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Forecasting the weather
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A global non-hydrostatic model mimicking energy conversions on all scales (ICONAM-hex)

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When studying the atmospheric circulation with the help of a global non-hydrostatic model, one has to mimick energy conversions as given by the underlying physical laws. This is especially important when considering gravity wave dynamics and turbulence, where energy is converted between potential, kinetic, and internal energy. The frictional heating, where kinetic energy is converted into unavailable potential energy, is often omitted in state-of-the-art atmospheric models, partly because the heating is unimportant for NWP applications, but also partly because the diffusion of momentum is often considered as a numerical nuisance and artefact with little physically based reasoning. Regarding the Lorenz energy cycle as an important aspect of the Earth's climate, or the wave braking processes in the upper atmosphere, the heating can not be omitted, and thus the momentum diffusion should not be considered as numerical remedy to avoid nonlinear instabilities, but rather as a Smagorinsky type nonlinear turbulent diffusion.

The prerequisite for such a philosophy is that the full numerics of a model has to be energetically consistent, and the smallest resolvable (2 delta x) waves have still to be visible to the numerics, hence not become stationary. In the framework of a gridpoint model, the C-grid staggering is thus a must. We present here a global model on Voronoi meshes, which comprises hexagonal and pentagonal grid boxes. All energy conversions are mimicked correctly by employing the method of discretising Poisson brackets for the reversible dry dynamics, and the numerical equivalent of the product rule differentiation for the relationship between momentum diffusion and frictional heating. The momentum equation comes in vector-invariant form. Terrain-following coordinates can easily be incorporated.

The talk will cover the discretisation method and examples of model runs, where the difference between the conventional approach without dissipative heating and the new philosophy will become visible. Standard testcases for global as well as for nonhydrostatic scales will be presented, which will reveal the strength of the new model as a tool for studying atmospheric dynamics.