Limited-area Geophysical Fluids Modeling Framework (L-GAME) Handbook

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Contents

Chapter 1

Overview

L-GAME is the application of the theory and numerics of GAME to a quadrilateral latitude-longitude grid in a regional domain. The spatial and temporal discretizations are identical, apart from the following differences:

1. The domain is regional and not global (as mentioned).
2. The grid is a quadrilateral (rotated) latitude-longitude grid.
3. The connections of the gridpoints in longitude direction are small circles instead of great circles.

This is only the handbook (manual) of L-GAME, it explains how to configure, compile and run (use) the model. For a scientific derivation of the model see [3] and the literature cited therein. The source code of the project is maintained on Github (https://github.com/OpenNWP/L-GAME).

Chapter 2

Code structure

The code of the model resides in the directory `src`.

2.1 Spatial operators

- Coriolis: [1] and [9] modified by [7]
- kinetic energy: [6]

2.2 Time stepping

A fully Eulerian time stepping is employed. The basic building structure is a two-time-level predictor-corrector scheme. In the vertical, at every substep, an implicit column solver is used, which makes it possible to violate the CFL criterion of vertically propagating sound and fast gravity waves. This has the cost of decreasing the accuracy of these modes, which is however a bearable trade-off, since these waves are of low meteorological relevance. Furthermore, a forward-backward scheme is used, where the divergence term is backward.

Chapter 3

Installation

3.1 Dependencies

The following dependencies must be installed before being able to successfully build the model:

- `sudo apt-get install gcc gfortran make cmake wget python3 python3-pip libnetcdf-dev libnetcdff-dev`
- Clone our fork of the RTE+RRTMGP repository: `git clone https://github.com/OpenNWP/rte-rrtmgp`

3.2 Building

`CMake` is used for building `L-GAME`. Execute `./compile.sh` to build the model.

Chapter 4

Running the model

4.1 Configuring the model domain

4.1.1 Vertical grid structure

The vertical grid structure is the same as in GAME, which is explained in [12].

4.2 Dynamics configuration

4.3 Physics configuration

4.4 Coupling to the radiation field

L-GAME employs the so-called RTE+RRTMGP (Radiative Transfer for Energetics + Rapid and Accurate Radiative Transfer Model for Geophysical Circulation Model Applications-Parallel) [8], [10] scheme.

4.5 Configuring Output

Chapter 5

Initialization

Chapter 6

Boundary conditions

Chapter 7

Physical surface properties

The properties of the surface of the Earth influence the evolution of the atmospheric fields. Therefore, physical surface properties need to be obtained from external sources and interpolated to the model grid. The following fields are required:

- The land distribution. source: `https://ral.ucar.edu/sites/default/files/public/product-tool/noah-multiparameteriz` `usgs/sfc-fields-usgs-veg30susgs.gz` [11]
- The orography. source: `https://www.ngdc.noaa.gov/mgg/global/relief/ETOPO1/data/ice_surface/grid_registered/netcdf/ETOPO1_Ice_g_gmt4.grd.gz` [4], [2]
- The lake fraction (share of a grid cell covered by lakes). source: `http://www.flake.igb-berlin.de/data/gldbv2.tar.gz` [5]
- The density of the soil.
- The specific heat capacity of the soil.
- The temperature diffusivity of the soil.
- For NWP runs without coupling to an ocean model, the SST needs to be prescribed in order to calculate sensible and latent heating rates at the ocean surface. source: `https://nomads.ncep.noaa.gov/pub/data/nccf/com/nsst/prod/` (The SST is set analytically for idealized simulations.)

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