



# Combination of meteorological nowcasting and ensemble methods in operational flood forecasting

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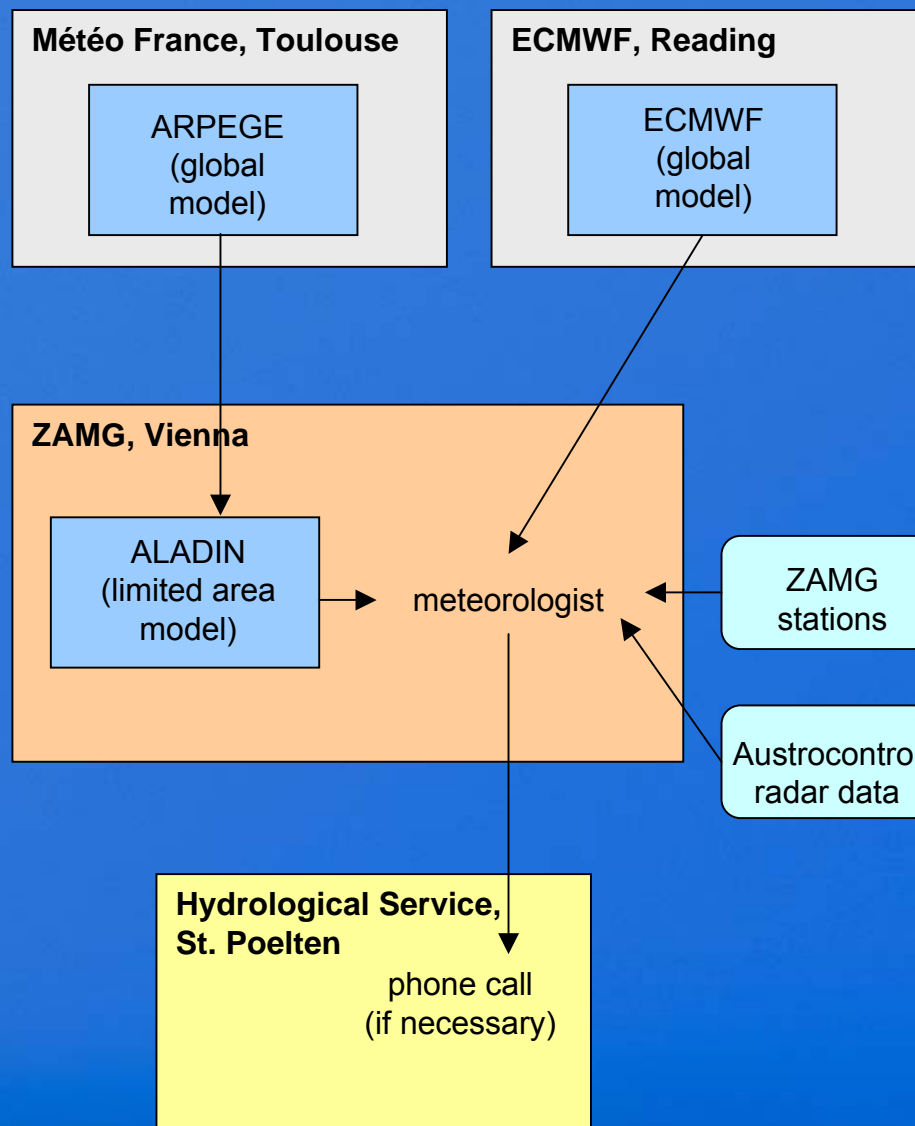


- Motivation & goals
- Description of the meteorological forecasting system „INCA“
- Forecast quality
- Case studies
- Conclusions and outlook



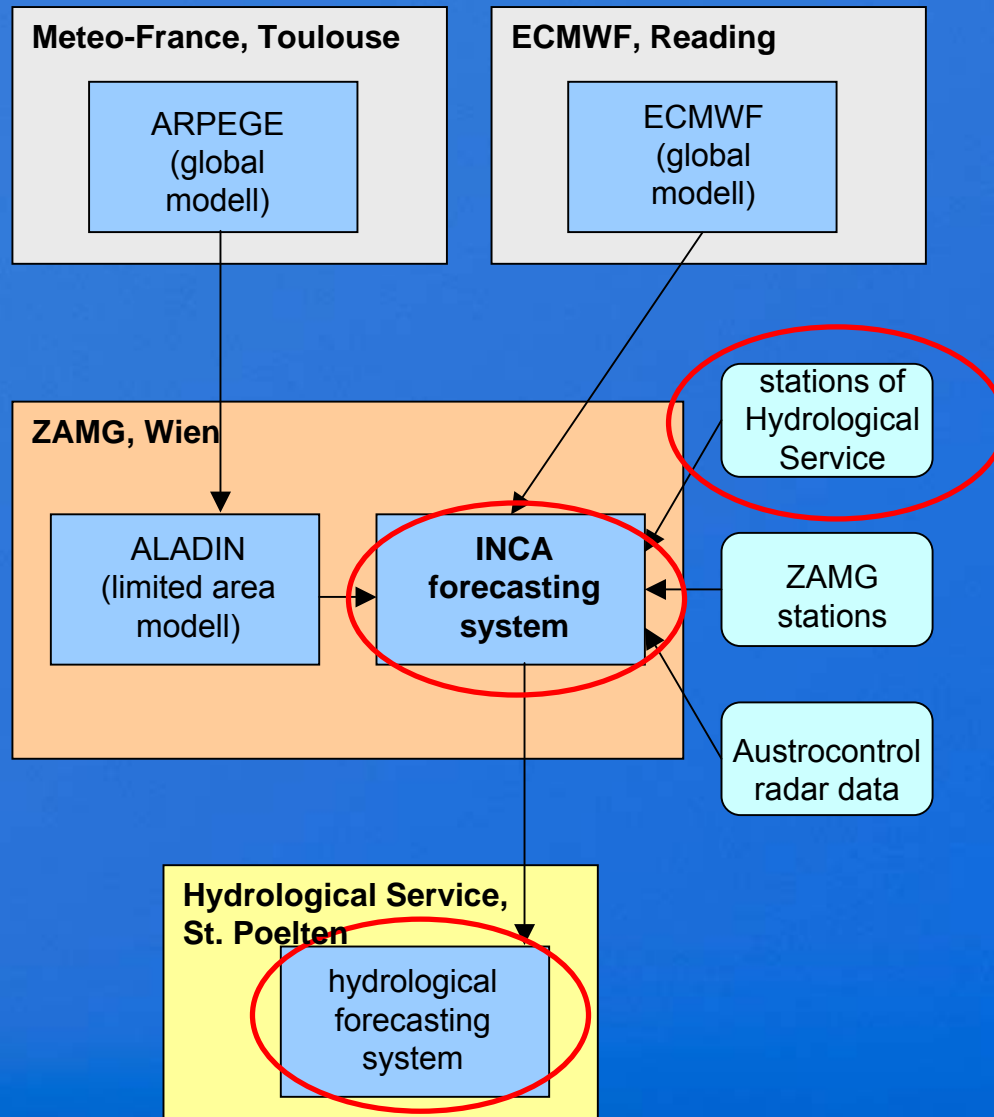
# 1. Motivation & goals

# Motivation & goals (1)



situation at  
the start of  
the project  
(2004)

# Motivation & goals (2)



operational  
system  
(2006)



## INCA forecasting system:

- Combination of numerical weather prediction (NWP) models and nowcasting techniques to create the best possible automatic short-range forecast at a very high temporal and spatial resolution



## 2. Description of the meteorological forecasting system „INCA“

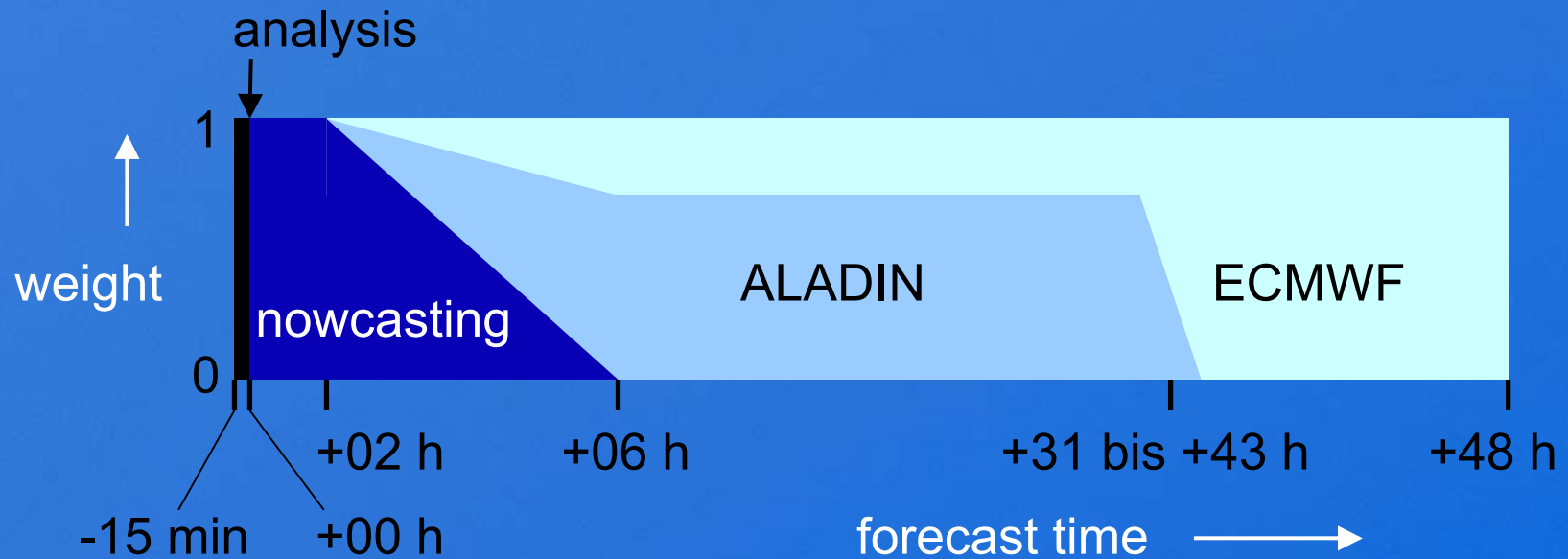


- INCA: „integrated nowcasting through comprehensive analysis“
- Forecasts of temperature, humidity, wind, cloud cover and precipitation
- High spatial ( $\Delta x = 1$  km) and temporal resolution ( $\Delta t = 15$  min)
- Forecast horizon: 48 hours
- Initialization: every 15 min (60 min)
- Available 20...25 min after initialization
- Ensemble precipitation forecasts on a coarser grid ( $\Delta x = 10$  km)





## INCA precipitation forecast:



update frequency:

ECMWF	12 h	(available at +9 h)	} NWP part
ALADIN	12 h	(available at +5 h)	
nowcasting	15 min	(available at +20...25 min)	



## NWP part:

- deterministic run + 51 ensembles
- OPT („optimized“) forecast is created by a combination of ECMWF and ALADIN:

$$P_{OPT} = w_{ALA} P_{ALA} + w_{ECM} P_{ECM}$$

weights of ALADIN and ECMWF  
(example)



## NWP part (continued):

- ECMWF: 51 ensemble runs
- ALADIN: 25 „artificial“ ensembles through limited shift of precipitation fields  
(example)



## Analysis part :

1. Interpolation of station precipitation measurements (distance weighting,  $n = 2$ )
2. Climatological pre-scaling of radar data
3. Individual calibration of radar data by a linear regression with neighbouring stations
4. Interpolation of radar precipitation at the station points (similar to 1.)
5. Analysis = sum of station precipitation field and radar structures  
(example)



## Nowcast part :

1. Calculation of motion vectors from two consecutive analyses and plausibility check with NWP model
2. Extrapolation of precipitation analysis (example)
3. Combination with NWP part => final INCA forecast  
(example – forecast for the Kamp catchment)



### 3. Forecast quality



- NWP part: „optimized“ forecast is about 20...30% better than ALADIN or ECMWF alone
- Nowcasting leads to significant improvement of forecast quality during the first ~2 hours
- Ensemble runs help the forecaster to estimate the forecast uncertainty (qualitatively)
- Is there any „active“ information e.g. in the ensemble median? => we don't know yet



## 4. Case studies





## Selected precipitation events over the Kamp catchment:

- Large-scale precipitation event
- Convective precipitation event



## 5. Conclusions and outlook



## Conclusions about INCA:

- Quantification and automatisisation of precipitation forecasts, e.g. (but not only) for hydrological purposes
- Significant improvement of forecast quality in nowcasting period (<6 hours) as compared to NWP models
- Best possible forecast beyond nowcasting period, but still some uncertainties
- Continuous monitoring of forecasts seems to be crucial!



## Outlook:

- Improvement of ensemble range scaling  
(example)
- Implementation of a conceptual life cycle model of convective precipitation cells
- Statistical optimization
- ...

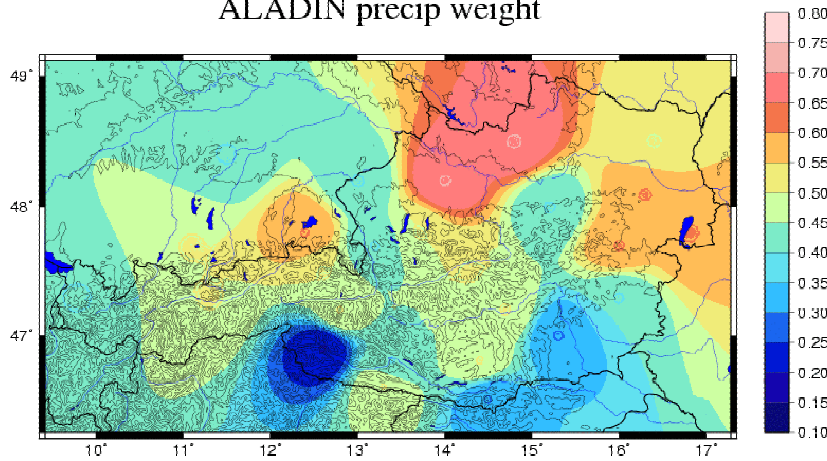
=> Hopefully, further improvements of forecast quality can be achieved



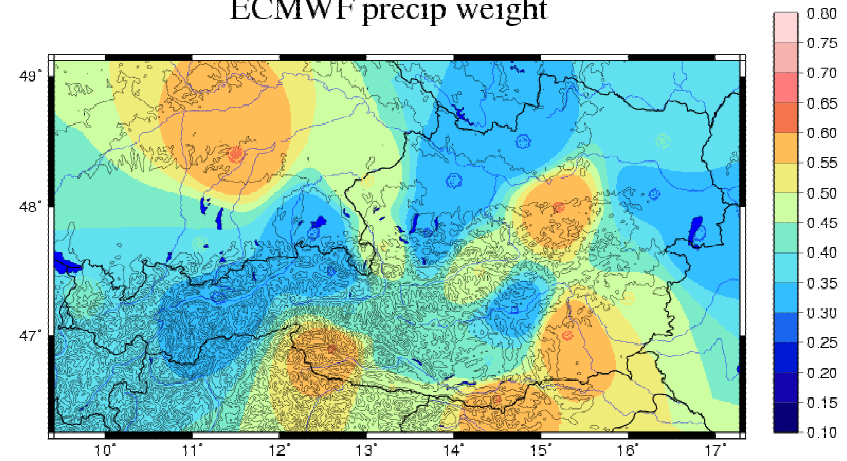
Thank you for your attention!



ALADIN precip weight



ECMWF precip weight

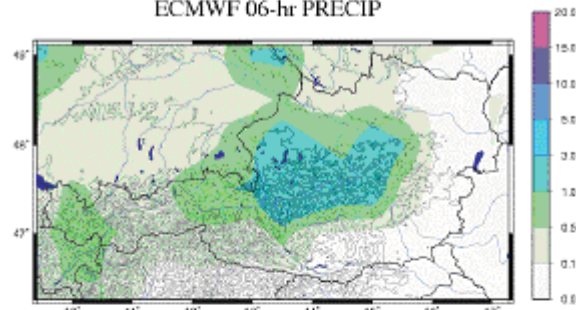


optimum weight for the Kamp catchment: 70% ALADIN  
+ 30% ECMWF

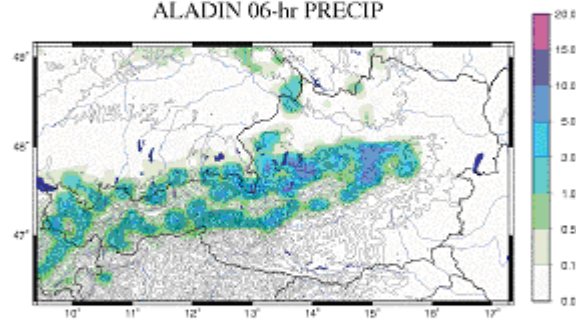
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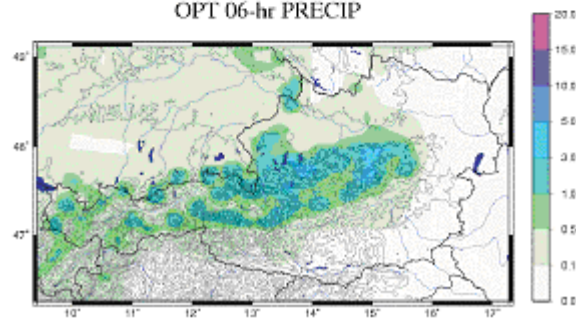
ECMWF 06-hr PRECIP



ALADIN 06-hr PRECIP



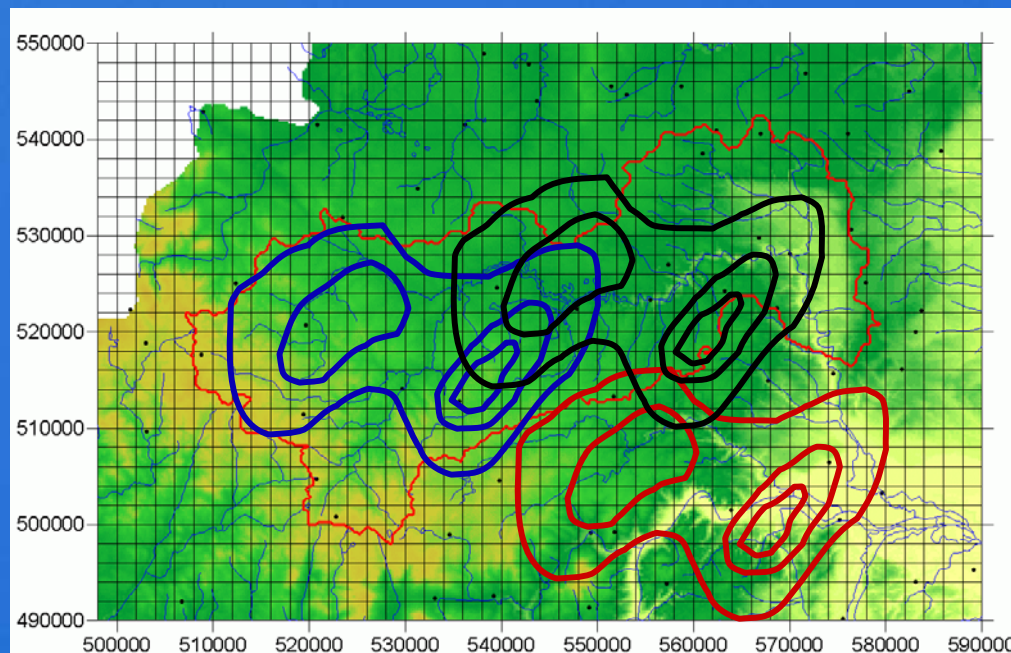
OPT 06-hr PRECIP



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## Maximum shift of precipitation field:

- 20 km in N-/S-direction
- 40 km in W-/E-direction



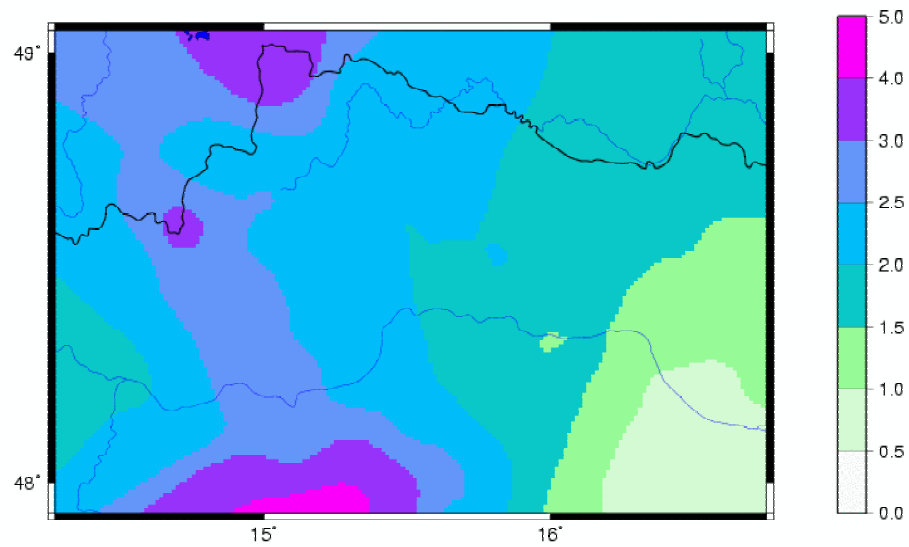
map: Vienna University of Technology

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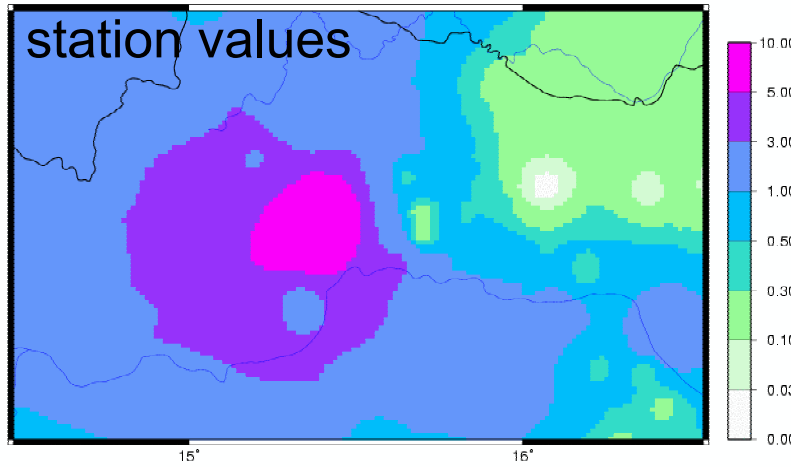
### INCA climscaling TAWHYD/RADAR 05-08\_P



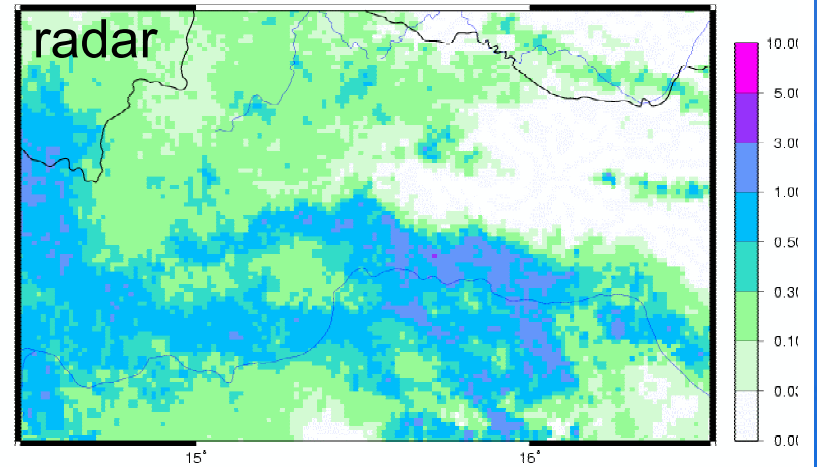
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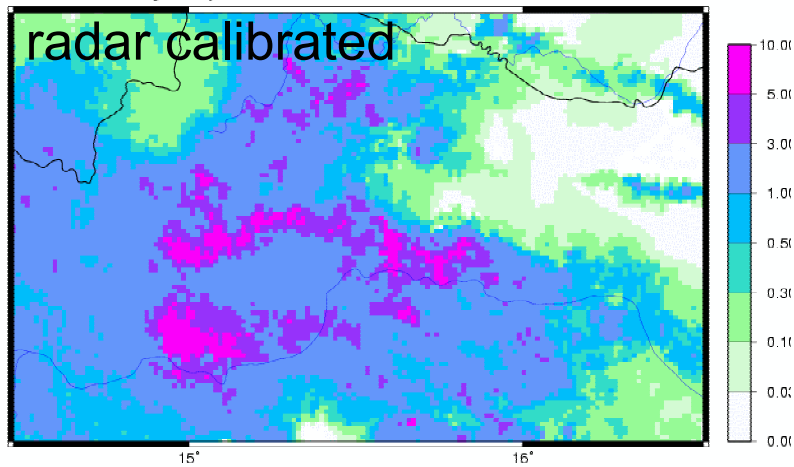
INCA Precip Analysis (mm/15min) 20020806 2230Z



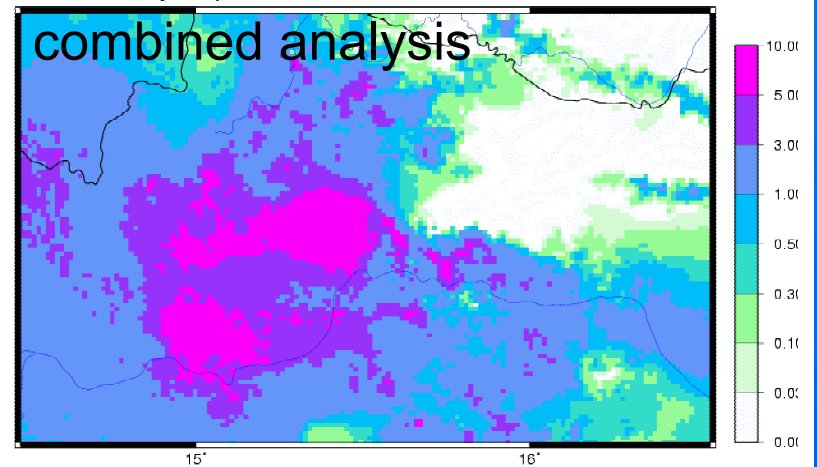
INCA Precip Analysis (mm/15min) 20020806 2230Z



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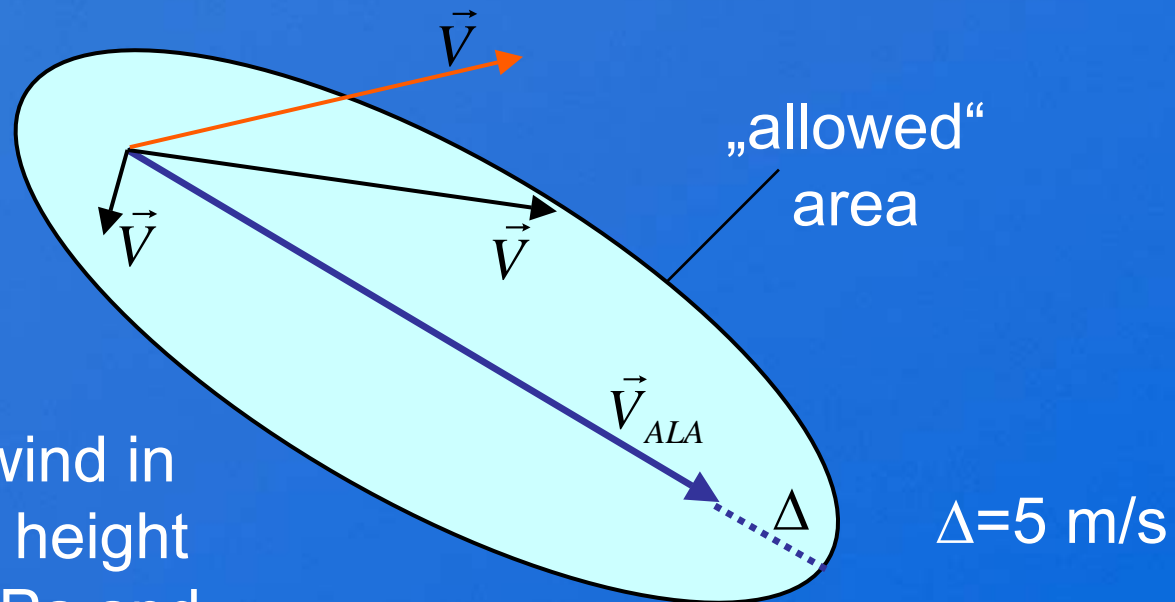


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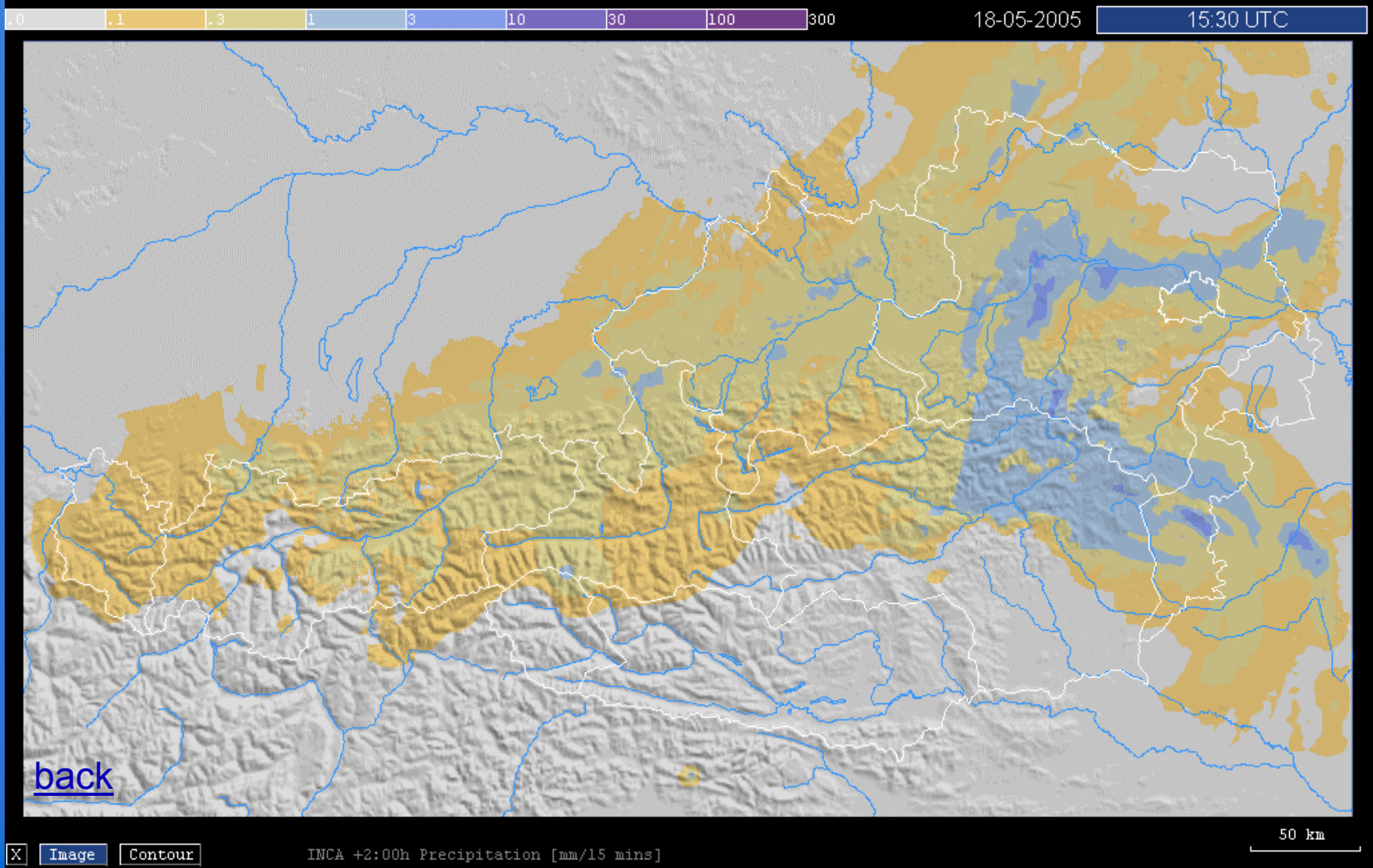
plausibility check:

$$|\vec{V}| + |\vec{V} - \vec{V}_{ALA}| \leq |\vec{V}_{ALA}| + 2\Delta$$

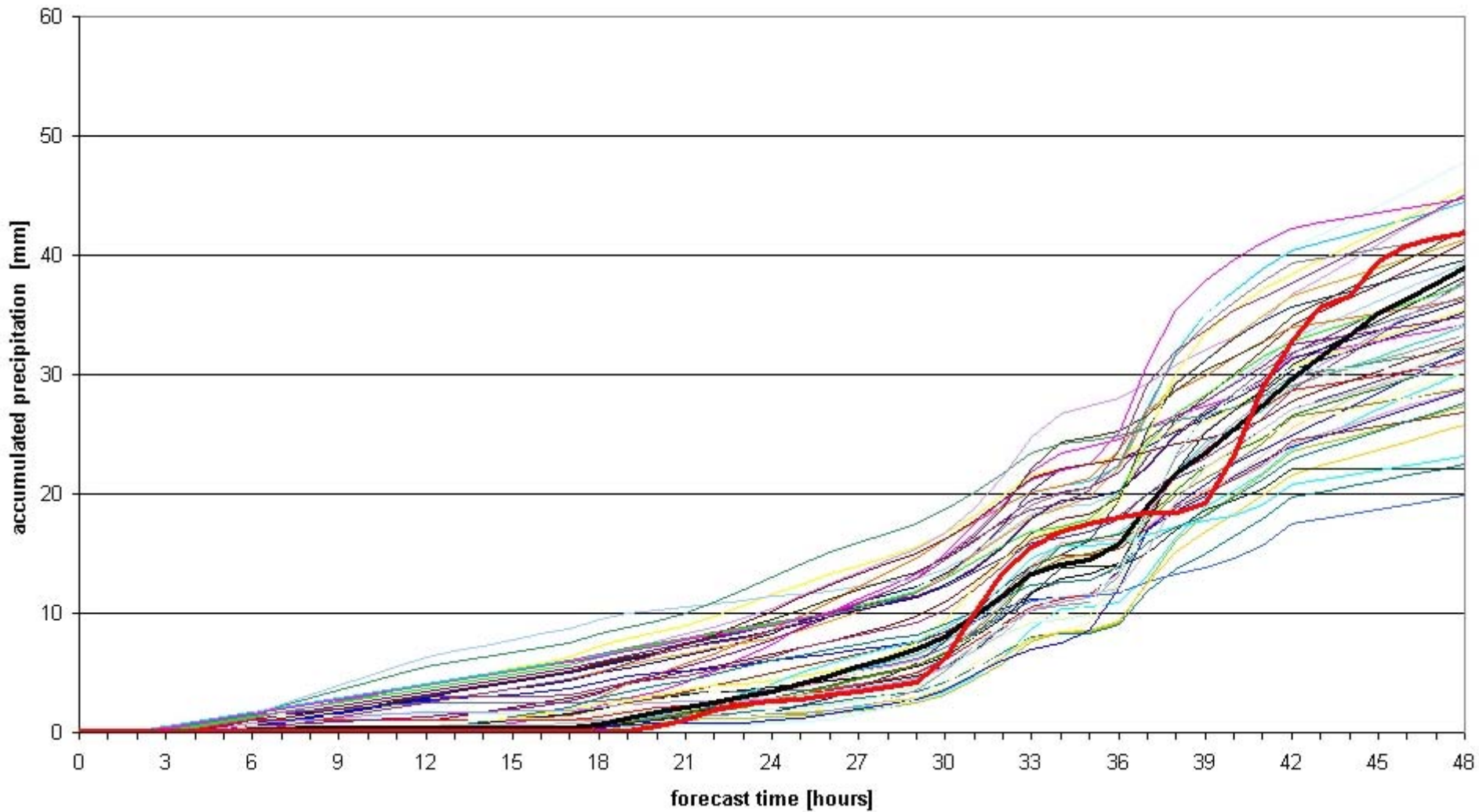


check with wind in  
two different height  
levels (700 hPa and  
500 hPa)

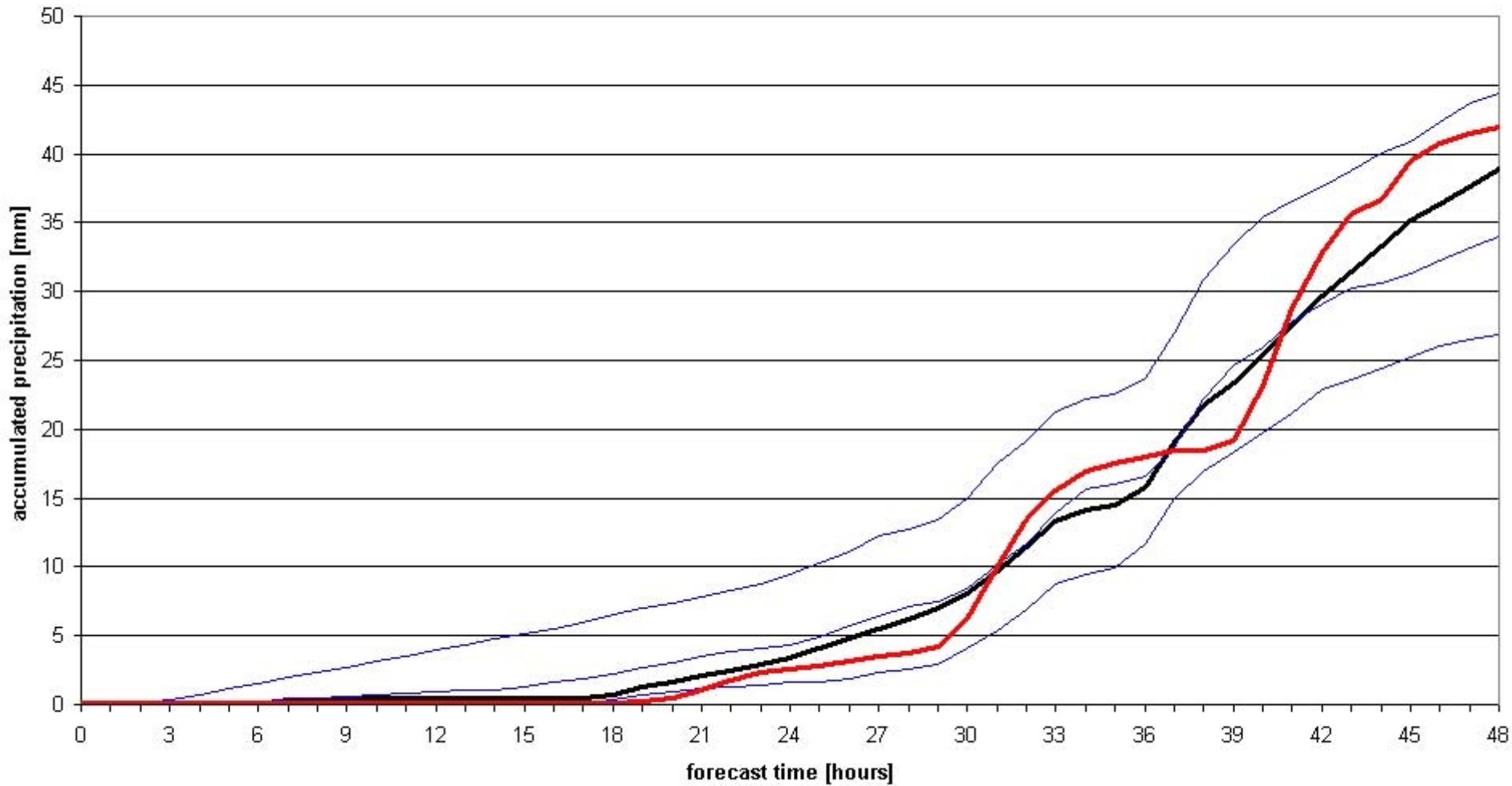
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## INCA precipitation forecast for the Kamp catchment, 20050708 1800 UTC

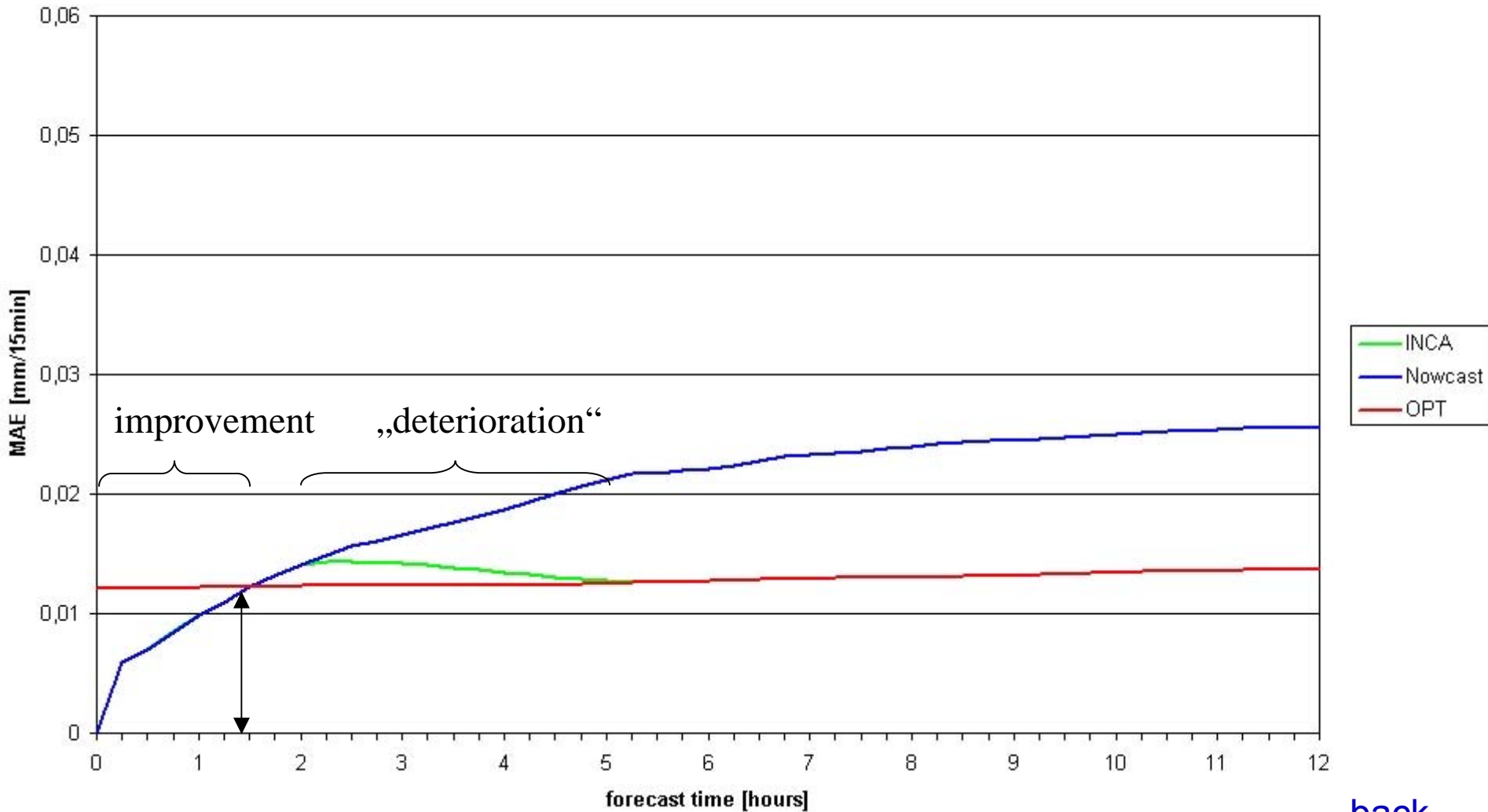


## INCA precipitation forecast for the Kamp catchment, 20050708 1800 UTC

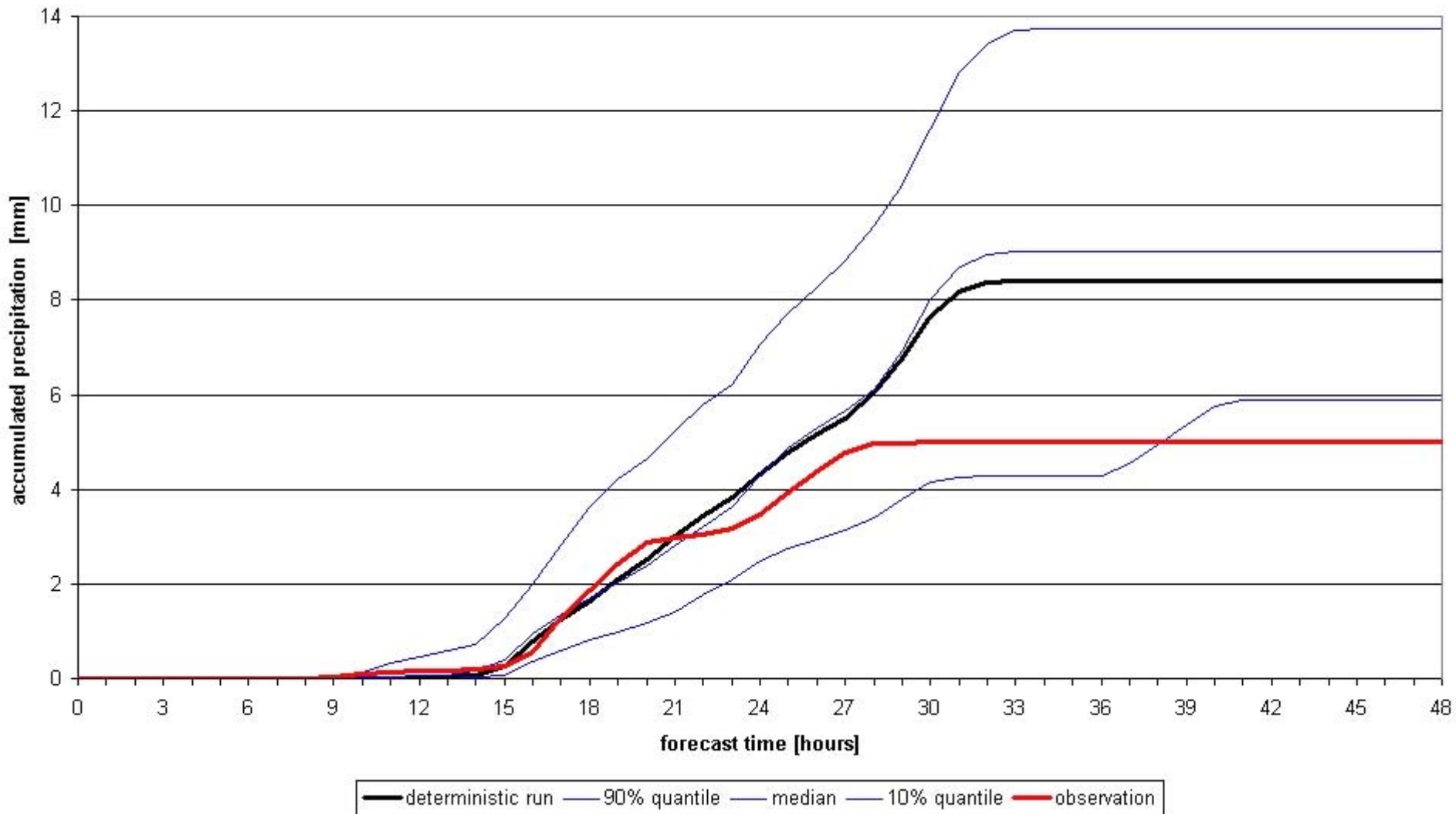
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— deterministic run — 90% quantile — median — 10% quantile — observation

## MAE Kamp catchment, 20050901 - 20060327 (appr. 17000 cases)

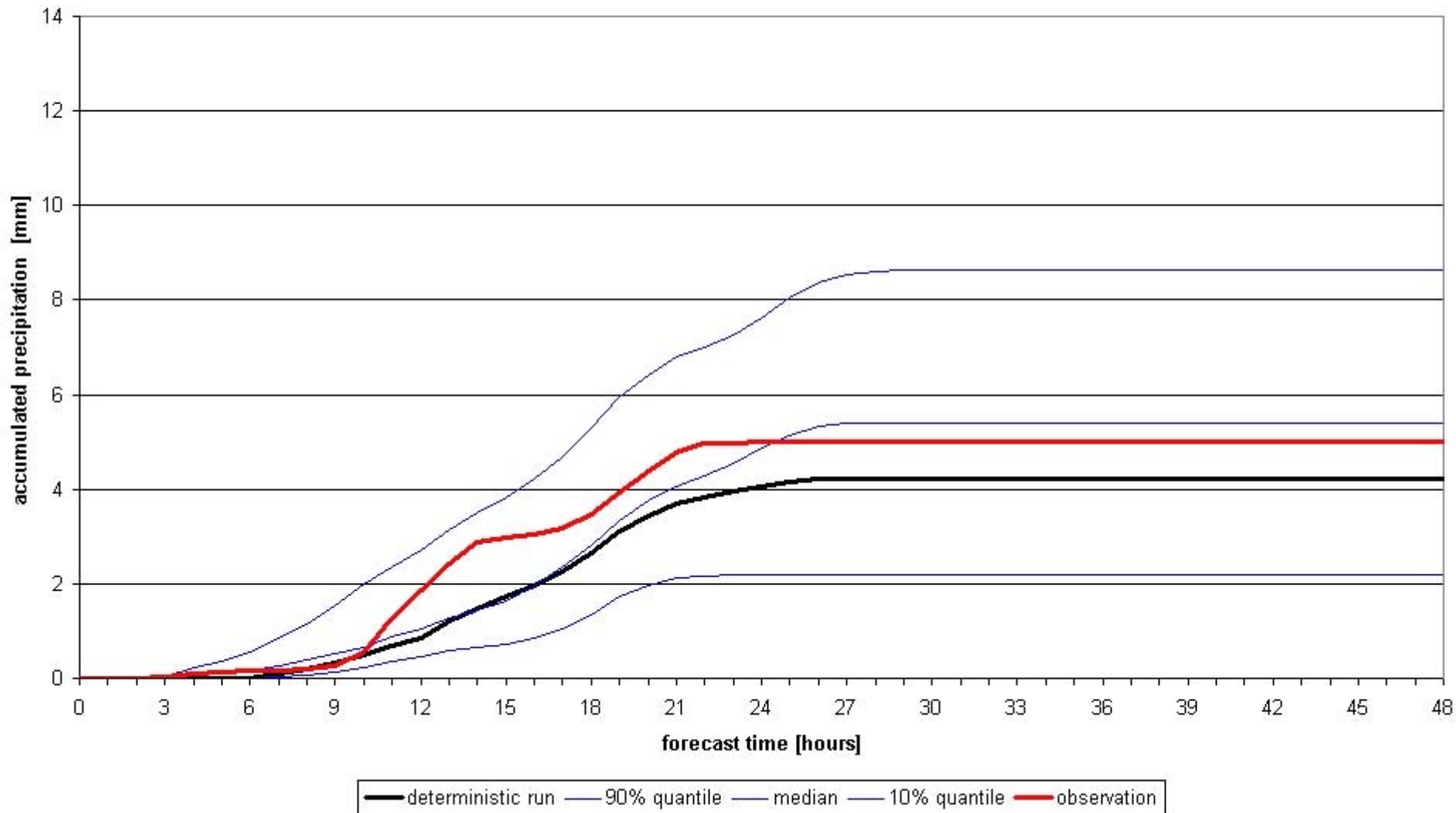
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## INCA precipitation forecast for the Kamp catchment, 20050318 1200 UTC

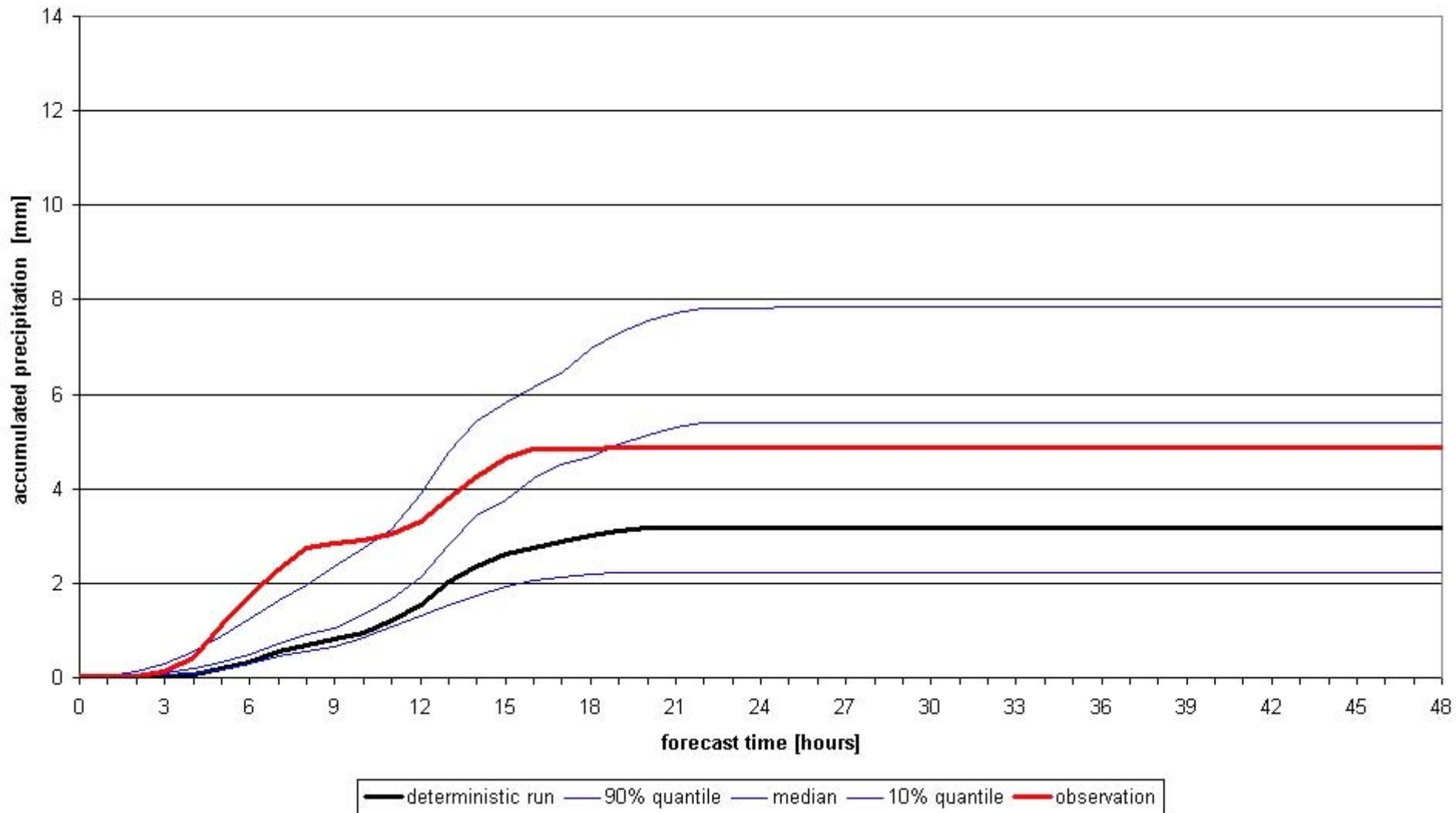




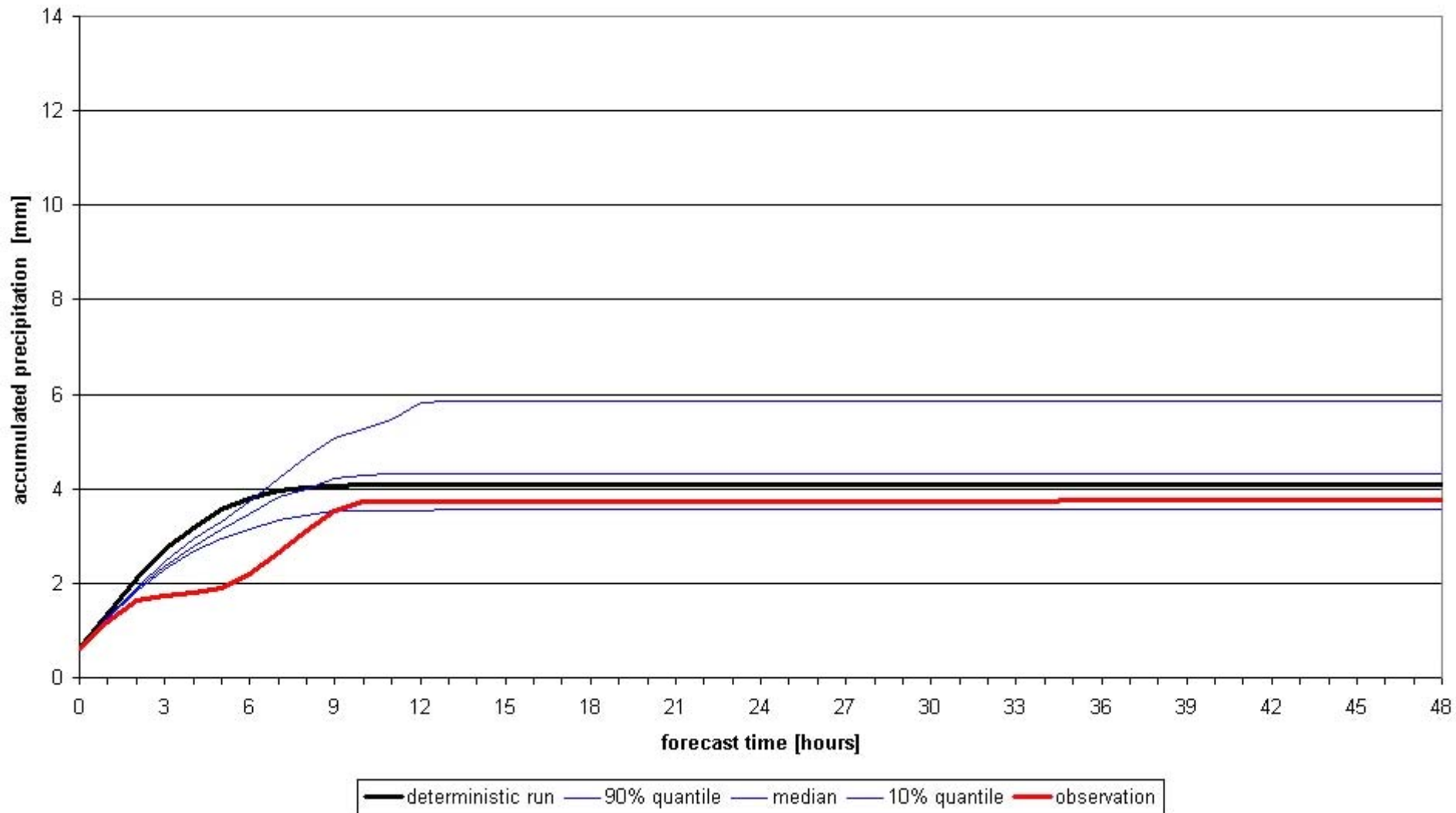
## INCA precipitation forecast for the Kamp catchment, 20050318 1800 UTC



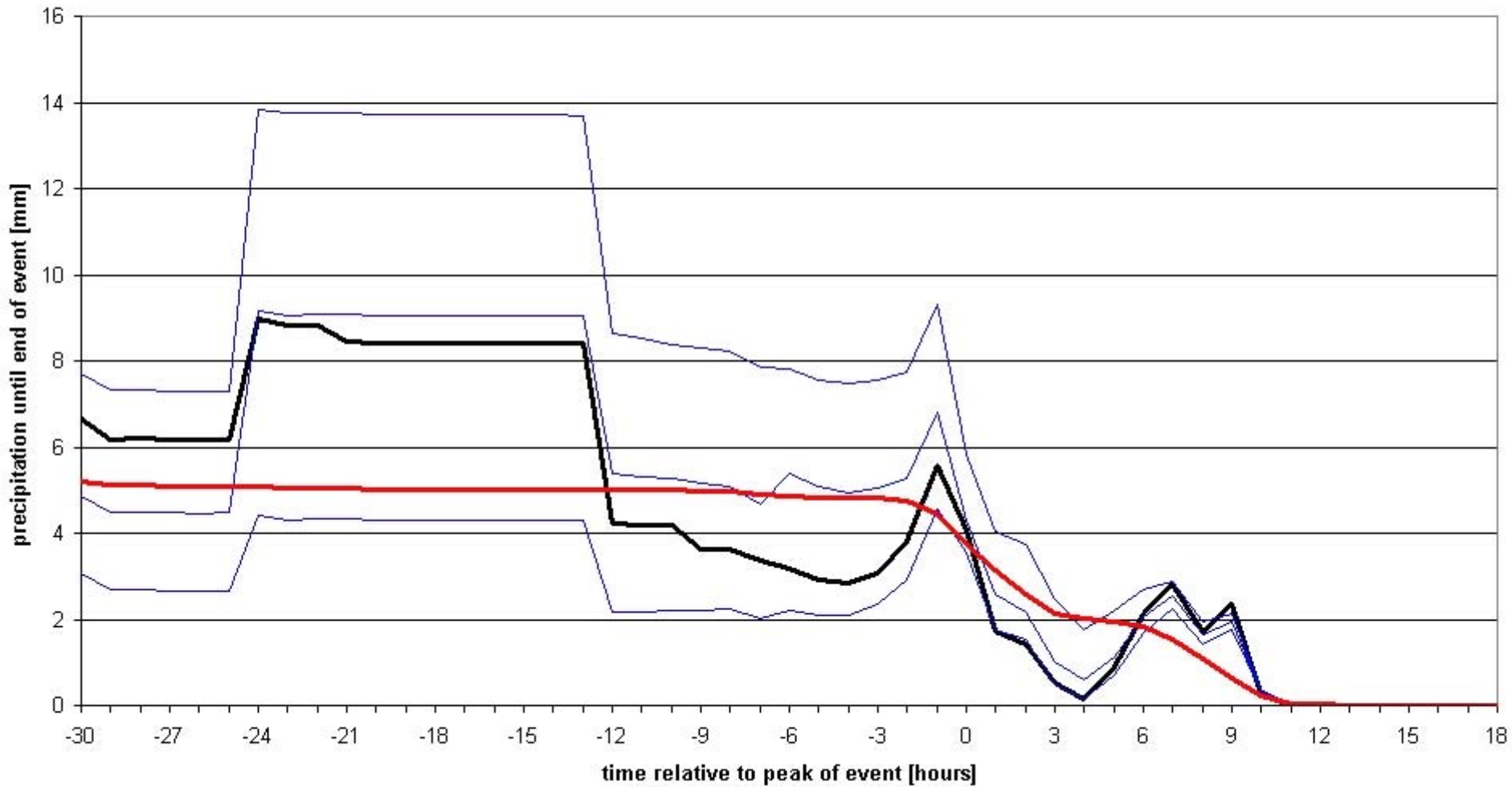
## INCA precipitation forecast for the Kamp catchment, 20050319 0000 UTC



## INCA precipitation forecast for the Kamp catchment, 20050319 0600 UTC

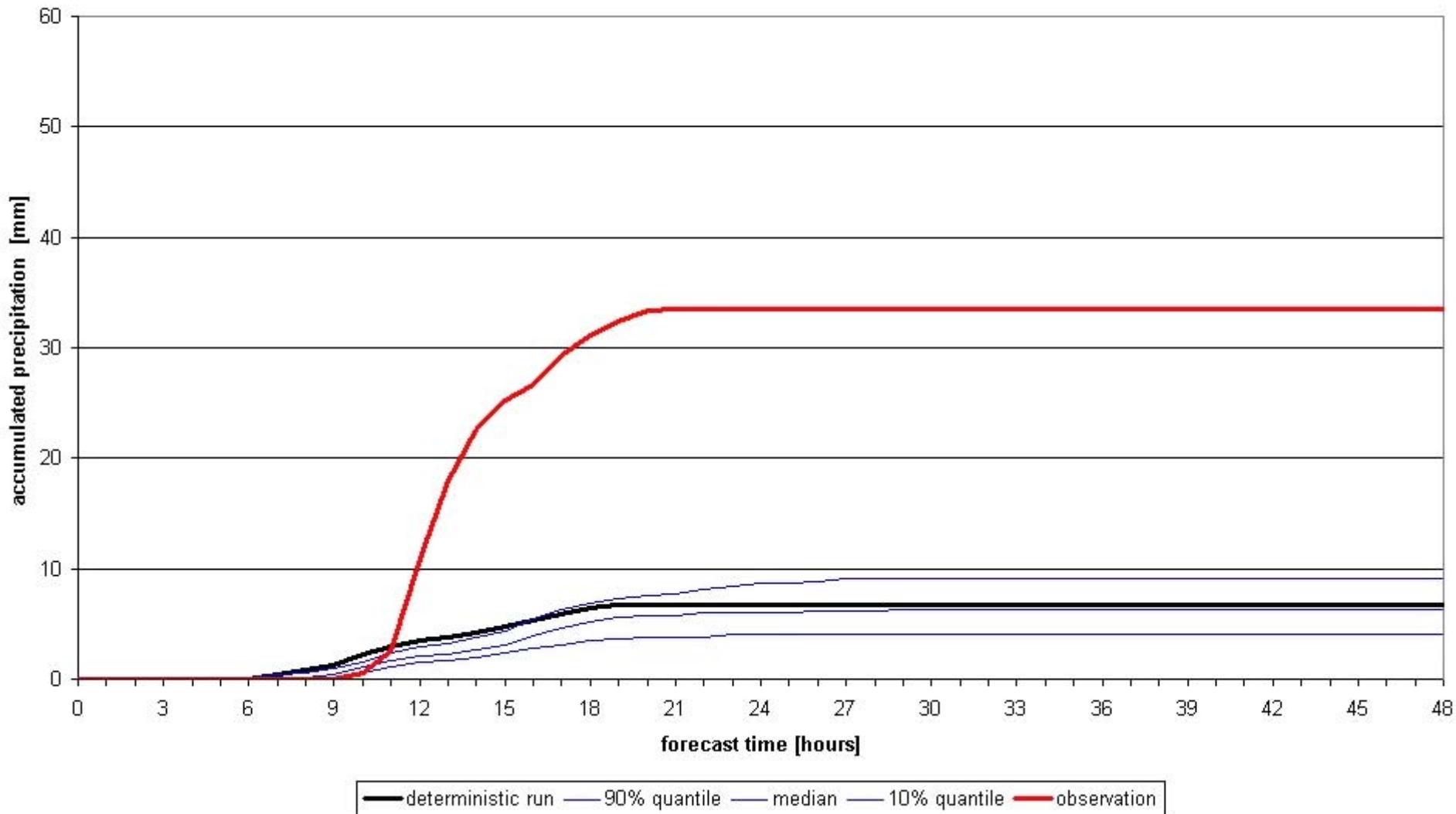


## case study: large-scale precipitation event (20050319)

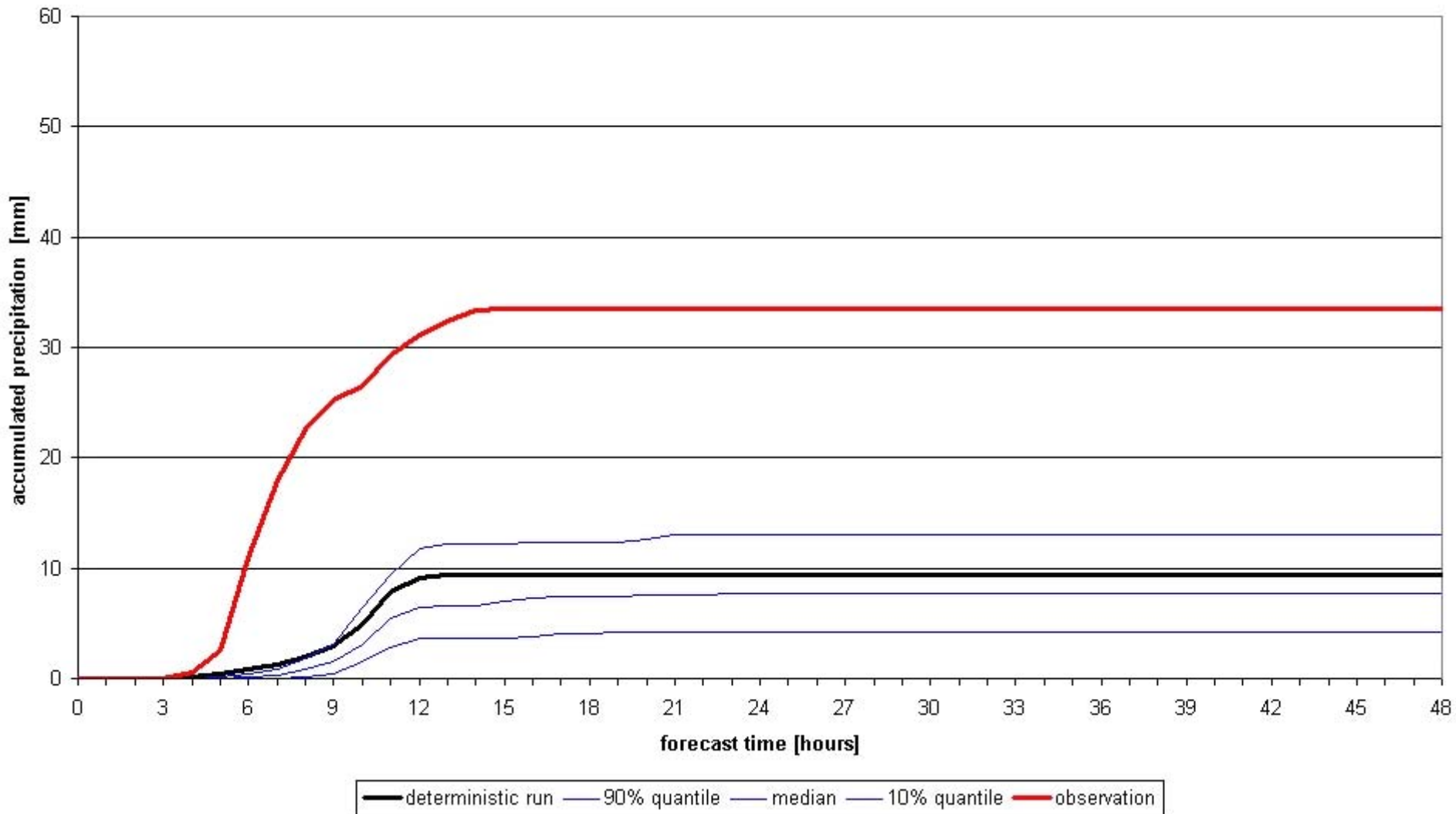
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— deterministic run — 90% quantile — median — 10% quantile — observation

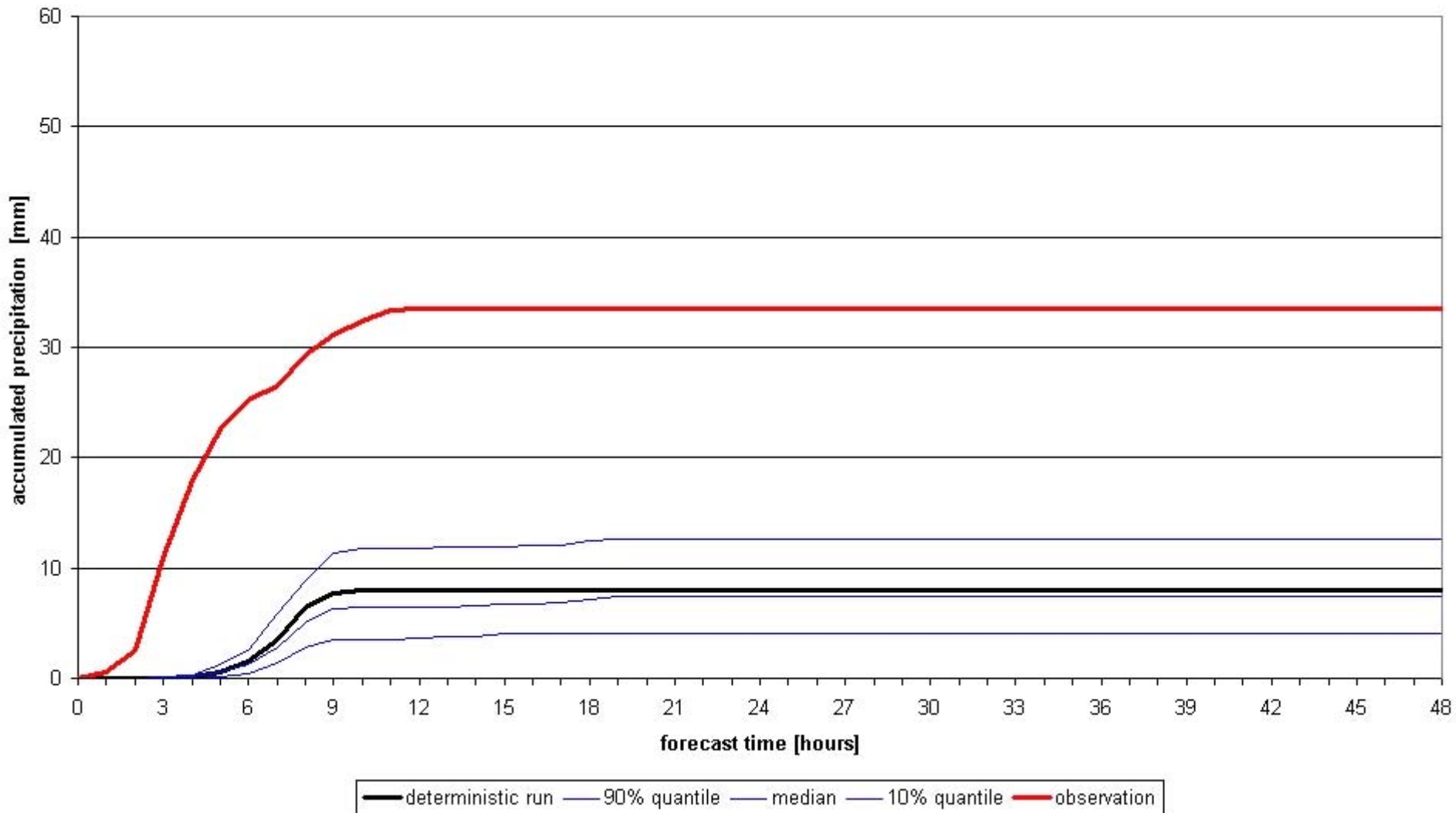
## INCA precipitation forecast for the Kamp catchment, 20050523 0300 UTC



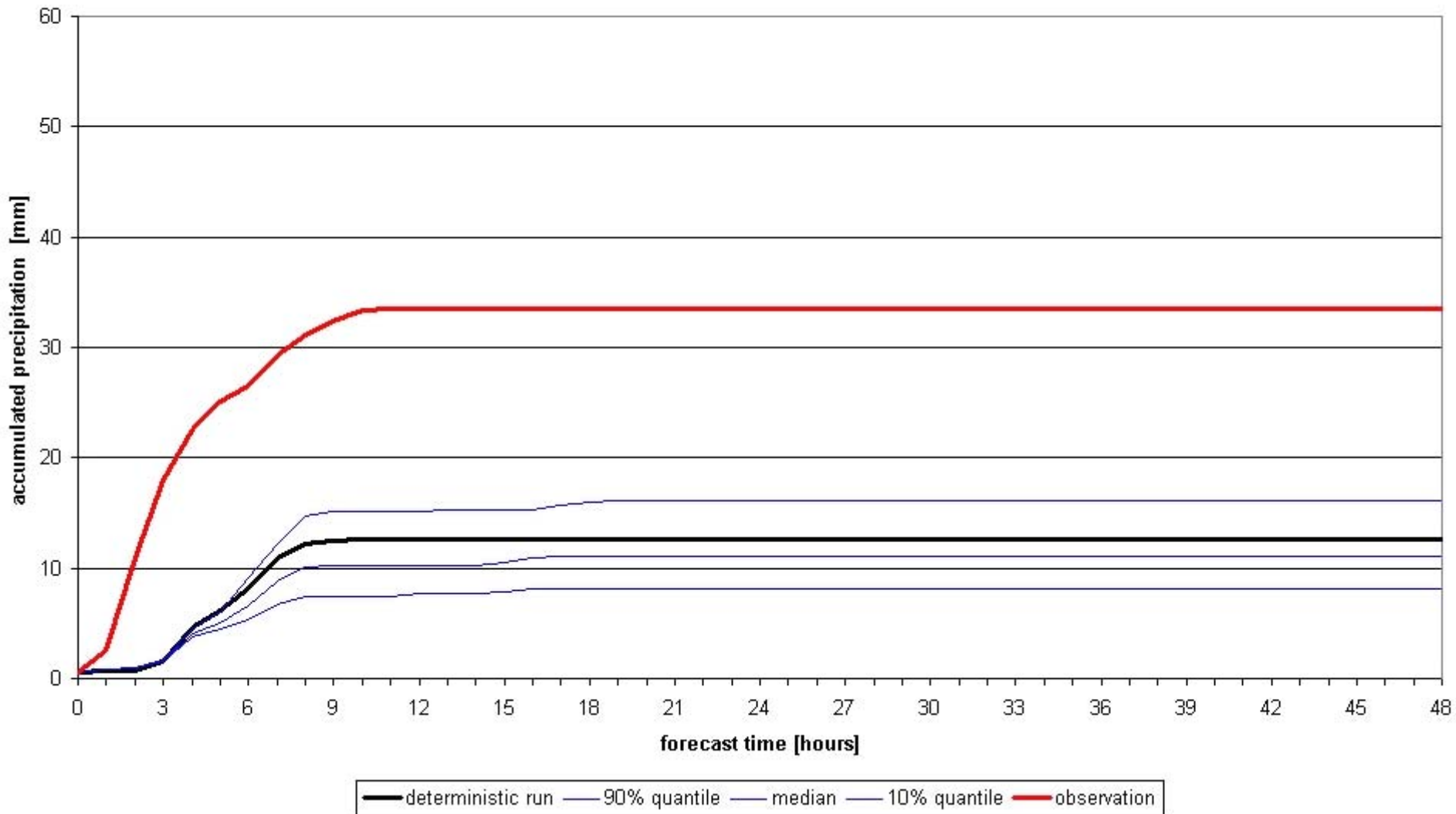
## INCA precipitation forecast for the Kamp catchment, 20050523 0900 UTC



## INCA precipitation forecast for the Kamp catchment, 20050523 1200 UTC

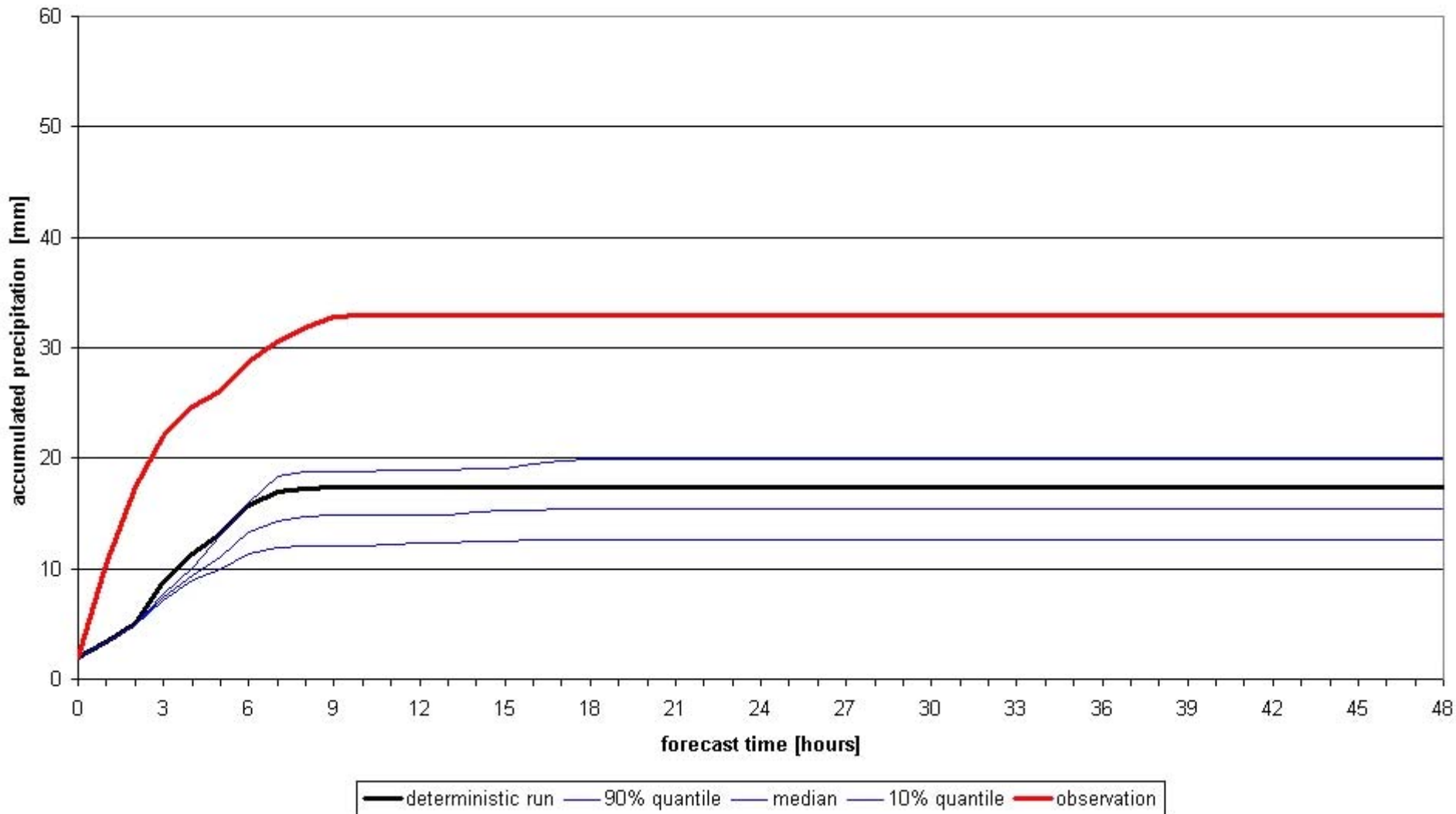


## INCA precipitation forecast for the Kamp catchment, 20050523 1300 UTC

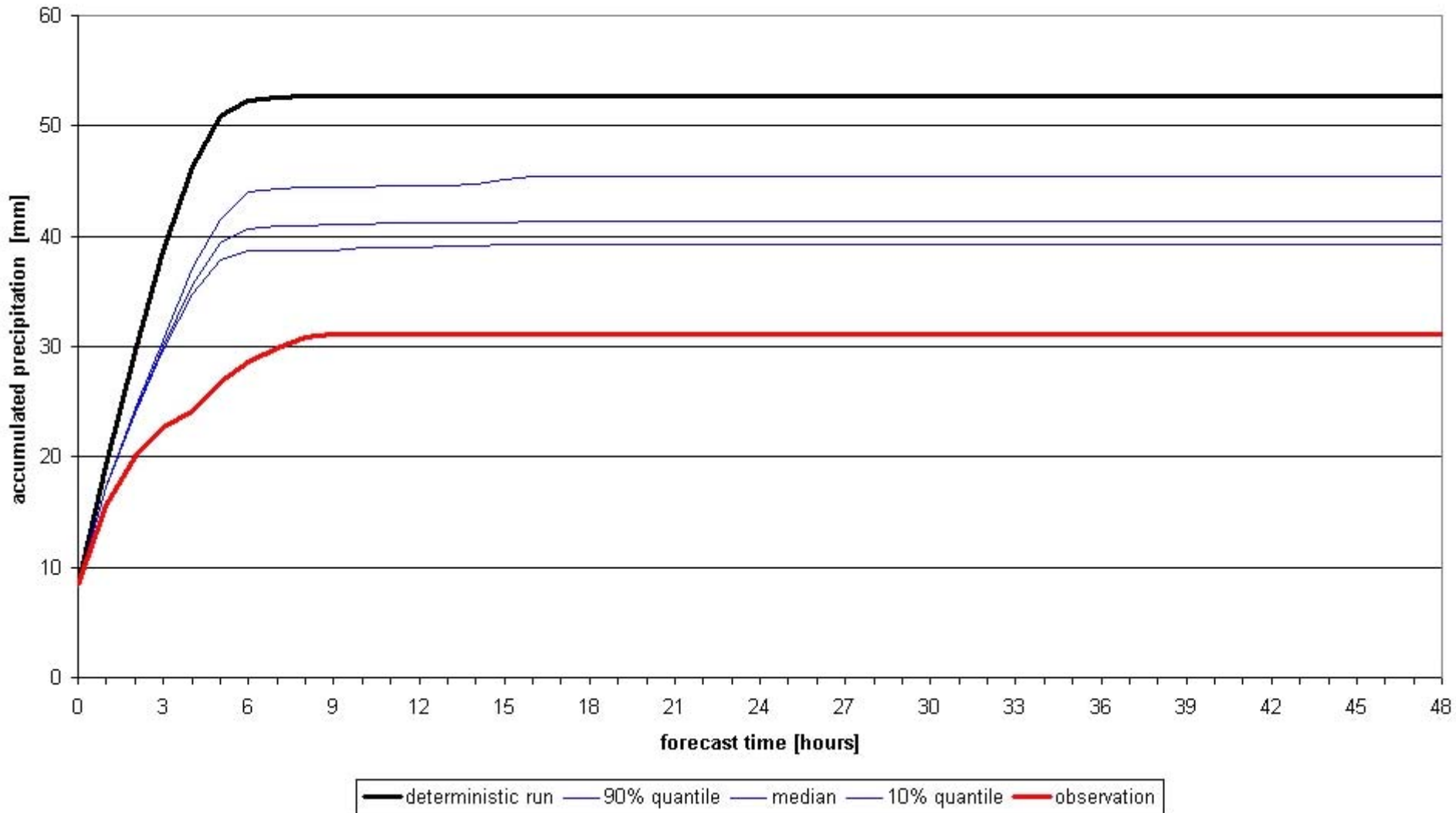




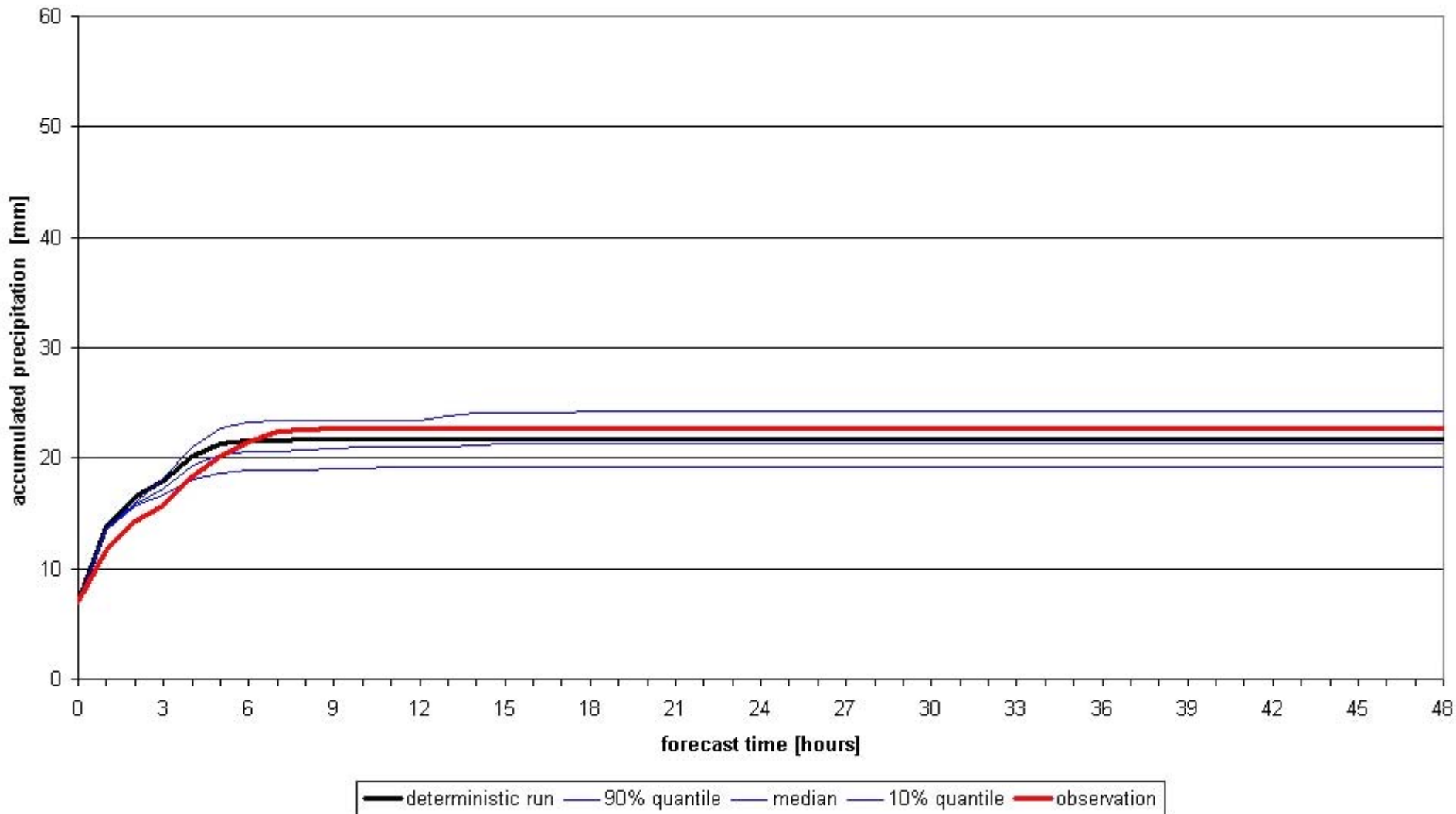
## INCA precipitation forecast for the Kamp catchment, 20050523 1400 UTC



### INCA precipitation forecast for the Kamp catchment, 20050523 1500 UTC

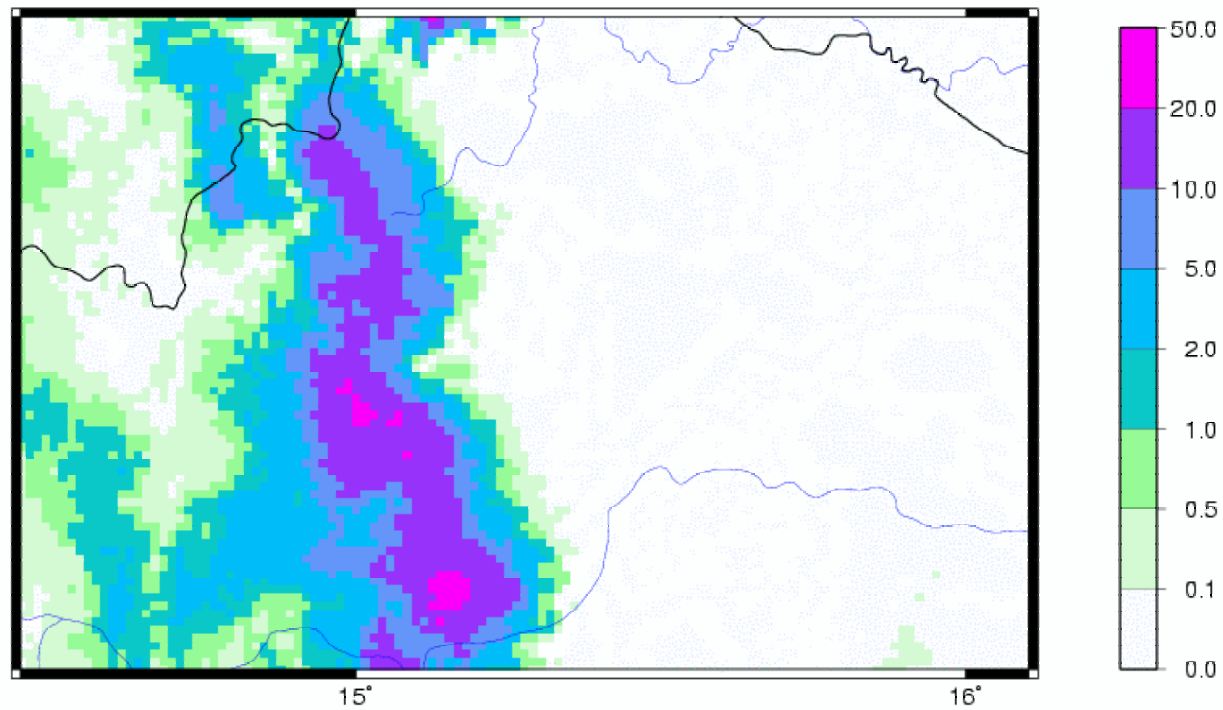


## INCA precipitation forecast for the Kamp catchment, 20050523 1600 UTC

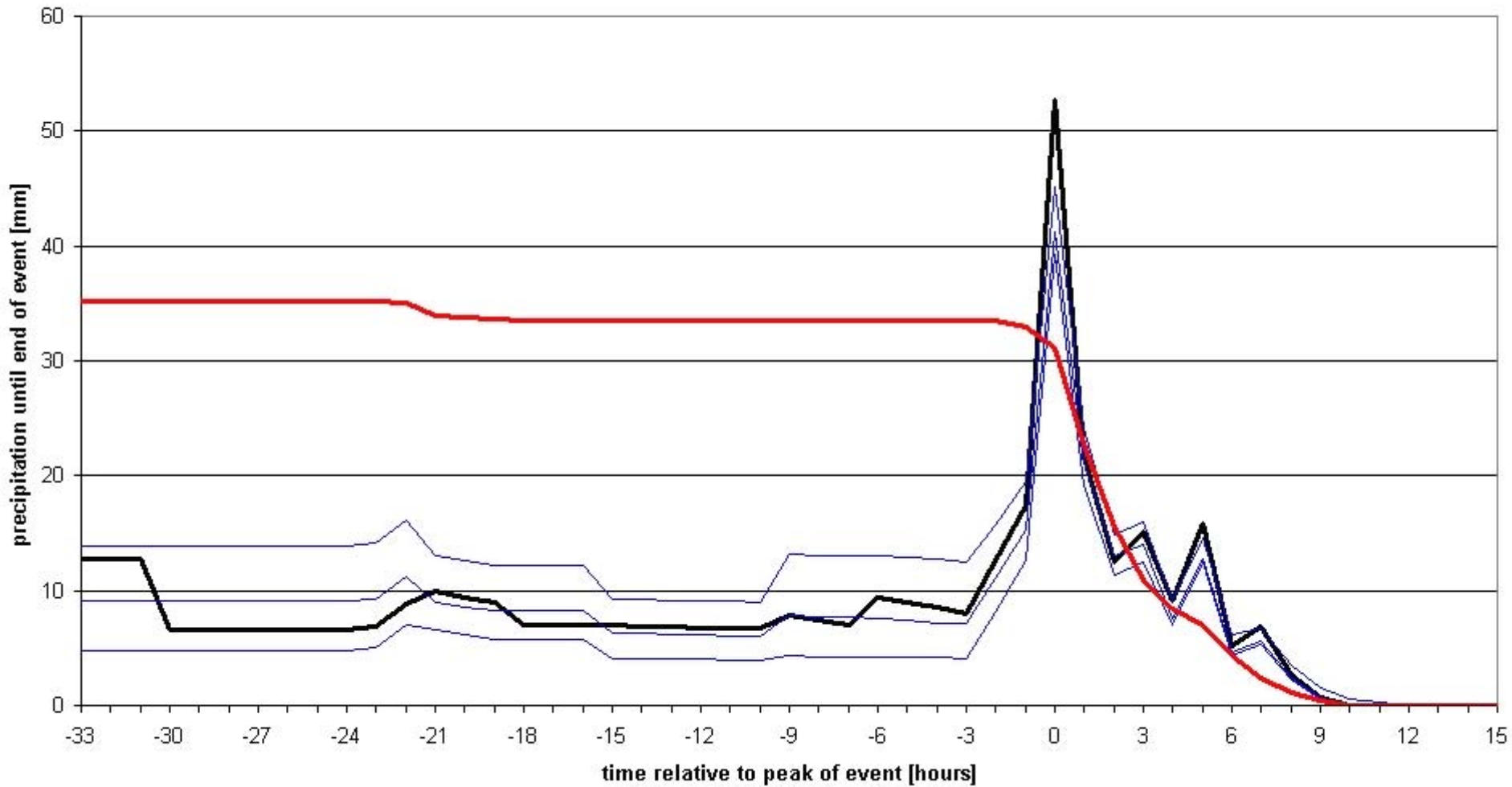




## INCA RR Analyse (mm/15min) 20050523 1500Z

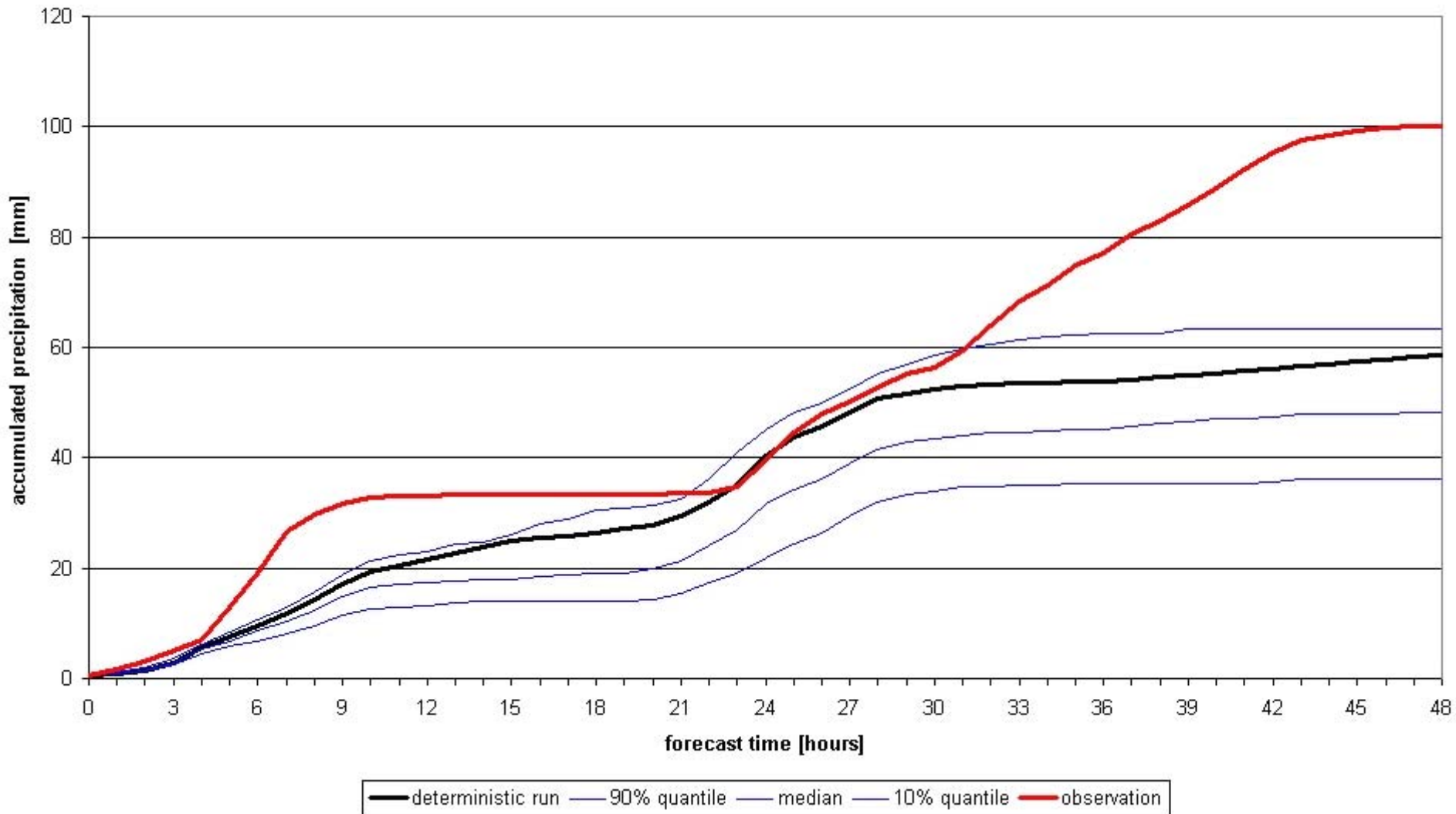


## case study: convective precipitation event (20050523)

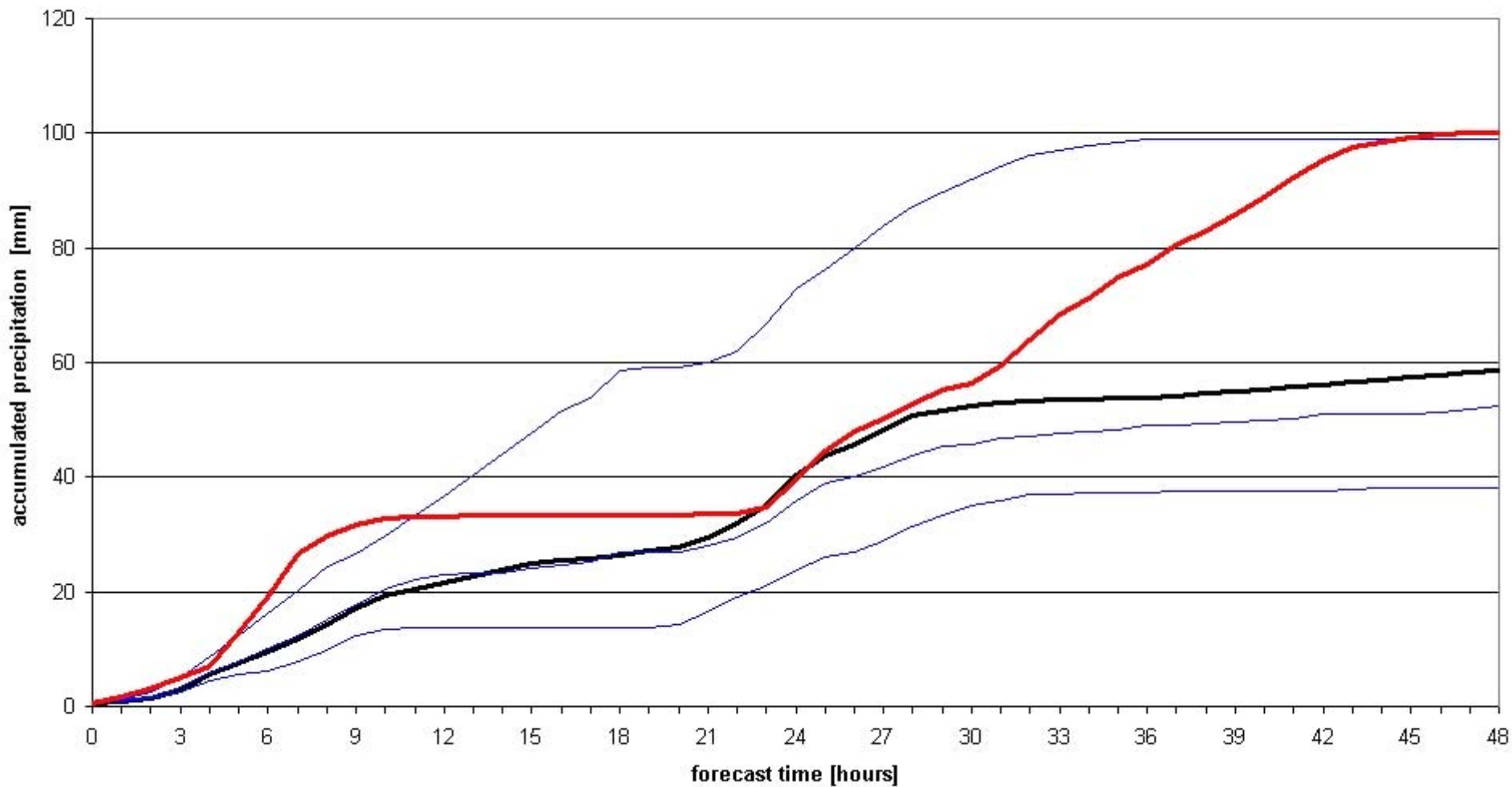
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— deterministic run — 90% quantile — median — 10% quantile — observation

## INCA precipitation forecast for the Kamp catchment, 20020811 1200 UTC (old ensemble scaling)



## INCA precipitation forecast for the Kamp catchment, 20020811 1200 UTC (new ensemble scaling)

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