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Physics-dynamics coupling with Galerkin methods: equal-area physics grid

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ABSTRACT

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1. Introduction

- Lander and Hoskins (1997): Believable scales
- Discuss Wedi (2014): spectral truncation and physics (physical) grid (see page 10; conclusions)
- Williamson (1999): keep physics scales constant with dynamical core refinement in spectral transform model
  - aid the convergence of the Hadley circulation
  - does not convergenge if the physics grid resolution is not held constant
  - parameterizations at the coarser grid do not include their own forcings from the finer scale, which appears to be contradictory to the purpose of parameterizations in the first place.
- Molod (2009): vertical refinement of physics grid (improvement)
- see complete list of possibly relevant papers in: `http://pdc.cicese.mx/program_day_by_day.html`

2. Methods

a. Remapping state: GLL grid → physics grid

Requirements for the mapping algorithm:

- mass-conservative,
- shape-preserving (monotone),
- consistent (preserves a constant),
- preserve basis function order for smooth fields.

A possible desirable property is total energy conservation (not pursued here).

In order to achieve conservation of scalar and air mass during the remapping process the constituent mixing ratios are weighted by the pressure level thickness Δp before the mapping:

$$\psi = \phi_k \Delta p_k, \tag{1}$$

where sub-script k refers to the level index. [conversion back]

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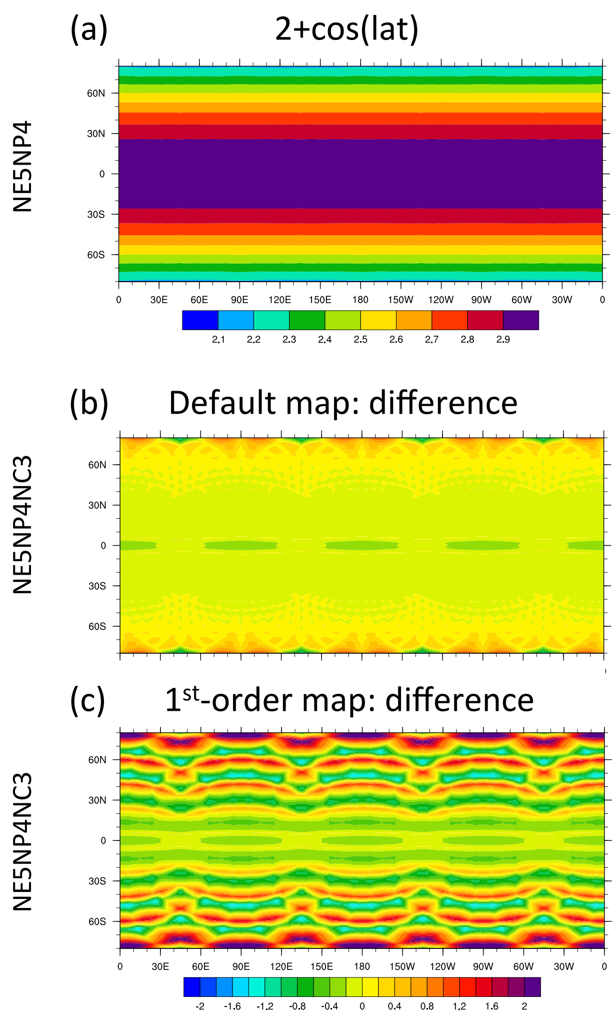

FIG. 1. (a) Smooth function $(2+\cos(\theta))$ initialized on the *NE5NP4* GLL grid. (b) and (c) show the difference between the interpolated field and the analytical value at the physics grid cell center. The interpolation is from the *NE5NP4* GLL grid to the NE5NP4NC3 physics grid (both have an approximate grid spacing of 6°). In (b) the interpolation algorithm is the default algorithm that is higher-order for smooth fields, shape-preserving, consistent, and mass-conservative. (c) is the same as (b) but using the first-order mapping method. All data has been bilinearly interpolated to a 1° regular latitude-longitude grid for plotting.

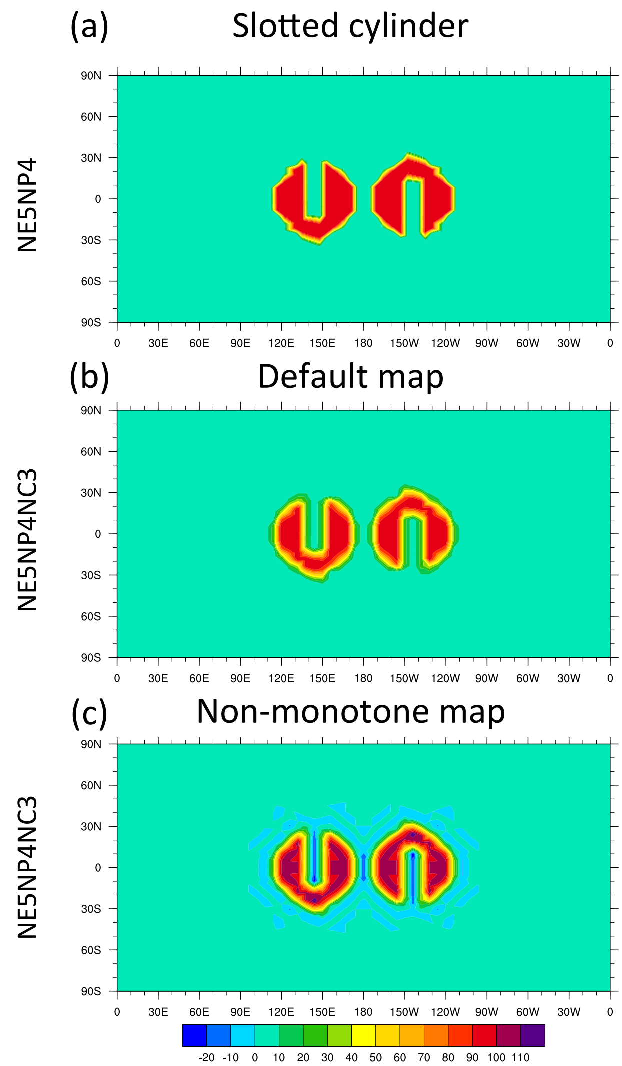

FIG. 2. (a) Slotted-cylinder distribution initialized on on the *NE5NP4* GLL grid (approximately 6° resolution). (b) Default mapping of the *NE5NP4* GLL grid data to the physics grid *NE5NP4NC3*. (c) Same as (b) but using the non-monotone map. All data has been bilinearly interpolated to a 1° regular latitude-longitude grid for plotting.

b. Remapping: physics grid → GLL grid

3. Results

Acknowledgments. Start acknowledgments here.

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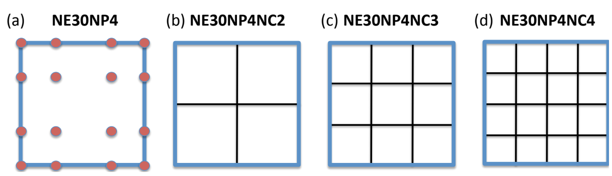

FIG. 3. A graphical illustration of the different physics coloumn configurations: (a) Gauss-Lobatto-Legendre quadrature grid for $np = 4$ (filled circles) and (b-d) 'equal-area' finite-volume grids of different resolutions ($nc = 2,3,4$).