Gridded monthly temperature fields for Croatia for the 1981–2010 period comparison with the similar global and European products

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This work has been supported in part by Croatian Science Foundation under the project 2831 (CARE).
• 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

Maximum annual snow load for 50 years return period, characteristic snow load [kNm$^{-2}$].

- Complement the existing national climate monitoring products from observations:

Data - temperature, climatic factors, LST

- **Ground stations data:**
  - mean monthly temperatures
  - long term monthly averages
  - 1981–2010
  - 108 stations
  - 56 000 km² area
Data – variability in the mean monthly temperature during 1981-2010
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, \( \lambda \)
- Depend on the semivariances of the observations and estimated semivariance on the prediction locations, empirical

\[ \hat{\gamma}(h_j) = \frac{1}{2N_j} \sum_{i=1}^{N_j} [\hat{\gamma}(s_i) - \hat{\gamma}(s_i + h)]^2, \]

\forall (s_i, s_i + h) : h \in [h_j, h_j + \Delta h], \]
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).

<table>
<thead>
<tr>
<th>DEPENDENT</th>
<th>PREDICTORS</th>
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<tbody>
<tr>
<td>EXP0 T1_8110 (JAN) to T12_8110 (DEC)</td>
<td>Climatic factors</td>
</tr>
<tr>
<td>EXP1 T1_T2006 (JAN) to T12_T2006 (DEC)</td>
<td>Climatic factors</td>
</tr>
<tr>
<td>EXP2 T1_T2006 (JAN) to T12_T2006 (DEC)</td>
<td>T8110: lrk.1 to lrk.12</td>
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<tr>
<td>EXP3 T1_T2006 (JAN) to T12_T2006 (DEC)</td>
<td>LST01 to LST12</td>
</tr>
<tr>
<td>EXP4 T1_T2006 (JAN) to T12_T2006 (DEC)</td>
<td>T8110, LST</td>
</tr>
</tbody>
</table>
Validation, $R^2$ and RMSE

- 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


0 0.2 0.4 0.6 0.8 1 1.2 1.4

1 2 3 4 5 6 7 8 9 10 11 12
Validation
CRU TS 3.23 compared to croclim, 1981-2010
Differences of the mean monthly temperature from the long term average 1981-2010 compared to current climate monitoring product
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


- 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