SICE
di Boaretto Claudio srl

IDSL: a contribution for Tsunami Early Warning Systems

Full Training Package

A. Annunziato

Timeline

- Day 1:
  - **Morning 2h (9:30 – 11:30)**
    - Introduction (15min)
    - Module 1: The IDSL system (1h)
    - Q/A 15 min
  - Afternoon **2 h (14:30-16:30)**
    - Module 2: Tsunami detection algorithm (1.5 h)
    - Q/A 30 min
- Day 2:
  - **Morning 2.5 h (9:30-12:00)**
    - Module 3: IDSL installation (1h)
    - Module 4: Preventive Maintenance (45 min)
    - Q/A 15 min
    - Module 5: IDSL initialization (30min + home work by participants)
- Day 3: <home work>
- Day 4: **2h**
  - **Morning 2h (9:30 – 11:30)**
    - Module 6: Discussion of the results of the initialization (1h)
    - Overall Q/A 30 min
    - Conclusions (30 min)

Introduction

- JRC effort between 2014-2019 to promote the use of a low cost device that could allow a wide number of devices installed and used for Tsunami Monitoring purposes
- Originally the cost of a station was in the order of 14-20 kEuro. The objective was to drop the cost to 1/10, maintaining the quality and the top performance
- First prototype realized in 2004 and installed in Imperia (Italy), then more than 50 devices installed worldwide in the following years

Documents produced so far for IDSL

- Installation Document
  - It describes in detail the installation mode of an IDSL. It contains an update of a previously produced document by JRC
- Initialization Document
  - It describes in detail how to prepare a SD card to be used in the IDSL. The document consider to start from the original OS of a raspberry and describes all the actions to perform to have a working device
- Preventive Maintenance Document
  - It describes how to have an efficient IDSl over the years, reporting the most frequent reasons for failure and indicating what to during maintenance visits
- This training Module
  - This large presentation (sorry)

Organization of this training

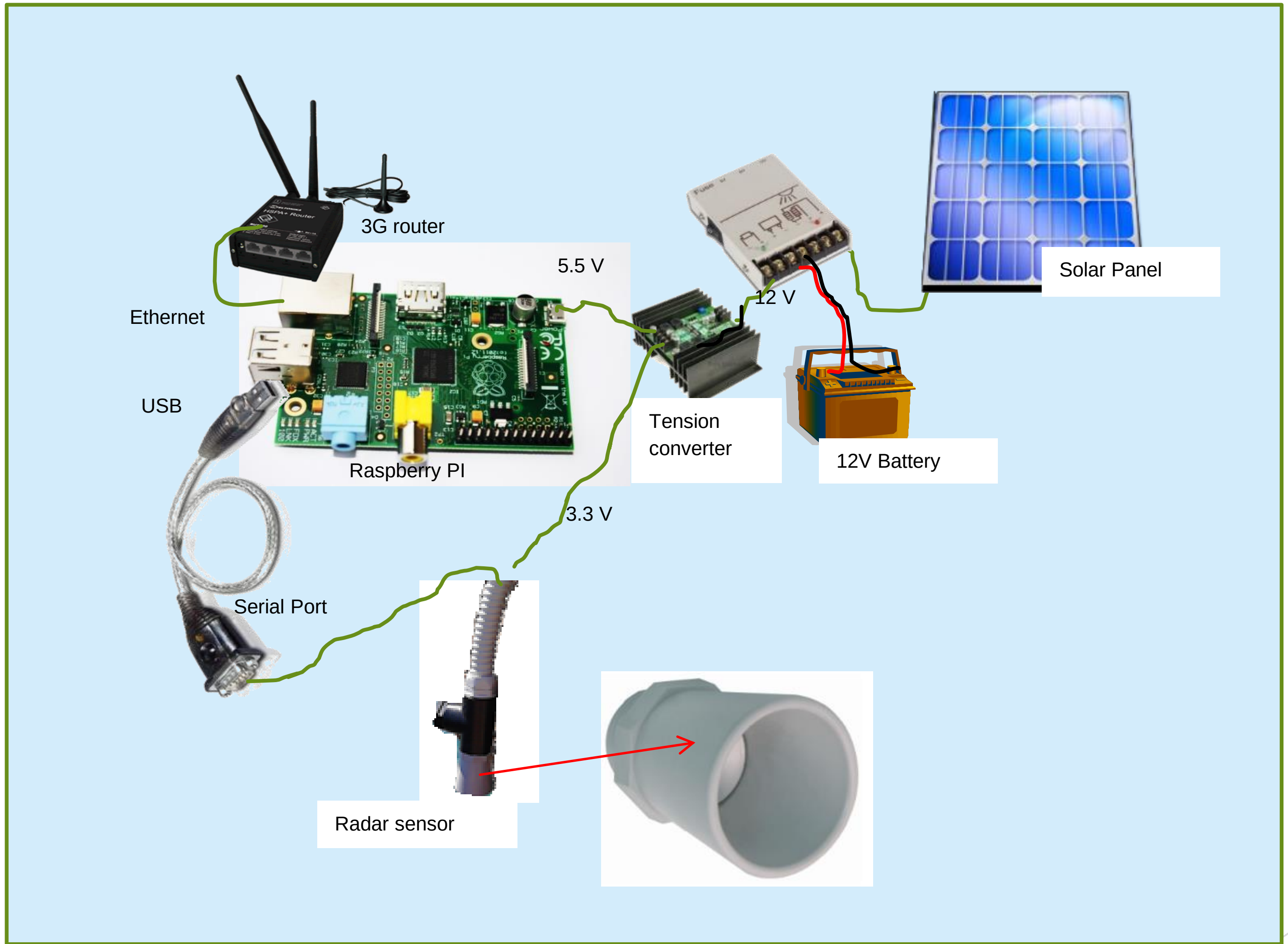
- Description of the IDSL
- Tsunami detection algorithm
- Installation strategies
- Preventive maintenance
- How to initialize an IDSL from scratch

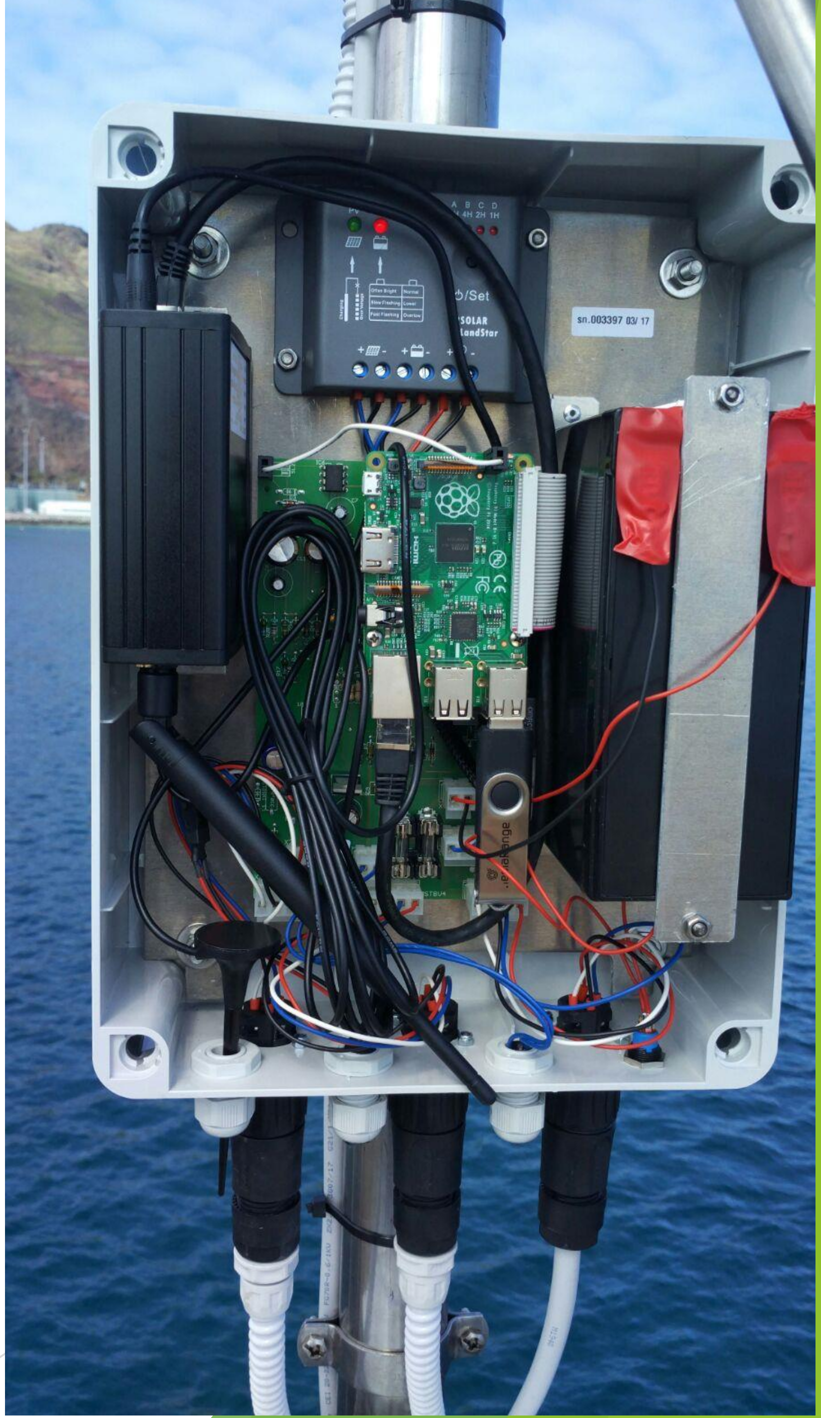
Module 1:
The IDSL System

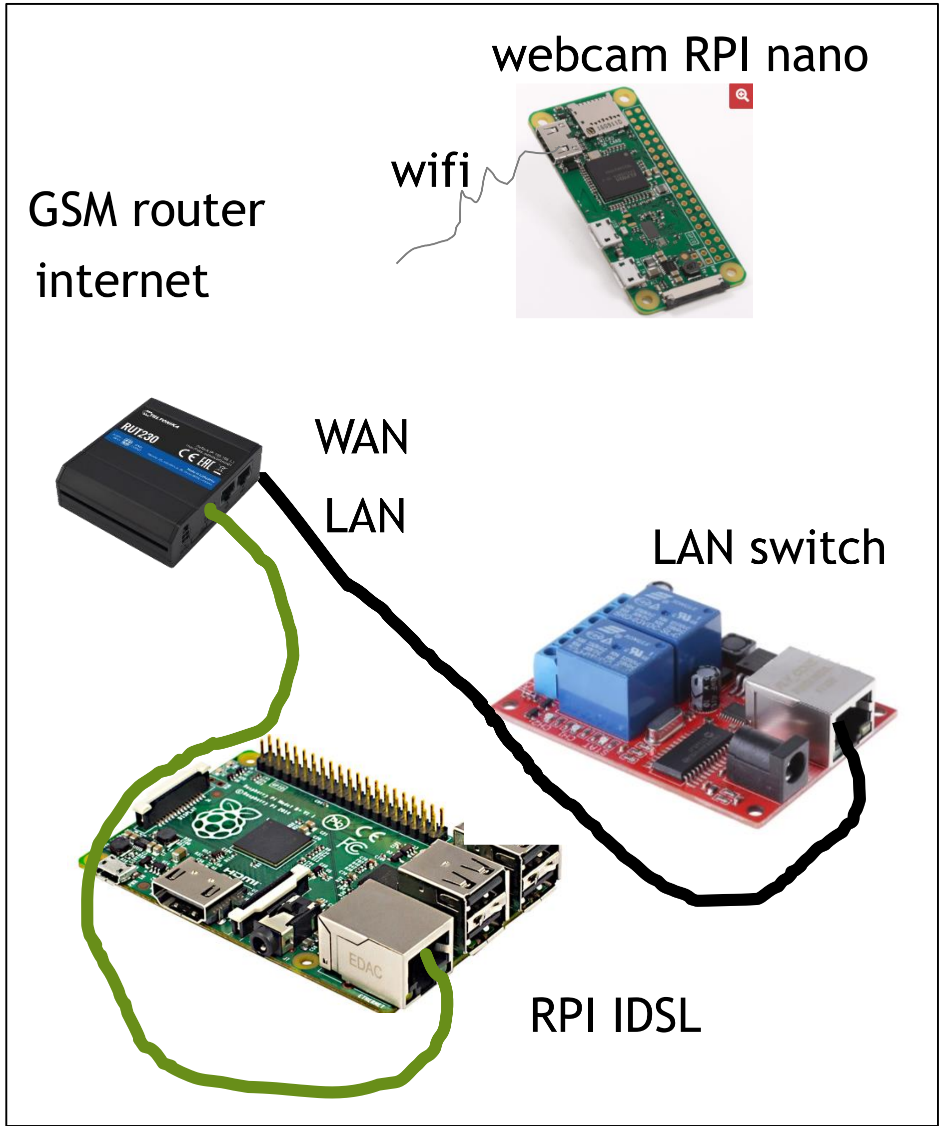
Module 1: the IDSL system

- Basic concepts
- Costs
- Installations
- Data quality
- Real cases

Initial prototype, with off-shelf components: <2.5 kEuro per station







Raspberry PI 3 is used to host the data collection programme

Raspberry Nano in webcam

Importance of the LAN switch

SMS control (several installations not activated or not possible)

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

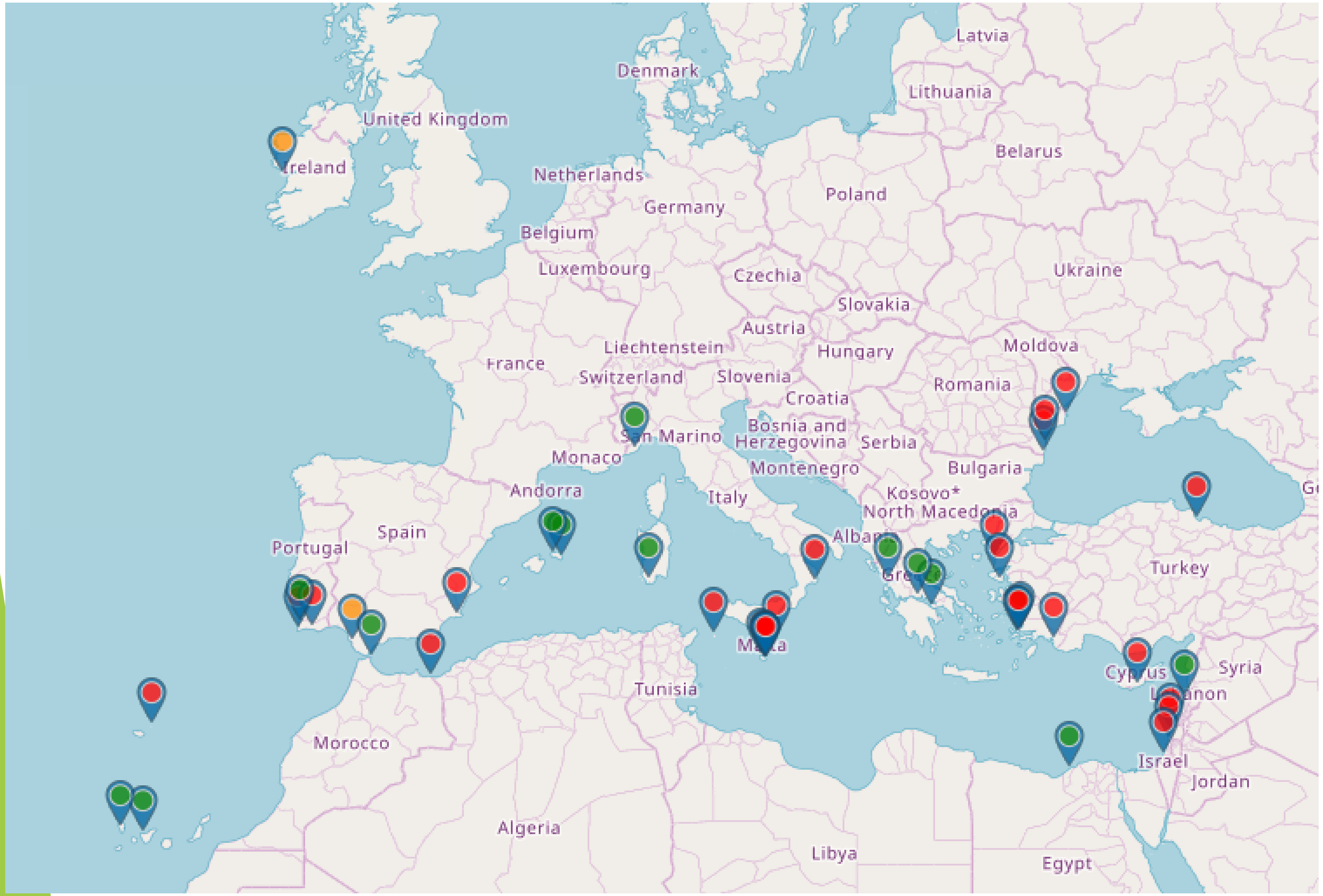
Data received through TAD_server method

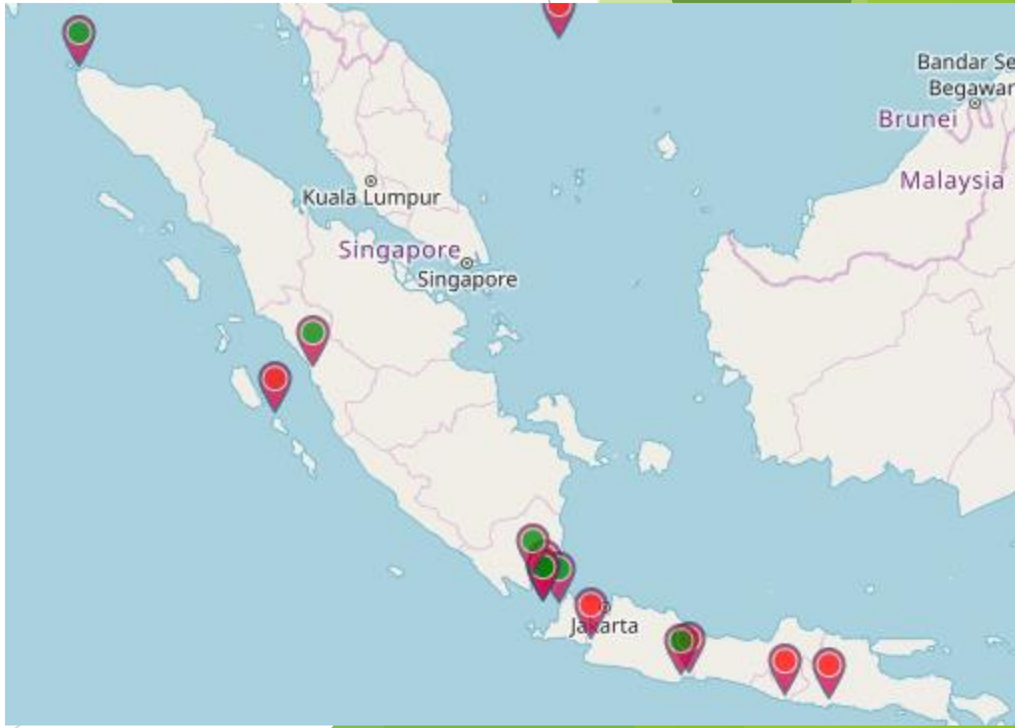
- Classical method:
  - All stations scanned by a central system every x min (i.e. 1 min)
  - In case of parallel scanning, the latency is given by the scanning interval

- 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 installations

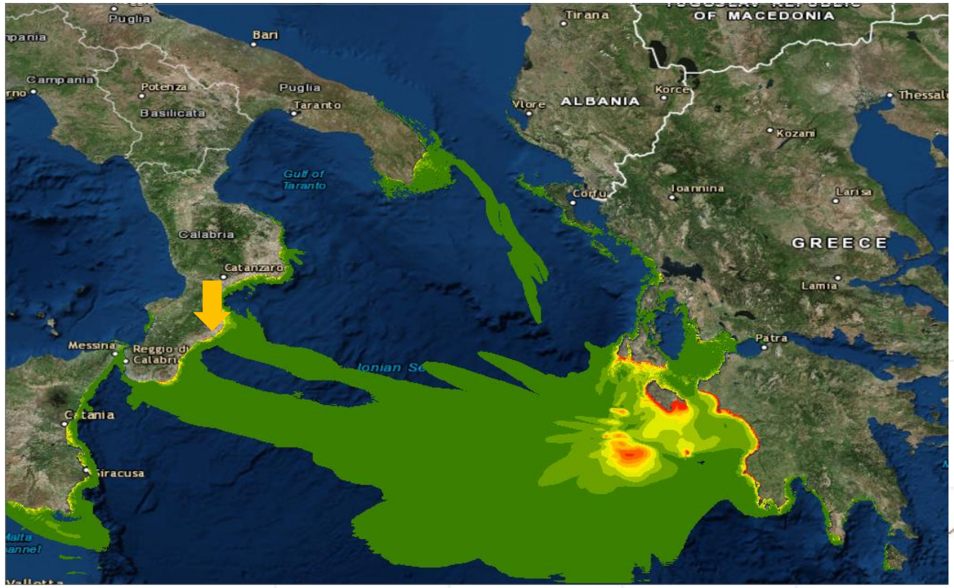
42 devices in the Mediterranean Sea, 9 devices in Indonesia
Several devices need maintenance. UNESCO CoastWave project will take care of the Med. Sea devices.

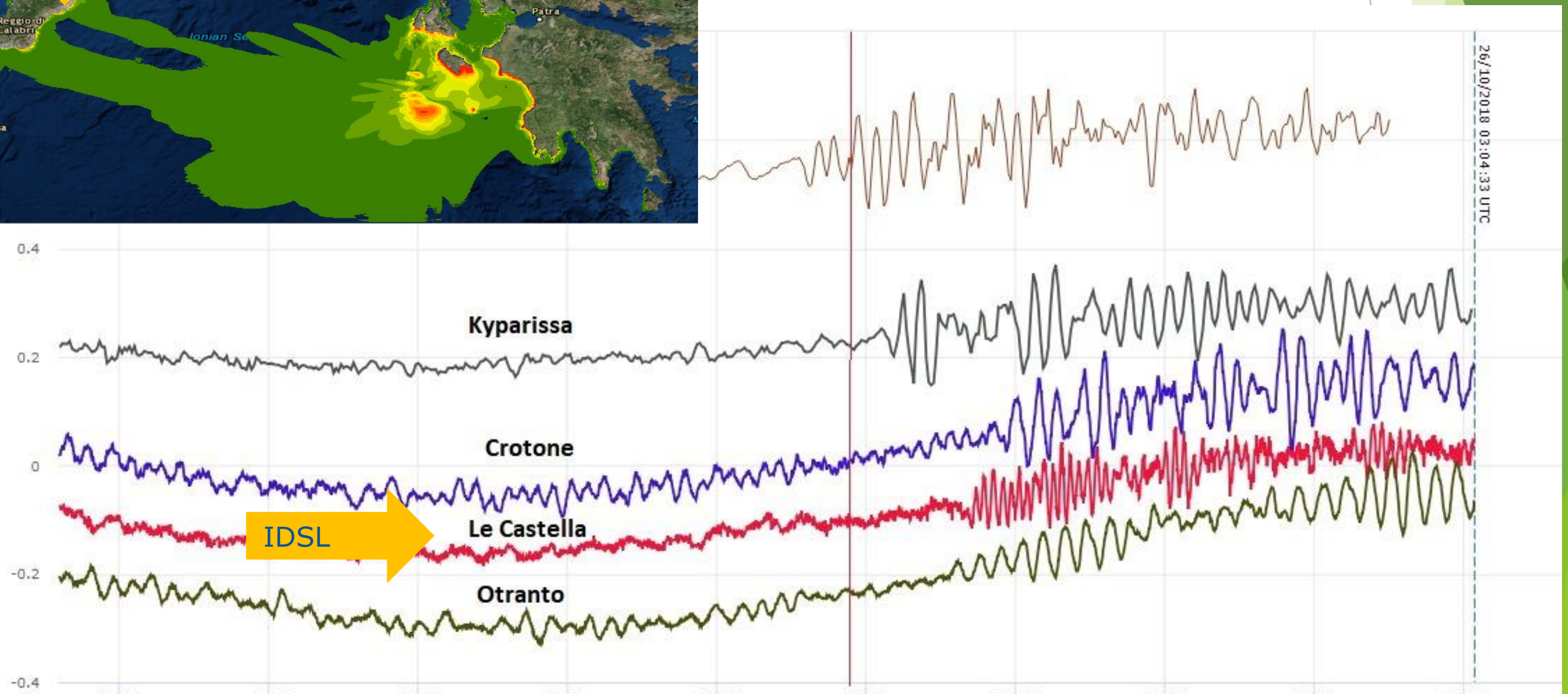




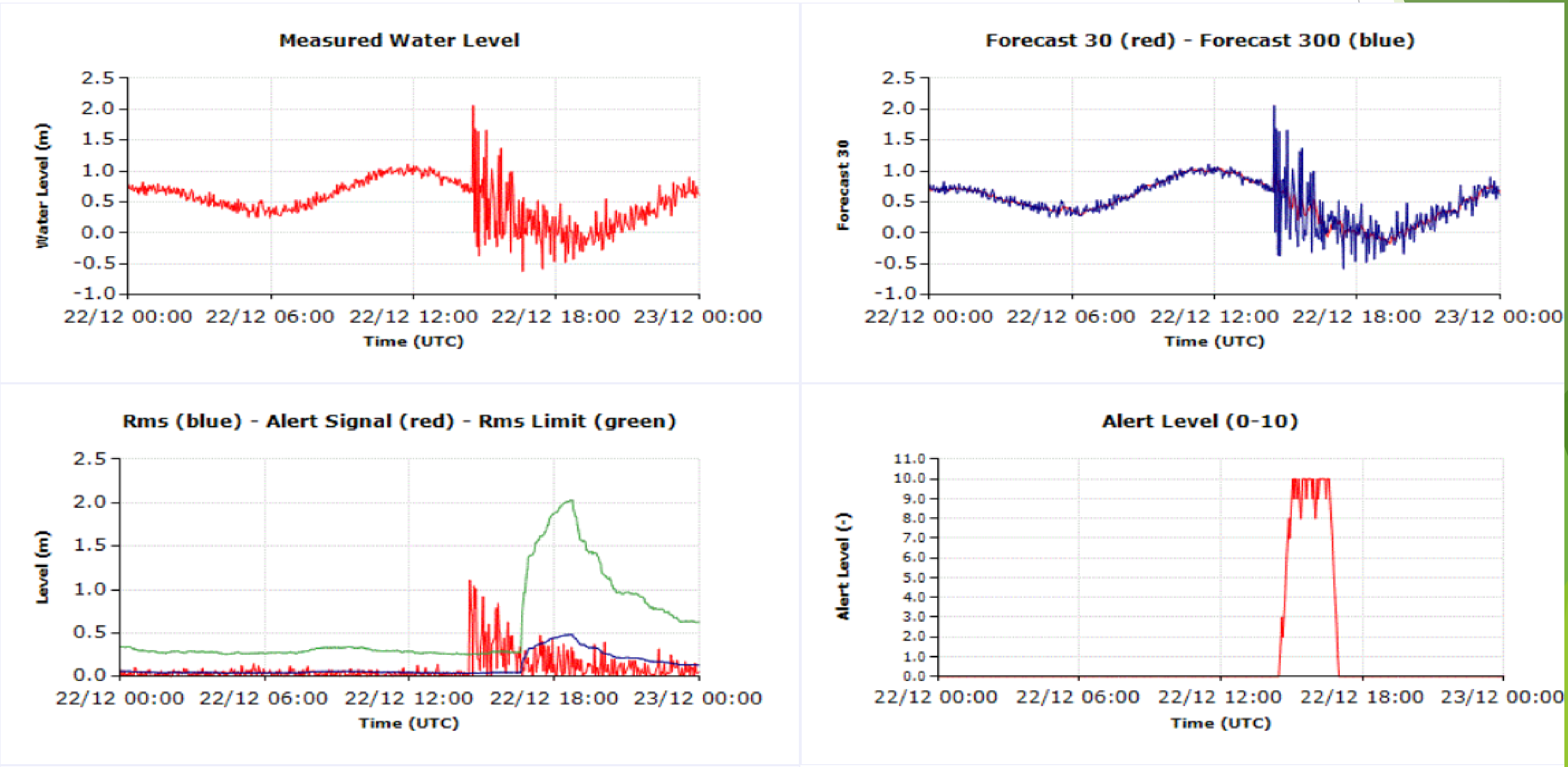
Mw 6.8 Zakyntos event: 25 Oct 2018

- IDSL-12 correctly detected the event



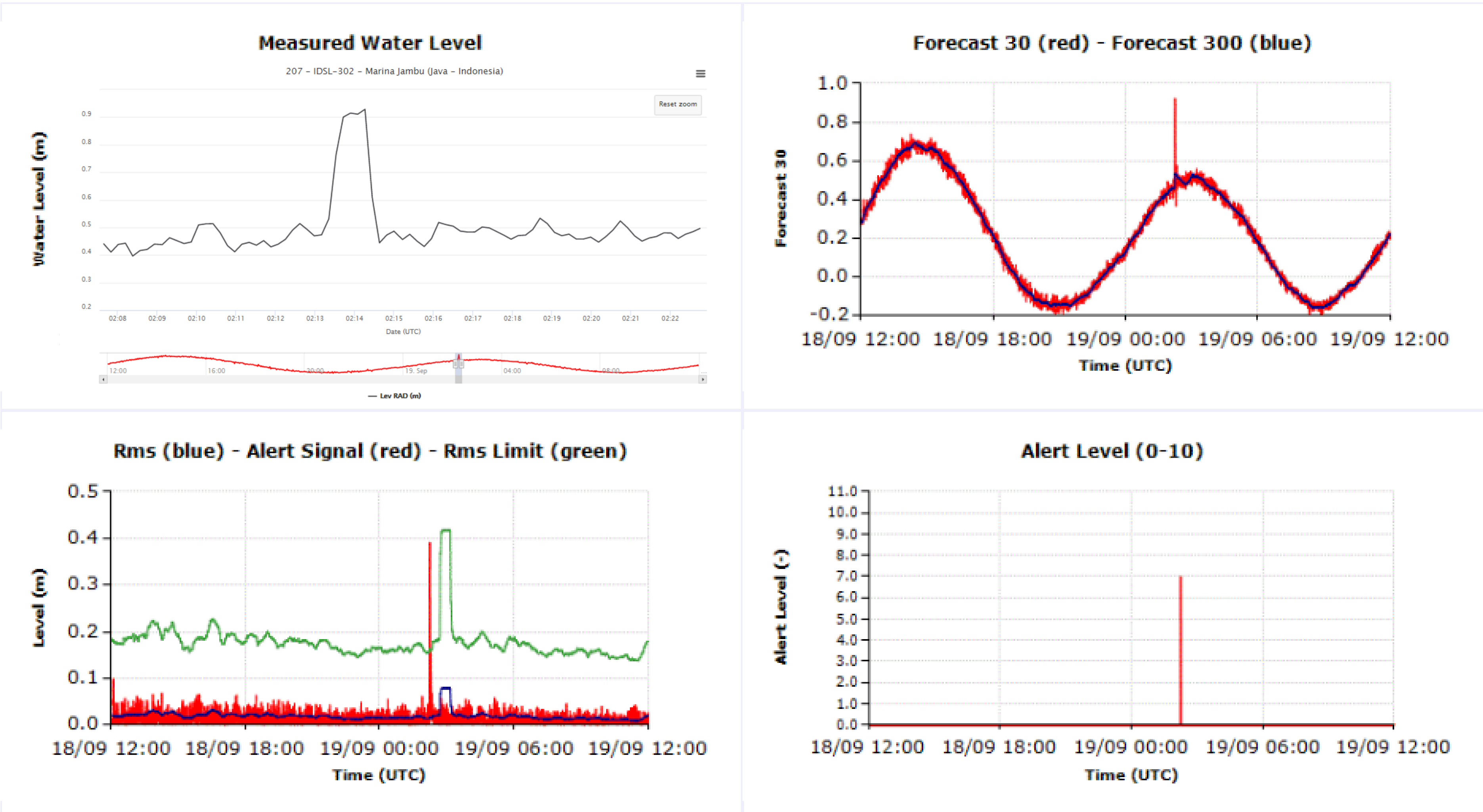


Alert mechanism, Krakatoa event 2018, using same routines of IDSL



Tonga event, 2022, Prigi

Alert mechanism for IDSL, False alerts



Alert mechanism for IDSL (2)

Reply | Reply All | Forward | Archive | Junk | Delete | More

From JRC-TAD <ec-gdacs-noreply@ec.europa.eu>
Subject *** [TAD_Server] IDSL-302 (Marina Jambu - Indonesia) ALERT 4 19/09/2019, 04:15
To Me <alessandro.annunziato@gmail.com>, alessandro.annunziato@ec.europa.eu, pgn@bmk 3 more

```
***  EMAIL ALERT FROM TAD_SERVER ***

DeviceID:    IDSL-302
Location:    Marina Jambu - Indonesia
Date:        19 Sep 2019 02:14
Level:       0.928559 m
AlertValue:  4 (0-10)

Show details: http://webcritech.jrc.ec.europa.eu/TAD_server/Device/IDSL-302

=======================================================
 Joint Research Centre - EC - TAD_server
=======================================================
DISCLAIMER:  JRC nor BMKG are responsible of false or
missing alerts from this system. The alert is given
to raise attention on a level anomaly only.
```

*** ALERT IDSL-302, Marina Jambu - Indonesia Level=0.910741 - ALERT=3 - 19 Sep 2019 02:14 UTC - JRC TAD System

*** ALERT IDSL-302, Marina Jambu - Indonesia Level=0.928559 - ALERT=4 - 19 Sep 2019 02:14 UTC - JRC TAD System

04:14

19 Sept 2019 2:14:00- Alert 3-4

Email
SMS
Image

Currently users that receive alert information:

- JRC
- MMAF
- IATsL
- BMKG
- BOM

Date
19 Sep 2019 02:14
14 Sep 2019 06:43
18 Jul 2019 01:25
26 Jun 2019 09:34
27 Apr 2019 10:12
27 Apr 2019 10:07
18 Apr 2019 05:41
19 Mar 2019 04:34
16 Feb 2019 12:19
15 Feb 2019 12:06

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

IDSL control

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

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

Some relevant IDSL installation: La Palma, Spain

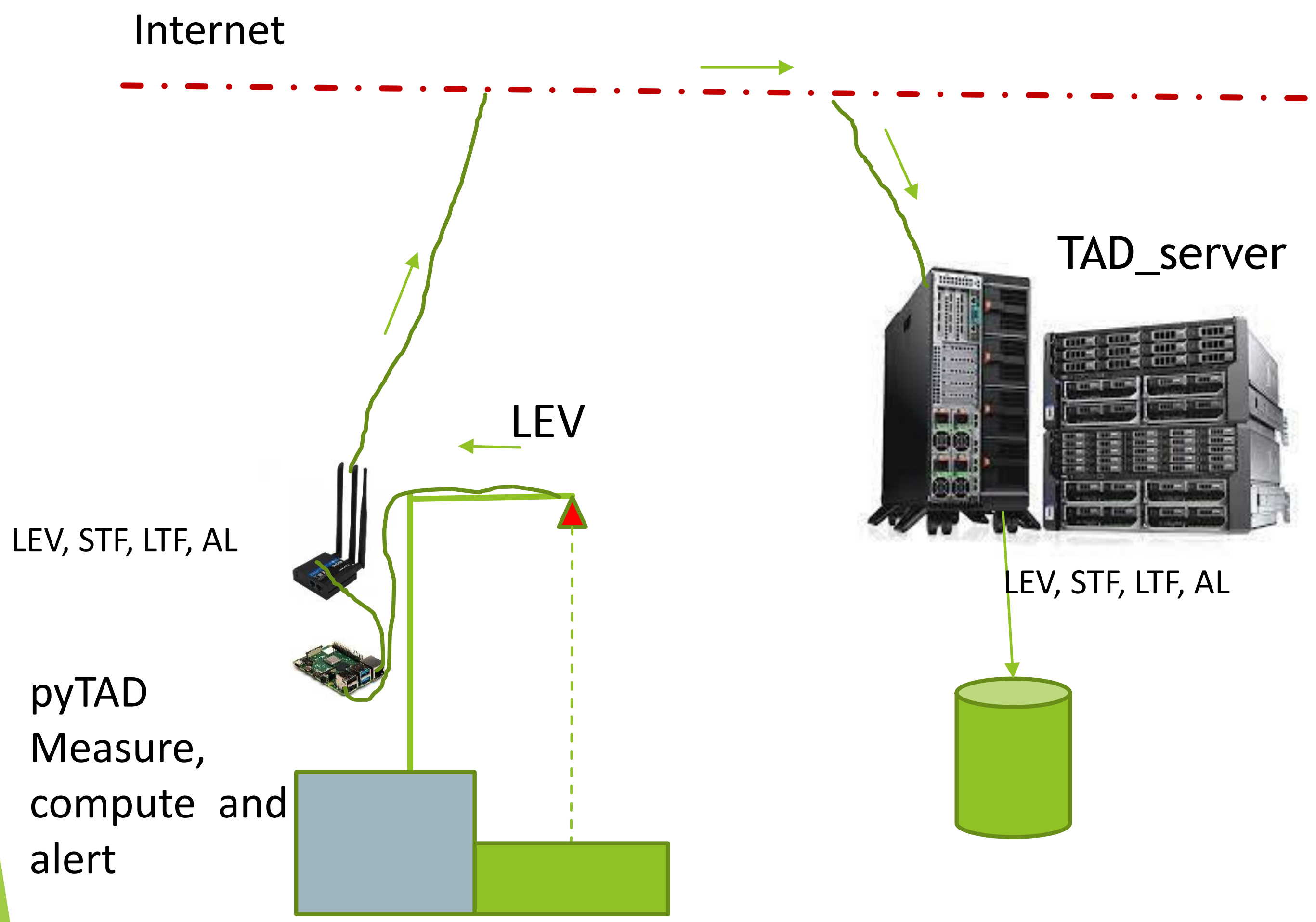
La Palma, Volcano
Tazacorte port
Oct 2021

Rakata, Island, Indonesia

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

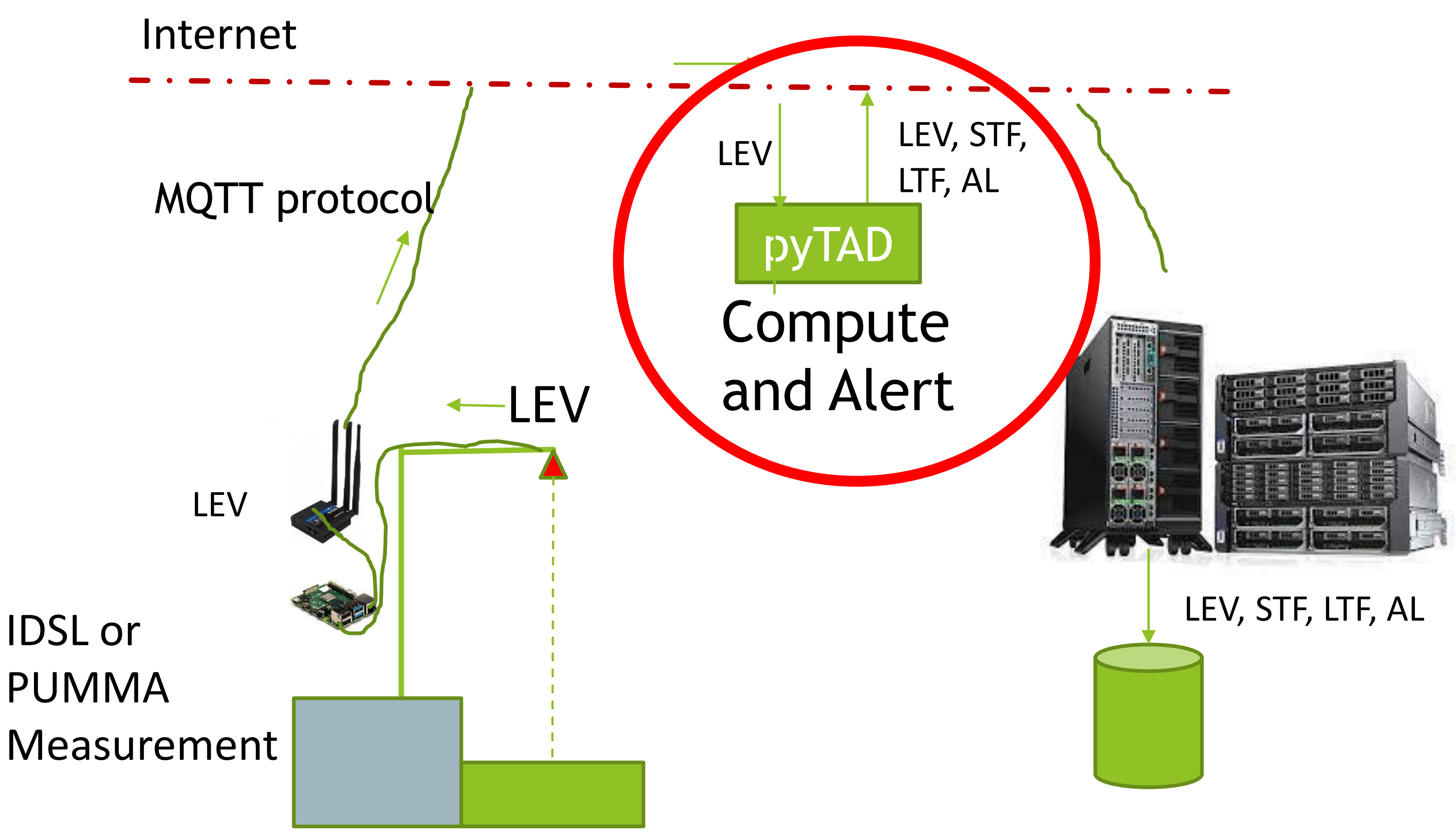
BMKG
KEMENTERIAN KELAUTAN DAN PERIKANAN
BAKTI
BADAN GEOLOGI
DIREKTORAT JENDERAL PERHUBUNGAN LAUT
European Commission
Joint Research Centre

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

End of Module 1

Back to Index

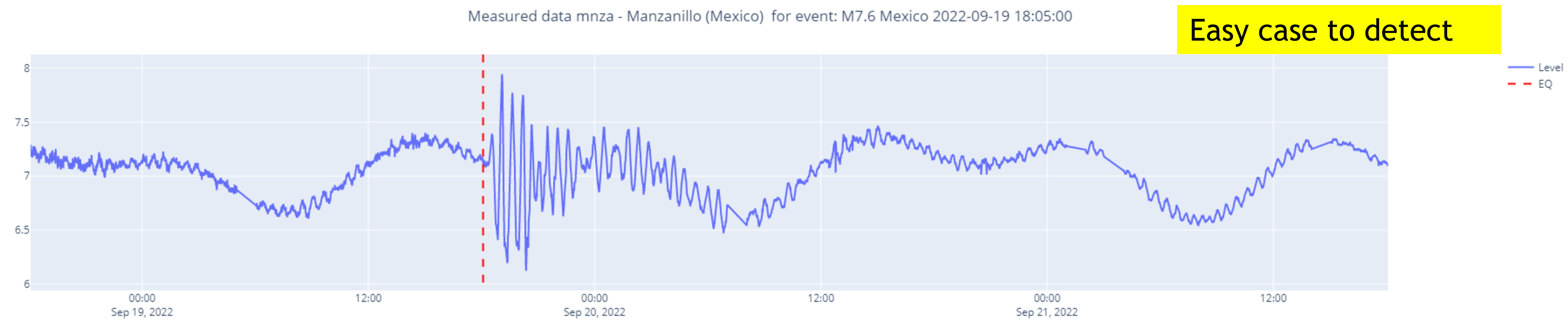
Module 2:
Tsunami Detection Algorithm

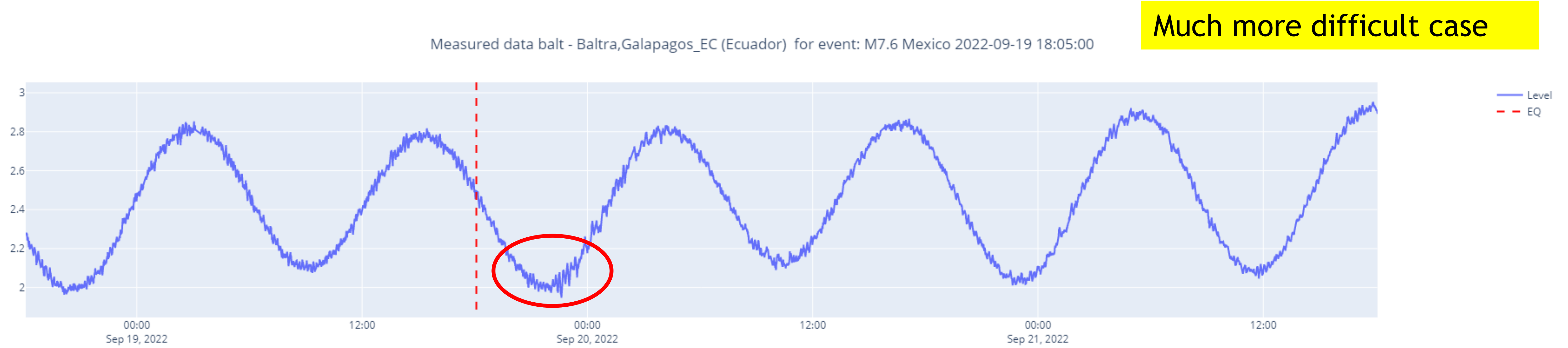
Tsunami detection

- The identification of a Tsunami event using sea level measurements is important for non seismic events: **volcanic eruptions and landslide**
  - Examples of operational volcanic sea level system:
    - Stromboli, Italy
    - Krakatoa, Indonesia

- Also in the case of Seismic **near shore events**, the Tsunami may arrive earlier than a proper seismic source is properly identified, characterized

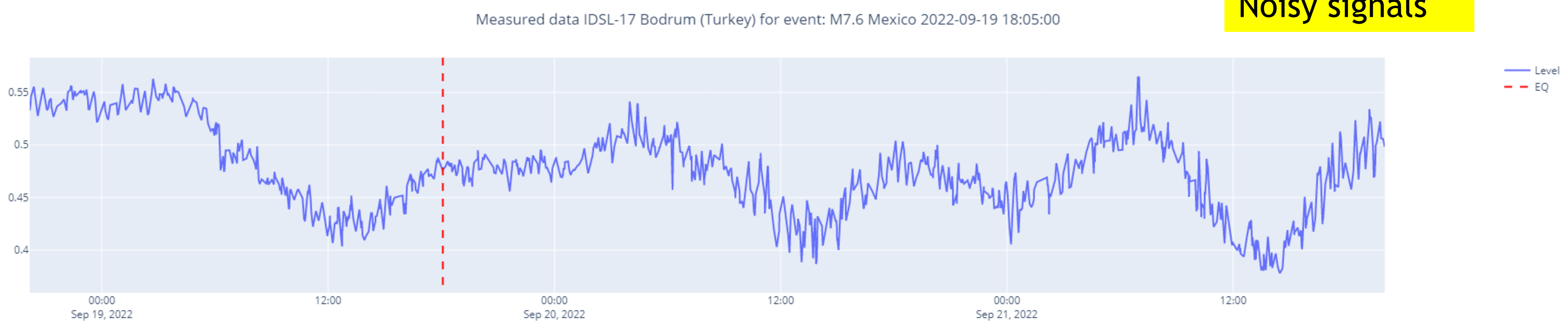
Tsunami detection: the problem



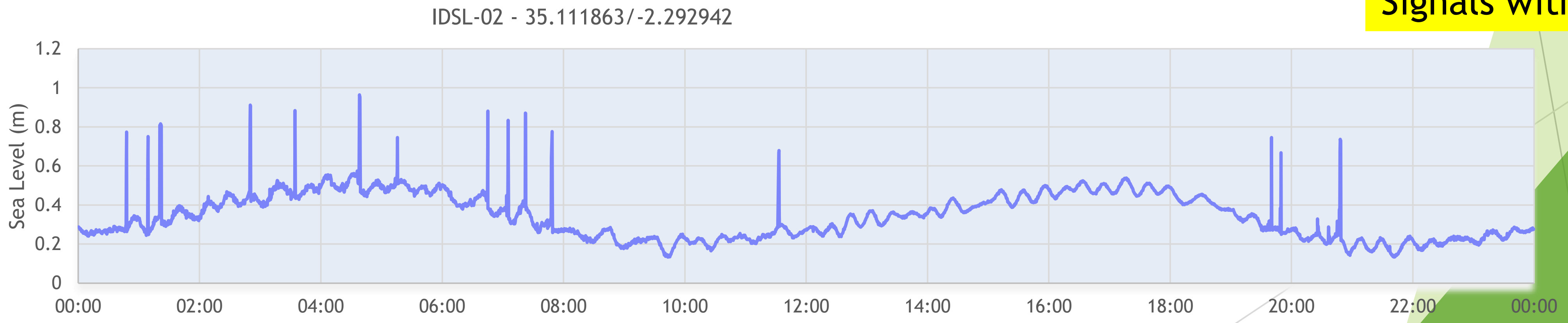


Tsunami detection: the problem, cont

Noisy signals



Signals with peaks



Various methods developed

- NOAA DART buoys include a low frequency tide interpolation of the last 3h. Alert for higher frequency data acquisition based on the threshold difference between signal and tide estimation
- F. Chierici et al. proposed a method based on the estimation of the tide for a specific location using a tidal effect removal based on a harmonics analysis of the least square method.
- Bressan et al. used a method called TEDA that was based on the instantaneous slope of the signal and the difference between two windows of different lengths to define an alerting function.
- Y. Wang et al. proposed a method that adaptively decomposed the time series into a set of intrinsic mode functions, where the tsunami signals of ocean-bottom pressure gauges (OBPGs) were automatically separated from the tidal signals, seismic signals and background noise. They retrospectively imitating real-time operations for tsunami early warning.

Except NOAA DART, none of the systems were used operationally

Tsunami detection model

- The detection model implemented inside the IDSL is used to:

The algorithm is based on the following procedure:

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

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.

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

geosciences MDPI

Article

Tsunami Detection Model for Sea Level Measurement Devices

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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)

Citation: Annunziato, A - Tsunami Detection Model for Sea Level Measurement Devices. *Geosciences* **2022**, 12, x. https://doi.org/10.3390/xxxxx

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Published: date

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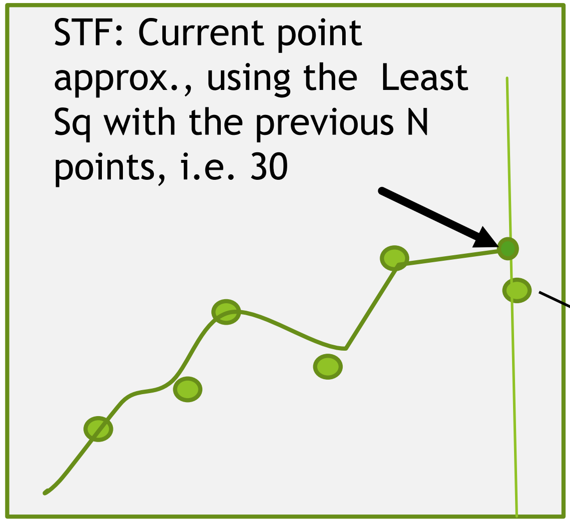
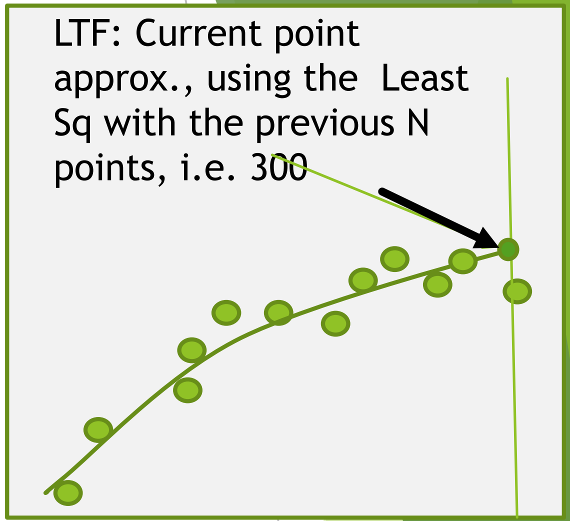
https://www.mdpi.com/1892362

Tsunami Alerting Model





$$A_s(t) = |STF_{N30}(t) - LTF_{N300}(t)\,|$$

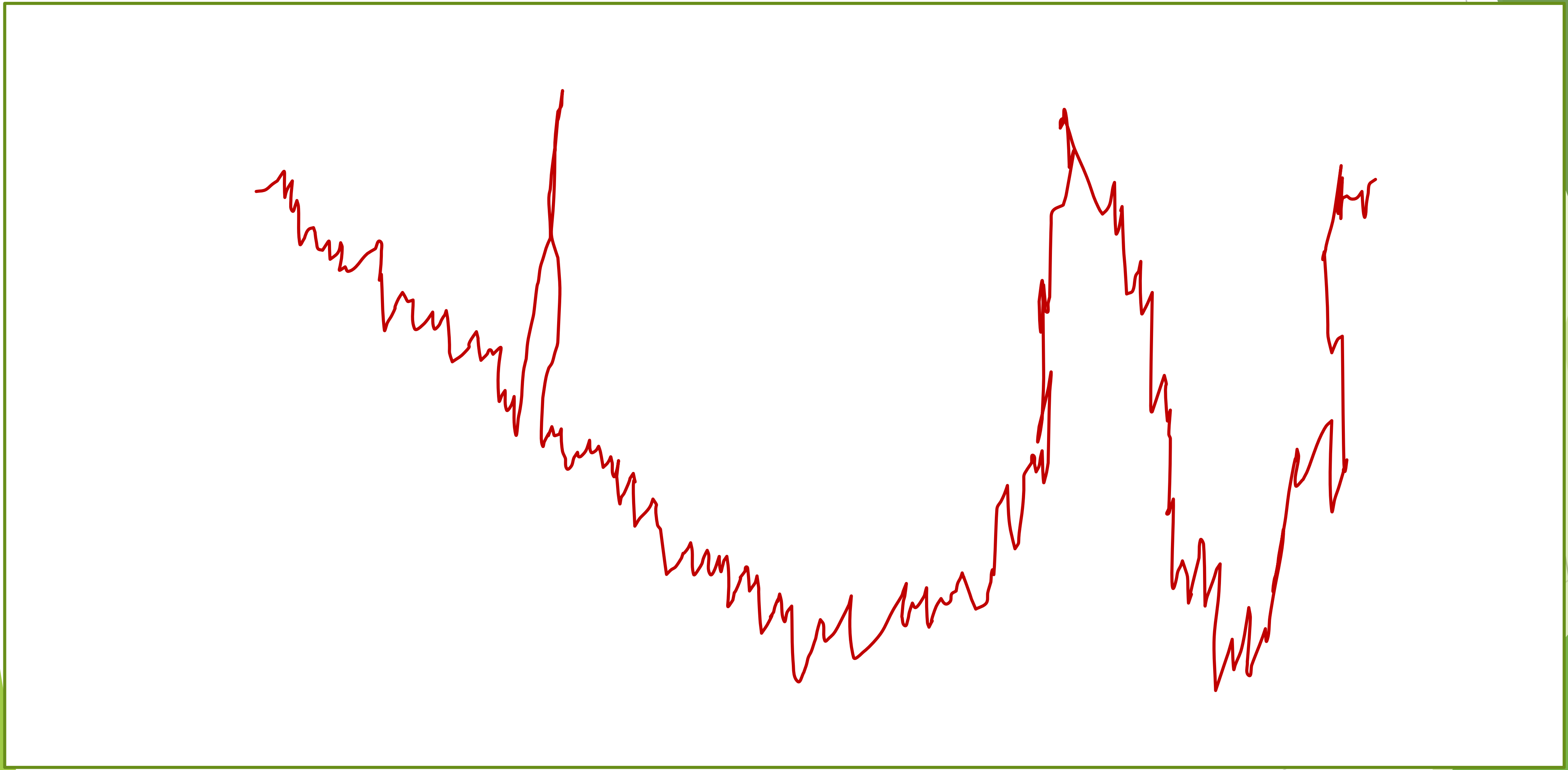
$$V_s(t) = rms\big(A_s(t)\big) * f_{rms} + \tau$$

$$\text{if } A_s(t) > V_s(t) \text{ and } A_s(t) > A_{min} \text{ then:}$$
$$AL(t) = AL(t) + 1$$
$$\text{else}$$
$$AL(t) = AL(t) - 1$$

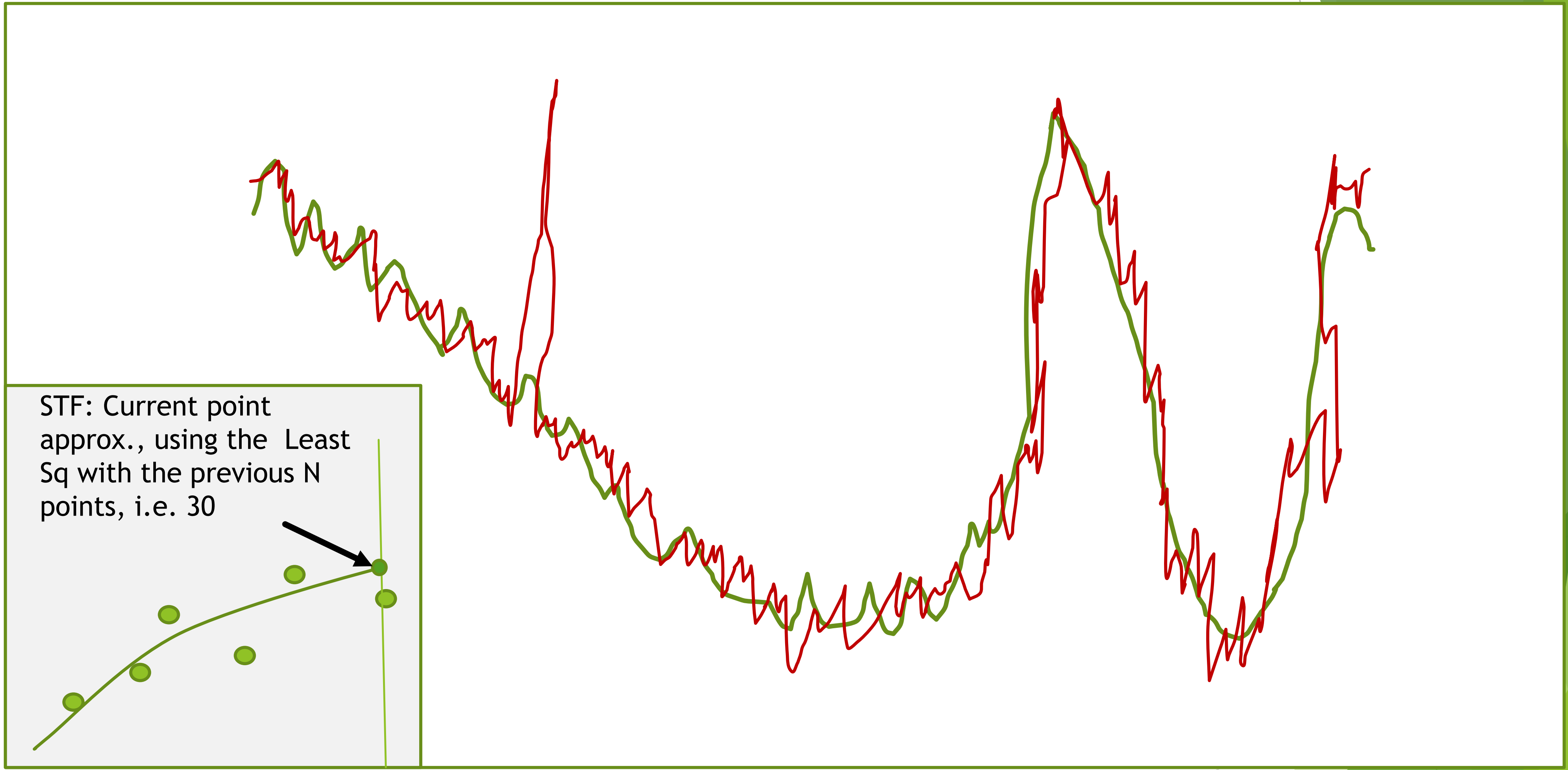
Tip: N300 and N30 means period of integration:

*N300*interval=TimeLong*
*N30*Interval=TimeShort*

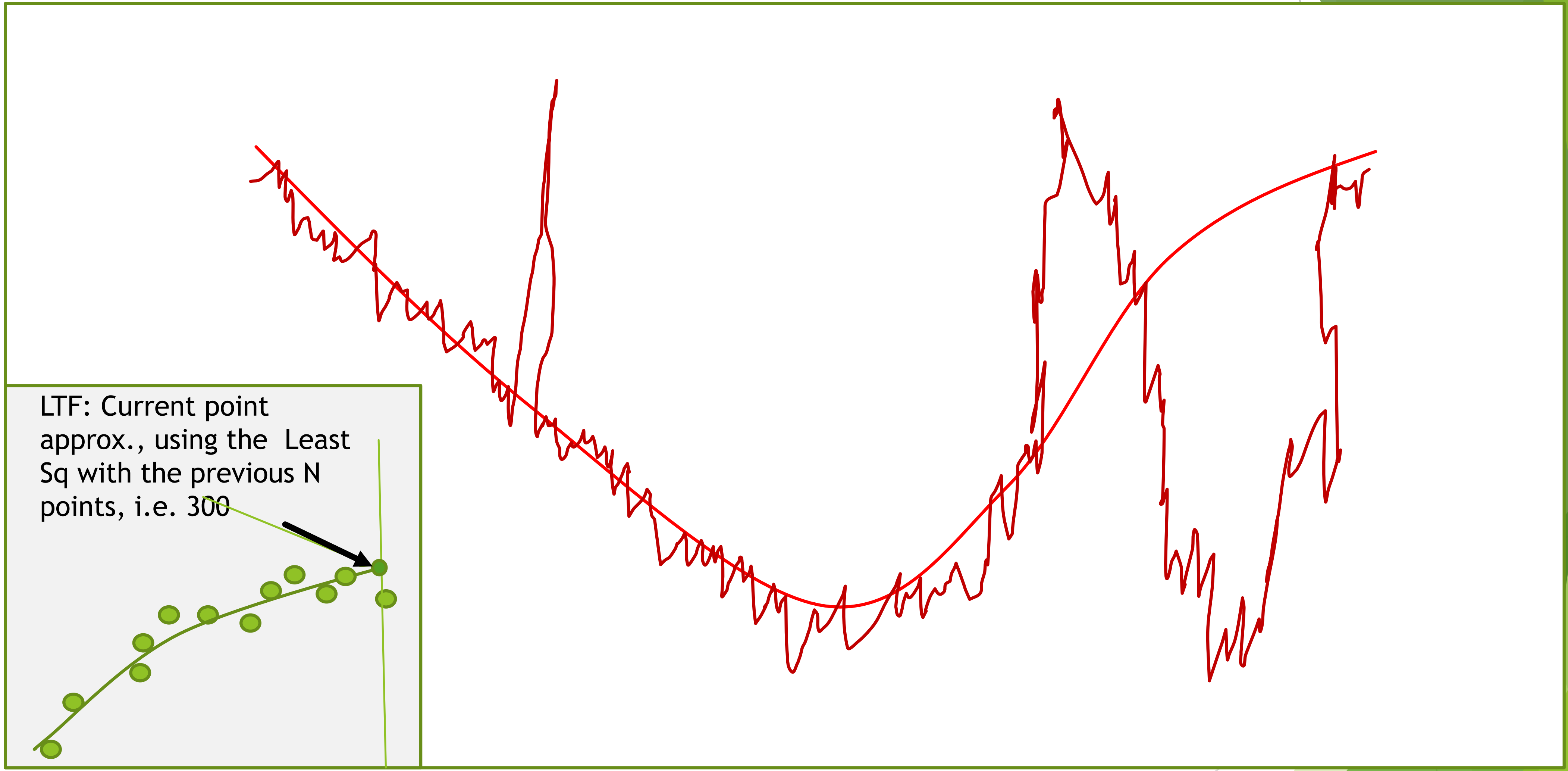
Original signal



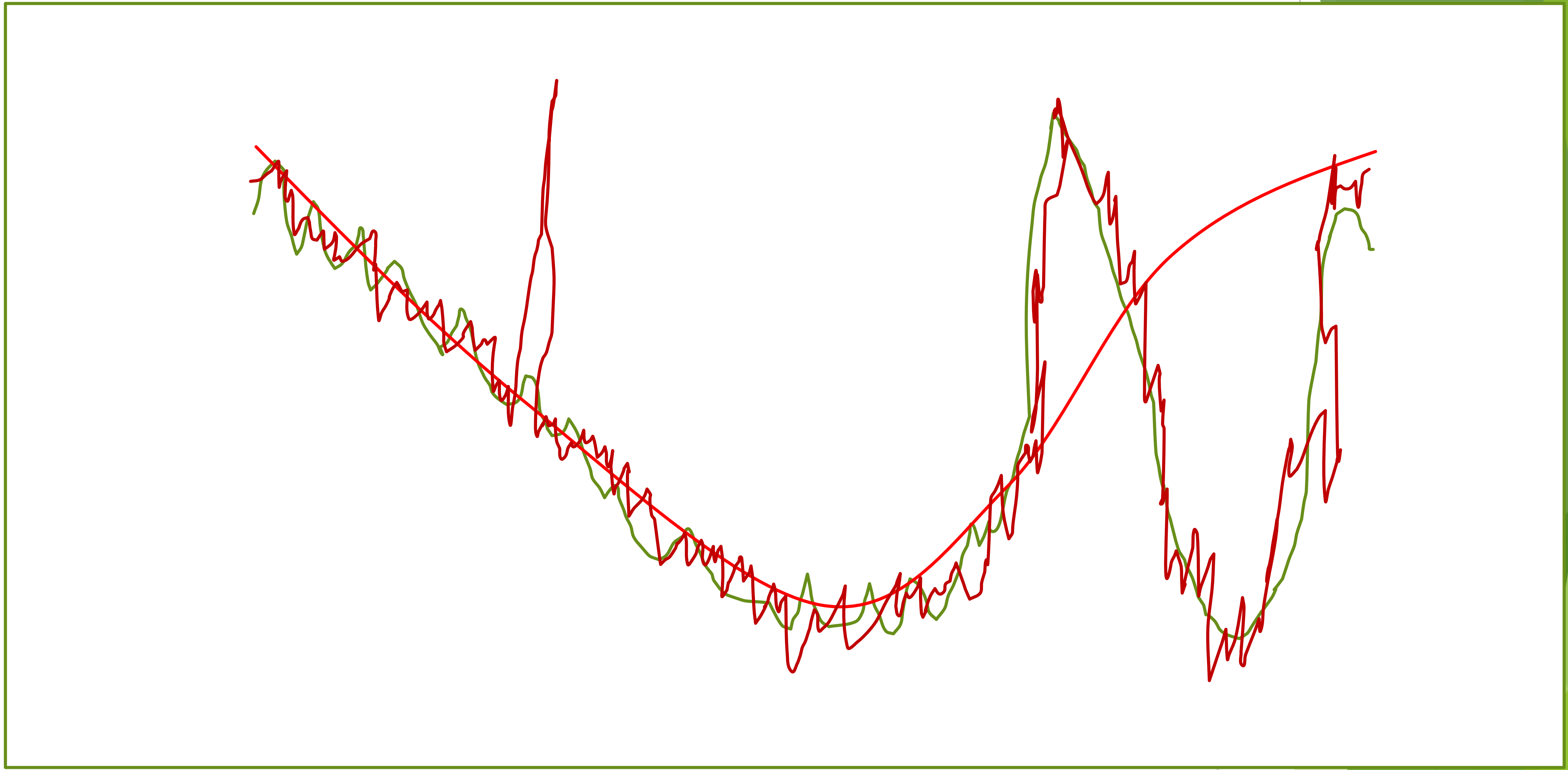
Short Term forecast



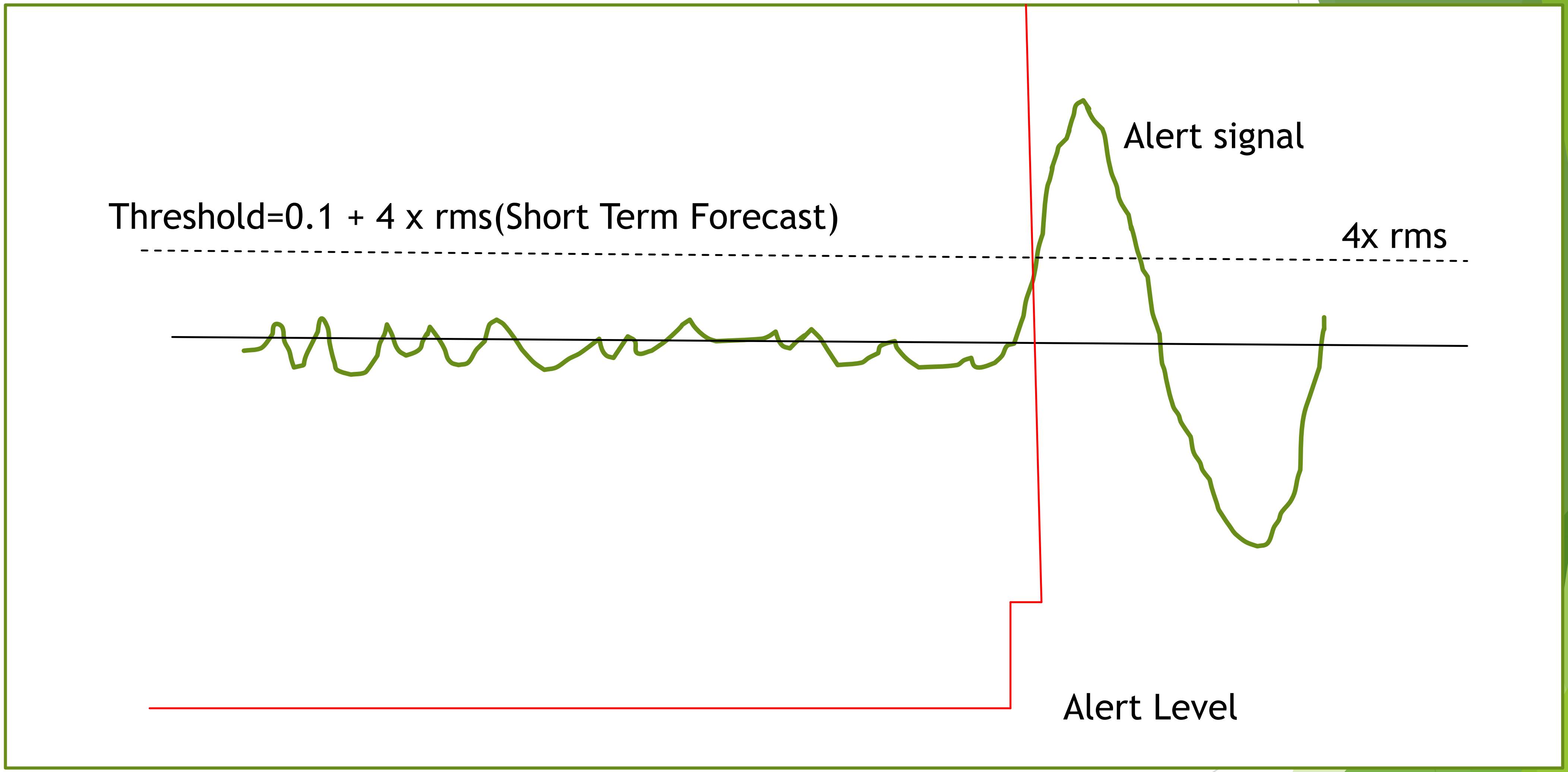
Long Term Forecast



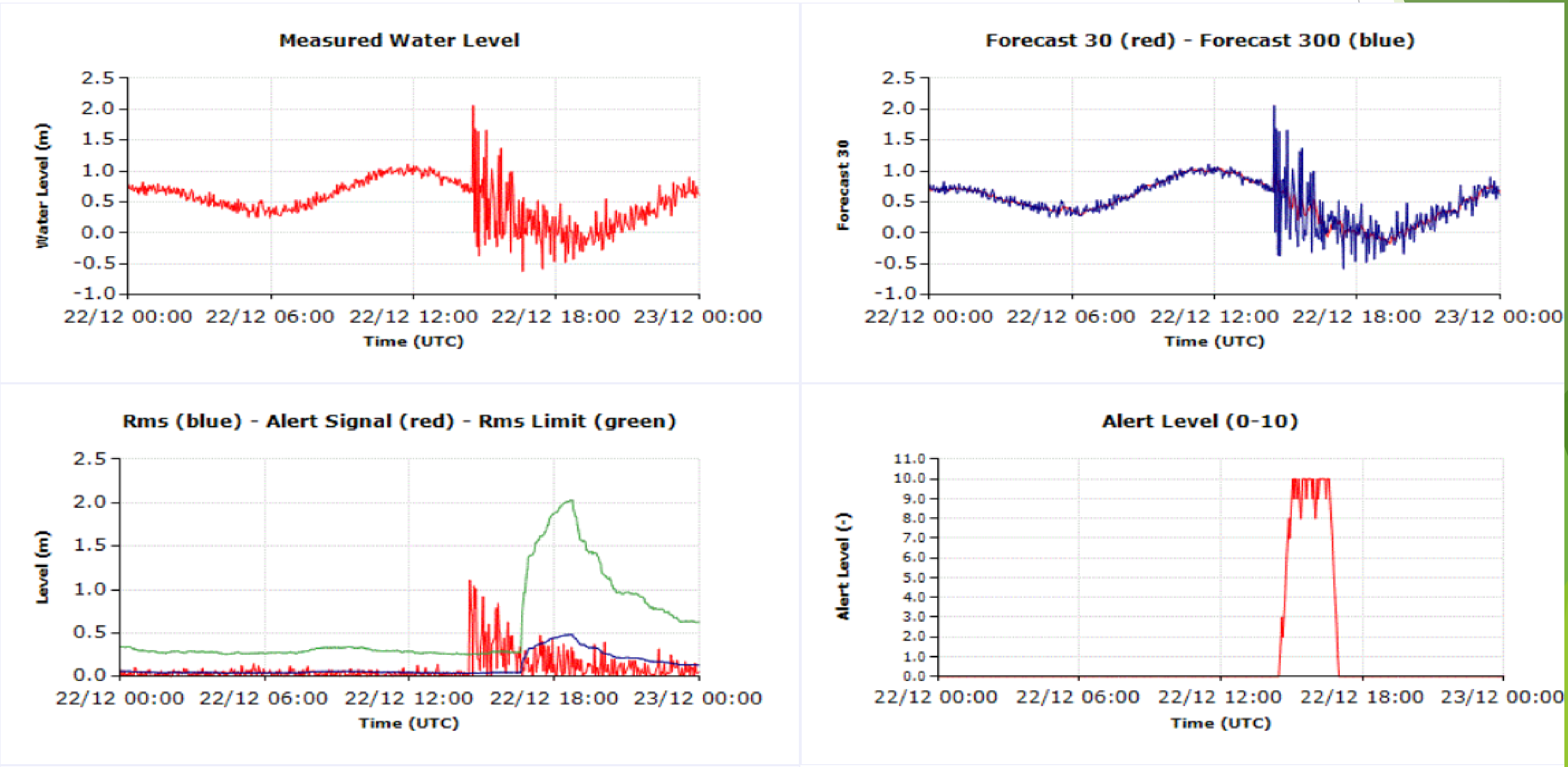
All signals together



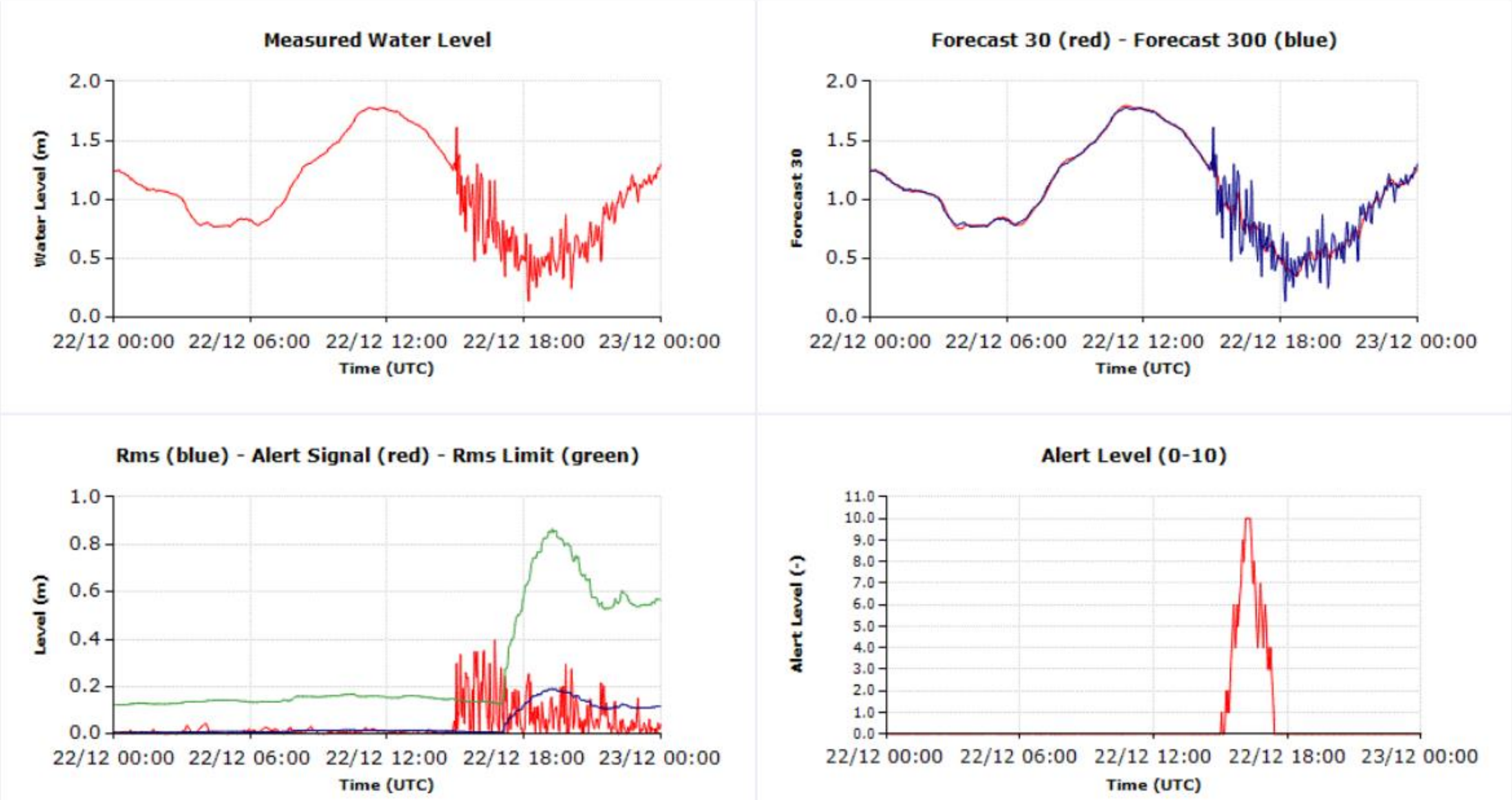
Short Term minus Long Term Forecast



Alert mechanism, Krakatoa event 2018, using same routines of IDSL for BIG tide gauge Marina Jambu

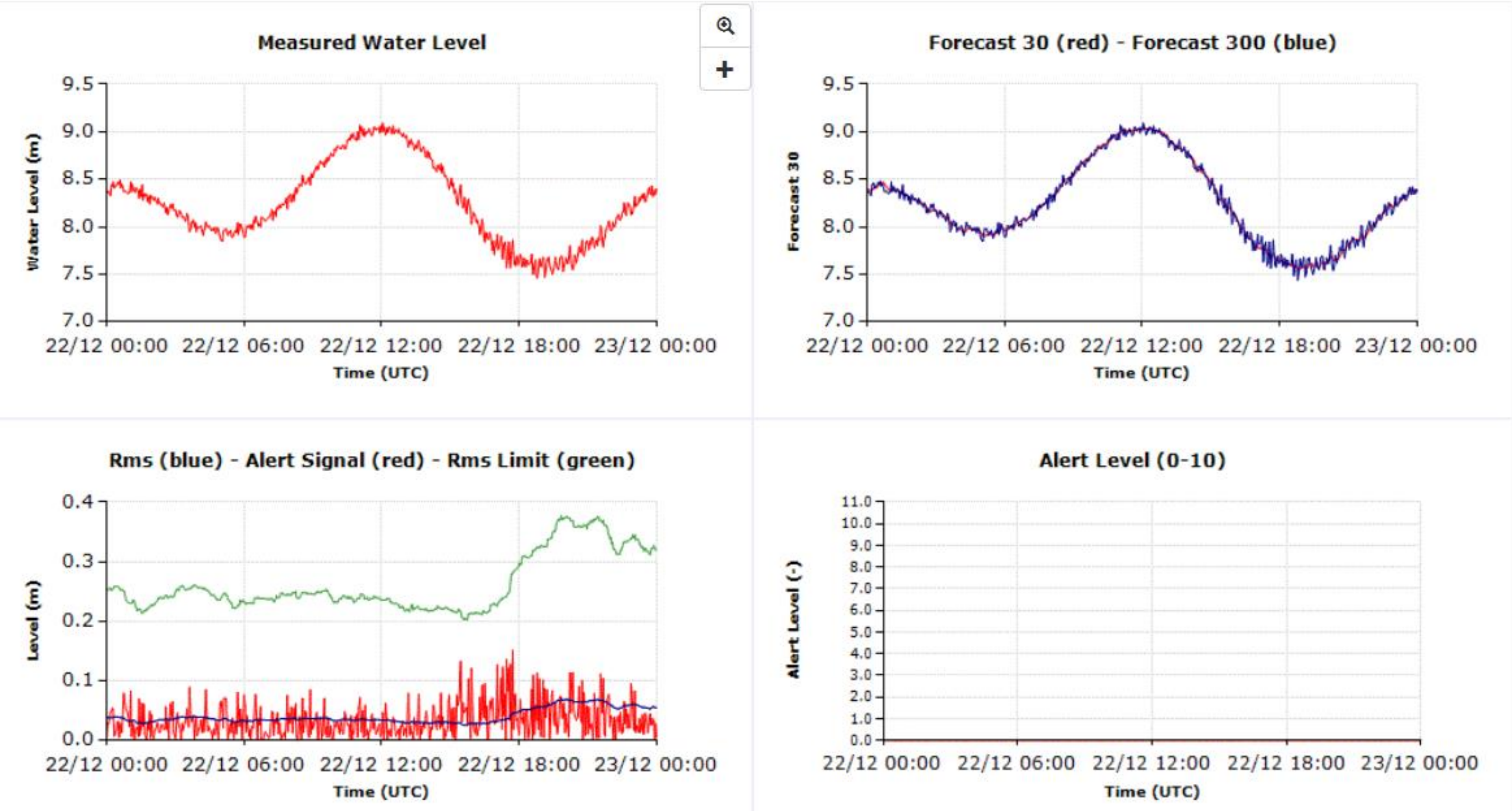


Pelhabuan Alert, Krakatoa event 2018



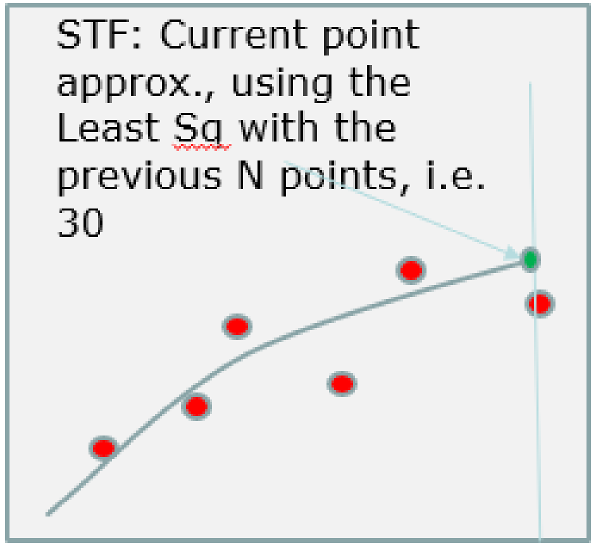
http://webcritech.jrc.ec.europa.eu/TAD_server/Device/BIG-007?tmin=22%20Dec%202018&tmax=23%20Dec%202018

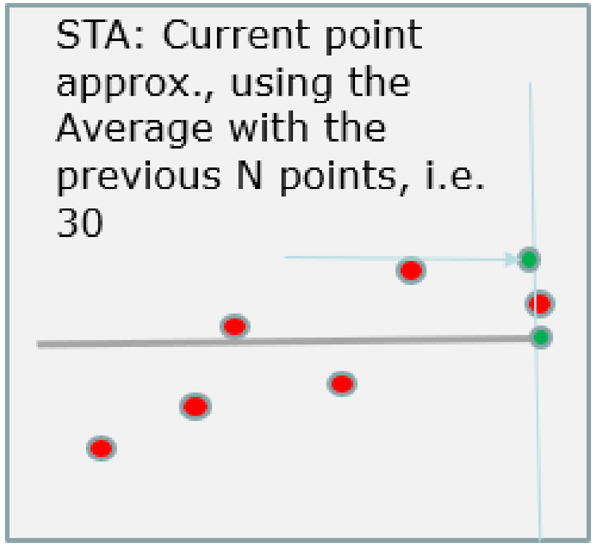
Binuangen, no alert



Difference between LTA/STA and LTF/STF methods

- **STA/LTA** uses the ratio among the average amplitudes
  - In seismic signals the long term signals oscillate around a baseline value
- **STF/LTF** uses the difference among the estimated point at the current time
  - In the case of a sea level the influence of the tide my be relevant in certain cases and therefore it is not possible to the an average of the signals in the long term.





Sea Level Machine

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	-95.856/16.32

TAD SERVER

Space, Security and Migration Directorate - JRC Ispra Site

European Commission > Webcritech > TAD > Home

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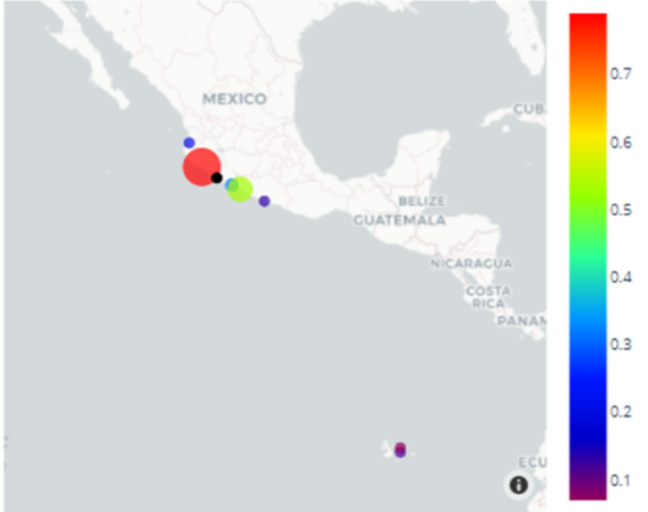
M7.6 Mexico

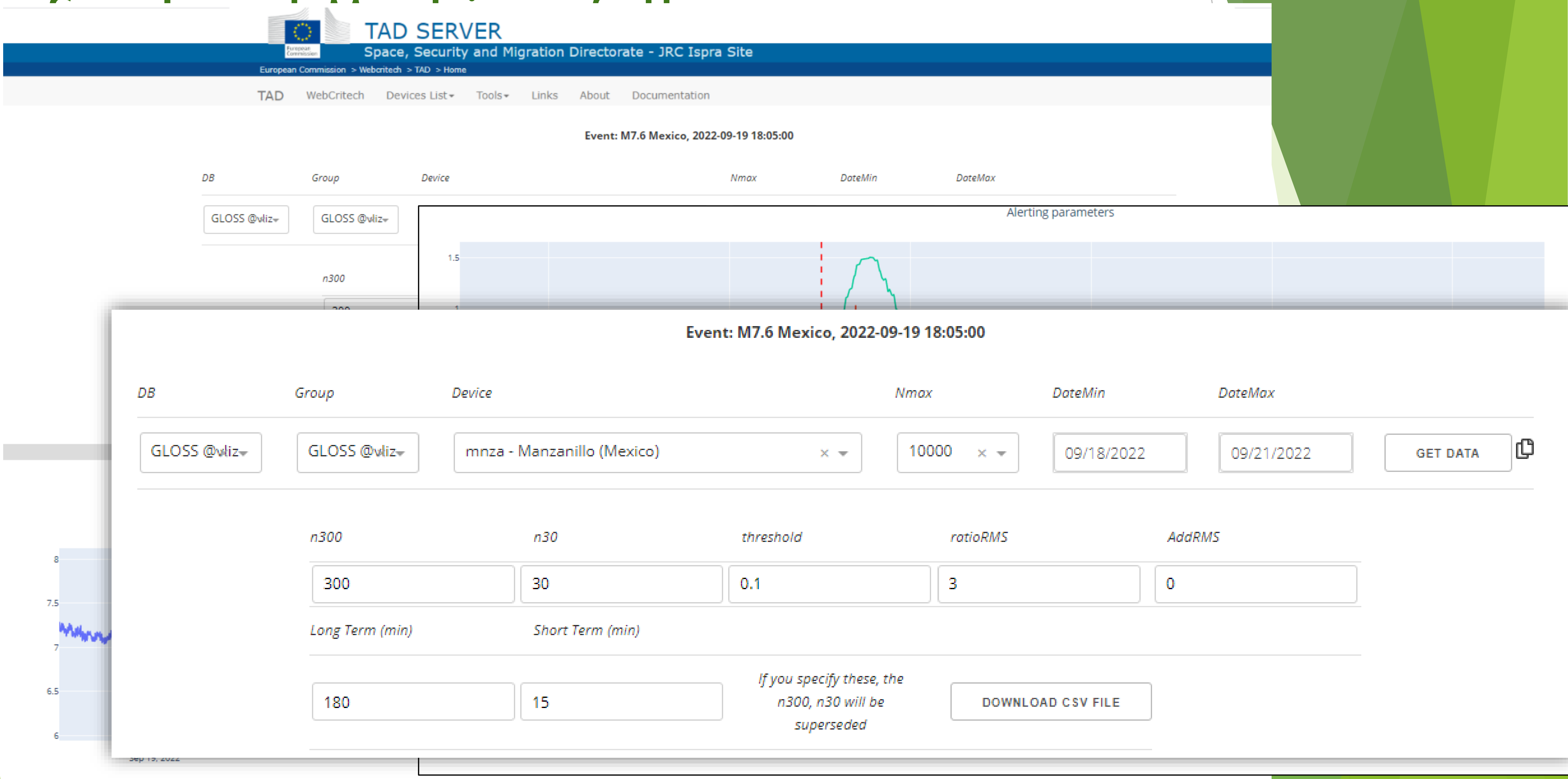
Event ID	1338437
Date of event	**19-09-2022 18:05:00**
Location	**Mexico**
Magnitude	**M7.6**
Depth	**16.13 km**
Lat/Lon	**18.3667/-103.2524**
Place of max height	**Manzanillo Mx**
Amplitude (period)	**0.79 m (32 min)**
GDACS Report	link



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)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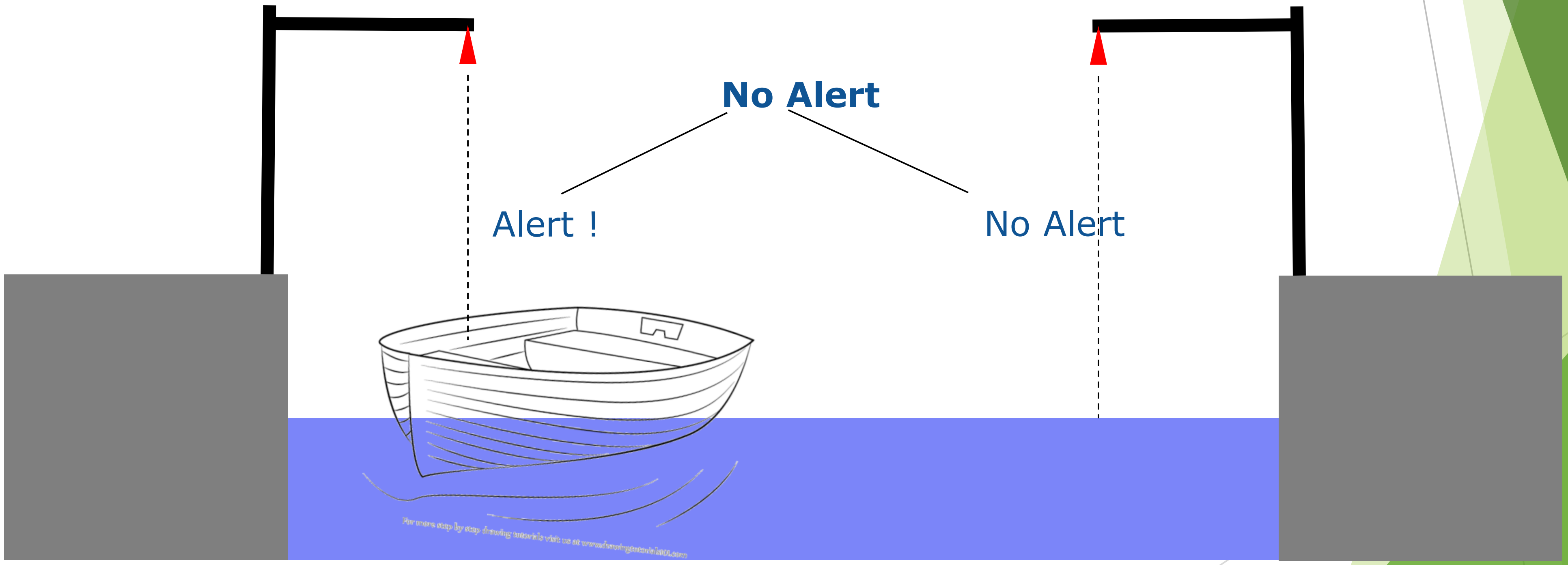
WebCritech
Devices List
Tools
Links
About
Documentation
Event: M7.6 Mexico, 2022-09-19 18:05:00
Alerting parameters
Event: M7.6 Mexico, 2022-09-19 18:05:00
DB
Group
Device
Nmax
DateMin
DateMax
GLOSS @vliz
GLOSS @vliz
mnza - Manzanillo (Mexico)
10000
09/18/2022
09/21/2022
GET DATA
n300
n30
threshold
ratioRMS
AddRMS
300
30
0.1
3
0
Long Term (min)
Short Term (min)
180
15
If you specify these, the n300, n30 will be superseded
DOWNLOAD CSV FILE

Why we need multiple devices at each location ?

- Redundancy in case of failure of one device
- To avoid spurious activations and false alerts, 2 devices are installed at close locations (2-3 km)



Take away concepts

- 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

- The same software can be used with whichever device, provided that an online analysis of the data is performed

- The application to several past events can be appreciated in the Sea Level Machine application, from JRC

Online material

- Software inside IDSL:
  - https://github.com/annunal/pyTAD
- Application Sea Level Machine:
  - https://slm.azurewebsites.net

References

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End of Module 2

Back to Index

Module 3:
IDSL Istallation

Developed in collaboration with JRC

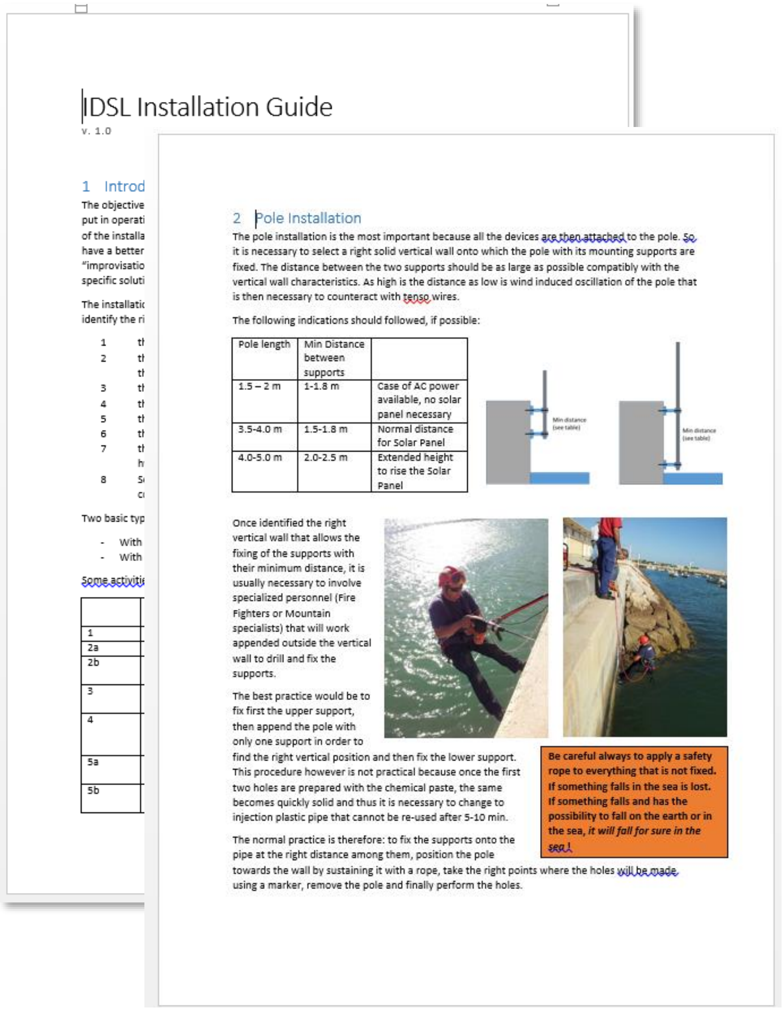
Module 3: Installation Guide

- Site selection
- Installation
- Testing

Site selection

- The installation should be done in a protected area (i.e. port) where a structure exists and that can host the installation pole of IDSL
- In the past dedicated offshore installation did not work because of too high wave action that destroyed the installation
- Also, the presence of large meteorological waves makes impossible to distinguish tsunami waves with much longer period.
- In addition the time difference between out of the port and inside the port installation is so small that out port installation is not justified
- Site characteristics to be considered in order of importance:
  - Wave protection
  - Site security
  - Communication availability (3g or more), stability, speed
  - Protection from objects in the sensor area (false alerts)

IDSL Installation Guide



IDSL Installation Guide

v. 1.0

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.

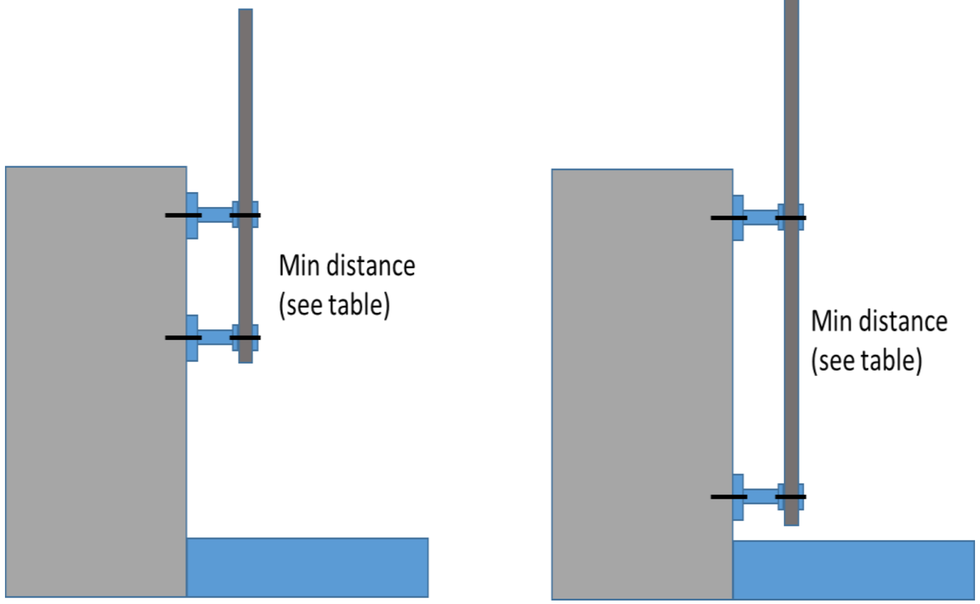
The best practice would be to fix first the upper support, then append the pole with only one support in order to find the right vertical position and then fix the lower support. This procedure however is not practical because once the first two holes are prepared with the chemical paste, the same becomes 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 !*

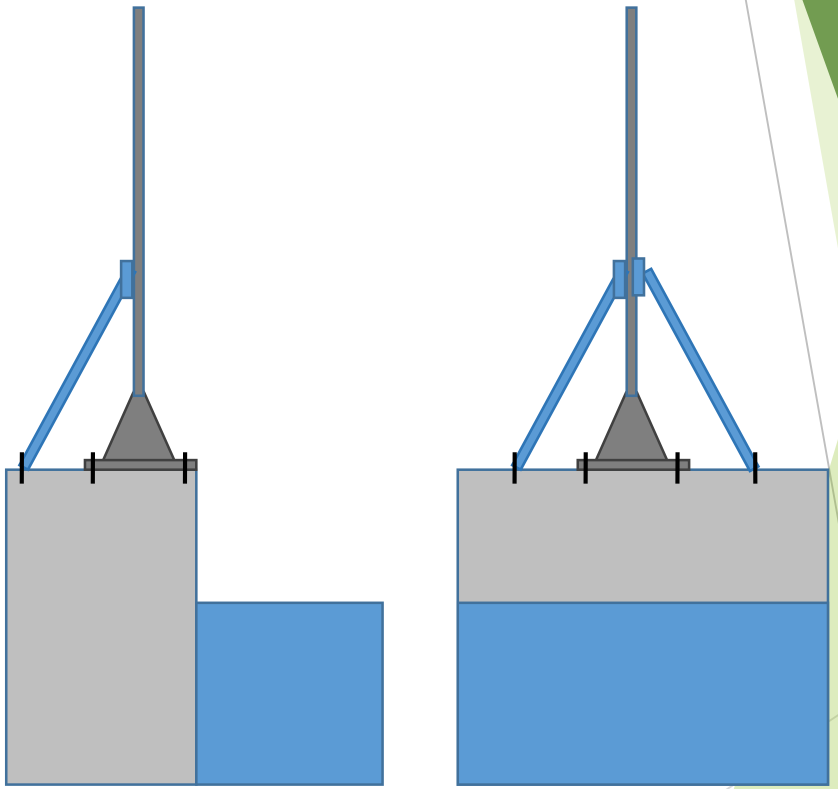
The normal practice is therefore: to fix the supports onto the pipe at the right distance among them, position the pole towards the wall by sustaining it with a rope, take the right points where the holes will be made using a marker, remove the pole and finally perform the holes.

- 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

Pole installation

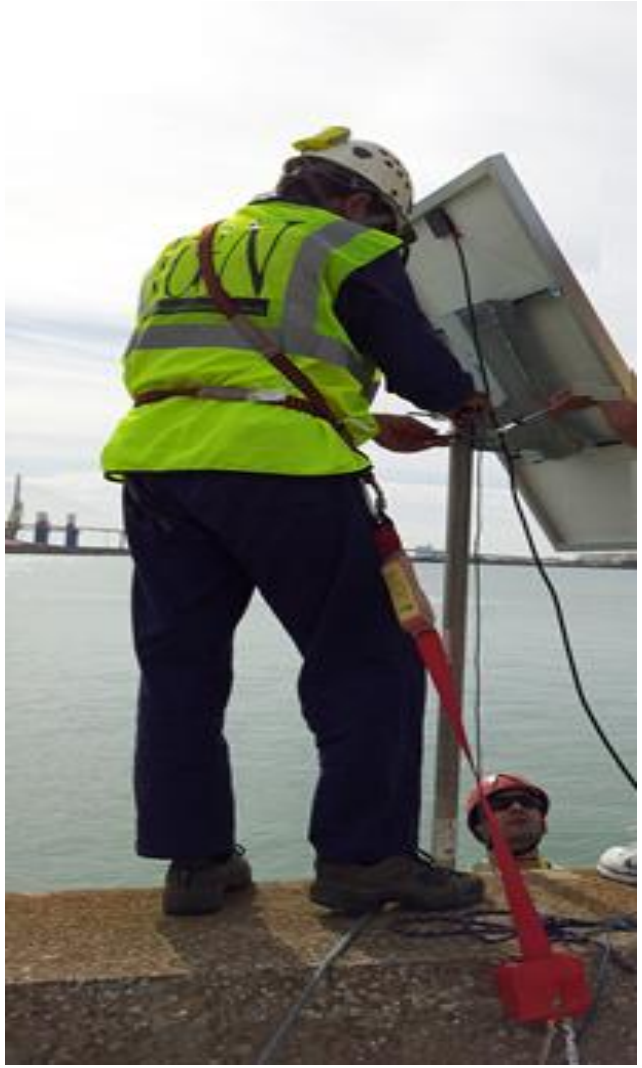


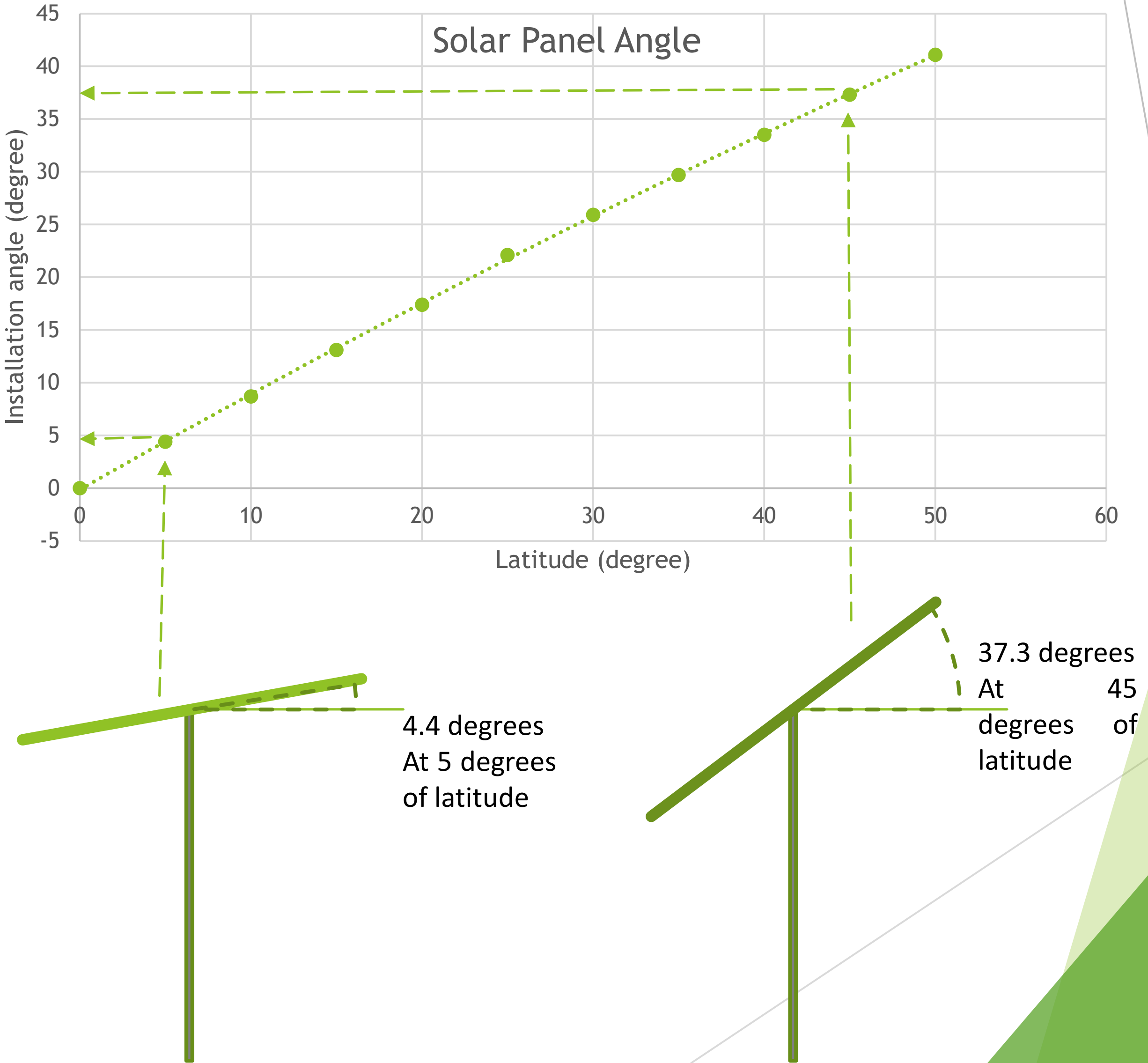
Vertical installation



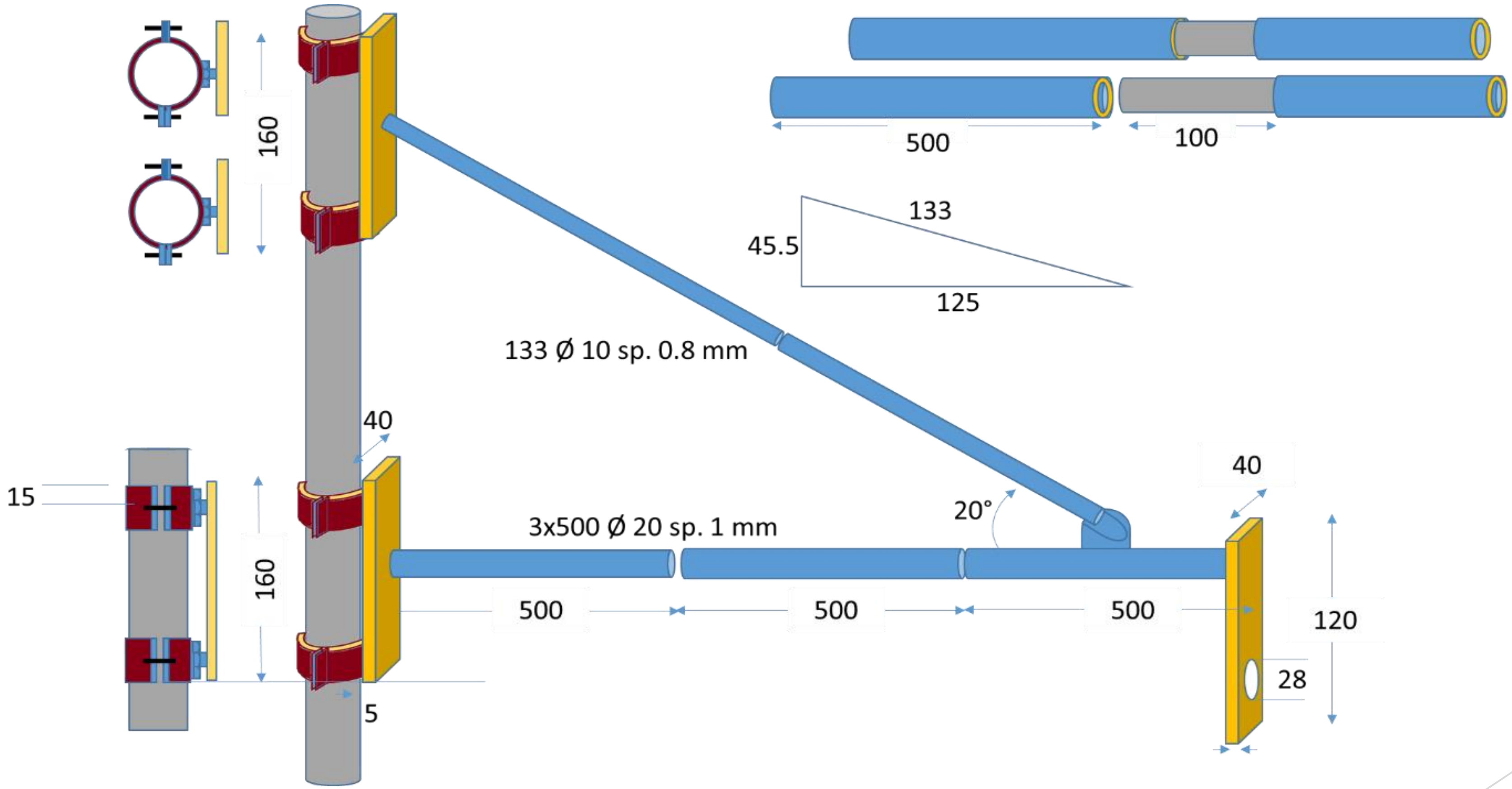
Horizontal installation

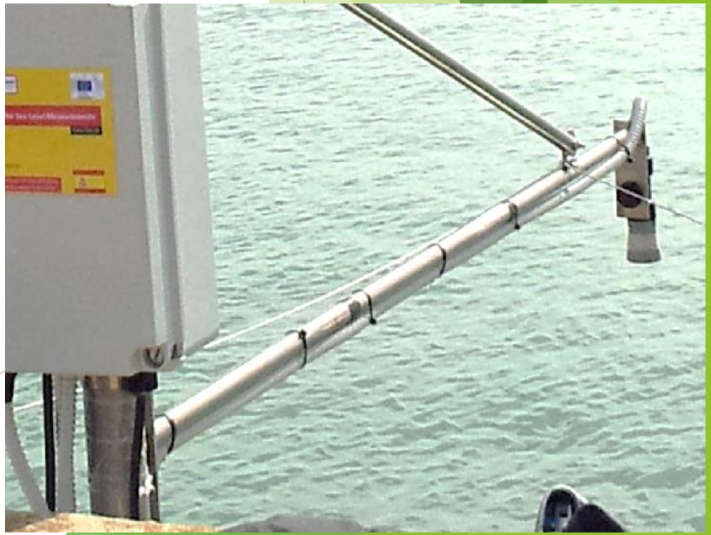
Solar panel installation



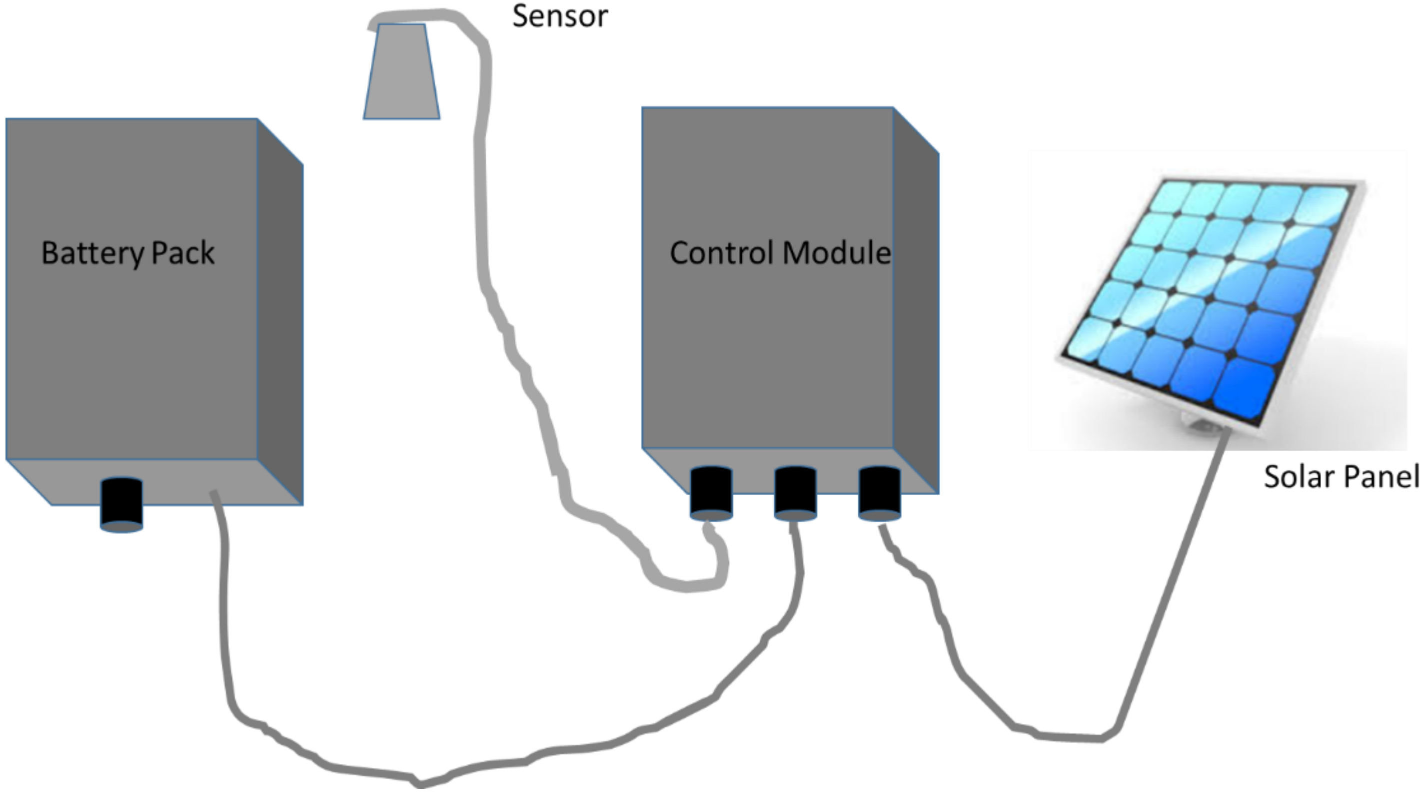


Sensor arm


160
160
15
40
5
500
100
133
45.5
125
133 Ø 10 sp. 0.8 mm
3x500 Ø 20 sp. 1 mm
20°
40
500
500
500
120
28

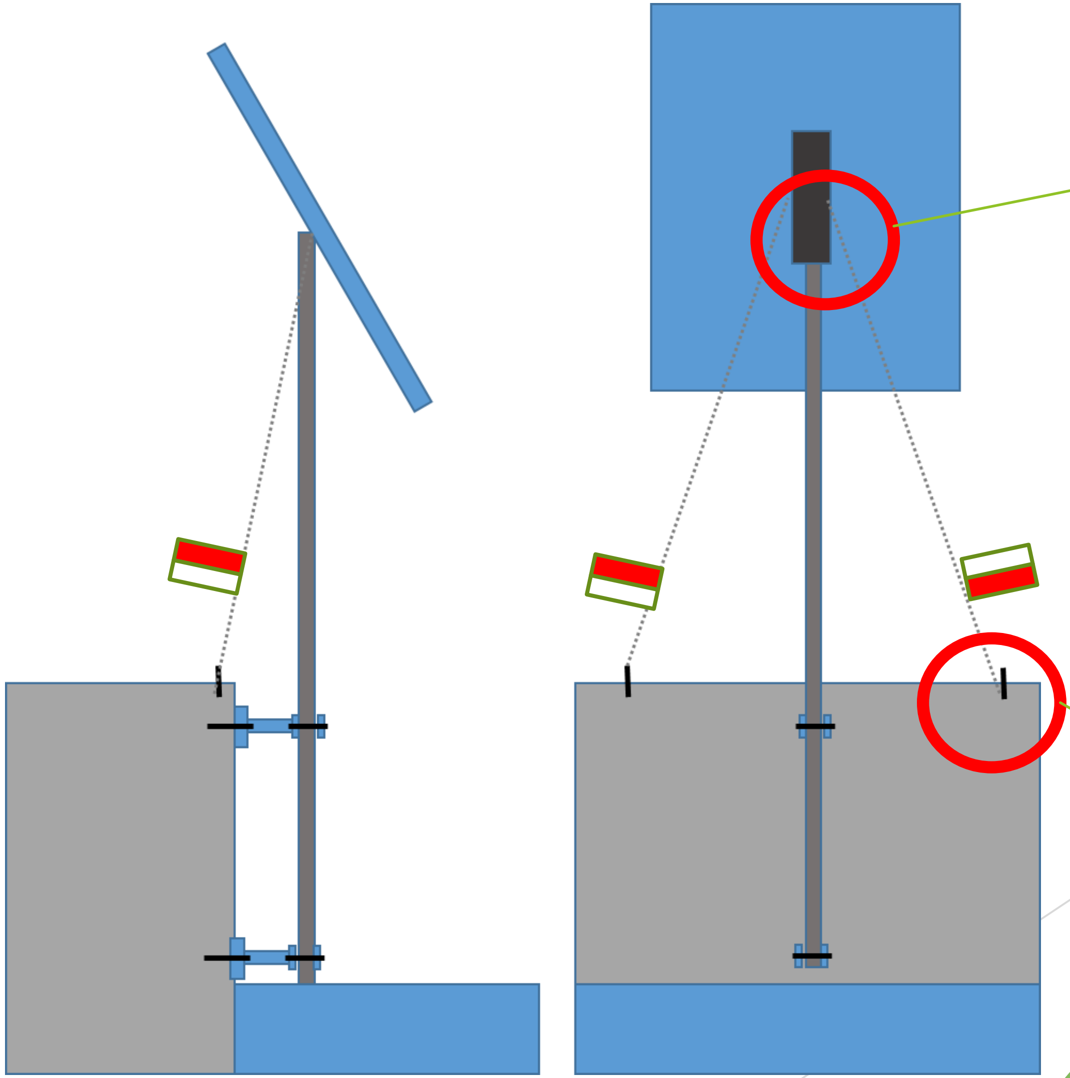


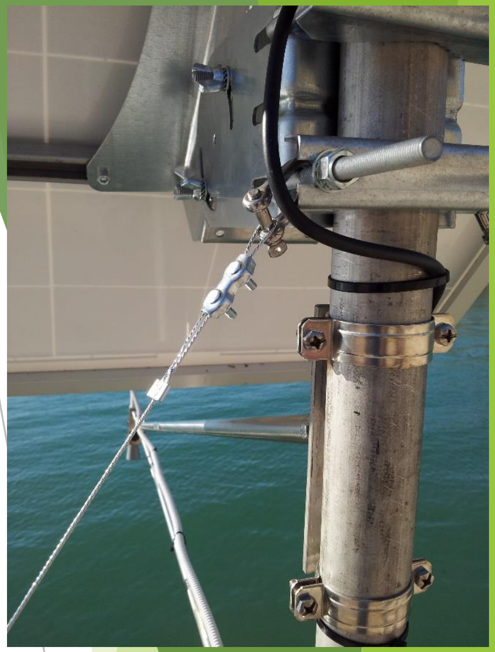
Wires connection

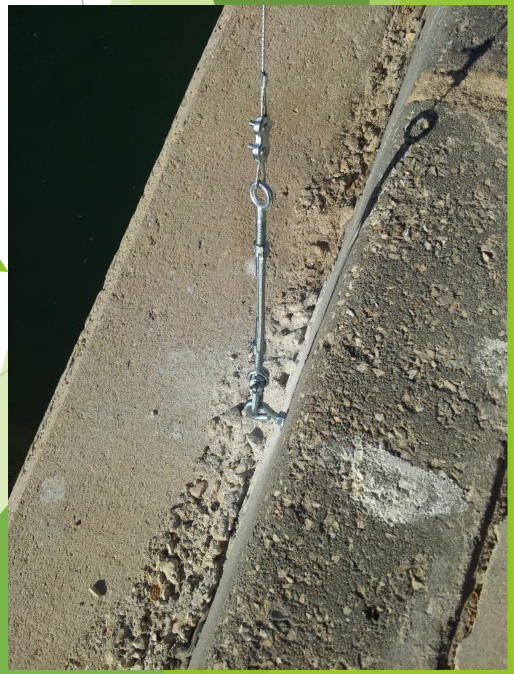


Tension wires

- Very important to prevent large oscillations of the solar panel, subject to wind
- They should be connected at the top of the pole , attached to the structure of the solar panel.
- These should not interfere with the oblique poles that are necessary for the stability of the pole.
- Remember to mark both the wires and the oblique poles with red/white tapes to make them well visible and avoid accidental hurts







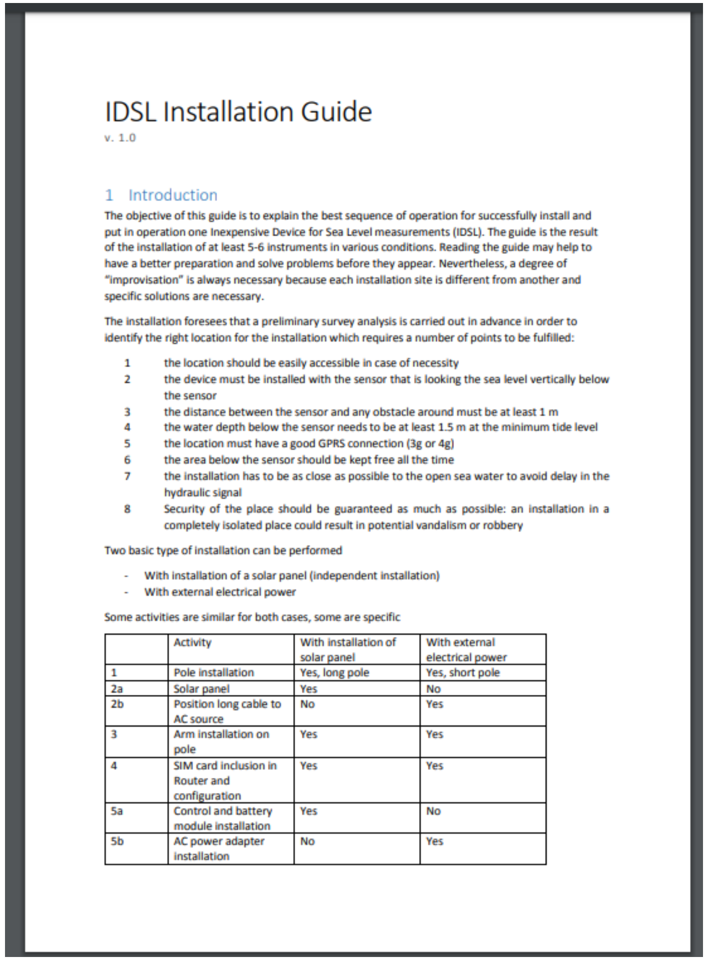
Installation sequence

- Preparing the holes for the supports of the pole either horizontally or vertically
- Define the location of the bases of the tripod
- Drilling the holes for the supports and the tripod bases
- Position the supports with the chemical glue
- Position the tripod bases with the chemical glue
- Wait the necessary time for fixing the glue
- Fix the solar panel with the right horizontal angle for the installation latitude
- Fix the pole
- Fix the sensor arm after having fixed the sensor at the end of it
- Rise the pole at the right height and rotate to orient the solar panel towards south
- Rotate the arm to extend straight on the sea
- Fix the tripod
- Install the control box and the battery(ies)
- Fix the tension wires
- Switch on the control box
- Check transmission of sea level on webcritech.jrc.ec.europa.eu or any other receiving system

Lessons learnt

- Use a rope to keep material and tools and avoid falling in water: anything on the sea must be secured (included the people).
- Bring all the appropriate tools and in particular
  - Driller with the series of Drill Bits, including the large ones for the chemical anchors
  - Chemical anchors glue
  - Allen key for the solar panels
  - Mechanical keys and at least numbers 7, 10, 13, 17
  - Angle grinder for cutting pieces
  - Electrical power source, either with wire or autonomous
  - Cutter
  - Several cable ties of various dimensions
  - Hammer
  - Pliers
- Ensure that the support unit onsite has the right equipment for descending on the vertical wall in case of vertical installation.
- Be sure to have replacement parts for:
  - All screws, bolts, sliding nuts
  - Router, Raspberry, power regulator or alternatively, if possible, one complete control box

Available documentation



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 measurements (IDSL). The guide is the result of the installation of at least 5-6 instruments in various conditions. Reading the guide may help to have a better preparation and solve problems before they appear. Nevertheless, a degree of "improvisation" is always necessary because each installation site is different from another and specific solutions are necessary.

The installation foresees that a preliminary survey analysis is carried out in advance in order to identify the right location for the installation which requires a number of points to be fulfilled:

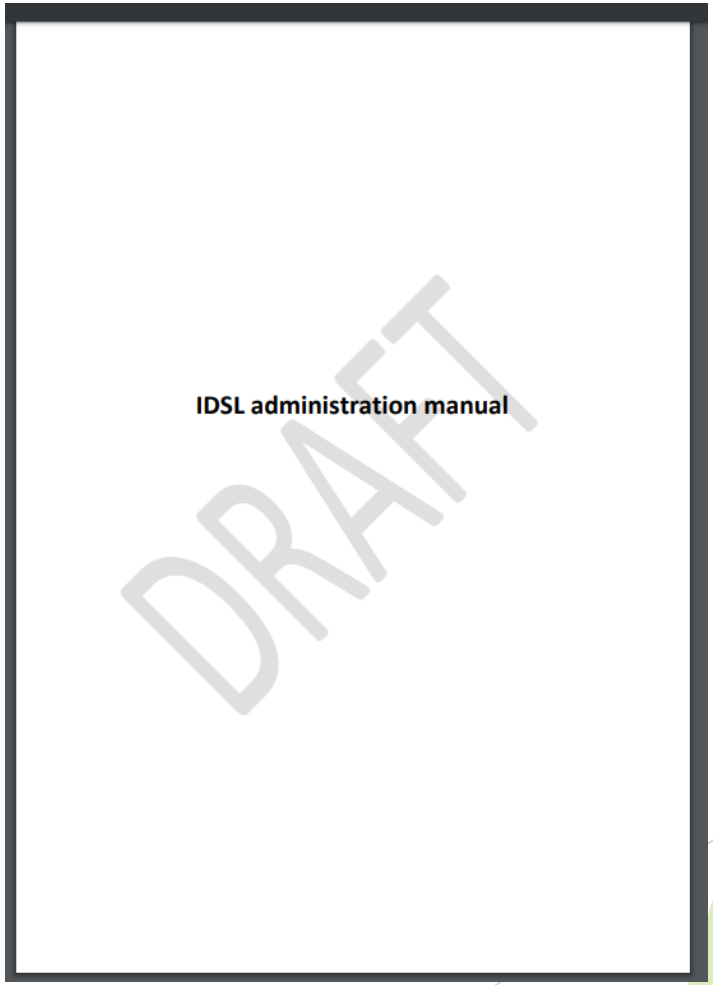
1. the location should be easily accessible in case of necessity
2. the device must be installed with the sensor that is looking the sea level vertically below the sensor
3. the distance between the sensor and any obstacle around must be at least 1 m
4. the water depth below the sensor needs to be at least 1.5 m at the minimum tide level
5. the location must have a good GPRS connection (3g or 4g)
6. the area below the sensor should be kept free all the time
7. the installation has to be as close as possible to the open sea water to avoid delay in the hydraulic signal
8. Security of the place should be guaranteed as much as possible: an installation in a completely isolated place could result in potential vandalism or robbery

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

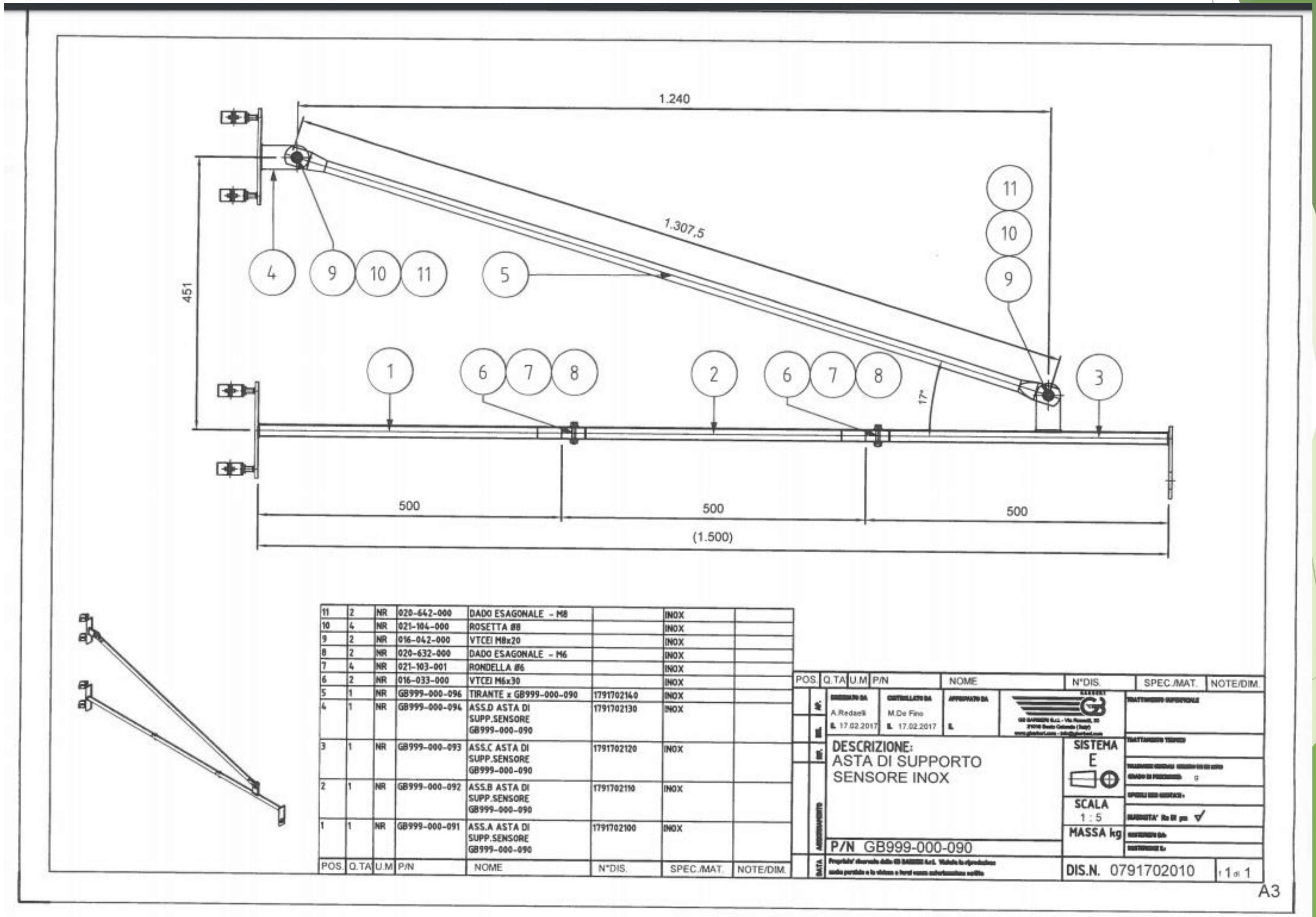
	Activity	With installation of solar panel	With external electrical power
1	Pole installation	Yes, long pole	Yes, short pole
2a	Solar panel	Yes	No
2b	Position long cable to AC source	No	Yes
3	Arm installation on pole	Yes	Yes
4	SIM card inclusion in Router and configuration	Yes	Yes
5a	Control and battery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



IDSL administration manual

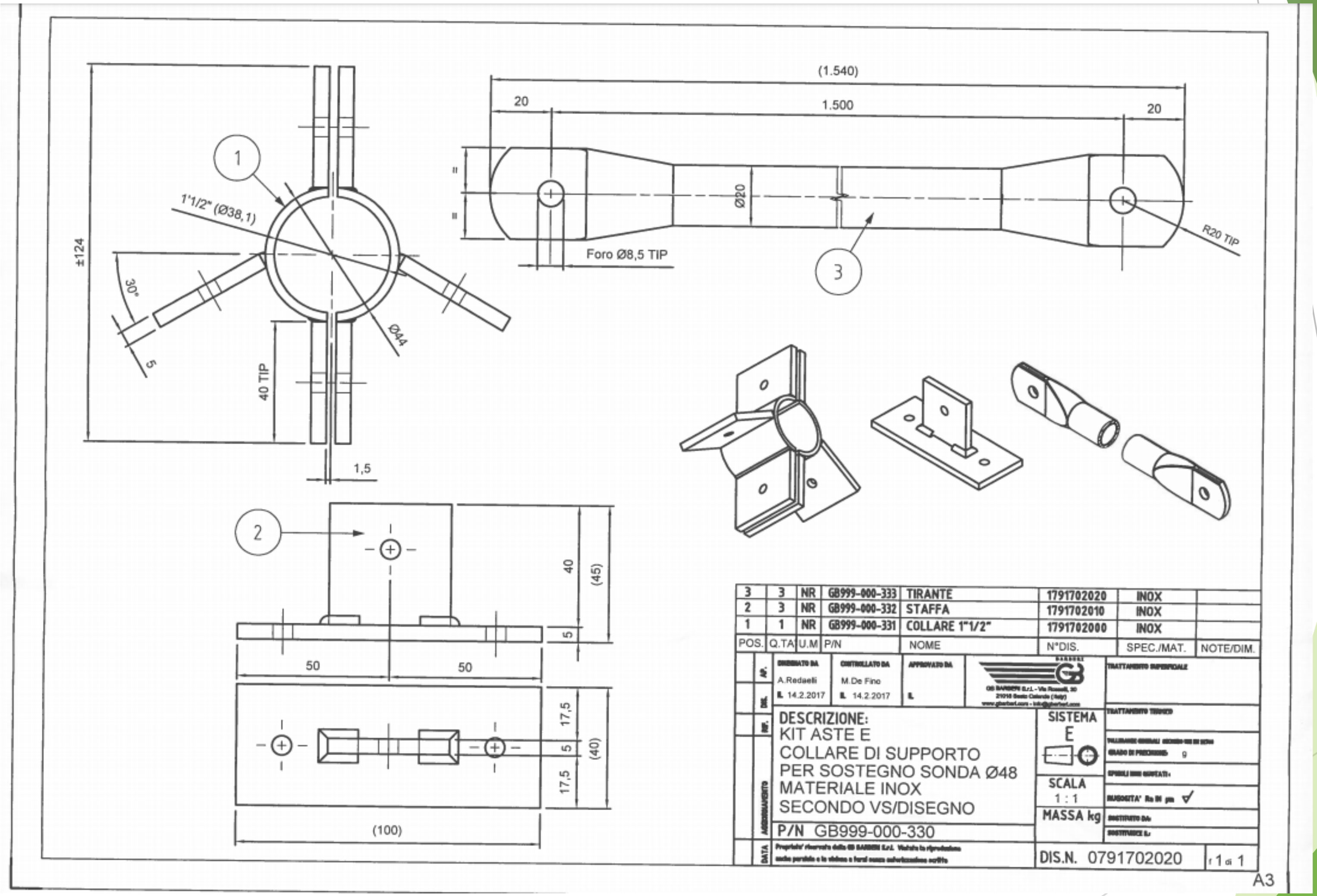
DRAFT

Mechanical drawings



POS.	Q.TA	U.M	P/N	NOME	N°DIS.	SPEC./MAT.	NOTE/DIM.
11	2	NR	020-642-000	DADO ESAGONALE - M8		INOX	
10	4	NR	021-104-000	ROSETTA Ø8		INOX	
9	2	NR	016-042-000	VTCEI M8x20		INOX	
8	2	NR	020-632-000	DADO ESAGONALE - M6		INOX	
7	4	NR	021-103-001	RONDELLA Ø6		INOX	
6	2	NR	016-033-000	VTCEI M6x30		INOX	
5	1	NR	GB999-000-096	TIRANTE x GB999-000-090	1791702140	INOX	
4	1	NR	GB999-000-094	ASS.D ASTA DI SUPP.SENSORE GB999-000-090	1791702130	INOX	
3	1	NR	GB999-000-093	ASS.C ASTA DI SUPP.SENSORE GB999-000-090	1791702120	INOX	
2	1	NR	GB999-000-092	ASS.B ASTA DI SUPP.SENSORE GB999-000-090	1791702110	INOX	
1	1	NR	GB999-000-091	ASS.A ASTA DI SUPP.SENSORE GB999-000-090	1791702100	INOX	

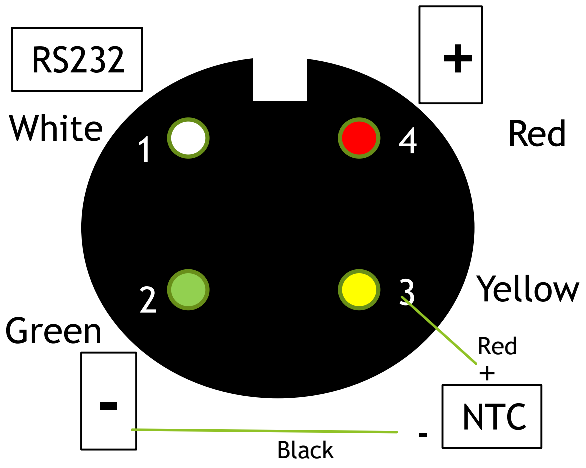
Mechanical drawings

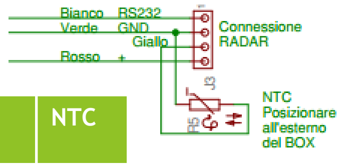



Beghelli
OFF
ON
RADAR SENSOR
ADDITIONAL
BATTERY
EXTR PWR

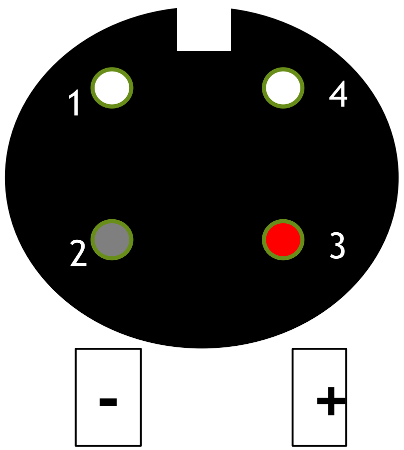
Connections pins

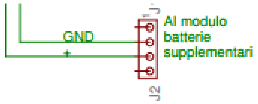
Sensor



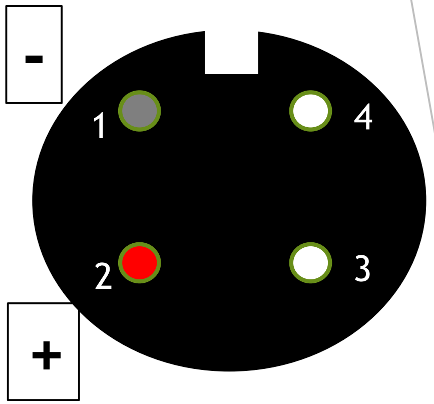


Additional Battery

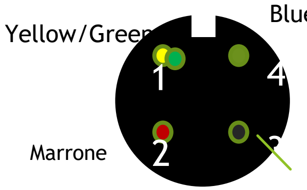




Solar Panel / AC transformer



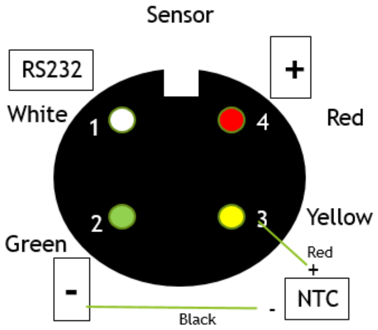
	Sensor	Prolong	NTC
1	White	Yell/Green	
2	Green	Brown	Black
3	Yellow	-	Red
4	Red	Blue	

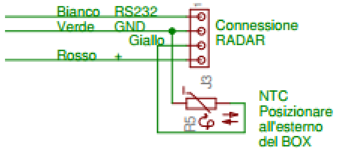


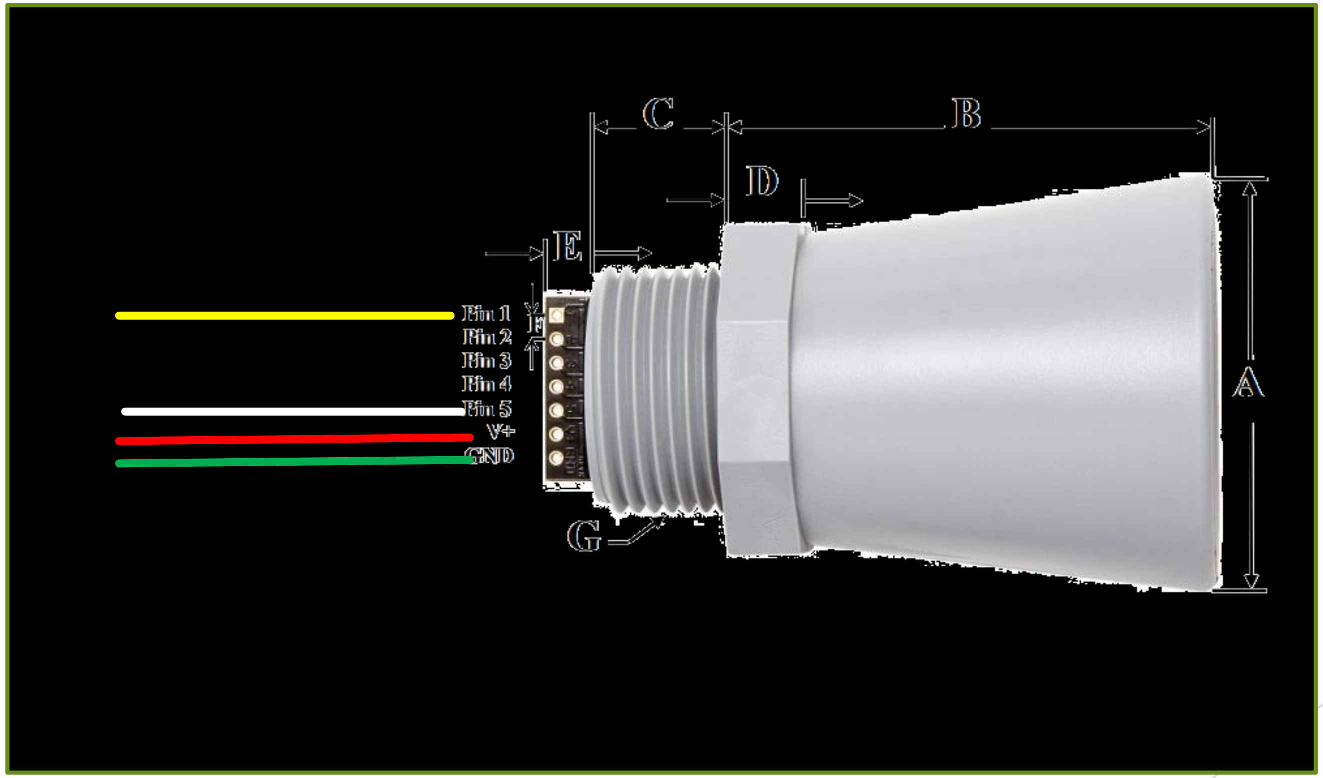
Prolong plug

Connection for MT7360

- ATTENTION: <u>if a different model is used check on Maxbotix Datasheet for the proper connection to avoid damage</u>







A	1.72" dia.	43.8 mm dia.
B	2.00"	50.7 mm
C	0.58"	14.4 mm
D	0.31"	7.9 mm
E	0.23"	5.8 mm
F	0.1"	2.54 mm
G	3/4"-14 NPS	
H	1.032" dia.	26.2 mm dia.
I	1.37"	34.8 mm
Weight, 1.76 oz., 50 grams		

Values Are Nominal

End of Module 3

Back to Index

Module 4: Preventive Maintenance

Maintenance

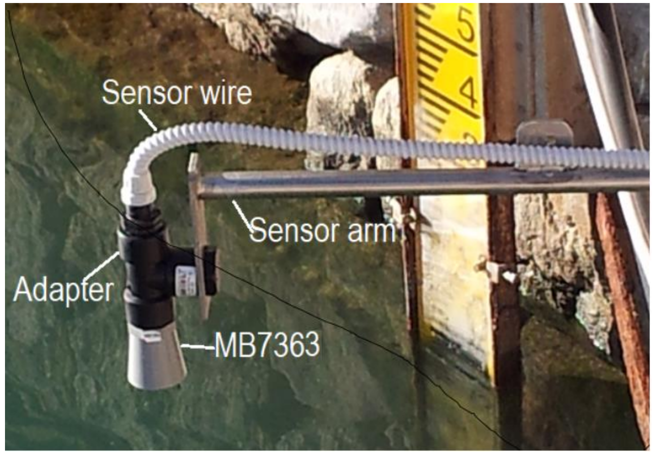
- Regular maintenance of IDSL is needed but the time of revisit strongly depend on the local conditions
- Factors that may influence IDSL efficiency
  - Crystal deposits on the sensor surface
    - The sensor stops working after 2-3 years; in some sporadic cases 1 year
  - Batteries degradation
    - 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

IDSL critical parts

- The most critical parts that have been identified over the 3 campaigns carried out by JRC are the following (in parenthesis the average working time before failure):
  - Maxbotix Sensor (2-4 years)
  - Batteries (2-3 years)
  - Memory card (occasionally or undefined period of time)
- With a less frequency of occurrence:
  - Teltonika router
  - External Battery box
  - Raspberry pi
  - Webcam

Sea Level Sensor

- We selected Maxbotix **MB7363**, but also other models can be used provided that they have serial card interface.
- Depending on the model, however the response can be in mm or cm and this need to be accounted in the configuration file
- Link to the page of the sensor: https://www.maxbotix.com/ultrasonic_sensors/mb7363.htm
- Datasheet: https://www.maxbotix.com/documents/HRXL-MaxSonar-WR_Datasheet.pdf
- The cost of this sensor, as of January 2023, is in the order of 150 euro. However the device needs to be prepared with a proper wiring connection and adapter connector so that it can be replaced directly, as it is received from the SICE company. The overall cost of a prepared device is about **250 euro**



Technical secifications of MB 7353 device

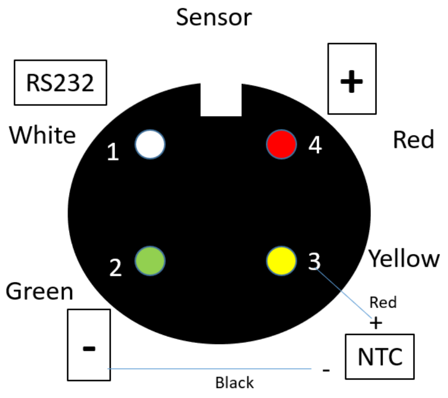
resolution of 1-mm
6Hz read rate
Internal temperature compensation
42kHz ultrasonic sensor measures distance to objects
RoHS Compliant
Read from all 3 sensor outputs: Analog Voltage, Serial, Pulse Width
Virtually no sensor dead zone, objects closer than 50cm typically range as 50cm
Operates from 2.7-5.5V
Low 2.9mA average current requirement
Small, light weight module
Designed for easy integration into your project or product
Operational temperature -40°C to +65°C (-40°F to +149°F)
Real-time automatic calibration (voltage, humidity, and ambient noise)
Firmware filtering for excellent noise tolerance and clutter rejection
Weather resistant (IP67), optional chemical resistant F-Option
Matches standard electrical 3/4-inch PVC pipe fittings for easy mounting (3/4-inch National Pipe Thread Straight)
Long, narrow detection zone
RS232 Serial Output
Great for long-range people detection
Maximum range of 10 meters (394 inches)

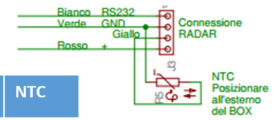
Sea Level Sensor, possible damages

- Salt deposits can affect the performance of the device
- Once is damaged it is difficult to clean it (we succeded only once)
- Other possible damage is attach and detach under tension. In some cases we have damaged the sensor

Connections

- If you buy yourself a new sensor, you need to connect to IDSL respecting the skeme on the side
- Soldering and preparing it with the provided plastic adapter so that fit into the arm and stay dry inside the connection area





	Sensor	Prolong	NTC
1	White	Yell/Green	
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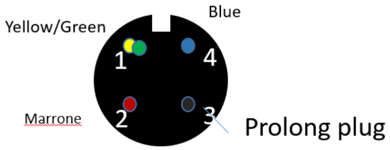
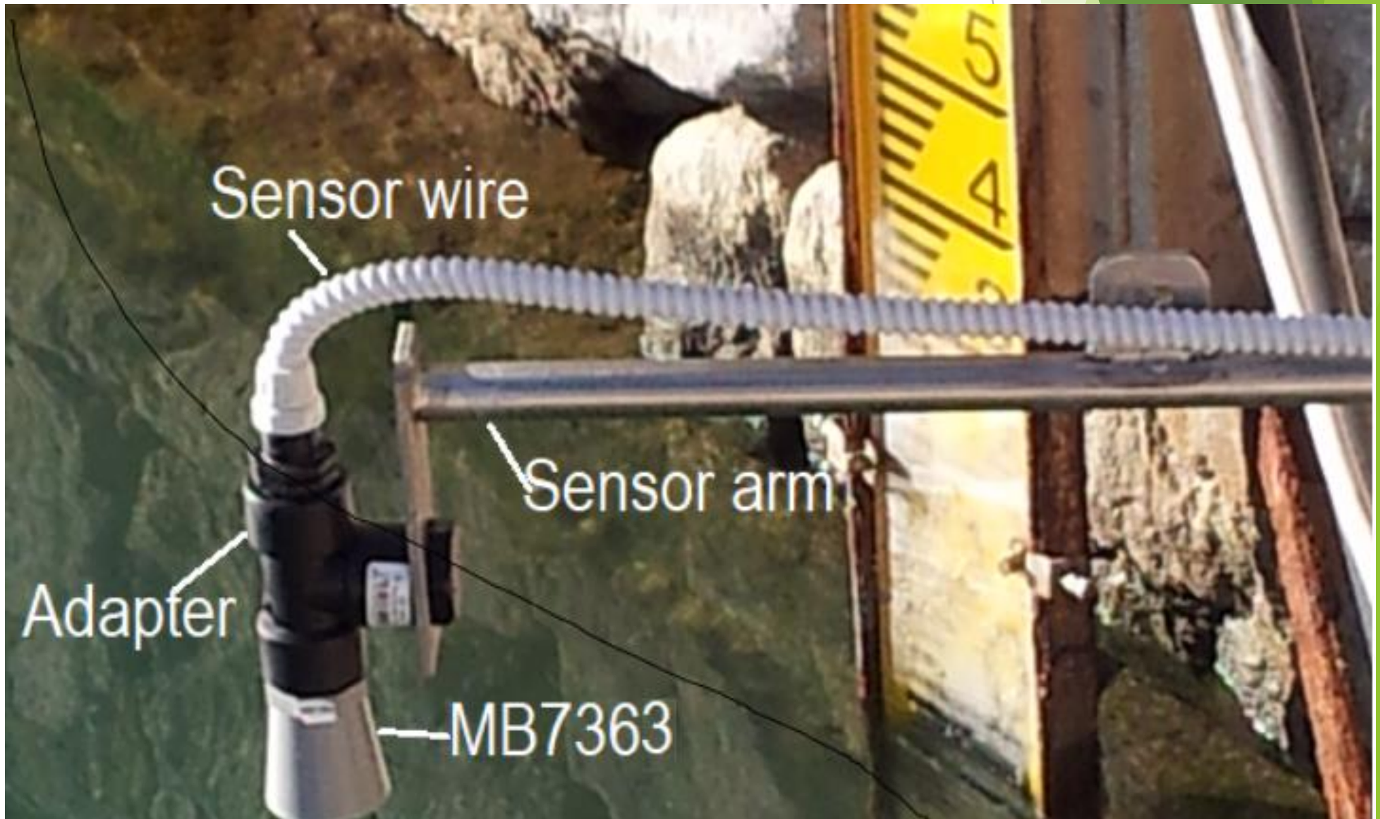
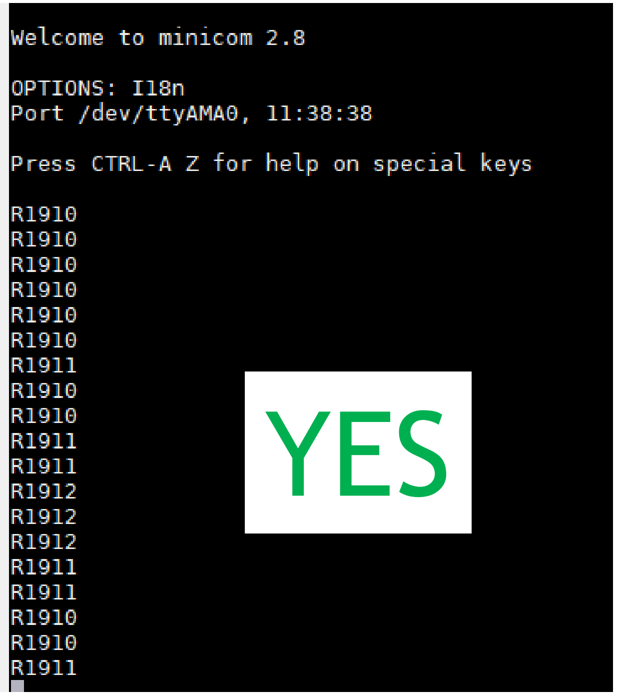
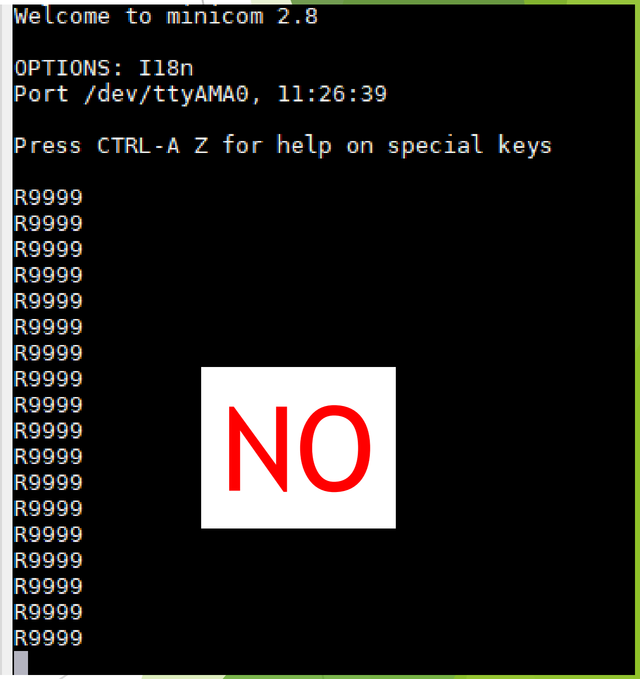




Testing the device

- With IDSL
  - Use minicom app
    - `sudo apt-get minicom`
    - `minicom –D /dev/ttyAMA0 –b 9600`
- With a Sensor Testing Unit
  - Attached to a PC and using a serial port reader





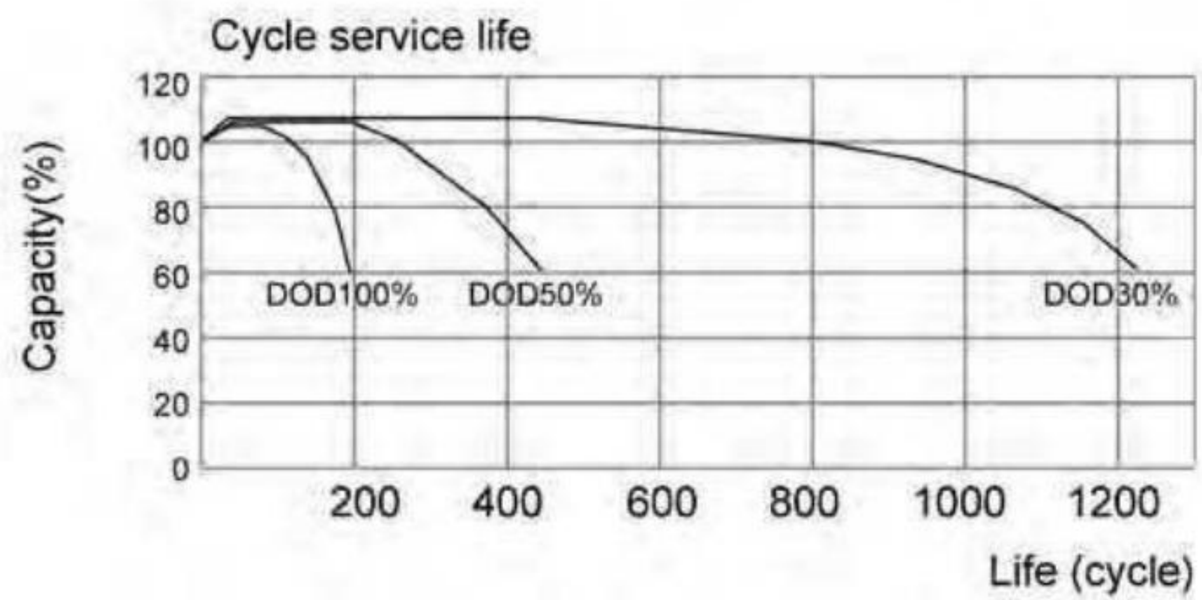
Sensor Preventive action

- According to the experience on the devices, 2 years is the average time for the life of a sensor. After 2 years the creation of salt deposits makes the working difficult. In some cases much longer periods have been noticed. Shorter life is very rare although not impossible.
- We suggest to be ready to change a sensor after 2 years

Device	**Suggested Replacement time**	**Need to force change at deadline**
Sea level sensor	2 years	No

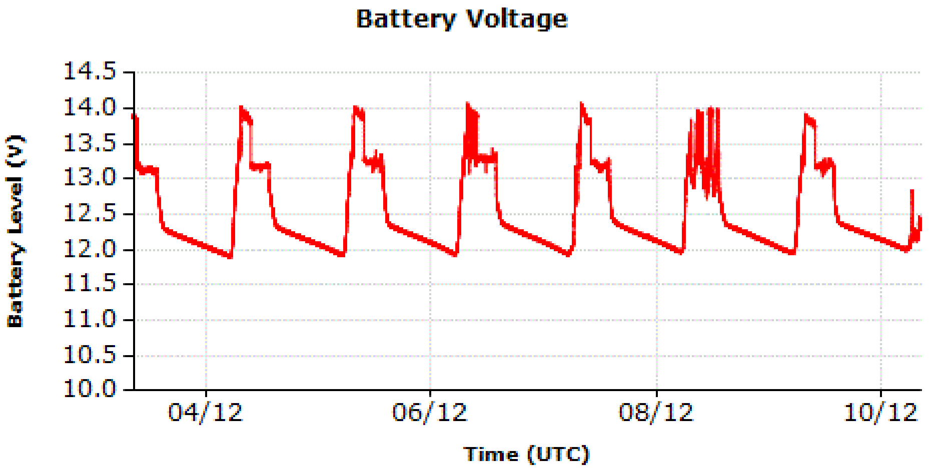
Batteries

- Considering that in the IDSL the cycles are 365 per year and that the autonomy is 3 days, it means that every day the discharge is about ⅓
- Therefore the life length should be rather long, 1200 cycles or 3 years.
- However in places where cloudy conditions are present, the discharge per cycle could also be 80% or even 100% if sun is not present for more than 3 days. The average DOD will therefore be higher than the theoretical 30% and, as a consequence, the life span of the batteries is strongly reduced.

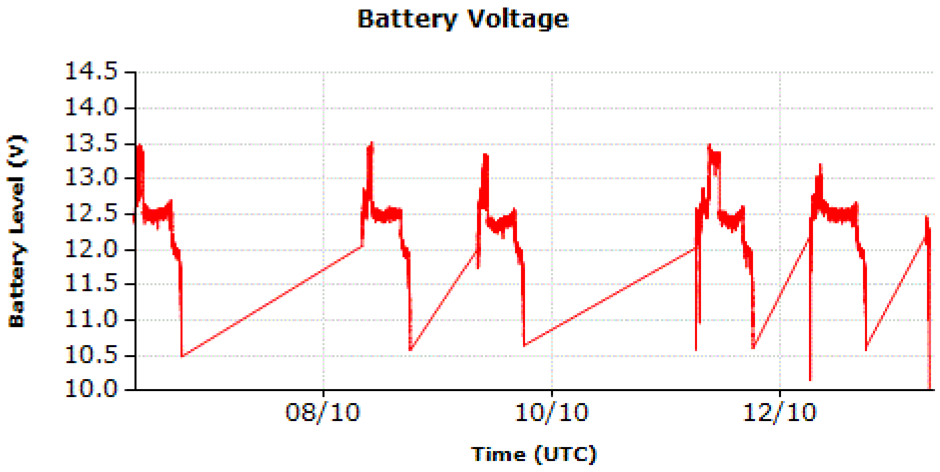


Batteries failure detection

- When battery sycling is degraded you need to change the batteries (all of them!) because frequent disconnections can cause degradation of the SD card



Correct voltage cycling



Degraded voltage cycling

Sensor Preventive action

- According to the experience on the devices, 2 years is the average time for the life of the batteries. We suggest to change the batteries after 2 years, even if they appear to be working properly.
- Given the relatively low cost of the batteries, unless it is not very convenient to go onsite, it is preferable to avoid discontinuity problems.
-

Device	**Suggested Replacement time**	**Need to force change at deadline**
Batteries	2 years	Yes

SD card

- *“Every SD Card in the market has a limited number of write cycles. This is a measure of the cards hardware lifespan. Writing and deleting is done by current that it is transferred through the SD Card cells, which gradually cases them to wear out. The lower the voltage required the greater the life expectancy of the SD Card.”*
- To create a new SD card (Module 5 of this training)
- For the reasons above we suggest to substitute the memory card every 5 years. Given the low cost of the card and the sudden stop working that cannot be anticipated, it is better to substitute the card even if it is still working correctly.

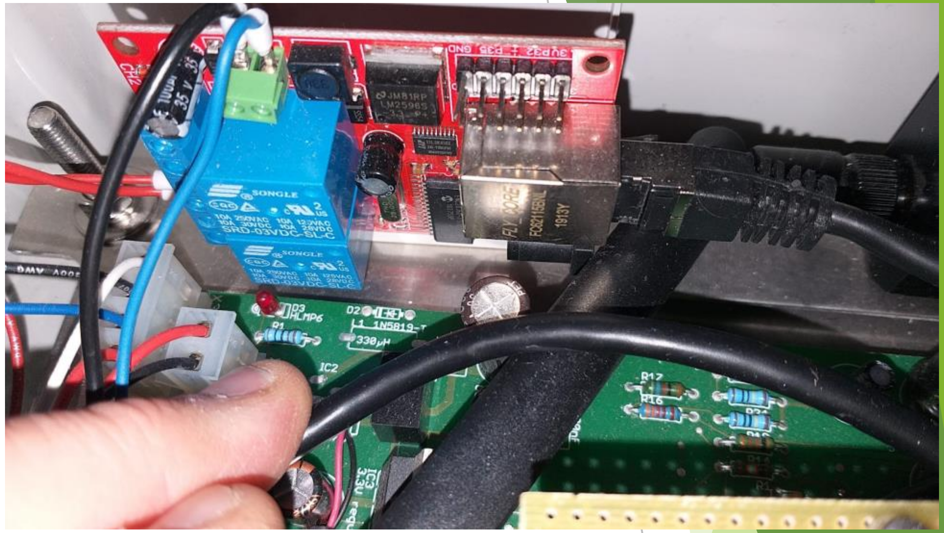
Device	**Suggested Replacement time**	**Need to force change at deadline**
Memory card	5 years	Yes

Teltonika Router

- The router installed in the IDSLs is RUT500 (3g) or RUT230 (4g). In general it is very unlikely that the router will be damaged. However events may happen:
  - The network changes or is stopped and the is restarted (it occurred 2 times over the course the IDSL life span until 2022).
  - The router transmits too large volume of data (it occurred for 3 devices over 50)
  - The router does not connect at all and is broken
  - The type of network does not allow the router to connect (change from 3g to 5g, for example)

- Network stopping: try using the LAN switch with SMS (if the LAN switch is present and if the telecom allows using SMSs and if this feature is installed)
- SMS with the following content:
  - CMDTELT /root/switchOffOn.sh

- No preventive maintenance for router. Change it only if is broken



External battery box

- What can happen is that the batteries life is too short before the 2 years of normal battery life
- Check the fuse
- In some cases (i.e. Preveza) we found corrosion in the connection inside the battery box which in turn caused short circuiting. We have excluded the connection to the additional battery box

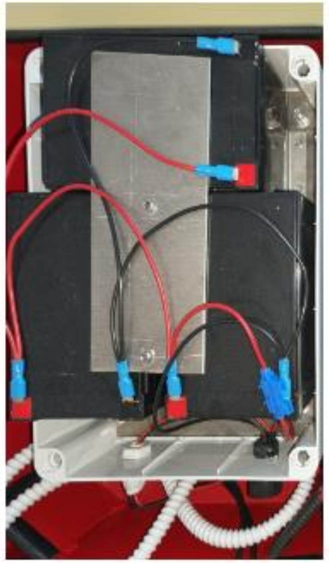


Fig. 14a - Battery pack internal

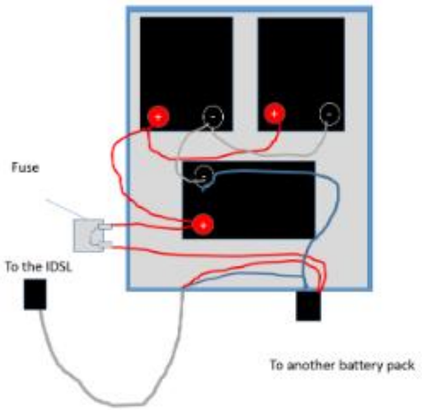


Fig. 14b - Connection scheme

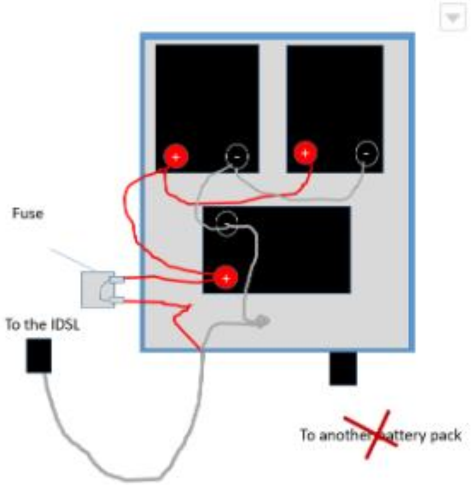


Fig. 14c -Modified connections in case of corrosion of the bottom

Raspberry and webcam

- No special need of preventive maintenance
- Only if you think is broken, replace the raspberry with a similar type if possible. If is not possible use another model but create a new SD card
- For the webcam, similar considerations ads for raspberry

Solar panel system

- Two are the possible damages to the wiring connections of the solar panel.
  - At the connection with the panel
  - At the connection between the two wires and the single wire
- No preventive maintenance except a generic cleaning of the panel surface

The problem came from water entering from the junction between the two cables from the solar panel and the single cable for the IDSL, as in the figure at side. The solution was to position the cable like the image above, to avoid penetration of water in the point where the two cables from the solar panel become one to the IDSL.

Summary of the actions

Device	**Suggested Replacement time**	**Need to force change at deadline**	**# to keep in stock per device**
Sea level sensor	**2 years**	**No**	**1**
Batteries	**2 years**	**Yes**	**1 set**
Memory card	**5 years**	**Yes**	**1**
Teltonika router	Only if damaged	n.a.	no
External battery box	Only if damaged	n.a.	no
Fuse of battery box	Only if damaged	n.a.	**2**
Raspberry PI	Only if damaged	n.a.	1*
Fuse of the IDSL	Only if damaged	n.a.	2
Webcam	Only if damaged	n.a.	no
Teltonika router	Only if is broken	n.a.	no
Solar PAnel	Only if is lost	n.a.	no
Periodic visits	**1 every 2 years**		

* per group of devices of the same institution

Year	1	2	3	4	5	6	7	8	9	10	Total	Unit Cost	Overall cost
Sea level Sensor			1			1			1		3	290	870
Batteries set			1			1			1		3	190	570
Memory Card						1				1	2	25	50
													1490

What is the real cost of a IDSL ?

- Although the initial cost of a IDSL can be relatively small, it is necessary to consider the maintenance and replacing parts cost
- This is similar also for other type of sensor which may have a larger initial cost and a lower parts replacing cost

Cost of IDSL device	1	2500-3000
Installation costs	1	2500
Maintenance package	1	1150
Replacing material (10 years)	1	1490
Periodic Maintenance visits (1 every 2 year)	3	3000
Total		**10640-11140**
Yearly cost		**1064-1114**

In case of more frequent visits (1 per year) the cost could be increased by 3000 euro for a total of 13640-14140 euro and 1364-1414 per year.

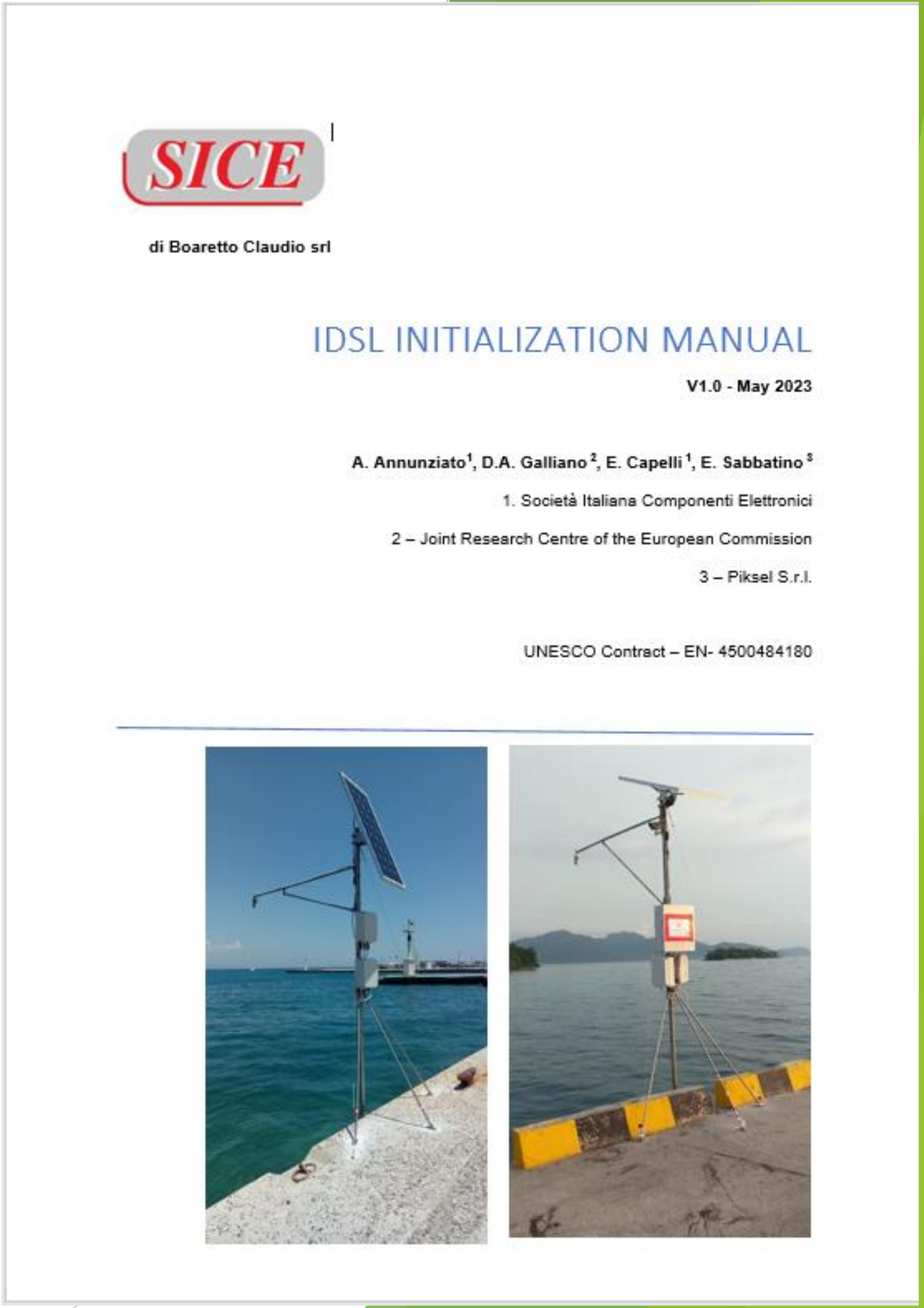
End of Module 4

[Back to Index](#)

Module 5: IDSL Initialization

Developed in collaboration with JRC

- Initializazion Manual, by A. Annunziato, D.A. Galliano, E. Capelli, E. Sabbatino
- Objective is to guide the operator to build a complete new IDSL system SD card (IDSL+webcam) in case of need
  - Downloading an existing image
  - Rebuiding the image
  - Personalize the system to the specific needs
- Why the SD card should be rebuilt ?
  - In case of a new system to install
  - Possible Damage
  - Periodic maintenance
  - Upgrade of the raspberry platform requiring an upgrade of the OS


SICE

di Boaretto Claudio srl

IDSL INITIALIZATION MANUAL

V1.0 - May 2023

A. Annunziato[1], D.A. Galliano[2], E. Capelli[1], E. Sabbatino[3]

1. Società Italiana Componenti Elettronici

2 – Joint Research Centre of the European Commission

3 – Piksel S.r.l.

UNESCO Contract – EN- 4500484180

Important Notes

- As soon as it is possible, do not give the commands copying from the installation manual but use copy/paste from that document to the raspberry terminal. This will avoid to introduce wrong commands in the configuration files.

- Print the initialization manual and mark every step with your signature to be sure you did exactly all the steps

IDSL SDcard

- To initialize an IDSL, it is necessary to:
  - Download the image of the basic operating system of the Raspberry PI 2 model 2 and up
  - Copy the software and prepare it for the execution
  - Initialize the device
  - Activate the VPN to allow a remote connection
- If a webcam is also included in the installation kit:
  - Download the image of the basic operating system of the Raspberry PI Zero W
  - Copy the software and prepare it for the execution
  - Initialize the device

How to perform the initialization

- Requirements:
  - Laptop with ssh programme (the best is MobaxTerm), https://mobaxterm.mobatek.net/download-home-edition.html
  - Raspberry PI, at least Model 3
  - Keyboard
  - External monitor to connect to a raspberry
  - SD card reader

First decisions

- Download an existing image from JRC server or SICE server
  - It is easier and faster (45’-1h)
  - Download time depends on the network but it will take some time if the network is not sufficiently fast
- Reinstall from zero a new SD card
  - Much longer time needed (4-5 h)
  - Some knowledge of Linux systems
  - Needed if raspberry changes or if OS changes

Installation in case of new from scratch

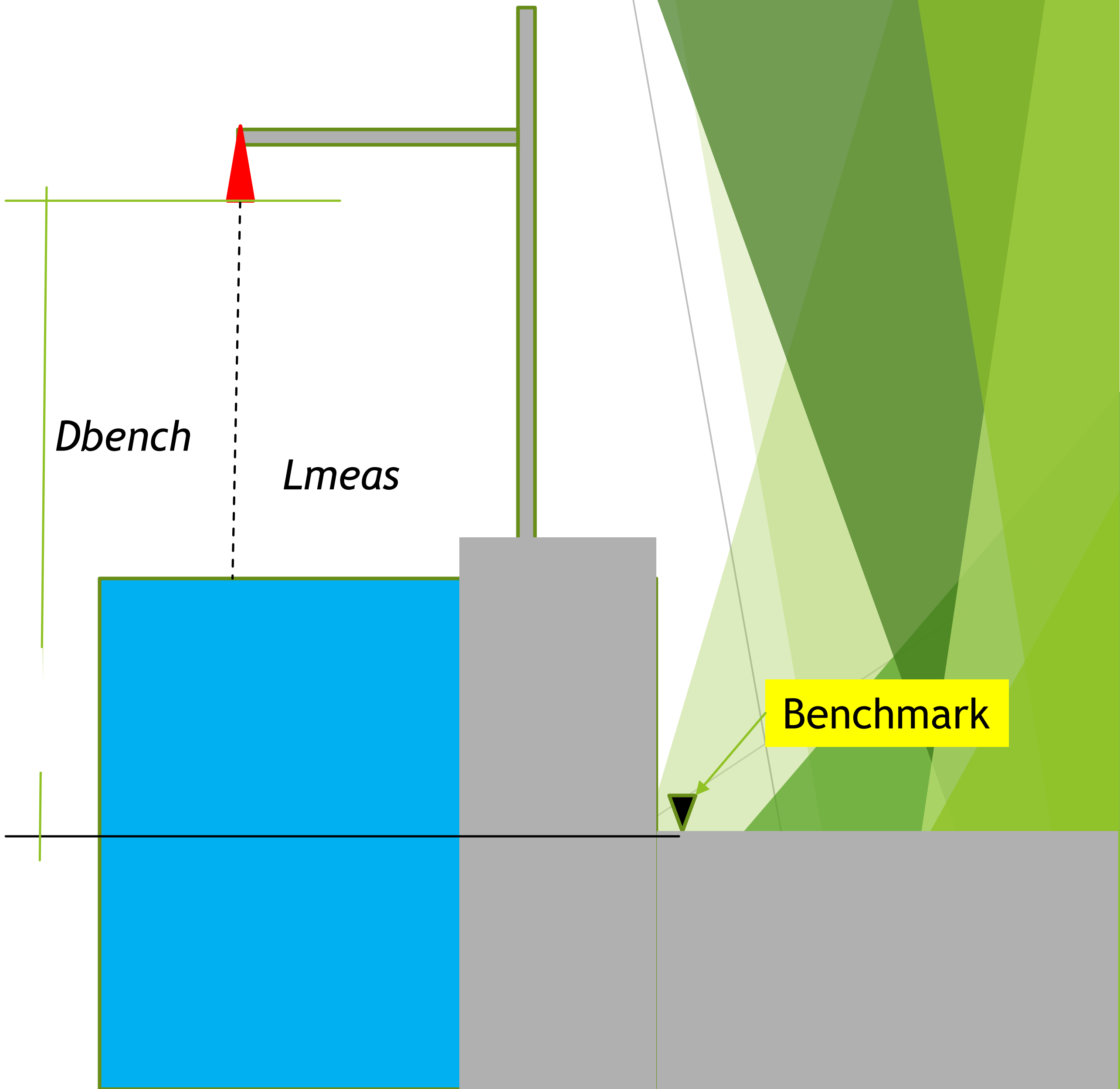
- Follow all the chapter 2 step by step to have a working system
- Install the software (c, python and C#)
- Decide which of the 3 system to use:
  - c version is the easiest one
  - Python is easier to modify if you want to have further processing
  - C# is the more stable even if the Tsunami detection model in some cases it does not give exactly the same results as the c or python versions
- Personalize the system applying calibration constants or temperature constants (see next 2 slides)
- Install the VPN to reach the system from remote

Level calibration

- Considering that **Lmeas** is the sensor measurement or the distance from the surface of the sensor to the surface of the water
- And that **Dbench** is the distance between the surface of the sensor and the height of the benchmark corresponsing to the national benchmark (that should be the average annual mean level at the installation site)
- The value that is stored is:
  - Meas=Dbench – Lmeas
- So the constants to apply in the configuration file are:

```
sensorMultFac  = multiplication factor for the level
sensorAddFac   = addition factor for the level
```

- SensorMultFract=-1
- SensorAddFac=Dbench
- In case a benchmark is not available, you can try to make sure that the level is closer to other levels in instruments closeby



Air temperature calibration

- The temperature is obtained by a NDT sensor using a ADC converter and using this formula:
  - T=Offset+Multiplier*1/t

  Where t is the measured voltage corresponding to the temperature, Offset and Multipliers two constants.
- The Offset and the Multiplier can be different instrument by instrument and therefore need to be calibrated
- To tune the sensor, use two random values, e.g. $Offset_0 = 10$ and $Multiplier_0 = -20$; then measure twice the temperature with an alternative mean and record the measurements generated by the device.
- Let the measured temperatures be T_1 and T_2, and their difference ΔT.
- Let the measurements from the device be D_1 and D_2, and their difference ΔD. Let the arbitrarily chosen offset and multiplier be $Offset_0$ and $Multiplier_0$. These equations will provide the operational values for Offset and Multiplier.
- Offset = $T_2 - \frac{\Delta T}{\Delta D} \cdot \frac{D_2 - Offset_0}{Multiplier_0}$
- Multiplier = $\frac{\Delta T}{\Delta D}$

Installation exercise

- Prepare a SD card following the Initialization manual
- Attribute the following host names: IDSL-INIT-<your countrycode>
  - IDSL-INIT-ES, IDSL-INIT-TR, IDSL-INIT-EG, IDSL-INIT-MA, IDSL-INIT-GR
- Use the following address as SaveURL:
  - http://bilance.ddns.net:9100
- Then, if you have a spare IDSL, activate it with this SD card, otherwise send me the image obtained and I will include in a IDSL for testing the result.
- The results will be visible at the address http://bilance.ddns.net:9100/
- Discussion will take place at the beginning of the next module

End of Module 5

[Back to Index](#)

Conclusions

- The IDSL system is a complex system to monitor and analyse sea level and provide alerts for potential Tsunami events
- The training attempted to provide all the elements for a great insight into the system and allow a proper management of the devices by the owner institutions
- The Tsunami detection model was described in detail and the coefficients explained
- The maintenance of an IDSL device can be improved applying a preventive maintenance programme in order to have an instrument in efficience over the years