



Project funded by
EUROPEAN UNION



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

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.

Scope of REDAS V1.1



ShakeMap



REDAS V1.1 Active Models

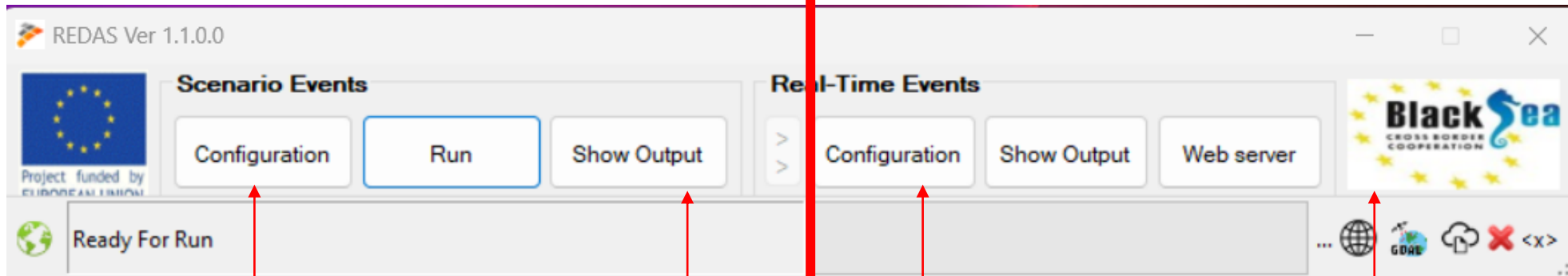
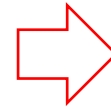
REDAS Interface and Modules

- Interface Design
- Folder Structures and File Systems

Main Interface

Scenario Based
To be utilized by users Manually

Event Based
Automatic triggering
First Priority for Analysis



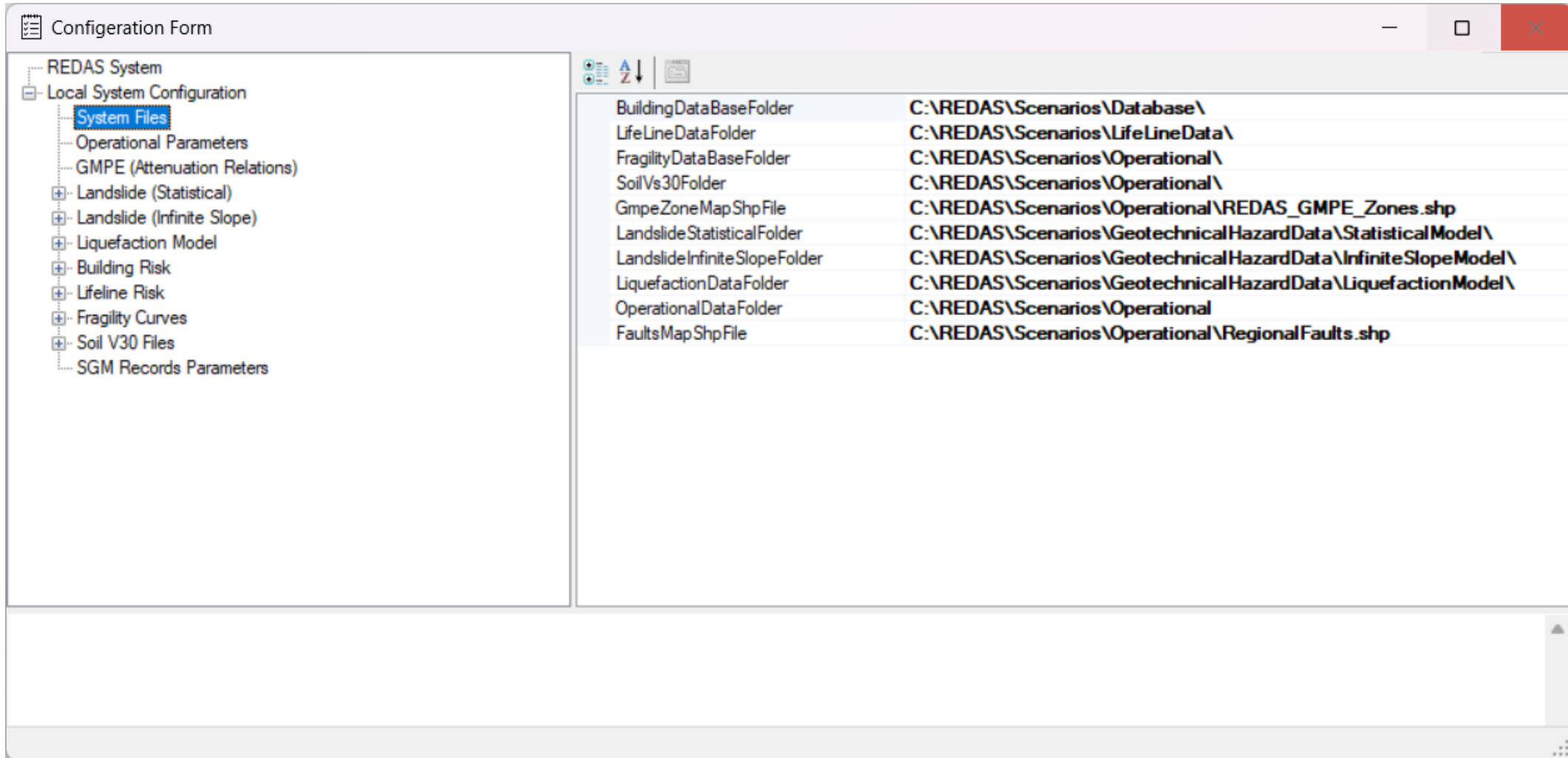
Configuration Can be changed by user

PC Based Results and Maps

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

www server Based Results and Maps

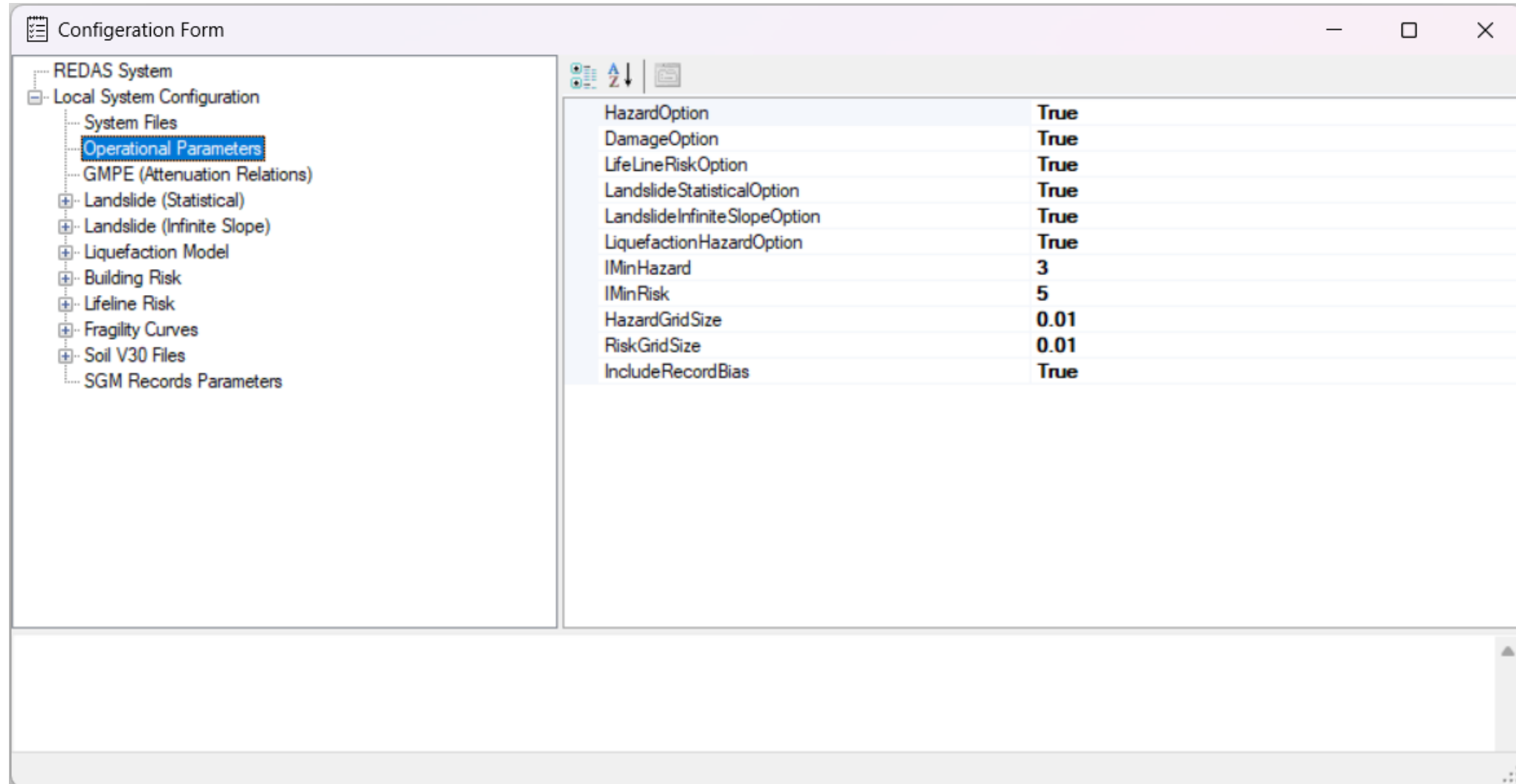
Configurations/*System Files*



The screenshot displays the 'Configuration Form' window for REDAS. The left sidebar shows a tree view under 'Local System Configuration' with 'System Files' selected. The main area shows a table of configuration parameters and their paths.

BuildingDataBaseFolder	C:\REDAS\Scenarios\Database\
LifeLineDataFolder	C:\REDAS\Scenarios\LifeLineData\
FragilityDataBaseFolder	C:\REDAS\Scenarios\Operational\
SoilVs30Folder	C:\REDAS\Scenarios\Operational\
GmpeZoneMapShpFile	C:\REDAS\Scenarios\Operational\REDAS_GMPE_Zones.shp
LandslideStatisticalFolder	C:\REDAS\Scenarios\GeotechnicalHazardData\StatisticalModel\
LandslideInfiniteSlopeFolder	C:\REDAS\Scenarios\GeotechnicalHazardData\InfiniteSlopeModel\
LiquefactionDataFolder	C:\REDAS\Scenarios\GeotechnicalHazardData\LiquefactionModel\
OperationalDataFolder	C:\REDAS\Scenarios\Operational
FaultsMapShpFile	C:\REDAS\Scenarios\Operational\RegionalFaults.shp

Configurations/*Operational Parameters*



The screenshot displays the 'Configuration Form' window. On the left, a tree view shows the 'Operational Parameters' section selected under 'Local System Configuration'. On the right, a table lists the parameters and their values.

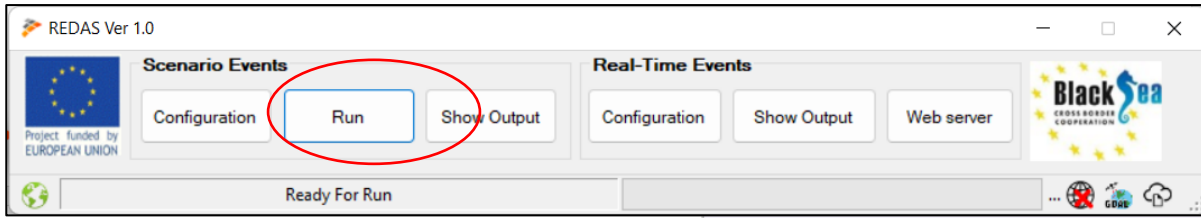
HazardOption	True
DamageOption	True
LifeLineRiskOption	True
LandslideStatisticalOption	True
LandslideInfiniteSlopeOption	True
LiquefactionHazardOption	True
IMinHazard	3
IMinRisk	5
HazardGridSize	0.01
RiskGridSize	0.01
IncludeRecordBias	True

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

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

id	20230607194447
netid	EU
network	NETWORK
lat	40.81551
lon	32.47989
mag	7
depth	0
mech	Unkown
year	2023
month	6
day	7
hour	19
minute	44
second	47
time	2023-06-07T19:44:47Z
timezone	GMT
locstring	Location
created	Created By
Fault_Name	Fault Name
Fault_Strike	70
Fault_Dip	45
Fault_Width	15
Fault_Top	2
Fault_Lat	(Collection)
Fault_Lon	(Collection)

Update fault Map

Refresh Map

Run Scenario Event

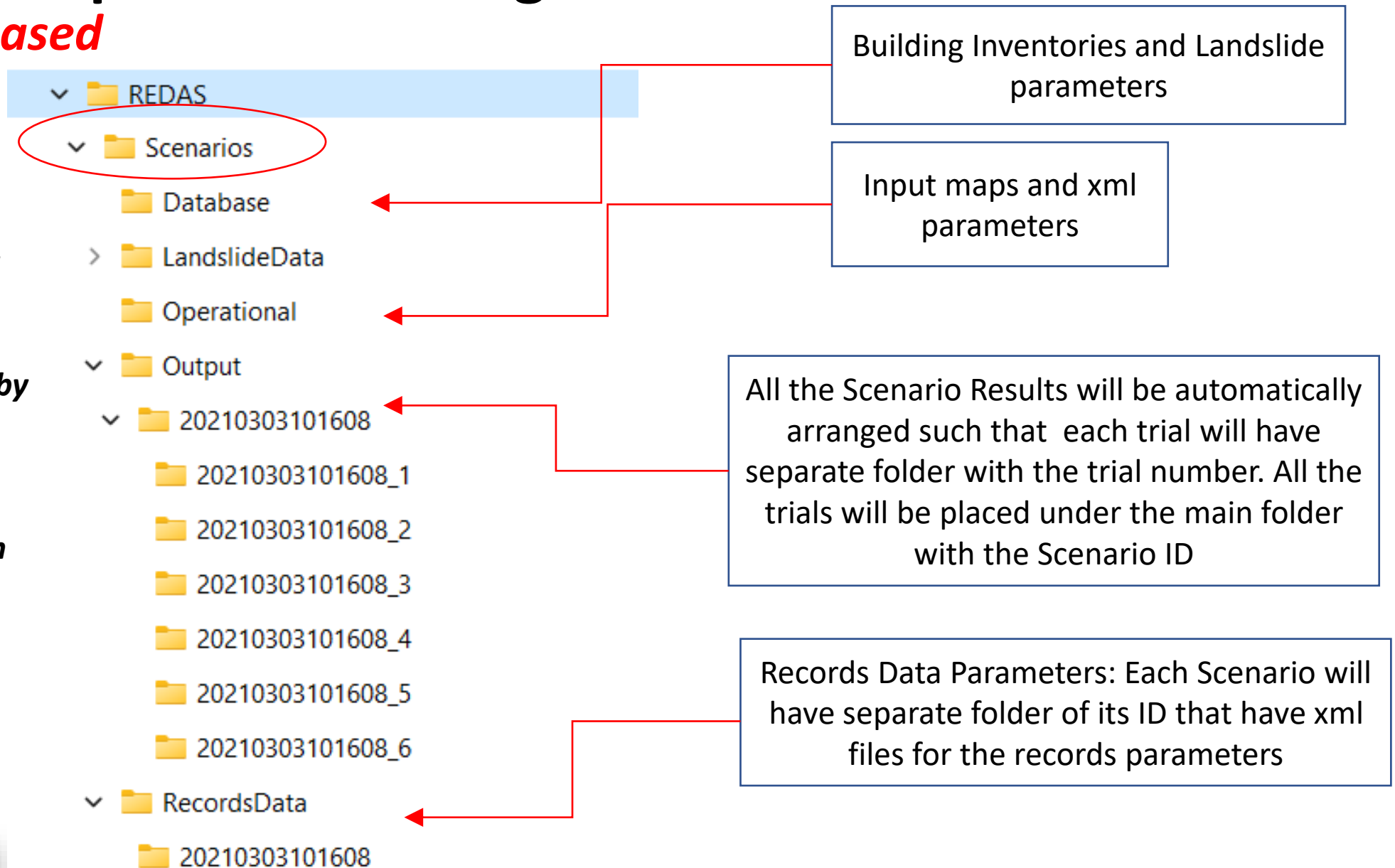
Cancel Start

Input & Output Data Management

Scenario Based

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

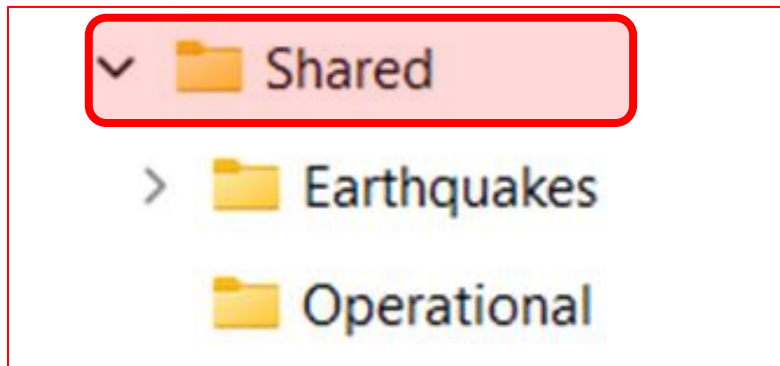
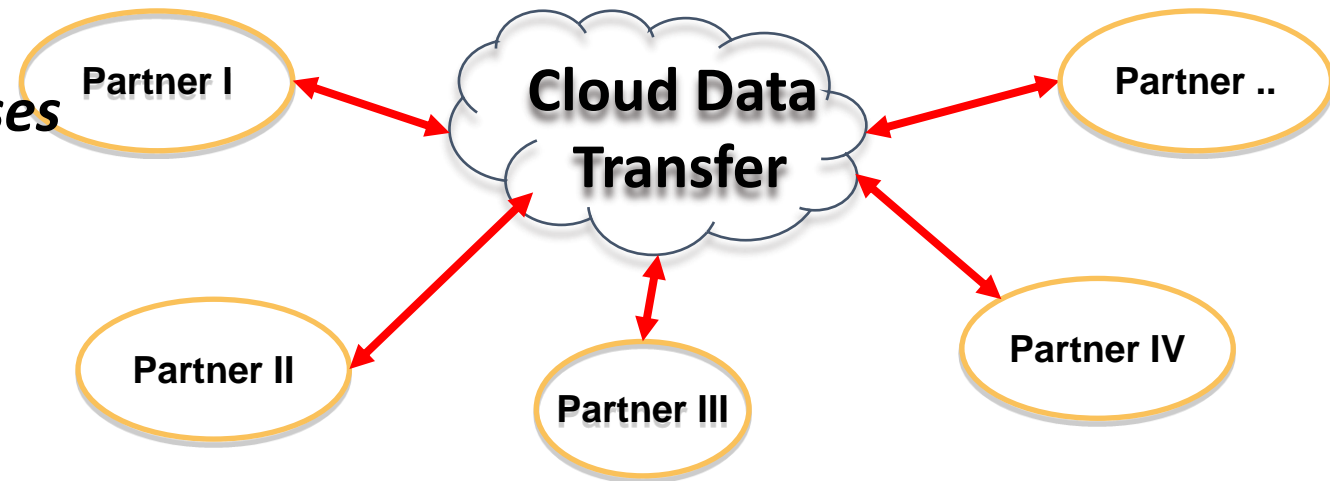
But the locations can be changed by the users



Cloud Data Transfer for the REDA System

Real Events

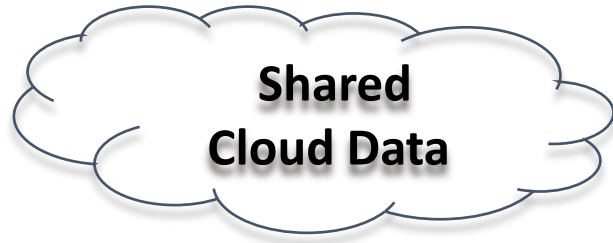
- *A Common Cloud service to be organized by all the partners. “Shared cloud folder” to be arranged*
- *No need-to-know Partners’ IP Addresses*
- *Easy to manage and install*
- *Flexible to Add new partners*
- *Flexible to Add new Servers*



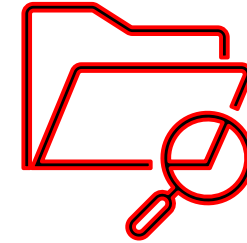
Cloud Data Transfer

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.

Online Event Processing Data for the REDA System



Real Events



Local Drive

Earthquakes

- [Event ID1](#)
 - [Event Trigger xml Files](#)
 - [Station Data xml Files](#)

REDA System Partner I

DataBase

- Buildings
- Population
- Lifelines
- Critical Facilities

Operational Data

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

Results>> local web server

- Intensity Maps
- PGA, PGV, PSA,...
- Local Building Damage Maps
- Local Lifeline Damage Maps
- ...

Event ID> Grid Based
Damage Data

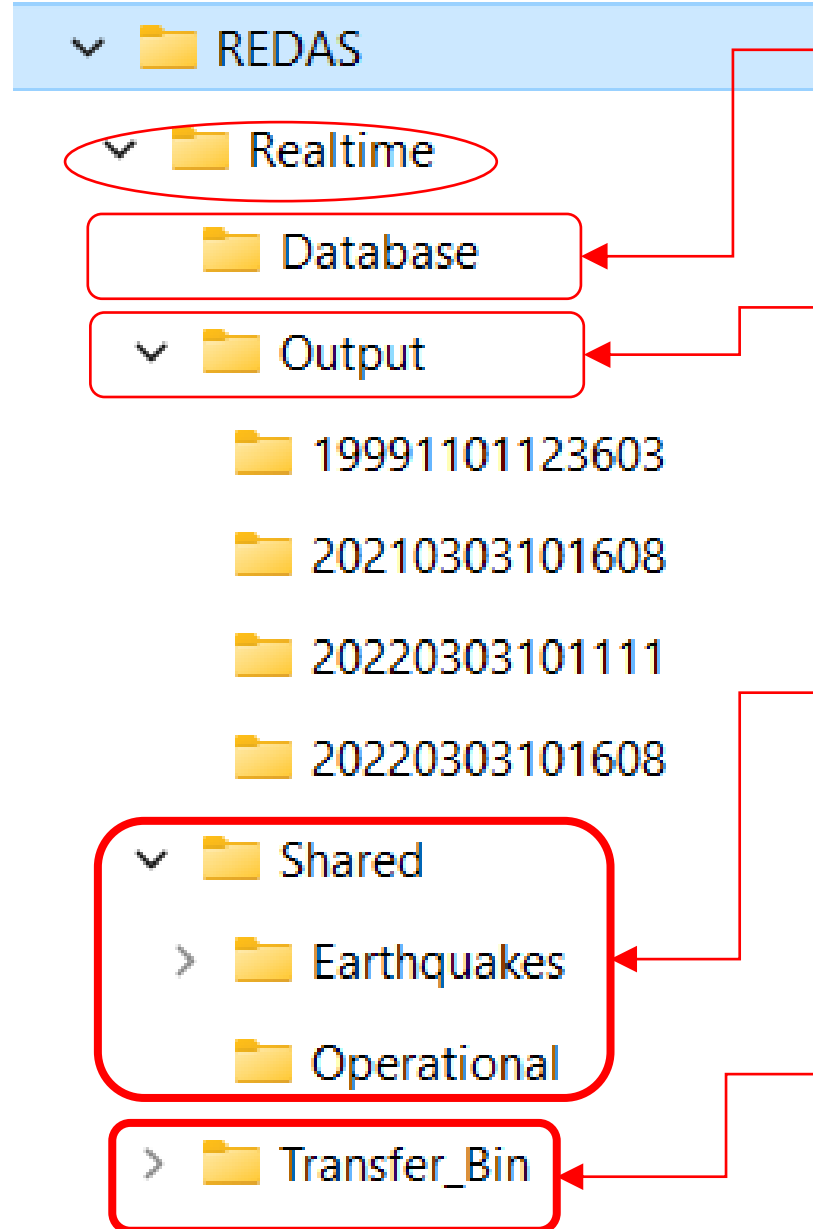
Processing

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.

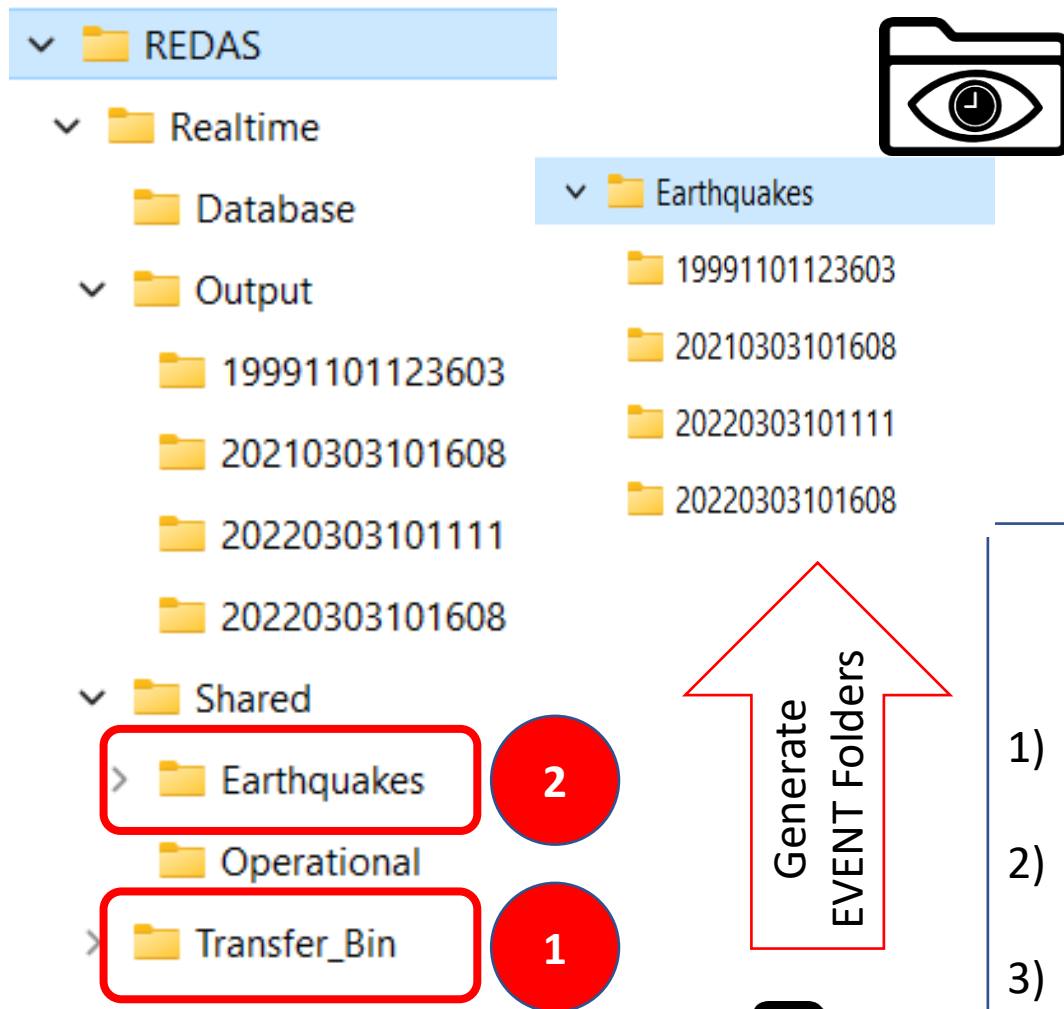
All Earthquake and Operational Parameters will be shared under "shared" Folder. **This Folder will be shared by Cloud among all the Joint Institutes.**
Earthquake Folder: The contents of the folder will be generated automatically by REDAS with the insertion of xml files into **Transfer_Bin**

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

Input & Output Data Management

File watchers for Real Events

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



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

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, ...)

Ground Motion Prediction Equations

Configuration Form

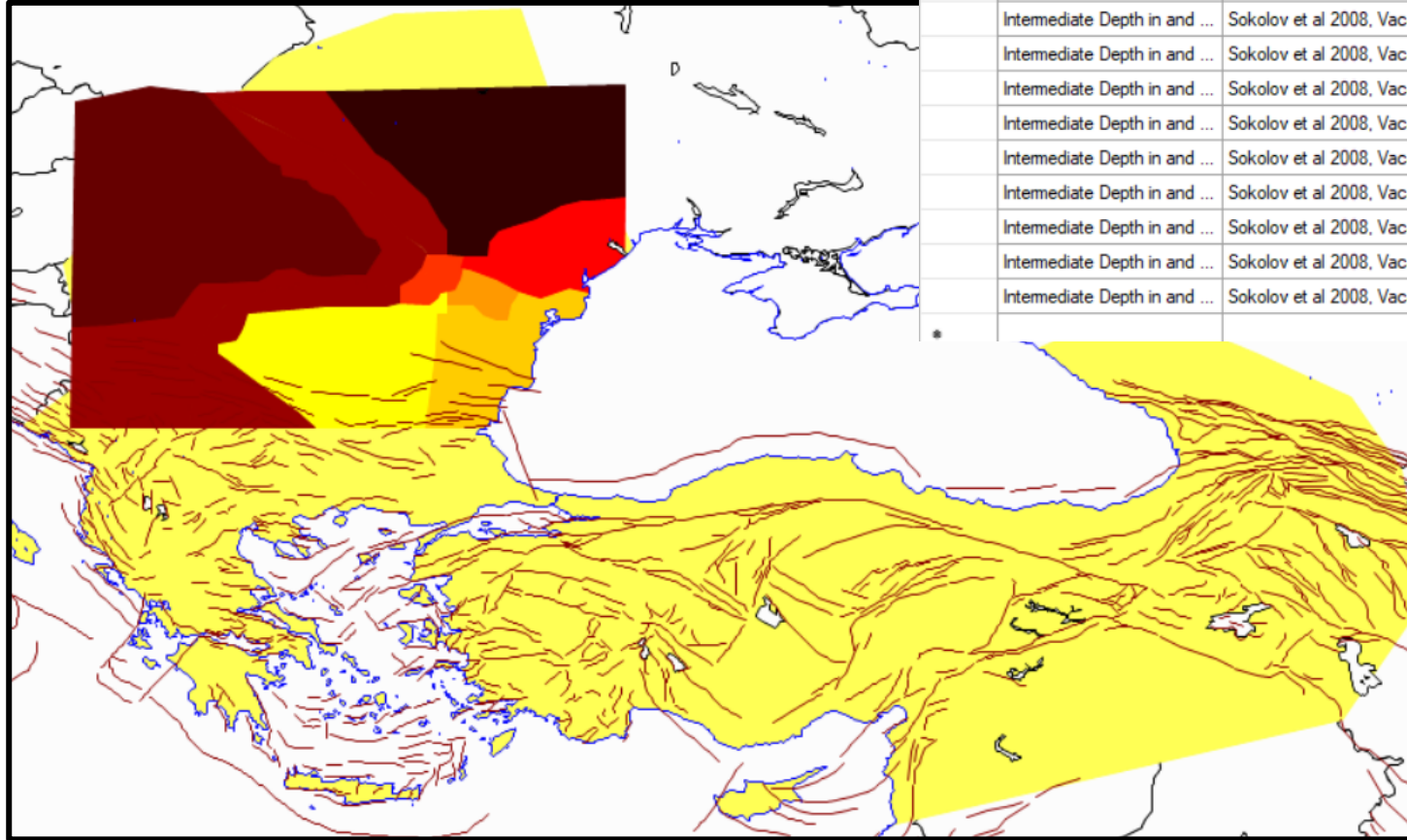
REDAS System

- Local System Configuration
 - System Files
 - Operational Parameters
 - GMPE (Attenuation Relations)
 - Landslide (Statistical)
 - Landslide (Infinite Slope)
 - Liquefaction Model
 - Building Risk
 - Lifeline Risk
 - Fragility Curves
 - Soil V30 Files
 - SGM Records Parameters

Name	String[] Array
[0]	Boore-Stewart-Seyhan-Atkinson, (2014) [BSSA14]
[1]	Campbell-Bozorgnia, (2014) [CB14]
[2]	Abrahamson-Silva-Kamai, (2014) [ASK14]
[3]	Chiou-Youngs, (2014) [CY14]
[4]	Akkar-Sandikkaya-Bommer, (2014) [ASB14]
[5]	Boore et al. (2021) w bias [BWTB21]
[6]	Boore et al. (2021) w/o bias [BWOB21]
[7]	Kale-Akkar-Ansari-Hamzehloo (2015) [KAAH15]
[8]	Sokolov et al (2008) [SKV08]
[9]	Vacareanu et al (2015) [VAC15]

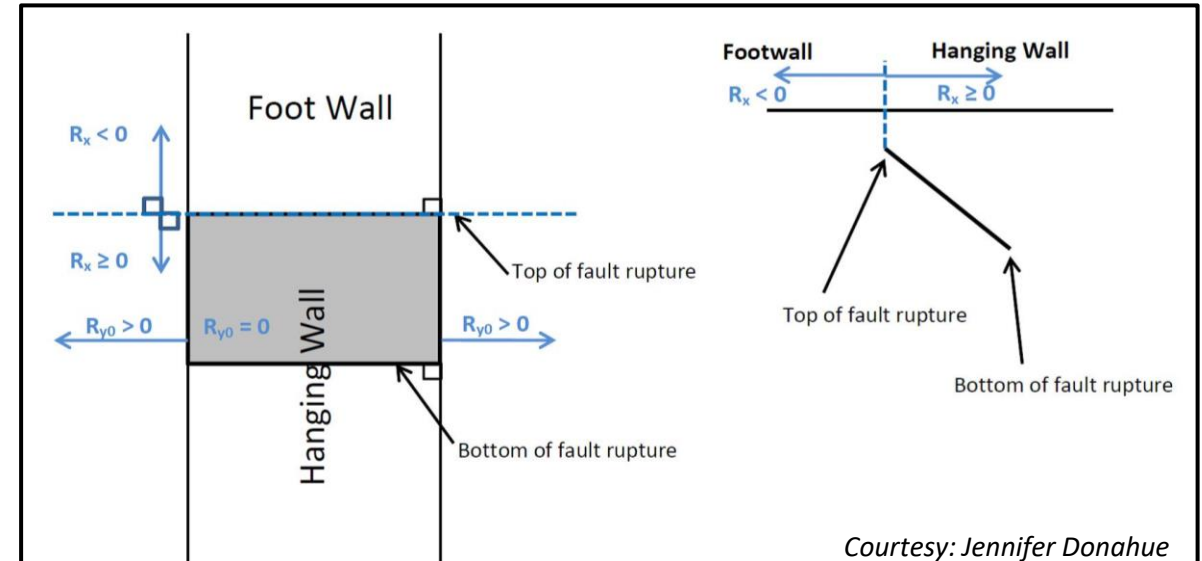
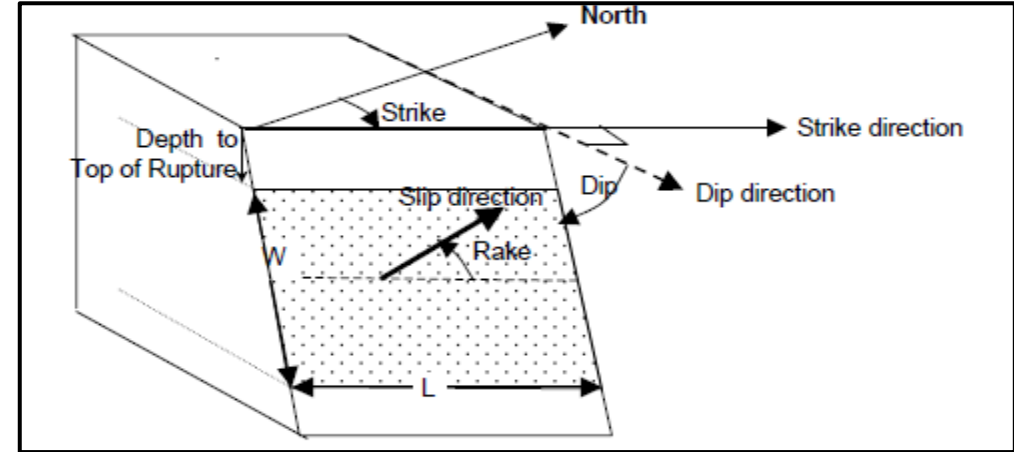
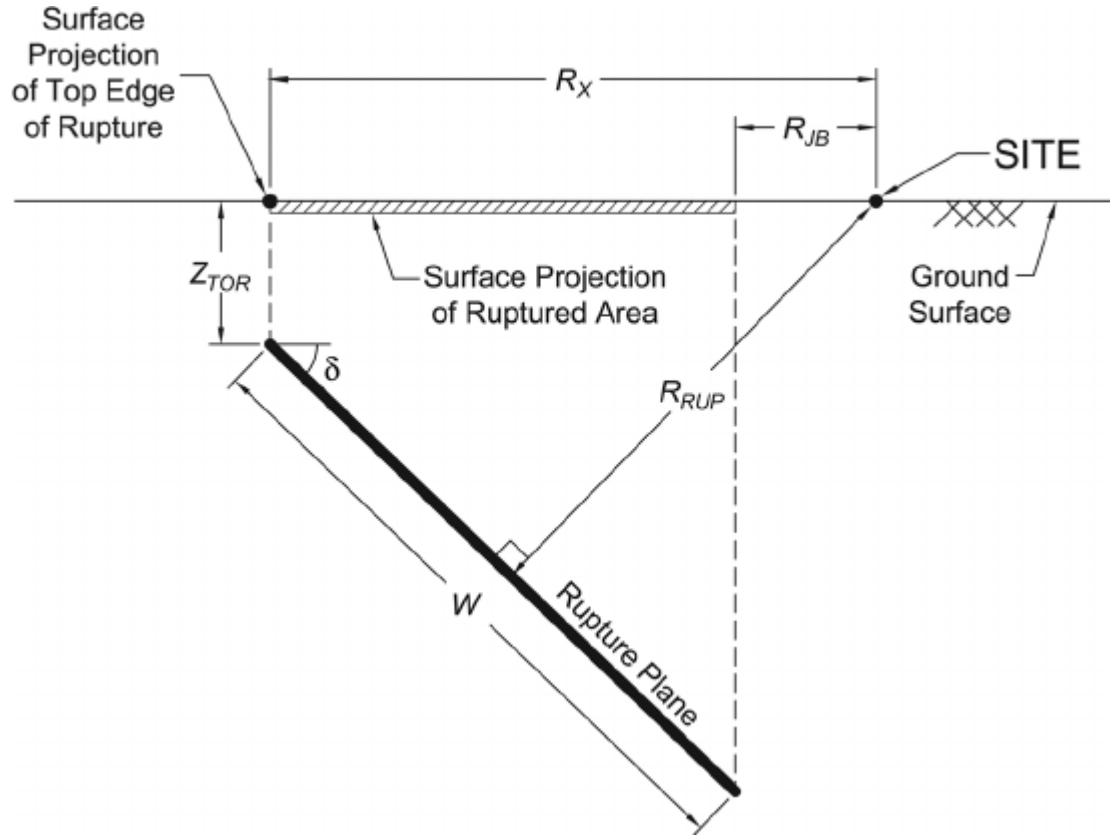
Alias	String[] Array
[0]	BSSA14
[1]	CB14
[2]	ASK14
[3]	CY14
[4]	ASB14
[5]	BWTB21
[6]	BWOB21
[7]	KAAH15
[8]	SKV08
[9]	VAC15

Ground Motion Prediction Equations



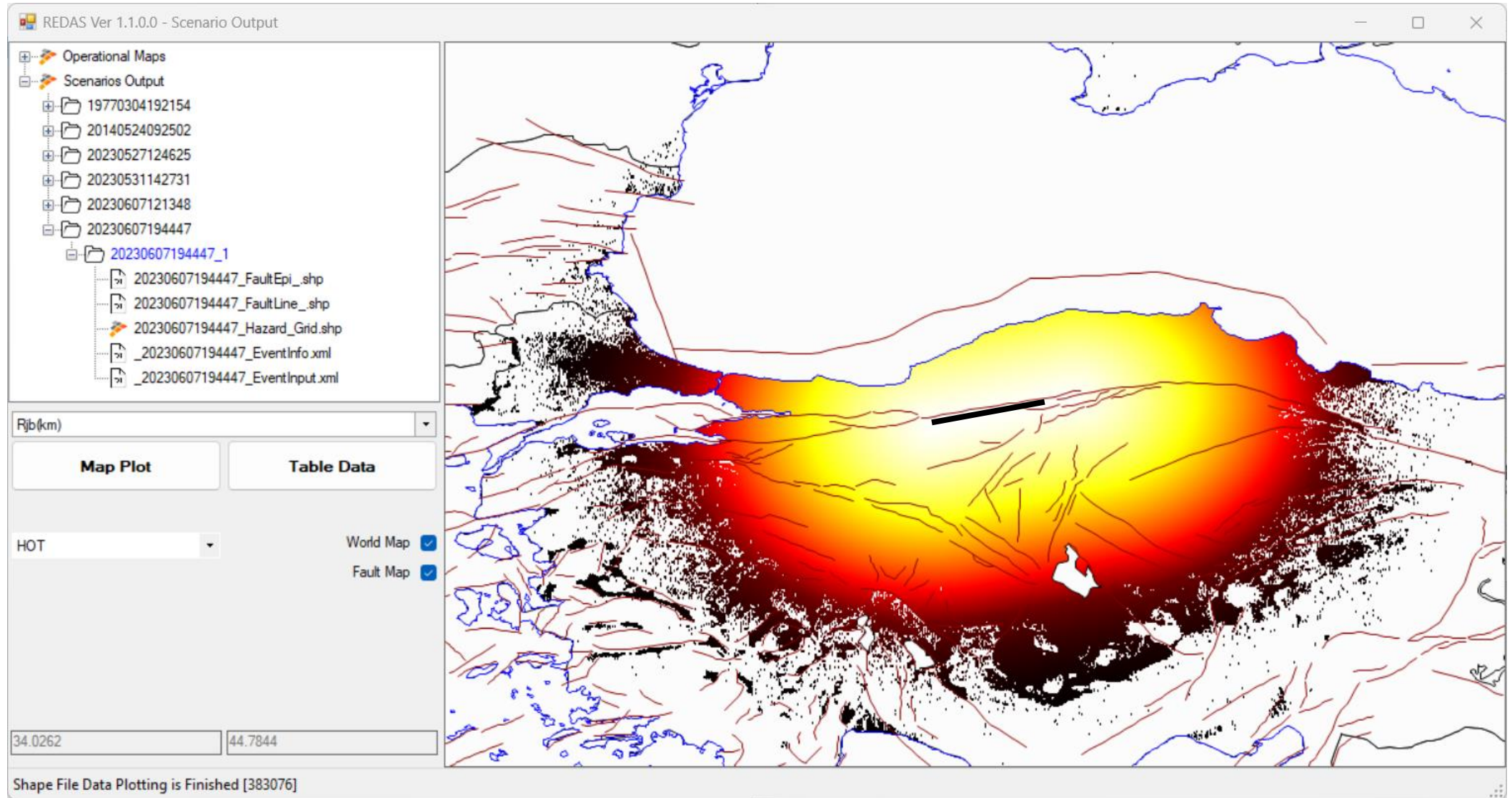
	ZONE	GMPE	BSSA14	CB14	ASK14	CY14	KAH15	BWTB21	BWOB21	SKV08	VAC15	ZMIN
▶	Crustal earthquakes in and...	Boore et al (2014), Cauzz...	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.000
	Crustal earthquakes in Vra...	Boore et al (2014), Cauzz...	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.000
	Crustal 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
	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

Rupture distance Calculation



Courtesy: Jennifer Donahue

Rupture distance Calculation



Soil Shear Wave Velocity Distribution, Vs30

Configuration Form

REDAS System

- Local System Configuration
 - System Files
 - Operational Parameters
 - GMPE (Attenuation Relations)
 - Landslide (Statistical)
 - Landslide (Infinite Slope)
 - Liquefaction Model
 - Building Risk
 - Lifeline Risk
 - Fragility Curves
 - Soil V30 Files
 - Global Vs30
 - Local > Vs30_Local_Serres
 - SGM Records Parameters

ID	Vs30_Global
CRS	GEOGCS["WGS 84",DATUM["WGS_1984",SPHEROID["WGS 84",6378137,298.257223563,AUTHORIT...
RasterFile	C:\REDAS\Scenarios\Operational\Vs30_Global.tif
Size	Int32[] Array
[0]	3735
[1]	6326
xLim	Double[] Array
[0]	10.979947416472669
[1]	63.696614083139316
yLim	Double[] Array
[0]	22.387225104959583
[1]	53.512225104959569

Global Vs30 Raster Map



Local Vs30 Raster Maps



REDAS V1.1 Active Models

Building Losses

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

Fragility Curves

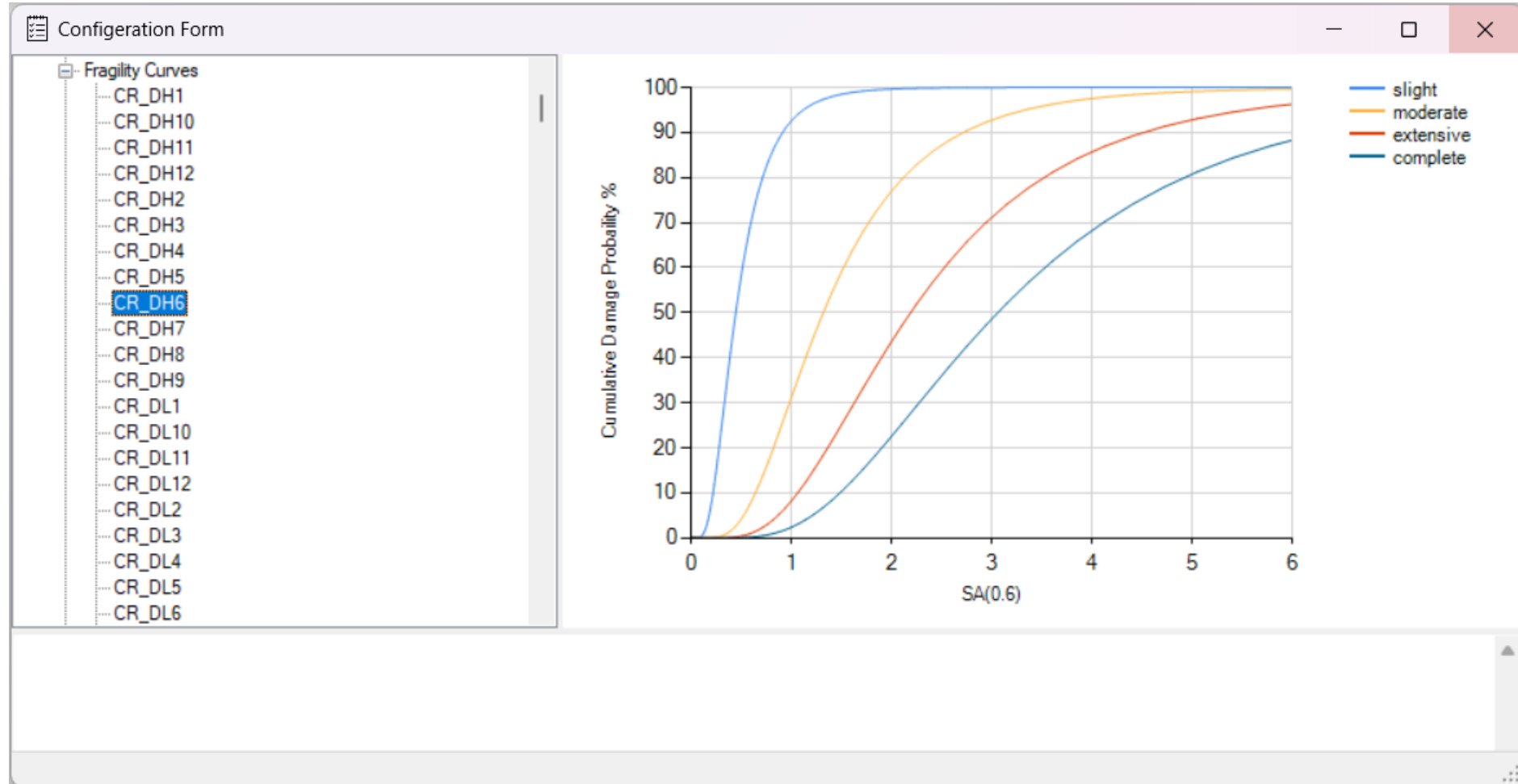
Configuration Form

Fragility Curves

- CR_LD_H1
- CR_LD_H10
- CR_LD_H11
- CR_LD_H12
- CR_LD_H2
- CR_LD_H3
- CR_LD_H4
- CR_LD_H5
- CR_LD_H6
- CR_LD_H7
- CR_LD_H8
- CR_LD_H9
- CR_LDUAL-DUL_H1
- CR_LDUAL-DUL_H10
- CR_LDUAL-DUL_H11
- CR_LDUAL-DUL_H12
- CR_LDUAL-DUL_H2
- CR_LDUAL-DUL_H3
- CR_LDUAL-DUL_H4
- CR_LDUAL-DUL_H5

id	CR_LD_H1
lossCategory	structural
assetCategory	
description	All Martins-Silva Fragility Curves
format	discrete
> limitStates	String[] Array
imt	PGA
noDamageLimit	0.02
imls	(Collection)
poes_1	(Collection)
poes_2	(Collection)
poes_3	(Collection)
poes_4	(Collection)

Fragility Curves



Building Inventory Shape File

Configuration Form

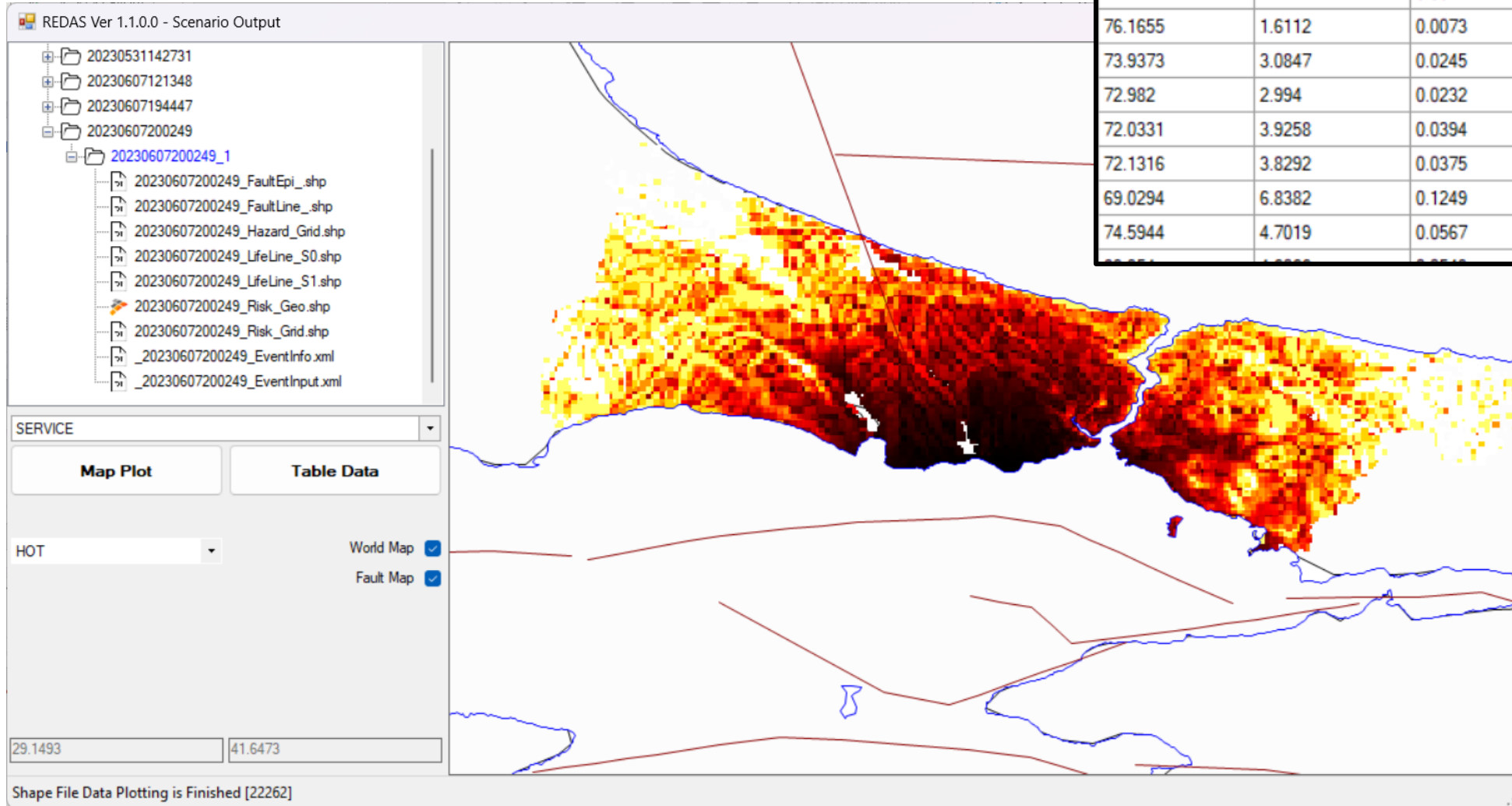
REDAS System

- Local System Configuration
 - System Files
 - Operational Parameters
 - GMPE (Attenuation Relations)
 - Landslide (Statistical)
 - Landslide (Infinite Slope)
 - Liquefaction Model
 - Building Risk
 - Building_Population_GeoGrid_DataBase
 - RO_buildings
 - sample_serres_wgs84
 - sample_thessaloniki_wgs84
 - Lifeline Risk
 - Fragility Curves
 - Soil V30 Files
 - SGM Records Parameters

ID	RO_buildings
CRS	WGS 84 EPSG4326
RecordCount	121
ShpFile	C:\REDAS\Scenarios\Database\RO_buildings.shp
▼ xLim	Double[] Array
[0]	27.271325201496893
[1]	29.715232742097406
▼ yLim	Double[] Array
[0]	45.467411239137405
[1]	43.733701483936386

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



REDAS V1.1 Active Models

Liquefaction Hazard

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

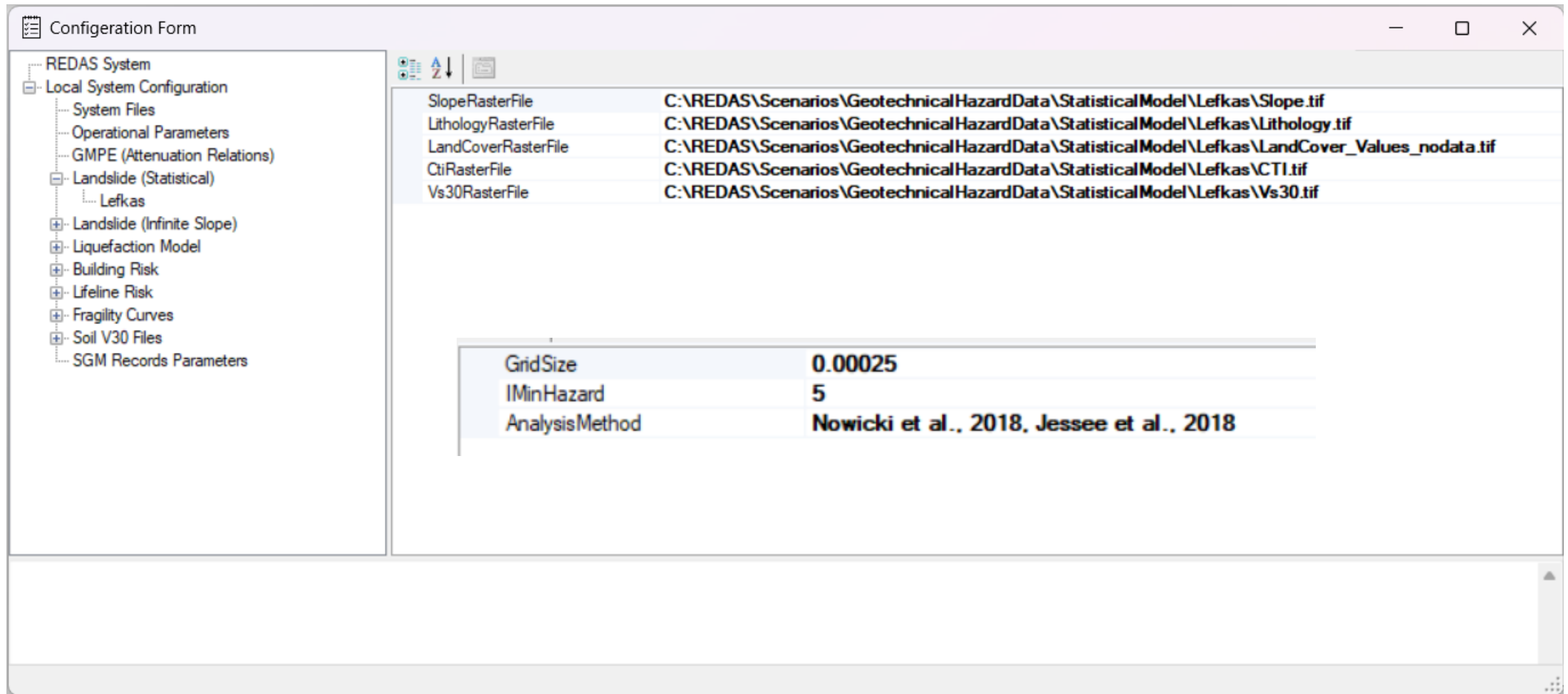
Landslide Hazard (Statistical)

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

Landslide Hazard (Physical)

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

Raster Files for Landslide Hazard (Statistical)

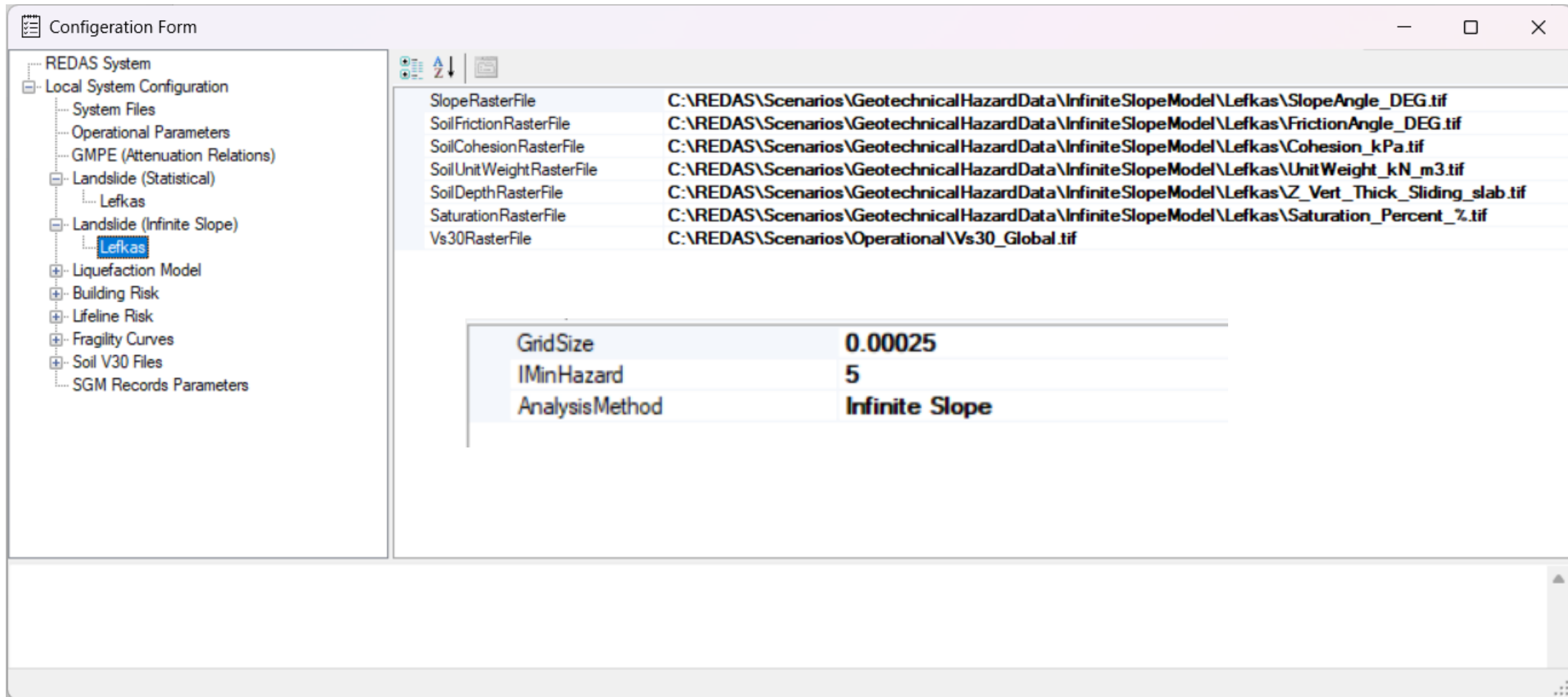


The screenshot displays the 'Configuration Form' window for REDAS. The left sidebar shows a tree view with 'Landslide (Statistical)' selected. The main area contains two tables of configuration data.

Parameter	Value
SlopeRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Statistical Model\Lefkas\Slope.tif
LithologyRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Statistical Model\Lefkas\Lithology.tif
LandCoverRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Statistical Model\Lefkas\LandCover_Values_nodata.tif
CtiRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Statistical Model\Lefkas\CTI.tif
Vs30RasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Statistical Model\Lefkas\Vs30.tif

GridSize	0.00025
IMinHazard	5
AnalysisMethod	Nowicki et al., 2018, Jessee et al., 2018

Raster Files for Landslide Hazard (Infinite Slope)



The screenshot displays the 'Configuration Form' window for REDAS. The left sidebar shows a tree view with 'Landslide (Infinite Slope)' selected, and 'Lefkas' highlighted under it. The main area shows a list of raster files and their paths, along with a summary table of analysis parameters.

Parameter	Value
SlopeRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Infinite Slope Model\Lefkas\SlopeAngle_DEG.tif
SoilFrictionRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Infinite Slope Model\Lefkas\FrictionAngle_DEG.tif
SoilCohesionRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Infinite Slope Model\Lefkas\Cohesion_kPa.tif
SoilUnitWeightRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Infinite Slope Model\Lefkas\UnitWeight_kN_m3.tif
SoilDepthRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Infinite Slope Model\Lefkas\Z_Vert_Thick_Sliding_slab.tif
SaturationRasterFile	C:\REDAS\Scenarios\Geotechnical Hazard Data\Infinite Slope Model\Lefkas\Saturation_Percent_%.tif
Vs30RasterFile	C:\REDAS\Scenarios\Operational\Vs30_Global.tif

GridSize	0.00025
IMinHazard	5
AnalysisMethod	Infinite Slope

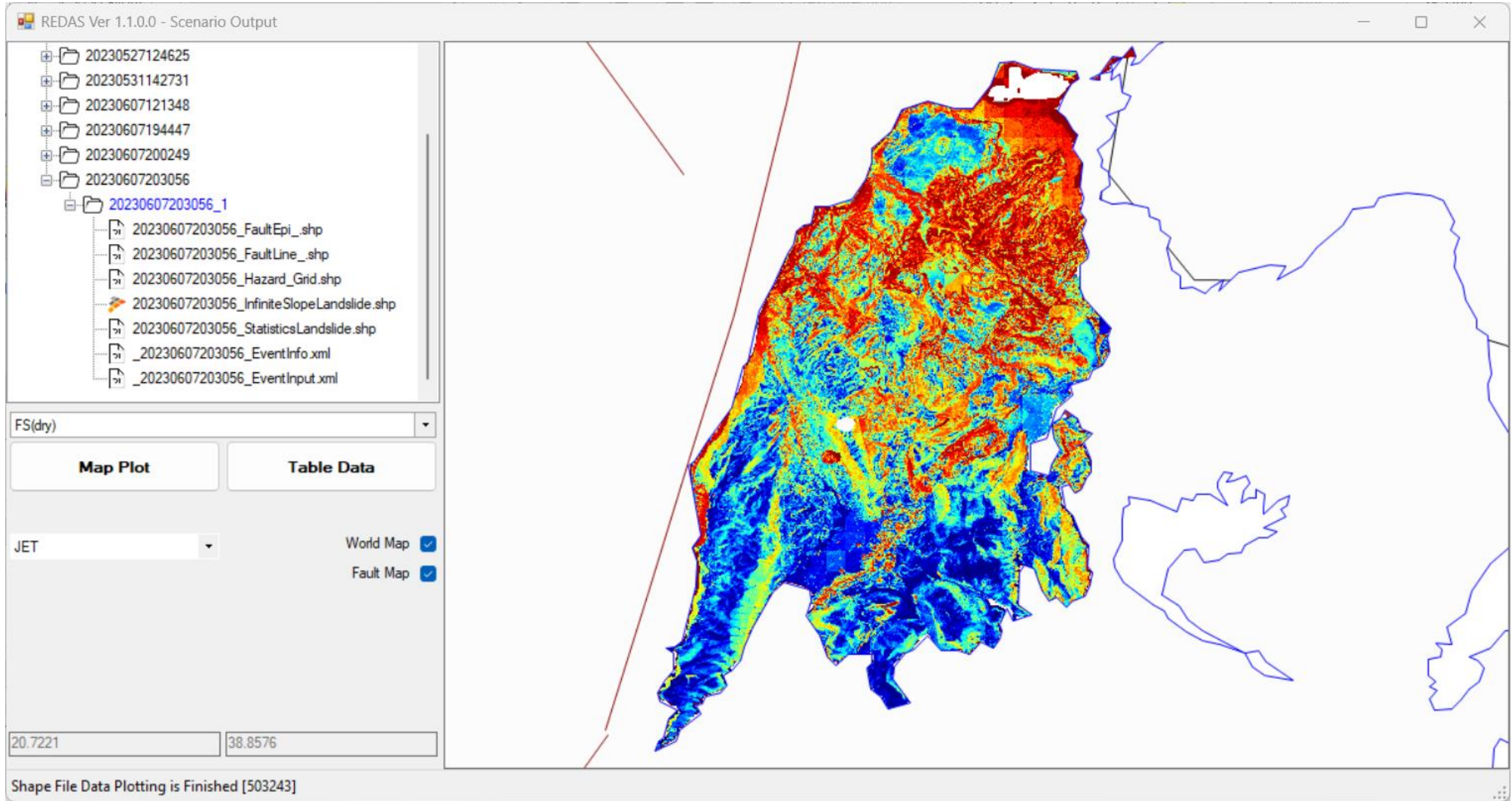
Raster Files for Liquefaction Model

The screenshot displays the 'Configuration Form' window for the REDACT software. The left-hand tree view shows the configuration hierarchy: REDAS System > Local System Configuration > Liquefaction Model > Larisa. The main area is divided into two sections. The top section is a table of raster files, and the bottom section is a table of model parameters.

Parameter	Value
Vs30RasterFile	C:\REDAS\Scenarios\GeotechnicalHazardData\LiquefactionModel\Larisa\Vs30_WGS84.tif
PrecipRasterFile	C:\REDAS\Scenarios\GeotechnicalHazardData\LiquefactionModel\Larisa\Annual_Precipitation_WC.tif
dcRasterFile	
drRasterFile	
dwRasterFile	C:\REDAS\Scenarios\GeotechnicalHazardData\LiquefactionModel\Larisa\DW_km_WGS84.tif
wtdRasterFile	C:\REDAS\Scenarios\GeotechnicalHazardData\LiquefactionModel\Larisa\WTD_mask.tif

GridSize	0.0025
IMinHazard	5
AnalysisMethod	Zhu et al (2017) methodology

Landslide Hazard Results



REDAS V1.1 Active Models

Pipeline Losses

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

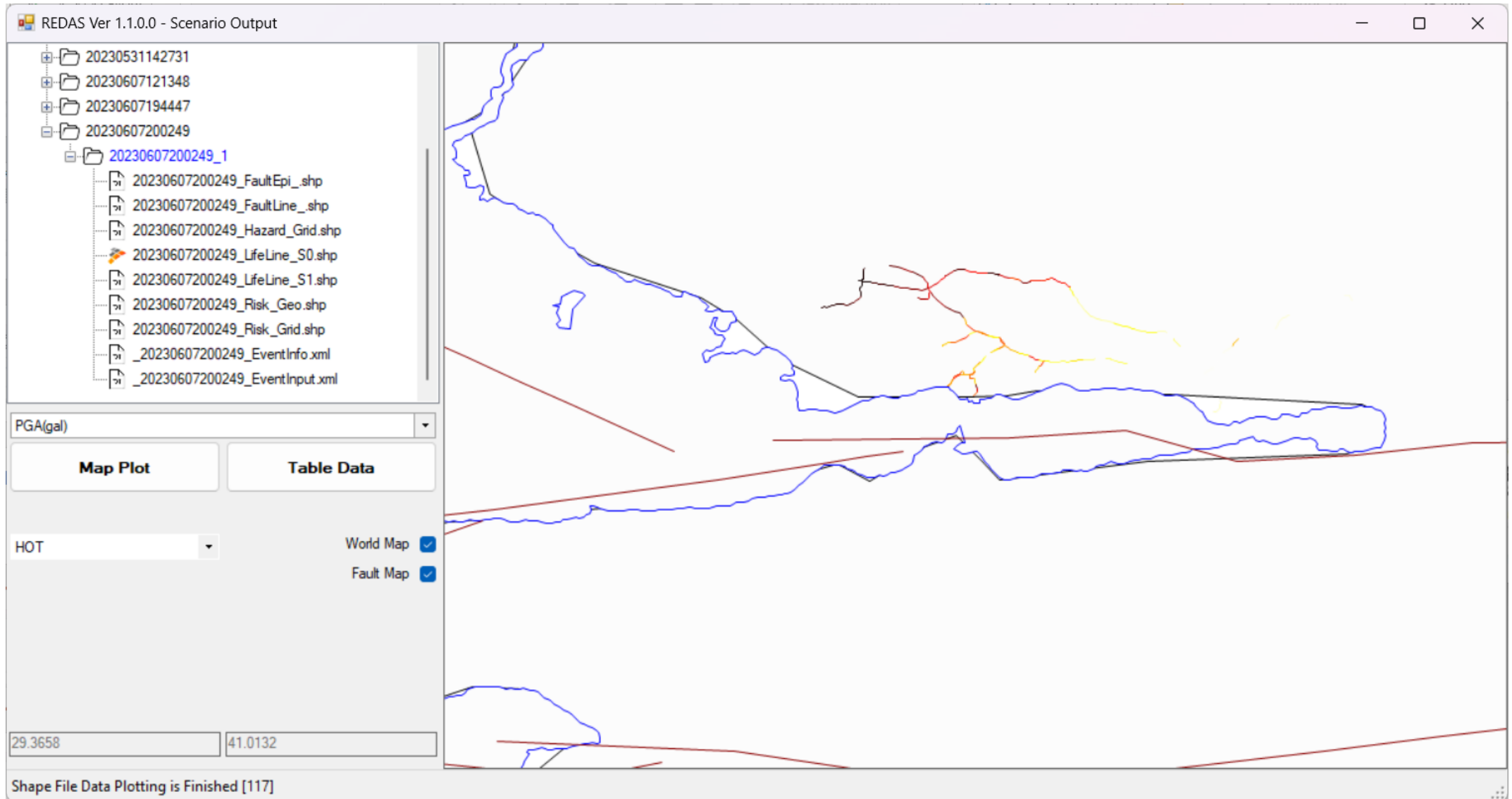
Pipeline Loss functions

The screenshot shows the 'Configuration Form' window for REDAS. The left pane displays a tree view of the system configuration, including 'Local System Configuration', 'System Files', 'Operational Parameters', 'GMPE (Attenuation Relations)', 'Landslide (Statistical)', 'Landslide (Infinite Slope)', 'Liquefaction Model', 'Building Risk', 'Lifeline Risk' (with sub-items 'botas_dogalgaz_boru_hatti' and 'TestLifeLineData'), 'Fragility Curves', 'Soil V30 Files' (with sub-items 'Global Vs30' and 'Local> Vs30_Local_Serres'), and 'SGM Records Parameters'.

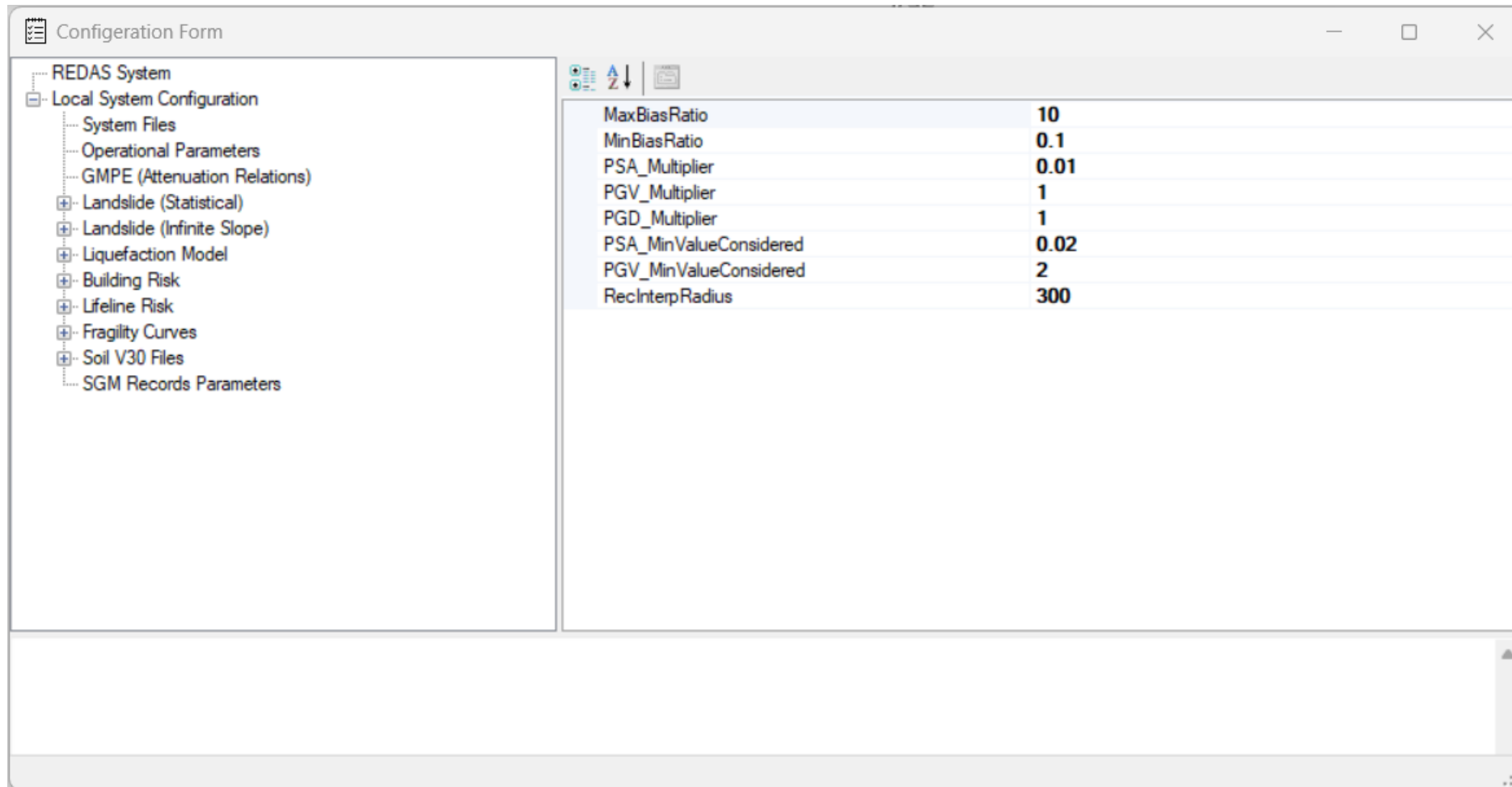
The right pane shows a table of configuration parameters for the selected 'LifeLineData' folder:

Parameter	Value
DataBaseFolder	C:\REDAS\Scenarios\LifeLineData\
AnalysisMethod	String[] Array
[0]	JWA (1998)
[1]	ALA (2001)
[2]	Chen et al.(2002)
Factor	Double[] Array
[0]	0.5
[1]	0.5
[2]	0

Pipelines Loss Results



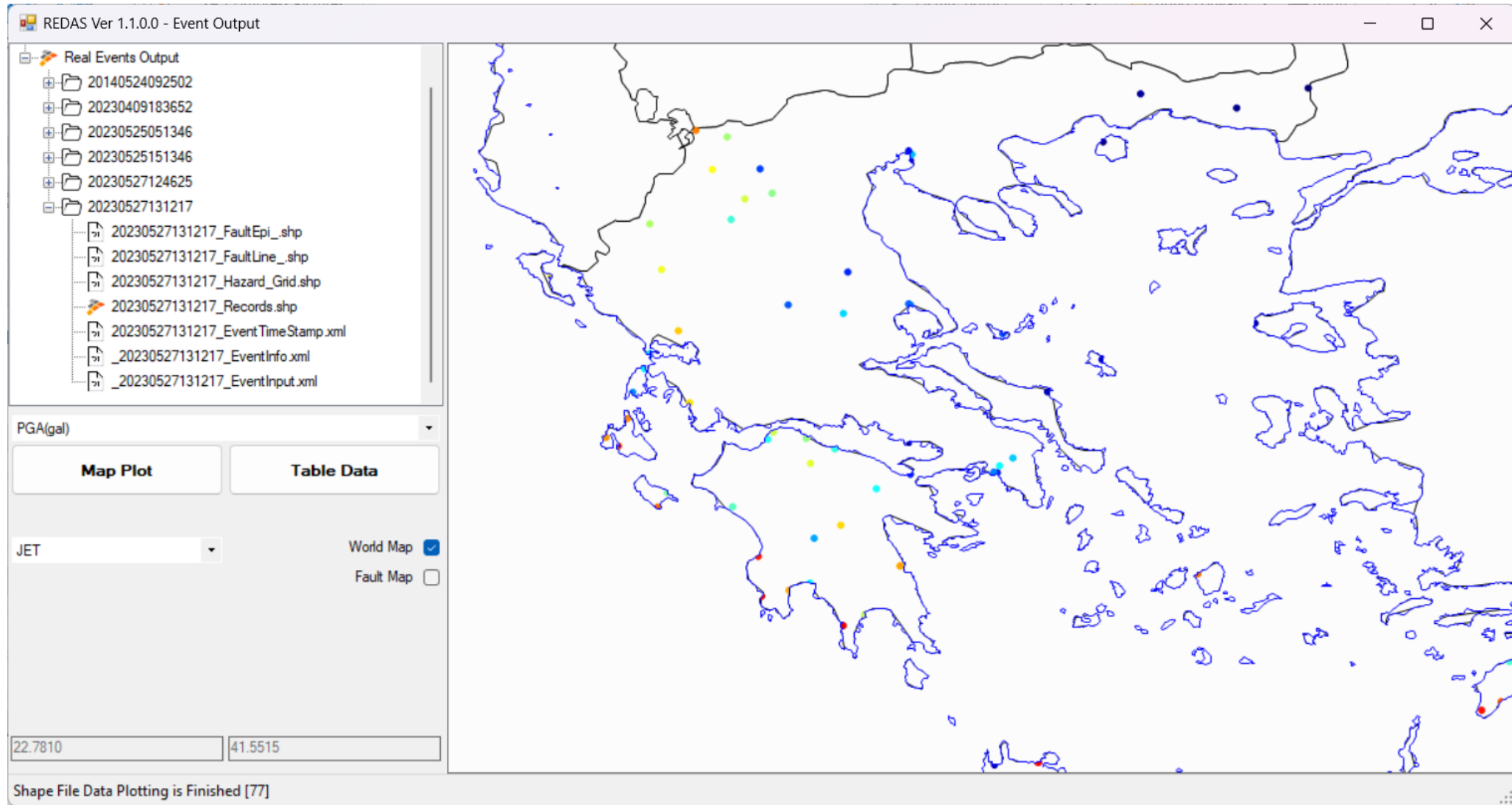
Station Data Integration



The screenshot displays the 'Configuration Form' window for REDAS. The left sidebar shows a tree view of configuration categories, with 'Local System Configuration' expanded. The main area on the right displays a list of parameters and their values:

MaxBiasRatio	10
MinBiasRatio	0.1
PSA_Multiplier	0.01
PGV_Multiplier	1
PGD_Multiplier	1
PSA_MinValueConsidered	0.02
PGV_MinValueConsidered	2
RecInterpRadius	300

Station Data Integration



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 ▲
▲ [C#] 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

Thanks ...