Accurate seismic dip and azimuth estimation using multi-window scanning of structure-tensor

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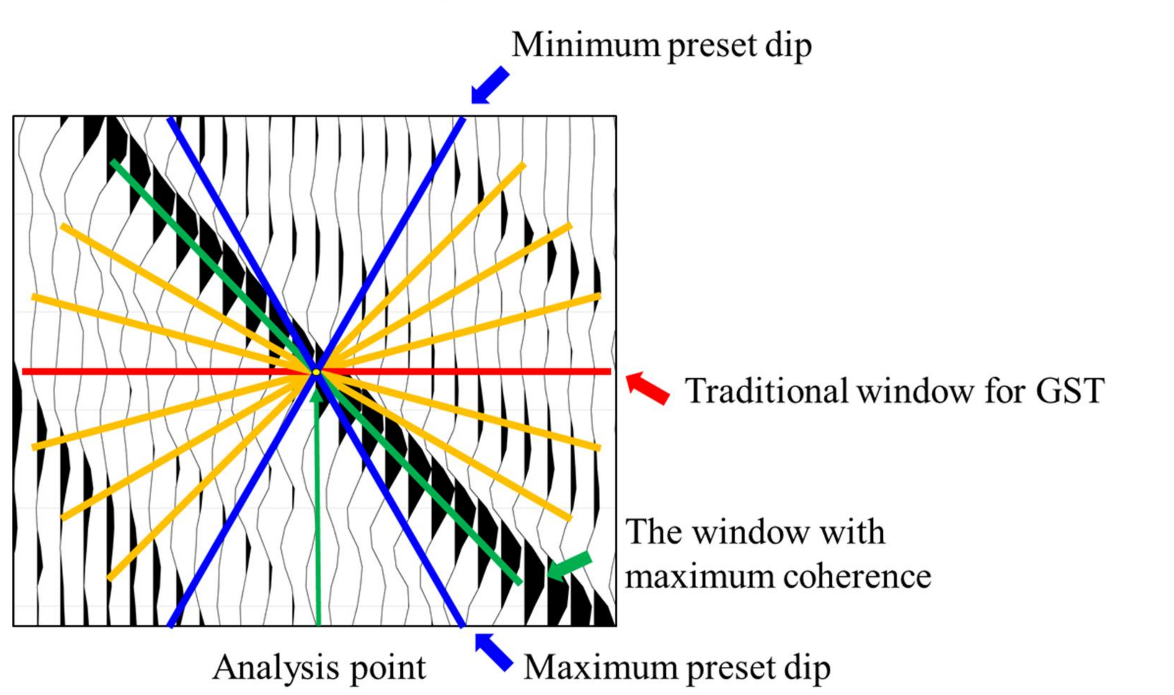
Summary

The seismic volumetric dip and azimuth are widely used in assisting seismic interpretation to depict geological structures in 3D seismic data. Current popular dip and azimuth estimation includes semblance-based multiple window scanning methods and gradient structure tensor (GST) analysis. However, accurate estimation of the volumetric dip and azimuth is still a challenging task. We propose a new algorithm to improve the accuracy of the seismic volumetric dip and azimuth estimation by integrating multiple windows scanning and GST analysis. We apply the proposed method to the F3 block from the Netherlands Offshore. The result shows that the seismic volumetric dips estimated using our proposed method is more accurately following the local seismic reflectors than dips computed from weighted structure tensors analysis and semblance based of multiple window scanning.

Method

The algorithm first defines a set of searching windows centered at the analysis point. The searching windows is generated by rotating the window along different user-defined dips and azimuths. The algorithm then calculates the semblance-based coherence within each searching window. The algorithm treats the window that has the highest coherence value is approximately parallel to the local seismic events. The algorithm next computes the dip and azimuth of the seismic reflector within the selected "parallel" window using GST analysis. The algorithm finally employs Kuwahara window search to determine the dip and azimuth of local reflectors.



(Modified from Marfurt, 2006)

Figure 1. Schematic showing a 2D semblance scanning method (Modified from Marfurt, 2006).

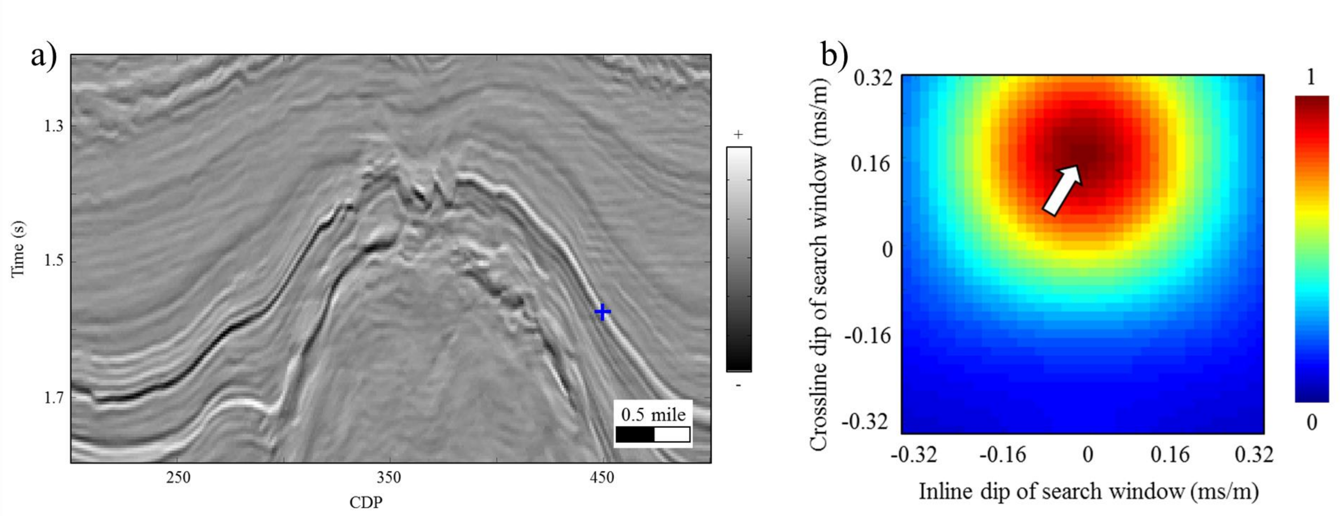


Figure 2. (a) A representative inline seismic section with an analysis point. (b) The computed semblance based coherence as a function of discrete candidate scanning windows.

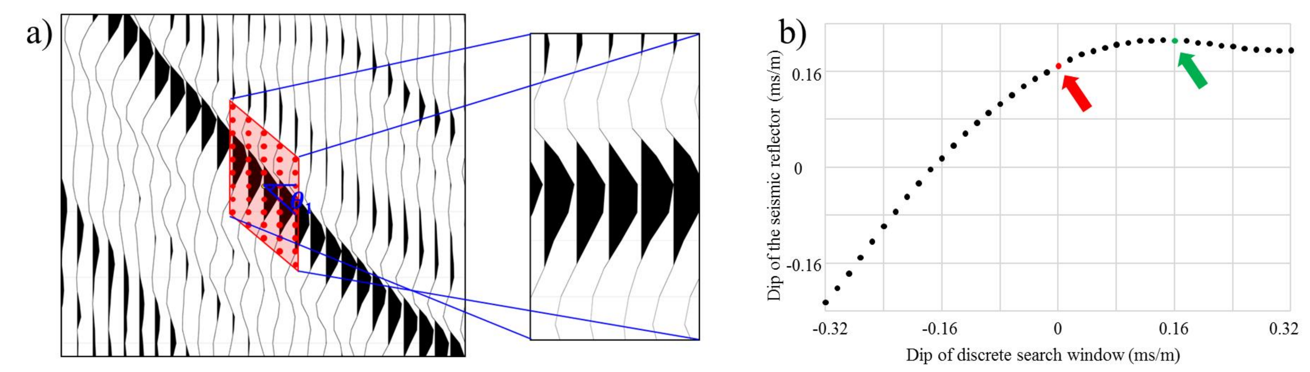


Figure 3. (a) Output GST based reflector's dip using the discrete candidate windows along the dips approximately parallel the local reflectors. (b) The computed GST based dip for the analysis point as a function of discrete candidate scanning windows.

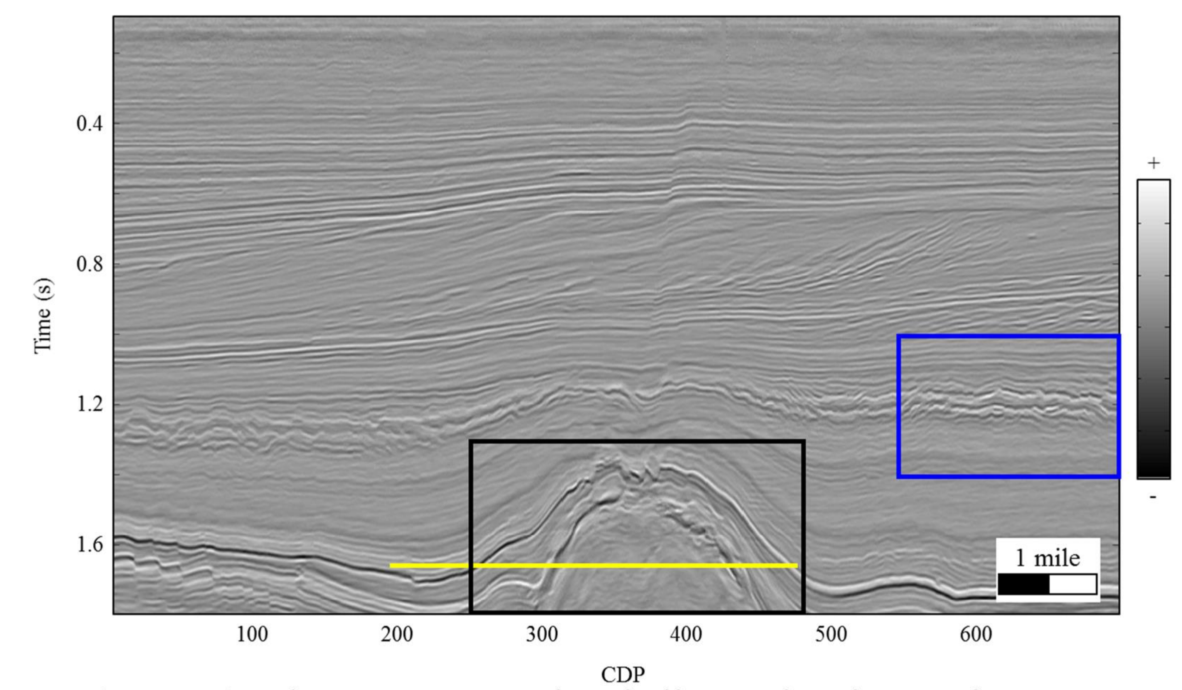


Figure 4. The representative inline seismic section.

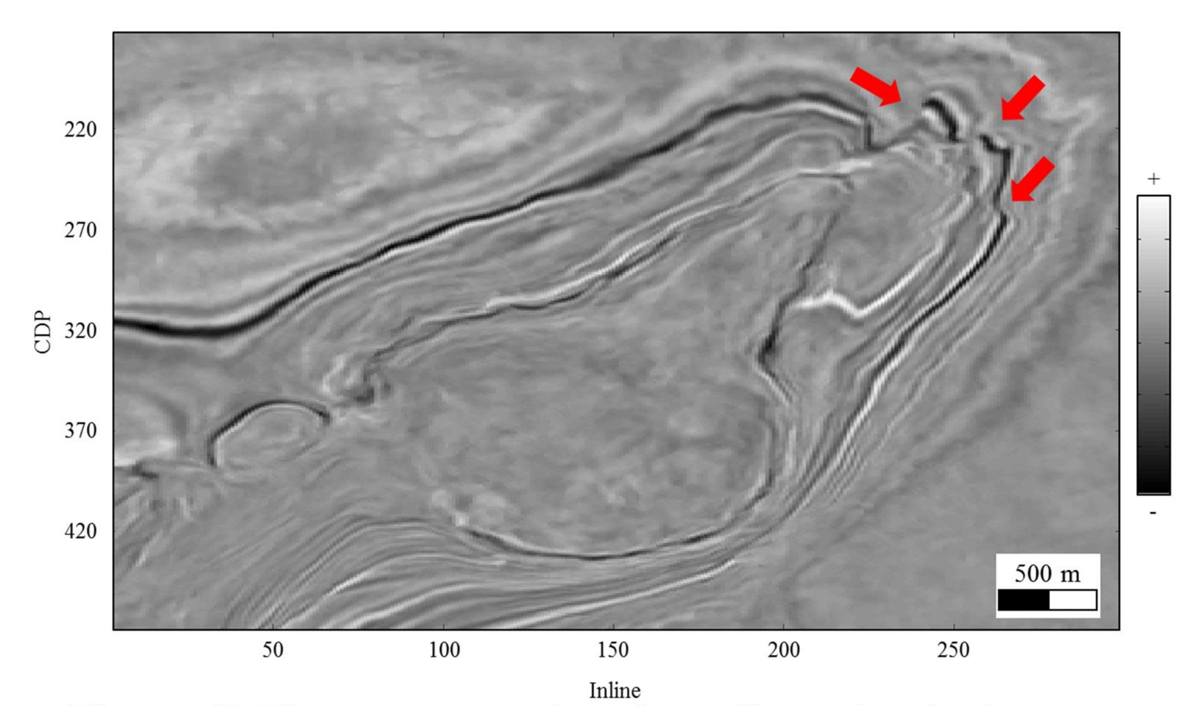


Figure 5. The representative time slice seismic dataset.

Conclusion

we propose a new method to improve the accuracy of volumetric dip estimation. The dip estimated using GST analysis is usually smaller than the true dip angle of seismic reflectors. Our workflow avoids the inaccurate dip estimation near discontinuous and steep structure zones by integrating the advantages of multiples window scanning and GST analysis. We improve the accuracy of dip estimation by applying GST analysis to the window, which is approximately parallel to the local seismic reflector. We employ the multiple window scanning method to find the window that is approximately parallel to the local seismic reflector. The results of the filed data examples show that our proposed method precisely estimates reflectors dip near steep structures. The field data application also demonstrates that the dip estimated using our method has better anti-noise performance, and the coherence generated using our method precisely highlights faults within the seismic image.

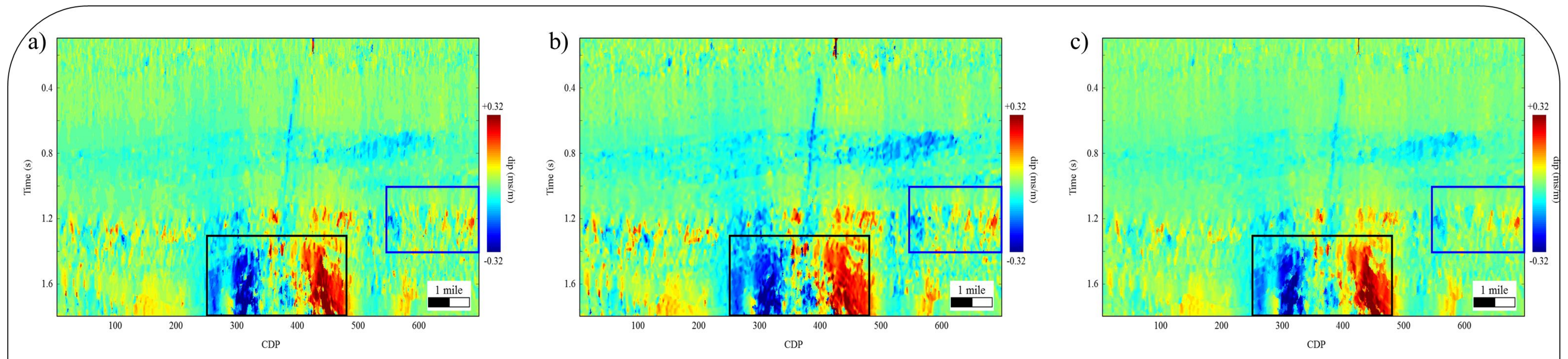


Figure 6. Compare crossline dip estimations of different methods for the inline seismic section in Figure 4. (a) Dip estimation based on semblance scanning method. (b) Dip estimation based on weighted GST method. (c) Dip estimation based on the proposed method.

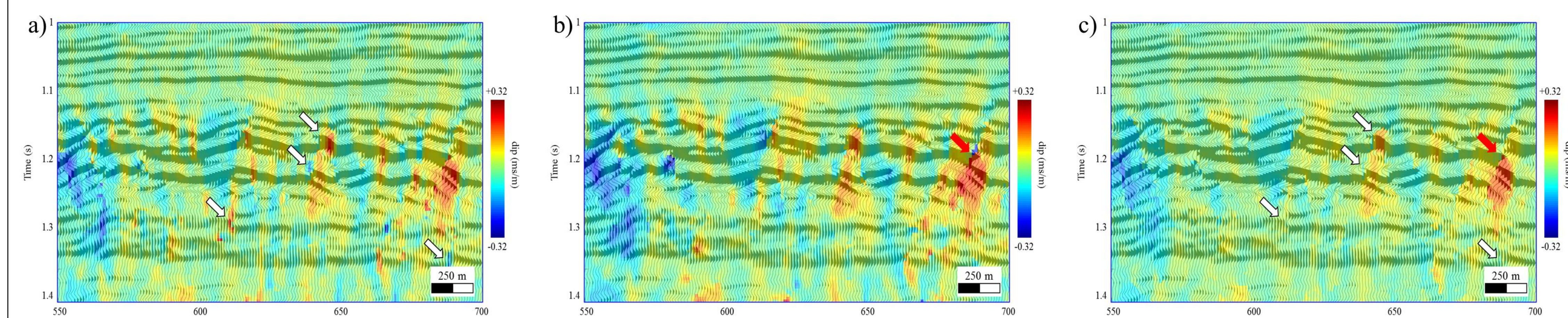


Figure 8. The zoomed in dip estimations in the blue box in Figure 4 overlay on the seismic section. (a) Dip estimation based on semblance scanning method. (b) Dip estimation based on weighted GST method. (c) Dip estimation based on the proposed method.

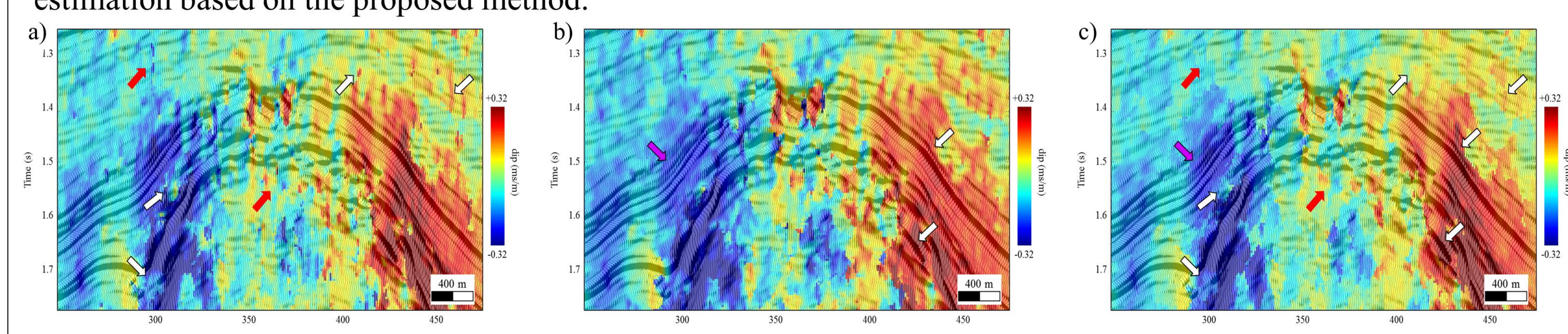


Figure 9. The zoomed in dip estimations in the black box in Figure 4 overlay on the seismic section. (a) Dip estimation based on semblance scanning method. (b) Dip estimation based on weighted GST method. (c) Dip estimation based on the proposed method.

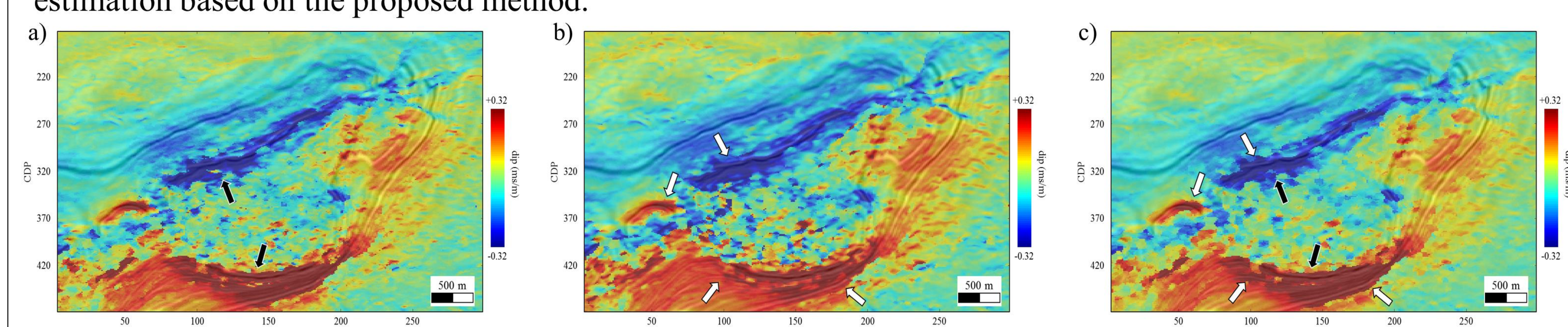


Figure 10. The crossline dip for the time slice in Figure 5. (a) Dip estimation based on semblance scanning method. (b) Dip estimation based on weighted GST method. (c) Dip estimation based on the proposed method.

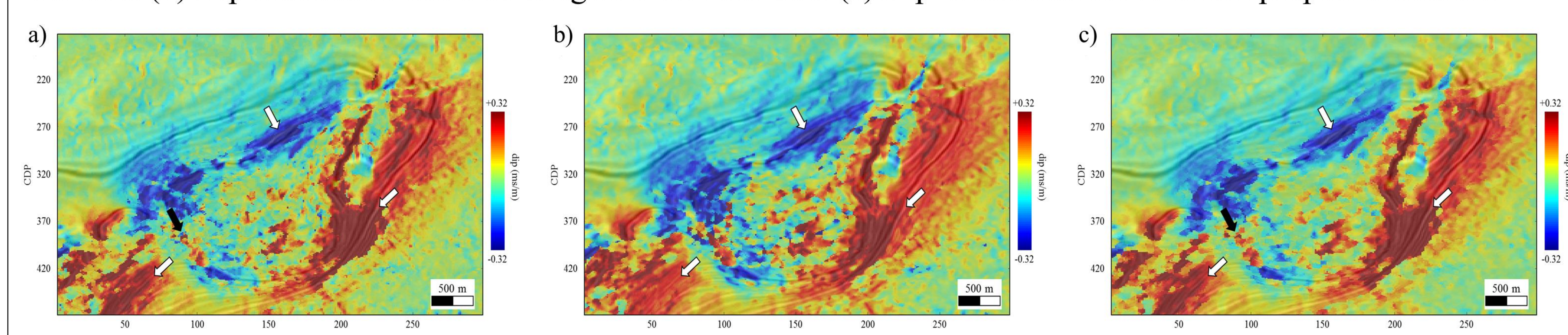


Figure 11. The inline dip for the time slice in Figure 5. (a) Dip estimation based on semblance scanning method. (b) Dip estimation based on weighted GST method. (c) Dip estimation based on the proposed method.