Optimization of Selection Methods and Localization of Infrasound Sources for Solving Problems in the Monitoring of the Comprehensive Test-Ban Treaty

A method for network selection and localization of global infrasound sources based on propagation velocities and azimuth deviations of infrasound signal arrivals at the infrasound stations of the International Monitoring System of the Comprehensive Nuclear Test-Ban Treaty is developed. The method uses a network likelihood ratio approach, incorporating REB bulletin statistics, as well as an algorithm for checking adequacy of applying models of high-altitude jet streams. To eliminate false signals that fall within the specified azimuth deviations and velocity ranges at each individual station, it is necessary to perform not only station selection but also network selection. For a large number of events from REB, histograms of azimuth deviations and changes in signal velocities are constructed, taking into account corrections for altitude jet streams. The likelihood ratio is defined as the ratio of probabilities for true and false sources. The network likelihood ratio is compared against a threshold determined using the Monte Carlo method. Signals from a real source that exceed this network selection threshold are considered true.

α − *true azimuth;*
α_{st} − *registered azimuth;*
α_{mean} − *high altitude jet streams mean azimuth;*
α_0 − *model azimuth in terms of high altitude jet streams influence;*
Δ − *azimuth deviation;*
Δ_0 − *azimuth deviation in terms of correction;*
V − *infrasound signal velocity;*
V_{mean} − *high altitude jet streams mean velocity;*
V_0 − *model velocity in terms of correction;*
N − *count of infrasound stations registered the signal.*

$$\alpha_0 = arctg\left(\frac{V * \sin\alpha - V_{mean} * \sin\alpha_{mean}}{V * \cos\alpha - V_{mean} * \cos\alpha_{mean}}\right)$$

$$V_0 = \sqrt{V^2 + V_{mean}^2 - 2VV_{mean}\cos(\alpha - \alpha_{mean})}$$

$$\Delta = \alpha - \alpha_{st} \qquad \Delta_0 = \alpha_0 - \alpha_{st}$$

Based on the REB data, the distributions $P_V(V)$, $P_{V_0}(V_0)$, $P_\Delta(\Delta)$, $P_{\Delta_0}(\Delta_0)$ will be constructed.

Conditions for the proper application of the atmospheric model:

$$\sum_i [P_{V_0}(V_{0i})] * V_{0i}^2 - \left[\sum_i [P_{V_0}(V_{0i})] * V_{0i}\right]^2 < \sum_i [P_V(V_i)] * V_i^2 - \left[\sum_i [P_V(V_i)] * V_i\right]^2$$

$$\sum_i [P_{\Delta_0}(\Delta_{0i})] * V_{0i}^2 - \left[\sum_i [P_{\Delta_0}(\Delta_{0i})] * \Delta_{0i}\right]^2 < \sum_i [P_\Delta(\Delta_i)] * \Delta_i^2 - \left[\sum_i [P_\Delta(\Delta_i)] * \Delta_i\right]^2$$

Conditions for the selection:

$$\prod_{j=1}^{N} P_{\Delta_0}(\Delta_{0i}) * P_{V_0}(V_{0j}) > \mathrm{G(N)}$$

The threshold G(N) is calculated using the Monte Carlo method under the condition that 99% of the model sources have exceeded the threshold.

Russian National Authority for CTBT

Authors: A.Rogovoy, I.Rybin, M.Goranov, S.Kniga, T.Litvinenko, D.Yablokov