Chapter One

Introduction

Sound is a mechanical wave that is an oscillation of pressure transmitted through some medium (like air or water) composed of frequencies which are within the range of hearing . Sound is transmitted through gases, plasma, and liquids as longitudinal waves also called compression waves. Through solids however it can be transmitted as both longitudinal waves pressure deviations from the equilibrium pressure causing local regions of compression and rarefaction while transverse waves (in solids) are waves of alternating shear stress at right angle to the direction of propagation.

There are two types of sound waves ultrasound it is one which use in multiplications in medical, detection, measurement and cleaning and also in many different application.

The infrasound is the second type of sound waves it is very important but not common like ultrasound it has many uses in detection of Wind turbine monitoring, Earthquake and tsunami monitoring, Volcano monitoring, and tornado.

In this project we take tornado because it is scary phenomena and our world is under threatening of tornado in this thesis we try to improve tornado warnings, how vortices generate and the relation between tornado and infrasonic how can improve detection of it.

Aim of project

Include infrasonic systems in experiments designed to study tornado storm dynamics or how can infrasonic improve tornado warnings

Presentation of the thesis

A part from the introduction, the thesis consists of three chapters
Chapter two is introduction of waves. In chapter three ultrasound and infrasound. In chapter four using infrasound to detection of tornadoes

Chapter two

2-1 Introduction

Wave is a disturbance or oscillation that travels through space and matter accompanied by transfer of energy or a wave is a disturbance or variation which travels through a medium.

The medium through which the wave travels may experience some local oscillations as the wave passes but the particles in the medium do not travel with the wave.

The disturbance may take any of a number of shapes from a finite width pulse to an infinitely long sine wave.

Transfers energy from one point to another, often with no permanent displacement of the particles of the medium that is with little or no associated mass transport. They consist instead of oscillations or vibrations around almost fixed locations. Waves are described by a wave equation which sets out how the disturbance proceeds over time. The mathematical form of this equation varies depending on the type of wave.

2-2 Wave equation

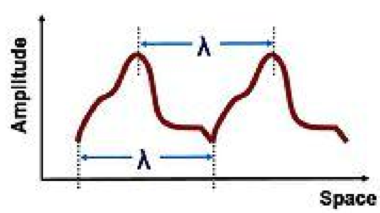

Figure 2-1 the relation between space and amplitude

Wavelength λ can be measured between any two corresponding points on a waveform.

The wave can then be described by the two-dimensional functions

$u(x,\ t) = F(x - v\ t)$ ⟶ (2-1)

(Waveform Ftraveling to the right)

$u(x,\ t) - G(x + v\ t)$ ⟶ (2-2)

(Waveform Gtraveling to the left)

Or, more generally, by d'Alembert's formula:

$$u(x,t) = F(x - vt) + G(x + vt). \longrightarrow \quad (2\text{-}3)$$

Representing two component waveforms $F$and Gtraveling through the medium in opposite directions. A generalized representation of this wave can be obtained as the partial differential equation

$$\frac{1}{v^2}\frac{\partial^2 u}{\partial t^2} = \frac{\partial^2 u}{\partial x^2}. \qquad \longrightarrow \qquad (2\text{-}4)$$

- In the $x$direction in space. E.g., let the positive $x$direction be to the right, and the negative $x$direction be to the left.
- with constant amplitude u
- with constant velocity v, where $v$is
  - o independent of wavelength (no dispersion)
  - o Independent of amplitude (linear media, not nonlinear).
- with constant waveform, or shape

2-3 Main types of waves

There are two main types of waves**. Mechanical waves** propagate through a medium, and the substance of this medium is deformed. The deformation reverses itself owing to restoring forces resulting from its deformation. For example sound waves propagate via air molecules colliding with their neighbors. When air molecules collide they also bounce away from each other (a restoring force). This keeps the molecules from continuing to travel in the direction of the wave. The second main types of wave **Electromagnetic waves** do not require a medium. Instead, they consist of periodic oscillations of electrical and magnetic fields generated by charged particles, and can therefore travel through a vacuum. These types of waves vary in wavelength, and include radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

A wave can be transverse or longitudinal depending on the direction of its oscillation. Transverse waves occur when a disturbance creates oscillations perpendicular (at right angles) to the propagation (the direction of energy transfer). Longitudinal waves occur when the oscillations are parallel to the direction of propagation. While mechanical waves can be both transverse and longitudinal, all electromagnetic waves are transverse. Further, the behavior of particles in quantum mechanics is described by waves A vibration can be defined as a back-and-forth motion around a reference value.

2-4 Amplitude and modulation

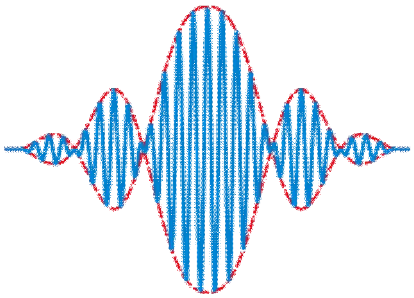

Figure 2-2 amplitude of waves

The amplitude of a wave may be constant (in which case the wave continuous wave) or may be modulated so as to vary with time and position. The outline of the variation in amplitude is called the envelope of the wave. Mathematically the modulated wave can be written in the form: q

$$u(x,\ t) = A(x,\ t)\sin(kx - \omega t + \phi) \longrightarrow \text{(2-5)}$$

where $A(x,\ t)$is the amplitude envelope of the wave, k is the wave number and ϕ is the phase. If the group velocity v_g is wavelength-independent, this equation can be simplified as;

$$u(x,\ t) = A(x - v_g\ t)\sin(kx - \omega t + \phi) \longrightarrow \text{(2-6)}$$

Showing that the envelope moves with the group velocity and retains its shape. Otherwise in cases where the group velocity varies with wavelength the pulse shape changes in a manner often described using an envelope equation

2-5 Phase velocity and group velocity:

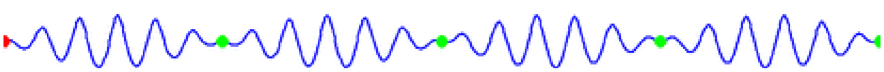

Figure 2-3 phase velocity

There are two velocities that are associated with waves the phase velocity and the group velocity.

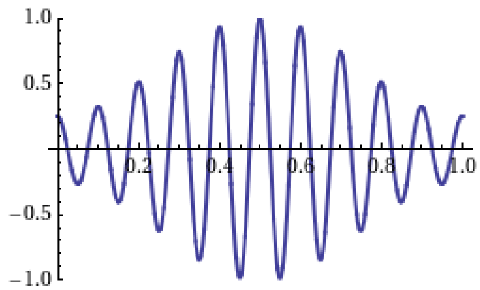

Figure 2-4 group velocity

This shows a wave with the Group velocity and Phase velocity going in different directions.

Phase velocity

$$v_p = \frac{\omega}{k}. \longrightarrow \quad (2\text{-}7)$$

Group velocity:

$$v_g = \frac{d\omega}{dk} \longrightarrow \quad (2\text{-}8)$$

In quantum mechanics the energy of a particle represented as a wave packet is

$$E = \hbar\omega = (\hbar k)^2 / (2m) \longrightarrow \quad (2\text{-}9)$$

Consequently for that wave situation, the group velocity is

$$v_g = \frac{\hbar k}{m} \longrightarrow \quad (2\text{-}10)$$

2-6 Wave forms

2-6-1 <u>Sinusoidal</u> waves

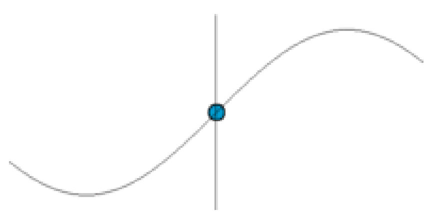

Figure 2-5 Sinusoidal waves correspond to simple harmonic motion.

Mathematically the most basic wave is the (spatially) one-dimensional sine wave (or harmonic wave or sinusoid) with amplitude $u$described by the equation:

$$u(x,\ t) = A\sin(kx - \omega t + \phi) \longrightarrow \text{(2-11)}$$

Where

- AIs the maximum amplitude of the wave maximum distance from the highest point of the disturbance in the medium (the crest) to the equilibrium point during one wave cycle in the illustration to the right this is the maximum vertical distance between the baseline and the wave.
- $t$is the time coordinate
- $\omega$is the angular frequency

The units of the amplitude depend on the type of wave. Transverse mechanical waves (e.g., a wave on a string) have amplitude expressed as a distance (e.g., meters), longitudinal mechanical waves (e.g., sound waves) use units of pressure (e.g., Pascal's) and electromagnetic waves (a form of transverse vacuum wave) express the amplitude in terms of its electric field (e.g., volts/meter).

The wavelength $\lambda$is the distance between two sequential crests or troughs (or other equivalent points) generally is measured in meters. Awave number k the spatial frequency of the wave in radians per unit distance (typically per meter), can be associated with the wavelength by the relation

$$k - \frac{2\pi}{\lambda}. \longrightarrow \qquad \text{(2-12)}$$

Frequency $f$is measured by hertz.

$$f = \frac{1}{T}. \longrightarrow \qquad \text{(2-13)}$$

The angular frequency is related to the frequency or period by

$$\omega = 2\pi f = \frac{2\pi}{T}. \longrightarrow \text{(2-14)}$$

The wavelength $\lambda$of a sinusoidal waveform traveling at constant speed v is given by:

$$\lambda = \frac{v}{f}, \longrightarrow \text{(2-15)}$$

Where v is called the phase speed

2-6-2 Plane waves

Standing waves

Figure 2-6 standing waves

A standing wave known as a stationary wave is a wave that remains in a constant position. This phenomenon can occur because the medium is moving in the opposite direction to the wave or it can arise in a stationary medium as a result of interference between two waves traveling in opposite directions.

The sum of two counter-propagating waves (of equal amplitude and frequency) creates a standing wave. Standing waves commonly arise when a boundary blocks further propagation of the wave thus causing wave reflection, and therefore introducing a counter-propagating wave.

2-7 properties of wave interaction with material

2-7-1 Absorption

Absorption of waves means if a kind of wave strikes a matter it will be absorbed by the matter. When a wave with that same natural frequency impinges upon an atom then the electrons of that atom will be set into vibrational motion. If a wave of a given frequency strikes a material with electrons having the same vibrational frequencies then those electrons will absorb the energy of the wave and transform it into vibrational motion.

2-7-2 Reflection

When a wave strikes a reflective surface it changes direction such that the angle made by the incident wave and line normal to the surface equals the angle made by the reflected wave and the same normal line.

2-7-3 Interference

Waves that encounter each other combine through superposition to create a new wave called an interference pattern. Important interference patterns occur for waves that are in phase.

2-7-4 Refraction

Refraction is the phenomenon of a wave changing its speed. Mathematically this means that the size of the phase velocity changes. Typically refraction occurs when a wave passes from one medium into another. The amount by which a wave is refracted by a material is given by the refractive index of the material. The directions of incidence and refraction are related to the refractive indices of the two materials by Snell's law.

2-7-5 Diffraction

A wave exhibits diffraction when it encounters an obstacle that bends the wave or when it spreads after emerging from an opening. Diffraction effects are more pronounced when the size of the obstacle or opening is comparable to the wavelength of the wave.

2-7-6 Polarization

A wave is polarized if it oscillates in one direction or plane. A wave can be polarized by the use of a polarizing filter. The polarization of a transverse wave describes the direction of oscillation in the plane perpendicular to the direction of travel.

Longitudinal waves such as sound waves do not exhibit polarization. For these waves the direction of oscillation is along the direction of travel.

2-7-7 Dispersion

A wave undergoes dispersion when either the phase velocity or the group velocity depends on the wave frequency. Dispersion is most easily seen by letting white light pass through a prism the result of which is to produce the spectrum of colures of the rainbow.

2-8 Quantum mechanical waves

2-8-1 The Schrödinger equation

The Schrödinger equation describes the wave-like behavior of particles in quantum mechanics. Solutions of this equation are wave functions which can be used to describe the probability density of a particle.

A propagating wave packet in general the envelope of the wave packet moves at a different speed than the constituent waves.

$$i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t) = \frac{-\hbar^2}{2m}\nabla^2\Psi(\mathbf{r},t) + V(\mathbf{r},t)\Psi(\mathbf{r},t) \longrightarrow \quad (2\text{- }16)$$

2-8-2 De Broglie waves

Louis de Broglie postulated that all particles with momentum have a wavelength

$$\lambda = h/p \qquad \longrightarrow \qquad (2\text{-}17)$$

Where h is Planck's constant, and p is the magnitude of the momentum of the particle. This hypothesis was at the basis of quantum mechanics. This wavelength is called the de Broglie wavelength.

However a wave like this with definite wavelength is not localized in space and so cannot represent a particle localized in space. To localize a particle de Broglie proposed a superposition of different wavelengths ranging around a central value in a wave packet a waveform often used in quantum mechanics to describe the wave function of a particle. In a wave packet the wavelength of the particle is not precise and the local wavelength deviates on either side of the main wavelength value.

2-8-3 Gaussian wave

In representing the wave function of a localized particle the wave packet is often taken to have a Gaussian shape and is called a Gaussian wave packet. Gaussian wave packets also are used to analyze water waves. For example a Gaussian wave function ψ might take the form:

$$\psi(x,\ t=0) = A\ \exp\left(-\frac{x^2}{2\sigma^2} + ik_0x\right)\ , \longrightarrow \quad (2\text{-}18)$$

At some initial time t = 0 where the central wavelength is related to the central wave vector k_0 as $\lambda_0 = 2\pi / k_0$. It is well known from the theory of Fourier analysis or from the Heisenberg uncertainty principle (in the case of quantum mechanics) that a narrow range of wavelengths is necessary to produce a localized wave packet and the more localized the envelope the larger the spread in required wavelengths. The Fourier transform of a Gaussian is itself a Gaussian. Given the Gaussian:

$$f(x) = e^{-x^2/(2\sigma^2)} \ , \quad \longrightarrow \qquad (2\text{-}19)$$

Chapter three

3-1 Ultrasounds

Ultrasound is an oscillating sound pressure wave with a frequency greater than the upper limit of the human hearing range. Ultrasound is thus not separated from 'normal' (audible) sound based on differences in physical properties only the fact that humans cannot hear it. Although this limit varies from person to person, it is approximately 20 kilohertz (20,000 hertz) in healthy young adults. Ultrasound devices operate with frequencies from 20 kHz up to several gigahertz.

Ultrasound is used in many different fields. Ultrasonic devices are used to detect objects and measure distances. Ultrasonic imaging (sonography) is used in both veterinary medicine and human medicine. In the nondestructive testing of products and structures ultrasound is used to detect invisible flaws. Industrially ultrasound is used for cleaning and for mixing and to accelerate chemical processes. Organisms such as bats and porpoises use ultrasound for locating prey and obstacles

Ultrasonic is the application of ultrasound. Ultrasound can be used for medical imaging, detection, measurement and cleaning. At higher power levels ultrasonic is useful for changing the chemical properties of substances [1].

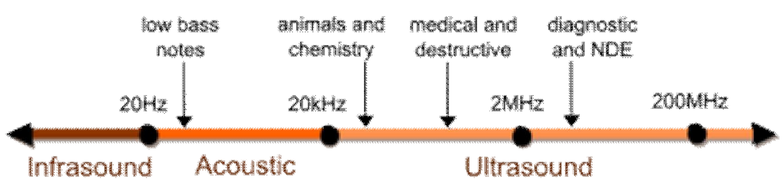

Image 3-1: Electromagnetic wave

3-1-2 Perception in humans and animals

a. Humans

The upper frequency limit in humans (approximately 20 kHz) is due to limitations of the middle ear which acts as a low-pass filter. Ultrasonic hearing can occur if ultrasound is fed directly into the human skull and reaches the cochlea through bone conduction without passing through the middle ear.

Children can hear some high-pitched sounds that older adults cannot hear because in humans the upper limit pitch of hearing tends to decrease with age. An American cell phone company has used this to create ring signals supposedly only able to be heard by younger humans but many older people can hear the signals which may be because of the considerable variation of age-related deterioration in the upper hearing threshold. The Mosquito is an electronic device that uses a high pitched frequency to deter loitering by young people.

Some people find high-frequency sounds and ultrasound extremely painful. This is often associated with autism and sensory defensiveness but can also be caused by hyperacusis

b. Animals

Bats use a variety of ultrasonic ranging (echolocation) techniques to detect their prey. They can detect frequencies beyond 100 kHz , possibly up to 200 kHz.

Many insects have good ultrasonic hearing and most of these are nocturnal insects listening for echolocating bats. This includes many groups of moths, beetles, praying mantids and lacewings. Upon hearing a bat, some insects will make evasive manoeuvres to escape being caught. Ultrasonic frequencies trigger a reflex action in the noctuid moth that causes it to drop slightly in its flight to evade attack. Tiger moths also emit clicks which may disturb bats' echolocation, but may also in other cases evade being eaten by advertising the fact that they are poisonous by emitting sound.

Dogs with normal hearing can hear ultrasound. A dog whistle exploits this by emitting a high frequency sound to call to a dog. Many such whistles emit sound in the upper audible range of humans but some such as the silent whistle emit ultrasound at a frequency in the range 18–22 kHz.

Toothed whales including dolphins can hear ultrasound and use such sounds in their navigational system (biosonar) to orient and capture prey. Porpoises have the highest known upper hearing limit, at around 160 kHz. Several types of fish can detect ultrasound. In the order Cuneiforms members of the subfamily Alumina (shad) have been shown to be able to detect sounds up to 180 kHz, while the other subfamilies (e.g. herrings) can hear only up to 4 kHz.

Ultrasound generator speaker systems are sold as Electronic pest control devices, that claim to frighten away rodents and insects but there is no scientific evidence that the devices work.

c. Human medicine

Medical sonography (ultrasonography) is an ultrasound-based diagnostic medical imaging technique used to visualize muscles, tendons, and many internal organs, to capture their size structure and any pathological lesions with real time tomographic images. Ultrasound has been used by radiologists and sonographers to image the human body for at least 50 years and has become a widely used diagnostic tool. The technology is relatively inexpensive and portable especially when compared with other techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). Ultrasound is also used to visualize fetuses during routine and emergency prenatal care Such diagnostic applications used during pregnancy are referred to as obstetric sonography As currently applied in the medical field properly performed ultrasound poses no known risks to the patient. Sonography does not use ionizing radiation and the power levels used for imaging are too low to cause adverse heating or pressure effects in tissue. Although the long term effects due to ultrasound exposure at diagnostic intensity are still unknown, currently most doctors feel that the benefits to patients outweigh the risks. The ALARA (As Low As Reasonably Achievable) principle has been advocated for an ultrasound examination — that is, keeping the scanning time and power settings as low as possible but consistent with diagnostic imaging — and that by that principle non-medical uses, which by definition are not necessary, are actively discouraged.

Ultrasound is also increasingly being used in trauma and first aid cases, with emergency ultrasound becoming a staple of most EMT response teams. Furthermore, ultrasound is used in remote diagnosis cases where teleconsultation is required, such as scientific experiments in space or mobile sports team diagnosis.

According to Radiology Info, ultrasounds are useful in the detection of pelvic abnormalities and can involve techniques known as abdominal (transabdominal) ultrasound, vaginal (transvaginal or endovaginal) ultrasound in women, and also rectal (transrectal) ultrasound in men.

d. Veterinary medicine

Diagnostic ultrasound is used externally in horses for evaluation of soft tissue and tendon injuries, and internally in particular for reproductive work – evaluation of the reproductive tract of the mare and pregnancy detection. It may also be used in an external manner in stallions for evaluation of testicular condition and diameter as well as internally for reproductive evaluation (deferent duct etc.).

Starting at the turn of the century, ultrasound technology began to be used by the beef cattle industry to improve animal health and the yield of cattle operations. Ultrasound is used to evaluate fat thickness, rib eye area, and intramuscular fat in living animals. It is also used to evaluate the health and characteristics of unborn calves.

Ultrasound technology provides a means for cattle producers to obtain information that can be used to improve the breeding and husbandry of cattle. The technology can be expensive, and it requires a substantial time commitment for continuous data collection and operator training. Nevertheless, this technology has proven useful in managing and running a cattle breeding operation.

3-1-2 Uses of ultrasound

a. Cleaning

Sometimes we use it to clean at frequencies from 20 to 40 KHz for jewelers, lenses, watches, dental instruments and other optical part and called it supersonic cleaners**.**

b. Disintegration

High power of ultrasound can be Disintegration biological cells including bacteria by produces cavitations that facilitate particle disintegration reactions.

C. welding

In ultrasonic welding of plastics with high frequency from 15 KHz to 40 KHz it used to create heat by way of friction between the materials to be joined.

D. weapons

Ultrasound has been studied as a basis for sonic weapons for applications such as riot control disorientation of attackers up to lethal levels of sound.

3-1-3 Safety

Occupational exposure to ultrasound in excess of 120 dB may lead to hearing loss. Exposure in excess of 155 dB may produce heating effects that are harmful to the human body, and it has been calculated that exposures above 180 dB may lead to death. The UK's independent Advisory Group on Non-ionizing Radiation (AGNIR) produced a report in 2010, which was a published by the UK Health Protection Agency (HPA). This report recommended an exposure limit for the general public to airborne ultrasound sound pressure levels (SPL) of 70 dB (at 20 kHz), and 100 dB (at 25 kHz and above).

3-2 Infrasound

Infrasound is type of sound waves that study low frequency than 20 Hz or cycles per second so human can not feel it. Infrasound may travel more than 965.6 km (600.0 miles) [2].

3-2-1 Threshold of human hearing

Infrasound is radiated from many geophysical processes and from some civilization sources. **Figure 3-1** shows typical signal sound pressure levels as a function of frequency, using the threshold of human hearing as a reference. The vertical scales are in dB relative to .0002 microbar, the threshold of human hearing (left scale) and also the absolute pressure in microbars (right scale).

The threshold of hearing and the threshold of feeling cross over at a frequency of about 20 Hz, which means that frequencies below this point are felt rather than heard. Other reference points on this plot include the levels and frequencies of physiological noise and typical hydrostatic pressure changes produced by the small altitude changes involved with running or walking. This figure is intended to provide a reference point for understanding the range of minute pressure changes usually occurring for atmospheric infrasound.

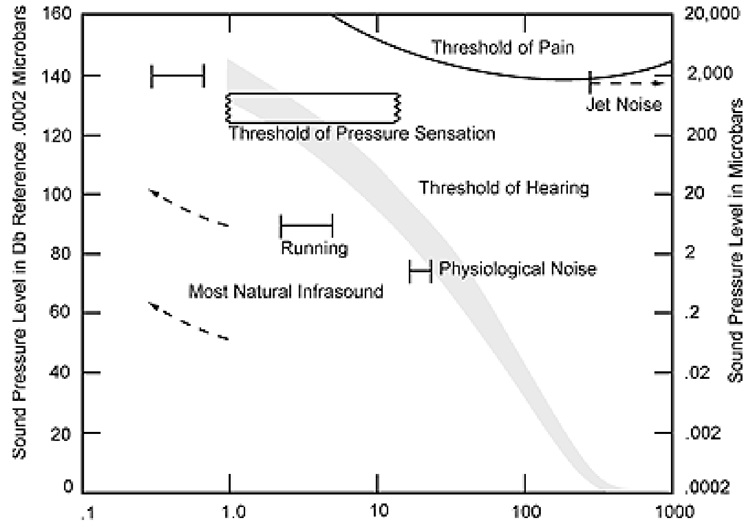

Figure 3-1 shows typical signal sound pressure levels as a function of frequency

3-2-2Signal types:

The amplitudes of a variety of infrasonic signal types as a function of period range in seconds over which they usually occur is shown in figure 3-2. This figure also presents suggested definitions to describe the different ranges. For example, periods between .05 to 1 second (20 to 1 Hz) are logically called near-infrasound (an analog to near-infrared). Periods between 1 and about 100 seconds (1 to .01 Hz) define the range of infrasound (well below the human hearing), and signals with periods greater than 100 seconds can be designated acoustic/gravity waves to indicate that the restoring force of gravity as well as compressibility is determining signal properties.

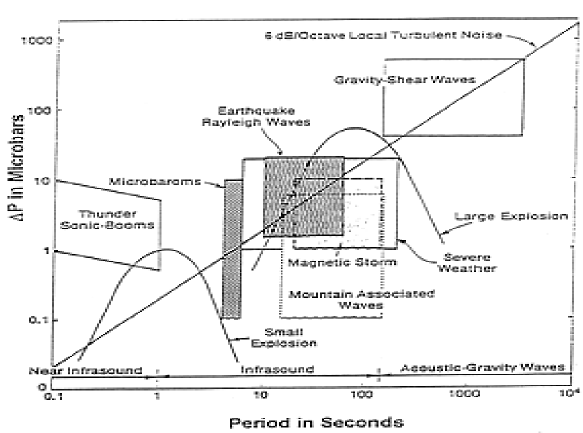

Figure 3-2 typical pressure amplitudes of infrasonic signals as a function of period in seconds with proposed definitions for the various frequency ranges indicated.

3-2-3 Sources

Infrasound sometimes results naturally from severe weather, surf, lee waves, avalanches, earthquakes, volcanoes, bolides, waterfalls, calving of icebergs, aurorae, meteors, lightning and upper-atmospheric lightning. Nonlinear ocean wave interactions in ocean storms produce pervasive infrasound vibrations around 0.2 Hz, known as microbaroms. Infrasonic arrays can be used to locate avalanches in the Rocky Mountains, and to detect tornadoes on the high plains several minutes before they touch down.

Infrasound also can be generated by human-made processes such as sonic booms and explosions (both chemical and nuclear), by machinery such as diesel engines and older designs of down tower wind turbines and by specially designed mechanical transducers (industrial vibration tables) and large-scale subwoofer loudspeakers such as rotary woofers. The Comprehensive Nuclear-Test-Ban Treaty Organization Preparatory Commission uses infrasound as one of its monitoring technologies, along with seismic, hydro acoustic, and atmospheric radionuclide monitoring [3].

3-2-4 Animal reactions to infrasound

Animals have been known to perceive the infrasonic waves going through the earth by natural disasters and can use these as an early warning.

a. **Whale**:

Whales use infrasound to communicate with each other and use as a method to attract mates

b. **American Alligator**:

During the mating season, alligator bulls use infrasound to establish status amongst the other bulls the infrasound waves are emitted, which encourages the bulls to challenge one another to Duels of strength and status to win over the female. The bulls convulse vertically in the Water causing the water to vibrate vertically along their body to Emitted infrasound waves [5].

c. **Birds**:

The common thought only large animals could generate infrasound like cassowary is very large bird it produces bellowing noises that approach the infrasound region but also small birds like pigeons can detect infrasound [4].

d. **Elephants**:

Although they live in completely different environments, Elephants and whales Have the most similarities for uses of infrasonic waves. Major differences are that Elephant waves are much higher. The lowest frequency of an elephant rumble is 14 to 40hertz. The other is that Elephants use the air and ground as mediums for their infrasound where as whales obviously use water [5].

3-2-5 Human reactions to infrasound

20 Hz is considered the normal low-frequency limit of human hearing. Experimentally the low frequency sound can cause people to have unusual experiences even though they cannot consciously detect infrasound. this level of sound may be cause people to have odd sensations that they attribute to a ghost.

3-2-6 Application of infrasound

a. Wind turbine monitoring.
b. Animal monitoring, including elephants, hippos, rhinos, giraffes, tigers, alligators, certain birds, etc.
c. Earthquake and tsunami monitoring.
d. Bolides or detonating fireball meteor monitoring.
e. Volcano monitoring.
f. Avalanche monitoring.
g. Thunderstorm, lightning and severe weather monitoring.
h. Sonic boom monitoring.
i. Explosion monitoring.
j. Aurora monitoring.
k. Alleged haunted site monitoring.
l. Rotating equipment monitoring.
m. Sick building analysis.
n. Environmental assessments.
o. Microbarom monitoring.
p. Helicopter monitoring.
q. Tornado monitoring.

3-2-7 Leakage of pipelines

Infrasonic wave is use to detect and locate the leakage of pipelines, can not only detect slow leakage of pipelines with little discharge on line, but also detect high compression ratio gas pipeline leak, which overcomes some shortages of detecting methods on line such as negative pressure wave. Infrasonic wave is suitable for leakage detection of all oil gas pipelines. However, owing to the limitation of frequency domain of sensor, when collecting infrasonic wave signals generated by pipe leakage, the tip of signals detected by sensor will be scrapped. In addition, environmental noise in nature intensively disturbs infrasonic wave signals. In order to reduce the rate of false, the tip signals should be compensated and disposed, the detected tip signals is compensated by special algorithm which could quickly separate the real leakage signals from interference signals. Then, compensated signal is processed by wavelet transformation, which makes the detected signals has excellent local characteristics in time-domain and frequency-domain and effectively overcomes the shortages of the Fourier exchanges. It has an inhibition effect on noise and precisely extracts catastrophe point of signals with different resolution at different sites in time frequency plane. The rates of misinformation and omission could be absolutely reduced by means of tip compensation and wavelet transformation above.

3-2-8 Sensors and techniques:

A critical need was the development of an effective method for -reducing noise from large but highly spatially incoherent pressure fluctuations, while still detecting infrasonic signals. Daniels (1959) made the critical breakthrough in devising a noise reducing line microphone. His concept was to match the impedance along a pneumatic transmission line using distributed input ports and pipe size changes to minimize attenuation. This- innovation exploiting the high spatial coherence of infrasound and the small spatial coherence of pressure changes related to turbulence, provided signal-to-noise ratio improvements of the order of 20 dB. Variations of his concept are currently in use worldwide. image 3-2 is a photo of a spatial filter using 12 radial arms with ports at one-foot intervals and covering a diameter of fifty feet. We have adapted porous irrigation hose for use as a distributed pressure signal transmission line (an infrasonic noise reducer), saving considerable costs in fabrication and maintenance. The present wind noise reducers can look a lot like an octopus (with four extra arms) with black porous hoses radiating outward from a central sensor [6].

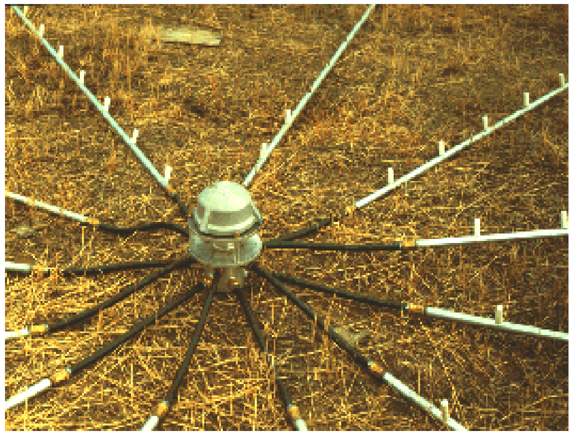

Image 3-2 Example of a space filter used with infrasonic microphones for noise reduction.

3-2-9 Example of infrasound detection and imaging of natural and civilization processes:

this table represents a range of phenomena, providing references, and indicating imaging potentials. Some items are identified with a question mark in parenthesis, signifying that at this point the capability may be possible, but has not been demonstrated.

Phenomena	Data interpretation and imaging
Avalanches	- location - Depth - Duration - Type
Earth quakes seismic waves	- Ground motion – magnitude - Source region details precursors
Explosions missile launches	- Location - Yield
Geomagnetic	- Location of particle impact
Activity	- Zones
Meteor space derbies supersonic aircraft	- Type of entry 1. Explosive , lower atmospheric 2. Shock , upper atmospheric

	- Meteor size and location - Ablation rates
Ocean waves (resulting signals are called microbrews)	- Location of waves interaction areas - Waves magnitude - Waves spectral content
Severe weather	- Location - Total storm energy - Storm processes
Tornadoes	- Location - Core radius - Vortex column length (at closer ranges) - Formation processes
Turbulence	- Location - Spatial extent - Strength - Causal mechanisms
Volcanoes	- Location - Energy released - Potential for eruption

Chapter four

4-1 Introduction

The word *tornado* is an altered form of the Spanish word tornado which means thunderstorm.

A tornado is a violently rotating column of air in contact with the ground either pendant from a cumuliform cloud or underneath a cumuliform cloud or often but not always visible as a funnel cloud. Tornadoes often begin as funnel clouds with no associated strong winds at the surface that is formations from the intense low pressure caused by the high wind speeds (as described by Bernoulli's principle) and rapid rotation usually causes water vapor in the air to condense into cloud droplets due to adiabatic cooling.

Tornadoes come in many shapes and sizes, but they are typically in the form of a visible condensation funnel whose narrow end touches the earth and is often encircled by a cloud of debris and dust

4-2 Type of tornado:-

4-2-1 multiple vortexes:-

A multiple vortex tornado is a type of tornado in which two or more columns of spinning air rotate around a common center. A multi vortex structure can occur in almost any circulation but is very often observed in intense tornadoes. These vortices often create small areas of heavier damage along the main tornado path this is a distinct phenomenon from a satellite tornado which is a weaker tornado which forms very near a large strong tornado contained within the same mesocyclone. The satellite tornado may appear to "orbit" the larger tornado (hence the name) giving the appearance of one large multi vortex tornado. However a satellite tornado is a distinct circulation and is much smaller than the main funnel [7].

Image 4-1 multiple vortexes

4-2-2 Waterspout:-

A waterspout is defined by the National Weather Service as a tornado over water. However researchers typically distinguish "fair weather" waterspouts from tornado waterspouts. Fair weather waterspouts are less severe but far more common and are similar to dust devils and lands pouts. They form at the bases of cumulus congest us clouds over tropical and subtropical waters. They have relatively weak winds smooth laminar walls and typically travel very slowly. They occur most commonly in the Florida Keys and in the northern Adriatic Sea. In contrast tornadic waterspouts are stronger tornadoes over water. They form over water similarly to mesocyclonic tornadoes or are stronger tornadoes which cross over water. Since they form from severe thunderstorms and can be far more intense faster and longer lived than fair weather waterspouts they are more dangerous. In official tornado statistics waterspouts are generally not counted unless they affect land though some European weather agencies count waterspouts and tornadoes together

Image 4-2 water spout

4-2-3Land spout:-

A *land spout* or *dust tube tornado* is a tornado not associated with a mesocyclone. The name stems from their characterization as a "fair weather waterspout on land". Waterspouts and land spouts share many defining characteristics including relative weakness, short lifespan, and a small smooth condensation funnel which often does not reach the surface. Land spouts also create a distinctively laminar cloud of dust when they make contact with the ground due to their differing mechanics from true mesoform tornadoes. Though usually weaker than classic tornadoes they can produce strong winds which could cause serious damage.

Image 4-3 Land spouts

4-3 Characteristics of tornado:

4-3-1 Size and shape:-

Tornadoes can appear in many shapes and sizes the small tornado like weak land spouts may be visible only as a small swirl of dust on the ground. Although the condensation funnel may not extend all the way to the ground if associated surface winds are greater than 40 mph (64 km/h) the circulation is considered a tornado.

Large single vortex tornadoes can look like large wedges stuck into the ground and so are known as "wedge tornadoes" or "wedge".

4-3-2Appearance:-

Tornadoes can have a wide range of colors depending on the environment in which they form those that form in dry environments can be nearly invisible marked only by swirling debris at the base of the funnel. Condensation funnels that pick up little or no debris can be gray to white. While traveling over a body of water (as a waterspout) tornadoes can turn very white or even blue. Slow moving funnels which ingest a considerable amount of debris and dirt are usually darker taking on the color of debris. Tornadoes in the Great Plains can turn red because of the reddish tint of the soil and tornadoes in mountainous areas can travel over snow covered ground turning white Lighting conditions are a major factor in the appearance of a tornado. A tornado which is "back lit" (viewed with the sun behind it) appears very dark. The same tornado viewed with the sun at the observer's back may appear gray or brilliant white. Tornadoes which occur near the time of sunset can be many different colors appearing in hues of yellow orange and pink.

4-3-3 Rotation:-

Tornadoes normally rotate cyclonically (when viewed from above, this is counterclockwise in the northern hemisphere and clockwise in the southern). While large-scale storms always rotate cyclonically due to the Coriolis Effect thunderstorms and tornadoes are so small that the direct influence of the Coriolis Effect is unimportant as indicated by their large Rossby numbers. Approximately 1 percent of tornadoes rotate in an anticyclone direction in the northern hemisphere. Typically systems as weak as land spouts and gustnadoes can rotate ant cyclonically and usually only those which form on the anticyclone shear side of the descending rear flank downdraft in a cyclonic super cell. On rare occasions anticyclone tornadoes form in association with the mesoanticyclone of an anticyclone super cell in the same manner as the typical cyclonic tornado or as a companion tornado either as a satellite tornado or associated with anticyclone eddies within a super cell.

4-3-4 Sound:-

Small tornadoes are reported as whistling, whining, humming, or the buzzing of innumerable bees or electricity, or more or less harmonic, whereas many tornadoes are reported as a continuous deep rumbling or an irregular sound of "noise"Tornadoes also produce identifiable inaudible infrasonic signatures

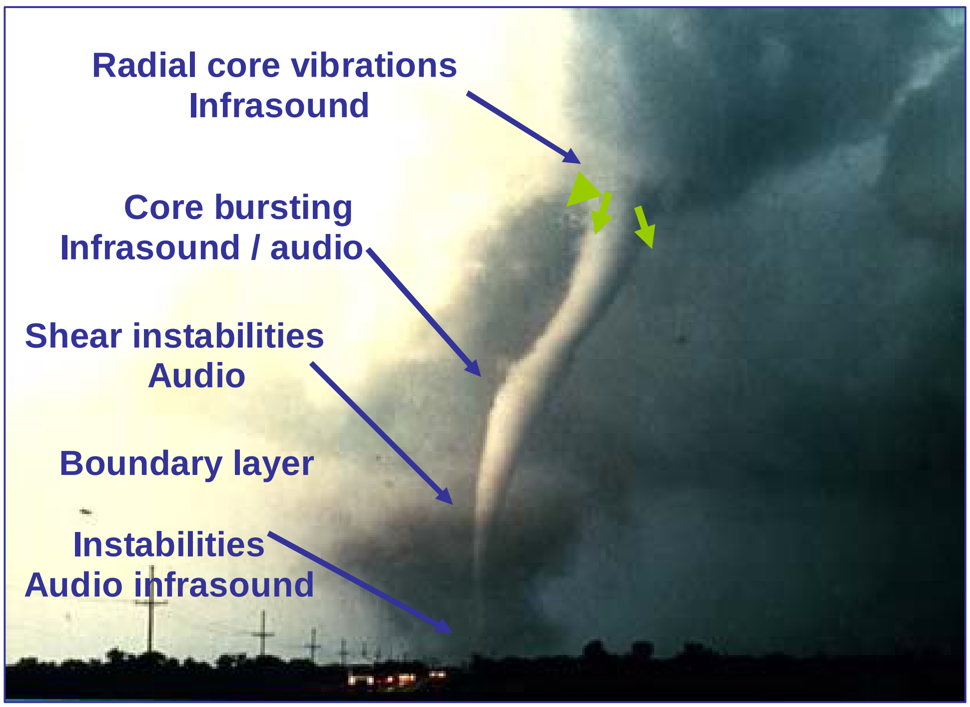

Image 4-4: Vortex generate sound

4-3-5 Electromagnetic and lightning:-

Tornadoes emit on the electromagnetic spectrum. There are observed correlations between tornadoes and patterns of lightning. Tornadic storms do not contain more lightning than other storms and some tornadic cells never produce lightning

4-4 Specific mechanism of movement

tornado spins on the same counter-clockwise in the northern half of the globe, and with the clock in the southern half of the globe, and with the rotation around itself is also moving horizontally speeds up to 65 km per hour, has cut daily distance of between 480 to 640 km, has cut the cyclone 4800 km in length during its life cycle and before fading.

4-5 Seasons of tornadoes

over the Indian Ocean for example, it has two season, the first starts from April to June, and the second season from September to December, and on the whole of the northern hemisphere most tornadoes arise between June and November, and more are in September, while in the southern hemisphere appear between November to April.

In the Middle East tornado does not appear because there is not enough Area to take his cycle.

4-6 Life cycles

4-6-1 Super cell relationship

Tornadoes often develop from a class of thunderstorms known as super cells. Super cells contain mesocyclones an area of organized rotation a few miles up in the atmosphere, usually 1–6 miles (2–10 km) across. Most intense tornadoes (EF3 to EF5) develop from super cells. In addition to tornadoes very heavy rain frequent lightning strong wind gusts, and hail are common in such storms. Most tornadoes from super cells follow a recognizable life cycle.

4-6-2 Formation

As the mesocyclone lowers below the cloud base it begins to take in cool moist air from the downdraft region of the storm. This convergence of warm air in the updraft and this cool air causes a rotating wall cloud to form. The RFD also focuses the mesocyclone's base causing it to siphon air from a smaller and smaller area on the ground. As the updraft intensifies it creates an area of low pressure at the surface. This pulls the focused mesocyclone down in the form of a visible condensation funnel. As the funnel descends the RFD also reaches the ground creating a gust front that can cause severe damage a good distance from the tornado. Usually the funnel cloud begins causing damage on the ground (becoming a tornado) within a few minutes of the RFD reaching the ground.

4-6-3 Maturity

Tornado has a good source of warm moist inflow to power it so it grows until it reaches the "mature stage". This can last anywhere from a few minutes to more than an hour and during that time a tornado often causes the most damage, and in rare cases can be more than one mile (1.6 km) across. Meanwhile the RFD now an area of cool surface winds begins to wrap around the tornado cutting off the inflow of warm air which feeds the tornado.

4-6-4 Dissipation

As the RFD completely wraps around and chokes off the tornado's air supply the vortex begins to weaken and become thin and rope-like.

This is the "dissipating stage" often lasting no more than a few minutes after which the tornado fizzles. During this stage the shape of the tornado becomes highly influenced by the winds of the parent storm and can be blown into fantastic pattern. Even though the tornado is dissipating it is still capable of causing damage.

Tornadoes can develop cyclically. As the first mesocyclone and associated tornado dissipate the storm's inflow may be concentrated into a new area closer to the center of the storm. If a new mesocyclone develops the cycle may start again, producing one or more new tornadoes

Although these is a widely accepted theory for how most tornadoes form live and die it does not explain the formation of smaller tornadoes such as land spouts long lived tornadoes or tornadoes with multiple vortices.

This each has different mechanisms which influence their development however most tornadoes follow a pattern similar to this one.

4-7 Classification of tornadoes

we classify according to the degree of wind speed, when winds of 63 to 118 km per hour is called a tropical storm, and from 119 to 153 km per hour is called a tornado in first-class, and if the winds from 154 to 177 km per hour become second-class, and 178 to 210 km per hour third class, and 211 to 250 km per hour to the fourth degree, if winds over 250 kilometers per hour in the cyclone became full strength, seriousness and a class of fifth degree.

4-8 Tornadoes fades

When tornado entering the area freely cool, or hit land begins to lose his energy and progressive weakness which starts and then fades, and continue to cycle between day to ten days approximately.

4-9 Infrasound detection of tornado

Tornadoes and tornado precursors are known to produce a pressure wave at a frequency of around 1Hz, lower than the range of human hearing. These pressure waves can travel thousands of kilometers without much attenuation. This system use extremely sensitive barometers and an Ubuntu Linux based logging machine to detect and record these low frequency pressure waves apart from the surrounding atmospheric pressure. Using multiple sensors showing in Image 4-5, and also can determine the direction from which this wave is propagating. It accomplishes this by arranging the sensors in a roughly square fashion and comparing the times at which the wave hits each sensor. The sensor closest to the angle of incidence will record the wave first and the time at which it hits each of the other sensors provides more information about the direction of the tornado. Our role in this project is to convert the project from using wired serial data transmission to wireless it consist of: data transmission rate, cost , serial interface ,detachable antenna. Ideally we will accomplish this with the 802.11g “WiFi” protocol showing in Image 4-6**,** serial RS232 or RS485 to 802.11 adapters, and modification to the existing server software running on the logger machine.

4-9-1 Advantages of wireless system

- Allows us to increase the number of barometers on the system .it was previously limited to for due to there only being four ports on the USB converter .
- Allows for potentially larger arrays (hundred meters on a side as opposed to 50) which would give larger areas, and in turn a more reliable pressure readout.
- Set-up becomes easier because trenches won't have to be dug for the hundreds of feet of serial cables.

Current Set-Up (Wired)

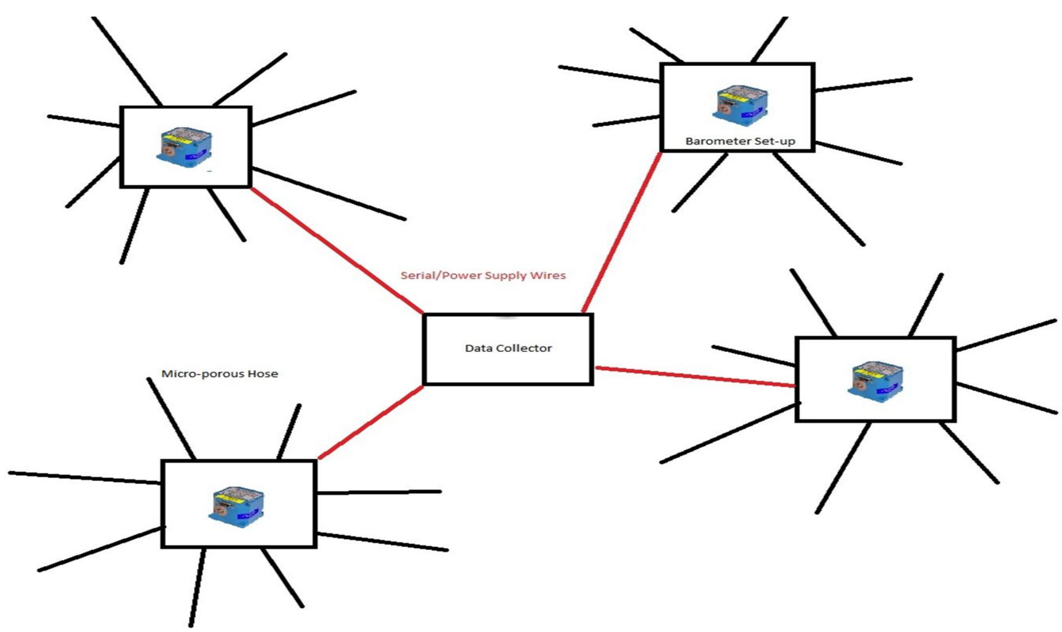

Image 4-5 Current Set-Up (Wired)

Future Set-Up (Wireless)

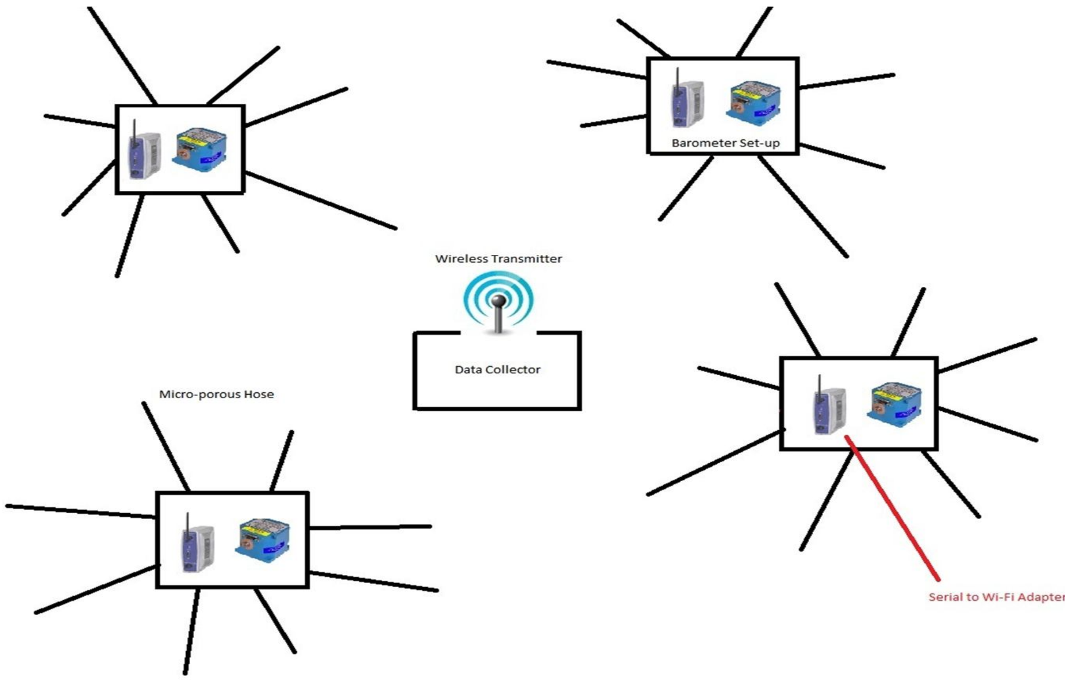

Image 4-6 Future Set-ups (Wireless)

3-10 Infrasonic observatories improve tornado warnings as follows:-

- Provide vortex detection capabilities where radar constraints exist (e.g. obstacle blocking longer ranges where radar resolution is degraded short ranges where high elevation radar scansare limited).
- Provide detection continuity between radar scans (The interval between consecutive Nexrad volume scans is 5 minutes).
- Provide information on smaller diameter vortices.
- Provide information on vortices of limited vertical extent which may not show clearly on volume scan displays.
- Potentially provide guidance for optimizing radar scans.
- Provide information on vortex core size.

Conclusion

In this research we discuss how the infrasonic wave developed to alert us from tornadoes and to the alertness equipments

And by using infrasonic wave to read the tornado movement and the rate danger the scientist success to help human to take care from tornadoes because its un devetable phenomena .

Recommendation

1- Improve detection hardware and software.

2- We should use Infrasound observing systems it could help accelerate development

3- Work closely with international labs such as (NSSL and FSL) and the NWS as we move toward implementation of a prototype demonstration Network.

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