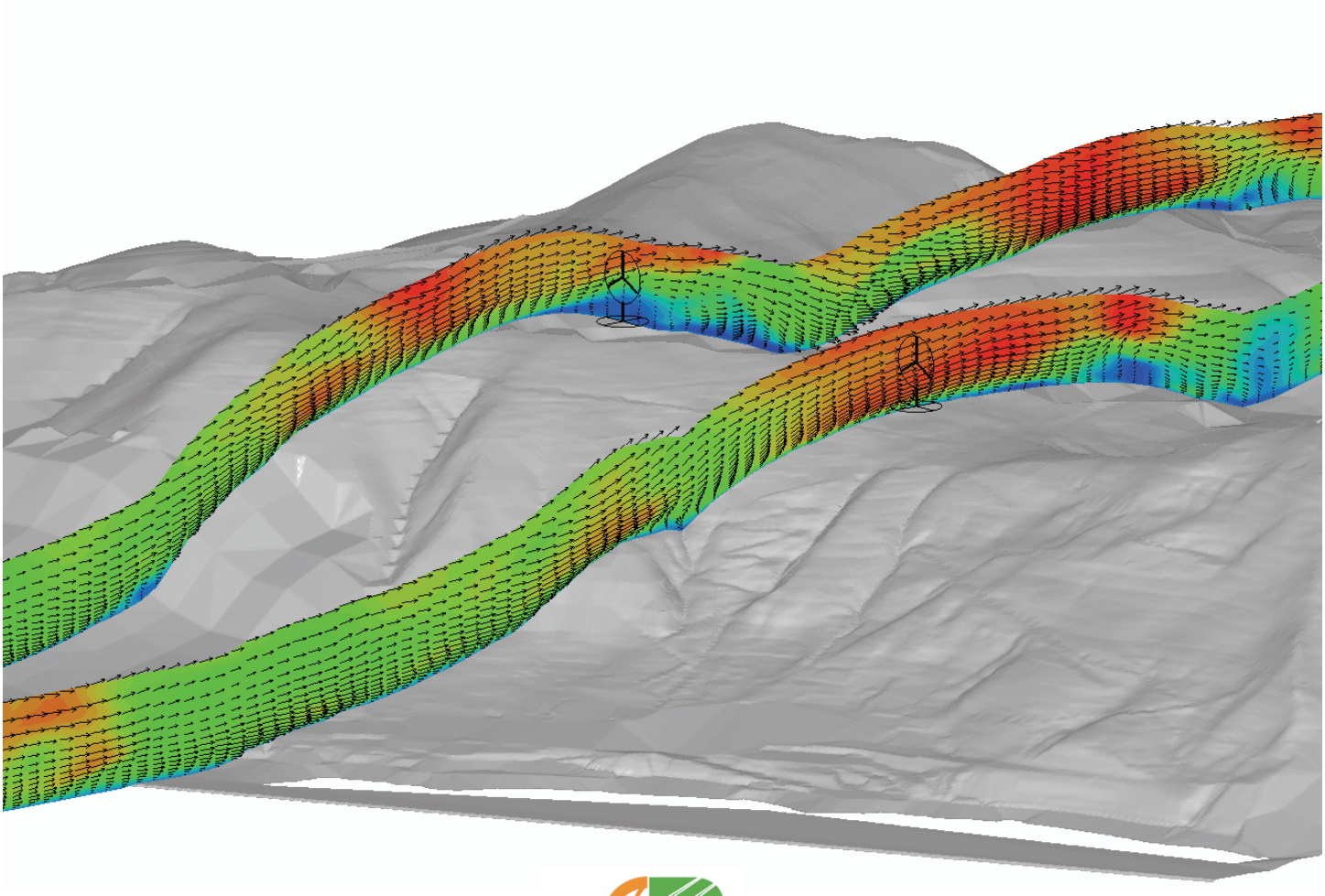
Unsteady Nonlinear Simulation CFD Software
RIAM-COMPACT® Natural Terrain Version
(LES Turbulence Model)

Indispensable Tool for Complex Terrain

Software is compatible with multi-CPU and multi-GPU parallel computing



RIAM-COMPACT

Venture corporation initiated from Kyushu University, Japan

RIAM-COMPACT CO., LTD.

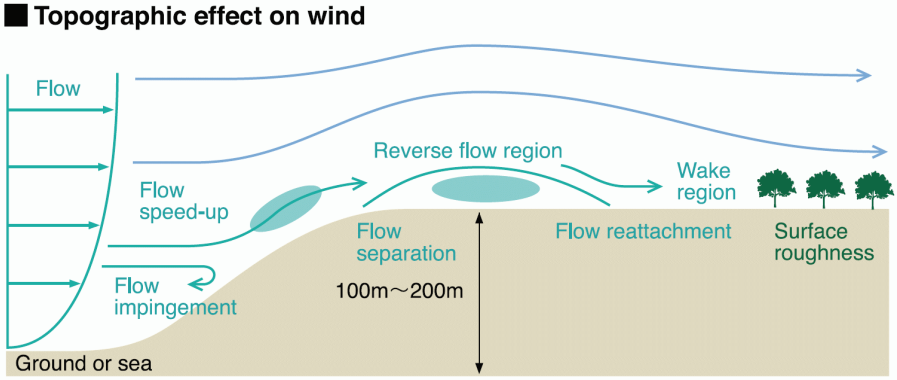
www.twd-wind.com/en/riam.html

Indispensable Tool for Complex Terrain

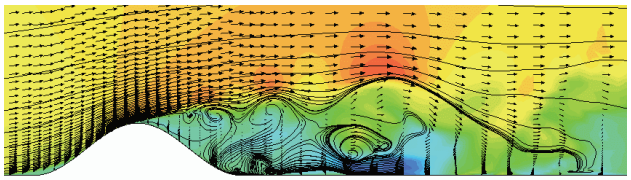
FAST LES CALCULATION
ACCURATE FLOW SIMULATION
FLOW VISUALIZATION for PRECISE TURBINE SITING

RIAM-COMPACT® (Research Institute for Applied Mechanics, Kyushu University, COMputational Prediction of Airflow over Complex Terrain), an unsteady nonlinear simulation CFD software, was developed specifically for accurate flow simulation for complex terrain. The software's calculation code is based on the Large-Eddy Simulation (LES) turbulence model. After years of development, the code has been successfully fine-tuned and optimised. With the use of multi-CPU and multi-GPU parallel computing, fast LES calculation is now achievable.

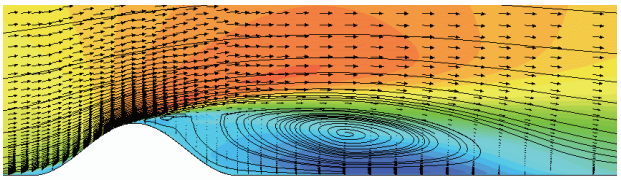
Terrain-induced turbulence over complex terrain is an important issue to consider during turbine layout planning. RIAM-COMPACT® features enhanced flow visualization which enables numerical simulation results to be visualized in the form of graphical animations. Excessive turbulence spots can be quickly identified. High wind speed with low turbulence areas suitable for turbine placement can be accurately determined, making this an indispensable tool not just for turbulence risk assessment but also for maximizing production of your wind farm.



WHAT DOES 「NONLINEAR」 AND 「UNSTEADY」 MEAN ?



(a) Unsteady nonlinear model (LES), RIAM-COMPACT®



(b) Steady nonlinear model (RANS)

Unsteady nonlinear models (LES turbulence model) such as RIAM-COMPACT® simulate the wind flow that we experience every day. The wind disturbances can be understood intuitively. Nonlinear models are applicable for both flat terrain and complex terrain with steep slopes. Steady nonlinear models (RANS turbulence model) simulate the same results but are averaged in time. Details of the transient turbulent structure can only be simulated by LES.

WHY RIAM-COMPACT® ?

High Accuracy

- Calculation solver is based on LES (Large-Eddy Simulation) turbulence model.
- LES is more accurate than RANS (Reynolds-Averaged Navier-Stokes) simulations for solving transient turbulence flow simulation.

Fast Calculation

- With the use of Intel multi-core CPU and NVDIA multi-GPU processors, fast calculation speed can be achieved even without the use of supercomputers.
- The optimised LES Solver is about 10 times faster than other commercial software.

Easy to Use

- Only a few calculation parameters are required from user inputs.
- Users do not need to have in-depth specialized knowledge of CFD.

Flow Visualization

- Simulation results in the form of animation with a wide range of visualization techniques available (velocity vectors, speed contours, color shading, streamlines, pathlines, streaklines, trajectories of tracked particles, timeline, surface path rendering, etc)

Useful Features

- User-friendly mesh generation engine
- Accepts a wide range of elevation data (WAsP map file, ALOS satellite topography data, etc) after conversion
- Time-series data of the three components of the wind velocity can be exported.
- Batch and simultaneous calculation
- Simulation data can be exported to Google Earth
- Production output based on simulation results can be estimated with wake loss model included.
- RIAM-COMPACT® software has been validated against wind tunnel experiments (Bolund island etc)
- The relative error to the real observation data of an annual average wind speed was within 10%.

Multi-Platform

- Operates on various computer systems from single desktop PC to supercomputer.
- Compatible with Intel multi-core CPU processors and NVIDIA multi GPU processors.

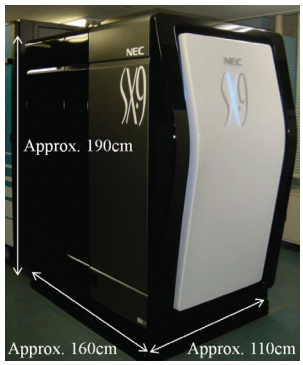
LEADING CFD SOFTWARE IN JAPAN

With over 60 licenses sold mostly in the wind energy sector but also in the non-wind energy sectors. RIAM-COMPACT® is the leading LES based CFD software in Japan for wind energy applications. Below is just a short sample of the customers.

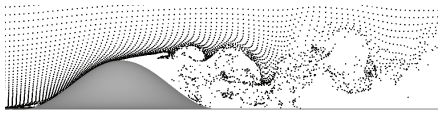
- Eurus Energy Holdings Corporation
- J-POWER / Electric Power Development Co., Ltd.
- Japan Wind Development Co., Ltd.
- Eco Power Co., Ltd. (COSMO OIL Co., Ltd.)
- Mitsubishi Heavy Industries, Ltd.
- Kyushu Electric Power
- West Japan Engineering Consultants, Inc.
- C-TECH CORPORATION
- Tsubasa Windfarm Design
- Beijing Tsinghua University, Beijing, China

FAST LES CALCULATION

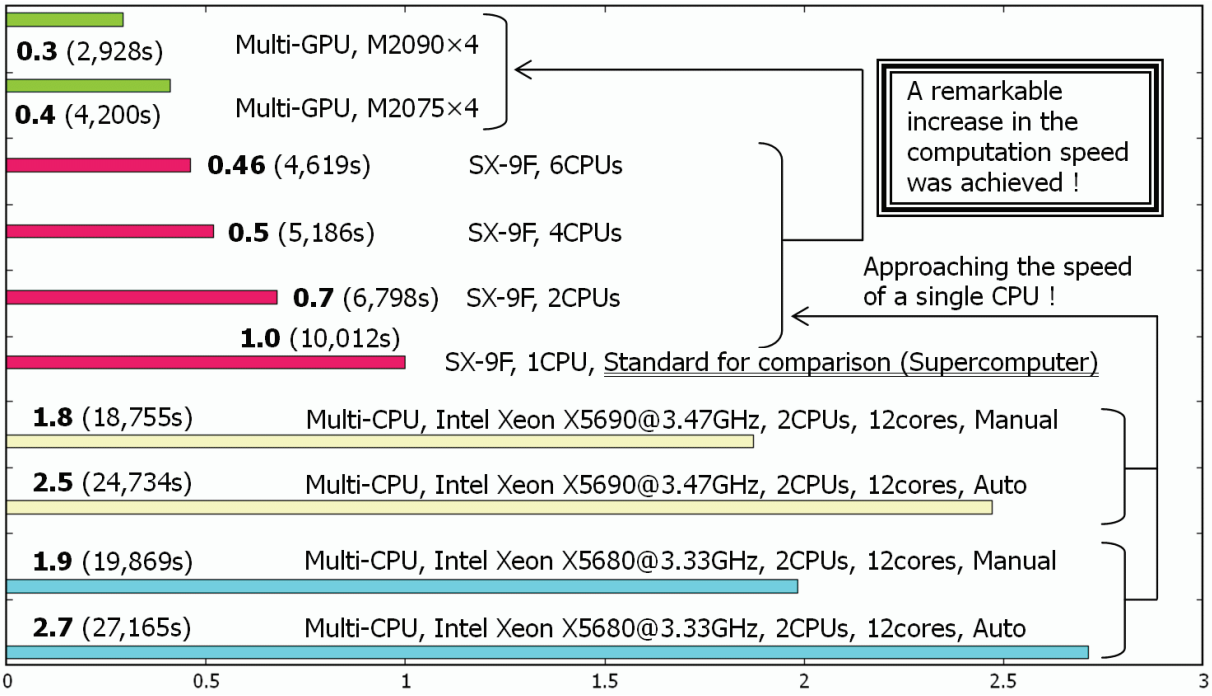
RIAM-COMPACT® has been optimised to solve LES equations in a fast and efficient manner. Comparison of computation speeds for simulations using 50 million grid points under the same condition are given in the table below.



NEC supercomputer



Benchmark testing: 3D simulation of complex turbulence field around an isolated hill



Bold numbers indicate the speed ratio with respect to a single CPU on the SX-9F (NEC supercomputer). Numbers inside parentheses represent the actual computation time. Memory Usage: approximately 15GB

KEY TECHNICAL REFERENCES

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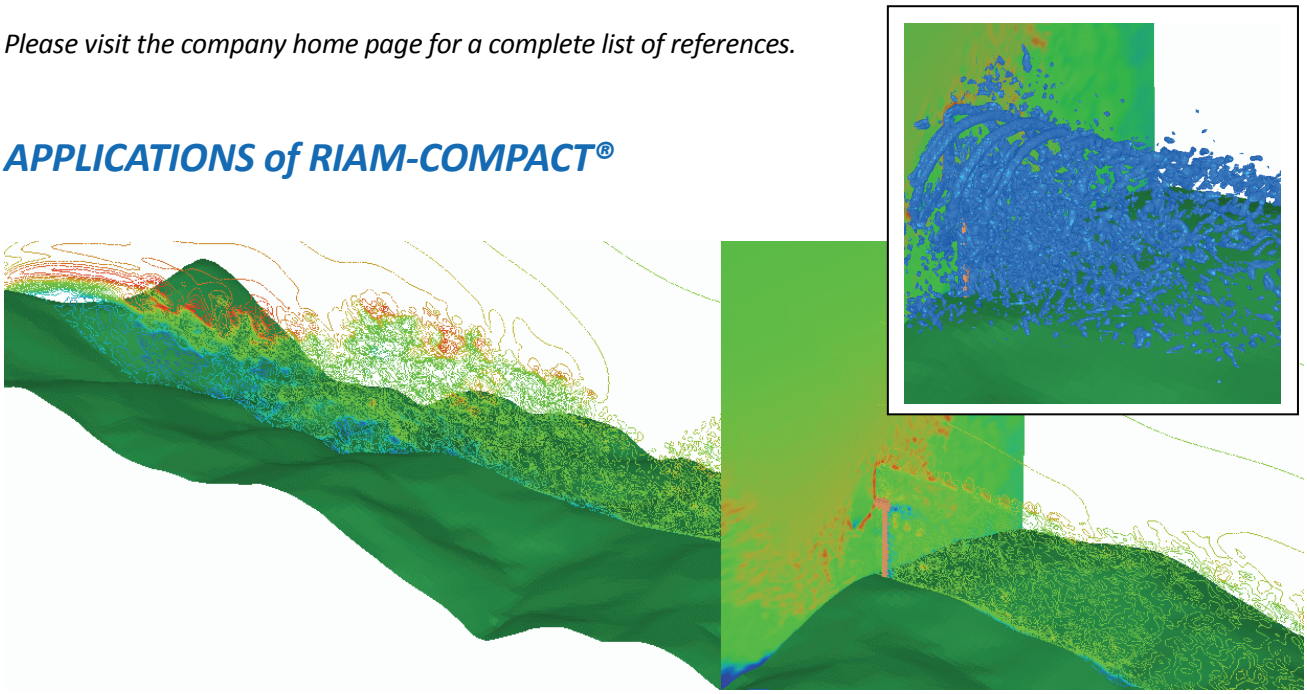
2. T. Uchida, Y. Ohya and K. Sugitani, Comparisons between the wake of a wind turbine generator operated at optimal tip speed ratio and the wake of a stationary disk, Modeling and Simulation in Engineering, Volume 2011
3. T. Uchida, T. Maruyama and Y. Ohya, New Evaluation Technique for WTG Design Wind Speed using a CFD-model-based Unsteady Flow Simulation with Wind Direction Changes, Modelling and Simulation in Engineering, Volume 2011
4. T. Uchida and Y. Ohya, Latest Developments in Numerical Wind Synopsis Prediction Using the RIAM-COMPACT® CFD Model -Design Wind Speed Evaluation and Wind Risk (Terrain-Induced Turbulence) Diagnostics in Japan, Energies, Vol.4, pp.458-474, 2011

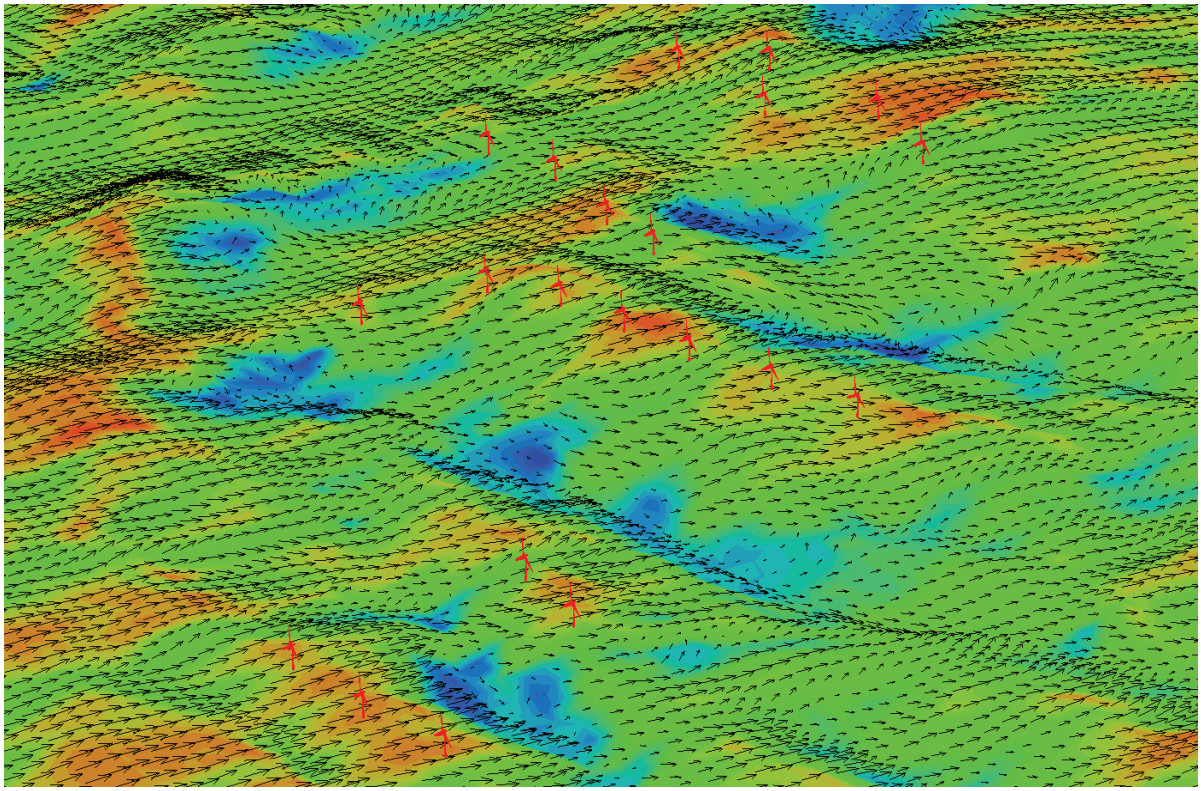
5. T.Uchida and Y.Ohya, Verification of the Prediction Accuracy of Annual Energy Output at Noma Wind Park by the Non-Stationary and Non-Linear Wind Synopsis Simulator, RIAM-COMPACT®, Journal of Fluid Science and Technology, Vol.3, No.3, pp.344-358, 2008
6. T. Uchida and Y. Ohya, Micro-siting Technique for Wind Turbine Generator by Using Large-Eddy Simulation, J. Wind Eng. Ind. Aerodyn., Vol.96, pp.2121-2138, 2008

Please visit the company home page for a complete list of references.

APPLICATIONS of RIAM-COMPACT®

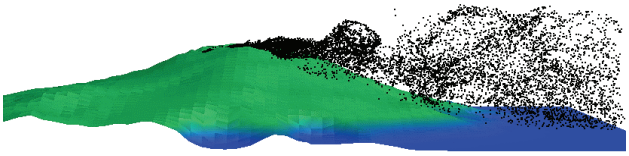


Wake simulation in complex terrain

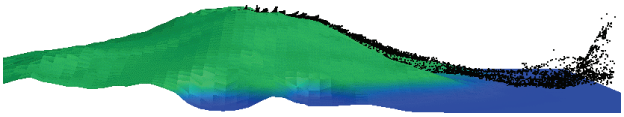


Siting and annual output prediction in complex terrain

APPLICATIONS of RIAM-COMPACT®

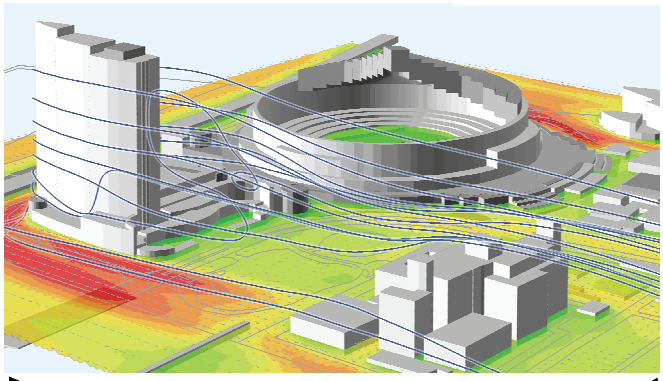


(a) Fr=∞ (non-stratified flow)



(b) Fr=1 (stably-stratified flow)

Prediction of advection and dispersion of volcanic gases (Miyake island)



Prediction of airflow past real urban area

RIAM-COMPACT® is developed by

Dr. Takanori Uchida - Associate Professor (Director of RIAM-COMPACT CO., LTD.)
Research Institute for Applied Mechanics (RIAM), Kyushu University
Fukuoka, Japan

Email : takanori@riam.kyushu-u.ac.jp
URL: www.riam-compact.com/en/index.html

RIAM-COMPACT® is distributed by

Graham Li - Founder and Chief Architect
Tsubasa Windfarm Design, Tokyo, Japan

Tel : 81 80 2379 2899
Email : graham@twd-wind.com
URL : www.twd-wind.com/en/riam.html