

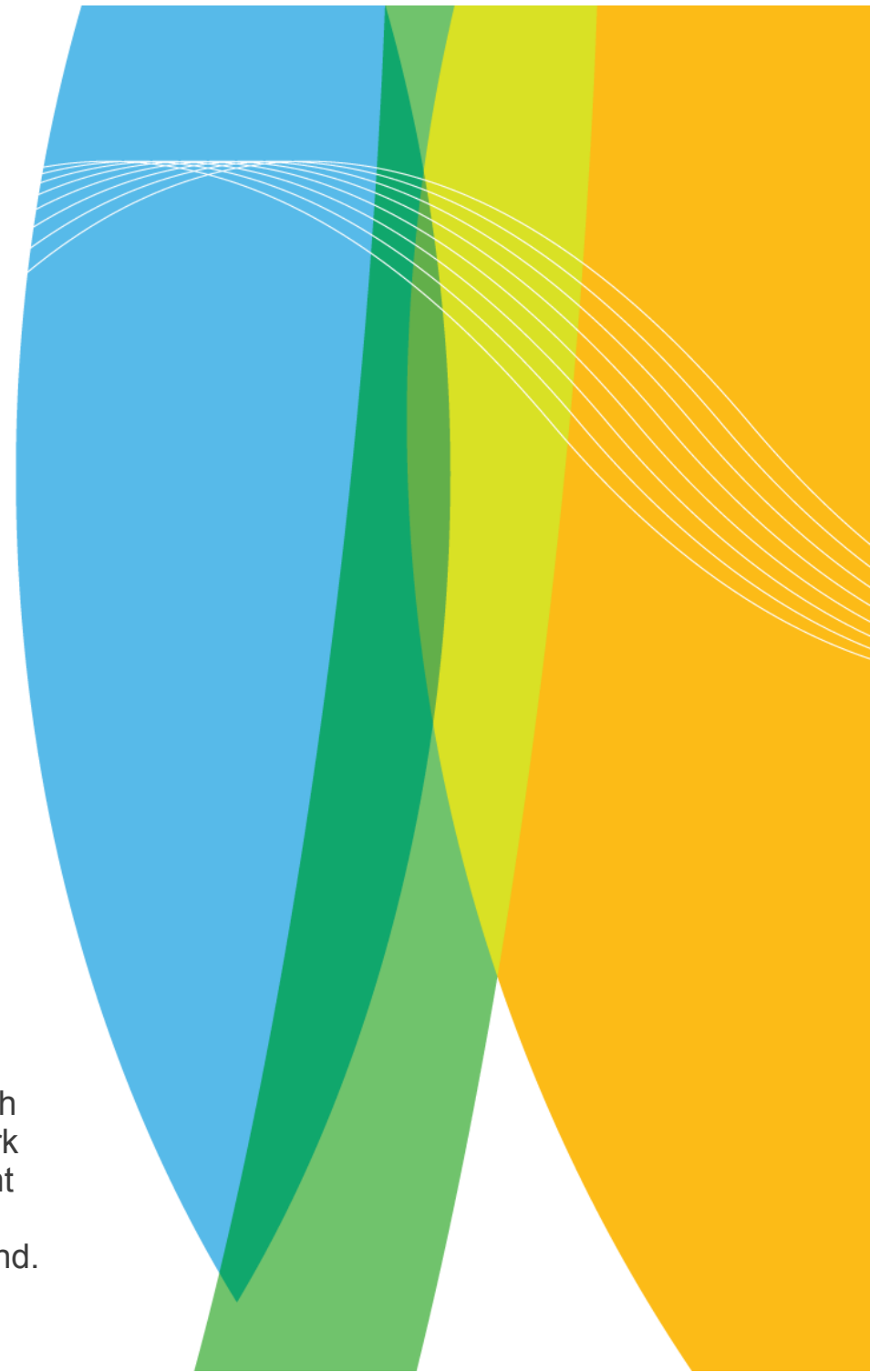


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GUMICS at CCMC

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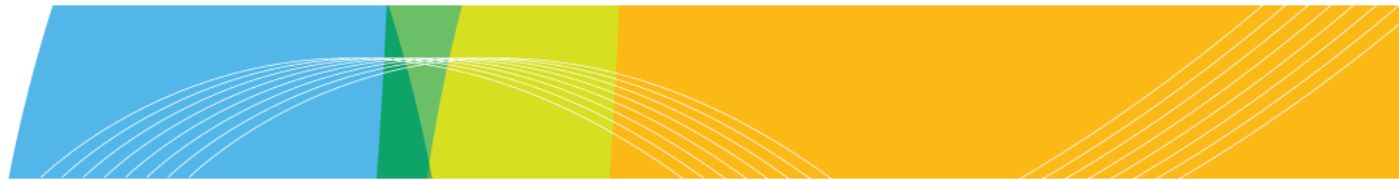
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Outline

- Challenges (past)
- Successes (present)
- Opportunities (future)

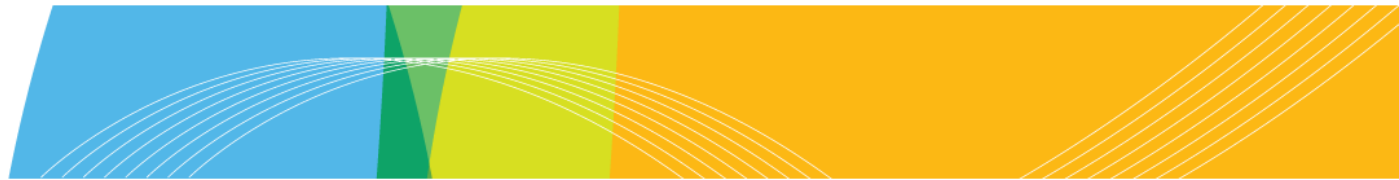
GUMICS: Grand Unified Magnetosphere-Ionosphere Coupling Simulation



Past

- GUMICS-1 (1993)
 - ~1000 km planar electrostatic ionosphere coupled to a 2D incompressible MHD fluid layer
 - Written in C
- GUMICS-2 (1995)
 - Ionosphere in spherical coordinates
 - Magnetosphere compressible MHD in uniform 3D
 - Outer magnetosphere modeled by Tsyganenko-89
 - Simplistic MHD solver

GUMICS versions 1-4 written by Pekka Janhunen



Past

- GUMICS-3 (1996)
 - Global ionosphere and magnetosphere
 - Cell-by-cell adapted (but static) grid in MHD
 - Temporal subcycling in MHD
 - Tanaka formulation of a Godunov type MHD solver
 - Transition from C to C++ started
- GUMICS-4 (2000)
 - Run-time adaptation of MHD grid
 - Cell-by-cell adapted (but static) grid in ionosphere
 - Triangular grid without singularities
 - Transition to C++ more or less complete

GUMICS versions 1-4 written by Pekka Janhunen

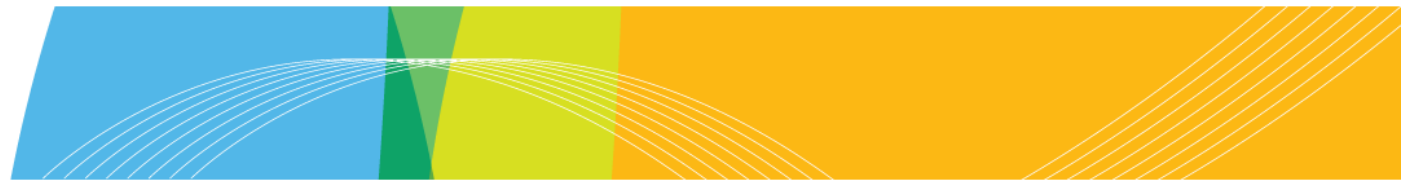


Present

- GUMICS the only European global MHD code
- Results used in over 40 peer reviewed publications:
 - Reconnection (in magnetopause, tail; drivers)
 - Energetics (transfer through mpause, dissipation in isphere)
 - Dynamics (substorm, cusp, tail)
 - Ionospheric heating, polar arcs
 - Signal propagation through magnetosphere

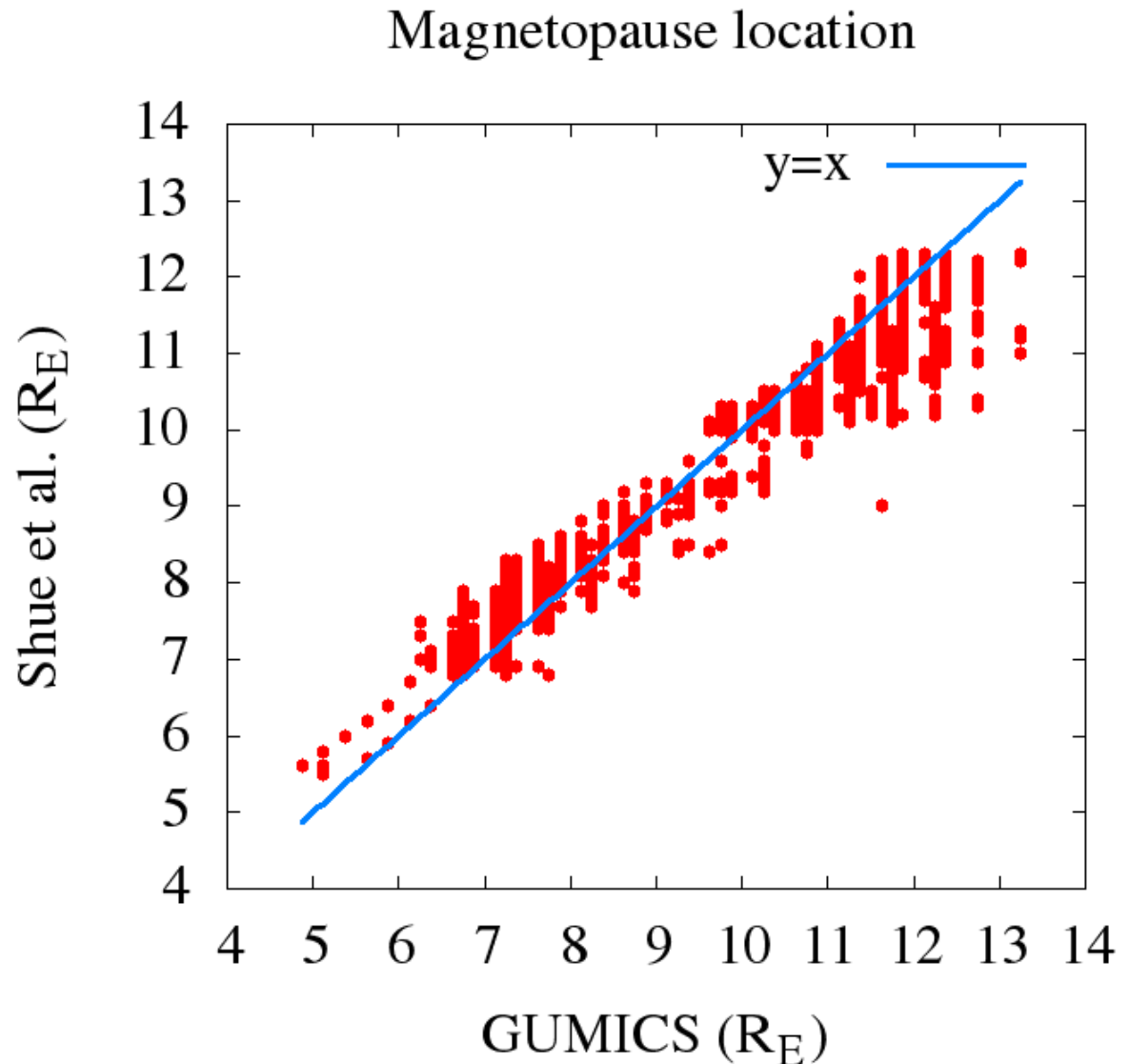
At CCMC

- GUMICS first available in late 2008 / early 2009
- Still the only non-US global mspheric model at CCMC
- So far used by about 20 different people



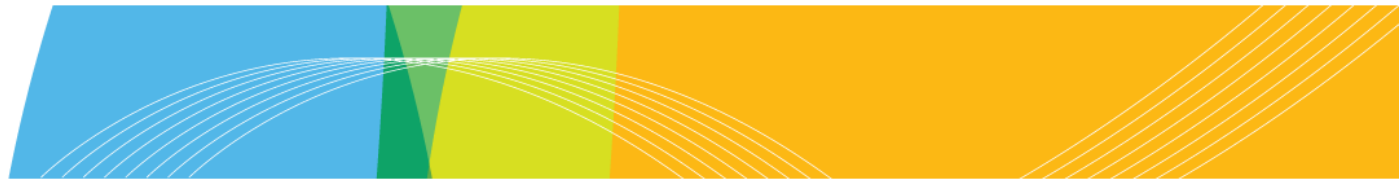
Example result from GUMICS

- Sunward last closed magnetic field line
- 1 point / output file
- 16 simulated events, between about 2000-2010
- Few differences in parameters:
 - solar wind
 - dipole tilt
 - maximum refinement level of MHD grid



Future

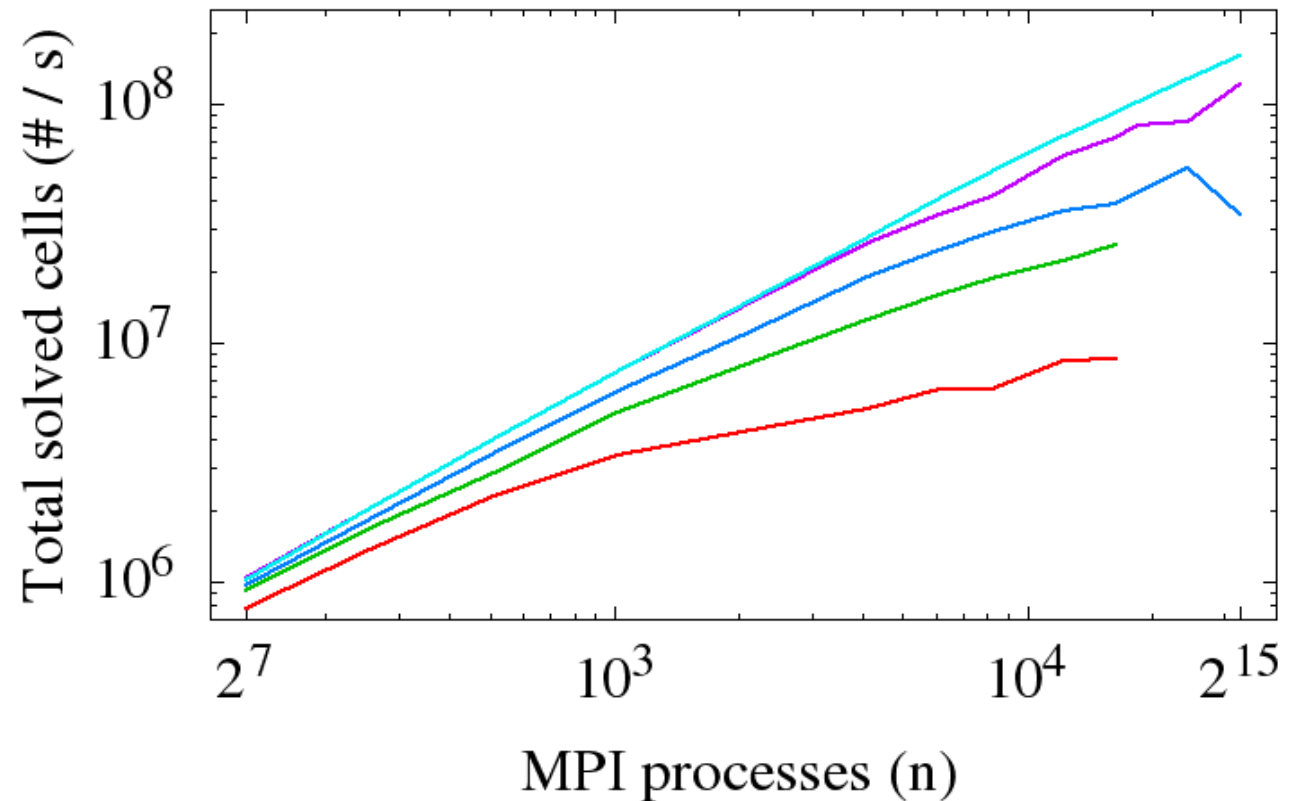
- Parallelization almost finished
 - GUMICS still the only serial mspheric model at CCMC
- Modernization with C++ continues
 - Separate parallel grid library (dccrg) with novel features:
 - Any C++ class / structure as cell data
 - Including variable amount of data / cell
 - Good scalability to tens of thousands of processes
 - Not GUMICS though due to serial ionosphere, etc.
 - Cell-by-cell adaptive mesh refinement (AMR)
 - Easy to use and freely available under GNU LGPL v3
 - Further abstractions of details using classes:
 - Solar wind, magnetosphere, ionosphere, AMR logic, background dipole, MHD solvers, file I/O, ...



MHD scalability

Blast wave scalability, in jugene

- 3D blast wave test
- No init, AMR, load balancing, file I/O



10000 cells — red —
50000 cells — green —
100000 cells — blue —
500000 cells — purple —
1000000 cells — cyan —



Future

- GUMICS will be free software under GNU GPL v3
 - Everyone can download, use, study, modify and share
- More users and developers:
 - Bugreports, fixes
 - Students (code not a black box, writing code for free?)
 - Added features, for example:
 - NASA, FAA, NOAA, AFWA space weather needs
 - User feedback from Nth CCMC workshop
 - More planets (new code or donated)
 - Small features (from summer schools, workshops, ...):
 - Solar wind boundary follows spacecraft
- Hopefully will lead to close world-wide collaboration on:
 - Magnetosphere and ionosphere model development
 - Code coupling (heliosphere, solar, thermosphere, ...)
 - ...

