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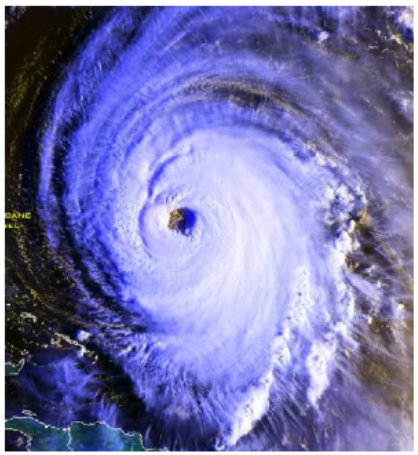


Multiple Scales in Fluid Dynamics and Meteorology
The DFG Priority Programme MetStröm

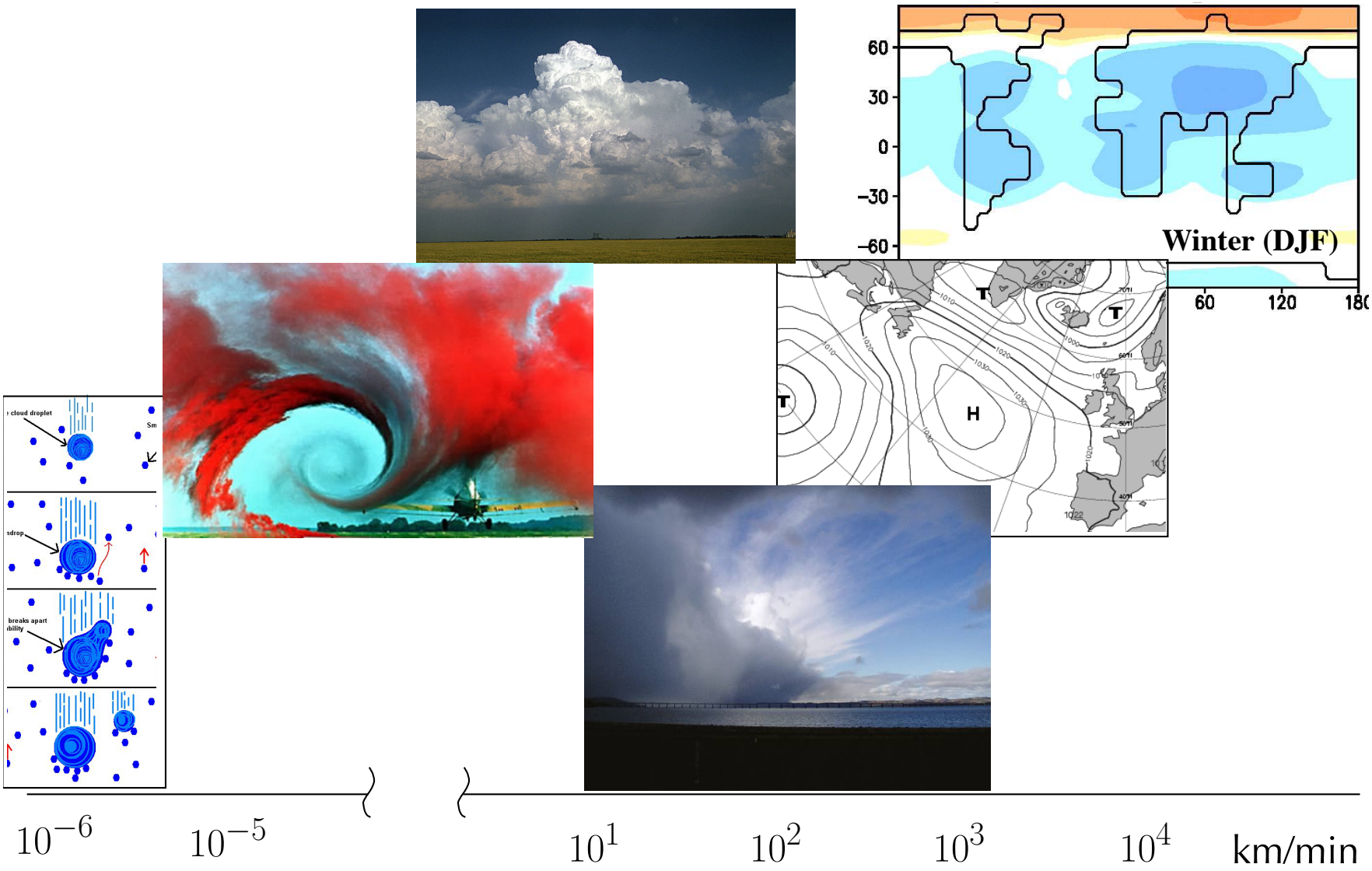
Thomas von Larcher Rupert Klein
Freie Universität Berlin, Germany

1st International Workshop of EULAG Users, Bad Tölz, 2008

Outline

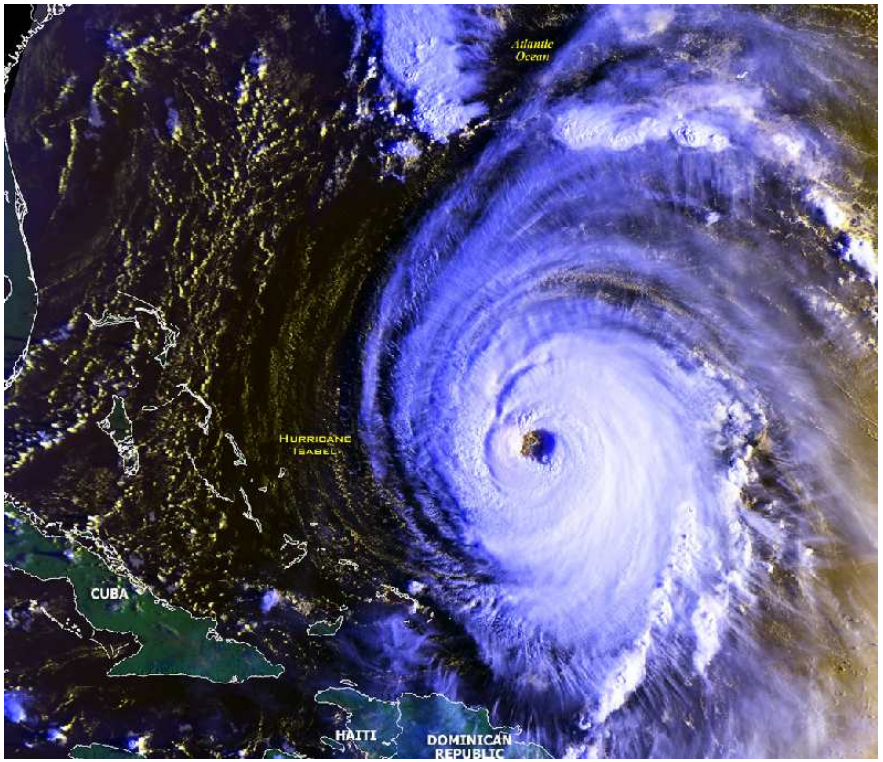
Outline

Scales in Meteorology and Fluid Dynamics



Motivation

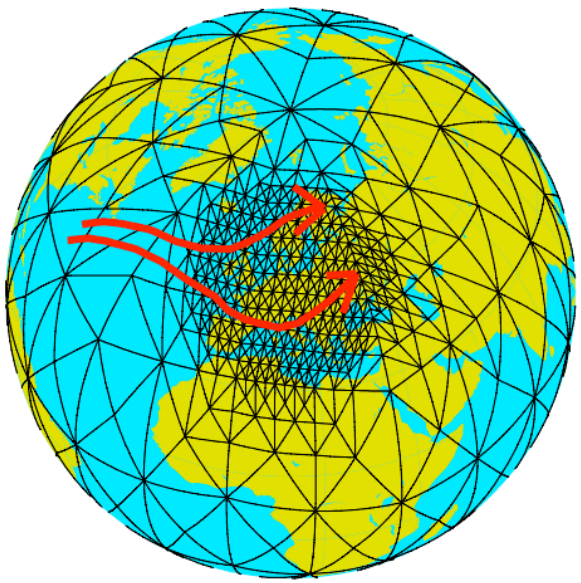
- Specific events in meteorology and fluid dynamics usually associated with processes on multiple spatio-temporal scales
- Representing multiscale interactions in numerical modelling accurately difficult due to limited rescources

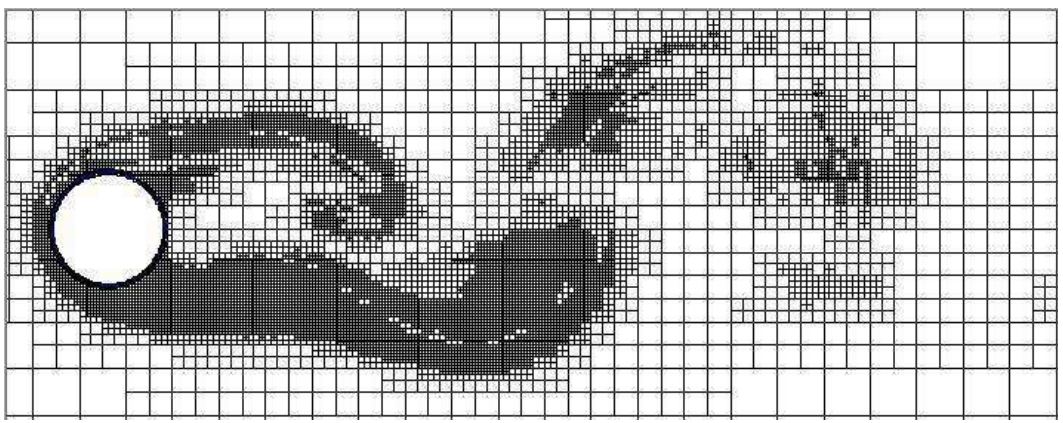


- Left: hurricane Isabell 2003
- Right: wake of multiple cylinders

Motivation

- promising approach: use of variable, dynamically adaptive spatio-temporal grid resolution models





Adaptive Models: Open Issues

Adaptive dynamic kernels for meteorological models and adaptive flow solvers exist today, but

- no systematic formulations of closure models or parameterizations for small scale, non-solved processes applicable on dynamically adaptive grids.
- parameterizations will have to depend on the type of numerical scheme adopted in the dynamic kernel.
  How do flow solvers and subgrid-scale closures interact, and how do numerical and subgrid-scale modelling errors conspire to perturb the accuracy of a simulation.

MetStröm: What it is / What it does

MetStröm ...

- covers Meteorology, Fluid Dynamics, and Applied Mathematics
- develops model- and grid-adaptive numerical simulation concepts in multidisciplinary projects

Goal

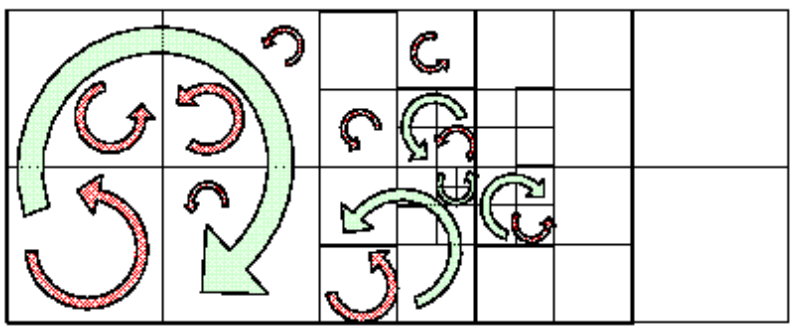
- simulation models which combines scale-dependent (mathematical) descriptions of key physical processes with adaptive flow discretization schemes
- focus on the theory and methodology of multiscale meteorological-fluid mechanics modeling
- reference experiments to support model validation

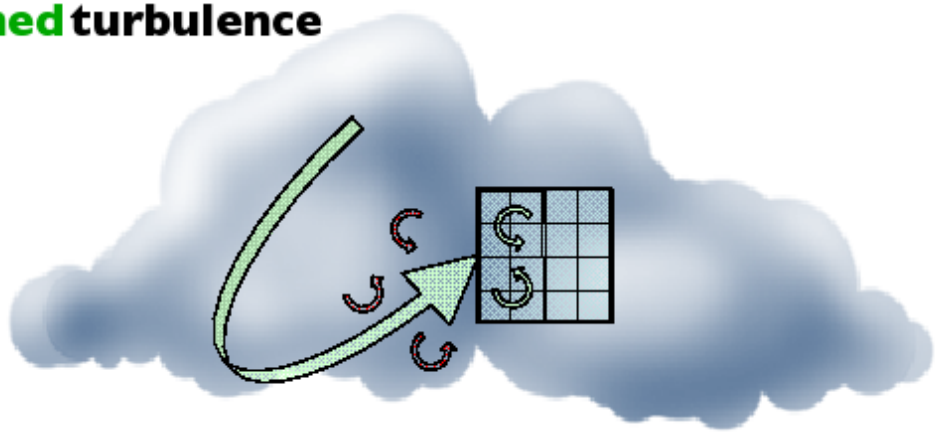
Outline

Turbulence modeling (LES)

interaction of subgrid model and numerical approximation considering discretization of high order

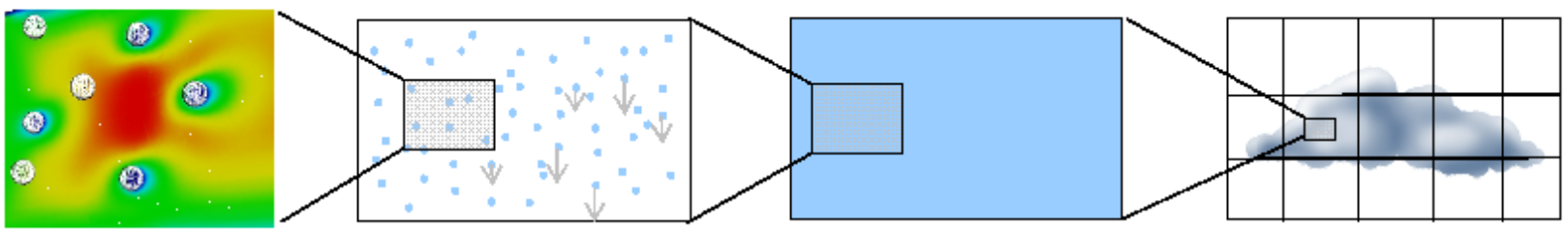
modelled turbulence becomes detached turbulence





Closure approaches

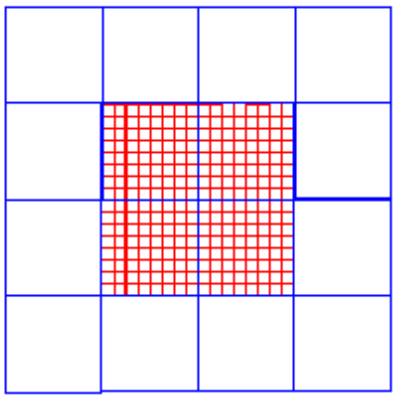
closely related to those used, e.g., in modelling chemical processes, bubble swarms, granular media



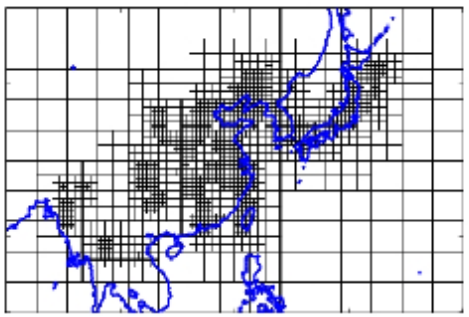
Adaptive modeling

issues and strategies for adaptive models: (sub-)grid improvement

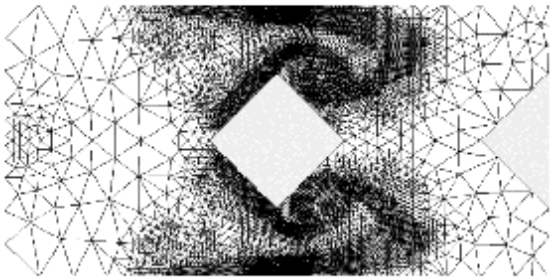
State of the art:
static grid nesting



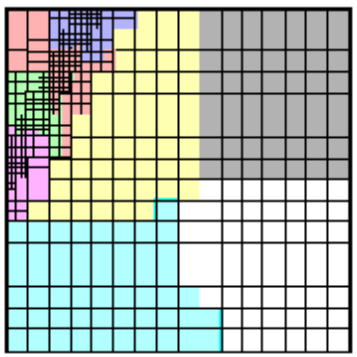
Goal:
dynamic adaptive grids



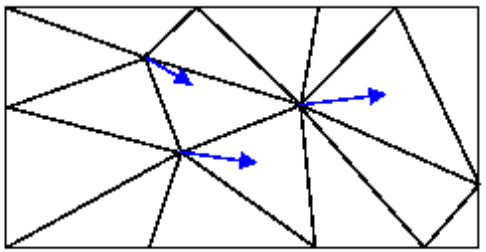
h-method



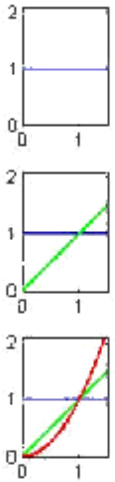
load balancing

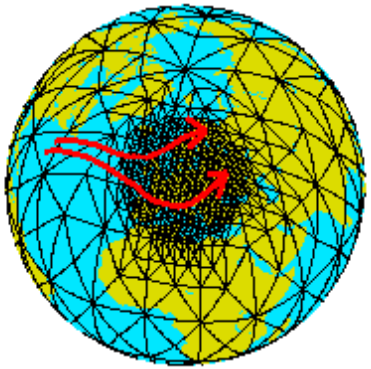


r-method



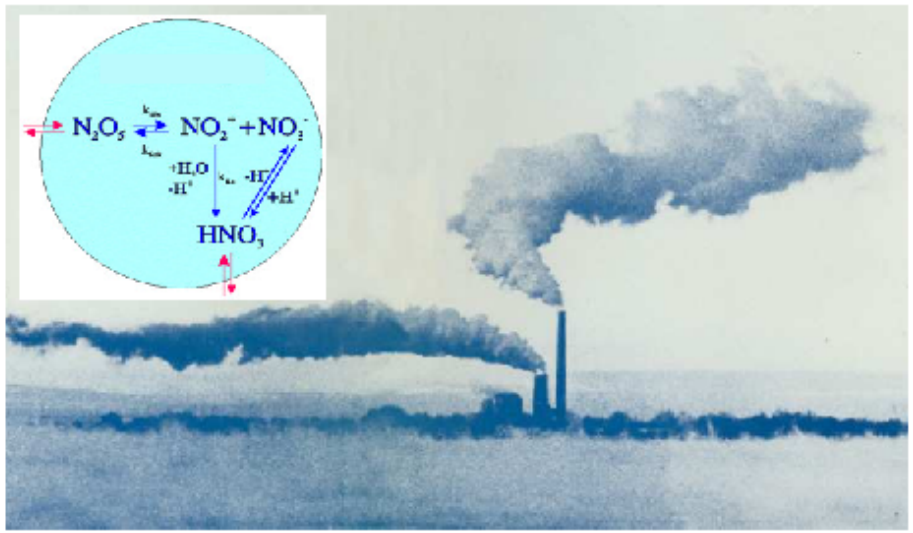
p-method



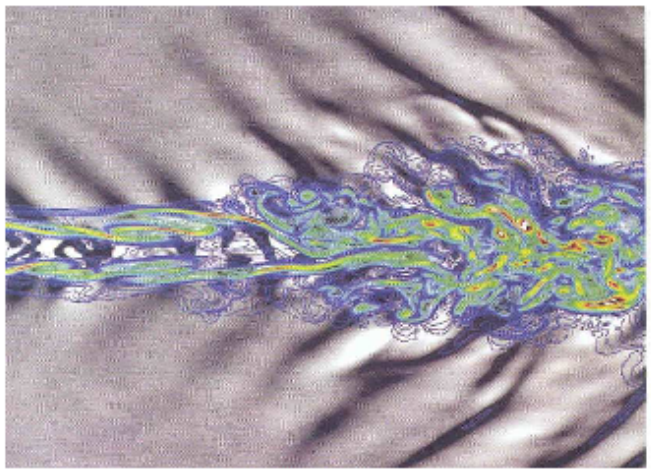


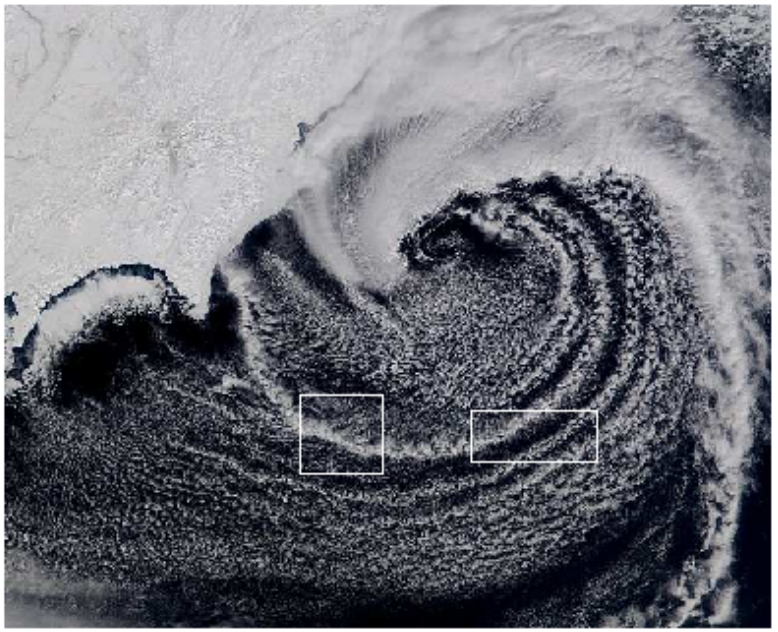
Outline

Topics: chemical transport processes, wave turbulence, atmospheric cyclones



reference experiment:
baroclinic waves
gravity waves





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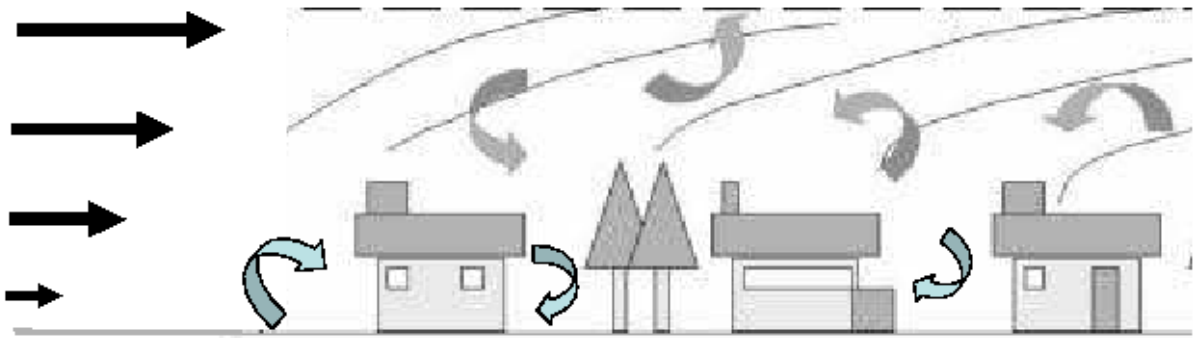
Topic: turbulent flows over complex surfaces

reference experiment:
urban boundary layer
(a) forest area
(b) wind tunnel



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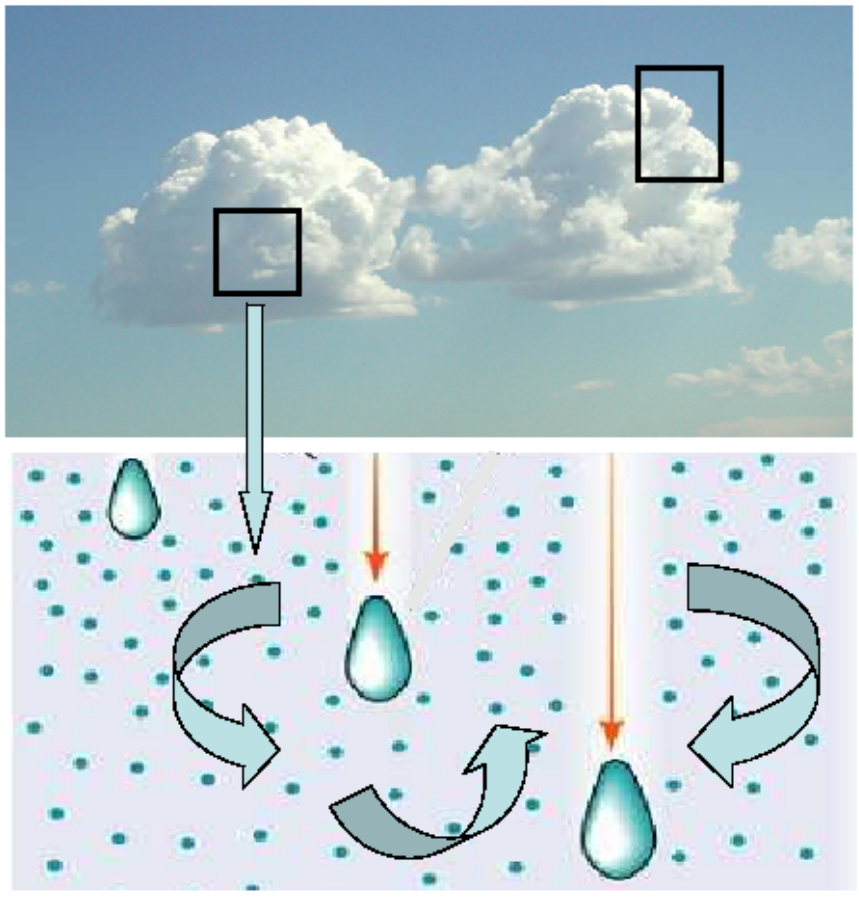
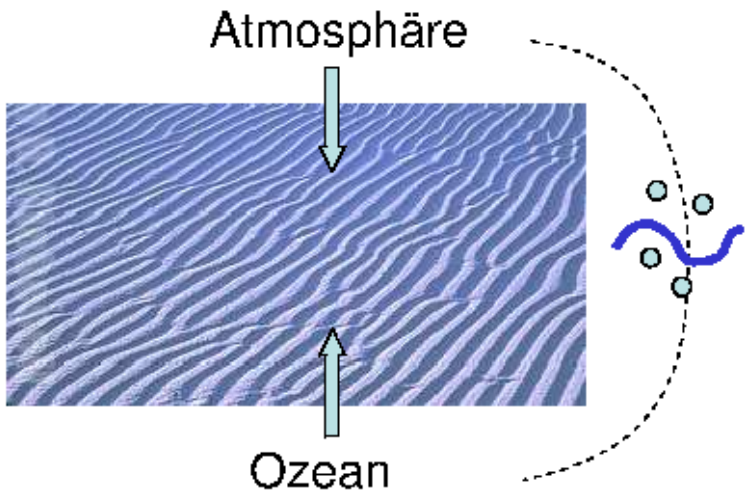
Topic: multi-phase flows



reference experiment: multi-phase wind tunnel (drop dynamics)



Outline

- Dedner, A., Baldauf, M. and Kröner, D.: Parallel adaptive solutions for multiscale-phenomena and transparent boundary conditions in atmospheric flows
- Egbers, C.: Reference experiment to study the dynamics and coexistence of large- and small scale flow patterns: baroclinic waves and gravity waves
- Gaßmann, A., Klein, R., Helzel, C., Knoth, O. and Wensch, J.: Modelling and approximation of moist atmospheric flows considering topographic effects
- Giorgetta, M.A., Korn, P. and Reich, S.: Space-Time Adjustable Regularizations for the Atmospheric Circulation model ICON (STAR)
- Grewe, V., Sausen, R., Reich, S. and Yserentant, H.: Development of a Lagrangian core for climate models
- Heuveline, V. and Jones, S.C.: Goal oriented adaptivity for tropical cyclones

- Bernhofer, C., Goldberg, V., Grundmann, R. Hildebrand, V. and Stiller, J.: Turbulent exchange processes between forested areas and the atmosphere
- Dörnbrack, A., Fröhlich, J. and Lang, J.: Large Eddy Simulation with adaptive moving grids addressed to meteorological issues
- Horenko, I., Schütte, C., Klein, R. and Munz, C-D.: Discrete-continuous hybrid models on the basis of the integrated conservation principles
- Raasch, S.: The turbulence structure in the urban surface layer: LES-reference studies and comparison with measurements in wind tunnels, scalemodels, and with field surveys
- Schatzmann, M. and Leitl, B.: Generation of high-resolution validation data for obstacle resolving LES flow and dispersion models

Multi-phase flows / clouds and convection

- Beheng, K.D., Etling, D., Raasch, S. and Schröder, W.: Experiments on the influence of turbulence in clouds with effects on condensation and precipitation
- Behrens, J., Hiller, W. and Wirth, V.: Interaction of small and large dynamical scales in an adaptive numerical model for atmospheric moist convection
- Braack, M., Maas, U. and Schlünzen, K.H.: Goal functional oriented reduction of atmospheric chemical transport models
- John, V. and Thévenin, J.M.: Reference experiments in the multi-scale wind tunnel, numerical simulation and validation
- Kupka, F. and Losch, M.: Modelling diffusive and double-diffusive convection
- Schmidt, H., Peters, N. and Stevens, B.: Towards modular front tracking for Stratocumulus clouds considering unsteady entrainment processes
- Spichtinger, P. and Lohmann, U.: Impacts of dynamics on cirrus clouds (associated project, funded by the Swiss National Science Foundation)

Outline

Summary and Outlook

MetStröm ...

- to provide model- and grid-adaptive numerical simulation concepts
- 1st period comprises 17 projects + 1 associated project, open to additional projects
- deadline for 2nd period proposals: December 30, 2008
- preparation meeting: November 3-4, 2008, Hannover, Germany
- 2nd period: 2009-2011, *3rd period: 2011-2013 (?)*

Acknowledgements

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