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Optical Fiber Infrasound Sensor Arrays: An Improved Alternative to Arrays of Rosette Wind Filters

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A key difficulty in infrasound signal detection is the noise created by spatially incoherent turbulence that is usually present in wind. Increasing wind speeds correlate with increasing noise levels across the entire infrasound band. Optical fiber infrasound sensors (OFIS) are line microphones that instantaneously integrate pressure along their lengths with laser interferometry. Although the sensor has a very low noise floor, the promise of the sensor is in its effectiveness at reducing wind noise without the need for a network of interconnected pipes. We have previously shown that a single 90 m OFIS (spanning a line) is just as effective at reducing wind noise as a 70 m diameter rosette (covering a circular area). We have also empirically measured the infrasound response of the OFIS as a function of back azimuth, showing that it is well predicted by an analytical solution; the response is flat for broadside signals and similar to the rosette response for endfire signals. Using that analytical solution, we have developed beamforming techniques that permit the estimation of back azimuth using an array of OFIS arms as well as an array deconvolution technique that accurately stacks weighted versions of the recordings to obtain the original infrasound signal. We show how a slight modification to traditional array processing techniques can also be used with OFIS arrays to determine back azimuth, even for signal-to-noise ratios much less than 1.

Recently several improvements to the OFIS instrumentation have been achieved. We have made an important modification to our interferometric technique that makes the interferometer insensitive to ambient temperature fluctuation. We are also developing a continuous real-time calibration system, which may eliminate the need for periodic array calibration efforts. We also report progress in comparing a newly installed 270 m long OFIS at Piñon Flat Observatory (PFO) to a collocated 70 m rosette of the I57US array. Specifically, we compare hundreds of wind noise spectra and two Vandenberg rocket launch infrasound signals that were recorded by both systems. The 70-m diameter rosette (L2) was connected to a Chaparral Physics Model 50 microphone, which is usually more sensitive than the MB2000 microbarometer in the 1-10 Hz band. The data show that in low wind, the noise floor of the OFIS is the same as the Chaparral. However, in moderate wind (5 m/s) the OFIS attenuates wind noise at 1 Hz by 10 dB better than L2. Similarly, the two rocket launch signals that were recorded in the presence of 3-4 m/s wind confirm that the signal-to-noise ratio improvement is 10 dB at 1 Hz. This confirms that at each signal frequency and direction, there exists an OFIS length threshold above which an OFIS wind filter will always outperform a rosette in terms recorded signal-to-noise ratio.

The OFIS technology is proven and mature for observatory installations. Work is underway to make the technology more portable for remote, DC-powered deployments. A DC-powered, ruggedized OFIS array will be installed for microbarom research in Northern California during the spring of 2010. We seek collaborations with other researchers that are interested in evaluating or assisting in the further development of the OFIS technology.