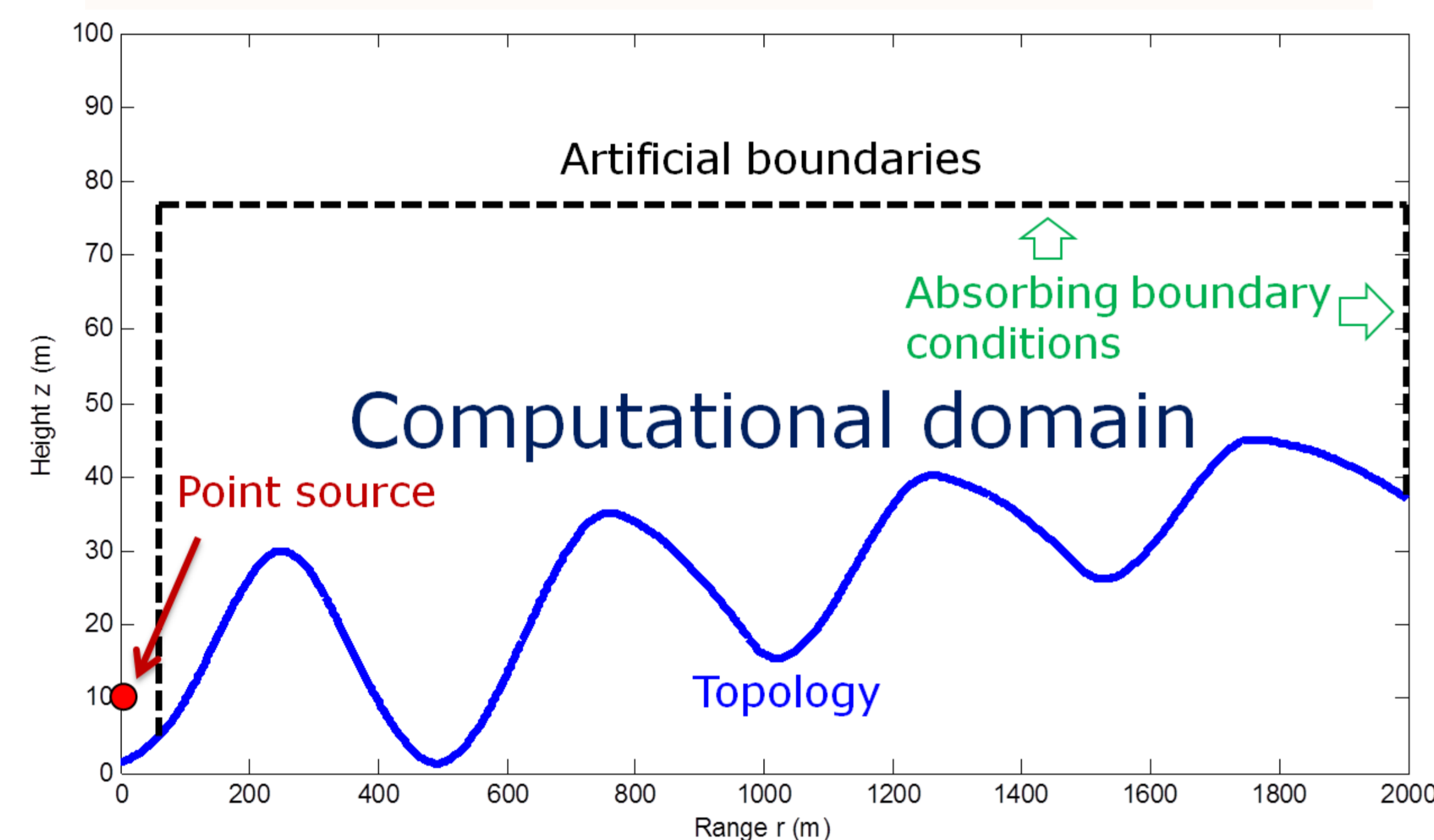


Atmospheric sound propagation over irregular terrain using high-order accurate finite difference approximations

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The Model

A sound source which emits spherical waves with a frequency of 50 Hz is placed as shown in the figure. The task was to compute the sound level at steady state, up to a height of 100 m. We truncated the domain by introducing artificial boundaries.



Boundary conditions

The left boundary condition was determined by the source. At the top and right boundary, the waves are not supposed to be reflected. Here first order Engquist Majda absorbing boundary conditions were used.



First order Engquist Majda absorbing boundary conditions are not good enough!

Solving the problem accurately with these boundary conditions requires that the top boundary is placed very high up, which leads to a large computational domain. This is very inefficient from a computational point of view.

Future research will investigate higher order Engquist Majda and other types of more efficient absorbing boundary conditions. The challenge is to find a boundary condition that is both efficient and yields an energy estimate.

The SBP-SAT technique

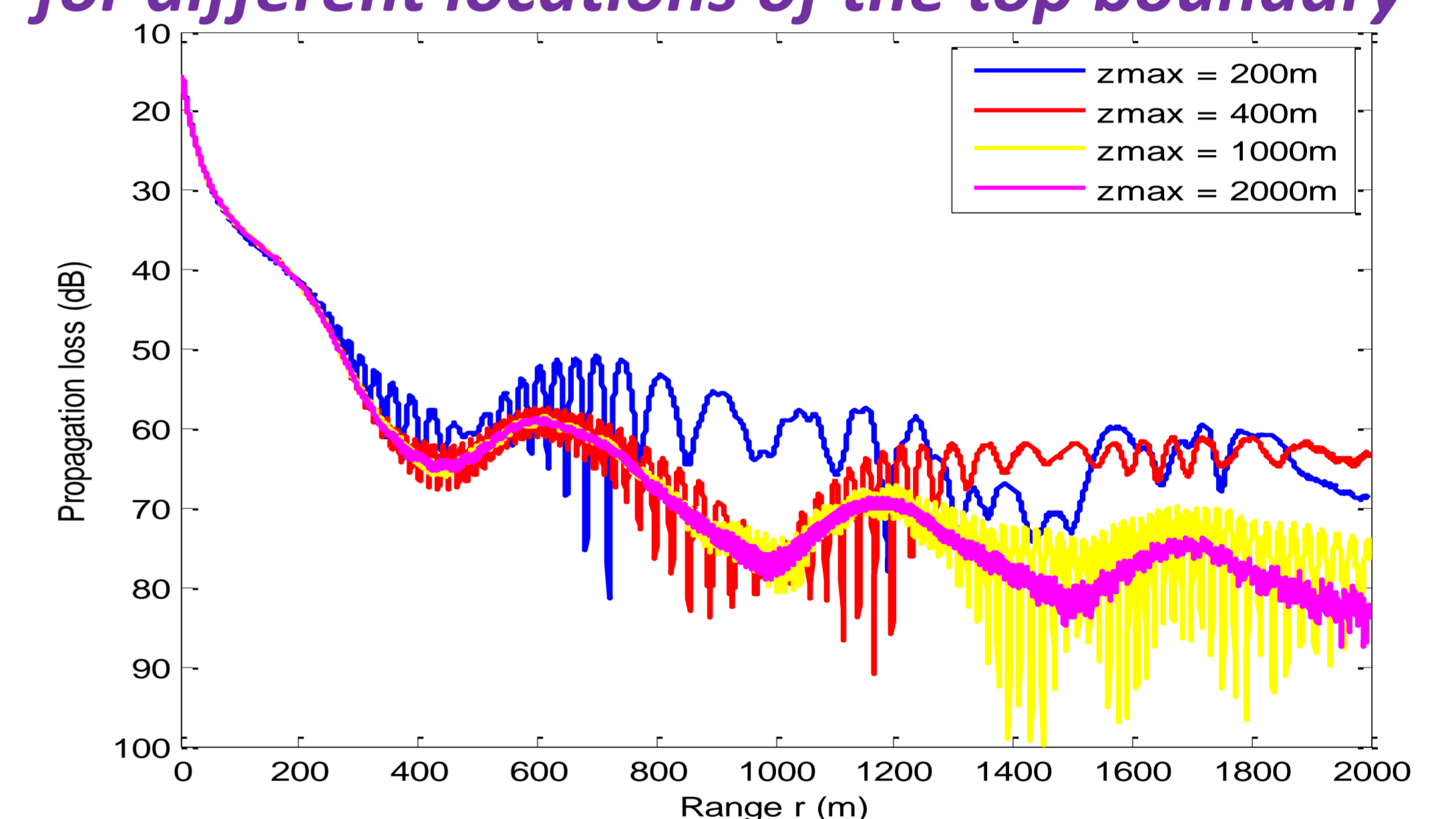
A semi-discrete finite difference approximation of the continuous problem was obtained by combining high-order accurate Summation-By-Parts (SBP) operators and the Simultaneous Approximation Term (SAT) method to impose the boundary conditions.

The primary strength of the SBP-SAT technique is that it makes it possible to derive an energy estimate for the discretized model, which exactly mimics the continuous energy estimate, thus proving strict stability.

Reflections from artificial boundaries affect the solution!

The figure below shows how the solution changes with the location of the top boundary. The violent oscillations are non-physical and appear only because of reflections from artificial boundaries. The higher we place the top boundary, the less significant these reflections become.

Propagation loss (dB) 1 m above the ground for different locations of the top boundary



As shown by the figure above, we have to place the top boundary at a height of 2000 m or higher to get an accurate solution. The figure below shows the solution obtained with the top boundary at 2000 m.

Propagation loss (dB)

