Expected climate changes in dry spells over Croatia

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Introduction

Data & Methods

Results & Discussion

Conclusion
The precipitation regime in Croatia is caused by the general circulation of atmosphere over northern middle latitudes & strongly modified by local factors (Mediterranean & Adriatic Sea, Dinaric Alps).

Significant spatial differences in average precipitation amounts and frequency between the continental, mountainous and coastal areas.

Croatia belongs to the transitional area between northern Europe with an increase in average precipitation & drying Mediterranean.
Recent studies...

• **Trends of extreme precipitation indices**
  
  Gajić-Čapka et al. (TAC, 2014) → 132 stations in Croatia, 1961-2010 → decreasing trend in annual precipitation is caused by a statistically significant increased frequency of dry days (prec. < 1 mm)

• **Dry spell → one of the extreme precipitation indices**
  
  Monitoring of dry spells during a month/ season provides another insight into particular precipitation → useful in engineering studies that deal with agricultural, irrigation or field operations systems

• **Very few dry spell studies in Croatia**
  
  Cindrić et al. (TAC, 2010) → 25 stations in Croatia, 1961-2000 → DS climate & DS trends → MEAN and MAX dry spell durations → (mostly) negative trend for autumn; (mostly) positive trend for other seasons and whole year (prec. < 0.1,1,5,10 mm)

  → no systematic climatological analysis of dry spells!
Drought in Croatia

- Causes the highest economic losses (39 %) inflicting serious damages, especially in agricultural sector.

- **2003** – damage on drought was 90 %
- **2011/2012** (Cindrić et al. 2014, TAC)
- **2015** (Ionita et al. 2017, HESS);
- **2017**
  - more than 100 consecutive days (prec. < 5 mm) & large precipitation deficit
  - & extremely high air temperature during summer months
**Drought in Croatia**

- **Main goal of this study:**
  - systematic spatial & temporal analysis of dry spells (DS) in Croatia for the extended period 1961–2015
  - projections and future changes in the DS statistics
  
  → for establishing the **drought risk assessment**

- **DriDanube - Drought risk in Danube Region**
  - to improve the drought emergency response
  - prepare better for the next drought
  - (search for the poster) 😊
• **Daily** precipitation data
• **132** stations
  (Croatian Meteorological and Hydrological Service - DHMZ)
• Time period: **1961-2015**
Regional climate model (RCM)

- from EURO-CORDEX initiative: RegCM4 (Giorgi et al. 2012)
- forced by the four CMIP5 global climate models (MOHC-HadGEM2-ES, CNRM-CERFACS, ICHEC-EC-EARTH, MPI-M-MPI-EMS-MR)
- European domain at the 12.5-km horizontal resolution (realistic orography & land-sea structures)

Data → 7 regions

Reg1: **Eastern mainland** → Osijek
Reg2: **Western mainland** → Zagreb
Reg3: **Central hinterland** → Ličko Lešće
Reg4: **Mountainous region** → Ravna Gora
Reg5: **Mountainous littoral** → Rijeka
Reg6: **North Adriatic coastal** → Mali Lošinj
Reg7: **Central & South Adriatic coastal** → Split

Gajić-Čapka et al. 2014, TAC
Dry spells (DS) – consecutive sequences of days having daily precipitation less than the given threshold (1, 5, 10 mm)

- DS beginning in one season but extending to the next is accounted in the season in which it started (Buishand, 1978)

Analysis of DS duration:

- MAX & Mean
- Annual & seasonal (DJF, MAM, JJA, SON)
Methods → trends

• Means of **Kendall’ tau** method (Sen 1968; Zhang et al. 2004)
  → statistically robust and resistant

• Non-parametric **Mann–Kendall** test (Gilbert 1987)
  → statistical significance of Kendall’s tau trend

• **Innovative partial trend** methodology (Öztopal and Şen, 2016)
  • MAX & Mean annual DS duration days
  • Comparation: 1961-1985 & 1986-2010
Methods → model

• 4 global models → RegCM4
• 1 station (grid cell) from each region
• Mean DS (5 mm)
• seasonal and annual timescale
• present & 2 future periods
• RCP4.5 & RCP8.5 scenario
Results & Discussion

- Annual Mean & MAX DS
- 3 categories (1, 5 and 10 mm)
- Reg 4 – the shortest DS
- Reg 1, 7 – the longest DS
- 1 mm – small differences
- 10 mm – large difference
Longer DS:

Continental regions

Adriatic region (south)
Results → trends

- Annual MAX & Mean DS durations days per decade
- prevailing POSITIVE trends
  → few sign. in MAX; prevailing sign. in Mean – Reg 5 & 6
### Results → trends

<table>
<thead>
<tr>
<th></th>
<th>SON</th>
<th>DJF</th>
<th>MAM</th>
<th>JJA</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAX</strong></td>
<td>−</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>0 (R7)</td>
<td>0 (R7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SIGN. Reg.</strong></td>
<td>4</td>
<td></td>
<td>5, 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>SIGN. Reg.</strong></td>
<td>5, 6</td>
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<td></td>
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</tr>
</tbody>
</table>
Results → partial trends

- MAX & Mean DS → similar results
- **1986-2010** (y axis) vs **1961-1985** (x axis)
- prevailing POSITIVE trends in recent period → Adriatic coastal (Reg 5, 6, 7)
- trend is not clear → continental & mountainous regions (Reg 1 – 4)
- **SUMMER** → increase in DS duration (especially for 2\textsuperscript{nd} period, ▼♦)
  → in agreement with general reduction of the total precipitation amount in RegCM4 projections

- **WINTER** → no clear signal

- Reg 3 & 4 → the **driest** one → diversity of Croatia is well captured in models

- Station Rijeka in Reg 5

- **HA** → the **driest** one

- **CN** → the **wettest** one
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(Future) – (Present) → DS (2\textsuperscript{nd} period, $\Delta$) > DS (1\textsuperscript{st} period, $\circ$)

DS (RCP4.5) $\approx$ DS (RCP8.5)
<table>
<thead>
<tr>
<th>Regions</th>
<th>Observation</th>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region’s mean</td>
<td>1 grid cell in region</td>
<td></td>
</tr>
<tr>
<td>Continental (1,2,4)</td>
<td>SON, DJF</td>
<td>MAM, JJA</td>
</tr>
<tr>
<td>Adriatic coastal (3,5-7)</td>
<td>JJA</td>
<td>MAM, JJA</td>
</tr>
</tbody>
</table>

Drier parts of the year
**Conclusion**

- **DRY SPELL analysis**
  - MAX & Mean, seasonal & annual timescale, 7 regions in Croatia
  - the **shortest** DS → in mountainous region
  - the **largest** DS → in continental (SON, DJF) & Adriatic region (MAM, JJA)
  - significant **positive** trend → in mountainous region in MAM, JJA
  - consistent **negative** trend → in SON in whole Croatia, **sign**. in mountainous region
- Climate models indicate DS **increase** in SUMMER, particularly for later period
- DS (2\(^{nd}\) period) > DS (1\(^{st}\) period)
- DS (RCP4.5) ≈ DS (RCP8.5)

- **Future work** → to include more RCMs (CLM & RCA4) in analysis to estimate uncertainties related to the selection of the RCM-GCM couple
Thank you for your attention!

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Drought on island Korčula, Croatia, 2017

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15 -16 November, Zagreb, Croatia
“U izradi ovog dokumenta korišteni su rezultati regionalnog klimatskog modela RegCM4 dobiveni u sklopu projekta „Jačanje kapaciteta Ministarstva zaštite okoliša i energetike za prilagodbu klimatskim promjenama te priprema Nacrta Strategije prilagodbe klimatskim promjenama (Broj ugovora: TF/HR/P3-M1-O1-010)” koji se financira sredstvima iz Prijelaznog instrumenta tehničke pomoći EU.”