Localization of Microbaroms detected by I17CI and I11CV in IMS data

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Abstract *By using IMS data from 2009 to 2015 of I17CI and I11CV infrasound stations, we study in 0.1Hz to 0.3Hz frequency band, with GPMCC software of NDC-in-Box, the microbaroms in summer et winter periods. We find that the microbaroms detected in winter period by both station comes from the north Atlantic (upper to 30°N). In summer (Jun, July and August), the microbaroms detected are located on equatorial Atlantic band (around 15°N) near the west side of West Africa. Note that, during the months May through October, les swells are thought to arrive from a south to south –westerly direction and are generated by storms in the South Atlantic Ocean in the region of 40° - 60°S. During the months October though April, the swells emanate from a north-westerly direction from the North Atlantic Ocean.*

1- Introduction

Infrasound detection is a key element of international efforts to monitor nuclear explosions in the context of the Comprehensive Nuclear-Test-Ban Treaty. From that perspective, microbaroms are viewed as noise, and sub- stantial research has been devoted to determining microbarom characteristics that are a function of geographical location, time of day, and time of year.

Microbaroms are observed as a continuous atmospheric pressure oscillation with most of its energy between 0.1 and 0.5Hz. They are believed to be generated by ocean wave interactions caused by severe weather, often at distances of several thousand kilometers.

In this work, we propose to analyze the origin and the localization of microbarom sources detected by I17CI and I11CV stations using the bulletin of the International Data Center (IDC).

2- Data and methods

The bulletins used for this work come from the IDC, from October 2009 to June 2016. The frequency band is [0.1 Hz – 0.3 Hz] and the number of detections is 55,081 for I17CI station and 8051 for I11CV station. Le number of bulletins is respectively 350 for I17CI and 325 for I11CV.

The Progressive Multi-Channel Correlation (PMCC) algorithm of Cansi et al. (1995) is the primary signal detection system used. PMCC uses the correlation between various groupings of three sensors, ***i,j, k*** to estimate the consistency of the lag-closure relation***:***

$r_{ijk} = \Delta t_{ij} + \Delta t_{ik} + \Delta t_{ki}$ where Δt_{ij} is the time delay between the arrival of a signal at sensors *i* and *j* (Cansi and Klinger, 1997). For an ideal wavefront, this consistency is equal to zero. A microbarom detection is only registered if the consistency is below 0.5 sec within the 0.1 - 0.5 Hz passband.

3- DTK-GPMCC and DTK-DIVA software

- The software used for data processing are DTK-GPMCC and DTK-DIVA made available by the CTBTO.
- GPMCC is an interactive graphic software that visualizes and analyzes data. It processes signals in multiple formats (wfdisc, Fonyx, miniSEED and ASCII) and generates a bulletin at the end of treatment
- DTK-DIVA is a visualization tool and processing Infrasound bulletins longer period

Missions of LAMTO Station

LAMTO Geophysical Station is specialized in the monitoring of environment and seismicity (ie earthquakes, underground and air nuclear explosions). It takes part in the International Monitoring System (IMS) of the Comprehensive nuclear Test Ban Treaty Organization (CTBTO).

4- Results

4-1- I17CI detections

The dominant microbaroms azimuths detected by I17CI station are given in Table below according to the month of year:

Azimuths	Month of the year
0° - 50°	May - June
190°-205°	July - August
240°-280°	March – April and September - October
320° - 340°	November- December- January-February

From January to August, there are three (3) phases of microbaroms detection. From September to December, the detection takes place in two (2) phases with a small transition in October (*Figure 1*). The analysis of this table shows a seasonal microbaroms detection pattern related to seasonal ocean surface circulation in this region. It should be noted that the wave emission frequencies for azimuths less than 100° are between 0.1 to 0.15Hz and are few whereas the azimuths between 100° to 360° have frequencies between 0.15 to 0.3Hz. (*Figure 2*).

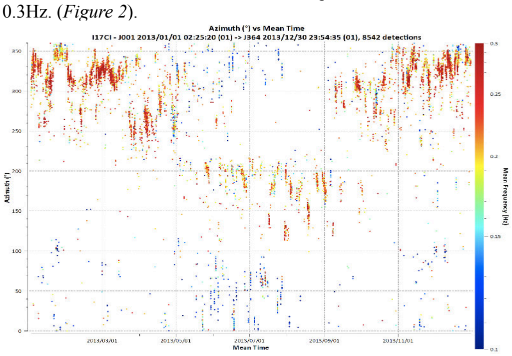

Figure 1*: Azimuth of microbaroms detected by I17CI station during 2013 year.*

In the figure (*Figure 2*), we distinguished the azimuth directions as function of the numbers of detections. The dominant azimuths are follow: 200°; 250°; 270° and 320° to 340°. Note that all these azimuths directions come from the west side of the I17CI Station.

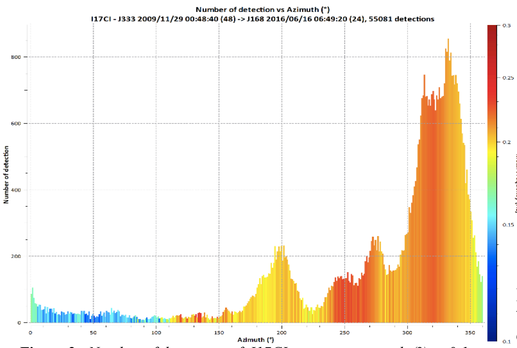

Figure 2: *Number of detections of I17CI station vs azimuth (°) in 0.1 to 0.3Hz frequency band.*

The search of microbaroms origins with a maximum distance of 3000km (*Figure 3*) from I17CI station shows that:

1- for azimuth around 200°: we found that microbaroms come from the Southern Tropical Atlantic of West Africa precisely towards the Atlantic Cold Tongue (ACT) area

2- for azimuth around 250° and 270°: microbaroms come from the oceanic front of Liberia.

3- for Azimuth between 320° and 340°: microbaroms also come from the oceanic front of Mauritania and Morocco (Western Sahara).

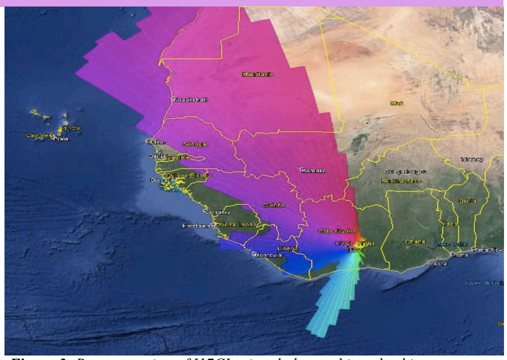

Figure 3: *Representation of I17CI azimuth detected in polar histogram on Google earth. The maximum distance is 3000km.*

4-2- I11CV detections

The microbaroms detected by I11CV station in the frequency bands from 0.1 to 0.3Hz are mainly in two directions. These detections occur during summer and winter boreal (Table below).

Azimuths	Month of the year
110°	June - July - August
300° - 330°	November- December- January-February

5- Discussion and Conclusion

Throughout the year, only the microbaroms emissions from November to February coincide and give the same azimuth direction between I11CV (300° - 330° azimuth) and I17CI (320° - 340° azimuth) stations. The crossing of these azimuths shows that the microbaroms detected by the I17CI station comes not only from the Mauritanian and Moroccan coasts as indicated above but also beyond this area, that is to say it also comes from America North (*Figure 4*).

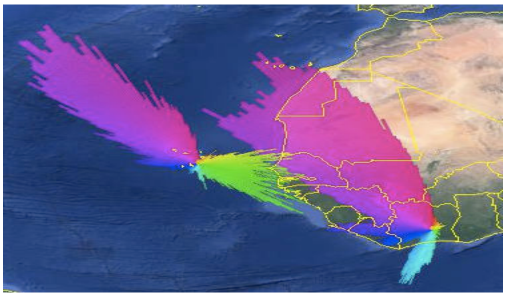

Figure 4: *Representation of I17CI and I11CV azimuth detected in polar histogram on Google earth. The maximum distance is 3000km*

During the summer period (July and August), the swell detected by the two stations does not come from the same direction: that detected by the IS17 station comes from the ACT while that detected by the I11CV station comes from the East Oceanic facade of West Africa.

The organization of high altitude wind fields (Not show) above these stations (I17CI lat: 6.7N and I11CV lat: 15.2N) from December to February between 5 and 21 km altitude shows a west wind jet regime (Jet of West Subtropical: JOST) centered on 25N. This jet is a waveguide for infrasound.

Some studies (Toualy et al. 2015) show that a particular extreme event of late August 2011 could be traced back to the southern Ocean 5-10 days previously. We can use infrasound to predict the occurrence of swell events in Gulf of Guinea

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