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RECENT ADVANCES IN DATA DRIVEN TURBULENCE MODELING

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ABSTRACT

Computational Fluid Mechanics (CFD) is an established key technology in aerodynamic design. Its predictions are considered reliable near the design point, where the flow stays attached. Therefore there is major interest to extend its application towards the borders of flight where the flow is partly separated.

For predicting separated flows correctly, the treatment of turbulence is of utmost importance. In principle, the Navier-Stokes equations provide an adequate description of any turbulent flow. However, at Reynolds numbers relevant for aeronautical applications, their solution is characterised by space and time-dependent fluctuations. The scales of these fluctuations cover several orders of magnitude in space and time, where the smallest ones are far below the scales of engineering interest. Hence, the effort required for scale-resolving methods like Direct Numerical Simulations (DNS) or Large-Eddy Simulations is usually beyond the scope of practitioners.

For this reason, methods based on the Reynolds-averaged Navier-Stokes (RANS) equations are still forming the backbone of CFD applications. In these equations, the turbulent fluctuations are replaced by the so-called Reynolds stresses representing their average effect on the mean flow. Modelling these Reynolds stresses is therefore crucial for the predictive accuracy of any RANS based method, particularly in case of separated flow.

Various approaches have been suggested for this task, starting with the idea of an eddy viscosity, increasing the viscosity of the fluid, up to full Reynolds-stress transport models, requiring the solution of 7 additional modelled transport equations. Recently, data-driven methods have emanated for improving RANS-based models, aiming at a reduction of the predictive error by exploiting available data. Such methods are successfully applied, e.g. to optimizing closure coefficients, augmenting models by missing terms or correcting the predicted Reynolds stresses. The Minisymposium addresses recent advances in this important developing area of research.