

Linking CitcomS and SPECFEM3D

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Procedure 1. set outpvut directory and filename prefix [CitcomS.solver]



6. log in CIG Seismology Web Portal: https://crust.geodynamics.org/portals/seismo/ 7. click **3D Models** tab, download the model

12. select model parameters: mesh size (controlling the shortest period in the seismograms), model (choose the model uploaded in step 5), and other flags (oceans, topography, and ellipticity are not supported when using CitcomS data)

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Domain Decomposition

 CitcomS uses rhombic dodecahedron projection to divide the sphere into 12 caps. (Blue mesh in the figure. Thick lines mark the cap edges.)

• SPECFEM3D uses cubic sphere and divides the sphere into 6 caps. (Yellow mesh in the figure. Only one cap is shown.)

• Both codes can subdivid the caps further into *Nx* \times Ny subcaps. Each subcap is assigned to one CPU. In total, CitcomS uses Nc CPUs, and SPECFEM3D uses *Ns* CPUs, where *Nc* and *Ns* can be as large as ~1000.

• There are *Nc* files to be read by *Ns* processes. This will crash the filesystem!

• Solution: each SPECFEM3D subcap only reads the files of the overlapping CitcomS subcaps.

Element Searching



datafile = foo

2. set seismic output

[CitcomS.solver.output] output_optional = seismic

- 3. choose mineral physics model
 - [CitcomS.solver.parm] mineral physics model = 3
- 4. run CitcomS development version (to be released as v3.1) 5. exam model results, pick a time step (ex: step 10000) for generating synthetic seismograms.

Mineral Physics Models Implemented: • Trampert, Vacher, and Vlaar, PEPI,

- 2001
- Planned: • Karato, GRL, 1993
- Stacy, PEPI, 1998
- Stixrude and Lithgow-Bertelloni, GJI,
- 2005
- Others? (suggestions welcomed)

citcoms_isotropic_no_crust



O 3D Models

By default, the code uses 3D mantle model S20RTS [Ritsema et al., 1999] and 3D crustal model Crust2.0 [Bassin et al., 2000]. Note that S20RTS uses ansversely isotropic PREM as a background model, and that we use the REM radial attenuation model when 'attenuation' is select

8. extract the downloaded tar file.

9. copy citcoms files foo.domain, foo.coord_bin.*, foo.seismic.*.10000 to directory shared/ inside the extracted directory.

10. edit citcoms parm.h

const char citcoms_model_filename_base[] = "@THIS DIR@/shared/foo"; const int citcoms_step = 10000;

11. tar the whole directory, upload the tar file to the portal.

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14. create and submit a new run

1 of 4 📑 ← 🔶 Show 🔗 Run 0149 Cluster: Lonestar specfem3dglobe.tar output_mesher.txt output_solver.txt Estimated run time: 1:54:00

s Mode Catalogs



. . . .

For each SPECFEM3D point (red figure out which CitcomS element (green patch) the point falls on. The element search algorithm must be efficient and scales well with the size of CitcomS and SPECFEM3D meshes. A trilinear interpolation is used to interpolate fields defined on CitcomS elements to SPECFEM3D point.

Three points O, A, and B define a flat plane, whose normal is:

 $\vec{n} = \vec{OA} \times \vec{OB}$

Point P is said on the "positive" side of plane OAB, if and only if $\overrightarrow{OP} \cdot \overrightarrow{n} > 0$

Point Q is on the "negative" side of plane OAB.

Points ABCD, ordered counterclockwisely, and point O form a pyramid without a base. Point P is on the "positive" sides of all planes OAB, OBC, OCD, and ODA. We can conclude that P falls within the pyramid. On the other hand, point Q is on the "negative" side of plane OCD, and is outside the pyramid as a result.



Points ABCD are of the same distance to point O (not shown). Ditto for points EFGH. If point P falls within the pyramid OABCD, and the length of OP is between the length of OA and OE, P is inside the element ABCDEFGH.

Results **CitcomS**: 64x64x64x12 elements, 20 tracers per element, 4x4x1x12 CPUs, Ra=1.38x10⁹, compressible convection, 1.0 _ 0.05 _

Upload

Tip: If your model file is too large to upload, use this form instead



high bulk modulus and high density material, temperature-dependent viscosity (1000x), no phase changes,

SPECFEM3D: 11696 elements per CPU, 384 CPUs, with attenuation. Earthquake source at North pole, 600 km depth. Stations at 45-135 degree. Record section aligned on S arrivals.











2. Convert to seismic model

1. Begin with a geodynamic model



6. Iterate on geodynamic model

Example of a Seismic/Geodynamic Forward-Modeling Cycle



3. Generate synthetic seismograms

> 4. Obtain relevant seismic data



geodynamics.org

Comparison of Earth structure from a mantle convection model with seismic data

In the diagram above, a code generates a geodynamics model such as temperature, pressure, and composition. These parameters would be converted into a set of seismic parameters (isotropic or anisotropic elastic constants, density, and attenuation) by a user-specified mapping. Values from the geodynamic mesh would be sent to another mesh to be used by a synthetic seismogram program. A data-searching program (like the IRIS "WEED" tool) would be accessed to identify and obtain real seismic data for this geographic region. The earthquake-station geometries would be the input for a 3-D synthetic seismogram code, and synthetic counterparts would be generated using the 3-D geodynamics-based velocity model. The fit of the geodynamics model would be determined at the project-specific level through comparison between the seismic data and synthetics using a cost function such as crosscorrelation coefficients. This cost function would then serve as a guide in the formulation of successive geodynamic models.