



# **norcowe**

**Norwegian Centre for Offshore Wind Energy**

## **An Introduction to Large Eddy Simulation and the Parallelized LES Model PALM**

August 22<sup>nd</sup> - 27<sup>th</sup>, 2010

Hardingasete, Norheimsund, NORWAY

<http://www.hardingasete.no/>

Organized by University of Bergen  
for NORCOWE

Please register no later than June 30<sup>th</sup>, 2010 to  
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# An Introduction to Large Eddy Simulation and the Parallelized LES Model PALM

Large eddy simulation (LES) is a numerical technique used to solve the partial differential equations governing turbulent fluid, e.g. for meteorological and oceanic boundary layers. LES models are explicitly resolving the larger eddies in the turbulent flow. The size of the smallest resolvable eddies is only limited by the available computational power and reaching dimensions of one meter and below for various relevant atmospheric applications. The main advantage of LES over the computationally cheaper RANS (Reynolds Averaged Numerical Simulations) approaches is the increased level of detail it can deliver. While RANS methods provide "averaged" results, LES is able to predict instantaneous flow characteristics and resolve turbulent flow structures. In times of increasing computational capacity, LES models therefore will be of increasing importance for the description of turbulence and turbulent exchange processes in the atmosphere and ocean in the future.

## Seminar contents

The seminar starts with a general introduction to large eddy simulation, followed by a discussion of the basic set of equations that are used to realize a LES model, and the numerical methods for their implementation. The course is intended to give a good insight in LES in general and will also address various topics arising from numerical modelling and discretization of equations.

Beside the theoretical lessons on LES in general, given in the morning, there will also be hands-on sessions in the afternoon, where participants carry out exercises under the guidance of the lecturers. For the practical training at the summer school, the parallelized LES model PALM will be used.



PALM is a parallelized large-eddy simulation model, which has been continuously developed at the department of meteorology and climatology, Leibniz Universität Hannover, Germany, since 1997. It is used to study micro- and mesoscale turbulent boundary layer flows in the atmosphere and ocean by different groups of researchers all over the world. Compared with many other LES models, PALM includes a number of advanced features like topography, non-cyclic horizontal boundary conditions, an embedded Lagrangian particle model, or an interface for adding user-defined code. The ocean option of PALM includes salinity and the equation of state for seawater. A coupling between PALM-atmosphere and PALM-ocean has recently been developed. Data output is in NetCDF format. PALM is optimized for high performance on all kind of state-of-the-art processor architectures and scales up to several thousands of processors. It is free to use for research and can be downloaded from the web. Download information and a detailed online documentation are available under [http://www.muk.uni-hannover.de/~raasch/PALM\\_group](http://www.muk.uni-hannover.de/~raasch/PALM_group). PALM is used to study micro- and mesoscale turbulent boundary layer flows in the atmosphere and ocean by different groups of researchers all over the world.

During the practical work, the one-week seminar will give an overview of PALM and its operation. The installation procedure is explained, and it is demonstrated how to carry out runs, either on Linux notebooks provided by the participants or on the Cray-XT4 machine at Bergen Center for Computational Science. The main focus is given on how to set up PALM jobs and how to run them using the ksh-shell scripts that are provided with PALM. Setups for several standard applications will be explained in detail (e.g. convection, flow around buildings, etc.). Further attention is also given to questions like how to extend PALM by user-defined code and how to debug the code. The discussion and interpretation of the results will be an important part of the research school.

The lecturers will be Siegfried Raasch, and other members of the PALM group from the Institute of Meteorology and Climatology, Leibniz Universität Hannover, Germany.

## Requirements

Participants should be familiar with CFD modelling, FORTRAN90, MPI, and Linux/Unix.

## Technical requirements

If participants intend to use their own Linux notebooks for running PALM during the seminar, these notebooks should have at least a dual-core processor. Required software on the notebook are a FORTRAN90 compiler, an MPI library, the NetCDF library (not later than version 3.6.3), graphics software to display NetCDF data (preferably NCL), the Korn-shell (ksh), as well as subversion (a revision control system necessary to download the PALM code). Subversion is already a part of many Linux distributions (e.g. openSuSe).



## Practical Information

The summer school will take place at [Hardingasete](#) which is ideally situated on the Hardanger Fjord 1 ½ hours drive from Bergen.

Departure from Bergen at 17:00 on Sunday August 22nd. Your flight should be scheduled to arrive at Bergen no later than 16:30 on Sunday. Bus transport will be organized from the city centre via Bergen Airport Flesland. Meeting spot in the city centre will be announced later.

The summer school starts with dinner at Hardingasete at 19:30 on Sunday August 22nd.

The seminar ends 16:00 on Friday August 27th. Arrival in Bergen at 18:00. Your flight should be scheduled no earlier than 18:30 from Bergen Airport Flesland.

There will be a daytrip in Hardanger (including a trip on the Hardanger fjord) on Saturday August 28th. Those who want to participate on the trip can stay at Hardingasete until Saturday morning.

## Costs/fee

Participant fee: 2.500 NOK for the summer school

Daytrip: 500 NOK

Accommodation: 8.000 NOK (Sun-Fri)

8.700 NOK (Sun-Sat)

The accommodation costs include all meals and transport between Bergen and Hardingasete.

Sign up by sending an email with name, contact information and position to [ragnhild@cmr.no](mailto:ragnhild@cmr.no) no later than 30<sup>th</sup> June, 2010.

Professional responsible: Joachim Reuder, [Joachim.Reuder@gfi.uib.no](mailto:Joachim.Reuder@gfi.uib.no)



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