



TOAST multiuser version

A client-server based tsunami warning system for the Indian Ocean and beyond

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Introduction

The Tsunami Observation and Simulation Terminal **TOAST**, developed by gempa, is a software package designed for tsunami early warning. Originally created for Indonesia, it is now utilized by agencies worldwide, including New Zealand, Thailand, Spain, Oman and Nicaragua.

TOAST compares real-time data with simulation models, offering a comprehensive platform for tsunami monitoring and warning. It features a versatile template system for automatic bulletin generation in various formats, along with images and animations. Additionally, TOAST supports wide-ranging dissemination channels, including the gempa Dissemination Server (GDS).

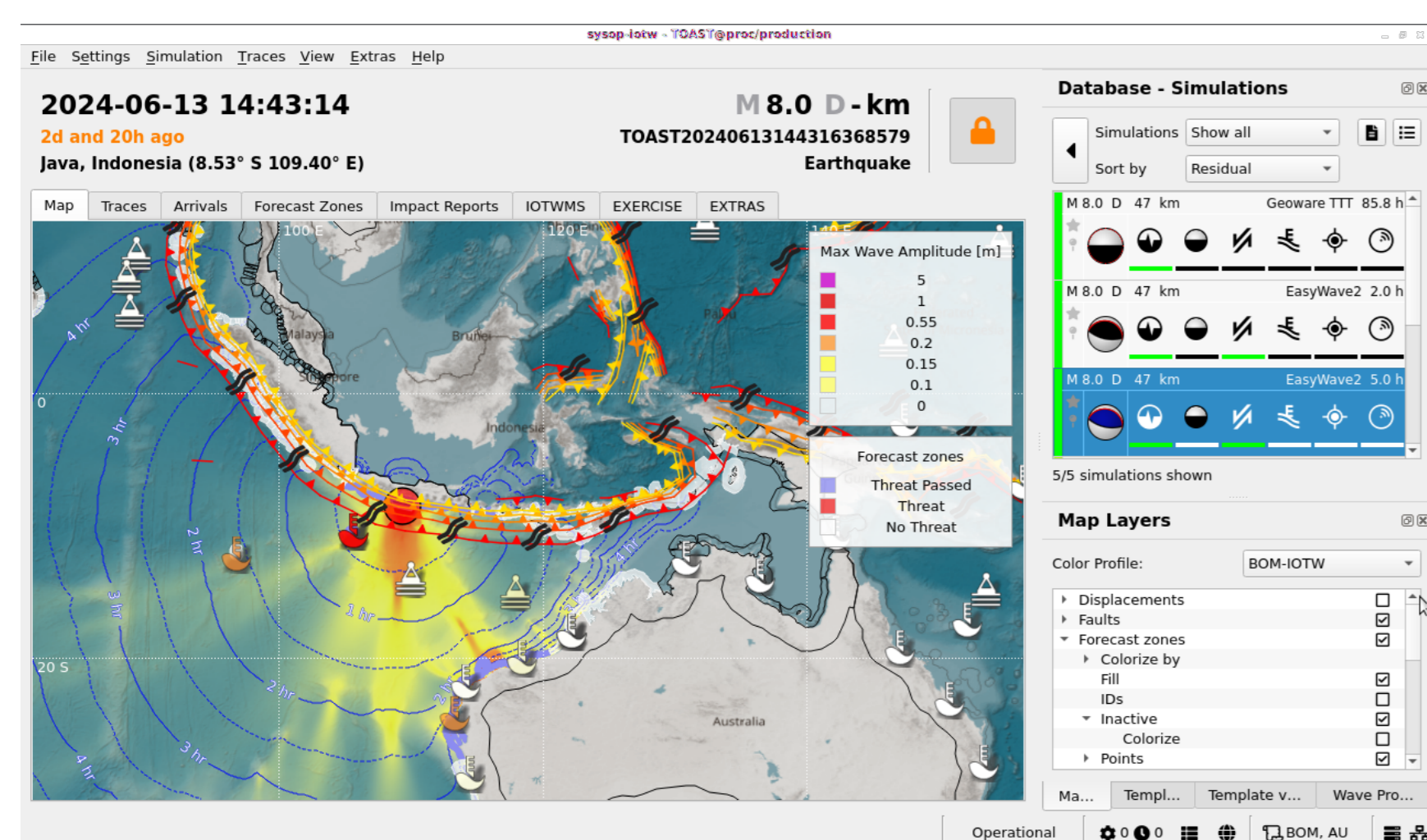


Figure 1: TOAST graphical user interface

Features

Integrated with the SeisComP ecosystem, TOAST efficiently processes seismic events, including those from standard SeisComP tools and gempa's moment tensor modules. The system's flexibility allows for automatic import from other sources. It is possible to evaluate real-time displacement vectors for improved earthquake source mechanism assessment.

- Complete integration into the SeisComP framework
- Automatic reception of event parameters
- GPU based on-the-fly tsunami simulation
- Flexible interface to support any kind of simulation like pre-calculated and other algorithms
- Automatic and interactive rupture generation
- Worst-case simulation aggregation
- Calculation of SSH, SSH max, isochrones, arrival times, coastal wave heights
- Evaluation of simulations through integration of oceanographic sensor data
- Computation and comparison of coseismic displacement
- Computation of threat levels for forecast zones
- Decision Support
- Template-based tsunami bulletin generation in various formats
- Dissemination of bulletins

New multiuser version

Responding to the Australian Bureau of Meteorology's request, TOAST has undergone a significant redesign to incorporate multiuser functionality. The system now comprises the TOAST server, client, and the gempa Simulation Server (GSS). This setup facilitates efficient hazard assessment, bulletin creation, and simulation management. GSS includes the EasyWave plugin for rapid scenario computation. Customer-specific simulation backends or precomputed simulation data bases can be adopted.

TOAST multi-user features:

- Allow several users concurrently working on the same incident
- Share simulations across workstations
- Shield database from user access and enable authentication
- Extended template system functionality
- Incident source can be edited including centroid parameters
- Threat level computation has been extended
- Impact reports can be added using the client
- Impact progress visualizes wave arrival at forecast zones

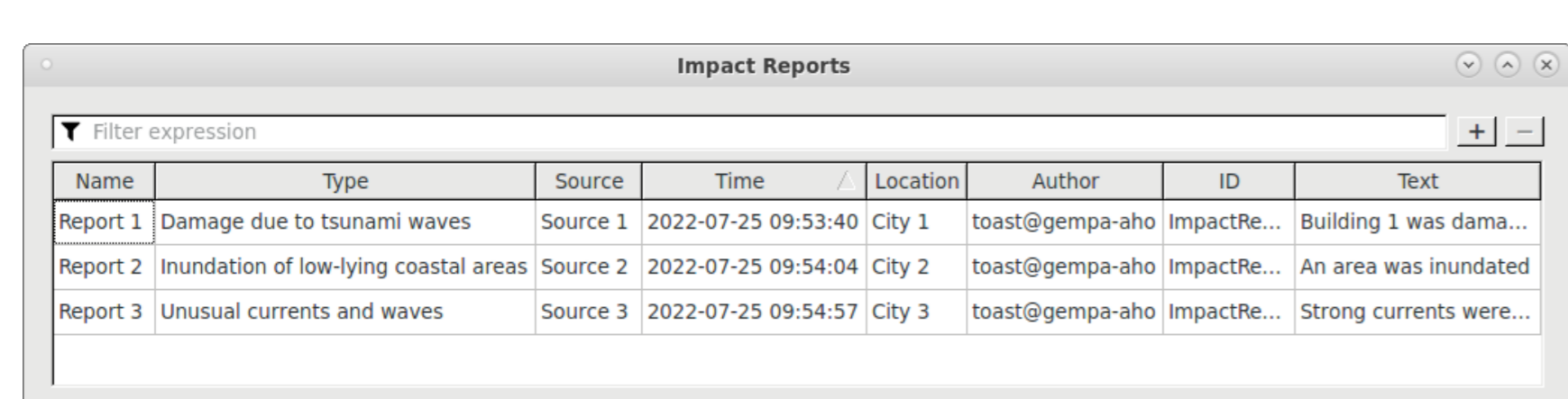


Figure 2: Impact reports can be added and used in the bulletins

Name	Place	Runup	T3 Value	Impact Time	Impact Progress	T1 Time	T2 Time	T3 Time
Ningaloo C.	Carri Bay, ...	1.123 m	1.627 m	32min		2022-08-04 11:40:50	2022-08-04 11:44:20	2022-08-04 12:37:50
Pilbara Co.	Exmouth, O.	0.896 m	2.514 m	35min		2022-08-04 11:44:20	2022-08-04 11:50:20	2022-08-04 12:41:50
Pilbara Co.	Dampier, F.	2.222 m	1.281 m	53min		2022-08-04 12:10:50	2022-08-04 12:10:50	2022-08-04 12:10:50
Cocos Island	Cocos Island	1.033 m	1.629 m	31:06min		2022-08-04 12:15:20	2022-08-04 13:23:50	2022-08-04 13:34:50
West Kimber.	Broom, De.	0.981 m	1.317 m	3h 42min		2022-08-04 12:51:20	2022-08-04 13:04:50	2022-08-04 13:15:50
Lancelin C.	Lancelin, Ju.	0.072 m	0.092 m	1h 48min		2022-08-04 12:57:20	2022-08-04 13:15:20	2022-08-04 13:15:50
Gascoyne	Denham, C.	0.403 m	0.403 m	1h 53min		2022-08-04 13:02:20	2022-08-04 13:09:50	2022-08-04 13:09:50
Sheraldown	Sheraldown, J.	0.054 m	0.054 m	1h 56min		2022-08-04 13:04:50	2022-08-04 13:08:20	2022-08-04 13:08:20
Perth Coast	Perth, Mand.	0.090 m	0.089 m	2h 00min		2022-08-04 13:09:20	2022-08-04 13:28:20	2022-08-04 13:28:20
Bunbury C.	Busselton, ...	0.063 m	0.063 m	2h 18min		2022-08-04 13:26:50	2022-08-04 13:30:20	2022-08-04 13:30:20
North West	Mitsaki, ...	0.060 m	0.059 m	2h 18min		2022-08-04 13:27:20	2022-08-04 13:27:20	2022-08-04 13:27:20
Christmas	Christmas I.	0.771 m	0.768 m	passed		2022-08-04 11:01:50	2022-08-04 12:12:50	2022-08-04 12:12:50

Figure 3: Impact progress for forecast zones

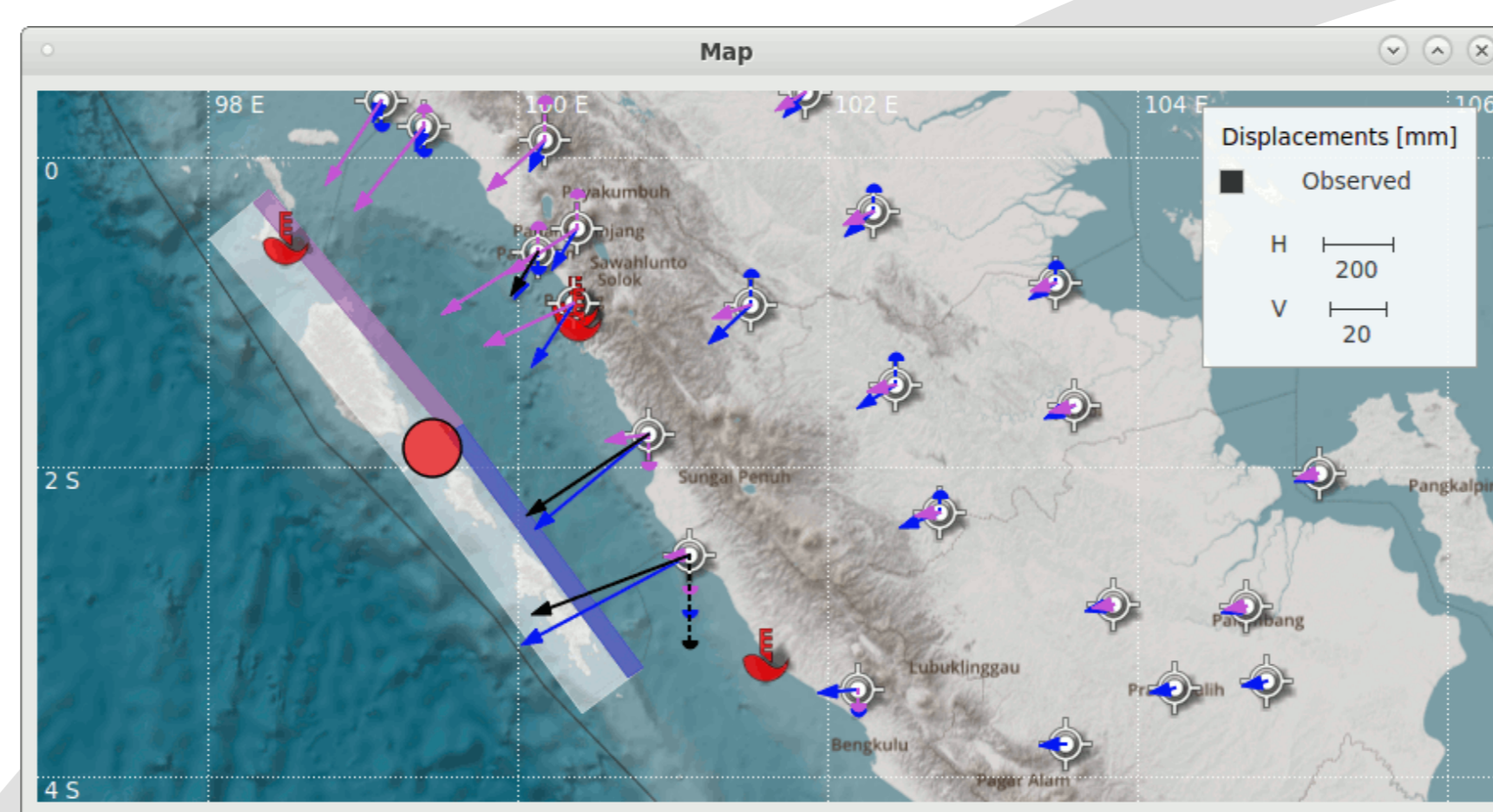


Figure 4: Observed and simulated coseismic displacement vectors can be used to evaluate simulation match

Architecture

TOAST-multiuser version consists of three components:

1. TOAST client
 - Graphical user interface
 - Evaluates templates to create bulletins
 - Computes threat levels
 - User triggers dissemination
2. TOAST server
 - Automatic incident and simulation creation
 - Central template configuration
 - Messaging and database access
3. GSS: Gempa Simulation Server

TOAST-multiuser version

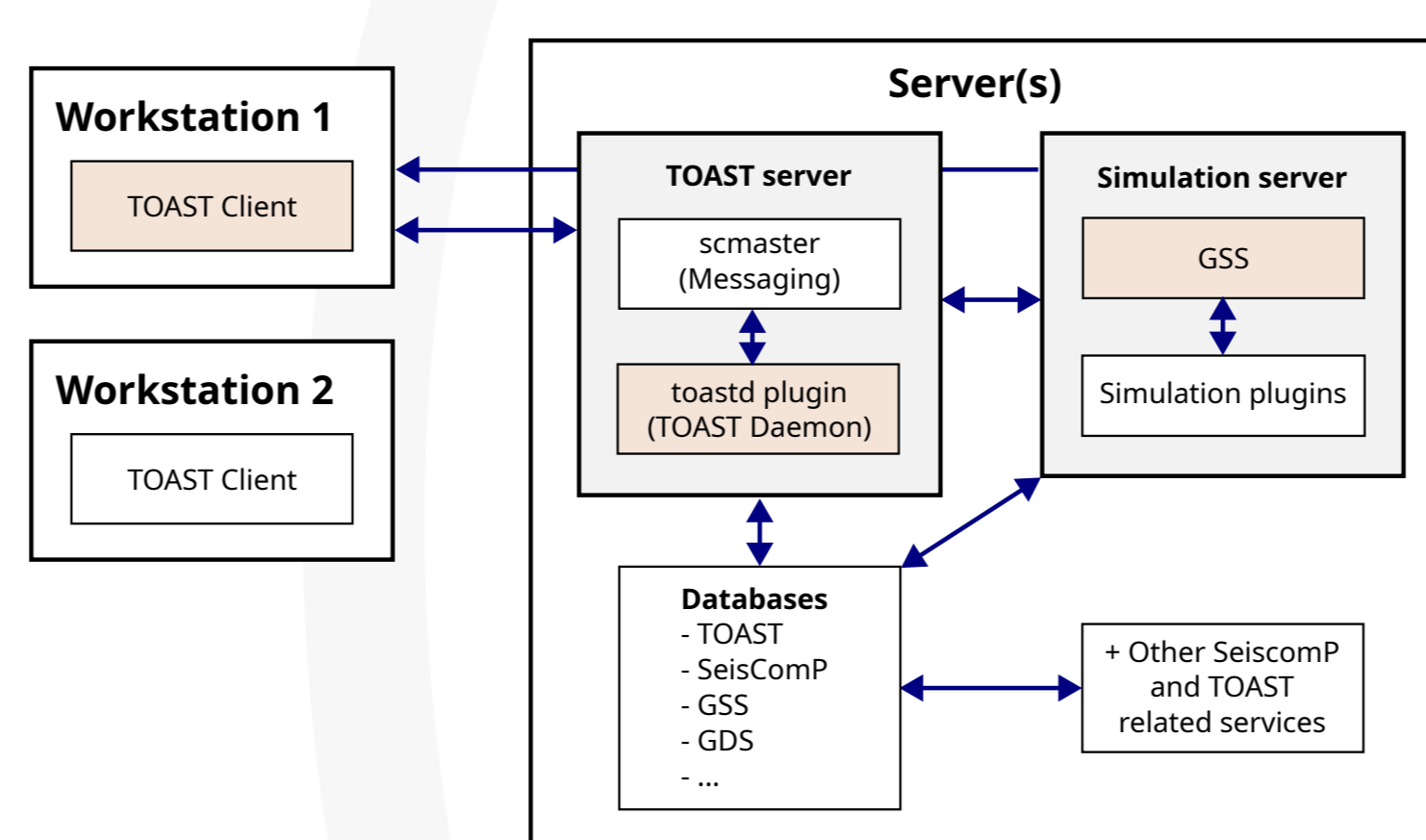


Figure 5: TOAST architecture

Template system

The new TOAST version extends bulletin capabilities:

- Templates are configured at the server as a hierarchical tree
- Live tabs are configured at the client with an entry point
- Templates are stored in the database per incident
- Templates can be edited from within the TOAST client
- Template variables can be edited with a variable editor
- Template revision counter indicates number of disseminations
- New ClearSilver functions extend the bulletin functionality

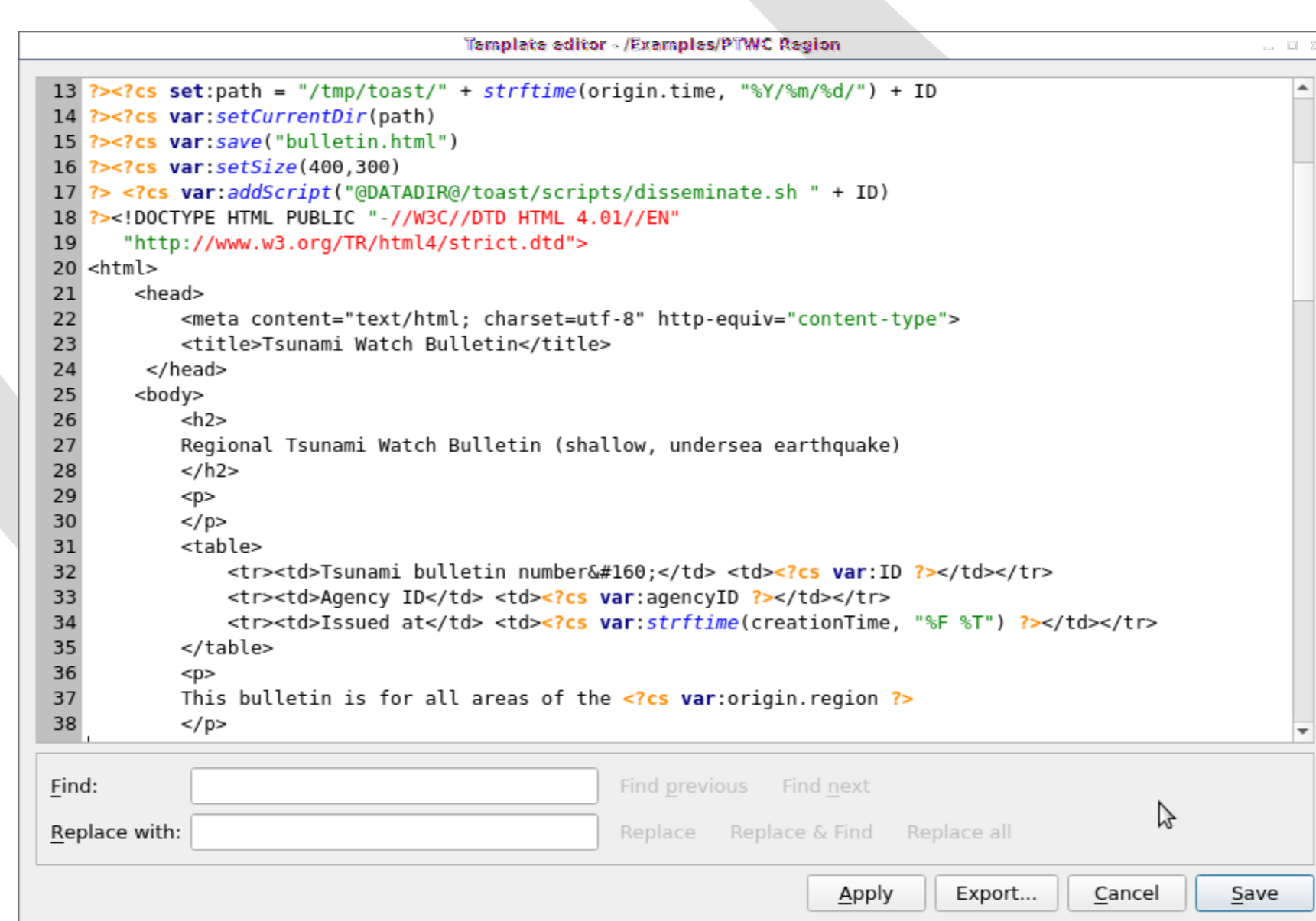


Figure 6: Editor showing template for bulletin in (Figure 7)

Bulletins can be created in any format as HTML, XML, JSON, or simple text for instance for SMS.

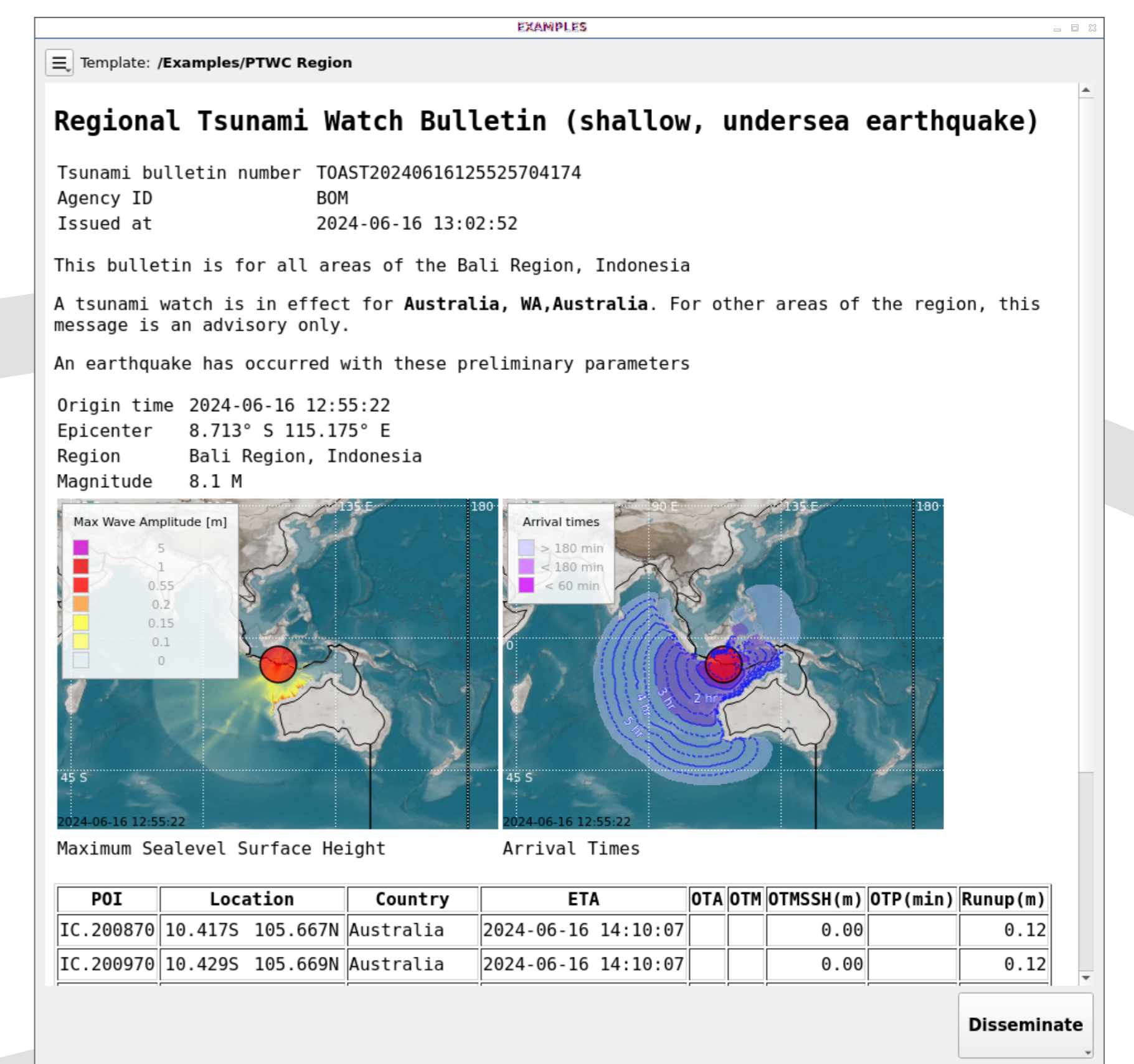
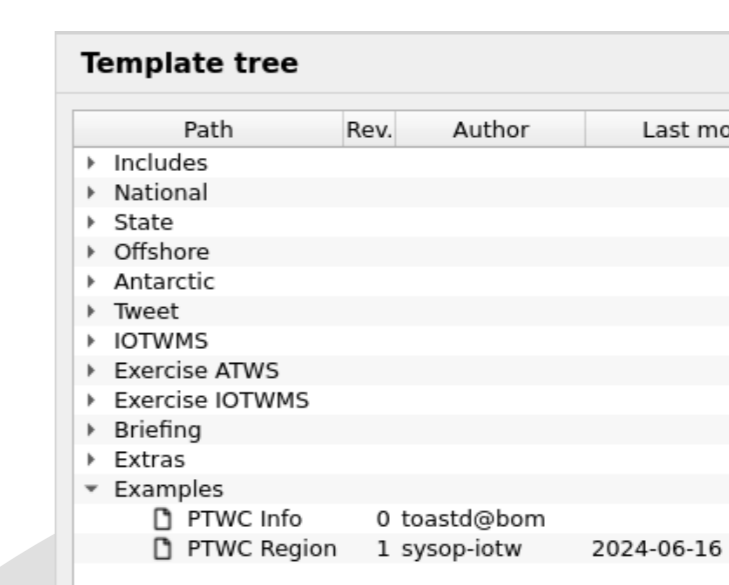


Figure 7: Example bulletin in HTML format

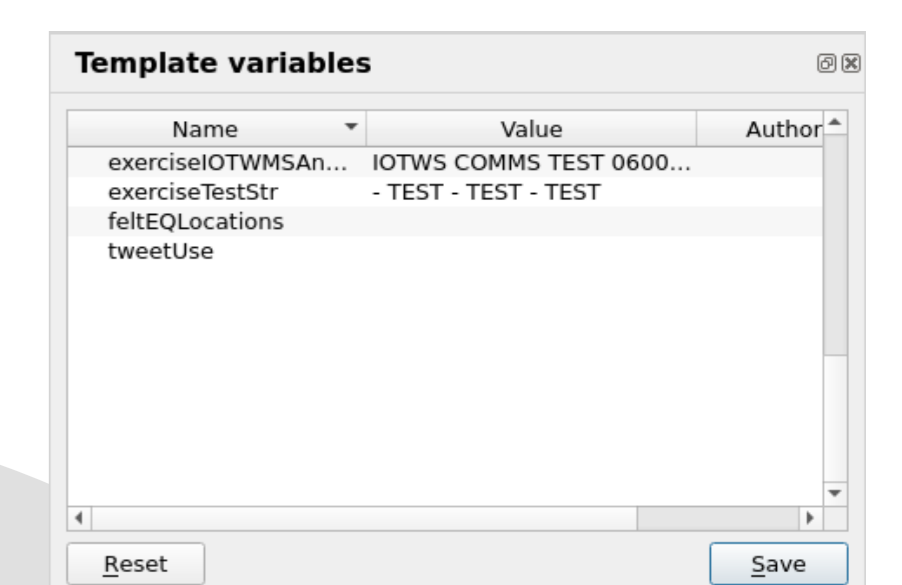
The templates and template variables of a specific incident can be edited from within the TOAST client using context menu in widgets.

Template tree widget



Shows template hierarchy

Template variables widget



Shows configured template variables and content

Dissemination

Bulletins can be disseminated directly from the TOAST client or by sending them to the gempa dissemination server GDS. This allows for more fine-grained receiver configuration and logging access using the GDS webinterface. Spoolers can be created for dissemination via email, SMS, other messaging platforms.

Outlook

The recent redesign introduced several other enhancements like editable templates, hierarchical template organization, and extended threat level computation. New features also include impact reports, event representation with additional centroid coordinates, relevance-guided simulation selection, magnitude estimation based on wave height comparisons, and the assessment of non-seismic events based on tsunami travel time predictions. This broadened perspective allows for a more comprehensive tsunami warning system capable of addressing a wider array of tsunami triggers.

Scheduled for official release by the end of 2024, the new multiuser version of TOAST represents a significant advancement in tsunami warning capabilities, offering unprecedented flexibility, accuracy, and efficiency in disaster response mechanisms.

About gempa GmbH

- Commercial spin-off of German Research Center for Geosciences, GFZ Potsdam
- Founded in 2008
- Owned by Dr. Bernd Weber and Jan Becker
- About 15 employees: seismologists, software engineers, system administrators
- Services: software development and maintenance, installation, tuning, training
- Clients: earthquake services, tsunami warning centers, research centers, energy and mining industry

