Project funded by EUROPEAN UNION

Black Sea CROSS BORDER COOPERATION

REDACt
Rapid Earthquake Damage Assessment ConsorTium

DESIGN OF REDAS VER 1.1

Thessaloniki Meeting, 08 June 2023

T2-Development of the Rapid Earthquake Damage Assessment System (REDAS)

Partners involved:

- Technological Educational Institute of Central Macedonia
- Institute of Engineering Seismology & Earthquake Engineering (ITSAK)
- Democritus University of Thrace
- Gebze Technical University
- Ovidius University of Constanta
- Institute of Geology and Seismology

REDACt
Rapid Earthquake Damage Assessment ConsorTium

Rapid Earthquake Damage Assessment-Near Real Time–Hazard and Loss Estimation Software

REDAS System consist of five main modules:

- Shakemap Generation Module,
- Hazard Module,
- Loss Module,
- Geotechnical Failure Module,
- Lifeline Module (Natural Gas Pipeline).

To produce earthquake hazard and loss maps in near real time by using offline/online station data.

REDACt
Rapid Earthquake Damage Assessment ConsorTium

Scope of REDAS V1.1

ShakeMap

REDACt
Rapid Earthquake Damage Assessment ConsorTium

REDAS V1.1 Active Models

REDAS Interface and Modules

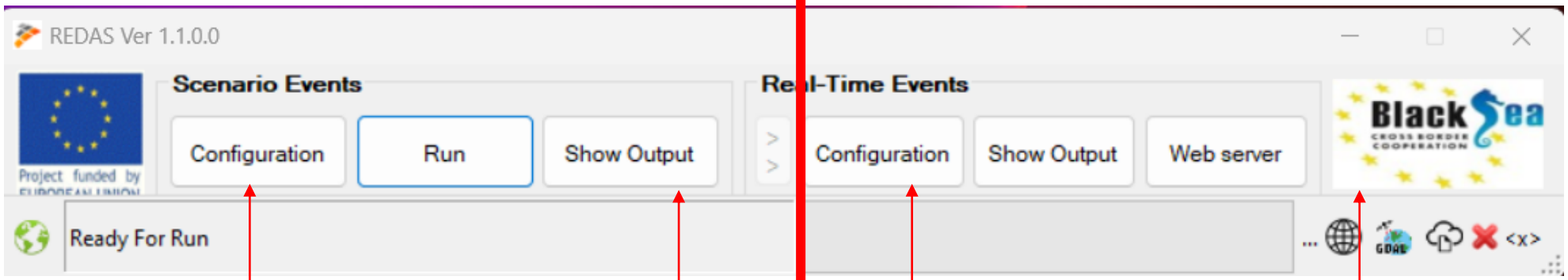
- Interface Design
- Folder Structures and File Systems

REDACt
Rapid Earthquake Damage Assessment ConsorTium

Main Interface

Scenario Based
To be utilized by users Manually

Event Based
Automatic triggering
First Priority for Analysis



Configuration Can be changed by user

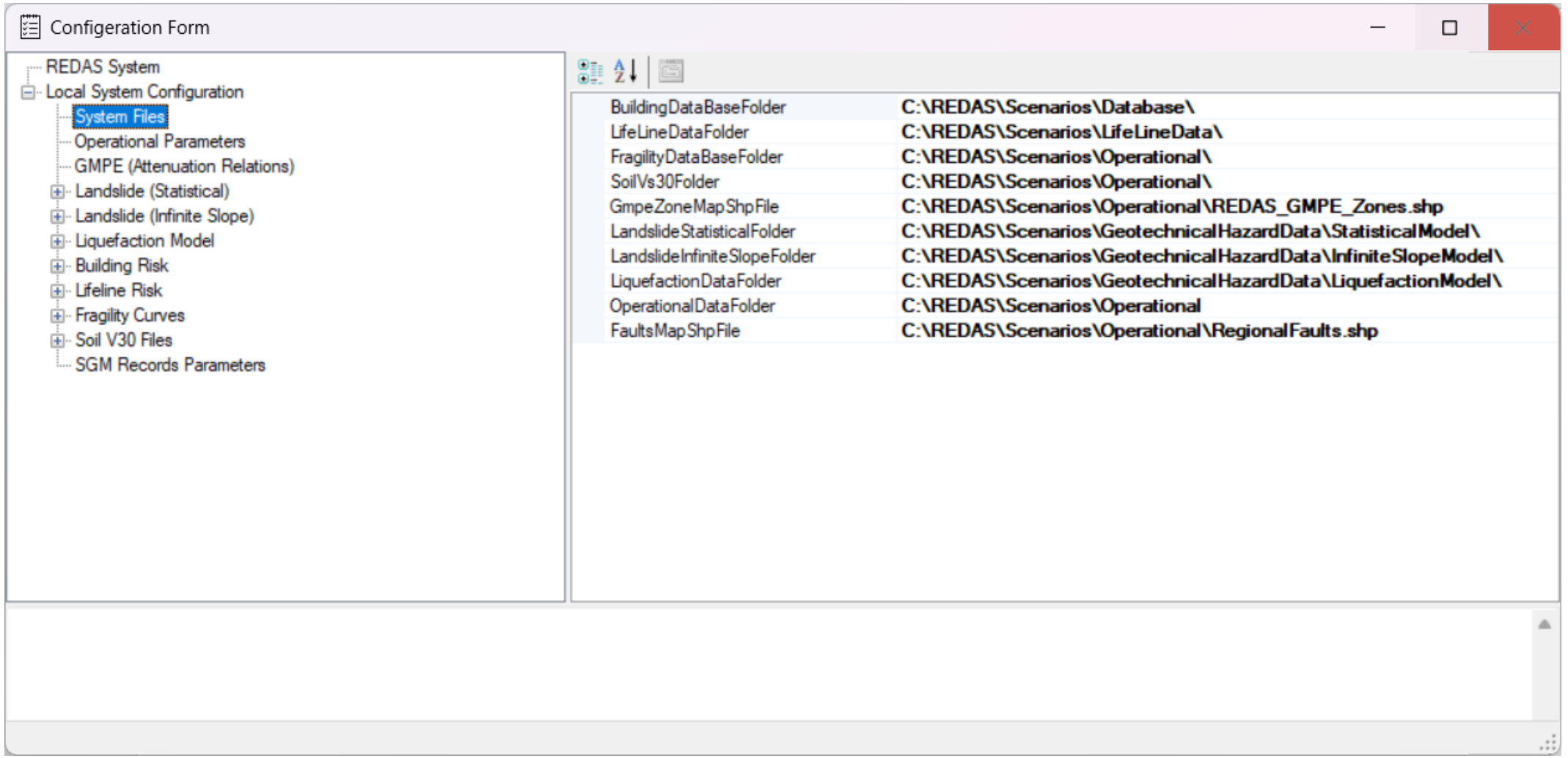
PC Based Results and Maps

Configuration is harmonized between the Shared servers/ Can not be Changed

www server Based Results and Maps

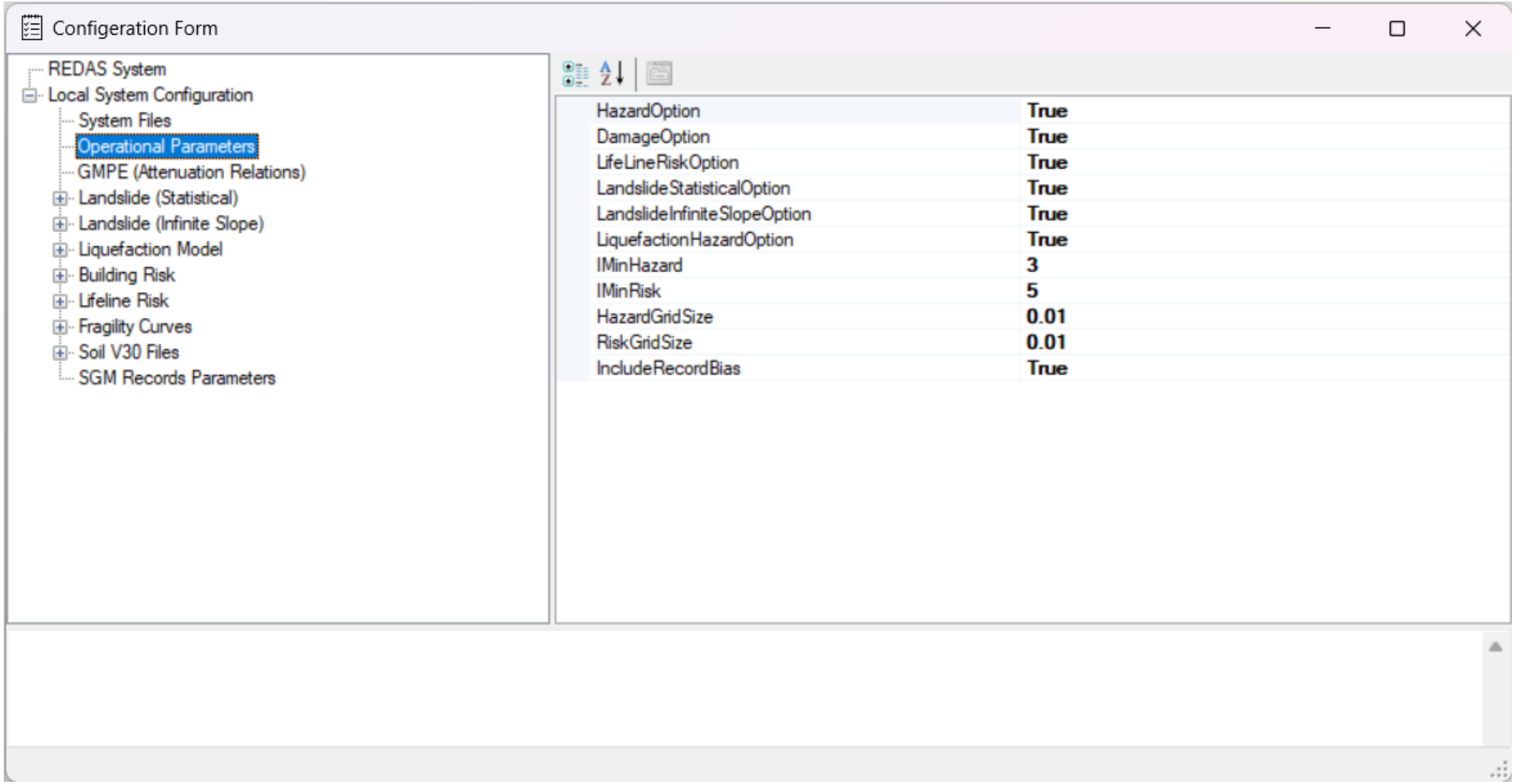
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Configurations/*System Files*



REDACt
Rapid Earthquake Damage Assessment ConsorTium

Configurations/*Operational Parameters*



REDACt
Rapid Earthquake Damage Assessment ConsorTium

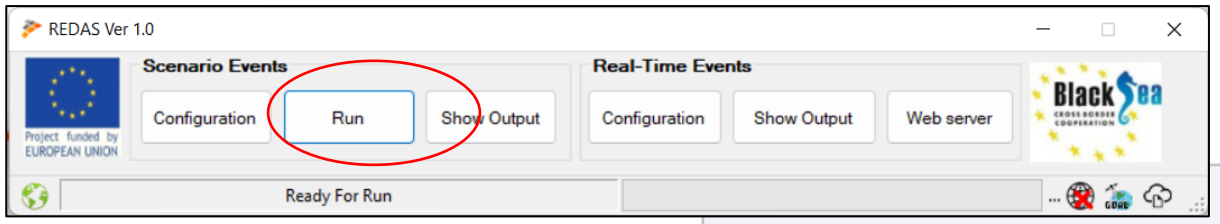
REDAS V1.1 Active Models

Scenario & Real Events

- Event data Xml File (Point Source)
- Event data Xml File (Fault Source)
- Event Data SGM Record xml Files
- Online Shared Events
- Online Shared Events SGM Record Data

REDACt
Rapid Earthquake Damage Assessment ConsorTium

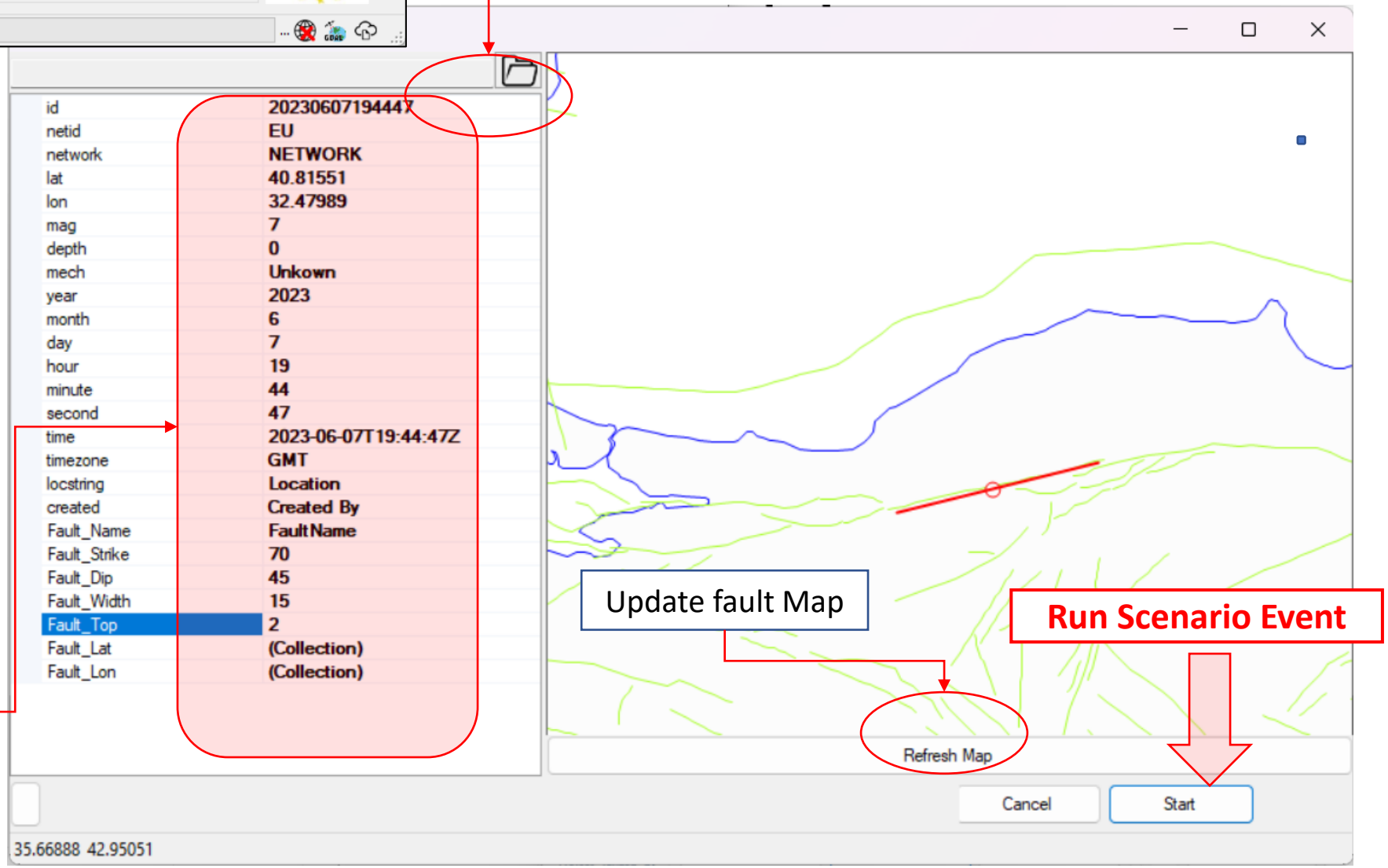
Run Event / Scenario Based



Open event Xml file

Scenario Event parameters can be entered directly to the input class form Or can be read from xml file

Event Parameters can be specified / modified



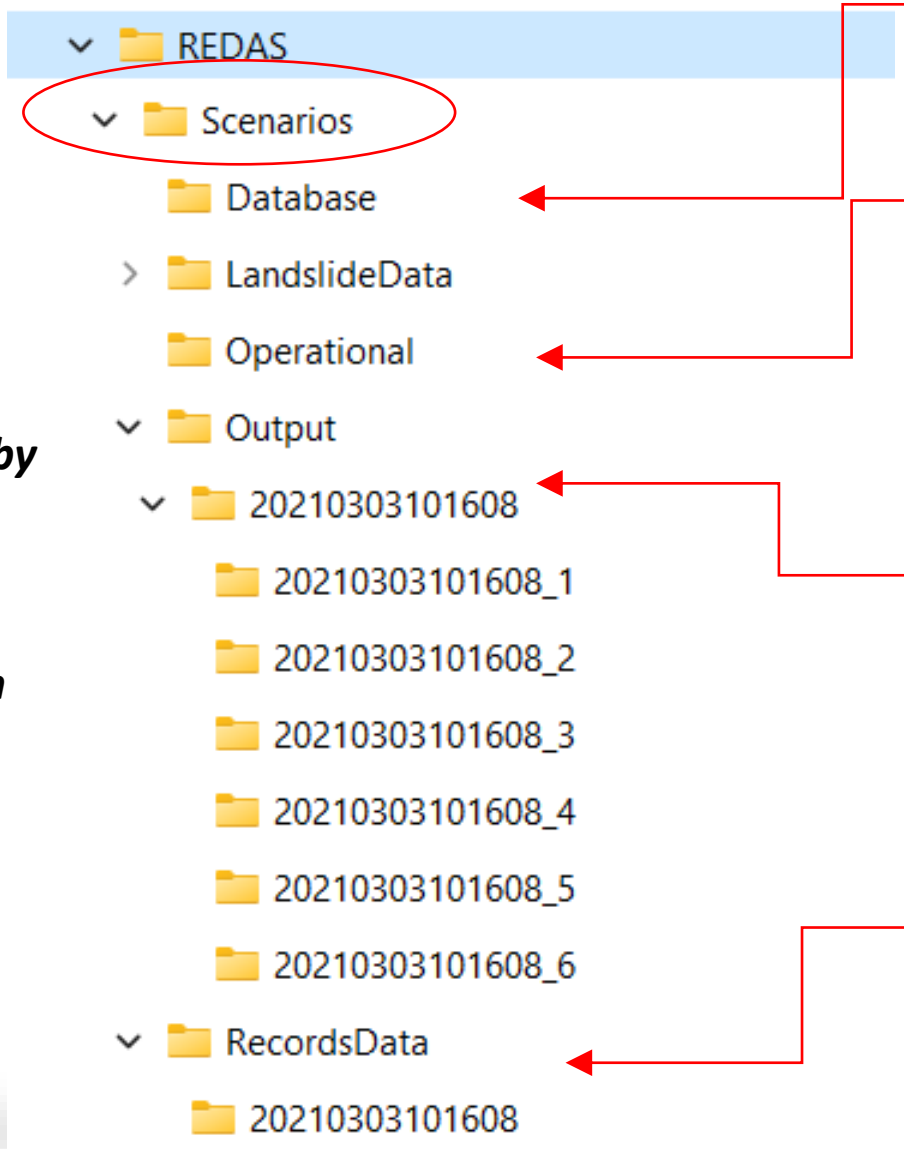
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Input & Output Data Management

Scenario Based

Scenario Based Data and Results Is located under REDAS/Local Folder by Default

But the locations can be changed by the users



Building Inventories and Landslide parameters

Input maps and xml parameters

All the Scenario Results will be automatically arranged such that each trial will have separate folder with the trial number. All the trials will be placed under the main folder with the Scenario ID

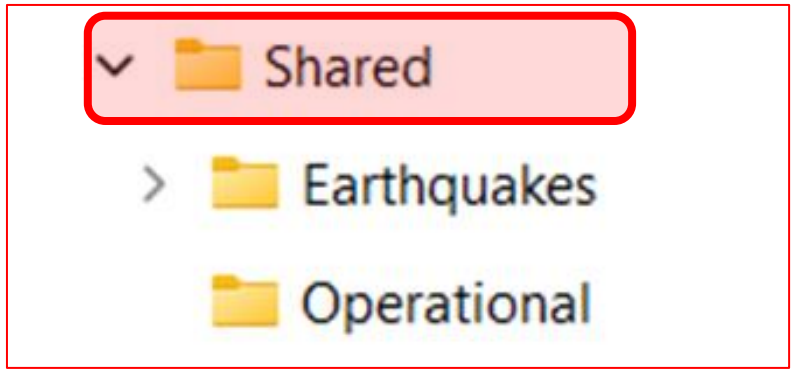
Records Data Parameters: Each Scenario will have separate folder of its ID that have xml files for the records parameters

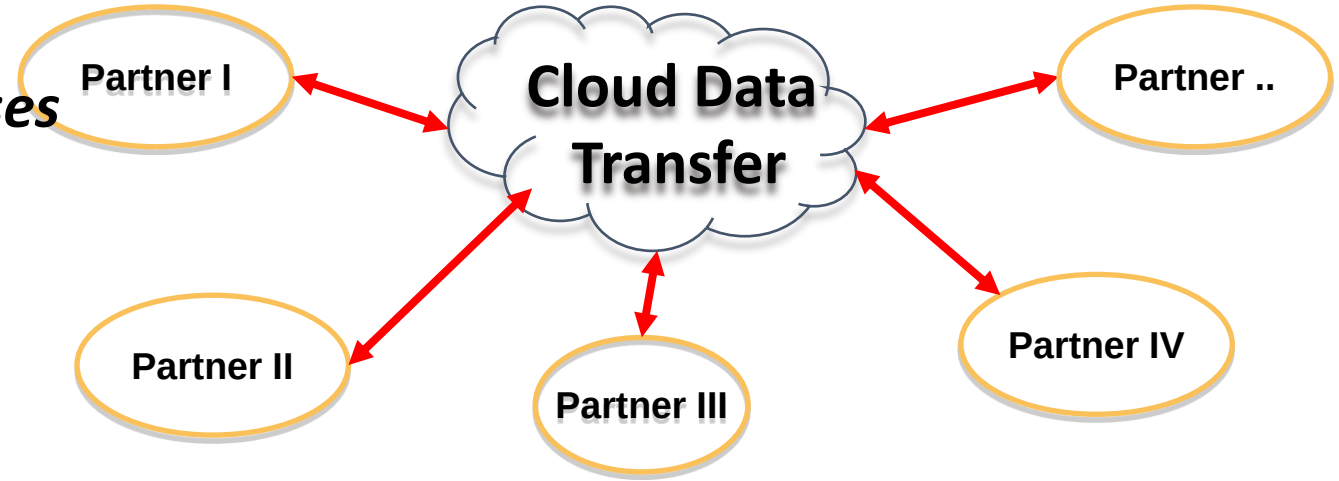
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Cloud Data Transfer for the REDA System

Real Events

- ***A Common Cloud service to be organized by all the partners. "Shared cloud folder" to be arranged***
  - ***No need-to-know Partners' IP Addresses***
  - ***Easy to manage and install***
  - ***Flexible to Add new partners***
  - ***Flexible to Add new Servers***





Cloud Data Transfer

The Cloud transfer folder can be configured to be a shared "Cloud folder" using a common cloud service such that gdrive, onedrive, dropbox, amazon, … etc. The physical location of the shared "Cloud folder" can be arranged according to the requirement of the cloud service. The expected size of each event will be in terms of 1 MB, so a standard service or even a free service can be utilized by all the partners.

REDACt
Rapid Earthquake Damage Assessment ConsorTium

Online Event Processing Data for the REDA System

Shared Cloud Data

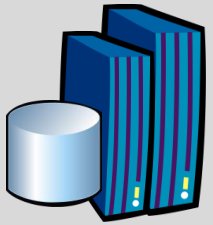
Real Events

Local Drive

Earthquakes
- Event ID1
  - Event Trigger xml Files
  - Station Data xml Files

Operational Data
- Faults Maps
- Vs30 Maps
- Fragility & Vulnerability Curves
- Triggering Areas Map
- Regional GMPE parameters

REDA System Partner I



DataBase
- Buildings
- Population
- Lifelines
- Critical Facilities

Processing ……..

Results>> local web server
- Intensity Maps
- PGA, PGV, PSA,…
- Local Building Damage Maps
- Local Lifeline Damage Maps
- ….

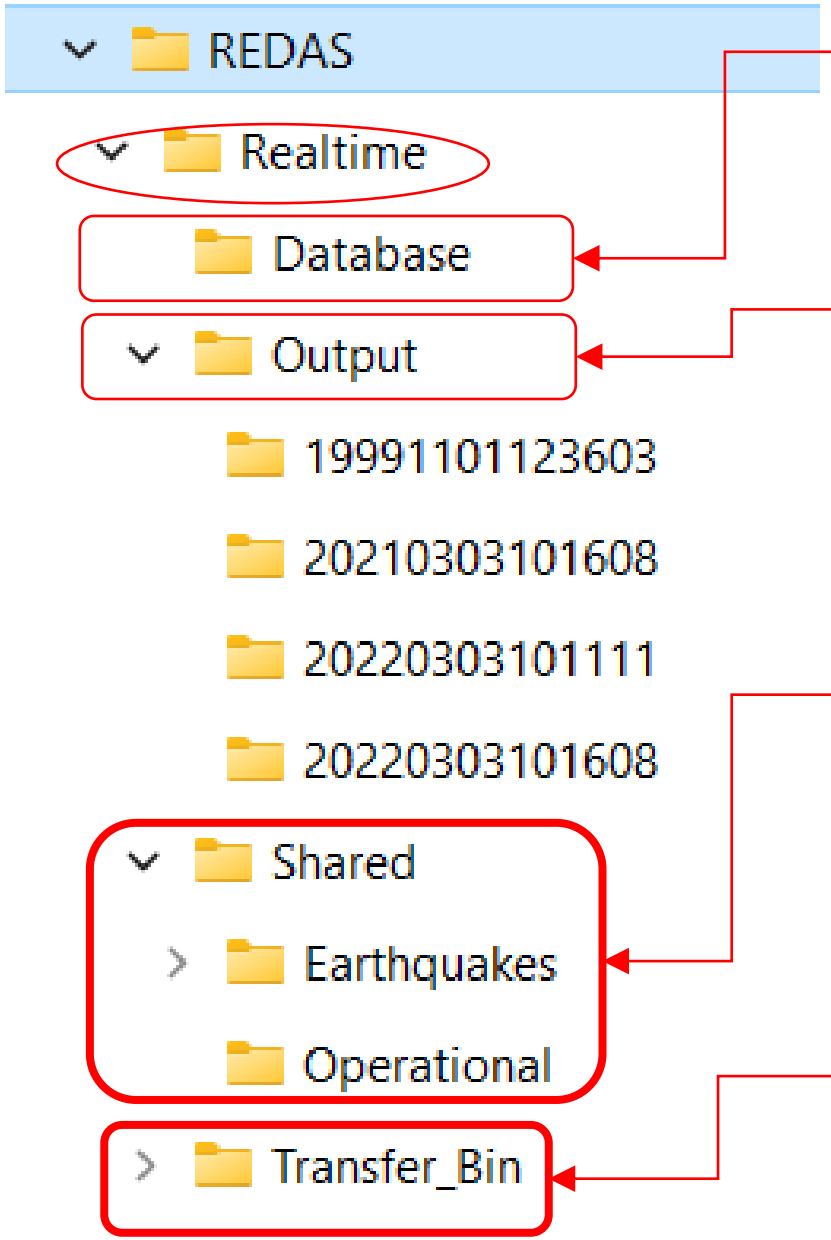
Event ID> Grid Based Damage Data

Input & Output Data Management

Real Events

Shared Event Based Data and Results Is located under REDAS/Shared Folder by Default

But the locations can not be changed by the users



Building Inventories and Landslide parameters (will not be Shared)

All the Events' Results will be automatically placed under the main folder with the Event ID. New Results will over-write the previous ones.

All Earthquake and Operational Parameters will be shared under "shared" Folder. This Folder will be shared by Cloud among all the Joint Institutes. **Earthquake Folder: The contents of the folder will be generated automatically by REDAS with the insertion of xml files into Transfer_Bin**

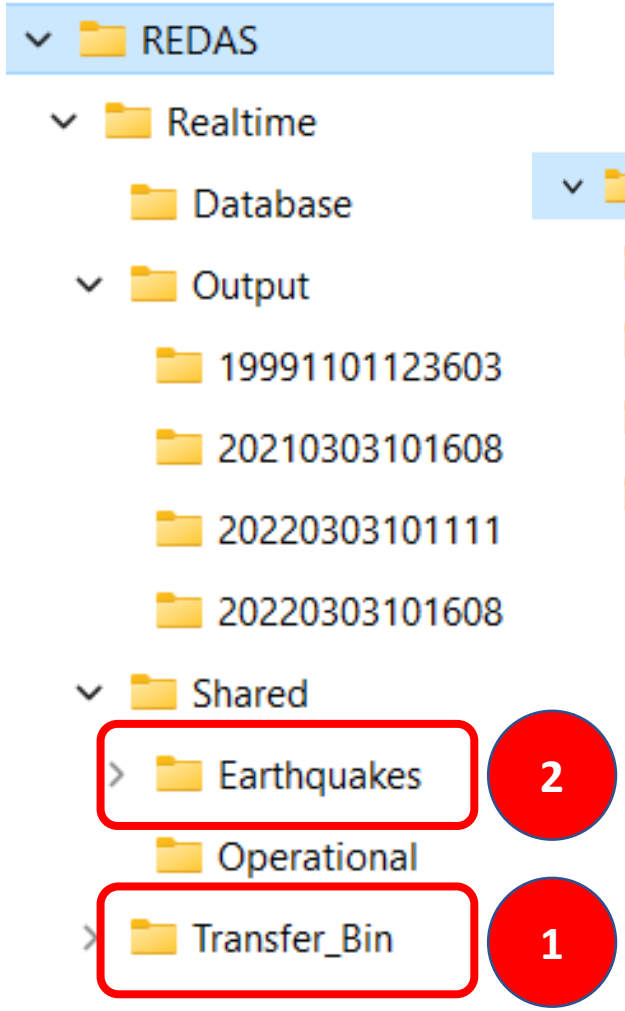
Transfer_Bin is used to transfer the data to cloud. Event and records xml files to be placed into "Transfer_Bin" directly

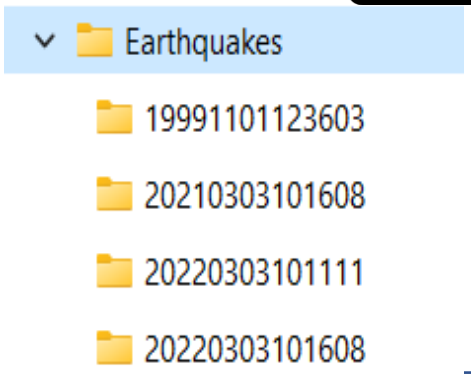
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Input & Output Data Management

File watchers for Real Events

Two File watchers are integrated into the system for Shared Event parameters





Generate EVENT Folders

Folder Watcher 2:

Control the changes in Earthquakes Folders

1. Process the event xml shared by different Institutes.
2. Decide the relevant Institute event xml files using the event location within triggering map areas.
3. Process the event together with the records' parameters if any.
4. The results will be generated under Events folder

Folder Watcher 1:

Control the xml files' changes in **Transfer_Bin**

If a new xml file is detected:

1) Create new folder with the Event ID or append existing event ID folder under **Cloud/Earthquakes**
2) Move Event.xml to **Cloud/Earthquakes/EVENT_ID** by Adding Institute ID to xml files (Event_TR.xml)
3) Records' parameters xml files will be moved If there is suitable EVENT folder with the same Event ID

REDACt
Rapid Earthquake Damage Assessment ConsorTium

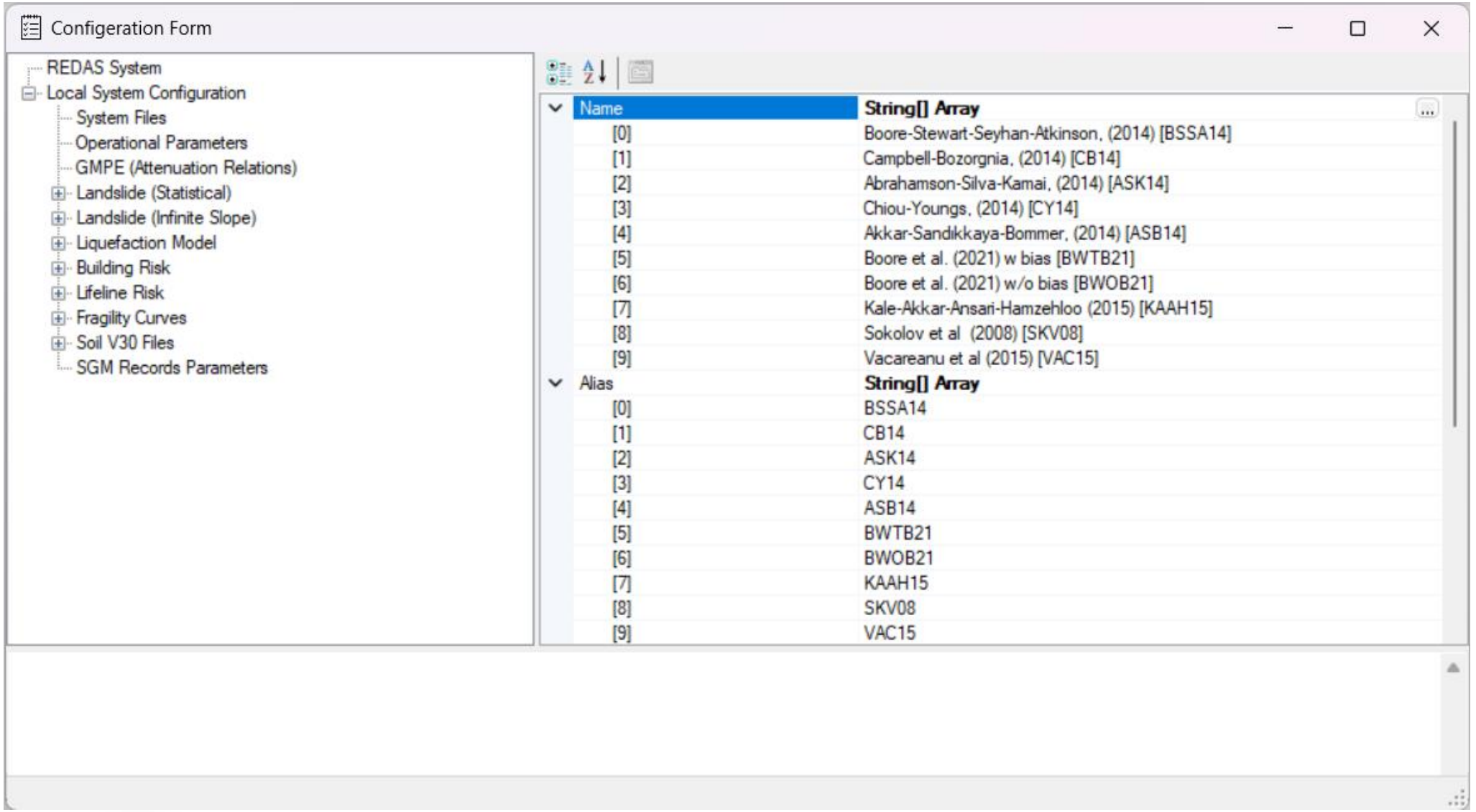
REDAS V1.1 Active Models

Ground Motion Maps

- Prediction Equations
- GMPE zone shape file and Zone-specific Weights
- Rupture distance Calculation
- Ground Motion Results (PGA, …)

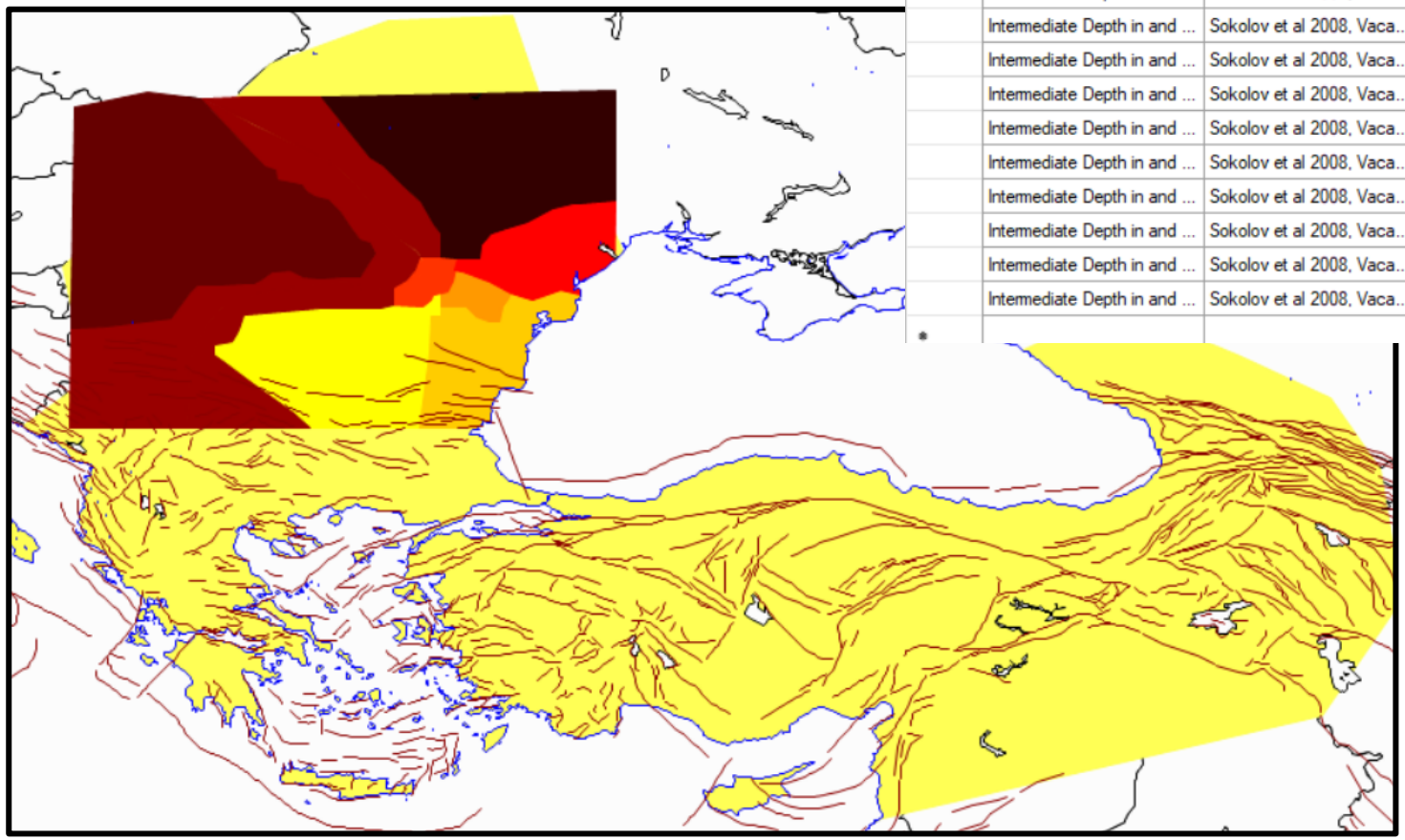
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Ground Motion Prediction Equations



REDACt
Rapid Earthquake Damage Assessment ConsorTium

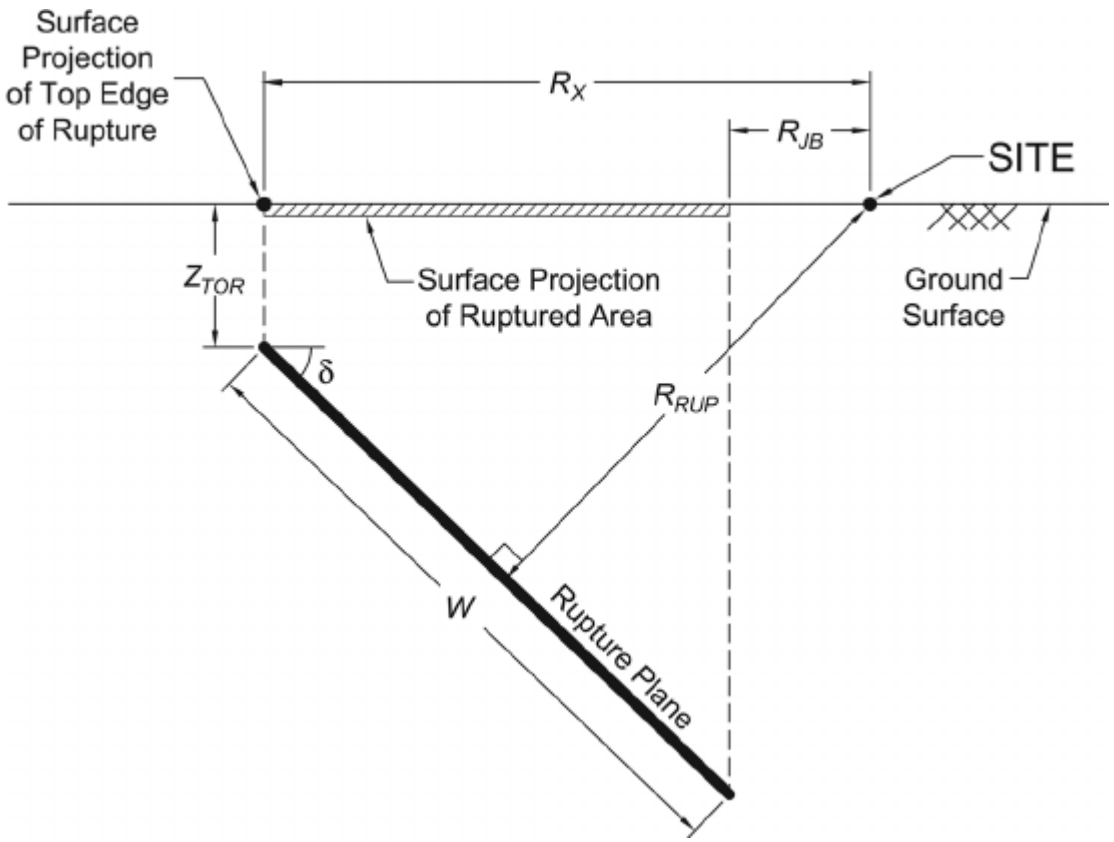
Ground Motion Prediction Equations

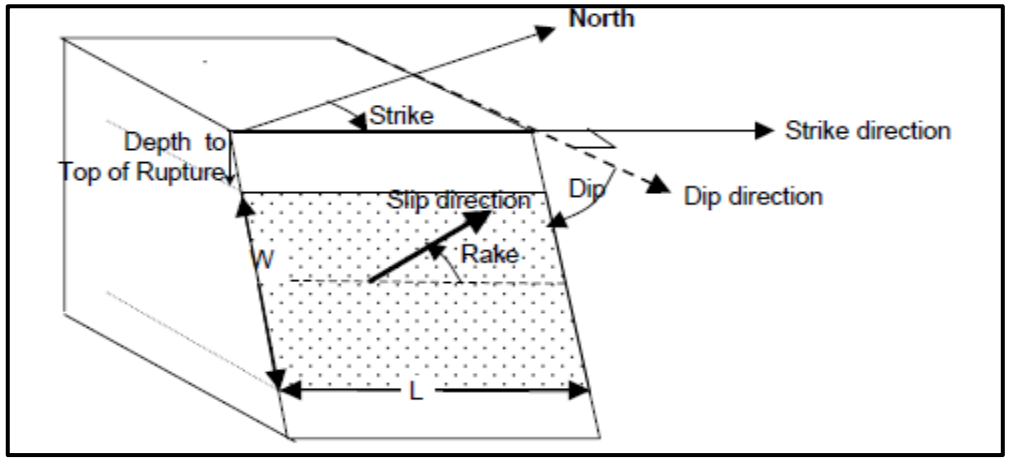


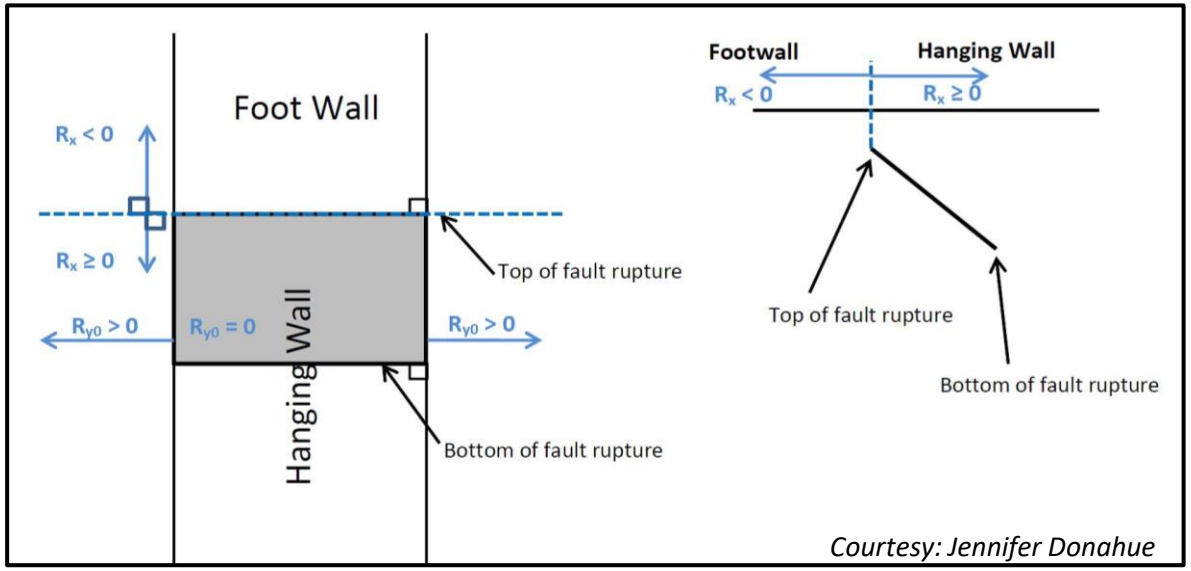
	ZONE	GMPE	BSSA14	CB14	ASK14	CY14	KAAH15	BWTB21	BWOB21	SKV08	VAC15	ZMIN
▶	Crustal earthquakes in and...	Boore et al (2014), Cauzz...	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.000
	Crustal earthquakes in Vra...	Boore et al (2014), Cauzz...	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.000
	Crustal earthquakes in and...	Boore et al (2021) with a...	0.00	0.00	0.00	0.00	0.34	0.33	0.33	0.00	0.00	0.000
	Intermediate Depth in and ...	Sokolov et al 2008, Vaca...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	60.000
	Intermediate Depth in and ...	Sokolov et al 2008, Vaca...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	60.000
	Intermediate Depth in and ...	Sokolov et al 2008, Vaca...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	60.000
	Intermediate Depth in and ...	Sokolov et al 2008, Vaca...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	60.000
	Intermediate Depth in and ...	Sokolov et al 2008, Vaca...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	60.000
	Intermediate Depth in and ...	Sokolov et al 2008, Vaca...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	60.000
	Intermediate Depth in and ...	Sokolov et al 2008, Vaca...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	60.000
	Intermediate Depth in and ...	Sokolov et al 2008, Vaca...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	60.000
	Intermediate Depth in and ...	Sokolov et al 2008, Vaca...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	60.000
*												

REDACt
Rapid Earthquake Damage Assessment ConsorTium

Rupture distance Calculation



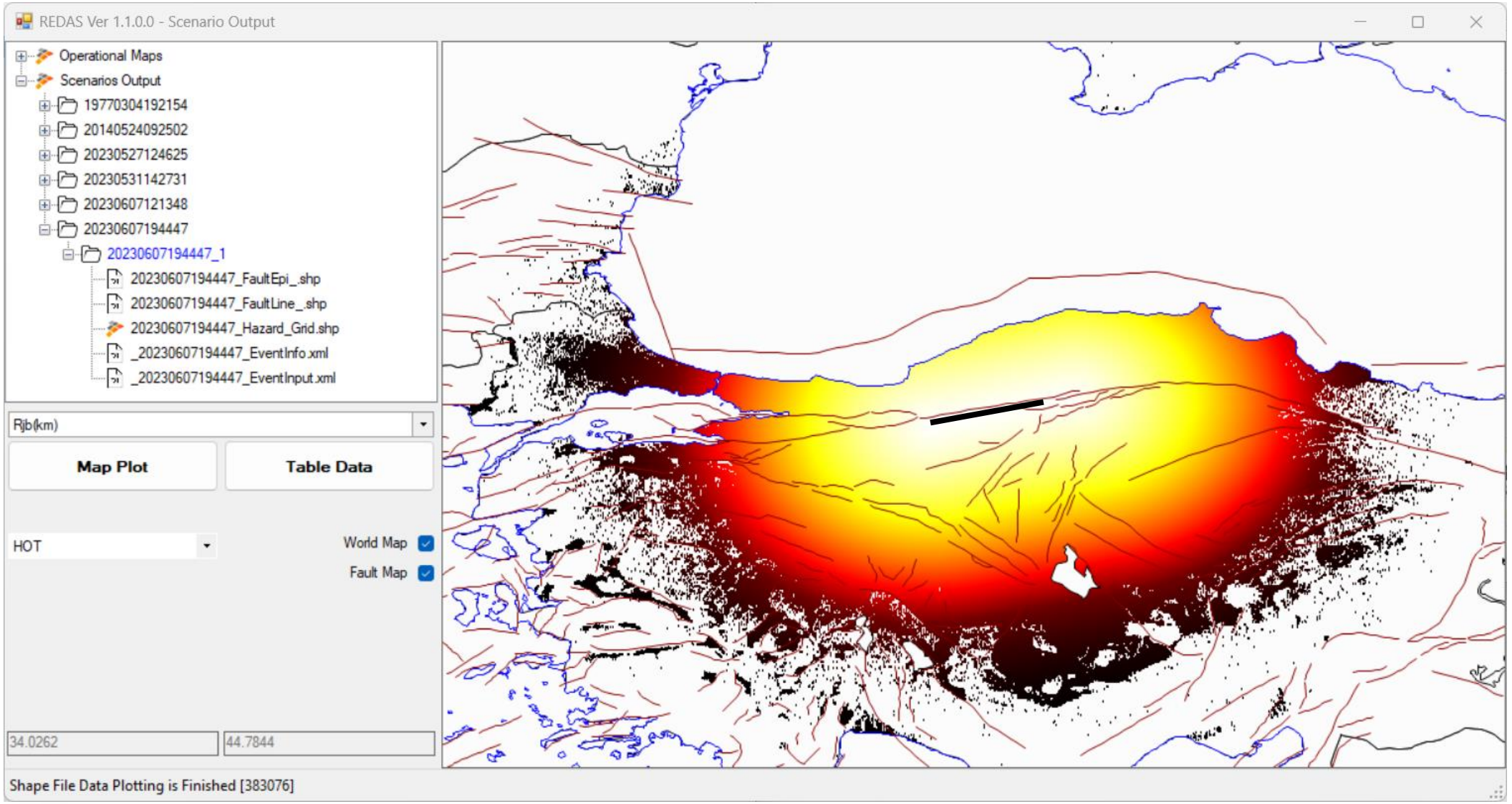




Courtesy: Jennifer Donahue

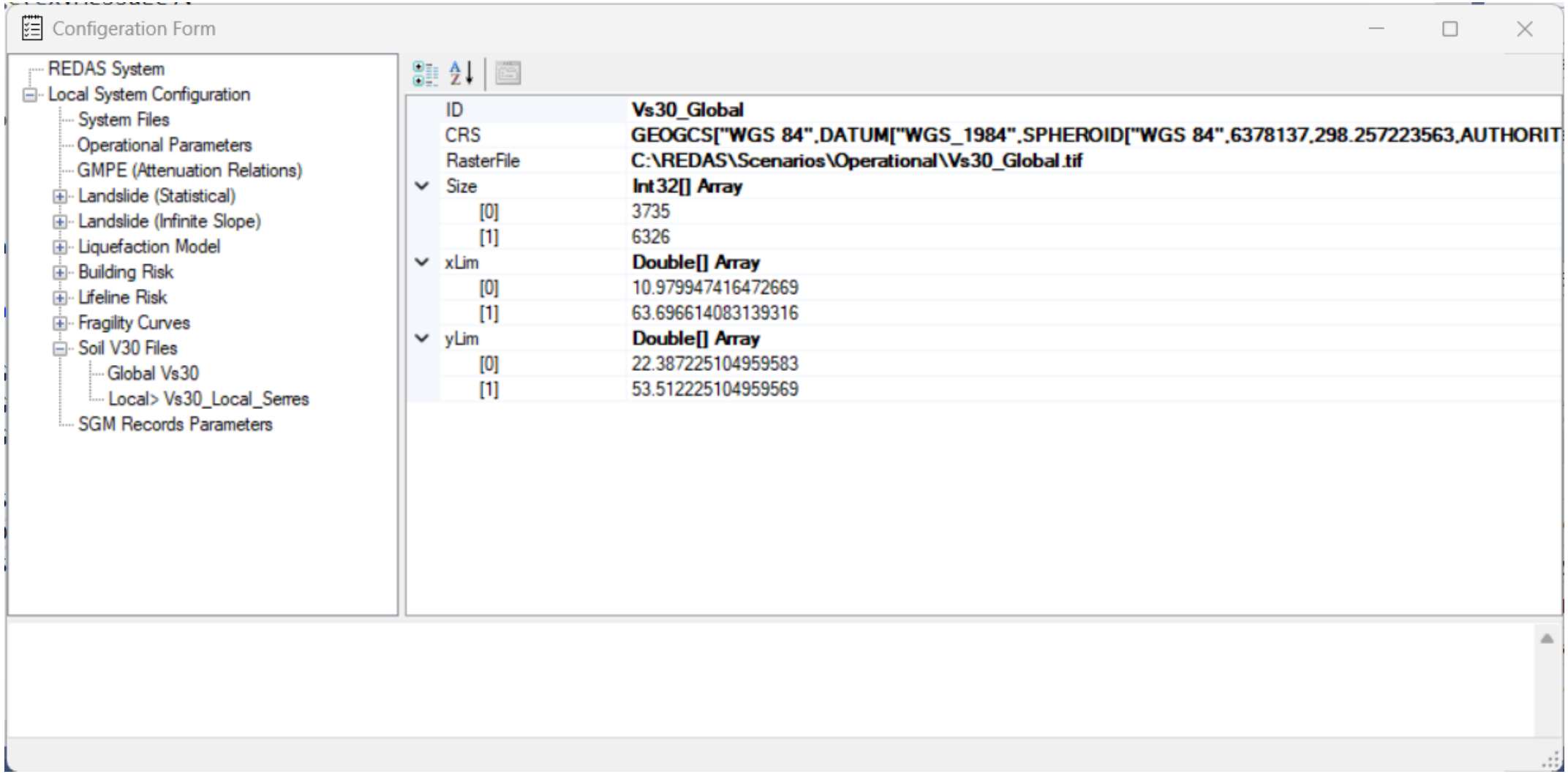
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Rupture distance Calculation



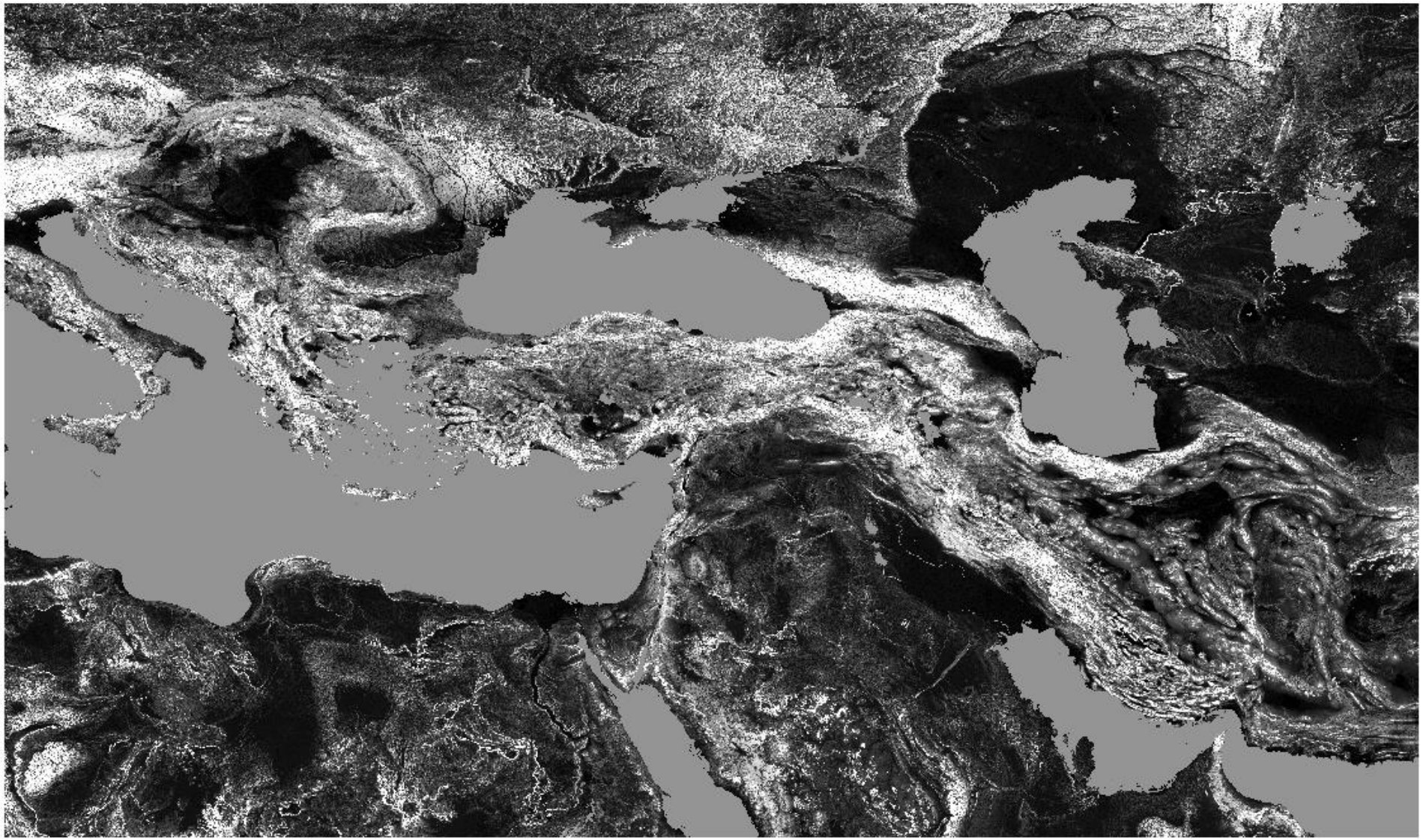
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Soil Shear Wave Velocity Distribution, Vs30



REDACt
Rapid Earthquake Damage Assessment ConsorTium

Global Vs30 Raster Map



REDACt
Rapid Earthquake Damage Assessment ConsorTium

Local Vs30 Raster Maps

REDACt
Rapid Earthquake Damage Assessment ConsorTium

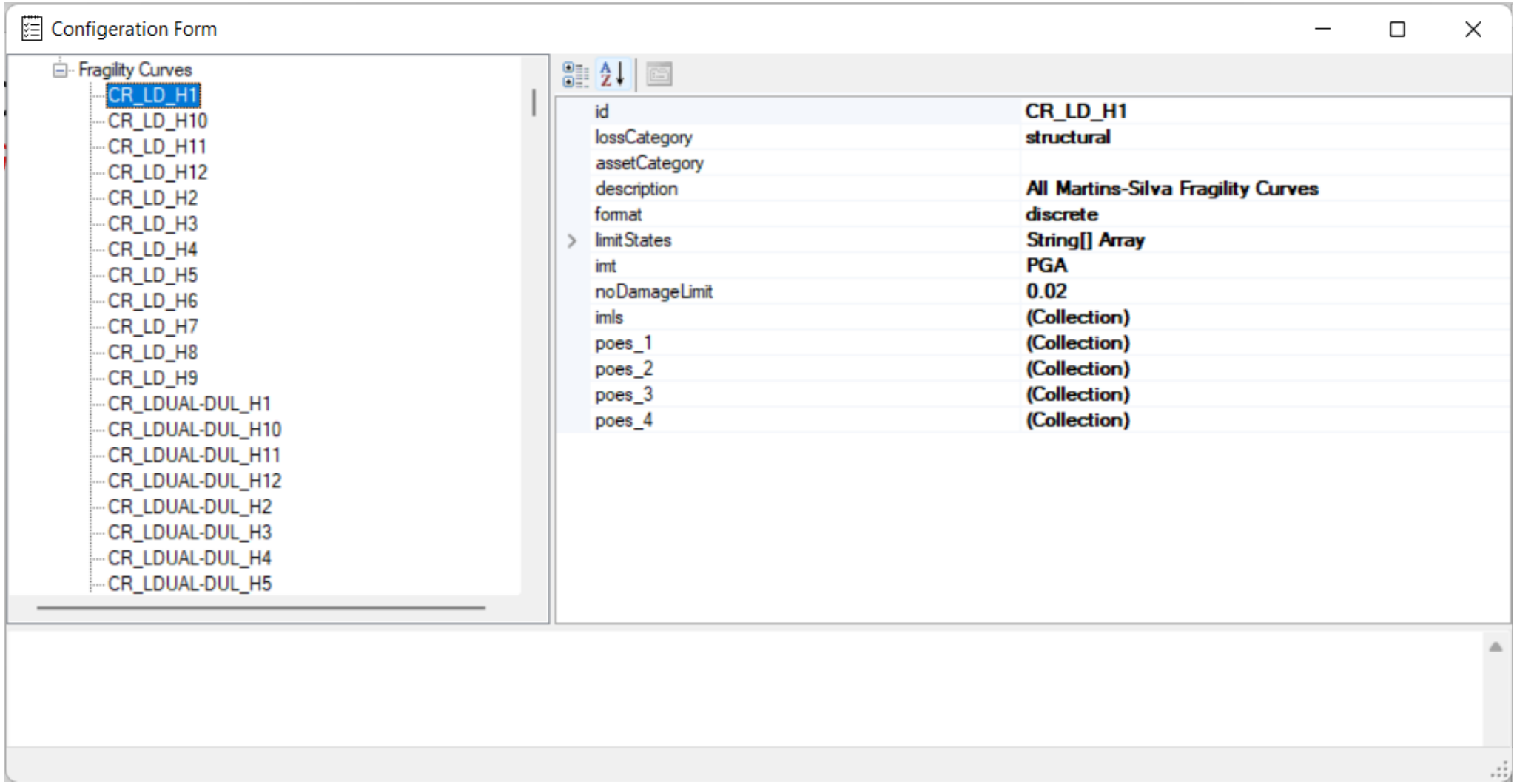
REDAS V1.1 Active Models

Building Losses

- Fragility Curves
- Building Inventory Shape File
- Building Loss Results
- Multi Regional Shape Files

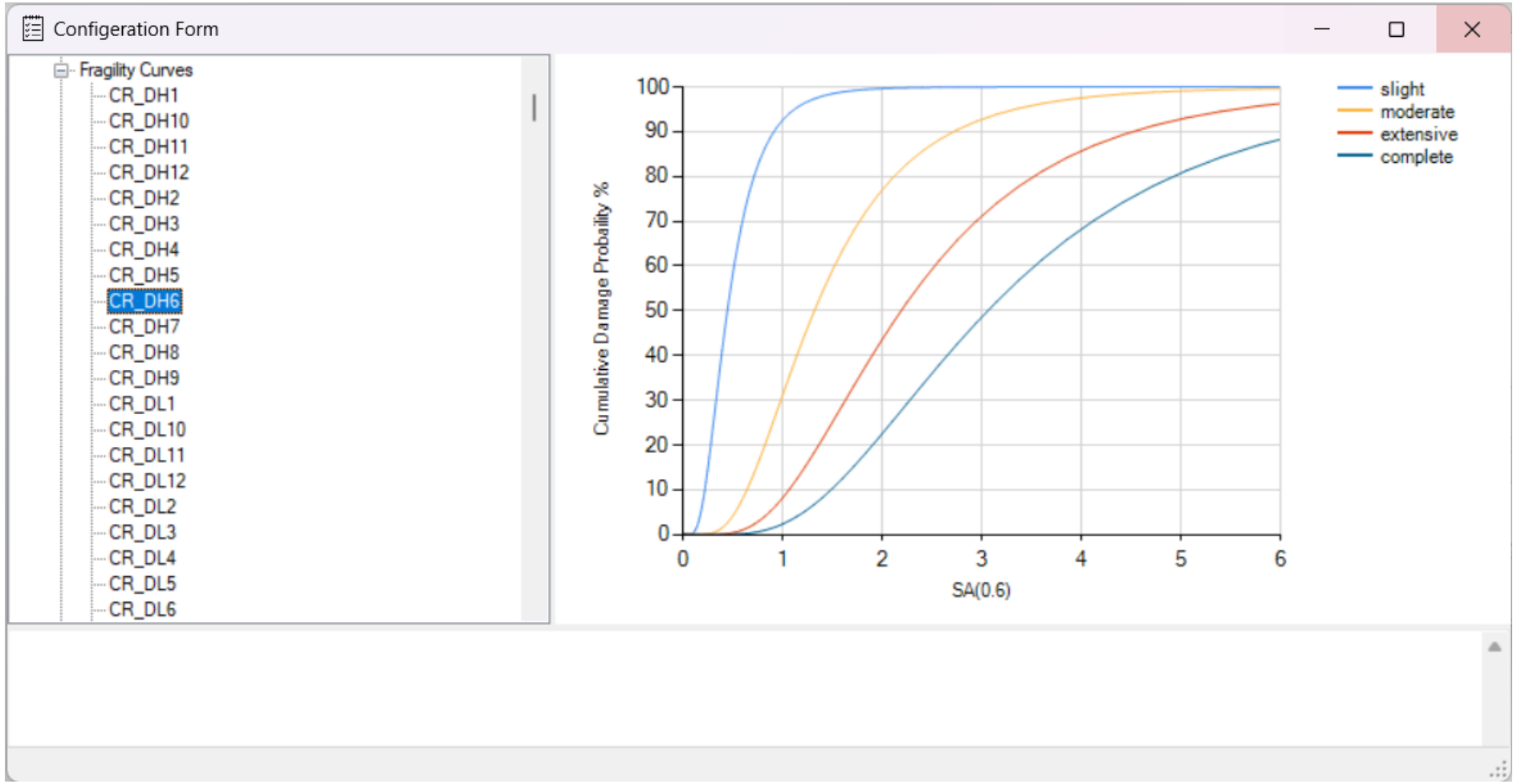
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Fragility Curves



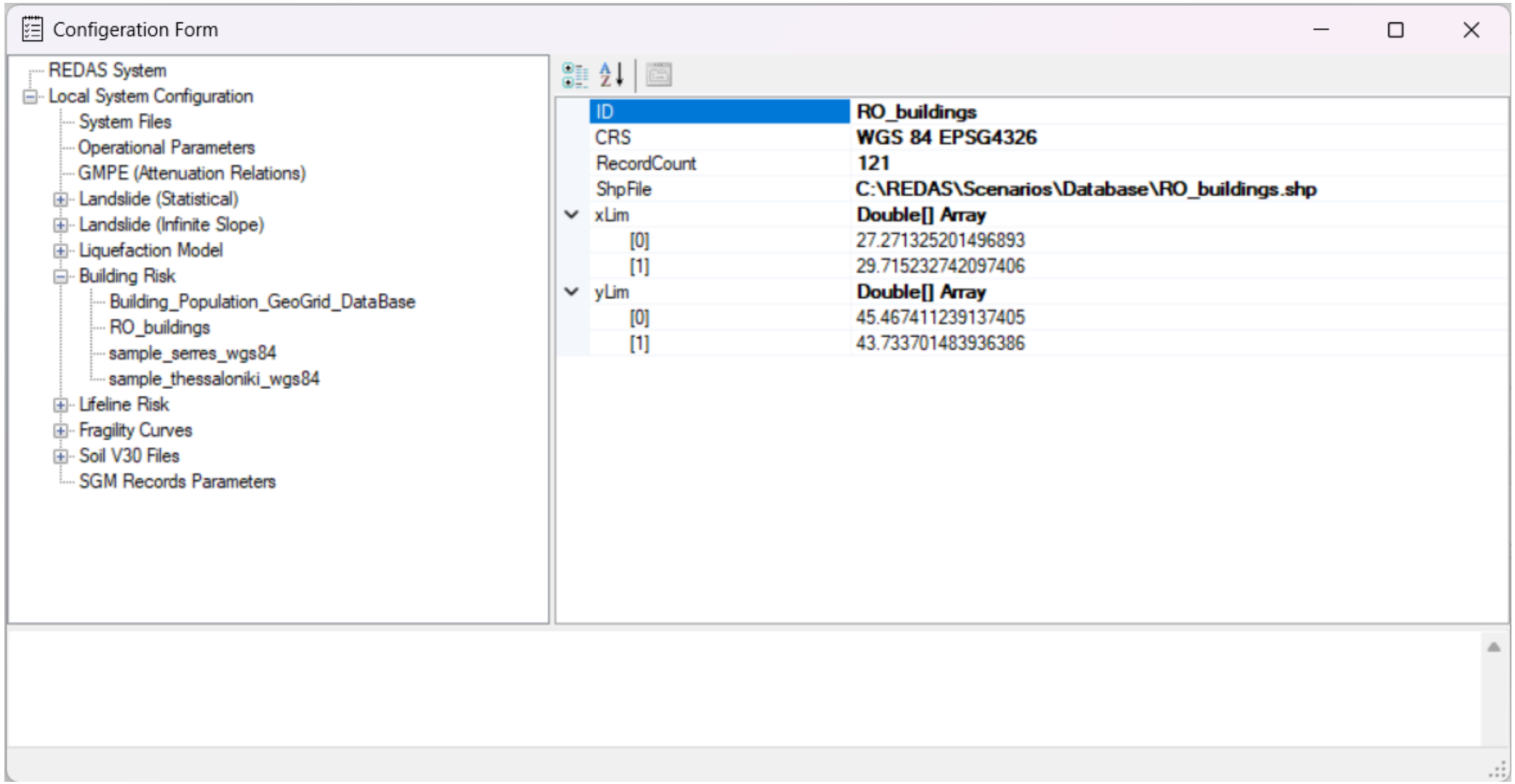
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Fragility Curves



REDACt
Rapid Earthquake Damage Assessment ConsorTium

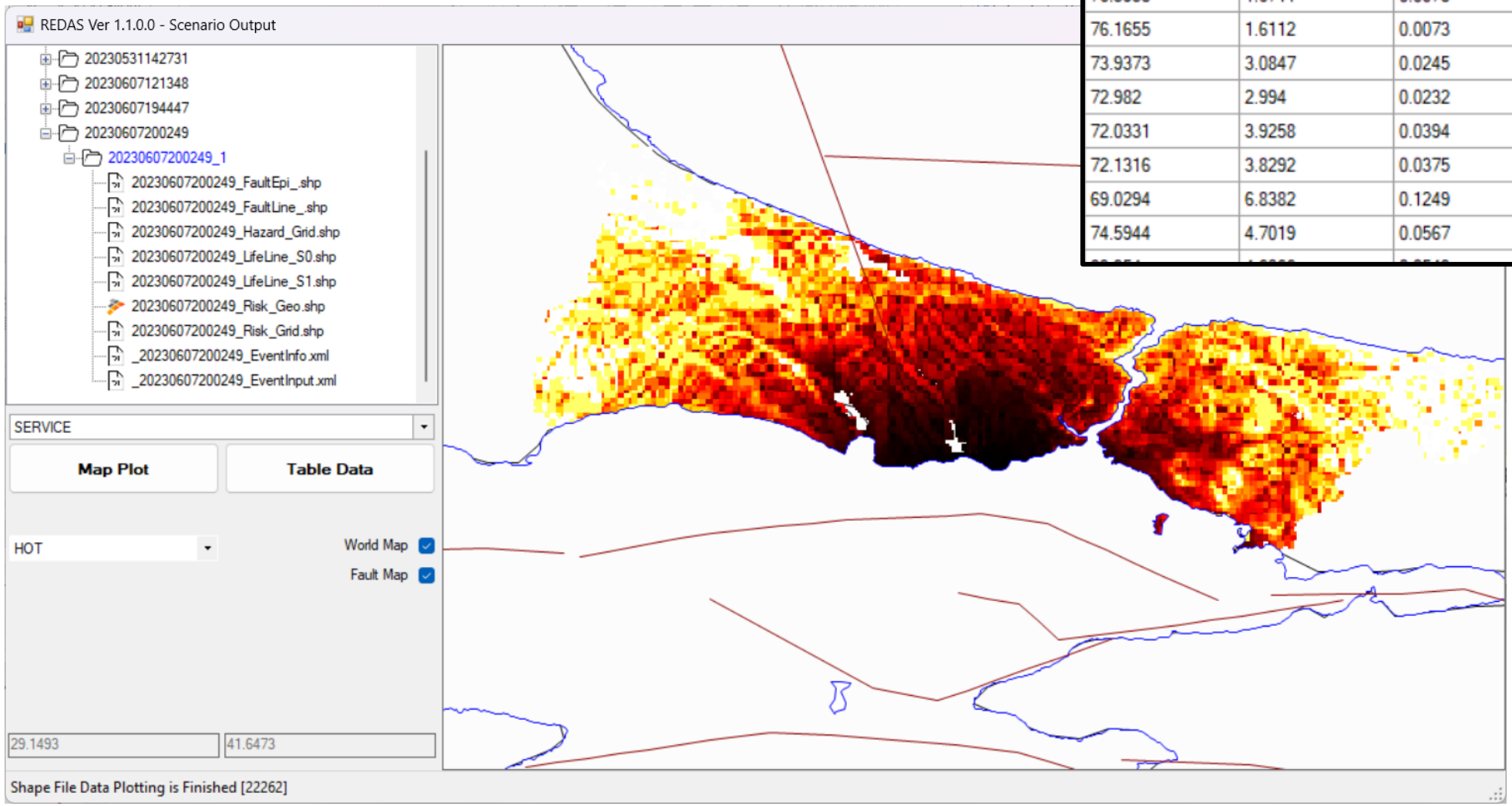
Building Inventory Shape File



REDACt
Rapid Earthquake Damage Assessment ConsorTium

Building Loss Results

NDAMAGE	SDAMAGE	MDAMAGE	EDAMAGE	CDAMAGE
60.1695	14.9114	0.8257	0.079	0.0144
60.403	14.712	0.7962	0.0752	0.0136
76.3938	1.6711	0.0078	0.0002	0
76.1655	1.6112	0.0073	0.0002	0
73.9373	3.0847	0.0245	0.0009	0.0001
72.982	2.994	0.0232	0.0008	0.0001
72.0331	3.9258	0.0394	0.0016	0.0002
72.1316	3.8292	0.0375	0.0015	0.0001
69.0294	6.8382	0.1249	0.0067	0.0008
74.5944	4.7019	0.0567	0.0025	0.0003



REDACt
Rapid Earthquake Damage Assessment ConsorTium

REDAS V1.1 Active Models

Liquefaction Hazard

- Hazard Procedure
- Raster Files
- Hazard Results
- Multi Regional Folders

Landslide Hazard (Statistical)

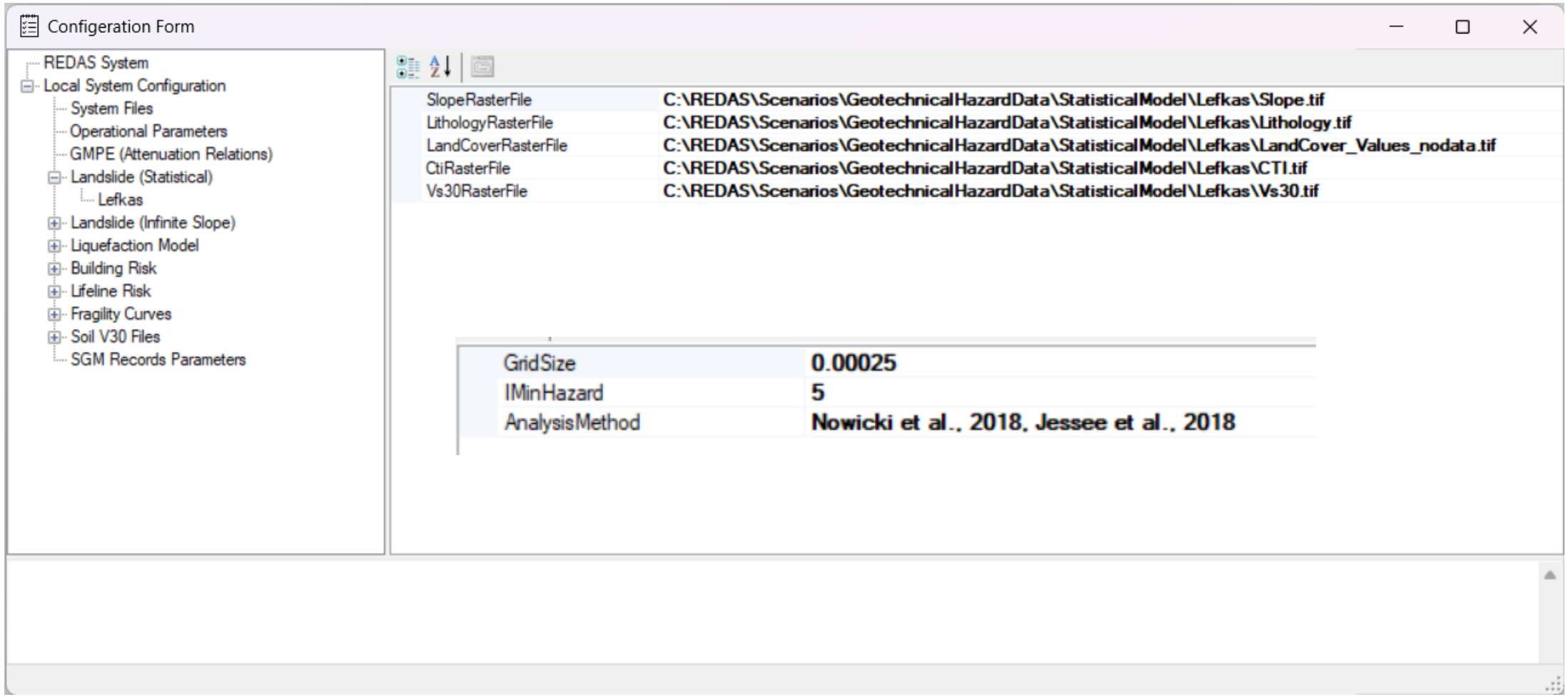
- Hazard Procedure
- Raster Files
- Hazard Results
- Multi Regional Folders

Landslide Hazard (Physical)

- Hazard Procedure
- Raster Files
- Hazard Results
- Multi Regional Folders

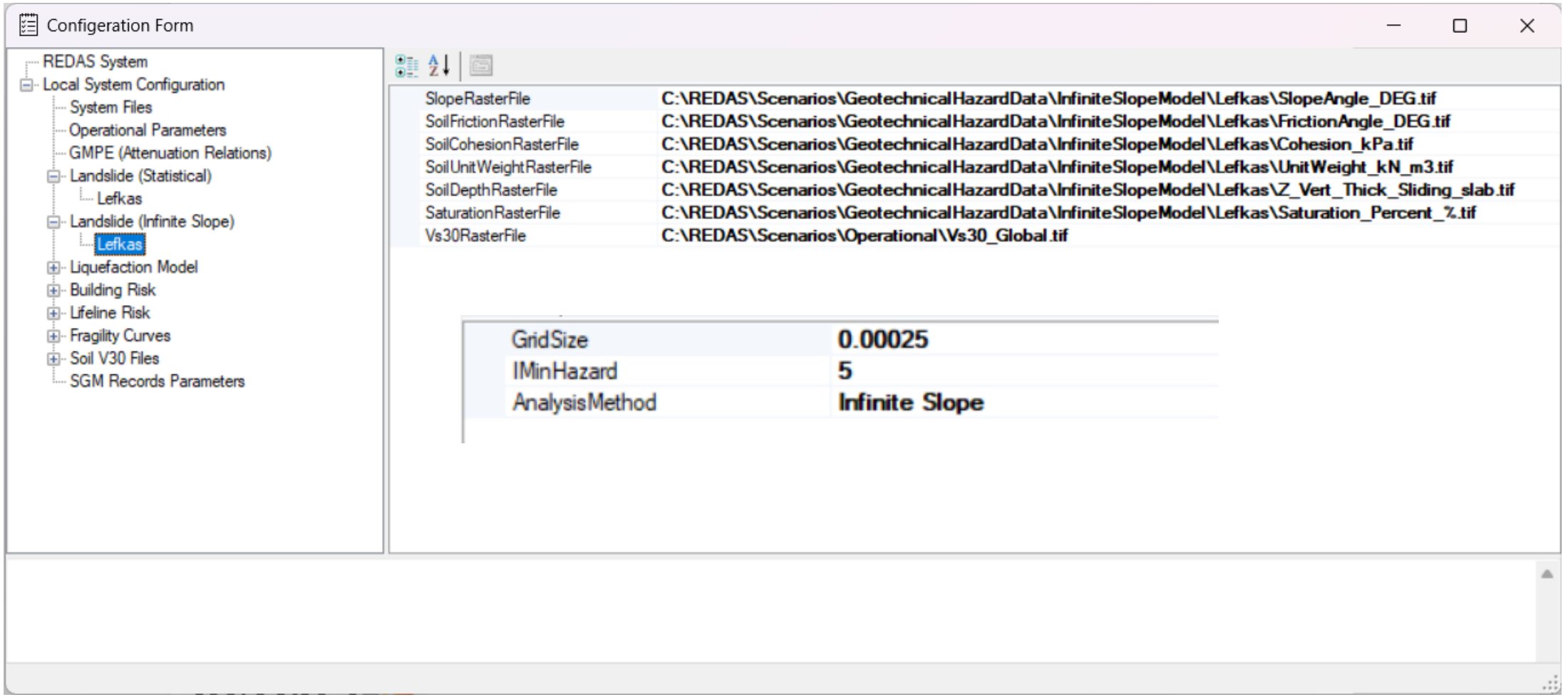
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Raster Files for Landslide Hazard (Statistical)



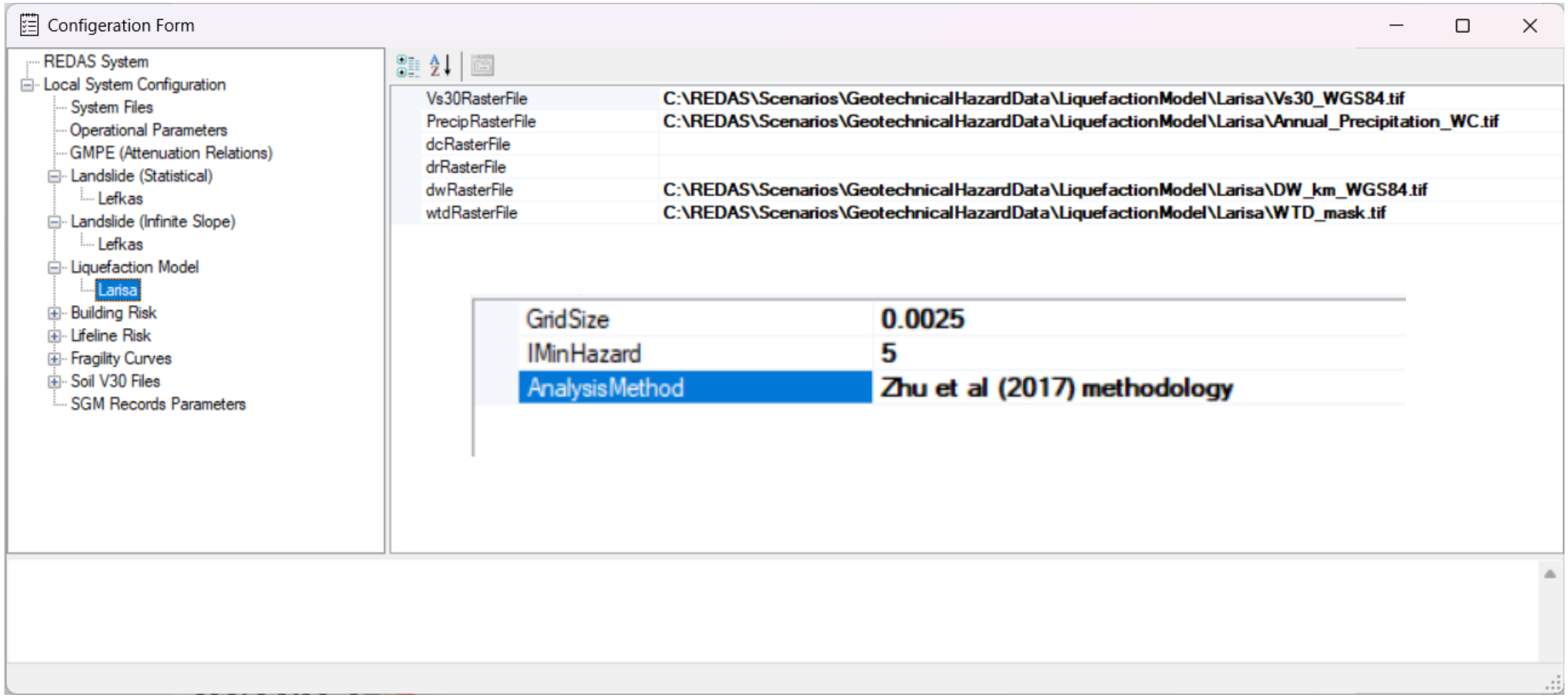
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Raster Files for Landslide Hazard (Infinite Slope)



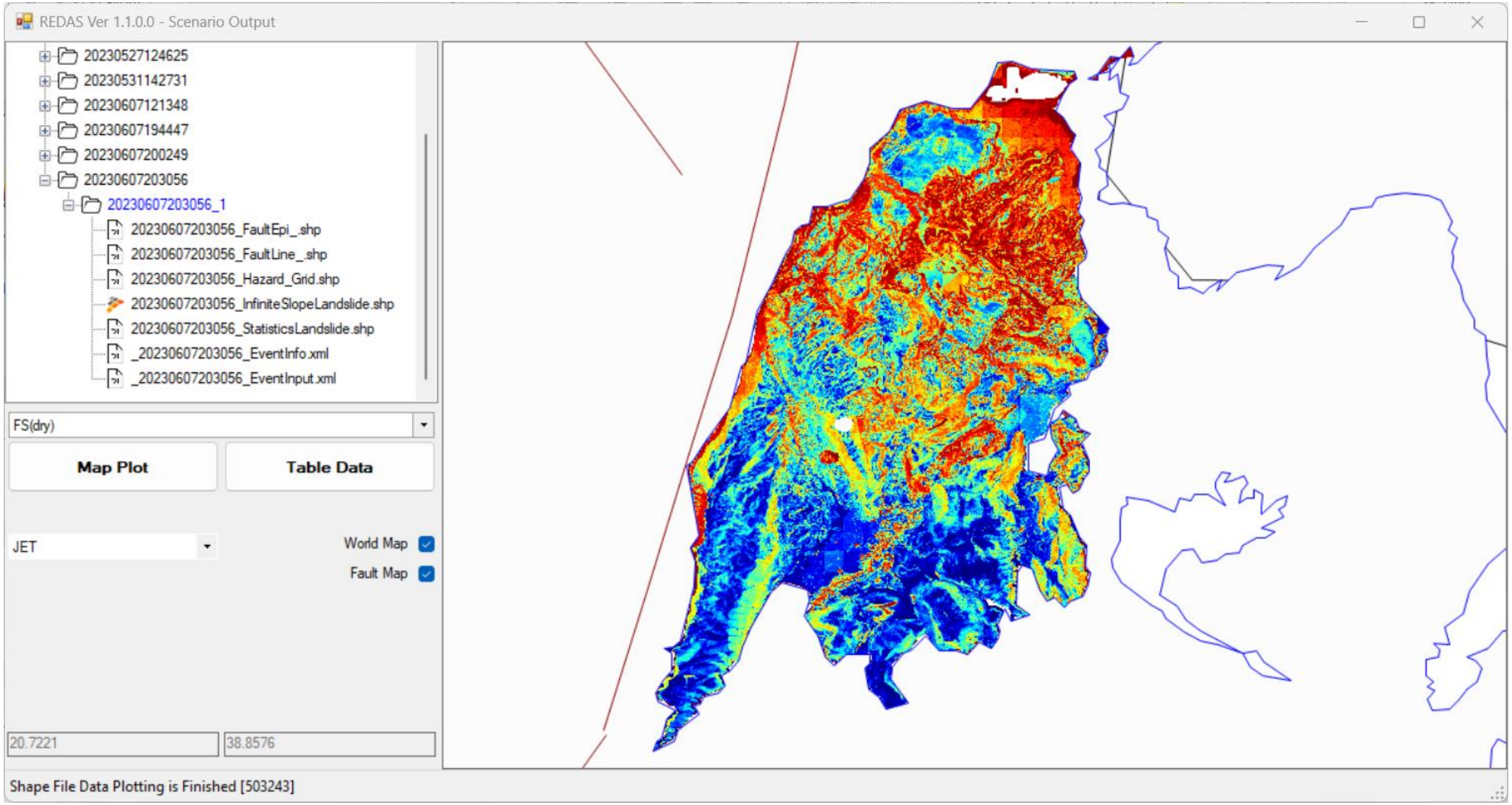
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Raster Files for Liquefaction Model



REDACt
Rapid Earthquake Damage Assessment ConsorTium

Landslide Hazard Results



REDACt
Rapid Earthquake Damage Assessment ConsorTium

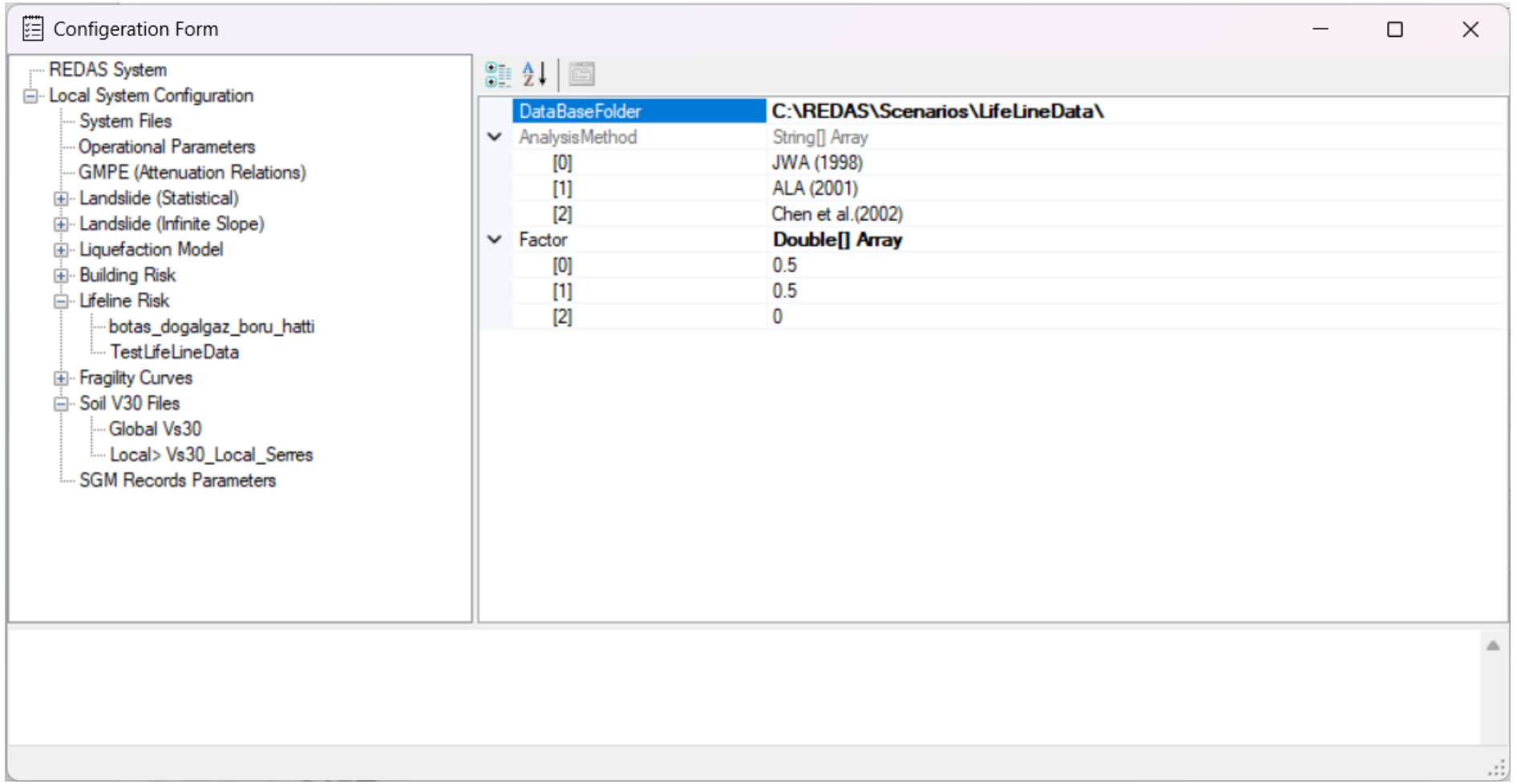
REDAS V1.1 Active Models

Pipeline Losses

- Loss functions
- Pipeline Inventory Shape Files
- Loss Results
- Multi Regional Shape Files

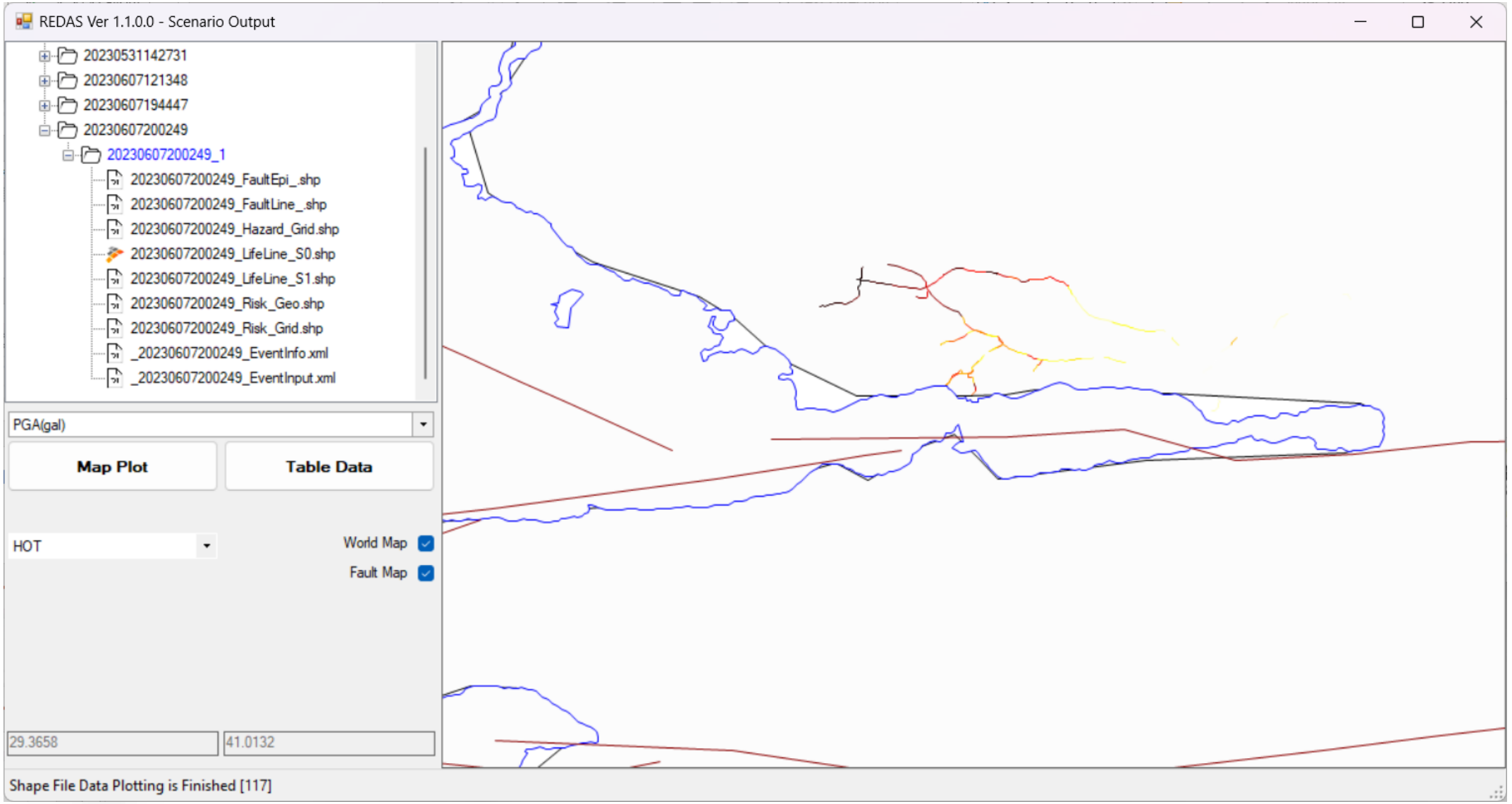
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Pipeline Loss functions



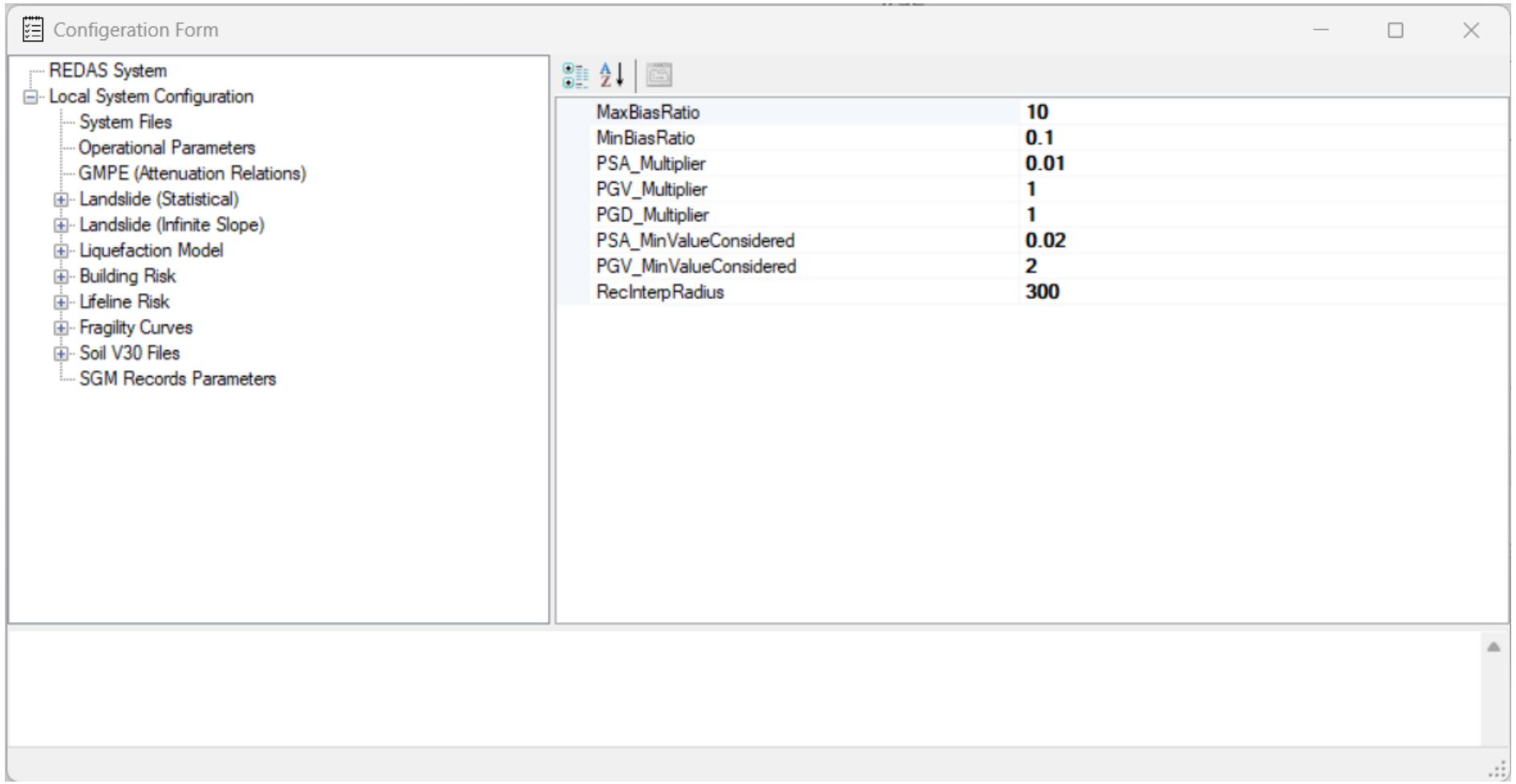
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Pipelines Loss Results



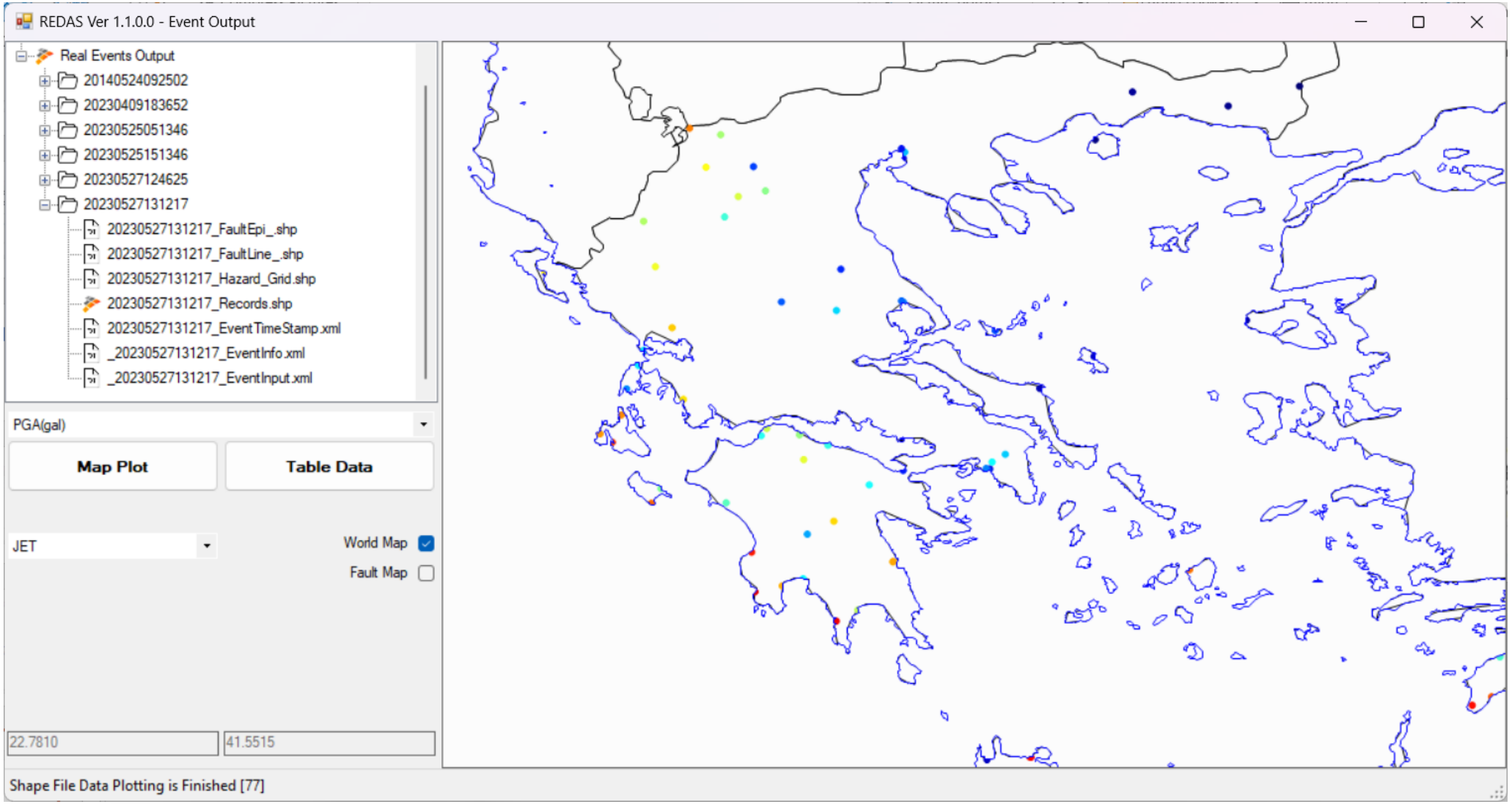
REDACt
Rapid Earthquake Damage Assessment ConsorTium

Station Data Integration



REDACt
Rapid Earthquake Damage Assessment ConsorTium

Station Data Integration



REDACt
Rapid Earthquake Damage Assessment ConsorTium

REDAS V1.1 Statistics

Coding Language: C#
Extra Resources: GDAL, EGIS
Number of Classes and variables used : 2200
Number of functions >200
Total number of coding lines > 18,513
Number of Windows Form: 8

Hierarchy	Maint...	Cyclom...	Depth...	Class ...	Lines of ...	Lines of Executable code
REDAS (Debug)	78	2,792	7	359	18,513	8,885
System.Windows.Forms	100	1	1	0	0	0
REDAS.IntensityEGISRenderSetting	89	15	1	7	94	20
REDAS.PolyLineEGISRenderSetting	88	17	1	10	93	22
REDAS.MainEGISRenderSetting	81	18	1	7	111	29
REDAS.ServiceEGISRenderSetting	80	20	1	10	106	29
REDAS.Properties	82	27	3	13	299	59
REDAS	78	2,694	7	350	17,810	8,726

REDACt
Rapid Earthquake Damage Assessment ConsorTium

Thanks …

REDACt
Rapid Earthquake Damage Assessment ConsorTium