Comparison of simulation results with measurements in case of a bio–contamination in a closed habitat

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INTRODUCTION
• In manned spaceflight, crew health is threatened by microorganisms and their enhanced pathogenicity due to microgravity
• Human immune response is weakened in microgravity
• It is mandatory to better understand the mechanisms of bio-contamination in confined habitats
• Microbial aerosols can be used as model particles when the dispersion and deposition of particles and reliability of the simulation methods are studied
• Computational fluid dynamics (CFD) can be used for evaluation of indoor microbial contamination and possible spread of harmful microbes in hermetic environments
• Aim of this study was to compare the deposition results of the CFD simulation with the measured particle deposition

CASE
• Experimental chamber similar size with Columbus Laboratory (ISS module)
• Three zones:
  1. Displacement ventilation zone
  2. Mixing ventilation zone
  3. Outlet (exhaust) zone

METHODS
• Open source software:
  • Salome for pre-processing (www.salome-platform.org)
  • cfMesh for grid generation (cfmesh.com)
  • OpenFOAM for solution (www.openfoam.org)
  • Paraview for post-processing (www.paraview.org)
• Air field:
  • WALE turbulence model (LES, large eddy simulation)
  • Simulated 300 s to obtain statistically steady field
  • After that, simulated 300 s and time-averaged
  • Grid: 81.1 million cells
  • Simulation time: Ten weeks with 400 CPU cores
• Particle simulation:
  • Lagrangian method using time-averaged air flow field
  • Simulated first removing all particles hitting wall from the simulation (1800 s, 10000 particles per second, measured size distribution)
  • After that, all particles hitting the wall is considered stuck on the wall and simulation is continued 1200 s
  • Simulation time: Couple of days using one to tens of CPU cores

RESULTS
• Comparison of simulated time-averaged velocity with measured velocity in:
  • Close to displacement inlet
  • Close to mixing inlet
  • Outlet chamber

Conclusions
• Particles mainly deposit on the floor surfaces but also to the supply air diffusers
• Both the CFD simulation and particle deposition in experiments with Bacillus particles resulted similar deposition sites
• Open source software tools are very capable simulation tools because of the three main factors:
  • Efficient and open implementation of the models
  • Heavy parallelization possible because absence of license fees
  • Possible customization because of open source code

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