Gridded monthly temperature fields for Croatia for the 1981–2010 period

comparison with the similar global and European products

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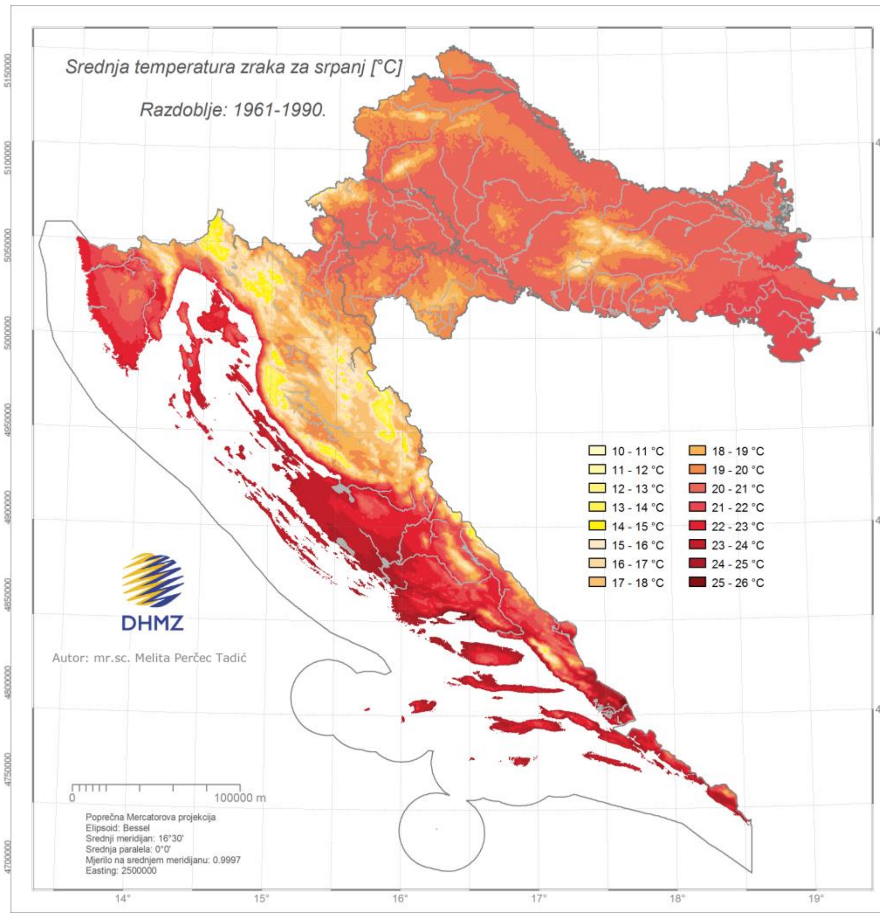
Outline

- Motivation: importance of the climatological gridded data, the need to complement the existing national climate monitoring products with monthly gridded data
- Framework: development of the Croatian climate service and research activities on the CARE project, Climate of the Adriatic Region in its Global Context , HRZZ-2831
- Data: monthly mean air temperature
- Methods: selection of the best regression parameters for regression kriging
- Results: gridded data for the 1981-2010 period
- Validation: LOOCV, comparison with European and global gridded data
- Conclusions
- References

Motivation

- Importance of the gridded data (Haylock et al, 2008):
- The best estimates of meteorological variables at locations away from observing stations, allowing studies of local climate in data-sparse regions
- Validation of Regional Climate Models (RCMs) that generally represent area averaged rather than point processes
- Monitoring of climate change at the regional and larger scale utilizing indices of area averages (e.g. continents, states)
- Input for the impact models for determining the possible consequences of climate forcing

- Complement the existing national climate monitoring products from observations:

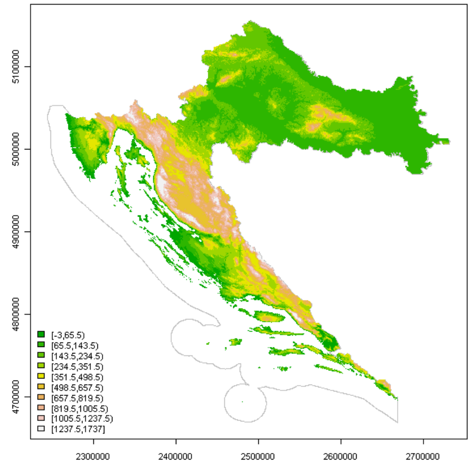


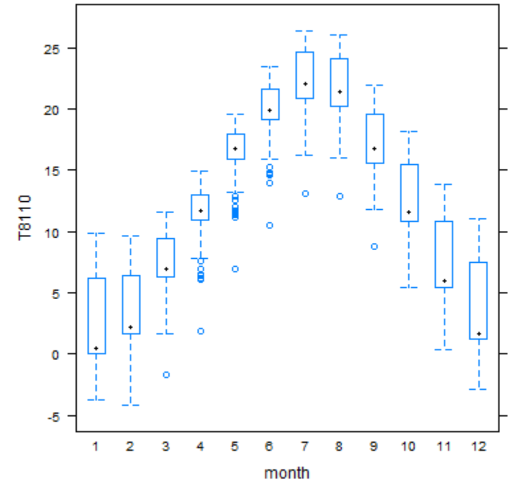
Long term averages in Climate Atlas 1961-1990, 1971-2000.

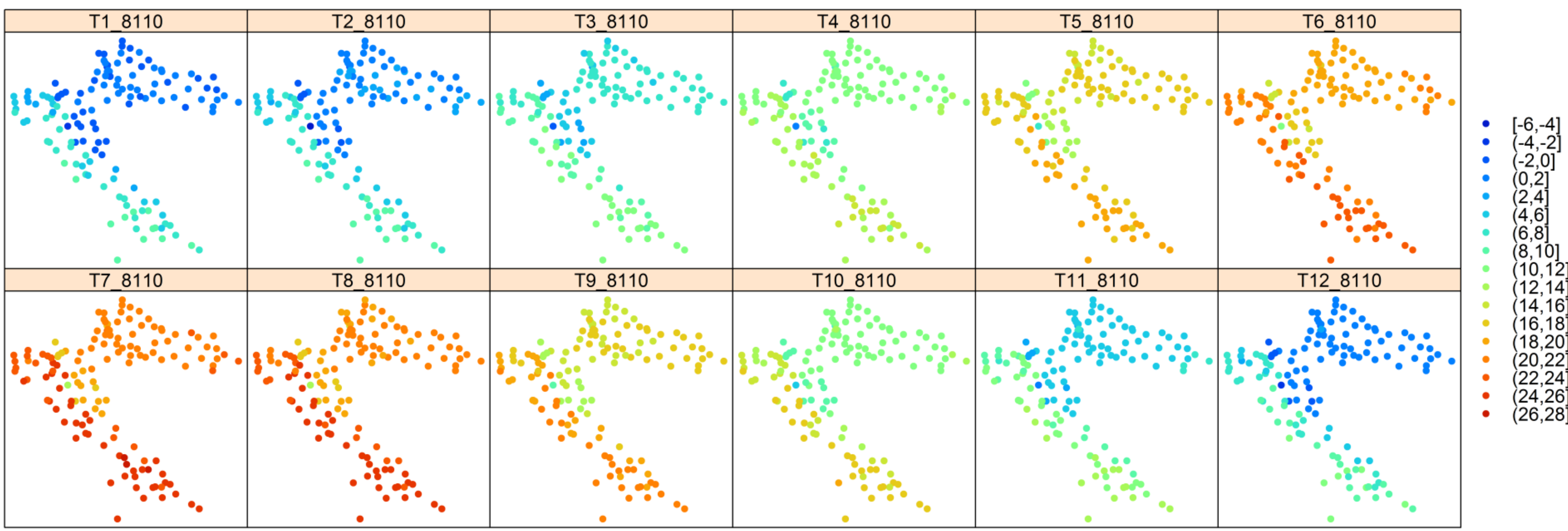
Maximum annual snow load for 50 years return period - characteristic snow load [kNm^{-2}]. Data: 1971-2000. HRN EN 1991-1-3:2012/NA:2012 Eurokod 1

Data - temperature, climatic factors, LST

- **Ground stations data**:
- mean monthly temperatures
- long term monthly averages
- 1981–2010
- 108 stations
- 56 000 km^2 area

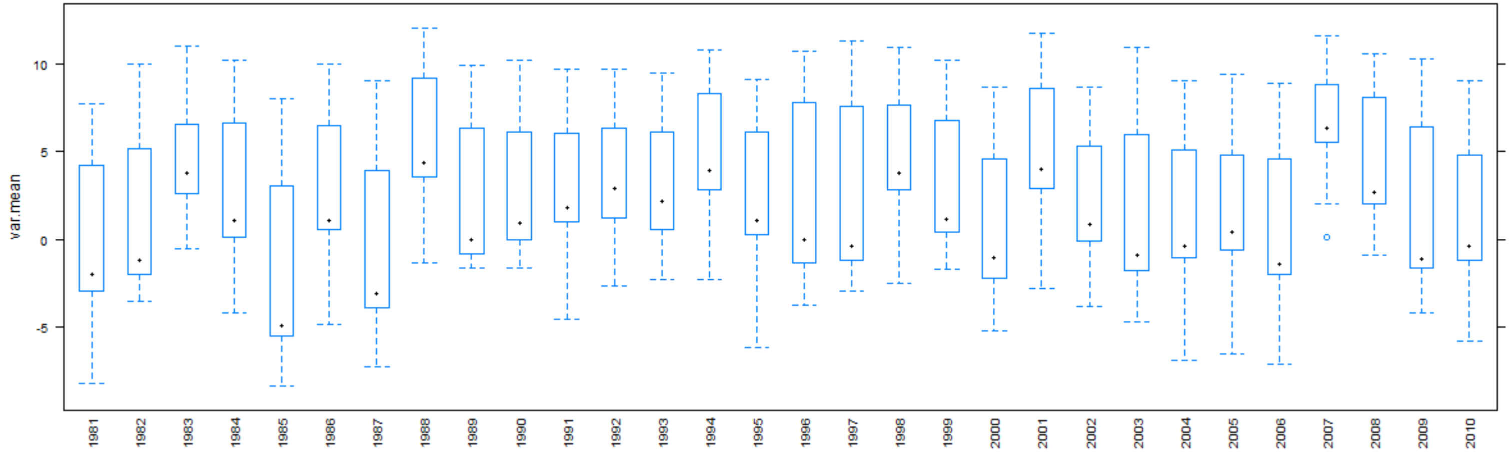




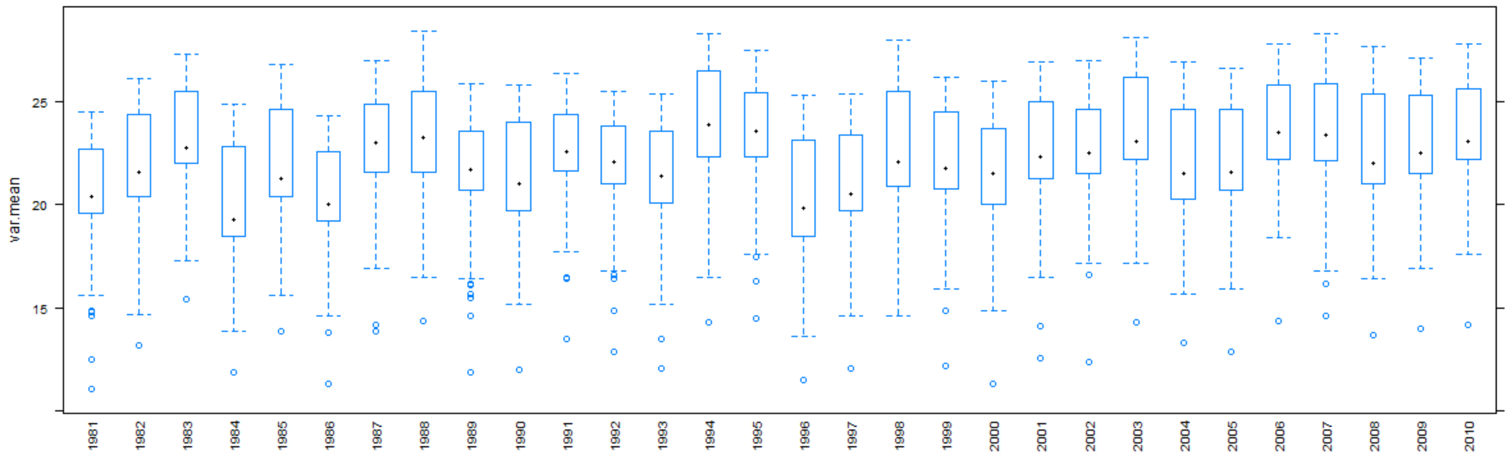


Data – variability in the mean monthly temperature during 1981-2010

JAN



JUL



Method – regression kriging

- Multiple linear regression on environmental predictors
- Estimation of the large scale spatial trend
- **Climatic factors** as a static predictors in the interpolation procedure:
- Altitude from SRTM DEM (1 km resolution)
- Distance to the coast
- Catchment area
- Wetness index
- Aspect
- Longitude and latitude...
- **MODIS land surface temperature** as a dynamic predictor (for every month that is being analyzed), MOD11C3 LST. Example for 2006.

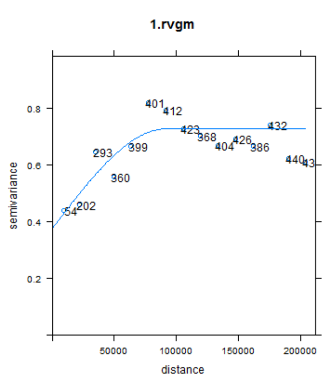
- Kriging of the residuals, geostatistical method
- Local, small scale spatial variations
- Prediction:

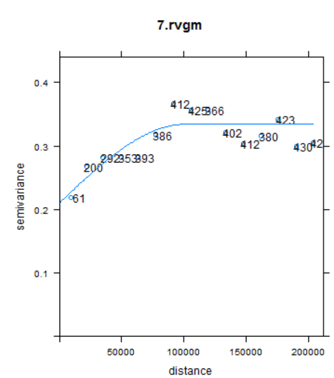
$$\hat{z}(x_0) = \sum_{i=1}^{n} \lambda_i z(x_i)$$

- Weights, λ
- Depend on the semivariances of the observations and estimated semivariance on the prediction locations, empirical

$$\hat{\gamma}\left(\bar{h}_j\right) = \frac{1}{2N_j} \sum_{i=1}^{N_j} \left[\hat{e}\left(s_i\right) - \hat{e}\left(s_i + h\right)\right]^2 ,$$

$$\forall \left(s_i, s_i + h\right) : h \in \left[h_j, h_j + \Delta h\right] ,$$





Methods

- selection of the best regression parameters for regression kriging

Table. Predictors in RK for the mean monthly long-term average (EXP0) and the mean monthly temperatures for 2006 (EXP1 to EXP4).

	DEPENDENT	**PREDICTORS**
EXP0	T1_8110 (JAN) to T12_8110 (DEC)	Climatic factors
EXP1	T1_T2006 (JAN) to T12_T2006 (DEC)	Climatic factors
EXP2	T1_T2006 (JAN) to T12_T2006 (DEC)	T8110: lrk.1 to lrk.12
EXP3	T1_T2006 (JAN) to T12_T2006 (DEC)	LST01 to LST12
EXP4	T1_T2006 (JAN) to T12_T2006 (DEC)	T8110, LST

Validation, R^2 and RMSE

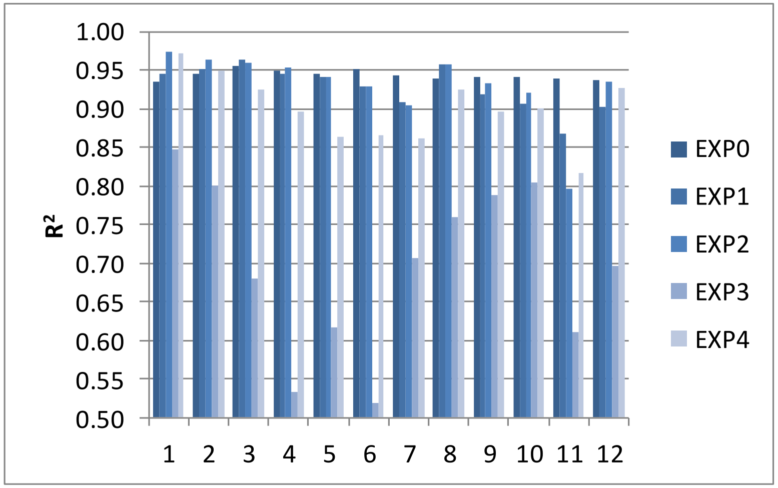


Fig. R^2 for the regression

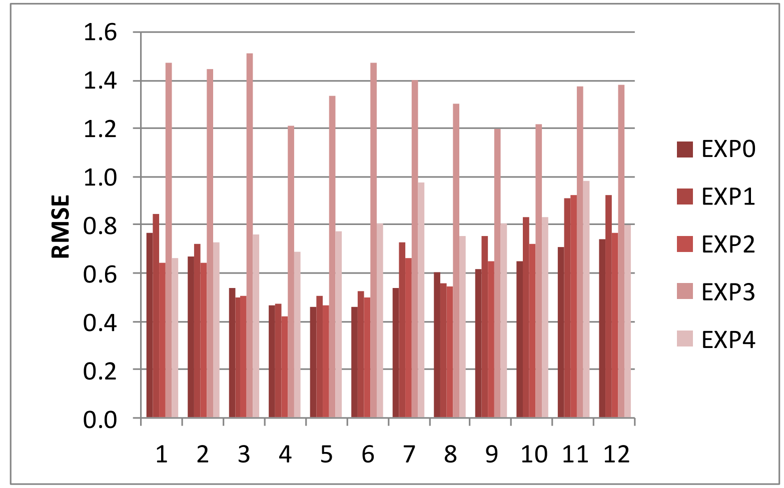


Fig. RMSE for LOOCV

- Coefficients of determination were from 0.95–0.96 for EXP0, the monthly long-term average regression.
- For the EXP1 and EXP2 R^2 were similar and the best, with R^2 from 0.87–0.98.

- RMSE was the lowest for the EXP2
- Unexpectedly, the worst predictor for the monthly temperature in 2006 was LST
- Some artifacts in the LST affected the correlation

Validation, LOOC for EXP3 (MODIS LST)

- It seems that MODIS product has some artificial pixels or errors that destroy the correlation with the ground stations data.
- Try to overcame this by testing the reconstructed MODIS data from recent project of Metz et al. (2014).

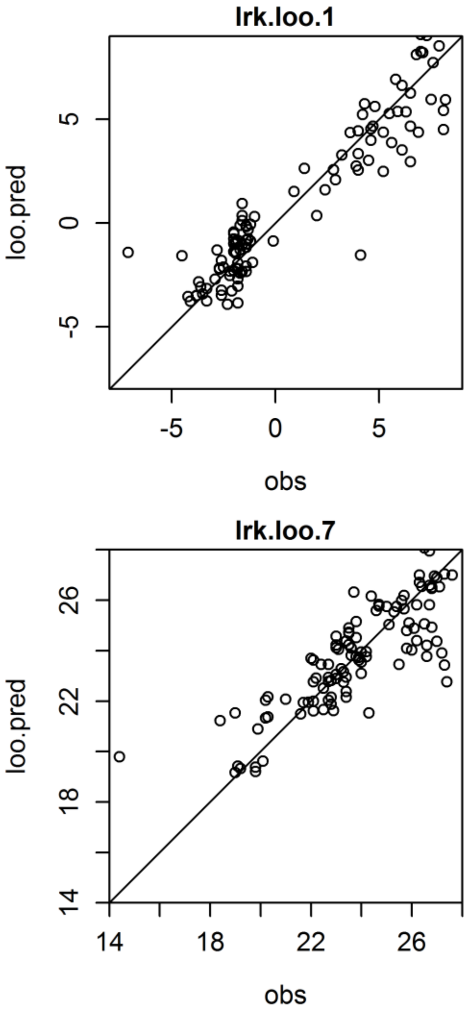
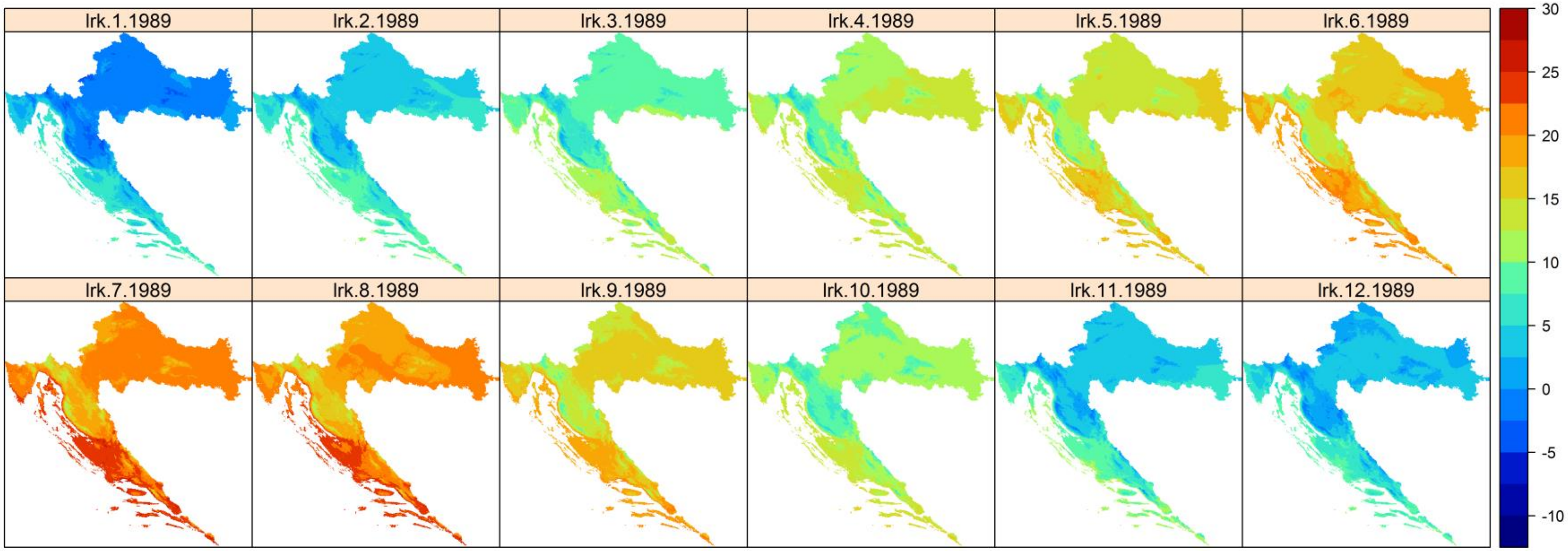
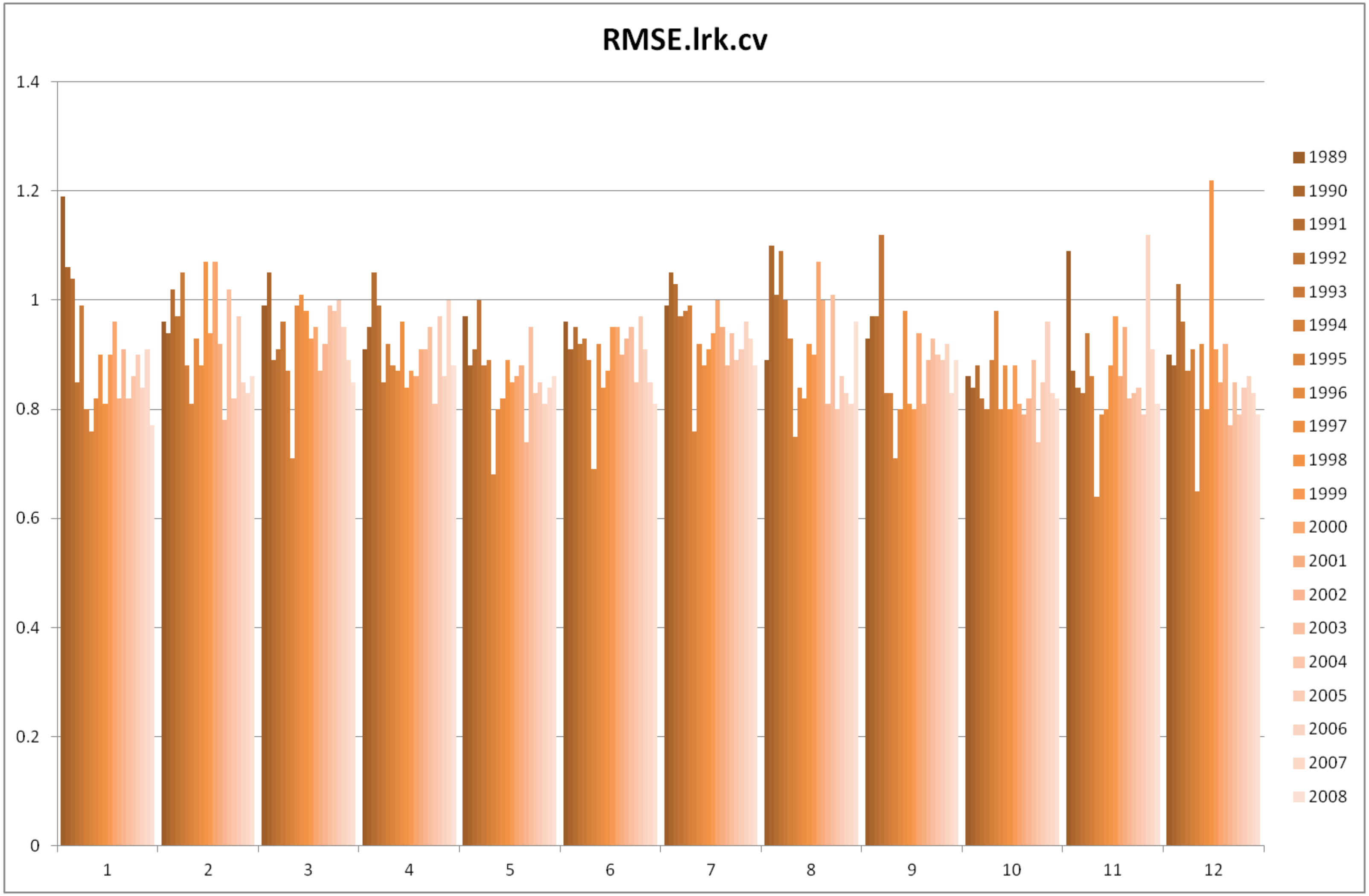


Fig. LOOCV, observed vs. RK predictions, JAN and JUL.

Results EXP2, monthly mean temperatures, period 1981-2010



Validation



RMSE.lrk.cv
1.4
1.2
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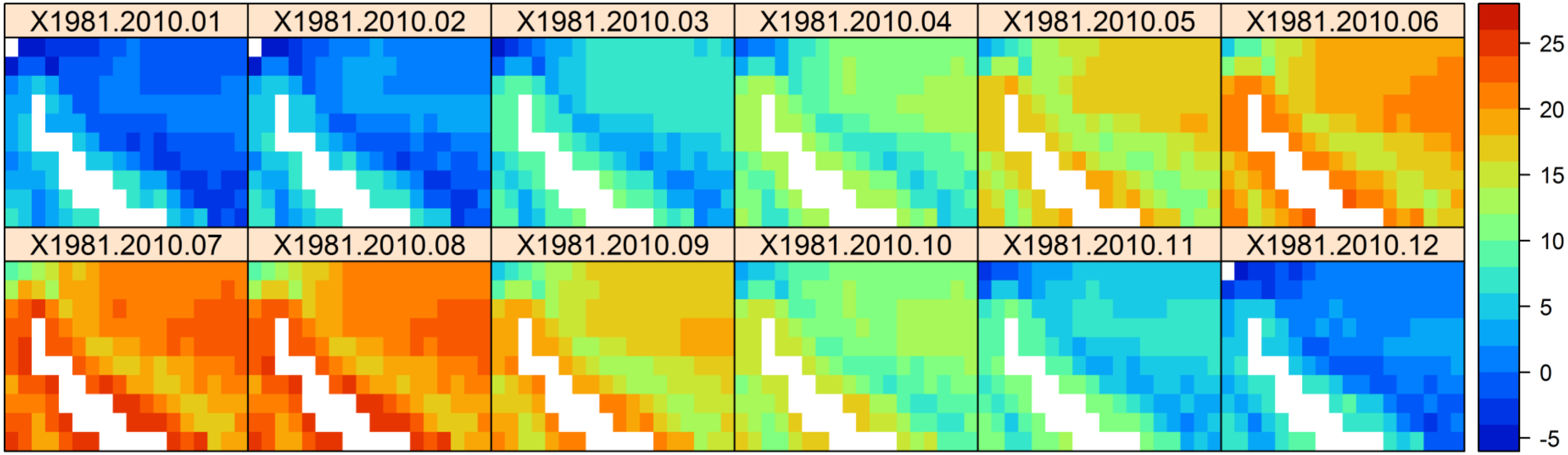
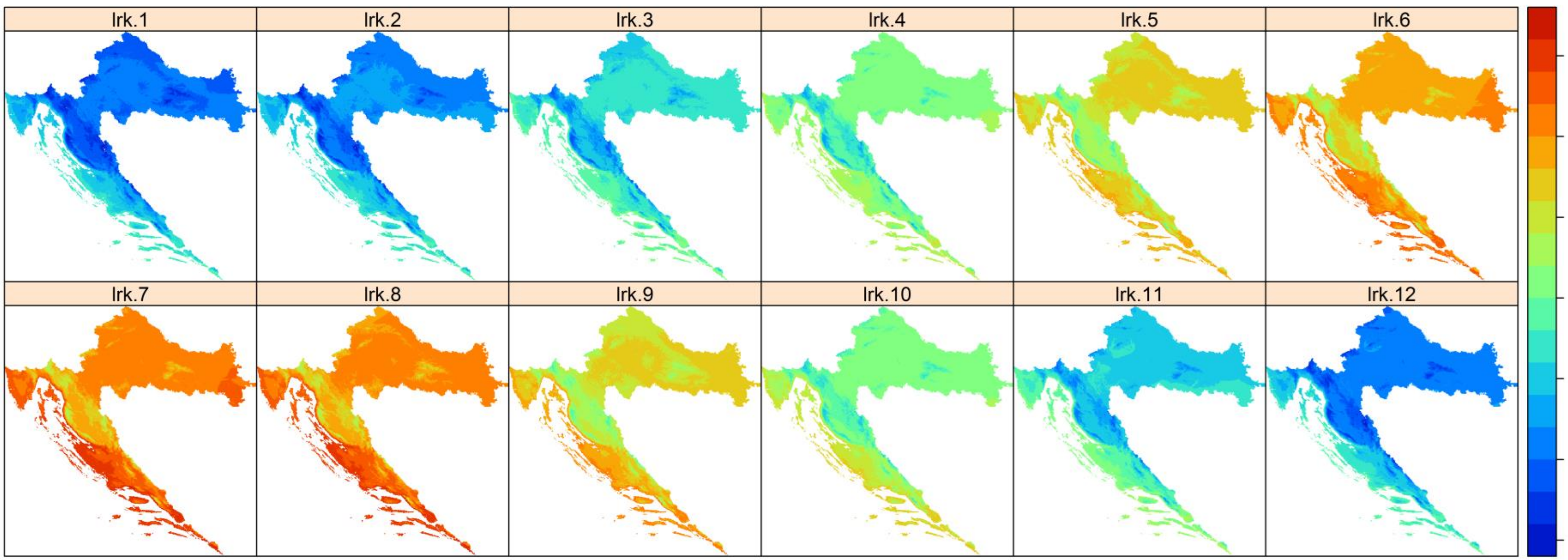
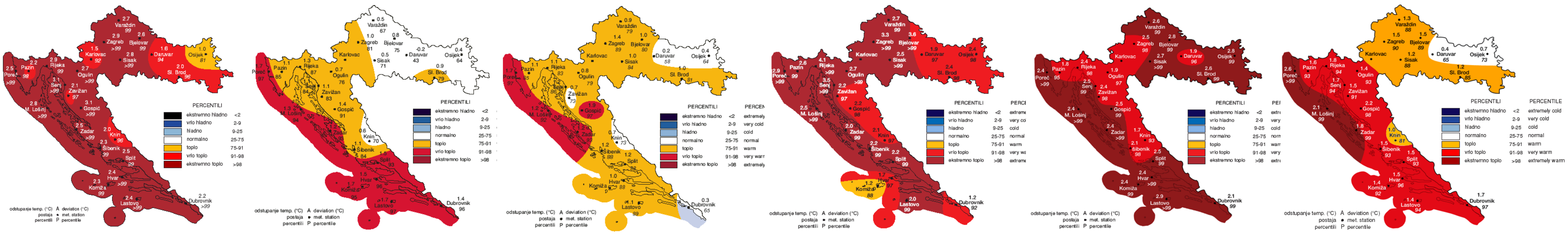
Validation
CRU TS 3.23 compared to croclim, 1981-2010



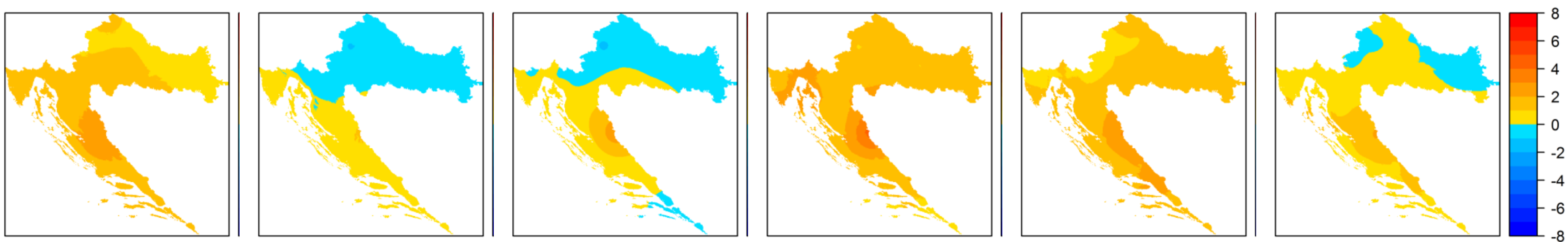


DHMZ

Differences of the mean monthly temperature from the long term average 1981-2010 compared to current climate monitoring product

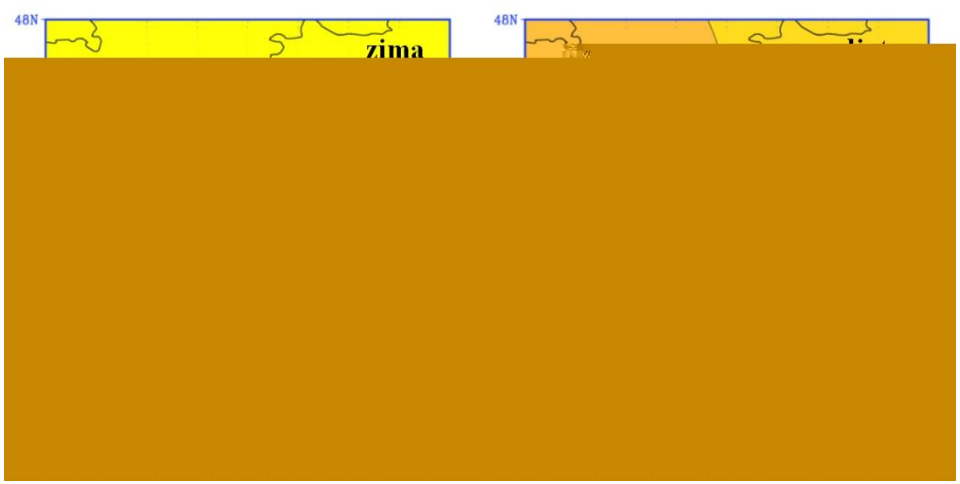


T7.2003 T7.2004 T7.2005 T7.2006 T7.2007 T7.2008



Conclusions

- Emphasize the importance of the ground-based or remote-sensed observations
- Promote climate models as a tools for assessing the current and future climate conditions in the Adriatic area
- Estimate climate conditions in Croatia
- Detect the regional patterns of the climate change signal from the gridded data
- Validate regional climate model's present and future climate
- Collaborations: Adaptation capacity of the Mediterranean forests in Croatia to environmental stress.
  - Leading partner: Croatian Forest Research Institute
  - Financing: Ministry of Agriculture, Croatia
- Future research: spatio-temporal regression kriging, random forest machine learning methods



Surface temperature change (°C) for 2041-2070 compared to 1961-1990, RegCM ensemble mean for the GHG A2 emission scenario.

References

- Haylock, M.R., N. Hofstra, A.M.G. Klein Tank, E.J. Klok, P.D. Jones and M. New. 2008: A European daily high-resolution gridded dataset of surface temperature and precipitation. J. Geophys. Res (Atmospheres), **113**, D20119, doi:10.1029/2008JD10201
- Hengl, T; Heuvelink, G B.M.; Perčec Tadić, M; Pebesma, E. 2012: Spatio-temporal prediction of daily temperatures using time-series of MODIS LST images. Theoretical and applied climatology. 107, 1/2; 265-277
- Kilibarda, M; Hengl, T; Heuvelink, G B.M.; Graeler, B; Pebesma, E; Perčec Tadić, M; Bajat, B. 2013: Spatio-temporal interpolation of daily temperatures for global land areas at 1 km resolution. Journal of geophysical research. 119, 5; 2294-2313
- Metz, M.; Rocchini, D.; Neteler, M. 2014: Surface temperatures at the continental scale: Tracking changes with remote sensing at unprecedented detail. Remote Sensing. 2014, 6(5): 3822-3840