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MAPPING MINIMUM DAILY TEMPERATURE IN SPAIN USING KRIGING WITH EXTERNAL DRIFT

Andrés CHAZARRA, José Vicente MORENO, Roser BOTEY

Agencia Estatal de Meteorología (AEMET)

achazarrab@aemet.es

Introduction

• The objective is to describe the methodology that has been applied in the Spanish Meteorological Agency (AEMET) for obtaining **high-resolution gridded fields of daily minimum temperature** in Spain.

• This project began in 2013 when AEMET was requested to generate high-resolution gridded fields of daily minimum temperature for **agricultural applications** for the period **2002-2013.**

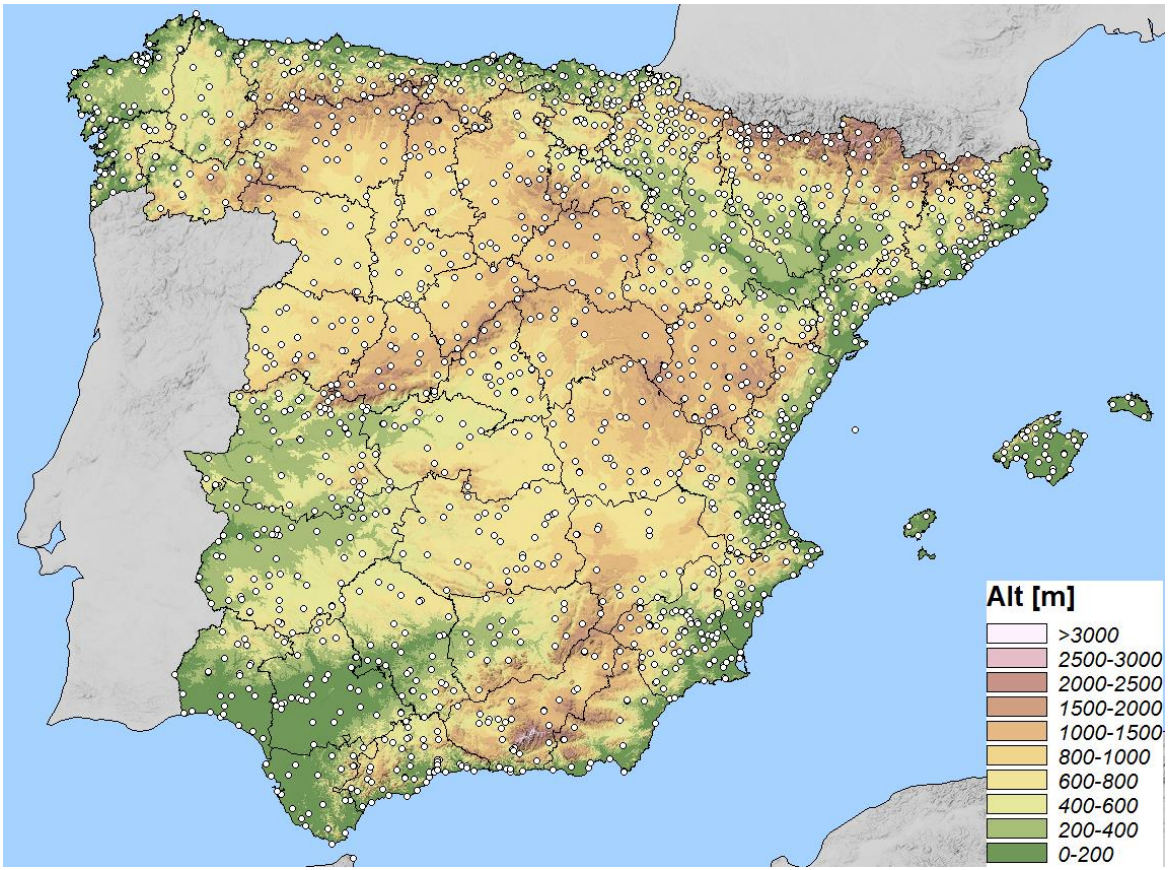
• Spatial interpolation of **daily temperature data** → a more complex problem than the case of monthly or annual mean temperature data. Very often we have to deal with **temperature inversions** and other local phenomena, specially in mountainous regions.

• Mountainous regions are often **data-sparse** in Spain→ it is necessary to consider **external variables**, such as the elevation, in the spatial interpolation process.

• After trying several spatial interpolation methods**, kriging with external drift with elevation and distance to the coast as external variables** was chosen.

Methodology

• **Data**: daily temperature data from Spain - not including the Canary Islands - from the twelve-year period 2002-2013.



Study area and location of the stations (~ 1700 stations)

• **Spatial interpolation method**: Kriging With External Drift (KED) with elevation and distance to the coast as external variables. Exponential semivariogram model.

• Other **spatial interpolation methods for comparison**:
  - Inverse Distance Weighted (IDW).
  - Ordinary Kriging (OK).
  - Regression Kriging (RK) with elevation and distance to the coast.

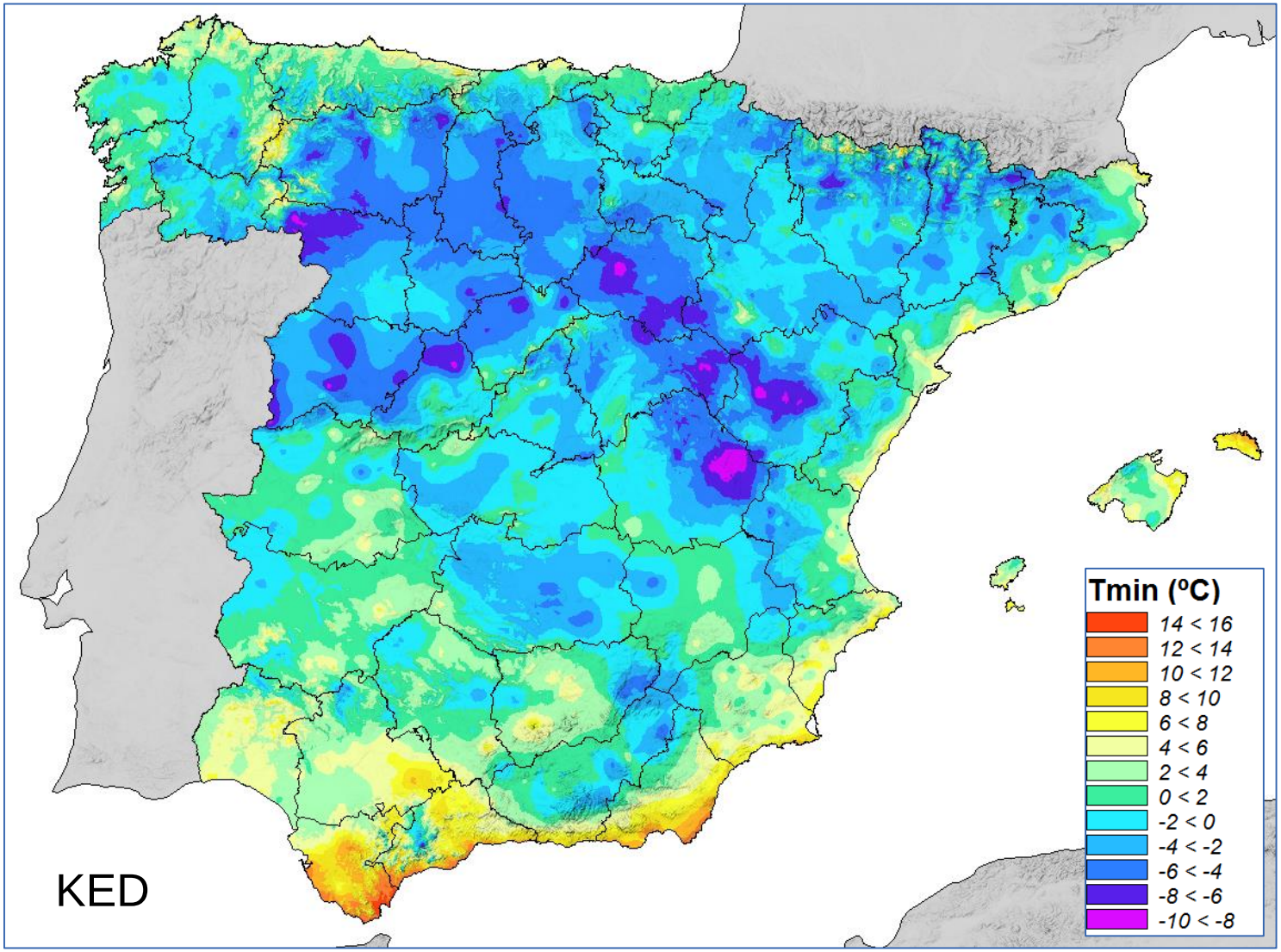
• **Cell size**: 1x1 km.

• **Software**: free open source SAGA GIS.

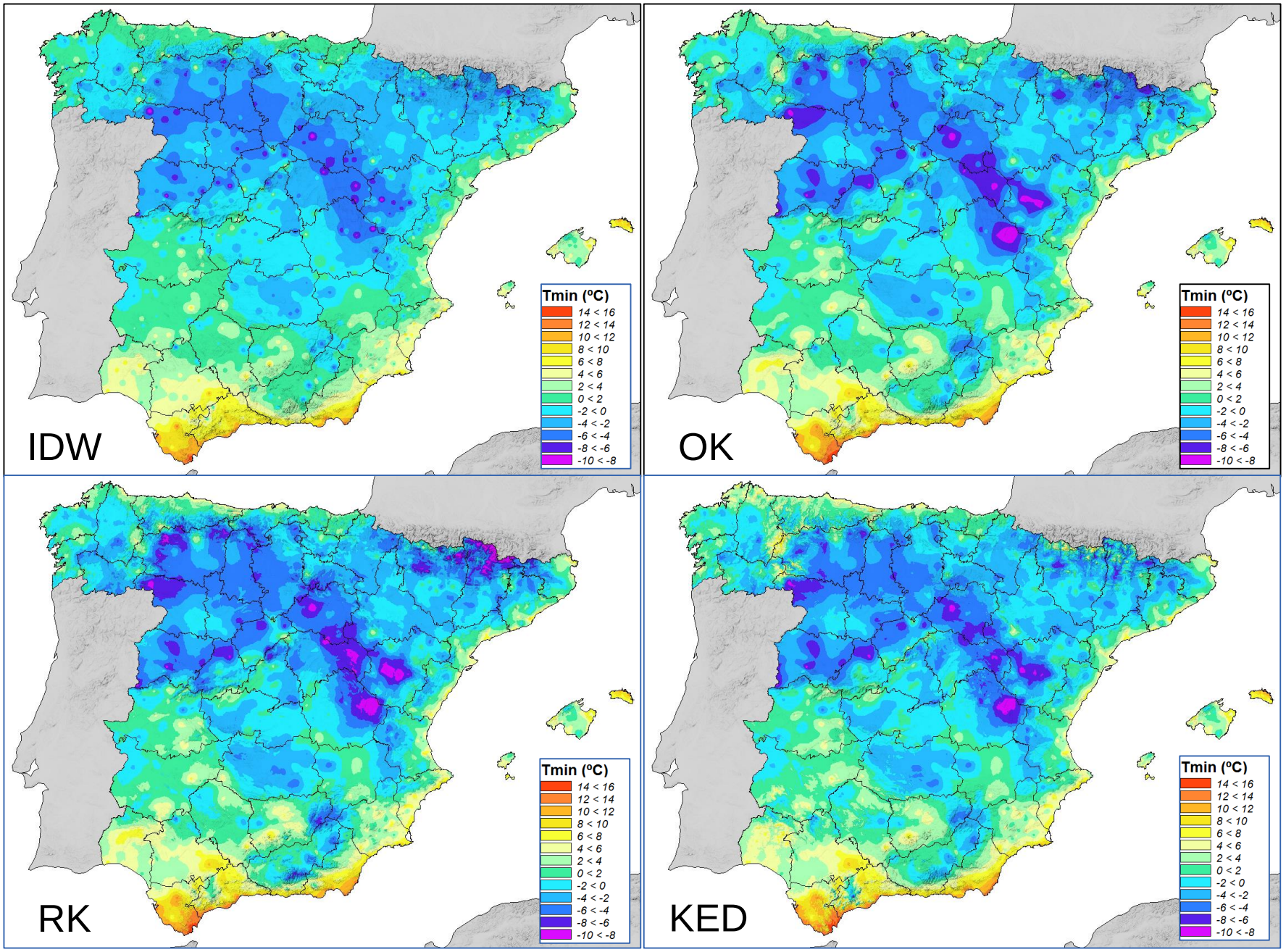
• 365x12+3= **4383** gridded fields of daily minimum temperature were created by KED

Mapping Minimum Daily Temperature In Spain Using Kriging With External Drift

Example: daily minimum temperature 10 January 2012

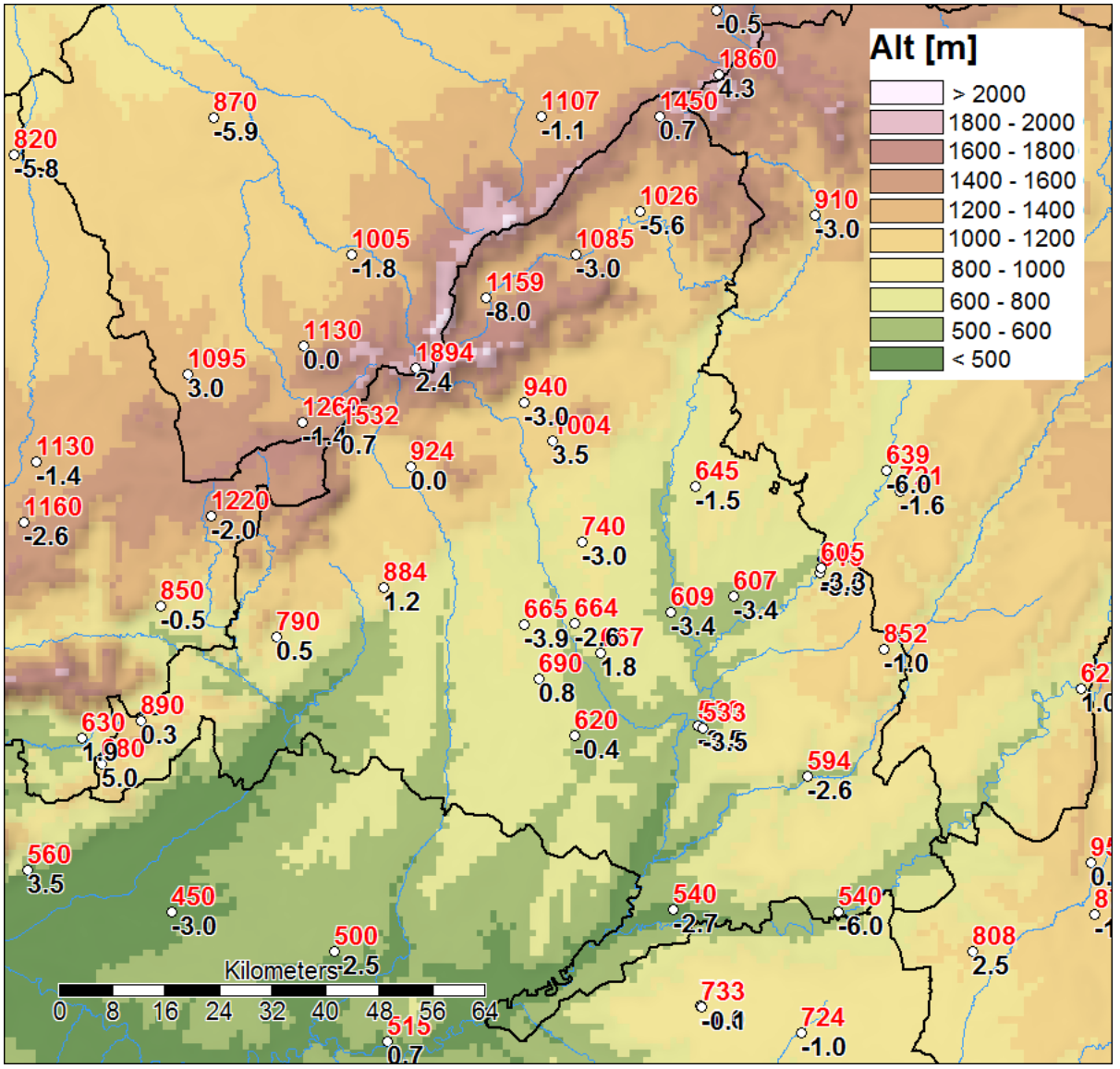


Visual comparison: daily minimum temperature 10 January 2012



Daily minimum temperature 10 January 2012

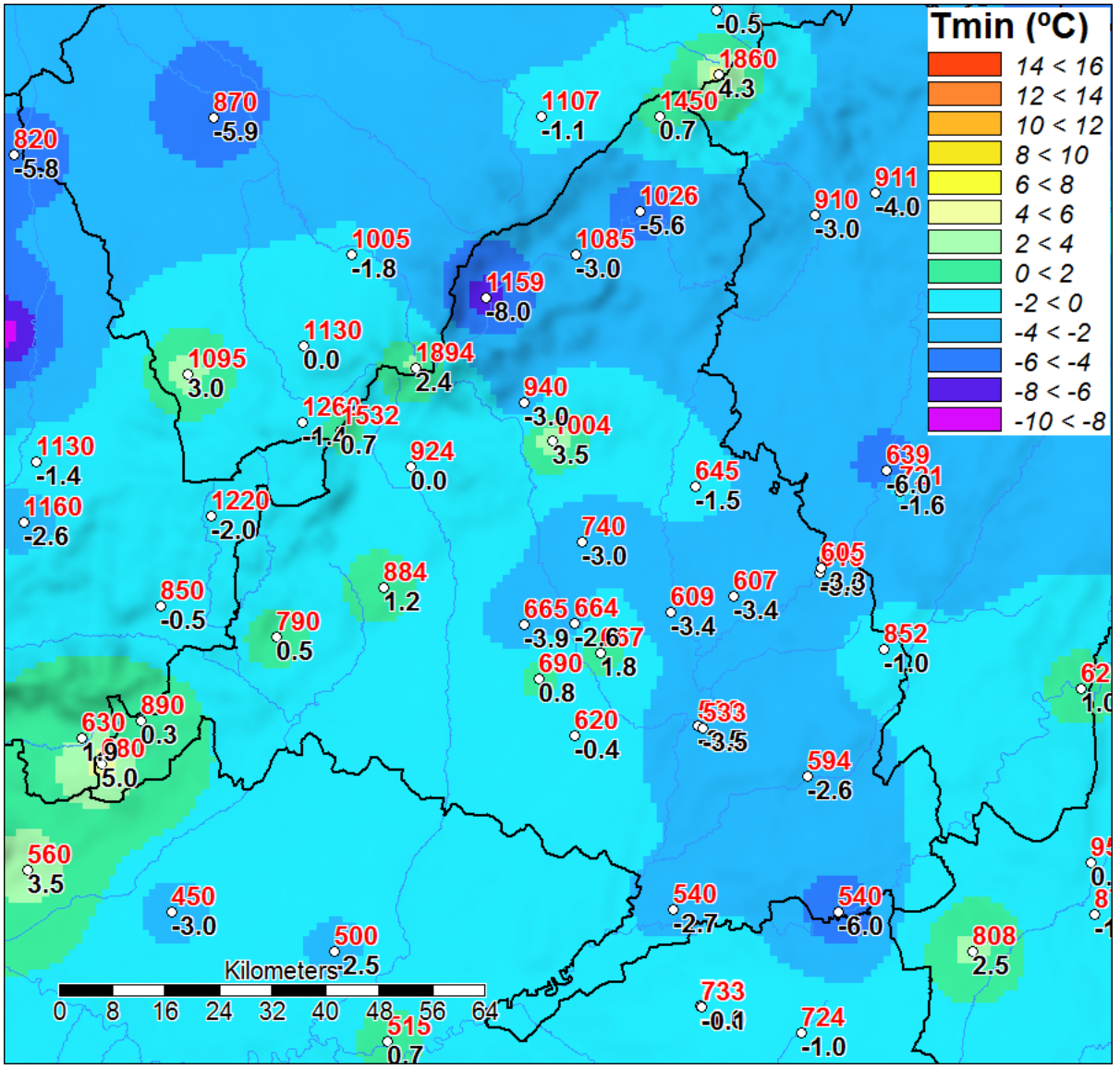
Community of Madrid



Minimum temperature data **(black)** and altitude of the stations **(red)**

Daily minimum temperature 10 January 2012

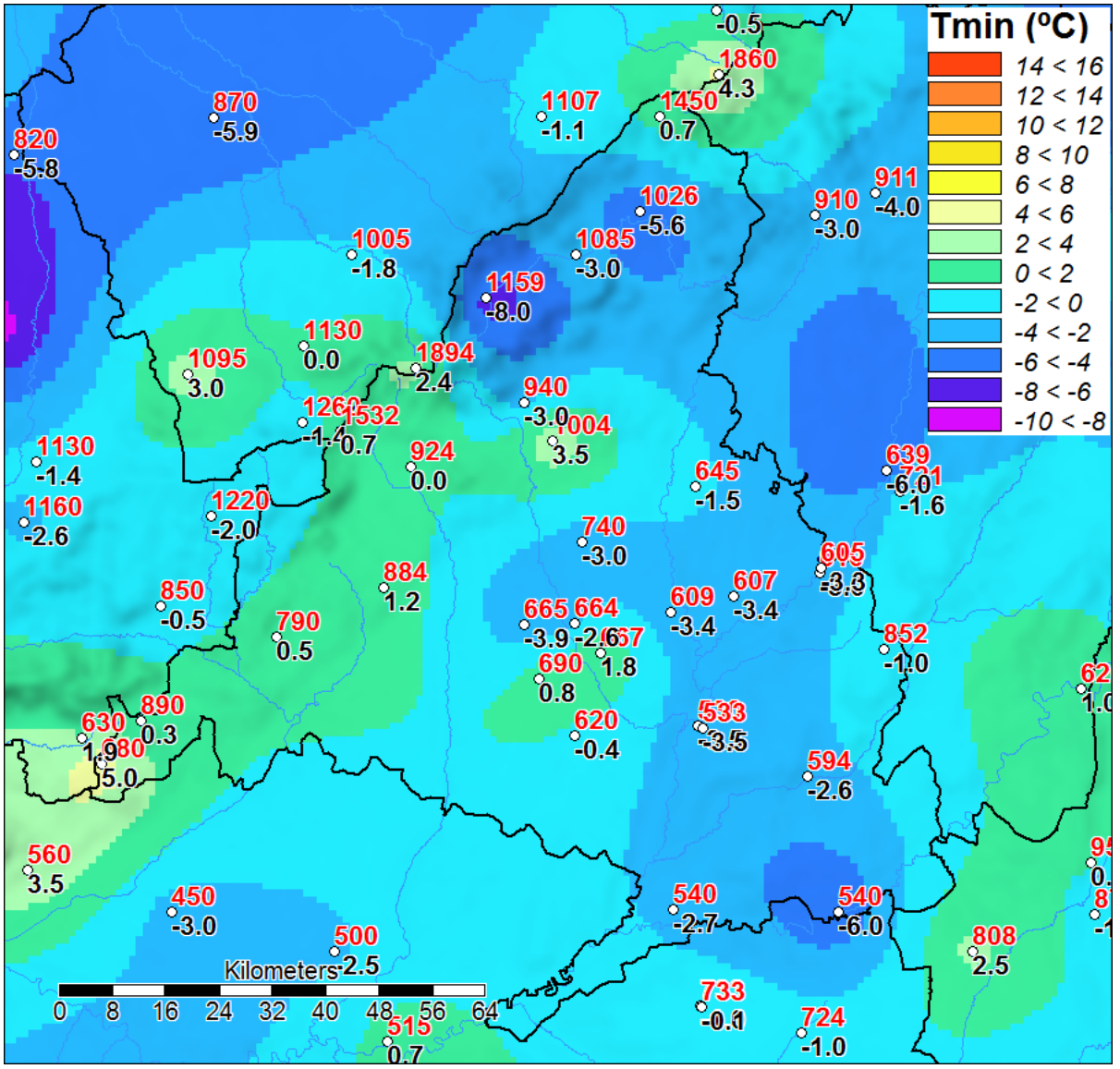
Community of Madrid



IDW

Daily minimum temperature 10 January 2012

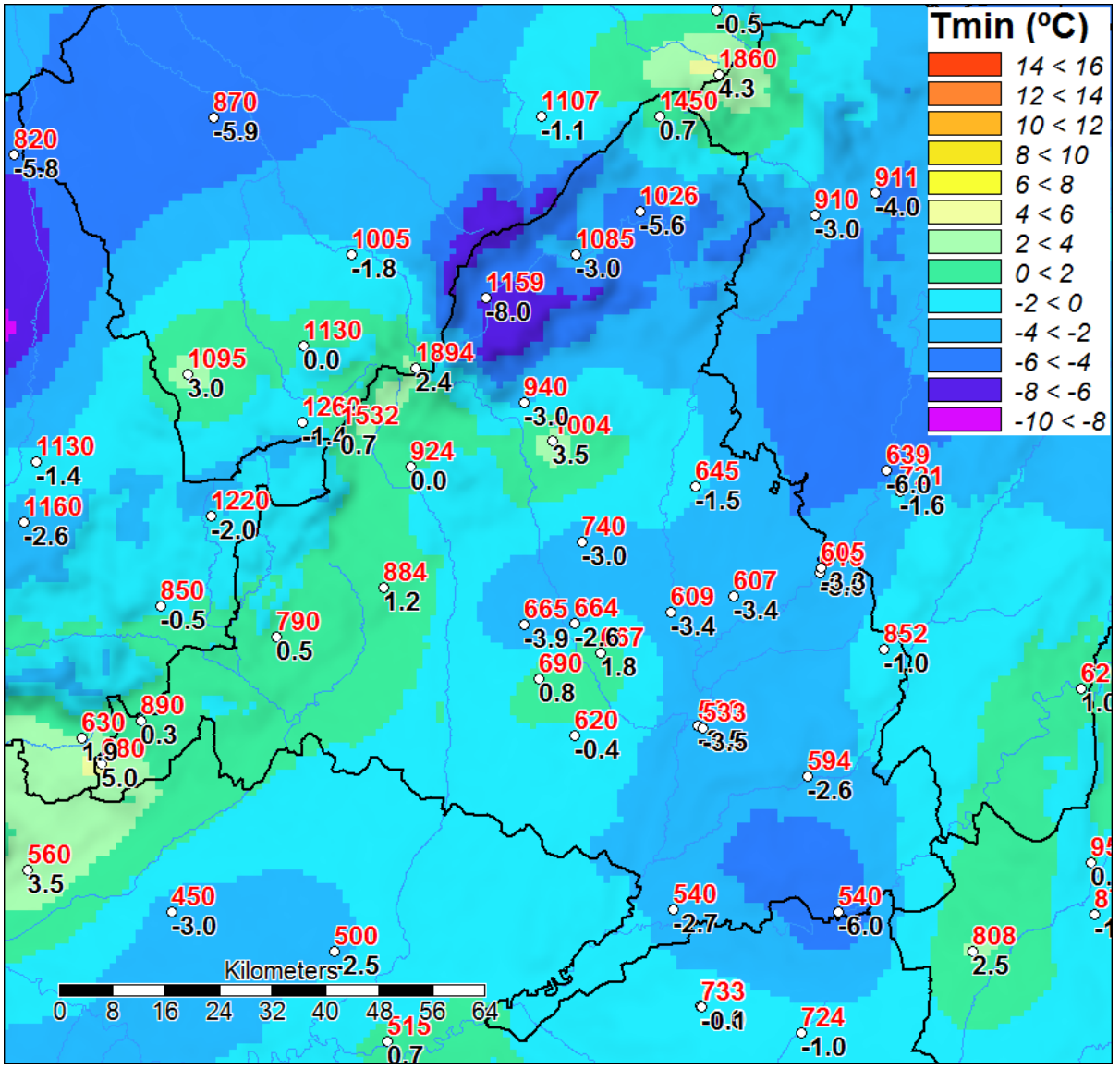
Community of Madrid



OK

Daily minimum temperature 10 January 2012

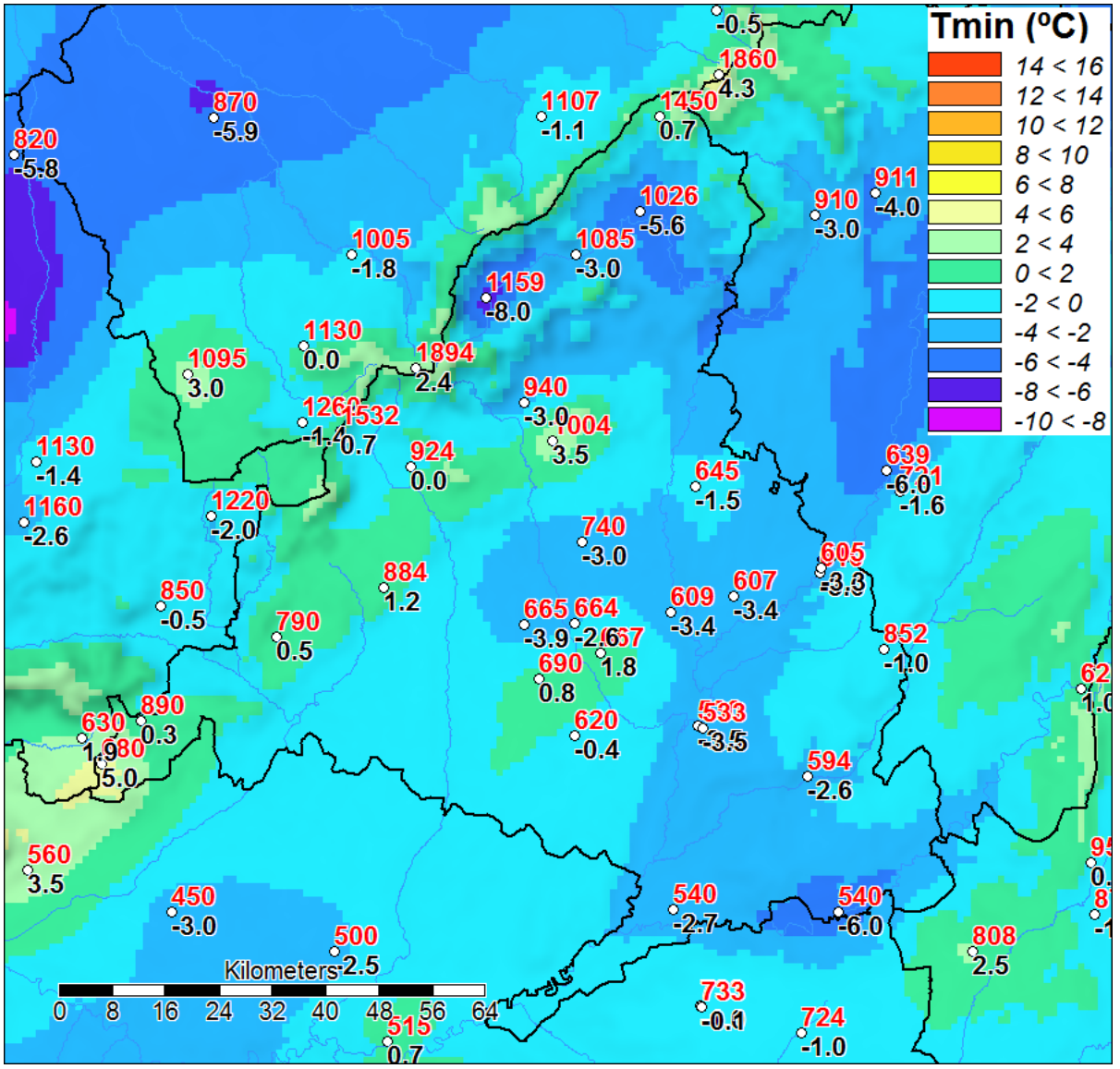
Community of Madrid



RK

Daily minimum temperature 10 January 2012

Community of Madrid



KED

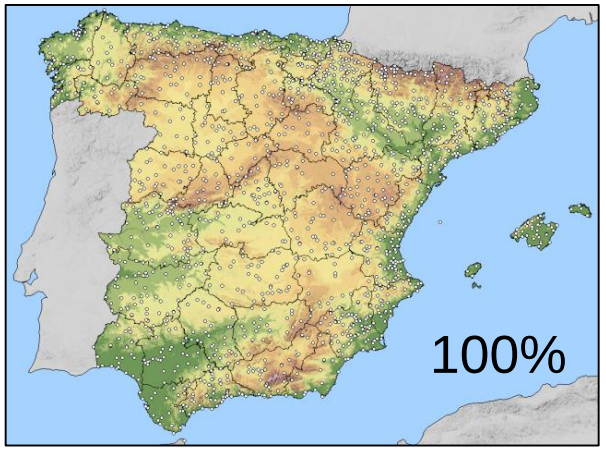
• From a **visual analysis**, we can see that the differences between the methods are generally **small in plain areas**.

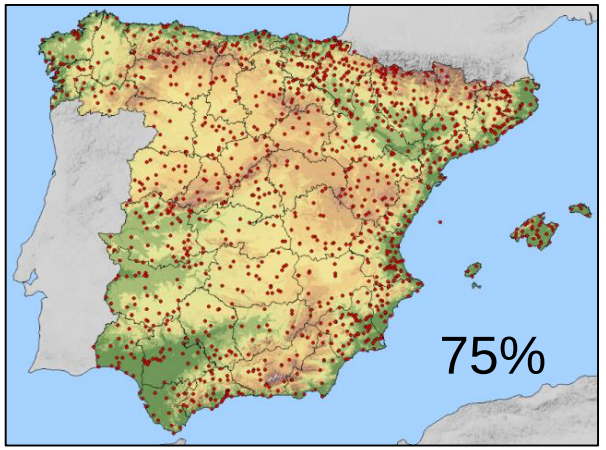
• KED provides better looking interpolations **in mountainous regions with high enough data density**, as it is able to model properly local temperature inversions.

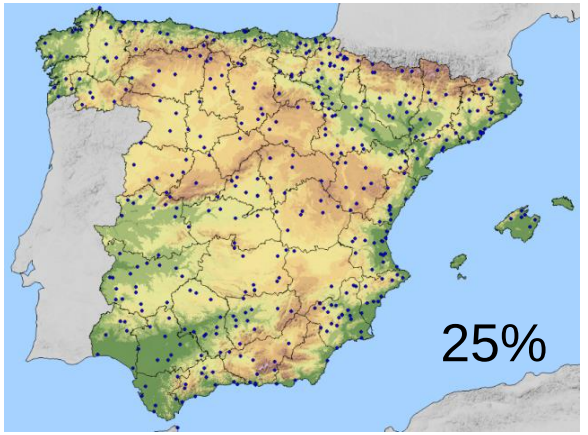
• However, we have detected that KED can lead to some **exaggerated extrapolation effects in areas with scarce and anomalous data** at the same time.

Validation

• A validation process was made by taking apart 25% of the data and repeating the process with the 75% remaining data **for every day of the year 2012** (366 days).







• The mean absolute error (MAE), the root mean square error (RMSE) and the correlation coefficient (R) between the observed and predicted values were used to measure the skill of the interpolation methods.

	R	MAE (ºC)	RMSE (ºC)
IDW	0.859	1.424	1.468
KO	0.858	1.437	1.480
RK	0.858	1.441	1.483
KED	**0.865**	**1.402**	**1.444**

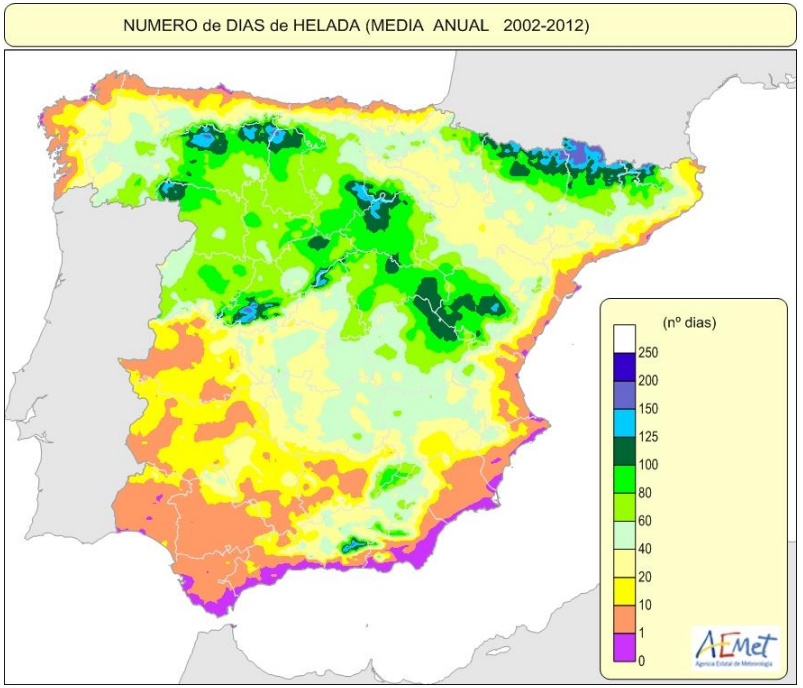
R = Pearson correlation coefficient
MAE = Mean absolute error
RMSE = Root mean square error

• **KED provides the best estimations** for the minimum daily temperature, although the differences with the other methods are small when considering the whole study area.

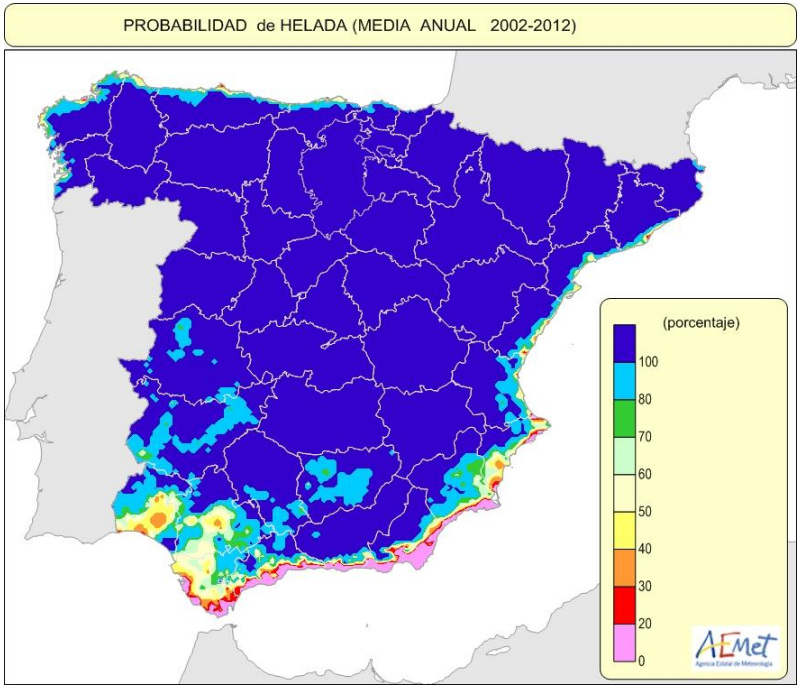
• However, the differences between KED and the other methods **would be greater if only mountainous regions were considered** in the validation.

Some examples of derived products

• Several map products have been generated for agroclimatological purposes by **combining daily gridded temperature fields** from the period 2002-2012

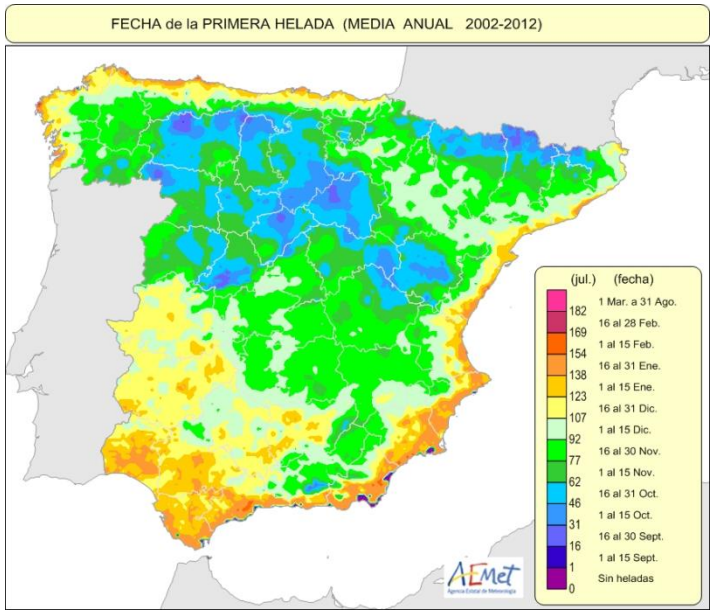


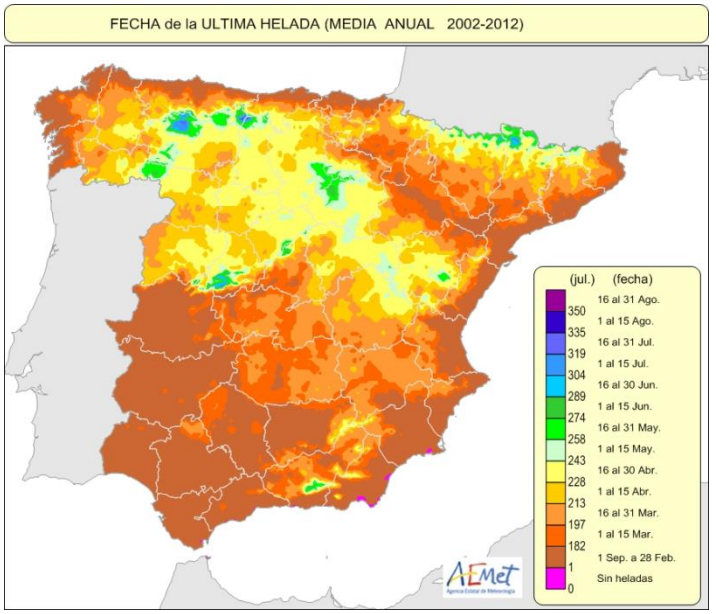
Mean annual number of frost days (2002-2012)



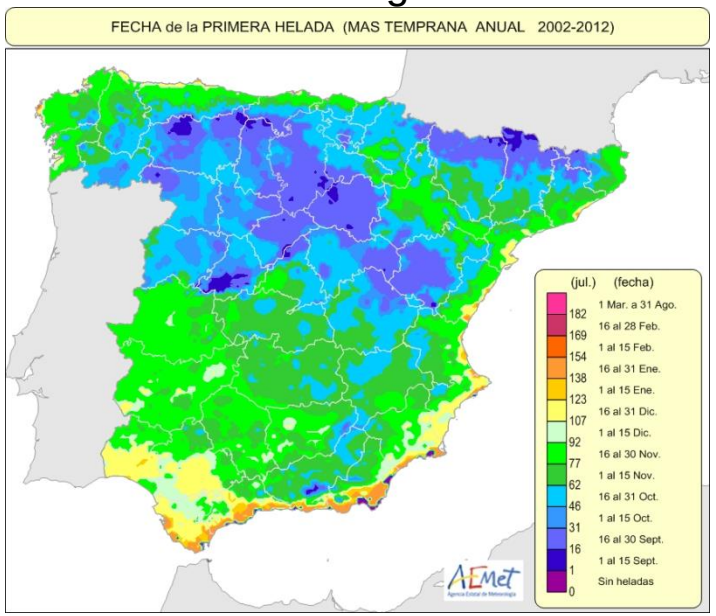
Mean annual probability of reaching temperatures below 0ºC (2002-2012)

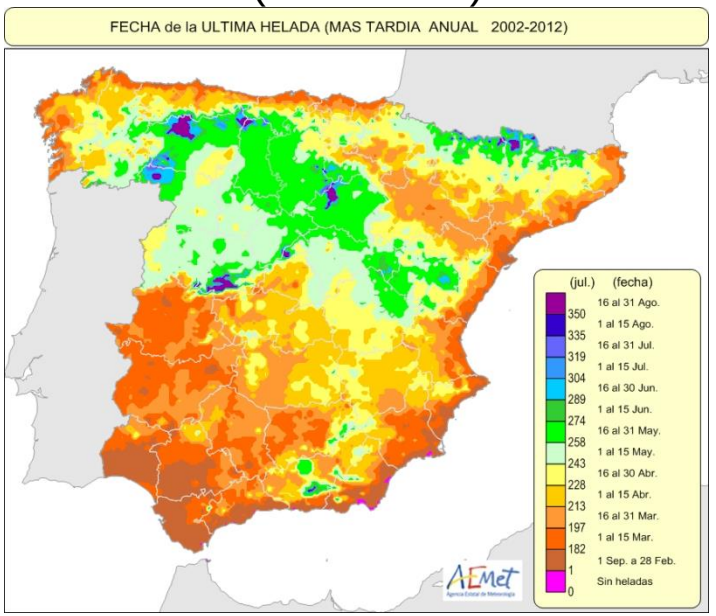
Mapping Minimum Daily Temperature In Spain Using Kriging With External Drift





Average first and last annual frost date (2002-2012)





First and last frost date recorded on the period 2002-2012

Conclusions

• Kriging with External Drift with altitude and distance to the coast as external variables has been proved to be **an appropriate method for obtaining gridded fields of daily minimum temperature data** in Spain.

• However, it must be considered that this method can lead to **exaggerated extrapolation effects in areas with scarce and anomalous data** at the same time.

• The same method has been also applied successfully to **daily maximum temperature data**.

• We are currently generating gridded fields of daily minimum and maximum temperature **over a longer period of time** (1981-2015)

Thank you for your attention!

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