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70 years

1950-2020

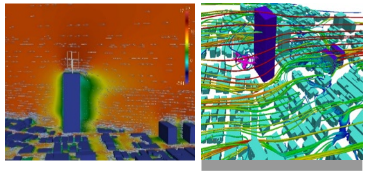
A NESTED MULTI-SCALE MODEL FOR ASSESSING URBAN WIND CONDITIONS : COMPARISON OF LARGE EDDY SIMULATION VERSUS RANS TURBULENCE MODELS THAT ARE OPERATING AT THE FINEST SCALE OF THE NESTING.

Mandar V TABIB[1], Knut Helge MIDTBØ[2], Tor SKASLIEN[2], Adil RASHEED[1], Trond KVAMSDAL[1]

1. SINTEF Digital, 7465 Trondheim, NORWAY,

2. Meteorologisk institutte, OsloSintef Digital

Slide 1. Motivation, Objective and Methodology

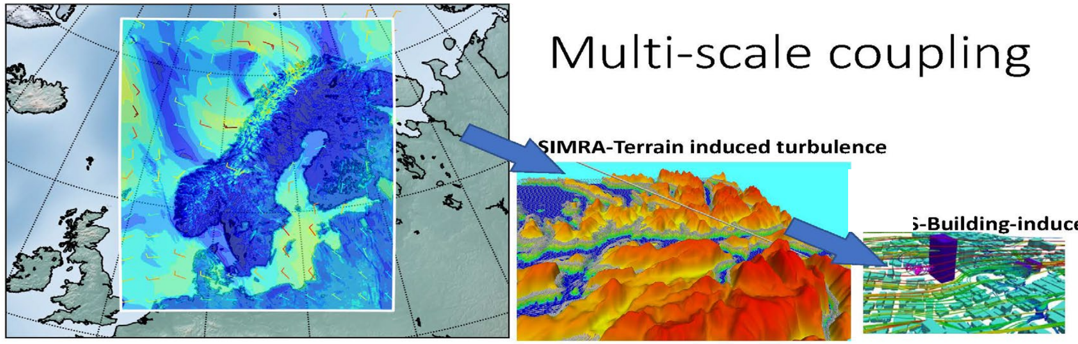


building induced flows

- **Motivation** : Improving urban-scale wind predictions for potential building-integrated wind energy and for making potential drone operations safer.
- **Knowledge gap**: Few multi-scale wind models exists for urban-flows. We wanted to investigate the influence of different approach with involvement of three levels of nested modelling with use of **LES model on finest scale**.
- **Methodology** to improve wind-prediction in urban-scale:

HARMONIE: Weather Forecasting models.

Multi-scale coupling



Grid resolution : 2.5 kms x 2.5 kms
Domain size : 1875km × 2400km × 16km.

Grid size = 112 m
Domain size = 18 kms x 18 kms

Grid size = 0.15 m near buildings
Domain size = 700 m x 600 m x 300 m (approimately).

Governing Equations

Harmonie, SIMRA, super-micro CFD

$$\nabla \cdot (\rho_s \mathbf{u}) = 0$$

$$\frac{D\mathbf{u}}{Dt} = -\nabla\left(\frac{p_d}{\rho_s}\right) + \mathbf{g}\frac{\theta_d}{\theta_s} + \frac{1}{\rho_s}\nabla \cdot \mathbf{R} + \mathbf{f}$$

$$\frac{D\theta}{Dt} = \nabla \cdot (\gamma_T \nabla \theta) + q$$

$$\varepsilon = (C_\mu^{1/2} K)^{3/2} / \ell_t$$

$$\ell_t \approx \frac{\min(\kappa z, 200m)}{1 + 5Ri}$$

$$Ri = \frac{(g/\theta)\partial\theta/\partial z}{(\partial u/\partial z)^2}$$

Mesoscale code

SIMRA- RANS equation

$$\frac{Dk}{Dt} = \nabla \cdot (\nu_T \nabla k) + P_k + G_\theta - \varepsilon$$

$$\frac{D\varepsilon}{Dt} = \nabla \cdot \left(\frac{\nu_T}{\sigma_e}\nabla \varepsilon\right) + (C_1 P_k + C_3 G_\theta)\frac{\varepsilon}{k} - C_2\frac{\varepsilon^2}{k}$$

CFD – building-induced flows
Both RANS and LES
- The work involves comparison of predictions by RANS and LES.

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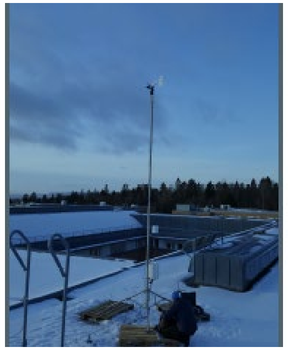
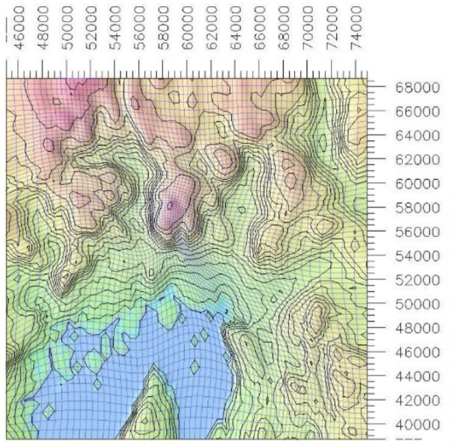
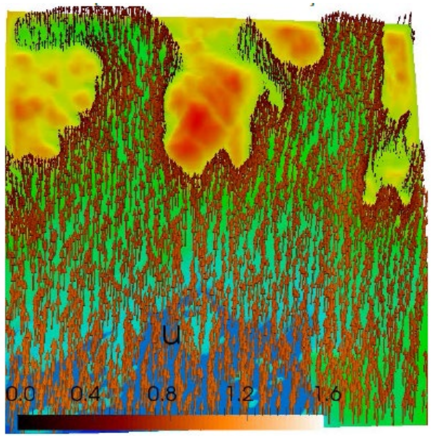
Slide 2. Case Study, Experimental validation, Set-up

Case study – Rikshospitalet, Oslo

Experimental Measurement masts for validation.
Case studies : 09th of February 2020, 180 Wind
13th of April 2020 , 344 Wind

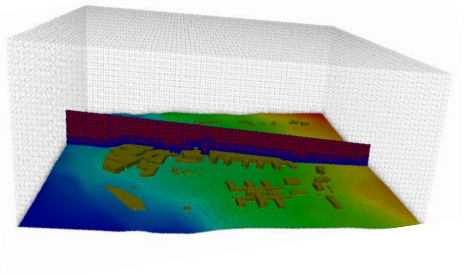




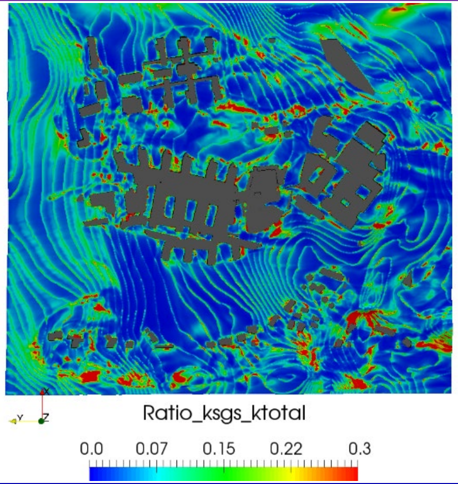


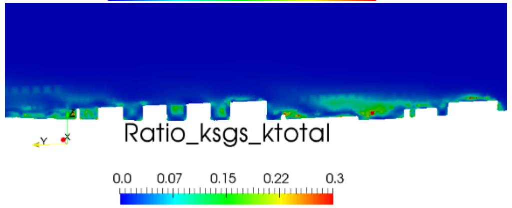
Grid size = 112 m
Domain size = 18 kms x 18 kms

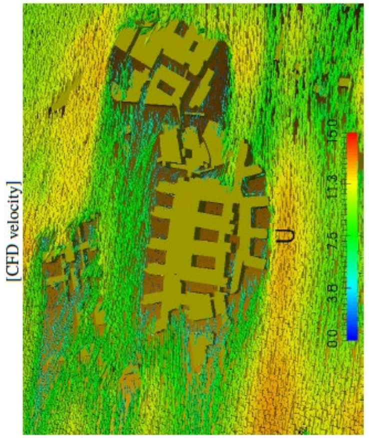
SIMRA



Grid size = 0.15 m near buildings
Domain size = 700 m x 600 m x 30(
(approximately).

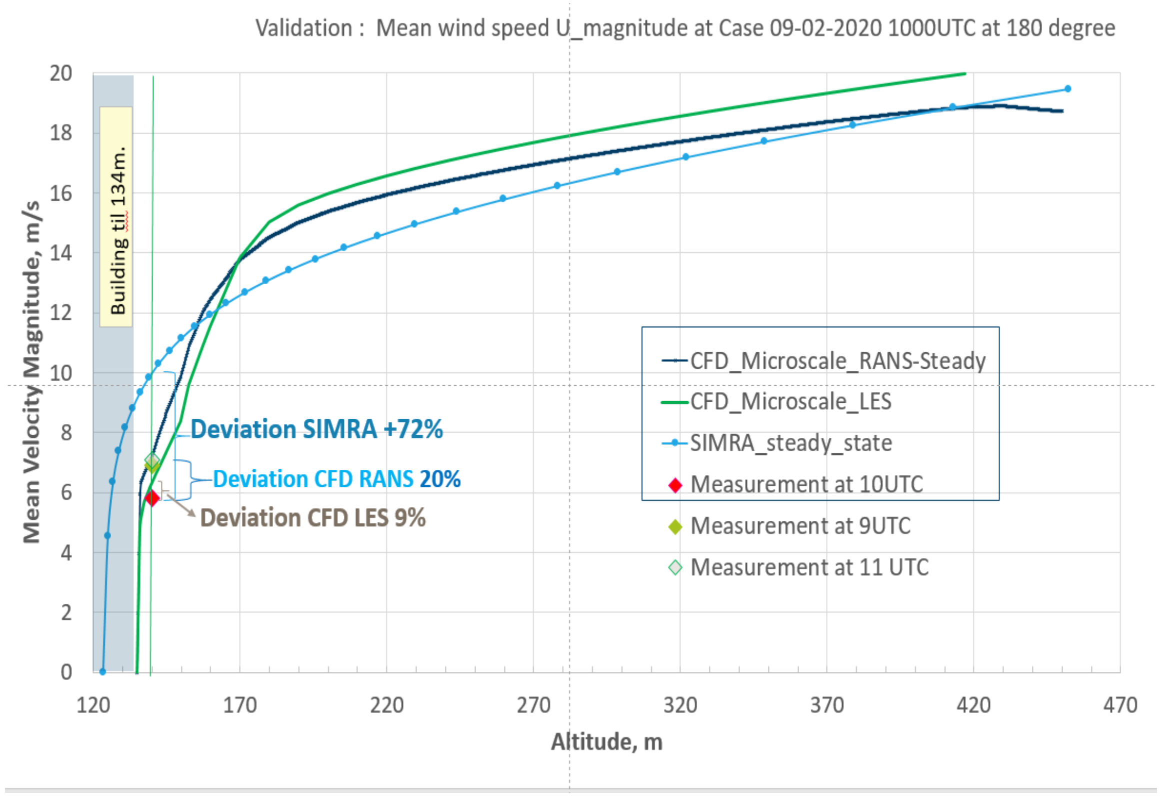




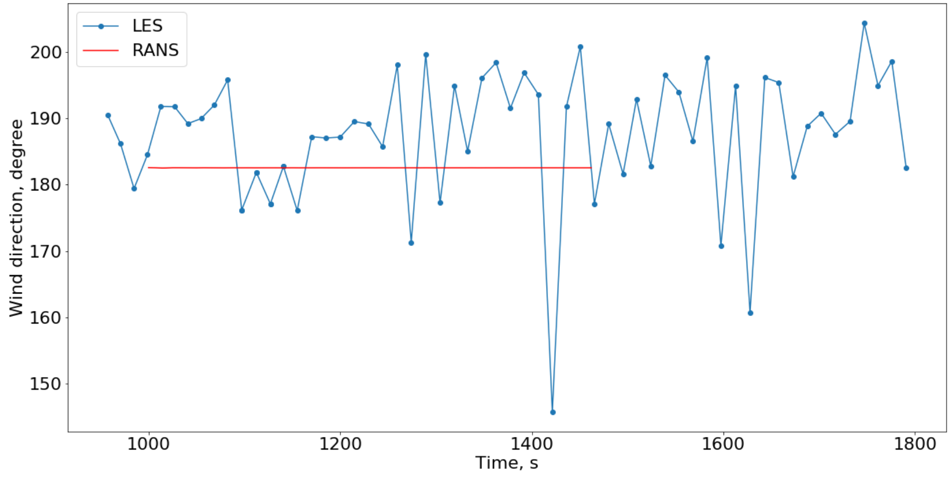


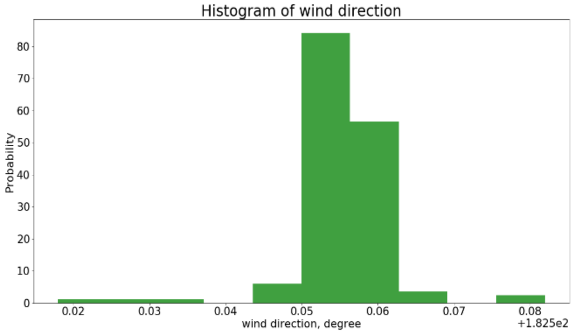
Building CFD

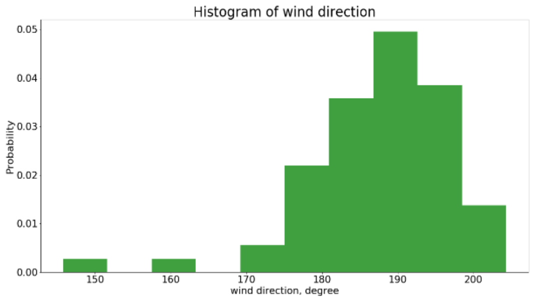
Slide 3. Results: LES vs RANS comparison (Quantitative validation and qualitative comparison)



Wind direction at measurement locationas predicted by LES and RANS.







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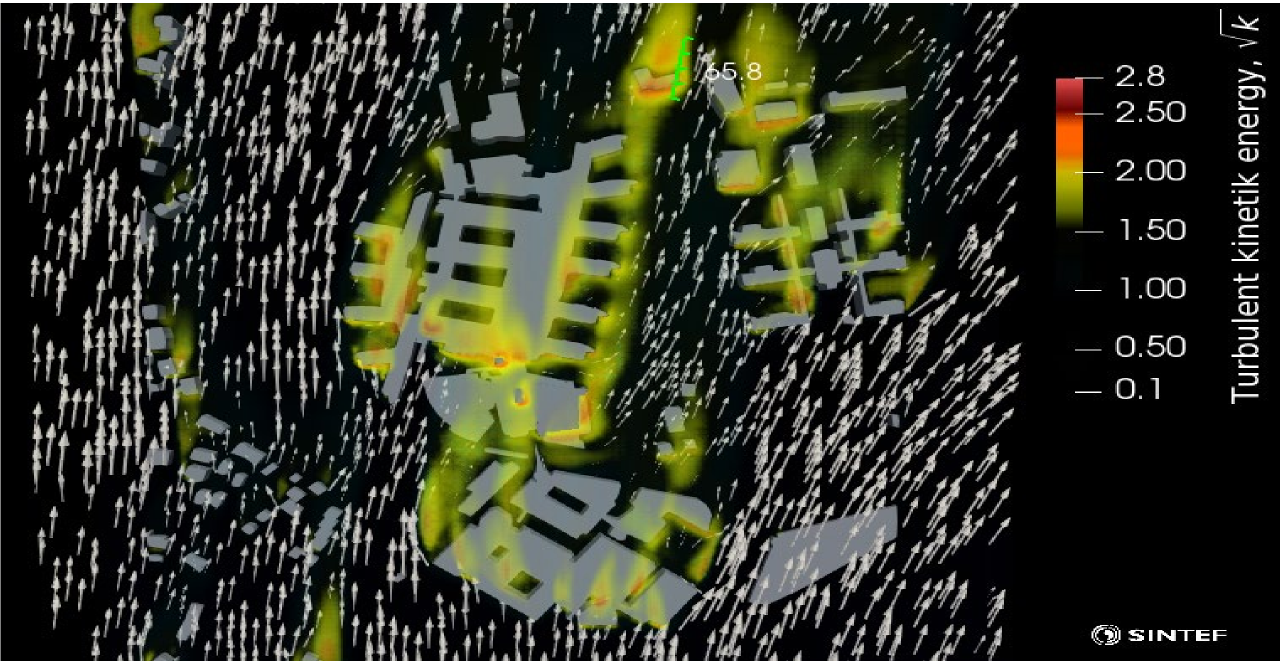
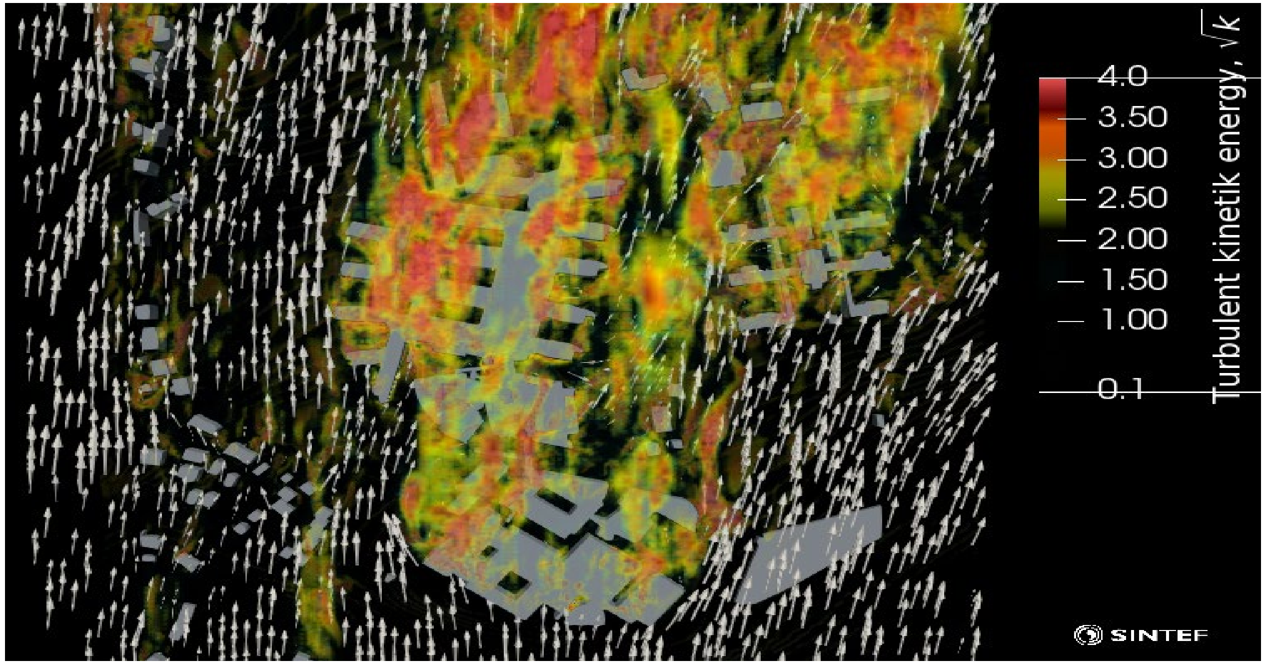
Slide 4. Results: LES vs RANS comparison (Quantitative validation and qualitative comparison)





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Slide 5. Summary from the comparison

- The microscale LES model shows lower deviation than RANS model for mean velocity when compared with a reference experimental measurement mast near the building site for a challenging dynamic practical wind scenario. This is attributed to ability of LES to capture the unsteady dynamics better than the RANS model.
- Also, both the RANS and LES models in the finer-scale CFD predict lower and more accurate value of velocity when compared to the higher-scale SIMRA model as they are able to account for the impact of buildings. This, thus justifies the inclusion of a finer-scale model in the multi-scale setup for urban-scale flows.
- Scope : Due to the computationally intensive nature of multiscale with LES, the validation is done for one challenging scenario in this work. Future work could involve conducting more such studies.