ANALYSIS OF THE AUGUST 2002 FLOOD OF THE DANUBE USING METEOROLOGICAL ENSEMBLES

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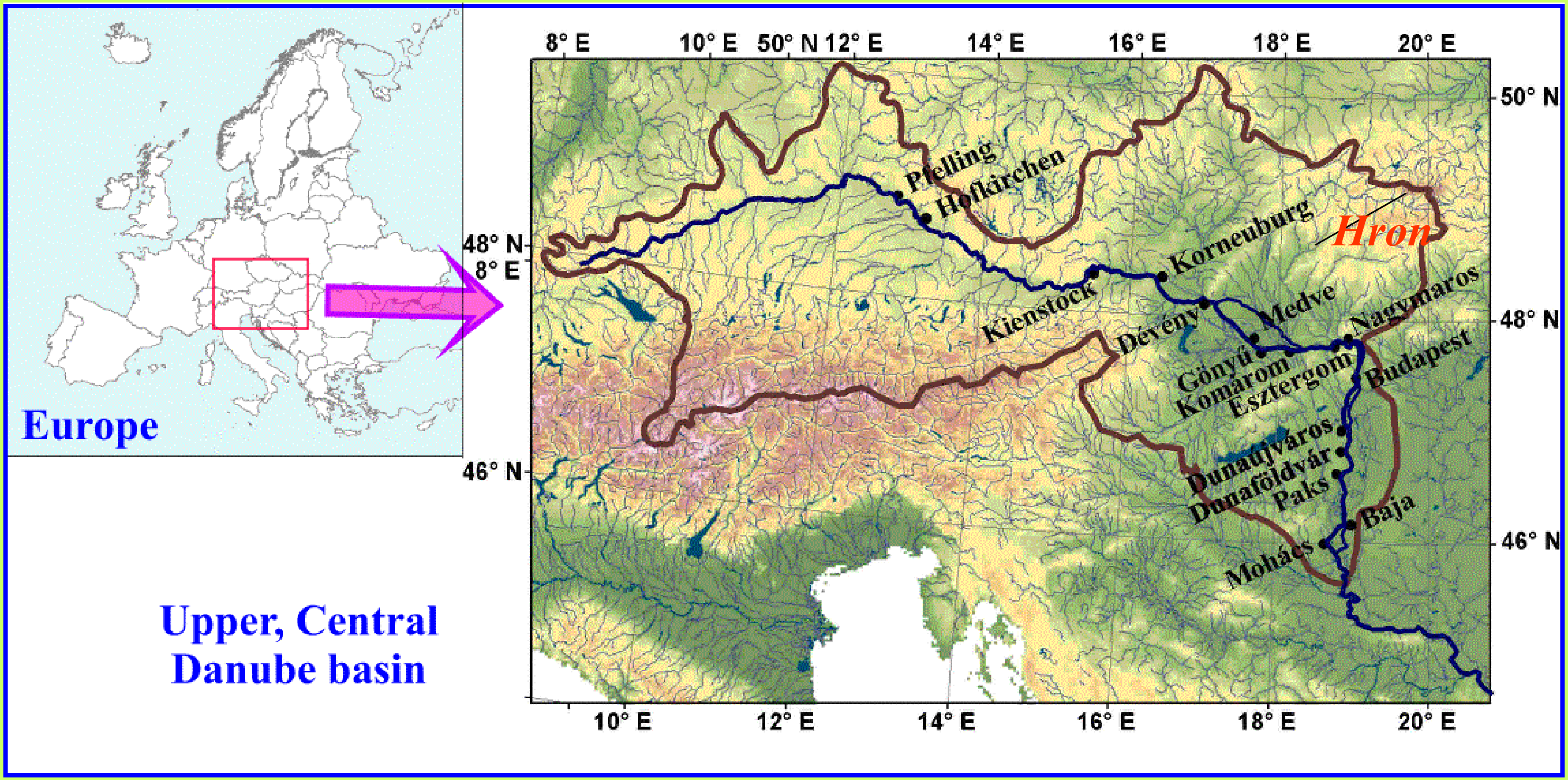
STUBA

CONTENT

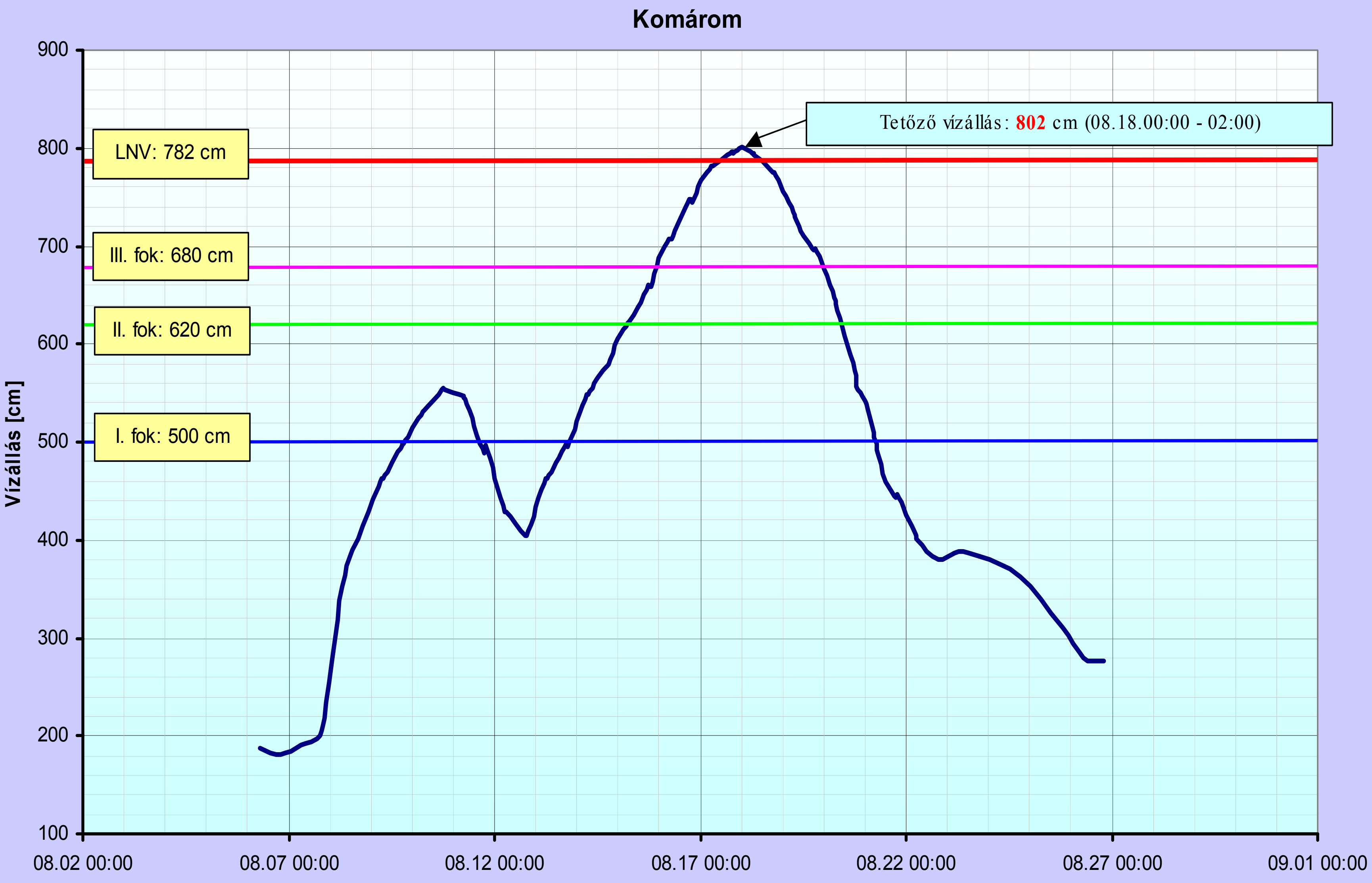
- **Danube and tributaries, August 2003 flood events**
- **Review of QPF forecasts**
- **Forecast runs of the flood**
- **Analysis of forecast error**

Map of Europe and Upper, Central Danube basin

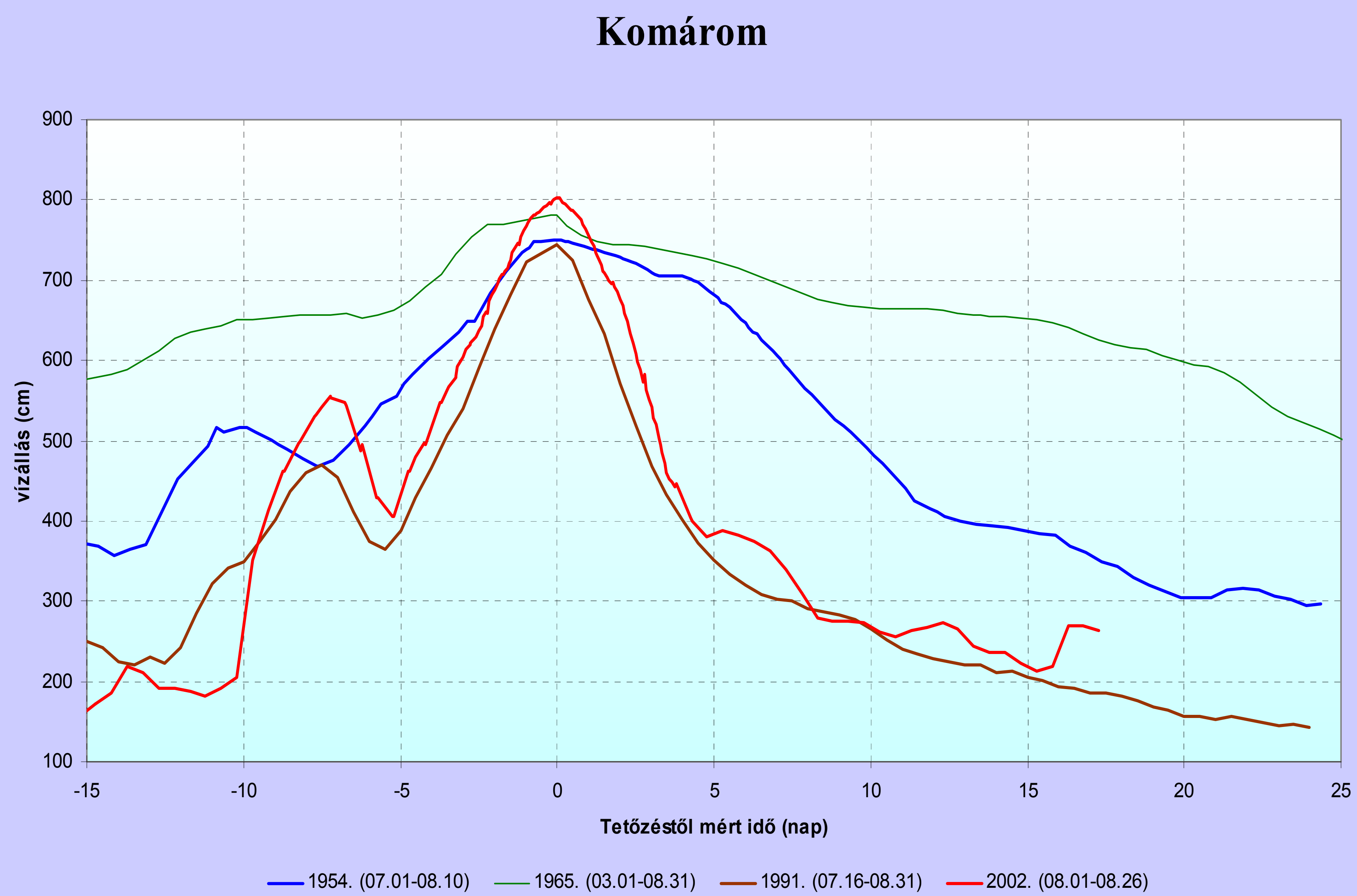


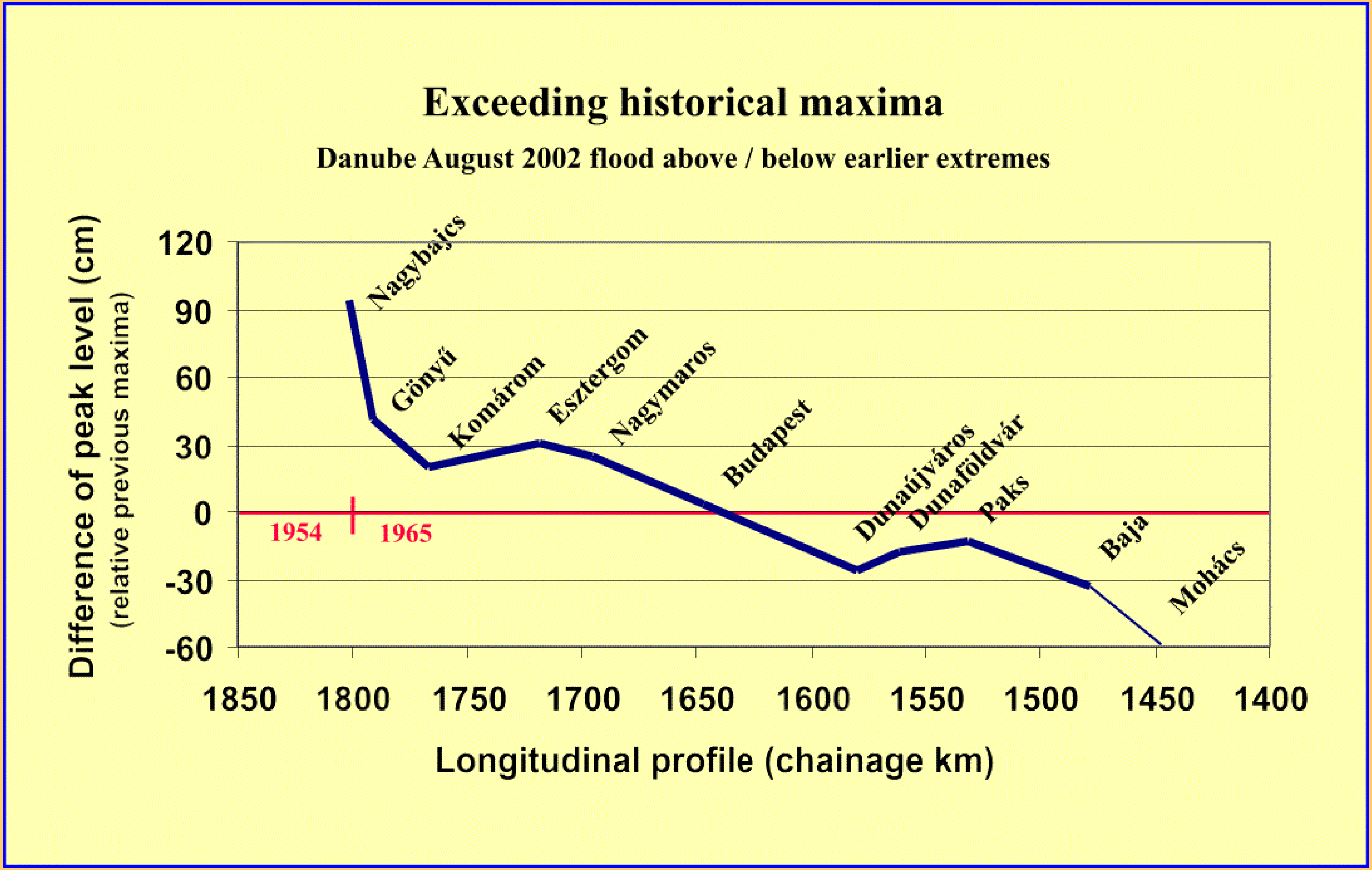
Case study connected with the Danube flood August 2002

Comparison with alert levels largest observed rainfall induced floods



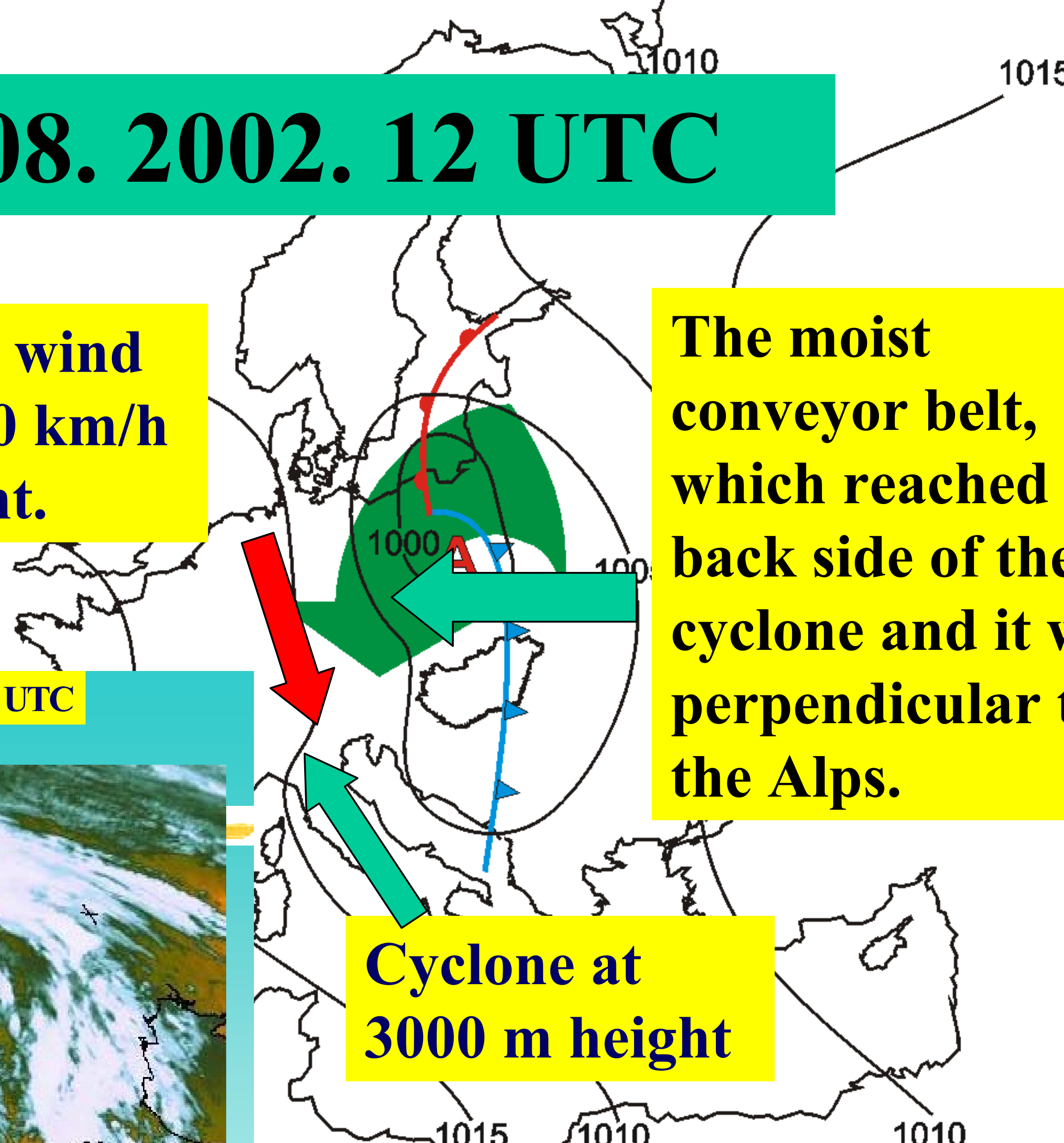
Komárom
Tetőző vízállás: 802 cm (08.18.00:00 - 02:00)
LNV: 782 cm
III. fok: 680 cm
II. fok: 620 cm
I. fok: 500 cm
Vízállás [cm]
900
800
700
600
500
400
300
200
100
08.02 00:00
08.07 00:00
08.12 00:00
08.17 00:00
08.22 00:00
08.27 00:00
09.01 00:00


Komárom
900
800
700
600
500
400
300
200
100
vízállás (cm)
-15
-10
-5
0
5
10
15
20
25
Tetőzéstől mért idő (nap)
1954. (07.01-08.10)
1965. (03.01-08.31)
1991. (07.16-08.31)
2002. (08.01-08.26)


Exceeding historical maxima
Danube August 2002 flood above / below earlier extremes
Difference of peak level (cm)
(relative previous maxima)
120
90
60
30
0
-30
-60
1850
1800
1750
1700
1650
1600
1550
1500
1450
1400
Longitudinal profile (chainage km)
Nagybajcs
Gönyű
Komárom
Esztergom
Nagymaros
Budapest
Dunaújváros
Dunaföldvár
Paks
Baja
Mohács
1954
1965

12.08. 2002. 12 UTC

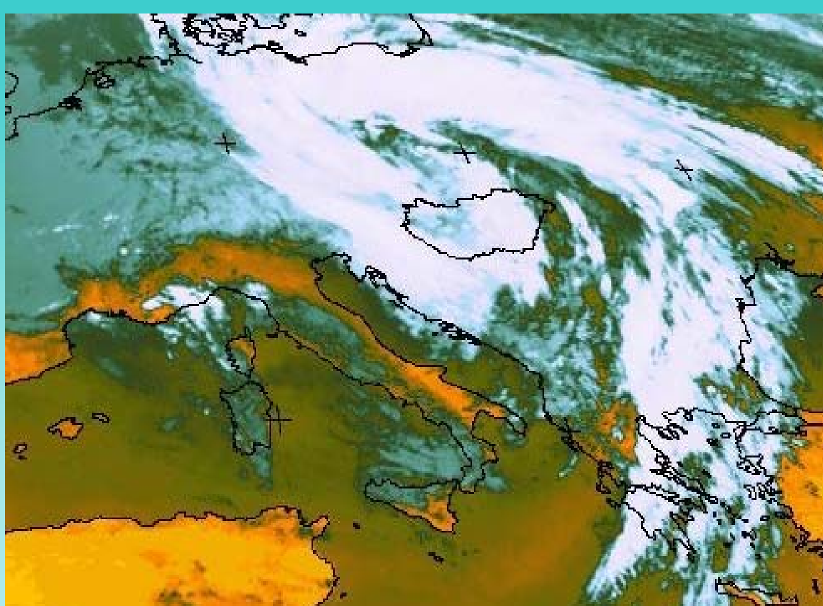
The north-west wind speed was 40-70 km/h at 1500 m height.



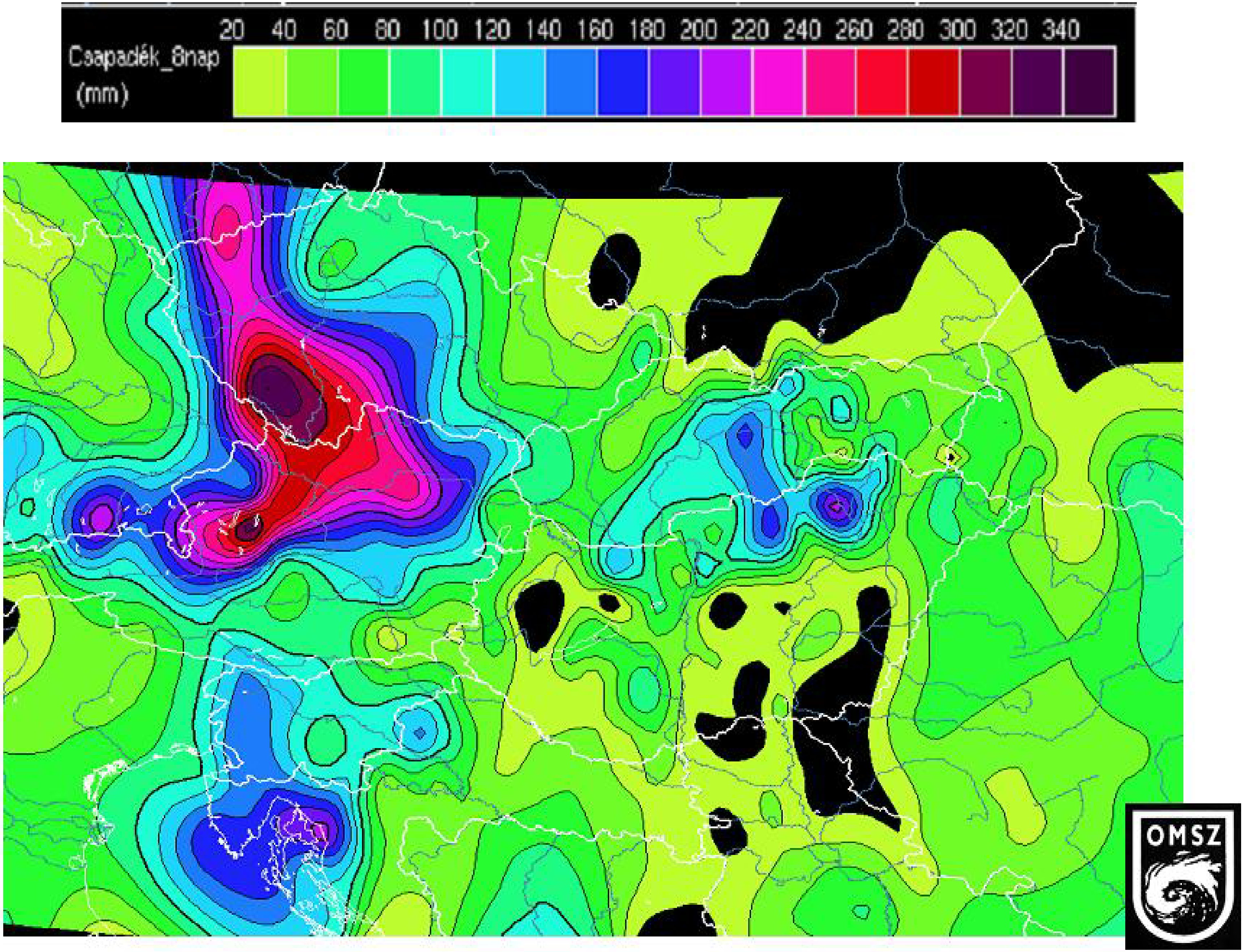
The moist conveyor belt, which reached the back side of the cyclone and it was perpendicular to the Alps.

Cyclone at 3000 m height

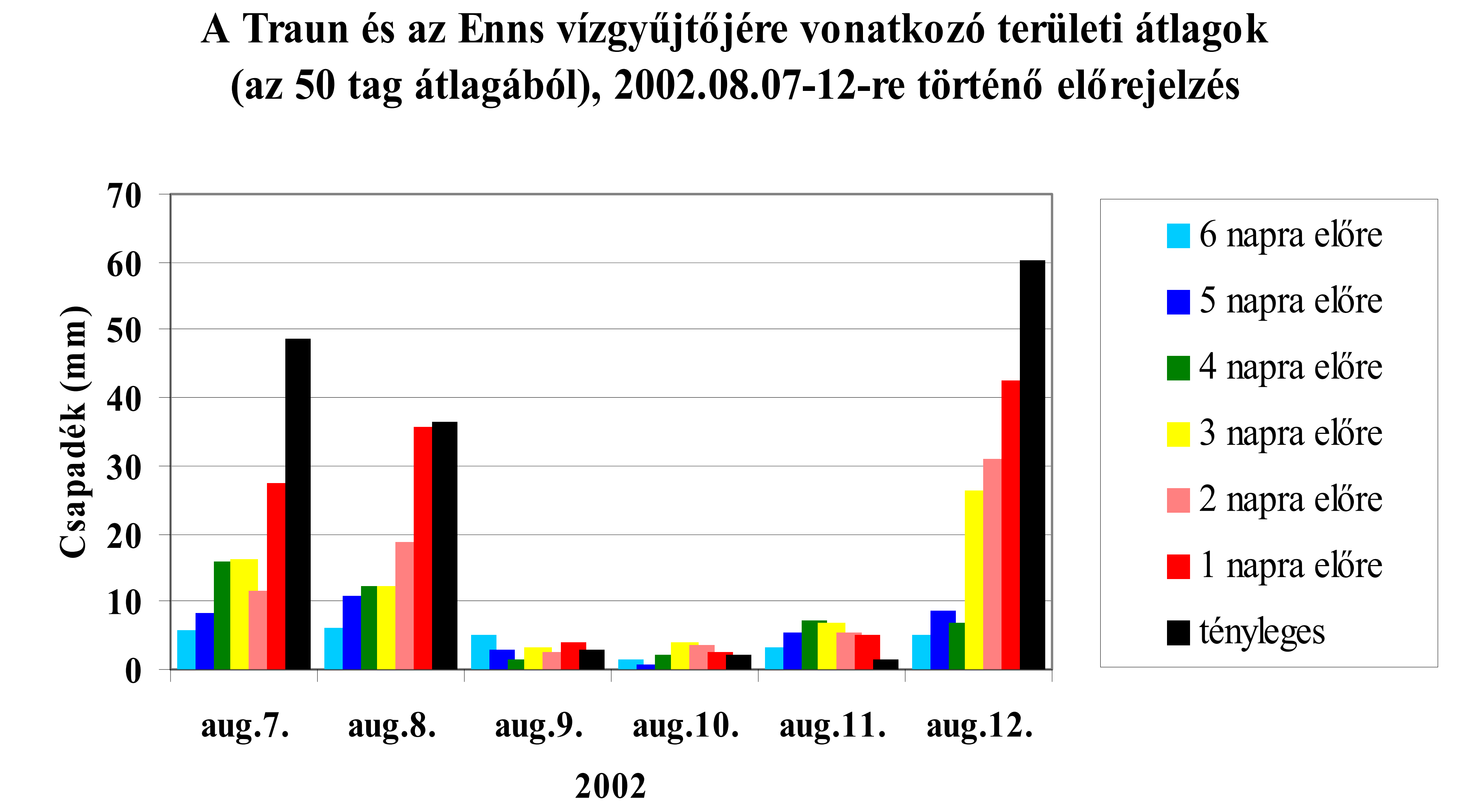
Satellite picture 12. 08. 2002. 12 UTC



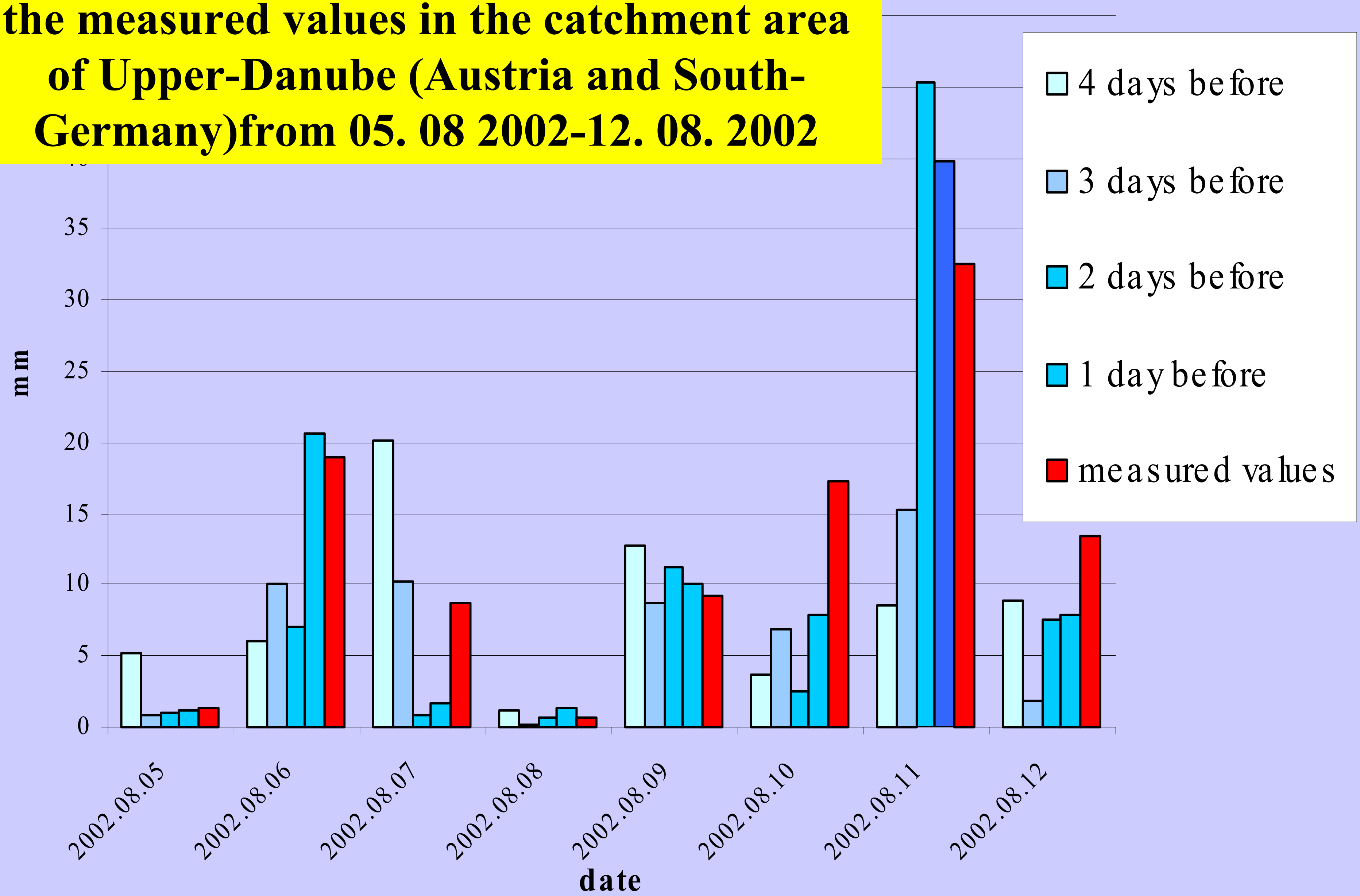
csapadék összege



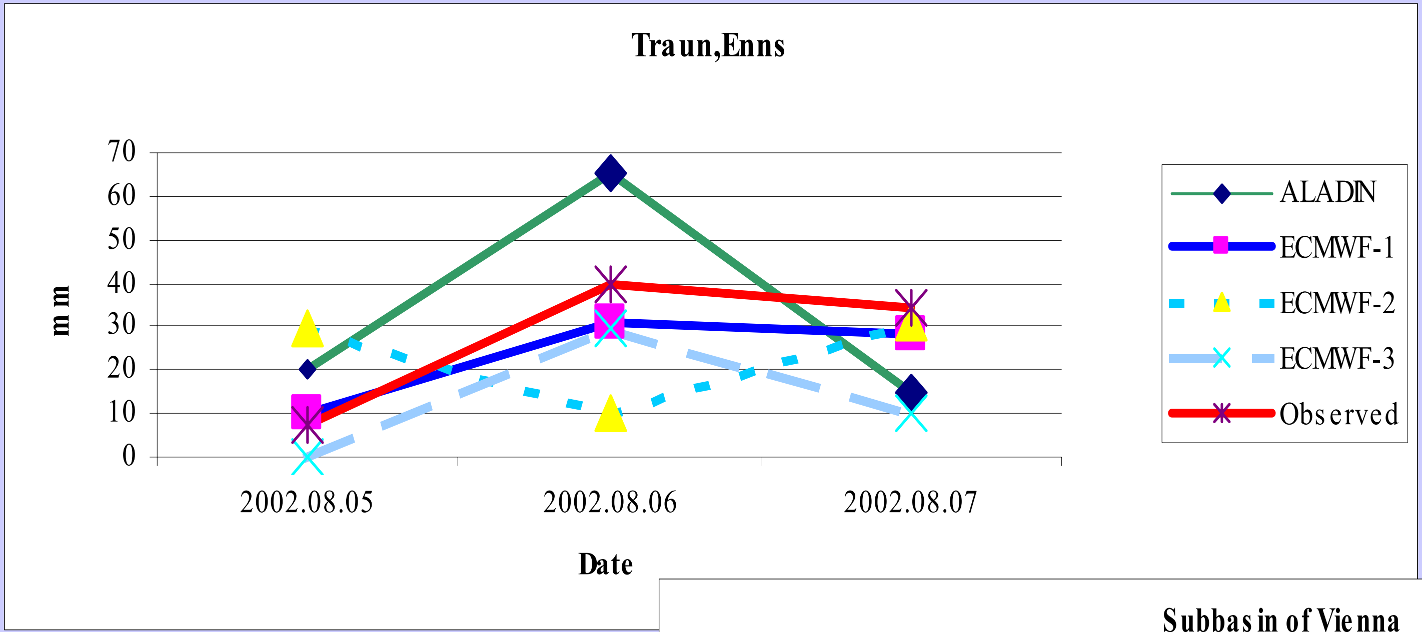
Prediction of the flood inducing precipitation

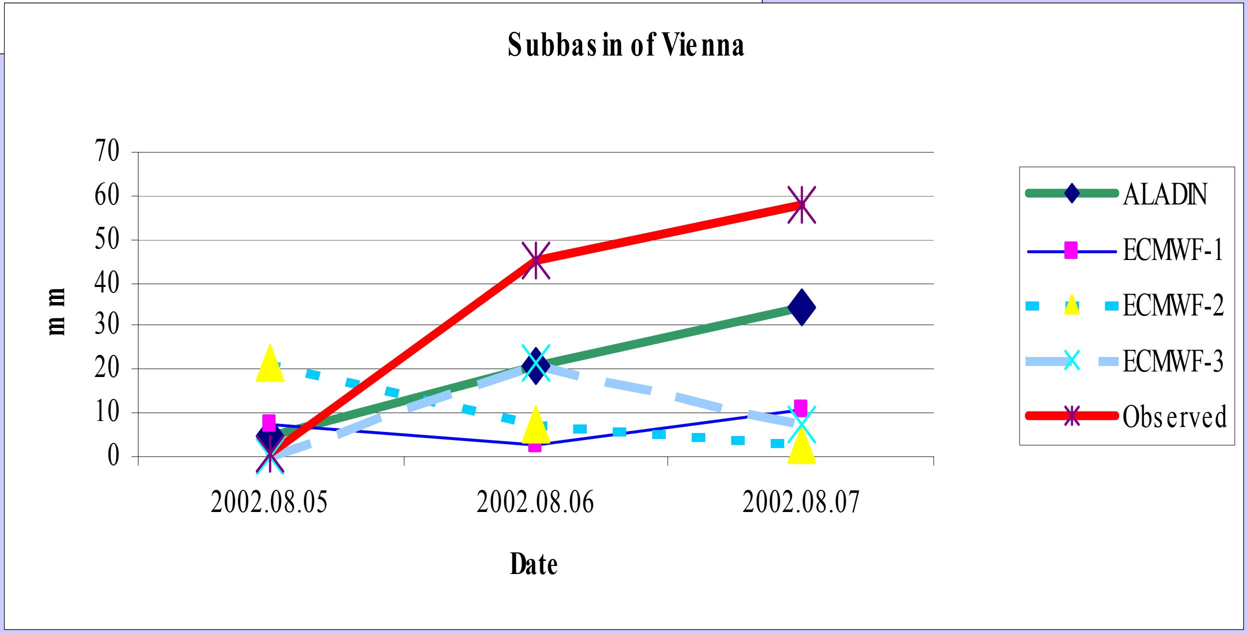


The predicted precipitation amount of ECMWF model (operational version) and the measured values in the catchment area of Upper-Danube (Austria and South-Germany)from 05. 08 2002-12. 08. 2002



The performance of the ALADIN and the ECMWF models in region Austria during flood in August 2002





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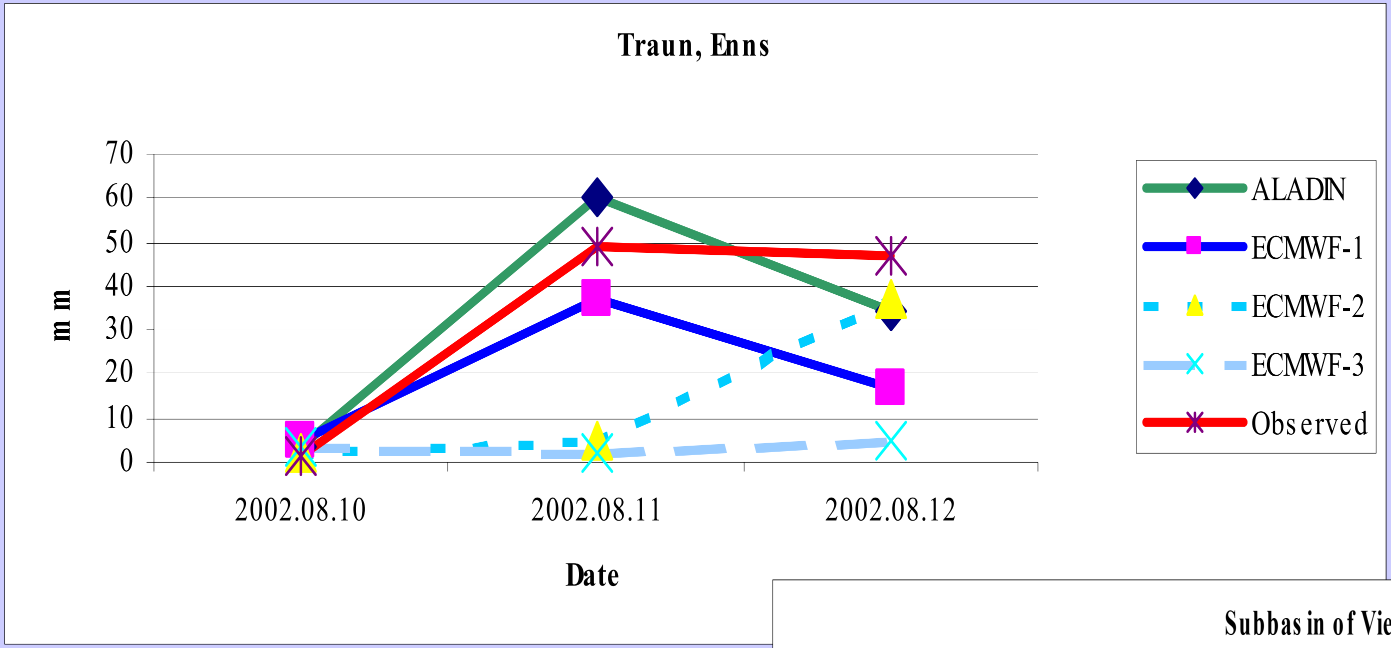
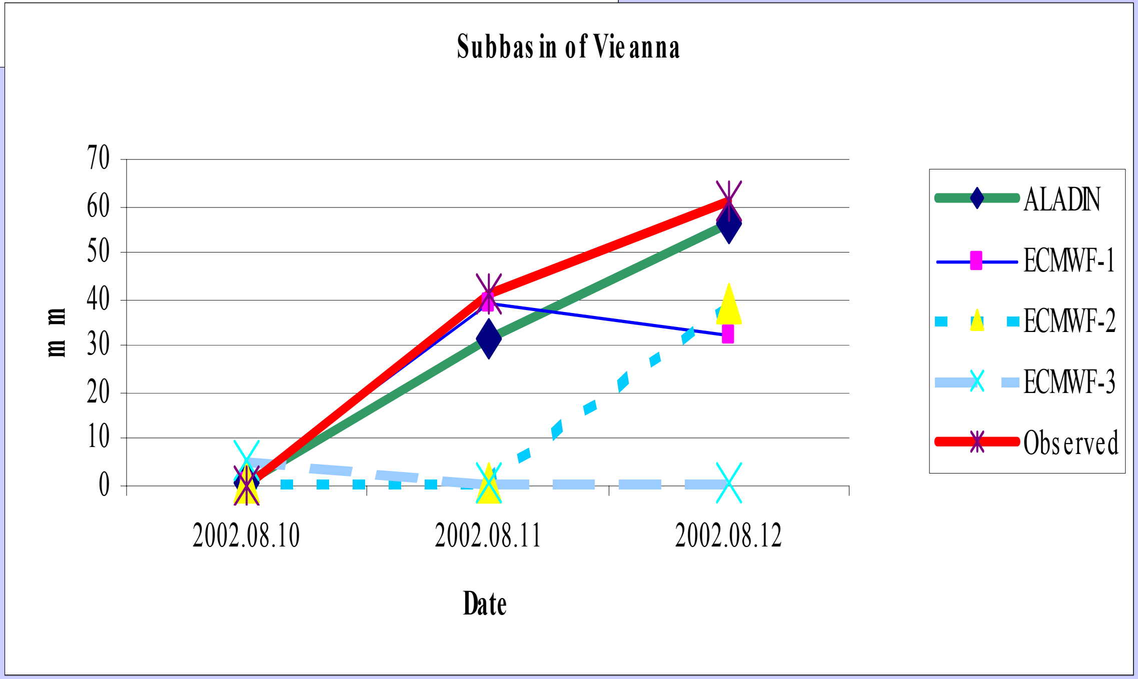
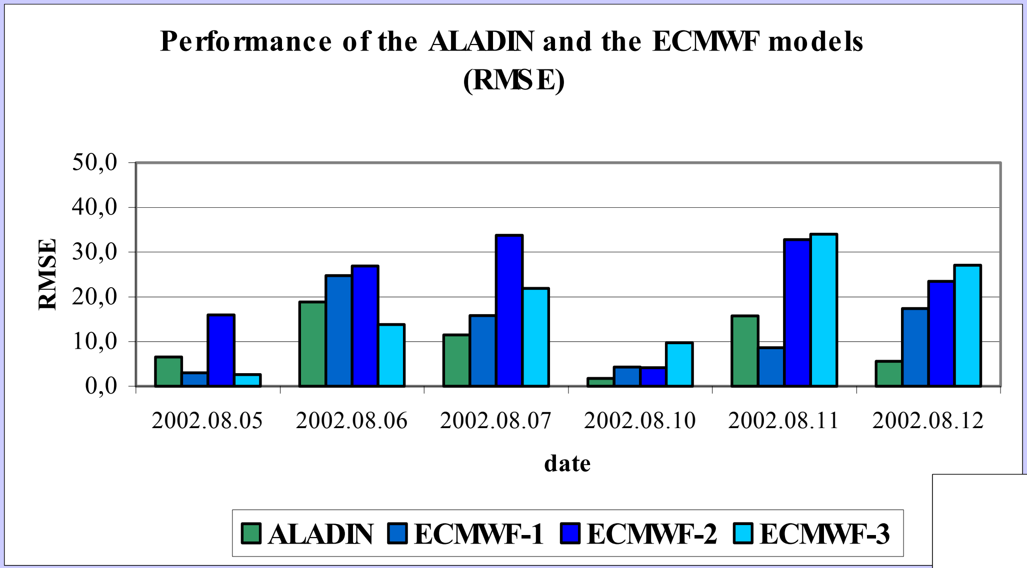
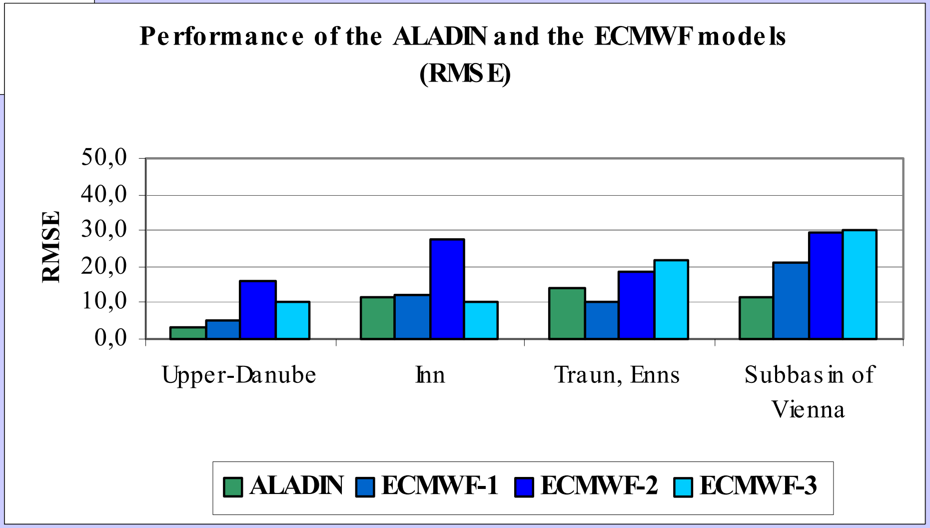


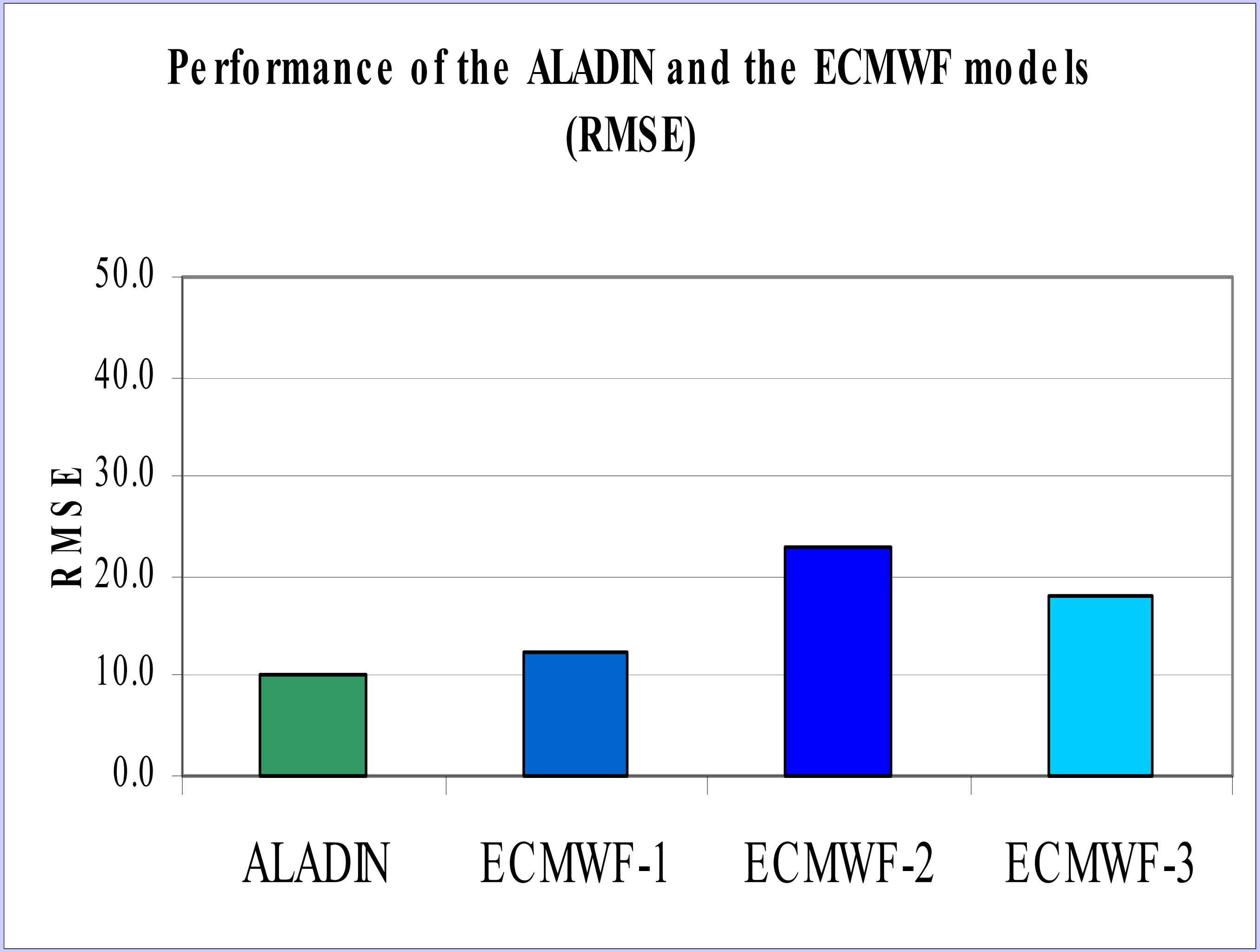


The total performance of the ALADIN and the ECMWF models in region Austria and South-Germany during flood in August 2002. The ECMWF-1 means the forecast one day, ECMWF-2 two days, ECMWF-3 tree days before the start of the event



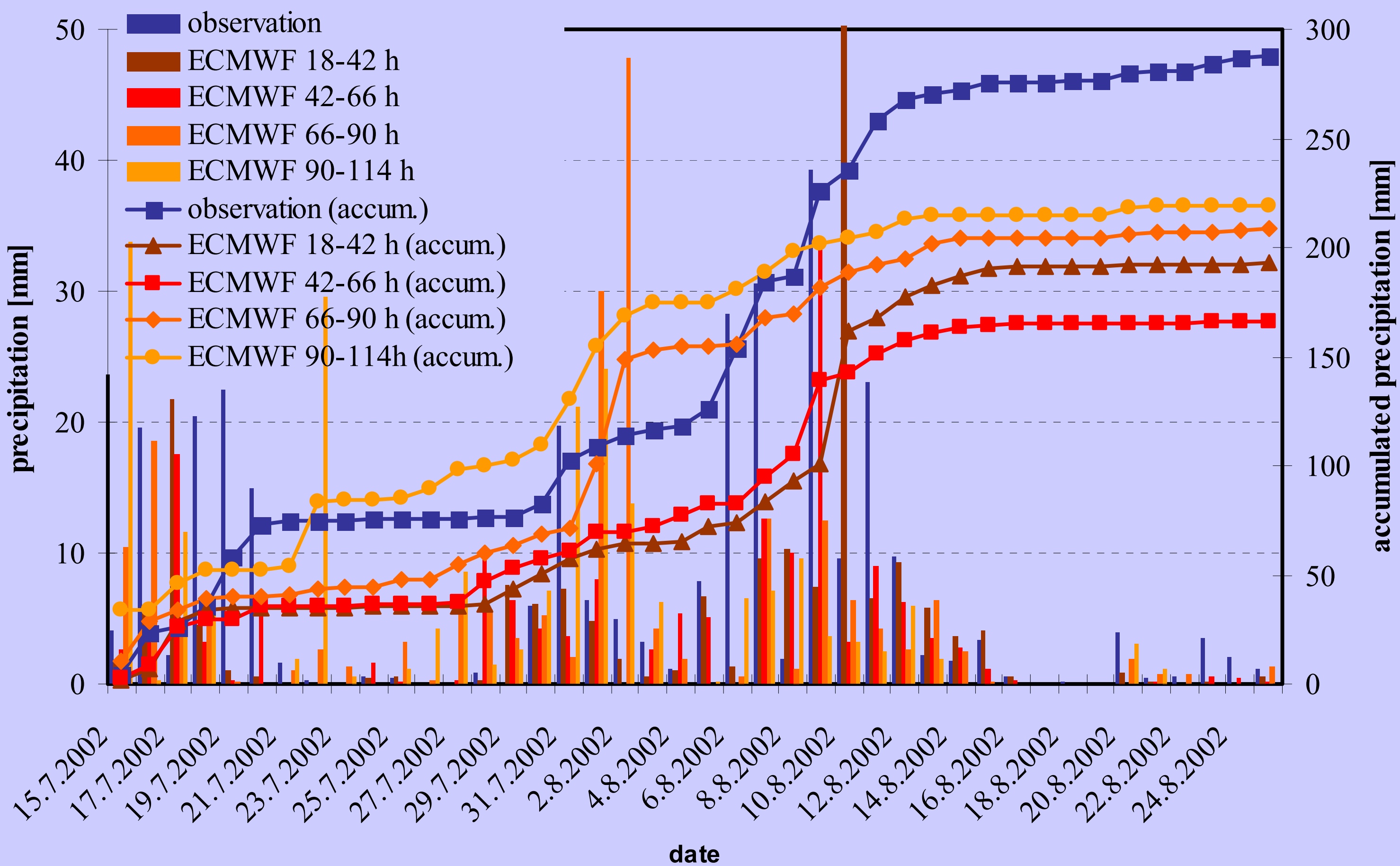


The total performance of the ALADIN and the ECMWF models in region Austria and South-Germany during flood in August 2002. The ECMWF-1 means the forecast one day, ECMWF-2 two days, ECMWF-3 tree days before the start of the event

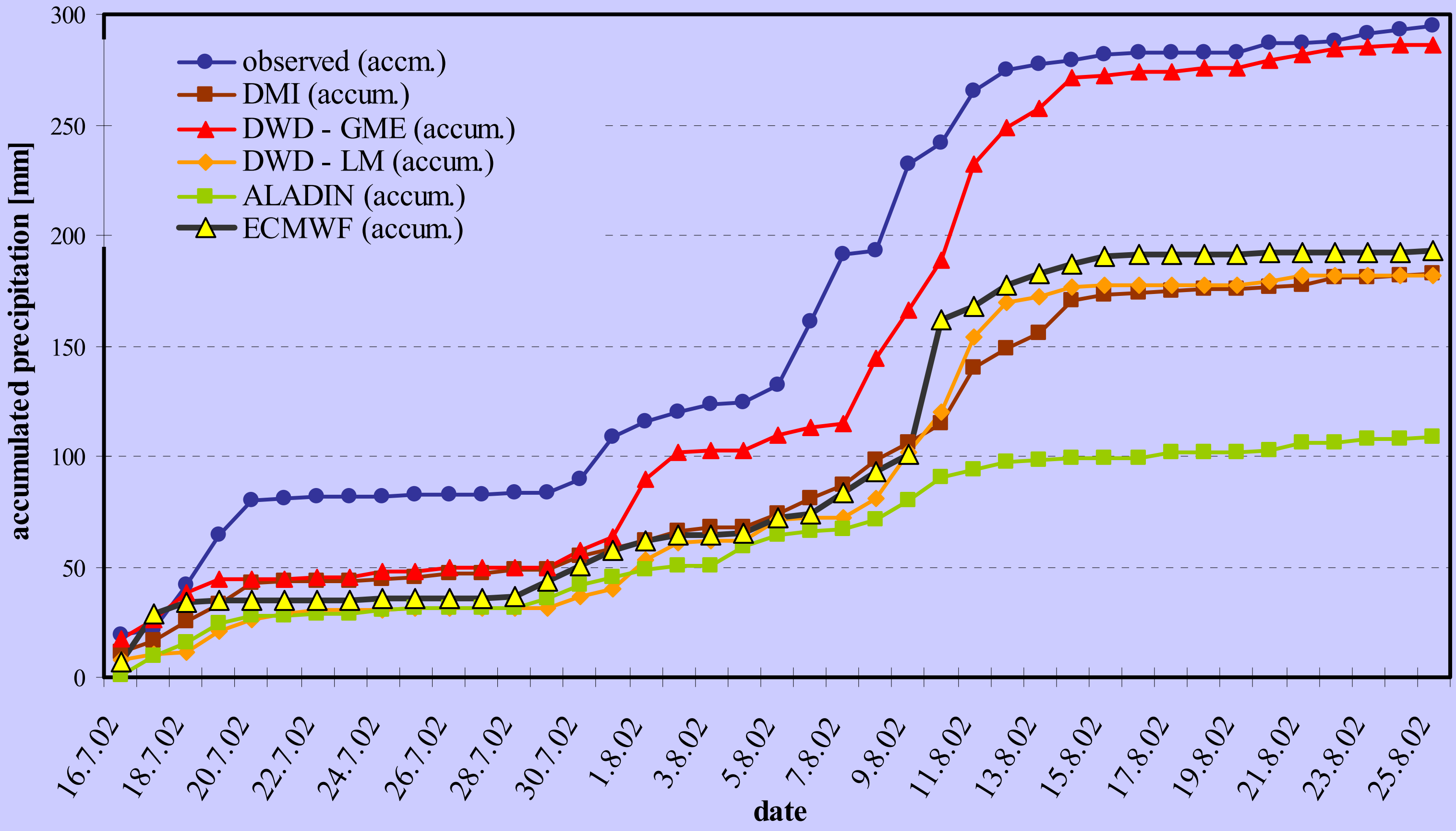


Hron Basin Slovakia

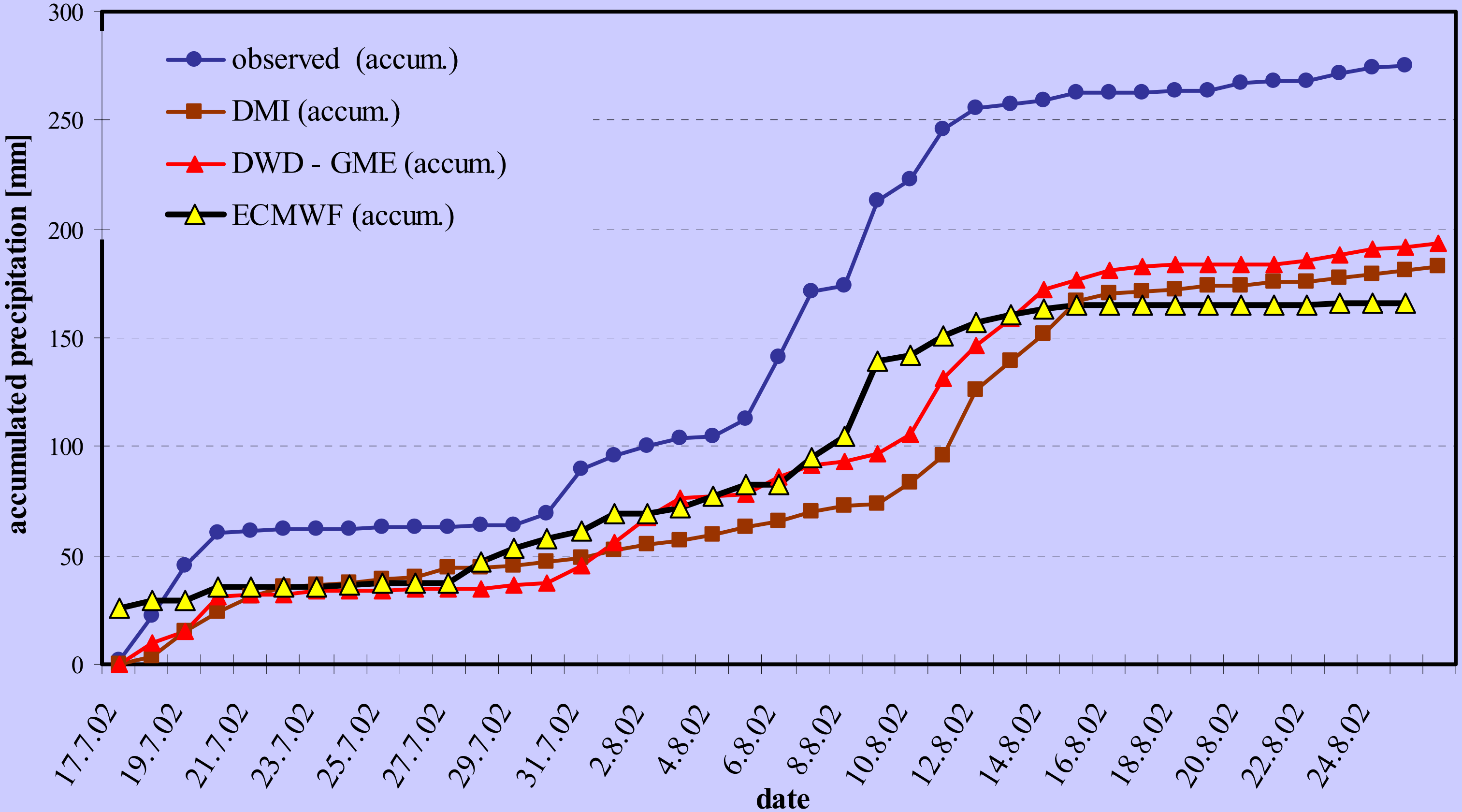
ECMWF
average precipitation (2002)



Comparison of 18-42 h forecasts (2002)



Comparison of 42-66 h forecasts (2002)



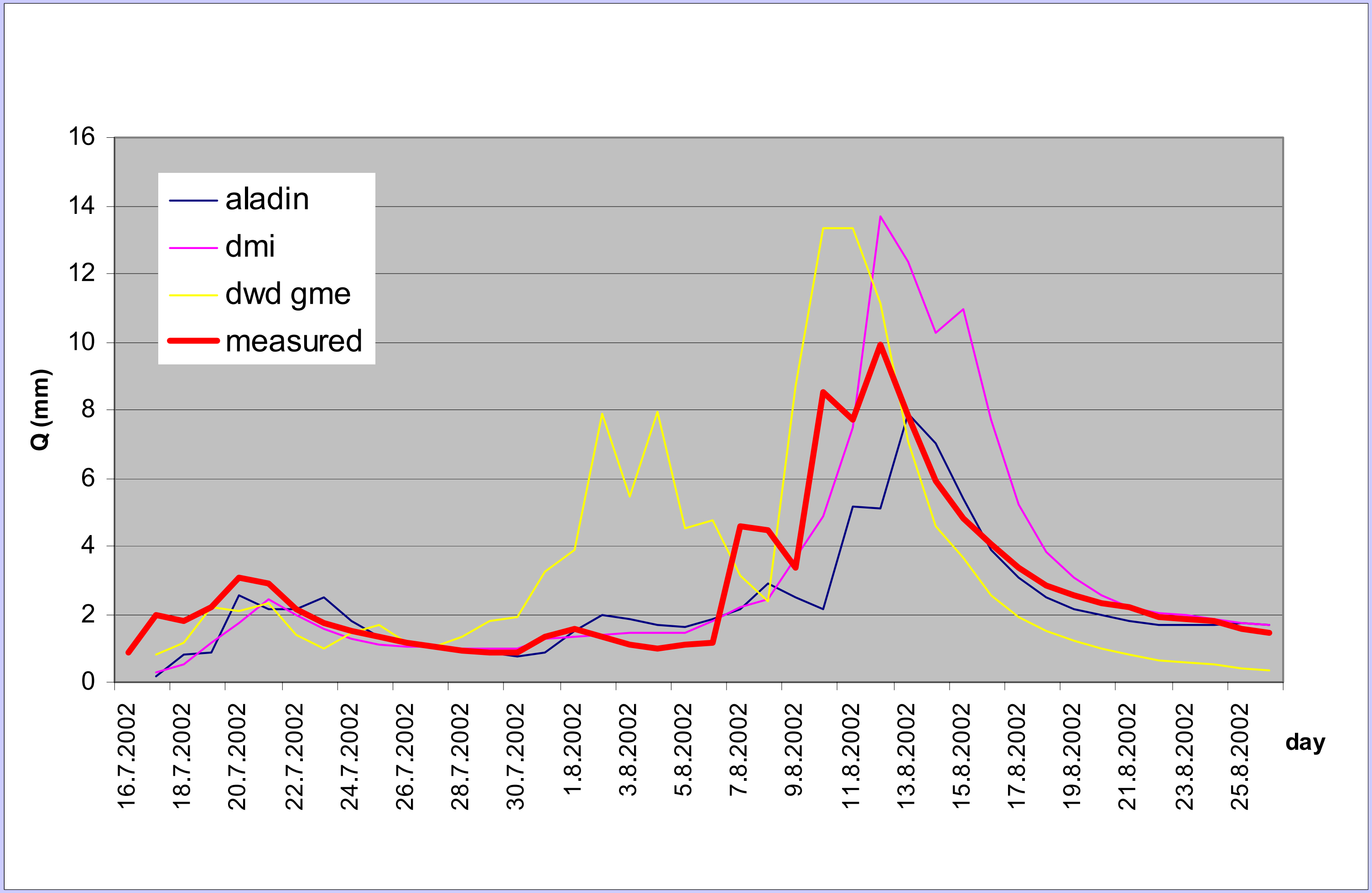
Comparison of precipitation forecasts

- Comparable results of all forecasts
- Measured accum. precip. was higher in all cases
- Relatively good timing, shifting 1-2 days
- DWD GME – the best in accum. precip.
- ALADINE – the worst in accum. precip.

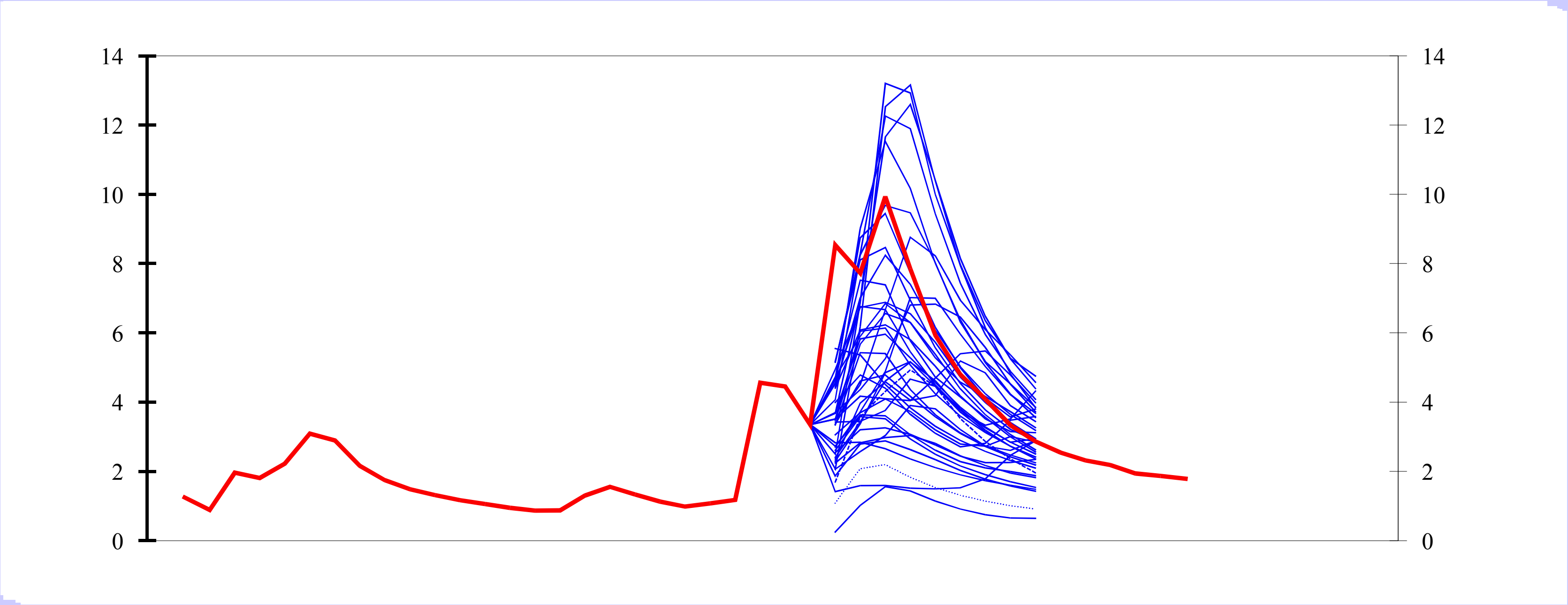
Steps of the Exercise

- ⇨ Transformation and interpolation of ECMWF input precipitation, temperature
- ⇨ Hydrological modelling system input arrays (observed precipitation, temperature, (initial) water level, flow rate)
- ⇨ Model runs water level/discharge, ensembles for 24 Danube gauges (Pfelling – Mohács) + Hron basin
- ⇨ Analysis of forecast/hindcast errrors

HBV Model runs
Hron Basin Slovakia



ECMWF- ensemble forecasts rooted 17.7.- 11.8.2002

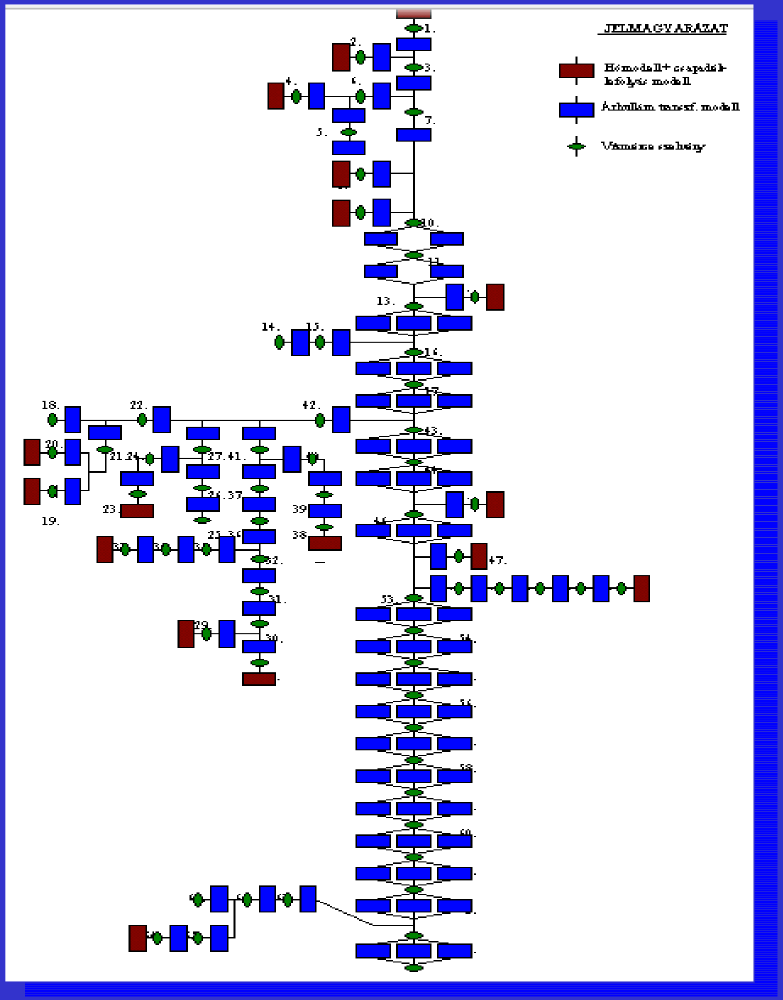


Hydrologicl ensembles, hindcasting of the Danube August 2003 flood

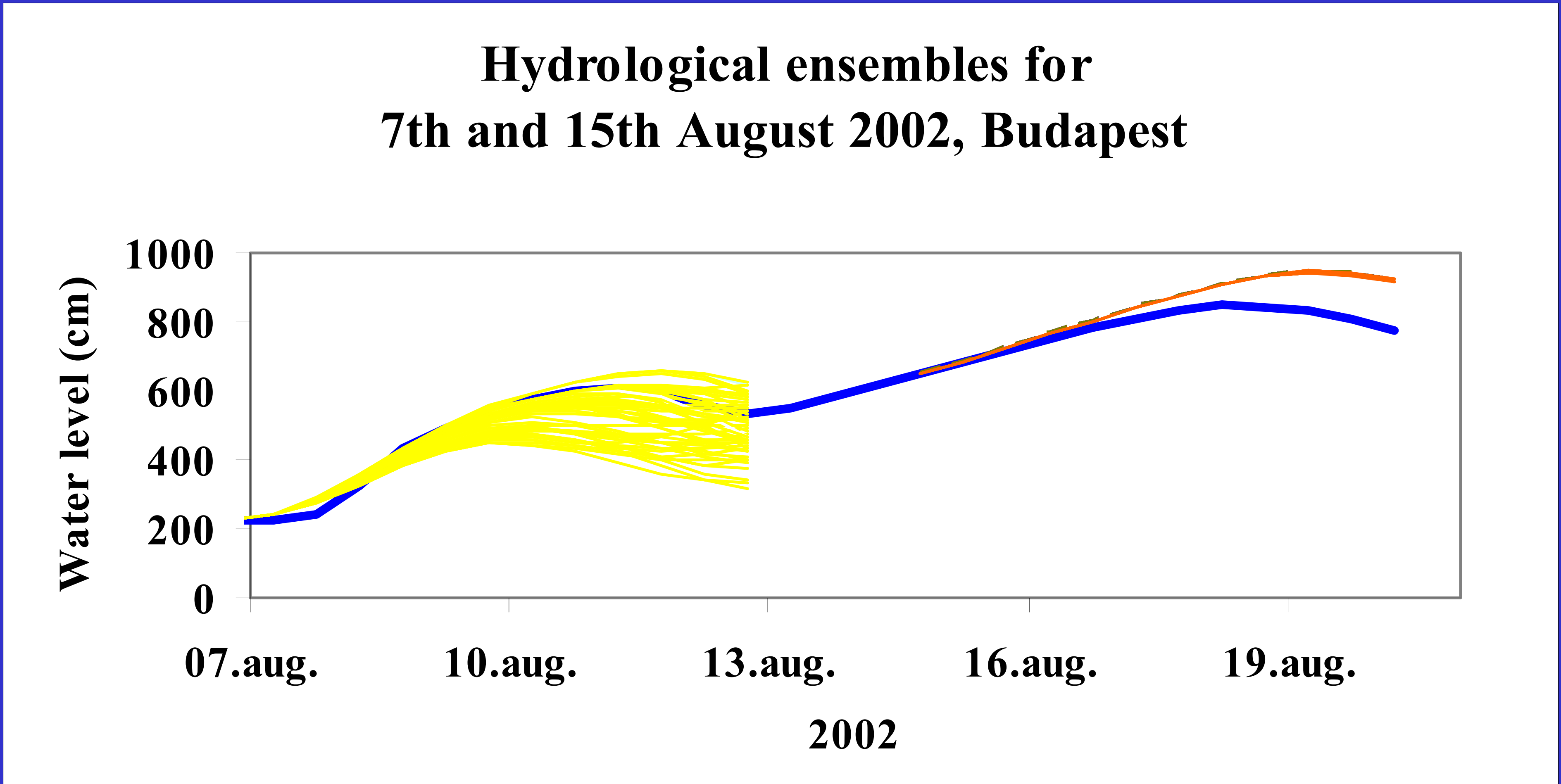
- **ECMWF ensemble (50)**
- **Near real-time data collection: Modelling-Forecasting system of VITUKI (HOLV-TAPI-DLCM)**

Scheme of the flood forecasting (hindcasting) system

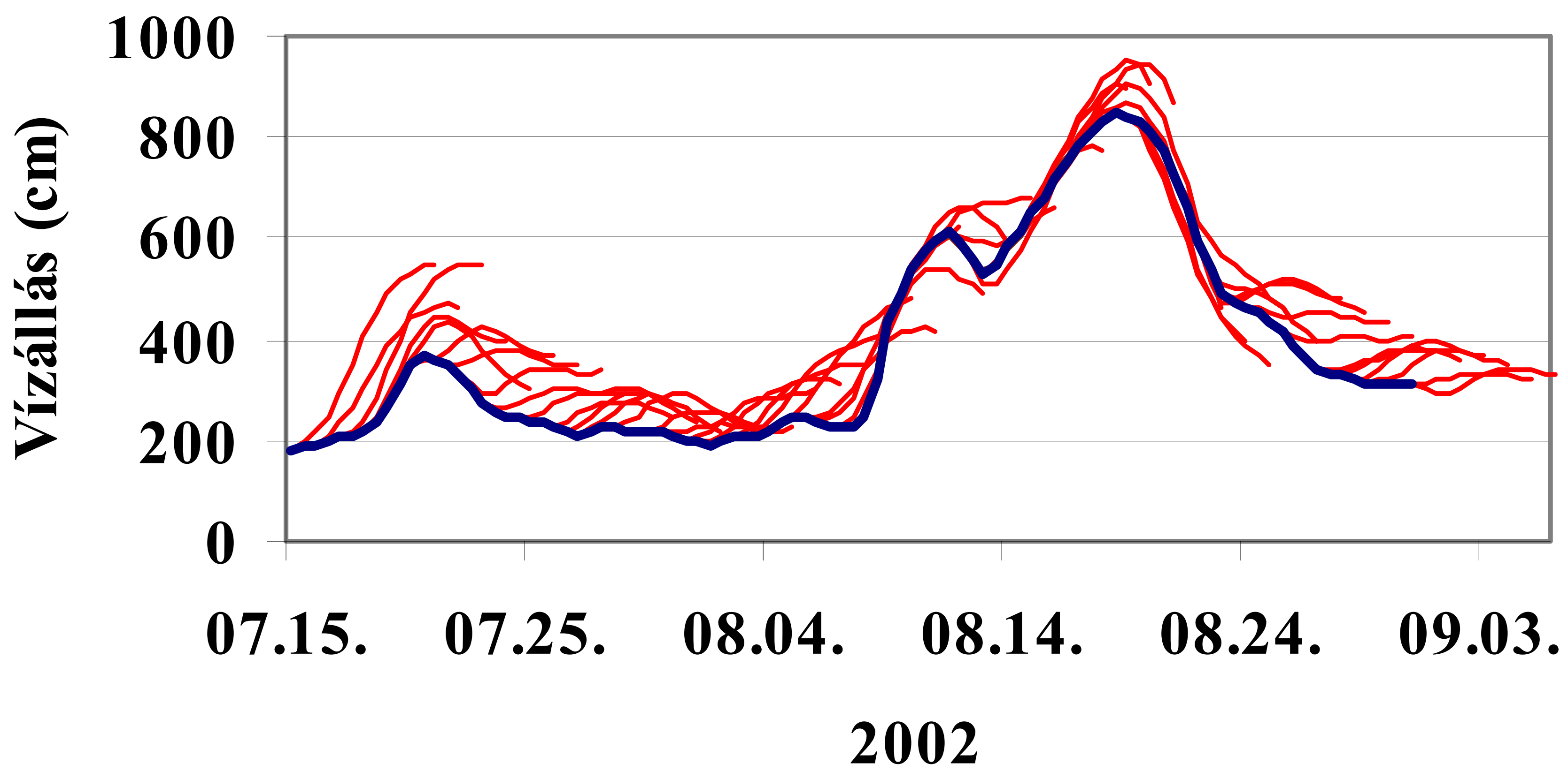
- QPF output of mesoscale and LAM models
- Conceptual hydrological models
  - Snow accumulation and ablation + soil frost
  - Rainfall - runoff module;
  - Flood routing module;
  - Backwater module
- Error correction



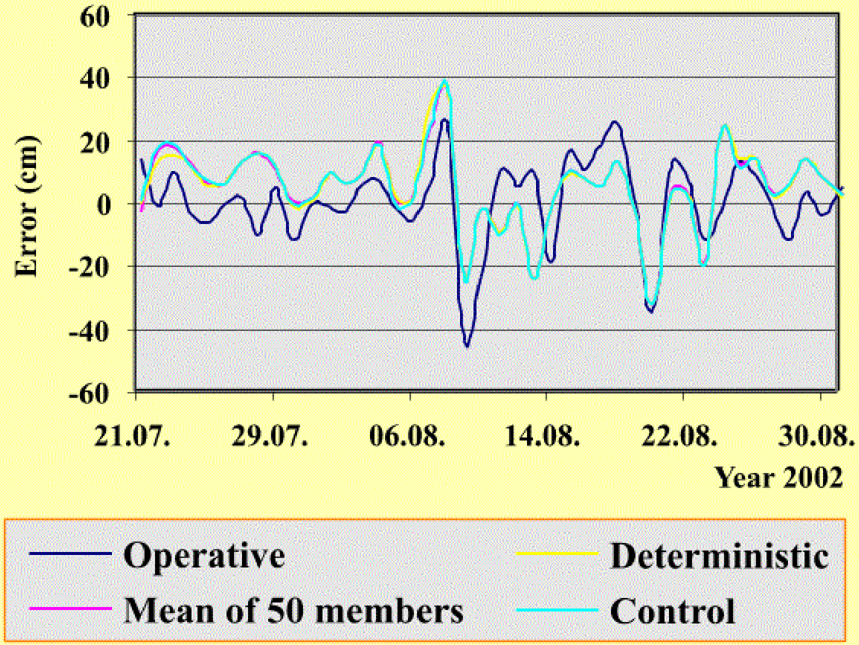
Example for hydrological ensemble



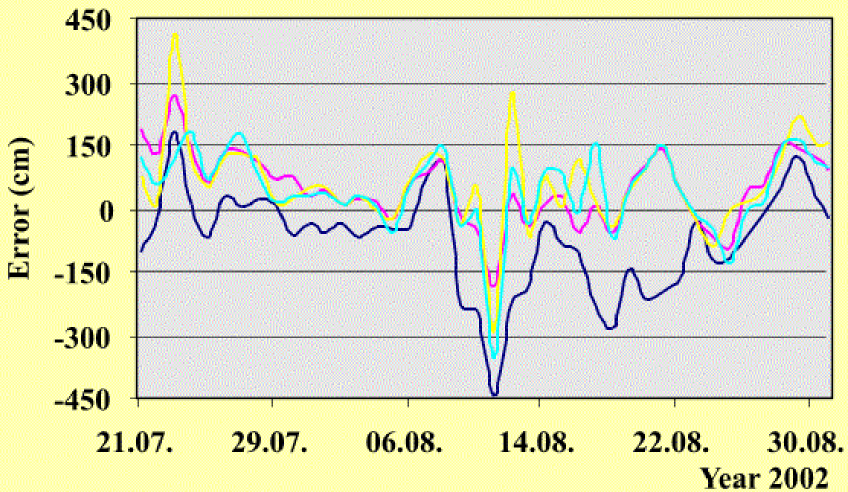
1-6-day ahead forecast, ensemble mean, 50 elements, Budapest



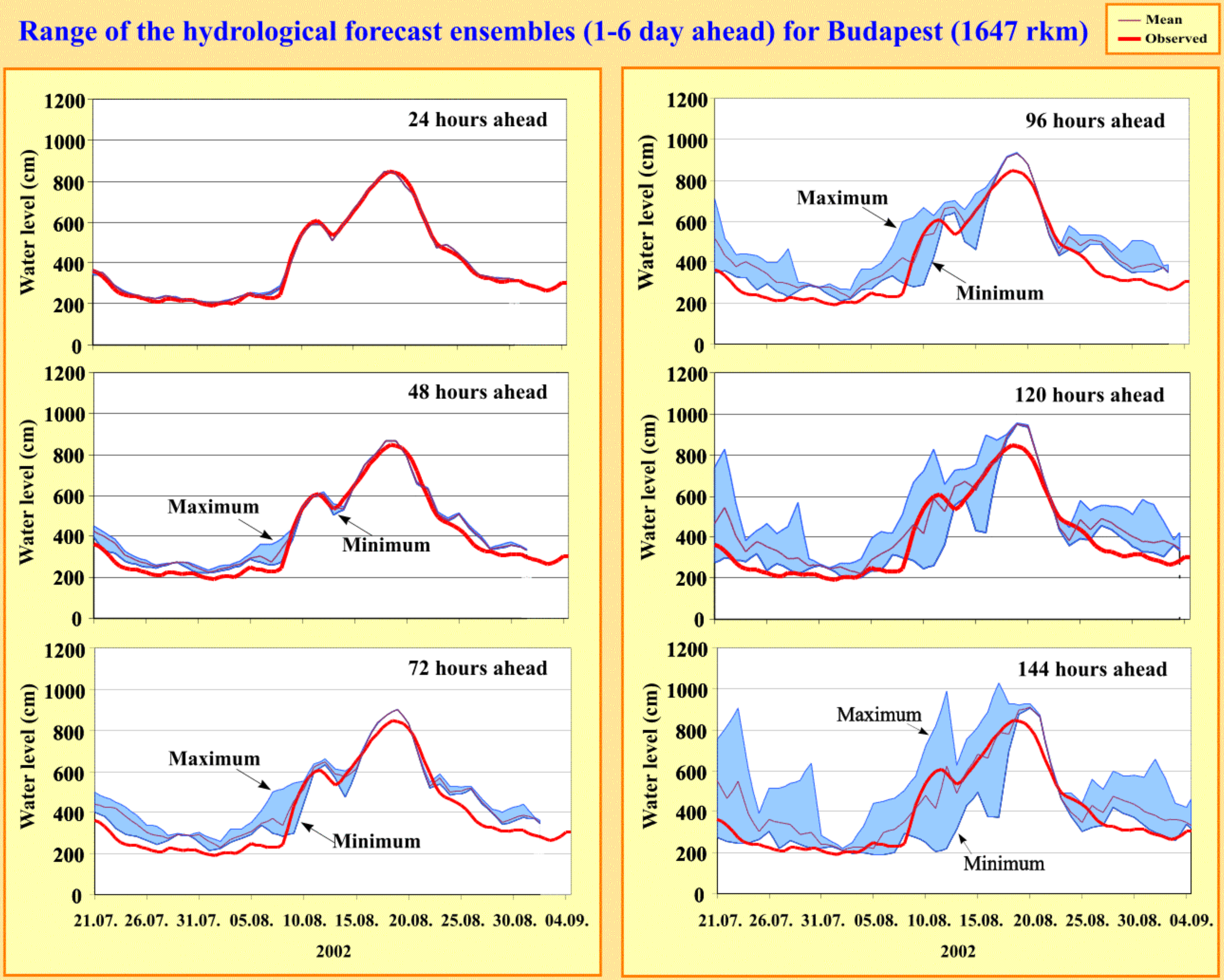
Error time-series of the 1-day forecast, Budapest



Error time-series of the 6-day forecast, Budapest



Range of the hydrological forecast ensembles (1-6 day ahead) for Budapest (1647 rkm)



The RMSE for period 21st July - 7th August 2002 (upper) and for period 8th August - 22nd August (lower)

Legend
Mean of 50 members
Operative

Station / Lead time	24 hours	48 hours	72 hours	96 hours	120 hours	144 hours
Pfelling	30.85	44.64	56.80	61.84	63.24	63.73
Hofkirchen	19.40	33.21	43.96	52.20	55.98	59.33
Kienstock	19.19	44.93	57.42	75.72	69.82	77.11
Korneuburg	11.20	30.76	42.28	53.70	52.88	57.78
Devin	16.85	31.32	47.77	79.44	80.06	86.21
Medvedovo	20.05	27.06	42.14	75.86	83.90	73.97
Gönyű	18.45	19.45	37.12	70.98	82.23	75.07
Komárom	16.66	24.40	36.07	61.45	74.19	72.18
Esztergom	10.25	15.30	24.42	45.44	61.41	62.07
Nagymaros	7.66	10.89	16.53	34.03	52.14	56.05
Budapest	6.59	12.30	18.78	34.56	57.84	66.23
Dunaújváros	6.51	11.89	15.12	21.94	41.67	51.85
Dunaföldvár	8.06	17.20	21.91	29.36	46.04	57.38
Paks	7.11	19.93	24.28	31.88	48.91	59.12
Baja	6.45	14.82	22.27	27.67	39.51	50.77
Mohács	6.75	11.34	17.77	24.46	33.64	45.40

Station / Lead time	24 hours	48 hours	72 hours	96 hours	120 hours	144 hours
Pfelling	39.31	62.07	87.69	121.21	147.56	166.59
Hofkirchen	23.28	42.32	58.43	77.42	103.52	124.08
Kienstock	88.17	137.63	144.33	167.50	202.13	241.38
Korneuburg	58.70	74.91	94.43	113.08	145.64	176.99
Devin	37.63	85.68	111.85	120.69	153.30	198.80
Medvedovo	40.29	63.94	90.79	97.07	117.46	158.64
Gönyű	28.47	54.88	75.73	92.91	105.80	151.07
Komárom	23.80	41.37	52.40	70.96	78.43	112.96
Esztergom	16.86	39.72	46.08	71.58	72.19	89.17
Nagymaros	14.87	30.12	45.92	71.28	74.45	78.15
Budapest	16.30	34.90	47.85	74.62	81.25	78.99
Dunaújváros	10.71	24.92	39.61	59.85	75.95	73.82
Dunaföldvár	9.65	22.51	40.51	64.76	84.10	81.74
Paks	10.93	20.47	38.42	61.96	85.46	85.98
Baja	11.19	16.86	24.77	40.10	76.46	86.77
Mohács	9.28	17.75	24.12	25.12	57.62	83.62

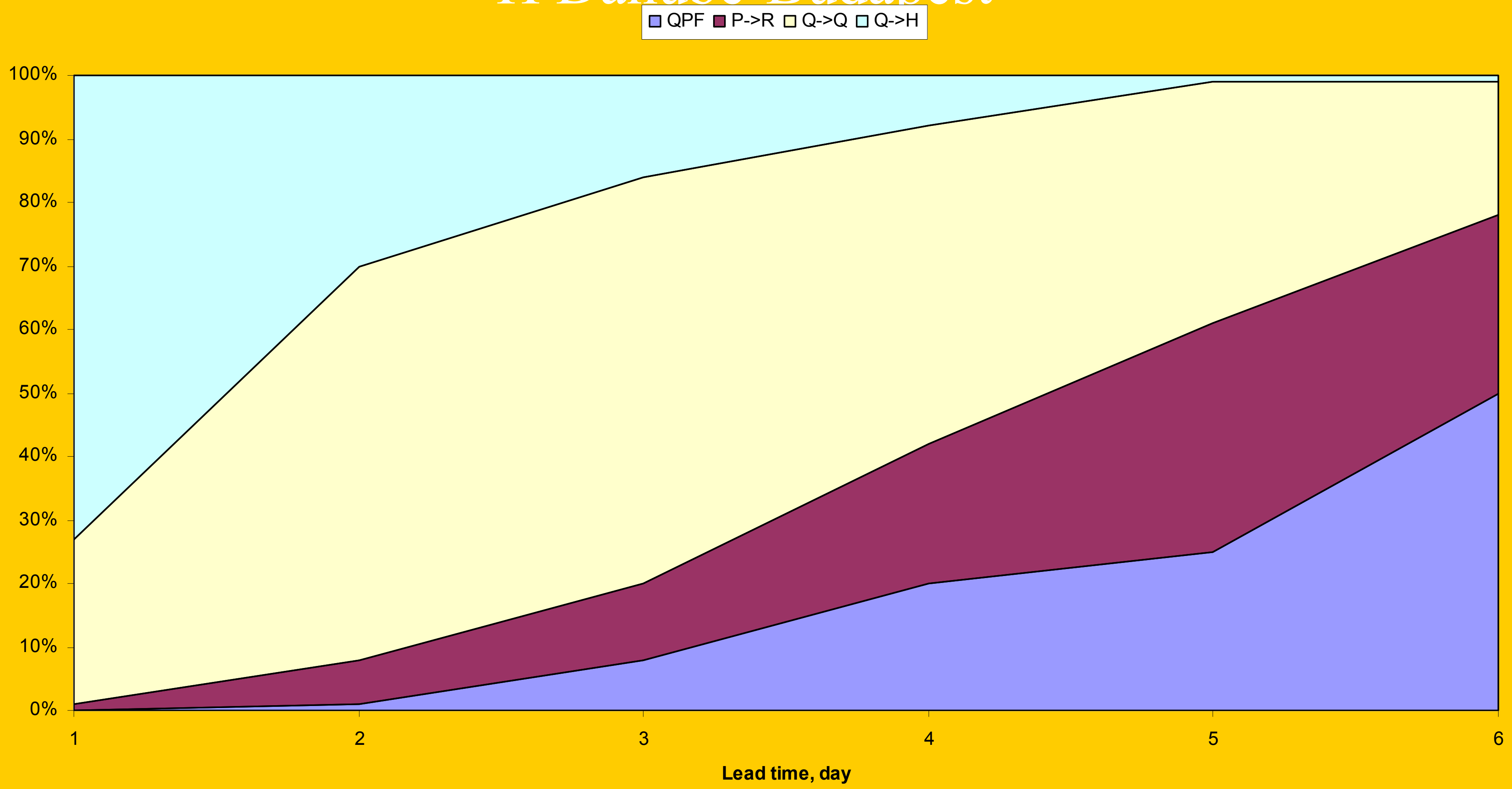
The efficiency index (upper) and Nash and Sutcliffe criterion (lower) for period 21st July - 31st August 2002

Legend
Mean of 50 members
Operative

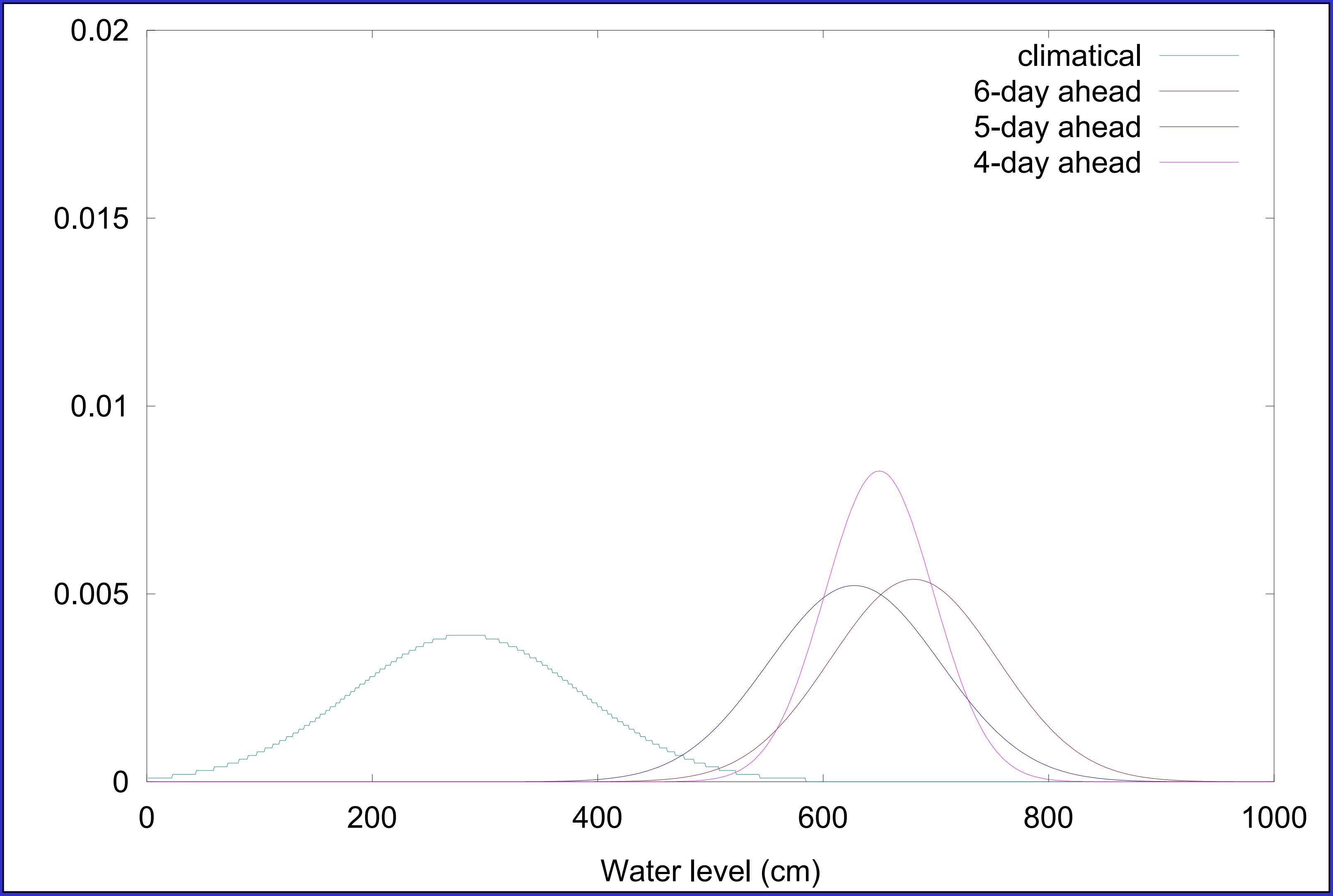
Station / Lead time	24 hours	48 hours	72 hours	96 hours	120 hours	144 hours
Pfelling	0.77	0.82	0.79	0.74	0.69	0.64
Hofkirchen	0.86	0.85	0.83	0.80	0.73	0.66
Kienstock	0.85	0.77	0.87	0.85	0.78	0.73
Korneuburg	0.79	0.80	0.86	0.84	0.77	0.71
Devin	0.95	0.88	0.88	0.89	0.85	0.78
Medvedovo	0.93	0.89	0.82	0.87	0.86	0.82
Gönyű	0.95	0.93	0.87	0.88	0.88	0.85
Komárom	0.95	0.92	0.88	0.89	0.90	0.87
Esztergom	0.97	0.96	0.92	0.86	0.89	0.88
Nagymaros	0.98	0.98	0.96	0.90	0.89	0.89
Budapest	0.97	0.97	0.96	0.92	0.88	0.89
Dunaújváros	0.98	0.97	0.97	0.94	0.89	0.89
Dunaföldvár	0.98	0.96	0.96	0.95	0.91	0.87
Paks	0.99	0.98	0.96	0.95	0.92	0.86
Baja	0.98	0.98	0.97	0.96	0.93	0.88
Mohács	0.98	0.98	0.97	0.97	0.95	0.90

Station / Lead time	24 hours	48 hours	72 hours	96 hours	120 hours	144 hours
Pfelling	0.91	0.79	0.62	0.40	0.21	0.04
Hofkirchen	0.95	0.86	0.72	0.57	0.37	0.18
Kienstock	0.93	0.70	0.72	0.66	0.54	0.37
Korneuburg	0.92	0.77	0.76	0.70	0.55	0.37
Devin	0.98	0.89	0.81	0.78	0.69	0.53
Medvedovo	0.98	0.92	0.78	0.78	0.74	0.62
Gönyű	0.99	0.95	0.86	0.82	0.79	0.67
Komárom	0.99	0.95	0.88	0.84	0.82	0.72
Esztergom	1.00	0.98	0.93	0.81	0.81	0.75
Nagymaros	1.00	0.99	0.96	0.87	0.80	0.76
Budapest	1.00	0.99	0.96	0.90	0.79	0.76
Dunaújváros	1.00	0.99	0.97	0.93	0.82	0.78
Dunaföldvár	1.00	0.99	0.97	0.94	0.86	0.75
Paks	1.00	0.99	0.98	0.95	0.88	0.75
Baja	1.00	0.99	0.98	0.96	0.91	0.81
Mohács	1.00	0.99	0.98	0.98	0.94	0.86

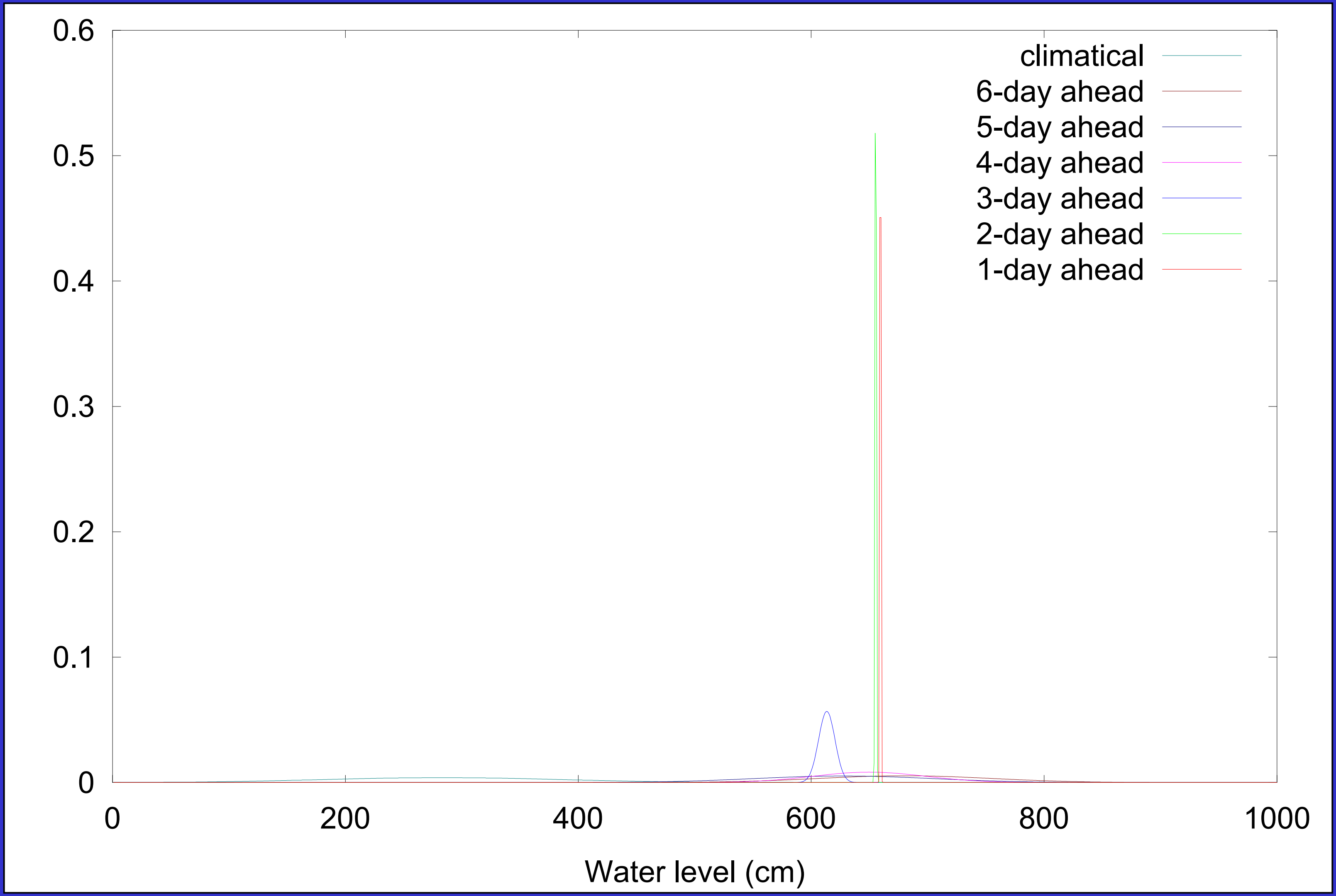
SENSITIVITY ANALYSIS, SOURCE OF ERROR
H Danube-Budapest



Comparison of distributions
4-day ahead forecast



Comparison of distributions 1-day ahead forecast



CONCLUSIONS

- **Best performance in rising limbs – when uncertainty is high and QPF forecast is successful**
- **Comparative efficiency: relative to climatic variability in longer rage forecast, naive forecast**
- **Parallel model runs, ensemble have larger role as lead time increases**
- **Poor performance in relative low flow period**
- **Future: Longer investigated period + different hydrological regime components (Snowmelt simulations)**

Thank you for your attention