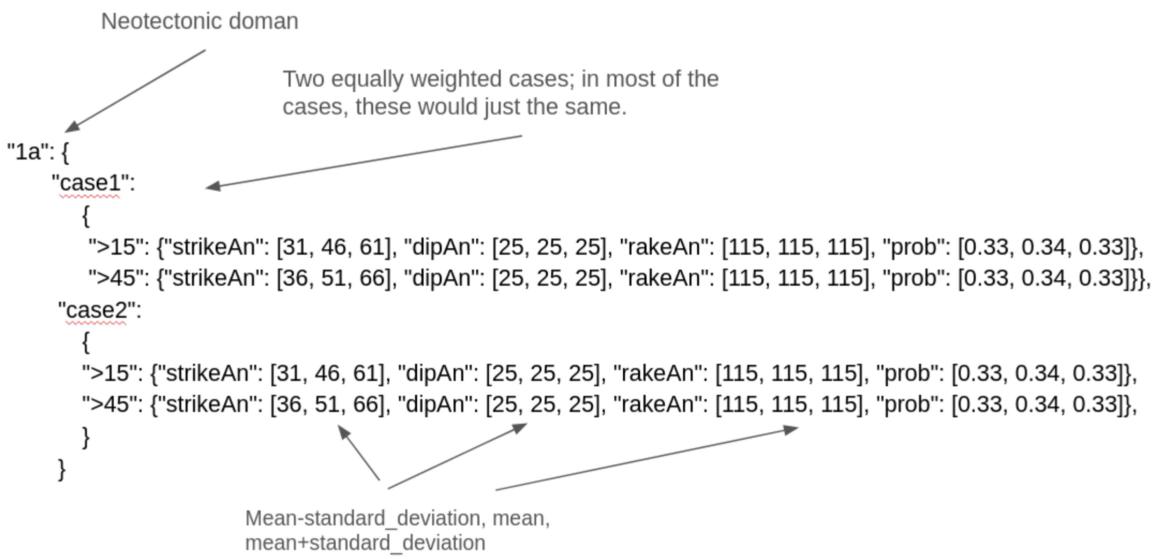
A Note on Focal Mechanism Models in the Distributed Seismicity Model of the New Zealand National Seismic Hazard Model.

Kiran Kumar Thingbaijam

Shallow crustal events:

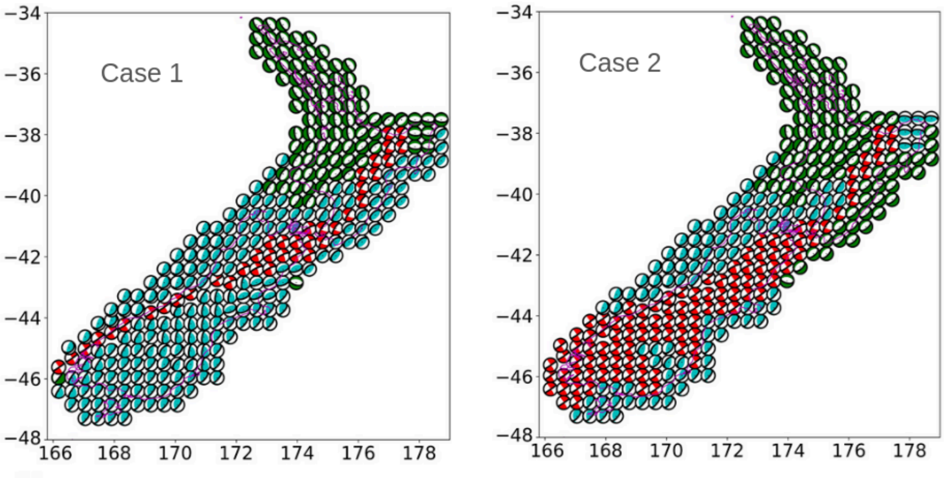
The files are:
*nzfocmecmod.json***:** This contains the focal mechanism model for shallow crustal events.
*ntdomains_modified.json***:** This contains the revised neotectonic zones.

A brief description of the nzfocmecmod.json file is as follows:



“>15” and “>45” refers to rupture length criteria; so, it would be necessary to calculate the rupture length (using a source scaling relation) in advance. The angles are degrees.

Note that we have two equally weighted cases (case 1 and case 2; these are considered to address rake uncertainty). In most cases, these cases are the same (see Figure below).



The approach that I adopted:
(1) get the neotectonic domain number (which is a string, not exactly a number, e.g. '1a') based on the longitude and latitude of the event, and
(2) extract the focal mechanism model for that domain number.

Limitation: If the event is not located in any of the domains, it will not work.

Additionally, for the GMDB - there might be a need to select only one focal mechanism. When case 1 is the same as case 2, one might simply use the mean values (largest probability). However, there could be a need to be creative where case 1 differs from case 2.

Subduction interface events:

The files for the Hikurangi and Puysegur zones are:
hik_focmec.npy
puy_focmec.npy

Please note that these are numpy binaries (interpolators). The reason we have binary is that the dip and strike angles are based on the subduction models, and have spatial variation. These files can be read using numpy/python. An example is as follows,

```
hik_focmmec = np.load('hik_focmec.npy', allow_pickle=True)[()]
fm_strike = hik_focmmec[0]
fm_dip = hik_focmmec[1]
fm_loc = np.transpose([[longiture], [latitude]])
strikeAn = fm_strike(fm_loc)[0],
dipAn = fm_dip(fm_loc)[0]
```

strikeAn and dipAn are to be rounded.

For the Puysegur interface, the following constraints are applied:

```
if dipAn<10.:
    dipAn = 10.0
if dipAn>45:
    dipAn = 45
if strikeAn>40:
    strikeAn = 40
if strikeAn<0:
    strikeAn = 0
```

For the Hikurangi interface, the following constraints are applied:

```
if dipAn<10.:
    dipAn = 10.0
if dipAn>45:
    dipAn = 45
if strikeAn>260:
    strikeAn = 260
if strikeAn<240:
    strikeAn = 240
```

Rake angle = 90 degrees is applied in all the cases. The model gives only one focal mechanism for one location.

The spatial bound or polygon for each subduction zone is also given in each file. Following the previous example,

```
pbounds = hik_focmmec[2]
```

Here, pbounds is a polygon and if the event is not within this polygon then we do not associate it with the subduction zone. The interpolator would not be applicable as the event is outside the zone.

Intraslab events

The file is slab-faulting2.json. The model is depth dependent for each subduction zone. However, spatial dependency has not been incorporated. A description of the json file is as follows:

Subduction tag

Mid depth

Strike, dip, rake, probability


```
{"hik":
    {"20": [[-144, 56.0, -85, 0.32], [229.0, 56.0, -85, 0.36], [242, 56.0, -85, 0.32]],
     "30": [[-143, 57.0, -84, 0.32], [230.0, 57.0, -84, 0.36], [243, 57.0, -84, 0.32]],
     "40": [[-141, 56.0, -89, 0.32], [231.0, 56.0, -89, 0.36], [243, 56.0, -89, 0.32]],
     "50": [[-138, 54.5, -76, 0.32], [235.5, 54.5, -76, 0.36], [248, 54.5, -76, 0.32]],
     "60": [[-140, 62.0, -78, 0.32], [239.0, 62.0, -78, 0.36], [258, 62.0, -78, 0.32]],
     "70": [[-145, 65.0, -123, 0.32], [236.0, 65.0, -123, 0.36], [257, 65.0, -123, 0.32]], ….
```


For a depth, the bin center is computed as follows:

```
def get_depbincenter(dep):
   fbs, min_x,max_x  =10, 20, 300
   x_bin = [d for d in range(min_x, max_x, fbs)]
   for db in x_bin:
      if (dep>=(db-fbs)) & (kdep<(db+fbs)):
         return(str(db))
   return None
```

References:

For shallow crustal events:

Thingbaijam, K.K.S., Rattenbury, M.S., Van Dissen, R.J., Gerstenberger, M.C., Ristau, J. and Fitzenz, D.D., 2024. Characterization of focal mechanisms for upper crustal distributed seismicity in Aotearoa New Zealand. *Seismological Research Letters*, *95*(1), pp.150-158.

For subduction interface events:

Kiran Kumar Thingbaijam, K.K.S, Gerstenberger, M.C., Rollins, C., Rastin, S.J., Rhoades, D., Iturrieta, P., Van Dissen, R., and Christophersen, A. (2022) A Framework for a Distributed Seismicity Model: A case study from the New Zealand National Seismic Hazard Model 2022 [Poster], New Zealand Society for Earthquake Engineering, Annual Technical Conference, 9-11 April 2024, Wellington, New Zealand

For intraslab events:

Thingbaijam, K.K.S., Gerstenberger, M.C., Rollins, C., Van Dissen, R.J., Rastin, S.J., Christophersen, A., Ristau, J., Williams, C.A., Fitzenz, D.D. and Pagani, M., 2024. A seismogenic slab source model for Aotearoa New Zealand. *Bulletin of the Seismological Society of America*, *114*(1), pp.95-110.