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CHIC – Coupling Habitability, Interior and Crust: A new Code for Modeling the Thermal Evolution of Planets and Moons

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We present a new numerical code (CHIC) for the simulation of the thermal evolution of terrestrial planets.

The code consists of both a 1d parameterised model to evaluate the temperature profile in the planet's interior and a 2d/3d convection model for the silicate mantle - the latter uses either a Cartesian box, a 2d cylindrical sphere or a 2d spherical annulus. The code is modular and can be easily extended (for example to include an atmosphere module). In the convection model next to the energy equation the conservation equations of mass and momentum are solved, as well. We apply either a Boussinesq approximation or an extended Boussinesq approximation for mantle convection; compressible treatment is planned for the future. The code provides information on the temperature field in the mantle, convective velocities and convective stresses. Simulations can be run under steady-state or thermal evolution conditions.

The CHIC code handles surface volcanism, crustal development, and different regimes of surface mobilization like plate tectonics. It is therefore well suited for studying scenarios related to the habitability of terrestrial planets.
The code provides a user updatable library of thermodynamic properties of iron and common mantle silicates as well as associated equations of state that allow to compute material properties at high pressure and temperature. Furthermore, the interior structure of a planet for given composition and mass can be determined, yielding the core and planet radius that can then be automatically used for the thermal evolution simulation.

CHIC does also accommodate a module for computing a simple parameterised thermal evolution model of a planet's core that includes the formation of an inner core. This module can be combined with either the 1d parameterised thermal evolution model or the 2d/3d mantle convection model.

The code has been benchmarked with different convection codes, and compared to published interior-structure models and 1d parameterised models.