A. Annunziato, D. Galliano, E. Sabbatino
Joint Research Centre, European Commission

"IDSL Low Cost Sea Level Measurements Technology"

27 al 30 de septiembre
Valparaíso - Chile

2021 2030 Decenio de las Naciones Unidas de las Ciencias Oceánicas para el Desarrollo Sostenible

C O N T R I B U C I Ó N

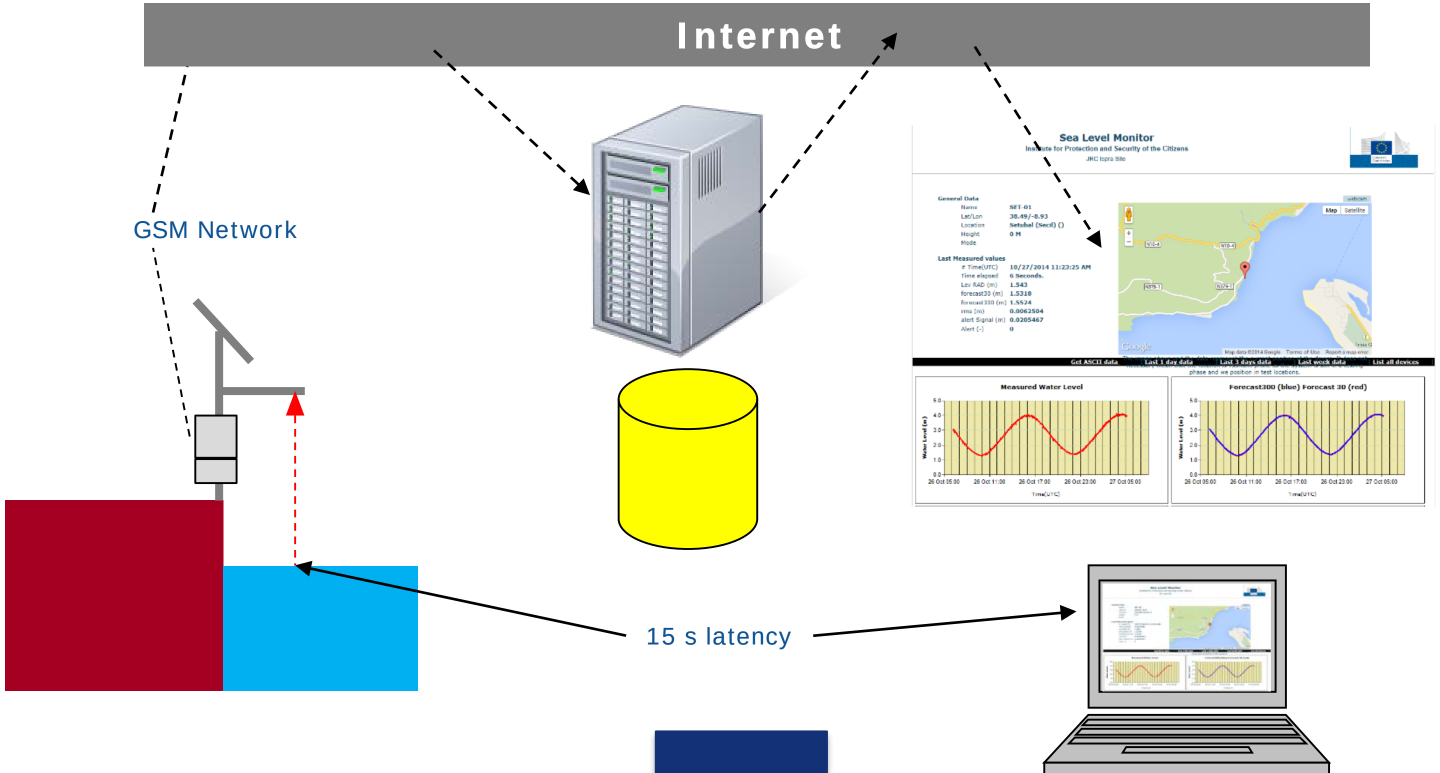
Summary

- IDSL Basics
- Communication
- Reliability
- Maintenance
- Tsunami Detection Model and SLM
- Conclusions

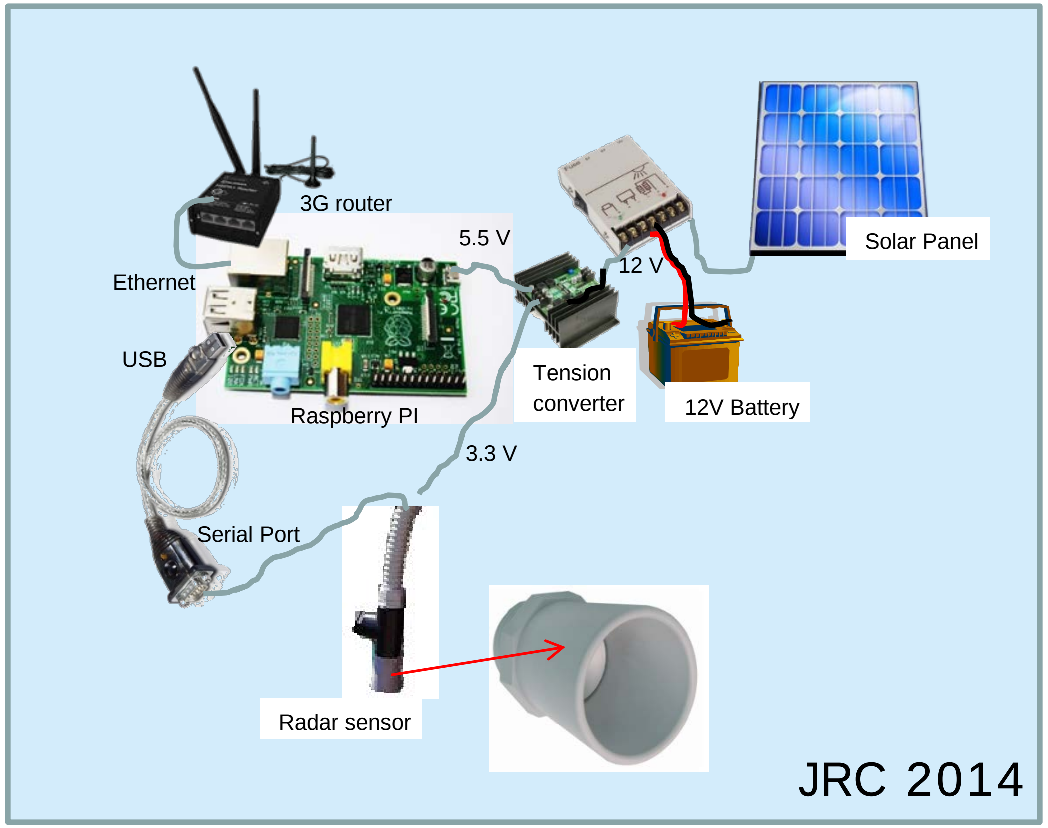
The IDSL device, since 2014

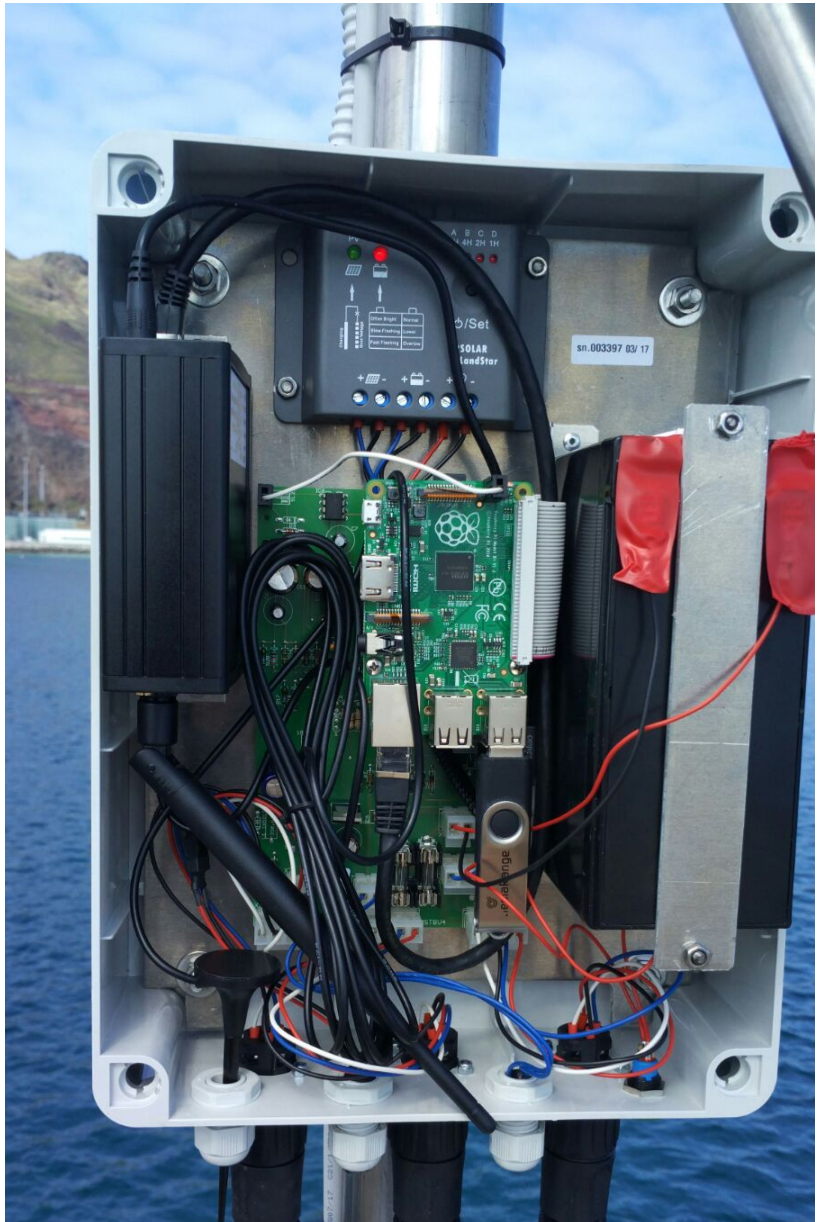
The design requirements of the mareographs were:

- High quality of the data with an error of **0.5 cm** maximum — **1 mm**
- Short acquisition time **interval**, **15 s maximum** — **5 s**
- Small transmission **latency**, smaller than **30 s** — **1÷2 s**
- Low overall cost, less than **2 kEuro** — **2.5 kEuro (incl webcam)**
- **Autonomy**, at least **3 days** without solar insulation — **3 days**



Initial prototype, with off-shelf components





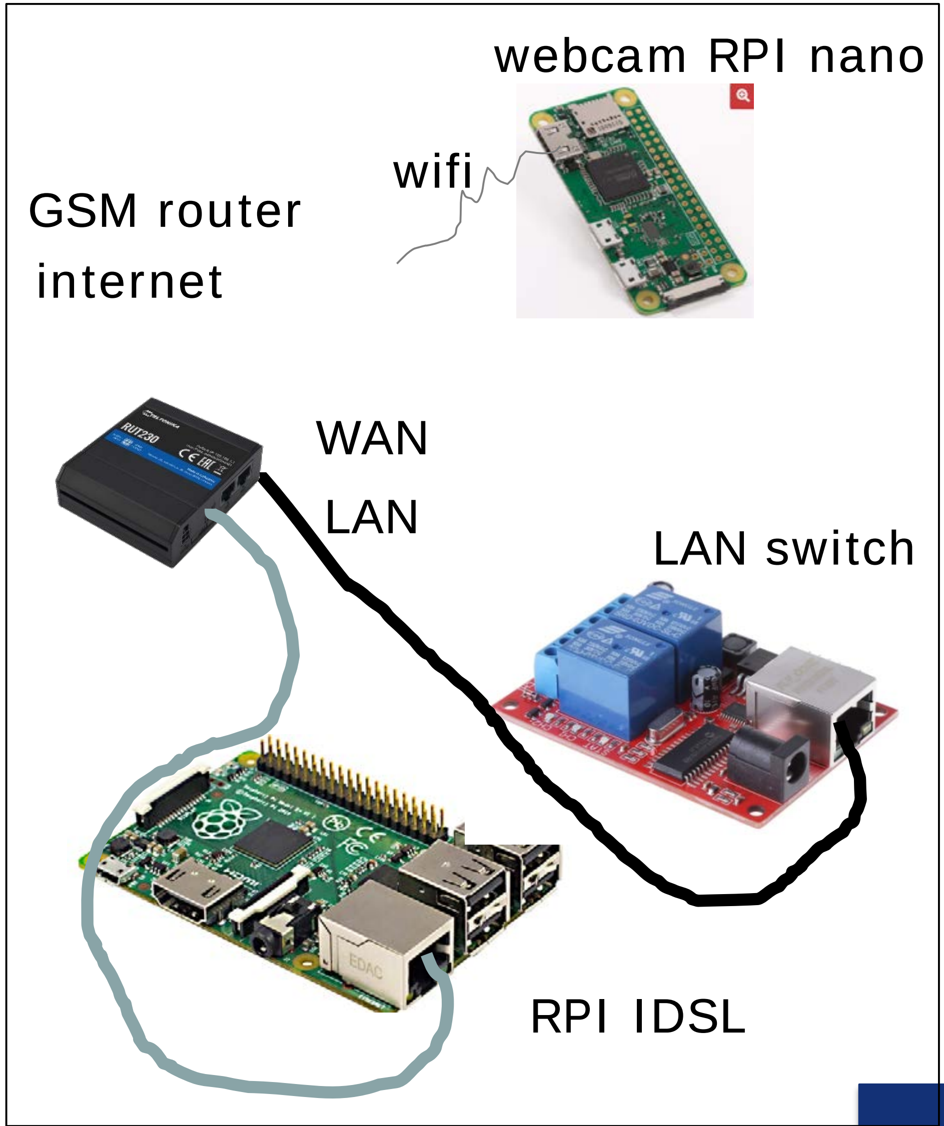
IDSL Power balance

- Teltonika 3.5 W
- Raspberry 1 W
- Board 1 W

- Total consumption 7 W (12 V means 0.58 A)

- Batteries:
  - 1 internal (7.2 Ah) + 3 external (12 Ah each)
  - Total: 43.2 Ah
    - 43.2/0.58= 74 h (about 3 days autonomy)

- To refill the batteries at 40 degree latitude we need solar panel 100 W



Raspberry PI 3 is used to host the data collection programme

Raspberry Nano in webcam

Importance of the LAN switch, to switch off and back on remotely, also via SMS

SMS control (several installations not activated or not possible)

All data received through TAD_server method

- Classical method:
  - All stations scanned by a central system every x min (i.e. 1 min)
  - In case of parallel scanning, the latency is given by the scanning interval

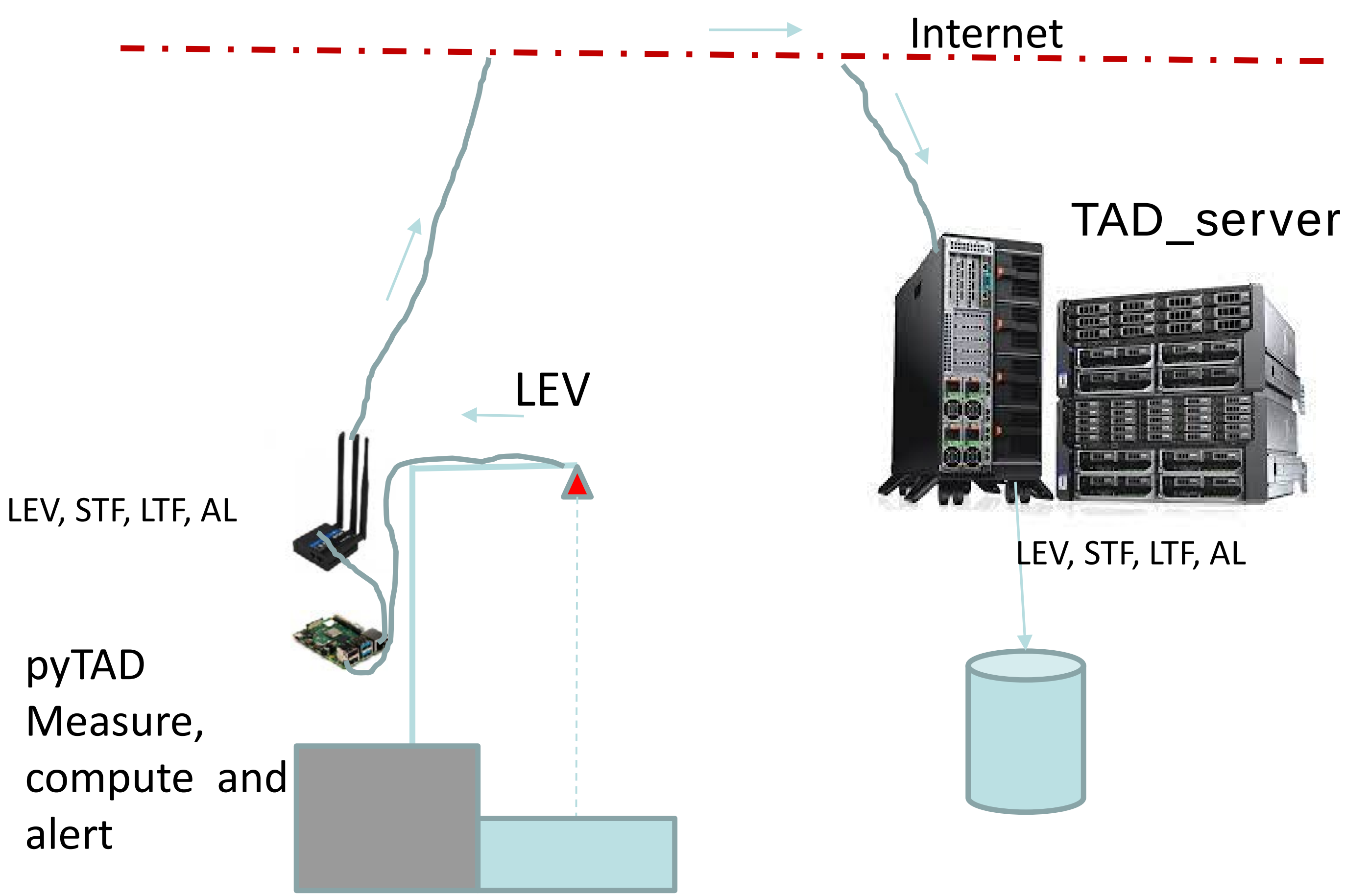
- TAD_server method: the stations transmit the data to the server as soon as it is available
  - It can be used also as backup method (transmission redundancy)
  - Latency is null or few seconds
  - IGN/PdE using for all Spanish stations and by ISPRA (Italian Mareographic Network) for 10 stations (FAST Method)

IDSL control

- IDSL is controlled, when necessary, via logmein VPN in remote desktop

- Traffic Consumption: about between 5 and 8 GB/month

Communication: basic configuration



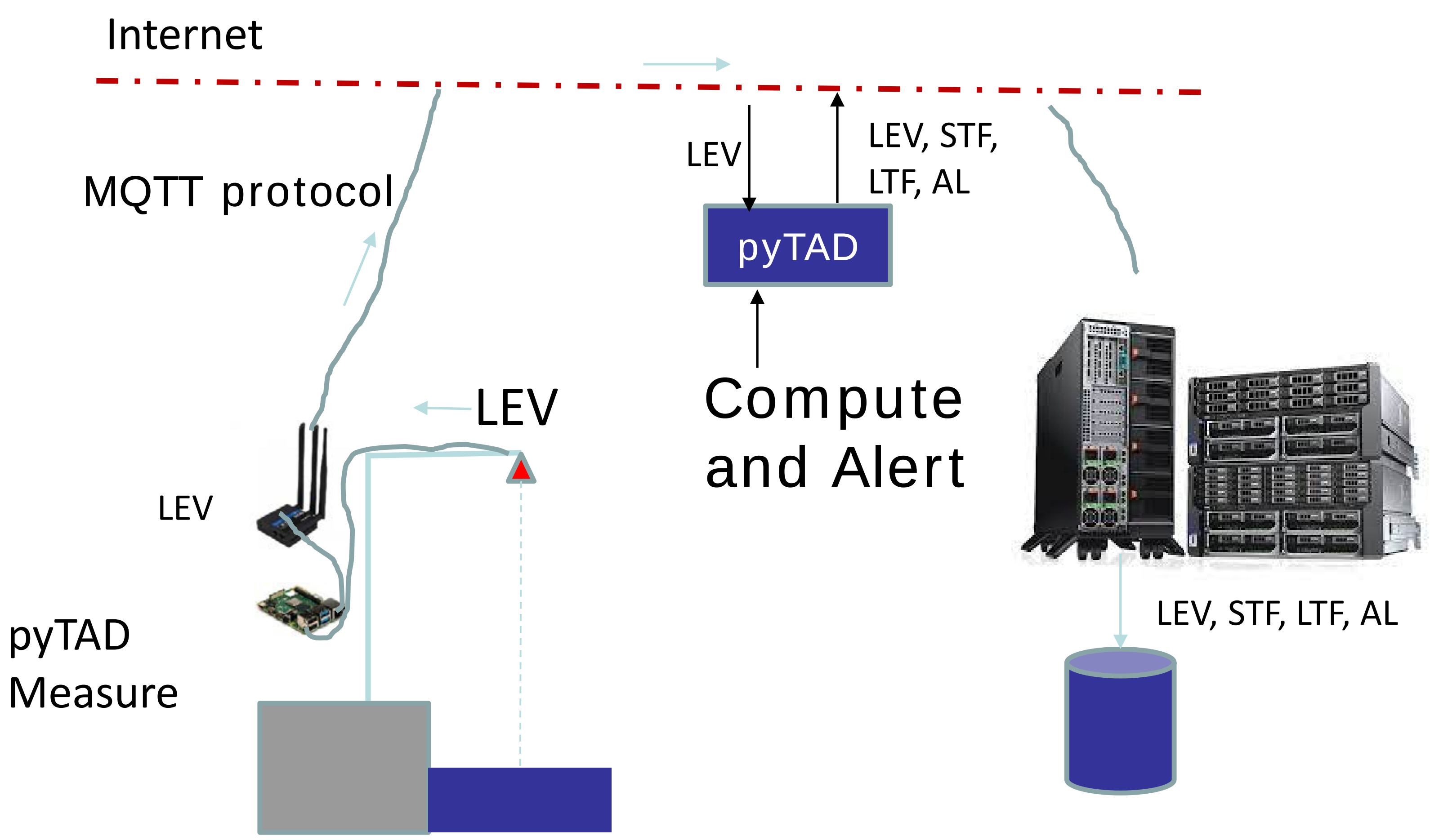
Main tasks of IDSL:

- Measure
- Compute
- Alert

TAD Server

- Data collection
- Data presentation and dissemination

Communication: split configuration



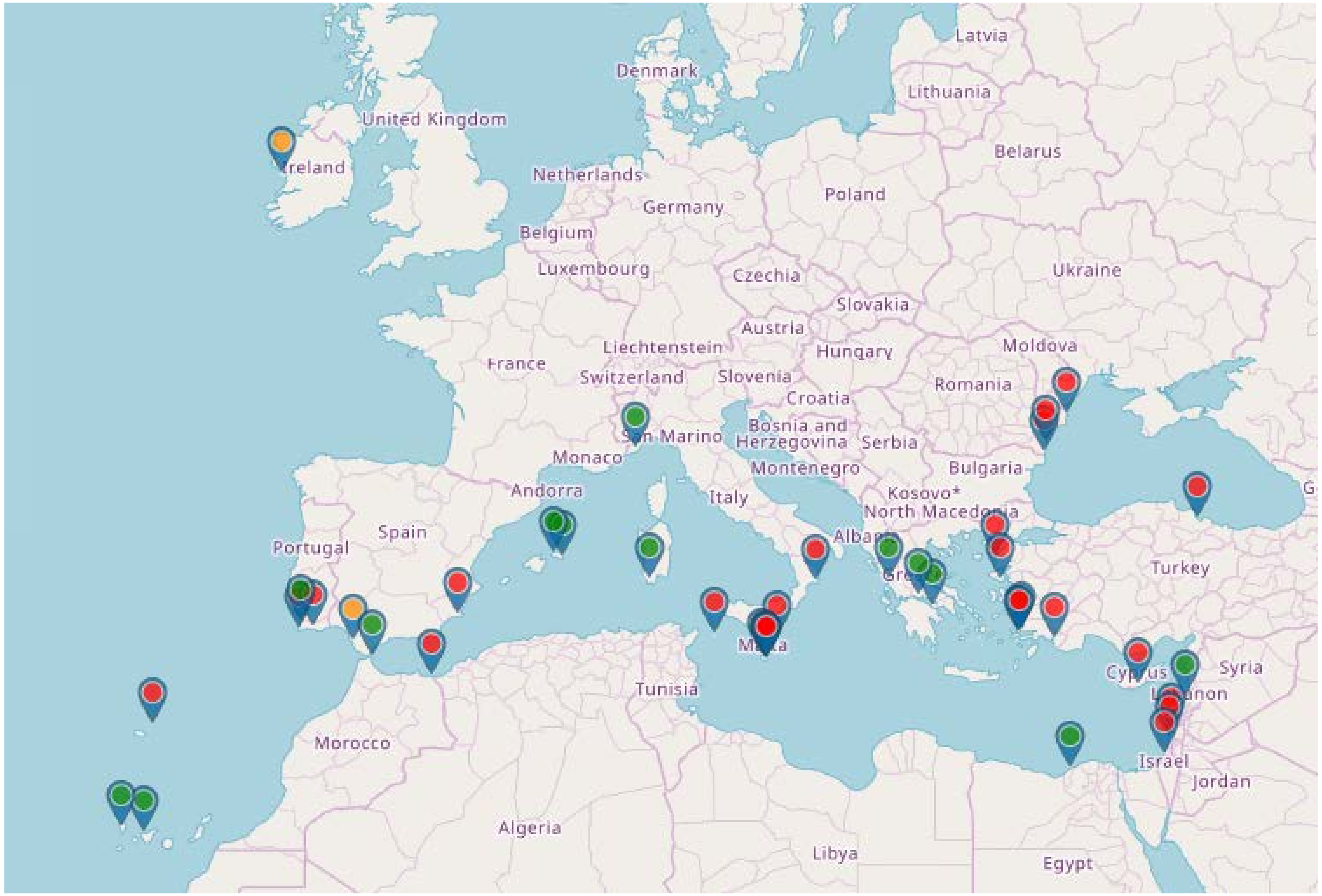
IDSL measures only

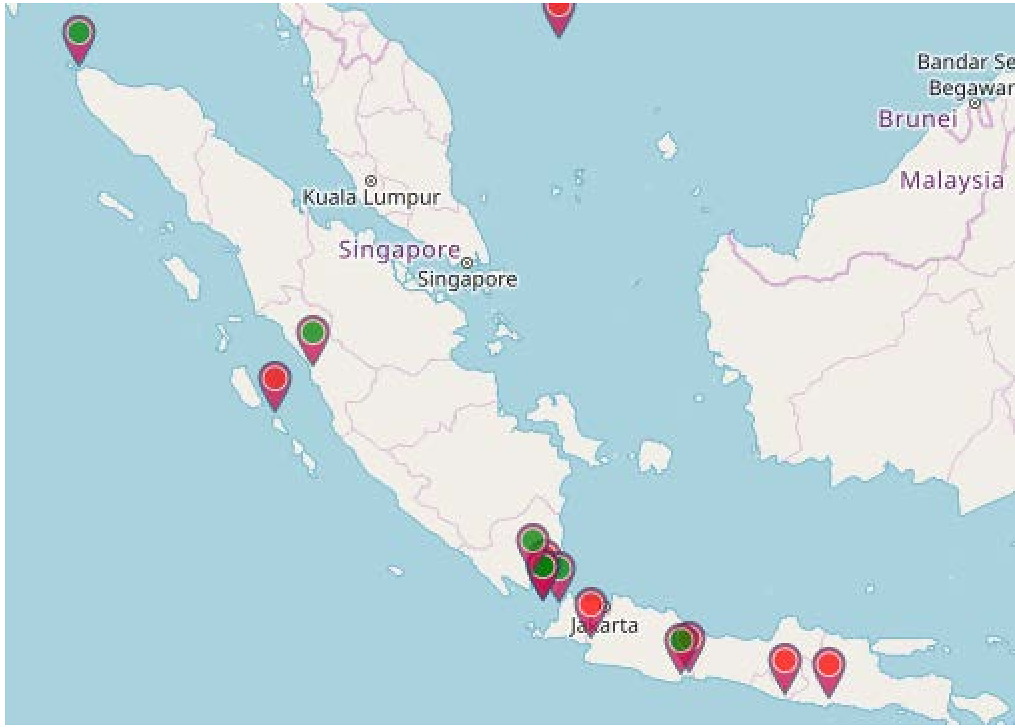
Computing and alerting demanded to an external programme, running in a computing center

Example: PUMMA devices

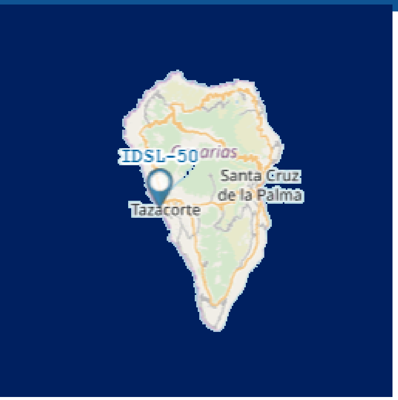
IDSL installations

42 devices in the Mediterranean Sea, 9 devices in Indonesia
Several devices need maintenance. UNESCO CoastWave project will take care of the Med. Sea devices.

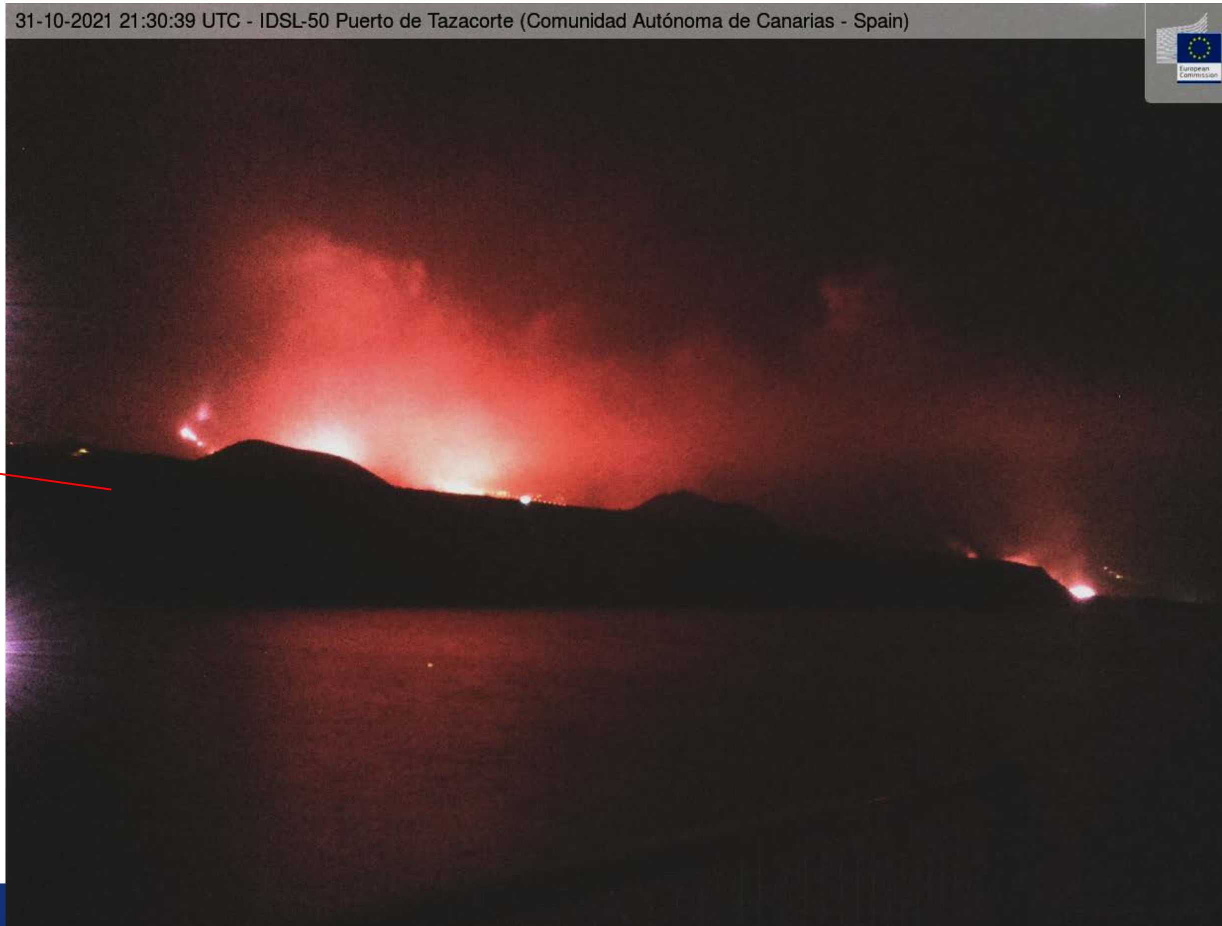




Some relevant IDSL installation: La Palma, Spain



La Palma, Volcano
Tazacorte port
Oct 2021



Rakata, Island, Indonesia

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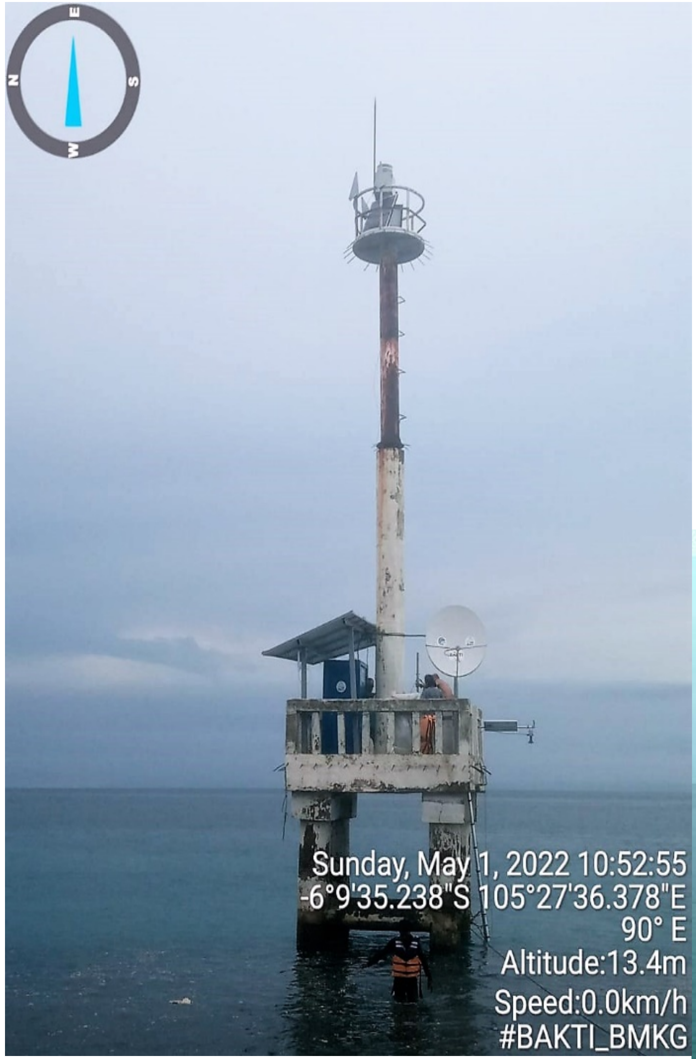

Rakata Island IDSL-309 communicates with a fast satellite communication system with Jakarta to get internet connection

BMKG
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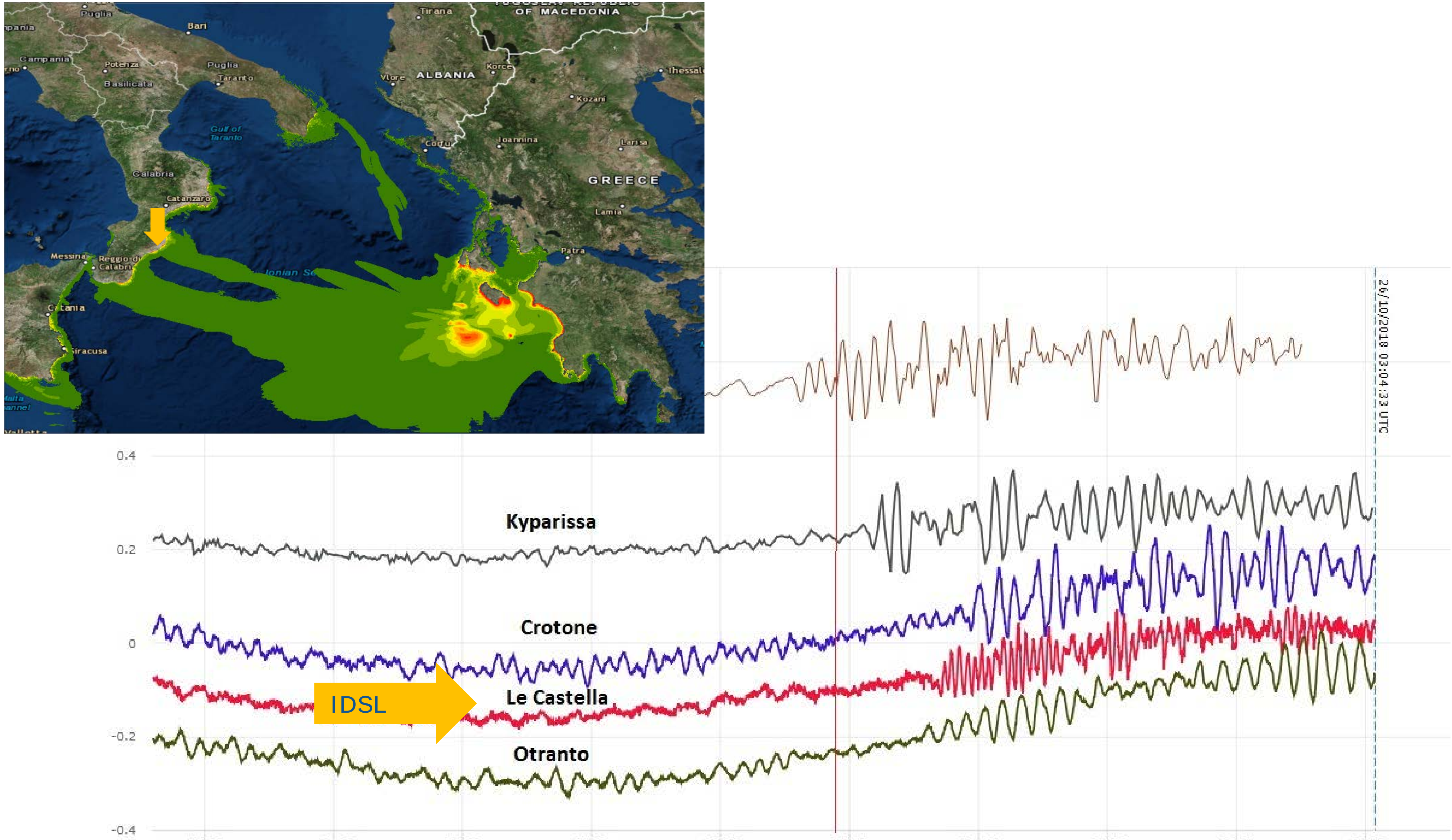
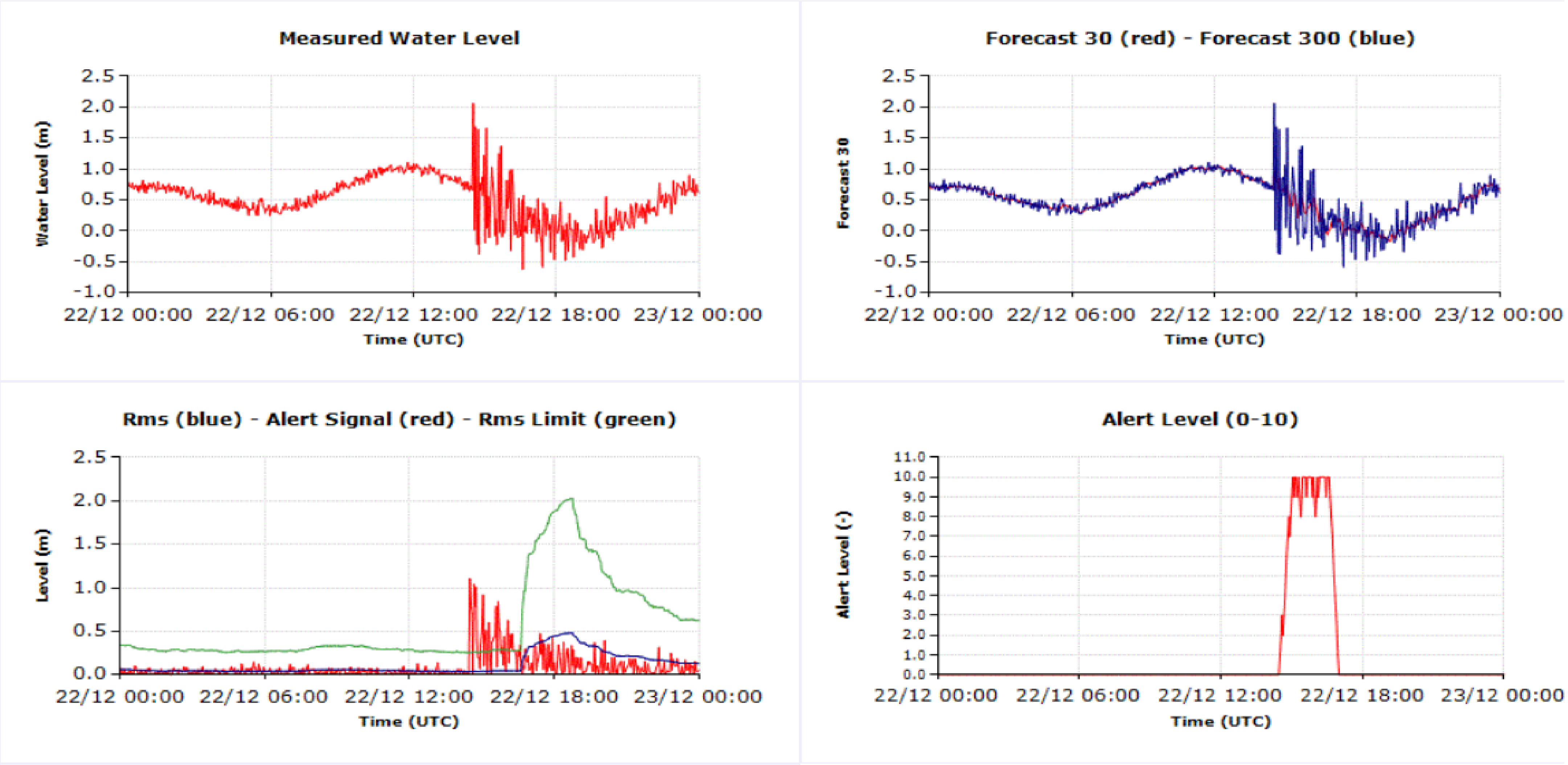
Mw 6.8 Zakyntos event: 25 Oct 2018

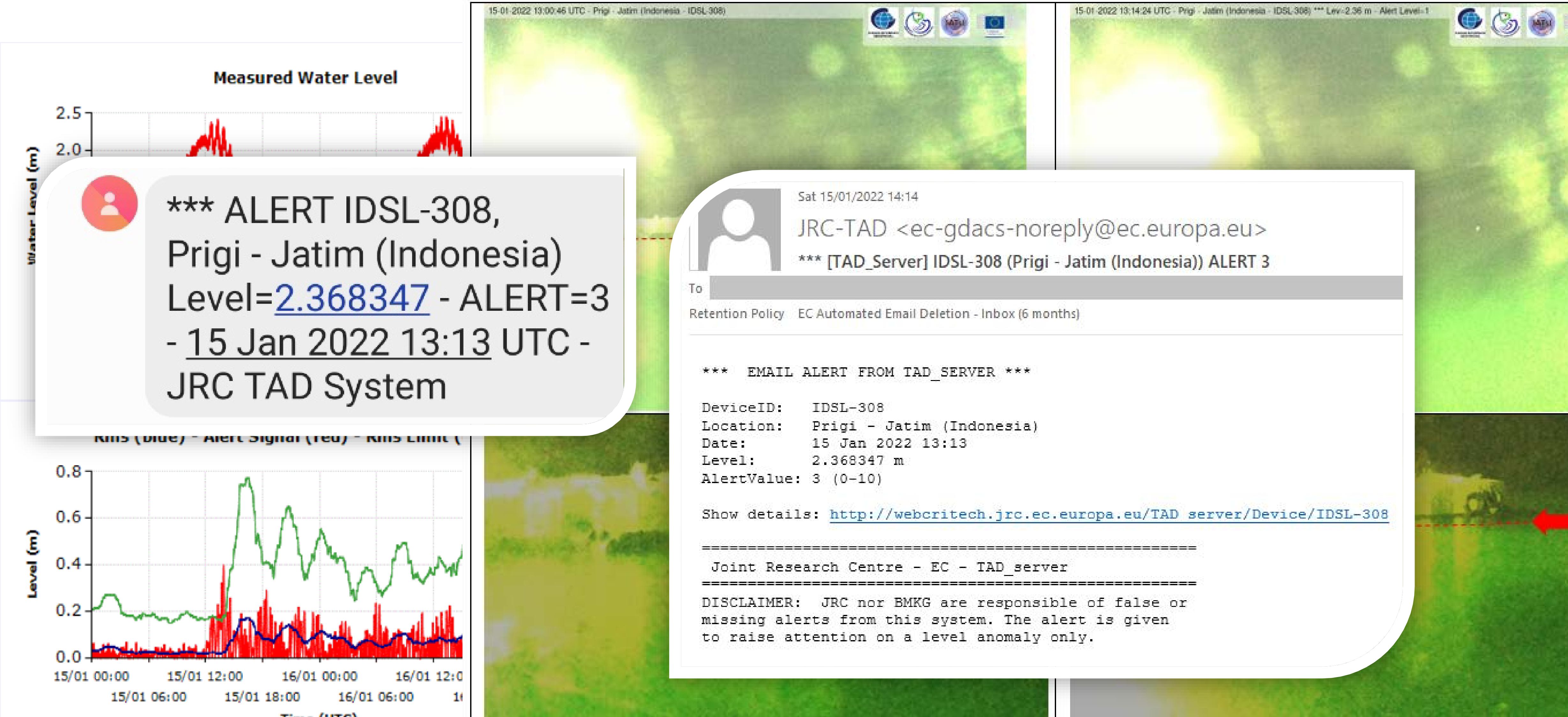
IDSL-12 correctly detected the event



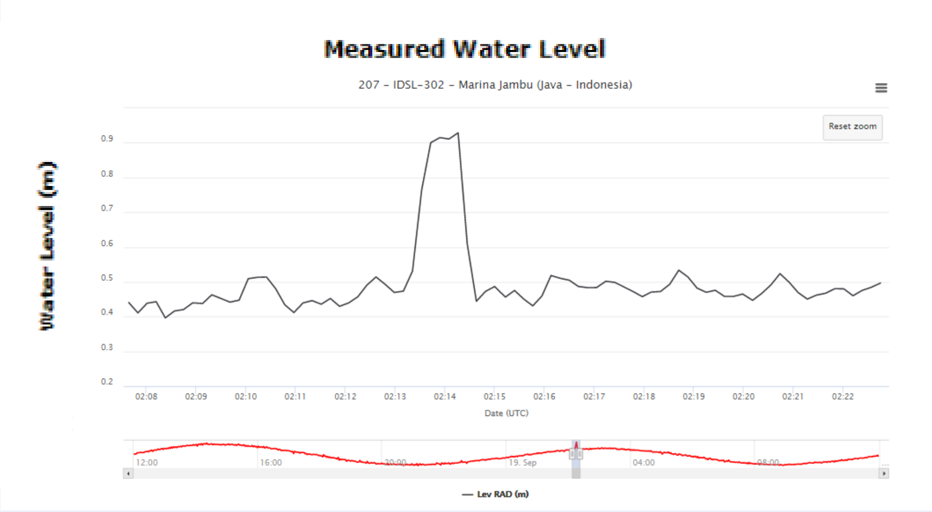
Alert mechanism, Krakatoa event 2018, using same routines of IDSL

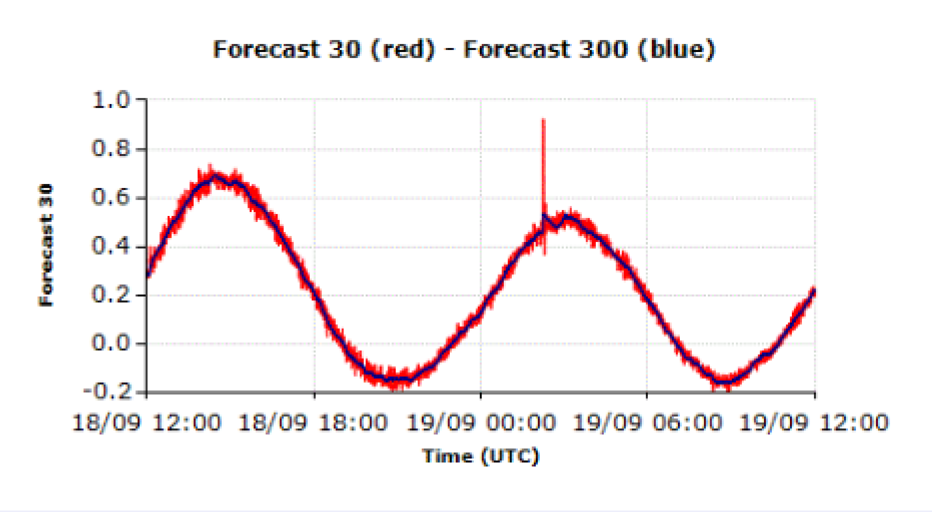


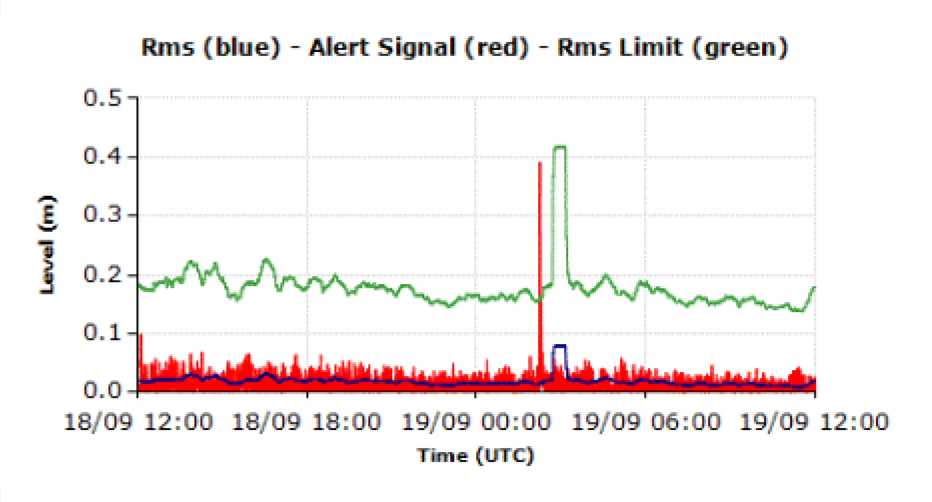
Tonga event, 2022, Prigi

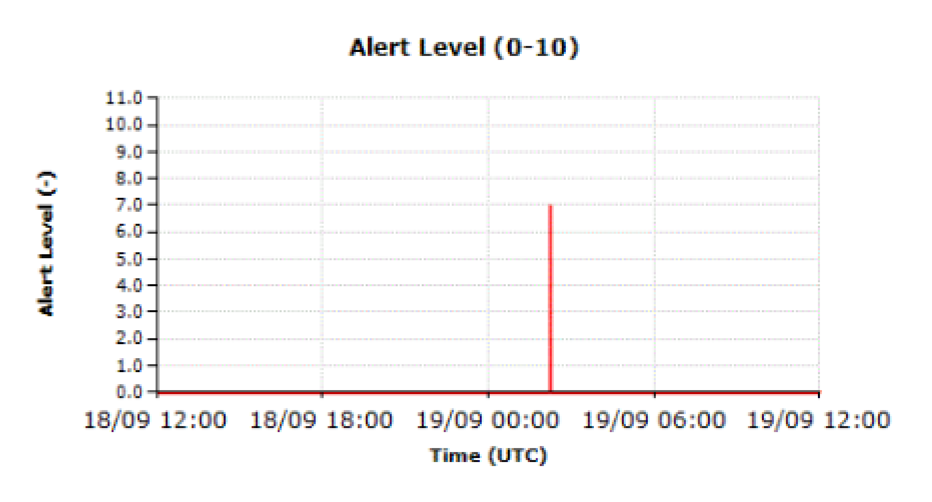


Alert mechanism for IDSL, False alerts



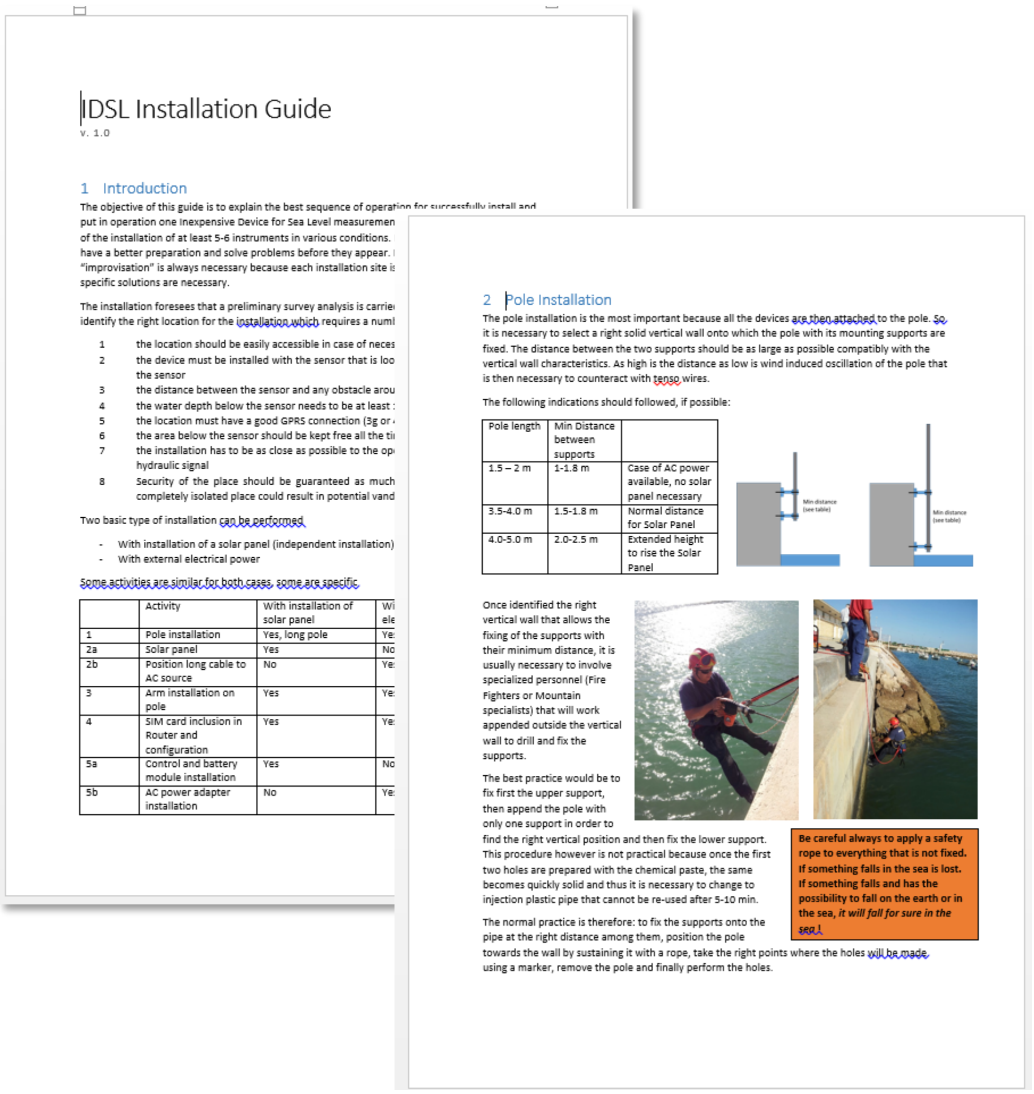






IDSL Installation Guide

- On the basis of the experience of the first 5 installations, an IDSL **installation guide** has been developed
- The objective is to have a sort of "**IKEA**" manual, i.e. a detailed and complete installation description
- The aim is to give the teams that will perform the next installations as much information as possible in order to conduct a successful installation
- In principle it could be possible to send the instruments without support from JRC



IDSL Installation Guide

v. 1.0

1 Introduction

The objective of this guide is to explain the best sequence of operation for successfully install and put in operation one Inexpensive Device for Sea Level measuremen
of the installation of at least 5-6 instruments in various conditions.
have a better preparation and solve problems before they appear.
"improvisation" is always necessary because each installation site i
specific solutions are necessary.

The installation foresees that a preliminary survey analysis is carrie
identify the right location for the installation which requires a num

1 the location should be easily accessible in case of neces
2 the device must be installed with the sensor that is loo the sensor
3 the distance between the sensor and any obstacle arou
4 the water depth below the sensor needs to be at least
5 the location must have a good GPRS connection (3g or
6 the area below the sensor should be kept free all the ti
7 the installation has to be as close as possible to the op hydraulic signal
8 Security of the place should be guaranteed as much completely isolated place could result in potential vand

Two basic type of installation can be performed

- With installation of a solar panel (independent installation)
- With external electrical power

Some activities are similar for both cases, some are specific.

	Activity	With installation of solar panel	Wi ele
1	Pole installation	Yes, long pole	Ye
2a	Solar panel	Yes	No
2b	Position long cable to AC source	No	Ye
3	Arm installation on pole	Yes	Ye
4	SIM card inclusion in Router and configuration	Yes	Ye
5a	Control and battery module installation	Yes	No
5b	AC power adapter installation	No	Ye

2 Pole Installation

The pole installation is the most important because all the devices are then attached to the pole. So, it is necessary to select a right solid vertical wall onto which the pole with its mounting supports are fixed. The distance between the two supports should be as large as possible compatibly with the vertical wall characteristics. As high is the distance as low is wind induced oscillation of the pole that is then necessary to counteract with tenso wires.

The following indications should followed, if possible:

Pole length	Min Distance between supports	
1.5 – 2 m	1-1.8 m	Case of AC power available, no solar panel necessary
3.5-4.0 m	1.5-1.8 m	Normal distance for Solar Panel
4.0-5.0 m	2.0-2.5 m	Extended height to rise the Solar Panel

Once identified the right vertical wall that allows the fixing of the supports with their minimum distance, it is usually necessary to involve specialized personnel (Fire Fighters or Mountain specialists) that will work appended outside the vertical wall to drill and fix the supports.

The best practice would be to fix first the upper support, then append the pole with only one support in order to find the right vertical position and then fix the lower support. This procedure however is not practical because once the first two holes are prepared with the chemical paste, the same becomes quickly solid and thus it is necessary to change to injection plastic pipe that cannot be re-used after 5-10 min.

Be careful always to apply a safety rope to everything that is not fixed. If something falls in the sea is lost. If something falls and has the possibility to fall on the earth or in the sea, *it will fall for sure in the sea !*

The normal practice is therefore: to fix the supports onto the pipe at the right distance among them, position the pole towards the wall by sustaining it with a rope, take the right points where the holes will be made, using a marker, remove the pole and finally perform the holes.

Reliability

- The system must work 24/7
- In case of errors it has to stop and restart autonomously
- If possible recover all the data when connection is possible
- Nothing written on the SD memory card
- Easy replacement of parts

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Regular maintenance of IDSL is needed but the time of revisit strongly depend on the local conditions

Factors that may influence IDSL efficiency

- Crystal deposits on the sensor surface
  - The sensor stops working after 2-3 years; in some sporadic cases 1 year
- Batteries degradation
  - Need to replace them regularly after 2 years of operation
- Disruption of SD card
  - Need to replace them regularly after 2 years of operation
- Break circuit or disconnection of internal battery wires (single box)
  - Rare but it may happen 1 every 5 years
- Interruption of solar panel electrical connection
  - Rare but it may happen 1 every 8-9 years

Tsunami detection model

- The detection model implemented inside the IDSL is used to:
  - Send alerts via email and SMS
  - Activate the webcam with images every 2 min and 10s video stream
- Full paper under review

The algorithm is based on the following procedure:

$$A_s(t) = |STF(t) - LTF(t)| \qquad (1)$$

Where A_s is the Alert signal, computed as absolute value of the difference between STF and LTF computed at a given time of (t). The STF or LTF represent the expected value at the current time t, obtained using least square method of second order estimated using two different times, typically 15 min and 2h. However those periods are strictly related to the installation site for which a period of testing is necessary before assigning the final values of the integration times.

$$V_s(t) = rms(A_s(t)) * f_{rms} + \tau \qquad (2)$$


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Article

Tsunami Detection Model for Sea Level Measurement Devices

Alessandro Annunziato [1]

[1] Joint Research Centre, European Commission;alessandro.annunziato@ec.europa.eu, alessandro.annunziato@gmail.com
* Correspondence: alessandro.annunziato@gmail.com; Tel.: (+39 329 9662159)

Abstract: Sea-level measurements are of critical importance in verification of a tsunami generation. When a large earthquake occurs in a subduction zone and the Regional Tsunami Service Providers of UNESCO/IOC issue alerts, sea level measurements are critically important to verify the tsunami generation to take further actions (i.e. evacuation of coastal areas). However, in some cases, if the tsunami source is very close to the coast, there is not enough time between the identification of an event and the issue of alerting bulletins. Also, when the tsunami is not generated by a large earthquake but is due to an atypical source (i.e. landslide or volcanic eruption) or a prior information from the earthquake is not available before the arrival of the tsunami, it is of vital importance to have other means for the verification of the tsunami generation. The algorithm presented in this paper, already installed in several operation al devices is capable of acquiring the data, processing them and then moving them back into the JRC or any other relevant database, can also be used for any sea level measurement of interest with corresponding triggering criteria.

Keywords: Tsunami, Sea Level Measurements, Early Warning Systems, python, volcanic eruption, landslides

1. Introduction

Sea-level measurements are of critical importance in verification of a tsunami generation. When a large earthquake occurs in a subduction zone and the Regional Tsunami Service Providers of UNESCO/IOC issue alerts, sea level measurements are critically important to verify the tsunami generation to take further actions (i.e. evacuation of coastal areas). However, in some cases, if the tsunami source is very close to the coast, there is not enough time between the identification of an event and the issue of alerting bulletins. Also, when the tsunami is not generated by a large earthquake but is due to a atypical source (i.e. landslide or volcanic eruption) or a prior information from the earthquake is not available before the arrival of the tsunami, it is of vital importance to have other means for the verification of the tsunami generation.

The Inexpensive Device for Sea Level Measurement (IDSL) [1, 2, 3, 4], developed at the Joint Research Centre of the European Commission (EC-JRC), is a low-cost focused innovative sea level measurement device consisting of a Linux based Raspberry PI board. It runs a software that allows the measurement of the sea level and its interpretation according to an algorithm that allows the anomalous waves detection in real time.

The JRC IDSL algorithm provides the following 3 functionalities:

- To create a trigger to send email and SMS to a list of users
- To activate the webcam (if available) and take images every 2 min
- To start a 10 s video recording from the webcam (if available)

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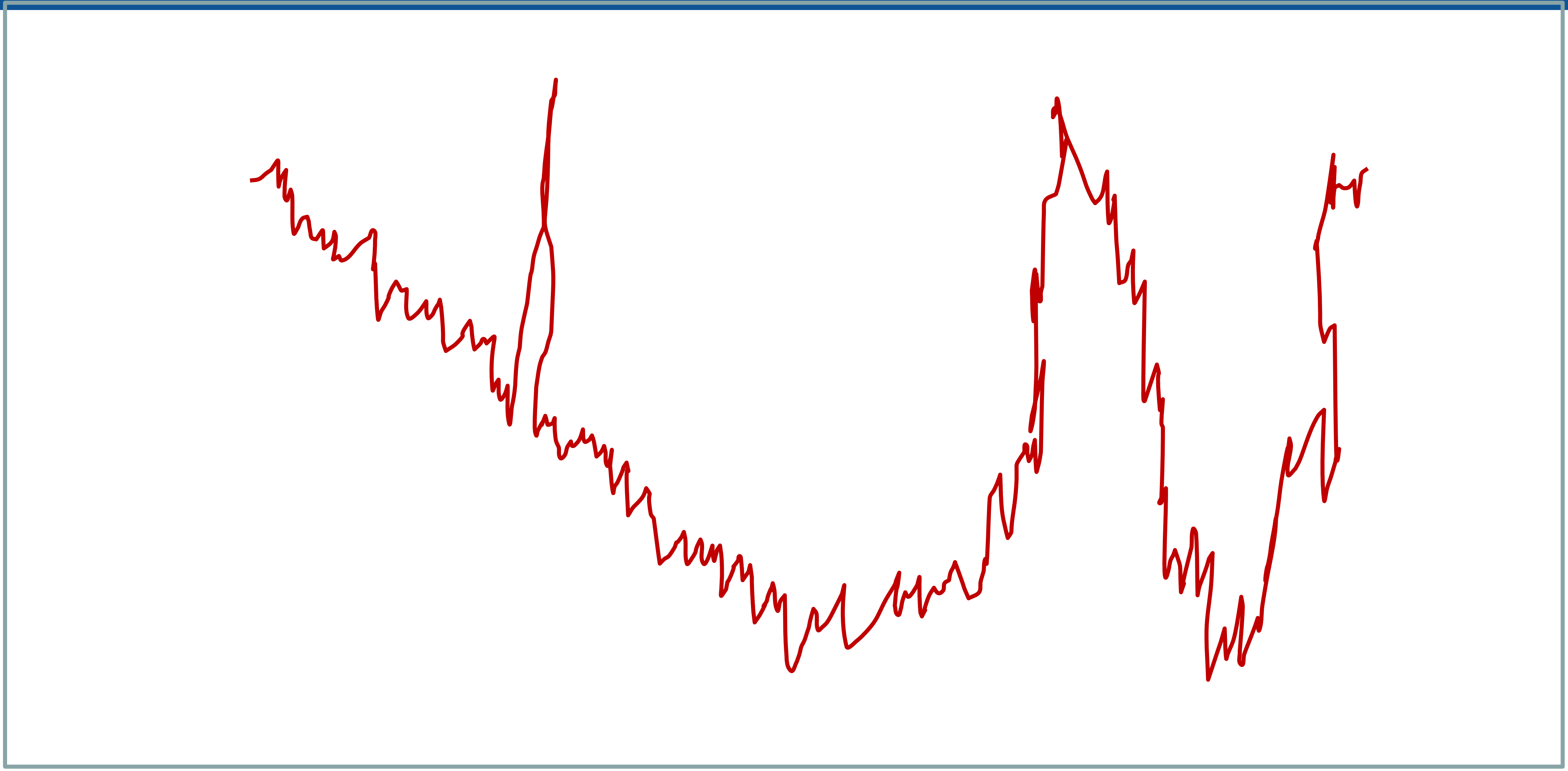
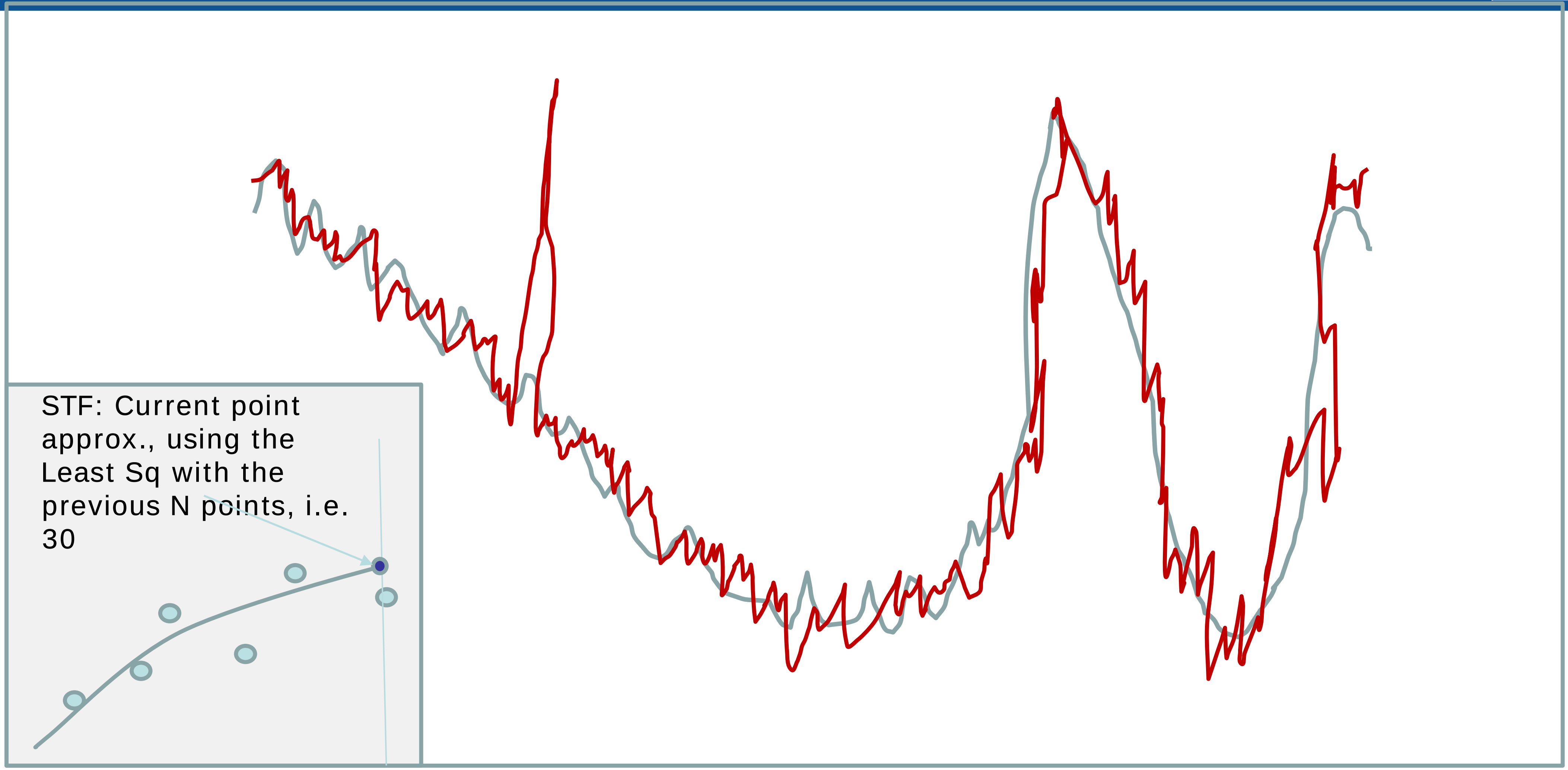
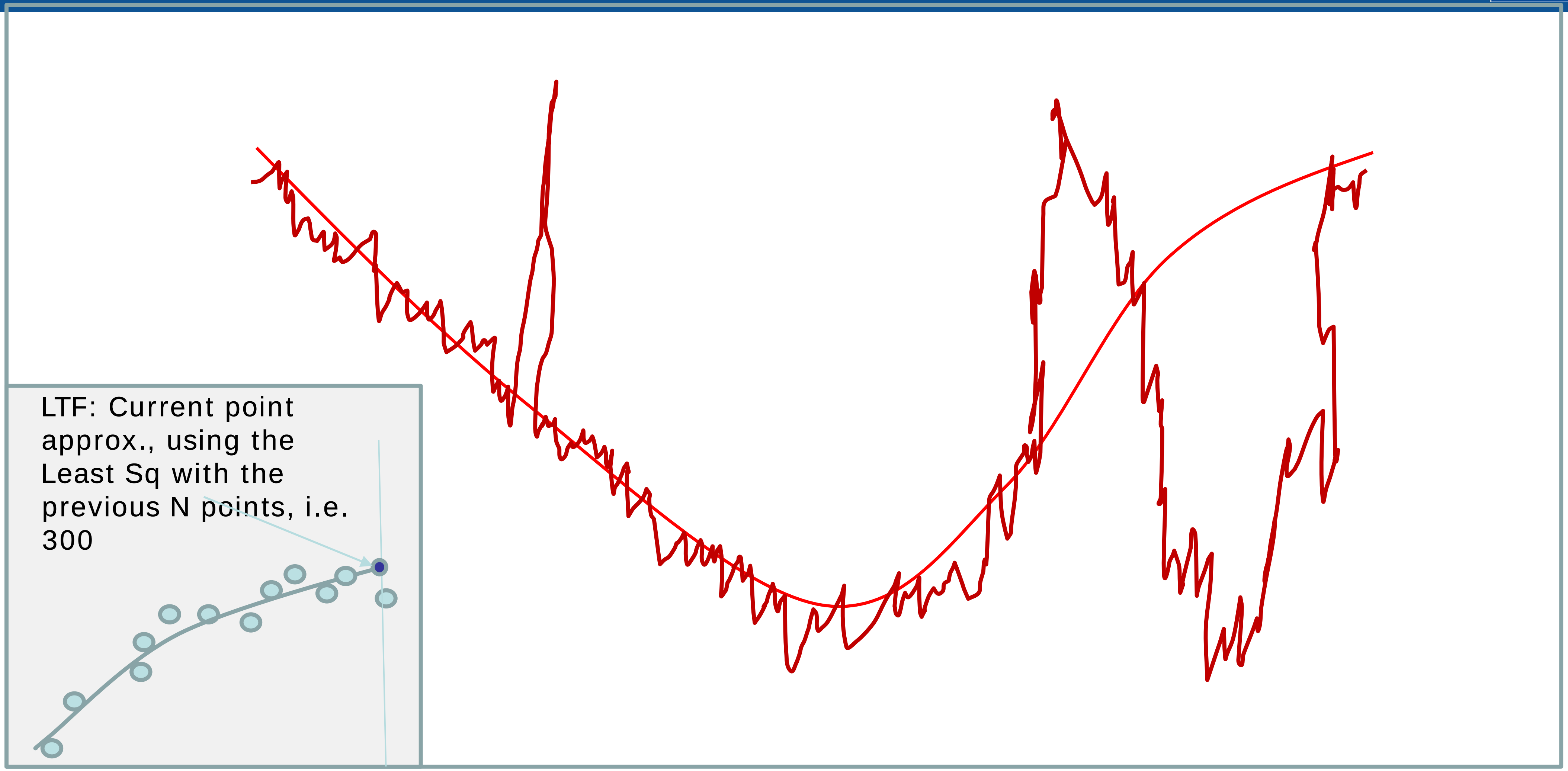
Original signal



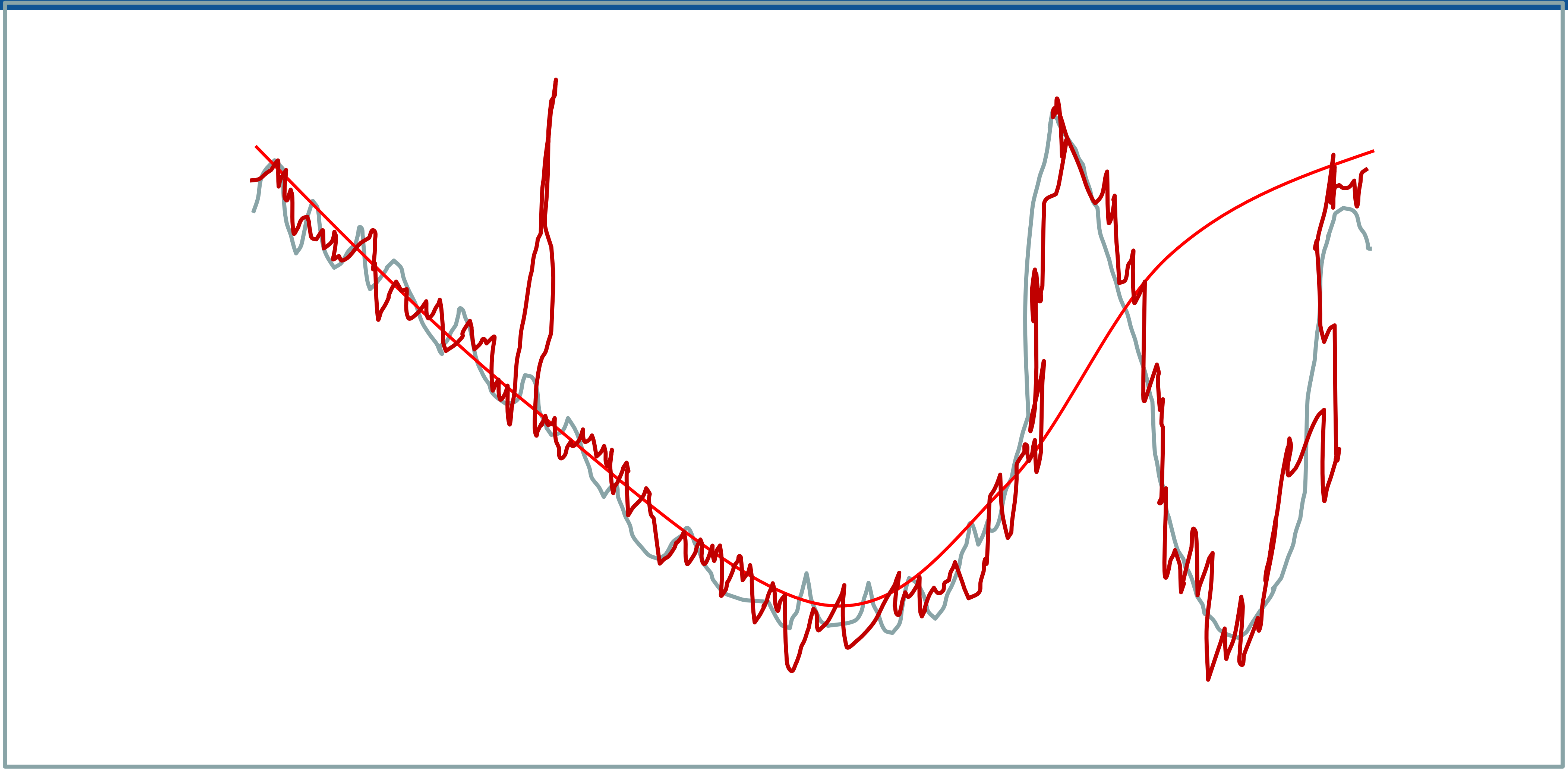
Short Term forecast



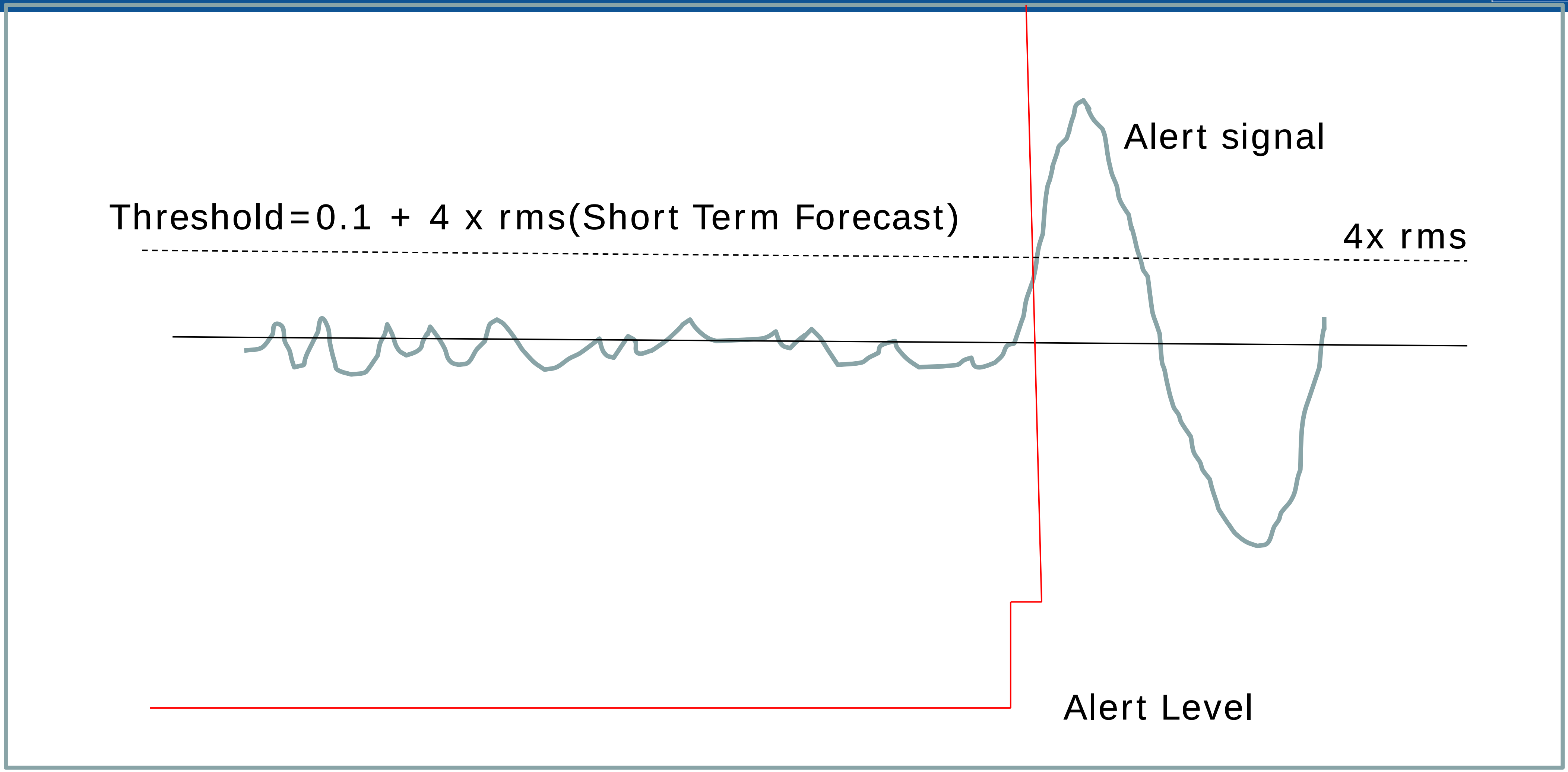
Long Term Forecast



All signals together



Short Term minus Long Term Forecast



Sea Level Machine (under development)

European Commission

TAD SERVER

Space, Security and Migration Directorate - JRC Ispra Site

European Commission > Webcritech > TAD > Home

TAD WebCritech Devices List Tools Links About Documentation

List of events with measured Tsunami

The map shows the Tsunami events for which measuremsnts are available and have bee
other events for which a GTS message was not available (restricted GTS) or the measurem
after the date, you will open the event and you can then see whcih sensor have

Minimum Magnitude	Minimum Height	GTS derived
Select...	Select...	Select...

2022

19-09-2022 18:05:00	**M7.6**	Mexico	-103.2524/18.3
27-07-2022 00:43:24	**M7.0**	N. LUZON ISLAND, PHILIPPINES	120.801/17.56
25-05-2022 21:43:02	**M5.5**	S. MEXICO, MEXICO	-95.856/16.325

TAD SERVER

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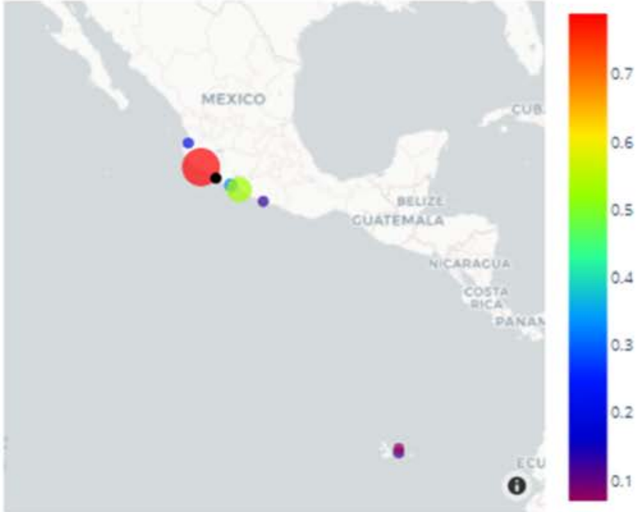
TAD WebCritech Devices List Tools Links About Documentation

M7.6 Mexico

Event ID	1338437
Date of event	**19-09-2022 18:05:00**
Location	**Mexico**
Magnitude	**M7.6**
Depth	**16.13 km**
Lat/Lon	**18.3667/-103.2524**
Place of max height	**Manzanillo Mx**
Amplitude (period)	**0.79 m (32 min)**
GDACS Report	link

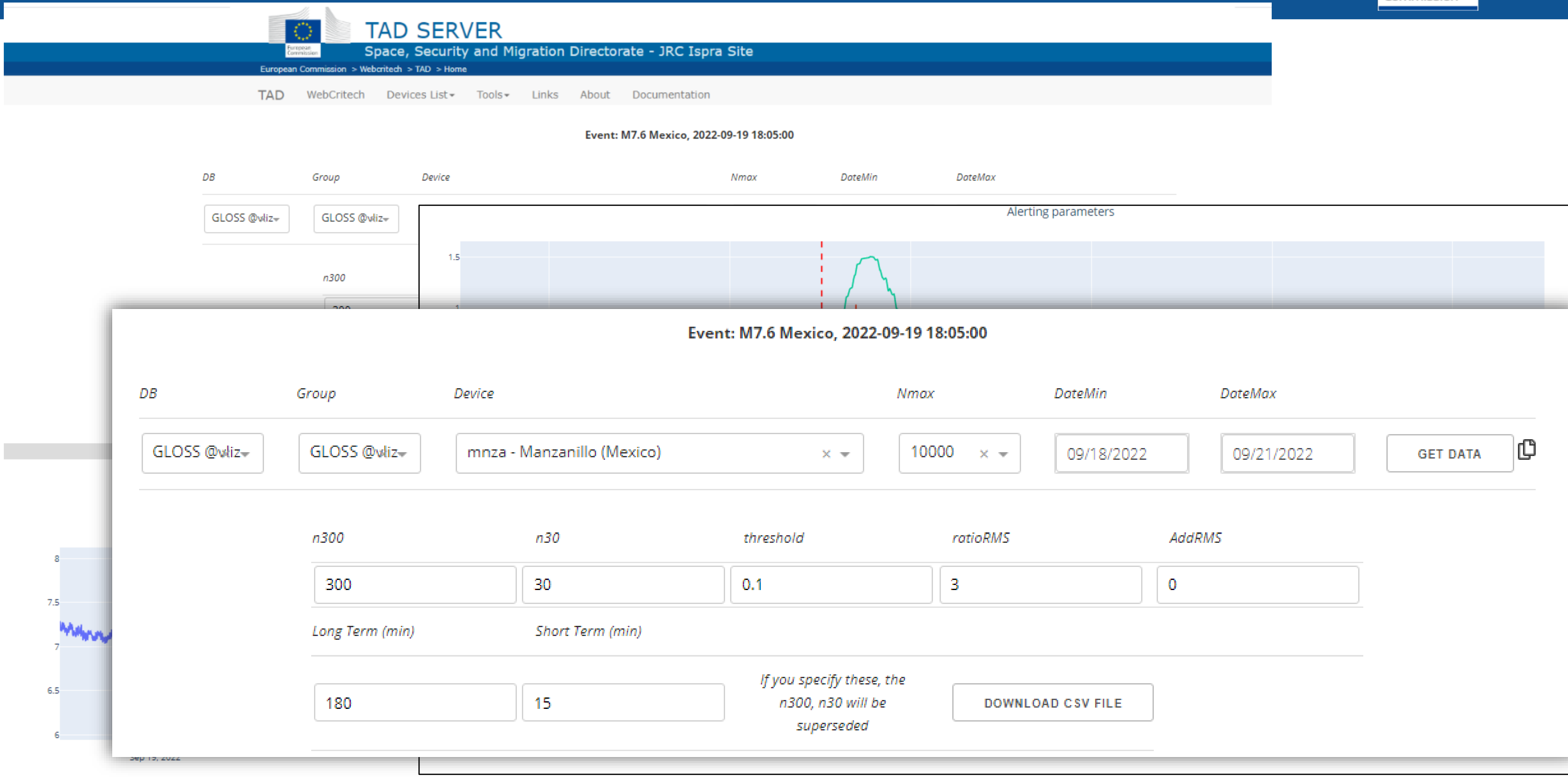


Clicking on the measurement location link, you will visualize the measured signals and apply the Tsunami detection algorithm.

Back to list of events

Santacruz Galapago	23:07:00	**0.12 m** m (1 min)
Baltra Galapags Ec	22:32:00	**0.07 m** m (12 min)
Lazaro Cardenas Mx	21:47:00	**0.32 m** m (14 min)
Zihuatanejo Mx	21:21:00	**0.53 m** m (16 min)
Manzanillo Mx	19:24:00	**0.79 m** m (32 min)
Acapulco Mx	19:07:00	**0.13 m** m (34 min)
Puerto Vallarta Mx	18:20:00	**0.21 m** m (6 min)

Sea Level Machine, follows



Conclusions

- The IDSL device proved to be a very good **alternative** to traditional sea level devices
- **Preventive maintenance** is necessary to ensure smooth and continuous operation but the cost of each piece is rather limited
- The use of such low cost device can notably improve the **availability of high quality tide gauge records** in case of events
- The involvement of **local administration and people** can allow a virtuous mechanism and facilitate the maintenance, in particular for very remote areas
- Interest by **Indonesia** authorities to produce a local version of the IDSL, named **PUMMA**, to install in hundreds of installations in the country
- The **Tsunami Detection Model** included in the IDSL proved to be useful to identify ongoing events and is particularly useful for non EQ related events (example Honga Tonga Volcano explosion); implemented in the **Sea Level Machine** application, under development

Thank you for your interest

alessandro.annunziato@ec.europa.eu
alessandro.annunziato@gmail.com