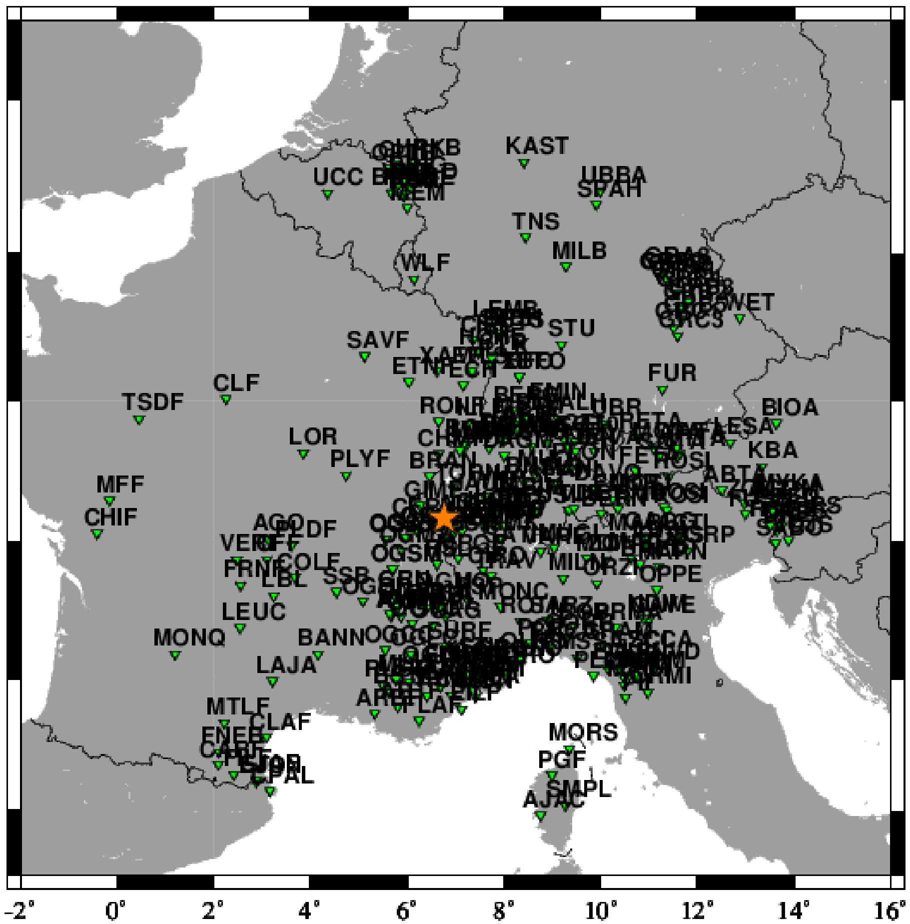
Analyse du séisme du 28 mai 2019 à 08h48 UTC de Ml 4.2

Haute-Savoie proche de Thonons-les-Bains, Abondance,
Montreux, frontière avec la Suisse

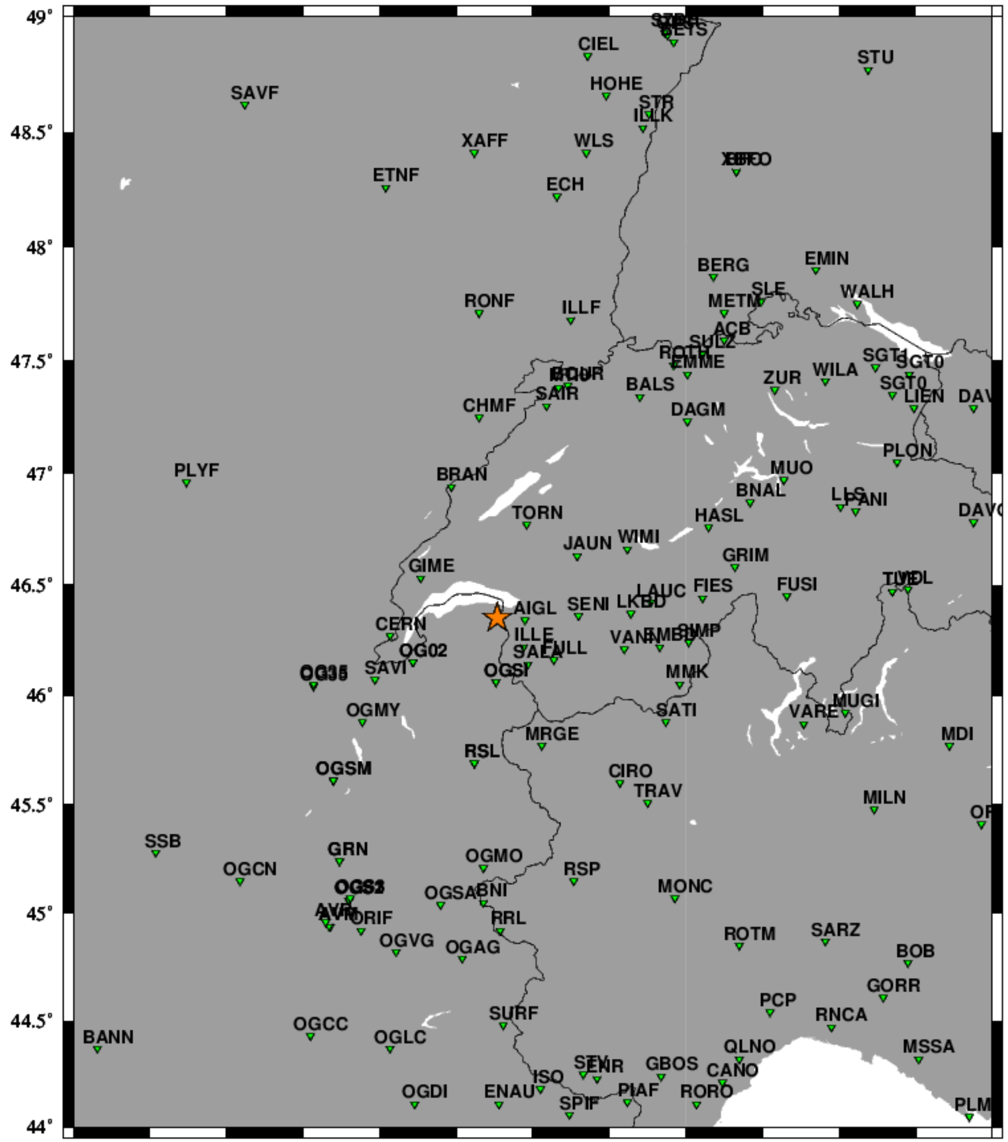
Bertrand Delouis, Géoazur, 29 mai 2019

Avec étude de l'impact de l'incertitude sur le modèle de vitesse

- Inversion de la localisation hypocentrale avec différents modèles de vitesse
- Inversion des formes d'ondes FMNEAR avec filtrage ajusté manuellement et deux modèles de vitesse



52°
50°
48°
46°
44°
42°
-2°
0°
2°
4°
6°
8°
10°
12°
14°
16°
KAST
UBBA
SPAH
UCC
TNS
MILB
WLF
STU
SAVF
CLF
TSDF
LOR
PLYF
MFF
CHIF
FUR
BIOA
KBA
LESA
MONQ
LEUC
LAJA
BANN
MTLF
CLAF
MORS
PGF
SMPL
OPPE



49°
48.5°
48°
47.5°
47°
46.5°
46°
45.5°
45°
44.5°
44°
4°
4.5°
5°
5.5°
6°
6.5°
7°
7.5°
8°
8.5°
9°
9.5°
10°
CIEL
STU
SAVF
HOHE
XAFF
WLS
ETNF
ECH
BERG
EMIN
RONF
ILLF
METM
SLE
WALH
ACB
SULZ
BALS
ZUR
WILA
CHMF
DAGM
PLYF
BRAN
MUO
BNAL
TORN
HASL
JAUN
WIMI
GRIM
GIME
FUSI
AIGL
SENI
LKBD
FIES
CERN
ILLE
SAVI
OGMY
VARE
MUGI
MDI
MRGE
RSL
OGSM
CIRO
TRAV
MILN
SSB
GRN
OGCN
OGMO
RSP
MONC
ORIF
OGVG
OGAG
RRL
ROTM
SARZ
BOB
GORR
PCP
RNCA
BANN
OGCC
OGLC
SURF
QLNO
MSSA
CANO
OGDI
ENAU
ISO
GBOS
RORO
SPIF
PIAF

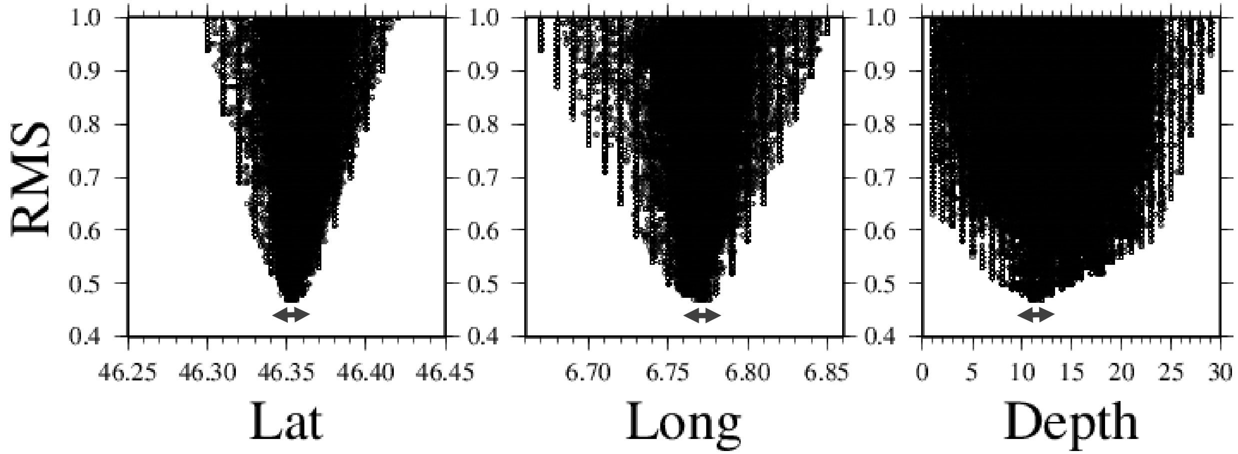
Inversion of P and S arrival times for lat, long, depth, and T0 combining a grid search, simulated annealing, and HYPOINVERSE-2000 (Klein, 2002), testing a series of velocity models with varying velocity gradient (Vp_top and Vp_base in the crust), Moho depth (35, 40, 45 km), and the Vp/Vs ratio (1.70, 1.73, 1.76)

Vp mantle fixed to 7.9 km/s

Distance weighting: weight is 1 if dist < 70 km, then weight decreases until reaching 0 for dist ≥ 420 km

Weighted phases retained:
97 P + 66 S

Graphs combining localisations obtained with 81 velocity models



Best solution found:

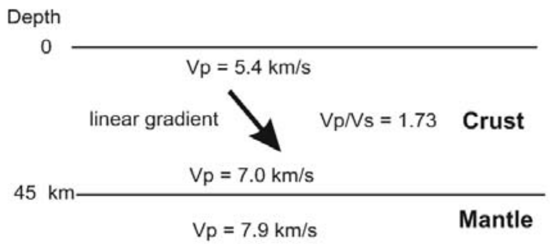
Lat: 46.350 Lon: 6.769 Depth: 12 km

T0: 5.4s RMS_{LOC}: 0.47s

Vp_top, Vp_base, depth_moho

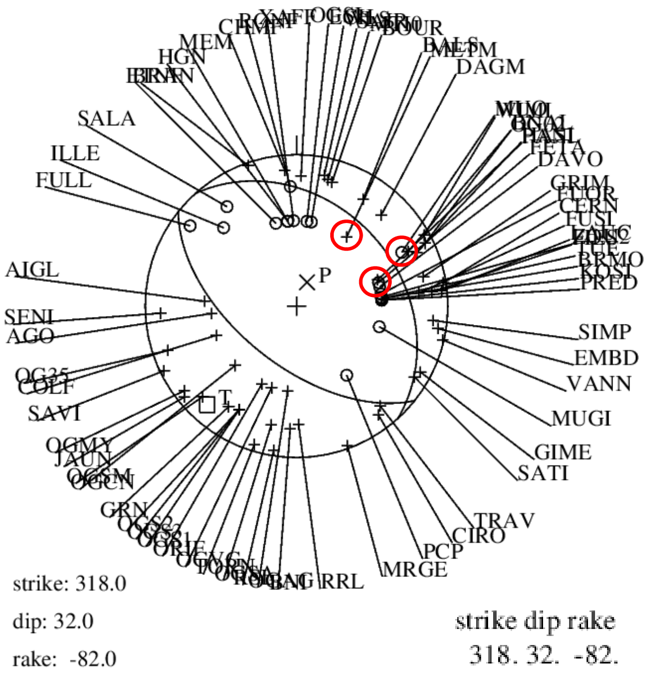
5.40 km/s 7.00 km/s 45.0 km

best Vp/Vs= 1.73

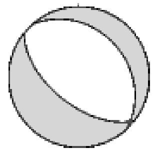


Focal mechanism from P first motions **With the best depth found, 12 km** (RMS_{loc} = 0.47)

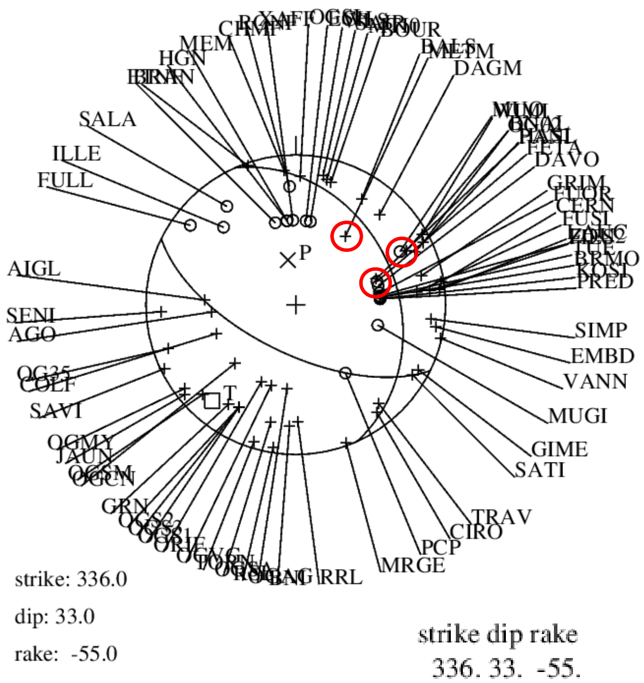
Sol FM 1



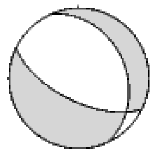
Plan 2:
Strike 129
Dip 58
Rake -95



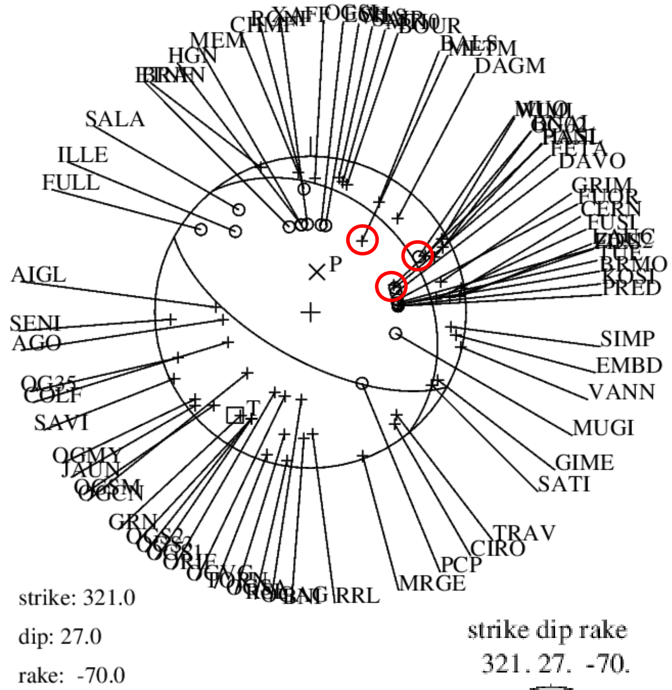
Sol FM 2



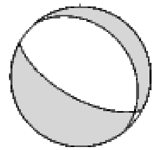
Plan 2:
Strike 116
Dip 64
Rake -110



Sol FM 3



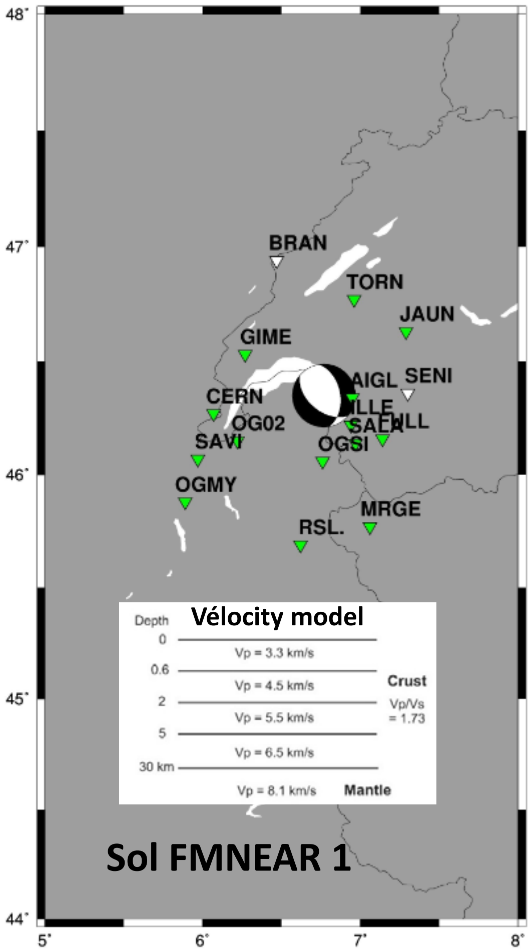
Plan 2:
Strike 119
Dip 65
Rake -100

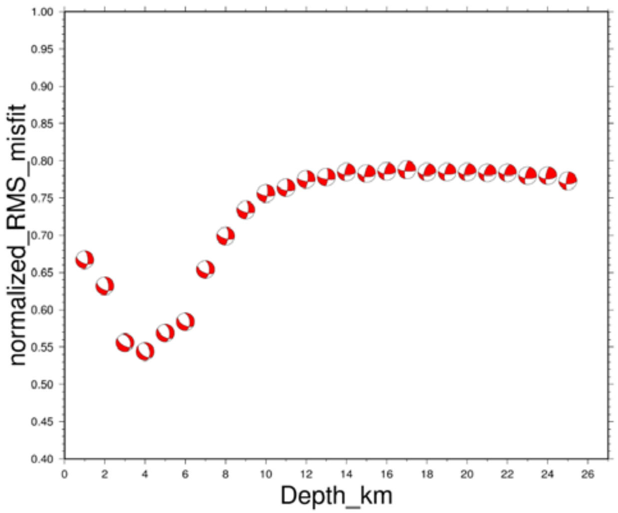


+ : first motion in compression (Zup) o : first motion in dilatation (Z down) ◯ : polarity in disagreement with the FM

Focal mechanism from waveform inversion (FMNEAR)

Standard velocity model
from routine FMNEAR inversions





strike dip rake
130.0 50.0 -118.2 : best focal mechanism

RMS = 0.544

Selected depth: 4.0 km

42 = number of components with freqband > 0.015Hz
80 % : index of confidence

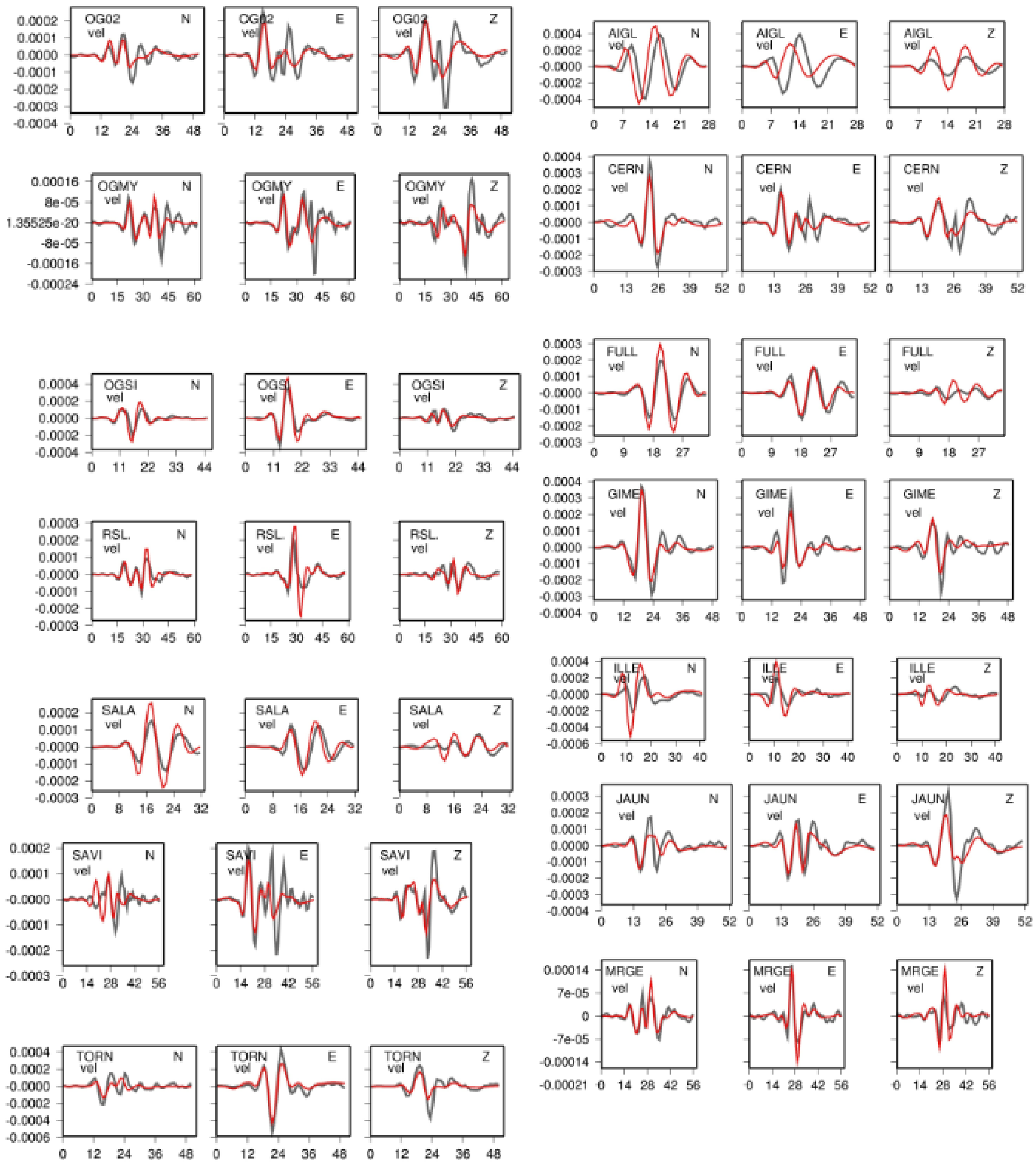
3.87 : Mw from waveform inversion

Epicenter used (lat,long): 46.350 6.769
Starting depth(km): 4.0

strike dip rake of the second nodal plane:
349.9 47.6 -60.6

****
****** quality: A ******
****

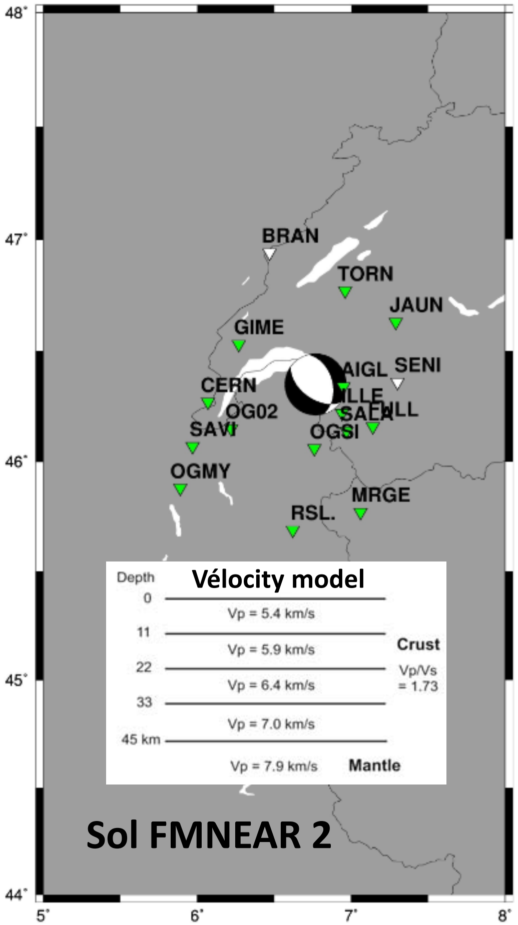
**** Signification of quality *******
A: focal mechanism STONGLY CONSTRAINED
B: focal mechanism WELL CONSTRAINED
C: focal mechanism MODERATELY CONSTRAINED
D: focal mechanism WEAKLY CONSTRAINED
E: focal mechanism BARELY CONSTRAINED
F: focal mechanism NOT CONSTRAINED
****

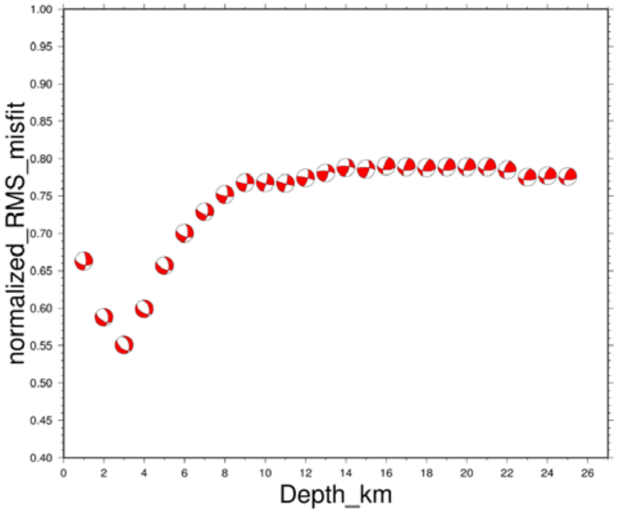


X axis: time in seconds Y axis: displacement in cm
Grey line: observed Red line: computed

Focal mechanism from waveform inversion (FMNEAR)

Specific velocity model
close to the gradient model found





strike dip rake
345.0 45.0 -60.2 : best focal mechanism

RMS = 0.551

Selected depth: 3.0 km

42 = number of components with freqband > 0.015Hz
87 % : index of confidence

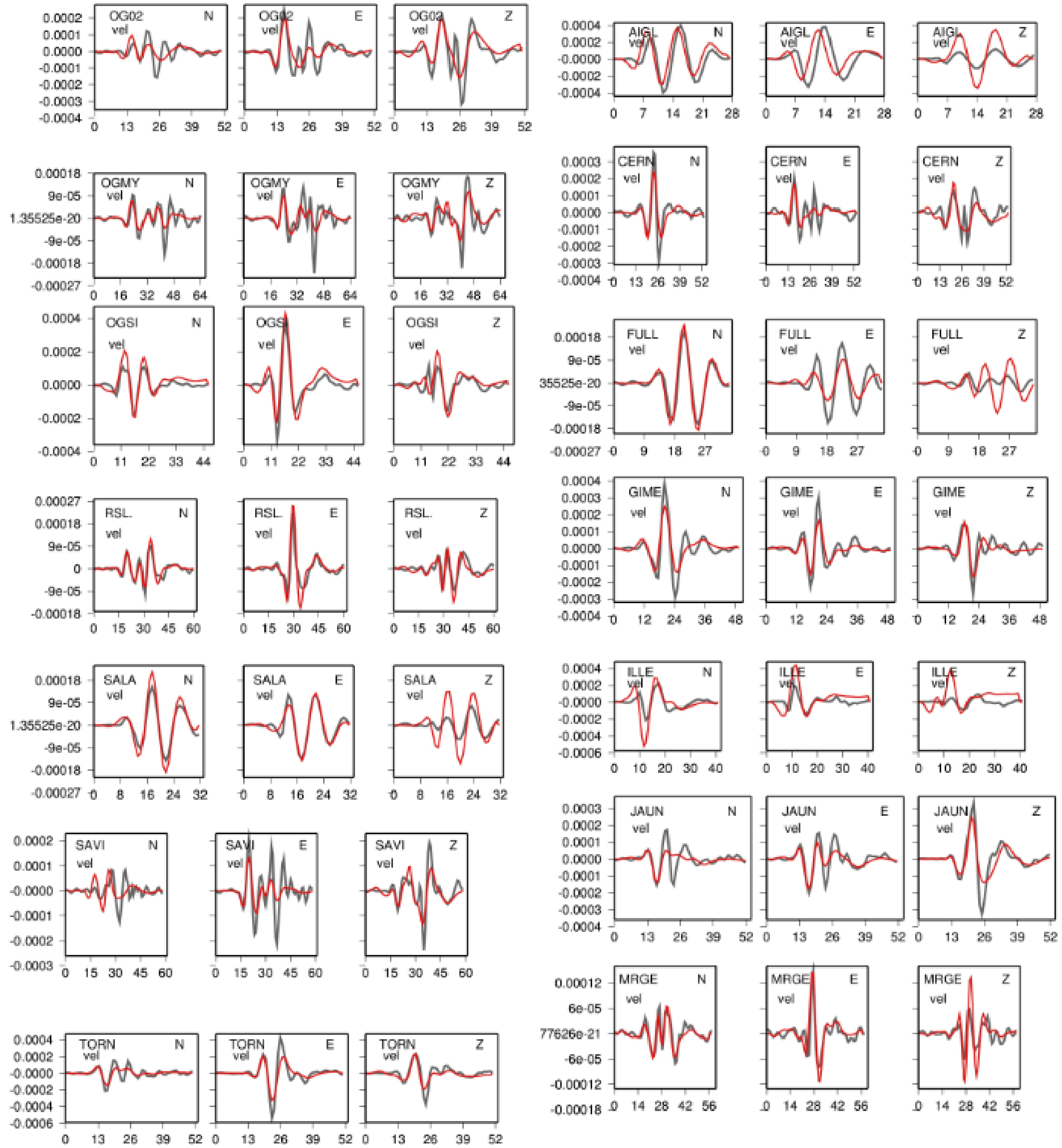
3.86 : Mw from waveform inversion

Epicenter used (lat,long): 46.350 6.769
Starting depth(km): 3.0

strike dip rake of the second nodal plane:
126.0 52.1 -116.4

****
****** quality: A ******
****

**** Signification of quality *******
A: focal mechanism STONGLY CONSTRAINED
B: focal mechanism WELL CONSTRAINED
C: focal mechanism MODERATELY CONSTRAINED
D: focal mechanism WEAKLY CONSTRAINED
E: focal mechanism BARELY CONSTRAINED
F: focal mechanism NOT CONSTRAINED
****



X axis: time in seconds Y axis: displacement in cm
Grey line: observed Red line: computed

Bande de fréquence (filtrage) utilisée par composante dans FMNEAR

```
AIGL N vel    0.0800 Hz to   0.1500 Hz
AIGL E vel    0.0800 Hz to   0.1500 Hz
AIGL Z vel    0.0800 Hz to   0.1500 Hz
CERN N vel    0.0500 Hz to   0.1500 Hz
CERN E vel    0.0500 Hz to   0.1500 Hz
CERN Z vel    0.0500 Hz to   0.1500 Hz
FULL N vel    0.0800 Hz to   0.1500 Hz
FULL E vel    0.0800 Hz to   0.1500 Hz
FULL Z vel    0.0800 Hz to   0.1500 Hz
GIME N vel    0.0500 Hz to   0.1500 Hz
GIME E vel    0.0500 Hz to   0.1500 Hz
GIME Z vel    0.0500 Hz to   0.1500 Hz
ILLE N vel    0.0500 Hz to   0.1500 Hz
ILLE E vel    0.0500 Hz to   0.1500 Hz
ILLE Z vel    0.0500 Hz to   0.1500 Hz
JAUN N vel    0.0500 Hz to   0.1500 Hz
JAUN E vel    0.0500 Hz to   0.1500 Hz
JAUN Z vel    0.0500 Hz to   0.1500 Hz
MRGE N vel    0.0500 Hz to   0.1500 Hz
MRGE E vel    0.0500 Hz to   0.1500 Hz
MRGE Z vel    0.0500 Hz to   0.1500 Hz
OG02 N vel    0.0500 Hz to   0.1500 Hz
OG02 E vel    0.0500 Hz to   0.1500 Hz
OG02 Z vel    0.0500 Hz to   0.1500 Hz
OGMY N vel    0.0500 Hz to   0.1500 Hz
OGMY E vel    0.0500 Hz to   0.1500 Hz
OGMY Z vel    0.0500 Hz to   0.1500 Hz
OGSI N vel    0.0500 Hz to   0.1500 Hz
OGSI E vel    0.0500 Hz to   0.1500 Hz
OGSI Z vel    0.0500 Hz to   0.1500 Hz
RSL. N vel    0.0500 Hz to   0.1500 Hz
RSL. E vel    0.0500 Hz to   0.1500 Hz
RSL. Z vel    0.0500 Hz to   0.1500 Hz
SALA N vel    0.0800 Hz to   0.1500 Hz
SALA E vel    0.0800 Hz to   0.1500 Hz
SALA Z vel    0.0800 Hz to   0.1500 Hz
SAVI N vel    0.0500 Hz to   0.1500 Hz
SAVI E vel    0.0500 Hz to   0.1500 Hz
SAVI Z vel    0.0500 Hz to   0.1500 Hz
TORN N vel    0.0500 Hz to   0.1500 Hz
TORN E vel    0.0500 Hz to   0.1500 Hz
TORN Z vel    0.0500 Hz to   0.1500 Hz
```

Mw par MWSYNTH (comparaison des plateaux des spectres en déplacement entre signaux observés et synthétiques précalculés pour différentes valeurs de Mw)

```
  3.85 +/-     0.25
 as computed Mw (mean) with +/- one sigma
  number of stations included:          59

rem1: the minimum and maximum magnitudes that
can be computed with this version are 2.0 and 9.0

rem2: only stations incuding the S wave plus
20s of signal are retained

rem3: stations whose Mw differs by more than 0.8
from the median Mw are discarded from the final
computation
```

detail by station

stat	inst	dist	azim	freq	Mw	weight
AIGL	vel	14.8	93.5	.1000	4.32	10.000000
BALS	vel	130.5	33.0	.1000	3.86	10.000000
BNI.	vel	144.3	182.5	.1000	4.12	10.000000
BOUR	vel	121.3	17.1	.1000	3.80	10.000000
BRAN	vel	68.9	341.5	.1000	4.16	10.000000
CERN	vel	54.0	260.2	.1000	4.04	10.000000
CHMF	vel	100.1	355.3	.1000	3.70	10.000000
CIRO	vel	103.9	143.1	.1000	3.49	10.000000
DAGM	vel	136.5	44.2	.1000	3.80	10.000000
EMBD	vel	83.6	100.2	.1000	3.79	10.000000
ETNF	vel	219.2	345.6	.2500	3.30	4.000000
FIES	vel	103.9	84.8	.1000	4.36	10.000000
FULL	vel	36.0	126.7	.2000	3.71	5.000000
GIME	vel	43.0	298.3	.1000	4.10	10.000000
GRN.	acc	146.1	212.6	.1500	3.74	6.666667
ILLE	vel	20.1	136.3	.1000	4.28	10.000000
JAUN	vel	51.4	52.2	.1000	3.99	10.000000
LAUC	vel	77.8	84.6	.1000	3.91	10.000000
LKBD	vel	67.8	87.7	.1000	3.85	10.000000
LOR.	vel	242.9	294.8	.2000	3.62	5.000000
MMK.	vel	98.3	109.8	.1000	3.28	10.000000
MRGE	vel	68.5	160.2	.1000	3.83	10.000000
MTI0	vel	118.4	15.1	.1000	3.75	10.000000
OG02	vel	46.8	242.3	.1000	4.17	10.000000
OG02	acc	46.8	242.3	.1500	3.72	6.666667
OG35	vel	97.4	249.6	.1000	3.75	10.000000
OG35	acc	97.4	249.6	.2500	3.55	4.000000
OGAN	acc	70.0	223.4	.2000	3.60	5.000000
OGAP	acc	69.2	224.2	.2500	3.68	4.000000
OGBL	acc	104.3	220.4	.2500	3.58	4.000000
OGEP	acc	68.9	228.4	.1500	3.72	6.666667
OGFO	acc	146.1	209.9	.2500	4.01	4.000000
OGIM	acc	142.9	210.6	.2000	3.67	5.000000
OGLE	acc	93.4	193.7	.3000	3.60	3.333333
OGME	acc	69.4	226.6	.2000	3.64	5.000000
OGMO	vel	126.9	182.7	.1000	3.78	10.000000
OGMO	acc	126.9	182.7	.2000	3.56	5.000000
OGMY	vel	84.9	232.2	.1000	3.80	10.000000
OGSA	acc	148.4	190.8	.2500	3.62	4.000000
OGSI	vel	32.6	180.5	.1000	4.15	10.000000
OGSI	acc	32.6	180.5	.1500	4.13	6.666667
OGSM	vel	116.1	224.9	.1000	3.77	10.000000
OGSM	acc	116.1	224.9	.2000	3.62	5.000000
OGSR	acc	150.8	211.6	.2000	3.86	5.000000
PLYF	vel	167.8	293.7	.1000	3.67	10.000000
RONF	vel	151.3	356.8	.1000	3.55	10.000000
RSL.	vel	74.2	188.1	.1000	3.91	10.000000
RSL.	acc	74.2	188.1	.2500	3.72	4.000000
SAIR	vel	108.7	13.2	.1000	3.88	10.000000
SALA	vel	28.1	144.4	.1000	4.01	10.000000
SAVI	vel	68.2	242.4	.1000	3.80	10.000000
SENI	vel	41.4	87.9	.1000	4.51	10.000000
SIMP	vel	97.4	97.2	.1000	3.67	10.000000
STDM	acc	183.4	357.3	.2000	3.58	5.000000
STFL	acc	85.9	349.9	.2500	3.39	4.000000
TORN	vel	49.4	17.9	.1000	4.04	10.000000
TRAV	vel	120.2	140.7	.1000	3.65	10.000000
VANN	vel	66.1	103.6	.1000	3.79	10.000000
WIMI	vel	74.7	62.1	.1000	3.78	10.000000

Conclusions

Profondeur hypocentrale:

- 10-13 km par inversions des Tp, Ts

(NB: une localisation avec les stations proches seules (dist < 70 km) conduit à une profondeur de 10 km également)

- 3 à 4 km par FMNEAR, pour deux modèles de vitesses différents

La détermination de la profondeur reste donc mal résolue, entre 3 et 13 km.

Mécanisme au foyer:

Solution stable avec les polarités. Le désaccord de quelques polarités avec le mécanisme est probablement lié à des variations de la profondeur du Moho (fort gradient dans les Alpes), alors que le Moho est horizontal dans le modèle de vitesse utilisé.

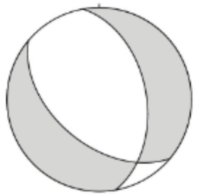
Mécanisme stable par FMNEAR, et très proche des solutions par polarités

Malgré les différences de profondeur suivant les approches, le mécanisme au foyer apparait comme bien contraint (normal avec petite composante décrochante).

Mw: 3.9 (FMNEAR et MWSYNTH)

Solution retenue:

strike dip rake
130. 50. -118.



Plan 2:
Strike 350
Dip 47
Rake -61