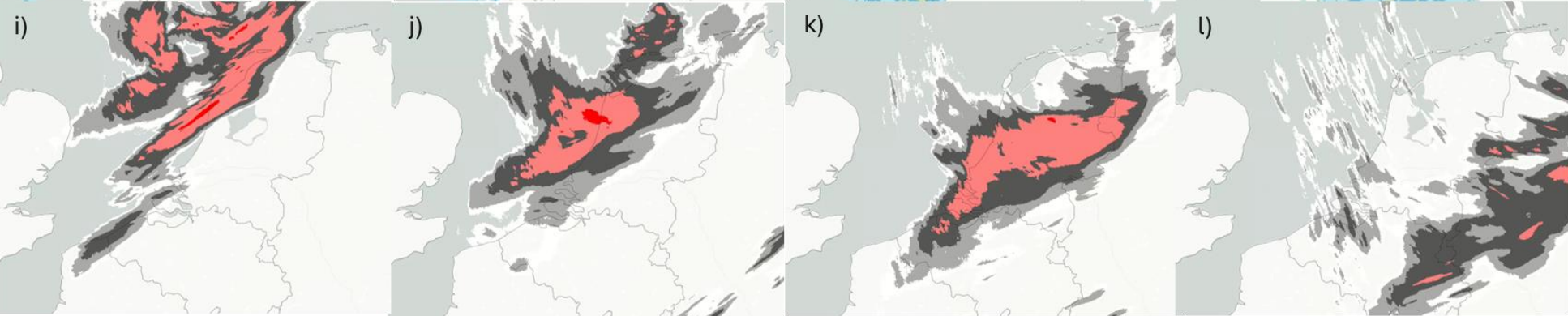


>3 mm/h

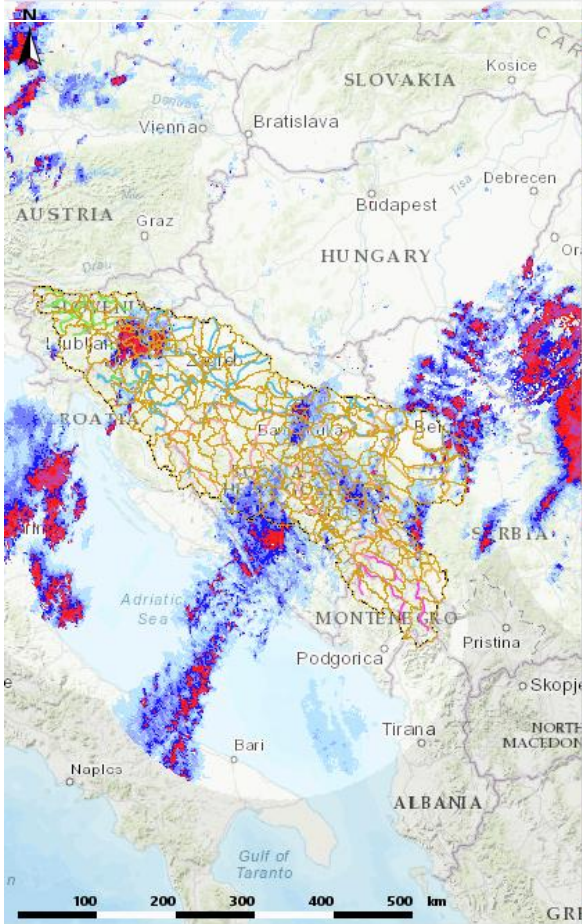


percent

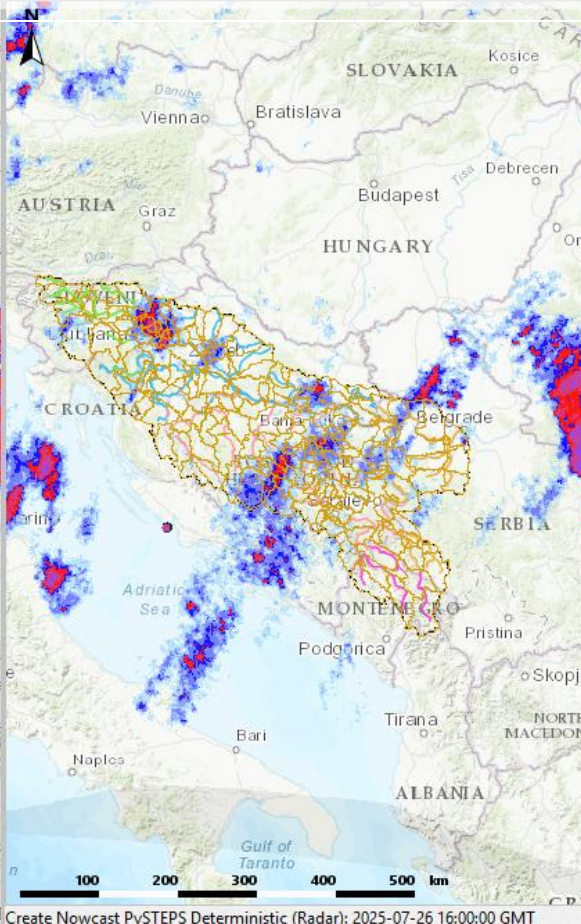
Observations



**OPERA observations
(1-h accumulation)**

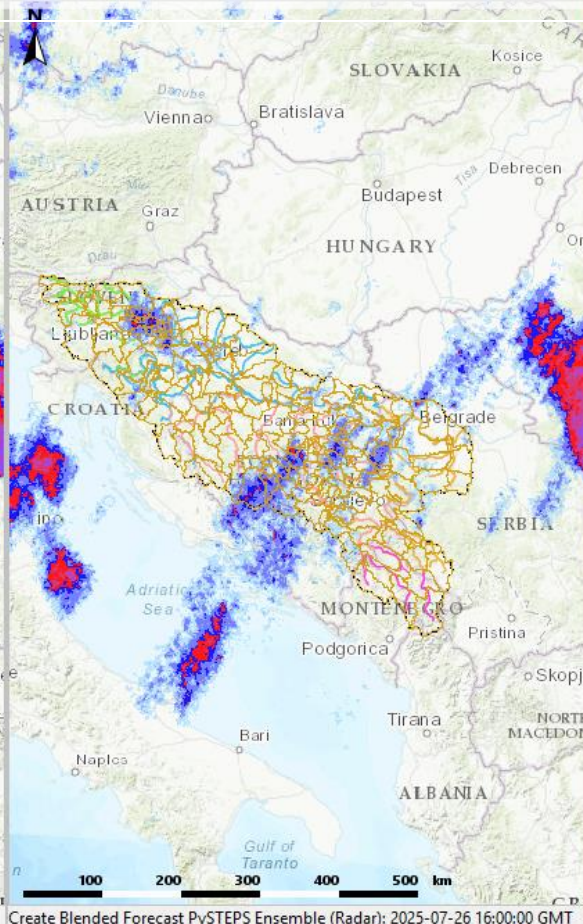


**Nowcast up to 6h ahead
(1-h accum.)**



Create Nowcast PySTEPS Deterministic (Radar): 2025-07-26 16:00:00 GMT Current

**Blended forecast up to
12h ahead (1-h accum.)**



Create Blended Forecast PySTEPS Ensemble (Radar): 2025-07-26 16:00:00 GMT Current

**Aladin (Croatia) forecast
(1-h accum.)**



Preprocess NWP for PySTEPS (Radar): 2025-07-26 12:00:00 GMT Current

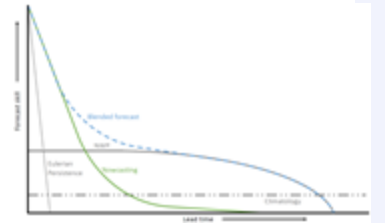
DWD



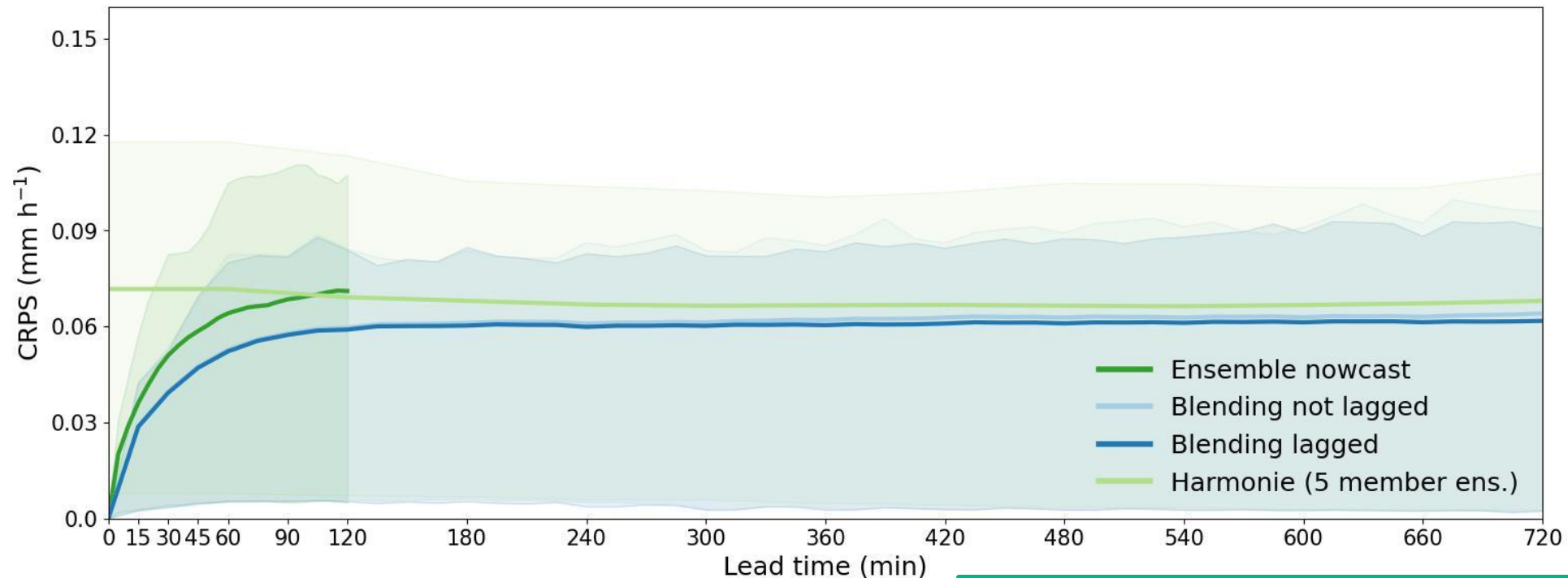
- Combination radar nowcasting and ICON
- Strong focus on thunderstorms and flash flood forecasting
- Just research and pilot or already operational product
- https://www.dwd.de/EN/research/researchprogramme/sinfony_iafe/sinfony_en_node.html



Quality of the seamless rainfall product for the Netherlands (convective summer case)



- Continuous Ranked Probability Score

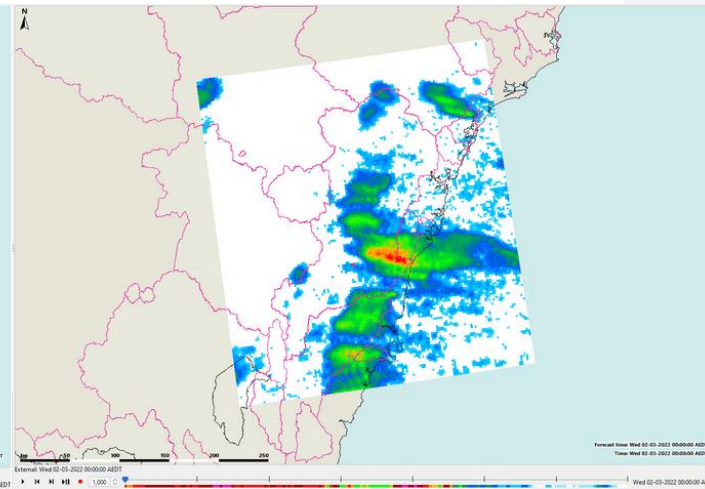
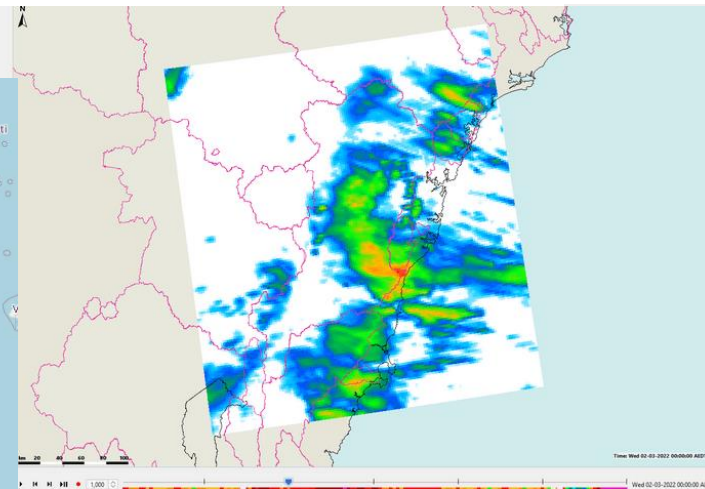
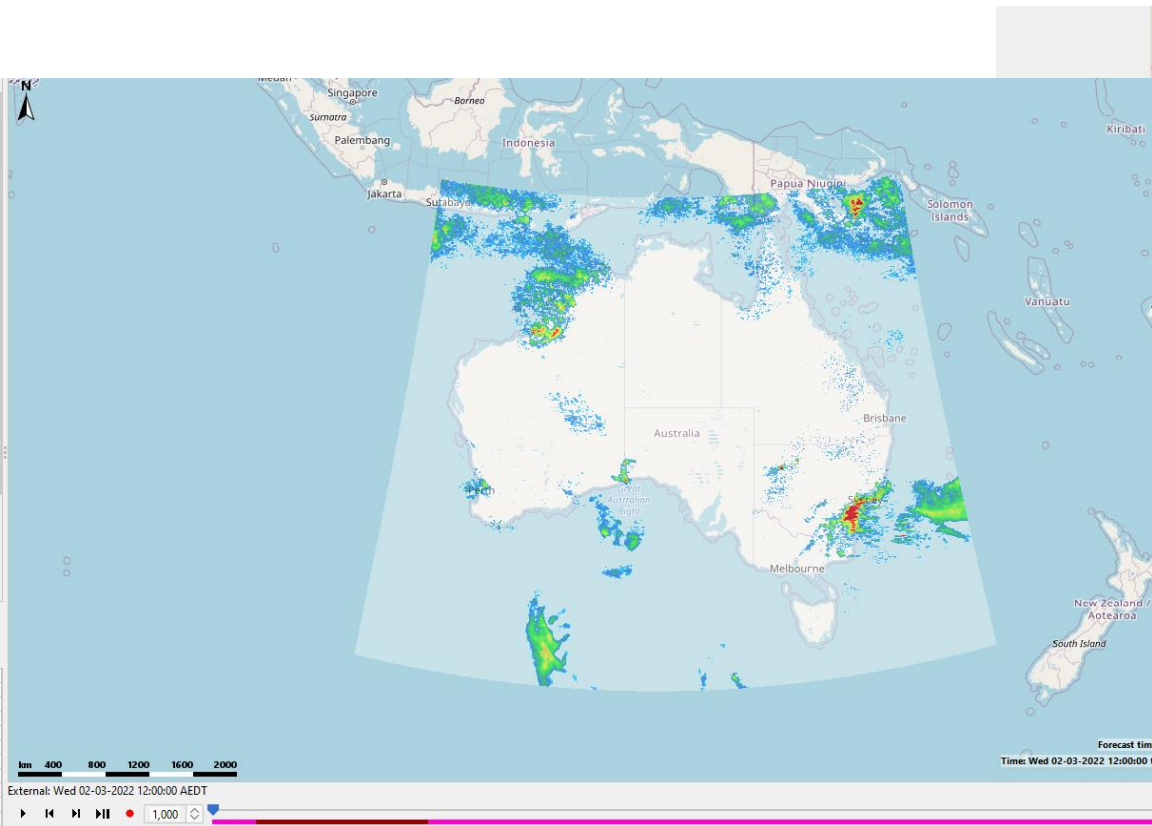


- Tested products:
- Harmonie with 5 ensemble members
 - Ensemble nowcast (20 members up to 2 hours)
 - Blending with 20 ensemble members, using most recent 5 ens. members NWP
 - Blending with lagged ensemble of 20 members

Taking this one step further in Australia: seamless forecasting up to 8 days ahead

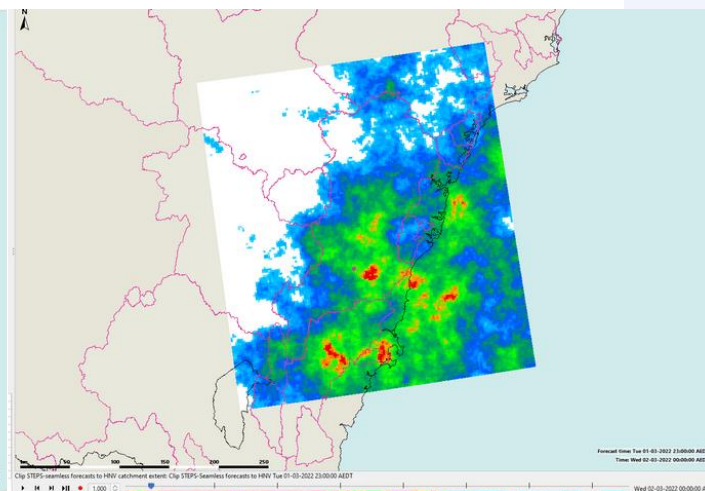
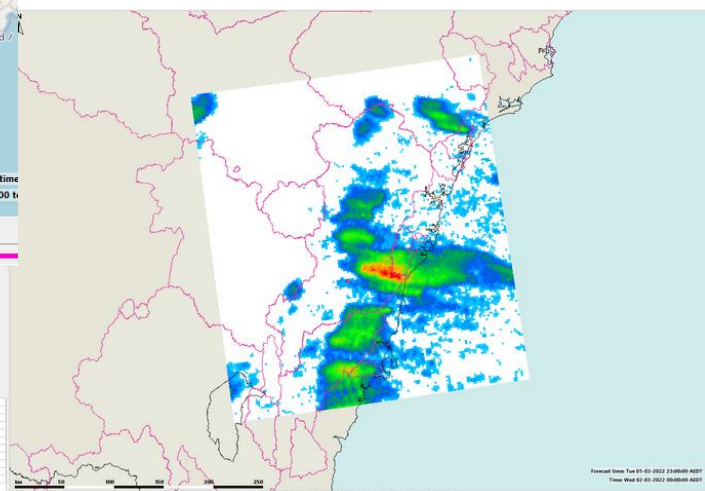
Reference observations

Salient blending



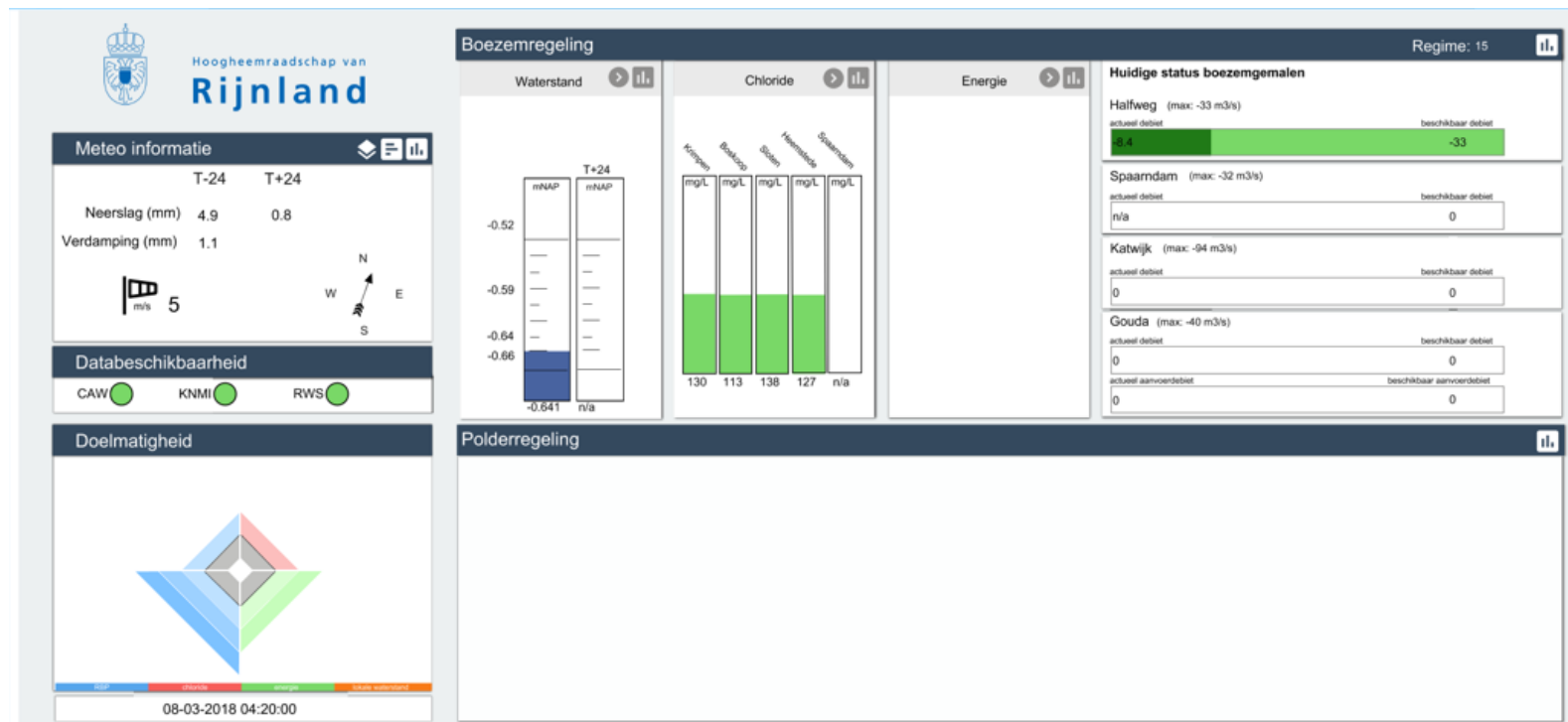
STEPS-NWP

STEPS-seamless

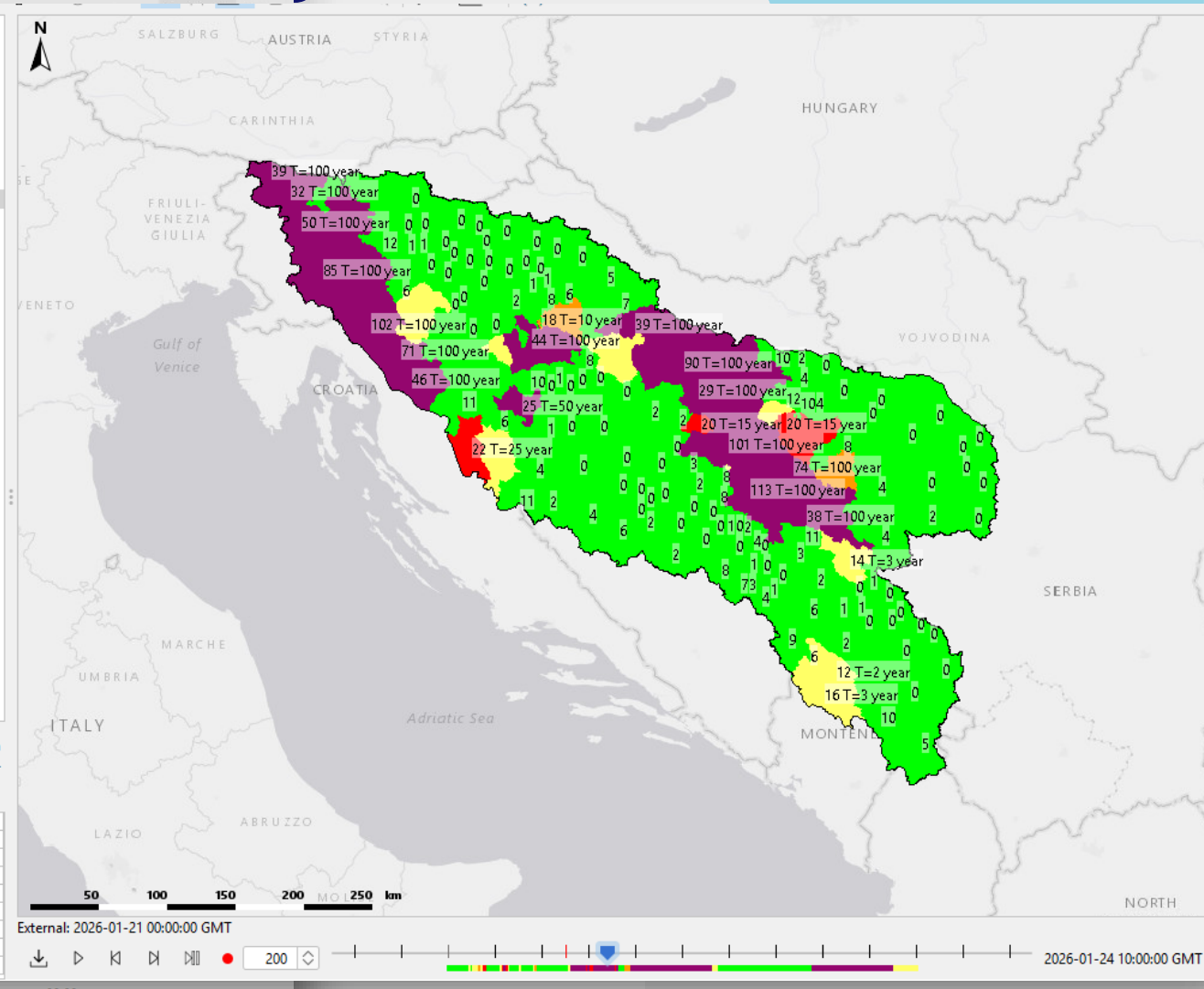
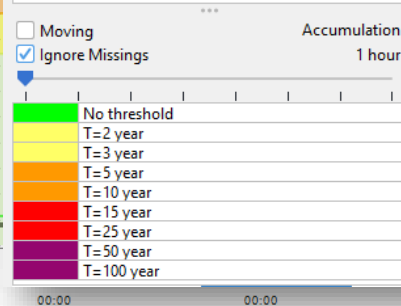
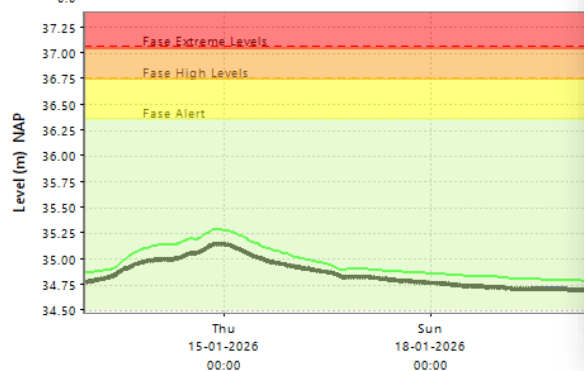
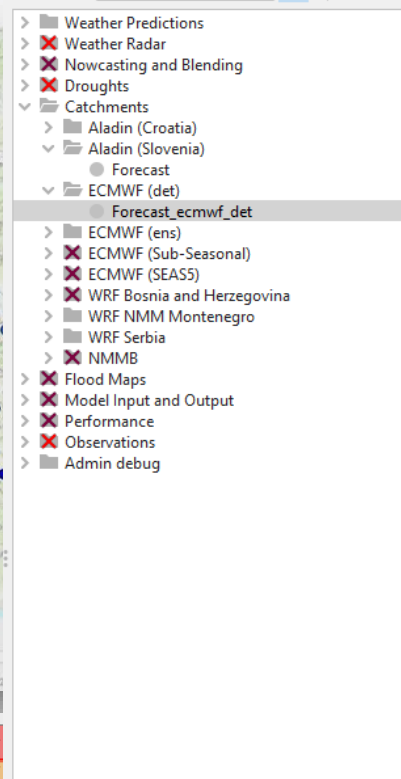
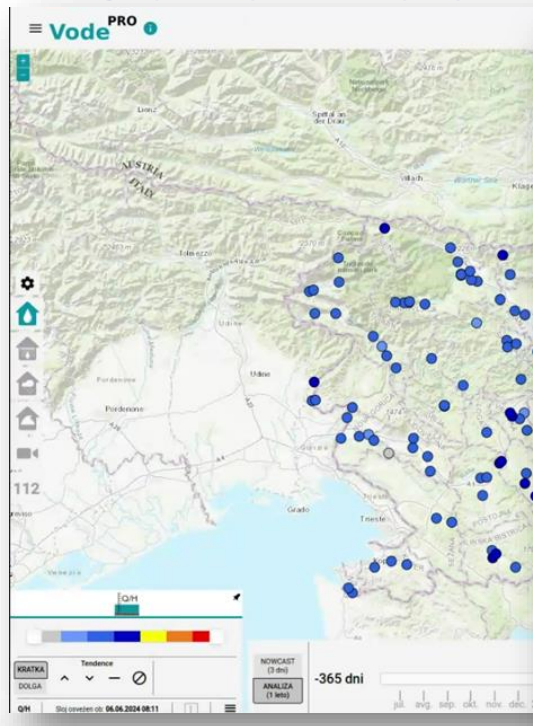


Applications in the Netherlands

- To bridge the gap to Harmonie product (current latency 3 hours)
- Applied at regional water management and larger cities
- Mainly for the purpose of real-time control of pumps and other structures



Sava Flash Flood Forecasting

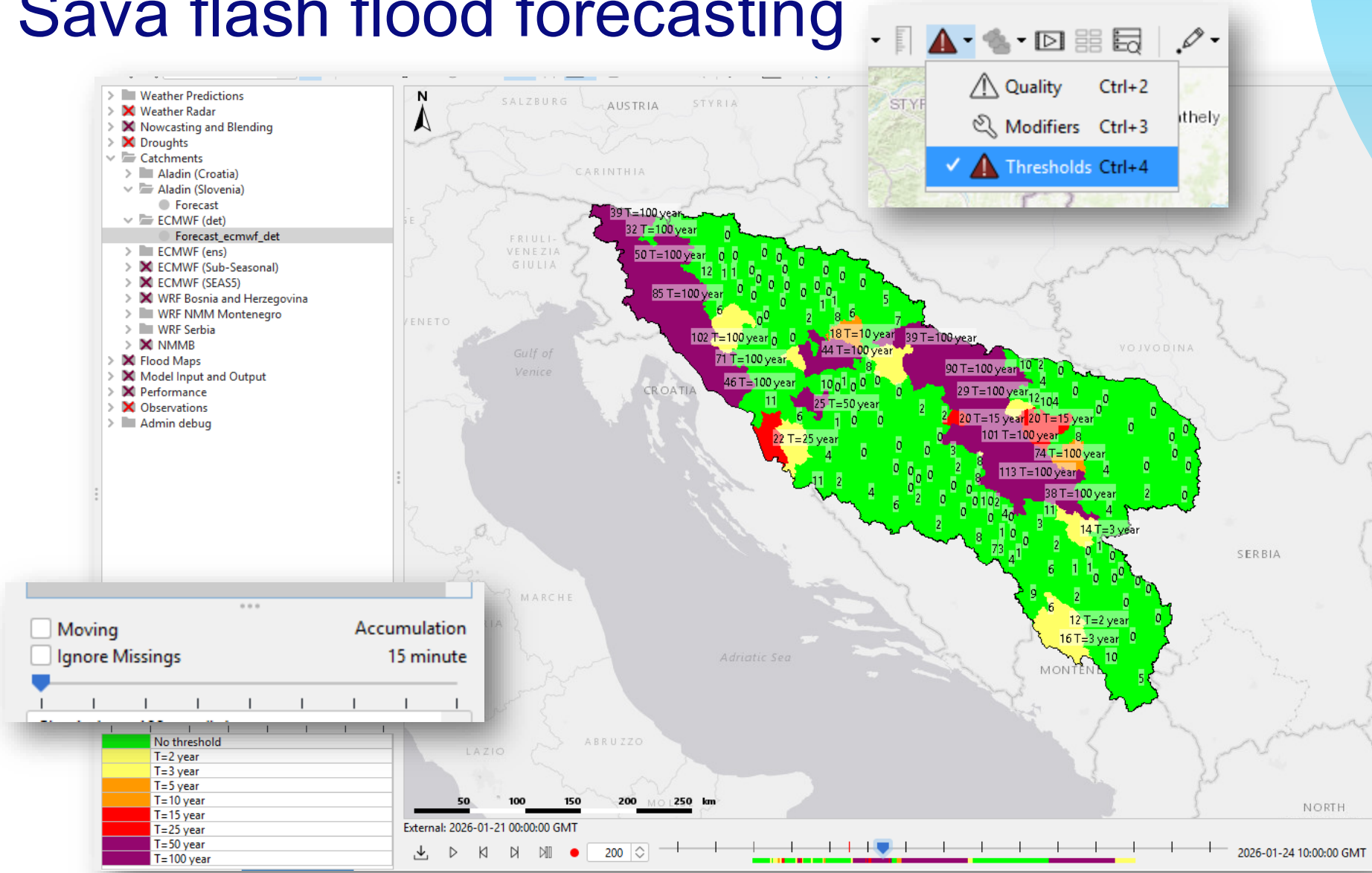


Typical thresholds for flash flood forecasting

- Based on precipitation amounts and intensities
- No time for hydrological models, such to be almost real-time
- Typical thresholds based on return periods, like
 - rolling duration 1, 3, 6, 12 and 24 hrs
 - T=0.5, 1, 2, 5, 10, 25, etc years

duration	T1	T2	T5	T10	T25	T50	T100	T250
1	19	25	33	38	47	53	61	71
3	26	34	44	52	63	72	81	96
6	33	44	56	65	78	89	101	118
12	38	50	64	75	89	101	114	132
24	48	64	80	93	110	123	137	157

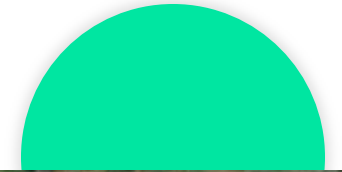
Sava flash flood forecasting





QUESTIONS

Thanks for your attention!



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