Methodology for hazards map construction

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Basic principles for the elaboration of hazards maps

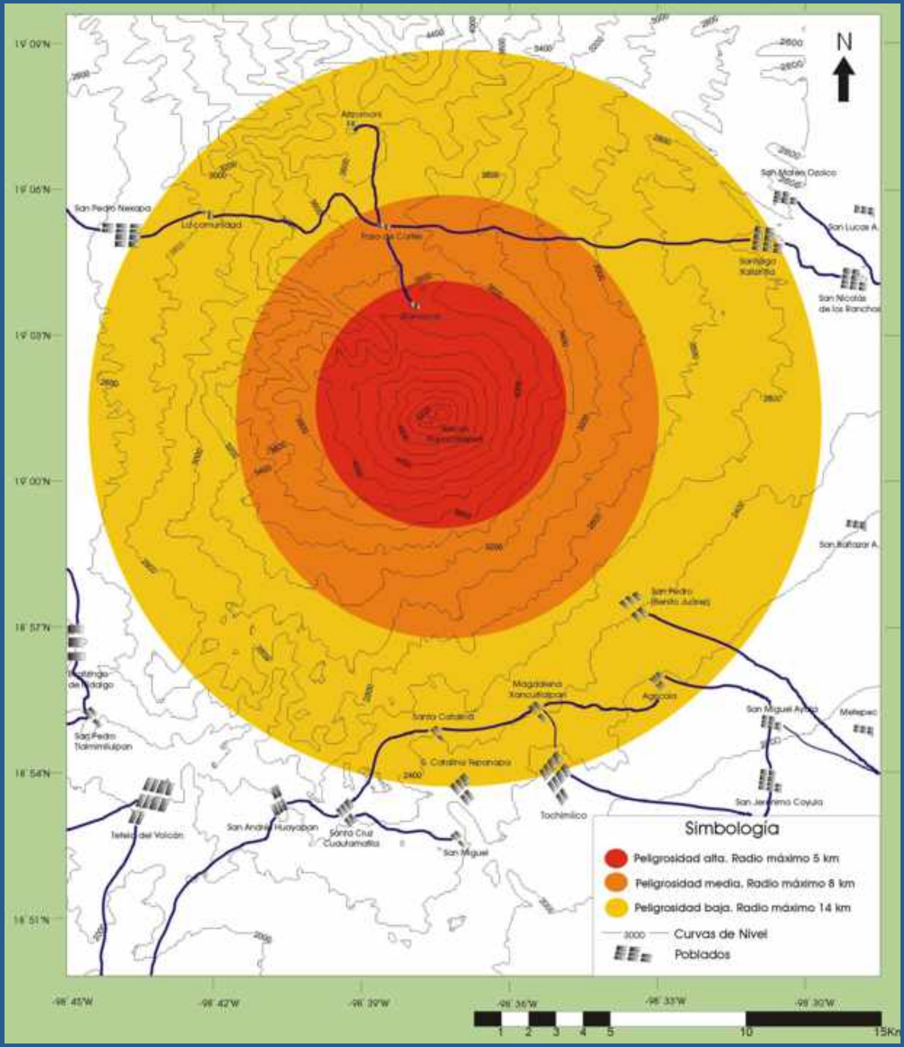
- Hazards maps should be based on sound scientific studies, as much geological and physical data as possible, modeling and simulations
- Even though the elaboration process implies scientific methodologies and data, hazards maps **are not** a product for scientists
- Hazards maps are tools designed for being used by non-specialists (authorities, people, media)
- Then, the maps should be **simple and accessible**
- An accessible and unified or basic methodology is needed for those who make hazards maps

Hazard maps are…

- probability maps:
  - tools depicting the probable/likely distribution, in space or time, of products related to the occurrence of certain volcanic process
  - tools that depict probable/likely magnitude scenarios of volcanic processes’ occurrence in accordance to actual events documented for a particular site, or to events occurred at a similar site for which detailed data is available
- forecast maps
  - simulation of calibrated events, at different magnitude scenarios establish volcanic process forecasts
  - however, forecasts are limited

Hazards Maps should be:

- Consistent
- Objective
- Simple
- Reproducible
- Sound
- Relevant
- Long-standing



however landscape changes…

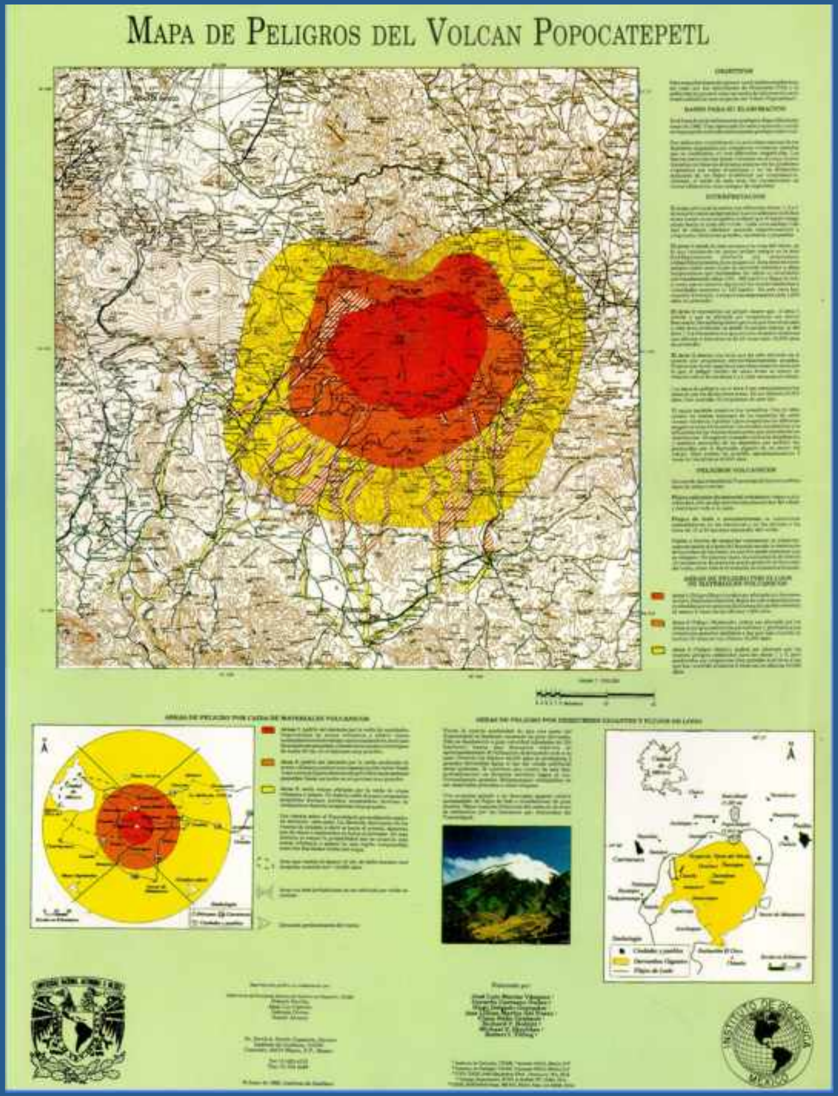
- *Very active geologic systems may strongly change the morphology of a region after an event*
- *Some phenomena should be followed as they occur in order to make real-time decisions*

Therefore, two types of hazards maps are envisaged according to purposes, scope and use:

- *Hazards Static Maps*
- *Hazards Dynamic Maps*

Hazards Static Maps are designed...

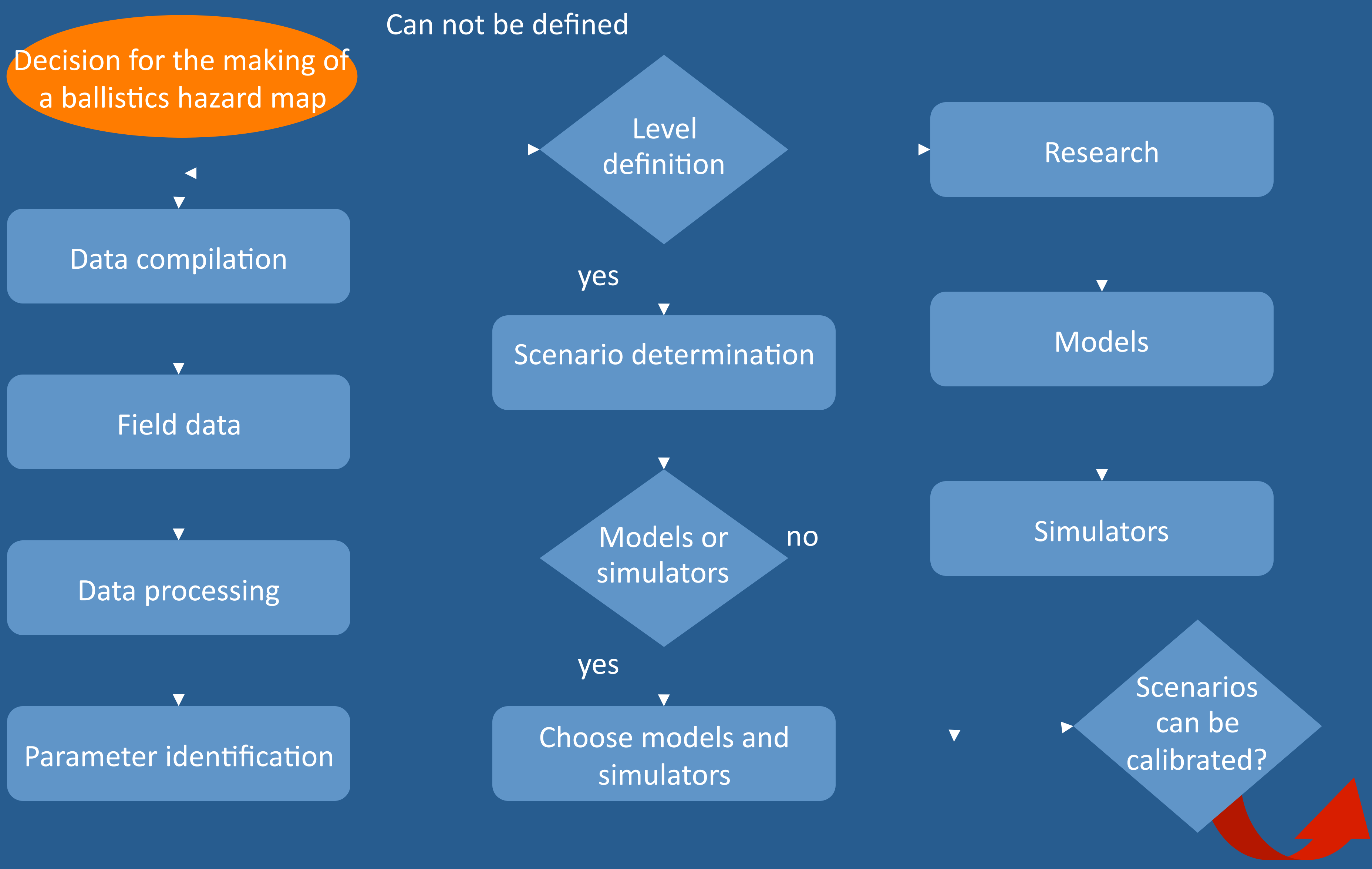
- <u>to be printed</u> or accessible through the internet
- <u>to be widely distributed</u> for everyone to know them, learn about the surrounding processes, how to protect against those processes, and how to use the maps
- <u>to stand for a long time</u> without large modifications, changes may provoke...
  - Confusions
  - Credibility loss



Hazards Dynamic Maps are designed...

- to be used by specialists and /or trained civil defense technicians
- to be changed at any time by authorized people
- to be used on a GIS framework
- to summarize and monitor geologic events and deploy them near real-time
- initially made from the static map, but as events come, it can be modified for emergency attendance

Methodology: examples



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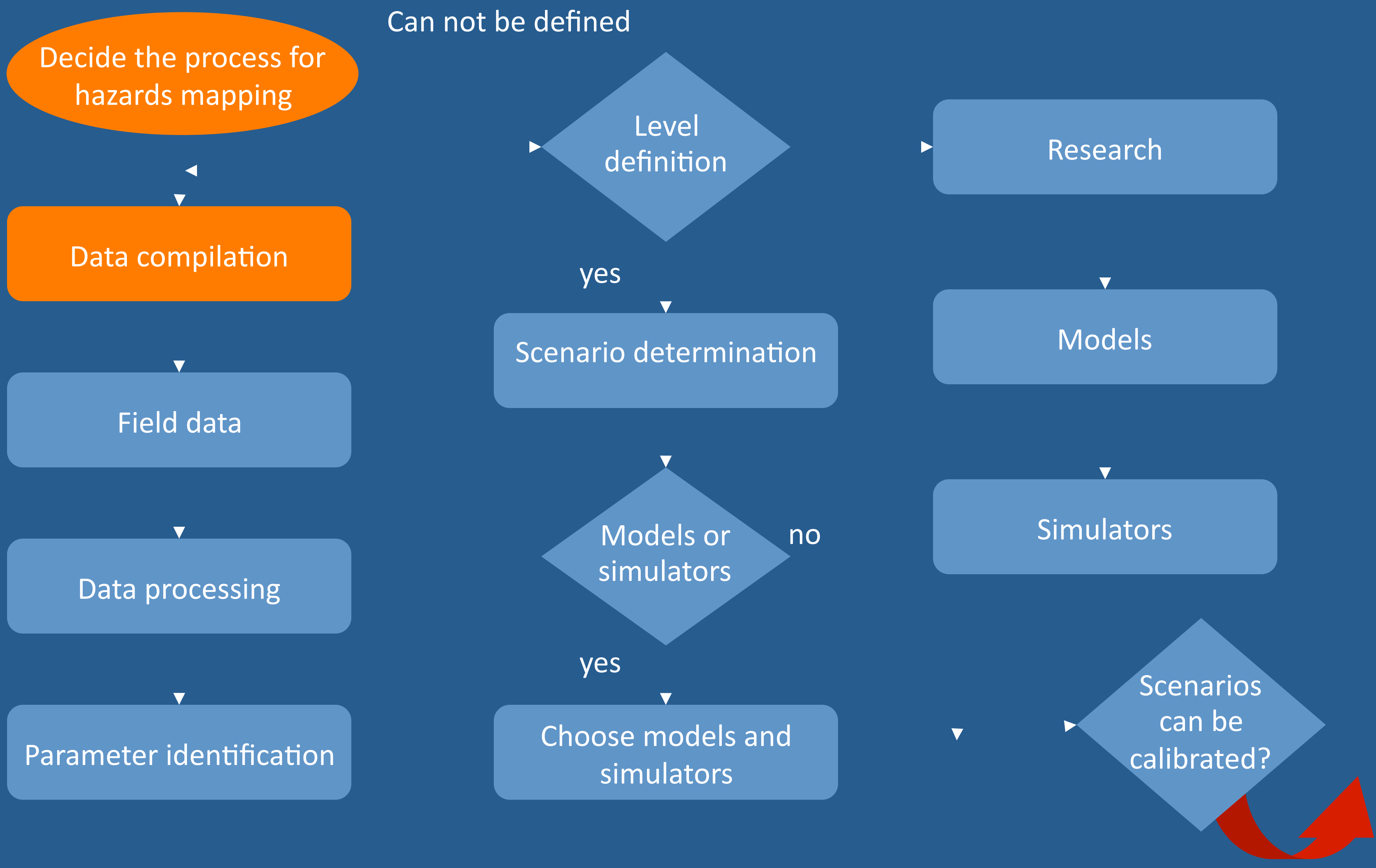


Year	VEI
1512	2
1519	3
1539-1540	2
1548	2
1571	2
1592	2
1642	2
1663	2
1664	3
1665	2
1697	2
1720	1
1804	1
1919-1920	2
1921	2
1925-1927	2
1994-1997	2
2000	3
2001-present	1-2

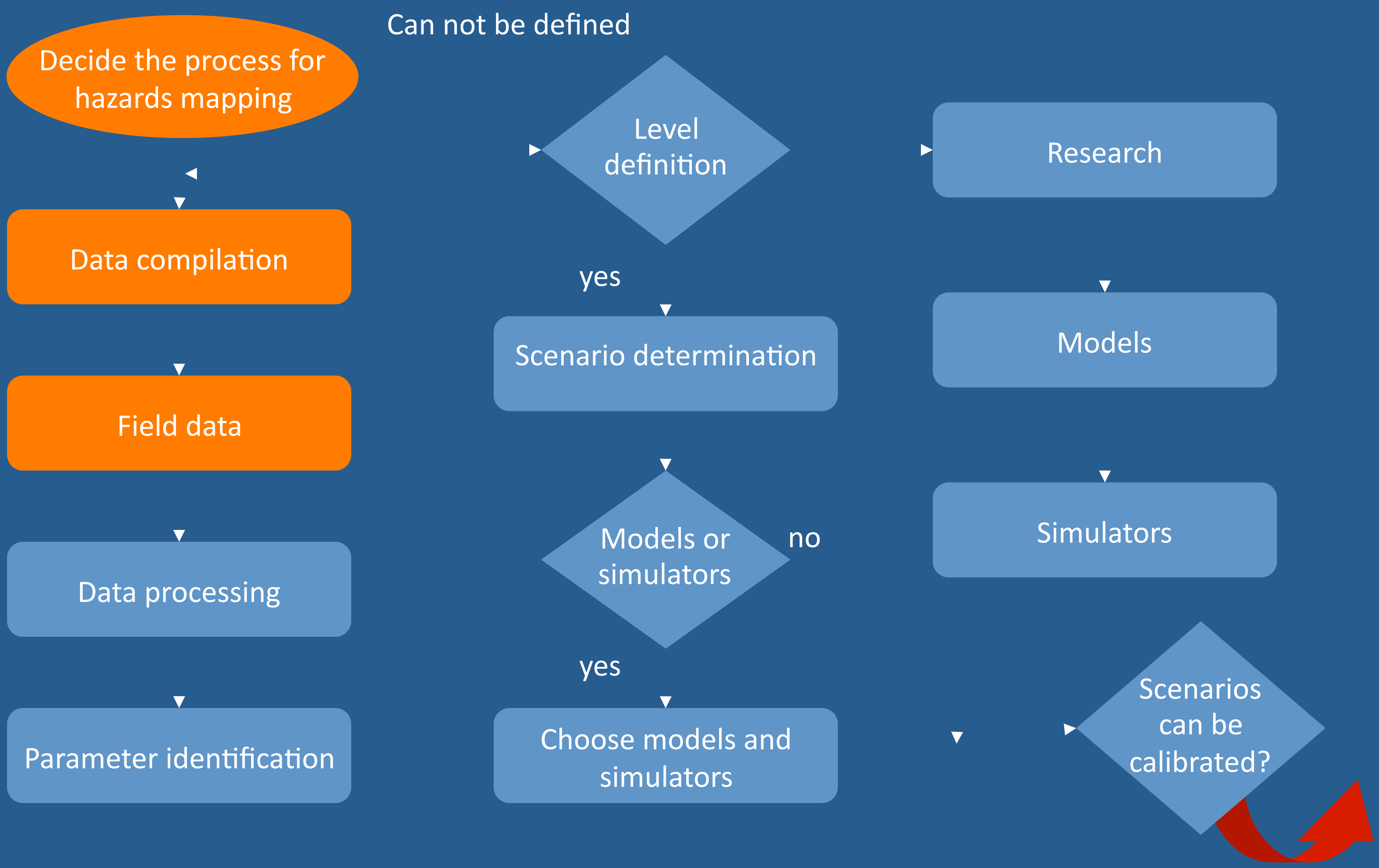
De la Cruz-Reyna et al., 1995

Binomial probabilities of at least one eruption in the corresponding VEI class at Popocatépetl volcano within any 20-year interval

VEI	$Pr_{vei}(20)$
2	0.410
3	0.113
4	0.039
5	0.013
6	0.005

De la Cruz-Reyna and Tilling, 2008

Methodology: examples

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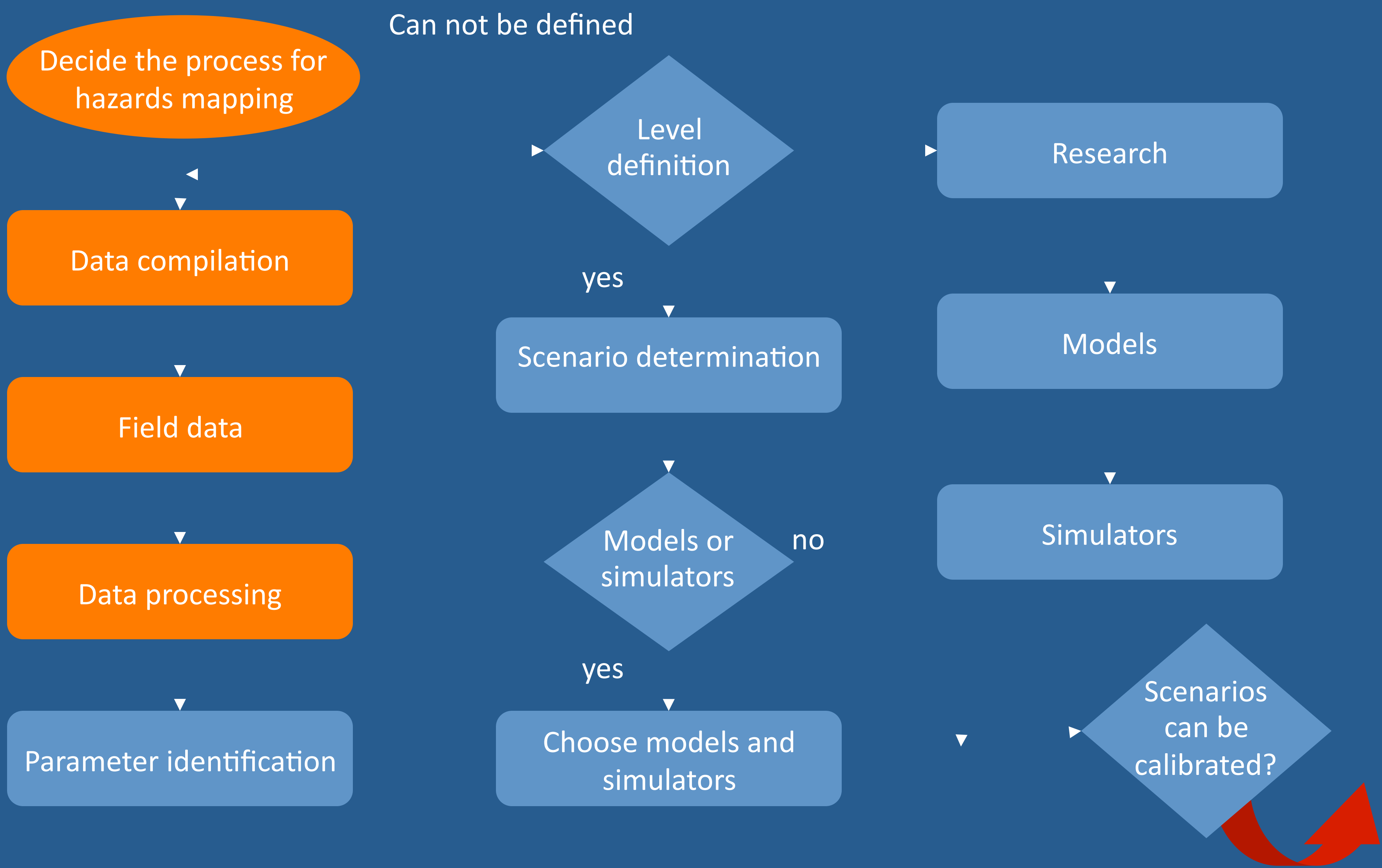
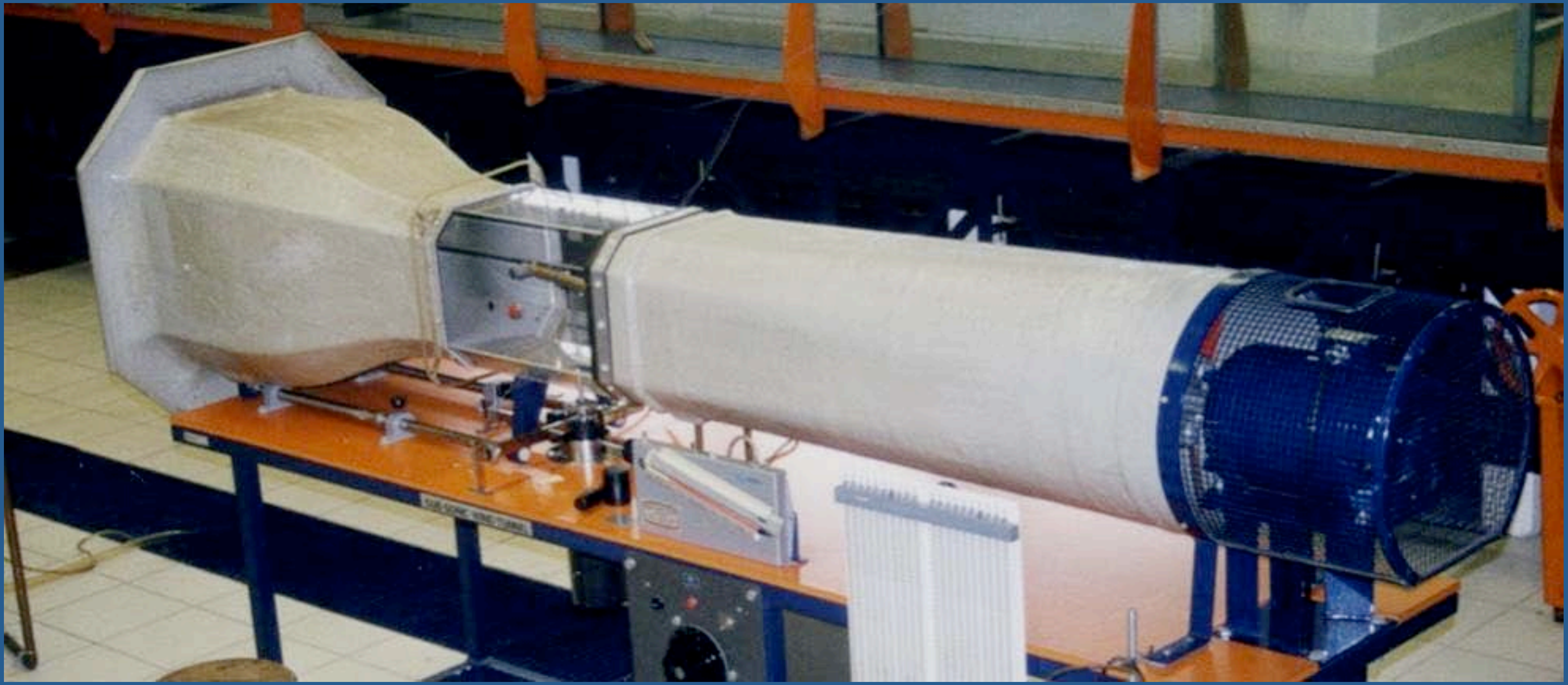
CENAPRED

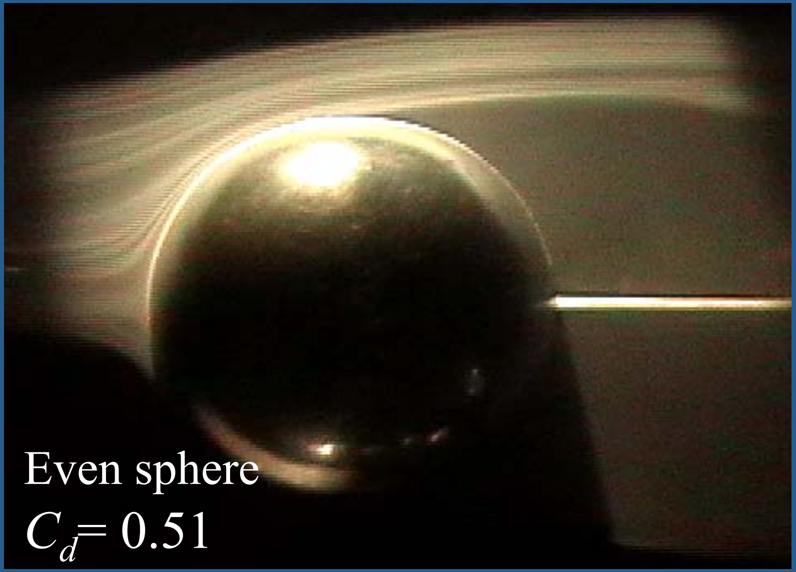

Cortesía: Martha Navarro

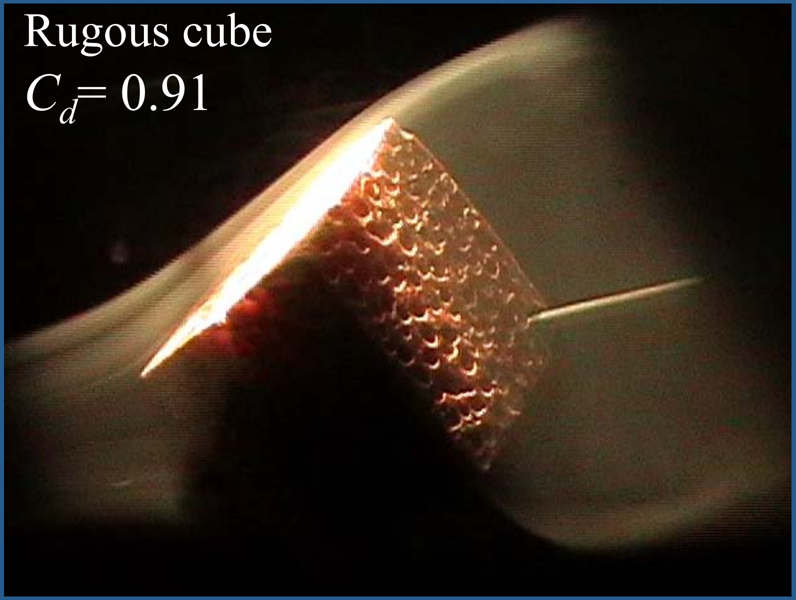
Methodology: examples



Subsonic wind tunnel







The relative size of the stele with the object is proportional to drag coefficient (C_d).

Experimental results

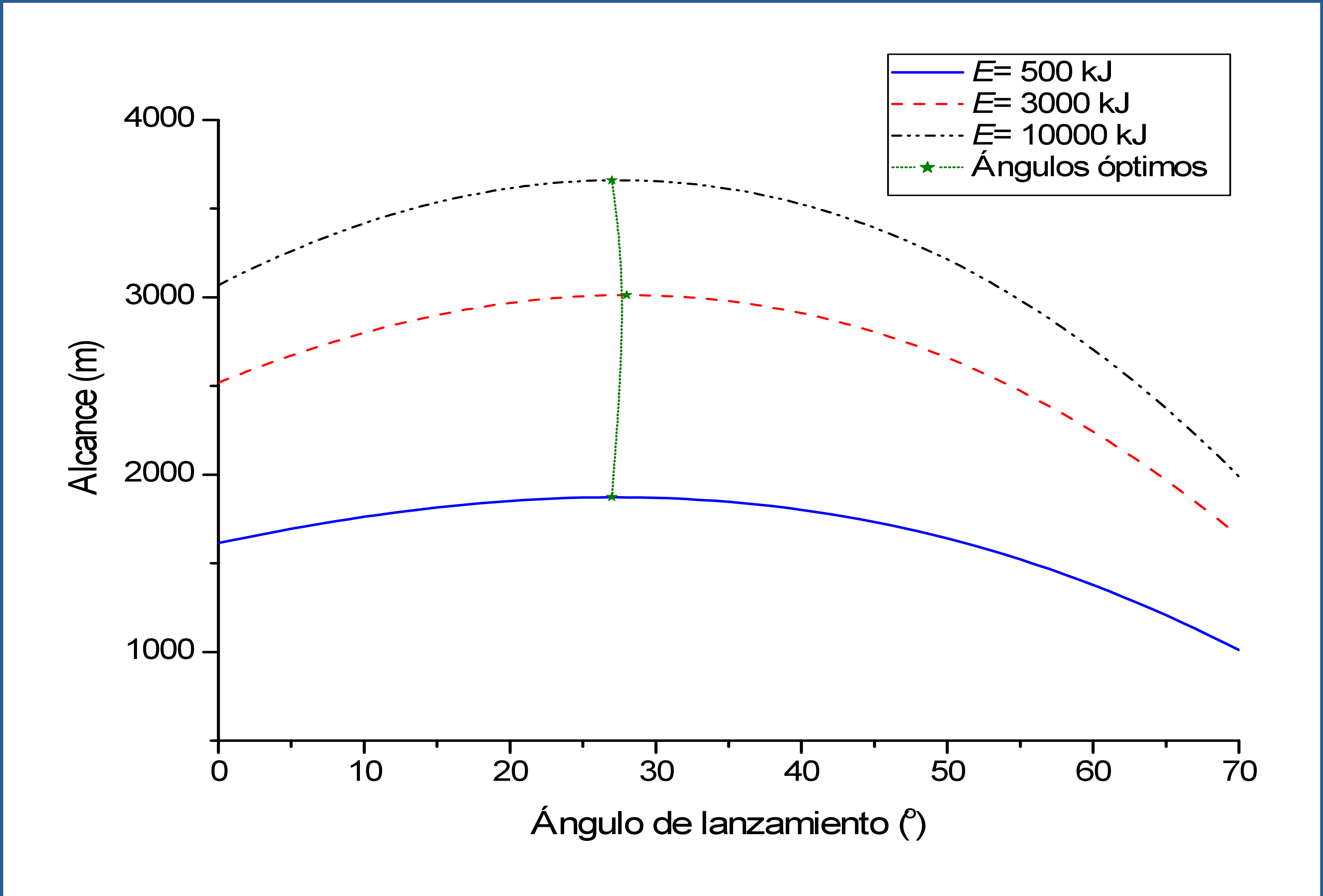
Sample	Area (cm^2)	Equivalent diameter (cm)	Drag coefficient
I	11.62	3.85	0.71
II	12.37	3.97	0.66
III	16.21	4.54	0.98
IV	16.29	4.55	1.01
V	28.72	6.05	0.74
VI	38.14	6.97	0.62

Calibration using an explosion from Popocatépetl

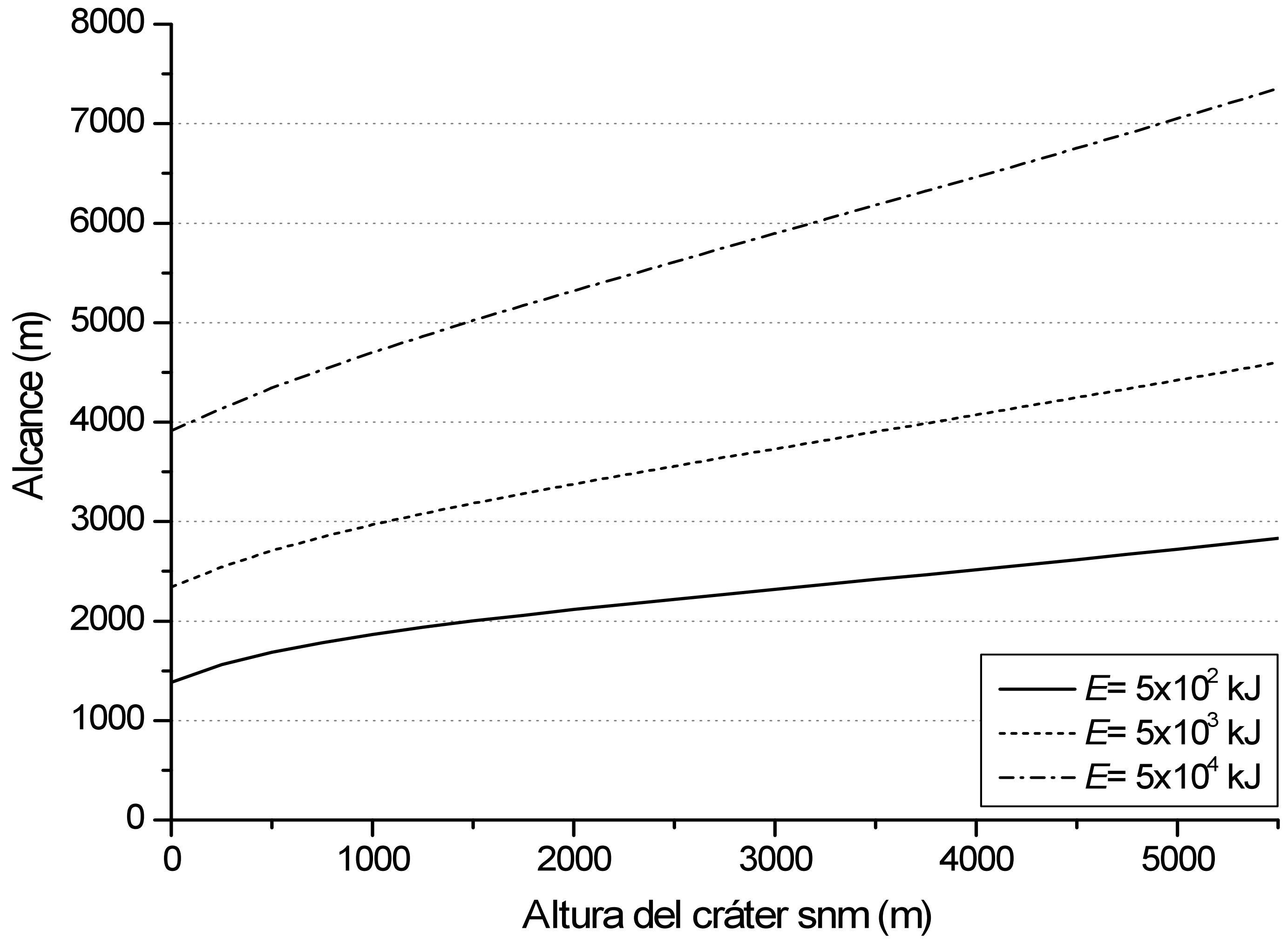
Time = 33 seg

	Maximum range (m)	kinetic energy(x10^6 J)
Measured	3700	-
This model	3650	2.2
C_d= 1.0	3000	2.5
Eject! Sphere	4750	1.1
Eject! Low cube	3430	2.6

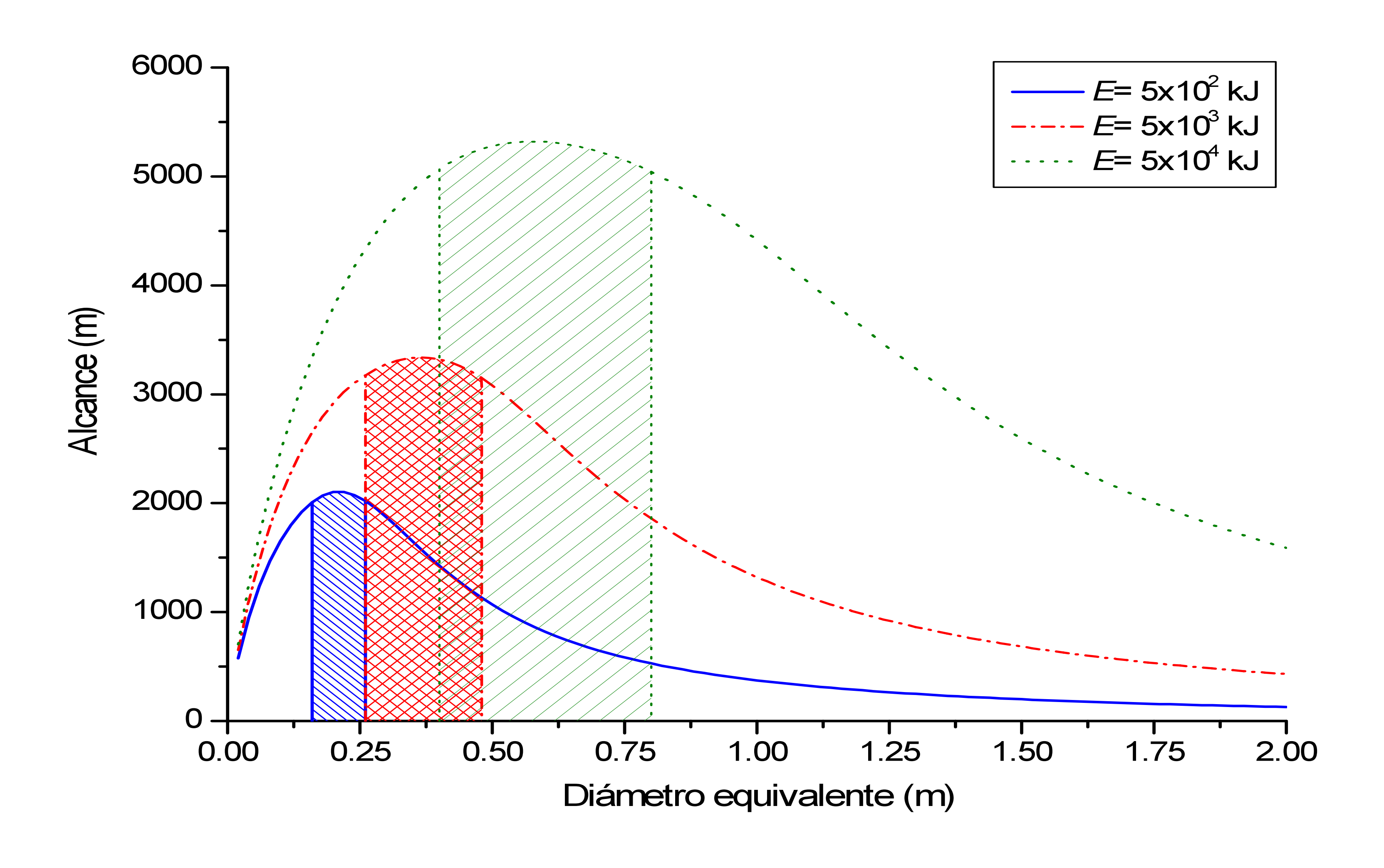
Range as a function of launching angle



Maximum range as a function of volcano's altitude



Maximum range as a function of the average diameter for different launching energies



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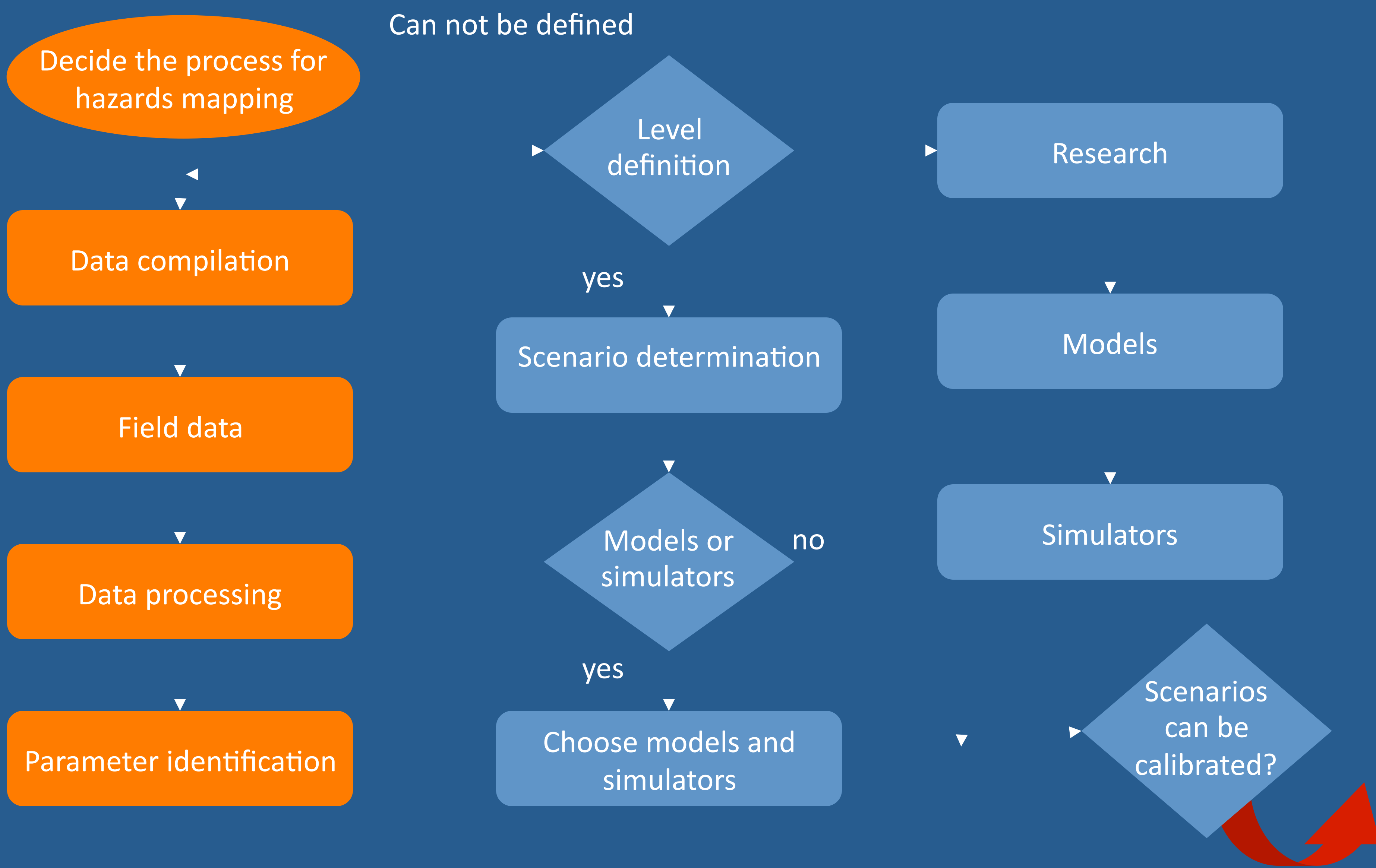


TLAMACAS

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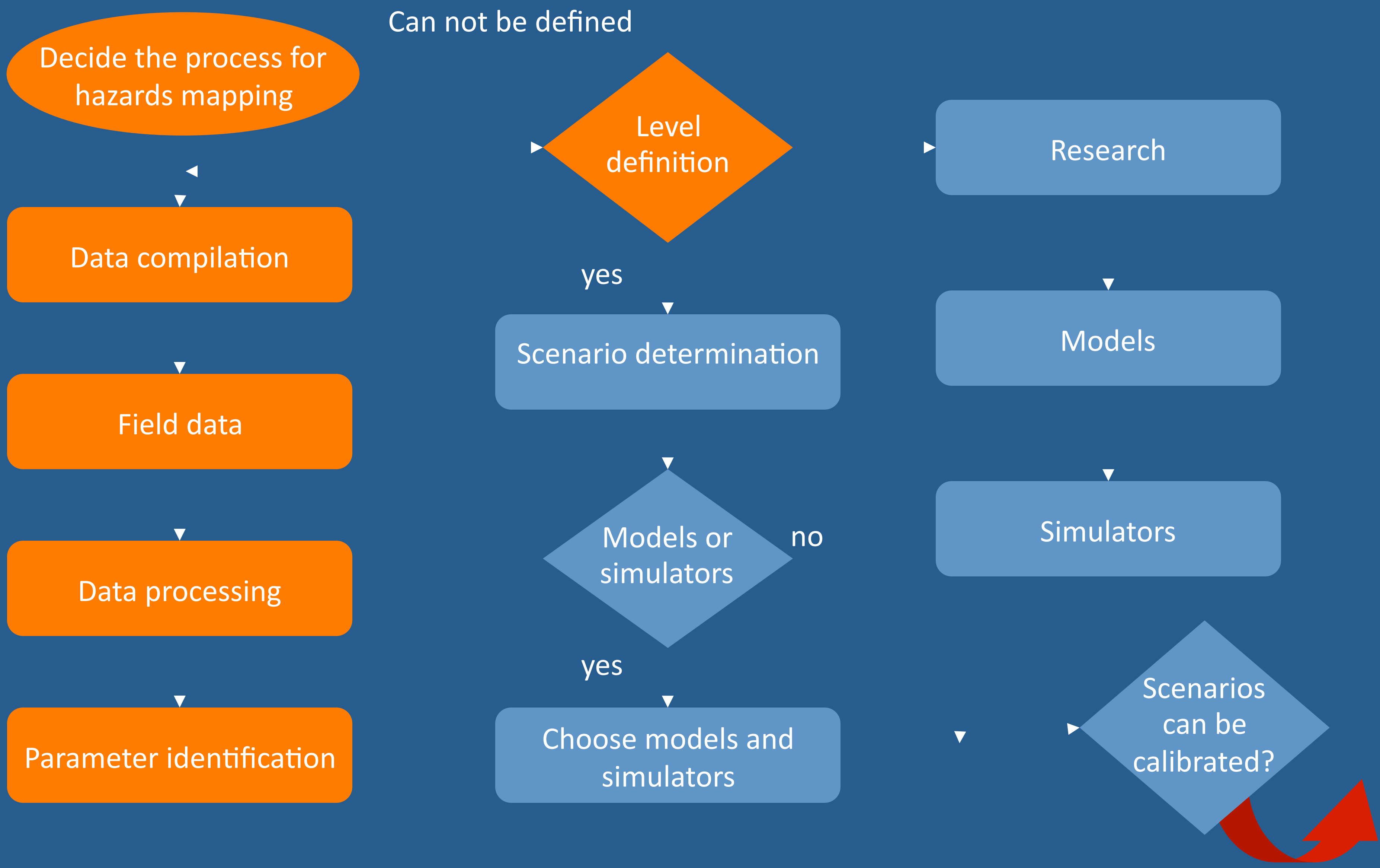

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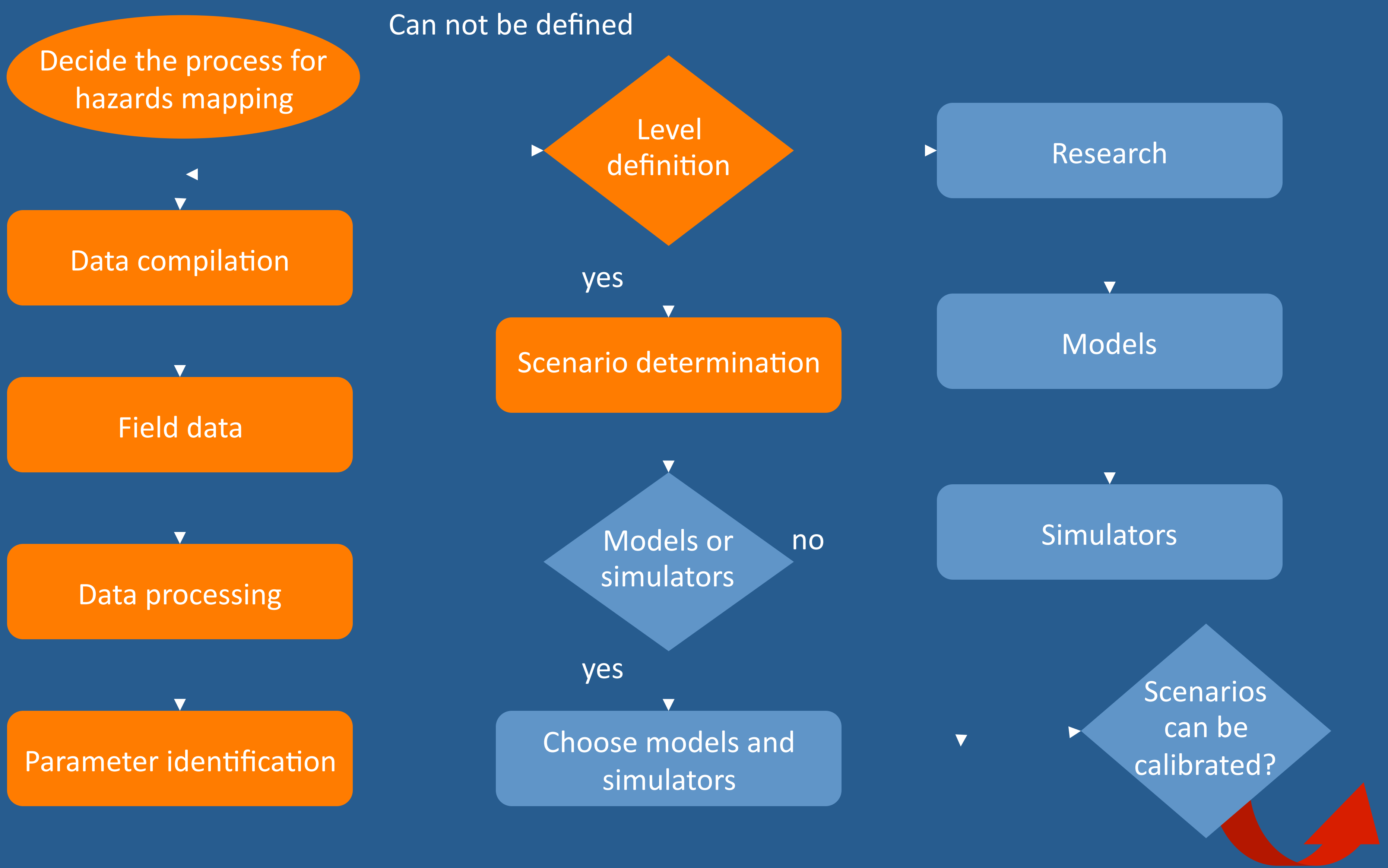

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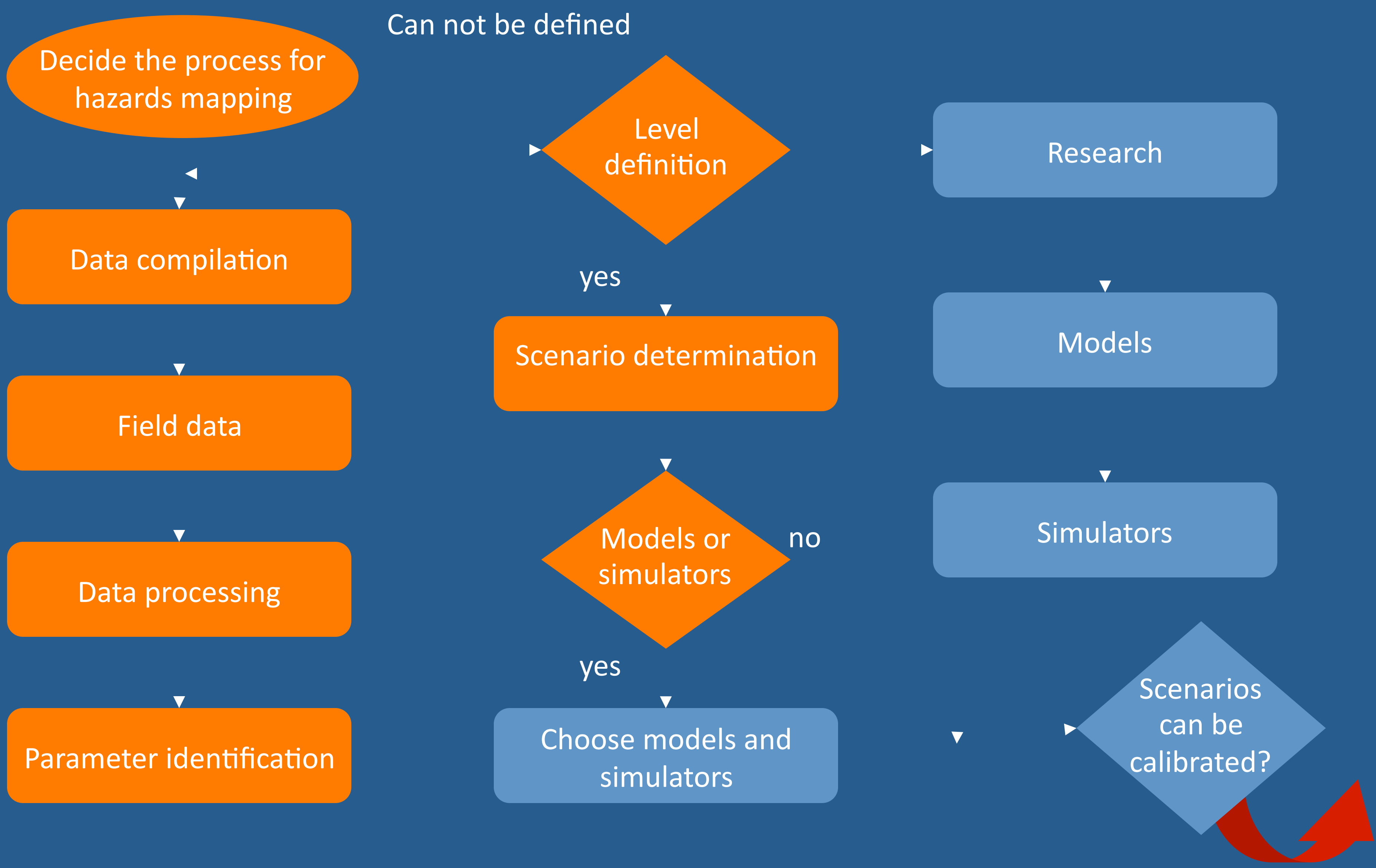


Movement Equation

$$\frac{d^2\vec{r}}{dt^2} = \vec{g} + \frac{C_d\left(\left|\vec{v}-\vec{u}\right|\right)\rho_a(z)A\left[\vec{v}-\vec{u}\right]^2}{2m}\widehat{F_a}$$

$\vec{g}$ = aceleración de la gravedad

C_d= coeficiente de arrastre

$\vec{v}$ = velocidad del balístico

$\vec{u}$ = velocidad del viento

ρ_a= densidad del aire

A= Área transversal

m= masa

$\hat{F}_a$= Vector unitario F. de arrastre

$$\frac{A}{m} = \frac{1}{\rho_b k D}$$

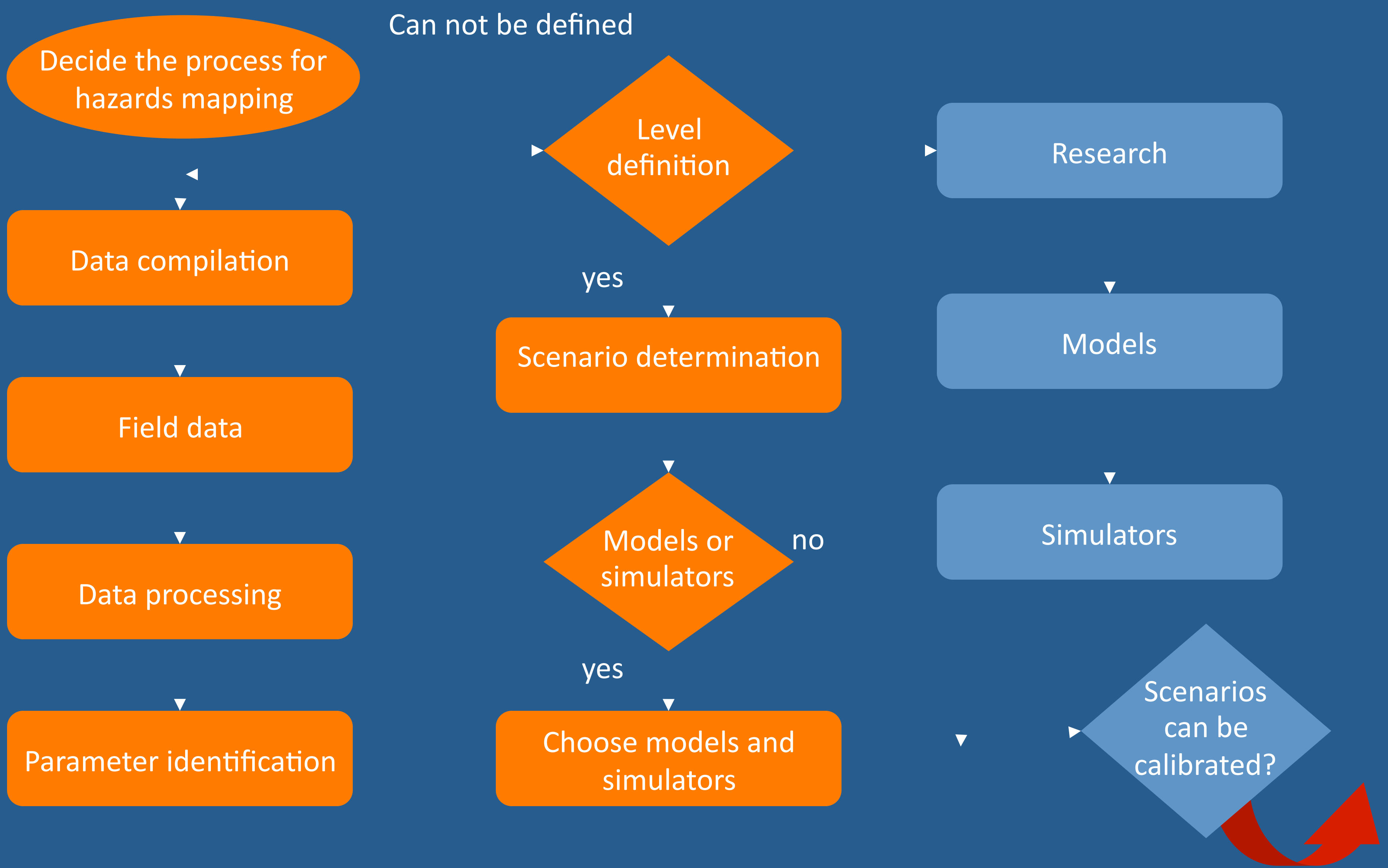
D= diámetro característico

ρ_b= densidad del balístico

k= constante de forma

Hazard	*Associated kinetic energy (kJ)*	*Maximum range (km)*	*Corresponding diameter (cm)*	*Maximum altitude (km asl)*
High	4.2×10^3	4.8	33	7.4
Intermediate	5.5×10^4	7.6	57	9.6
Low	7.0×10^5	13.8	95	14.7

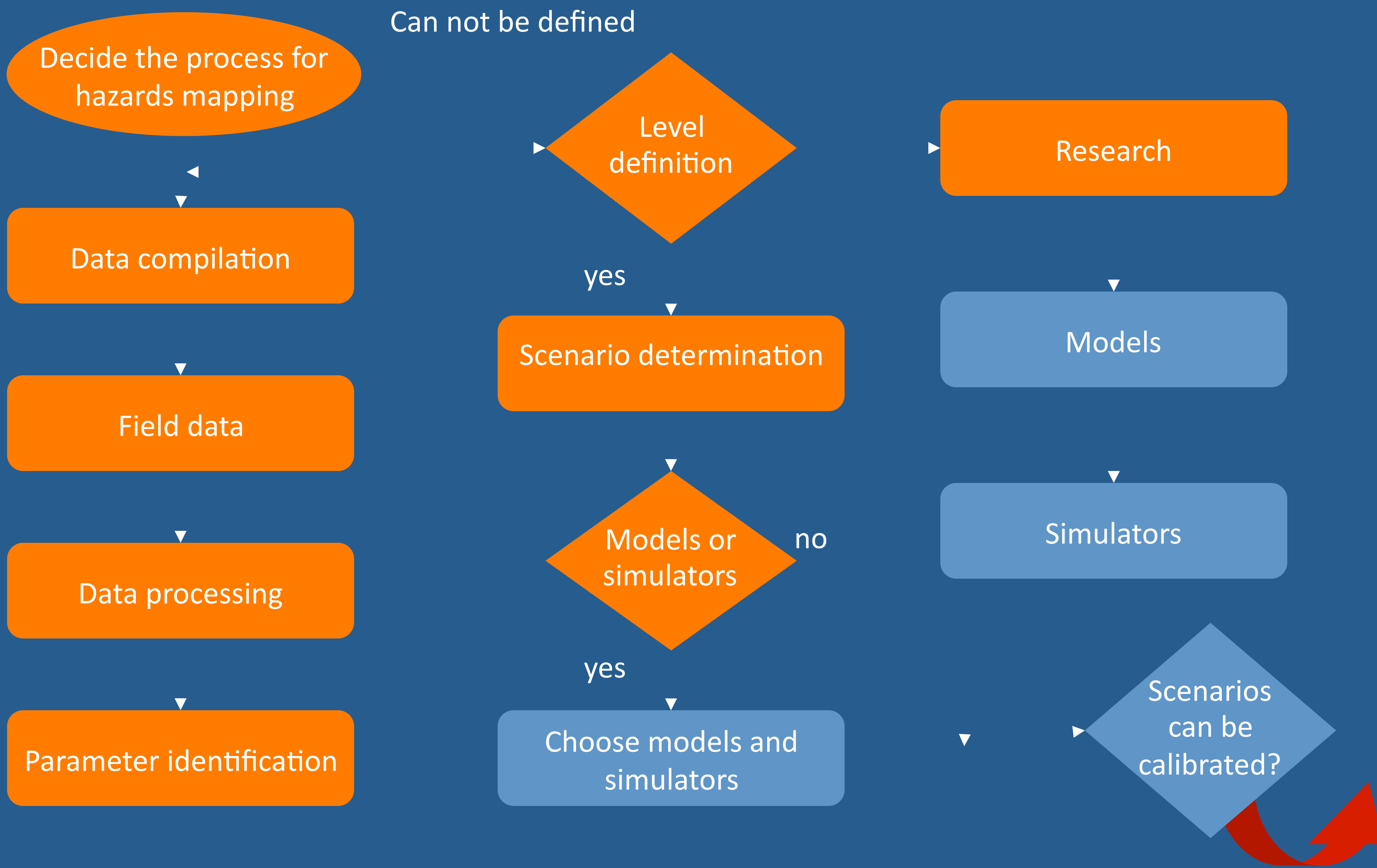
Methodology: examples



Tools: depend on the process

- Ballistic projectiles
  - *Eject!*
  - *Ballistic*
- Ash fall
  - *ASHFALL*
  - *Fall3D*
- Pyroclastic flows
  - *Flow3D*
  - *Titan2D*
- Lahars
  - *LAHARZ*
  - *Flow3D*
  - *VOLCFLOW*
  - *DAN3D*
  - *MSF*
- Collapse
  - *Flow3D*
  - *Titan2D*

Methodology: examples



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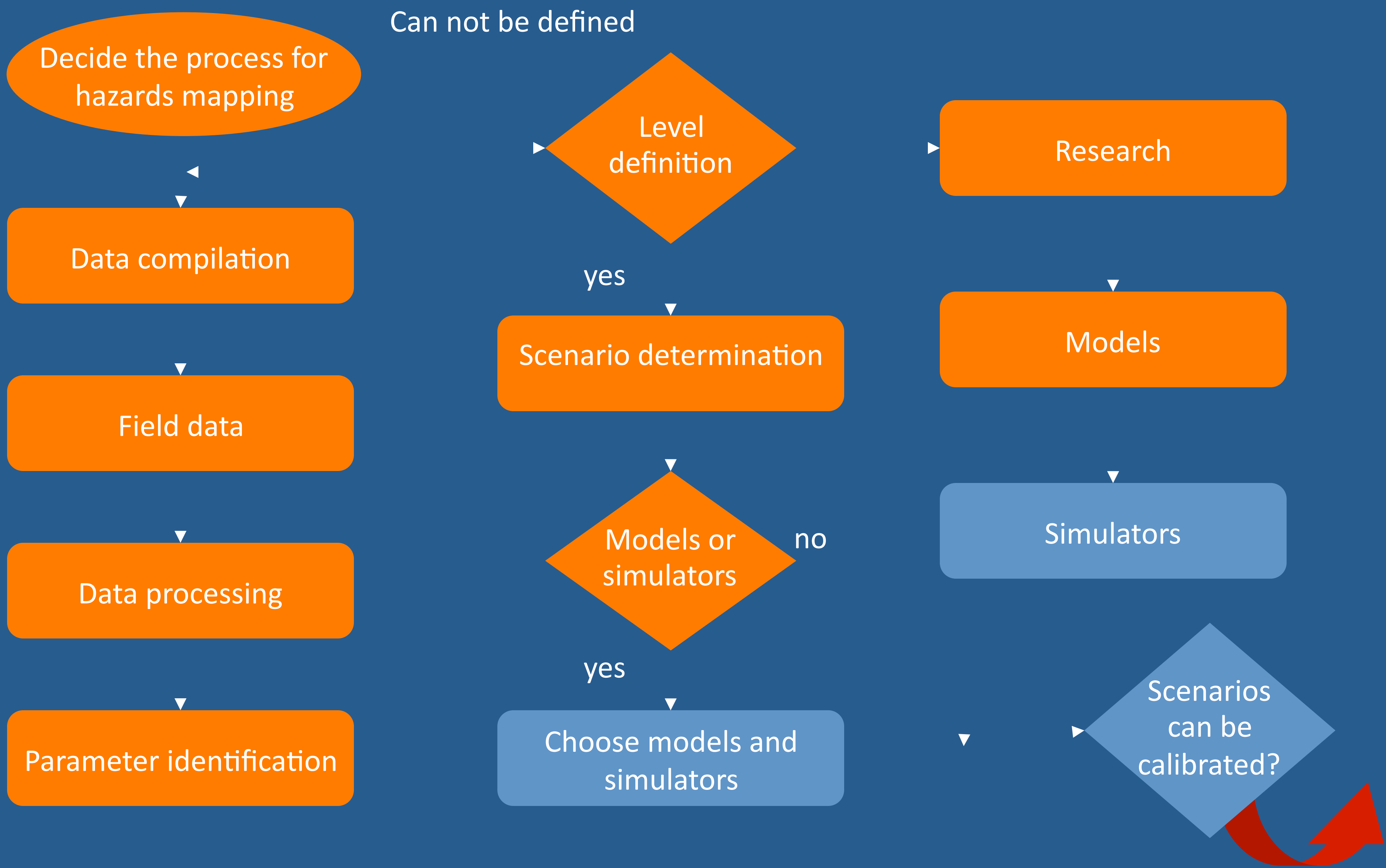

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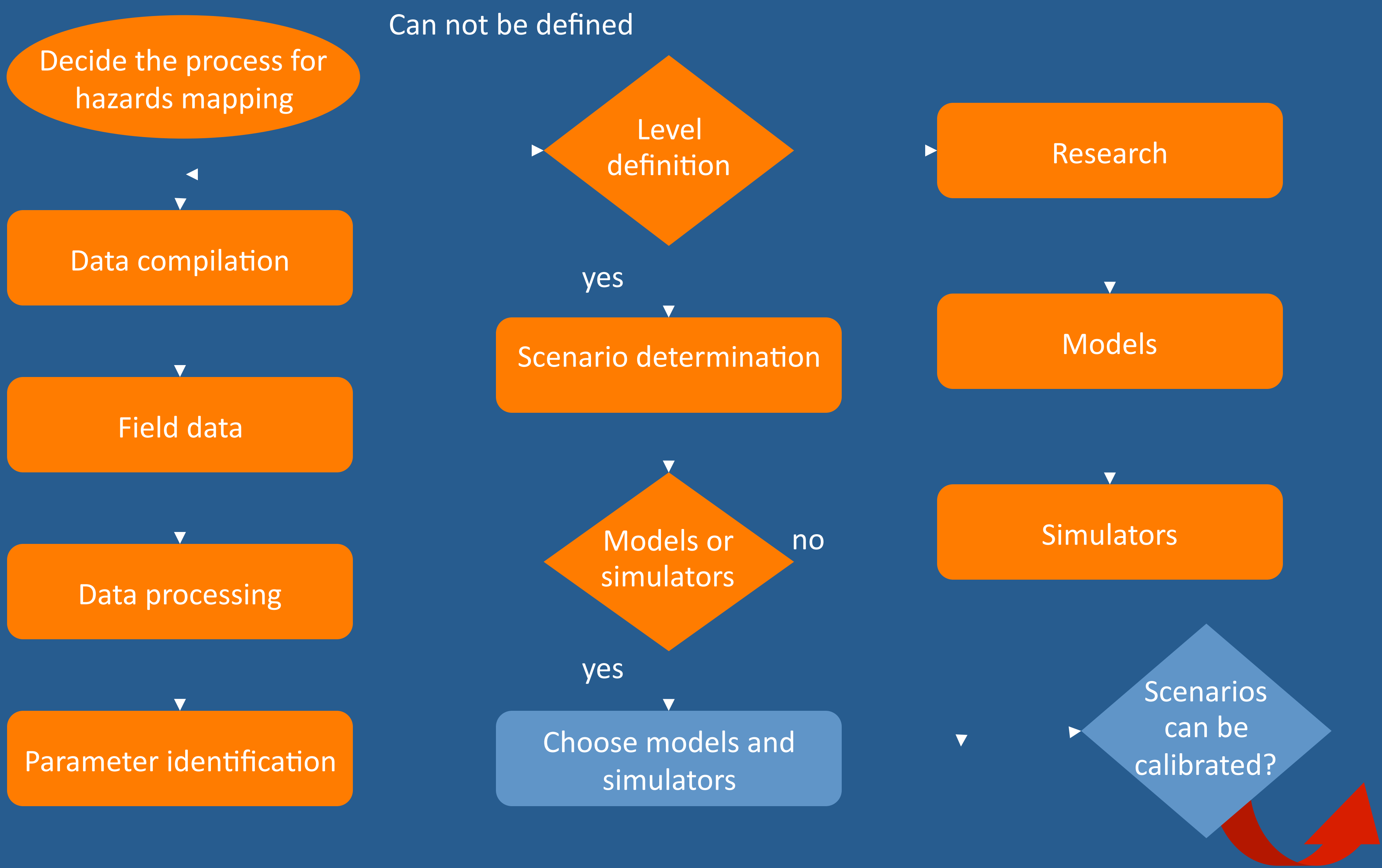

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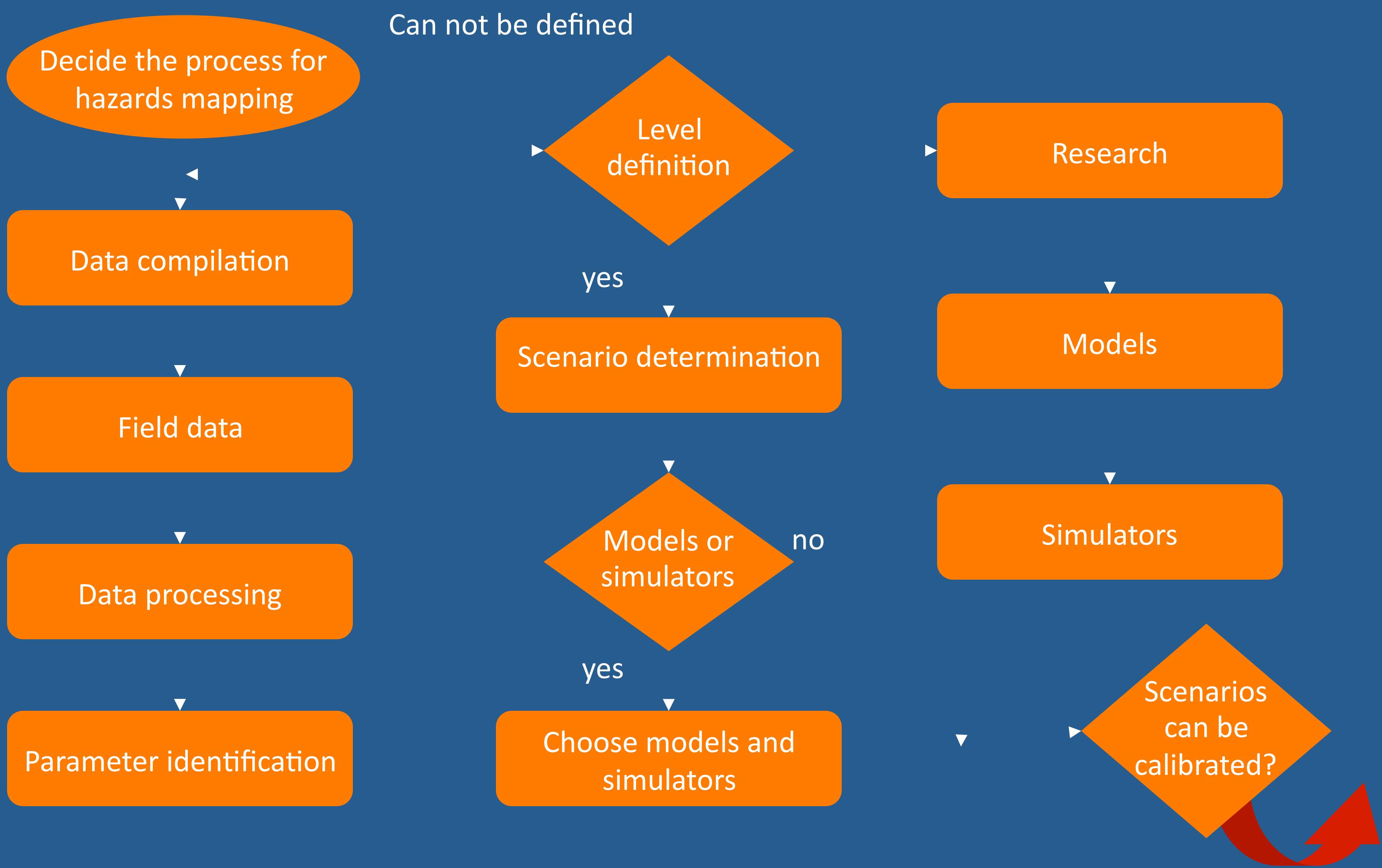

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UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
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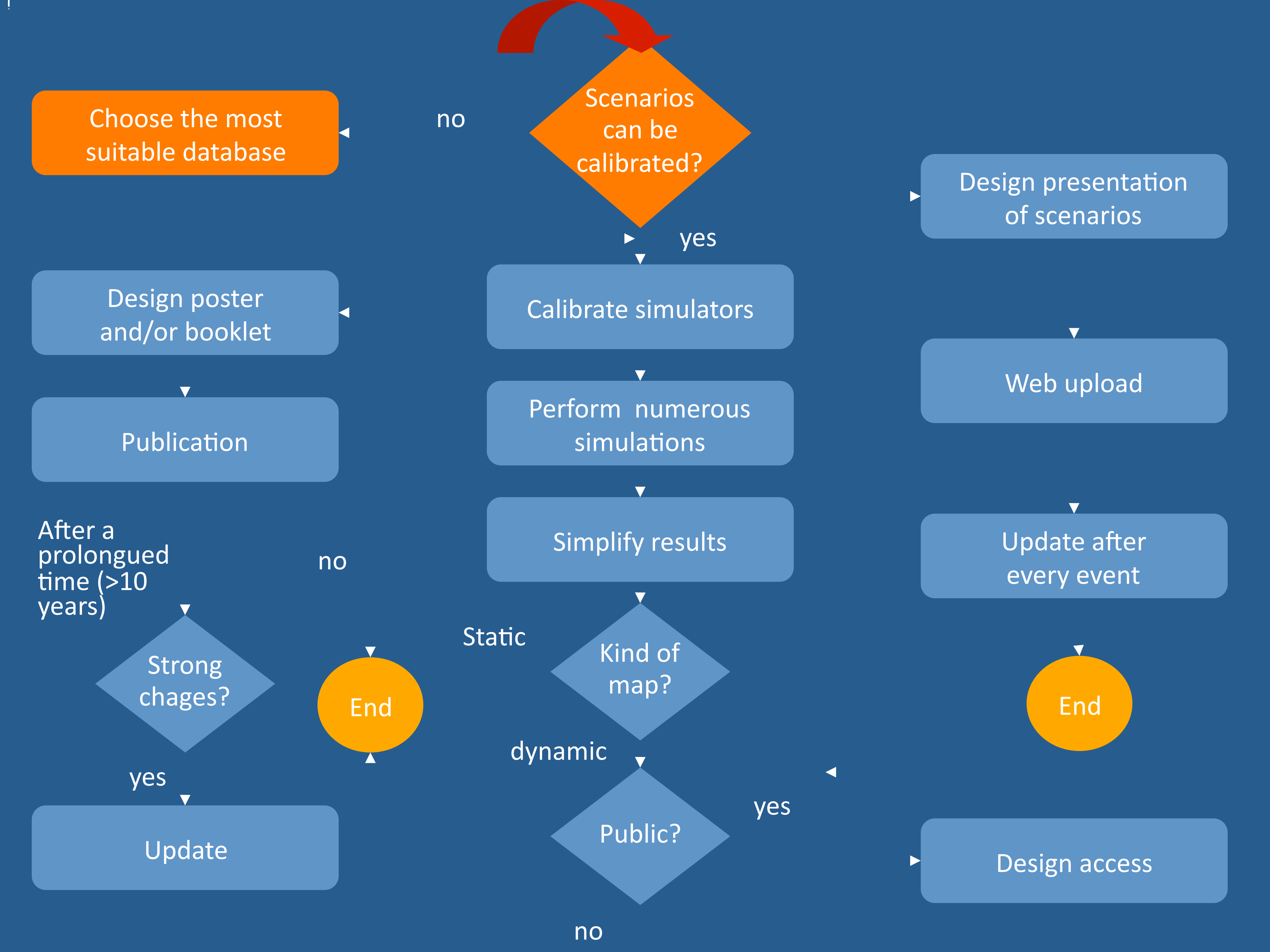
BALLISTIC

Programa para calcular la trayectoria y alcance
de proyectiles balisticos volcanicos

Por: Miguel Angel Alatorre Ibarguengoitia
Dr. Hugo Delgado Granados


Scenarios can be calibrated?
no
Choose the most suitable database
yes
Calibrate simulators
Perform numerous simulations
Simplify results
Kind of map?
Static
dynamic
Public?
yes
no
Design presentation of scenarios
Web upload
Update after every event
End
Design access
Design poster and/or booklet
Publication
After a prolonged time (>10 years)
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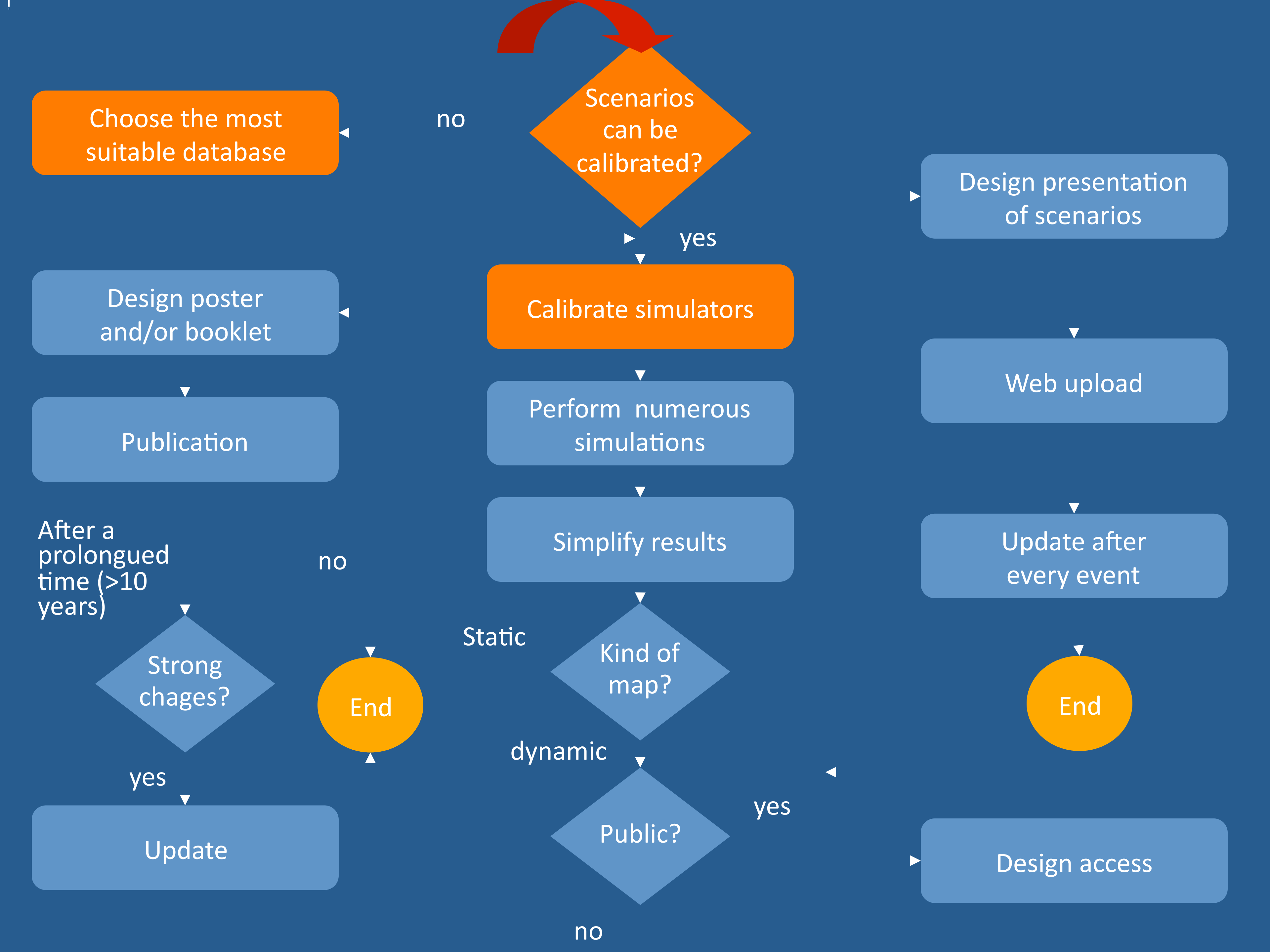
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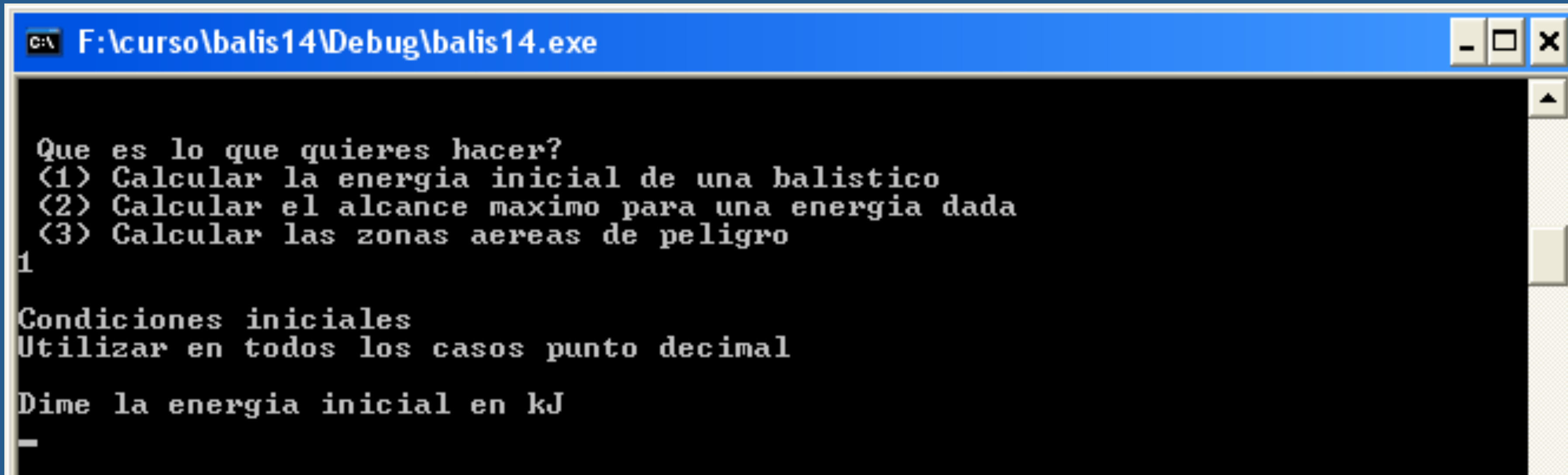
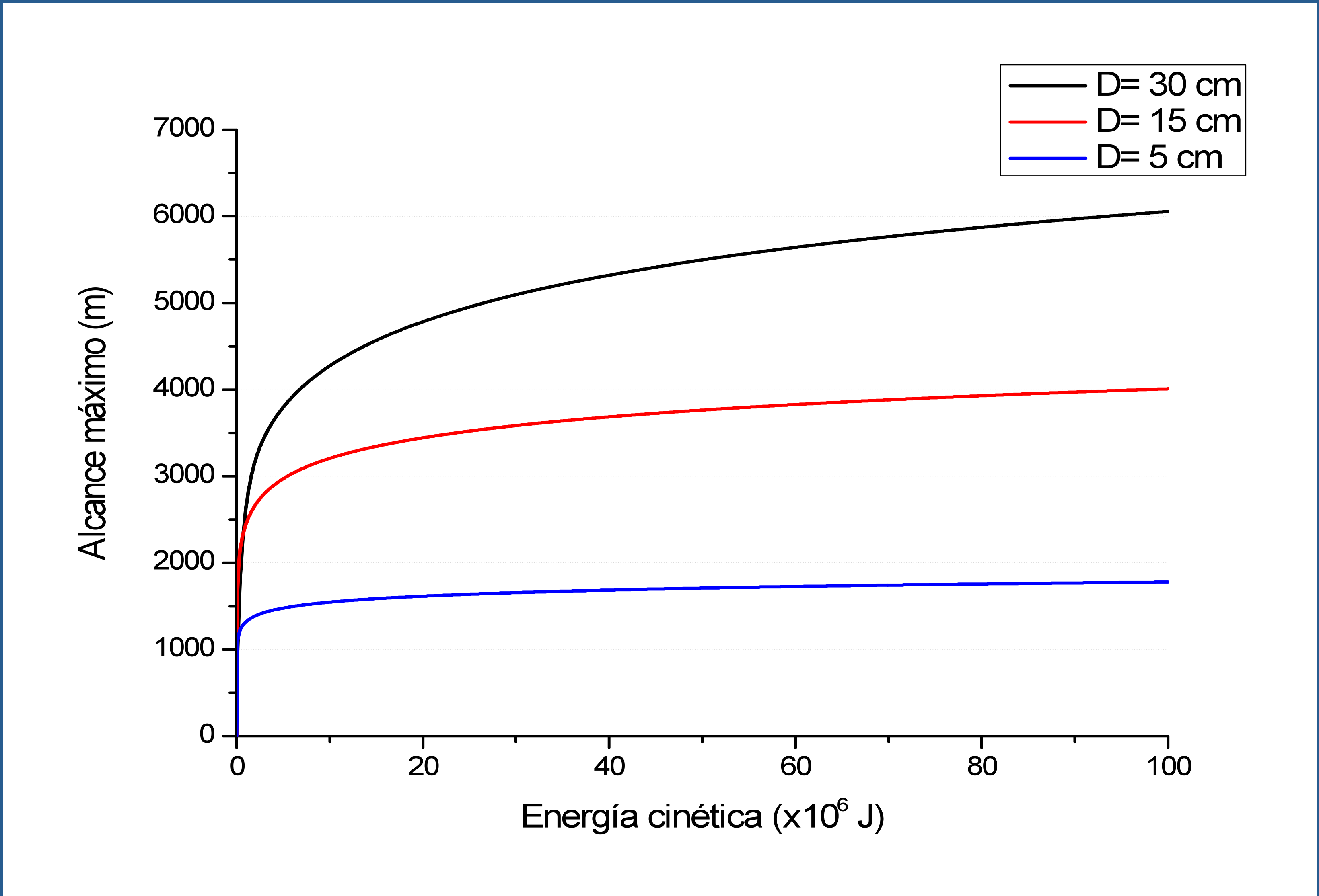


Launching angle	Wind velocity	Crater's altitude	Altitude fall	Diameter	Density	Range
40.	0	5000. m	2882. m	.54 x .32 x .23 average: 0.32 m	2500. kg/m3	

Maximum range as a function of the energy for diferent diameters



Ballistics used to define the hazard scenarios for the Popocatépetl hazards map

High probability scenario (Vulcanian)

Launching angle	Wind velocity	Crater's altitude	Fall altitude	Diameter	Density	Range
45.	10	5000. m	2820. m	0.50 m	2500. kg/ m3	11000

Maximum range

Launching angle	Wind velocity	Crater's altitude	Fall altitude	Diameter	Density	Range
35-50.	20	5000. m	15000. m	0.90- 1.3 m	2500. kg/m3	

Parameters of the hazards map by ballistic projectile impact

Popocatépetl volcano

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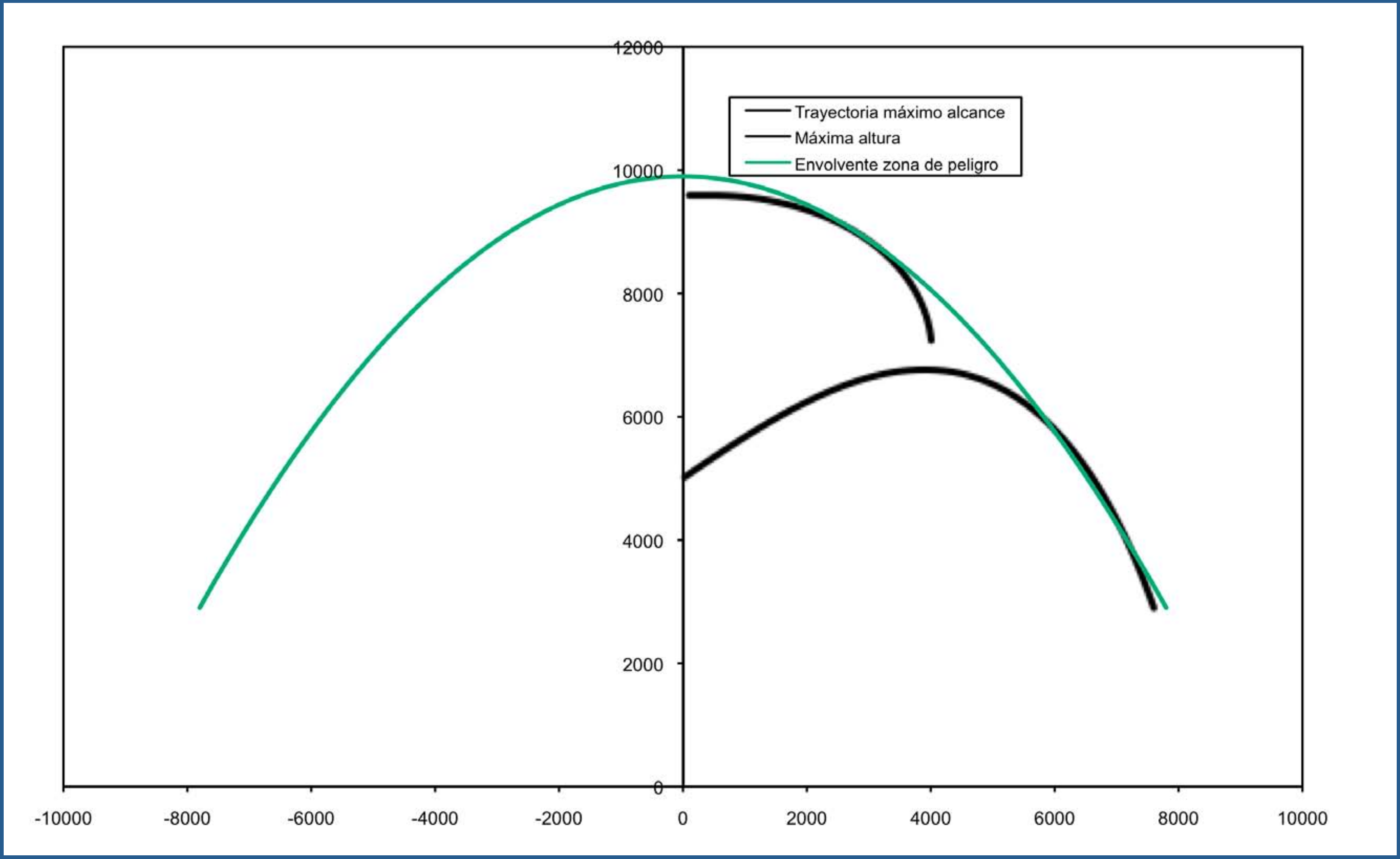
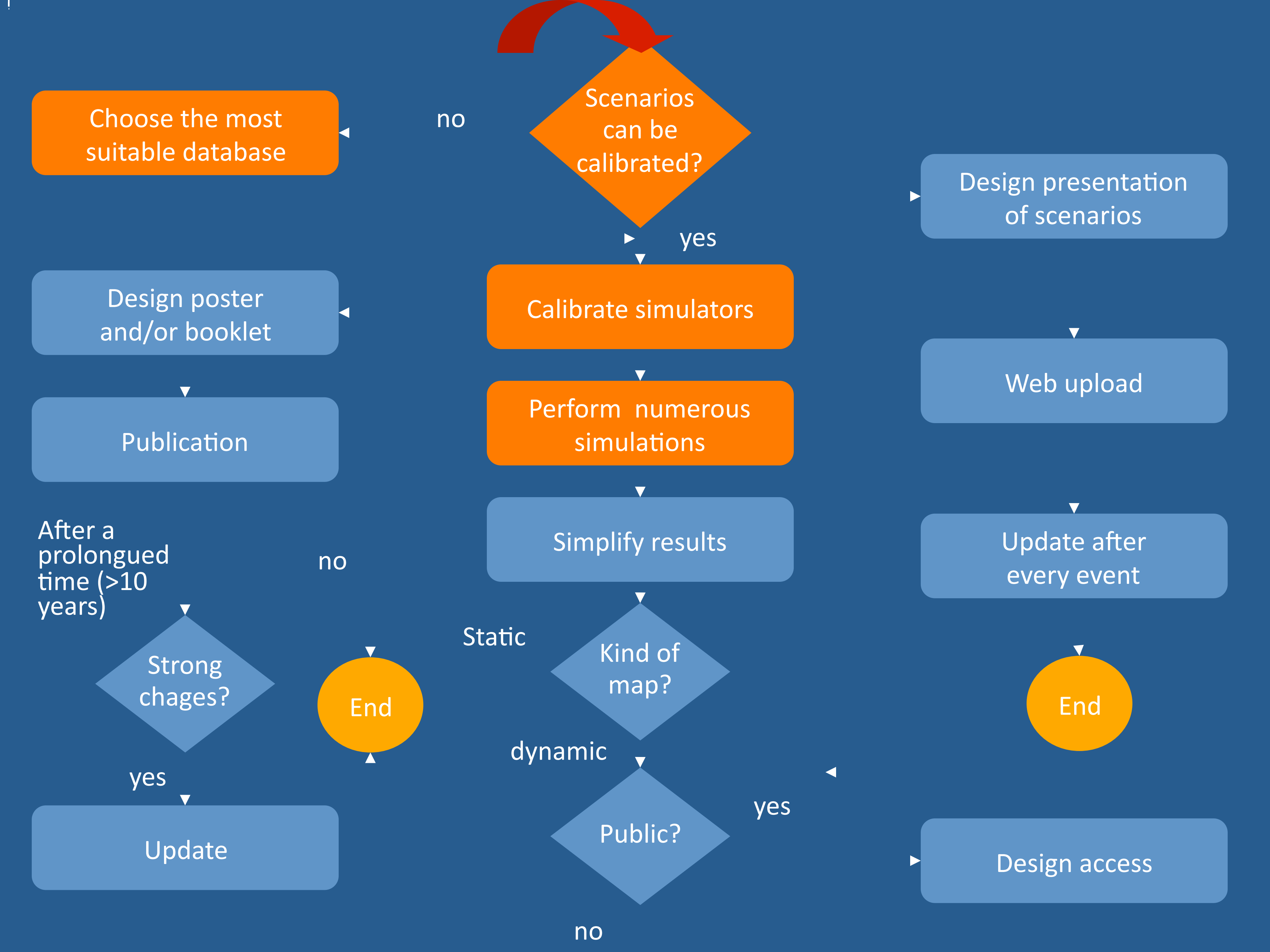


Trayectoria máximo alcance
Máxima altura
Envolvente zona de peligro
12000
10000
8000
6000
4000
2000
0
-10000
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000
10000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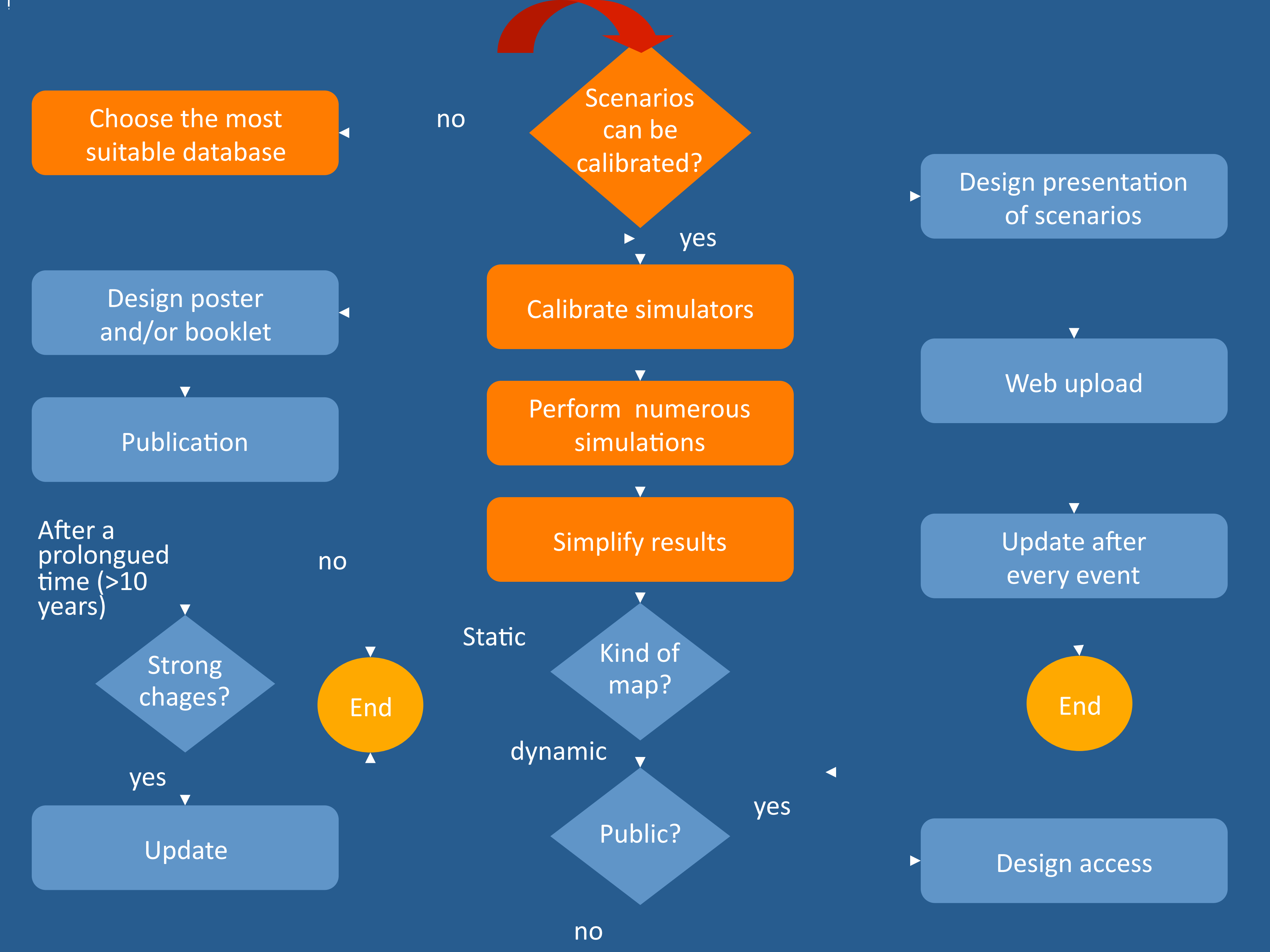

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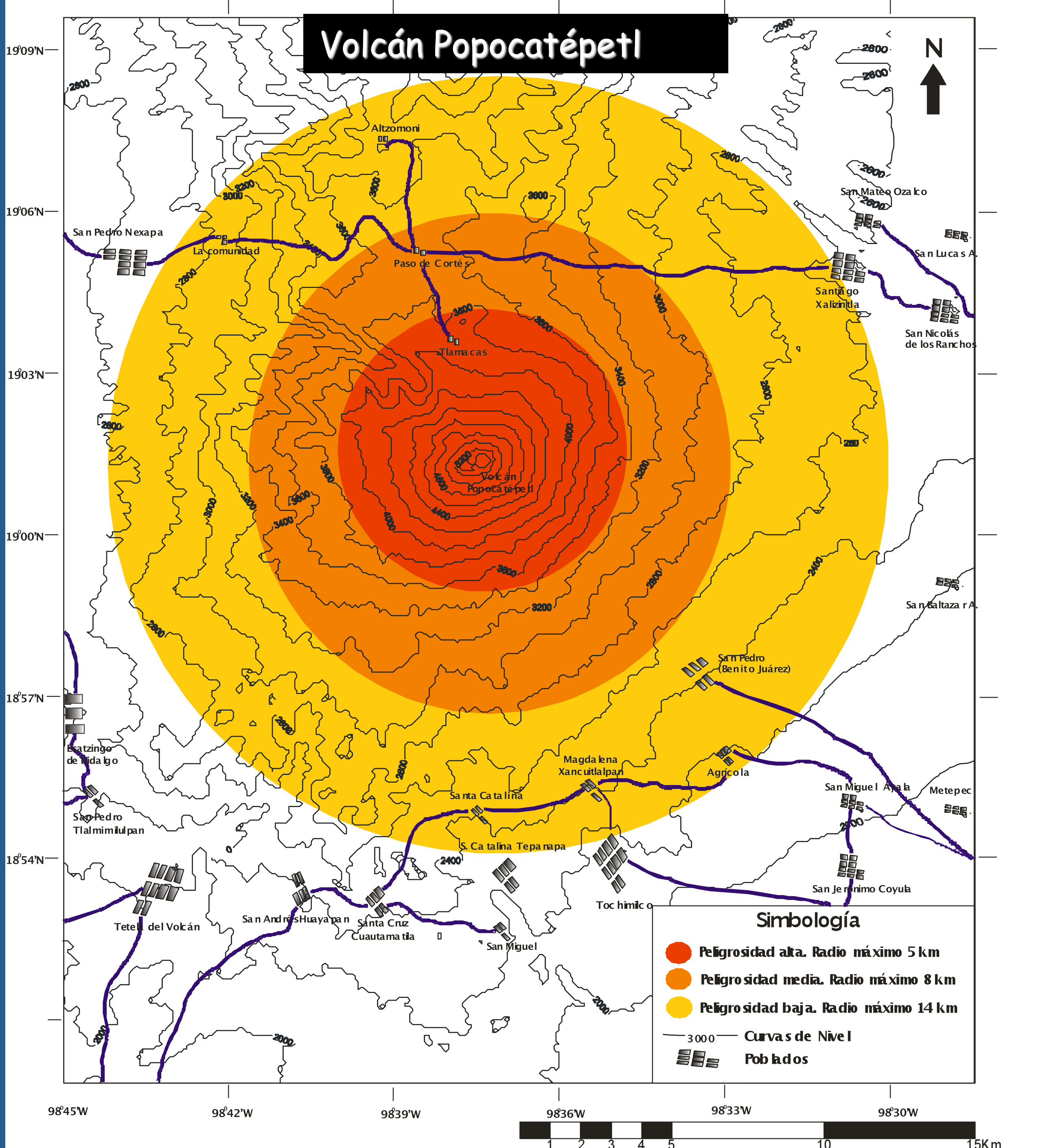
Volcán Popocatépetl
N
Altzomoni
San Pedro Nexapa
La comunidad
Paso de Cortés
Tlamacas
Volcán Popocatépetl
San Mateo Ozalco
San Lucas A.
Santiago Xalizintla
San Nicolás de los Ranchos
San Baltazar A.
San Pedro (Benito Juárez)
Agrícola
Magdalena Xancuitlalpan
Santa Catalina
S. Catalina Tepanapa
San Miguel Ayala
Metepec
San Jerónimo Coyula
Tochimilco
Atzitzingo de Hidalgo
San Pedro Tlalmimilulpan
Tetela del Volcán
San Andrés Huayapan
Santa Cruz Cuautamatila
San Miguel
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19°03'N
19°00'N
18°57'N
18°54'N
98°45'W
98°42'W
98°39'W
98°36'W
98°33'W
98°30'W
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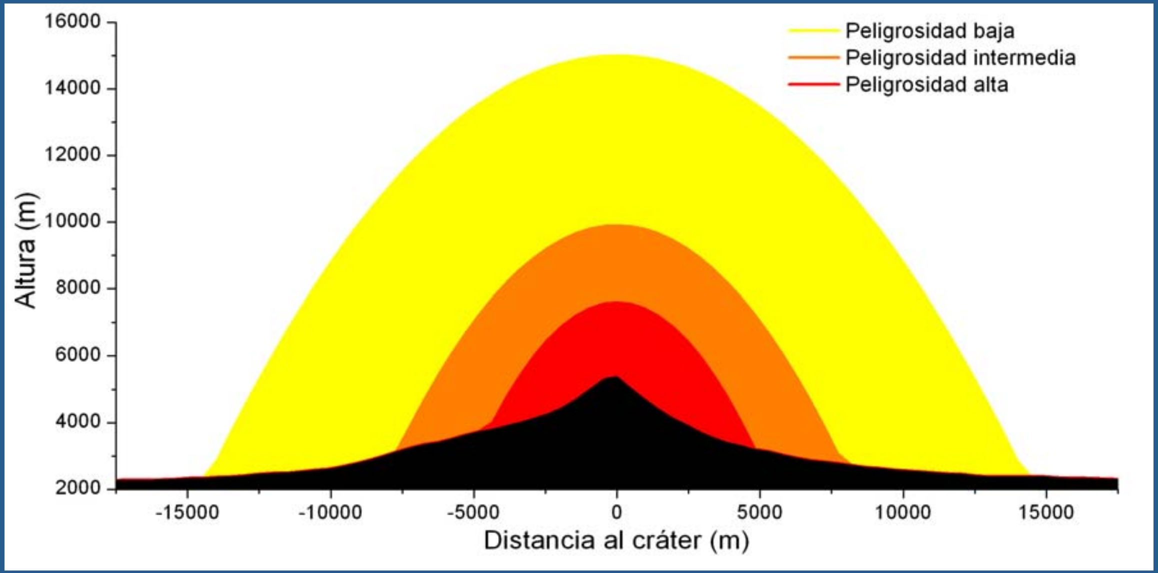
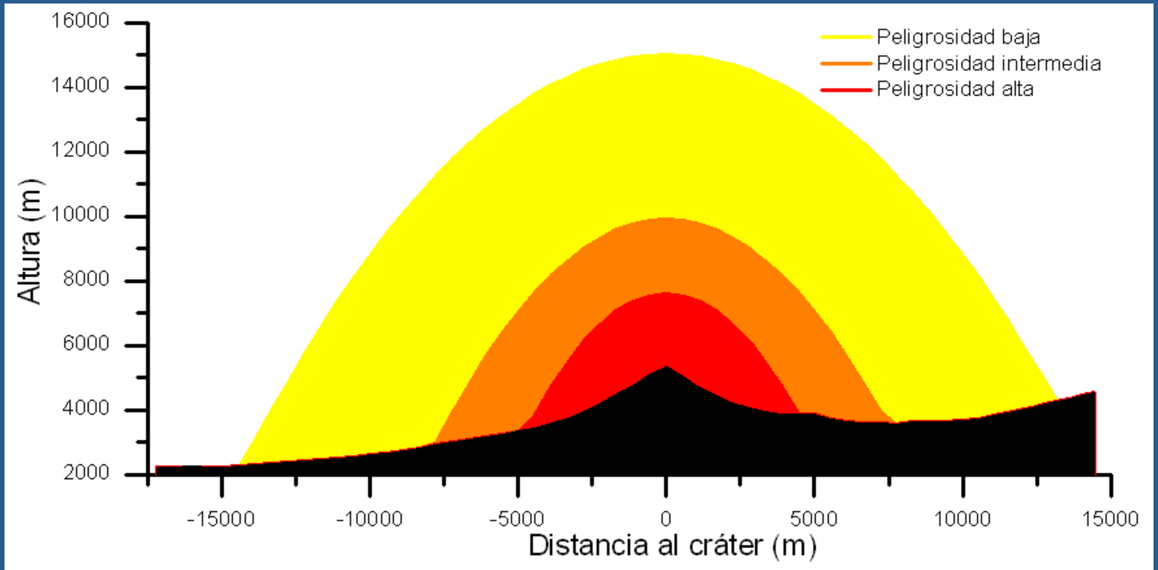
3
4
5
10
15Km
Simbología
Peligrosidad alta. Radio máximo 5 km
Peligrosidad media. Radio máximo 8 km
Peligrosidad baja. Radio máximo 14 km
3000 Curvas de Nivel
Poblados

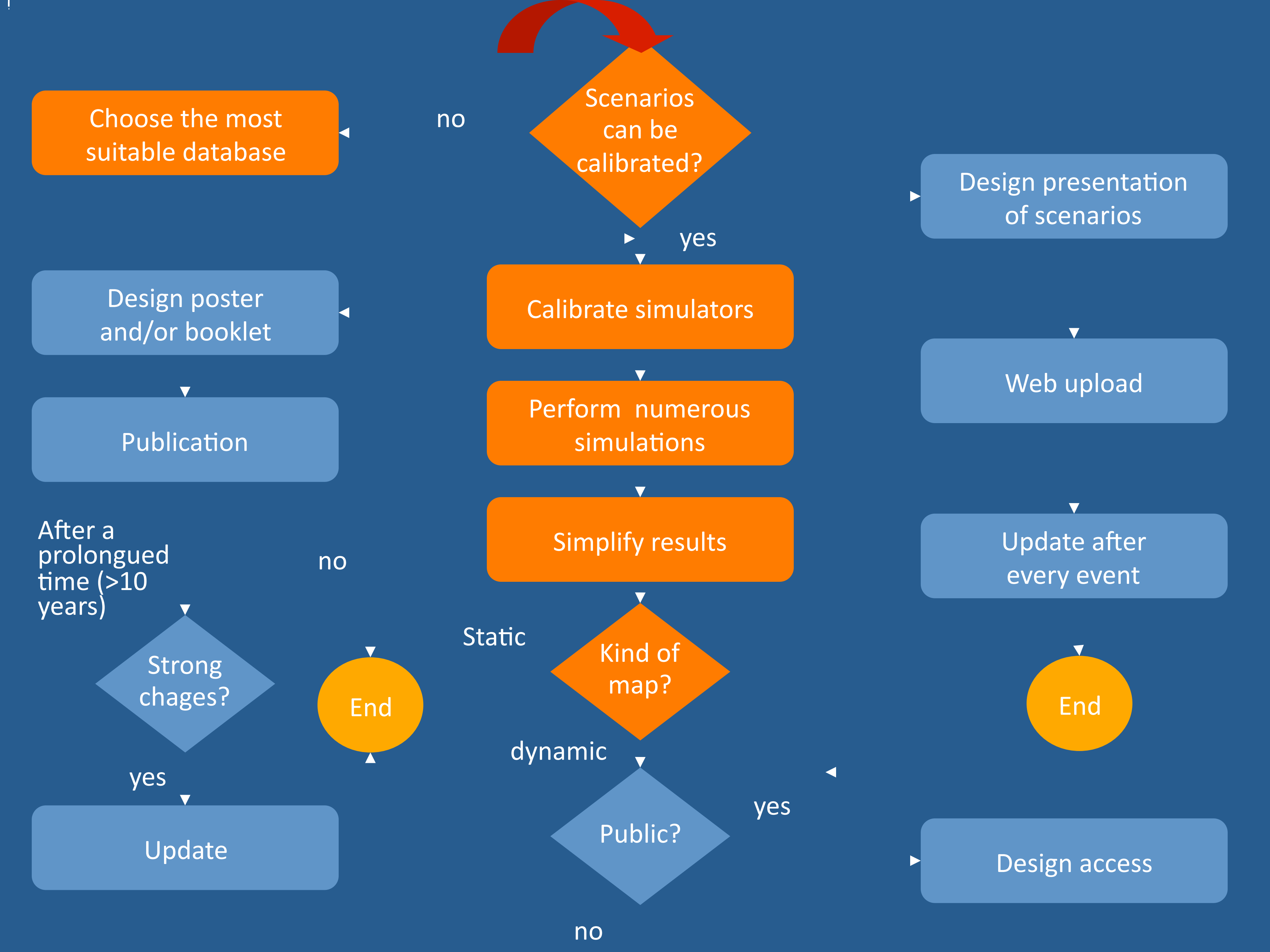
Volcán Popocatépetl

Perfil Oeste-Este



Perfil Sur-Norte

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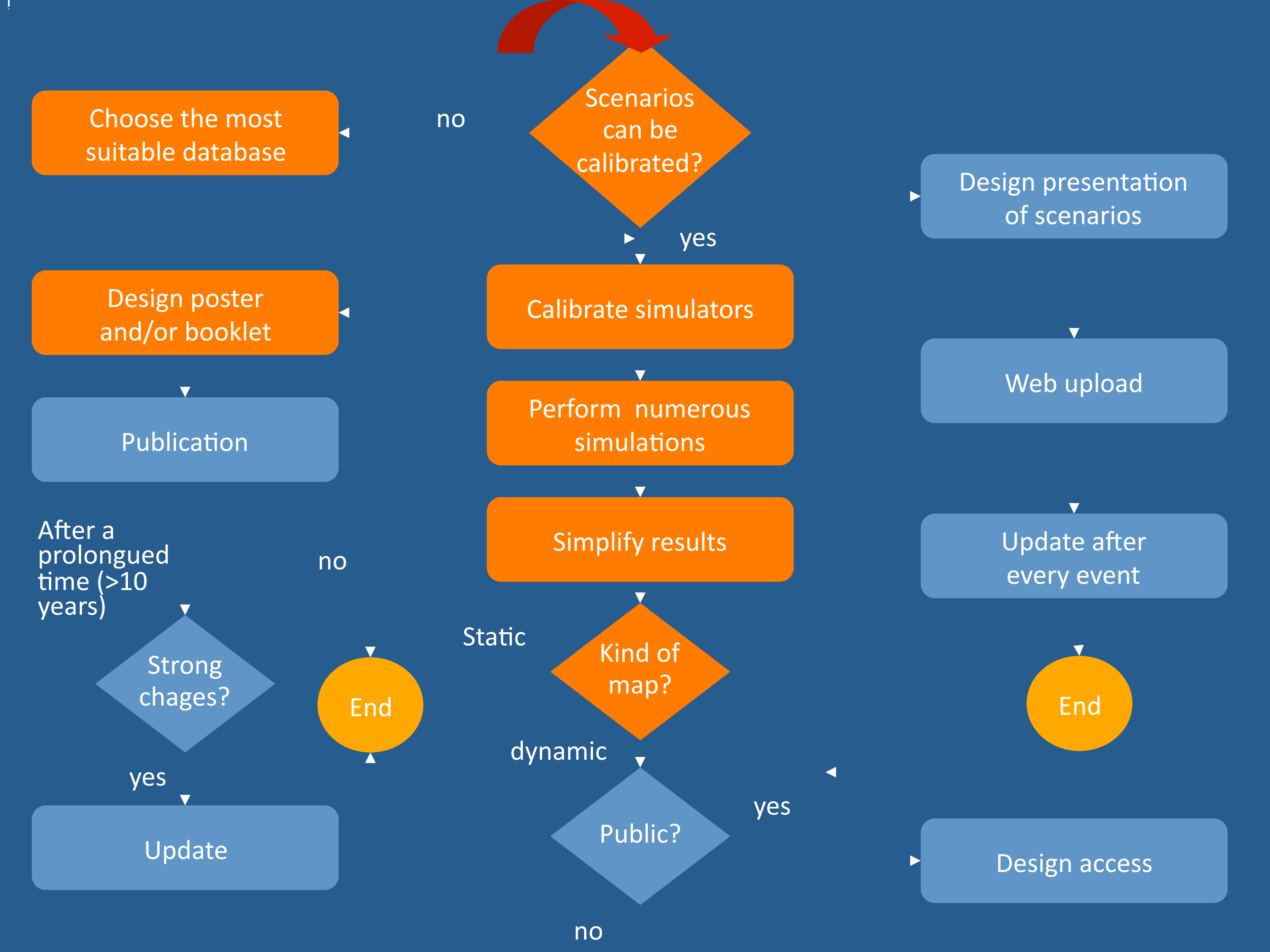
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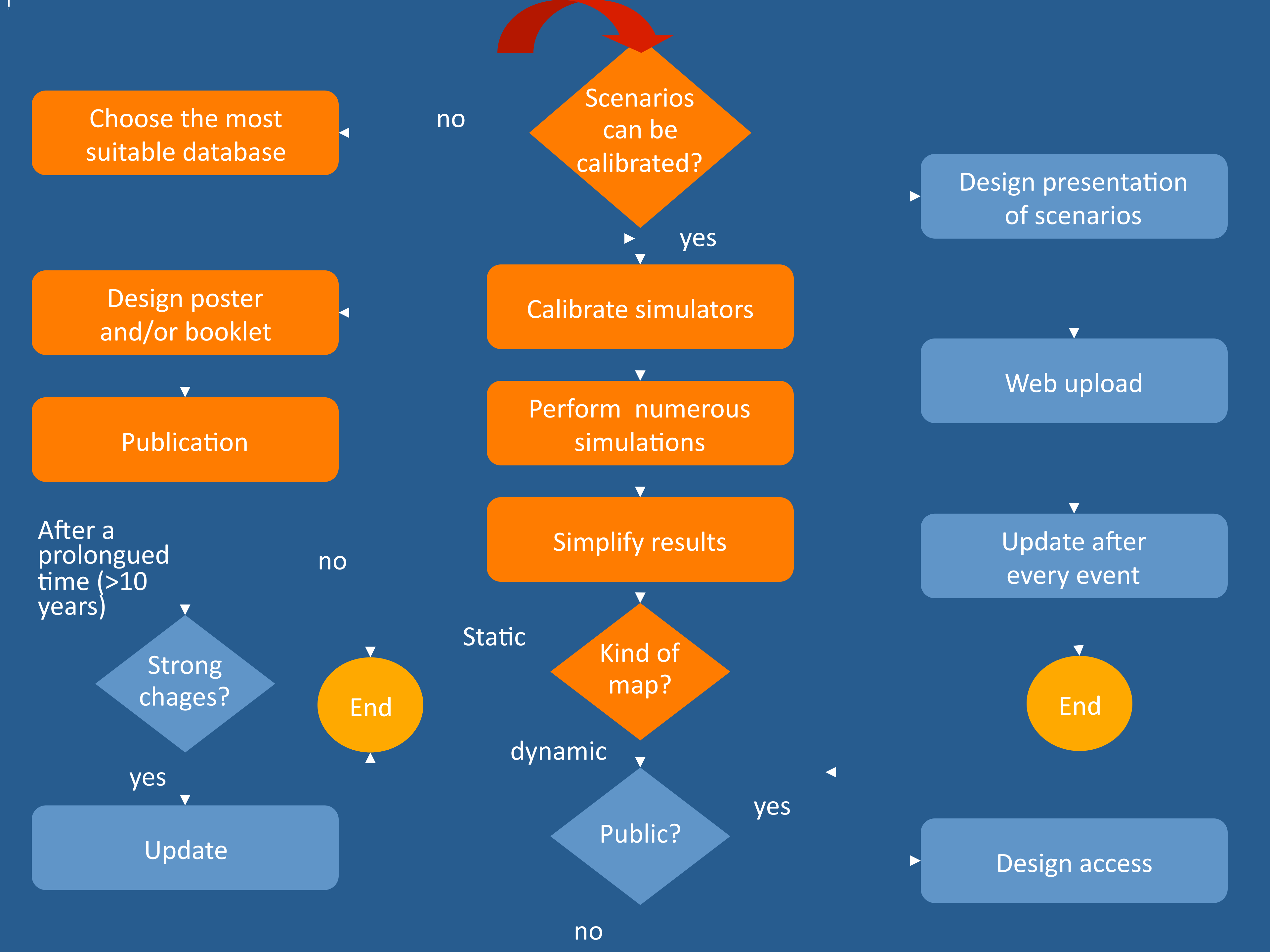

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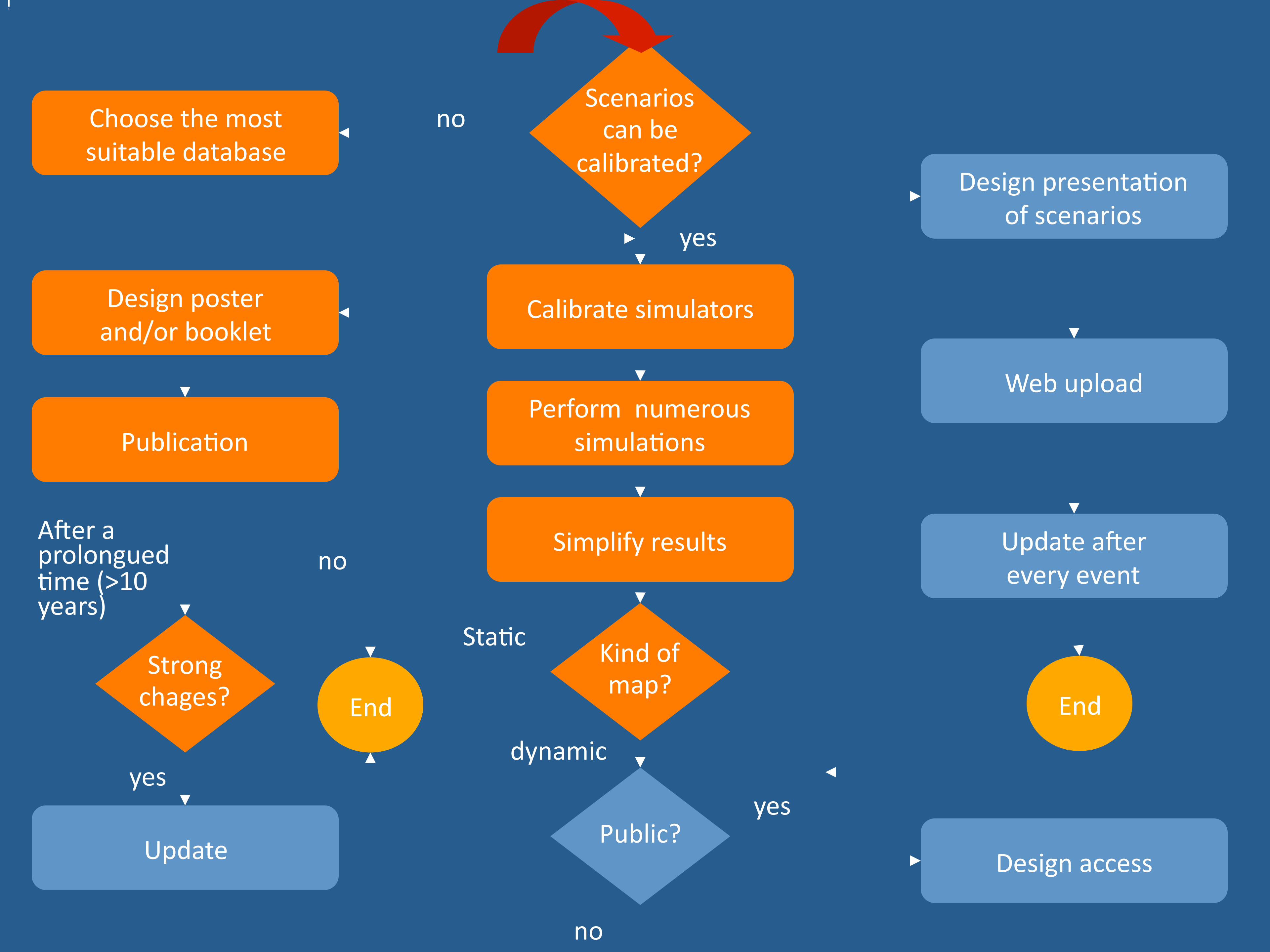

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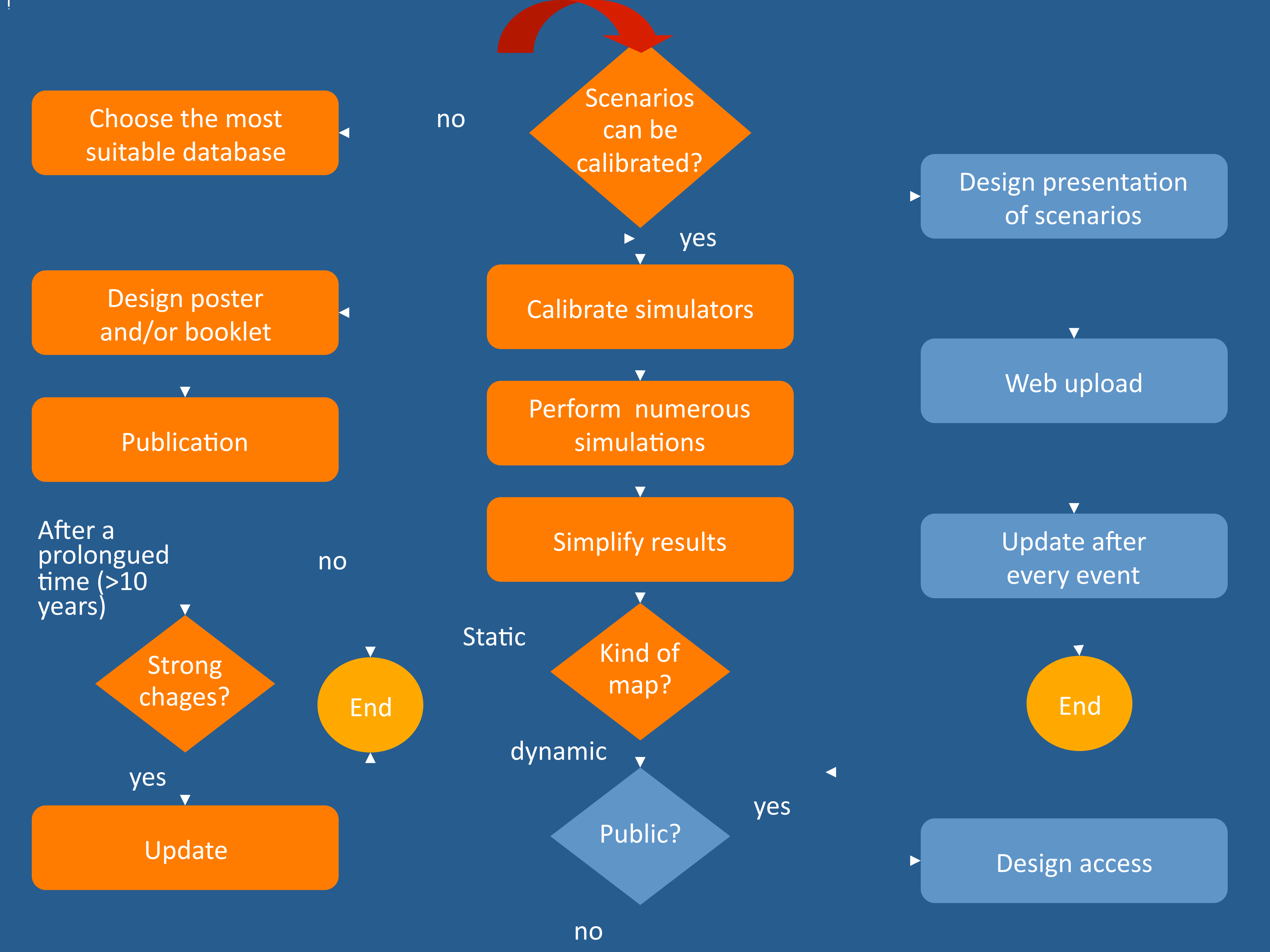
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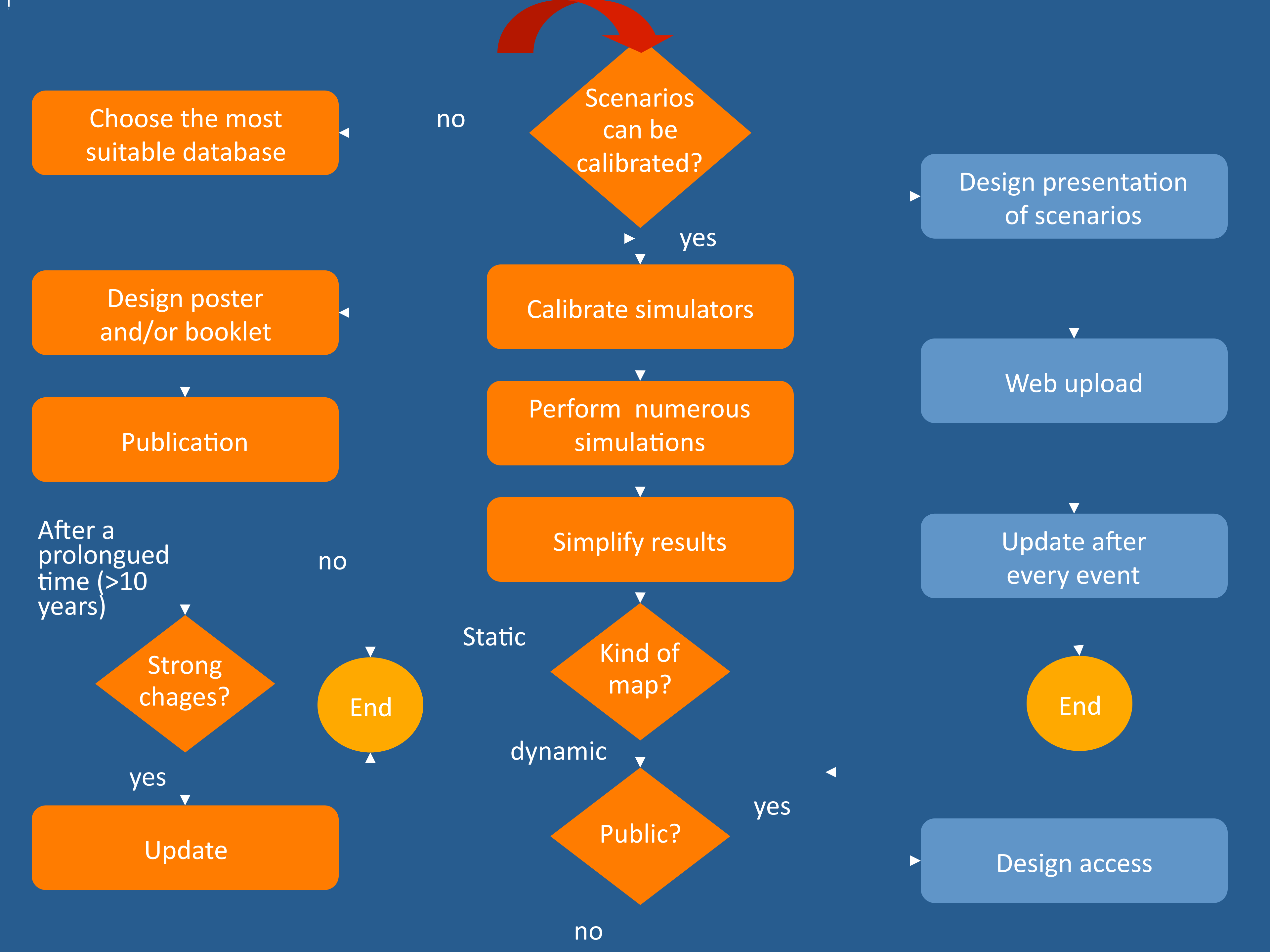

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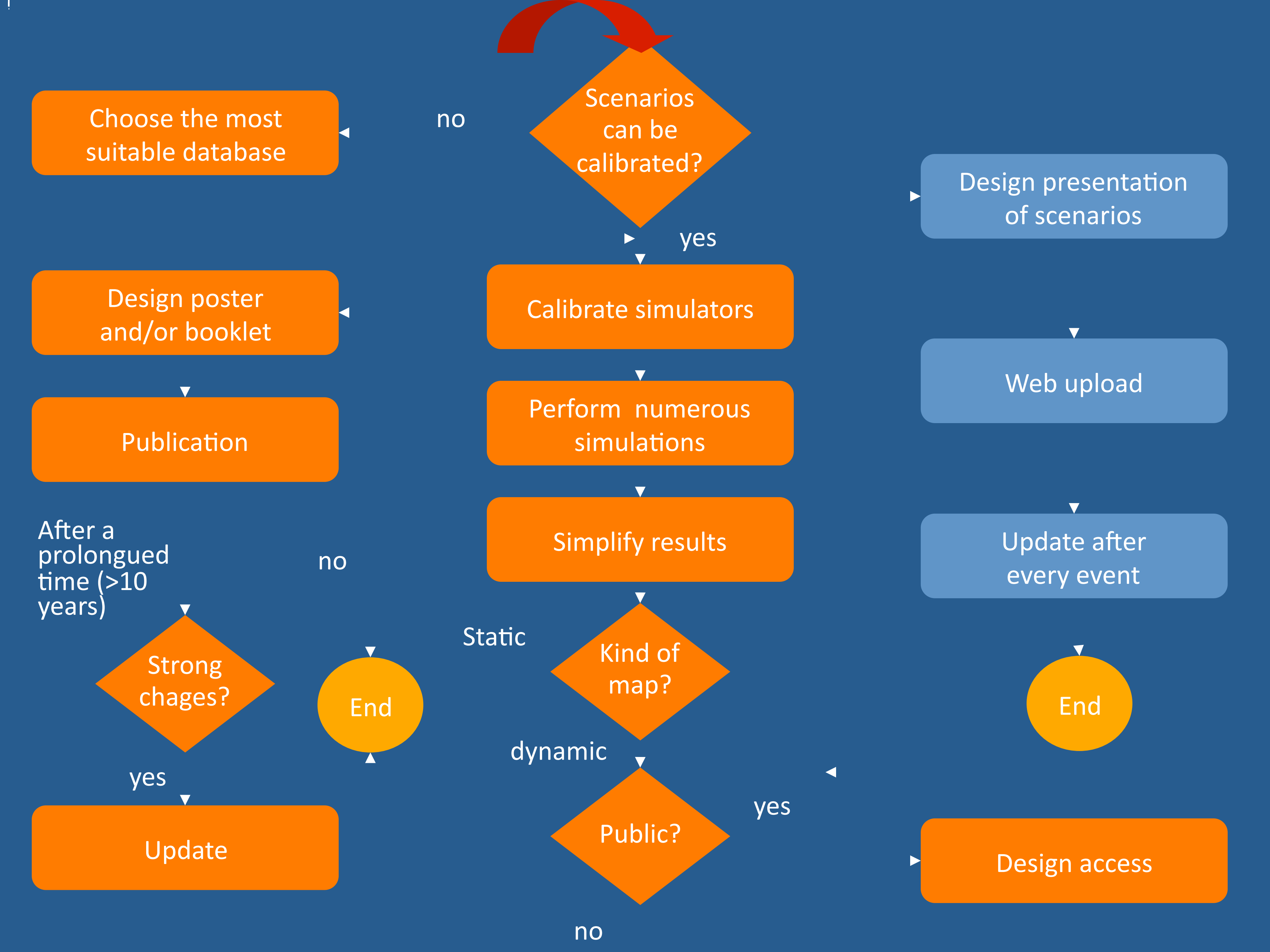
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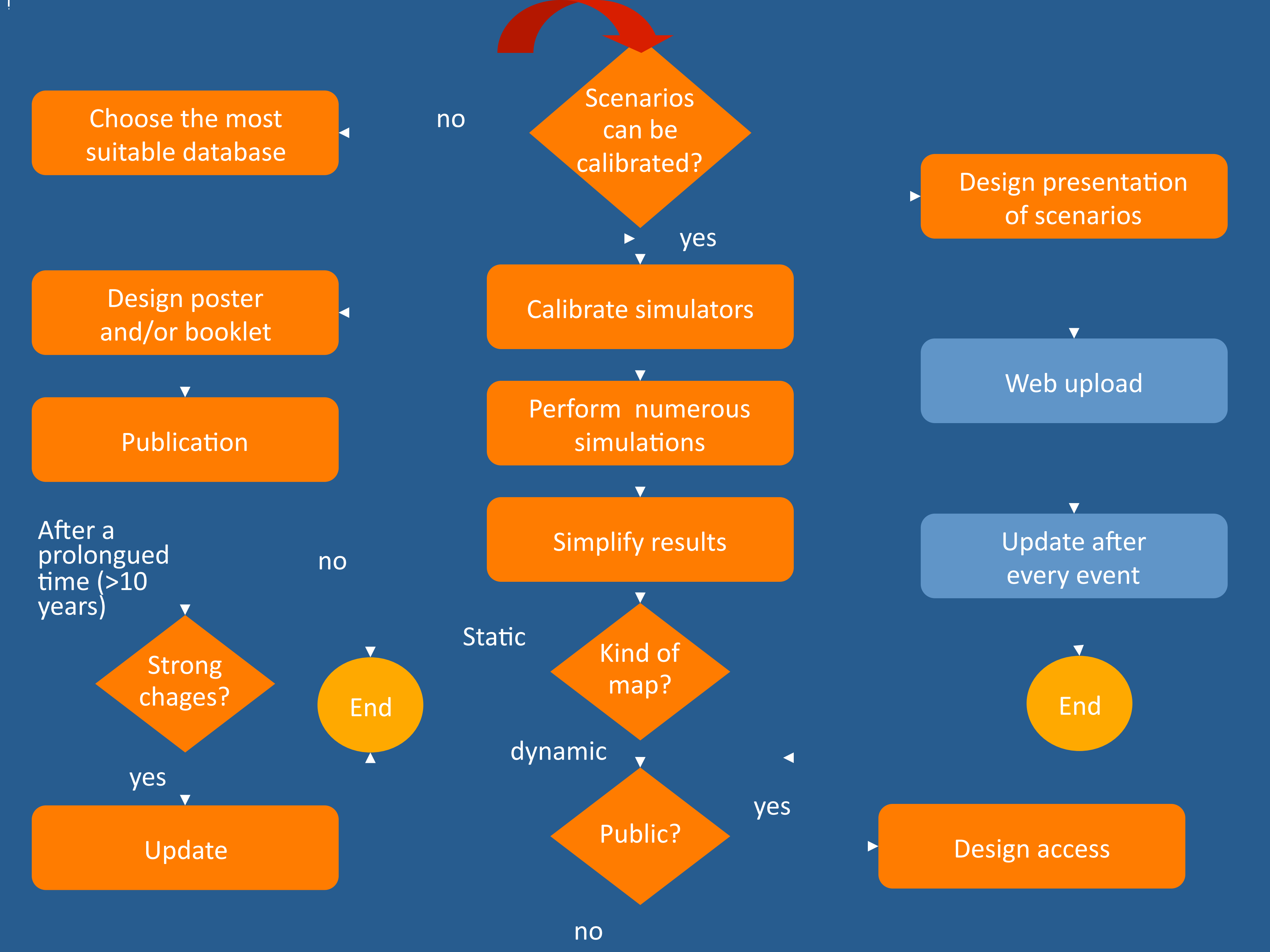

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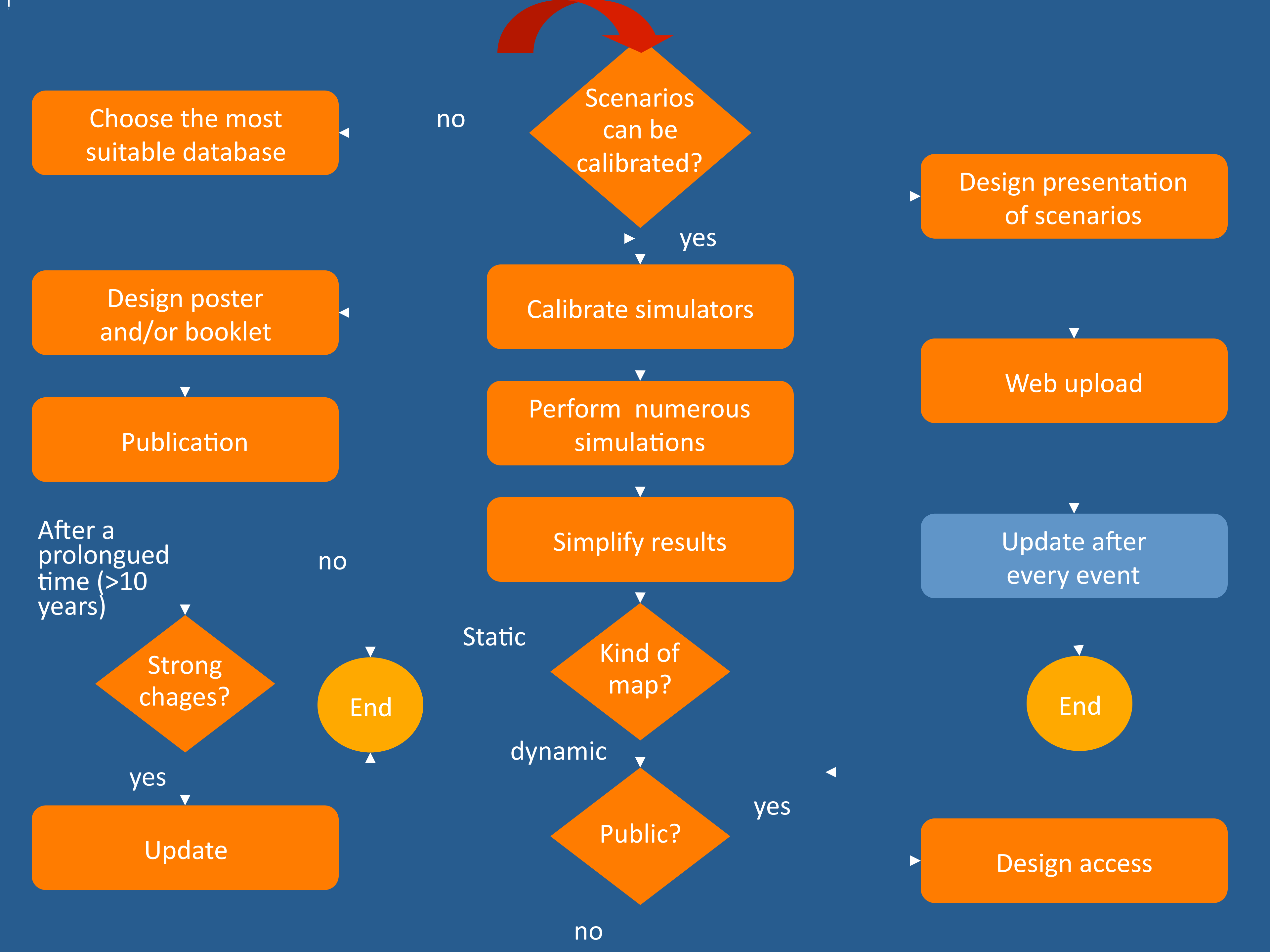
Strong chages?
End
End
dynamic
yes
yes
Public?
Update
Design access
no



Choose the most suitable database
no
Scenarios can be calibrated?
Design presentation of scenarios
yes
Design poster and/or booklet
Calibrate simulators
Web upload
Publication
Perform numerous simulations
Simplify results
Update after every event
After a prolongued time (>10 years)
no
Static
Kind of map?
Strong chages?
End
End
dynamic
yes
yes
Public?
Update
Design access
no

SNET Aplicaciones

Riesgo | Geología | Meteorología | Hidrología | Referencia

Mapa de Amenaza Volcánica Complejo volcánico de San Miguel

Referencia
- [x] Sitios Poblados
- [x] Etiquetas
- [ ] Red Vial
- [ ] Asentamientos
- [ ] Escuelas

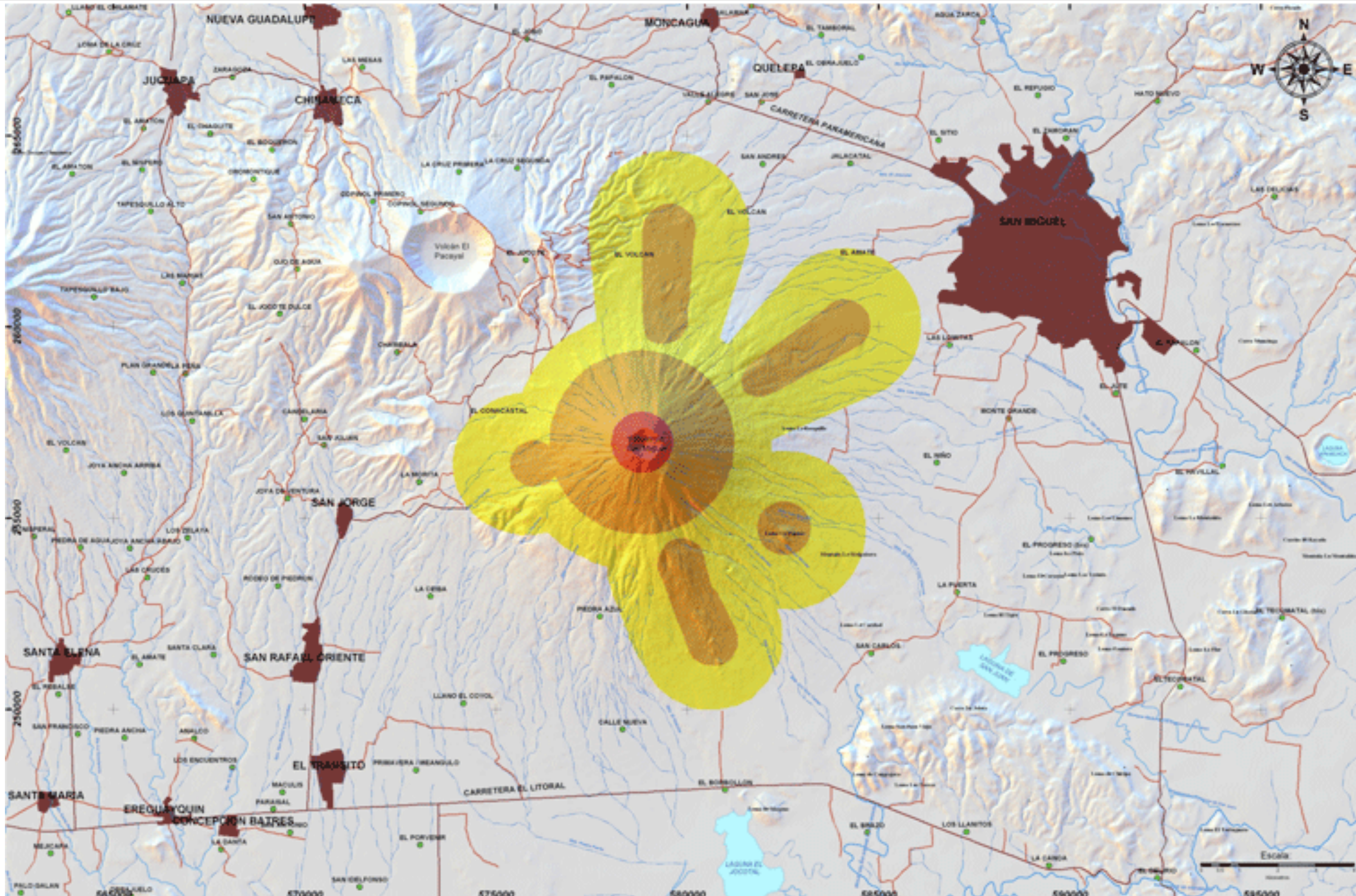
Lahares
- [x] Escenario 1
- [ ] Escenario 2
- [ ] Escenario 3

Caida de Balísticos
- [x] Escenario 1
- [x] Escenario 2
- [x] Escenario 3

Caida de Cenizas
- [ ] Escenario 1
- [ ] Escenario 1
- [ ] Escenario 2
- [ ] Escenario 2
- [ ] Escenario 3
- [ ] Escenario 3

Flujos de Lava
- [ ] Escenario 1
- [ ] Escenario 2

Actualizar



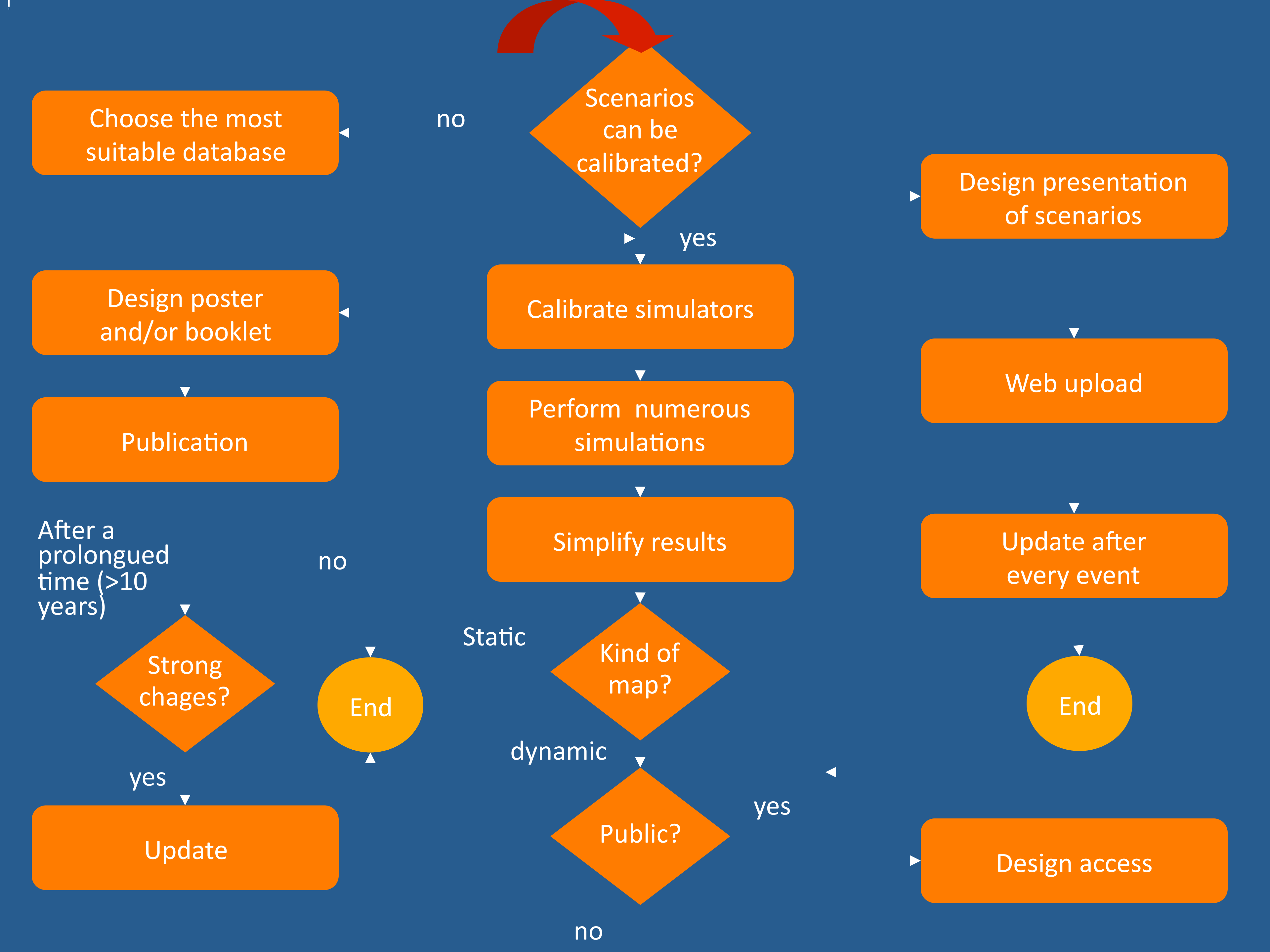
Deshabilitar Java

Nota Aclaratoria

El propósito de este mapa es ser una herramienta útil para orientar las acciones de prevención y mitigación necesarias para reducir la posibilidad de pérdidas y daños dentro de la zona de influencia del volcán. Las áreas representadas en el mapa son el resultado de la aplicación de modelos numéricos y portanto una aproximación a la realidad del fenómeno. Los límites de las áreas delimitadas deben tomarse con precaución, considerándolos como referencias y no como absolutos.

Powered by...

riesgo / geología / meteorología / hidrología / referencia



Choose the most suitable database
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Strong chages?
End
End
dynamic
yes
yes
Public?
Update
Design access
no

Optimizando el proceso de elaboración de mapas de amenaza volcánica: la suite VOLCWORKS

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Elaboración de mapas de amenazas en la última década

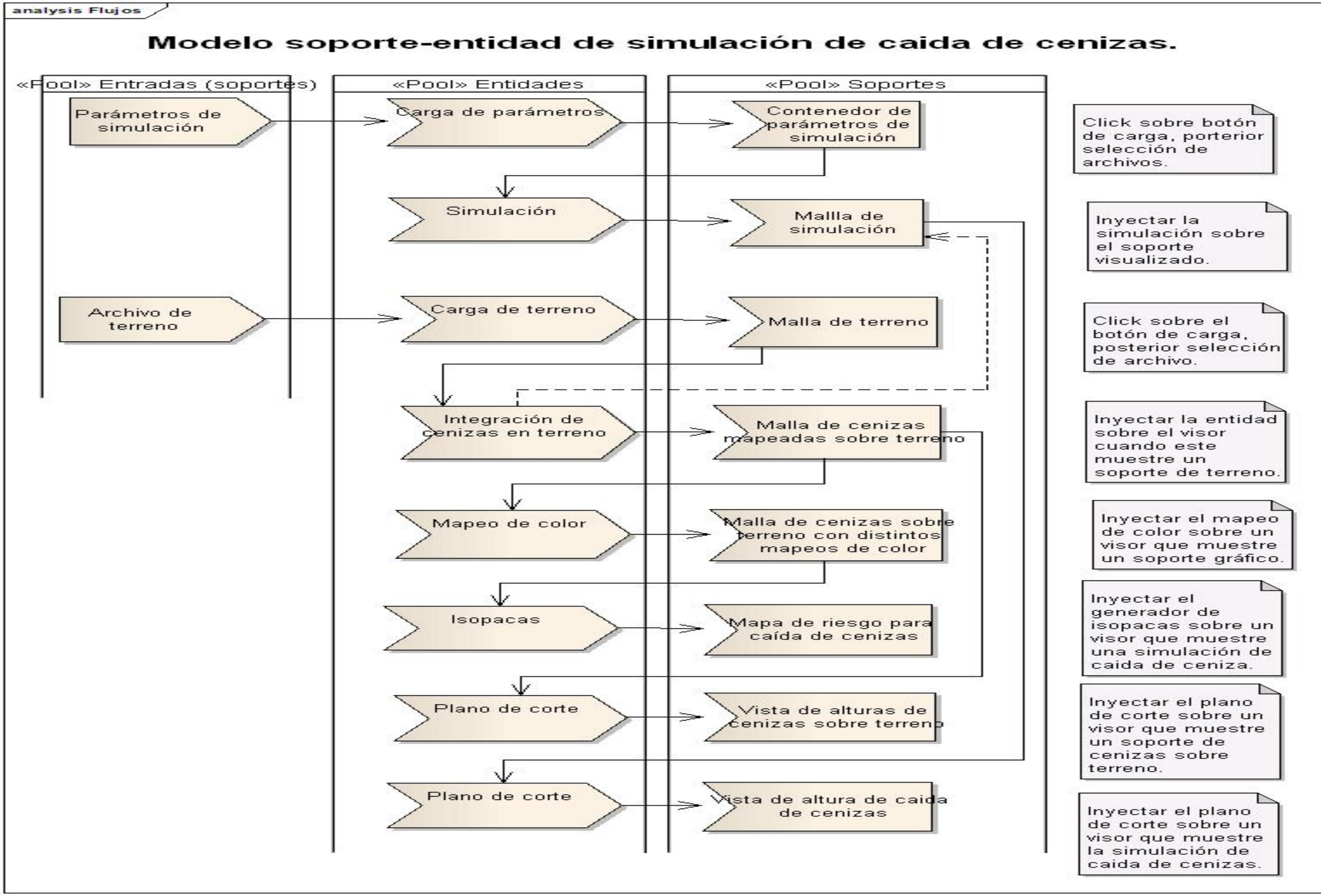
- Se han utilizado paquetes de cómputo que permiten simular diferentes procesos volcánicos:
  - Caída de cenizas
  - Caída de proyectiles balísticos
  - Flujos piroclásticos
  - Flujos de lava
  - Flujos lahĂáricos
- Los paquetes utilizados son por ejemplo:
  - ASHFALL
  - FALL3D
  - BALLISTICS
  - FLOW3D
  - TITAN2D
  - LAHARZ

Problemas a los que se enfrenta quien elabora un mapa de amenazas

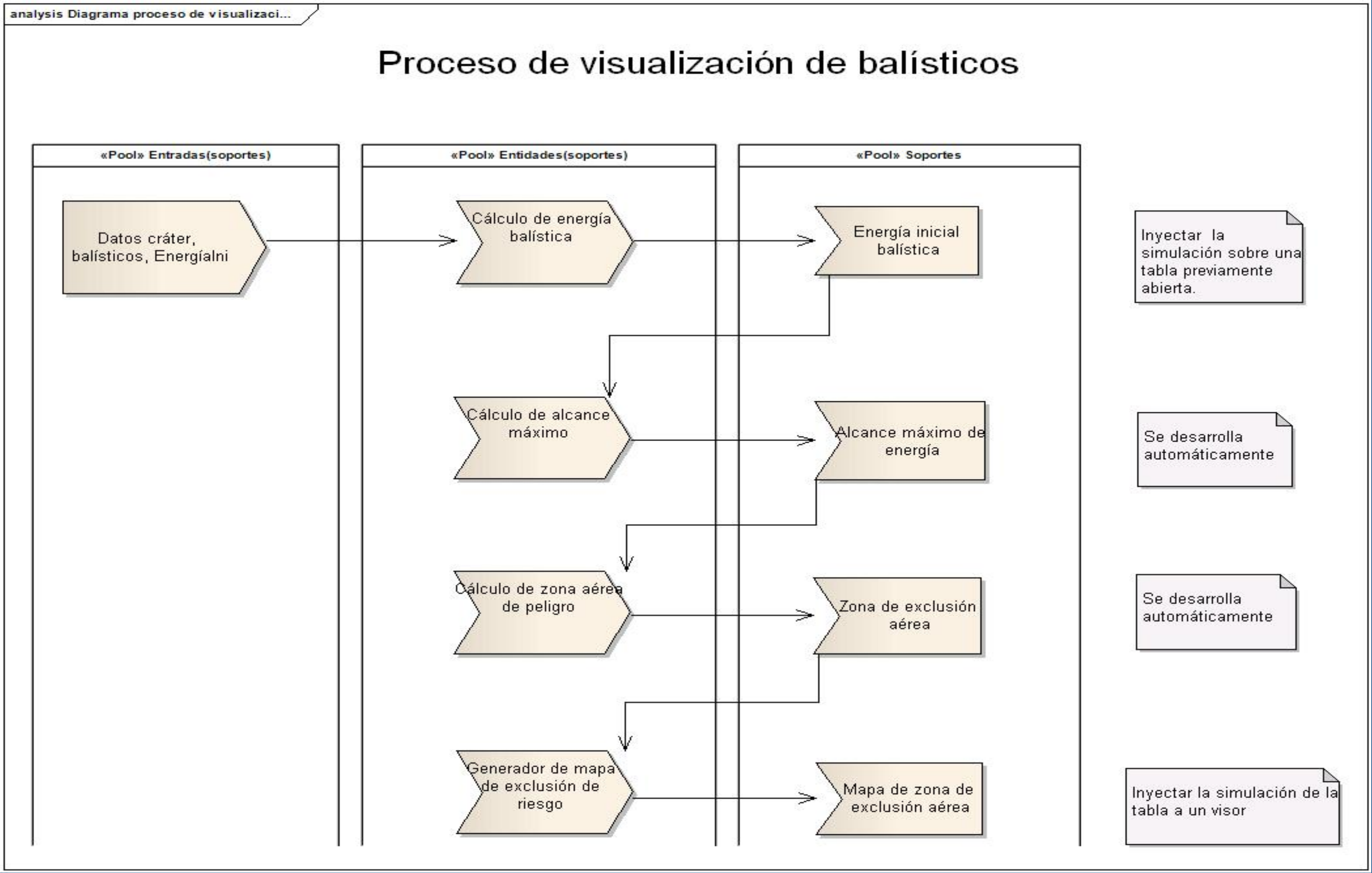
- Paquetes/software poco amigables (elaborados por geólogos/ vulcanólogos)
- Incompatibilidad
- Recursos de cómputo
- Portabilidad
- Consumo de tiempo excesivo
  - Aprendizaje
  - Bugs
  - Salida del software
  - Formatos de salida
- Estos paquetes han sido escritos en diferentes lenguajes:
  - ASHFALL
  - FALL3D
  - BALLISTICS
  - FLOW3D
  - TITAN2D
  - LAHARZ

The suite VOLCWORKS

Modelo soporte -Entidad caída de cenizas



Modelo soporte-entidad balísticos



Sistema de simulación de caída de cenizas.

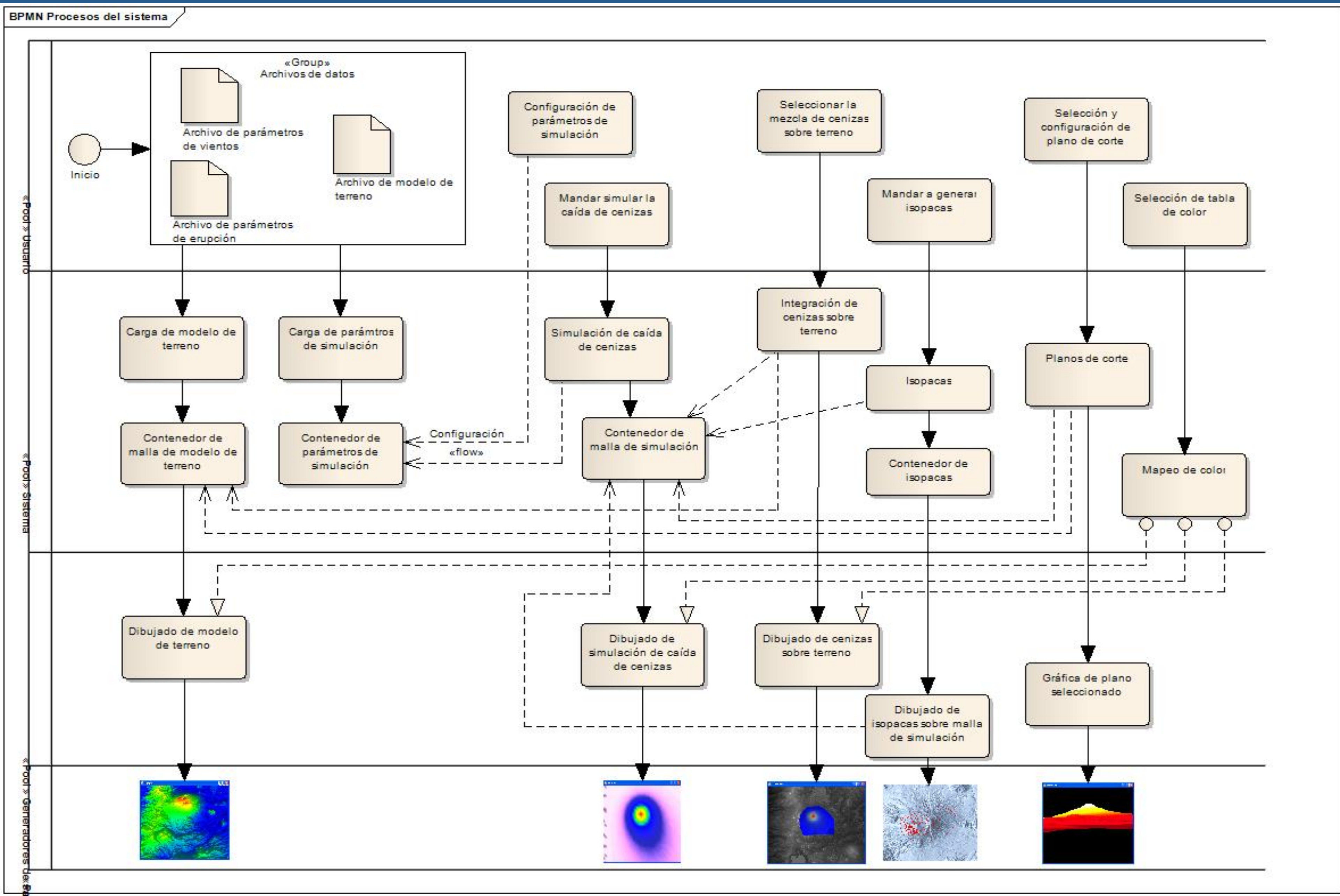
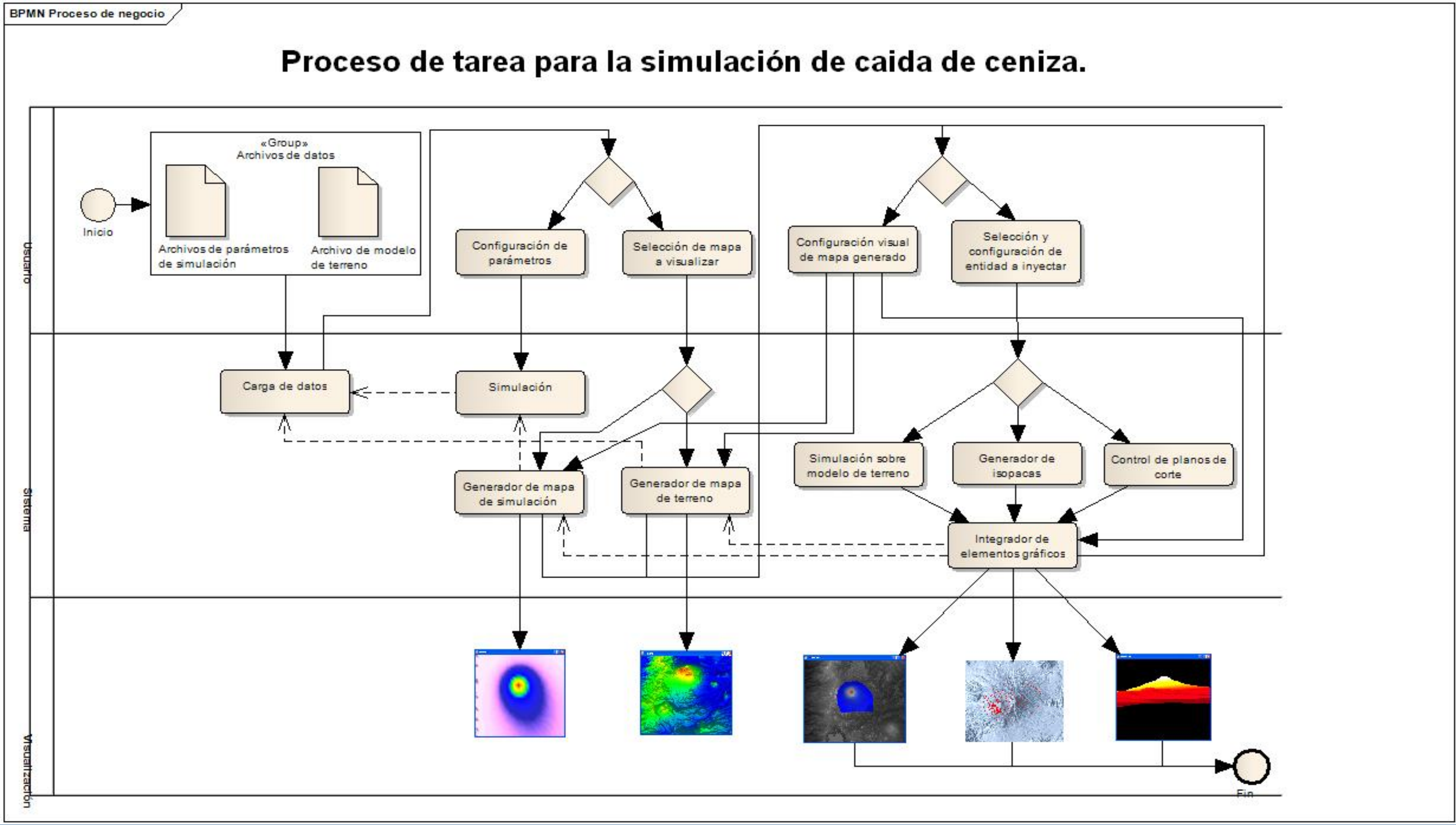


Diagrama de vista particular del proceso de caída de cenizas



Proceso de tarea para la simulación de caida de ceniza.

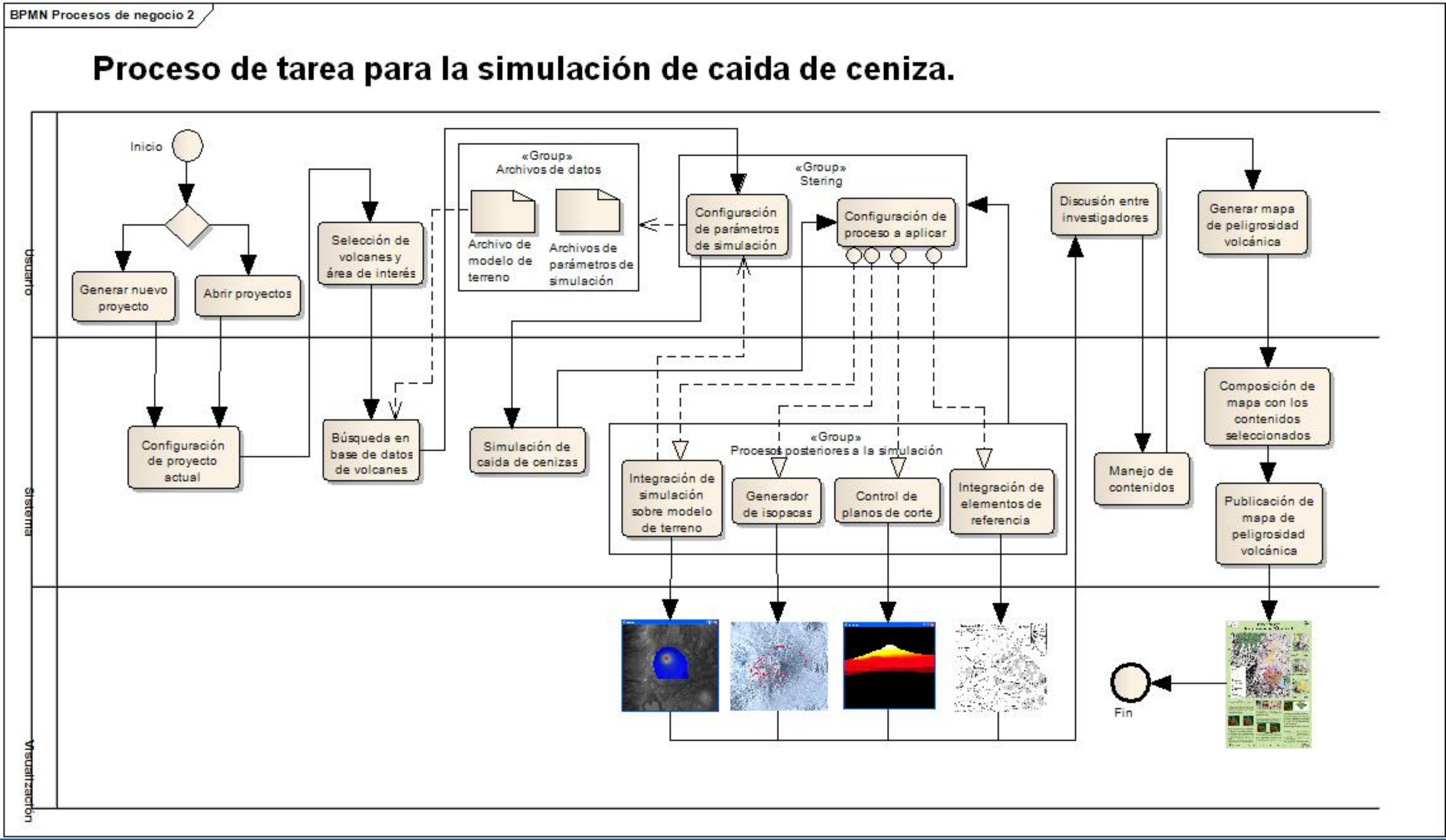


Diagrama de vista general del flujo de balísticos

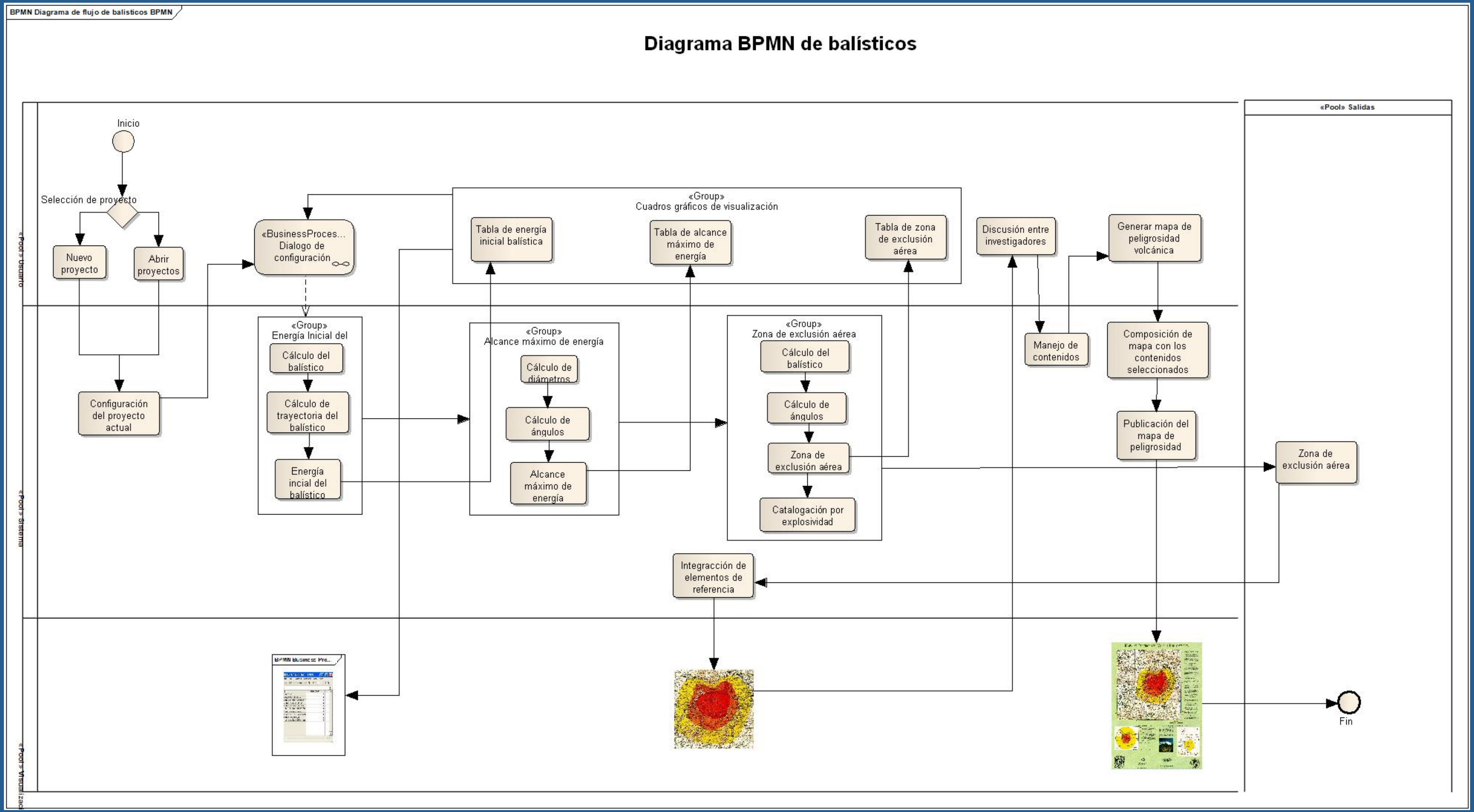
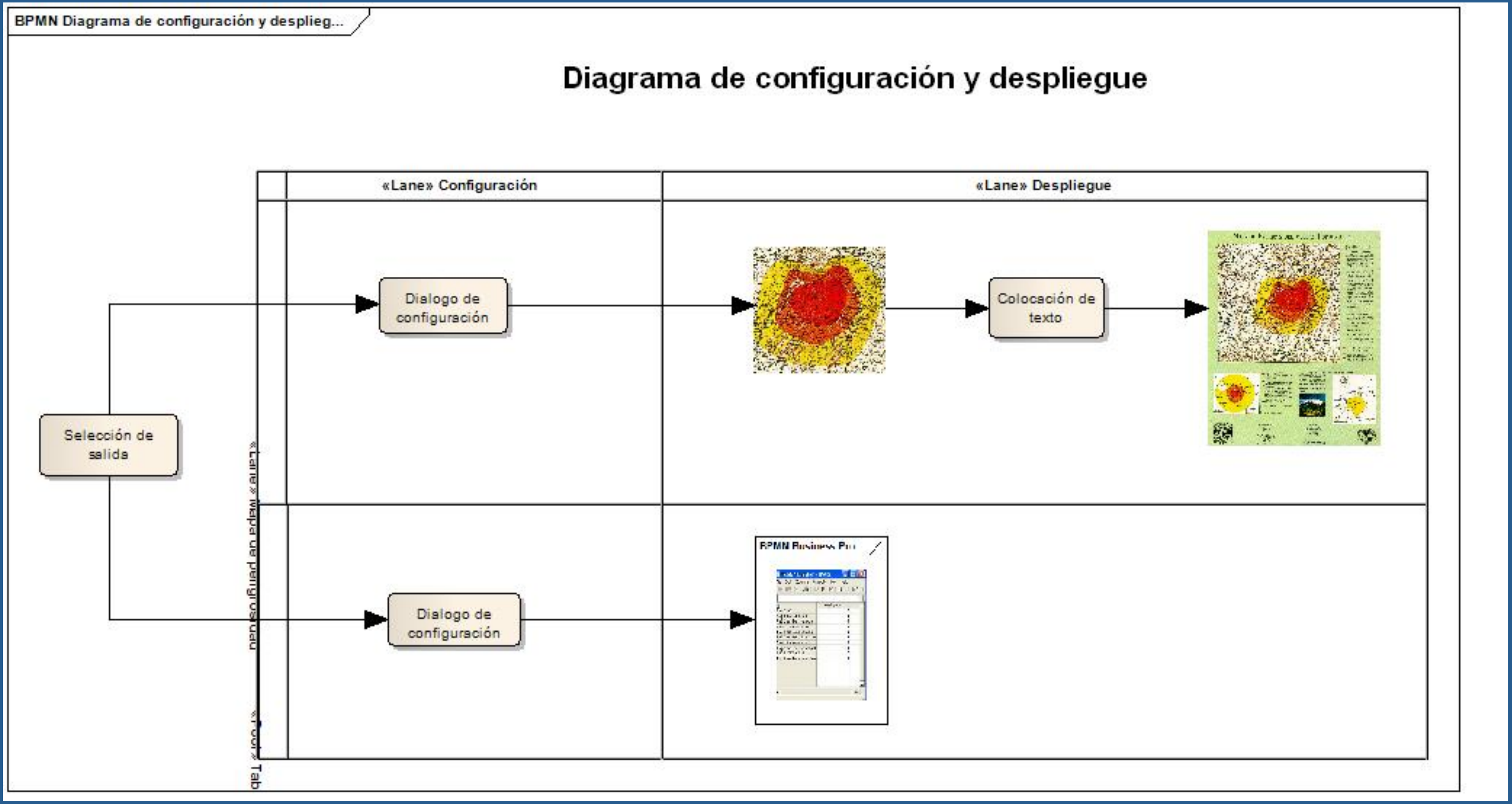
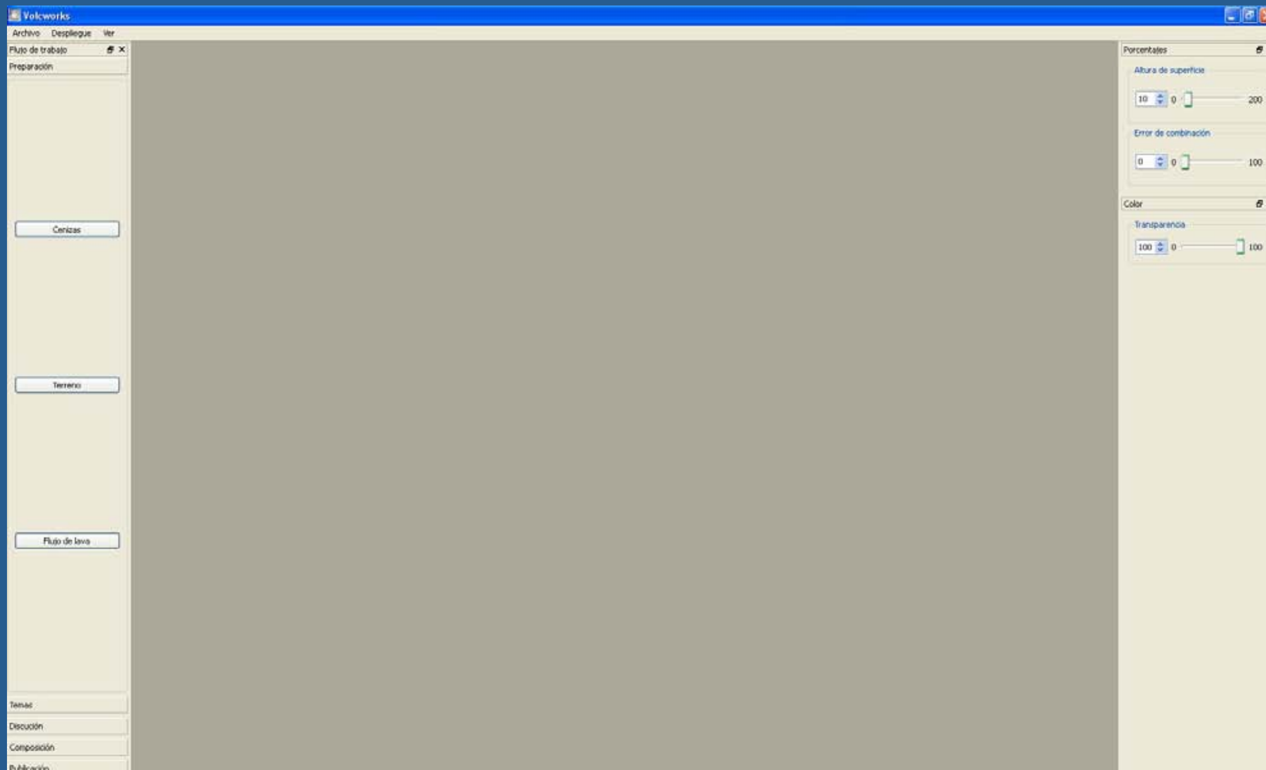


Diagrama del flujo de visualización.



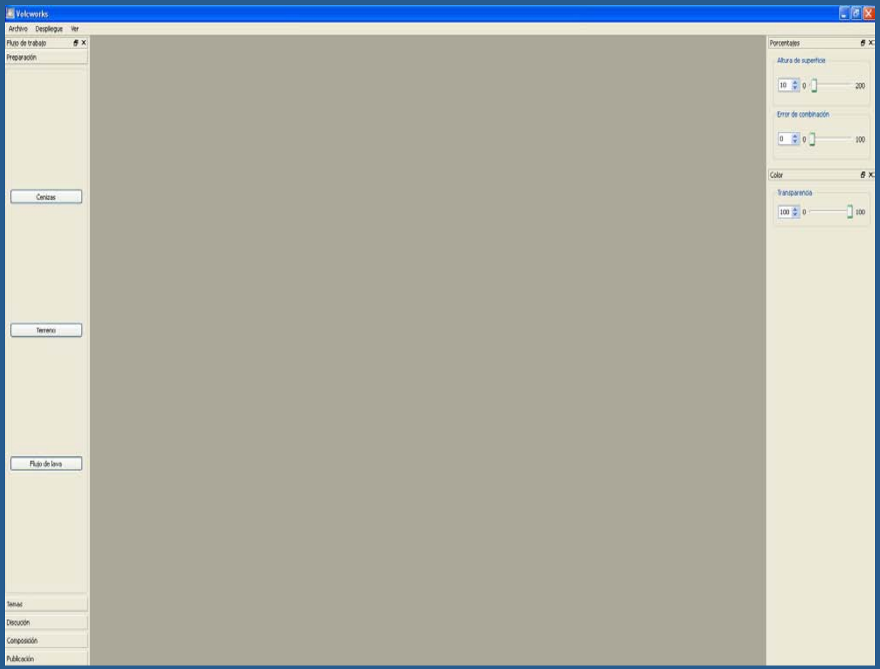
Secuencia del uso de volcworks

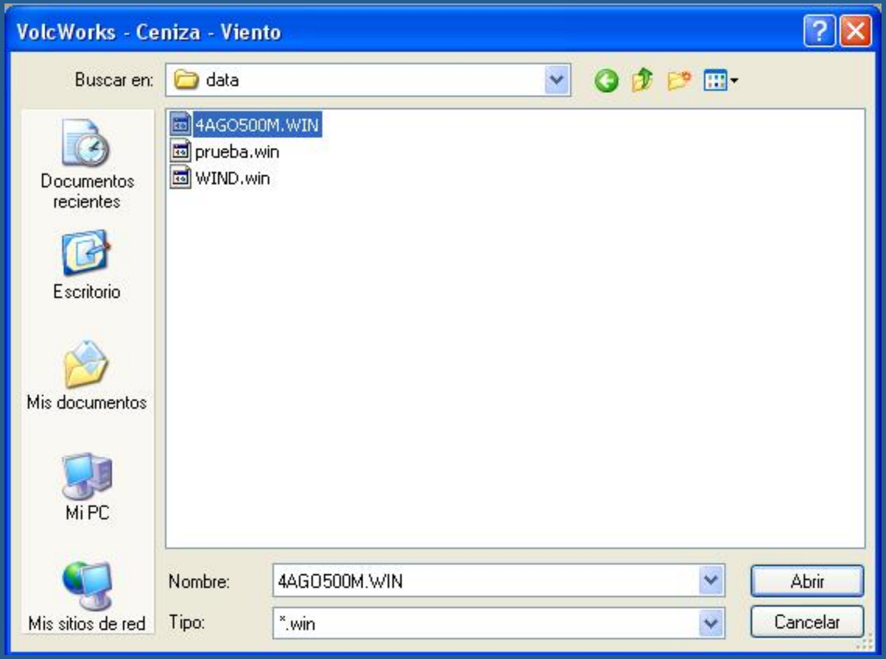
Paso 1



Abrir programa VOLCWORKS, esta es la pantalla principal

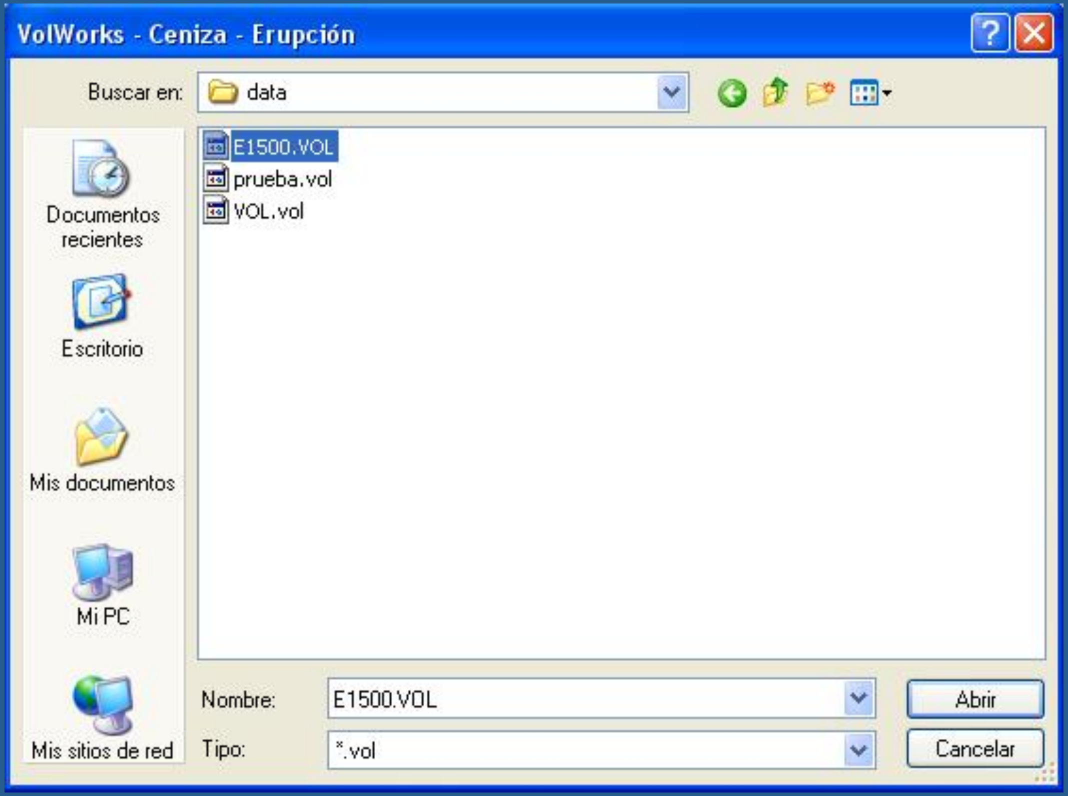
Paso 2





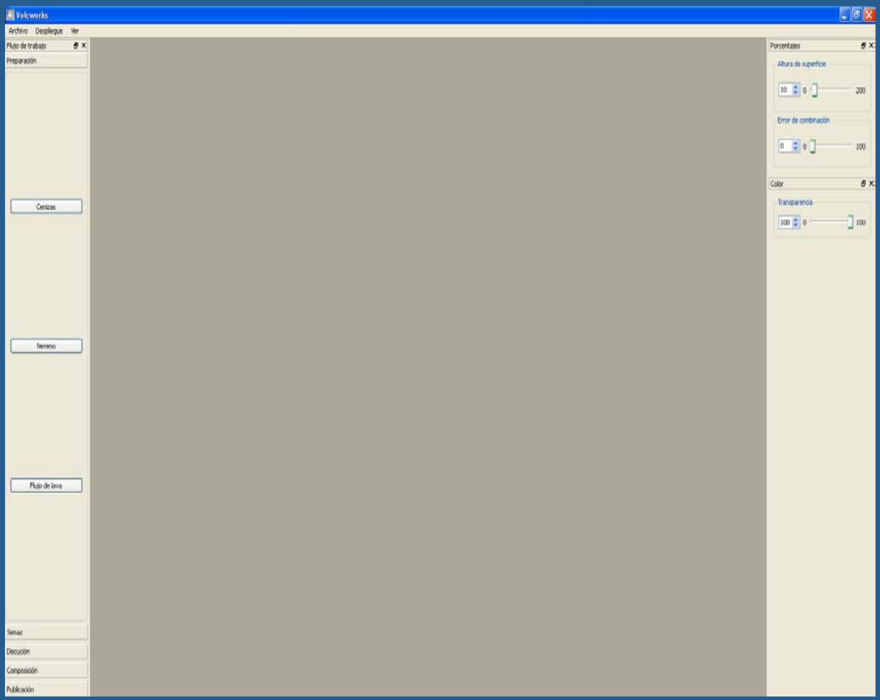
Seleccionar el botón cenizas y a continuación nos muestra una ventana para seleccionar el archivo de cenizas

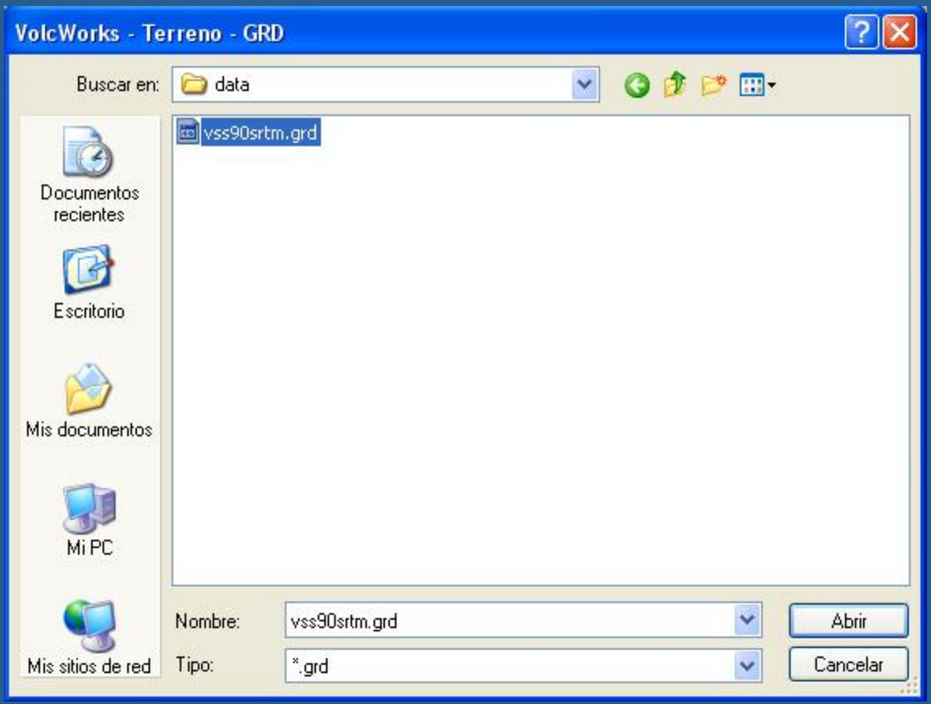
Paso 3



Una vez que damos clic en aceptar nos aparece una ventana en donde debemos seleccionar el archivo de erupciones ubicados estos archivos en la carpeta data, seleccionamos el archivo y damos clic en abrir.

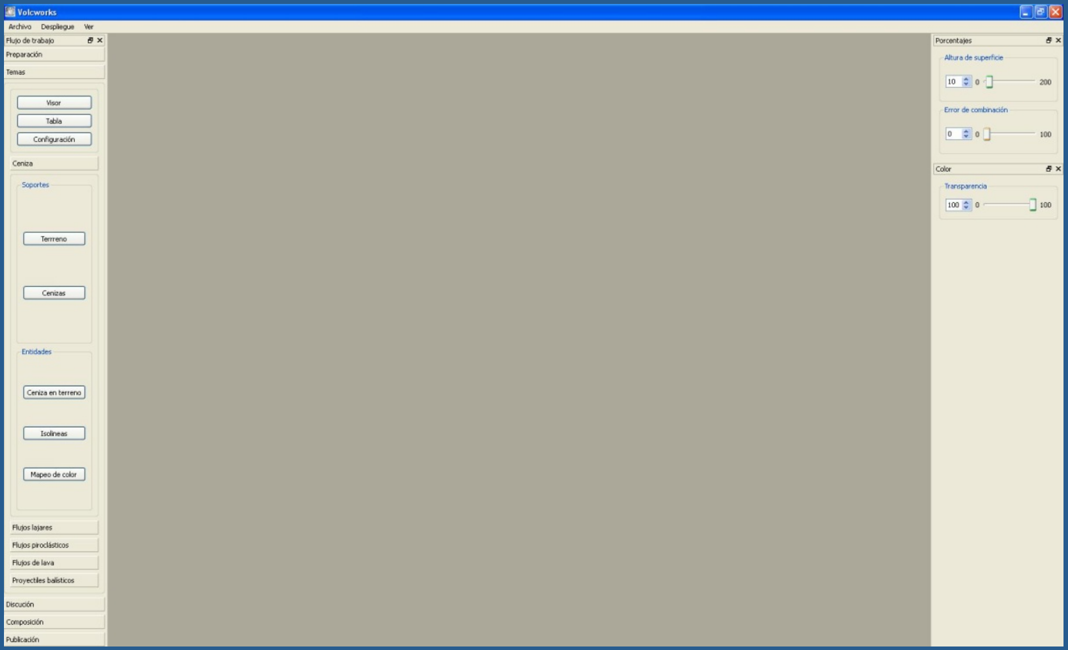
Paso 4





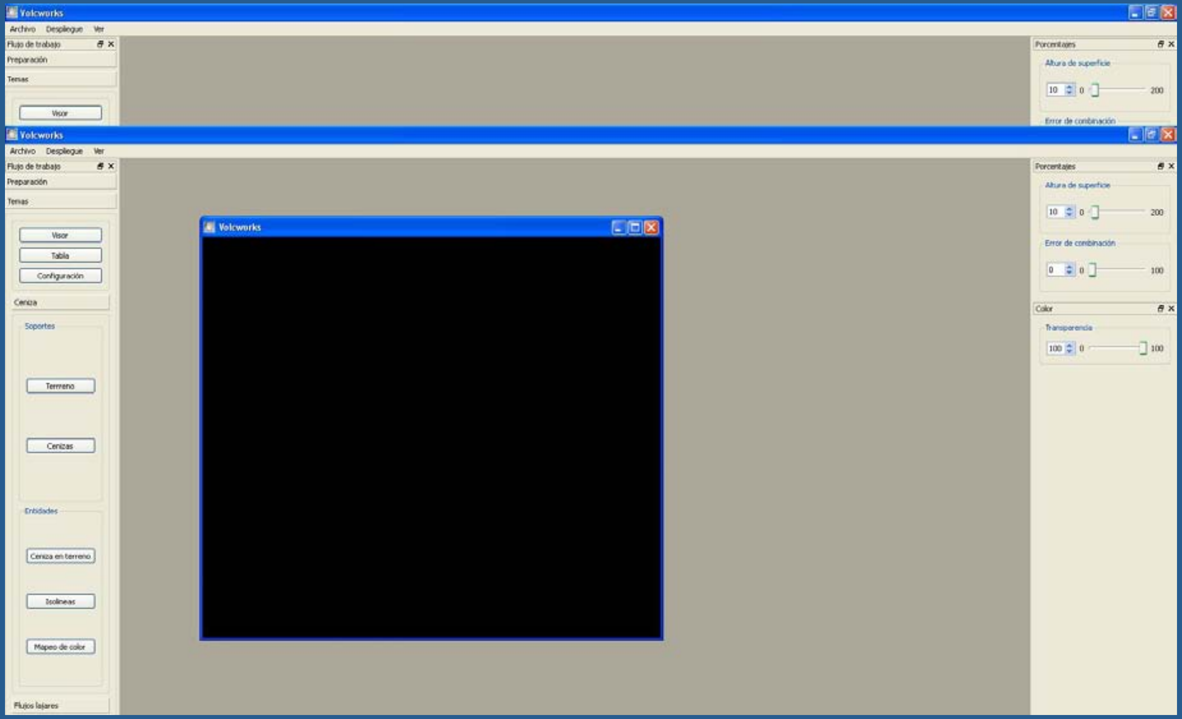
Ahora nos vamos al botón de seleccionar terreno y nos aparece una ventana en donde indicamos el modelo de terreno que utilizaremos, damos clic en abrir

Paso 5



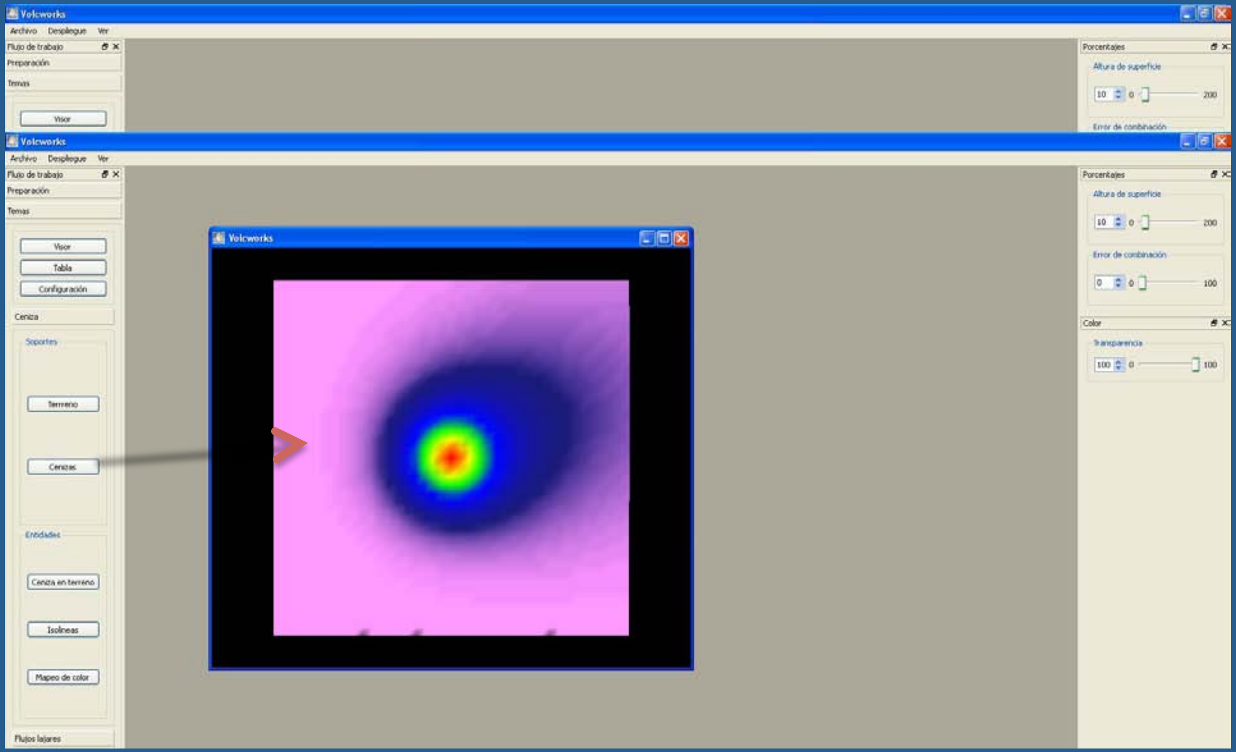
Ahora tenemos todo cargado para poderlo visualizar, ahora nos posicionamos dentro de la pestana preparación.

Paso 6



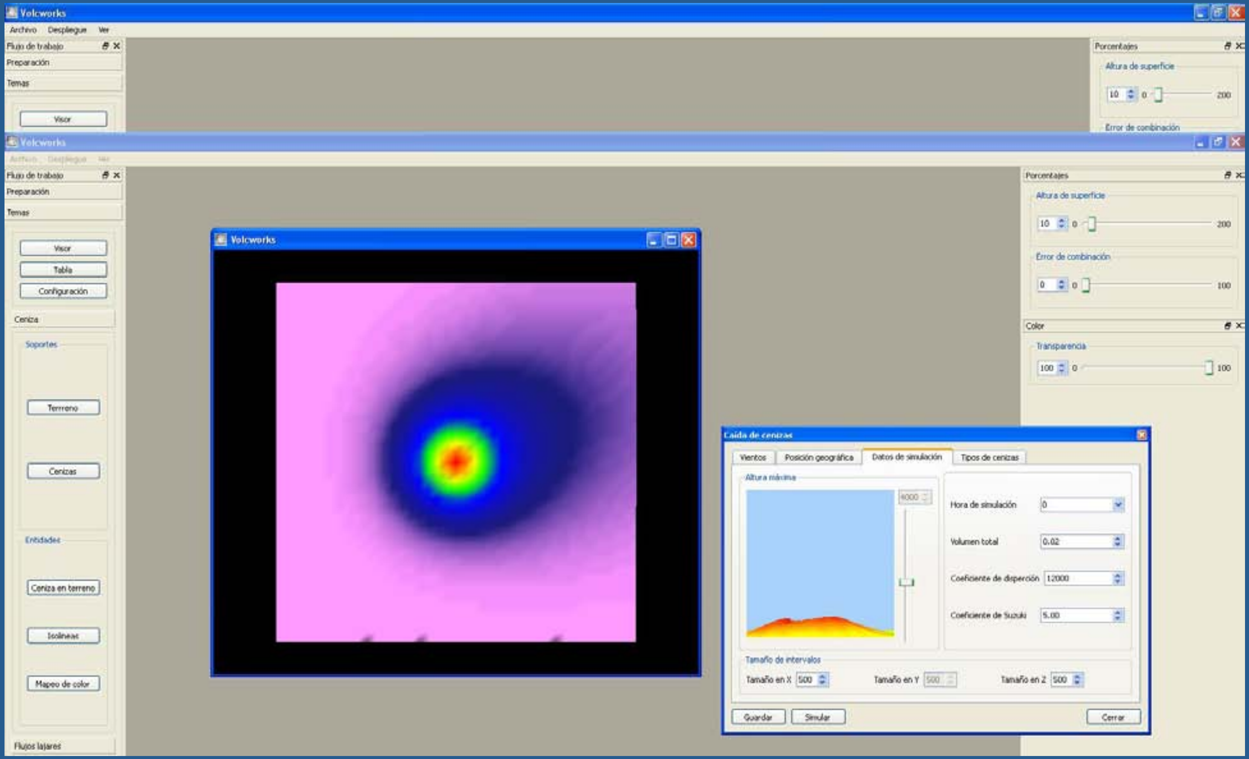
Una ves que seleccionamos esta pestana nos aparece esta vista para poder ver el terreno seleccionamos la opción de visor y nos aparece la ventana negra, es aquí donde se visualizará el terreno.

Paso 7



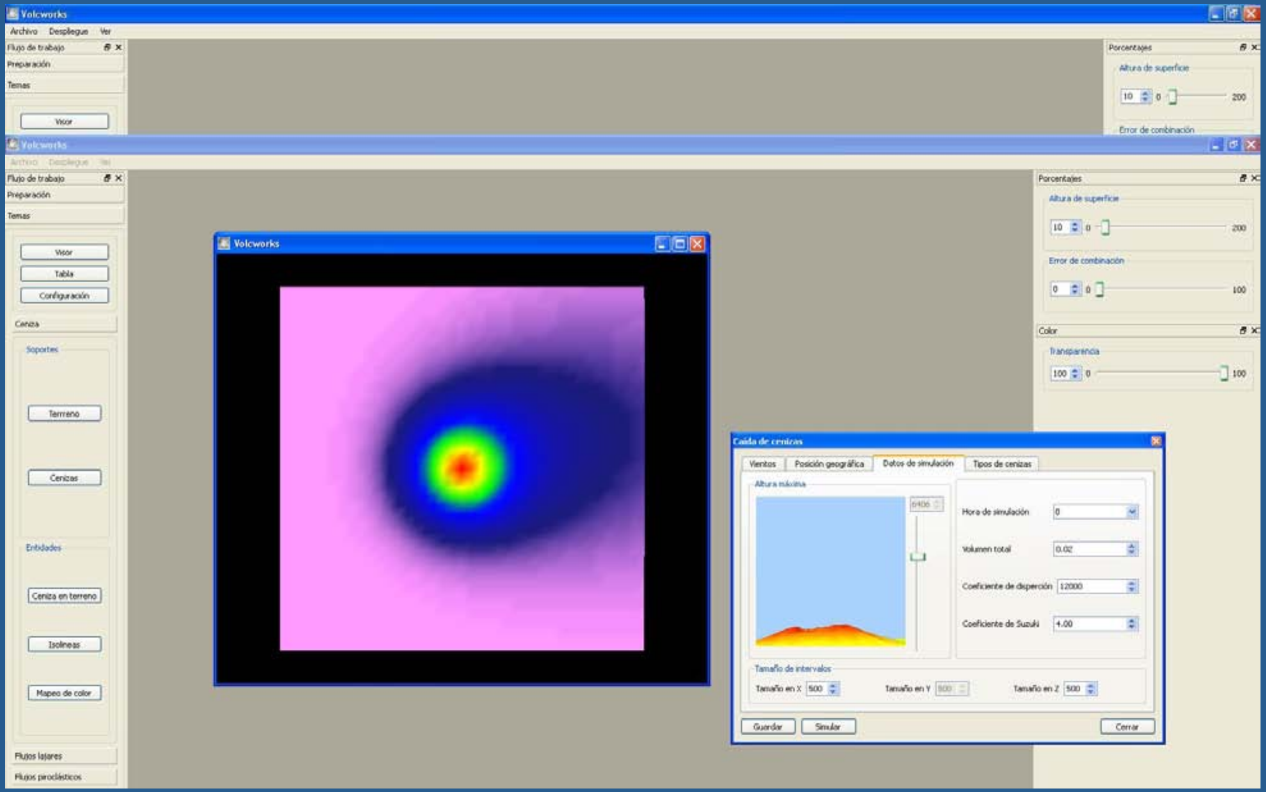
Para poder visualizar la caída de cenizas arrastramos el botón de cenizas directamente al visor.

Paso 8



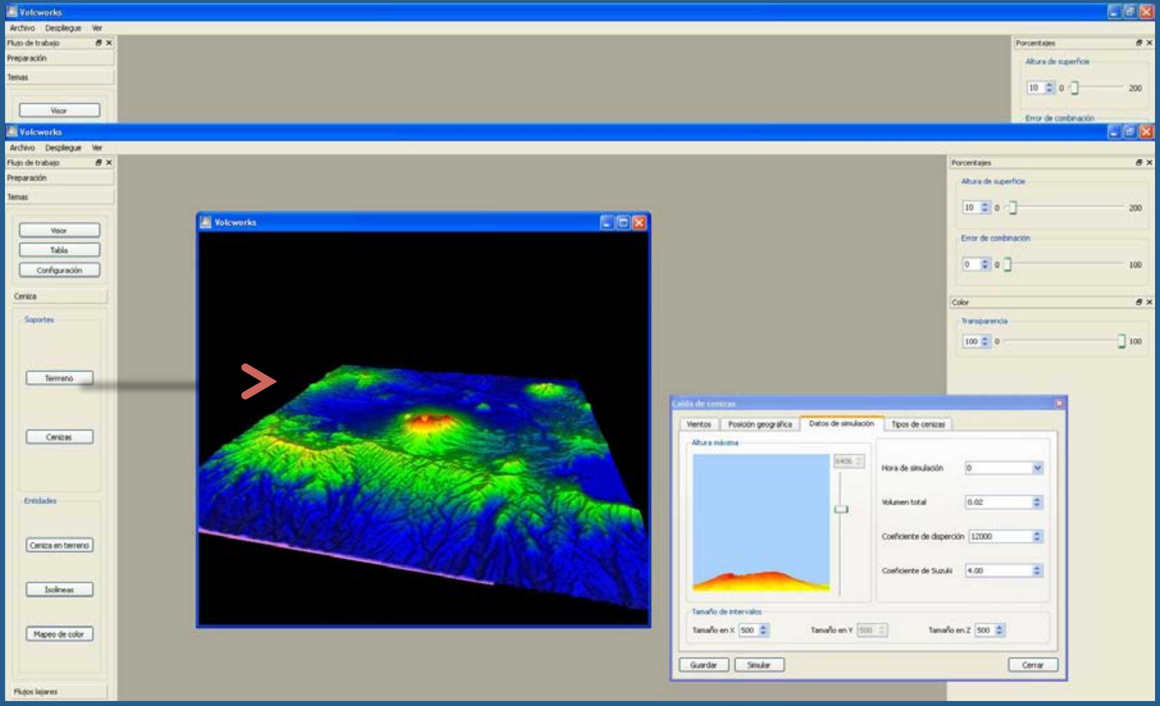
Para poder cambiar la configuración de la caída de cenizas lo podeos hacer desde la opción de configuración, una vez que tenemos hecha la configuración deseada, damos clic en simular, para que esta se muestre.

Paso 9



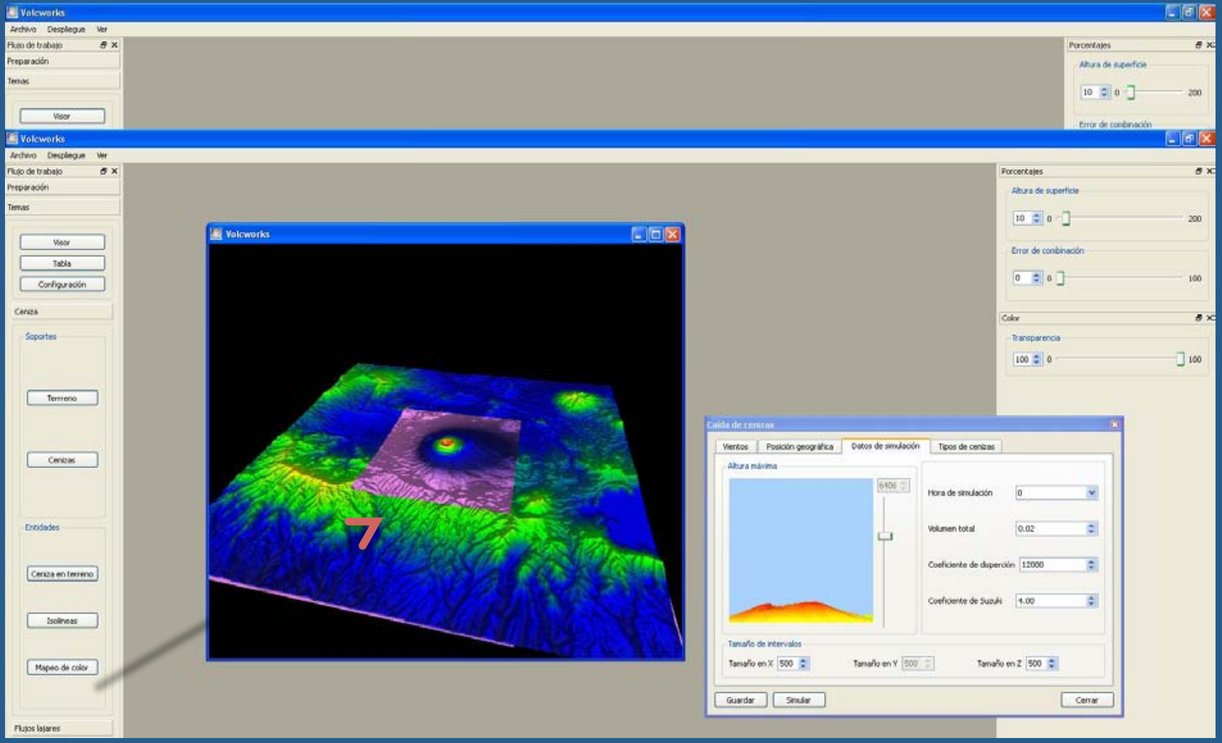
Esta es la nueva vista de la caída de cenizas mostrada.

Paso 10



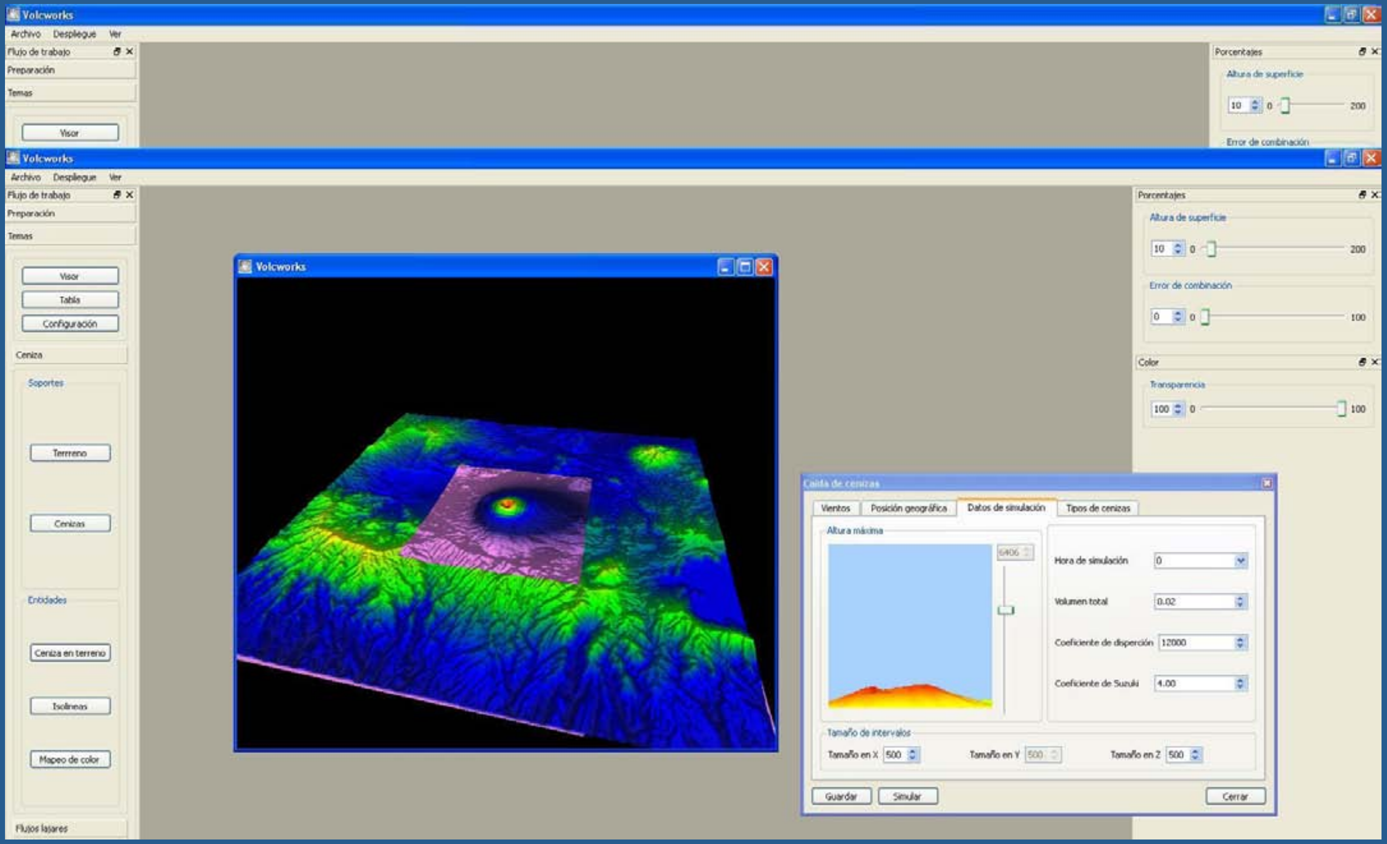
Ahora seleccionamos el modelo de terreno que se encuentra dentro de las opciones y arrastramos dentro del visor, en esta opción también podemos configurar las propiedades del terreno y realizar las modificaciones como en el paso anterior.

Paso 11



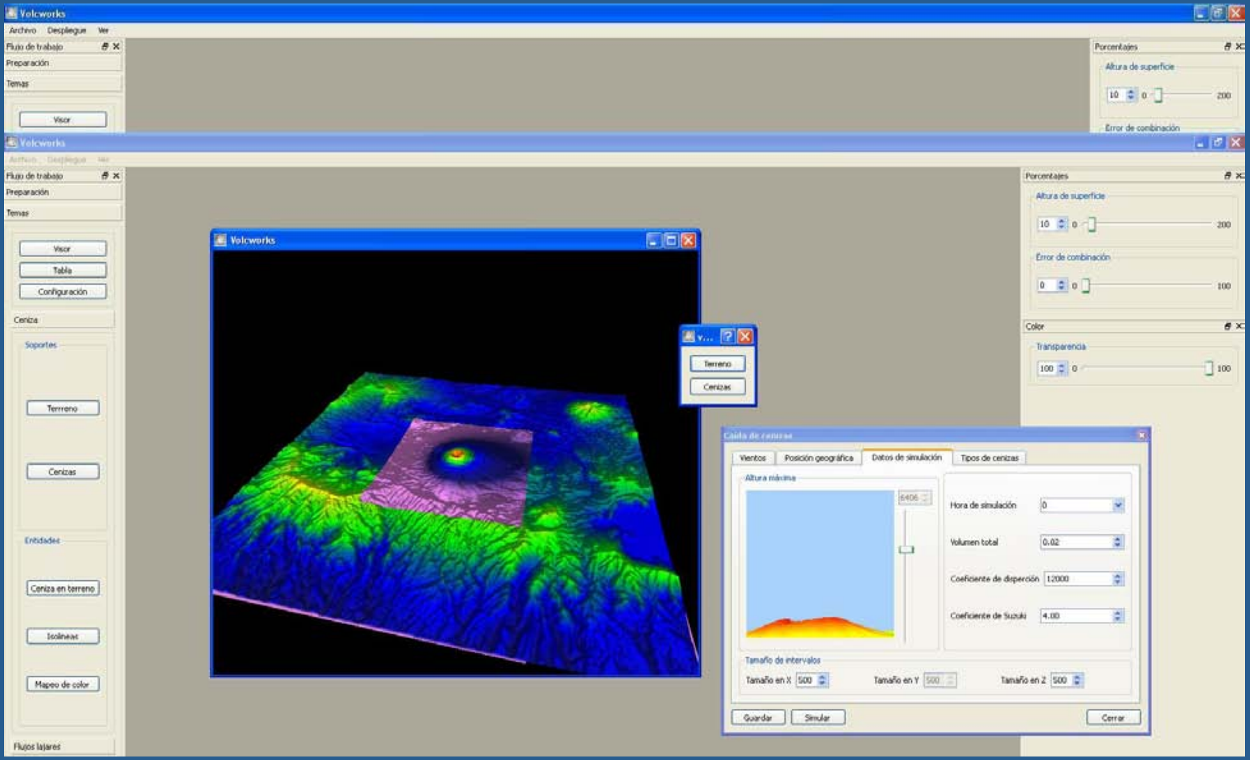
Si queremos ver las cenizas sobre el terreno seleccionamos la opción de terreno en cenizas y arrastramos al visor, esta opción también se puede configurar.

Paso 12



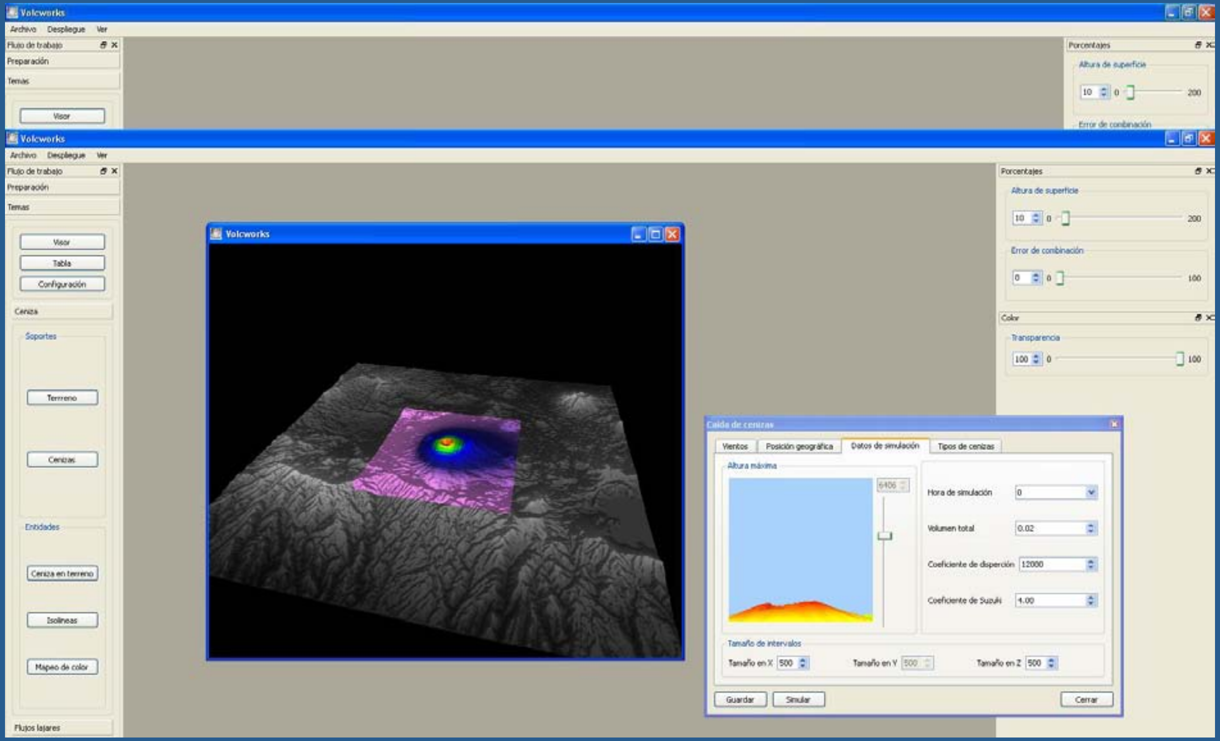
Esta es la vista de los cambios que se realizan en configuración

Paso 13



Para cambiar el mapeo de color sobre el terreno o las cenizas nos vamos a la opción de mapeo de color y seleccionamos el tipo de mapeo que deseamos, además de seleccionar en donde se realiza si en el terreno o en las cenizas

Paso 14



Esta es la vista del mapeo de color

Metas de volcworks

- Generación de mapas de amenaza de una manera más amigable
- Simular diferentes procesos volcánicos con recursos de entrada y salida compatibles
- Realizar simulaciones para tres niveles de usuarios: educativo, operativo e investigación
- VOLCWORKS será multi plataforma (Macintosh, PC, LINUX…)
- La idea es que la suite sea portátil
- Inicialmente el idioma de la suite será en español, para luego, de ser necesario, traducirse a otros idiomas
- Realizar simulaciones para tres niveles de usuarios: educativo, operativo e investigación
- Formación de un catálogo de casos de erupciones con la mayor cantidad de información posible: MDE, parámetros físicos, parámetros de salida, etc.

Thank you

Questions?