Mónika Lakatos, Tamás Szentimrey, Beatrix Izsák, Olivér Szentes, Lilla Hoffmann, Andrea Kircsi, Zita Bihari:

Comparative study of CARPATCLIM, E-OBS and ERA5 dataset

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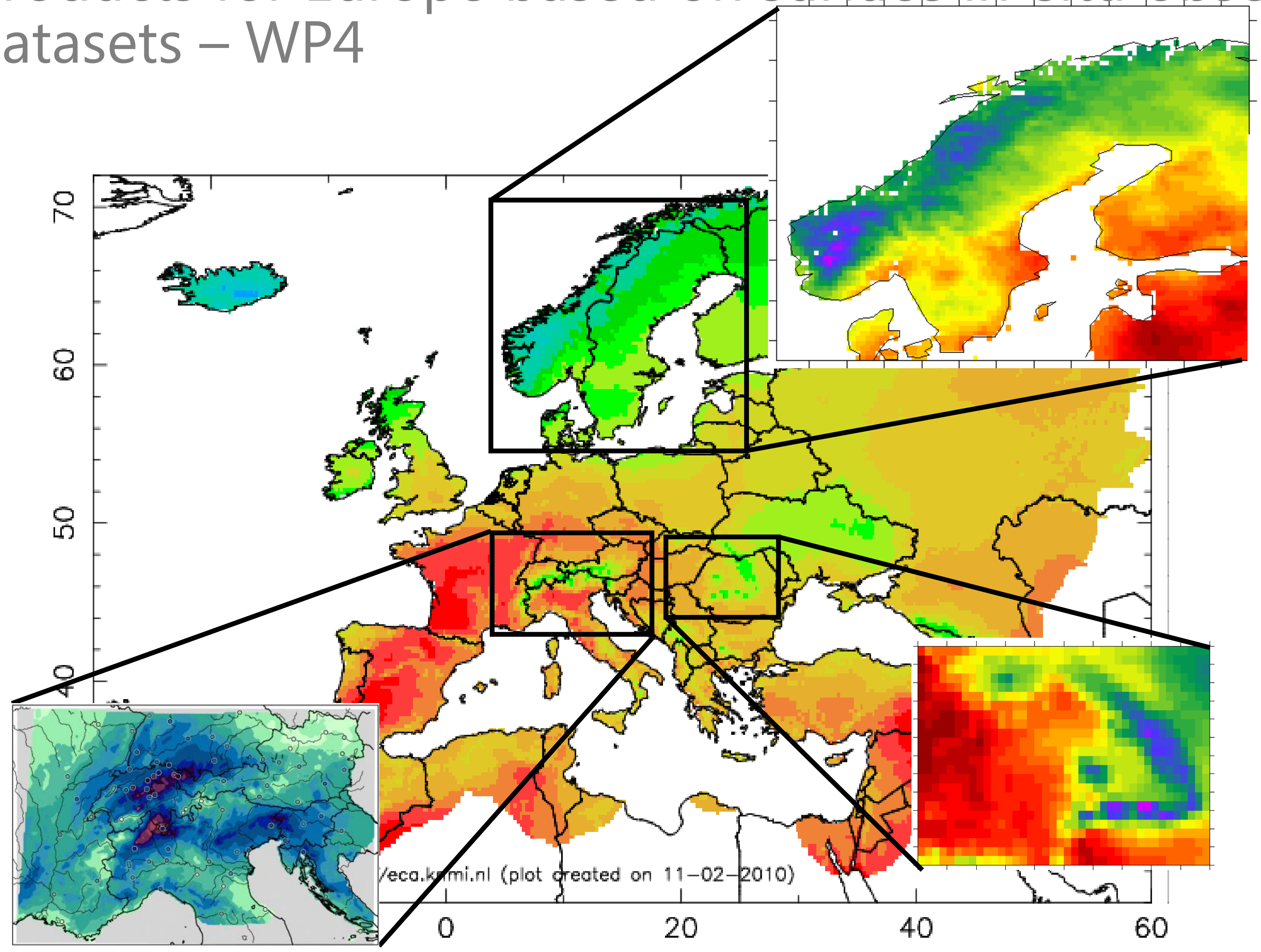
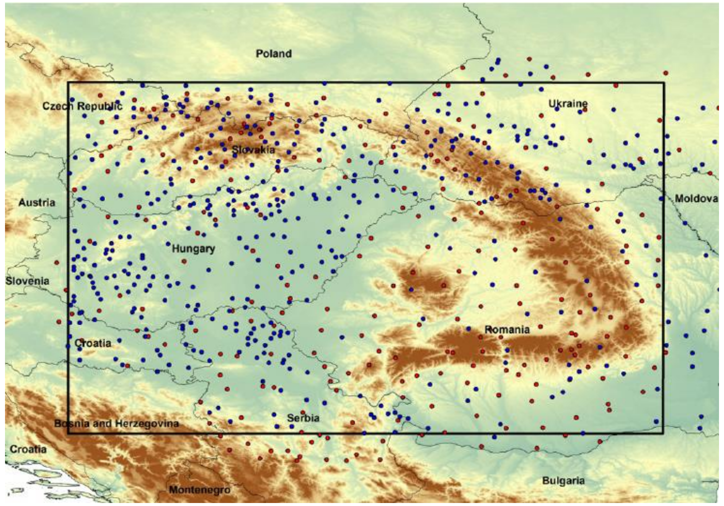
ORSZÁGOS METEOROLÓGIAI SZOLGÁLAT
1870-2020

COPERNICUS C3S_311a_Lot4 (C3Surf) project: Climate monitoring products for Europe based on surface in-situ observations - Sub-regional datasets – WP4



Copernicus Climate Change Services, 2nd, General Assembly, Berlin, 24 - 28 September 2018

CARPATCLIM regional dataset for the Carpathian Region



- JRC support, duration 2010-2013
- Consortium leader: OMSZ, 9 countries
- Commonly used methods: MASH (Szentimrey) –MISH (Szentimrey,Bihari)
- Results: 13 basic meteorological variables, and 37 climate indicators, daily, 0.1 degree resolution
- 1961-2010, static in Copernicus C3Surf project
- DanubeClim

www.carpatclim-eu.org/

Variable	Description	units
Ta	2 m mean daily air temperature	°C
Tmin	Minimum air temperature	°C
Tmax	Maximum air temperature	°C
p	Accumulated total precipitation	mm
DD	10 m wind direction, Degrees	0-360
VV	10 m horizontal wind speed	m/s
Sunshine	Sunshine duration	hours
cc	Cloud cover	tenths
Rglobal	Global radiation	J/cm^2
RH	Relative humidity	%
pvapour	Surface vapour pressure	hPa
pair	Surface air pressure	hPa
Snow depth	Snow depth (ZAMG model)	cm

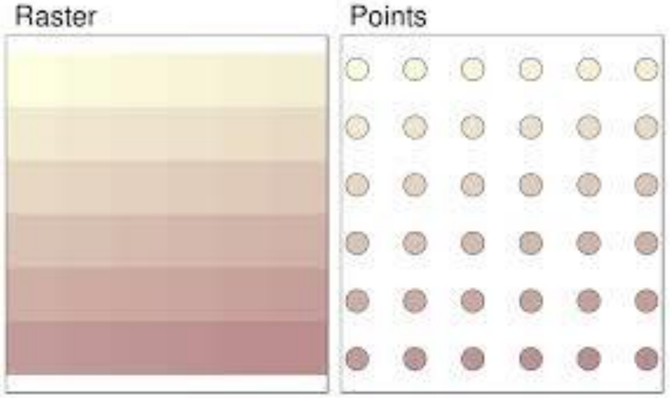
D4: Scientific report on evaluation of new E-OBS data set - COPERNICUS C3S_311a_Lot4

Name	Domain	CRS	Grid res.	Time coverage/ ensemble size	Variables
COSMO-REA6	Alps	rotpol	0.055°	1997-2008	RR
E-OBS	EU	latlon	0.1°	1950-2018	RR, TG, TX, TN
E-OBS-Ens	EU	latlon	0.1°	1950-2018 / 100 ensemble members	RR, TG, TX, TN
ERA5-HRES	EU	latlon	0.25°	1979-2018	RR, TG, TX, TN
ERA5-ENDA	EU	latlon	0.5°	1979-2018 / 10 ensemble members	RR, TG, TX, TN
ERA5-LAND	EU	latlon	0.125°	2000-2018	RR, TG, TX, TN

Name	Domain	CRS	Grid res.	Time coverage/ ensemble size	Variables
APGD	Alps	laea	5 km	1971-2008	RR
APGD-Ens	Alps	laea	catch ments	1971-2008 / 100 ens. members	RR
CARPATCLIM	Carpath ians	lonlat	0.1°	1961-2010	RR, TX, TN
LAPrec	Alps	laea	5 km	1871/1901-2010	RR
NGCD-1	Fennosc andia	laea	1 km	1961-2019	RR, TG, TX, TN
NGCD-2	Fennosc andia	laea	1 km	1957-2017	RR, TG, TX, TN

Conversion of CARPATCLIM dataset is necessary to comparisons

The CARPATCLIM dataset includes interpolated data for gridpoints while E-OBS includes gridbox averages



CARPATCLIM data can be converted to gridbox average, thanks to the special methodology of MISH

The MISH speciality is that the statistical parameters - like spatial trend and correlation structure - are modelled and saved

regridding CARPATCLIM to the E-OBS grid to make them comparable

ERA5 the data was downscaled from 0.25° to 0.1° with a bilinear interpolation

Measures used for evalutaion of Tx and Tn

- ANOVA (ANalysis Of VAriance)
- The yearly cycle, the mean annual diurnal temperature range (DTR), the Q95 and Q05 quantiles, daily and monthly maxima and minima
- TXx and TNn, SU and FD temperature indices
- RMSE and MSESS (daily, monthly and seasonal)
- Linear trend model was fitted to yearly mean TX and TN
- homogeneity test of the E-OBS gridded temperatures for testing the residual inhomogeneity
- The methods are detailed in *Szentimrey 2019: Mathematical methodology and software for comparison of gridded datasets (manuscript).*

ANOVA- Partitioning of Total Variance (Theorem)

$$\hat{D}^2 = \frac{1}{N}\sum_{j=1}^{N}\left(\hat{E}(\mathbf{s}_j) - \hat{E}\right)^2 + \frac{1}{N}\sum_{j=1}^{N}\hat{D}^2(\mathbf{s}_j) = \frac{1}{n}\sum_{t=1}^{n}\left(\hat{E}(t) - \hat{E}\right)^2 + \frac{1}{n}\sum_{t=1}^{n}\hat{D}^2(t)$$

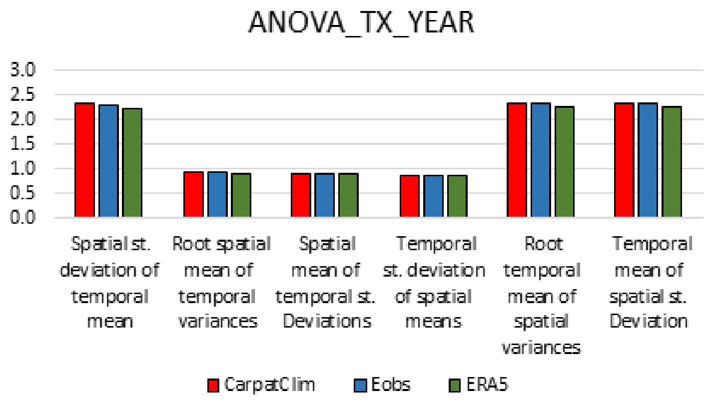
spatial variance of temporal means

spatial mean of temporal variances

temporal variance of spatial means

temporal mean of spatial variances

Lakatos, M., Szentimrey, T., Izsák, B., Hoffmann, L.: Comparison of E-OBS and CARPATCLIM gridded datasets of minimum temperatures, maximum temperatures and precipitation by Analysis of Variance (ANOVA)
9th Seminar for Homogenization and Quality Control in Climatological Databases and 4th Conferences on Spatial Interpolation Techniques in Climatology and Meteorology, Budapest, 2017. április 3-7.
http://www.wmo.int/pages/prog/wcp/wcdmp/wcdmp_series/WCDMP_85.pdf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2.0
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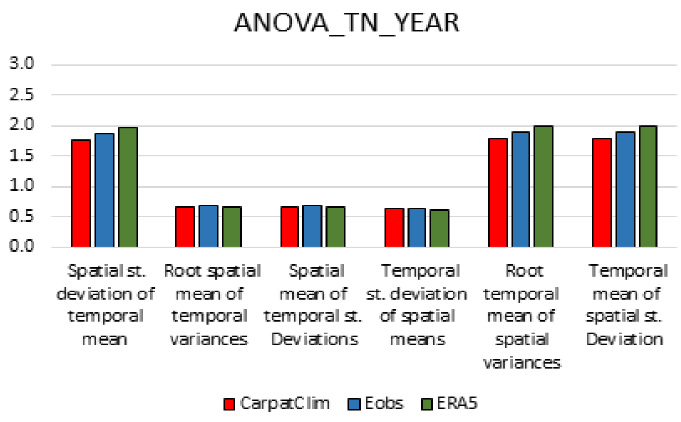
0.0
Spatial st. deviation of temporal mean
Root spatial mean of temporal variances
Spatial mean of temporal st. Deviations
Temporal st. deviation of spatial means
Root temporal mean of spatial variances
Temporal mean of spatial st. Deviation
CarpatClim
Eobs
ERA5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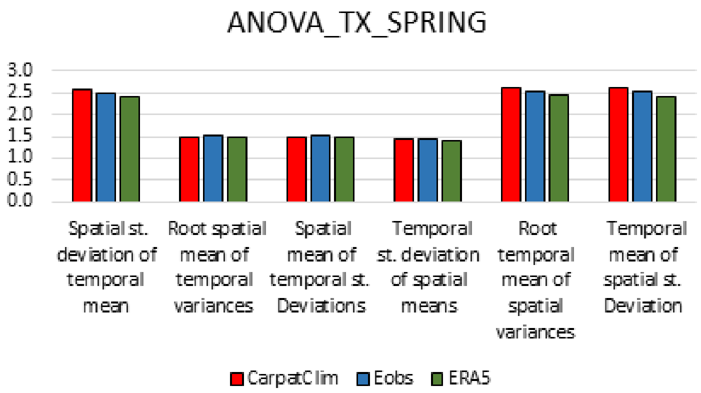
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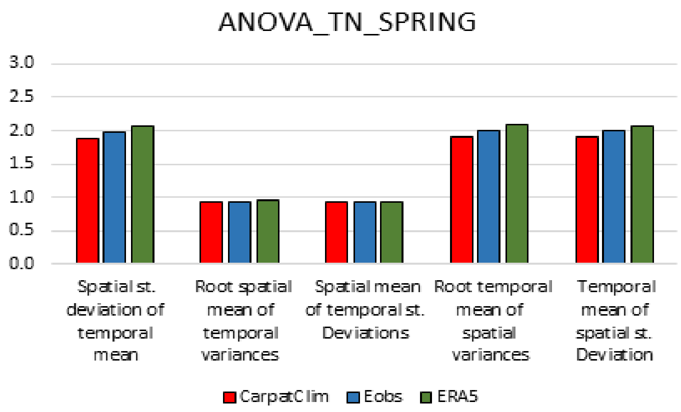
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Root spatial mean of temporal variances
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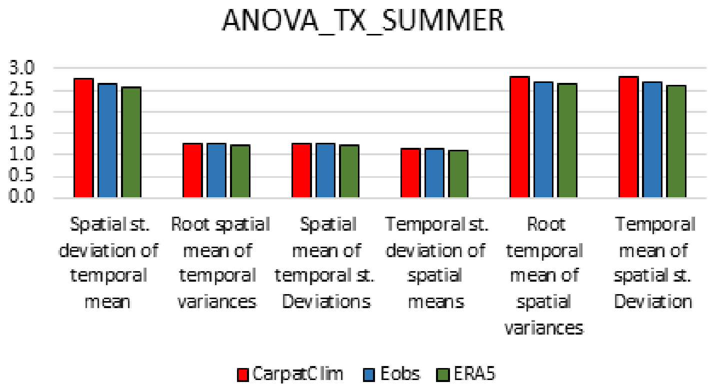
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Root spatial mean of temporal variances
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Temporal mean of spatial st. Deviation
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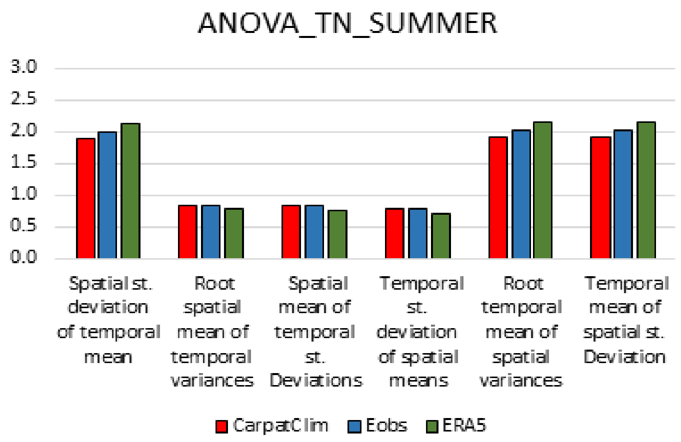
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Spatial st. deviation of temporal mean
Root spatial mean of temporal variances
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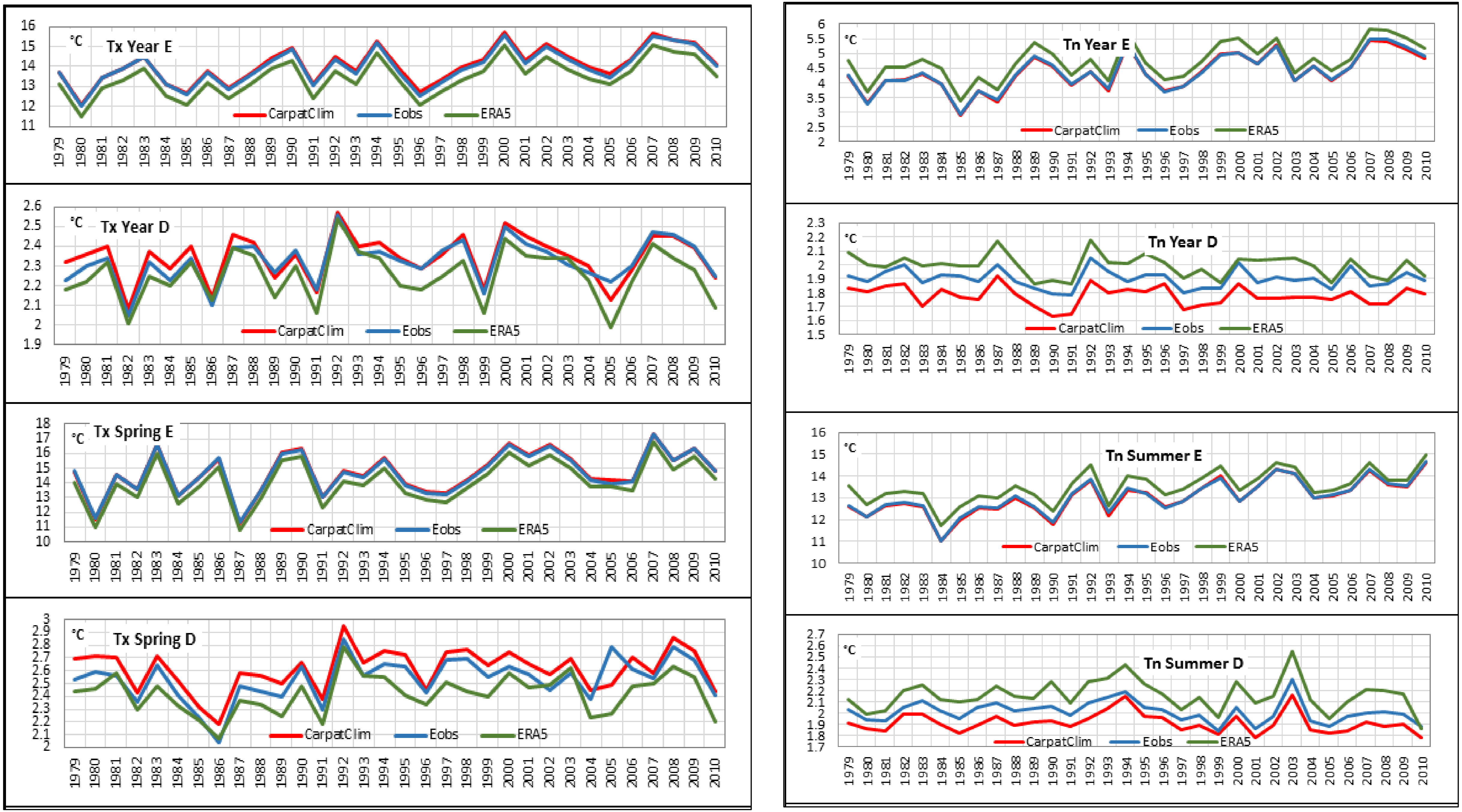
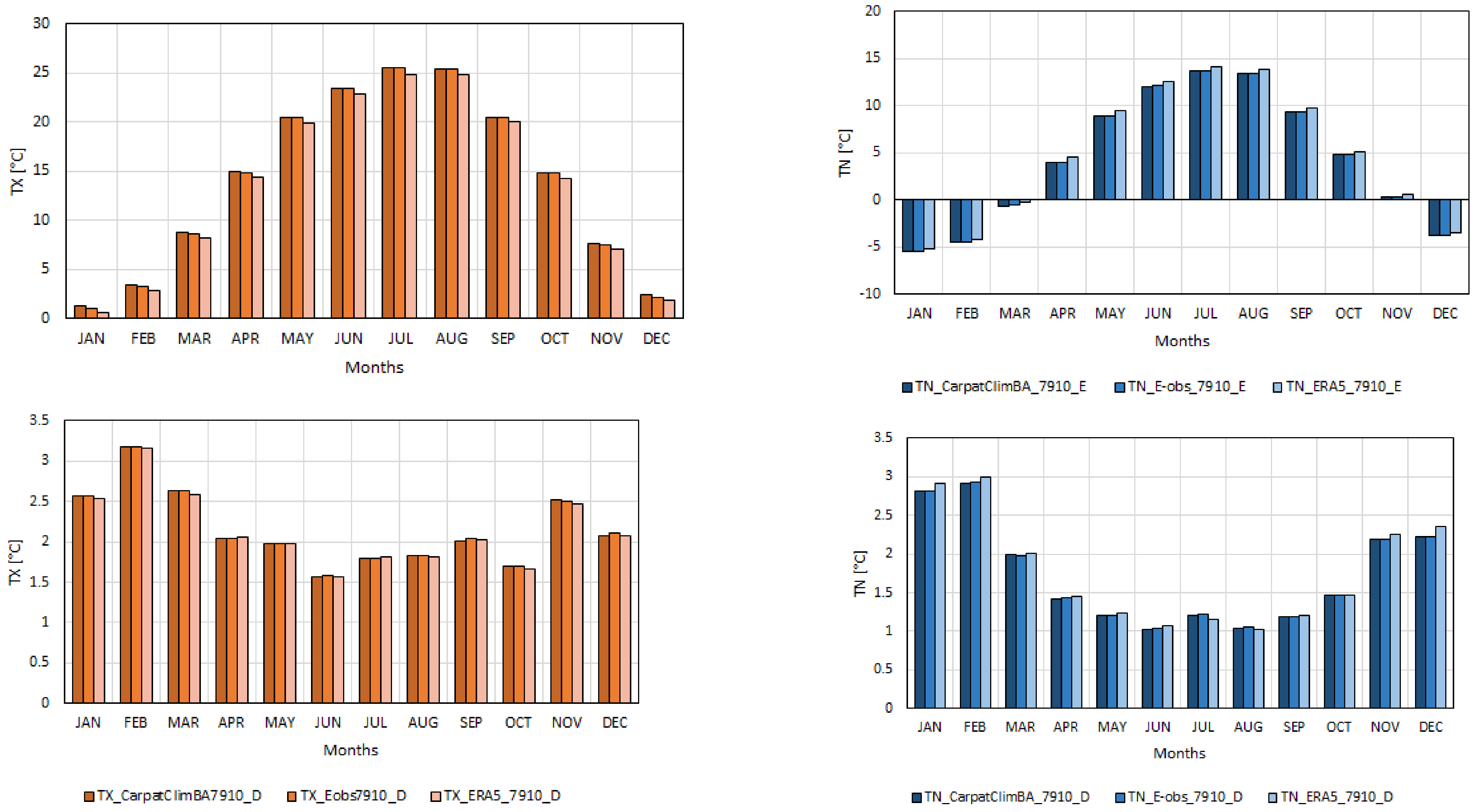
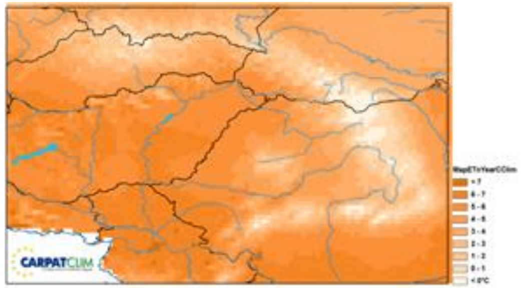
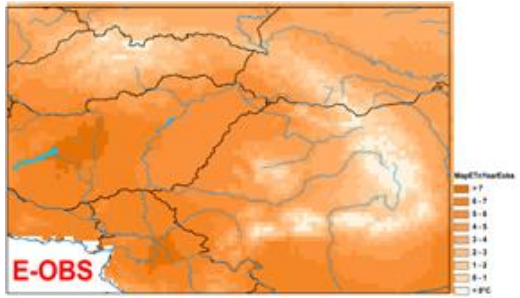
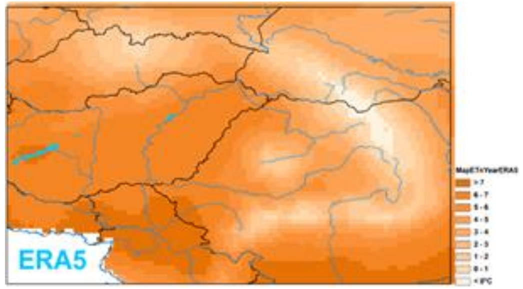


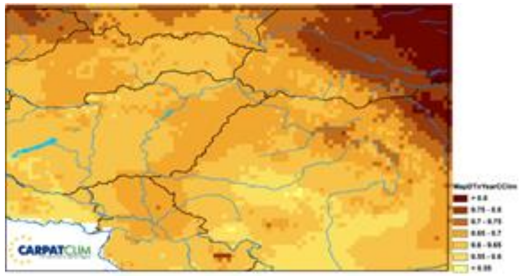
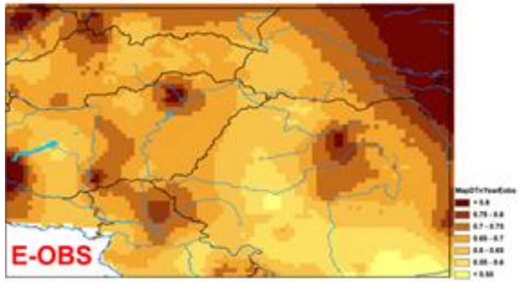
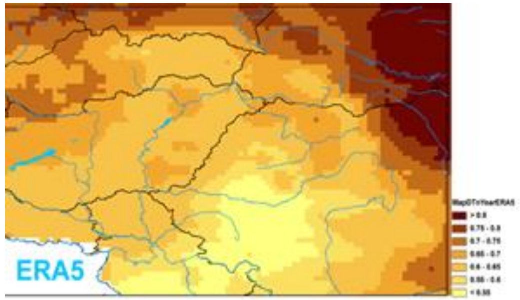
°C Tx Year E
16 15 14 13 12 11
CarpatClim Eobs ERA5
1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
°C Tx Year D
2.6 2.5 2.4 2.3 2.2 2.1 2 1.9
CarpatClim Eobs ERA5
°C Tx Spring E
18 17 16 15 14 13 12 11 10
CarpatClim Eobs ERA5
°C Tx Spring D
3 2.9 2.8 2.7 2.6 2.5 2.4 2.3 2.2 2.1 2
CarpatClim Eobs ERA5
°C Tn Year E
6 5.5 5 4.5 4 3.5 3 2.5 2
CarpatClim Eobs ERA5
°C Tn Year D
2.3 2.2 2.1 2 1.9 1.8 1.7 1.6 1.5
CarpatClim Eobs ERA5
°C Tn Summer E
16 15 14 13 12 11 10
CarpatClim Eobs ERA5
°C Tn Summer D
2.7 2.6 2.5 2.4 2.3 2.2 2.1 2 1.9 1.8 1.7
CarpatClim Eobs ERA5

Yearly cycle-monthly means and standard dev.

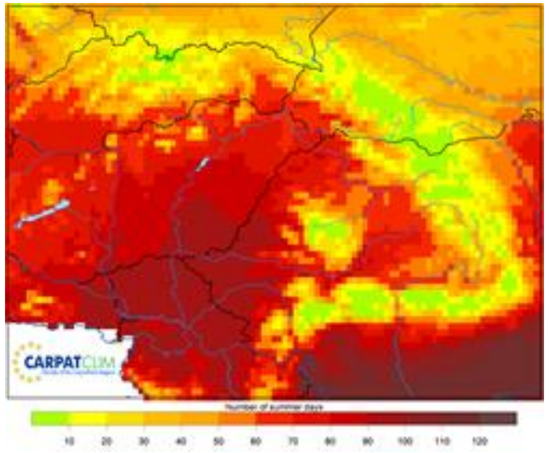
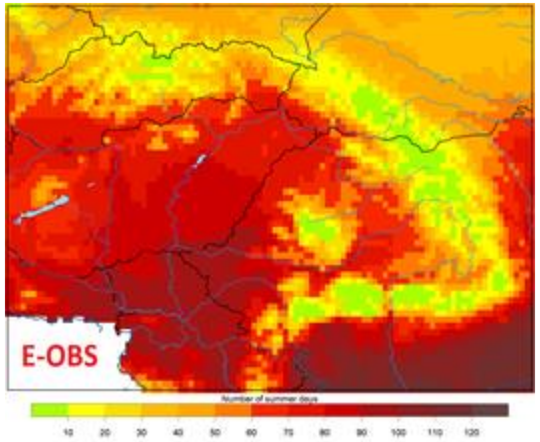
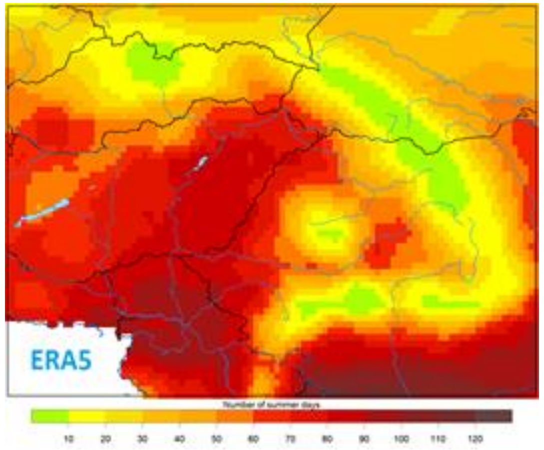


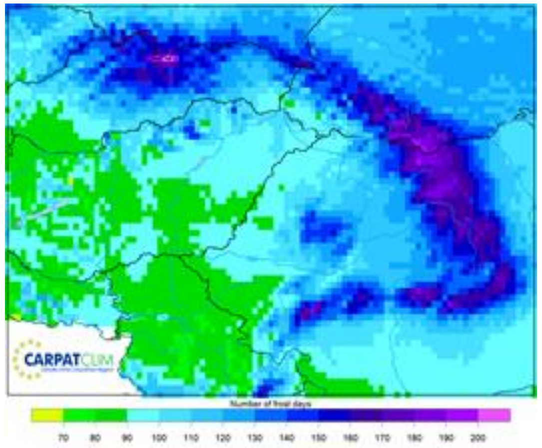
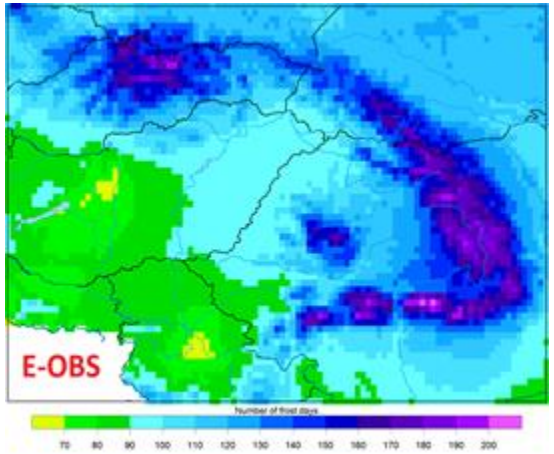
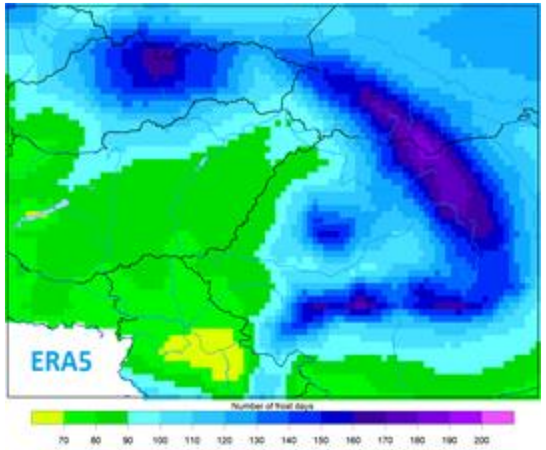
Temporal means and st. deviations of annual mean Tn

Tn CARPATCLIM EOBS, ERA5 E Year	
	
	

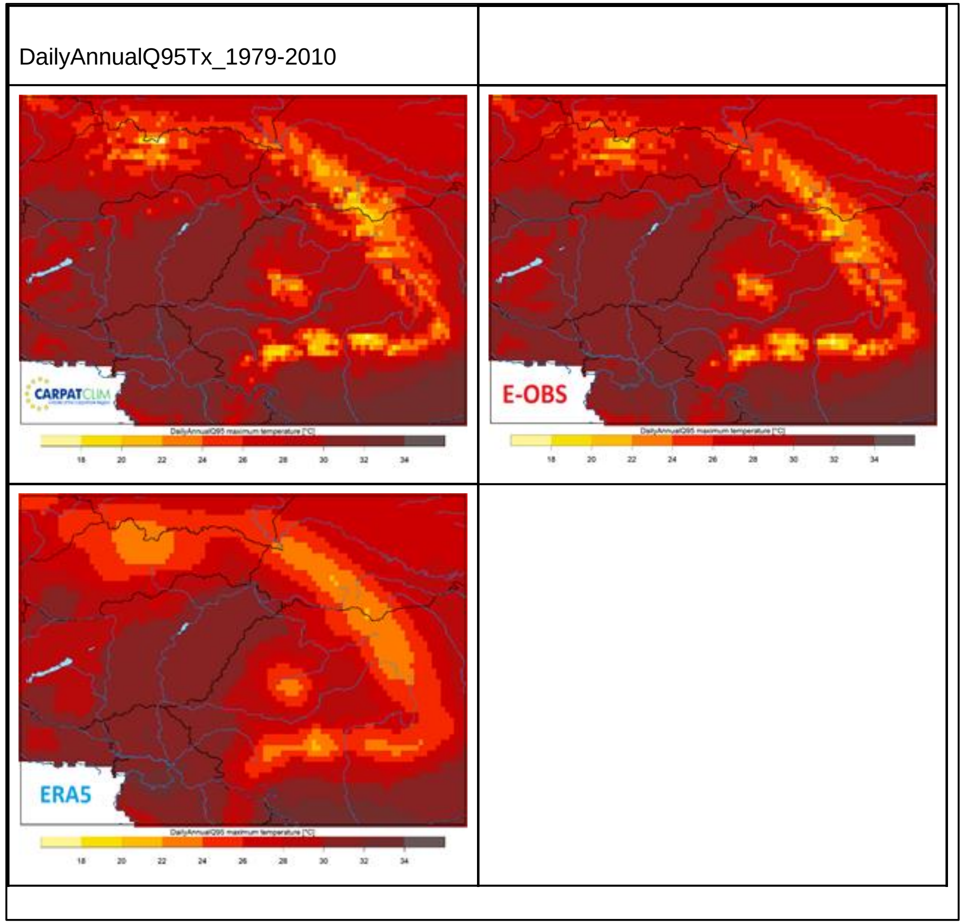
Tn CARPATCLIM EOBS, ERA5 D Year	
	
	

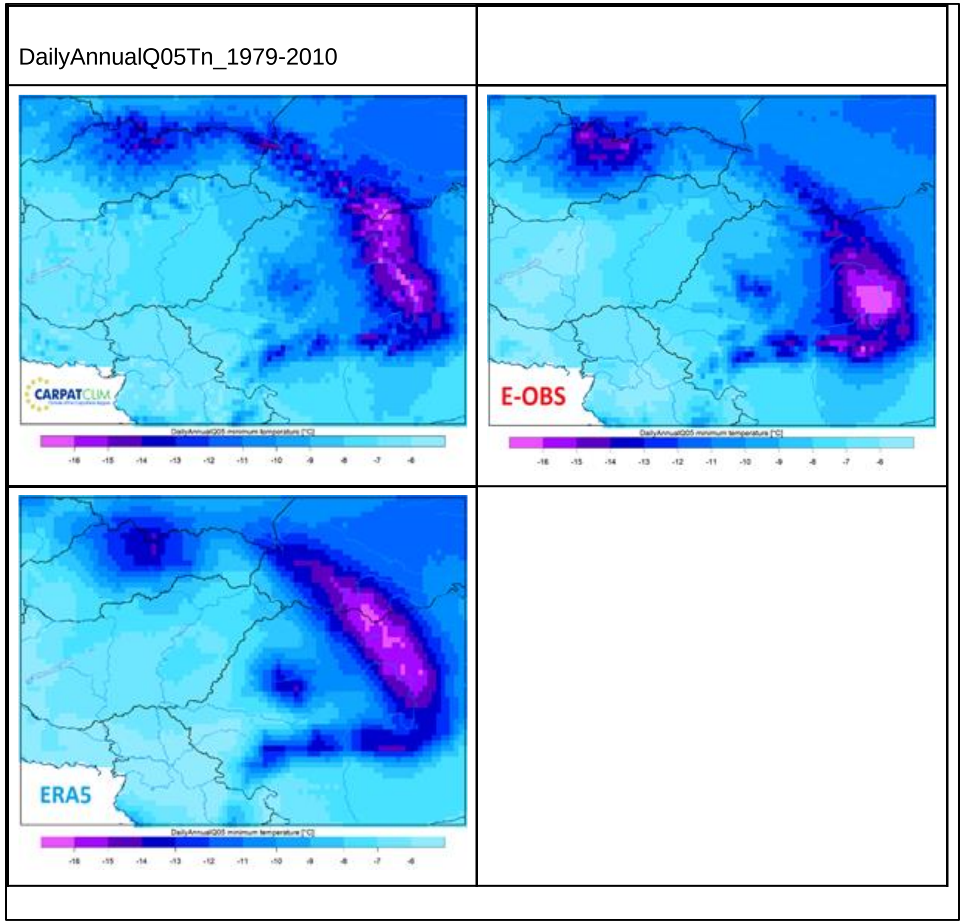
Summer days (SU) and frost days (FD)

TX25 1979-2010	
	
	

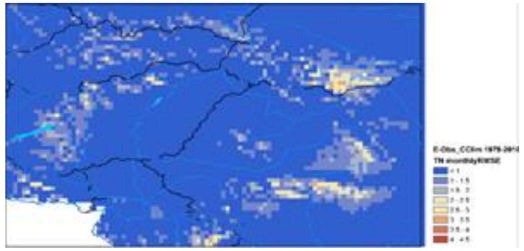
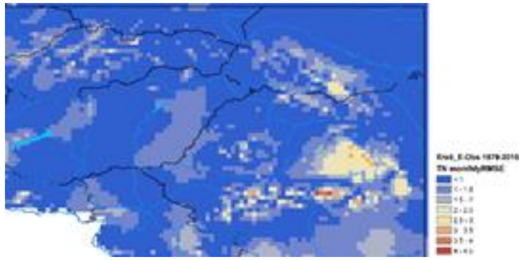
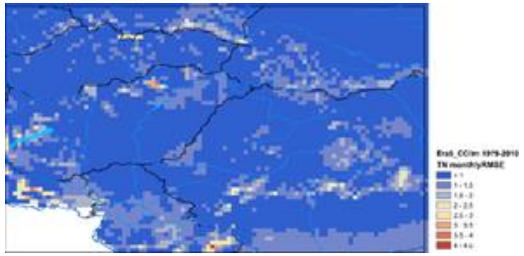
TN0 1979-2010	
	
	

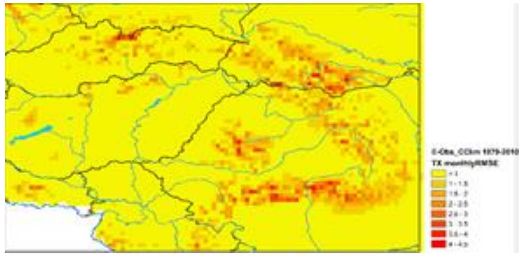
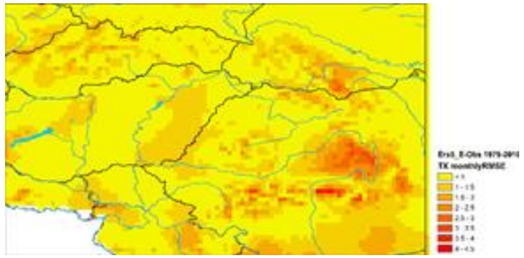
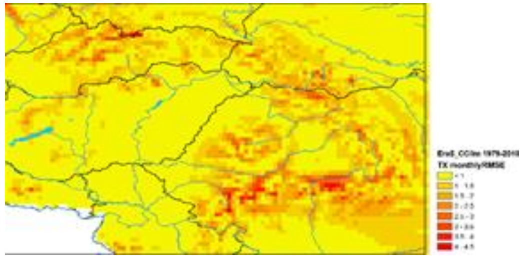
Extreme quantiles Q95 and Q05 Tn





RMSE (monthly) Tn and Tx

RMSE Tn monthly	
	
	

RMSE Tx monthly	
	
	

Yearly RMSE (degC) for monthly Tn and Tx of E-OBS with the reference of CARPATCLIM (top left), of ERA5 with the reference of E-OBS (top right), of ERA5 with the reference of CARPATCLIM (bottom left)

Linear trend (degC/32year) for annual mean Tx and Tn 1979-2010

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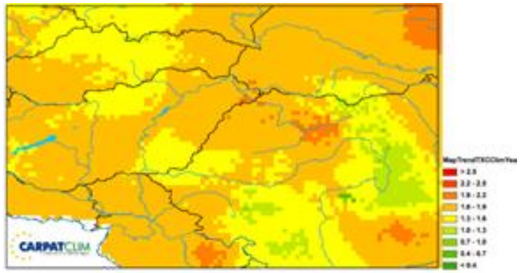
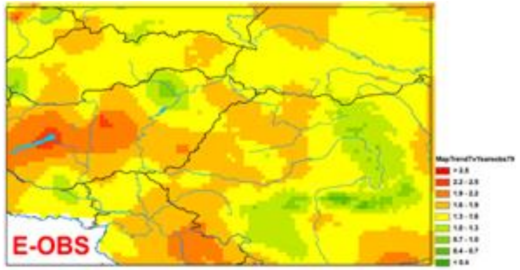
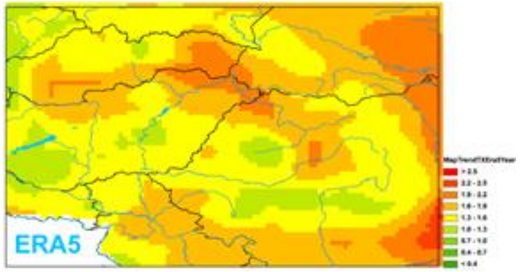
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
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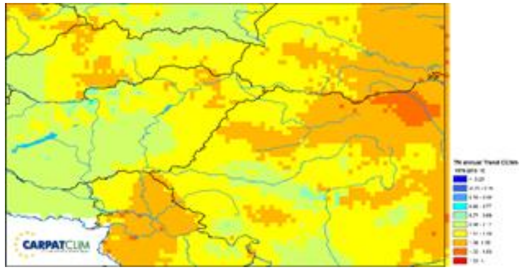
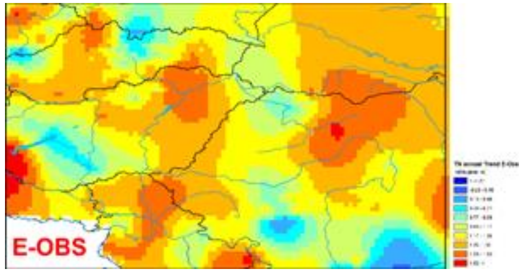
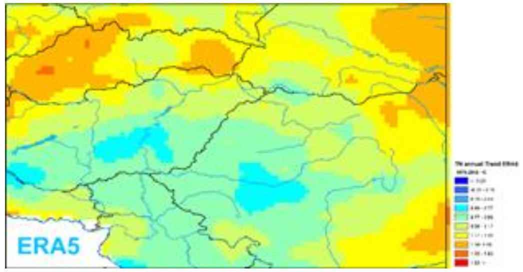
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
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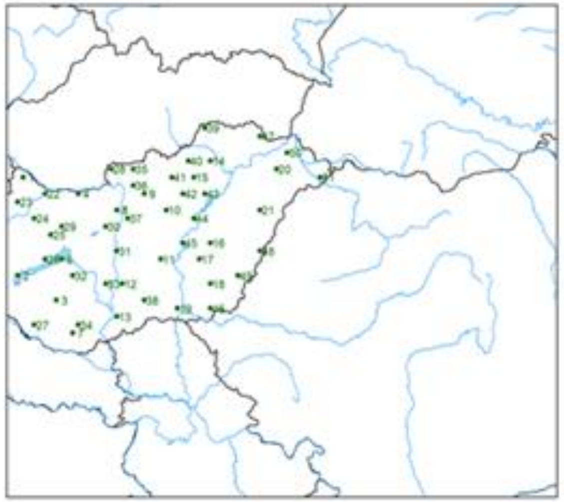
Homogeneity test, 1961-2010



Test Statistics After Homogenization **for TX in E-OBS**

AVERAGE: 108.51

Test Statistics After Homogenization **for TX in CARPATCLIM**

AVERAGE: 22.26

Test Statistics After Homogenization **for TN in E-OBS**

AVERAGE: 117.77

Test Statistics After Homogenization **for TN in CARPATCLIM**

AVERAGE: 22.34

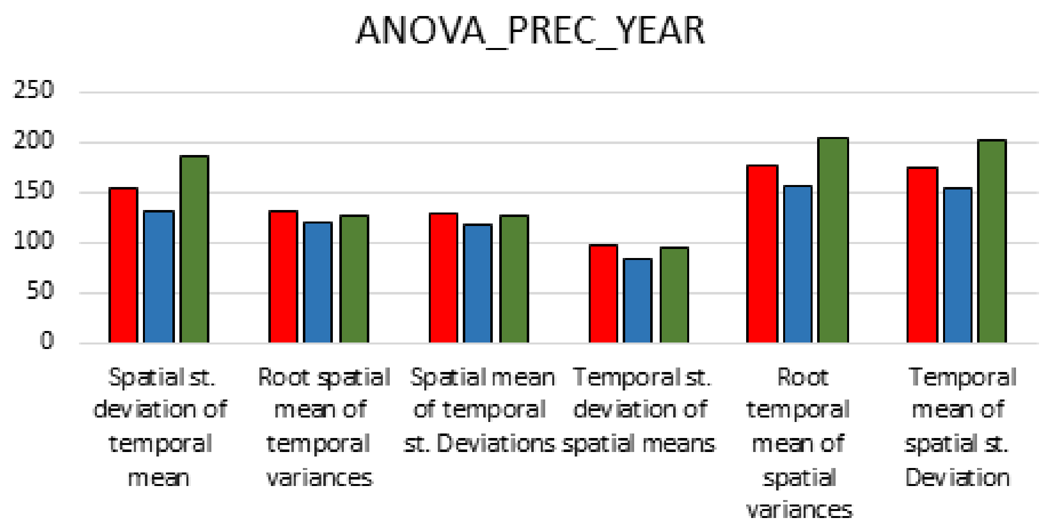
Test Statistics After Homogenization **for TN in E-OBS**

The critical value related to significance level 0.05 is 20.86

Series	TSA	Series	TSA	Series	TSA
37	529.82	6	417.25	13	366.72
36	342.52	11	322.14	15	291.76
14	265.76	38	261.02	41	182.02
22	176.71	20	170.18	24	163.54
26	152.44	5	150.96	8	150.96
34	148.13	9	128.54	33	124.65
40	106.52	1	103.2	23	99.75
27	96.67	49	84.07	10	81.79
47	68.82	31	63.15	25	60.87

Precipitation

(see Moritz Banhauer’s presentation too, the ANOVA results, the comparison of trends and the homogeneity test results are presented here as a complementary analysis)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200
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Spatial st. deviation of temporal mean
Root spatial mean of temporal variances
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Temporal st. deviation of spatial means
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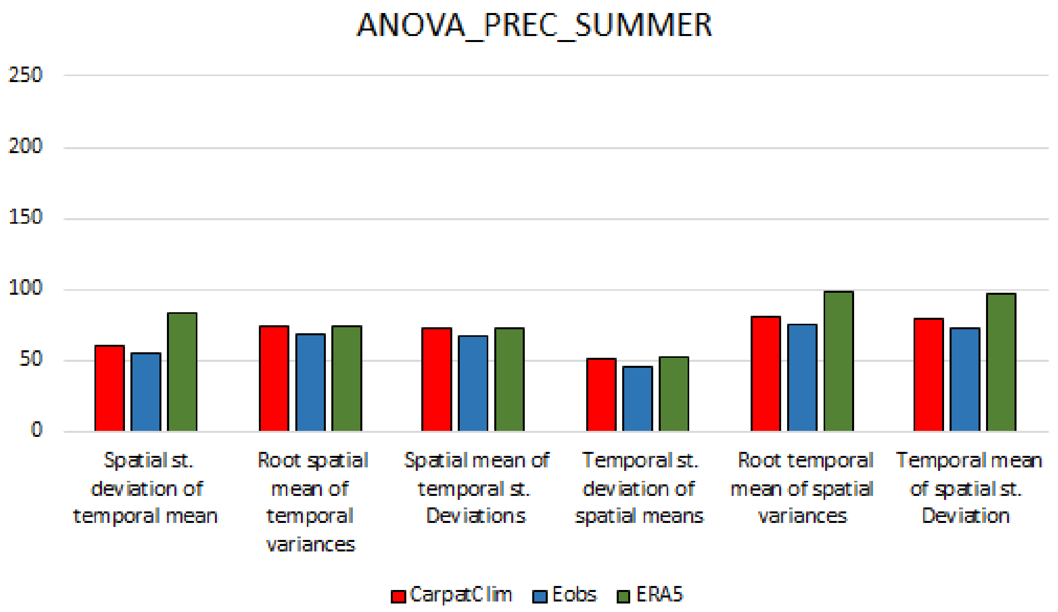
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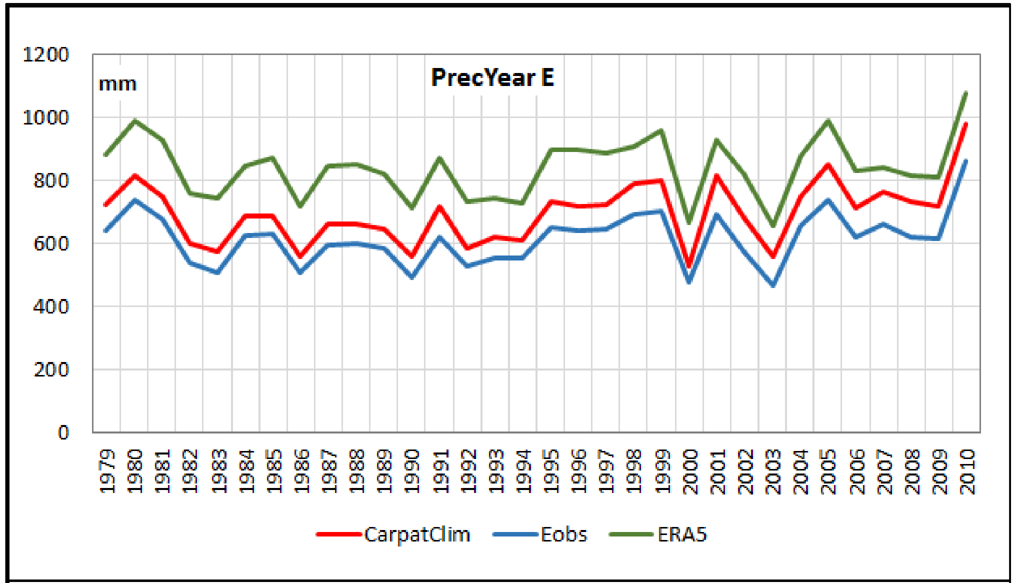
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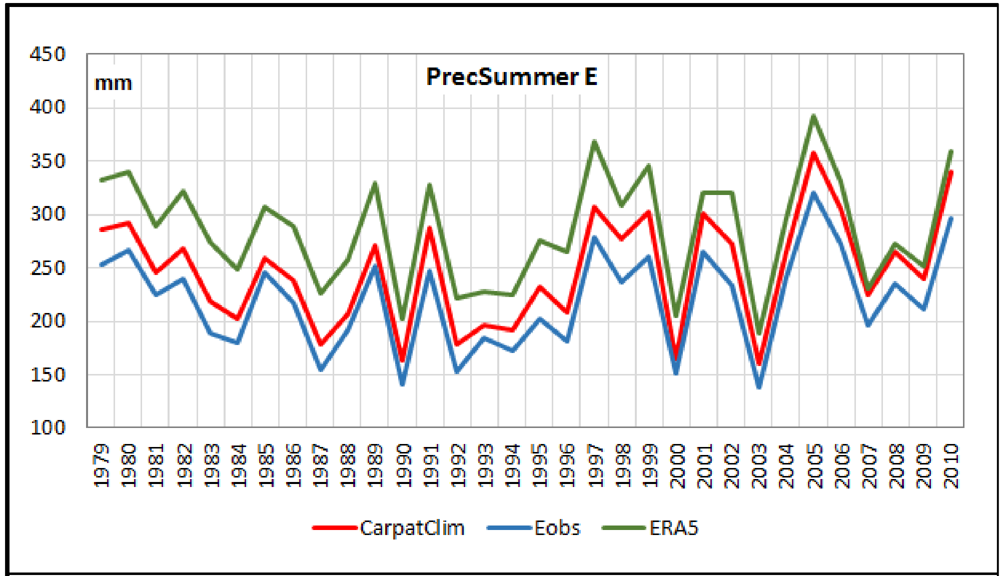
PrecSummer E
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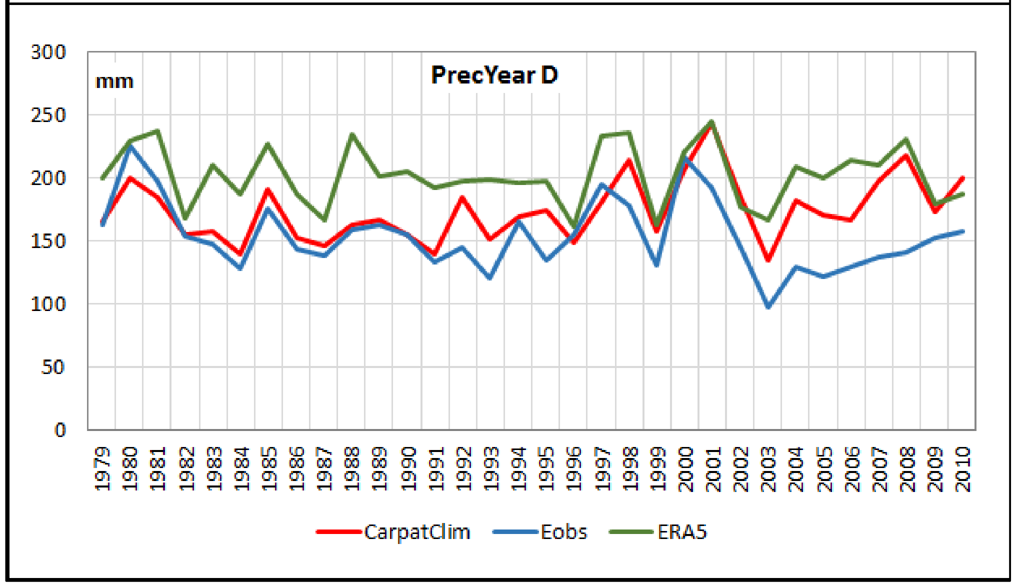
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mm
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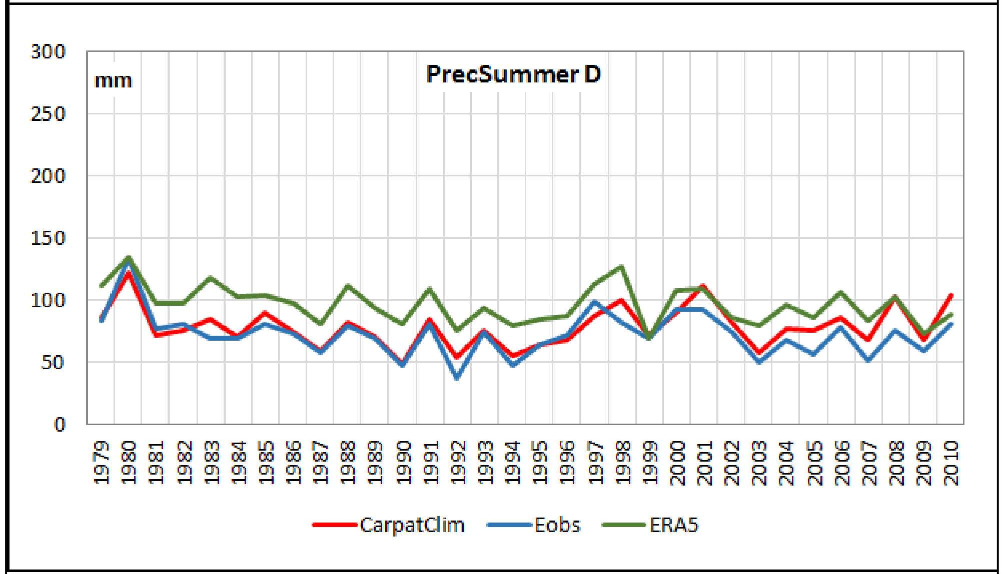
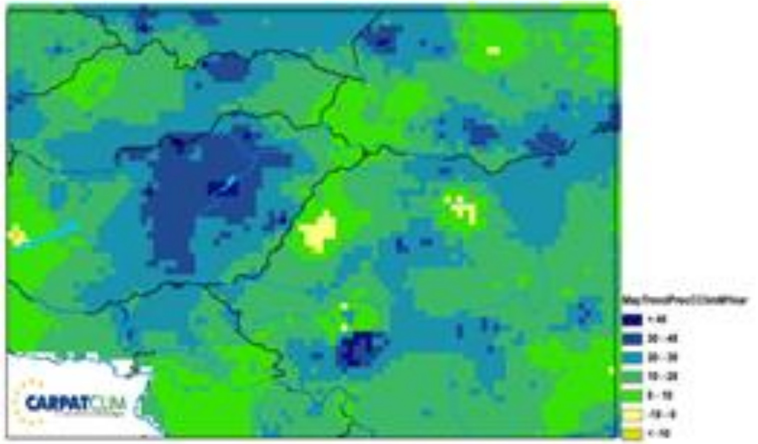
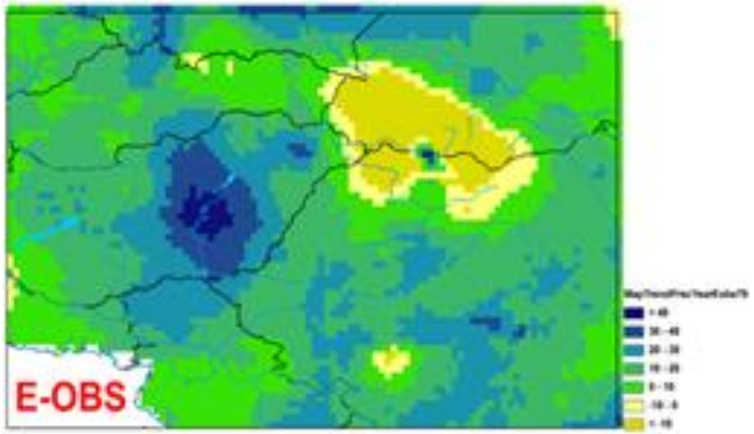
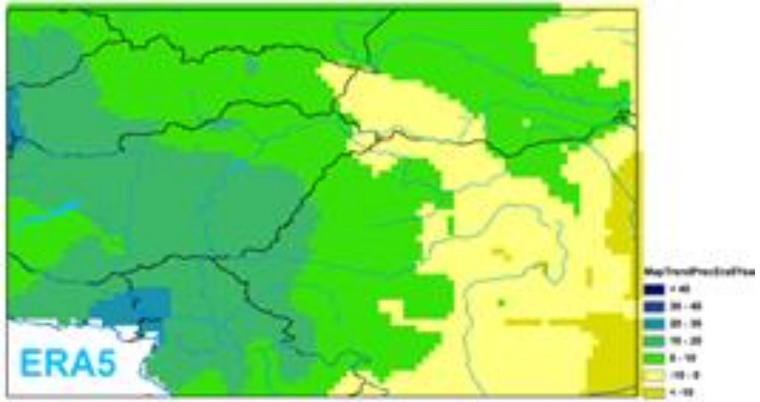

PrecSummer D
mm
CarpatClim
Eobs
ERA5

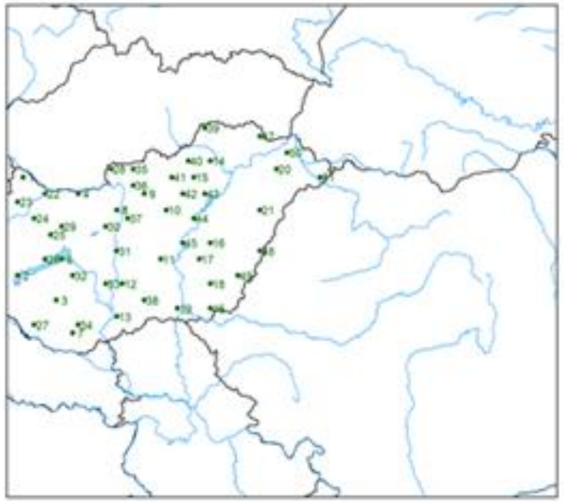
Exponential trend fitting for yearly precipitation in %/ 32 year







Homogeneity test, 1961-2010



Test Statistics After Homogenization **for Prec in E-OBS**

AVERAGE: 25.77

Test Statistics After Homogenization **for Prec in CARPATCLIM**

AVERAGE: 17.88

The critical value related to significance level 0.01 is 31

Series	TSA	Series	TSA	Series	TSA
42	50.53	2	36.04	6	36.03
37	34.07	49	32.05	46	30.12
50	29.21	12	28.13	29	27.51
44	27.06	5	25.00	8	25.00
40	23.11	17	22.71	20	20.79
16	20.55	43	19.92	3	19.49
21	18.67	1	17.75	14	17.37
48	16.86	39	16.71	15	16.65
32	15.81	31	15.62	13	15.28
4	14.80	9	14.68	33	14.64
35	14.32	51	14.20	41	14.05
18	13.45	38	13.37	23	13.27
22	12.71	25	11.78	7	11.49
11	10.71	47	9.86	26	9.14
19	9.07	30	8.91	45	8.17
36	7.89	27	7.24	24	6.11
34	5.30	10	4.58	28	4.30

Main outcomes (C3S_311a_Lot4 Deliverable D4)

- The spatial distribution of the yearly mean Tx and Tn is similar regarding the datasets including in this comparative study. The standard deviation of the yearly average Tx is low in ERA5 almost in the whole territory of Romania.
- As a regard for the yearly cycle the CARPATCLIM and E-OBS produce almost the same monthly mean Tx values. The ERA5 monthly average maxima are lower at least half degree during the year on average.
- As for the RMSE values, the observational datasets are closer to each other than ERA5 either to CARPATCLIM or E-OBS in general.
- The highest MSESS values appear in the plain region, the orography is one of the main determining factors. The Tn is a more problematic climate variable than Tx, as regards the difficulties arise of its interpolation and modelling
- The temperature trends are remarkably different for the examined datasets. The spatial distribution of the change of the daily maximum and minimum temperatures from 1979 to 2010 is unexpectedly heterogeneous in E-OBS, possibly due to the residual inhomogeneity
- The E-OBS is obviously drier than CARPATCLIM, particularly in plane regions in the centre and in the south-eastern border of the domain.
- The spatial pattern of the precipitation changes remarkably diverge in the analysed datasets. An extended region with decreasing precipitation emerges in Ukraine, Transcarpatia in E-OBS, possibly due to that less data were used for gridding in that region. The ERA5 produces 10% or even major precipitation decrease in the eastern part of the domain which is missing from the observational datasets. Possibly the residual inhomogeneities in E-OBS contribute to the highly variable precipitation trend in the Carpathian region

Thank you for your kind attention!

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