Medium range deterministic and EPS performance in recent years

Objective forecast verification in Hungary

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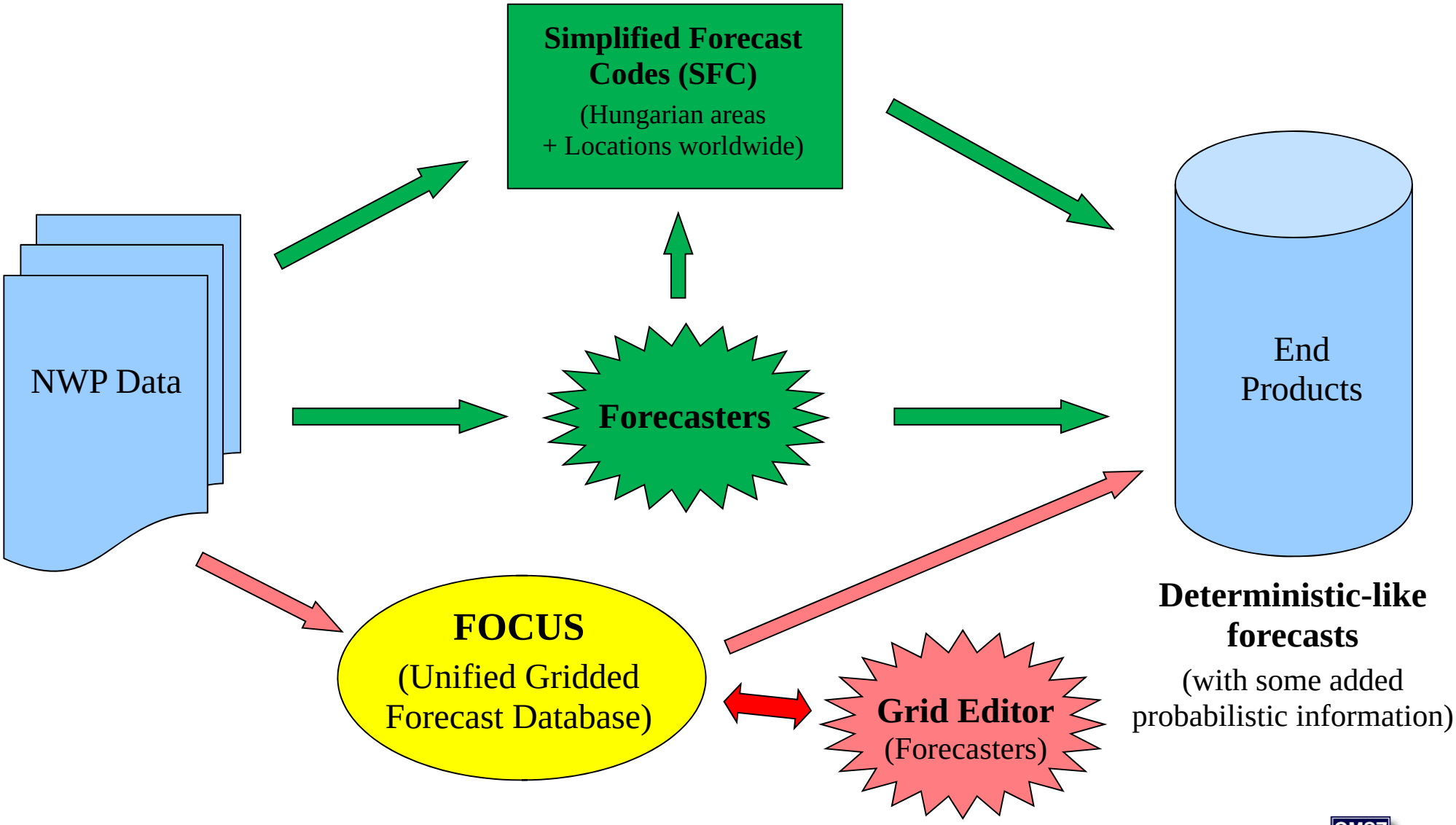
Outline

- **Overview of the forecast production and forecast verification system at the Hungarian Meteorological Service**
- **ECMWF high resolution and EPS scores**
- **About the precipitation type forecasts (snow-rain relation)**
- **Model performance in large temperature changes**
- **Short range forecast verification**
- **Summary**

Schematic of the medium-range forecast production



Simplified Forecast Code

OOSSSSII HHNN BBJJ CCVW SSSS AALL YYXX

1284300	1111	8///	6/3/	32//	0614	04//
1277200	1111	9/11	6/3/	32//	0307	04//
1288200	1111	9/11	6/3/	32//	0308	05//
1298200	1111	9//1	6/3/	32//	0511	05//
1293200	1111	97/1	6/3/	32//	0513	03//
1282500	1111	94//	6/3/	32//	0514	02//

Day1

1284301	1112	30/2	8/2/	32//	0413	//09
1277201	1112	82/1	682/	27//	0308	//08
1288201	1112	86/1	682/	27//	0308	//09
1298201	1112	72/1	681/	32//	0412	//10
1293201	1112	2//1	8/1/	3223	0308	//11
1282501	1112	2//1	861/	3223	0308	//10

Day2

1284302	1113	17/1	////	23//	0206	0012
1277202	1113	28/1	////	23//	0207	0010
1288202	1113	28/1	////	23//	0307	0211
1298202	1113	14/1	8/1/	23//	0307	0113
1293202	1113	2//2	////	23//	0307	0113
1282502	1113	3//2	////	23//	0205	0012

Day3

Forecast for Budapest

Mostly cloudy first then sunny

Patches of fog in the morning

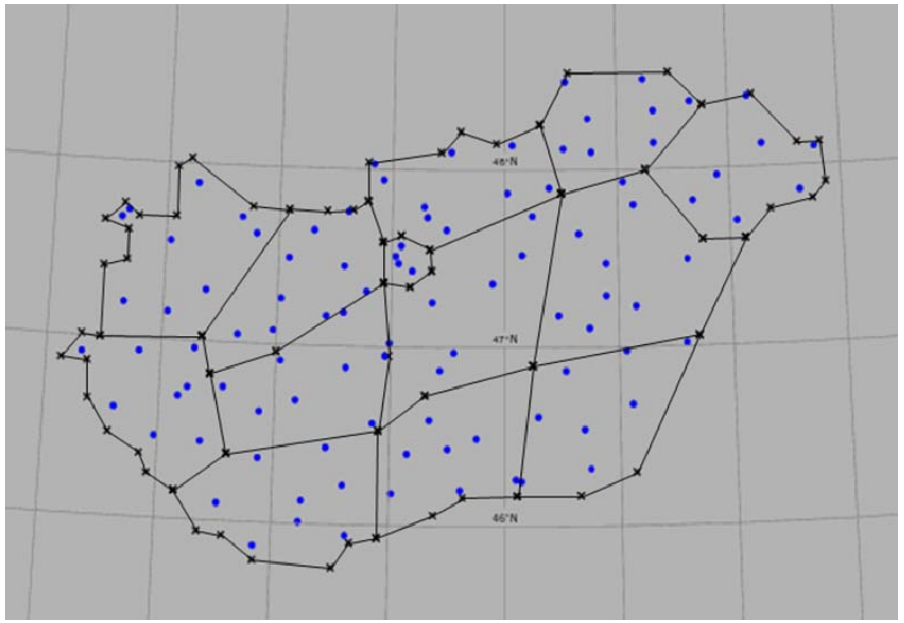
Showers possible

NW-erly wind with gusts up to 40-55 km/h

Tmax: 9 degrees

- Forecasts for predefined periods (12-, 18-, or 24-hour)
- Pre-processed forecast values/codes for the main weather parameters
  - Cloudiness, Mist / fog / thunderstorm, Precipitation (type / amount / probability), Wind (direction / mean speed / gust), Temperature (minimum / maximum)
- For different regions in Hungary and locations worldwide
- Produced operationally from the following sources:
  - Forecasters
  - Deterministic and EPS models (with unified algorithms)
- Used currently in various applications (FOCUS is the future):
  - Every day operational forecasting
  - Web / media forecasts
  - Verification

SFC and verification



- For model verification purposes the SFC with 13 subareas of Hungary was introduced (in the operational forecasting 6 areas are used)
- Each forecast is valid for an area (locations correspond to a small area around the point)
  - We have areal mean
  - Or yes/no forecast values (anywhere in the area)
- Verification is done against SYNOP observations
  - Apprx. 100 stations including ~15 manned stations with visual observations

- For preparing the SFC values/codes from NWP data and for verifying it by the SYNOP data the same algorithms are used
- We process each grid point (SFC preparation) or SYNOP station (SFC verification) falling in the area
- Similarly each forecast step or observation hour falling in the forecast period is processed

SFC forecast algorithms

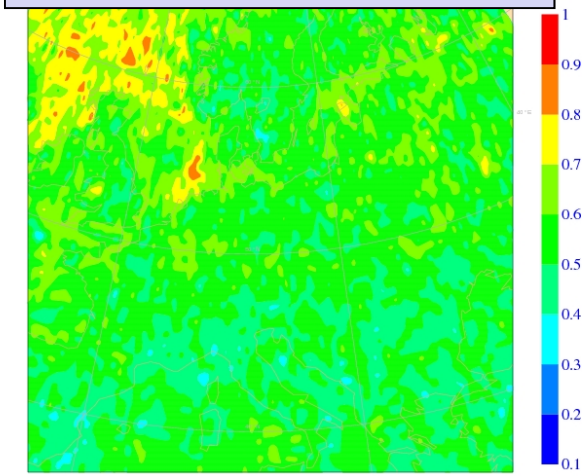
- **Parameters with mean sense**
  - Where it is meaningful we process the EPS in the deterministic way by using directly the EPS-mean
  - For average wind speed, cloudiness, precipitation, maximum wind gust, precipitation amount and min/max temperature the regional forecast code is an areal mean of mean/accumulation/extreme values representing the forecast period at each grid point

- **Parameters with occurrence / direction meaning**
  - For occurrence of weather events and wind direction the mean sense (the EPS-mean) can not be used.
  - Instead we derive the forecast code based on the distribution of forecast values. All grid points in the area, forecast steps in the period and forecast members (1 for deterministic models and more for ensemble models – 51 for the EPS)
  - For wind direction we compute the frequency of the 8 main directions. We weight these frequencies by the average wind speed in each category. The wind direction code is the highest value

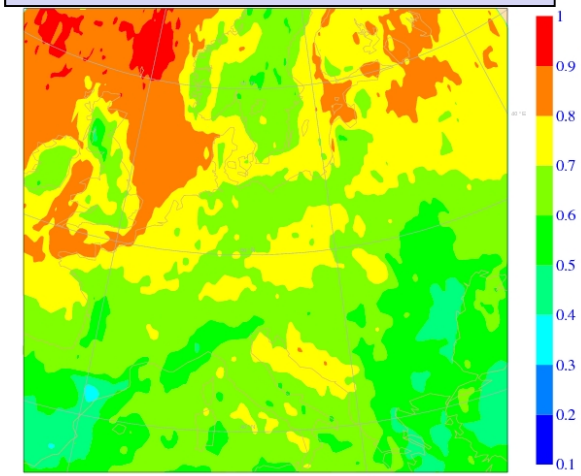
About the algorithms

- The precipitation types are determined based on the snow/total precip (for rain-snow), and convective/lscale precip distinction of the model (for showery/not showery precip). To detect freesing rain we use some lower tropospheric temperatures of the model. **A freesing rain parameter would be very welcome in the model!**
- Precipitation occurrence is coded when the EPS probability for precip is higher than the “EPS precip-probability climate” related threshold value (one threshold for each forecast range). This threshold is determined to ensure that on average we code precip as frequent as it actually occurs in the EPS (in the shortest range). For the EPS probability climate we could only use archived EPS forecasts.

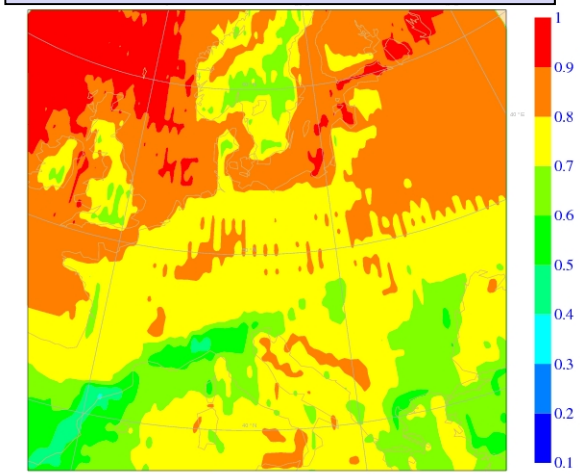
Probability threshold for coding precip at day1



Probability threshold for coding precip at day6

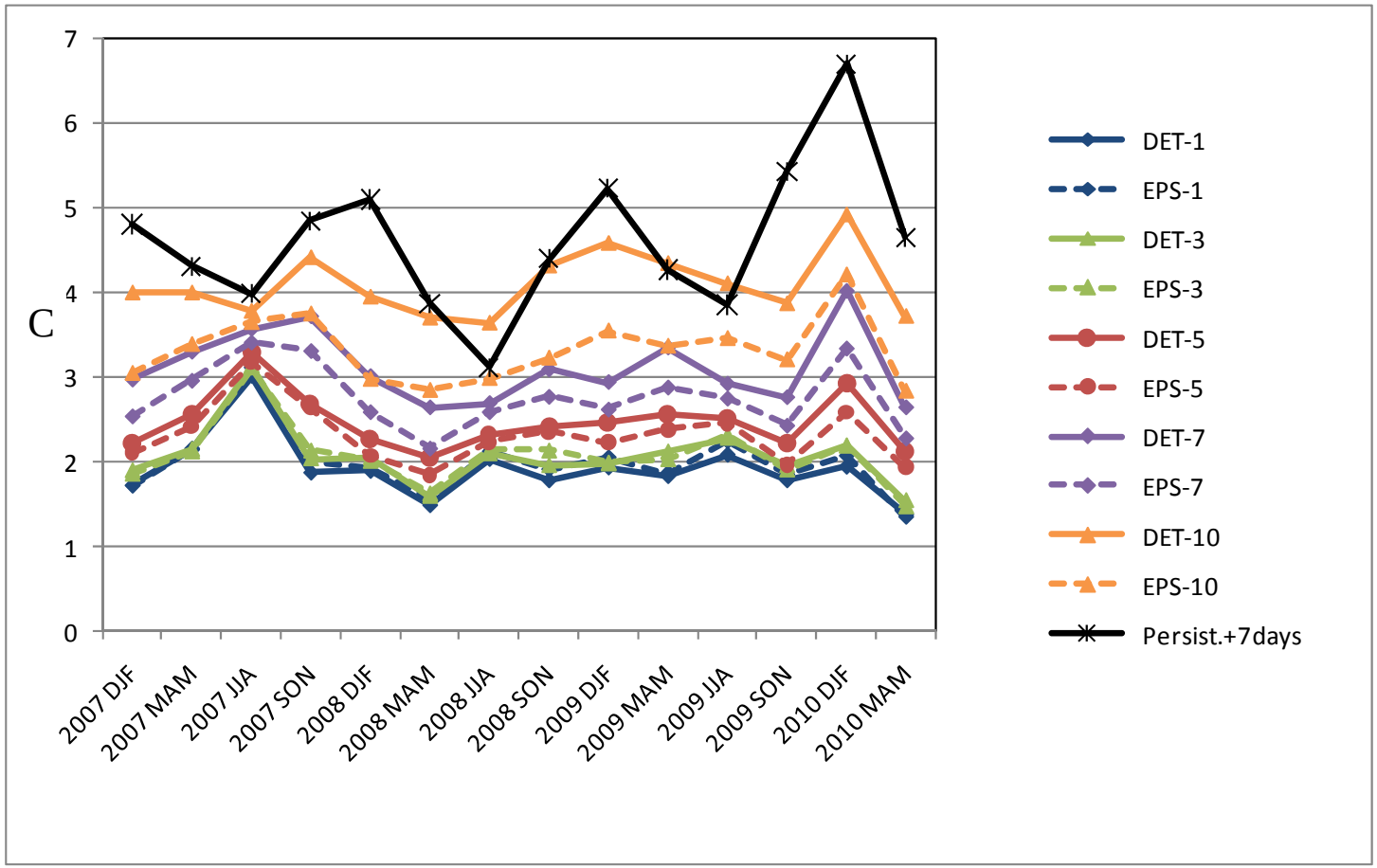


Probability threshold for coding precip at day14



Seasonal score time series

Minimum Temperature, RMSE, Oct 2006 – May 2010, every 00z run



Seasonal score time series

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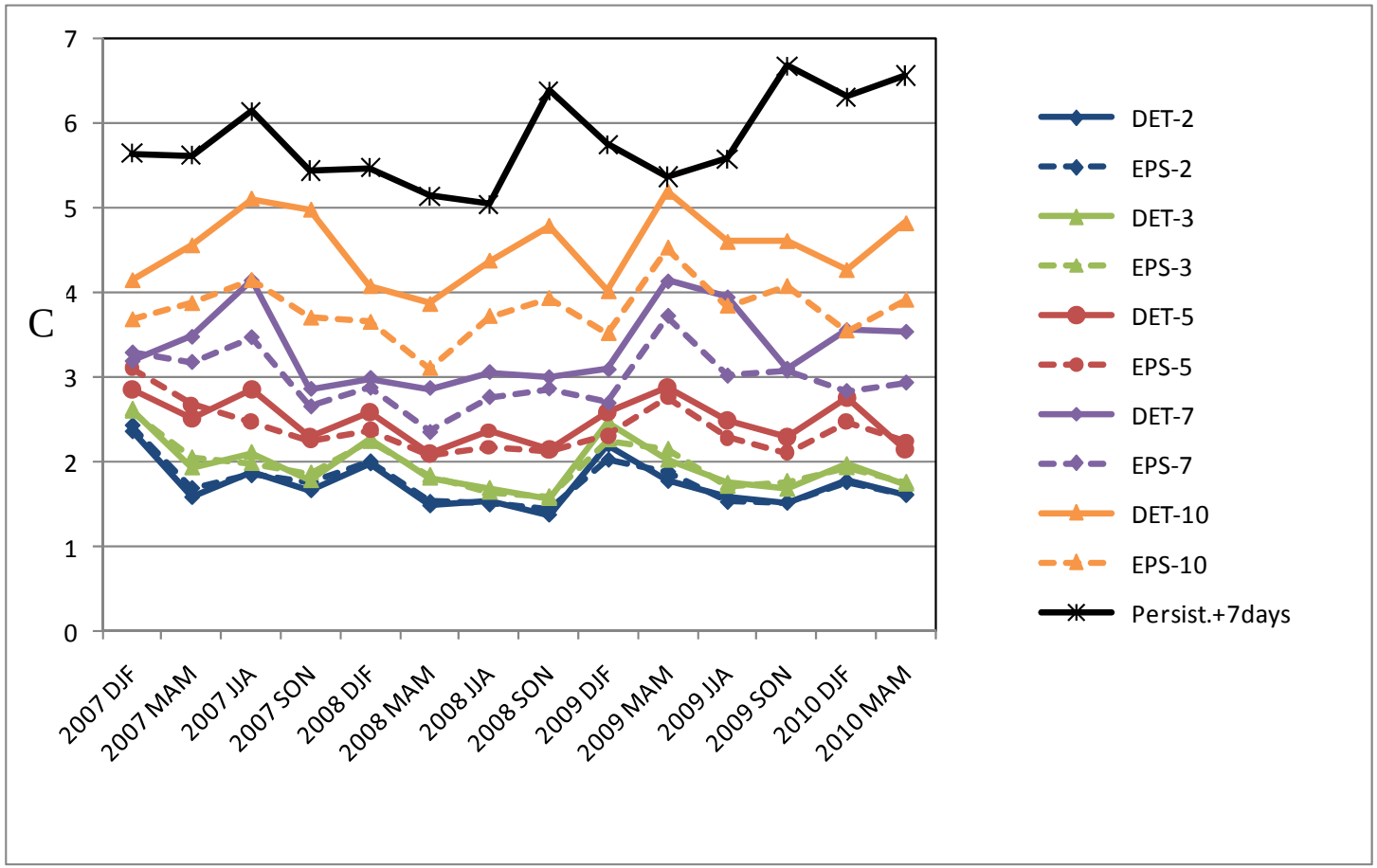
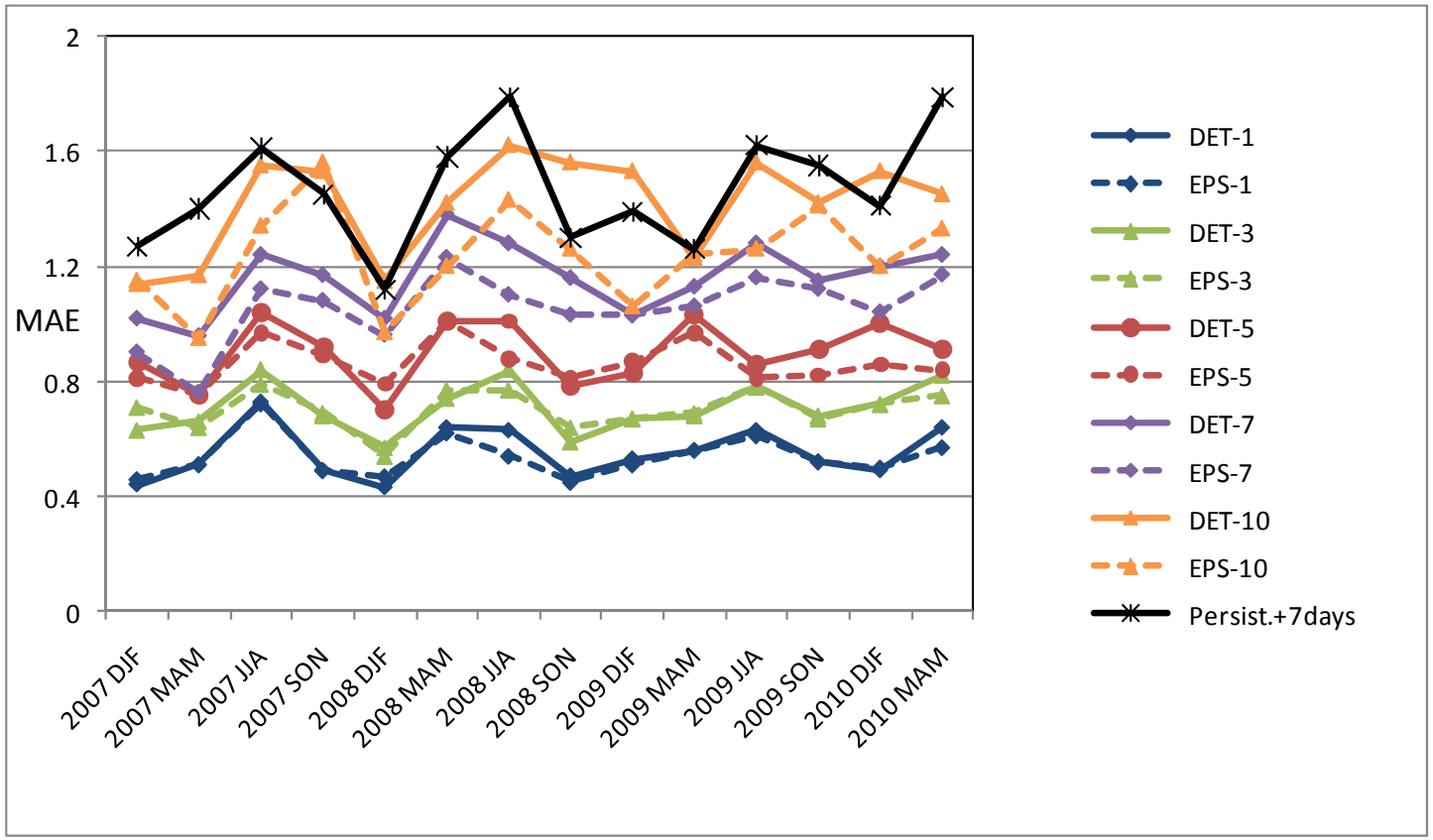


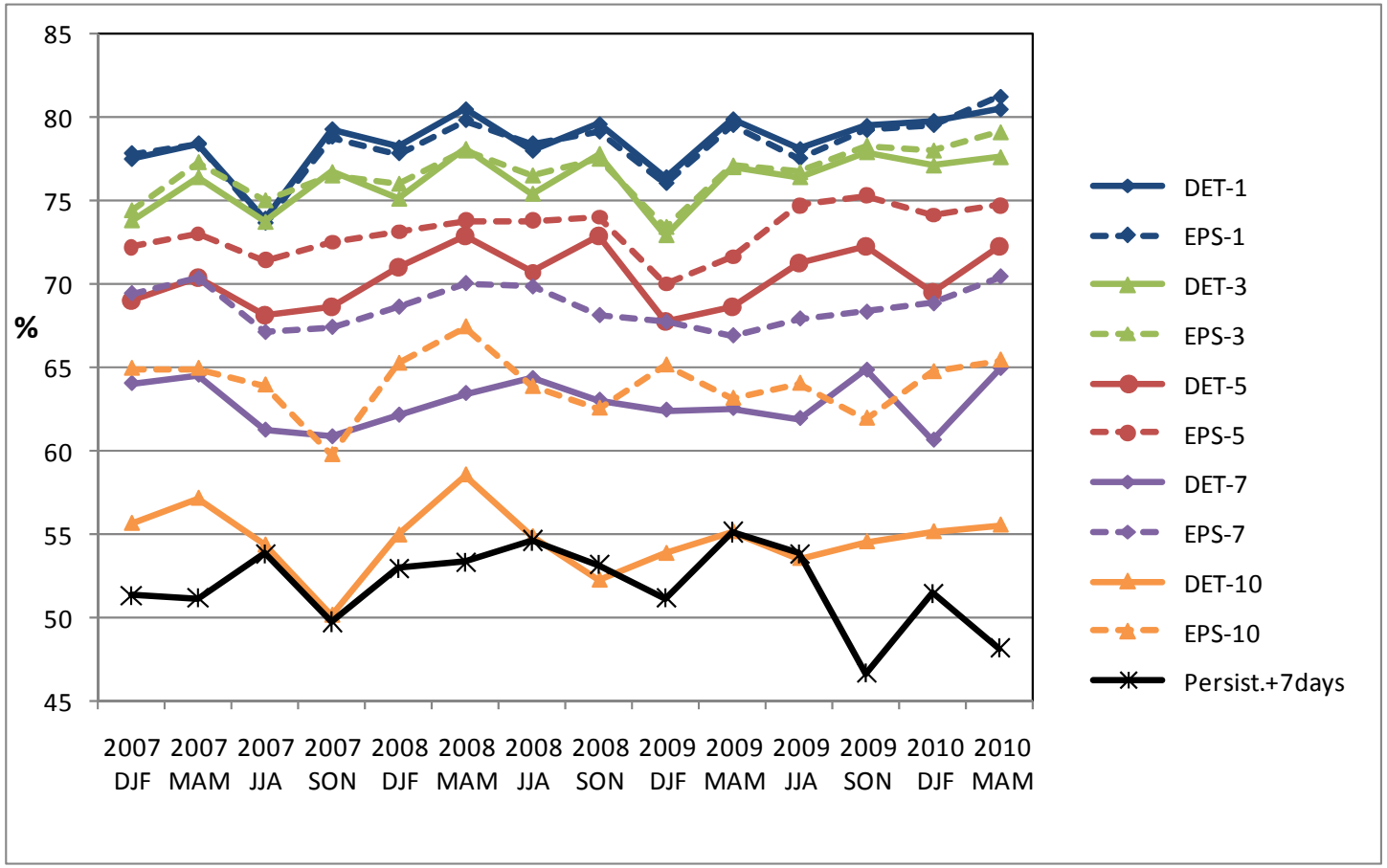
Seasonal score time series

Precipitation Category, MAE, Oct 2006 – May 2010, every 00z run



Seasonal score time series

Summary (complex) Score, Oct 2006 – May 2010, every 00z run



EPS vrs. high resolution deterministic score summary

DET (high res. at 00z), **EPS** (at 00z) and **EPS-DET** scores for the period Oct 2006 – May 2010

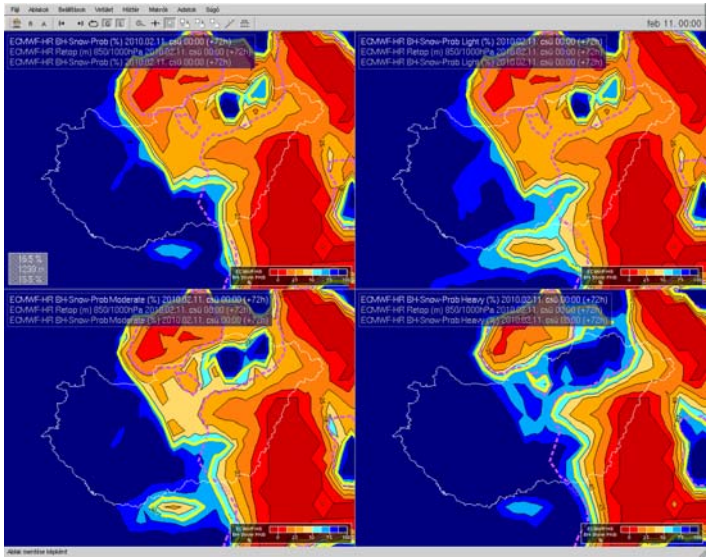
EPS worse EPS better

SOURCE		Tmin ME	Tmin MAE	Tmax ME	Tmax MAE	P-Occ FBI	P-Occ ETS	P-Qua ME	P-Qua MAE	Wdir MAE	Wgust ME	Wgust MAE	Wg12 FBI	Wg12 ETS	Cloud ME	Cloud MAE	Snow-Rain ME	Snow-Rain MAE	Lsc-Cv ME	Lsc-Cv MAE	SUM
Day-1	DET	0.74	1.52			1.13	0.42	0.00	0.84	0.84	0.26	1.37	1.26	0.47	-0.17	0.78	-0.04	0.17	0.62	0.92	78.2
	EPS	0.89	1.58			1.06	0.45	0.06	0.85	0.85	0.37	1.47	1.33	0.45	-0.02	0.73	-0.03	0.17	0.54	0.93	78.0
	EPS-DET		0.06				0.03		0.01	0.01		0.10		-0.02		-0.05		0.00		0.01	-0.2
Day-2	DET			0.03	1.29	1.14	0.40	0.20	1.02	0.79	0.32	1.50	1.30	0.45	-0.22	0.81	-0.05	0.18	0.63	0.93	78.0
	EPS			-0.15	1.34	1.13	0.42	0.28	1.06	0.80	0.53	1.59	1.41	0.43	-0.05	0.71	-0.04	0.19	0.53	0.95	78.2
	EPS-DET				0.05		0.02		0.04	0.01		0.09		-0.02		-0.10		0.01		0.02	0.2
Day-3	DET	0.79	1.63	0.04	1.47	1.07	0.38	0.27	1.39	0.86	0.18	1.66	1.27	0.42	-0.21	0.84	-0.04	0.18	0.66	0.98	75.9
	EPS	0.90	1.65	-0.19	1.50	1.07	0.40	0.34	1.40	0.86	0.47	1.69	1.36	0.41	-0.01	0.72	-0.02	0.19	0.51	0.96	76.5
	EPS-DET		0.02		0.03		0.02		0.01	0.00		0.03		-0.01		-0.12		0.01		-0.02	0.6
Day-4	DET	0.78	1.77	0.00	1.64	1.07	0.35	0.23	1.59	0.94	0.23	1.87	1.28	0.36	-0.21	0.98	-0.03	0.20	0.70	1.02	73.2
	EPS	0.86	1.73	-0.25	1.66	1.07	0.38	0.26	1.51	0.93	0.47	1.83	1.31	0.38	0.01	0.79	-0.02	0.21	0.51	0.99	74.9
	EPS-DET		-0.04		0.02		0.03		-0.08	-0.01		-0.04		0.02		-0.19		0.01		-0.03	1.7
Day-6	DET	0.75	2.15	0.01	2.19	1.05	0.23	0.29	2.05	1.18	0.22	2.45	1.30	0.22	-0.12	1.30	-0.01	0.25	0.70	1.06	66.1
	EPS	0.76	2.00	-0.27	2.10	1.07	0.27	0.08	1.79	1.13	0.49	2.22	1.17	0.27	0.05	0.99	0.02	0.28	0.48	1.01	70.3
	EPS-DET		-0.15		-0.09		0.04		-0.26	-0.05		-0.23		0.05		-0.31		0.03		-0.05	4.2
Day-8	DET	0.82	2.71	0.02	2.84	1.08	0.12	0.25	2.39	1.45	0.39	3.00	1.39	0.14	-0.12	1.64	0.00	0.36	0.71	1.12	59.3
	EPS	0.73	2.35	-0.30	2.58	1.08	0.18	0.01	2.01	1.34	0.60	2.54	1.03	0.19	0.03	1.13	0.01	0.37	0.47	1.05	66.4
	EPS-DET		-0.36		-0.26		0.06		-0.38	-0.11		-0.46		0.05		-0.51		0.01		-0.07	7.1
Day-10	DET	0.70	3.24	-0.11	3.54	1.07	0.06	0.20	2.55	1.67	0.28	3.36	1.35	0.06	-0.16	1.84	0.02	0.46	0.75	1.18	54.3
	EPS	0.61	2.64	-0.34	3.03	1.05	0.11	-0.15	2.05	1.52	0.53	2.69	0.74	0.13	0.03	1.25	-0.01	0.47	0.46	1.05	63.6
	EPS-DET		-0.60		-0.51		0.05		-0.50	-0.15		-0.67		0.07		-0.59		0.01		-0.13	9.3

- EPS is better than high resolution deterministic forecasts mainly from day3/day4
- Minimum temperature is overforecast by almost a degree
- Too much convective precipitation is produced by the model (compared to SYNOP observations)

Evaluation of precipitation form forecasts - Snow/Rain

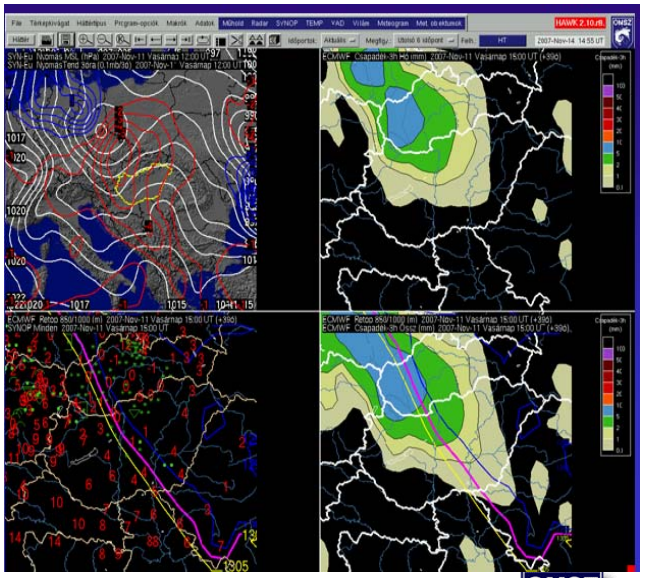
The new **snow probability product** in HMS is a refinement of the Retop850/1000 based snow/rain separation in the 1285-1306 range where precip phase is uncertain (in the past the 1299 value was only used). It is based on statistics using Budapest TEMP and SYNOP measurements from 1962-2009 with the Retop850/1000, T850, T2d and MSLP parameters



❖ **We verified three versions of snow characterisation**

- The new statistical snow probability product
- The model's snow/totprecip rate
- The model snow rate corrected at near below 0 degree to pure snow if T850<-2 and T925<-1 (or sleet if T2 is too high at the same time)

Source	ME	MAE
Statistical Snow Prob	0.02	0.28
Model Snow Prob	-0.14	0.32
Corrected Model Snow Prob	0.02	0.26



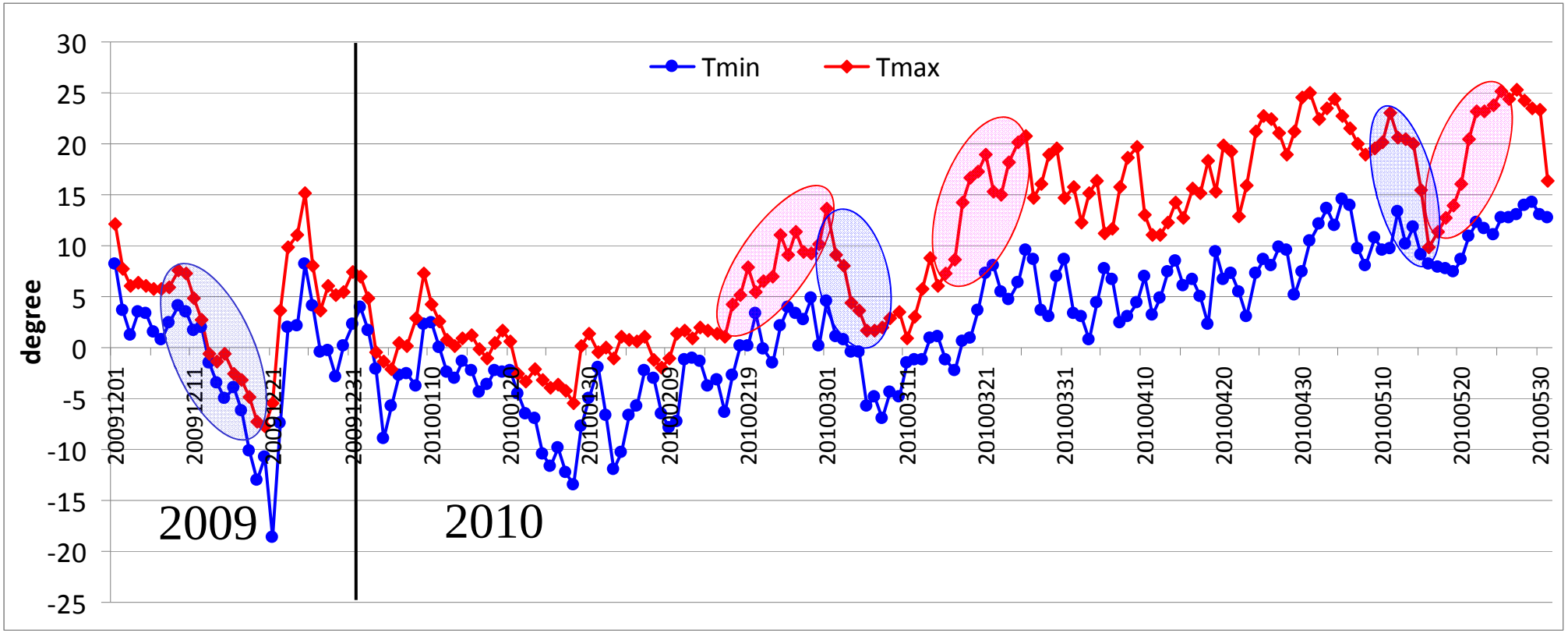
Conclusions:

❖ The statistical snow probability provides better background than raw model snow parameter for snow/rain characterisation. Model snow amount on average clearly underpredicts real snow

❖ By a simple correction the error gets lower significantly

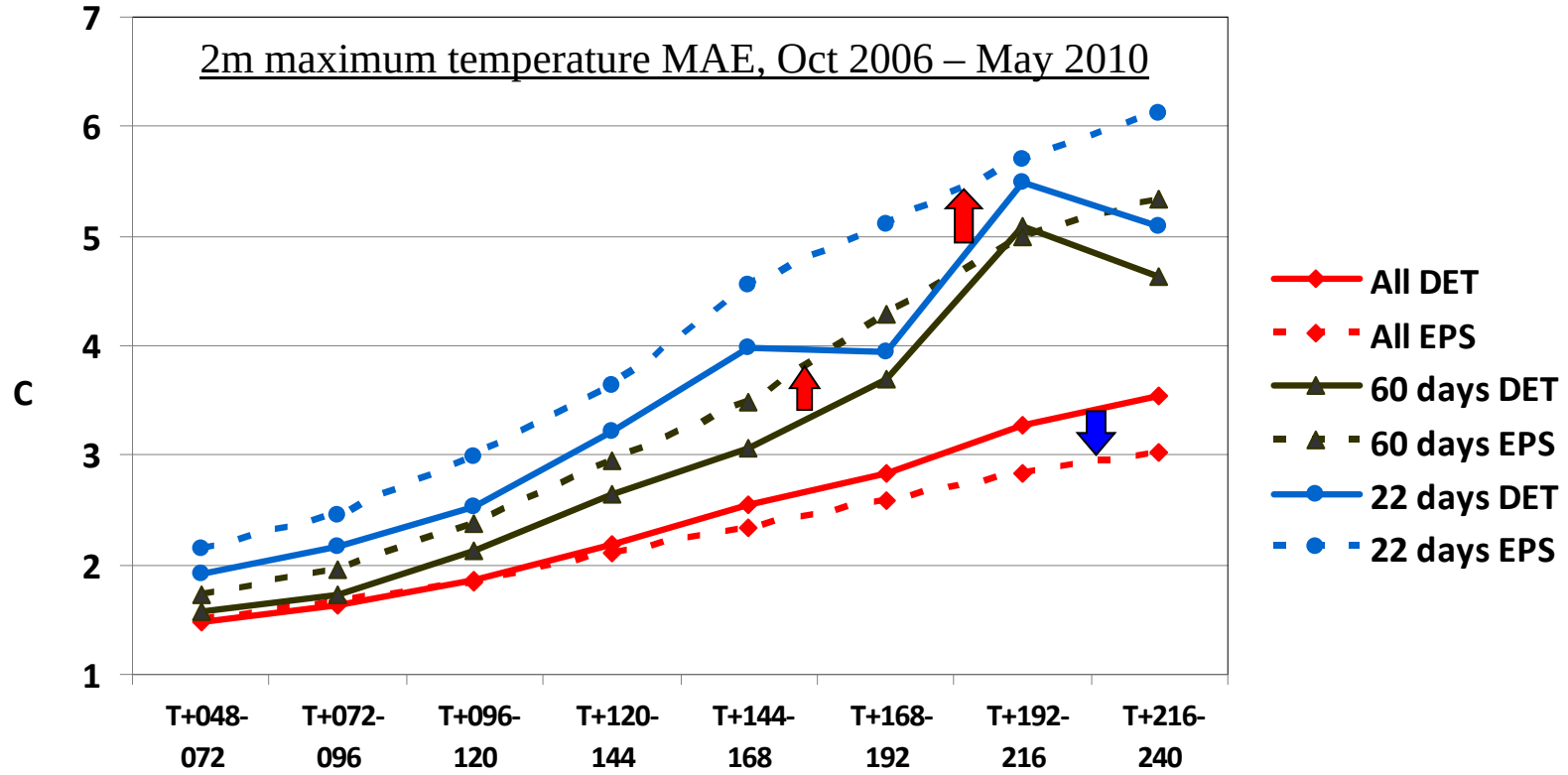
EPS – DET performance at major weather changes

Daily min & max temperature over Hungary, Dec 2009 – May 2010



- Individual days were selected to assess the performance of DET and EPS forecasts verifying on these days.
- Each date is the beginning of a lot warmer or colder period after a significant temperature change (focussing on the maximum temperature).
- 22 days were selected as a primary list with extention to 60 days including also smaller, but still significant changes in the period from Oct 2006 to May 2010.

EPS – DET performance at major weather changes

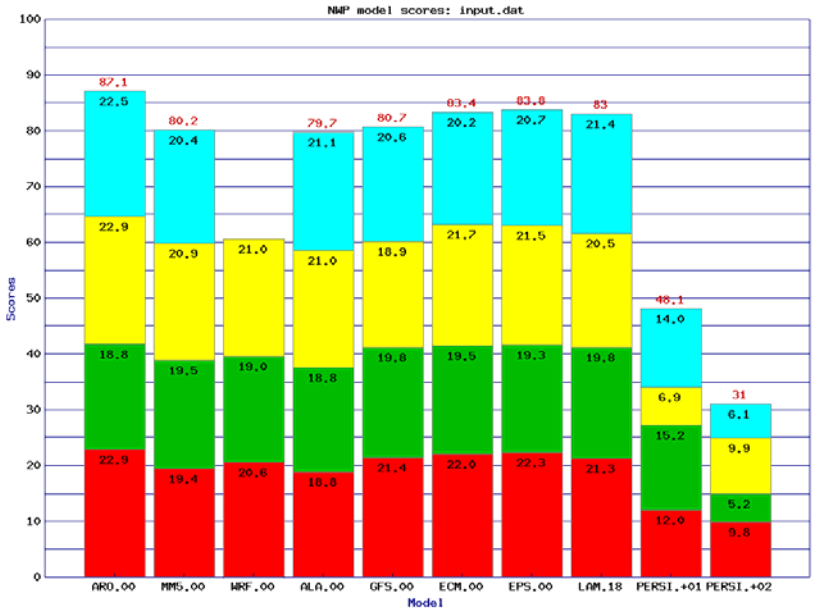


- The EPS in general reaches a 1.5-day advantage by Day10 over the high resolution forecast
- Whereas scores for subsamples including only 60 and 22 major temperature events suggest that the deterministic forecast for these special cases rather has a substantial lead (0.5-1.5 days) over the EPS
- In the minimum temperature the improvements of the deterministic scores compared to the EPS is present but much less pronounced (the DET and EPS scores get roughly the same for all forecast ranges)

Short range objective model verification

❖ We verify all the models used for different purposes at short forecast range at HMS (since early 2010)

- AROME, WRF, MM5 (non-hidrostatic)
- ALADIN & LAMEPS
- ECMWF DET & EPS
- NCEP



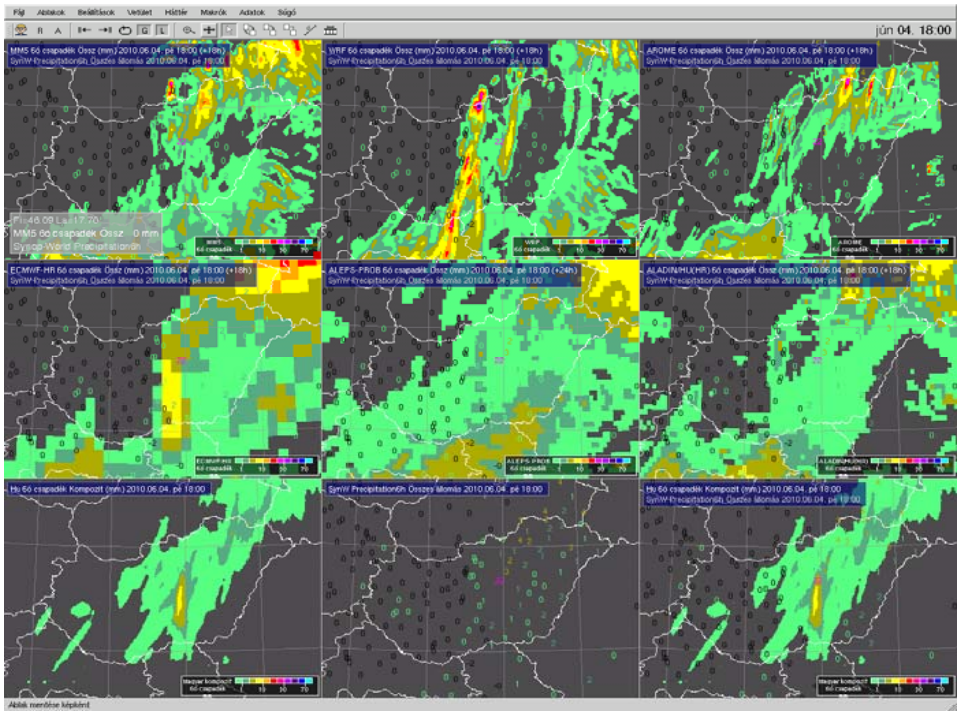
❖ Fresh score summaries of the performance of the latest model runs (in text form and as summary diagram) are prepared and e-mailed to different colleagues twice a day (verification of day time and night time)

❖ Sumary of day time scores for the 4-month period (Feb 2010 – May 2010)

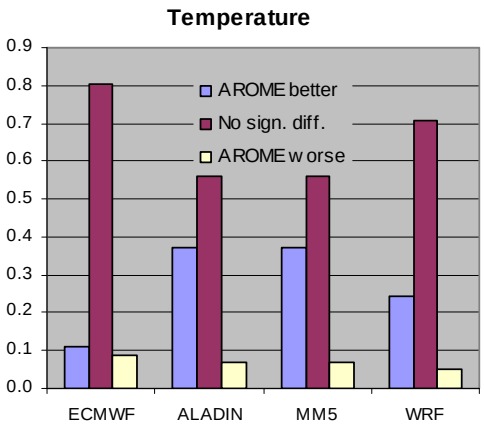
TEMPERATURE		PRECIPITATION		WIND		CLOUDINESS		SUMMARY	
DET	20.2	WRF	21.4	AROME	21.2	LAMEPS	21.7	EPS	82.4
EPS	20.1	ALADIN	20.7	ALADIN	21.1	EPS	21.0	DET	82.0
AROME	20.0	MM5	20.6	DET	21.0	DET	20.5	AROME	81.6
WRF	19.3	AROME	20.5	EPS	21.0	GFS	20.3	ALADIN	80.5
GFS	18.9	LAMEPS	20.3	LAMEPS	19.9	ALADIN	20.2	LAMEPS	80.4
ALADIN	18.6	EPS	20.3	MM5	19.5	AROME	19.9	GFS	77.9
LAMEPS	18.4	DET	20.3	WRF	19.4	MM5	12.6	MM5	70.6
MM5	17.9	GFS	19.8	GFS	18.9	WRF	-	WRF	-
PERS.+ 1	16.2	PERS.+ 1	16.8	PERS.+ 1	15.7	PERS.+ 1	17.1	PERS.+ 1	65.8
PERS.+ 2	13.4	PERS.+ 2	15.6	PERS.+ 2	14.5	PERS.+ 2	16.9	PERS.+ 2	60.5

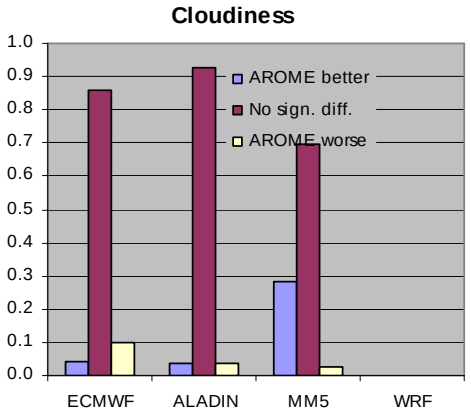
Subjective verification of AROME vrs. other models

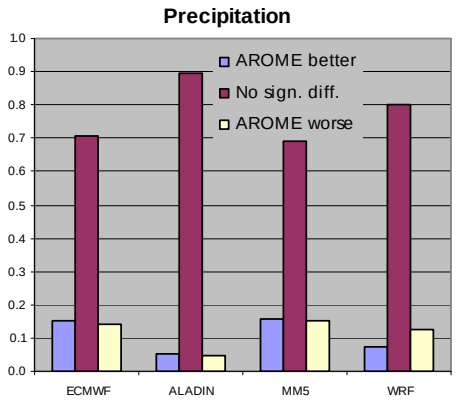
- As a support to the AROME model development work we have started recently a subjective model evaluation campaign
- MM5, WRF, ALADIN and ECMWF (high res.) is compared with AROME
- 3 grades are possible for the four main parameters (precipitation, cloudiness, wind and temperature)
- We build a web base database of each verified date including grades, comments, pictures

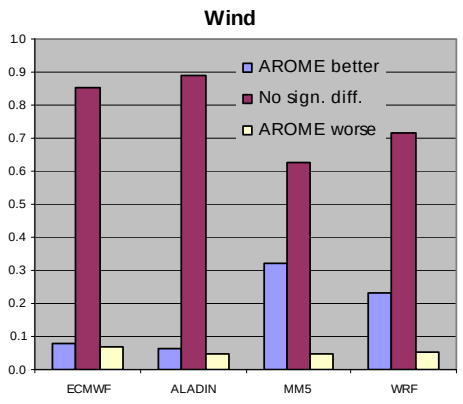


- Summory for 6 months (Dec 2009-May 2010)









Summary

- The forecast production is designed in line with various verification requirements at HMS
- All the models used at operations are verified together with the forecasters' operational forecasts
- EPS models are processed and verified similarly to the deterministic models in this context
- Regarding ECMWF performance from Oct 2006 to May 2010
    - The usual general upward trend in the scores is present for Hungary
    - The minimum temperature is overforecast in general by almost a degree
    - The model gives too mush convective precipitation
    - The model's snow parameter gives indication of sleet events too often when T925 & T850 temperatures are somewhat below zero but the favourable precip should be snow
    - The EPS gradually gets better then the high resolution mostly from day3/day4 (as expected)
    - However by selecting the most interesting temperature events in the 3.5-year period scores show the different picture and the high resolution model keeps a steady advantage over the maximum temperature EPS mean all the way from day1 to day10
- A short range objective and subjective model assessment system has just started recently at HMS

Thank you!