Edge-elements for geophysical electromagnetic problems: A new implementation challenge

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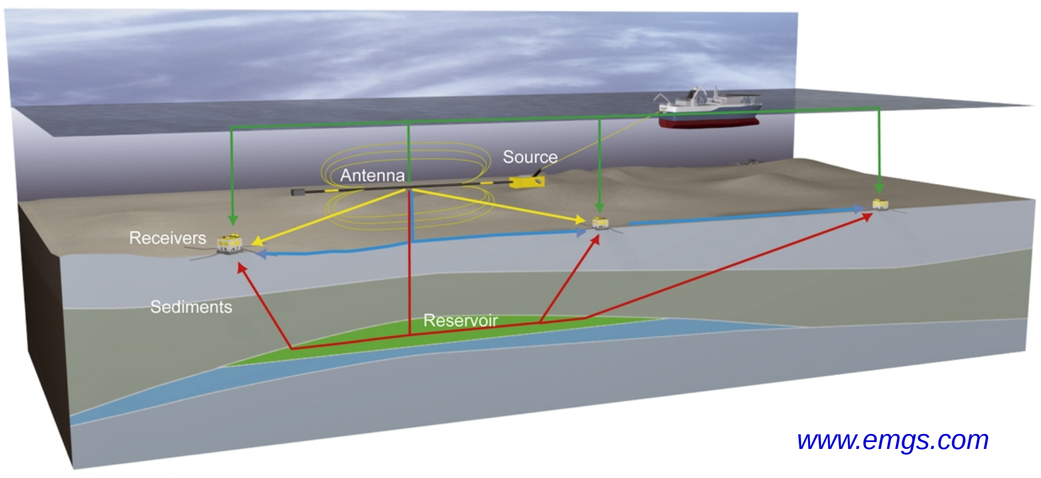
Motivation & goal

- Exploration geophysics is of great societal value
- Electromagnetic Methods (EM) are an established tool in geophysics
- Edge-elements for electromagnetic simulations: No spurious solutions
- Understand, implement and optimize the Edge-elements approach in HPC platforms to simulate EM for oil industry

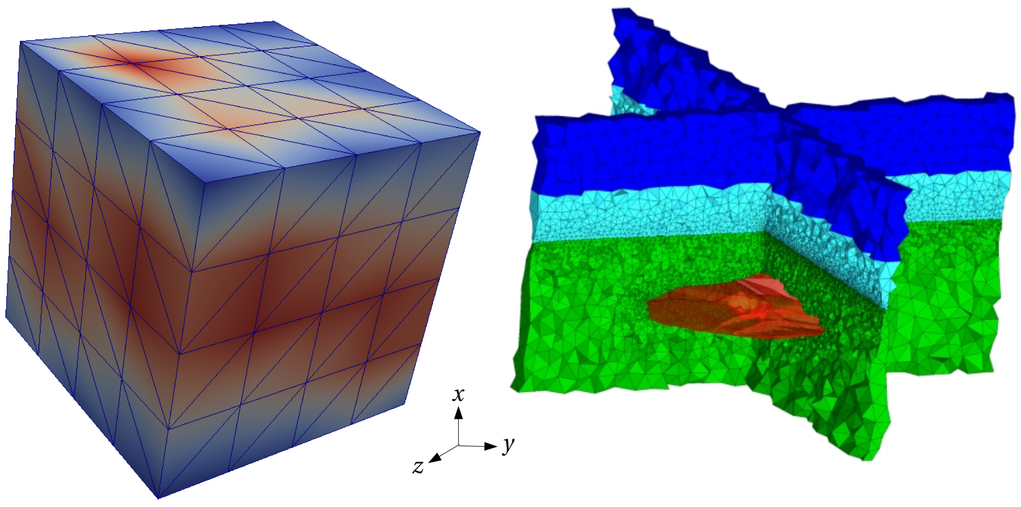


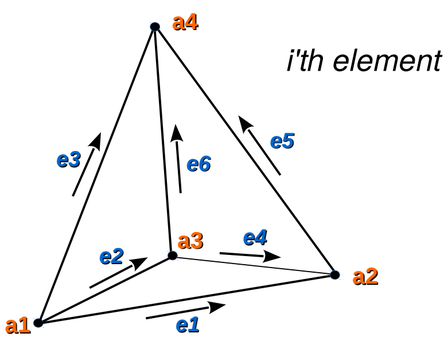
www.emgs.com

- Complex geometries
- Anisotropic domains
- Reduce uncertainty
- Increase awareness of the earth's subsurface

Formulation

- Edge-elements (Nédélec) Method uses vector basis functions
- Divergence free but not curl free





Column … a1 … a2 … a3 … a4 …

nodes = … x … x … x … x … / … y … y … y … y … / … z … z … z … z …

Column … i …

elements = … a1 … / … a2 … / … a3 … / … a4 …

Column … e1 … e2 … e3 … e4 … e5 … e6 …

edges = … a1 … a1 … a1 … a3 … a2 … a3 … / … a2 … a3 … a4 … a2 … a4 … a4 …

Column … i …

elements = … e1 … / … e2 … / … e3 … / … e4 … / … e5 … / … e6 …

Column … i …

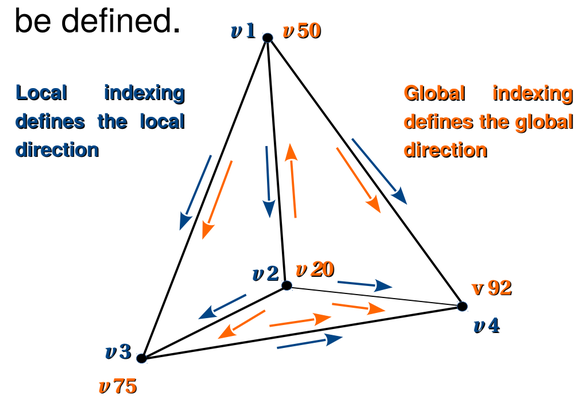
signs = … ±e1 … / … ±e2 … / … ±e3 … / … ±e4 … / … ±e5 … / … ±e6 …

Transformation stage in pre-processing

Key issues

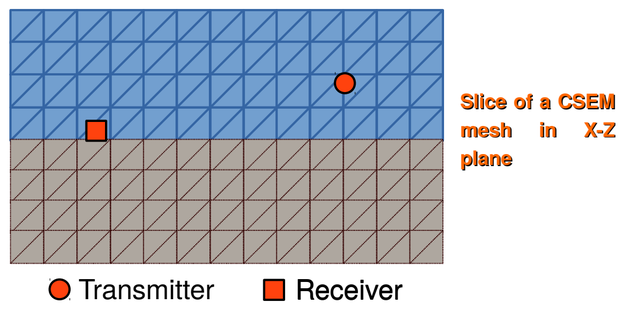
Edge direction

- To ensure tangential continuity, a unique global edge direction should be defined.

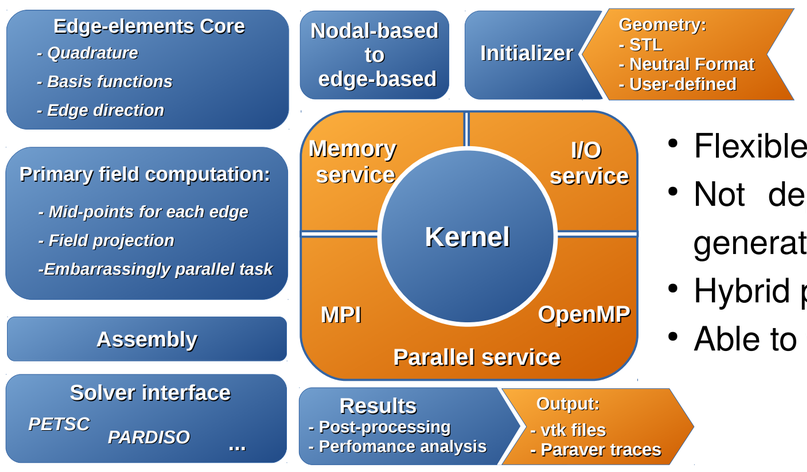


CSEM simulations

- Primary field is calculated analytically for a background layered-earth model.
- Secondary field is discretized using edge-elements.



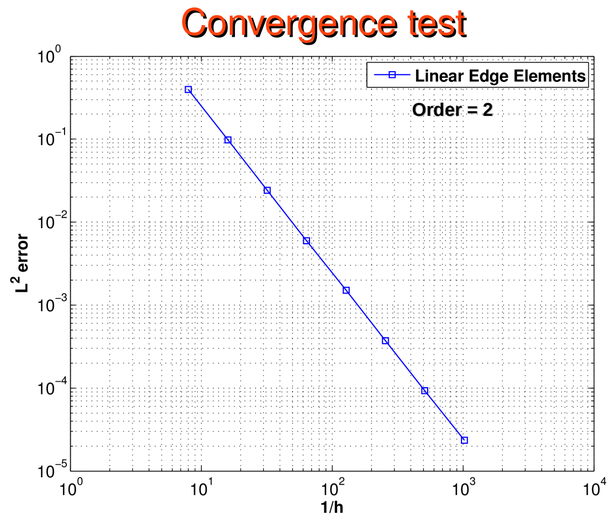
Framework



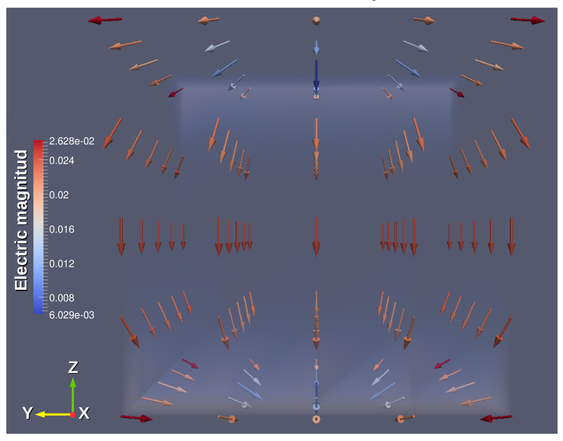
- Flexible
- Not dependent on a specific mesh generator
- Hybrid parallel approach
- Able to work with unstructured meshes

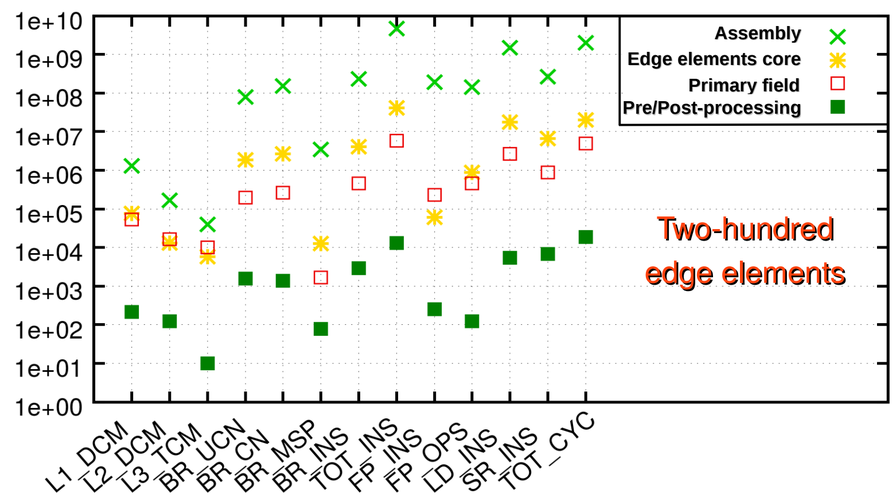
Preliminary results

Convergence test



Z-directed dipole





Performance Analysis

PAPI Counters

Acknowledgements

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