SW4 for Chandan

Kindly do it

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1 Introduction

Chandan asked, "Can you run MZZ, MXX, MYY seismograms for a layered medium in your SW4 and send me the output with the model?"

We obtained SW4 v3.0 from GitHub and compiled on macos with MPICH using the following `make.inc` file:

```
proj = yes
# homebrew version of proj is fine
SW4ROOT = /opt/homebrew
fftw = yes
# homebrew version uses openmpi so installed fftw for mpich
FFTWHOME = /Users/ford17/Applications/fftw-3.3.10
FC = mpif90
CXX = mpicxx
# need Accelerate for blas on macos
EXTRA_LINK_FLAGS = -framework Accelerate -L/opt/homebrew/lib/gcc/current -lgfortran
```

2 Method

The requirements are:

- Station at (x,y,z) = (60, 0, 0)
- Source at (x,y,z) = (10, 0, 10)
- WUS model
- PPW for 5 Hz
- Dirac (delta) source

So we use the following SW4 input `run.sw4in` file:

```
fileio pfs=1 nwriters=16 path=mxx.dir printcycle=1000
grid x=70e3 y=35e3 z=50e3 h=100
time t=60
refinement zmax=35000
block vp=7900.0 vs=4620.0 rho=3276.0 qp=60976 qs=27027
block vp=6352.0 vs=3756.5 rho=2805.6 qp=658 qs=293 z2=35000
block vp=5544.5 vs=3295.3 rho=2608.9 qp=287 qs=128 z2=8000
block vp=3406.5 vs=2008.9 rho=2215.0 qp=331 qs=147 z2=1900
source x=10e3 y=0 z=10e3 mxx=1e18 type=Dirac
rec x=60e3 y=0 z=0 file=rec sacformat=1
image mode=s y=0 cycle=1
```

Note that refinement was used for a more efficient calculation.

And to calculate the results we could use the command:

```
mpirun -np 16 sw4 mxx.sw4in
```

In practice we used many more processors available on ruby from LC with the slurm script:

```
#SBATCH -N 36
#SBATCH -J run
#SBATCH -t 360
#SBATCH -p pbatch
#SBATCH --license=lustre1
#SBATCH -A gmp
#SBATCH -o run.sw4out
#SBATCH -e run.sw4err

# Max: 1440 minutes (24 hours) on 520 nodes

# Set CPUS/nodes for RUBY (limit 520 nodes for 24 hours)
@ CPUSPERNODE = 56
# Compute number of CPUs
@ NCPUS = ( $SLURM_JOB_NUM_NODES * $CPUSPERNODE )

srun -n$NCPUS /usr/workspace/ford17/sw4/optimize_ruby_mp/sw4 mxx.sw4in
srun -n$NCPUS /usr/workspace/ford17/sw4/optimize_ruby_mp/sw4 myy.sw4in
srun -n$NCPUS /usr/workspace/ford17/sw4/optimize_ruby_mp/sw4 mzz.sw4in
```

Our goal for an accurate calculation is to have a minimum points per wavelength (PPW) of between 6 and 10. The PPW is related to the smallest wave velocity v [m/s] divided by the grid spacing h [m] divided by the maximum frequency represented f [1/s]. For the grid used here ($v = 2008.9$ m/s, $h = 50$ m) the points per wavelength for a 5 Hz maximum frequency is:

$$\text{PPW} = v/h/f = 2008.9/50/5 \approxeq 8$$

3 Results

The shear wave velocity model is shown in Figure 1.

Calculated displacements low passed at 5 Hz are shown in Figure 2.

4 Comparison with CPS

Dispalcements are also calculated using CPS and shown in Figure 3.

Bob Herrmann produced an excellent tutorial that guided our work here. In that tutorial, Bob found "execellent agreement" between SW4 and CPS.

5 Conclusions

SW4 and CPS are excellent tools for wavefield calculations.

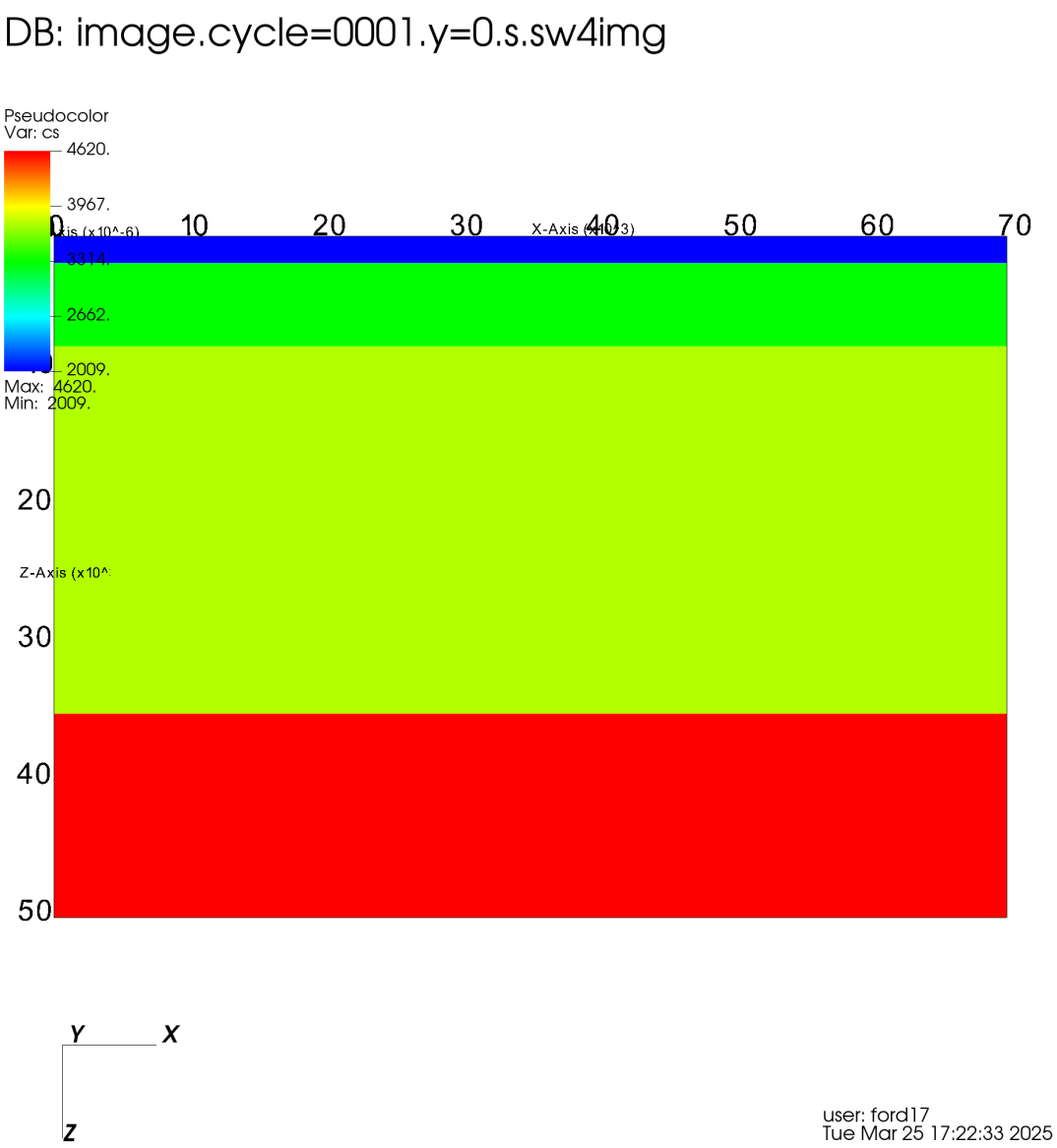
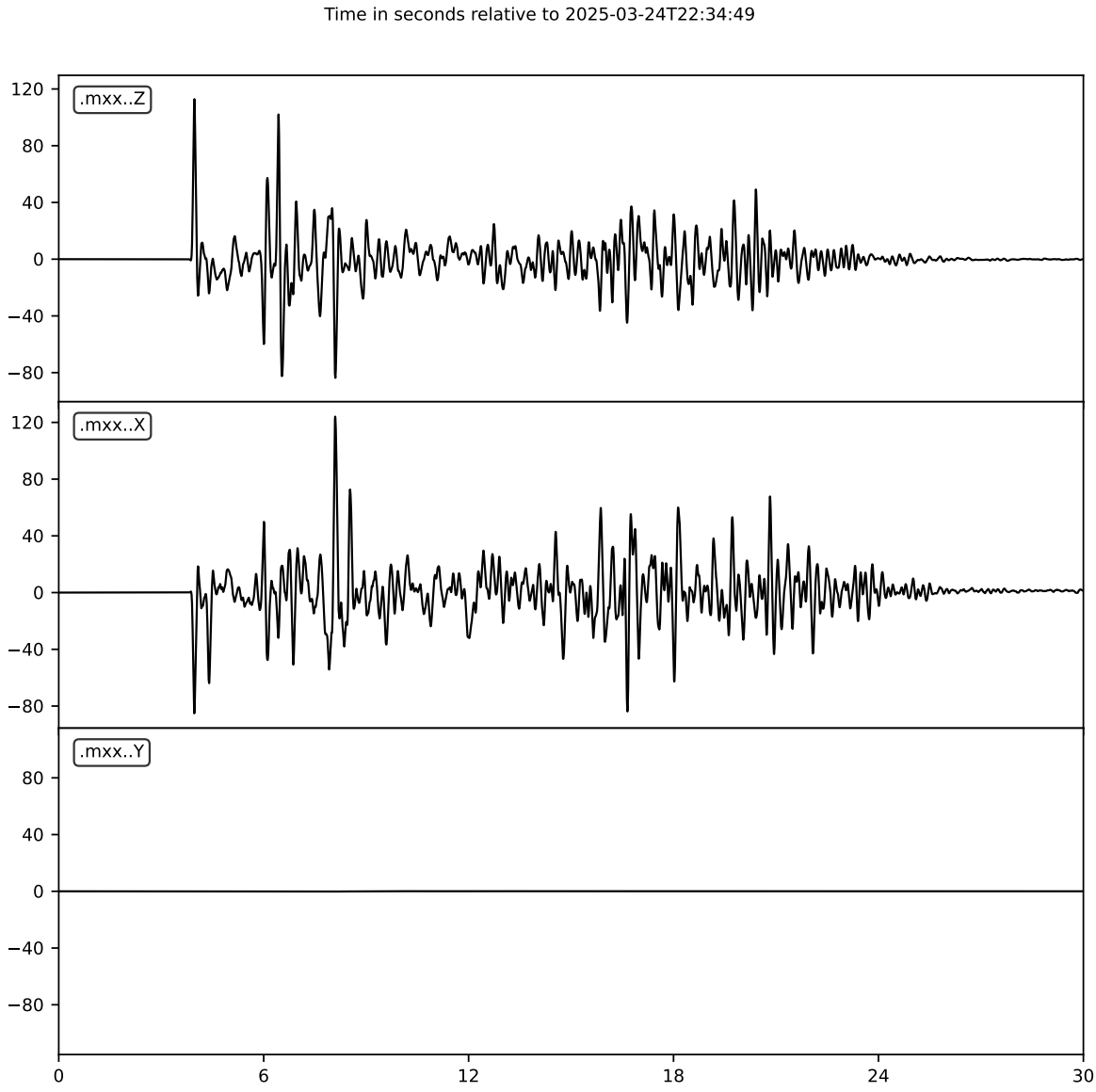
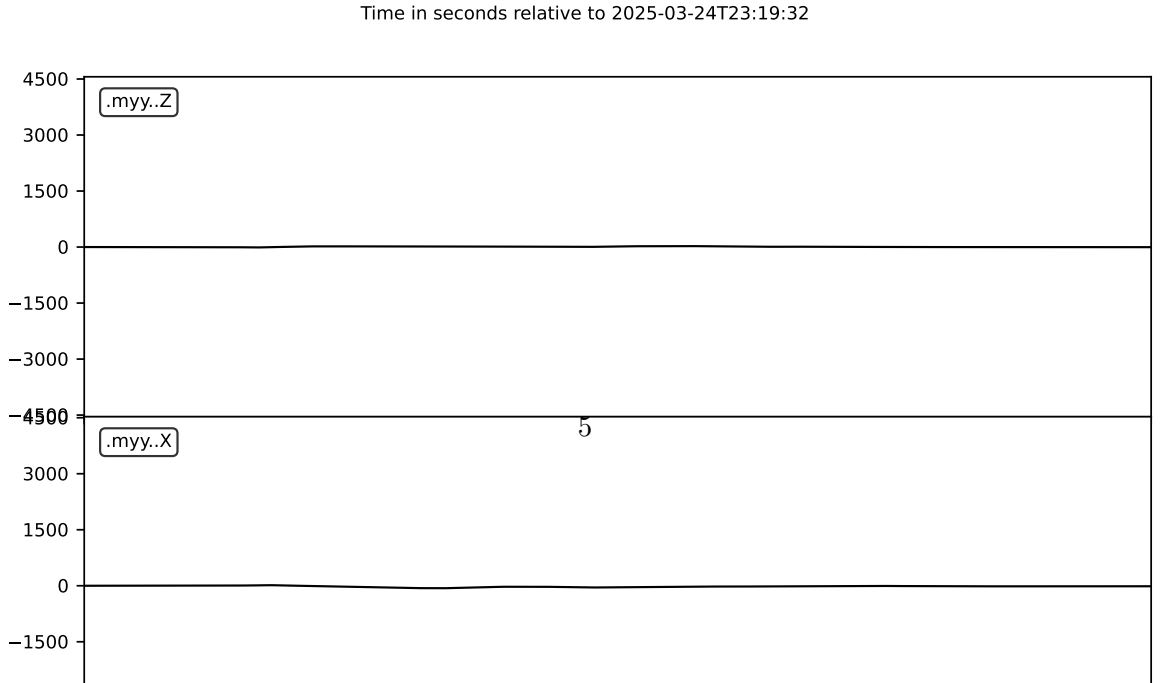
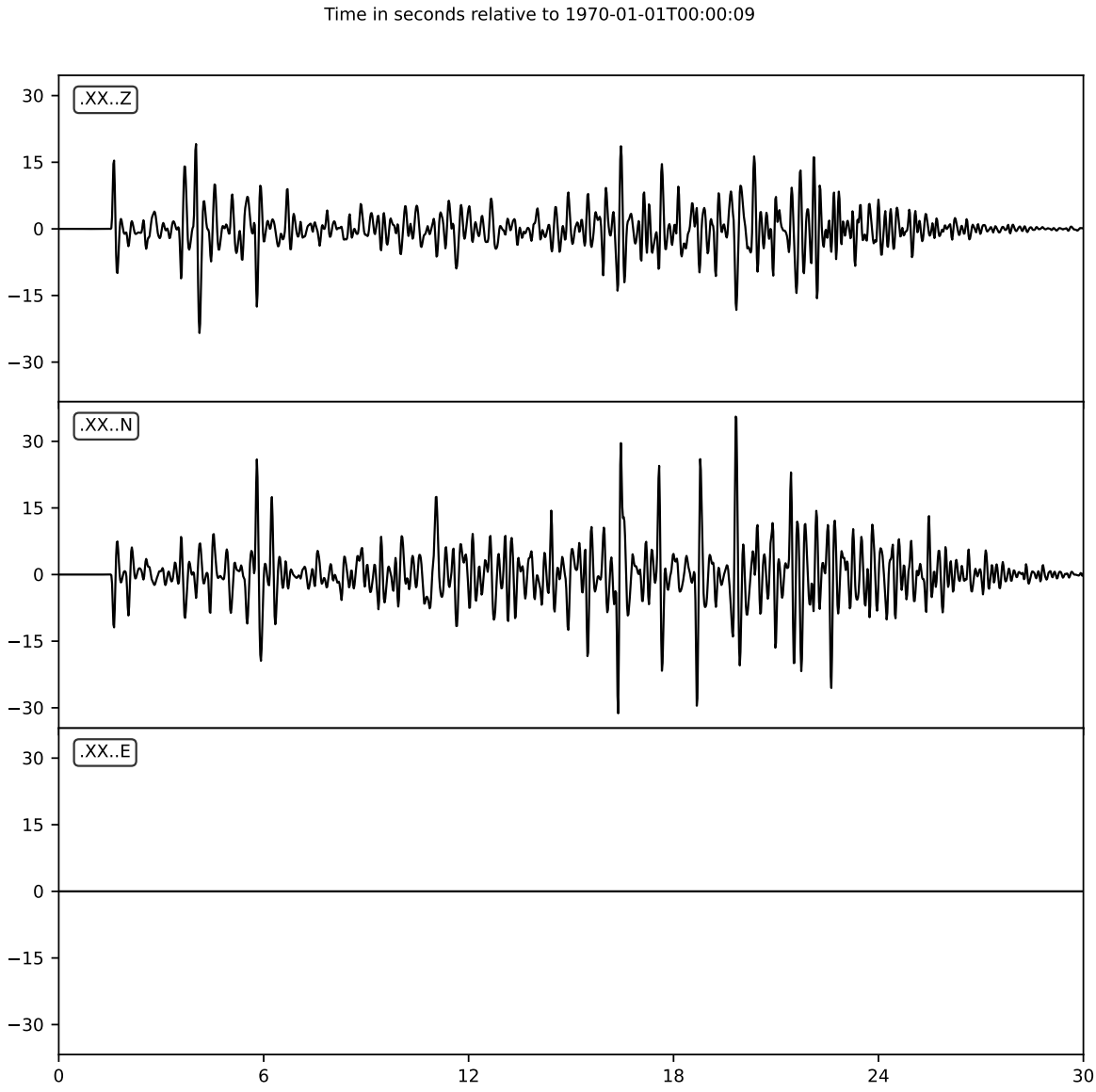


Figure 1: Shear wave velocity model plotted with VisIt

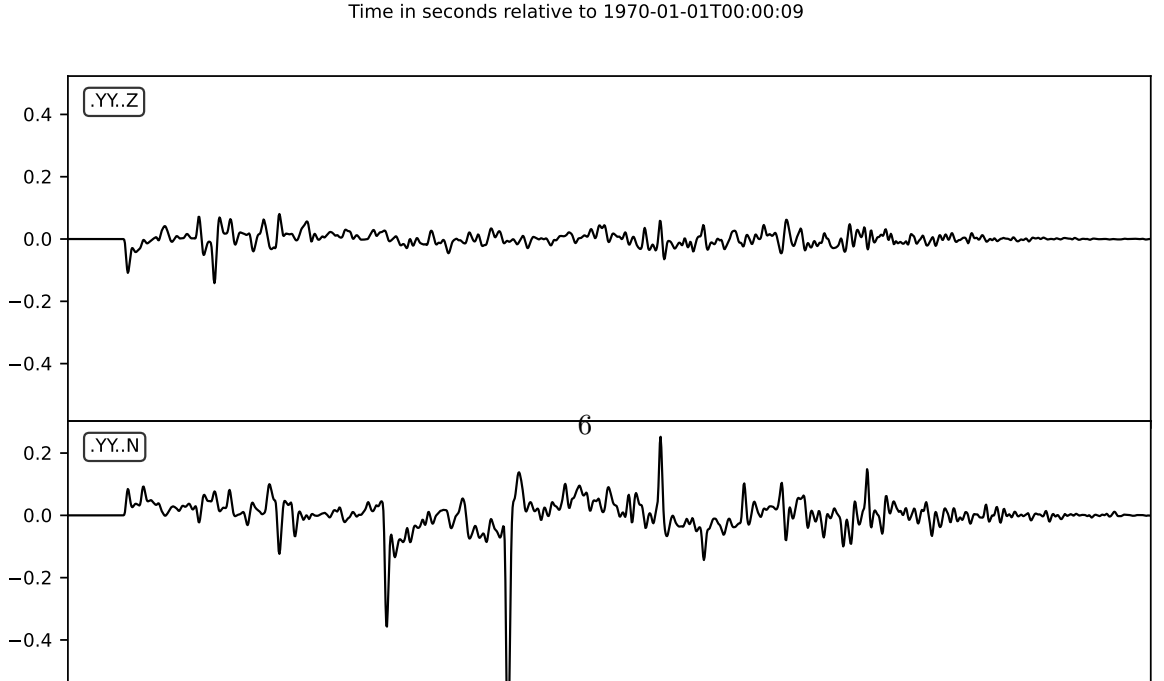

Time in seconds relative to 2025-03-24T22:34:49
.mxx..Z
.mxx..X
.mxx..Y
120
80
40
0
−40
−80
0
6
12
18
24
30

(a) MXX


Time in seconds relative to 2025-03-24T23:19:32
.myy..Z
.myy..X
4500
3000
1500
0
−1500
−3000
−4500


Time in seconds relative to 1970-01-01T00:00:09
.XX..Z
.XX..N
.XX..E
30
15
0
−15
−30
0
6
12
18
24
30

(a) MXX


Time in seconds relative to 1970-01-01T00:00:09
.YY..Z
.YY..N
0.4
0.2
0.0
−0.2
−0.4