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Multiple Scales in Fluid Dynamics and Meteorology: The DFG Priority Programme 1276 MetStröm

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Geophysical fluid motions are characterized by a very wide range of length and time scales, and by a rich collection of varying physical phenomena. The mathematical description of these motions reflects this multitude of scales and mechanisms in that it involves strong non-linearities and various scale-dependent singular limit regimes. Considerable progress has been made in recent years in the mathematical modelling and numerical simulation of such flows in detailed process studies, numerical weather forecasting, and climate research. One task of outstanding importance in this context has been and will remain for the foreseeable future the *subgrid scale parameterization* of the net effects of non-resolved processes that take place on spacio-temporal scales not resolvable even by the largest most recent supercomputers.

Since the advent of numerical weather forecasting some 60 years ago, one simple but efficient means to achieve improved forecasting skills has been increased spacio-temporal resolution. This seems quite consistent with the concept of convergence of numerical methods in Applied Mathematics and Computational Fluid Dynamics (CFD) at a first glance. Yet, the very notion of *increased resolution* in atmosphere-ocean science is very different from the one used in Applied Mathematics: For the mathematician, increased resolution provides the benefit of getting closer to the ideal of a converged solution of some *given* partial differential equations. On the other hand, the atmosphere-ocean scientist would naturally refine the computational grid *and* adjust his mathematical model, such that it better represents the relevant physical processes that occur at smaller scales.

This conceptual contradiction remains largely irrelevant as long as geophysical flow models operate with fixed computational grids and time steps and with subgrid scale parameterizations being optimized accordingly. The picture changes fundamentally when modern techniques from CFD involving spacio-temporal grid adaptivity get invoked in order to further improve the net efficiency in exploiting the given computational resources. In the setting of geophysical flow simulation one must then employ subgrid scale parameterizations that dynamically adapt to the changing grid sizes and time steps, implement ways to judiciously control and steer the newly available flexibility of resolution, and invent novel ways of quantifying the remaining errors.

The DFG priority program MetStröm covers the expertise of Meteorology, Fluid Dynamics, and Applied Mathematics to develop model- as well as grid-adaptive numerical simulation concepts in multidisciplinary projects. The goal of this priority programme is to provide simulation models which combine scale-dependent (mathematical) descriptions of key physical processes with adaptive flow discretization schemes. Deterministic continuous approaches and discrete and/or stochastic closures and their possible interplay are taken into consideration. Research focuses on the theory and methodology of multiscale meteorological-fluid mechanics modelling. Accompanying reference experiments support model validation.