

MODELLING AIRCRAFT POLLUTANT DISPERSION TO REDUCE ENVIRONMENTAL IMPACT

MARENOSTRUM5 GPP

Led by



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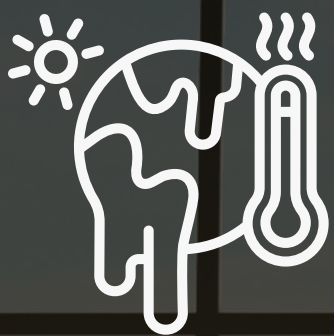
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WHAT IS THE FATE OF AIRCRAFT EMISSIONS?



Aircraft engines burn kerosene, **releasing pollutants into the atmosphere**

Around airports and nearby communities, these emissions can **reduce air quality and affect human health**



More broadly, aviation emissions **contribute to climate change and alter atmospheric chemistry**

Understanding how these pollutants spread is essential to assess their **environmental impact** and develop **strategies to reduce it**



WHAT DETERMINES HOW POLLUTANTS DISPERSE?

2

The **dispersion of pollutants** from aircraft engine emissions is governed by the **aerodynamic wake**



As the aircraft moves, the airflow rolls up into **powerful rotating vortices**

These **vortices trap and transport pollutants**, making this vortex roll-up phase the dominant stage of the dispersion process



Accurately modelling how these vortices form is key to **predicting how pollutants disperse** in the atmosphere

3

WHAT ARE THE MAIN MODELLING CHALLENGES?



Traditional modelling approaches **cannot accurately reproduce** the vortex roll-up phase

At the same time, **simulating the airflow** around the entire aircraft **with full detail** is **computationally infeasible**



To overcome this challenge, the **vortex sheet method** was adapted to directly model how the **wake rolls up into vortices**

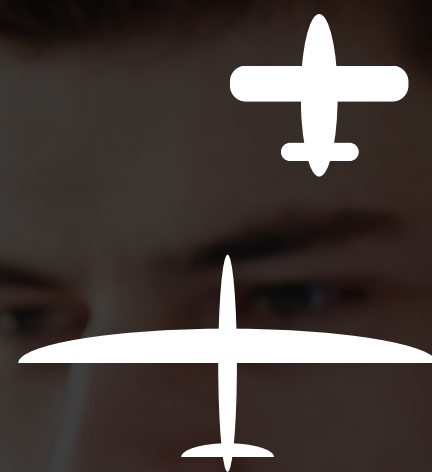
Combined with HPC resources, this approach **accurately captures the key physics** of the roll-up process



WHAT DID THE SIMULATIONS REVEAL?

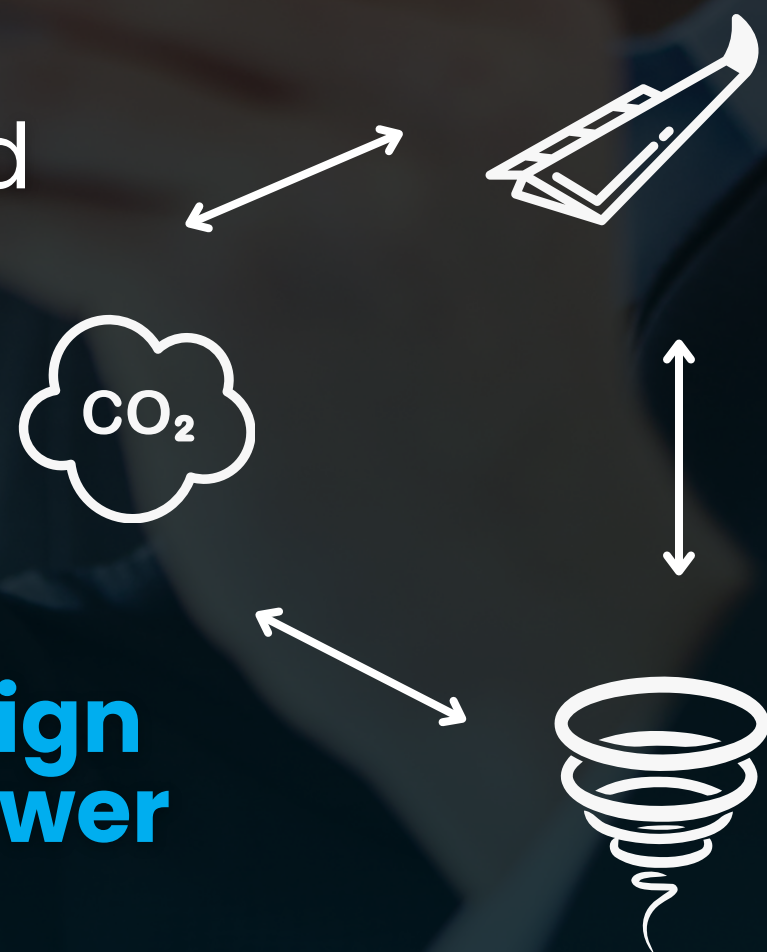
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HPC resources made it possible to simulate pollutant dispersion in **conventional and high aspect ratio wings**

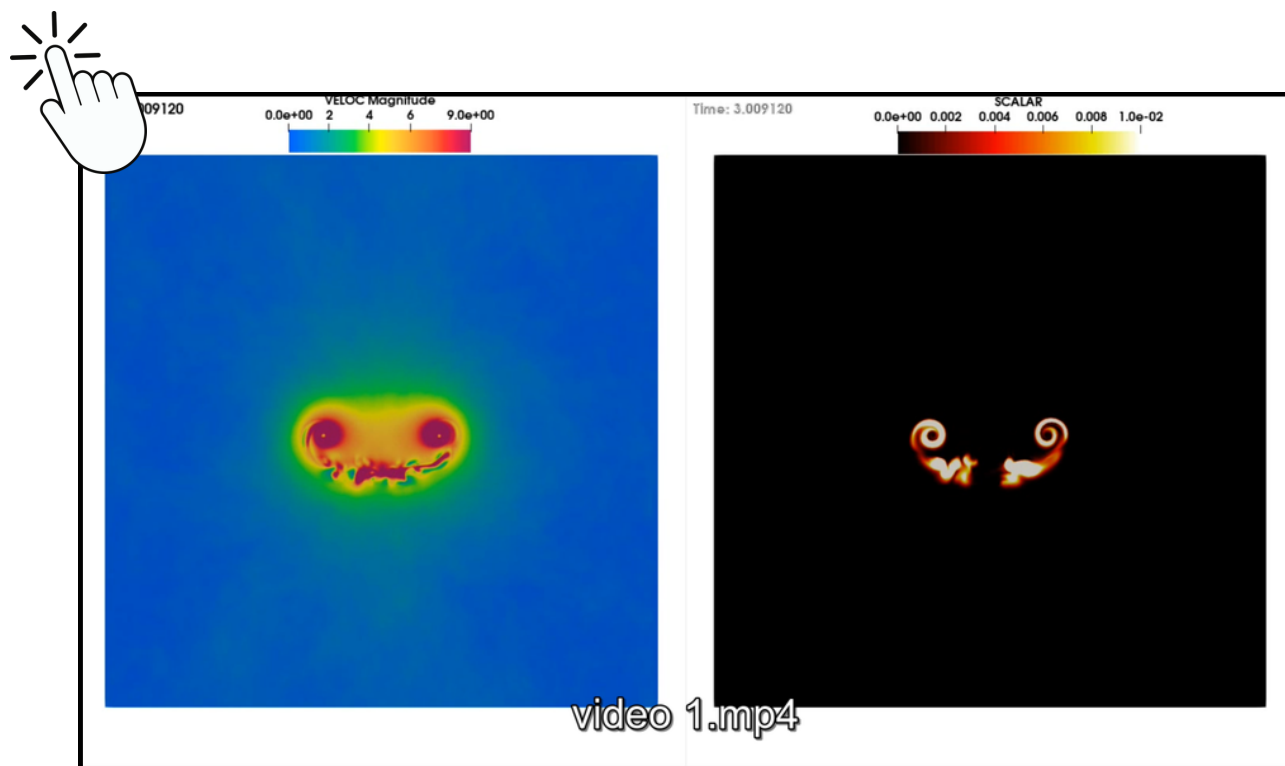


The method accurately **predicted** both the **formation of the vortices and their evolution**

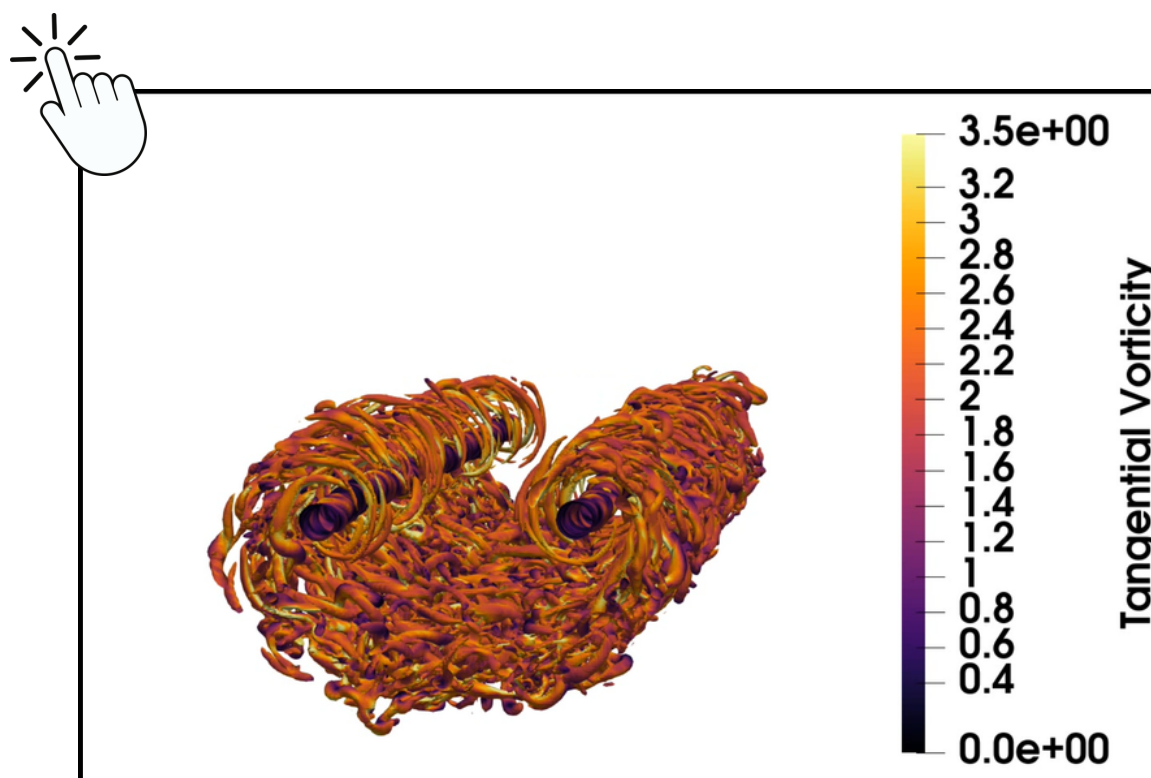
The simulations also revealed a **direct link** between **wing design, vortex behaviour, and pollutant dispersion**



This knowledge can help **design future aircraft** that have a **lower environmental impact**



2D view showing the passive scalar plumes following the vortex during roll-up and descent, illustrating the dominant role of vortex dynamics in scalar diffusion.



Process of a vortex roll, where the vortex sheet is first created by the reaction force of the wing on air, and then rolls up in a pair of counter rotating vortices.