# STSM Report

## of Prof. Colin Price (Tel Aviv University, Israel)

Collaboration: between Colin Price (Tel Aviv University) and Elisabeth Blanc (CEA, France)

Location of STSM: ARISE Workshop (Reading, UK)

Dates: 18-21 September, 2012

Topic: **Infrasound and Thunderstorms**

1) Purpose of the Visit: Infrasound technology using micro-pressure sensors (microbarometers) has been experimented with for a long time, starting in the aftermath of the Second World War to detect atmospheric nuclear tests. The potential of this technology was to observe most of the atmospheric disturbances that rapidly appear. But sensors were often isolated, and it was only possible to extract and analyze the largest disturbances from the ambient infrasound noise. In the seventies, arrays of infrasound sensors started to be used, which permitted the identification of a wide variety of infrasound sources. The introduction of arrays opened up a whole range of possibilities for this technology.

All the technical aspects of infrasound monitoring have been redeveloped for the Comprehensive Test Ban Treaty (CTBT) verification. In 2000, the infrasound network was still in its infancy with only 1 of 60 operating IMS station. Nowadays, approximately 43 stations have been installed and are sending data (see figures below). The IMS network is unique by its global and homogeneous coverage and its data quality. The IMS infrasound network allows infrasound observations with an unprecedented precision, thanks to the use of a large number of arrays of sensors uniformly distributed throughout the world. It is dedicated to be in operation over a very large period of time. Its potential for imaging the atmosphere is high and it opens many scientific studies in relation with atmosphere and climate.

*Example of infrasound station equipment*

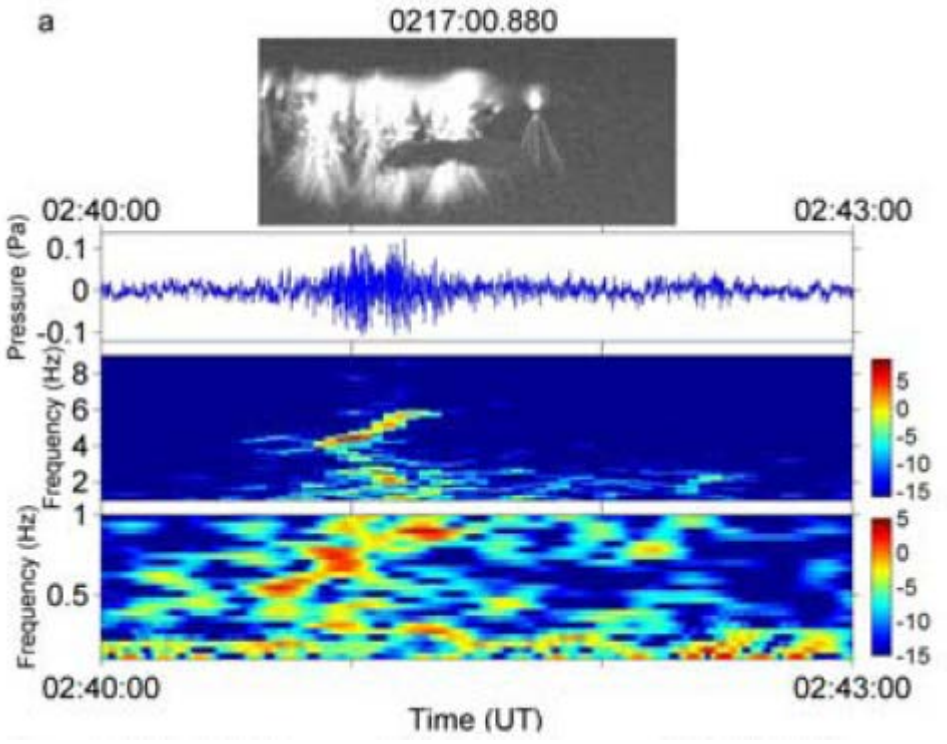
*Map of CTBTO infrasound stations*

The infrasound arrays are very sensitive acoustic antennas, which are able to detect and characterize any coherent infrasound signals. Since 2000 an improvement of signal-to-noise ratio (SNR) of up to 50% at many infrasound stations has been achieved due to technical

factors such as optimized array design, introduction of higher standards for grounding, use of wind-noise reduction devices. The large dynamic range of the instruments allow the observations of both very strong events close to the station and very small ones at distances of a few thousand kilometers.

During the last decade, there have been significant technical and scientific advances in terms of satellite and meteorological data applications. The availability of high resolution models describing the state of the atmosphere in real-time shows that realistic simulation of infrasound wave propagation has become a reality. For example the atmospheric models provided by the European Centre for Medium-range Weather Forecasting (ECMWF) are available every 3h, with 0.5 degree resolution data up to 70km altitude. These models recently started to be tested to feed ray tracing software that predict infrasound arrival times and azimuth deviations for a given source and receiver.

The increasing number of infrasound stations has motivated an increasing number of scientific studies. Dr. Elisabeth Blanc is one of the world experts in the field of thunderstorm studies using infrasound (Farges et al., 2005; Le Pichon et al., 2009; Farges and Blanc, 2010), in particular, the detection of lightning and sprites using infrasound (figure below). Furthermore, Prof. Price has access to the infrasound station data collected by the National Data Center (NDC) in Israel. Hence, this STSM visit was to start the collaboration between the research groups in France and Israel on the topic of infrasound and thunderstorms.




*Sprite optical image, together with the infrasound raw time series, and the spectrogram below in color, for two different frequency ranges (Farges and Blanc, 2005).*

2) Description of Work carried out: To initiate this new collaboration, Prof. Price attended the first ARISE Workshop held at the University of Reading near London, UK, and led by Dr. Elisabeth Blanc (PI of ARISE FP7 project).

The workshops explored several themes:

- Three novel monitoring technologies for the atmosphere which make up ARISE project (Infrasound, LIDAR and airglow).
- How these technologies can be used in concert?
- The use of the three technologies to monitor extreme events in the Earth system.
- The use of the technologies for numerical weather prediction and for climate simulation
- The design and maintenance of a network made up of the three technologies

3) Description of main results: Prof. Price attended the entire workshop as a way to learn more about infrasound from Dr. Blanc's research group, and to discuss ways to get involved in this field of research (both experimental methodologies, as well as modeling tools for understanding the infrasound propagation). In addition to the discussions and learning over the few days, Prof. Price also delivered a talk on his research related to very low frequency (VLF) radio wave technology and the possibility to include this technology in studying changes in the upper atmosphere (one of the infrasound uses).

Besides Dr. Elisabeth Blanc, meetings were also held with Dr. Alexis Le Pichon, who is the expert on infrasound software analysis in Dr. Blanc's group. An Israeli student may be sent in the coming year to France to be trained on the French software, and to get hands-on experience.

In addition, there were discussions about using infrasound data from African stations, particularly Ivory Coast, to study the thunderstorm activity in tropical Africa. This is the region of the globe with the highest amount of thunderstorm and lightning activity, while also being the breading ground of thunderstorms that often move into the Atlantic and develop into hurricanes. One topic of future research will be to study the link between the infrasound signatures and hurricane genesis in central Africa.

4) Future collaborations: In the coming year we plan to send a student from Israel to CEA (France) to work with E. Blanc, T. Farges and A. Le Pichon in a training school on infrasound. In addition, Prof. Price and his PhD student may attend the summer school planned for June 2013 in France related to the ARISE project. The plan would be to bring infrasound data from Israel to France with us, and then to work together with our French partners on analyzing and understanding the signals in the data. In Israel we also have archived sprite images from winter thunderstorms (with GPS timing) that we wish to correlate with infrasound signals detected in Israel. The French group has a lot of experience in this, and will help the Israeli team advance in this field.

On the other hand, Prof. Price has a lot of experience in thunderstorms research, as well as severe weather and hurricanes. This will contribute to the knowledge of the French team when analyzing their data in remote regions of the globe, such as tropical Africa.