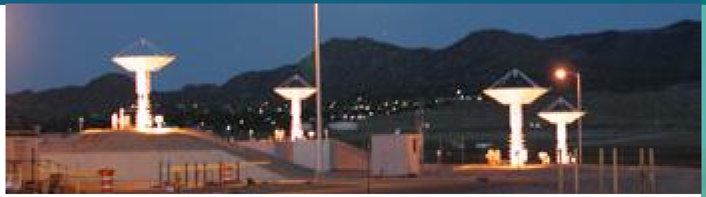
SAND2022-0116C

High-Fidelity CFD Workshop 2022: Blottner Sphere and HiFire1 problem overview



PRESENTED BY

Travis Fisher

2022 AIAA 1st High-Fidelity CFD Workshop

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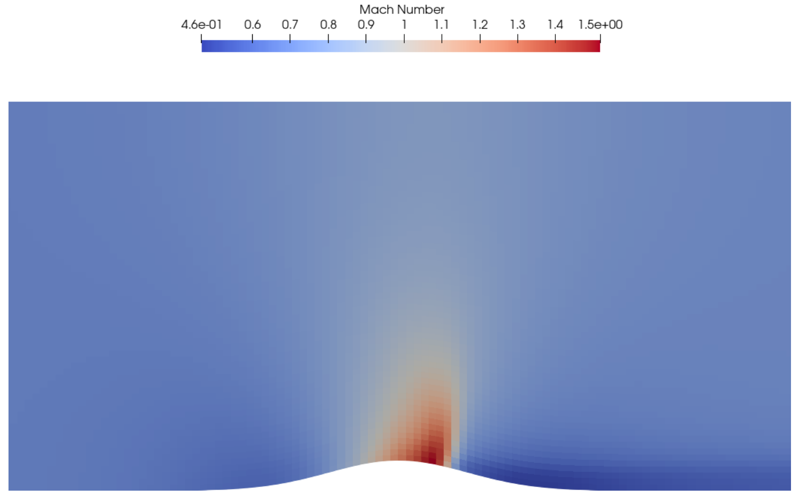
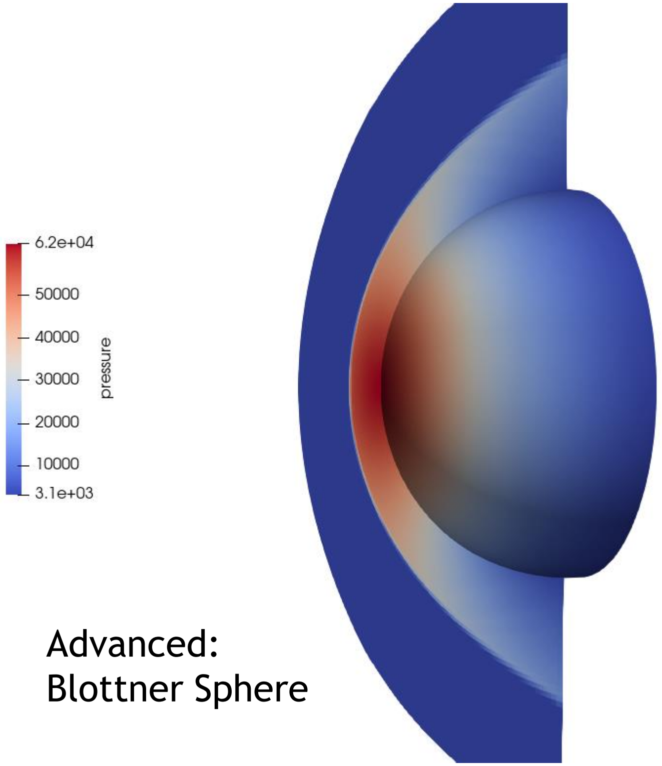
Workshop Cases

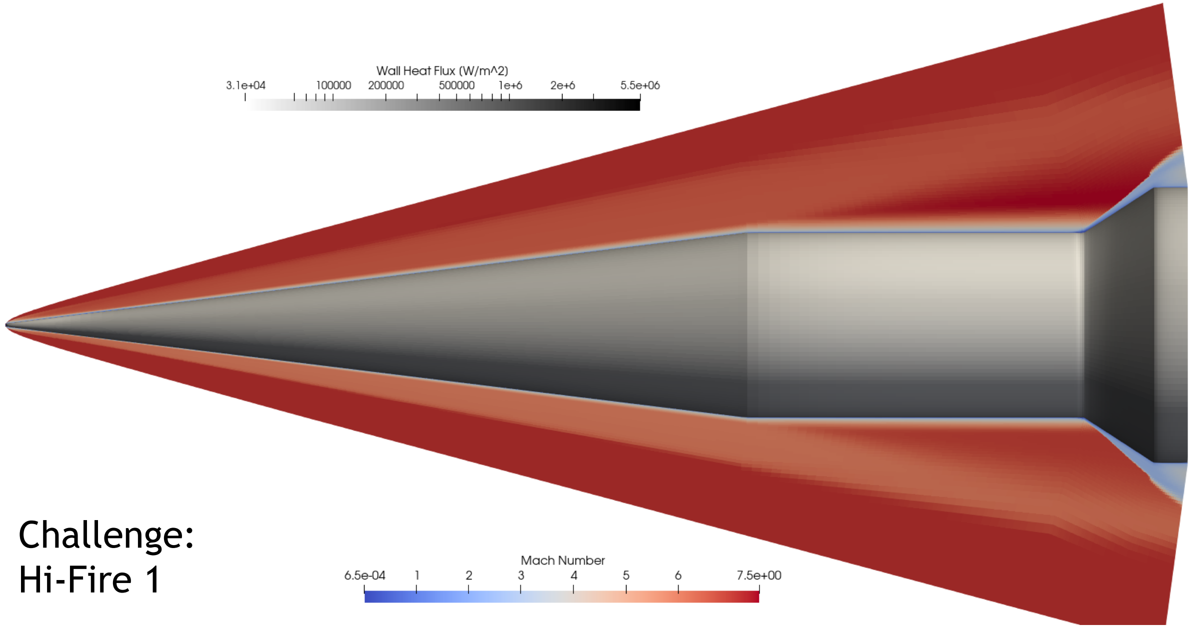
Visit workshop website for up-to-date case descriptions and meshes: https://turbmodels.larc.nasa.gov/highfidelitycfd_workshop2022.html



Verification:
Supersonic Inviscid Bump



Advanced:
Blottner Sphere



Challenge:
Hi-Fire 1

Blottner Sphere Problem Info

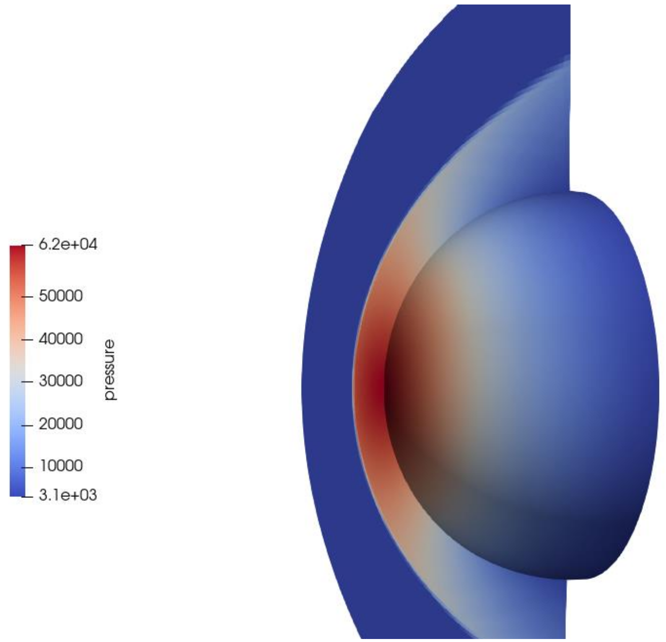
Viscous flow around half sphere

Sensitive to numerical methods
- Entropy fix
- Shock alignment
- Limiters

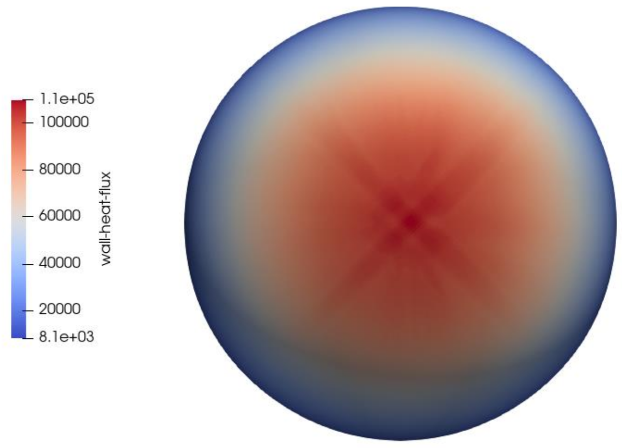
Run full 3D problem

Meshes provided
- Strucutred multi-block
- Unstructured hex, including curved high-order
- Unstructured tet, including curved high-order

Specific Heat Ratio, γ	1.4
Mach Number, Ma	5.0
Reynolds Number, Re_D	1.8875×10^6
Prandtl Number, Pr	0.72
Wall Temperature Ratio, T_w/T_∞	1.308



Contours of pressure in the volume and on the sphere surface



Contours of heat flux on the sphere surface

Blottner Sphere Required Outputs

Stagnation heat flux

Integrated wall heat flux

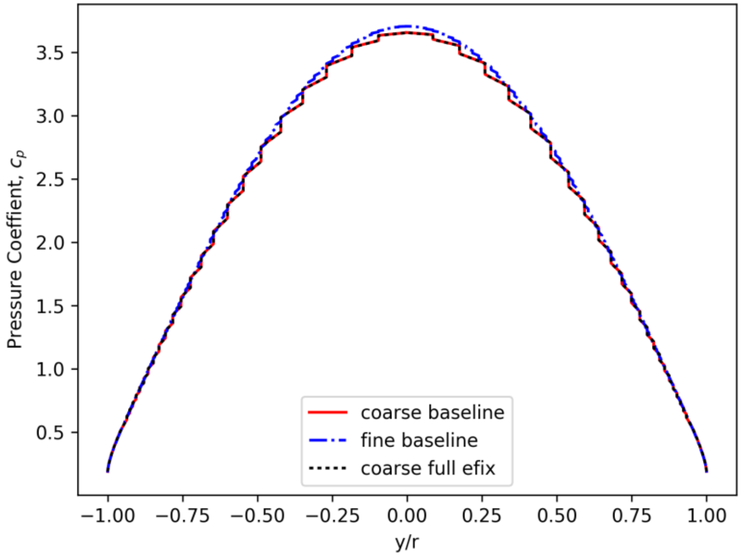
Wall heat flux profiles
- Intersecting x-y plane
- Intersecting 45 degrees rotation from x-y plane

Static pressure
- Intersecting x-y plane
- Intersecting 45 degrees rotation from x-y plane

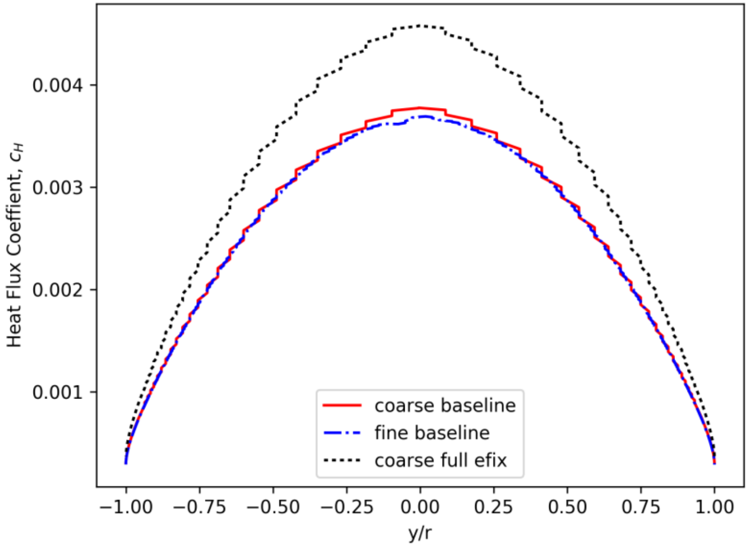
Stagnation streamline pressure

Stagnation streamline temperature

Work units for each solution



Pressure coefficient along the intersection of the surface and the x-y plane for three different simulations



Heat flux coefficient along the intersection of the surface and the x-y plane for three different simulations

Hi-Fire I Problem Description

Mach 7.2 flow around more complex geometry

Goal is to demonstrate convergent, cross-solver heat flux predictions of laminar and turbulent sections

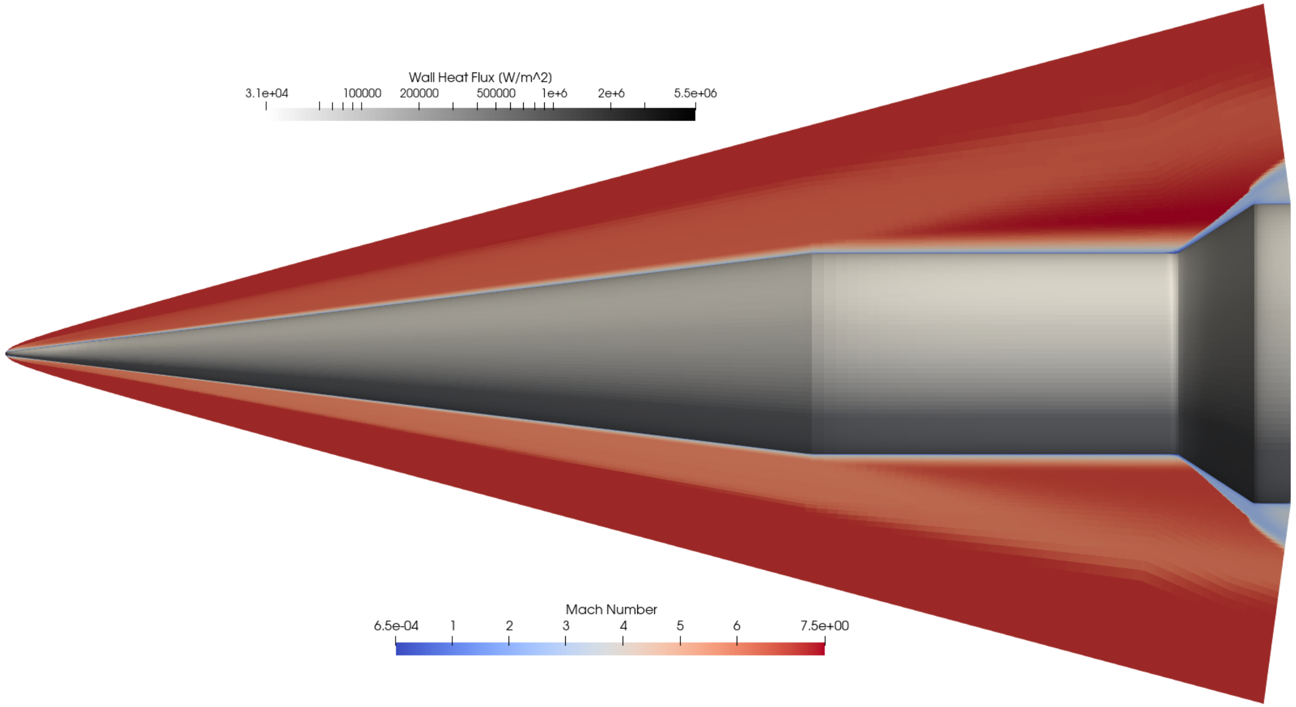
- Laminar simulation over conical forebody
- Fully turbulent simulation using SA-negative model over entire geometry

Need half geometry to predict with 2 degree AOA

Meshes provided

- Strucutred multi-block
- Unstructured hex, including curved high-order
- Unstructured tet, including curved high-order

Specific Heat Ratio, γ	1.4
Mach Number, Ma	7.18
Freestream Reynolds Number, Re_∞	$10.123 \times 10^6\ /m$
Prandtl Number, Pr	0.72
Angle-of-Attack, α	2°
Wall Temperature Ratio, T_w/T_∞	1.279



Hi-Fire I Required Outputs

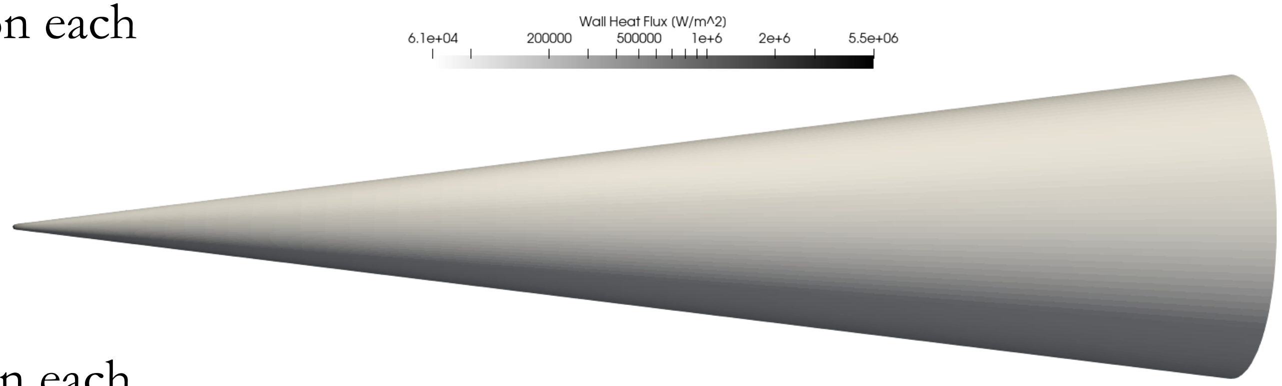
Wall heat flux profiles for laminar and turbulent on each mesh

- Intersection with x-y plane on the windward side
- Intersection with x-y plane on the lee side
- Intersection of x-z plane

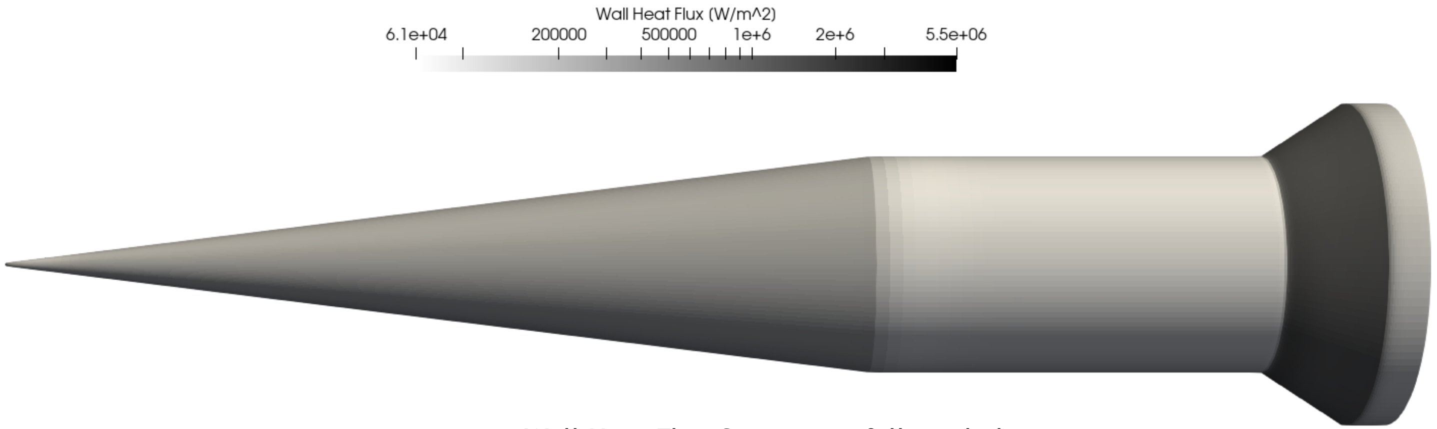
Static pressure profile for laminar and turbulent on each mesh

- Intersection with x-y plane on the windward side
- Intersection with x-y plane on the lee side
- Intersection of x-z plane

Work units for each solution

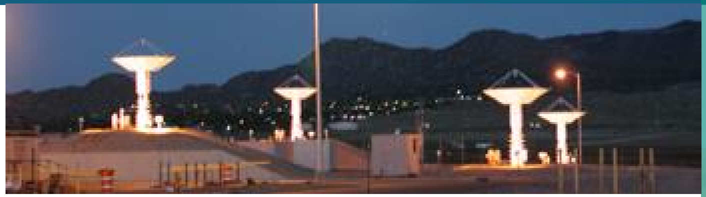


Wall Heat Flux Contour on laminar simulation of cone forebody



Wall Heat Flux Contour on fully turbulent simulation of entire geometry

High-Fidelity CFD Workshop 2022: Blottner Sphere and HiFire1 results



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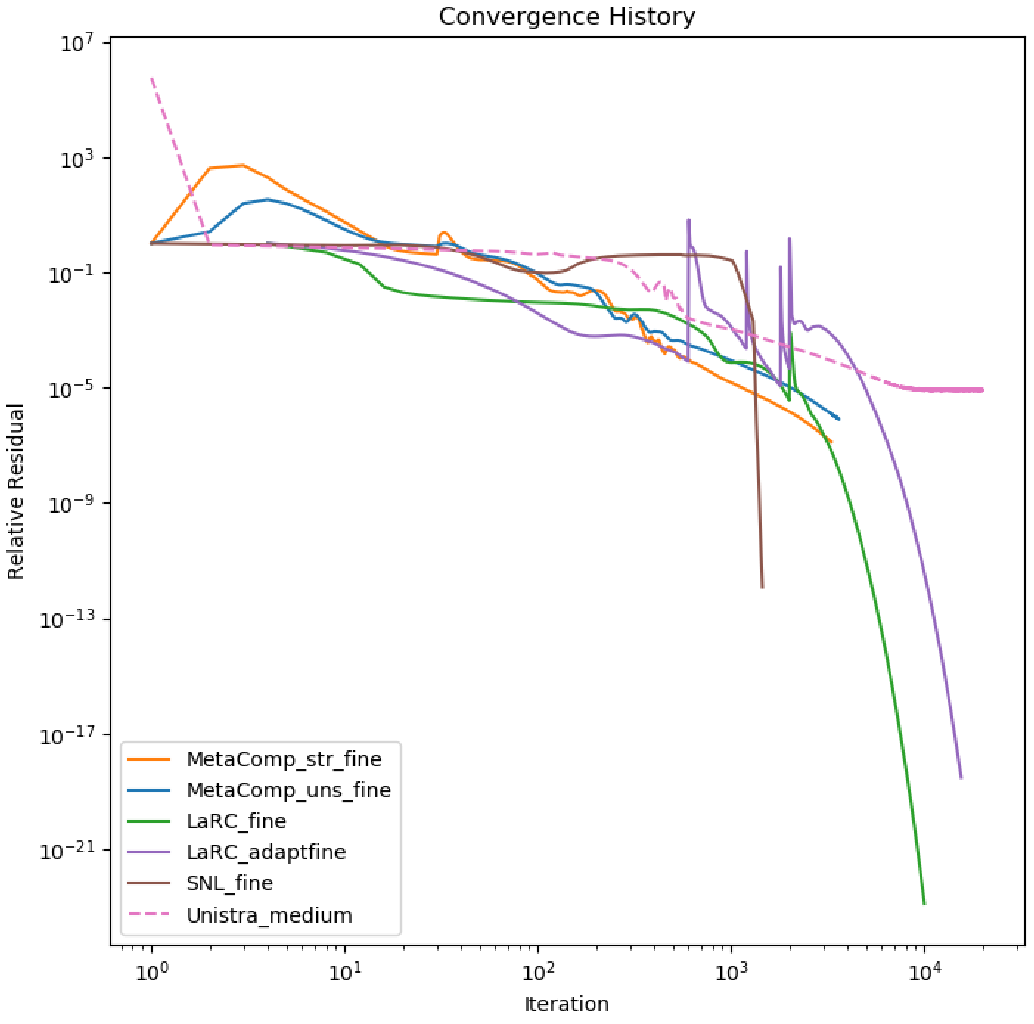
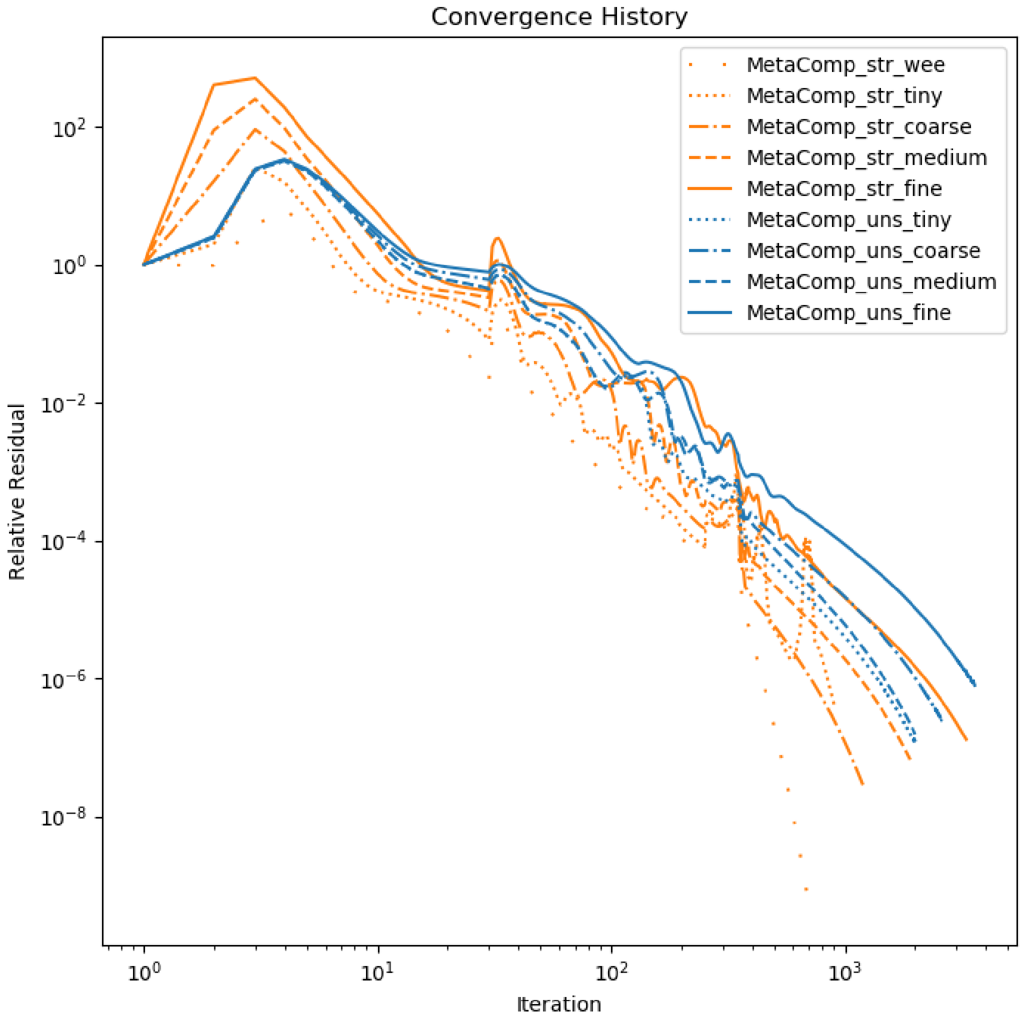
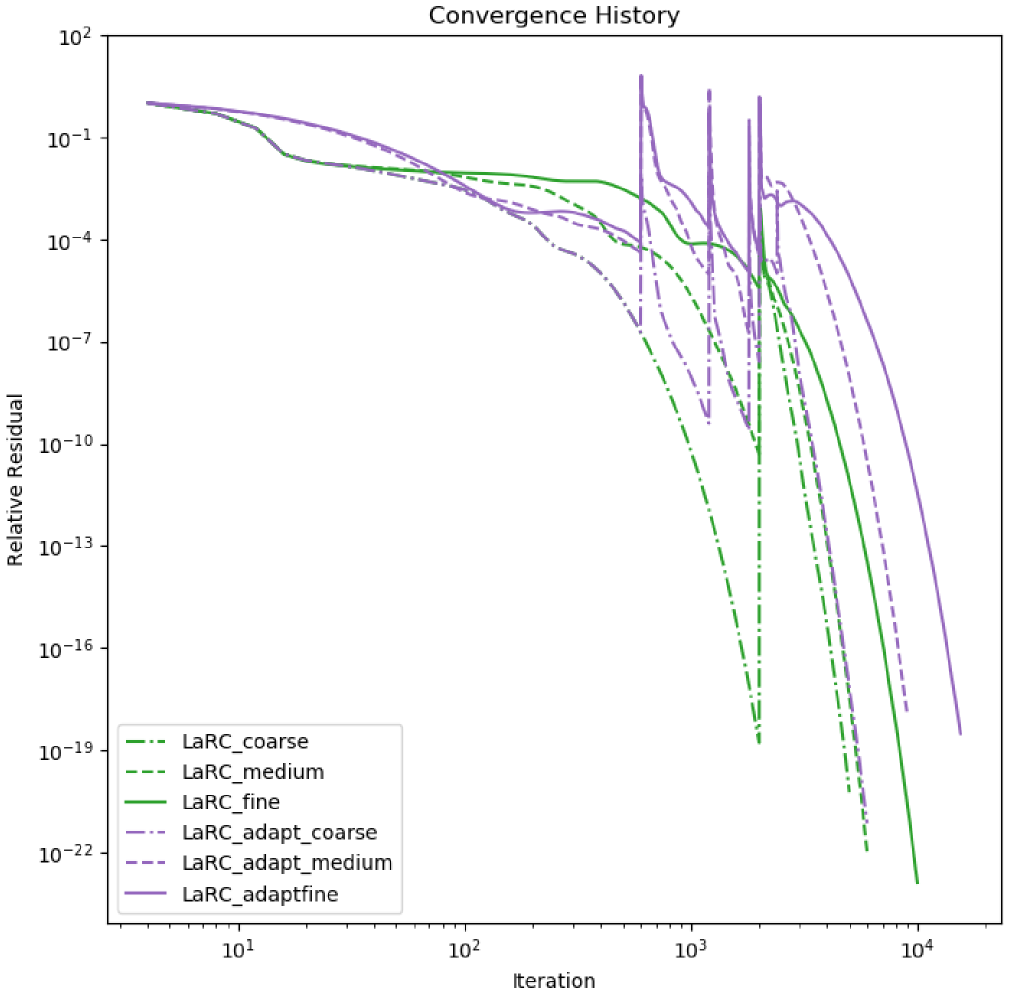
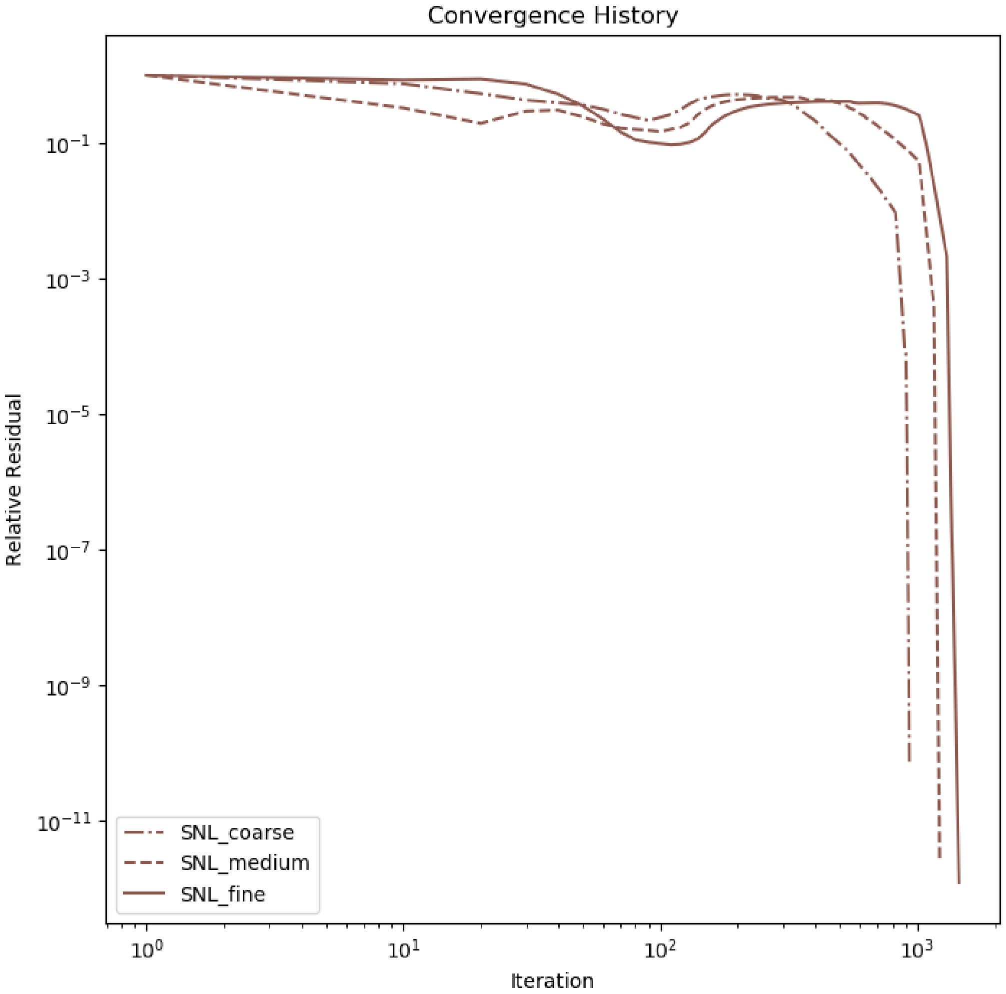
Blottner Results





Blottner Results





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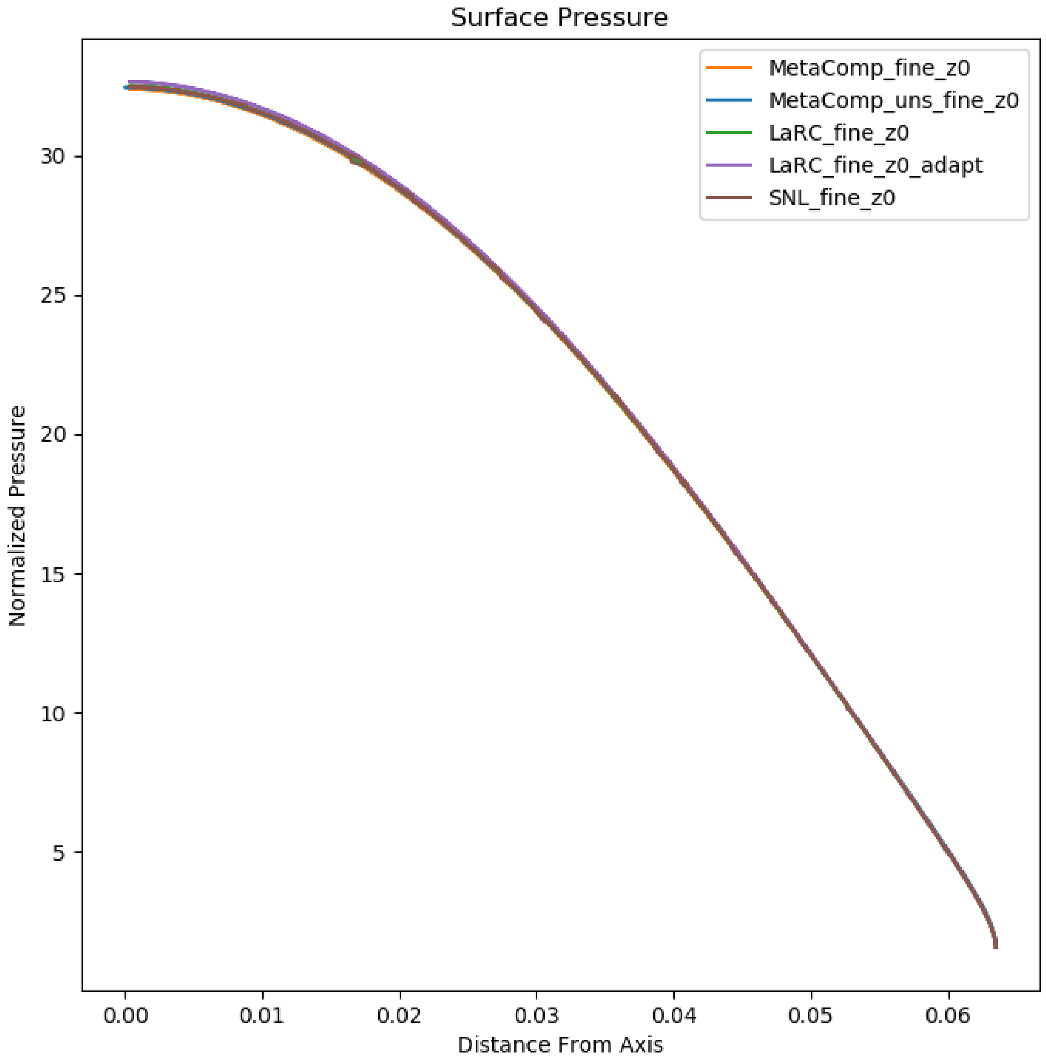

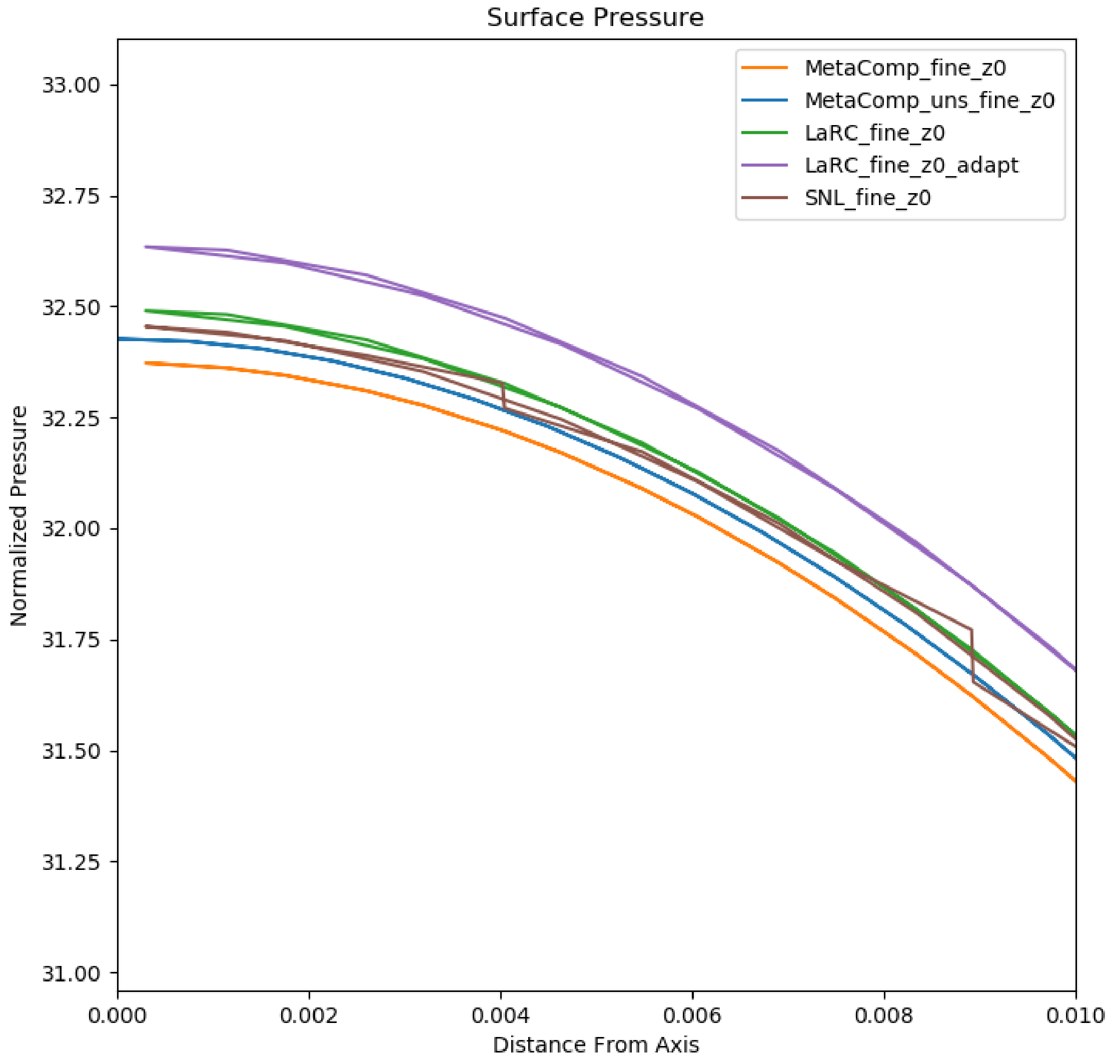

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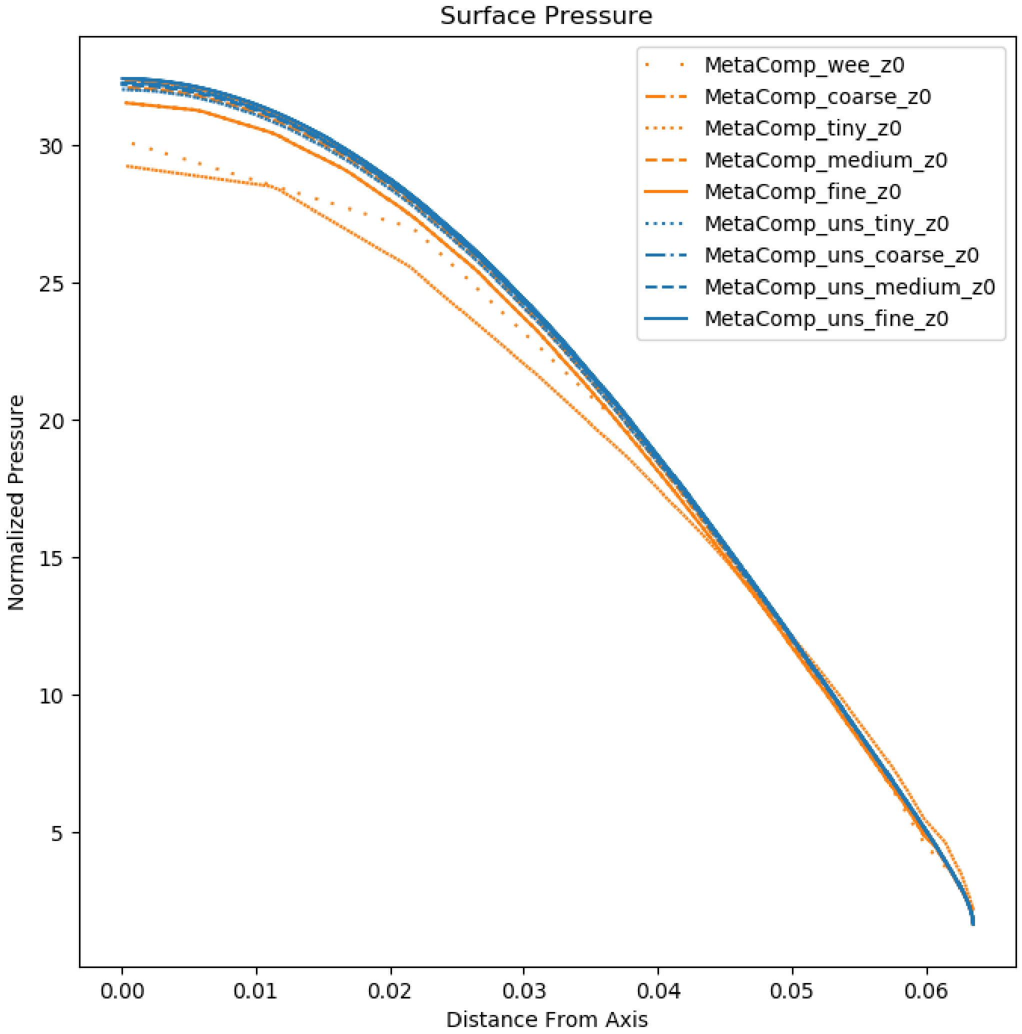

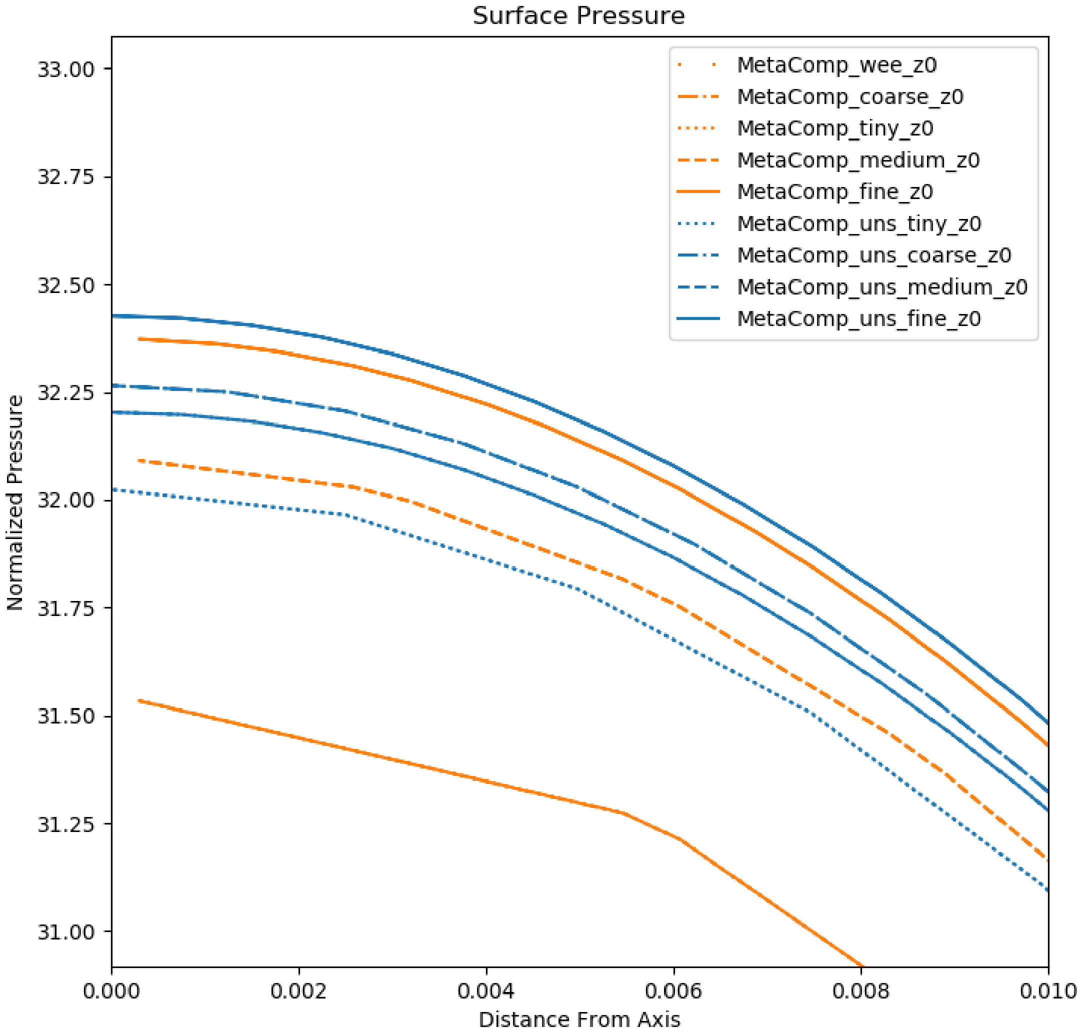

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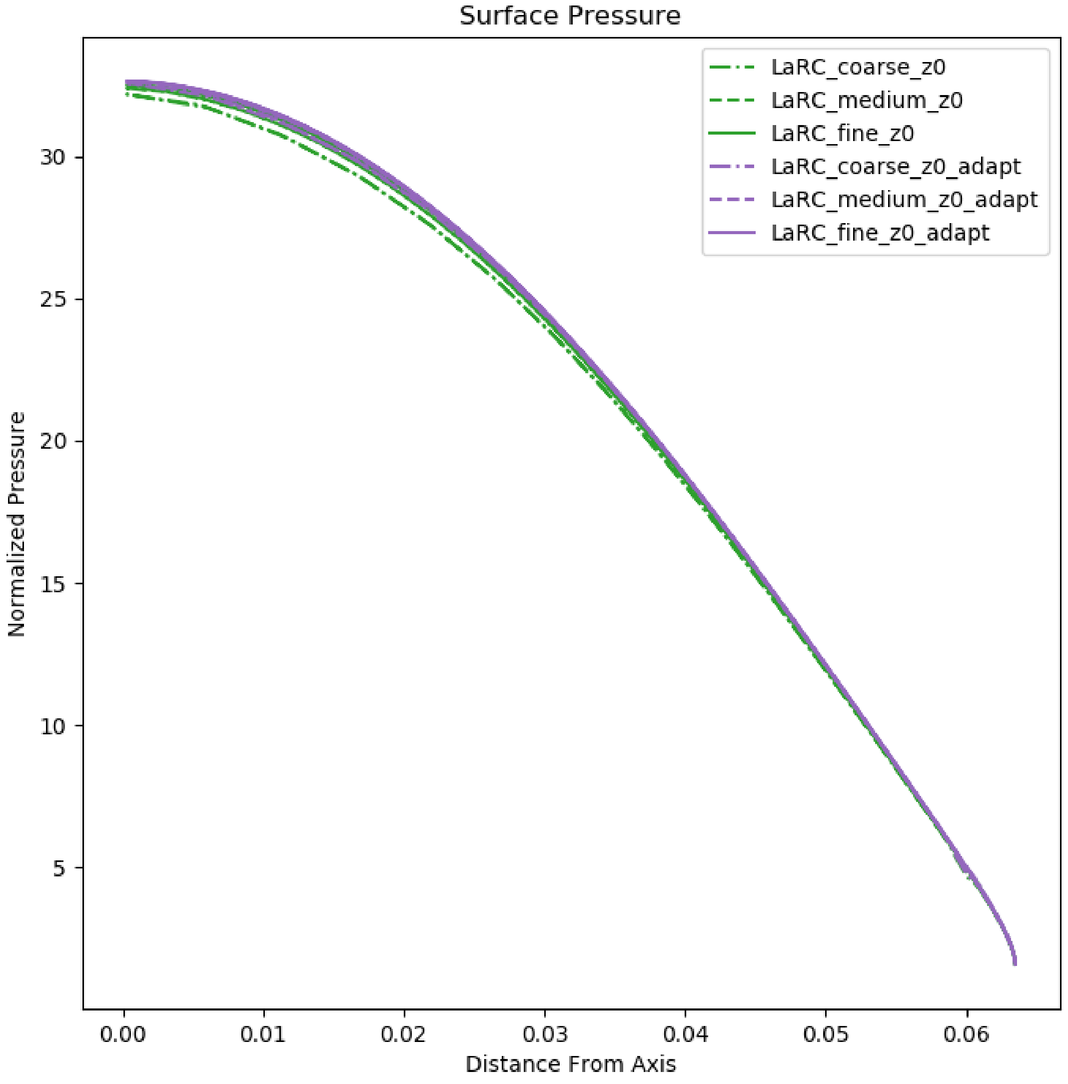

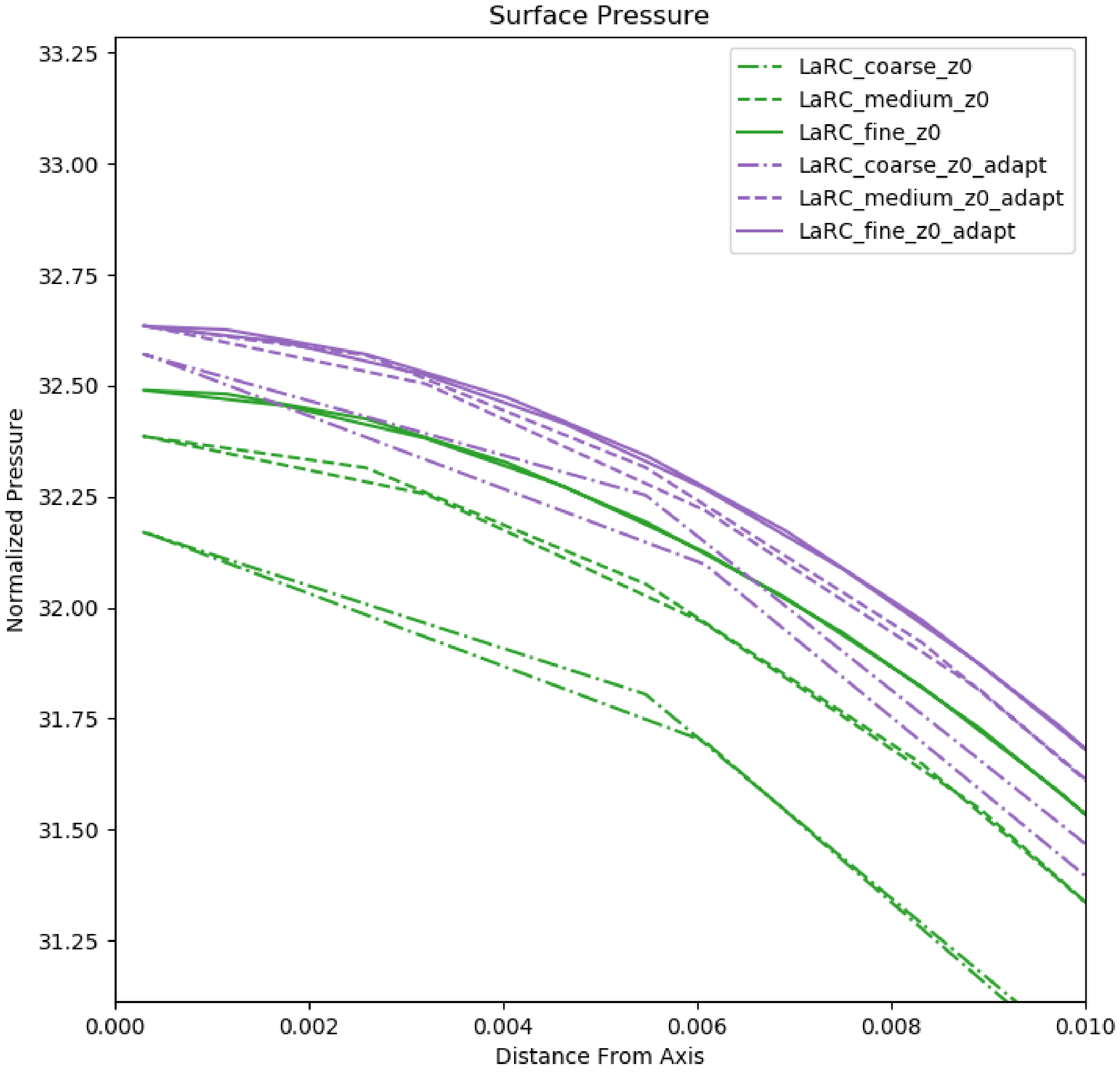

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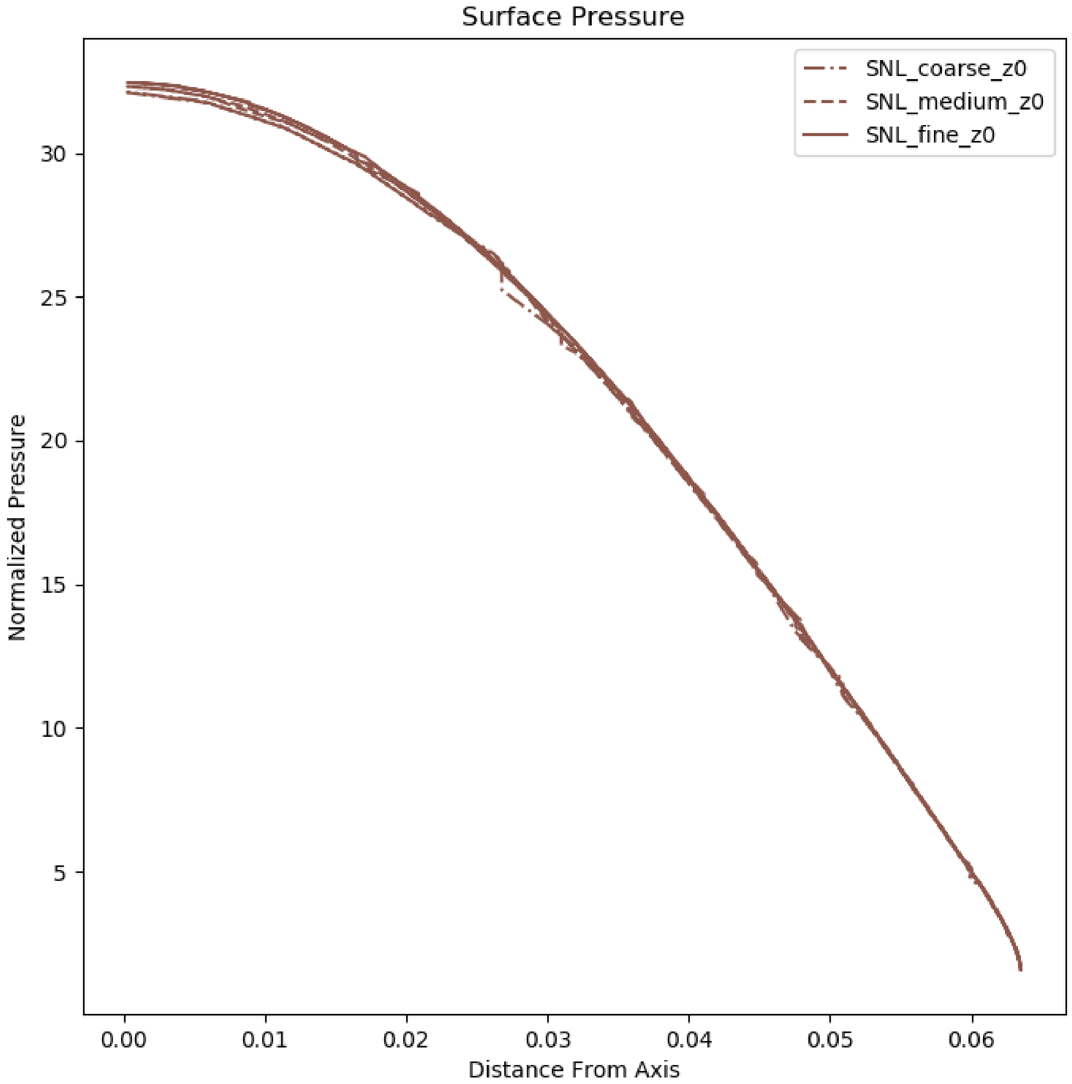

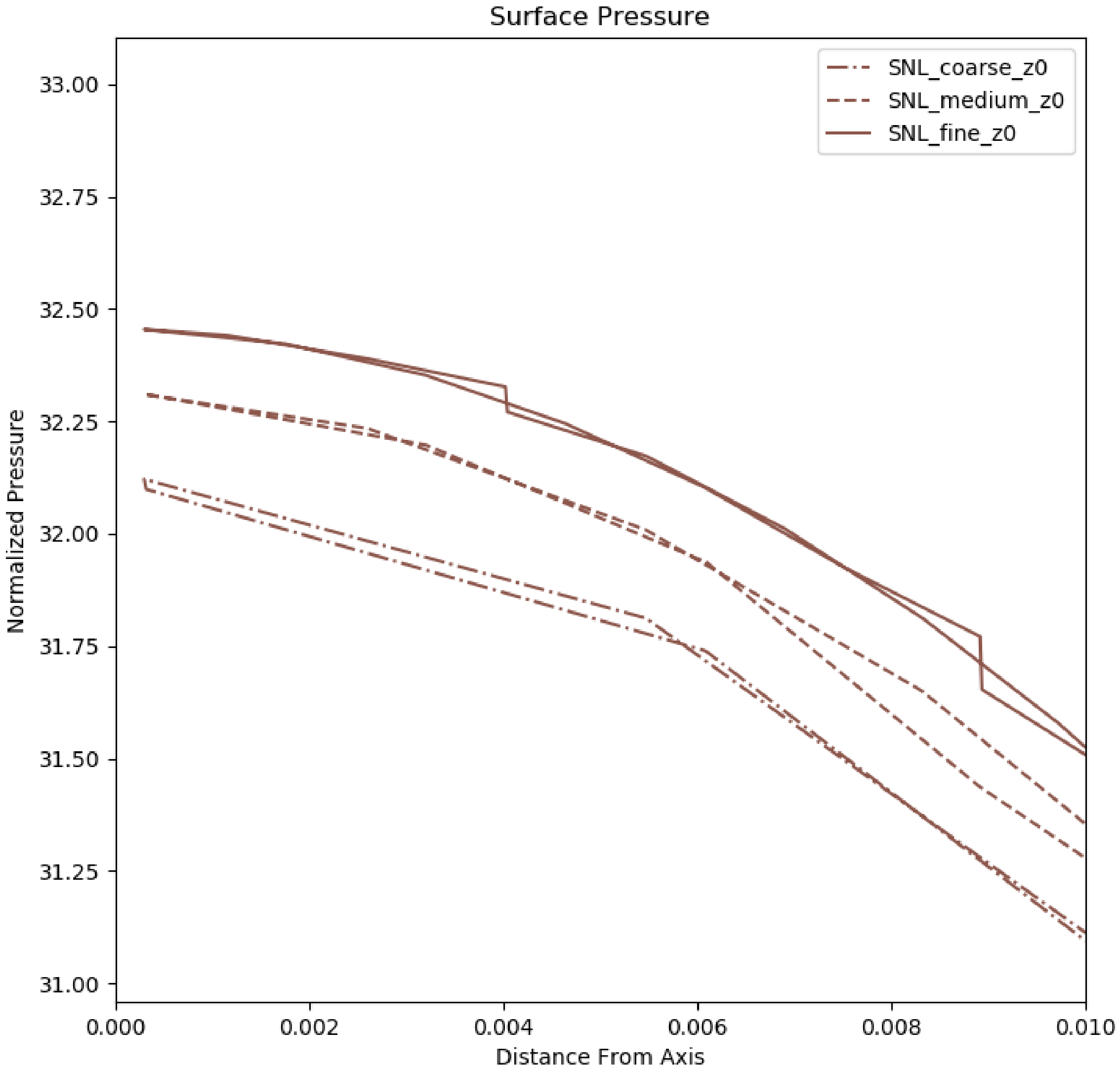

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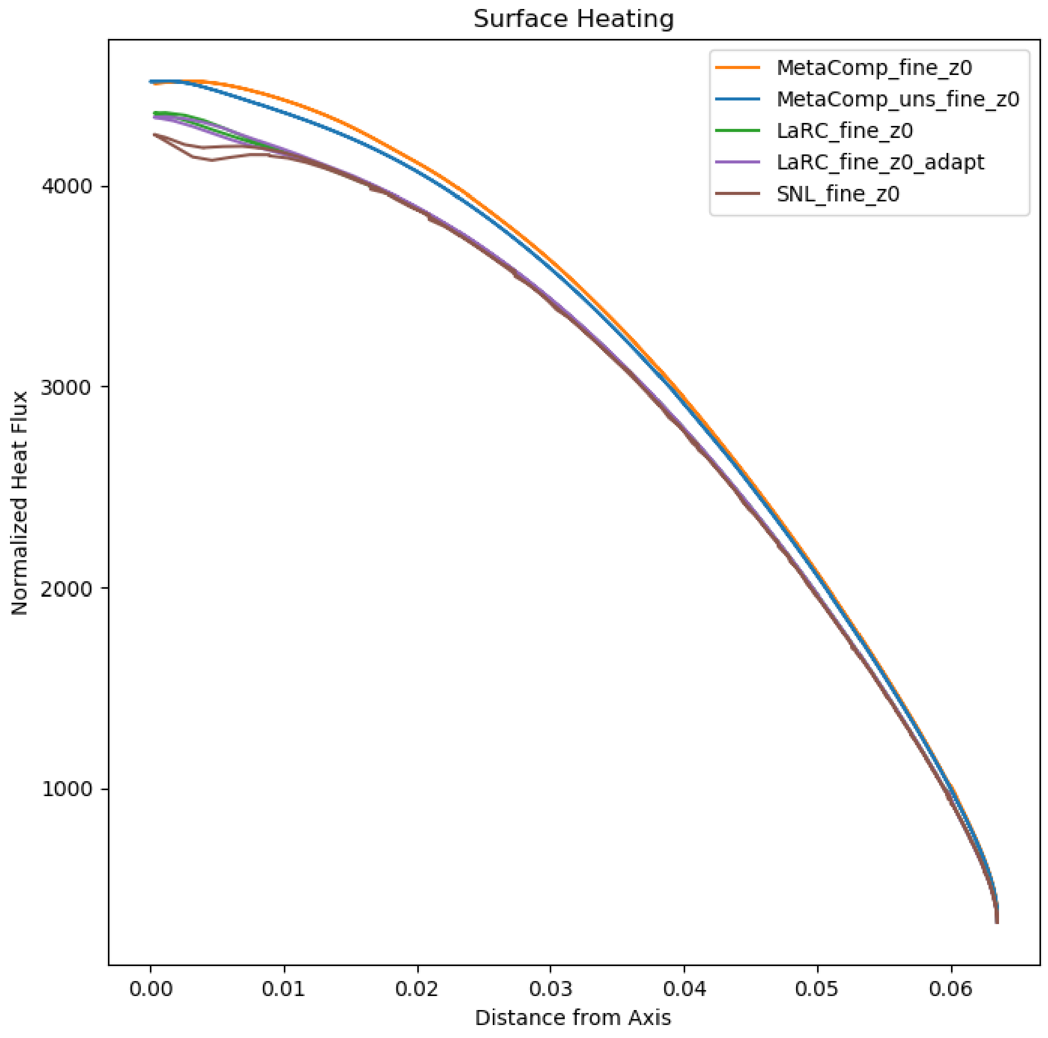

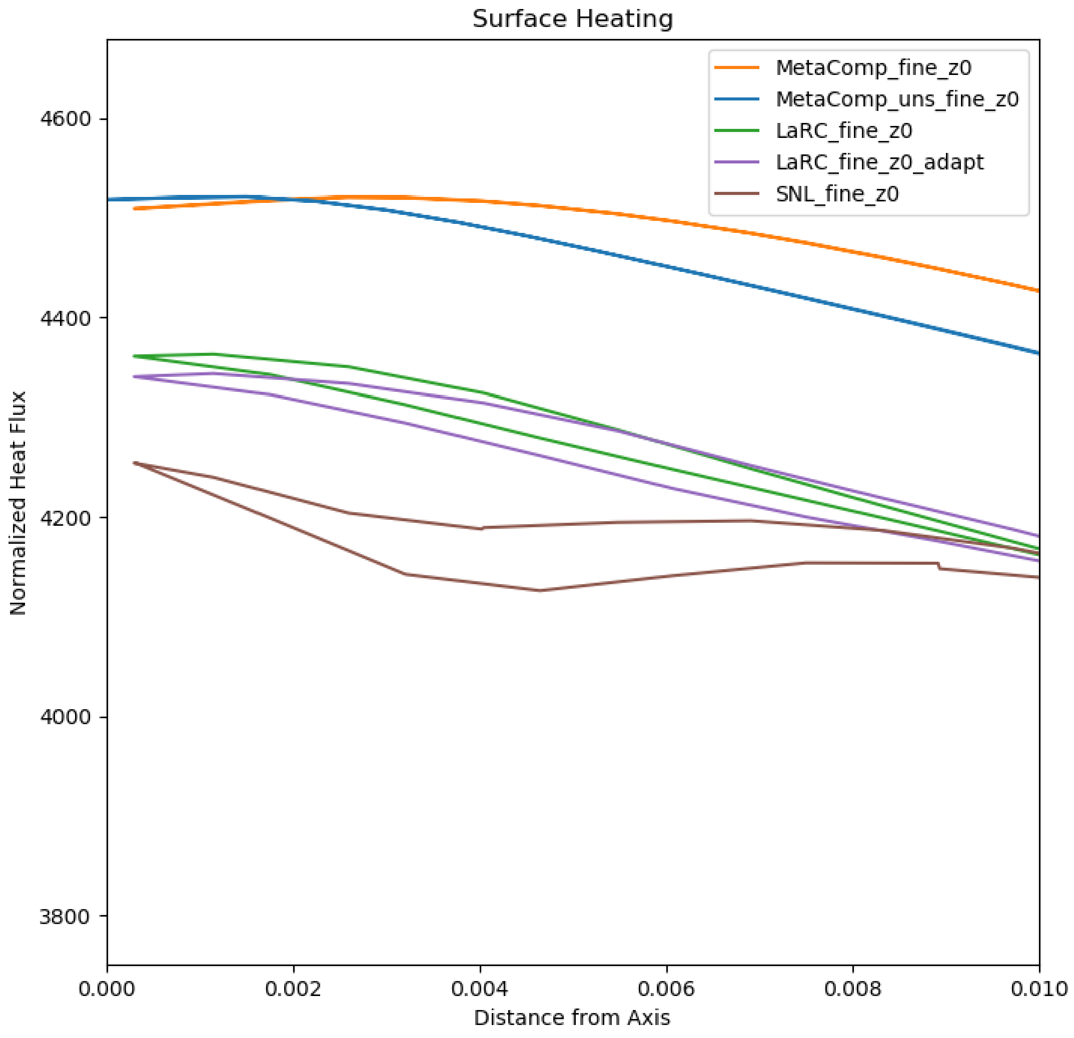

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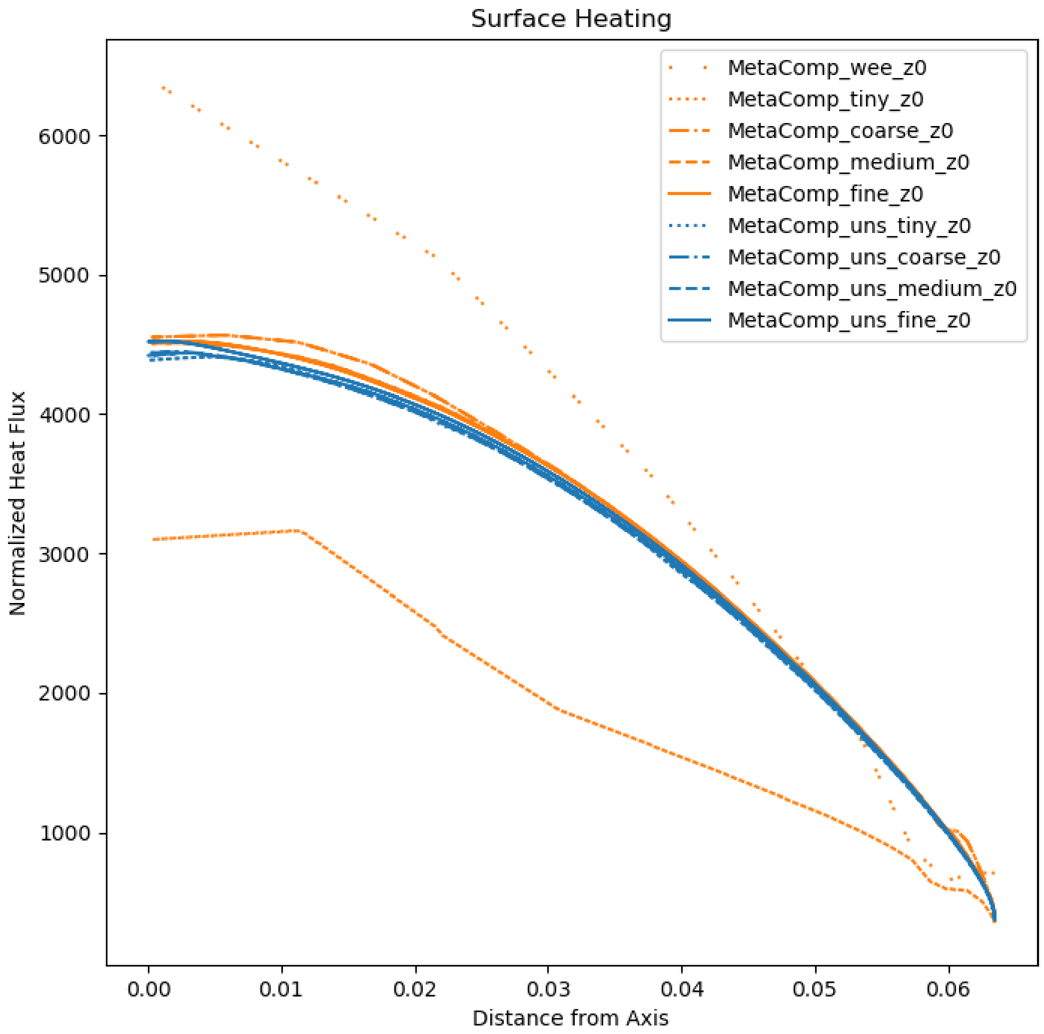

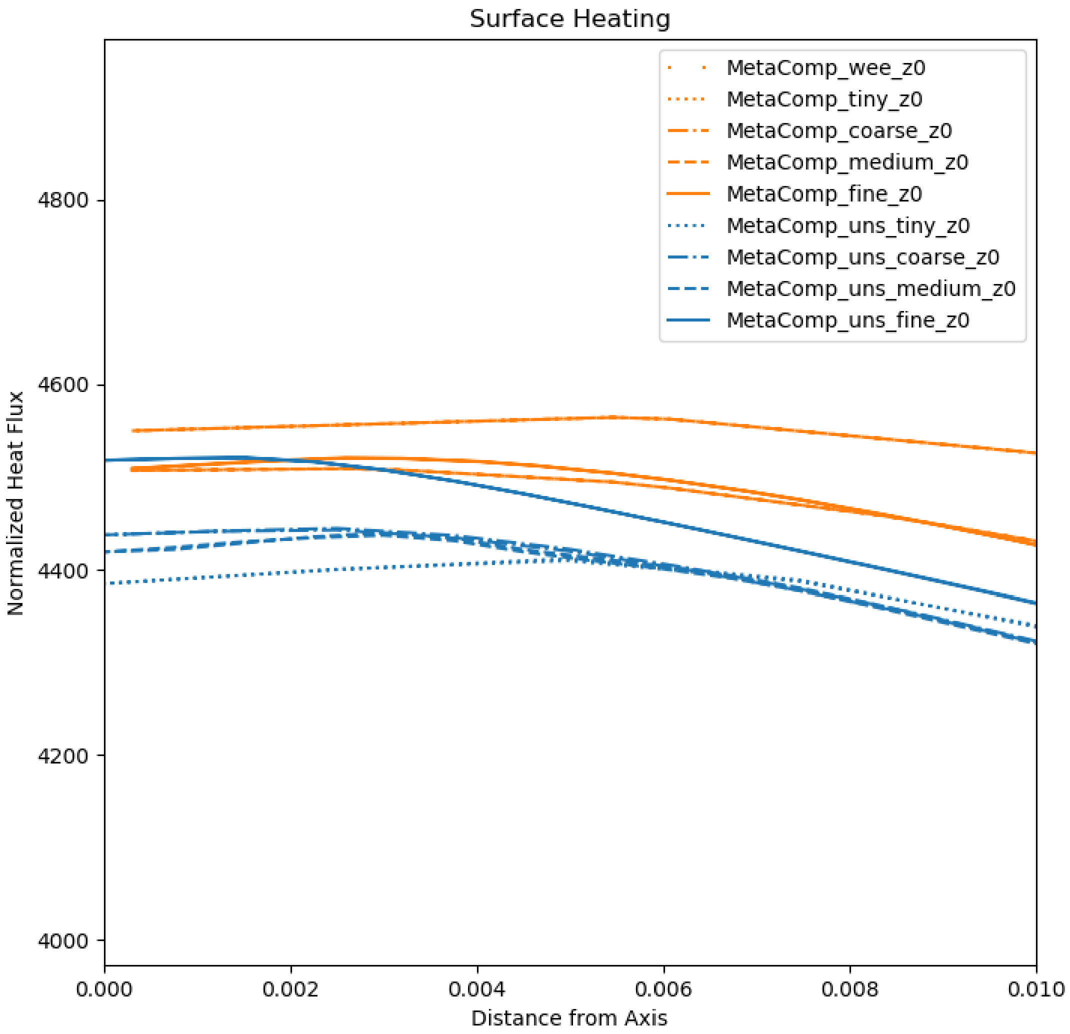

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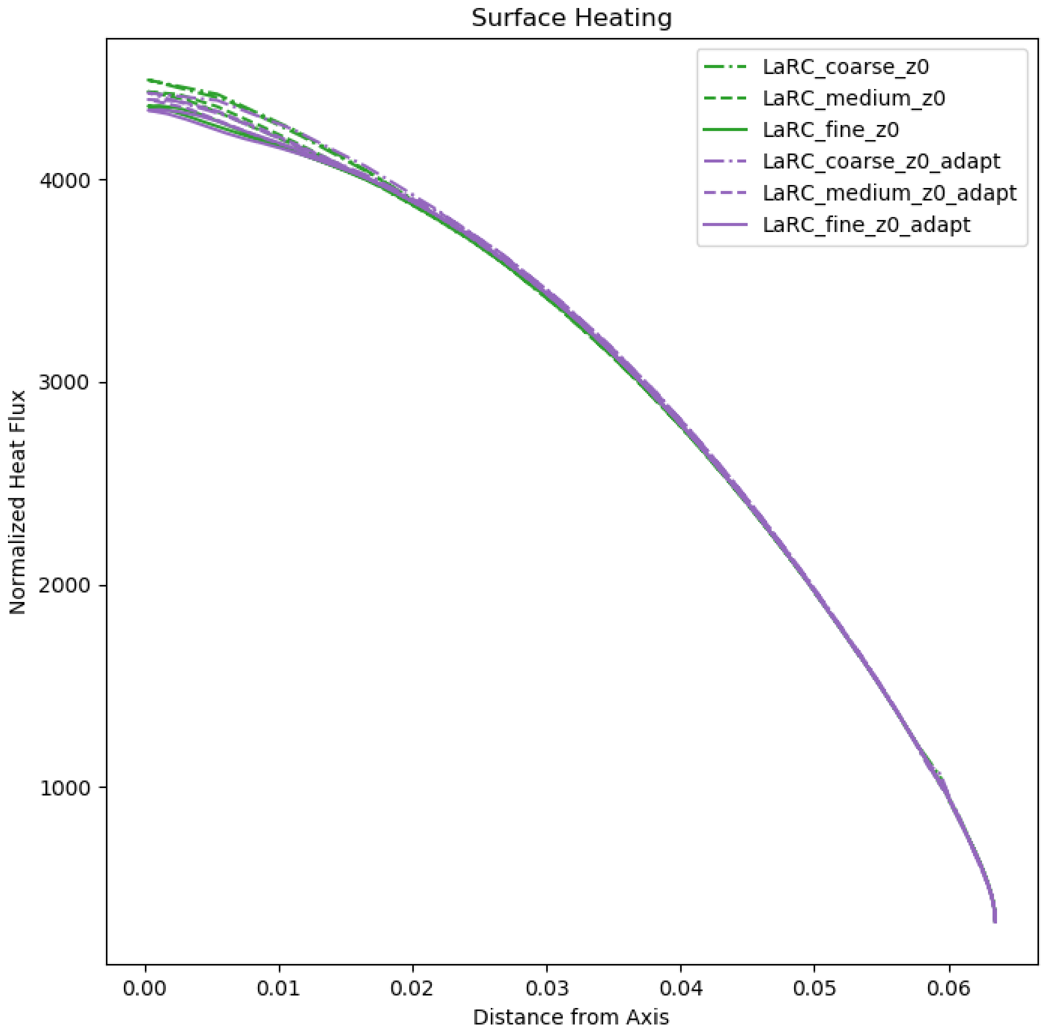

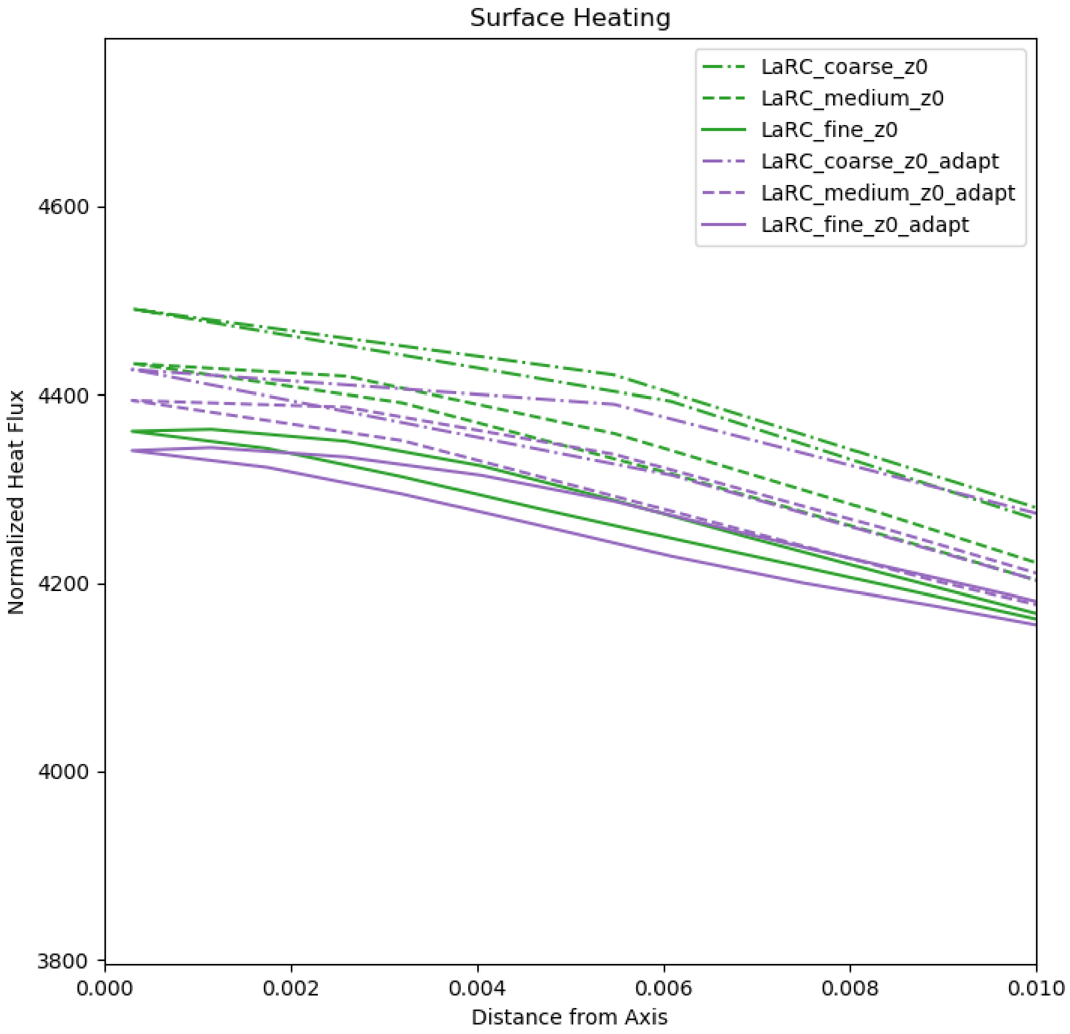

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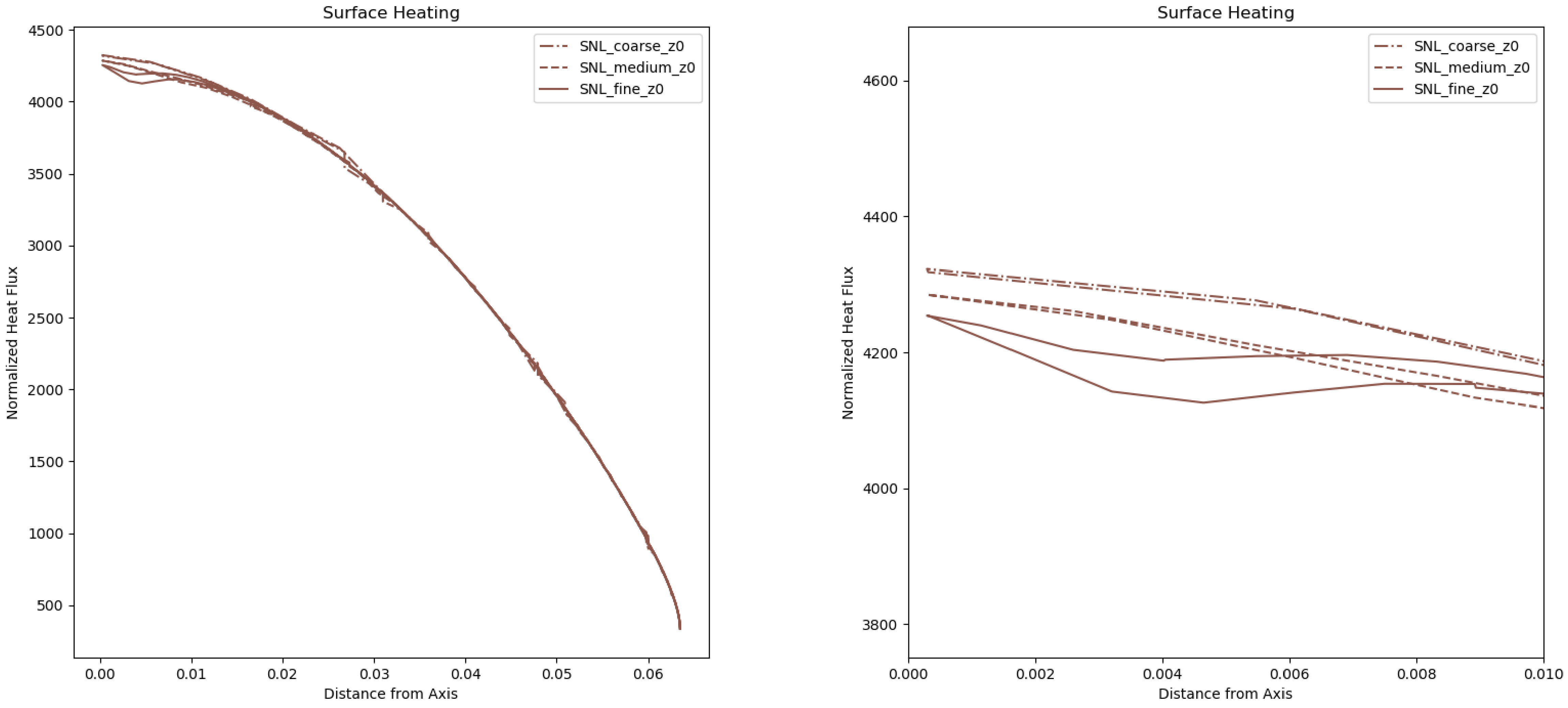


Blottner Observations

Pressure spread approx. 0.5

Heat Flux spread approx. 2000

Very different nonlinear convergence strategies

Artificial dissipation seems well controlled in most cases

Metacomp Structured	Work Units	Rel Residual
Structured Wee	21	1.00E-09
Structured Tiny	193	1.00E-06
Structured Coarse	1819	1.00E-07
Structured Medium	28042	1.00E-07
Structured Fine	299430	1.00E-06

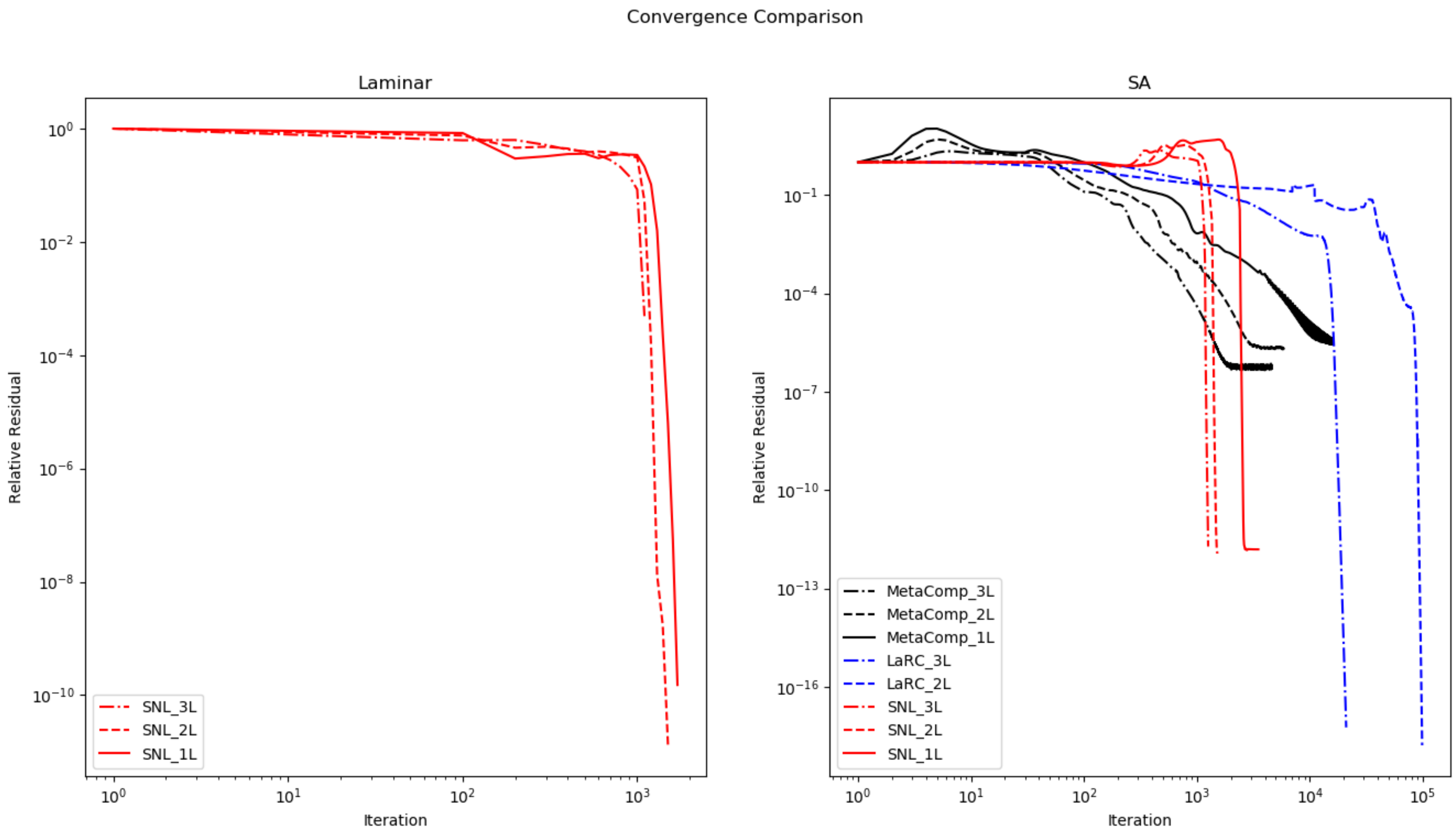
LaRC	Work Units	Rel Residual
Coarse	1855	1.00E-22
Medium	15470	1.00E-20
Fine	214036	1.00E-23

SNL	Work Units	Rel Residual
Coarse	1974	1.00E-12
Medium	23592	1.00E-12
Fine	356395	1.00E-12

Metacomp Unstructured	Work Units	Rel Residual
Unstructured Tiny	6576	1.00E-07
Unstructured Coarse	72741	1.00E-07
Unstructured Medium	225501	1.00E-06
Unstructured Fine	1503055	1.00E-06

LaRC-adapt	Work Units	Rel Residual
Coarse	2201	1.00E-18
Medium	22576	1.00E-21
Fine	331508	1.00E-19

HiFire Results



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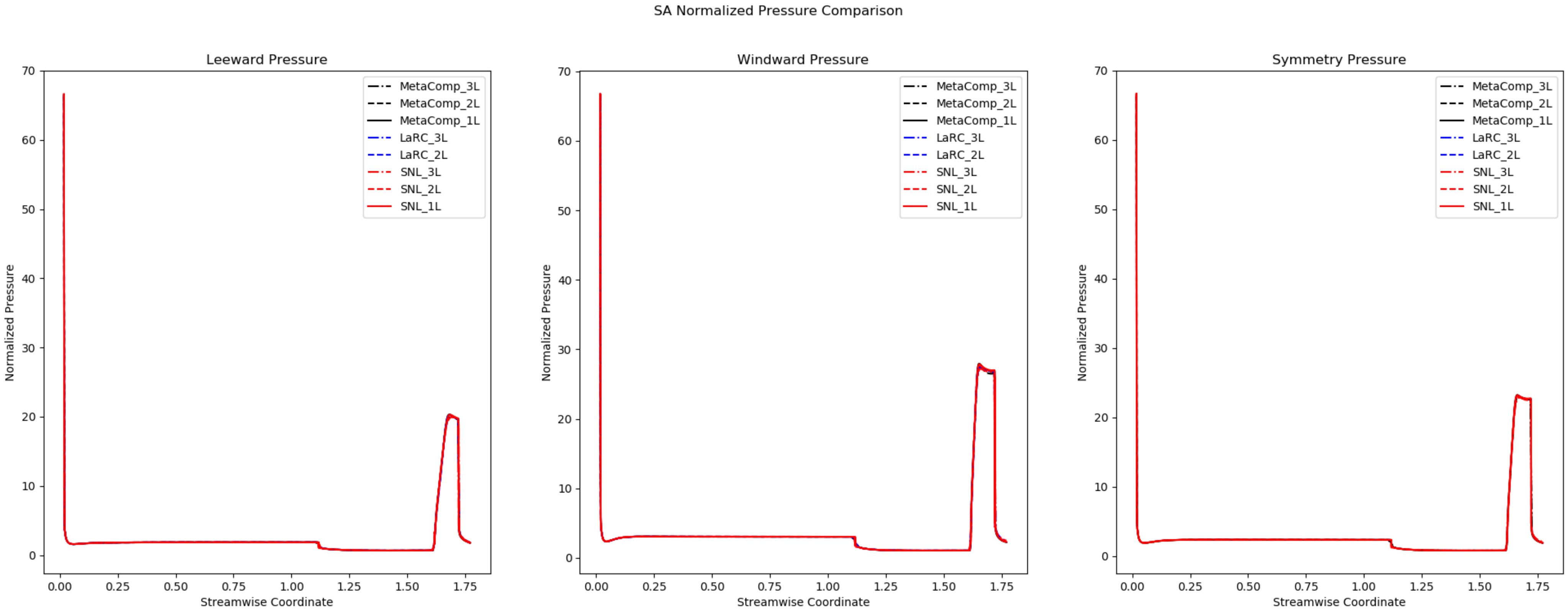

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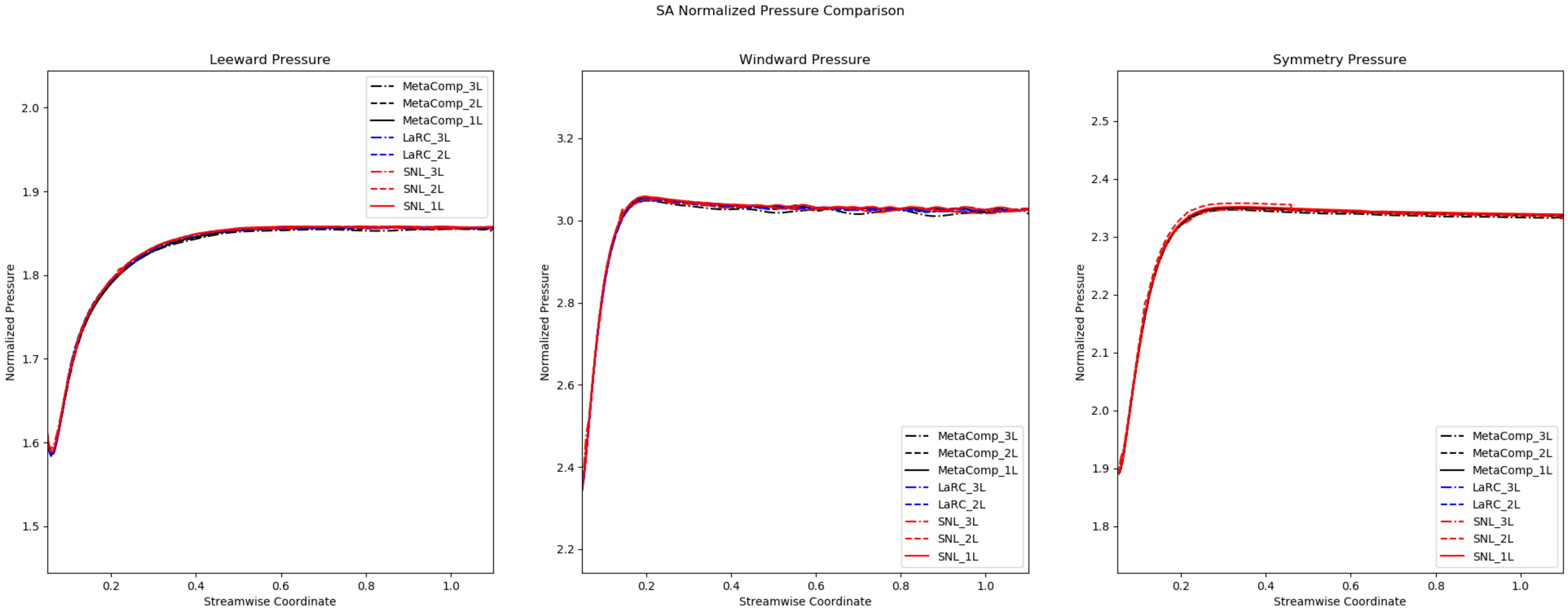

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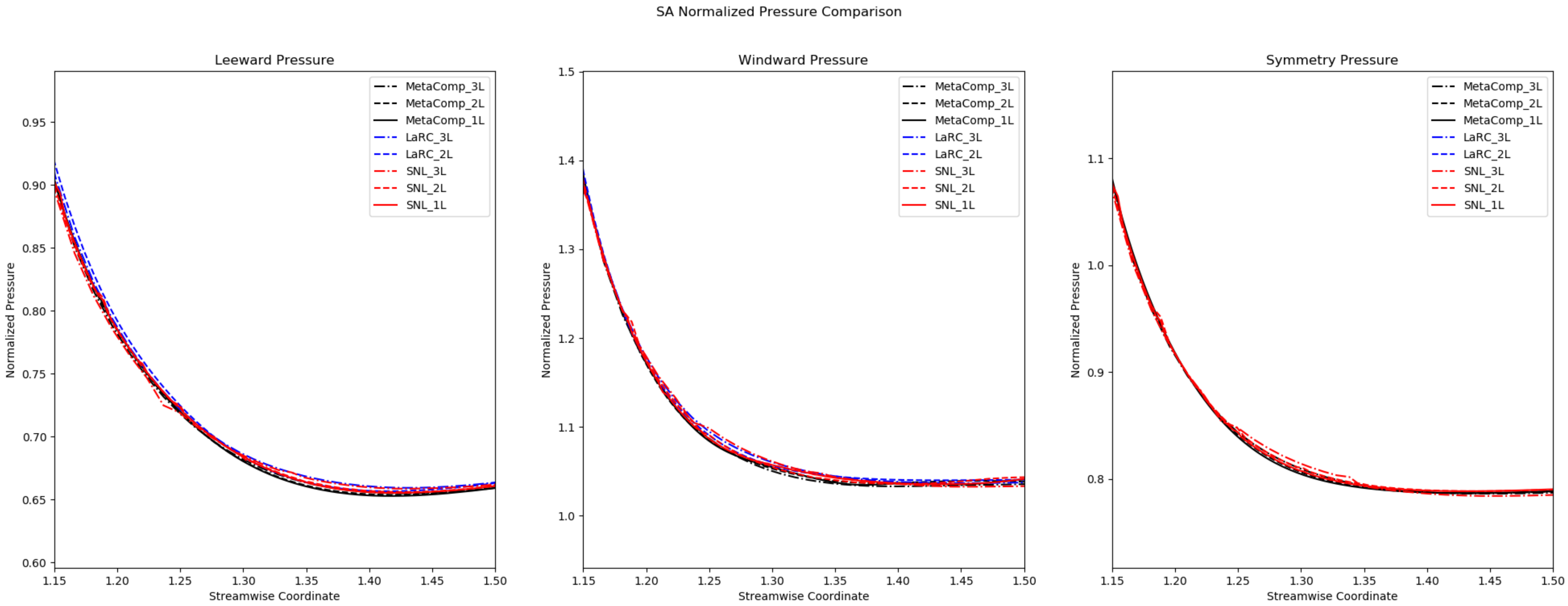

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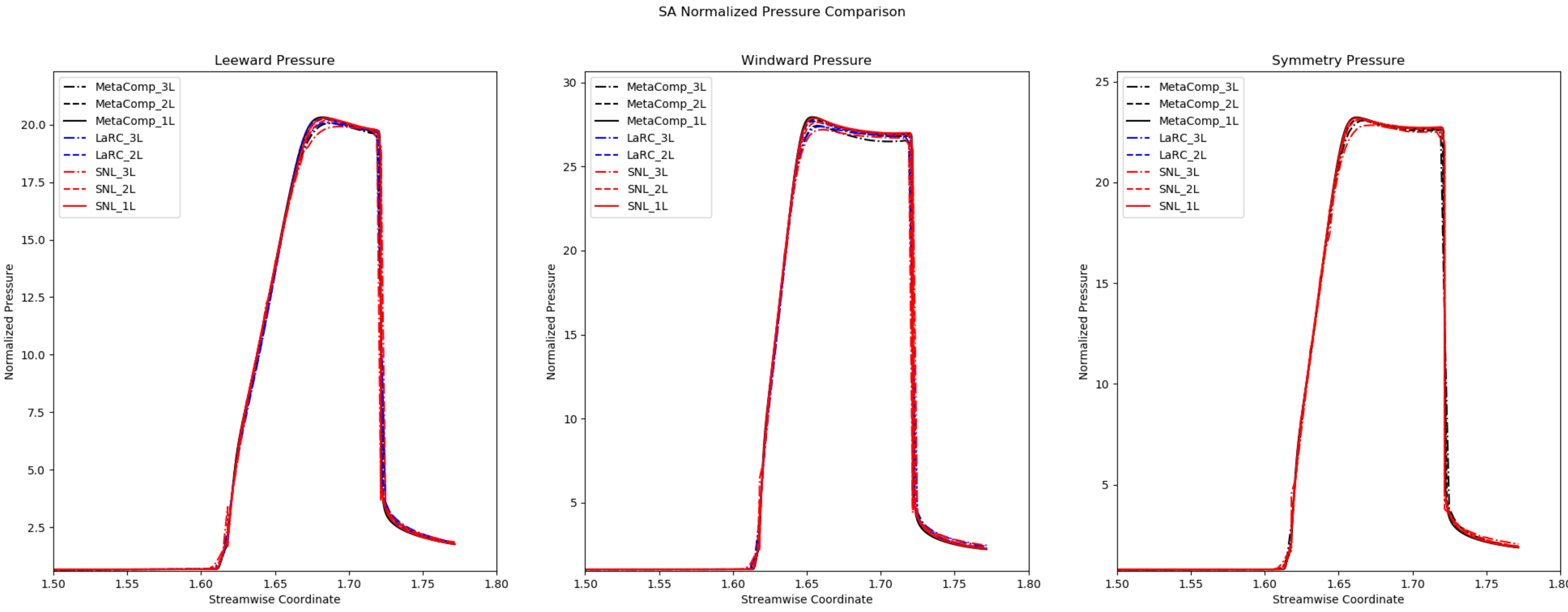

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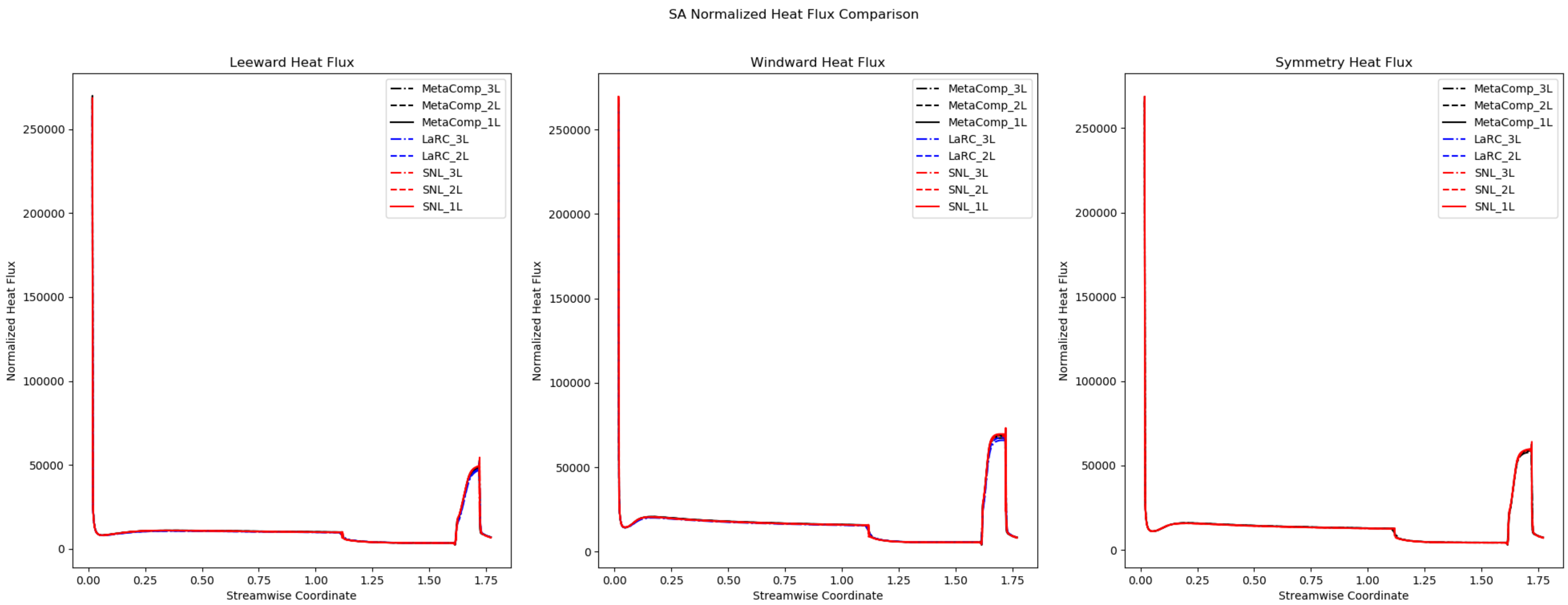

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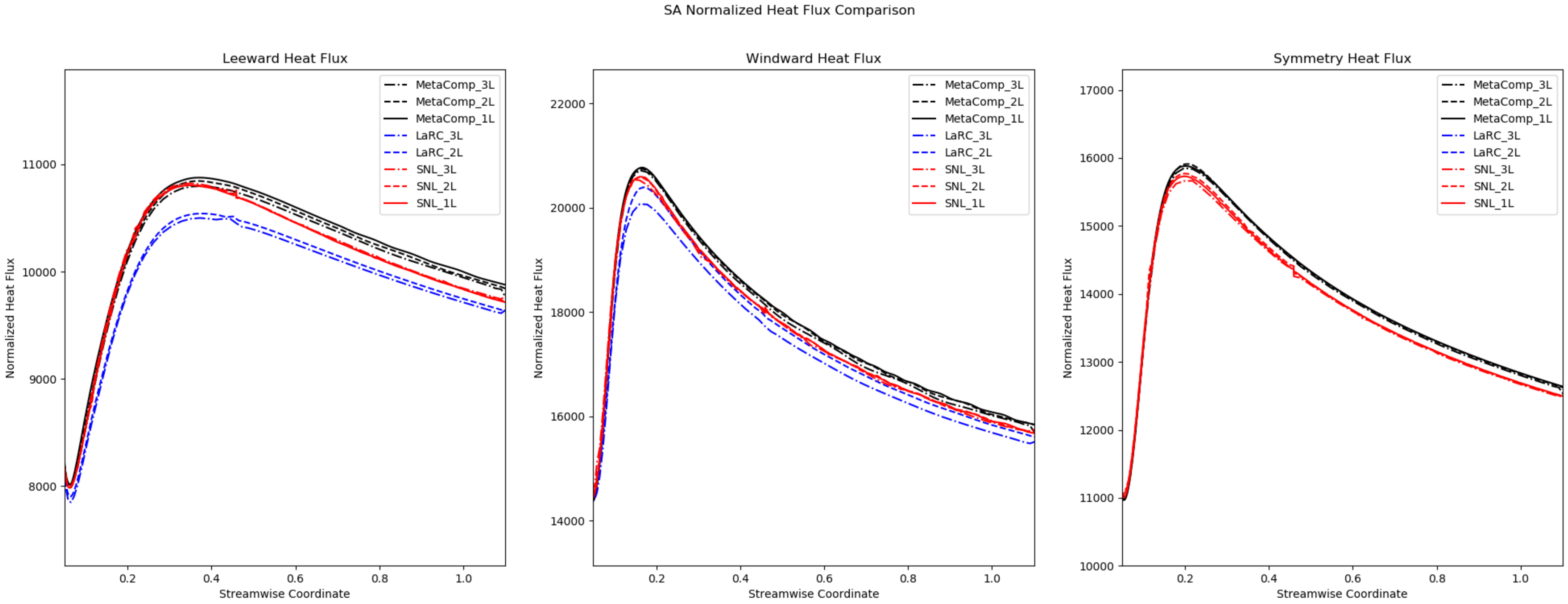

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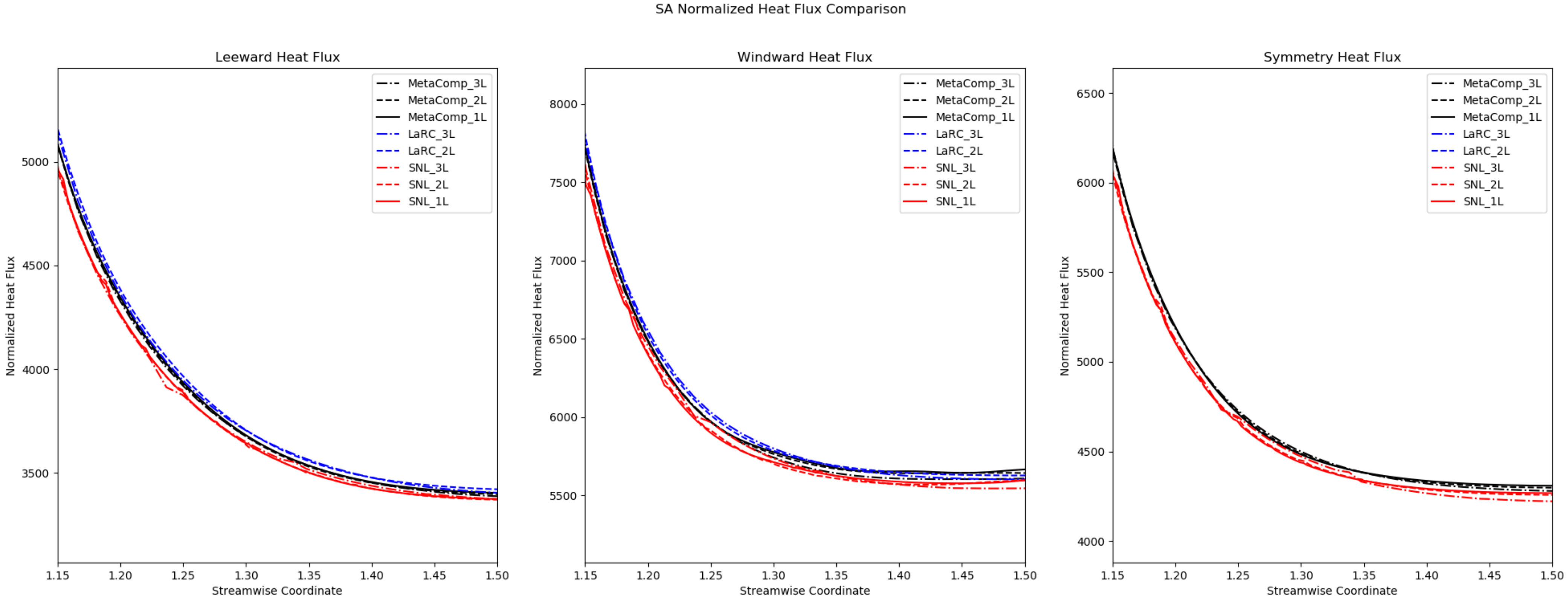

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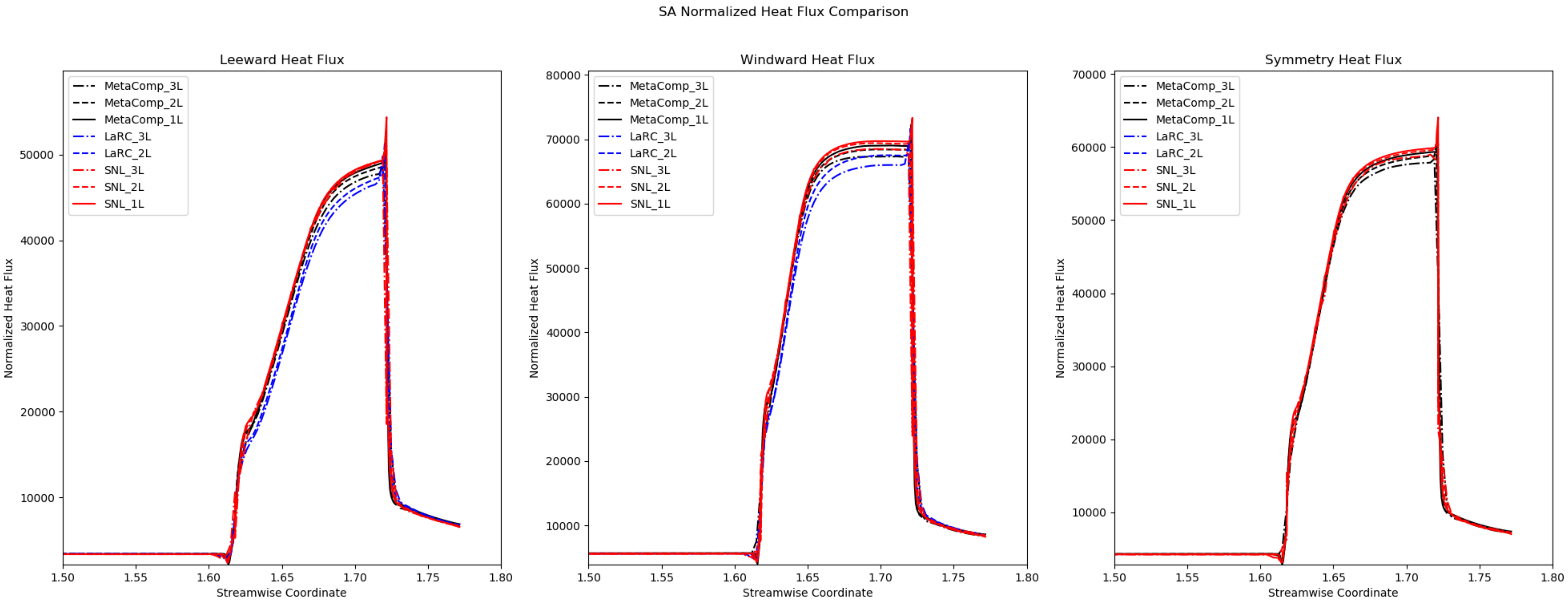

HiFire Observations

Artificial dissipation again well-controlled

Good overall convergence on meshes

Differences are concentrated in separated region

Not enough difference to draw additional conclusions

Metacomp	Work Units	Rel Residual
3L	2.37E+04	1.00E-06
2L	4.05E+05	1.00E-05
1L	3.90E+07	1.00E-05

LaRC	Work Units	Rel Residual
3L	9.99E+04	1.00E-17
2L	3.72E+06	1.00E-18

SNL	Work Units	Rel Residual
3L	3.98E+04	1.00E-12
2L	5.30E+05	1.00E-12
1L	2.34E+07	1.00E-11

Individual Contributor Questions to Answer/Discuss

How do you control numerical dissipation?

- Especially in the boundary layer?
- Did you have to fiddle with it based on mesh resolution or problem setup?

Do you get good nonlinear convergence?

- If not, do you know what's holding your scheme up?
- Please describe your nonlinear and linear solver strategy either way.

Did you run the cases in different ways? How did the results vary?

Did you have difficulties running the cases?

- What were they?
- Did you resolve them or are they unresolved?