Version 2.0 of 
NCAR Global Model Topography Generation Software 
https://github.com/NCAR/Topo

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What’s new in version 2.0?

● Command-line execution:

```bash
./cube_to_target --grid_descriptor_file ne30pg3.nc --intermediate_cs_name
gmte2010_modis_bedmachine-ncube3000-220518.nc --output_grid ne30pg3 --smoothing_scale 100.0
--name_email_of_creator 'Peter Hjort Lauritzen, pel@ucar.edu'
```

● New improved source topography data (ice sheet regions)

● Internal iterative Laplacian smoother with “no leak” option

● Support for SCRIP and ESMF grid descriptor file formats

● Seamless support for variable resolution grids
  (sub-grid-scale variables and smoothing seamlessly adapts to resolution changes)

● CESM compliant metadata on netCDF file
New improved source topography data:

“old” GMTED2010 dataset merged with the GrIS and AIS high resolution bedmachine data, for more accurate representation of ice sheets. Figure shows new minus old PHIS/g

More details: https://github.com/NCAR/Topo/issues/10
Internal iterative Laplacian smoother with “no leak” option

Smoothing of PHIS occurs on intermediate cubed-sphere grid (used to separate scales for SGH and SGH30); changed from distance weighted smoother to Laplacian:

For an arbitrary variable $U$, the Laplacian terms in the above equation can be written in the following explicit form:

$$
\sqrt{G} \nabla^2 U = \sqrt{G} \text{div}[\text{grad}(U)] \\
= \frac{\partial}{\partial x^1} \left[ \sqrt{G} G^{11} \frac{\partial U}{\partial x^1} + \sqrt{G} G^{12} \frac{\partial U}{\partial x^2} \right] \\
+ \frac{\partial}{\partial x^2} \left[ \sqrt{G} G^{21} \frac{\partial U}{\partial x^1} + \sqrt{G} G^{22} \frac{\partial U}{\partial x^2} \right].
$$

$$
G_{ij} = \frac{R^2}{\rho^4 \cos^2 x^1 \cos^2 x^2} \begin{bmatrix}
1 + \tan^2 x^1 & -\tan x^1 \tan x^2 \\
-\tan x^1 \tan x^2 & 1 + \tan^2 x^2
\end{bmatrix},
$$

where $i, j \in \{1, 2\}$ and $\rho^2 = 1 + \tan^2 x^1 + \tan^2 x^2$. The Jacobian of the transformation (the metric term) is $\sqrt{G} = [\text{det}(G_{ij})]^{1/2}$.

Note: must use the inverse of $G_{ij}$ in equation (3) that uses $G^{ij}$.

Internal iterative Laplacian smoother with “no leak” option

“No leak” option: Do not apply Laplacian smoother over ocean (\texttt{LANDFRAC=0 .and. PHIS==0}) and scale PHIS so that the volume of topography is preserved

Figure shows effect of not smoothing over ocean (using -m option)

The differences over land are due to “topographic volume” lost over ocean.
Internal iterative Laplacian smoother with “no leak” option

“No leak” option: Do not apply Laplacian smoother over ocean (\texttt{LANDFRAC=0 .and. PHIS==0}) and scale \texttt{PHIS} so that the volume of topography is preserved

Figure shows effect of scaling topography to preserve volume (\texttt{PHIS; m2/s2})

New \texttt{PHIS} minus \texttt{PHIS} without scaling to preserve volume.
Seamless support for variable resolution grids

Example: spectral-element refined grid over Greenland 1 degree -> $\frac{1}{8}$ degree
Seamless support for variable resolution grids

Example: spectral-element refined over Greenland 1 degree -> \( \frac{1}{8} \) degree
How to setup topo software and test it

1. The instructions below assume you have cloned this repository and are in the repository directory. For example:

   % git clone https://github.com/NCAR/Topo
   % cd Topo

2. To run latest science validated tag:

   % git checkout NCAR_Topoo_2_0

3. Code to generate topography data is in:

   % cd cube_to_target

4. Compile code (on NCAR’s Cheyenne cluster). Any specific compiler options can be changed in machine_settings.make

   % module load gnu/9.1.0
   % make

5. To test that code works properly you may run one of the fast regression tests:

   % source regr_test1.sh

6. If the regression test passed you should see

User’s guide:
https://github.com/NCAR/Topo/wiki/Documentation
Extra slides
Seamless support for variable resolution grids

Example: MPAS refinement ~60km -> 3km

```
./cube_to_target --write_rfac_to_topo_file --grid_descriptor_file=/glade/p/cgd/amp/pel/topo/grids/mpas-60-3km-WestPacific/mpas_x20.835586.wpac.1_scrip.nc
--intermediate_cs_name='../regression-test-data/gmted2010_bedmachine-ncube0540-220518.nc' --output_grid='mpas-60-3km-WestPacific' --smoothing_scale=50.0 -u 'Peter Hjort Lauritzen, pel@ucar.edu' -q 'output/' -r -y 20
```