CARPATCLIM

Climate of the Carpathian Region

Gridding in CARPATCLIM (Climate of Carpathian Region) project

Zita Bihari[1], T. Szentimrey[1], M. Lakatos[1] and S. Szalai[2]

[1]Hungarian Meteorological Service, [2]Szent István University

Overview of the main steps for gridded datasets in CARPATCLIM

- Near border data exchange before homogenization
- Homogenization (MASH)
- Data exchange after homogenization
- Controlling of the cross-border harmonization (MASH)
- Gridding, interpolation (MISH) per country, with exchanged data
- Compilation of gridded series from countries in one file per variable

Common attributes of MISH-MASH systems

- Strong mathematical basis
- A lot of exe program files based on the mathematics
  - MASH: about 140, MISH: about 90
- Algorithms, software for automatic and interactive procedures
- Huge amount of data in CARPATCLIM
  - 12 meteorological variables
  - large number of stations,
  - e.g.: >300 stations at temperature, >600 stations at precipitation
  - time resolution: about 18 000 days
  - spatial resolution: about 6000 gridpoints

The main features of MISHv1.03

- I. Modelling system for climate statistical parameters in space
  - Based on long homogenized data series and model variables
  - Modelling procedure must be executed only once before the interpolation applications
- II. Spatial interpolation system
  - Additive (e.g. temperature) or multiplicative (e.g. precipitation) model and interpolation formula can be used depending on the climate elements
  - Daily, monthly, annual values and many years' means can be interpolated
  - The expected interpolation error is modelled too
  - Capability for application of background information such as satellite, radar, forecast data
  - Capability for gridding of data series

Main steps for Gridding in CARPATCLIM

- 1. Spatial modelling of climate statistical parameters (local and stochastic parameters) by MISH on national level, but using the near border data
  - Determination of some supplementary deterministic model variables, altitude and e.g. other topographic variables (AURELHY principal components) for the station locations as well as for a half minutes (0.5’x0.5’) grid that covers the given area.
  - Modelling of the statistical parameters for the above half minutes grid by use of the derived monthly station data series and the model variables.
    - Result: For each month, 4 tables of parameters for the half minutes grid, altogether 12x4 tables of parameters per countries.
  - Controlling of the cross-border harmonization of the above parameter tables between the neighbouring countries.

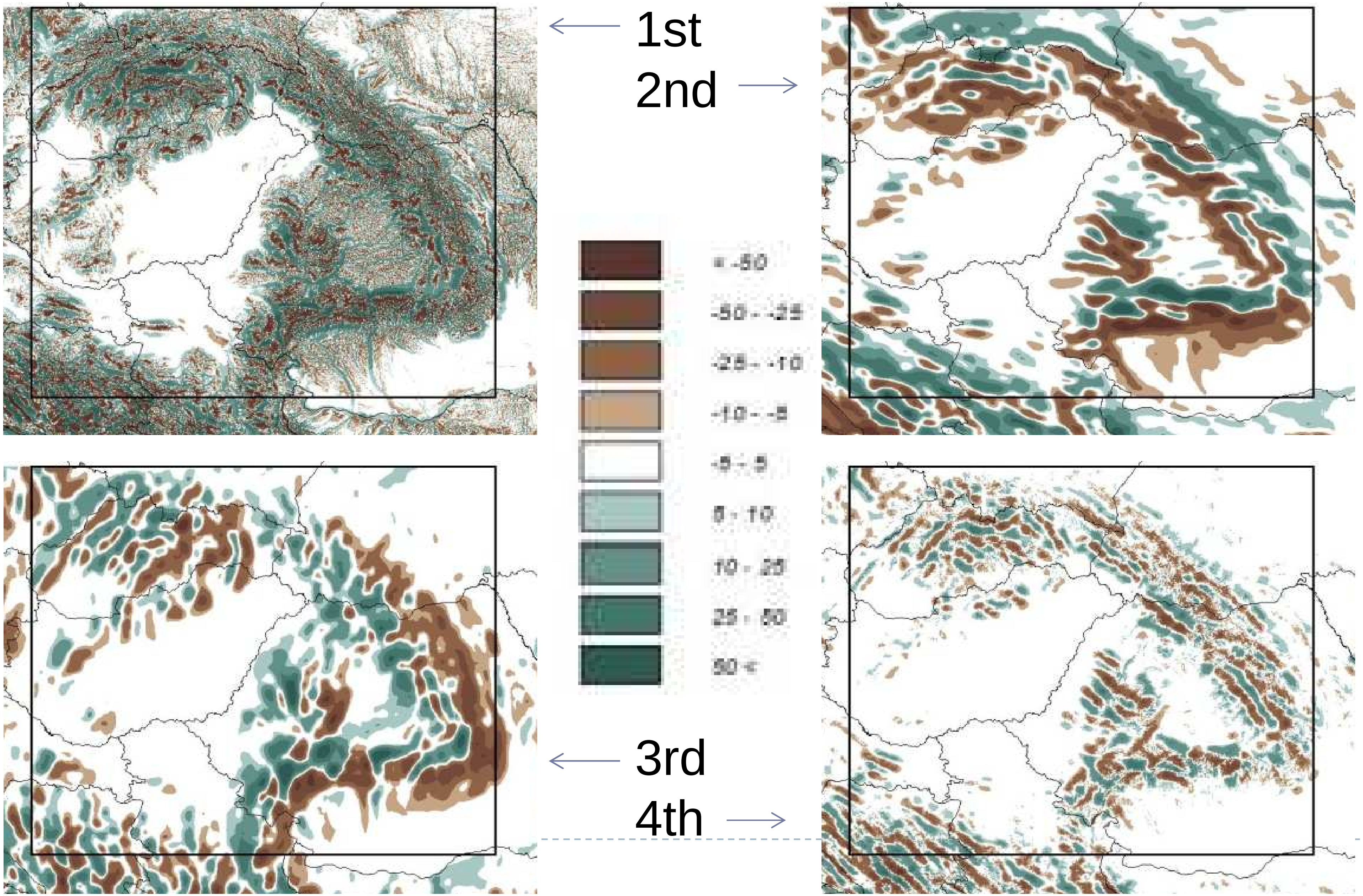
Main steps for Gridding in CARPATCLIM

- 2. Interpolation of daily data series for a grid (gridding) by MISH on national level, but using the near border data.
  - Determination of the grid at 0.1°*0.1° (≈10km*10 km) resolution
  - Interpolation for the grid by use of the homogenized, controlled, complemented daily station data series and the 12x4 tables of parameters
    - Result: Interpolated daily data series of good quality for the grid

Modelling part, AURELHY principal components

- Each grid point is characterized by its elevation and the elevation differences between the central point and 1616 neighbouring points
- Condensation of the informations by principal component analysis, thus the grid points are represented by their elevation and the appropriate values of the first 15 principal components, which account for about 90% of the orography variance
- First five principal components (PC) can easily be interpreted geometrically
  - PC 1 indicates peeks (positive values) and valleys (negative values)
  - PC 2 indicates east-west slopes
  - PC 3 indicates north-south slopes
  - PC 4 indicates north-south saddles
  - PC 5 indicates northeast-southwest saddles
- Common digital elevation map of the CARPATCLIM region: DEM of NOAA, WGS84, resolution of maps is 30 arc-second

AURELHY principal components



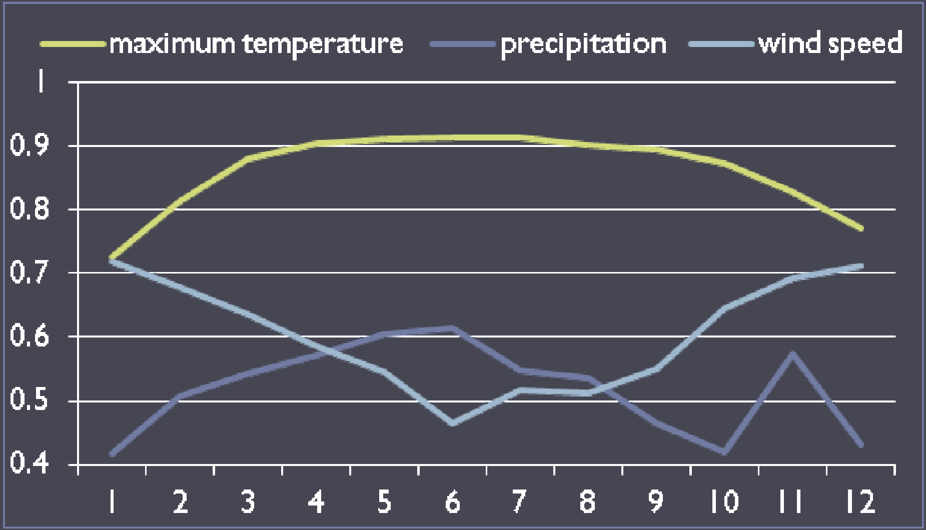
Results of modelling part

- Modelled parameters for each month, 4 tables of parameters for the half minutes grid, input to the interpolation part
- Monthly modelling results for the spatial trend of the series
- Monthly benchmark results for the interpolation parameters
- Monthly ANOVA (Analysis Of Variance) results for the series (only for Croatia and Hungary)

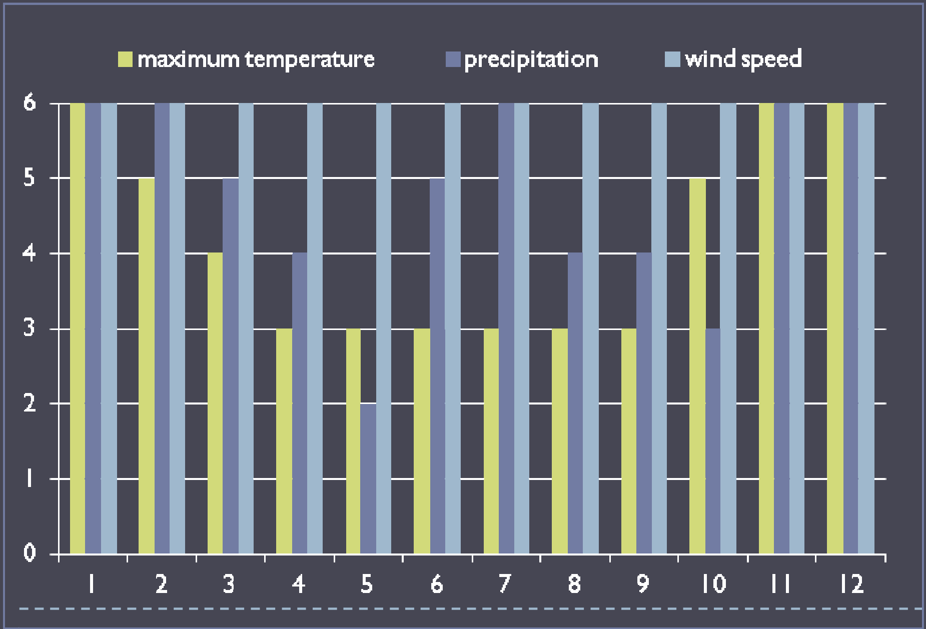
Monthly modelling results for the spatial trend of the series

- Number of applied modell variables
- Correlation
- Index of applied (AURELHY) parameters
- Coefficients of the linear regression

Monthly modelling results for the spatial trend of the series



Correlations

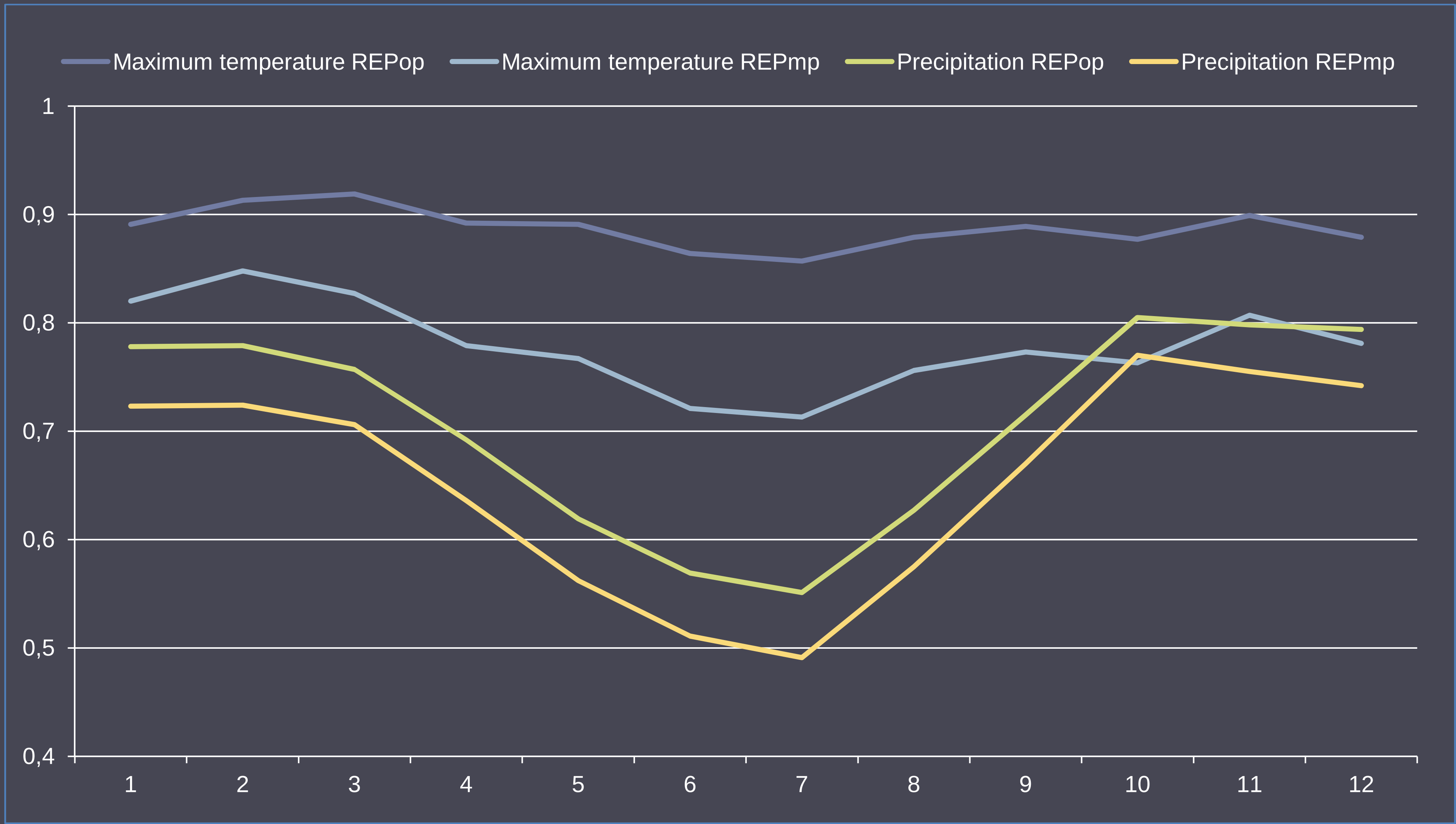


Number of applied variables

Monthly benchmark results for the interpolation parameters

- Based on cross-validation test, interpolation between the stations
- REP=1-RMSE/(Standard Deviation)
- REPop: interpolation with optimum parameters
- REPmp: interpolation with modelled parameters

Monthly benchmark results for the interpolation parameters



Monthly ANOVA results for the series

- The efficiency of the spatial trend modelling and the benchmark results are depending not only on the method and sampling, but also on the spatial probability distribution of the variables

Notations:

$X(\mathbf{s}_j, t)\ (j = 1,.., N;\ t = 1,...., n)$ – monthly data series $(\mathbf{s}_j$: location; t : time $)$

$E(\mathbf{s}_j) = \frac{1}{n}\sum_{t=1}^{n} X(\mathbf{s}_j, t) \quad (j = 1,.., N)$ – mean at station $\mathbf{s}_j$

$D^2(\mathbf{s}_j) = \frac{1}{n}\sum_{t=1}^{n}\left(X(\mathbf{s}_j, t) - E(\mathbf{s}_j)\right)^2 \quad (j = 1,.., N)$ – variance at station $\mathbf{s}_j$

$E = \frac{1}{N}\sum_{j=1}^{N} E(\mathbf{s}_j)$ – total mean

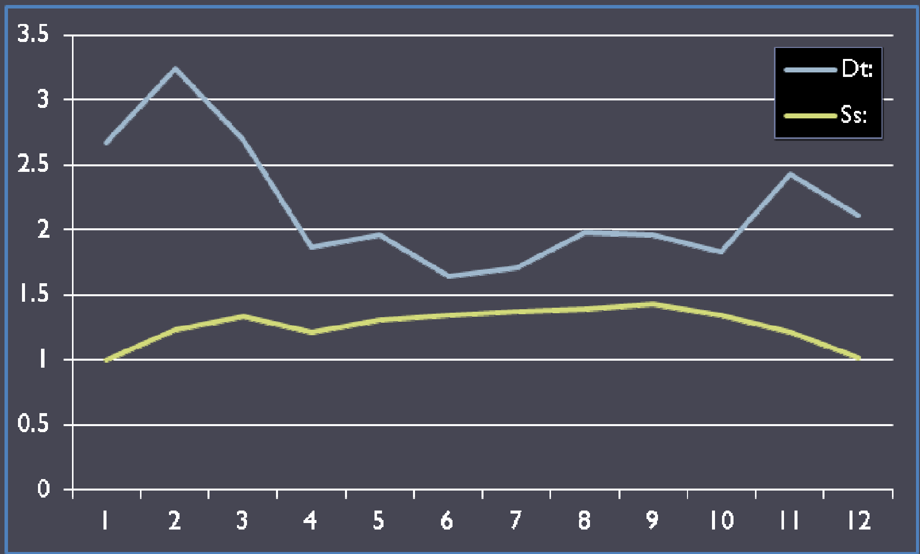
Total variance:

$$\frac{1}{N \cdot n}\sum_{j=1}^{N}\sum_{t=1}^{n}\left(X(\mathbf{s}_j, t) - E\right)^2 = \frac{1}{N}\sum_{j=1}^{N}\left(E(\mathbf{s}_j) - E\right)^2 + \frac{1}{N}\sum_{j=1}^{N} D^2(\mathbf{s}_j) = S^2_{space} + D^2_{time} \quad ,$$

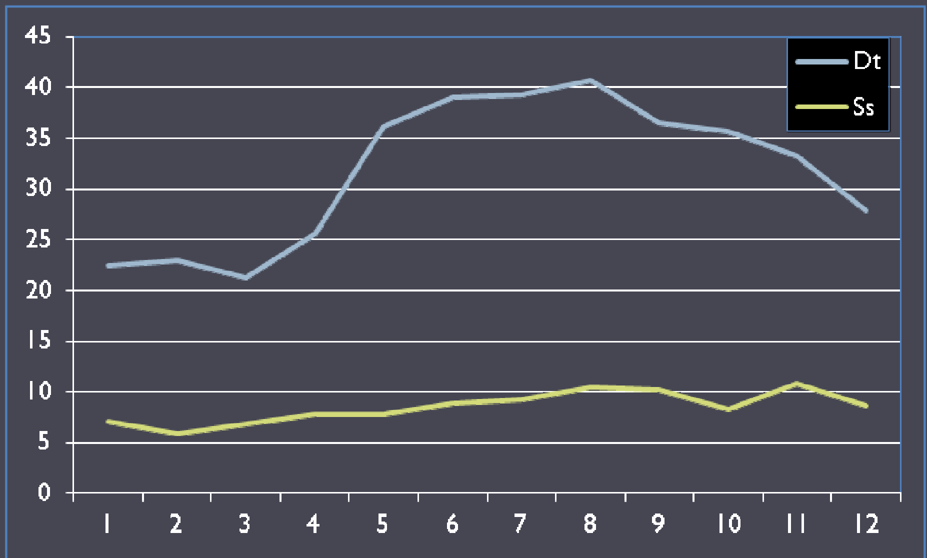
where $S^2_{space} = \frac{1}{N}\sum_{j=1}^{N}\left(E(\mathbf{s}_j) - E\right)^2$ is the variance of spatial trend

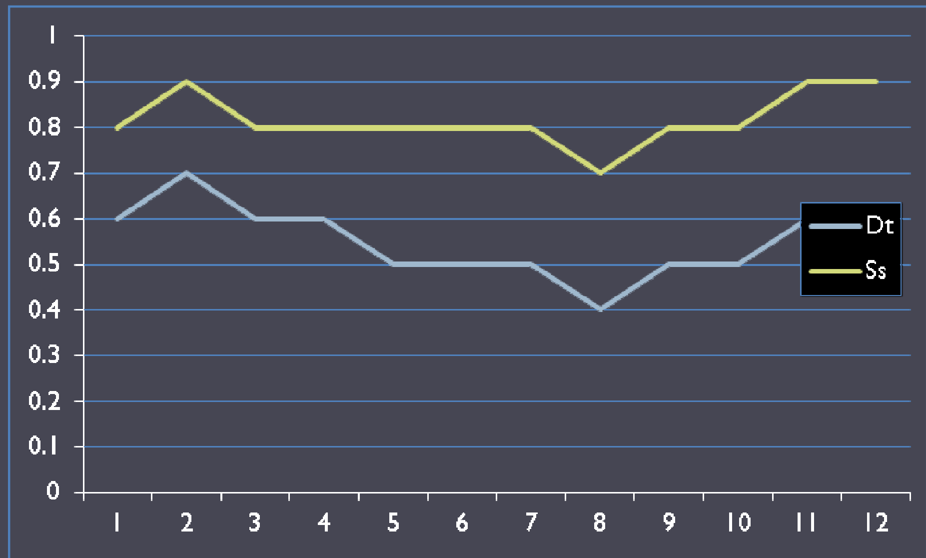
$D^2_{time} = \frac{1}{N}\sum_{j=1}^{N} D^2(\mathbf{s}_j)$ is the mean temporal variance.

Monthly ANOVA results for the series



Maximum temperature





Precipitation

Wind speed

Gridding of daily data series

- Executed per countries for the 0.1°*0.1° grid applying the homogenized station data series (included near border data from the neighbouring countries)
- Automatic procedure
  - Can be run in one step for one variable
- Compilation of gridded series from countries in one file per variable

Gridding of wind

- Gridding of daily mean wind speed and daily mean wind direction
  - 3 measurements per day
  - Daily mean wind speed: arithmetical mean of the absolute values of the 3 measurements
  - Daily mean speed direction: direction of the vectorial mean of the 3 measurements (*u*,*v* components)
- Additional modell variables: heights of anemometers (*wh*) and roughness length (*r*)
- Wind profile

Wind profil

- Derived from the power law and logarithmic profile models
- The wind speed at location s, observation height wh, roughness r:

$$z(wh,r;\mathbf{s})=\left(\frac{\ln(wh/r)}{\ln(wh/0.1)}\right)^{\gamma}\cdot\left(\frac{wh}{10}\right)^{\alpha}\cdot z(10,\,0.1;\mathbf{s})$$

- where $z(10,0.1;s)$ is the wind speed at location s, wh=10 m, r=0.1 m
- Constants α, γ can be calculated on the base of the data series
- Similarly u and v components:

$$u(wh,r;\mathbf{s})=\left(\frac{\ln(wh/r)}{\ln(wh/0.1)}\right)^{\gamma}\cdot\left(\frac{wh}{10}\right)^{\alpha}\cdot u(10,\,0.1;\mathbf{s})$$

$$v(wh,r;\mathbf{s})=\left(\frac{\ln(wh/r)}{\ln(wh/0.1)}\right)^{\gamma}\cdot\left(\frac{wh}{10}\right)^{\alpha}\cdot v(10,\,0.1;\mathbf{s})$$

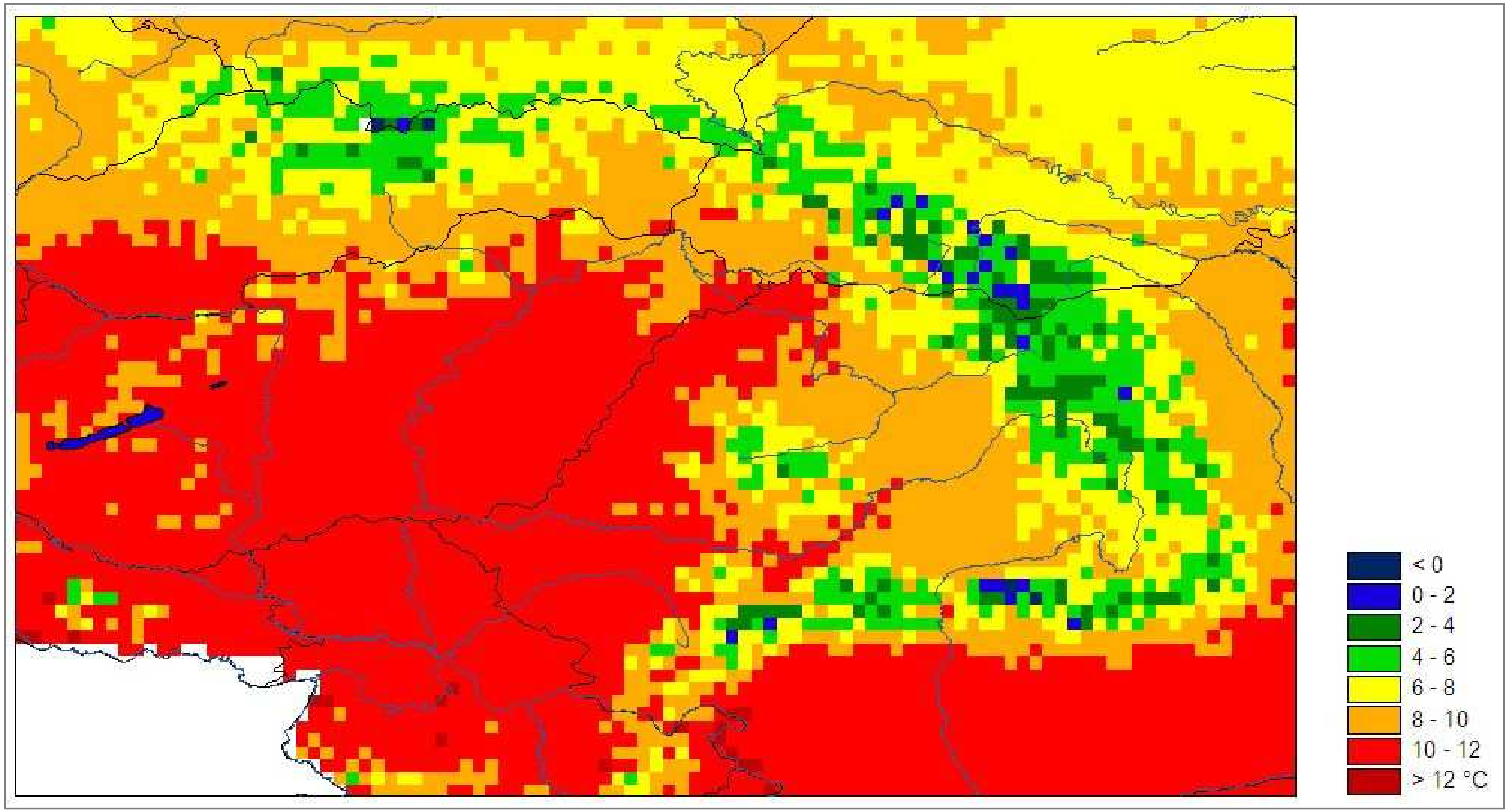
Modelling and Interpolation of wind speed and direction by MISH

wind speed z and wind direction Φ

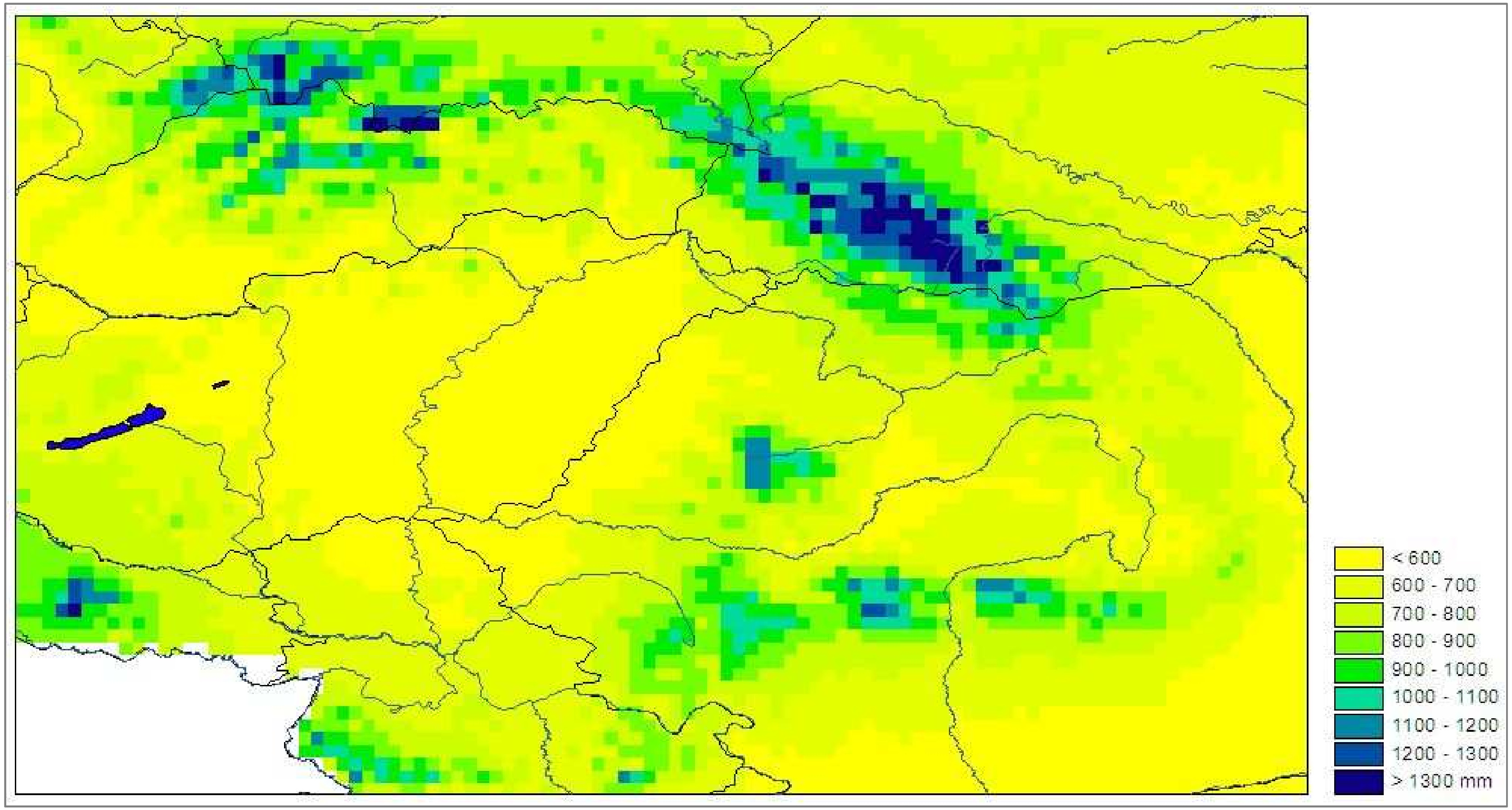
- Modelling
  - Calculation of wind components u,v data from z and Φ data
  - Modelling of wind speed z by MISH with multiplicative model
    Special model variables are based on wind observation heights (wh) and roughness (r)
    Special output is the wind profile parameters α , γ by months
  - Transformation of the components , u,v data for wh=10m, r=0.1 by using the wind profile parameters α, γ : u_0,v_0
  - Modelling of components u_0 and v_0 by MISH with additive model.

- Interpolation applications
  - Calculation of wind components , u,v data from z and Φ data.
  - Interpolation applications for wind speed z by MISH
    Special input is the modelled wind profile parameters α, γ by months.
  - Transformation of the components u,v data for wh=10 m, r=0.1 by using the wind profile parameters α, γ : u_0, v_0
  - Interpolation applications for components u_0 and v_0 by MISH.
  - Calculation of interpolated wind direction Φ data from the interpolated components u_0, v_0 data.

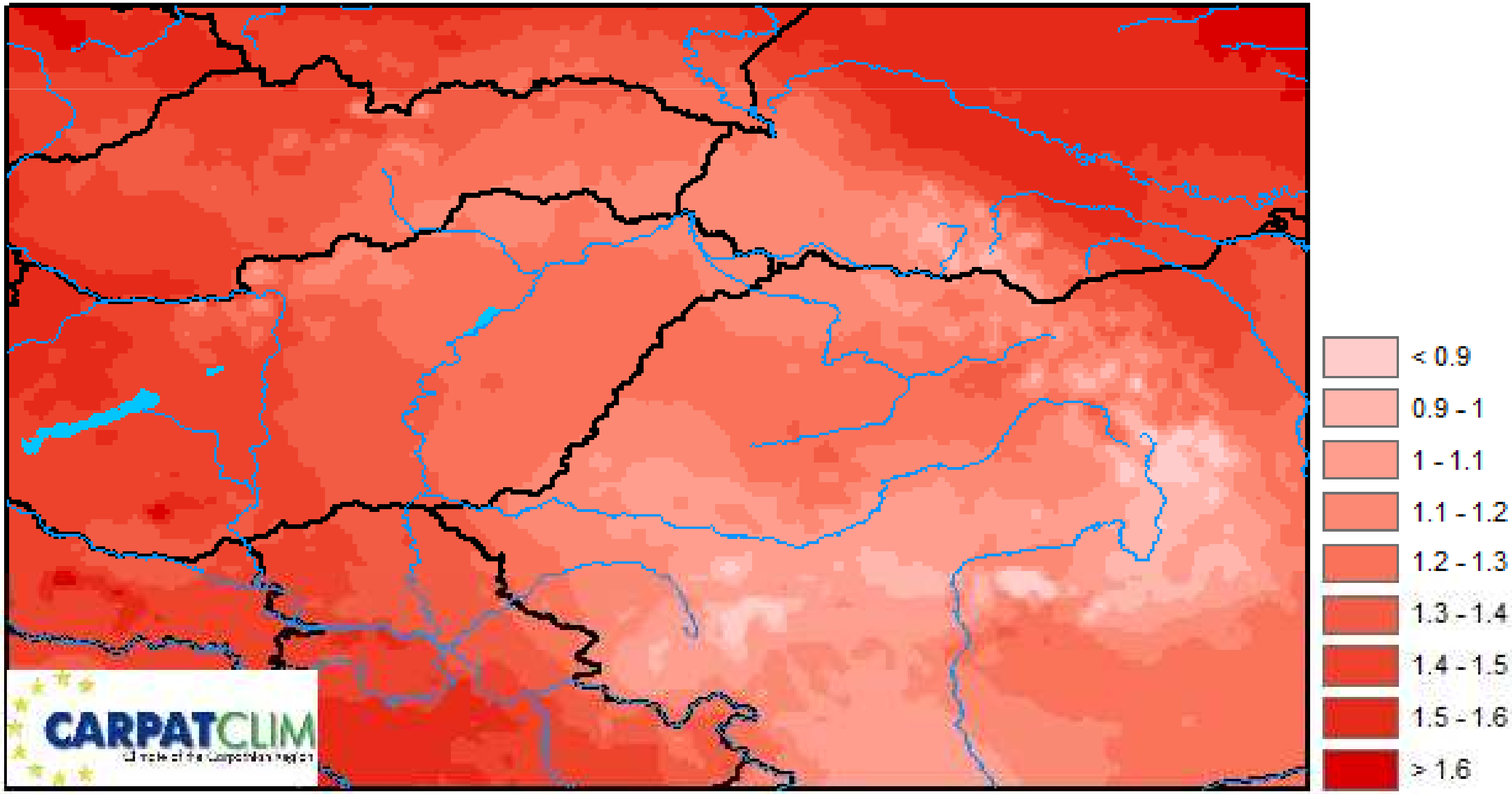
Annual mean temperature, average for1961-2010



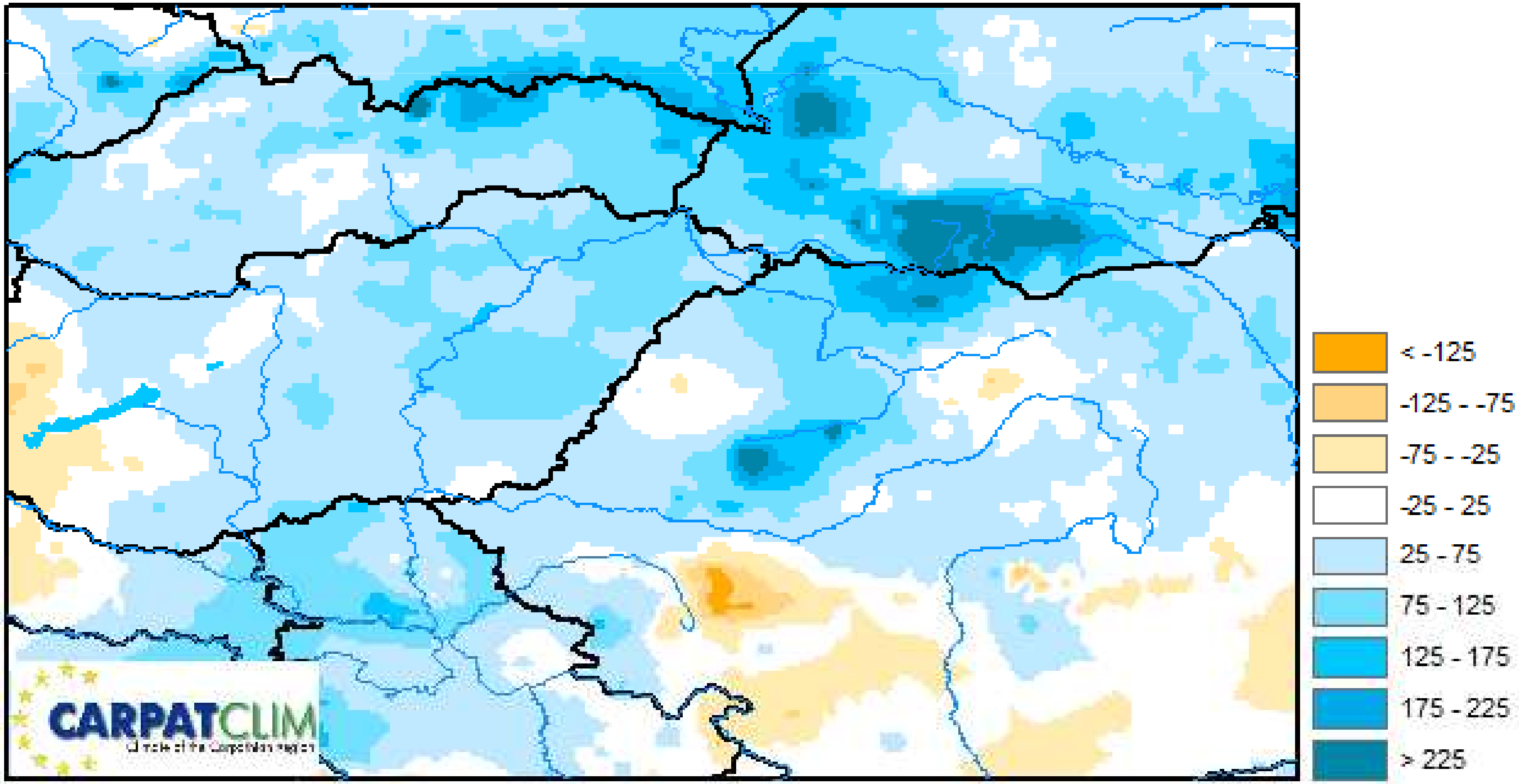
Annual precipitation, average for1961-2010



Change in annual mean temperature, 1961-2010



Change in annual precipitation, 1961-2010



http://www.carpatclim-eu.org

- Tamás Szentimrey et al.: CARPATCLIM Deliverable D2.9 Final report on the creation of national gridded datasets, per country

Thank you for your attention!