
Flash flood event in Western Germany

(Ahr valley -- 14/15th July 2021)

Precipitation forecasts of ICON model suite

WG5 parallel session – COSMO GM 2021

Christoph Gebhardt, Michael Baldauf, Klaus Stephan, Axel Seifert, Michael Hoff

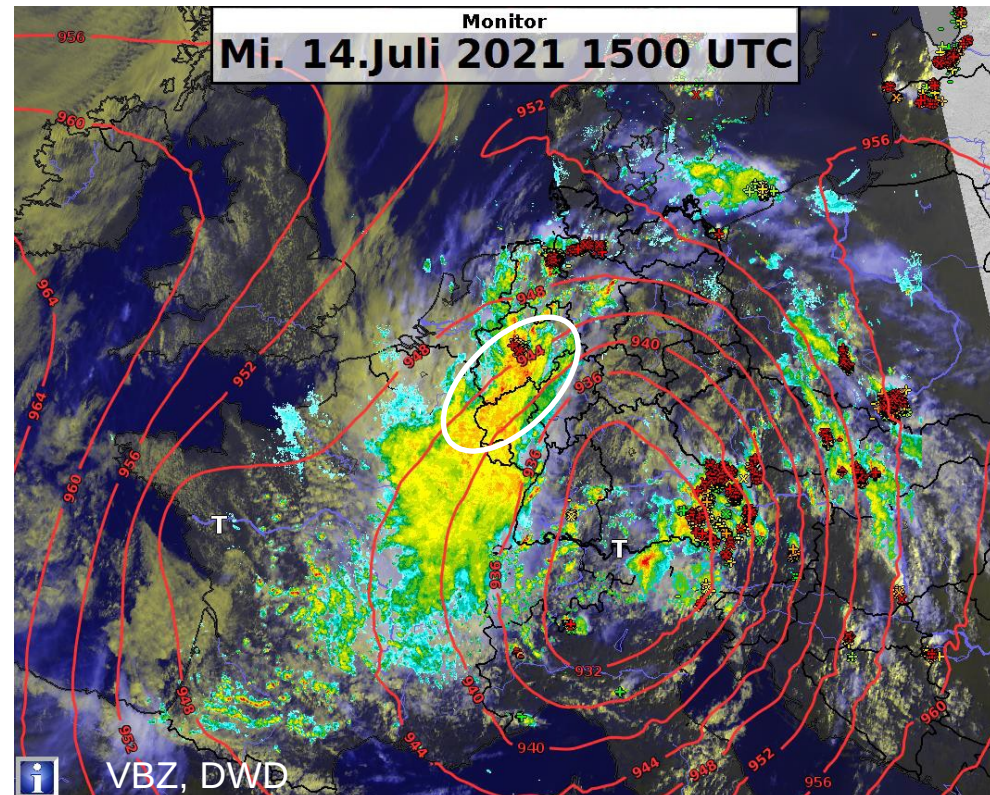
Deutscher Wetterdienst, DWD



Outline

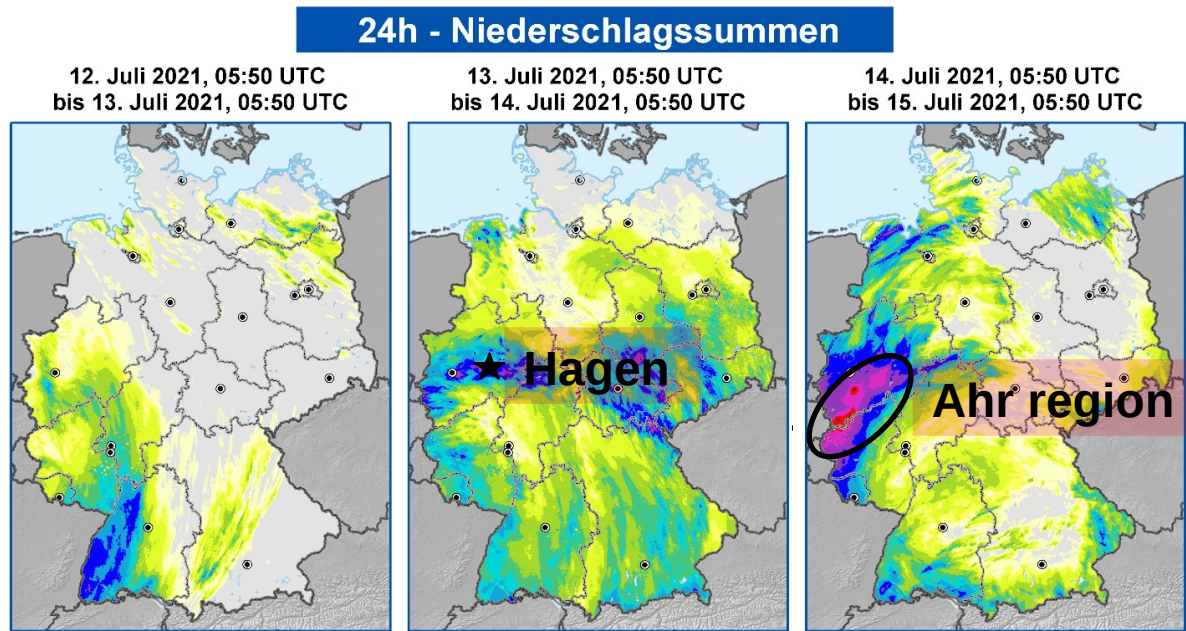
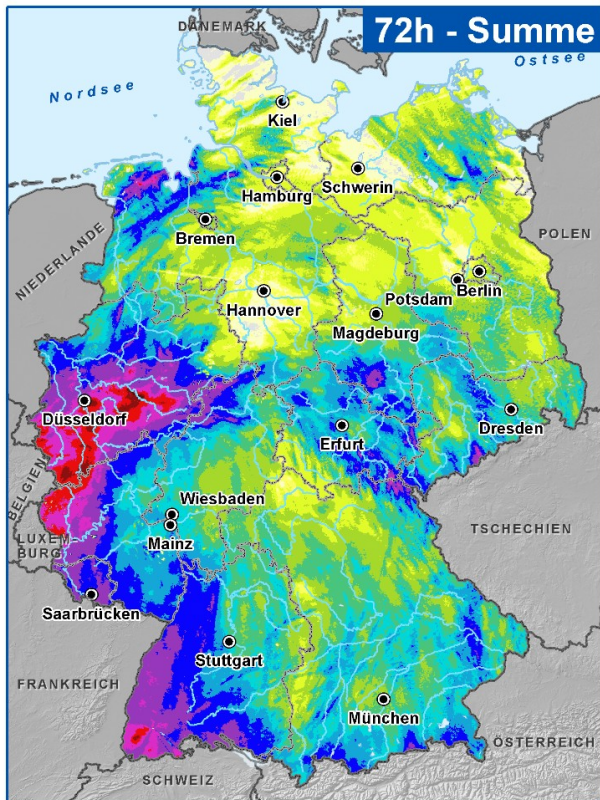
- broad overview of the precipitation event and impacts
- What happened in and around the Ahr valley?
- forecasts of ICON-EU and global models
- forecasts of ICON-D2 and ICON-D2-EPS
- assimilated radar data and ICON-D2 (preliminary assessment)
- verification of precipitation for ICON-D2 (general characteristics)

- cut-off low over Western Europe
- slowly moving (north)-eastwards
- coincidence of *upper-level trough* and *low-level convergence* favourable for an *uplift of very moist air*
- *continuous* and *embedded heavy rainfall* in different regions following the 12th of July 2021



precipitation (radar) 12th July 05:50 UTC to 15th July 05:50 UTC

Tief **Bernd** über Deutschland,
Summe des Niederschlags aus Radar: 12. Juli, 05:50 UTC - 15. Juli 2021, 05:50 UTC



Niederschlagssumme [mm]



Junghänel et al.

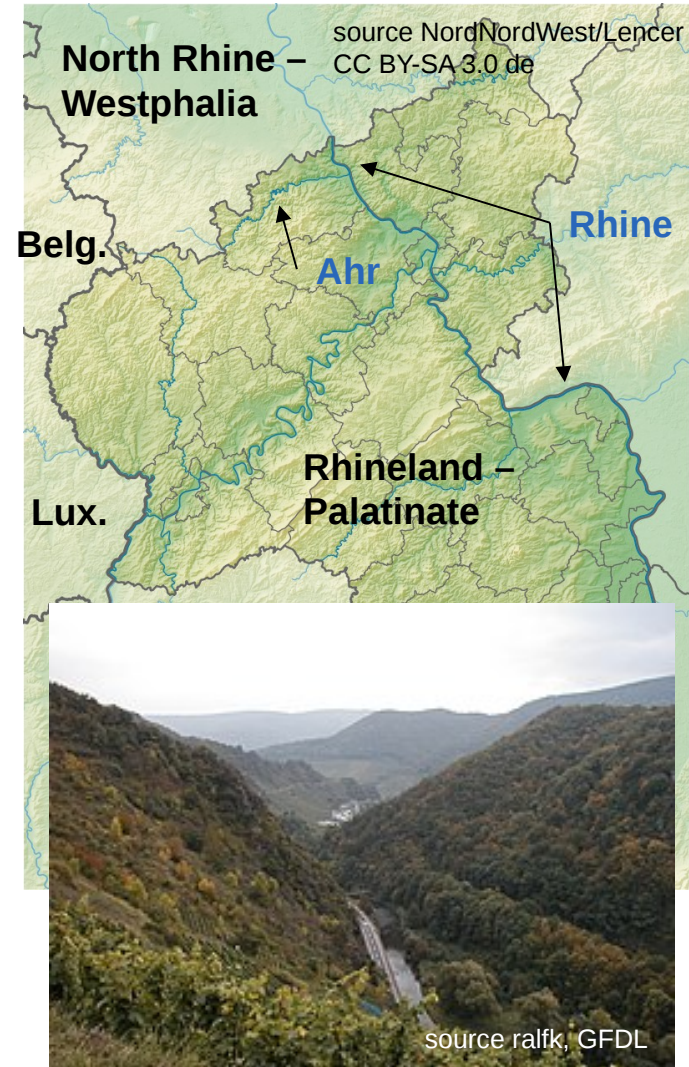
Klimadaten und Darstellung: © Deutscher Wetterdienst 2021 (Stand: 15.07.2021); Geodaten: © GeoBasis-DE/BKG 2020 (Stand: 01.01.2020).

- 13th of July
 - high precipitation sums in mid and western Germany
 - Ruhr area, cities of Hagen and Wuppertal with up to 66 mm within 1 hour and 240 mm within 22 hours
- 14th of July
 - most severe precipitation in Western Germany, Belgium, Luxemburg, Netherlands, France
 - flooding/flash floods (small rivers, Maas)
 - casualties: 180 (Germany), 41 (Belgium)
 - destroyed houses, bridges, roads, rail tracks
 - destroyed communication infrastructure
 - destroyed water and electricity supply
 - contaminated drinking water

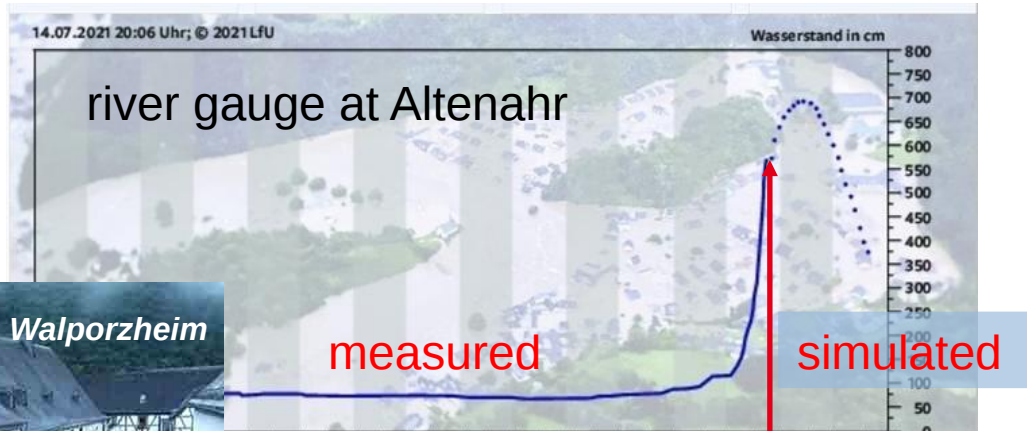


Impact in the Ahr-Valley

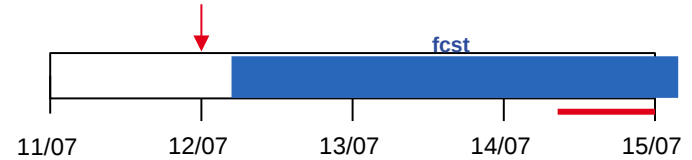
- the Ahr is a comparably small river with 85 km length and a drainage area of 897 km²
- narrow valley with steep slopes
- most intense precip started on 14th and lasted until the early morning of 15th July
- locally up to 147 mm in 24 hours (radar est.) (average of 94 mm in the drainage area)
- 130 casualties
- ca. 3000 buildings damaged (ca. 450 destroyed)
- 62 destroyed bridges (incl. all bridges for trains)
- destroyed streets (75km) and rail tracks (20km)
- estimation of damage: €500 -1300 mio (overall ca. € 25 billions in Germany)



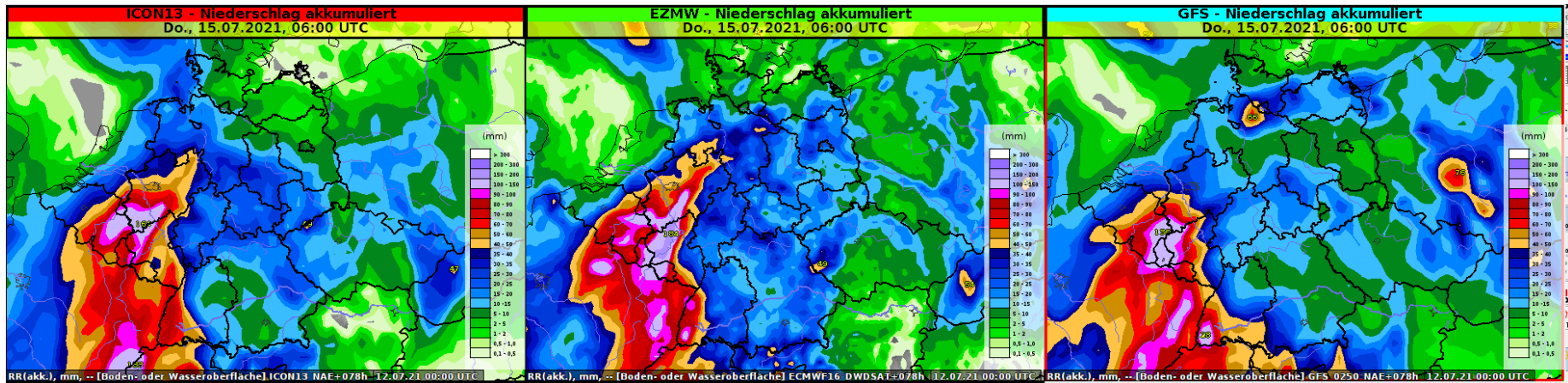
Impact in the Ahr-Valley *Village Schuld*



forecasts of global models



accumulated precipitation for 72 hours 12th 06UTC to 15th July 06UTC
(forecast start at 12th 00 UTC)



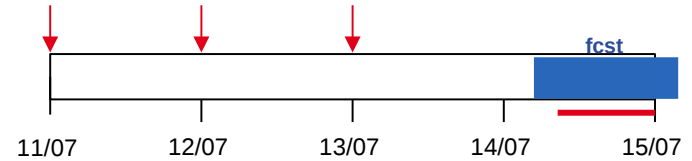
ICON global

IFS

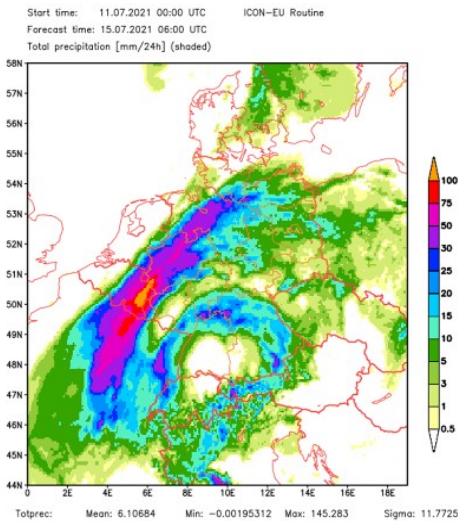
GFS

more than 100mm in the affected regions in all three models

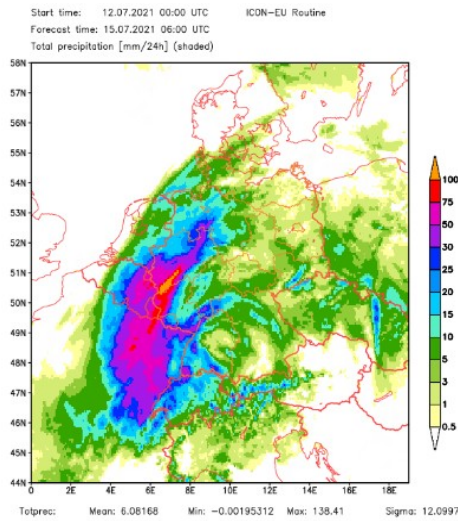
forecasts of ICON-EU



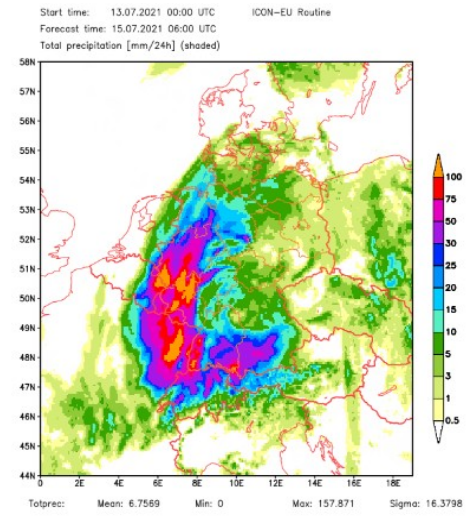
accumulated precipitation for 24 hours from 14th 06 UTC to 15th July 06UTC



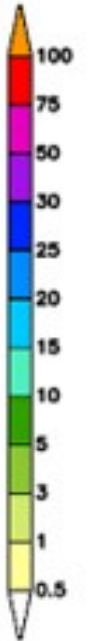
11/07 00 UTC run



12/07 00 UTC run

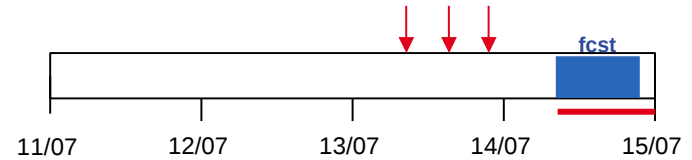


13/07 00 UTC run



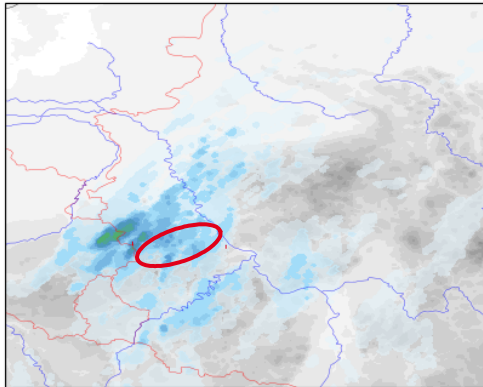
high precipitation sums over 100mm close to or in the relevant region (a bit too far to the west in the oldest forecast)

forecasts of ICON-D2-EPS



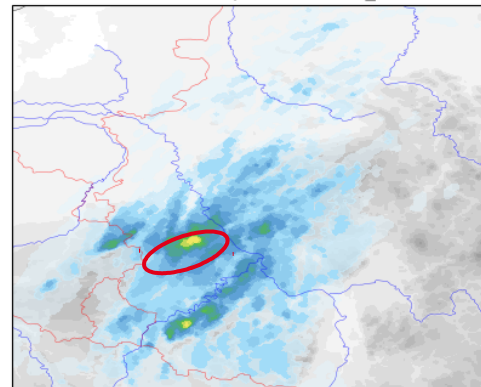
Probability >70mm/12hours for 14th July 09 UTC to 21UTC

ICON-D2, 2021071309+36h, prob. for TOT_PREC > 70mm



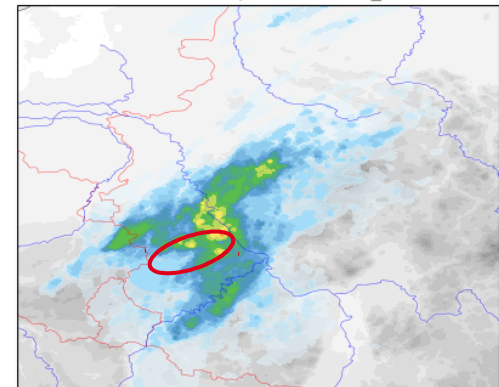
13/07 09 UTC run

ICON-D2, 2021071315+30h, prob. for TOT_PREC > 70mm

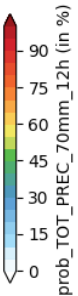


13/07 15 UTC run

ICON-D2, 2021071321+24h, prob. for TOT_PREC > 70mm/12h

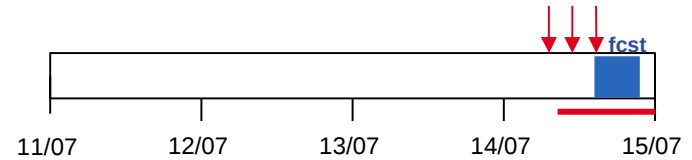


13/07 21 UTC run

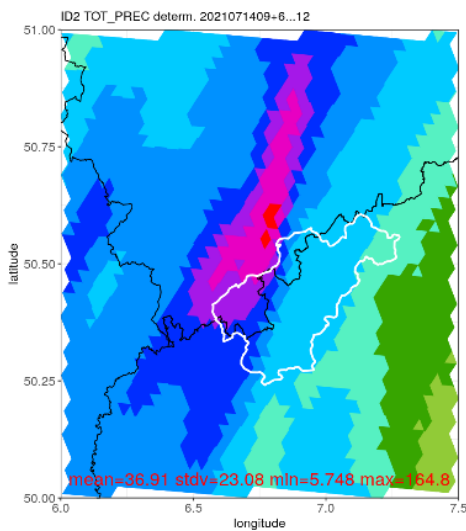


Increasing probability of exceedance with improving match of the affected regions with decreasing leadtime

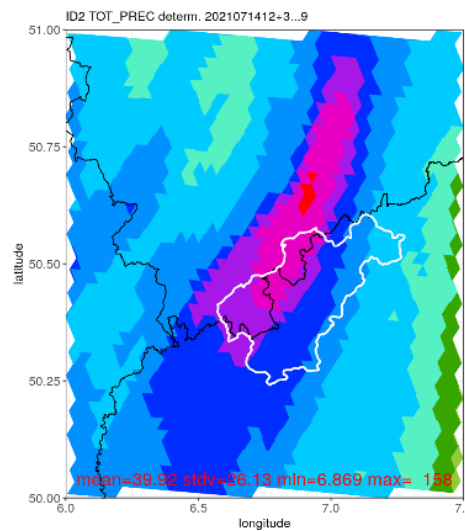
forecasts of ICON-D2(-EPS)



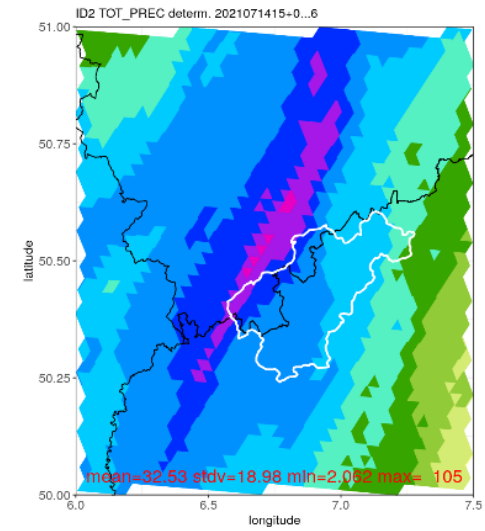
deterministic forecast of 6hr precipitation sum for 14th July 15 UTC to 21UTC



14/07 09 UTC run



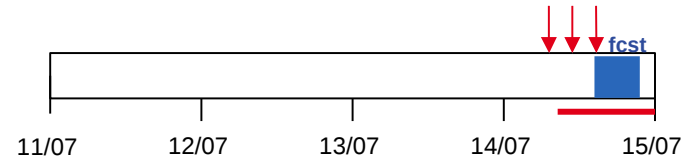
14/07 12 UTC run



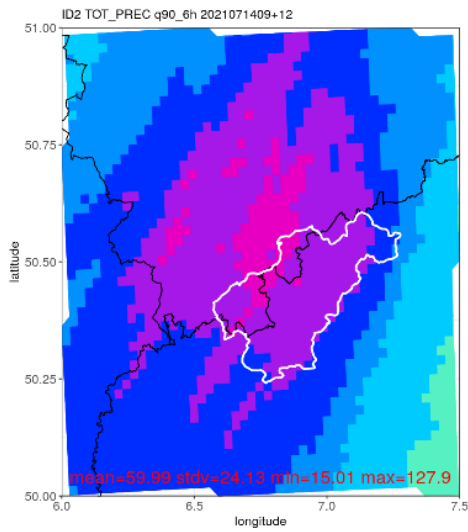
14/07 15 UTC run

Values $\geq 100\text{mm}/6\text{h}$ within the drainage area of the Ahr (white contour) for 09 and 12 UTC run, but clear decrease in the 15 UTC run

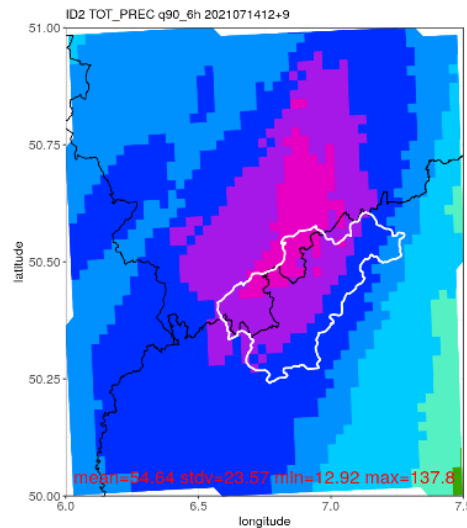
forecasts of ICON-D2(-EPS)



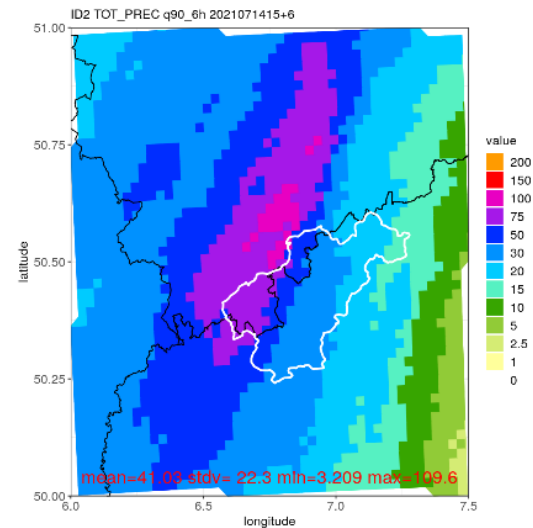
EPS 90%-percentile of 6hr precipitation sum for 14th July 15 UTC to 21UTC



14/07 09 UTC run



14/07 12 UTC run



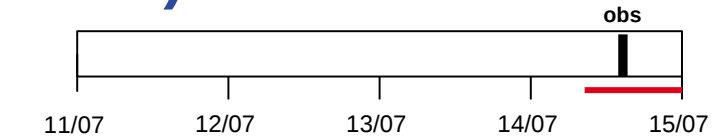
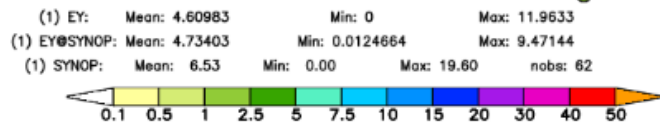
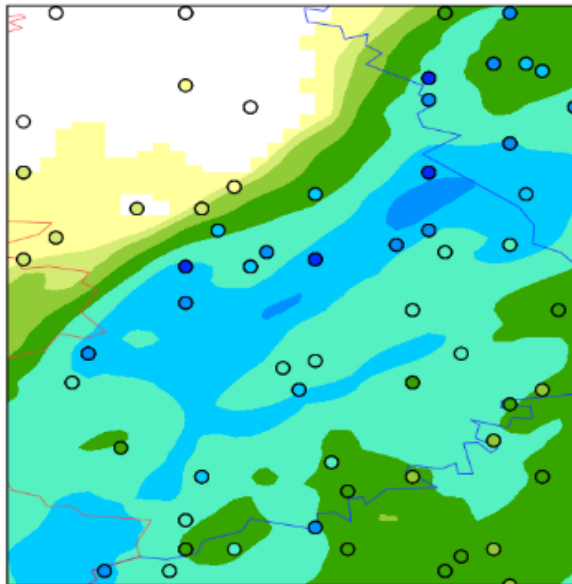
14/07 15 UTC run

More consistent in the EPS with higher values for all runs, but still reduced in this 15 UTC run

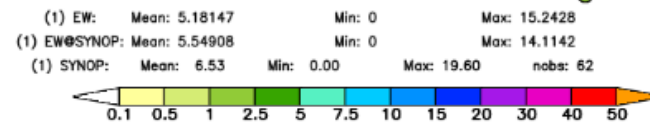
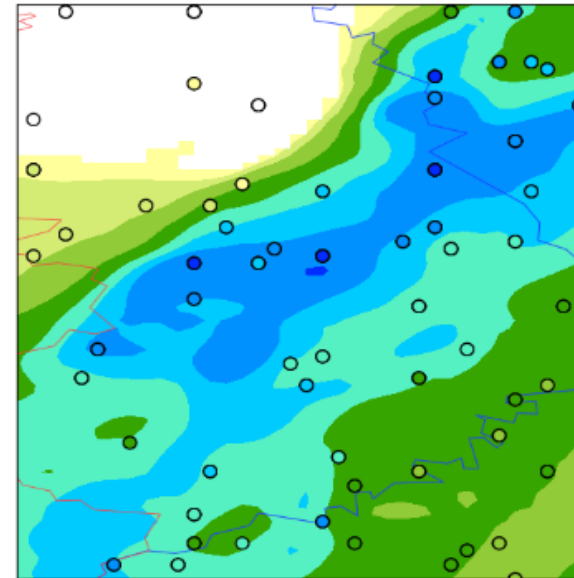
Radar data and rain gauges (SYNOP)

Precipitation from 14 to 15 UTC

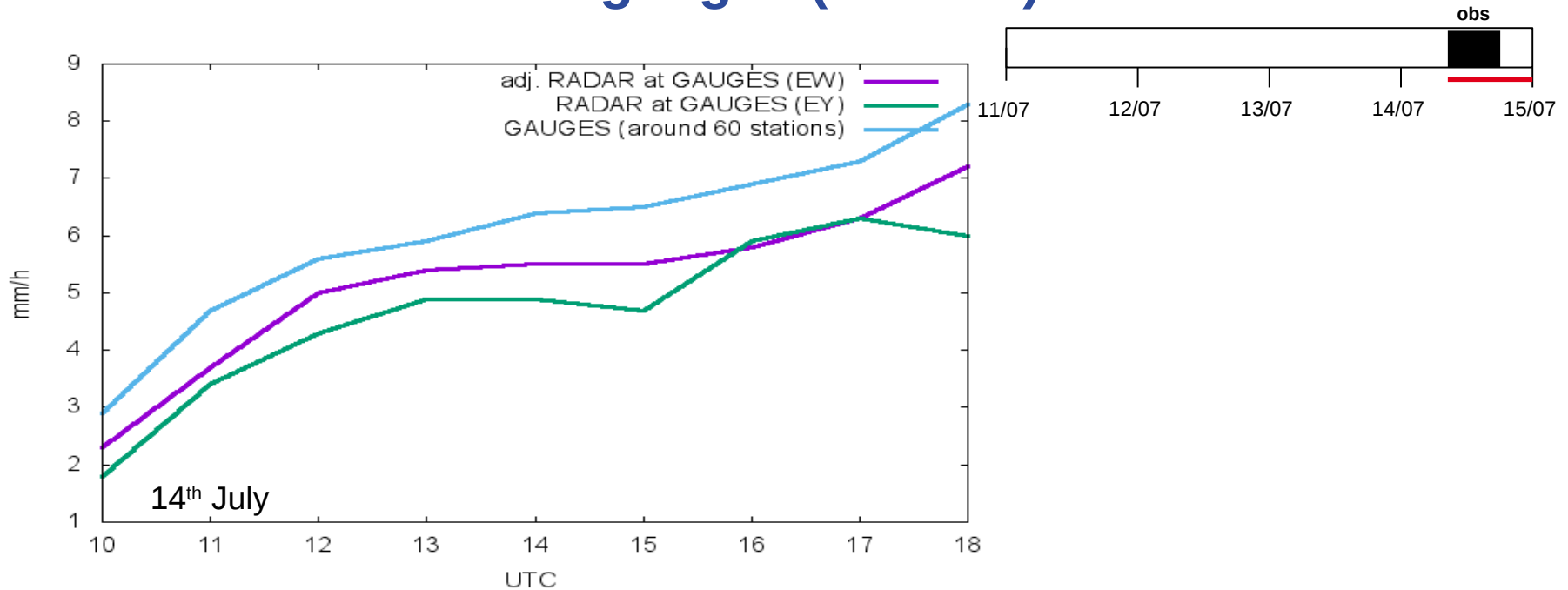
Radar (used in assimilation) and gauges



Radar adjusted to gauges and gauges

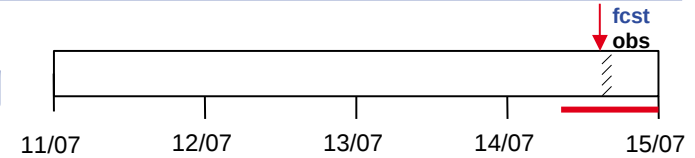


Radar data and rain gauges (SYNOP)



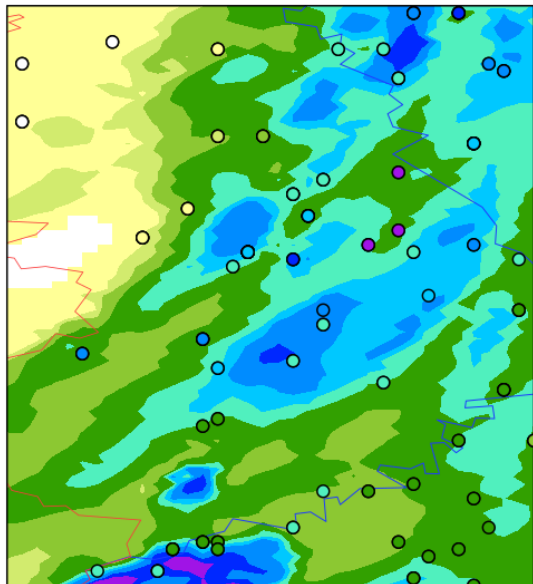
- Radar estimates consistently below gauge measurements in the relevant region
- „dip“ at 15 UTC *one possible* reason for the reduced intensity of the 15 UTC run
- this „dip“ *could be caused* by damping along the radar beam or by a wet radom
- **further investigations needed !!!!**

Test: switch off Latent heat nudging

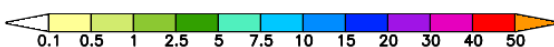


Precipitation from 15 to 16 UTC, forecast start 15 UTC

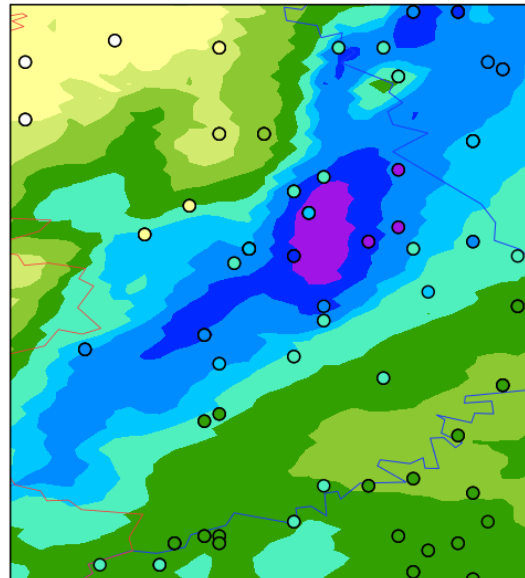
**ICON-D2 with LHN
and assim of 3D reflect.**



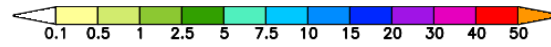
(1) MODEL: Mean: 4.68367 Min: 0.0185547 Max: 33.9385
 (1) MOD@SYN: Mean: 5.88256 Min: 0.200195 Max: 17.4707
 (1) SYNOP: Mean: 6.90 Min: 0.00 Max: 28.70 nobs: 59



**ICON-D2 without LHN
but with assim of 3D reflect.**



(1) MODEL: Mean: 6.36063 Min: 0.101562 Max: 25.2881
 (1) MOD@SYN: Mean: 7.48476 Min: 0.240234 Max: 22.4629
 (1) SYNOP: Mean: 6.90 Min: 0.00 Max: 28.70 nobs: 59



**Reason for this
effect to be clarified**

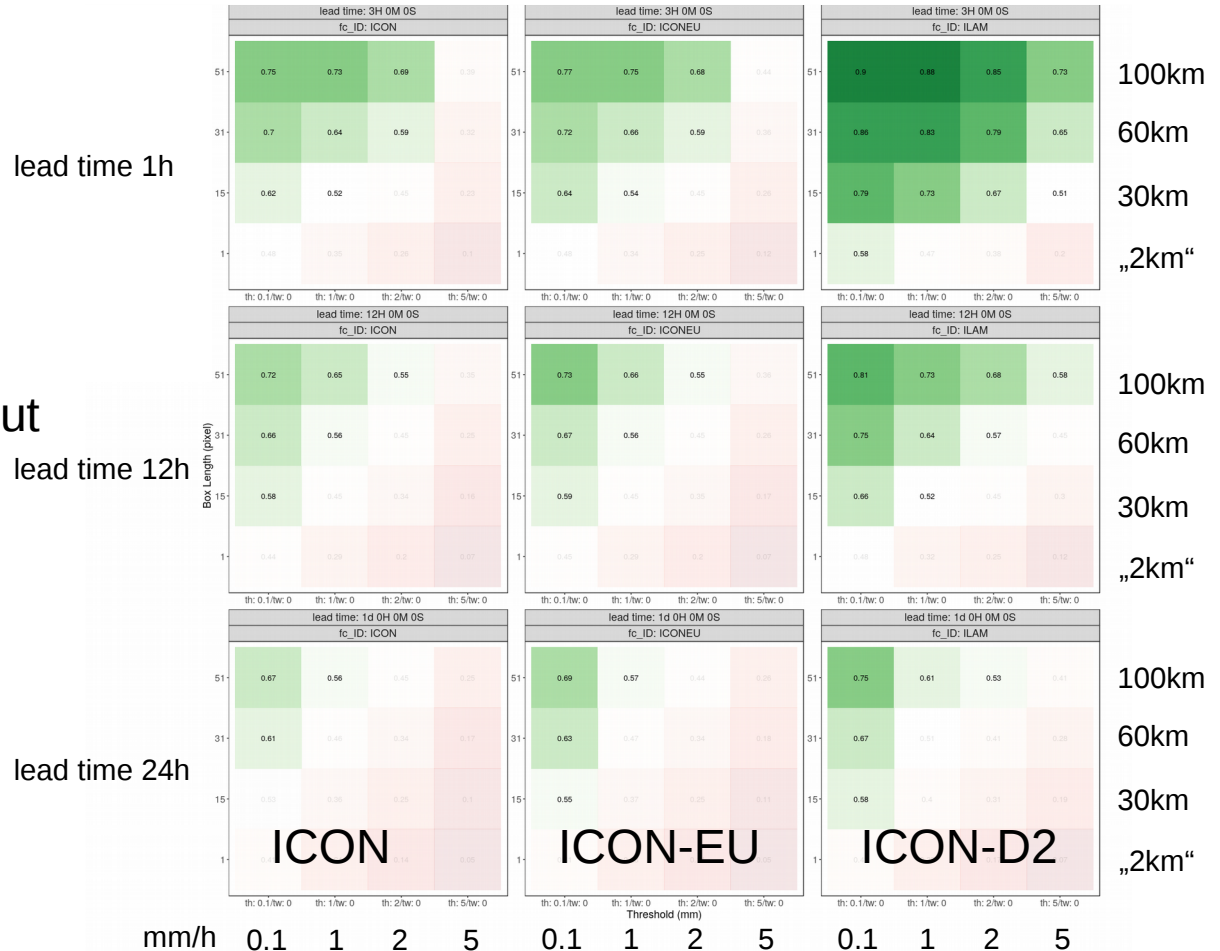
- data quality ?
- assimilation method ?
- random ?

Verification against radar for JJA 2021 (fraction skill score)

(for thresholds faaaaar below the values of the 14th July)

the greener,
the higher above 0.5

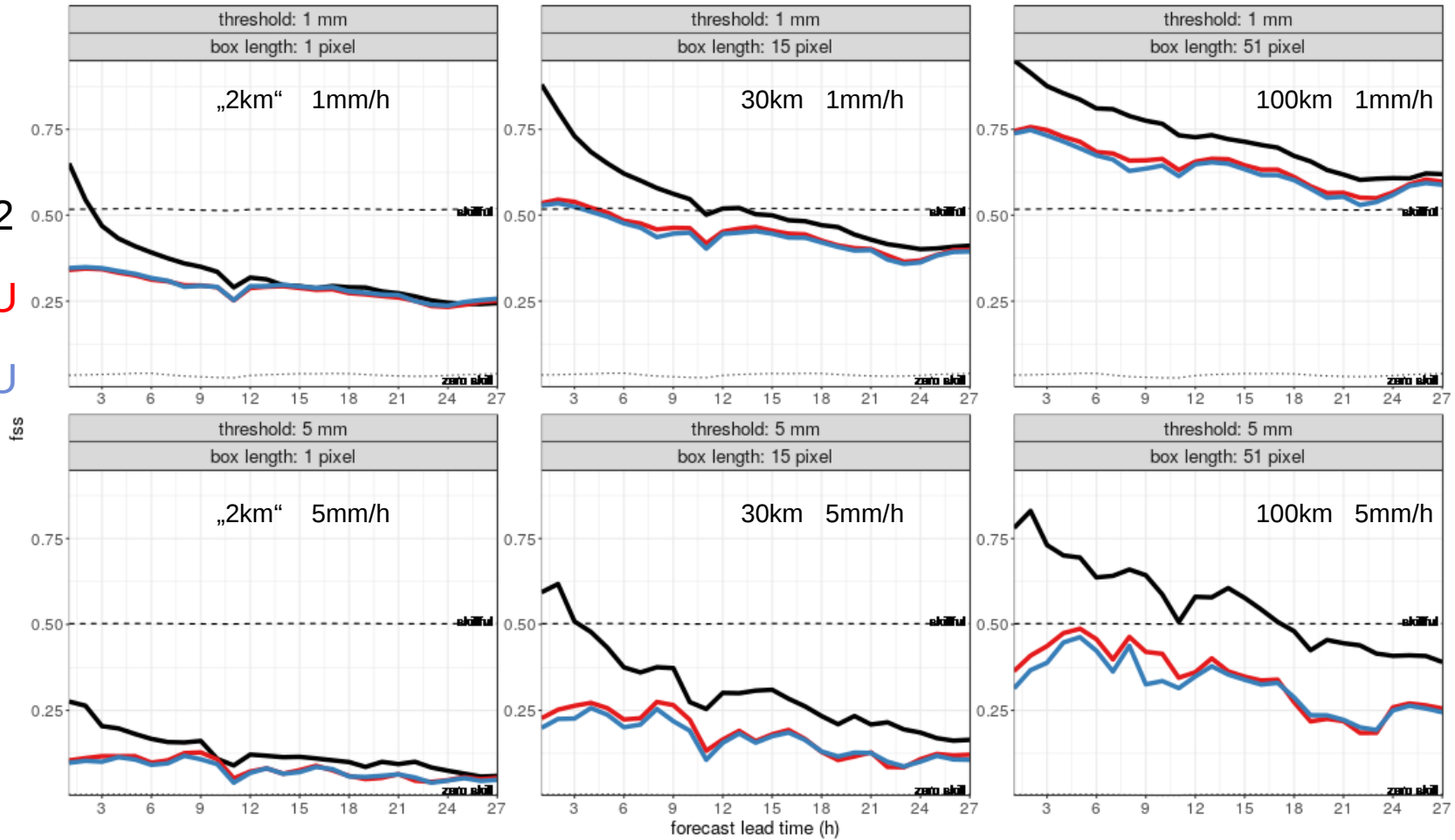
unskillful FSS faded out



Verification against radar for JJA 2021 (fraction skill score)

(for thresholds faaaaar below the values of the 14th July)

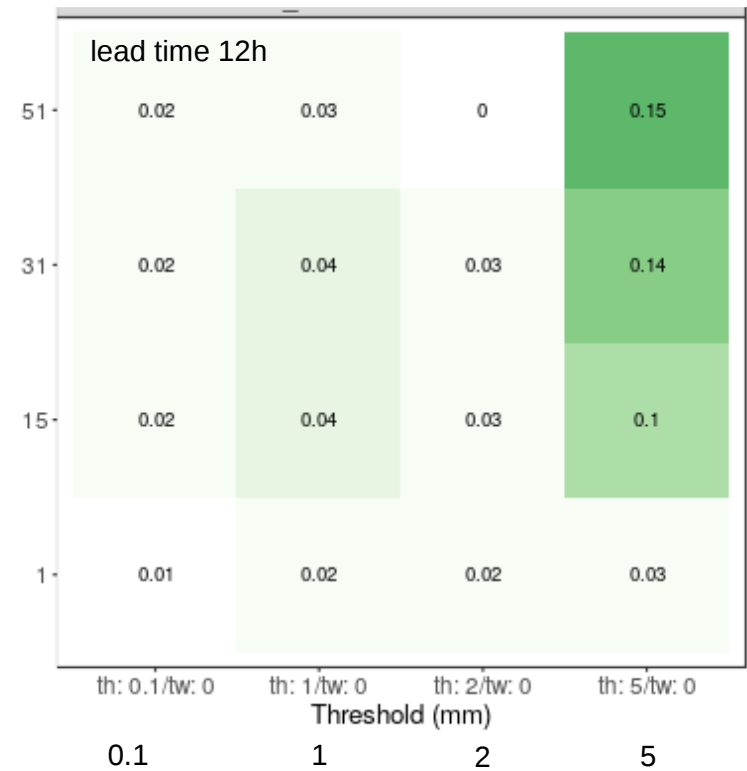
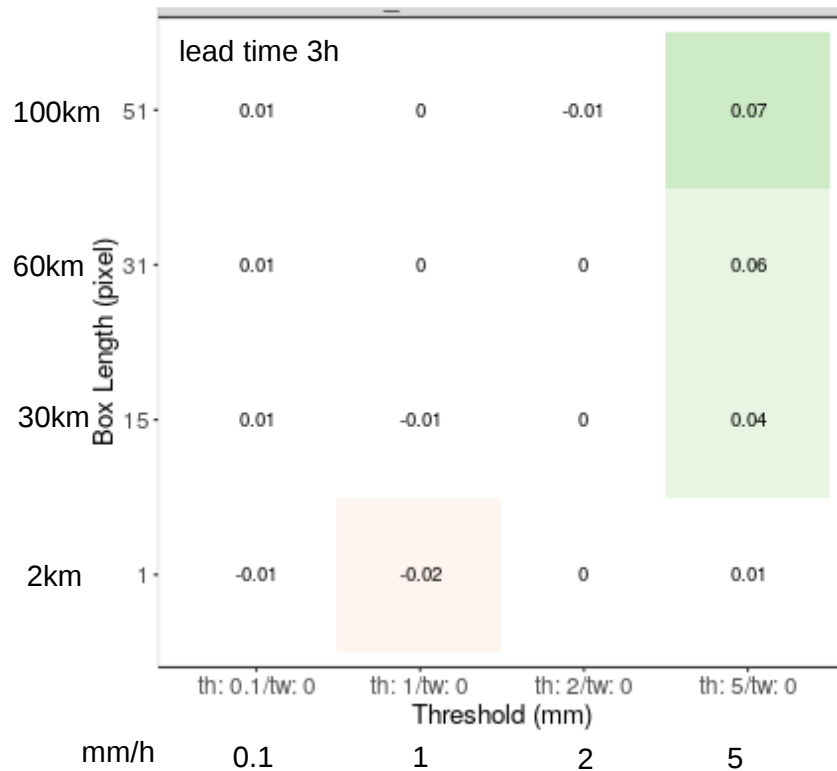
ICON-D2
 ICON-EU
 ICON-EU



ICON-D2 vs. COSMO-D2 for JJA 2020 (fraction skill score)

difference in FSS

green: ICON-D2 better than COSMO-D2

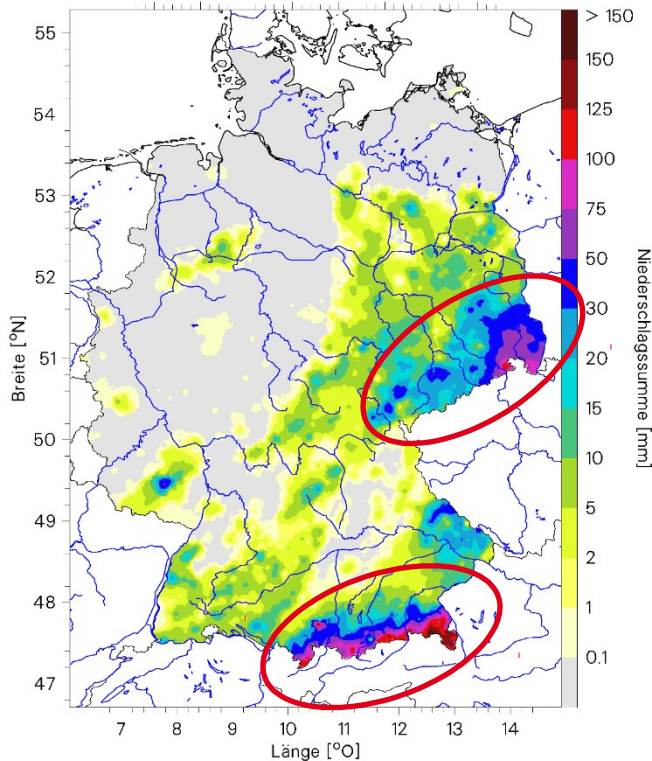


Summary

- Severe precipitation events lasting from 13th to 18th of July leading locally to destructive flooding and flash floods
- Generally good forecasts by the ICON model suite with uncertainties to be expected on the relevant temporal and spatial scales
- Variability between forecast runs (i.e. ICON-D2+EPS) which seems to be attributable partially to systematic differences beyond statistical uncertainty
- The forecast quality for precipitation increases with model resolution and spatial scale, but decreases with precipitation threshold
- There is a lack of data for a robust verification of such events and the standard scores are not focused on statistically extreme events

Precipitation (radar) 16th July to 18th July

HYRAS Deutschland
16.07.2021 – 18.07.2021



Mittelwert: 6,0 Minimum: 0,0
Std.Abweichung: 14,0 Maximum: 173,7



Geographiedaten: GSHHS/WDBII (c) Deutscher Wetterdienst/Hydrometeorologische Beratungsdienste (20.07.2021)

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➤ precipitation events and flash floods

- Lichtenhain-Mittelndorf 77,5 l/m² in 6 h
111,7 l/m² in 24 h

1 person died
€70 Mio. estimated damage in
in this region only

- Berchtesgaden 67,5 l/m² in 3 h
99,3 l/m² in 24 h

1 person died
€86 Mio. estimated damage in
public infrastructure in this region only