The `GAME` Model

Scientific overview

Max H. Balsmeier
mhbalsmeier@gmail.com

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1 Spatial discretization

The `Geophysical Fluids Modeling Framework (GAME)` is a non-hydrostatic hexagonal C-grid dynamical core, comparable to `MPAS` [5] and `ICON-IAP` [1]. The spatial discretization is based on Poisson-brackets, which is a tool out of Hamiltonian mechanics [2]. This leads to excellent self-consistency properties of the model in terms of mass, energy and entropy. The only remaining approximation of the dynamical core is the spherical geopotential approximation [6]. The self-consistency is exactly fulfilled even in terrain-following coordinates.

2 Temporal discretization

`GAME` uses a *HEVI-scheme (horizontally explicit, vertically implicit)*, allowing for a time step that is limited by horizontally (instead of vertically) propagating sound waves. The basic structure of the time stepping is oriented at an RK2-scheme (Runge-Kutta 2nd order), allowing for fast and reasonably accurate integrations. The scheme is modified to become a forward-backward procedure [3], increasing stability. In contrast to other models like the `ICON` model [7], no empiricial constants are needed in the temporal integration.

3 Radiation

Radiation is the fundamental energy source of the Earth system. `GAME` is coupled to the `RTE+RRTMGP` radiation scheme [4], which is a state-of-the-art radiation code for planet atmospheres.

4 Moisture

Moisture and latent heat release are crucial parts of weather and climate analysis. `GAME` simulates an atmosphere with six constituents: dry air, water vapour, snow, rain, cloud ice and cloud water. All these components interact with the radiation.

5 Surface

Simulating the evolution of the soil temperature is an important part of an atmospheric model, because large parts of the radiation-atmosphere interaction incorporate the reflection or absorption at the surface. `GAME` solves the heat conduction equation in a configurable number of soil layers. Surface quantities like albedo, emissivity, roughness length and volumetric heat capacity are interpolated from real datasets to the model grid.

6 Links

- `https://bestweathermodel.com/efs/game/`
- A deep scientific description can be found in this[1] German textbook on theoretical meteorology.

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[1] https://raw.githubusercontent.com/MHBalsmeier/kompendium/master/kompendium.pdf

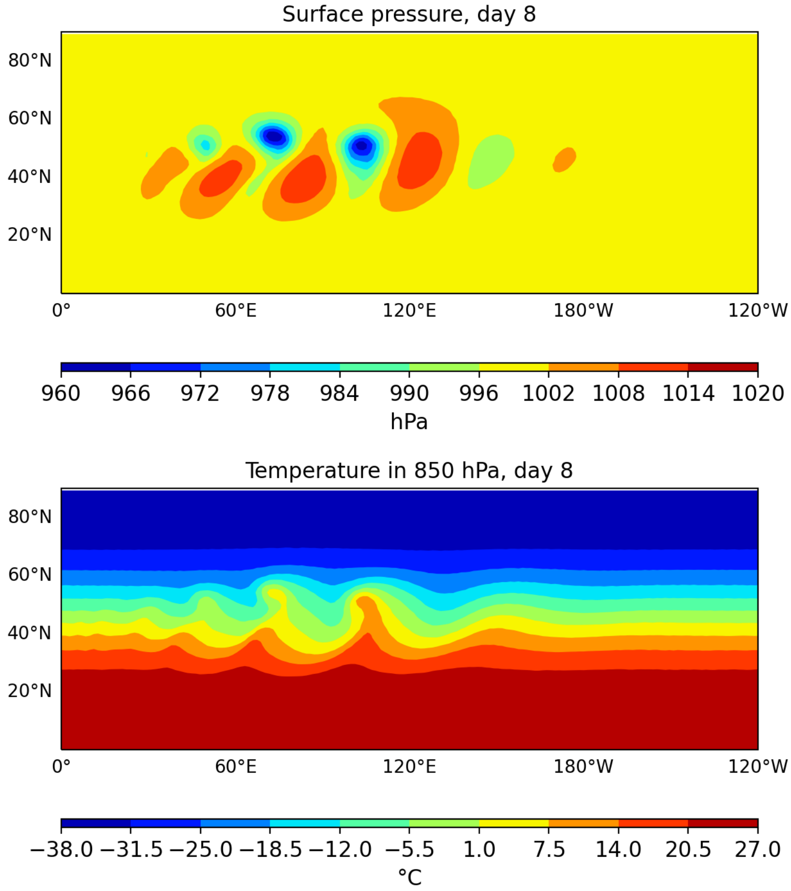

Figure 1: Surface pressure and 850 hPa temperature on day eight of an evolution of a baroclinic wave in a dry atmosphere without any diffusion, approx. resolution 112 km.

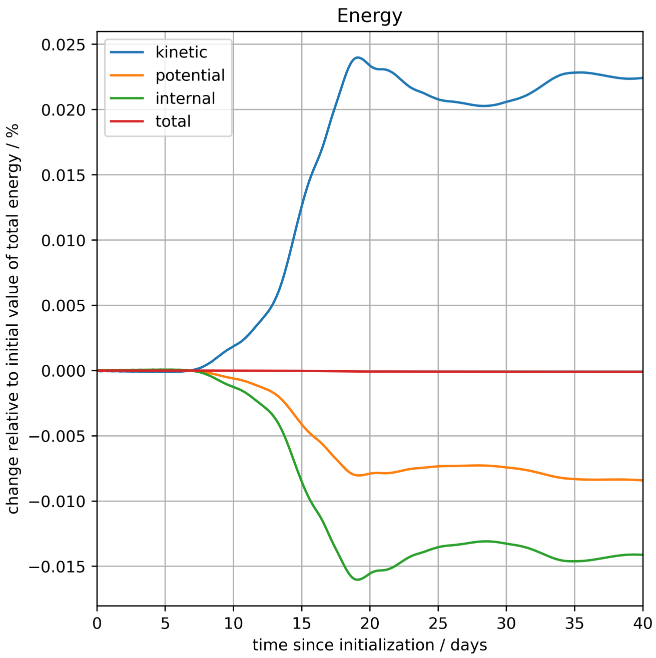

Figure 2: Global energy integrals during the development of a baroclinic wave in a run with horizontal momentum diffusion at 224 km horizontal resolution. The relative total energy error after 40 days is $-1 \cdot 10^{-6}$, which reflects the self-consistent dissipative heating rate.

References

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