Absorbing boundary domain for CSEM 3D modelling

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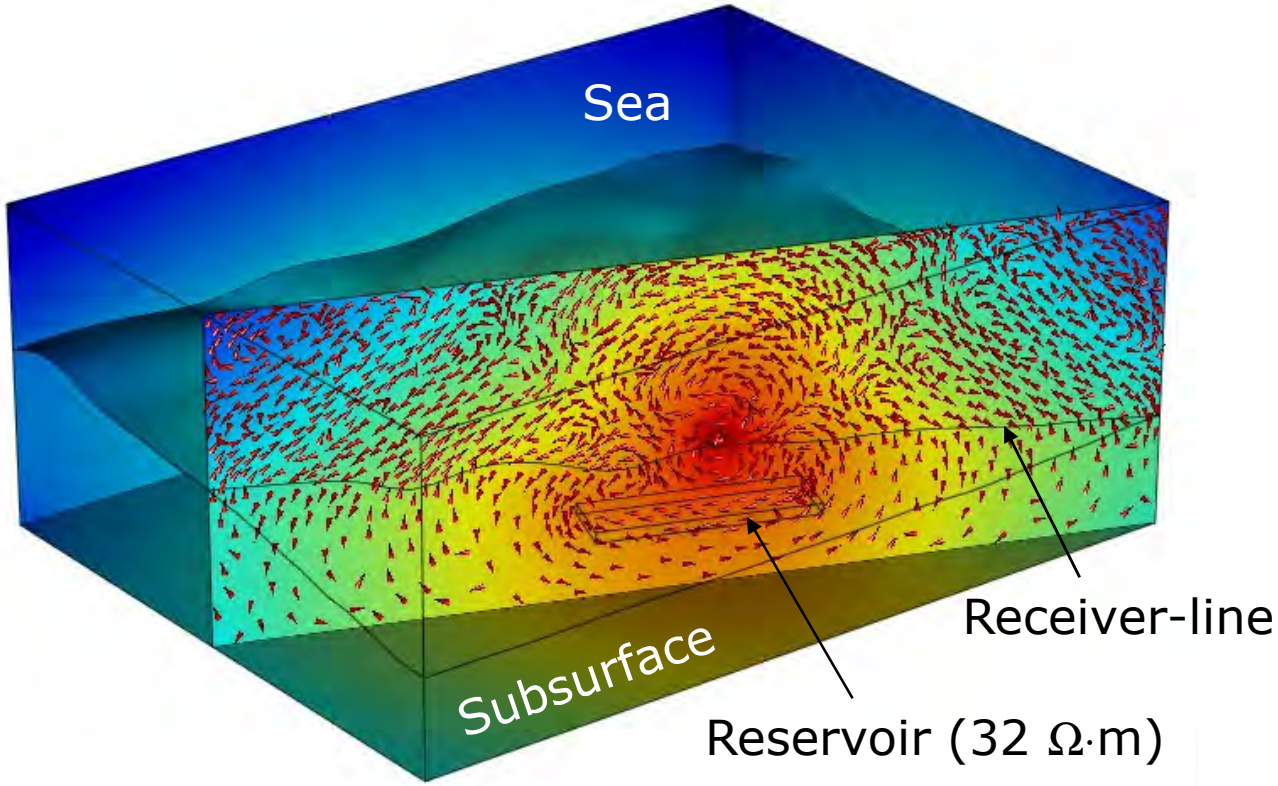
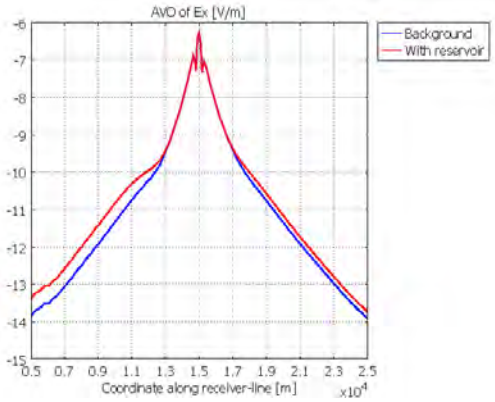
Content

- Marine CSEM, principle
- PML, (short) history
- Proposed PML/ABD and implementation to COMSOL Multiphysics, RF module
- Test examples:
  1. Deep water
  2. Shallow water
- Comments on mesh
- Summary

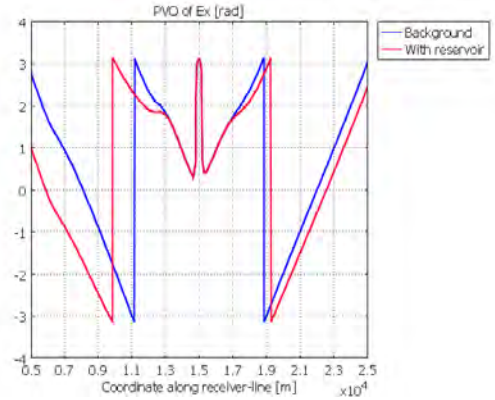
Marine CSEM, principle



AVO, receiver-line



PVO, receiver-line



Source: HED, 0.25 Hz. Plot: Electric field

PML, history

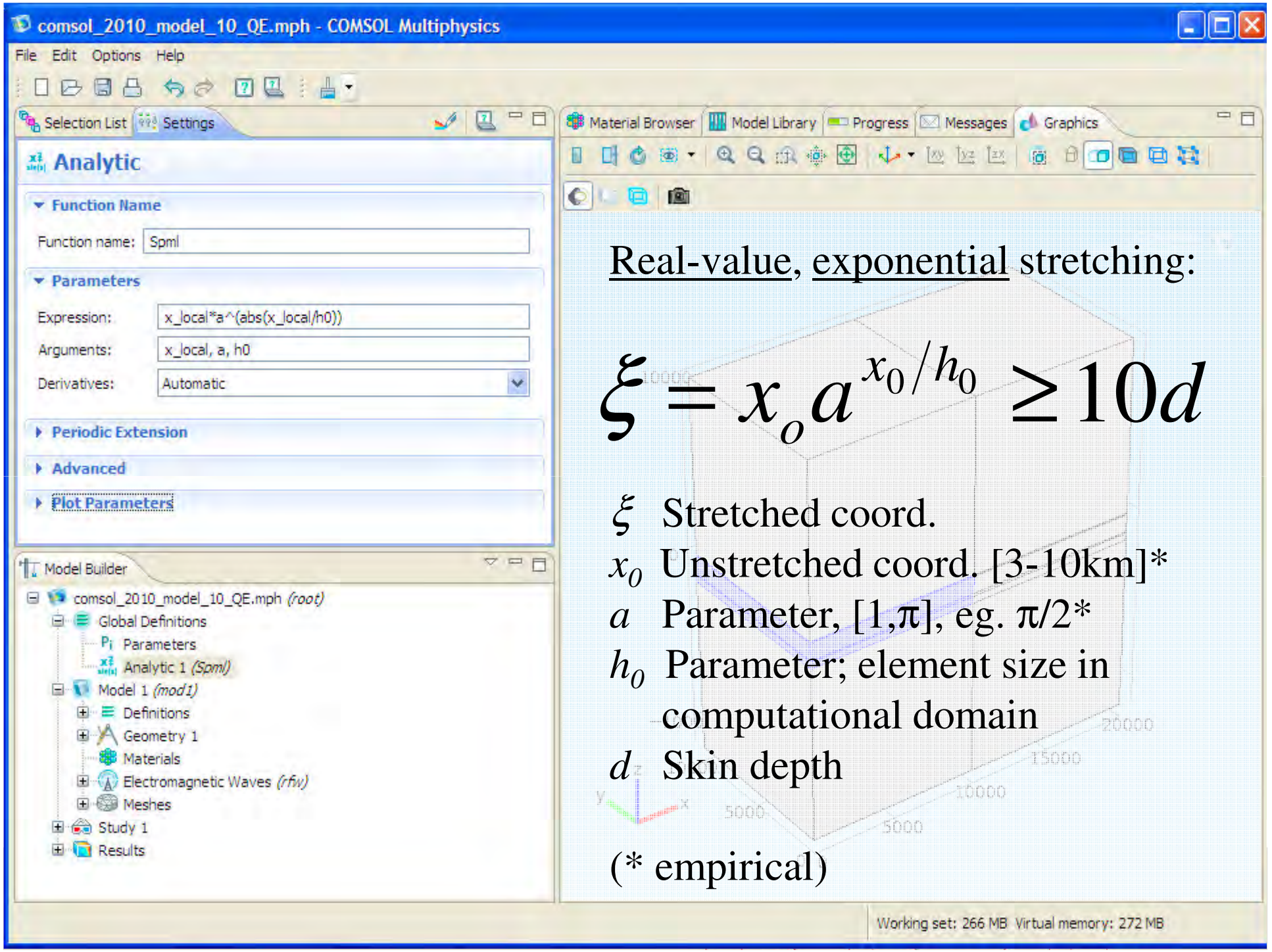
Complex-value stretching
For our application: Not efficient enough due to high attenuation

- Berenger, J., A perfectly matched layer for the absorption of electromagnetic waves, J. Comput. Phys. 114(2), 185-200. (1994).
- Etc.

Yet,

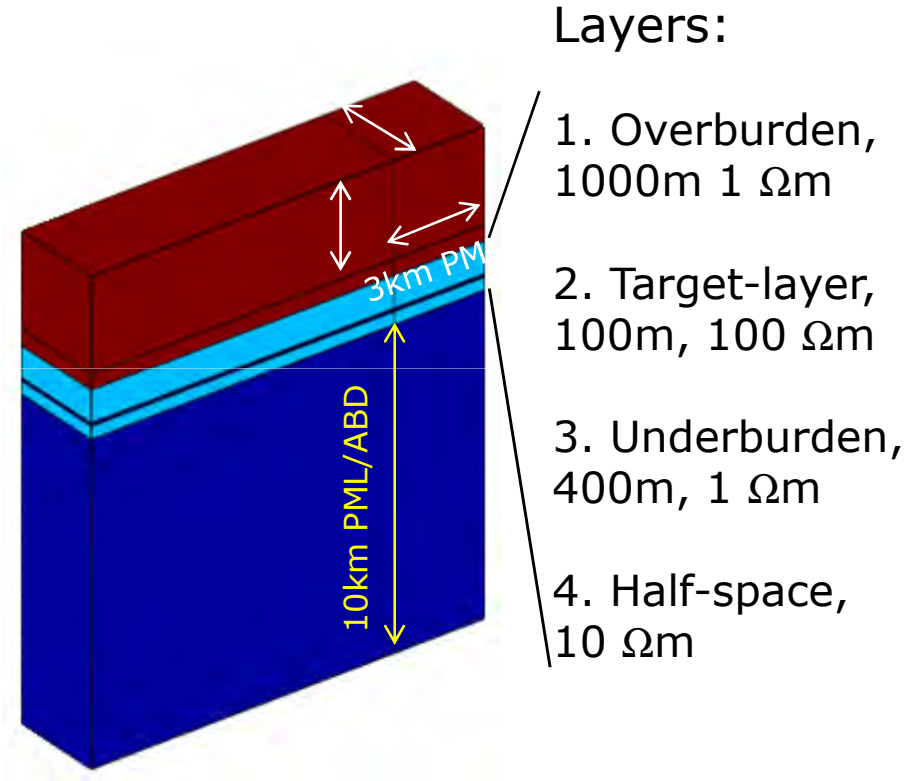
Real-value stretching

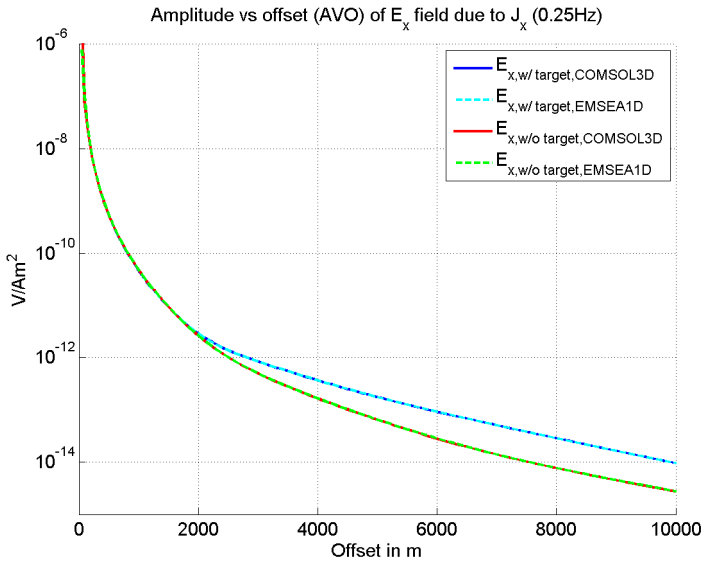
- Lysmer, J., M. Tabatabaie-Raissi, F. Tajirian., S. Vahdani,. and F. Ostadan (1981). SASSI - A system for analysis of soil-structure interaction, Report UCB/GT 81-02, Univ. of California, Berkeley, USA.

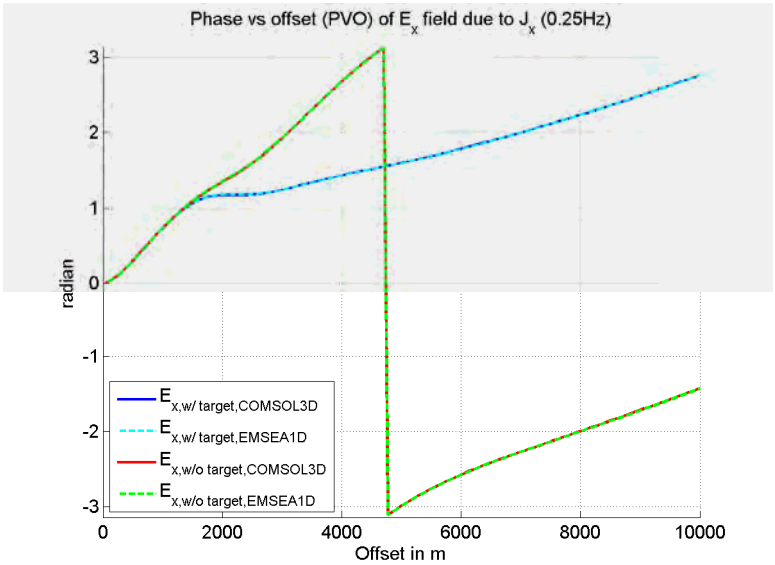

comsol_2010_model_10_QE.mph - COMSOL Multiphysics
File Edit Options Help
Selection List
Settings
Analytic
Function Name
Function name: Spml
Parameters
Expression: x_local*a^(abs(x_local/h0))
Arguments: x_local, a, h0
Derivatives: Automatic
Periodic Extension
Advanced
Plot Parameters
Model Builder
comsol_2010_model_10_QE.mph (root)
Global Definitions
Parameters
Analytic 1 (Spml)
Model 1 (mod1)
Definitions
Geometry 1
Materials
Electromagnetic Waves (rfw)
Meshes
Study 1
Results
Material Browser
Model Library
Progress
Messages
Graphics
Real-value, exponential stretching:
$\xi = x_o a^{x_0/h_0} \geq 10d$
ξ Stretched coord.
x_0 Unstretched coord. [3-10km]*
a Parameter, [1,π], eg. π/2*
h_0 Parameter; element size in computational domain
d Skin depth
(* empirical)
Working set: 266 MB Virtual memory: 272 MB

Test example 1: infinite-deep water without air-wave effect

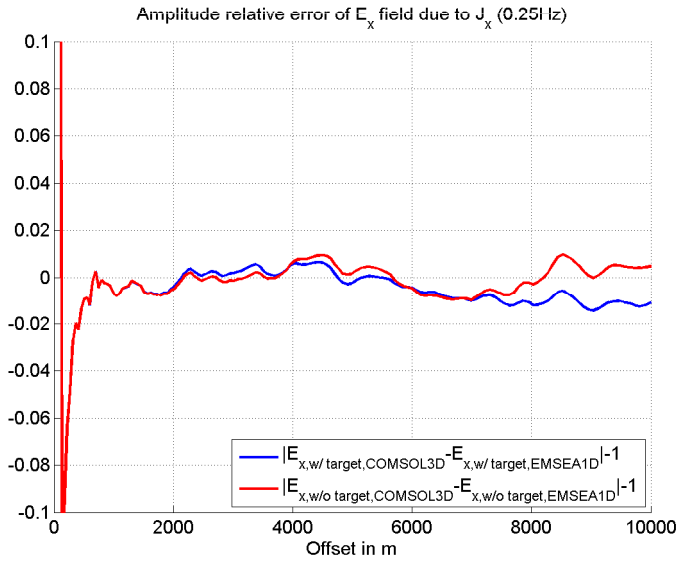
- Infinite deep seawater
- 0.25Hz inline HED
- Receiver line: 0–10km, or 0–5km on seabed
- The subsurface consists of four layers
- ABD sizes are 3 and 10 km

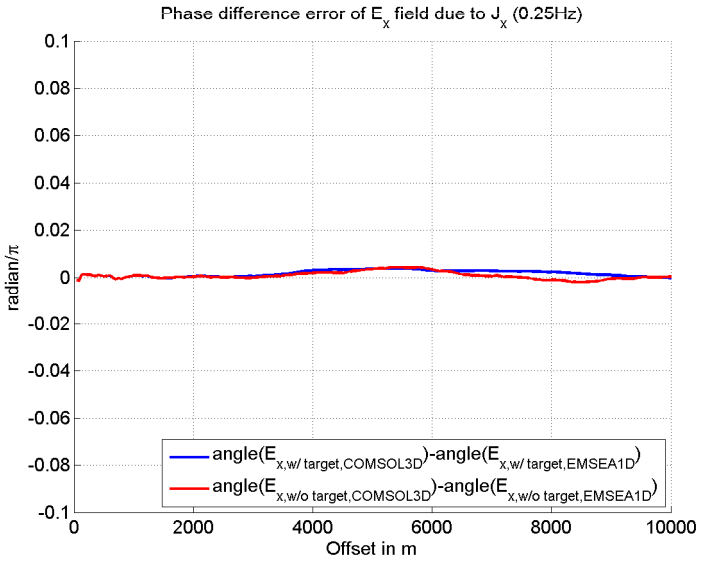




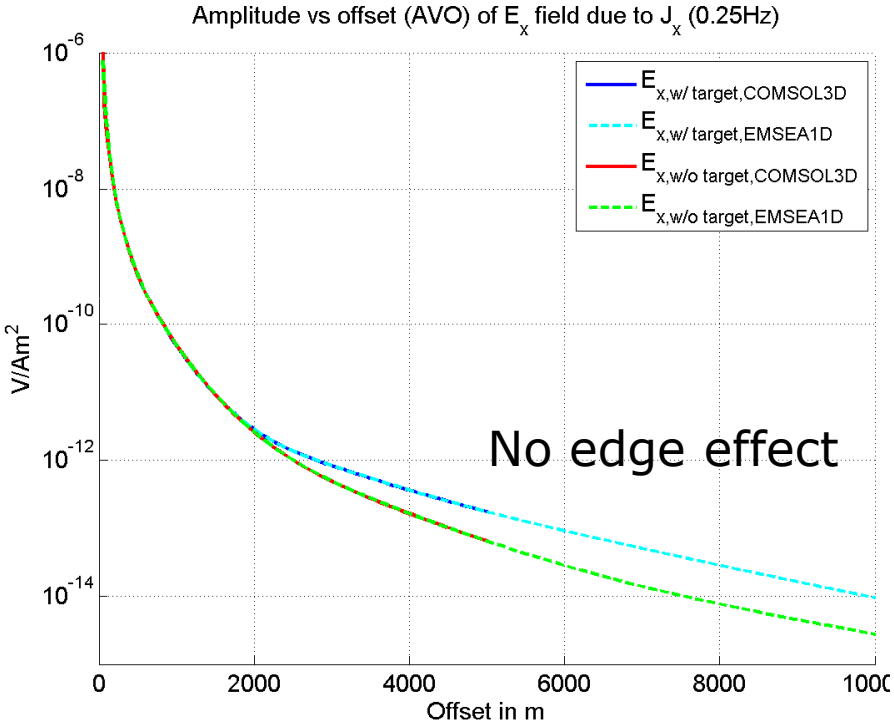


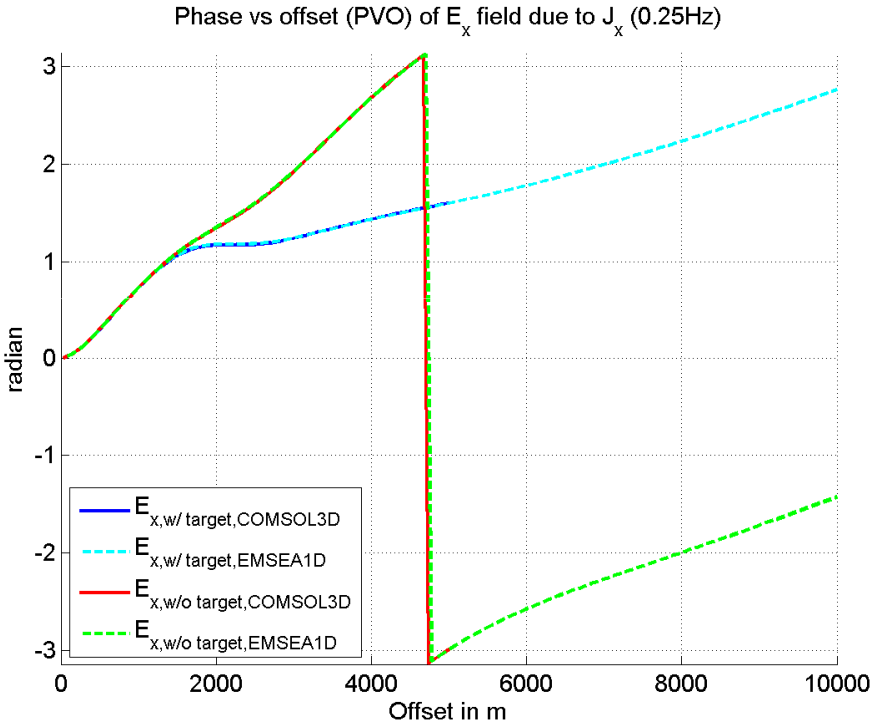
(n)AVO and (d)PVO for 10km model





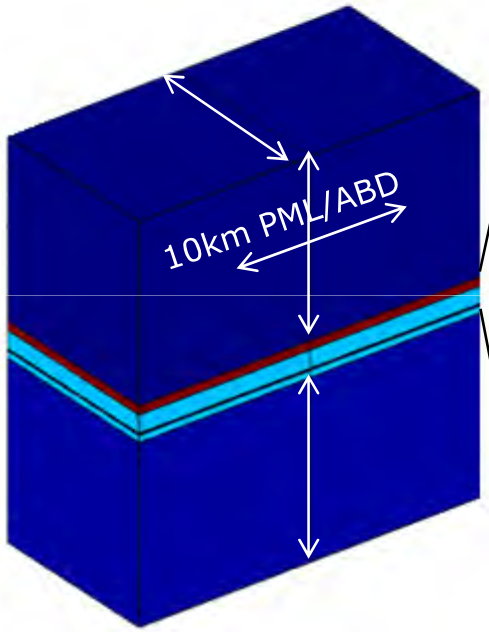
AVO and PVO for 5km model





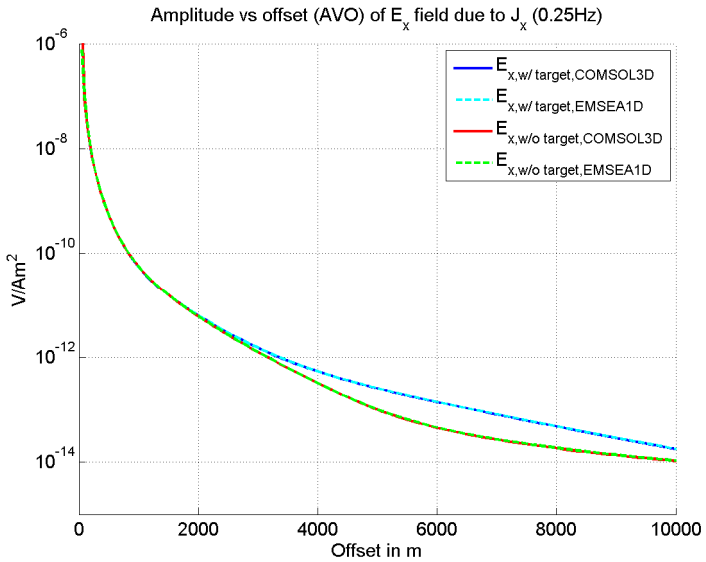
Test example 2: shallow water with air-wave effect

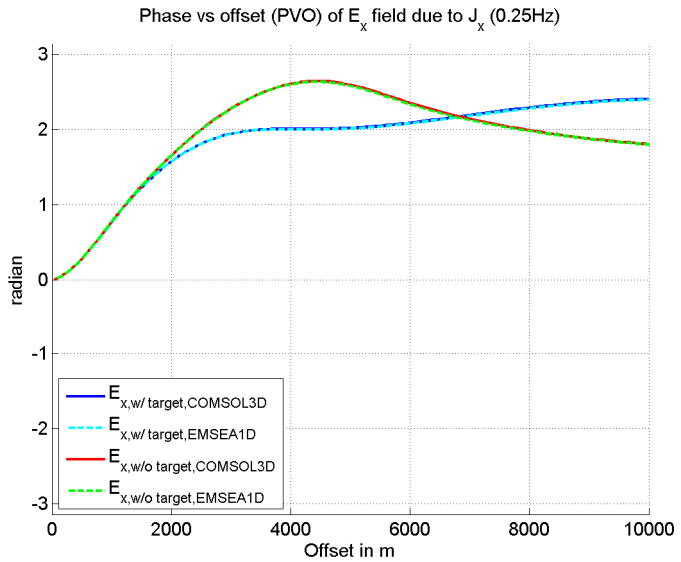
- 500m water depth
- 0.25Hz inline HED
- Receiver line: 0–10km, or 0–5km on seabed
- Subsurface consists of four layers
- ABD size is10km



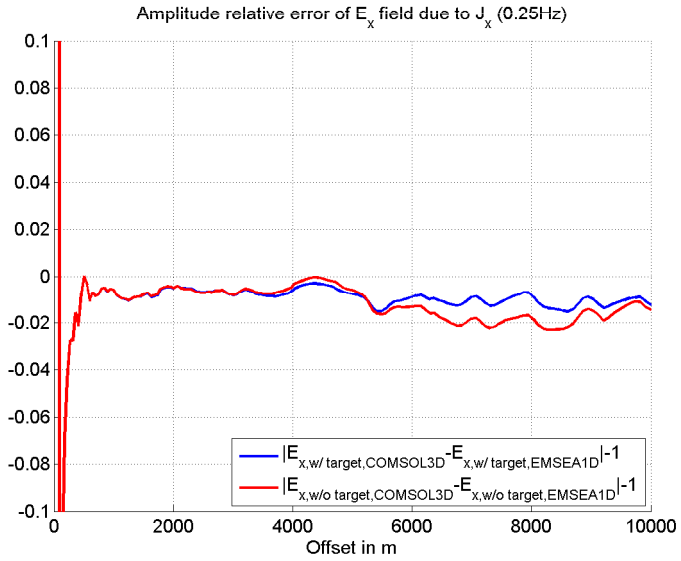
Layers:

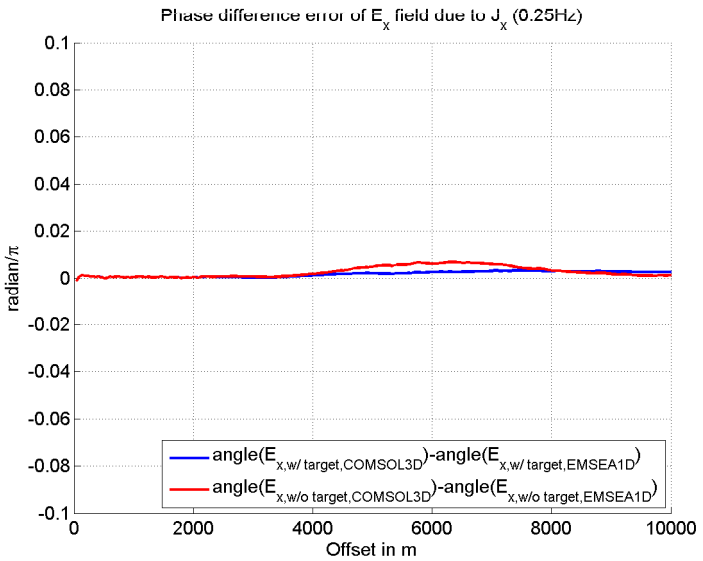
1. Overburden, 1000m 1 Ωm
2. Target-layer, 100m, 100 Ωm
3. Underburden, 400m, 1 Ωm
4. Half-space, 10 Ωm



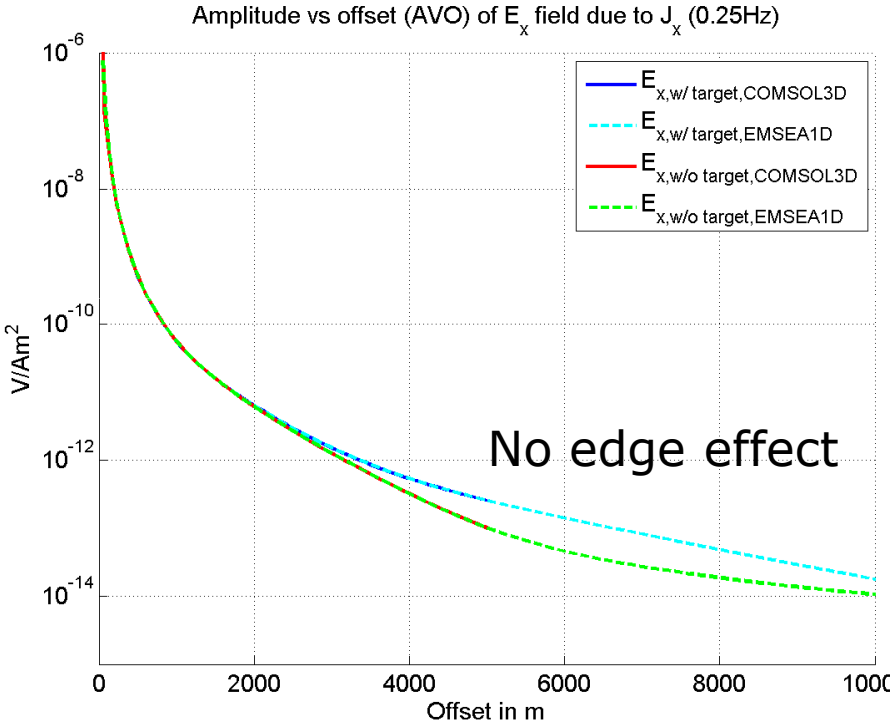


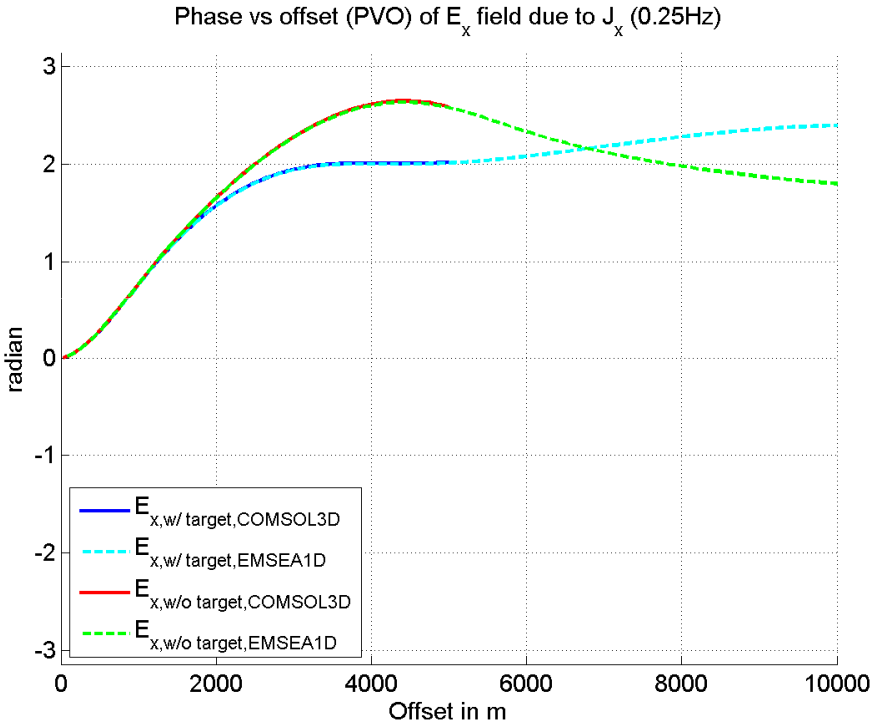
(n)AVO and (d)PVO for 10km model





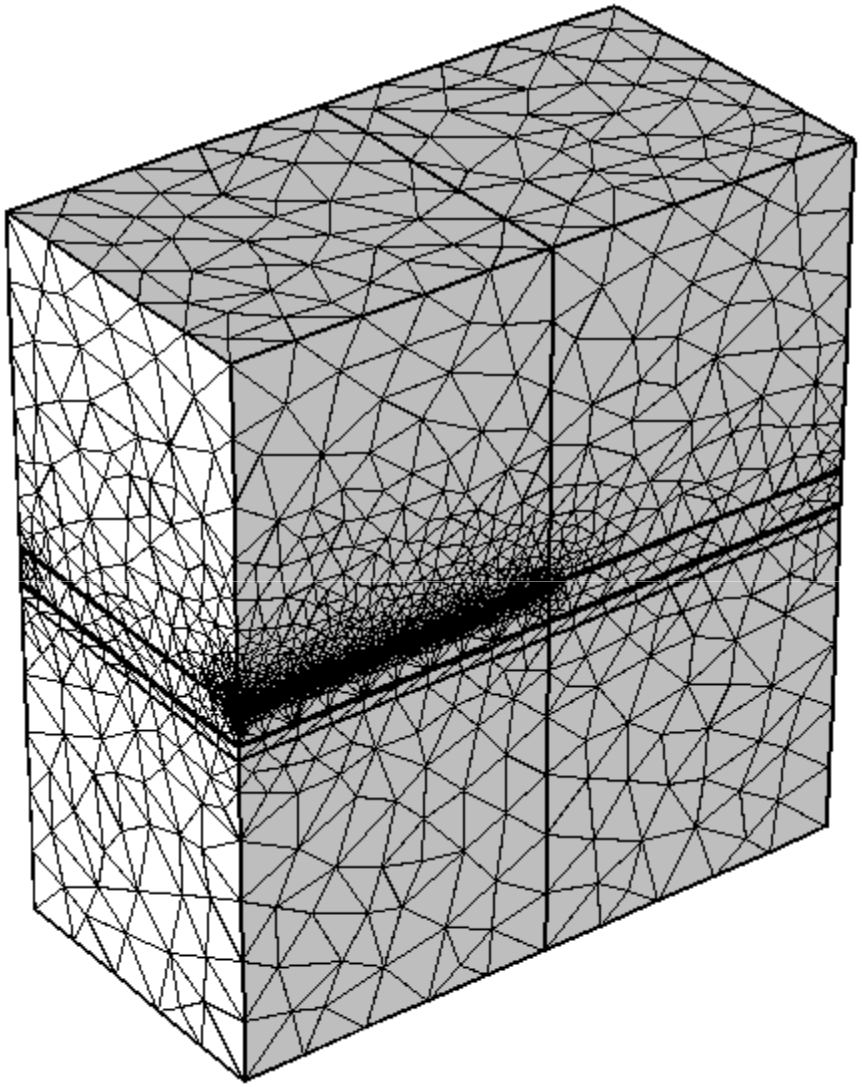
AVO and PVO for 5km model





Mesh

- Note that mesh size in ABD is rather big
- Note that dense mesh near the the receiver lines are made



Summary

- An efficient absorbing boundary domain technique is implemented and evaluated in COMSOL
  - Real-valued (and complex-valued) exponential stretching

- Acknowledgements:
  - Thank to Statoil, MultiField Geophysics, and NGI for their financial support for this study and permission to present