Covid 19 Flows: study and practical recommendations

Abstracts of invited talks

Dispersal of Small Airborne Aerosols in Buildings

Andy Woods

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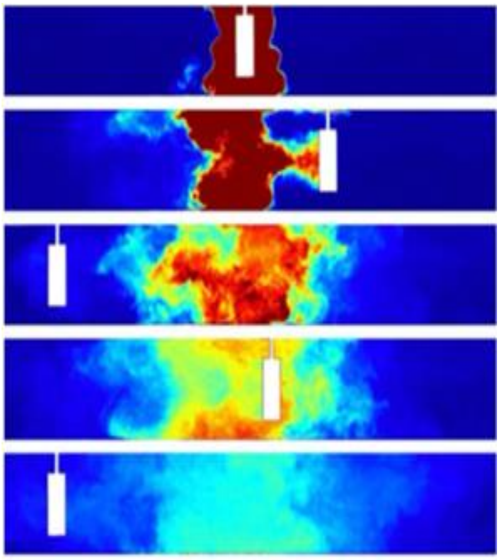

Mixing produced by a person walking along a corridor

In this talk, we will consider the processes responsible for the transport and mixing of fine aerosols in enclosed spaces. We will consider the impact of ventilation flows, convective circulation and the dispersion associated with the motion of people. The models will be informed by analogue laboratory experiments in which we systematically explore and quantify the different processes. We will also present data on the mixing of the air in a number of buildings for comparison with the modelling. Finally we will consider the implications of this modelling for the pathways followed by and residence time of airborne aerosols in buildings, and their relevance for airborne transmission of infection.

Role of Forced Air Warming Blowers in Dispersion of Microbial Skin Colonizers in an Operating Room

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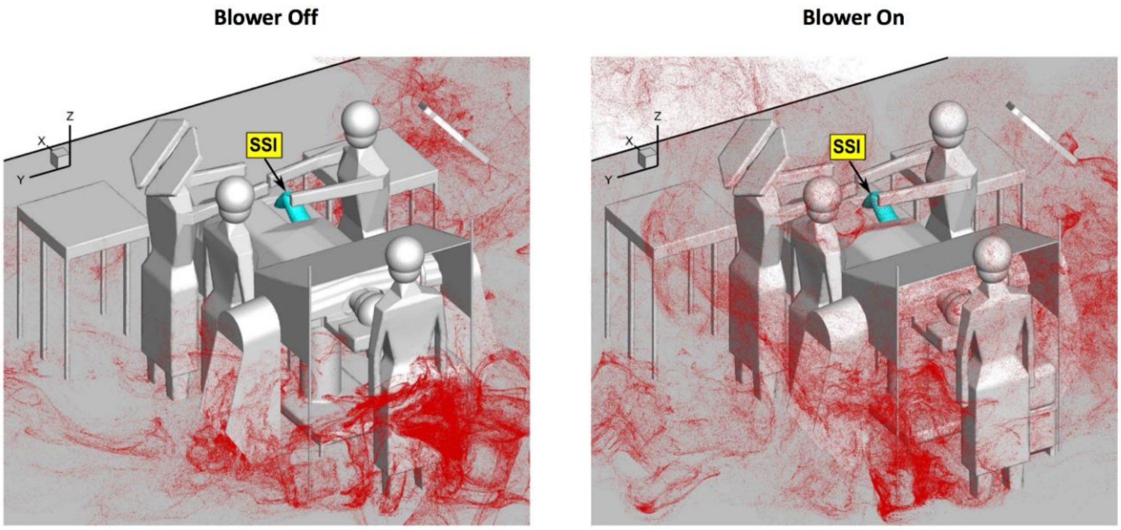
Microbial skin colonizers, such as Staphylococcus aureus, are known as a major cause of surgical site infections in operating rooms (OR). Although the rate of nosocomial infections is significantly low in the United States (< 2.2%), it is still responsible for a huge additional cost on the healthcare system ($10 billion per annum). These bacteria typically colonize on human skin cells or squames (size ~4-20 microns) which are routinely shed by humans, roughly about 10M particles per day. To prevent perioperative hypothermia, hot air blowers are commonly used to force warm air into a plastic blanket and onto the patient's skin. This hot air gives rise to turbulent, buoyant, thermal plumes that can potentially lift-off squames scattered on the OR floor. The interaction between the ultra-clean ventilation flow from the ceiling and the rising plumes from near the operating table plays a critical role in the dispersion of the squames. Whether such forced air warming devices and resultant thermal plumes can increase the probability of squames reaching the surgical site is a major unresolved problem. Predictive, large-eddy simulations (LES) of this complex thermal-fluids problem are performed to obtain three-dimensional, time-dependent flow field in a real OR including a patient undergoing knee surgery, medical staff members, and other medical devices. Lagrangian point-particle tracking is used to accurately capture the dispersion of squames. Simulations with the blower turned on and off are used to contrast the flow patterns and particle dispersion. The probability of squames reaching the surgical site is evaluated and found to be sufficient to cause infections. These simulations highlight the need for predictive numerical studies and their potential in this biomedical application.



With blower off, squames dispersed away by ventilation air

With blower on, rising plumes move squames near SSI

Reimagining the Utah Symphony using Computational Fluid Dynamics

Tony Saad

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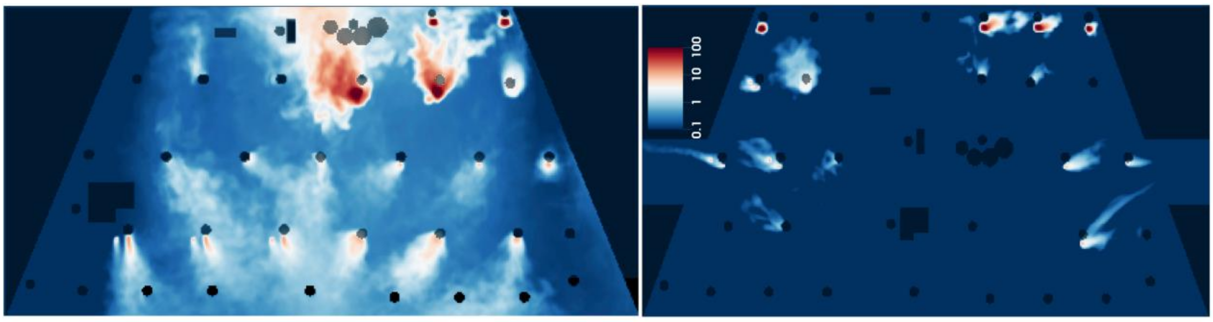
The Covid-19 outbreak and ensuing shutdown have caused a significant impact on the economic productivity and well being of everyone around the world. The “creative” economy was particularly impacted - with the performing arts industries, such as choirs and orchestras, being the most affected with estimated losses of almost 1.4 million jobs and $42.5 billion in sales. While masking can be an effective strategy to inhibit the spread of the virus in the general population, it is impractical to mask wind instruments and vocalists. In May 2020, the Utah Symphony approached our team to better understand if modeling can help in developing a

Covid-19 mitigation strategy for them. Because Covid-19 is primarily spread via respiratory aerosol emissions, modeling its transport using CFD can be part of a general risk mitigation strategy. In this talk, I will discuss how we used high resolution CFD calculations along with concentration transport to model the dispersion of wind-instrument emissions for the Utah Symphony at Abravanel Hall and Capitol Theater. Our proposed mitigation strategies included (1) changing the air flow by manipulating the HVAC, opening doors, and building ducts to reroute the air, and (2) rearranging the orchestra. This resulted in an effective reduction of particle concentration by a factor of 100 in the breathing zone of the stage area. Our work shows that risk mitigation of pathogen transport is not complete without a detailed understanding of the fluid dynamics and droplet transport at a given venue.



Time averaged particle concentrations (#/L, log scale) in the breathing zone for the Original (left) and modified HVAC and seating arrangement (right) for the Utah Symphony at Abravanel Hall.

A Summary of Numerical and Experimental Evaluations of Airborne Pathogen Transmission: From Human Physiology, Saliva Instabilities, and Studies of Safety in a Classroom Setting

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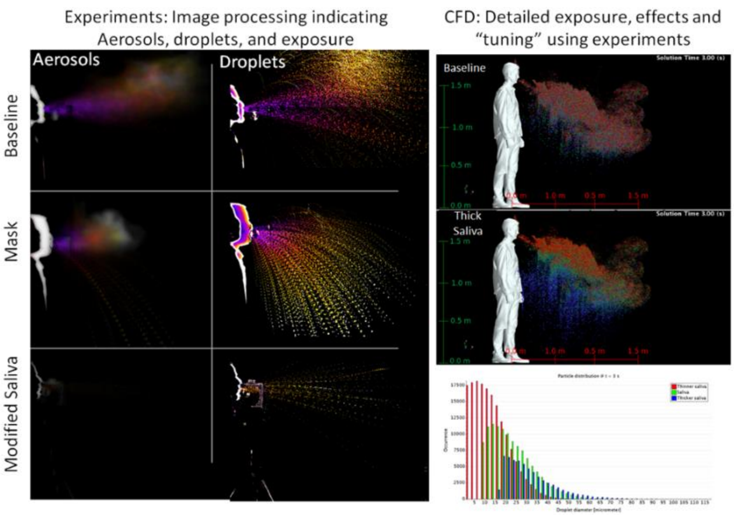

This talk will summarize four different efforts oriented around the COVID-19 pandemic at the University of Central Florida. The first two studies are oriented around human sneeze events, followed by studies of how safe classroom environments are and how can we relax social distancing in the context of mask mandates. The first study involves computational fluid dynamics (CFD) studies of human physiology on the dispersion of droplets and aerosols. In this work we find that the details of the upper respiratory tract and buccal cavity can drive dispersion 60% further or 40% shorter depending on the variations. Additionally, we find that saliva/mucous viscosity also drives this process and is associated with the primary breakup mechanisms. These findings are linked to physical attributes to potentially identify profiles of superspreaders. The second study experimentally evaluates droplet and aerosol exposure levels with respect to modulating the behavior on ones saliva. In these studies, we find that lozenges increase transmissibility by over 200%, but we also discovered food-grade colloids/anticholinergics that actively reduce droplets and aerosols by over 80%. These findings a leading to novel forms of PPE. Additionally, the CFD is also utilized in conjunction with Wells-Riley predictions of transmission probability in the context of a classroom environment. These studies identify uncertainty in the Well-Riley predictions, as well as also indicate the correlation that increased distance does not imply safety in the context of aerosols.