Analysis of laminar-turbulent transition models along blimp boundary layers in stratospheric conditions

universidad de león

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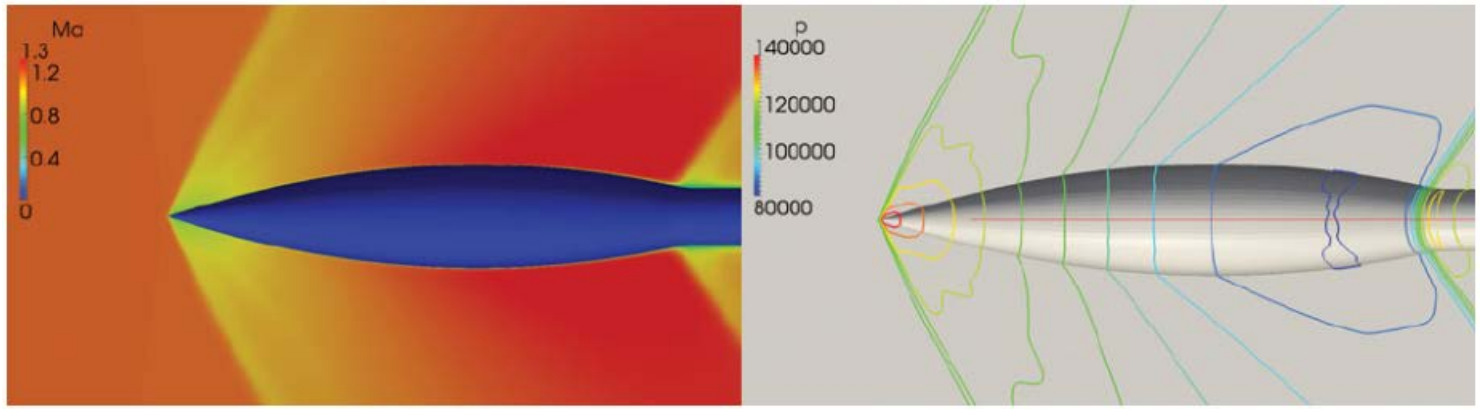
SCAYLE
SUPERCOMPUTACIÓN CASTILLA Y LEÓN

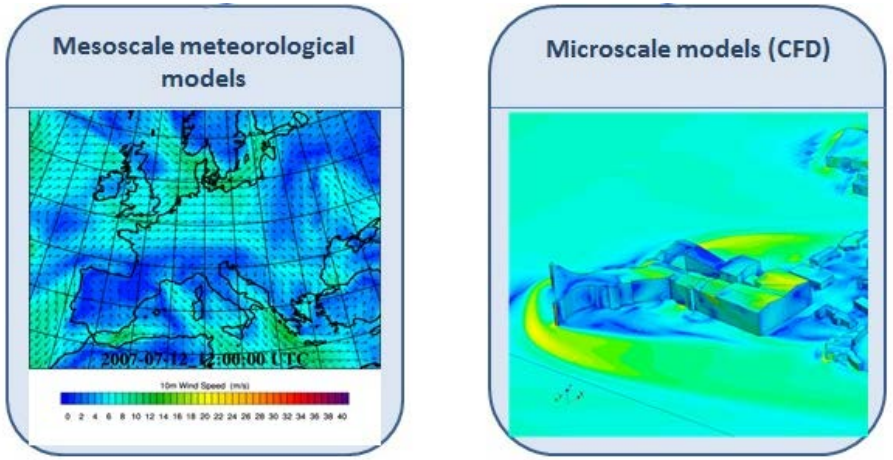
Who & where are we?

León – Campus de Vegazana

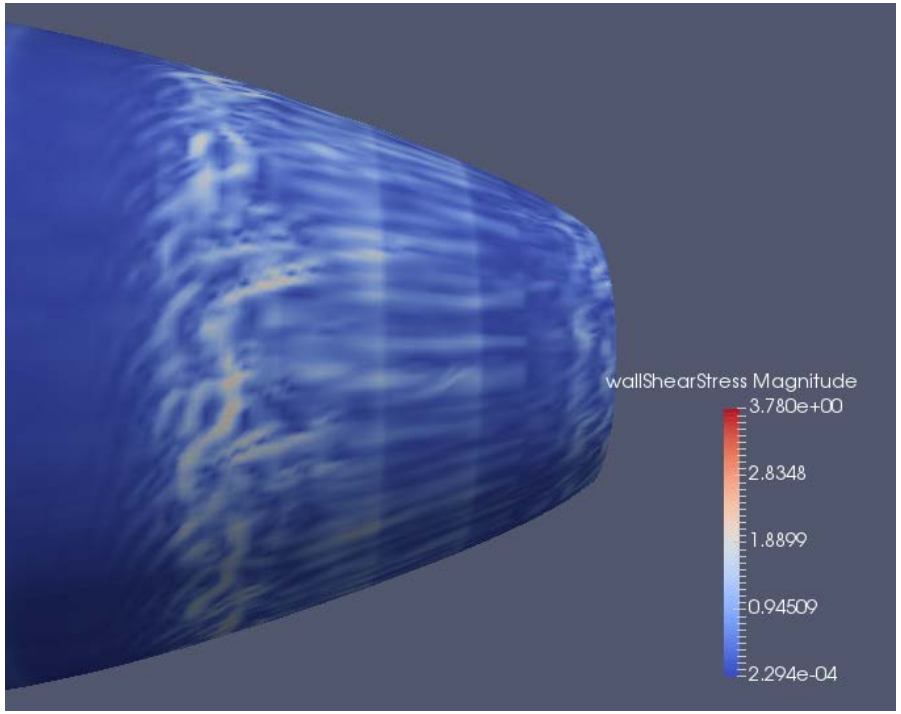
Our experience with OpenFOAM



Supersonic Aerodynamics



Atmospheric Boundary Layer



Laminar-turbulent transition

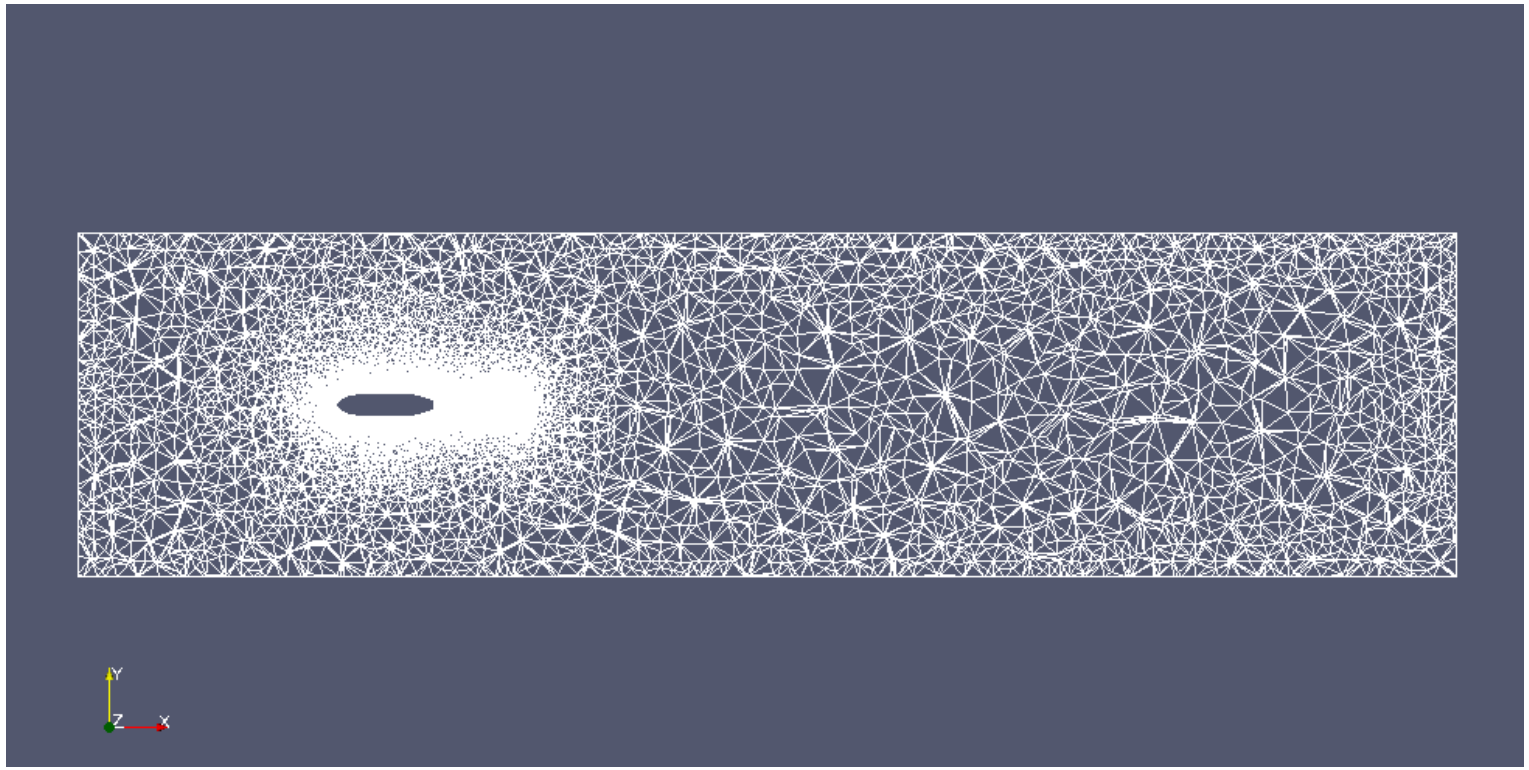
Stratospheric blimps

- The problem
  - Dimensions
  - Velocities
  - Viscosity
  - Density

  } Reynolds number 500000
- Aerodynamic forces
- Experimental data
- Simulation analysis
  - Laminar-turbulent transition point

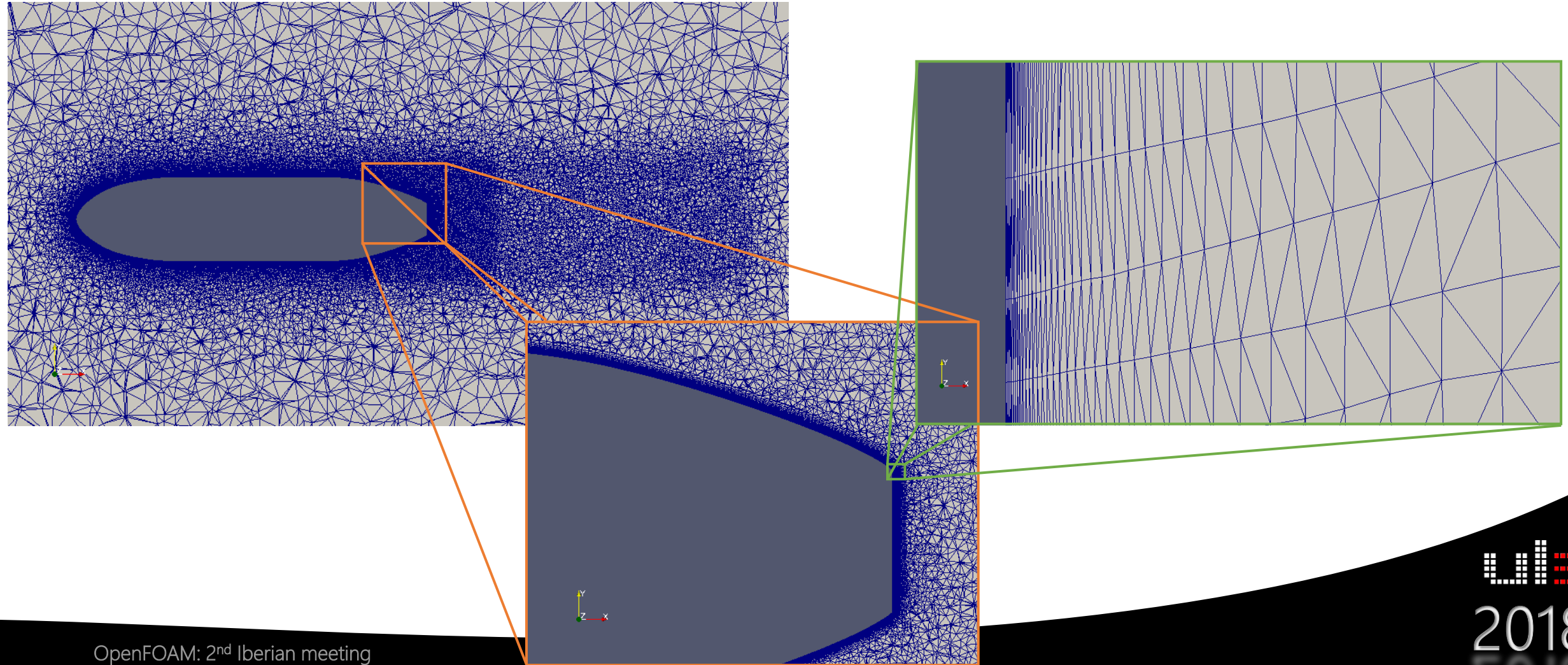
The model

- Scale
- Turbulence models
  - SST k-Omega
  - k-kl-Omega
- Boundary conditions
  - yPlus ~ 1
  - First cell height
- The mesh
  - Mesh strategy and mesh generator



The mesh

- Refinement regions
- Boundary layer



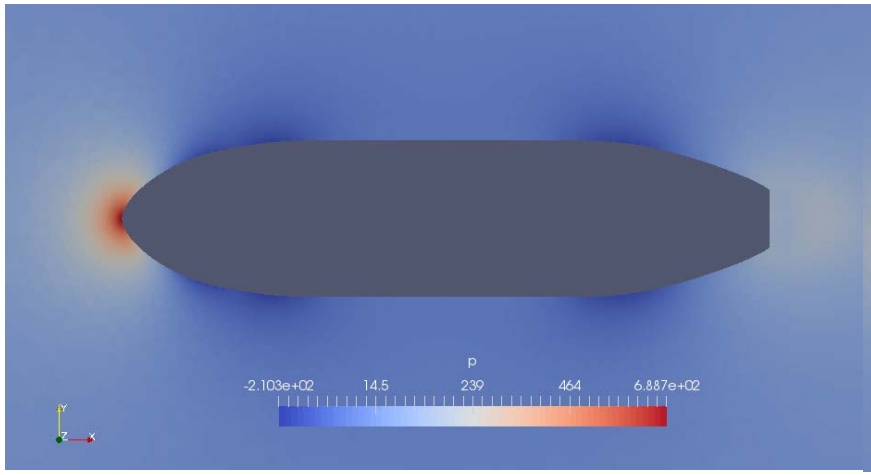
Simulations

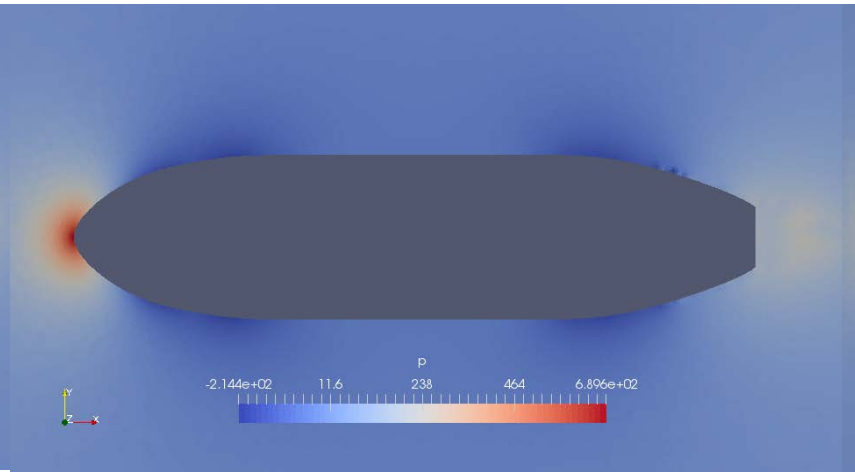
- Some numbers
  - Number of cells
    - 5.5 M cells
    - 15.9 M cells
  - Number of subdomains
  - Total time per simulation

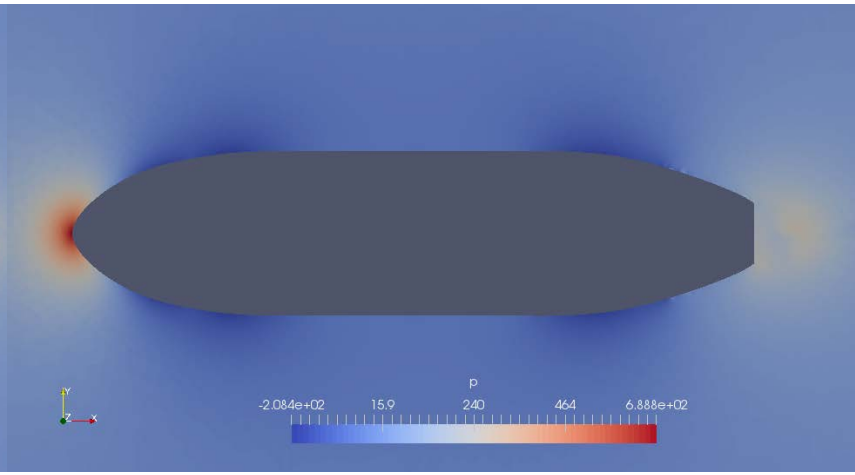
- Computations resources
  - Caléndula

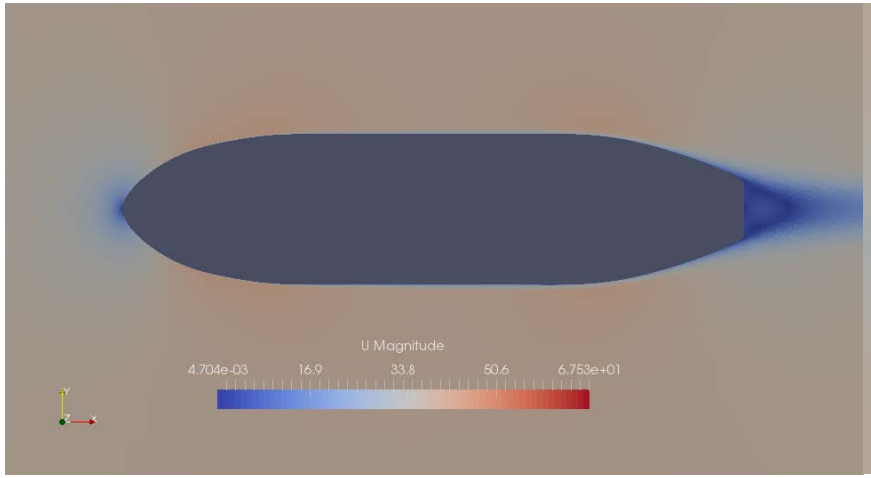
Results

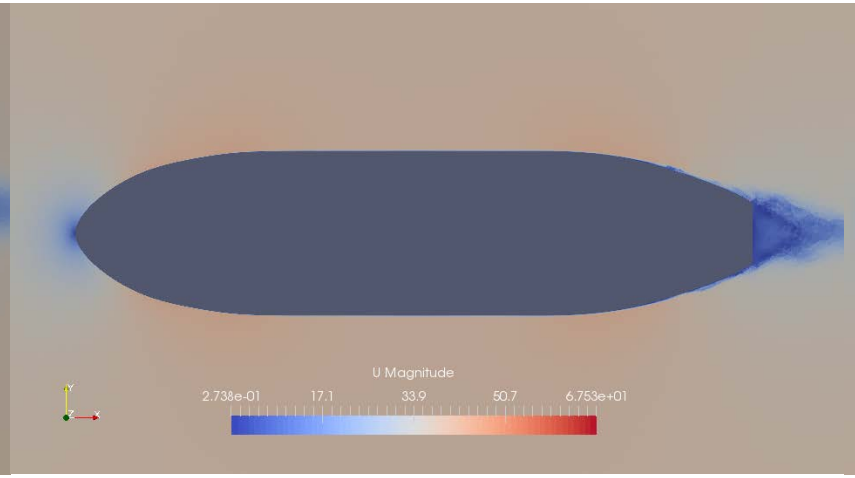
- SST k-Omega
- k-kl Omega 1
- k-kl Omega 2

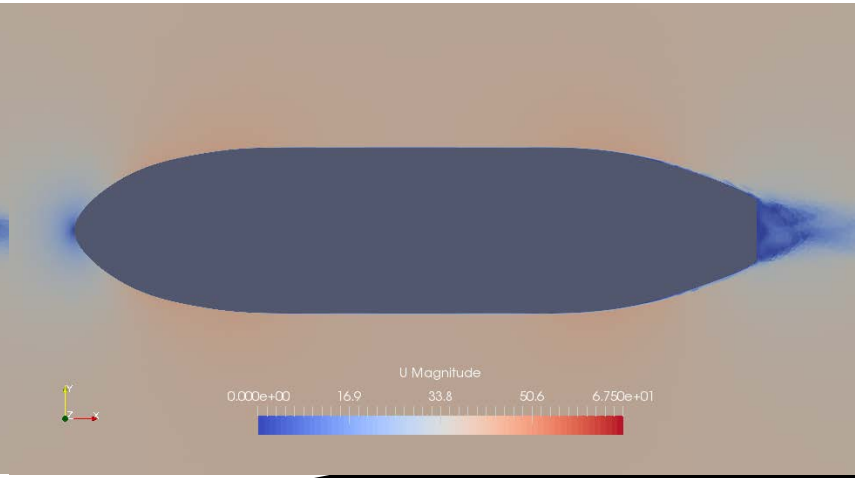








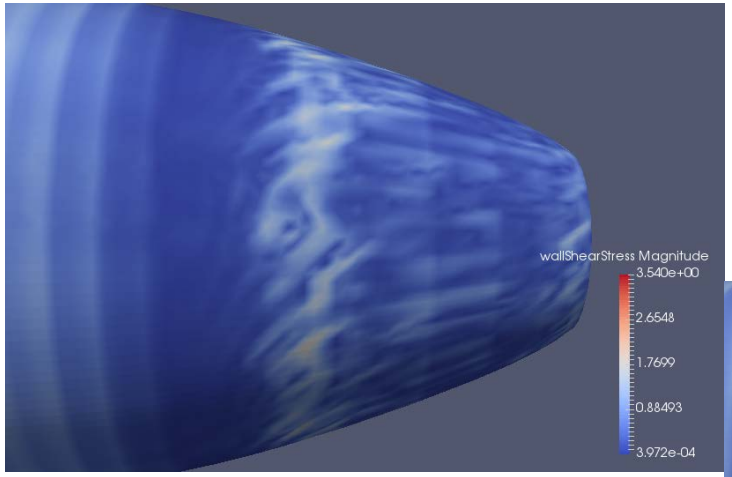


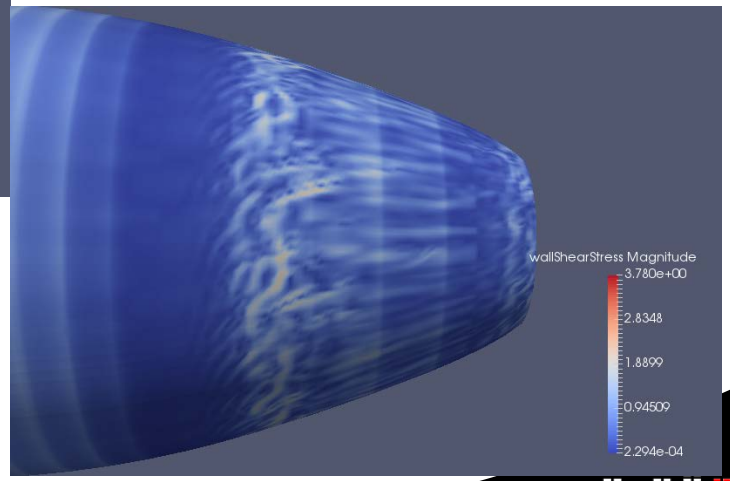


Results

- Forces & force coefficients
  - Lift ~ 0
  - Drag
    - 45% to 48% reduction
  - Viscous contribution
    - No transition model: 77%
    - Transition model: 41% to 46%

- Friction coefficient
  - wallShearStress





Conclusions

- Cd depends on Reynolds number
- Cd is strongly dependant on laminar-turbulent transition point in this context
- Detailed mesh study
- Latest turbulence model: kOmegaSSTLM

Question time!