WP5 - INDICES TIME EVOLUTION AND RELATIONS WITH THE ATMOSPHERE

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Albert Osso, Philip Craig (also Len Shaffrey, Emily Black, Ed Hawkins)
WP5 - Indices Time Evolution & Relations with Atmosphere

**Aim:** quantify variability/change in indices and establish link to atmospheric circulation patterns

**Deliverables:**
- Inventory and Catalogue of Indicators of circulation variability for comparison with the INDECIS-ISD
- Report on temporal evolution of the INDECIS-QCHDS and INDECIS-ISD, including the time-emergence of climate-change signals and relation with atmospheric patterns
- Report on the relation between INDECIS-QCHDS and INDECIS-ISD and atmospheric patterns

Compile teleconnection indices
- Evaluate physical linkages between atmospheric variability, extremes & sectorial indices

Analyse temporal evolution of INDECIS-QCHDS/ISDs
- Investigate time-emergence of observed climate change signal

WP 2, 3, 4

WP 6, 7
Observed and thermodynamically driven total precipitation (RT) tendency (Osso et al, Univ Reading)

- WP5.2 delivered; WP5.3 under development (Osso)
- Atmos circulation precursors to extreme UK rainfall (Allan)
- Time of emergence of INDECIS variables and comparison with climate models (paper) (Osso, Hawkins, All)
- Links between INDECIS variables and atmospheric circulation patterns: thermodynamic/dynamic components (Osso, All)
- New plans based on this meeting (Craig/Osso/All)

\[
I_{\text{obs}}(t) = \sum_{i=1}^{i=8} \beta_i P_{\text{Ci}}(t) + \varepsilon(t)
\]

1. Indices anomalies: \(I_{\text{obs}}(t)\)
2. Modes of atmospheric variability: \(P_{\text{Ci}}(t)\)
3. Error term: \(\varepsilon(t)\) ~ non-dynamic contributions to \(I_{\text{obs}}(t)\).

**Observed tendency (DJF)**

**Thermodynamic tendency (DJF)**

**Scandinavian RT anomalies (DJF)**

- 2.6 ± 0.7
- 1.2 ± 0.6
- 1.4 ± 0.4
UC/ICH – trends and links with atmospheric teleconnections

![Regression coefficients for RR1 ~ NAO (days/season)](image)

Fig. 7 Regression coefficients for RR1 ~ NAO (days/season). Statistically significant values (p-value < 0.05) are depicted in purple.

The most important relationships between RR1 and EA are found in western Europe in winter, in the Atlantic watershed in spring and in the British Isles and southern Norway in summer (Fig. 8). Some negative correlations are found in the eastern Mediterranean area.
Surface responses for blocking and ridge regimes

Heat extremes and atmospheric patterns (Aug 18, Jun/Jul 19) (Sousa, Trigo)

Ongoing: New automated blocking – ridge detection scheme

FFCUL: Surface responses for blocking and ridge regimes

Opposite responses all year round:

**Ridge**
- wet north
- dry south

**Block**
- dry north
- wet south

Rainfall

blocks

ridges
Extreme heat episodes in Central Europe – June/July 2019

June 2019
First time ever that France registered >45ºC

July 2019
First time ever that Belgium & Netherlands registered >40ºC

Since the historical 2003 heatwave, summer mean temperatures have increased >1ºC in Europe.

In just 15 years!!!

Frequency of new records has been increasing over and over

Continuous temperatures rises at European and Global scales!
BSC: Indices relationship with the Euro-Atlantic circulation patterns (Capacity Factor at tall towers) (Soret et al)

Indices relationship with the Euro-Atlantic circulation patterns (Capacity Factor at tall towers)
CNR-DTA: methods to evaluate trends in TRMM precipitation over Italy

Negative trend of precipitation in central-eastern Italy

Shift from Autumn to Winter for north-western Italy

Tommaso Caloiero, Giulio N. Caroletti & Roberto Coscarelli
Further studies: changes in precipitation response to teleconnections through time

E.g., comparing correlation results from 1951-1980 with those from 1981-2010

<table>
<thead>
<tr>
<th>Indicator</th>
<th>1951-1980</th>
<th>1981-2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAO</td>
<td>12 (1)</td>
<td>17 (0)</td>
</tr>
<tr>
<td>MOI</td>
<td>9 (2)</td>
<td>16 (2)</td>
</tr>
<tr>
<td>ONI/ENSO</td>
<td>16 (0)</td>
<td>10 (0)</td>
</tr>
<tr>
<td>WeMOI</td>
<td>17 (0)</td>
<td>15 (0)</td>
</tr>
<tr>
<td>EA</td>
<td>16 (1)</td>
<td>12 (0)</td>
</tr>
<tr>
<td>EA/WR</td>
<td>17 (1)</td>
<td>13 (0)</td>
</tr>
<tr>
<td>SCAND</td>
<td>21 (1)</td>
<td>11 (1)</td>
</tr>
</tbody>
</table>

Number of months(#) when a teleconnection (left) has the strongest correlation with monthly precipitation (and, in brackets, the number of months when this correlation is equal or above 0.4). **Tirreno 2 rain zone**: 1951-1980 (center), 1981-2010 (right).

Giulio N. Caroletti, Roberto Coscarelli & Tommaso Caloiero
RMI plans for WP5

Van de Vyver, Van Schaeybroeck

- So far:
  - Methodology to study sub-hourly rainfall extremes (IDF & relation with temperature, based on observations)

- Next step 1:
  - Validation based on methodology of sub-hourly rainfall extremes of convective-permitting models (WIP)

- Next step 2:
  - Projected trends in modeled sub-hourly rainfall extremes
Publications

- Hawkins et al. Submitted paper on Time of Emergence
WP5 ongoing work/plans

- **UREAD**: WP5.2 delivered; WP5.3 under development (Osso)
  - Atmos circulation precursors to extreme UK rainfall (Allan)
  - Time of emergence of INDECIS variables and comparison with climate models (paper) (Osso, Hawkins, All)
  - Links between INDECIS variables and atmospheric circulation patterns: thermodynamic/dynamic components (Osso, All)
  - New plans based on this meeting (Craig/Osso/All)
- **BSC**: Indices relationship with the Euro-Atlantic circulation patterns (Capacity Factor at tall towers) (Soret et al)
- **CNR**: Time evolution/trends in precipitation-Italy (Caroletti/Coscarelli/Caloiero)
  - changes in precipitation response to teleconnections through time
- **UC/IHC**: trends and links with atmospheric teleconnections
  Casanueva/Bedia/Herrera/Frías/Fernández/Cofiño/Gutiérrez/del Jesús/Espejo/Izaguirre/Bueno
- **FFCUL**: Surface responses for blocking and ridge regimes, heat extremes and atmospheric patterns (Aug 18, Jun/Jul 19) (Sousa, Trigo)
  - Ongoing: New automated blocking – ridge detection scheme
- **RMIB**: Methodology to study sub-hourly rainfall extremes (IDF & relation with temperature, based on observations) (Van de Vyver, Van Schaeybroeck)
  - Validation based on methodology of sub-hourly rainfall extremes of convective-permitting models (WIP)
  - Projected trends in modelled sub-hourly rainfall extremes
Summary/Actions

• D5.2 on time variability and time of emergence ready
• D5.3 on links with atmospheric circulation well advanced, can be updated to final datasets
• Albert Osso leaves Reading for Graz but continues in WP5; hiring of new researcher Philip Craig underway
• Focus on key publications: emphasis on opportunities for collaborative work
  – e.g. UoReading/UCR to on variability in sectoral indices and atmospheric circulation including blocking/weather typing
  – Link WP5/WP6 by including reanalysis products (e.g. dynamic/thermodynamic components of change; time of emergence of extremes in observations and models
  – Agree on set of standard and non-standard/sectorial relevant metrics to analyse (extreme precipitation, fire, snow, ...)
  – How can WP5 more toward what sectors want? Need input
  – Coordinated analysis of wind power (WP4/5/6)?
Extra WP5 slides from University of Reading

Albert Ossó, Richard Allan, Len Shaffrey, Ed Hawkins and Emily Black
Observed emergence of the climate change signal of extreme events

Motivation

- Changes in climate are usually considered in terms of trends or differences over time. However, for many impacts which will require adaptation, it is the amplitude of the change relative to the local amplitude of climate variability which is more relevant.

- Signal-to-noise (S/N) is important for climate impacts, especially for ecosystems which have a limited ability to adapt and so large changes outside past experience could be particularly harmful.
Methodology

\[ L(t) = \alpha TsG(t) + \beta \]

\( L(t) \) is the local change over time, \( TsG(t) \) is a smoothed version of GMST change over the same period, \( \alpha \) defines the linear scaling between \( L \) and \( TsG \), and \( \beta \) is a constant.

The ‘signal’ of global temperature change is defined as the value of the smoothed GMST in 2017, the component of local climate change explained by GMST is \( \alpha G \) and the ‘noise’ is defined as the standard deviation of the residuals \( (L - \alpha G) \).

We use the INDECIS indices, HadCRU4 and CMIP6 (historical + rcp4.5) for the period (1950-2017).
We adopt the language of Frame et al. [2017]:

S/N<2 Familiar climate.

S/N>2 Unusual climate.

S/N>3 Unknown climate.

S/N>5 Inconceivable climate
Time of Emergence in summertime

Relationship between the simulated and observed temperature signal and model bias over Southern Europe

Based on the CMIP5 set and the SMURPHS ensemble
Thermodynamic vs Dynamic change

We quantify the thermodynamically driven trend by removing by linear regression the contribution of atmospheric circulation to the indices temporal evolution.

If we assume that the temporal changes in the atmospheric circulation can be represented with PCs of Z500, the regression model can be described as follows (similarly with Ceppi et al. 2012):

\[ I_{obs}(t) = \sum_{i=1}^{8} \beta_i PC_i(t) + \varepsilon(t) \]  \hspace{1cm} (1)
Surface responses for blocking and ridge regimes

**2m temperature**

Z500 composites

winter

summer

i) Opposite responses in winter:
- **Ridge** - mild
- **Block** – cold

ii) More similar responses in summer:
- **Block** - hot north
- **Ridge** - hot south
Surface responses for blocking and ridge regimes

**Rainfall**

blocks  
ridges

Opposite responses all year round:

**Ridge**
- wet north
- dry south

**Block**
- dry north
- wet south
Recent record-breaking temperature events in Europe

Sousa et al. (2019)
Weather and Climate Extremes
Extreme heat episode in Portugal – August 2018

i) More than 50% of the country with Tmax>40°C

ii) 17 stations with Tmax>45°C

iii) 40% of stations broke all-time records

First time ever here

Typical location of desert air masses

Intrusion persistence

Subtropical ridge with Saharan intrusion
Extreme heat episodes in Central Europe – June/July 2019

June 2019
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Ongoing work: New automated blocking – ridge detection scheme

i) New dynamical methodology

ii) Captures Blocks (distinguishing Omega and Rex types)

iii) Captures the extent of subtropical ridges (subtropical intrusions)

iv) Auto-calibrated, so usable for different models and different climate scenarios

Sousa et al. (2019) in preparation