New Climate Models:
The ICON modeling system

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Introduction

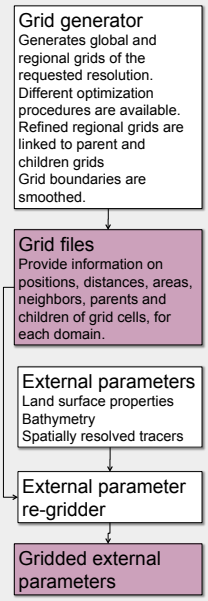
The ICON modeling system is developed jointly by the Max Planck Institute for Meteorology (MPI-M) and the German Weather Service / Deutscher Wetterdienst (DWD) to obtain a new model system with the following capabilities:

- **Unified model for climate research and operational numerical weather prediction**
- **Common infrastructure** for **atmosphere and ocean** models
- Consistent and conservative air and tracer transport
- **Parameterization packages** for scales from ~100 km for long term coupled climate simulations to ~1 km for cloud (atm.) or eddy (ocean) resolving regional simulations.
- **Quasi uniform grid resolution with optional regional refinement.** Currently 1-way or 2-way nesting can be used for atm. simulations.
- High scalability to run on largest German and European HPC machines
- **Portability**

Models

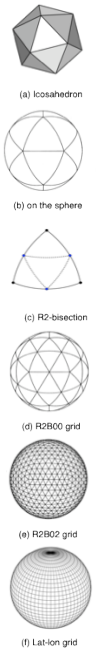
- **Hydrostatic atmosphere** → **Poster W26B and W27A**
- **Non-hydrostatic atmosphere** → **Poster W27B**
- **Hydrostatic ocean** → **Poster W49B and W25A**
- **Shallow water equations**
- **Coupled atmosphere + ocean**

Grids + gridded external parameters

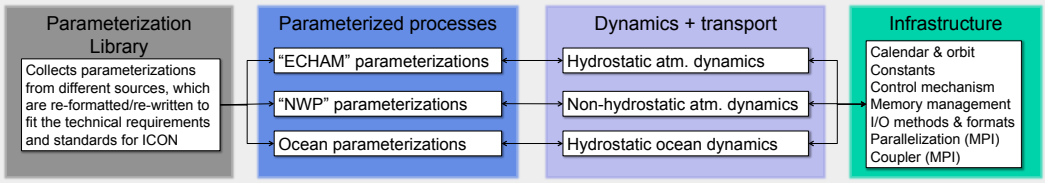


Grid generator

- The original icosahedron **(a)** is projected onto a sphere.
- This spherical icosahedron **(b)** consists of 20 equilateral spherical triangles.
- The edges of each triangle are bisected into equal halves or more generally into n equal sections. Connecting the new edge points by great circle arcs yields 4 or more generally n^2 spherical triangles within the original triangle **(c)**.
- ICON grids are constructed by an initial root division into n sections (Rn) followed by k bisection steps (Bk), resulting in a RnBk grid. **(d)** and **(e)** show R2B0 and R2B2 grids.
- Such grids avoid polar singularities of latitude-longitude grids **(f)** and allow a high uniformity in resolution over the whole sphere.
- Grid properties can be optimized following Heikes and Randall (1995) or Tomita et al (2002).

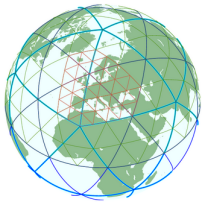


Model structure



Grid refinement

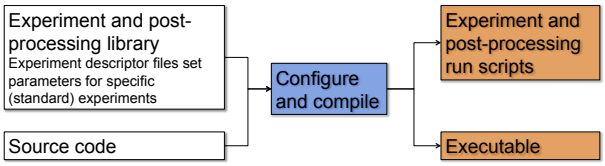
- **Light blue**
The spherical icosahedron (R1B0).
- **Dark blue**
1st bisection (R2B0) on the whole globe.
- 2nd bisection (R2B1) on the Northern hemisphere.
- 3rd bisection (R2B2) in a region over Europe.



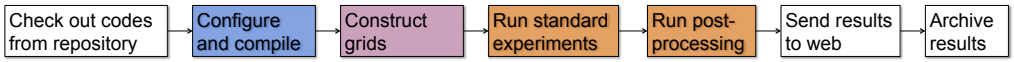
Portability

ICON models run on different cache based (IBM Power6) and vector (NEC-SX9) high performance computers as well as on Linux / Unix / MacOS systems.

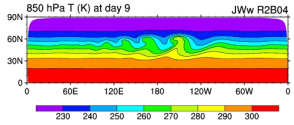
The configuration environment makes the executable and the run scripts for specific architecture, compilers and parallelization methods.



Quality assurance

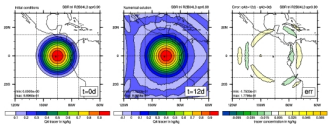


A test suite runs every night on several systems at MPI-M and DWD using different compilers (IBM, NEC, GCC, NAG, Intel, PGI, Sun) and parallelization set-ups seq., MPI, OpenMP, MPI&OpenMP). Each test consists of a set of standardized experiments (e.g.



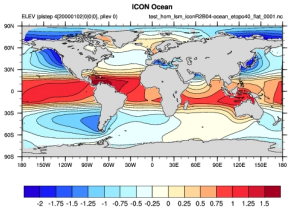
Jablonowski-Williamson baroclinic wave test, Temperature at 850 hPa after 9 days at resolution R2B4 (~140 km) in the hydrostatic atmosphere.

Jablonowski and Williamson (2006) baroclinic wave test, wind forced ocean basin, …) and related post-processing. Results are posted to a web-site for visual inter-comparison, and archived for later analysis.



Solid body rotation test, initial tracer field (left), after 12 days (middle) and difference (right).

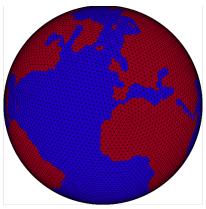
Failure at any step of the test suite is tracked by the Buildbot software, which controls the test suite. The test suite can be triggered manually, tailored to subsets and selected steps of the full test suite.



Wind forced ocean test, height (m) after 1 day.

Grid boundaries / Land sea maps

Care is taken to obtain smooth ocean currents at continental boundaries by allowing at most one edge of an ocean triangle on the coast line. The illustration shows the land sea mask at resolution R2B04.



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