Downscaling of ECMWF grid meteorological data: comparison with ground stations and validation

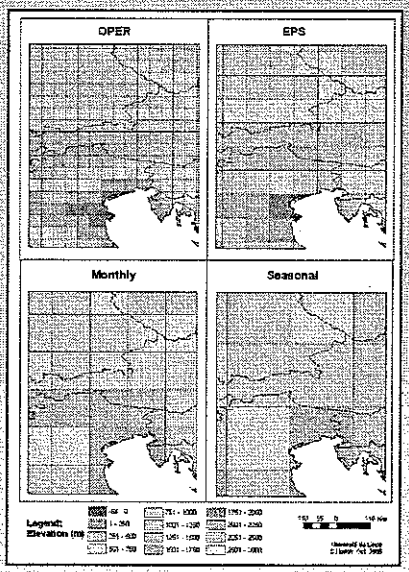
Bernard TYCHON and Stéphanie HORION
University of Liège

Asemars LOT IV

III CGMS Experts meeting - Arlon
23/10/2006

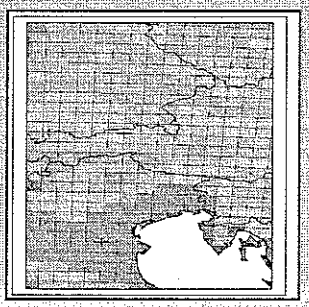
Downscaling

0.35°



1.12°

0.7°



25 X 25 km

1.87°

III CGMS Experts meeting - Arlon
23/10/2006

Validation protocol

- Objective : verify the meteo field values after downscaling procedure and check their adequacy with weather stations.
- Comparison with WMO station = reference data
- Selection of couple of Grid and WMO stations
  - Search for the grid which is the most similar to the WMO station (the closest most of the time, WMO station inside the selected grid).
  - Use of the CGMS Score procedure

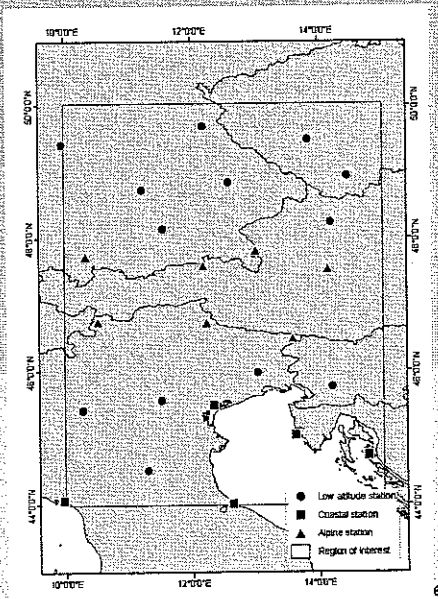
Validation protocol

- Target Area
  - Plains
  - Coast
  - Mountain

Validation protocol

- 4 methods
  - Method A : CGMS interpolation method based on selected grids according to their score values
  - Method B : inverse distance interpolation
  - Method C : Statistical correction Method 1 based on a Meteo Consult Model output statistics (MC-MOS) (statistical station based approach)
  - Method D : Statistical correction Method 2 (MC-MOS)(statistical global approach)
- All data were provided by Meteo Consult

Validation protocol : Weather stations selection



Criteria :

- be included into the target area
- have enough data (>500 days)
- well space distributed
- well distributed between class of stations (plain, mountain, coast)

Validation protocol : Weather stations selection

Main characteristics of the 25 stations selected for the validation; the GRID_NB column corresponds to the number of CGMS grid effectively coupled to the station.

WMO_NO	WMO_NAME	LATITUDE	LONGITUDE	ALTITUDE	CLIMATE_BA	COUNTRY_CO	GRID_NB	Score
10688	Weiden	49.67	12.18	436	0	DE	5550620	4.13
10743	Niederstett	49.40	9.97	468	0	DE	5450595	13.48
10788	Straubing	48.83	12.57	350	0	DE	5350630	16.49
10853	Neuburg/Don	48.72	11.22	380	0	DE	5350615	8.33
10865	München Cit	48.13	11.55	520	-2	DE	5200615	24.01
10946	Kempten	47.72	10.33	705	-2	DE	5100595	46.65
11010	Linz	48.23	14.18	298	-2	AT	5250655	9.77
11130	Kufstein	47.58	12.17	495	-2	AT	5100625	88.43
11150	Salzburg-Fl	47.80	13.00	430	-2	AT	5150635	31.75
11157	Aigen Im En	47.53	14.13	638	-2	AT	5100655	54.04
11487	Kocelovice	49.47	13.83	519	0	CZ	5550645	23.64
11541	Ceske Budej	48.93	14.45	432	0	CZ	5450660	22.53
13107	Rovinj/Sv.I	45.05	13.62	6	0	HR	4500650	4.70
13112	Postojna	45.77	14.20	533	0	SI	4700650	15.66
13216	Rab	44.75	14.77	24	0	HR	4400670	5.62
16008	S. Valentin	46.75	10.53	1459	2	IT	4600600	114.81
16033	Dobbiaco	46.73	12.22	1222	2	IT	4600625	9.88
16040	Tarvisio	46.50	13.58	777	2	IT	4650650	9.92
16045	Udine/Rivol	45.98	13.03	51	0	IT	4750640	7.58
16080	Brescia/Ghe	45.42	10.28	102	2	IT	4600600	10.22
16094	Vicenza	45.57	11.52	39	2	IT	4650620	17.52
16105	Venice/Tess	45.50	12.33	2	0	IT	4600630	3.13
16125	Sarzana/Lun	44.08	9.96	9	0	IT	4300595	15.10
16140	Bologna/Bor	44.53	11.30	36	0	IT	4400615	6.70
16149	Rimini	44.03	12.62	12	0	IT	4350635	3.46

Fitting parameters

- Global on the all set of stations
- Weather station class based
  - Plain
  - Mountainous area
  - near the coasts

- Root mean square error (RMSE)
- Intercept
- Slope
- R^2

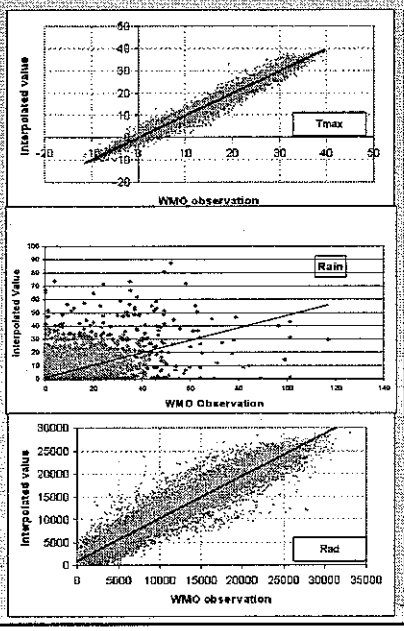
Spatial analysis on some weather events (see MC presentation)

Results (statistical analysis)

Operational model

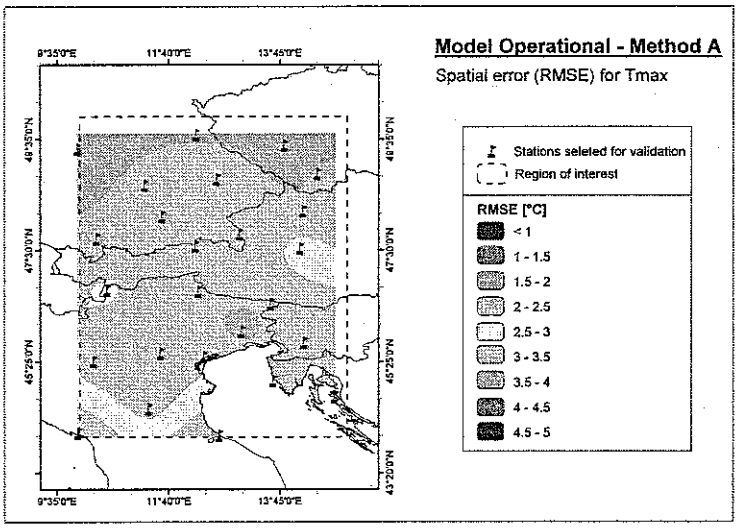
A	Tmx	[°C]	Tmn	[°C]	Wind	[m/s]	RR	[mm]	Rad	[KJ/m²day]
	RMSE	std	RMSE	std	RMSE	std	RMSE RR	logRR	RMSE	std
Global	2.28	0.69	2.28	0.62	1.22	0.49	6.12	0.339	2975	574
Land	1.94	0.36	2.00	0.51	1.00	0.50			2963	419
Coast	3.05	0.28	2.28	0.64	1.72	0.67			3084	593
Alps	2.36	0.48	2.79	0.66	1.27	0.41			2918	418
B	**Tmx**	**[°C]**	**Tmn**	**[°C]**	**Wind**	**[m/s]**	**RR**	**[mm]**	**Rad**	**[KJ/m²day]**
Global	2.95	1.43	2.31	0.97	1.12	0.55	5.73	0.340	3005	702
Land	2.29	0.50	1.94	0.31	0.99	0.27			2996	660
Coast	2.80	1.57	2.14	0.74	1.33	0.46			3136	696
Alps	4.28	1.79	3.13	1.45	1.21	0.55			2926	275
C	**Tmx**	**[°C]**	**Tmn**	**[°C]**	**Wind**	**[m/s]**	**RR**	**[mm]**	**Rad**	**[KJ/m²day]**
Global	1.62	0.40	1.51	0.55	0.76	0.25	5.78	0.340	2167	358
Land	1.47	0.25	1.25	0.21	0.74	0.24			2079	240
Coast	1.75	0.70	1.82	1.03	0.90	0.48			2486	535
Alps	1.79	0.24	1.77	0.52	0.74	0.22			2088	297
D	**Tmx**	**[°C]**	**Tmn**	**[°C]**	**Wind**	**[m/s]**	**RR**	**[mm]**	**Rad**	**[KJ/m²day]**
Global	2.04	0.61	2.08	0.62	1.00	0.31	5.81	0.348	2633	537
Land	1.90	0.25	1.89	0.32	1.02	0.34			2630	316
Coast	1.79	0.25	1.96	0.59	1.00	0.56			2769	453
Alps	2.46	1.01	2.51	0.90	0.97	0.32			2541	302

Operational model : method C

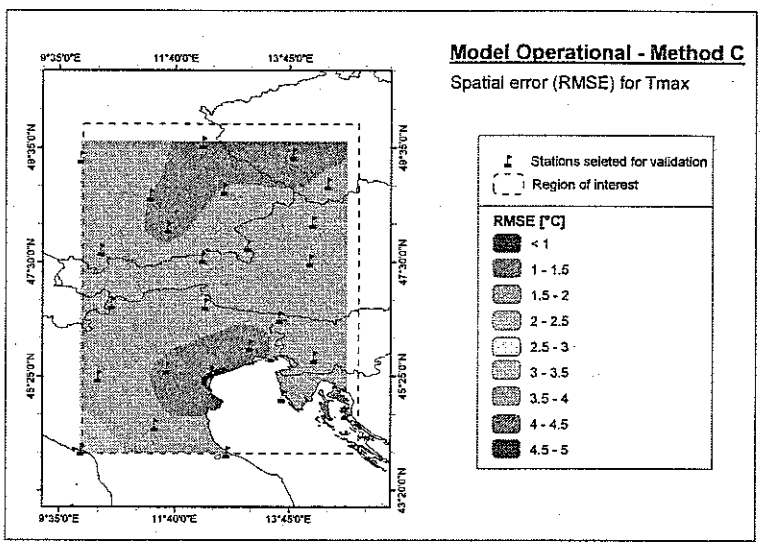


Scatterplots of WMO observations against grid interpolated values with the best downscaling method (Period 2002-2003) for: maximum temperature in [°C], minimum temperature in [°C], rainfall in [mm], wind speed at 10 m in [m/s], calculated radiation [KJ/m² day].

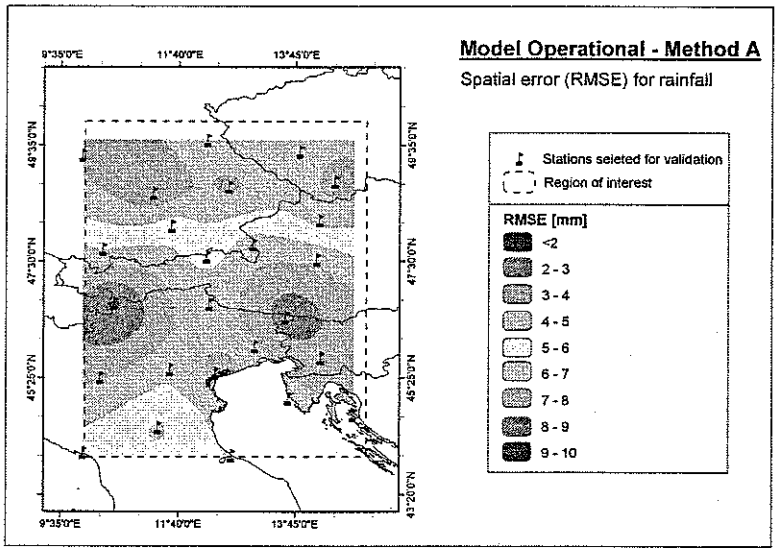
Operational model : spatial error



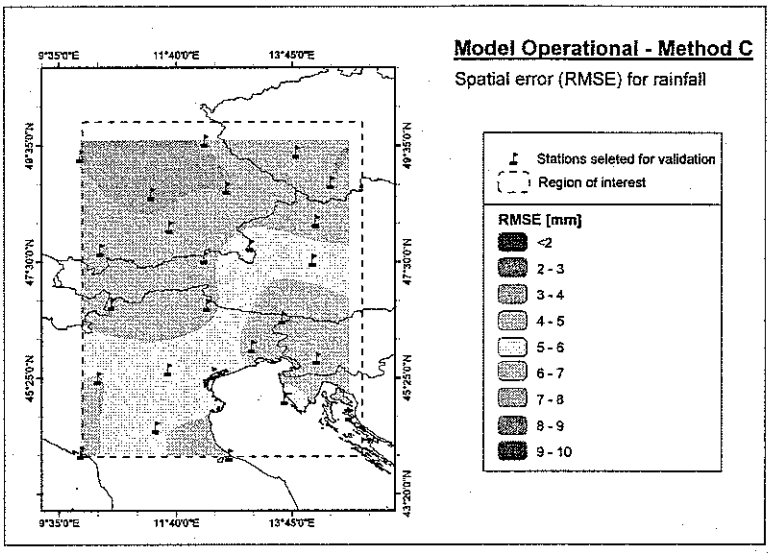
Operational model : spatial error



Operational model : spatial error



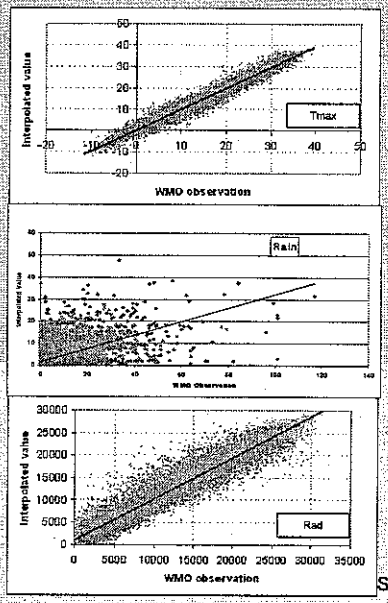
Operational model : spatial error



Ensemble Prediction System Model

A	Tmx		Tmn		Wind		RR		Rad	
	RMSE	std	RMSE	std	RMSE	std	RMSE RR	RMSE logRR	RMSE	std
Global	2.20	0.49	2.58	0.84	1.21	0.36	6.42	0.358	2703	613
Land	2.12	0.33	2.31	0.58	1.09	0.29			2572	432
Coast	2.11	0.87	2.70	1.24	1.51	0.48			2531	945
Alps	2.44	0.37	2.99	0.79	1.23	0.31			3257	312
B	Tmx		Tmn		Wind		RR		Rad	
Global	3.14	1.22	2.40	0.73	1.12	0.51	6.29	0.355	2621	476
Land	2.86	1.34	2.45	0.76	1.04	0.25			2558	474
Coast	2.95	1.06	1.73	0.52	1.26	0.47			2948	555
Alps	3.81	0.96	2.79	0.59	1.17	0.29			2498	362
C	Tmx		Tmn		Wind		RR		Rad	
Global	1.82	0.35	1.76	0.48	0.79	0.22	5.51	0.350	2208	378
Land	1.72	0.25	1.52	0.16	0.77	0.23			2181	330
Coast	1.85	0.64	1.97	0.91	0.93	0.17			2418	476
Alps	1.98	0.21	1.96	0.40	0.72	0.21			2105	374
D	Tmx		Tmn		Wind		RR		Rad	
Global	2.09	0.53	2.03	0.37	1.05	0.29	6.17	0.347	2591	440
Land	1.93	0.21	2.01	0.27	1.05	0.31			2556	412
Coast	2.05	0.36	1.69	0.22	1.06	0.24			2612	277

Ensemble Prediction System Model

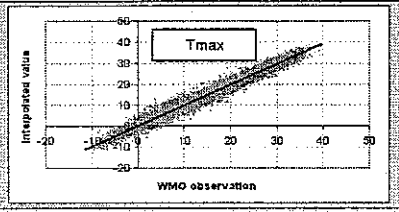


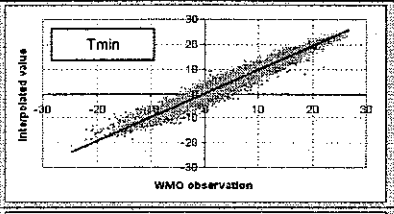
Scatter plots of WMO observations against interpolated grid values with the best downscaling method (Period 2002-2003) for: maximum temperature in [°C], minimum temperature in [°C], rainfall in [mm], wind speed at 10 m in [m/s], calculated radiation [KJ/m² day].

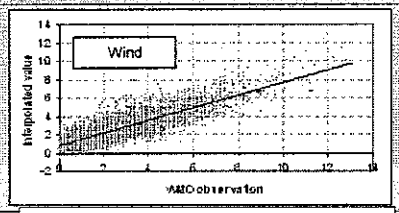
Monthly Model

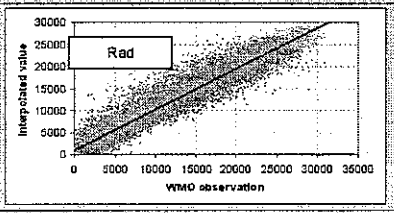
A	Tmx		Tmn		Wind		RR		Rad	
	RMSE	std	RMSE	std	RMSE	std	RMSE RR	logRR	RMSE	std
Global	2.23	0.48	2.63	0.55	1.23	0.45	6.36	0.357	2701	611
Land	2.13	0.42	2.46	0.78	1.09	0.27			2555	495
Coast	2.34	0.69	2.91	0.98	1.67	0.76			3324	869
Alps	2.33	0.41	2.76	0.50	1.18	0.25			2505	386
B	Tmx		Tmn		Wind		RR		Rad	
Global	3.26	1.22	2.47	0.75	1.12	0.28	6.09	0.356	2587	526
Land	3.12	1.45	2.53	0.85	1.06	0.25			2515	508
Coast	3.23	1.09	2.19	0.76	1.24	0.33			2935	631
Alps	3.54	0.93	2.54	0.52	1.15	0.30			2462	540
C	Tmx		Tmn		Wind		RR		Rad	
Global	1.75	0.27	1.65	0.28	0.78	0.21	5.50	0.347	2141	345
Land	1.71	0.26	1.55	0.15	0.78	0.23			2151	330
Coast	1.60	0.29	1.52	0.17	0.85	0.18			2183	407
Alps	1.94	0.20	1.91	0.36	0.71	0.20			2095	369
D	Tmx		Tmn		Wind		RR		Rad	
Global	2.16	0.52	2.16	0.44	1.06	0.29	6.07	0.350	2580	440
Land	1.98	0.30	2.04	0.38	1.05	0.27			2528	395
Coast	2.14	0.31	2.04	0.51	1.07	0.25			2556	339
Alps	2.50	0.79	2.48	0.38	1.06	0.38			2685	665

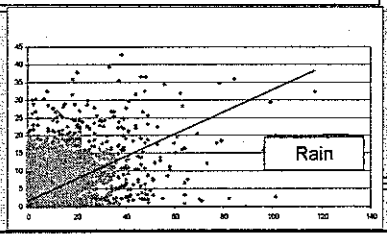
Monthly model





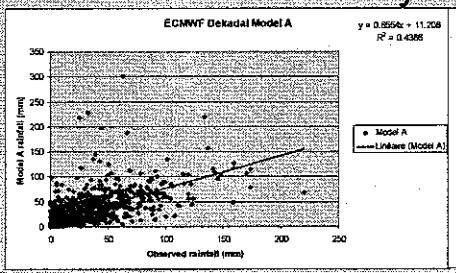


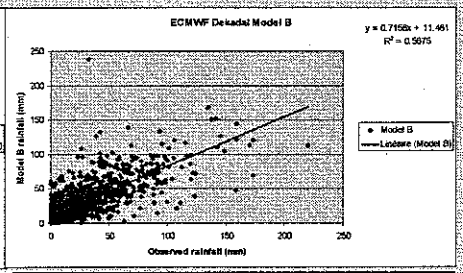


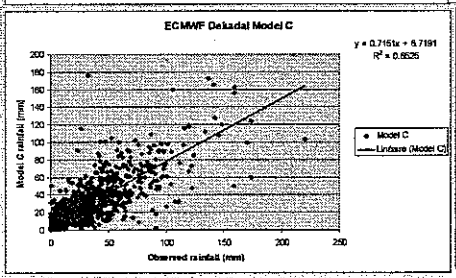


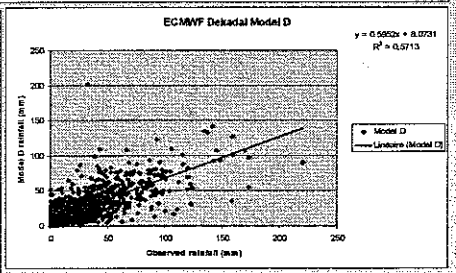
Experts meeting - Arlon
23/10/2006

10-daily rainfall data









III CGMS Experts meeting - Arlon
23/10/2006

10-daily rainfall data

OPER	Method A	Method B	Method C	Method D
RMSE	22.83	19.48	16.42	18.19
Equation	Y=0.655X+11.21	Y=0.716X+11.46	Y=0.715X+6.72	Y=0.595X+8.07
R^2	0.437	0.568	0.625	0.571
EPS				
RMSE	21.60	21.04	18.57	21.02
Equation	Y=0.566X+12.30	Y=0.592X+12.96	Y=0.537X+10.27	Y=0.534X+11.91
R^2	0.433	0.466	0.550	0.441
Monthly				
RMSE	21.92	20.51	18.60	20.54
Equation	Y=0.538X+12.08	Y=0.571X+13.49	Y=0.543X+10.12	Y=0.575X+12.49
R^2	0.411	0.478	0.548	0.474

Conclusions

- Accuracy level : be aware of the prediction models limits (rain RMSE > 5 mm on a two-year daily data set !)
- Accuracy decreases from Operational to Seasonal Model Grid Size
- Downscaling process : Method C >Method D > Method A > Method B
- Rainfall and in a lesser extent, wind poor estimation…

Thank you