Delta weights for footprint suppression in 3D prestack migration

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Outline

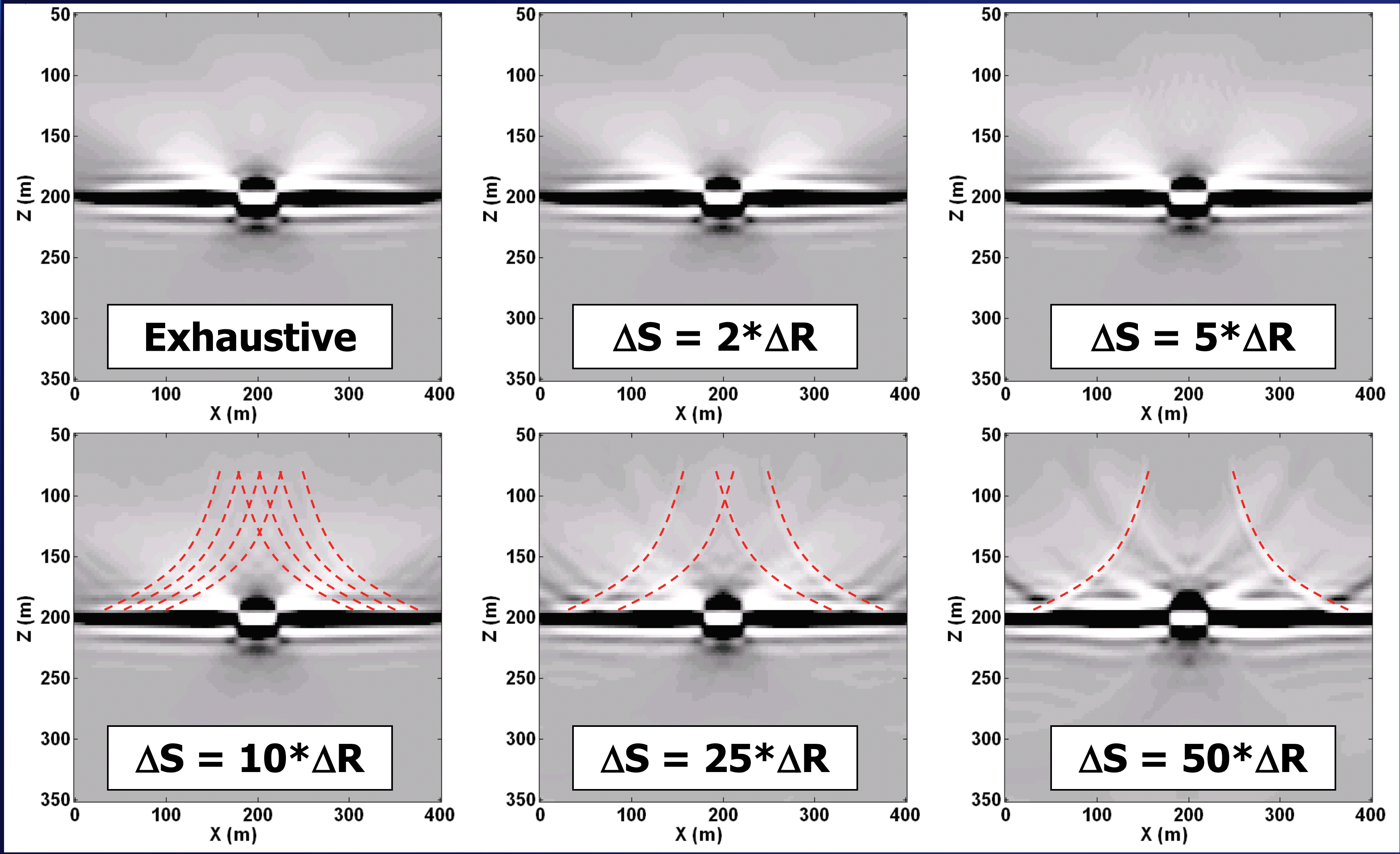
- Review of previous 2D results
- Review of method for angle-weighted stacking
- Application of method in 3D
- Conclusions

Recap: 2D Footprint Simulations

- Modelled an exhaustive 2D dataset: shots and receivers spaced at 5 m intervals over a 400 m long model
- Created five shot decimations with shot spacings of 10 m, 25 m, 50 m, 100 m, and 200 m
- Applied Kirchhoff prestack migration and stacked migrated shot records

Recap: 2D Simulations

- Prestack migrated sections:

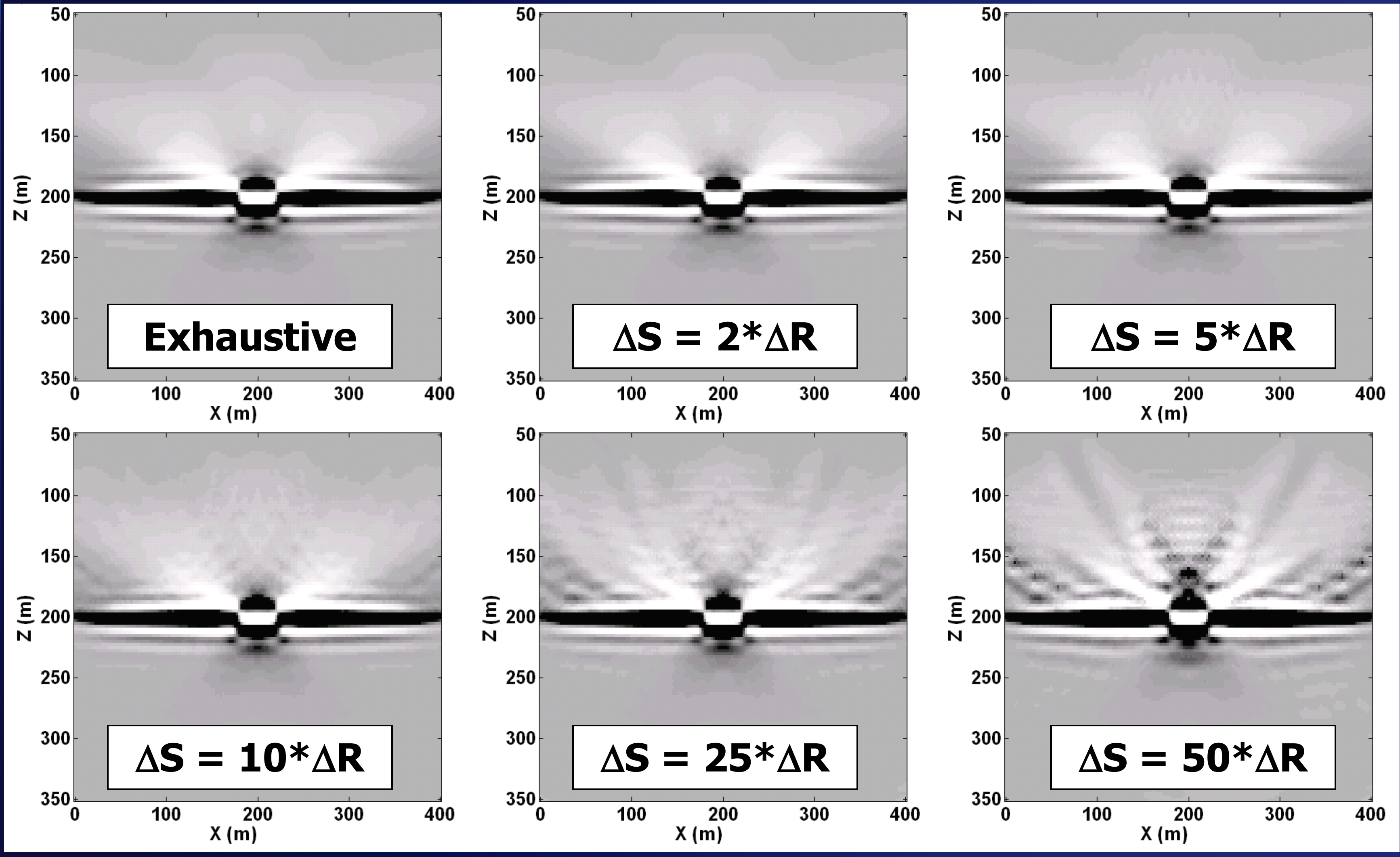


Recap: 2D Footprint Simulations

- Footprint manifests as residual migration wavefronts
- Hypothesis: prestack migration weights may allow for proper interference of wavefronts, thereby reducing these artefacts
- Applied Kirchhoff prestack migration with delta-ratio weighting

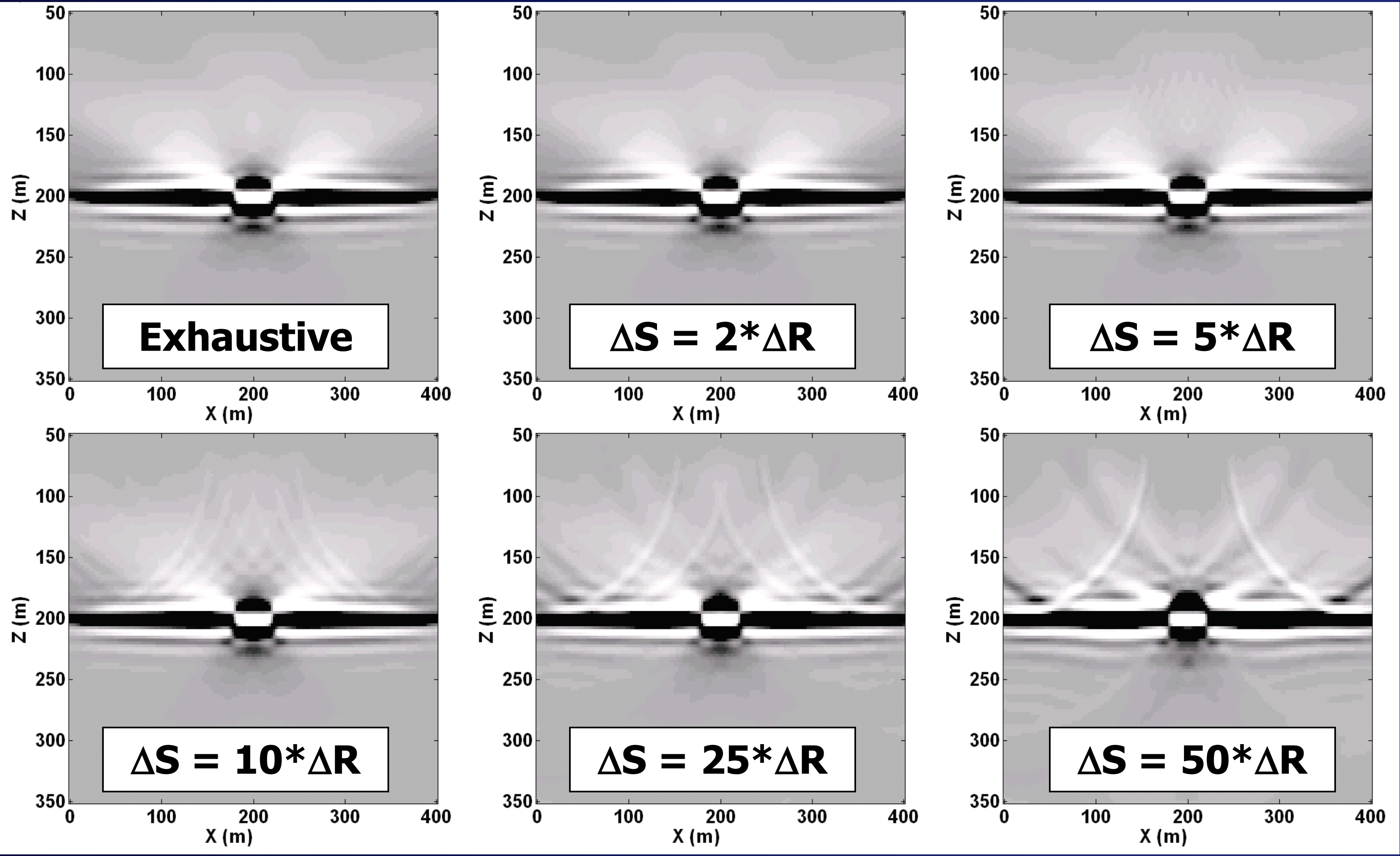
Recap: 2D Simulations

- Results: delta-ratio weights



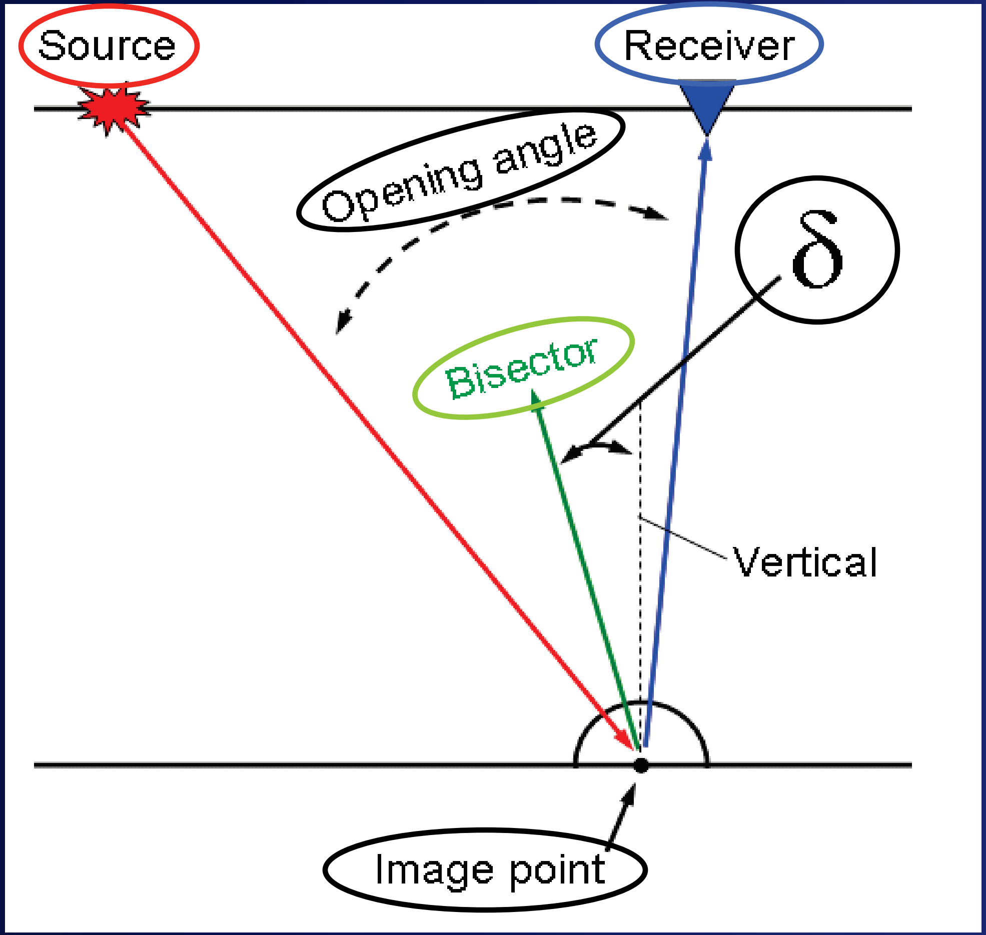
Recap: 2D Simulations

- Prestack migrated sections:



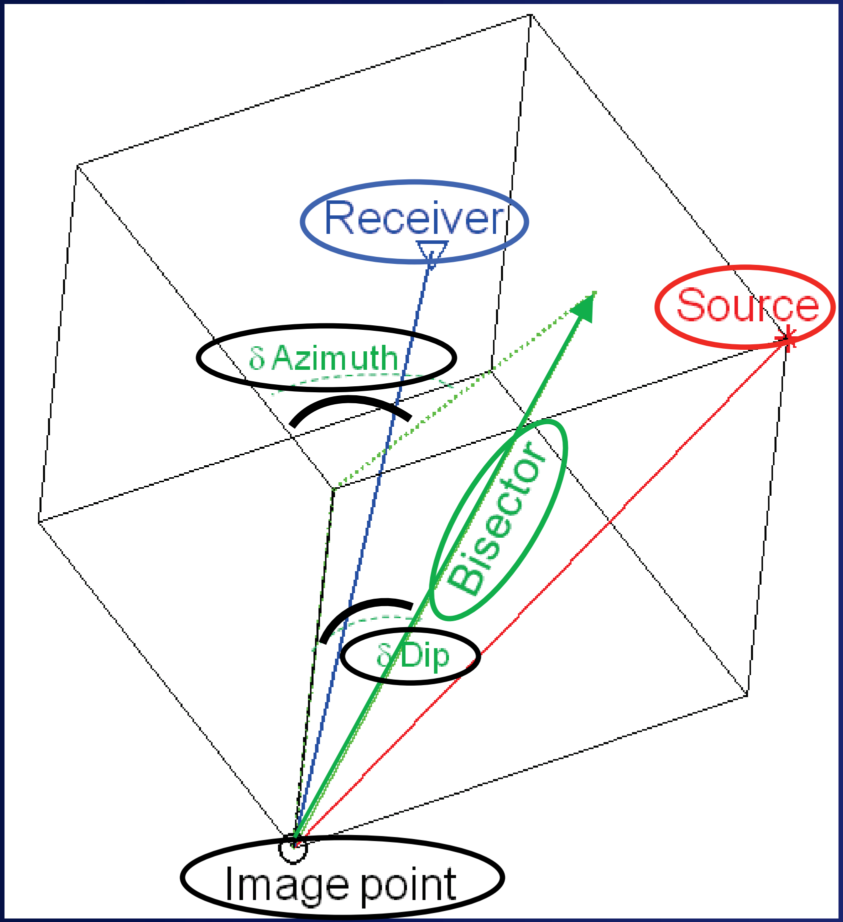
Recap: Method

- Concept: illumination of image point by delta angles



Recap: Method

- Concept: illumination of image point by delta angles



Method

- Measure hit counts in delta bins at each image point
- Want to achieve uniform illumination by normalizing by delta hit counts
  - Method 1: Make hit counts in each bin equal ("delta-fold weights")
  - Method 2: Make hit counts in each bin equal to what they would be in the exhaustive survey ("delta-ratio weights")

Method

- Migrate each shot record into delta-limited volumes and apply weights during stacking:

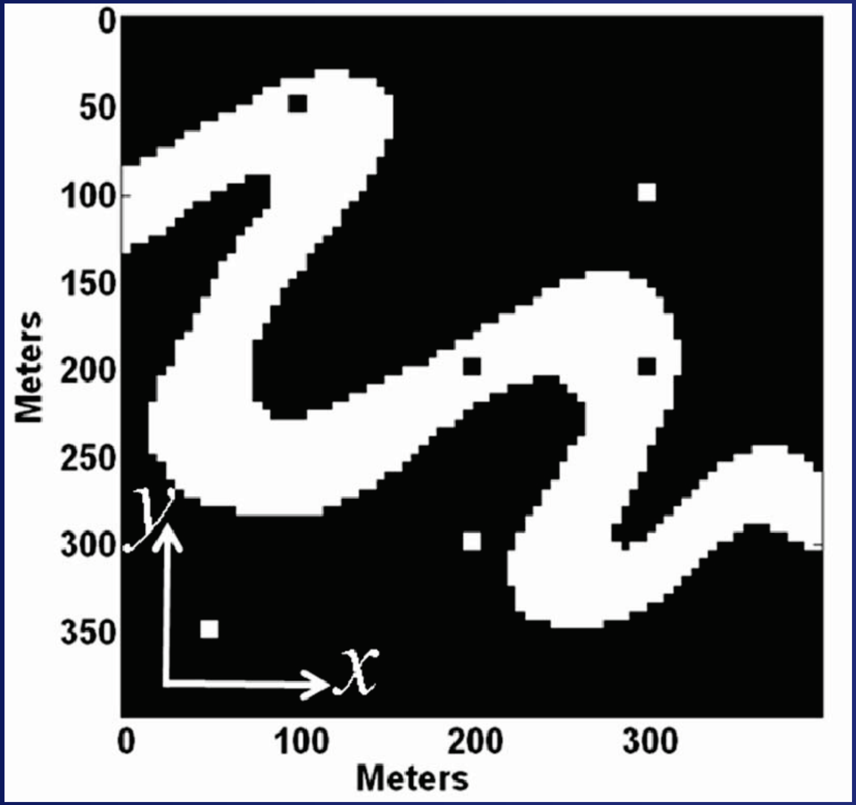
$$\mathrm{Im}\left(\underline{x}\right)=\sum_{j\ shots}\left[\sum_{k\ bins}W_k\left(\underline{x}\right)*\phi_j\left(\underline{x},\delta_k\right)\right],$$

where $W_k\left(\underline{x}\right)=1/n\left(\underline{x},\delta_k\right)$ (delta-fold)

or $W_k\left(\underline{x}\right)=n_{exh}\left(\underline{x},\delta_k\right)/n\left(\underline{x},\delta_k\right)$ (delta-ratio)

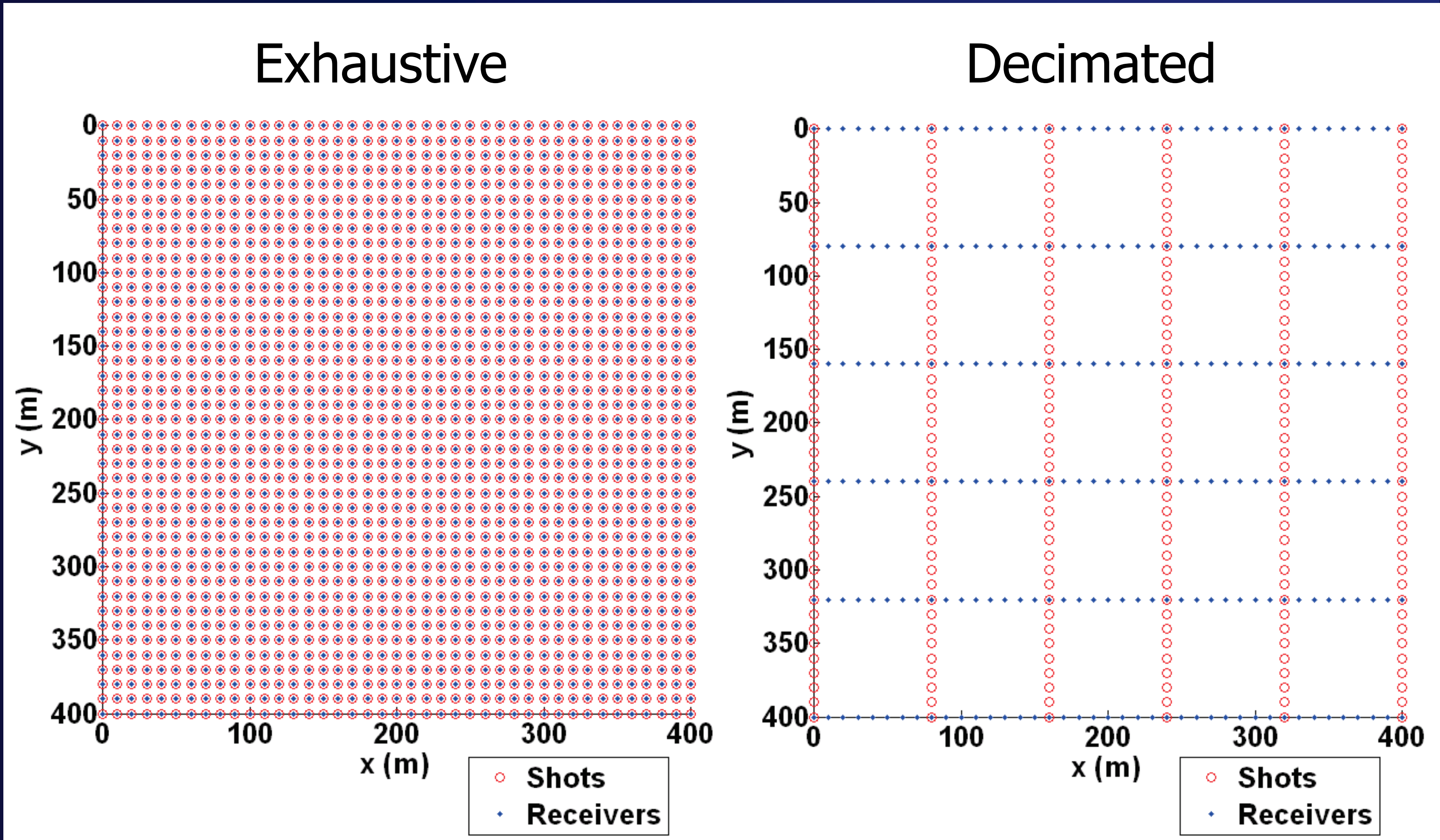
Recap: 3D Model

- v(z) model with three flat reflectors
- Featureless reflectors at 100m and 180m depth
- Channel reflector at 200m depth



Recap: 3D Model

- Survey geometries

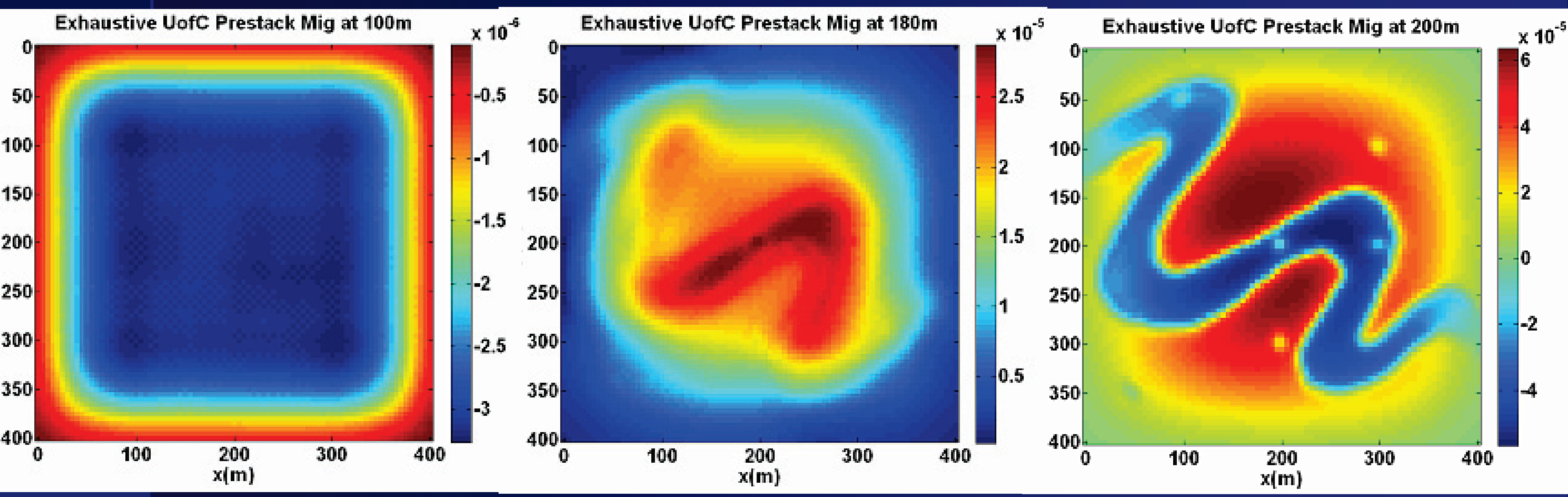


3D Results

- Migrations of exhaustive and decimated datasets from previous study (2007)
- Migrations with delta-ratio weights with several choices for azimuth binning
- Migrations with delta-fold weights
- Migrations with common-offset weights
- Comparison of migrations to true reflectivity as percent differences

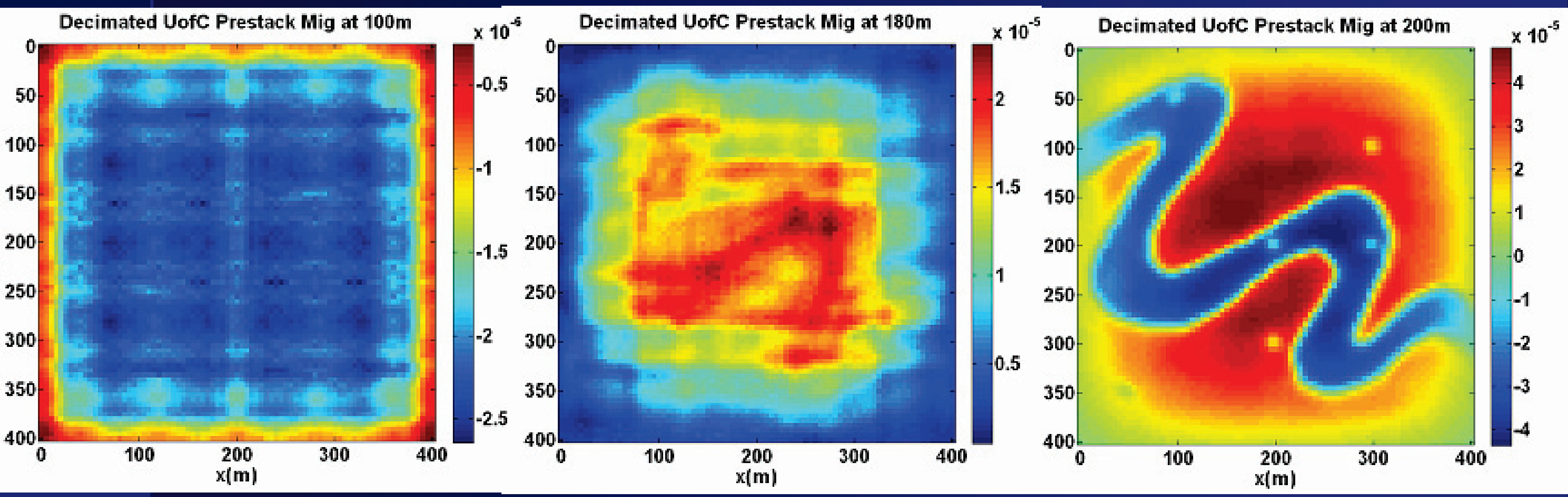
Recap: 3D Results

- Depth slices from prestack migration of exhaustive dataset



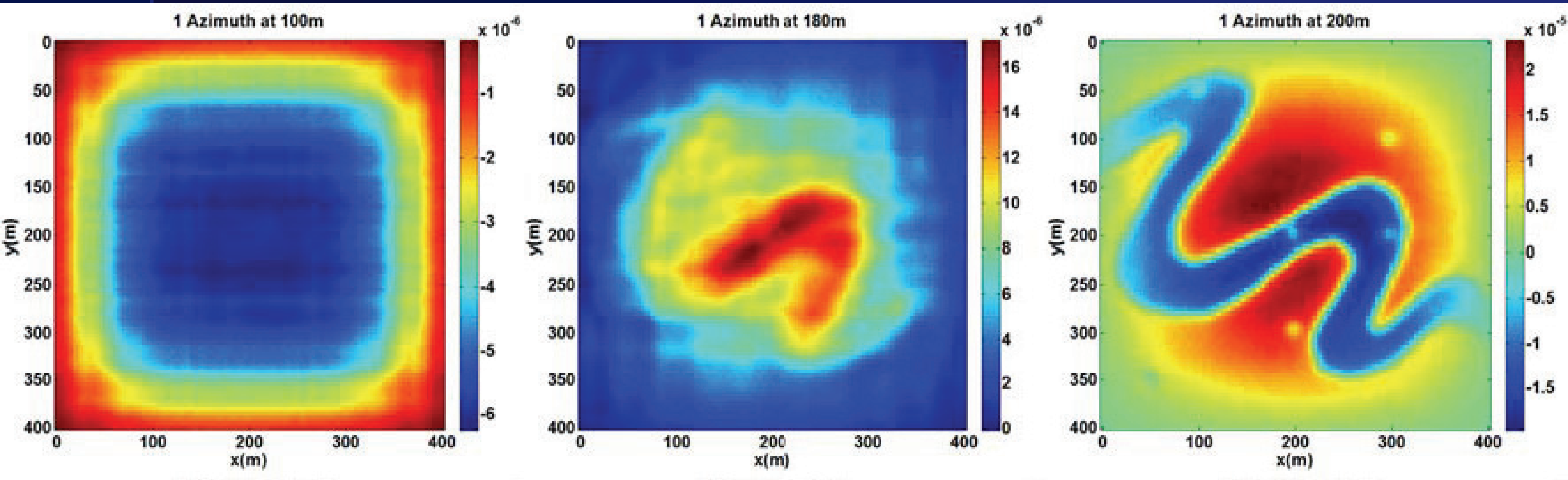
Recap: 3D Results

- Depth slices from prestack migration of decimated datset



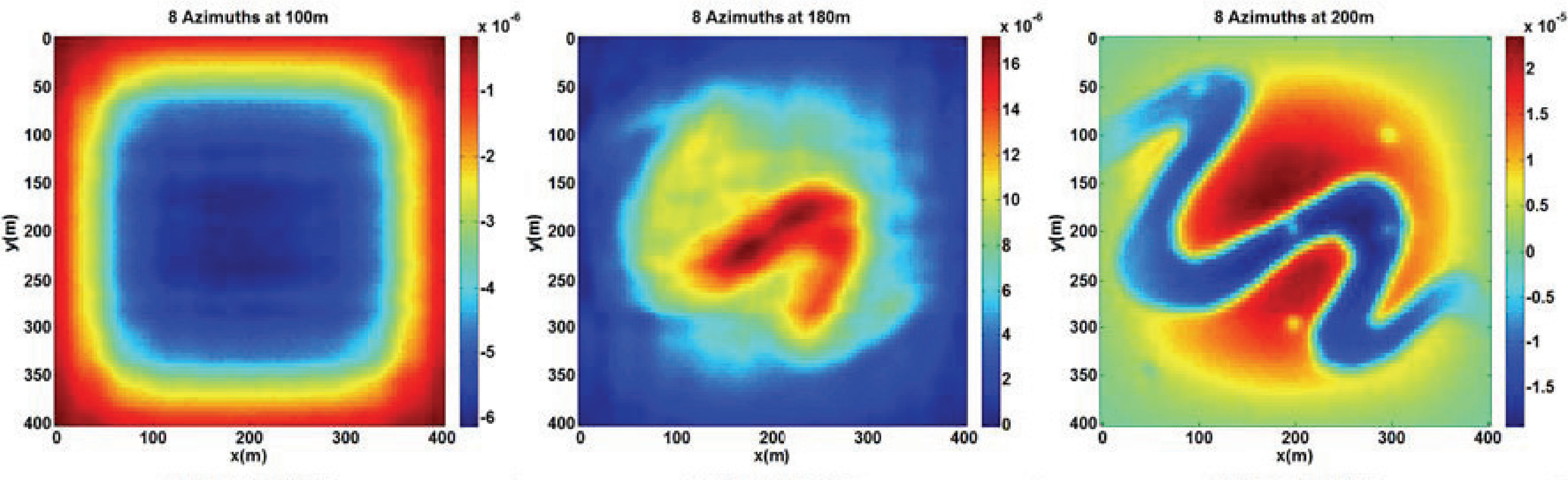
3D Results: delta-ratio

- Delta-ratio weights with 5 degree bins in dip and 1 azimuth bin



3D Results: delta-ratio

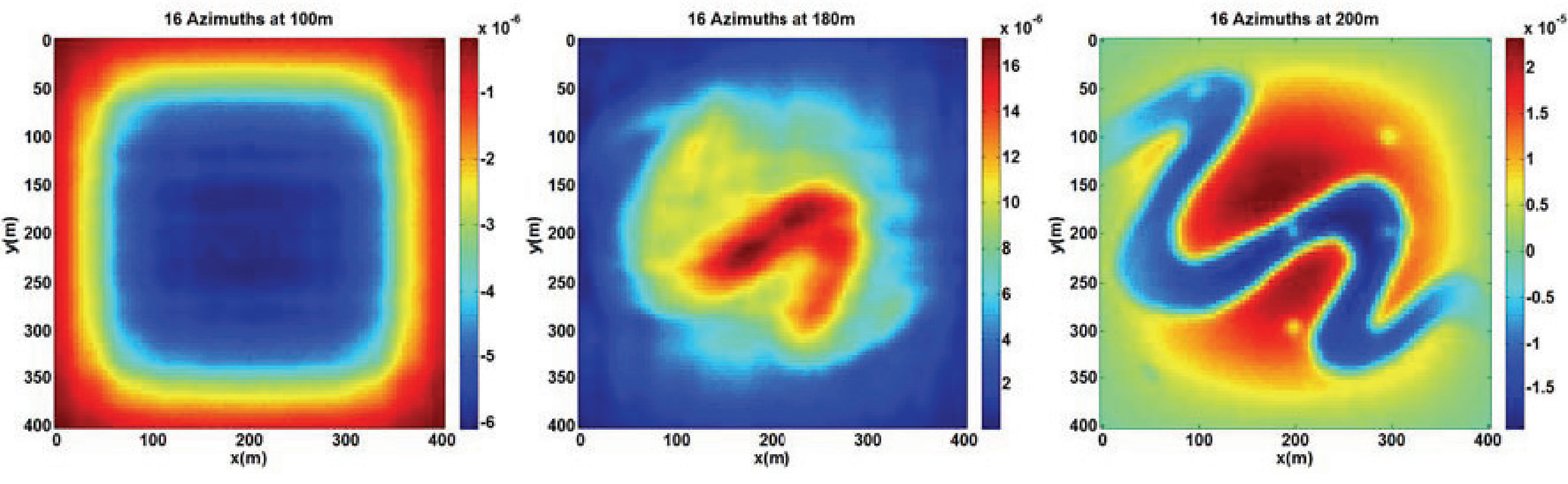
- Delta-ratio weights with 5 degree bins in dip and 8 azimuth bins



  – Binning azimuth is important

3D Results: delta-ratio

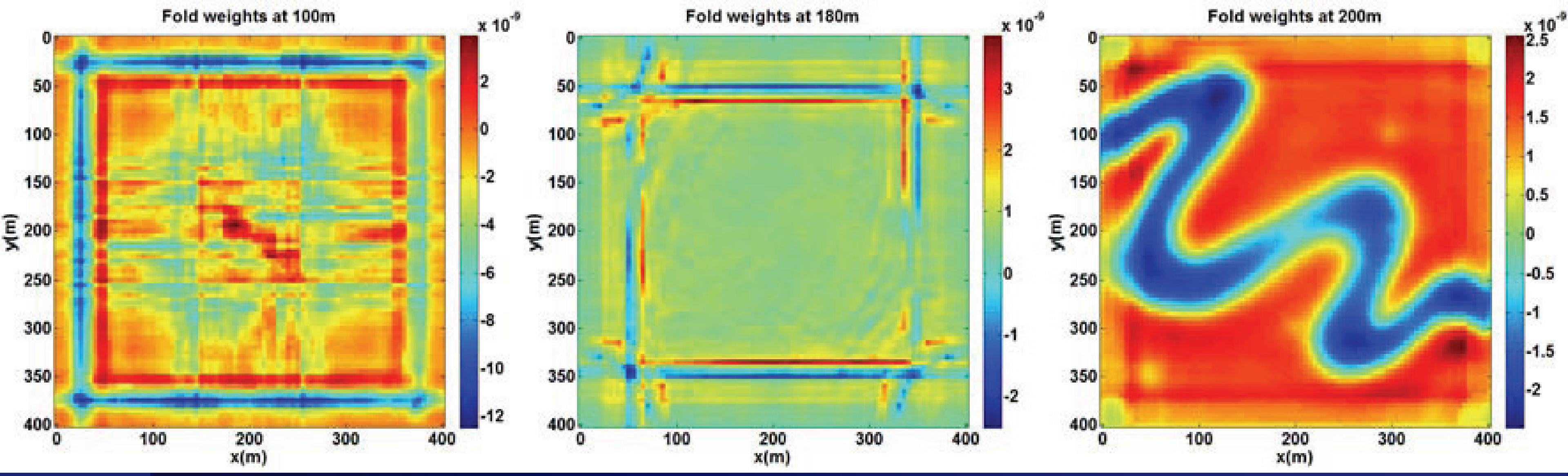
- Delta-ratio weights with 5 degree bins in dip and 16 azimuth bins



  – An optimal bin size/number of bins exists

3D Results: delta-fold

- Delta-fold weights with 5 degree bins in dip and 8 azimuth bins

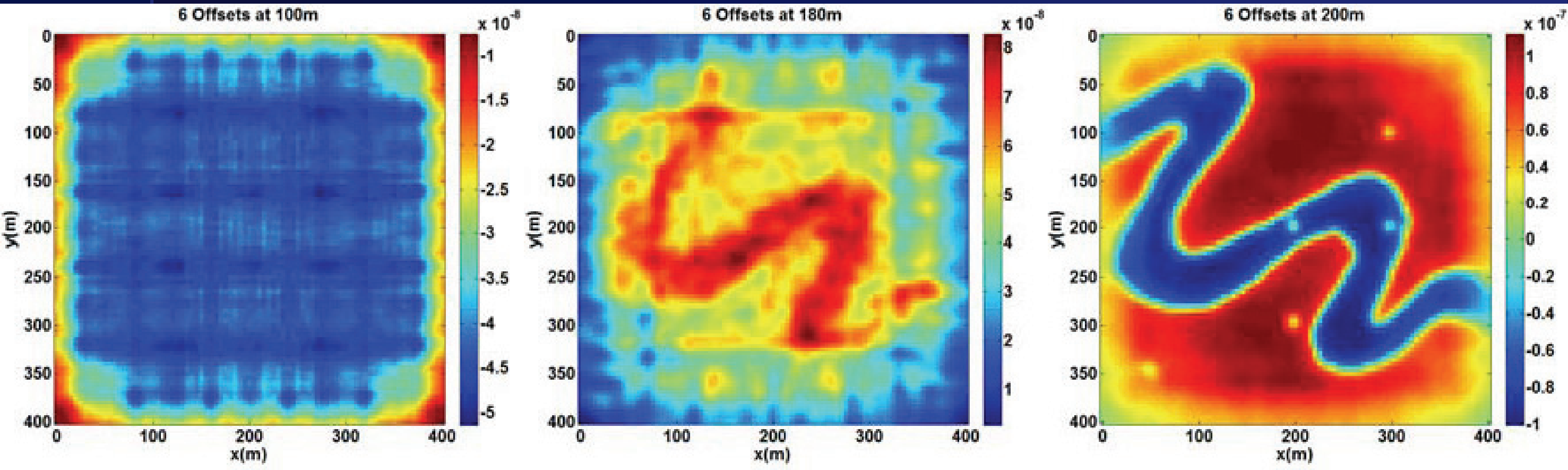


3D Results: common-offset

- Recall: common-offset weighting method
- Choose offset bins
- Calculate offset-limited fold
- Pre-weight traces by 1/fold
- Prestack migrate

3D Results: common-offset

- Common-offset weights with 100m offset bins

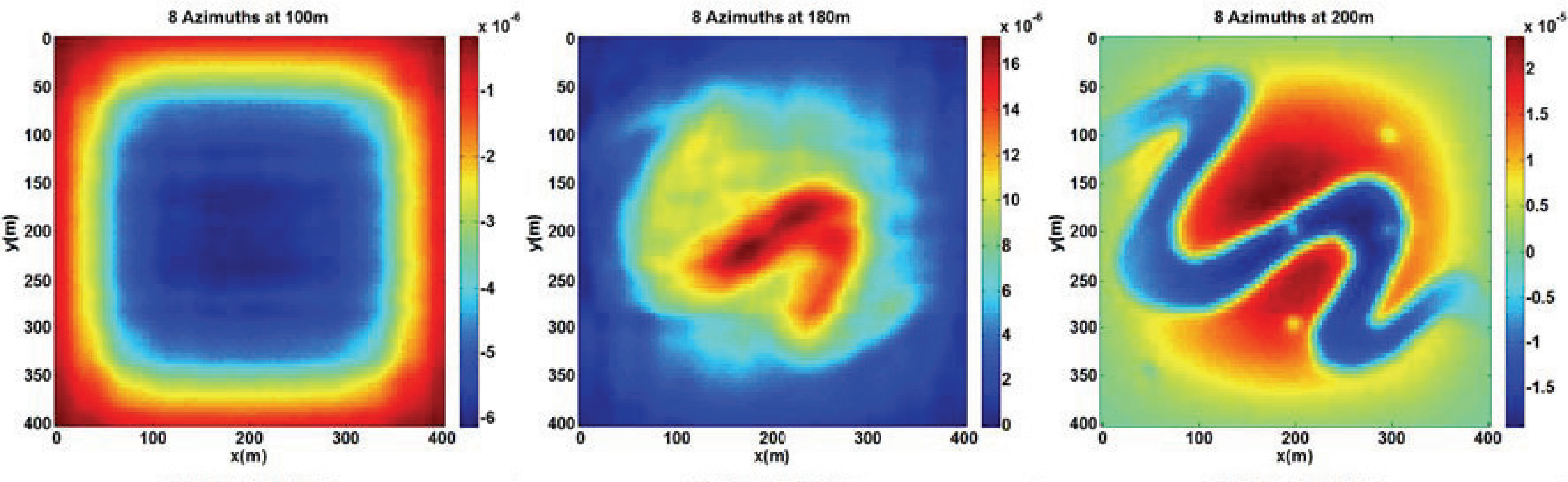


3D Results: aperture filter

- Want to quantitatively compare migrated depth slices to the true reflectivity
- Different weighting schemes result in different aperture imprints
- Want to remove these differences to isolate internal footprint artefacts
- Method: smooth slices to estimate aperture, then divide

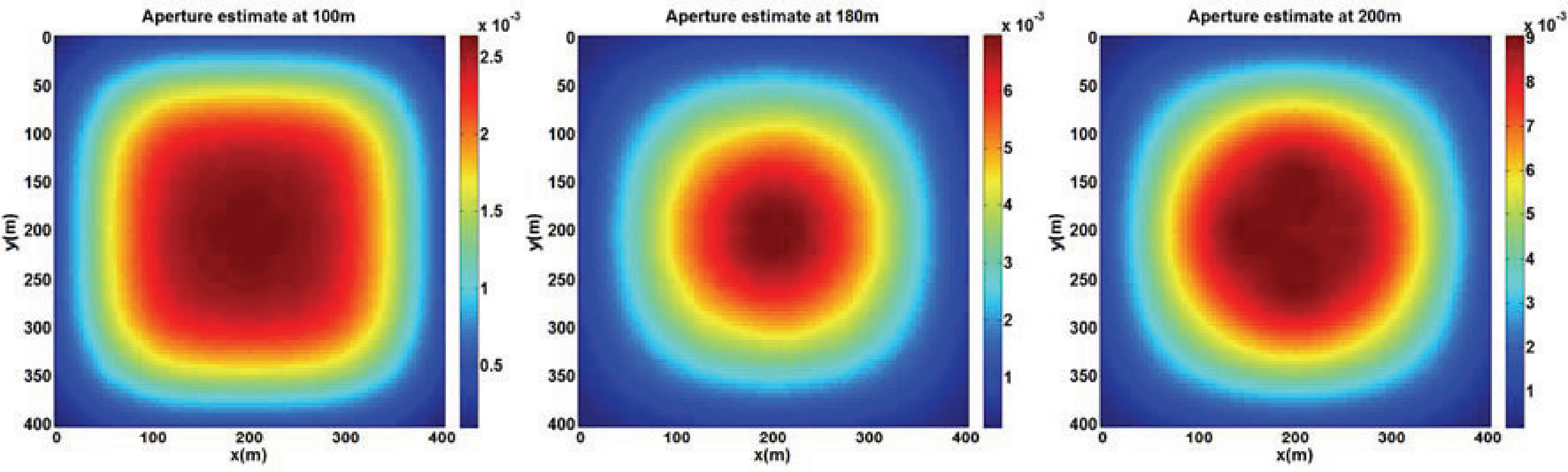
3D Results: aperture filter

- Delta-ratio slices with aperture imprint



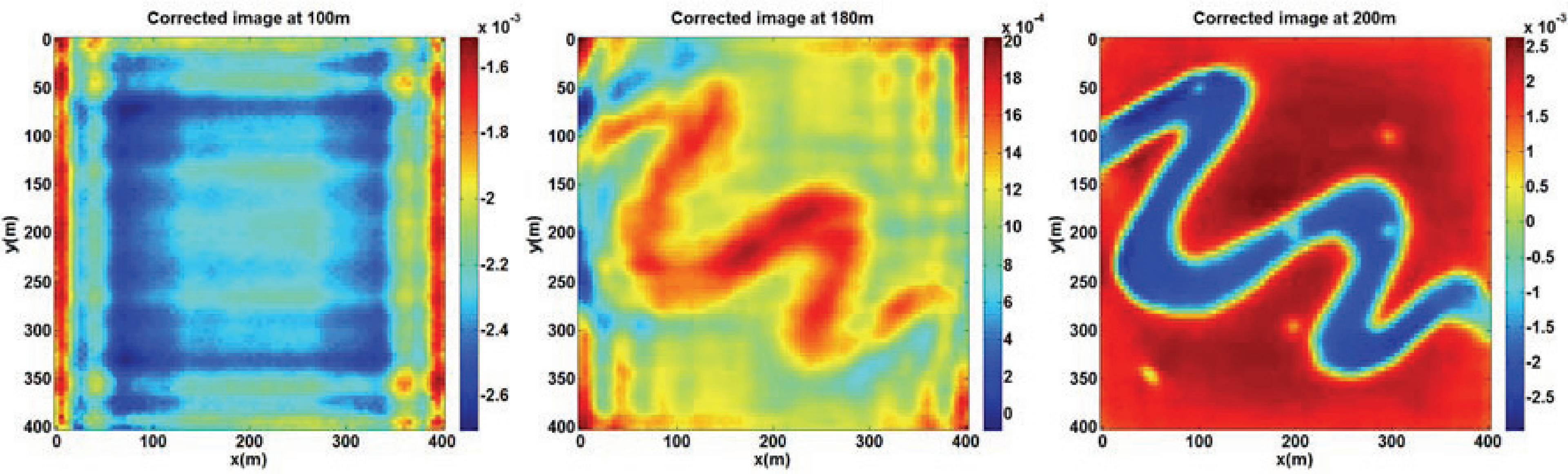
3D Results: aperture filter

- Aperture estimate



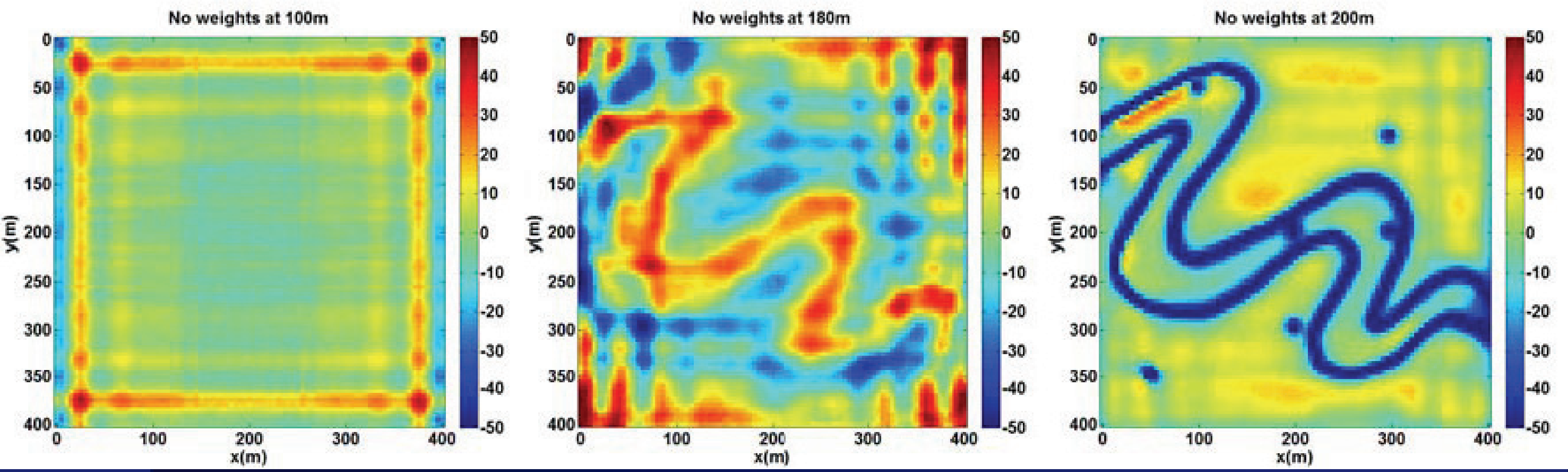
3D Results: aperture filter

- Delta-ratio slices after aperture removal



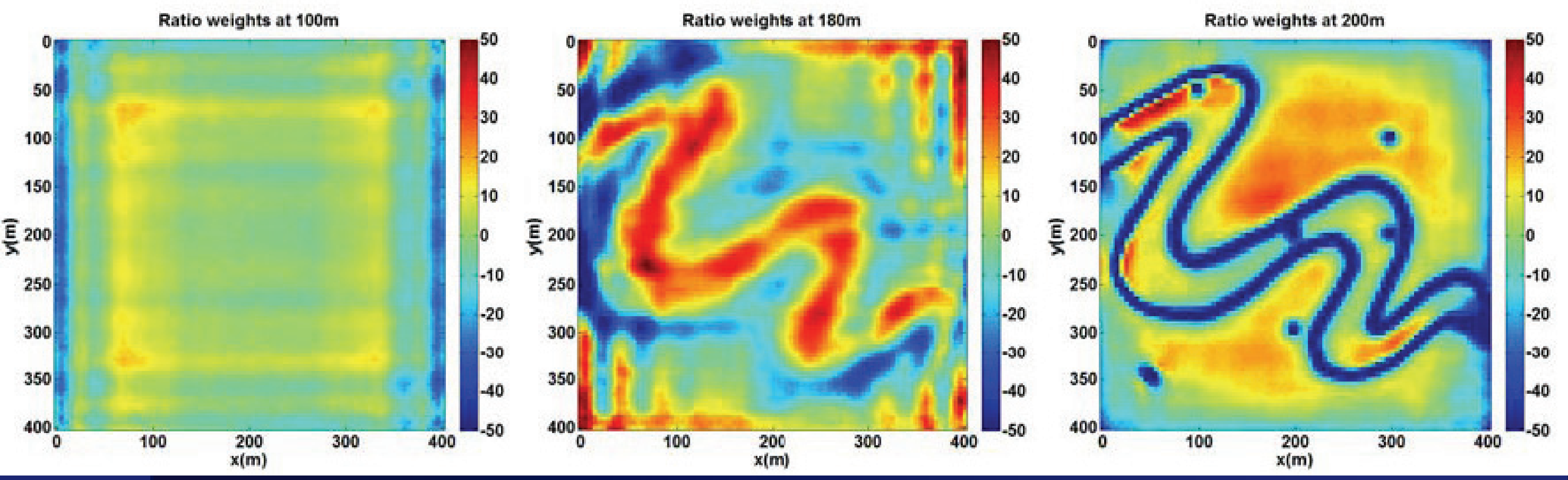
3D Results: % difference

- Difference between true reflectivity and unweighted migration



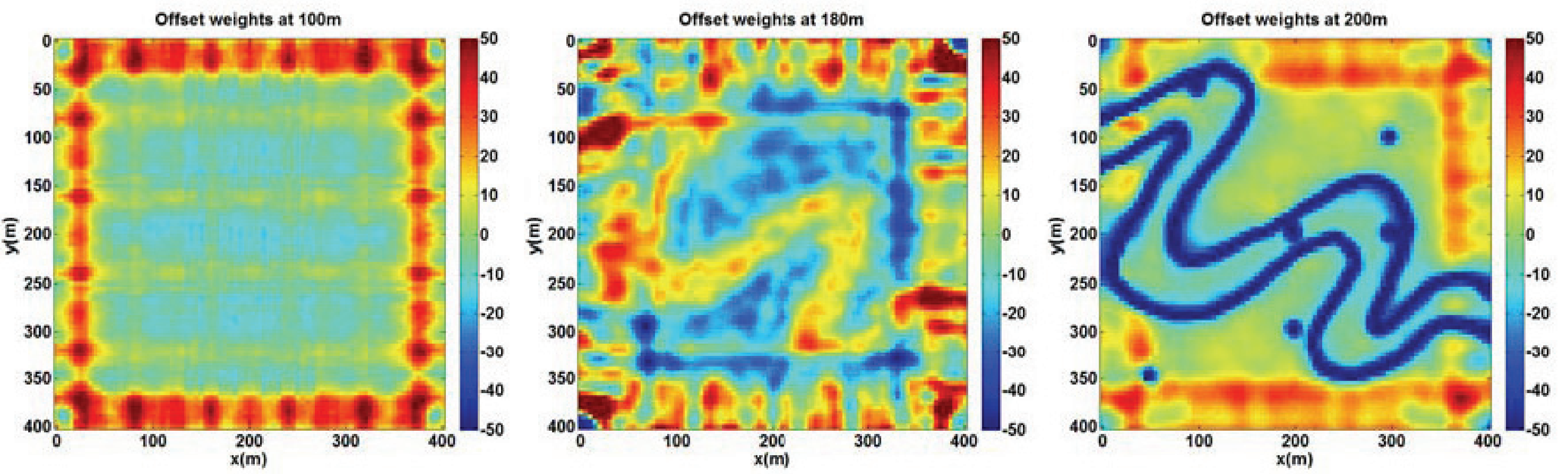
3D Results: % difference

- Difference between true reflectivity and delta-ratio-weighted migration



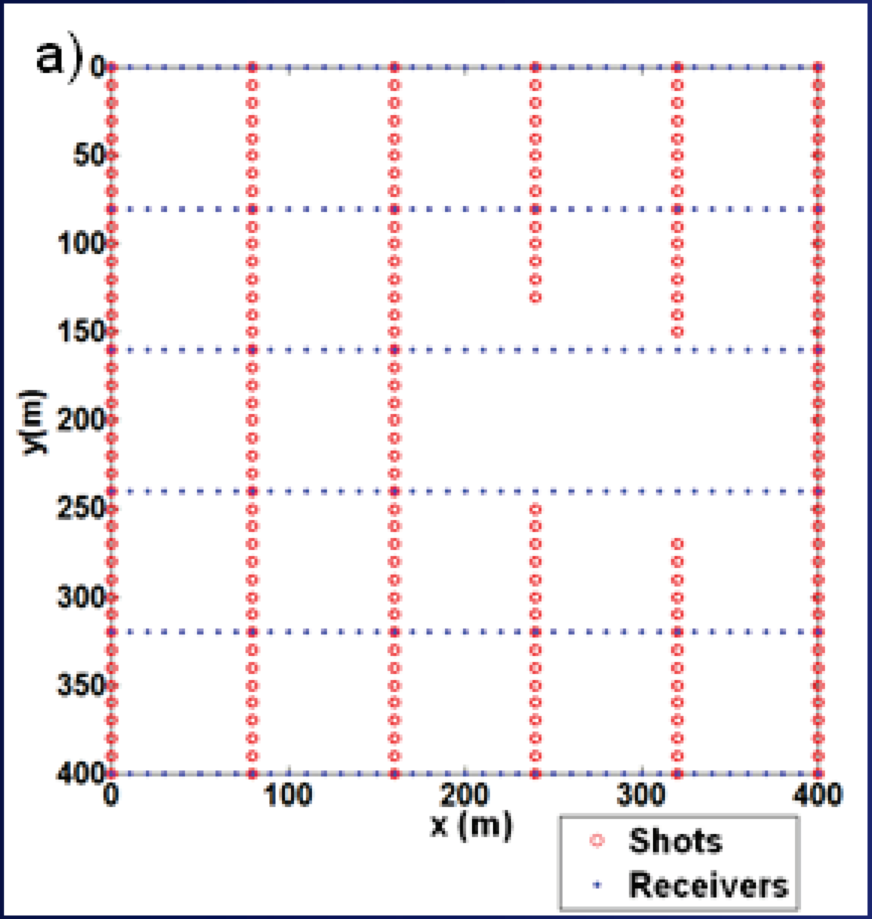
3D Results: % difference

- Difference between true reflectivity and common-offset-weighted migration



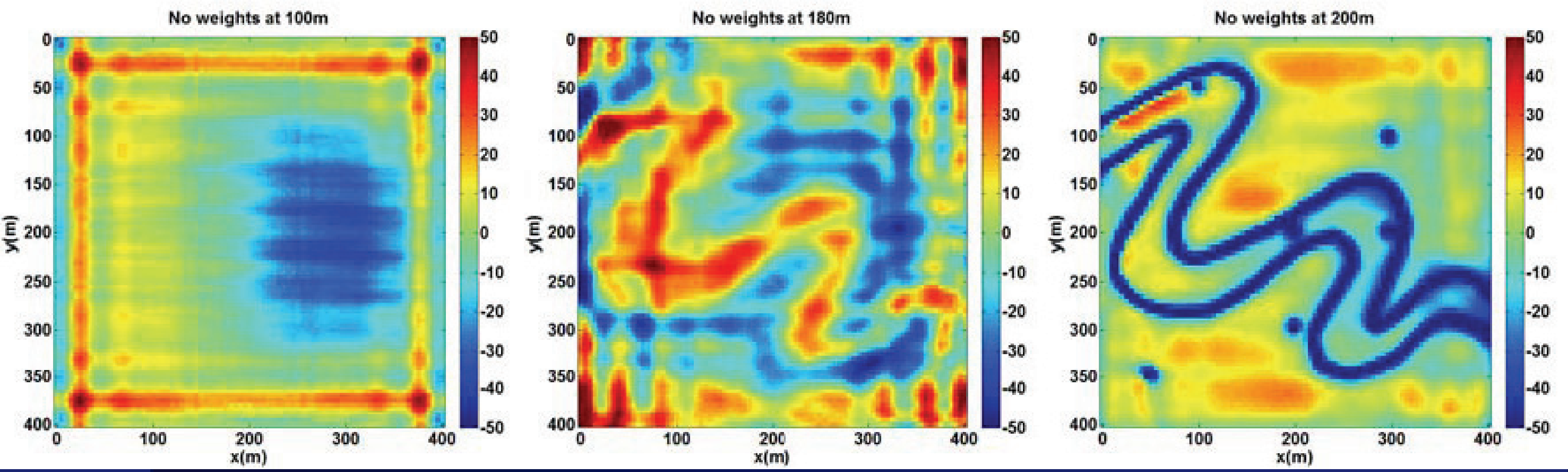
3D Results

- Additional decimated geometry



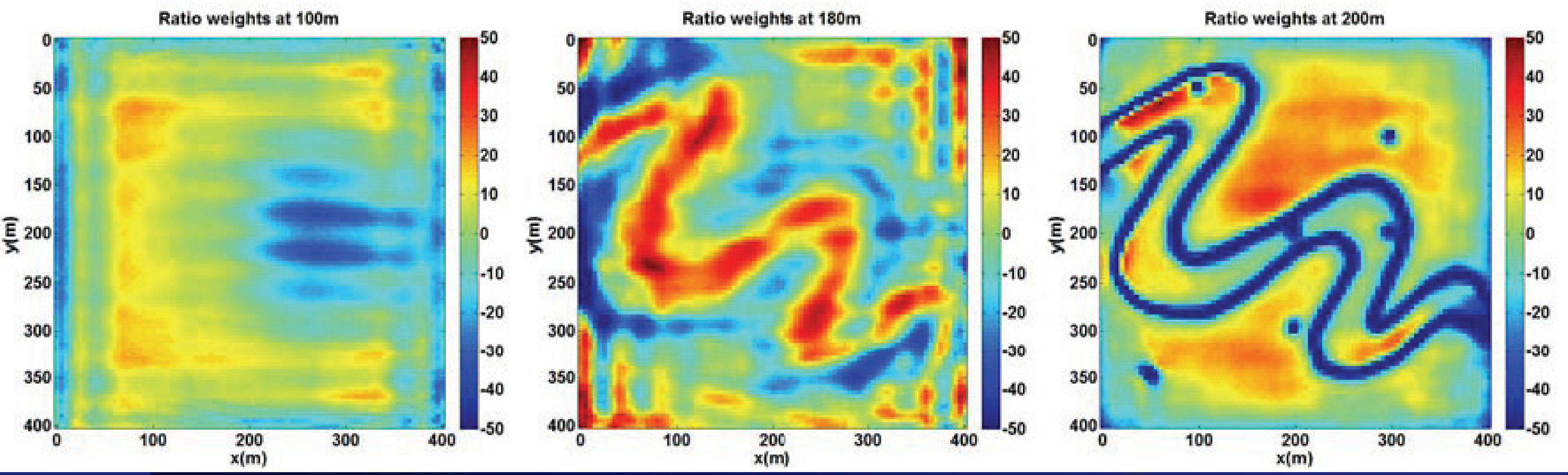
3D Results: % difference

- Difference between true reflectivity and unweighted migration with hole



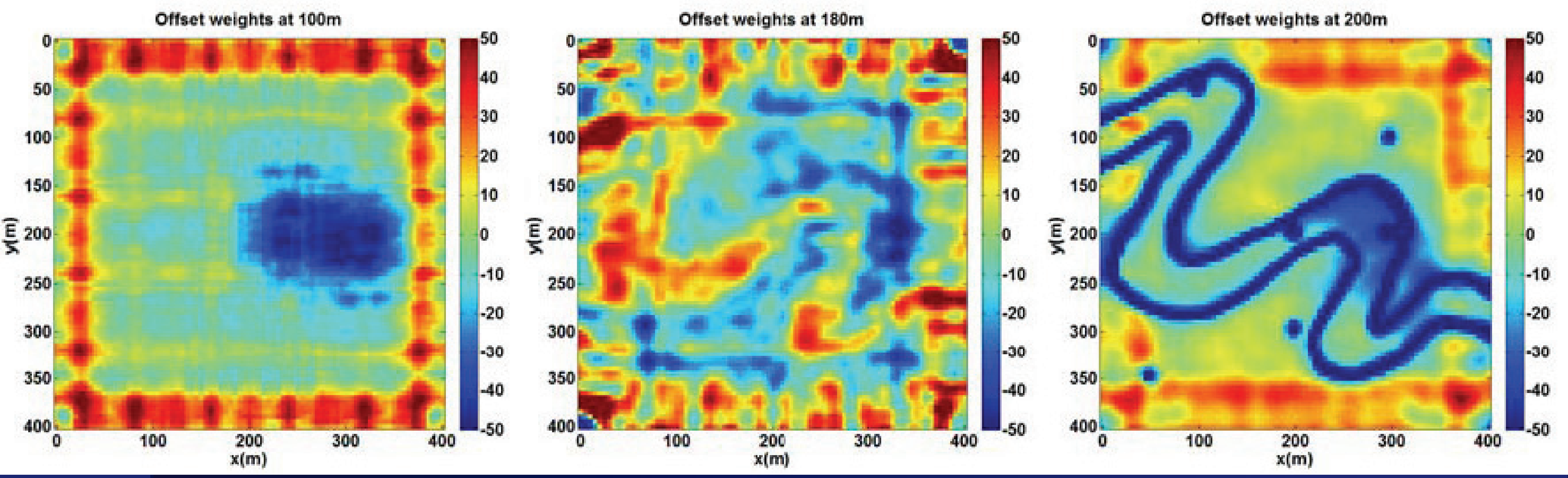
3D Results: % difference

- Difference between true reflectivity and delta-ratio migration with hole



3D Results: % difference

- Difference between true reflectivity and common-offset migration with hole



Conclusions

- Though not a replacement for proper sampling, delta-ratio weights appear to reduce footprint in 2D and 3D by compensating for irregular image point illumination
- In a comparison of “bare-bones” algorithms, delta-ratio weights outperformed common-offset weights

Acknowledgements

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