Spatiotemporal characterization of very long dry spells in the Mediterranean region

Florian RAYMOND¹, Albin ULLMANN¹, Pierre CAMBERLIN¹ & Philippe DROBINSKI²

¹ CRC, Biogéosciences, CNRS/University of Burgundy, Dijon, France (florian.raymond@u-bourgogne.fr)
² IPSL/LMD, Palaiseau and Paris, France

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Context

Does it rain less or does it rain less often?

How much weather control dry spells?
- Lack of Mediterranean global analyzes (actually, mainly in eastern part)

Saaroni et al. (2015)

Change in cold season precipitation for the period 1971–2010 minus 1902–70

How much winter dry spells impacts environment and society?

John Mccolgan/US Forest Service  BBC  waterforourcentury
Objectives

Very Long Dry Spells events variability during the second half of the 20\textsuperscript{th} century: where (location), when (seasonality), how much (frequency), how long (duration) and why (associated conditions)?

\textbf{Very Long Dry Spells event are considered as an \textit{Object}}
(spatial and temporal grid-point grouping)

\textbf{Winter period = \textit{“rainy season”} > September to April.}

2 axes developed for the current conditions:

1. focus on the Very Long Dry Spells events (VLDS) for the 1979-2013 period:
   - detection of Very Long Dry Spells events;
   - VLDS characteristics;
   - classification (HAC) into main kinds of VLDS events;
   - analyze of the main atmospheric forcings.

2. capacity of the MED-CORDEX runs to reproduce VLDS events (1979-2009):
   - the 80\textsuperscript{th} centile value on models;
   - detection of VLDS events on models;
   - models VLDS classifications.
Daily grid point data series

- **1979-2013**:  
  - E-OBS v10.0 (European Climate Assessment & Dataset) daily precipitation amount (0.25° resolution).
  - ERA-INTERIM reanalysis (European Center for Medium range Weather Forecasting) Sea Level Pressure and Z500 Geopotential (1° resolution).

- **1979-2009**: MED-CORDEX runs evaluated

<table>
<thead>
<tr>
<th>Platform</th>
<th>Resolution</th>
<th>RCM</th>
<th>Coupled</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNRM</td>
<td>MED-44</td>
<td>ALADIN 52</td>
<td>-</td>
<td>1979-2011</td>
</tr>
<tr>
<td>ICTP</td>
<td>MED-44</td>
<td>RegCM4 v4</td>
<td>-</td>
<td>1979-2012</td>
</tr>
<tr>
<td>CMCC</td>
<td>MED-44</td>
<td>CCLM4</td>
<td>-</td>
<td>1979-2012</td>
</tr>
<tr>
<td>LMDZ</td>
<td>MED-44</td>
<td>LMDZ4</td>
<td>-</td>
<td>1979-2009</td>
</tr>
<tr>
<td>LMDZ</td>
<td>MED-44</td>
<td>LMDZ4</td>
<td>NEMOMED8</td>
<td>1979-2009</td>
</tr>
</tbody>
</table>

The MED-CORDEX resolution have been adapted to the E-OBS grid (0.25°)
1.1. How to detect Very Long Dry Spells events? (1/2)

Method:

- dry spells length → number of consecutive dry days;
- unique value of dry spells length;

- **Very Short Dry Spells**: $\text{VSDS} < 20^{\text{th}} \text{ centile}$;
- **Short Dry Spells**: $20^{\text{th}} \text{ centile} < \text{SDS} < 40^{\text{th}} \text{ centile}$;
- **Medium Dry Spells**: $40^{\text{th}} \text{ centile} < \text{MDS} < 60^{\text{th}} \text{ centile}$;
- **Long Dry Spells**: $60^{\text{th}} \text{ centile} < \text{LDS} < 80^{\text{th}} \text{ centile}$;
- **Very Long Dry Spells**: $\text{VLDS} > 80^{\text{th}} \text{ centile}$;

**Example:**

Grid Point n°8977
(40.125°N & 21.125°E)
1.1. How to detect Very Long Dry Spells events? (2/2)

**Binary matrix to select VLDS:**

- **value “0”** > rainy grid points or grid points where dry spells are shorter than the 80th centile;
- **value “1”** > all grid points belonging to dry spells longer than the 80th centile.

**Sliding scan to obtain spatially and temporally coherent events:**

- to the 8228 days:
  - square of 6 degree longitude/latitude;
  - sliding by 0.5° longitude/latitude increment;
  - sea grid point not taken into account.

**VLDS day:** if 90% of the grid points contained in at least one square have the value “1”.

**VLDS event “object” is characterized by location, spatial extension, duration and associated atmospheric conditions.**

Adapted from Stefanon et al., 2012
1.2. Very Long Dry Spells events characteristics

62 VLDS spread throughout 7 Mediterranean sub-regions (102 location of events)

<table>
<thead>
<tr>
<th>Region</th>
<th>Events</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maghreb</td>
<td>19</td>
<td>56 days</td>
</tr>
<tr>
<td>Iberian Peninsula</td>
<td>23</td>
<td>53 days</td>
</tr>
<tr>
<td>France &amp; Italy</td>
<td>9 &amp; 4</td>
<td>53.7 &amp; 48 days</td>
</tr>
<tr>
<td>Balkans</td>
<td>15</td>
<td>48.2 days</td>
</tr>
<tr>
<td>Anatolia</td>
<td>14</td>
<td>59.9 days</td>
</tr>
<tr>
<td>Middle East</td>
<td>16</td>
<td>61.6 days</td>
</tr>
</tbody>
</table>

Number of events beginning in September:

- Maghreb: 5
- Iberian Peninsula: 4
- France & Italy: 2
- Balkans: 6
- Anatolia: 10
- Middle East: 16
1.3. Very Long Dry Spells classification

62 VLDS events for total duration of 2822 days. 12 of these events are classified as “multiple” event: 2 or more events occur in the same day in different locations.

Multiple events regrouped in single events > 62 to 48 events.

Hierarchical clustering applied to the median day of each of the 48 events.

Class 1
North-West Mediterranean
6 events
10.6% of 2822 VLDS days

Class 2
West Mediterranean
5 events
14.7% of 2822 VLDS days

Class 3
Generalized
19 events
31.8% of 2822 VLDS days

Class 4
North-East Mediterranean
5 events
13.1% of 2822 VLDS days

Class 5
South-East Mediterranean
13 events
29.8% of 2822 VLDS days
1.4. Very Long Dry Spells atmospheric forcing (1/2)

The 3 smallest clusters

North-West Mediterranean

9.7%
Of the VLDS

West Mediterranean

12.9%
Of the VLDS

North-East Mediterranean

16.1%
Of the VLDS

Context and Objectives

Data

Results

Conclusion & Perspectives

VLDS in the North-West, West and North-East Mediterranean classes associated with z500 and SLP positive anomalies; anticyclonic conditions.
1.4. Very Long Dry Spells atmospheric forcing (2/2)

Generalized class associated with slightly z500 and SLP positive anomalies (anticyclonic conditions); > many events in different localizations.

South-East class associated with z500 positive anomalies but SLP negative anomalies; heat low conditions?
2.1. Models capacity to reproduce the 80\textsuperscript{th} centile value

- rainy day: 1mm threshold ;
- 80\textsuperscript{th} centile on the unique value of dry spells length.

CCLM4 slightly overestimates the 80th centile length

On the contrary, the other models slightly underestimate the 80\textsuperscript{th} centile length

All models overestimate the 80\textsuperscript{th} centile length in the south of Middle East: problem with the models or E-OBS data?
2.2. Models capacity to detect the VLDS events (1/2)

<table>
<thead>
<tr>
<th></th>
<th>E-obs</th>
<th>CCLM4</th>
<th>RegCM4 v4</th>
<th>ALADIN_52</th>
<th>LMDZ4</th>
<th>LMDZ4NEMOMED8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of events detected</td>
<td>56</td>
<td>57</td>
<td>45</td>
<td>49</td>
<td>55</td>
<td>58</td>
</tr>
<tr>
<td>Including multiple events</td>
<td>11</td>
<td>10</td>
<td>7</td>
<td>8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Average number of events</td>
<td>1.87</td>
<td>1.9</td>
<td>1.5</td>
<td>1.63</td>
<td>1.83</td>
<td>1.93</td>
</tr>
<tr>
<td>Total location of events</td>
<td>92</td>
<td>128</td>
<td>89</td>
<td>97</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>Average number of sub-regions</td>
<td>1.64</td>
<td>2.25</td>
<td>1.98</td>
<td>1.98</td>
<td>1.91</td>
<td>1.81</td>
</tr>
</tbody>
</table>

All the models overestimate the spatial extension of the VLDS events.

Mean duration of the events per Mediterranean sub-regions

<table>
<thead>
<tr>
<th>Sub-region</th>
<th>E-obs</th>
<th>CCLM4</th>
<th>RegCM4 v4</th>
<th>ALADIN_52</th>
<th>LMDZ4</th>
<th>LMDZ4NEMOMED8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iberian Peninsula</td>
<td>54.7</td>
<td>59.8</td>
<td>53.9</td>
<td>47.6</td>
<td>50</td>
<td>52.4</td>
</tr>
<tr>
<td>Maghreb</td>
<td>57.1</td>
<td>62.1</td>
<td>60.5</td>
<td>55.6</td>
<td>52.8</td>
<td>57.4</td>
</tr>
<tr>
<td>France</td>
<td>56.7</td>
<td>67.6</td>
<td>58.9</td>
<td>62.7</td>
<td>54</td>
<td>45.3</td>
</tr>
<tr>
<td>Italy</td>
<td>48</td>
<td>60.4</td>
<td>38.7</td>
<td>49</td>
<td>35.5</td>
<td>38.7</td>
</tr>
<tr>
<td>Balkans</td>
<td>44.7</td>
<td>62.4</td>
<td>41.5</td>
<td>41.7</td>
<td>49.1</td>
<td>43.6</td>
</tr>
<tr>
<td>Anatolia</td>
<td>57.1</td>
<td>72.5</td>
<td>55.4</td>
<td>48.7</td>
<td>81</td>
<td>75.1</td>
</tr>
<tr>
<td>Middle East</td>
<td>62.3</td>
<td>77.1</td>
<td>54.5</td>
<td>49.1</td>
<td>84</td>
<td>79.3</td>
</tr>
</tbody>
</table>

56 underestimate 56 overestimate 56 within the uncertainty range
2.2. Models capacity to detect the VLDS events (2/2)

Do the models reproduce the seasonality of the events?

Models seems to pretty good reproduce the non-seasonality/seasonality of the VLDS events for the 7 Mediterranean Sub-regions
### 2.3. Models capacity to detect the same 5 clusters as the E-OBS? (1/2)

<table>
<thead>
<tr>
<th></th>
<th>E-OBS</th>
<th>CCLM4</th>
<th>Reg_CM4</th>
<th>ALADIN_52</th>
<th>LMDZ4</th>
<th>LMDZ4 NEMOMED8</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-West Med.</td>
<td>6 events (12.5%)</td>
<td>5 events (10.4%)</td>
<td>12 events (32.4%)</td>
<td>6 events (14.6%)</td>
<td>8 events (18.2%)</td>
<td>9 events (18.7%)</td>
</tr>
<tr>
<td>West Med.</td>
<td>5 events (10.4%)</td>
<td>5 events (10.8%)</td>
<td>12 events (32.4%)</td>
<td>6 events (14.6%)</td>
<td>8 events (18.2%)</td>
<td>9 events (18.7%)</td>
</tr>
<tr>
<td>Generalized</td>
<td>19 events (39.6%)</td>
<td>[ ]</td>
<td>[ ]</td>
<td>26 events (63.4%)</td>
<td>14 events (31.8%)</td>
<td>15 events (31.2%)</td>
</tr>
<tr>
<td>North-East Med.</td>
<td>5 events (10.4%)</td>
<td>8 events (17.4%)</td>
<td>8 events (21.6%)</td>
<td>6 events (13.6%)</td>
<td>7 events (14.5%)</td>
<td></td>
</tr>
<tr>
<td>South-East Med.</td>
<td>13 events (27.1%)</td>
<td>10 events (21.7%)</td>
<td>[ ]</td>
<td>3 events (7.3%)</td>
<td>10 events (22.7%)</td>
<td>15 events (31.2%)</td>
</tr>
</tbody>
</table>

Classification in models VLDS don’t separate North-West cluster and West cluster as in E-OBS.
2.3. Models capacity to detect the same 5 clusters as the E-OBS? (2/2)

2 news clusters created by the VLDS models classification

CCLM4

ALADIN_52

Reg_CM4

Global events

3 events

2 events

1 event

LMDZ4

Reg_CM4

Anatolian events

6 events

4 events

Percent of events concerning each grid points
Conclusion & Perspectives

Conclusion:

- There are little number of VLDS events detected (48 single events) for the 1979-2013 period to the E-OBS data (> difficulty to observe evolutions) but they represented 34% of the studied days;
- Rainy season in the Middle East (from November to March) may explain the seasonality of the VLDS events in the Eastern part of the Mediterranean Basin;
- Strongly anticyclonic conditions mainly explain the VLDS events presence in almost all the Mediterranean Basin, except to the Middle-East;
- Models strongly overestimate the length of 80\textsuperscript{th} centile value in the South of the Middle East compare to the E-OBS data:
  - CCLM4, LMDZ4 and LMDZ4NEMOMED8 strongly overestimate the duration of VLDS in Middle East and Anatolia;
- CCLM4, ALADIN\textsubscript{52} and Red_CM4 models showed “global” event, located almost to the entire Mediterranean Basin;
- The 5 models overestimate the special extension of the VLDS events compare to the E-OBS data;

Perspectives:

- Apply the method to the models historical runs and to the models RCP4.5 and RCP8.5 runs (daily precipitation data);
- Do the same work to the Long Dry Spells events (60\textsuperscript{th} centile < LDS < 80\textsuperscript{th} centile).
Thanks’ for your attention.