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Introduction to semi-implicit integrations of non-hydrostatic PDEs of atmospheric dynamics

Monday, 9 March 2020 13:30 (1 hour)

The aim of this set of lectures is to systematically build theoretical foundations for Numerical Weather Prediction at nonhydrostatic resolutions. In the first part of the lecture, we will discuss a suite of all-scale nonhydrostatic PDEs, including the anelastic, the pseudo-incompressible and the fully compressible Euler equations of atmospheric dynamics. First, we will introduce the three sets of nonhydrostatic governing equations written in a physically intuitive Cartesian vector form, in abstraction from the model geometry and the coordinate frame adopted. Then, we will combine the three sets into a single set recast in a form of the conservation laws consistent with the problem geometry and the unified solution procedure. In the second part of the lecture, we will build and document the common numerical algorithm for integrating the generalised set of the governing PDEs put forward in the first part of the lecture. Then, we will compare soundproof and compressible solutions and demonstrate the efficacy of this unified numerical framework for two idealised flow problems relevant to weather and climate.

By the end of the lectures you should be able to:

• explain the form, properties and role of alternative systems of nonhydrostatic PDEs for all scale atmospheric dynamics;

• explain the importance and key aspects of continuous mappings employed in all-scale atmospheric models;

• explain the difference between the explicit and semi-implicit algorithms for integrating nonhydrostatic PDEs, the importance of consistent numerical approximations, and the fundamental role of transport and elliptic solvers

Presenter: Dr SMOLARKIEWICZ, Piotr (National Center for Atmospheric Research)