CAT (Centro Allerta Tsunami)

@ INGV

(Istituto Nazionale di Geofisica e Vulcanologia)
Rome, Italy

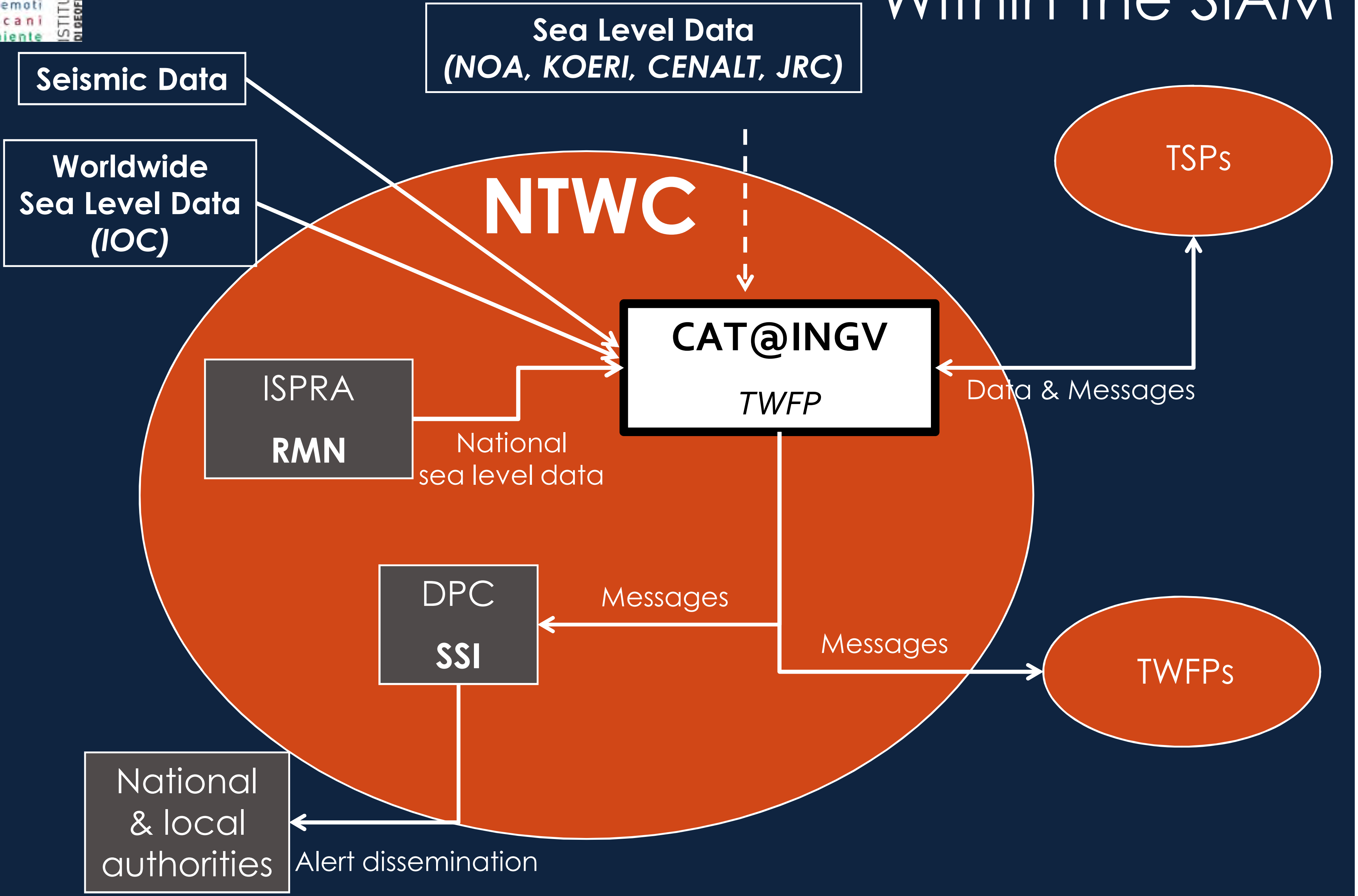
Fabrizio Romano

Italian Tsunami Service Provider for NEAMTWS

Information Workshop on NEAMTWS: Reducing Tsunami Risk through EWS, Preparedness and Awareness, 25-26 September 2017, Madrid, Spain

INGV
terremoti
vulcani
ambiente
ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

CAT-INGV - IT-TSP
Within the SiAM



Sea Level Data
(NOA, KOERI, CENALT, JRC)

Seismic Data

Worldwide
Sea Level Data
(IOC)

NTWC

TSPs

CAT@INGV
TWFP

Data & Messages

ISPRA
RMN

National
sea level data

DPC
SSI

Messages

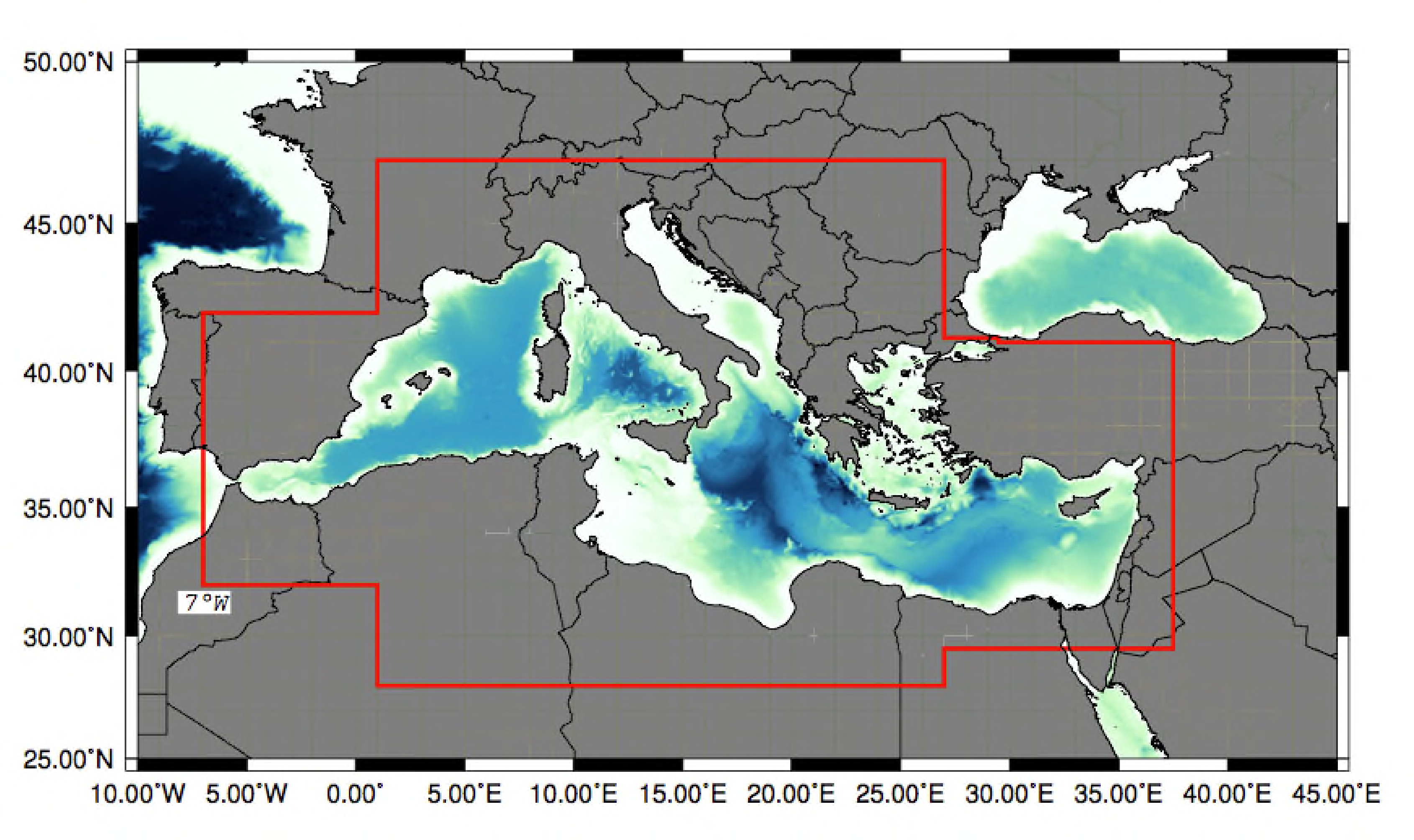
Messages

TWFPs

National
& local
authorities

Alert dissemination

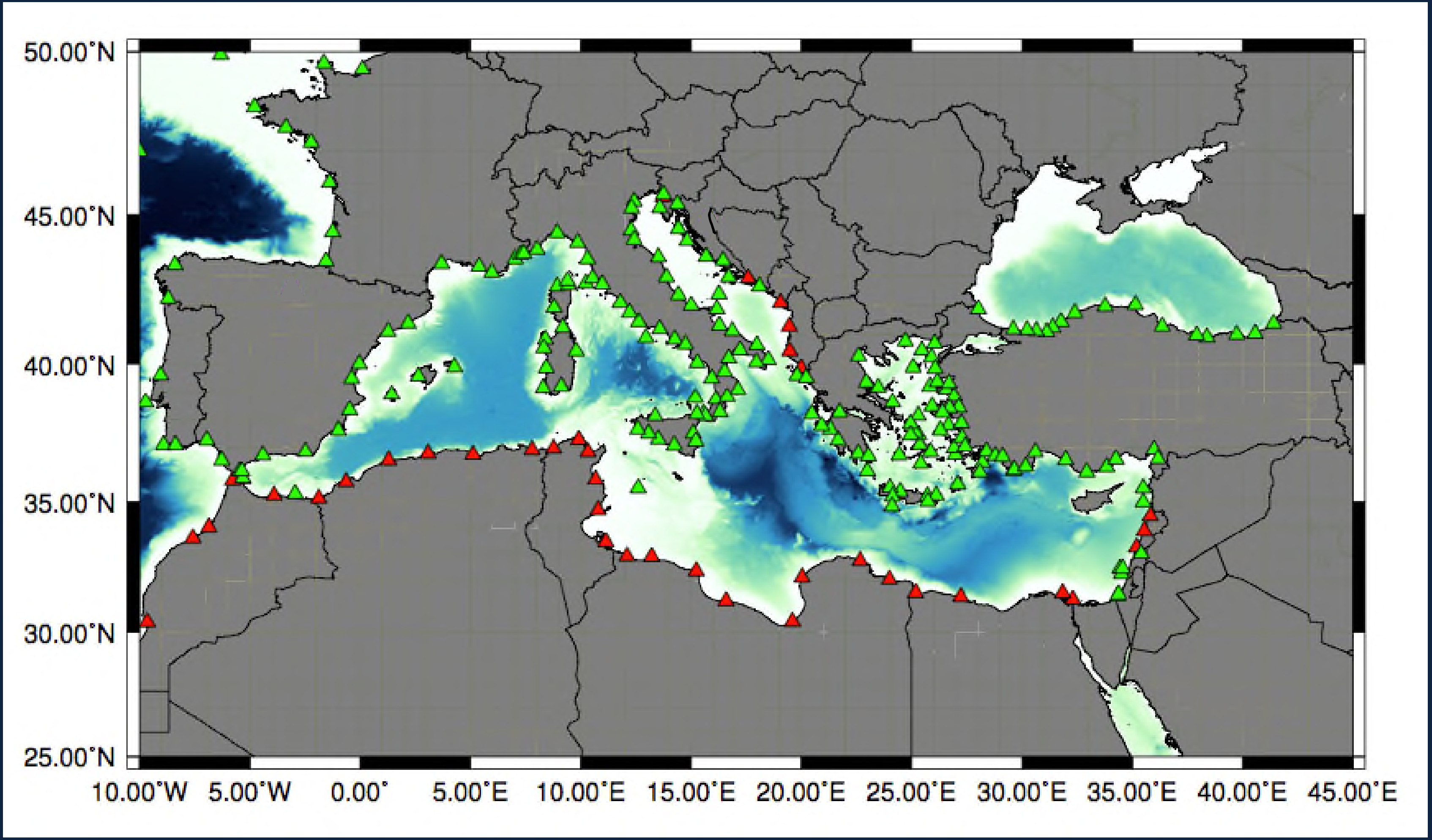
IT-TSP
Source Monitoring Area


50.00°N
45.00°N
40.00°N
35.00°N
30.00°N
25.00°N
7°W
10.00°W
5.00°W
0.00°
5.00°E
10.00°E
15.00°E
20.00°E
25.00°E
30.00°E
35.00°E
40.00°E
45.00°E

All Mediterranean Sea

100 km West of Gibraltar; Marmara Sea

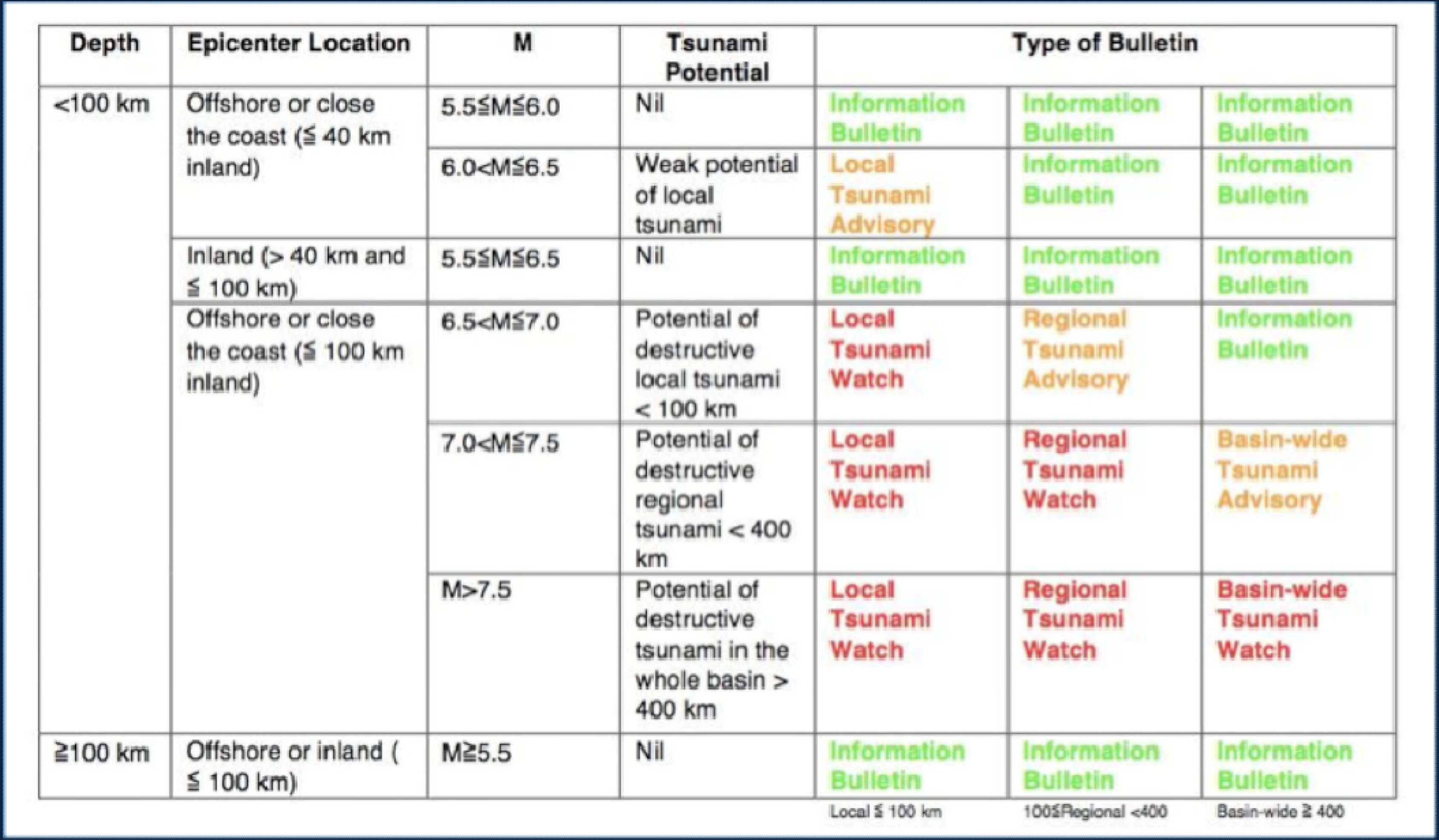
IT-TSP
Forecast Points


50.00°N
45.00°N
40.00°N
35.00°N
30.00°N
25.00°N
10.00°W
5.00°W
0.00°
5.00°E
10.00°E
15.00°E
20.00°E
25.00°E
30.00°E
35.00°E
40.00°E
45.00°E

- 🟩 NEAM **official** forecast points (provided by the countries)
- 🟥 **Unofficial** forecast points (adopted by INGV)

IT-TSP

The Decision Matrix adopted by CAT-INGV



Depth	Epicenter Location	M	Tsunami Potential	Type of Bulletin		
<100 km	Offshore or close the coast (≦ 40 km inland)	5.5≦M≦6.0	Nil	Information Bulletin	Information Bulletin	Information Bulletin
		6.0<M≦6.5	Weak potential of local tsunami	Local Tsunami Advisory	Information Bulletin	Information Bulletin
	Inland (> 40 km and ≦ 100 km)	5.5≦M≦6.5	Nil	Information Bulletin	Information Bulletin	Information Bulletin
	Offshore or close the coast (≦ 100 km inland)	6.5<M≦7.0	Potential of destructive local tsunami < 100 km	Local Tsunami Watch	Regional Tsunami Advisory	Information Bulletin
		7.0<M≦7.5	Potential of destructive regional tsunami < 400 km	Local Tsunami Watch	Regional Tsunami Watch	Basin-wide Tsunami Advisory
		M>7.5	Potential of destructive tsunami in the whole basin > 400 km	Local Tsunami Watch	Regional Tsunami Watch	Basin-wide Tsunami Watch
≧100 km	Offshore or inland (≦ 100 km)	M≧5.5	Nil	Information Bulletin	Information Bulletin	Information Bulletin
				Local ≦ 100 km	100≦Regional <400	Basin-wide ≧ 400

IT-TSP
Recipients/Interested Countries

Recipients:

- *Member States subscriptions*
  - Egypt (NIOF and MWRI)
  - Lebanon (CNRS)
  - Israel (PMO and GII)
  - Germany (BSH)

- *Other TSP*
  - KOERI (Turkey)
  - NOA (Greece)
  - CENALT (France)
  - IPMA (Portugal)

- IOC/UNESCO

- *Other institutions*
  - ERCC (EC DG-ECHO), JRC (EC)
  - DPC (Italian CPA), ISPRA (Italian Sea-Level Data Provider)

CAT-INGV – Main steps

- Candidate TSP since October 2014
- Accreditation NEAMTWS – Summer – Fall 2016 → Tsunami Service Provider (TSP)
- Operational from January 1°, 2017 – National level → Civil Protection Dept. (DPC)
- Directive “SiAM” (Italian System for Tsunami Alert) by Prime Minister Office – 2017 with DPC (coord.) and ISPRA

CAT-INGV – Documentation

- Implementation of documents for regulatory needs arising from the Directive “SiAM” and from the Italian law system (civil and criminal)
- Autonomous definition of documents because specific laws/rules at national and international levels are lacking. Rules borrowed by other disciplines (e.g. medical), in cooperation with law experts (C. Valbonesi)

CAT-INGV – Documents

- Institutional resolution CAT by the INGV Administration Board (feb. 2017)
- Protocol for personnel on duty 7/24 (researchers, expert technicians)
- Protocol for Senior experts on duty
- Standard Operational Protocol of INGV
- Protocol INGV-DPC
- Protocol INGV-ISPRA
- Guidelines

The INGV Seismic center and the CAT

Integration between Seismic surveillance and Tsunami alert

Personnel in seismic room (7/24)

- 2 seismologists among researchers
- 1 IT
- **1 “tsunamist” (seismologist/geophysicist)** among researchers (~40)

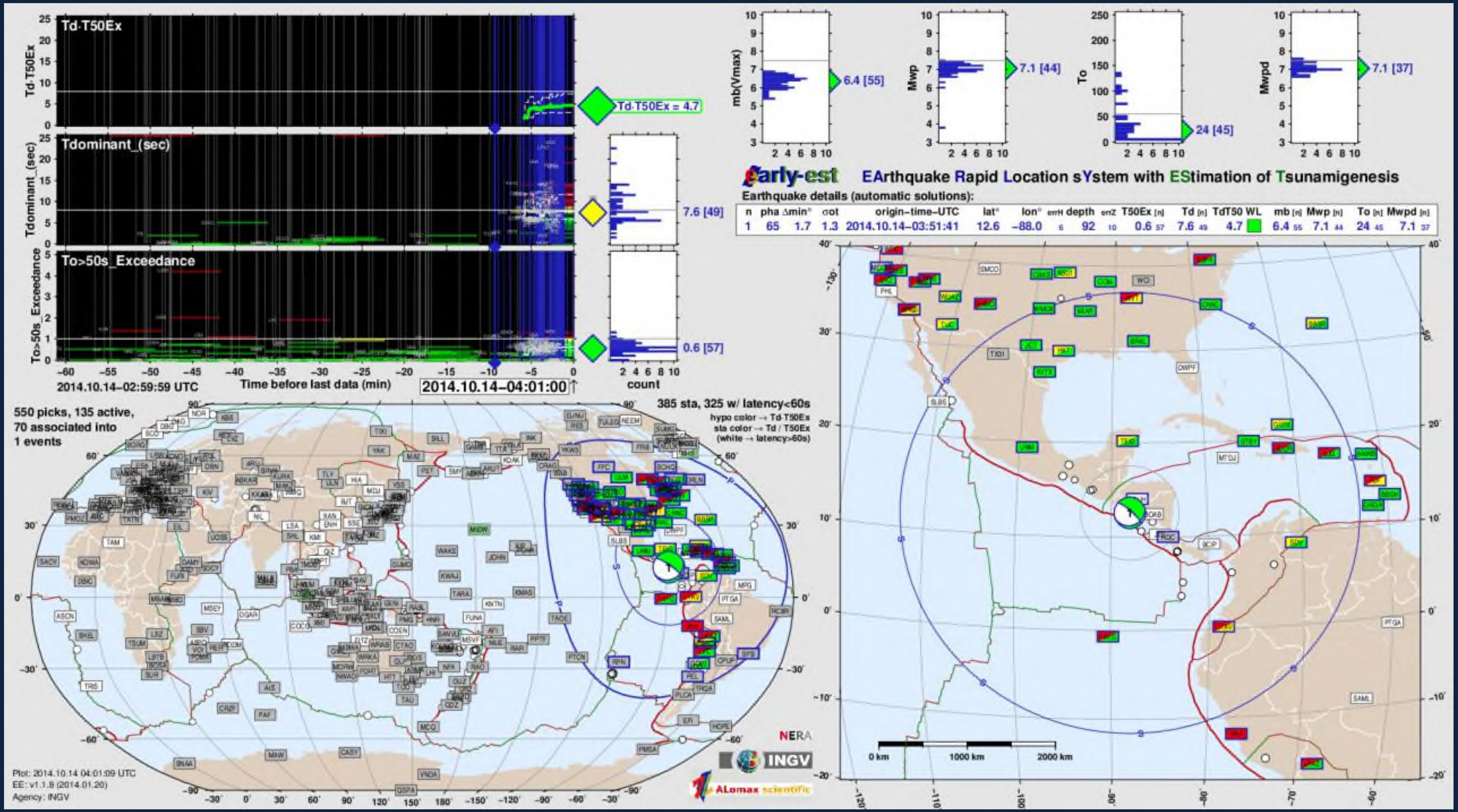
Senior seismologist on call (weekly) (M≥4 in Italy or large eq global)

Senior “tsunamist” on call (weekly)

IT-TSP

Automatic Earthquake detection / estimate

Global scale Earthquake detection (**Early-Est**) for continuous training


Td-T50Ex
Td·T50Ex = 4.7
Tdominant_(sec)
7.6 [49]
To>50s_Exceedance
0.6 [57]
2014.10.14–02:59:59 UTC
Time before last data (min)
2014.10.14–04:01:00
count
mb(Vmax)
6.4 [55]
Mwp
7.1 [44]
To
24 [45]
Mwpd
7.1 [37]
550 picks, 135 active,
70 associated into
1 events
385 sta, 325 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)
Plot: 2014.10.14 04:01:09 UTC
EE: v1.1.8 (2014.01.20)
Agency: INGV
NERA
INGV
ALomax scientific
0 km
1000 km
2000 km

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Earthquake details (automatic solutions):

n	pha	Δmin°	σot	origin-time-UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]	Td [n]	TdT50 WL	mb [n]	Mwp [n]	To [n]	Mwpd [n]
1	65	1.7	1.3	2014.10.14–03:51:41	12.6	–88.0	6	92	10	0.6 57	7.6 49	4.7 🟩	6.4 55	7.1 44	24 45	7.1 37

IT-TSP
Response Timeline

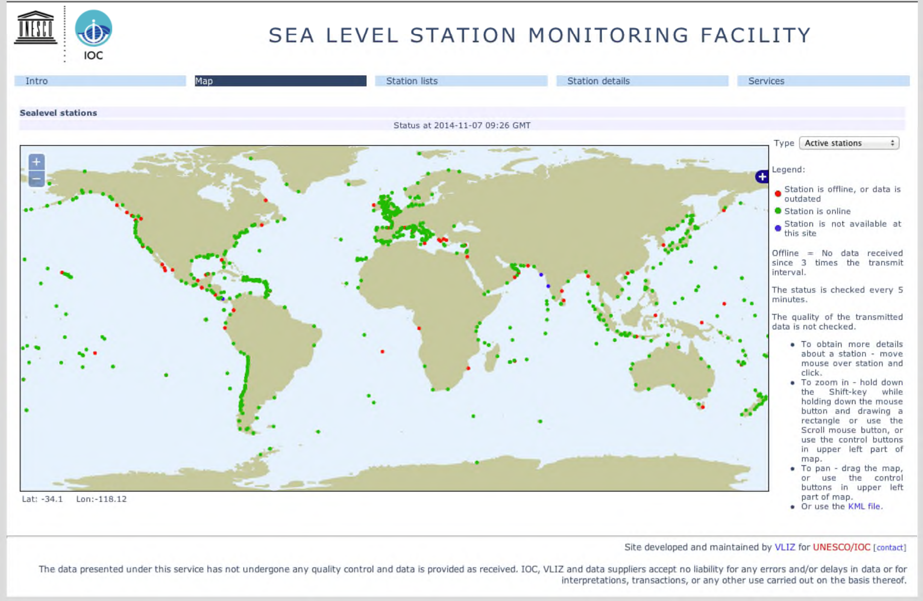
- Within zone of competence
  - 2-3 minutes for first location (000 EE index)
  - 4-5 minutes for first ”good” estimate (002 EE index)
  - 7-8 minutes for stable location (005 EE index)
  - 10-11 minutes for final location (008 EE index)

- First alert within 14 minutes based on the NEAM Decision Matrix
- Automatic locations and magnitudes
- Tsunami Scenario-based alert in testing phase

IT-TSP
Checking tsunami generation

Sea Level Monitoring (**ISPRA-RMN**, **IOC**)

From August 2013 ISPRA is sending in real time to CAT@INGV sea level measurements recorded by its RMN (National Mareographic Network)


UNESCO
IOC
Intro
Map
Station lists
Station details
Services
Type
Active stations
Lat: -34.1
Lon:-118.12

SEA LEVEL STATION MONITORING FACILITY

Sealevel stations

Status at 2014-11-07 09:26 GMT

Legend:

- 🟥 Station is offline, or data is outdated
- 🟩 Station is online
- ● Station is not available at this site

Offline = No data received since 3 times the transmit interval.

The status is checked every 5 minutes.

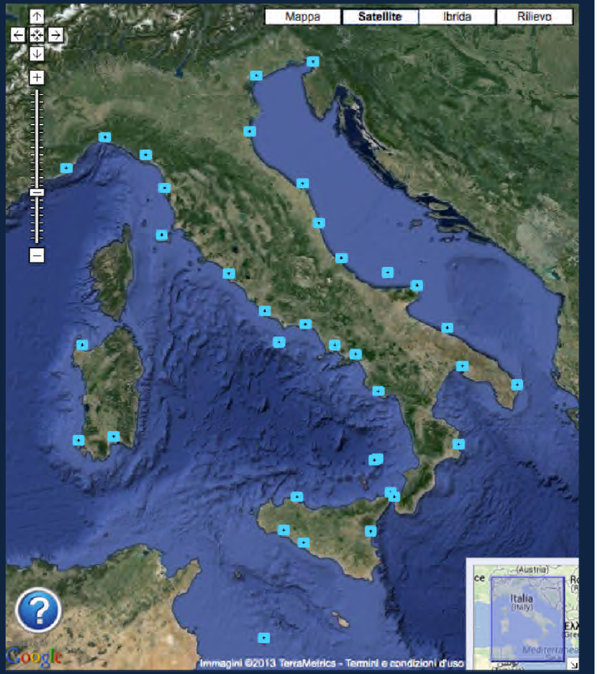
The quality of the transmitted data is not checked.

- To obtain more details about a station - move mouse over station and click.
- To zoom in - hold down the Shift-key while holding down the mouse button and drawing a rectangle or use the Scroll mouse button, or use the control buttons in upper left part of map.
- To pan - drag the map, or use the control buttons in upper left part of map.
- Or use the KML file.

Site developed and maintained by VLIZ for UNESCO/IOC [contact]

The data presented under this service has not undergone any quality control and data is provided as received. IOC, VLIZ and data suppliers accept no liability for any errors and/or delays in data or for interpretations, transactions, or any other use carried out on the basis thereof.

IOC

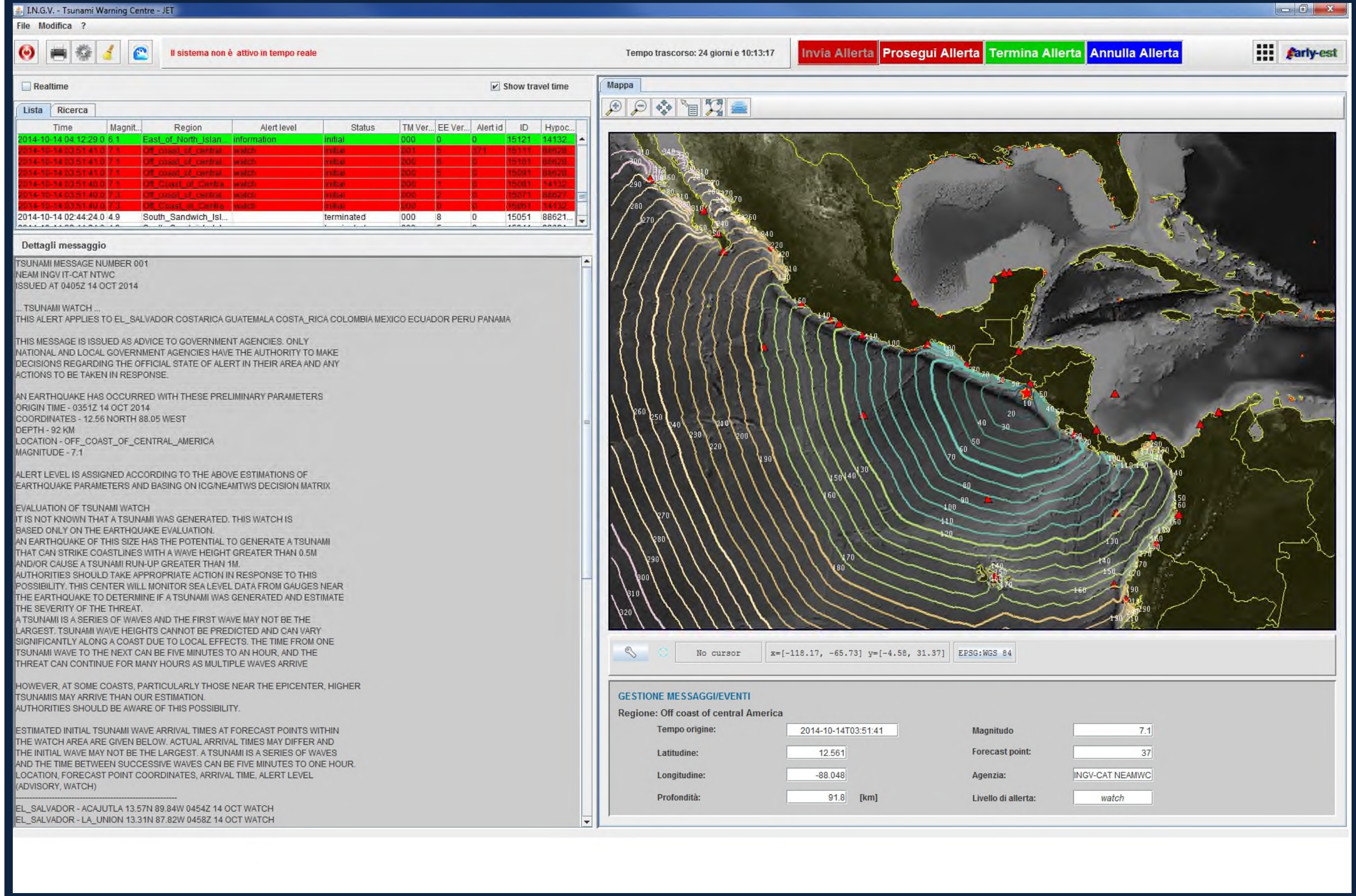

Mappa
Satellite
Ibrida
Rilievo
Italia
Google
Immagini ©2013 TerraMetrics - Termini e condizioni d'uso

ISPRA-RMN

Data format: MINI-SEED

IT-TSP
JET (Java Estimate Tsunami)

Tsunami Evaluation


I.N.G.V. - Tsunami Warning Centre - JET
File Modifica ?
Il sistema non è attivo in tempo reale
Tempo trascorso: 24 giorni e 10:13:17
Invia Allerta
Prosegui Allerta
Termina Allerta
Annulla Allerta
early-est
Mappa
No cursor
x=[-118.17, -65.73] y=[-4.58, 31.37]
EPSG:WGS 84

☐ Realtime ☑ Show travel time

Lista | Ricerca

Time	Magnit...	Region	Alert level	Status	TM Ver...	EE Ver...	Alert id	ID	Hypoc...
2014-10-14 04:12:29.0	6.1	East_of_North_Islan...	information	initial	000	0	0	15121	14132...
2014-10-14 03:51:41.0	7.1	Off_coast_of_central...	watch	initial	001	5	371	15111	88628...
2014-10-14 03:51:41.0	7.1	Off_coast_of_central...	watch	initial	200	8	0	15101	88628...
2014-10-14 03:51:41.0	7.1	Off_coast_of_central...	watch	initial	200	5	0	15091	88628...
2014-10-14 03:51:40.0	7.1	Off_Coast_of_Centra...	watch	initial	200	1	0	15081	14132...
2014-10-14 03:51:40.0	7.3	Off_coast_of_central...	watch	initial	200	2	0	15071	88627...
2014-10-14 03:51:40.0	7.3	Off_Coast_of_Centra...	watch	initial	200	0	0	15061	14132...
2014-10-14 02:44:24.0	4.9	South_Sandwich_Isl...		terminated	000	8	0	15051	88621...

Dettagli messaggio

```
TSUNAMI MESSAGE NUMBER 001
NEAM INGV IT-CAT NTWC
ISSUED AT 0405Z 14 OCT 2014

... TSUNAMI WATCH ...
THIS ALERT APPLIES TO EL_SALVADOR COSTARICA GUATEMALA COSTA_RICA COLOMBIA MEXICO ECUADOR PERU PANAMA

THIS MESSAGE IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES. ONLY
NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE
DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND ANY
ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS
ORIGIN TIME - 0351Z 14 OCT 2014
COORDINATES - 12.56 NORTH 88.05 WEST
DEPTH - 92 KM
LOCATION - OFF_COAST_OF_CENTRAL_AMERICA
MAGNITUDE - 7.1

ALERT LEVEL IS ASSIGNED ACCORDING TO THE ABOVE ESTIMATIONS OF
EARTHQUAKE PARAMETERS AND BASING ON ICG/NEAMTWS DECISION MATRIX

EVALUATION OF TSUNAMI WATCH
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LOCATION, FORECAST POINT COORDINATES, ARRIVAL TIME, ALERT LEVEL
(ADVISORY, WATCH)
------------------------------------------------------------
EL_SALVADOR - ACAJUTLA 13.57N 89.84W 0454Z 14 OCT WATCH
EL_SALVADOR - LA_UNION 13.31N 87.82W 0458Z 14 OCT WATCH
```

GESTIONE MESSAGGI/EVENTI

Regione: Off coast of central America

Tempo origine:	2014-10-14T03:51:41	Magnitudo	7.1
Latitudine:	12.561	Forecast point:	37
Longitudine:	-88.048	Agenzia:	INGV-CAT NEAMWC
Profondità:	91.8 [km]	Livello di allerta:	*watch*

- Earthquake parameters ->Early-Est

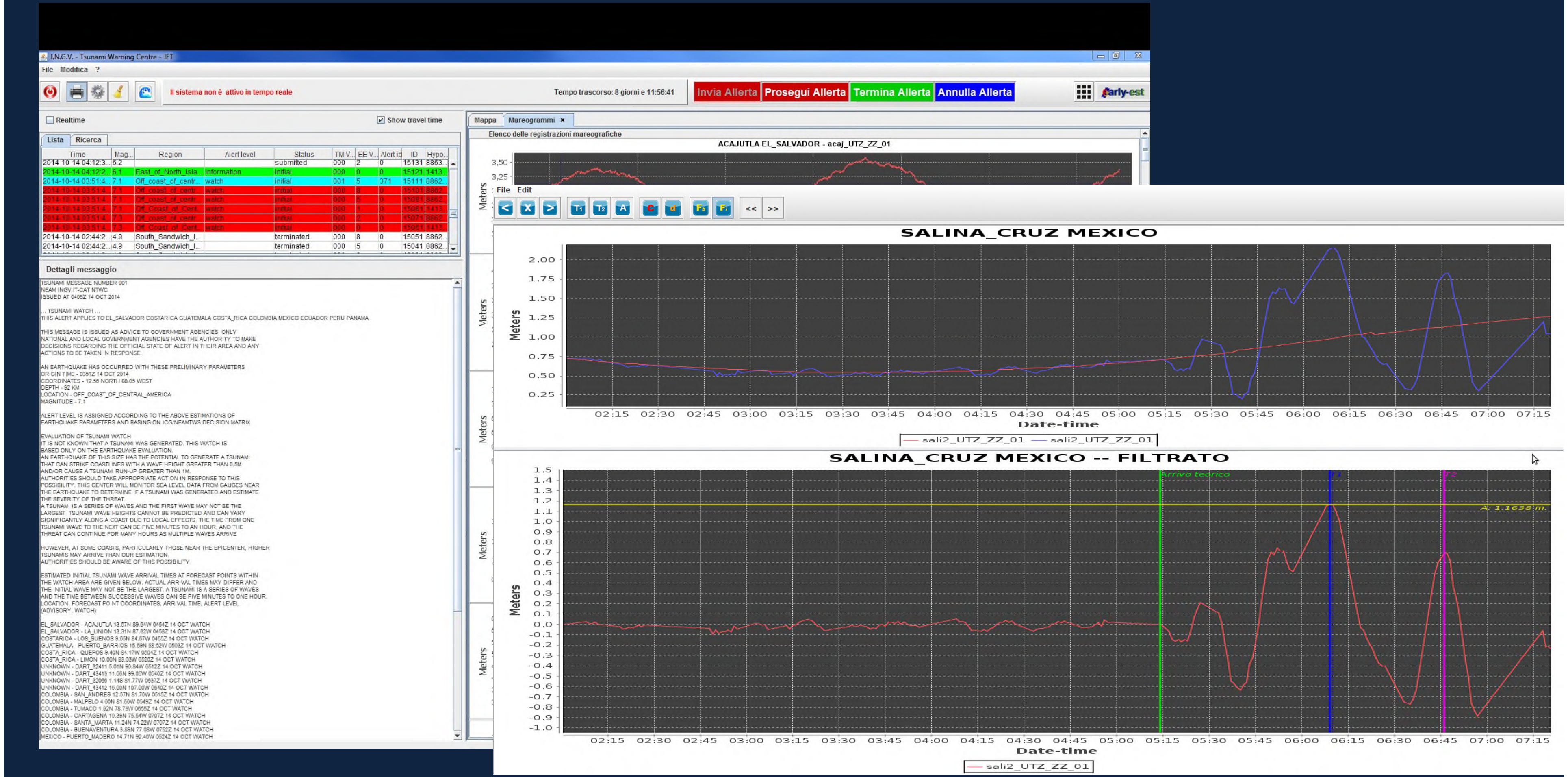
- Alert levels -> NEAM Decision Matrix

-Theoretical tsunami arrival times (TTT sw)

- Training through continuous monitoring of seismic events at global-scale

Messages in English (NEAM) and in Italian (SiAM)
with a different structure for rapid dissemination (Json and CAP-TSU)

IT-TSP
JET


I.N.G.V. - Tsunami Warning Centre - JET
File Modifica ?
Il sistema non è attivo in tempo reale
Tempo trascorso: 8 giorni e 11:56:41
Invia Allerta
Prosegui Allerta
Termina Allerta
Annulla Allerta
Early-est
☐ Realtime
☑ Show travel time
Lista
Ricerca
Mappa
Mareogrammi
Elenco delle registrazioni mareografiche
ACAJUTLA EL_SALVADOR - acaj_UTZ_ZZ_01
3,50
3,25
File Edit
<<
>>
SALINA_CRUZ MEXICO
Meters
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
02:15
02:30
02:45
03:00
03:15
03:30
03:45
04:00
04:15
04:30
04:45
05:00
05:15
05:30
05:45
06:00
06:15
06:30
06:45
07:00
07:15
Date-time
sali2_UTZ_ZZ_01
sali2_UTZ_ZZ_01
SALINA_CRUZ MEXICO -- FILTRATO
Meters
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
Arrivo teorico
T1
T2
A: 1.1638 m
Date-time
sali2_UTZ_ZZ_01

Time	Mag...	Region	Alert level	Status	TM V...	EE V...	Alert id	ID	Hypo...
2014-10-14 04:12:3...	6.2			submitted	000	2	0	15131	8863...
2014-10-14 04:12:2...	6.1	East_of_North_Isla...	information	initial	000	0	0	15121	1413...
2014-10-14 03:51:4...	7.1	Off_coast_of_centr...	watch	initial	001	5	371	15111	8862...
2014-10-14 03:51:4...	7.1	Off_coast_of_centr...	watch	initial	000	8	0	15101	8862...
2014-10-14 03:51:4...	7.1	Off_coast_of_centr...	watch	initial	000	5	0	15091	8862...
2014-10-14 03:51:4...	7.1	Off_Coast_of_Cent...	watch	initial	000	1	0	15081	1413...
2014-10-14 03:51:4...	7.3	Off_coast_of_centr...	watch	initial	000	2	0	15071	8862...
2014-10-14 03:51:4...	7.3	Off_Coast_of_Cent...	watch	initial	000	0	0	15061	1413...
2014-10-14 02:44:2...	4.9	South_Sandwich_I...		terminated	000	8	0	15051	8862...
2014-10-14 02:44:2...	4.9	South_Sandwich_I...		terminated	000	5	0	15041	8862...

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(ADVISORY, WATCH)
________________________________
EL_SALVADOR - ACAJUTLA 13.57N 89.84W 0454Z 14 OCT WATCH
EL_SALVADOR - LA_UNION 13.31N 87.82W 0458Z 14 OCT WATCH
COSTARICA - LOS_SUENOS 9.65N 84.67W 0455Z 14 OCT WATCH
GUATEMALA - PUERTO_BARRIOS 15.69N 88.62W 0503Z 14 OCT WATCH
COSTA_RICA - QUEPOS 9.40N 84.17W 0504Z 14 OCT WATCH
COSTA_RICA - LIMON 10.00N 83.03W 0520Z 14 OCT WATCH
UNKNOWN - DART_32411 5.01N 90.84W 0512Z 14 OCT WATCH
UNKNOWN - DART_43413 11.06N 99.85W 0540Z 14 OCT WATCH
UNKNOWN - DART_32066 1.14S 81.77W 0637Z 14 OCT WATCH
UNKNOWN - DART_43412 16.00N 107.00W 0640Z 14 OCT WATCH
COLOMBIA - SAN_ANDRES 12.57N 81.70W 0515Z 14 OCT WATCH
COLOMBIA - MALPELO 4.00N 81.60W 0549Z 14 OCT WATCH
COLOMBIA - TUMACO 1.82N 78.73W 0655Z 14 OCT WATCH
COLOMBIA - CARTAGENA 10.39N 75.54W 0707Z 14 OCT WATCH
COLOMBIA - SANTA_MARTA 11.24N 74.22W 0707Z 14 OCT WATCH
COLOMBIA - BUENAVENTURA 3.89N 77.08W 0752Z 14 OCT WATCH
MEXICO - PUERTO_MADERO 14.71N 92.40W 0524Z 14 OCT WATCH
```

Sea level Data analysis

IT-TSP

Information provided by Early-Est

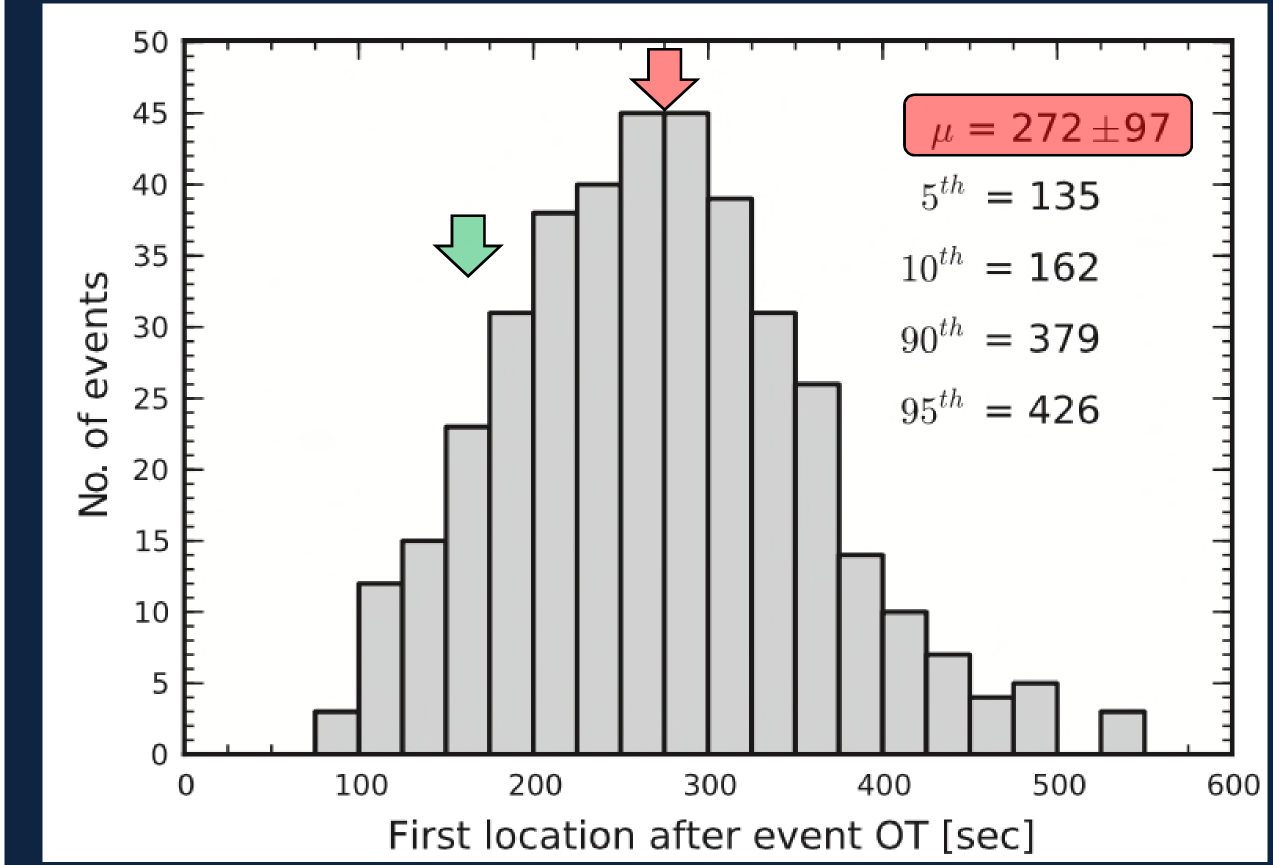
- **Location**
  - **Lon, Lat, Depth**
  - **Non linear probabilistic location (derived from NonLinLoc)**

- **Magnitude*:* mb, Mwp, Mwpd**

Preferred magnitude	**Minimum number of seismic stations**	**Range of validity**
m_b	≥ 6	$M_{wp} < 5.8$
M_{wp}	≥ 6	$5.8 \leq M_{wp} < 7.2$
M_{wpd}	≥ 6	$M_{wp} \geq 7.2$

IT-TSP
Early-Est: performances 1

First location after origin time (globally)

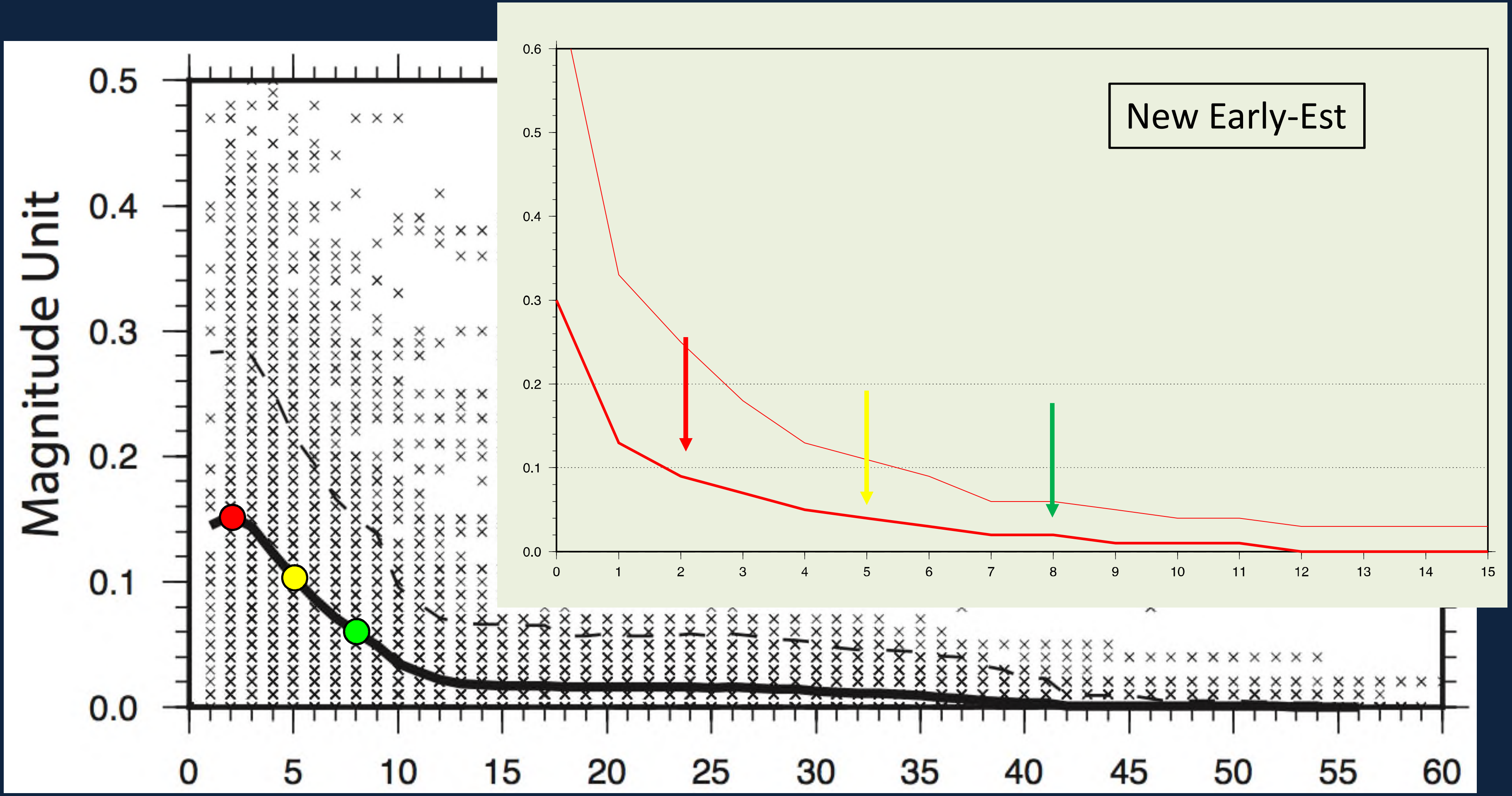


After ~4 minutes on average

After 2-3 minutes in Mediterranean

IT-TSP
Early-Est: performances 2

Errors on magnitude for progressive solutions



Loc. 2: error ~0.15

Loc. 5: error ~0.1

Loc. 8: error ~0.06

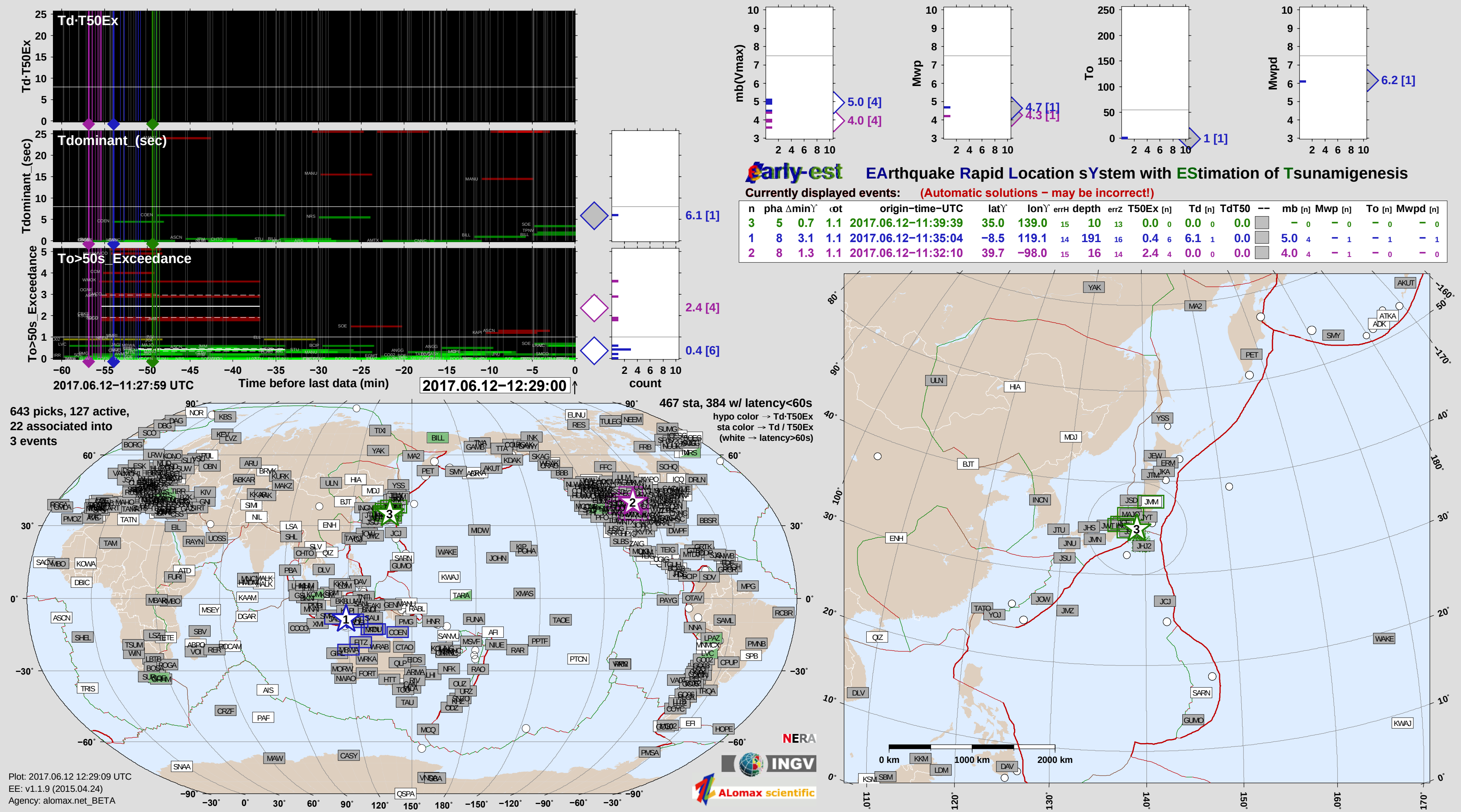
Recent cases

Recent relevant events in the Mediterranean Sea

Origin Time UTC	Location	Mag	Alert Level	Message UTC
16/04/15 18:07	Crete (Greece)	6.4	watch	18:16 (9’)
17/11/15 07:10	Ionian (Greece)	6.5	advisory	07:22 (12’)
25/01/16 04:22	Gibraltar	6.5	advisory	04:33 (11’)
12/6/17 12:28	Greece-Turkey	6.4	advisory	12:38 (10’)
20/7/17 22:31	Turkey-Greece	6.6	watch	22:41 (10’)

IT-TSP

2017/06/12 Aegean Sea M=6.5


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Time before last data (min)
2017.06.12−11:27:59 UTC
2017.06.12−12:29:00
count
6.1 [1]
2.4 [4]
0.4 [6]
mb(Vmax)
5.0 [4]
4.0 [4]
Mwp
4.7 [1]
4.3 [1]
To
1 [1]
Mwpd
6.2 [1]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex	[n]	Td	[n]	TdT50	−−	mb	[n]	Mwp	[n]	To	[n]	Mwpd	[n]
3	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0
1	8	3.1	1.1	2017.06.12−11:35:04	−8.5	119.1	14	191	16	0.4	6	6.1	1	0.0	▨	5.0	4	−	1	−	1	−	1
2	8	1.3	1.1	2017.06.12−11:32:10	39.7	−98.0	15	16	14	2.4	4	0.0	0	0.0	▨	4.0	4	−	1	−	0	−	0

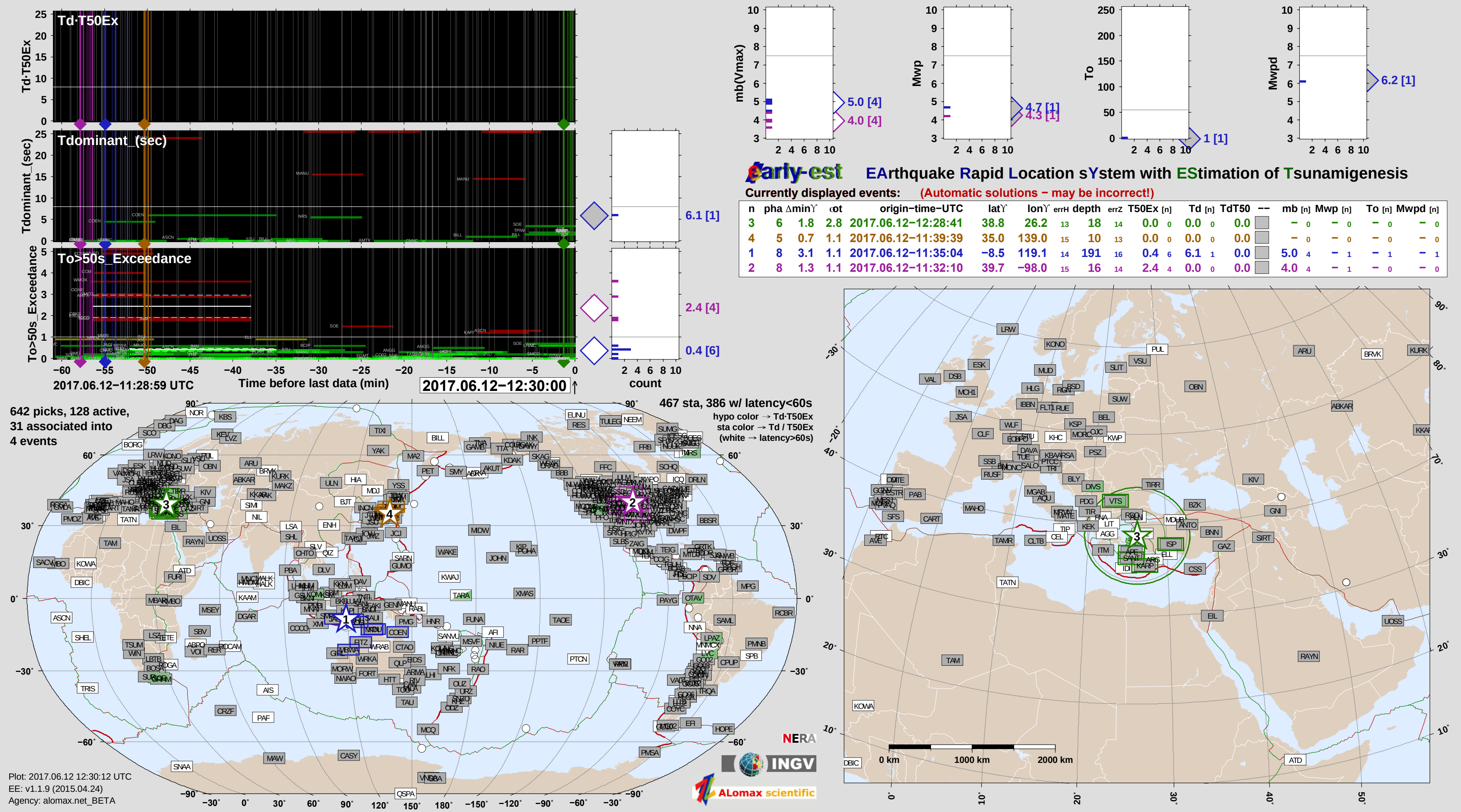
643 picks, 127 active,
22 associated into
3 events

467 sta, 384 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.06.12 12:29:09 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/06/12 Aegean Sea M=6.5


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Time before last data (min)
2017.06.12−11:28:59 UTC
2017.06.12−12:30:00
count
6.1 [1]
2.4 [4]
0.4 [6]
mb(Vmax)
5.0 [4]
4.0 [4]
Mwp
4.7 [1]
4.3 [1]
To
1 [1]
Mwpd
6.2 [1]
642 picks, 128 active,
31 associated into
4 events
467 sta, 386 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

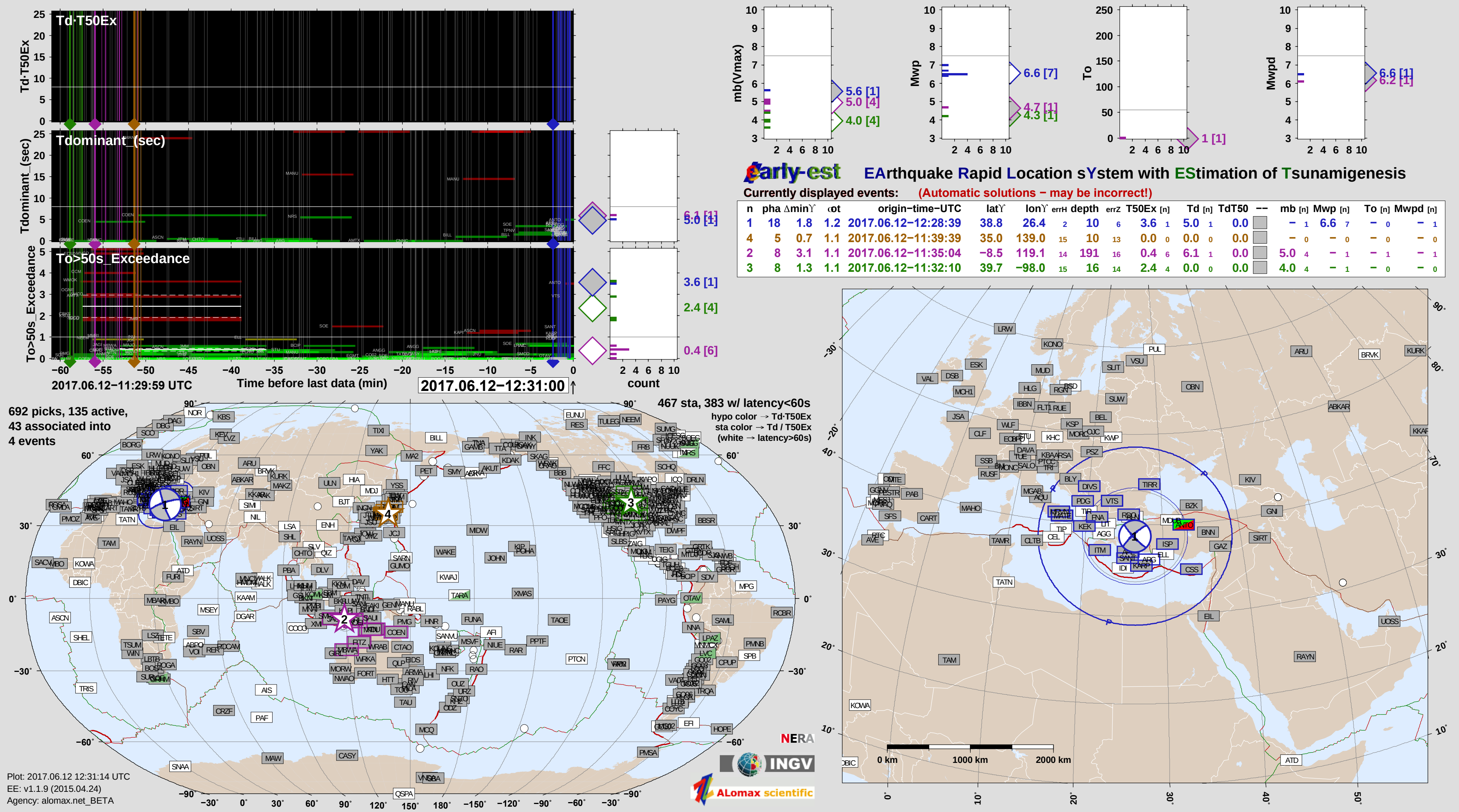
n	pha	ΔminΥ	σot	origin−time−UTC	latΥ	lonΥ	errH	depth	errZ	T50Ex	[n]	Td	[n]	TdT50	−−	mb	[n]	Mwp	[n]	To	[n]	Mwpd	[n]
3	6	1.8	2.8	2017.06.12−12:28:41	38.8	26.2	13	18	14	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0
4	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0
1	8	3.1	1.1	2017.06.12−11:35:04	−8.5	119.1	14	191	16	0.4	6	6.1	1	0.0	▨	5.0	4	−	1	−	1	−	1
2	8	1.3	1.1	2017.06.12−11:32:10	39.7	−98.0	15	16	14	2.4	4	0.0	0	0.0	▨	4.0	4	−	1	−	0	−	0

Plot: 2017.06.12 12:30:12 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

First automatic location after ~2’ from EQ origin time

IT-TSP

2017/06/12 Aegean Sea M=6.5


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Time before last data (min)
2017.06.12−11:29:59 UTC
2017.06.12−12:31:00
count
mb(Vmax)
Mwp
To
Mwpd
5.6 [1]
5.0 [4]
4.0 [4]
6.6 [7]
4.7 [1]
4.3 [1]
1 [1]
6.6 [1]
6.2 [1]
6.1 [1]
5.0 [1]
3.6 [1]
2.4 [4]
0.4 [6]
NERA
INGV
ALomax scientific
0 km
1000 km
2000 km

early-est **EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis**

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex	[n]	Td	[n]	TdT50	−−	mb	[n]	Mwp	[n]	To	[n]	Mwpd	[n]
1	18	1.8	1.2	2017.06.12−12:28:39	38.8	26.4	2	10	6	3.6	1	5.0	1	0.0	▨	−	1	6.6	7	−	0	−	1
4	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0
2	8	3.1	1.1	2017.06.12−11:35:04	−8.5	119.1	14	191	16	0.4	6	6.1	1	0.0	▨	5.0	4	−	1	−	1	−	1
3	8	1.3	1.1	2017.06.12−11:32:10	39.7	−98.0	15	16	14	2.4	4	0.0	0	0.0	▨	4.0	4	−	1	−	0	−	0

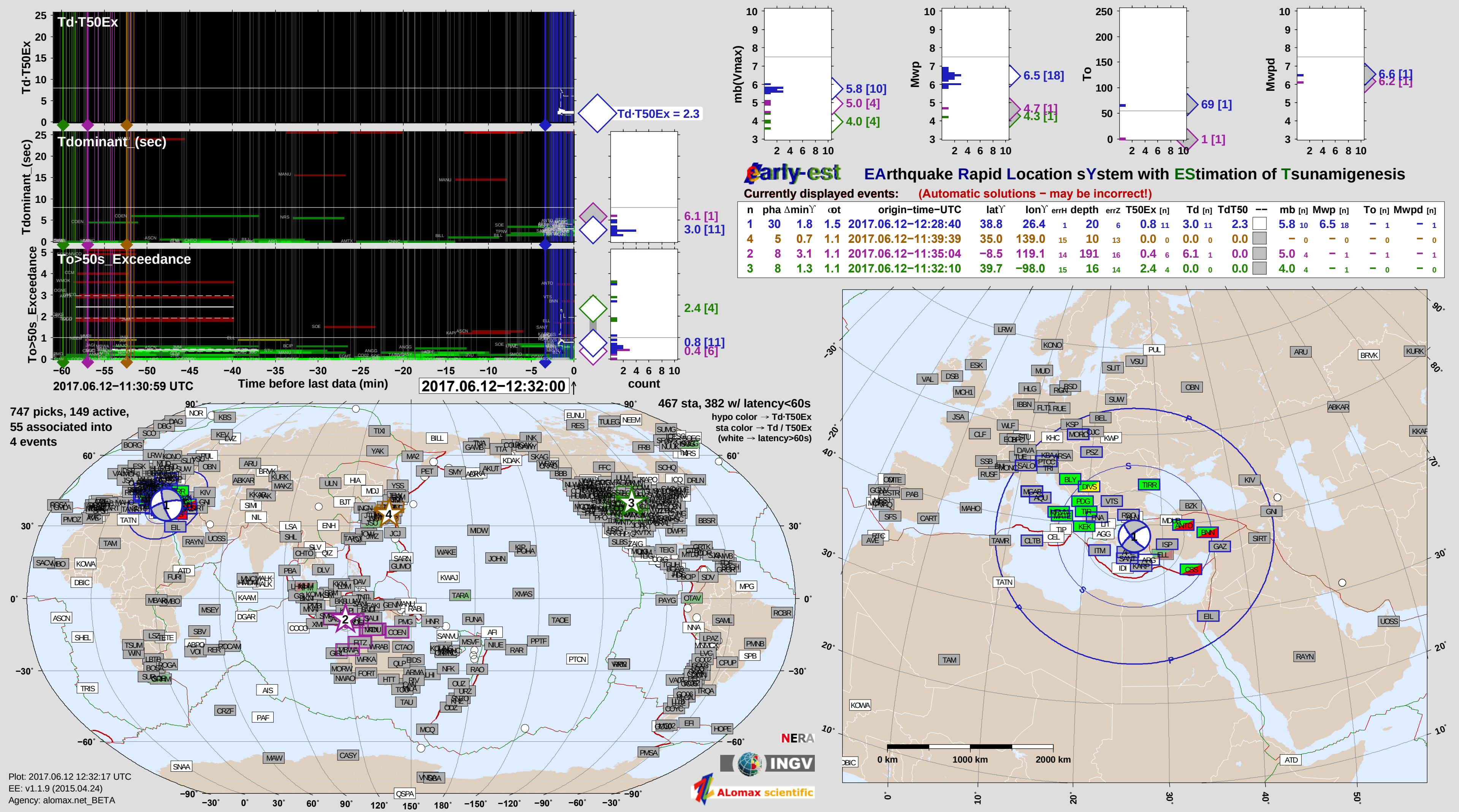
692 picks, 135 active,
43 associated into
4 events

467 sta, 383 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.06.12 12:31:14 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/06/12 Aegean Sea M=6.5


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 2.3
6.1 [1]
3.0 [11]
2.4 [4]
0.8 [11]
0.4 [6]
Time before last data (min)
2017.06.12−11:30:59 UTC
2017.06.12−12:32:00
count
mb(Vmax)
5.8 [10]
5.0 [4]
4.0 [4]
Mwp
6.5 [18]
4.7 [1]
4.3 [1]
To
69 [1]
1 [1]
Mwpd
6.6 [1]
6.2 [1]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex	[n]	Td	[n]	TdT50	--	mb	[n]	Mwp	[n]	To	[n]	Mwpd	[n]
1	30	1.8	1.5	2017.06.12−12:28:40	38.8	26.4	1	20	6	0.8	11	3.0	11	2.3	☐	5.8	10	6.5	18	−	1	−	1
4	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0
2	8	3.1	1.1	2017.06.12−11:35:04	−8.5	119.1	14	191	16	0.4	6	6.1	1	0.0	▨	5.0	4	−	1	−	1	−	1
3	8	1.3	1.1	2017.06.12−11:32:10	39.7	−98.0	15	16	14	2.4	4	0.0	0	0.0	▨	4.0	4	−	1	−	0	−	0

747 picks, 149 active,
55 associated into
4 events

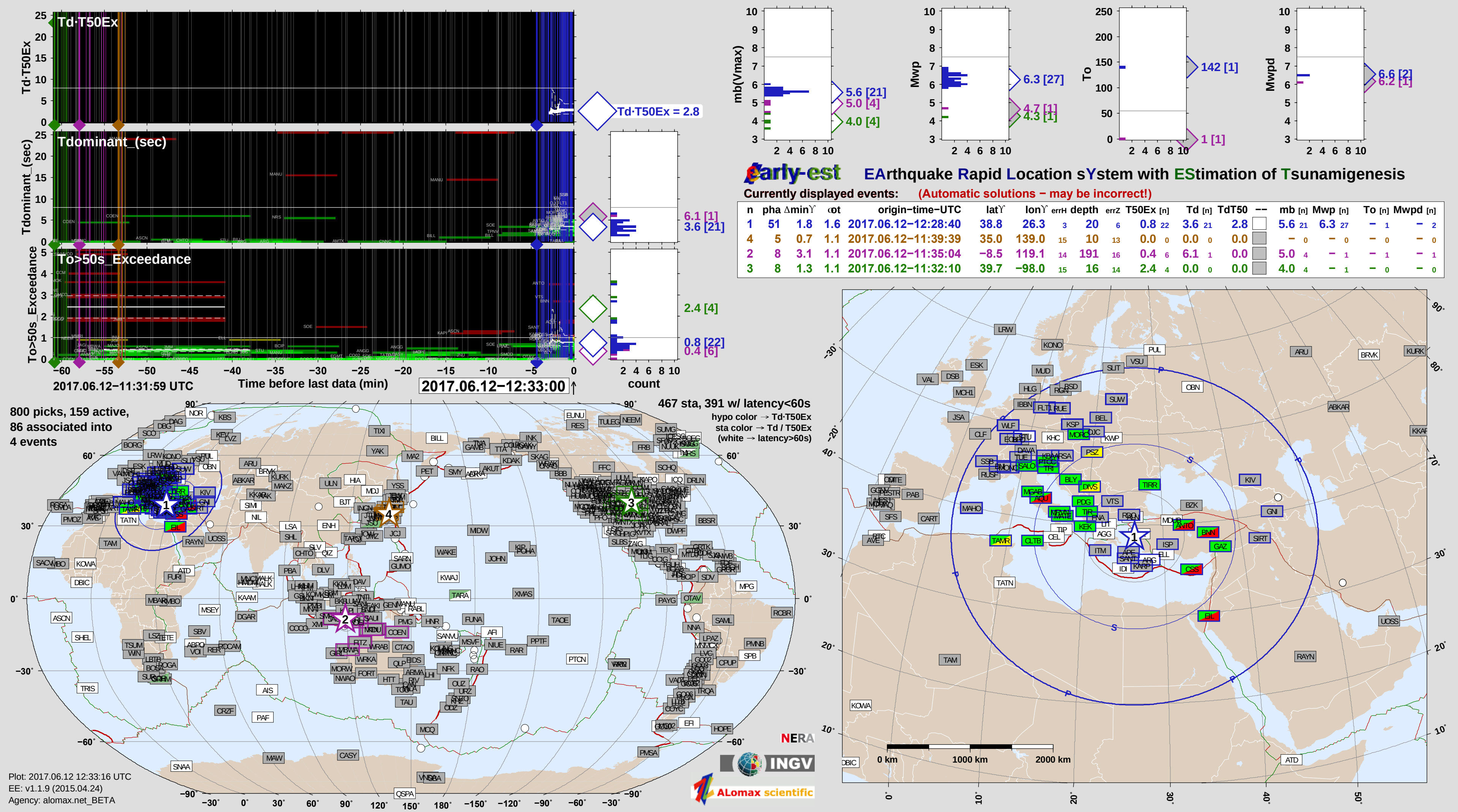
467 sta, 382 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.06.12 12:32:17 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

Location no. 2 ~ 4’ after Origin time - M 6.5

IT-TSP

2017/06/12 Aegean Sea M=6.5



Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 2.8
6.1 [1]
3.6 [21]
2.4 [4]
0.8 [22]
0.4 [6]
2017.06.12−11:31:59 UTC
Time before last data (min)
2017.06.12−12:33:00
count
mb(Vmax)
5.6 [21]
5.0 [4]
4.0 [4]
Mwp
6.3 [27]
4.7 [1]
4.3 [1]
To
142 [1]
1 [1]
Mwpd
6.6 [2]
6.2 [1]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δminϒ	σot	origin−time−UTC	latϒ	lonϒ	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	−−	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	51	1.8	1.6	2017.06.12−12:28:40	38.8	26.3	3	20	6	0.8	22	3.6	21	2.8	☐	5.6	21	6.3	27	−	1	−	2
4	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0
2	8	3.1	1.1	2017.06.12−11:35:04	−8.5	119.1	14	191	16	0.4	6	6.1	1	0.0	▨	5.0	4	−	1	−	1	−	1
3	8	1.3	1.1	2017.06.12−11:32:10	39.7	−98.0	15	16	14	2.4	4	0.0	0	0.0	▨	4.0	4	−	1	−	0	−	0

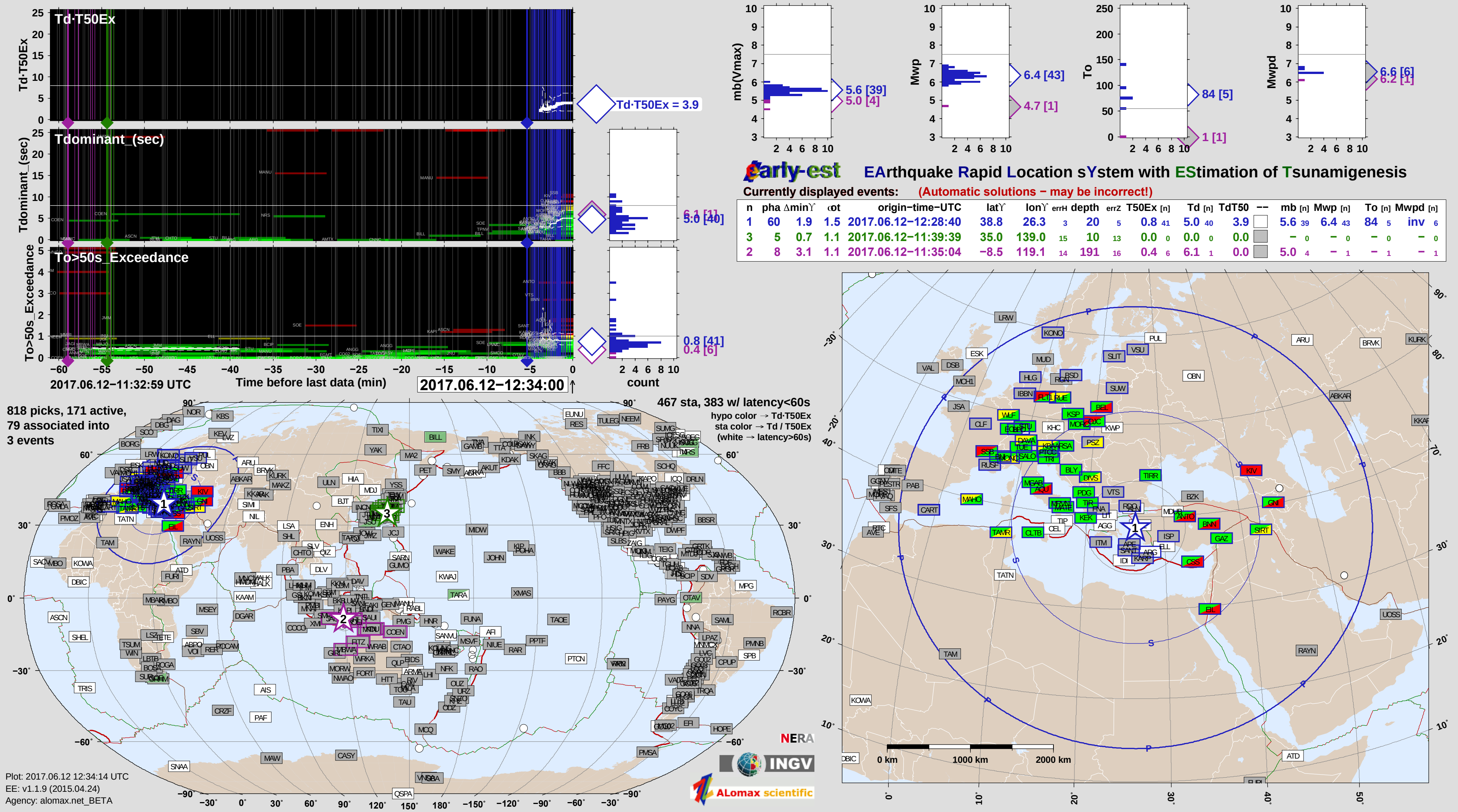
800 picks, 159 active,
86 associated into
4 events

467 sta, 391 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.06.12 12:33:16 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/06/12 Aegean Sea M=6.5


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 3.9
6.1 [1]
5.0 [40]
0.8 [41]
0.4 [6]
−60 −55 −50 −45 −40 −35 −30 −25 −20 −15 −10 −5 0
2017.06.12−11:32:59 UTC
Time before last data (min)
2017.06.12−12:34:00
2 4 6 8 10
count
mb(Vmax)
5.6 [39]
5.0 [4]
Mwp
6.4 [43]
4.7 [1]
To
84 [5]
1 [1]
Mwpd
6.6 [6]
6.2 [1]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	ΔminΥ	σot	origin−time−UTC	latΥ	lonΥ	errH	depth	errZ	T50Ex	[n]	Td	[n]	TdT50	−−	mb	[n]	Mwp	[n]	To	[n]	Mwpd	[n]
1	60	1.9	1.5	2017.06.12−12:28:40	38.8	26.3	3	20	5	0.8	41	5.0	40	3.9	☐	5.6	39	6.4	43	84	5	inv	6
3	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0
2	8	3.1	1.1	2017.06.12−11:35:04	−8.5	119.1	14	191	16	0.4	6	6.1	1	0.0	▨	5.0	4	−	1	−	1	−	1

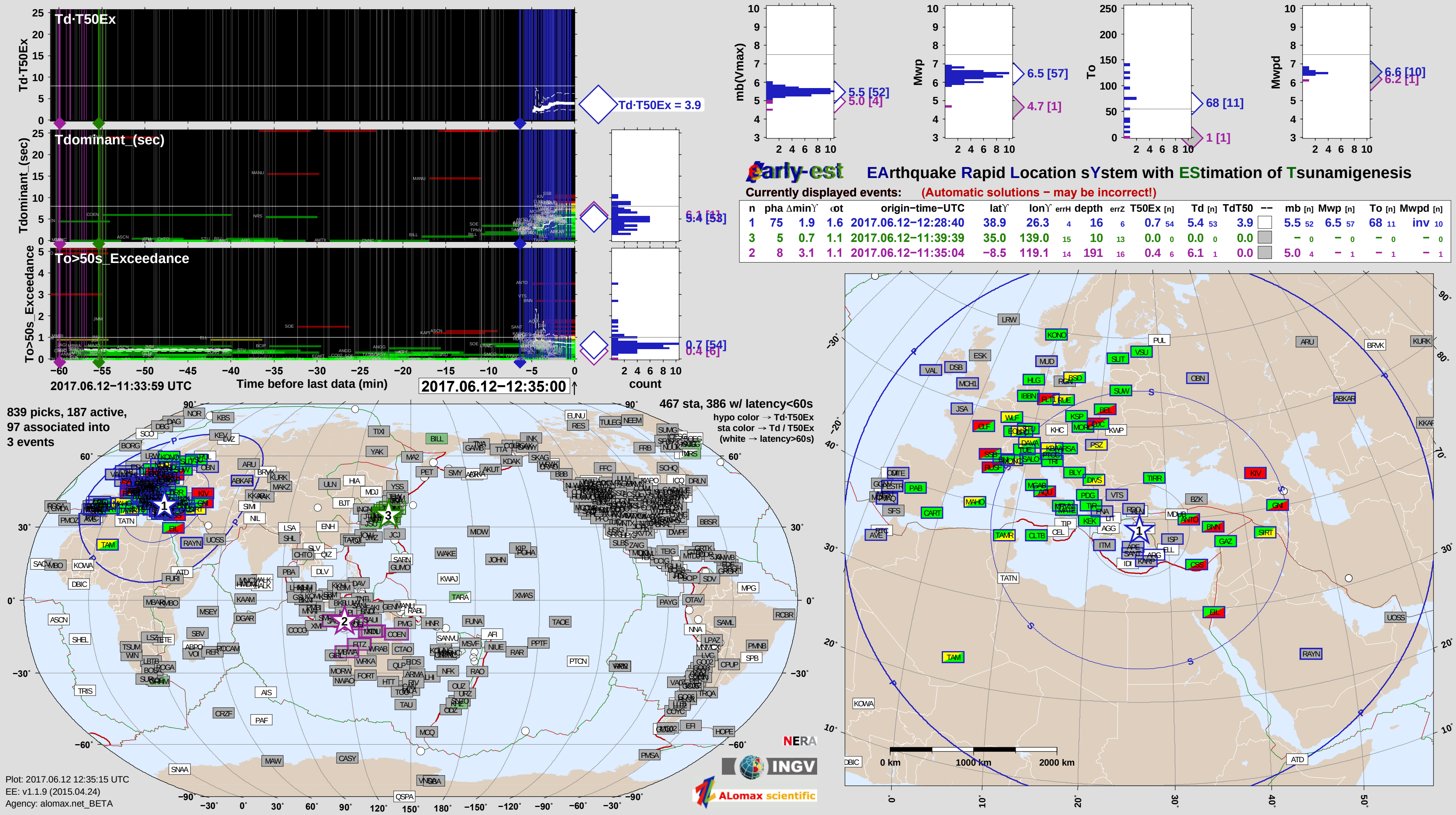
818 picks, 171 active,
79 associated into
3 events

467 sta, 383 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.06.12 12:34:14 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/06/12 Aegean Sea M=6.5


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 3.9
5.4 [53]
6.1 [1]
0.7 [54]
0.4 [6]
Time before last data (min)
2017.06.12−11:33:59 UTC
2017.06.12−12:35:00
count
mb(Vmax)
5.5 [52]
5.0 [4]
Mwp
6.5 [57]
4.7 [1]
To
68 [11]
1 [1]
Mwpd
6.6 [10]
6.2 [1]
839 picks, 187 active,
97 associated into
3 events
467 sta, 386 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	−−	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	75	1.9	1.6	2017.06.12−12:28:40	38.9	26.3	4	16	6	0.7	54	5.4	53	3.9	☐	5.5	52	6.5	57	68	11	inv	10
3	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0
2	8	3.1	1.1	2017.06.12−11:35:04	−8.5	119.1	14	191	16	0.4	6	6.1	1	0.0	▨	5.0	4	−	1	−	1	−	1

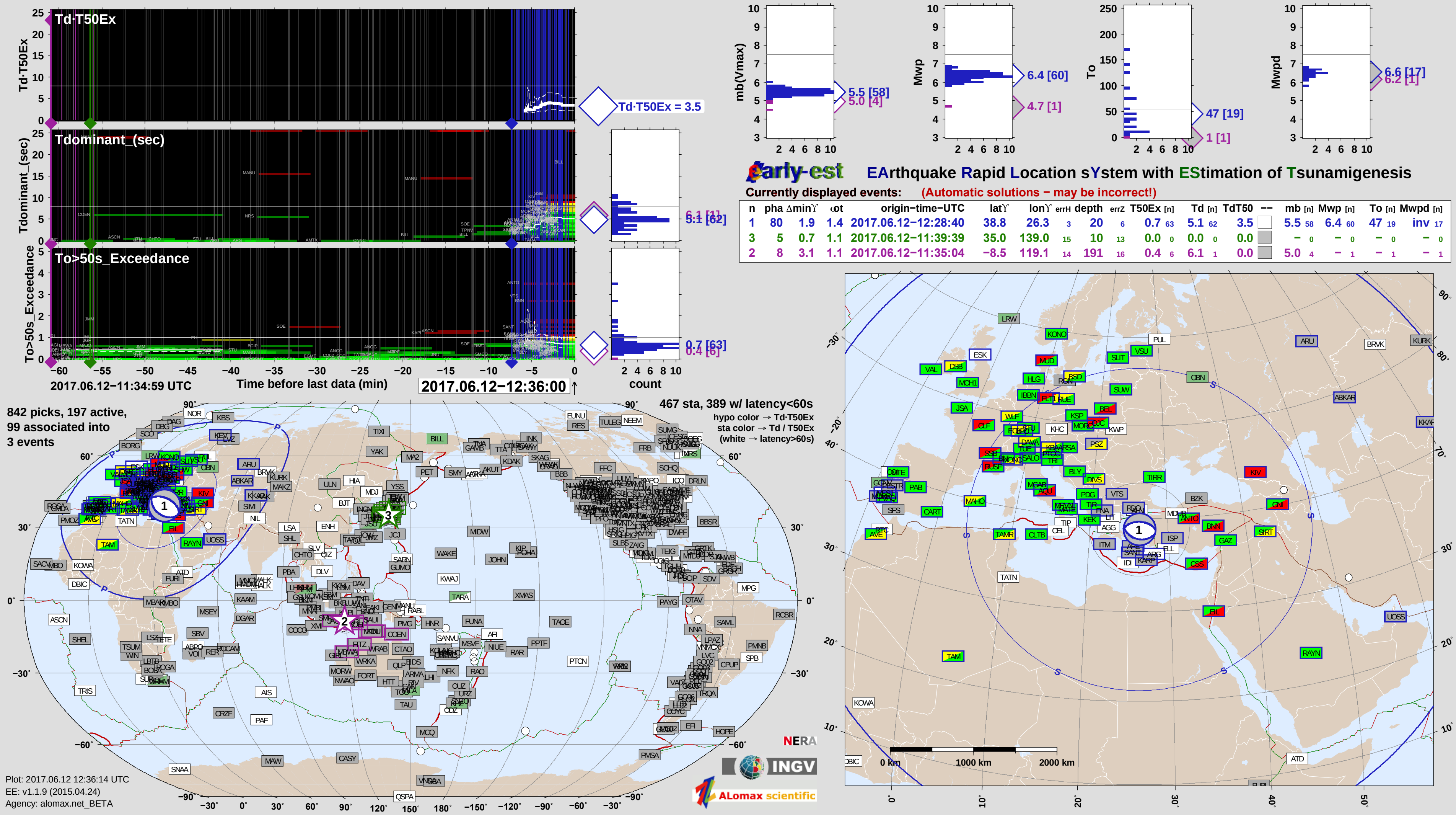
Plot: 2017.06.12 12:35:15 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

5

Location no. 5 ~ 7’ after Origin time - M6.5

IT-TSP

2017/06/12 Aegean Sea M=6.5



early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex	[n]	Td	[n]	TdT50	--	mb	[n]	Mwp	[n]	To	[n]	Mwpd	[n]
1	80	1.9	1.4	2017.06.12−12:28:40	38.8	26.3	3	20	6	0.7	63	5.1	62	3.5	☐	5.5	58	6.4	60	47	19	inv	17
3	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0
2	8	3.1	1.1	2017.06.12−11:35:04	−8.5	119.1	14	191	16	0.4	6	6.1	1	0.0	▨	5.0	4	−	1	−	1	−	1

842 picks, 197 active, 99 associated into 3 events

467 sta, 389 w/ latency<60s

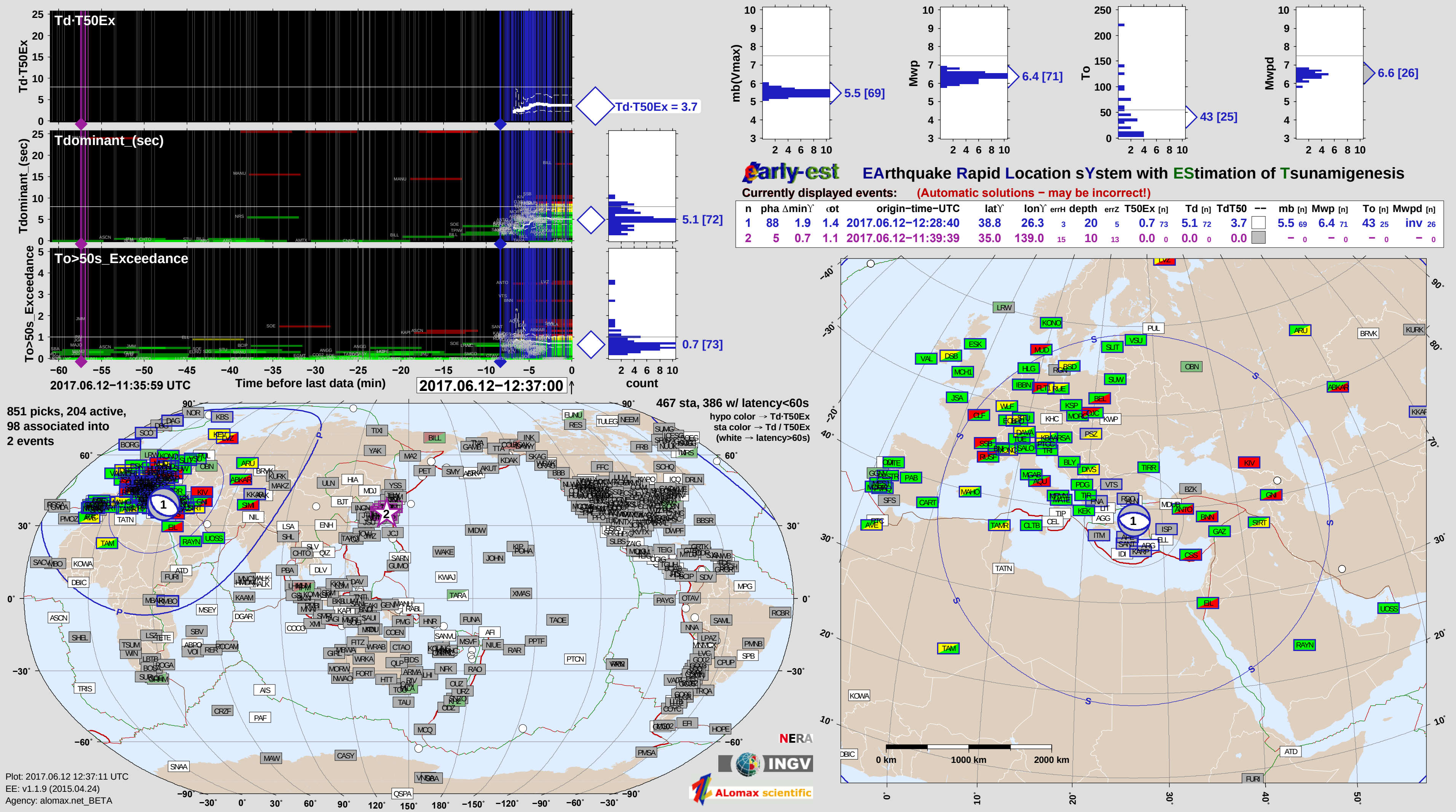
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.06.12 12:36:14 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 3.5
6.1 [1]
5.1 [62]
0.7 [63]
0.4 [6]
2017.06.12−11:34:59 UTC
Time before last data (min)
2017.06.12−12:36:00
count
mb(Vmax)
5.5 [58]
5.0 [4]
Mwp
6.4 [60]
4.7 [1]
To
47 [19]
1 [1]
Mwpd
6.6 [17]
6.2 [1]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

IT-TSP

2017/06/12 Aegean Sea M=6.5


Td·T50Ex
Td·T50Ex
Td·T50Ex = 3.7
Tdominant_(sec)
Tdominant_(sec)
5.1 [72]
To>50s_Exceedance
To>50s_Exceedance
0.7 [73]
−60 −55 −50 −45 −40 −35 −30 −25 −20 −15 −10 −5 0
Time before last data (min)
2 4 6 8 10
count
mb(Vmax)
5.5 [69]
Mwp
6.4 [71]
To
43 [25]
Mwpd
6.6 [26]
early-est
EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis
1000 km
2000 km
NERA
INGV
ALomax scientific

2017.06.12−11:35:59 UTC

2017.06.12−12:37:00

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	ΔminΥ	σot	origin−time−UTC	latΥ	lonΥ	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	−−	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	88	1.9	1.4	2017.06.12−12:28:40	38.8	26.3	3	20	5	0.7	73	5.1	72	3.7	☐	5.5	69	6.4	71	43	25	inv	26
2	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0

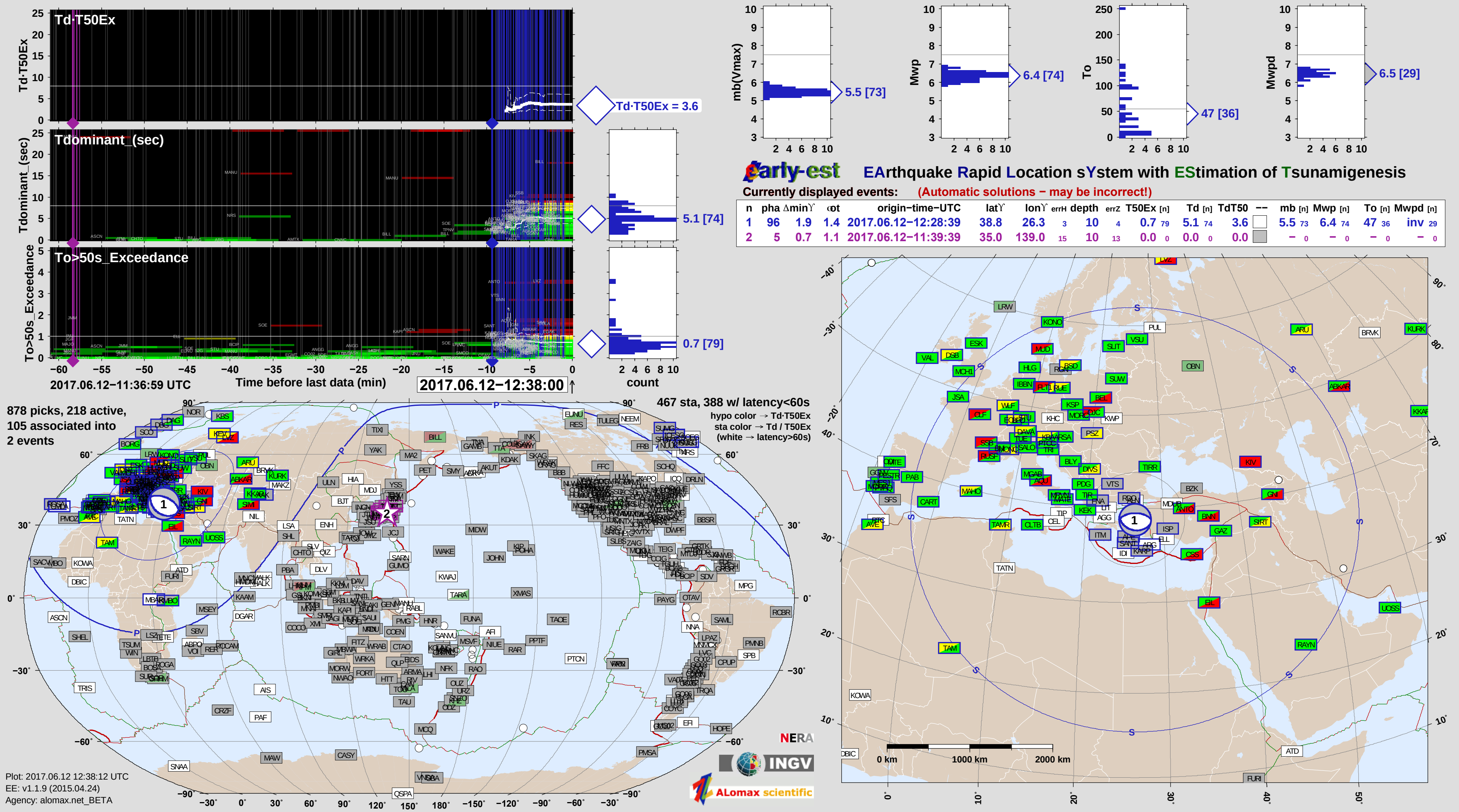
851 picks, 204 active,
98 associated into
2 events

467 sta, 386 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.06.12 12:37:11 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/06/12 Aegean Sea M=6.5


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 3.6
5.1 [74]
0.7 [79]
2017.06.12−11:36:59 UTC
Time before last data (min)
2017.06.12−12:38:00
count
mb(Vmax)
5.5 [73]
Mwp
6.4 [74]
To
47 [36]
Mwpd
6.5 [29]
878 picks, 218 active,
105 associated into
2 events
467 sta, 388 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)
Plot: 2017.06.12 12:38:12 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA
NERA
INGV
ALomax scientific
0 km
1000 km
2000 km

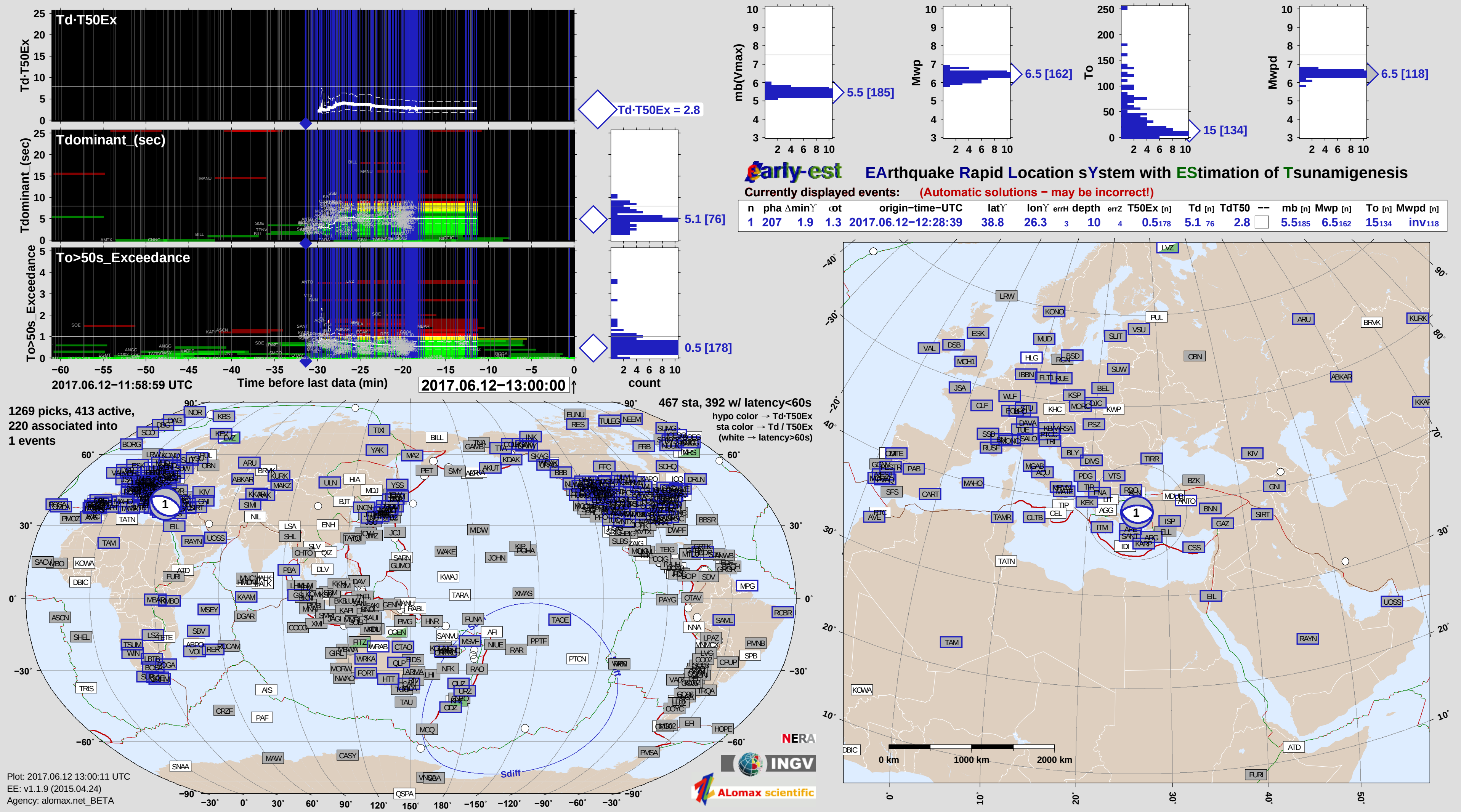
early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	ΔminΥ	ꝏt	origin−time−UTC	latΥ	lonΥ	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	−−	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	96	1.9	1.4	2017.06.12−12:28:39	38.8	26.3	3	10	4	0.7	79	5.1	74	3.6	☐	5.5	73	6.4	74	47	36	inv	29
2	5	0.7	1.1	2017.06.12−11:39:39	35.0	139.0	15	10	13	0.0	0	0.0	0	0.0	▨	−	0	−	0	−	0	−	0

IT-TSP

2017/06/12 Aegean Sea M=6.5



Early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	ΔminΥ	σot	origin−time−UTC	latΥ	lonΥ	errH	depth	errZ	T50Ex [n]	Td [n]	TdT50	--	mb [n]	Mwp [n]	To [n]	Mwpd [n]
1	207	1.9	1.3	2017.06.12−12:28:39	38.8	26.3	3	10	4	0.5_{178}	5.1 76	2.8	☐	5.5_{185}	6.5_{162}	15_{134}	inv_{118}

1269 picks, 413 active,
220 associated into
1 events

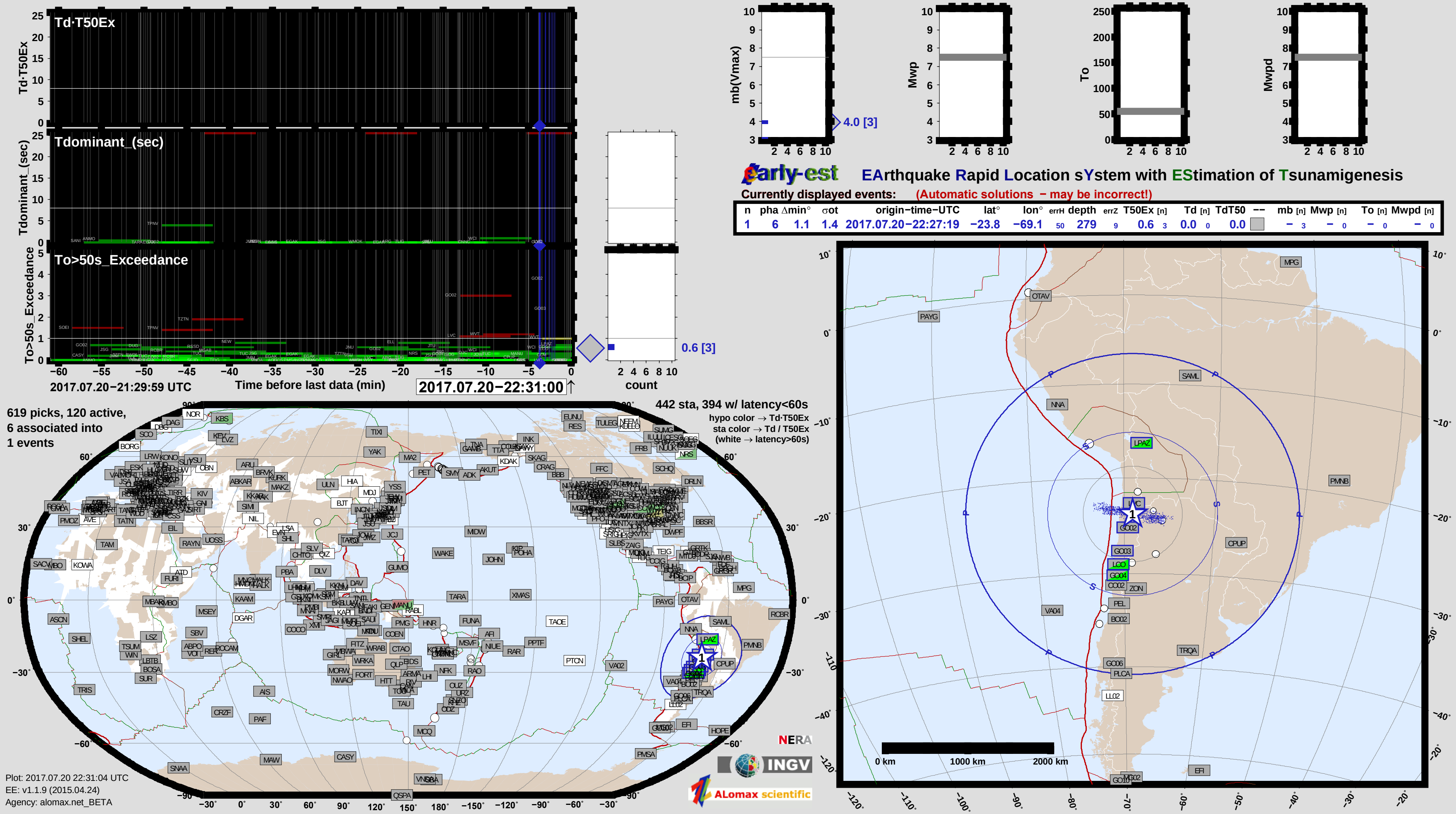
467 sta, 392 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.06.12 13:00:11 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 2.8
5.1 [76]
0.5 [178]
−60 −55 −50 −45 −40 −35 −30 −25 −20 −15 −10 −5 0
2017.06.12−11:58:59 UTC
Time before last data (min)
2017.06.12−13:00:00
count
mb(Vmax)
5.5 [185]
Mwp
6.5 [162]
To
15 [134]
Mwpd
6.5 [118]
0 km 1000 km 2000 km
Sdiff
NERA
INGV
ALomax scientific

IT-TSP

2017/07/20 Bodrum-Kos M=6.6


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Time before last data (min)
2017.07.20−21:29:59 UTC
2017.07.20−22:31:00
count
4.0 [3]
0.6 [3]
mb(Vmax)
Mwp
To
Mwpd
442 sta, 394 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	--	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	6	1.1	1.4	2017.07.20−22:27:19	−23.8	−69.1	50	279	9	0.6	3	0.0	0	0.0	▨	−	3	−	0	−	0	−	0

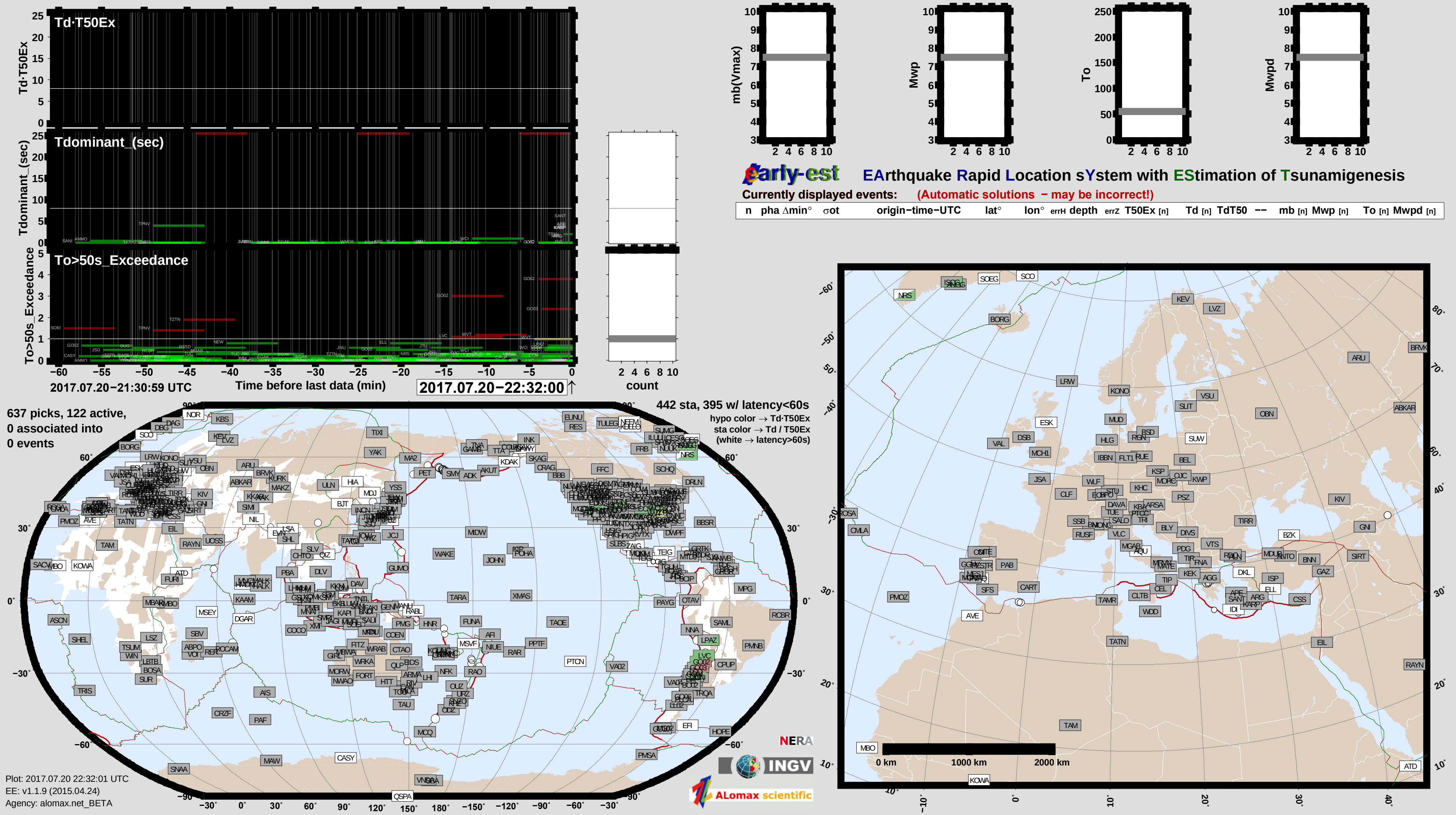
619 picks, 120 active,
6 associated into
1 events

Plot: 2017.07.20 22:31:04 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

-2

IT-TSP

2017/07/20 Bodrum-Kos M=6.6


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Time before last data (min)
2017.07.20−21:30:59 UTC
2017.07.20−22:32:00
count
mb(Vmax)
Mwp
To
Mwpd
early-est
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n pha Δmin° σot origin−time−UTC lat° lon° errH depth errZ T50Ex [n] Td [n] TdT50 −− mb [n] Mwp [n] To [n] Mwpd [n]

637 picks, 122 active,
0 associated into
0 events

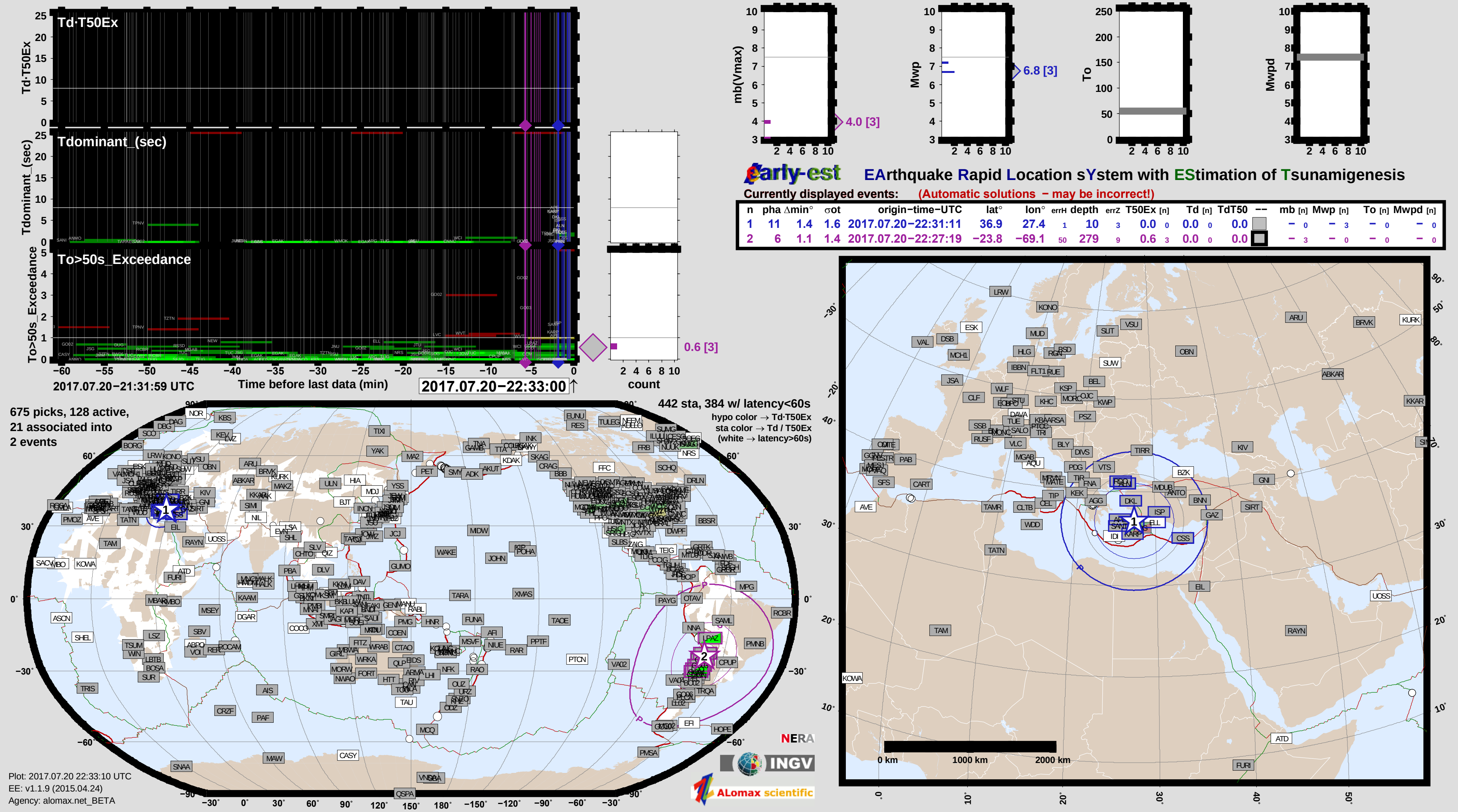
442 sta, 395 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.07.20 22:32:01 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

-1

IT-TSP

2017/07/20 Bodrum-Kos M=6.6


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Time before last data (min)
2017.07.20−21:31:59 UTC
2017.07.20−22:33:00
count
0.6 [3]
4.0 [3]
6.8 [3]
mb(Vmax)
Mwp
To
Mwpd
early-est
NERA
INGV
ALomax scientific
0 km
1000 km
2000 km

EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex	[n]	Td	[n]	TdT50	−−	mb	[n]	Mwp	[n]	To	[n]	Mwpd	[n]
1	11	1.4	1.6	2017.07.20−22:31:11	36.9	27.4	1	10	3	0.0	0	0.0	0	0.0	▨	−	0	−	3	−	0	−	0
2	6	1.1	1.4	2017.07.20−22:27:19	−23.8	−69.1	50	279	9	0.6	3	0.0	0	0.0	▣	−	3	−	0	−	0	−	0

675 picks, 128 active,
21 associated into
2 events

442 sta, 384 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

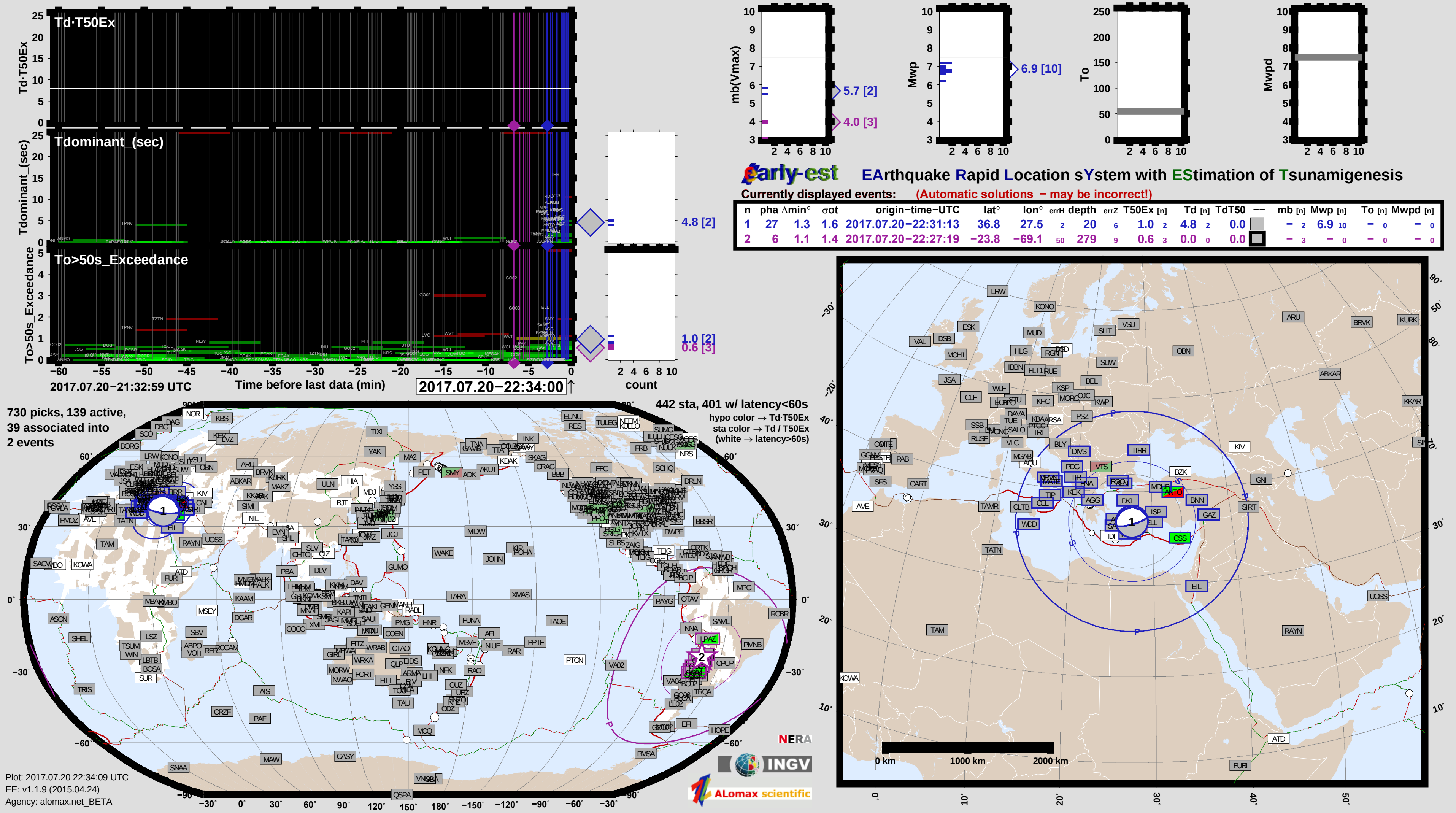
Plot: 2017.07.20 22:33:10 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

0

First automatic location and Mwp after ~2’ from EQ origin time

IT-TSP

2017/07/20 Bodrum-Kos M=6.6


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Time before last data (min)
2017.07.20−21:32:59 UTC
2017.07.20−22:34:00
count
4.8 [2]
1.0 [2]
0.6 [3]
mb(Vmax)
5.7 [2]
4.0 [3]
Mwp
6.9 [10]
To
Mwpd
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	−−	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	27	1.3	1.6	2017.07.20−22:31:13	36.8	27.5	2	20	6	1.0	2	4.8	2	0.0	▢	−	2	6.9	10	−	0	−	0
2	6	1.1	1.4	2017.07.20−22:27:19	−23.8	−69.1	50	279	9	0.6	3	0.0	0	0.0	▣	−	3	−	0	−	0	−	0

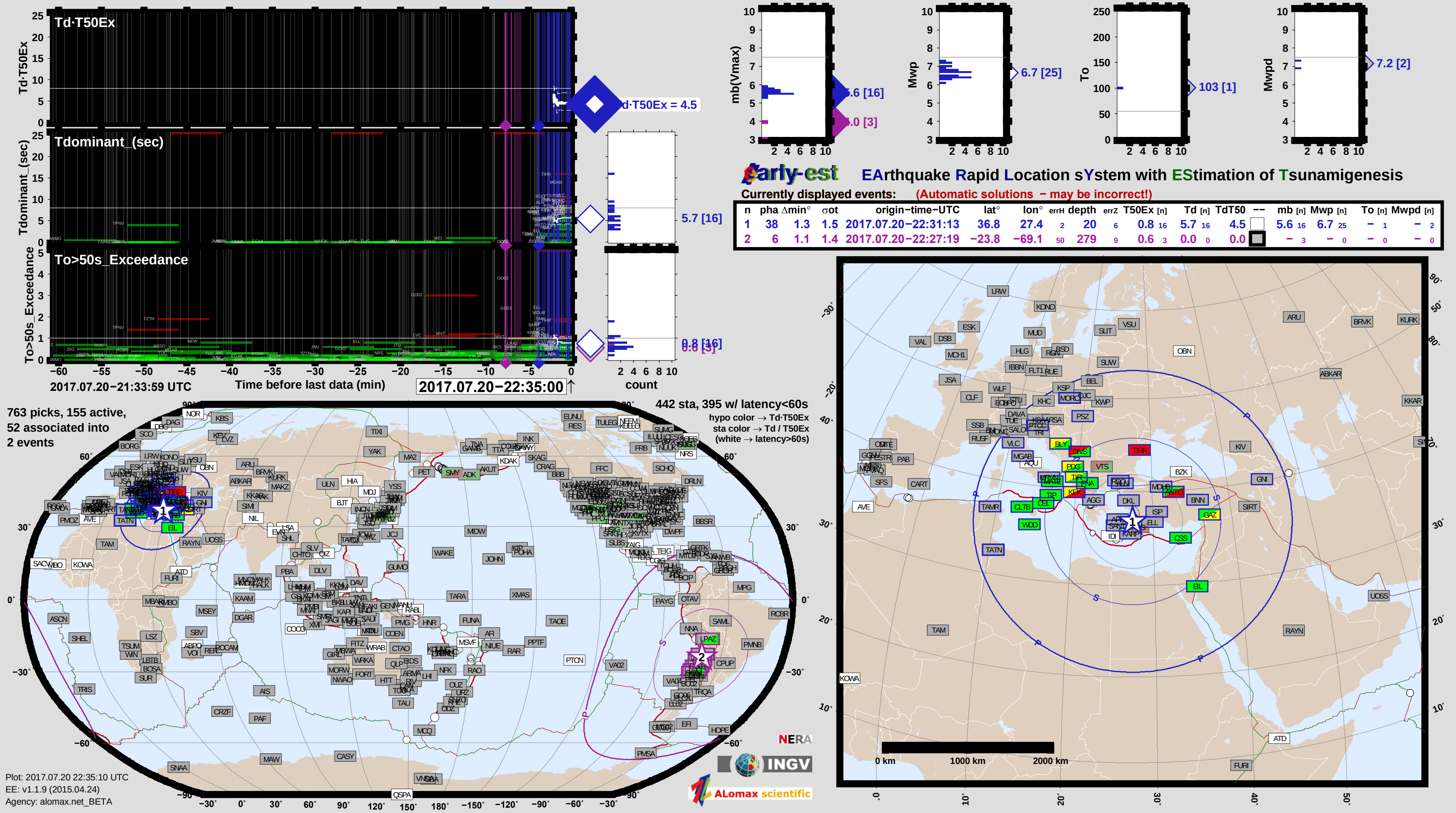
730 picks, 139 active,
39 associated into
2 events

442 sta, 401 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.07.20 22:34:09 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/07/20 Bodrum-Kos M=6.6



Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 4.5
5.7 [16]
0.8 [16]
0.8 [3]
2017.07.20−21:33:59 UTC
Time before last data (min)
2017.07.20−22:35:00
count
mb(Vmax)
5.6 [16]
4.0 [3]
Mwp
6.7 [25]
To
103 [1]
Mwpd
7.2 [2]
442 sta, 395 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)
NERA
INGV
ALomax scientific
0 km
1000 km
2000 km

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	−−	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	38	1.3	1.5	2017.07.20−22:31:13	36.8	27.4	2	20	6	0.8	16	5.7	16	4.5	☐	5.6	16	6.7	25	−	1	−	2
2	6	1.1	1.4	2017.07.20−22:27:19	−23.8	−69.1	50	279	9	0.6	3	0.0	0	0.0	▨	−	3	−	0	−	0	−	0

763 picks, 155 active,
52 associated into
2 events

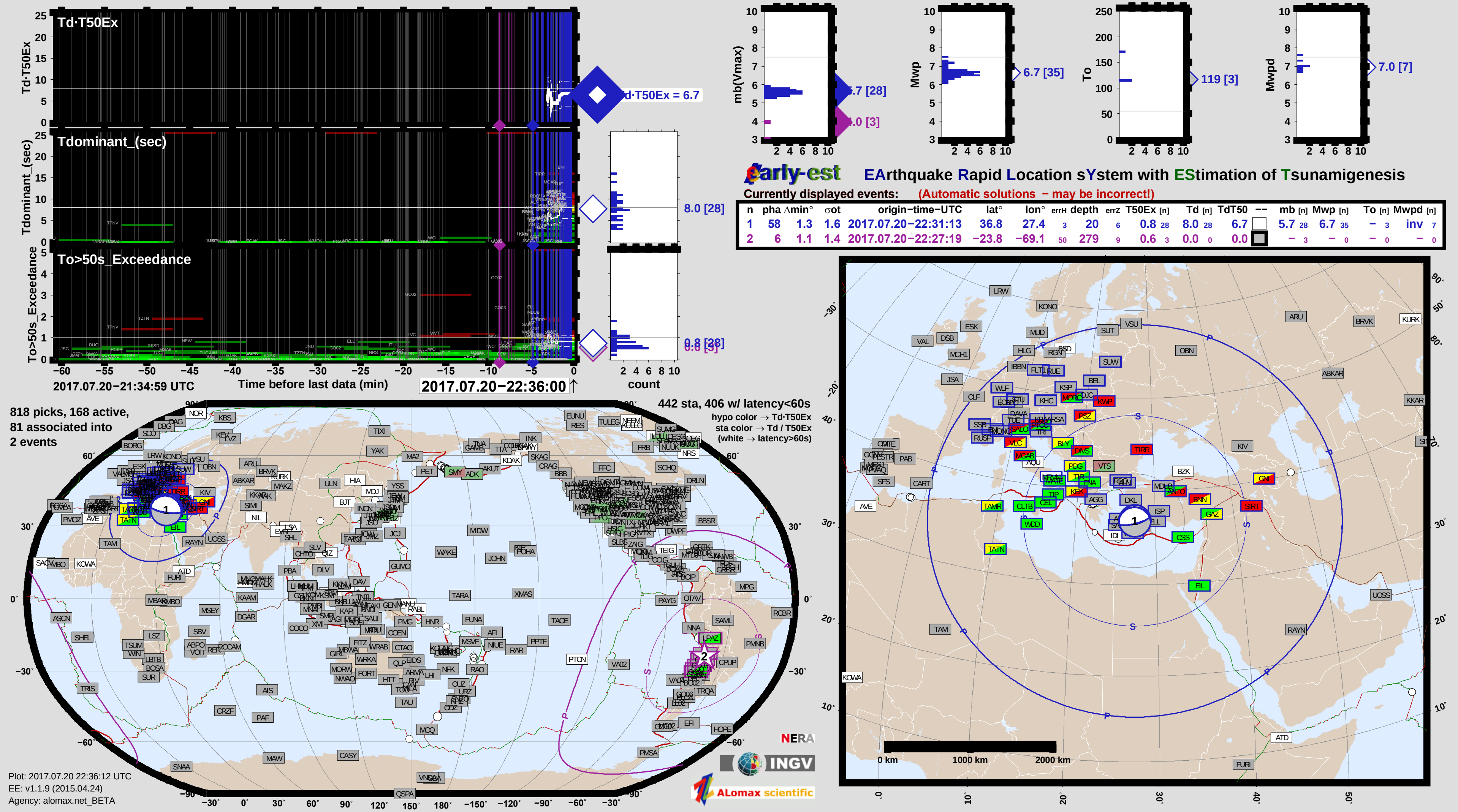
Plot: 2017.07.20 22:35:10 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

2

Location no. 2 Mwp after ~4’

IT-TSP

2017/07/20 Bodrum-Kos M=6.6



Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 6.7
8.0 [28]
0.8 [28]
0.0 [3]
Time before last data (min)
2017.07.20−21:34:59 UTC
2017.07.20−22:36:00
count
mb(Vmax)
6.7 [28]
4.0 [3]
Mwp
6.7 [35]
To
119 [3]
Mwpd
7.0 [7]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est **EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis**

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex	[n]	Td	[n]	TdT50	−−	mb	[n]	Mwp	[n]	To	[n]	Mwpd	[n]
1	58	1.3	1.6	2017.07.20−22:31:13	36.8	27.4	3	20	6	0.8	28	8.0	28	6.7	☐	5.7	28	6.7	35	−	3	inv	7
2	6	1.1	1.4	2017.07.20−22:27:19	−23.8	−69.1	50	279	9	0.6	3	0.0	0	0.0	■	−	3	−	0	−	0	−	0

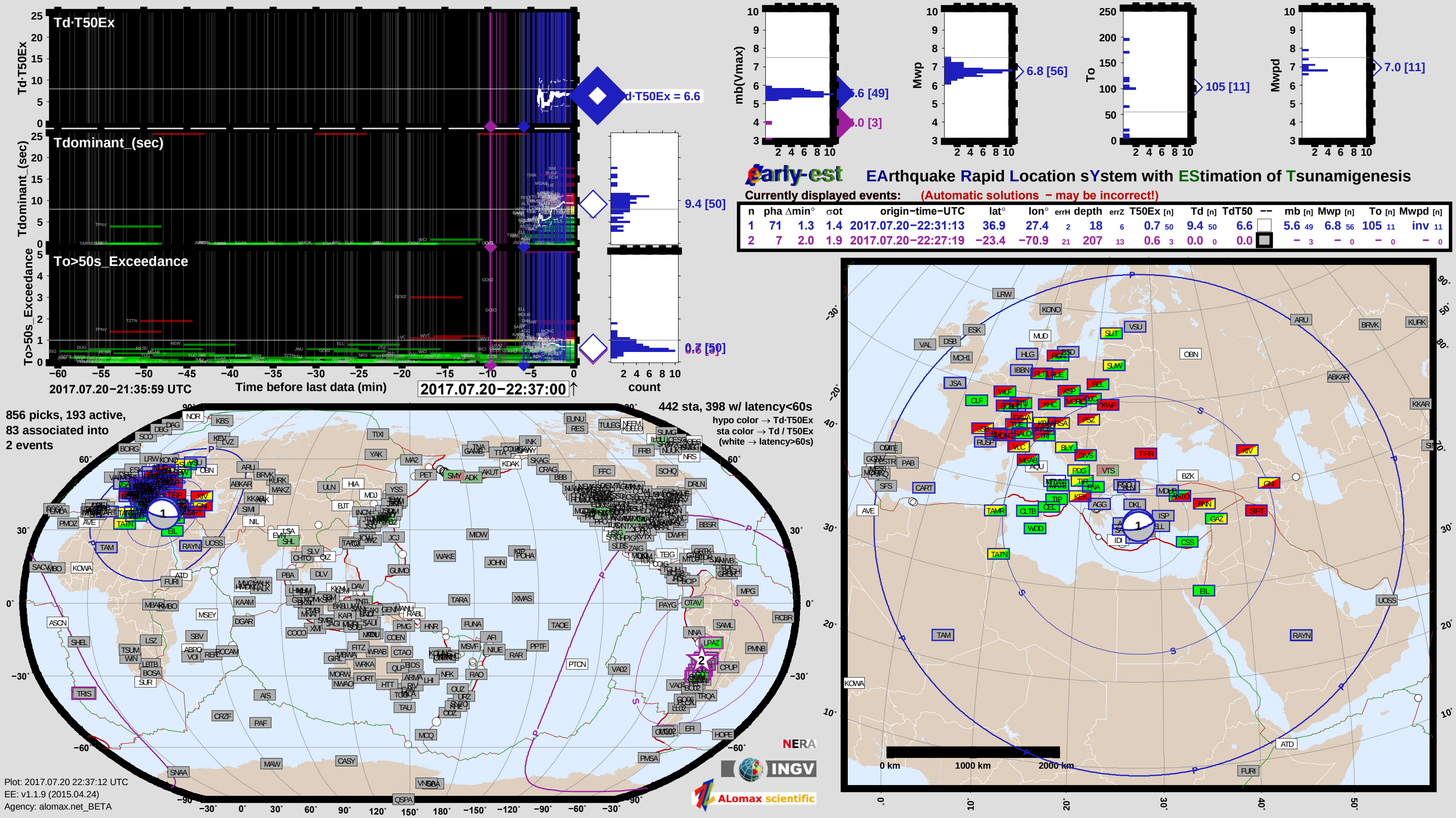
818 picks, 168 active,
81 associated into
2 events

442 sta, 406 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.07.20 22:36:12 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/07/20 Bodrum-Kos M=6.6



Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Time before last data (min)
2017.07.20−21:35:59 UTC
2017.07.20−22:37:00
Td·T50Ex = 6.6
9.4 [50]
0.7 [50]
count
mb(Vmax)
5.6 [49]
4.0 [3]
Mwp
6.8 [56]
To
105 [11]
Mwpd
7.0 [11]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	−−	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	71	1.3	1.4	2017.07.20−22:31:13	36.9	27.4	2	18	6	0.7	50	9.4	50	6.6	☐	5.6	49	6.8	56	105	11	inv	11
2	7	2.0	1.9	2017.07.20−22:27:19	−23.4	−70.9	21	207	13	0.6	3	0.0	0	0.0	■	−	3	−	0	−	0	−	0

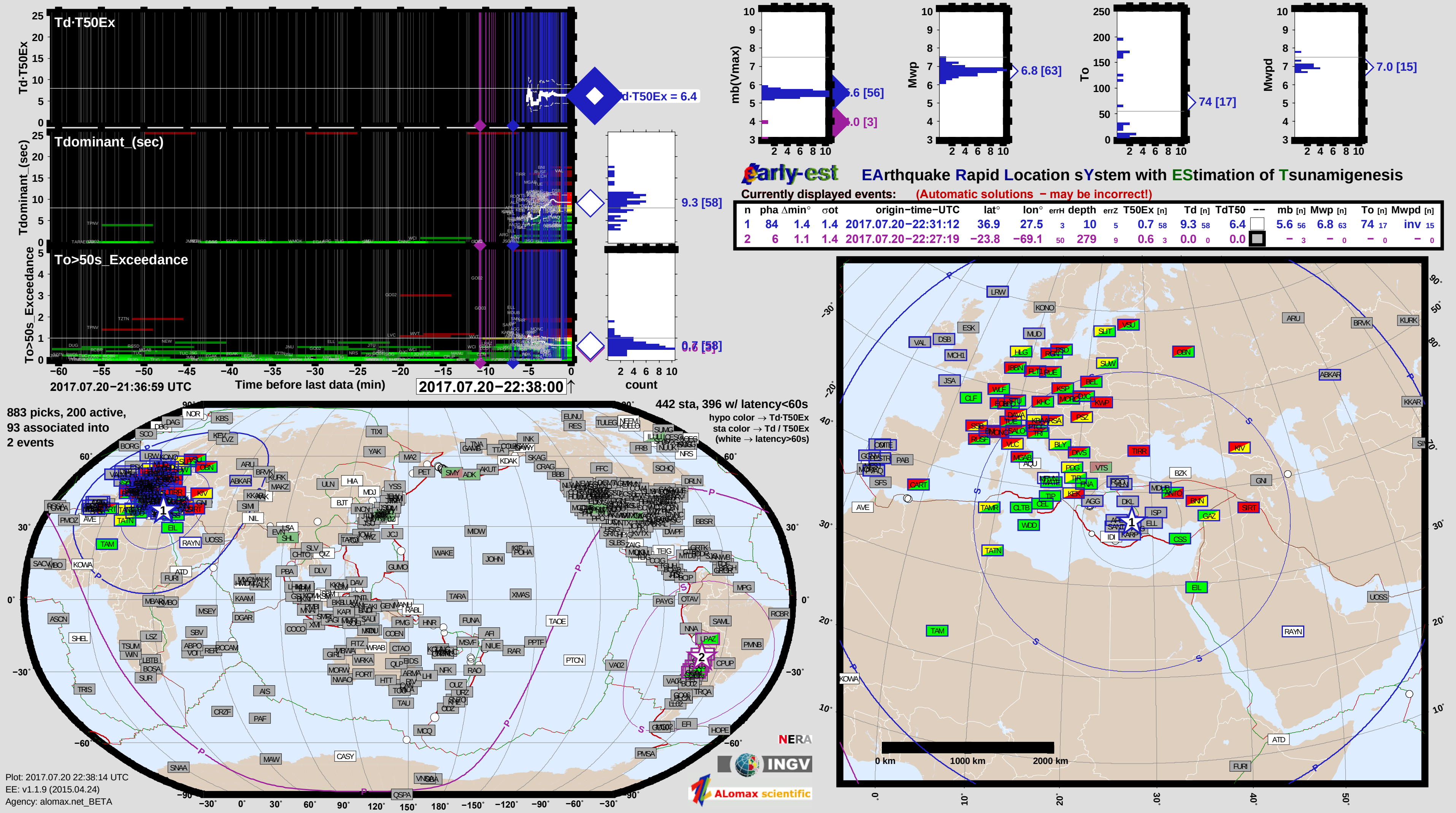
856 picks, 193 active,
83 associated into
2 events

442 sta, 398 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.07.20 22:37:12 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/07/20 Bodrum-Kos M=6.6


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 6.4
9.3 [58]
0.7 [58]
2017.07.20−21:36:59 UTC
Time before last data (min)
2017.07.20−22:38:00
count
mb(Vmax)
5.6 [56]
4.0 [3]
Mwp
6.8 [63]
To
74 [17]
Mwpd
7.0 [15]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]	Td [n]	TdT50	--	mb [n]	Mwp [n]	To [n]	Mwpd [n]
1	84	1.4	1.4	2017.07.20−22:31:12	36.9	27.5	3	10	5	0.7 58	9.3 58	6.4	☐	5.6 56	6.8 63	74 17	inv 15
2	6	1.1	1.4	2017.07.20−22:27:19	−23.8	−69.1	50	279	9	0.6 3	0.0 0	0.0	■	− 3	− 0	− 0	− 0

883 picks, 200 active, 93 associated into 2 events

442 sta, 396 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.07.20 22:38:14 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

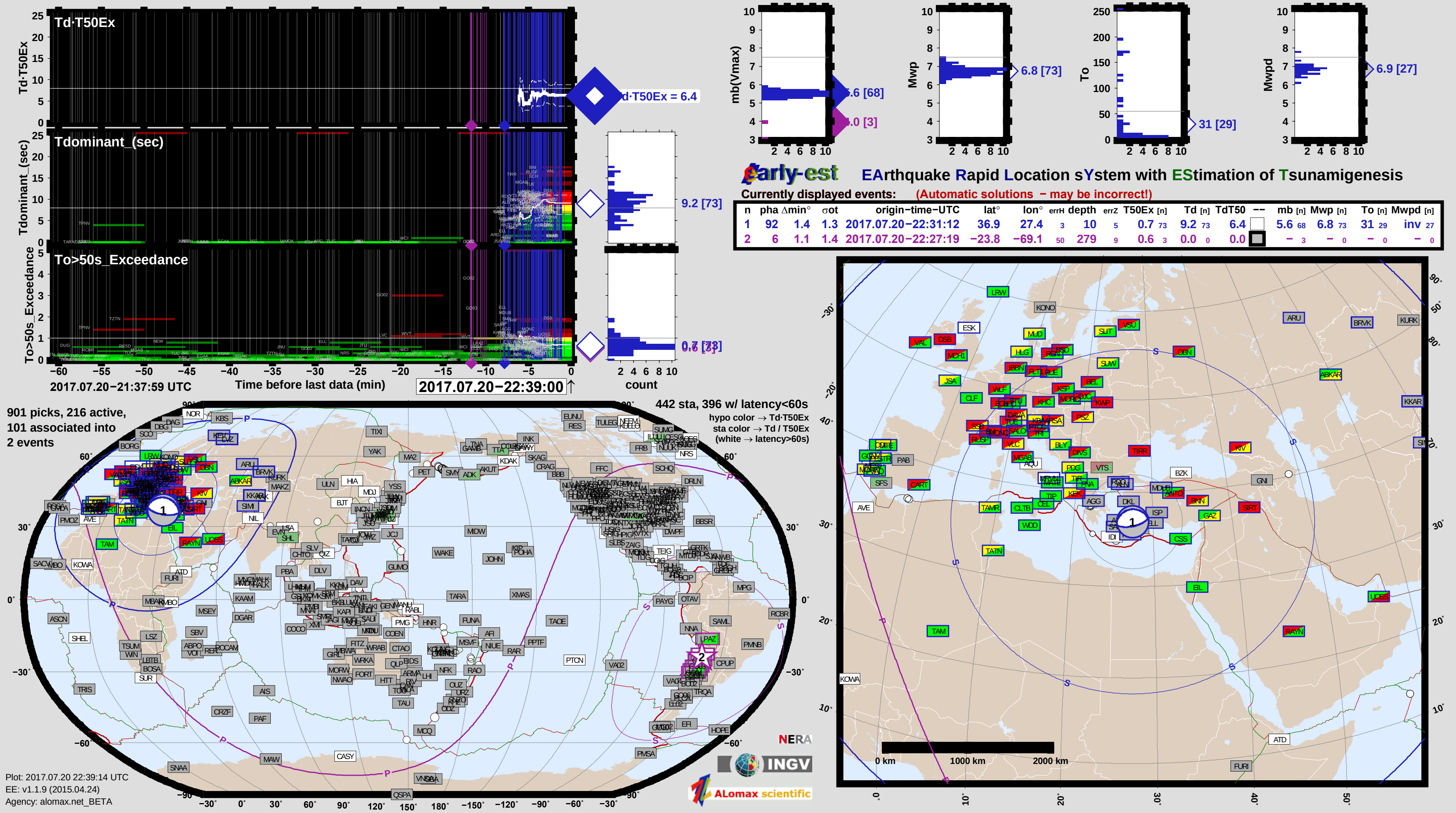
5

Location no. 5 and Mwp after ~7’

INGV terremoti vulcani ambiente
ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

IT-TSP

2017/07/20 Bodrum-Kos M=6.6


Td·T50Ex
Td·T50Ex
Tdominant_(sec)
Tdominant_(sec)
To>50s_Exceedance
To>50s_Exceedance
Td·T50Ex = 6.4
9.2 [73]
0.7 [73]
mb(Vmax)
5.6 [68]
4.0 [3]
Mwp
6.8 [73]
To
31 [29]
Mwpd
6.9 [27]
−60 −55 −50 −45 −40 −35 −30 −25 −20 −15 −10 −5 0
2017.07.20−21:37:59 UTC
Time before last data (min)
2017.07.20−22:39:00
2 4 6 8 10
count
0 km 1000 km 2000 km
NERA
INGV
ALomax scientific

early-est **EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis**

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]	Td [n]	TdT50	−−	mb [n]	Mwp [n]	To [n]	Mwpd [n]
1	92	1.4	1.3	2017.07.20−22:31:12	36.9	27.4	3	10	5	0.7 73	9.2 73	6.4	☐	5.6 68	6.8 73	31 29	inv 27
2	6	1.1	1.4	2017.07.20−22:27:19	−23.8	−69.1	50	279	9	0.6 3	0.0 0	0.0	■	− 3	− 0	− 0	− 0

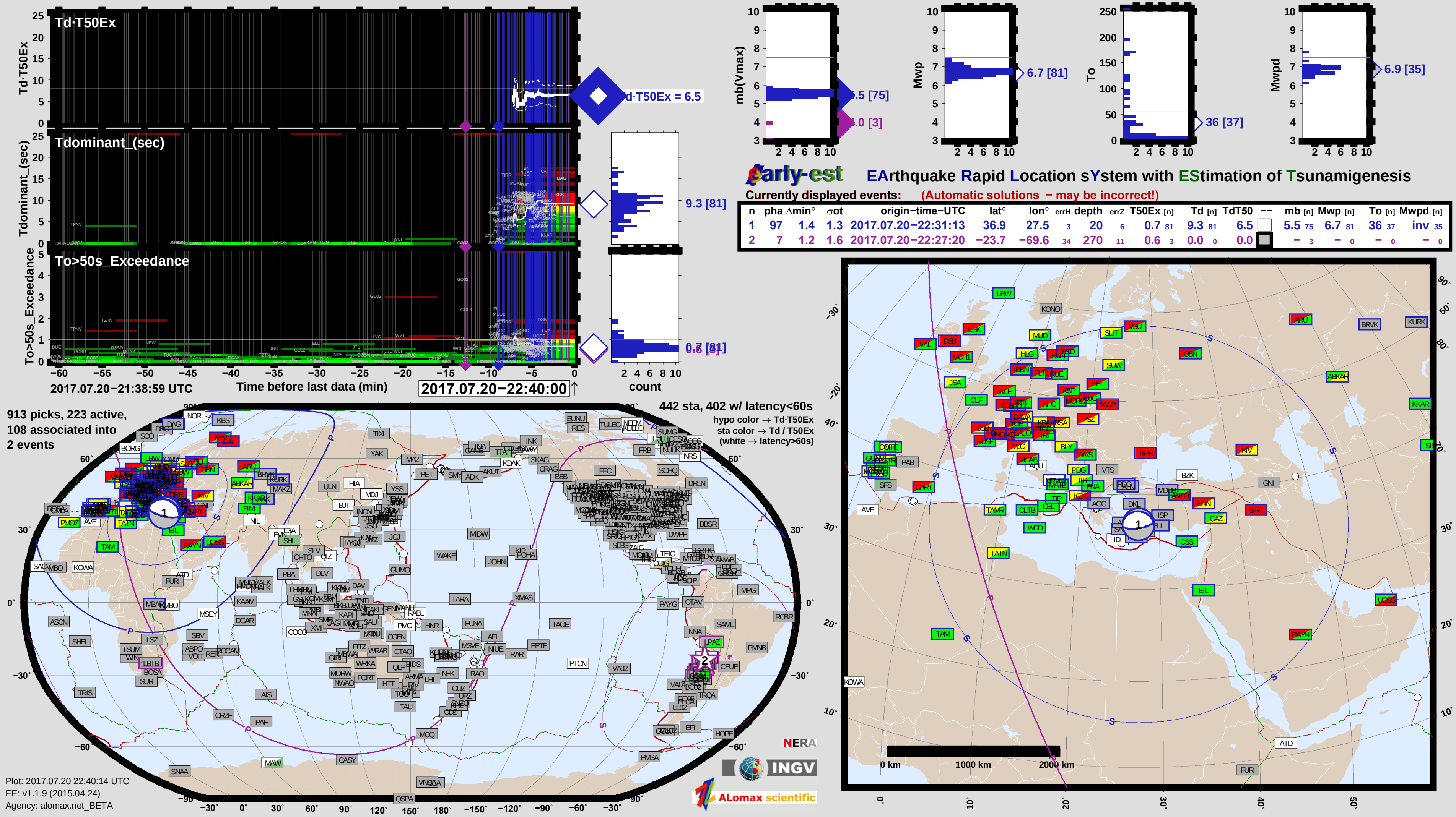
901 picks, 216 active,
101 associated into
2 events

442 sta, 396 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.07.20 22:39:14 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/07/20 Bodrum-Kos M=6.6


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 6.5
9.3 [81]
0.7 [81]
Time before last data (min)
2017.07.20−21:38:59 UTC
2017.07.20−22:40:00
count
mb(Vmax)
5.5 [75]
4.0 [3]
Mwp
6.7 [81]
To
36 [37]
Mwpd
6.9 [35]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	−−	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	97	1.4	1.3	2017.07.20−22:31:13	36.9	27.5	3	20	6	0.7	81	9.3	81	6.5	☐	5.5	75	6.7	81	36	37	inv	35
2	7	1.2	1.6	2017.07.20−22:27:20	−23.7	−69.6	34	270	11	0.6	3	0.0	0	0.0	■	−	3	−	0	−	0	−	0

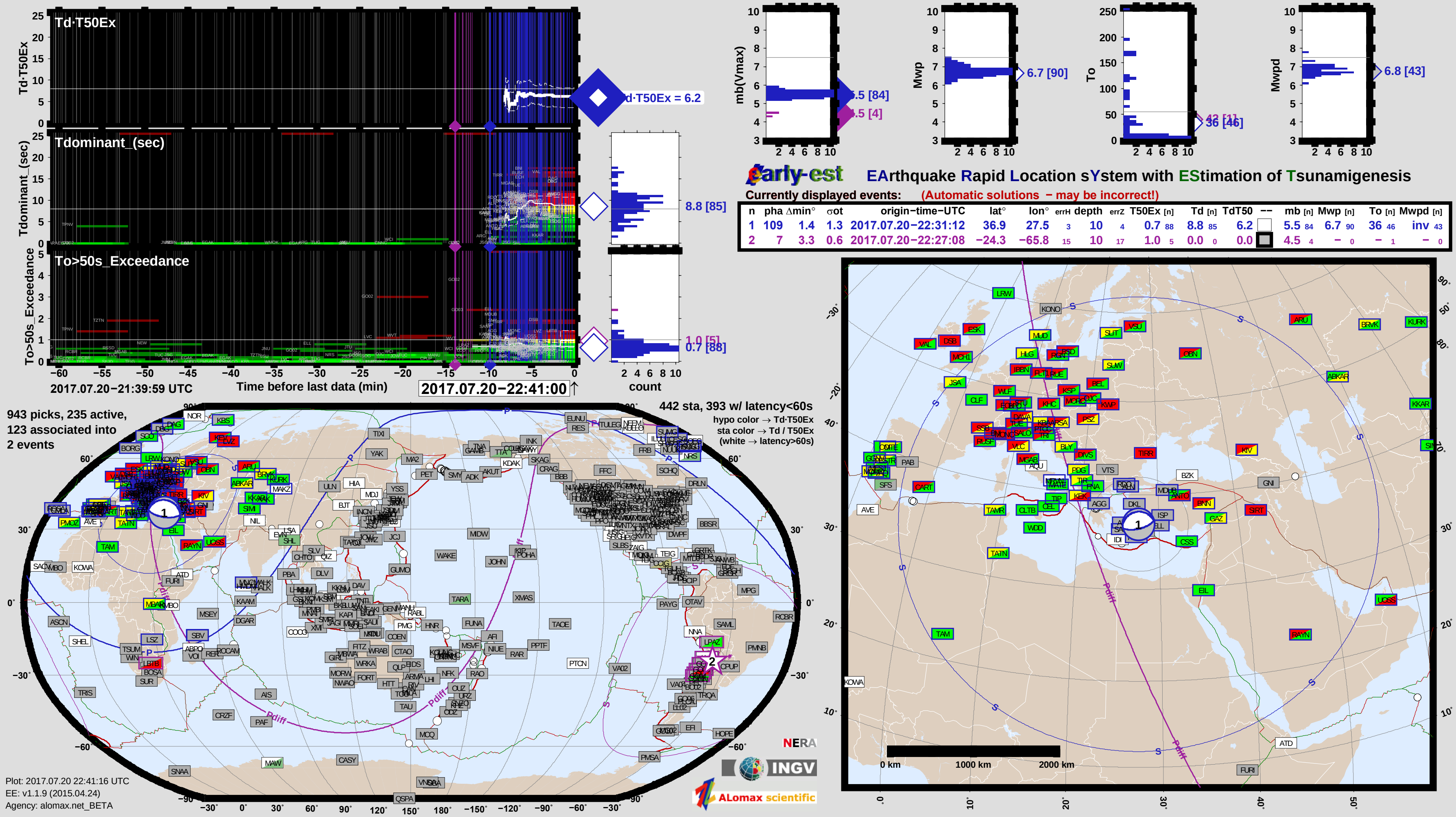
913 picks, 223 active,
108 associated into
2 events

442 sta, 402 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.07.20 22:40:14 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

IT-TSP

2017/07/20 Bodrum-Kos M=6.6


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 6.2
8.8 [85]
1.0 [5]
0.7 [88]
Time before last data (min)
2017.07.20−21:39:59 UTC
2017.07.20−22:41:00
count
mb(Vmax)
.5 [84]
.5 [4]
Mwp
6.7 [90]
To
42 [1]
36 [46]
Mwpd
6.8 [43]
0 km
1000 km
2000 km
Pdiff
NERA
INGV
ALomax scientific

early-est EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]		Td [n]		TdT50	--	mb [n]		Mwp [n]		To [n]		Mwpd [n]	
1	109	1.4	1.3	2017.07.20−22:31:12	36.9	27.5	3	10	4	0.7	88	8.8	85	6.2	☐	5.5	84	6.7	90	36	46	inv	43
2	7	3.3	0.6	2017.07.20−22:27:08	−24.3	−65.8	15	10	17	1.0	5	0.0	0	0.0	■	4.5	4	−	0	−	1	−	0

943 picks, 235 active, 123 associated into 2 events

442 sta, 393 w/ latency<60s

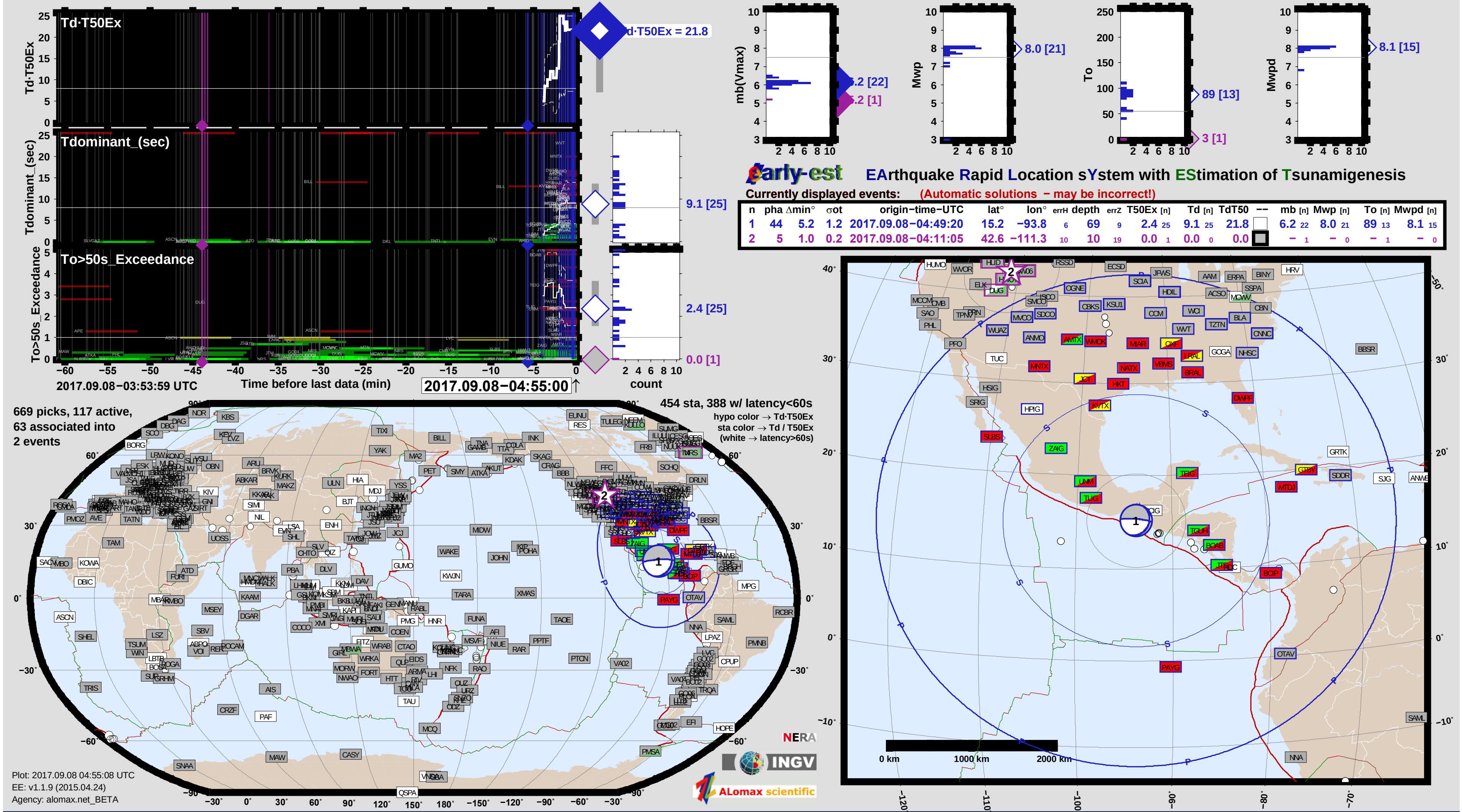
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.07.20 22:41:16 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

Location no.8 and Mwp after ~10’

IT-TSP

2017/09/08 Mexico M=8.1


Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 21.8
9.1 [25]
2.4 [25]
0.0 [1]
count
Time before last data (min)
2017.09.08−03:53:59 UTC
2017.09.08−04:55:00
mb(Vmax)
6.2 [22]
6.2 [1]
Mwp
8.0 [21]
To
89 [13]
3 [1]
Mwpd
8.1 [15]
early-est
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]	Td [n]	TdT50	--	mb [n]	Mwp [n]	To [n]	Mwpd [n]
1	44	5.2	1.2	2017.09.08−04:49:20	15.2	−93.8	6	69	9	2.4 25	9.1 25	21.8	☐	6.2 22	8.0 21	89 13	8.1 15
2	5	1.0	0.2	2017.09.08−04:11:05	42.6	−111.3	10	10	19	0.0 1	0.0 0	0.0	■	− 1	− 0	− 1	− 0

669 picks, 117 active,
63 associated into
2 events

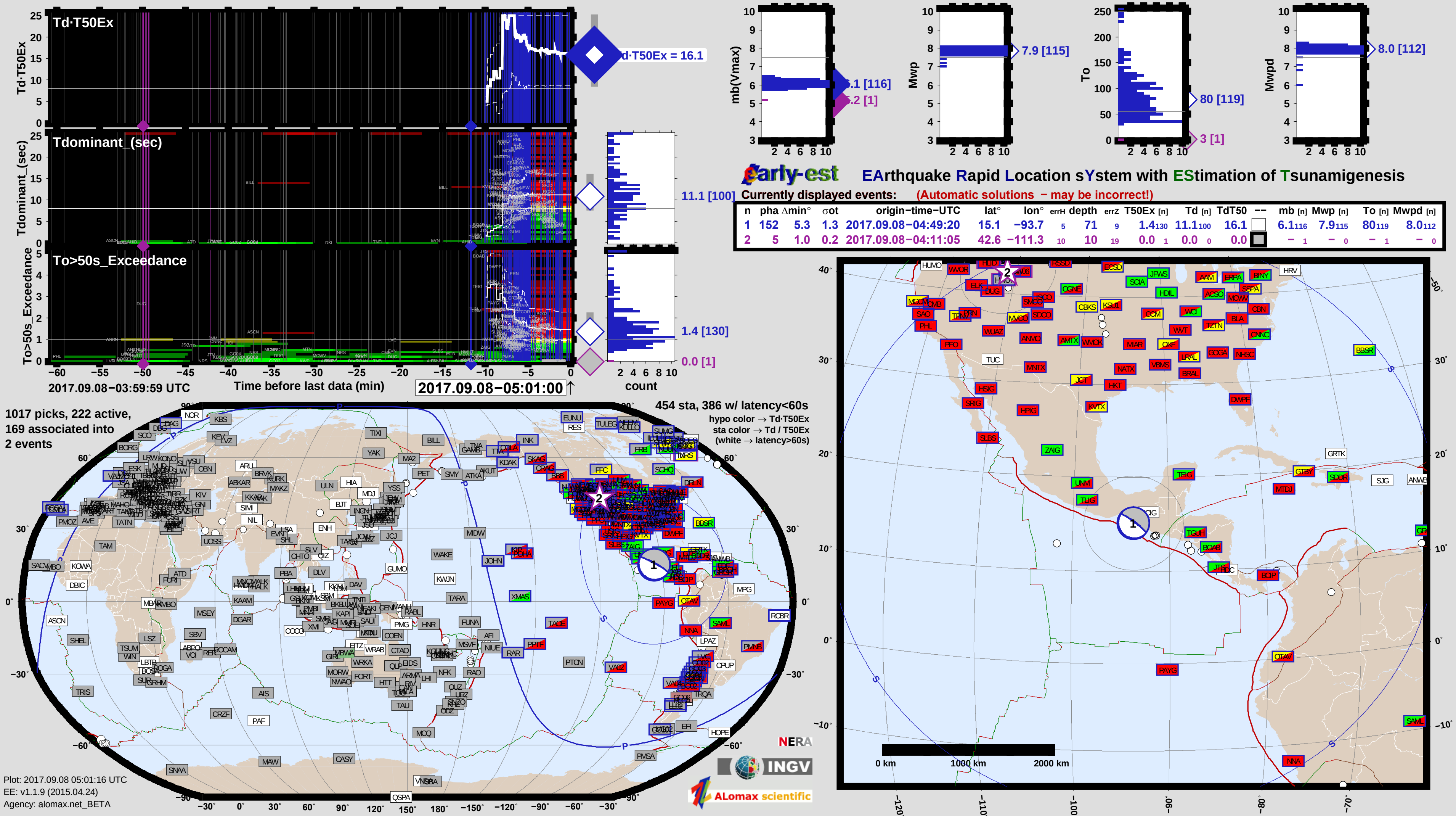
454 sta, 388 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.09.08 04:55:08 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

Location no.2 and Mwpd after ~6’

IT-TSP

2017/09/08 Mexico M=8.1



EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis

Currently displayed events: (Automatic solutions − may be incorrect!)

n	pha	Δmin°	σot	origin−time−UTC	lat°	lon°	errH	depth	errZ	T50Ex [n]	Td [n]	TdT50	−−	mb [n]	Mwp [n]	To [n]	Mwpd [n]
1	152	5.3	1.3	2017.09.08−04:49:20	15.1	−93.7	5	71	9	1.4_{130}	11.1_{100}	16.1	☐	6.1_{116}	7.9_{115}	80_{119}	8.0_{112}
2	5	1.0	0.2	2017.09.08−04:11:05	42.6	−111.3	10	10	19	0.0_{1}	0.0_{0}	0.0	■	$−_{1}$	$−_{0}$	$−_{1}$	$−_{0}$

1017 picks, 222 active,
169 associated into
2 events

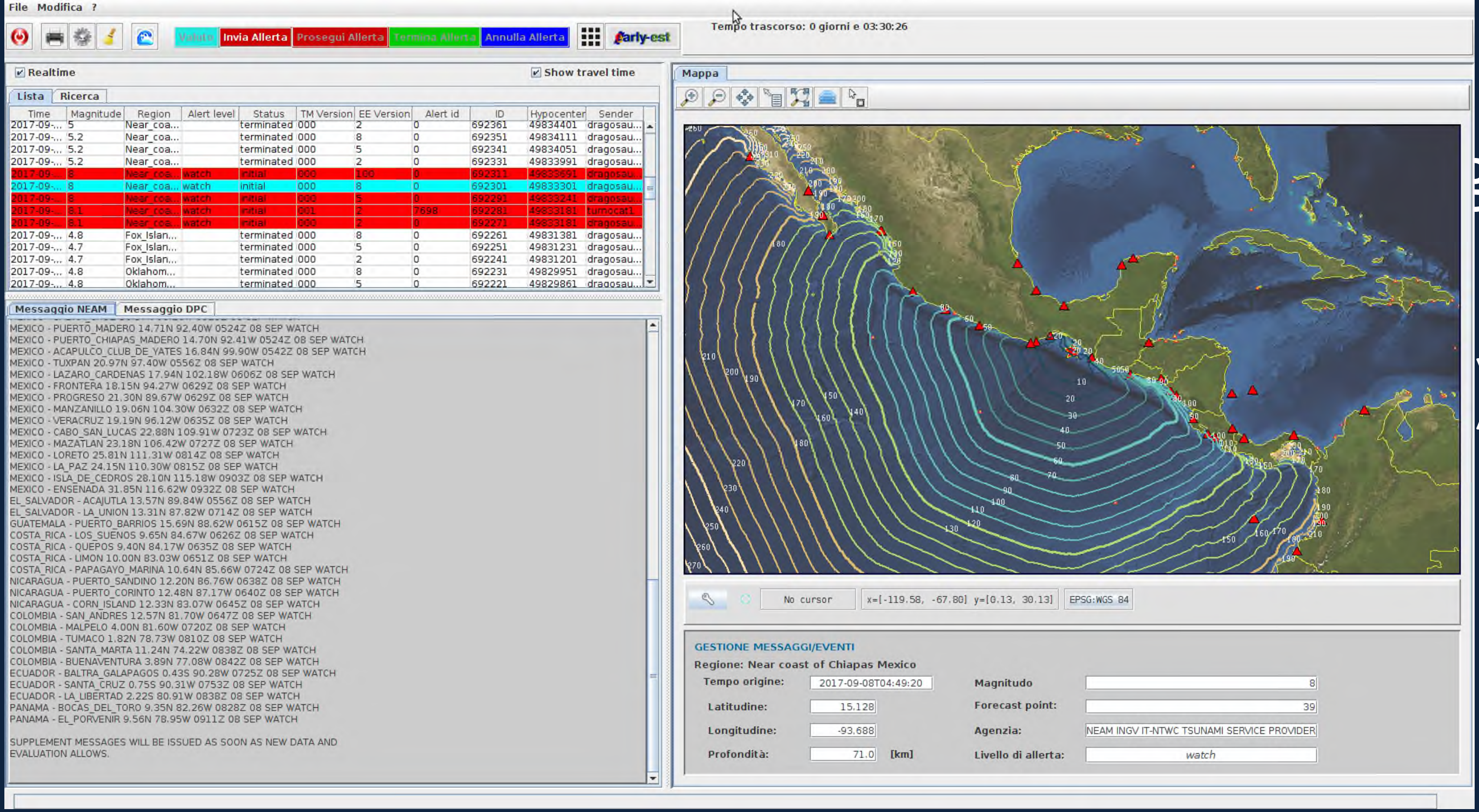
454 sta, 386 w/ latency<60s
hypo color → Td·T50Ex
sta color → Td / T50Ex
(white → latency>60s)

Plot: 2017.09.08 05:01:16 UTC
EE: v1.1.9 (2015.04.24)
Agency: alomax.net_BETA

Td·T50Ex
Tdominant_(sec)
To>50s_Exceedance
Td·T50Ex = 16.1
11.1 [100]
1.4 [130]
0.0 [1]
count
Time before last data (min)
2017.09.08−03:59:59 UTC
2017.09.08−05:01:00
mb(Vmax)
6.1 [116]
6.2 [1]
Mwp
7.9 [115]
To
80 [119]
3 [1]
Mwpd
8.0 [112]
0 km
1000 km
2000 km
NERA
INGV
ALomax scientific

IT-TSP

The rule for personnel on duty



Tempo trascorso: 0 giorni e 03:30:26

☑ Realtime ☑ Show travel time

Time	Magnitude	Region	Alert level	Status	TM Version	EE Version	Alert id	ID	Hypocenter	Sender
2017-09-...	5	Near_coa...		terminated	000	2	0	692361	49834401	dragosau...
2017-09-...	5.2	Near_coa...		terminated	000	8	0	692351	49834111	dragosau...
2017-09-...	5.2	Near_coa...		terminated	000	5	0	692341	49834051	dragosau...
2017-09-...	5.2	Near_coa...		terminated	000	2	0	692331	49833991	dragosau...
2017-09-...	8	Near_coa...	watch	initial	000	100	0	692311	49833691	dragosau...
2017-09-...	8	Near_coa...	watch	initial	000	8	0	692301	49833301	dragosau...
2017-09-...	8	Near_coa...	watch	initial	000	5	0	692291	49833241	dragosau...
2017-09-...	8.1	Near_coa...	watch	initial	001	2	7698	692281	49833181	turnocat1
2017-09-...	8.1	Near_coa...	watch	initial	000	2	0	692271	49833181	dragosau...
2017-09-...	4.8	Fox_Islan...		terminated	000	8	0	692261	49831381	dragosau...
2017-09-...	4.7	Fox_Islan...		terminated	000	5	0	692251	49831231	dragosau...
2017-09-...	4.7	Fox_Islan...		terminated	000	2	0	692241	49831201	dragosau...
2017-09-...	4.8	Oklahom...		terminated	000	8	0	692231	49829951	dragosau...
2017-09-...	4.8	Oklahom...		terminated	000	5	0	692221	49829861	dragosau...

```
MEXICO - PUERTO_MADERO 14.71N 92.40W 0524Z 08 SEP WATCH
MEXICO - PUERTO_CHIAPAS_MADERO 14.70N 92.41W 0524Z 08 SEP WATCH
MEXICO - ACAPULCO_CLUB_DE_YATES 16.84N 99.90W 0542Z 08 SEP WATCH
MEXICO - TUXPAN 20.97N 97.40W 0556Z 08 SEP WATCH
MEXICO - LAZARO_CARDENAS 17.94N 102.18W 0606Z 08 SEP WATCH
MEXICO - FRONTERA 18.15N 94.27W 0629Z 08 SEP WATCH
MEXICO - PROGRESO 21.30N 89.67W 0629Z 08 SEP WATCH
MEXICO - MANZANILLO 19.06N 104.30W 0632Z 08 SEP WATCH
MEXICO - VERACRUZ 19.19N 96.12W 0635Z 08 SEP WATCH
MEXICO - CABO_SAN_LUCAS 22.88N 109.91W 0723Z 08 SEP WATCH
MEXICO - MAZATLAN 23.18N 106.42W 0727Z 08 SEP WATCH
MEXICO - LORETO 25.81N 111.31W 0814Z 08 SEP WATCH
MEXICO - LA_PAZ 24.15N 110.30W 0815Z 08 SEP WATCH
MEXICO - ISLA_DE_CEDROS 28.10N 115.18W 0903Z 08 SEP WATCH
MEXICO - ENSENADA 31.85N 116.62W 0932Z 08 SEP WATCH
EL_SALVADOR - ACAJUTLA 13.57N 89.84W 0556Z 08 SEP WATCH
EL_SALVADOR - LA_UNION 13.31N 87.82W 0714Z 08 SEP WATCH
GUATEMALA - PUERTO_BARRIOS 15.69N 88.62W 0615Z 08 SEP WATCH
COSTA_RICA - LOS_SUENOS 9.65N 84.67W 0626Z 08 SEP WATCH
COSTA_RICA - QUEPOS 9.40N 84.17W 0635Z 08 SEP WATCH
COSTA_RICA - LIMON 10.00N 83.03W 0651Z 08 SEP WATCH
COSTA_RICA - PAPAGAYO_MARINA 10.64N 85.66W 0724Z 08 SEP WATCH
NICARAGUA - PUERTO_SANDINO 12.20N 86.76W 0638Z 08 SEP WATCH
NICARAGUA - PUERTO_CORINTO 12.48N 87.17W 0640Z 08 SEP WATCH
NICARAGUA - CORN_ISLAND 12.33N 83.07W 0645Z 08 SEP WATCH
COLOMBIA - SAN_ANDRES 12.57N 81.70W 0647Z 08 SEP WATCH
COLOMBIA - MALPELO 4.00N 81.60W 0720Z 08 SEP WATCH
COLOMBIA - TUMACO 1.82N 78.73W 0810Z 08 SEP WATCH
COLOMBIA - SANTA_MARTA 11.24N 74.22W 0838Z 08 SEP WATCH
COLOMBIA - BUENAVENTURA 3.89N 77.08W 0842Z 08 SEP WATCH
ECUADOR - BALTRA_GALAPAGOS 0.43S 90.28W 0725Z 08 SEP WATCH
ECUADOR - SANTA_CRUZ 0.75S 90.31W 0753Z 08 SEP WATCH
ECUADOR - LA_LIBERTAD 2.22S 80.91W 0838Z 08 SEP WATCH
PANAMA - BOCAS_DEL_TORO 9.35N 82.26W 0828Z 08 SEP WATCH
PANAMA - EL_PORVENIR 9.56N 78.95W 0911Z 08 SEP WATCH

SUPPLEMENT MESSAGES WILL BE ISSUED AS SOON AS NEW DATA AND
EVALUATION ALLOWS.
```

GESTIONE MESSAGGI/EVENTI

Regione: Near coast of Chiapas Mexico

Tempo origine: 2017-09-08T04:49:20

Latitudine: 15.128

Longitudine: -93.688

Profondità: 71.0 [km]

Magnitudo: 8

Forecast point: 39

Agenzia: NEAM INGV IT-NTWC TSUNAMI SERVICE PROVIDER

Livello di allerta: *watch*

- The Senior expert decides to send the no.2 (if eq. Is large and/or close to the Italian coasts)

IT-TSP
Personnel training

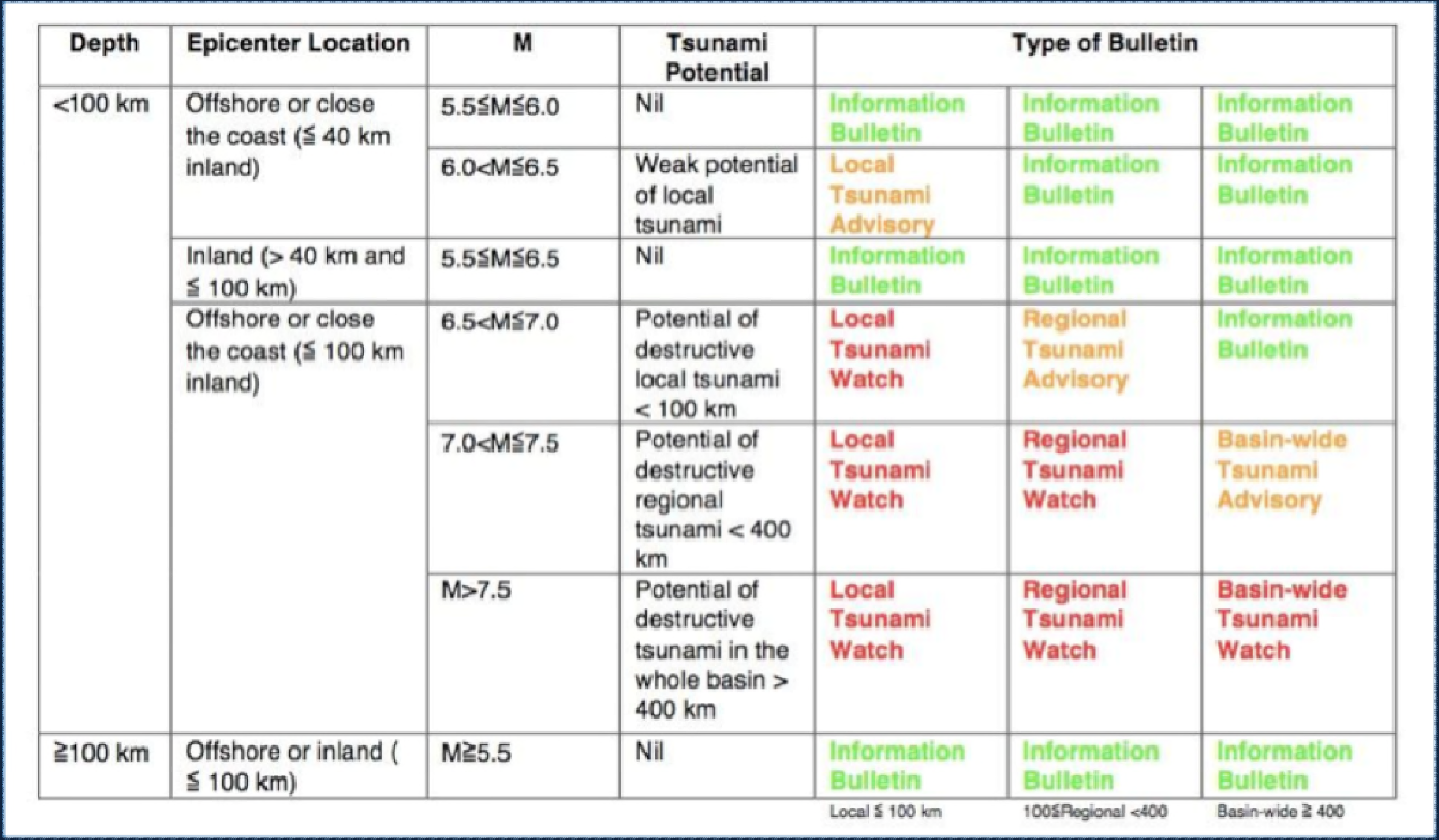
- **Frontal lectures plus practical training**
  - On tsunamis and protocols (total 8 hours)
  - Training at small groups (8 hours + 12 hours)
  - Apprenticeship (36 hours)

- **Shifts**
  - On site continuous training with global earthquakes and potential tsunamis worldwide (e.g., September 2017 Mexico M8.1 event)

  - Training of Civil Protection personnel envisaged

IT-TSP

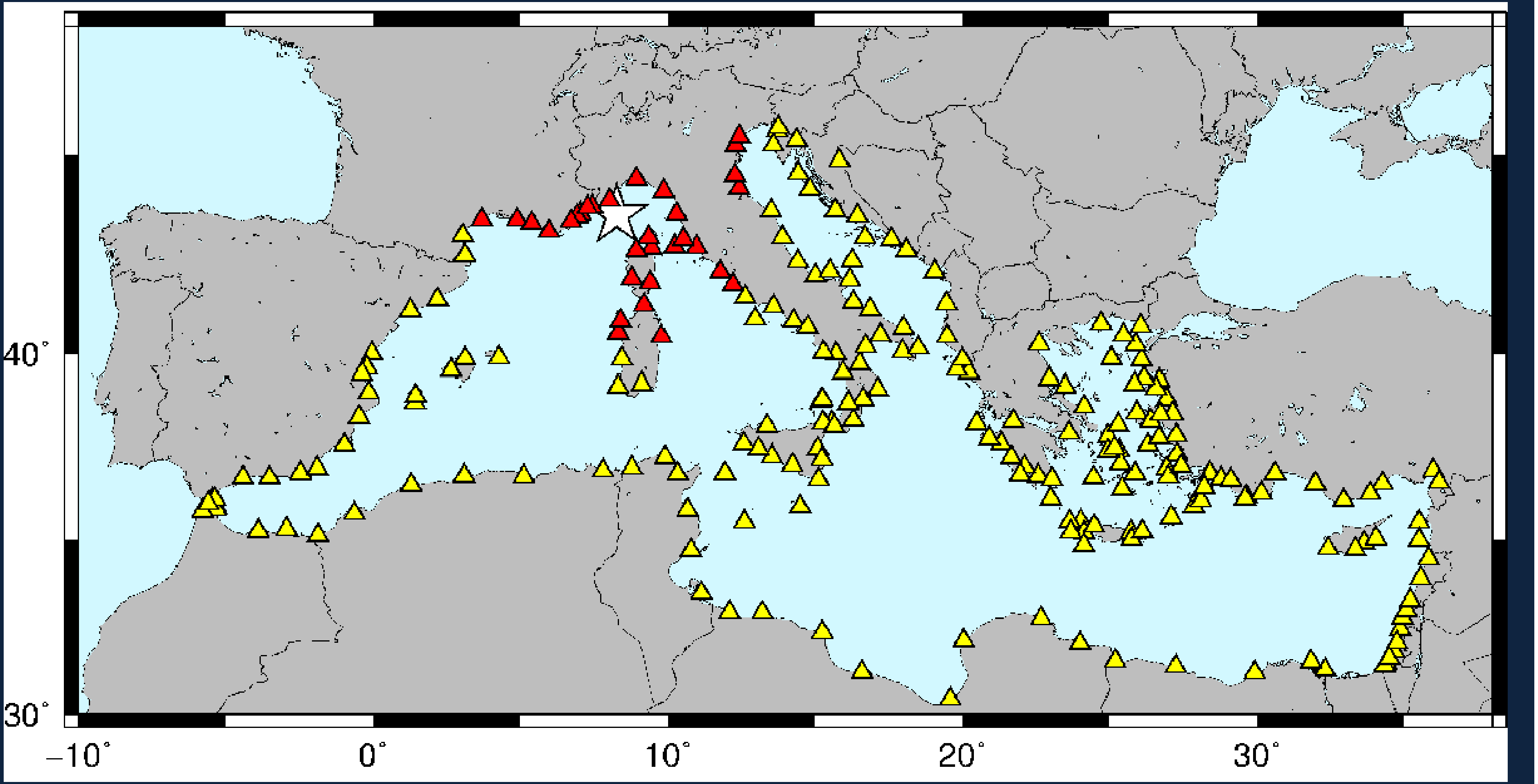
The Decision Matrix adopted by CAT-INGV



Depth	Epicenter Location	M	Tsunami Potential	Type of Bulletin		
<100 km	Offshore or close the coast (≦ 40 km inland)	5.5≦M≦6.0	Nil	Information Bulletin	Information Bulletin	Information Bulletin
		6.0<M≦6.5	Weak potential of local tsunami	Local Tsunami Advisory	Information Bulletin	Information Bulletin
	Inland (> 40 km and ≦ 100 km)	5.5≦M≦6.5	Nil	Information Bulletin	Information Bulletin	Information Bulletin
	Offshore or close the coast (≦ 100 km inland)	6.5<M≦7.0	Potential of destructive local tsunami < 100 km	Local Tsunami Watch	Regional Tsunami Advisory	Information Bulletin
		7.0<M≦7.5	Potential of destructive regional tsunami < 400 km	Local Tsunami Watch	Regional Tsunami Watch	Basin-wide Tsunami Advisory
		M>7.5	Potential of destructive tsunami in the whole basin > 400 km	Local Tsunami Watch	Regional Tsunami Watch	Basin-wide Tsunami Watch
≧100 km	Offshore or inland (≦ 100 km)	M≧5.5	Nil	Information Bulletin	Information Bulletin	Information Bulletin
				Local ≦ 100 km	100≦Regional <400	Basin-wide ≧ 400

IT-TSP

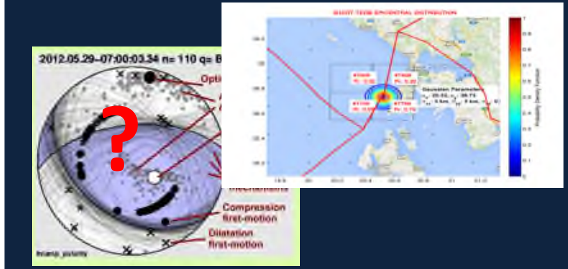
Leaving the Decision Matrix

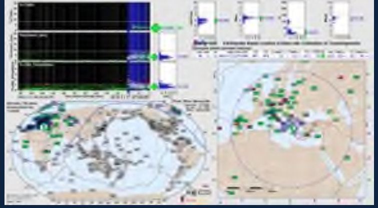


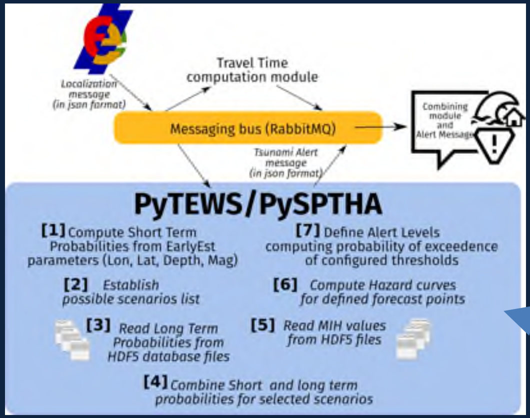
40˚
30˚
−10˚
0˚
10˚
20˚
30˚

Future developments: Probabilistic Tsunami Forecast (PTF)

Real Time Eq Parameters
Location, depth,
focal mechanism?






Localization message (in json format)
Travel Time computation module
Messaging bus (RabbitMQ)
Combining module and Alert Message
Tsunami Alert message (in json format)

PyTEWS/PySPTHA

[1] Compute Short Term Probabilities from EarlyEst parameters (Lon, Lat, Depth, Mag)

[2] *Establish possible scenarios list*

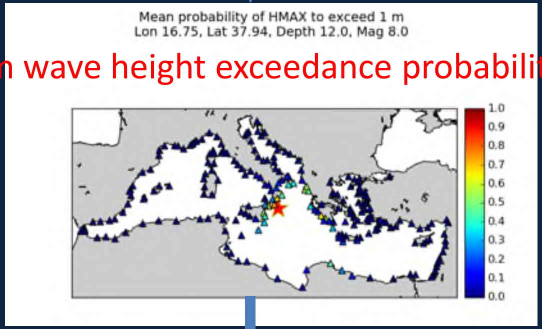
[3] *Read Long Term Probabilities from HDF5 database files*

[4] *Combine Short and long term probabilities for selected scenarios*

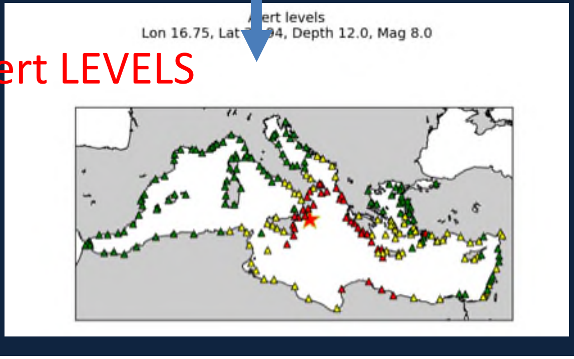
[5] *Read MIH values from HDF5 files*

[6] *Compute Hazard curves for defined forecast points*

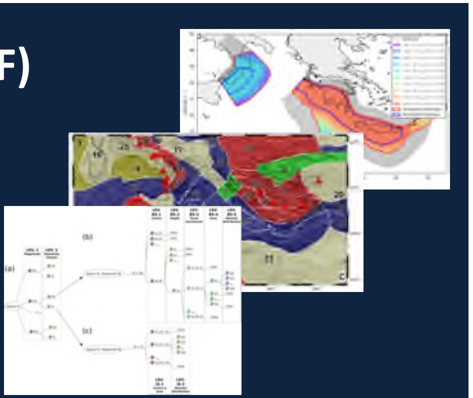
[7] Define Alert Levels computing probability of exceedence of configured thresholds


Mean probability of HMAX to exceed 1 m
Lon 16.75, Lat 37.94, Depth 12.0, Mag 8.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

1 m wave height exceedance probability


ert levels
Lon 16.75, Lat
94, Depth 12.0, Mag 8.0

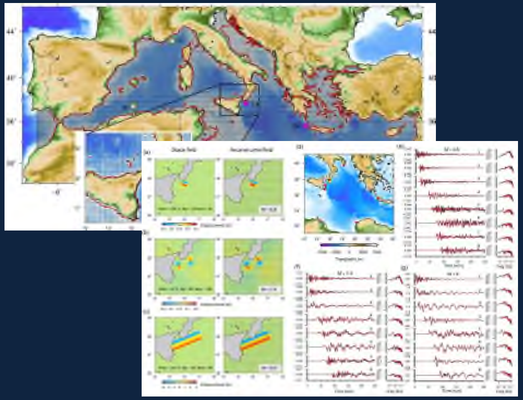
Alert LEVELS



Prior Earthquake Mechanism
From PTHA

+

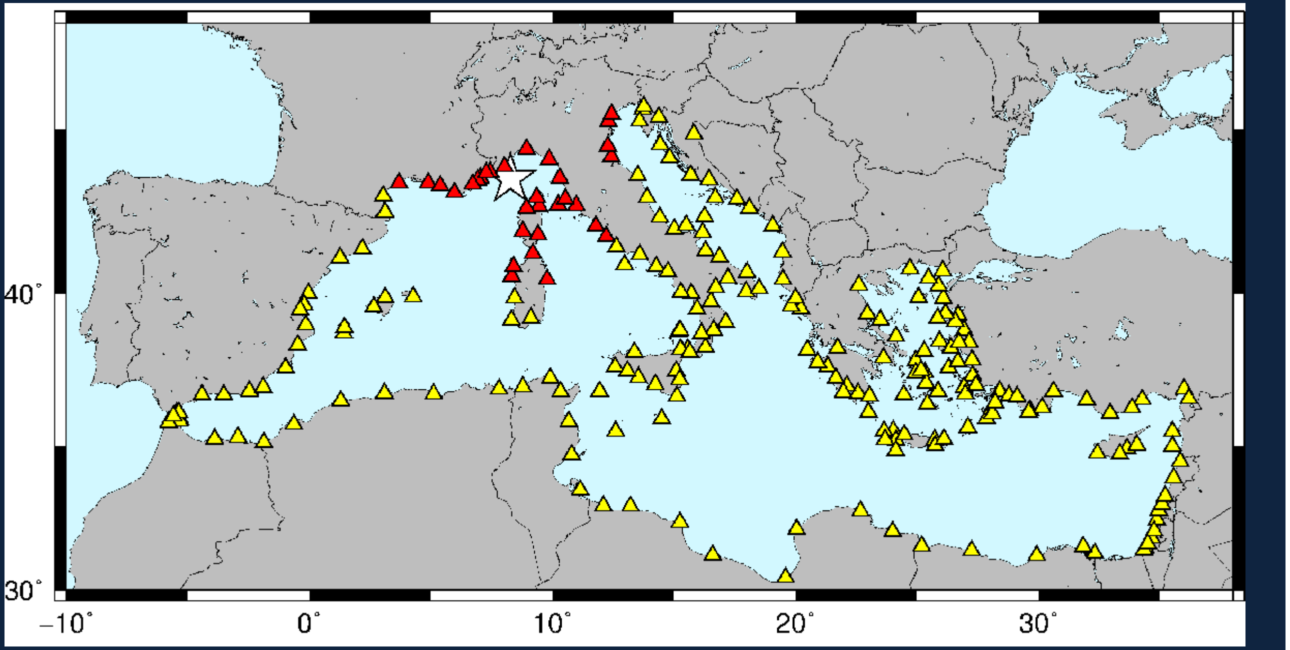
Precalculated Tsunami
Scenario Database



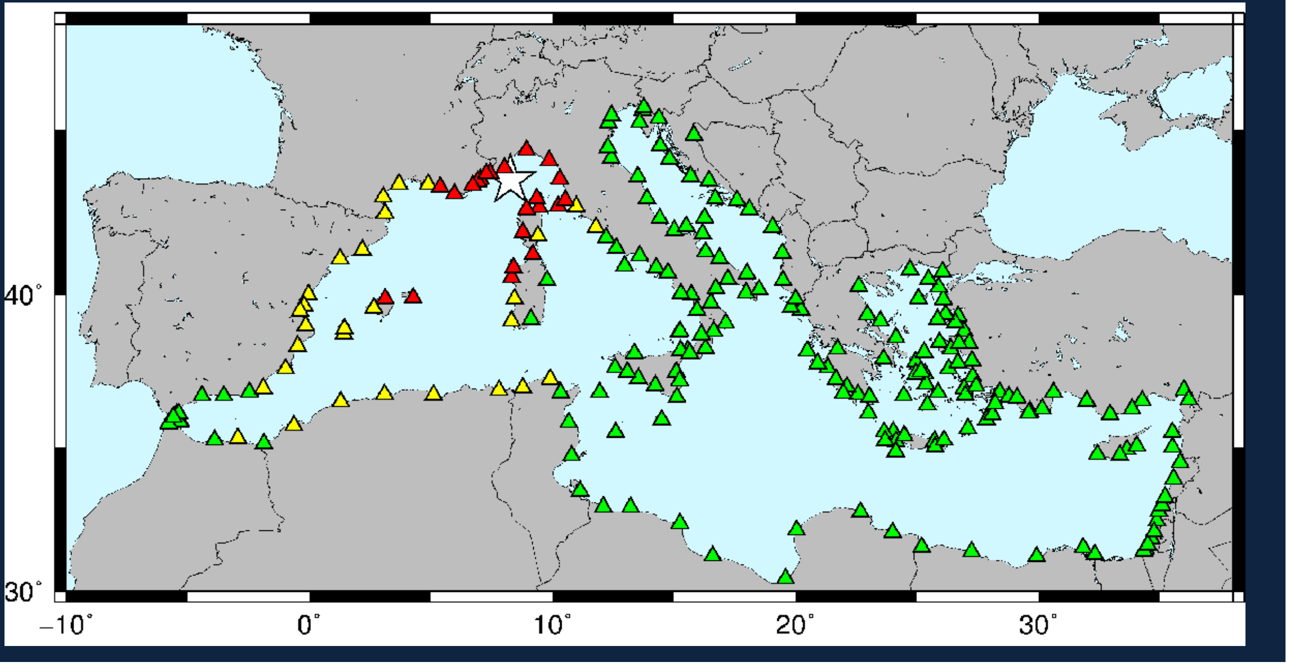
Future developments: Probabilistic Tsunami Forecast (PTF)

M7.5 Ligurian Sea

Decision Matrix

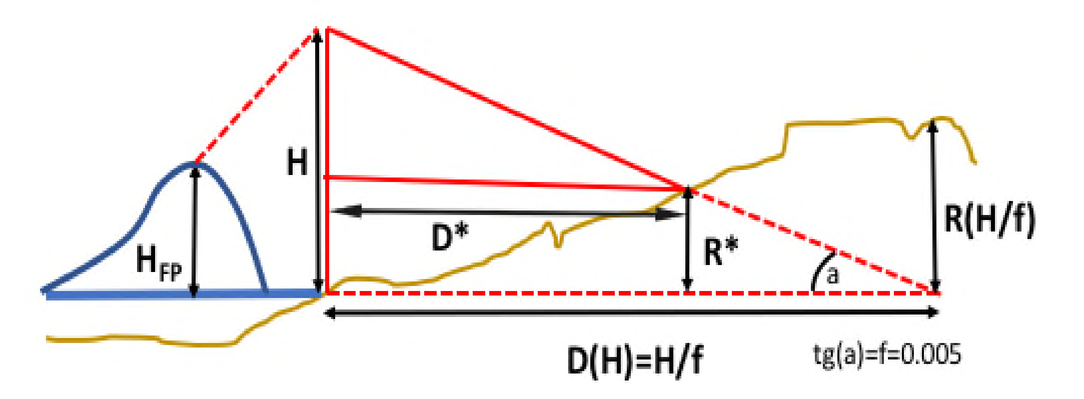

40˚
30˚
−10˚
0˚
10˚
20˚
30˚

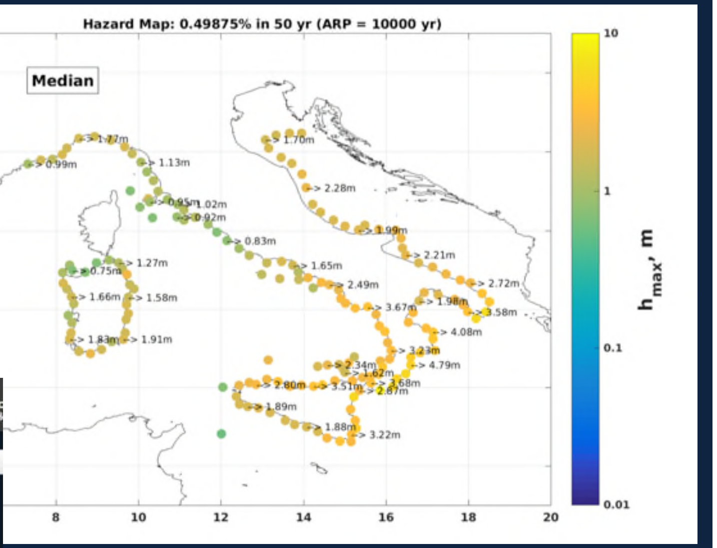
PTF

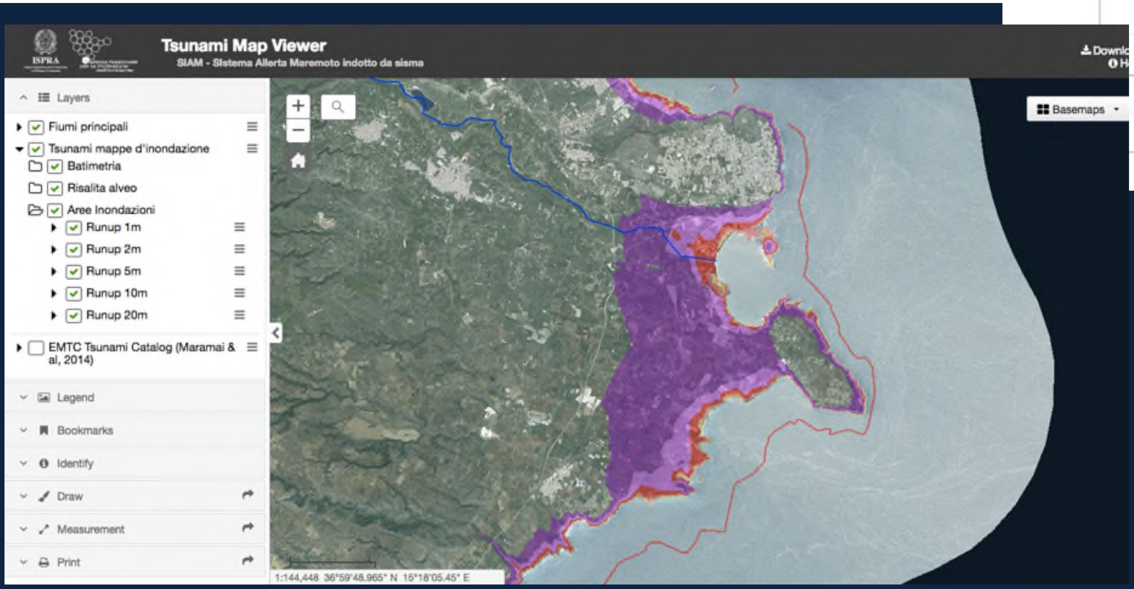

40˚
30˚
−10˚
0˚
10˚
20˚
30˚

Future developments: Coastal evacuation zones
DPC+ISPRA+INGV

Tsunami Offshore forecast
+ GIS mapping (Attenuation, Obstacles, Rivers)
+ Long term tsunami hazard


H
H_{FP}
D*
R*
R(H/f)
a
D(H)=H/f
tg(a)=f=0.005


Hazard Map: 0.49875% in 50 yr (ARP = 10000 yr)
Median
46
44
42
40
8
10
12
14
16
18
20
--> 0.99m
--> 1.77m
--> 1.13m
--> 0.95m
1.02m
--> 0.92m
--> 0.83m
--> 1.27m
--> 0.75m
--> 1.66m
--> 1.58m
--> 1.83m
--> 1.91m
--> 1.70m
--> 2.28m
--> 1.99m
--> 2.21m
--> 1.65m
--> 2.49m
--> 2.72m
--> 3.67m
--> 1.98m
--> 3.58m
--> 4.08m
--> 3.23m
--> 4.79m
--> 2.34m
--> 1.62m
--> 3.68m
--> 2.80m
--> 3.51m
--> 2.87m
--> 1.89m
--> 1.88m
--> 3.22m
10
1
0.1
0.01
h_{max}, m


Tsunami Map Viewer
SIAM - Sistema Allerta Maremoto indotto da sisma

ISPRA
Downlo
H
Basemaps

Layers
- ☑ Fiumi principali
- ☑ Tsunami mappe d'inondazione
  - ☑ Batimetria
  - ☑ Risalita alveo
  - ☑ Aree Inondazioni
    - ☑ Runup 1m
    - ☑ Runup 2m
    - ☑ Runup 5m
    - ☑ Runup 10m
    - ☑ Runup 20m
- ☐ EMTC Tsunami Catalog (Maramai & al, 2014)

Legend
Bookmarks
Identify
Draw
Measurement
Print

1:144,448 36°59'48.965" N 15°18'05.45" E

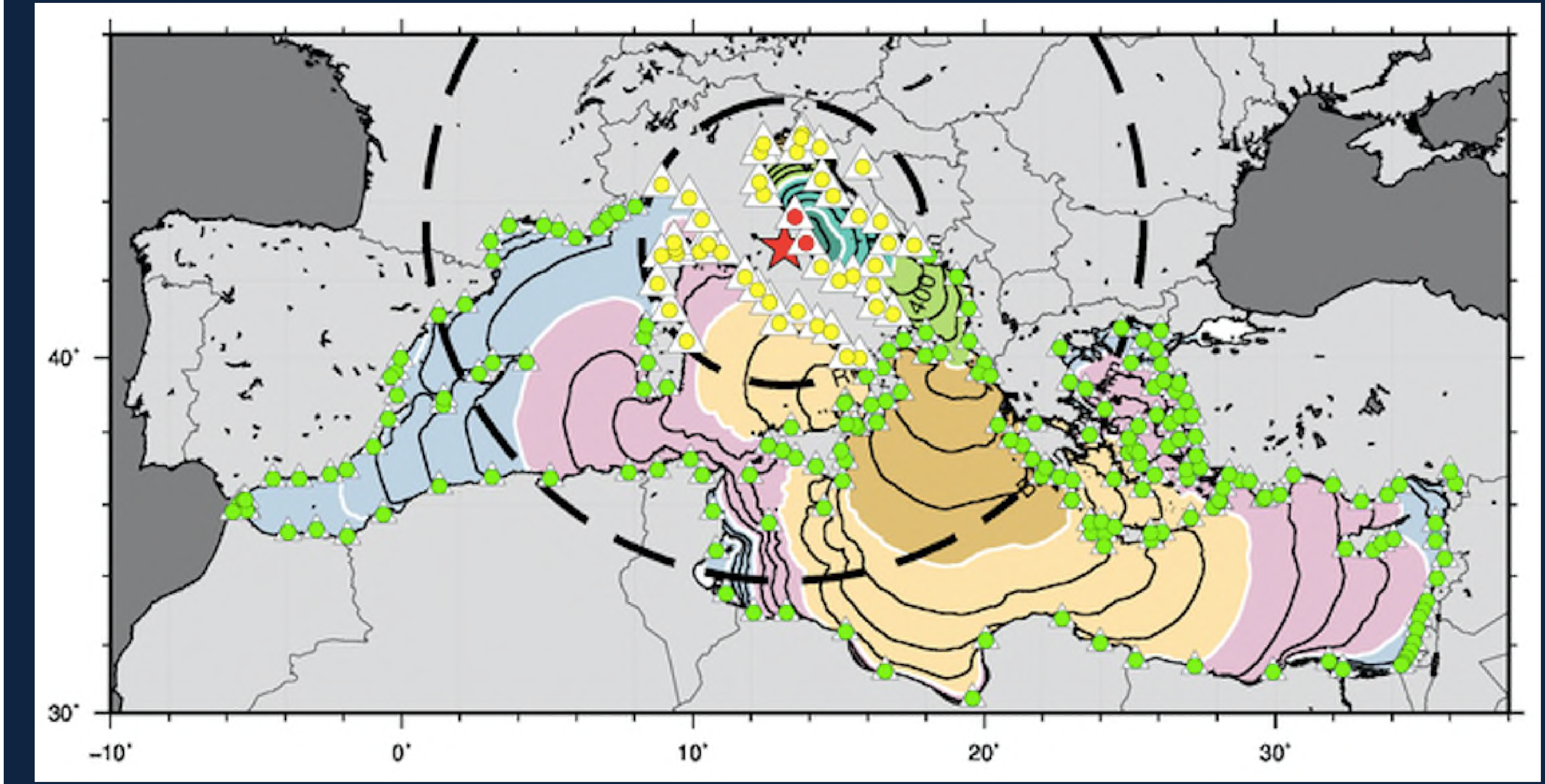
Present challenges of CAT-INGV

- Be more rapid (maintaining accuracy)
- Better estimates of alert levels (PTF)
- From alert messages to local response (with DPC and ISPRA)
- Protocols, documentation, training
- Communication strategy
- GPS…
- Joint actions with all the centres for interoperability, performance monitoring and common strategies

Thank you

IT-TSP

Leaving the Decision Matrix


400
40°
30°
−10°
0°
10°
20°
30°