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Prospects of High-Frequency Acoustic Sounding at Maitri, Antarctica

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INTRODUCTION

The group at the National Physical Laboratory, New Delhi has exploited a monostatic acoustic sounding system installed at Maitri, Antarctica in studying the Planetary Boundary Layer (PBL) processes over Maitri, Antarctica in an extensive manner (Pasricha et al., 1991; Naithani et al., 1994, 1995; Naithani, 1997; Ashok Kumar, 2002; Gajananda, 2002; Gananda and Dutta, 2005; Gajananda et al., 2004, 2007, 2011;Ved Parkash, 2008; Bishnoi, 2010; Gajananda et al., 2011; Deb et al., 2010a,b; Singh and Dutta, 2011). Later on, the group transferred the technology of monostatic acoustic sounder developed for Antarctica to a private firm (Dutta and Naithani, 1994), resulting in benefits of Antarctica to be harnessed by the scientific and technological society in India. The group also utilized the Antarctica PBL data in getting an international patent (Gera et al., 2005, 2011). Later on, the group worked extensively on the development of a shipborne acoustic sounder and the successful attempt has resulted in important contributions at the global level (Bishnoi et al., 2005; Singh and Dutta, 2011; Dutta et al., 2011).

Based on the acoustic probing of the Planetary Boundary Layer up to a height of 1 km at Maitri, it has been realized that almost all the important ice-air-ocean interactive phenomena are in the lowest domain and instead of going to 1 km as the probing height, a much lower probing height would be good enough for all practical purposes. It was realized that maintaining a low frequency acoustic sounder (using 6 feet parabolic dish surrounded by an acoustic shield) in the open environment is a herculean task, especially during blizzards and during winter period. During blizzards, so much of snow gets accumulated on the parabolic dish antenna that it has to be removed immediately so that the observations start without major break. Any delay in physical removal of snow may hamper the observational part seriously. Some groups are providing heating in the antenna itself to melt the snow/ice. This is an attempt which has not been made by our group, as it would mean, redesigning the antenna to fit the inbuilt heating coils.

At the same time, many groups in the world have ventured to use high frequency acoustic signals in capturing the advantage of portability (Coulter and Martin, 1986; Mursch-Radlgruber and Wolfe, 1993; Coulter et al., 1994; Woülfelmaier et al., 1999; Kouznetsov, 2009) but it limits the probing range to within about 300 m (Coulter and Martin, 1986), without really compromising on its capability to detect drainage flows in the rocky mountains (Woülfelmaier et al., 1999).

Based on this important input, an innovative approach would be to go for high frequency acoustic sounding, especially in Antarctica so that the whole antenna is small enough to physically shift it inside a room during blizzards. Moreover, the height range of even high frequency acoustic sounding is good enough to yield answers for many unresolved atmospheric processes and issues in Antarctica. High frequency would also remove possibility of reflections from nearby tall structures. Although, we do not have these kinds of issues at Maitri, Antarctica but the advantage cannot be ruled out.

Work Carried Out During 25th Expedition

With this background in mind, the group at NPL, New Delhi deployed a high frequency acoustic sounder at Maitri, Antarctica during the 25th Indian Scientific Expedition to Antarctica and the present report highlights the experiences for its future growth in India and its prospects of installation at Maitri, Antarctica.

Design Philosophy

Based on the inputs from the published literature, it was decided to use a 2 feet parabolic dish with a high frequency acoustic transducer fitted at the focus. In fact, we carried various types of acoustic transducers which had the capacity to operate at higher frequencies. It may be pointed out that while choosing a transducer; almost all the companies would give specifications about the transmitting characteristics. However, their receiving functional parameters are missing and this is something that has to be assessed either in the laboratory or directly in the field itself. Moreover, for receiving side, environmental temperature is extremely important. We have not been able to create this type of a facility to have a perfect trial but the testing around zero degree was carried out to assure functionality atleast during summer period.

The detailed specifications of the system are given in Table 1. In reality, the earlier acoustic sounder was based on an AD card (ADDA-16) and now, the sound card available on the PC board itself, serves the

Table 1—System specifications of high frequency acoustic sounder

System Operation	
System operation	Automatic, PC controlled
Transmit Channel	
Frequency of operation	4000 Hz
Transducer	Ahuja High frequency transducer
Alternative transducer	Philips transducer
Transmit power	4 Watts
Transmit pulse length	75ms
Pulse repetition frequency	1.8s
Electronic device producing sound output	Sound card fitted in the PC itself
Parabolic dish size	2 feet fitted with transducer at focus
Antenna cuff	Fiberglass molded with the antenna itself.
Receiving Channel	
Receiving channel	Sound card receive port
Signal processing	Band pass filtered amplitude detection
Signal display	Facsimile up to 300 m
Time delay between successive pulses	programmable

purpose of transmitting a sound signal and to convert the received signals in a.wav file. This file is then processed to assess the signal amplitude at various heights. The facsimile chart is produced as a gray shade chart and the digital data remains in the PC itself for digital processing of the data in various operations.

It is important to note that while testing is done in India, things may seem to be working fine, but the moment system starts working in Antarctica, it has to face several challenges on account of low temperature, high static charges and possibility of having no earthing in the electrical connection etc. Fortunately, we do not have any major source of electrical noise present nearby so we do not have to worry about the electronic noise being caused by external sources. The noise problem comes only when the winds are higher. In fact, when winds are higher, the effective aperture area also reduces, limiting the utility of low frequency acoustic sounder.

OBSERVATIONS

The moment equipment was shifted from the ship to Maîtri, it was installed close to a summer hut and the system was put in operation within no time. However, it did not function as per the expectations and a thorough inspection showed that the transducer was creating a problem at low temperature. The transducer was then thermally shielded and heated with 12 Volt supply and then it started functioning satisfactorily.

The first successful facsimile chart was received on the night of January 24, 2006. It shows a surface based layer and several elevated layers in the lowest atmosphere. In receiving this facsimile, although sweep rate was just 1.8 seconds but between two successive pulses, a dead time of 6 seconds was incorporated. In fact, it was known from the

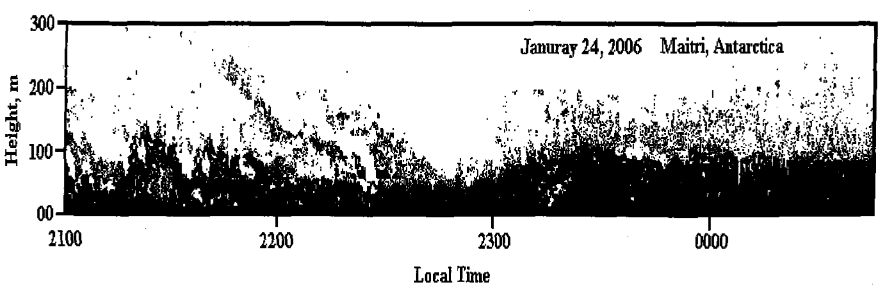

Fig. 1: Surface based and elevated layers observed with a high frequency acoustic sounder installed at Maitri, Antarctica

earlier observations that nothing dramatically changes within 6 seconds in the PBL over Antarctica and the aim of this expedition was to really assess the health of various components being established as part of high frequency acoustic sounding over Maitri, Antarctica.

It is known that surface based invasions are caused by the radiative cooling of the earth's surface and it is these inversions (Naithani, 1997; Ashok Kumar, 2002; Gajananda, 2002) which create katabatic winds in Antarctica.

The other important observation in the PBL was recorded on January 28, 2006 between 0300 hrs to 0600 hrs., when the surface heating of the rocky region created thermal convection. In fact, thermal convection at the periphery of Antarctica is rare and it causes fine particulate matter and other microorganisms to spread from one point to another (Gajananda, 2002; Gajananda et al., 2004). Figure 2 shows the thermal plumes touching right up to 300 m and this reflects that it will be advantageous to operate both the low frequency and high frequency acoustic sounders in order to carry out the probing of Antarctic PBL effectively.

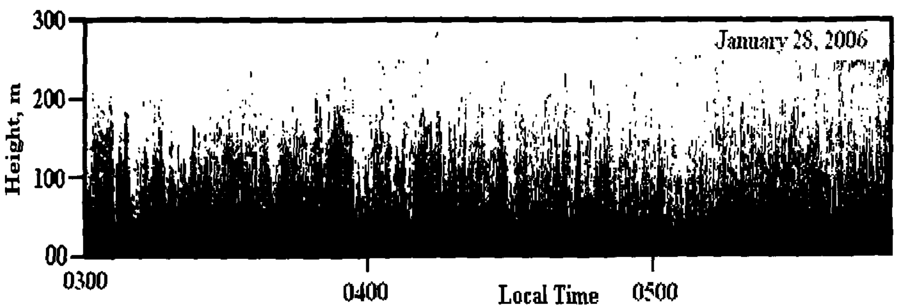

Fig. 2: Thermal convection recorded at Maitri, Antarctica

In the acoustic sounding data received from Antarctica, we have been able to identify the simple images (Deb et al., 2010 a,b).

However, a large volume of data remains as complex structures and it really needs a close association with the pattern recognition software professionals in India. One such case of a complex structure is plotted in Figure 3. This type of structure normally prevails when a low temperature layer develops in the upper regions, pulling the underneath air in the vertical direction. In fact, to ensure there is no return from the earlier pulses, a delay of several seconds was incorporated.

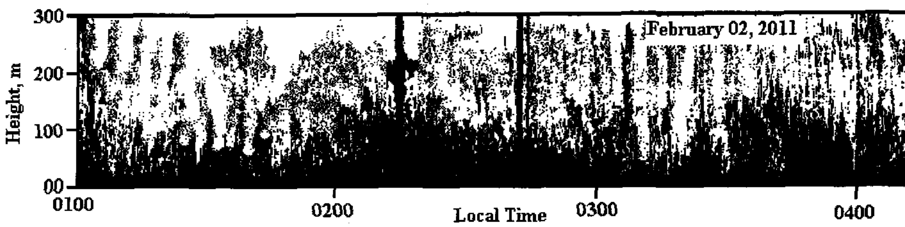

Fig. 3: Complex structure observed at Maitri, Antarctica

DISCUSSION AND RECOMMENDATIONS

The present work, carried out for an extremely limited period, has shown the possibility of a successful operation of a high frequency acoustic sounder in Antarctica and all the components for this equipment are indigenously available.

On the basis of the PBL studies and the experiences gained during various expeditions, it is recommended that the PBL program should be shifted to NCAOR, so that at least three identical system be fabricated-one for installation and training at NCAOR, Goa and the other two for the field observations at Maitri and the upcoming third Indian Antarctic station. At the same time, transmitting and receiving transducer characteristics must be evaluated at realistic temperatures, which the transducers have to face in Antarctica.

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