Comparison Of Short Term Rainfall Forecasts For Model Based Flow Prediction In Urban Drainage Systems

Søren Thorndahl, Aalborg University
Troels Sander Poulsen, Krüger, Veolia Water
Thomas Bøvith, Danish Meteorological Institute
Morten Borup, Technical University of Denmark
Malte Ahm, Aalborg University
Jesper Ellerbæk Nielsen, Aalborg University
Morten Grum, Krüger, Veolia Water
Michael R. Rasmussen, Aalborg University
Rasphall Gill, Danish Meteorological Institute
Peter Steen Mikkelsen, Technical University of Denmark

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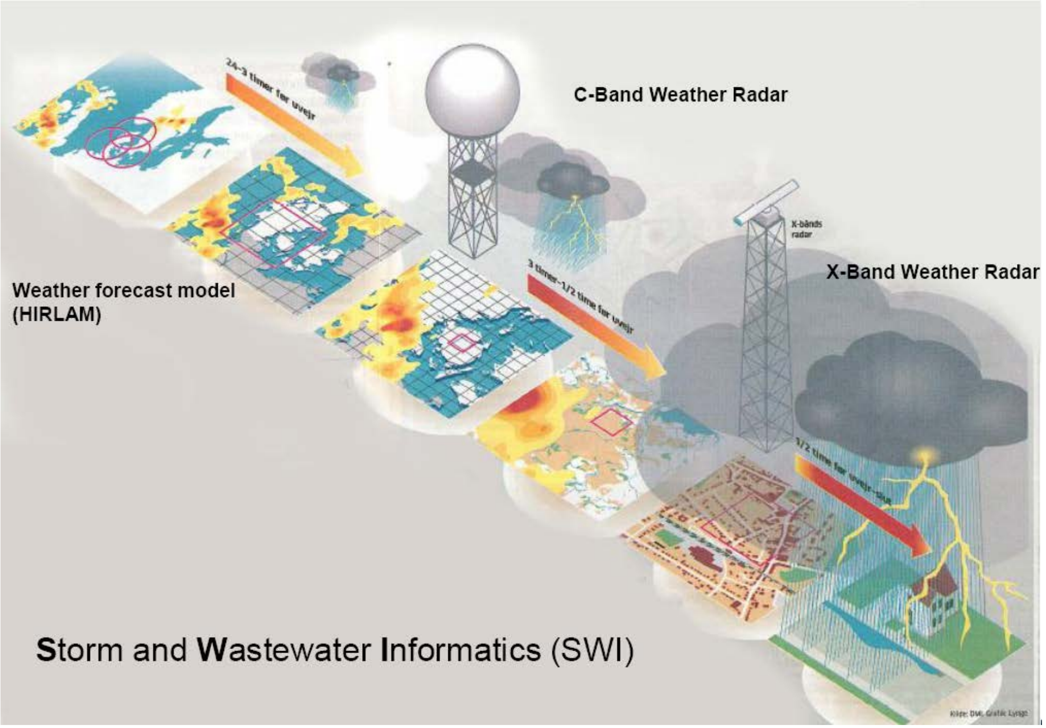
The Storm and Wastewater Informatics (SWI) project

- Collaboration between Danish universities, research institutions, utility companies, and private companies

- Funded by The Danish Council for Strategic Research



Objectives

- To investigate potentials for model based flow (and water level) forecasting in key points of drainage systems comparing different rainfall inputs:

    - Rain gauge observations
    - Weather radar observations
    - Weather radar nowcasts
    - Numerical Weather Prediction models (NWP)

- How does these inputs perform in forecasting inflow to a Waste Water Treatment Plant?

The Lynetten WWTP catchment

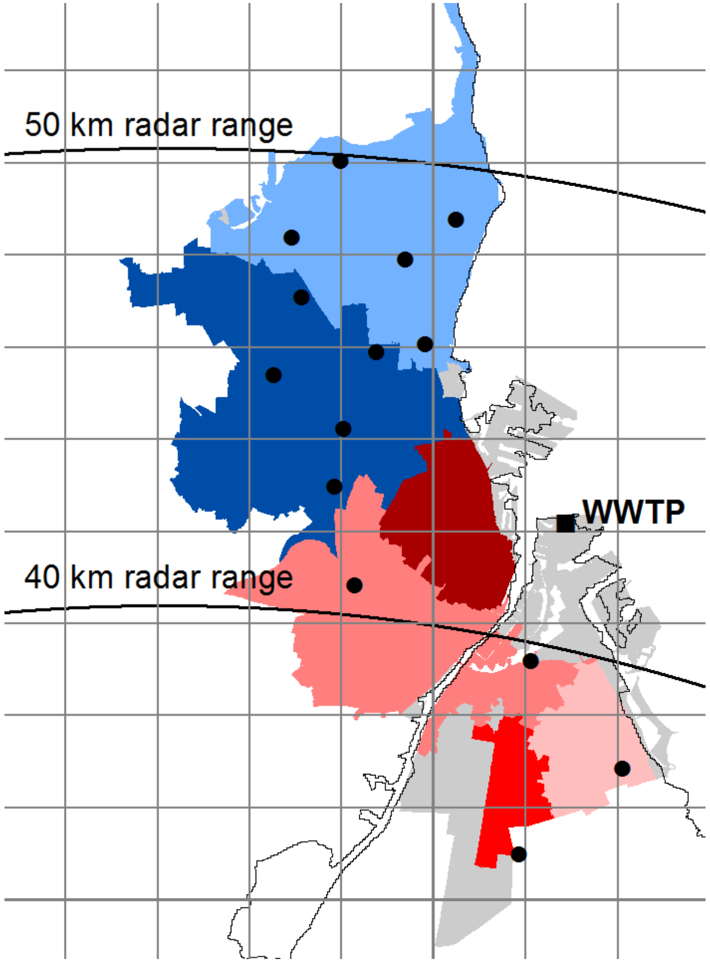
- Area: 77 km^2
- 30 % impervious area
- 87 % combined and 13 % separate sewer systems
- 500.000 inhabitants

- Key point: Inlet flow to the WWTP

- Wet weather operation (ATS operation) is implemented when the inlet flow exceeds 4.7 m^3/s

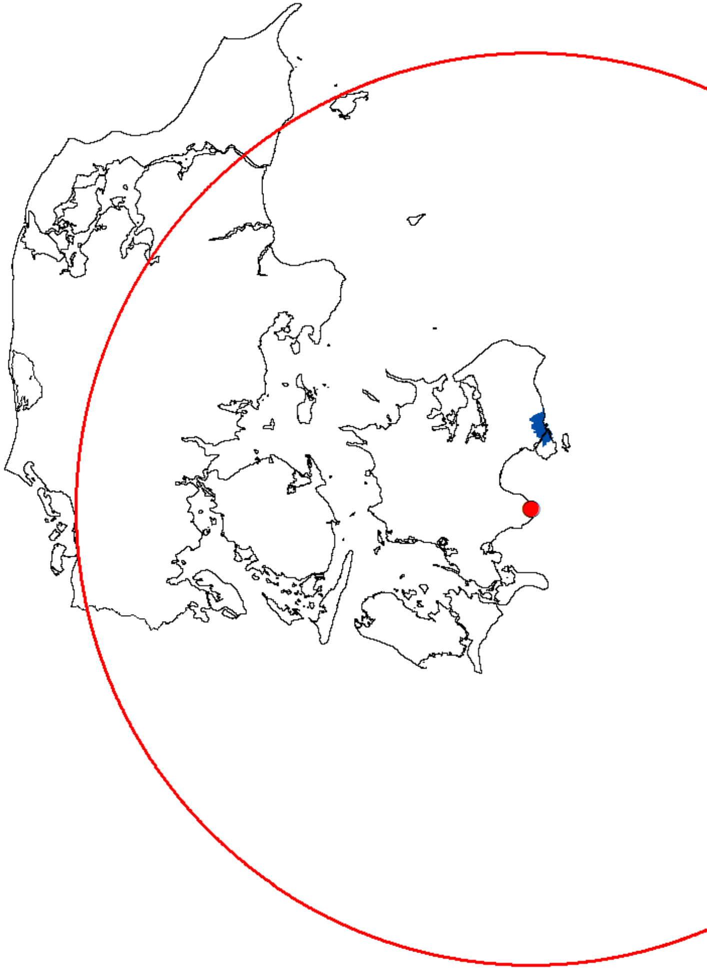
- The maximal inlet flow to the WWTP is 12 m^3/s

- **It is expected that forecast of the inflow to the WWTP will improve treatment during rain.**



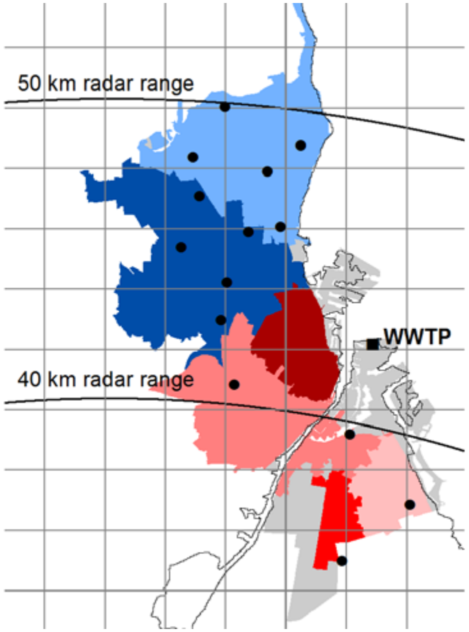
Radar data

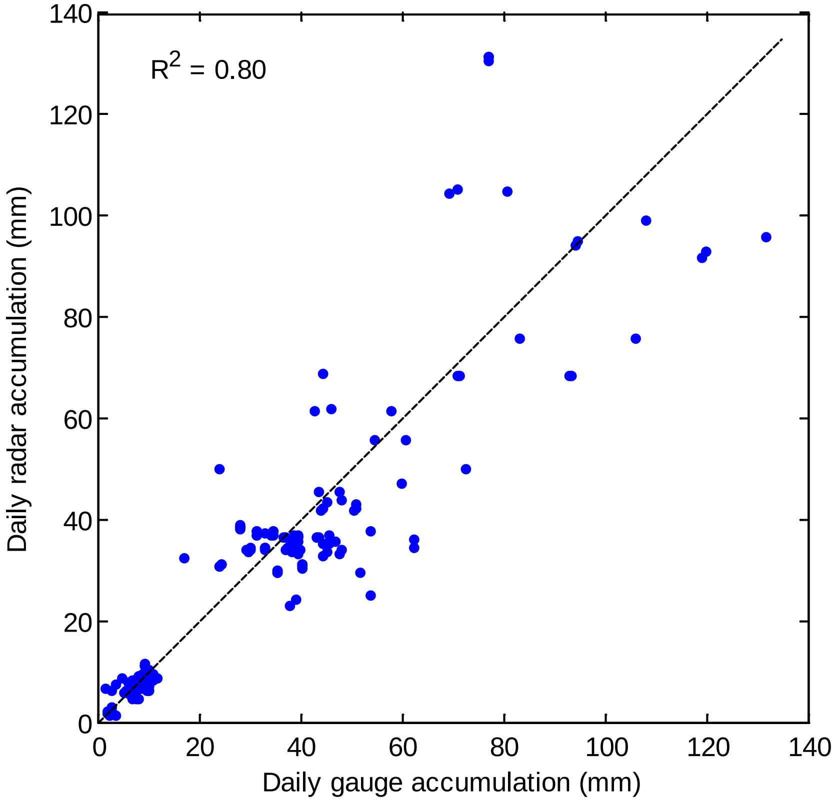
- One single C-band radar located at Stevns approx. 50 km south of Copenhagen
- Range 0-240 km
- Quantitative range 0-75 km
- Spatial resolution 2 x 2 km^2
- Temporal resolution: 10 min
- QPE from Marshall and Palmer Z-R relationship with standard parameters (A=200 and B=1.6)



Radar data

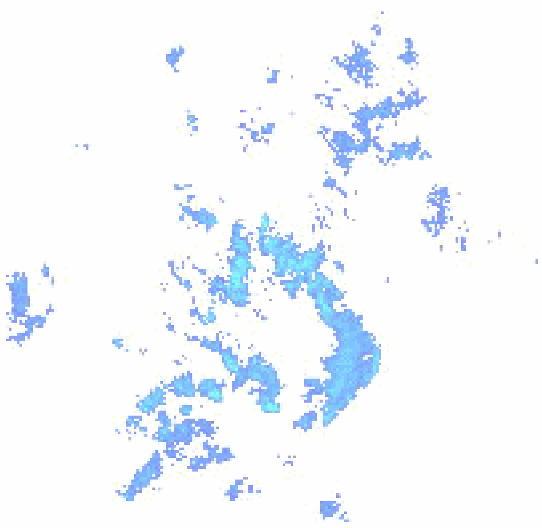
- Radar data is bias corrected on daily rain gauge accumulations
- 14 rain gauges are located within the catchment





Radar nowcast (AAUforecast)

- Extrapolation of observed radar rainfall based on correlation between radar images
- Method: CO-TREC
- Lead time: 0 – 2 hours
- No growth/decay
- A new nowcast is produced every 10 min

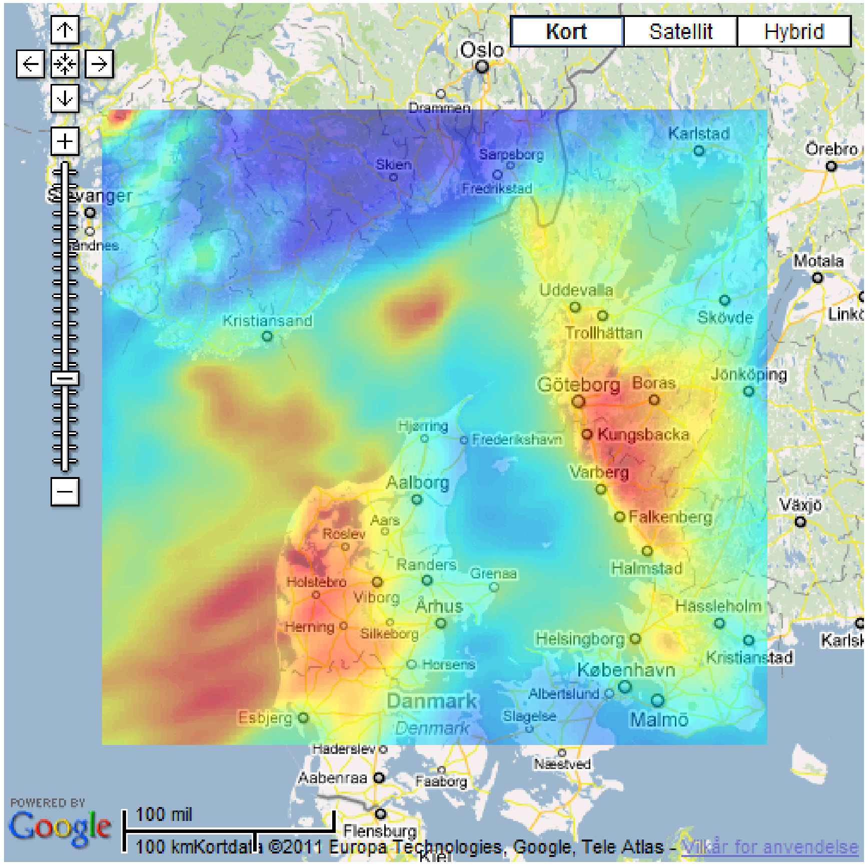


Observation

Nowcast model

Numerical weather prediction (NWP) model: DMI-HIRLAM-S05

- Spatial resolution: 0.05° (approx 5 km) over 40 vertical levels
- Temporal resolution: 1 hour
- Lead time: 1 - 24 h (in this study)
- The NWP model is run every 6 hours at 00, 06, 12, 18 UTC

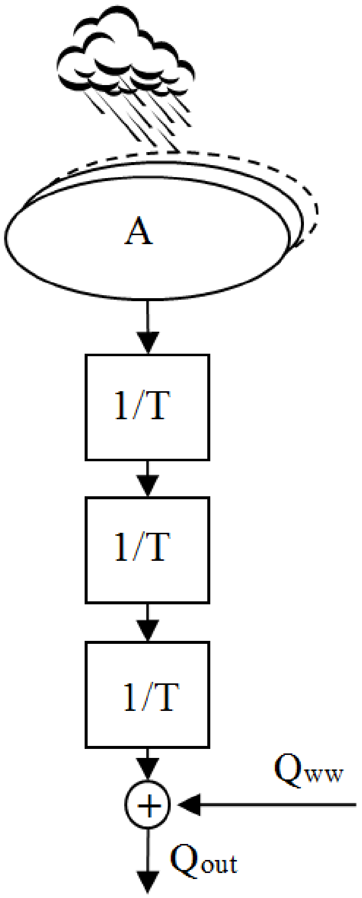


Wed Nov 18 2009 20:00:00 GMT+0100 (Central Europe Standard Time)
http://www.aalborgvejrradar.dk/nobackup-data/hirlam/data/2009/11/18/2009111800_20.pı

DMI-HIRLAM S-05

Runoff model

- WaterAspects (Krüger, Veolia Water)
- Simple linear reservoir model
- Parameters
    - Contributing Area (*A*)
    - Time constant (*T*)
    - Dry weather flow (Q_{ww})
- In the current setup the Lynetten catchment is divided into two sub-catchments
- The model must be calibrated against observations in the drainage system



Runoff model – auto-calibration

- The runoff model is auto-calibrated against flow observations at the WWTP using the past 48 hours of data

- Method: Quasi-Newton optimization

- The concept is to obtain the best possible model fit of the observed flow at the current time step before initiation of the flow forecast.

- This ensures the best possible initial conditions for the runoff model before simulating future flow based on the forecasted rainfall input.

Events

Event 1: 1 - 4 July 2011

Event 2: 13 - 16 August 2011

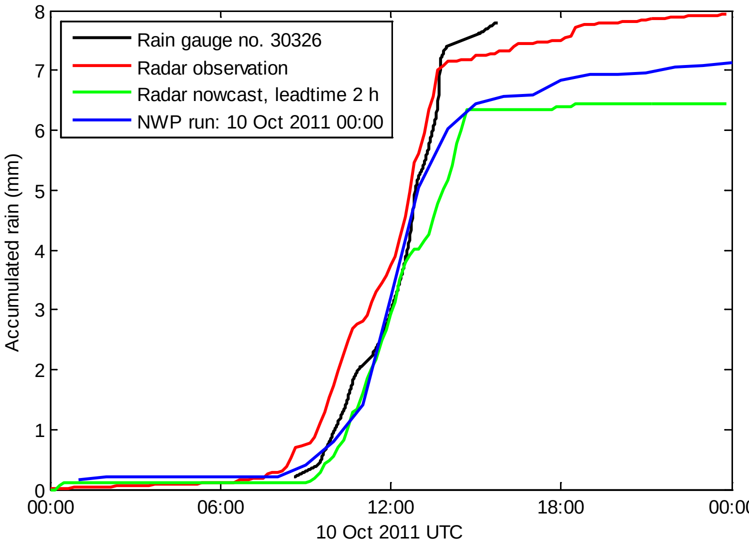
Event 3: 5 - 8 October 2011

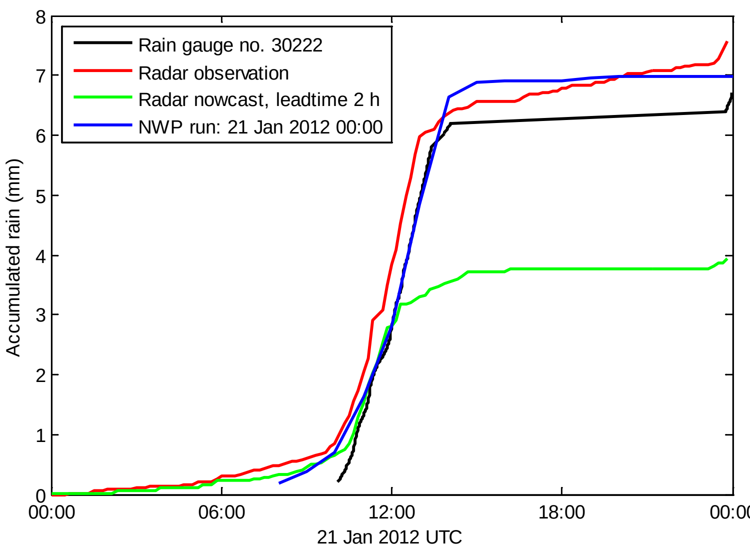
Event 4: 10 -12 October 2011

Event 5: 17 – 19 January 2012

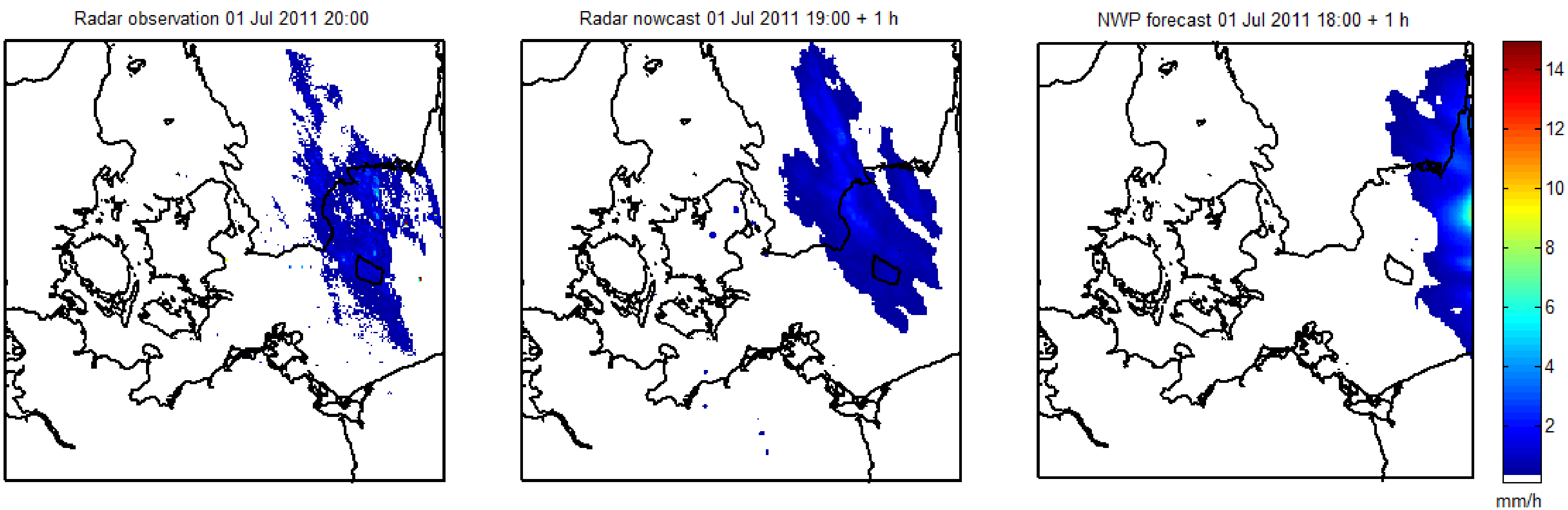
Event 6: 21 – 24 January 2012

These events are simulated as historical events, but the system is currently running in real time.



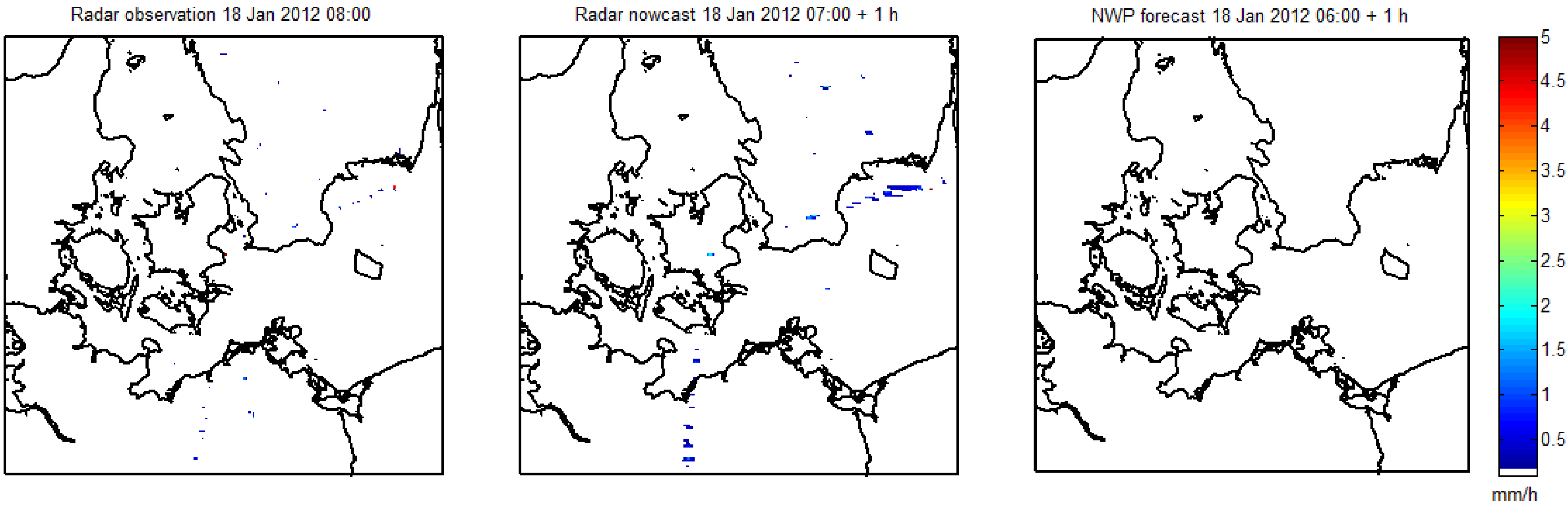


Event 1: 2 July 2011



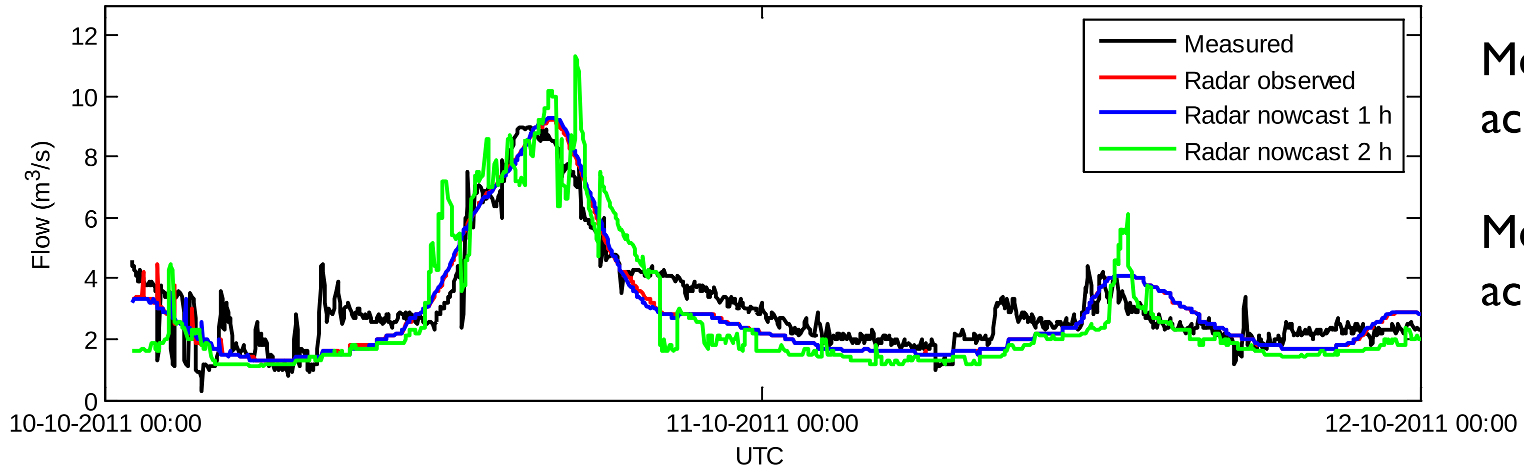
	Rain gauges	Radar obs.	Radar nowcast		NWP model forecast				
Leadtime	0h	0 h	1 h	2 h	1 h	2 h	6 h	12 h	24 h
Mean accum. (mm)	68.2	63.0	40.6	21.4	41.0	69.7	99.9	7.8	21.7

Event 6: 18 January 2012



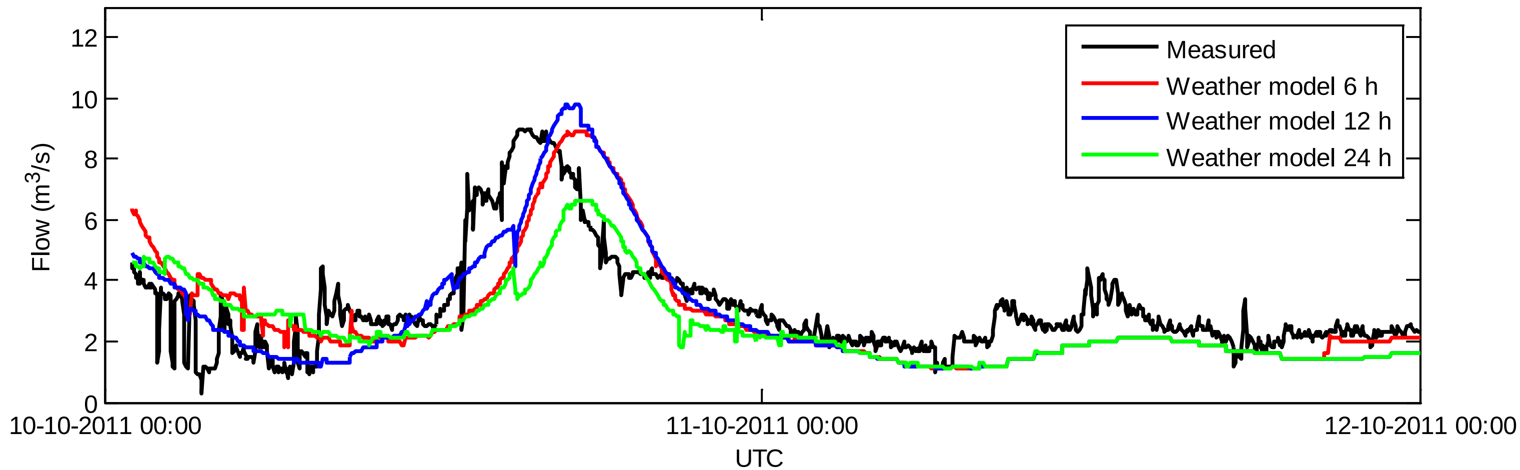
	Rain gauges	Radar obs.	Radar nowcast		NWP model forecast				
Leadtime	0h	0 h	1 h	2 h	1 h	2 h	6 h	12 h	24 h
Mean accum. (mm)	8.6	7.3	7.0	3.5	8.4	9.0	9.0	8.8	8.6

Flow forecast results - Event 4: 10 - 12 October 2011

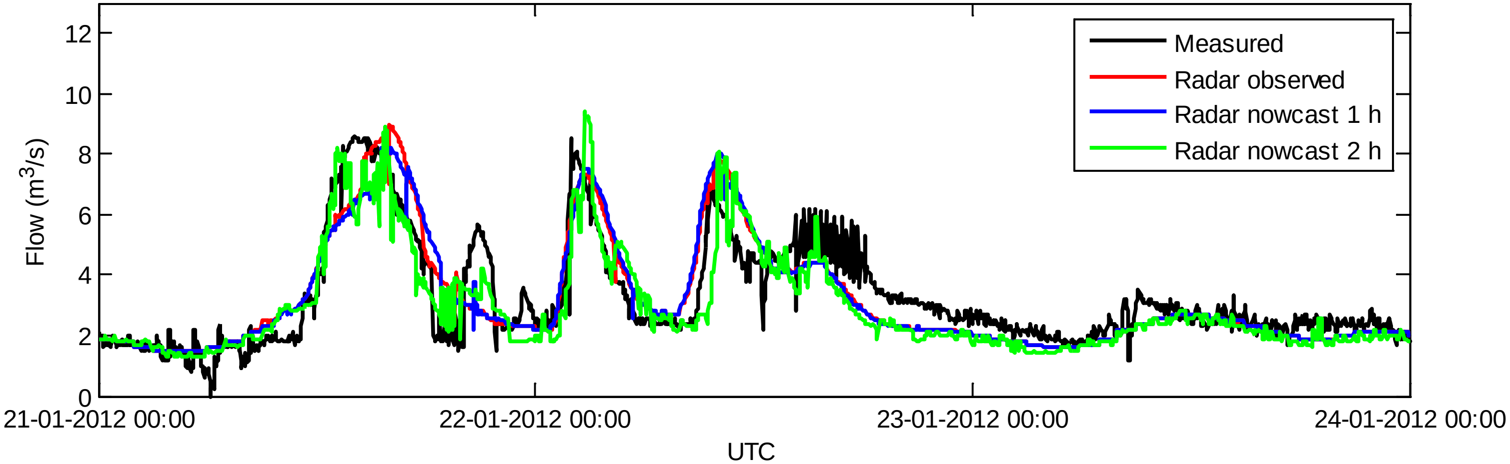


Mean rain gauge accum.: 8.5 mm

Mean obs. radar accum.: 9.1 mm

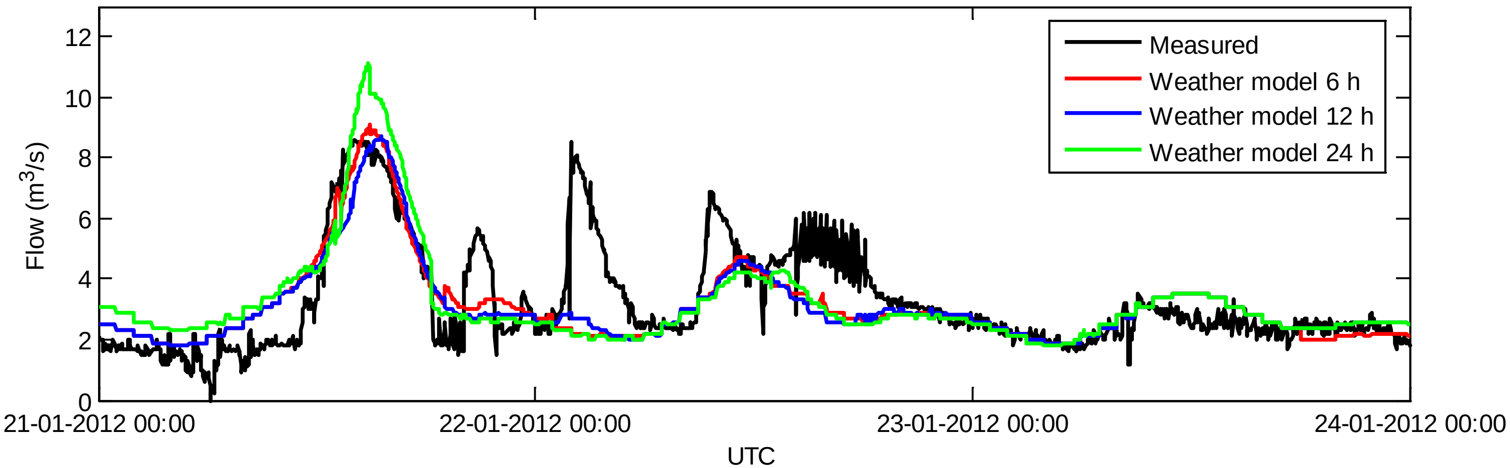


Flow forecast results - Event 6: 21 – 24 January 2012

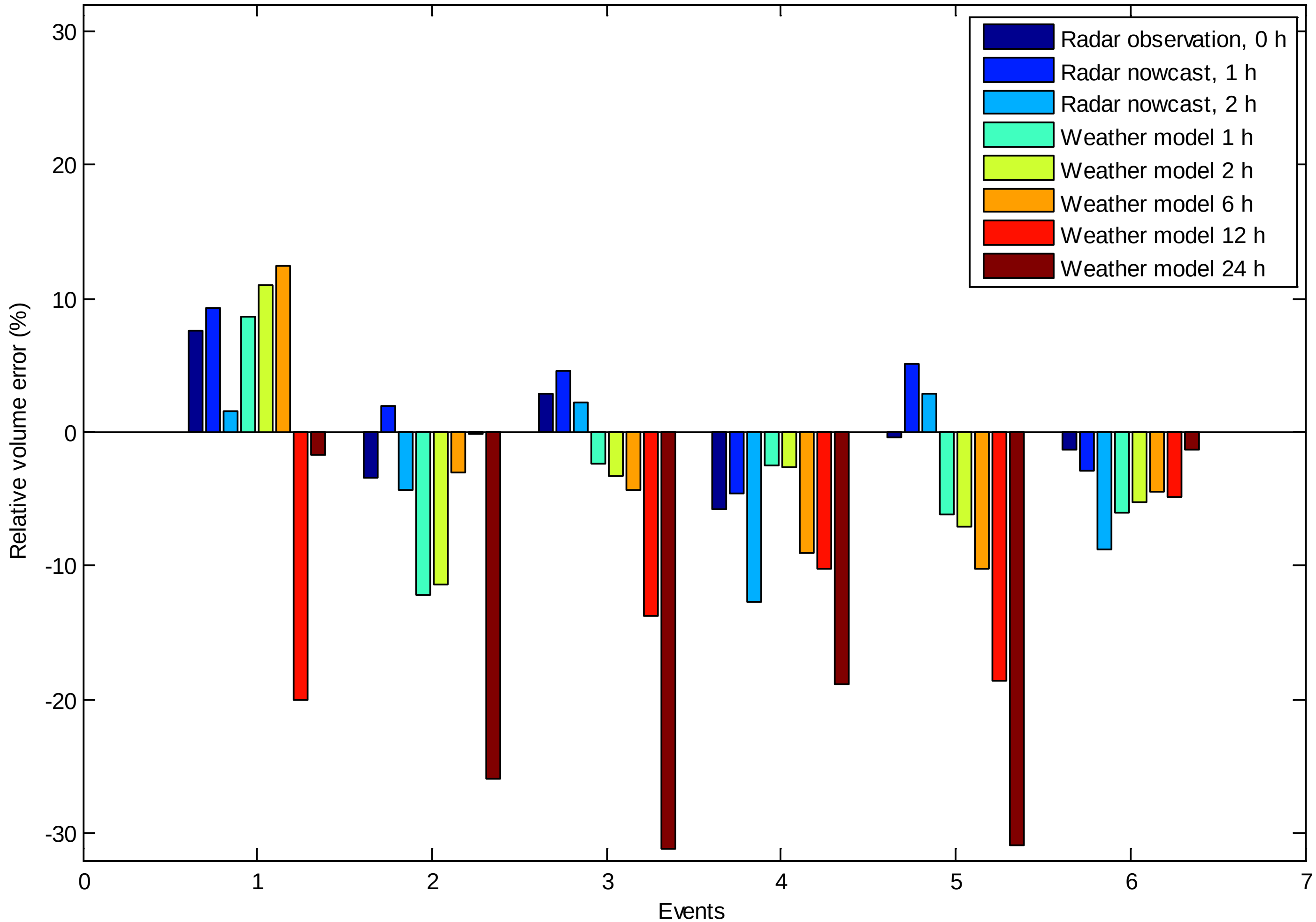


Mean rain gauge accum.: 8.6 mm

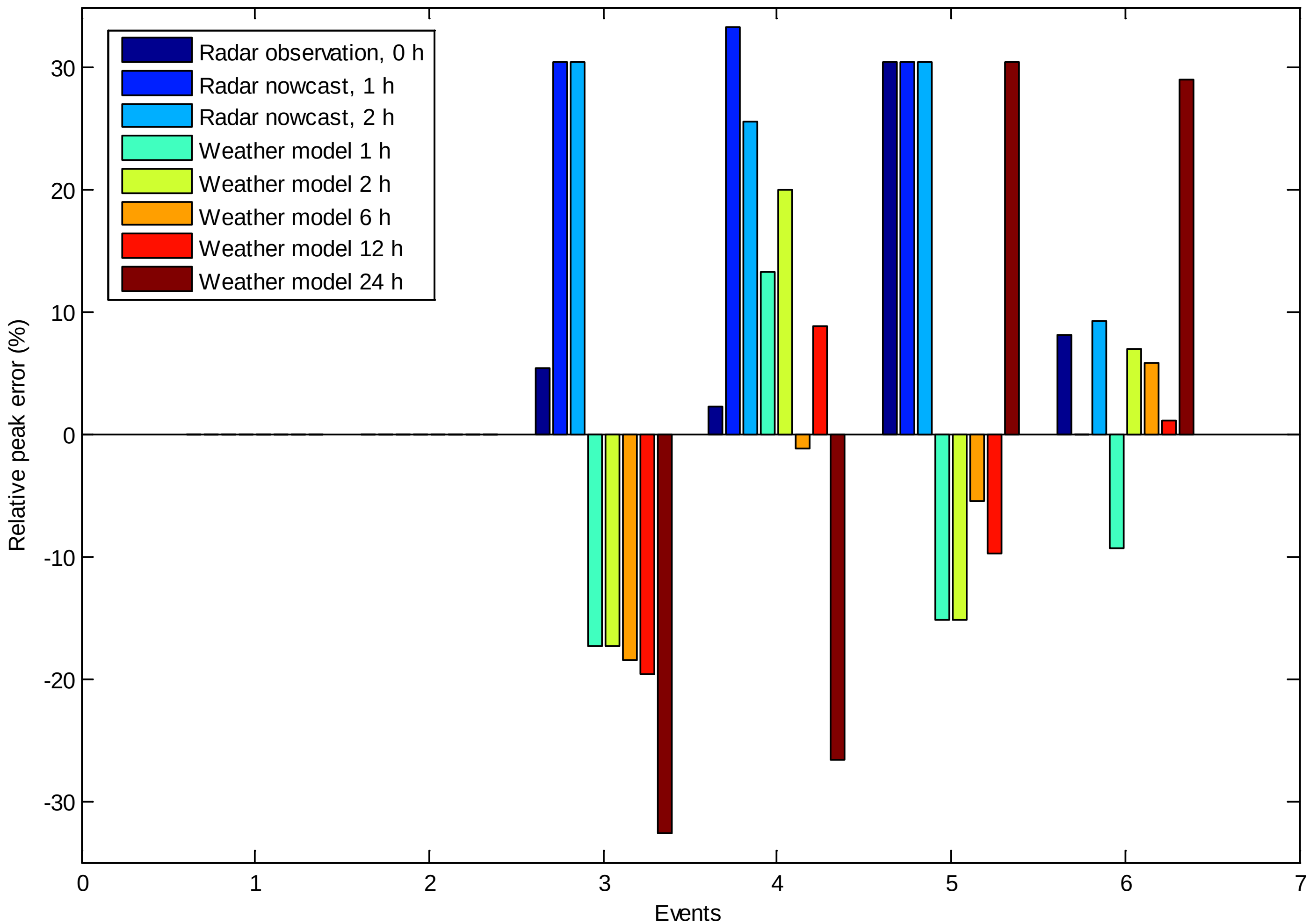
Mean obs. radar accum.: 7.3 mm



Relative volume errors – observed vs. forecasted flow

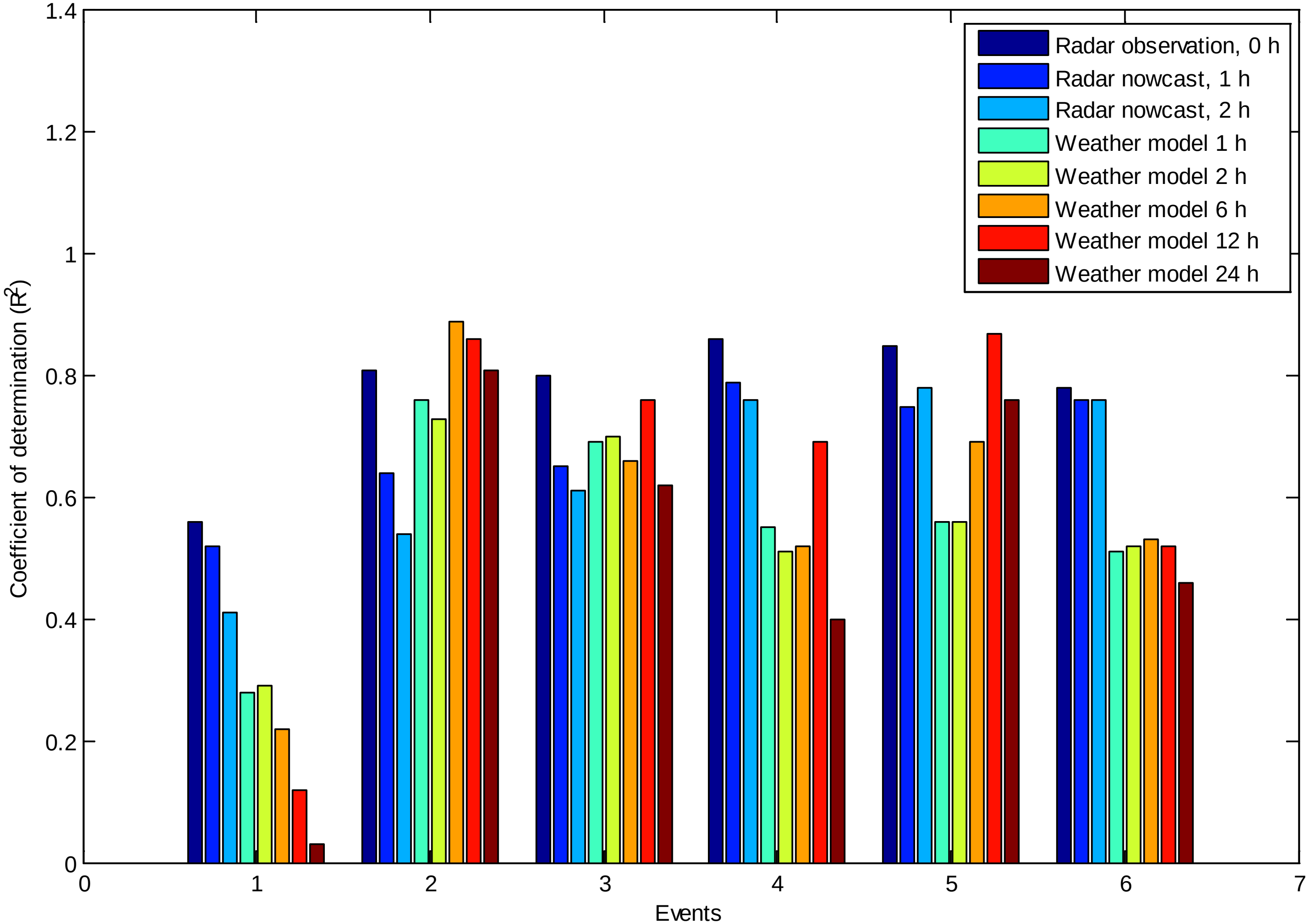


Relative peak errors – observed vs. forecasted flow



No peak errors in the two first events due to max. flow of 12 m^3/s in inlet to WWTP

Coefficient of determination (R^2) - observed vs. forecasted flow time series



Conclusions I

- It is possible to forecast the inlet flows with both radar nowcast and weather model forecasts with remarkable good results.

- Radar nowcast shows best performance during stratiform conditions, but even though it underpredicts rainfall rates during convective conditions, the timing seems to be reasonable.

- The numerical weather forecast shows better performance predicting rainfall with lead times from 6 to 12 hours than with shorter lead times, due to implementation of the initial conditions and succeeding spin-off in the HIRLAM model.

Recommendation:

- Apply radar nowcast for short leadtimes (0-2 hours) and the NWP data for leadtimes > 2 hours.

- combine the two products by a blending technique

Conclusions II

- Volume errors are generally low due to implementation of the auto-calibration routine.
- In almost every situation it is possible to produce reliable results as long as the timing on the rainfall forecast is accurate.
- In 5 out of 6 events the system is able to produce a reliable forecast with lead time most likely long enough to improve the treatment at the WWTP.
- 2 July 2011 which caused massive flooding and combined sewer overflows in Copenhagen, is too large to benefit from extended lead time of the system. In such extreme events flooding and combined sewer overflow is unavoidable, however the system could be applied to issue warnings rather than to optimize the waste water treatment.

Further work and improvements

- Distributed runoff modeling in order to forecast flows in other key points
- Comparisons with MOUSE/Mike Urban simulations
- Quantification of uncertainties on both input data and runoff output
- Evaluation of more than 6 events.
- Documentation of real time implementation

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