the model) by minimizing the misfit between the observed data and the modeled data. The seismic data are modeled using the physics of wave-propagation in conjunction with a current model. The misfits are fed back in to the inversion and the model is updated. This process is iterative and it continues until a satisfactory match between the modeled data and the observed data is reached.

[0007] A key component of the FWI process is the definition of the misfit between the modeled data and the observed data, which is also known as the objective function. The most commonly used objective function is the least-squares direct data misfit. For the least-squares direct data misfit, the inversion is driven to minimize the squared difference between the two data sets (i.e., the sum of the square of the sample-by sample subtraction of modeled and observed data). While this objective function is very intuitive and straightforward it is very sensitive to the choice of the starting model. For example, if the modeled data and the observed data are shifted by more than half-a-wavelength with respect to each other, the process of FWI driven by direct data misfit does not converge to the global minimum value. It is said to be trapped in a local minimum, where the FWI has inadvertently converged to a local minimum of the squared difference.

SUMMARY

[0007a] According to a first aspect of the present disclosure, there is provided a method, including: selecting a first objective function of a full waveform inversion (FWI) from a set of objective functions; selecting a second objective function of the FWI from the set of objective functions; calculating a first misfit based upon the first objective function using modeled data with respect to observed data, calculating a first search direction based upon the first misfit between the modeled data and the observed data; calculating a second misfit based upon the second objective function using the modeled data with respect to the observed data, calculating a second search direction based upon the second misfit between the modeled data and the observed data; and combining the first search direction with the second direction and computing an update to the modeled data based upon the first search direction and the second search direction combination.

[0007b] According to a second aspect of the present disclosure, there is provided a tangible and non-transitory machine readable medium, comprising instructions to cause a processor to: select a first objective function of a full waveform inversion (FWI) from a set of objective functions; select a second objective function of the FWI from the set of objective functions; calculate a first misfit based upon the first objective function using modeled data with respect to observed data, calculate a first search direction based upon the first misfit between the modeled data and the observed data; calculate a second misfit based upon the second objective function using the modeled data with respect to the observed data, calculate a second search direction based upon the second misfit between the modeled data and the observed data; and combine the first search direction with the second direction and computing an update to the modeled data based upon the first search direction and the second search direction combination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Various aspects of this disclosure may be better understood upon reading the following detailed description and upon reference to the drawings in which:

[0009] FIG. 1 illustrates a flow chart of various processes that may be performed based on analysis of seismic data acquired via a seismic survey system;

[0010] FIG. 2 illustrates a marine survey system in a marine environment;

[0011] FIG. 3 illustrates a land survey system in a land environment;

[0012] FIG. 4 illustrates a computing system that may perform operations described herein based on data acquired via the marine survey system of FIG. 2 and/or the land survey system of FIG. 3;

[0013] FIG. 5 illustrates a flow diagram of an operation to carry out full waveform inversion (FWI) with cycle skip avoidance;

[0014] FIG. 6 illustrates a graphical representation of an example of an input data and modeled input data usable with FWI;