



Computer Simulation of Fluid Flow, Heat Flow,
and Chemical Reactions.

WindSim User Meeting 2019

Recent and Ongoing Developments of the PHOENICS Solver

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Contents

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- CHAM and PHOENICS
- Unification of Processing of Boundary Conditions
- Latest Turbulence Models
- Solvers and Preconditioners
- Code Infrastructure
- Grid Types



CHAM and PHOENICS

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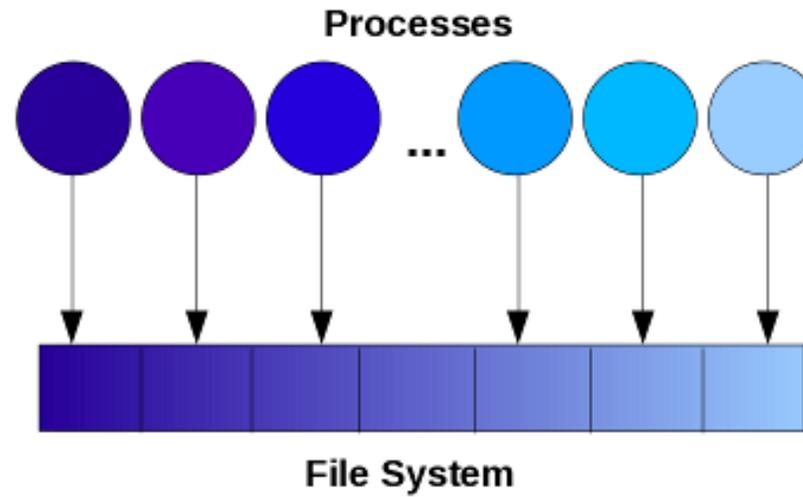
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- Concentration, Heat and Momentum Limited (CHAM)
- CFD consultancy and software house
- Founded by Prof. Brian Spalding in 1974
- PHOENICS - the first commercially available, general purpose CFD Software, initially released in 1981.
- Being further developed ever since!
- CFD engine behind WindSim



Parallel I/O

- Unification of sequential and parallel processing of boundary conditions

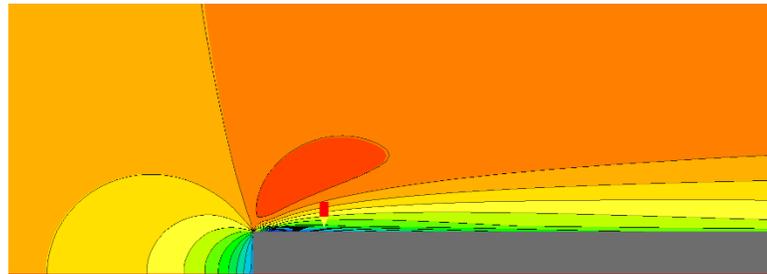




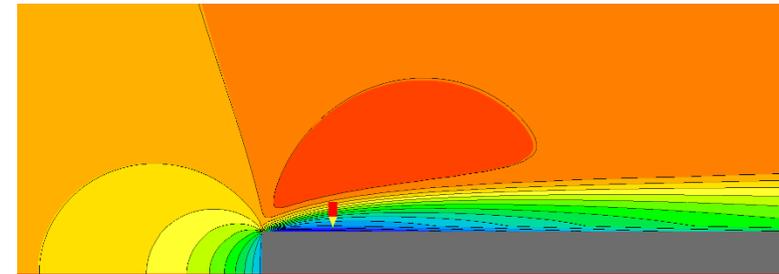
Turbulence Models

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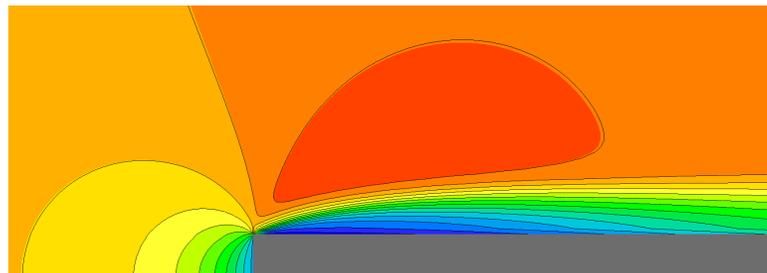
- Implementation of latest turbulence models
- Variations of k-omega, including SST



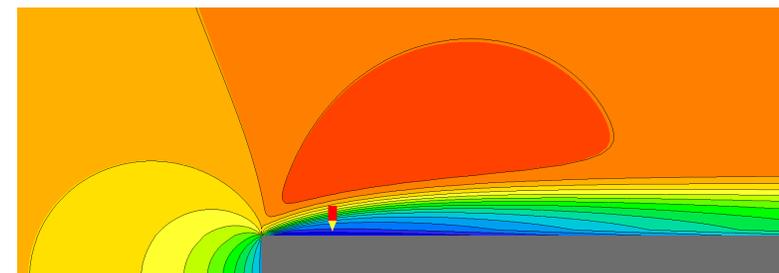
Standard K-Epsilon



K-Omega (Wilcox 2008)



Chen-Kim K-Epsilon



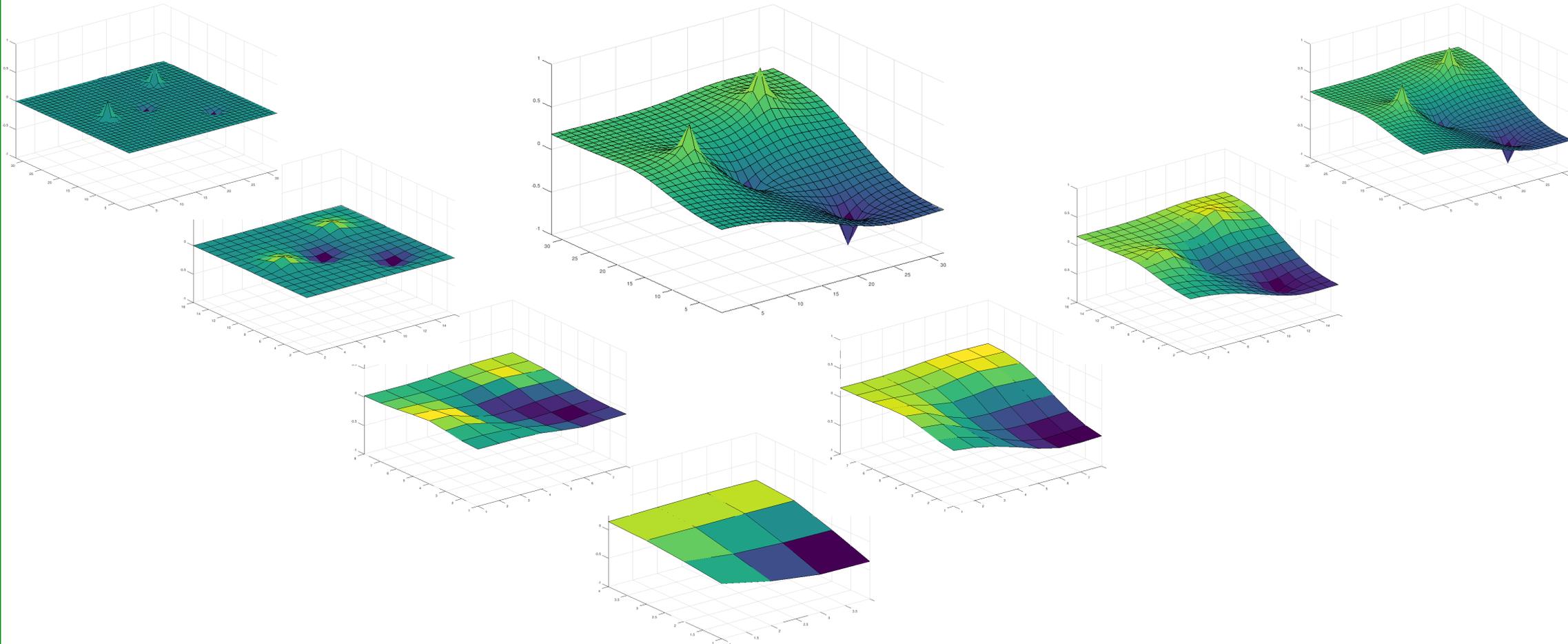
K-Omega SST



Solvers I

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- *hypre* high-performance preconditioners and solvers

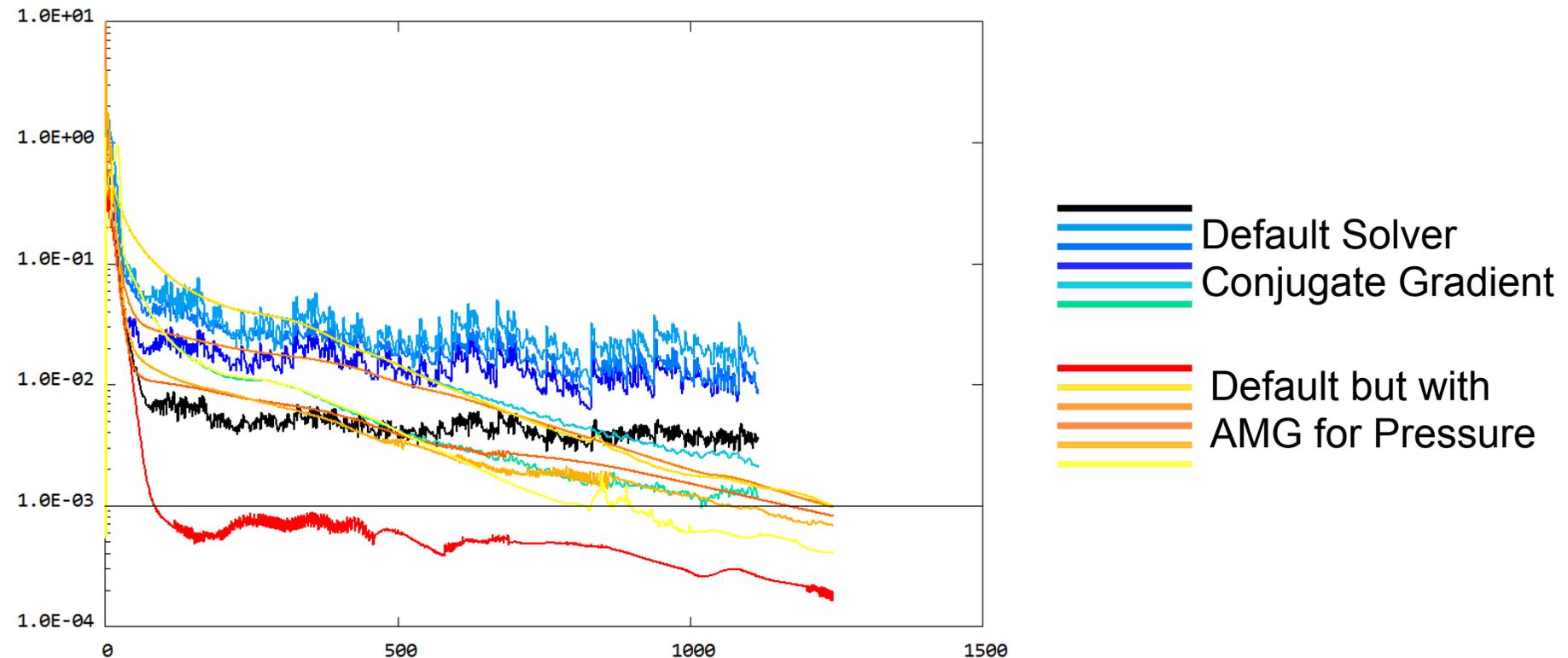


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Solvers II

- *hypre* high-performance preconditioners and solvers





Solvers III

- *hypr* high-performance preconditioners and solvers

$$\begin{array}{l} \boxed{\begin{array}{l} [A_u] \mathbf{u} = S_u \\ [A_v] \mathbf{v} = S_v \\ [A_w] \mathbf{w} = S_w \\ [A_{pp}] \mathbf{p}' = S_{pp} \end{array}} \end{array}$$

Segregated

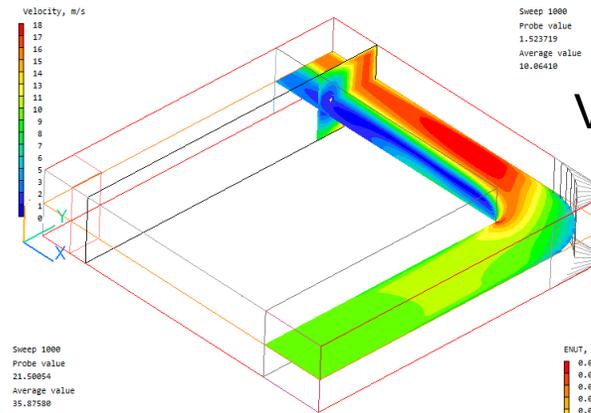
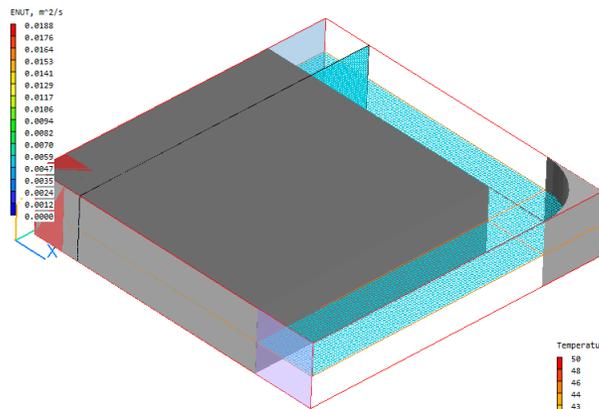
$$\boxed{\begin{array}{l} \begin{bmatrix} A_u & A_{uv} & A_{uw} & A_{up} \\ A_{vu} & A_v & A_{vw} & A_{vp} \\ A_{wu} & A_{wv} & A_w & A_{wp} \\ A_{pu} & A_{pv} & A_{pw} & A_p \end{bmatrix} \begin{bmatrix} \mathbf{u} \\ \mathbf{v} \\ \mathbf{w} \\ \mathbf{p} \end{bmatrix} = \begin{bmatrix} S_u \\ S_v \\ S_w \\ S_p \end{bmatrix} \end{array}}$$

Coupled

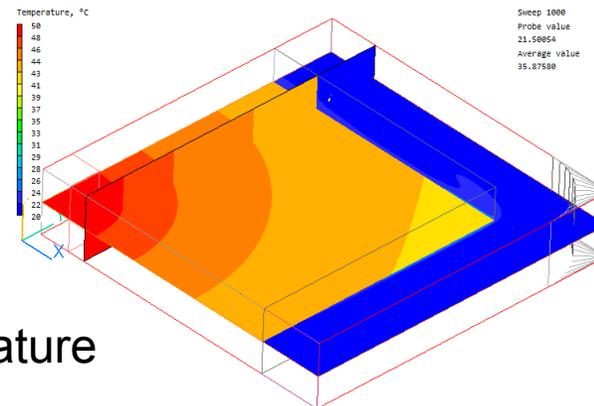


Solvers IV

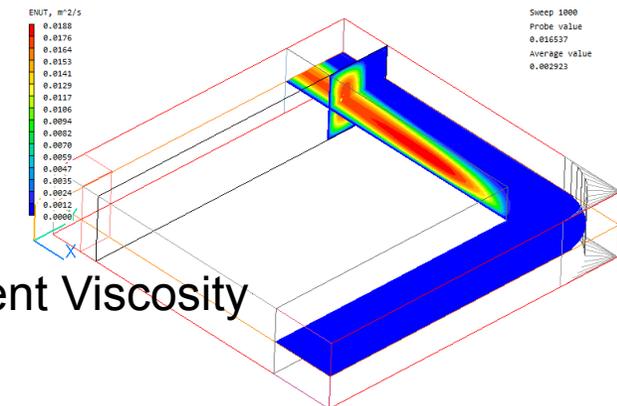
- Use of the HYPRE BoomerAMG Solver
 - This example shows the effect of the new solvers. The geometry is flow in an L-shaped duct:



Velocity



Temperature

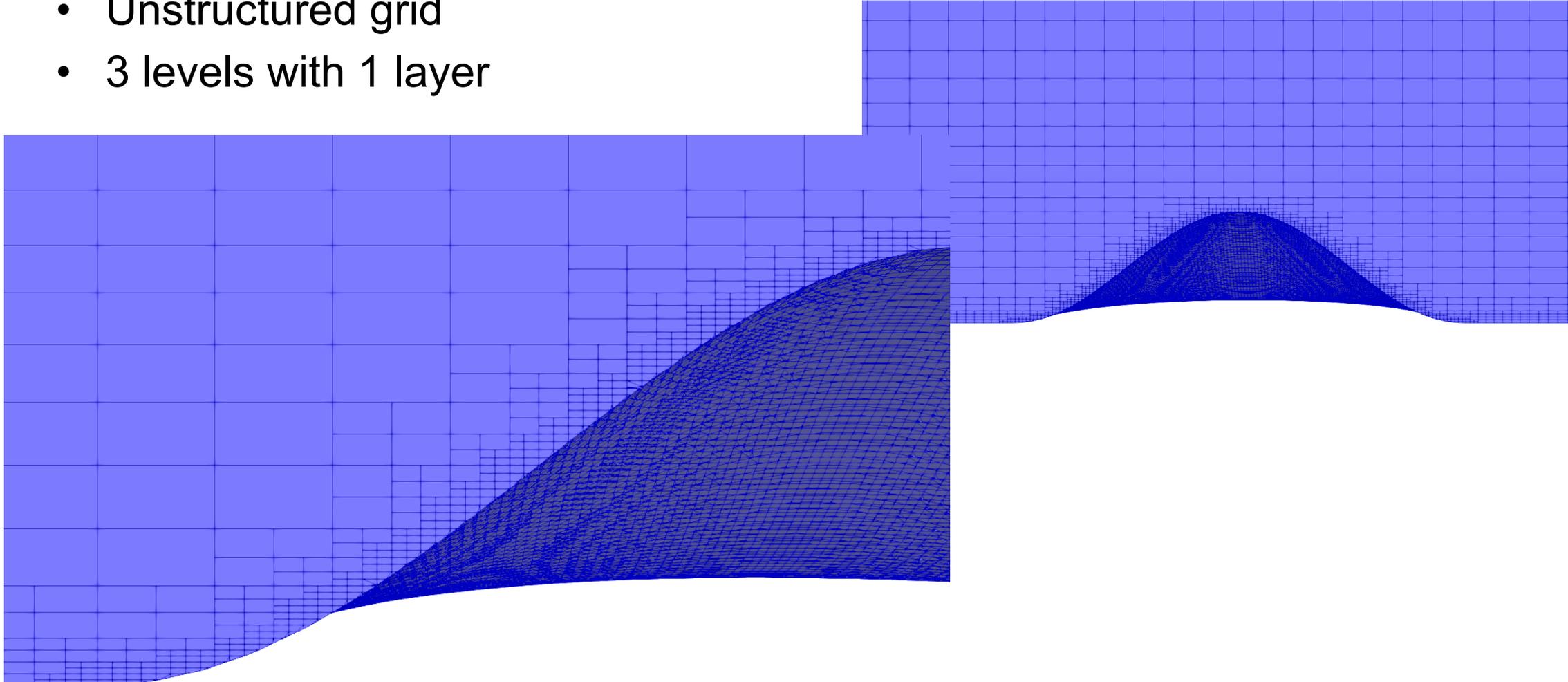


Turbulent Viscosity



Grid Types I

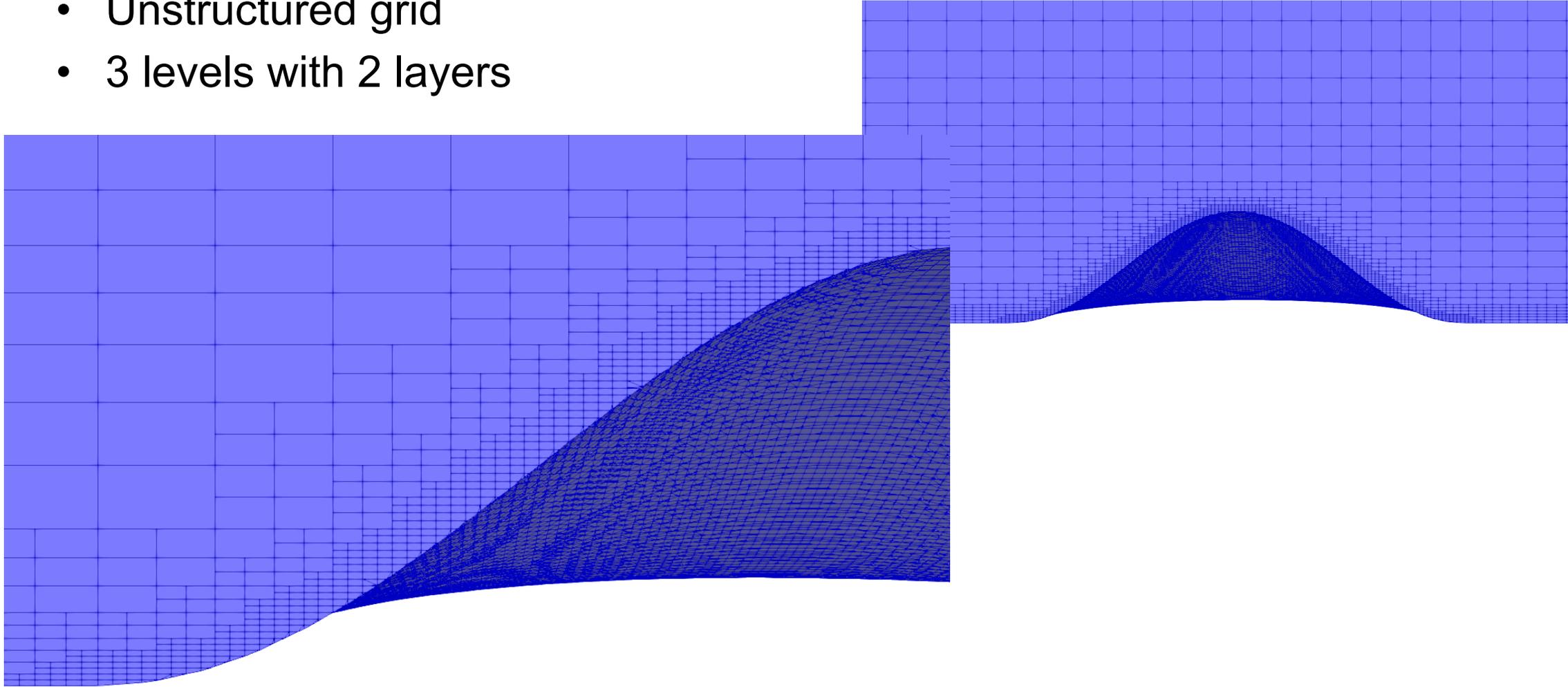
- Unstructured grid
- 3 levels with 1 layer





Grid Types II

- Unstructured grid
- 3 levels with 2 layers





Thank you very much for your attention!