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Multiple Scales and Structure Preservation for Conservation Laws in Geophysical Applications

Transport oriented processes in atmosphere and ocean can often be described by mathematical conservation equations of mixed hyperbolic and parabolic type. Very subtle balances from equilibrium states play an important role as main driving forces in these geophysical applications. In order to simulate atmosphere or ocean circulation, tracer transport or wave dispersion, these balances and corresponding conservation principles need to be preserved in numerical discretization schemes.

As an additional difficulty, most of the important processes in the atmosphere or oceans interact in a multitude of scales. Representing the smallest influential spatial or time scales in a global domain poses severe demands on computational resources as well as mathematical tools for accurate representation.

In this presentation, we will introduce a few examples of such multi-scale conservation laws, derived from applications such as volcano ash transport or tsunami wave dispersion. We will list requirements to discretization schemes for accurate representation of the underlying conservation principles, and give alternative structure-preserving discretizations, solving the above mentioned problems. With such carefully designed mathematical methods implemented in modern algorithms scientific computing - as a sub-branch of mathematical sciences - can help prepare for and mitigate natural disaster.