Inverse scattering series internal multiple prediction with depth dependent scalars

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Abstract

One prospective method to attenuate interbed multiples uses the inverse scattering series developed by Weglein et al in the 1990's. The method predicts internal multiples from the recorded data with no additional subsurface information requirements. Displayed is how a depth dependent scalar can be added to the inverse scattering series algorithm to account for errors in the prediction amplitude and improve accuracy for specific cases.

Inverse Scattering Series

$$b_3(\omega) = \int_{-\infty}^{\infty} dz_1 e^{-i2\frac{\omega}{c_0}z_1} b_1(z_1) \left[\int_{z_1+\varepsilon}^{\infty} dz_2 e^{i2\frac{\omega}{c_0}z_2} b_1(z_2) \right]^2$$

b_3 is the interbed multiple prediction, b_1 is the prepared input data, z_1 and z_2 are the depths chosen to satisfy lower-higher-lower criteria and ε is the search limiting parameter

Internal multiples are predicted by solving for all sub-event combinations by searching through the possible z_1 values which obey lower-higher-lower criteria for each frequency (ω)

Geologic Model

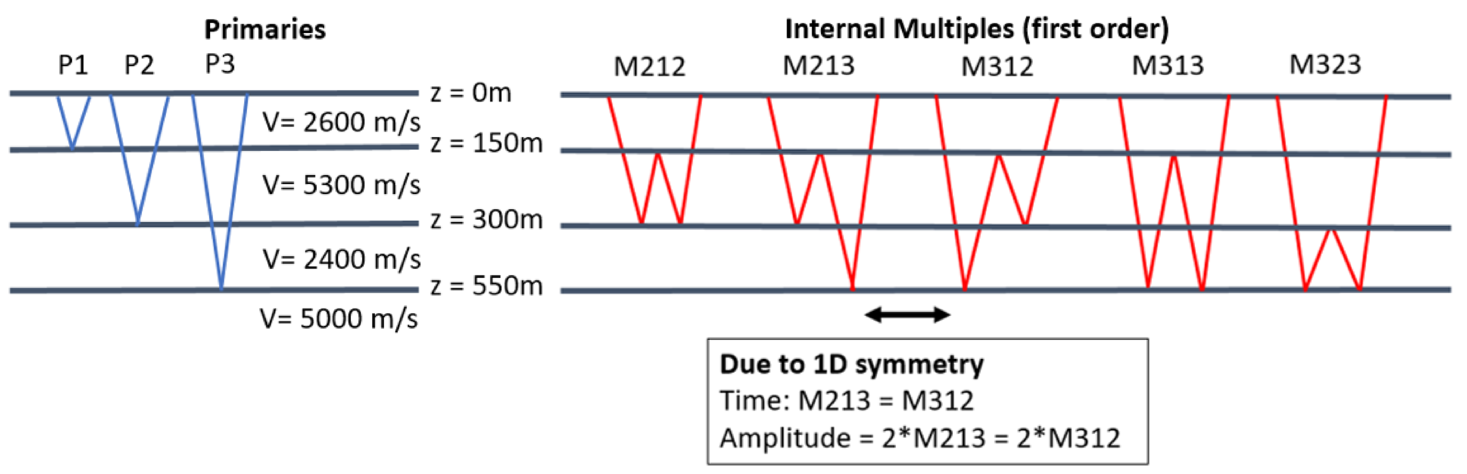


FIG. 1. (Left) Primary events for a three-layer model plus half-space with velocity and depths (Right) First order internal multiples for the three-layer model plus half-space

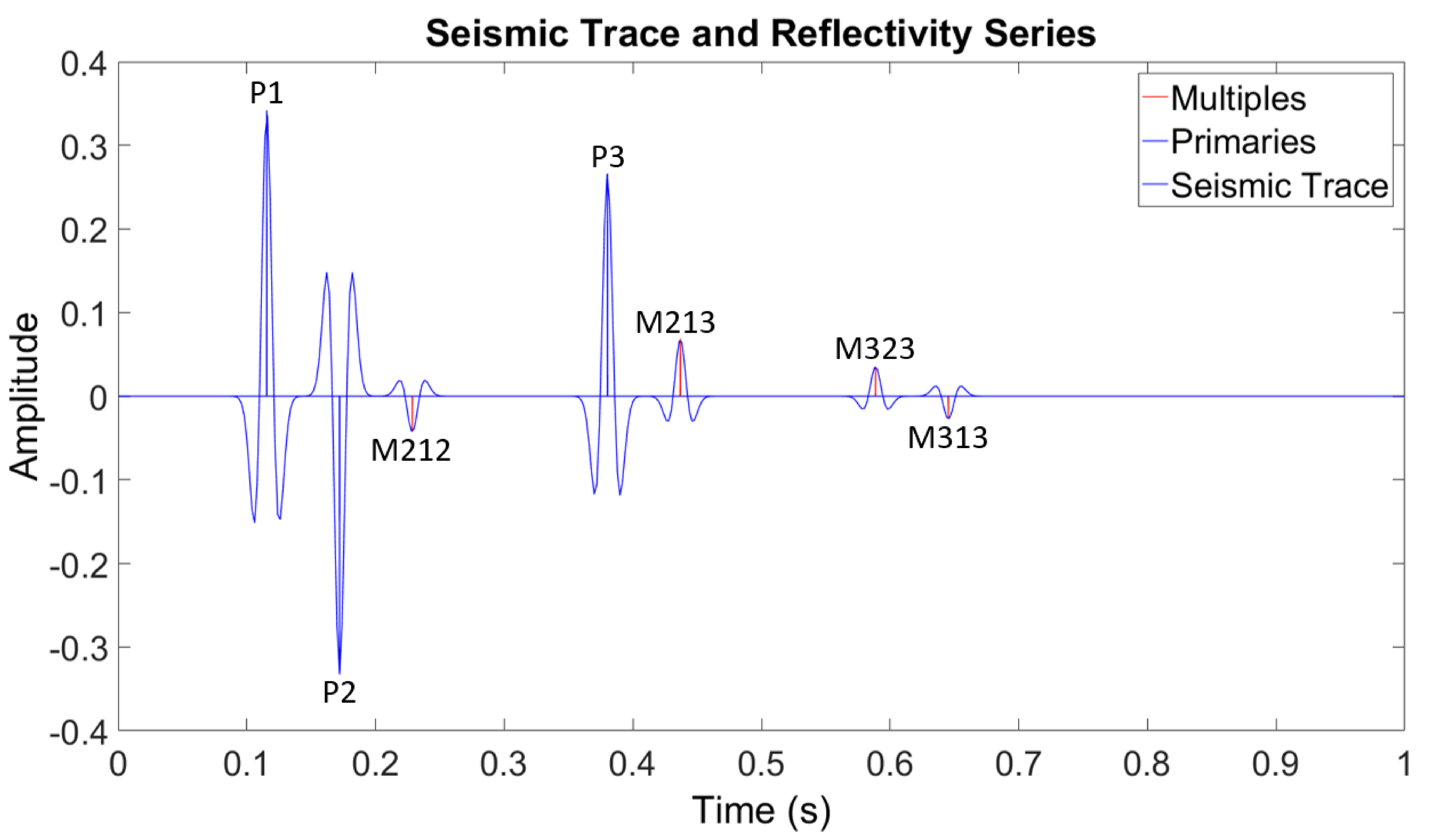


FIG. 2. Reflectivity series for primaries and first order multiples and seismic trace

Internal Multiple Prediction

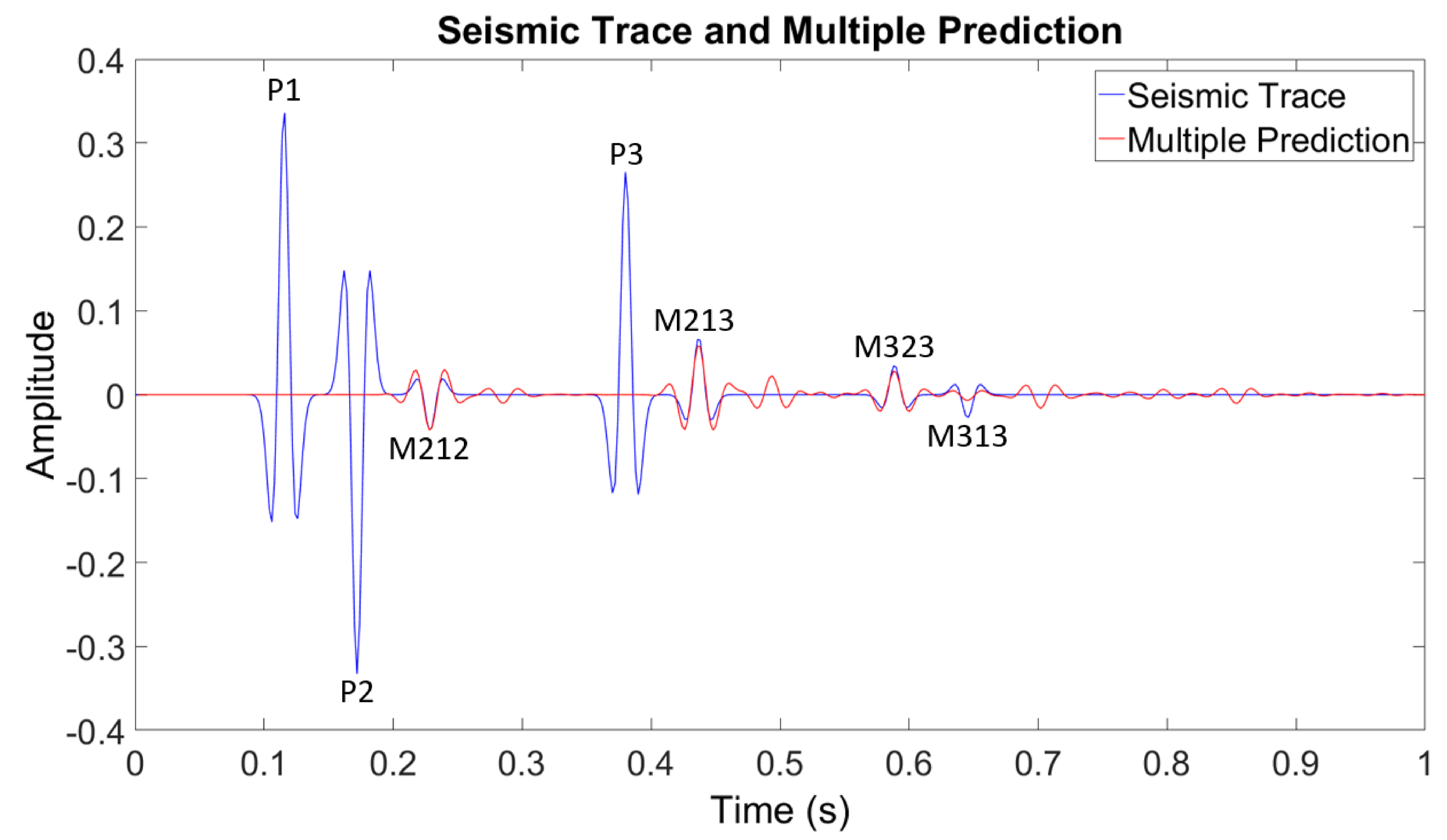


FIG. 3. Input seismic trace and 1D internal multiple prediction with multiples defined by reflection interface

Scalar Implementation

```
for ik = kz1:kzmax {

  Ipos = exp(i*kzPos(ik)*z)
  Ineg = exp(-i*kzPos(ik)*z)
  intPos = b1z*Ipos;
  intNeg = b1z*Ineg;

  for iz = z1:zmax {

    inner = sum(intPos(iz+ε:zmax))
    pred(ik) = pred(ik) + intNeg(iz)*inner*inner
  }
}
```

```
for iz = z1:zmax {

  for ik = kz1:kzmax {

    Ipos = exp(i*kzPos(ik)*z)
    Ineg = exp(-i*kzPos(ik)*z)
    intPos = b1z*Ipos;
    intNeg = b1z*Ineg;

    inner = sum(intPos(iz+ε:zmax))
    pred(iz, ik) = intNeg(iz)*inner*inner
  }
  pred(iz, : ) = pred(iz, : )*φ(iz)
}
spred(ik) = sum(pred(iz, ik))
```

FIG. 4. (Left) Summing over wavenumber then depth (Right) Proposed order of operations alteration summing over depth then wavenumber with scalar applied to give scaled prediction. Outputting prediction to be a function of both z_1 and ω.

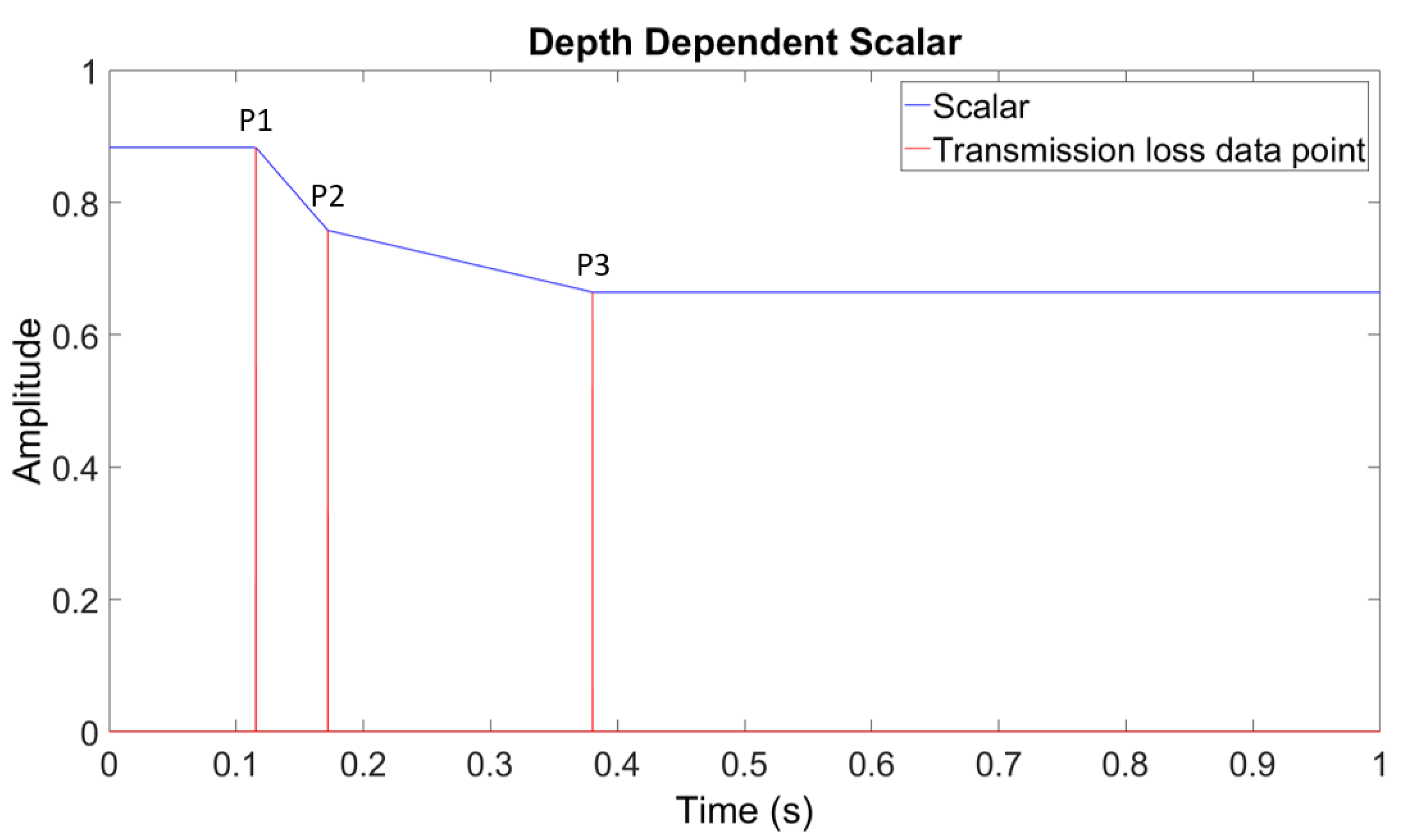


FIG. 5. Transmission loss scalar for internal multiple prediction for the displayed model.

Prediction with Scalar

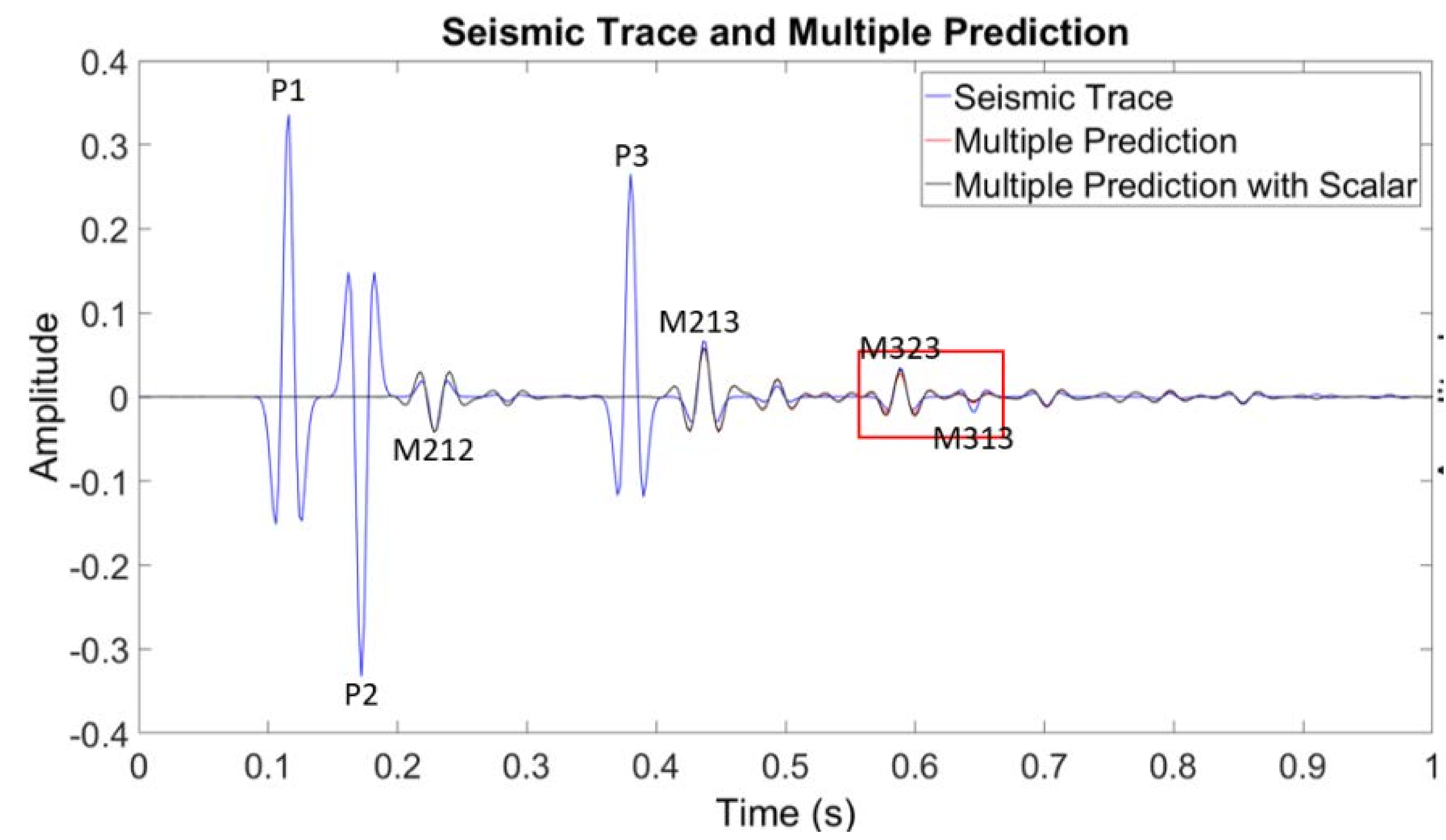
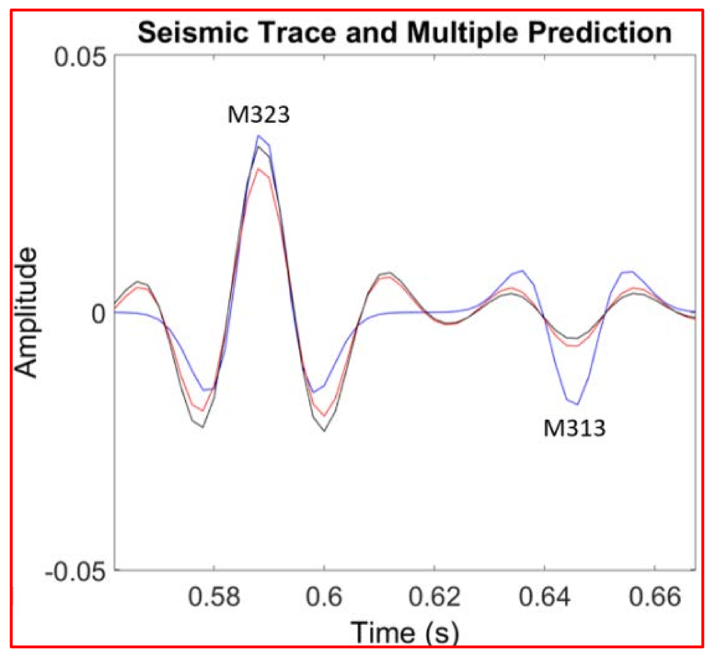


FIG. 6. Input seismic trace and 1D internal multiple prediction with and without scalars

FIG. 7. For M323 amplitude of the multiple with scalars has better accounted for transmission effects, where M313 has a slightly lower amplitude prediction. This depth dependent scalar has improved the prediction for one multiple and been detrimental to another.



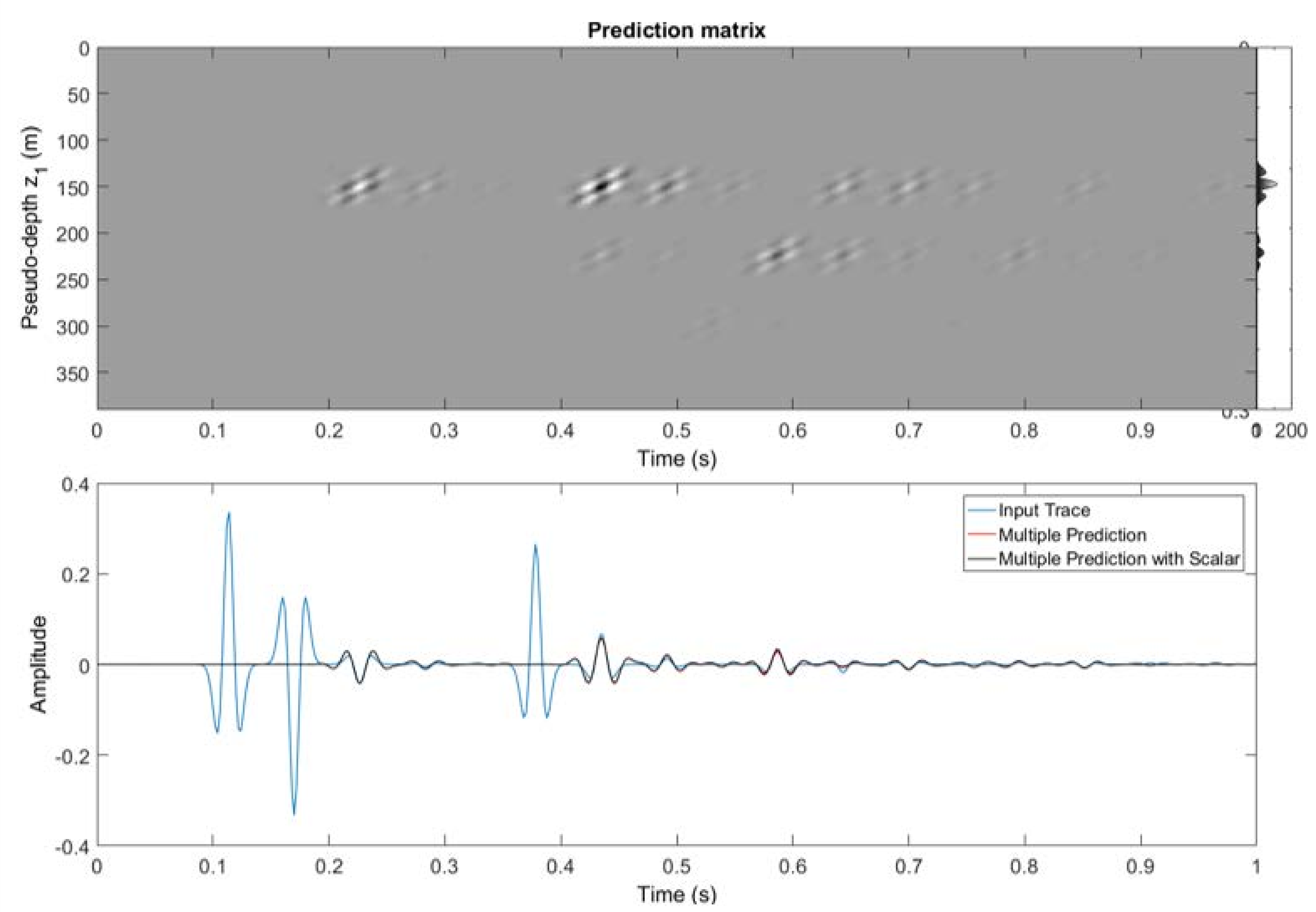


FIG. 8. (Top) pseudo-depth and time plot with scalar applied (Bottom) Trace and multiple prediction through summation over pseudo-depth

Acknowledgments

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