Extreme Events in the Arab Region: Case of Cold Waves and Heat Waves in Tunisia

Pr. Dr. Habib BEN BOUBAKER
University of Tunis
Chairman Ass. Tunisian Geographers

5th Expert Group Meeting on the Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR). Amman, 11-12 december 2013
Plan

• 1. Methodological development

• 2. Results: Risks and Trends

• 3. Vulnerability and socio-economic impacts related to CC
Introduction: Methodological development

• 1. Data and indicators?
  – Daily observations: Day / night
  – 3 hours observations
  – ambient indicators: $T^\circ$ / Humidity / wind ...

• 2. What relevant thresholds?
  • ➔ most thresholds and approaches are designed in cold countries ➔ Are they suitable for hot countries???
I. Strong heats and Heat waves
I. Methodological development

I.1. Thresholds adapted to a hot country

It is essential to combine day and night $T^\circ$:

- 3 items: Hot days: *hot, very hot, torrid*

<table>
<thead>
<tr>
<th>TN</th>
<th>TX</th>
<th>33°C</th>
<th>34°C</th>
<th>35°C</th>
<th>36°C</th>
<th>37°C</th>
<th>38°C</th>
<th>39°C</th>
<th>40°C</th>
<th>41°C</th>
<th>42°C</th>
<th>43°C</th>
<th>44°C</th>
<th>45°C</th>
<th>&gt;=46°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°C</td>
<td>26,5</td>
<td>27</td>
<td>27,5</td>
<td>28</td>
<td>28,5</td>
<td>29</td>
<td>29,5</td>
<td>30</td>
<td>30,5</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>21°C</td>
<td>27</td>
<td>27,5</td>
<td>28</td>
<td>29</td>
<td>29,5</td>
<td>30</td>
<td>30,5</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33,5</td>
<td>34</td>
<td>34,5</td>
</tr>
<tr>
<td>22°C</td>
<td>27,5</td>
<td>28</td>
<td>29</td>
<td>29,5</td>
<td>30</td>
<td>30,5</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33,5</td>
<td>34</td>
<td>34,5</td>
<td>35</td>
</tr>
<tr>
<td>23°C</td>
<td>28</td>
<td>29</td>
<td>29,5</td>
<td>30</td>
<td>30,5</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33,5</td>
<td>34</td>
<td>34,5</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>24°C</td>
<td>28,5</td>
<td>29</td>
<td>29,5</td>
<td>30</td>
<td>30,5</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33,5</td>
<td>34</td>
<td>34,5</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>25°C</td>
<td>29</td>
<td>29,5</td>
<td>30</td>
<td>30,5</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33,5</td>
<td>34</td>
<td>34,5</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26°C</td>
<td>29,5</td>
<td>30</td>
<td>30,5</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33,5</td>
<td>34</td>
<td>34,5</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27°C</td>
<td>30</td>
<td>30,5</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33,5</td>
<td>34</td>
<td>34,5</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28°C</td>
<td>30,5</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33,5</td>
<td>34</td>
<td>34,5</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;=29°C</td>
<td>31</td>
<td>31,5</td>
<td>32</td>
<td>32,5</td>
<td>33</td>
<td>33,5</td>
<td>34</td>
<td>34,5</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Légende

- Moyenne $TM$ ($=TX+TN)/2$
- Journée

| >= 33,5°C | Torride |
| 30° à 33°C | Très forte chaleur |
| 26,5° à 29,5°C | Forte chaleur |
I.2. Hot days: Results

Annual average frequency of hot days (Nb. D. / year)
Frequency of heat waves (duration ≥ 7d.) according to their intensity and persistence (Observed 1968-2008)

(source : Ben Boubaker H, 2011)
A warming trend? 
Inter-annual frequency of **hot days**
Modeling extreme temperature records:

*Gumbel* law: return periods

![Graph of temperature return periods]

Figure 5: Période de retour des températures maximales extrêmes les plus élevées à Sidi Bouzid (observations de 1964-2008)

Figure 6: Période de retour des températures minimales extrêmes les plus élevées à Sidi Bouzid (observations de 1964-2008)
II. Cold waves

II.1. Thresholds adapted to a hot country

Cold days:
- Fresh days,
- quit cold days,
- cold days,
- very cold days

<table>
<thead>
<tr>
<th>TN</th>
<th>TX</th>
<th>≤ 0°C</th>
<th>1°C</th>
<th>2°C</th>
<th>3°C</th>
<th>4°C</th>
<th>5°C</th>
<th>6°C</th>
<th>7°C</th>
<th>8°C</th>
<th>9°C</th>
<th>10°C</th>
<th>11°C</th>
<th>12°C</th>
<th>13°C</th>
<th>14°C</th>
<th>15°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤-5,0°C</td>
<td>-2,5</td>
<td>-2,0</td>
<td>-1,5</td>
<td>-1,0</td>
<td>-0,5</td>
<td>0,0</td>
<td>0,5</td>
<td>1,0</td>
<td>1,5</td>
<td>2,0</td>
<td>2,5</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td></td>
</tr>
<tr>
<td>-4°C</td>
<td>-2,0</td>
<td>-1,5</td>
<td>-1,0</td>
<td>-0,5</td>
<td>0,0</td>
<td>0,5</td>
<td>1,0</td>
<td>1,5</td>
<td>2,0</td>
<td>2,5</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td>5,5</td>
<td></td>
</tr>
<tr>
<td>-3°C</td>
<td>-1,5</td>
<td>-1,0</td>
<td>-0,5</td>
<td>0,0</td>
<td>0,5</td>
<td>1,0</td>
<td>1,5</td>
<td>2,0</td>
<td>2,5</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td>11,0</td>
<td>12,0</td>
<td></td>
</tr>
<tr>
<td>-2°C</td>
<td>-1,0</td>
<td>-0,5</td>
<td>0,0</td>
<td>0,5</td>
<td>1,0</td>
<td>1,5</td>
<td>2,0</td>
<td>2,5</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td>11,0</td>
<td>12,0</td>
<td>13,0</td>
<td></td>
</tr>
<tr>
<td>-1°C</td>
<td>-0,5</td>
<td>0,0</td>
<td>0,5</td>
<td>1,0</td>
<td>1,5</td>
<td>2,0</td>
<td>2,5</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td>5,5</td>
<td>6,0</td>
<td>6,5</td>
<td>7,0</td>
<td></td>
</tr>
<tr>
<td>0°C</td>
<td>0,0</td>
<td>0,5</td>
<td>1,0</td>
<td>1,5</td>
<td>2,0</td>
<td>2,5</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td>5,5</td>
<td>6,0</td>
<td>6,5</td>
<td>7,0</td>
<td>7,5</td>
<td></td>
</tr>
<tr>
<td>1°C</td>
<td>0,0</td>
<td>1,5</td>
<td>2,0</td>
<td>2,5</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td>5,5</td>
<td>6,0</td>
<td>6,5</td>
<td>7,0</td>
<td>7,5</td>
<td>8,0</td>
<td>8,5</td>
<td></td>
</tr>
<tr>
<td>2°C</td>
<td>2,0</td>
<td>2,5</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td>5,5</td>
<td>6,0</td>
<td>6,5</td>
<td>7,0</td>
<td>7,5</td>
<td>8,0</td>
<td>8,5</td>
<td>9,0</td>
<td>9,5</td>
<td></td>
</tr>
<tr>
<td>3°C</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td>5,5</td>
<td>6,0</td>
<td>6,5</td>
<td>7,0</td>
<td>7,5</td>
<td>8,0</td>
<td>8,5</td>
<td>9,0</td>
<td>9,5</td>
<td>10,0</td>
<td>10,5</td>
<td></td>
</tr>
<tr>
<td>4°C</td>
<td>4,0</td>
<td>4,5</td>
<td>5,0</td>
<td>5,5</td>
<td>6,0</td>
<td>6,5</td>
<td>7,0</td>
<td>7,5</td>
<td>8,0</td>
<td>8,5</td>
<td>9,0</td>
<td>9,5</td>
<td>10,0</td>
<td>10,5</td>
<td>11,0</td>
<td>11,5</td>
<td></td>
</tr>
<tr>
<td>5°C</td>
<td>5,0</td>
<td>5,5</td>
<td>6,0</td>
<td>6,5</td>
<td>7,0</td>
<td>7,5</td>
<td>8,0</td>
<td>8,5</td>
<td>9,0</td>
<td>9,5</td>
<td>10,0</td>
<td>10,5</td>
<td>11,0</td>
<td>11,5</td>
<td>12,0</td>
<td>12,5</td>
<td></td>
</tr>
<tr>
<td>6°C</td>
<td>6,0</td>
<td>6,5</td>
<td>7,0</td>
<td>7,5</td>
<td>8,0</td>
<td>8,5</td>
<td>9,0</td>
<td>9,5</td>
<td>10,0</td>
<td>10,5</td>
<td>11,0</td>
<td>11,5</td>
<td>12,0</td>
<td>12,5</td>
<td>13,0</td>
<td>13,5</td>
<td></td>
</tr>
<tr>
<td>7°C</td>
<td>7,0</td>
<td>7,5</td>
<td>8,0</td>
<td>8,5</td>
<td>9,0</td>
<td>9,5</td>
<td>10,0</td>
<td>10,5</td>
<td>11,0</td>
<td>11,5</td>
<td>12,0</td>
<td>12,5</td>
<td>13,0</td>
<td>13,5</td>
<td>14,0</td>
<td>14,5</td>
<td></td>
</tr>
<tr>
<td>8°C</td>
<td>8,0</td>
<td>8,5</td>
<td>9,0</td>
<td>9,5</td>
<td>10,0</td>
<td>10,5</td>
<td>11,0</td>
<td>11,5</td>
<td>12,0</td>
<td>12,5</td>
<td>13,0</td>
<td>13,5</td>
<td>14,0</td>
<td>14,5</td>
<td>15,0</td>
<td>15,5</td>
<td></td>
</tr>
<tr>
<td>9°C</td>
<td>9,0</td>
<td>9,5</td>
<td>10,0</td>
<td>10,5</td>
<td>11,0</td>
<td>11,5</td>
<td>12,0</td>
<td>12,5</td>
<td>13,0</td>
<td>13,5</td>
<td>14,0</td>
<td>14,5</td>
<td>15,0</td>
<td>15,5</td>
<td>16,0</td>
<td>16,5</td>
<td></td>
</tr>
<tr>
<td>10°C</td>
<td>10,0</td>
<td>10,5</td>
<td>11,0</td>
<td>11,5</td>
<td>12,0</td>
<td>12,5</td>
<td>13,0</td>
<td>13,5</td>
<td>14,0</td>
<td>14,5</td>
<td>15,0</td>
<td>15,5</td>
<td>16,0</td>
<td>16,5</td>
<td>17,0</td>
<td>17,5</td>
<td>18,0</td>
</tr>
</tbody>
</table>

Légende

Moyenne (TX+TN)/2  Journée
< 2,5°C  Très froid
2,5°C à 4,5°C  Froid
5,0°C à 7,0°C  Assez Froid
7,5°C à 10,0°C  Frais
Annual average and monthly frequency of cold days (all categories) in Tunisia (1950-2008)
**Winter warming trend?**

*Inter-annual frequency of cold days*

Tendance (Tunis-C):

\[ y = -0.2188x + 23.309 \]

\[ R^2 = 0.1718 \]

Nombre de jours froids (toutes catégories)/an

- Tunis-C
- Sfax
- Tabarka
- Jerba

Nombre de jours froids (toutes catégories)/an

- Jendouba
- Kef
- Kairouan
- Bouzid
- Thala
II.2. Synthesis results
A warming trend confirmed?
Interannual variability in types of biothermic ambiances ($T^\circ$, RH, Wind)
Impacts affecting: Water resources, agriculture, vegetation, health, ...

Annual average frequency of days depending on the categories of heating and cooling in Tunisia (moy.1968-2008)
Length of the extreme Saisons: what tendency?
III. Socio-economic impacts

• Impacts on:
  – Environment
  – Natural resources
  – Health, ...

• But:

• *Differentiel adaptative capacity and resilience*
Strong heats as well as Cooling ➔ ... kill ....

Monthly average mortality regime in Tunis

Decadal average temperatures (TX+TN) for days and torrid heat very strong and effective decadal average death (all ages combined) in Gabes (1991-07)
Strong heats kill .... Exp: summer 2003

Températures (Tunis-C) et effectifs de décès au gouvernorat de Tunis (1er mai au 31 octobre 2003, échelle moy. Mobile décadaire)

Températures (station de Monastir) et effectifs de décès au gouvernorat de Monastir du 1er mai au 31 octobre 2003 (échelle moy. mobile décadaire)
Strong heats can be responsible of reemerging diseases: Exp. Of in SBZ (Tunisia):

Total yearly frequency of cases of ZCL and hot days (all categories combined)
Rate equipment of households in air conditioners and poverty rates

Taux d’équipement des ménages en climatiseurs

Taux de ménages pauvres

(source: Lamine, 2009)

Differentiel resilience capacity

No equality face to natural diseases, face to death, …
High temperatures particularly morbid and deadly in large cities: Case of Greater Tunis

- Spatially, the equipment of households in air conditioners rate moves in the opposite direction to that of poor households.

- We deduce the greatest socio-economic vulnerability of the poorest social classes, which combines a natural vulnerability already shared with the rest of the population.
Conclusions

- Urgency for the Arab region to:
  - contribute to the **struggle against the sources** of CC
  - build capacity for:
    - **Prevention**
    - **Adaptation**

- This requires strategies for strengthening:
- The skills, knowledge, scientific research, cooperation between neighboring countries (groups / sub-groups)
- initiatives undertaken by RICCAR represent opportunities not to be missed
Thank you for your attention

Habib BEN BOUBAKER
hboubaker@yahoo.fr