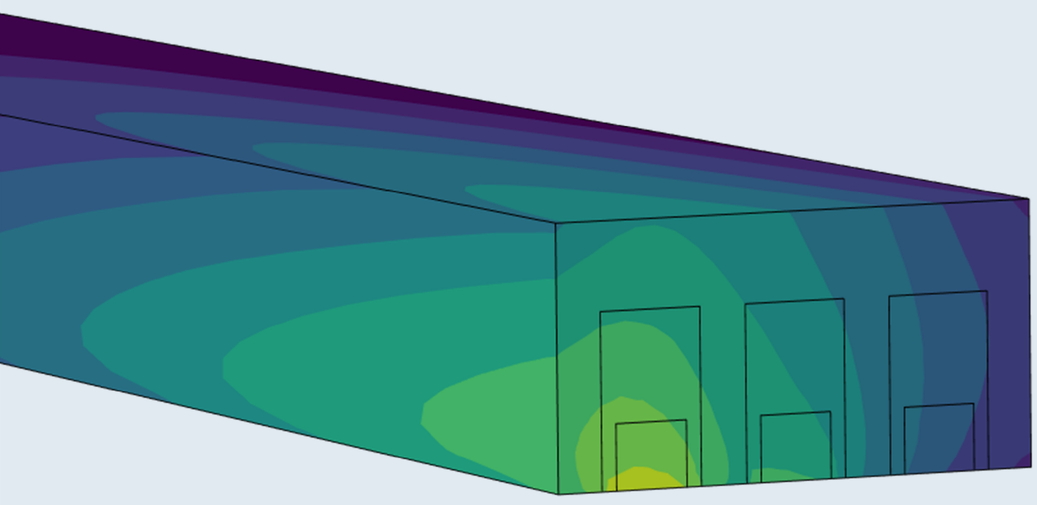

Traffic Tunnel Troubles: Flows & Pollution

Modelling realistic airflow and pollution dispersion in road tunnels due to traffic to improve air quality and explore air purification techniques.

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Introduction and Future Prospects

Urban road tunnels offer a promising solution to extend existing infrastructure while mitigating air pollution and nuisances affecting nearby residential areas. This poster focuses on a realistic yet computational favorable implementation of traffic in 3D models. In this preliminary study, airflow and pollution due to traffic is simulated using a **quasi-static method**. A distinction between trucks and cars is made, as well as traffic distribution over different lanes.

While this model demonstrates effectiveness, further study and validation are planned for future research. The methodology can be applied to assess tunnel infrastructure's impact on the environment in future models. Beyond impact assessment, it can prove useful for the development and optimization of an air purification system to address air pollution within tunnels. This will be the subject of future research wherein particle tracing will be integrated to get additional insights.

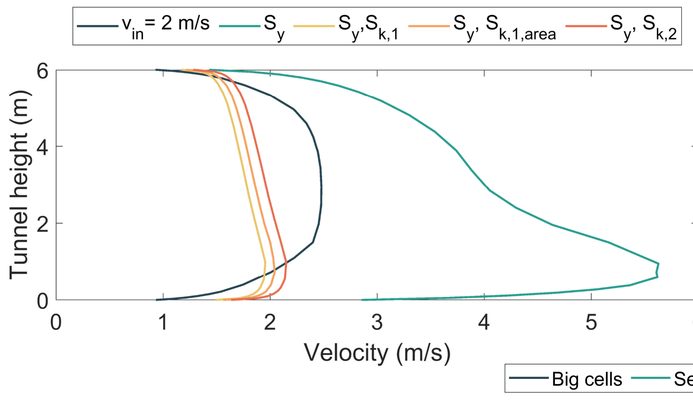

FIGURE 1 – Outgoing velocity profile for different turbulence equations, using small cells.

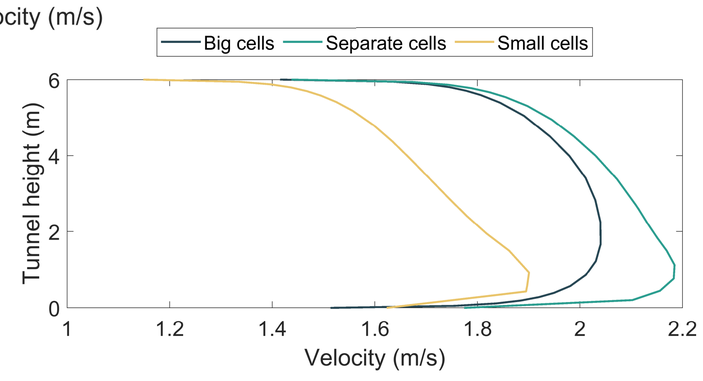

FIGURE 2 – Outgoing velocity profile for different cell sizes, using $S_{k,1}$ with area correction.

Methodology

A RANS $k-\varepsilon$ turbulence model coupled with transport of diluted species through reacting flow (Kays-Crawford)

Traffic induced **momentum** → volume force

$$S_u = 0.5\,\rho\, n_{veh,L}\, A_v/A_{cell}\, C_D\, |U_v - u_{air}|(U_v - u_{air})$$

Traffic induced **turbulence** → weak contribution, 2 options:

$$S_{k,1} = 0.41\,\rho\, \dot{Q}_{veh}(U_v - u_{air})^2\, A_v/A_{cell}$$

$$S_{k,2} = S_u(U_v - u_{air})$$

→ area correction factor

Volume reactions using traffic emission factors (coupling with MATLAB®)

Results

Taking traffic into account results in less uniform velocity and concentration profiles. An area correction is needed when different cell sizes are used. Driving faster causes higher flow velocities, thus lower concentration. More and heavier traffic also causes faster flow, but results in higher concentrations. When heavy traffic is crammed on one side of the tunnel, the pollution distribution becomes skewed.

Impact assessment, PM capture devices

Complex geometries, PM movement, model validation, surrounding environment

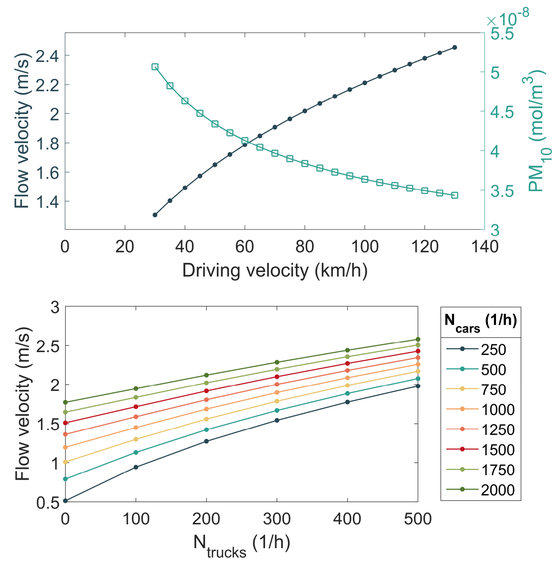

FIGURE 3 – Average flow velocity and PM10 concentration under different driving conditions. More, heavier and faster traffic results in higher velocities.

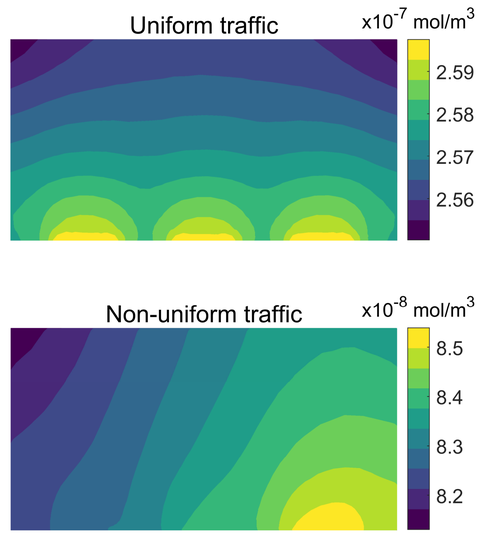

FIGURE 4 – Outgoing PM10 concentrations in case of even traffic distribution (top); trucks right, cars left distribution (down). Traffic distribution results in skewed concentration profiles.

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