USER-MANUAL

GENERALIZED GROUND MOTION MODEL (GGMM) (SUBDUCTION)

This tool, named as Generalized Ground Motion Model for Subduction environment (*GGMMSubd*), uses a hybrid Recurrent Neural Network (RNN) framework to estimate a 35×1 cross -dependent vector (denoted as **IM**) of RotD50 Spectral Acceleration (RotD50S_a) at 31 periods and geometric means of Arias Intensity ($I_{a_{geom}}$), Significant Duration ($D_{5-95_{geom}}$), Peak Ground Acceleration, (PGA_{geom}) and Peak Ground Velocity (PGV_{geom}) using a set of seismic source and site parameters as inputs. The source and site inputs to the RNN framework include a vector of 6 values including Subduction fault slab mechanism (F), magnitude (M_w), closest rupture distance (R_{rup}), Joyne-Boore distance (R_{JB}), soil shear-wave velocity (V_{s30}), and hypocentral depth (Z_{hyp}). The residuals of the RNN framework are used to construct between-event and within-event covariance matrices to account for the between-event and within-event variabilities of the ground motions. Hence, given the source and site parameters, this tool returns a median prediction of the **IM** and estimated correlated variance bands. The executable is developed by Jawad Fayaz (https://jfayaz.github.io/layouts/codeandsoft.html/) and collaborators (Miguel Medalla, Pablo Torres, and Carmine Galasso). For further details please read the article mentioned in the “Reference”.

https://www.dropbox.com/scl/fo/lqcz9p7sk2mea3a1itlx5/AD6Z9OJWoQMyk5Y-svSxKH0?rlkey=l0wh0v5le3nu05mz8rtrjqu87&dl=0

1. *GGMMSubd* Inputs (in order)

i. Subduction Fault Mechanism (F)

Subduction Mechanism (F)	Value
Interslab	0
Intraslab	1

ii. Magnitude (M_w): $3 \leq M_w \leq 9$

iii. Closest Rupture Distance (R_{rup}) in kilometers (km): $0 \leq R_{rup} \leq 300$

iv. Depth of Hypocenter (Z_{hyp}) in kilometers (km): $0 \leq Z_{hyp}$

v. Joyne-Boore Distance (R_{JB}) in kilometers (km): $0 \leq R_{JB} \leq 300$

vi. Shear-Wave Velocity (V_{s30}) in meters per second (m/s): $0 \leq V_{s30} \leq 3000$

vii. Conditional Period (T^*)

IM	Input for T*
PGV_{geom}	-3
$D_{5-95_{geom}}$	-2
$I_{a_{geom}}$	-1
PGA_{geom}	0
T =0.01	0.01
T =0.05	0.05
T =0.1	0.1
T =0.15	0.15
T =0.2	0.2
T =0.25	0.25
T =0.3	0.3
T =0.4	0.4
T =0.5	0.5
T =0.6	0.6
T =0.7	0.7
T =0.8	0.8
T =0.9	0.9
T =1.0	1.0
T =1.2	1.2
T =1.4	1.4
T =1.6	1.6
T =1.8	1.8
T =2.0	2.0
T =2.25	2.25
T =2.5	2.5
T =2.75	2.75
T =3.0	3.0
T =3.25	3.25
T =3.5	3.5
T =3.75	3.75
T =4.0	4.0
T =4.25	4.25
T =4.5	4.5
T =4.75	4.75
T =5.0	5.0

viii. Name of Output Folder (*OutputFolderName)*

2 Calling *GGMMSubd*

The tool package consists of the executable application "GGMMSubd.exe" which can be easily called from any command line or programming language/software. An example to run the GGMM program is given in Figure 1 where the inputs are in the same order as mentioned in above section "GGMM Inputs". The generalized syntax to run the executable is as follows:

$$\text{GGMMSubd.exe} \quad F \quad M_w \;\; R_{rup} \;\; Z_{hyp} \;\; R_{JB} \;\; V_{s30} \;\; T^* \; OutputFolderName$$

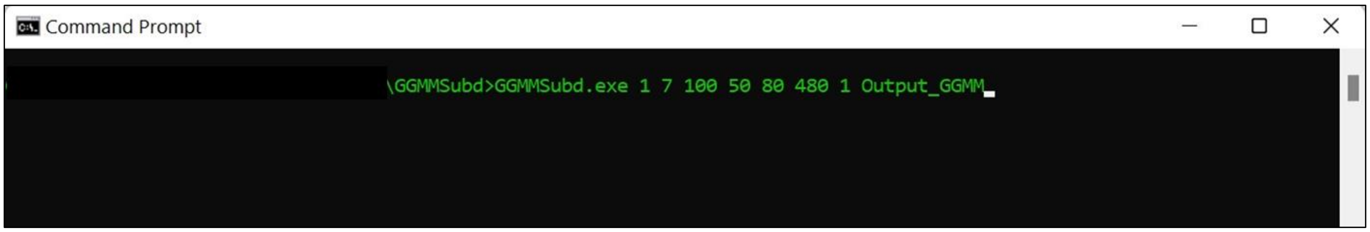

Figure 1: Calling "GGMMSubd.exe"

In case all the inputs are not properly provided the tool will throw an error as shown in Figure 2.

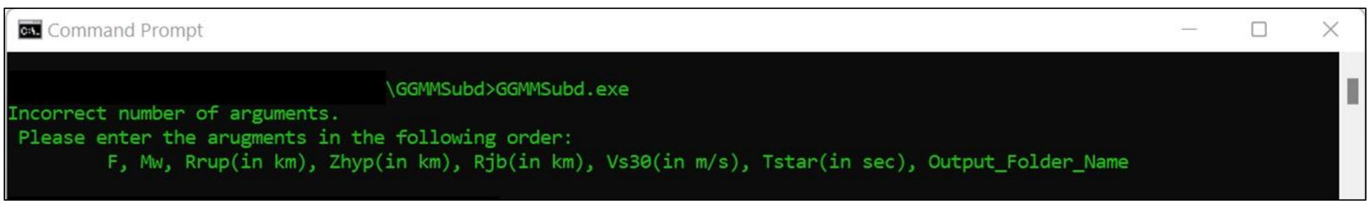

Figure 2: Error screen of "GGMMSubd.exe"

3 *GGMMSubd* Outputs

The tool creates a folder named as inputted by the user in the *OutputFolderName* (as described) within the current directory of the tool. The output screen of the framework is shown in Figure 3.

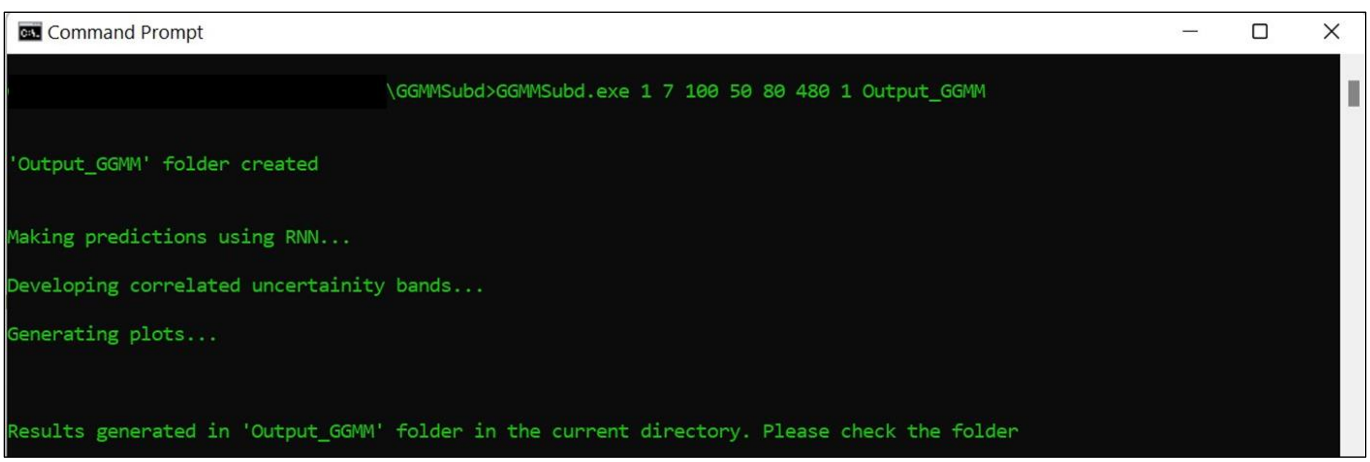

Figure 3: Output screen of "GGMMSubd.exe"

The outputs consist of two files: 1) "GGMM.out" file containing the estimated median **IM** predictions and its conditional correlated variance bands (hence there is no variability at *T**) and 2) "GGMM.jpg" file showing the median and sigma bands of the estimated intensity measures in **IM** vector. The outputs are shown in Figures 4 and 5.

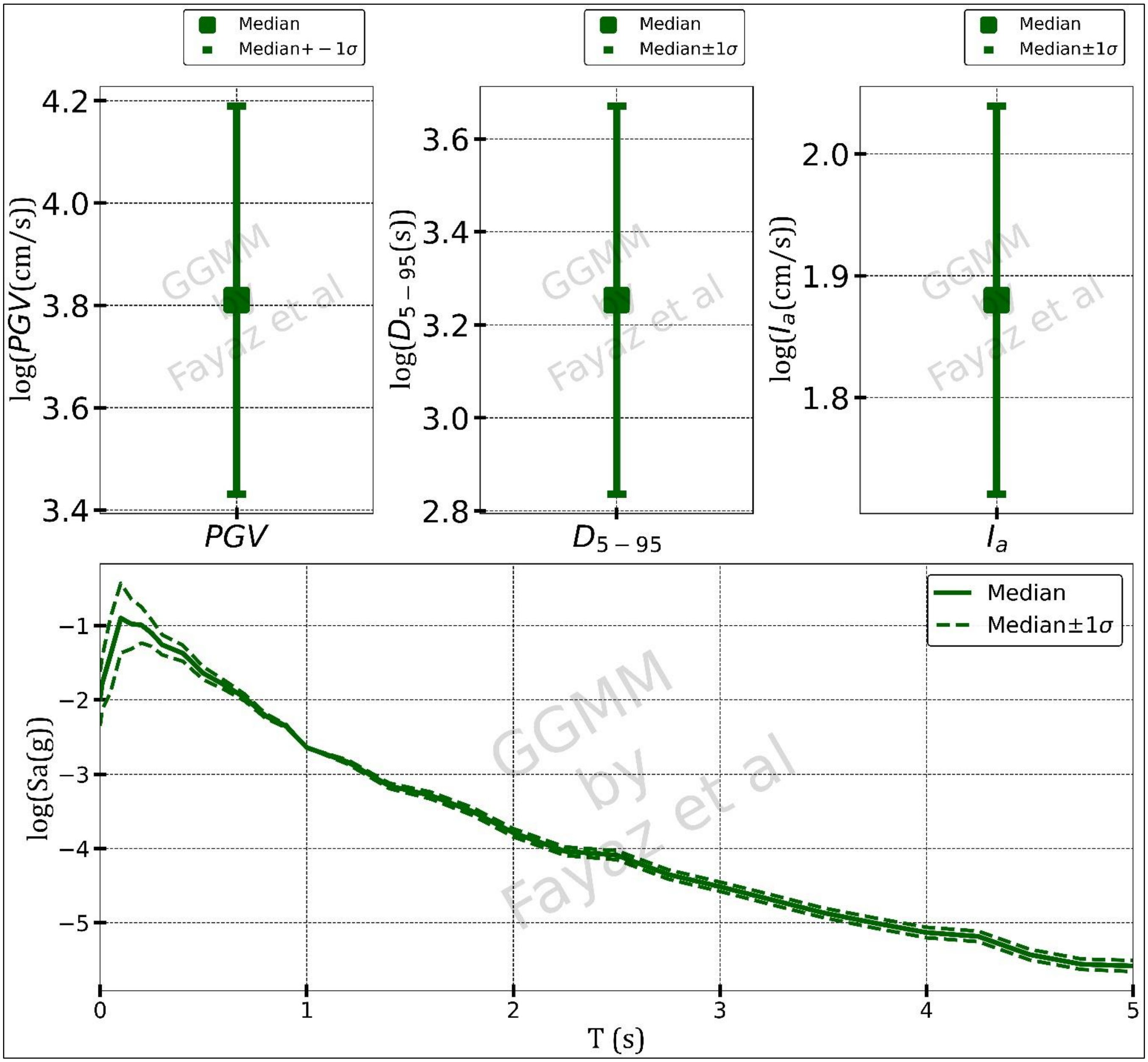

Figure 4: Estimated **IM** output

GGMM.out

```
T   Median  Median-sigma    Median+sigma
PGV -0.37695977091789246    -0.37695977091789246    -0.37695977091789246
D595    2.84094500541687    1.9415109758606557  3.7403790349730848
Ia  -0.12560594081878662    -0.6437176423300242 0.3925057606924509
PGA -3.9913647174835205 -4.549281966901205  -3.433447468065836
0.01    -3.4784090518951416 -4.019641574367986  -2.937176529422297
0.05    -3.1990227699279785 -3.7877270182943117 -2.6103185215616453
0.1 -2.7986066341400146 -3.4092391452642703 -2.187974123015759
0.15    -2.496680974960327  -3.0927318929626475 -1.9006300569580068
0.2 -2.737539529800415  -3.3293273380219186 -2.1457517215789115
0.25    -2.6430089473724365 -3.2195390012699114 -2.0664788934749616
0.3 -2.865675449371338  -3.428094653340792  -2.303256245401884
0.4 -3.1758267879486084 -3.7518747284814182 -2.5997788474157986
0.5 -3.1301863193511963 -3.7030378114551072 -2.5573348272472853
0.6 -3.288729429244995  -3.860323643904333  -2.717135214585657
0.7 -3.7680866718292236 -4.330125305414816  -3.2060480382436314
0.8 -3.741262912750244  -4.29845794290837   -3.1840678825921183
0.9 -4.0367889404296875 -4.588907961692457  -3.4846699191669184
1.0 -4.398294925689697  -4.94463090435241   -3.851958947026984
1.2 -4.965432643890381  -5.494882551893186  -4.435982735887576
1.4 -5.36202335357666   -5.879500909413421  -4.844545797739899
1.6 -5.661406517028809  -6.1707681936936    -5.1520448403640176
1.8 -6.044726371765137  -6.5506246416367935 -5.53882810189348
2.0 -6.283880710601807  -6.787887088724079  -5.779874332479534
2.25    -6.401032447814941  -6.9025169688225745 -5.899547926807308
2.5 -6.5673747062683105 -7.067221321513552  -6.067528091023069
2.75    -6.818793296813965  -7.3182220553598984 -6.319364538268031
3.0 -6.978192329406738  -7.478020503324831  -6.478364155488646
3.25    -7.162293910980225  -7.662787496390374  -6.661800325570075
3.5 -7.231132984161377  -7.733609523677808  -6.728656444644946
3.75    -7.508701801300049  -8.011055252541407  -7.0063483500586905
4.0 -7.671975135803223  -8.176972429713691  -7.166977841892753
4.25    -7.896575450897217  -8.404686456182528  -7.3884644456119055
4.5 -7.711543560028076  -8.221055945399781  -7.202031174656372
4.75    -7.842799663543701  -8.354660168020564  -7.33093915906684
5.0 -7.909265995025635  -8.423843580153179  -7.39468840989809
```

Figure 5: Estimated **IM** output in the “GGMM.out” file

Reference

Jawad Fayaz, Miguel Medalla, Pablo Torres, and Carmine Galasso (2023). "Recurrent Neural Networks based Generalized Ground Motion Model for Chilean Subduction Seismic Environment". *Structural Safety*. https://www.sciencedirect.com/science/article/pii/S0167473022000893?via%3Dihub.