Instituto Universitario de Investigación en Ciencias Ambientales de Aragón
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ISAC

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

CLIMA, AGUA CAMBIO GLOBAL Y SISTEMAS NATURALES

Comparison of different interpolation methods for generating a new climatology in Spanish mainland of maximum and minimum temperatures

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Michele Brunetti, José Carlos González-Hidalgo

Motivation

- The **climatology** of temperatures is a working tool in different fields of science (climatology, hydrology, geomorphology ...)

- In order to minimize errors in any climatology it is necessary to work with homogeneous and **dense spatial database**

- The best **interpolation method should** reduce the bias in the estimation

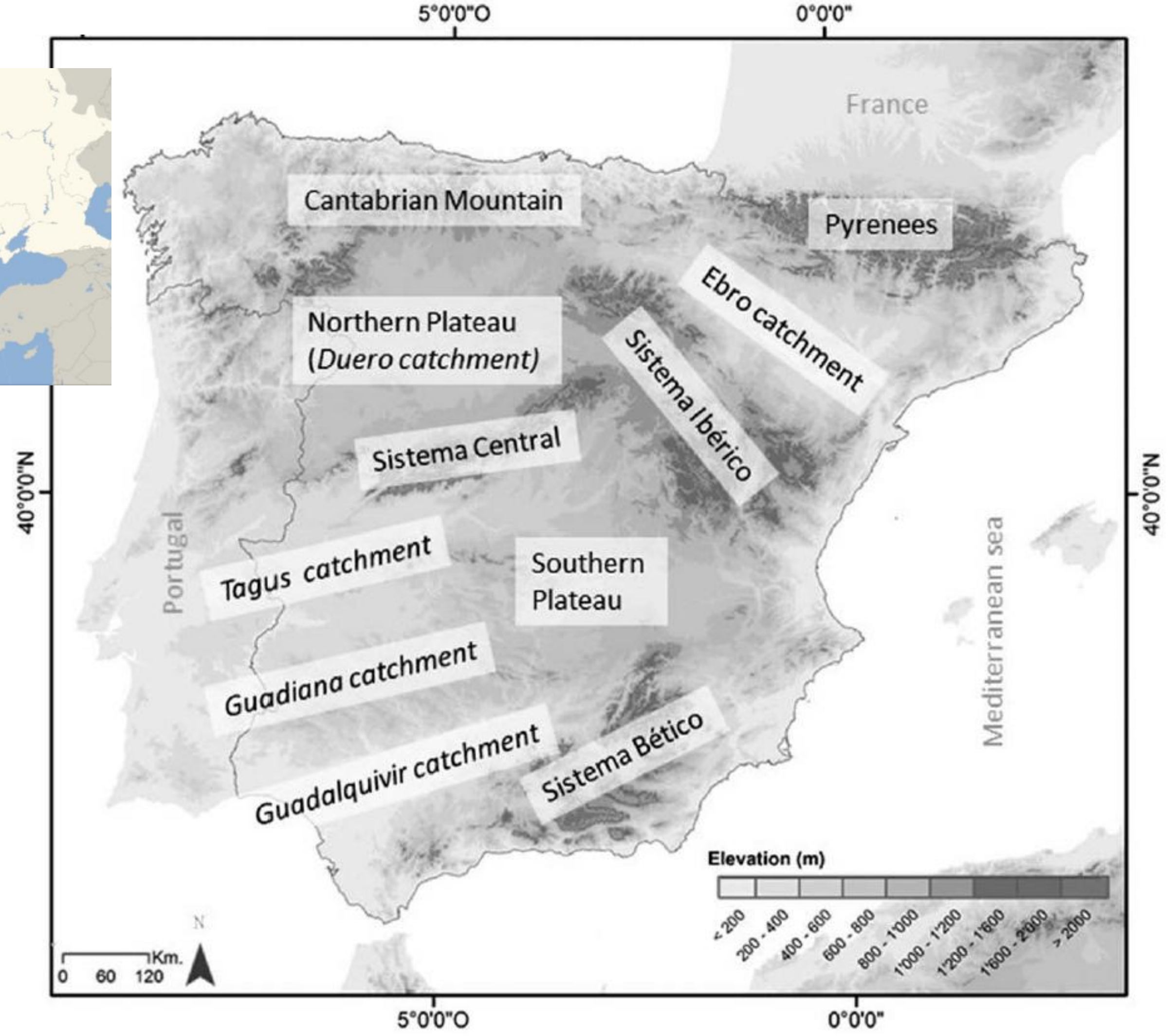
- Given the increase in temperatures during the last decades the climatologies from 60’s-70’s could be obsoleted
- Therefore climatologies **need to be updated**

GOAL

Elaborate an updated new monthly mean value climatologies of Tmax and Tmin in Spanish mainland by comparison of different interpolation approach

Area of study: Spanish mainland

- Latitudinal position
- North-South extension
- Contrasting landscapes
- Located between two water masses



Marked complexity in spatial distribution of temperature

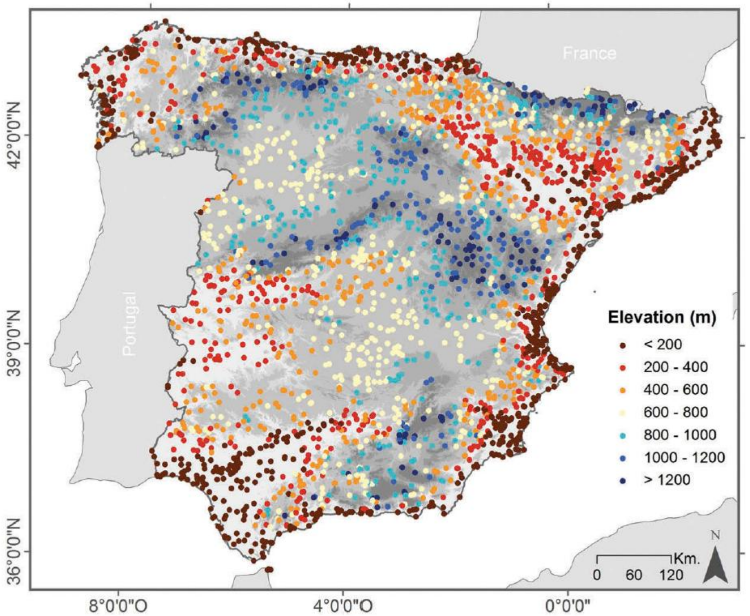
Local multivariate regression models could be much more suitable than global methods to estimate the spatial gradients of temperatures

Dataset

- ***MOTEDAS*** - High resolution grid from 1951-2010 (10x10km)
- Original series from **AEMet** (National Meteorological Agency of Spain)

The final series used in the development of temperature climatology were characterized as follows:

- Series with original complete information (**11 stations**)
- Series reconstructed with reference series from neighboring stations (**2865 stations in Tmax and 2869 in Tmin**).
- Series in which MOTEDAS made an incomplete reconstruction but contained more than 7 years of original information were reconstructed. (**136 stations in Tmax and 141 in Tmin**).



Distribution of the metrological stations according to altitudinal ranges

González-Hidalgo J.C., Peña-Angulo D., Brunetti M., Cortesi, C. (2015a): MOTEDAS: a new monthly temperature database for mainland Spain and the trend in temperature (1951-2010). International Journal of Climatology 31, 715–731. DOI: 10.1002/joc.4298

Methods

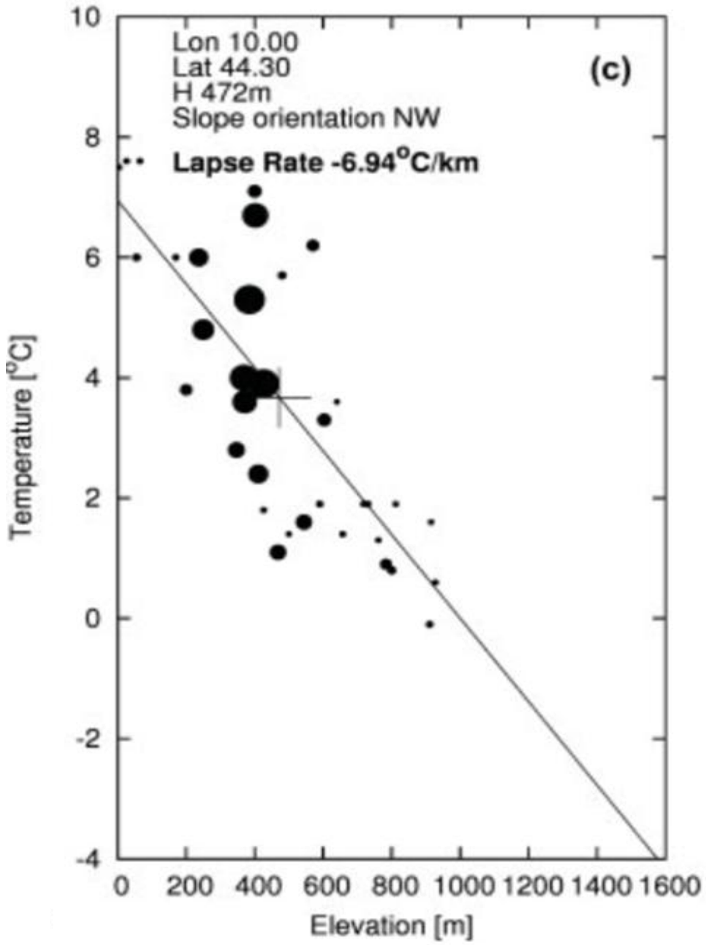
Interpolation methods	Validation
▪ Regression Kriging with Stepwise (RKS) ▪ Regression Kriging (RK) ▪ Local Weighted Linear Regression (LWLR)	▪ Mean Bias Error ▪ Coefficient of determination

Local Weighted Linear Regression (LWLR)

- Relationship between temperature (T) and the elevation (h)

$$T = a+b*h+e$$

- Each cell has more weight to nearby stations with similar topographical features
- Minimum (15) and maximum (35) stations
- The weights are calculated using a Gaussian function



High-resolution temperature climatology for Italy: interpolation method intercomparison
Brunetti, et al., 2014. International Journal of Climatology

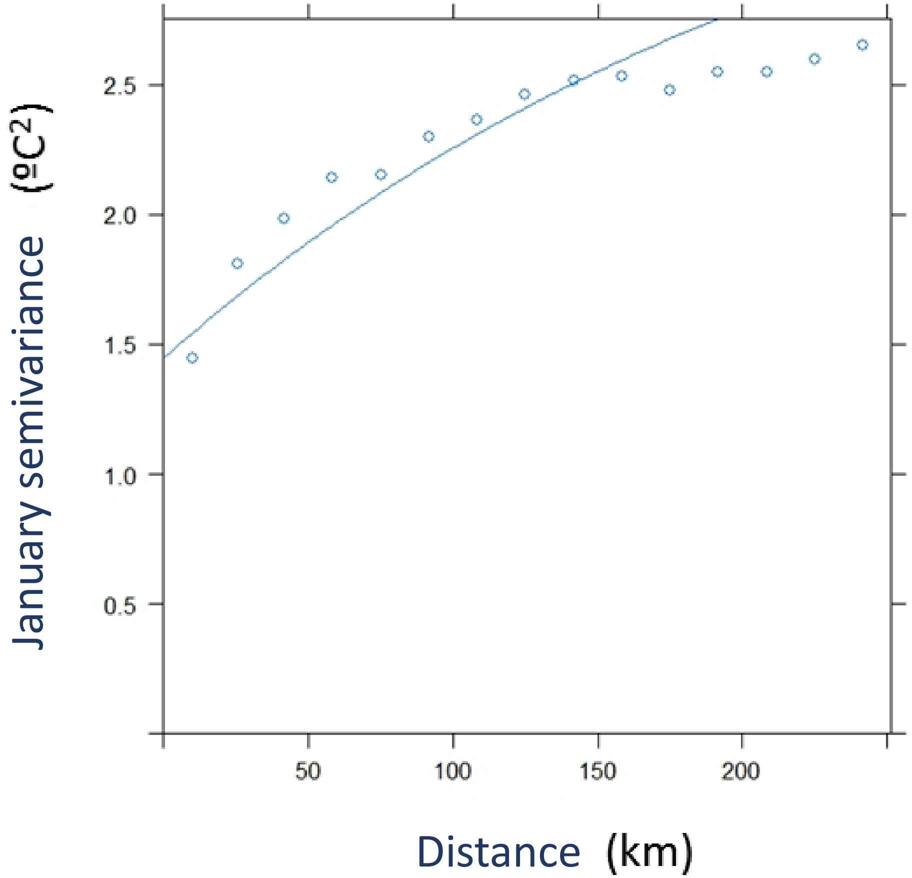
Regression Kriging (RK)

- Residual linear model
  Temperature (Elevation)

- Exponential model variogram

- Maximum distance between pairs of points: 250km

- Grouped in distance intervals: 10km



Regression Kriging with stepwise selection (RKS)

- Residual linear model
  Temperature (Elevation,Latitude,Longitude, Orientation,Slope,Distance to the sea)
- Forward Stepwise type and AIC selection criteria
- It is a small improvement over RK

Validation

- Validation procedure: leave-one-out for all stations
- The estimated value was compared with the observed value
- Four error measures:
  - the Mean Bias Error (MBE)
  - the Mean Absolute Error (MAE)
  - the RMSE
  - the Index of Agreement
- Coefficient of determination

Table 1. Monthly and annual error model measurements for T_{max}.

T_{max}	LWLR MBE	LWLR RMSE	LWLR MAE	LWLR R^2	LWLR D	RK MBE	RK RMSE	RK MAE	RK R^2	RK D	RKS MBE	RKS RMSE	RKS MAE	RKS R^2	RKS D
January	−0,006	0,823	0,608	0,927	0,981	0,001	0,823	0,605	0,927	0,981	0,002	0,832	0,612	0,925	0,980
February	−0,012	0,814	0,606	0,922	0,979	0,002	0,815	0,608	0,922	0,979	0,002	0,832	0,621	0,919	0,978
March	−0,020	0,860	0,644	0,907	0,975	0,001	0,890	0,667	0,901	0,972	0,002	0,890	0,668	0,901	0,972
April	−0,024	0,913	0,680	0,907	0,975	0,001	0,947	0,706	0,901	0,972	0,001	0,937	0,698	0,903	0,973
May	−0,031	0,978	0,736	0,898	0,972	0,002	1,036	0,775	0,887	0,968	0,000	1,002	0,752	0,894	0,970
June	−0,038	1,100	0,829	0,897	0,972	0,004	1,179	0,876	0,883	0,967	0,000	1,115	0,839	0,895	0,971
July	−0,037	1,163	0,880	0,911	0,976	0,002	1,272	0,946	0,893	0,970	−0,002	1,188	0,895	0,907	0,975
August	−0,040	1,133	0,856	0,906	0,975	0,002	1,223	0,912	0,891	0,970	−0,001	1,157	0,869	0,903	0,973
September	−0,033	0,993	0,747	0,899	0,972	0,000	1,047	0,782	0,888	0,968	−0,001	1,014	0,763	0,895	0,971
October	−0,020	0,863	0,642	0,910	0,976	0,001	0,884	0,657	0,906	0,974	0,003	0,888	0,659	0,905	0,974
November	−0,009	0,823	0,608	0,925	0,980	0,001	0,820	0,604	0,926	0,981	0,000	0,832	0,615	0,924	0,980
December	−0,006	0,839	0,620	0,924	0,980	0,001	0,844	0,620	0,924	0,980	0,002	0,845	0,621	0,924	0,980
Annual	−0,023	0,813	0,612	0,919	0,978	0,001	0,848	0,633	0,904	0,976	0,001	0,844	0,633	0,908	0,977

Table 2. Monthly and annual error model measurements for T_{min}.

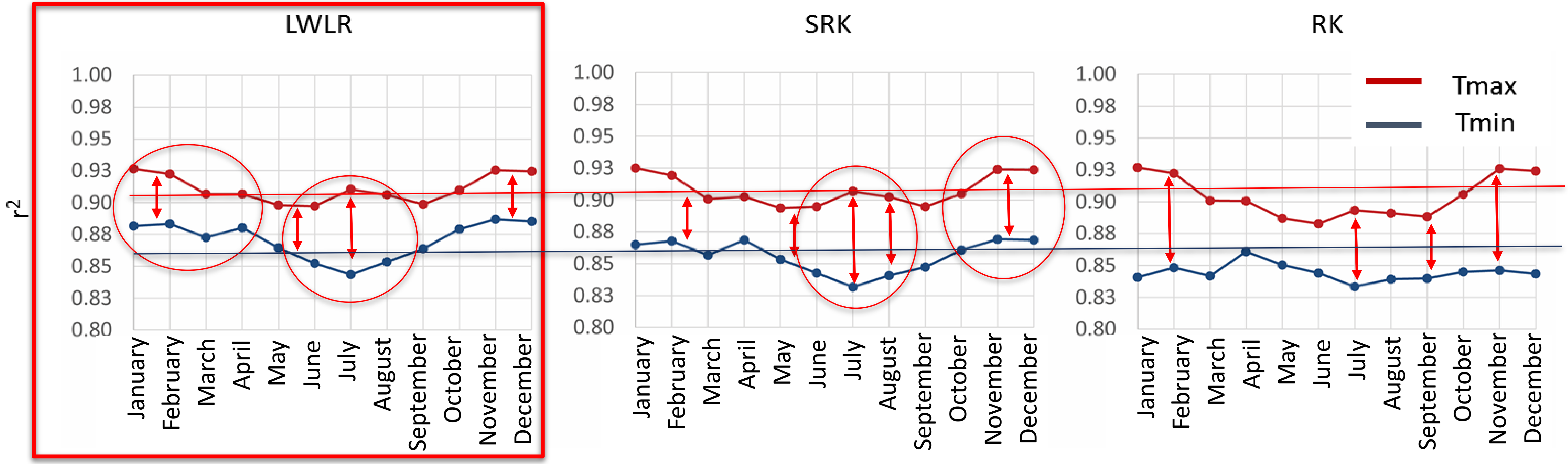
T_{min}	LWLR MBE	LWLR RMSE	LWLR MAE	LWLR R^2	LWLR D	RK MBE	RK RMSE	RK MAE	RK R^2	RK D	RKS MBE	RKS RMSE	RKS MAE	RKS R^2	RKS D
January	−0,007	1,020	0,796	0,882	0,968	0,000	1,193	0,936	0,841	0,957	−0,001	1,089	0,864	0,865	0,963
February	−0,009	1,020	0,801	0,883	0,969	−0,001	1,172	0,928	0,848	0,959	−0,001	1,085	0,864	0,868	0,964
March	−0,005	1,024	0,808	0,873	0,965	−0,001	1,148	0,915	0,842	0,957	−0,001	1,085	0,867	0,857	0,961
April	0,003	0,968	0,765	0,880	0,968	−0,002	1,048	0,831	0,861	0,963	−0,004	1,013	0,802	0,869	0,964
May	0,004	1,000	0,785	0,865	0,963	0,001	1,054	0,831	0,850	0,959	−0,002	1,040	0,819	0,854	0,960
June	0,005	1,104	0,856	0,852	0,959	0,003	1,137	0,887	0,844	0,957	0,000	1,141	0,892	0,843	0,957
July	0,005	1,248	0,959	0,844	0,956	0,003	1,291	0,998	0,833	0,954	0,001	1,296	1,004	0,832	0,953
August	0,001	1,256	0,966	0,854	0,960	0,001	1,320	1,025	0,839	0,956	0,000	1,311	1,018	0,841	0,956
September	−0,002	1,178	0,917	0,864	0,963	0,000	1,285	1,011	0,840	0,956	−0,001	1,249	0,984	0,847	0,958
October	−0,004	1,064	0,838	0,879	0,967	−0,001	1,216	0,966	0,845	0,958	−0,001	1,143	0,911	0,861	0,962
November	−0,009	1,031	0,808	0,887	0,970	0,000	1,215	0,956	0,846	0,958	0,001	1,109	0,881	0,869	0,964
December	−0,005	1,018	0,791	0,885	0,969	−0,001	1,199	0,937	0,844	0,958	0,000	1,089	0,859	0,869	0,964
Annual	−0,002	1,011	0,797	0,877	0,967	−0,001	1,130	0,899	0,844	0,960	−0,002	1,078	0,860	0,856	0,962

Results (by month)

Are there differences in the spatial interpolation between **Tmax and Tmin**?

Are there differences in the results of validation between **months**?

What is the **best** method of spatial interpolation?

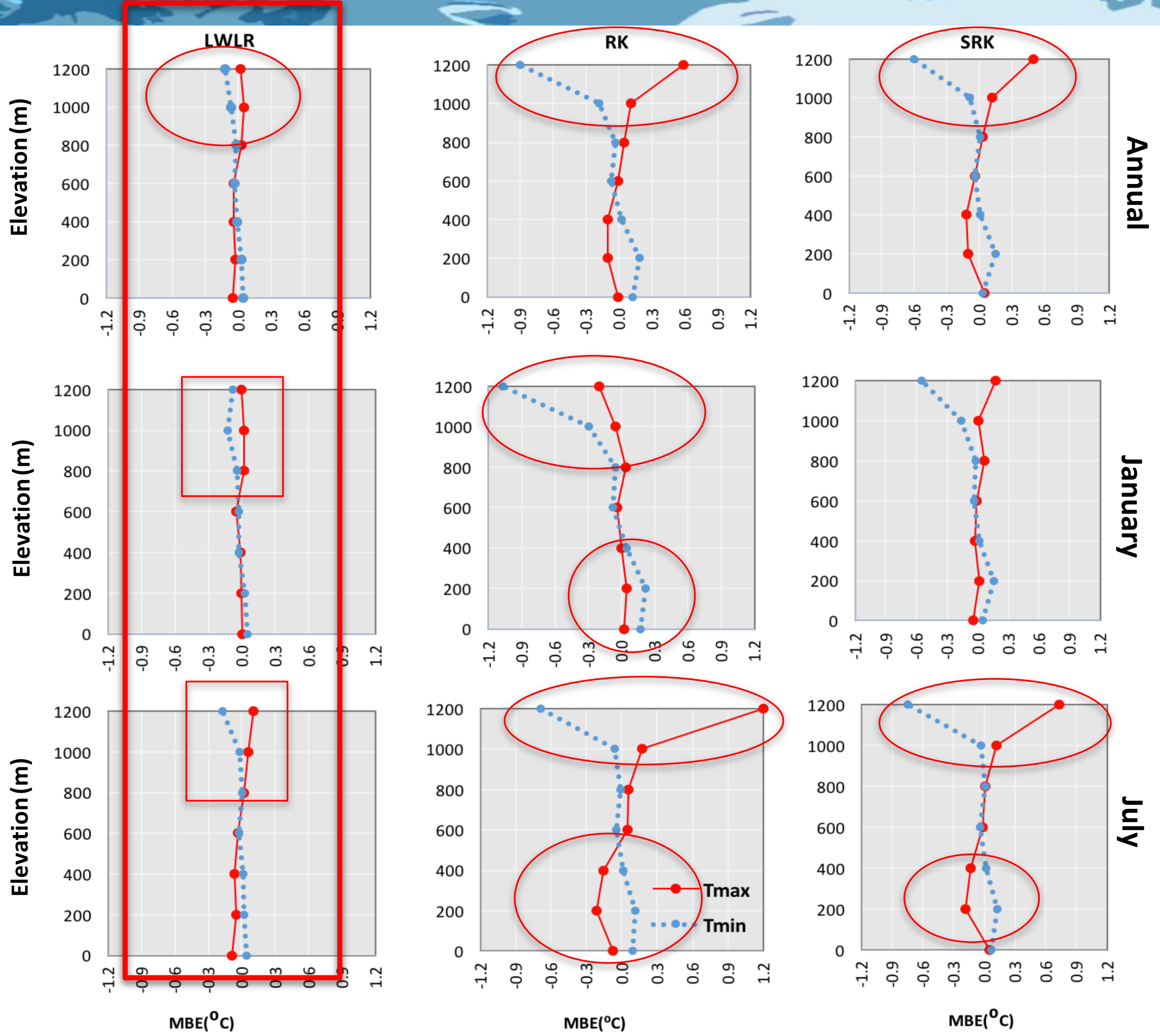


Results (by altitudinal range)

What differences can be observed between interpolation methods?

- By altitude
- Between months
- Between thermometric measurements

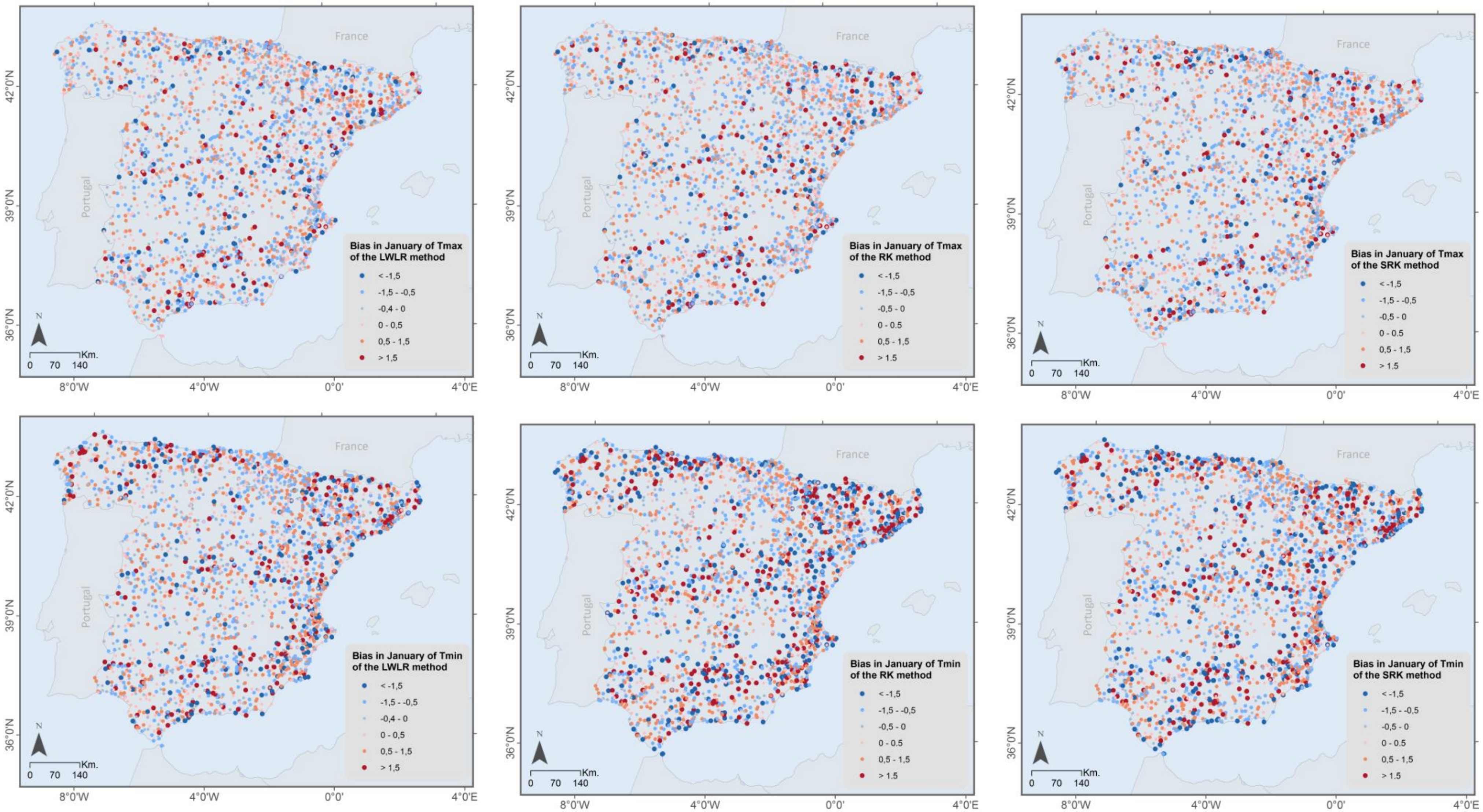
So… What's the best method?



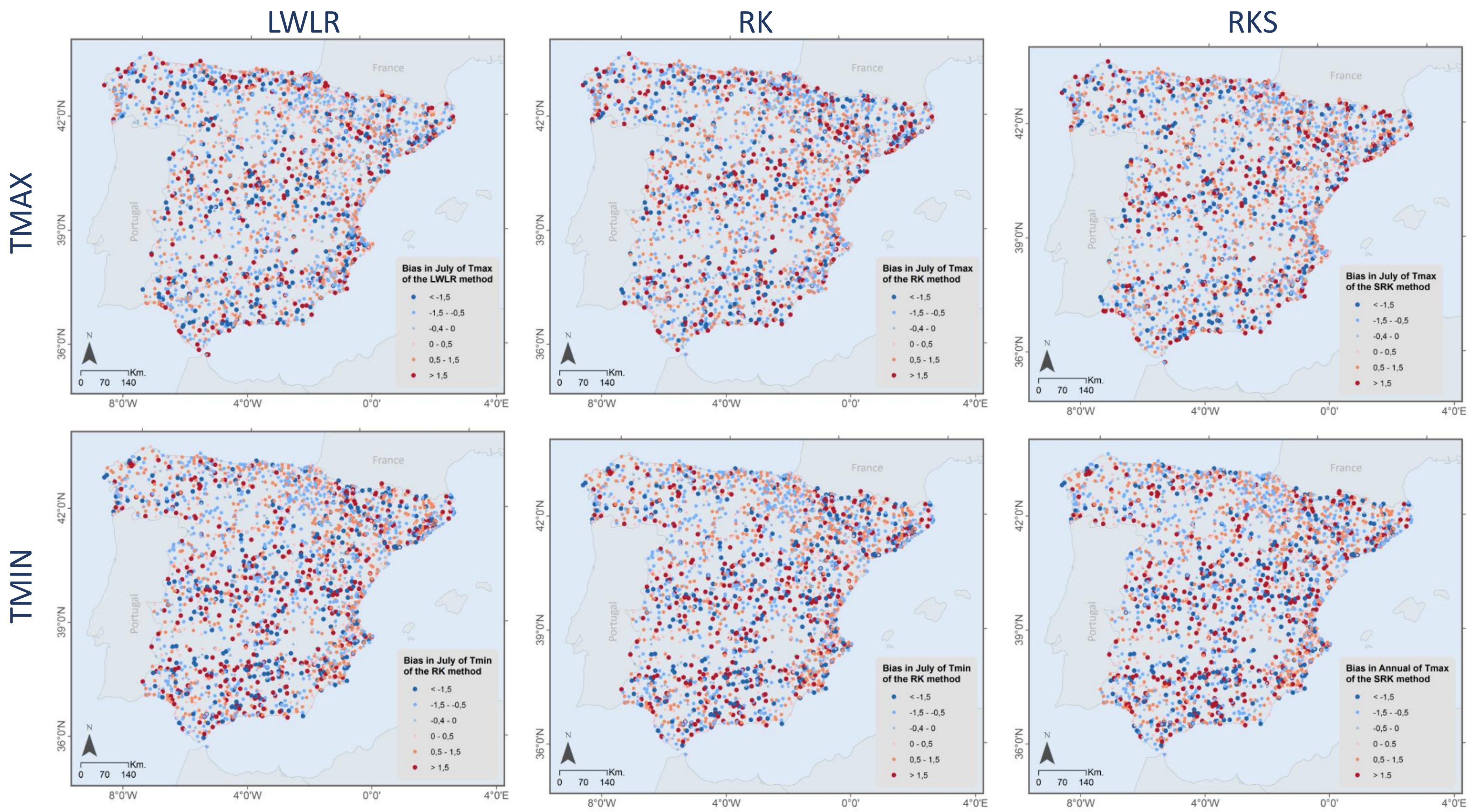
JANUARY

LWLR | RK | RKS

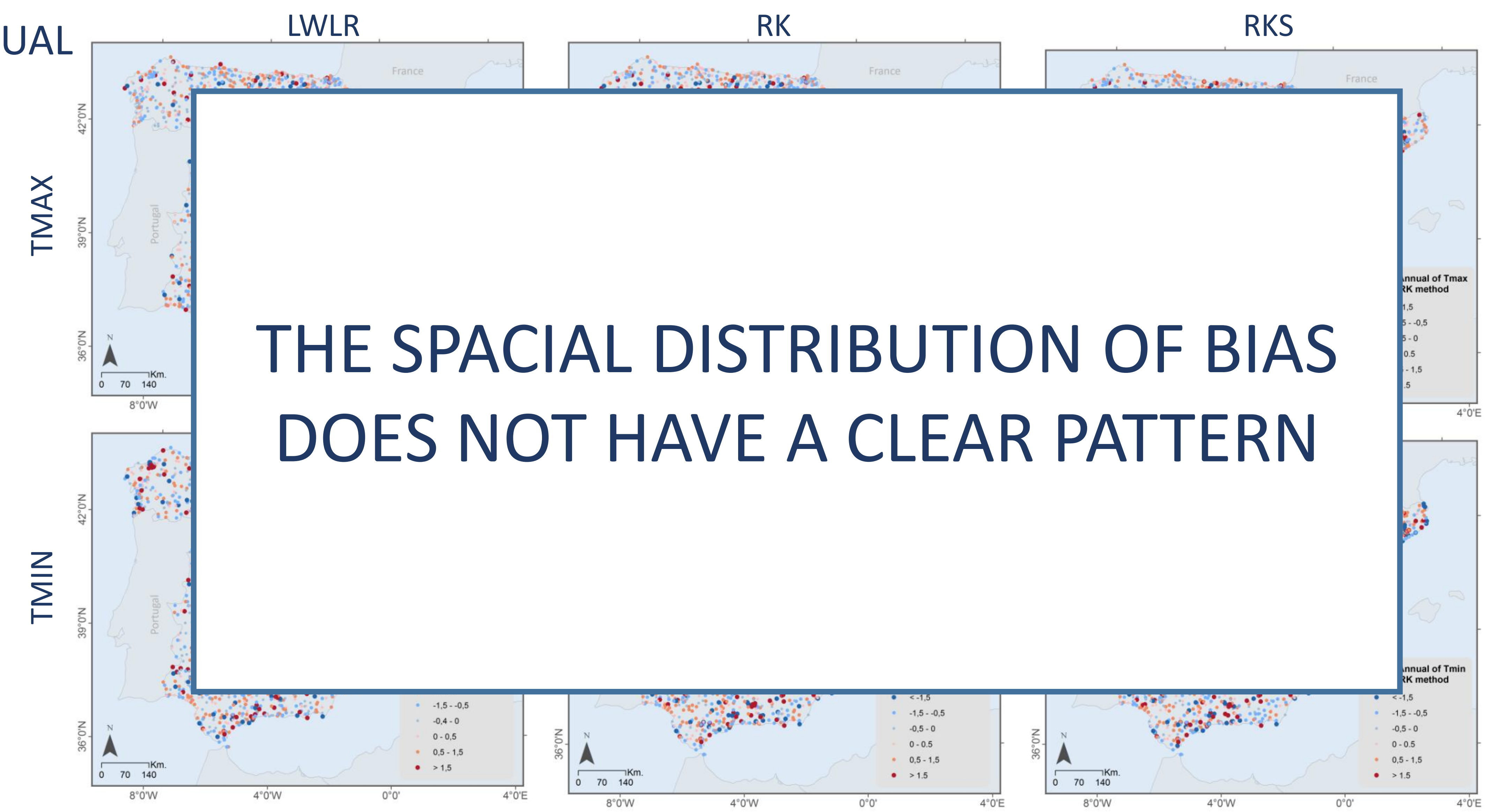
TMAX / TMIN



JULY


LWLR
RK
RKS
TMAX
TMIN
France
Portugal
42°0'N
39°0'N
36°0'N
8°0'W
4°0'W
0°0'
4°0'E
0 70 140 Km.
N
Bias in July of Tmax of the LWLR method
Bias in July of Tmax of the RK method
Bias in July of Tmax of the SRK method
Bias in July of Tmin of the RK method
Bias in July of Tmin of the RK method
Bias in Annual of Tmax of the SRK method
< -1,5
-1,5 - -0,5
-0,4 - 0
-0,5 - 0
0 - 0,5
0,5 - 1,5
> 1,5

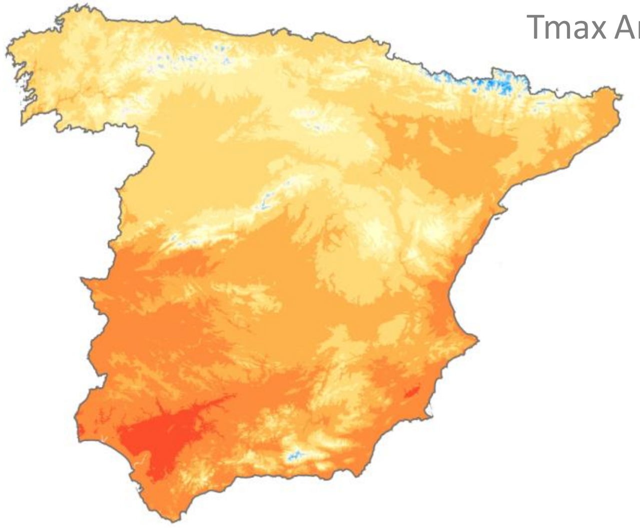
ANNUAL



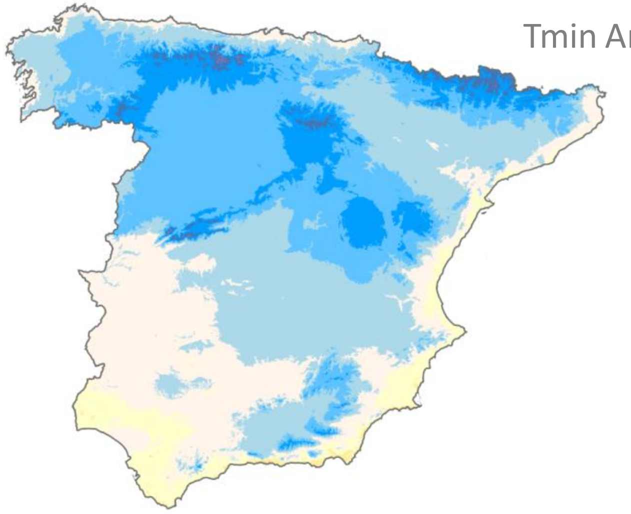
THE SPACIAL DISTRIBUTION OF BIAS DOES NOT HAVE A CLEAR PATTERN

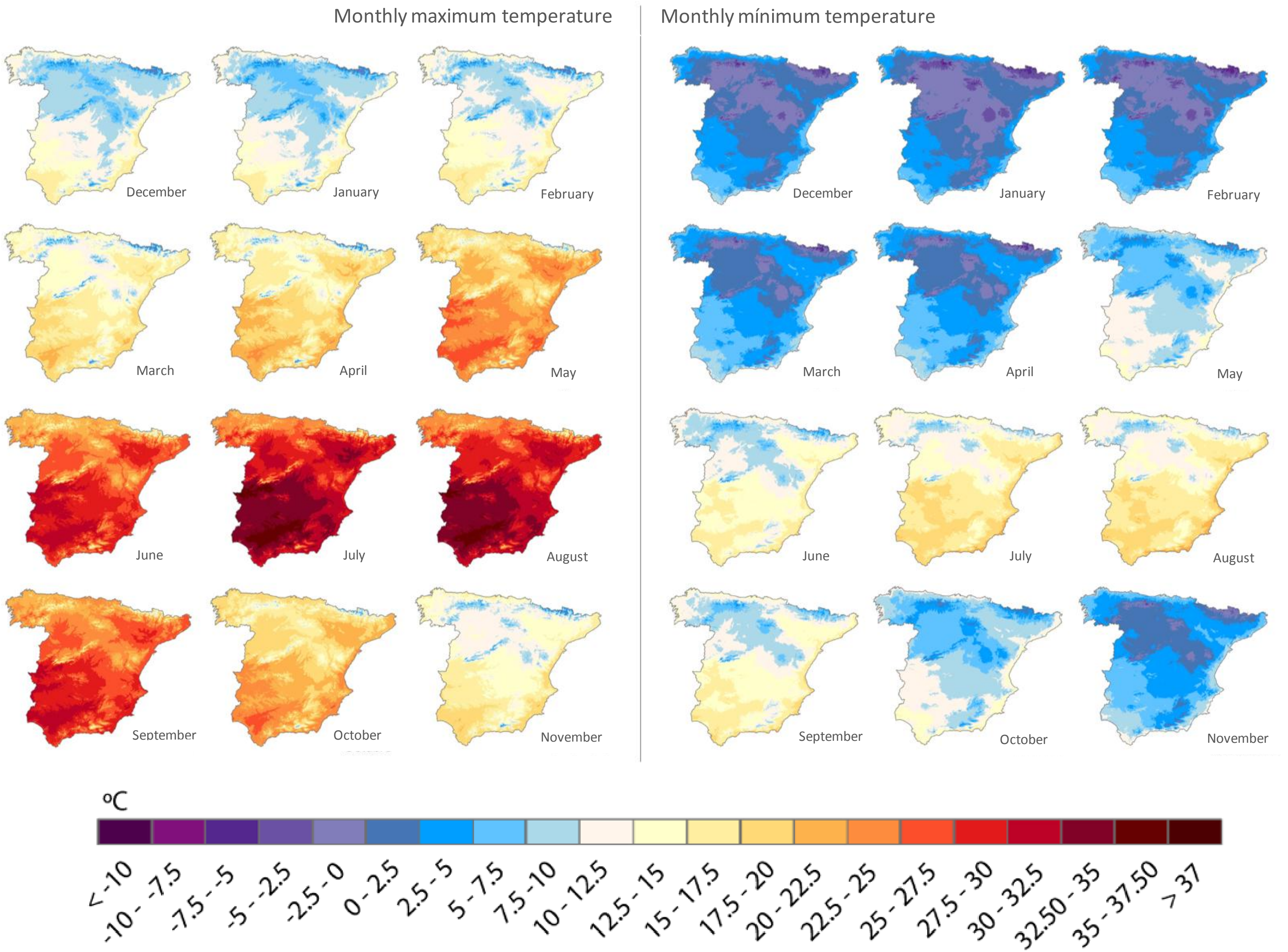
Results

Tmax Annual

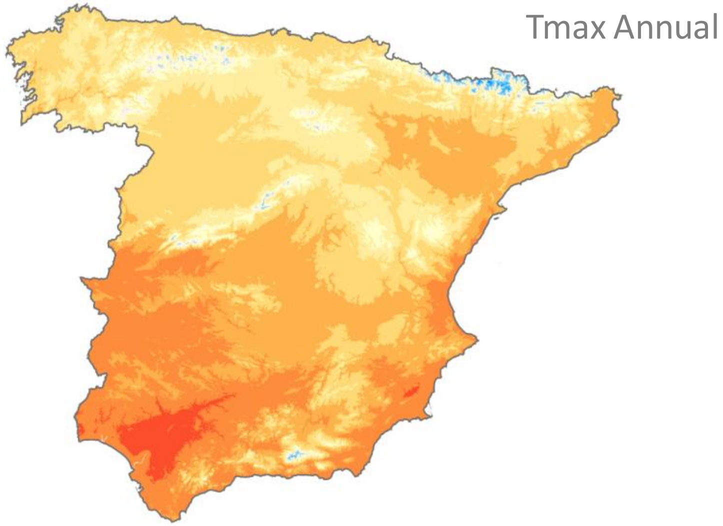


Tmin Annual

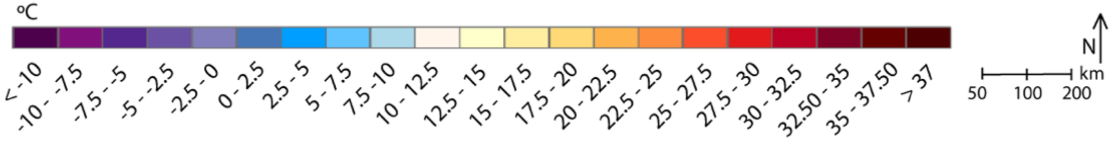


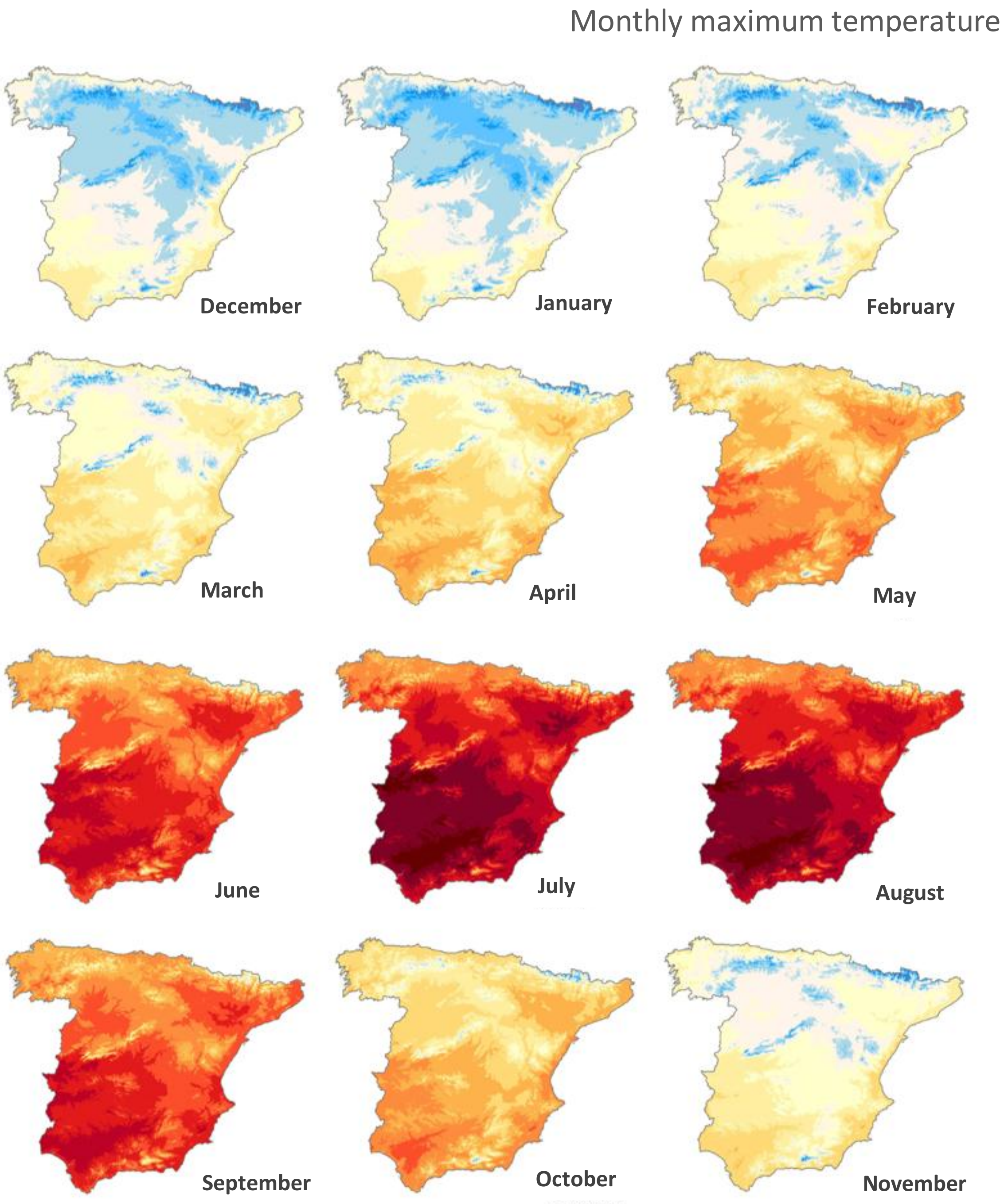


Results (Tmax)



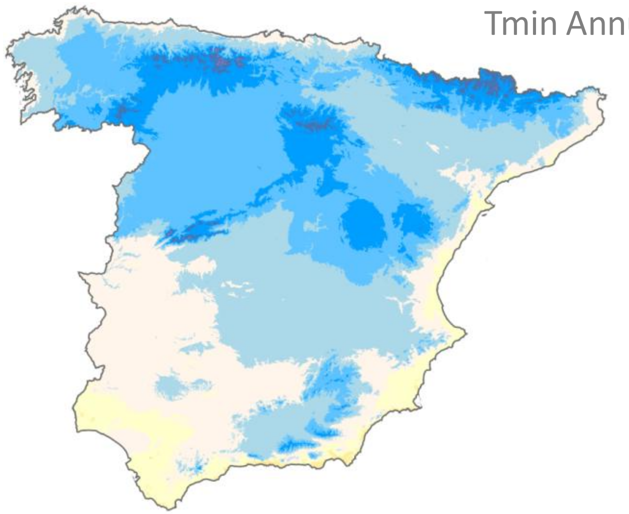
- North-south gradient in the inland catchments (Ebro-Duero)
- Mountain areas isolated from surrounding areas
- Difference between coastal areas
- West-east gradient (southern)



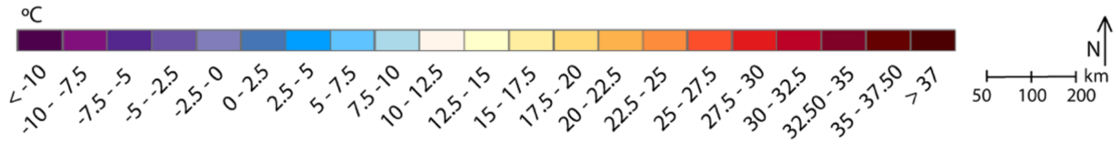


Results (Tmin)

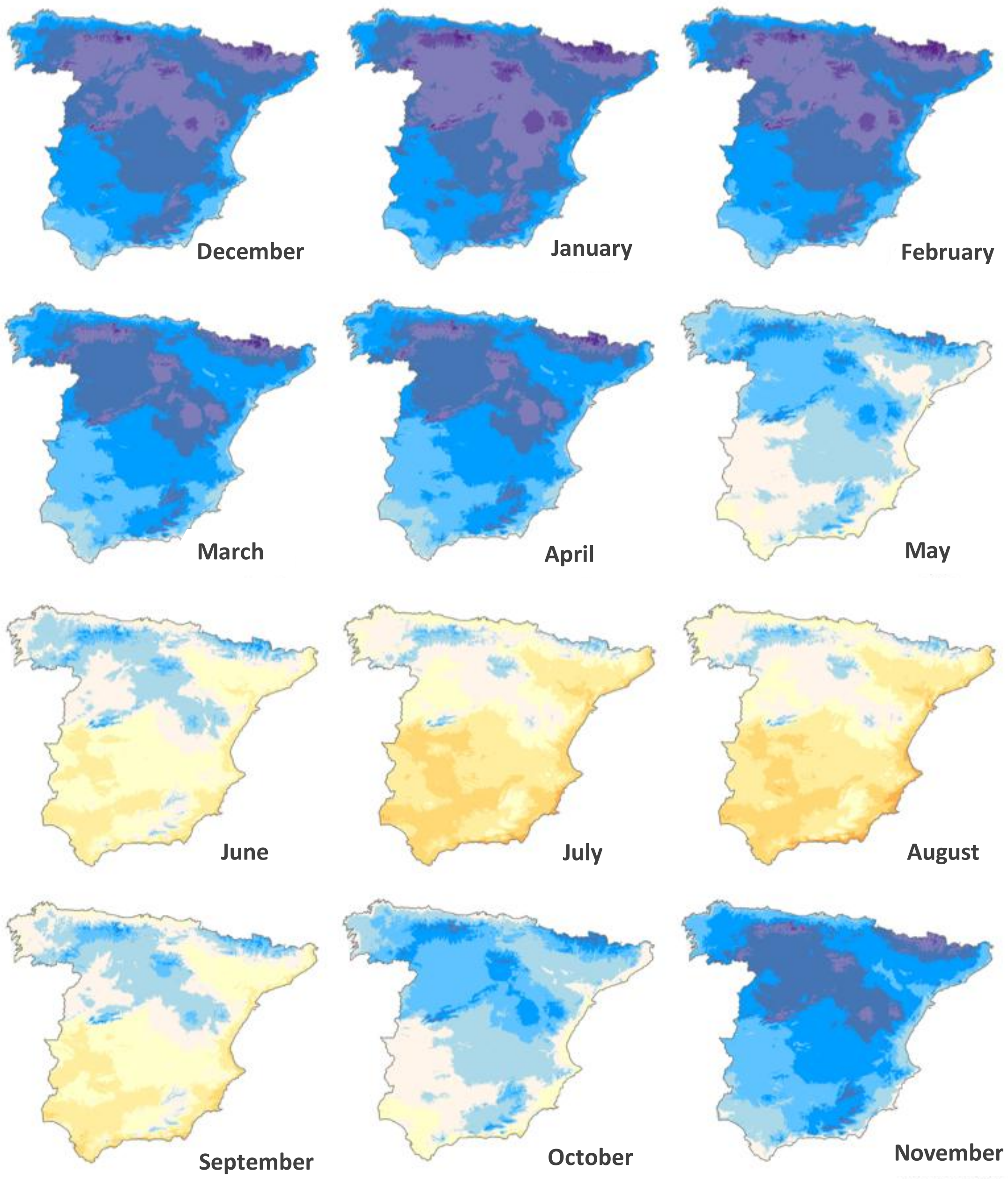
Tmin Annual



- Spatial differences of Tmin values lower than Tmax
- North–south gradient
- Difference between coastal areas



Monthly minimum temperature



Conclusions

- The poorest values in the estimation are located in **mountain areas**
- Models are less precise during **summer months**
- The **Local Weighted Linear Regression (LWLR)** offers the better result
- **The new high resolution climatology** (1x1km) is available to the scientific community upon request

What are we doing now?

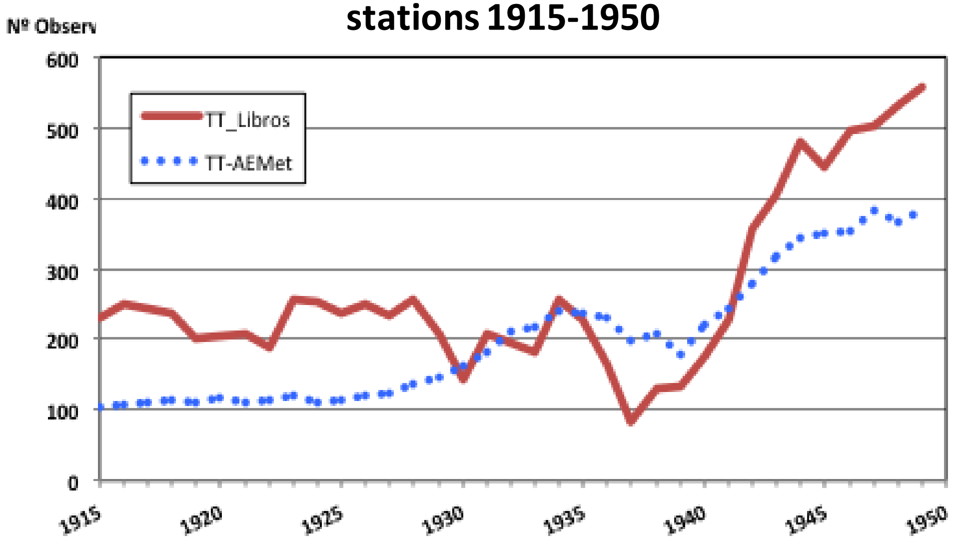
PROYECT CLICES

CLImate of the last **CE**ntury in **S**panish mainland

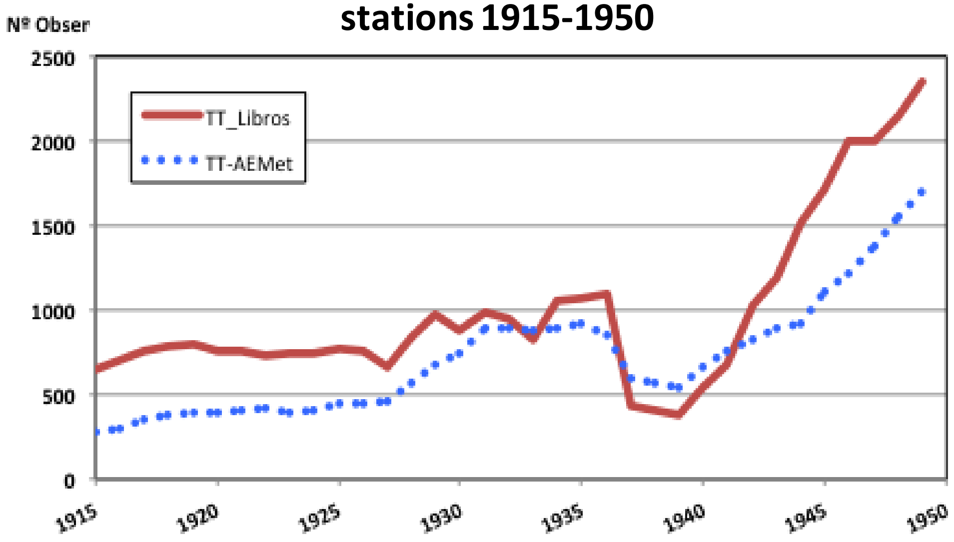
Objective

Gridded fields reconstruction of monthly mean values of Tmax and Tmin and total monthly precipitation from *1916 to 2015* ***(a century)*** *at the highest resolution as possible, combining climate data from two sources:* AEMet digitalized data *and Annual Books.*

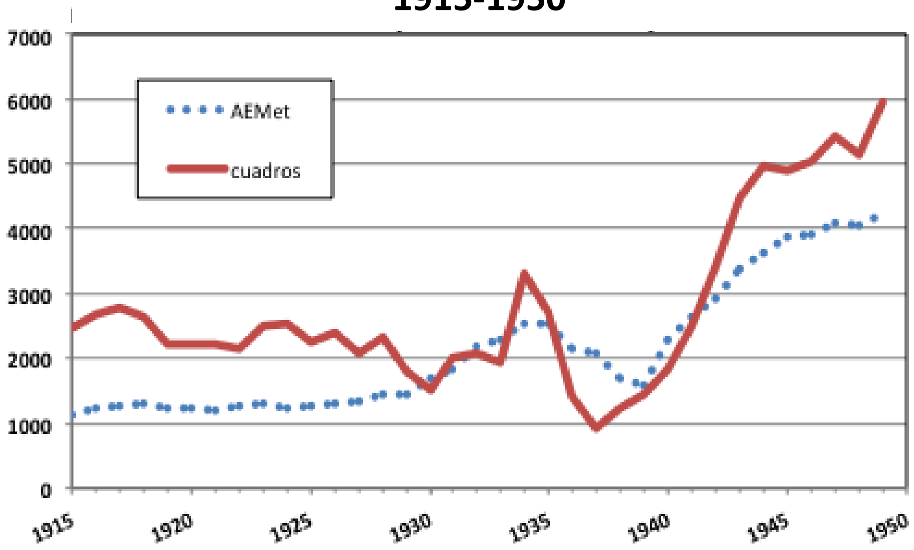
Evolution of the number of thermometric stations 1915-1950



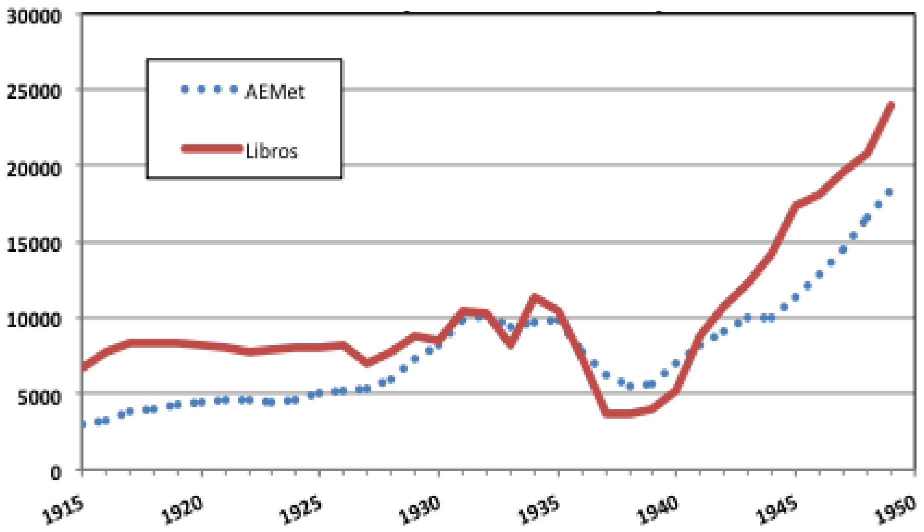
Evolution of the number of pluviometric stations 1915-1950



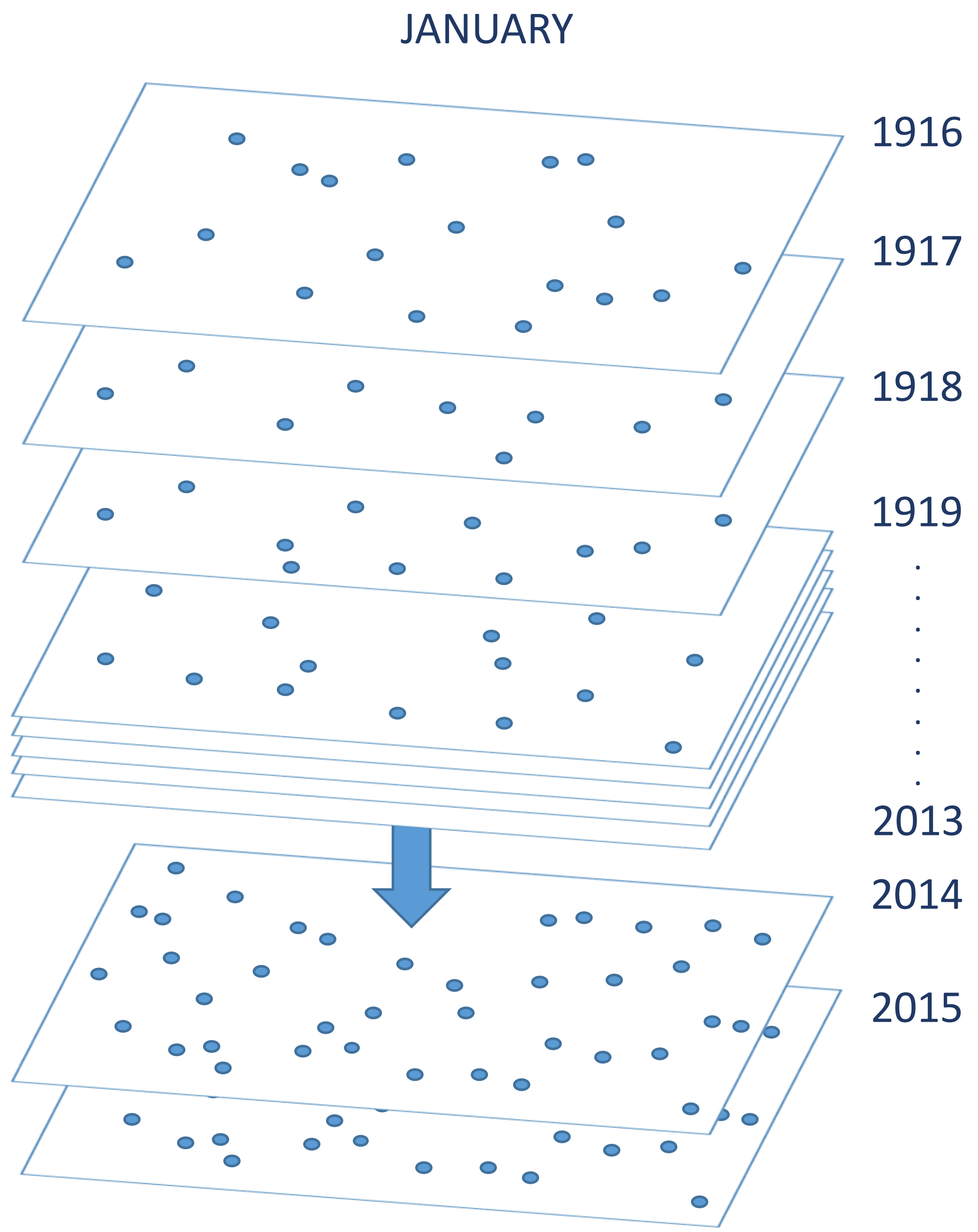
Months with thermometric information 1915-1950



Months with pluviometric information 1915-1950



CLICES propose **a new approach based on an ergodic assumption**: instead of reconstructing a temporal series for each grid node of the spatial domain starting from the monthly station series, CLICES will proceed toward **the reconstruction of monthly spatial fields**, starting from the available information month by month, i.e. : we suggest to apply an *ergodic transformation to reconstruct monthly series.*



Thanks for your attention!

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