

Field Testing of Multiple Simultaneous Vibrators Controlled by Filtered m-Sequences

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and

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**UNIVERSITY OF
CALGARY**



CREWES

Introduction

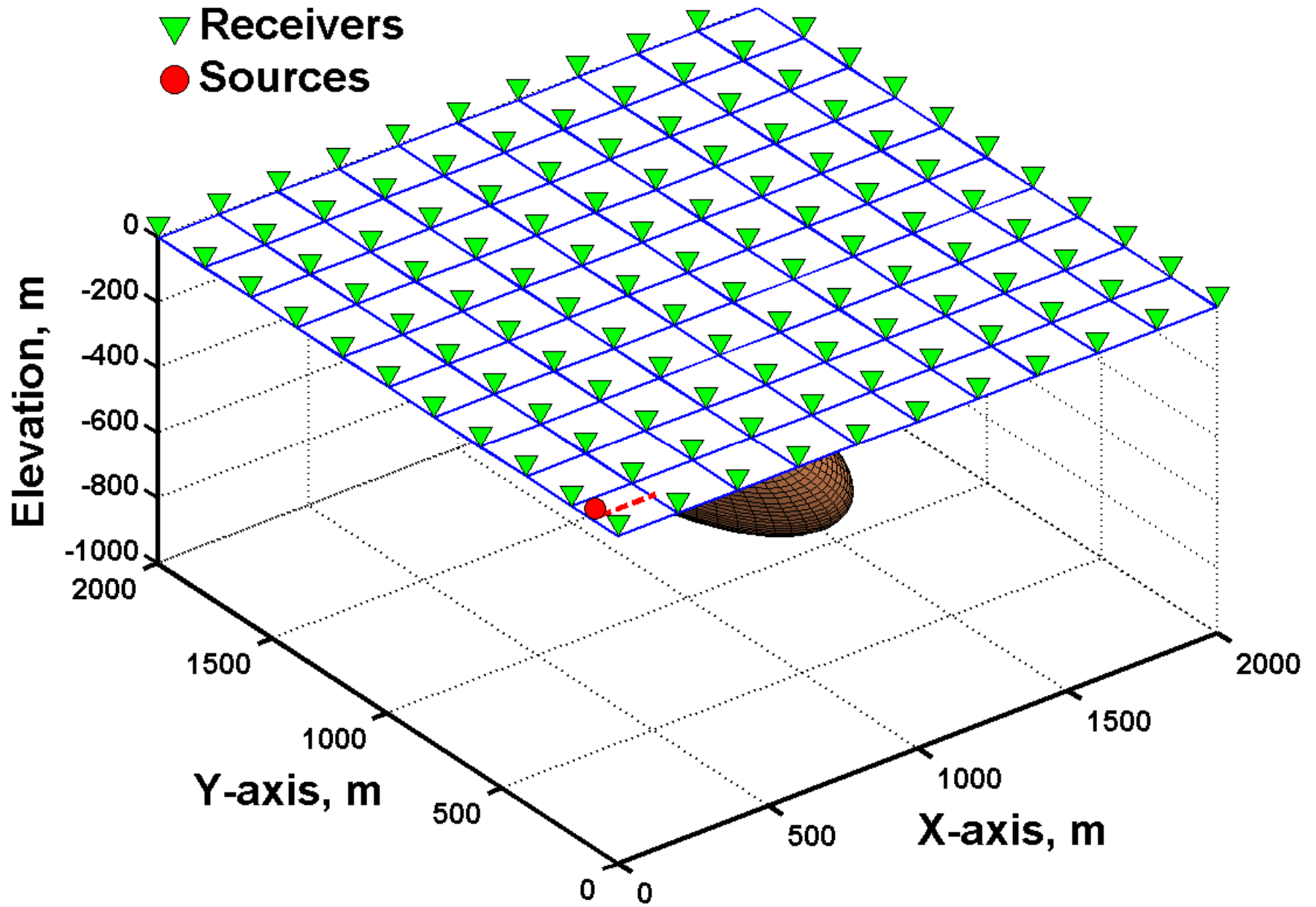
Motivation:

Increased efficiency in completing high-resolution 3D land surveys.

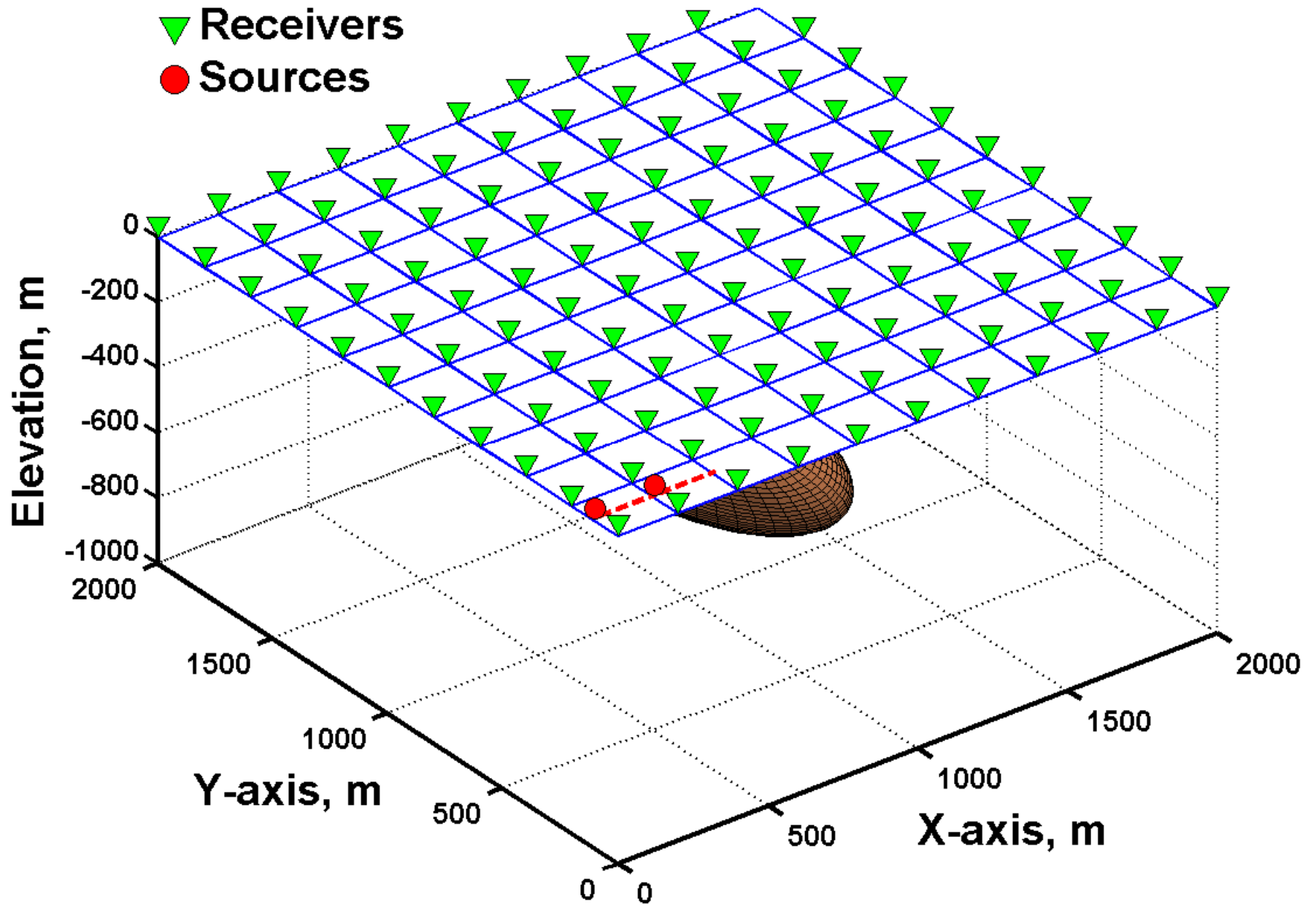
Method:

Use multiple simultaneous vibrators sources controlled by quasi-orthogonal pilot signals.

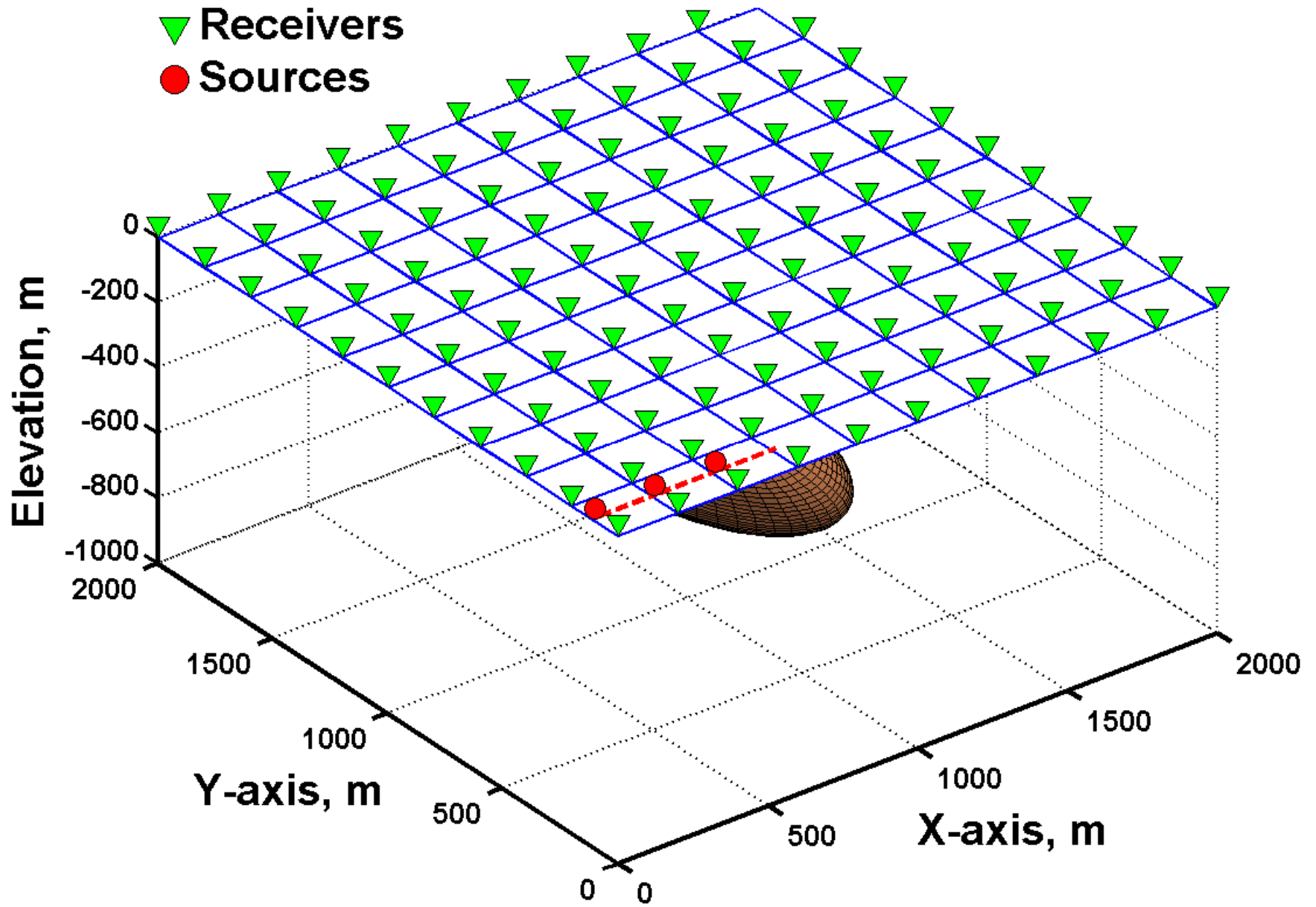
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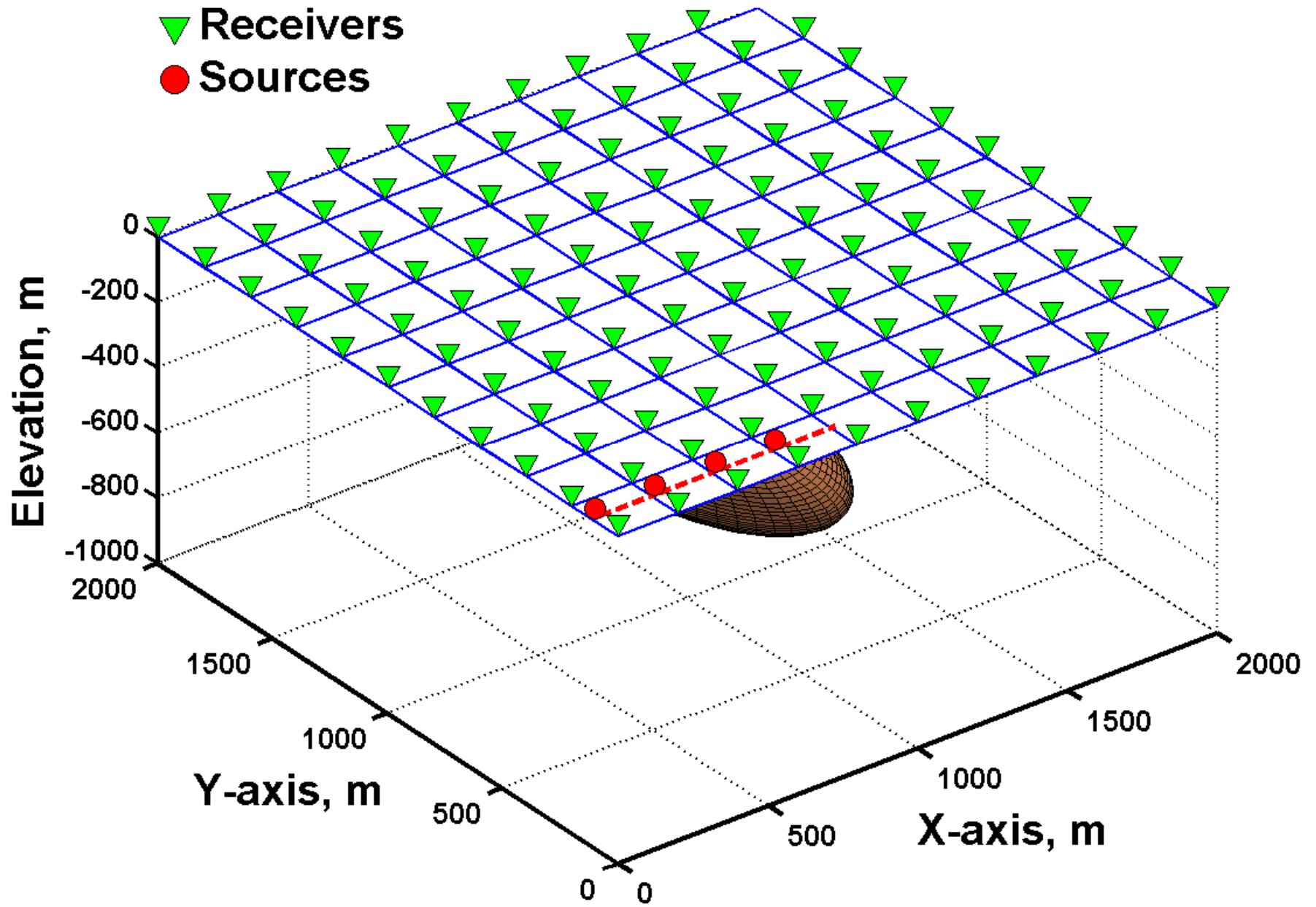
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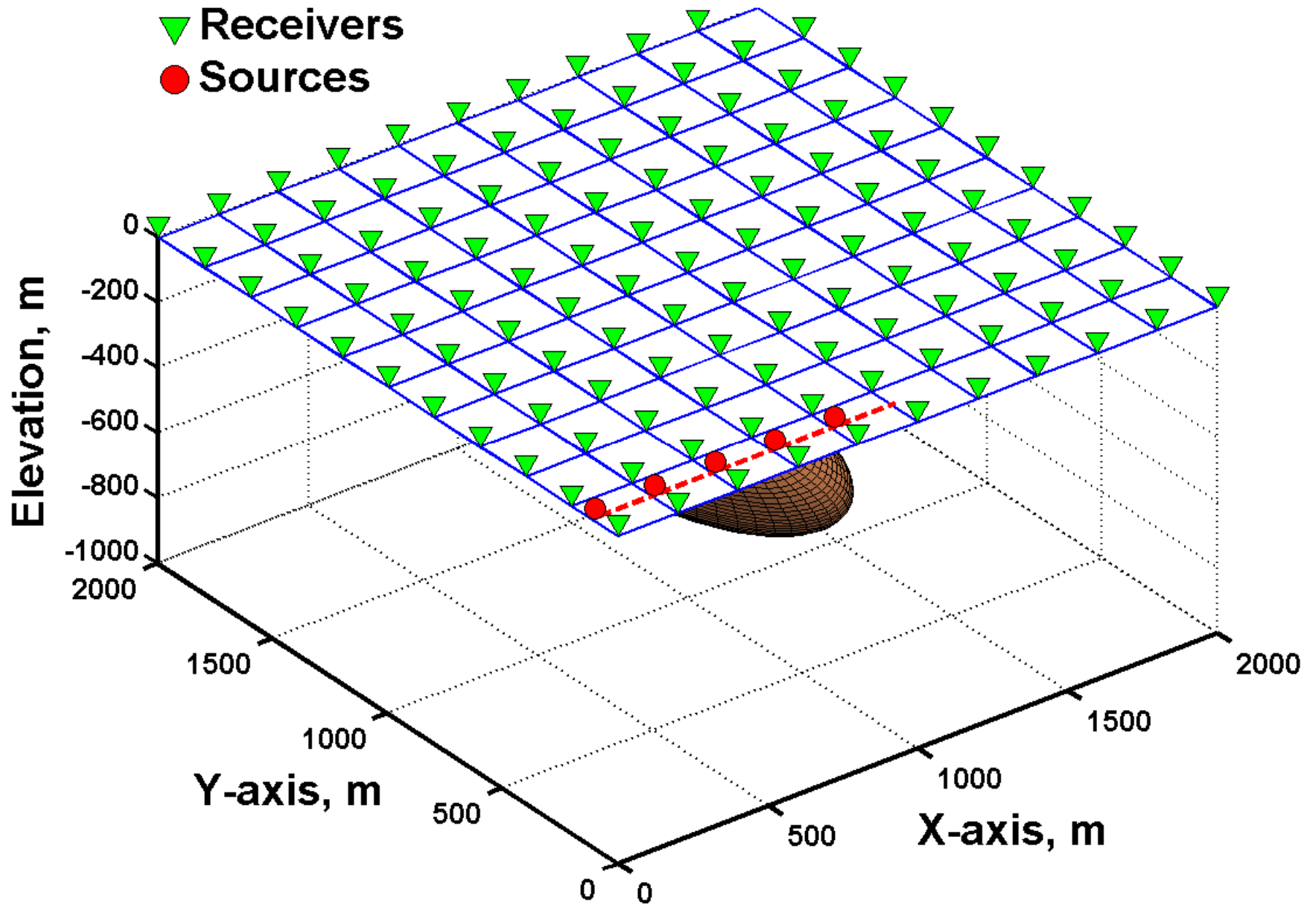
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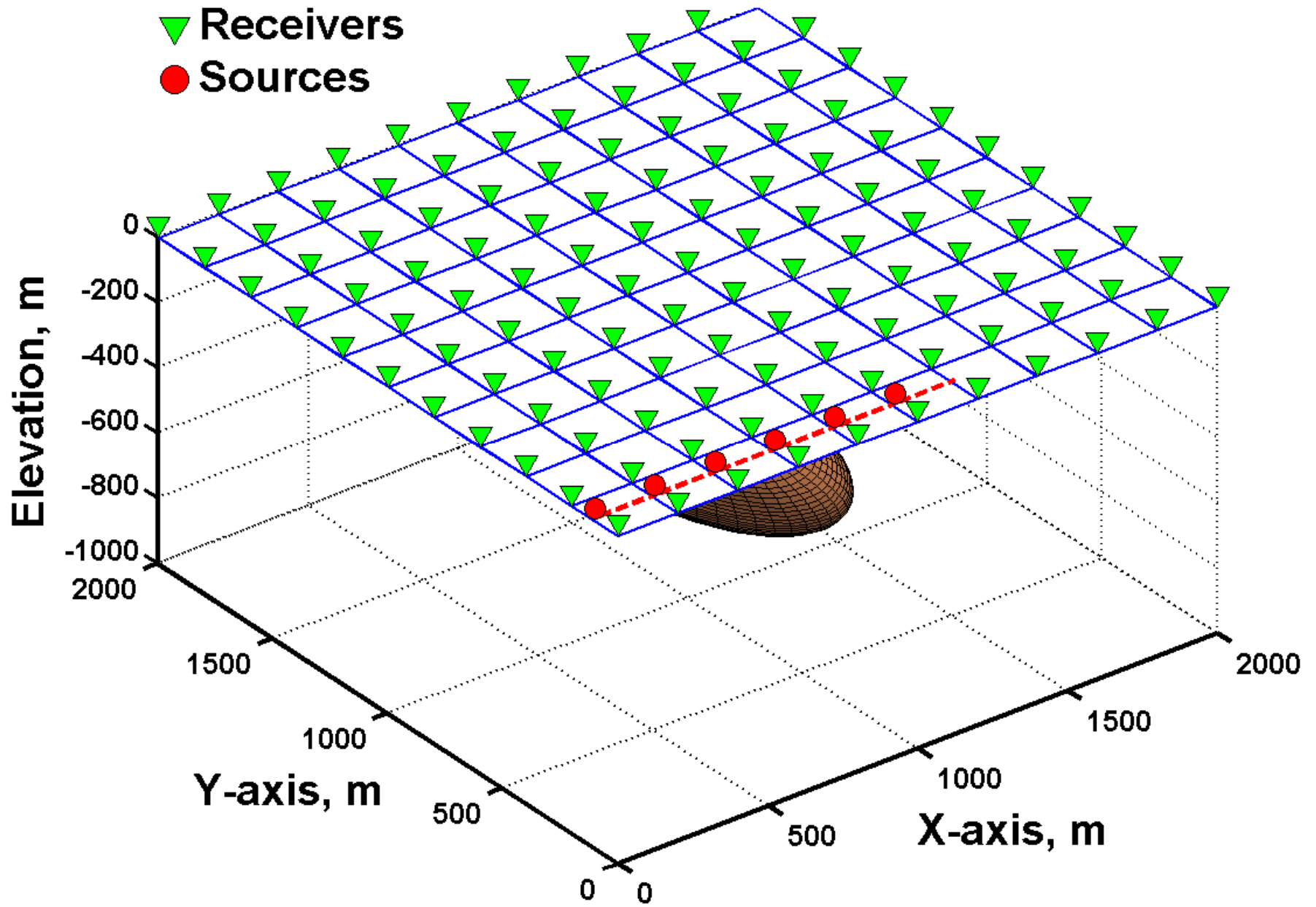
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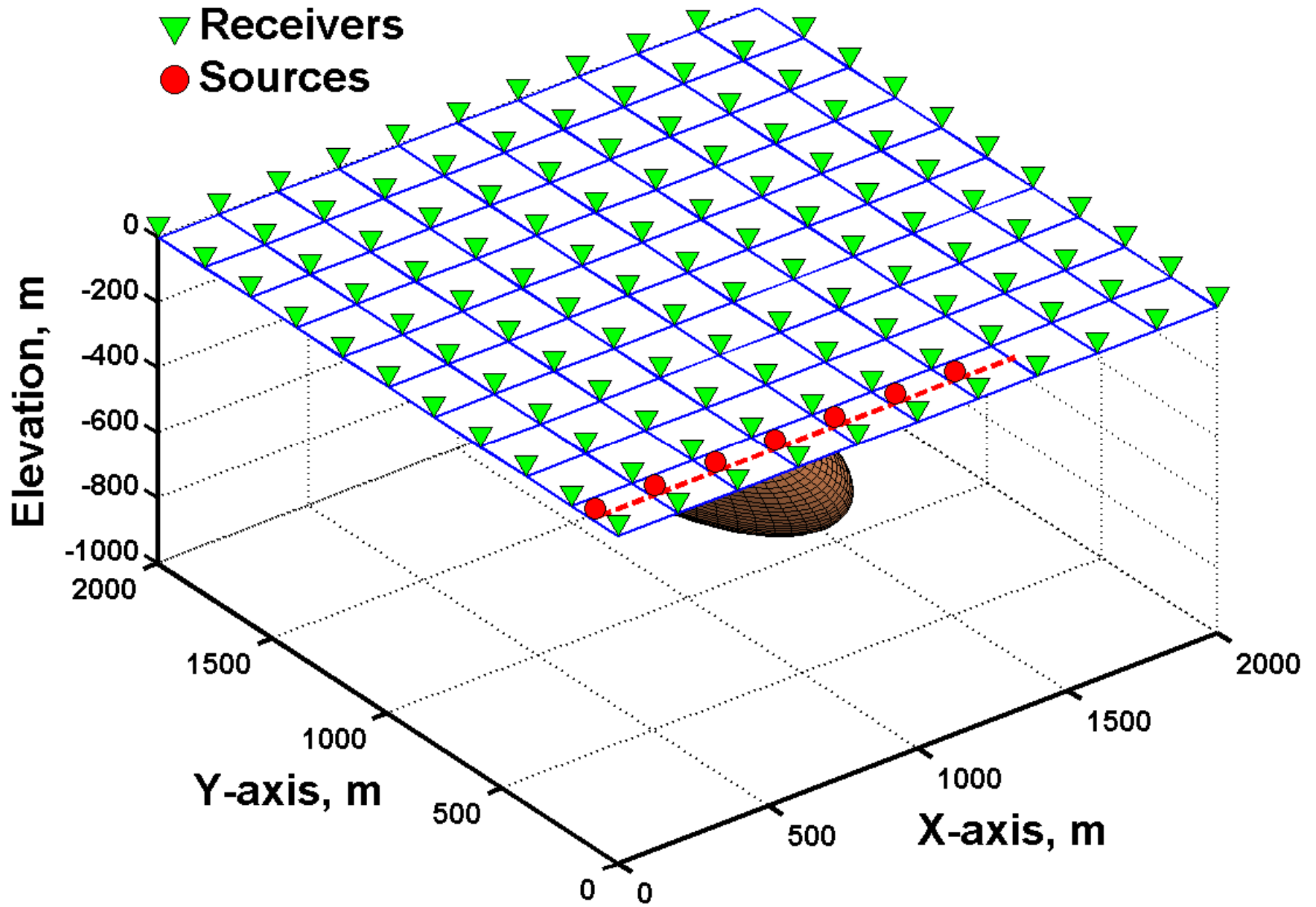
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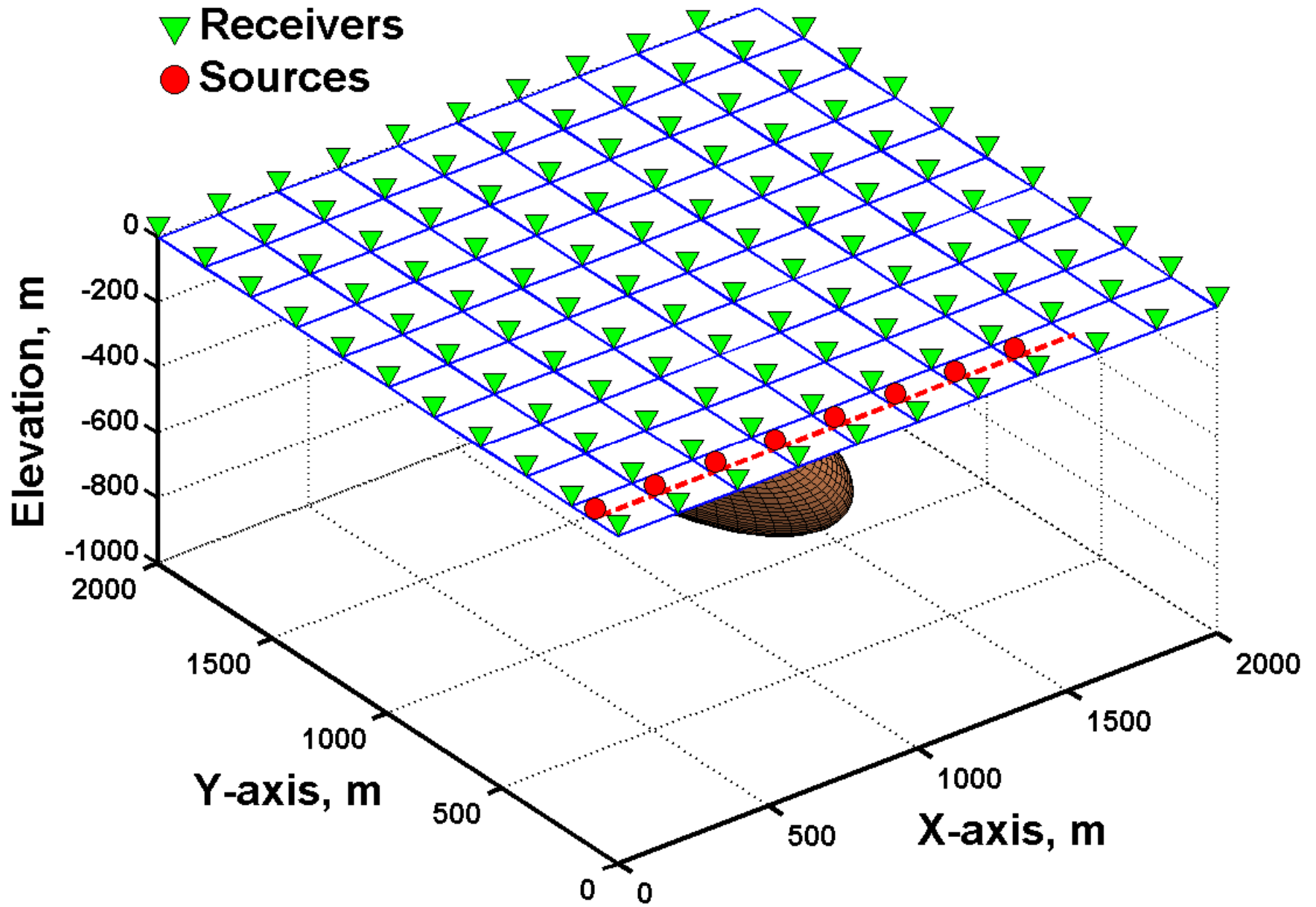
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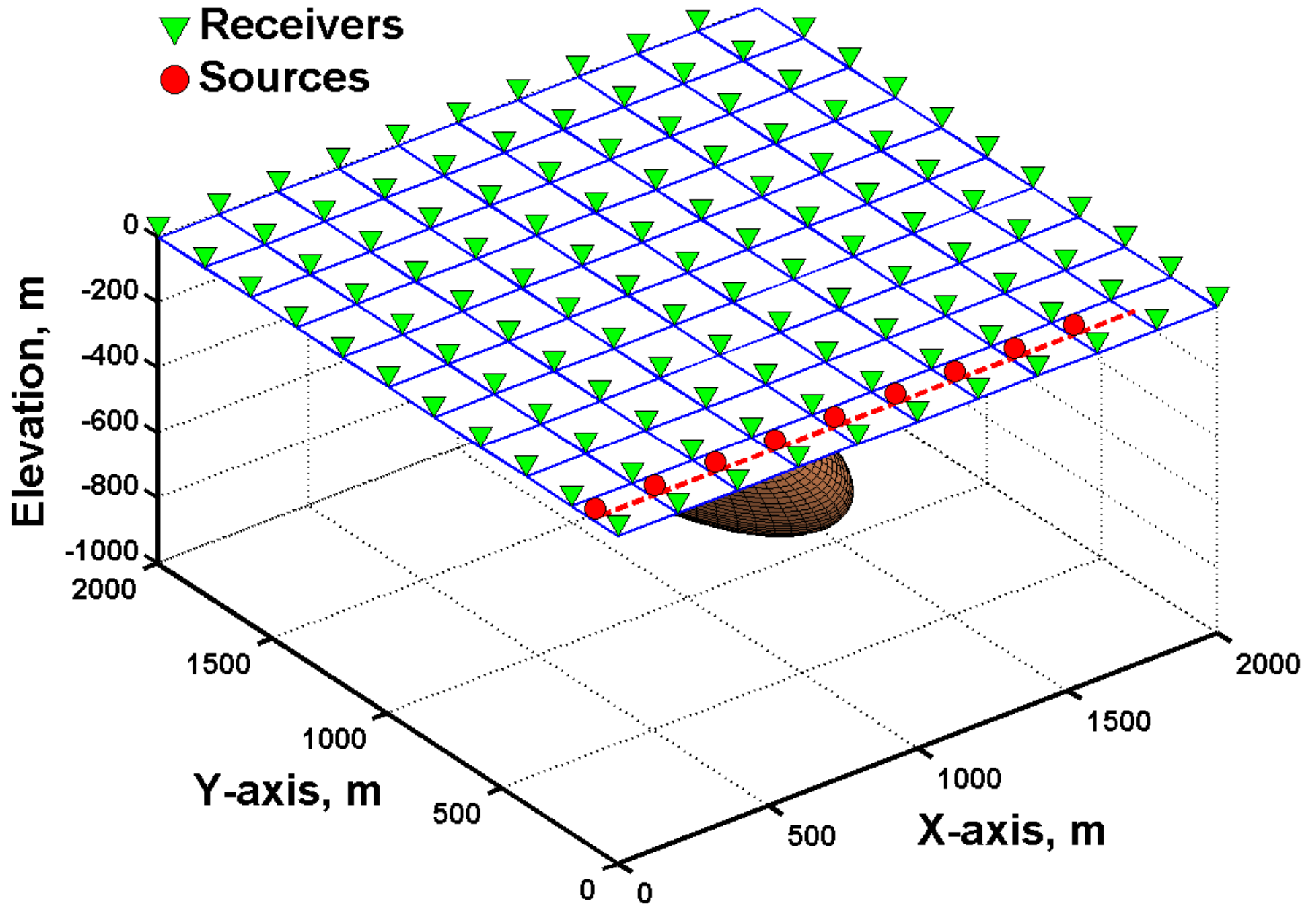
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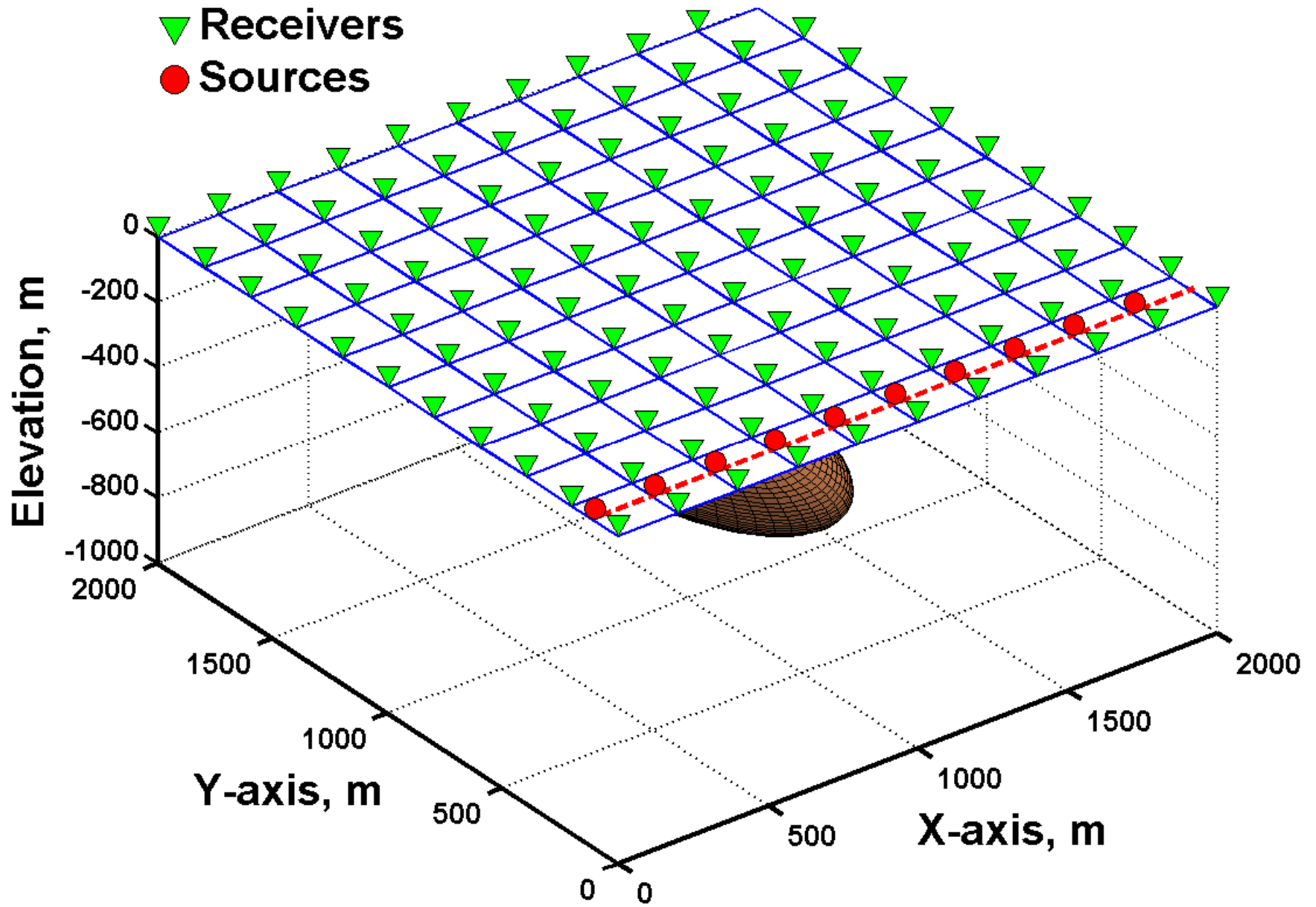
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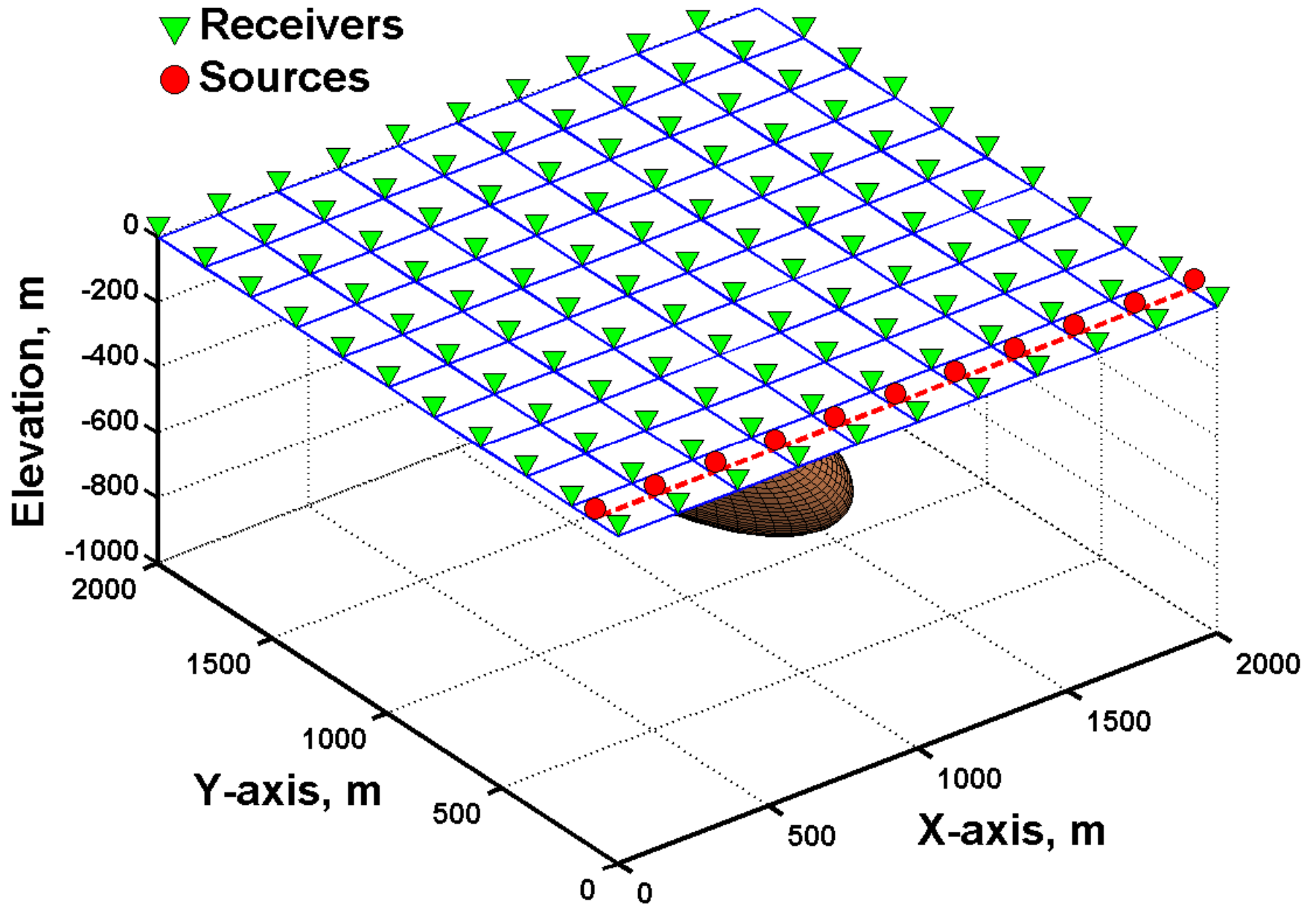
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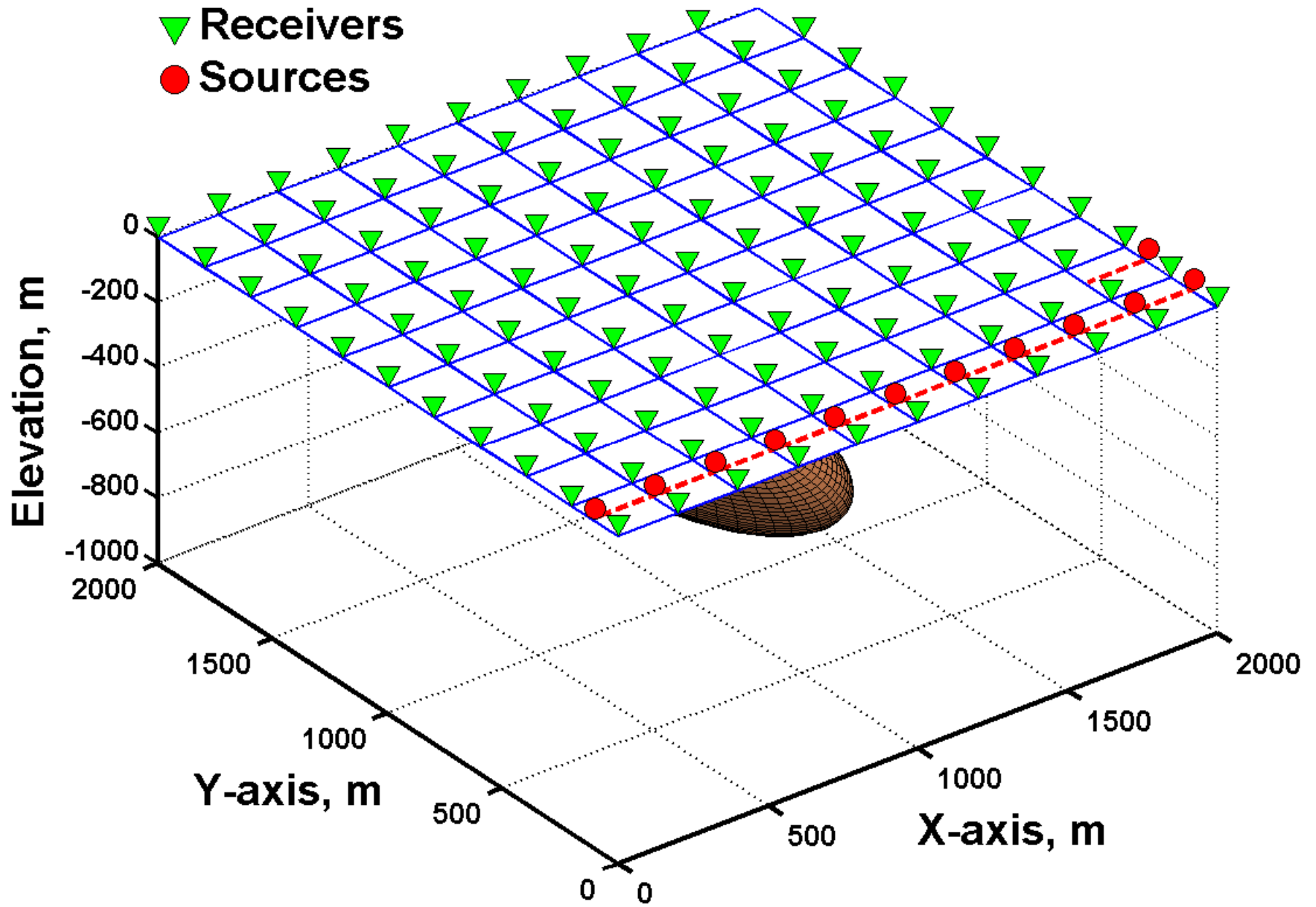
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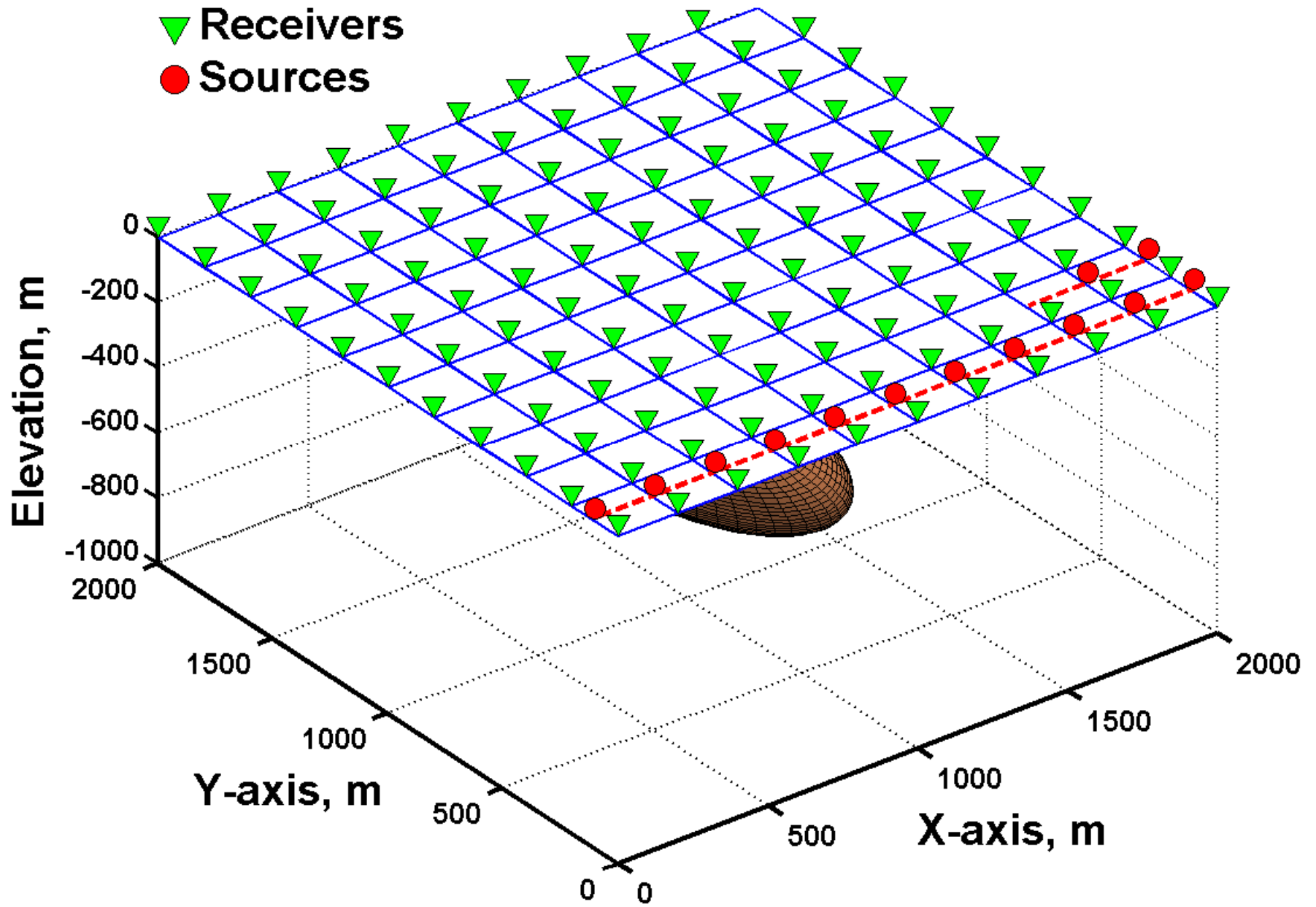
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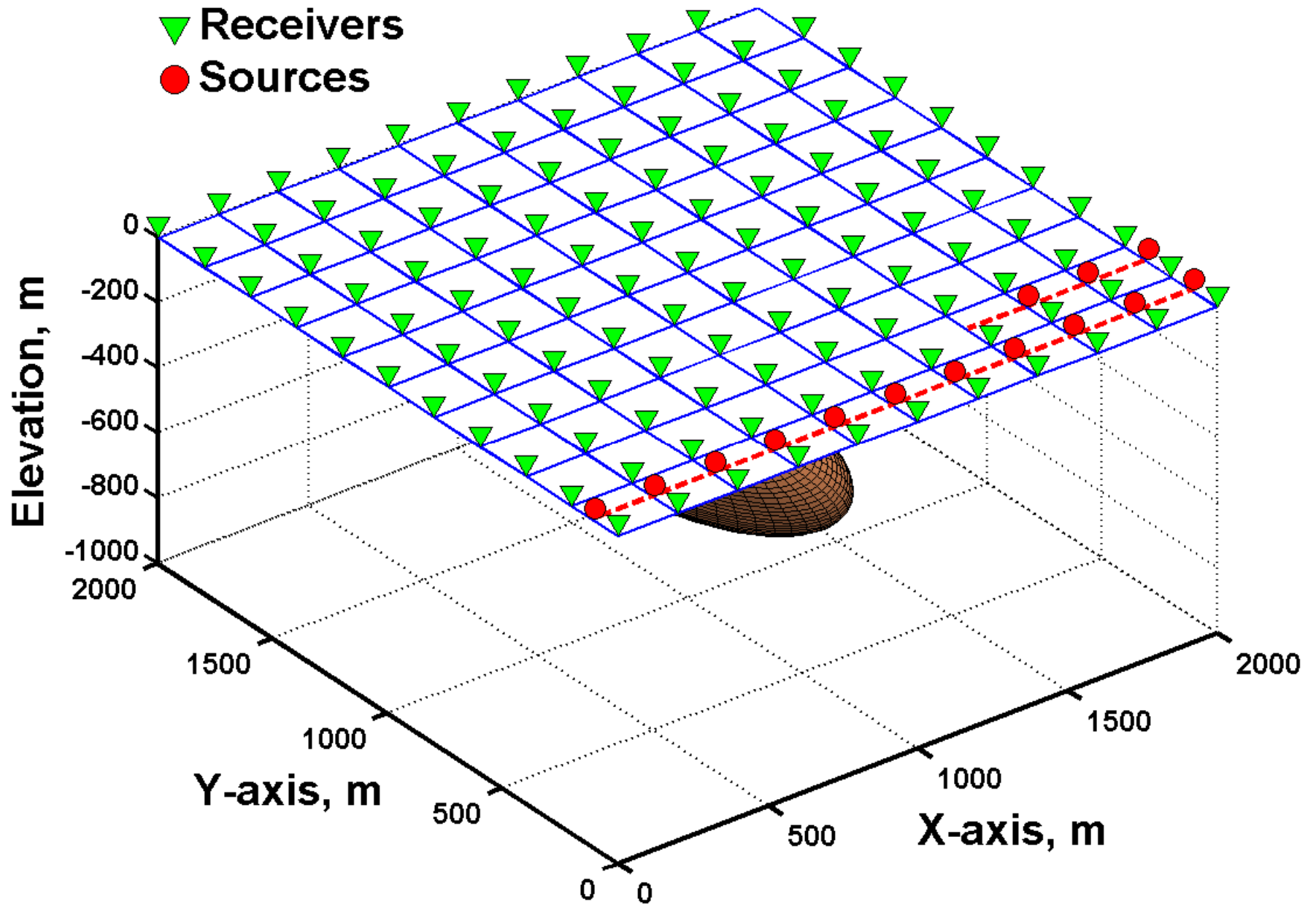
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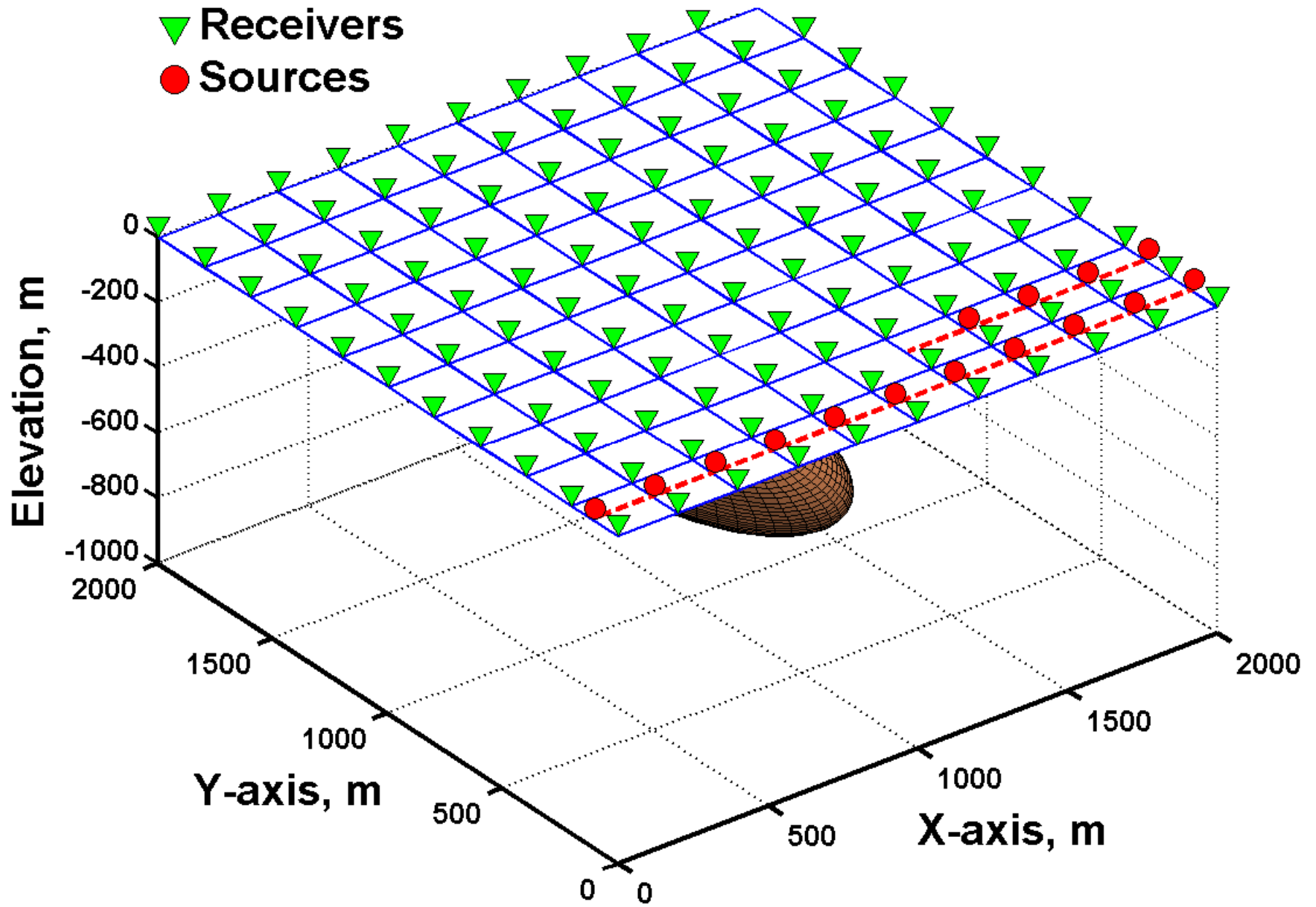
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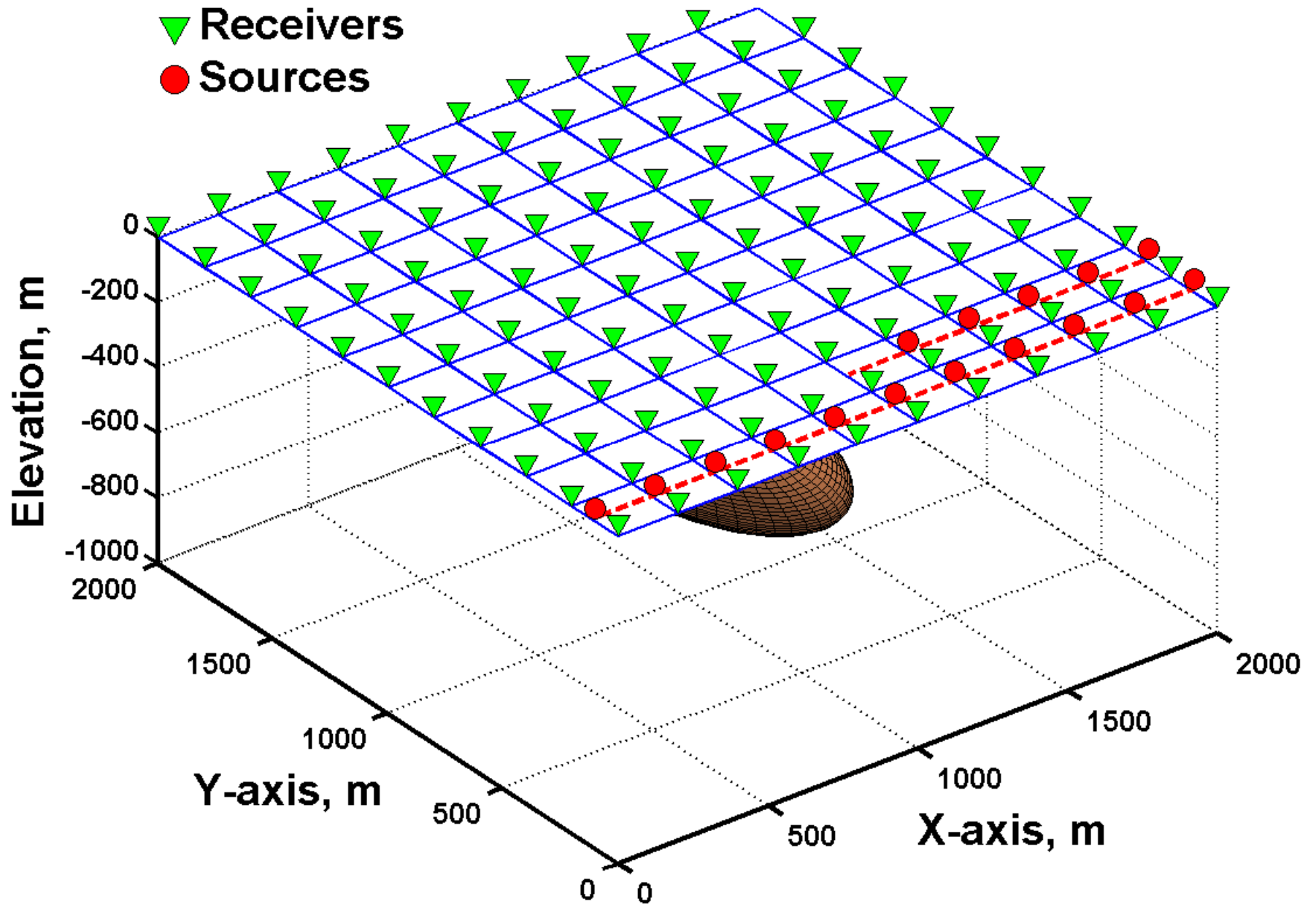
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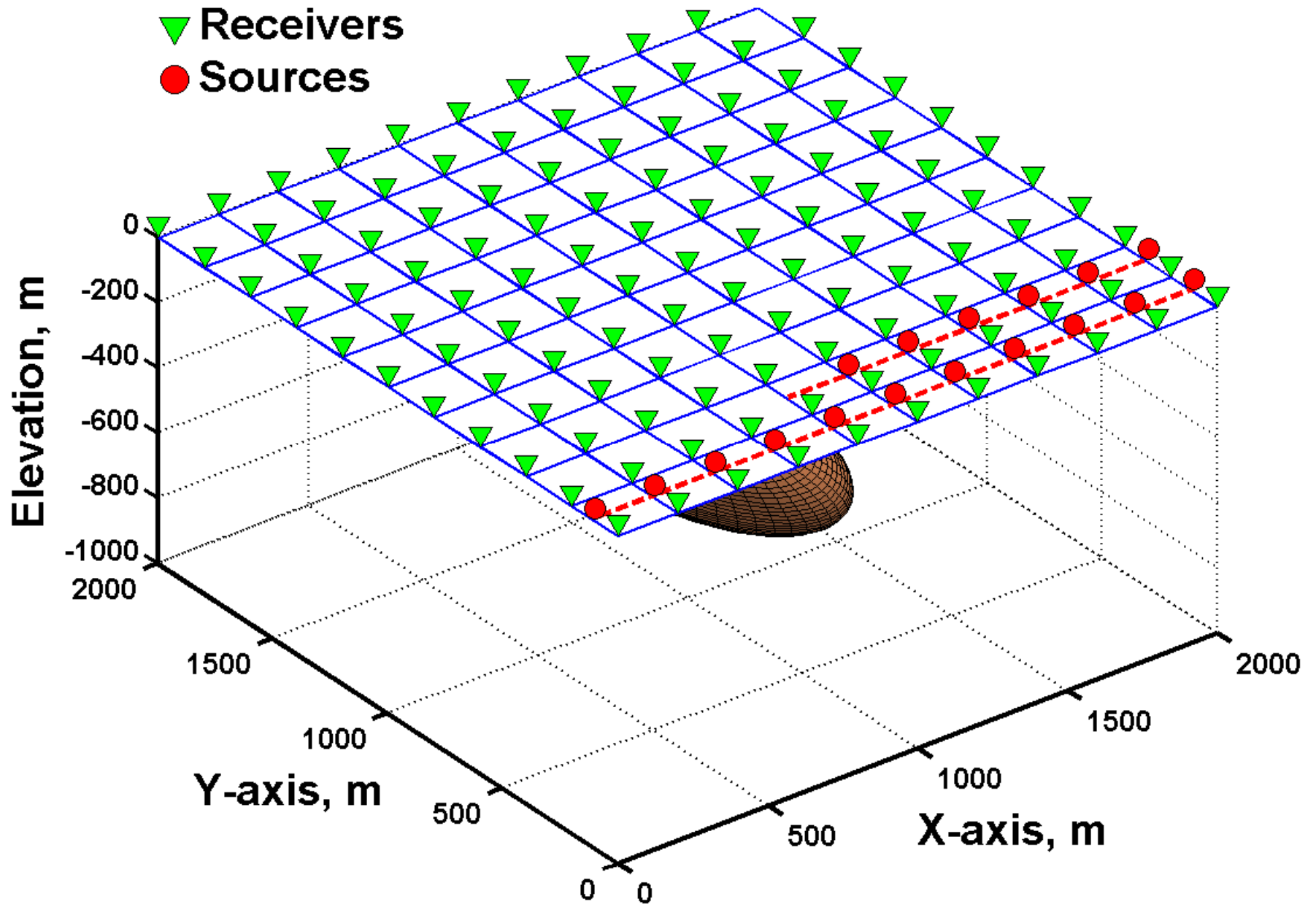
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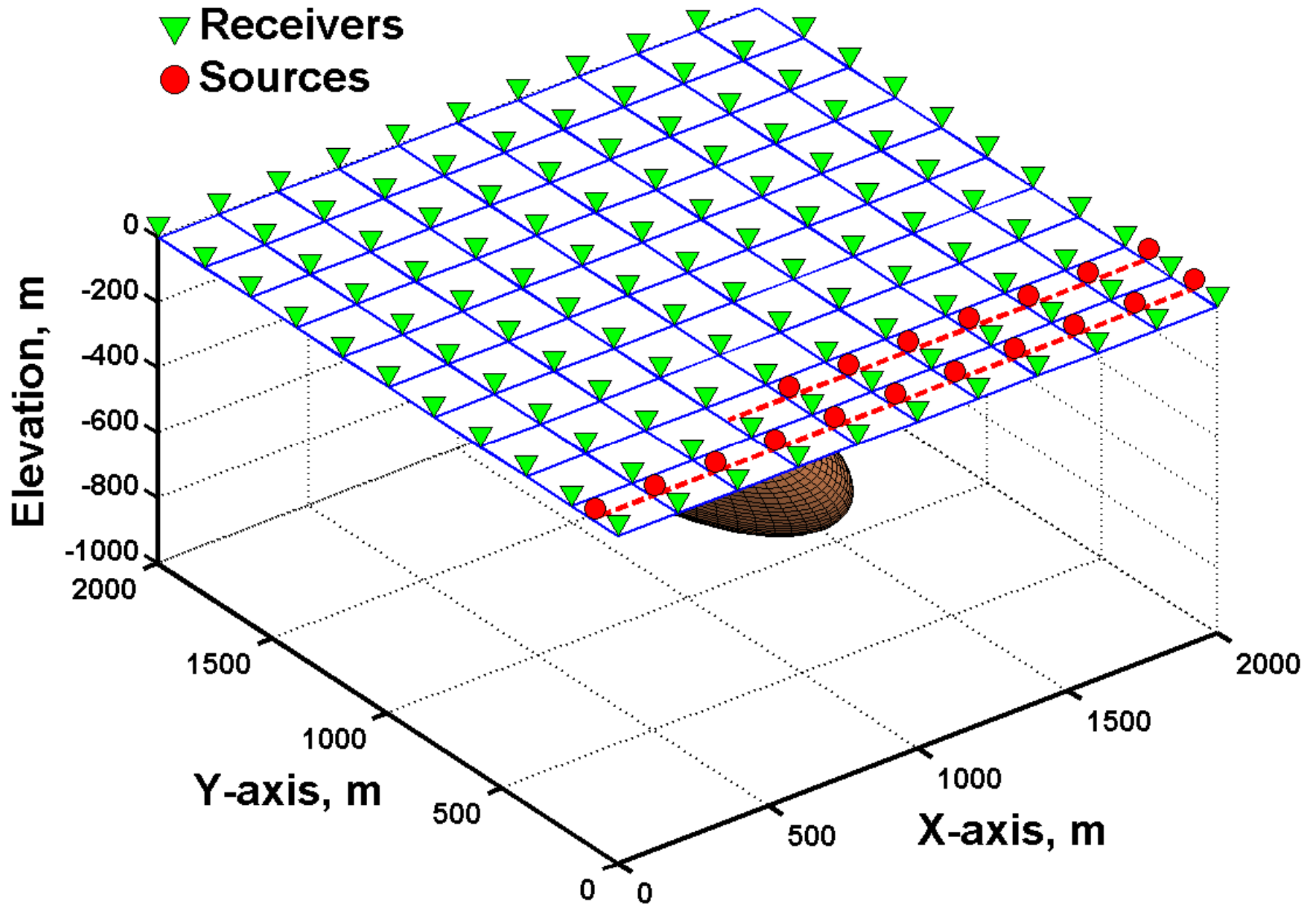
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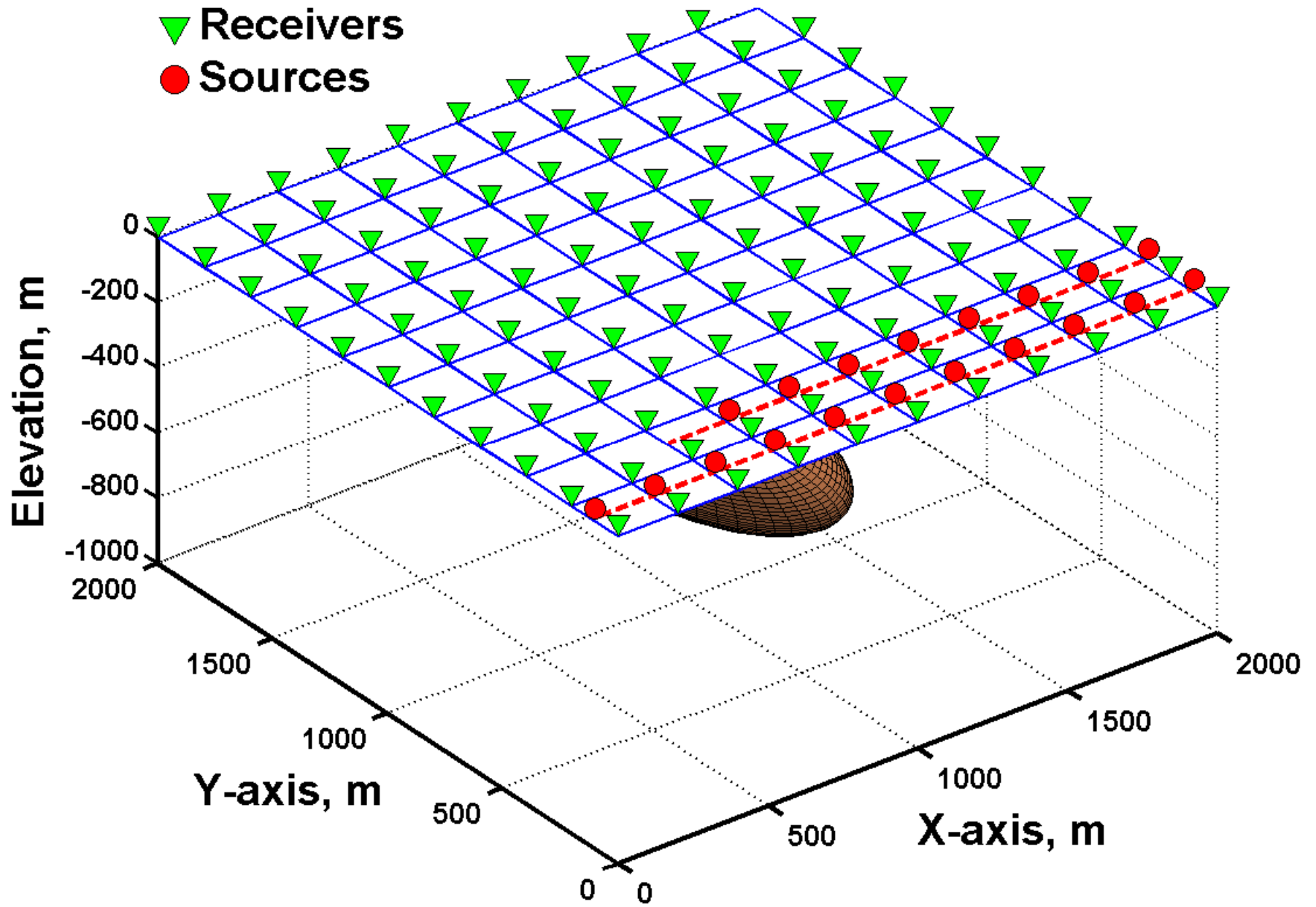
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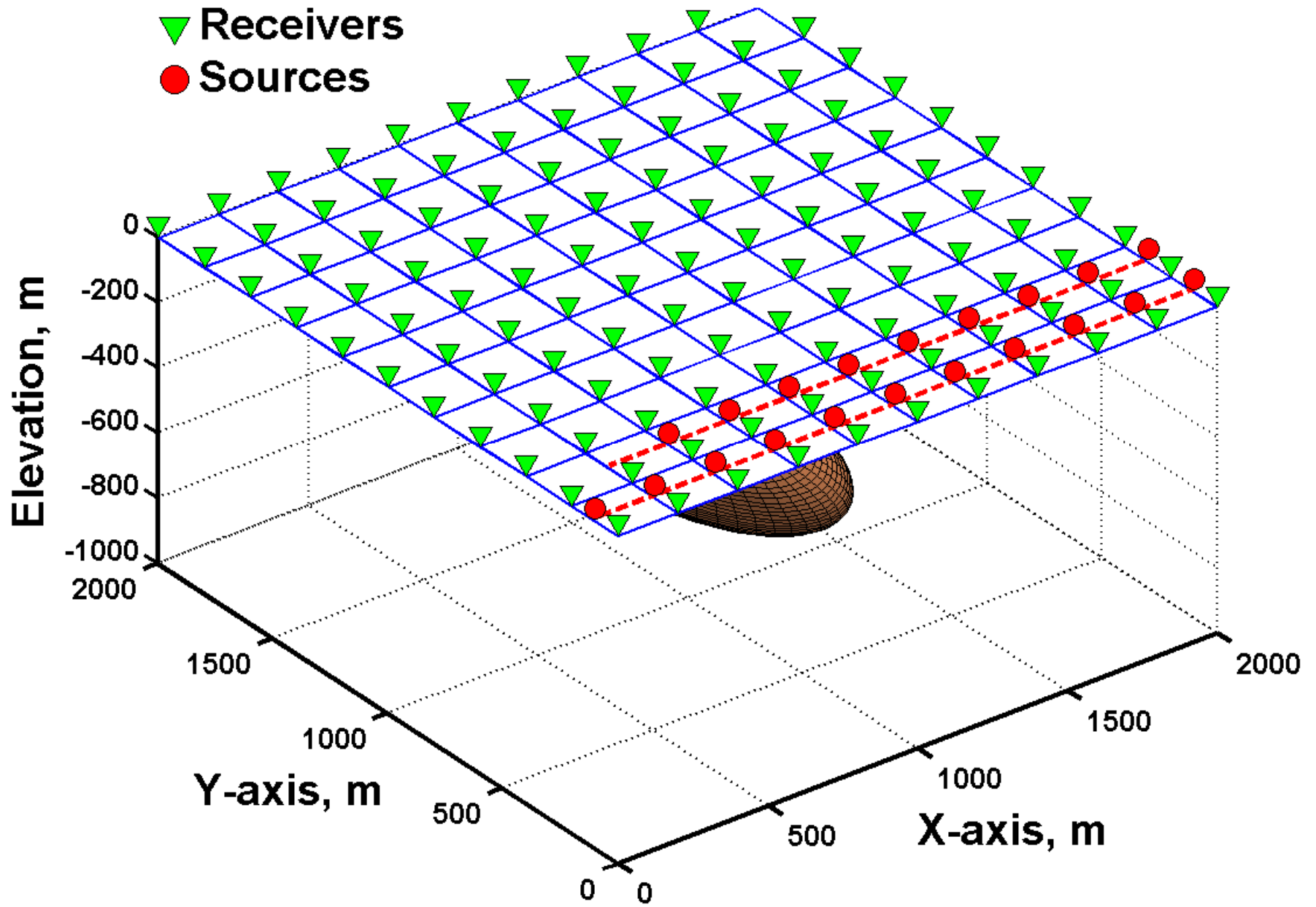
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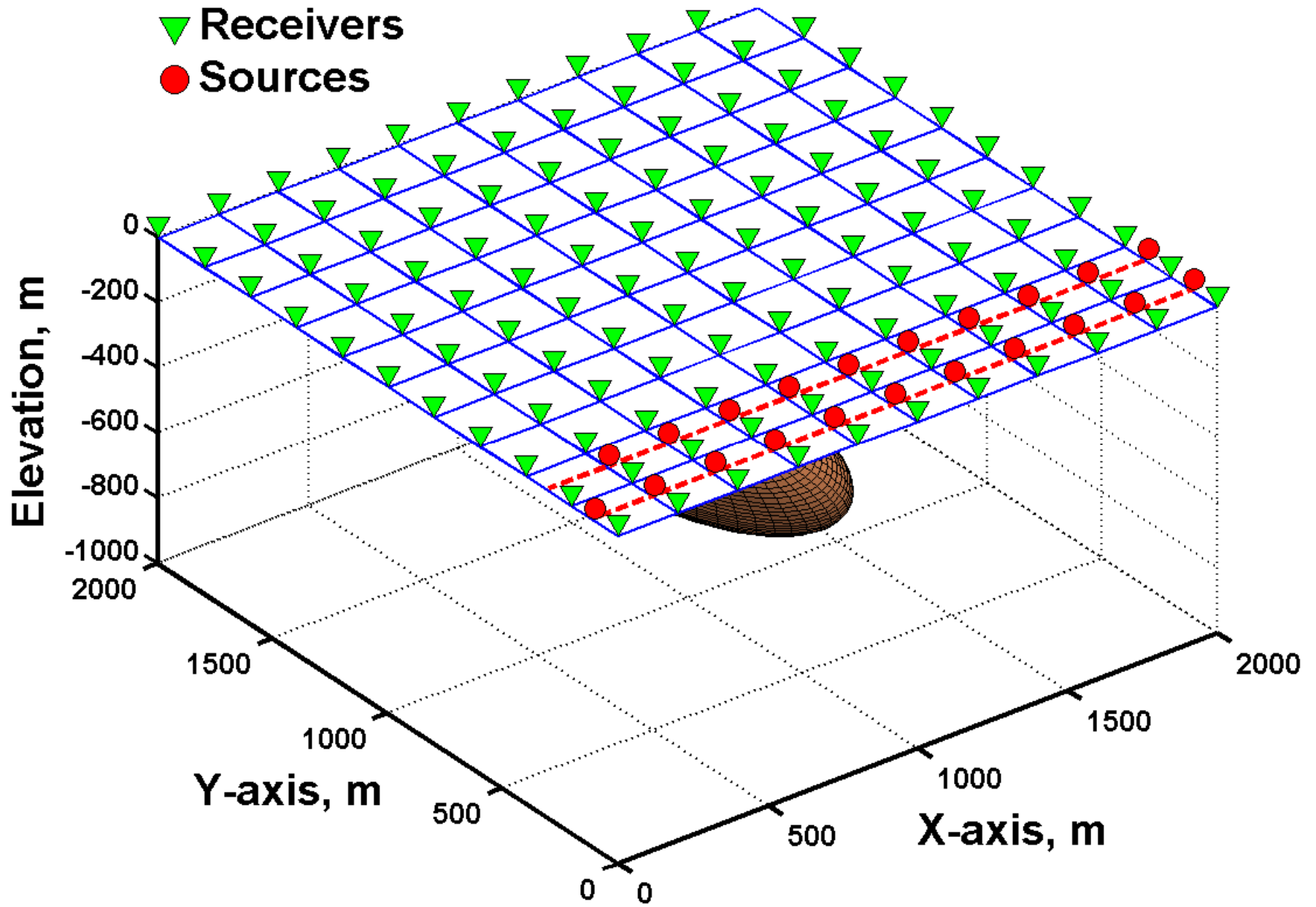
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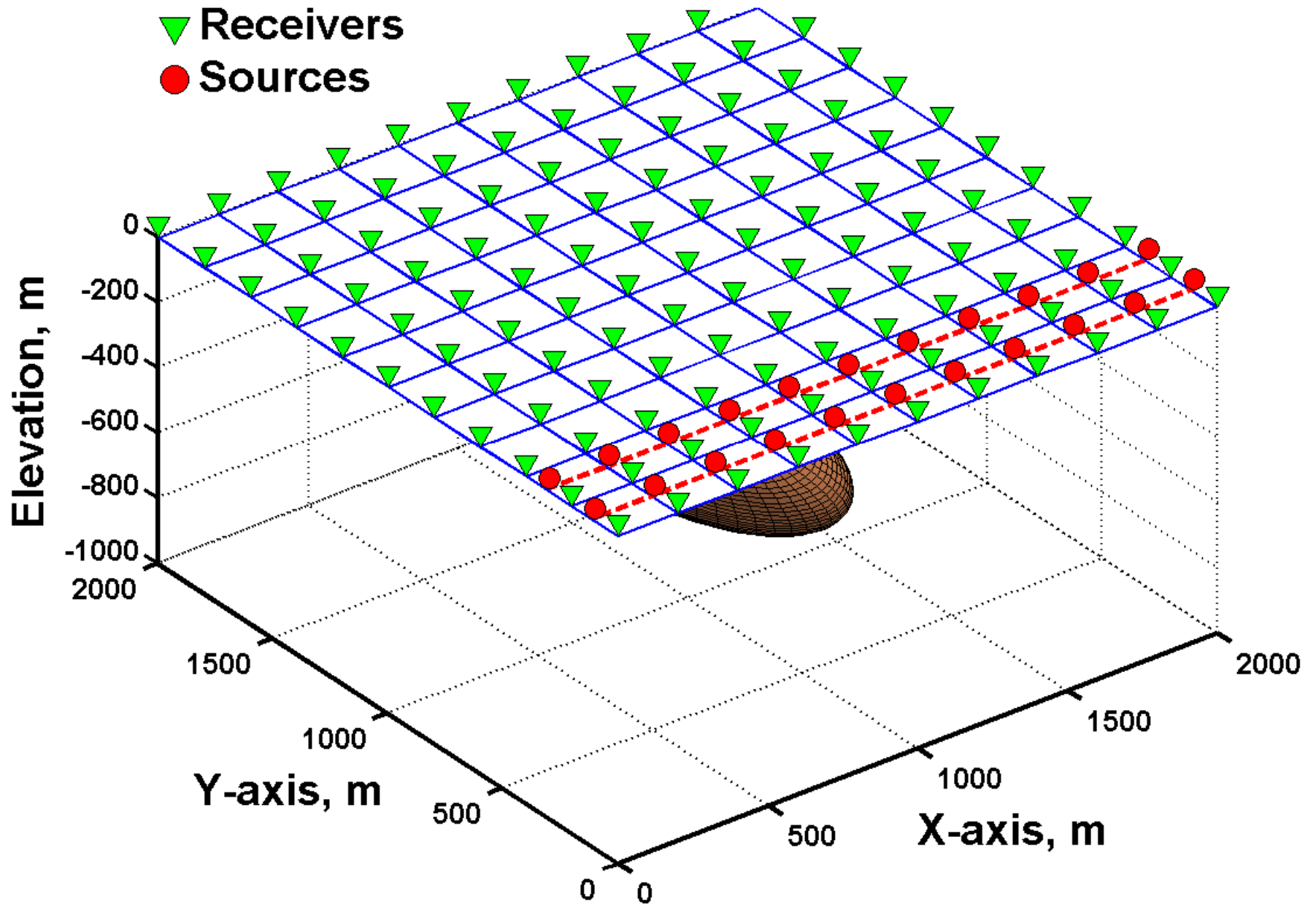
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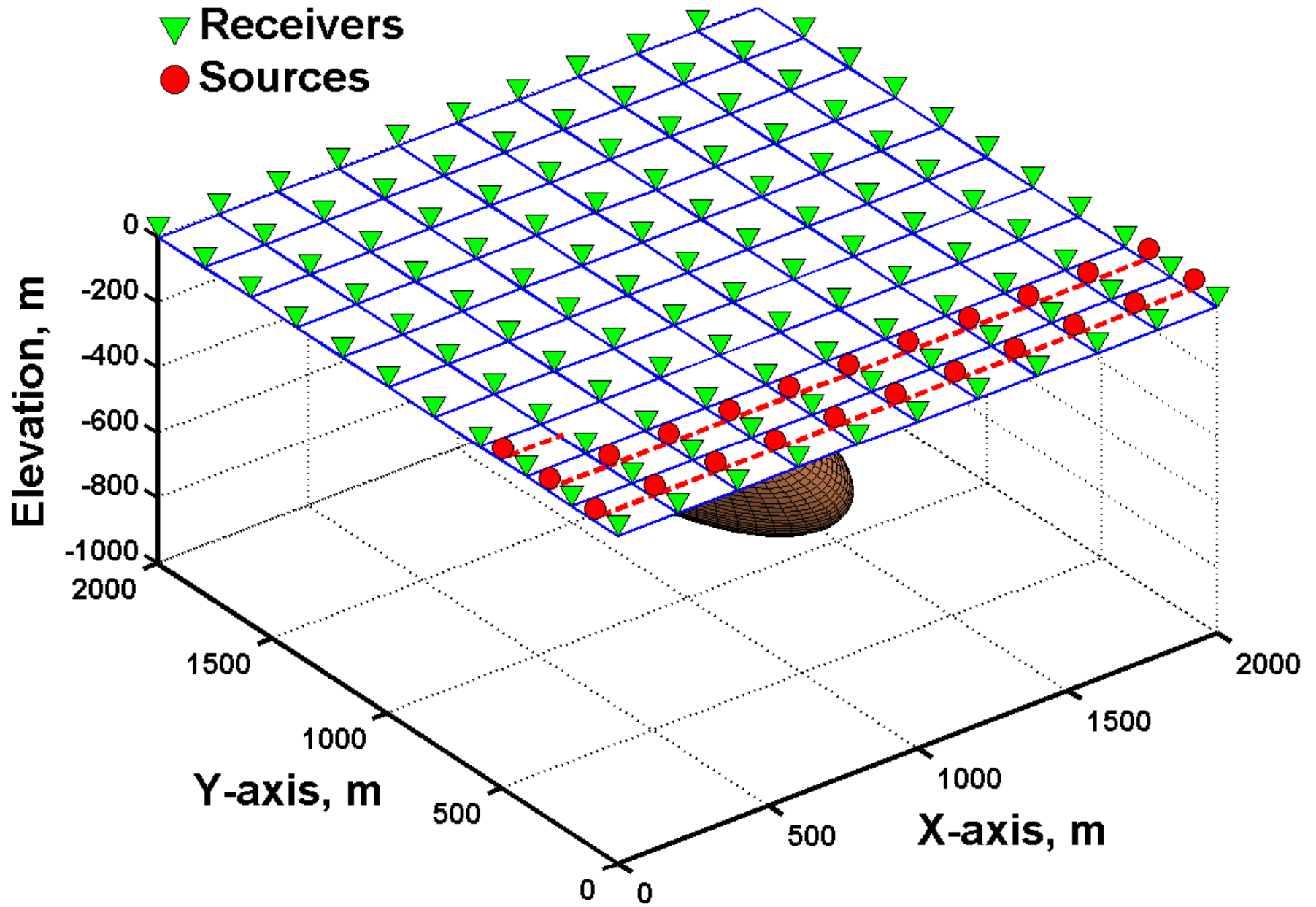
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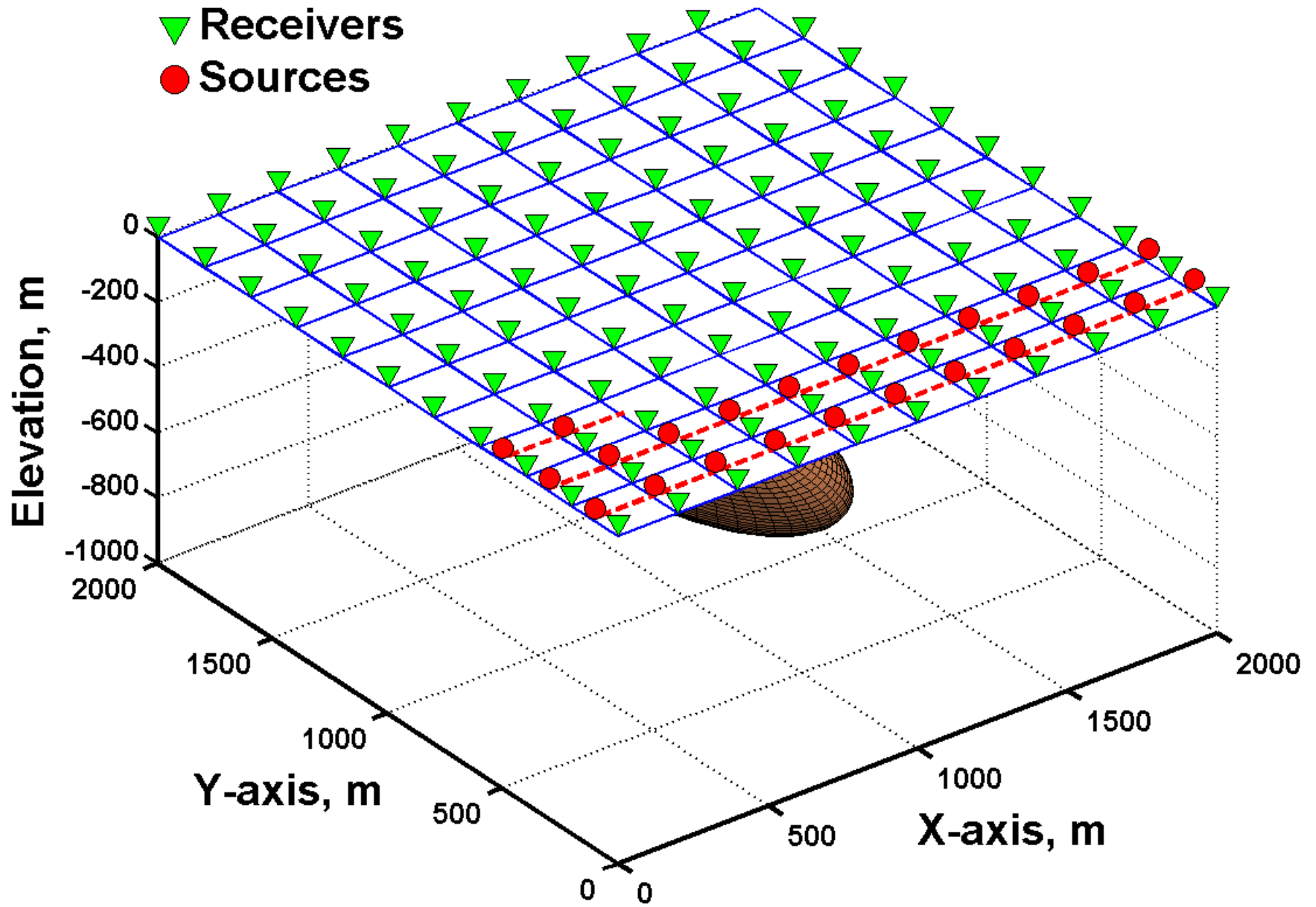
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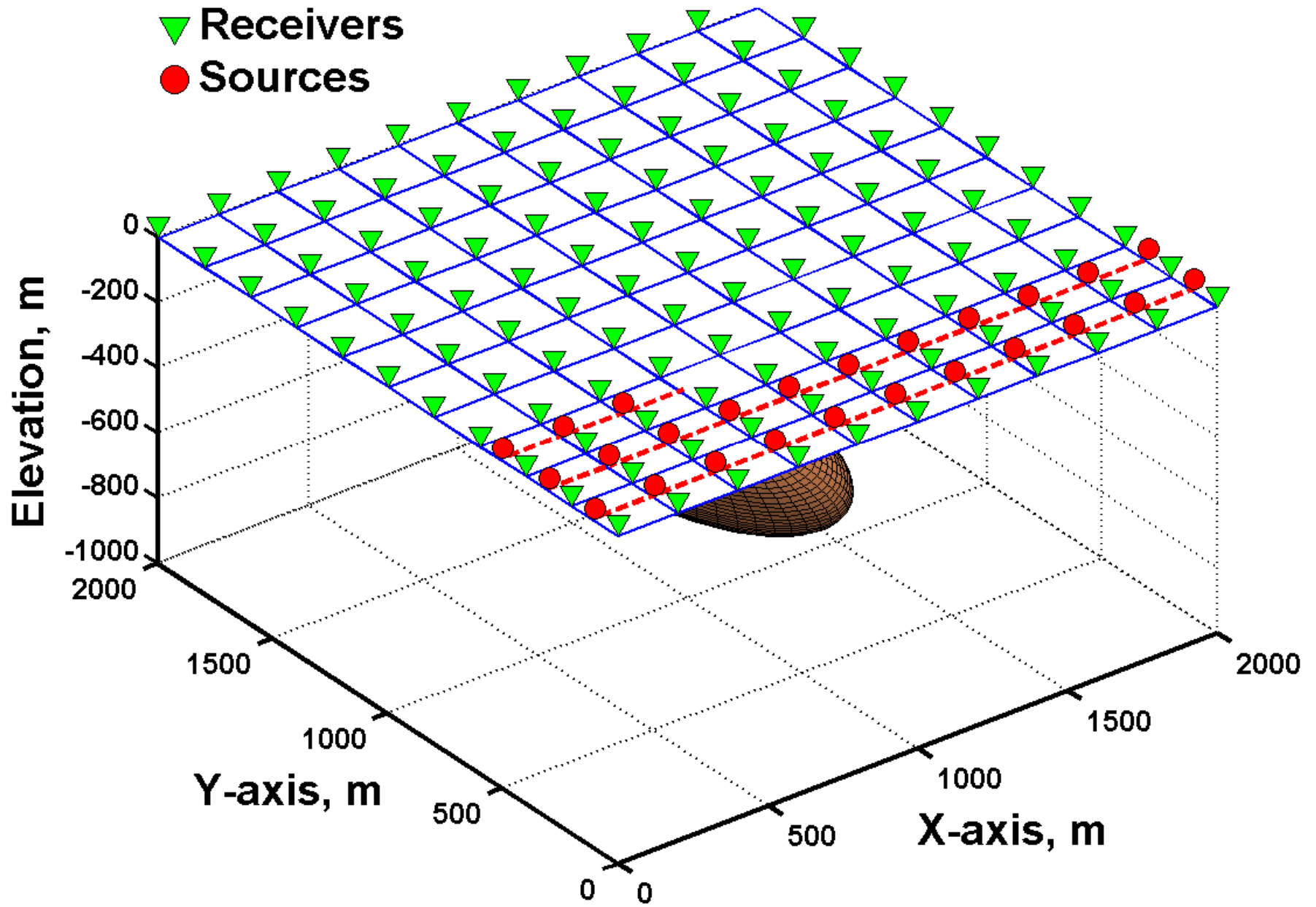
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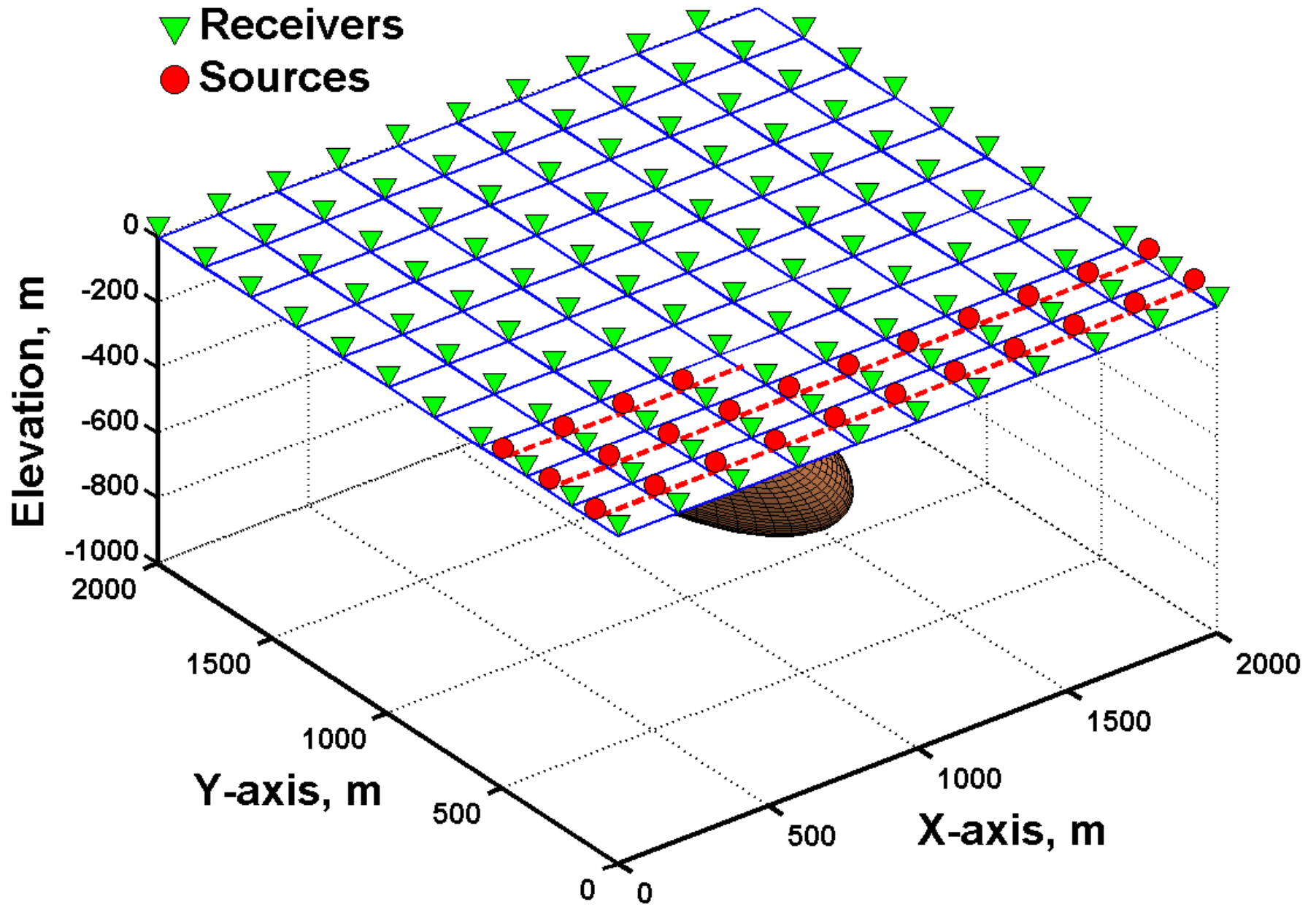
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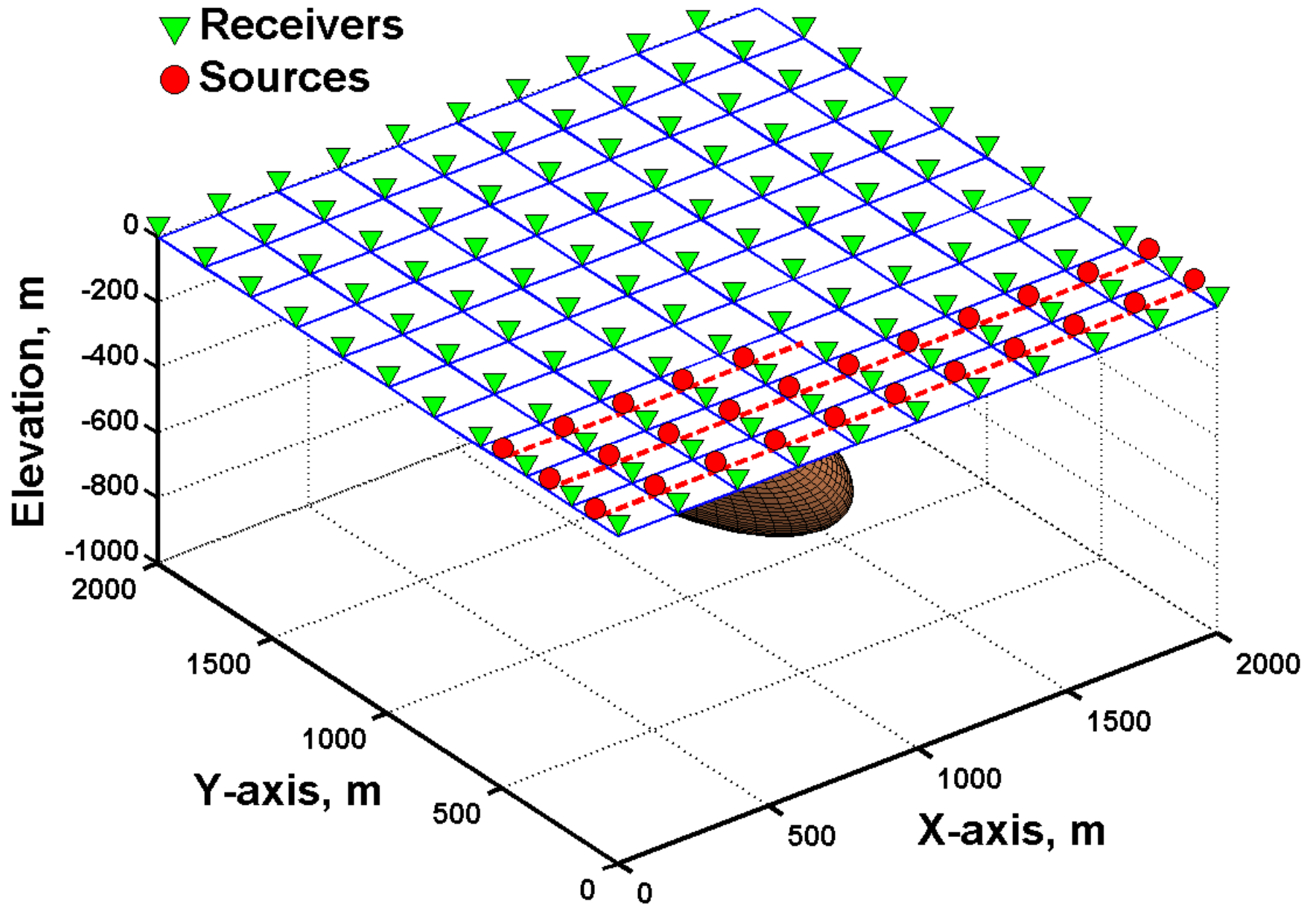
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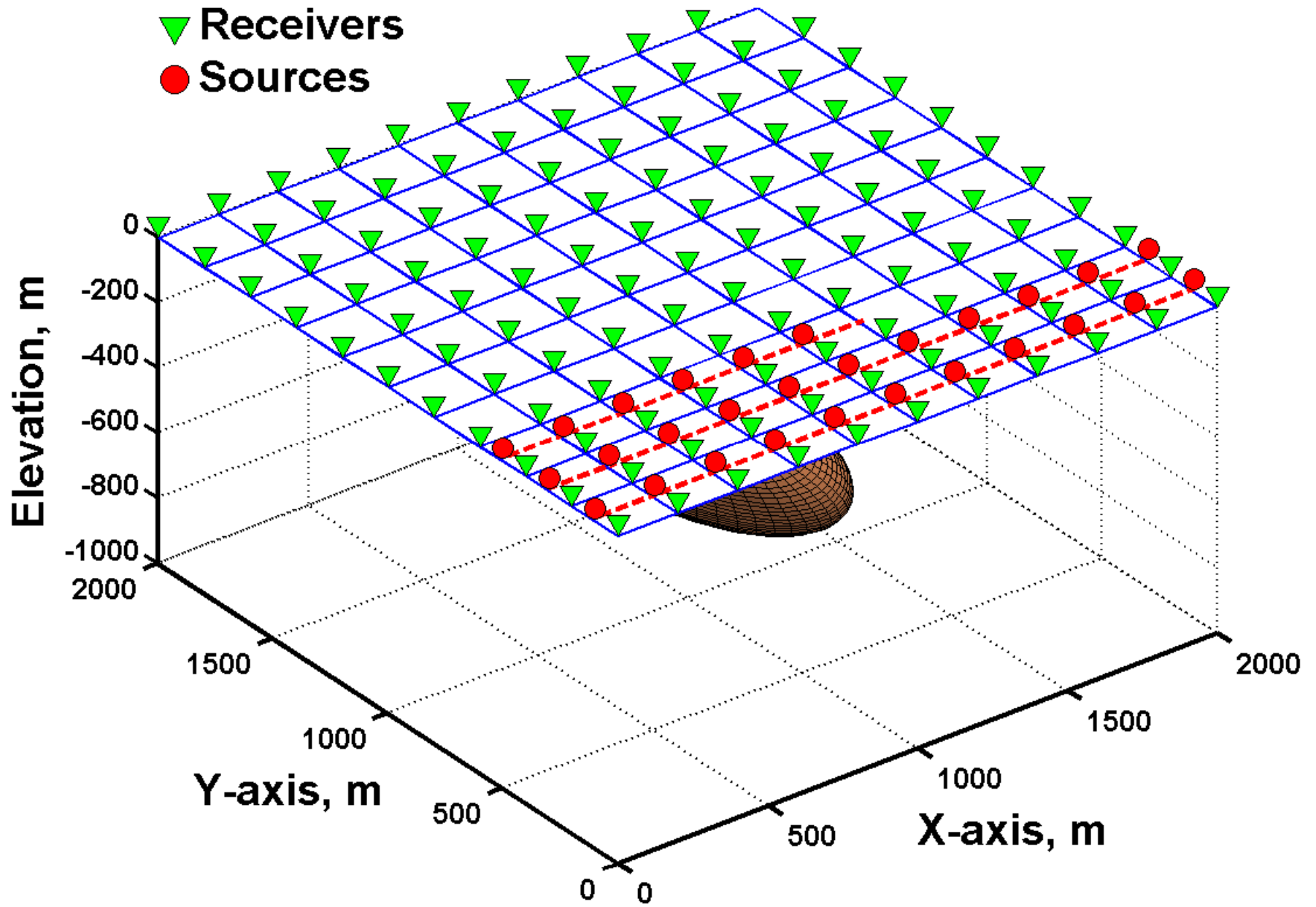
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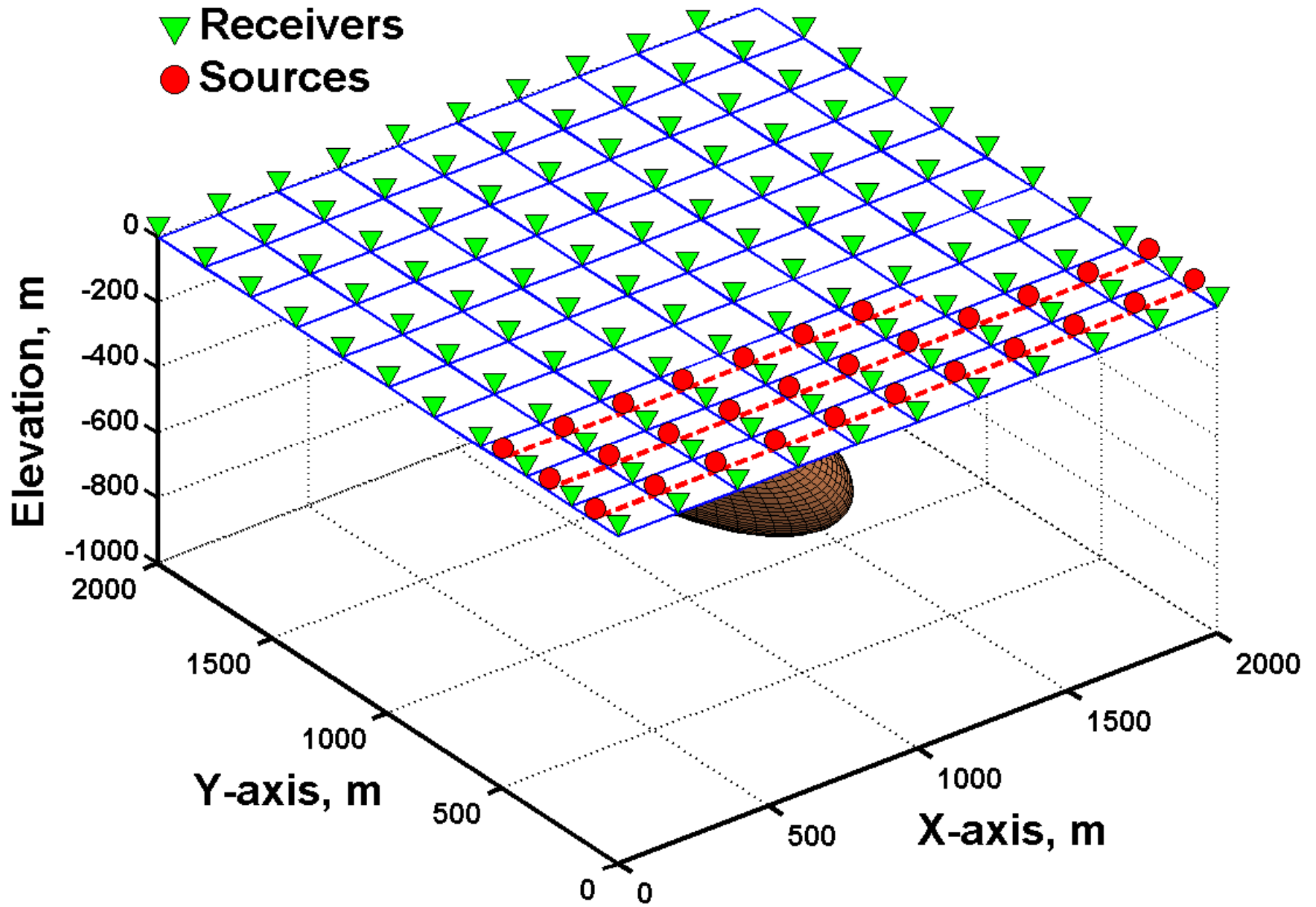
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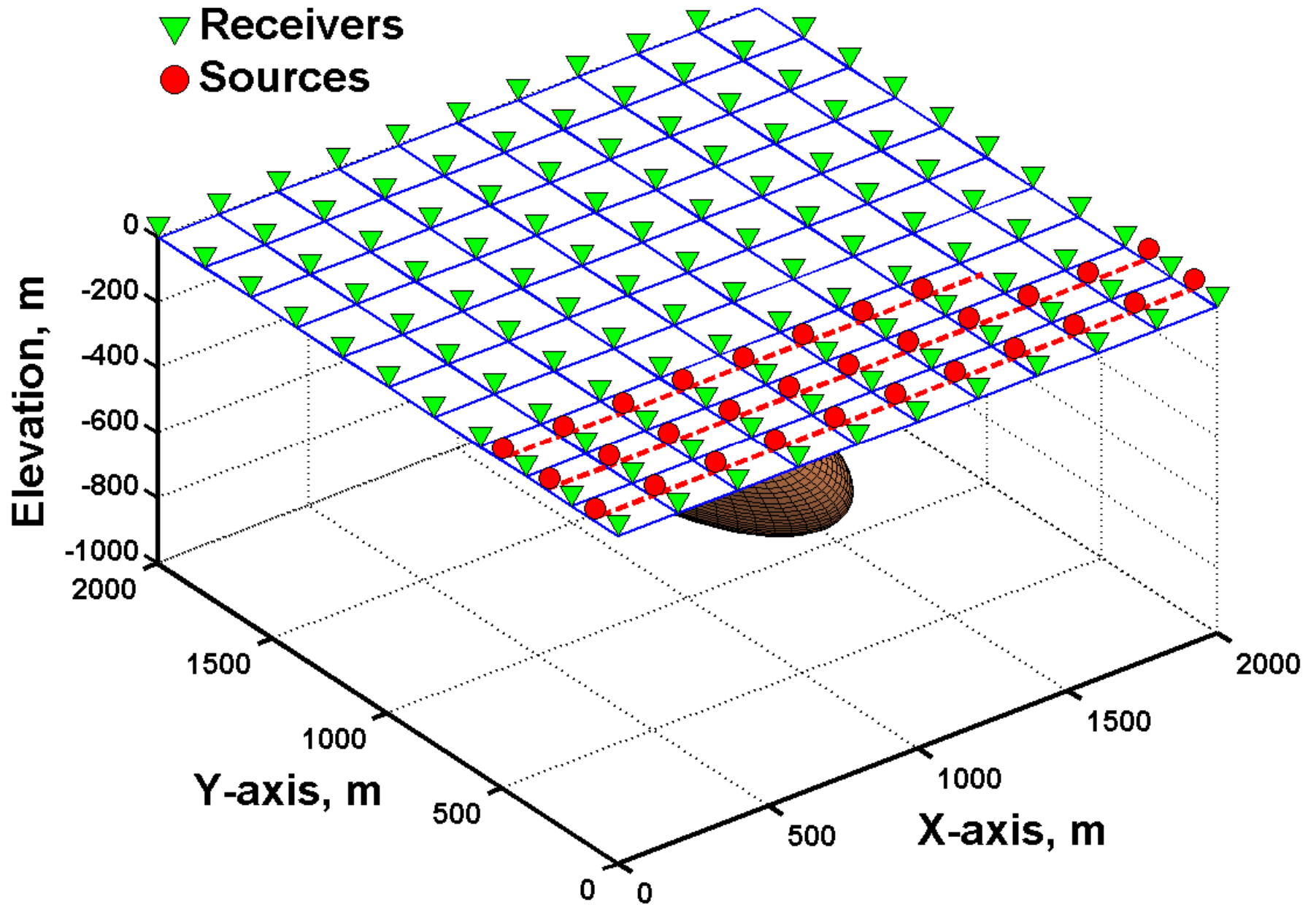
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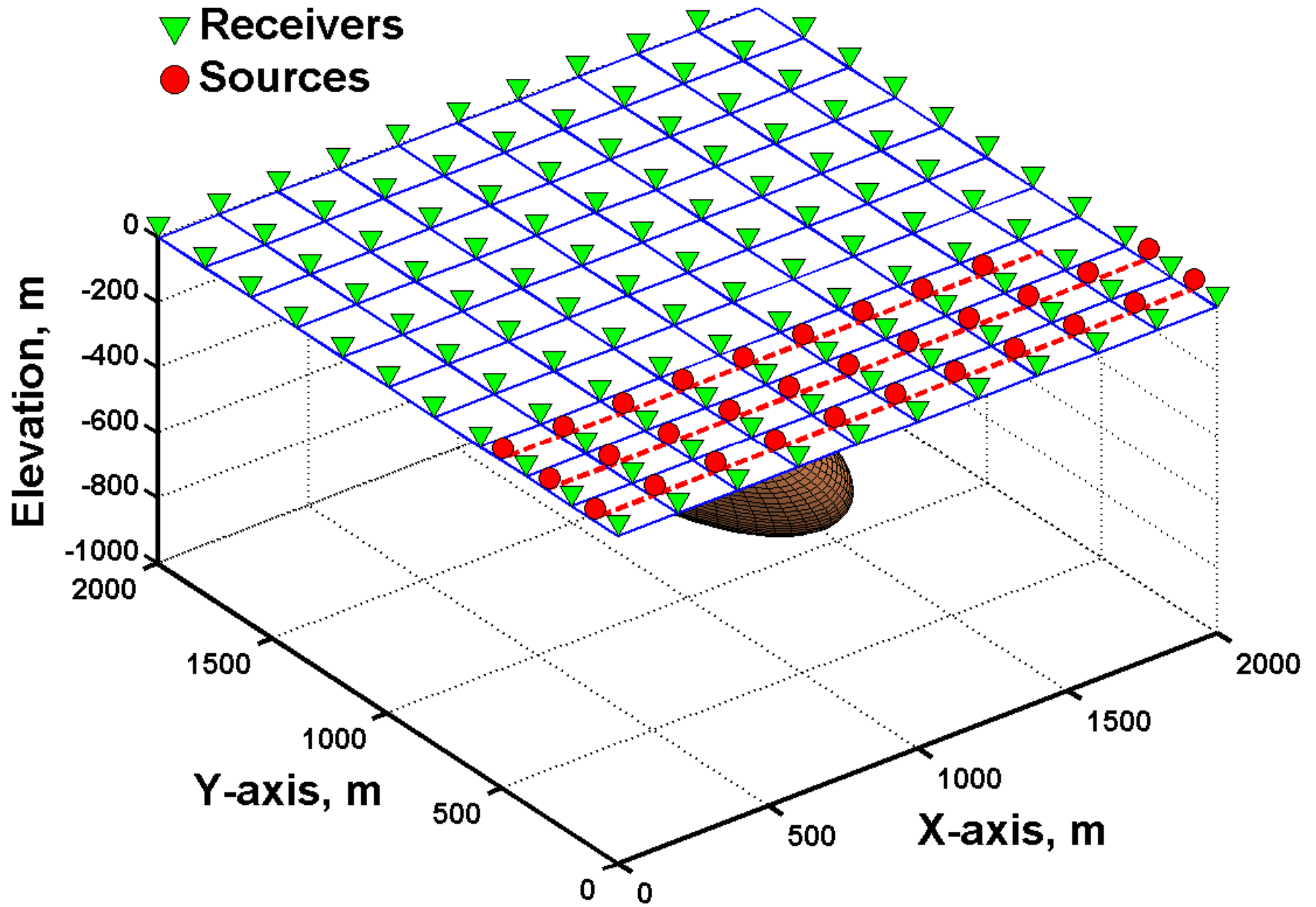
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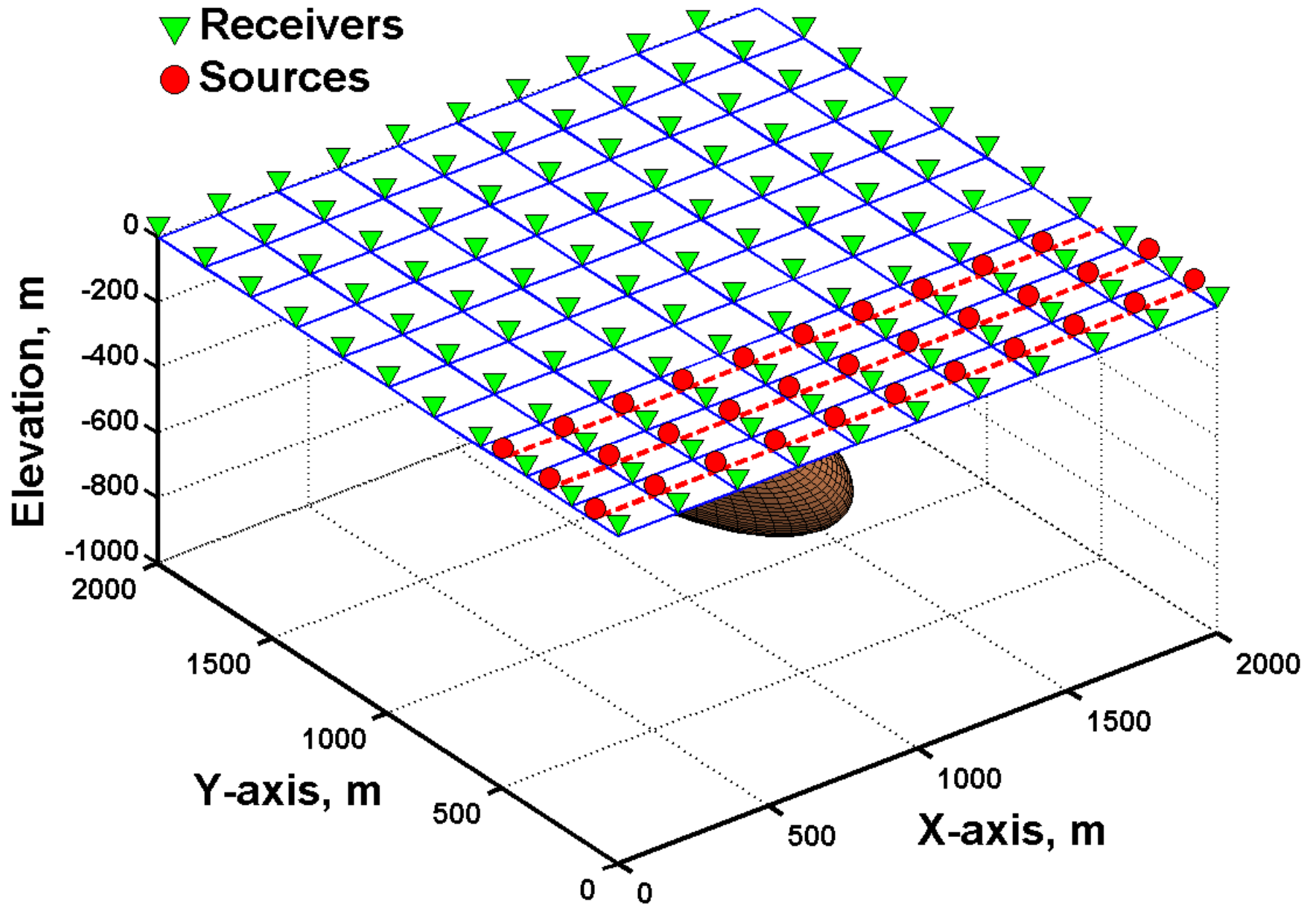
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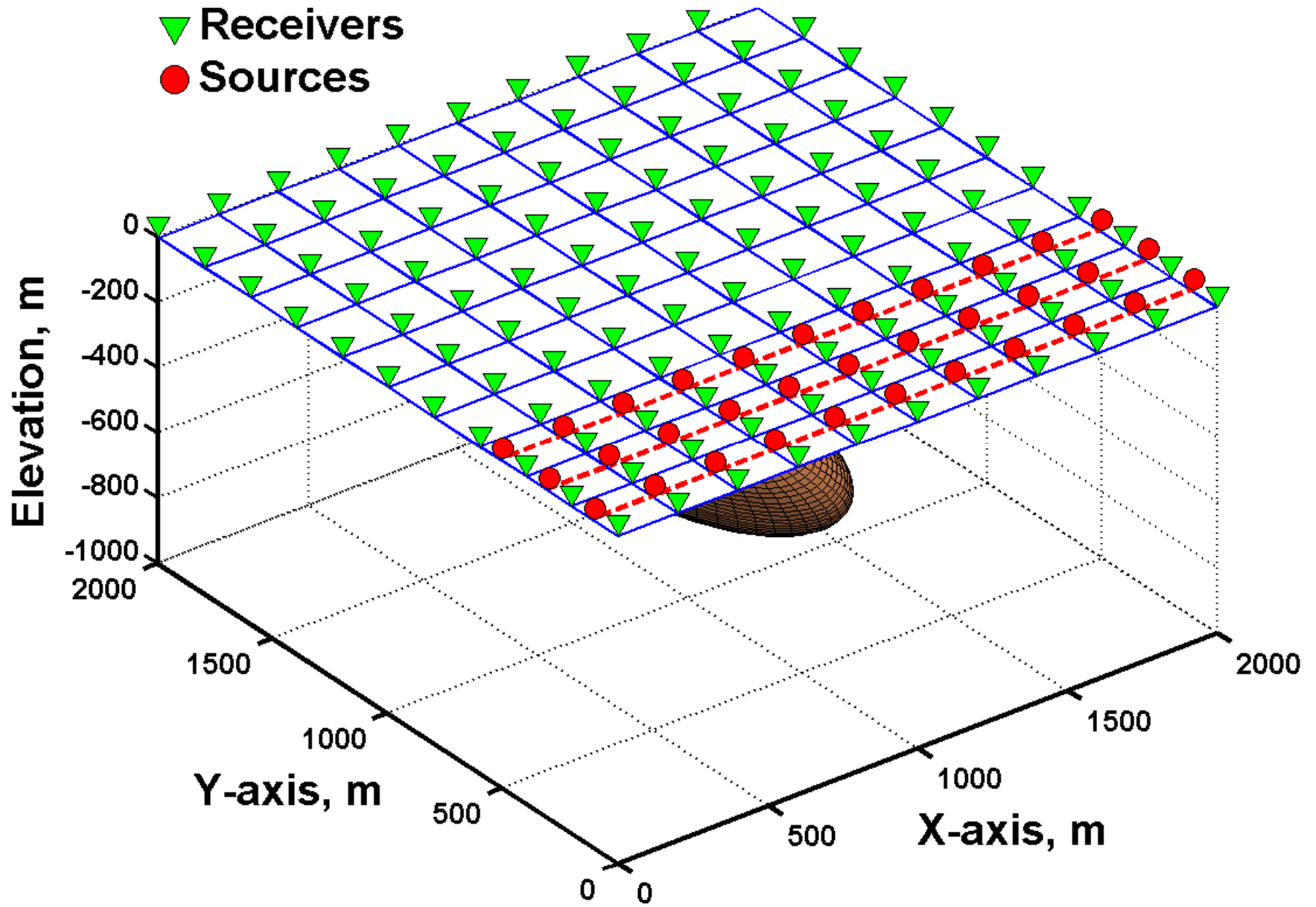
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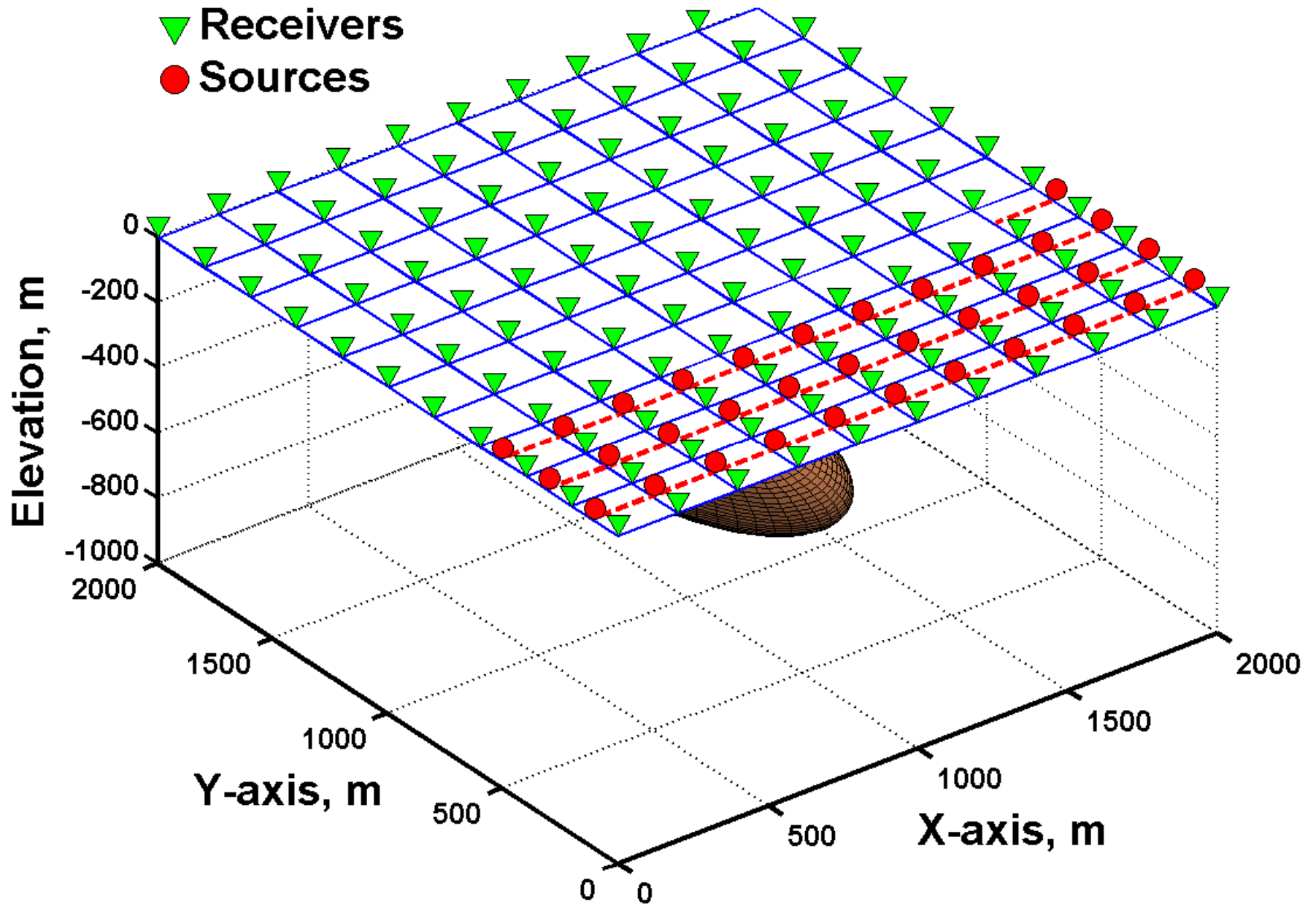
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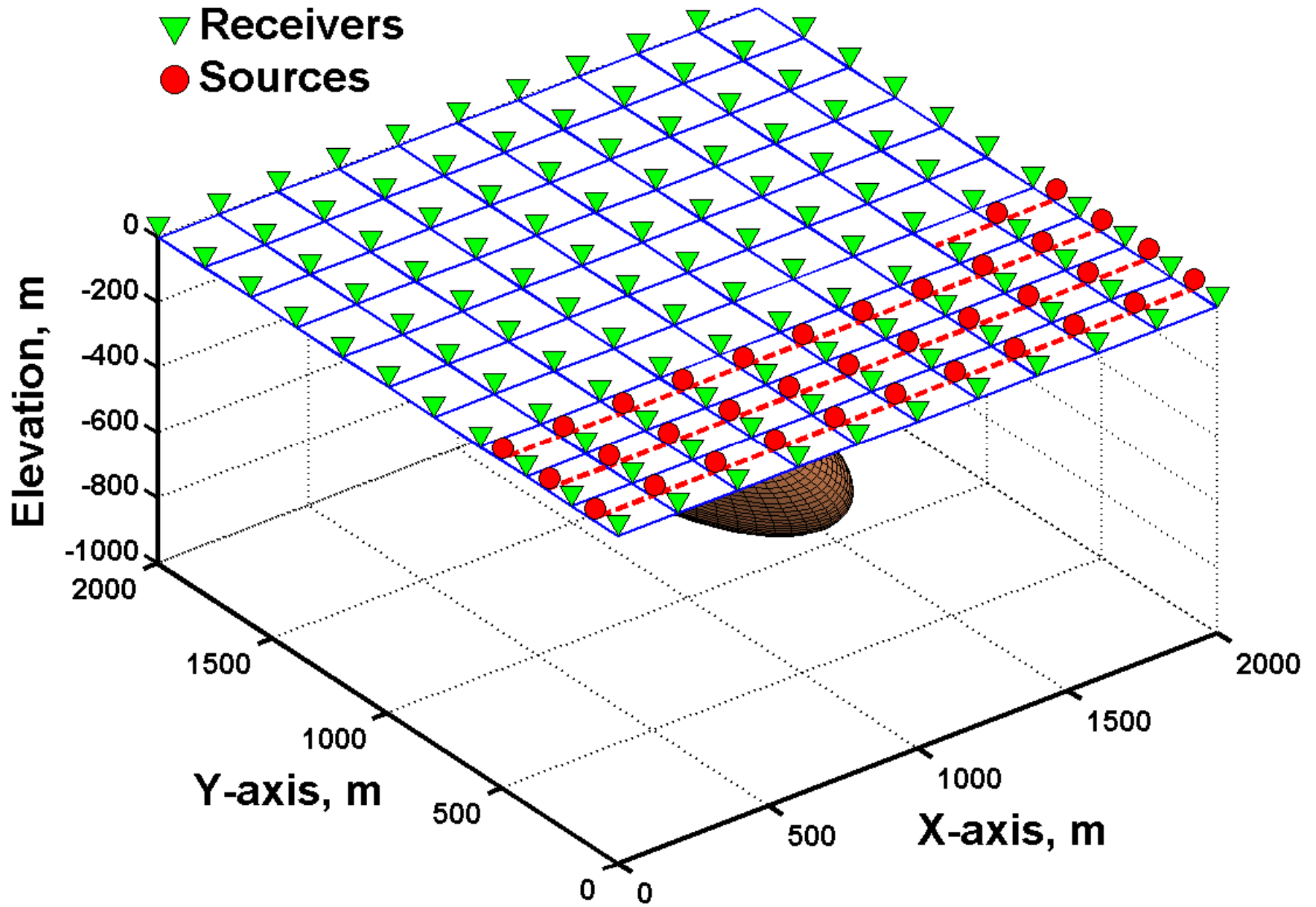
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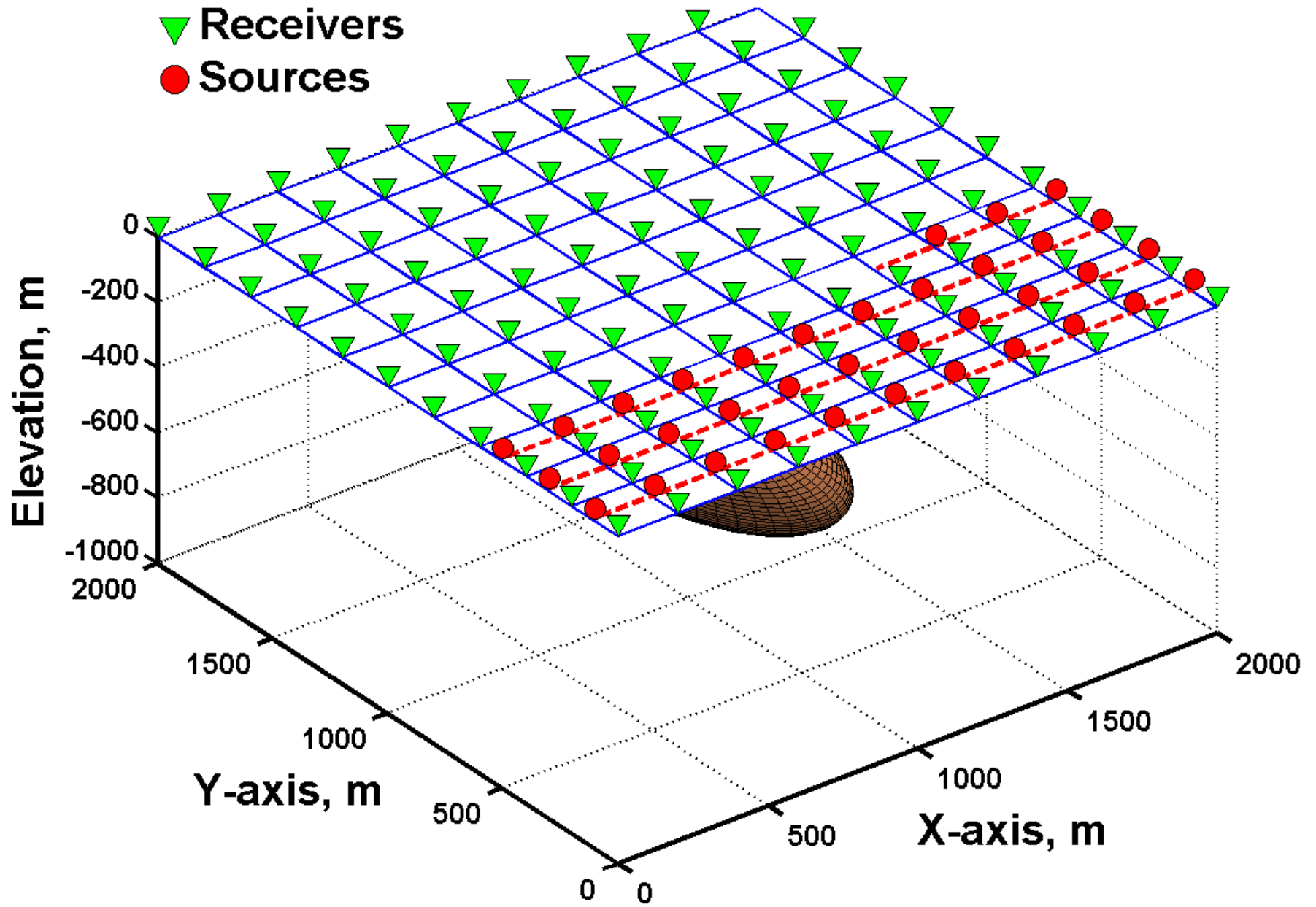
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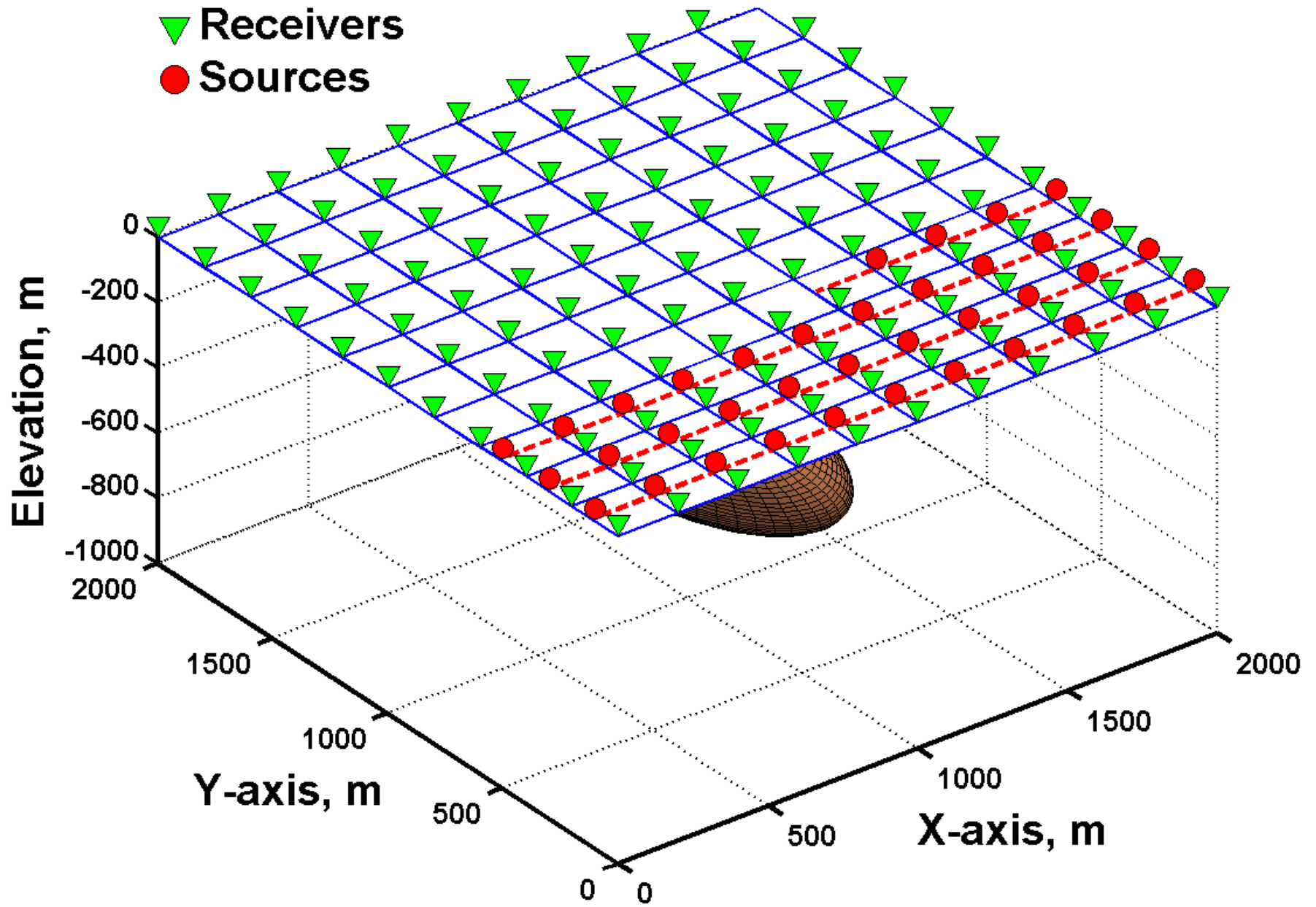
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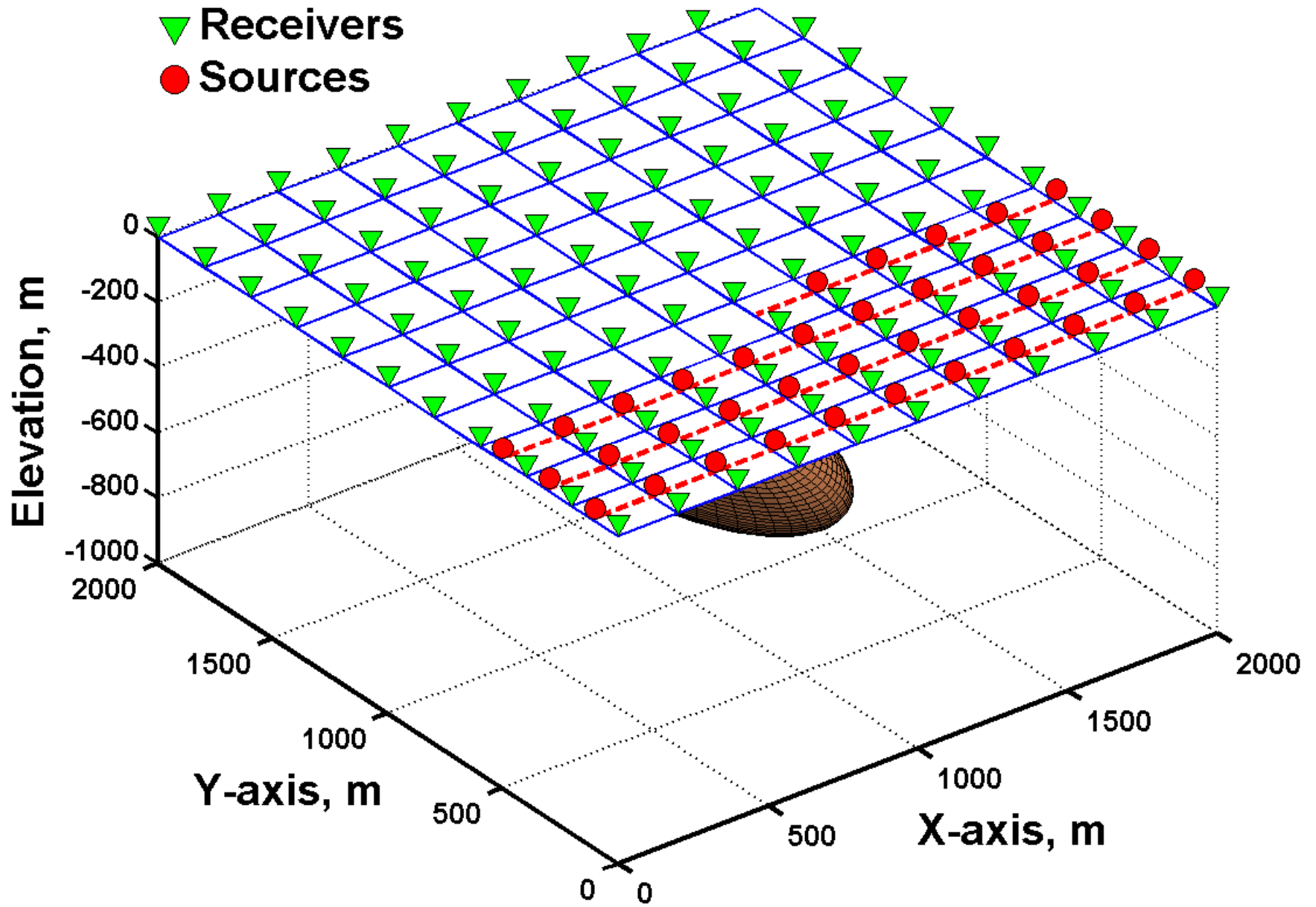
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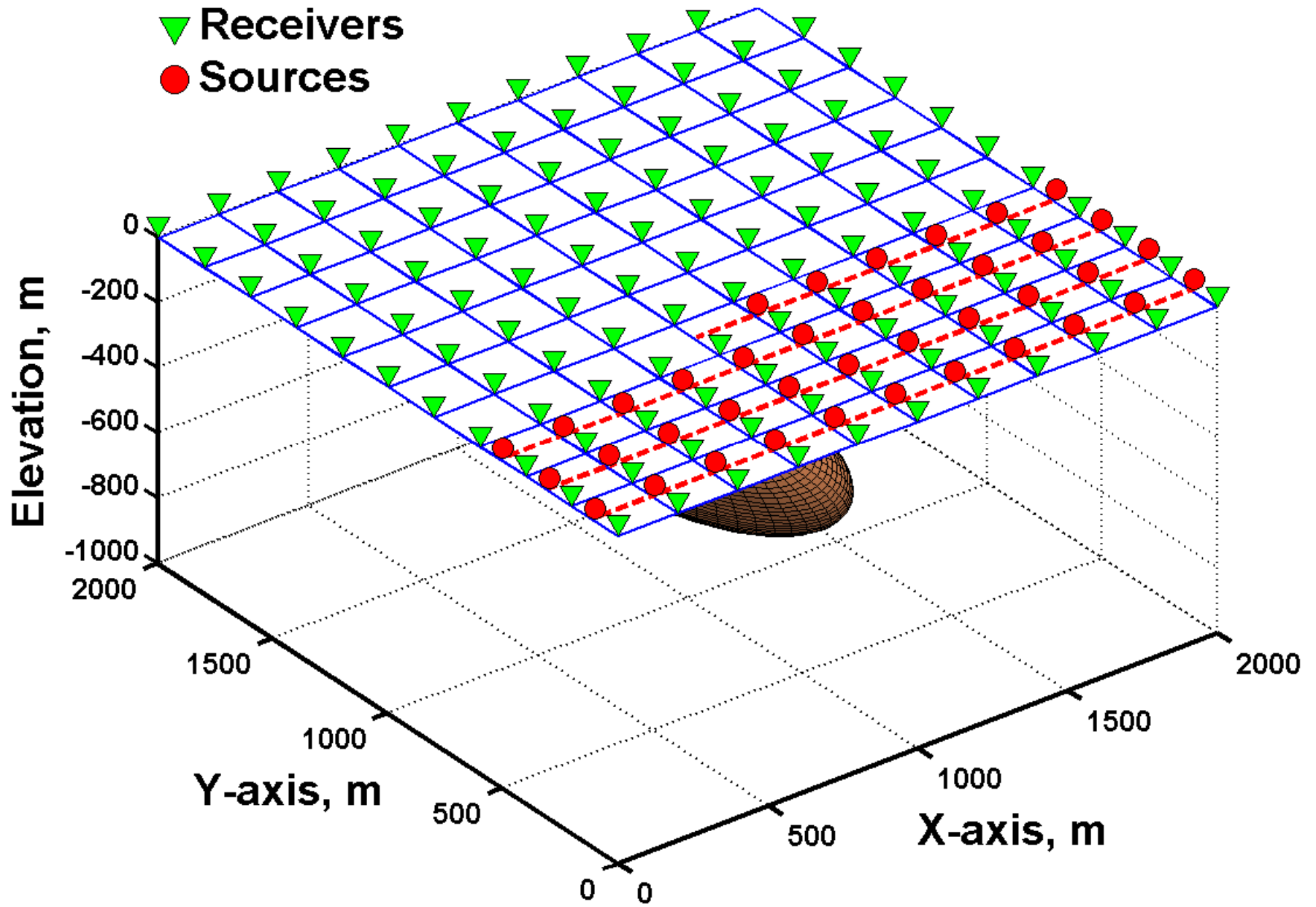
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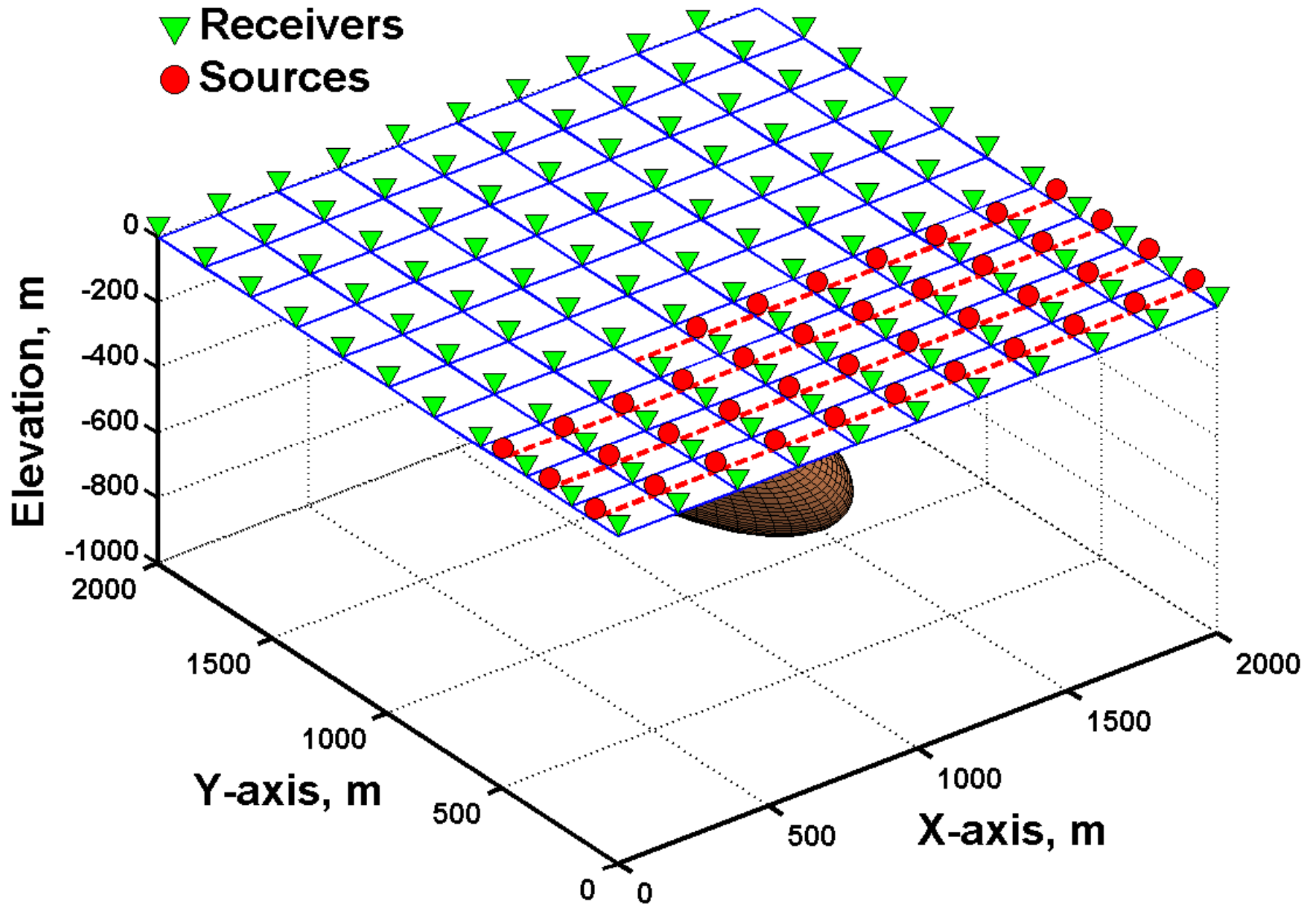
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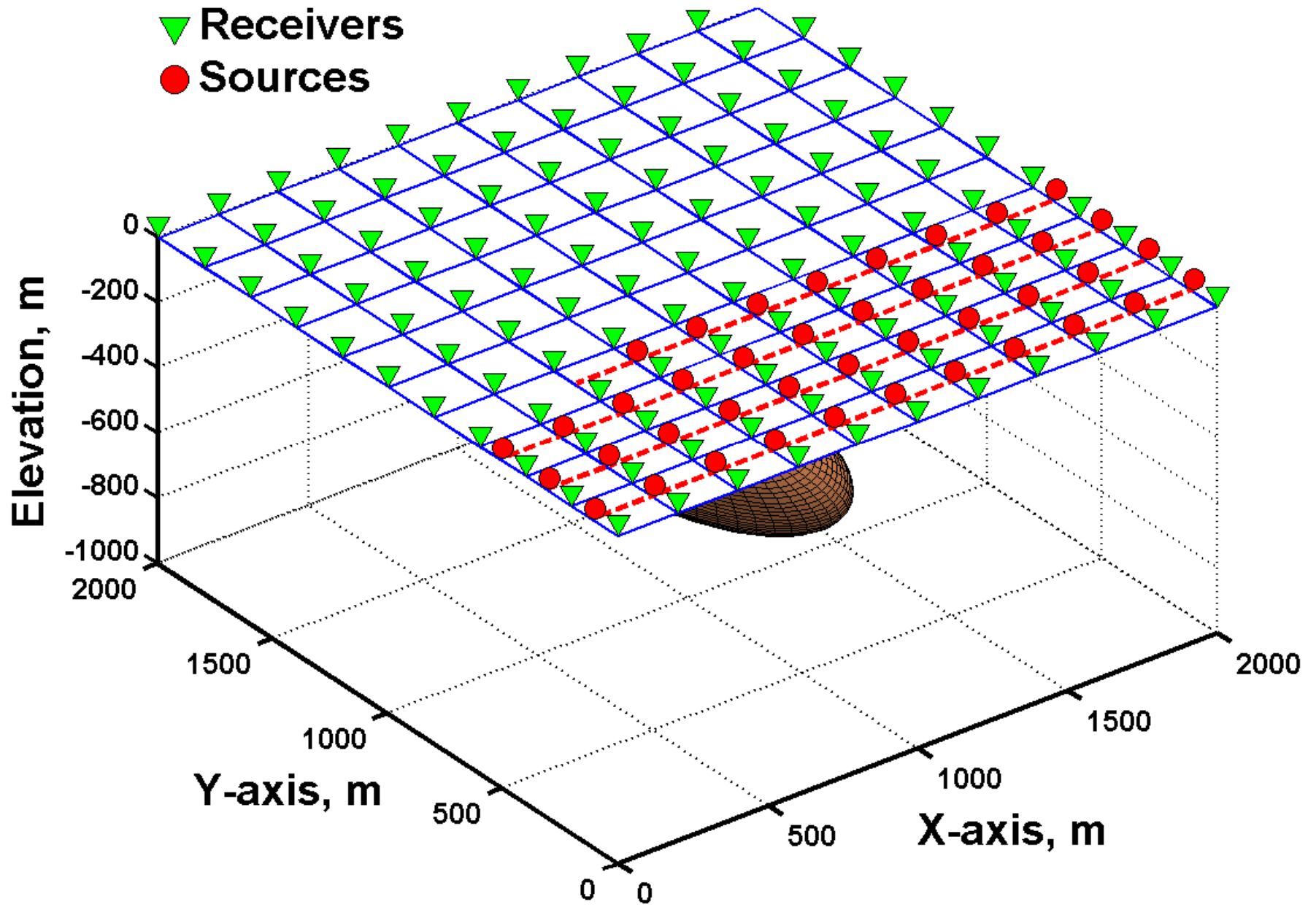
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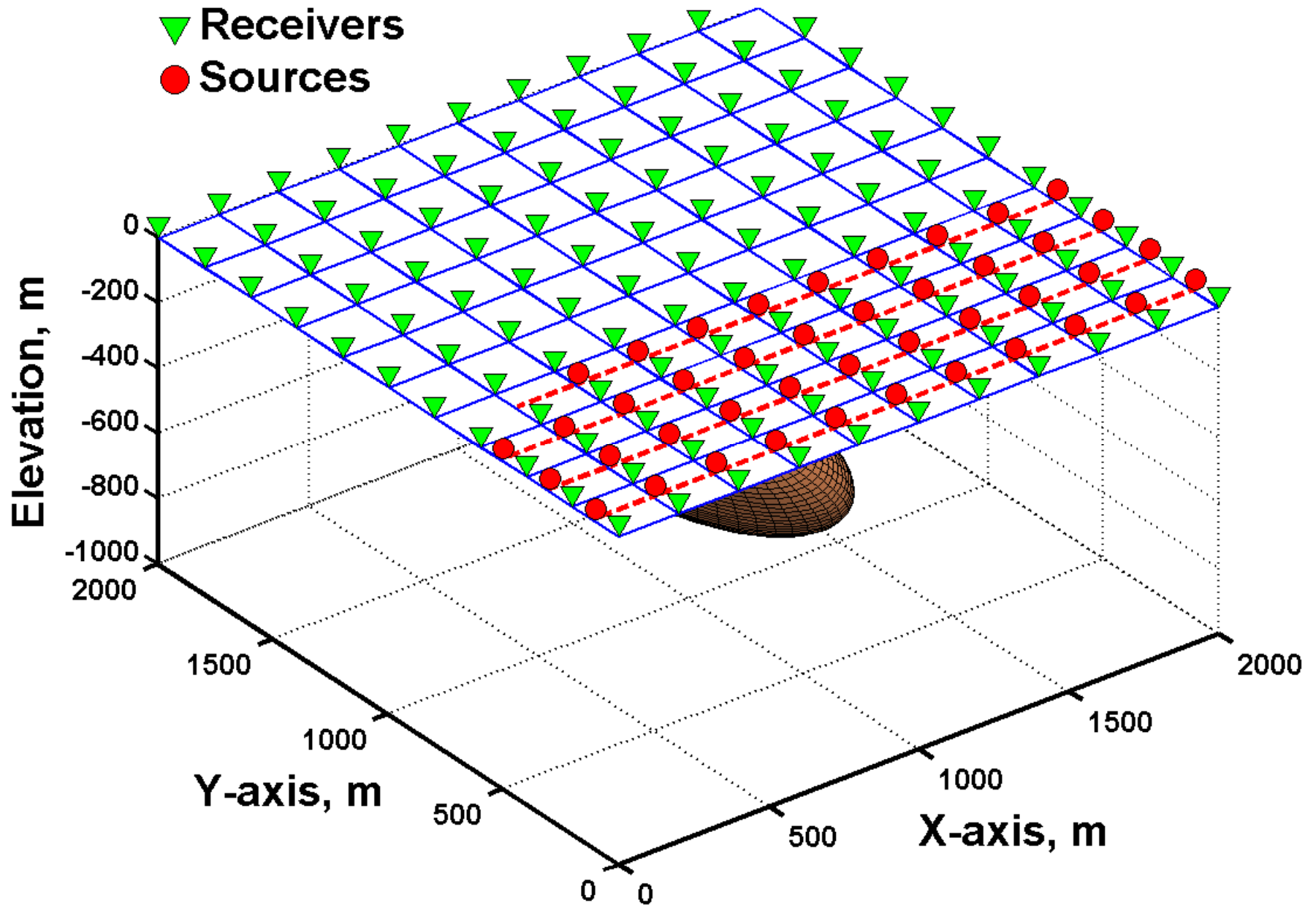
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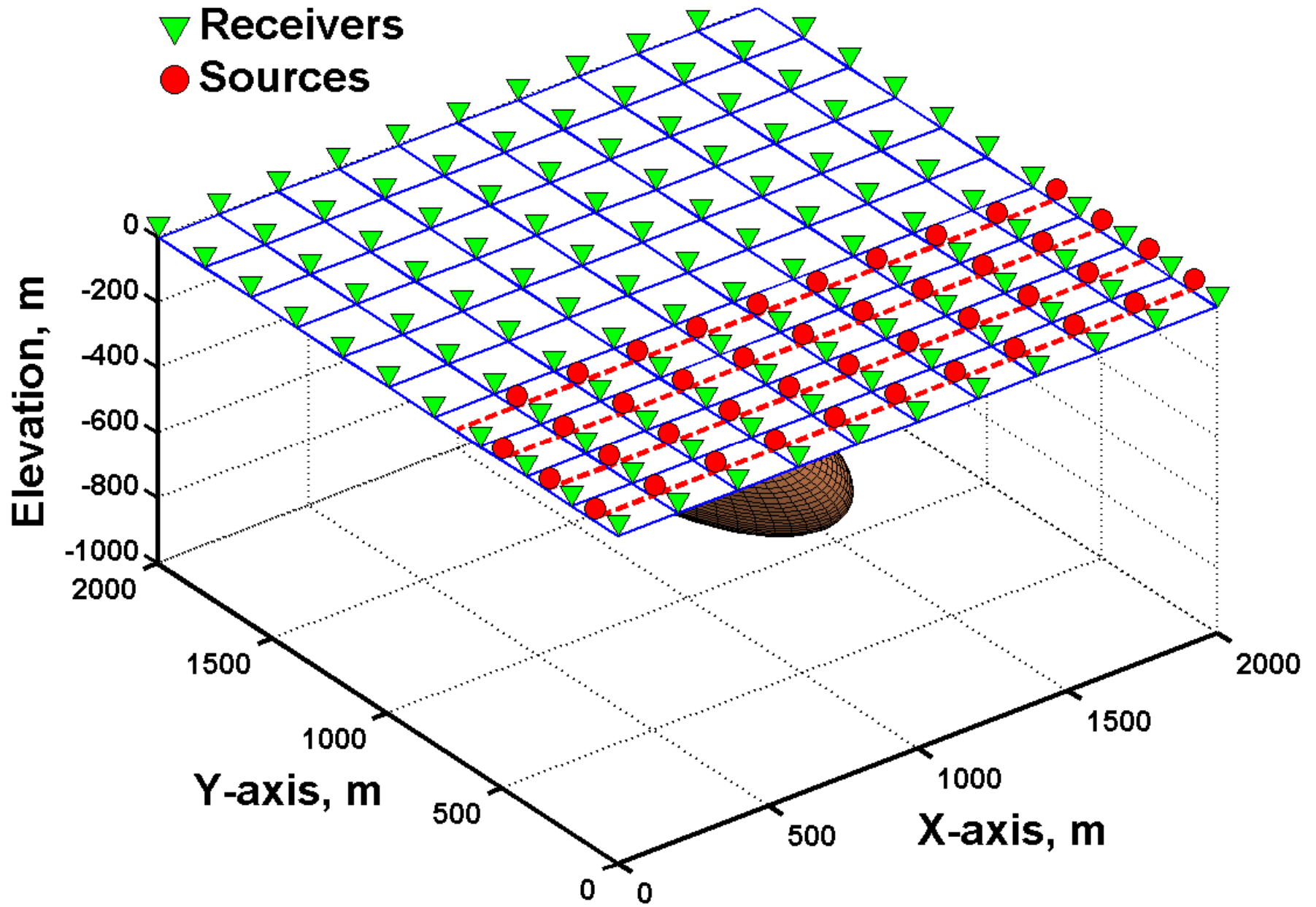
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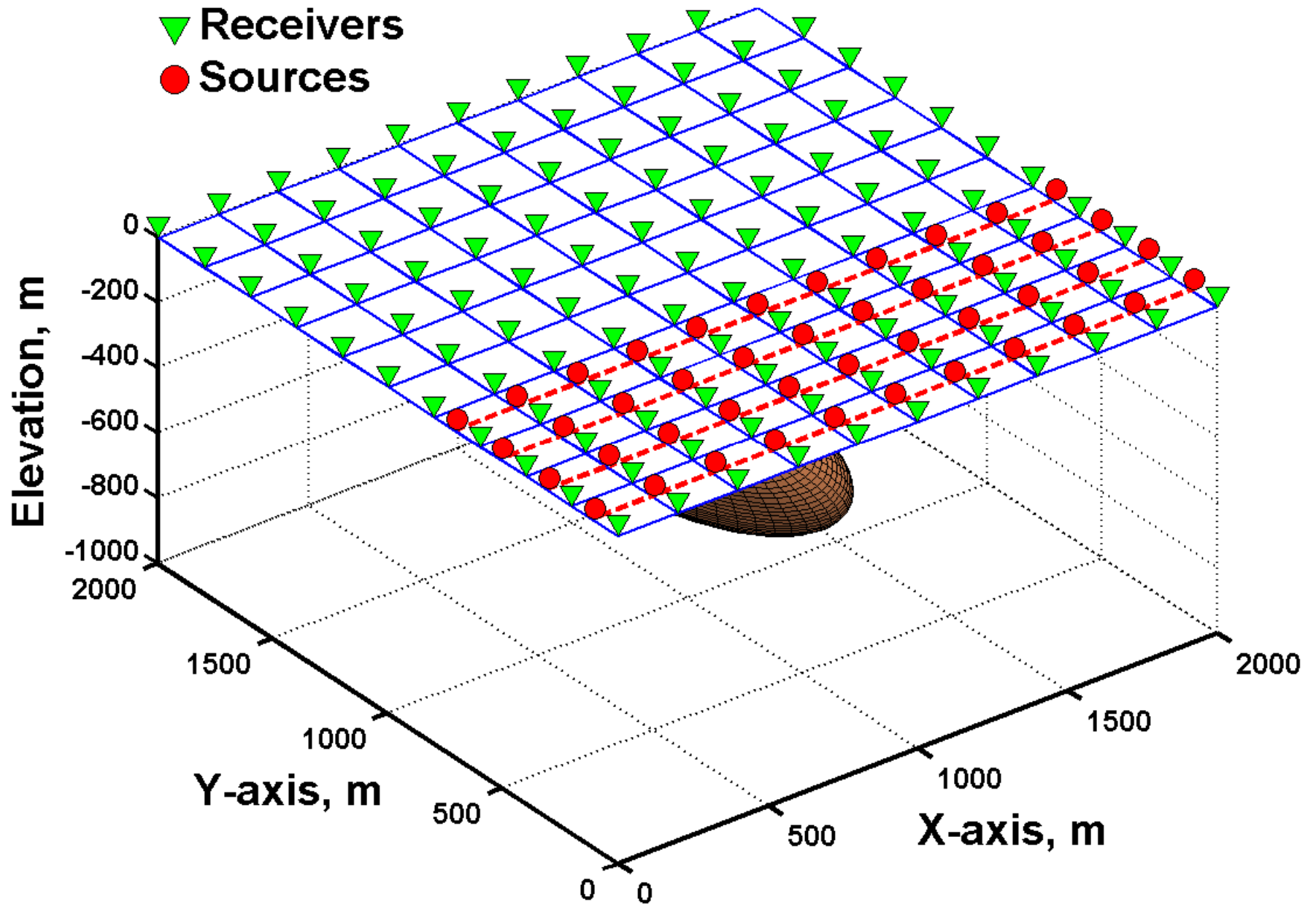
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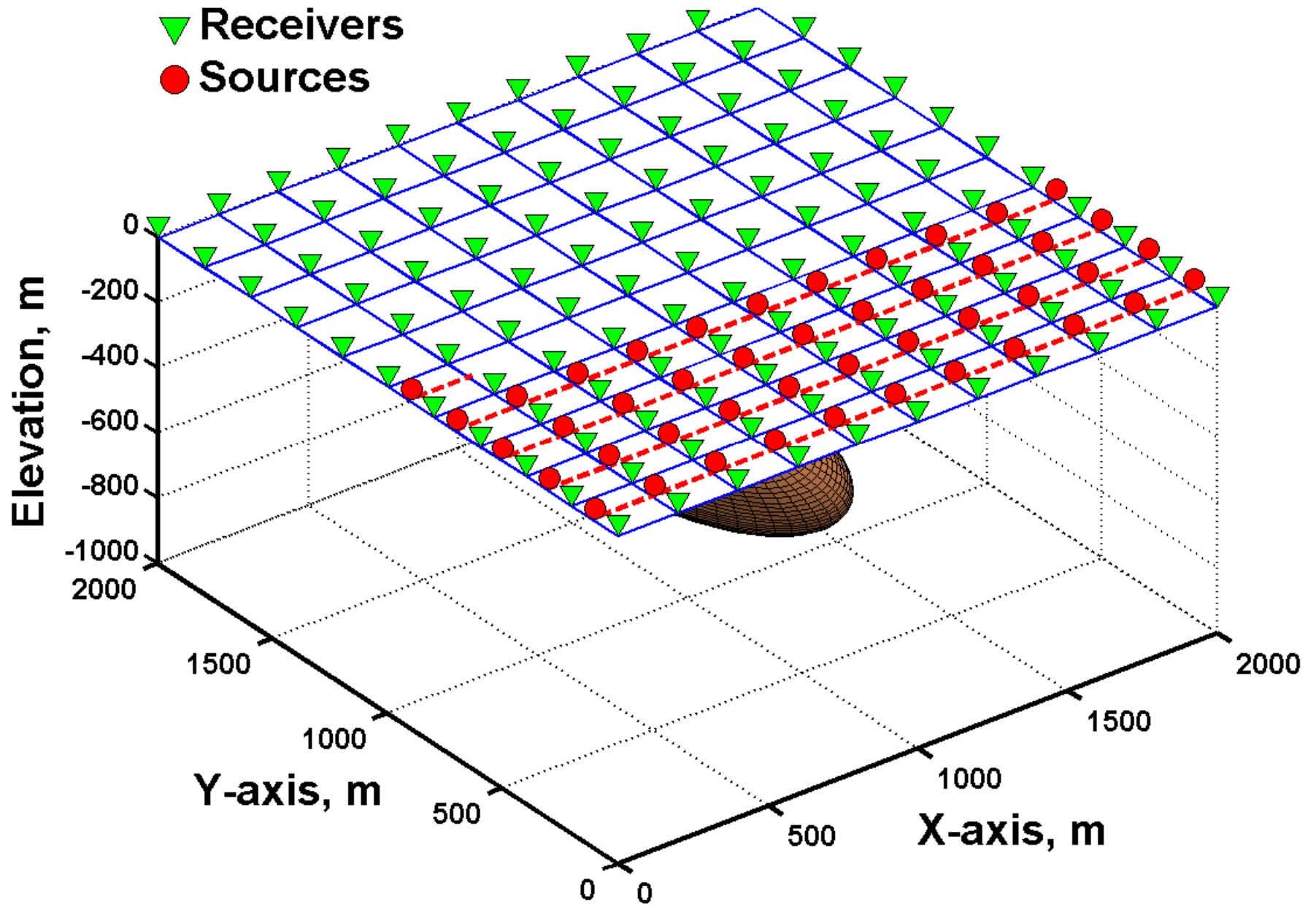
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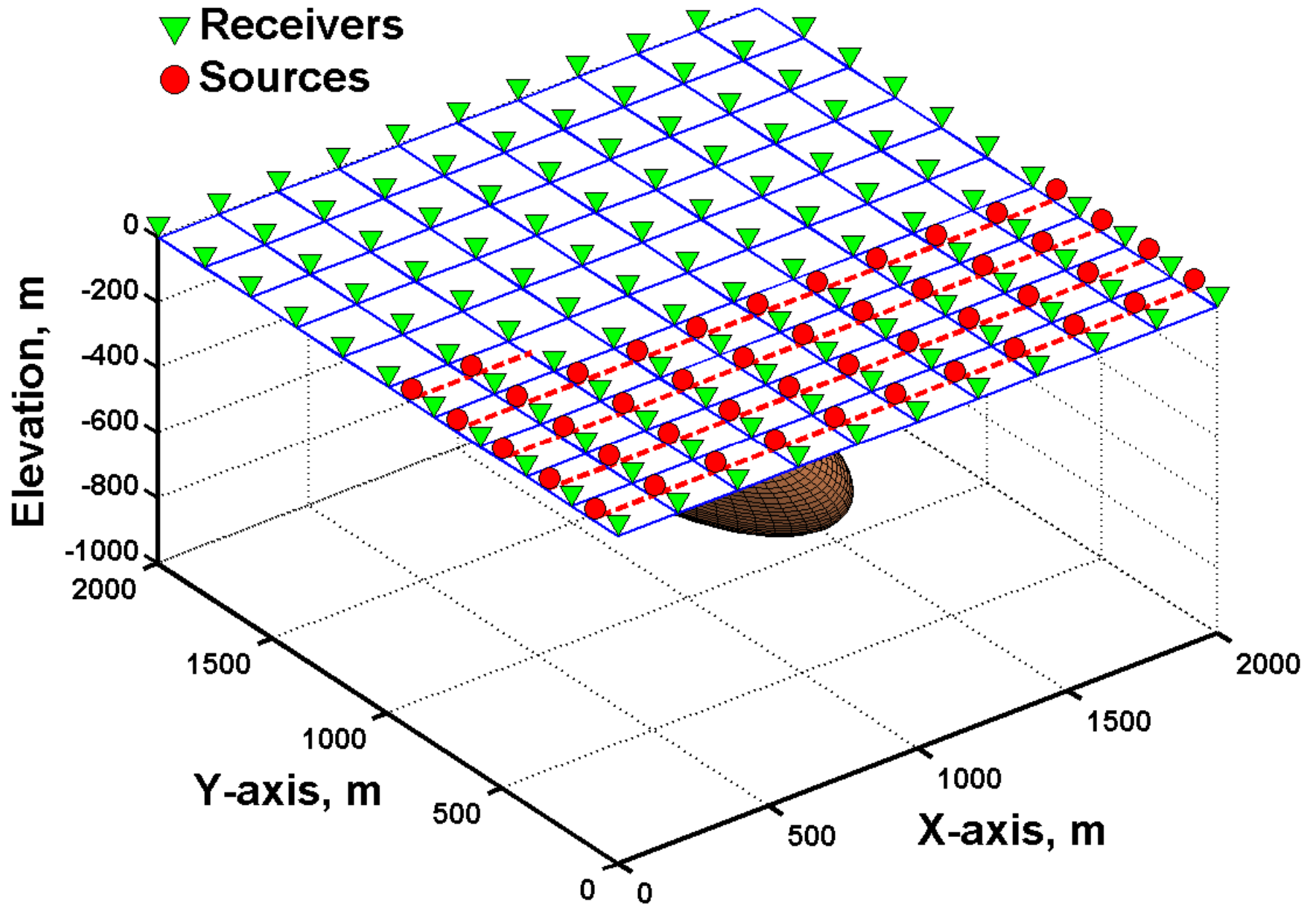
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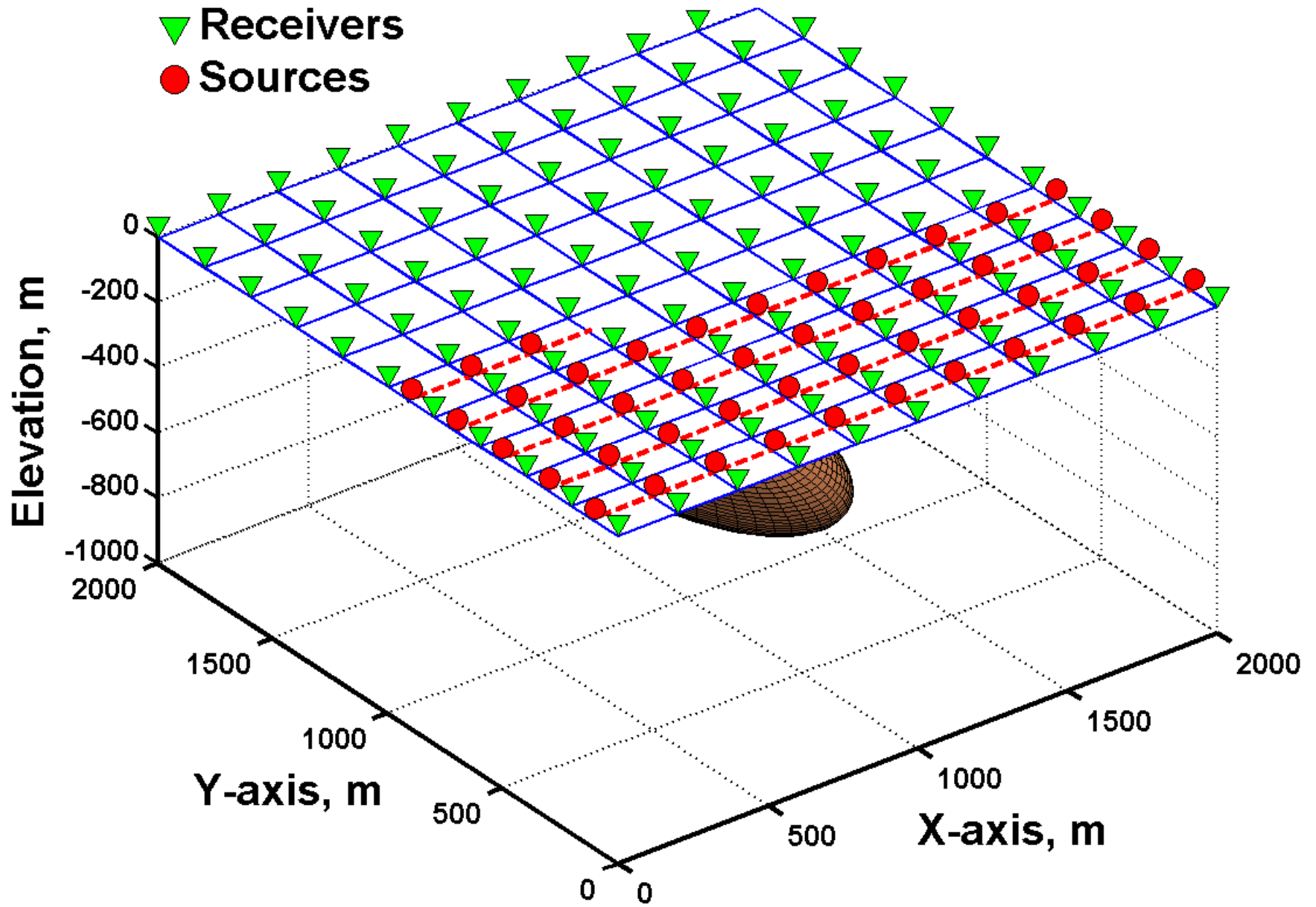
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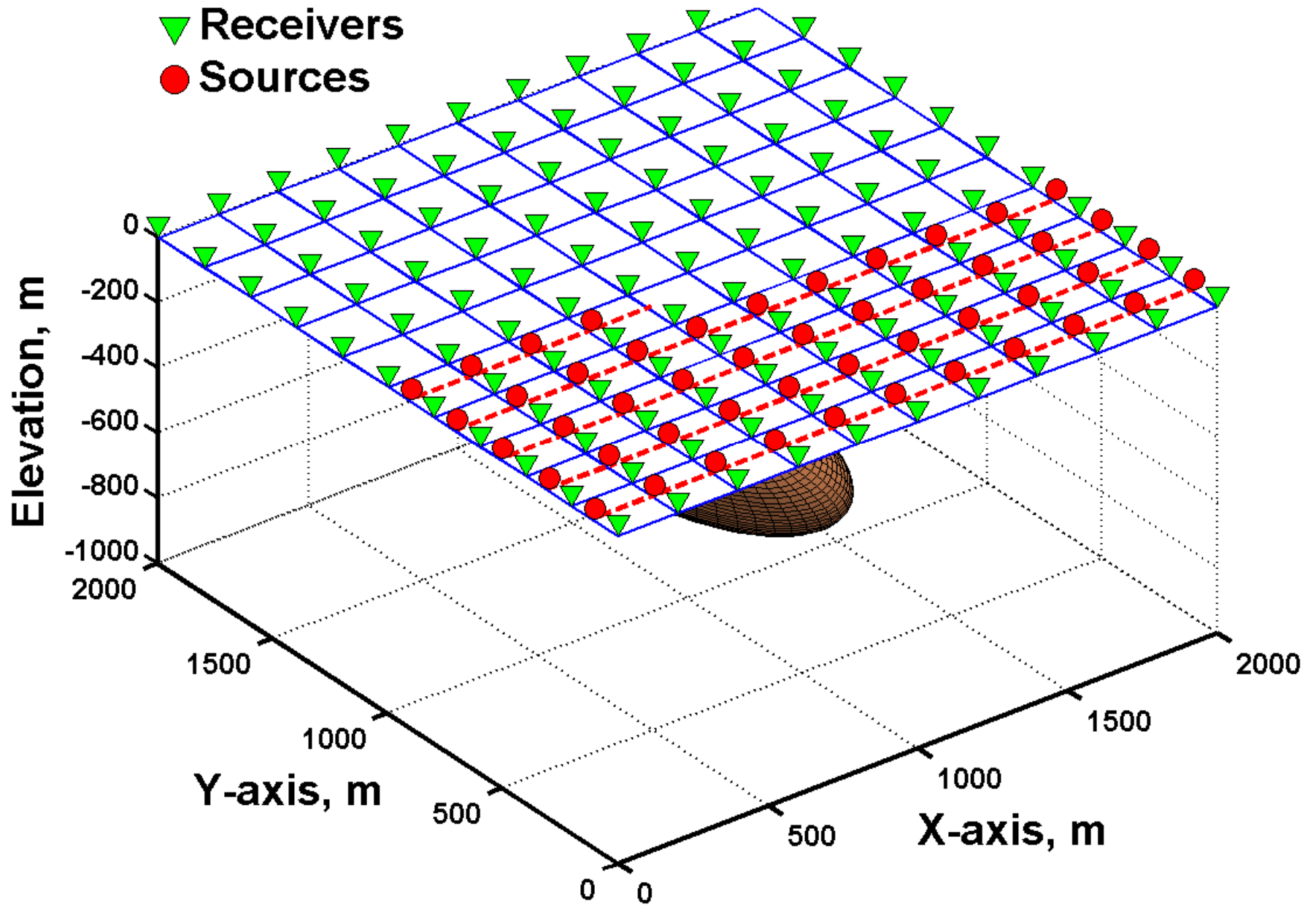
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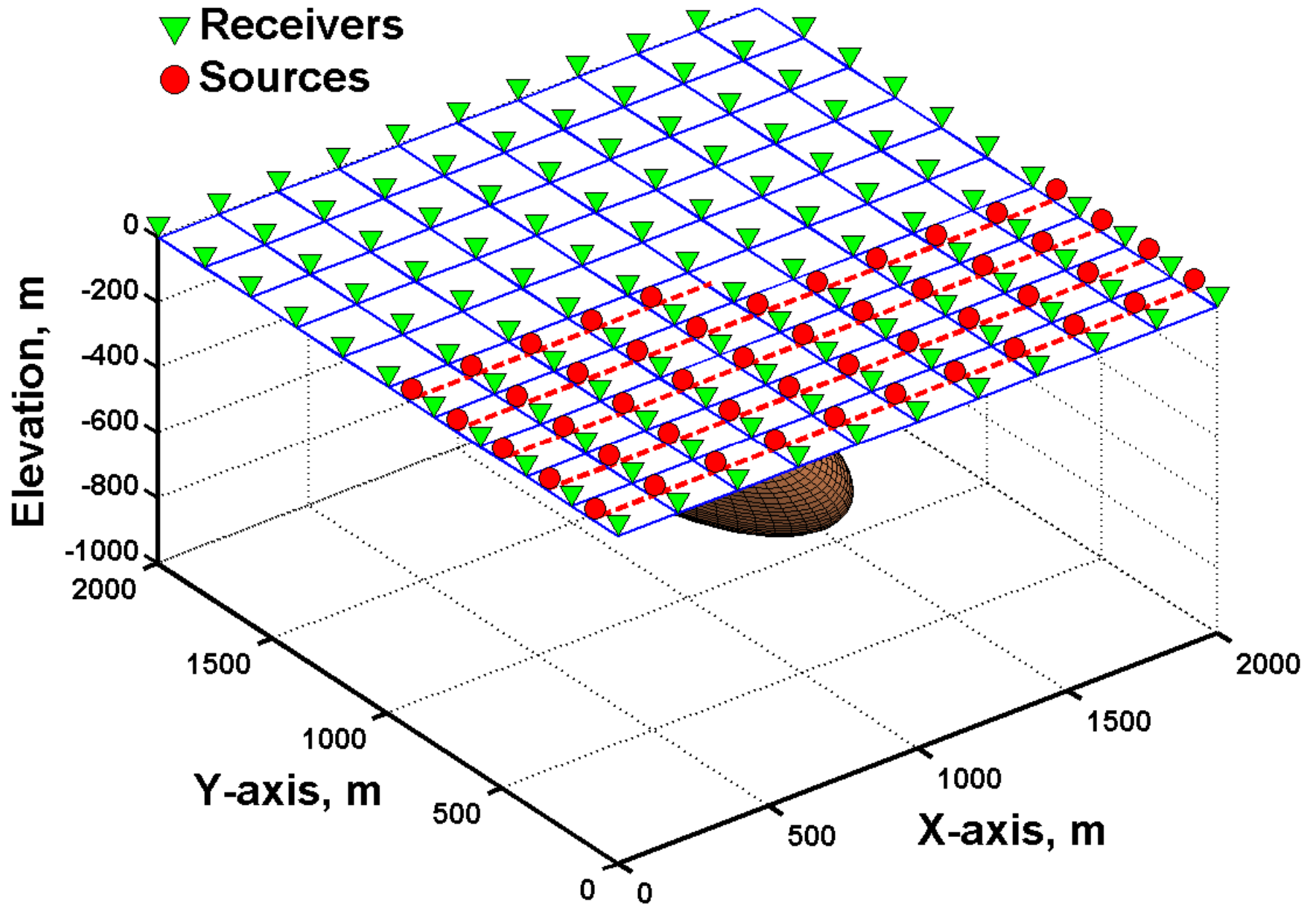
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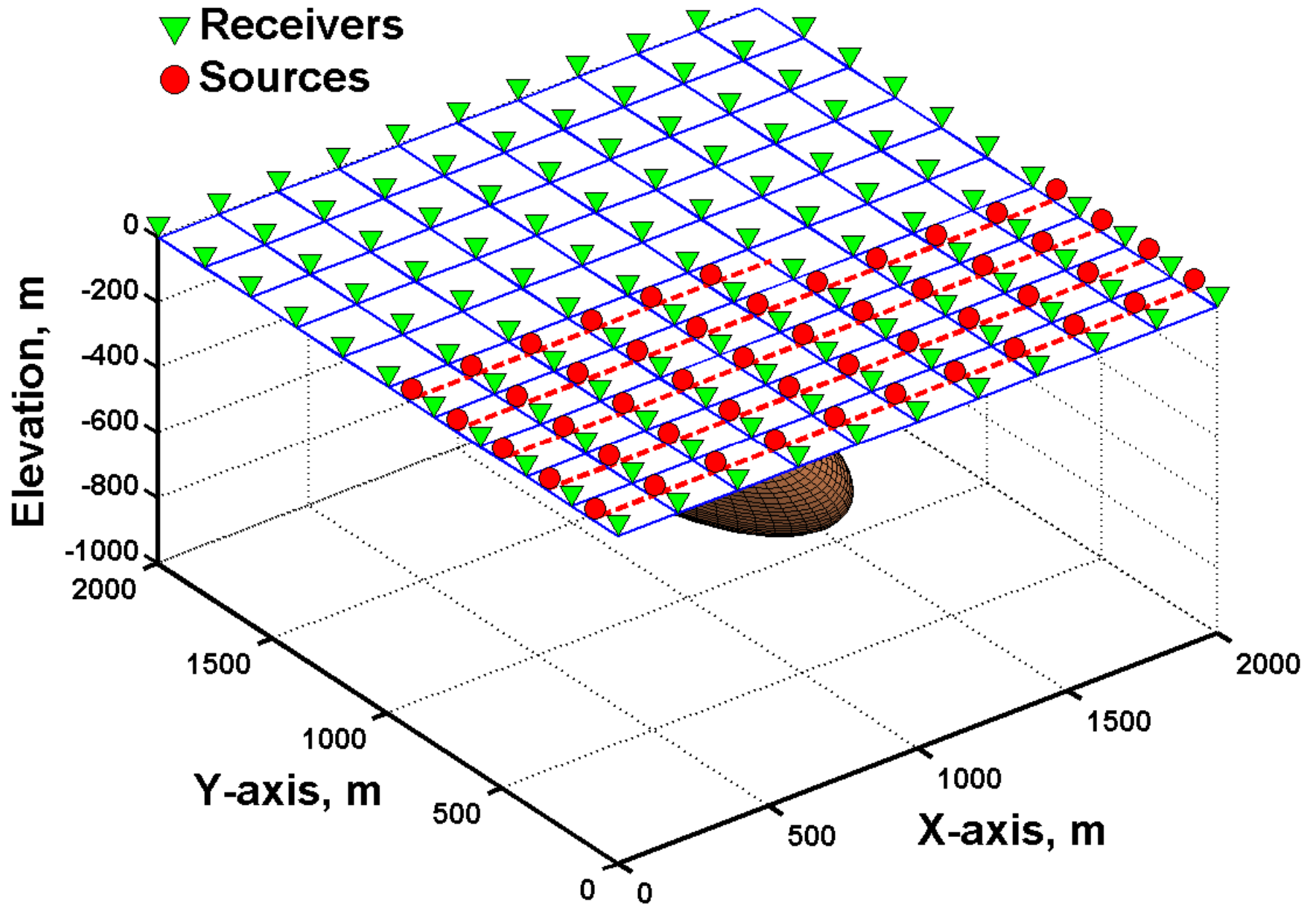
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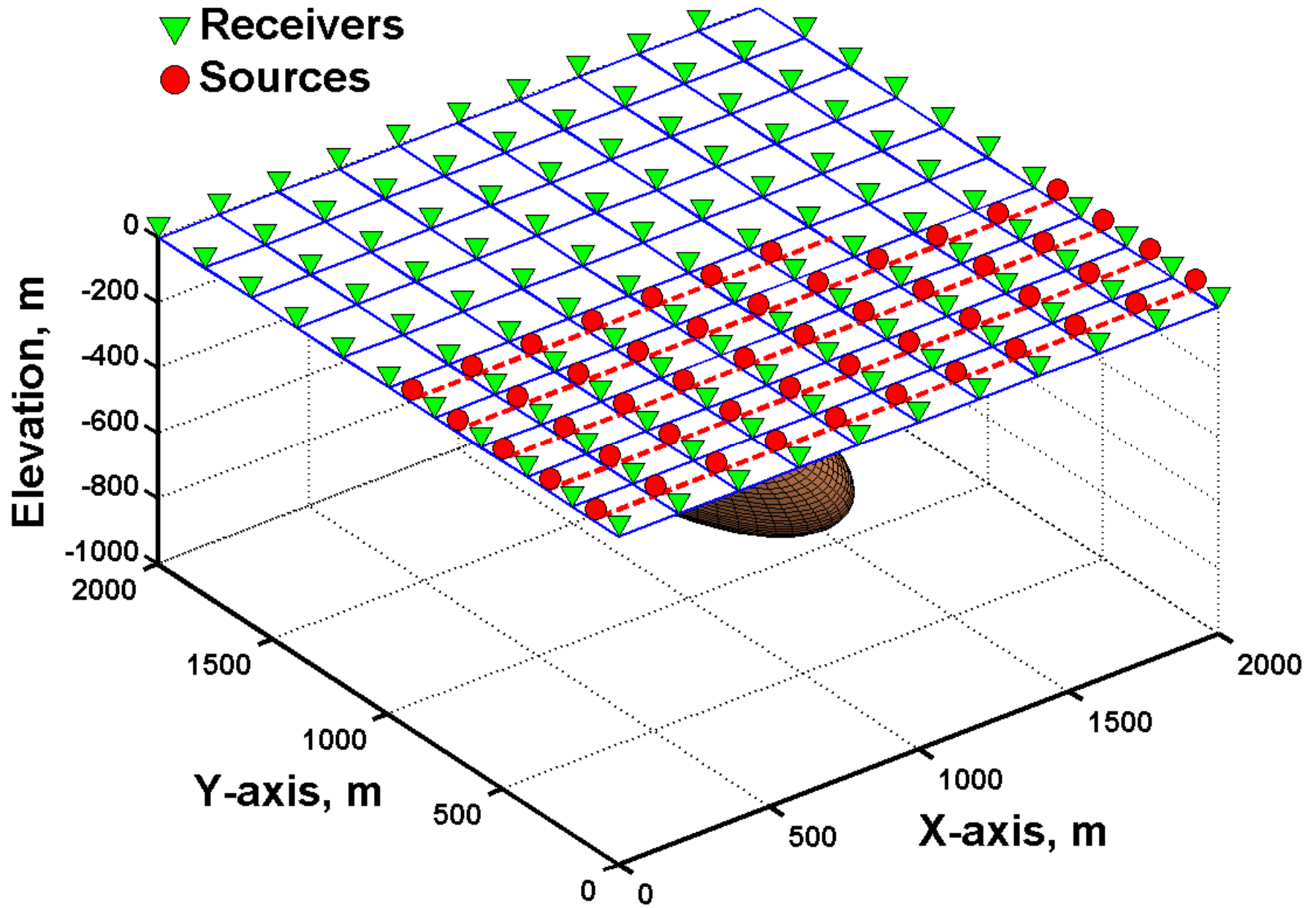
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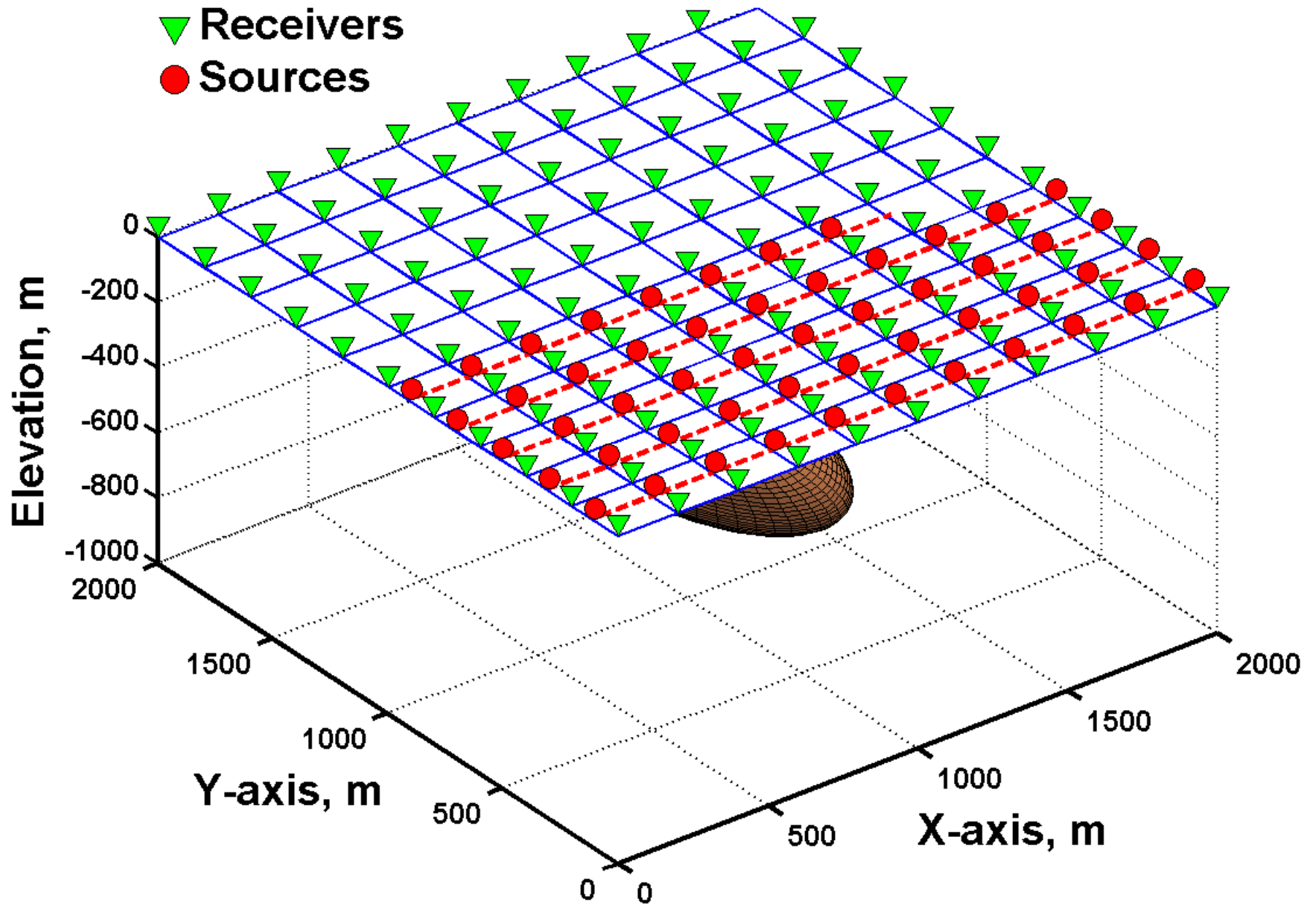
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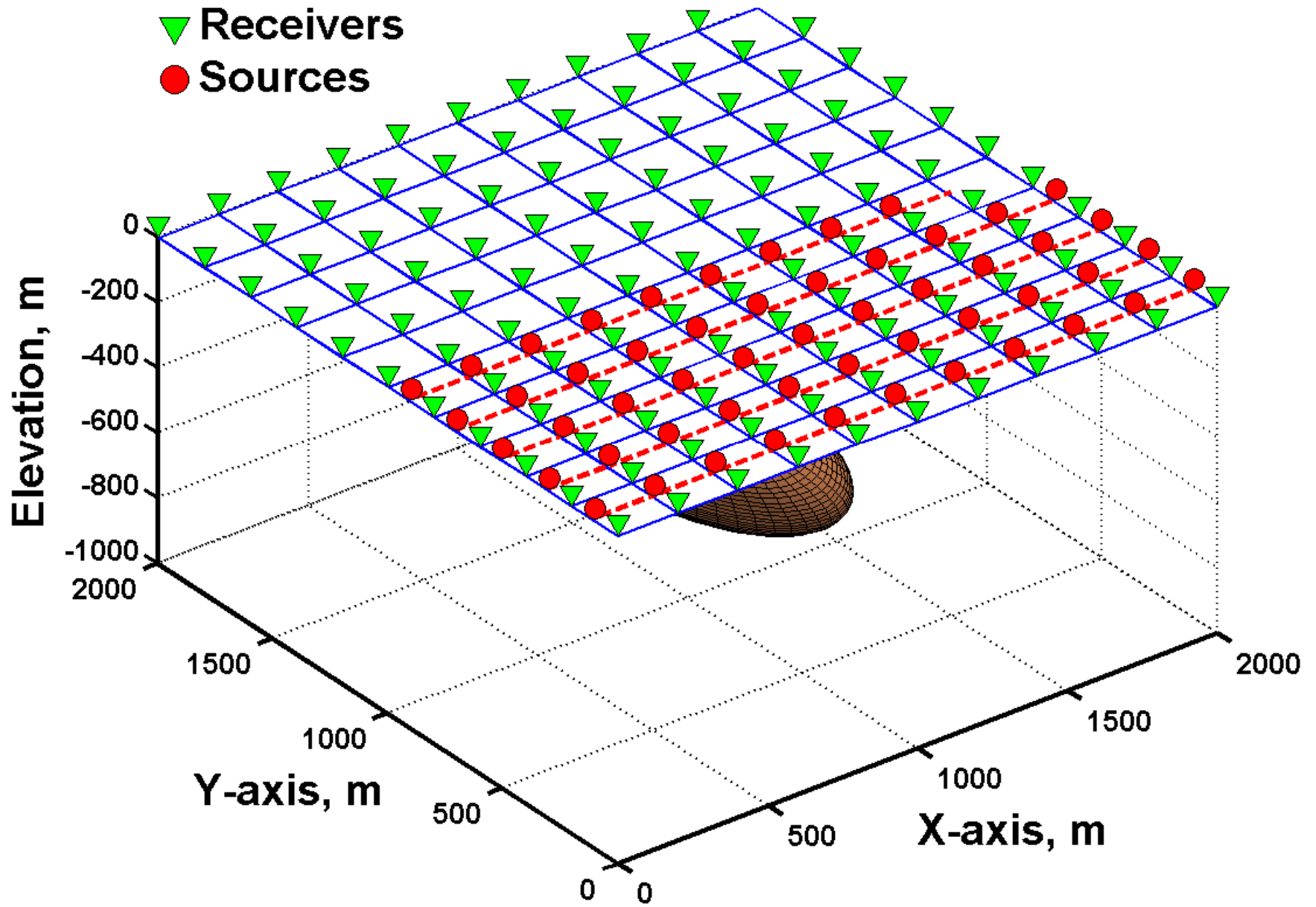
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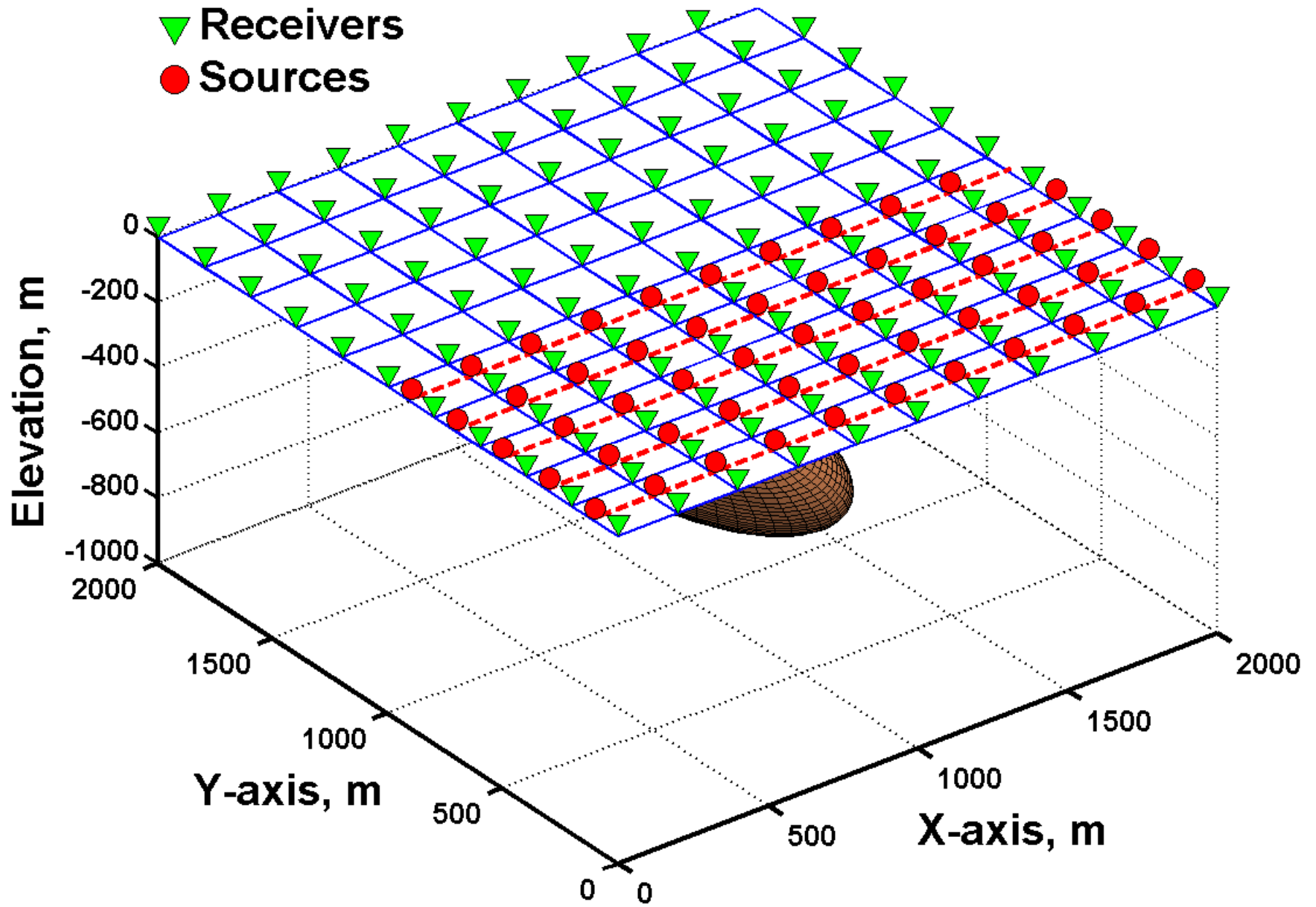
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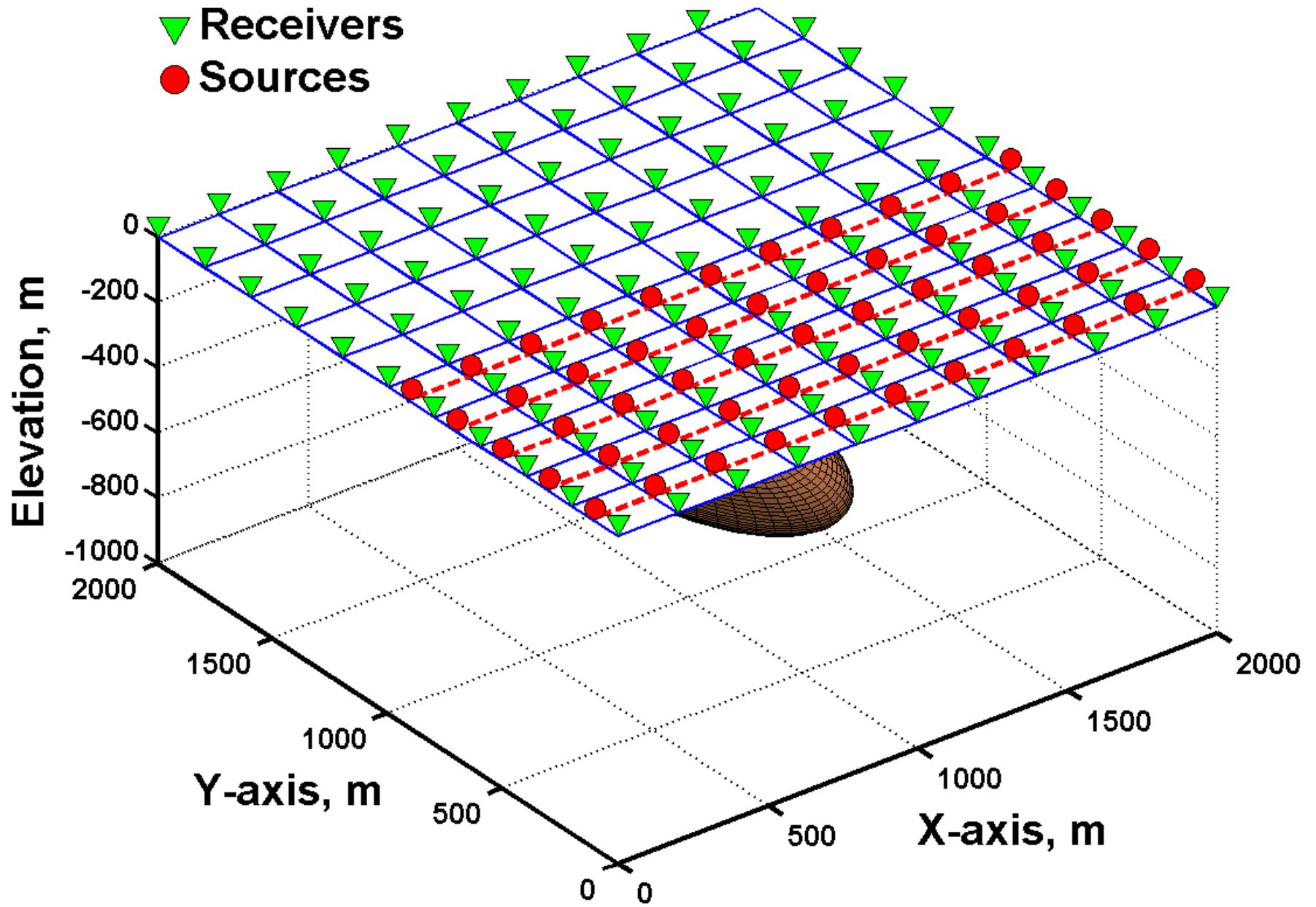
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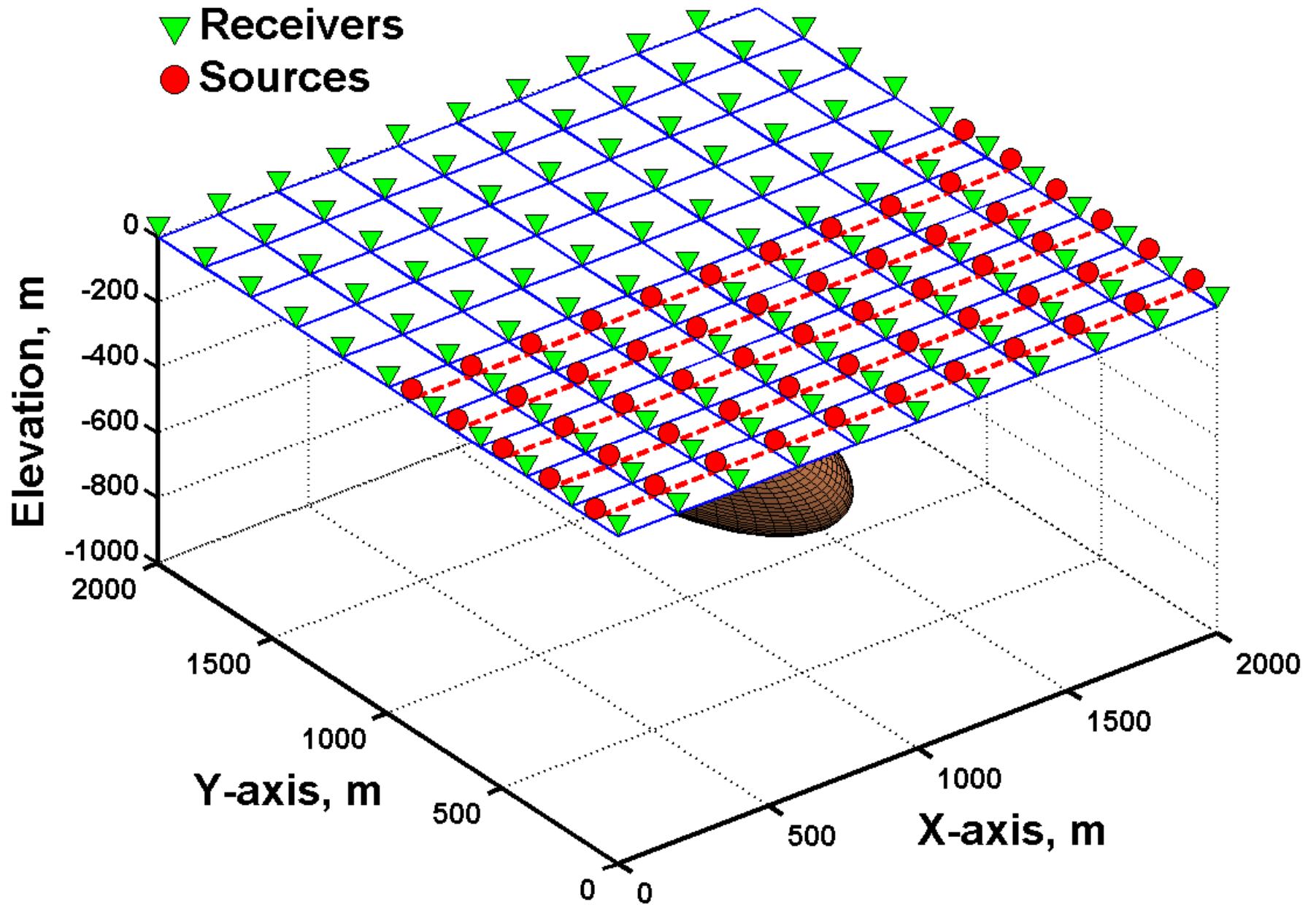
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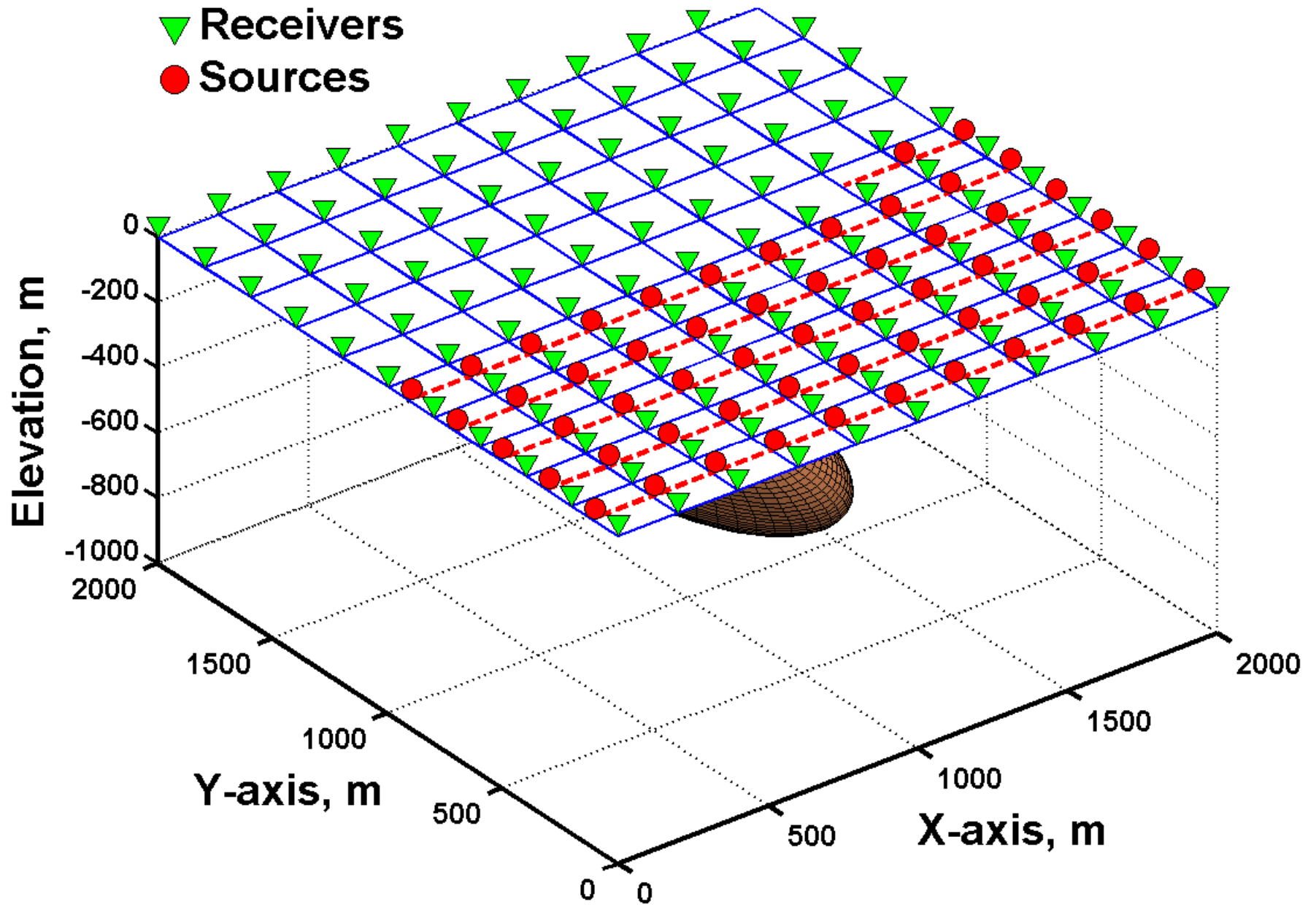
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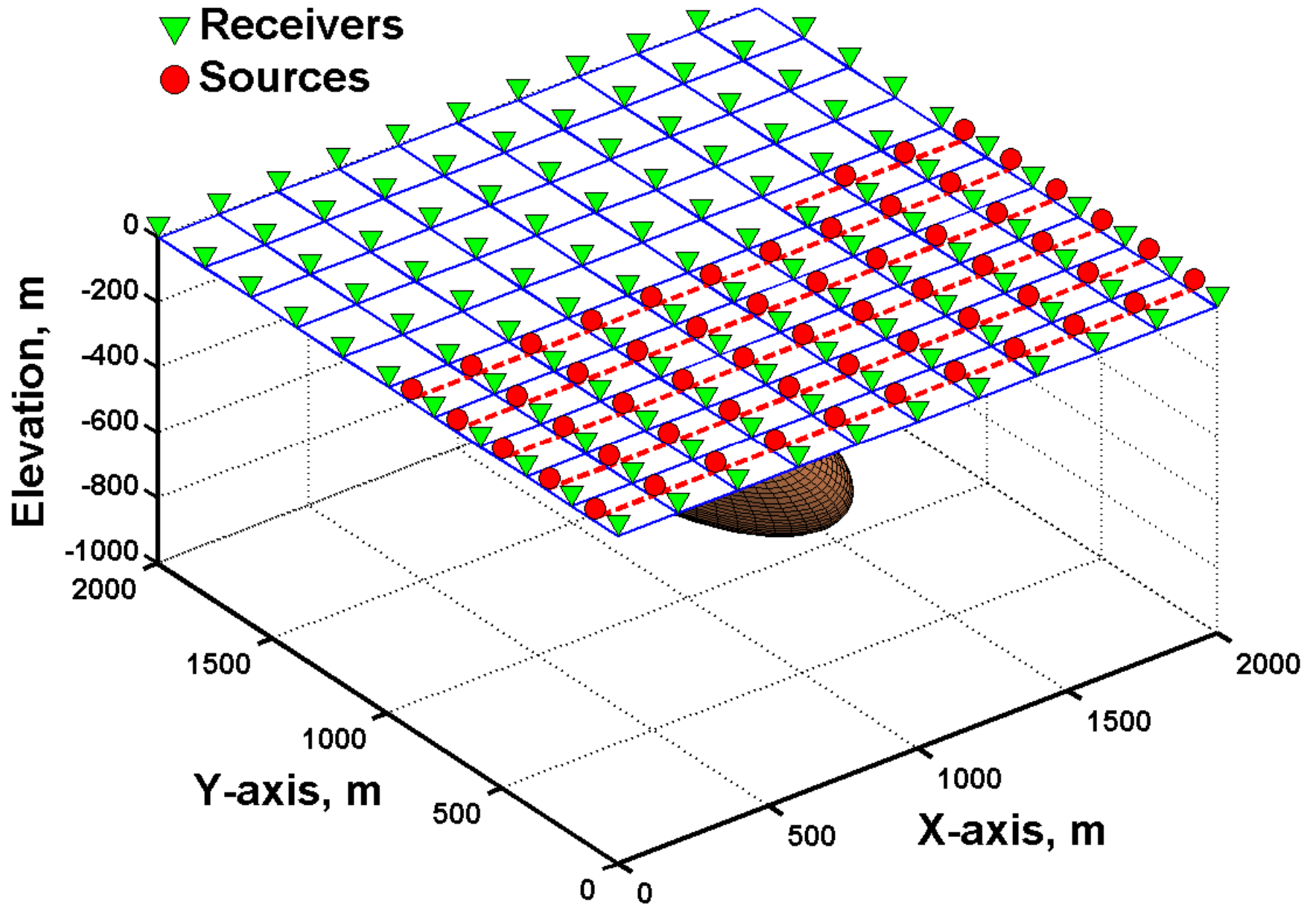
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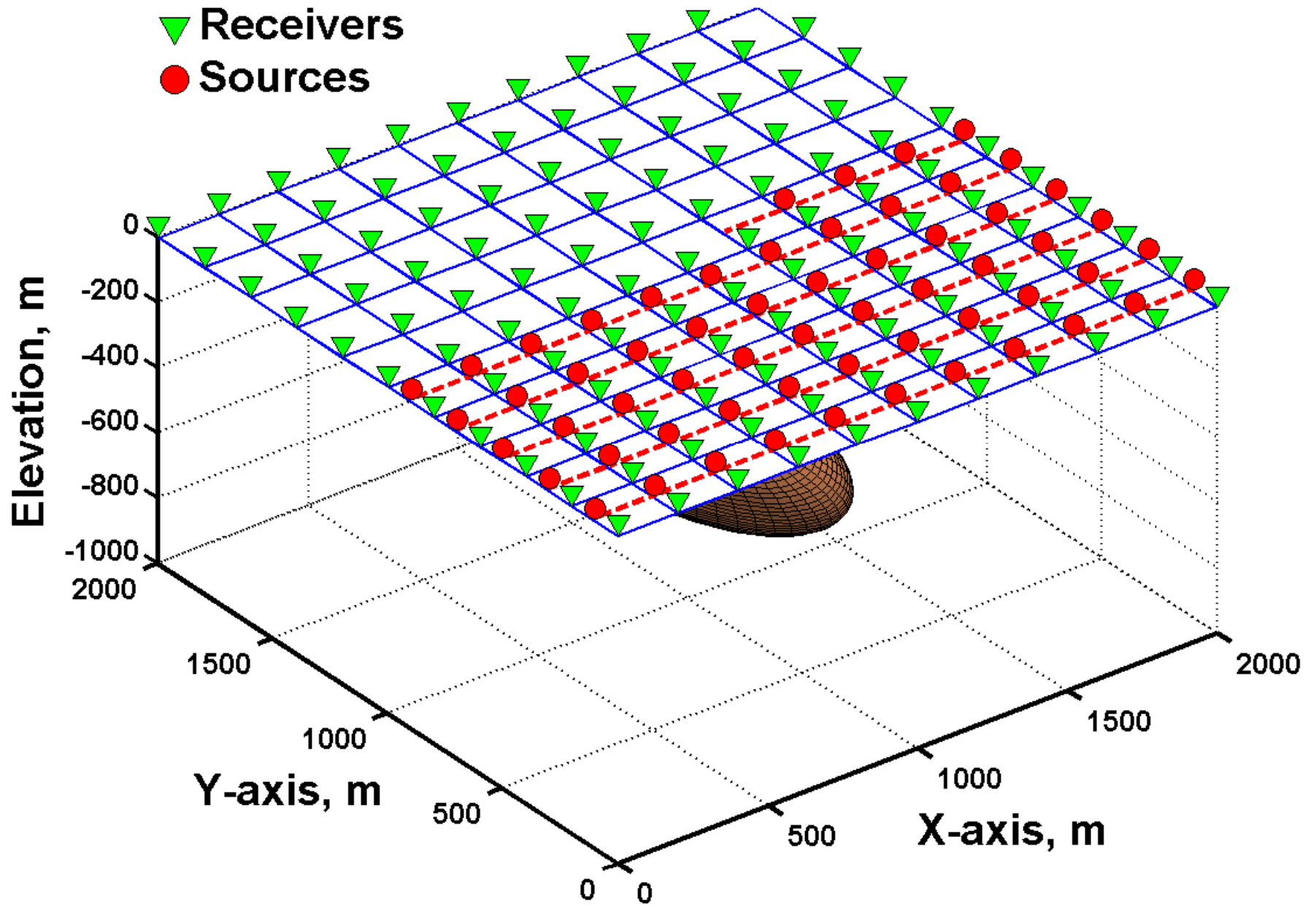
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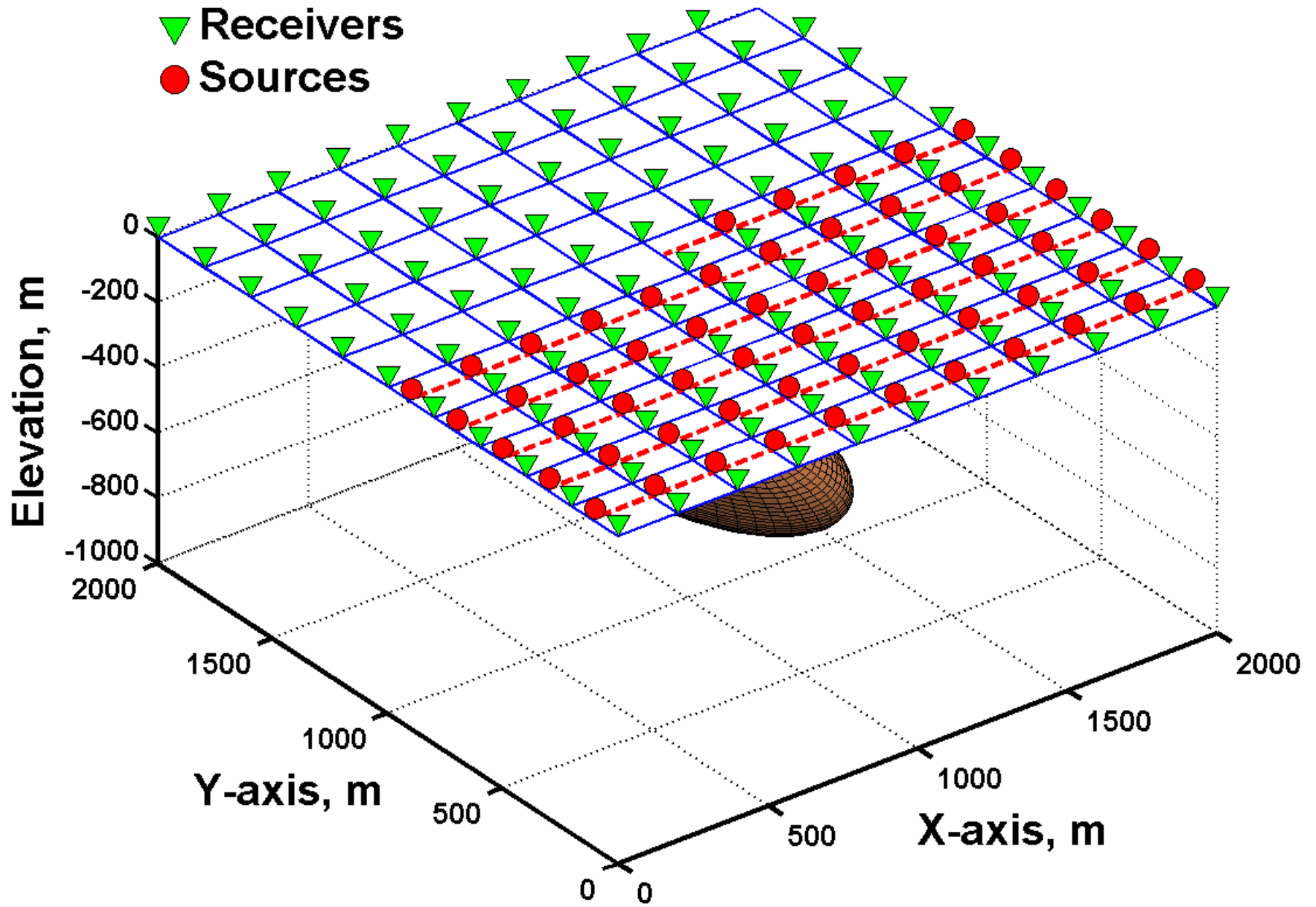
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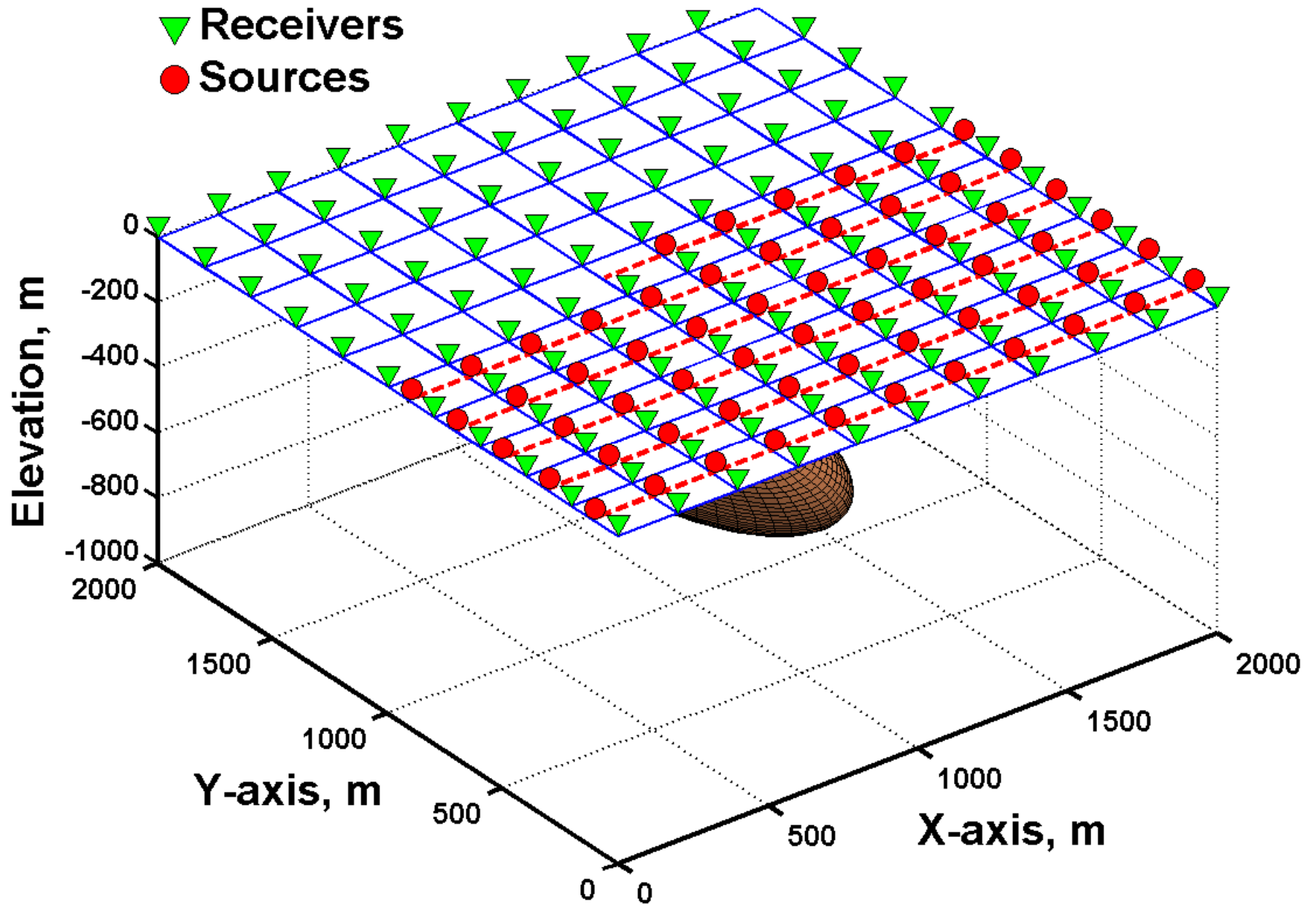
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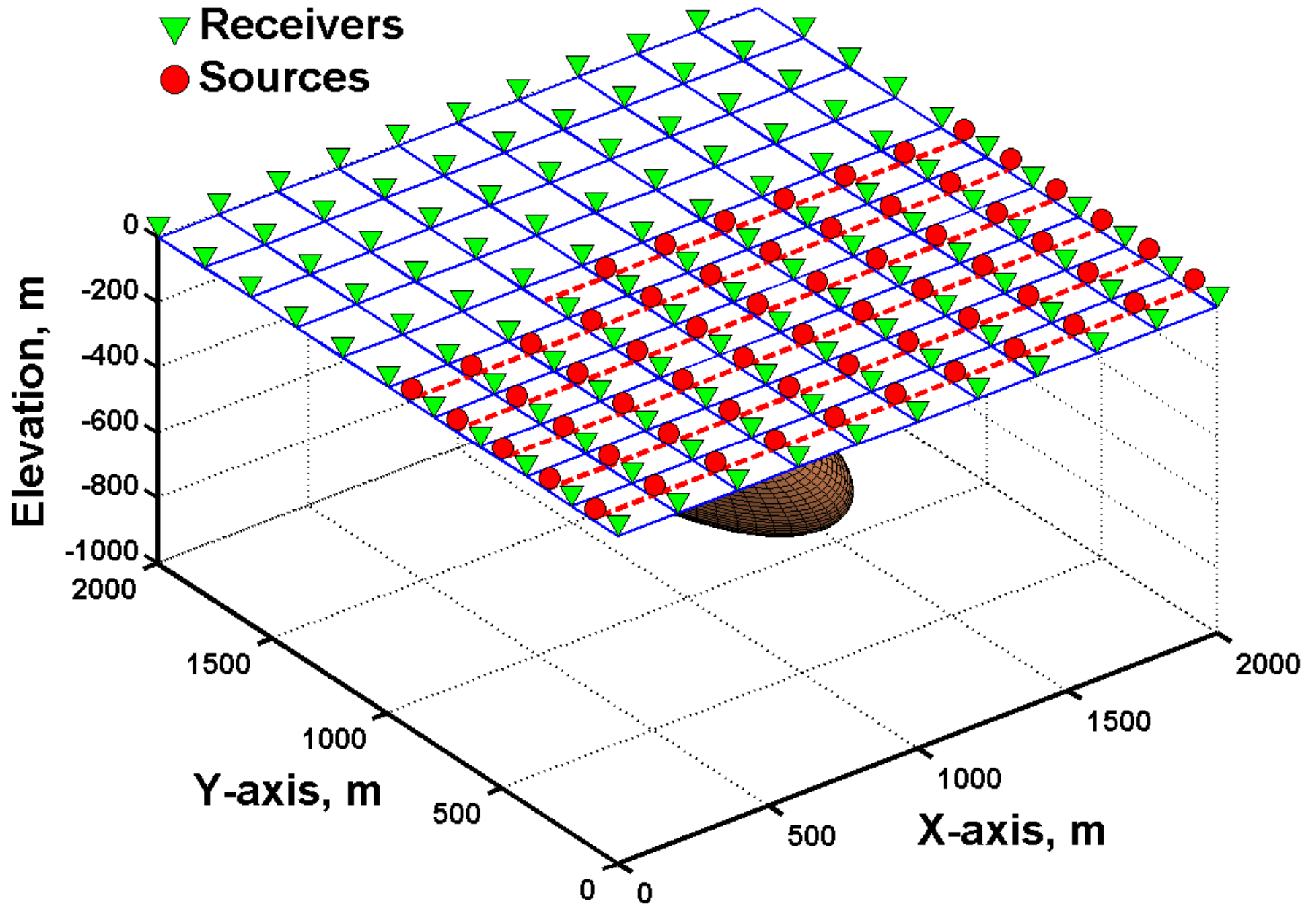
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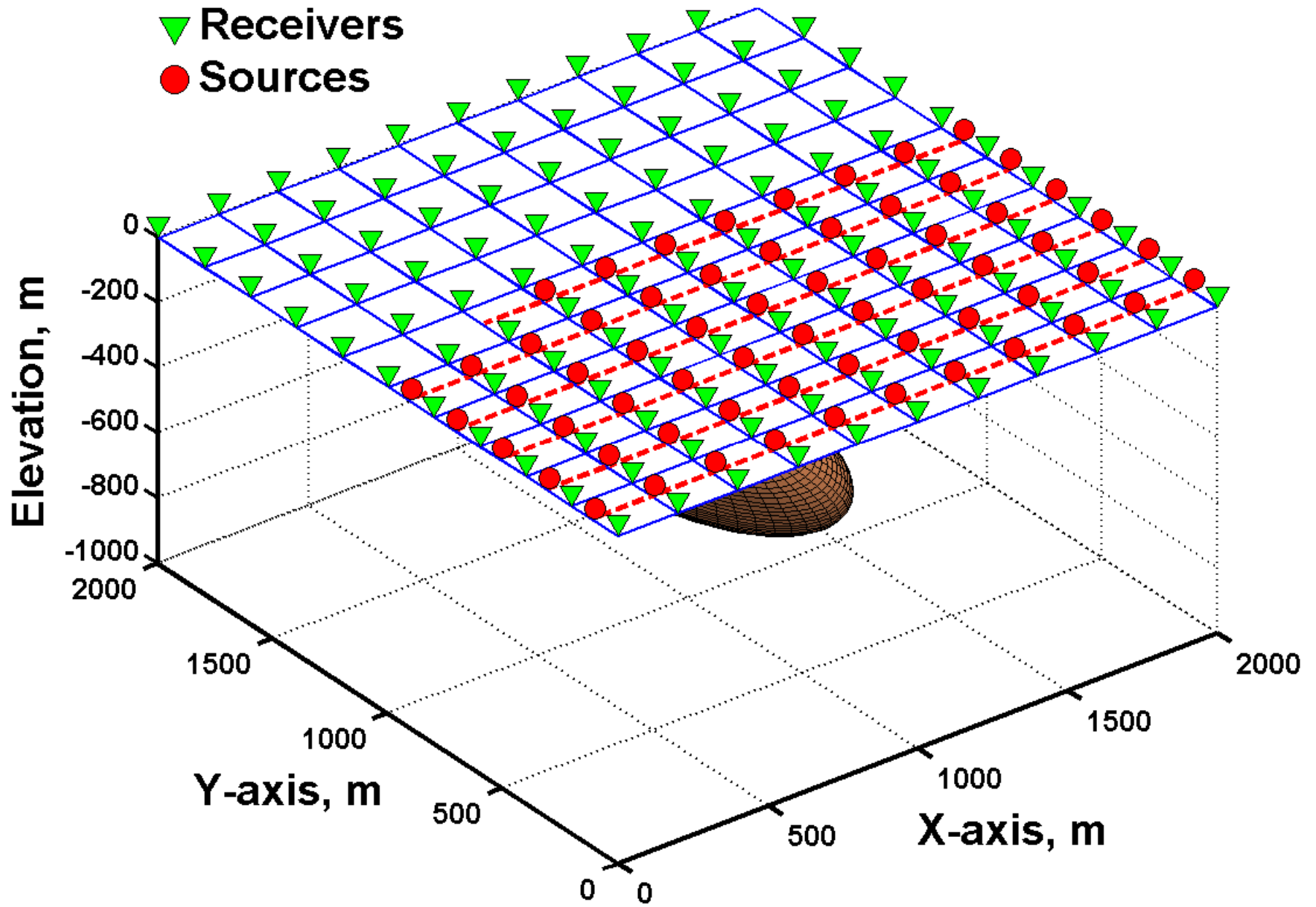
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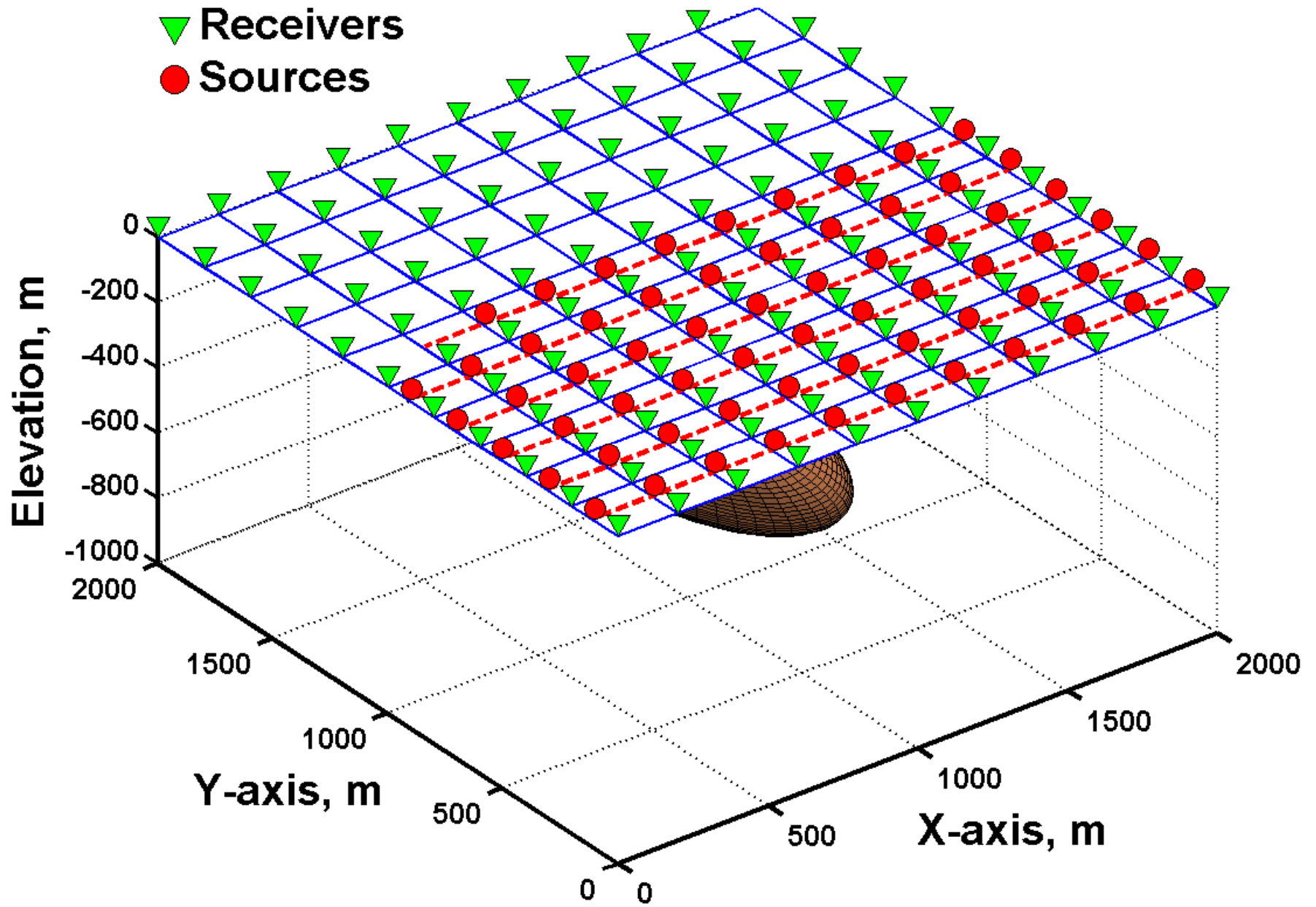
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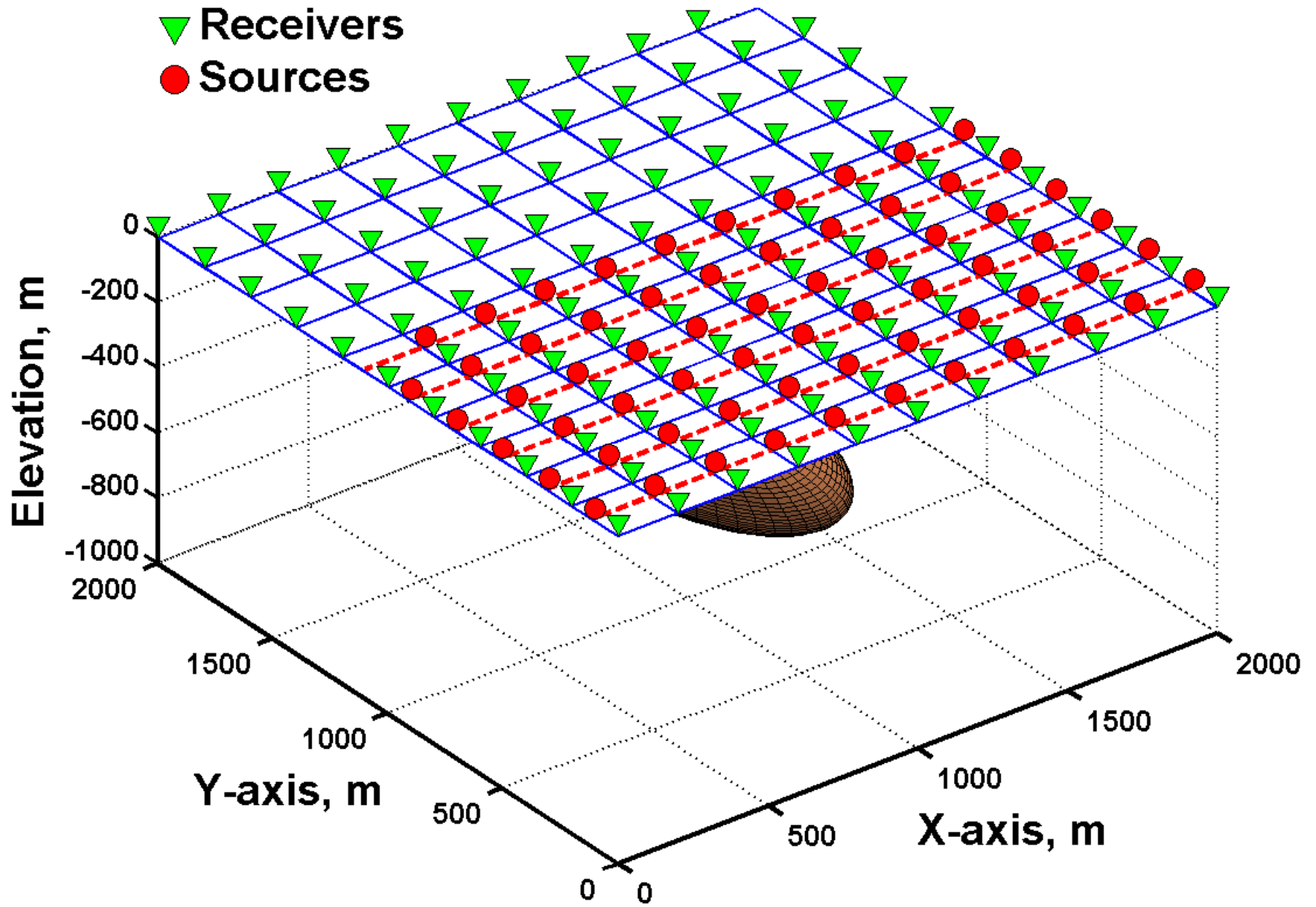
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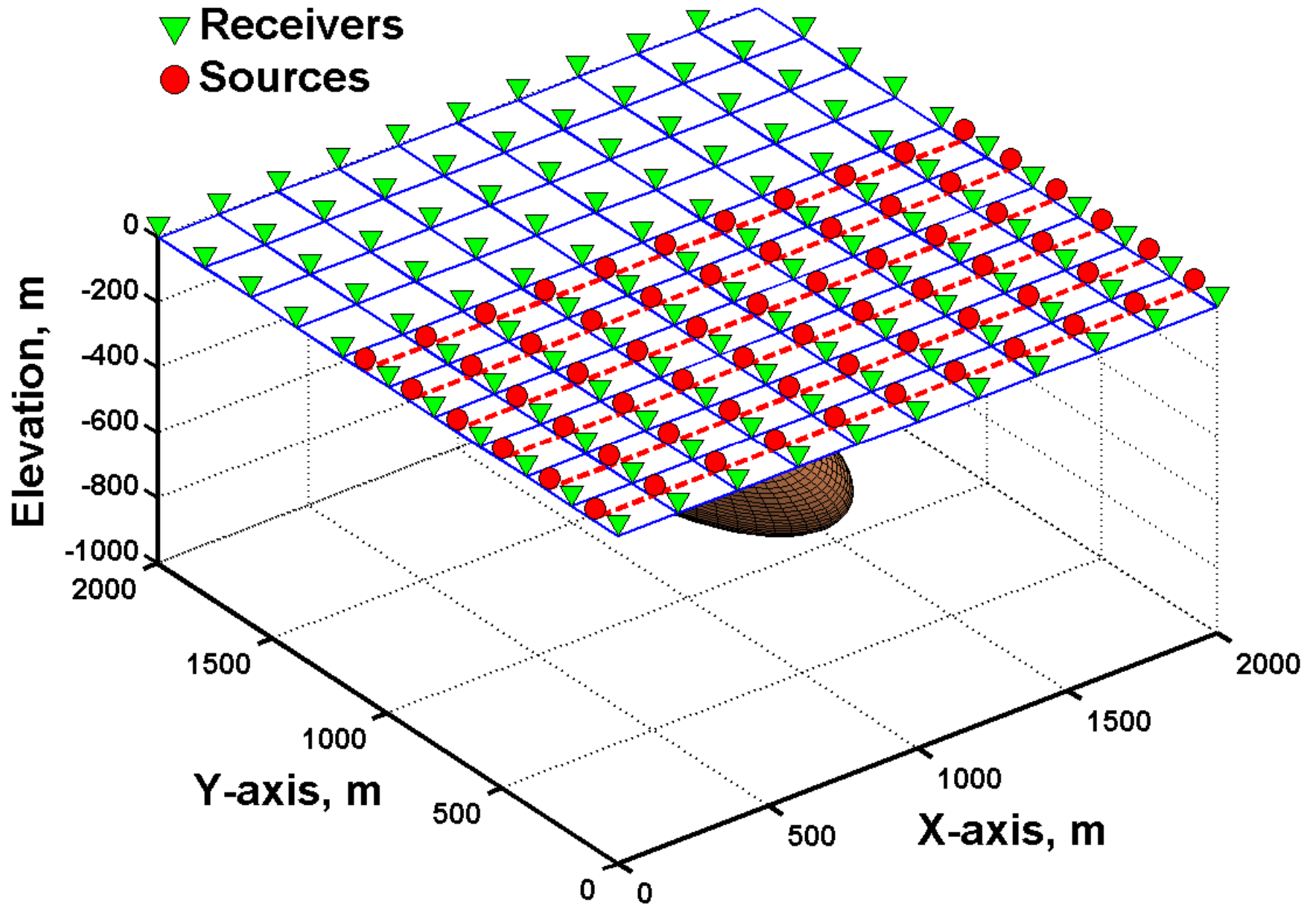
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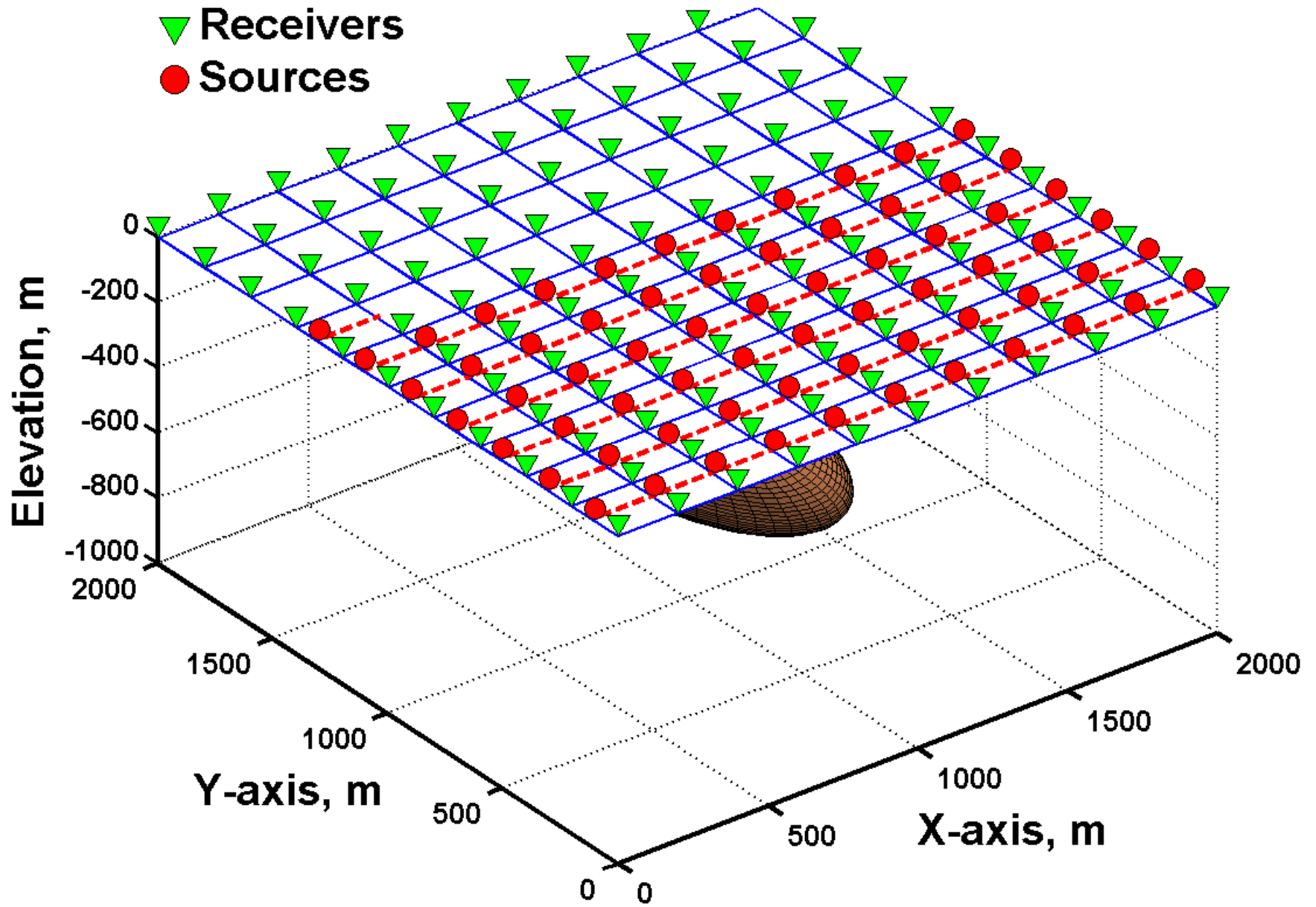
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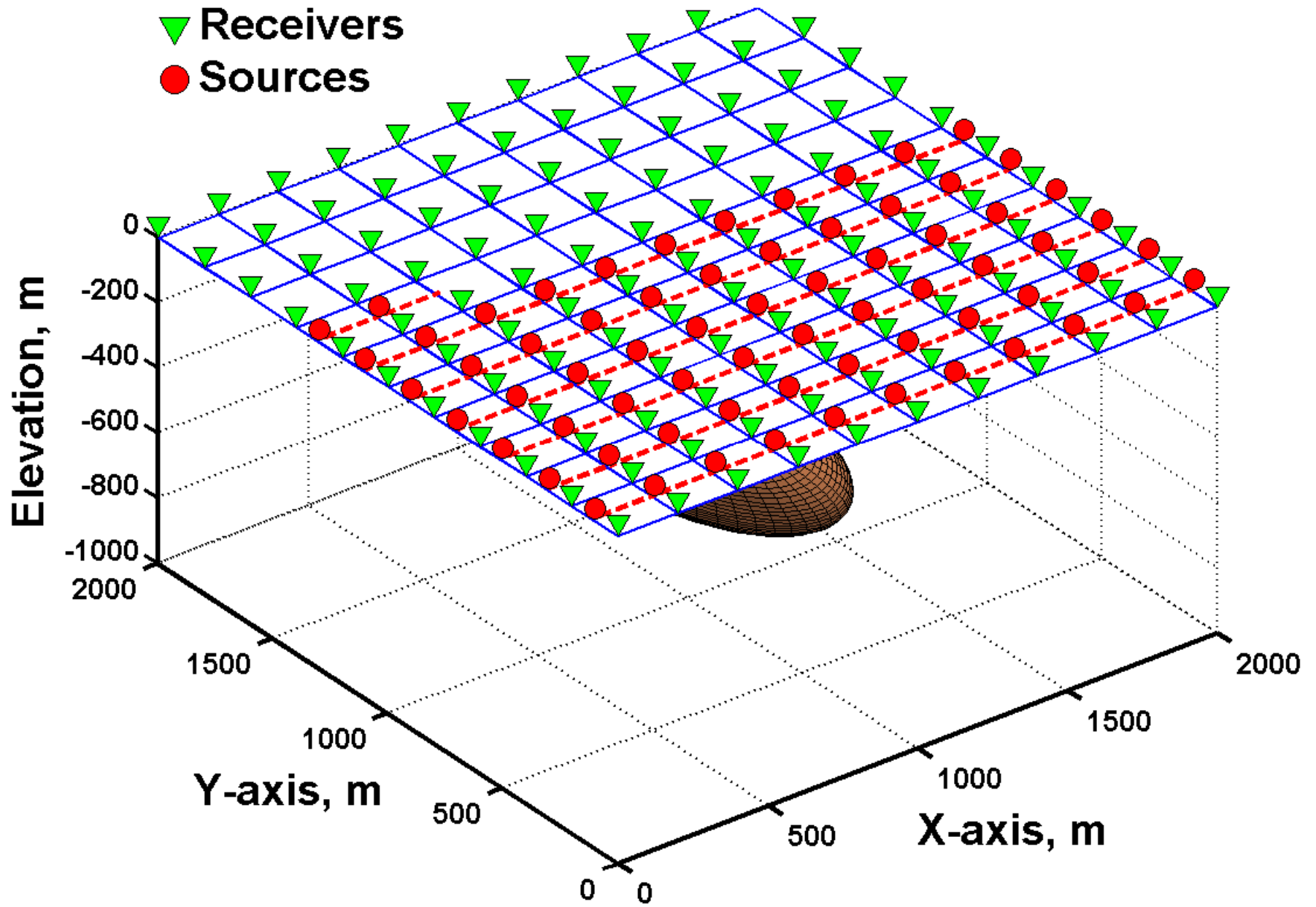
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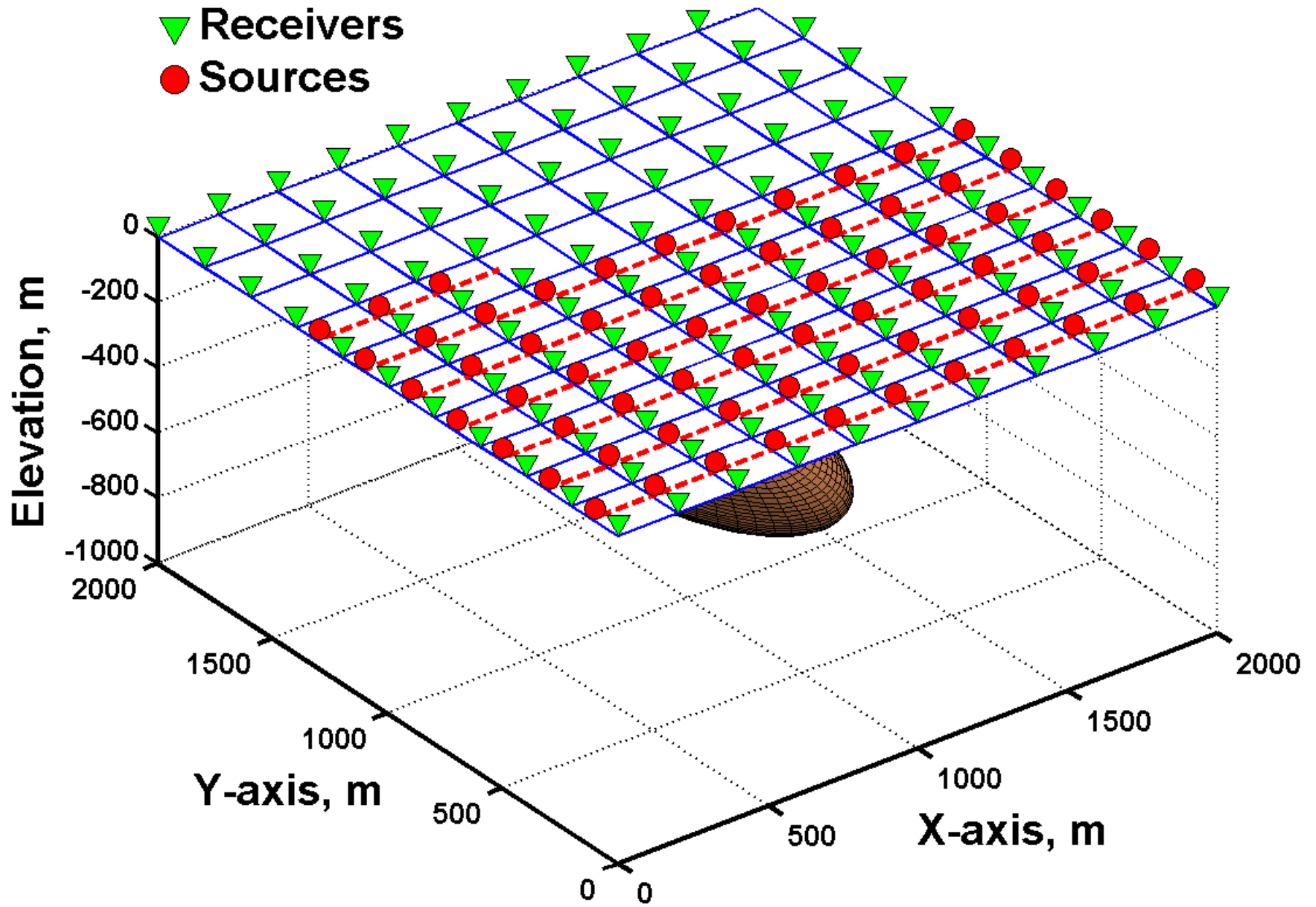
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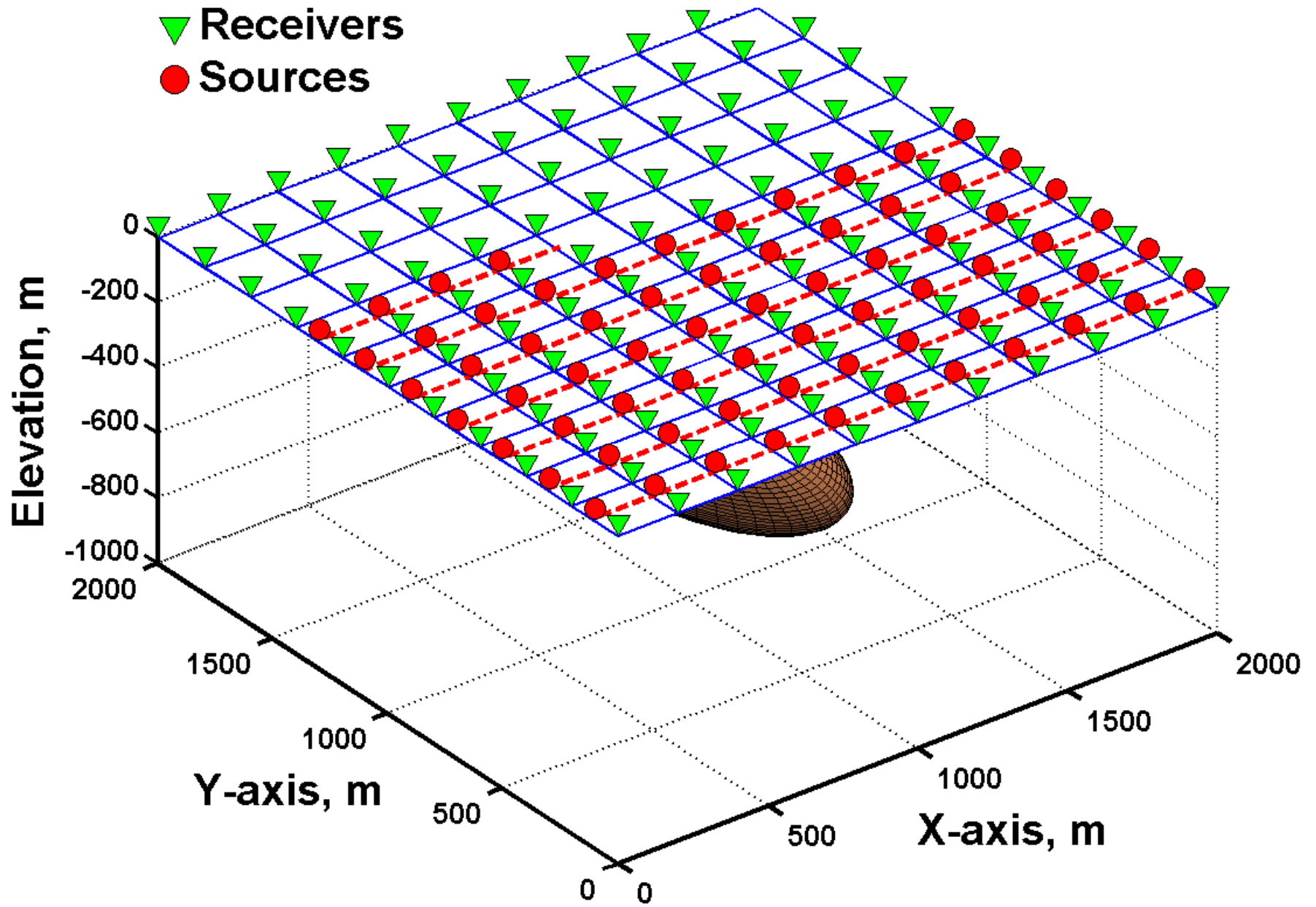
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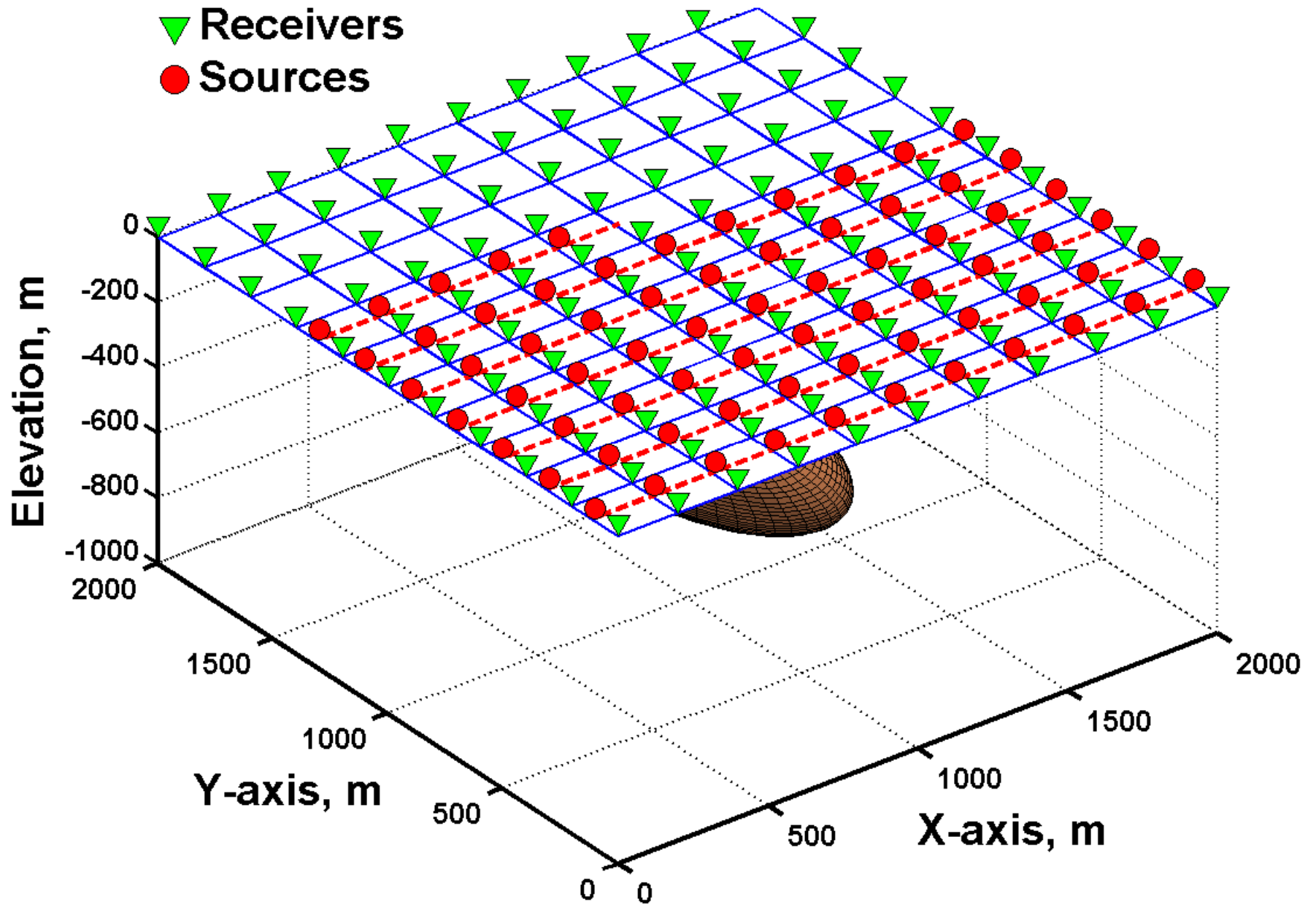
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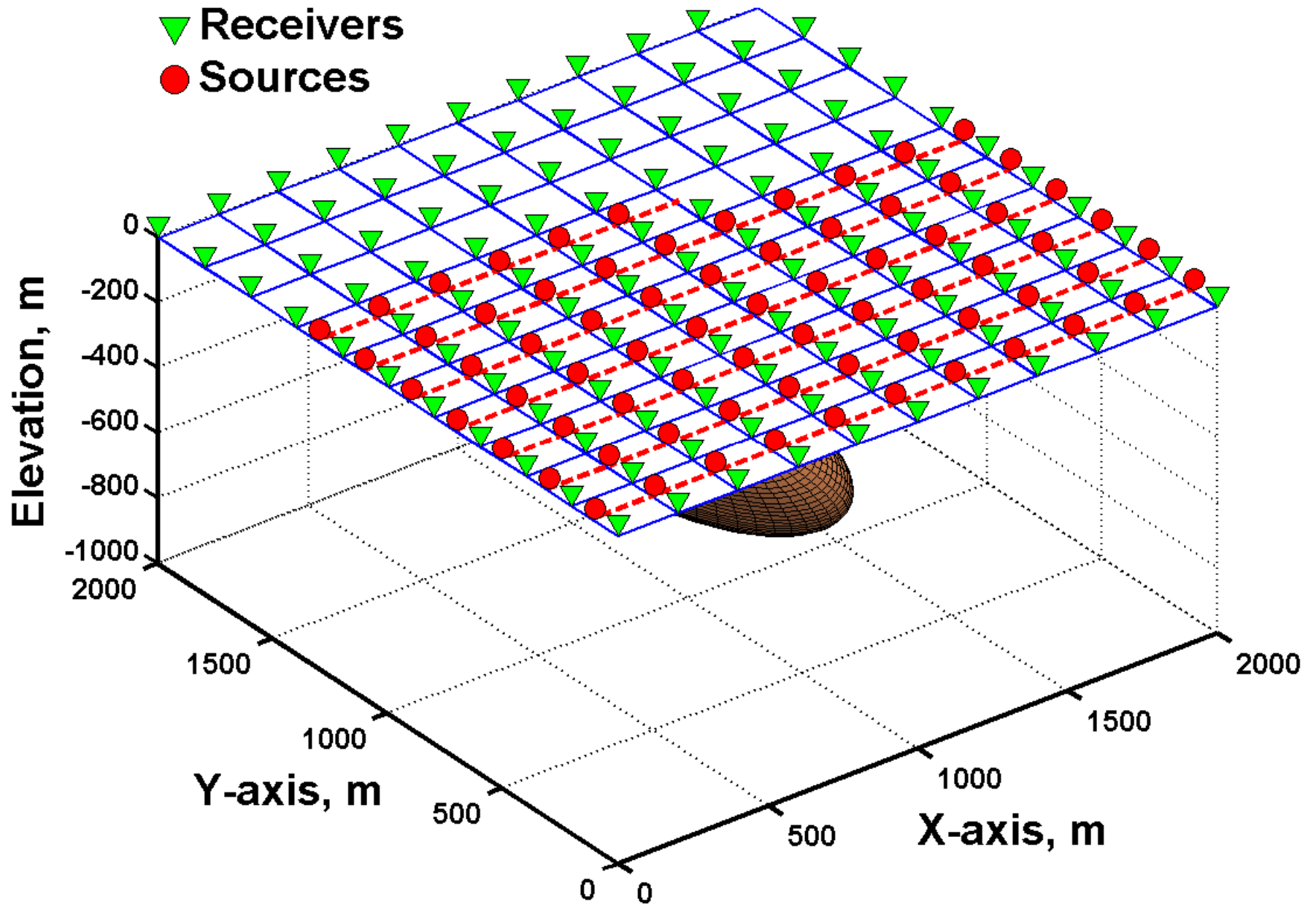
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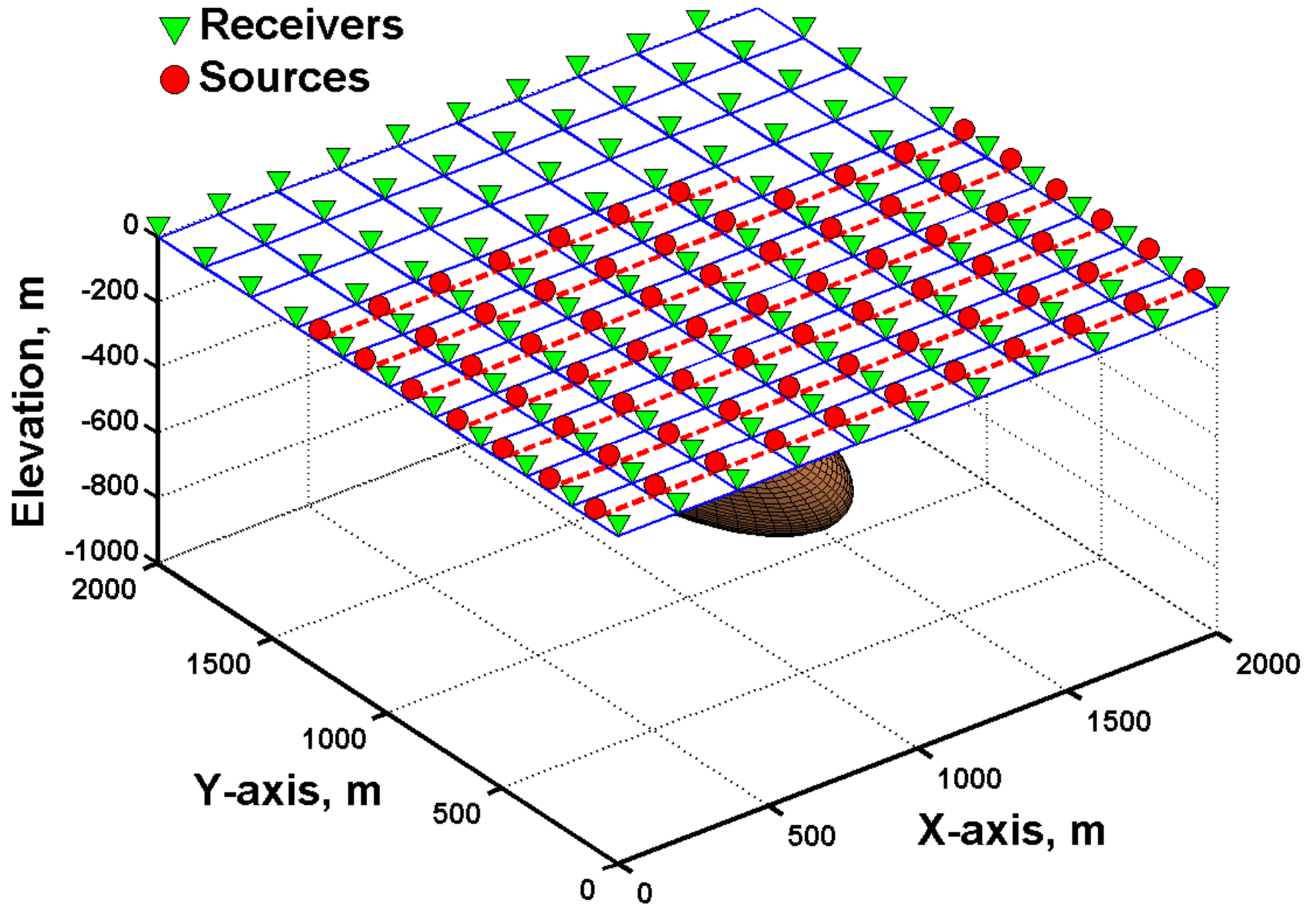
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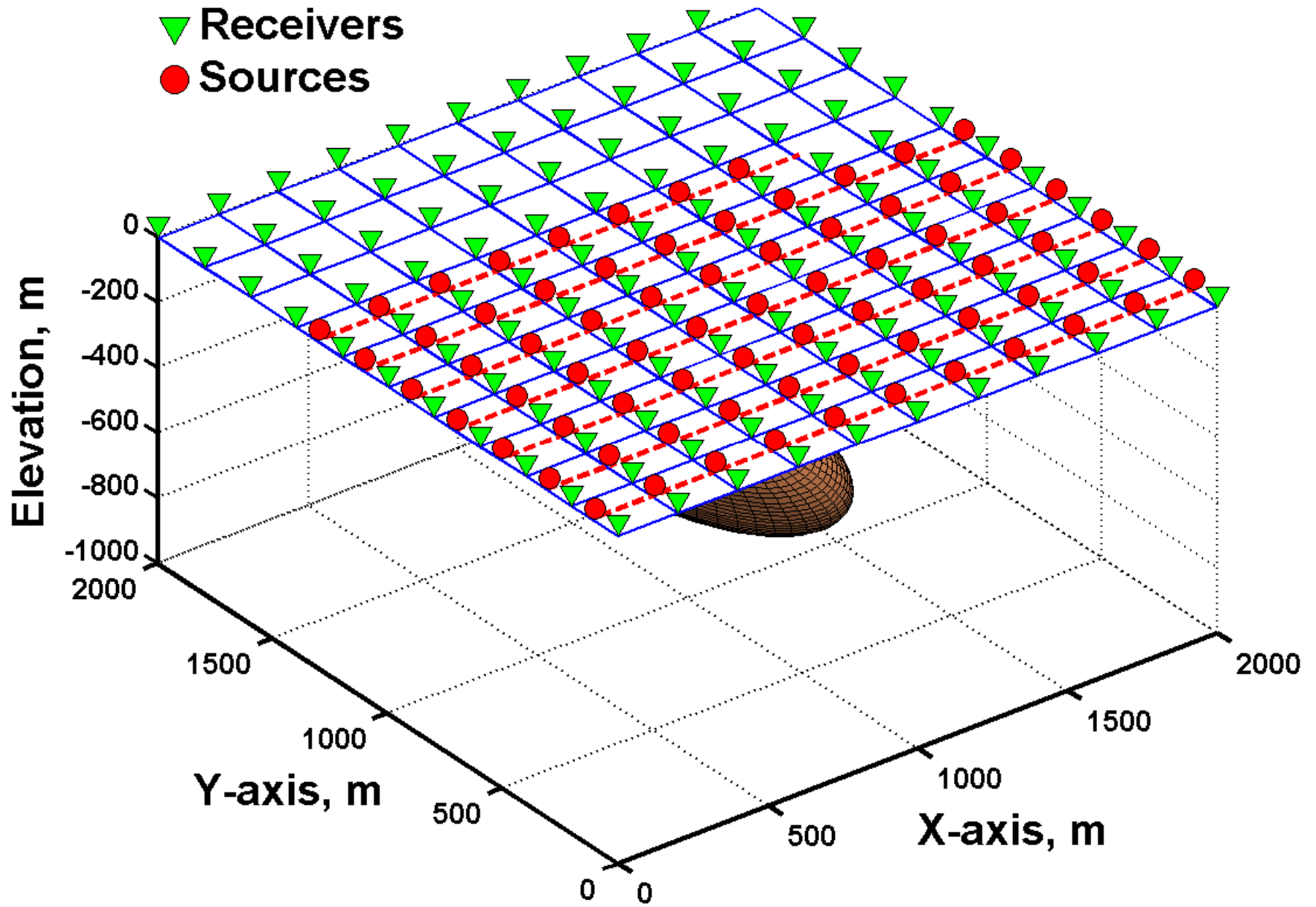
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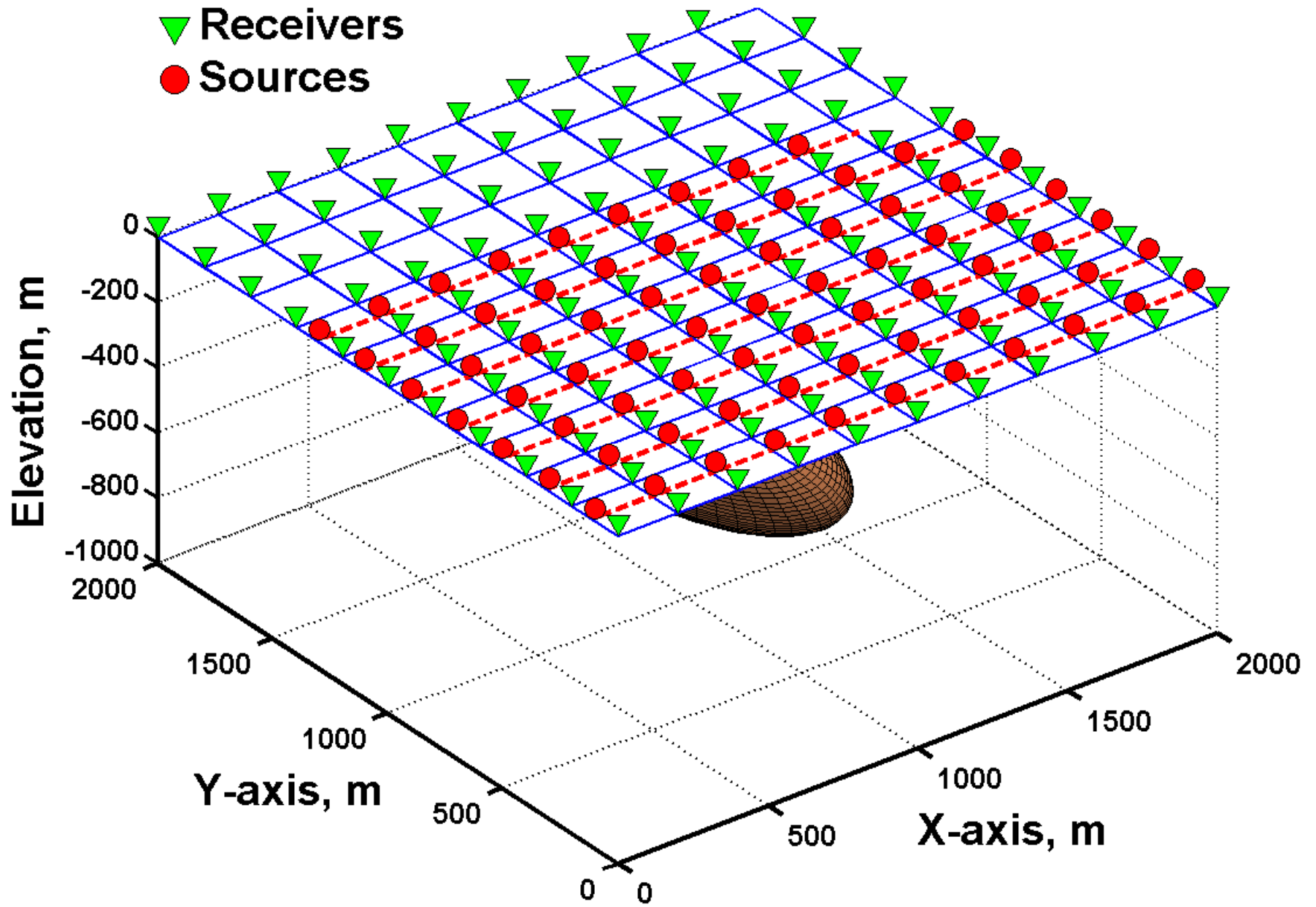
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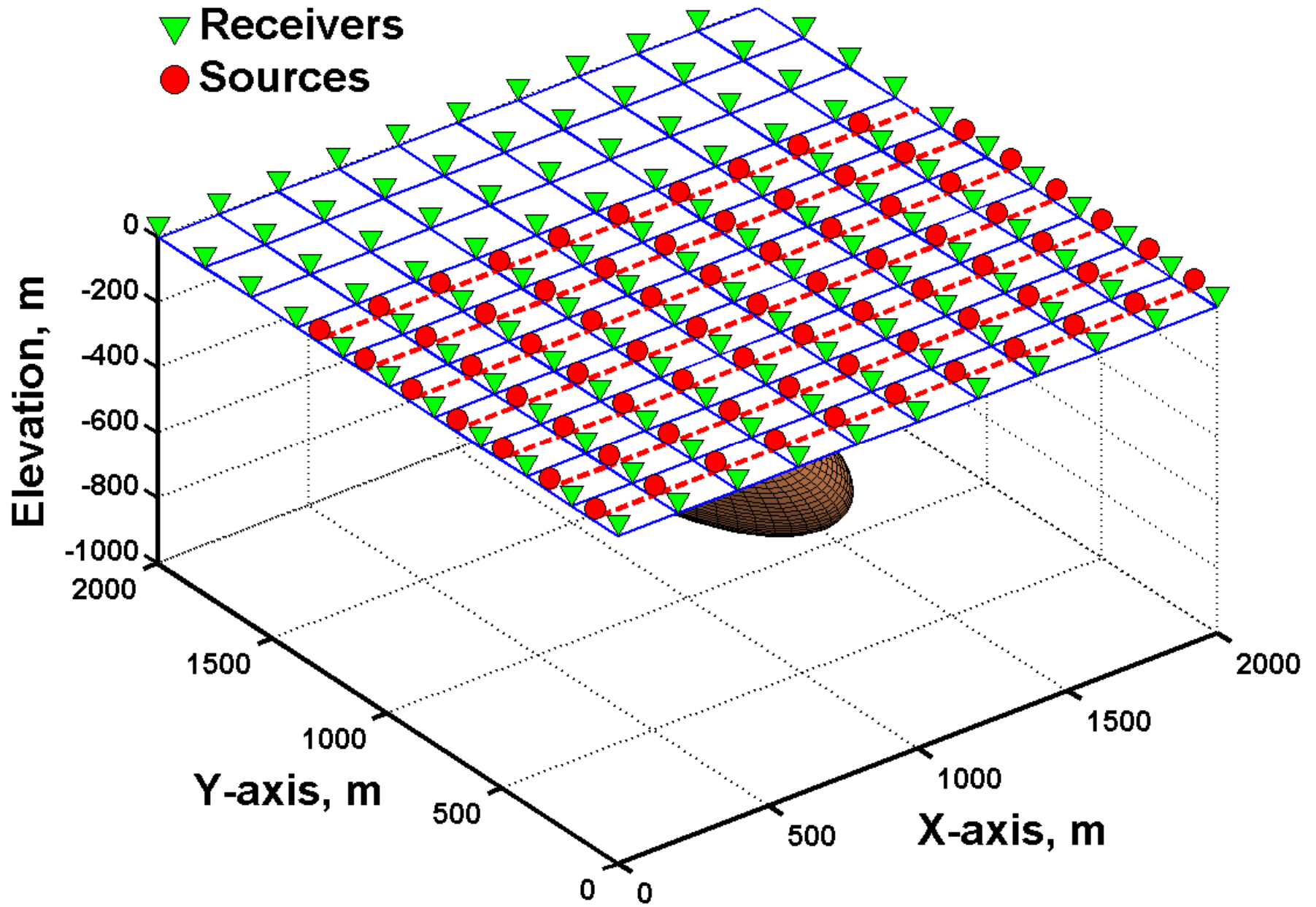
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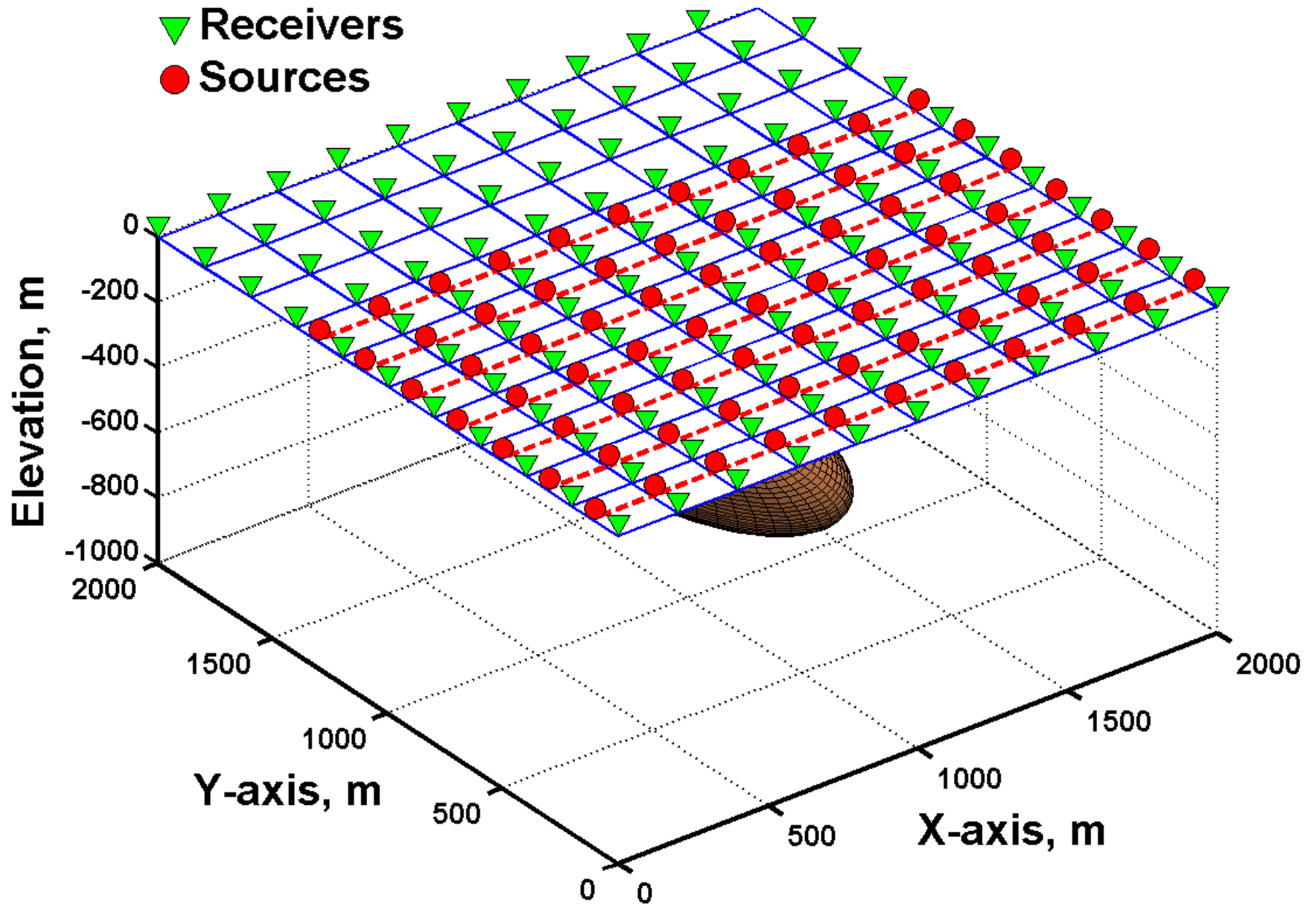
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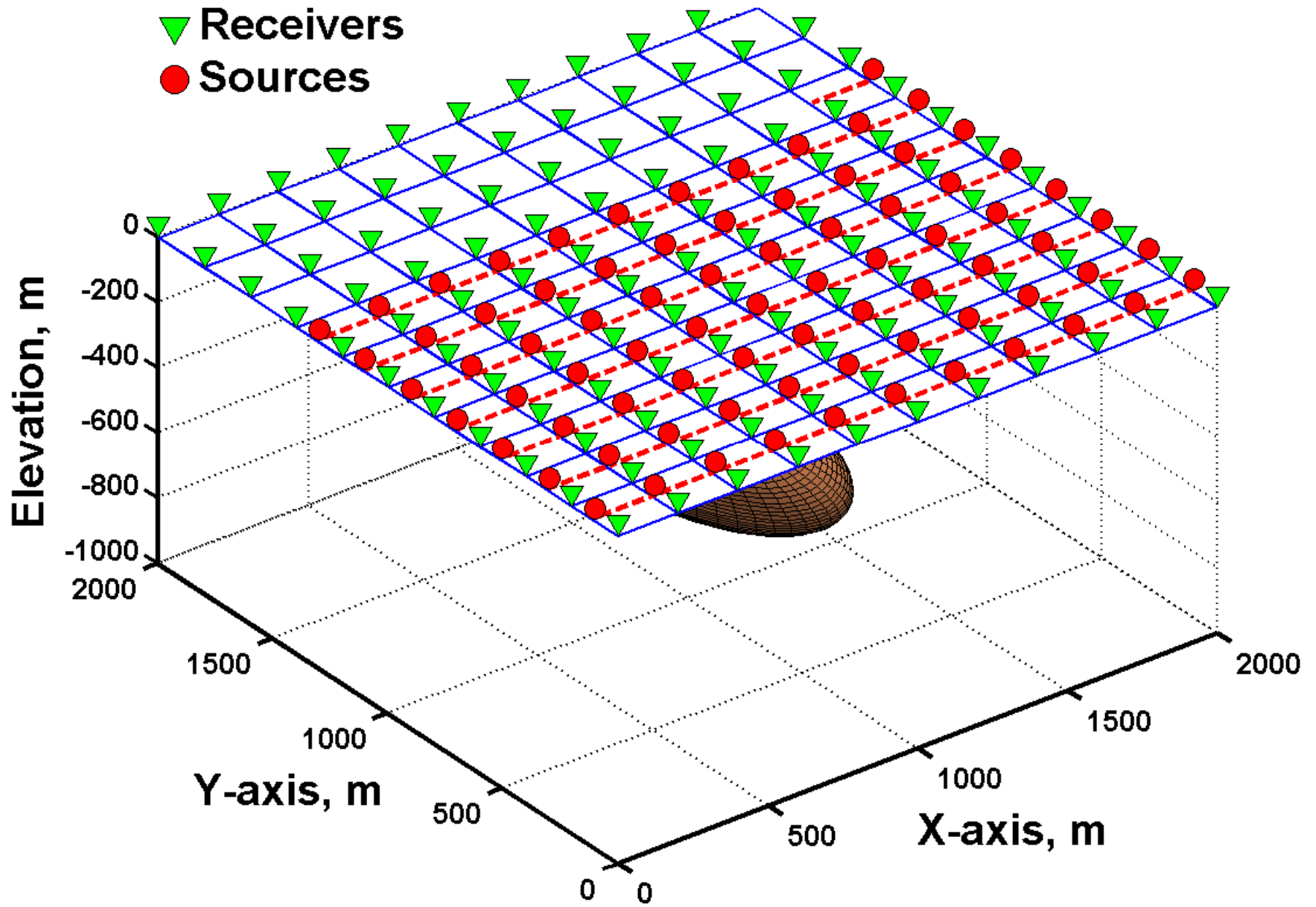
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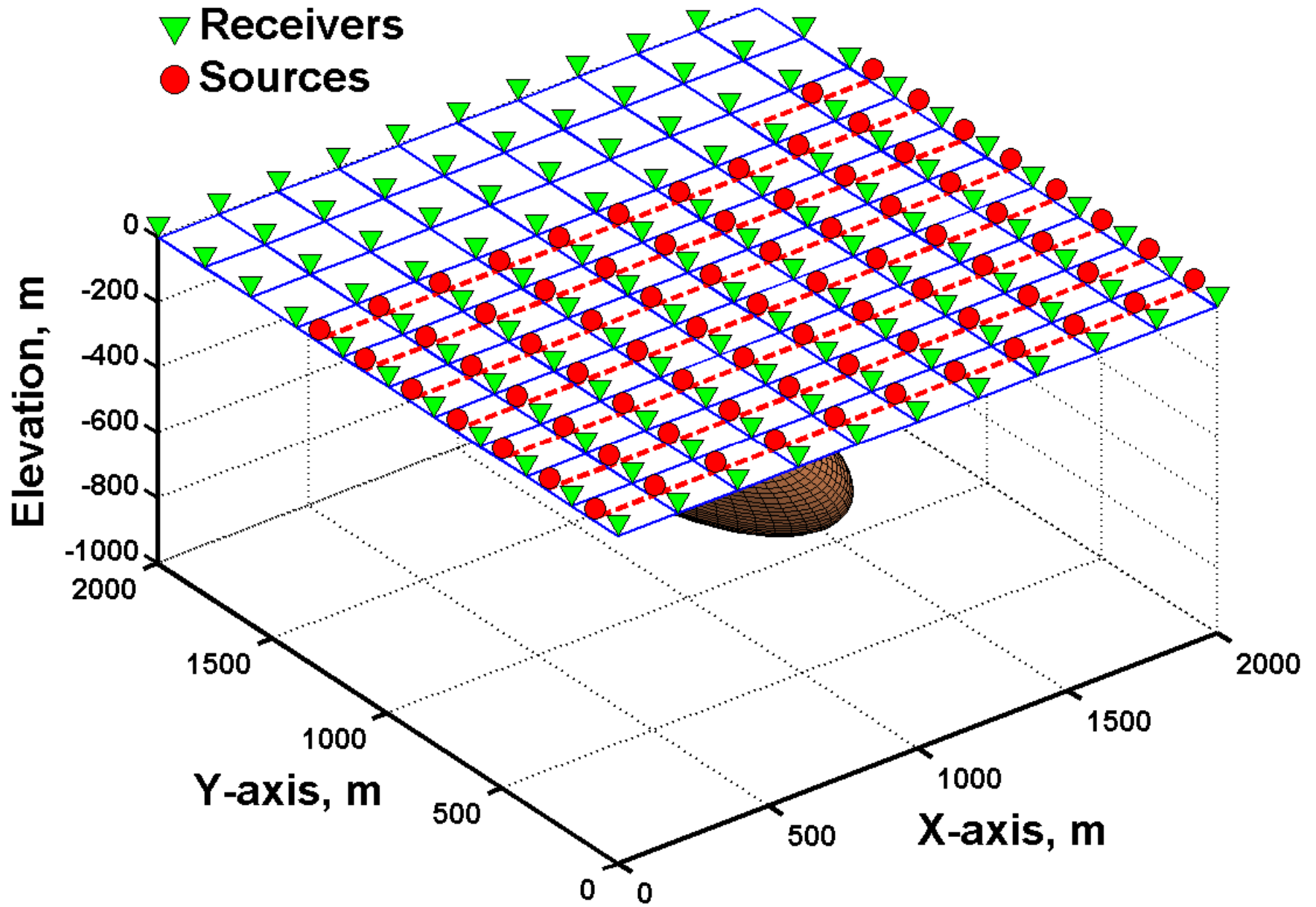
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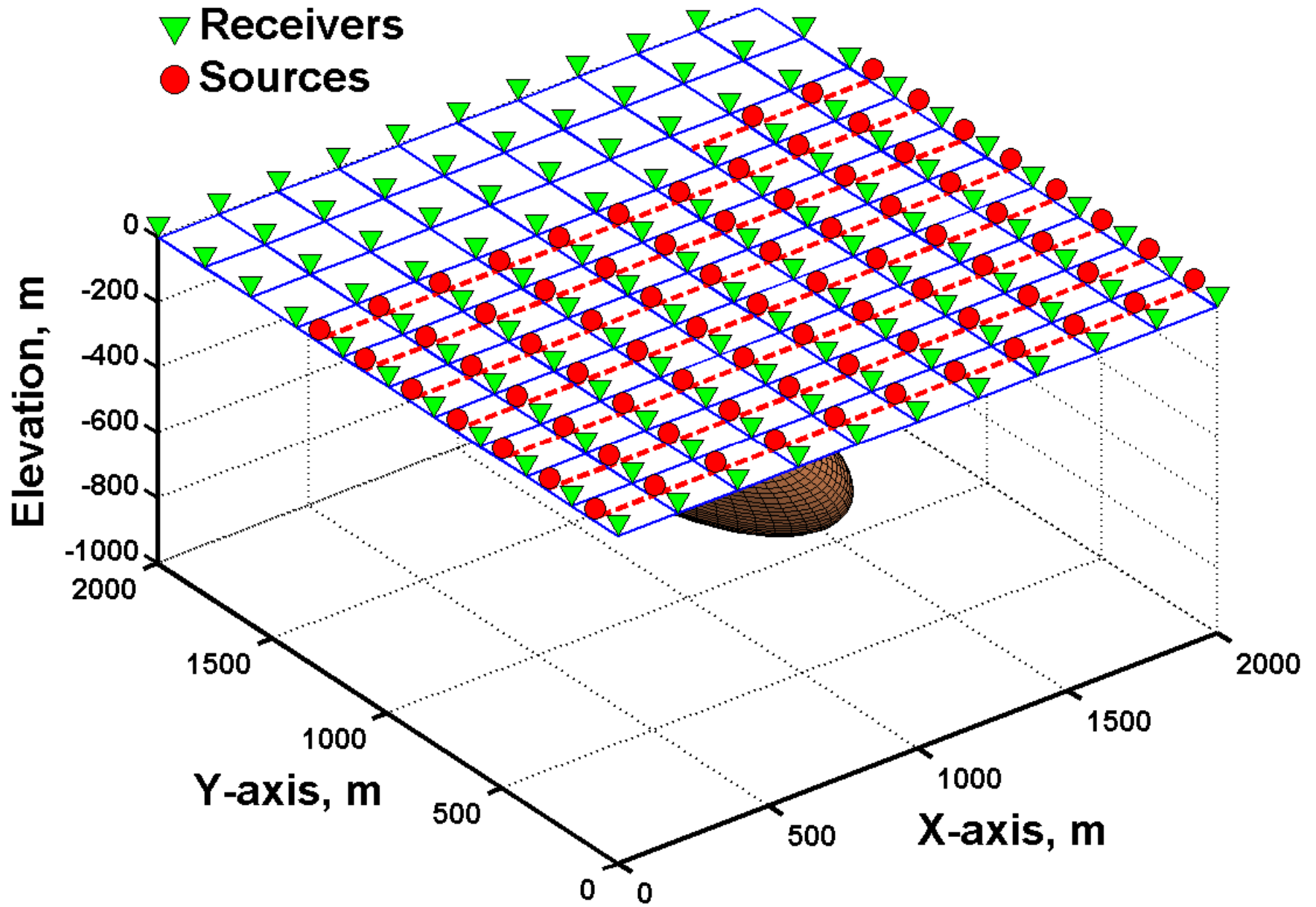
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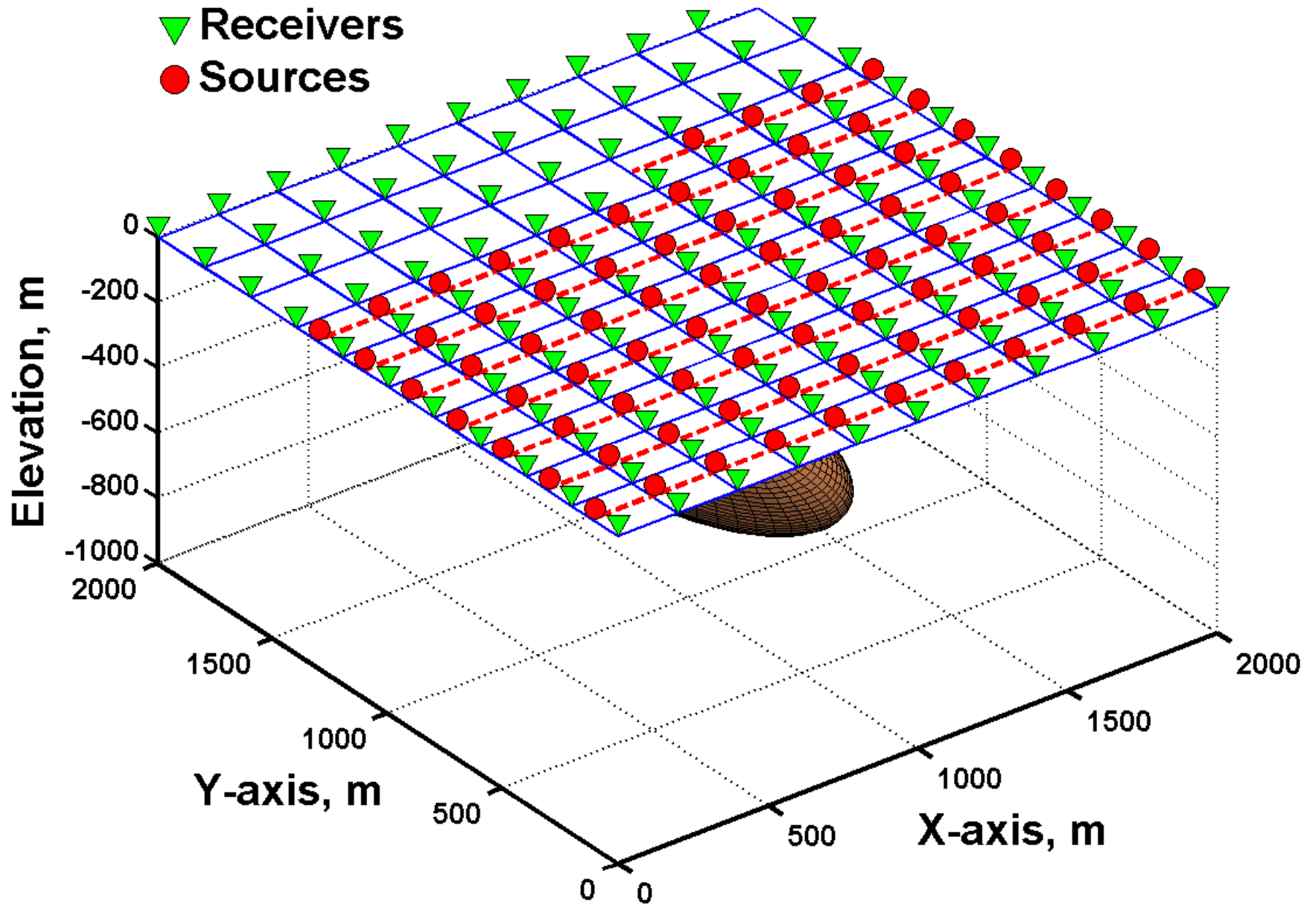
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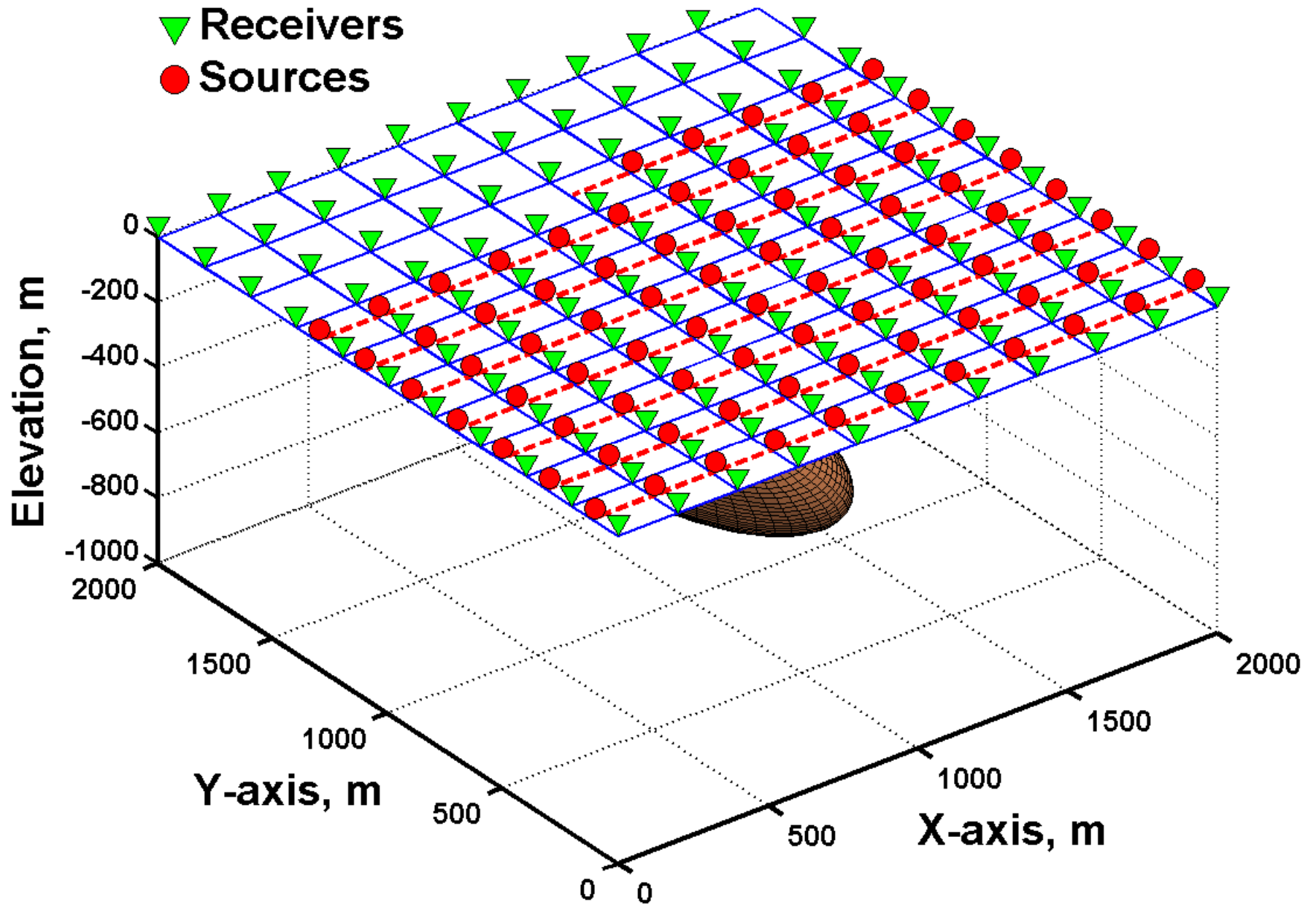
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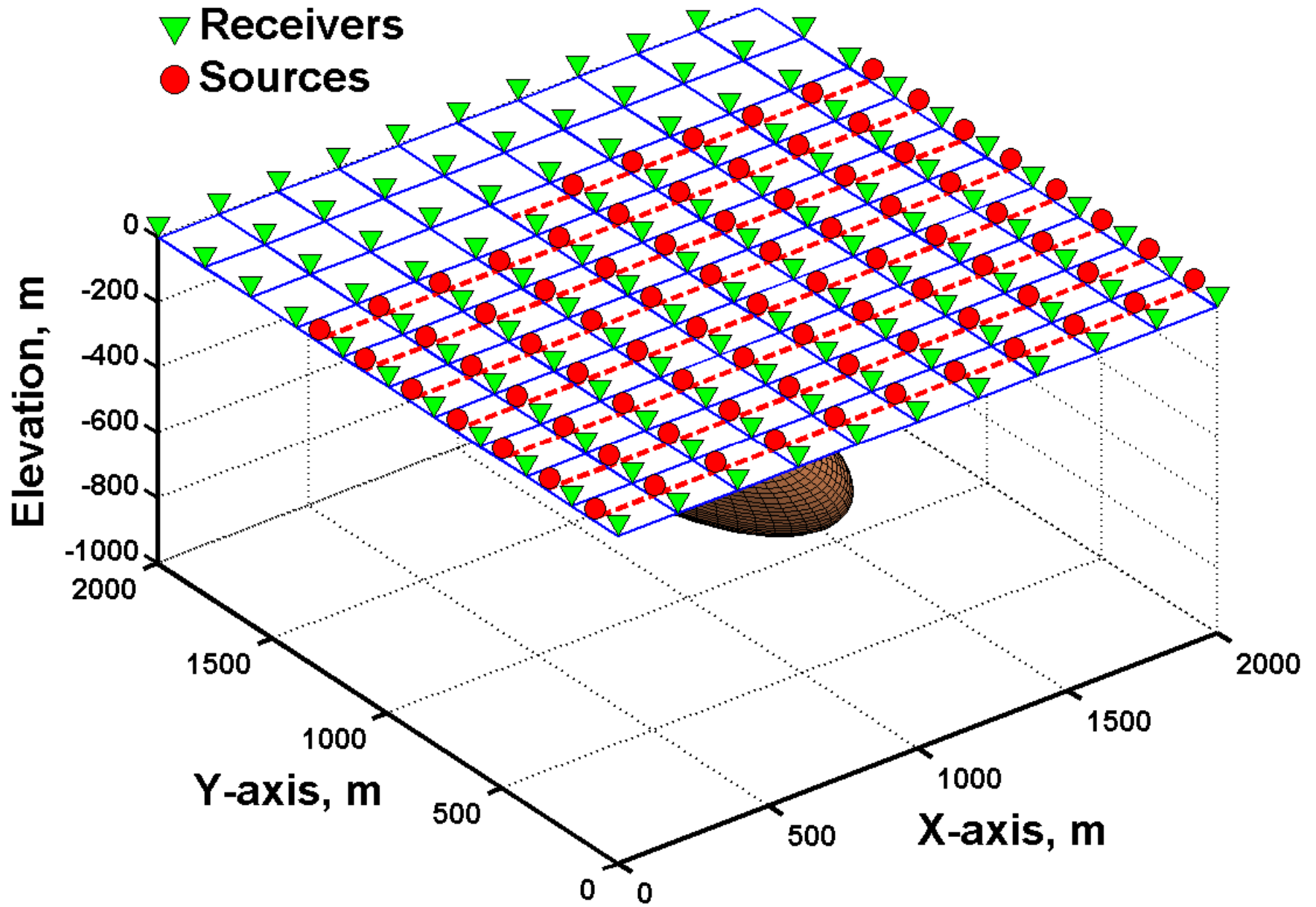
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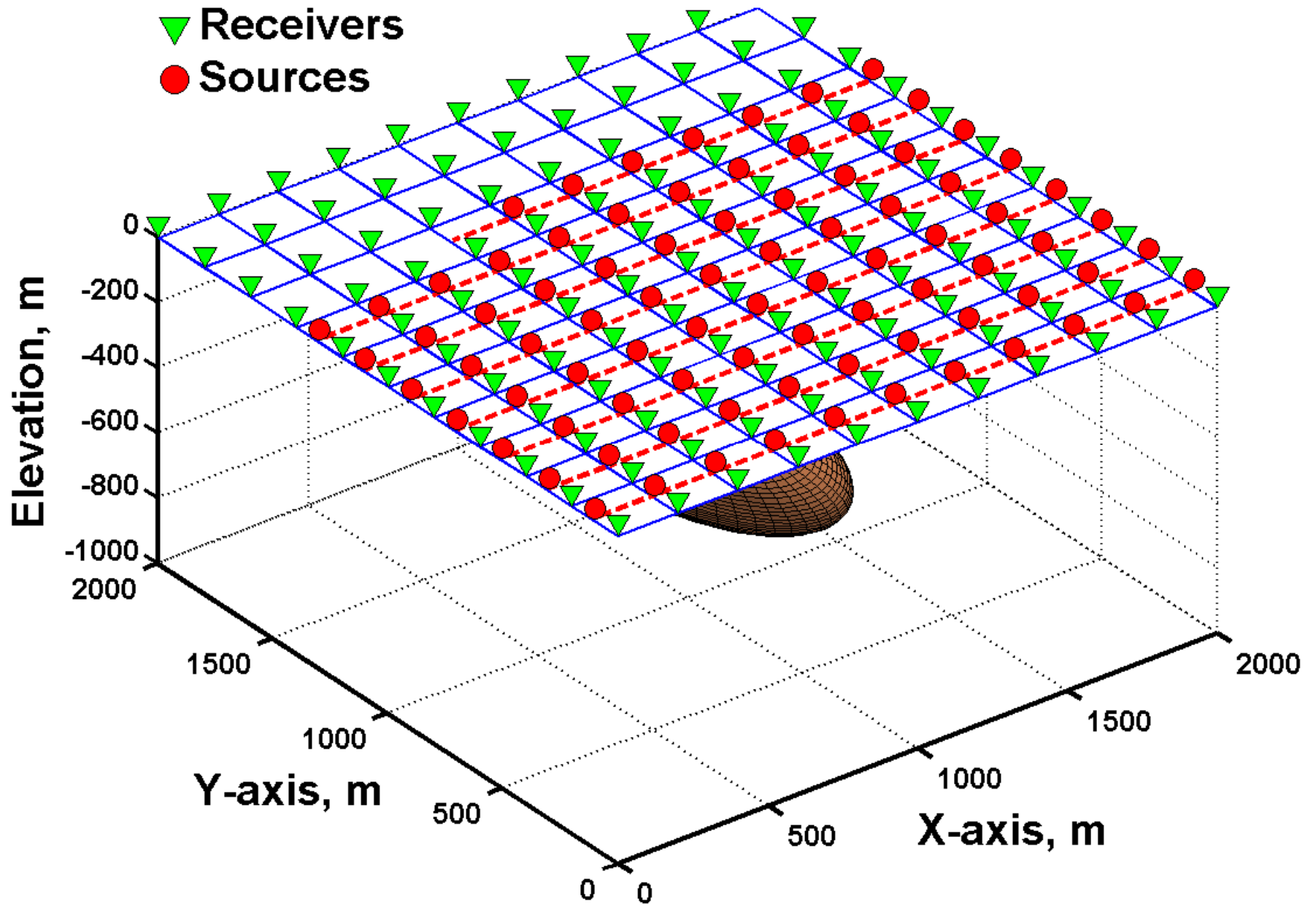
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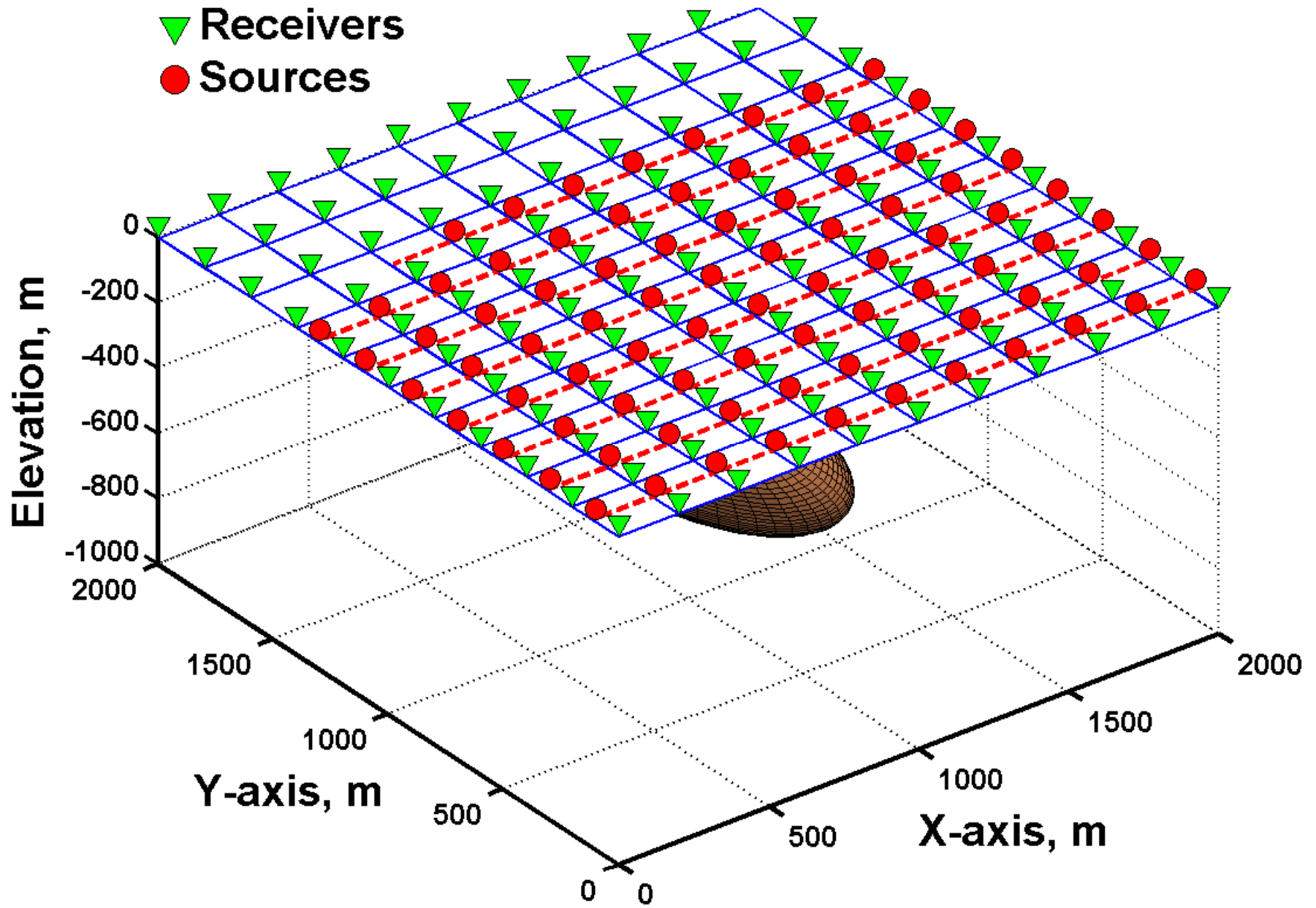
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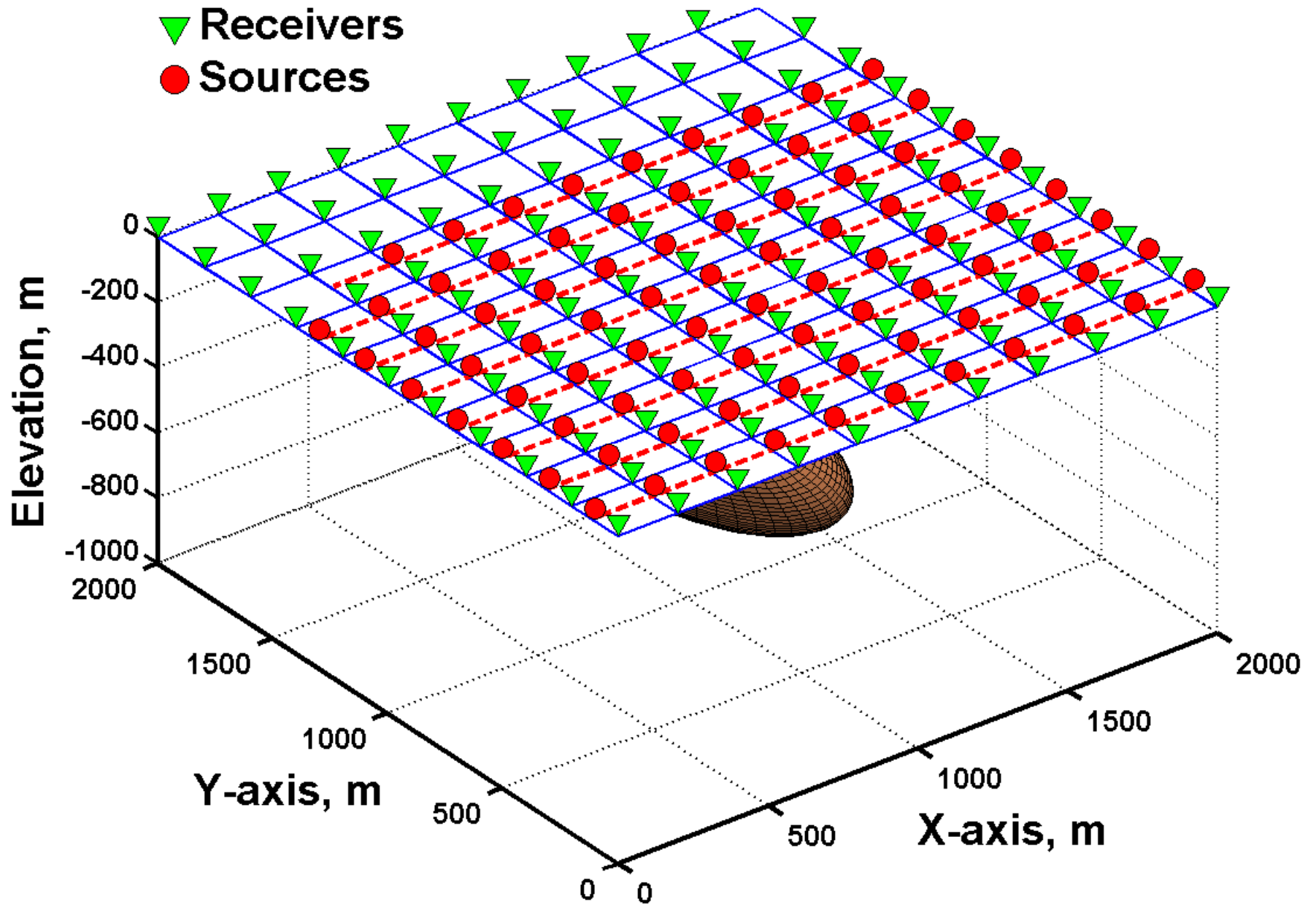
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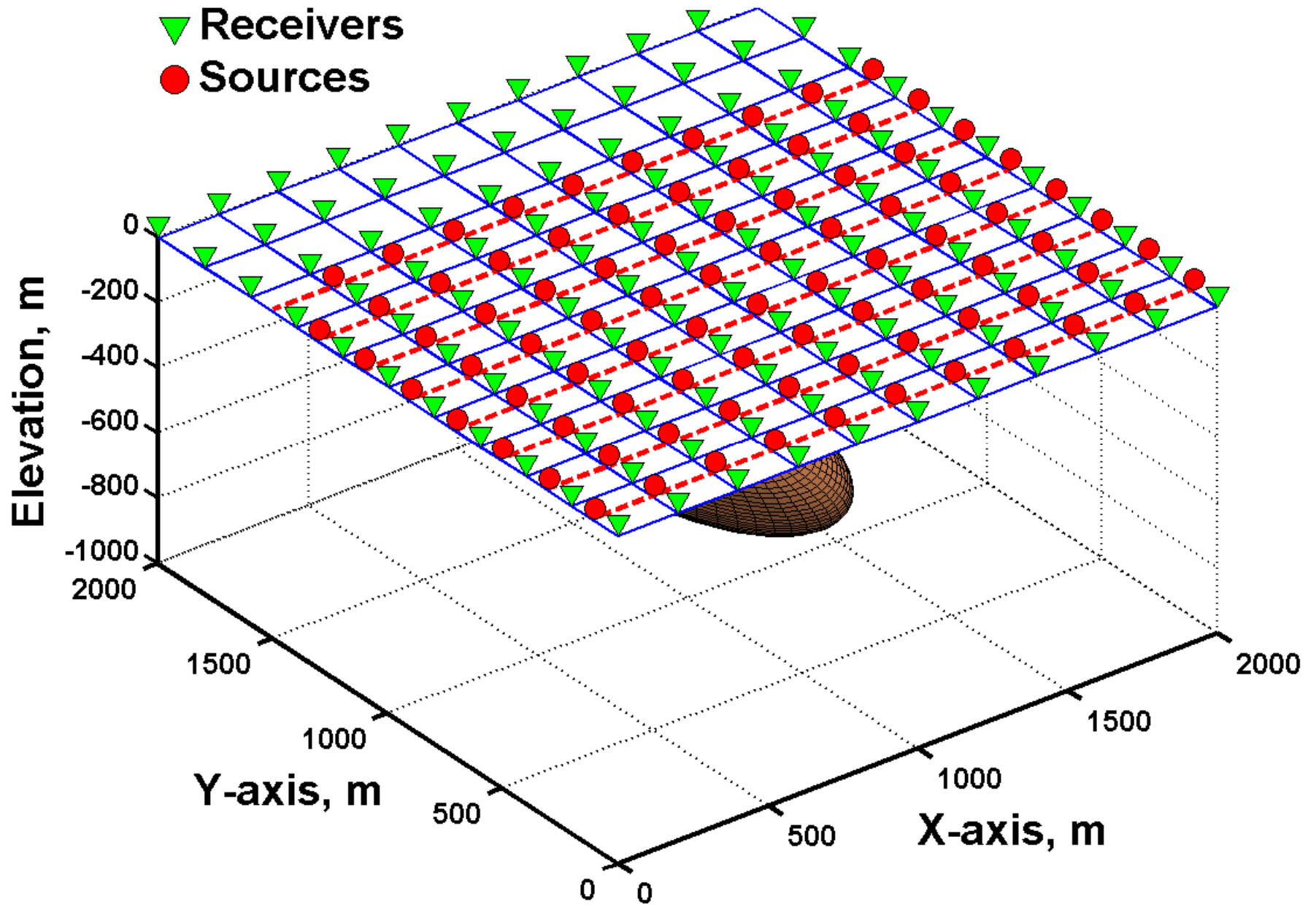
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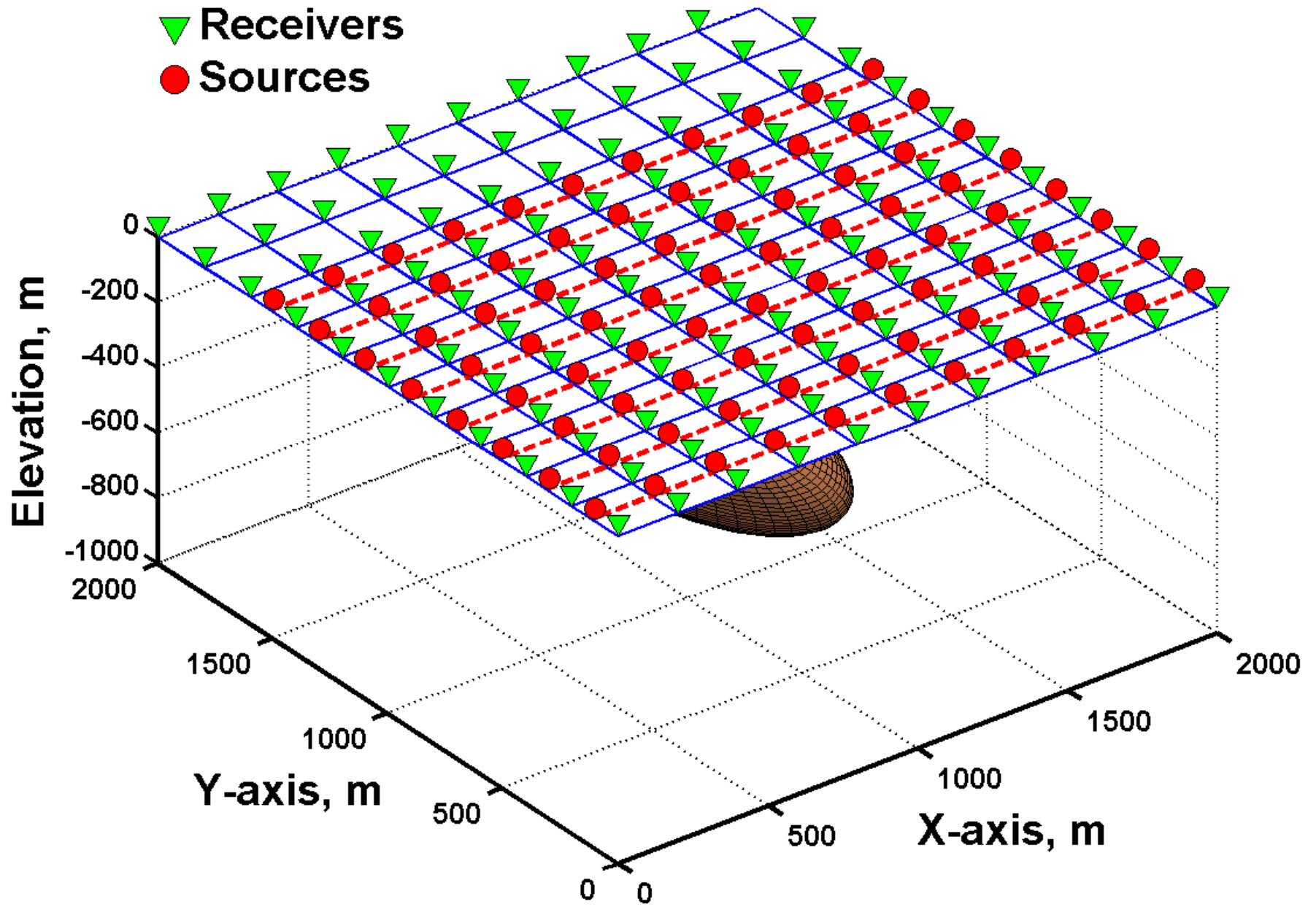
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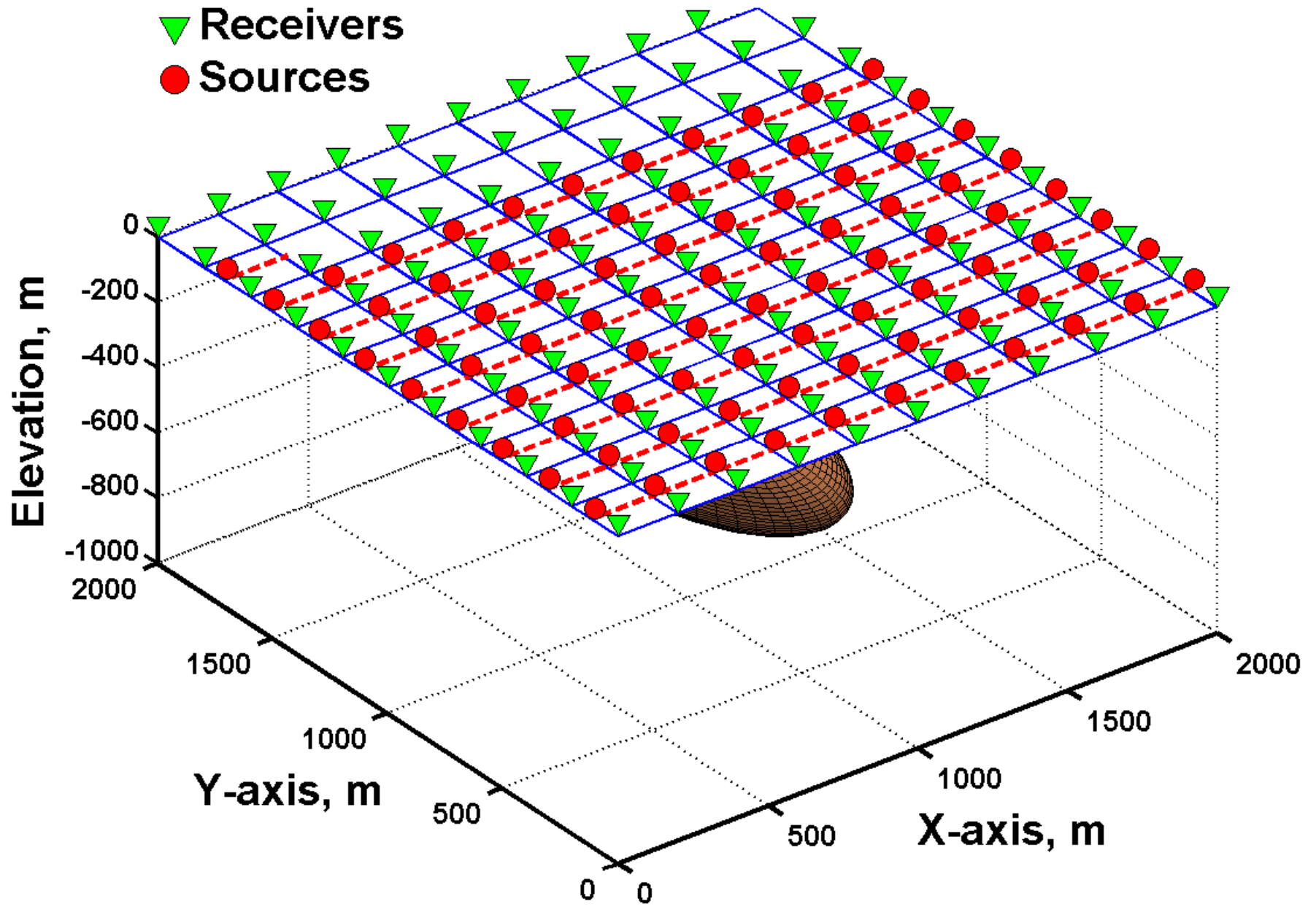
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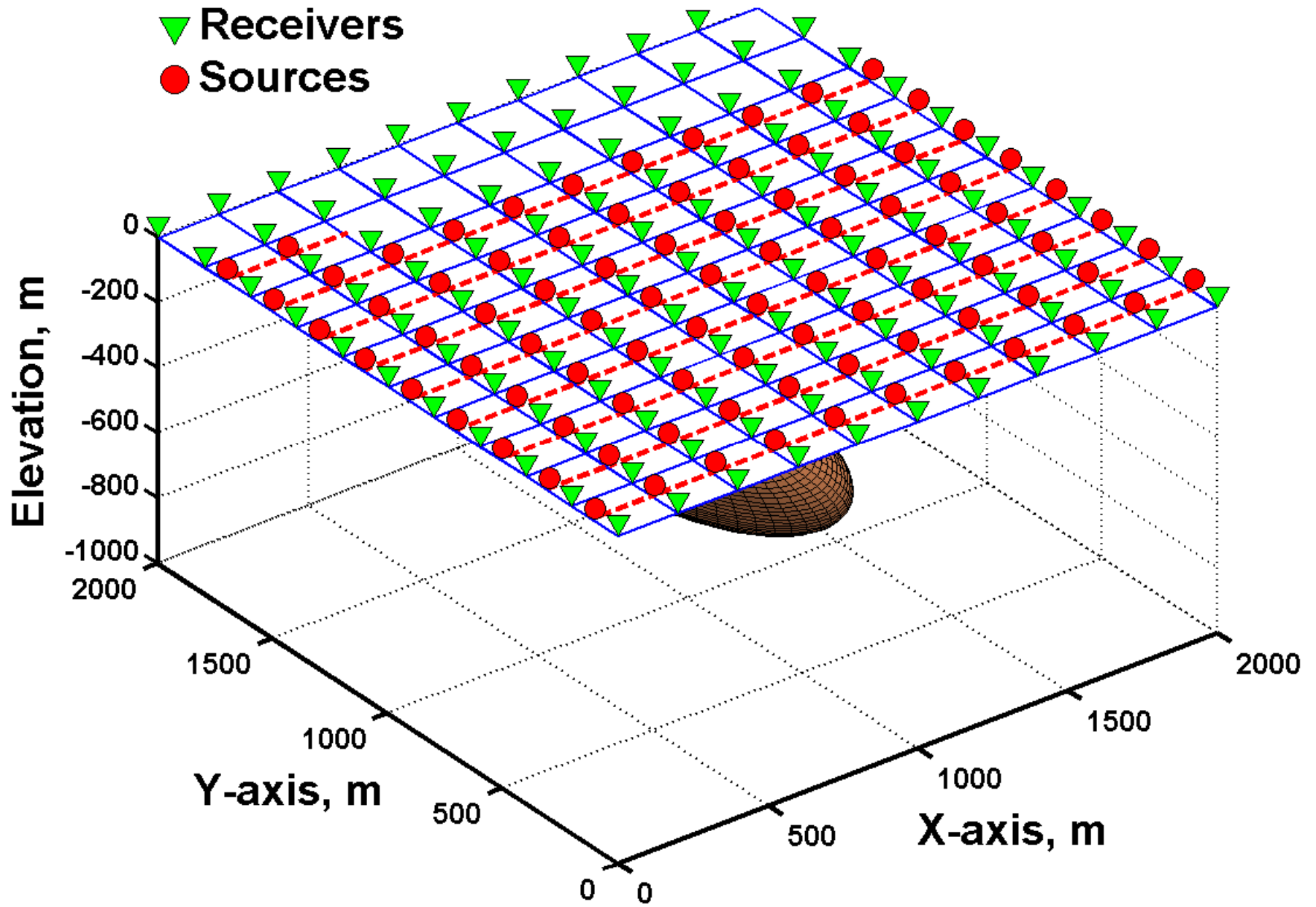
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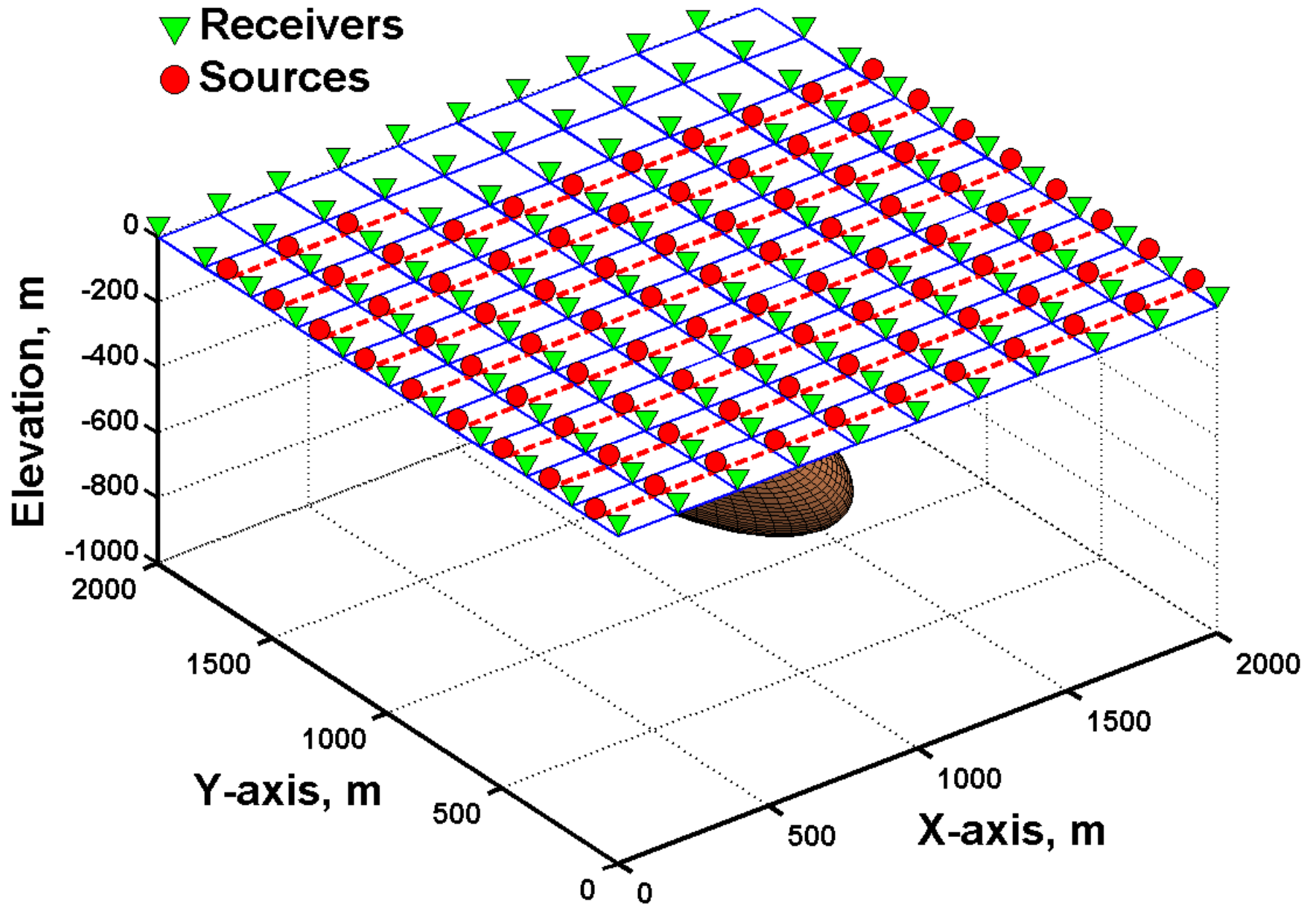
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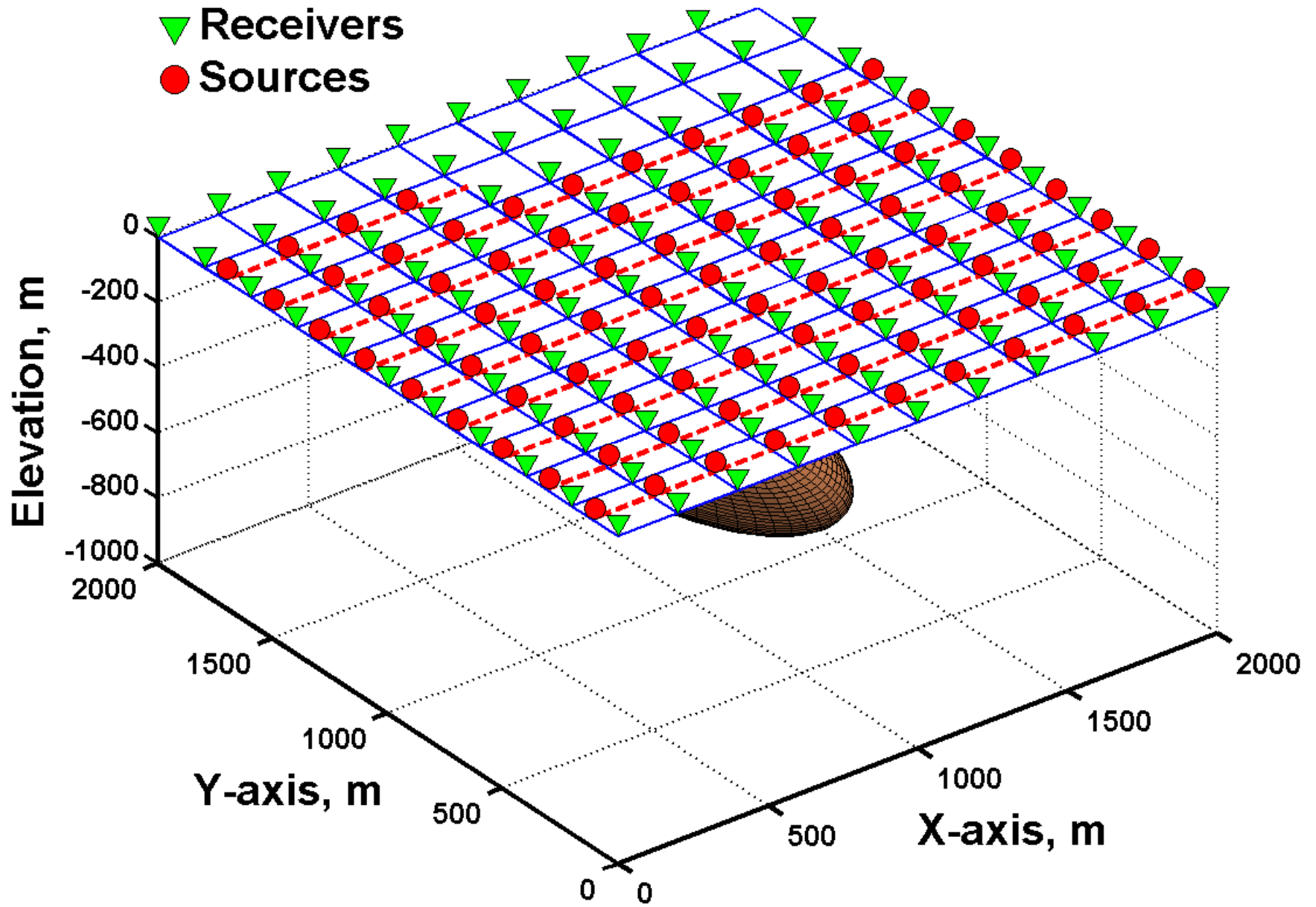
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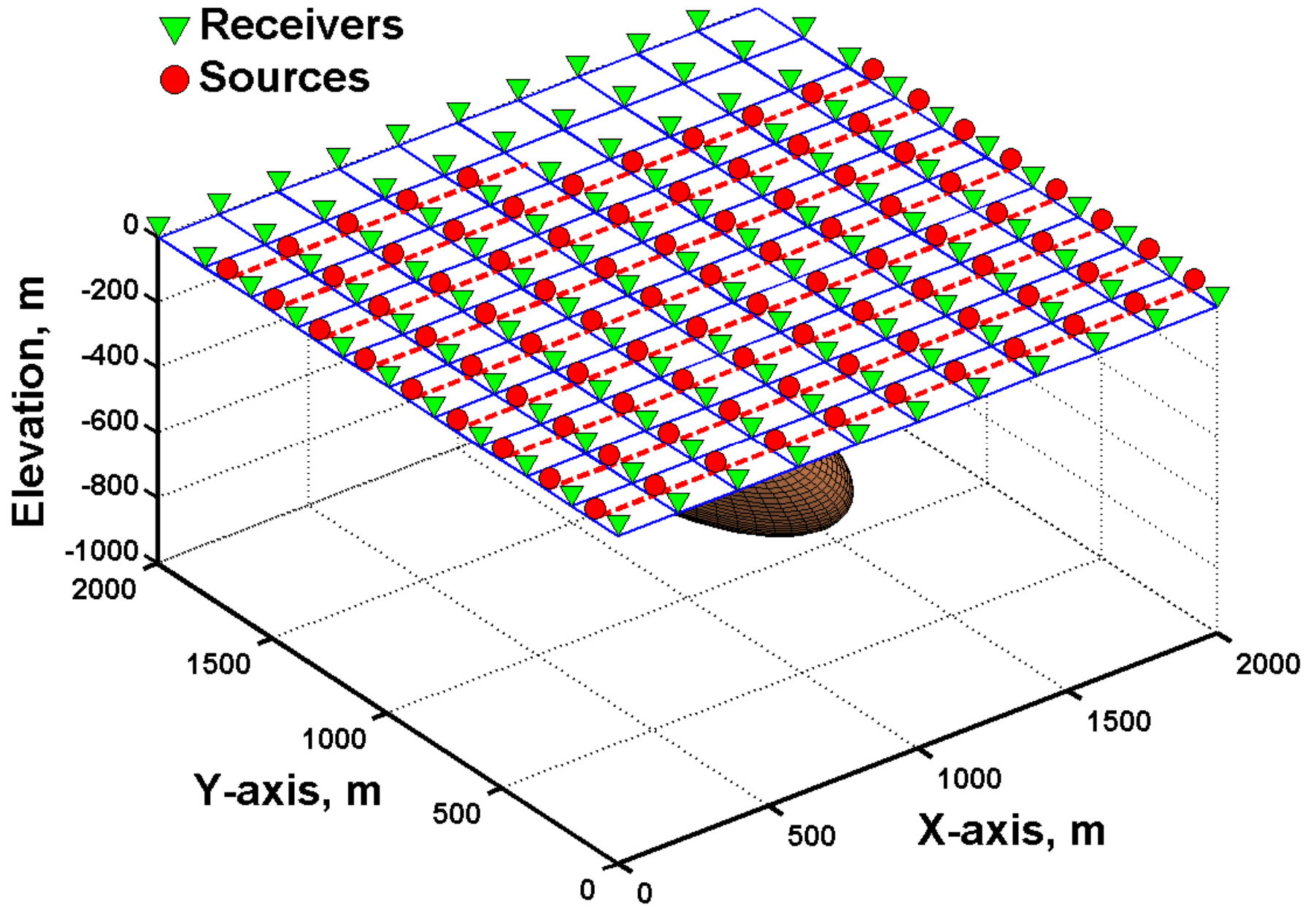
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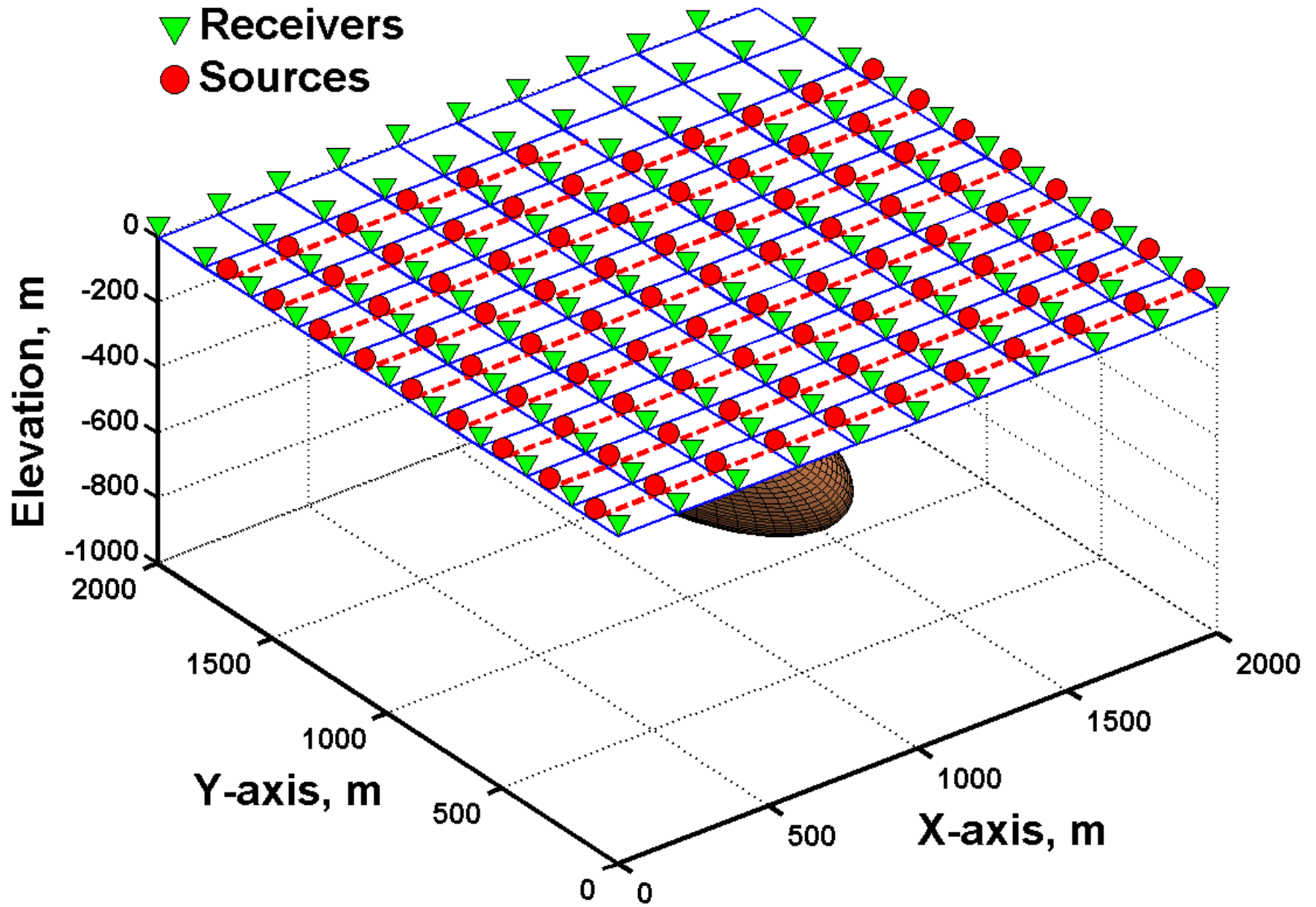
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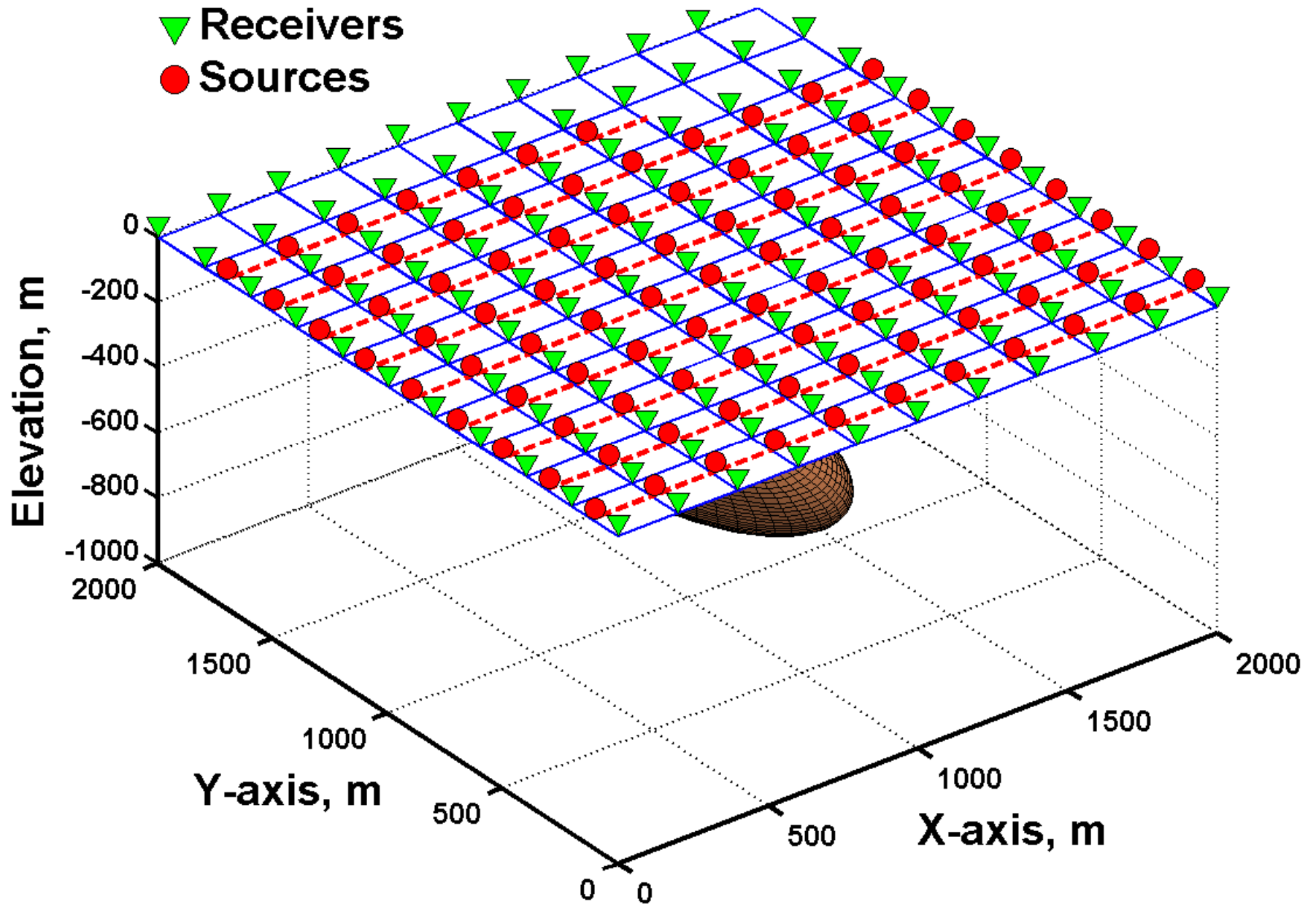
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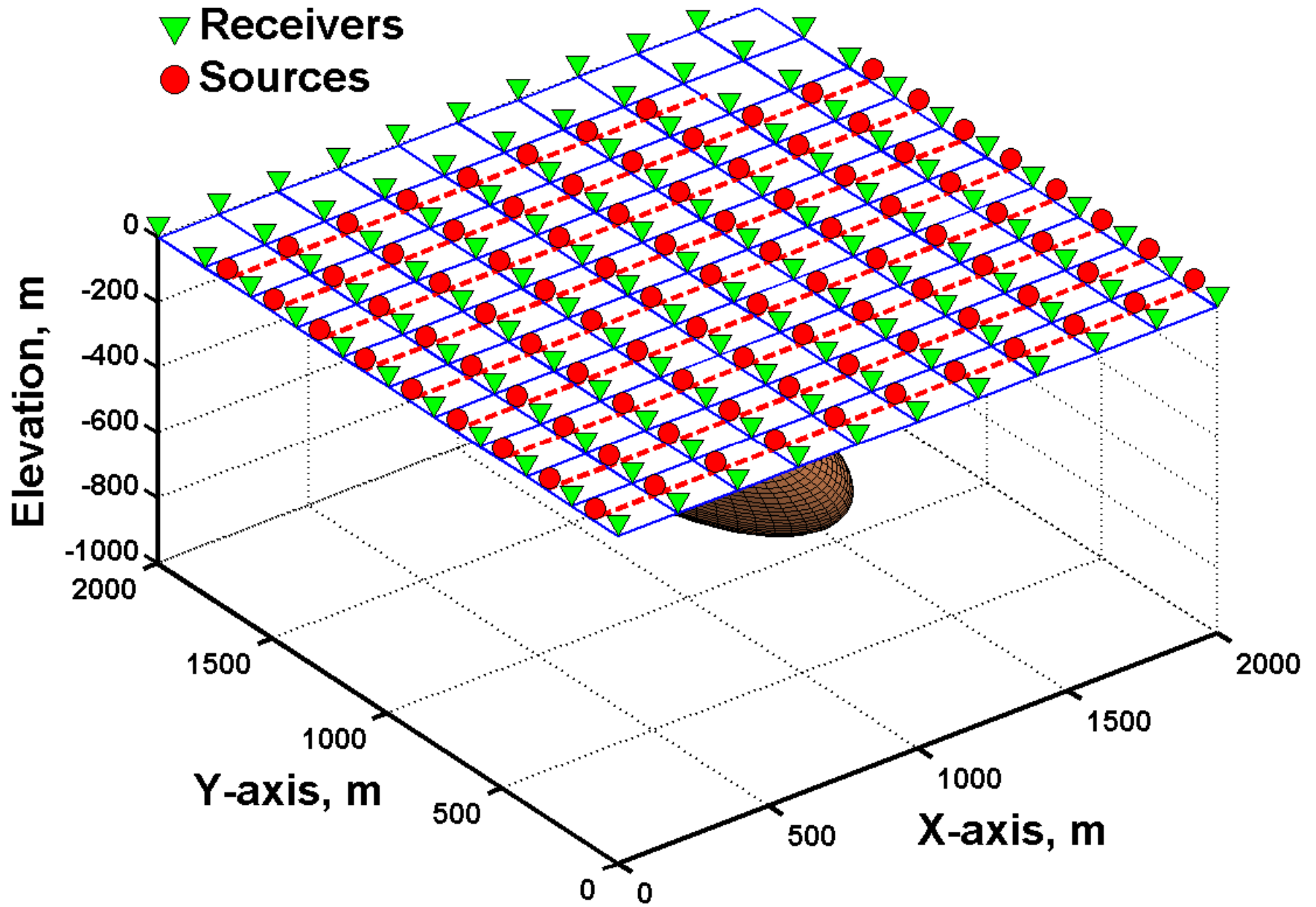
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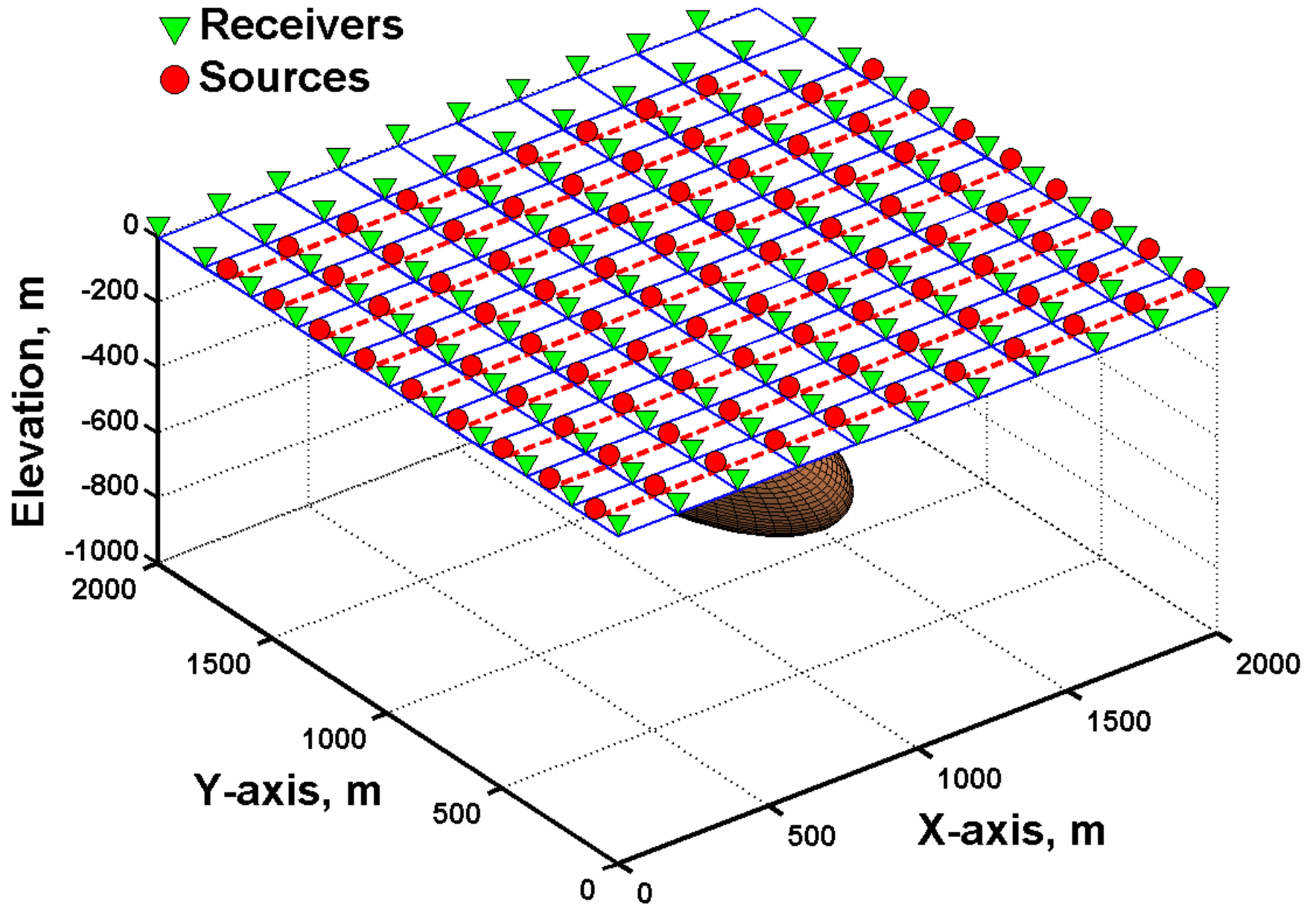
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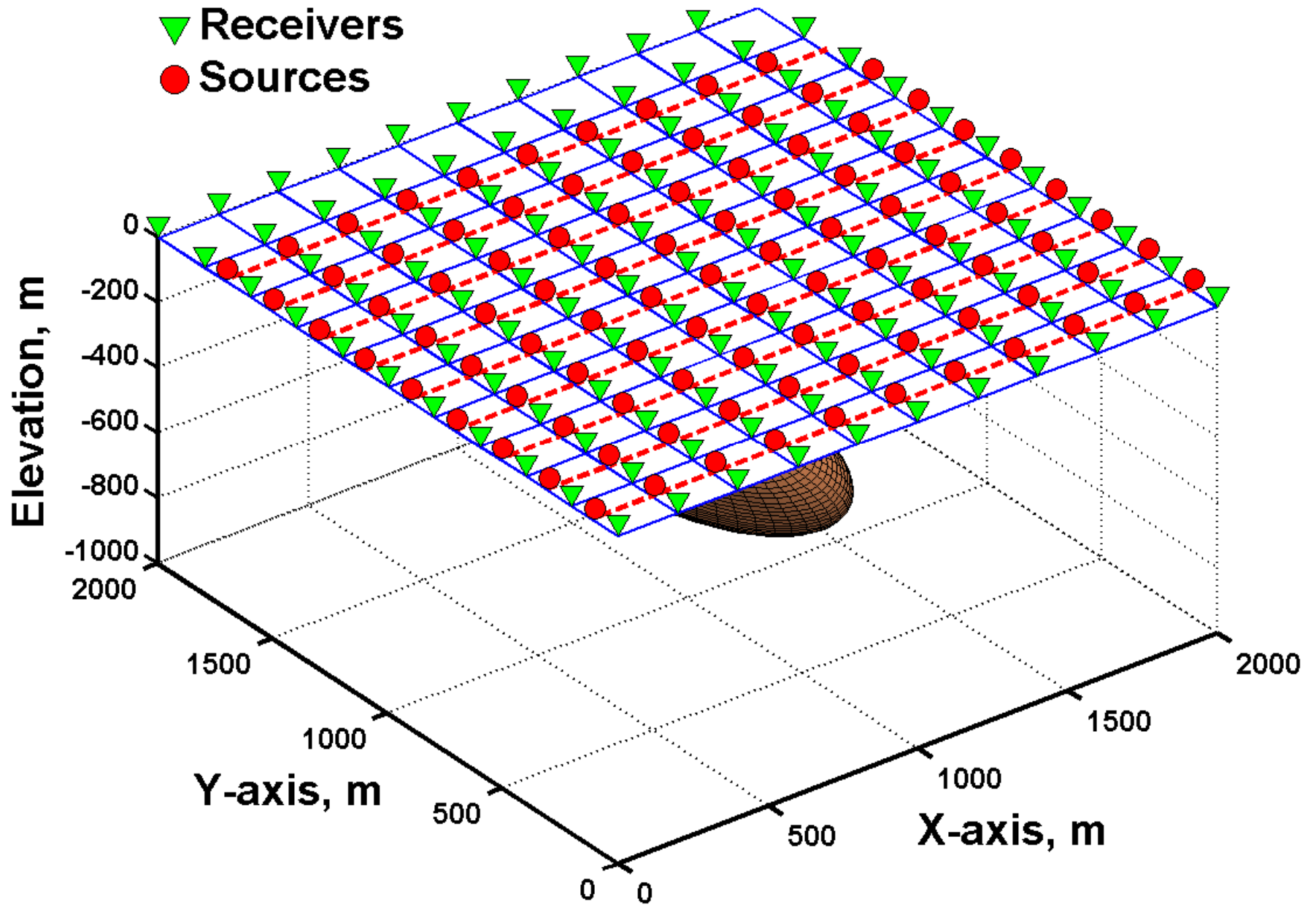
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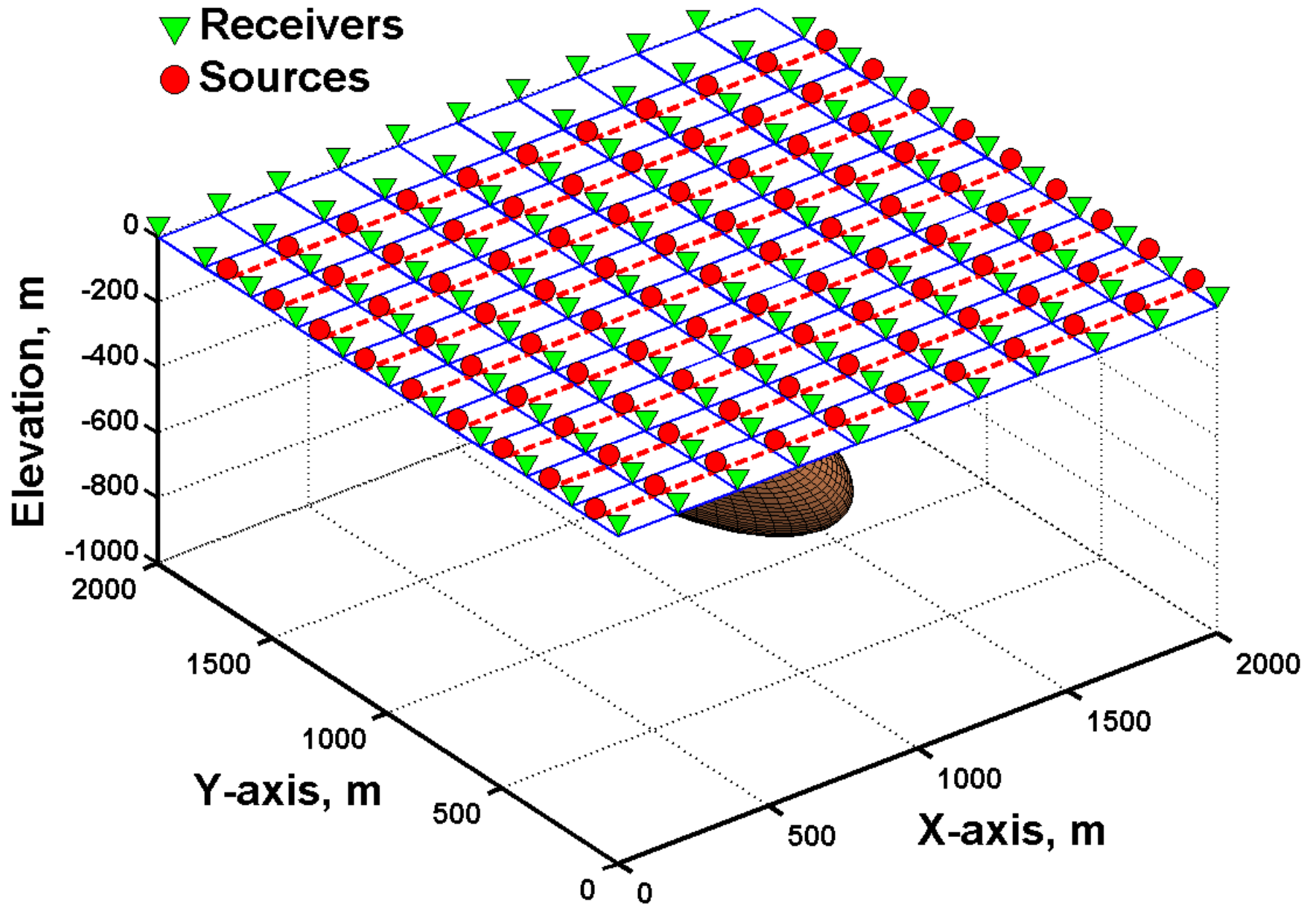
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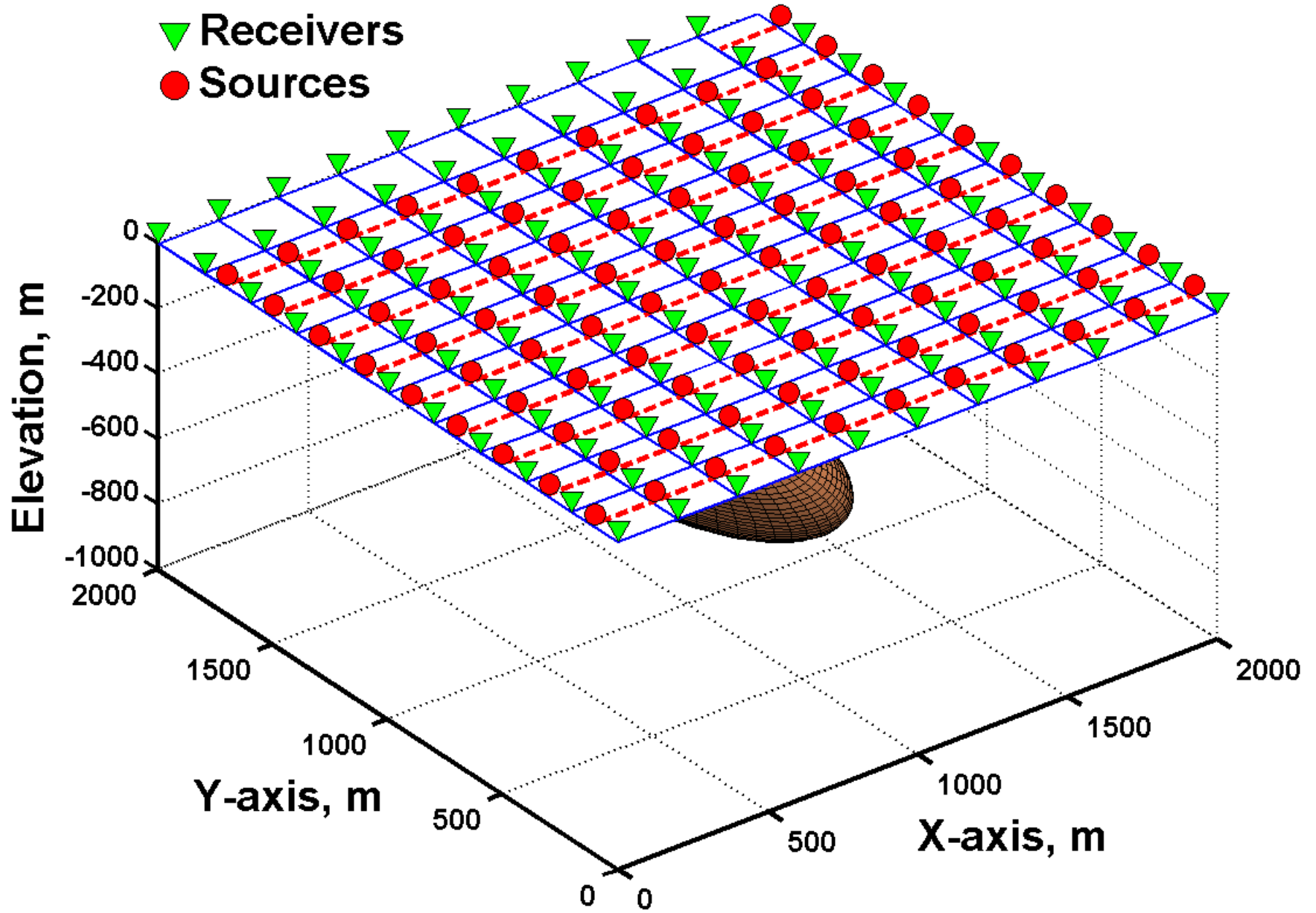
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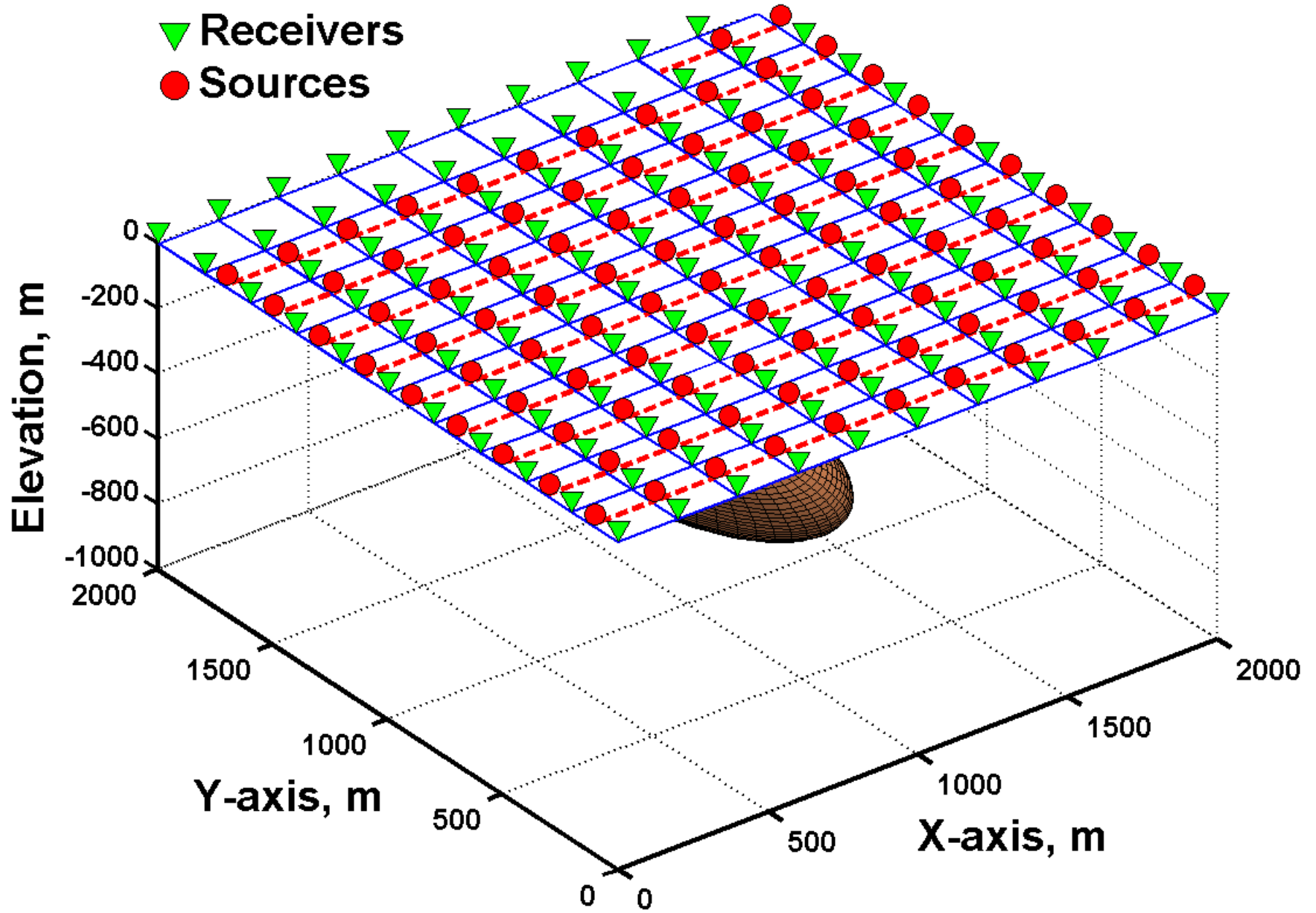
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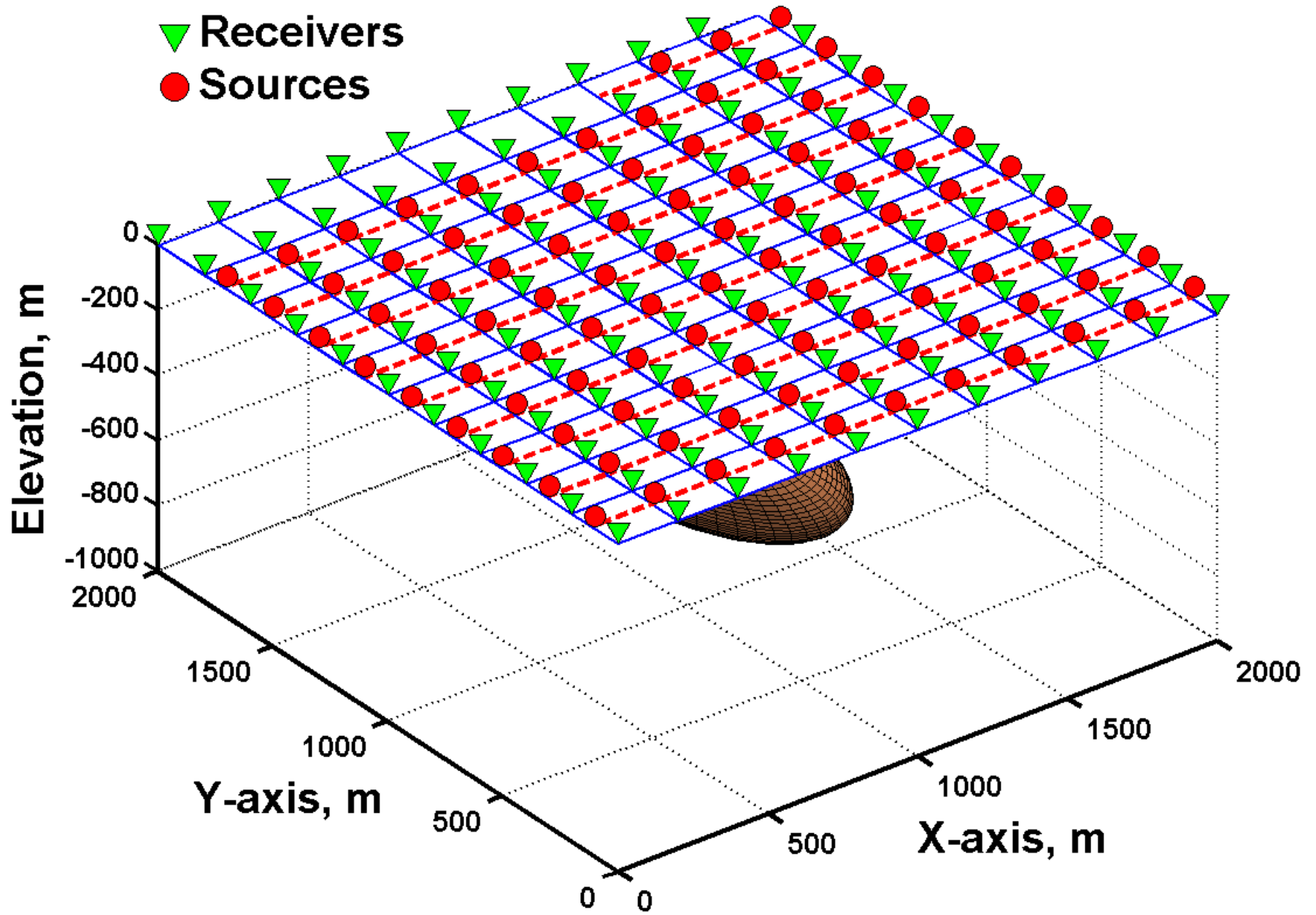
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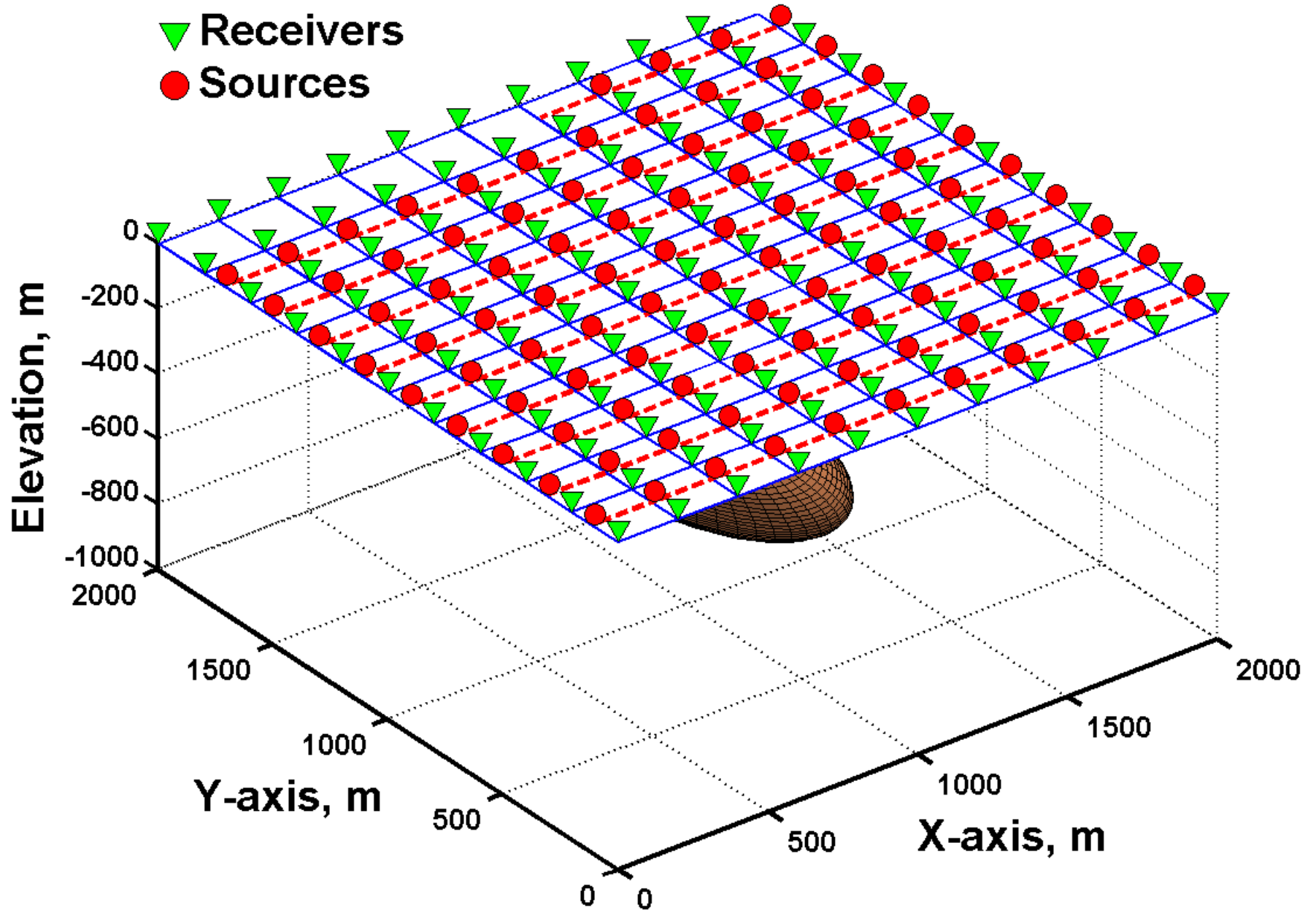
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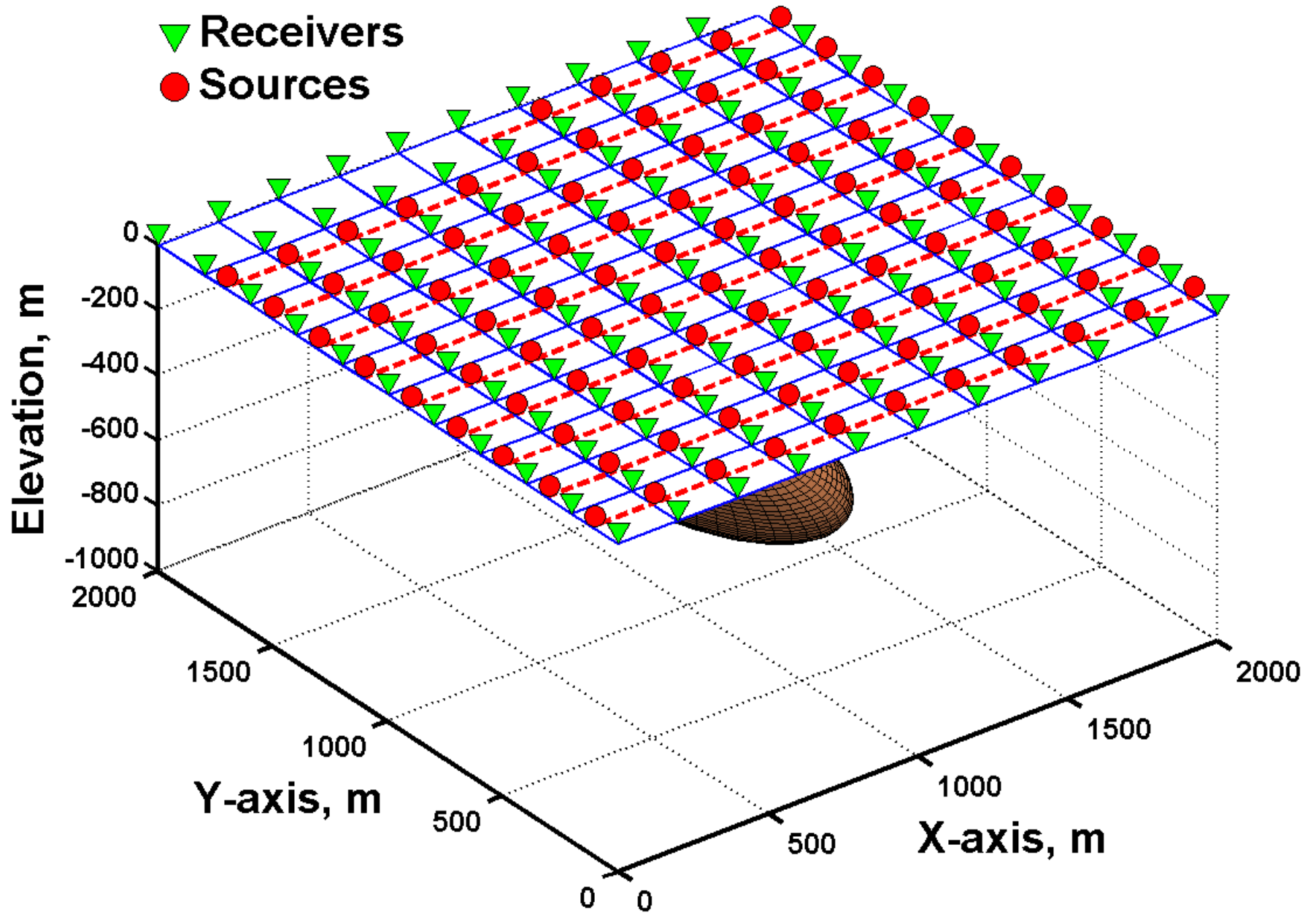
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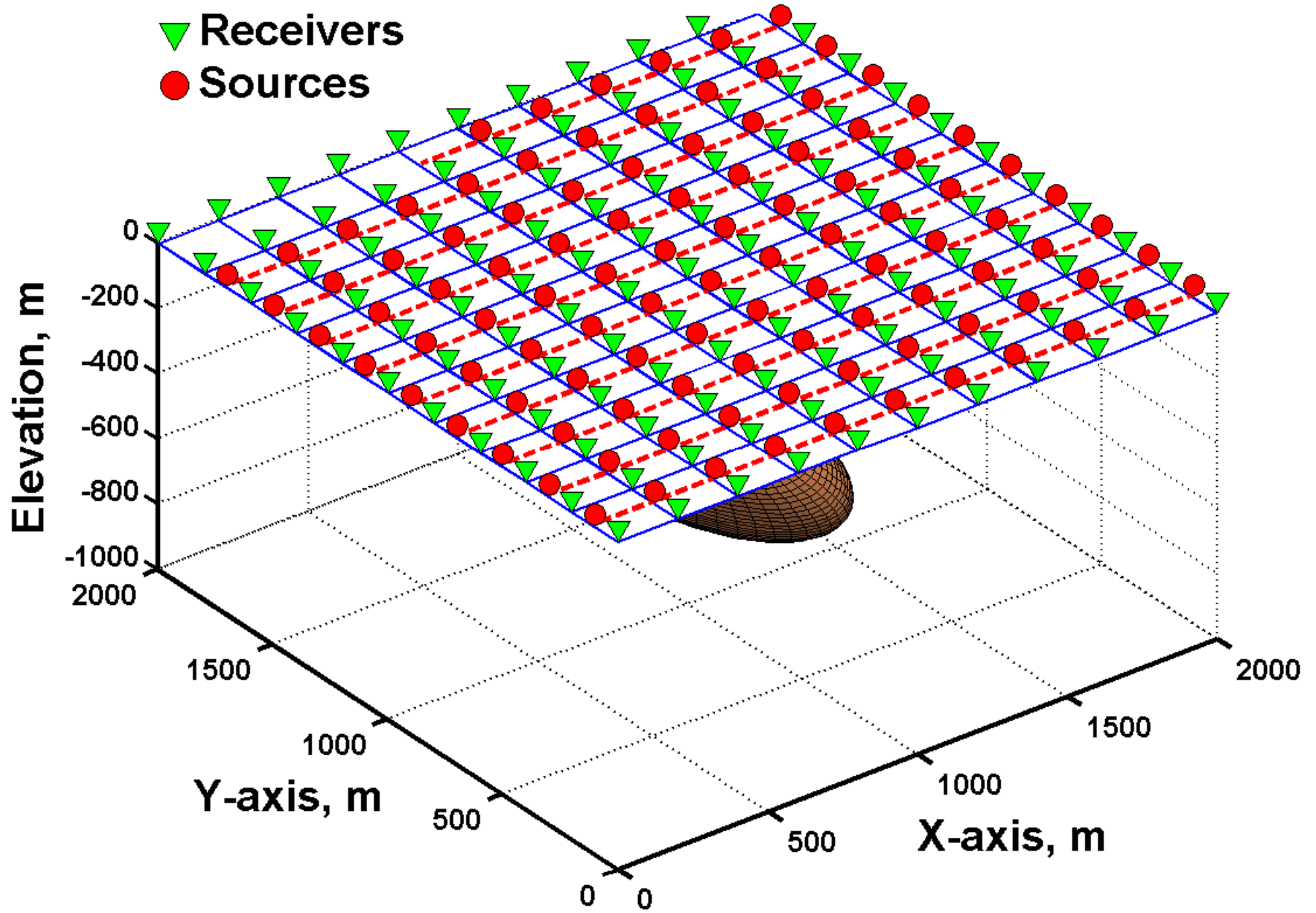
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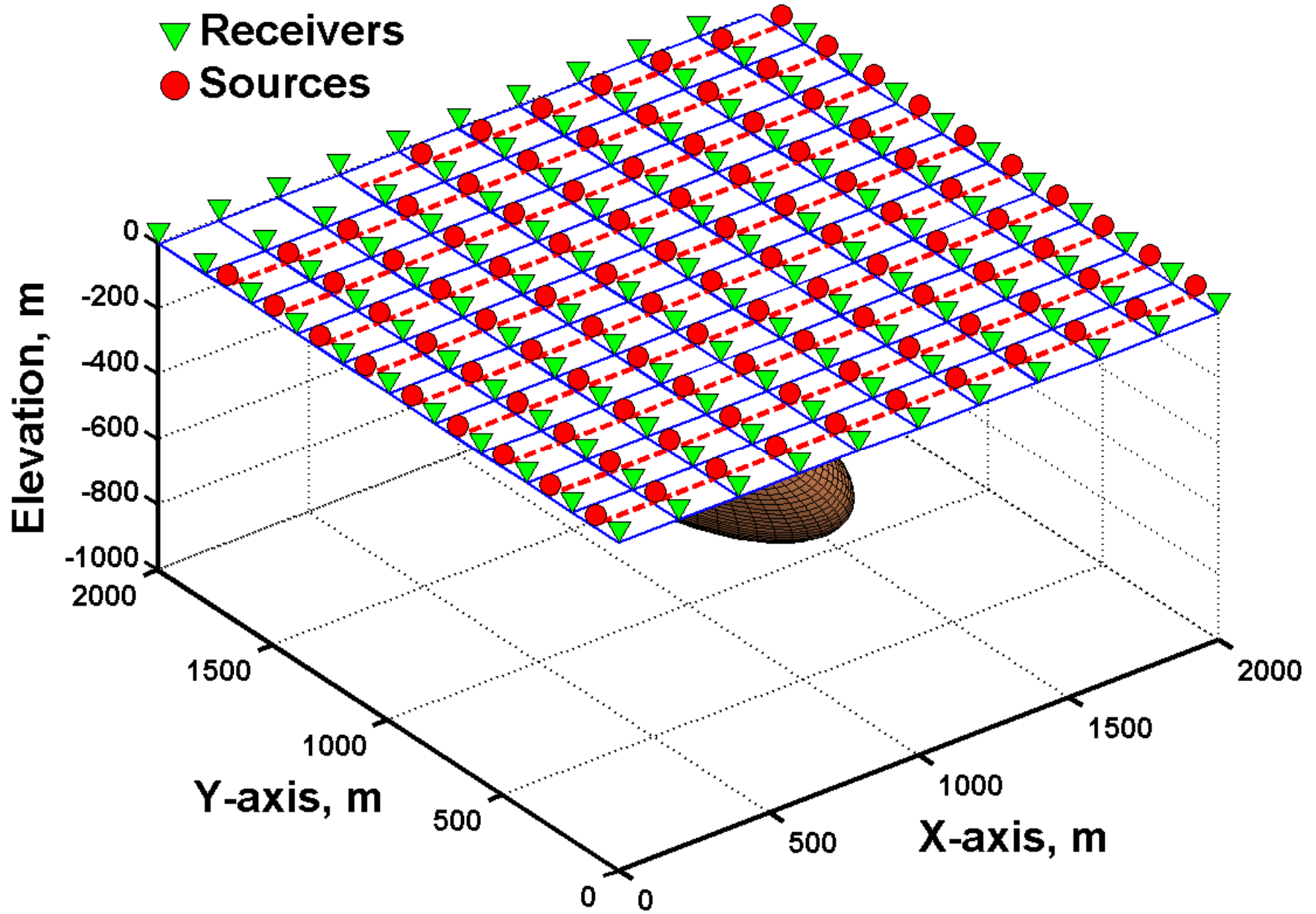
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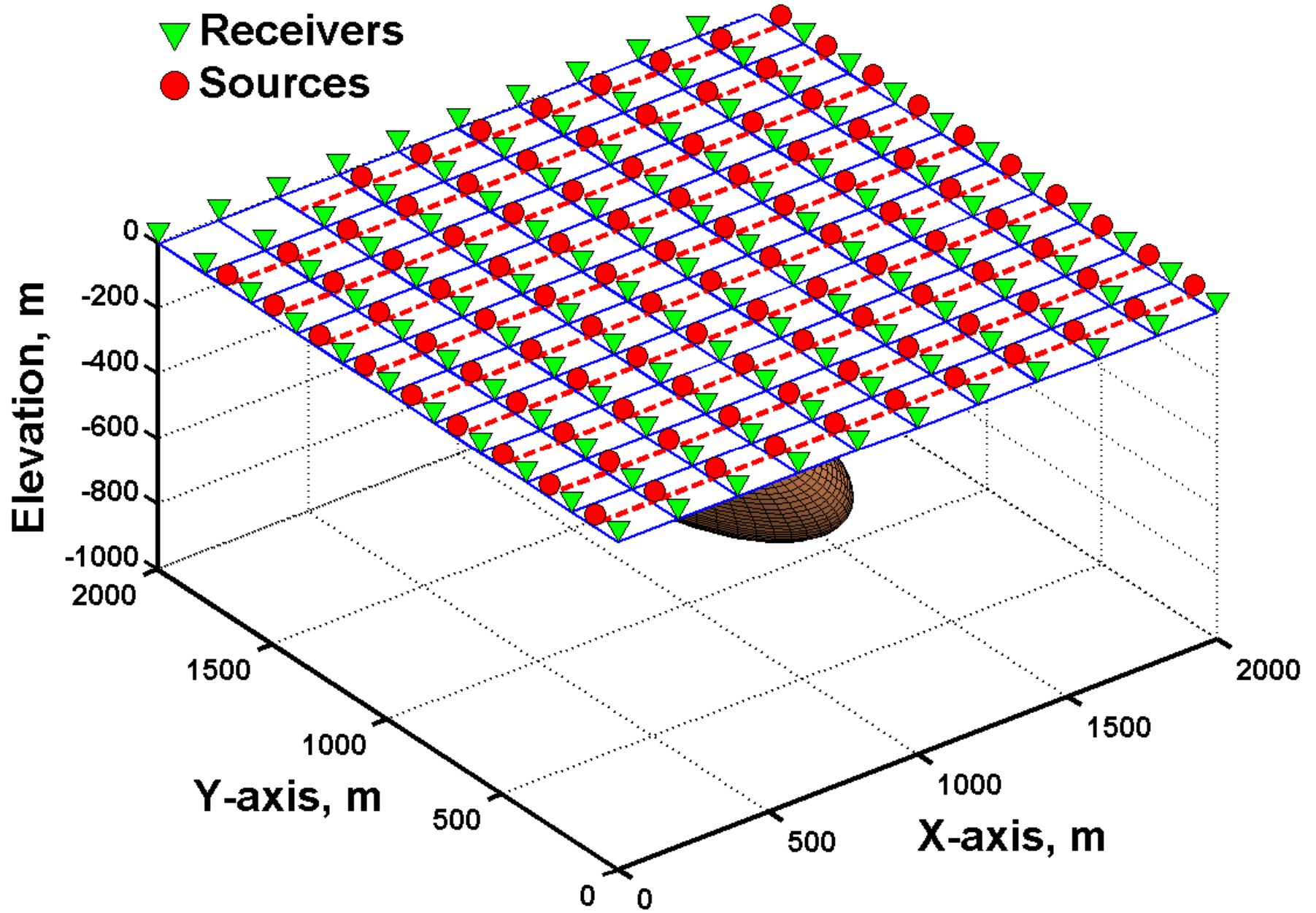
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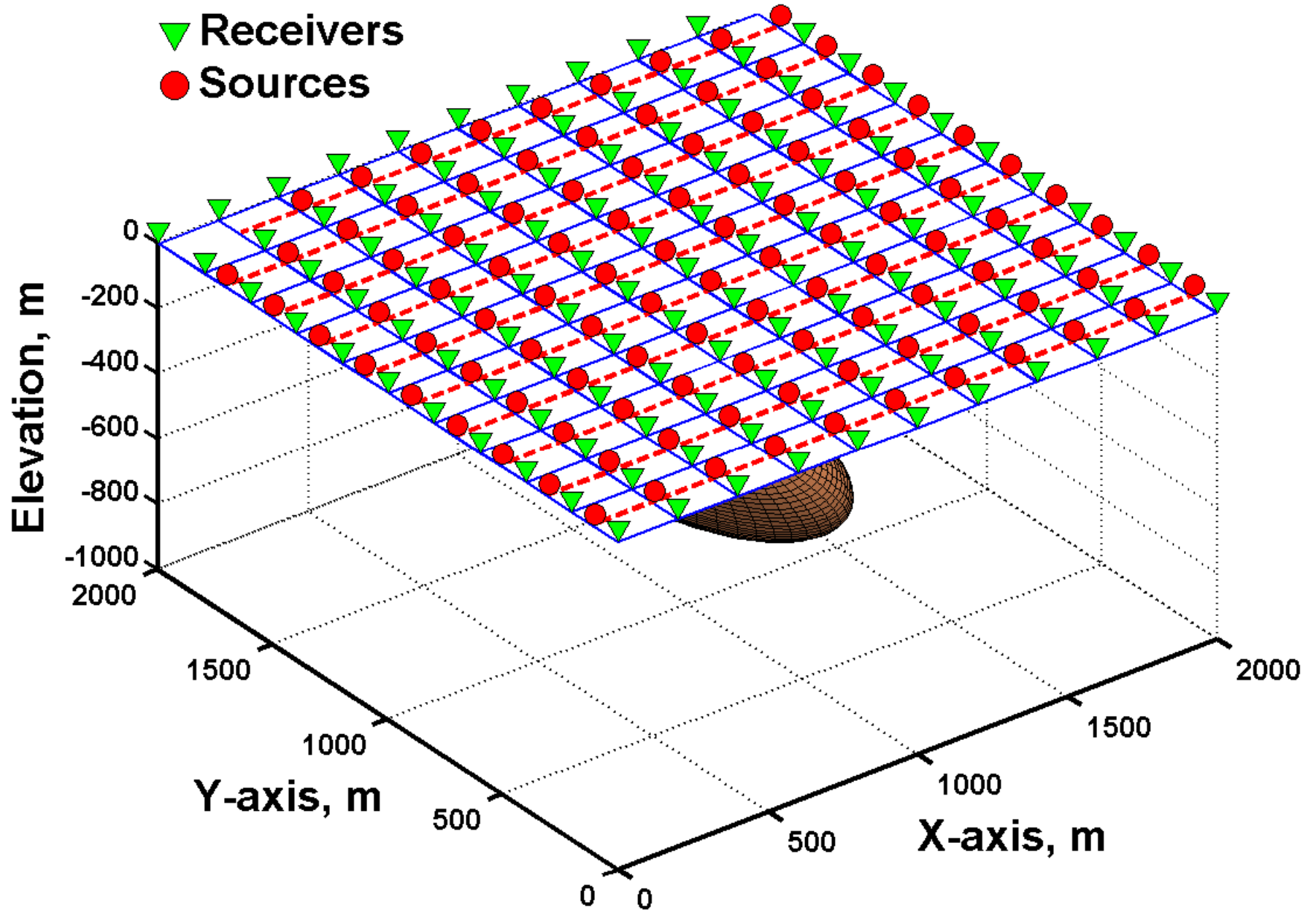
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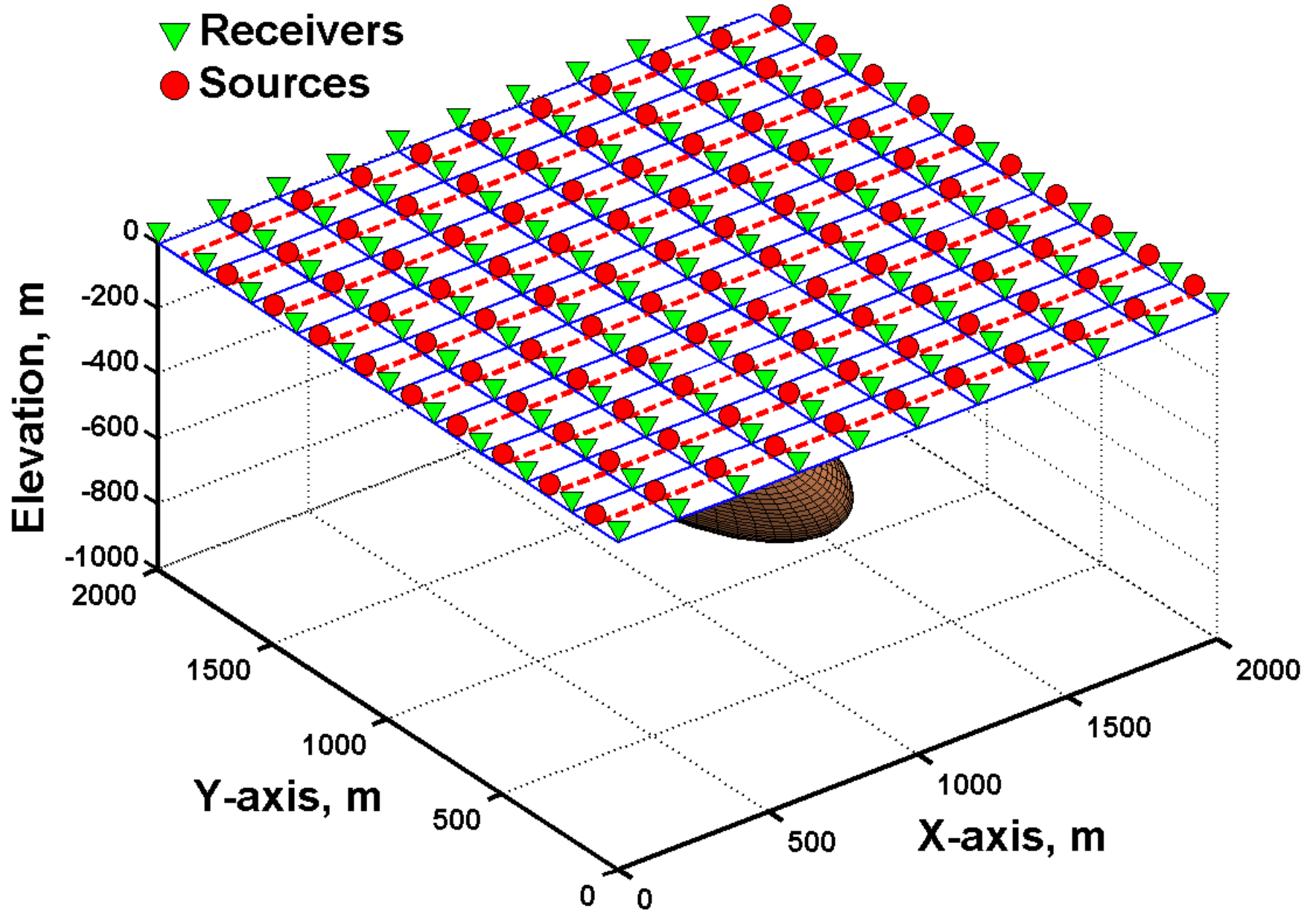
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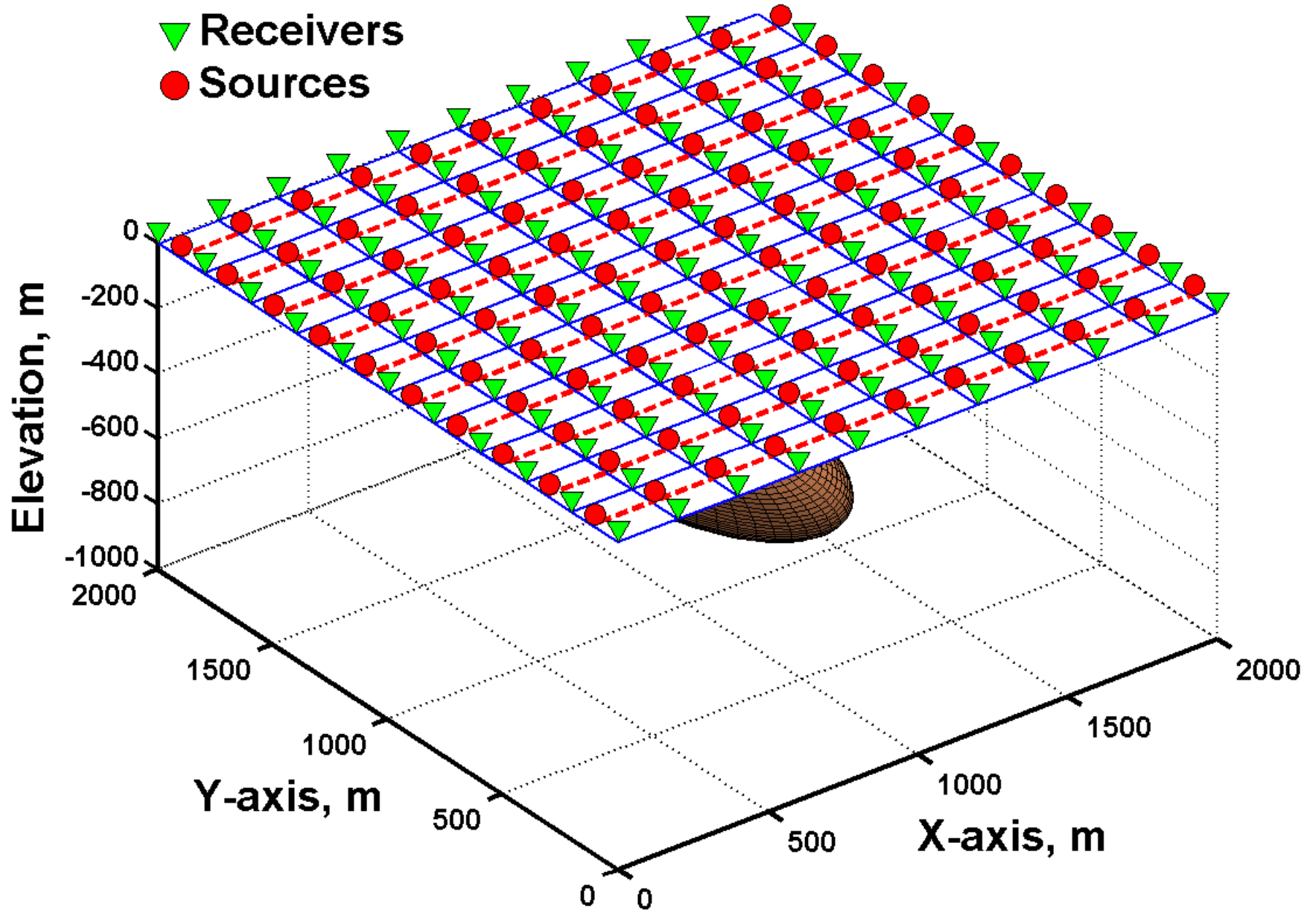
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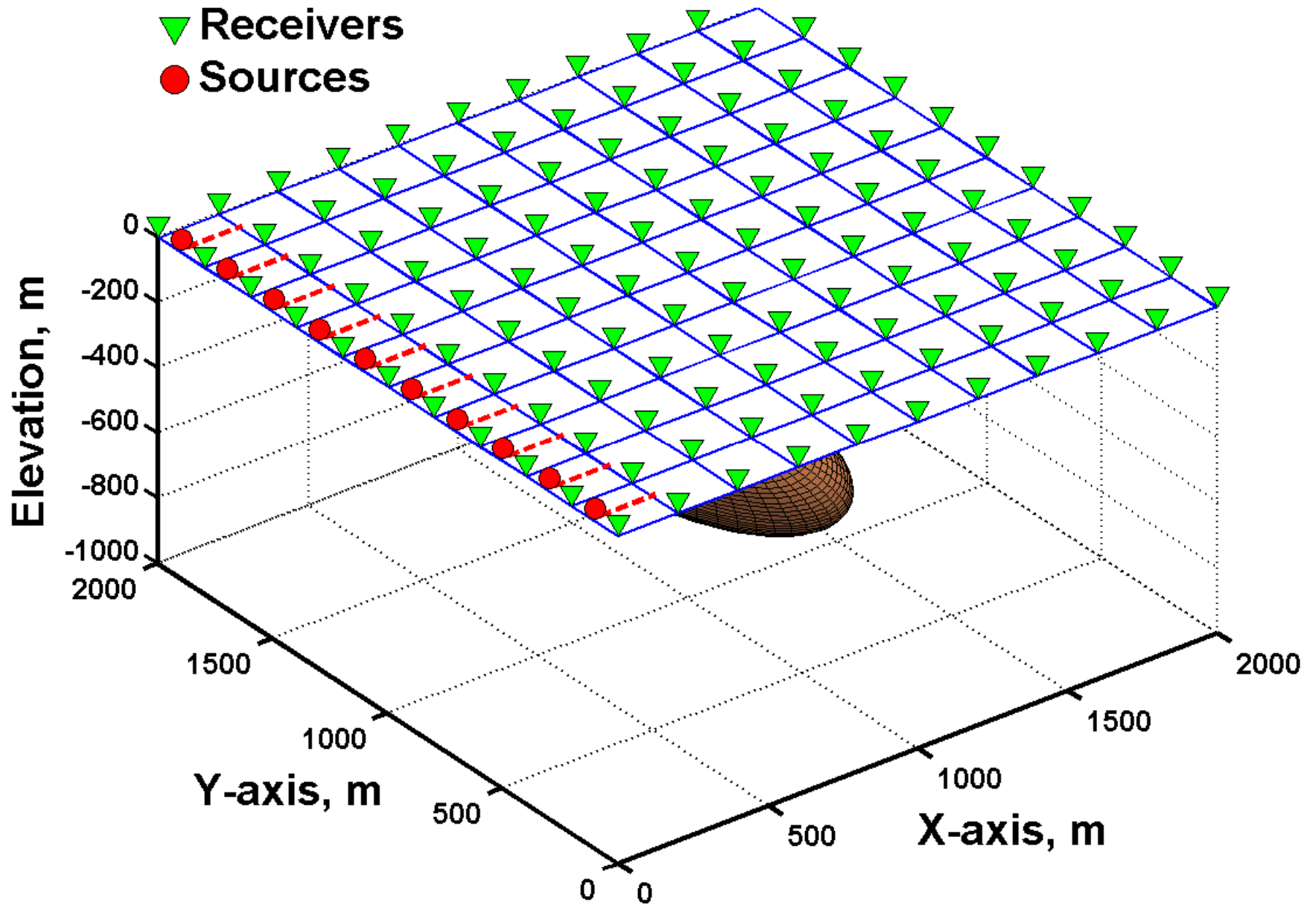
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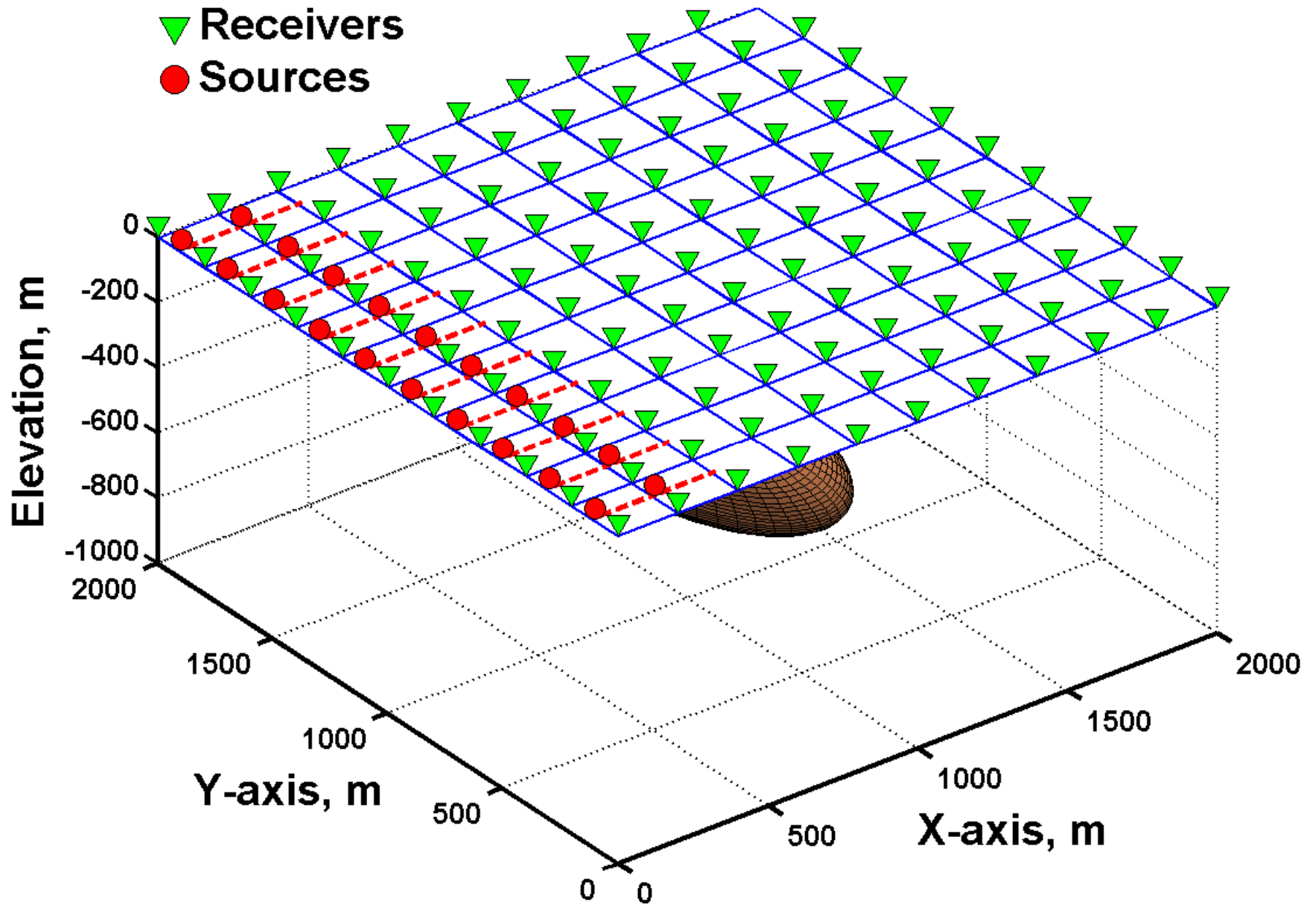
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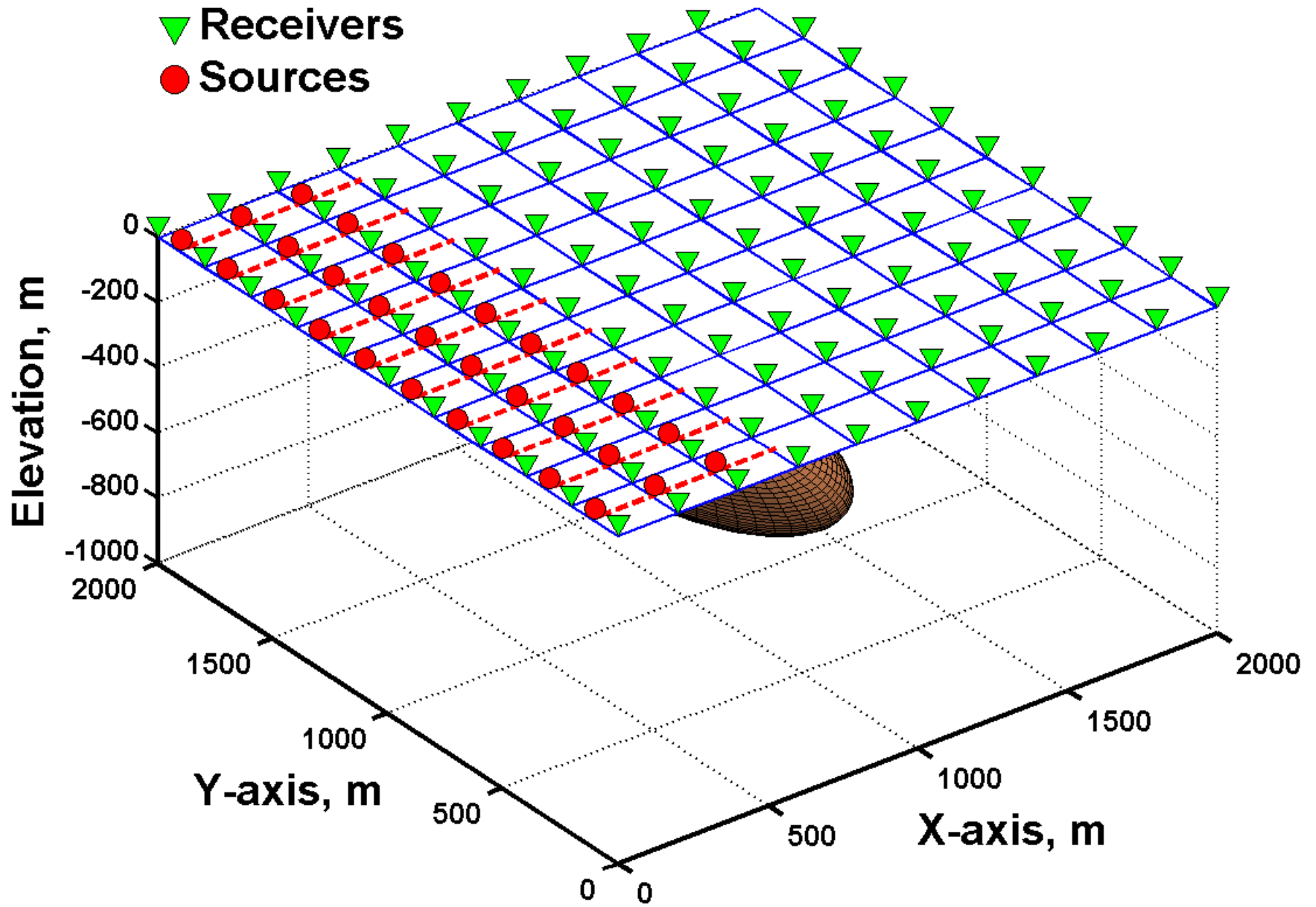
TEN-SOURCE ACQUISITION



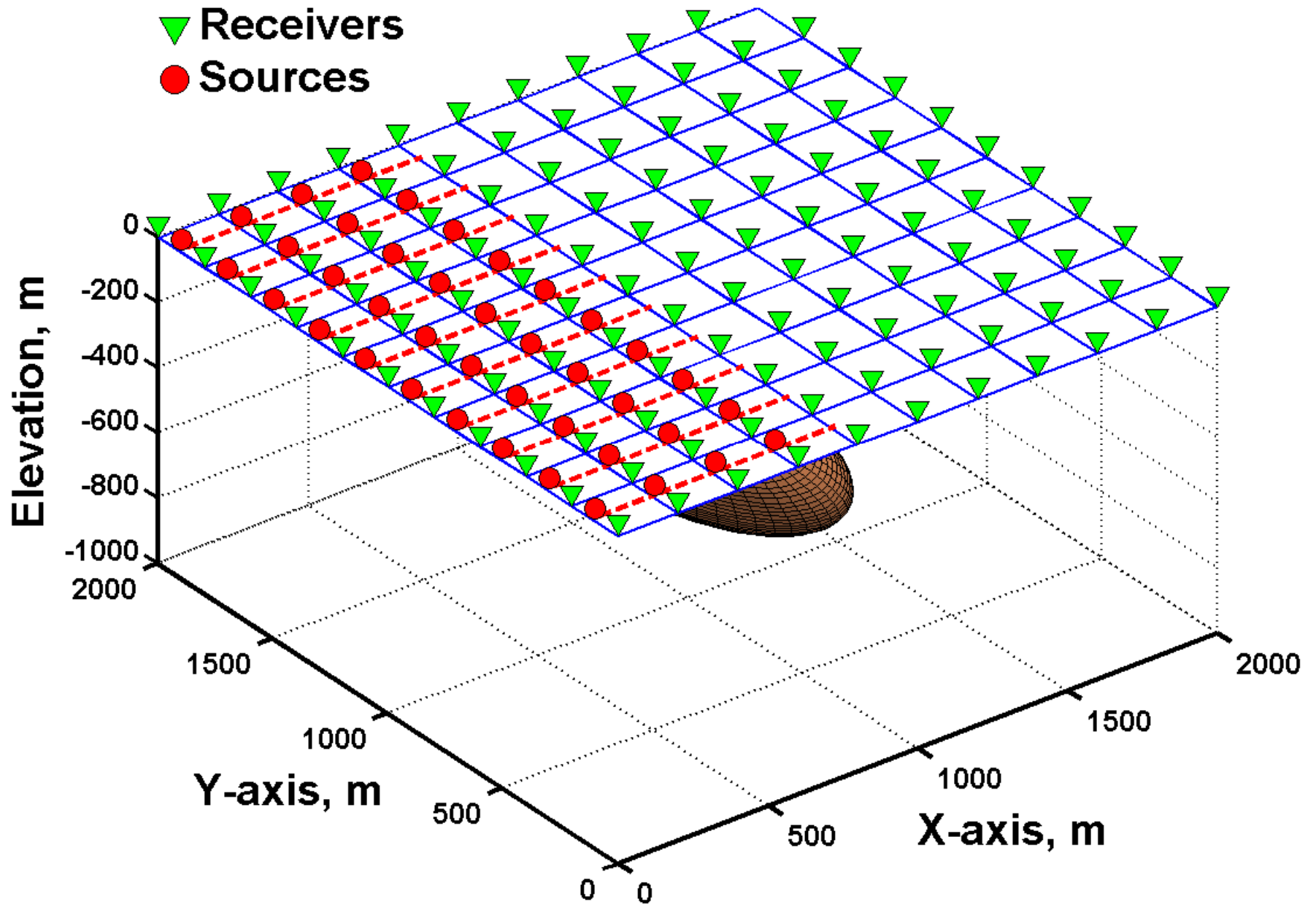
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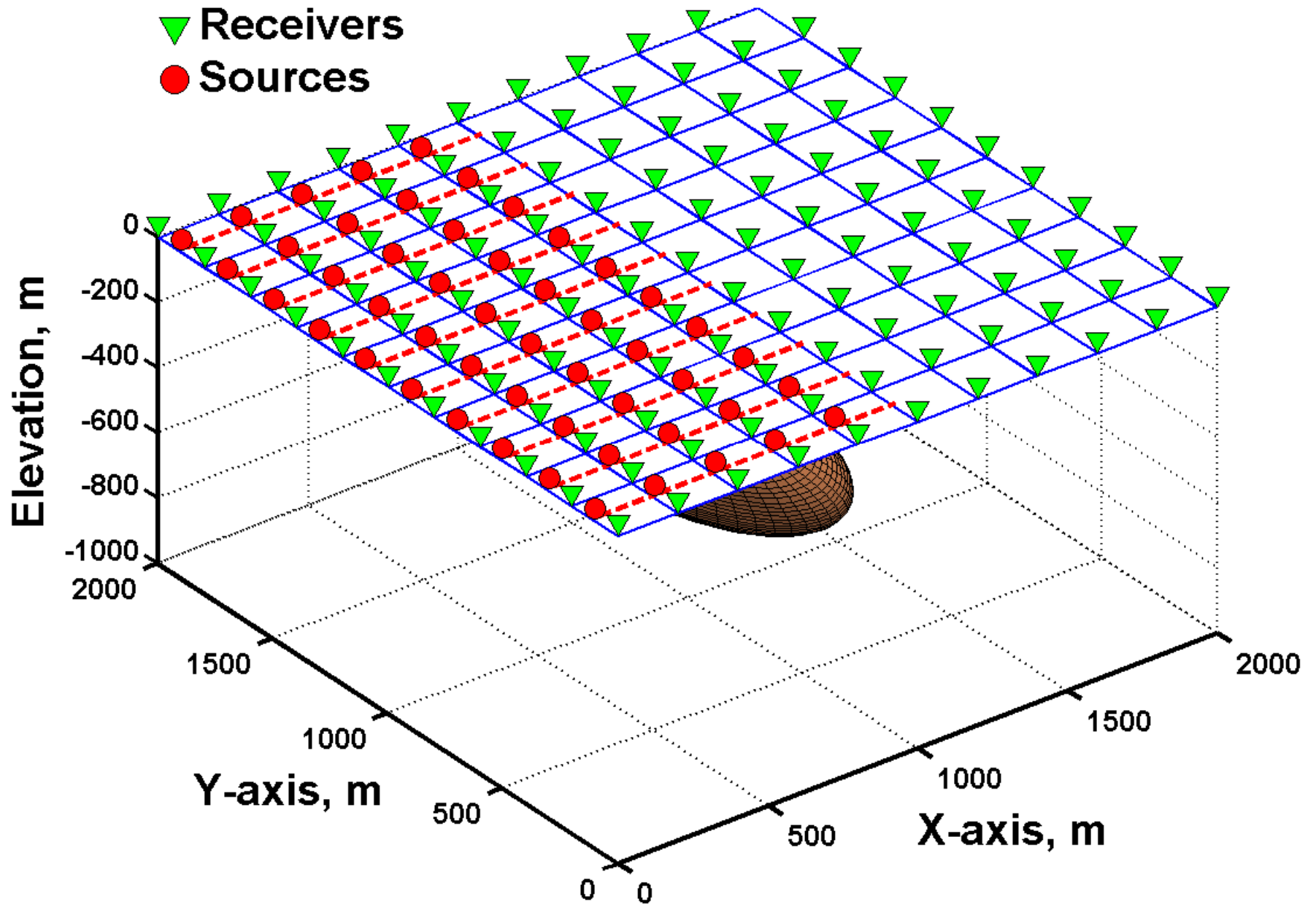
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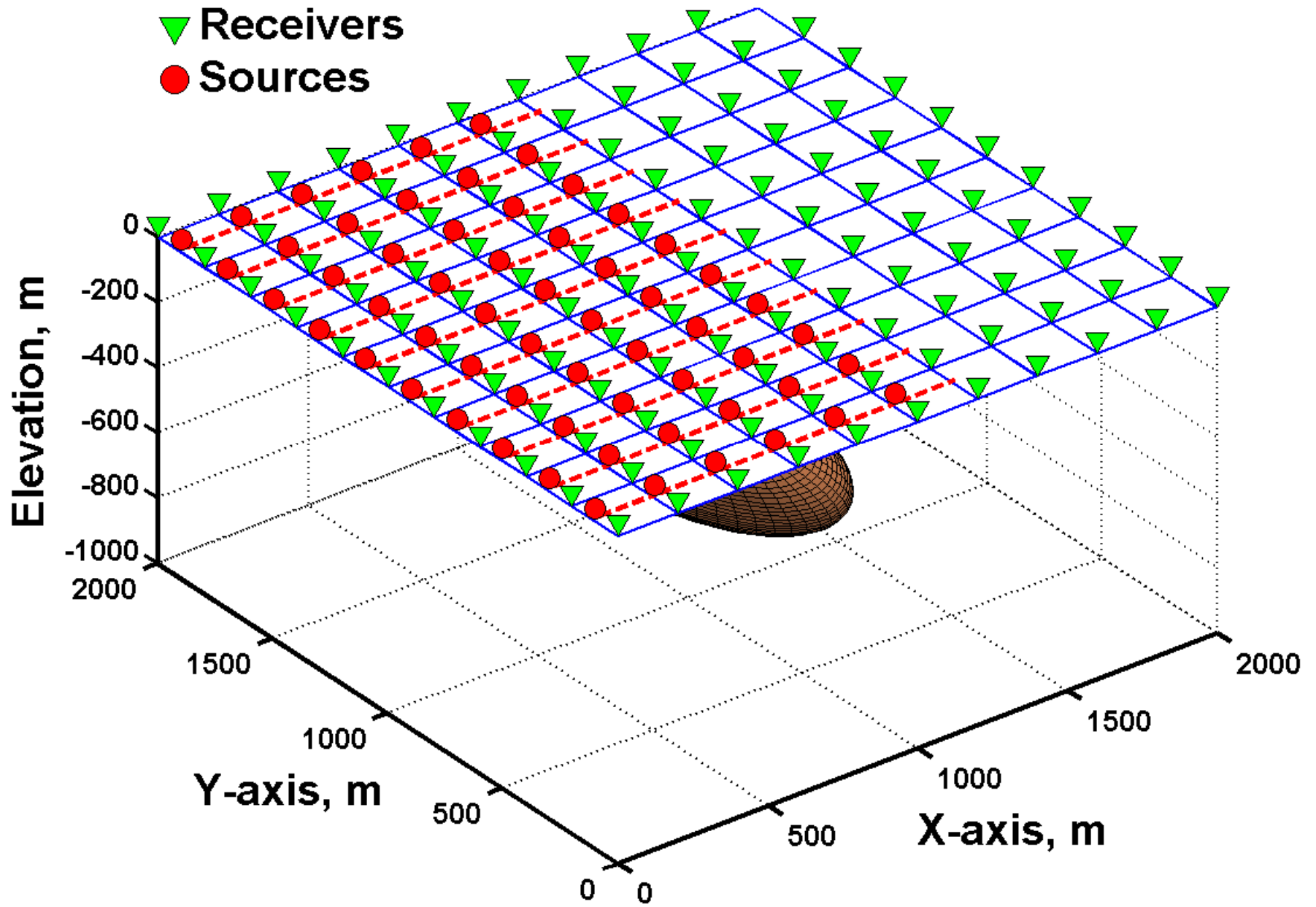
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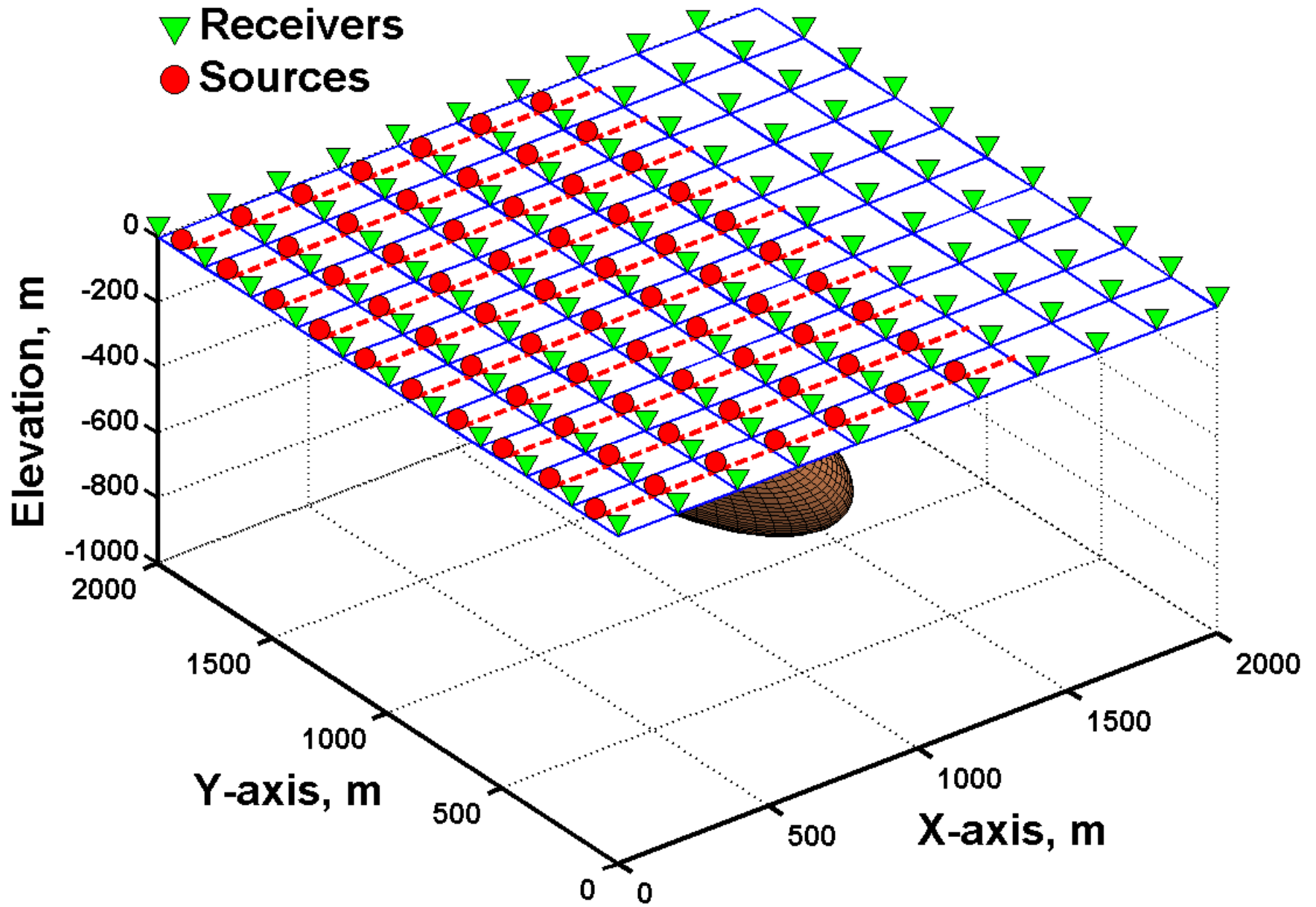
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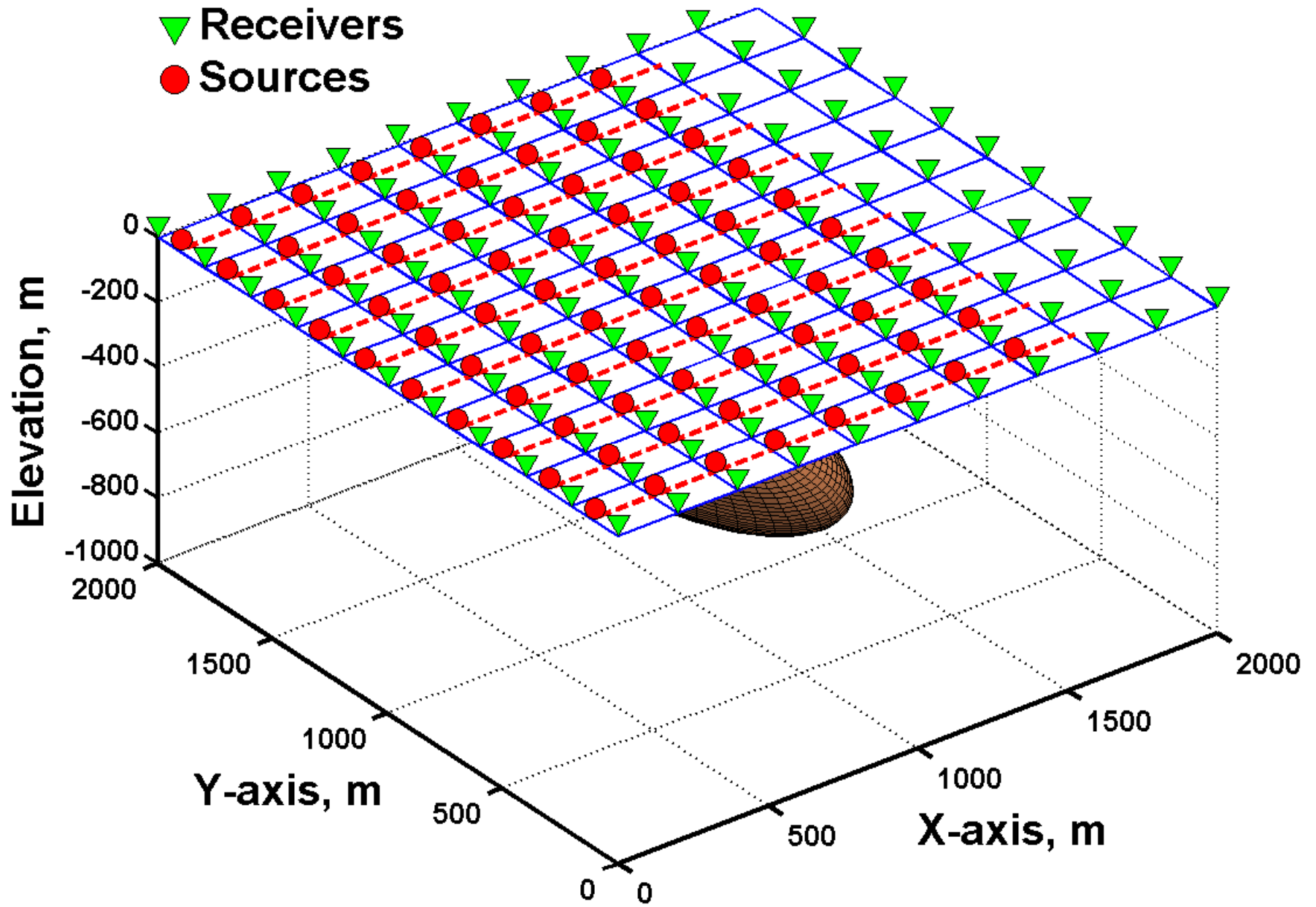
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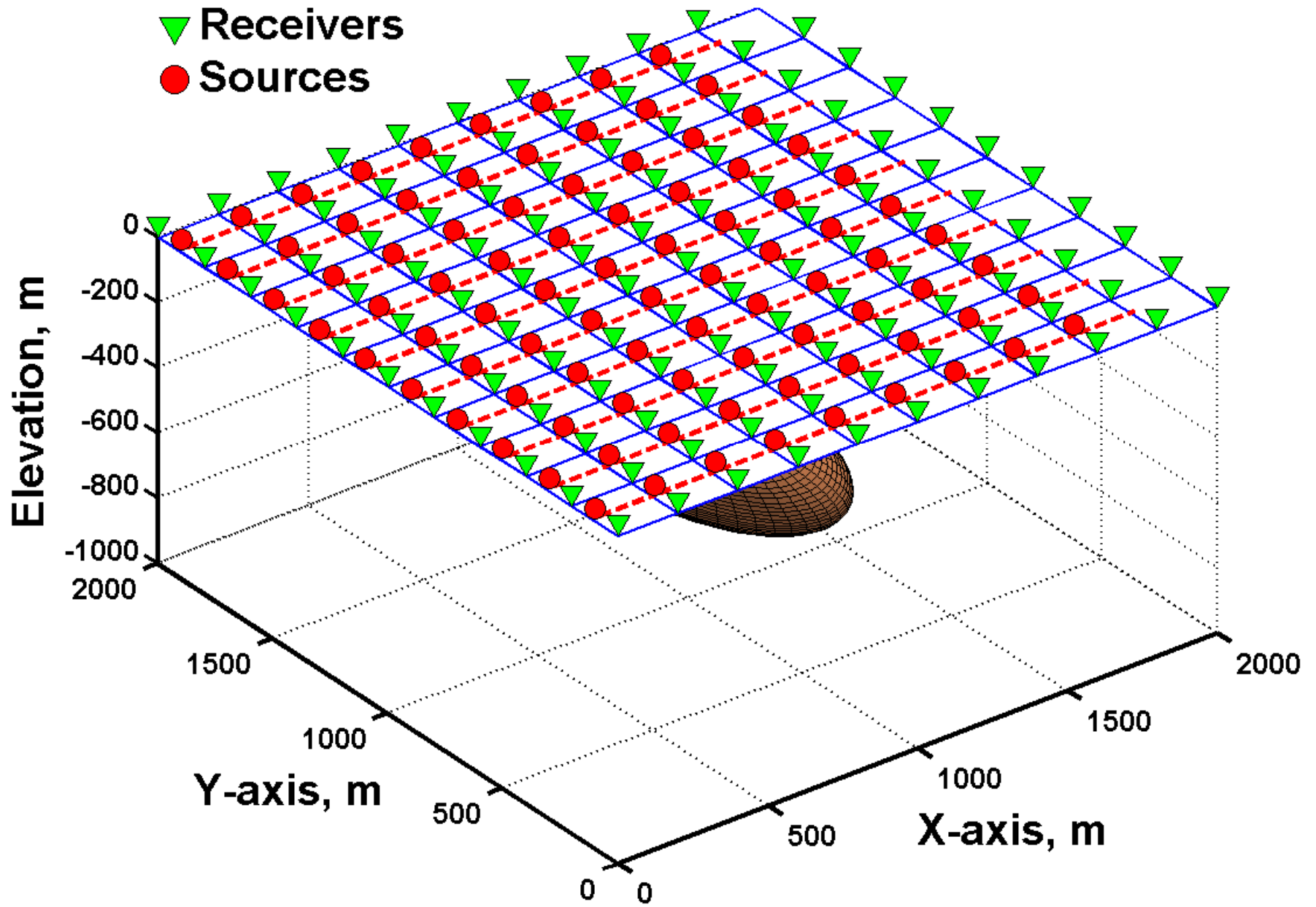
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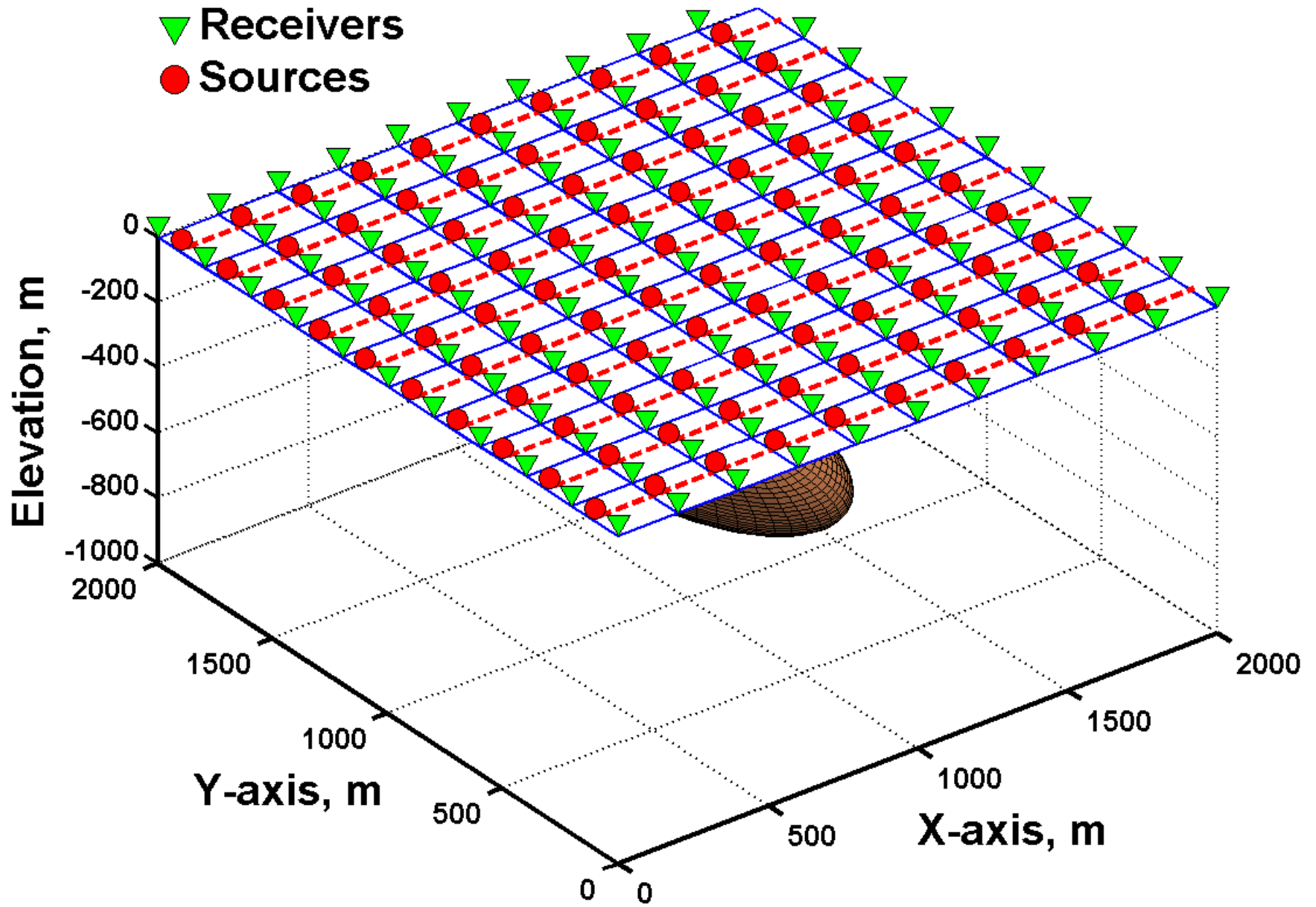
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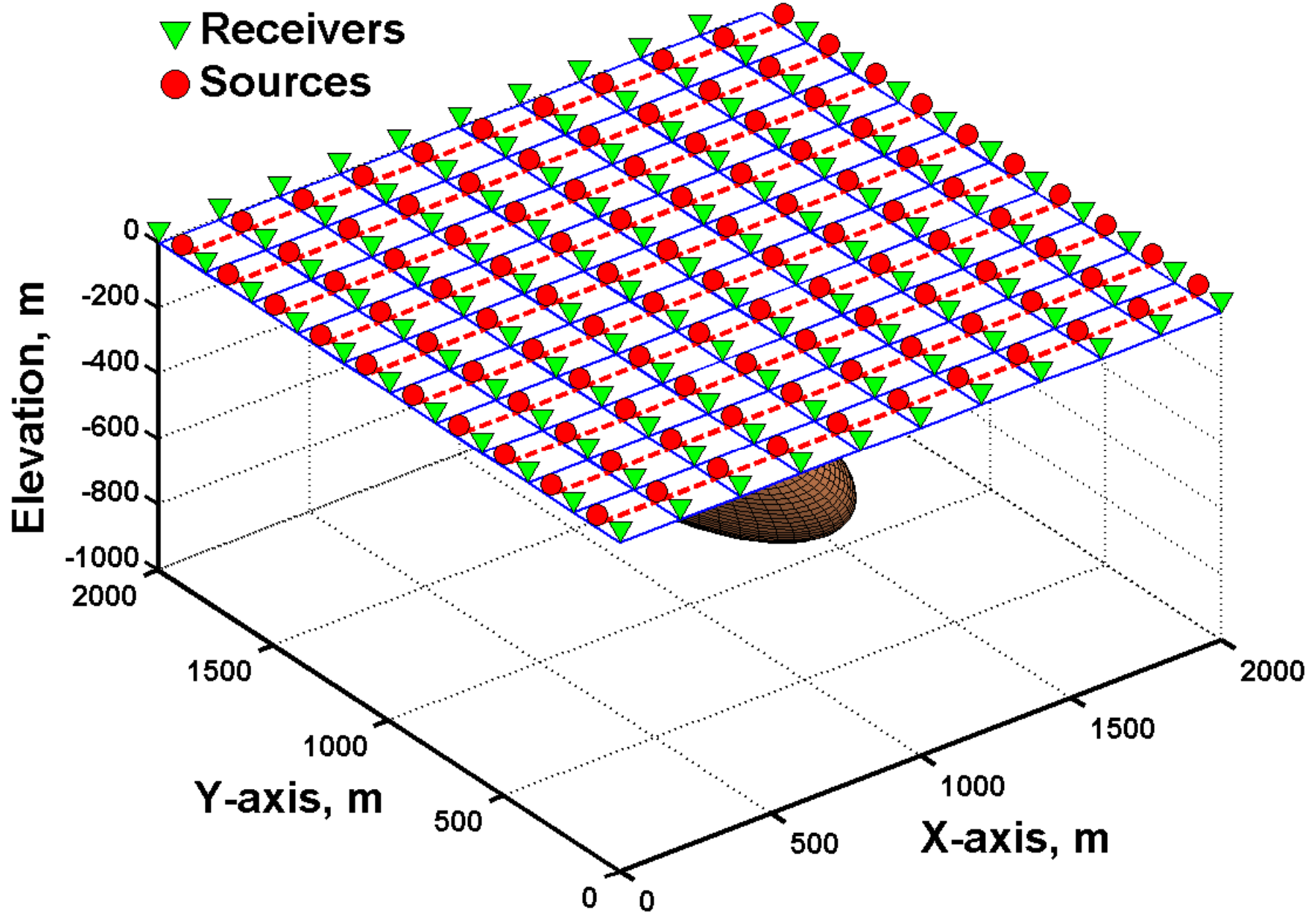
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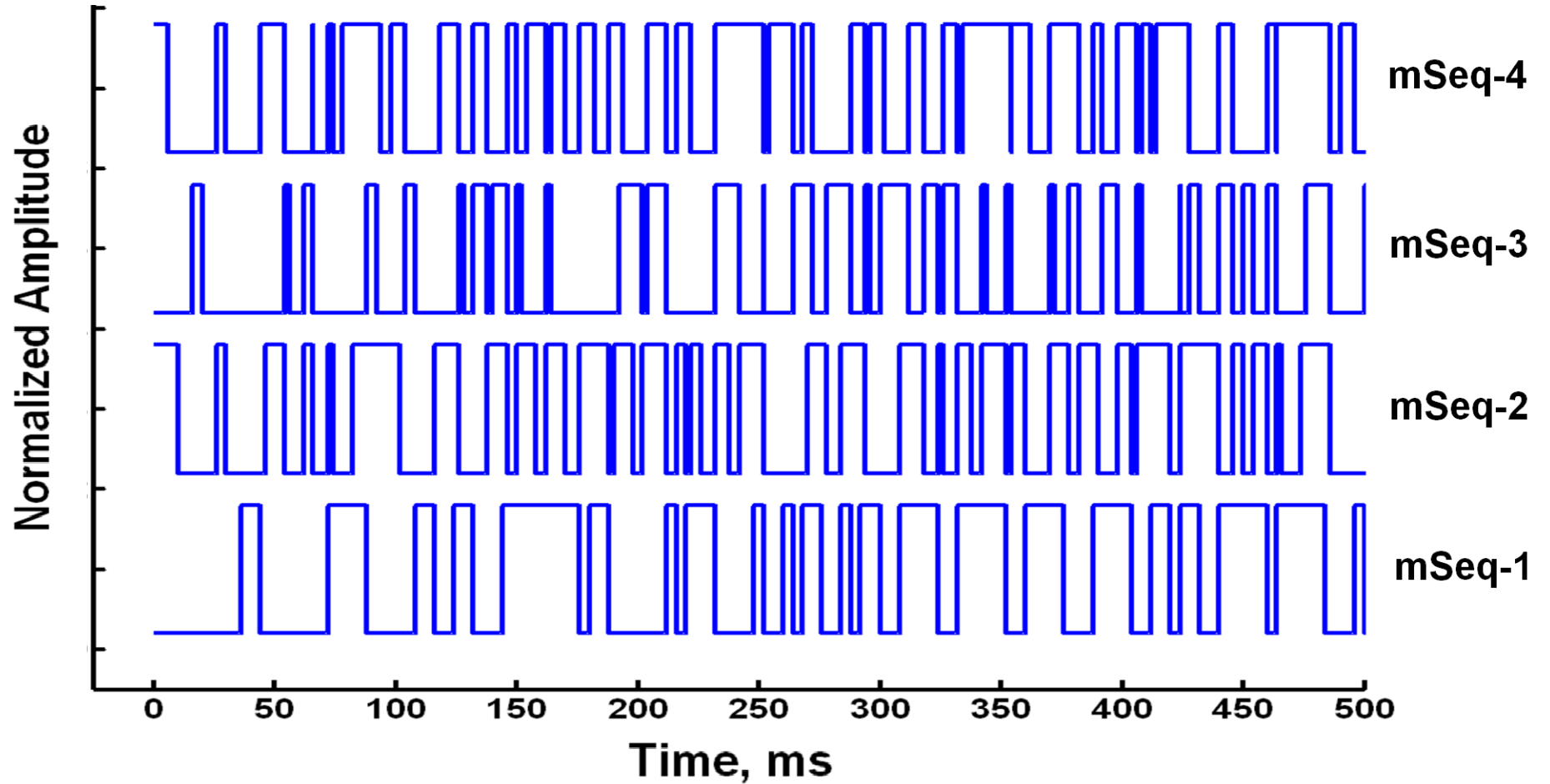
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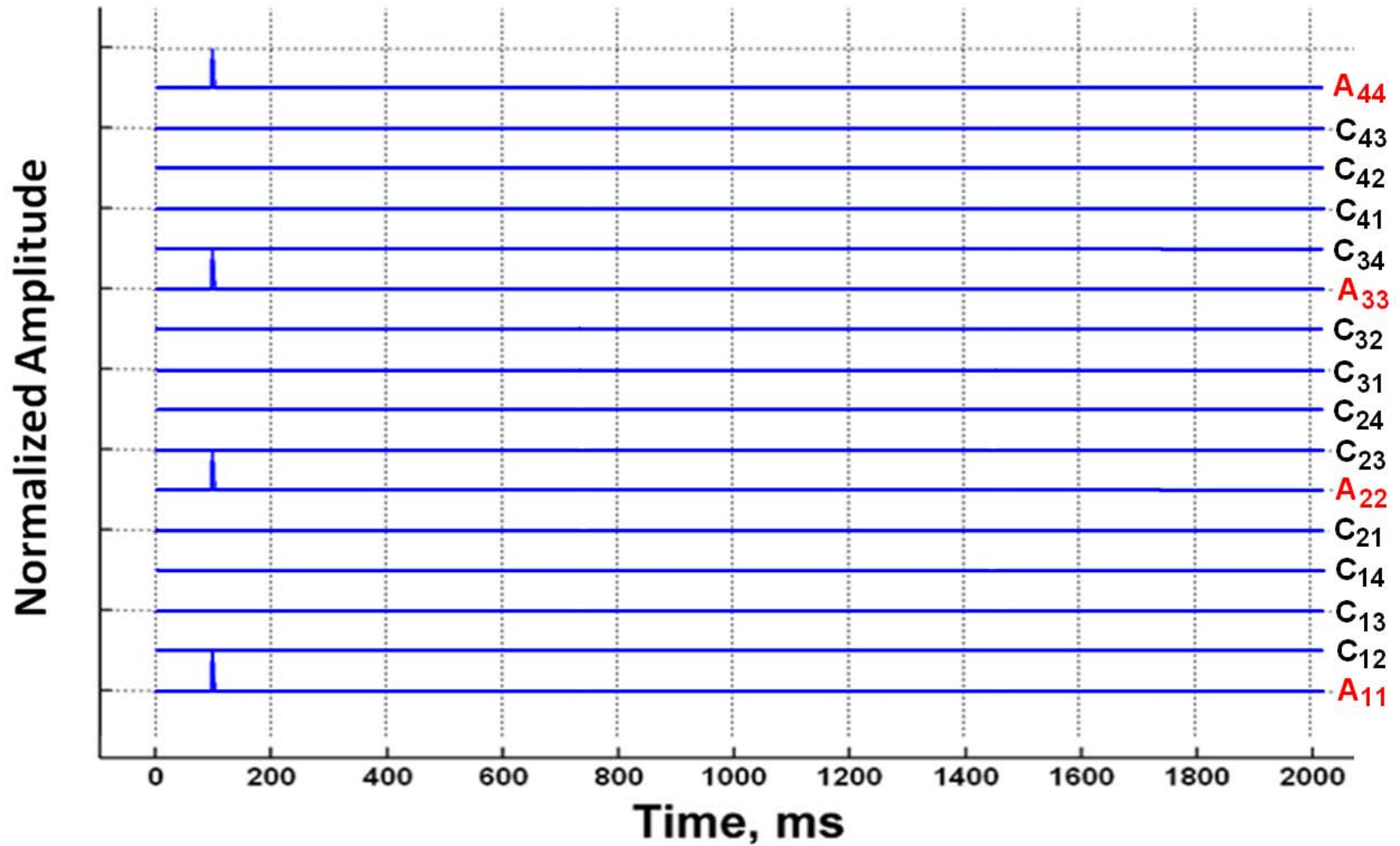


TEN-SOURCE ACQUISITION



QUASI-ORTHOGONAL SET OF FOUR PURE M-SEQUENCES



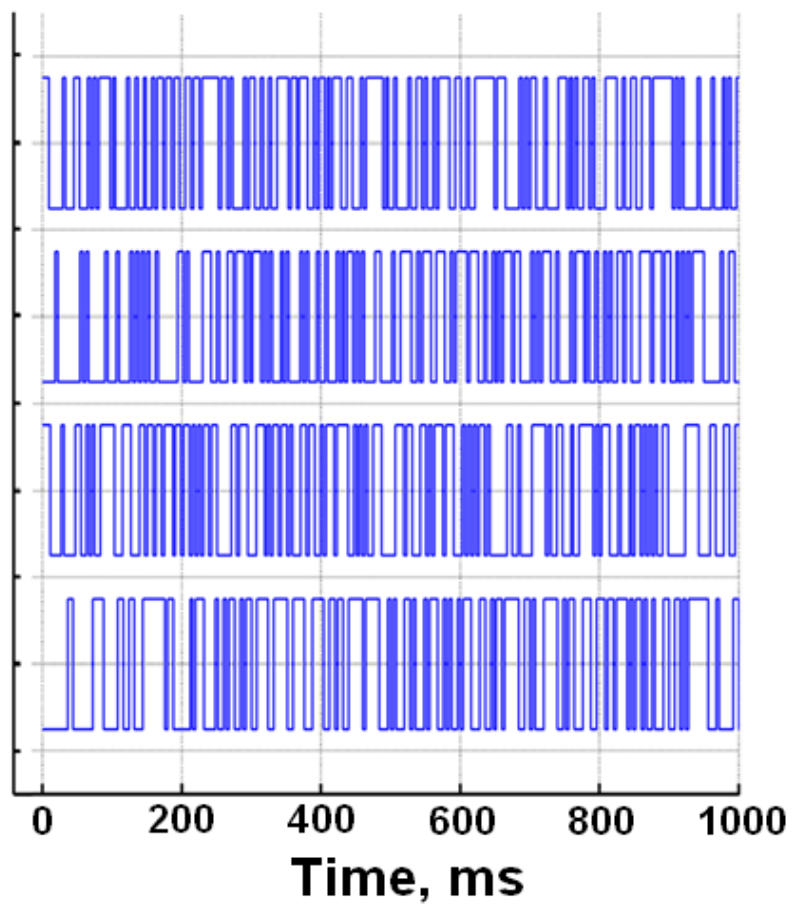


Wong, J., 2012. Multiple simultaneous vibrators controlled by m-sequences: CREWES Research Report, 24, 86.1-86-20.

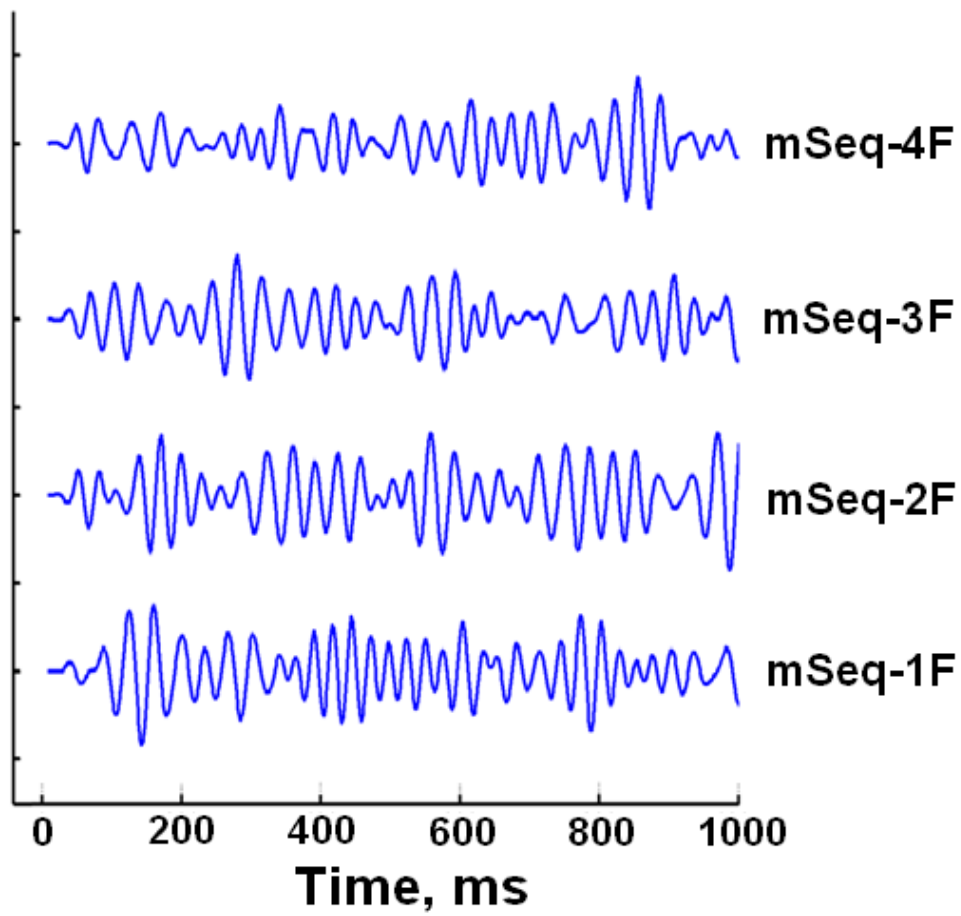
Two Simultaneous Vibrators

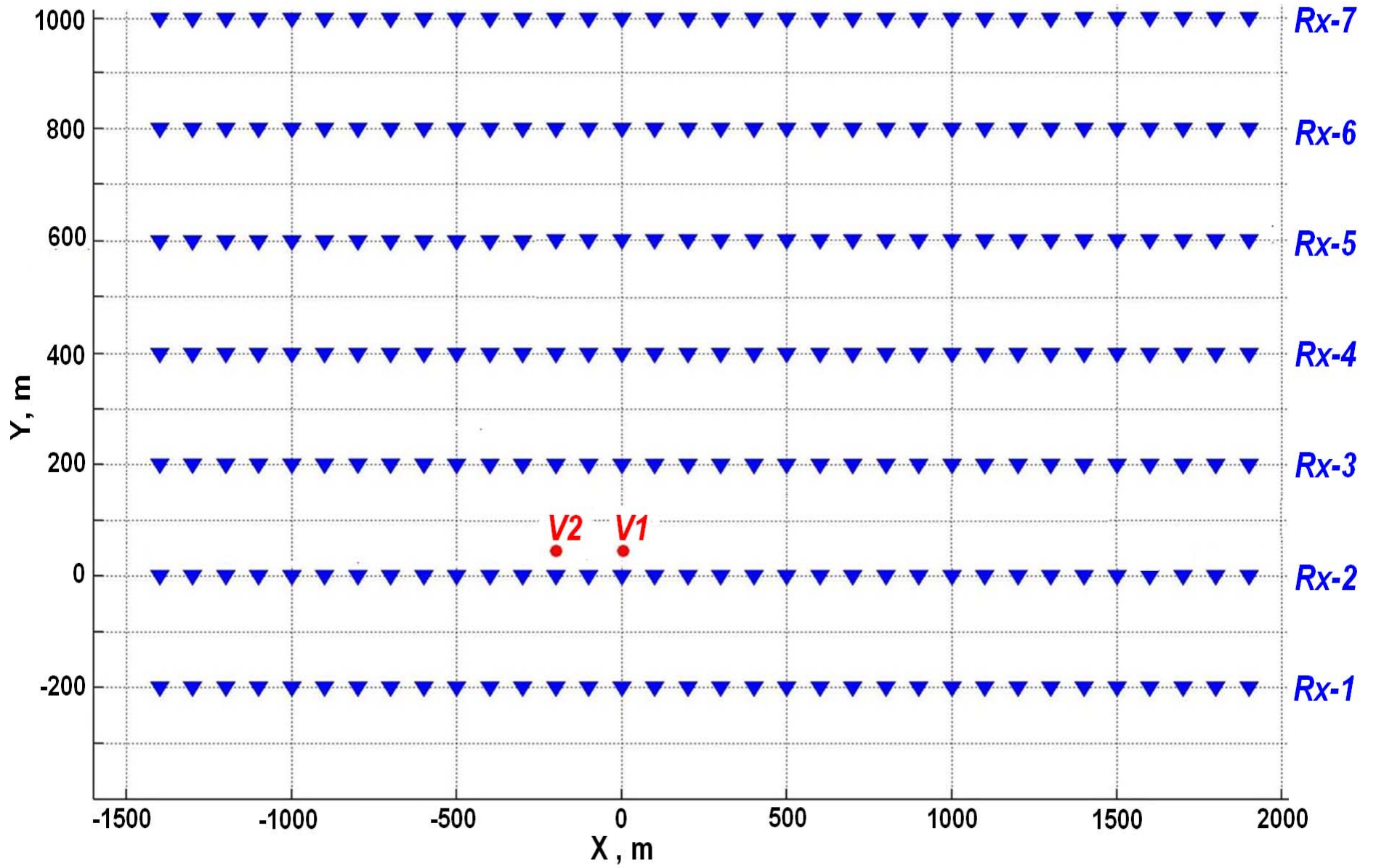


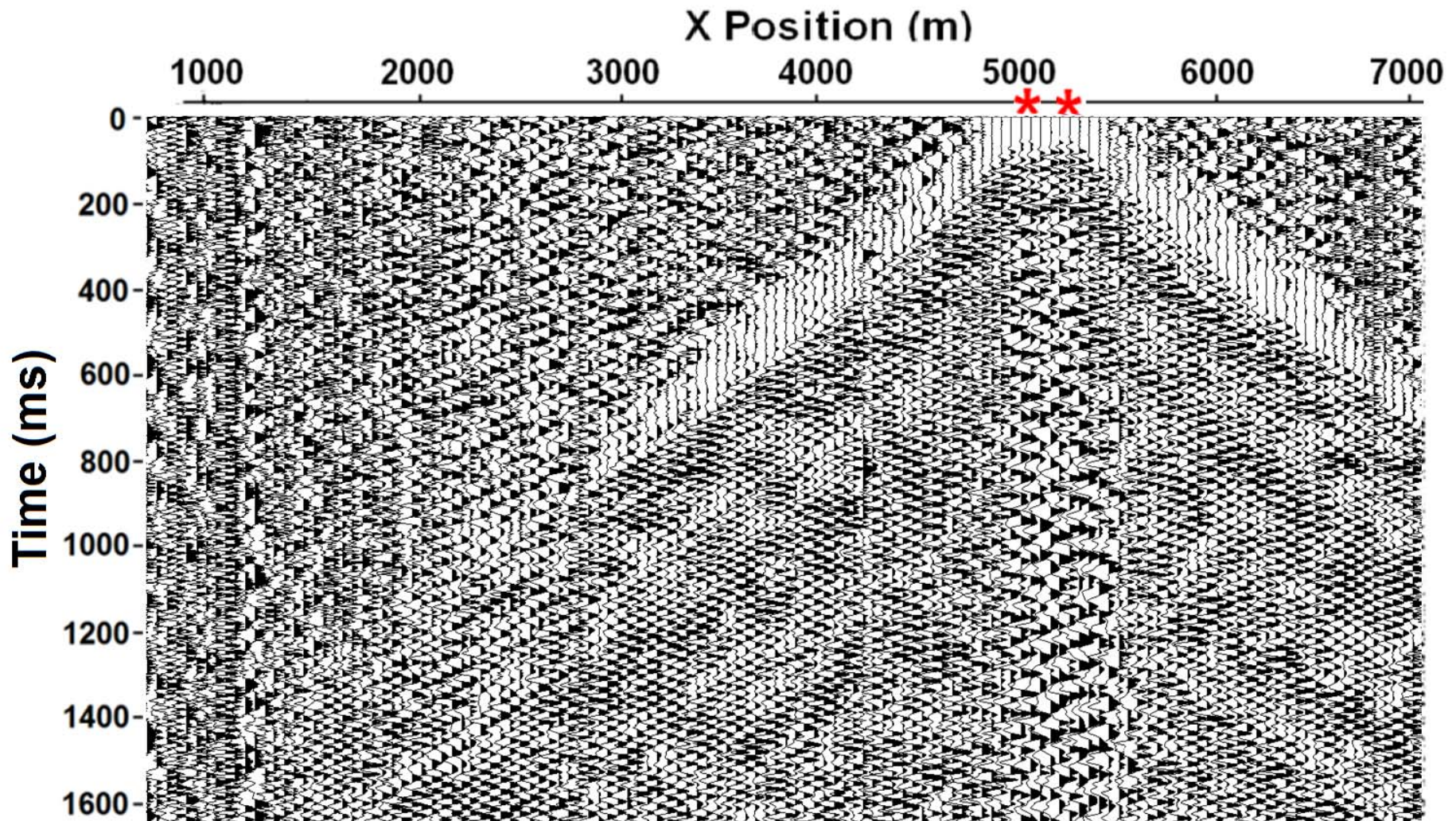
Pure m-Sequences



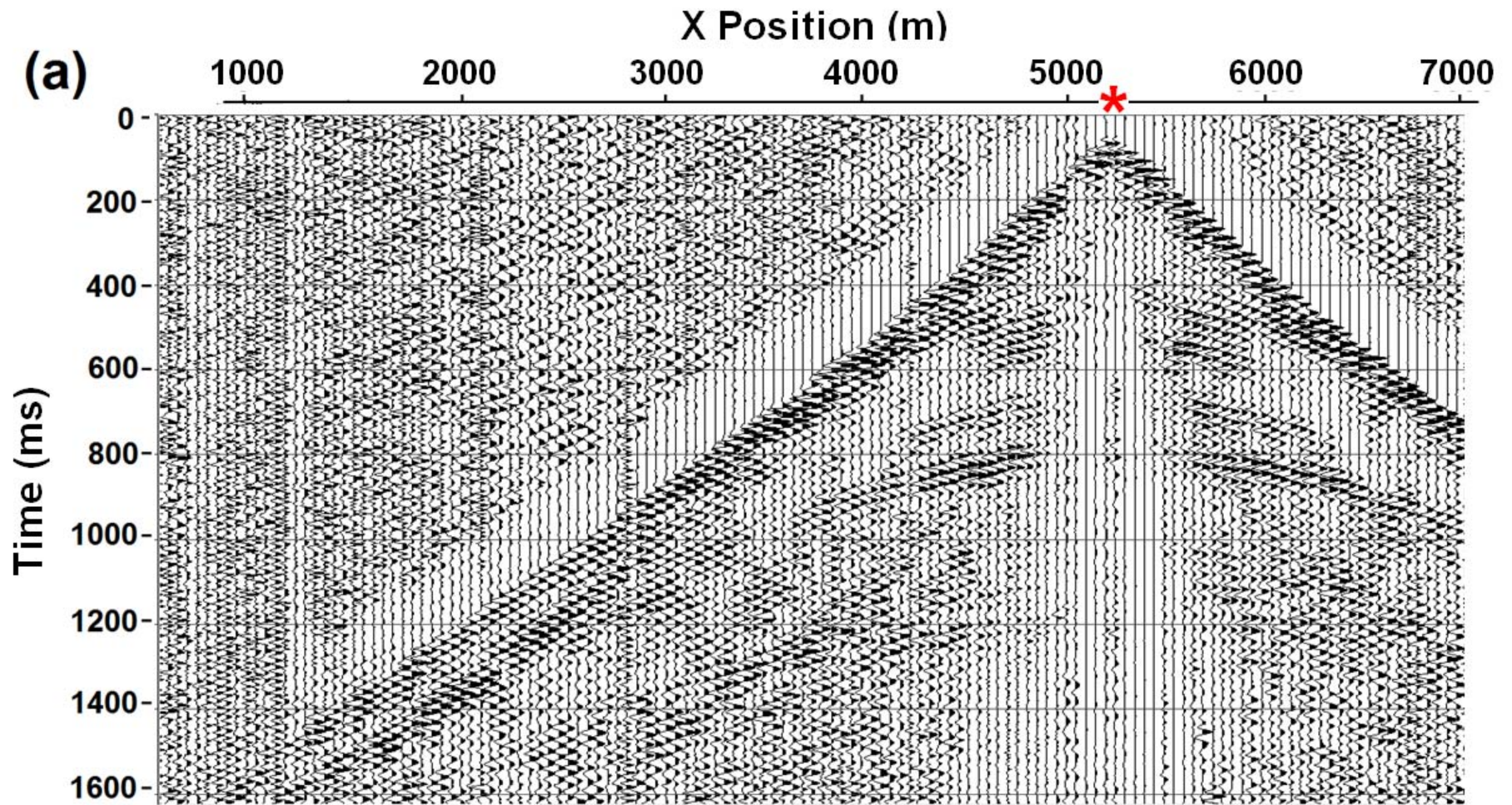
Filtered m-Sequences



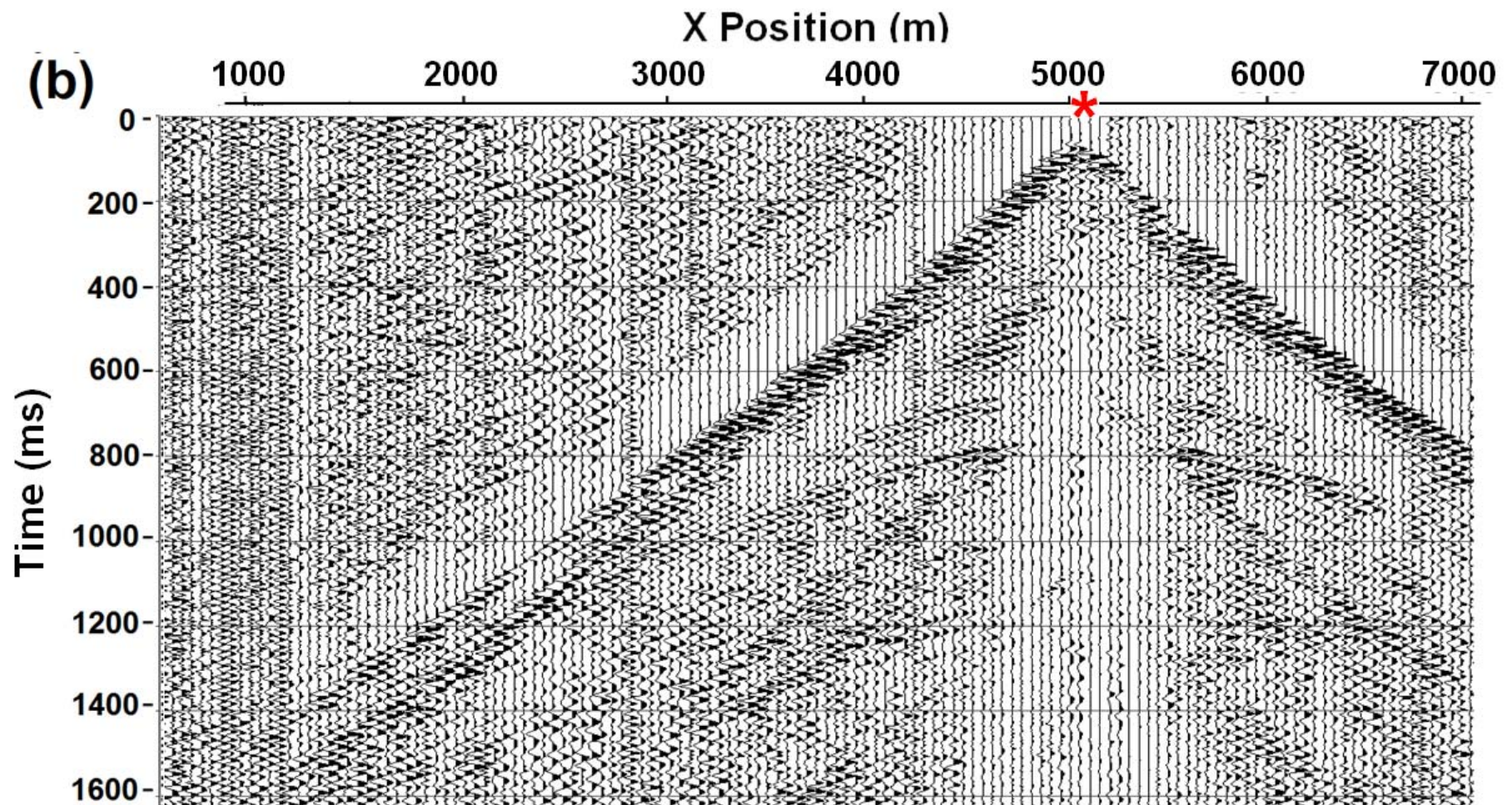




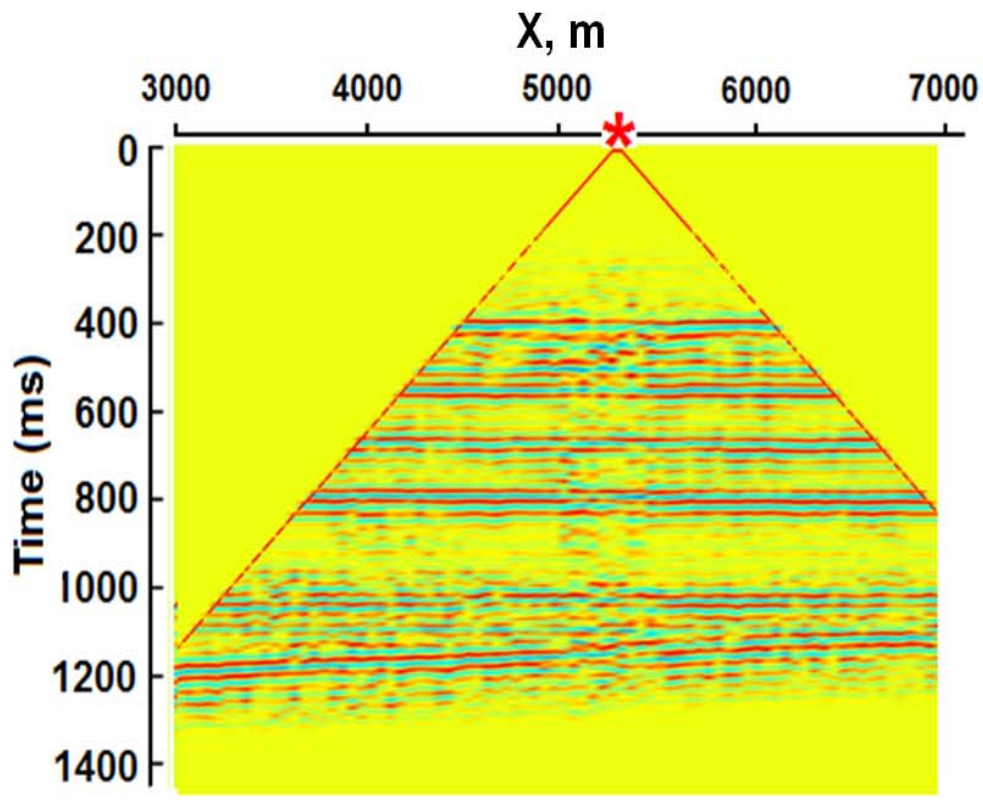
Blended raw field data for two simultaneous vibrators.
Filtered m-sequence pilots = mSeq-1F and mSeq-2F.
Sweep Time ~ 16.4 s, Listen Time ~ 22 s.



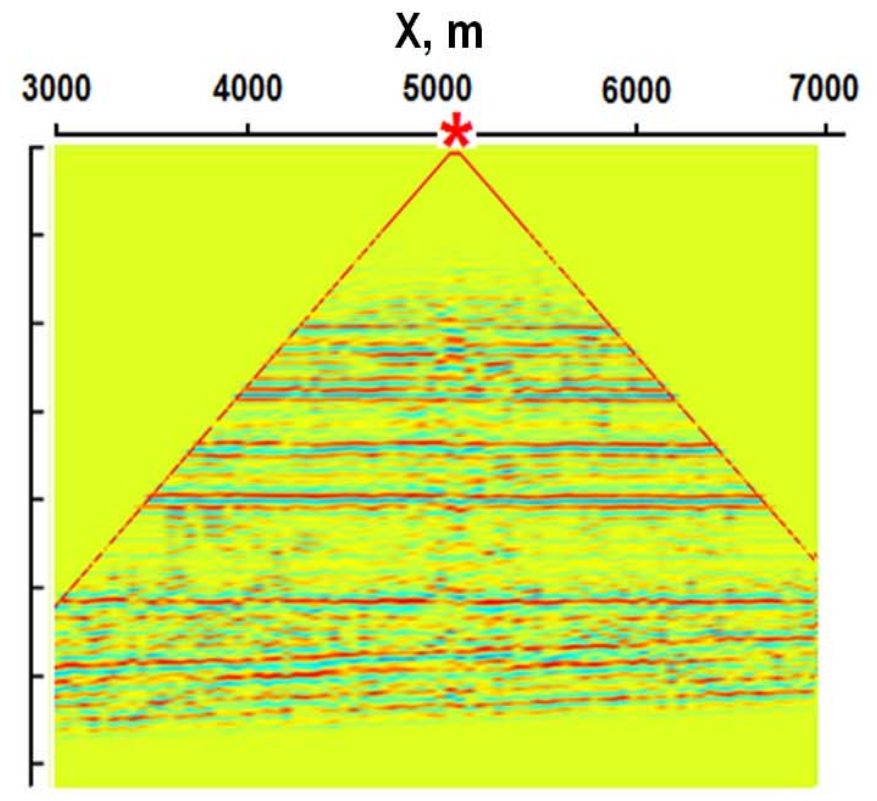
CSG for V1 source, deblended/extracted with mSeq-1F pilot.



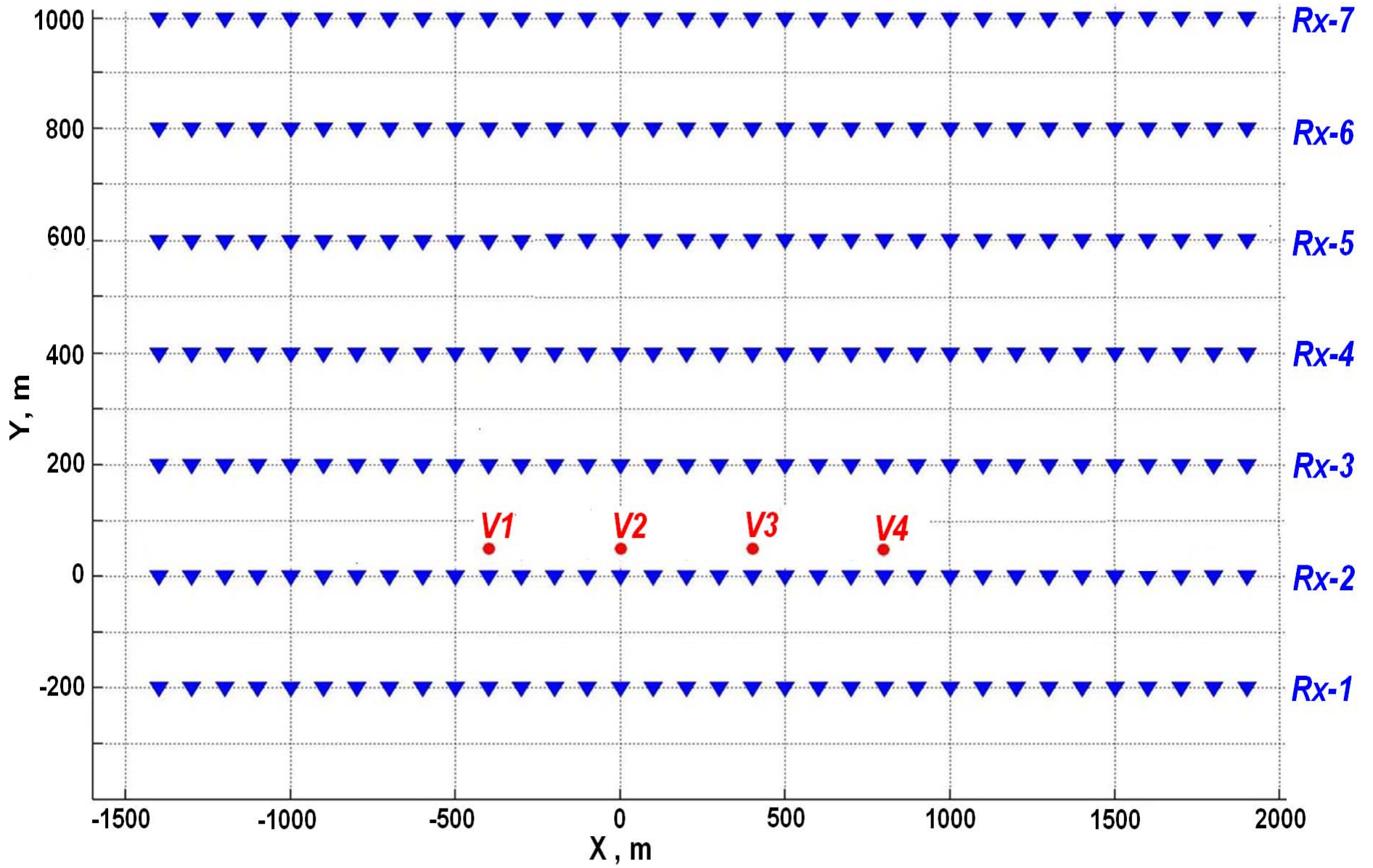
CSG for V2 source, deblended/extracted with mSeq-2F pilot.



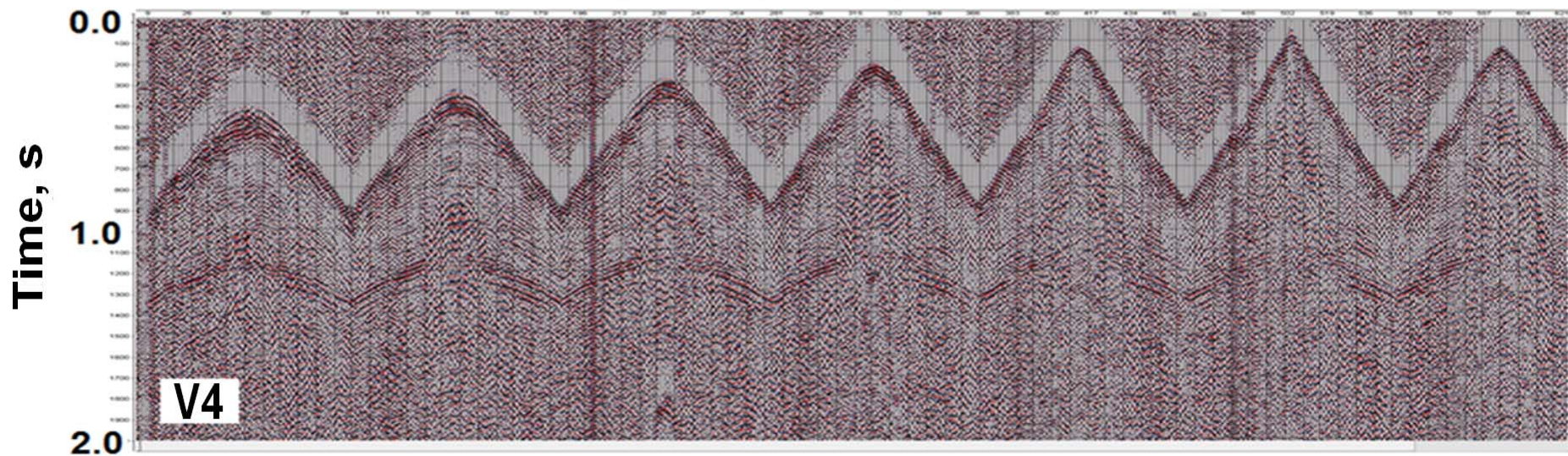
V1 with mSeq-1F pilot



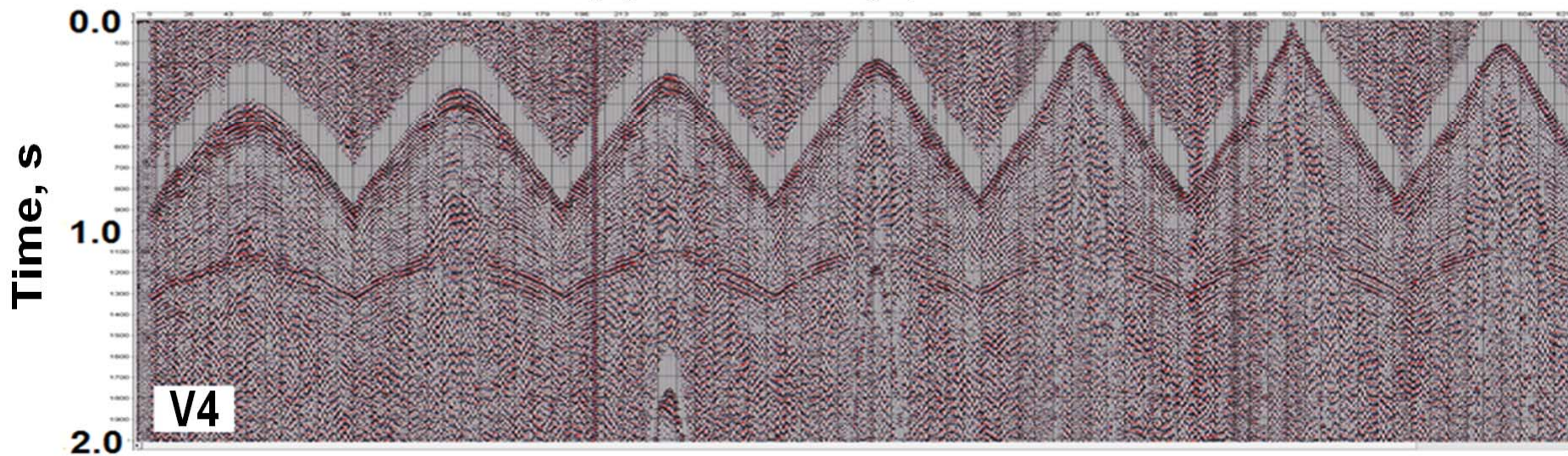
V2 with mSeq-2F pilot

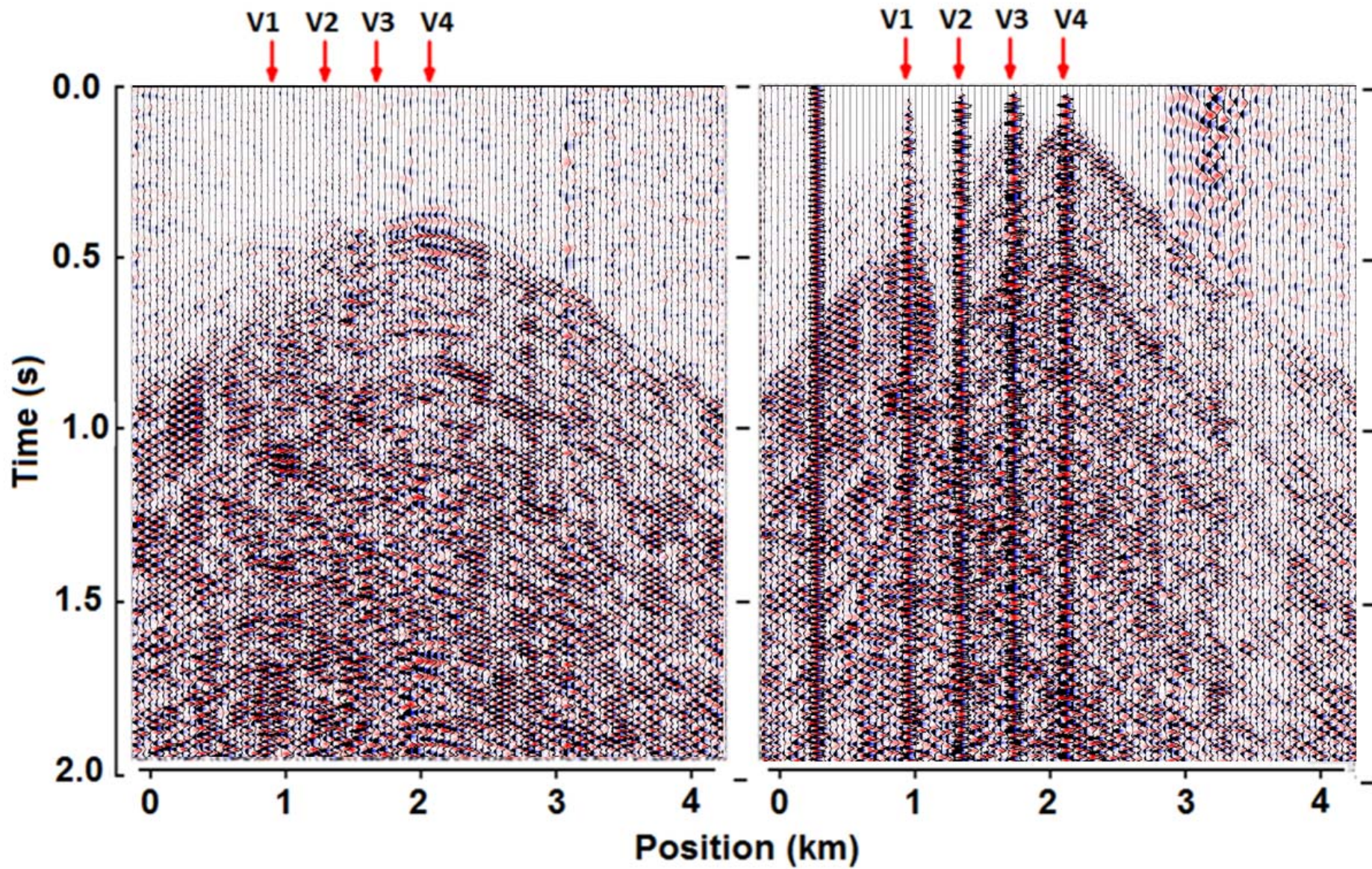


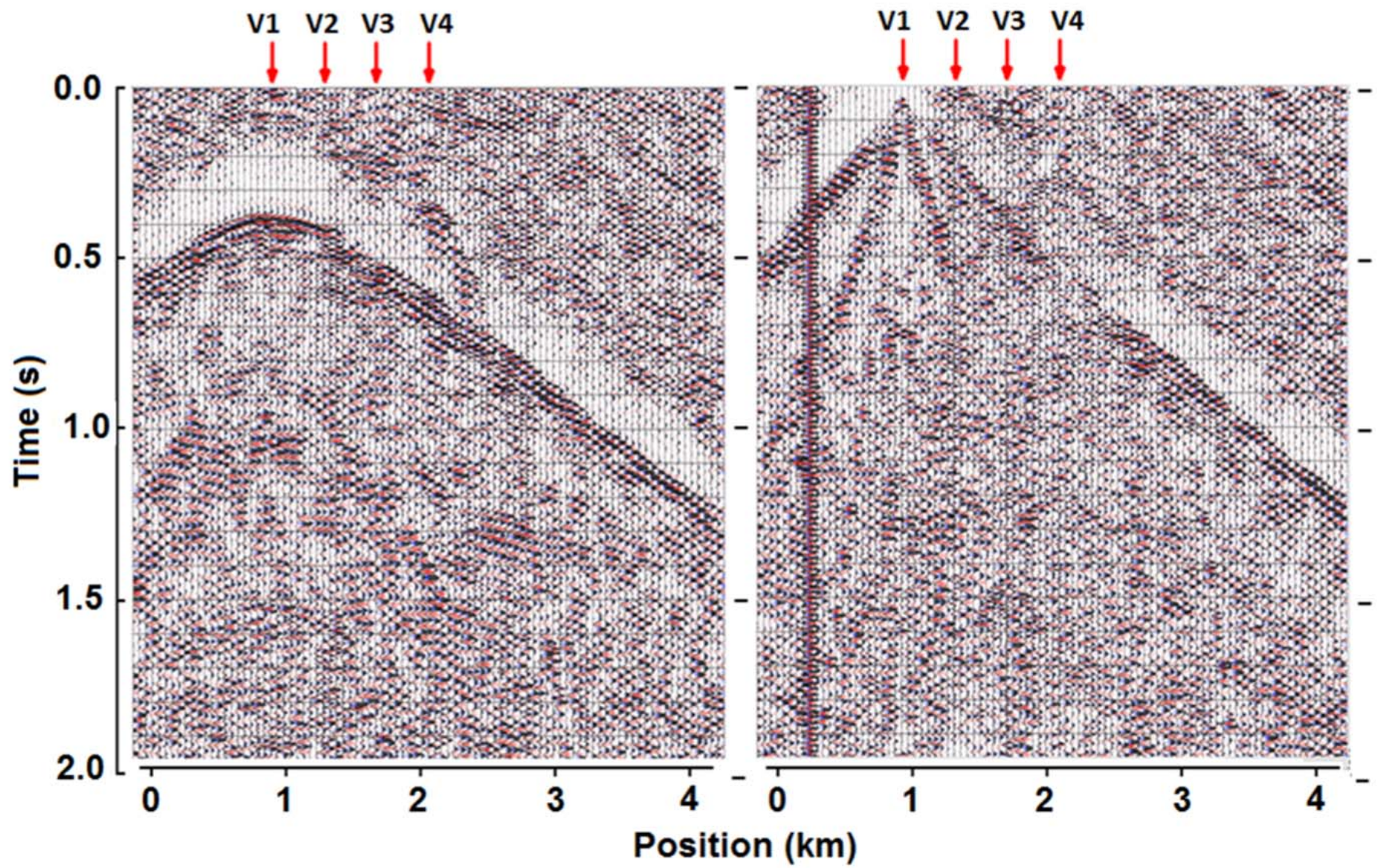
(a) m-sequence pilot

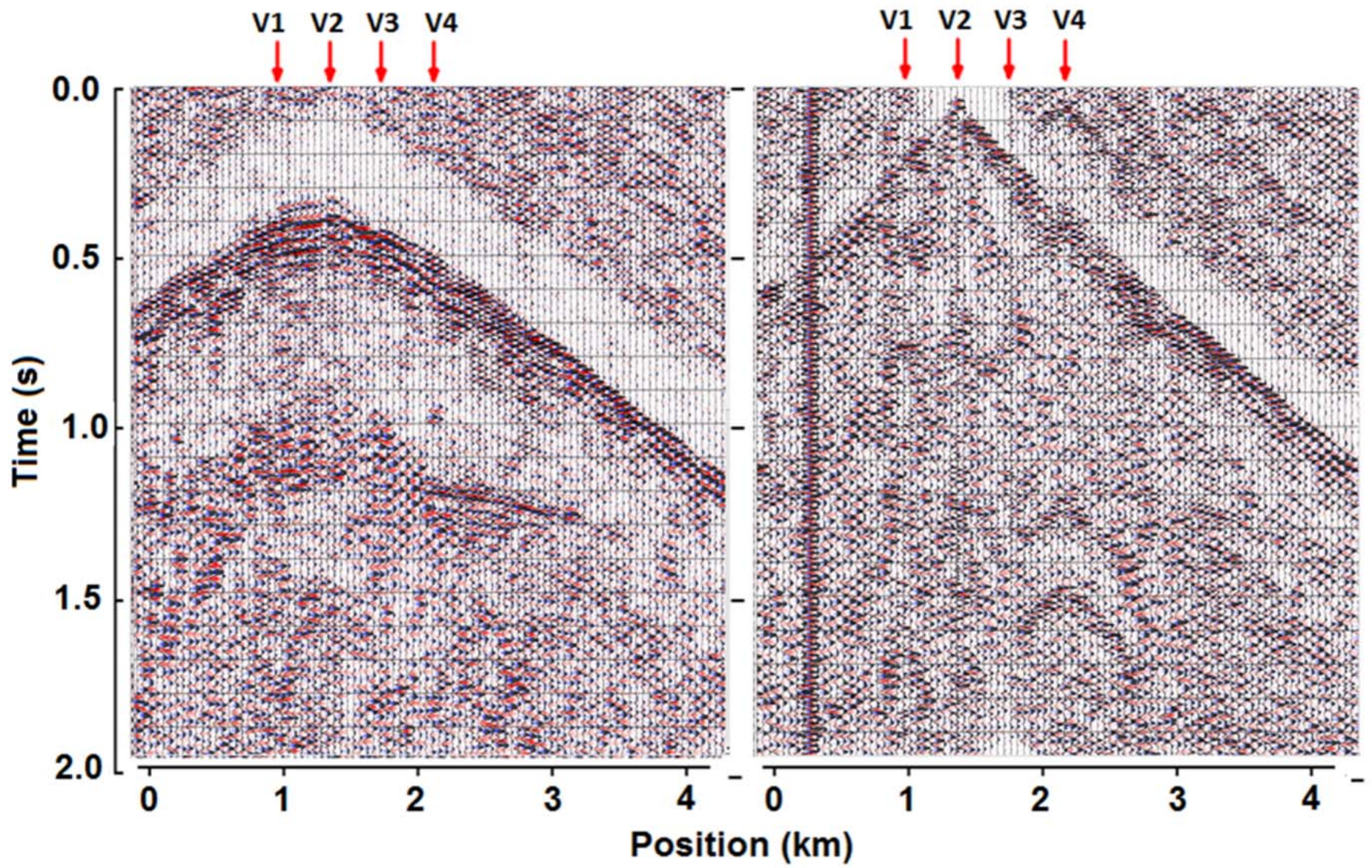


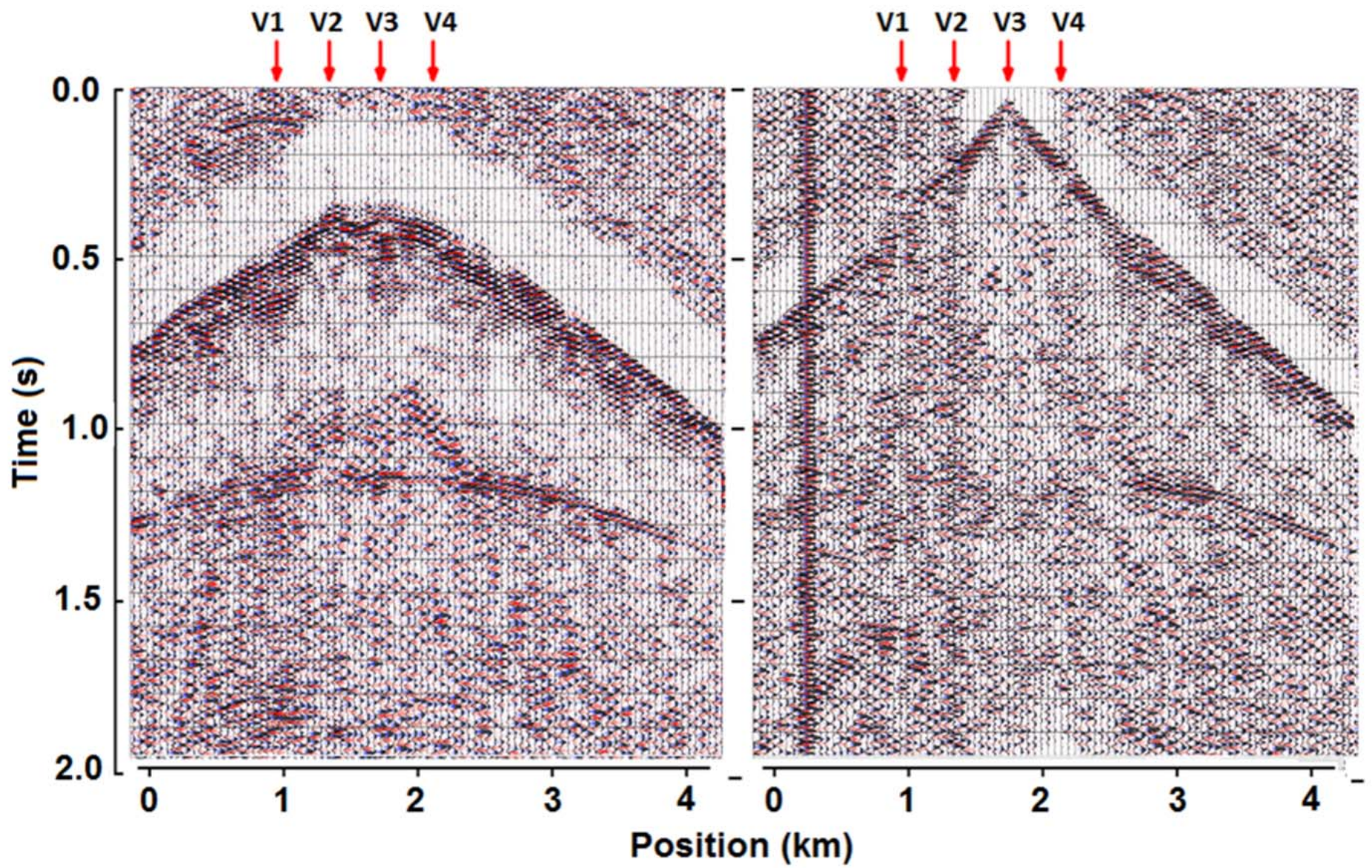
(b) linear sweep pilot

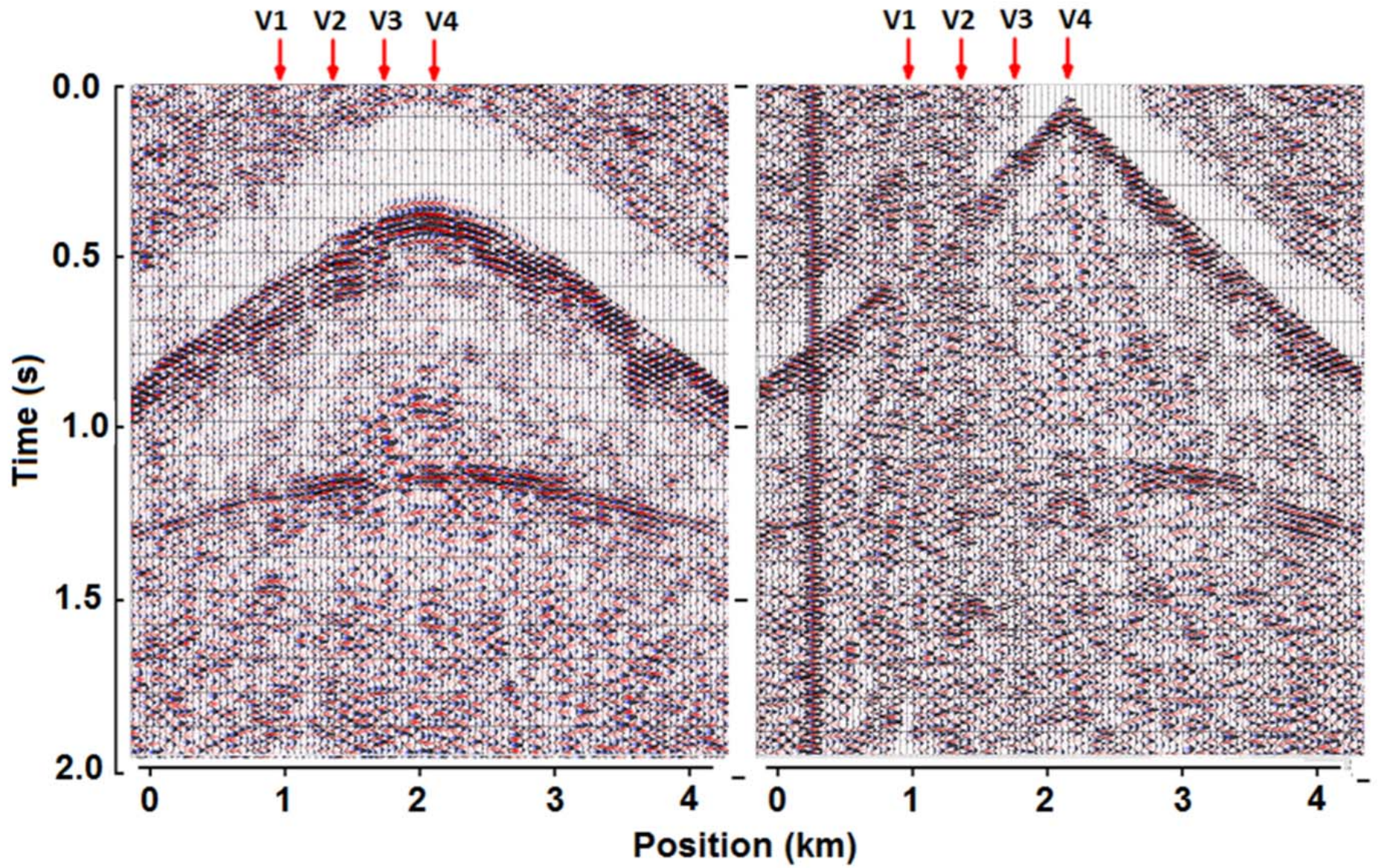


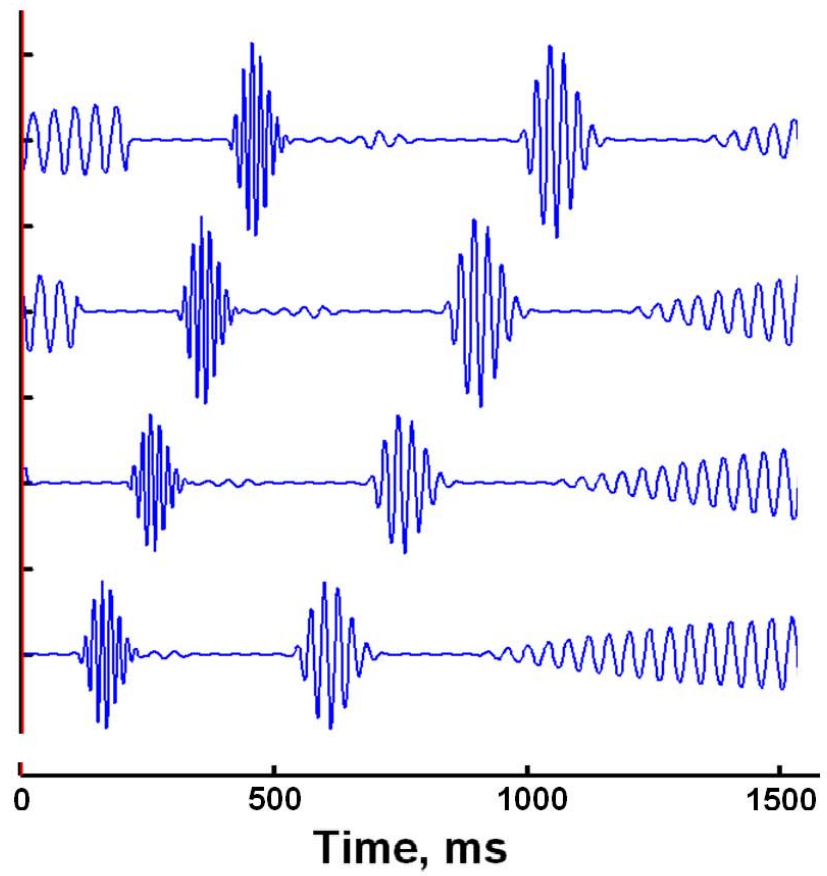
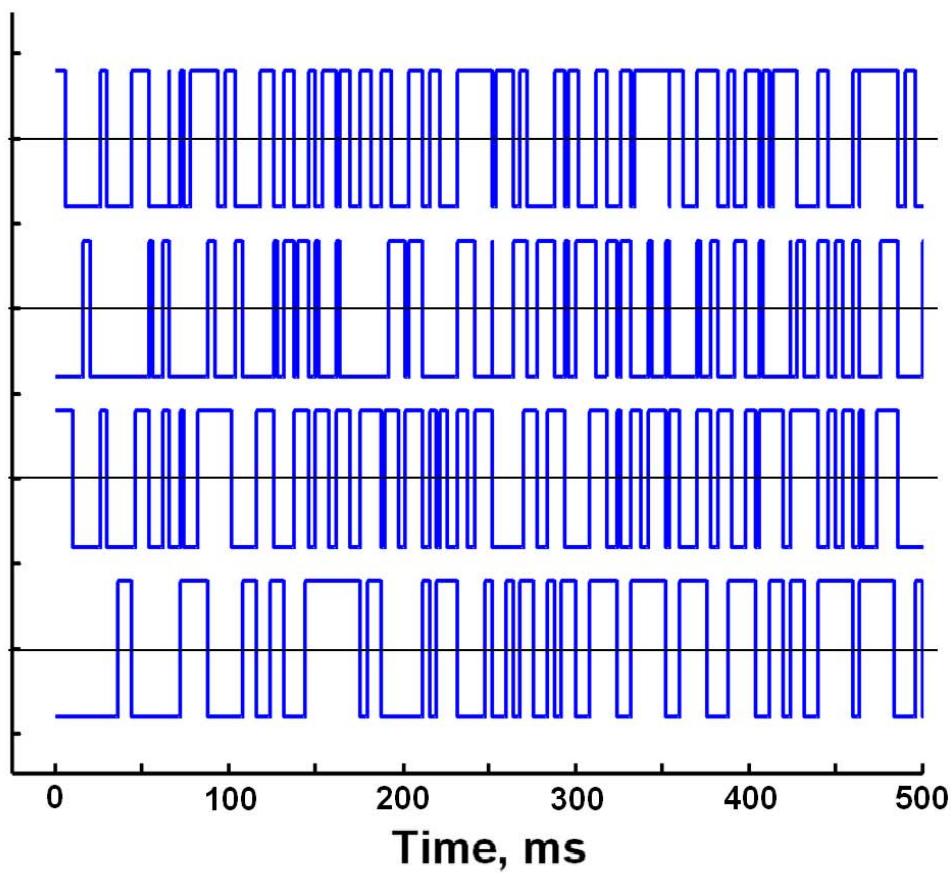


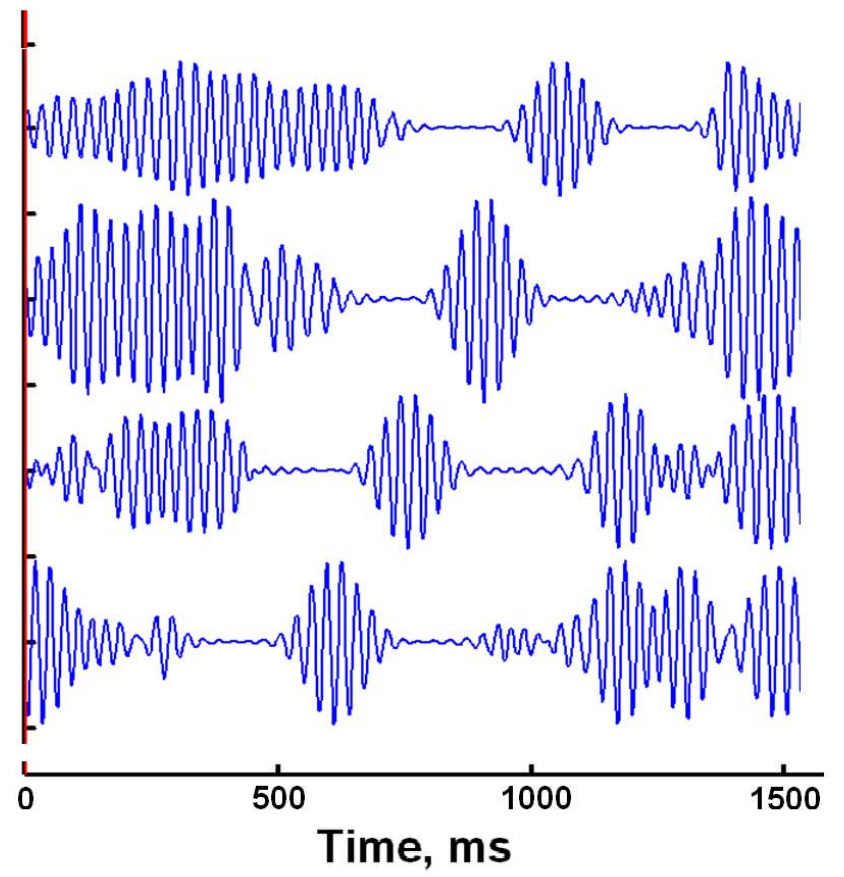
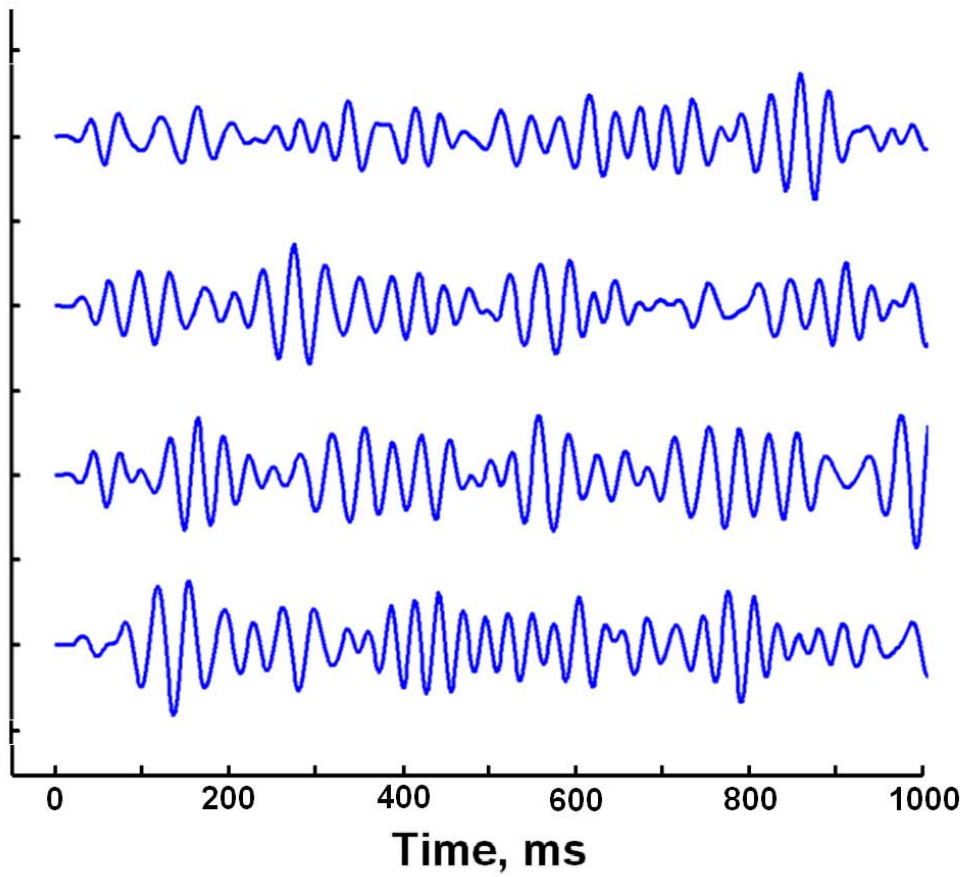




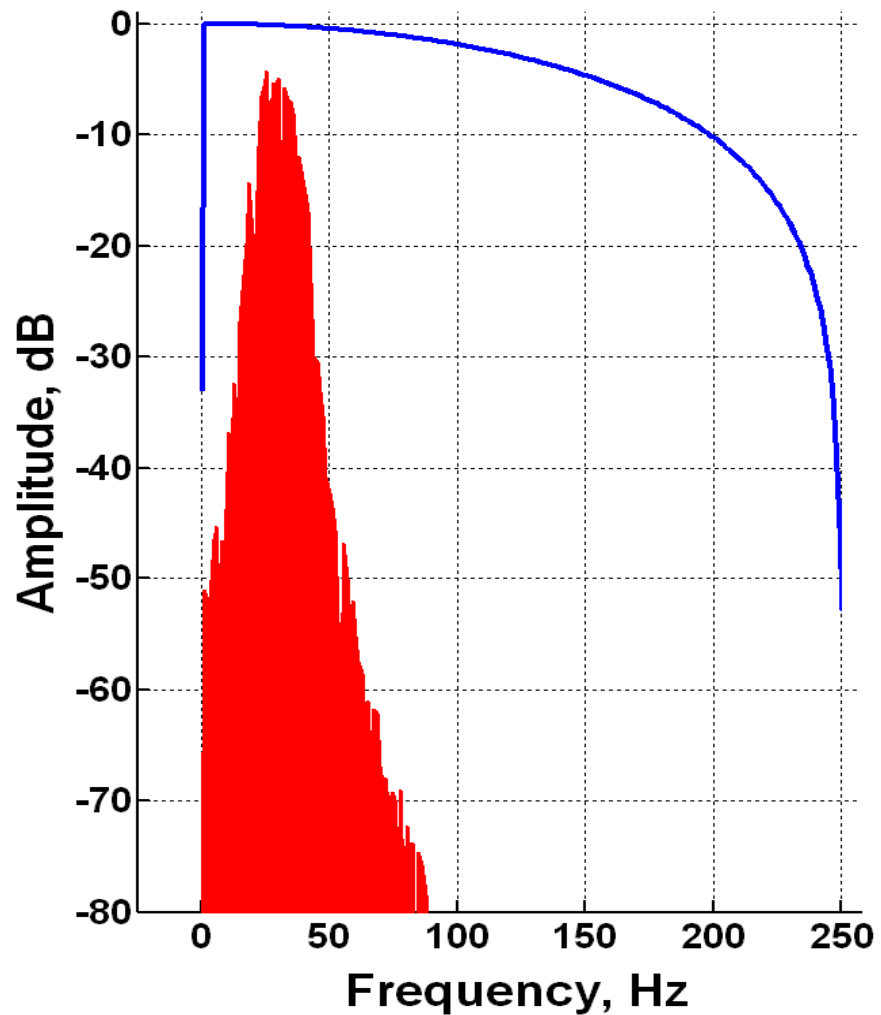




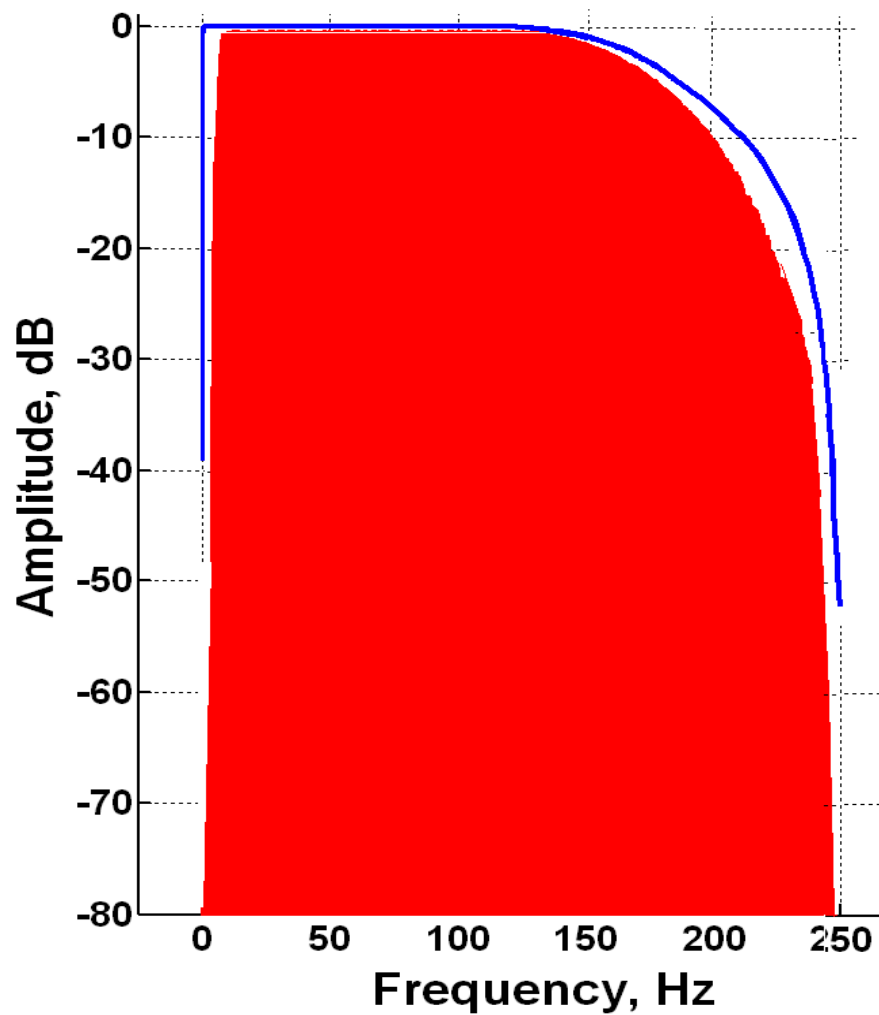


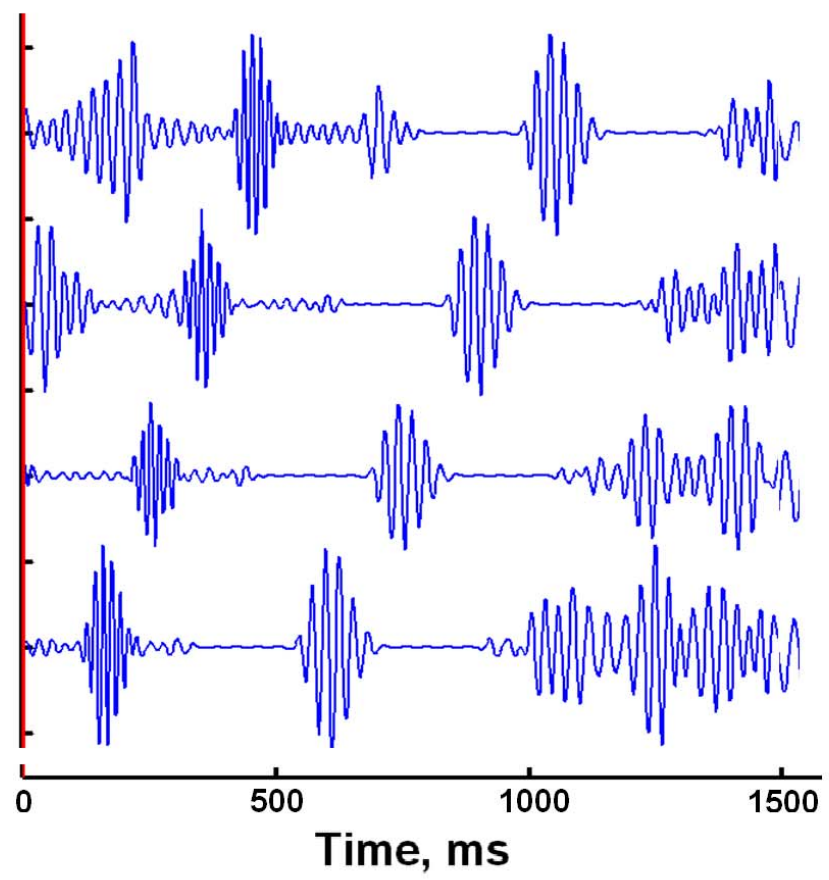
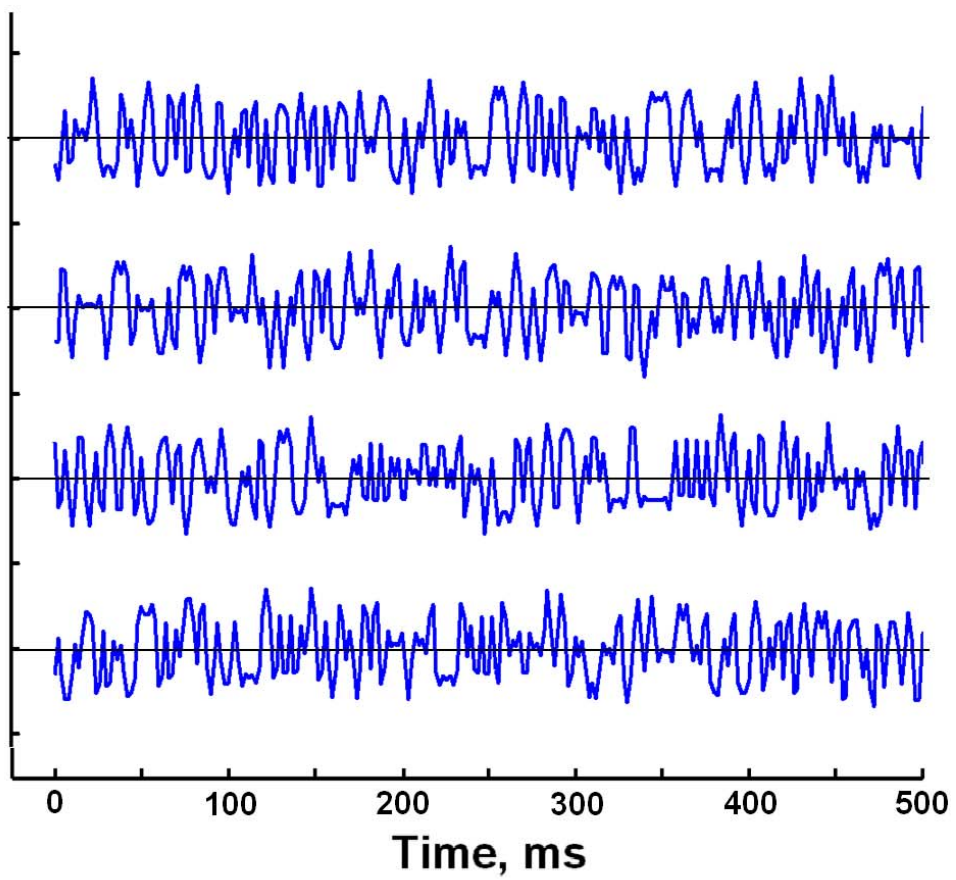


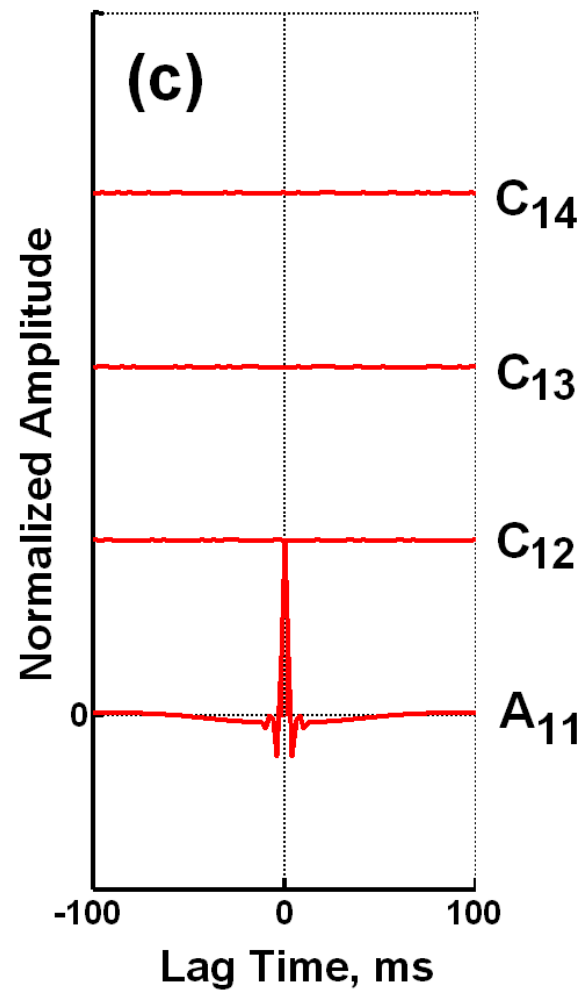
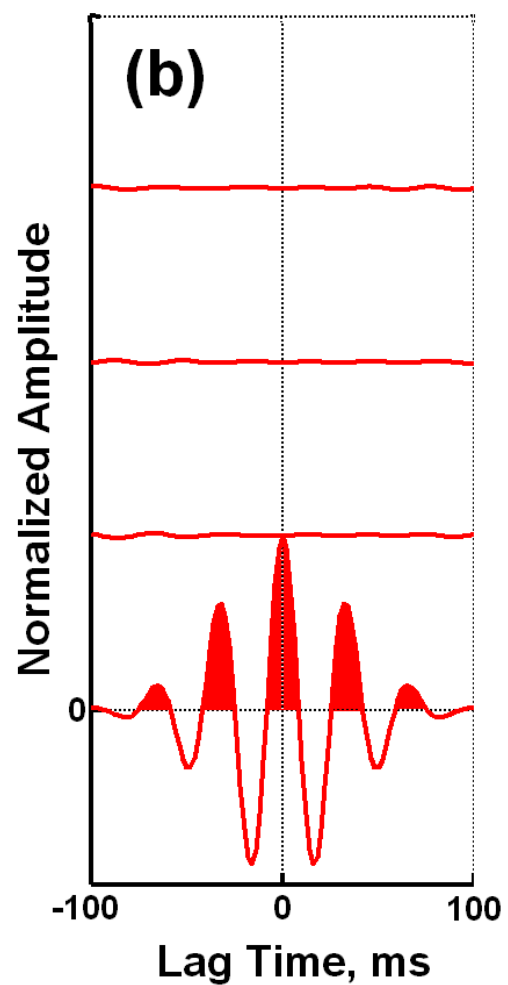
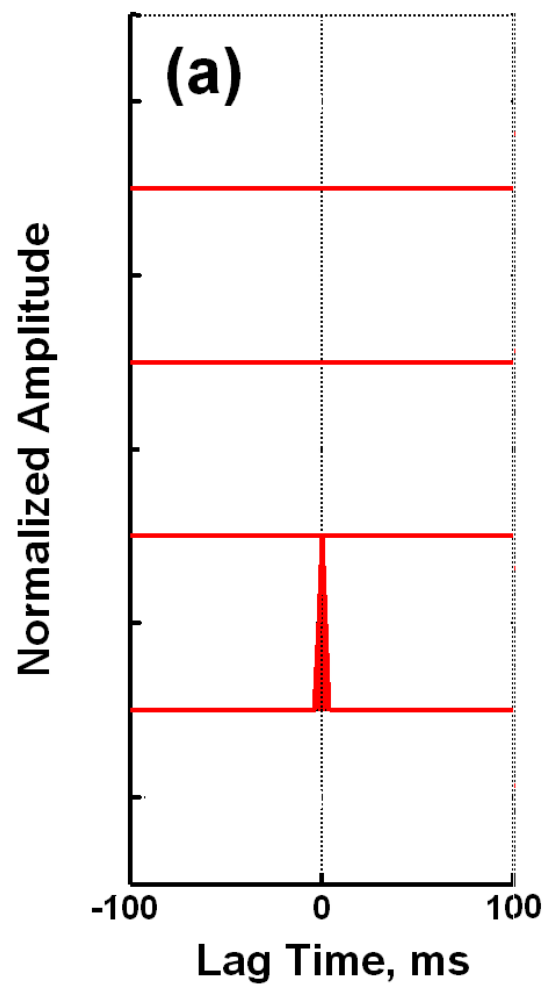
Time Domain Filter Applied

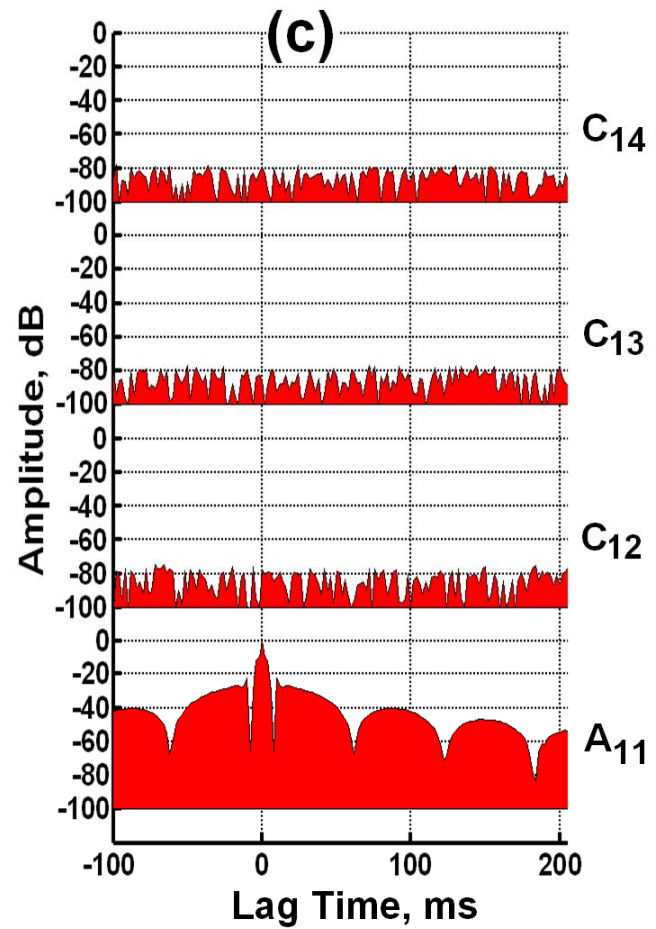
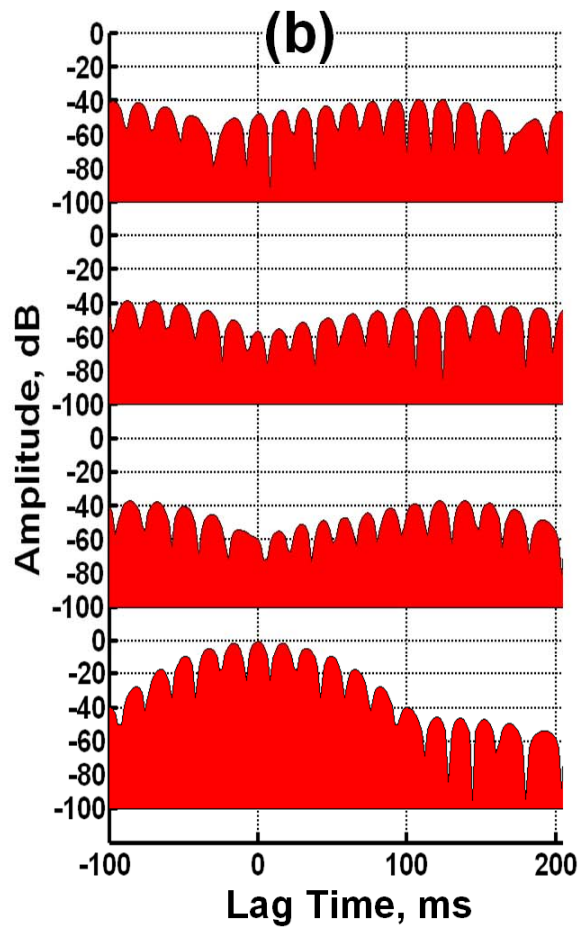
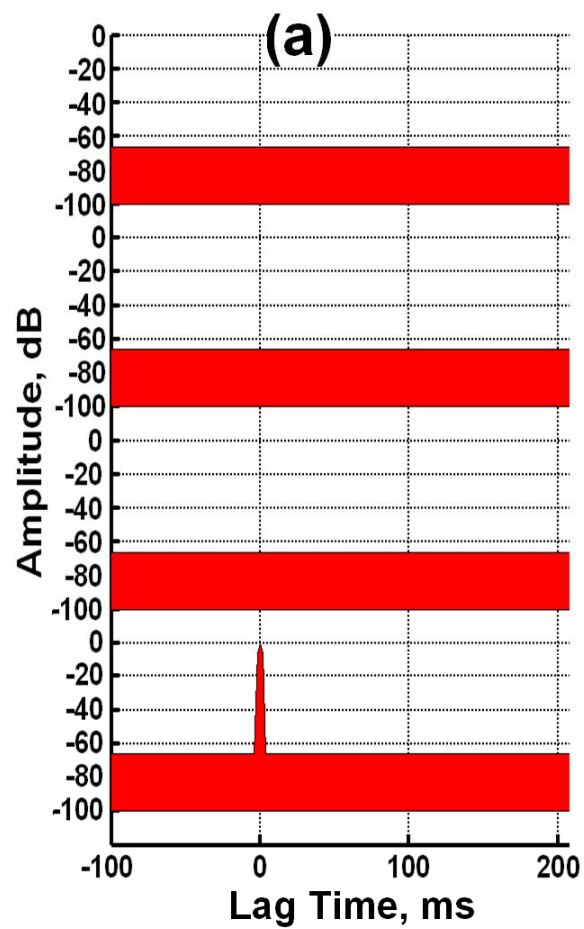


Frequency Domain Filter Applied









Conclusion

- *Filtered m-sequence pilots and linear sweep pilots are equally suitable for controlling land vibrators.*
- *In numerical simulations, improved filtered m-sequence pilots (with carefully controlled spectra) are effective in deblending very weak signals from very strong signals.*
- *We will continue to field-test simultaneous multi-sourcing using the improved filtered m-sequence pilots to control four and eight vibrators.*

ACKNOWLEDGEMENTS

We thank :

- Keith Radcliffe and Tom Phillips for assisting with setting up custom pilot signals in the vibrator controllers;

- Devon Energy Corporation for permission to present these results.

CREWES is supported by its industrial sponsors and by the Natural Sciences and Engineering Research Council of Canada (NSERC).

INVITATION TO COLLABORATE

- Field-test simultaneous multi-sourcing.***
- Use 1, 2, 4 or 8 vibrators.***
- Control with improved m-sequence pilots.***

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