Analysis of 2014 winter patterns and its effects in Basque Country Coastal Area

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Introduction

2014 winter time is characterized by a large cyclogenetic activity in the North Atlantic, which has resulted in a continuous generation of deep lows and wind storms, many of which have been developed as explosive cyclogenesis. These events have led to violent sea storms, which have forced a lot of severe weather episodes in the cantabric coastal area, especially due to wind and waves.

During the cold season, in Basque Country area, we have suffered comparable sea storms in regards to wave height, but always are punctual events, they never occurs with the temporal continuity shown this year. Although no individual storm can be regarded as exceptional, the clustering and persistence of storms are highly unusual.

Preliminary analysis suggests that strong and linear polar jet on the areas of greatest contrast between the polar and subtropical air mass as the underlying cause of this anomaly. Other cause can be the SST warm anomaly of subtropical Atlantic, which supply power to the cyclogenetic activity associated with the jet.

In this work the characteristics of the atmospheric circulation of this winter and its impact on the Basque Country area are analyzed, translated into numerous events with strong waves , causing serious damages in the Basque coast.

NAO

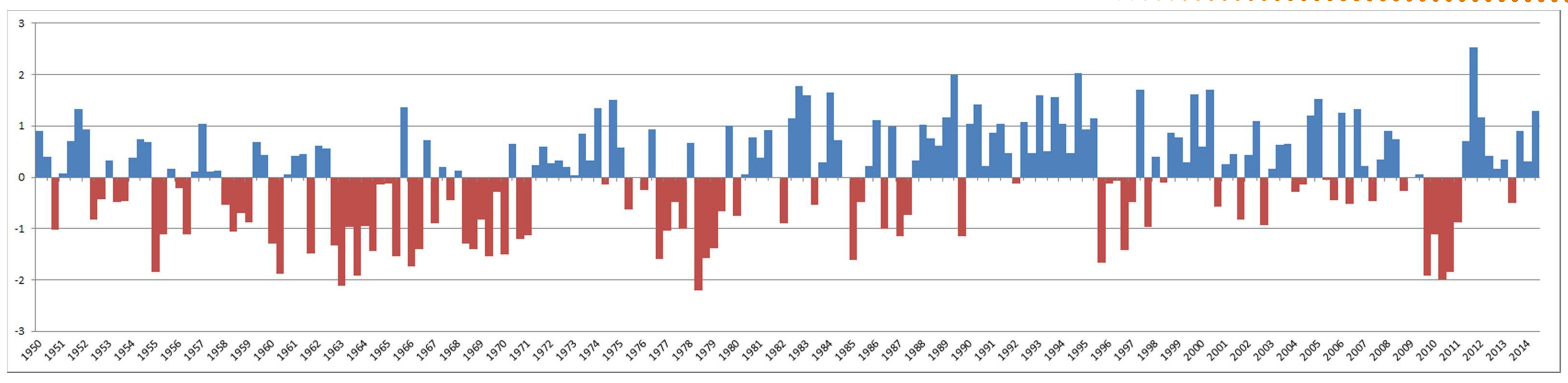

Fig.1: Monthly winter (DJF) NAO index from 1950-2014.

The clustered arrival of this winter season's storms in northern Europe was likely influenced by the maintenance of the North Atlantic Oscillation in positive phase (daily values mostly between 0.5 and 1.2 standard deviations). It is known that under NAO+ conditions extratropical cyclones tend to track toward Europe in a northeastward direction, bringing wind and precipitation to northern Europe.

The positive temperature gradient at the entrance of the North Atlantic Jet acted to strengthen the jet and provide the conditions for active cyclogenesis, which in turn led to a sequence of strong storms across western Europe throughout winter (the North Atlantic jet was, on average, as much as 30% stronger than normal). Compared to recent years, the tracks of the storms fell at a relatively low latitude, giving severe gales along the Cantabrian coast.

Episodes

25-26 DECEMBER 2013.

A deep depression in the Atlantic is formed and travels north to the British Islands. This depression called Dirk has a minimum central pressure at 927 mb, which is unusual for the North Atlantic. This depression generates a wind storm in the Basque Country and subsequently waves on 25 and 26 December, also favoured by the strong zonal circulation. This episode can be considered the first significant wave event of the 2013-2014 winter season. The significant wave height reaches around 6-7 meters, with a maximum of 7.6 meters. The peak wave period is around 15-18 seconds. Tides are not important and there is no evidence of significant damage.

6-7 JANUARY 2014.

A very deep depression with minimal pressure around 936 mb, travels across the Atlantic to the British Islands. The wind flow in the Basque Country is southwest and it is very intense, especially on the west coast (a wind gust of 136 km / h is recorded). A significant wave height of 10 meters is recorded. Tides are normal around 4 meters. The highlight of this episode is the wave period, and peak wave periods to 23 seconds are reached, generating powerful waves. The force of the waves causes many problems along the coast, especially in the port of Bermeo with the sinking of several boats and Donostia-San Sebastián with the flooding of numerous streets near the boardwalk.

27-28 JANUARY 2014.

A deep windstorm of 956 mb is located northwest of the British Islands and it is moved along a northwest-southeast trajectory and generates westerly winds in the Bay of Biscay, oscillating between southwest and northwest. A wind gust of 125 km / h is recorded. The significant wave height is around up to 6-7 meters, reaching a maximum of 7.9 meters during the morning of the 28th. The peak wave period is 16-17 seconds. Tides are not relevant. Some specific problems occur, but the worst happens in Ondarroa where a man dies after being hit and dragged by a wave.

1-2 FEBRUARY 2014.

Deep storm in the northwest of the British Islands is generated, which quickly deepens to reach 940 mb. The westerly wind is intense reaching a wind gust of 112 km / h. The significant wave height is around 7 meters, reaching a peak of 8.5 meters. Moreover, the worst coincides with the high tide, being exceptional spring tides, the sea level reaches 4.9 meters in Bilbao. The peak wave period reaches 20 seconds. The extraordinary of this episode is the coincidence of the maximum wave with high and very high tides. Numerous property damages occured. In fact it is an historic wave event, the worst in terms of damage to the coastline considering the economy harm.

5 FEBRUARY 2014.

It generates a powerful depression in the Atlantic southwest of the British Islands. The storm deepened rapidly, reaching 948 mb. The southwest wind is strong, although adverse weather thresholds are not found. The significant wave height reaches 9.5 meters. Tides are not relevant. The peak wave period is around 17-18 seconds. There are no known damages.

8-9 FEBRUARY 2014.

In the Atlantic a storm deepens as it moves northeastward towards the British Isles. The storm reaches 944 mb at its centre. The west wind is strong in the Basque Country. The maximum significant wave height reaches during the morning of day 9 10.5 meters. The peak wave period is around 17-18 seconds with a maximum of 20 seconds. The tide is very low, less than 3.5 meters, so the effect of swell in the coast of Basque Country is not relevant.

28 FEBRUARY-1 MARCH 2014.

A deep depression moves from the British Isles to Brittany. The northwest wind is very strong and exceeds 120 km / h in parts of the coast. The significant wave height is around 9 meters with peak wave periods between 15 and 17 seconds. Tide is relevant (4.4 to 4.8 meters) but in the moment of high tide the significant wave height is around 6-7 meters. There is no evidence of significant damage.

3-4 MARCH 2014.

A deep depression of 968 mb is moving to the British Isles, generating a high fetch. The northwest wind on the coast is very intense reaching a wind gust of 146 km / h. The maximum significant wave height reaches 11.2 meters at the end of day 3, the highest value of this 2014 winter, although this moment coincides with the time of low tide. Tide is very relevant (4.6 to 4.8 meters), but does not coincide with the maximum wave, so damages are not substantial, although they are relevant.

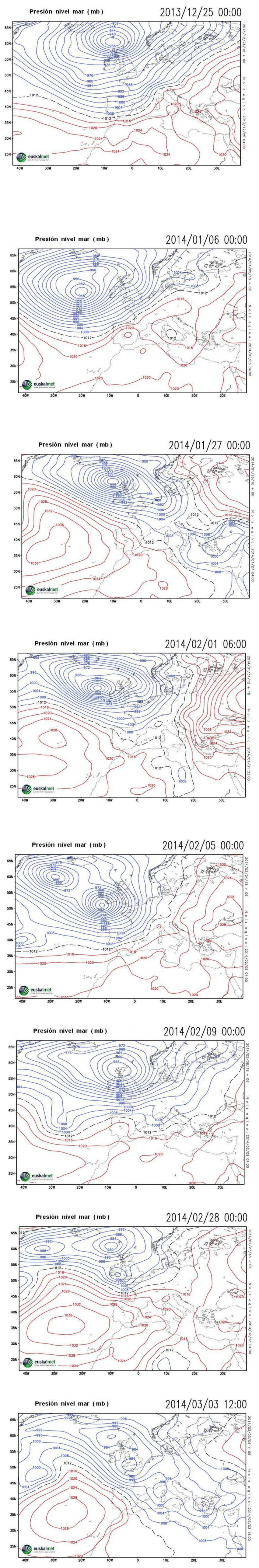

Fig.5: See level pressure maps representative for in the different episodes.

Winter analysis

SLP average NCEP reanalysis for DJF, shows an area of intense low pressure at northwest of the British Islands. It is the result of intense zonal flow pattern with low pressures generally with a trajectory from southwest to northeast in the vicinity of the British Islands. Many of the storms have been exceptionally deep, derived from explosive cyclogenesis and shifted by lower latitudes than normal, although in general the center of the same through the British Islands. This pattern has left in Basque Country a warm winter (temperatures above normal, with qualifier from warm to very warm) without significant cold surges, with normal precipitation generally due to the passage of the different fronts associated with these deep depressions and predominance of westerly intense winds.

A positive anomaly of the wind at latitudes slightly lower than the British Islands, and a negative anomaly in latitudes between Iceland and the British Islands are observed. This is, a sign that the deep storms this winter have moved to lower latitudes than normal, immersed in the intense zonal circulation, making a more pronounced horizontal north-south temperature gradient and generating powerful storms, also favored by the sea temperature positive anomaly of lower latitudes. The maximum wind anomaly is produced at southwest of the British Islands and this means the arrival of significant swell in our shores.

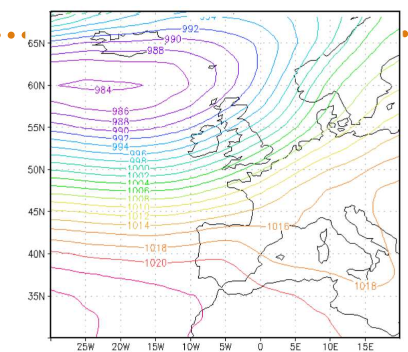

Fig.2: Mean SLP (mb) from December 2013 to February 2014 (NCEP reanalysis).

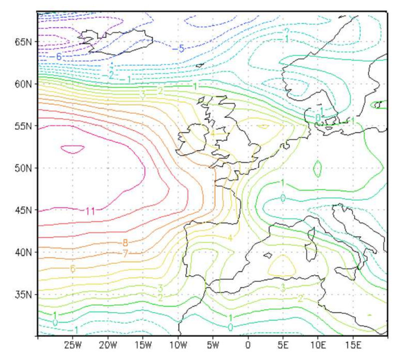

Fig.3: Mean u wind component (m/s) from December 2013 to February 2014 (NCEP reanalysis).

Date	Synoptic features	Maritime features	SLP min (mb)	Name	Explosive Cyclogenesis	Barometric Tide (cm)	Tide (m)	Peak Wave Period (Seg)	Wave direction	Obs buoy max sig heigth (m)	Euskalmet warning level issued	Effects	Stimated Damages (k€)
25-26-Dec-2013	Iberic-maritime, zonal, Britannic low	Strong maritime wind with high fecht	927	Dirk	√	10	3,5	15-18	NW (290-300 º)	7,6	orange	light	no relevant
6-7-Jan-2014	Iberic, zonal, Britannic low	Offshore wind with swell	936	Christina	√	no sig	4	23	NW (290-300 º)	10	orange	moderate	270
27-28-Jan-2014	Maritime, zonal, Britannic low	Strong maritime wind with high fecht	945	Lilli	√	no sig	3,7-4	16-17	NW (290-300 º)	7,9	orange	moderate	608
1-2-Feb-2014	Maritime, zonal, Azores high	Strong maritime wind with high fecht	940	Nadja	√	no sig	4,9	20	NW (290-300 º)	8,5	red	strong	18558
5-Feb-2014	Iberic, zonal, Britannic low	Offshore wind with swell	948	Petra	√	no sig	3,9	17-18	NW (290-300 º)	9,5	orange	light	?
8-9-Feb-2014	Maritime, zonal, Britannic low	Strong maritime wind with high fecht	944	Ruth	√	no sig	3,3	20	NW (290-300 º)	10,5	orange	light	?
28 Feb-1 Mar-2014	Maritime, zonal, Britannic low	Strong maritime wind with high fecht	992	Andrea		no sig	4,4-4,8	15-17	NW (300-310 º)	9	orange	light	?
3-4-Mar-2014	Maritime, zonal, Britannic low	Strong maritime wind with high fecht	968	Christine		10	4,6-4,8	19	NW (290-300 º)	11,1	red	strong	820

Table.1: Summary of 8 events where different aspects such as synoptic and maritime characteristics, wave and tidal parameters and effects are presented.

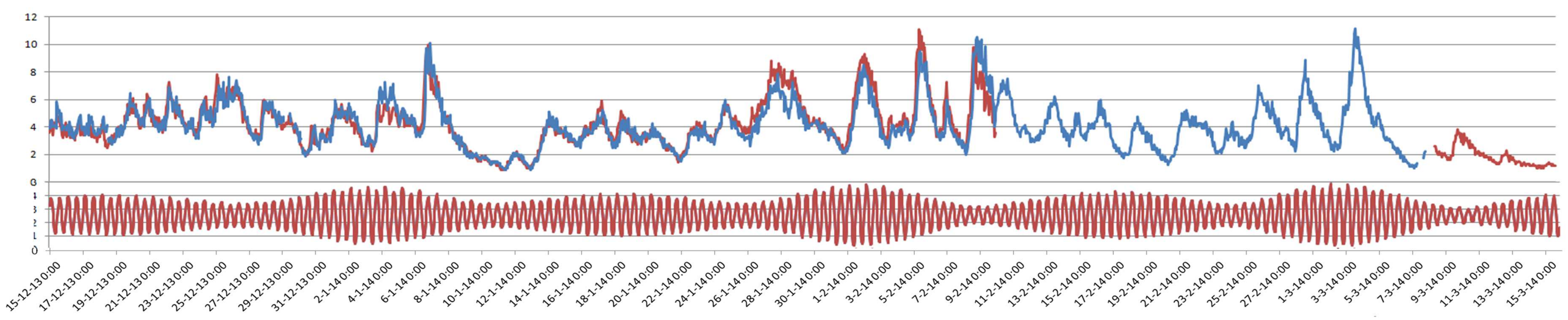

Fig.4: Significant wave height in different Basque buoys (m) and tide (m) from 15 December 2013 to 15 March 2014.

Summary and Conclusion

The exceptional of this 2014 year is not that we have had exceptional Hs episodes, but what is exceptional is the clustering and persistence of the storms (eight relevant events, when the normal may be one or two per winter) and the peak wave period has been exceptionally high, generating waves of high energy capable of producing severe damage to coastal infrastructure. Coincidence with high tides must be added to this fact, especially at February 2.

Most depressions were generated by explosive cyclogenesis and they were very deep, and their trajectories were lower latitudes than usual, but without being low latitudes, generating waves that reached our coast with significant height and period.

2 February event was the worst episode due to the coincidence of very high tides with strong swell. The damages exceed 18 million euros and this means that it is the worst episode due to waves ever recorded. The wave characteristics of that day are not exceptional but the maximum wave, with the maximum peak wave period coincides exactly with the time of high tide. It is complicated to link damages with the events occurred after February 2.

In the 3-4 March event coincided very high spring tides and high waves (the highest heights of all this winter), but not produced many problems, especially because the maximum wave height not coincided with the moment of high tide. Anyway substantial damage occurs. Besides, damage assessment is complicated by being around the coastline badly damaged.

Storm surges were insignificant because the path of the storms was generally through the British Isles.

In the past ten years the event that most resembles to the February 2 event is the March 11 2008 event.

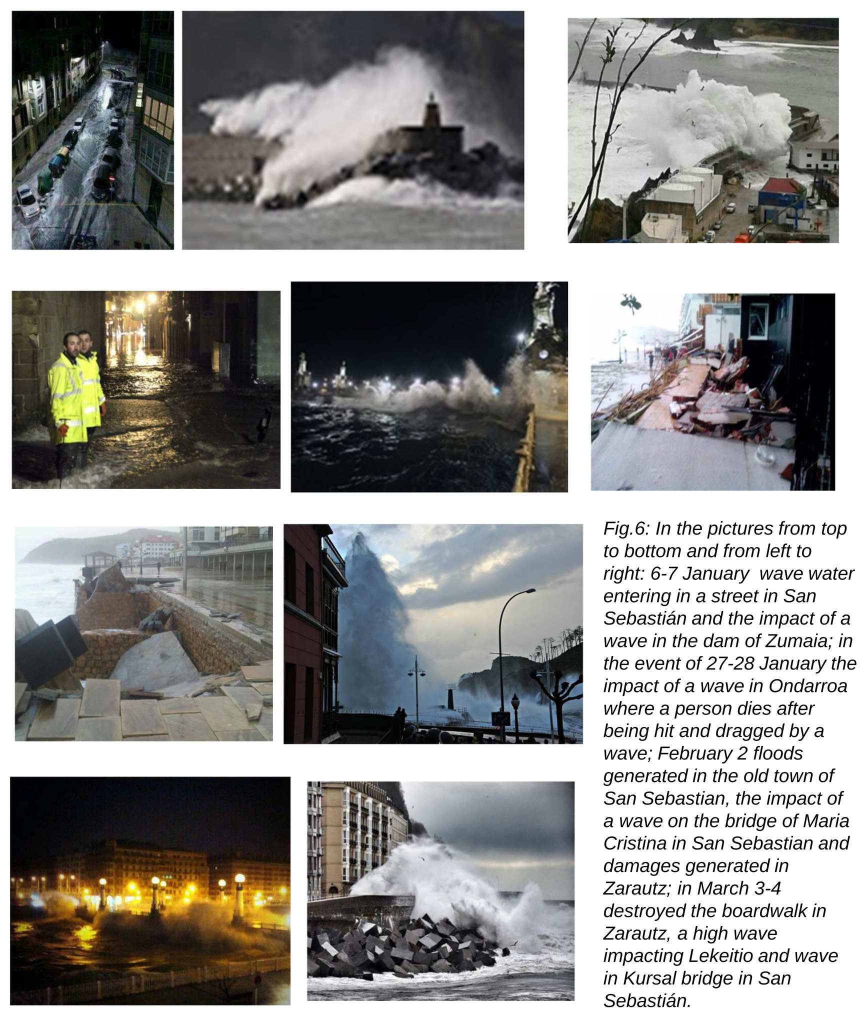

Fig.6: In the pictures from top to bottom and from left to right: 6-7 January wave water entering in a street in San Sebastián and the impact of a wave in the dam of Zumaia; in the event of 27-28 January the impact of a wave in Ondarroa where a person dies after being hit and dragged by a wave; February 2 floods generated in the old town of San Sebastian, the impact of a wave on the bridge of Maria Cristina in San Sebastian and damages generated in Zarautz; in March 3-4 destroyed the boardwalk in Zarautz, a high wave impacting Lekeitio and wave in Kursal bridge in San Sebastián.

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