OpenDA applications

Open source software environment for data assimilation

Data assimilation for OpenFOAM®

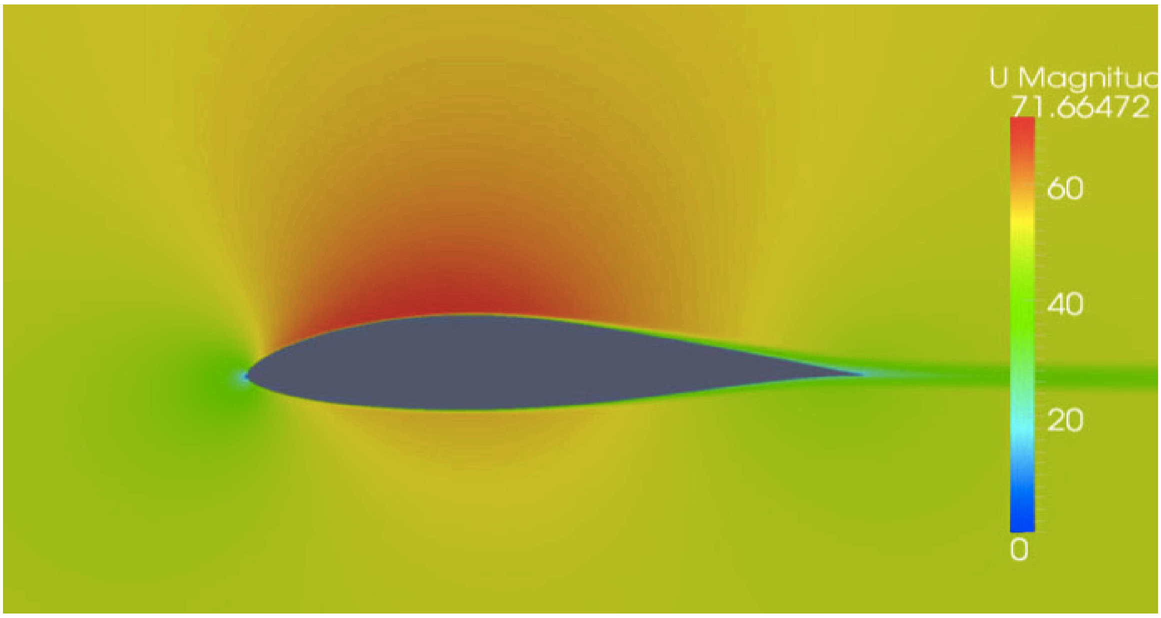

Figure 1: Flow field around an airfoil from a wind turbine, computed with OpenFOAM®. Courtesy of Richard Dwight, aerodynamics group from the Aerospace Engineering Faculty of Delft University of Technology.

OpenFOAM®

OpenFOAM®: OpenFOAM® (www.openfoam.com) is a very popular open source CFD (Computational Fluid Dynamics) package. The fact that OpenFOAM® is free (as opposed to other CFD packages that are usually rather expensive) certainly helps to explain its popularity. But the openness is probably just as important for users. By accessing the source code, they can inspect the methods that have been implemented and extend or improve them according to their needs. This has made it the platform of choice for much of the CFD research that is going on today.

Experiment: Kalman filtering for OpenFOAM®

OpenFOAM® does not yet have a standard facility for data assimilation and calibration. OpenDA might be a good candidate to fill this gap. If an effective combination can be made of OpenDA and OpenFOAM®, it will open up a load of useful functionality for OpenFOAM® users. The OpenDA Association decided to develop a link between OpenFOAM® and OpenDA in close cooperation with the aerodynamics group from the Aerospace Engineering Faculty of Delft University of Technology.

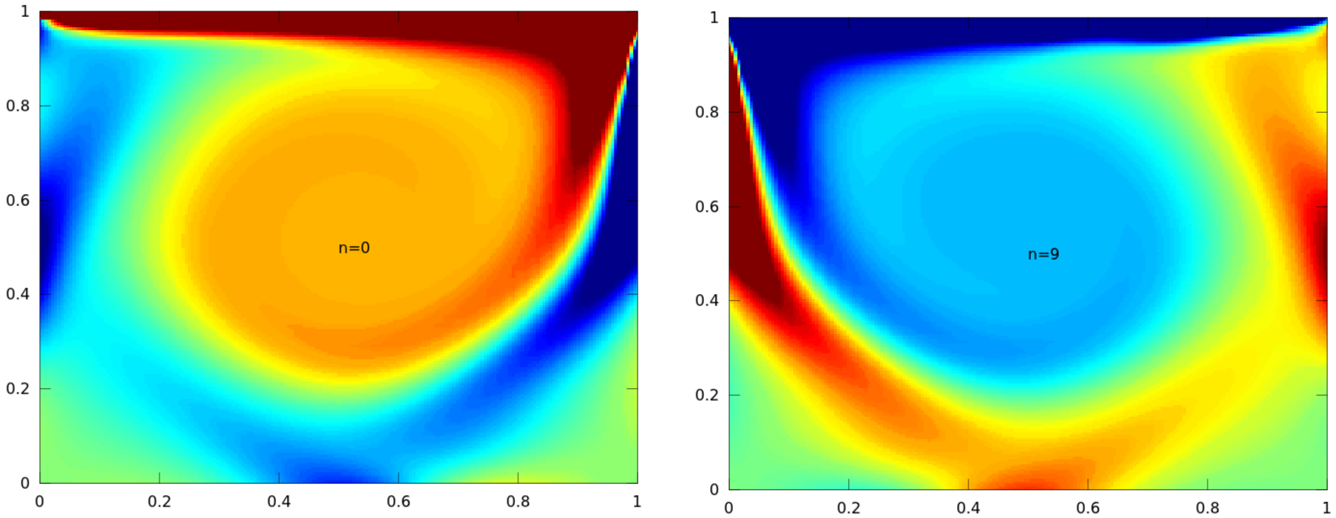

Figure 2: Left: the initial flow field with flow at the lid going to the right. Right: after assimilating observations from a model with leftward flow at the lid the flow in the entire cavity changes its direction.

The connection was done in the simplest way: by using the OpenDA black box wrapper. In this case, OpenDA just reads output files from an OpenFOAM® run and produces modified input files for the next OpenFOAM® timesteps. Although this may seem inefficient, the actual overhead from reading and writing files was only 10% of the total computation time for a significant case.

The OpenDA noise model was extended such that it can now define noise models based on the OpenFOAM® mesh that is used in the computation. Several useful noise models for OpenFOAM® meshes have been implemented. In addition, several performance improvements were introduced in OpenDA to facilitate the handling of really large grids.

Results

Several experiments have been done with the OpenDA/ OpenFOAM® combination. One interesting example is a lid driven cavity, where the OpenFOAM® model initially assumes that the lid induces a flow to the right. Then observations from the same model with the flow at the lid going to the left are fed into the model using OpenDA. Filtering with the OpenDA EnKF filter successfully modifies the flow to be consistent with the observations, flowing left at the lid.

Conclusions

Conclusions: A generic coupling between OpenDA and OpenFOAM® has been implemented, providing a powerful and versatile data assimilation facility for OpenFOAM®.

References

www.openda.org, www.openfoam.com