Neo-deterministic Seismic Hazard Assessment

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Methodology - Modal Summation Technique

- Expression of the displacement generated by a double-couple point source in a flat layered halfspace

$$u_y^L(x,z,\omega) = \sum_{m=1}^{\infty} \frac{e^{-i3\pi/4}}{\sqrt{8\pi\omega}} \frac{e^{-ik_m x}}{\sqrt{x}} \frac{\left(\chi_m^L(h_s,\omega)\right)}{\sqrt{c_m v_m I_m}} \frac{\left(F_y(z,\omega)\right)}{\sqrt{v_m I_m}}$$

$$u_x^R(x,z,\omega) = \sum_{m=1}^{\infty} \frac{e^{-i3\pi/4}}{\sqrt{8\pi\omega}} \frac{e^{-ik_m x}}{\sqrt{x}} \frac{\left(\chi_m^R(h_s,\omega)\right)}{\sqrt{c_m v_m I_m}} \frac{\left(F_x(z,\omega)\right)}{\sqrt{v_m I_m}}$$

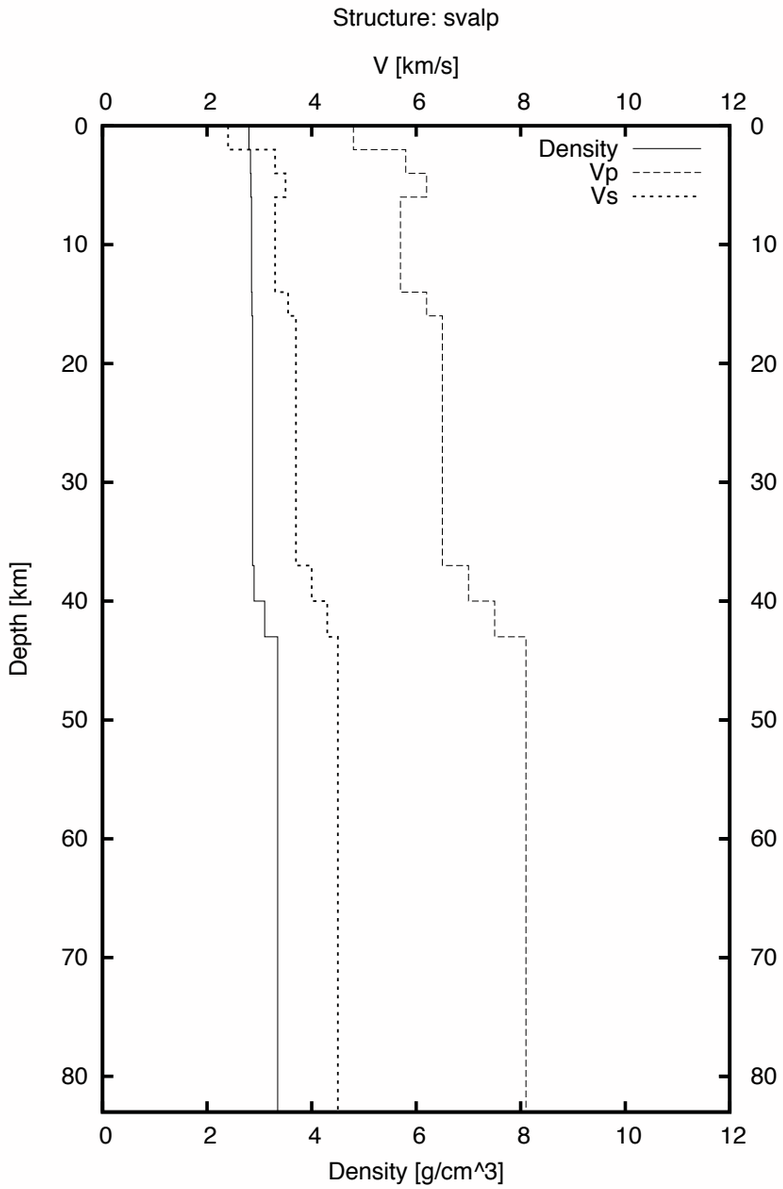
$$u_z^R(x,z,\omega) = \sum_{m=1}^{\infty} \frac{e^{-i\pi/4}}{\sqrt{8\pi\omega}} \frac{e^{-ik_m x}}{\sqrt{x}} \frac{\left(\chi_m^R(h_s,\omega)\right)}{\sqrt{c_m v_m I_m}} \frac{\left(F_z(z,\omega)\right)}{\sqrt{v_m I_m}}$$

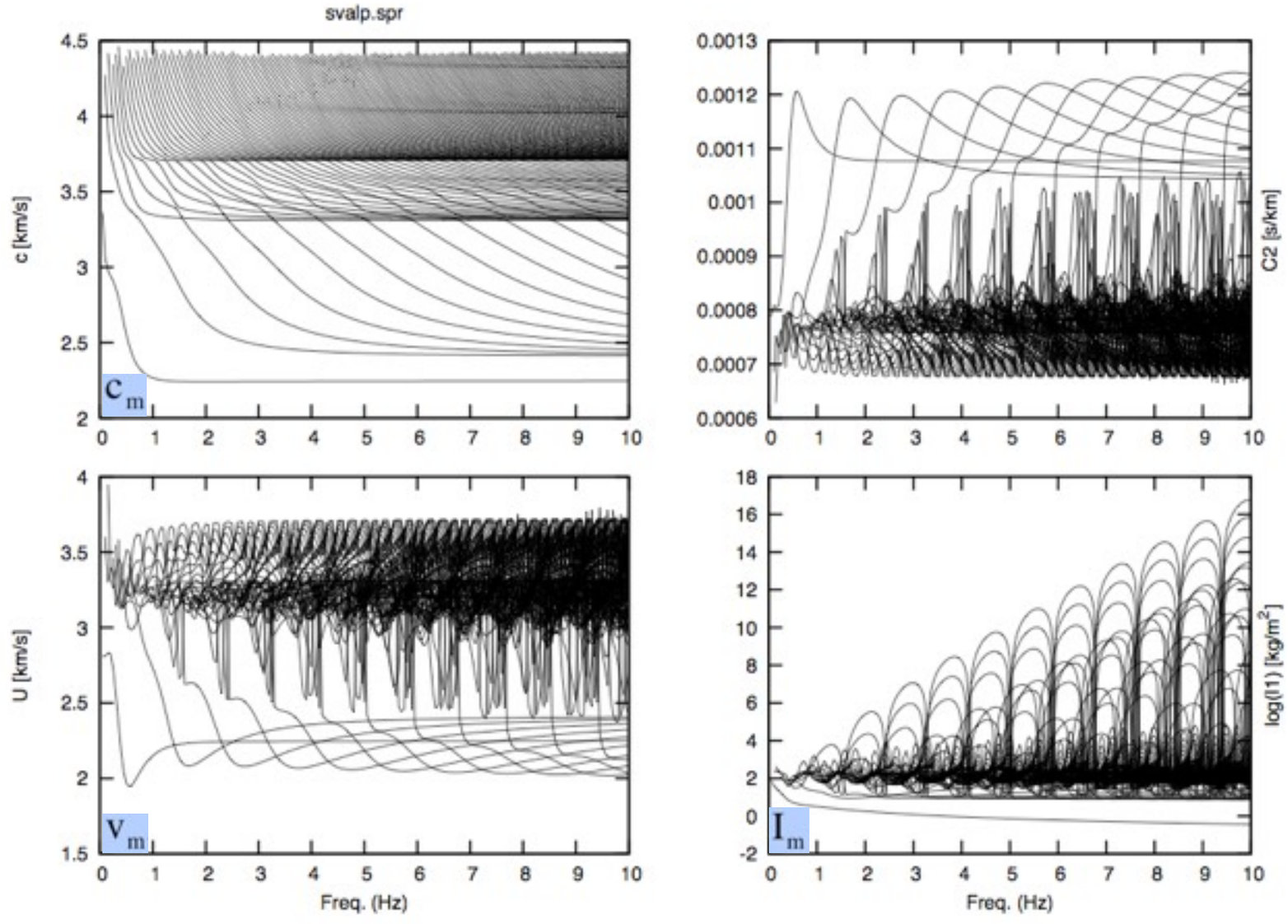
source structure receiver

Methodology - Modal Summation Technique

- Example of quantities associated with a structure

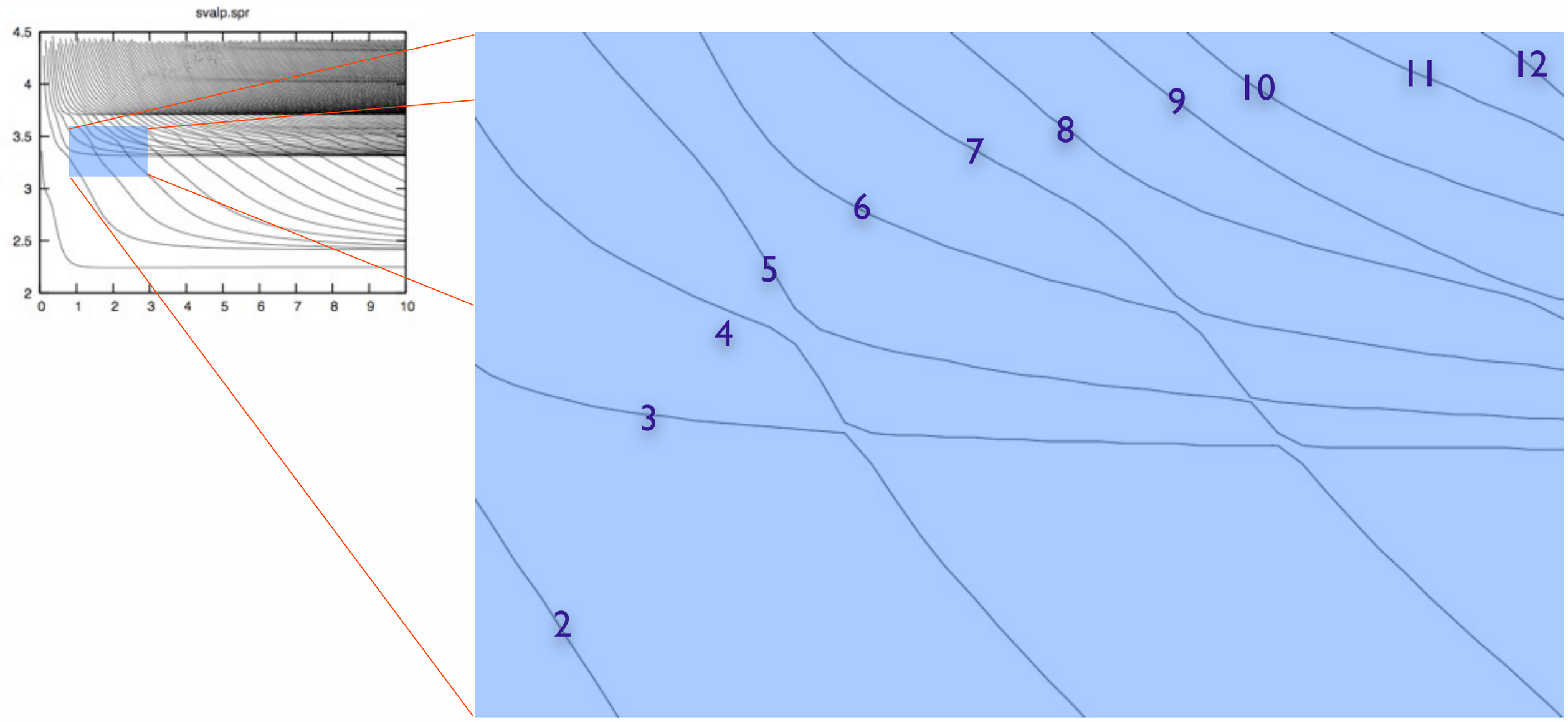
$$\sqrt{c_m v_m I_m} \qquad \sqrt{v_m I_m}$$





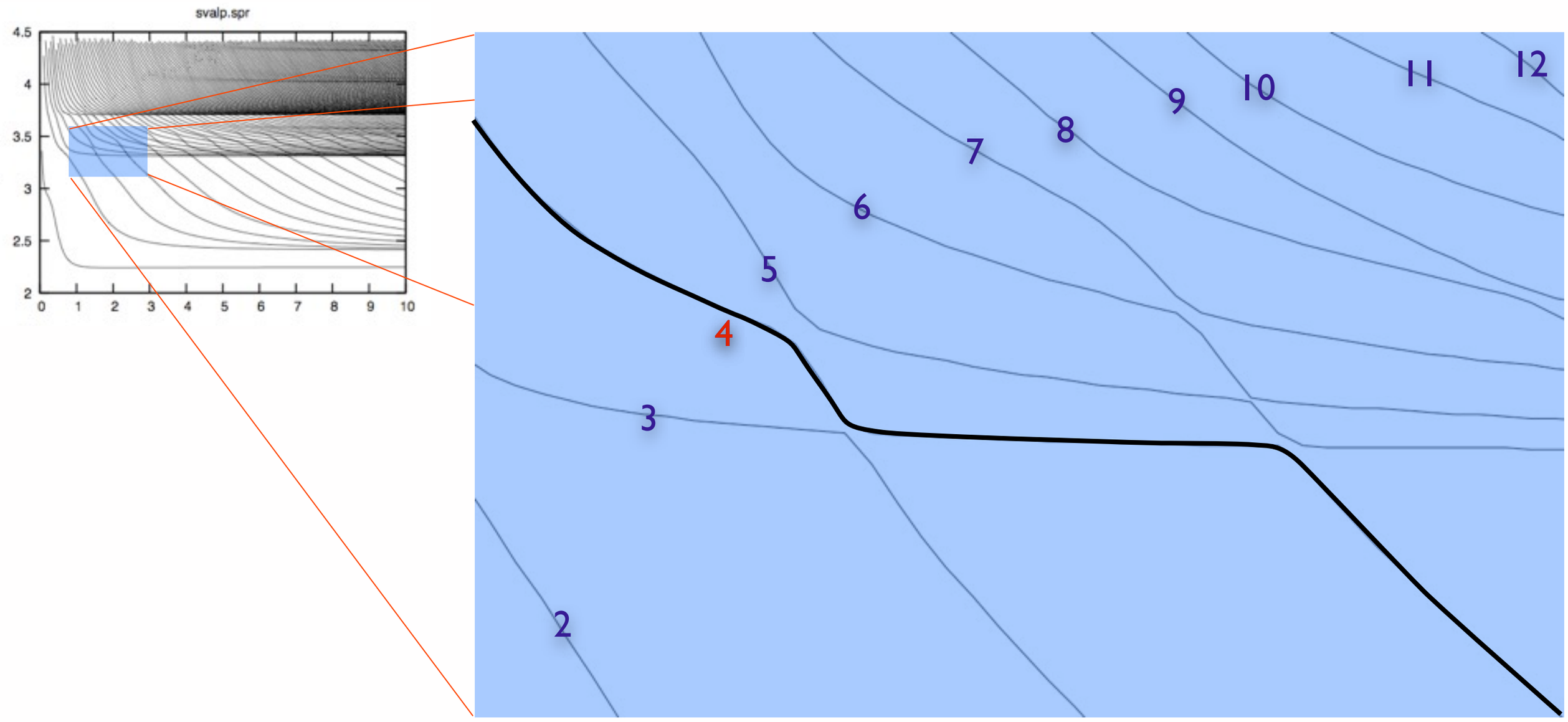
Methodology - Modal Summation Technique

- Phase velocity dispersion curve



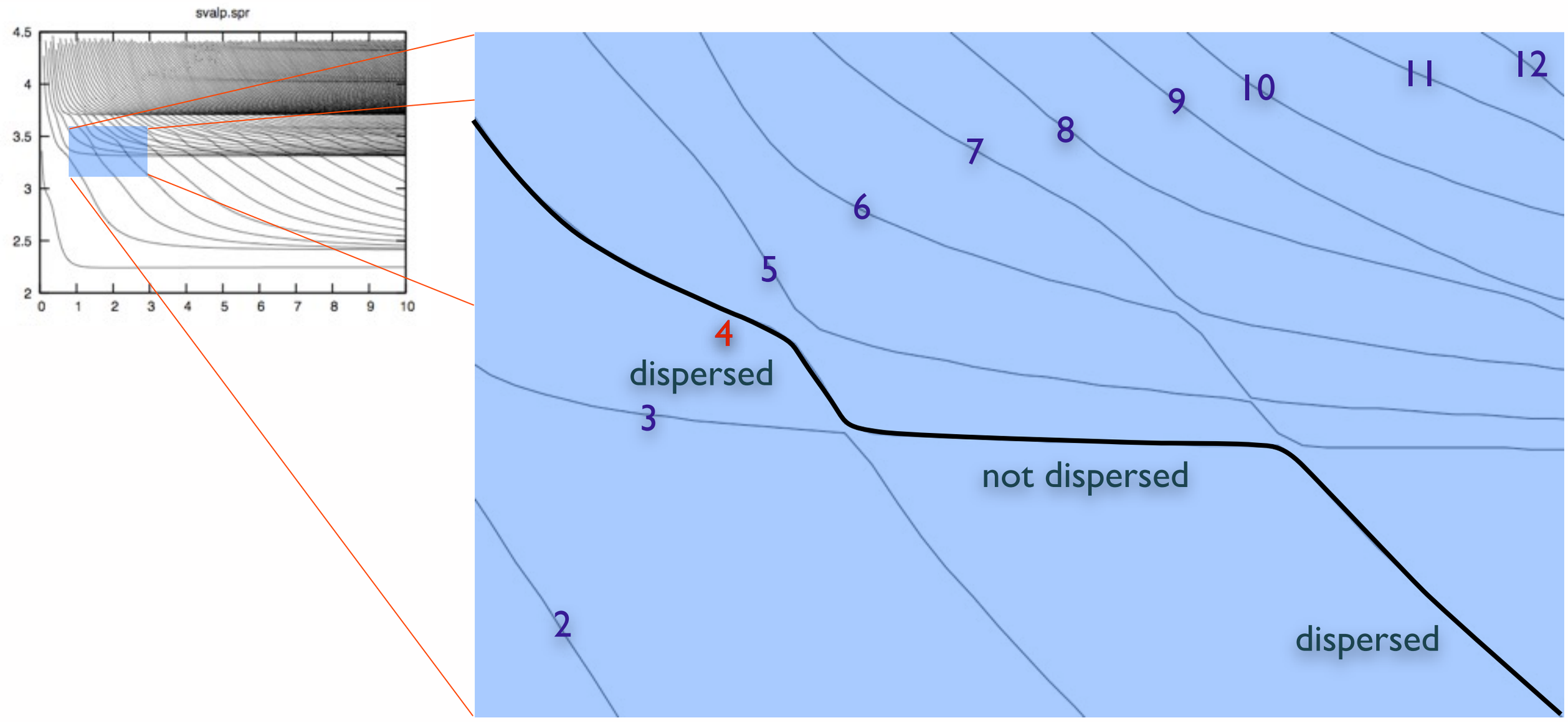
Methodology - Modal Summation Technique

- Phase velocity dispersion curve



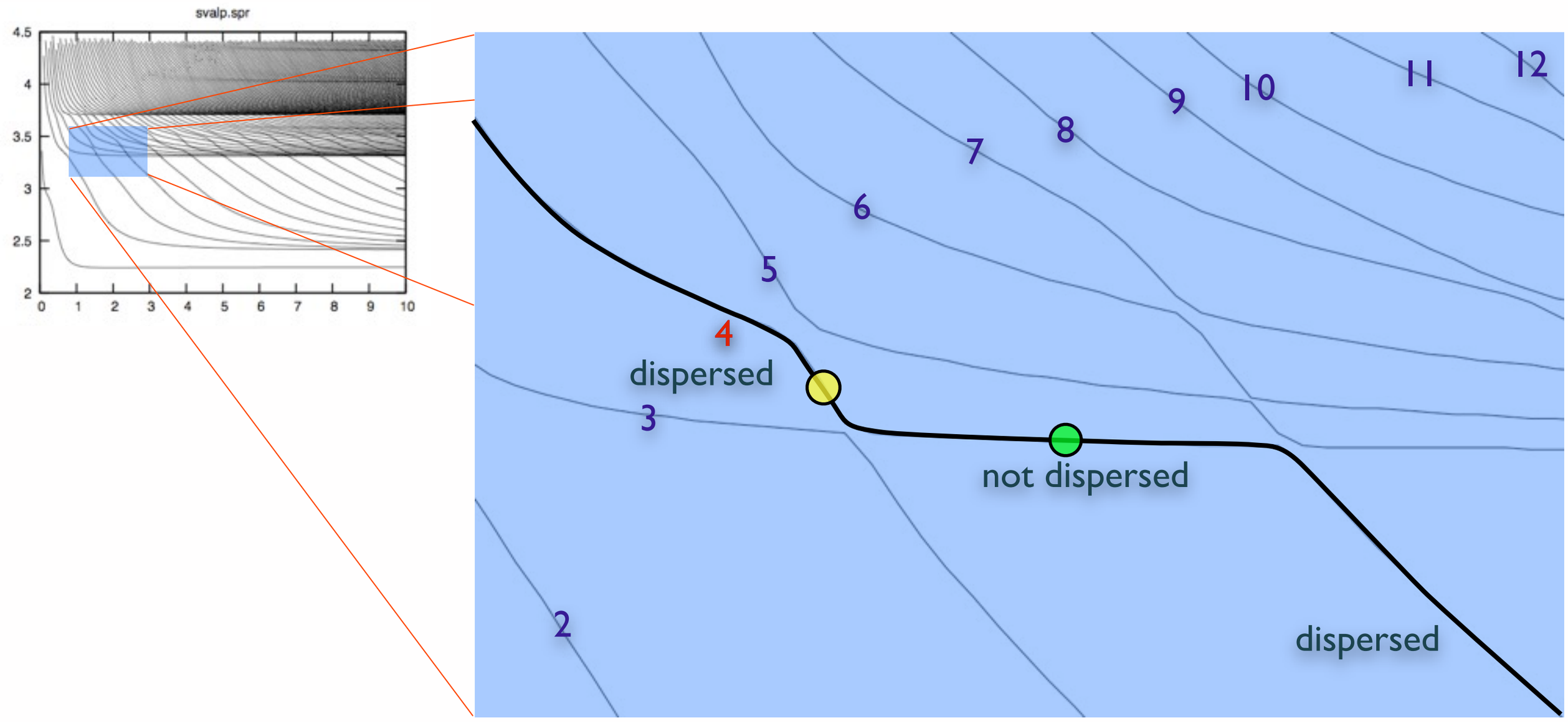
Methodology - Modal Summation Technique

- Phase velocity dispersion curve



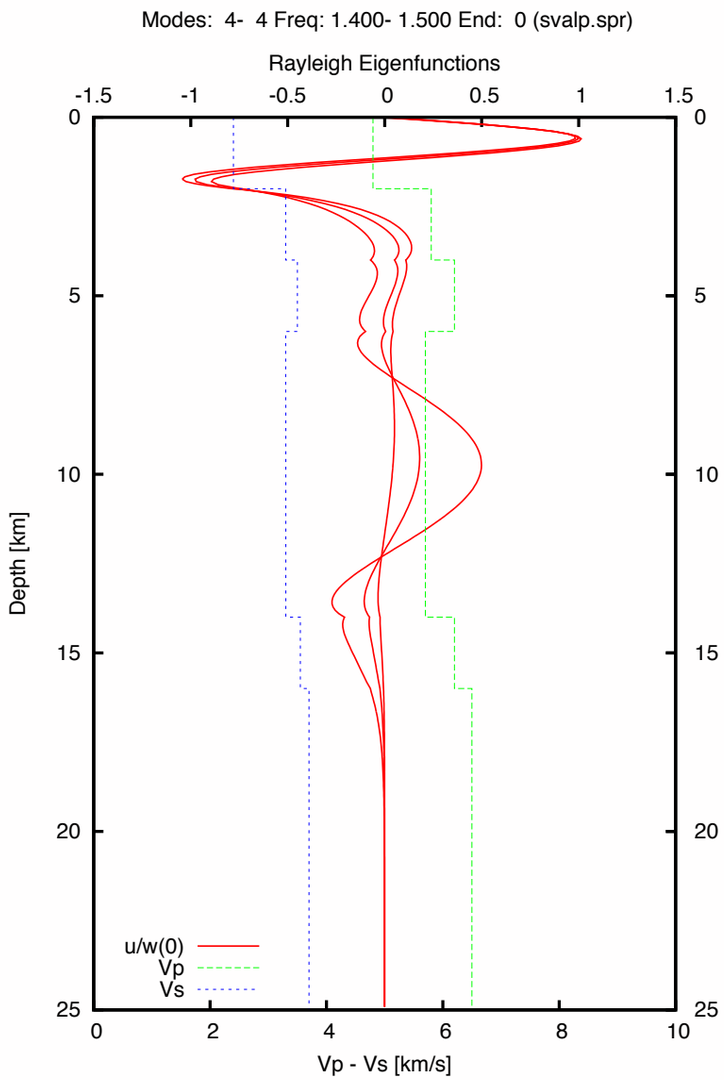
Methodology - Modal Summation Technique

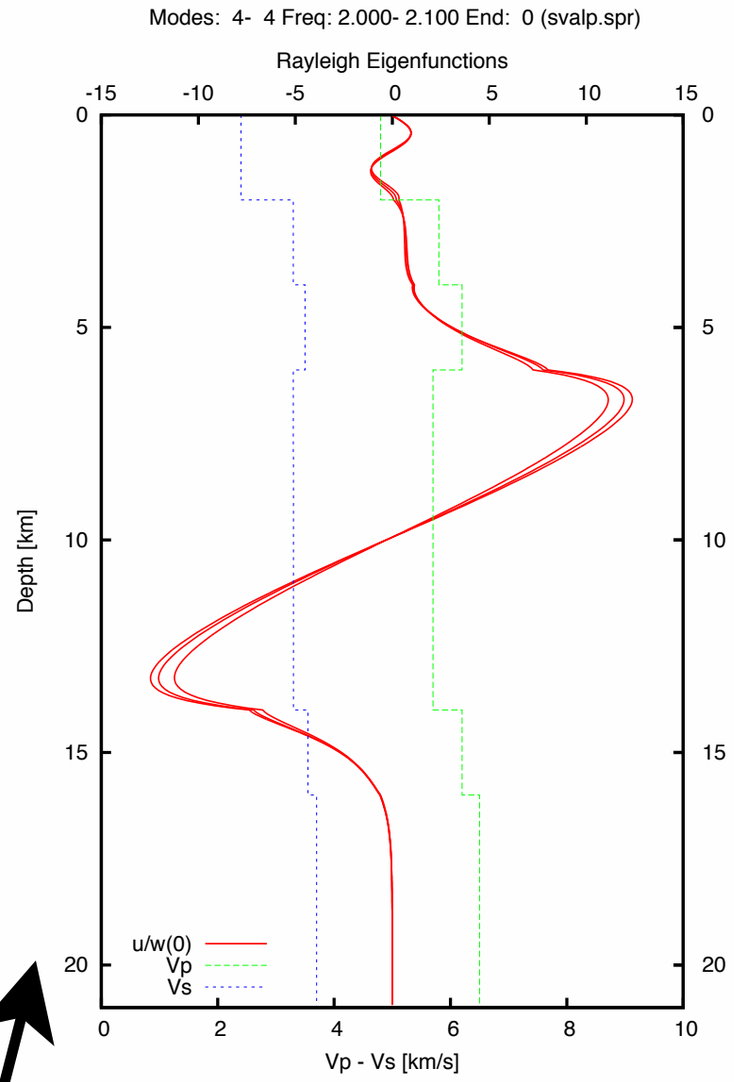
- Phase velocity dispersion curve

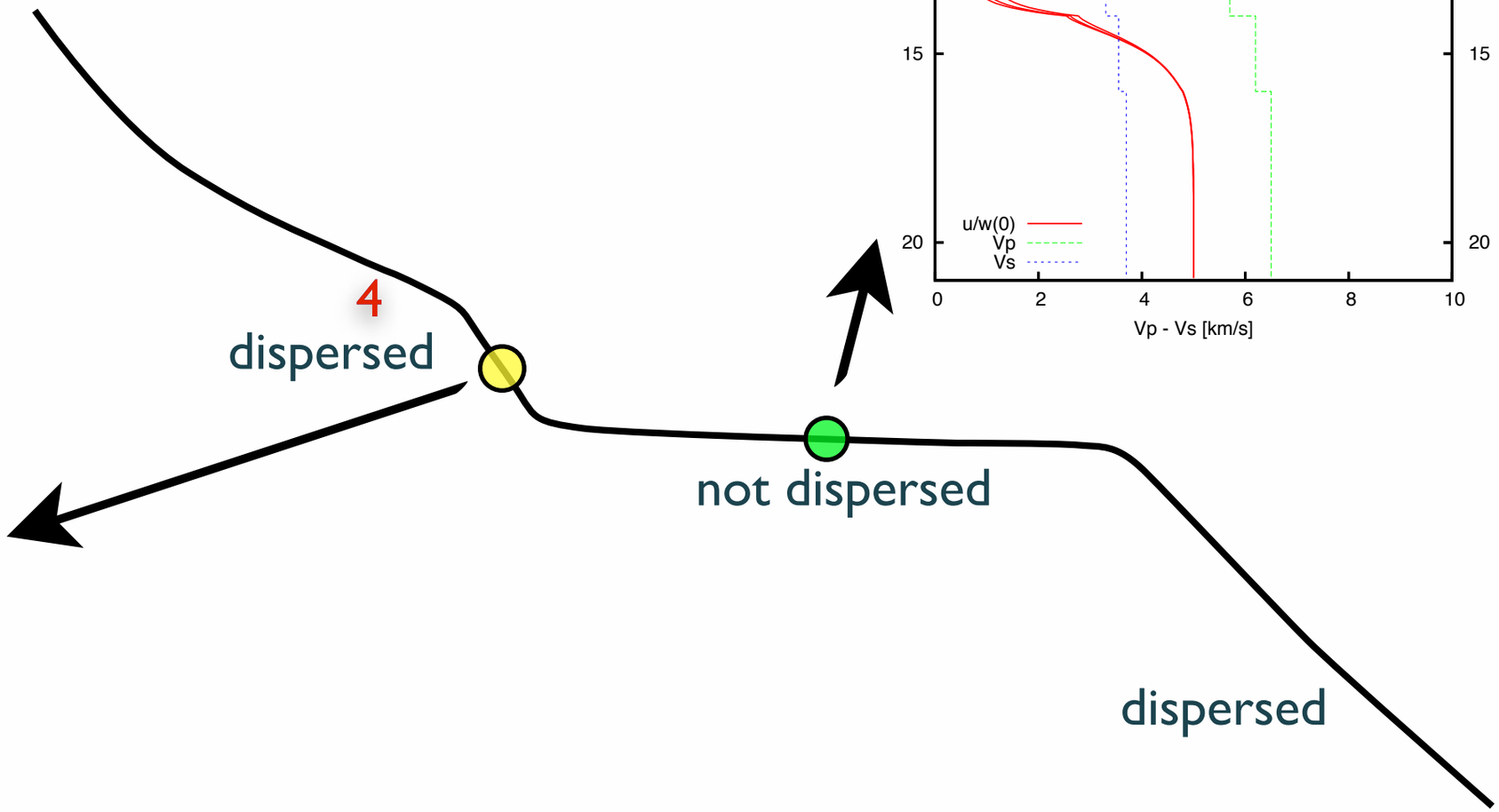


Methodology - Modal Summation Technique

Eigenfunctions

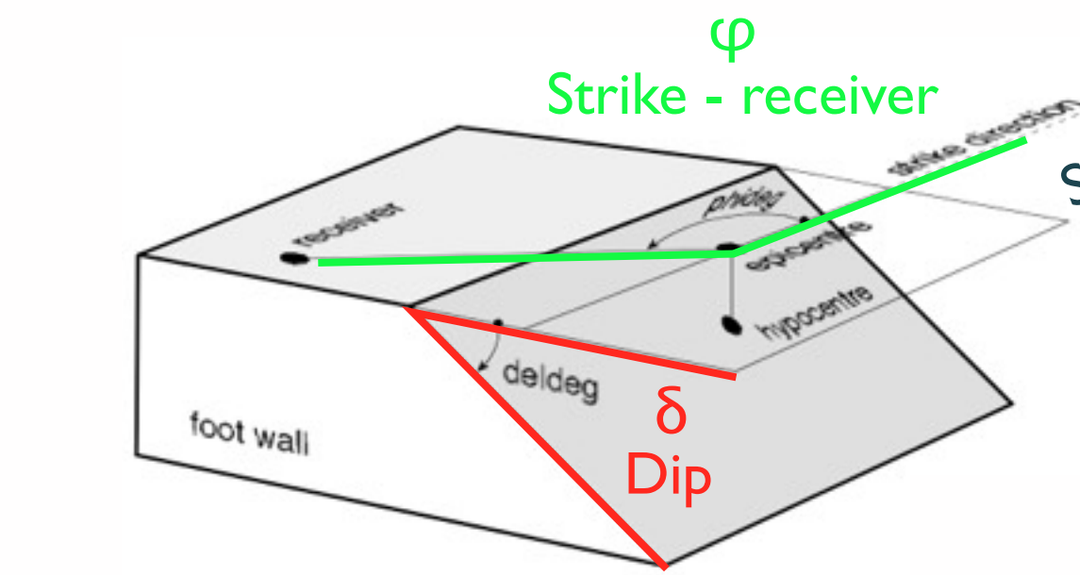


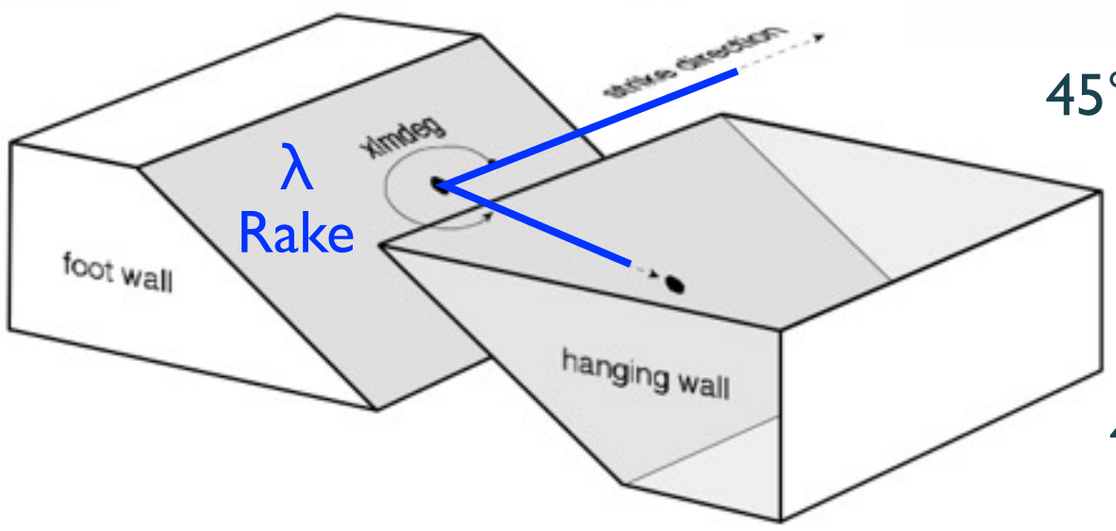




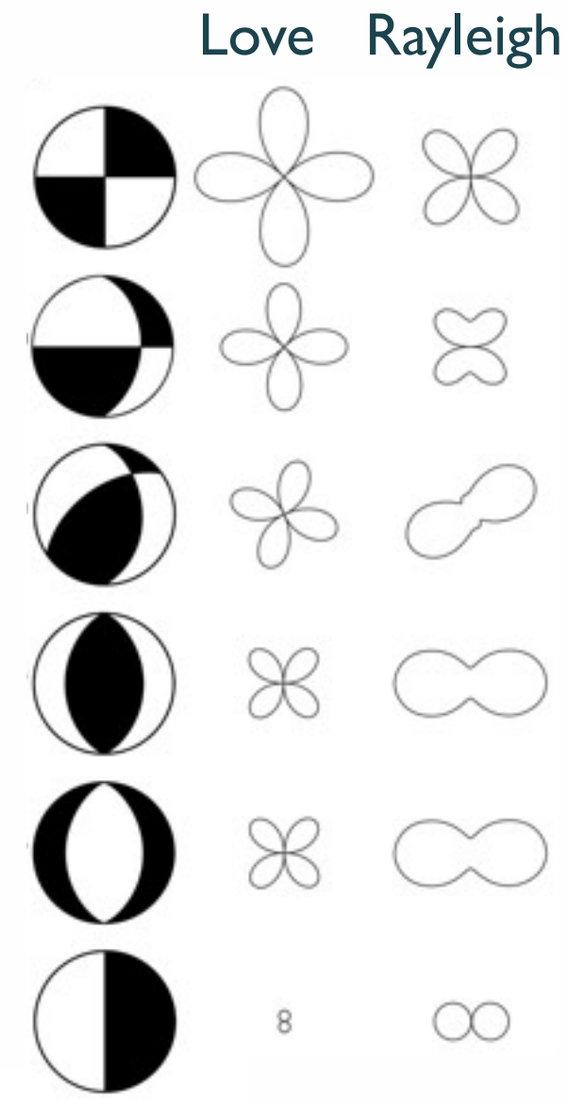
Methodology - Modal Summation Technique

- Source definition and examples of radiation pattern





$$\left(\chi_m^L(h_s,\omega)\right) \qquad \left(\chi_m^R(h_s,\omega)\right)$$



Methodology - Modal Summation Technique

- Expression of the source radiation pattern

$$\chi_L = i(d_{1L}\sin\varphi + d_{2L}\cos\varphi) + d_{3L}\sin 2\varphi + d_{4L}\cos 2\varphi$$

$$\chi_R = d_0 + i(d_{1R}\sin\varphi + d_{2R}\cos\varphi) + d_{3R}\sin 2\varphi + d_{4R}\cos 2\varphi$$

where

$$d_{1L} = G(h_s)\cos\lambda\sin\delta \qquad d_0 = \frac{1}{2}B(h_s)\sin\lambda\sin 2\delta$$

$$d_{2L} = -G(h_s)\sin\lambda\cos 2\delta \qquad d_{1R} = -C(h_s)\sin\lambda\cos 2\delta$$

$$d_{3L} = \frac{1}{2}V(h_s)\sin\lambda\sin 2\delta \qquad d_{2R} = -C(h_s)\cos\lambda\cos\delta$$

$$d_{4L} = V(h_s)\cos\lambda\sin\delta \qquad d_{3R} = A(h_s)\cos\lambda\sin\delta$$

$$d_{4R} = -\frac{1}{2}A(h_s)\sin\lambda\sin 2\delta$$

$$A(h_s) = -\frac{F_x^*(h_s)}{F_z(0)}$$

$$B(h_s) = -\left(3 - 4\frac{\beta^2(h_s)}{\alpha^2(h_s)}\right)\frac{F_x^*(h_s)}{F_z(0)} - \frac{2}{\rho(h_s)\,\alpha^2(h_s)}\frac{\sigma_{zz}^*(h_s)}{\dot{F}_z(0)/c}$$

$$C(h_s) = -\frac{1}{\mu(h_s)}\frac{\sigma_{zx}(h_s)}{\dot{F}_z(0)/c}$$

$$G(h_s) = -\frac{1}{\mu(h_s)}\frac{\sigma_{zy}^*(h_s)}{\dot{F}_y(0)/c}$$

$$V(h_s) = \frac{\dot{F}_y(h_s)}{\dot{F}_y(0)/c} = \frac{F_y(h_s)}{F_y(0)/c}$$

$$\left(\chi_m^L(h_s,\omega)\right) \qquad \left(\chi_m^R(h_s,\omega)\right)$$

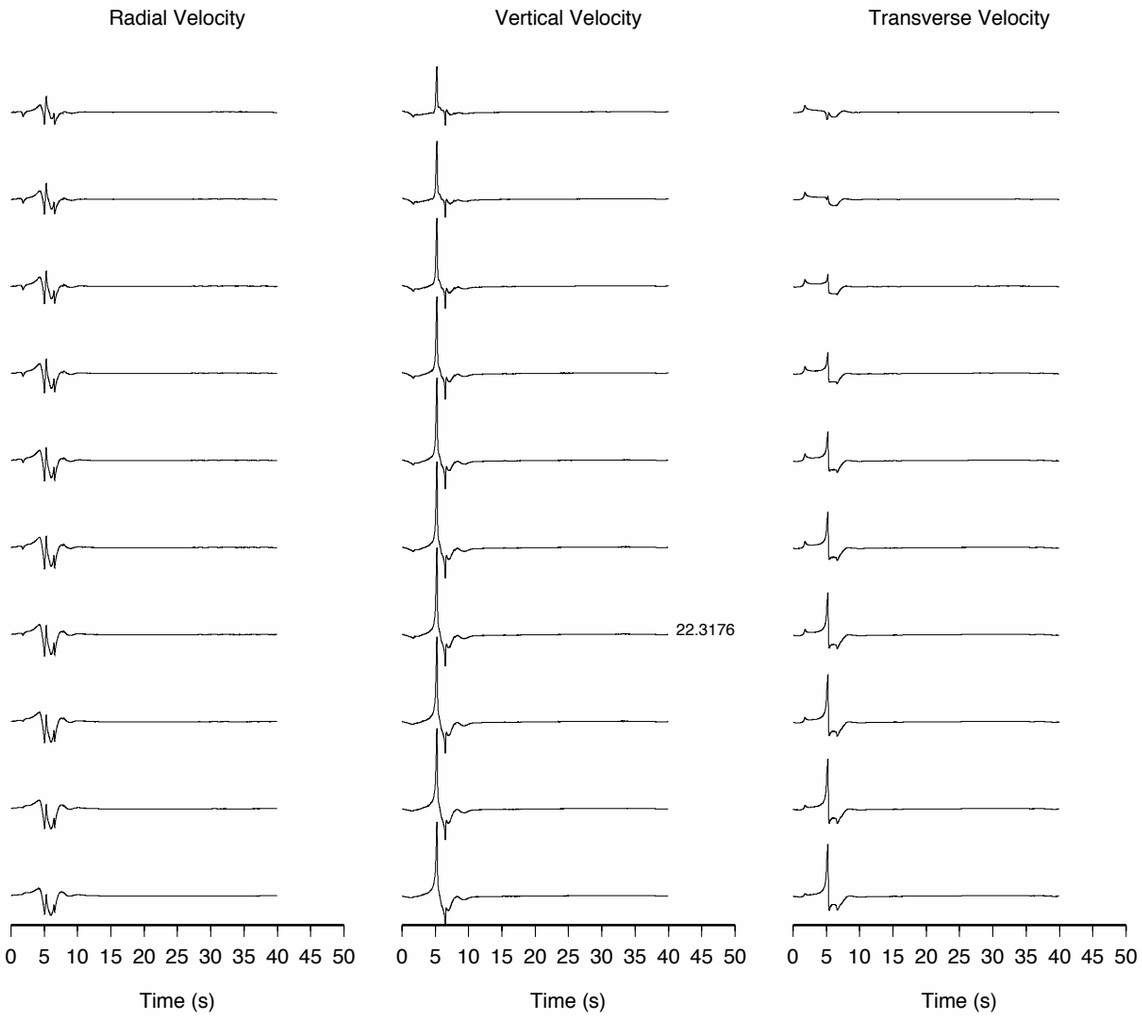
Methodology - Modal Summation Technique

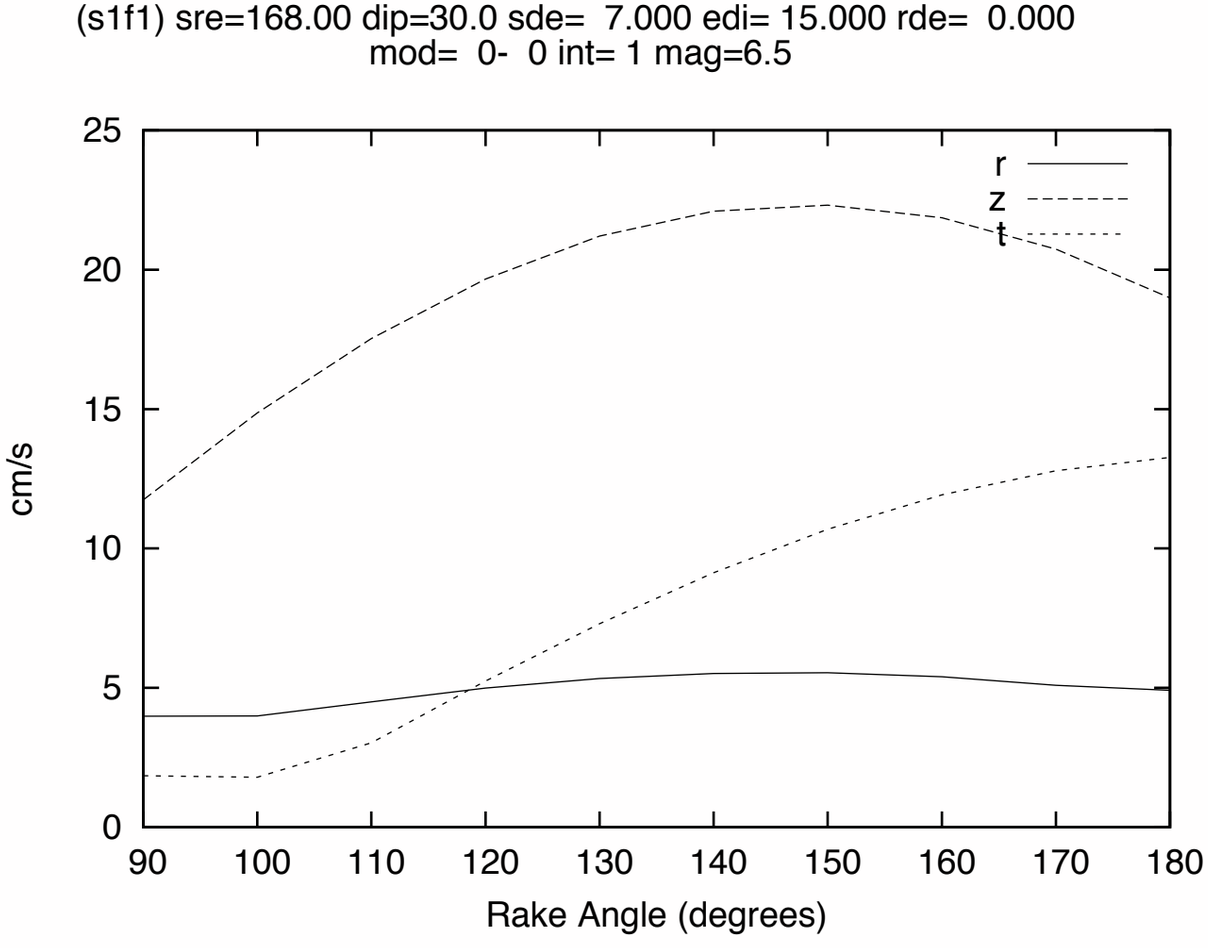
- Synthetic seismograms
- Parametric tests

$$u_y^L(x,z,\omega) = \sum_{m=1}^{\infty} \frac{e^{-i3\pi/4}}{\sqrt{8\pi\omega}} \frac{e^{-ik_m x}}{\sqrt{x}} \frac{\left(\chi_m^L(h_s,\omega)\right)}{\sqrt{c_m v_m I_m}} \frac{\left(F_y(z,\omega)\right)}{\sqrt{v_m I_m}}$$

$$u_x^R(x,z,\omega) = \sum_{m=1}^{\infty} \frac{e^{-i3\pi/4}}{\sqrt{8\pi\omega}} \frac{e^{-ik_m x}}{\sqrt{x}} \frac{\left(\chi_m^R(h_s,\omega)\right)}{\sqrt{c_m v_m I_m}} \frac{\left(F_x(z,\omega)\right)}{\sqrt{v_m I_m}}$$

$$u_z^R(x,z,\omega) = \sum_{m=1}^{\infty} \frac{e^{-i\pi/4}}{\sqrt{8\pi\omega}} \frac{e^{-ik_m x}}{\sqrt{x}} \frac{\left(\chi_m^R(h_s,\omega)\right)}{\sqrt{c_m v_m I_m}} \frac{\left(F_z(z,\omega)\right)}{\sqrt{v_m I_m}}$$

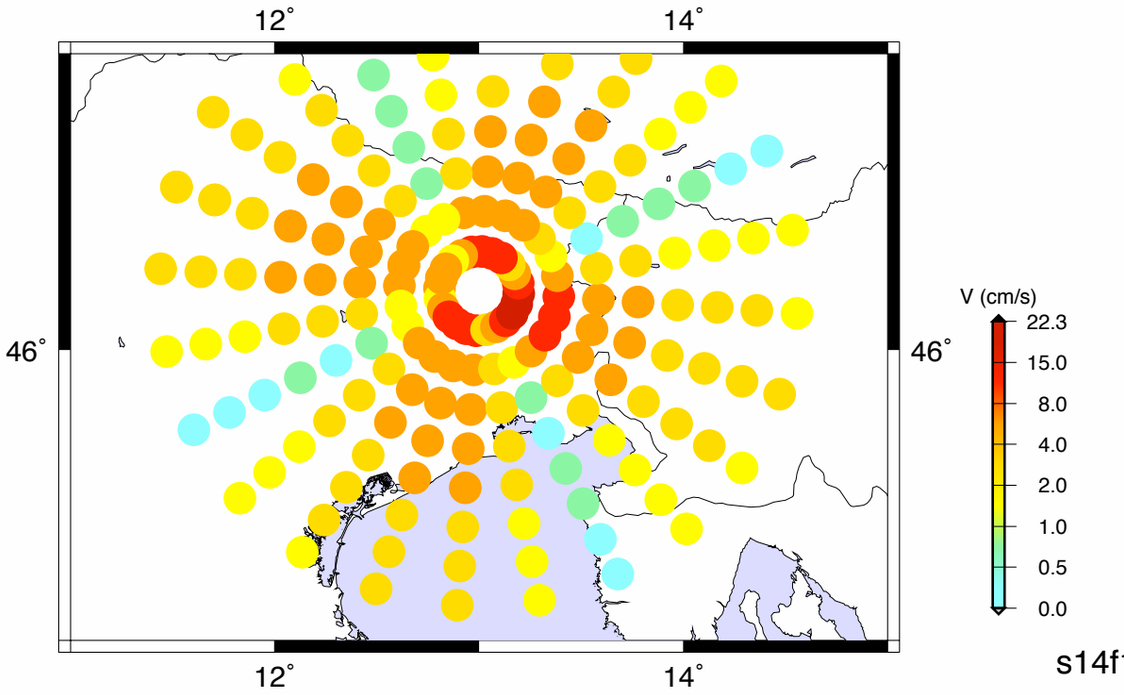




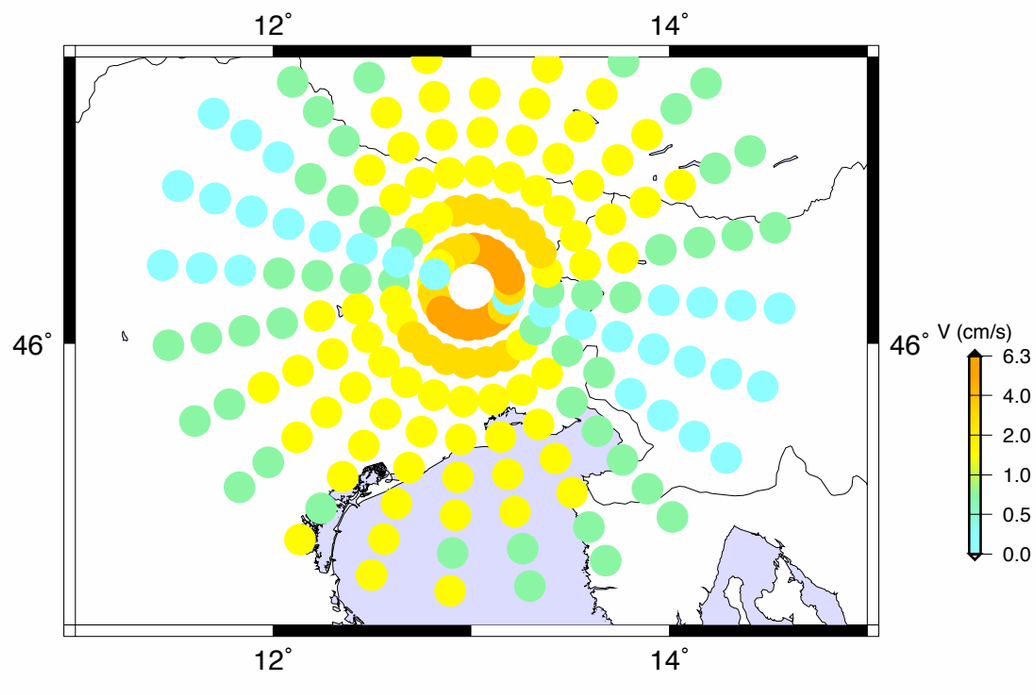
Regional Scale - Modal Summation Technique

Earthquake scenarios for single events

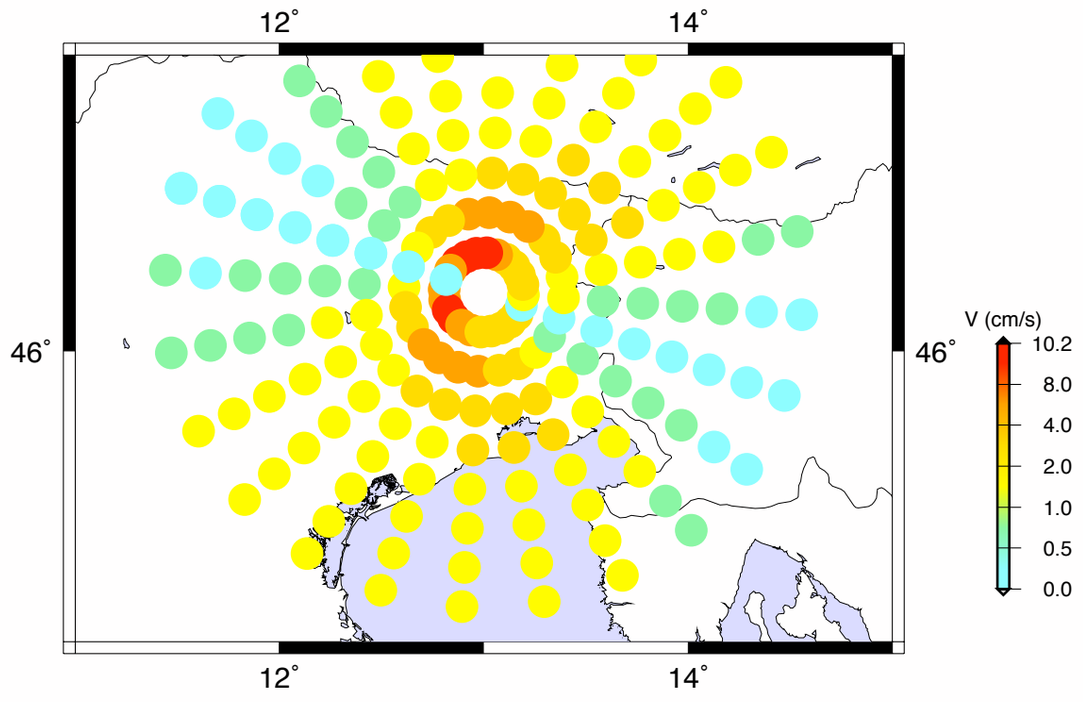
s14f1tra.amx



s14f1rad.amx

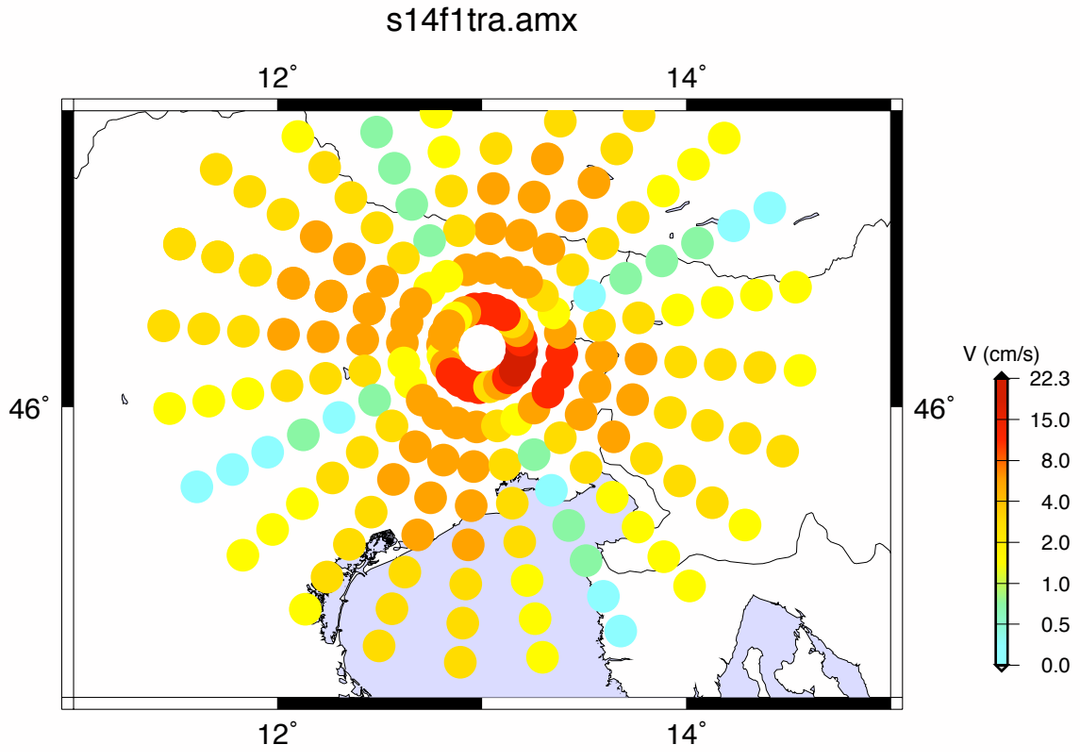


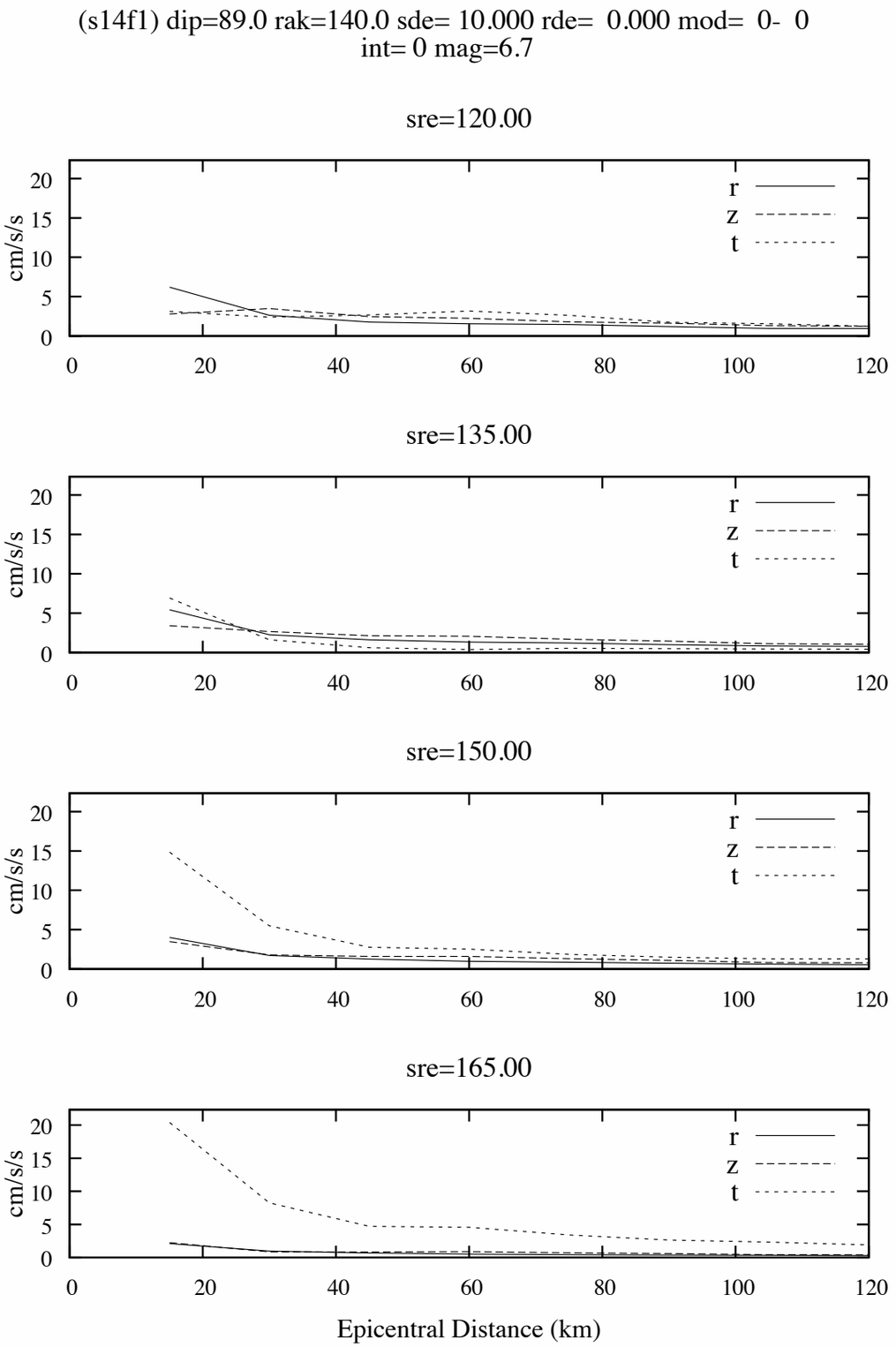
s14f1ver.amx



Regional Scale - Modal Summation Technique

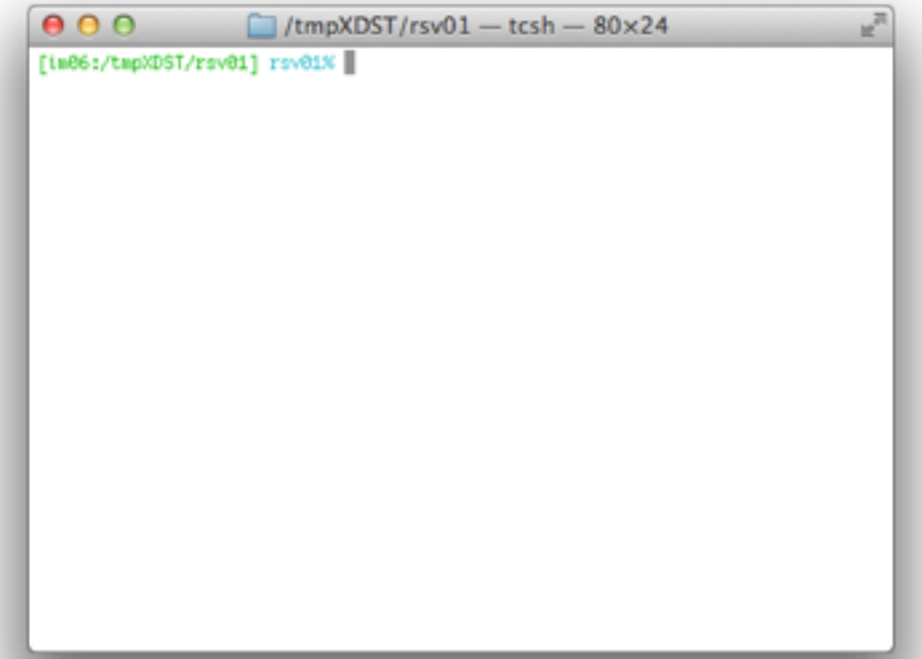
Earthquake scenarios



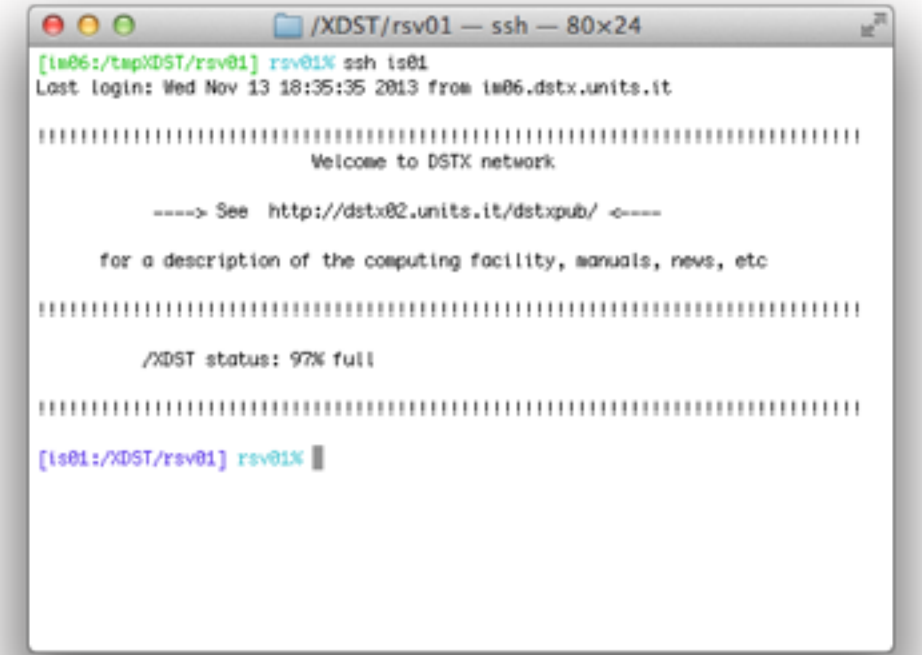


Computer exercises - Terminal

- Local computer

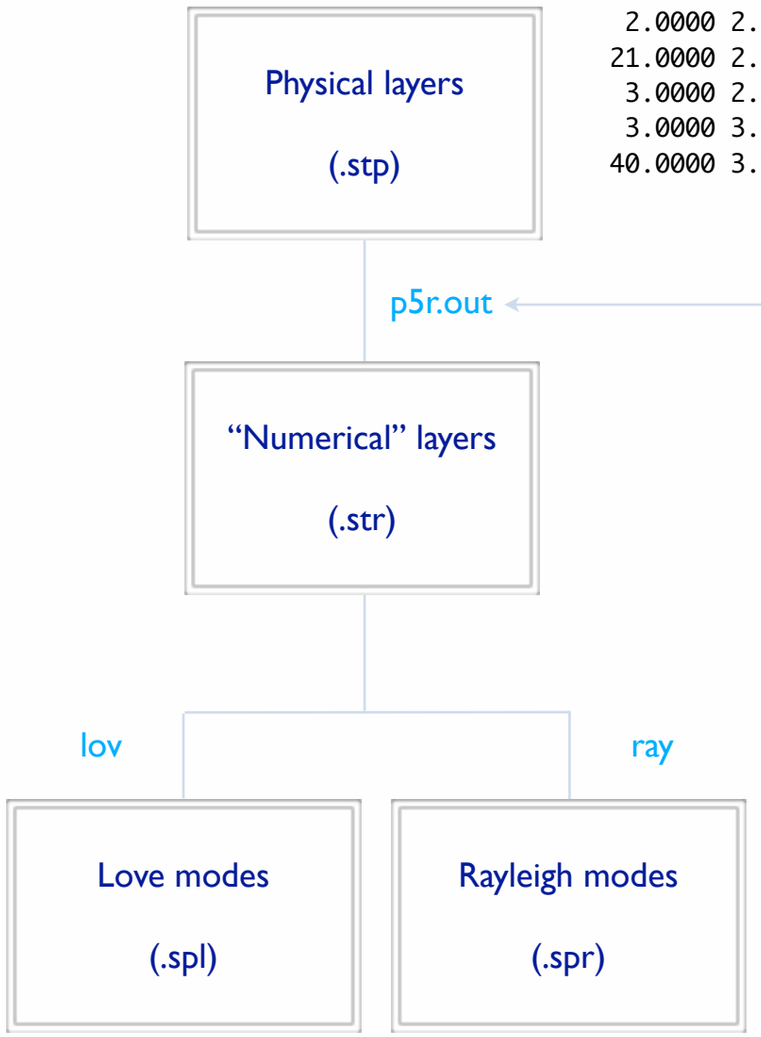


- Server (is01)



Computer exercises - Modes computation

```
thk(km) rho   Vp(km/s)  Vs(km/s)    Qp       Qs     depth(km) layer
 2.0000 2.80  4.800000  2.400000   399.99   199.99    2.00000   1
 2.0000 2.83  5.800000  3.300000   399.99   200.00    4.00000   2
 2.0000 2.84  6.200000  3.500000   400.01   200.00    6.00000   3
 8.0000 2.85  5.700000  3.300100   400.00   200.00   14.00000   4
 2.0000 2.86  6.200000  3.550000   400.01   200.00   16.00000   5
21.0000 2.87  6.500000  3.700000   400.00   200.00   37.00000   6
 3.0000 2.90  7.000000  4.000000   400.00   200.00   40.00000   7
 3.0000 3.10  7.500000  4.300000   399.99   200.00   43.00000   8
40.0000 3.35  8.100000  4.500000   400.00   200.00   83.00000   9
```

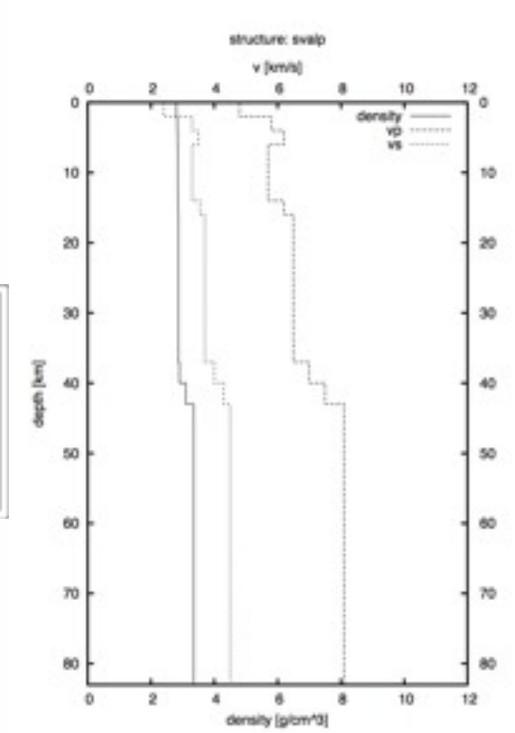



```
Parameters file for program p5r
0                                   reference structure (0 = none)
10.                                 max frequency (10 Hz or 1 Hz or 0.1 Hz)
4.50                                min velocity for halfspace (1Hz=6.42,10Hz=4.50)
0.                                  max depth (0=use vel; x=km,if in channel stay above)
1                                   split more at physical interfaces (0=no, 1=YES)
1                                   add num gradient to num layers (0=no, 1=YES)
1                                   take care of low-velocity channels (0=no, 1=YES)
2.0                                 largest Vs to split using wavelength (sugg. 2.0)
1.0                                 wavelength correction factor (suggested 1.0)
0                                   max depth for plotting (0=all)
svalp.stp                           physical layers first structure
```

Computer exercises - Modes computation

Physical layers

(.stp)



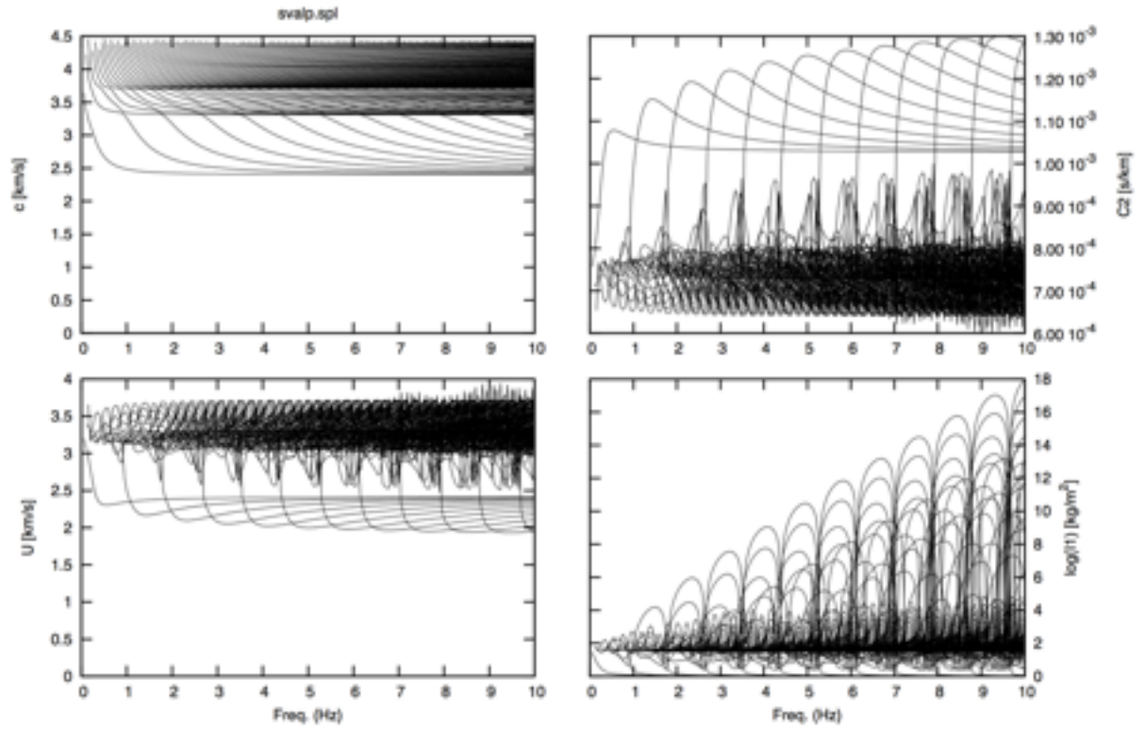
lov

p5r.out

ray

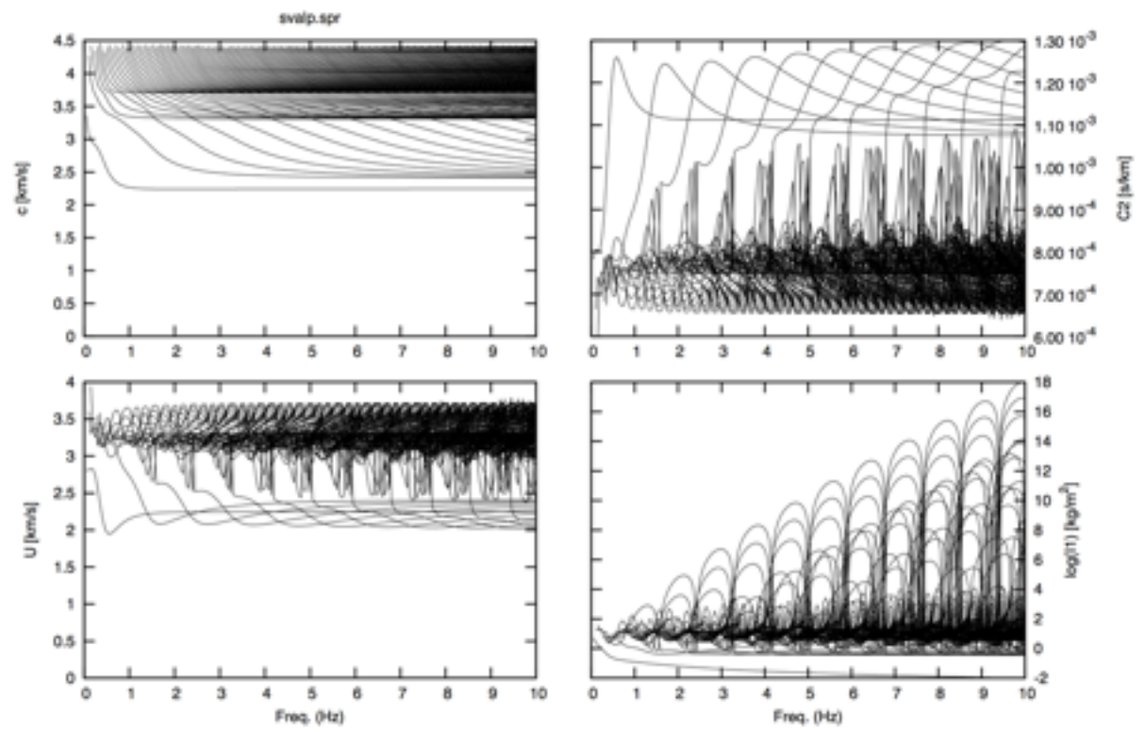
Love modes

(.spl)



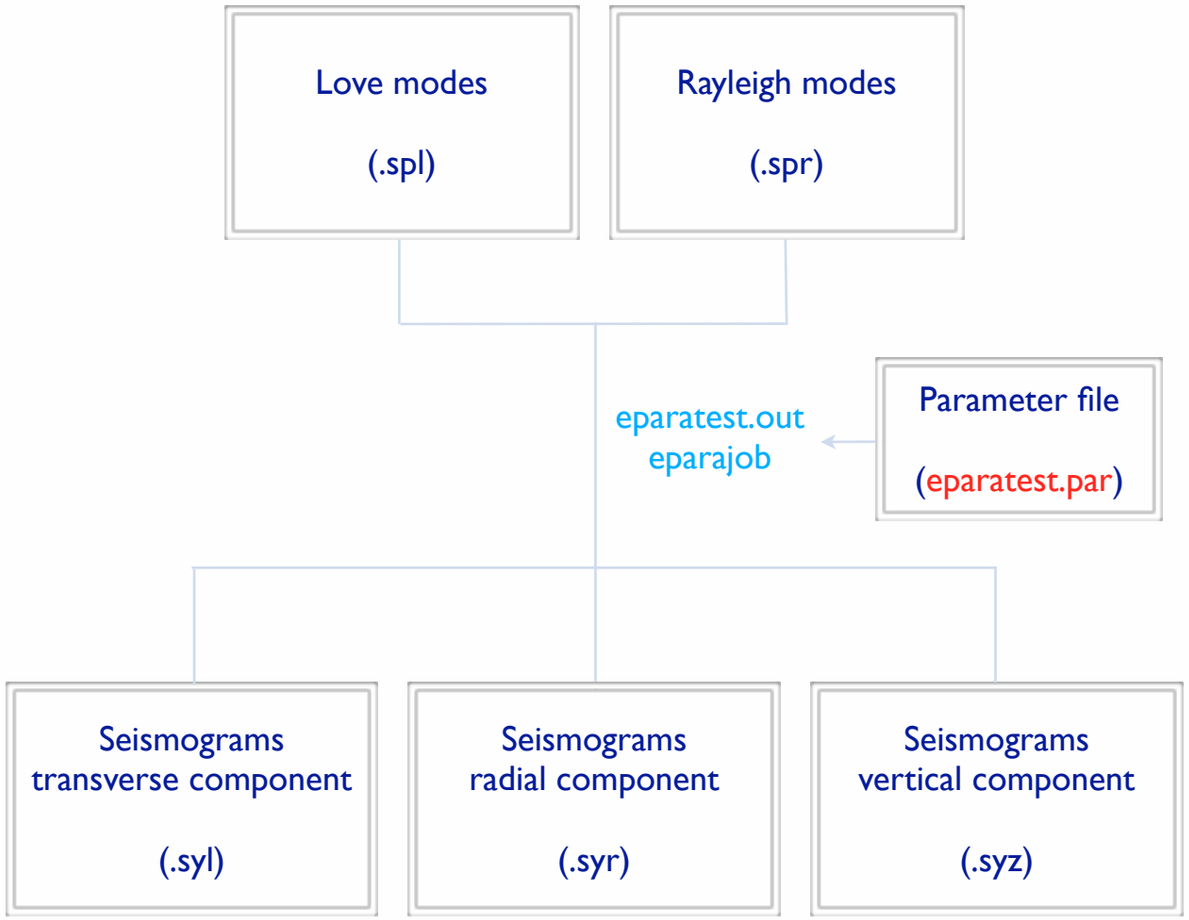
Rayleigh modes

(.spr)

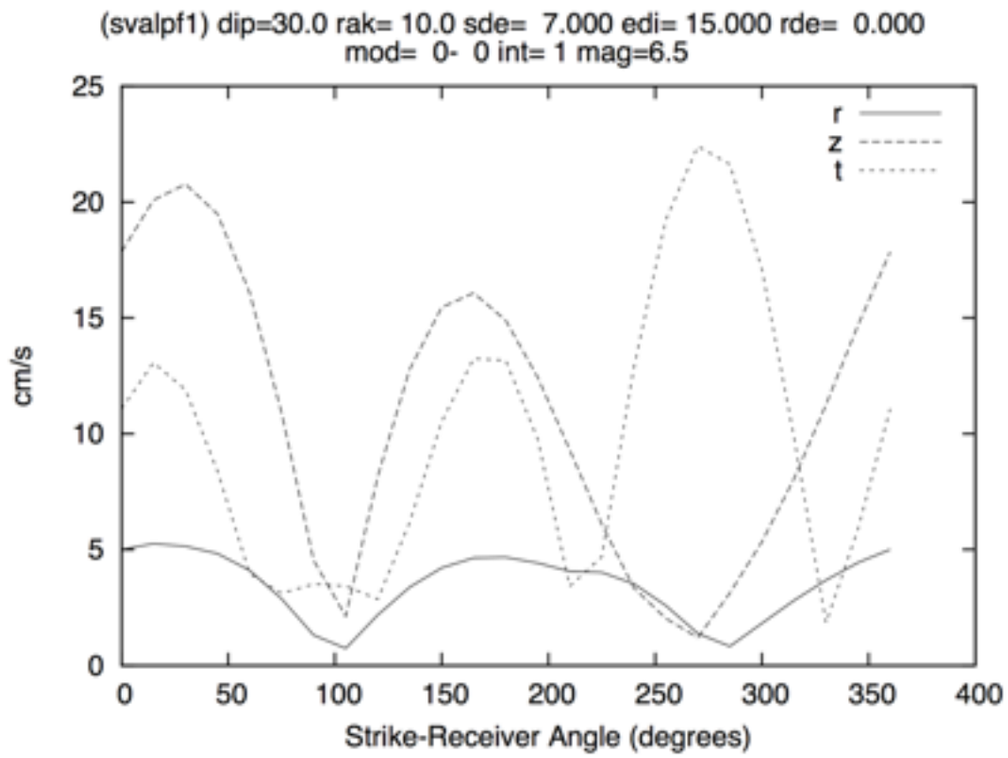


Computer exercises - Synthetic seismograms

Parametric tests

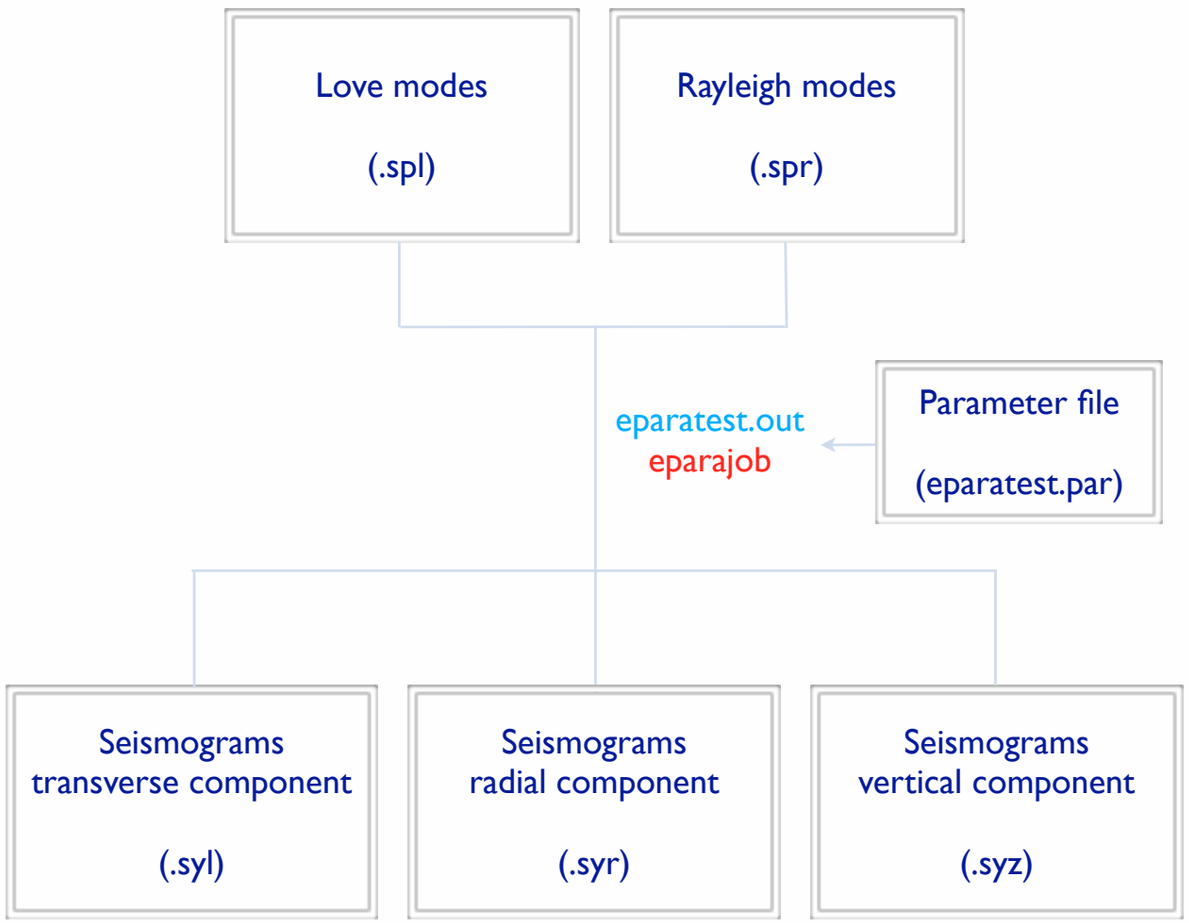



```
Parameter file for program eparatest
--------------------------------------------------------------------------------
svalp                 Test label (root for output filenames - 13 chars max)
0                     Ref. box for values not listed below (0=no, 13 chars max)
svalp.spl             Love spectrum file
svalp.spr             Rayleigh spectrum file
2                     Motion (1=displ, 2=vel, 3=acc)
50                    Time length for plot seismograms (s)
1  13.0 45.0 80       Source (1=point, 2=extended), lon, lat, strike (Nord)
SRE 1   0 360 15      Strike (loop 0=no,1=yes, start, stop, step) (Degrees)
DIP 0  30  90 10      Dip (loop 0=no,1=yes, start, stop, step) (Degrees)
RAK 0  10  40 10      Rake (loop 0=no,1=yes, start, stop, step) (Degrees)
SDE 0   7   9  1      Source Depth (loop 0=no/1=yes, start, stop, step) (km)
EDI 0  15 200 15      Epic. Distance (loop 0=no/1=yes, start, stop, step) (km)
RDE 0   0   3  1      Receiver Depth (loop 0=no/1=yes, start, stop, step) (km)
MOD 0   0   0  1      Modes (loop 0=no/1=yes, start, stop (step must be 1) )
INT 0   1  30  1      Interpolation (0-9) (flag 0=no,1=yes, start, stop, step)
MAG 0 6.5 7.0 .1      Magnitude (flag 0=no,1=yes, start, stop, step)
```



Computer exercises - Synthetic seismograms

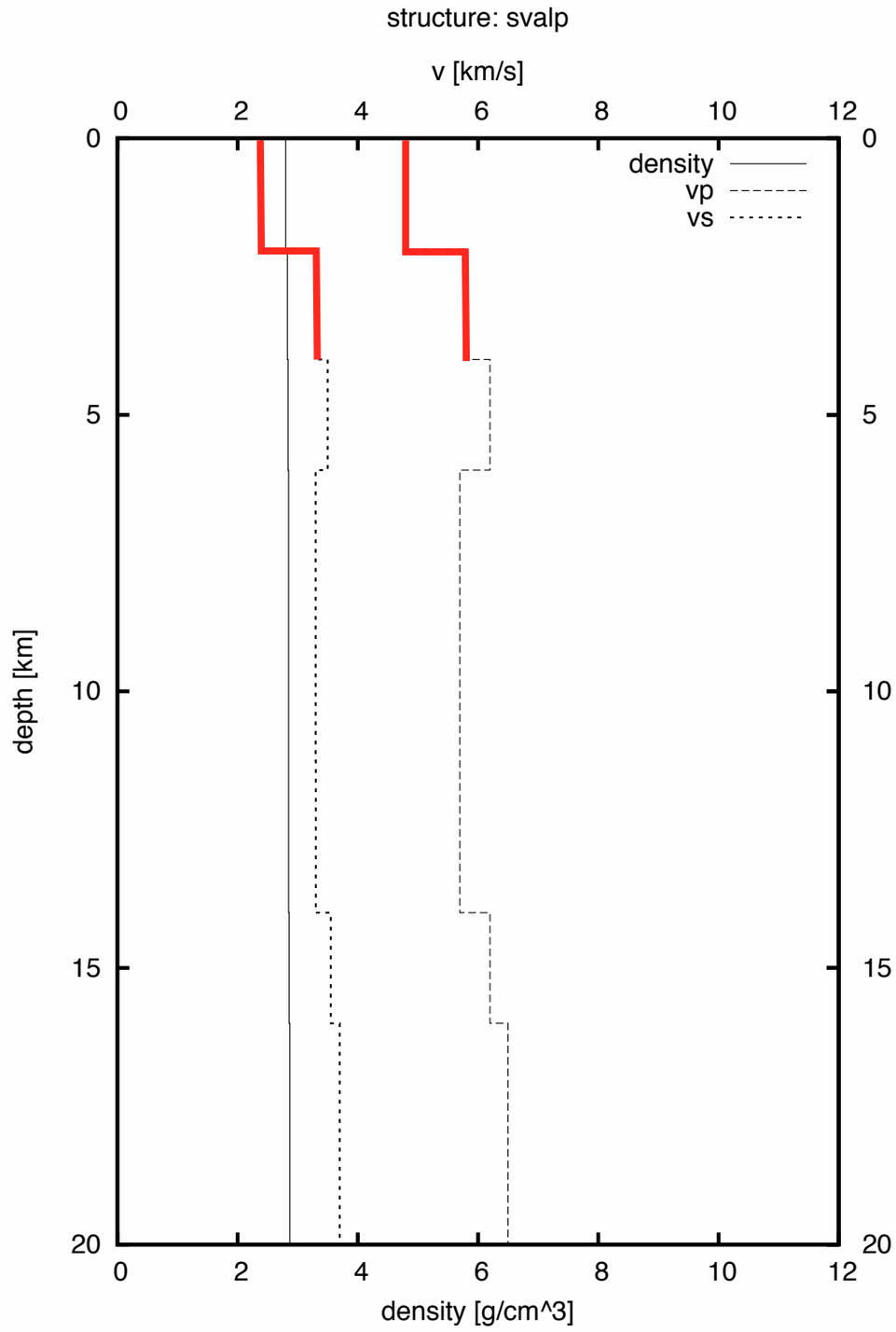
Parametric tests




```
#!/bin/bash
set -e
echo $$ > eparajob.pid
date>svalpparajob.pri
echo "Start of parajob job">>svalpparajob.pri
cp syr.cntl.r syr.cntl
echo "Computing Radial Component..."
syr0048.out
date>>svalpparajob.pri
echo "Radial Computed">>svalpparajob.pri
cp syr.cntl.z syr.cntl
echo "Computing Vertical Component..."
syr0048.out
date>>svalpparajob.pri
echo "Vertical Computed">>svalpparajob.pri
cp syl.cntl.t syl.cntl
echo "Computing Transverse Component..."
syl0048.out
date>>svalpparajob.pri
echo "Transverse Computed">>svalpparajob.pri
date>>svalpparajob.pri
echo "Scaling seismograms..."
efft.out
echo "Computing Resultant, NS and EW Components..."
rot.out
date>>svalpparajob.pri
cat tmploop | awk '{ print $1,$2 }'  > tmploopsel
grep amaxa svalpf1.syr | awk '{ print $8 }'  > tmpr
grep amaxa svalpf1.syz | awk '{ print $8 }'  > tmpz
grep amaxa svalpf1.syl | awk '{ print $8 }'  > tmpl
grep amaxa svalpf1.res | awk '{ print $9 }'  > tmpres
grep amaxa svalpf1.sns | awk '{ print $8 }'  > tmpsns
grep amaxa svalpf1.sew | awk '{ print $8 }'  > tmpsew
echo '#num sre  PGV rad   PGV ver   PGV tra   PGV res   PGV sns   PGV sew   dip=30.0
rak= 10.0 sde=  7.000 edi= 15.000 rde=  0.000\n\ mod=  0-  0 int= 1 mag=6.5' >
svalp.sta
paste tmploopsel tmpr tmpz tmpl tmpres tmpsns tmpsew >> svalp.sta
minmax -C tmpr | awk '{ print $2 }' > tmpsort
minmax -C tmpz | awk '{ print $2 }' >> tmpsort
minmax -C tmpl | awk '{ print $2 }' >> tmpsort
minmax -C tmpres | awk '{ print $2 }' >> tmpsort
minmax -C tmpsns | awk '{ print $2 }' >> tmpsort
minmax -C tmpsew | awk '{ print $2 }' >> tmpsort
MAX=`(cat tmpsort | sort -rn | head -1 )`
rm -f tmploop tmploopsel tmpr tmpz tmpl tmpres tmpsns tmpsew tmpsort *.plot
gnuplot svalp.sre.gplot
echo " "
sisplots.pl
echo "*** To plot the seismograms: gs svalp.sre.sis.*.ps"
echo "*** To plot the peak values: gs svalp.sre.ps"
echo " "
```

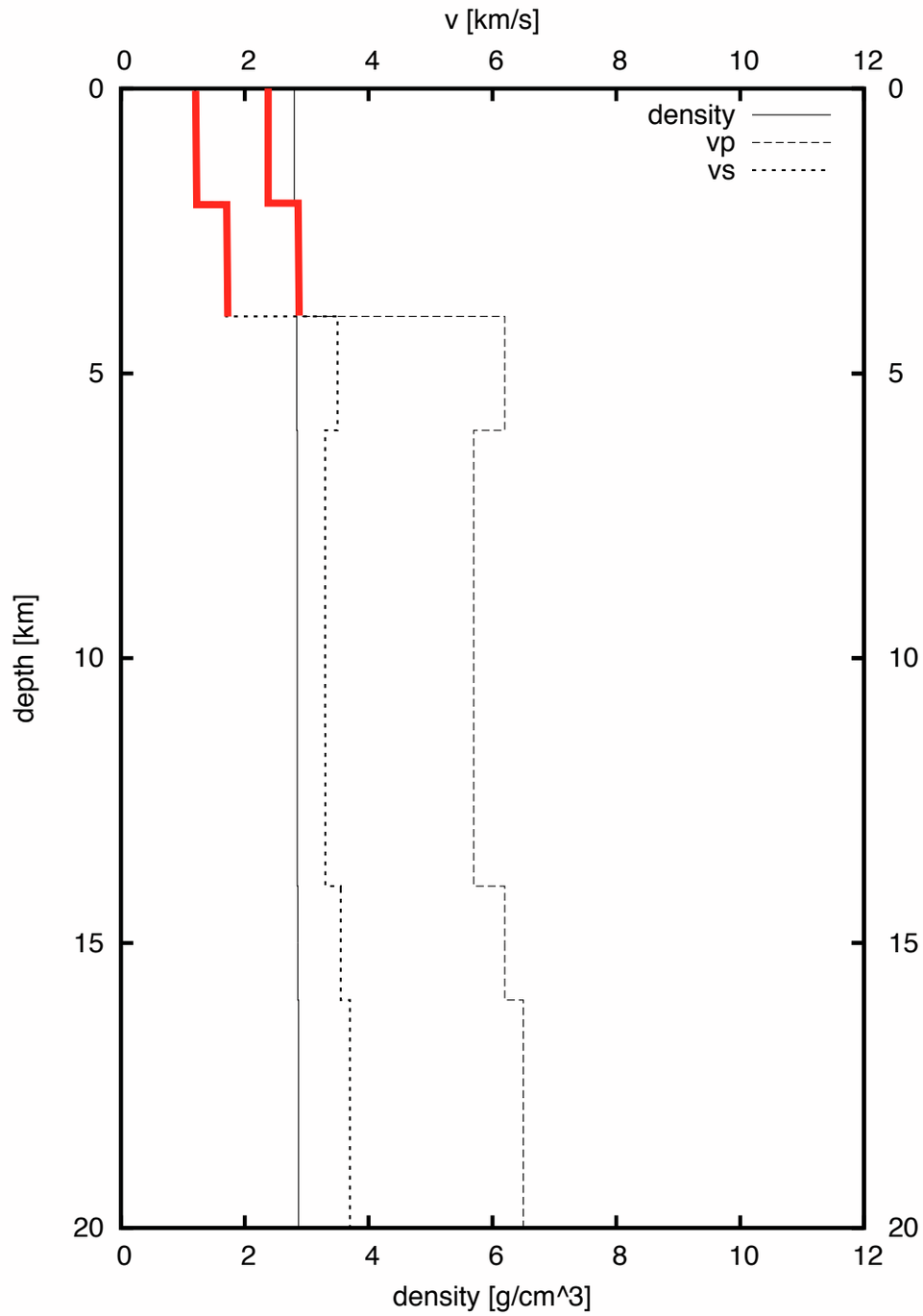
Computer exercises - Synthetic seismograms

Parametric tests



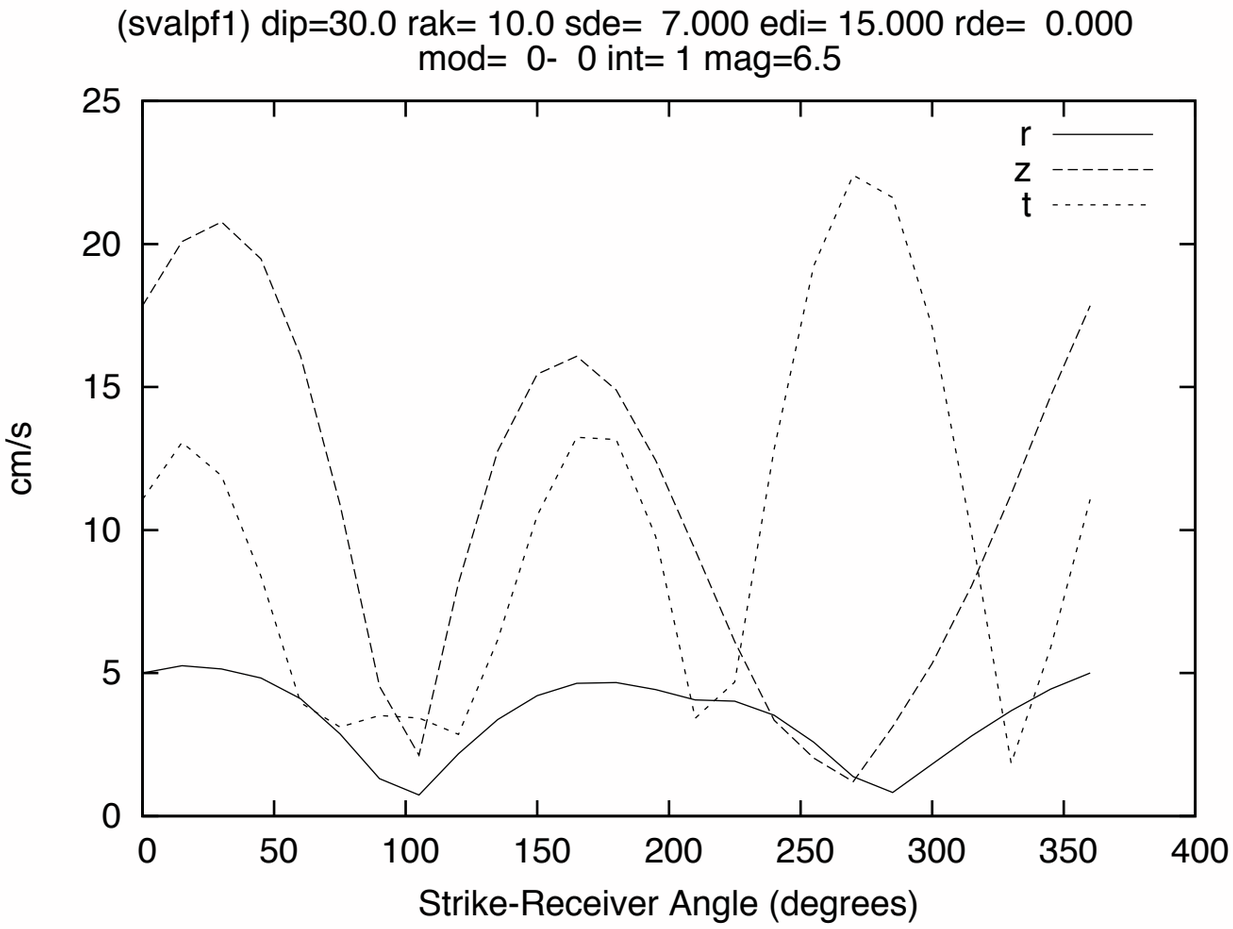
Computer exercises - Synthetic seismograms

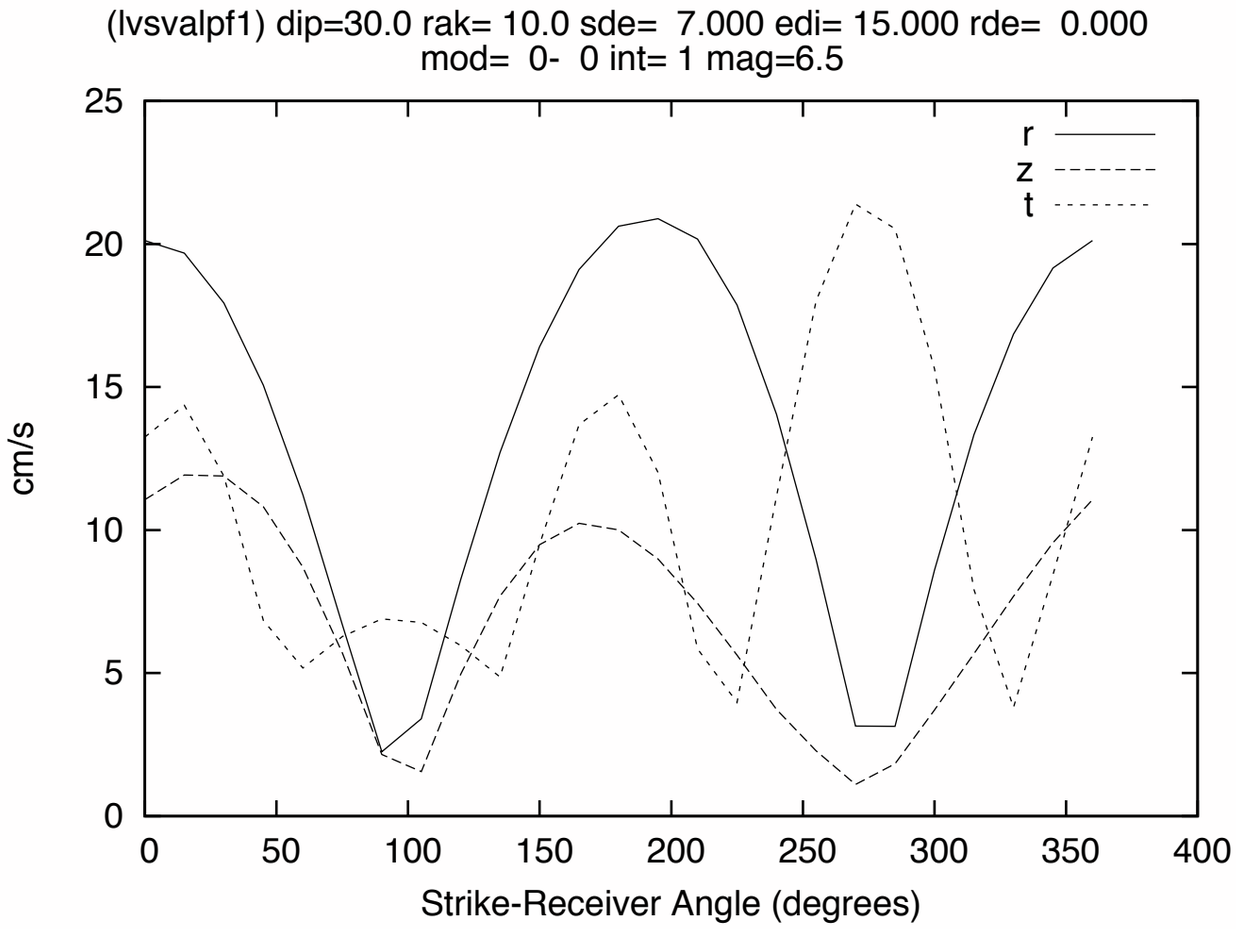
Parametric tests



Computer exercises - Synthetic seismograms

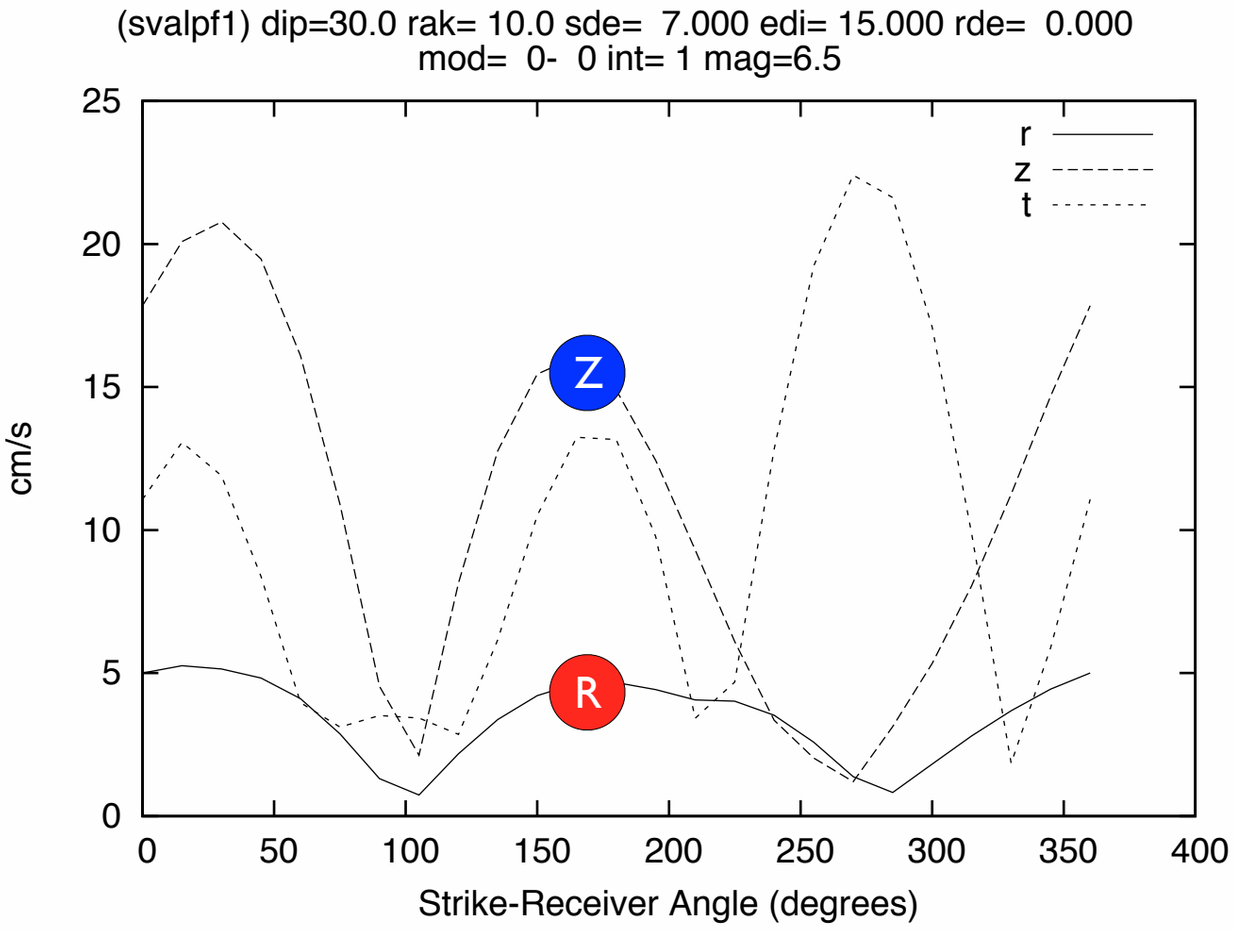
Parametric tests

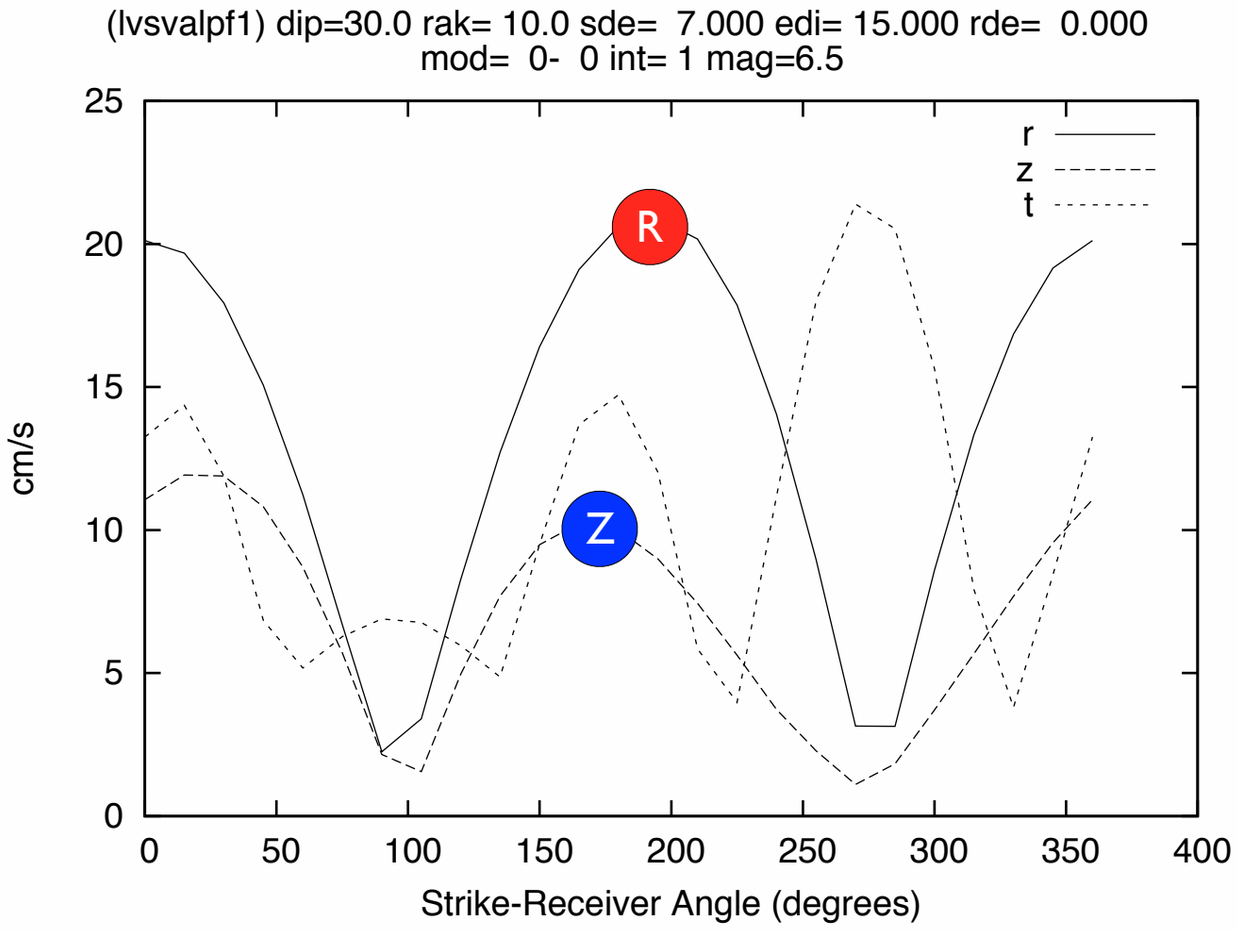


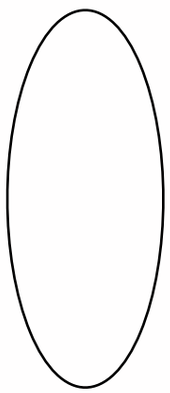


Computer exercises - Synthetic seismograms

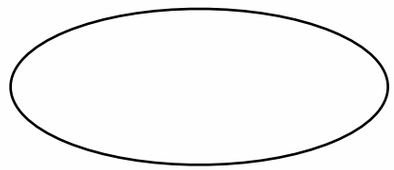
Parametric tests





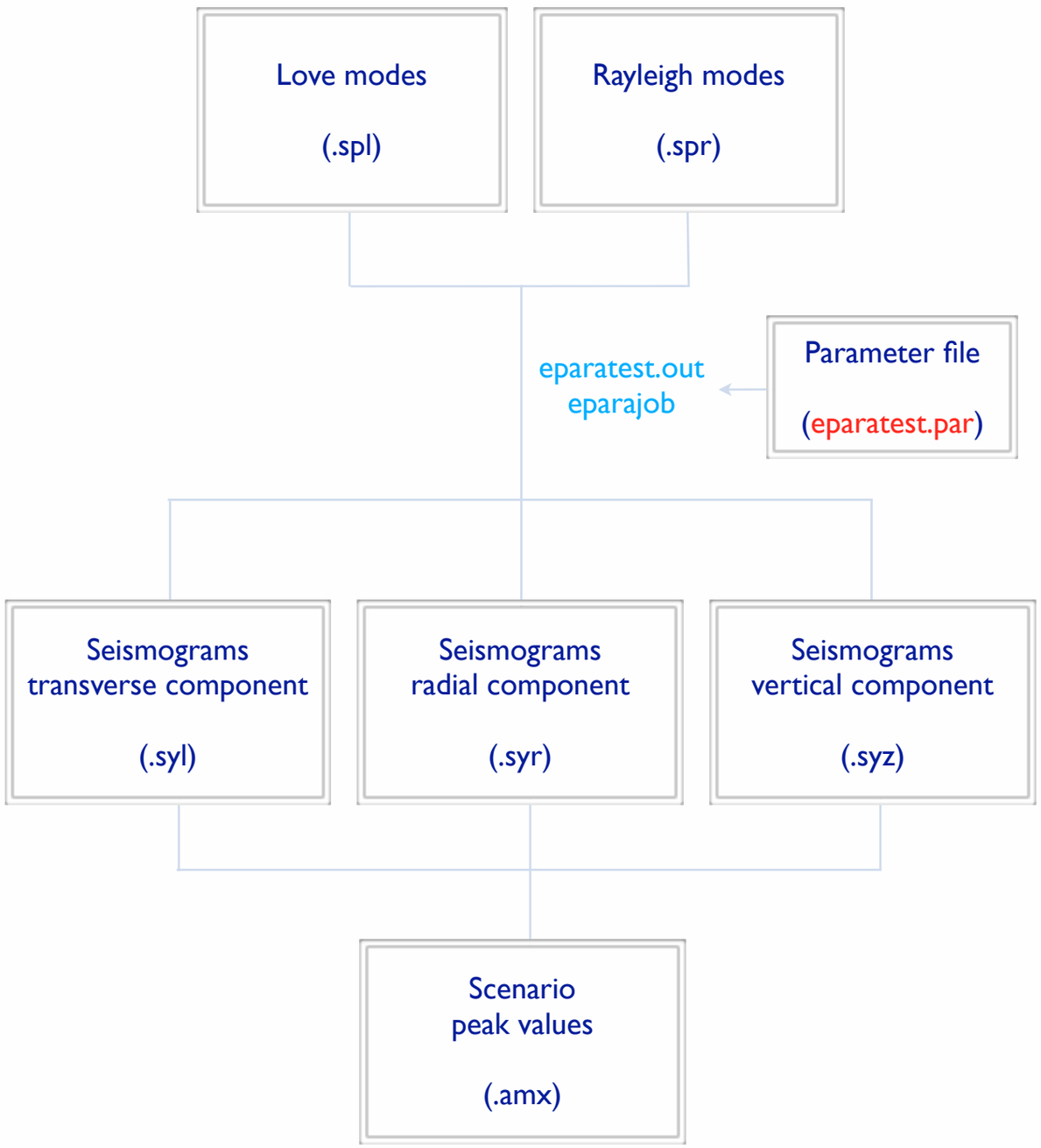


Ellipticity of Rayleigh waves particle motion

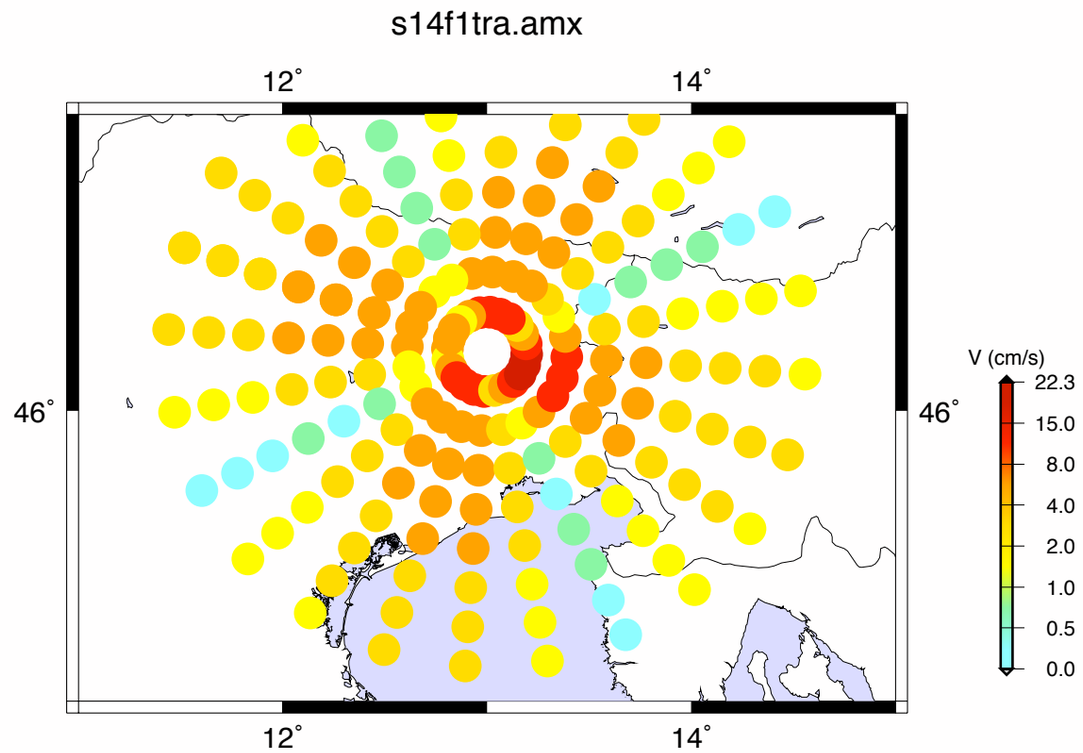


Computer exercises - Synthetic seismograms

Single event scenario




```
Parameter file for program eparatest
--------------------------------------------------------------------------------
test2                 Test label (root for output filenames - 13 chars max)
0                     Ref. box for values not listed below (0=no, 13 chars max)
z1d0014.spl           Love spectrum file
z1d0014.spr           Rayleigh spectrum file
2                     Motion (1=displ, 2=vel, 3=acc)
100                   Time length for plot seismograms (s)
1  13.0 46.2 289      Source (1=point, 2=extended), lon, lat, strike (Nord)
SRE 1   0 360 15      Strike (loop 0=no,1=yes, start, stop, step) (Degrees)
DIP 0  90  90 10      Dip (loop 0=no,1=yes, start, stop, step) (Degrees)
RAK 0 140  40 10      Rake (loop 0=no,1=yes, start, stop, step) (Degrees)
SDE 0  10   9  1      Source Depth (loop 0=no/1=yes, start, stop, step) (km)
EDI 2  15 120 15      Epic. Distance (loop 0=no/1=yes, start, stop, step) (km)
RDE 0   0   3  1      Receiver Depth (loop 0=no/1=yes, start, stop, step) (km)
MOD 0   0   0  1      Modes (loop 0=no/1=yes, start, stop (step must be 1) )
INT 0   0  30  1      Interpolation (0-9) (flag 0=no,1=yes, start, stop, step)
MAG 0 6.0 7.0 .1      Magnitude (flag 0=no,1=yes, start, stop, step)
```



Computer exercises - Synthetic seismograms

Single event scenario

```
#!/bin/bash
set -e
echo $$ > eparajob.pid
date>test2parajob.pri
echo "Start of parajob job">>test2parajob.pri
cp syr.cntl.r syr.cntl
echo "Computing Radial Component..."
syr0048.out
date>>test2parajob.pri
echo "Radial Computed">>test2parajob.pri
cp syr.cntl.z syr.cntl
echo "Computing Vertical Component..."
syr0048.out
date>>test2parajob.pri
echo "Vertical Computed">>test2parajob.pri
cp syl.cntl.t syl.cntl
echo "Computing Transverse Component..."
syl0048.out
date>>test2parajob.pri
echo "Transverse Computed">>test2parajob.pri
date>>test2parajob.pri
echo "Scaling seismograms..."
efft.out
echo "Computing Resultant, NS and EW Components..."
rot.out
date>>test2parajob.pri
cat tmploop | awk '{ print $1,$2,$6 }'  > tmploopsel
grep amaxa test2f1.syr | awk '{ print $8 }'  > tmpr
grep amaxa test2f1.syz | awk '{ print $8 }'  > tmpz
grep amaxa test2f1.syl | awk '{ print $8 }'  > tmpl
grep amaxa test2f1.res | awk '{ print $9 }'  > tmpres
grep amaxa test2f1.sns | awk '{ print $8 }'  > tmpsns
grep amaxa test2f1.sew | awk '{ print $8 }'  > tmpsew
echo '#num sre edi  PGV rad   PGV ver   PGV tra   PGV res   PGV sns   PGV sew   dip=90.0 rak=140.0 sde=
10.000 rde=  0.000 mod=  0-  0\n\ int= 0 mag=6.0' > test2.sta
paste tmploopsel tmpr tmpz tmpl tmpres tmpsns tmpsew >> test2.sta
echo 'amaxa values' > test2f1rad.amx.tmp
echo '    2 0.1000E+01 : file type and normalizing factor' >> test2f1rad.amx.tmp
echo 'MINLATITUDE MAXLATITUDE : min. and max. latitude  of the area' >> test2f1rad.amx.tmp
echo 'MINLONGITUD MAXLONGITUD : min. and max. longitude of the area' >> test2f1rad.amx.tmp
echo '0.00000E+00             : cell size' >> test2f1rad.amx.tmp
echo 'amaxa values' > test2f1tra.amx.tmp
echo '    2 0.1000E+01 : file type and normalizing factor' >> test2f1tra.amx.tmp
echo 'MINLATITUDE MAXLATITUDE : min. and max. latitude  of the area' >> test2f1tra.amx.tmp
echo 'MINLONGITUD MAXLONGITUD : min. and max. longitude of the area' >> test2f1tra.amx.tmp
echo '0.00000E+00             : cell size' >> test2f1tra.amx.tmp
echo 'amaxa values' > test2f1ver.amx.tmp
echo '    2 0.1000E+01 : file type and normalizing factor' >> test2f1ver.amx.tmp
echo 'MINLATITUDE MAXLATITUDE : min. and max. latitude  of the area' >> test2f1ver.amx.tmp
echo 'MINLONGITUD MAXLONGITUD : min. and max. longitude of the area' >> test2f1ver.amx.tmp
echo '0.00000E+00             : cell size' >> test2f1ver.amx.tmp
echo 'amaxa values' > test2f1res.amx.tmp
echo '    2 0.1000E+01 : file type and normalizing factor' >> test2f1res.amx.tmp
echo 'MINLATITUDE MAXLATITUDE : min. and max. latitude  of the area' >> test2f1res.amx.tmp
echo 'MINLONGITUD MAXLONGITUD : min. and max. longitude of the area' >> test2f1res.amx.tmp
echo '0.00000E+00             : cell size' >> test2f1res.amx.tmp
echo 'amaxa values' > test2f1sns.amx.tmp
echo '    2 0.1000E+01 : file type and normalizing factor' >> test2f1sns.amx.tmp
echo 'MINLATITUDE MAXLATITUDE : min. and max. latitude  of the area' >> test2f1sns.amx.tmp
echo 'MINLONGITUD MAXLONGITUD : min. and max. longitude of the area' >> test2f1sns.amx.tmp
echo '0.00000E+00             : cell size' >> test2f1sns.amx.tmp
echo 'amaxa values' > test2f1sew.amx.tmp
echo '    2 0.1000E+01 : file type and normalizing factor' >> test2f1sew.amx.tmp
echo 'MINLATITUDE MAXLATITUDE : min. and max. latitude  of the area' >> test2f1sew.amx.tmp
echo 'MINLONGITUD MAXLONGITUD : min. and max. longitude of the area' >> test2f1sew.amx.tmp
echo '0.00000E+00             : cell size' >> test2f1sew.amx.tmp
paste tmpmap tmpr >> test2f1rad.amx.tmp
paste tmpmap tmpl >> test2f1tra.amx.tmp
paste tmpmap tmpz >> test2f1ver.amx.tmp
paste tmpmap tmpres >> test2f1res.amx.tmp
paste tmpmap tmpsns >> test2f1sns.amx.tmp
paste tmpmap tmpsew >> test2f1sew.amx.tmp
MINLG=`(minmax -C tmpmap | awk '{ print $1 }')`
MAXLG=`(minmax -C tmpmap | awk '{ print $2 }')`
MINLT=`(minmax -C tmpmap | awk '{ print $3 }')`
MAXLT=`(minmax -C tmpmap | awk '{ print $4 }')`
sed 's/MINLATITUDE/'`echo $MINLT`'/g' test2f1rad.amx.tmp > test2f1rad.amx.tmp1
sed 's/MAXLATITUDE/'`echo $MAXLT`'/g' test2f1rad.amx.tmp1 > test2f1rad.amx.tmp2
sed 's/MINLONGITUD/'`echo $MINLG`'/g' test2f1rad.amx.tmp2 > test2f1rad.amx.tmp3
sed 's/MAXLONGITUD/'`echo $MAXLG`'/g' test2f1rad.amx.tmp3 > test2f1rad.amx
sed 's/MINLATITUDE/'`echo $MINLT`'/g' test2f1tra.amx.tmp > test2f1tra.amx.tmp1
sed 's/MAXLATITUDE/'`echo $MAXLT`'/g' test2f1tra.amx.tmp1 > test2f1tra.amx.tmp2
sed 's/MINLONGITUD/'`echo $MINLG`'/g' test2f1tra.amx.tmp2 > test2f1tra.amx.tmp3
sed 's/MAXLONGITUD/'`echo $MAXLG`'/g' test2f1tra.amx.tmp3 > test2f1tra.amx
sed 's/MINLATITUDE/'`echo $MINLT`'/g' test2f1ver.amx.tmp > test2f1ver.amx.tmp1
sed 's/MAXLATITUDE/'`echo $MAXLT`'/g' test2f1ver.amx.tmp1 > test2f1ver.amx.tmp2
sed 's/MINLONGITUD/'`echo $MINLG`'/g' test2f1ver.amx.tmp2 > test2f1ver.amx.tmp3
sed 's/MAXLONGITUD/'`echo $MAXLG`'/g' test2f1ver.amx.tmp3 > test2f1ver.amx
sed 's/MINLATITUDE/'`echo $MINLT`'/g' test2f1res.amx.tmp > test2f1res.amx.tmp1
sed 's/MAXLATITUDE/'`echo $MAXLT`'/g' test2f1res.amx.tmp1 > test2f1res.amx.tmp2
sed 's/MINLONGITUD/'`echo $MINLG`'/g' test2f1res.amx.tmp2 > test2f1res.amx.tmp3
sed 's/MAXLONGITUD/'`echo $MAXLG`'/g' test2f1res.amx.tmp3 > test2f1res.amx
sed 's/MINLATITUDE/'`echo $MINLT`'/g' test2f1sns.amx.tmp > test2f1sns.amx.tmp1
sed 's/MAXLATITUDE/'`echo $MAXLT`'/g' test2f1sns.amx.tmp1 > test2f1sns.amx.tmp2
sed 's/MINLONGITUD/'`echo $MINLG`'/g' test2f1sns.amx.tmp2 > test2f1sns.amx.tmp3
sed 's/MAXLONGITUD/'`echo $MAXLG`'/g' test2f1sns.amx.tmp3 > test2f1sns.amx
sed 's/MINLATITUDE/'`echo $MINLT`'/g' test2f1sew.amx.tmp > test2f1sew.amx.tmp1
sed 's/MAXLATITUDE/'`echo $MAXLT`'/g' test2f1sew.amx.tmp1 > test2f1sew.amx.tmp2
sed 's/MINLONGITUD/'`echo $MINLG`'/g' test2f1sew.amx.tmp2 > test2f1sew.amx.tmp3
sed 's/MAXLONGITUD/'`echo $MAXLG`'/g' test2f1sew.amx.tmp3 > test2f1sew.amx
rm -f tmpmap
rm -f test2f1rad.amx.tmp test2f1rad.amx.tmp1 test2f1rad.amx.tmp2 test2f1rad.amx.tmp3
rm -f test2f1tra.amx.tmp test2f1tra.amx.tmp1 test2f1tra.amx.tmp2 test2f1tra.amx.tmp3
rm -f test2f1ver.amx.tmp test2f1ver.amx.tmp1 test2f1ver.amx.tmp2 test2f1ver.amx.tmp3
rm -f test2f1res.amx.tmp test2f1res.amx.tmp1 test2f1res.amx.tmp2 test2f1res.amx.tmp3
rm -f test2f1sns.amx.tmp test2f1sns.amx.tmp1 test2f1sns.amx.tmp2 test2f1sns.amx.tmp3
rm -f test2f1sew.amx.tmp test2f1sew.amx.tmp1 test2f1sew.amx.tmp2 test2f1sew.amx.tmp3
hazcpt.out
sh hazgmt.sh test2f1rad.amx test2f1tra.amx test2f1ver.amx test2f1res.amx test2f1sns.amx test2f1sew.amx
minmax -C tmpr | awk '{ print $2 }' > tmpsort
minmax -C tmpz | awk '{ print $2 }' >> tmpsort
minmax -C tmpl | awk '{ print $2 }' >> tmpsort
minmax -C tmpres | awk '{ print $2 }' >> tmpsort
minmax -C tmpsns | awk '{ print $2 }' >> tmpsort
minmax -C tmpsew | awk '{ print $2 }' >> tmpsort
MAX=`(cat tmpsort | sort -rn | head -1 )`
sed 's/XXX/set yrange [0:'`echo $MAX`']/g' test2.plot > test2.gplot
rm -f tmploop tmploopsel tmpr tmpz tmpl tmpres tmpsns tmpsew tmpsort *.plot
gnuplot test2.gplot
echo " "
cp sisplots.par.rad sisplots.par
sisplots.pl
cp sisplots.par.ver sisplots.par
sisplots.pl
cp sisplots.par.tra sisplots.par
sisplots.pl
echo "*** To plot the seismograms: gs test2.sis.*.ps"
echo "*** To plot the peak values: gs test2.ps"
echo " "
echo "*** To plot the maps: gs test2f1*.amx.ps"
```

Computer exercises - Synthetic seismograms

Soil categories

A - *Formazioni litoidi o suoli omogenei molto rigidi* caratterizzati da valori di V_{S30} superiori a 800 m/s, comprendenti eventuali strati di alterazione superficiale di spessore massimo pari a 5 m.

B - *Depositi di sabbie o ghiaie molto addensate o argille molto consistenti*, con spessori di diverse decine di metri, caratterizzati da un graduale miglioramento delle proprietà meccaniche con la profondità e da valori di V_{S30} compresi tra 360 m/s e 800 m/s (ovvero resistenza penetrometrica $N_{SPT} > 50$, o coesione non drenata c_u>250 kPa).

C - *Depositi di sabbie e ghiaie mediamente addensate, o di argille di media consistenza*, con spessori variabili da diverse decine fino a centinaia di metri, caratterizzati da valori di V_{S30} compresi tra 180 e 360 m/s ($15 < N_{SPT} < 50$, $70 < c_u < 250$ kPa).

D - *Depositi di terreni granulari da sciolti a poco addensati oppure coesivi da poco a mediamente consistenti* , caratterizzati da valori di $V_{S30} < 180$ m/s ($N_{SPT} < 15$, c_u<70 kPa).

E - *Profili di terreno costituiti da strati superficiali alluvionali*, con valori di V_{S30} simili a quelli dei tipi C o D e spessore compreso tra 5 e 20 m, giacenti su di un substrato di materiale più rigido con $V_{S30} > 800$ m/s.

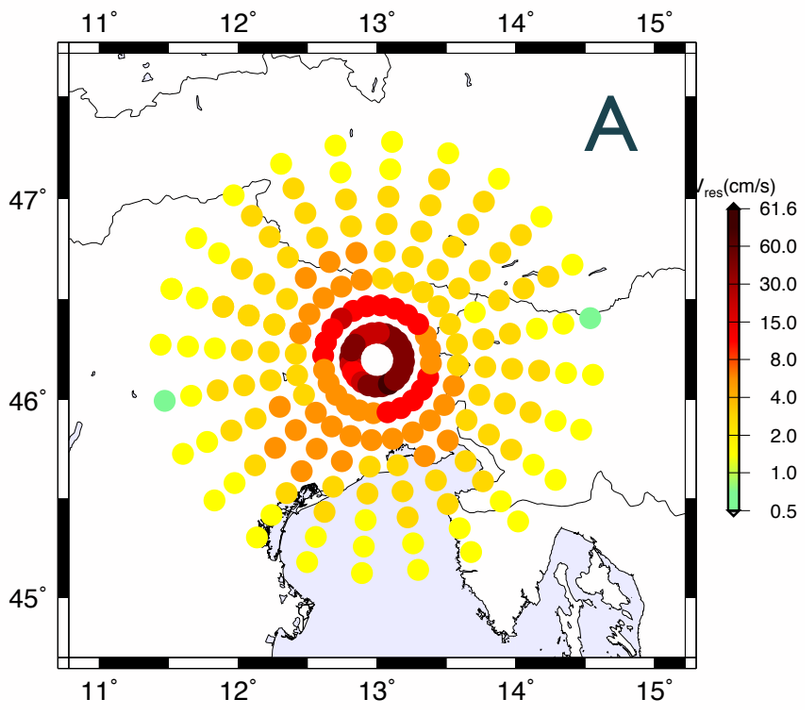
In aggiunta a queste categorie, per le quali nel punto 3.2 vengono definite le azioni sismiche da considerare nella progettazione, se ne definiscono altre due, per le quali sono richiesti studi speciali per la definizione dell'azione sismica da considerare:

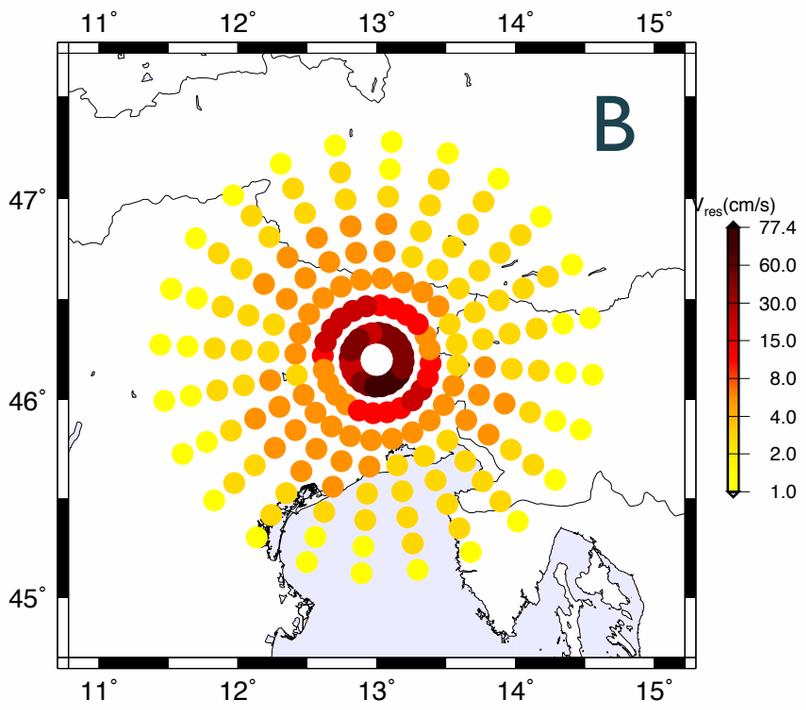
S1 - Depositi costituiti da, o che includono, uno strato spesso almeno 10 m di argille/limi di bassa consistenza, con elevato indice di plasticità (PI > 40) e contenuto di acqua, caratterizzati da valori di $V_{S30} < 100$ m/s ($10 < c_u < 20$ kPa)

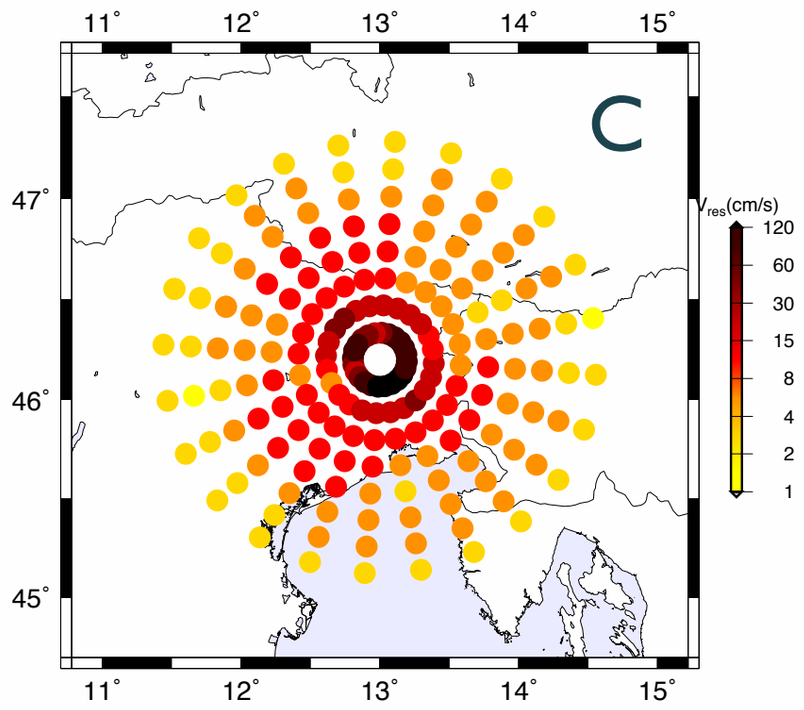
S2 - Depositi di terreni soggetti a liquefazione, di argille sensitive, o qualsiasi altra categoria di terreno non classificabile nei tipi precedenti

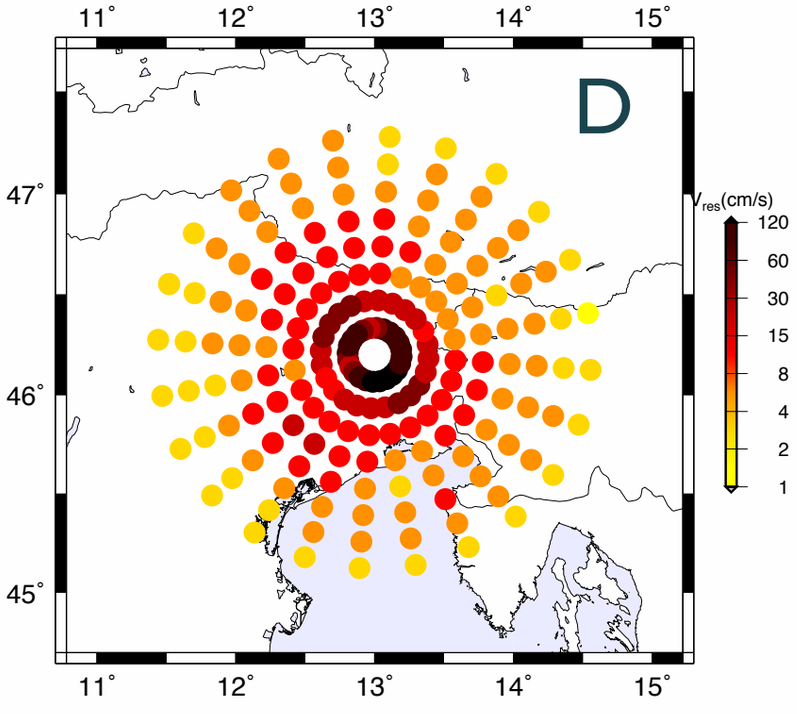
Computer exercises - Synthetic seismograms

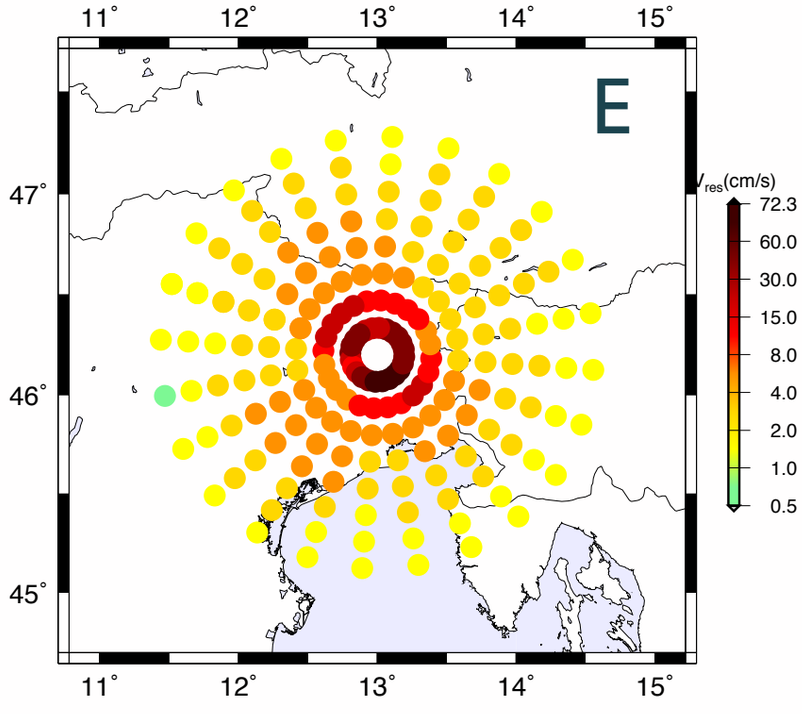
Single event scenario, parametric tests for soils A,B,C,D,E - low Q











Computer exercises - Synthetic seismograms

- Single event scenario, parametric tests for soils A,B,C,D,E - high Q