ECond, A powerful estimator for source placement quality in MFS

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Introduction

- The source placement for the MFS is a standing question for this powerful and simple method,
- Introducing the use of the Effective Condition Number (ECond) within the context of the MFS as a tool to determine whether the assumed source points configuration gives accurate results or not.
- Problems with linear and non-linear differential operators are considered such as Navier equation of elasticity and Navier-Stokes equations of fluid mechanic

What is ECond

For a system of equations : $[\mathrm{A}]\{\mathrm{x}\} = \{\mathrm{b}\}$

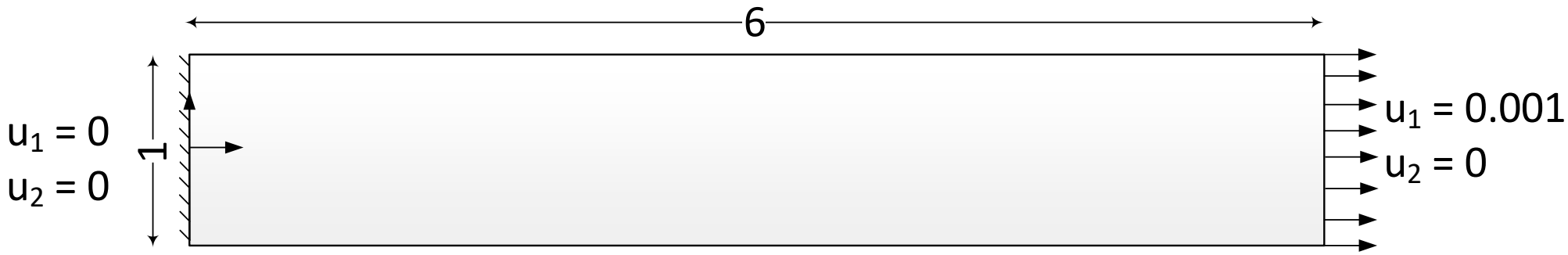
ECond is defined as $ECond = \frac{\|\{\mathrm{b}\}\|}{\sigma_n \|\{\mathrm{x}\}\|}$

Where σ_n the smallest non-zero singular value from SVD for $[A]$

ECond measures how a small change in the known vector B would affect the unknown vector X

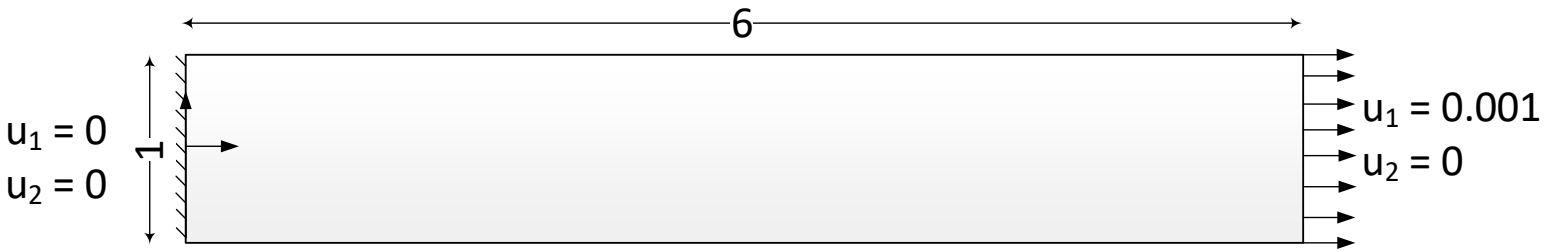
Where ECond is Maximized, this indicates that the best possible results are obtained when the system is most sensitive to perturbations.

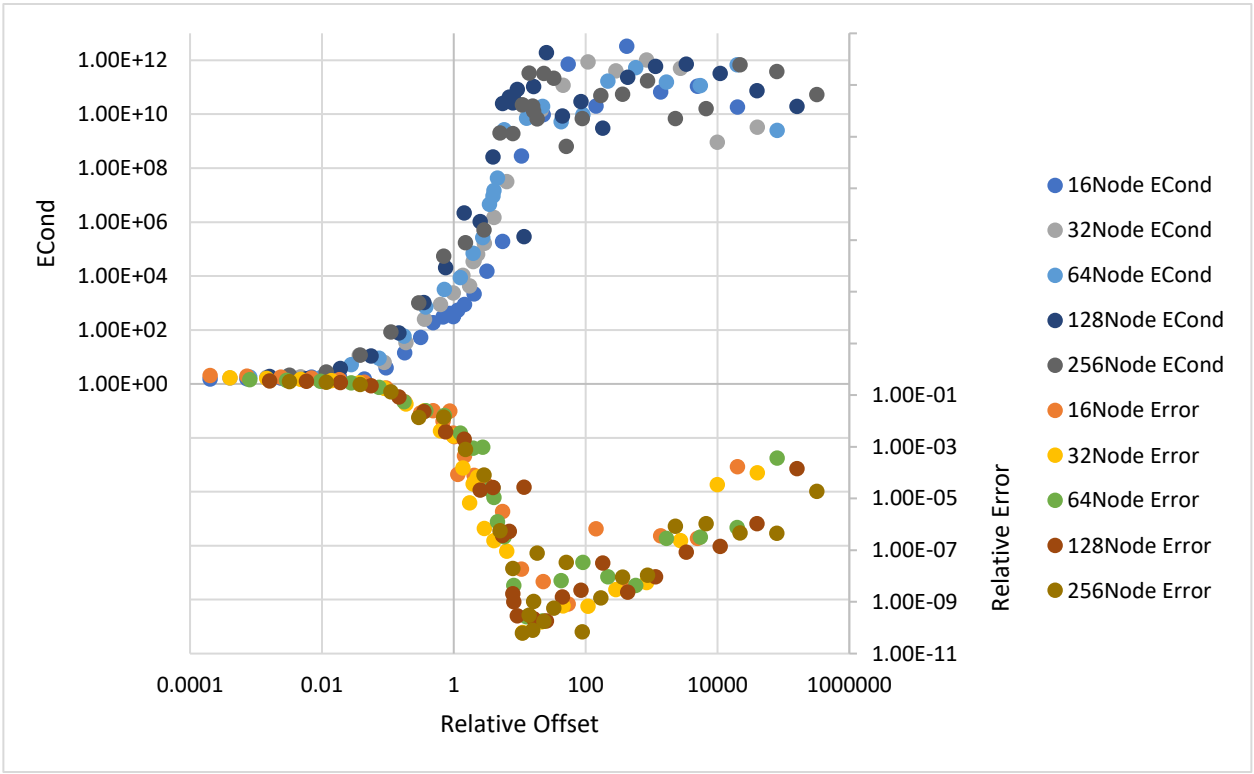
Elasticity problems



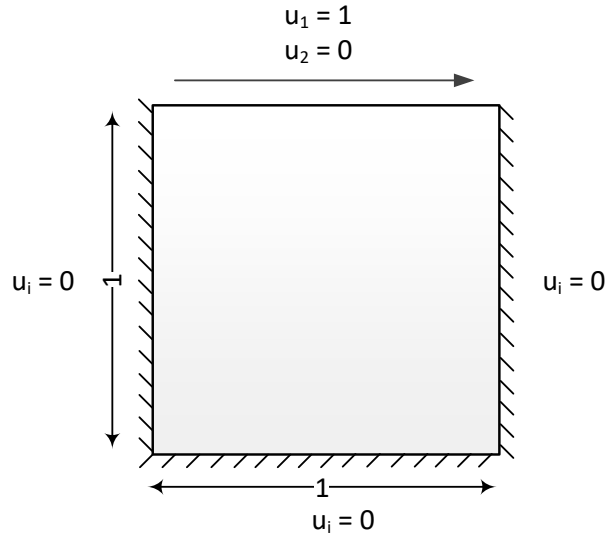
The first elasticity problem is a 1x6 bar element subjected to 0.001 displacement at one of its ends.

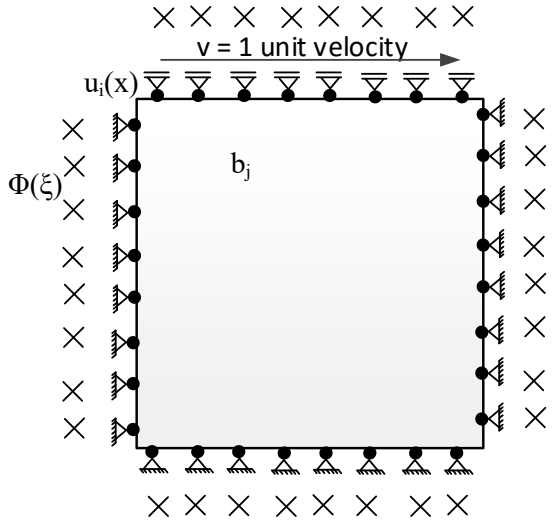
Elasticity problems





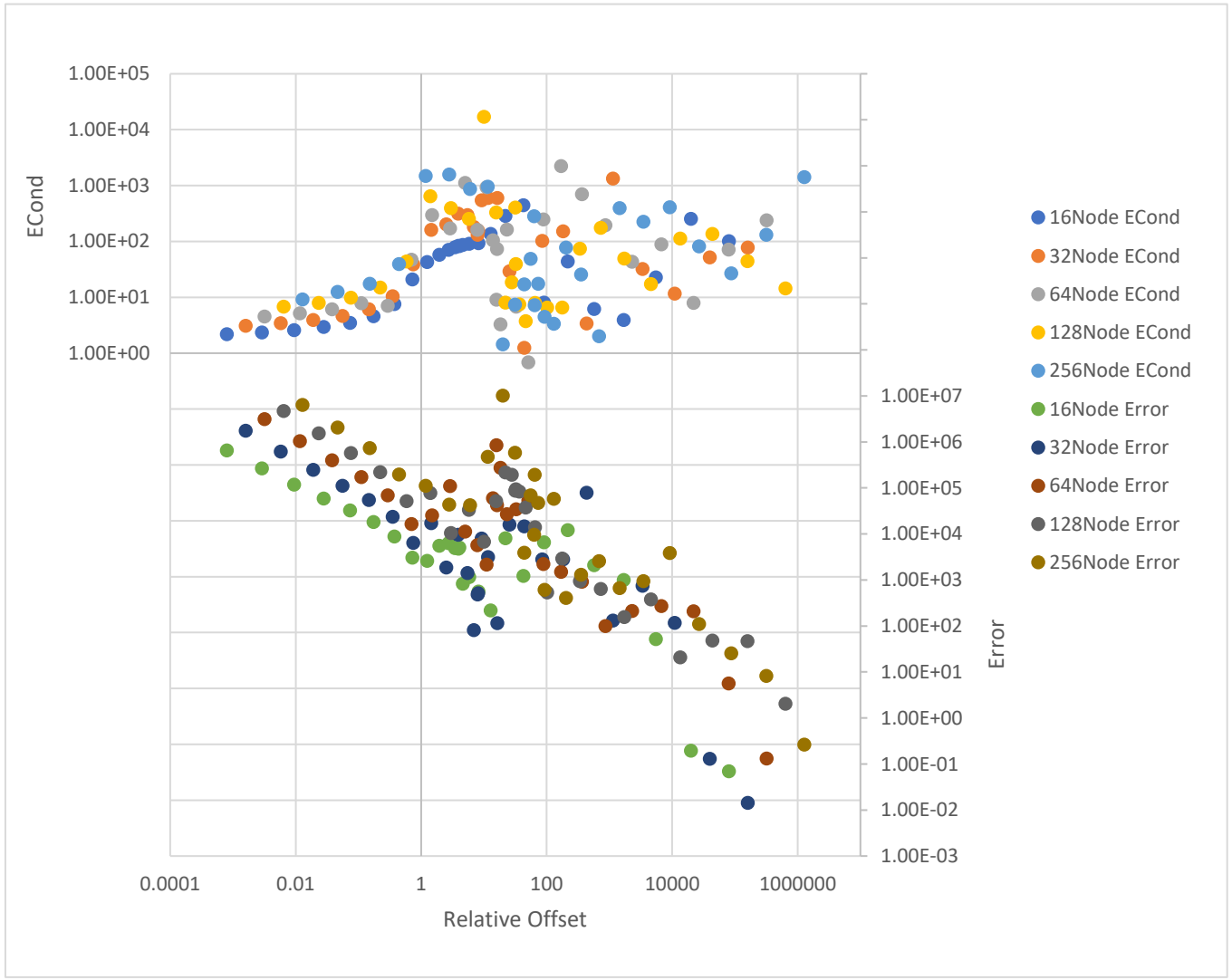
Fluid Mechanics Problems

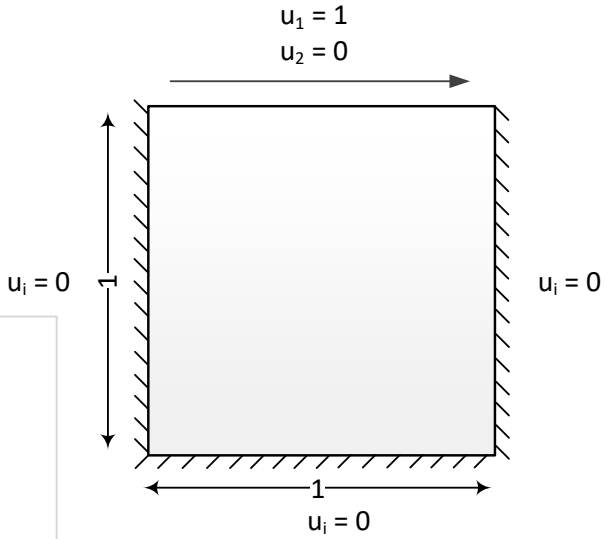


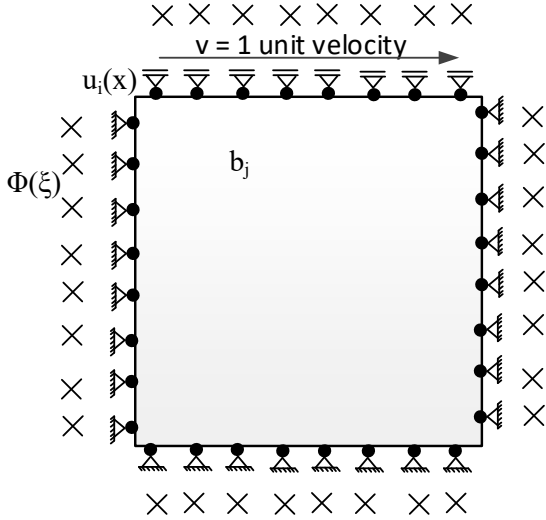


- The lid-driven cavity problem is investigated in two phases:
- the first phase is the test of the initial elasticity problem (where no convective term is applied) in a manner similar to that of the bar problem
- The second phase is an investigation of the effective condition number with the change in the domain convective term

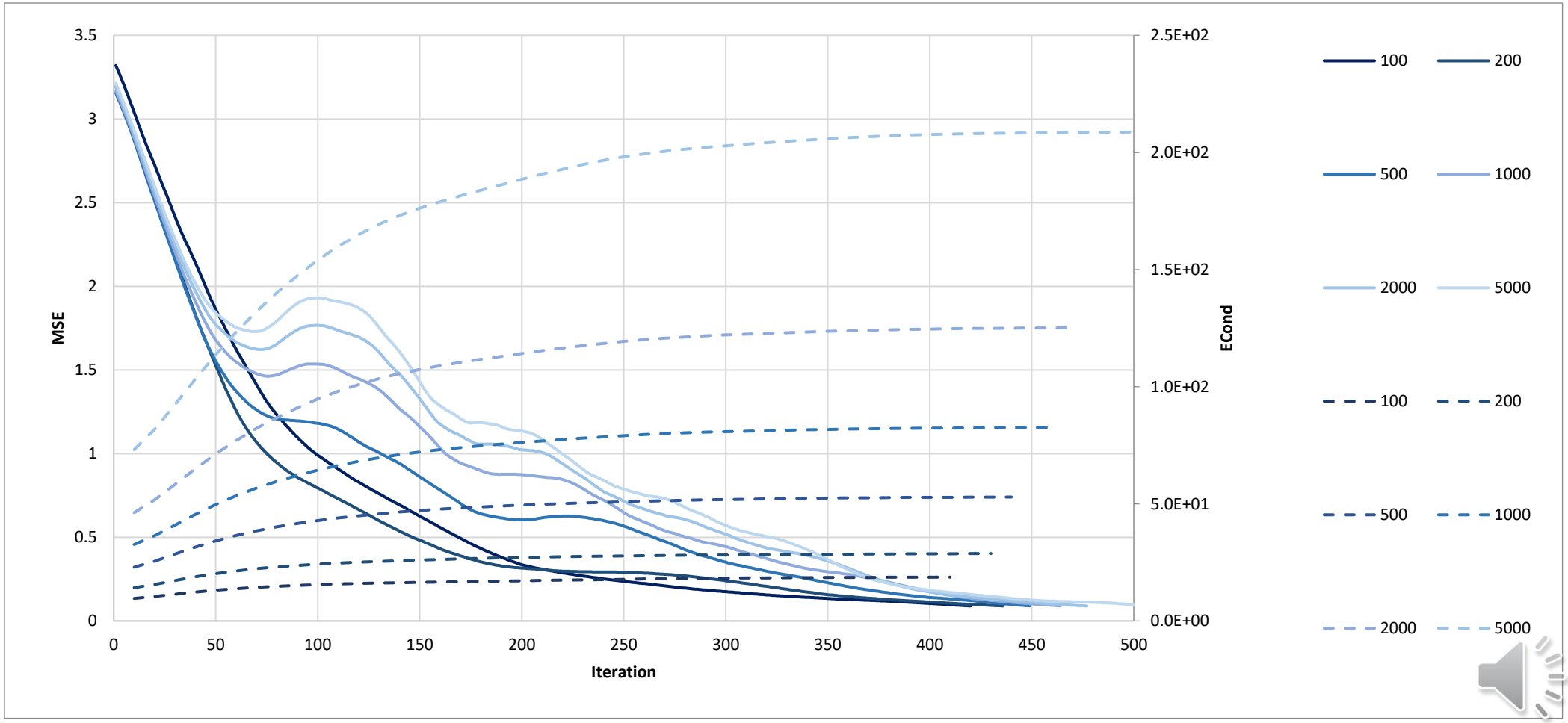
Fluid Mechanics Problems







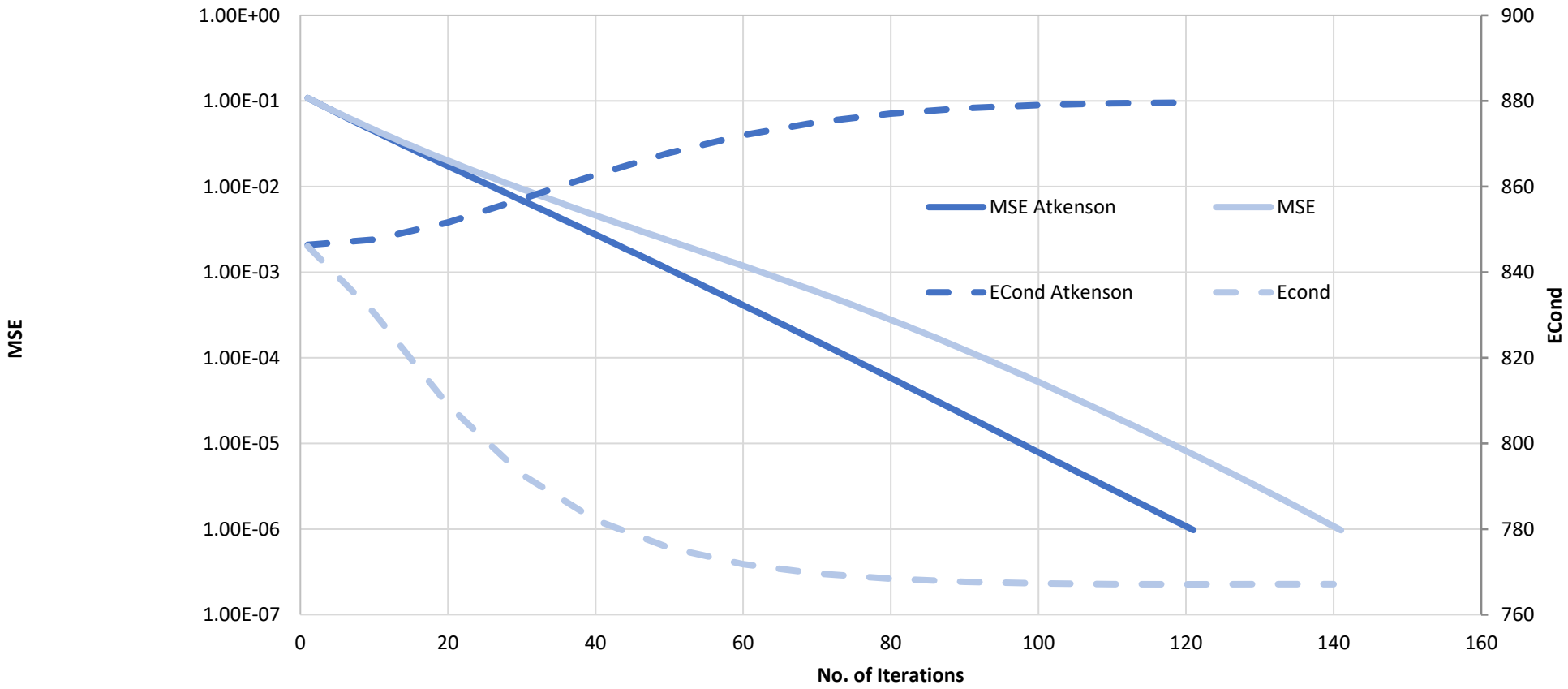
Steady-state convergence with ECond



Atkinson Method

- When solving the fluid mechanics using a multi domain approach the particular integral could be calculated using domain effect from each domain individually and applied to this domain boundary points.
- The second approach is to calculate the particular integral using domain effect from the entire problem combined and then applied to the domain boundary points for each domain.

Atkinson Method



Conclusion

- In the first segment the background for the ECond is presented.
- The ECond is a good indicator for the quality of the source location.
- The elasticity problem and the first step of fluid mechanics problem both exhibit the same behavior in terms of ECond value.
- The introduction of domain term (convective term) greatly decrease the ECond value, and throughout the convergence steps. However, the ECond increases when the problem approaches a converged state.
- In the previous segment, the method of Atkinson demonstrated a slightly better stability during the convergence phase with increasing ECond.