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STAR Center for
EQS Environmental Quality Systems

CFD Simulations of the Personal Micro-Environment

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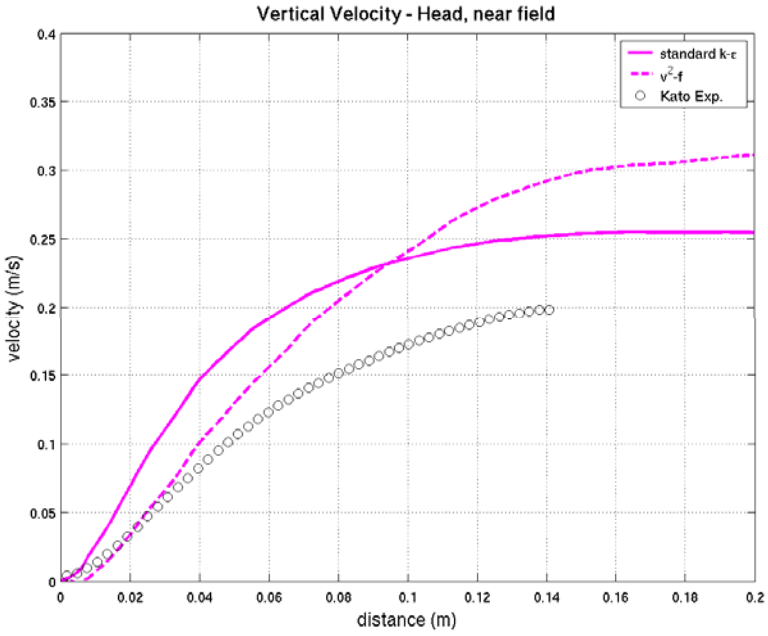
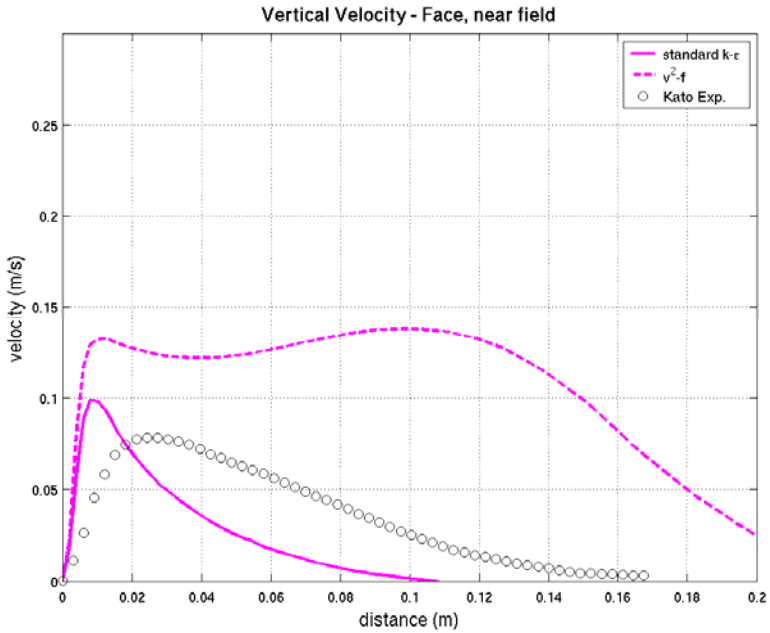
Validation - Experimental Comparison

- Without radiation, RANS models over-predict the magnitude and mis-predict shape.
- Incorporating radiation is essential.



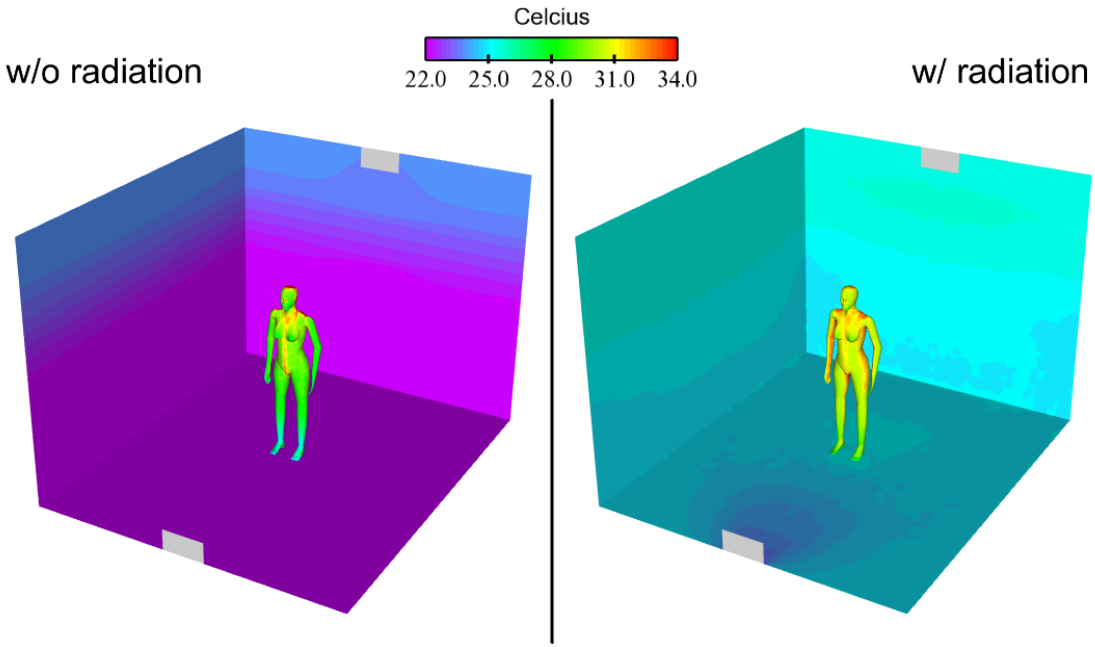
Head



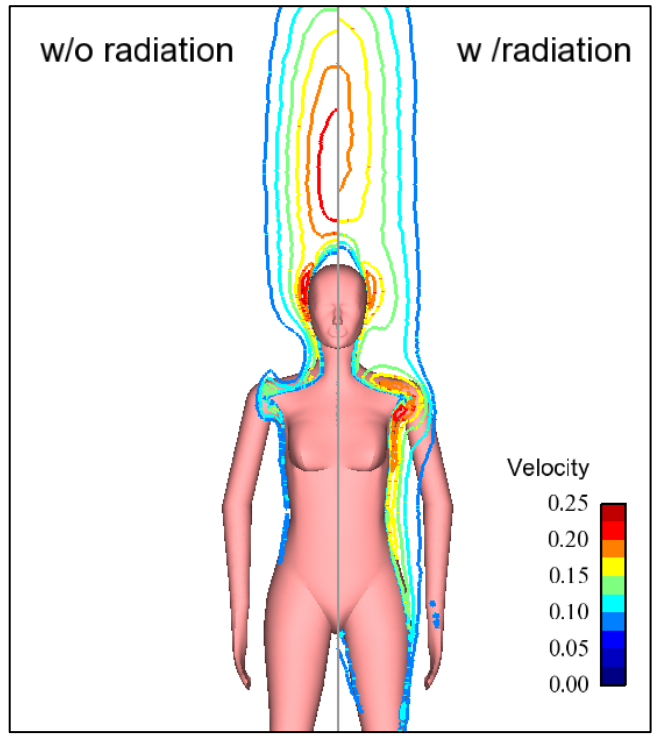
Face

Validation - Radiative Heat Transfer

- If heat-flux BC is used, we **must** include radiation



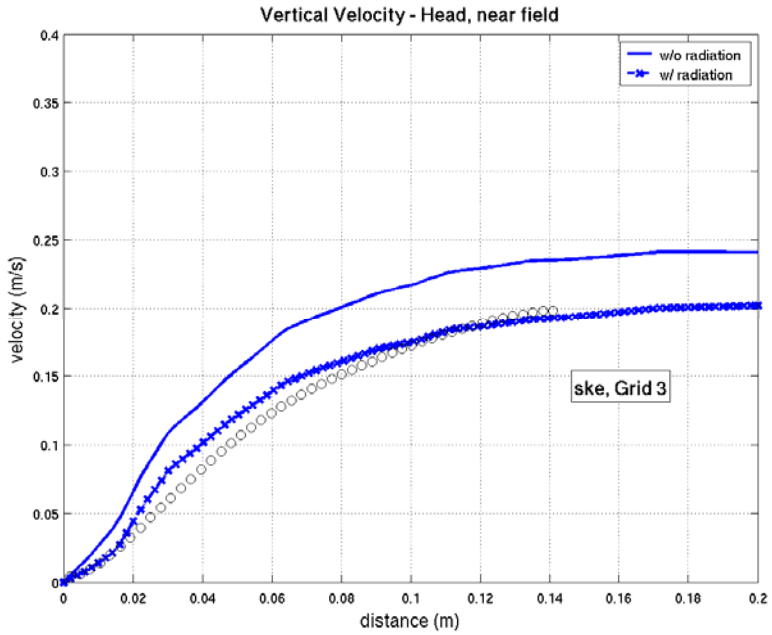
Surface temperature comparison



Plume comparison

Validation - Radiative Heat Transfer

- Radiation calculation of non-participating medium
- Results above head compare well with data
- Improvement at face (torso) but peak value not correct (similar trends for v^2-f)



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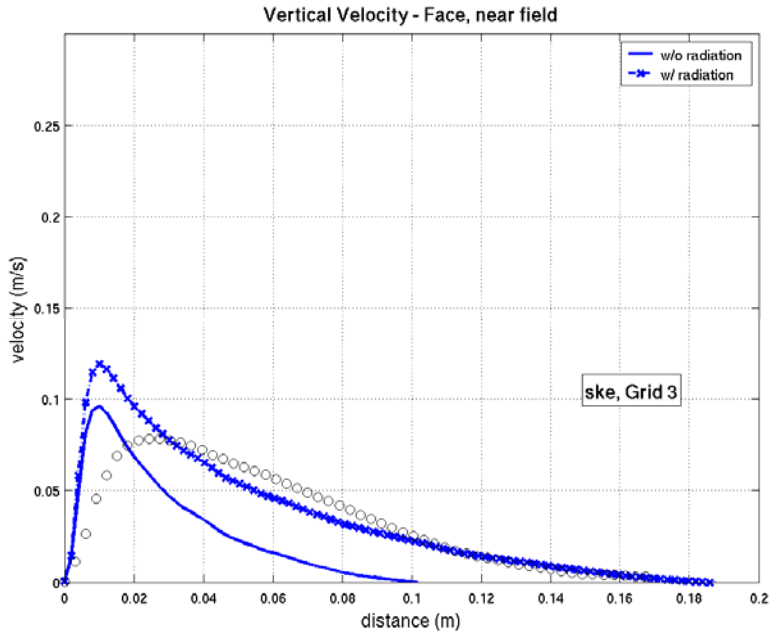
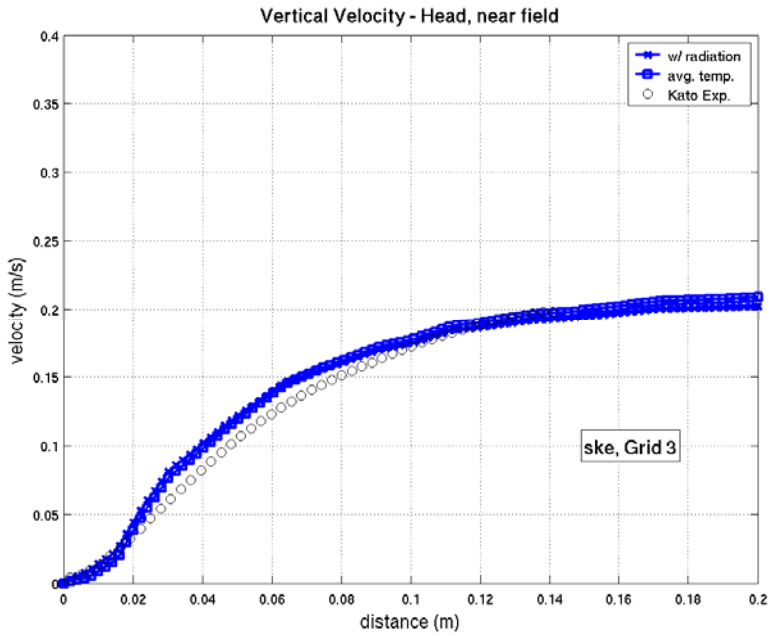


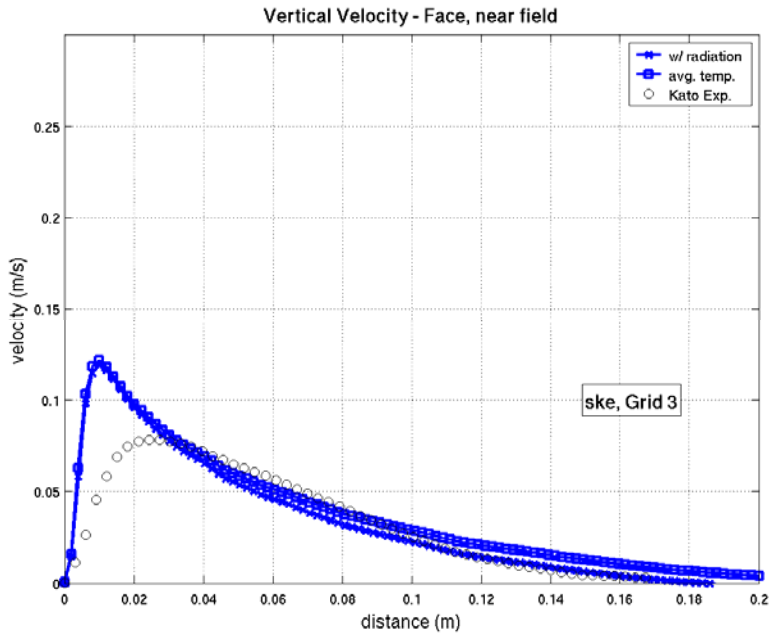
Face

Heat-Flux vs. Temperature BC

- Use surface temperature instead of heat flux BC.
- Detail description of temperature difficult → use averaged surface temperature
- Minimal impact on PME flow



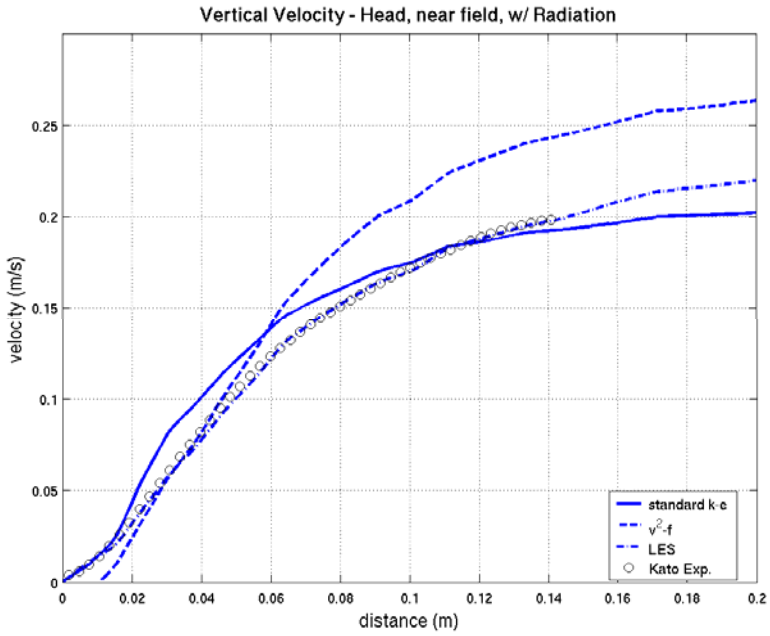
Head



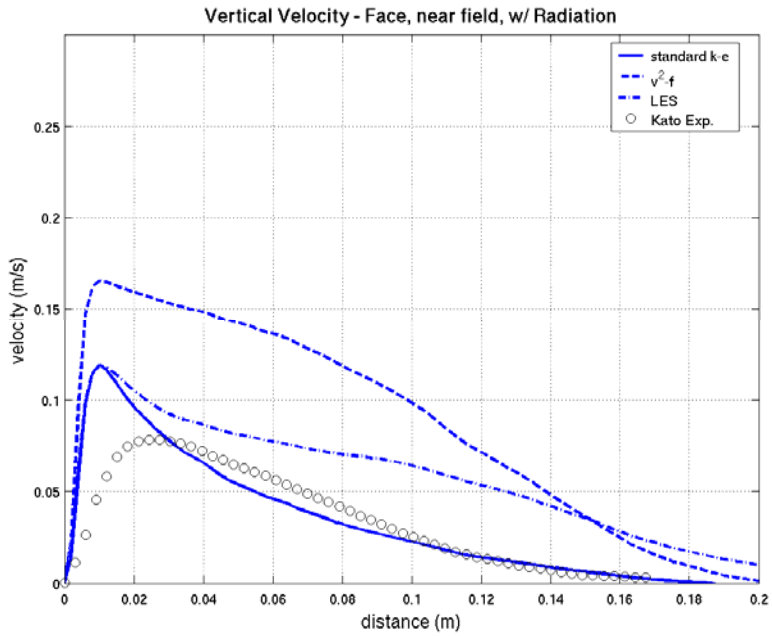
Face

Large Eddy Simulation (LES)

- Low Re and thermally generated turbulence difficult for RANS
- LES does not suffer from RANS deficiencies but typically requires fine meshes and is inherently unsteady
- LES better above head but no better at face or torso (worse?)



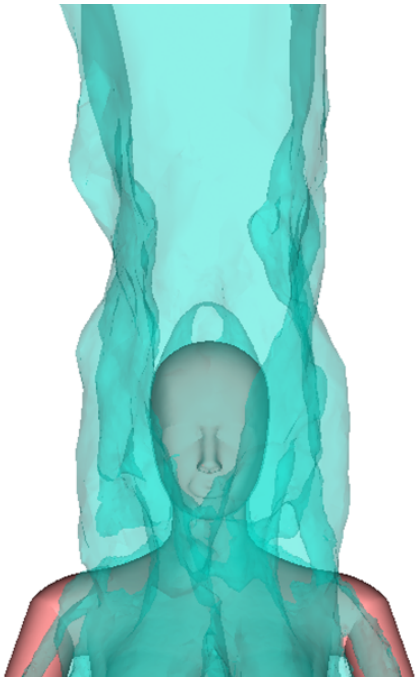
Head

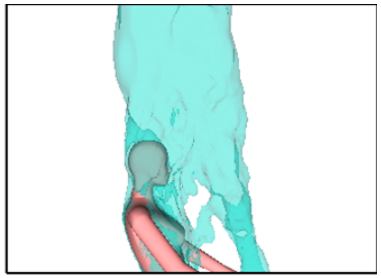


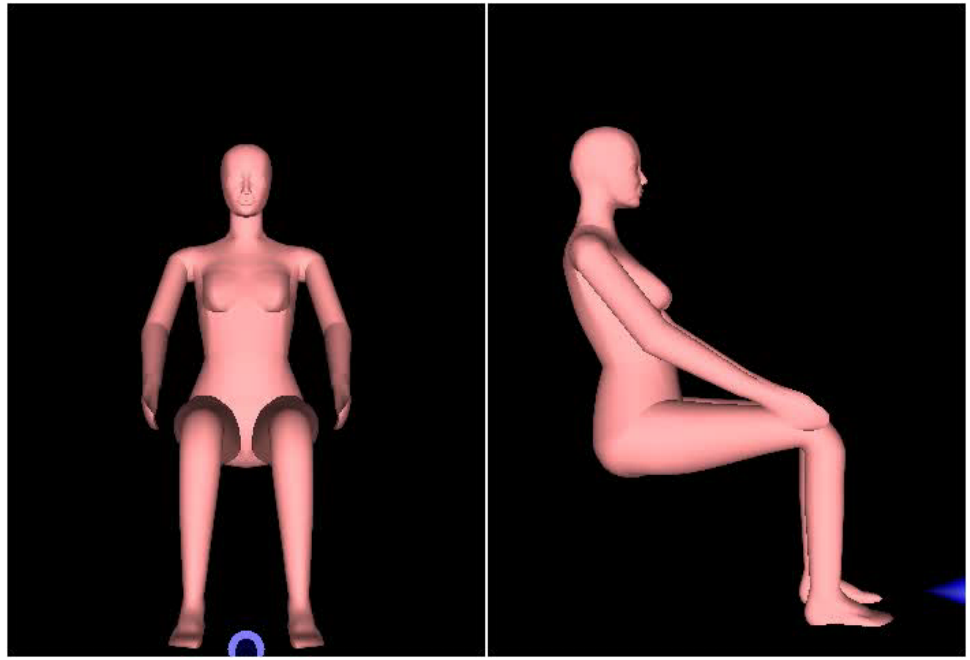
Face

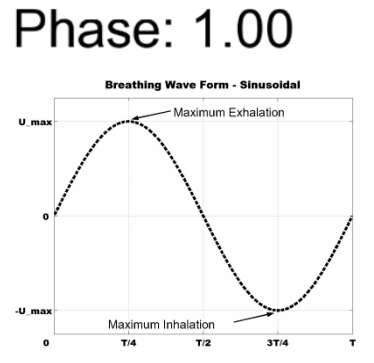
Breathing

- In seated position, plume overwhelms exhaled air – wide plume, short jet throw
- Determine effect of breathing on breathing zone concentration – need to determine effect on plume and re-breathed air



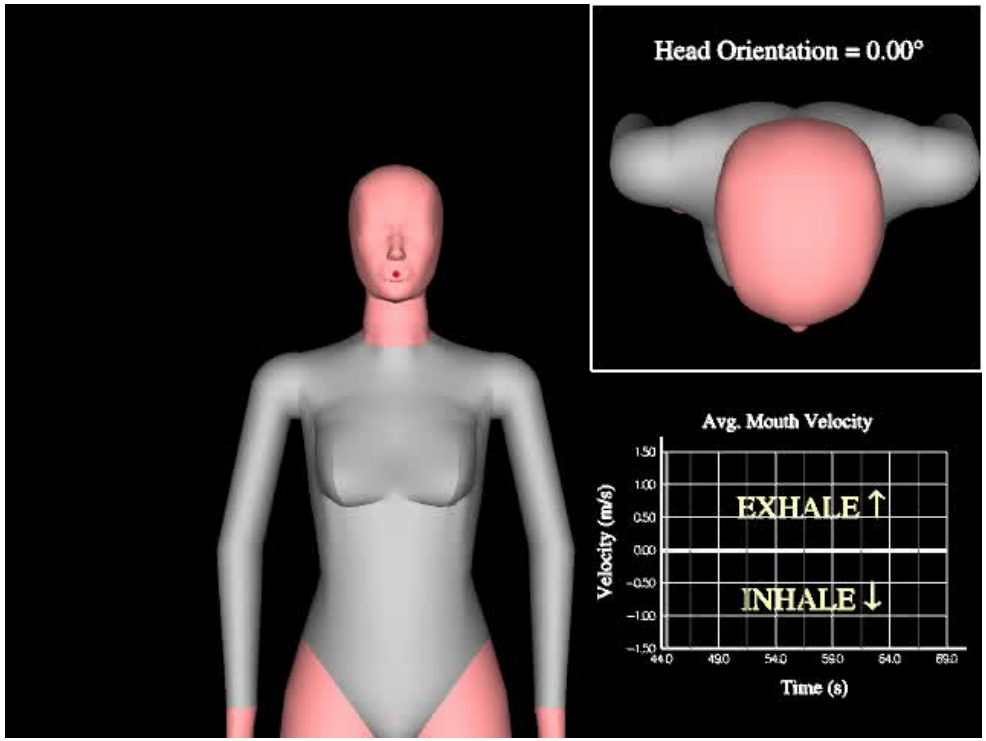




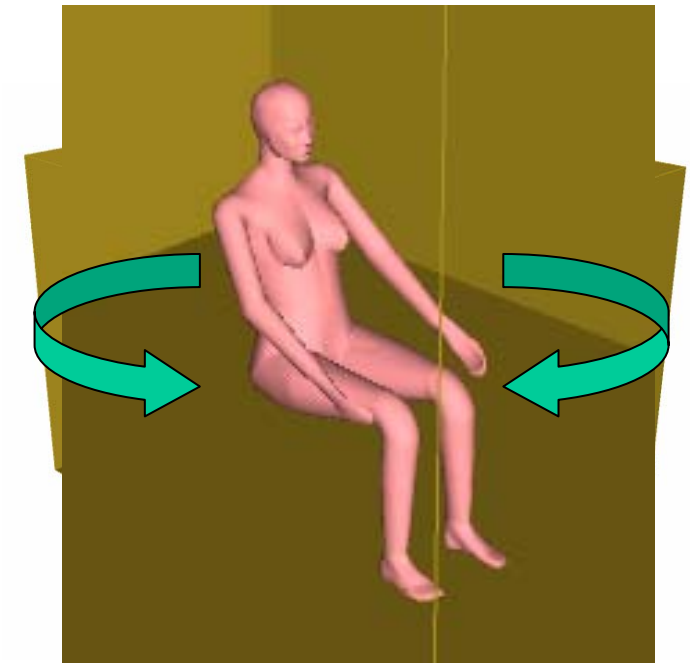


Body Motion

- People typically are not completely stationary for long periods of time.
  – reading or talking; moving around in office chair.
- Motion may affect the plume.



Head Rotation



Body Rotation

PME Summary

- True grid convergence requires several (~5) million cells but may not be necessary (depends on relevant quantities).
- Radiation OR effects of radiation cannot be neglected.
- If PME flow (not thermal comfort) is of interest, surfaces temperatures sufficient (single point).
- For this case, LES does not yield significant improvements over simpler RANS.
- Exposure determined by plume – how does breathing and typical motions affect exposure/plume?
- Knowledge of these effects can help the design of air delivery/cleaning strategies, especially personal ventilation systems.