Three HPEs of 2024 in the DEODE On-Demand DTs

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April 1st 2025

5th ACCORD All-Staff Workshop, Zalakaros, Hungary

Models In the Comparisons

- **IFS:**
  ECMWF IFS-HRES global model, 9 km grid spacing

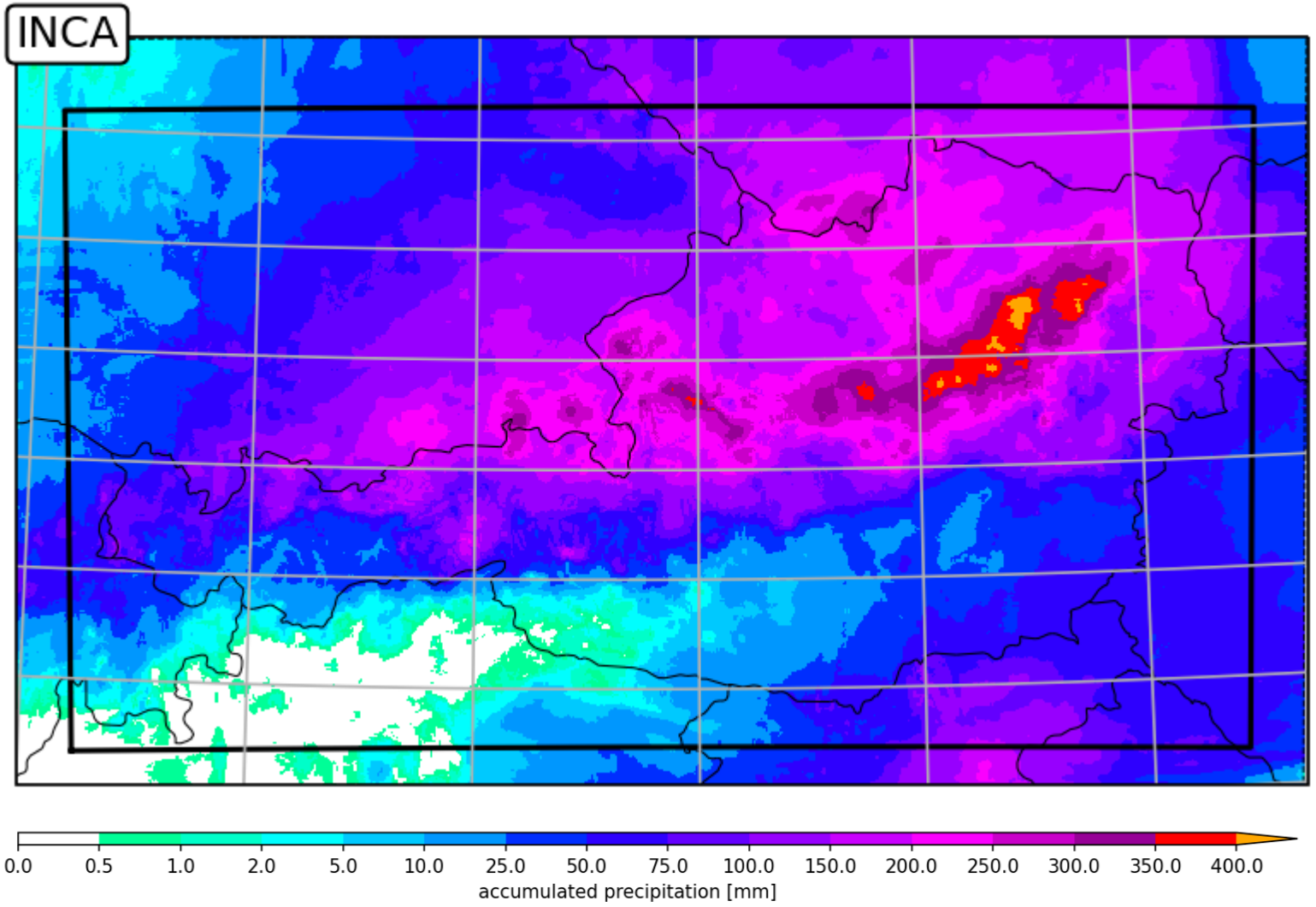
- **DT:**
  ECMWF IFS Digital Twin, 4.5 km grid spacing

- **AROME, ALARO, HARMONIE:**
  Different CSCs of AROME which are being used in DEODE, Austrian national models, resolution ranges from 500 m to 2.5 km

Verification of the September 13 - 16 HPE over Central Europe

GeoSphere Austria

96 h acc. precip. from 13 Sep 00 UTC to 17 Sep 00 UTC

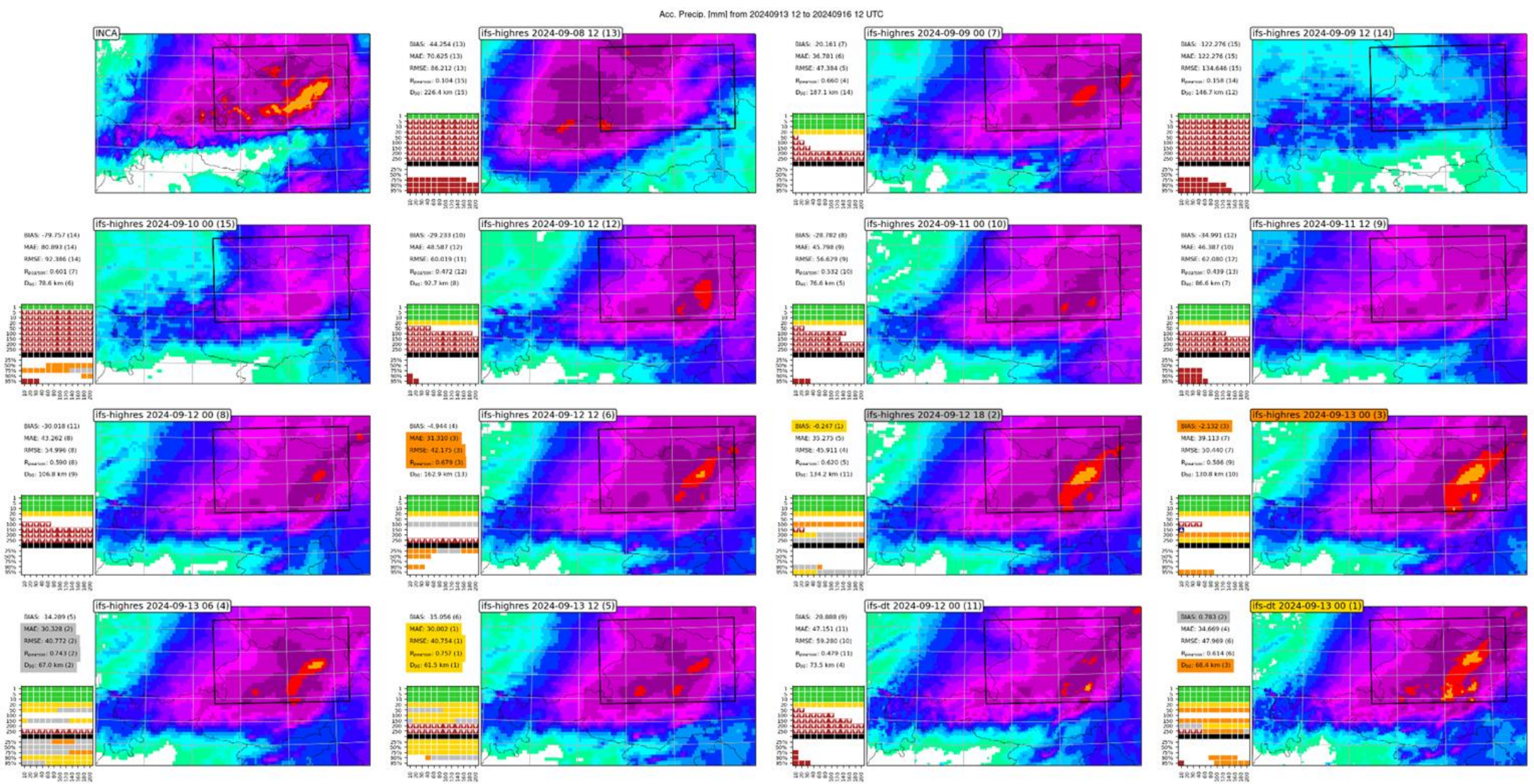


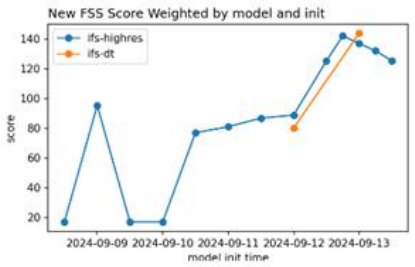
What happened?

In Austria, some regions received over 400 mm of precipitation in just 96 hours. Average annual precipitation in at this location can be as low as 700 mm.

The event lasted from 13 to 16 September, but it was most intense between 14 Sep 12 UTC and 15 Sep 12 UTC.

The following slides will show precipitation verification against the Austrian 1 km gridded INCA precipitation analysis at increasingly smaller spatial and temporal scales.





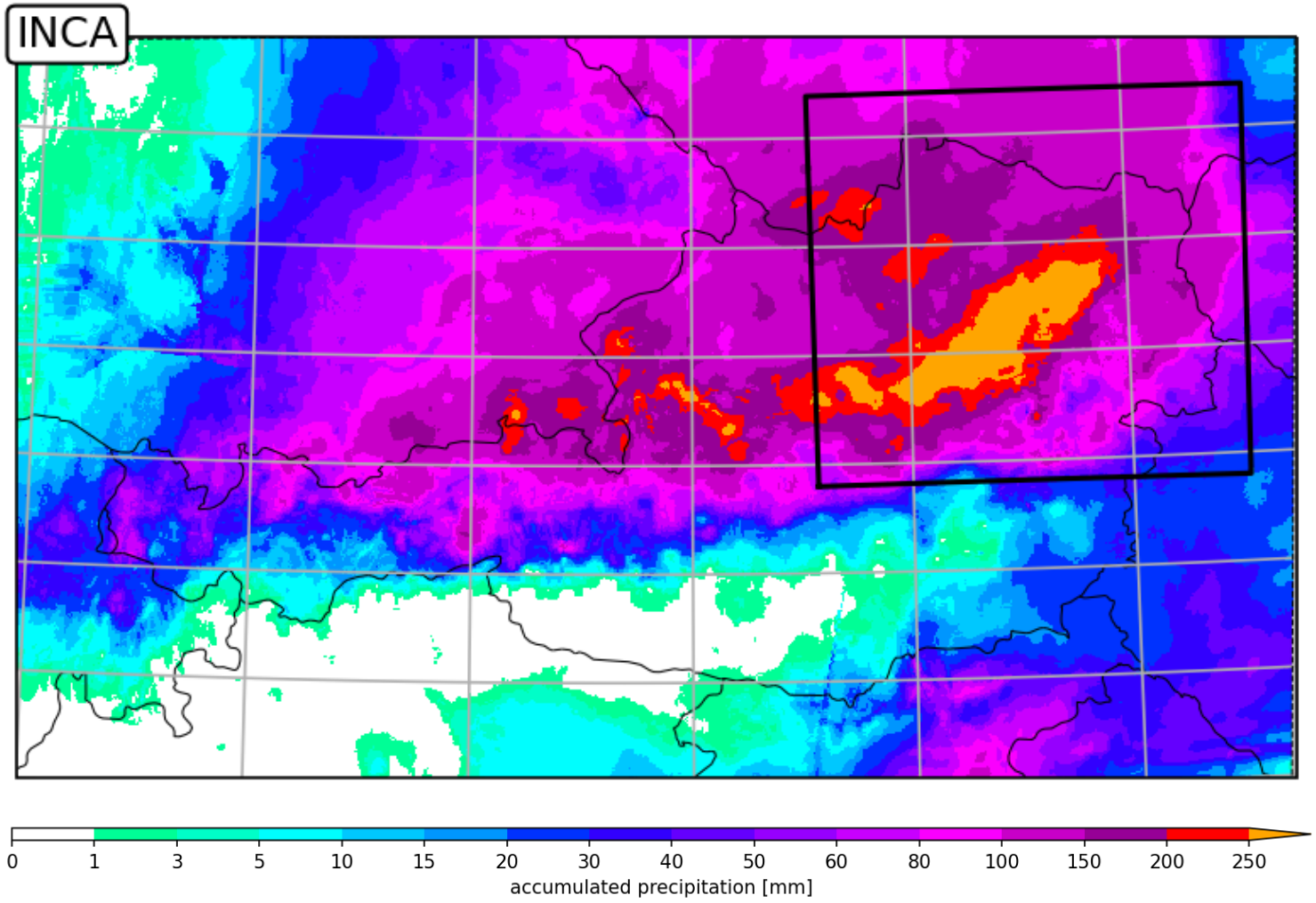
Overview: 72 hour accumulated precipitation from 13 Sep 12 UTC to 16 Sep 12 UTC
Comparison: IFS HRES + Global DT

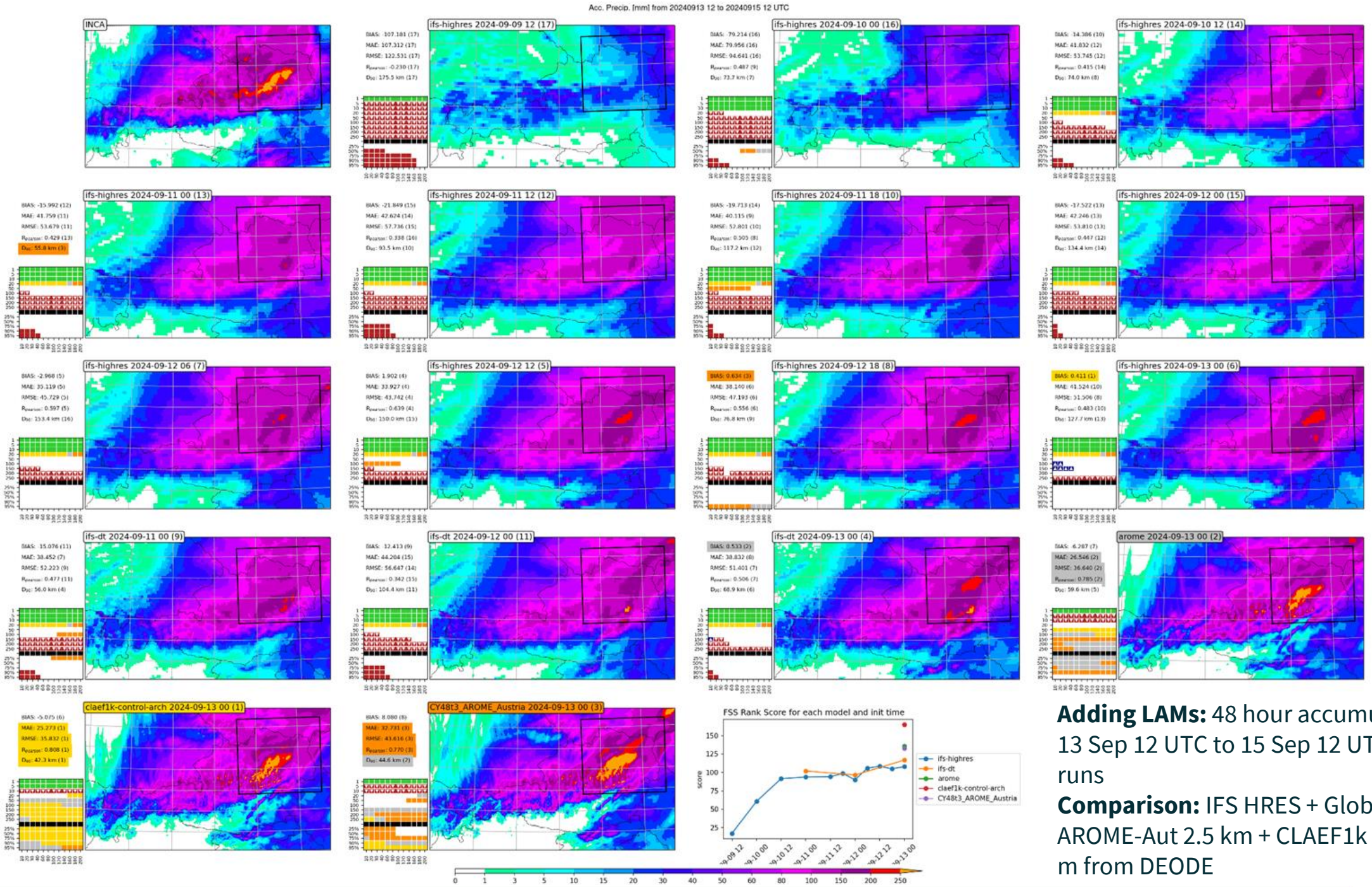
The forecast quality is relatively **volatile early on**, despite showing heavy precipitation several days in advance, but as the event approaches the **forecast quality increases and stabilizes**. The DT does not clearly outperform HRES

Verification of the September 13 - 16 HPE over Central Europe

GeoSphere Austria

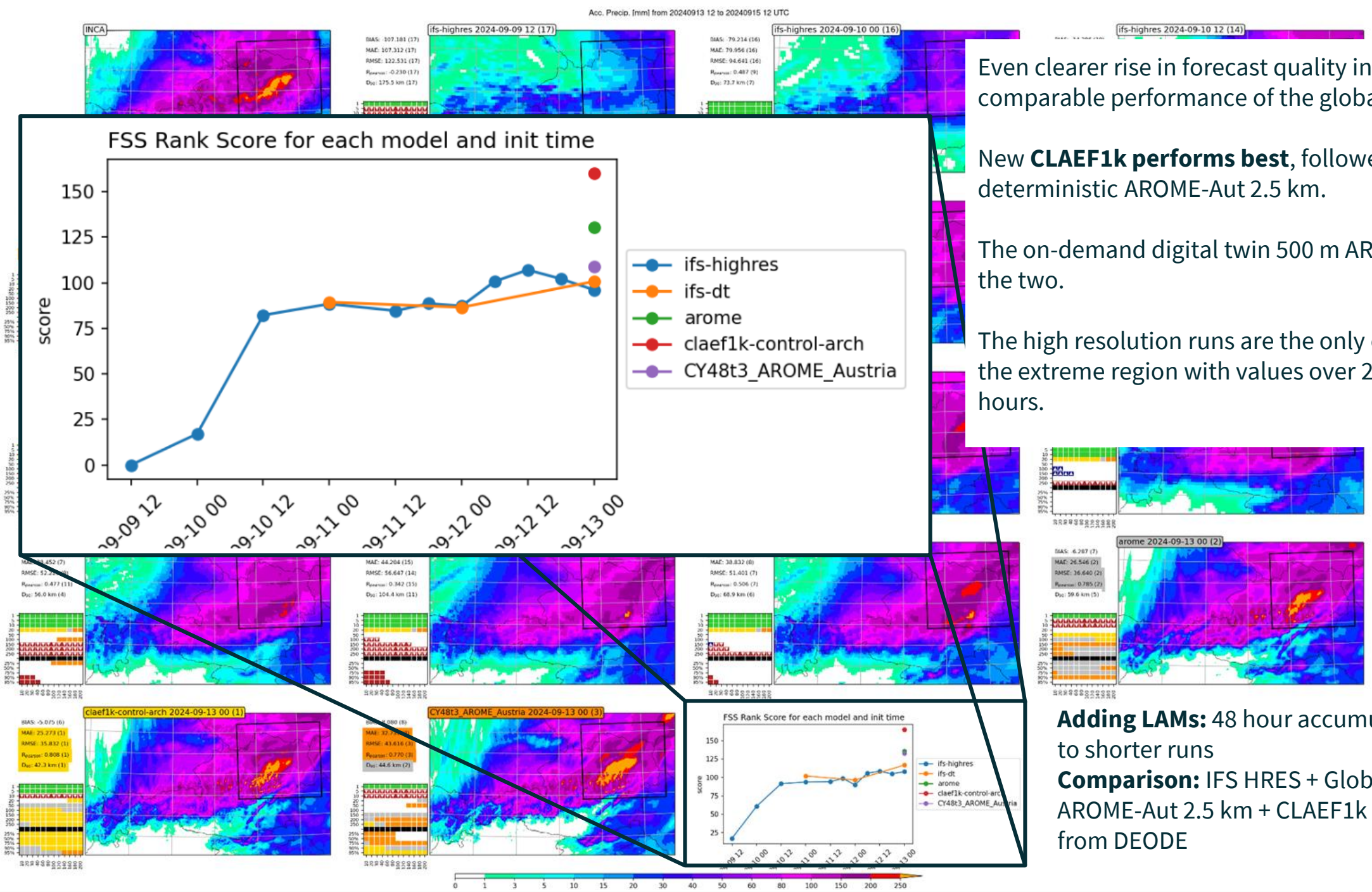
72 h acc. precip. from 13 Sep 00 UTC to 17 Sep 00 UTC (different scale!)





Adding LAMs: 48 hour accumulated precipitation, 13 Sep 12 UTC to 15 Sep 12 UTC, due to shorter runs

Comparison: IFS HRES + Global DT + deterministic AROME-Aut 2.5 km + CLAEF1k (1 km) + AROME 500 m from DEODE



Even clearer rise in forecast quality in IFS HRES, comparable performance of the global DT.

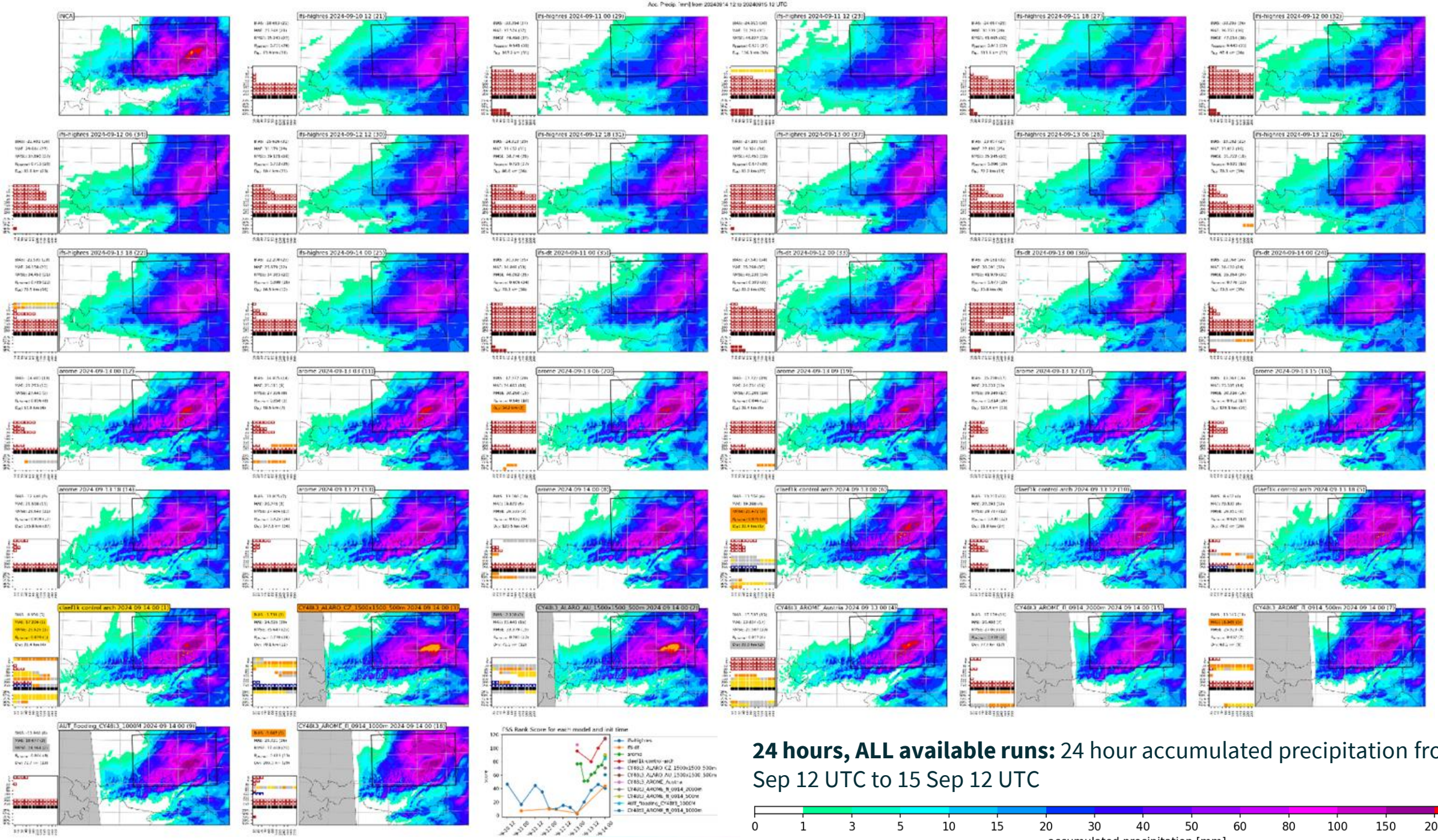
New **CLAEF1k performs best**, followed by deterministic AROME-Aut 2.5 km.

The on-demand digital twin 500 m AROME is between the two.

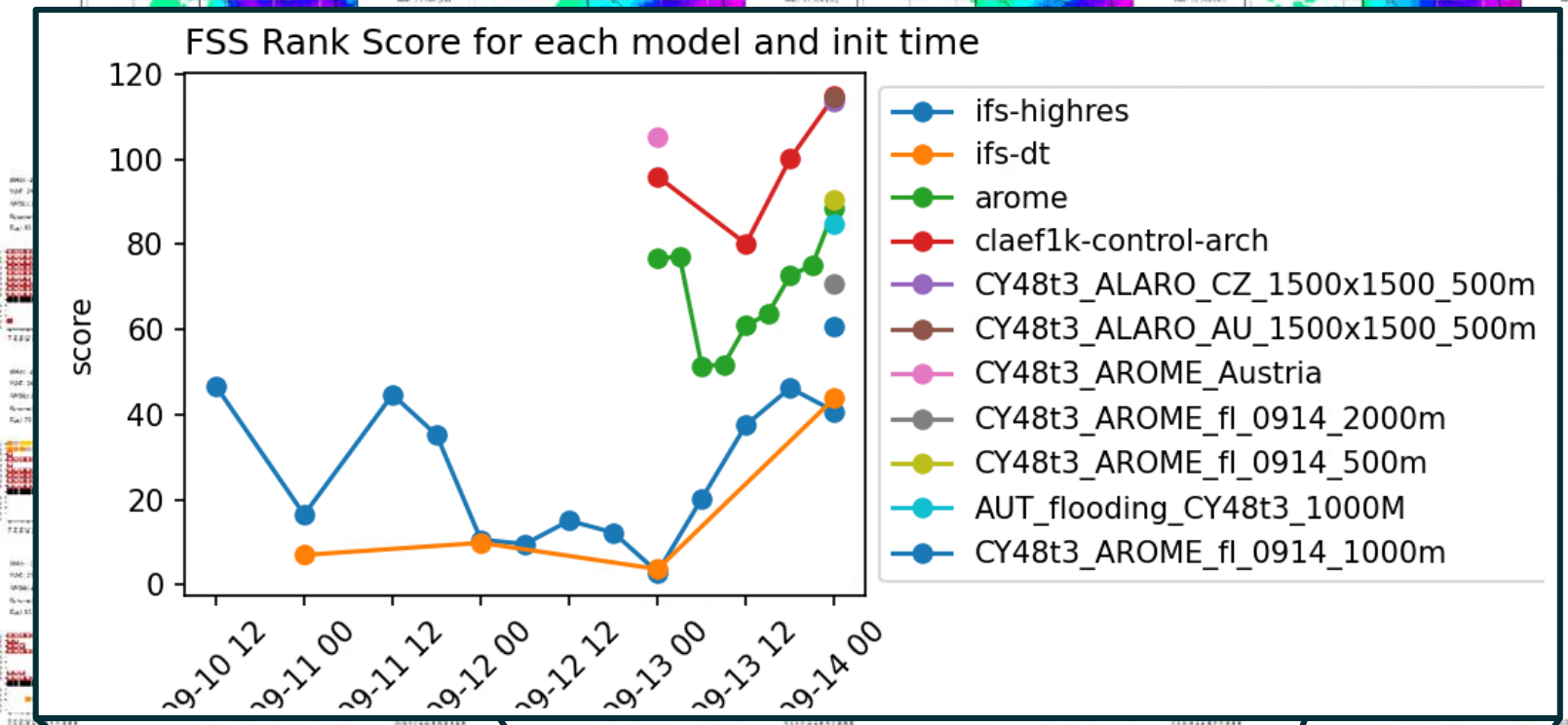
The high resolution runs are the only one capturing the extreme region with values over 250 mm in 48 hours.

Adding LAMs: 48 hour accumulated precipitation due to shorter runs

Comparison: IFS HRES + Global DT + deterministic AROME-Aut 2.5 km + CLAEF1k (1 km) + AROME 500 m from DEODE

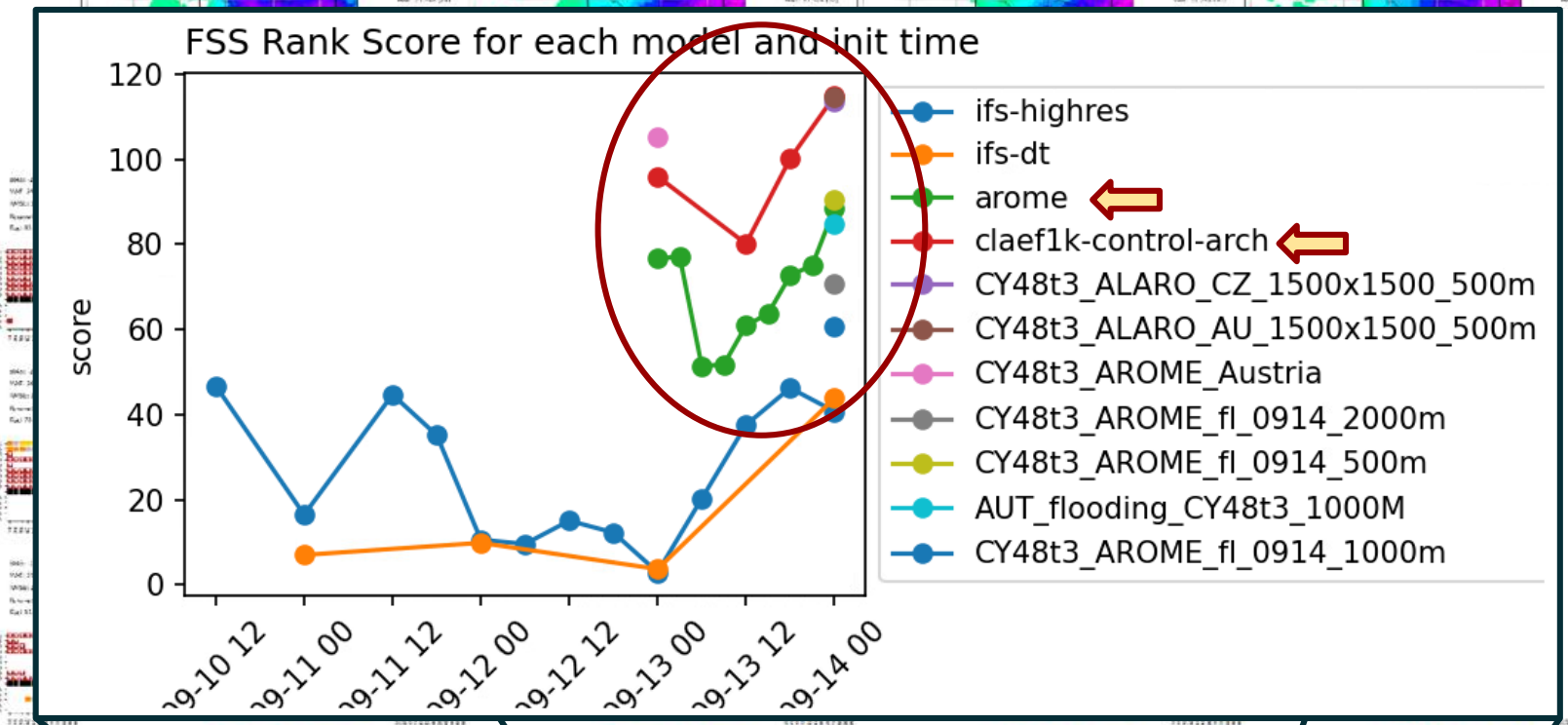


24 hours, ALL available runs: 24 hour accumulated precipitation from 14 Sep 12 UTC to 15 Sep 12 UTC



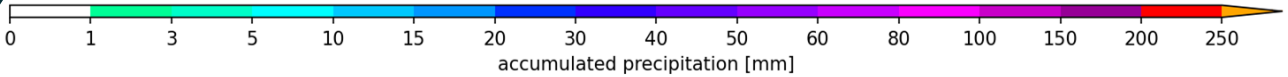
Forecast **volatility increases on shorter scales**, especially HRES. **Global DT seems low**, but the lines are deceiving, it **outperforms HRES on 2 out of 3 runs**.

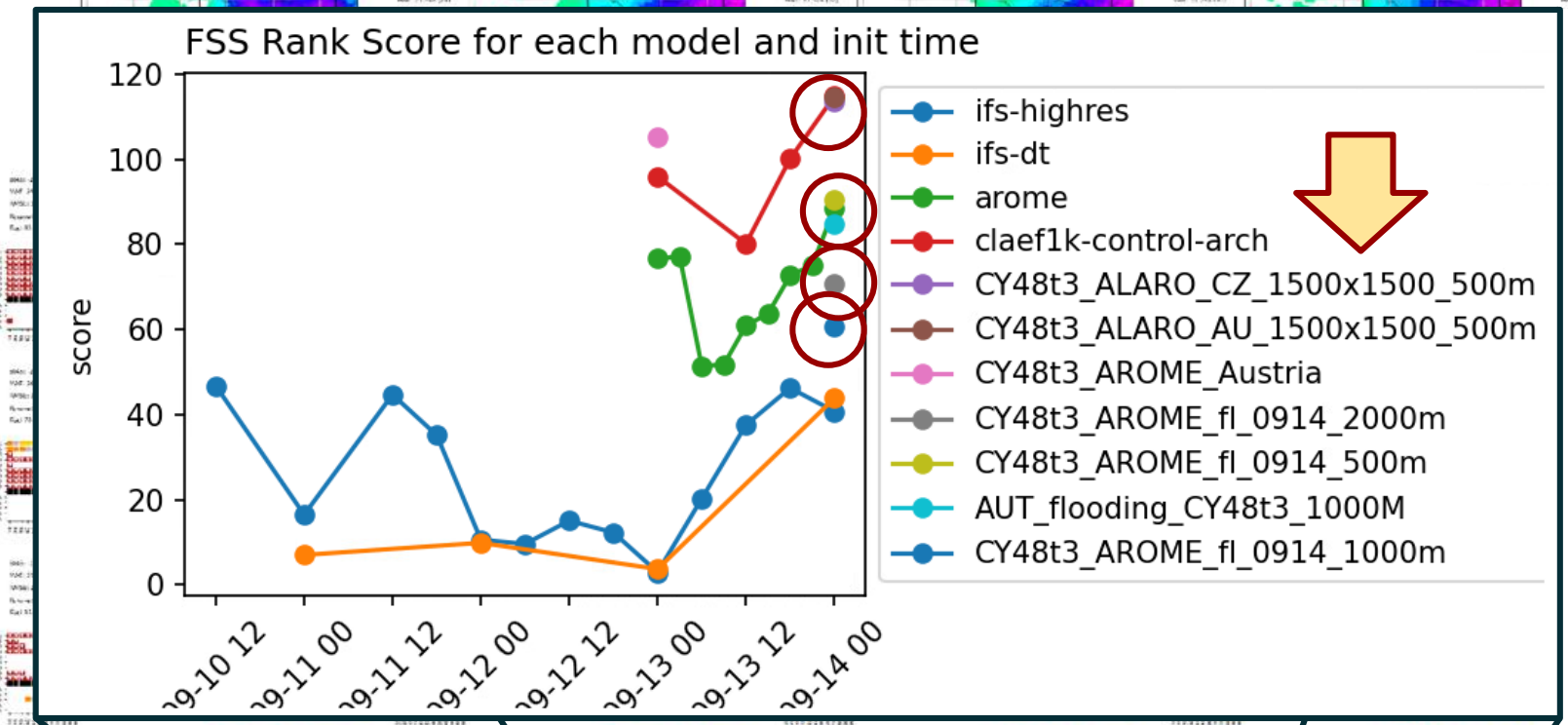
24 hours, ALL available runs: 24 hour accumulated precipitation from 14 Sep 12 UTC to 15 Sep 12 UTC

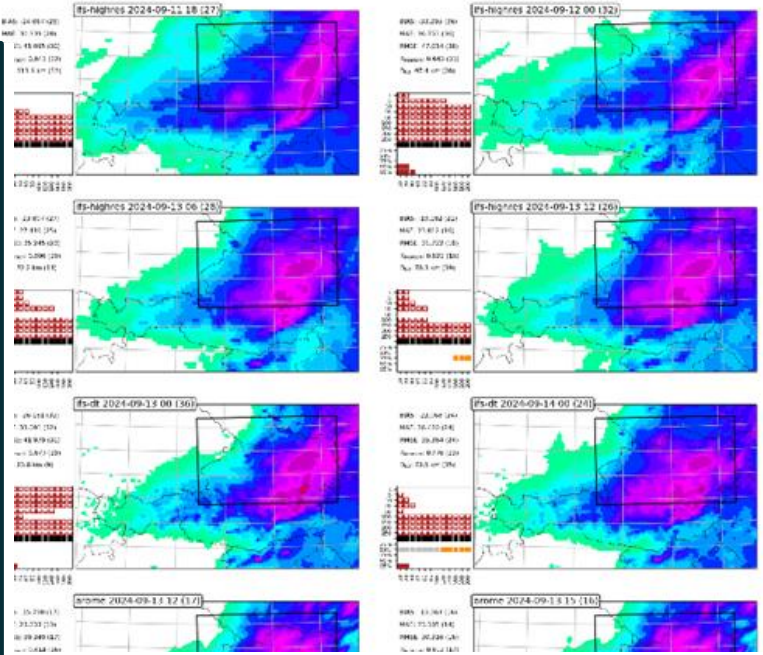


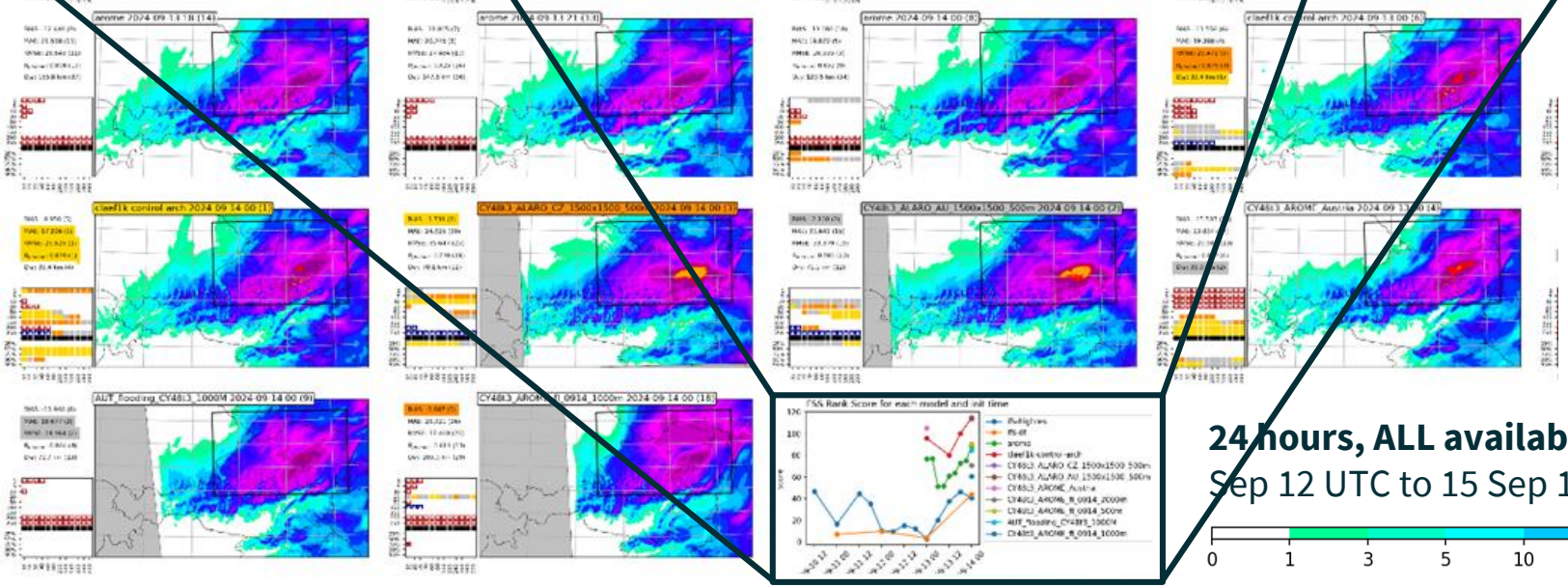
Forecast **volatility increases on shorter scales**, especially HRES. **Global DT seems low**, but the lines are deceiving, it o**utperforms HRES on 2 out of 3 runs**.

Operational L**AMs outperform global models** consistently, **CLAEF1k 1 km ahead of AROME-Aut 2.5** km.







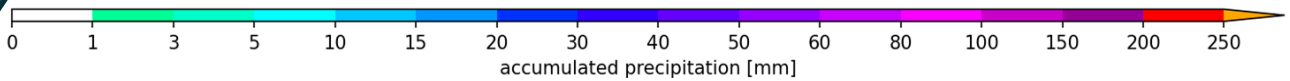


On demand digital twins also show variable performance, for this even there are severe different runs on several domains covering the event.

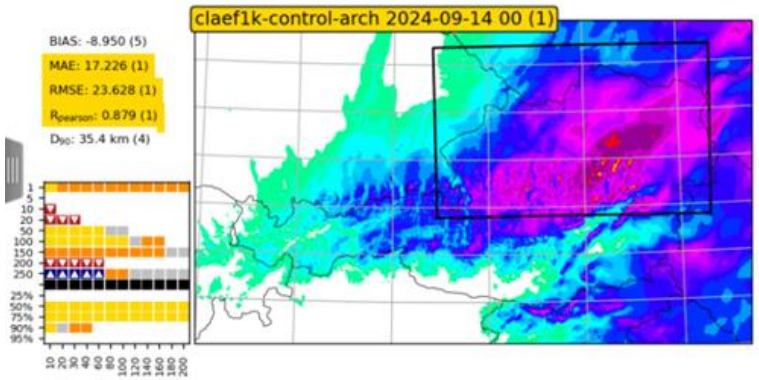
Depending on the verification domain, time window, and precipitation thresholds used for FSS calculation, their ranking changes, but **overall their performance is similar to that of operational LAMs** in this case.

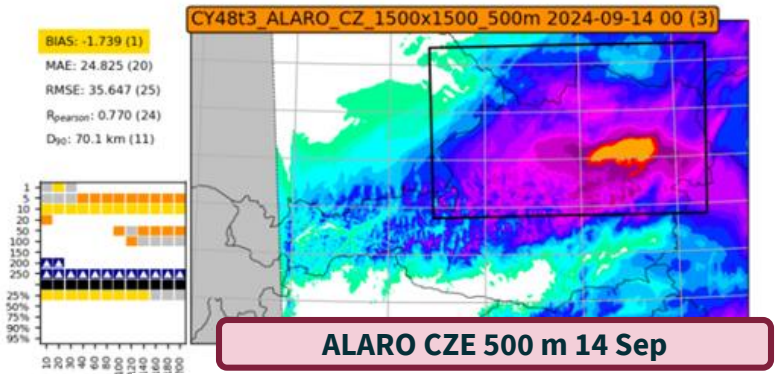
However, their **short forecast range** and **late arrival** means they would have been of limited use.

24 hours, ALL available runs: 24 hour accumulated precipitation from 14 Sep 12 UTC to 15 Sep 12 UTC

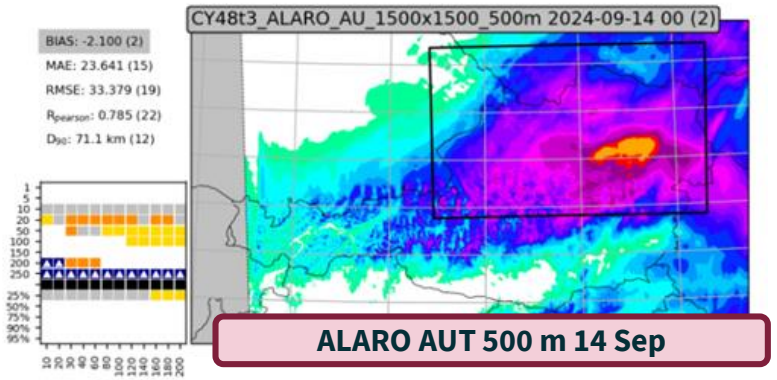


14 Sep 12 UTC 24 h Accumulated Rain – On-Demand DTs

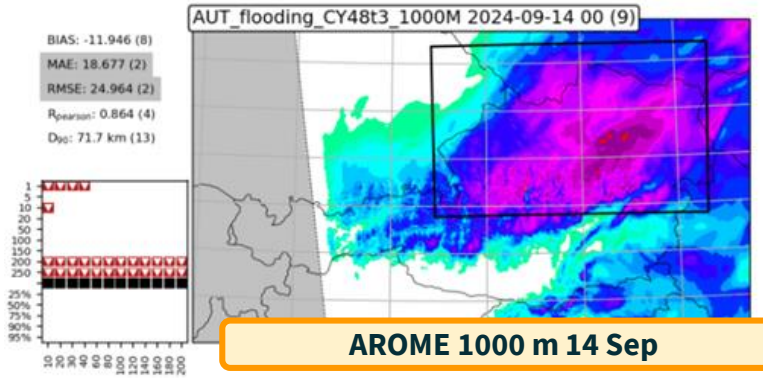




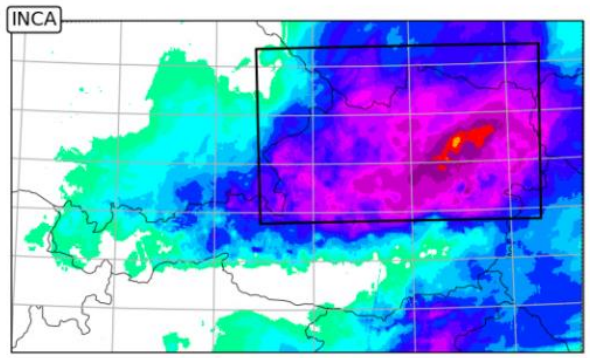
ALARO CZE 500 m 14 Sep

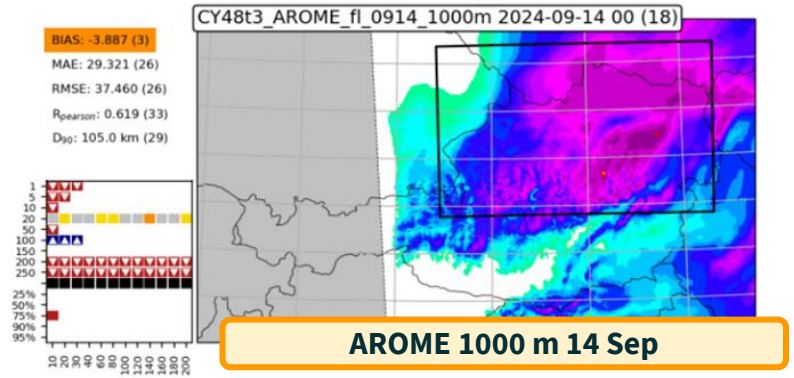


ALARO AUT 500 m 14 Sep

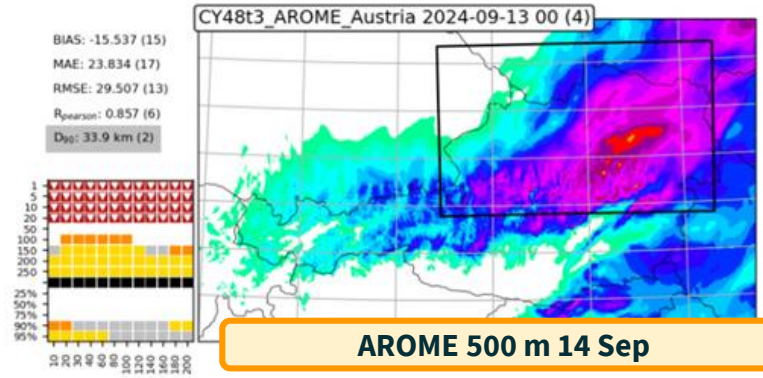


AROME 1000 m 14 Sep

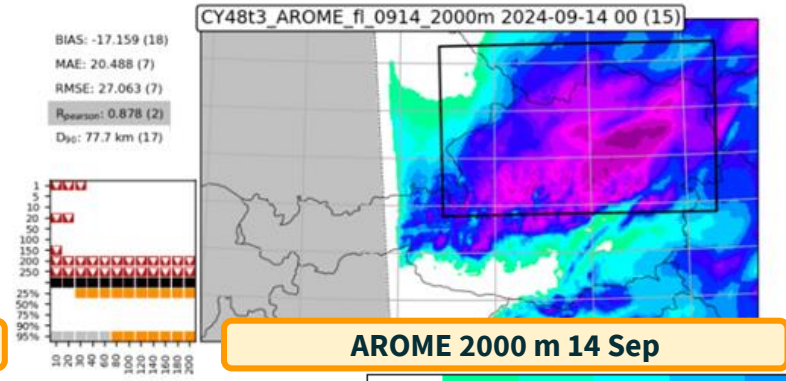




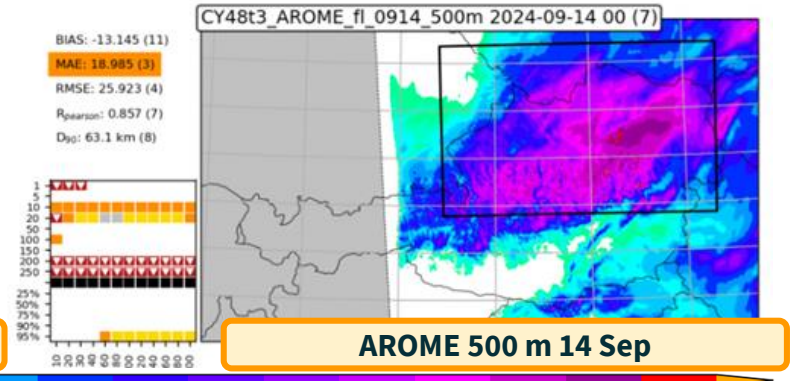
AROME 1000 m 14 Sep



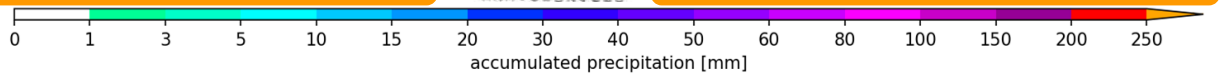
AROME 500 m 14 Sep



AROME 2000 m 14 Sep



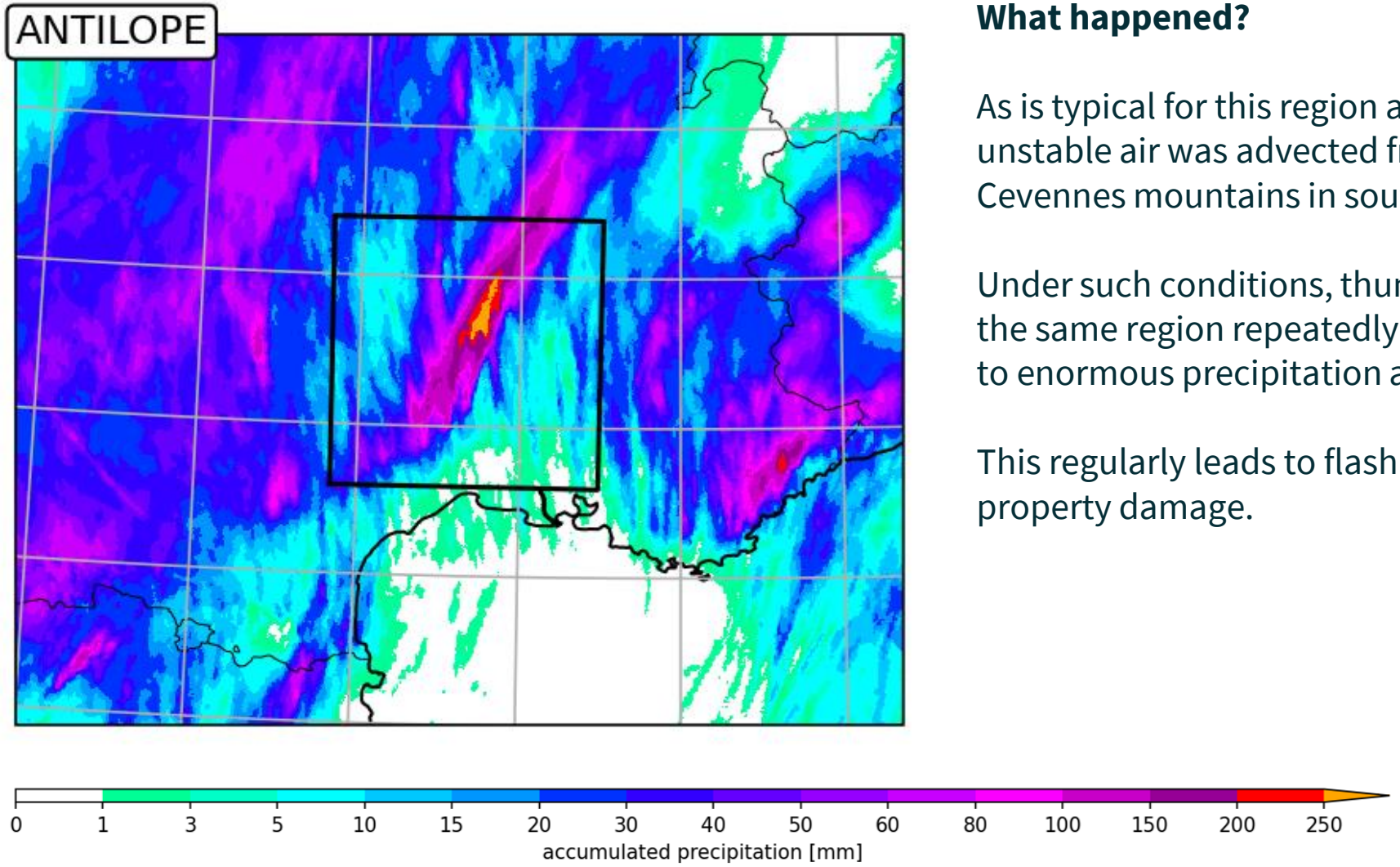
AROME 500 m 14 Sep



Verification of the October 17 Cevenol HPE

GeoSphere Austria

24 h acc. precip. for 17 Oct 2024



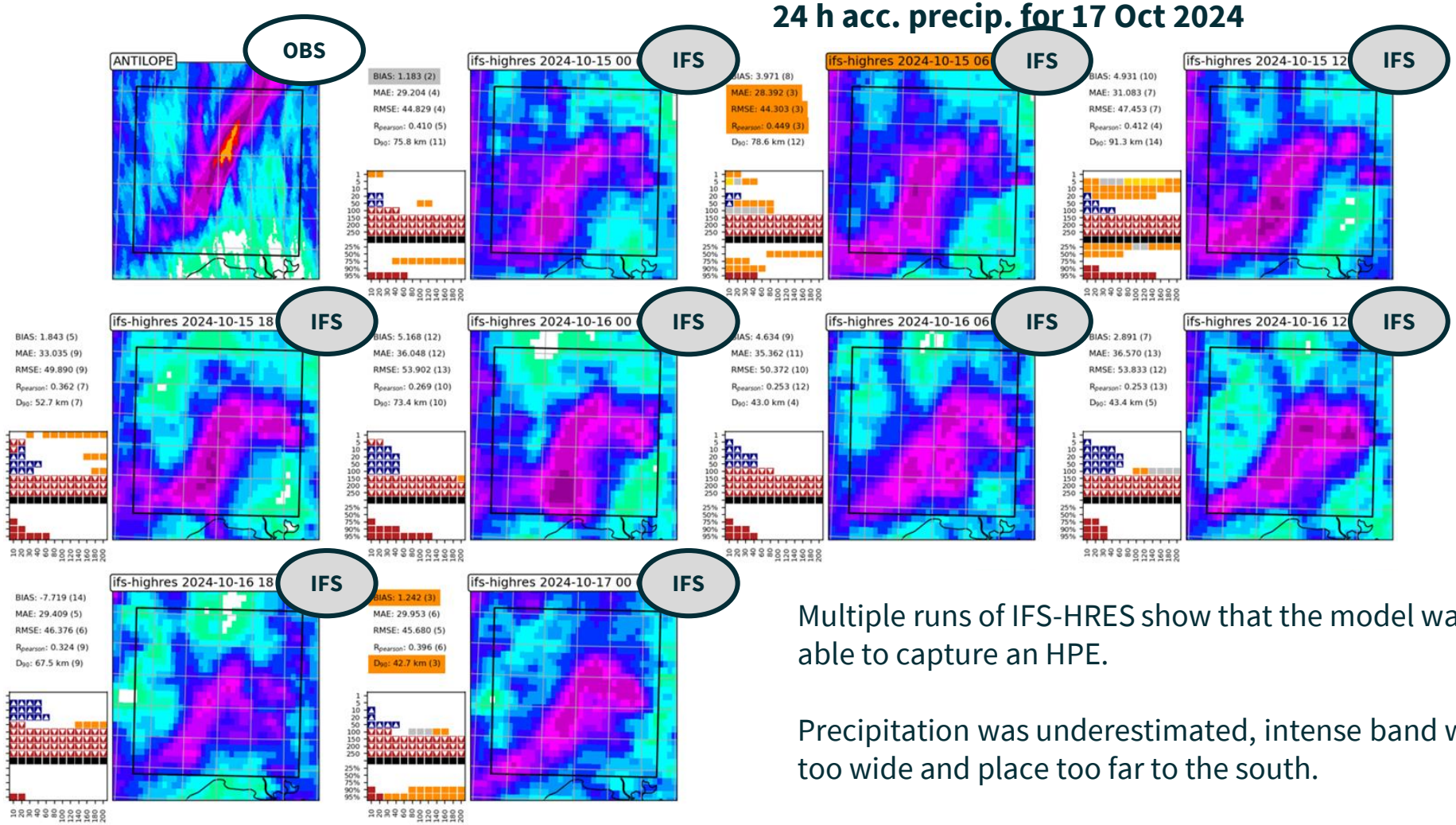
What happened?

As is typical for this region and time of year, moist unstable air was advected from the south toward the Cevennes mountains in southern France.

Under such conditions, thunderstorms can form over the same region repeatedly over many hours, leading to enormous precipitation accumulations.

This regularly leads to flash floods, injuries, death, and property damage.

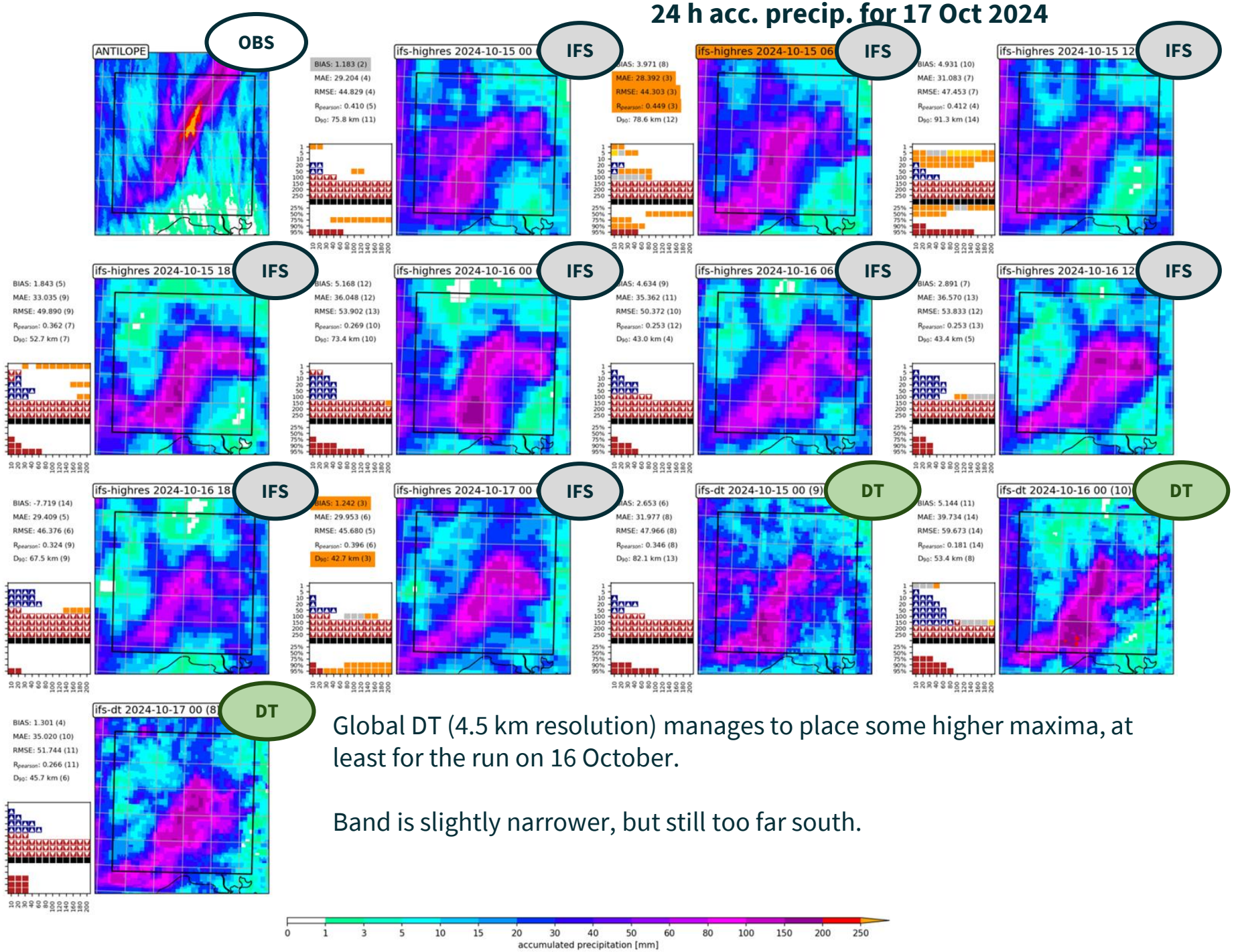
24 h acc. precip. for 17 Oct 2024



Multiple runs of IFS-HRES show that the model was able to capture an HPE.

Precipitation was underestimated, intense band was too wide and place too far to the south.

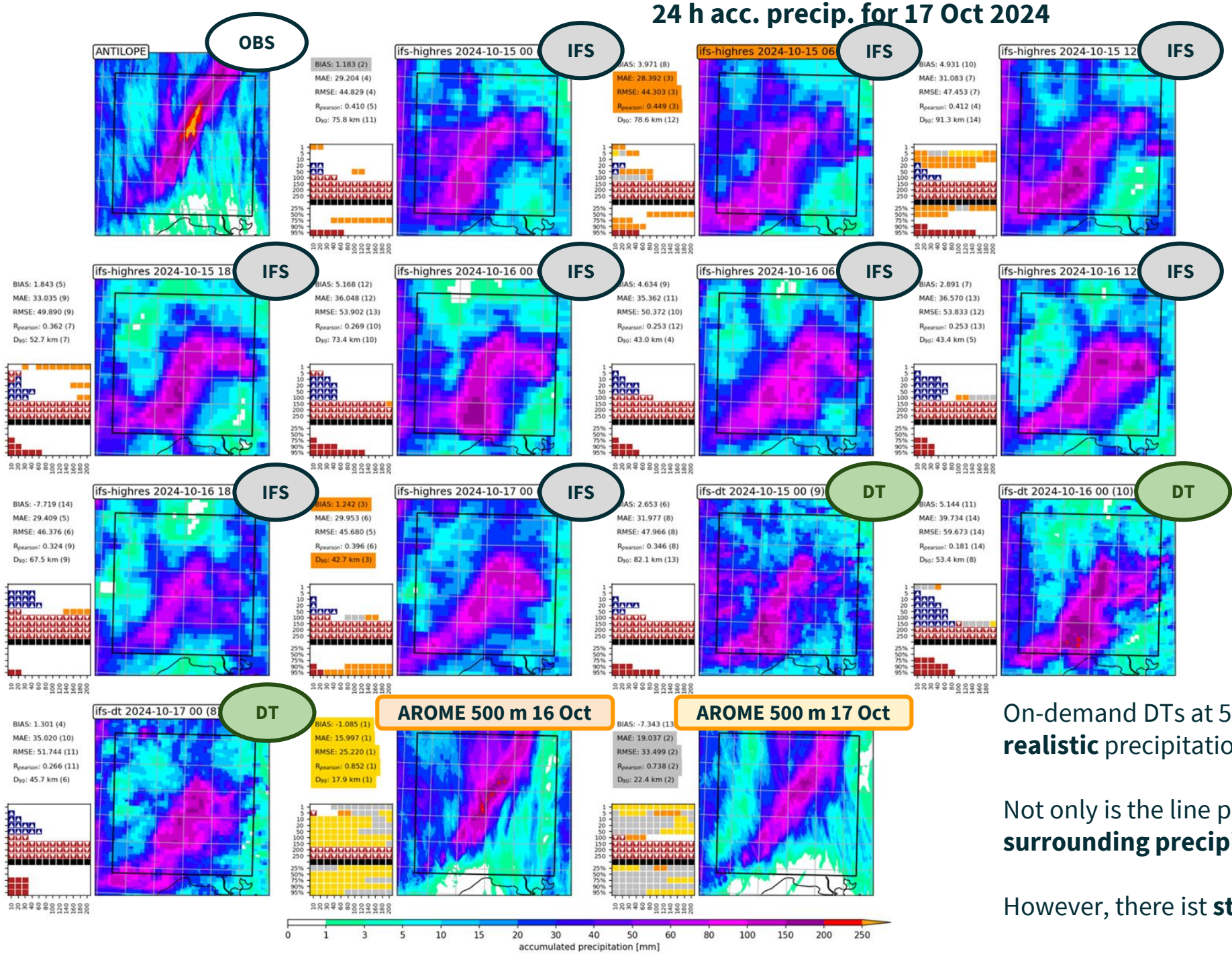
24 h acc. precip. for 17 Oct 2024



Global DT (4.5 km resolution) manages to place some higher maxima, at least for the run on 16 October.

Band is slightly narrower, but still too far south.

24 h acc. precip. for 17 Oct 2024



On-demand DTs at 500 m are able to predict a **much more realistic** precipitation field.

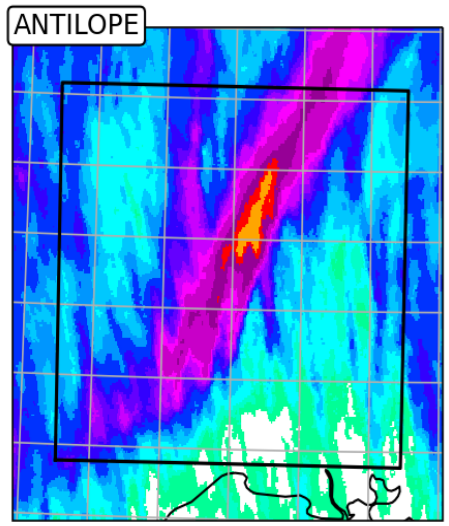
Not only is the line placed well, it also greatly improves the **surrounding precipitation** structure.

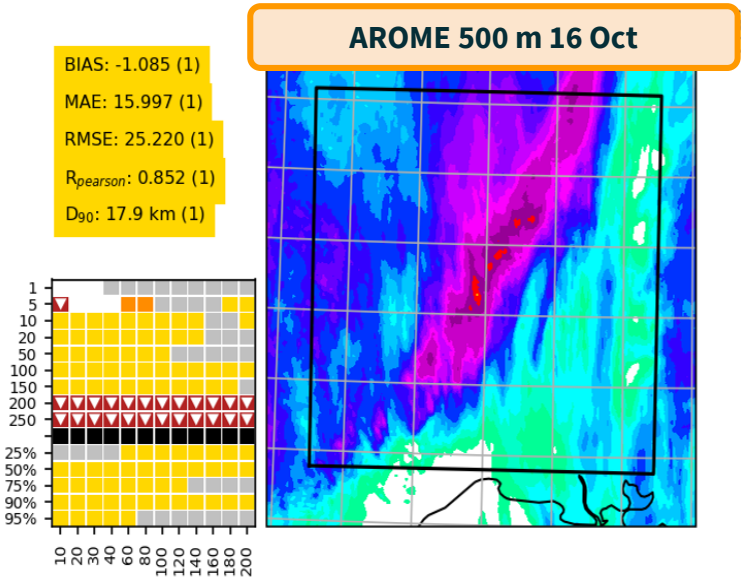
However, there ist **still underestimation**.

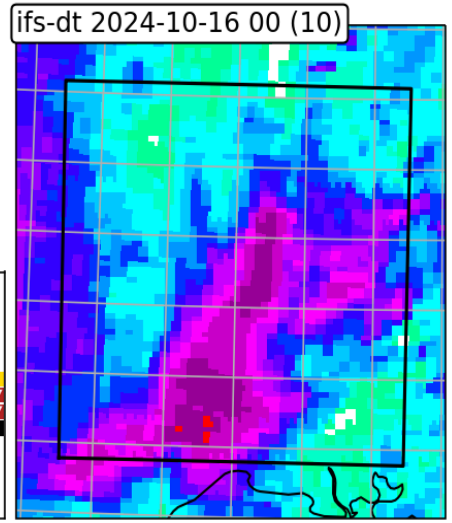
24 h Acc. Precip. for 17 Oct 2024 – Best of Each Model

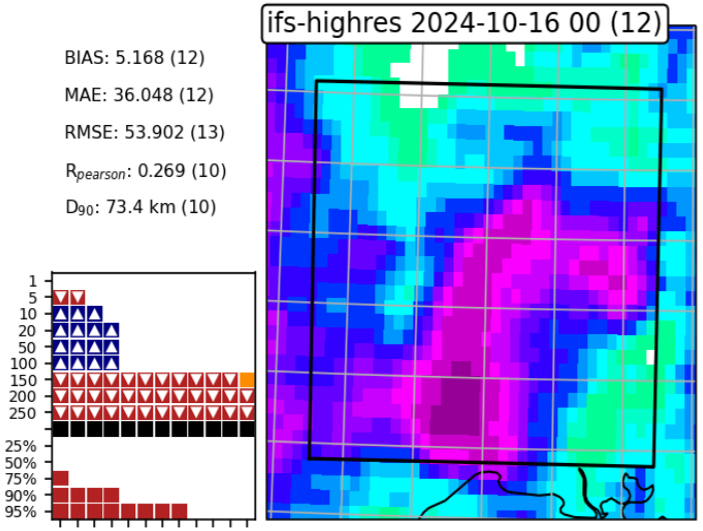
GeoSphere Austria

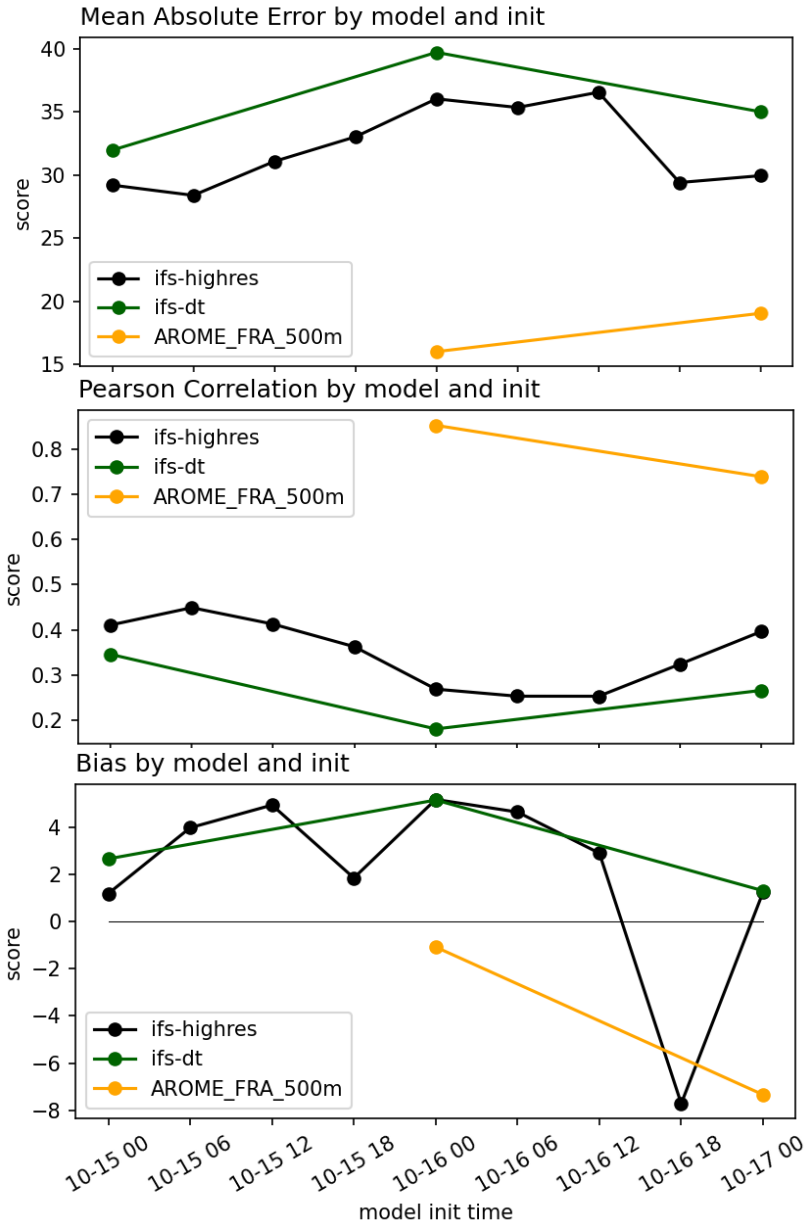
24 h acc. precip. for 17 Oct 2024







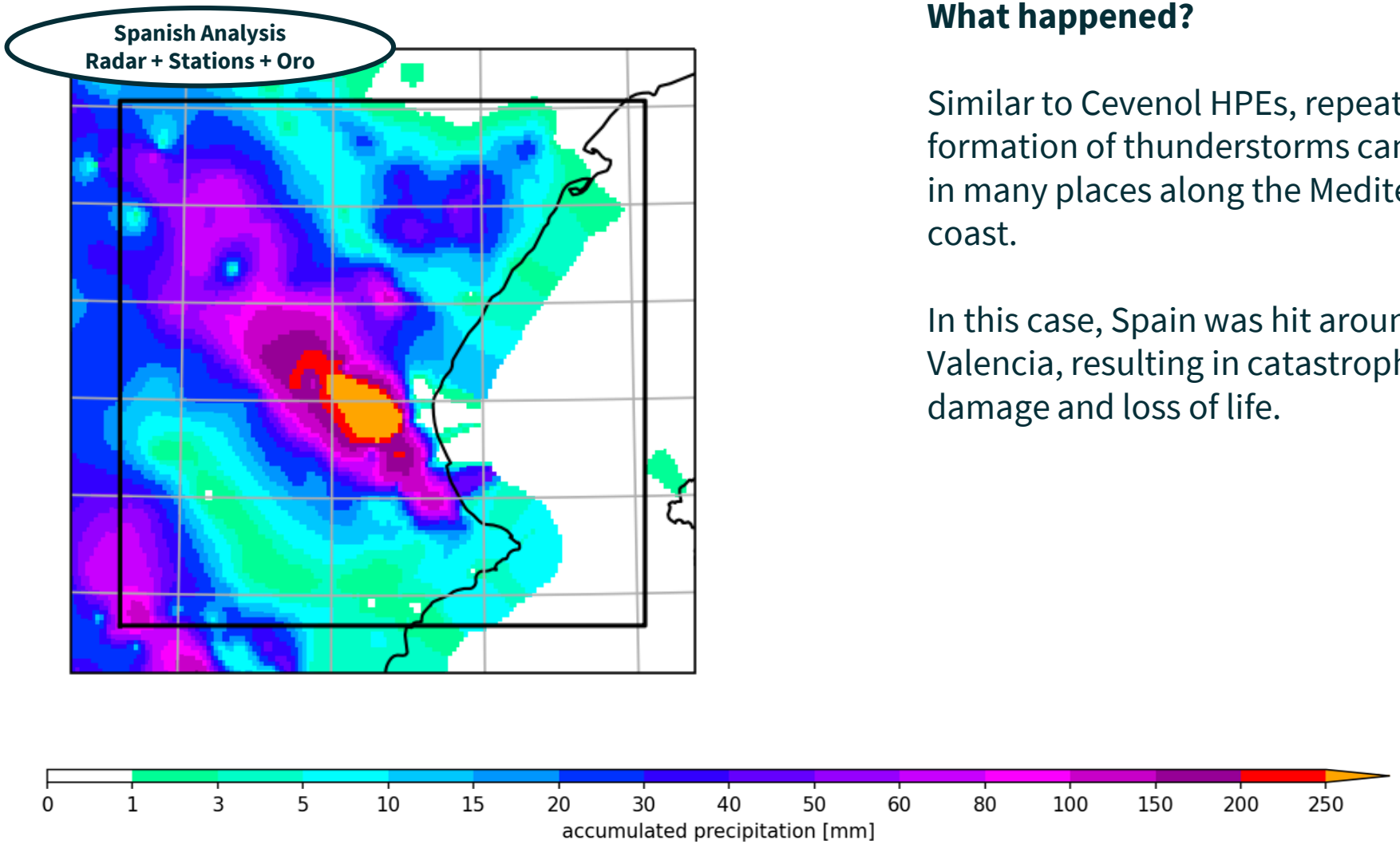




Verification of the October 29 Valencia HPE

GeoSphere Austria

24 h acc. precip. for 17 Oct 2024

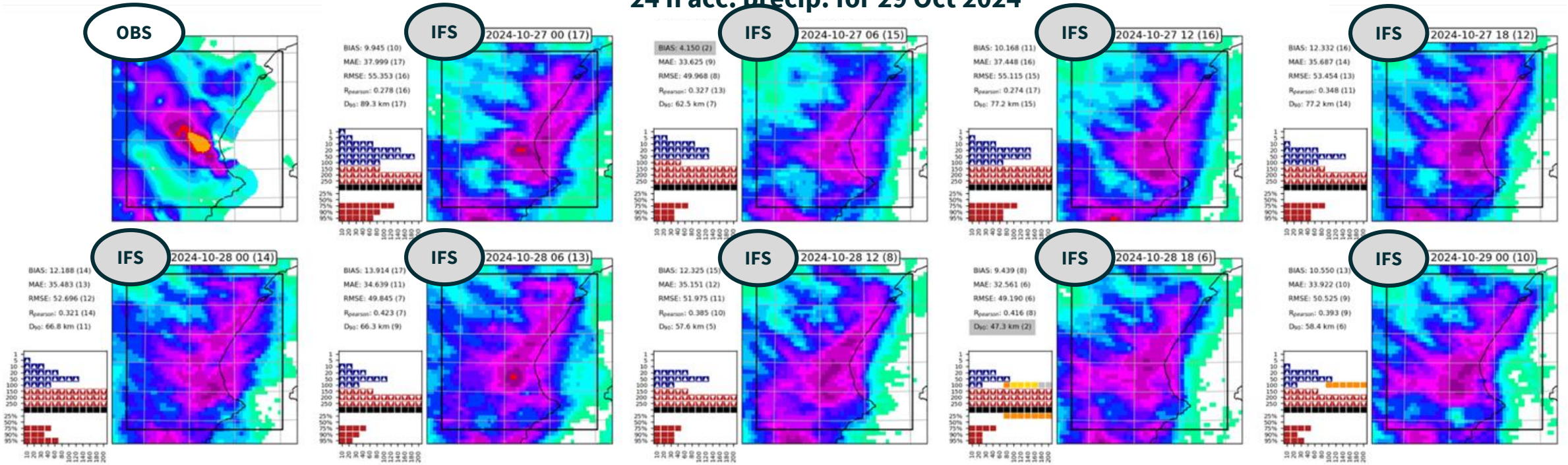


What happened?

Similar to Cevenol HPEs, repeated formation of thunderstorms can happen in many places along the Mediterranean coast.

In this case, Spain was hit around Valencia, resulting in catastrophic damage and loss of life.

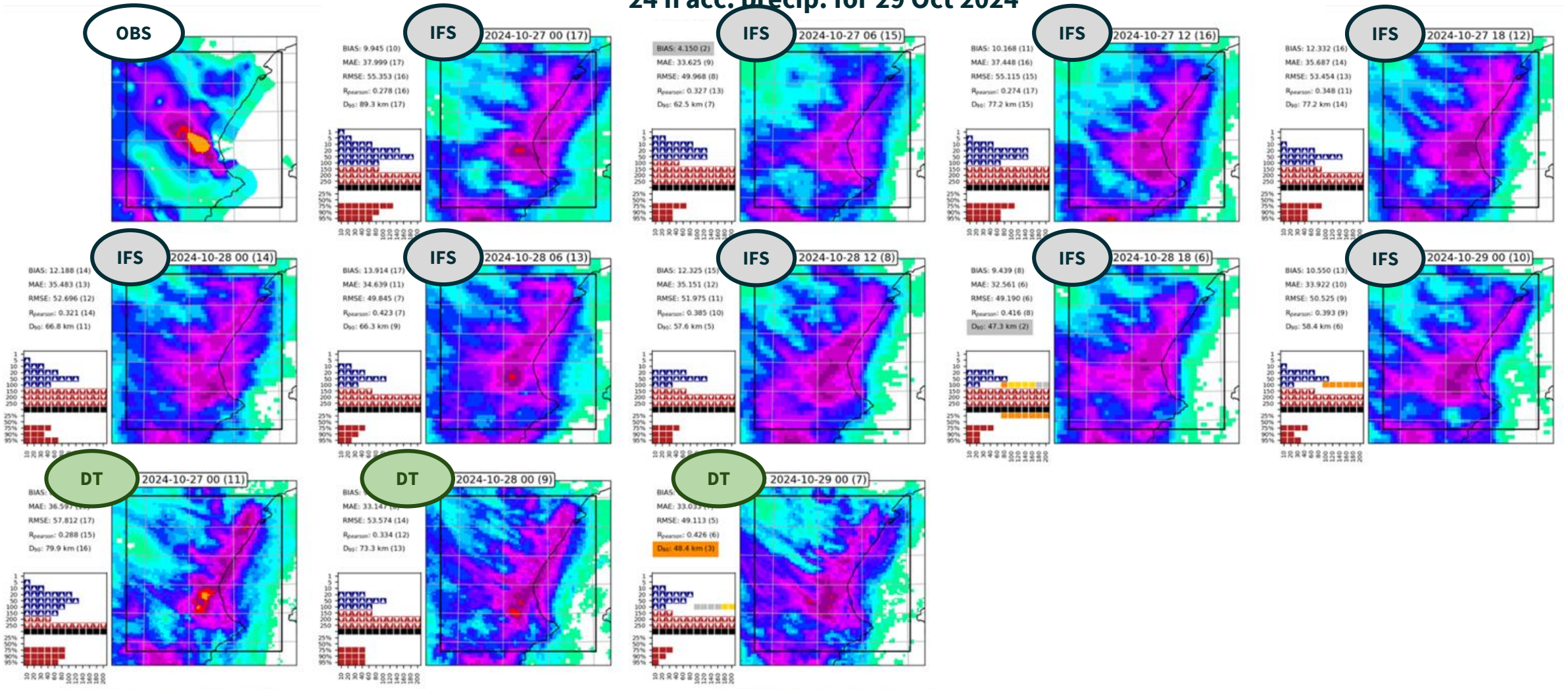
24 h acc. precip. for 29 Oct 2024



IFS-HRES has similar problems as with the Cevenol HPE, the precipitation **maximum is too low** and the field **too widespread**. Too much rain is predicted along the coast rather than inland.

No run predicts 200 mm or more.

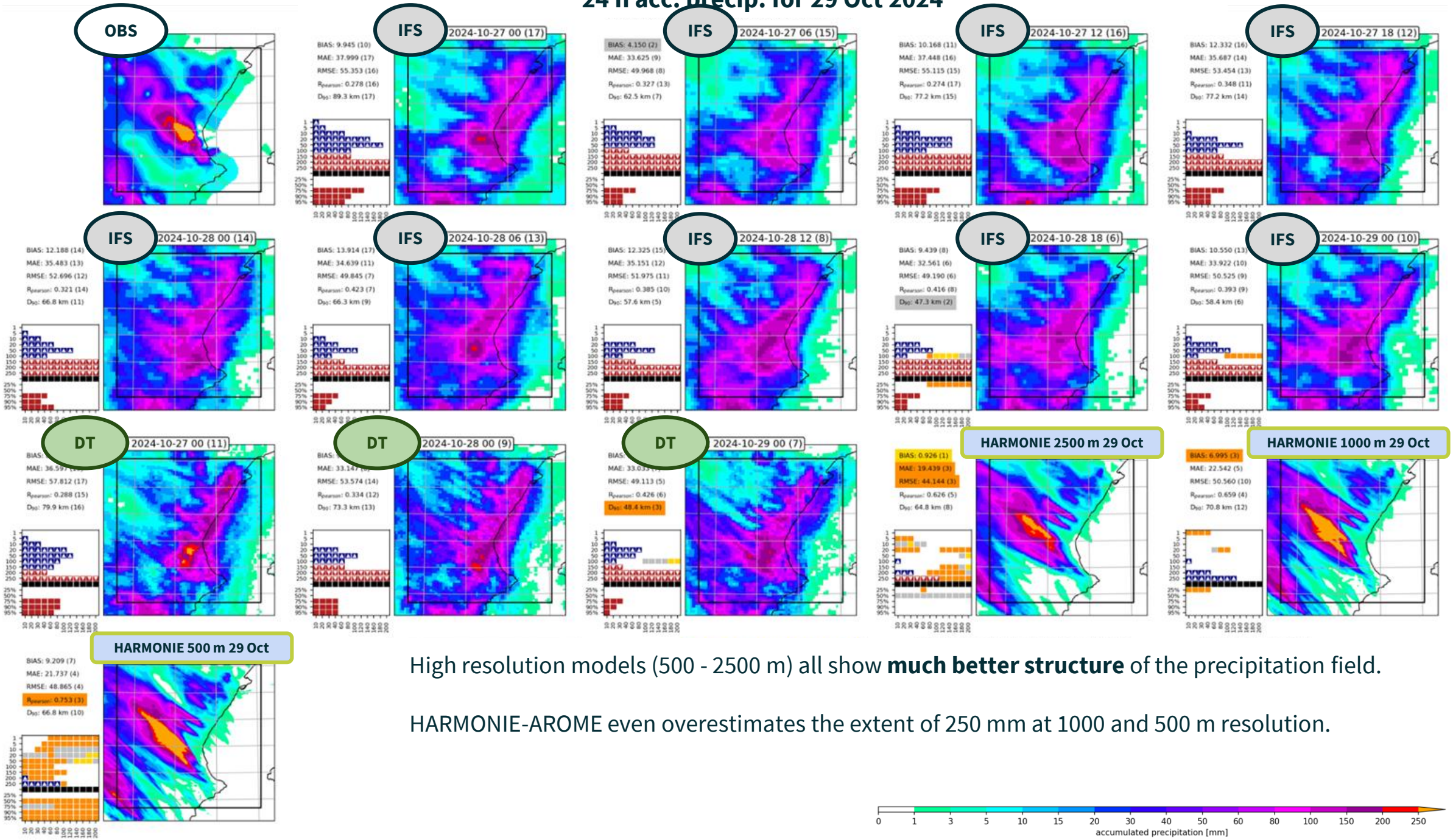
24 h acc. precip. for 29 Oct 2024



Global DT (4.5 km resolution) shows **higher maxima, up to > 250 mm**, albeit on a **too small** region.

It also places too much precipitation along the coast

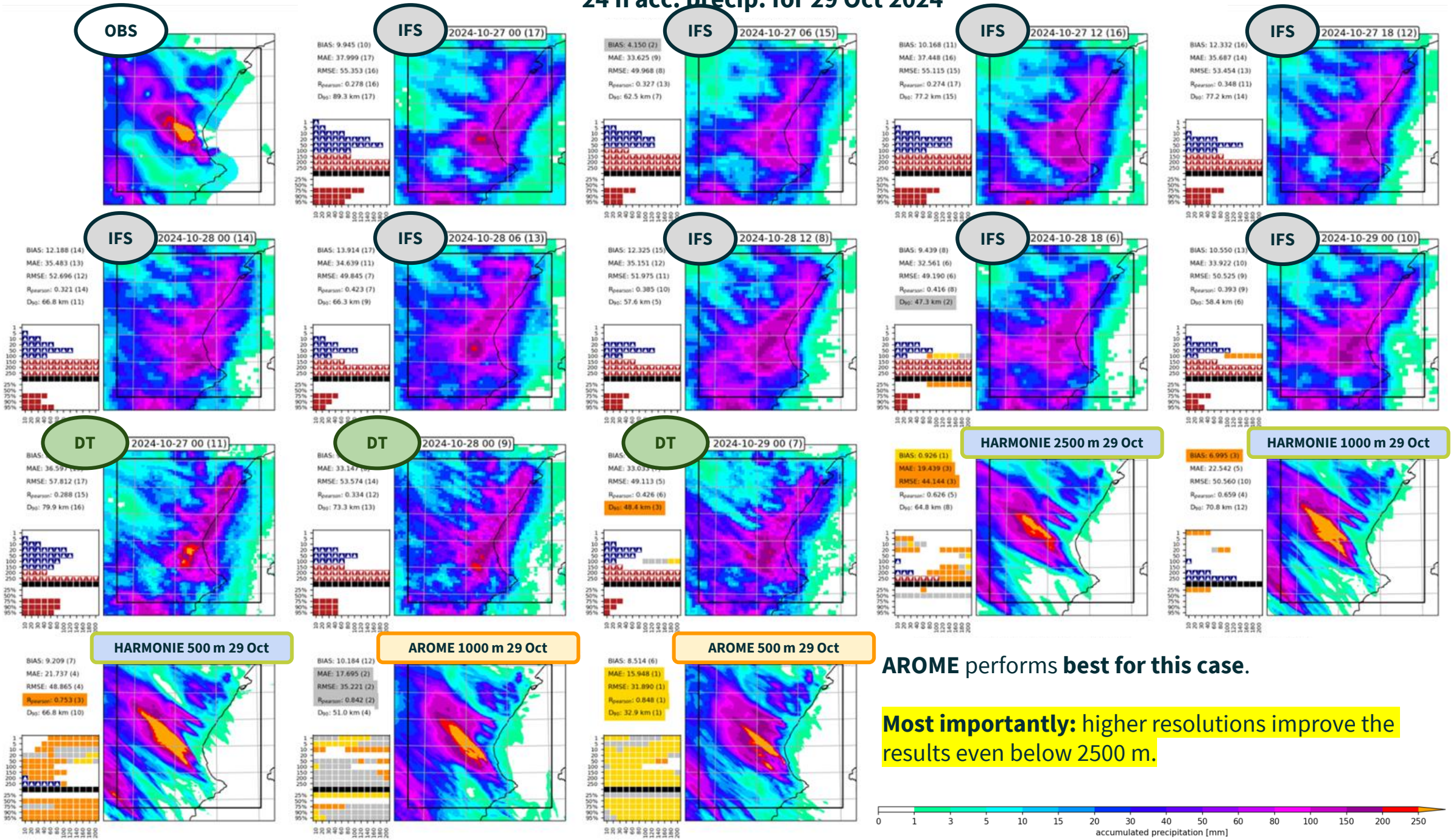
24 h acc. precip. for 29 Oct 2024



High resolution models (500 - 2500 m) all show **much better structure** of the precipitation field.

HARMONIE-AROME even overestimates the extent of 250 mm at 1000 and 500 m resolution.

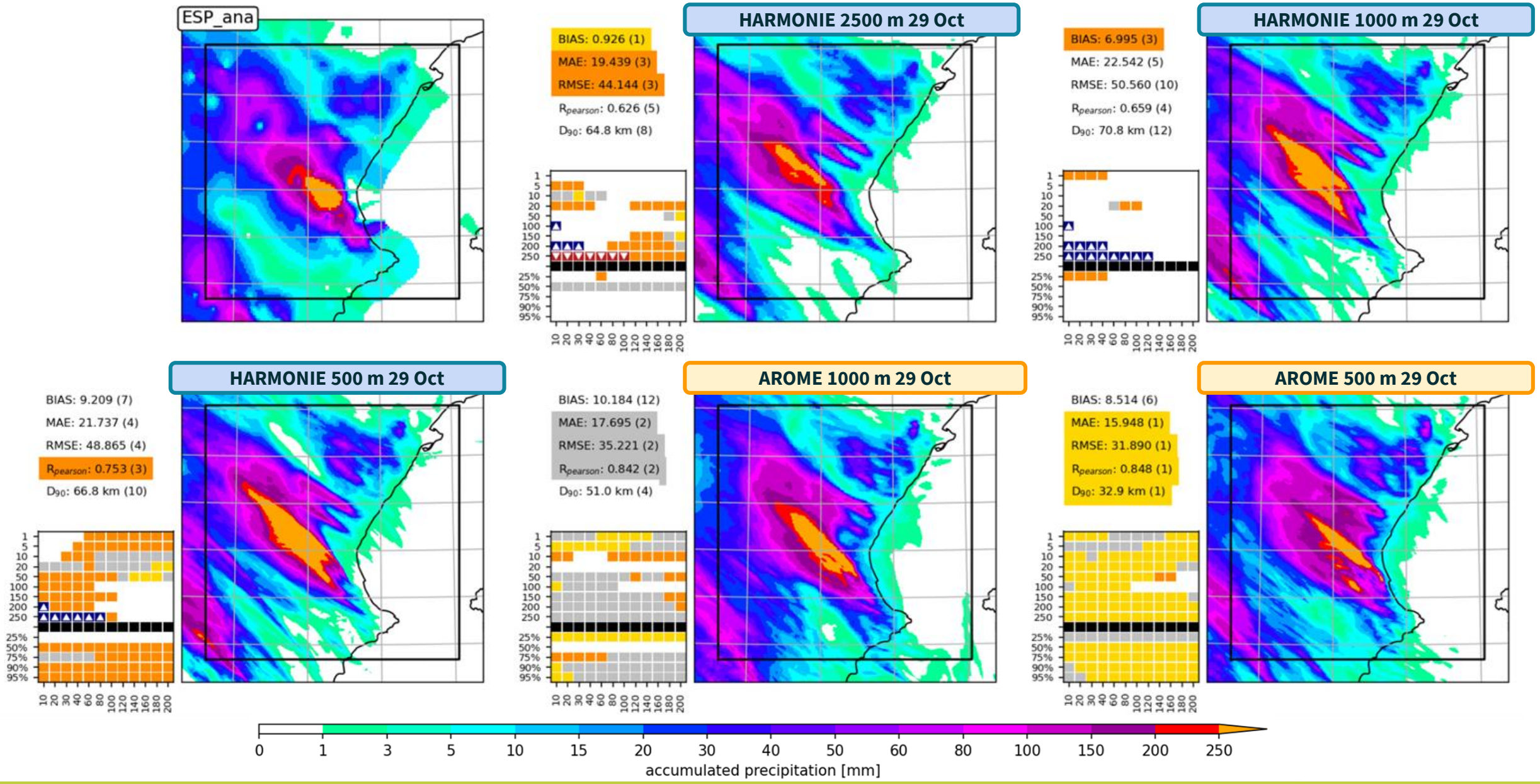
24 h acc. precip. for 29 Oct 2024



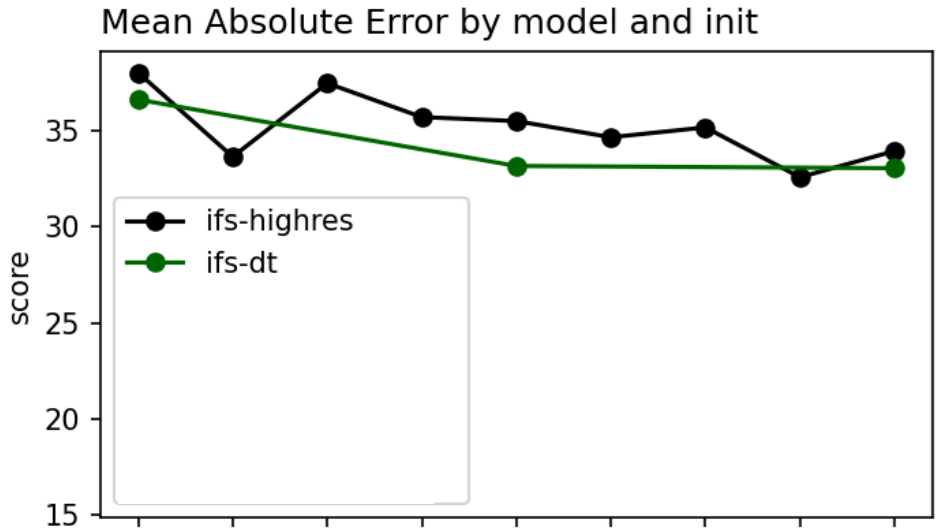
AROME performs **best for this case**.

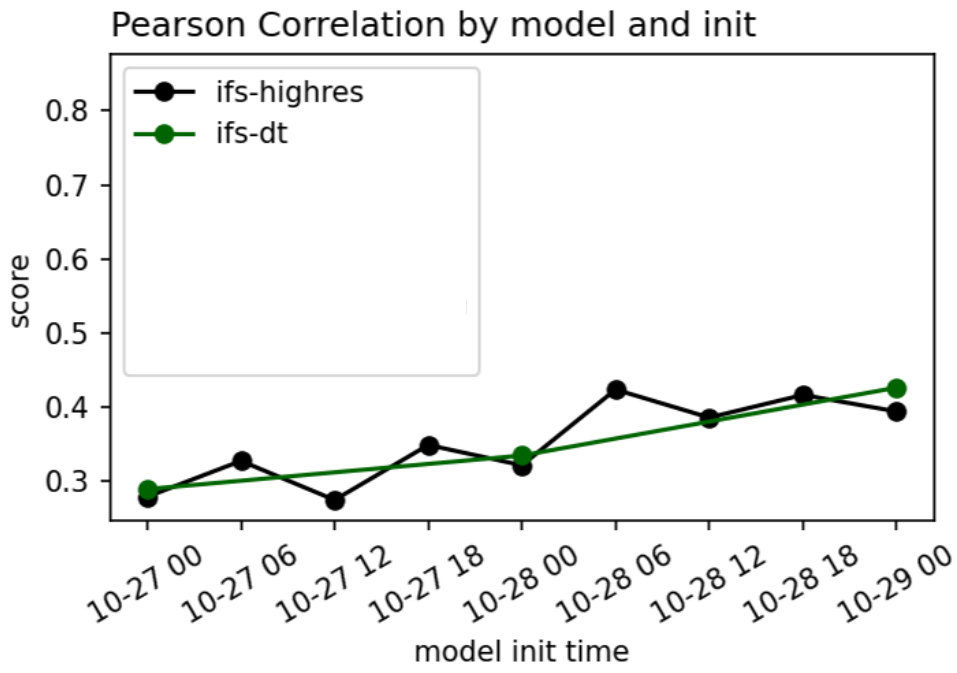
Most importantly: higher resolutions improve the results even below 2500 m.

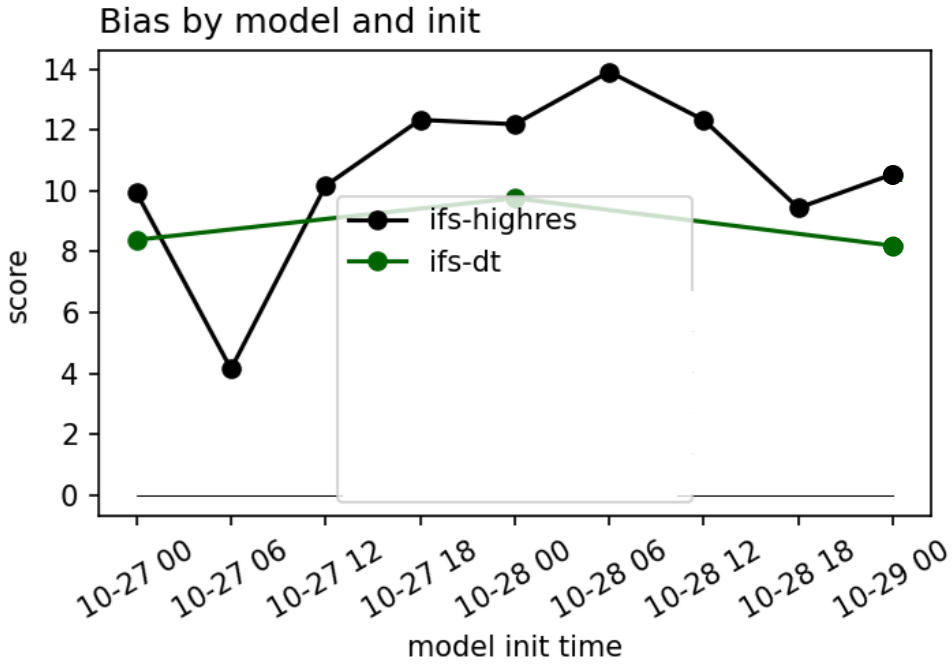
24 h Acc. Precip. for 29 Oct 2024 – On-Demand DTs



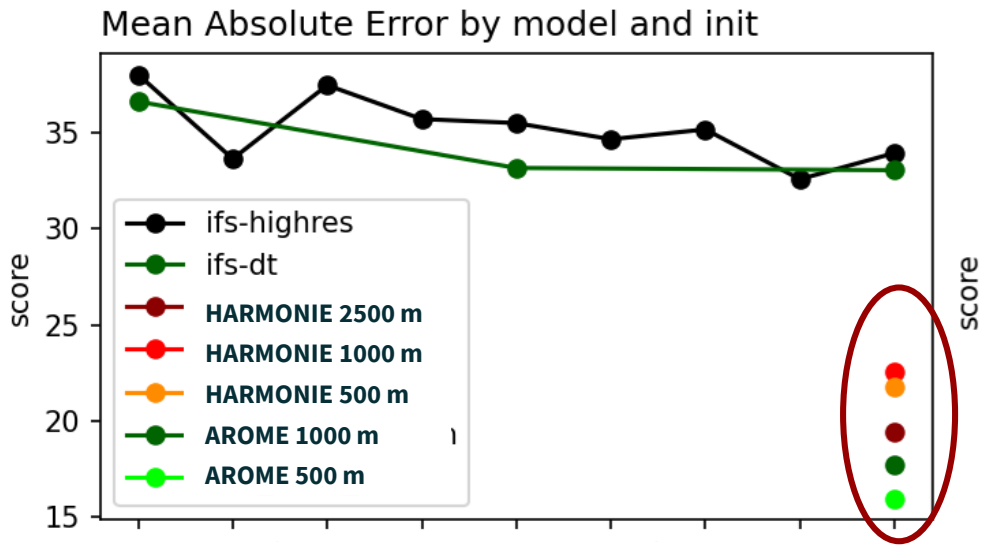
24 h Acc. Precip. for 29 Oct 2024 – Classical Scores

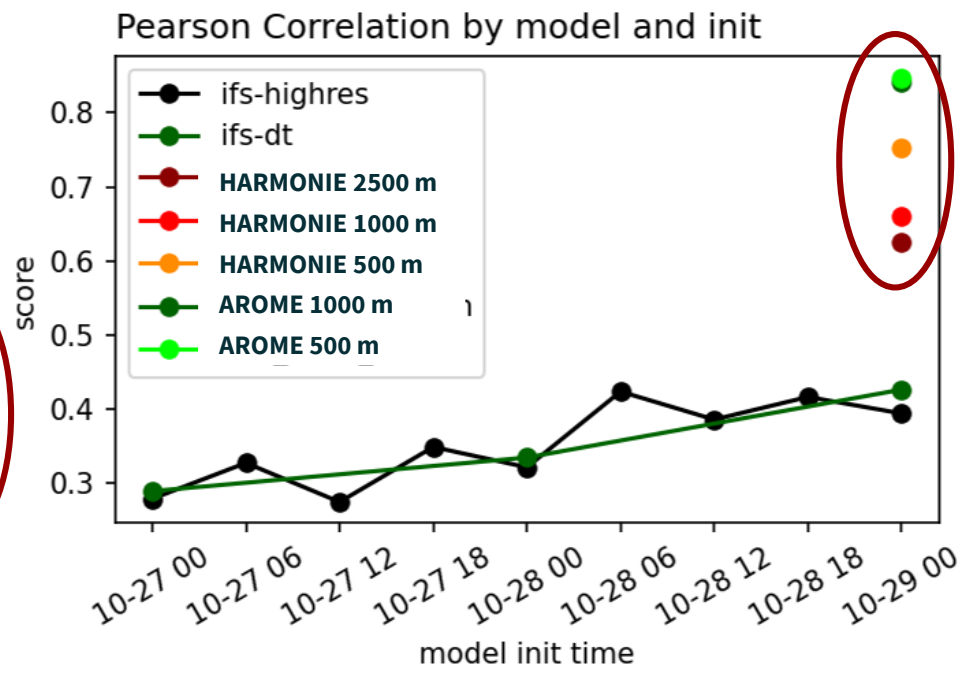


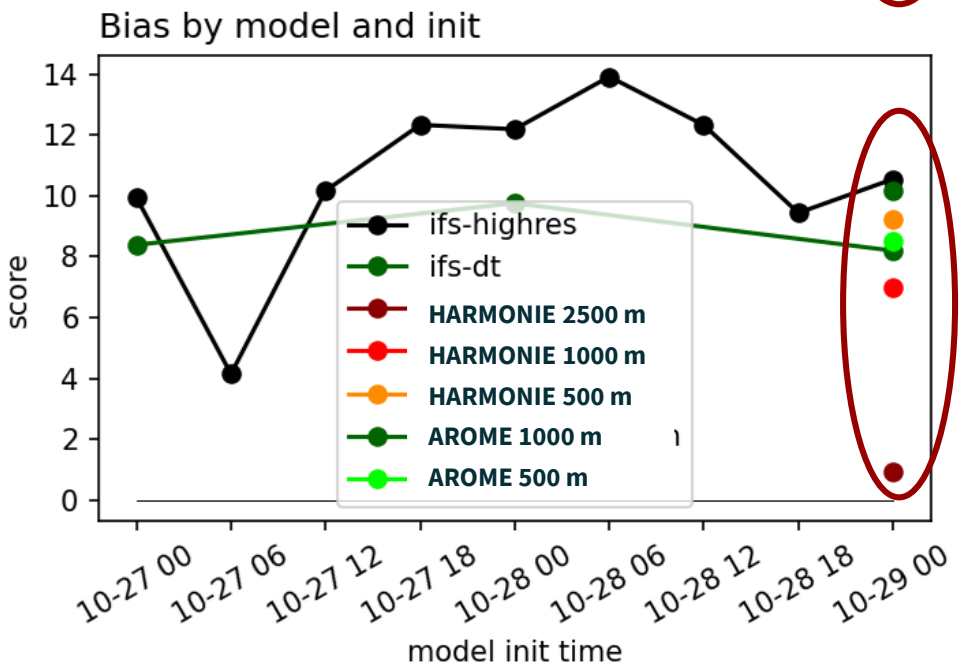




24 h Acc. Precip. for 29 Oct 2024 – Classical Scores







Conclusions and Outlook

The three extreme events how that **On-Demand DTs can capture high precipitation much better than the global models**, even with pure downscaling.

Comparison with national LAMs shows **performance at a similar level.**

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What's next?

Regular spatial verification for regions and times when observations are available, with **an emphasis on national analyses**, like INCA in Austria, ANTILOPE in France, etc., and OPERA as a backup

The plan is to **implement Panelification within a Deode-Workflow plugin** and automatically verify any flooding and convection cases, and then present the results alongside the HARP visualization.