Application and verification of ECMWF products 2019

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1. Summary of major highlights

The verification of ECMWF products has continued as in previous years.

2. Use and application of products

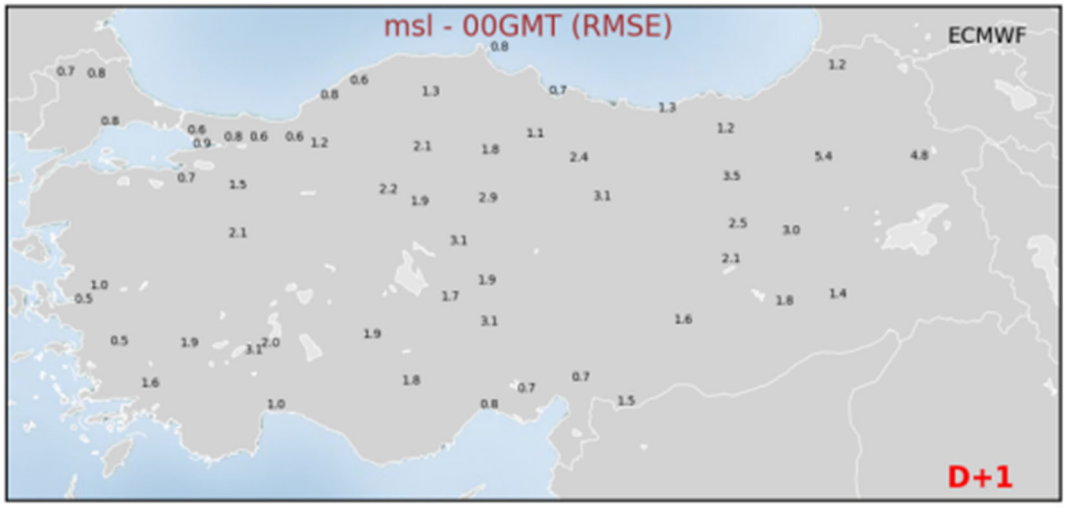
3. Verification of products

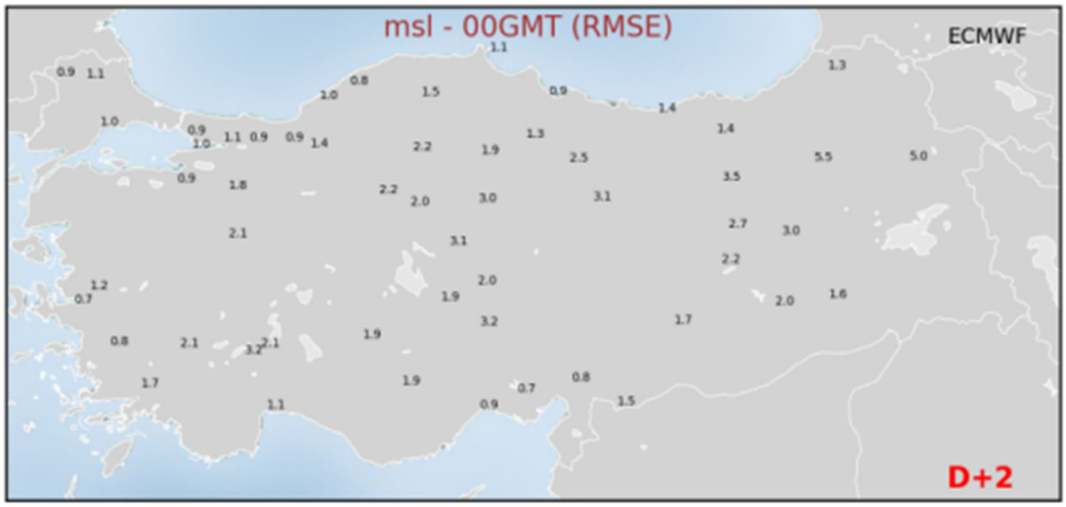
3.1. Objective verification

3.1.1 Direct ECMWF model outputs

24 hourly forecasts between T+00 and T+144 of 00 UTC and 12 UTC deterministic model run are operationally verified with standard statistical score of root mean square error.
All time steps forecasts between T+00 and T+240 of 00 UTC and 12 UTC deterministic model run are operationally verified with standard statistical score of root mean square error. For the verification of 2 meter temperature, mean sea level pressure and wind speed 7 Turkish synoptic stations (Ankara, Istanbul, Adana, Samsun, Isparta, Diyarbakır, and Izmir) were used, covering the period from 1 January to 31 December 2018.
Interpolated model outputs of local weather parameters (00 UTC and 12 UTC of 2 meter temperature, mean sea level pressure, wind speed and total precipitation) verified with the corresponding observations. For this process, suitable time steps of model outputs were used.

Fig.1 Turkish synoptic and radio-sonde stations used in this study.


msl - 00GMT (RMSE)
ECMWF
D+1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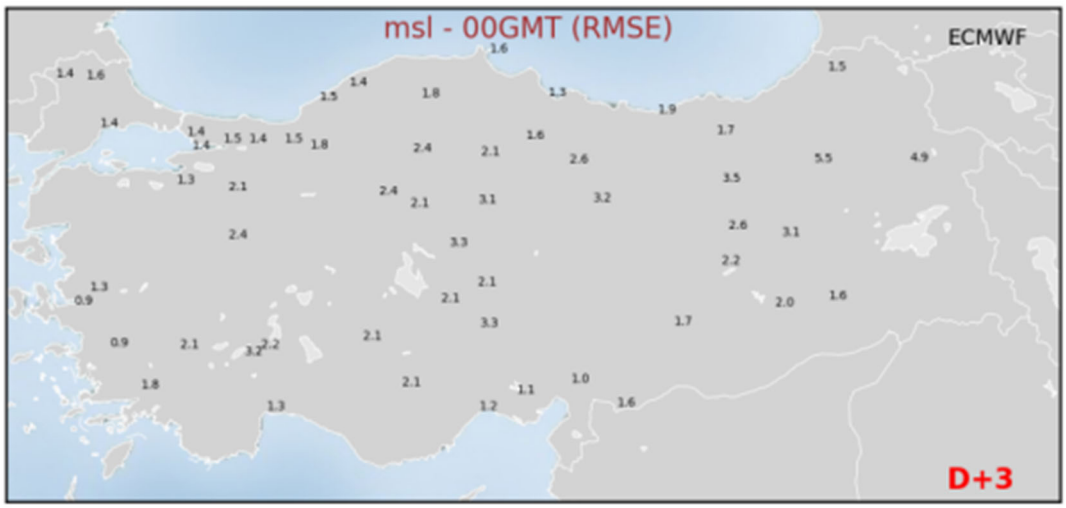
D+2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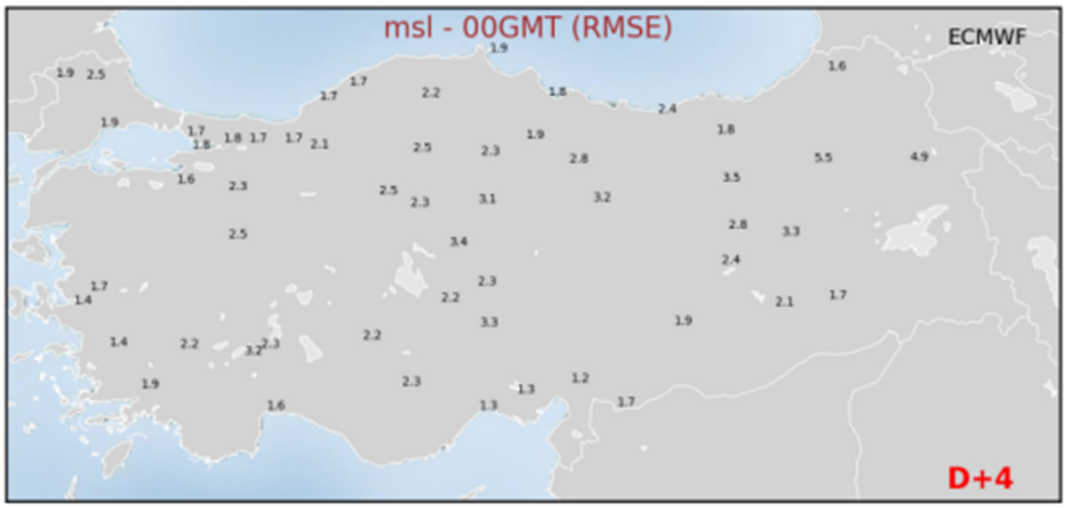
ECMWF
D+3


msl - 00GMT (RMSE)
ECMWF
D+4

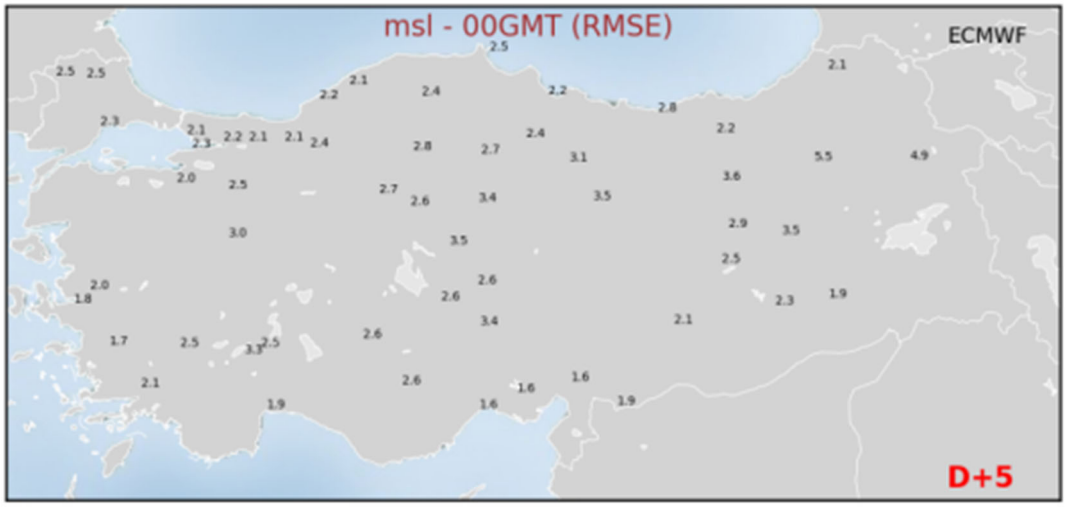
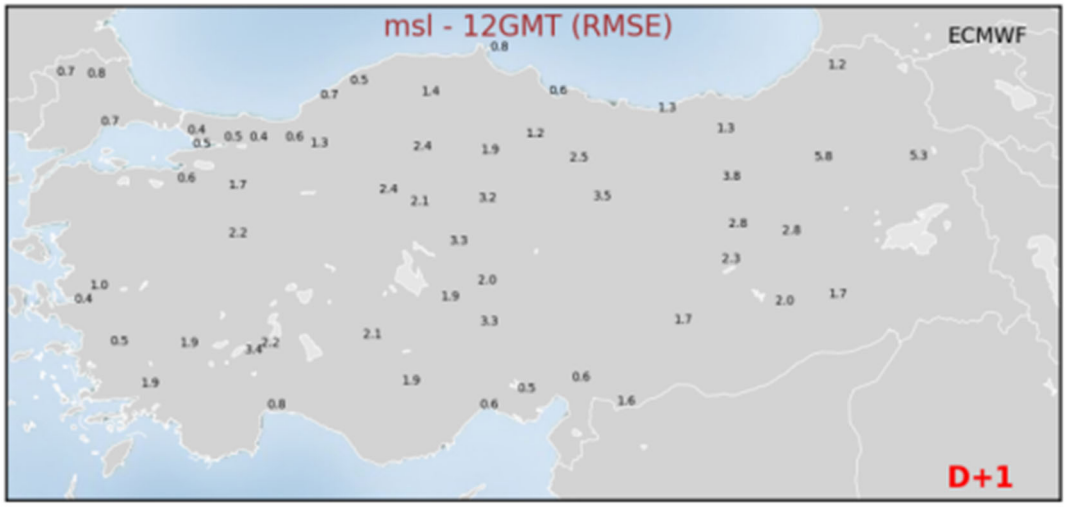
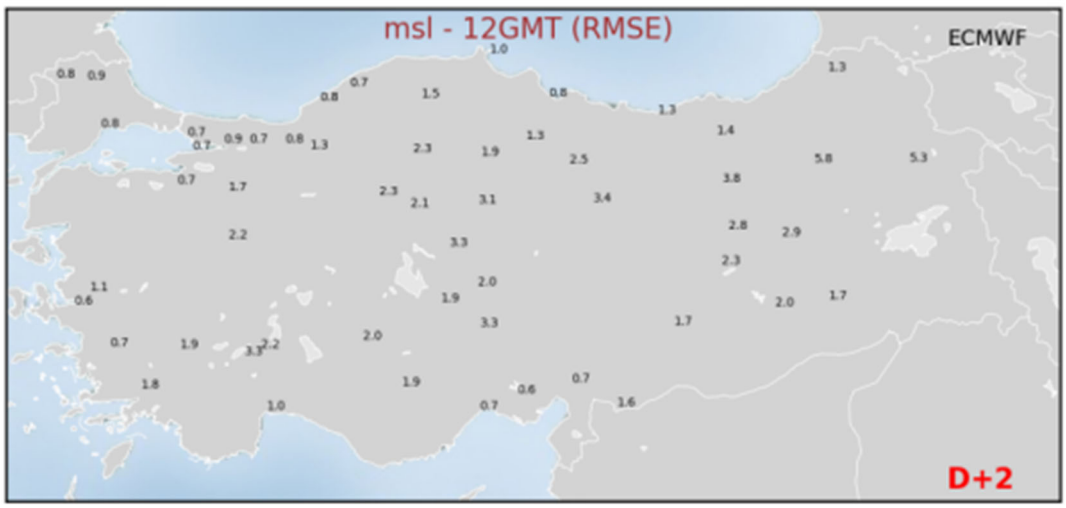


Fig.2 00 UTC RMSE Values of MSLP for D+1 to D+5





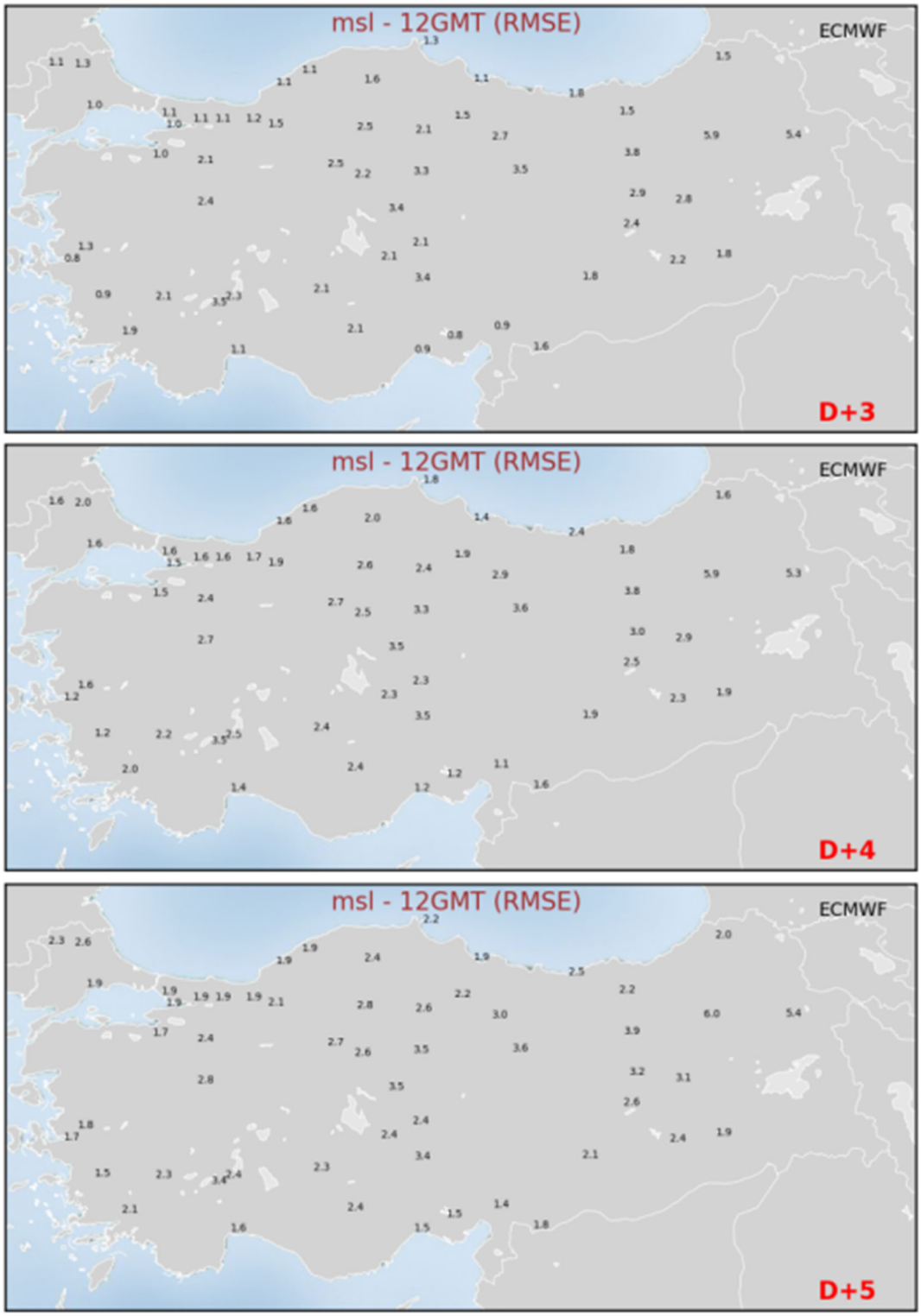
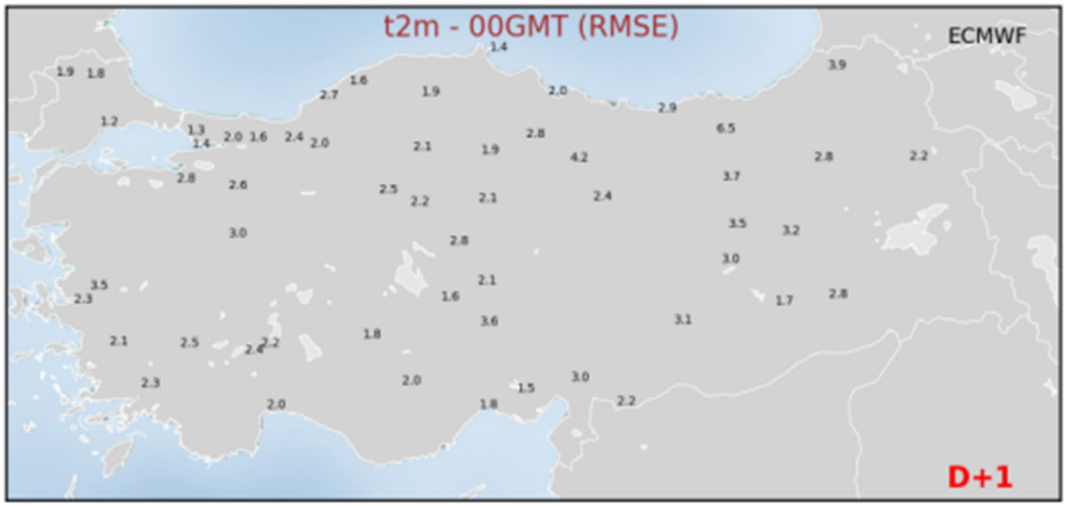
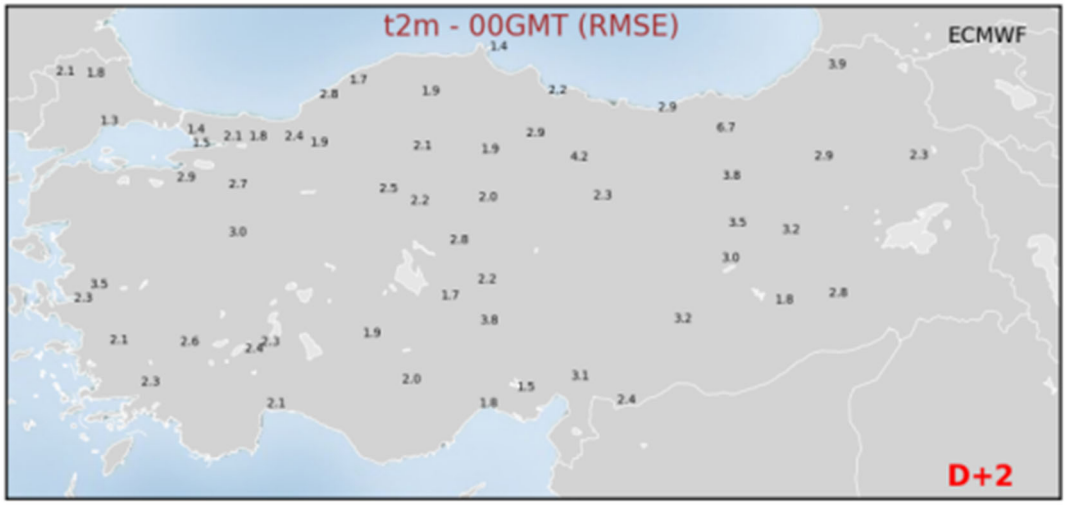
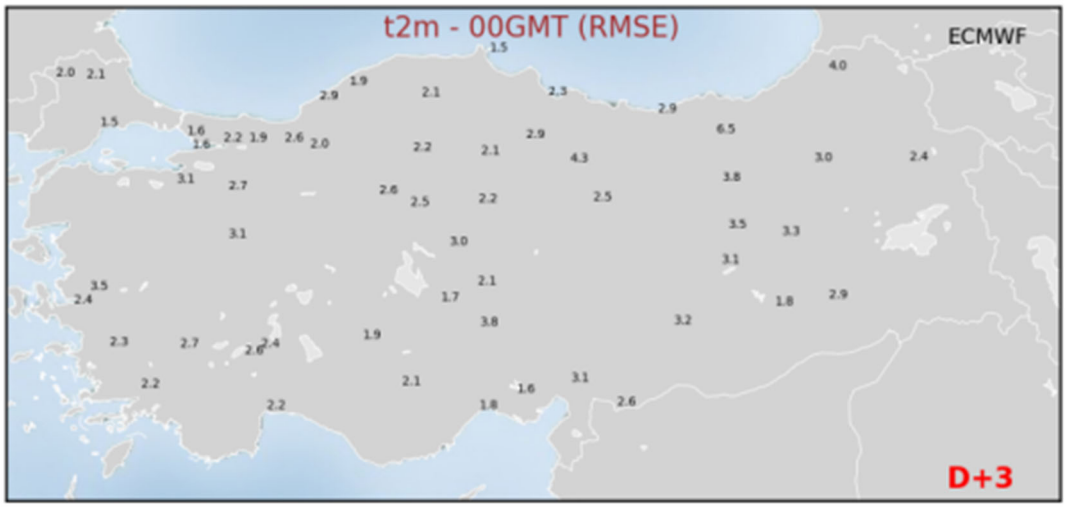


Fig.3 12 UTC RMSE Values of MSLP for D+1 to D+5


t2m - 00GMT (RMSE)
ECMWF
D+1


t2m - 00GMT (RMSE)
ECMWF
D+2


t2m - 00GMT (RMSE)
ECMWF
D+3

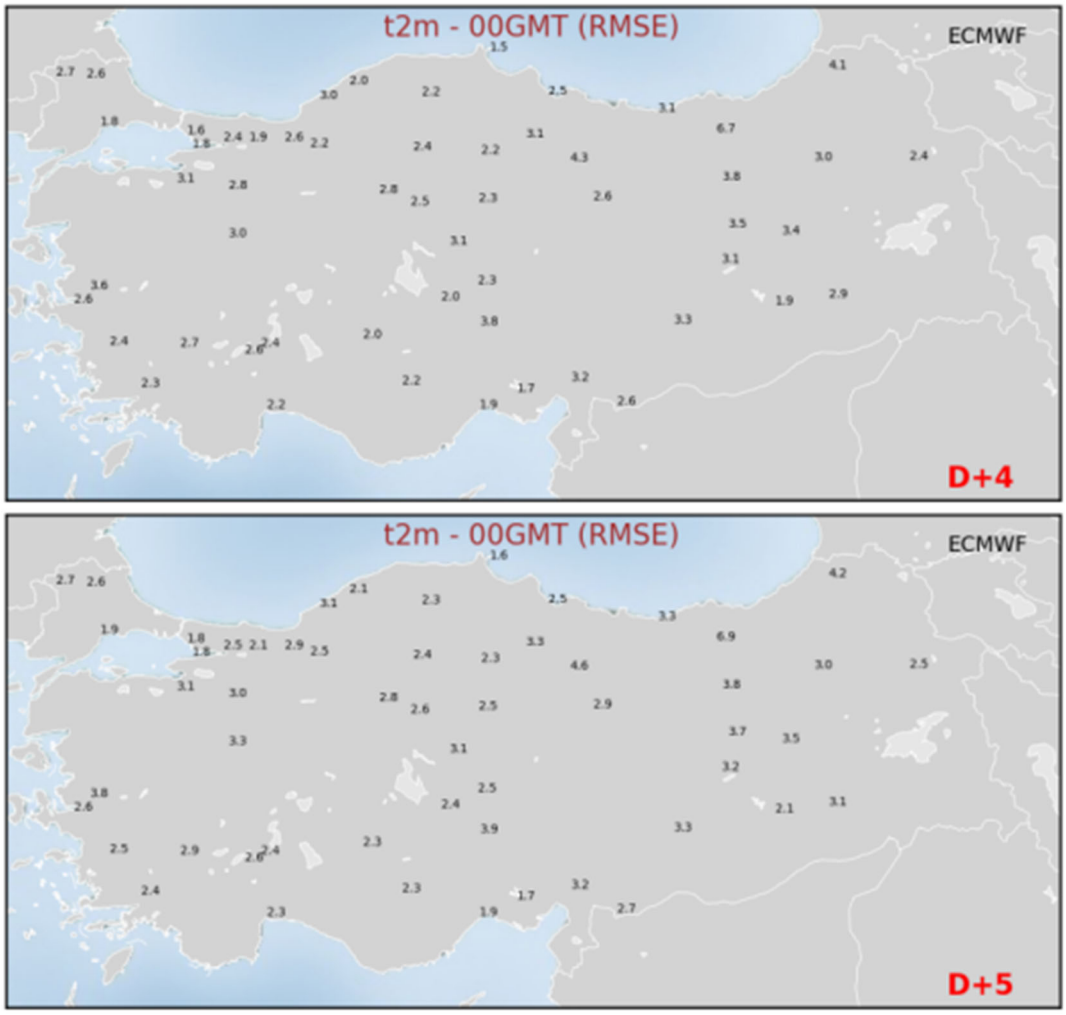
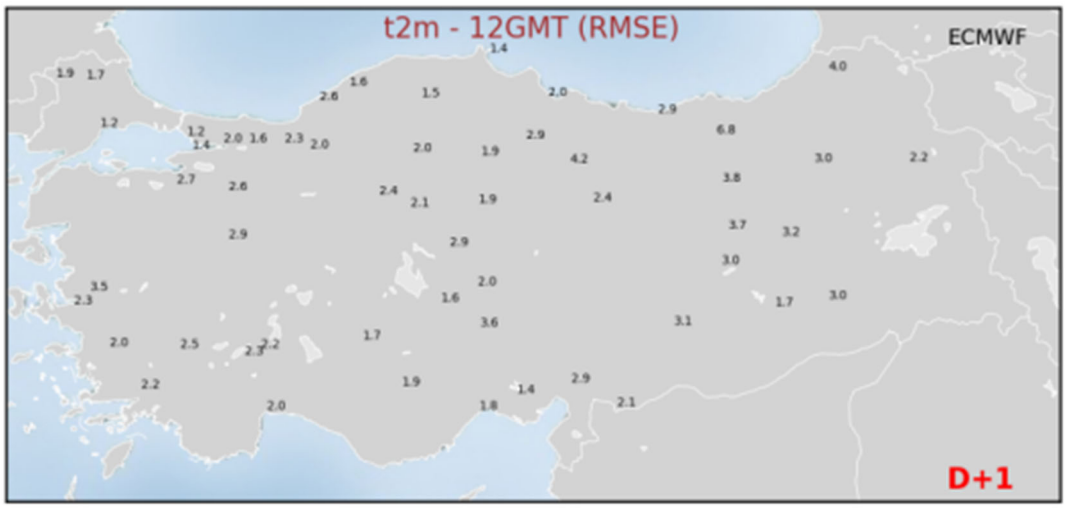
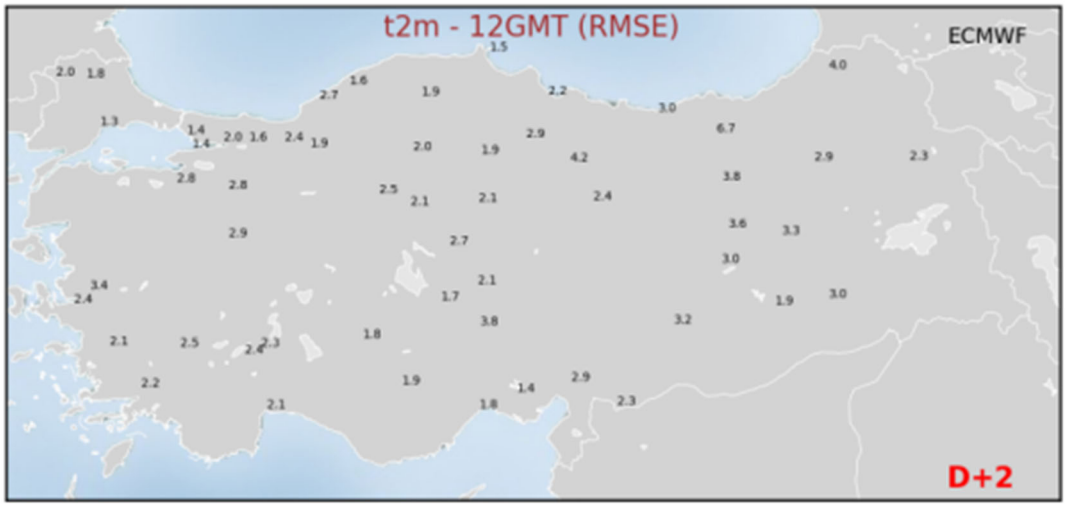
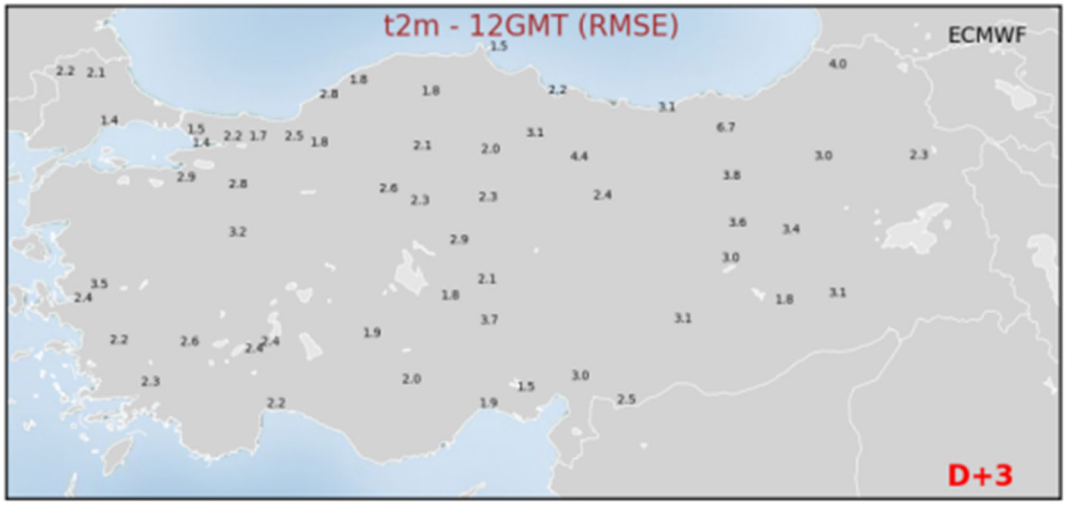
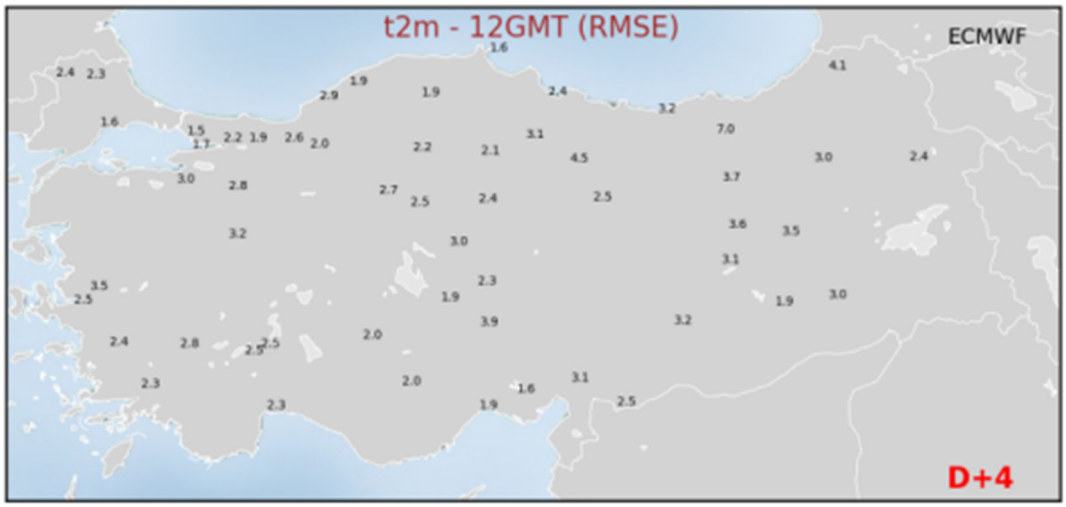


Fig.4 00 UTC RMSE Values of 2m temperature for D+1 to D+5




t2m - 12GMT (RMSE)
ECMWF
D+2


t2m - 12GMT (RMSE)
ECMWF
D+3


t2m - 12GMT (RMSE)
ECMWF
D+4

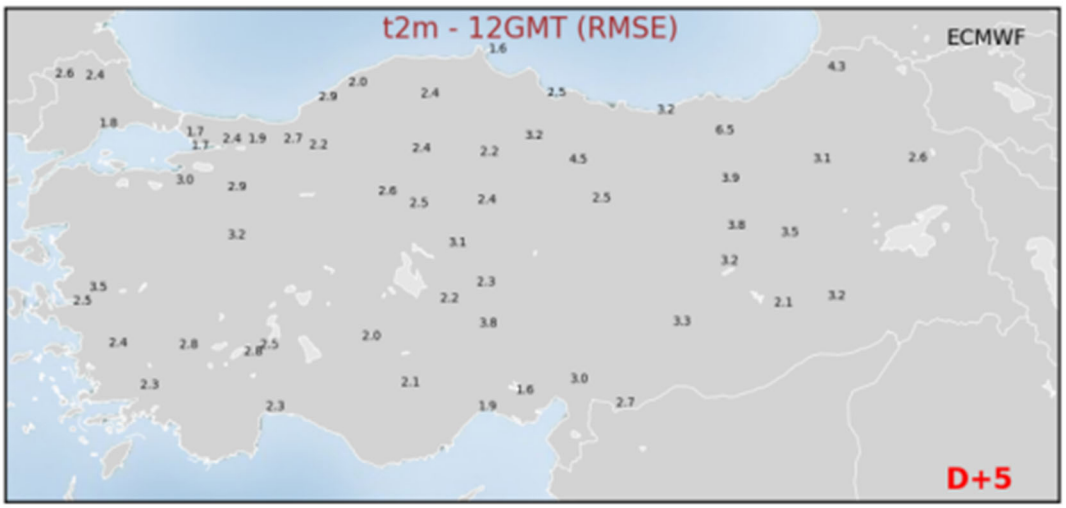
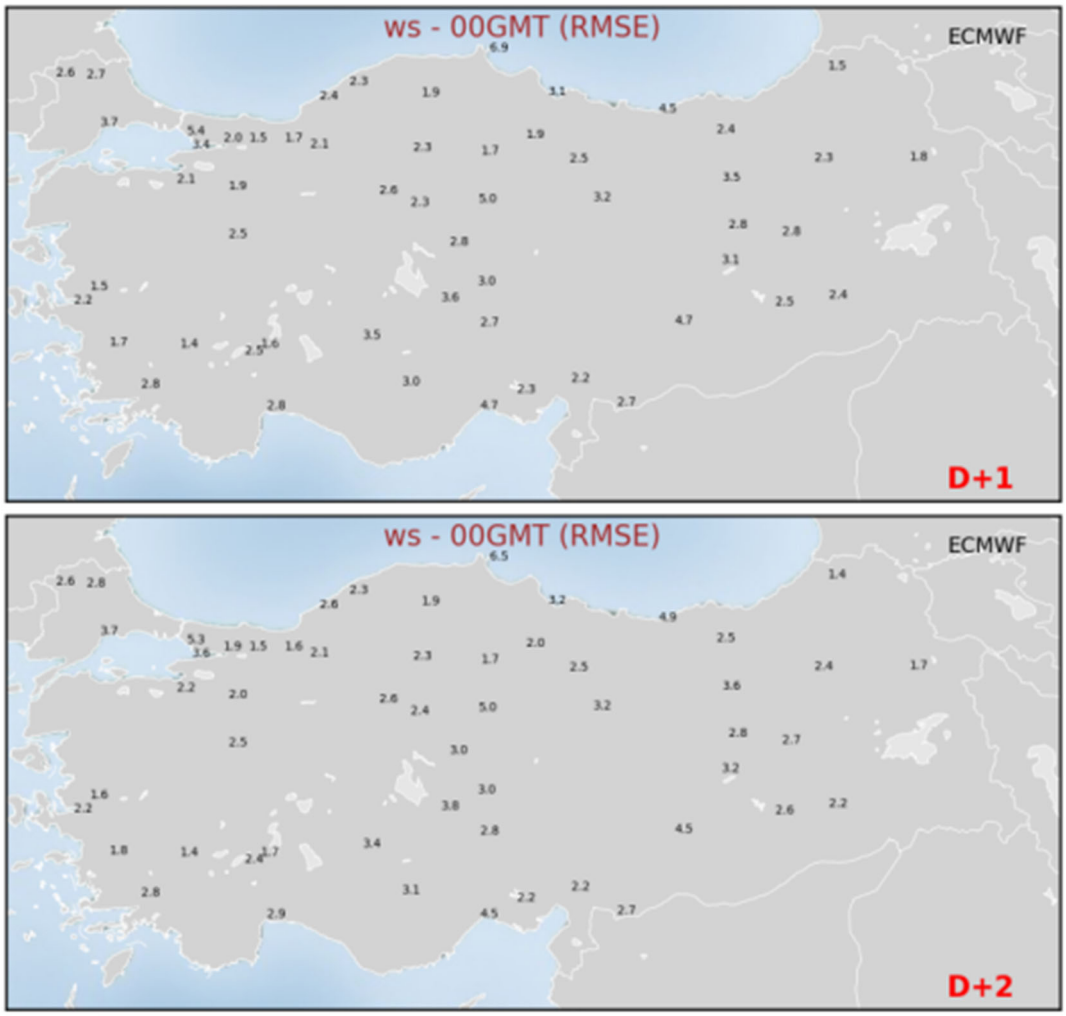


Fig.5 12 UTC RMSE Values of 2m temperature for D+1 to D+5



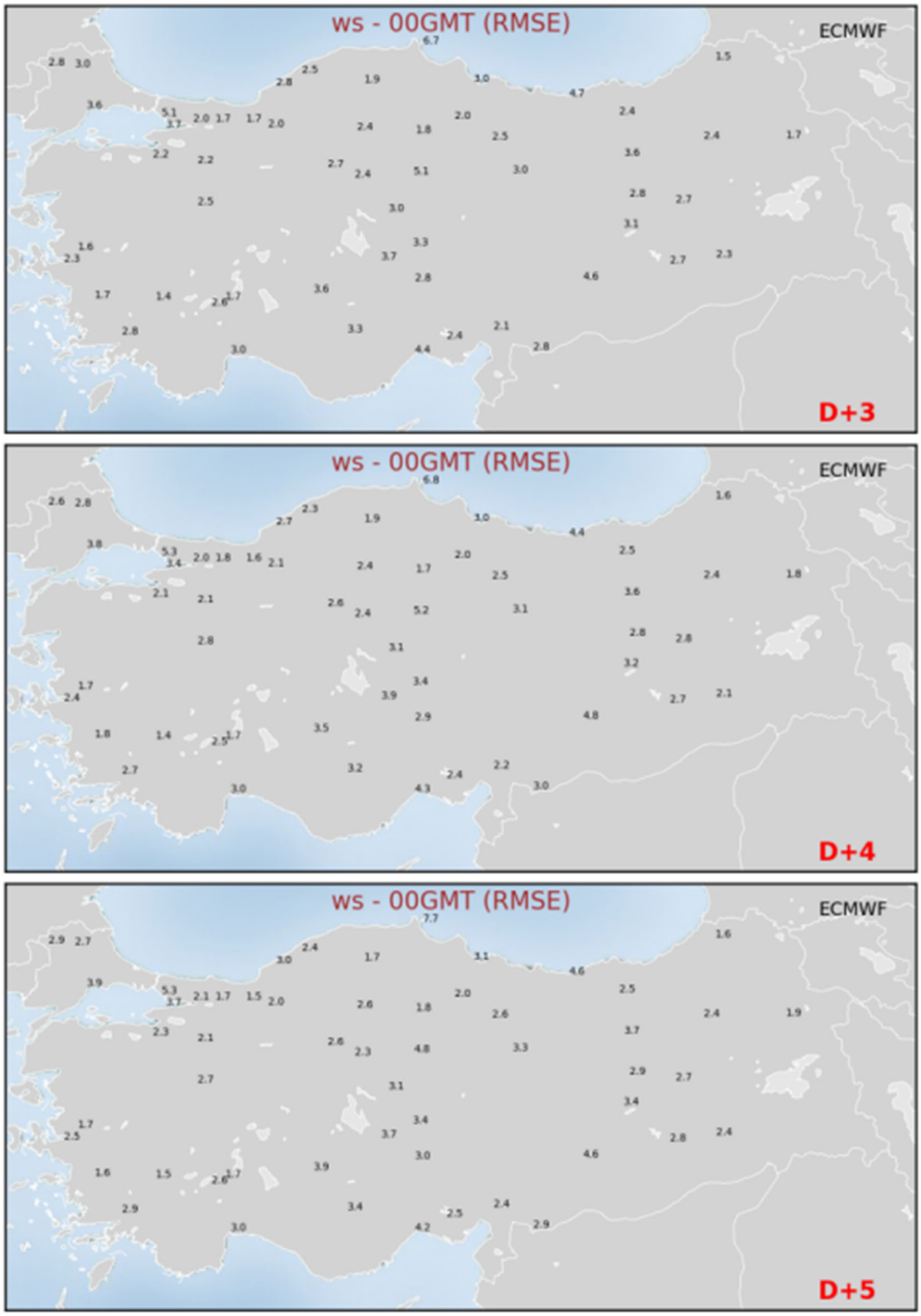
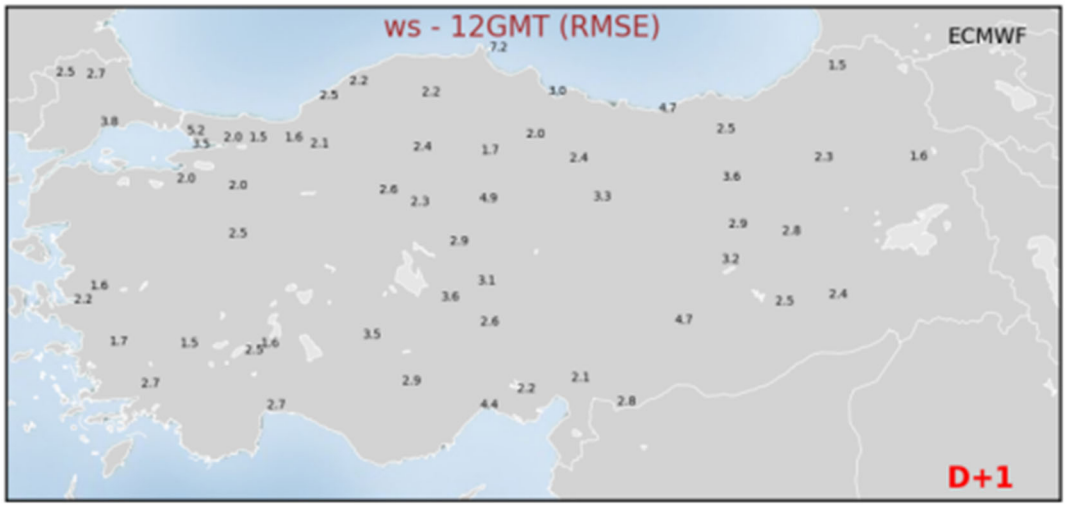
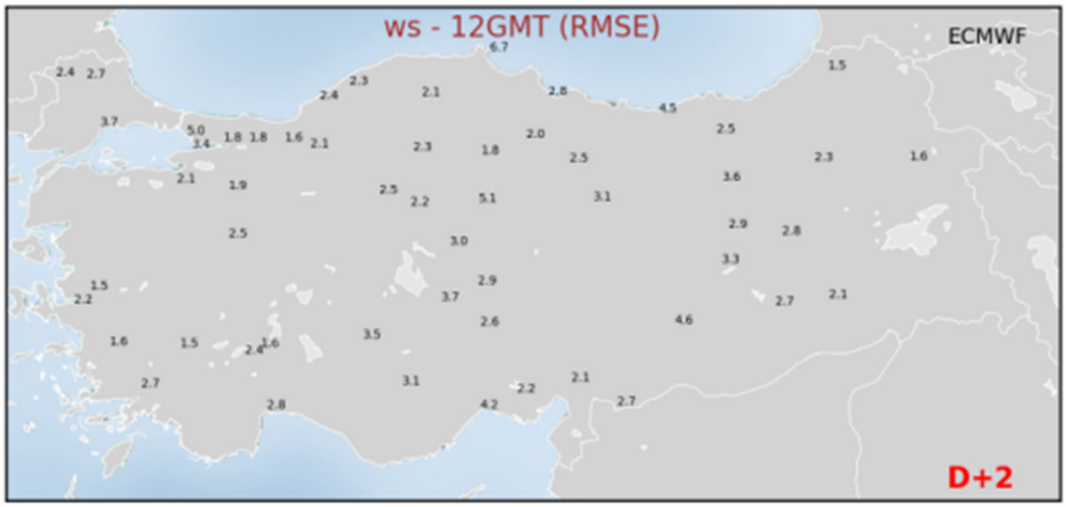
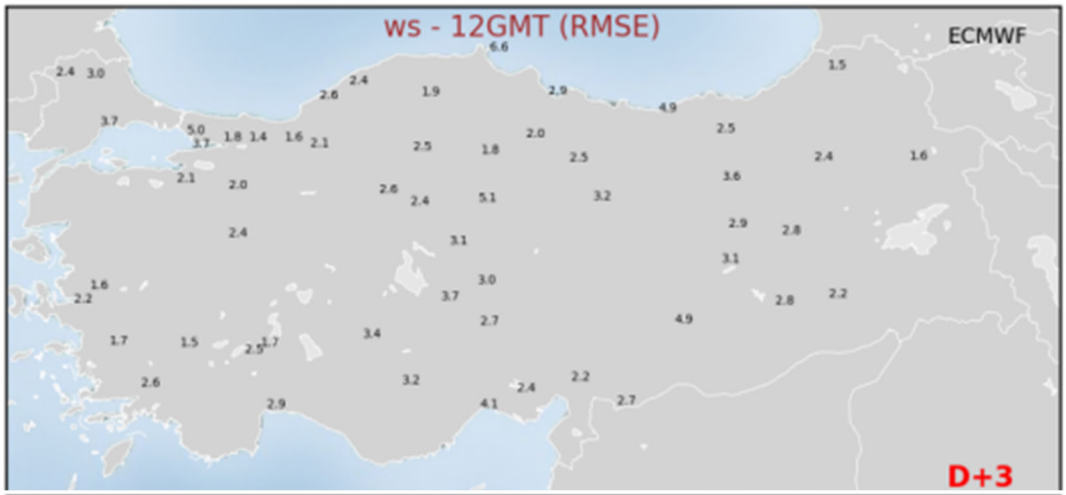
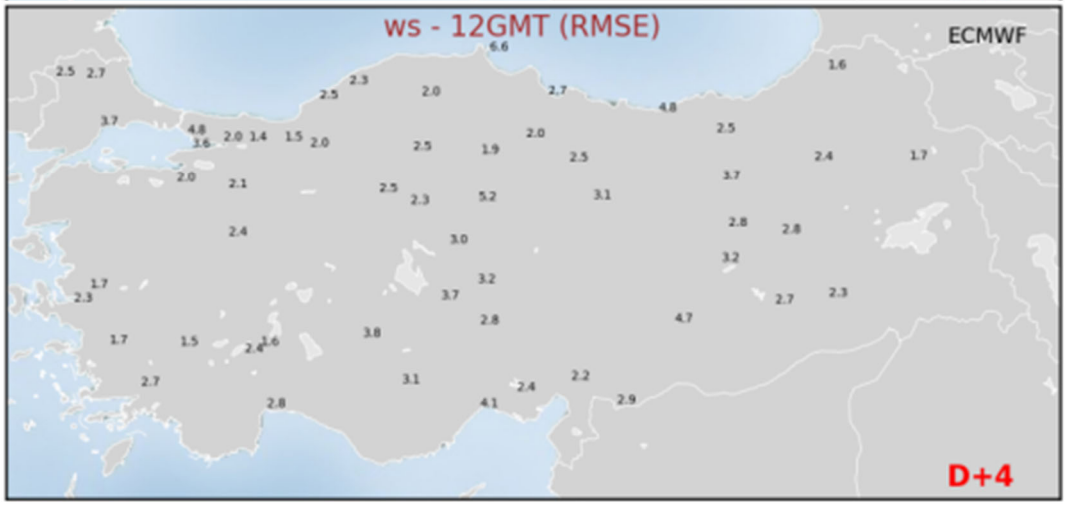


Fig.6 00 UTC RMSE Values of wind speed for D+1 to D+5


ws - 12GMT (RMSE)
ECMWF
D+1


ws - 12GMT (RMSE)
ECMWF
D+2


ws - 12GMT (RMSE)
ECMWF
D+3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ECMWF
D+4

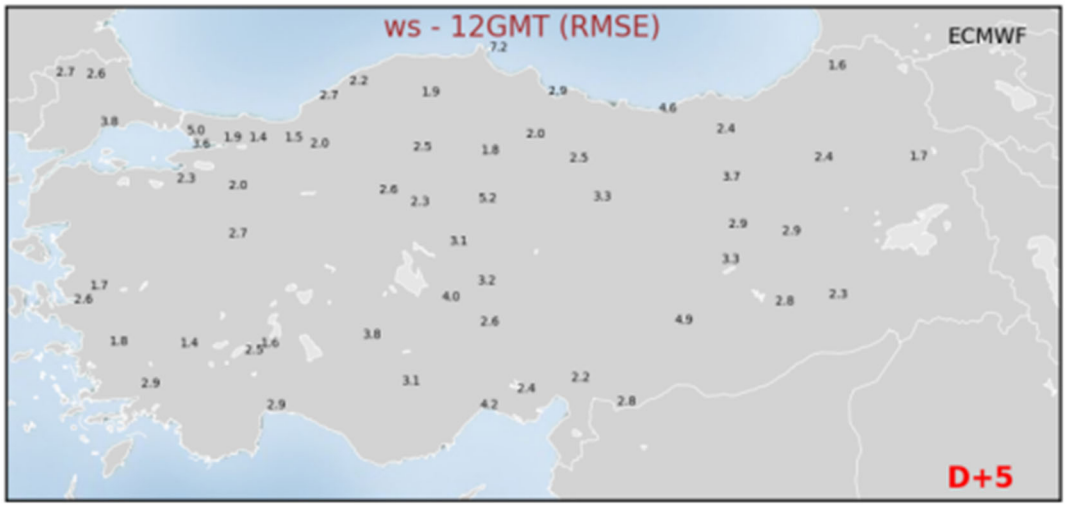

Fig.7. 12 UTC RMSE Values of wind speed for D+1 to D+5

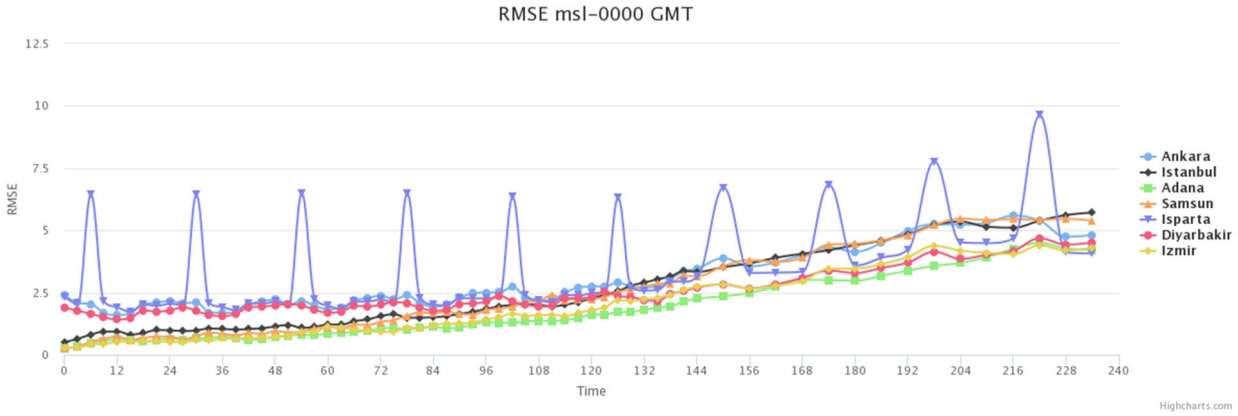

Fig.8 RMSE of 00 UTC MSLP forecasts as a function of forecast range for 7 Turkish radio-sonde stations

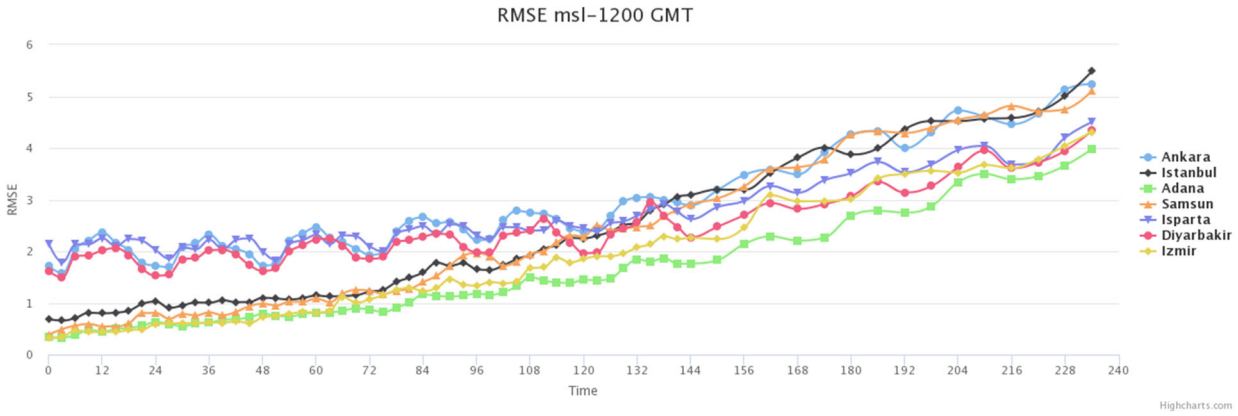

Fig.9 RMSE of 12 UTC MSLP forecasts as a function of forecast range for 7 Turkish radio-sonde stations

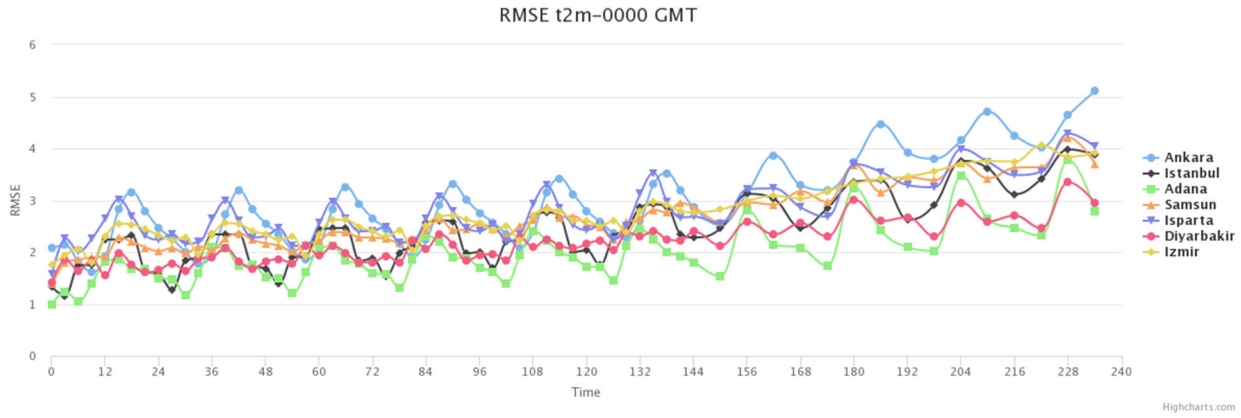

Fig.10 RMSE of 00 UTC 2m temperature forecasts as a function of forecast range for 7 Turkish radio-sonde stations

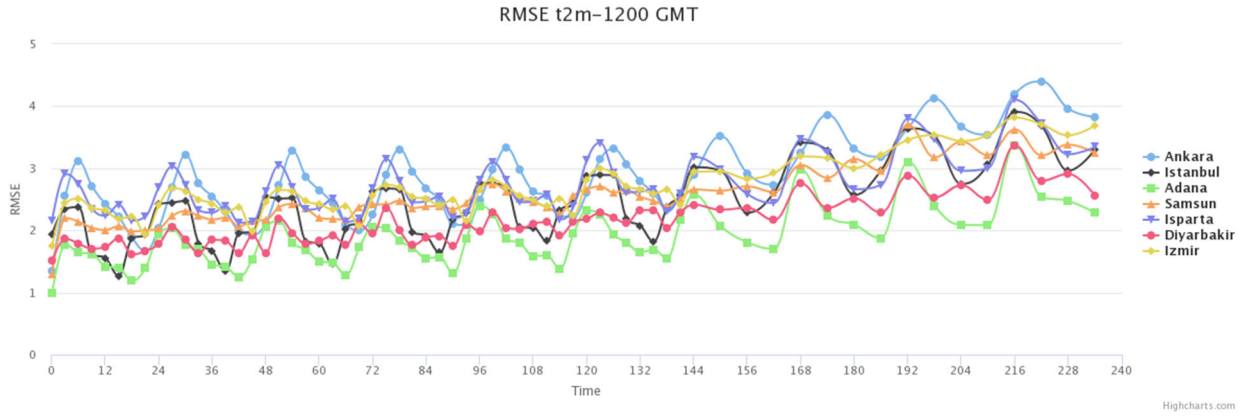

Fig.11 RMSE of 12 UTC 2m temperature forecasts as a function of forecast range for 7 Turkish radio-sonde stations

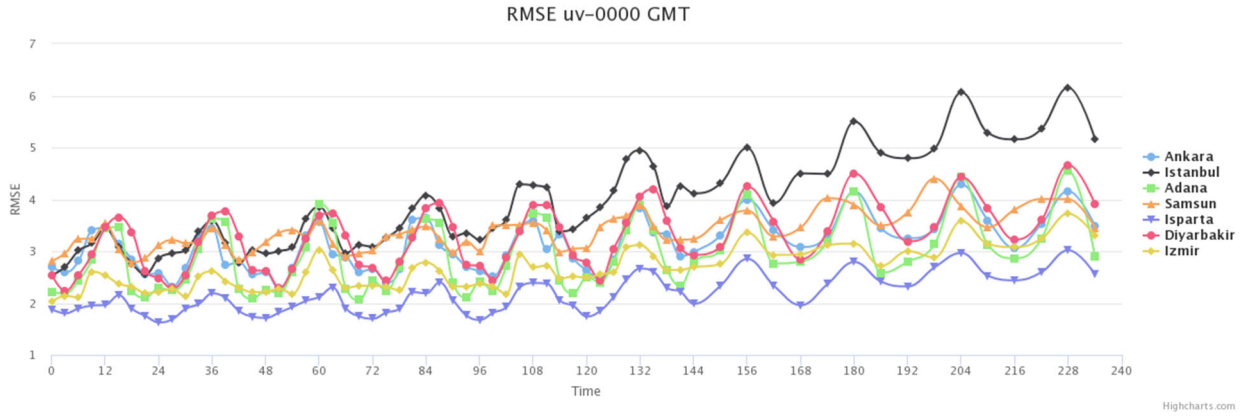

Fig.12 RMSE of 00 UTC wind speed forecasts as a function of forecast range for 7 Turkish radio-sonde stations

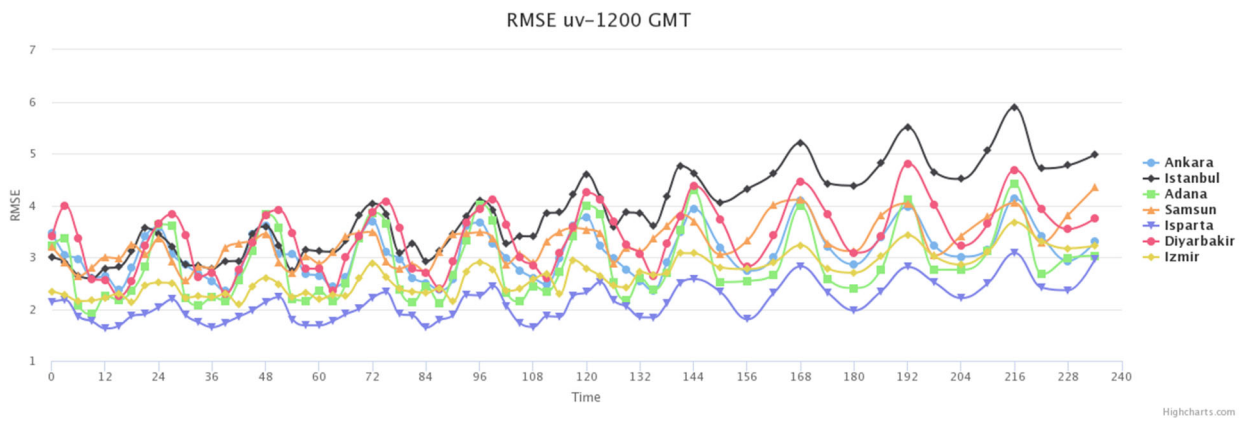

Fig.13 RMSE of 12 UTC wind speed forecasts as a function of forecast range for 7 Turkish radio-sonde stations

Verification of Precipitation

Precipitation forecasts of the ECMWF are interpolated to the station points. Actual values (observed) and interpolated forecast values are compared. 24 hourly total precipitations classified as follows (Nurmi, 2003);

		Observation	
		Yes	**No**
Forecast	**Yes**	a	b
	No	c	d

BIAS = (a+b)/(a+c) **PC** = (a+d)/(a+b+c+d)

POD = a/(a+c) **FAR** = b/(a+b)

F = b/(b+d) **KSS** = POD-F

HSS = 2(ad-bc) / {(a+c)(c+d)+(a+b)(b+d)}

ETS = (a-ar)/(a+b+c-ar) *where* ar =(a+b)(a+c)/(a+b+c+d)

TS = a/(a+b+c) **OR** = ad/bc

ORSS = (ad-bc) / (ad+bc)

TURKEY **TURKEY**

Stations (D+1) 00 GMT and (D+2) 00 GMT Model Outputs :

D+1	Ankara	Istanbul	Isparta	İzmir	D+2	Ankara	Istanbul	Isparta	İzmir
a	96	99	106	71	**a**	102	99	106	71
b	75	99	73	53	**b**	78	104	70	60
c	15	6	5	7	**c**	10	7	5	6
d	131	113	133	186	**d**	127	107	136	180
Total	317	317	317	317	**Total**	317	317	317	317
FAR	0,44	0,50	0,41	0,43	**FAR**	0,43	0,51	0,40	0,46
HIT	0,72	0,67	0,75	0,87	**HIT**	0,72	0,65	0,76	0,79
BIAS	1,54	1,89	1,61	1,59	**BIAS**	1,61	1,92	1,59	1,70
POD	0,89	0,94	0,95	0,91	**POD**	0,91	0,93	0,95	0,92
TS	0,45	0,49	0,58	0,54	**TS**	0,54	0,47	0,59	0,52
F	0,34	0,47	0,35	0,22	**F**	0,38	0,49	0,34	0,25
HSS	0,43	0,39	0,53	0,57	**HSS**	0,47	0,35	0,54	0,54
ETS	0,27	0,24	0,36	0,40	**ETS**	0,30	0,21	0,37	0,37
ORSS	0,88	0,90	0,95	0,95	**ORSS**	0,89	0,87	0,95	0,95
PC	0,71	0,67	0,75	0,81	**PC**	0,72	0,65	0,76	0,79
KSS	0,55	0,48	0,60	0,68	**KSS**	0,53	0,44	0,62	0,67
ORR	17,10	11,36	84,64	68,67	**ORR**	14,61	9,82	21,43	32,84

Contingency table for 24 hourly precipitations (mm) for D+2 in the period Jan-Dec 2018

Adana 00 UTC model outputs :

obs/for	0-0	0,1-1	1,1-5	5,1-10	10,1-20	for>20
0-0	144	78	21	3	0	0
0,1-1	3	9	5	0	0	0
1,1-5	2	5	6	4	0	0
5,1-10	0	2	2	3	2	0
10,1-20	1	0	6	2	6	2
obs>20	1	3	1	3	8	2
Correct (Hit Rates)		%	52,8	Sign. Error Rate	%	0,1

Small Error Rate	%	33,4	Large Err. Rate	%	0,1
Moderate Error Rate	%	10,8	Very Large Err.	%	0,0

Ankara 00 UTC model outputs :

obs/for	**0-0**	**0,1-1**	**1,1-5**	**5,1-10**	**10,1-20**	**for>20**
0-0	131	64	9	0	0	0
0,1-1	7	19	5	0	0	0
1,1-5	8	18	17	3	0	0
5,1-10	0	8	3	0	0	0
10,1-20	0	2	12	2	1	0
obs>20	0	0	3	1	2	0

Correct (Hit Rates)	%	53,3	Sign. Error Rate	%	0,2
Small Error Rate	%	33,0	Large Err. Rate	%	0,0
Moderate Error Rate	%	12,0	Very Large Err.	%	0,0

Diyarbakır 00 UTC model outputs :

obs/for	**0-0**	**0,1-1**	**1,1-5**	**5,1-10**	**10,1-20**	**for>20**
0-0	165	40	11	1	0	0
0,1-1	6	13	4	2	0	0
1,1-5	2	14	9	2	1	0
5,1-10	2	3	2	4	2	0
10,1-20	0	4	7	2	2	0
obs>20	0	1	3	6	7	0

Correct (Hit Rates)	%	61,2	Sign. Error Rate	%	0,3
Small Error Rate	%	25,0	Large Err. Rate	%	0,0
Moderate Error Rate	%	10,0	Very Large Err.	%	0,0

Erzurum 00 UTC model outputs :

obs/for	**0-0**	**0,1-1**	**1,1-5**	**5,1-10**	**10,1-20**	**for>20**
0-0	77	72	12	2	0	0
0,1-1	2	26	11	3	0	0
1,1-5	4	18	16	4	4	0
5,1-10	1	7	14	5	3	0
10,1-20	0	2	5	4	4	1
obs>20	0	2	8	2	1	0

Correct (Hit Rates)	%	41,2	Sign. Error Rate	%	0,4
Small Error Rate	%	41,9	Large Err. Rate	%	0,0
Moderate Error Rate	%	11,9	Very Large Err.	%	0,0

Istanbul 00 UTC model outputs :

obs/for	**0-0**	**0,1-1**	**1,1-5**	**5,1-10**	**10,1-20**	**for>20**
0-0	113	86	12	0	0	0
0,1-1	4	19	4	0	0	0

1,1-5	1	15	15	0	1	0
5,1-10	0	2	5	4	1	0
10,1-20	1	3	5	8	3	0
obs>20	0	4	4	5	1	0

Correct (Hit Rates)	%	48,7	Sign. Error Rate	%	0,2
Small Error Rate	%	39,2	Large Err. Rate	%	0,0
Moderate Error Rate	%	0,8	Very Large Err.	%	0,0

Isparta 00 UTC model outputs :

obs/for	**0-0**	**0,1-1**	**1,1-5**	**5,1-10**	**10,1-20**	**for>20**
0-0	133	65	5	2	0	0
0,1-1	2	19	8	2	0	0
1,1-5	3	18	14	1	0	0
5,1-10	0	9	13	1	2	0
10,1-20	0	5	3	3	1	2
obs>20	0	0	6	1	0	0

Correct (Hit Rates)	%	52,8	Sign. Error Rate	%	0,4
Small Error Rate	%	35,8	Large Err. Rate	%	0,0
Moderate Error Rate	%	0,7	Very Large Err.	%	0,0

Izmir 00 UTC model outputs :

obs/for	**0-0**	**0,1-1**	**1,1-5**	**5,1-10**	**10,1-20**	**for>20**
0-0	186	42	9	1	0	0
0,1-1	4	15	7	0	0	0
1,1-5	2	8	6	4	0	0
5,1-10	1	4	4	1	0	0
10,1-20	0	2	3	2	0	0
obs>20	0	1	3	5	3	1

Correct (Hit Rates)	%	66,1	Sign. Error Rate	%	0,2
Small Error Rate	%	24,0	Large Err. Rate	%	0,0
Moderate Error Rate	%	0,7	Very Large Err.	%	0,0

Samsun 00 UTC model outputs :

obs/for	**0-0**	**0,1-1**	**1,1-5**	**5,1-10**	**10,1-20**	**for>20**
0-0	101	72	14	0	0	0
0,1-1	13	19	9	0	1	0
1,1-5	2	23	13	0	1	0
5,1-10	0	5	10	6	2	0
10,1-20	1	1	5	4	1	0
obs>20	0	1	3	4	3	1

Correct (Hit Rates)	%	44,7	Sign. Error Rate	%	0,1
Small Error Rate	%	43,1	Large Err. Rate	%	0,0
Moderate Error Rate	%	0,9	Very Large Err.	%	0,0

3.1.2 ECMWF model output compared to other NWP models

A meso-scale WRF model is running 4 times a day for a range of 72 hours. We perform verification for WRF pressure, 2m temperature, 10 meter u-v wind components and total precipitation parameters of WRF model (00-12 UTC run). However, no objective scores of comparison have been computed at ECMWF and WRF model. In the subjective verification, 2m temperature values of ECMWF give more accurate result than those of WRF. Whereas, WRF model forecasts for the total precipitation are better than ECMWF.

Another meso-scale model ALARO is running 4 times a day for a range of 72 hours except 18 UTC for 60 hours. Currently we perform verification for 2m temp, 10 meter wind speed and direction, MSLP and total precipitation of 00 and 12 UTC ALARO run. In the subjective verification ALARO model forecasts for 10 meter wind speed and direction are better than ECMWF forecasts.

Also, meso-scale model AROME has been running 4 times a day for a range of 48 hours. Currently we haven't enough data for verification.

3.1.3 Post-processed products

Kalman Filtering

Kalman Filtering applied to 960 stations including 42 foreign stations from D+1 to D+5 for 2-meter maximum and minimum temperatures. Generally, Kalman Filtering outputs are %5-25 better then direct model outputs.

3.1.4 End products delivered to users

3.2 Subjective verification

3.2.1 Subjective scores

Our Weather Analysis and Forecasting Division (WAFD) uses ECMWF outputs for wide range of purposes from short-range forecasts to the special reports. We compared ECMWF forecasts and those of WAFD forecasts (based on bench forecasters' experience) with observed values. The verification results were based on the observed values received from 81 stations, which are indicated above in the figures, for temperature and for precipitation throughout Turkey and ECMWF's D+1, D+2, D+3 and D+4 corresponding forecasts. When "yes-no" type of verification applied for ECMWF precipitation forecasts, little improvements were noted. Most of the figures show a continuing upward trend over the past few years. Based on ECMWF's upward trend, with combining their experiences and ECMWF model outputs, WAFD made better precipitation forecasts than previous years.

3.2.2 Synoptic Studies

None

4.References

Nurmi, P. (2003): Recommendations on the verification of local weather forecasts, ECMWF Technical Memoranda No:430, December 2003.