WEATHER REGIMES, WEATHER TYPES AND THEIR RELATIONS WITH LOCAL SCALE PHENOMENA

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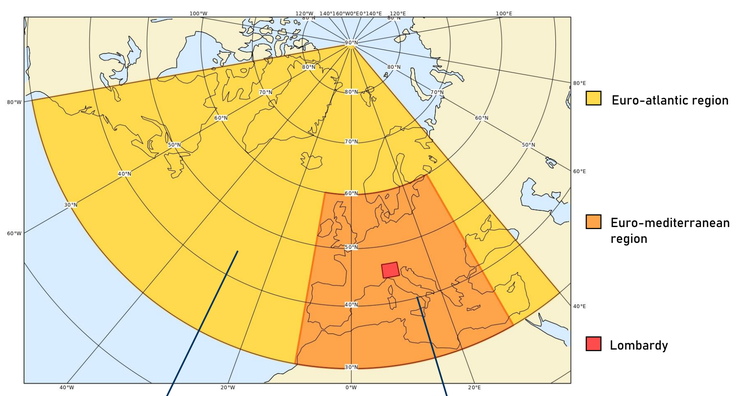
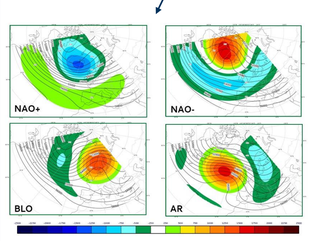
1 WEATHER REGIMES, WEATHER TYPES

The phenomena of interest to operational meteorology, which occur at a local scale, are linked to processes occurring at different spatio-temporal scales. Processes occurring at larger spatio-temporal scales can be predicted at longer time ranges. Consequently, an understanding of the large-scale atmospheric dynamics involved in determining local-scale phenomena can be very useful for forecasting purposes.

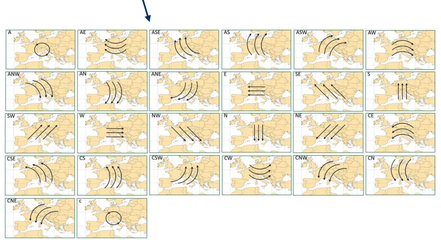
The aim of this study is to understand the role of large-scale circulation patterns in determining weather conditions over Lombardy.

For this purpose, the following spatial domains were considered:
- the Euro-Atlantic region, studied in term of Weather Regimes (WR)
- the Euro-Mediterranean region, analyzed classifying the circulation into Weather Types (WT)





Geographical patterns of the four Euro-Atlantic climatological regimes (both anomalies and full fields) for the cold season (ONDJFMA). The geopotential anomalies (colour shading) and geopotential (contours) at 500 hPa in units of m^2/s^2 are derived from ERA5 reanalysis data.



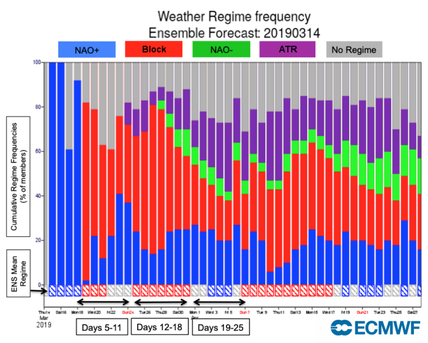
Lamb weather types scheme: the atmospheric flow is classified on the basis of its direction and curvature.

Some events of interest from the point of view of operational meteorology and their impact were analyzed in terms of weather regimes and weather types.

➡ CASE STUDIES (see below)

The aim of the investigation is to probe the ability of these schemes to characterize weather-related events occurring in Lombardy.
Any connections that emerge from this analysis apply in the context of the medium-range forecast.
In particular, it might lead to:
- develop new forecasting tools
- give a more precise meaning to some already available tools, e.g. the ECMWF Weather Regimes Probabilities Chart

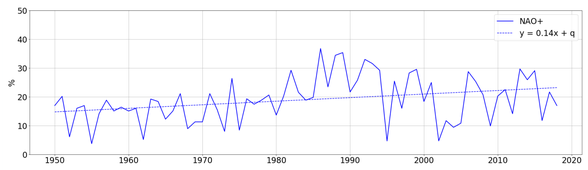
How can the ECMWF Weather Regimes Probabilities chart support meteorologist in Lombardy to provide more accurate forecast?



Daily probabilities for the occurrence of Euro-Atlantic weather regimes. The coloured bars indicate the proportion of ensemble members forecasting a specific regime for each day of the forecast: positive (blue) and negative (green) North Atlantic Oscillation, Scandinavian Blocking (red), Atlantic Ridge (purple).

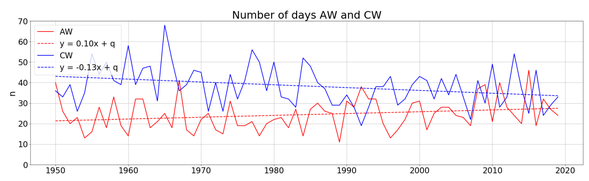
2 TIME SERIES ANALYSIS

After computing the four WRs over the Euro-Atlantic area (NAO+, NAO-, BLO, AR), the 1950-2019 daily series of occurrence of the regimes was constructed.
Trend analysis showed an increase in the occurrence of the NAO- regime during the cold season (ONDJFMA), particularly evident in the time span 1975-90.

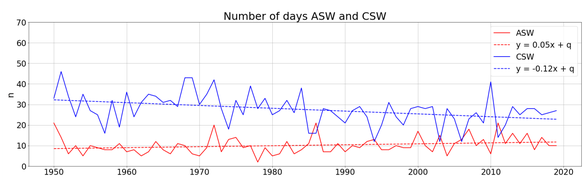


NAO- regime time series and trend line. Each value represents the percentage of NAO- days in the corresponding cold season.

The 1950-2019 daily series of Lamb weather types was constructed using the algorithm of Jenkinson and Collison.
Increasing trends were found in the occurrence of types AW and ASW, decreasing trends in the series of types CW and CSW



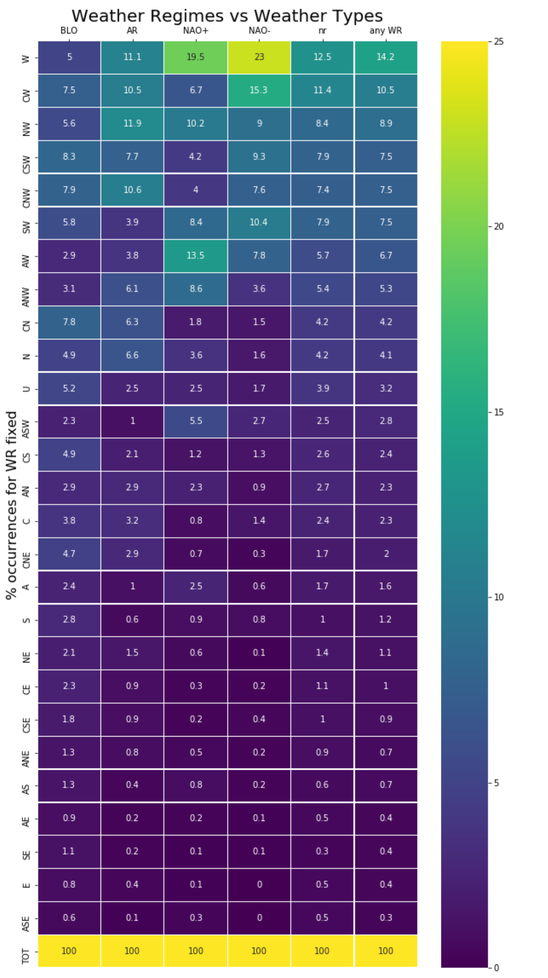
Time series of AW and CW weather types. Each value represents the number of days per year belonging to each WT. The straight lines represent the trend of the series.



Time series of ASW and CSW weather types. Each value represents the number of days per year belonging to each WT. The straight lines represent the trend of the series.

3 COMPARING THE TWO SCHEMES

For each regime, the percentage of occurrence of WTs has been computed.
The table below shows how each WR over the Euro-atlantic area affects the distribution of weather types over the Euro-mediterranean area.

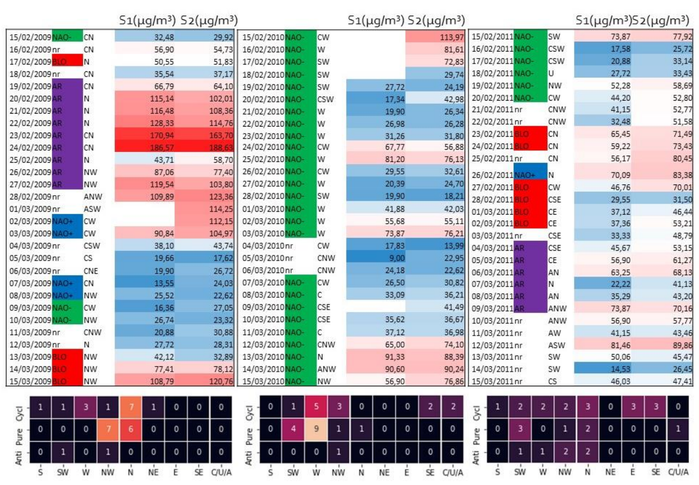


Weather types distribution for each weather regime. In the last column the frequencies over the total number of days. 1950-2019 period.

4 CASE STUDIES

PM10 concentrations drop in winter 2010

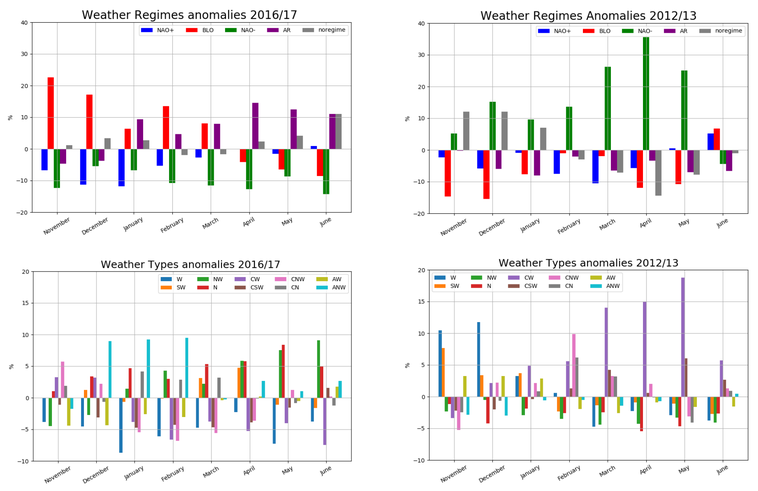
In 2010 an unexpected drop in PM10 winter concentrations was recorded in Lombardy. PM10 values measured by two stations in Milan in the years 2009, 2010, 2011 are compared together with WR and WT occurrences in the period 15 February – 15 March.
- ➢ the NAO- regime prevails during periods of low pollution levels
- ➢ the persistence of the regimes appears to be decisive in influencing PM10 concentrations
- ➢ the combination WR -WT appears also to play a relevant role



Wetaher regimes, weather types and PM10 daily concentrations measure by two station in Milan (Città studi and Verziere). 15 february – 15 march of the years 2009, 2010, 2011. The heatmaps represent the WTs distributions.

Drought in 2017

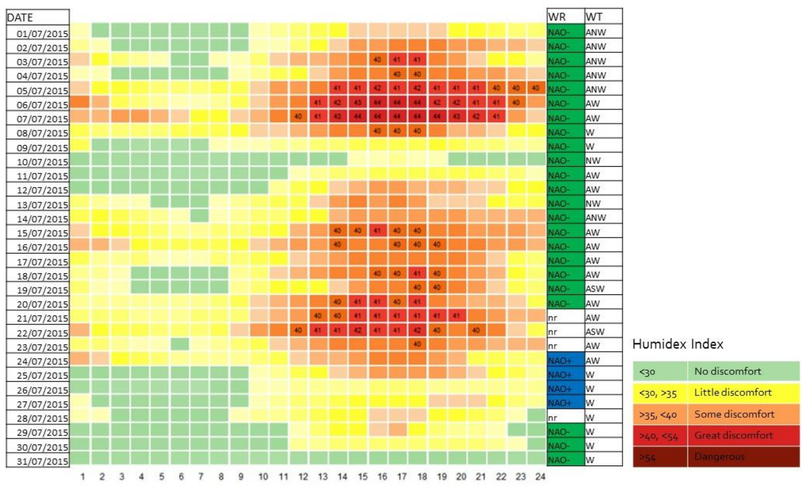
In early summer 2017 a water crisis was recorded due to the scarcity of rainfall in the preceding months.
The distribution of WRs and WTs over time spans of 3 or 6 months for this period was compared to the distribution for a wet period (2013):
- ➢ The dry period is characterized by the prevalence of the BLO and AR regimes, the wet period is associated with the presence of the NAO- regime.
- ➢ The distributions of WT in the dry and wet periods show very different, in some ways opposite, characteristics



Weather regimes distribution anomalies (up) and weather types distribution anomalies (down). A dry period (left) and a wet one (rigth) compared. Distributions are calculated over 3-months time span. Only the ten more frequent WTs are represented.

Heat waves in July 2015

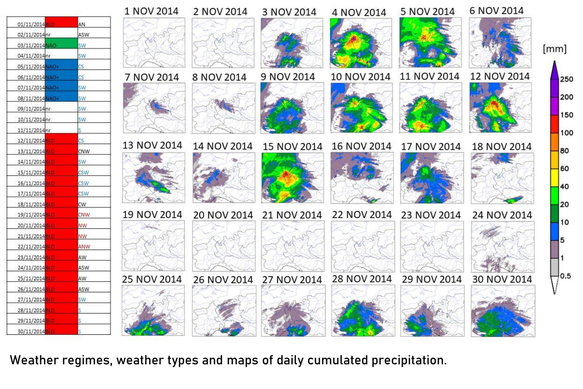
During July 2015 two strong heat waves caused a drop in the number of visitors at the EXPO event in Milan.
- ➢ Long NAO- sequences seem to be associated with high temperatures in summer
- ➢ July 2015 is characterized by the prevalence of AW and ANW weather types and the absence of CW, CNW and SW weather types



Hourly Humidex values measured at Milan EXPO site, weather regimes and weather types. July 2015.

Heavy rainfall in November 2014

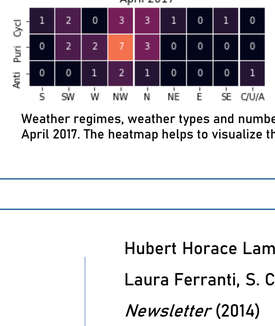
Between 3 and 18 November 2014 heavy rainfall occurred in Lombardy, totals above 700mm in some parts.
- ➢ The correspondence between WTs and rainfall is straightforward, as well known by local meteorologists
- ➢ it is not possible to identify a causal relationship between regimes and observed daily rainfall amounts



Weather regimes, weather types and maps of daily cumulated precipitation.

Wildfires in spring 2017

A well above-average of wildfires was recorded during spring 2017 in the Alps, favoured by dry and windy (foehn) conditions.
- ➢ the AR regime, which prevailed in April 2017, could play a role in determining weather conditions that help the ignition and spread of fires
- ➢ March and April 2017 were characterized by WT with N and NW components

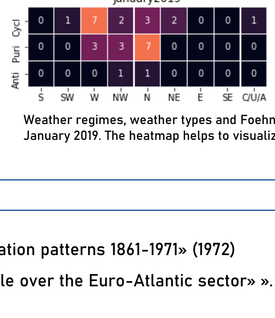


DATE	WR	WT	N wildfires
01/04/2017	nr	CS	4
02/04/2017	nr	CSE	1
03/04/2017	BLO	CNE	
04/04/2017	nr	CN	3
05/04/2017	AR	CN	1
06/04/2017	AR	N	7
07/04/2017	AR	N	1
08/04/2017	AR	AN	4
09/04/2017	AR	A	5
10/04/2017	AR	ANW	
11/04/2017	AR	NW	1
12/04/2017	AR	ANW	1
13/04/2017	AR	NW	2
14/04/2017	nr	NW	3
15/04/2017	nr	W	4
16/04/2017	AR	NW	1
17/04/2017	AR	NW	3
18/04/2017	AR	CNW	7
19/04/2017	AR	CNW	9
20/04/2017	AR	CN	5
21/04/2017	AR	N	2
22/04/2017	AR	NW	
23/04/2017	AR	NW	
24/04/2017	AR	AW	
25/04/2017	AR	W	
26/04/2017	nr	SW	
27/04/2017	NAO+	CSW	
28/04/2017	NAO+	CSW	
29/04/2017	NAO+	CNW	
30/04/2017	nr	SW	1

Weather regimes, weather types and number of wildfires recorded in April 2017. The heatmap helps to visualize the WTs distribution.

Foehn episodes in winter 2018-19

Winter is the season most exposed to foehn winds in Lombardy. From December 2018 to March 2019 a total of 48 foehn days was recorded.
- ➢ the month with the highest number of Foehn episodes is January 2019, characterized by a long sequence of AR
- ➢ In the whole period there were very few NAO- days.
- ➢ The WTs with N and NW components are the most frequent, as expected



DATE	WR	WT
01/01/2019	AR	AN
02/01/2019	AR	N
03/01/2019	nr	CN
04/01/2019	nr	CN
05/01/2019	BLO	N
06/01/2019	AR	N
07/01/2019	AR	N
08/01/2019	AR	NW
09/01/2019	AR	CNW
10/01/2019	AR	CNE
11/01/2019	AR	CNE
12/01/2019	AR	N
13/01/2019	AR	NW
14/01/2019	AR	NW
15/01/2019	AR	N
16/01/2019	AR	ANW
17/01/2019	AR	W
18/01/2019	AR	W
19/01/2019	AR	CW
20/01/2019	AR	CW
21/01/2019	AR	CW
22/01/2019	AR	CW
23/01/2019	AR	CSW
24/01/2019	AR	C
25/01/2019	AR	CN
26/01/2019	AR	N
27/01/2019	nr	W
28/01/2019	NAO+	CW
29/01/2019	NAO+	CNW
30/01/2019	nr	CW
31/01/2019	nr	CW

Weather regimes, weather types and Foehn days (yellow) recorded in January 2019. The heatmap helps to visualize the WTs distribution.

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