GITpy:
A Python-based tool for Generalized Inversion Technique

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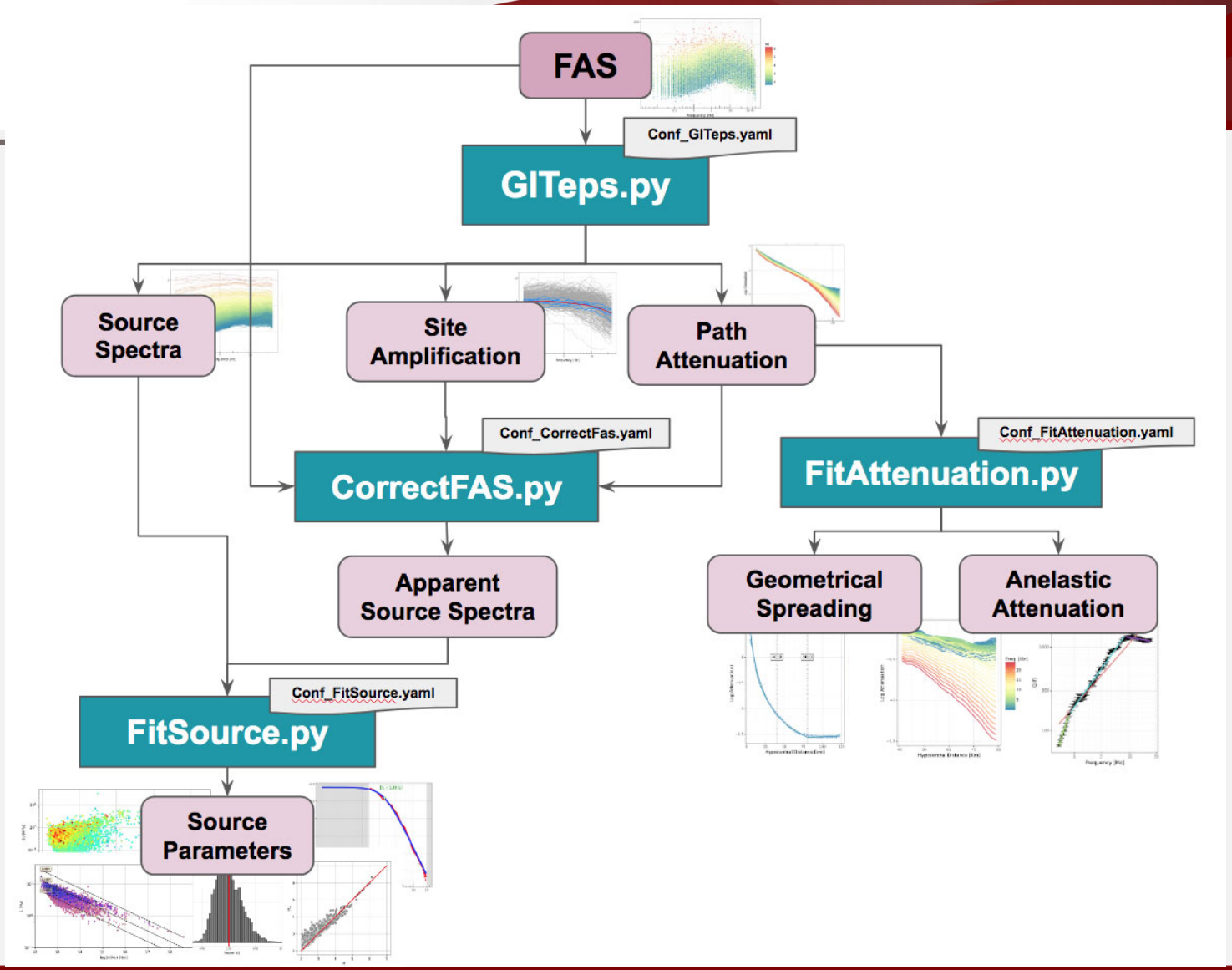
The Generalized Inversion Technique (GIT)

- Tecnica di inversione che consente di separare i contributi di sorgente, attenuazione e sito partendo dai FAS

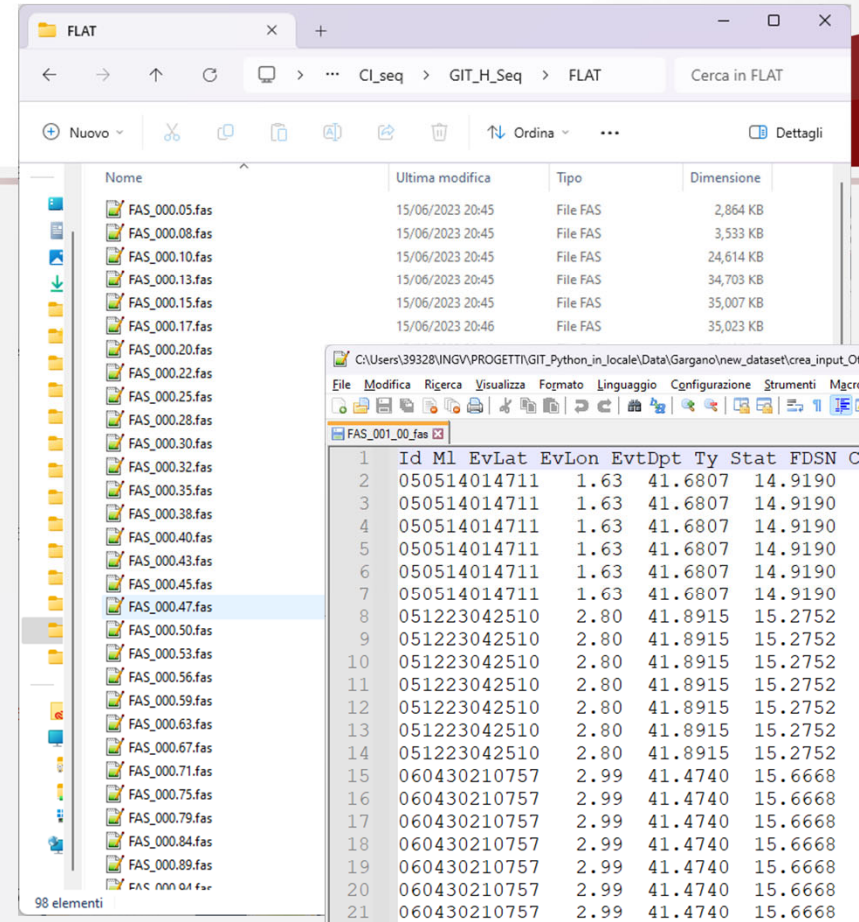
$$\log_{10} U_{ij}(f, R_{ij}) = \log_{10} S_i(f) + \log_{10} G(f, R_{ij}) + \log_{10} Z_j(f)$$

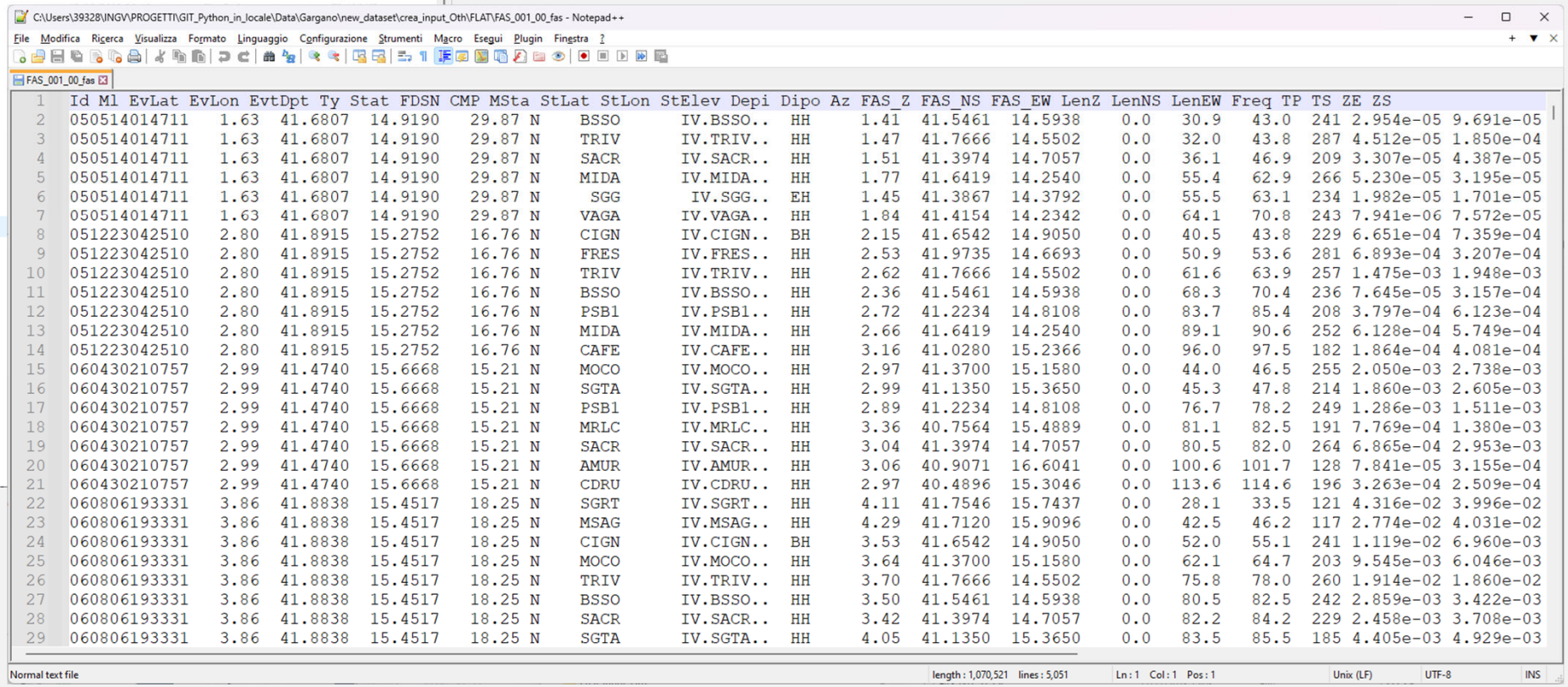
- Parametrico:
  - richiede specifica forma funzionale (riduzione del numero di parametri)
  - poco flessibile (adatto a regioni non troppo complesse)
  - Cataldi et al., (2023) in NE Italy e Zollo et al., (2014) in Irpinia

- Non-Parametrico:
  - data-driven (non assume forme funzionali ma «impara» dai dati)
  - flessibile (gestisce distribuzioni complesse di dati)
  - fornisce soluzioni non parametriche (model-free) che possono essere utilizzate per la selezione del modello in un secondo momento
  - fornisce soluzioni relative a condizioni di riferimento assunte a priori (es. condizioni del sito di riferimento; M_0 vincolati degli eventi di riferimento; distanza di attenuazione di riferimento)
  - One-step (Oth et al., 2011) Two-steps (Castro et al., 1990; Bindi et al., 2009)


FAS
Conf_GITeps.yaml
GITeps.py
Source Spectra
Site Amplification
Path Attenuation
Conf_CorrectFas.yaml
CorrectFAS.py
Conf_FitAttenuation.yaml
FitAttenuation.py
Apparent Source Spectra
Geometrical Spreading
Anelastic Attenuation
Conf_FitSource.yaml
FitSource.py
Source Parameters

Input Files

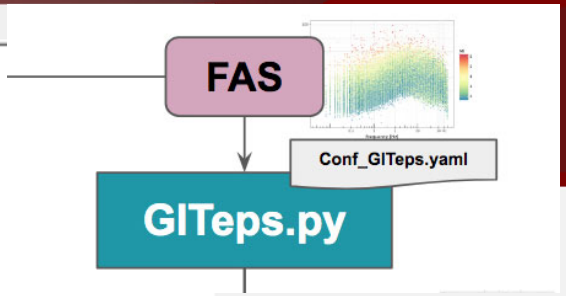




Id	Ml	EvLat	EvLon	EvtDpt	Ty	Stat	FDSN	CMP	MSta	StLat	StLon	StElev	Depi	Dipo	Az	FAS_Z	FAS_NS	FAS_EW	LenZ	LenNS	LenEW	Freq	TP	TS	ZE	ZS
1	050514014711	1.63	41.6807	14.9190	29.87	N	BSSO	IV.BSSO..	HH	1.41	41.5461	14.5938	0.0	30.9	43.0	241	2.954e-05	9.691e-05								
2	050514014711	1.63	41.6807	14.9190	29.87	N	TRIV	IV.TRIV..	HH	1.47	41.7666	14.5502	0.0	32.0	43.8	287	4.512e-05	1.850e-04								
3	050514014711	1.63	41.6807	14.9190	29.87	N	SACR	IV.SACR..	HH	1.51	41.3974	14.7057	0.0	36.1	46.9	209	3.307e-05	4.387e-05								
4	050514014711	1.63	41.6807	14.9190	29.87	N	MIDA	IV.MIDA..	HH	1.77	41.6419	14.2540	0.0	55.4	62.9	266	5.230e-05	3.195e-05								
5	050514014711	1.63	41.6807	14.9190	29.87	N	SGG	IV.SGG..	EH	1.45	41.3867	14.3792	0.0	55.5	63.1	234	1.982e-05	1.701e-05								
6	050514014711	1.63	41.6807	14.9190	29.87	N	VAGA	IV.VAGA..	HH	1.84	41.4154	14.2342	0.0	64.1	70.8	243	7.941e-06	7.572e-05								
7	051223042510	2.80	41.8915	15.2752	16.76	N	CIGN	IV.CIGN..	BH	2.15	41.6542	14.9050	0.0	40.5	43.8	229	6.651e-04	7.359e-04								
8	051223042510	2.80	41.8915	15.2752	16.76	N	FRES	IV.FRES..	HH	2.53	41.9735	14.6693	0.0	50.9	53.6	281	6.893e-04	3.207e-04								
9	051223042510	2.80	41.8915	15.2752	16.76	N	TRIV	IV.TRIV..	HH	2.62	41.7666	14.5502	0.0	61.6	63.9	257	1.475e-03	1.948e-03								
10	051223042510	2.80	41.8915	15.2752	16.76	N	BSSO	IV.BSSO..	HH	2.36	41.5461	14.5938	0.0	68.3	70.4	236	7.645e-05	3.157e-04								
11	051223042510	2.80	41.8915	15.2752	16.76	N	PSB1	IV.PSB1..	HH	2.72	41.2234	14.8108	0.0	83.7	85.4	208	3.797e-04	6.123e-04								
12	051223042510	2.80	41.8915	15.2752	16.76	N	MIDA	IV.MIDA..	HH	2.66	41.6419	14.2540	0.0	89.1	90.6	252	6.128e-04	5.749e-04								
13	051223042510	2.80	41.8915	15.2752	16.76	N	CAFE	IV.CAFE..	HH	3.16	41.0280	15.2366	0.0	96.0	97.5	182	1.864e-04	4.081e-04								
14	060430210757	2.99	41.4740	15.6668	15.21	N	MOCO	IV.MOCO..	HH	2.97	41.3700	15.1580	0.0	44.0	46.5	255	2.050e-03	2.738e-03								
15	060430210757	2.99	41.4740	15.6668	15.21	N	SGTA	IV.SGTA..	HH	2.99	41.1350	15.3650	0.0	45.3	47.8	214	1.860e-03	2.605e-03								
16	060430210757	2.99	41.4740	15.6668	15.21	N	PSB1	IV.PSB1..	HH	2.89	41.2234	14.8108	0.0	76.7	78.2	249	1.286e-03	1.511e-03								
17	060430210757	2.99	41.4740	15.6668	15.21	N	MRLC	IV.MRLC..	HH	3.36	40.7564	15.4889	0.0	81.1	82.5	191	7.769e-04	1.380e-03								
18	060430210757	2.99	41.4740	15.6668	15.21	N	SACR	IV.SACR..	HH	3.04	41.3974	14.7057	0.0	80.5	82.0	264	6.865e-04	2.953e-03								
19	060430210757	2.99	41.4740	15.6668	15.21	N	AMUR	IV.AMUR..	HH	3.06	40.9071	16.6041	0.0	100.6	101.7	128	7.841e-05	3.155e-04								
20	060430210757	2.99	41.4740	15.6668	15.21	N	CDRU	IV.CDRU..	HH	2.97	40.4896	15.3046	0.0	113.6	114.6	196	3.263e-04	2.509e-04								
21	060806193331	3.86	41.8838	15.4517	18.25	N	SGRT	IV.SGRT..	HH	4.11	41.7546	15.7437	0.0	28.1	33.5	121	4.316e-02	3.996e-02								
22	060806193331	3.86	41.8838	15.4517	18.25	N	MSAG	IV.MSAG..	HH	4.29	41.7120	15.9096	0.0	42.5	46.2	117	2.774e-02	4.031e-02								
23	060806193331	3.86	41.8838	15.4517	18.25	N	CIGN	IV.CIGN..	BH	3.53	41.6542	14.9050	0.0	52.0	55.1	241	1.119e-02	6.960e-03								
24	060806193331	3.86	41.8838	15.4517	18.25	N	MOCO	IV.MOCO..	HH	3.64	41.3700	15.1580	0.0	62.1	64.7	203	9.545e-03	6.046e-03								
25	060806193331	3.86	41.8838	15.4517	18.25	N	TRIV	IV.TRIV..	HH	3.70	41.7666	14.5502	0.0	75.8	78.0	260	1.914e-02	1.860e-02								
26	060806193331	3.86	41.8838	15.4517	18.25	N	BSSO	IV.BSSO..	HH	3.50	41.5461	14.5938	0.0	80.5	82.5	242	2.859e-03	3.422e-03								
27	060806193331	3.86	41.8838	15.4517	18.25	N	SACR	IV.SACR..	HH	3.42	41.3974	14.7057	0.0	82.2	84.2	229	2.458e-03	3.708e-03								
28	060806193331	3.86	41.8838	15.4517	18.25	N	SGTA	IV.SGTA..	HH	4.05	41.1350	15.3650	0.0	83.5	85.5	185	4.405e-03	4.929e-03								

Conf_GITeps.yaml

```yaml
---
GLOBAL:
    job_name: "Test GITeps"
    fas_dir: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/GITpy_db/"
    out_dir: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/out_dir/"
    gui_env: ['Qt5Agg','TkAgg','nbAgg'] #['Qt5Agg','TkAgg','nbAgg','WebAgg']
    cmp:     "H"
    plot_graph: True
    save_graph: True
    mean: "VECTORIAL"
    fmin: 0.5
    fmax: 26.0
    mmin: 1.5
    mmax: 6.5
DIST BIN:
    type_bin: LIN
    dist_min: 5
    dist_max: 125
    dist_step:  5
    nbin_dist: 200
    dist_file: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/gitpy-v1.0.2/input_examples/DistFile.txt"
SUBSET:
    type_sel: NONE
    event_remove: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/gitpy-v1.0.2/input_examples/remove_events.txt"
    station_remove: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/gitpy-v1.0.2/input_examples/remove_stations.txt"
CONSTRAINT DREF:
    dref: 10
    weight_dref: 5
    vdref: 1
CONSTRAINTS SITES:
    SITES: IT.LSS..,IT.MNF..,IT.SLO..,IT.SNO..,IT.SDM..,IT.NRN..
    weight_site: 5
    Knot: 0.0
    Fk: 10
CONSTRAINTS SMOOTH DIST:
    weight_smo: 25
LSQR INVERSION:
    nrow_min: 100
    damp: 1e-06
    atol: 1e-08
    btol: 1e-08
    iter_lim: 1000
```



Inversion

remove_events.txt

```
NUM;EVENTS
1;220601004054
2;150120071722
3;131223045810
4;131223042038
```

A

remove_stations.txt

```
NUM;STATIONS
1;IV.ILOS..
2;IV.IST3..
```

B

DistFile.txt

```
1
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
```

C

python ./GITeps.py --config $path/file_conf_inversion.yaml --log logfile (senza path)

Inversion Outputs

A

TI > GIT_Python_in_locale > CI > output_inversion >

Ordina | Visualizza | ...

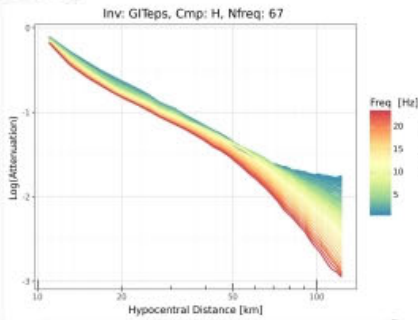
Nome	Ultima modifica	Tipo	Dime
GRAPH	23/10/2023 08:42	Cartella di file	
SITES	23/10/2023 08:43	Cartella di file	
SOURCES	05/02/2024 09:11	Cartella di file	
Attenuation.txt	20/10/2023 02:53	File TXT	
logfile_test1.log	06/11/2023 14:33	File LOG	

B

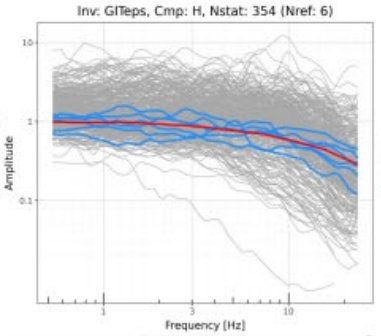
ython_in_locale > CI > output_inversion > GRAPH

Cerca in GRAPH

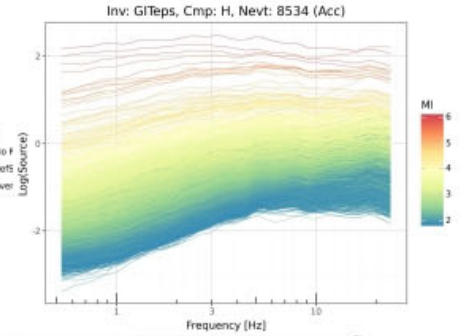
Ordina | Visualizza | ... | Anteprima



Attenuation.jpg



Sites.jpg



Sources.jpg

C

ıt_inversion > SOURCES

Cerca in SOURCES

ualizza | ... | Anteprima

Nome	Ultima modifica	Tipo
150107193604.source	09/02/2024 15:58	File SOURCE
150114035514.source	09/02/2024 15:58	File SOURCE
150214074039.source	09/02/2024 15:58	File SOURCE
150220135411.source	09/02/2024 15:58	File SOURCE
150221011852.source	09/02/2024 15:58	File SOURCE
150311012219.source	09/02/2024 15:58	File SOURCE

D

t_inversion > SITES

Cerca in SITES

ualizza | ... | Antepri

Nome	Ultima modifica	Tipo
3A.MZ01..EH_H.site	20/10/2023 02:55	File SITE
3A.MZ02..EH_H.site	20/10/2023 02:55	File SITE
3A.MZ03..EH_H.site	20/10/2023 02:55	File SITE
3A.MZ04..EH_H.site	20/10/2023 02:55	File SITE
3A.MZ05..EH_H.site	20/10/2023 02:55	File SITE
3A.MZ06..EH_H.site	20/10/2023 02:55	File SITE

Attenuation.txt

A

```
GITeps H 10.000000 GIT_CI
 Dist_[km]     0.53      0.56      0.59      0.63      0.67      0.71      0.75      0.79      0.84
       5.0    0.4034    0.4000    0.3965    0.3885    0.3801    0.3793    0.3706    0.3782    0.3645
       7.0    0.2731    0.2705    0.2674    0.2619    0.2564    0.2552    0.2494    0.2526    0.2445
       9.0    0.1240    0.1222    0.1197    0.1171    0.1146    0.1127    0.1104    0.1100    0.1087
      11.0   -0.1240   -0.1222   -0.1197   -0.1171   -0.1146   -0.1127   -0.1104   -0.1100   -0.1087
      13.0   -0.3308   -0.3265   -0.3215   -0.3173   -0.3117   -0.3058   -0.2983   -0.2922   -0.2906
      15.0   -0.4684   -0.4634   -0.4585   -0.4529   -0.4440   -0.4363   -0.4285   -0.4230   -0.4226
      17.0   -0.5672   -0.5604   -0.5532   -0.5485   -0.5418   -0.5355   -0.5310   -0.5265   -0.5259
```

150114035514.source

B

```
GITeps H 150114035514  2.02   42.643   13.038    11.20    -0.365
      0.53 -2.775778e+00
      0.56 -2.779892e+00
      0.59 -2.771785e+00
      0.63 -2.758310e+00
      0.67 -2.752726e+00
      0.71 -2.748023e+00
      0.75 -2.729245e+00
      0.79 -2.698018e+00
      0.84 -2.670990e+00
      0.89 -2.642269e+00
      0.94 -2.627568e+00
      1.00 -2.614667e+00
      1.06 -2.566381e+00
      1.12 -2.530473e+00
      1.19 -2.482571e+00
      1.26 -2.438929e+00
      1.33 -2.391753e+00
      1.41 -2.327910e+00
```

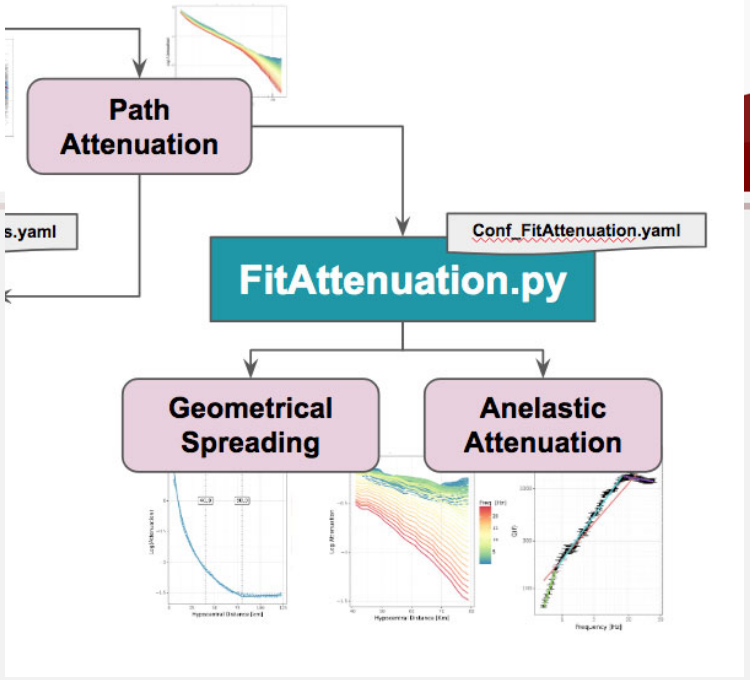
IV.NRCA..HH_H.site

C

```
GITeps IV.NRCA..    HH H   42.834   13.114    0.000   False
      0.53   1.692
      0.56   1.661
      0.59   1.621
      0.63   1.616
      0.67   1.566
      0.71   1.529
      0.75   1.468
      0.79   1.418
      0.84   1.355
      0.89   1.301
      0.94   1.290
      1.00   1.265
      1.06   1.231
      1.12   1.172
      1.19   1.117
      1.26   1.086
      1.33   1.041
```

Inversion Outputs

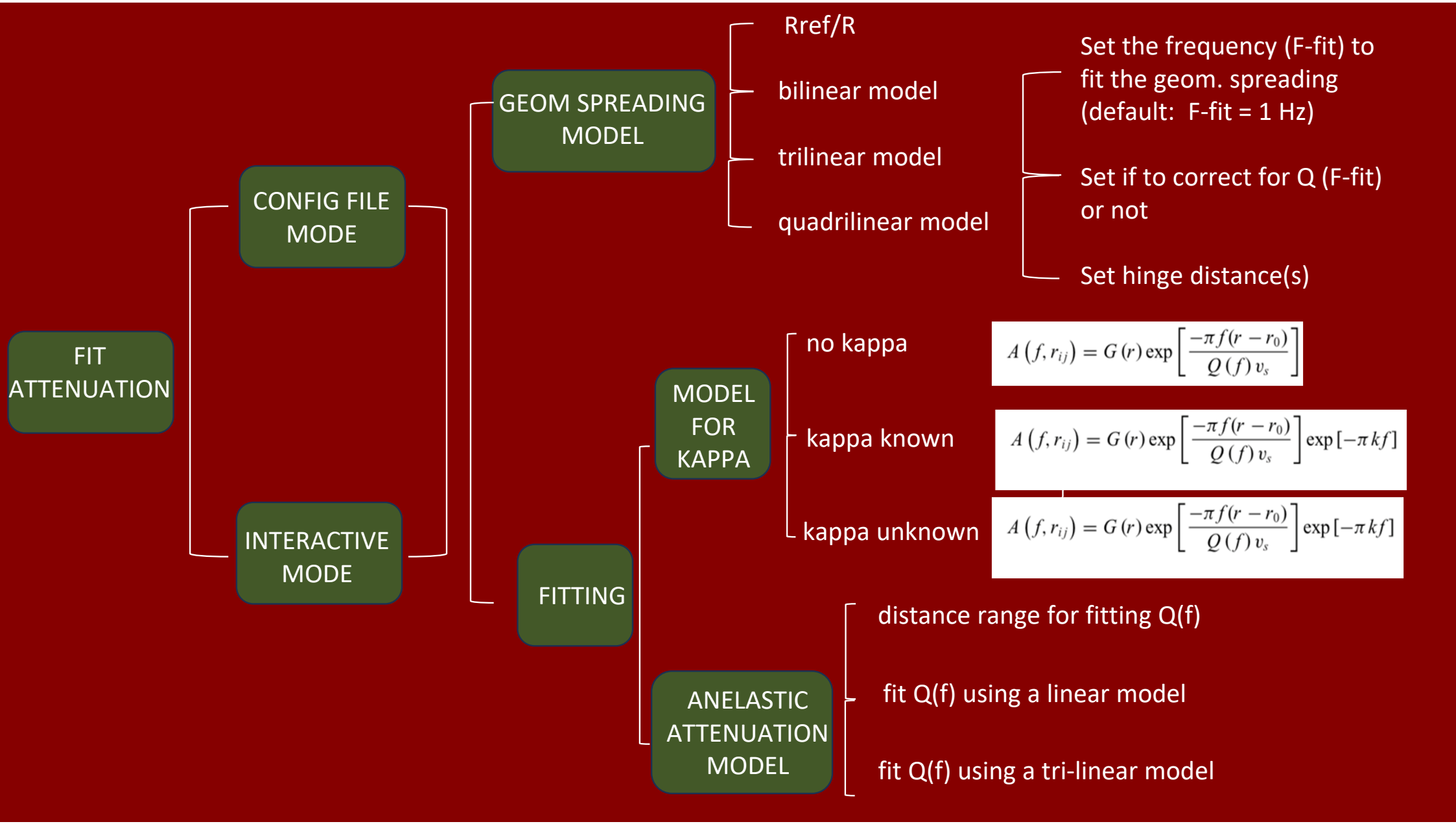
Attenuation Modeling



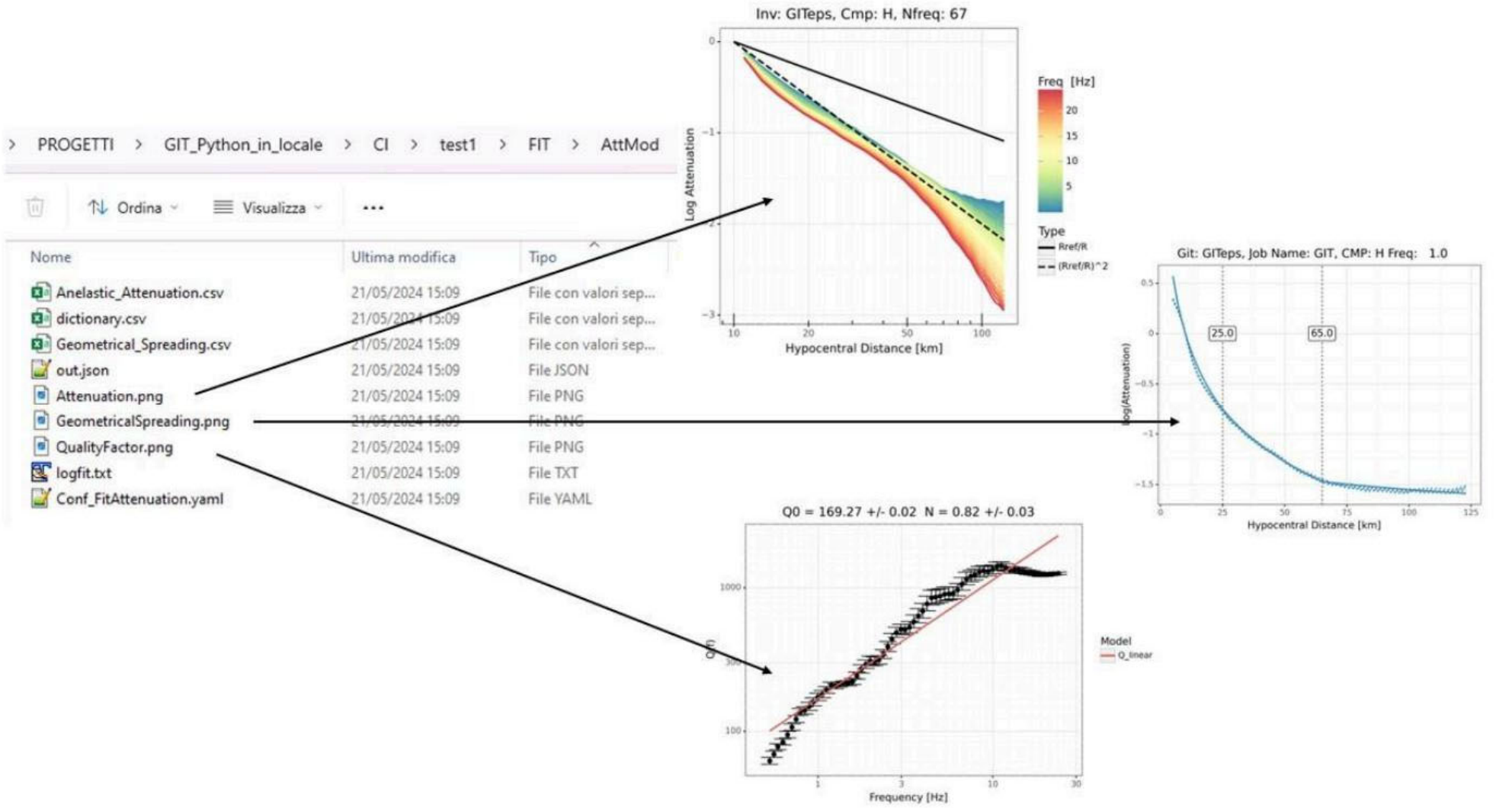
Conf_FitAttenuation.yaml

```yaml
---
GLOBAL:
    att_dir: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/out_dir/"
    att_file: "Attenuation.txt"
    out_dir: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/FIT/AttMod"
PLOT:
    plot_graph: True
    save_graph: True
FREQUENCY GS:
    f_step: 0.2
    freq: 1
GEOMETRICAL SPREADING:
    gs_model: 3
    HD1: 30
    HD2: 70
    HD3: None
ANELASTIC ATTENUATION:
    case: 3
    corr_fact_flag: 1
    Q_type: 1
    Q0_corr: 200
    dist_min_Q: 40
    dist_max_Q: 60
    Vs: 3.2
    HF1: 3
    HF2: 10
KAPPA:
    hingfreq: 10
    k_known: 0.004
```

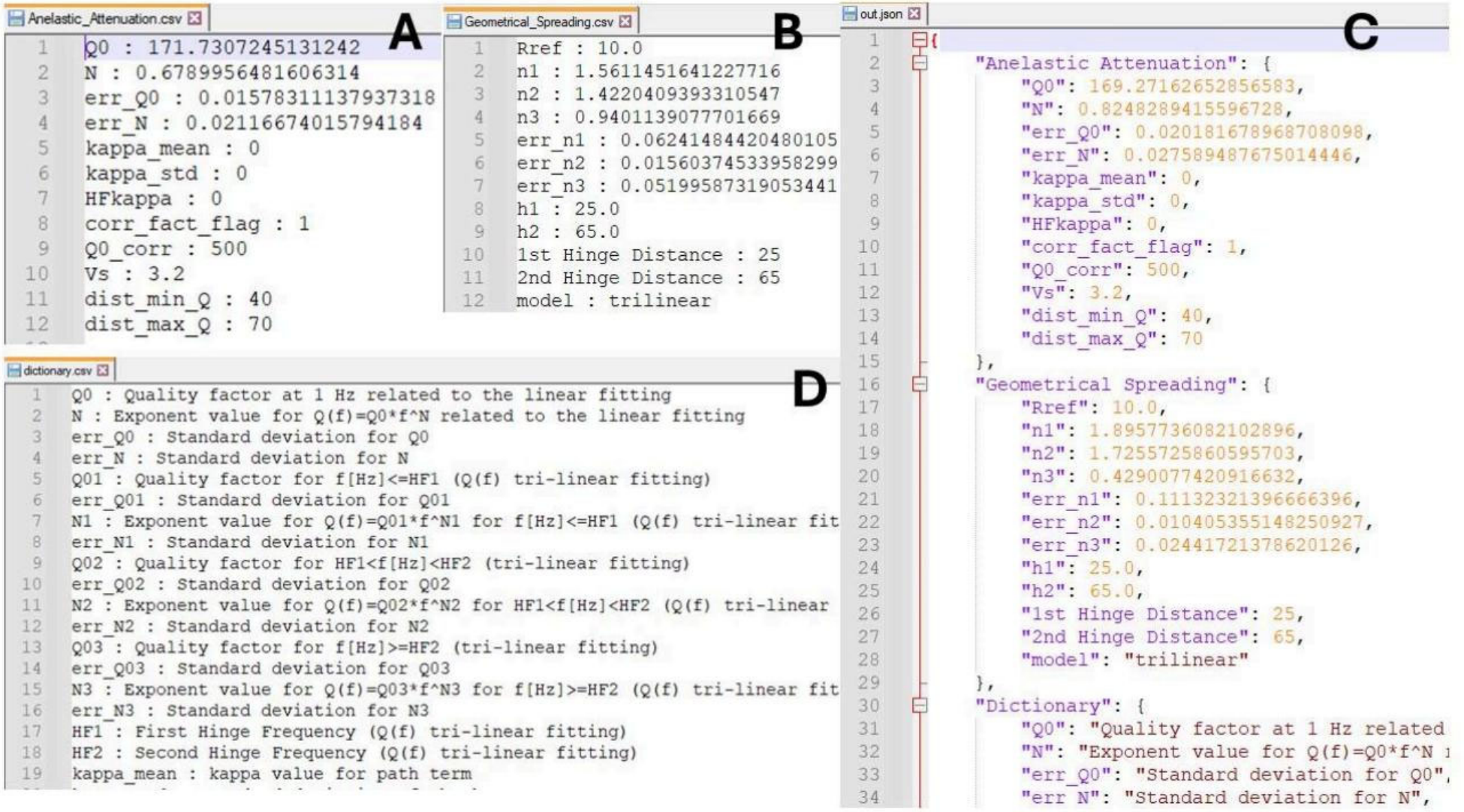
```
python ./FitAttenuation.py  --input   $path/Attenuation.txt
python ./FitAttenuation.py  --config  $path/Conf_FitAttenuation.yaml --log logFitAtt.txt
```


FIT ATTENUATION
CONFIG FILE MODE
INTERACTIVE MODE
GEOM SPREADING MODEL
Rref/R
bilinear model
trilinear model
quadrilinear model
Set the frequency (F-fit) to fit the geom. spreading (default: F-fit = 1 Hz)
Set if to correct for Q (F-fit) or not
Set hinge distance(s)
FITTING
MODEL FOR KAPPA
no kappa
kappa known
kappa unknown
$A(f, r_{ij}) = G(r) \exp\left[\frac{-\pi f (r - r_0)}{Q(f) v_s}\right]$
$A(f, r_{ij}) = G(r) \exp\left[\frac{-\pi f (r - r_0)}{Q(f) v_s}\right] \exp[-\pi k f]$
$A(f, r_{ij}) = G(r) \exp\left[\frac{-\pi f (r - r_0)}{Q(f) v_s}\right] \exp[-\pi k f]$
ANELASTIC ATTENUATION MODEL
distance range for fitting Q(f)
fit Q(f) using a linear model
fit Q(f) using a tri-linear model

Fit Attenuation Outputs



Fit Attenuation Outputs



Anelastic_Attenuation.csv

A

```
Q0 : 171.7307245131242
N : 0.6789956481606314
err_Q0 : 0.01578311137937318
err_N : 0.02116674015794184
kappa_mean : 0
kappa_std : 0
HFkappa : 0
corr_fact_flag : 1
Q0_corr : 500
Vs : 3.2
dist_min_Q : 40
dist_max_Q : 70
```

Geometrical_Spreading.csv

B

```
Rref : 10.0
n1 : 1.5611451641227716
n2 : 1.4220409393310547
n3 : 0.9401139077701669
err_n1 : 0.06241484420480105
err_n2 : 0.01560374533958299
err_n3 : 0.05199587319053441
h1 : 25.0
h2 : 65.0
1st Hinge Distance : 25
2nd Hinge Distance : 65
model : trilinear
```

out.json

C

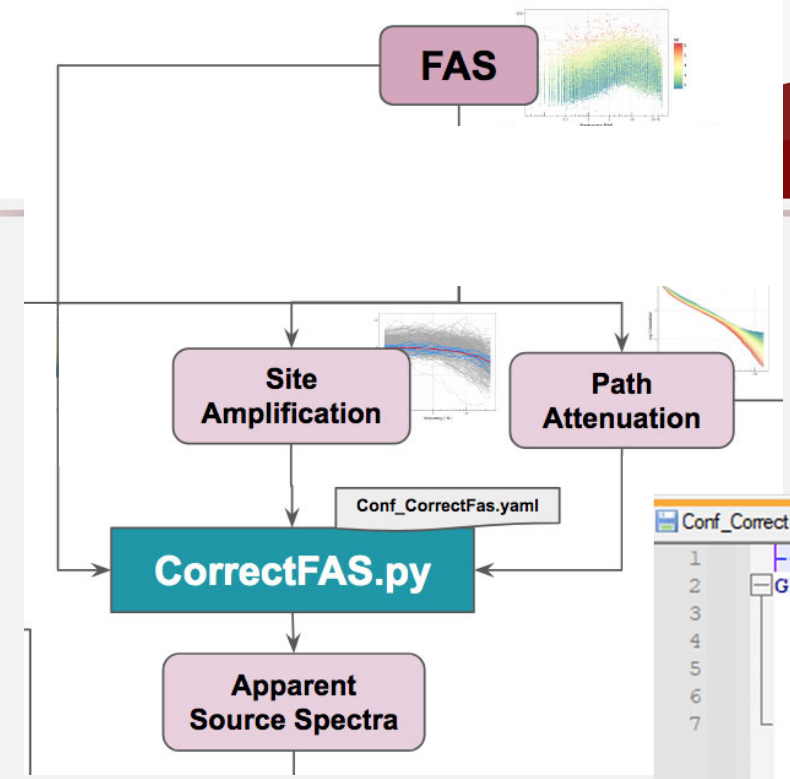

```
{
    "Anelastic Attenuation": {
        "Q0": 169.27162652856583,
        "N": 0.8248289415596728,
        "err_Q0": 0.020181678968708098,
        "err_N": 0.027589487675014446,
        "kappa_mean": 0,
        "kappa_std": 0,
        "HFkappa": 0,
        "corr_fact_flag": 1,
        "Q0_corr": 500,
        "Vs": 3.2,
        "dist_min_Q": 40,
        "dist_max_Q": 70
    },
    "Geometrical Spreading": {
        "Rref": 10.0,
        "n1": 1.8957736082102896,
        "n2": 1.7255725860595703,
        "n3": 0.4290077420916632,
        "err_n1": 0.11132321396666396,
        "err_n2": 0.010405355148250927,
        "err_n3": 0.024417213786201 26,
        "h1": 25.0,
        "h2": 65.0,
        "1st Hinge Distance": 25,
        "2nd Hinge Distance": 65,
        "model": "trilinear"
    },
    "Dictionary": {
        "Q0": "Quality factor at 1 Hz related
        "N": "Exponent value for Q(f)=Q0*f^N
        "err_Q0": "Standard deviation for Q0",
        "err N": "Standard deviation for N",
```


dictionary.csv

D

```
Q0 : Quality factor at 1 Hz related to the linear fitting
N : Exponent value for Q(f)=Q0*f^N related to the linear fitting
err_Q0 : Standard deviation for Q0
err_N : Standard deviation for N
Q01 : Quality factor for f[Hz]<=HF1 (Q(f) tri-linear fitting)
err_Q01 : Standard deviation for Q01
N1 : Exponent value for Q(f)=Q01*f^N1 for f[Hz]<=HF1 (Q(f) tri-linear fit
err_N1 : Standard deviation for N1
Q02 : Quality factor for HF1<f[Hz]<HF2 (tri-linear fitting)
err_Q02 : Standard deviation for Q02
N2 : Exponent value for Q(f)=Q02*f^N2 for HF1<f[Hz]<HF2 (Q(f) tri-linear
err_N2 : Standard deviation for N2
Q03 : Quality factor for f[Hz]>=HF2 (tri-linear fitting)
err_Q03 : Standard deviation for Q03
N3 : Exponent value for Q(f)=Q03*f^N3 for f[Hz]>=HF2 (Q(f) tri-linear fit
err_N3 : Standard deviation for N3
HF1 : First Hinge Frequency (Q(f) tri-linear fitting)
HF2 : Second Hinge Frequency (Q(f) tri-linear fitting)
kappa_mean : kappa value for path term
```

FAS correction

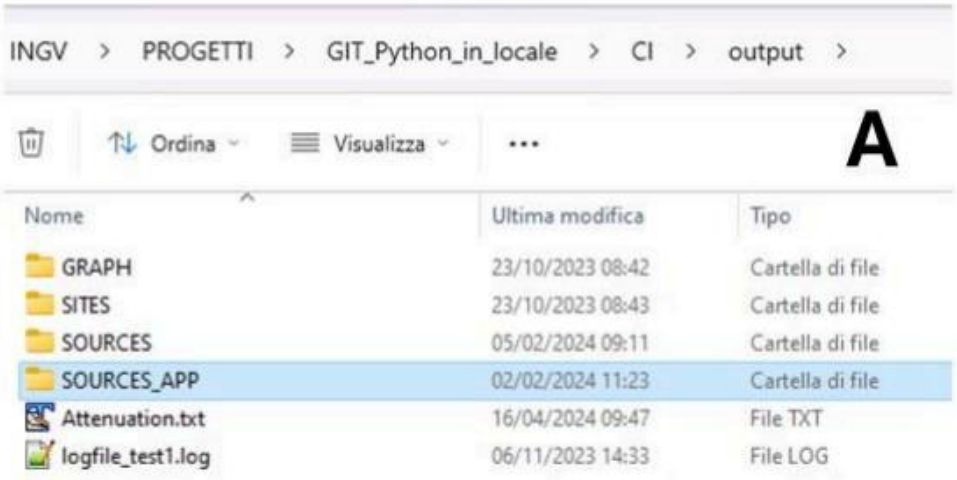


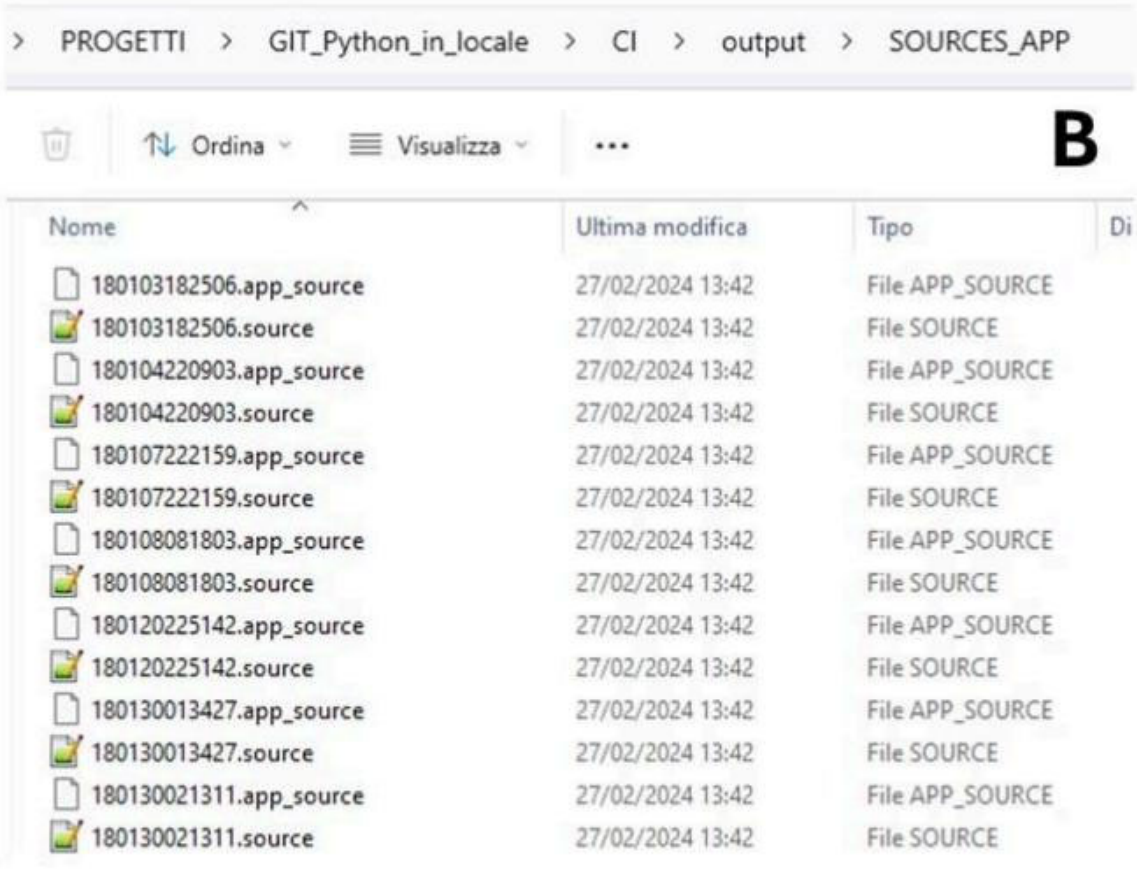
Conf_CorrectFas.yaml

```yaml
---
GLOBAL:
    job_name: "Correct-FAS"
    att_file: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/out_dir/Attenuation.txt"
    fas_dir:  "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/GITpy_db/"
    site_dir: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/out_dir/SITES/"
    out_dir:  "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/APP_SOURCES/"
```

```
python ./gitpy-v1.0.2/CorrectFas.py  --config ./Conf_CorrectFas.yaml --log logCorrectFAS.txt
```

Output CorrectFas.py





180104220903.app_source

A

```
CorrectFas H 180104220903 1.94 46.7355 10.4948 5.72
    FDSN       Dist    Az    Bz     0.50     0.53     0.56     0.59     0.63     0.67     0.71     0.75     0.79     0.84     0.89     0.94     1.00
CH.BERNI..    51.10  45.1 225.5      nan      nan      nan 2.02e-04 2.26e-04 2.77e-04 2.94e-04 3.07e-04 3.20e-04 3.32e-04 3.27e-04 3.07e-04 4.09e-04 6.48e-
CH.DAVOX..    47.50  95.9 276.3      nan      nan      nan 1.98e-04 2.05e-04 2.32e-04      nan      nan      nan      nan 2.23e-04 2.70e-04 2.82e-04 3.28e-04 4
CH.FUORN..    22.50  54.0 234.2      nan      nan      nan 4.28e-05 5.15e-05 6.48e-05 8.32e-05 9.34e-05 1.08e-04 1.18e-04 1.29e-04 1.36e-04 1.75e-04 1.95e-
IV.BRMO..     30.80  18.0 198.1      nan      nan      nan 7.56e-05 8.34e-05 9.17e-05 9.64e-05 1.01e-04 1.12e-04 1.33e-04 1.41e-04 1.50e-04 1.72e-04 1.97e-
IV.CTI..     117.10 311.1 130.3      nan      nan      nan 2.23e-04      nan      nan      nan 1.91e-04 2.15e-04 2.23e-04 2.16e-04      nan      nan      nan 1.8
SI.MOSI..     15.00 342.5 162.4      nan      nan      nan 6.02e-05 5.98e-05 6.35e-05 6.89e-05 9.20e-05 1.19e-04 1.80e-04 2.49e-04 3.16e-04 4.05e-04 4.50e-
ST.OZOL..     56.60 311.0 130.6      nan      nan      nan 2.54e-04 2.65e-04 2.80e-04 2.98e-04 3.12e-04 3.13e-04 3.31e-04 3.08e-04 2.77e-04 3.48e-04 5.30e-
OE.FETA..     36.80 209.4  29.3      nan      nan      nan      nan 2.30e-04 2.69e-04 2.76e-04 2.79e-04 3.22e-04 4.34e-04 4.78e-04 4.57e-04 4.61e-04 4.45e-0
SI.LUSI..     93.00 338.3 158.0      nan      nan      nan      nan      nan 2.67e-04 2.79e-04 2.87e-04 3.04e-04 3.59e-04 3.49e-04 3.41e-04 3.68e-04 4.03e-04
SI.ROSI..     73.20 253.3  72.6      nan      nan      nan      nan      nan      nan      nan      nan      nan 2.32e-04 2.83e-04 2.61e-04 3.03e-04 3.45e-04 4.3
ST.CARE..     38.10 336.1 156.0      nan      nan      nan      nan      nan      nan      nan      nan      nan 1.07e-04 9.97e-05 8.04e-05 8.90e-05 1.01e-04 1.1
MN.TUE..      92.60  71.2 252.0      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan 1.63e-04 1.41e-04 1.26e-
ST.GAGG..     80.90 334.0 153.6      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan
ST.ZIAN..     96.50 302.3 121.5      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan      nan
```

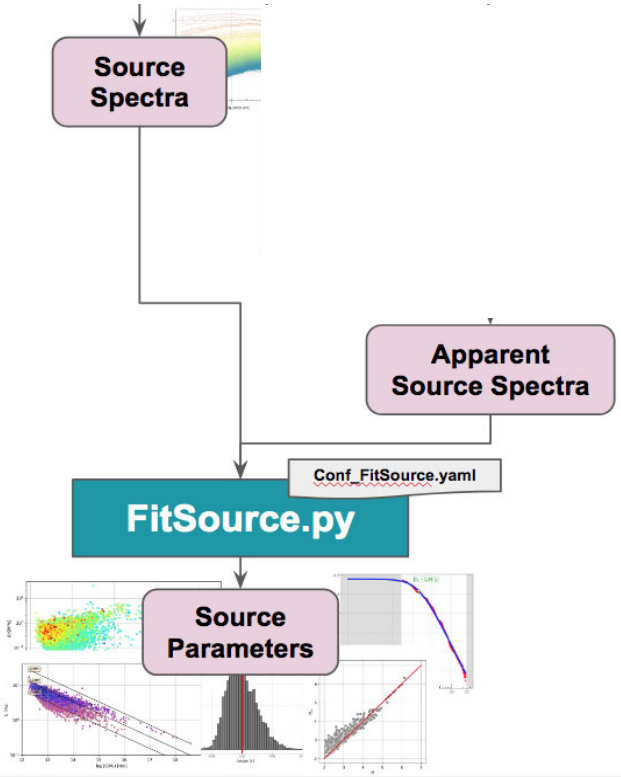
180104220903.source

B

```
CorrectFas H 180104220903 1.94 46.7355 10.4948 5.72
    0.50 nan  nan 0
    0.53 nan  nan 0
    0.56 nan  nan 0
    0.59 -3.703774e+00  2.943667e-01 7
    0.63 -3.688549e+00  2.843163e-01 7
    0.67 -3.603855e+00  2.775362e-01 8
    0.71 -3.559047e+00  2.716843e-01 7
    0.75 -3.636001e+00  2.283668e-01 8
    0.79 -3.592473e+00  2.074113e-01 8
    0.84 -3.642705e+00  2.053966e-01 10
    0.89 -3.604294e+00  1.958477e-01 11
    0.94 -3.563213e+00  2.147492e-01 10
    1.00 -3.519183e+00  2.133625e-01 11
    1.06 -3.462448e+00  2.438731e-01 11
    1.12 -3.374529e+00  2.758885e-01 11
    1.19 -3.334520e+00  2.868831e-01 11
    1.26 -3.301765e+00  2.876364e-01 10
    1.33 -3.314228e+00  3.094900e-01 13
    1.41 -3.309243e+00  2.841269e-01 13
    1.49 -3.280095e+00  2.428169e-01 13
    1.58 -3.319348e+00  2.436167e-01 13
```

Output CorrectFas.py

Source Modeling



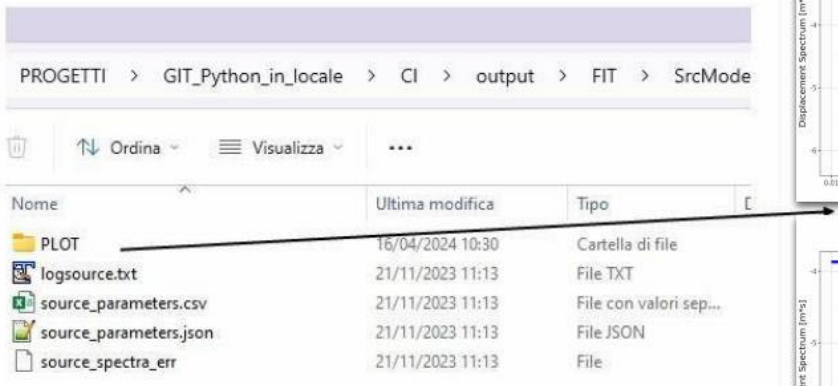
Conf_FitSource_APP.yaml

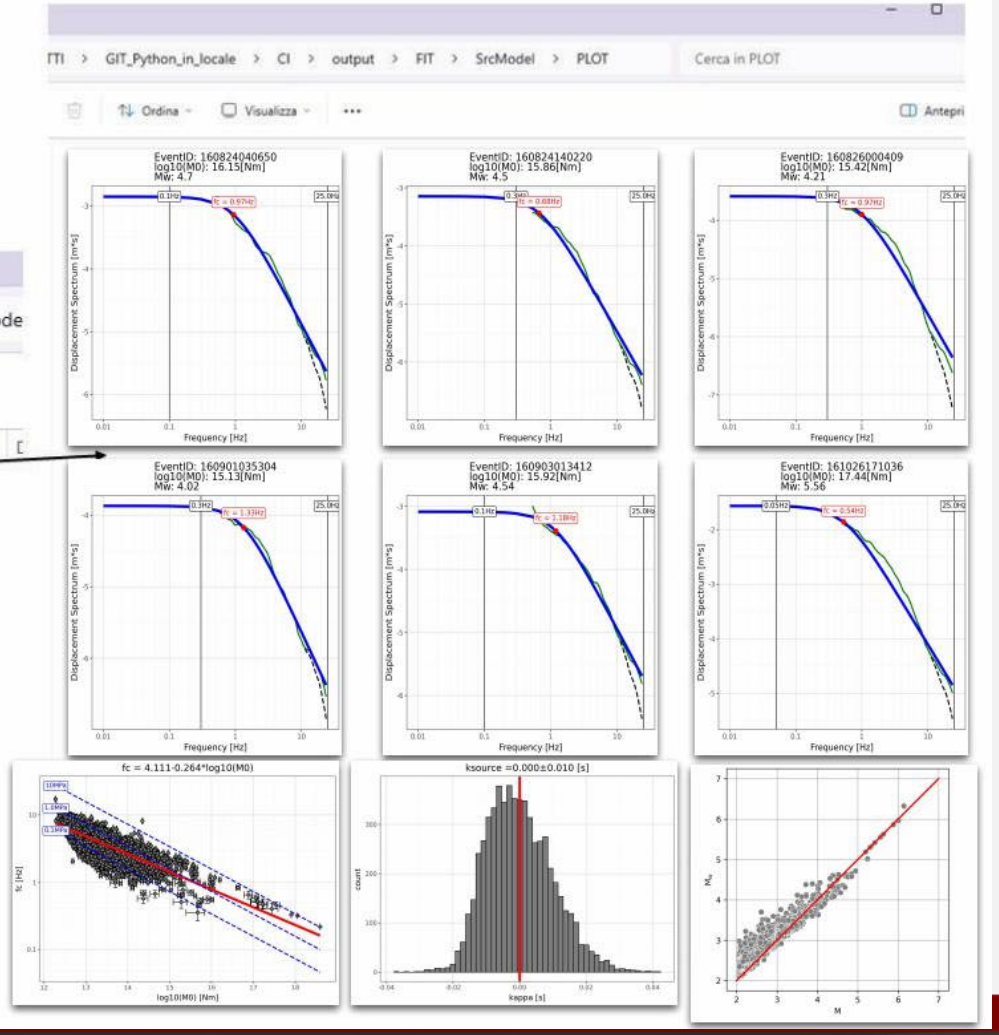
```yaml
---
GLOBAL:
    job_name: "FitSource"
    source_dir: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/APP_SOURCES"
    out_dir: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/FIT/SrcMod_APP_SOURCES"

CONSTRAINT:
    dref: 10
    Rp: 0.55
    Fs: 2
    En: 1
    magnitude_file: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/gitpy-v1.0.2/inp
    AnchorageMw: 0

CRUSTALMODEL:
    type_model: HETEROGENEOUS
    crustal_model: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/gitpy-v1.0.2/inpu
    Vs: 3.2
    rho: 2.7

SOURCEFITTING:
    type: 1
    sourcemodel: 1
    f_range: 1
    f_range_file: "C:/Users/39328/INGV/PROGETTI/GIT_Python_in_locale/TEST_V1.0.2/gitpy-v1.0.2/input
    appflag: 1      #   0:working on median source spectra (*.source);      1:working on apparent s
    list_eve: [160826040803]

KAPPA:
    hingfreq: 10

PLOT:
    param: DISP
    plot_graph: True
    list_eve: [160826040803]

SAVE:
    save_graph: True
    list_eve: [160826040803]
```

```
python ./gitpy-v1.0.2/FitSource.py --config ./Conf_FitSource.yaml --log logFitSrc.txt
```

Output Source Modeling

For median non-parametric source spectra derived from GITeps.py (*.source files).



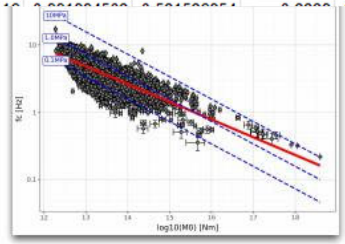


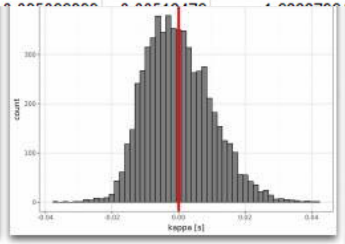
Output Source Modeling

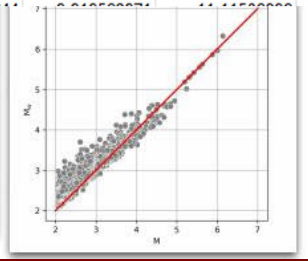
For median non-parametric source spectra derived from GITeps.py (*.source files).

ITI › GIT_Python_in_locale › CI › output › FIT › SrcModel › PLOT Cerca in PLOT

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	EveId	Longitude [Deg]	Latitude [Deg]	Depth [Km]	M	MWcat	fmin [Hz]	fmax [Hz]	M0 [Nm]	M0_err	fc [Hz]	fc_error	M0_fc_corr	kappa [s]	k_err	stress_drop [MPa]	stress_drop_err	log10_Er_mod [J]	AppStress [Pa]	log_10_Er_oss [J]
2	150725205749	13.031	42.638	10.4	3.08	-9	2.23	25	2.27684E+14	4.40339E+13	2.193563296	0.244403411	-0.9864	0.014315352	0.00161982	0.436261133	0.08437786	8.745978685	88799.0447	8.756665563
3	160824013632	13.233	42.698	8.1	6	5.97	1.41	25	1.14E+18	0	0.363786005	0.015578926	9999	0.028659675	0.00122096	9.91974594	0.099879683	13.79622314	1999798.2	14.19403059
4	160824020555	13.281	42.616	6.7	3.96	-9	1.88	25	1.60E+20	4.34E+24	0.00430811	58.59110416	-1	0.026538847	0.002236575	0.002317466	63.0357764		-38.72573193	10.17165437
5	160824023328	13.151	42.792	8	5.42	5.29	2.11	25	1.08E+17	0	0.711598788	0.024228733	9999	0.028616339	0.001366815	7.090358374	0.04085677	12.63392629	1441084.072	12.96480427
6	160824030810	13.252	42.624	10.6	3.76	-9	1.99	25	1.15E+16	3.33E+16	0.488053198	0.718457288	-0.9999	0.018603781	0.004479018	0.241672754	0.703027751	10.18914683	48983.09778	9.948970216
7	160824031759	13.138	42.759	7.8	3.84	3.842516898	1.33	25	2.48165E+15	4.2573E+14	1.117159514	0.105003242	-0.992	0.025813834	0.001916224	0.628128294	0.107804762	9.941513687	127801.6664	9.940820775
8	160824040051	13.231	42.737	10.4	3.22	-9	2.37	25	3.30617E+14	6.19604E+13	2.161102451	0.230809145	-0.9888	0.021139968	0.002718139	0.605778183	0.113550912	9.050535719	123303.0387	9.127460192
9	160824040650	13.124	42.771	6.2	4.45	-9	1.88	25	6.425E+15	2.75227E+15	1.266656292	0.292118987	-0.9957	0.030297218	0.001528357	2.370349163	1.015418274	10.9314678	482344.6377	11.13440128
10	160824043809	13.223	42.629	9.5	3.55	-9	1.88	25	1.55666E+15	4.9361E+14	1.087470995	0.182590756	-0.9974	0.01780465	0.002708016	0.363420081	0.115270903	9.501312499	73940.47655	9.448200847
11	160824053124	13.132	42.783	10.6	3.43	-9	2.11	25	1.39042E+15	5.38569E+14	1.146756614	0.234410755	-0.9978	0.011751091	0.003223981	0.380646539	0.147475688	9.472405983	77450.36702	9.391569739
12	160824053132	13.194	42.663	9.6	3.43	-9	2.51	25	7.31E+19	2.22E+24	0.004803518	72.90066548	-1	0.022065872	0.002176174	0.00147146	44.66315952		-22.43408029	9.378810911
13	160824065454	13.186	42.799	8.8	3.43	-9	1.77	25	2.62E+19	2.08E+23	0.007924462	31.51913309	-1	0.023441029	0.002055213	0.002363444	18.80086111		-14.3241452	9.48535477
14	160824094347	13.293	42.664	8.4	3	-9	2.65	25	2.68E+19	2.66E+24	0.004125479	204.5299443	-1	0.005503292	0.008405369	0.000341895	33.90039257		-5.897873412	8.398916267
15	160824115959	13.143	42.833	10.2	3.33	-9	2.51	25	5.86E+19	1.72E+24	0.004639631	68.29607282	-1	0.021729666	0.001961153	0.001062	31.26553504		-16.70565265	9.159012855
16	160824121827	13.153	42.834	11.1	3.36	-9	2.23	25	5.64492E+14	1.19183E+14	1.712622992	0.199345066	-0.9933	0.013974895	0.002419092	0.514761273	0.108704656	9.212127565	104768.9594	9.213017197
17	160824130923	13.166	42.806	9.4	3.21	-9	2.11	25	1.88366E+15	1.82464E+15	0.750446596	0.372698917	-0.9995	0.017606223	0.002433792	0.1445191	0.139998078	9.18327577	29378.89926	8.959328796
18	160824133243	13.162	42.769	9.9	3.08	-9	2.81	25	1.10E+16	3.24E+17	0.204074103	3.003642717	-1	0.050910622	0.007449182	0.016979009	0.49918386	9.000684978	3302.645446	8.252133047
19	160824140220	13.24	42.8	8.3	3.89	-9	1.88	25	3.14E+20	3.00E+25	0.002617926	125.1858676	-1	0.026950548	0.002036823	0.001023233	97.85904236		-22.22105205	10.09186935
20	160824174609	13.215	42.659	10.3	4.49	-9	2.11	25	7.17263E+15	5.5159E+15	1.203624488	0.490771351	-0.9975	0.030790664	0.002632264	2.270460366	1.746096265	10.96055336	461995.8795	11.16114439
21	160824183606	13.173	42.688	10.1	3.03	-9	2.51	25	4.10E+17	2.95E+20	0.038814642	13.94927603	-1	0.017788145	0.001607025	0.004355874	3.130671985	9.57045531	328.9216288	8.488838164
22	160825031716	13.193	42.745	9	4.64	-9	1.77	25	7.54E+20	2.31E+25	0.004399001	67.33338934	-1	0.029028948	0.00176868	0.011658486	356.9006388		-191.6845135	11.48590899
23	160825041211	13.235	42.691	9.7	3.36	-9	1.77	25	2.83462E+14	1.95534E+13	2.410023092	0.101236144	-0.971	0.027479734	0.002084415	0.720311435	0.049722696	9.058922305	146619.3292	9.063864702
24	160825123605	13.282	42.6	7.5	4.37	-9	1.77	25	4.97674E+15	3.39345E+15	1.10983702	0.403360326	-0.9966	0.023396654	0.001881447	1.235052826	0.84215799	10.53735246	251287.0844	10.84622579
25	160826040739	13.203	42.805	10.7	3.02	-9	1.58	25	9.95348E+13	9.27808E+12	3.441363613	0.220016886	-0.9311	0.023837311	0.003460843	0.736426055	0.068681502	8.614034824	149907.3705	8.626826707
26	160826040803	13.228	42.699	10.8	3.04	-9	1.41	25	1.54539E+14	1.37231E+13	2.47798614	0.139948702	-0.9532	0.014779808	0.002501754	0.426871487	0.037928309	8.568245362	86890.13148	8.567825413







Output Source Modeling

For median non-parametric source spectra derived from GITeps.py (*.source files).

Parameter	Description
EveId	Event Identification Number
M	Magnitude from FAS input files (the User should know what kind of magnitude he included in his input data files)
MWcat	Mw derived from reference catalog (see figure 12)
fmin [Hz]	Min frequency used for the source spectra fitting
fmax [Hz]	Max frequency used for the source spectra fitting
M0 [Nm]	Seismic moment [Nm]
M0_err	Standard error on seismic moment [Nm]
fc [Hz]	Corner frequency [Hz]

fc_error	Standard error on corner frequency [Hz]
M0_fc_corr	Correlation coefficient between M_0 and f_c
kappa [s]	Source kappa [s]
k_err	Standard deviation of the source kappa [s]
stress_drop [MPa]	Stress drop [MPa]
stress_drop_err	Error propagation on stress drop
log10_Er_mod [J]	log10 of radiated energy (from Brune's model)
AppStress [Pa]	Apparent stress by Wyss 1970 (using Er_mod)
log_10_Er_oss [J]	log10 of radiated energy [J] obtained from non-parametric spectrum
log_10_Er_oss_fit [J]	log10 of radiated energy [J] obtained from fitted spectrum in the range fmin and fmax
AppStress_oss [Pa]	Observed apparent stress by Wyss 1970 (using Er_oss)
log_10_Er_tot [J]	Total energy: Er_oss and extrapolated for low and high frequency [Ide and Beroza, 2001]
log_10_Er_tot_fmin_fmax_fit [J]	Total Energy: Er_oss_fit and extrapolated for low and high frequency (Ide and Beroza 2001)
ηSW	Savage-Wood seismic efficiency ηSW (Apparent stress / stress drop)
κv	Ratio between the estimated energy and the total energy considering the entire frequency range [Ide and Beroza, 2001]
κv_fmin_fmax_fit	Ratio between the estimated energy and the total energy considering the frequency range [fmin,fmax] [Ide and Beroza, 2001]
Mw	Moment magnitude

Output Source Modeling

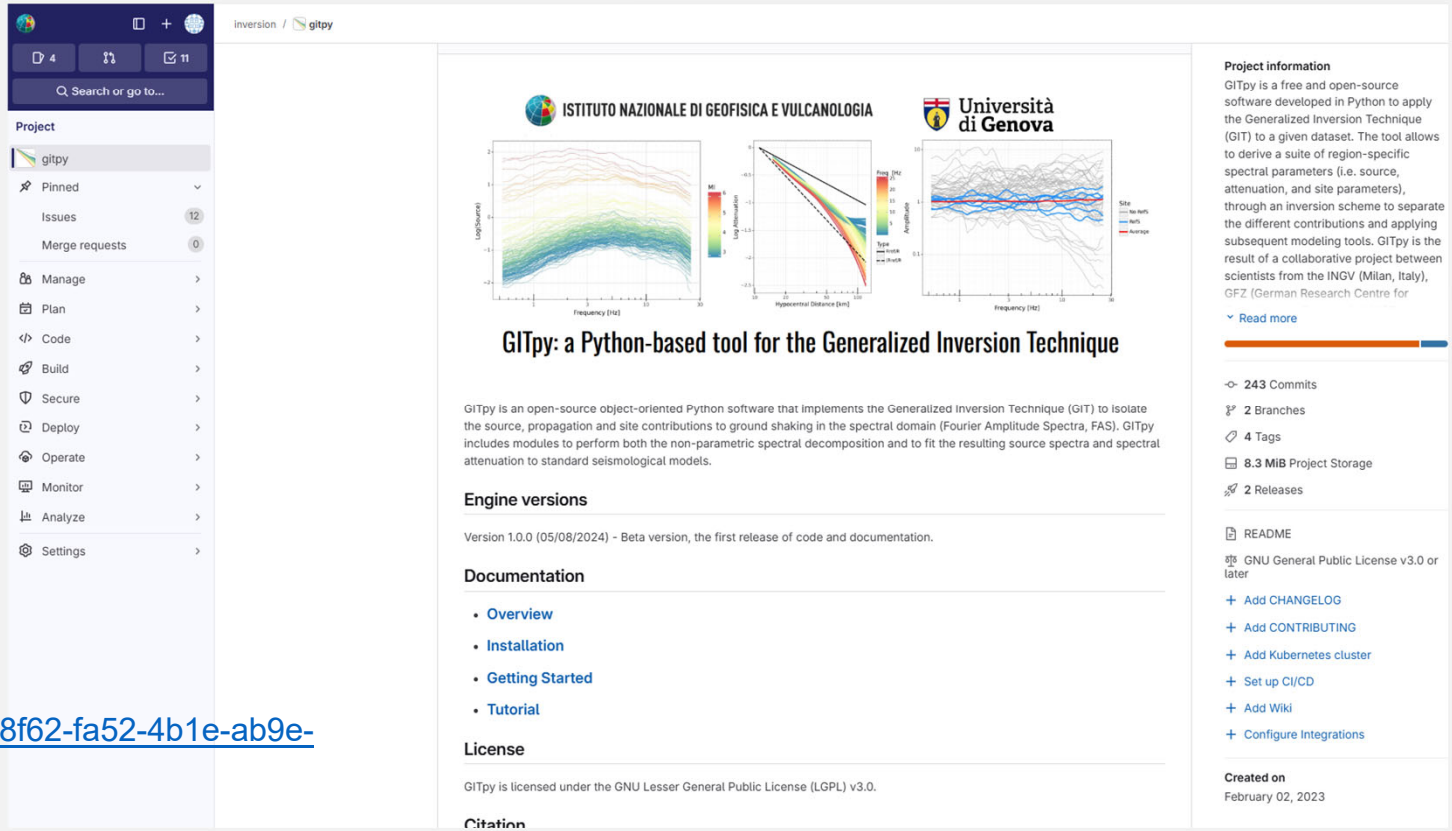
For apparent source spectra derived from CorrectFas.py (*.source files).

	A	B	C	D	E	F	G	H	I	J	K	L
1	FDSN	IT.ACT..	IT.SULP..	IT.SULA..	IT.GNU..	IT.LSS..	IV.MMO1..	IV.ATSC..	IV.VCEL..	IV.PTQR..	IV.T1212..	IV.T1202..
2	Dist	20.2	89.8	90.3	56	28.5	26	92.4	61.4	77.3	19.4	10.8
3	Az	242.1	320.1	321	101.9	53.6	200	151.1	304.1	349.4	111.1	149.7
4	Bz	62	139.6	140.6	282.4	233.7	19.9	331.5	123.7	169.3	291.2	329.8
5	ideve	160826040803	160826040803	160826040803	160826040803	160826040803	160826040803	160826040803	160826040803	160826040803	160826040803	160826040803
6	evelon	13.2283	13.2283	13.2283	13.2283	13.2283	13.2283	13.2283	13.2283	13.2283	13.2283	13.2283
7	evelat	42.6992	42.6992	42.6992	42.6992	42.6992	42.6992	42.6992	42.6992	42.6992	42.6992	42.6992
8	evedepth	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
9	M	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04
10	Mcat	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9
11	MWflag	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9
12	fminl	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	fmaxh	25	25	25	25	25	25	25	25	25	25	25
14	M0	1.38E+16	1.22E+16	3.36E+16	3.36E+16	5.26E+16	2.33E+16	9.59885E+14	1.71E+16	6.72E+16	5.26E+16	7.77842E+15
15	M0_error	2.65107E+15	1.90328E+15	1.07E+16	3.65053E+15	7.69134E+15	6.02103E+15	2.56253E+15	2.93344E+15	1.08E+16	1.26E+16	1.2609E+15
16	fc	0.631185598	0.834910198	0.469571557	0.392297756	0.303419951	0.522226234	99.99999991	0.784134164	0.256433454	0.29827585	1.372652486
17	fc_error	0.065731337	0.075743939	0.08026906	0.022583695	0.023043576	0.073468695	9200.165886	0.077472764	0.021292155	0.036942328	0.141781513
18	M0_fc_corr	-0.9916	-0.9685	-0.9922	-0.9954	-0.998	-0.9895	-0.5141	-0.9726	-0.9988	-0.9981	-0.9291
19	kappa	-0.030107588	0.026042568	-0.009544493	0.004955976	-0.006288728	0.020130536	1.075664416	0.022427554	0.001037869	-0.001170605	0.017833602
20	kappa_error	0.00339743	0.004632562	0.002286116	0.000689729	0.000820653	0.002709052	0.15649004	0.002955866	0.000251396	0.003055859	0.004359101
21	stressd	0.630145405	1.292446594	0.630614563	0.367710573	0.266558679	0.602710585	174253.6491	1.496253981	0.205685639	0.253229736	3.652039825
22	stressd_error	0.121446271	0.202234835	0.200467291	0.040056763	0.039062848	0.15595392	465192.2016	0.257306863	0.033174581	0.060988098	0.593025936

Getting Started

Basic requirements using a Python3 virtual environment for both Linux and Windows Users

Element	Version
Python	3.9
numpy	1.24.4
scipy	1.13.0
pandas	2.2.2
plotnine	0.13.6
setuptools	69.5.1
pyyaml	6.0.1
obspy	1.4.1
openpyxl	3.1.2
lmfit	1.2.2



CODICE:
https://gitlab.rm.ingv.it/inversion/gitpy

REPORT/MANUALE:
https://www.earth-prints.org/entities/publication/6b148f62-fa52-4b1e-ab9e-3a36e8ce49db/details-manuscript

DATASET:
https://drive.google.com/file/d/1RbGhe6y2QTUb479qmCute7fc3I0NLu5c/view

REFERENCE:
Morasca, P., D'Amico, M., Spallarossa, D., Bindi, D., Picozzi, M., Oth, A..,F.Pacor GITpy: a Python implementation of the Generalized Inversion Technique. SRL (accepted)

Summary

- GITpy è un software **open-source** e con struttura **object oriented**.
- Semplifica il processo di modellazione dell'attenuazione e della sorgente tramite **file di configurazione e procedure interattive** per test rapidi di diversi modelli.
- Permette di scegliere tra **diversi livelli di complessità** nella modellazione dell'attenuazione (diffusione geometrica e attenuazione anelastica).
- Offre opzioni per la modellazione dello spettro della sorgente, tra cui **modelli crostali omogenei o eterogenei** e la possibilità di definire l'intervallo di frequenze per il fitting del modello.
- Consente di calcolare **spettri apparenti** della sorgente specifici per ogni stazione, correggendo l'amplificazione locale e l'attenuazione non parametrica. Questo è utile per studi di direttività e per una stima rapida dei parametri della sorgente in caso di eventi forti.
- Fornisce **diversi parametri di sorgente** tra cui Er, stress apparente, efficienza della radiazione oltre ai valori di M_0,fc e stress drop.

FUTURE IMPLEMENTAZIONI

- Vincolo sui siti di riferimento con le funzioni di amplificazione
- Inversione con vincolo su sorgente e attenuazione invece che su sito e attenuazione
- Aggiungere nuovi modelli di sorgente oltre a Brune (1970)
- Fitting delle sorgenti a tre step (Bindi e Kota 2020)
- Inversione a 2 step
- ……..

Invitiamo e incoraggiamo ricercatori e/o sviluppatori a contribuire con altre idee da sviluppare in collaborazione

FINE