



From flood forecast to mitigation

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Flood Forecasting, Models & Uncertainty

Organization flood warning service

Flood 2024 from forecast to mitigation

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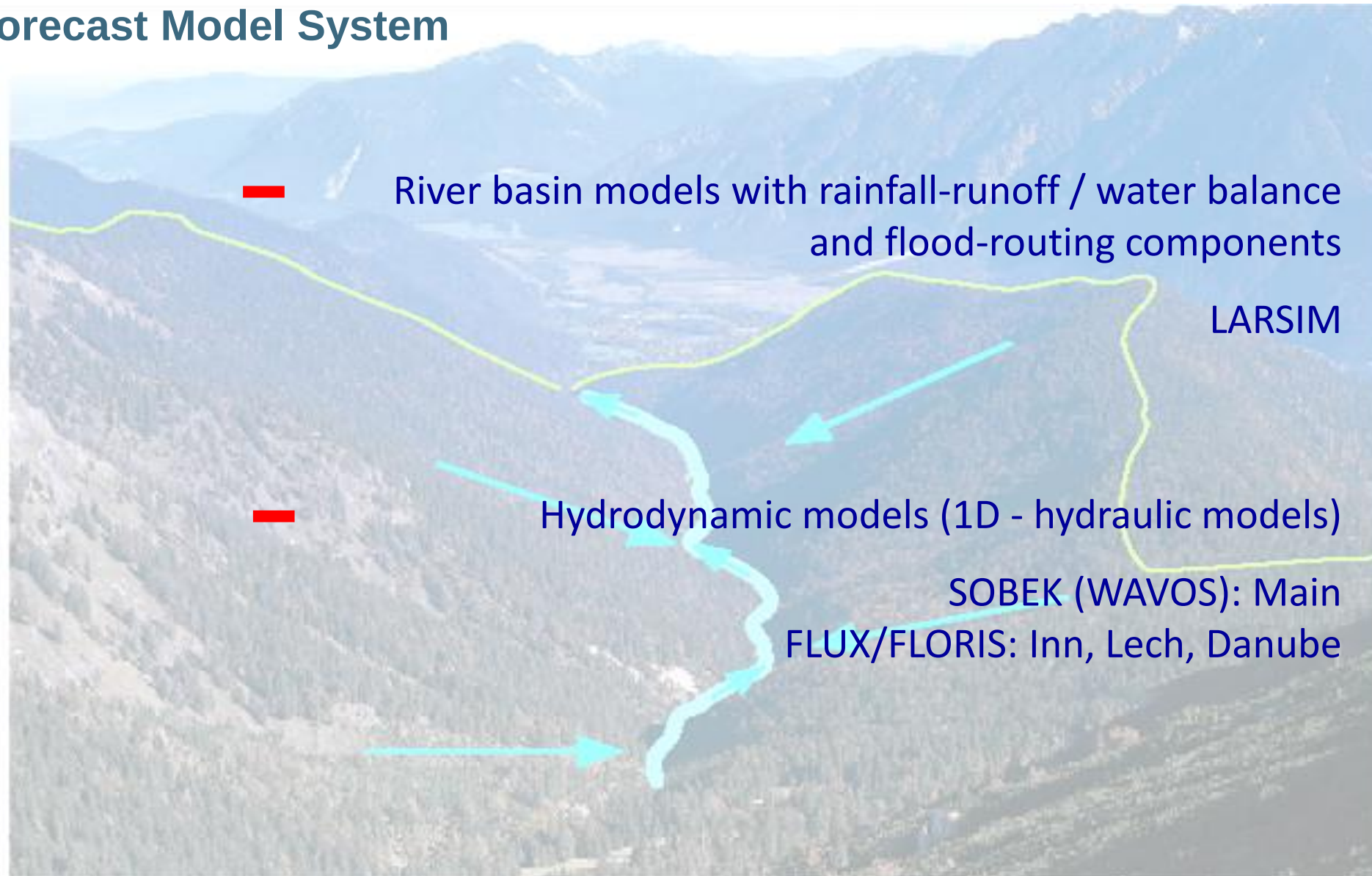


After Flood 1999 – flood forecasts are being initialized for Bavaria





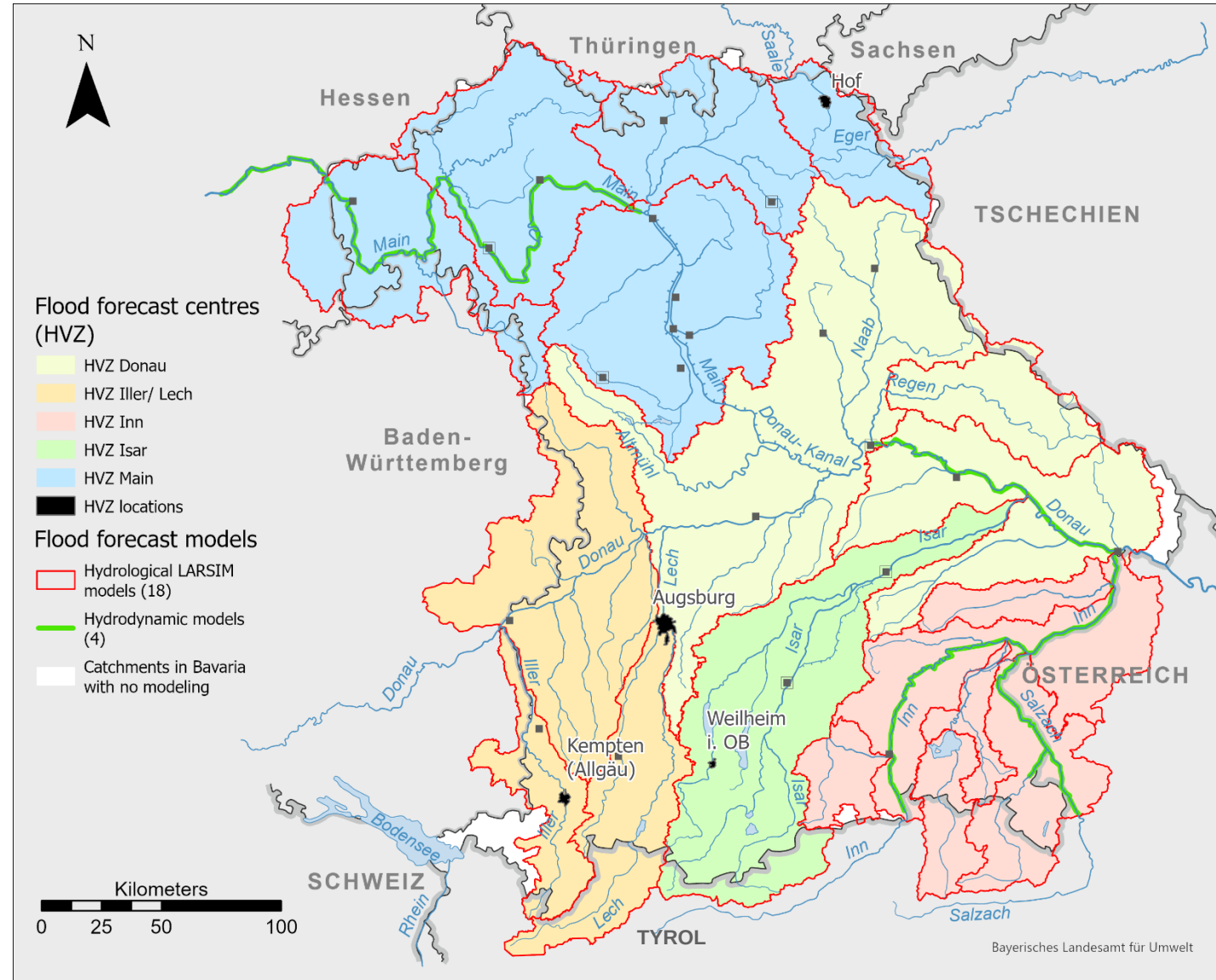
Flood Forecast Model System





Flood Forecast models

- Flood forecast models in Bavaria and implemented forecasts from neighbouring states





Numerical Weather Forecast: deterministic product range

ICON-RUC (DWD, DEU, regional)
grid 2.2 km, forecasts up to 14 h

ICON-D2 (DWD, DEU, regional)
grid 2.2 km, forecasts up to 48 h

ICON-EU (DWD, DEU, Central Europe)
grid 6.5 km, forecasts up to 120 h

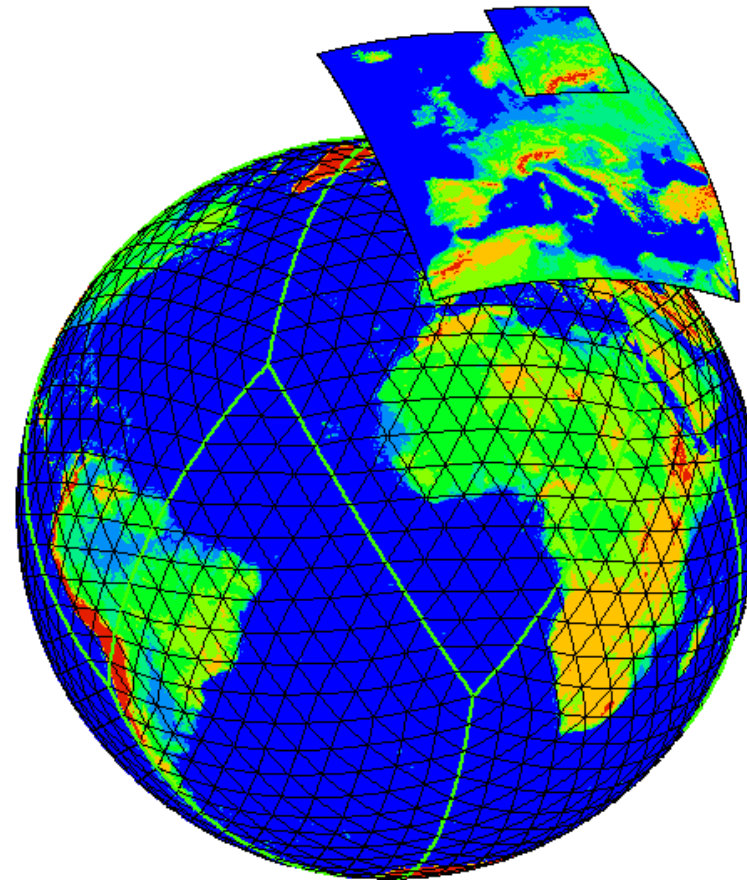
ICON (DWD, DEU, global)
grid 13 km, forecasts up to 7 d

SNOW 4 (DWD, DEU, Central Europe)
grid 2.8 km, forecasts up to 72 h

ECMWF (ECMWF, GB, global)
grid 7 km, forecasts up to 15 d

GFS (NOAA, USA, global)
grid 30 km, forecasts up to 7 d

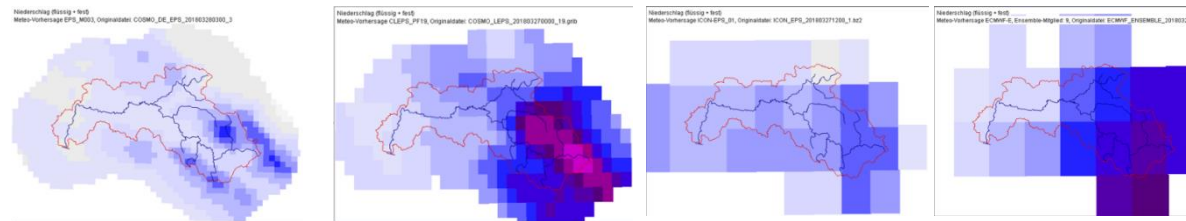
INCA-seamless (GeoSphere Austria, Alpine region and
parts of Danube basin)
grid 1 km, forecasts up to 61 h





Numerical Weather Forecast: Ensemble-Models

Ensemble-Model	SINFONY-RUC-EPS	ICON-D2-EPS	COSMO-LEPS	ICON-EU-EPS	EZMWF-ENS
Grid [km x km]	2,2 x 2,2	2,2 x 2,2	7 x 7	13 x 13	13 x 13 26 x 26
Number of members	20	20	20	40	50
Forecast up to	14 hours	2 days	5 days	5 days	15 days
Model runs a day	24	8	2	2	2



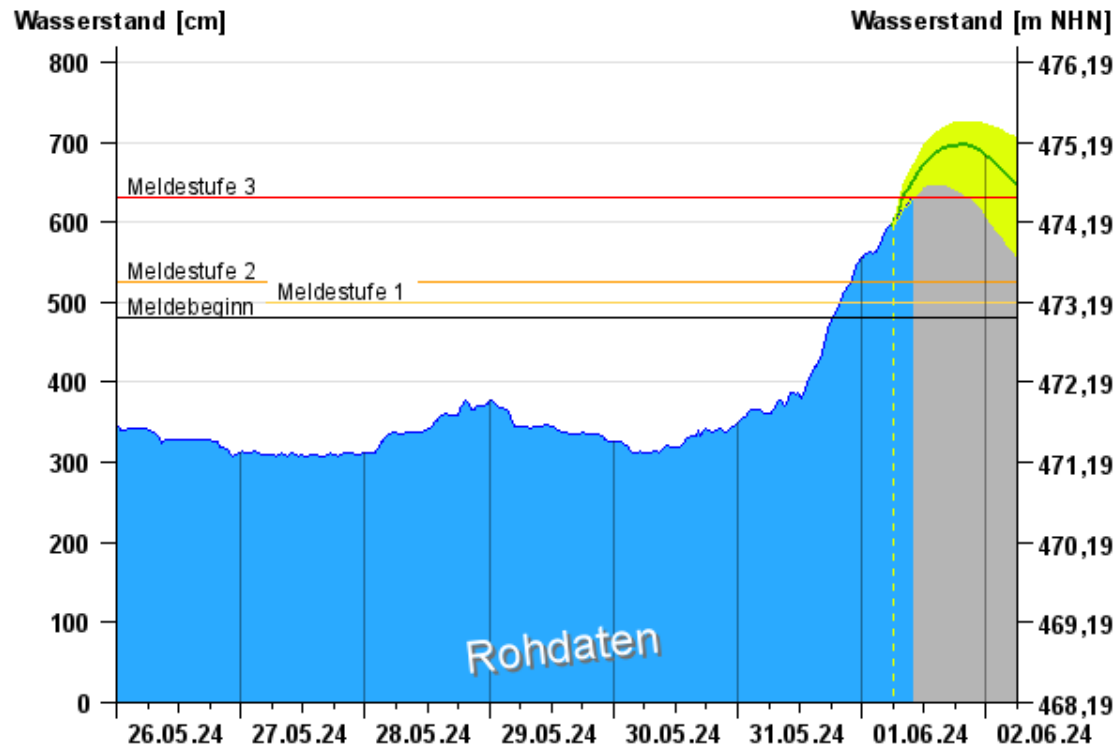
- + Hydrological Ensembles (variations of T, N, soil moisture, ...)
- + poor man ensembles

Organization flood warning service

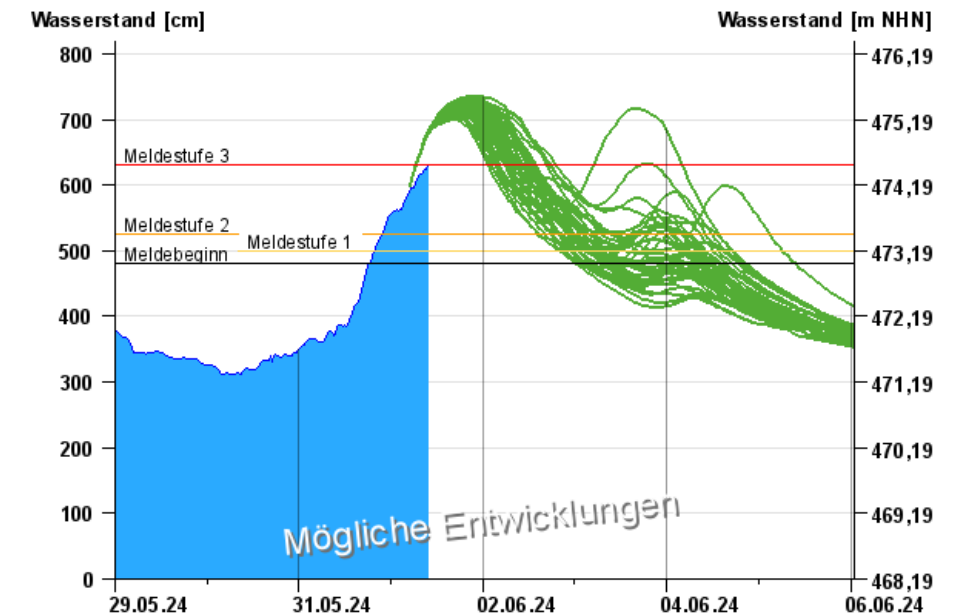
Products: Flood Forecasts – internet presentation:

Used for warning: Deterministic forecast

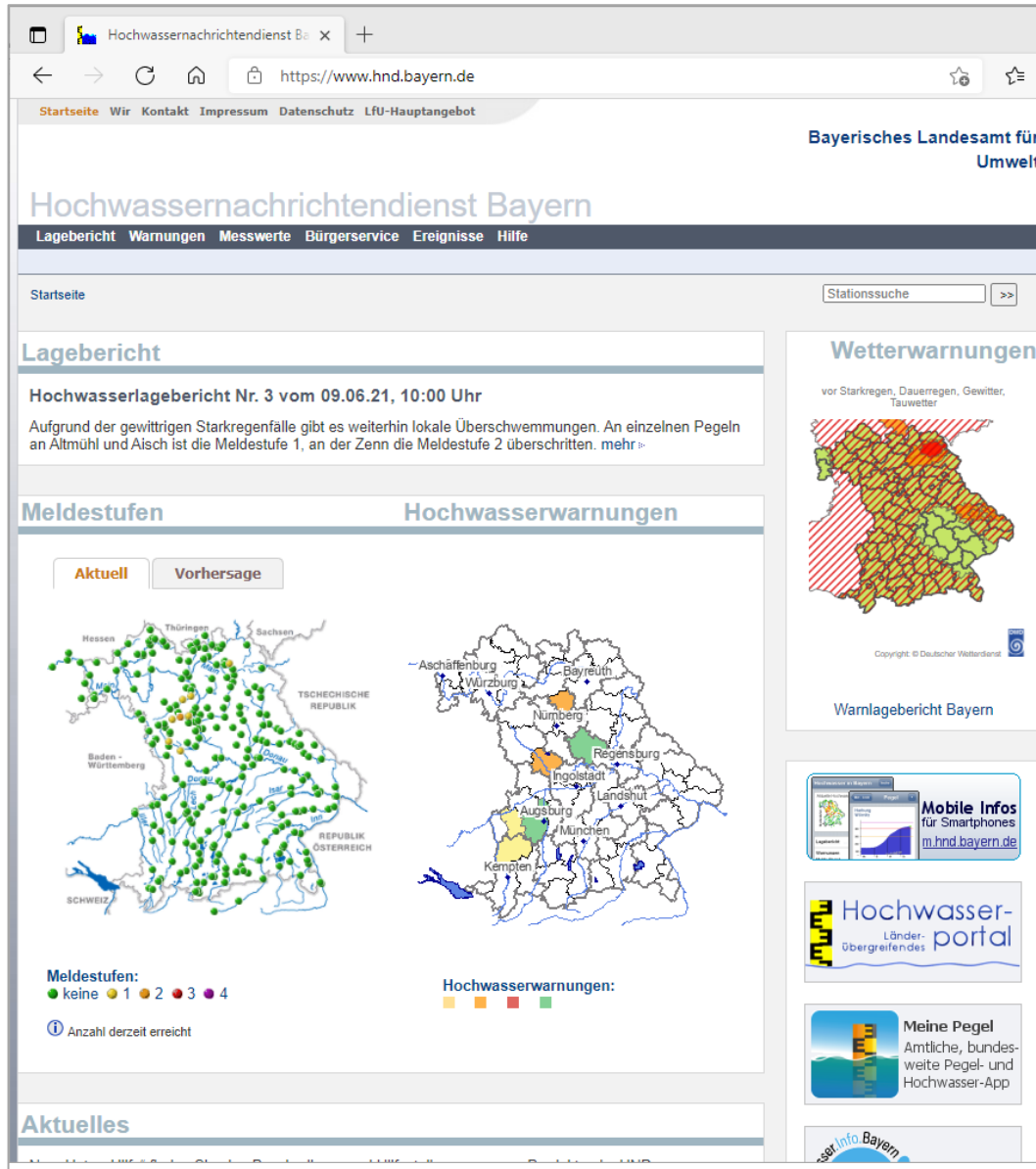
- Short term 6 to 24 hours dependent on catchment size
- Medium range 24 to 48 hours (trend)



Additional information:
Ensemble forecasts (2 days to 15 days)



Vorhersage: keine | 12-Std.-Vorhersage | 2-Tage-Trend
Mögliche Entwicklungen: 2 Tage-Trend (ICON-D2) | 5-Tage-Trend (ICON) | 15-Tage-Trend (ECMWF)
Darstellungsart der möglichen Entwicklung: Ensemble-Member | Perzentilbänder



Organization flood warning service

Three Warning levels

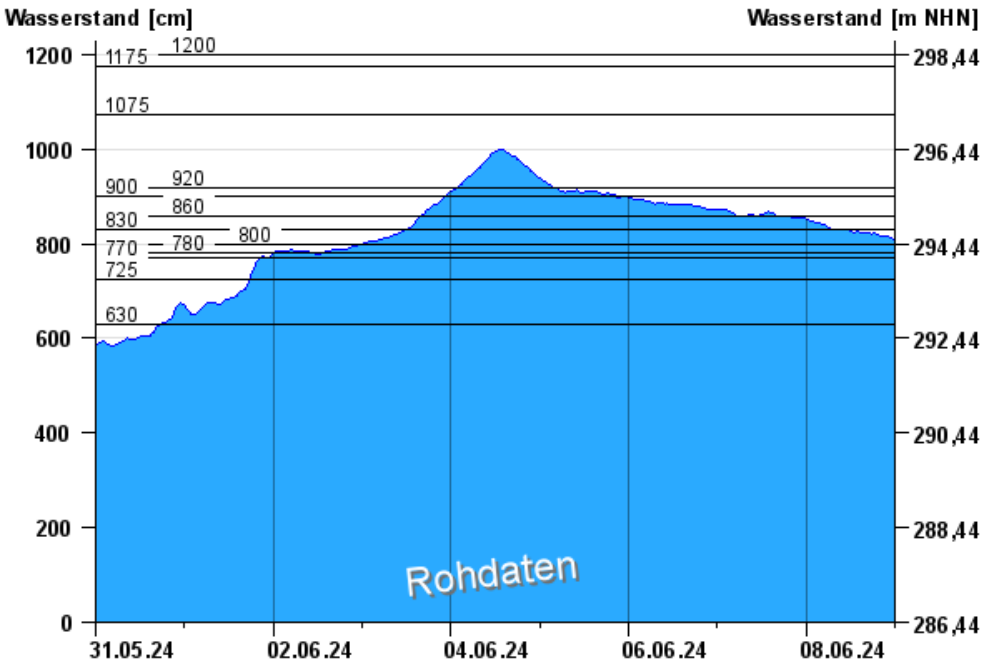
- Early warning (1-2 days ahead)
- Warning of minor flooding at alert level 1 or 2
- Warning of severe flooding at alert level 3 or 4



Organization flood warning service

Products: Water level triggers action – Passau Donau

W cm	Place	Type of measure or hazard
630	Passau	Advance warning to the police by the regulatory agency
720	Passau	Flooding of the upper Zollände in Passau and the harbour area Racklau.
720	Passau	Flooding of the Fritz-Schäffer-Promenade at the tavern -Tiroler-, removal of the motor vehicles.
740	Passau	Flooding of the Fritz-Schäffer-Promenade, traffic stoppage.
750	Passau	Evacuation of the parking lots at Schanzl.
750	Passau	Traffic blocking at the upper Donaulände
770	Passau	Flooding of the high road ST 2132 at Löwmühle
770	Passau	Evacuation of garages and souvenir shops at the lower Donaulände. flooding of the harbour area Racklau
780	Passau	Highest water lever for water navigation (HSW).
790	Passau	Flooding of the approach to the Nagelschmied- and Höllgasse
800	Passau	Flooding of the posterior Donaulände downstream of the Schanzl bridge.
800	Passau	Warning by loudspeaker for the upper Donaulände, Regensburgerstreet, Rindermarkt and Ort.
810	Passau	'Ort' partly flooded.
...		



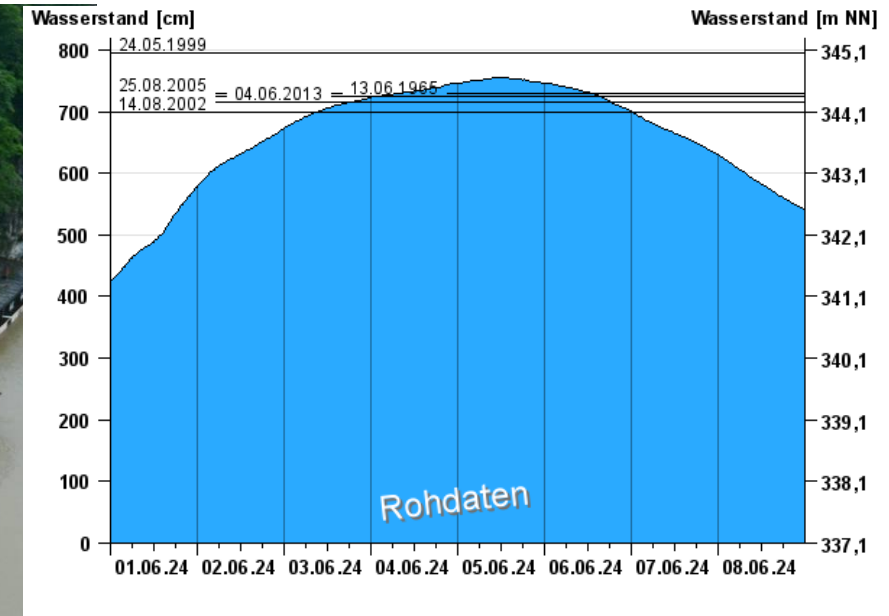


Organization flood warning service

Products: Water level triggers action - Kloster Weltenburg Mobile Protection



2013-06-03 Kloster Weltenburg / Donau



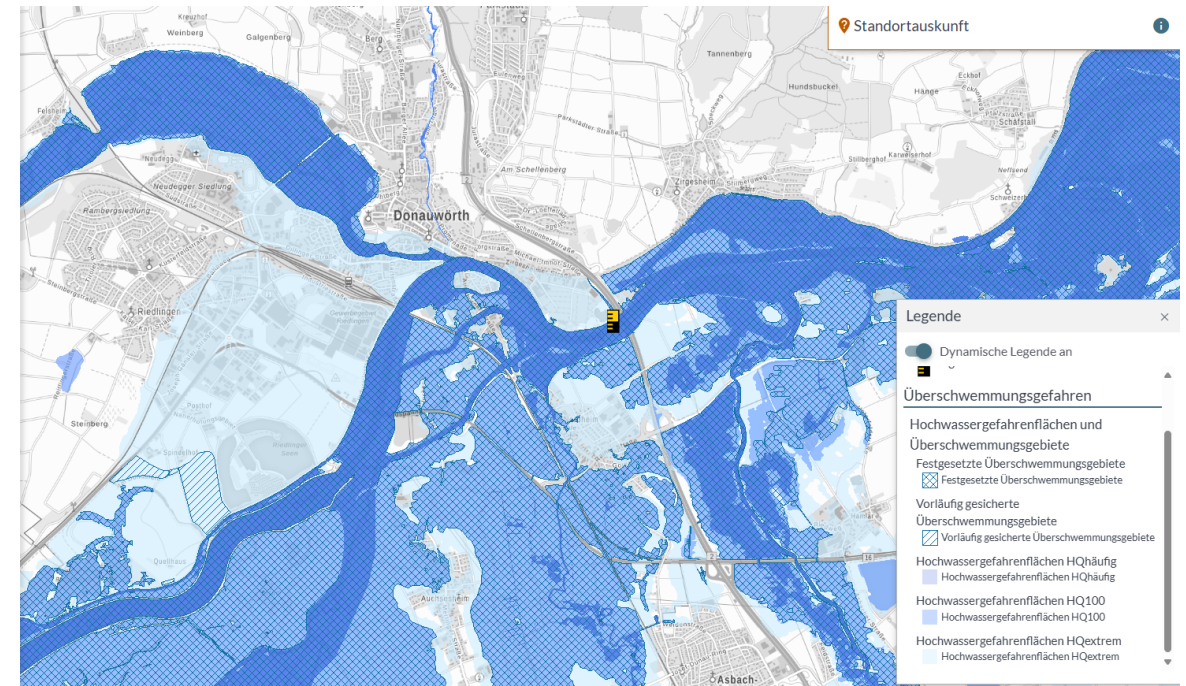
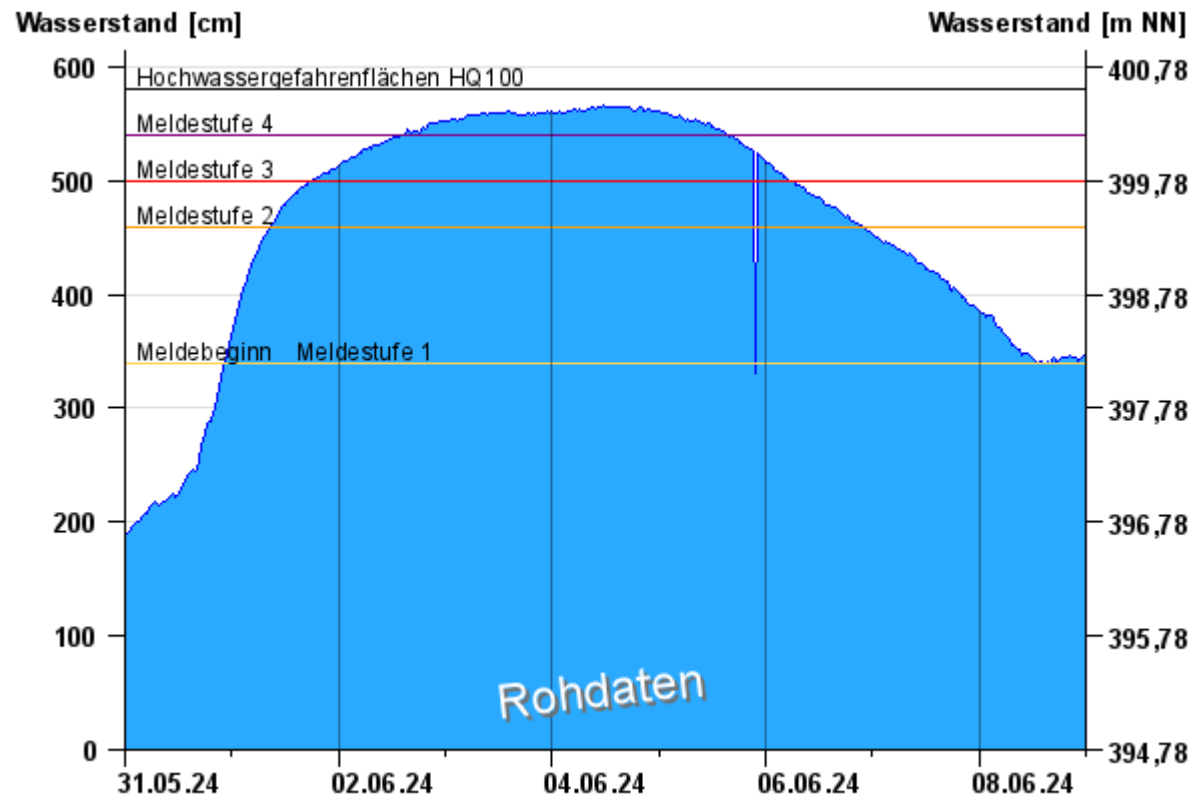
Comparison with historic floods

Organization flood warning service

Products: Connecting water level to flood inundation maps

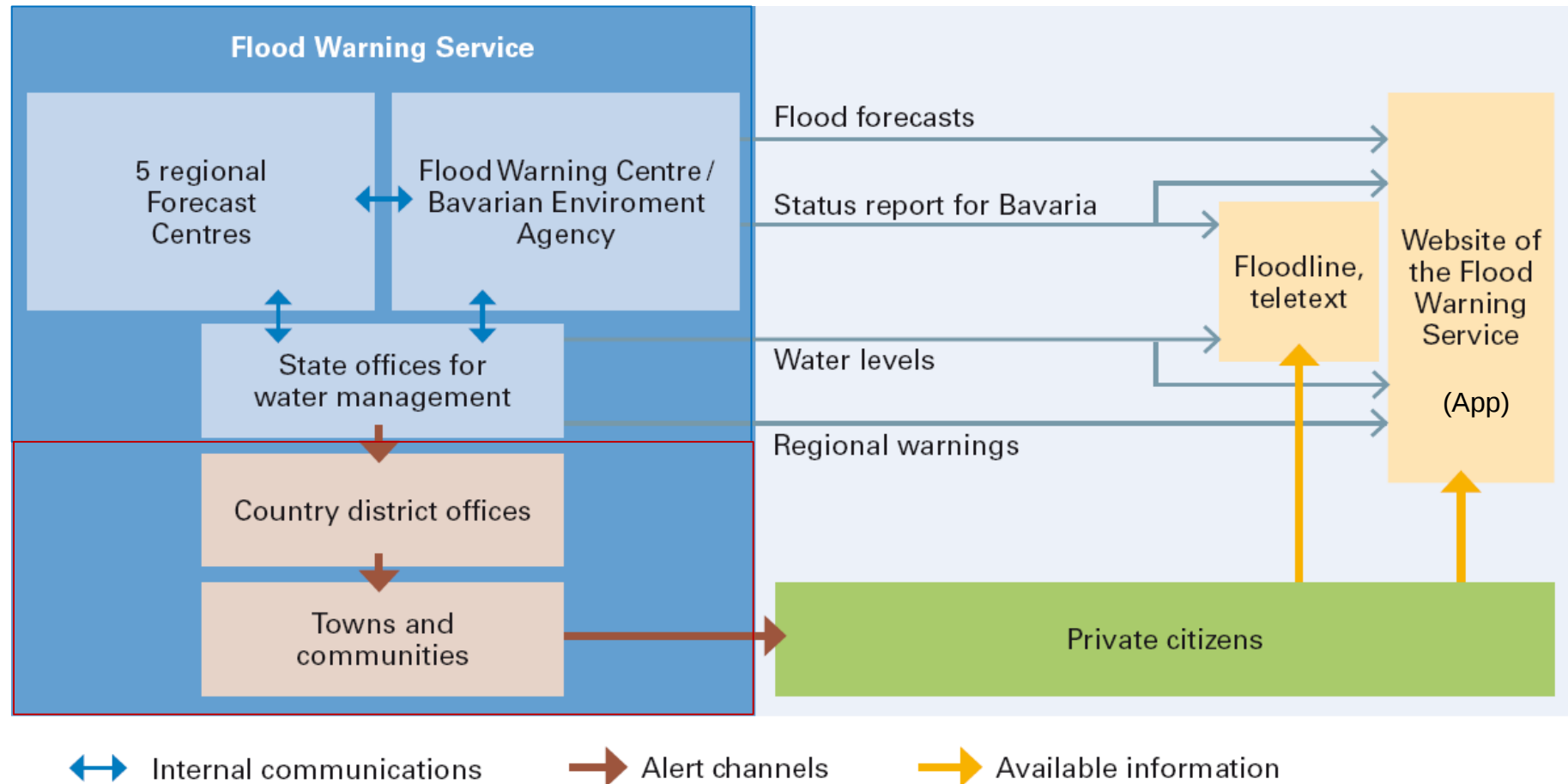
• Donauwörth

EU flood directive medium probability flood 100a





Organization of the flood warning service (HND)





Flood 2024 from forecast to mitigation

- What were the challenges for a correct warning?



Weather
system

Information for Mitigation: green adapted action possible – red missing information



Time (start,
peak, warning
levels)



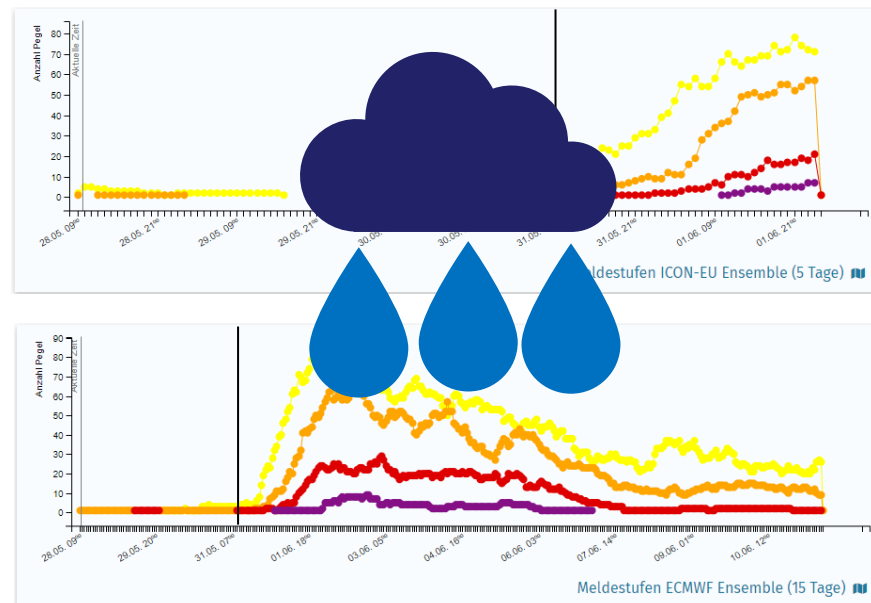
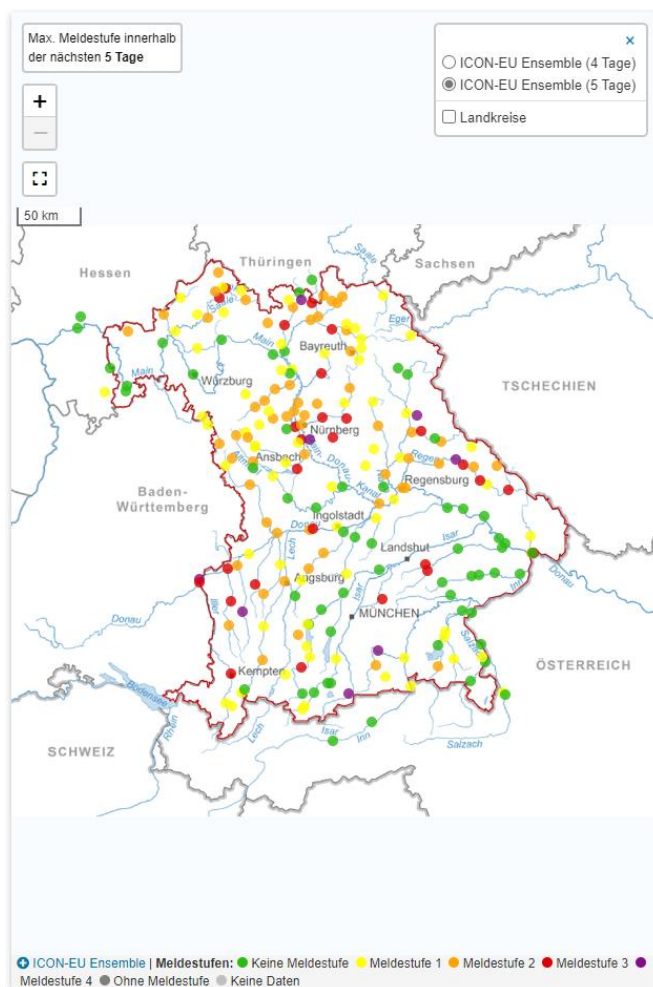
location



Max. water
levels



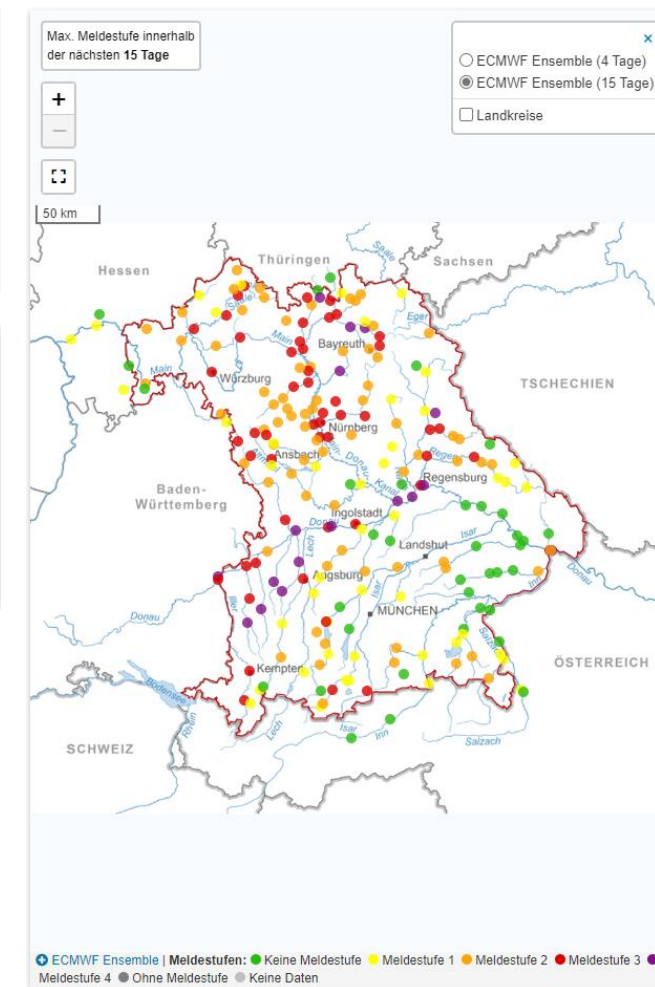
Limits of early warning – weather prediction and discharge forecast 28.05.2024



event start 31.05.2024



?????



Flood information service

29.05.2024, Wednesday

Information: Potential weather situation for a large to very large flood from Friday 31.05. to 04.06.2024

Action: advance information via the warning channel for “service readiness for large floods”, information Ministry of the Interior, flood staff of Ministry of Environment and Consumer Protection



30.05.2024, Thursday (public holiday)

Information: uncertainty is still too high for detailed warnings

Action: Pre-Information on the flood situation for the public



31.05.2024, Friday

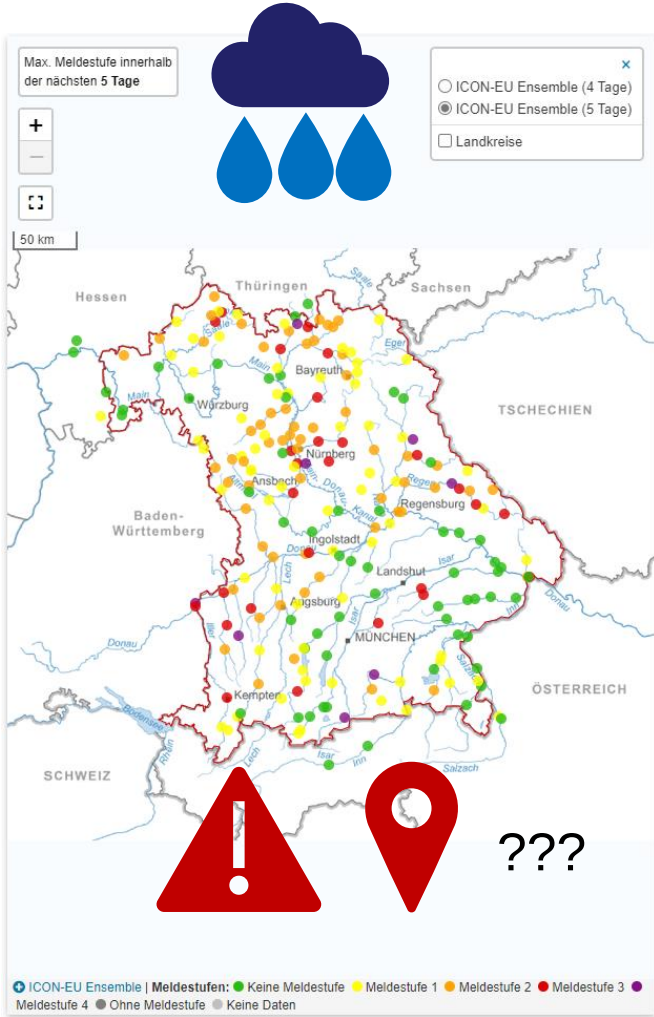
Action: official (pre-)warnings of the affected water management authorities, continuously adapted during the event



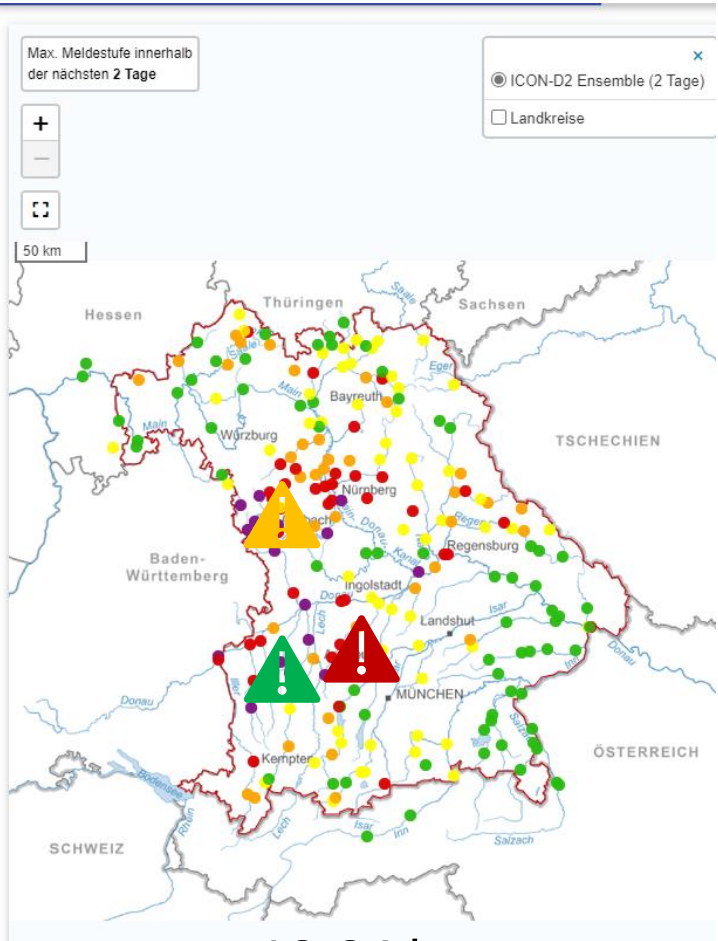
Challenges for flood forecasting:

- Extreme event: Water level-discharge relationships, Overflow of protective structures
- Precipitation forecast

28.05.2024

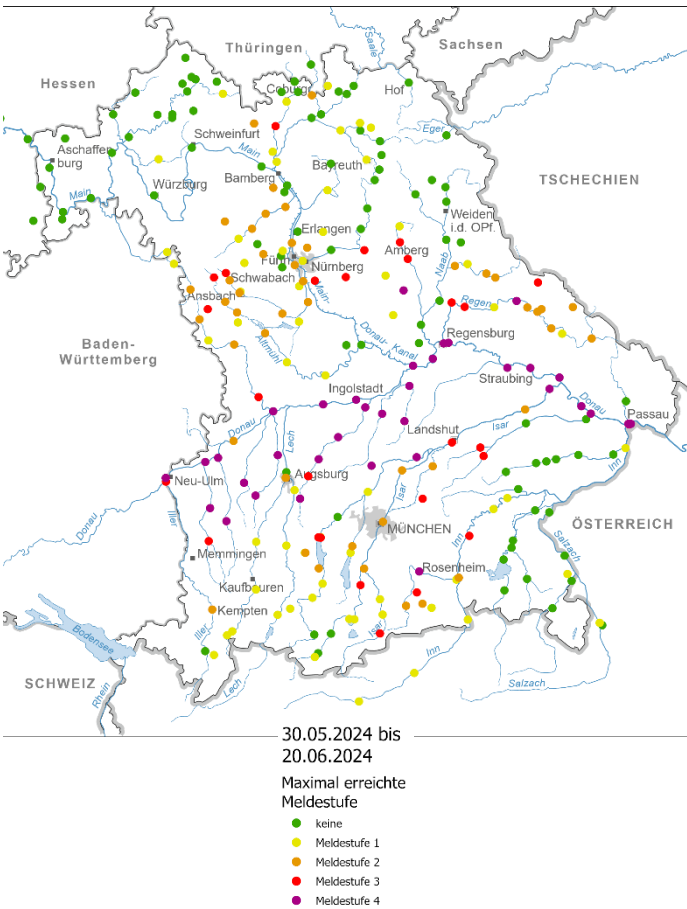


31.05.2024 14:00



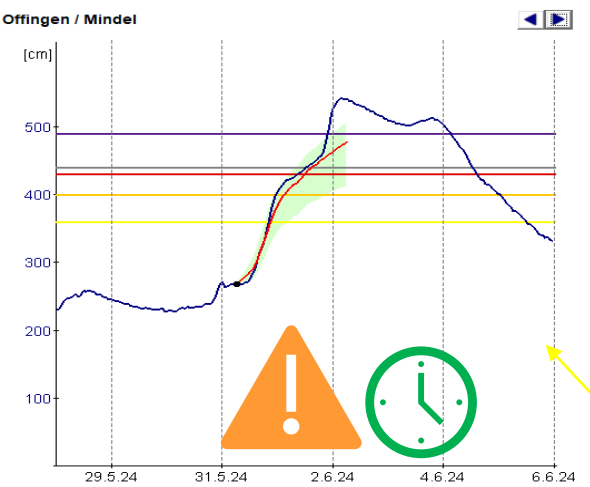
12-24 h

Real Max flood-event

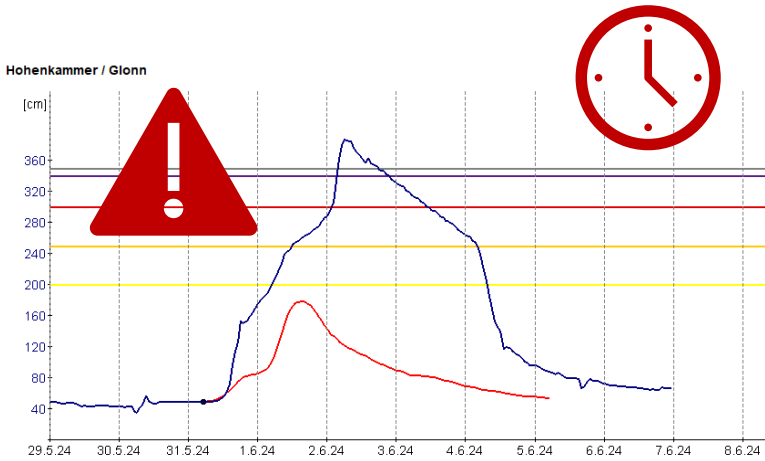
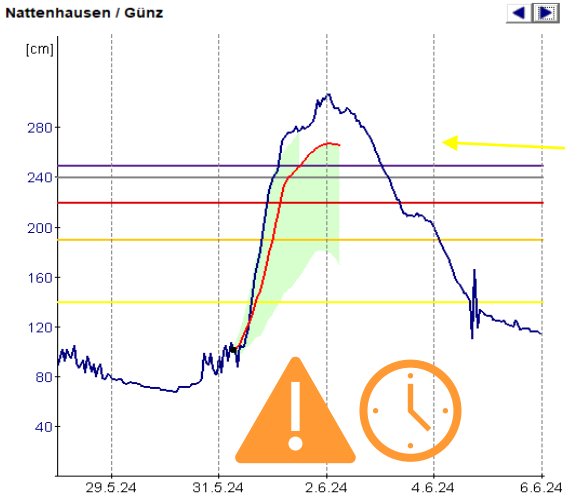
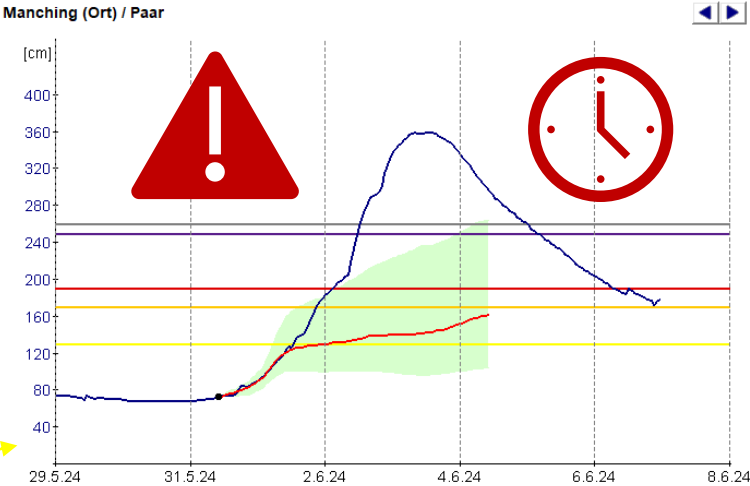
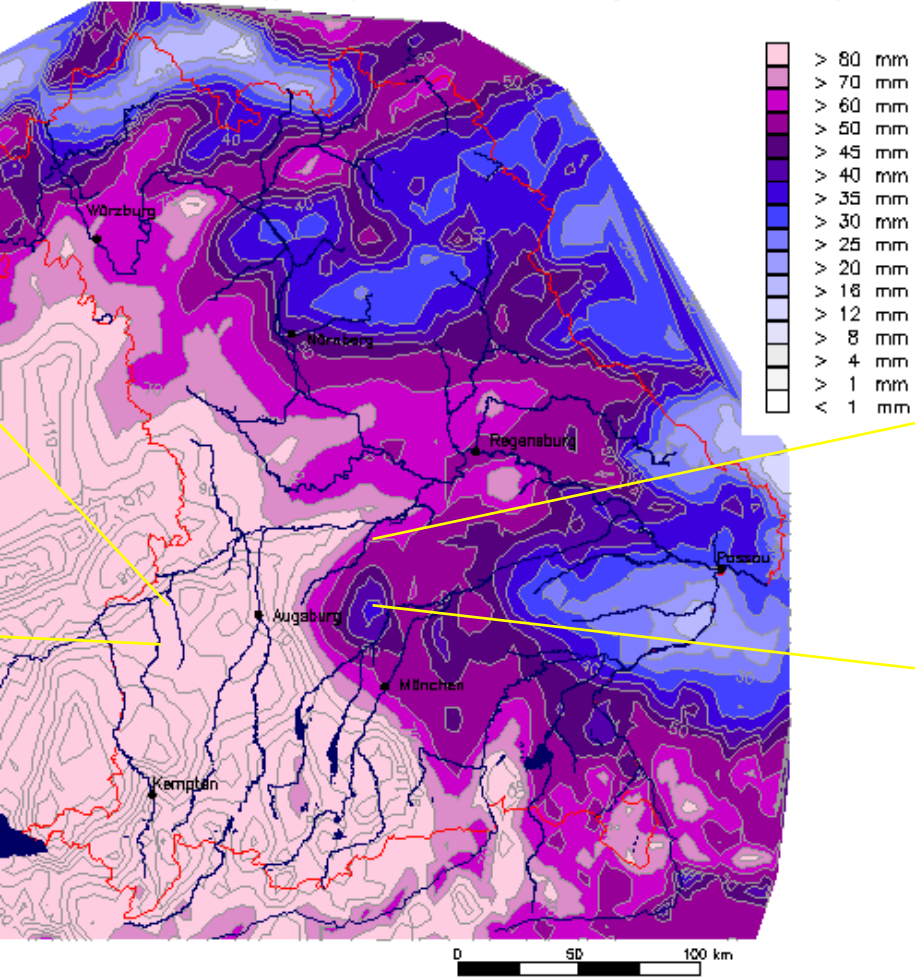


Forecast – Friday event starts

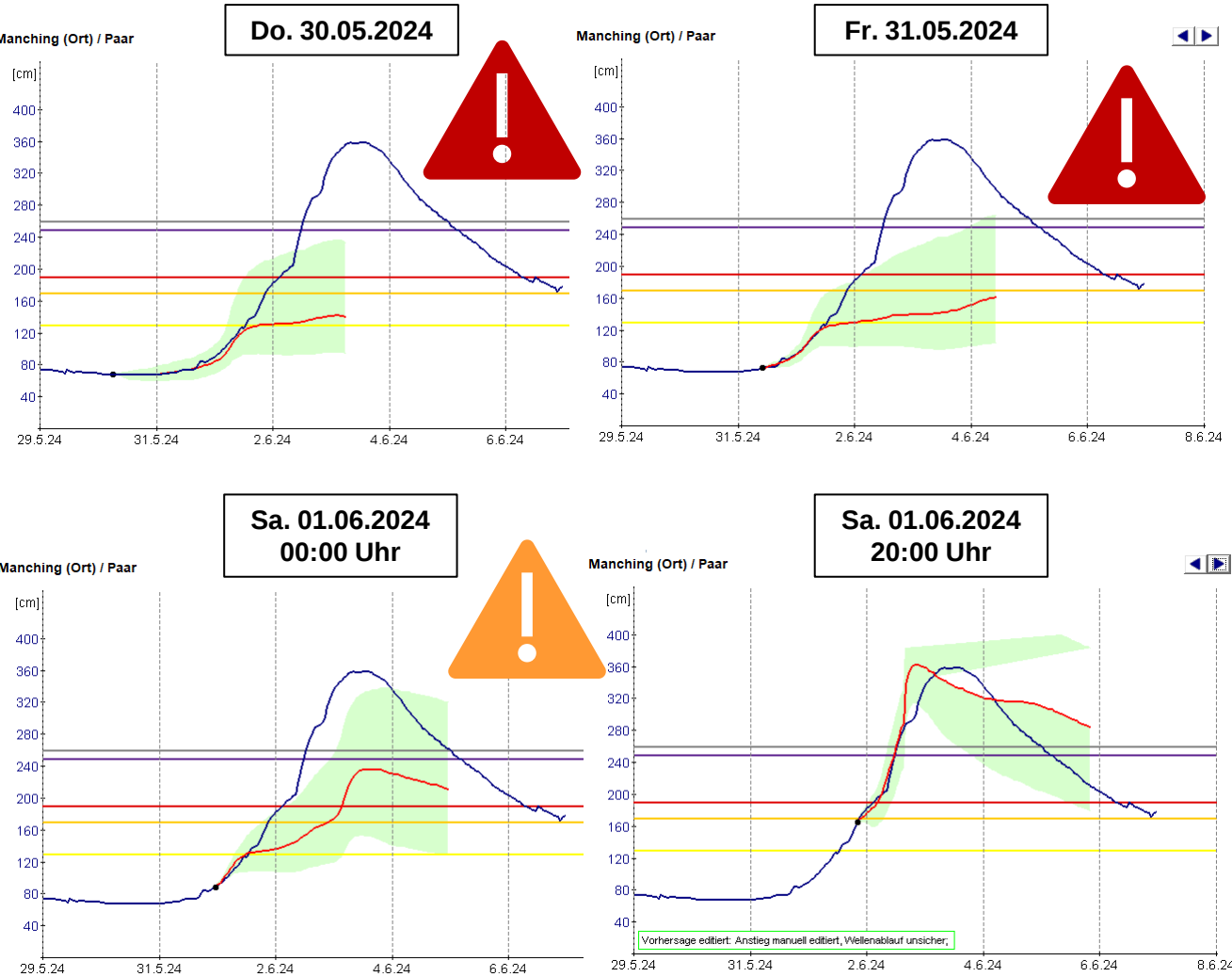
Fr. 31.05.2024 6:00 forecast



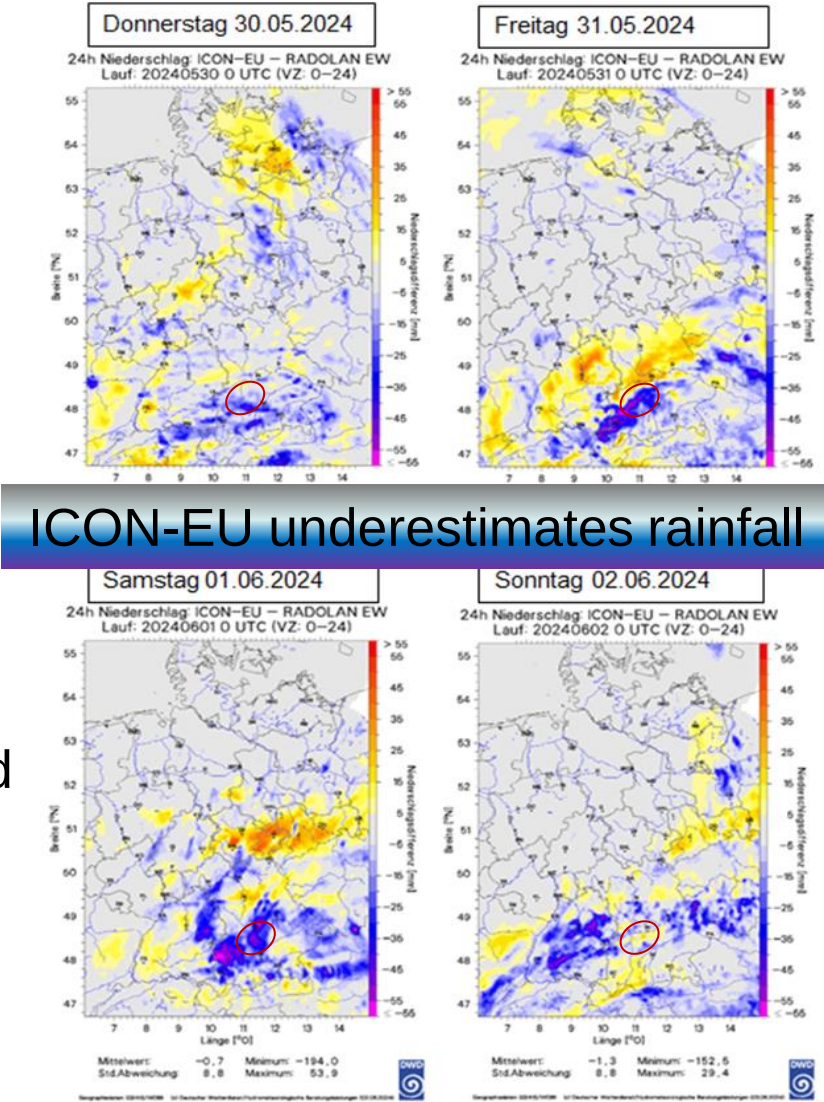
ICE kum. NS-Summe (gesamt) 31. 5 01 UTC für folg. 114 Std. (Bavern)



Forecast for Paar: underestimated during the whole event

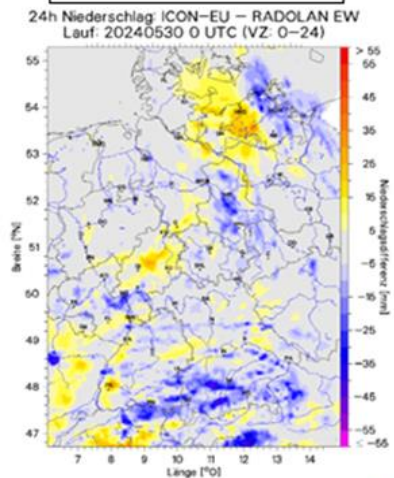


rainfall
measured
- forecast
correct

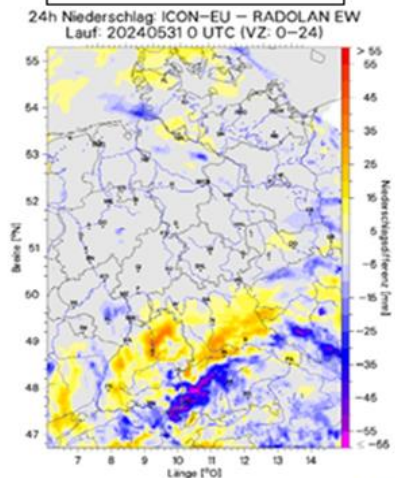




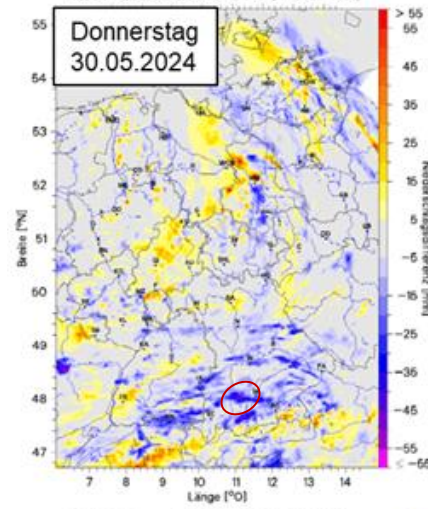
Donnerstag 30.05.2024



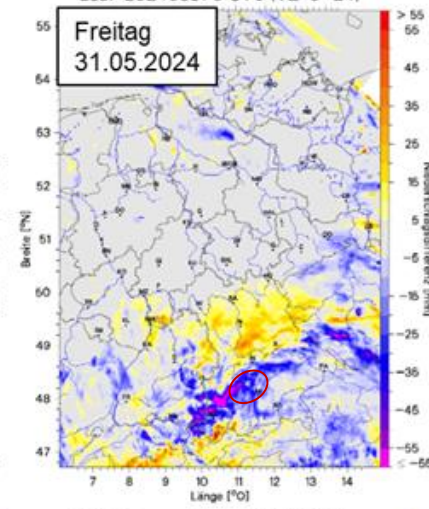
Freitag 31.05.2024



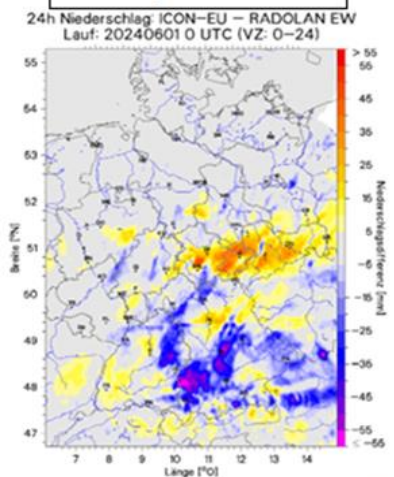
24h Niederschlag: ICON-D2 – RADOLAN EW
Lauf: 20240530 0 UTC (VZ: 0–24)



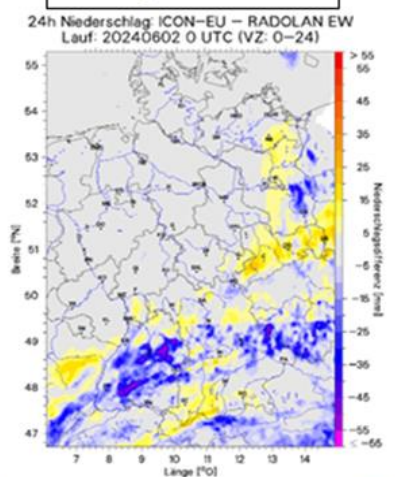
24h Niederschlag: ICON-D2 – RADOLAN EW
Lauf: 20240531 0 UTC (VZ: 0–24)



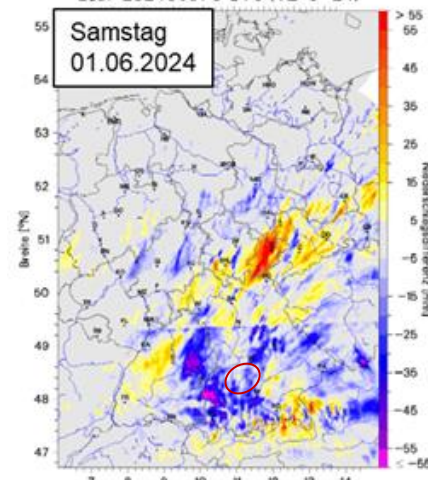
Samstag 01.06.2024



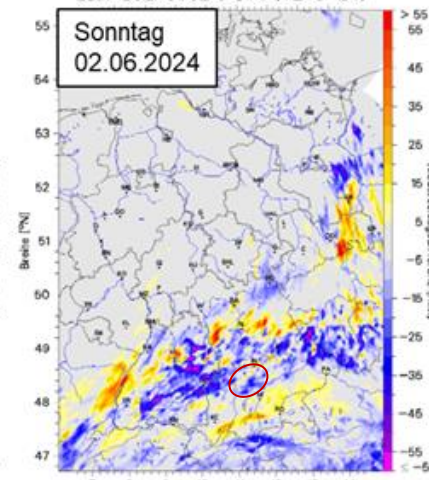
Sonntag 02.06.2024



24h Niederschlag: ICON-D2 – RADOLAN EW
Lauf: 20240601 0 UTC (VZ: 0–24)



24h Niederschlag: ICON-D2 – RADOLAN EW
Lauf: 20240602 0 UTC (VZ: 0–24)



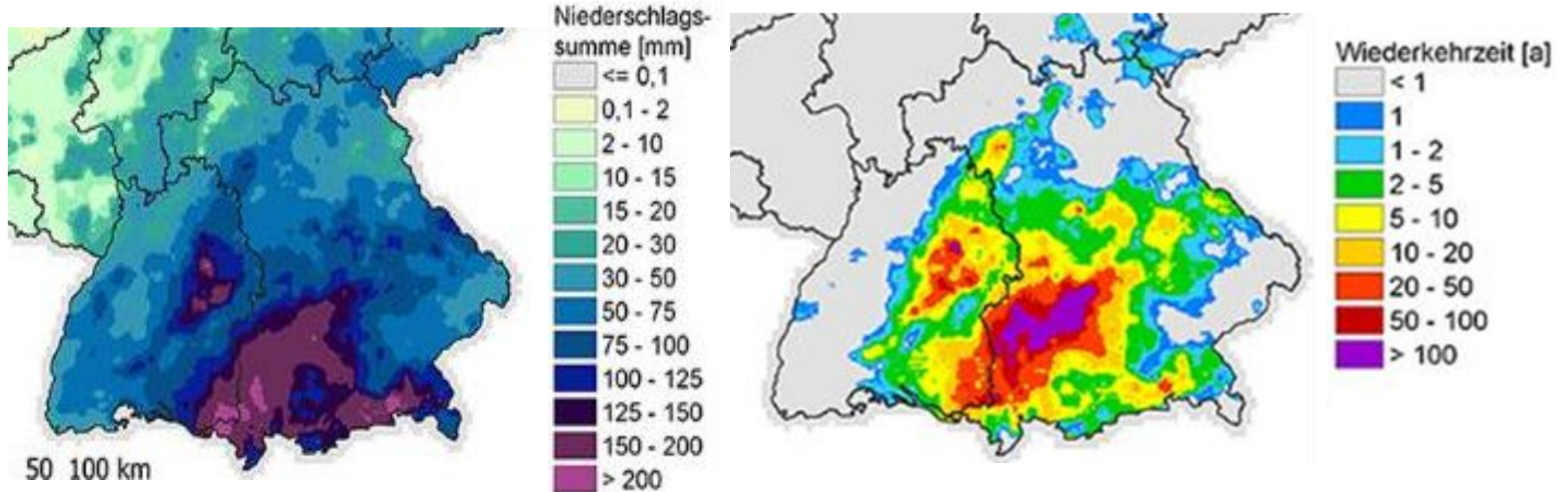
ICON-D2-Verification

colour range

ICON-D2 overestimates rainfall

ICON-D2 underestimates rainfall

Rainfall distribution June 2024 with statistics

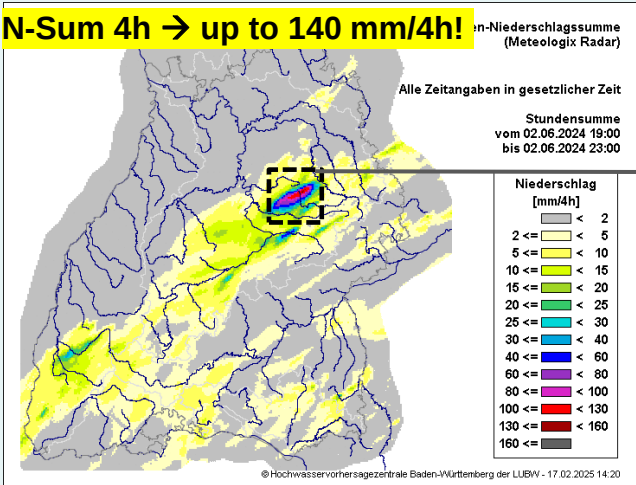


- The precipitation forecasts were significantly too low, especially for the most affected region (> N100)
- even the highest ensembles did not reflect this development
- Affected region: normally not high precipitation compared to alpine regions > severe event

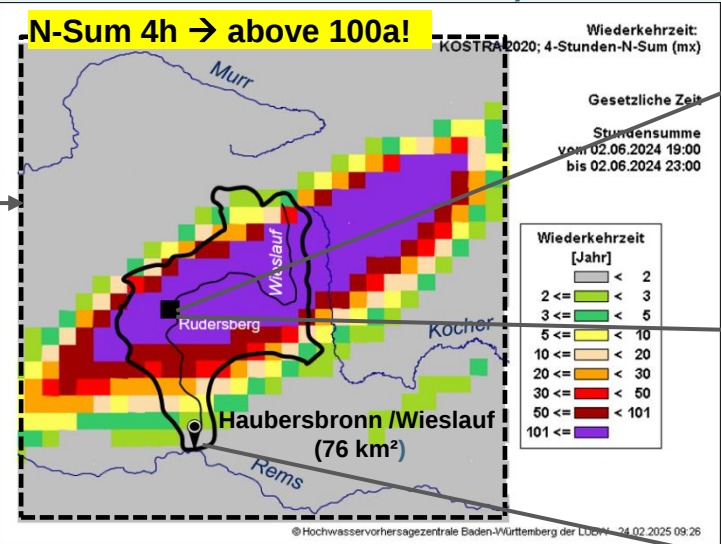
Observation: 02.06.24 - 03.06.24

Heavy Precipitation

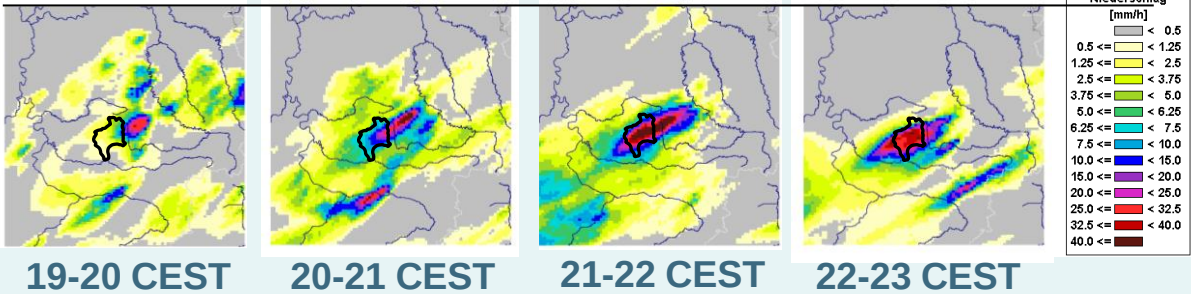
Radar
4h Accumulated Precipitation in mm
19 - 23 CEST on 02.06.24



Return period
for 4h-Precipitation (Radar and
KOSTRA-DWD-2020)



N-1h-Sum in mm up to 55 mm/h!

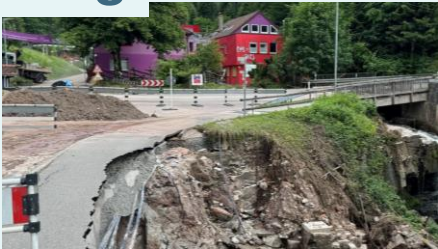


The precipitation cell persisted over an area for several hours!

Flooding

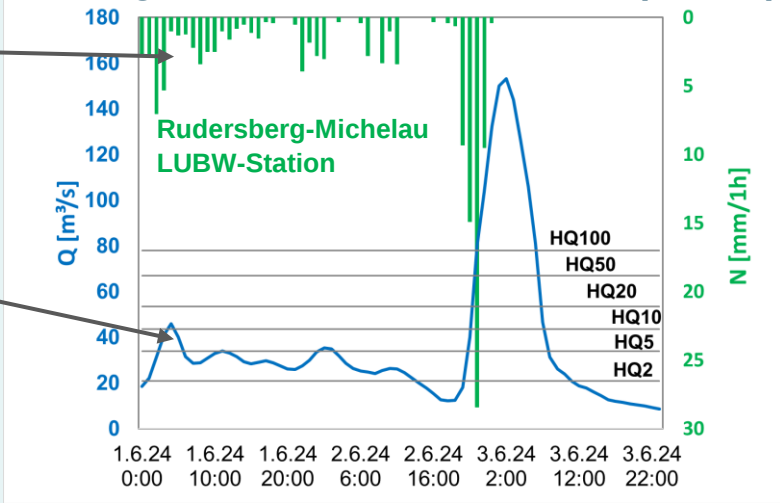


Rudersberg / Wieslauf



Wieslauftal near Rudersberg

Gauge: Haubersbronn / Wieslauf (76 km²)



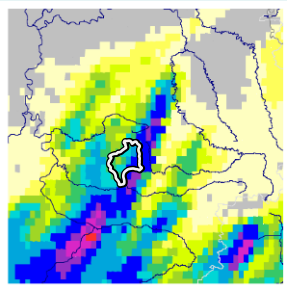
- HQ >>> 100a
- HHQ on June at 02:00 CEST since 1949

Forecast: 02.06.24 - 03.06.24

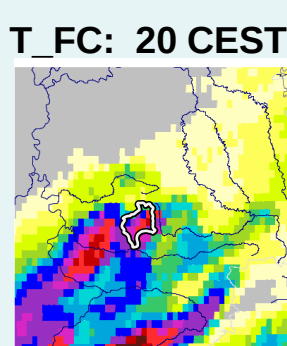
ICON D2 det, DWD VHS 48h

4h Accum. Precipitation in mm
19 - 23 CEST on 02.06.24

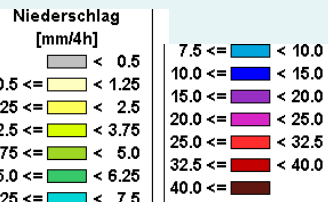
T_FC: 17 CEST



T_FC: 20 CEST

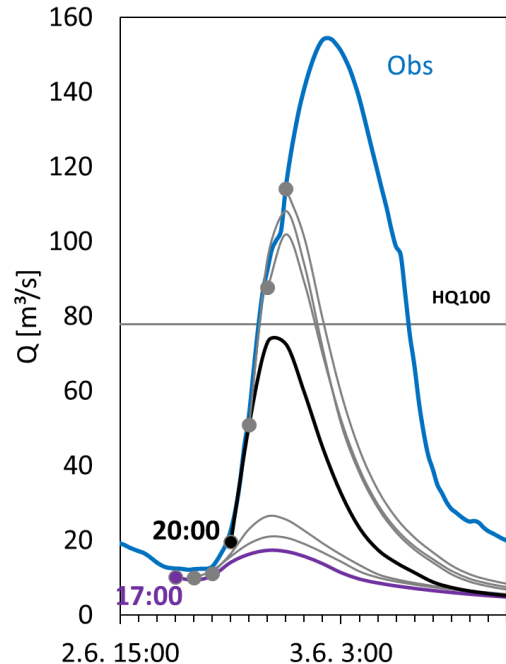


4h-Accum. in 20-00



LARSIM

HVZ „Best Guess“-
Forecast upto 48h based
on ICON-D2 Forecast

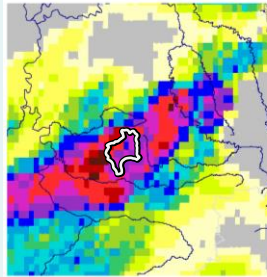


Sinfony- Intense EPS, DWD VHS 12h, 21 member

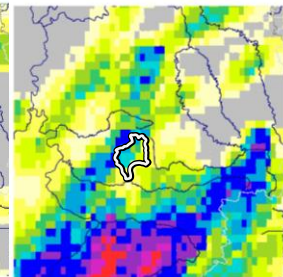
4h Accum. Precipitation in mm: 19 - 23 CEST on 02.06.24

T_FC: 17 CEST

m14 (max)

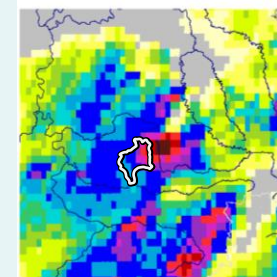


m00 (min)



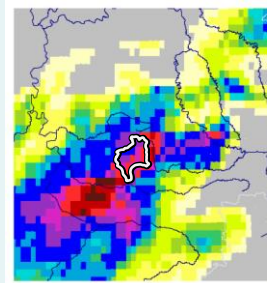
T_FC: 19 CEST

m00 (~median)

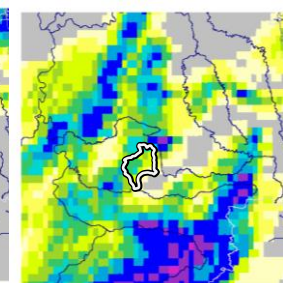


T_FC: 18 CEST

m14 (max)

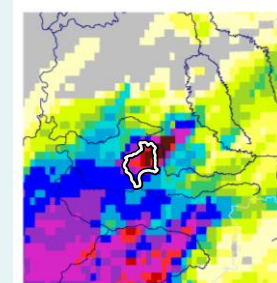


m00 (min)



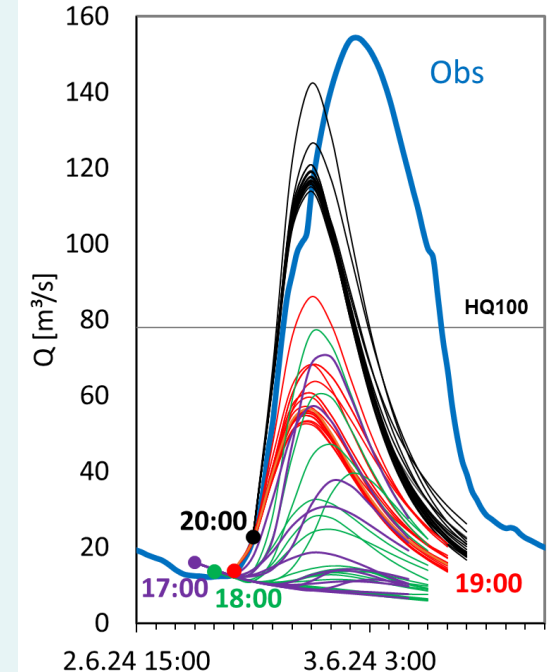
T_FC: 20 CEST

m00 (~median)



LARSIM

Sinfony- Intense - in operational test
mode since summer 2024



ICON D2 vs Sinfony- Intense EPS:

- Intense: Up-to-date information through hourly rapid updates. Clear detection of the cell by 19 CEST in every ensemble member
- Intense: High variability in forecasts between ensemble members at earlier forecast times (17 und 18 CEST) : ranging from mean flow to HQ100



Were the
task forces
able to
properly
mitigate the
flood?

