Notes on tomography studies in southern California,

with emphasis on the models used in SPECFEM3D_BASIN

Carl Tape
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This file: /home/carltape/latex/notes/socal_notes.tex
Matlab file: /home/carltape/matlab/scripts/socal1D.m

Contents

1 1D models for southern California

Kanamori and Hadley (1975); *Hadley and Kanamori* (1977); *Dreger and Helmberger* (1990); *Wald et al.* (1995)

See Table 1.

1.1 The Moho depth in the "standard" SoCal model

The depth for the Moho was listed as 37 km in *Dreger and Helmberger* (1990, 1991a), 35 km in *Dreger and Helmberger* (1991b, 1993), and 32 km in *Wald et al.* (1995), who noted: "The crustal model used in the routine processing of all southern California events, the Hadley–Kanamori model (*Hadley and Kanamori*, 1977), has knowingly been in error since 1977. It has had an incorrect Moho depth of 37 km instead of 32 km." The depth presently used in the routine processing is 32 km (Kate Hutton, personal communication, 05-July-2007). According to Don Helmberger (personal communication, 05-July-2007), the depth of 37 km listed in *Dreger and Helmberger* (1990, 1991a) "is wrong". Support for the 35 km depth can be found in *Dreger and Helmberger* (1991b, Figure 2), "which compares complete waveforms and has the SmS phase marked. At GSC the agreement is quite good, whereas at PFO observed SmS seems early and there also appears to be an initial Sn" (Doug Dreger via Brian Savage, email communication, 11-July-2007).

Thus, the depth of 32 km is considered "standard" and agrees with more recent receiver function results (Section 2.1), while the depth of 35 km is the preferred value used by Doug Dreger (see email below), and also what has been used in the 1D model implemented in `SPECFEM3D_BASIN`.

2 3D models for southern California

2.1 Moho topography in southern California

Hearn (1984); *Richards-Dinger and Shearer* (1997); *Zhu and Kanamori* (2000); *Yan and Clayton* (2007)

Zhu and Kanamori (2000, p. 2969): "Applying this technique to 84 digital broadband stations in southern California reveals that the Moho depth is 29 km on average and varies from 21 to 37 km."

2.2 Seismic velocity models

Regional models:

Hauksson (2000); *Magistrale et al.* (2000); *Süss and Shaw* (2003); *Yang and Forsyth* (2006); *Lin et al.* (2007)

Local models:

Hearn and Clayton (1986a,b); *Savage et al.* (2003); *Savage and Helmberger* (2004)

LA basin: *Zhao et al.* (2005)

2.2.1 Models derived from ocean microseisms

Background papers: *Shapiro and Campillo* (2004); *Sabra et al.* (2005a)

Results: *Shapiro et al.* (2005); *Sabra et al.* (2005b)

2.3 Simulations

Komatitsch et al. (2004); *Liu et al.* (2004); *Liu and Tromp* (2006)

Sources: *Clinton et al.* (2006)

3 The models used in SPECFEM3D_BASIN

3.1 1D model

The Socal-1D model used in SPECFEM3D_BASIN is specified according to the following parameters. From constants.h, we have:

```
! layers in the So-Cal regional model
  double precision, parameter :: DEPTH_5p5km_SOCAL = -5500.d0
  double precision, parameter :: DEPTH_16km_SOCAL = -16000.d0
  double precision, parameter :: DEPTH_MOHO_SOCAL = -35000.d0
```

and from Par_file we have

```
DEPTH_BLOCK_KM = 60.d0
```

3.1.1 subroutine socal_model.f90

The flag parameters are specified in constants.h:

```
! define flag for elements
  integer, parameter :: IFLAG_ONE_LAYER_TOPOGRAPHY = 1
  integer, parameter :: IFLAG_BASEMENT_TOPO = 2
  integer, parameter :: IFLAG_16km_BASEMENT = 3
  integer, parameter :: IFLAG_MOHO_16km = 4
  integer, parameter :: IFLAG_HALFSPACE_MOHO = 5
```

The subroutine is presently (28-June-2007) based on the model listed in *Dreger and Helmberger* (1991b)[1]:

```
  subroutine socal_model(idoubling,rho,vp,vs)

  implicit none

  include "constants.h"

  integer idoubling
  double precision rho,vp,vs

  if(idoubling == IFLAG_HALFSPACE_MOHO) then
        vp=7.8d0
        vs=4.5d0
        rho=3.0d0

  else if(idoubling == IFLAG_MOHO_16km) then
        vp=6.7d0
        vs=3.87d0
        rho=2.8d0

  else if(idoubling == IFLAG_ONE_LAYER_TOPOGRAPHY .or. idoubling == IFLAG_BASEMENT_TOPO) then
        vp=5.5d0
        vs=3.18d0
```

[1] *Dreger and Helmberger* (1991b) specify a 35 km depth for the Moho, whereas *Dreger and Helmberger* (1990) list 37 km; see Table 1.

```
      rho=2.4d0

  else
      vp=6.3d0
      vs=3.64d0
      rho=2.67d0
  endif

! scale to standard units
  vp = vp * 1000.d0
  vs = vs * 1000.d0
  rho = rho * 1000.d0

  end subroutine socal_model
```

3.2 3D model

Table 1: Various published versions of southern California 1D models. Here we take the bottom of the domain to be 60 km, the depth used in the 3D simulations for southern California.

layer	top m	bottom m	thickness m	α m s^{-1}	β m s^{-1}	ρ kg m^{-3}	Reference
1	0	5500	5500	5500	3180	2400	*Dreger and Helmberger* (1990)
2	5500	16000	10500	6300	3640	2670	*Dreger and Helmberger* (1990)
3	16000	32000	16000	6700	3870	2800	*Dreger and Helmberger* (1990)
4	†32000	60000	28000	7800	4500	3000	*Dreger and Helmberger* (1990)
1	0	5500	5500	5500	—	—	*Wald et al.* (1995)
2	5500	16000	10500	6300	—	—	*Wald et al.* (1995)
3	16000	32000	16000	6700	—	—	*Wald et al.* (1995)
4	32000	60000	28000	7800	—	—	*Wald et al.* (1995)
1	0	4000	4000	5500	—	—	*Kanamori and Hadley* (1975)
2	4000	27400	23400	6300	—	—	*Kanamori and Hadley* (1975)
3	27400	32400	5000	6800	—	—	*Kanamori and Hadley* (1975)
4	32400	60000	27600	7800	—	—	*Kanamori and Hadley* (1975)

†See Section 1.1. The depth for the Moho was listed as 37 km in *Dreger and Helmberger* (1990, 1991a), 35 km in *Dreger and Helmberger* (1991b, 1993), and 32 km in *Wald et al.* (1995).

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