# Scalability of Fluid Turbulence Simulations (EBL) Enhanced up to 40x by HECToR dCSE Team

*Gary Coleman, University of Southampton*
*David Scott, Edinburgh Parallel Computing Centre (EPCC)*
*HECToR CSE Team, Numerical Algorithms Group Ltd (NAG)*

HPC experts from EPCC, working under NAG's Computational Science and Engineering (CSE) support service for HECToR, the UK's national academic supercomputing facility, have enhanced the EBL turbulence application with improved 2D decomposition to achieve substantial increases in scalability, thus making it possible to do larger simulations in a feasible time than previously.

Commenting on the dCSE success, the Principal Investigator Dr Gary Coleman (University of Southampton) said "*This dCSE project breathed new life into a code that was facing extinction, with regard to its use on current and future HPC resources. As a result of Dr Scott's work, the EBL code is now - and is expected to continue to be for the foreseeable future - able to again perform the numerical experiments on canonical turbulent flows for which it was designed.*"

Describing the new science enabled by this project, Dr Coleman said "*The current focus is upon understanding the interaction of arrays of wind turbines and the atmospheric boundary layer within which they are embedded. This should yield important new insight into how best the turbines should be arranged to optimise their efficiency. EBL will also be applied to more fundamental studies, to address questions such as the degree to which wall-bounded turbulence exhibits universality at Reynolds numbers much higher than previously considered, and how best this type of turbulence can be modelled by engineers and meteorologists.*"

## HECToR

HECToR is managed by EPSRC on behalf of the participating Research Councils with a mission to support capability science and engineering in UK academia. The Cray XT supercomputers, located at the University of Edinburgh, are managed by UoE HPCx Ltd. The CSE Support Service is provided by NAG Ltd and ensures users have access to appropriate HPC expertise to effectively exploit advanced supercomputers for their science. A critical feature of the CSE Support Service is the distributed CSE (dCSE) programme which, through lightweight peer review, delivers dedicated performance and scalability projects on specific codes in response to proposals from users. The dCSE programme now consists of nearly 40 focused projects complementing the traditional HPC user applications support and training also provided by NAG.

The dCSE projects completed so far have delivered outstanding examples of the cost savings and new science that can be enabled through dedicated CSE effort. The EBL project reported here adds to these success stories with a valuable code scalability improvement.

## Project Background

This goal of this dCSE project was to improve the scalability of turbulence applications (principally the EBL code) from hundreds of cores to thousands of cores. This was necessary in order to exploit HECToR properly and to allow advances in the scientific investigations that use these applications. EBL (named after the Ekman Boundary Layer) is used to investigate pressure-driven flow over a flat surface in a rotating domain. The Reynolds number of a flow determines the size of the smallest domain that may be used to study it. This means that when the EBL code is run there is a minimum size of lattice that may be used and that the lattice whilst cuboidal is not a cube. This project demonstrates that, by employing two dimensional decompositions of the problem domain and despite the increased communication overhead, three-dimensional spectral codes can be made to scale from hundreds of cores to thousands of cores.

David Scott of EPCC carried out the 12 person-month project in collaboration with the NAG CSE team and the EBL developers.

## Project Results

The existing EBL code has been re-engineered such that for a problem size that previously would have used a maximum of 365 cores, good scaling can now be achieved for up to 14,000 cores. EBL can now run with much larger problem sizes and with higher Reynolds numbers due to the two-dimensional domain decomposition. The techniques demonstrated in this work are transferable to other 3 dimensional spectral codes, e.g. SWT and SS3F.

EBL is used within the UK Turbulence Consortium which has an allocation of around 400 million AUs (allocation units) at a nominal cost of around £5,000,000 on HECToR.

---

A full technical report can be found at http://www.hector.ac.uk/cse/distributedcse/reports/

For more information contact: HECToR CSE Team
The Numerical Algorithms Group Ltd, Wilkinson House, Jordan Hill Road, Oxford, OX2 8DR, United Kingdom
Telephone: 01865 511 245 Email: hector-cse@nag.co.uk Web: http://www.hector.ac.uk/cse/

*HECToR – A Research Councils UK High End Computing Service*