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CFD simulation of atmospheric dispersion over a flat field in low-wind stable conditions using anisotropic turbulence models

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Low wind conditions (wind speed < 1-2m/s) are the most critical atmospheric states for the dispersion of a pollutant due to highly non-stationary and inhomogeneous diffusion conditions governed by the meandering, weak, sporadic and intermittent turbulence. These atmospheric conditions coupled with thermal stable conditions remain a challenge for the numerical modelling of turbulent flows and dispersion at local scale.

Numerical simulation of a pollutant dispersion in these atmospheric conditions using the RANS (Reynolds Averaged Navier Stokes) equations is known to be highly dependent on selected turbulence models. On one hand, the modelling of turbulence and dynamic of wind field, by means of first order Eulerian closure models based on the turbulent viscosity hypothesis, lacks an adequate and complete representation of the anisotropic effect. On the other hand, the isotropic aspect attributed to the dispersion of the pollutant, through the simple gradient diffusion model, tends to underestimate the horizontal diffusion of the pollutant, thus overestimating the concentration along the plume axis near the source.

Therefore, the purpose of this study is to investigate the behaviour of anisotropic RANS models for dispersion of a pollutant in low wind stable conditions. The models used to simulate the dynamic field are the second order RSM (Reynolds Stress models), whereas the algebraic models used to model the concentration turbulent flux of concentration are either the AFM (Algebraic Flux model) or the GGDH (Generalized Gradient Diffusion Model). The simulations are performed using a 3-dimensional CFD code, *Code_Saturne*® (EDF), in which these turbulence models are implemented.

The models are validated with a well-known Idaho Falls experiment (USA) for the dispersion of a passive tracer under low-wind stable conditions. Various inflow boundary conditions for wind profiles and turbulence parameters are applied. In order to assess the predictive capacity of these models, a comparative statistical analysis is performed using standard statistical performance measures. The model results are also compared with the results from a Gaussian plume dispersion model.