Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: *AEROFLIPHY, CFDMPS*
Corresponding author: BOUHAFID Younes
e-mail of corresponding author: younes.bouhafid@onera.fr
Type: Oral
Status of corresponding author: Student
For student corresponding author: student member of one of the following:

Title

Aerodynamic simulation of the near-field of an aircraft using different mesh adaptation strategies

Authors

Younes BOUHAFID [1], Nicolas BONNE [2], Laurent JACQUIN [3]*

** Corresponding author*
[1] DMPE, ONERA, Université Paris Saclay, F-91123 Palaiseau - France, younes.bouhafid@onera.fr
[2] DMPE, ONERA, Université Paris Saclay, F-91123 Palaiseau - France, nicolas.bonne@onera.fr
[3] DSG, ONERA, Université Paris Saclay, F-91123 Palaiseau - France, laurent.jacquin@onera.fr

Abstract

Condensation trails, also known as contrails, are ice crystals clouds that are formed by aircraft emissions at high altitudes. The formation and evolution of contrails can have a significant impact on the atmosphere and climate as shown by a recent compilation of studies on the impact of aviation on climate change [1]. In this context, the investigation of contrail formation near the aircraft may be helpful in order to develop strategies to reduce their undesirable impacts.
The early stage of a contrail's life is dominated by the ice formation microphysics, the dilution due to the jet dynamic and the mixing of the plume around the wing-tip vortices. Thus, in order to better understand the near field, it is important to carry out simulations that accurately solve these processes. However, numerical diffusion tends to dissipate the vortices, which leads to a reduction of vortex strength and an underestimation of the plume mixing around the wing-tip vortices. As wing-tip vortices carry the ice crystals downward, spreading them vertically, their role in the formation of persistent contrails is important. These simulations can be improved by using anisotropic mesh adaptation techniques [2] to better resolve regions of high flow gradients, such as the regions near the aircraft engine exhaust where contrails are formed and the regions of wing-tip vortices. By using mesh adaptation, the simulations can help accurately predict the formation and evolution of contrails, as well as their impact on the atmosphere and climate. Additionally, mesh adaptation can be used to reduce the computational cost of these simulations, which can enable the exploration of a wider range of flight conditions and aircraft designs.
This work focuses on the aerodynamic simulation of the near-field for the Common Research Model [3] configuration representative of a B777 and for which engines were added [2]. In this paper, we present a comparison of three different mesh adaptation strategies based respectively on the three different sensors: the crossflow speed, the total energy of the mean field and the kinetic energy of the mean field plus the turbulent field. We evaluate the performance of these mesh adaptation strategies in terms of accuracy for the wing-tip vortex circulation and for the wing lift coefficient for which theoretical and experimental values are known. The CFD prediction of the temperature field inside the engine jet is also assessed.

References

[1] Lee, D. S., Fahey, D. W., Skowron, A., Allen, M. R., Burkhardt, U., Chen, Q., ... & Wilcox, L. J. (2021). The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. Atmospheric Environment, 244, 117834.
[2] Montreuil, E., Ghedhaifi, W., Chmielaski, V., Vuillot, F., Gand, F., & Loseille, A. (2018). Numerical Simulation of contrail formation on the Common Research Model wing/body/engine configuration. In *2018 Atmospheric and Space Environments Conference* (p. 3189).
[3] Vassberg, J., DeHaan, M., Rivers, M., and Wahls, R., "Development of a Common Research Model for Applied CFD Validation Studies", AIAA Paper 2008-6919, 2008.