Monitoring Mediterranean Hurricanes using Infrasound

Joew Bedon*
Editorial office, Journal of Climatology & Weather Forecasting, United Kingdom

*Corresponding Author**

Joew Bedon
Editorial Office
Journal of Climatology and Weather Forecasting
United Kingdom
E-mail: Climatejournal@res.com

Received: 07-Nov-2022, Manuscript No. JCWF-23-21982; **Editor assigned:** 09-Nov-2022, PreQC No. JCWF-23-21982 (PQ); **Reviewed:** 20-Nov-2022, QC No. JCWF-23-21982 (Q); **Revised:** 27-Nov-2022, Manuscript No. JCWF-23-21982 (R); **Published:** 30-Nov-2022, DOI: 10.35248/2332-2594.22.10(11).341

Abstract

Sometimes or twice a year, tropical-like storms called medicanes, often known as Mediterranean hurricanes, emerge over the Mediterranean Sea. These mesocyclones' powerful winds and heavy rainfall seriously endanger coastal infrastructure and human life. This work intends to characterise the first infrasound detections that might be linked to meccane. Infrasound technology has already been used to analyse the acoustic characteristics of catastrophic weather occurrences.

Keywords: Medicane •Tropical-like mediterranean cyclone • Mesocyclone • Hurricane • Infrasound

Introduction

Mediterranean hurricanes or medicanes, also known as Mediterranean tropical-like cyclones, are meteorological hazards that mostly occur in the Mediterranean Sea between the months of September and January on average once or twice annually. Such mesoscale cyclones (a few hundred kilometres in diameter) cause countless fatalities and significant harm to coastal infrastructure (flooding, landslides, debris flows, etc.) because of their powerful winds and heavy rains when they make landfall. With wind speeds up to 54 m/s, recent medinae that hit the Greek beaches caused 640 mm of rainfall in less than 24 hours . Due to high storm surge impacts and large waves, the shores of Sicily have also been severely affected by medicanes. Although medicanes are also known to have formed in other areas of the Mediterranean Basin, such as the Adriatic Sea the western Mediterranean region (between the Balearic Islands and Sardinia) and the Ionian Sea are preferred sites of creation. More generally, medicanes have historically affected a number of coastal regions in southern Europe and northern Africa, resulting in losses and deaths that have been reported since the middle of the 20th century. By the end of the century, it is anticipated that such cyclonic windstorms may become more intense due to climate change even if a warming ocean and atmosphere may not result in an increase in their frequency of occurrence. The main instrument for comprehensive observational research is satellite data which is supported by modelling experiments for a thorough examination of the synoptic-to-microscale processes at work. These research are also considerably aided by in-situ observations and ground-based meteorological stations.

The upper troposphere is first preconditioned by the presence of an upper-level potential vorticity streamer, which causes a cut-off low or high-altitude cold low. Next, a combination of surface baroclinic instability and diabatic

heating from convective processes results in the formation of medicanes. As a result, the vortex develops a heated core and a vertical, axisymmetric structure that is encircled by convective clouds. Another component for enhancing upward water vapour surface fluxes and transforming the cyclone into a tropical-like structure is a high sea surface temperature.

Understanding, predicting, and monitoring such threats are required and supplementary actions to one or many, to which infrasound technology may contribute, in order to limit the detrimental effects associated to these events. The lowest audible frequency for humans is 20 Hz, and infrasound waves are atmospheric longitudinal waves with frequencies spanning roughly between 0.01 Hz and that number. Compared to audible sound, they may travel farther distances with less attenuation since absorption rises with the square of frequency. Due to this characteristic, infrasound has become the method for assessing whether the Comprehensive Nuclear Test Ban Treaty (CTBT) is being complied with in the atmosphere. Infrasound signatures have been associated with storms, more especially cyclones, mesoscale convective systems, and mesocyclones, according to a number of studies. For example, Blom and Waxler have shown how infrasound at 0.2 Hz, which is produced by the surge (microbarom), refracts during cyclonic windstorms. More recently, Chunchuzov et al. demonstrated how meteorological fronts could emit infrasound (0.05 Hz-1 Hz) modulated by gravity waves (0.001 Hz-0.004 Hz) triggered by the same meteorological system. Indelárová et al. showed the detection of infrasound originating from a convective storm over central Europe in the 1 Hz-4 Hz range, linking it to increased lightning activity. Another research used a mobile infrasound station in the 1 Hz-4 Hz band to record the split of a mesoscale convective storm in Ivory Coast. After this groundbreaking study, Bedard determined that vortices were a highly plausible candidate for the infrasound that thunderstorms generate, with varying frequency ranges depending on the process for vortex generation. Also, the author discovered a connection between hail generation and infrasound during storms, but only when rotation was present. Yet, the large-scale spinning of a mesocyclone would not be as closely associated with rotation-related infrasound emission as tornadoes would. Lastly, Petrin and Elbing emphasise the connection between the generation of hail, vortices, and infrasound by recalling the significance of downdrafts for tornadogenesis and how the former are driven by high evaporation, sublimation, but most crucially, melting . Nonetheless, it's interesting to note that Bedard, Passner and Noble, and even non-tornadic mesocyclones did provide evidence of infrasound detection in the 5 Hz-10 Hz range without providing a good explanation for the mechanisms causing these tones. This shows that even in the absence of tornadogenesis, large-scale spinning systems may emit infrasound. On a more theoretical note, Akhalkatsi and Gogoberidze and Schecter illustrated the function of heat production and condensation or melting as an infrasound source in convective storms at frequencies above 0.1 Hz through calculations resulting from the acoustic wave equation and simulation experiments, respectively. In order to be able to explain tornado-related infrasound emissions, Schecter went on to address the significance of the thermal fluctuation of the columnar vortex caused by phase shift through latent heating or cooling. Moreover, lightning has a long history of being a reliable generator of infrasound above 1 Hz. According to Farges and Blanc, thunderstorm motion within 300 km a single infrasound station may detect lightning created in it and then follow it. By examining 15 years' worth of IMS infrasound data collected in the Ivory Coast, Farges et al. have increased the range to 500 km. Also, they discovered that in direct or tropospheric waveguide transmission, the loudness of the infrasound from lightning declined with the distance d as 0.717. The fact that tornadoes can develop during medanes and that the severe precipitation brought on by these cyclones is expectedly tied to cold microphysics involving glacial ice and big particles suggests that all the elements for the creation of infrasound may be present. Also, lightning is frequently seen within medicanes, typically during intensification times.

Infrasound data and processing tool

The wind noise reduction device has been installed at the IMS station IS48 in Kesra, Tunisia since 2017, greatly enhancing its detection capacity. IS48 is an eight-element (MB2005 sensors) array with a roughly two-kilometer aperture. Studies including the Etna and other natural sources in the Mediterranean have effectively involved it. The Progressive Multi-Channel Correlation (PMCC) algorithm is used to analyse waveforms supplied by the French National Data Centre (NDC) between 0.05 Hz and 8 Hz with a 1/3 octave band progression and 90% overlap across time periods. To accept low frequencies over extended time periods, the latter uses a logarithmic progression. Only time-frequency pixels that confirm this criteria and belong to a family of pixels are taken into consideration with the detection criterion (consistency) set at 0.1 s. Families are collections of pixels with similar backazimuth, trace velocity (horizontal wavefront projection), frequency, and temporal wavefront characteristics.

Meteorological data

In order to study infrasound guidance in the middle atmosphere, ECMWF (European Centre for Medium-Range Weather Forecasting) reanalysis products ERA include wind and temperature fields. The Copernicus Climate Change Service (C3S) across the Mediterranean area extracts fields from the Meteorological Archival and Retrieval System (MARS) of the European Centre for Medium Range Weather Forecasts (ECMWF). The ERA5 fields are offered on a standard horizontal grid of 0.25 by 0.25 and are available at an hourly output of 0.01 hPa (around 80 km height) from the surface. These fields originate from simulations of the Integrated Forecasting System (IFS) model run at a horizontal resolution of 30 km by the ECMWF. The 2 m wind and gusts were also retrieved at the station to test the ERA5 fields' capacity to take into account the local wind noise circumstances that influence the sensors despite being tailored to take into account regional-scale dynamics issues.

Satellite data for convection

Data from the Meteosat Second Generation (MSG) satellites, more especially the Brightness Temperature (BT) from the Spinning Enhanced Visible and Infrared Imager (SEVIRI) were utilised to detect Deep Moist Convection (DC) during medicanes. Convective clouds are distinguished from other opaque clouds using a technique similar to Olander and Velden's that compares the differences between the Water Vapour (WV) channel WV6.2 and the window channel IR10.8 (BT) of SEVIRI pixels at the native spatial resolution of 3 km. The WV6.2 channel peaks at roughly 350 hPa while the IR10.8 channel has a peak spectral response near to or at the Earth's surface during clear skies, hence BT is often negative. Its spectral response can dramatically alter and even flip to positive values in the presence of convective clouds. Significant WV transport during severe DC can occur in the upper troposphere or lower stratosphere, where it is reemitted at greater temperatures in the WV6.2 channel compared to the window channel. Positive BT (WV6.2 IR10.8>0) values are linked to overshooting tops and vigorous convection that reaches the tropopause.

World-wide lightning location network

The World Wide Lightning Location Network (WWLLN) uses 70 sensors to find lightning strikes with a 10 km location precision by detecting Very Low Frequency (VLF) electromagnetic waves. The development of lightning activity in tropical cyclones has been studied using this dataset. The WWLLN detection efficiency varies significantly over land and ocean, but is higher over oceans by a factor of 2 or 3 and will largely miss intra-cloud lightning. It ranges from 10% to 20% for cloud-to-ground flashes but rises to between 50% and 80% for intense flashes (defined with peak current>50 kA). This dataset was extensively used by Farges et al. to explain infrasound lightning detections from tropical storms in Western Africa.

Acoustic source model for microbaroms

It makes use of a fresh source model for microbaroms created by De Carlo et al. This model was effectively compared to an earlier source model in De Carlo et al., for which theoretical limits were addressed, as well as to IMS observations. Furthermore successfully applied in case studies was the acoustic source model. As a result, the Atmospheric Infrasound by Ocean Waves (ARROW) dataset was developed, which builds on the wave interaction products for which hindcasts for the years 1993 to 2020 are available. A worldwide mapping of the wave interaction product and the associated acoustic source product (microbaroms source model) is provided by the ARROW product, to put it briefly.