GEMINI test descriptions

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1 Purpose of this document

The **G**eospace **E**nvironment **M**odel of **I**on-**N**eutral **I**nteractions (GEMINI) is a general-purpose, three-dimensional (3D) terrestrial ionospheric model capable of describing most processes relevant to the ionosphere at medium to small spatial scales (200 m to 10000 km). The main source code repository for GEMINI can be found at `https://github.com/gemini3d/GEMINI`. This document describes the formulation of tests used to verify the GEMINI build and functioning.

2 Diffusion solver test

As discussed in the formulation document `https://github.com/gemini3d/GEMINI-docs/blob/master/formulation/GEMINI.pdf`, the parabolic portions of the energy equations are solved using implicit finite difference methods (including TRBDF2 and backward Euler). These are tested via solution of a simple heat equation describing the evolution of temperature $T(x,t)$:

$$\frac{\partial T}{\partial t} - \lambda \frac{\partial^2 T}{\partial x^2} = 0. \tag{1}$$

For purposes of testing we solve this equation on the *bounded* domain $0 \leq x \leq 1$. Invoking separation of variables we presume $T(x,t) = X(x)\mathcal{T}(t)$ and substitute back into the original equation:

$$\frac{1}{\lambda \mathcal{T}} \frac{\partial \mathcal{T}}{\partial t} - \frac{1}{X} \frac{\partial^2 X}{\partial x^2} = 0. \tag{2}$$

Each term depends solely on one of the independent variables x, t, which implies that for this relation to be valid for all x, t then each term must be equal to a constant.

$$-\frac{1}{\lambda \mathcal{T}} \frac{d\mathcal{T}}{dt} = k^2 \tag{3}$$

$$\frac{1}{X} \frac{d^2 X}{dx^2} = -k^2. \tag{4}$$

Note also that since we have dependence on only one variable that we may convert the derivatives into *ordinary* derivatives.

3 Error reporting

Please create an issue on our GitHub website `https://github.com/gemini3d/`

4 Contributors

Major contributors to GEMINI source code and testing include: M. Hirsch, G. Grubbs, and M. Burleigh.