5th IHO TIDAL AND WATER LEVEL WORKING GROUP MEETING

14 - 16 MAY 2013, HELSINKI, FINLAND

CHILEAN SEA LEVEL NETWORK

Juan Fierro C.

Lecture Overview

- Tsunami, Offshore Maule, Chile
- Current State and ongoing upgrade
- Sea level station components
- Data transmission improvements
- Conclusions

Tsunami, Offshore Maule, Chile

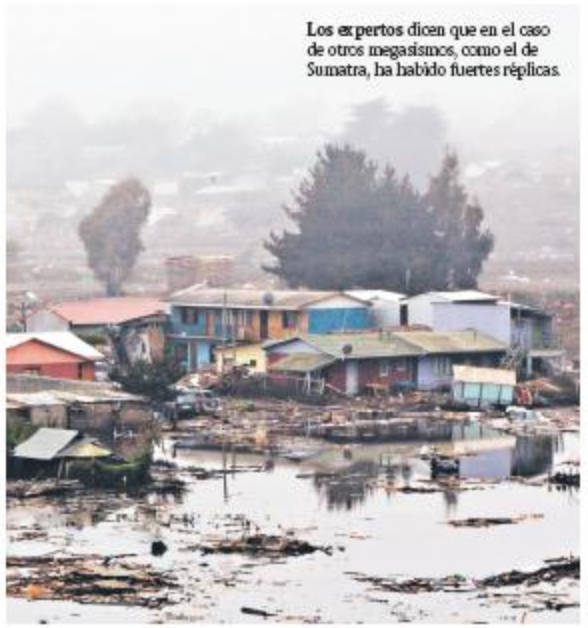
Introduction

- At 3:34 local time, February 27th, a devastating earthquake M 8.8 struck Chile
- The earthquake also triggered a tsunami which crossed into the Pacific Ocean
- Historic world earthquake after 1900 listed by magnitude

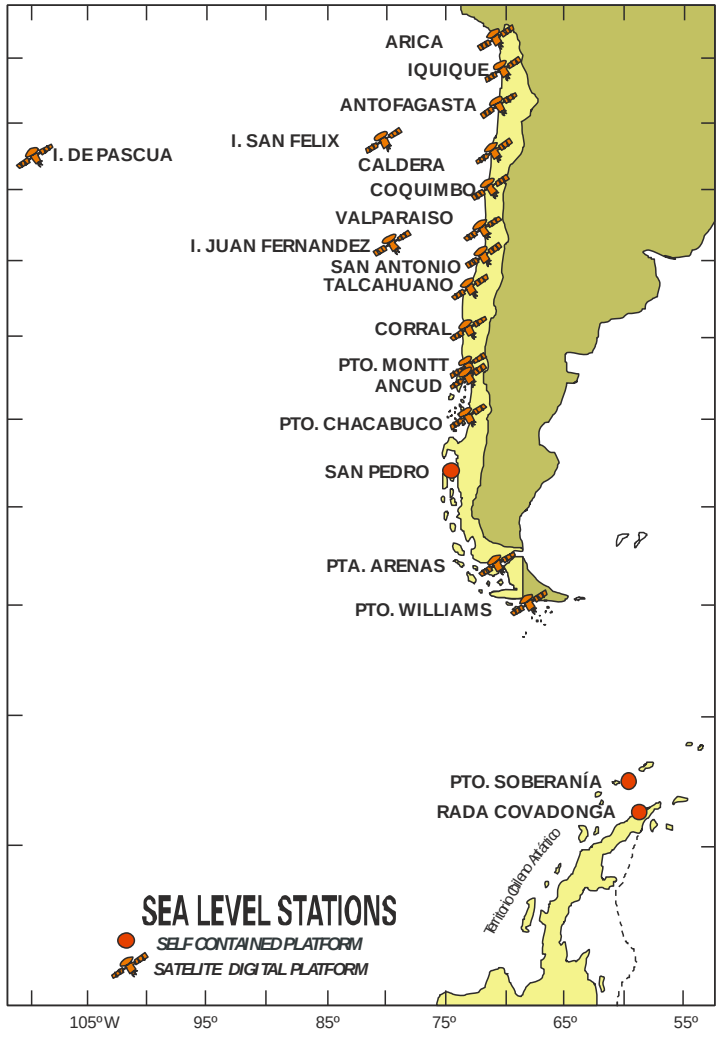
  - 1960 05 22 Valdivia, Chile – M 9.5
  - 1964 03 28 Prince William Sound, Alaska – M 9.2
  - 2004 12 26 Sumatra – Andaman Island – M 9.1
  - 1952 11 04 Kamchatka – M 9.0
  - 2011 03 11 Honshu, Japan – M 9.0
  - 2010 02 27 Offshore Maule, Chile – M 8.8

- Sea level stations contribute strongly as tsunami detection systems with potential warning time from minutes to hours, depending on proximity of source location


Valparaíso
Juan Fernández
Santiago
Rancagua
Constitución
Talca
Cobquecura
Chillán
Concepción
Temuco


Los expertos dicen que en el caso de otros megasismos, como el de Sumatra, ha habido fuertes réplicas.

Chilean Sea Level Network
Some damage



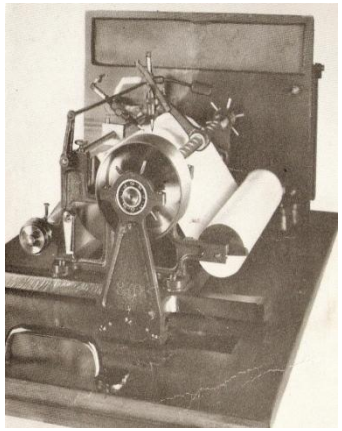
Current State and Ongoing Upgrade

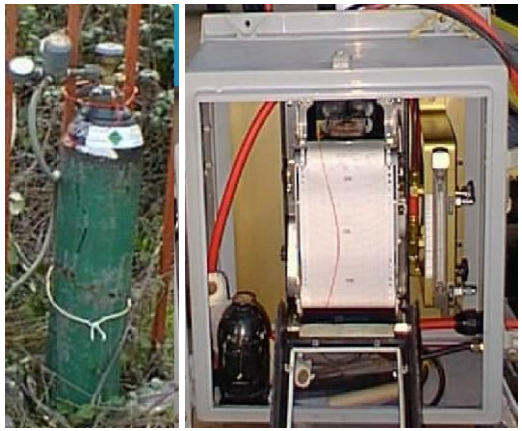
Chilean Sea Level Network
Hardware Upgrade process

Feb 27th 2010

Near Real Time | Real Time

1941 | 1970 | 1999 | 2010





dry purged recording tide gauge

Data collecting platforms

A reinforced upgrade

-Improving telemetry

-New platforms and sensors

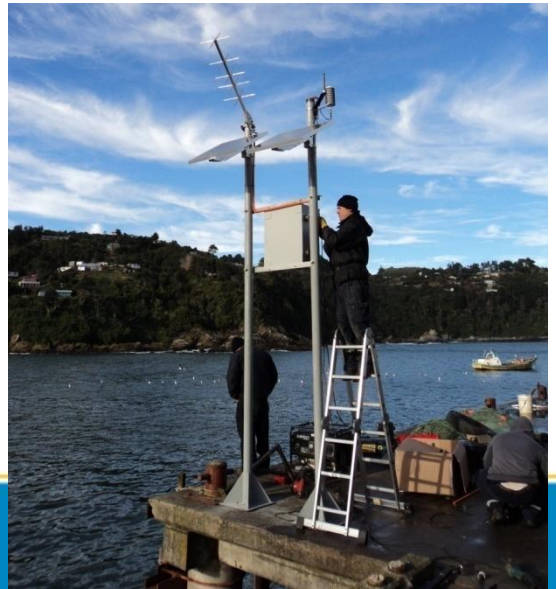
Mechanical devices

Digital equipments

Chilean Sea Level Network

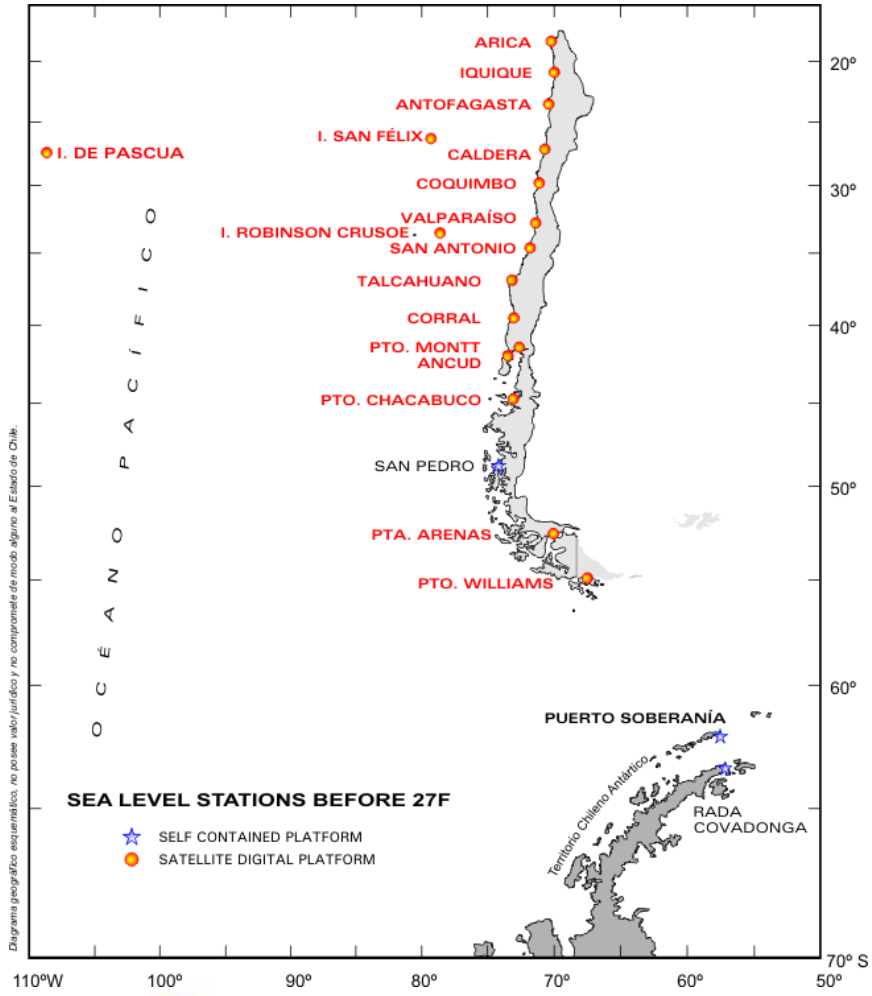
Hardware Upgrade process March 2010 – May 2013

Date	27th 2010	Dec 2010	Dec 2011	Dec 2012	May 2013
Satellite digital platform	17	24	32	35	38
Autoself contained platform	3	3	3	2	2
Total of Stations	**20**	**27**	**35**	**37**	**40**

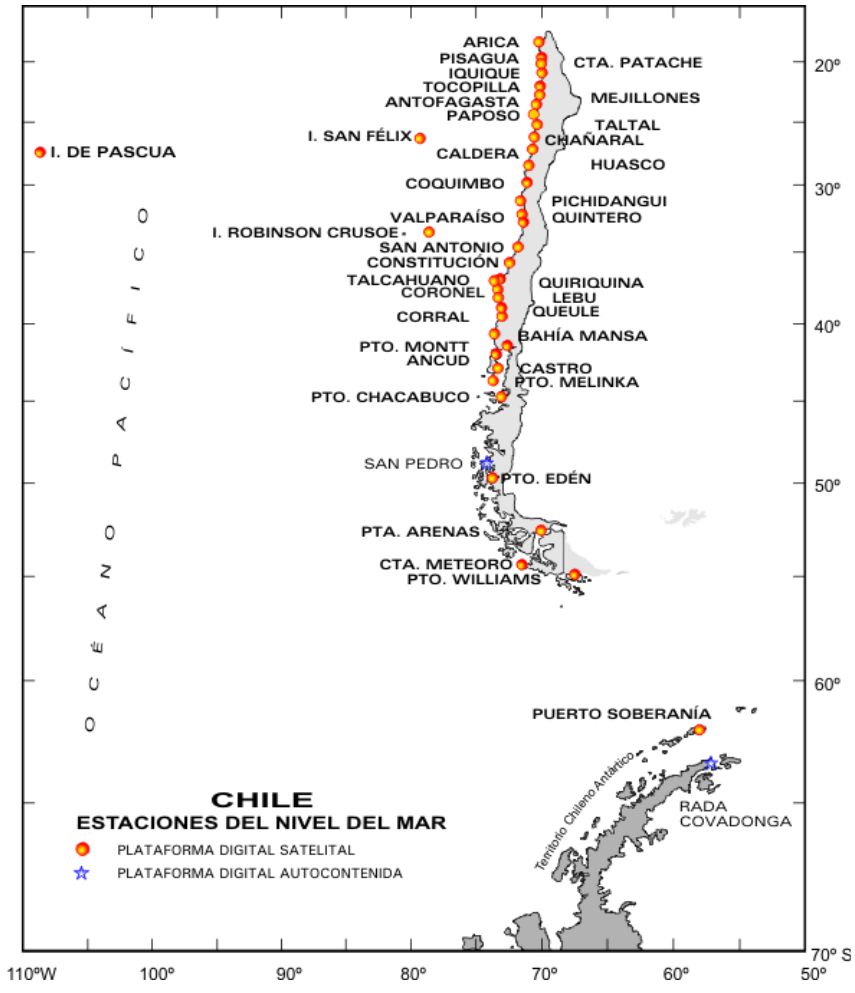


Chilean Sea Level Stations Network

Before 27 Feb 2010



Updated to May 2013



Chilean Sea Level Stations Network

Current State at May 2013

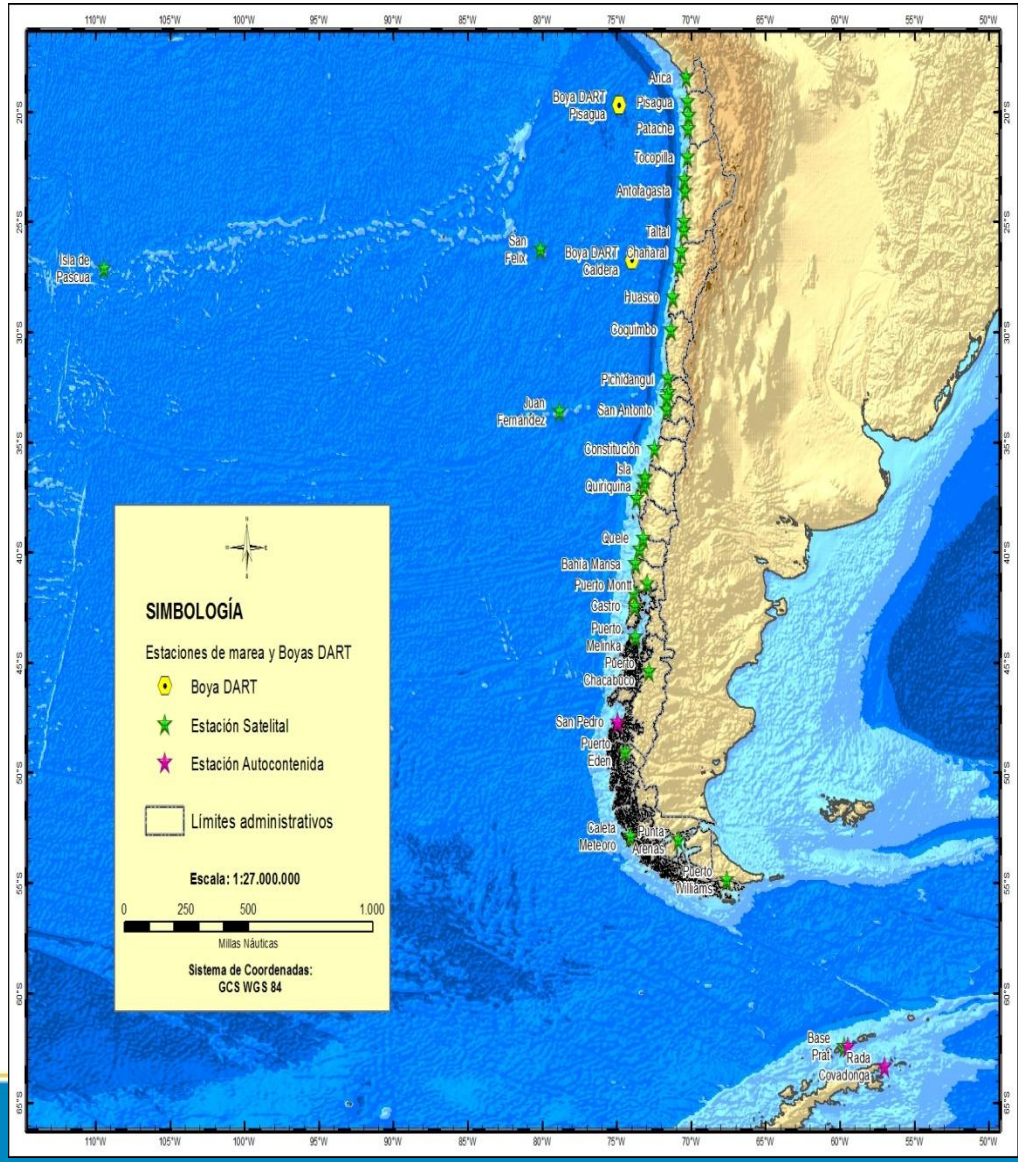
- **38 Stations with real time transmission:**

  Sampling interval: 1 minute
  Tx transmission: 1, 5, 10, 15, 60 min

  Sensor Standard configuration
  Sea Level
  Water Temperature
  Combined Air Temp and humidity
  Atmospheric pressure

- **2 Self contained platforms:**

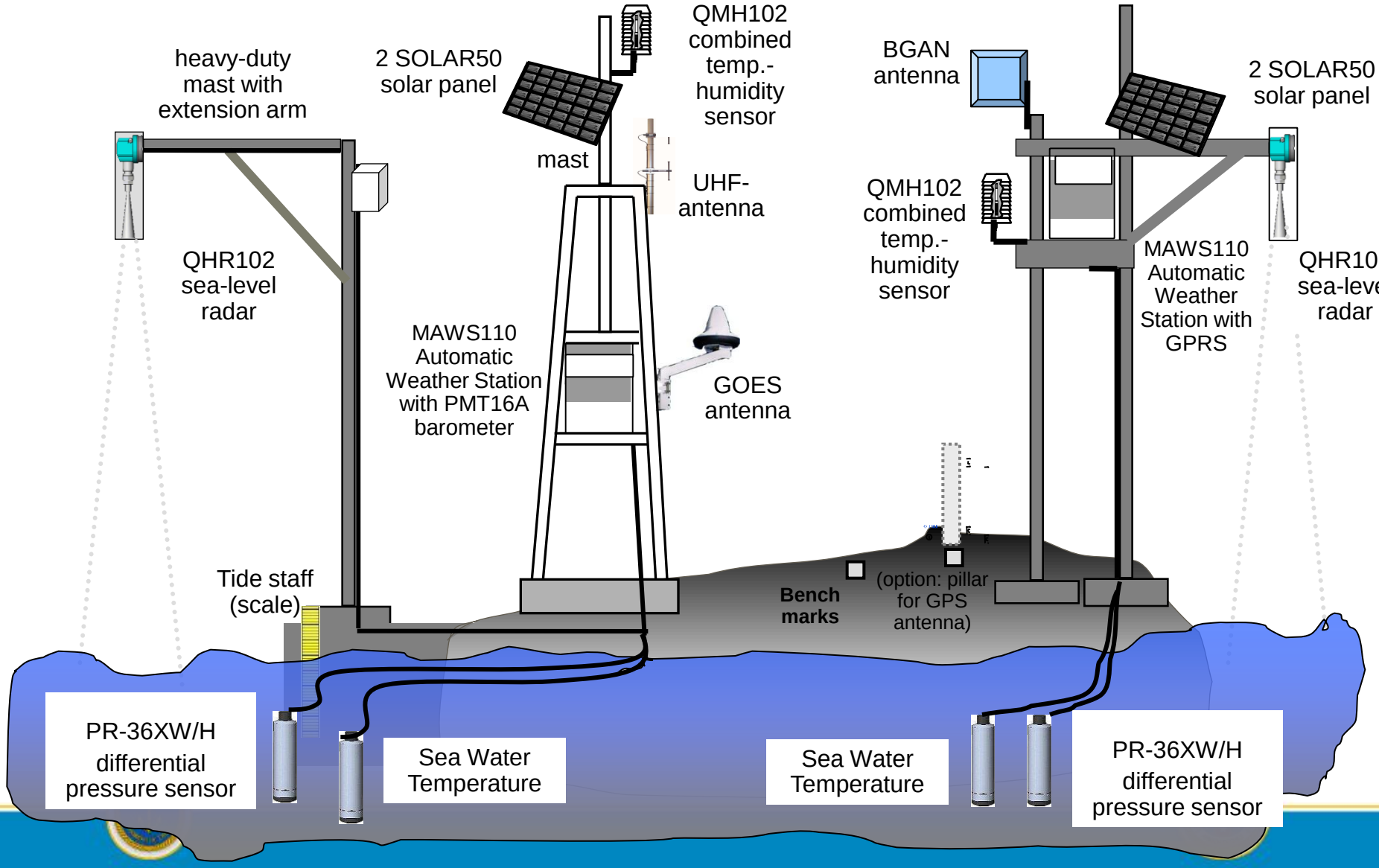
  San Pedro
  Rada Covadonga



Sea Level Station Components

Tide Station for Tsunami Monitoring

Two Configurations of Installation



Radar Water Level Sensor QHR104

Sea Level Station Components

Mounting Configuration – GOES/Internet Transmission

Pyramid of aluminum

Masts of steel

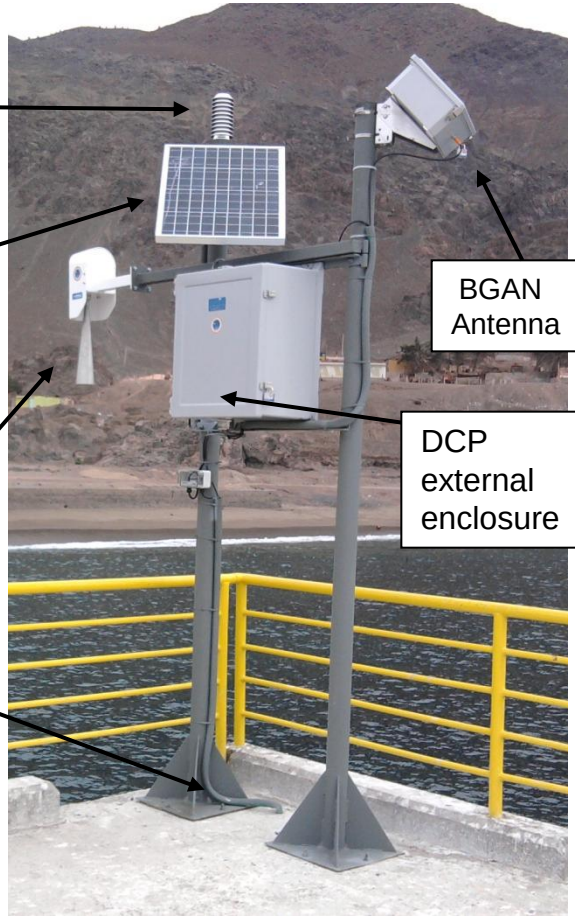
Sea Level Station Components
BGAN/GPRS Transmission

Air Temp. and relative humidity Sensor

Solar 50 Panel

QHR102 sea-level radar

Submerged sensors cables



BGAN Antenna

DCP external enclosure

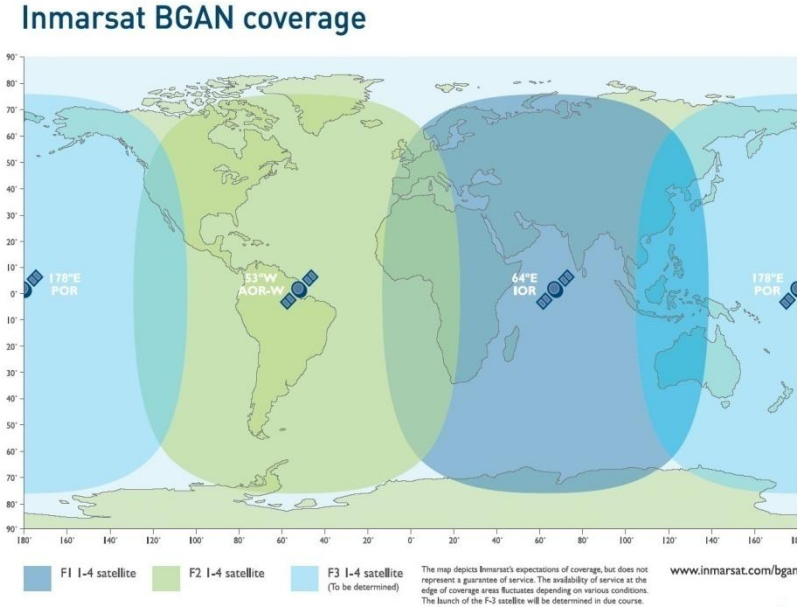
BGAN Antenna

Thrane&Thrane 300

GPRS Modem

Centurion 300

Satellite Systems: BGAN Terminal



	Thrane & Thrane Explorer 300	Hughes 9502
Power Consumption Transmit Mode	14 W	Less than 20 W
Weight	1.4 Kg	1.5 Kg
Outdoor Enabled	No	Yes (antena)
Minimum CDR	10 Kb	1 Kb
Cost per conexion	100 Kb	None
Watchdog reset	No	Yes
Yearly Transmission Cost per station	873 USD	2,185 USD

Gauge Contact Point (CP)

- The CP is a type of ´Benchmark´, which must be connected to the TGBM.
- Is a vertical reference mark, associated with the gauge itself.

  - Radar gauges
  - Pressure gauges

Contact Point

Experiences from Chile Telemetry systems

Primary Transmission Telemetry

Satellites Systems

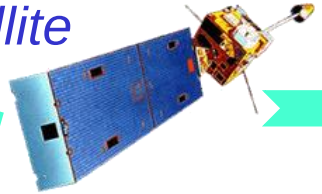
Main Server

Server 2

Server 3

GOES Satellite Telemetry

GOES E Satellite



DRGS

ADC0D056121391807 51G43+0NN217EXE00104
2263 2251 2143 2339 2101
4100 4183 4024 4229 4
21.2
068
17.9
1012.8
14.3
428
382

Main Server

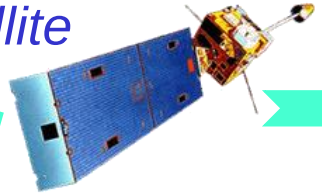
Server 2
Server 3

Formatting Script

(S:ARI_GOES;D:180512;T:180751;WL-K:2101;WL-V:4019;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3;ROC_K:128;ROC_V:130)
(S:ARI_GOES;D:180512;T:180651;WL-K:2339;WL-V:4229;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3; ROC_K:019;ROC_V:018)
(S:ARI_GOES;D:180512;T:180551;WL-K:2143;WL-V:4024;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3; ROC_K:005;ROC_V:002)
(S:ARI_GOES;D:180512;T:180451;WL-K:2251;WL-V:4183;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3; ROC_K:054;ROC_V:073)
(S:ARI_GOES;D:180512;T:180351;WL-K:2263;WL-V:4100;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3; ROC_K:092;ROC_V:105)

Alternatives Paths: GOES Data Reception

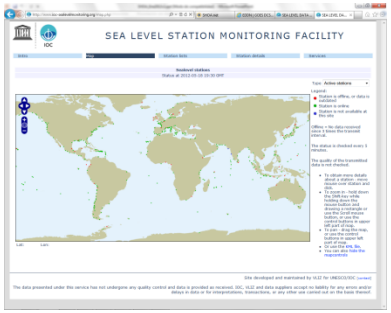
GOES E Satellite



DRGS
NOAA

GTS

Tide Tools



IOC Website

Formatting Script

Main Server

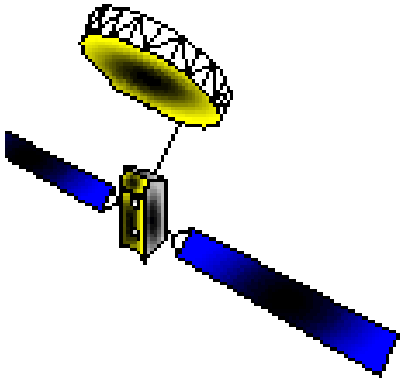
Server 2

Server 3

ORACLE Server

METMAN System

BGAN Satellite Telemetry



Main Server

ORACLE Server

(S:TAL_BGAN;D:180511;T:171520;WL-K:2101;WL-V:4010;ROC_K:021;ROC_V:068)
(S:TAL_BGAN;D:180512;T:171620;WL-K:2156;WL-V:4173;ROC_K:045;ROC_V:050)

Secondary Transmission Telemetry

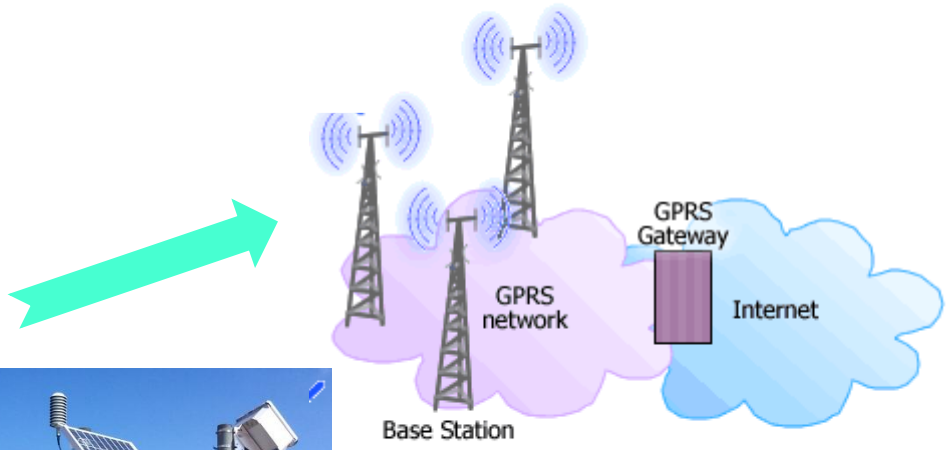
Land Based Systems

Main Server

Server 2

Server 3

Telemetría GPRS



Main Server

(S:TAL_GPRS;D:180512;T:120351;WL-K:2101;WL-V:4019;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3; ROC_K:128;ROC_V:130)
(S:TAL_GPRS;D:180512;T:120451;WL-K:2339;WL-V:4229;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3; ROC_K:056;ROC_V:064)
(S:TAL_GPRS;D:180512;T:120551;WL-K:2143;WL-V:4024;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3; ROC_K:126;ROC_V:135)
(S:TAL_GPRS;D:180512;T:120651;WL-K:2251;WL-V:4183;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3; ROC_K:143;ROC_V:139)
(S:TAL_GPRS;D:180512;T:120751;WL-K:2263;WL-V:4100;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3; ROC_K:112;ROC_V:132)

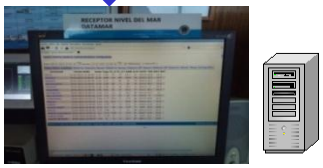
Main Server

Server 2

Server 3

Naval WAN Telemetry

WAN



DTMR Server

Main Server

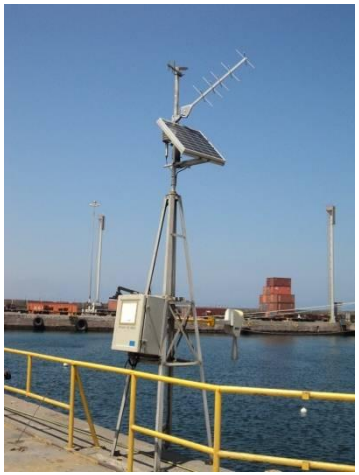
Server 2

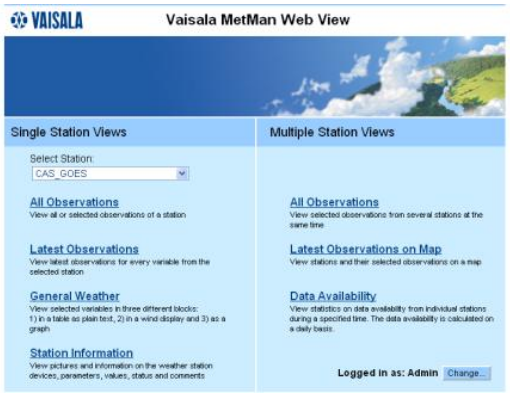
Server 3

(S:TAL_WAN;D:180512;T:180651;WL-K:2101;WL-V:4019;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3;ROC_K:028;ROC_V:010)
(S:TAL_WAN;D:180512;T:180751;WL-K:2339;WL-V:4229;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3;ROC_K:-122;ROC_V:120)

Naval WAN Telemetry

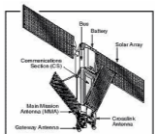
METMAN SERVER A



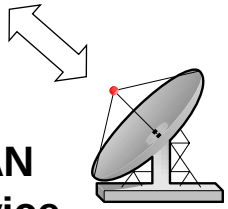


(S:TAL_GPRS;D:180512;T:180751;WL-K:2101;WL-V:4019;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3;ROC_K:028;ROC_V:010)
(S:TAL_GPRS;D:180512;T:180651;WL-K:2339;WL-V:4229;TA:21.2;RH:068;TW:17.9;BP:1012.8;BAT:14.3;ROC_K:-122;ROC_V:120)

SHOA Operational Data Collection

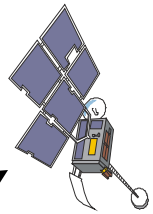


INMARSAT-BGAN

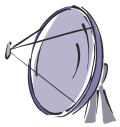


BGAN Service Provider

GOES



BGAN Terminal

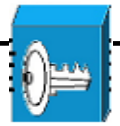


GOES Ground Station

SHOA

Stations in new Places or upgraded

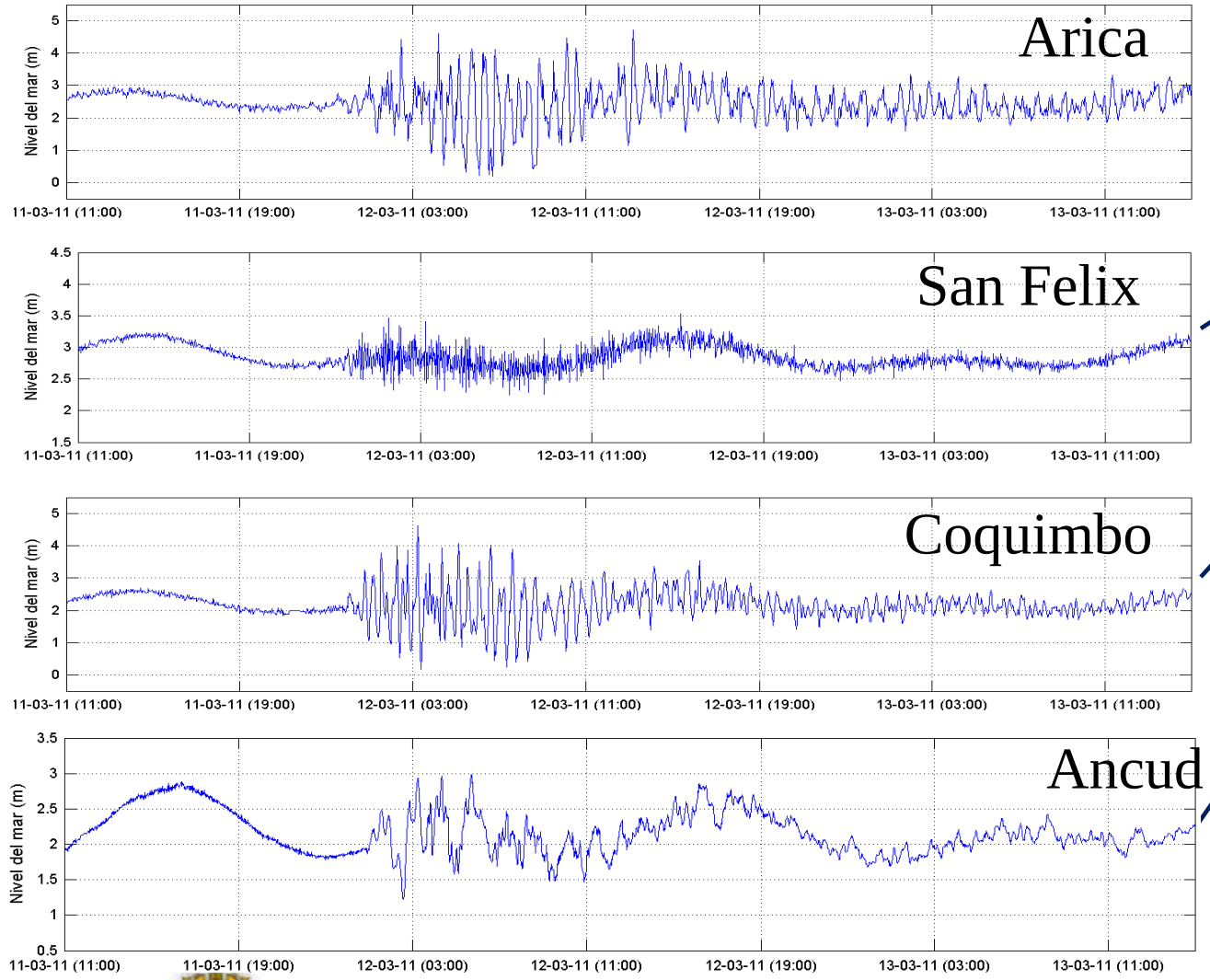
Stations Installed before Feb 27th 2010

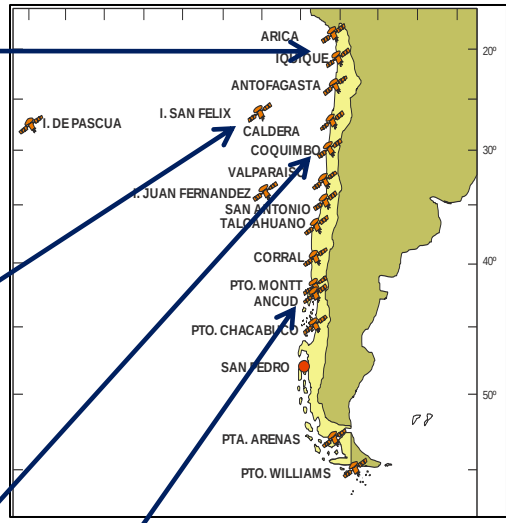


Secure Communication Using Secure navy VPN (backup)

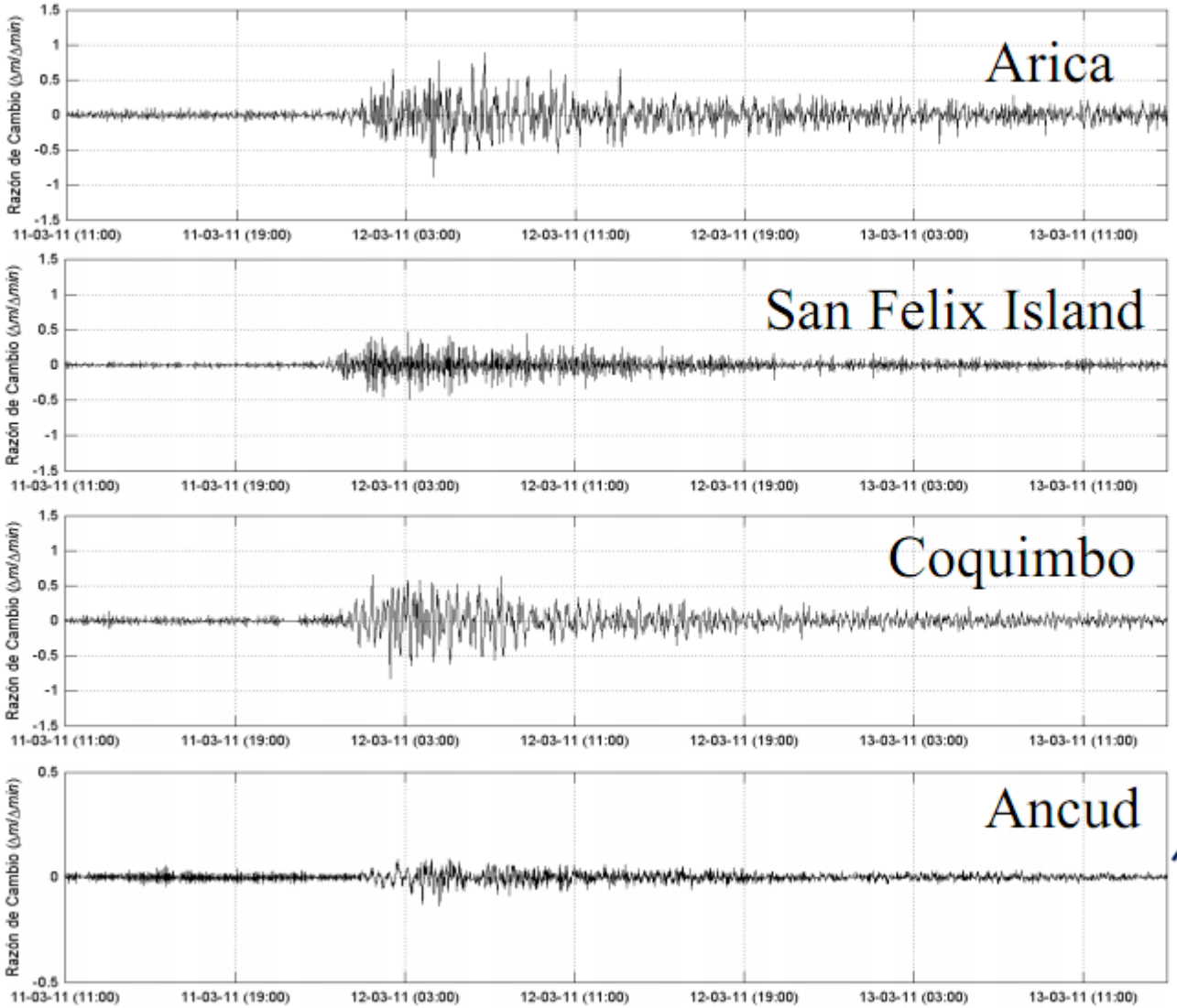
GPRS (backup)

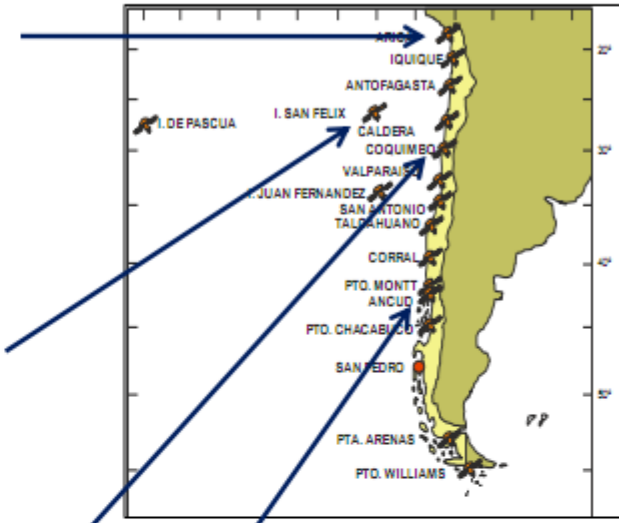
Sea Level Register 11-13 March 2011





Rate of Change 11-13 March 2011

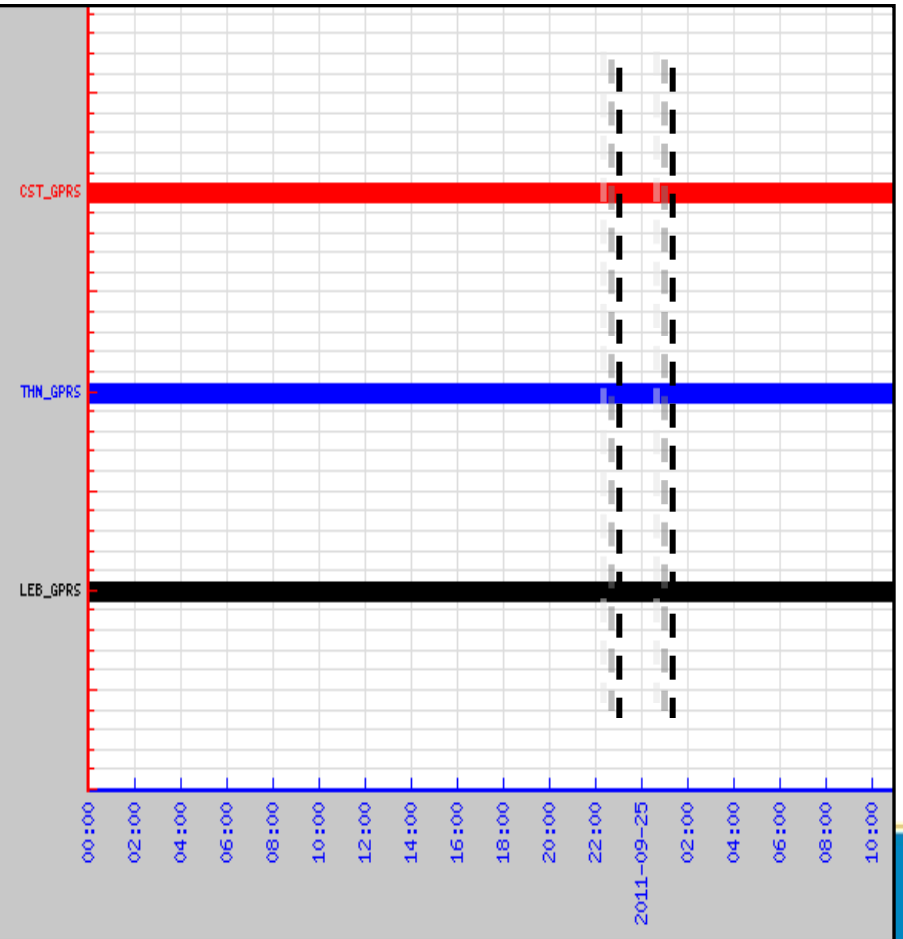




Blackout in Chile: Sept 24th 2011
20:30 to 21:45 local time (23:30 to 00:45 UTC)

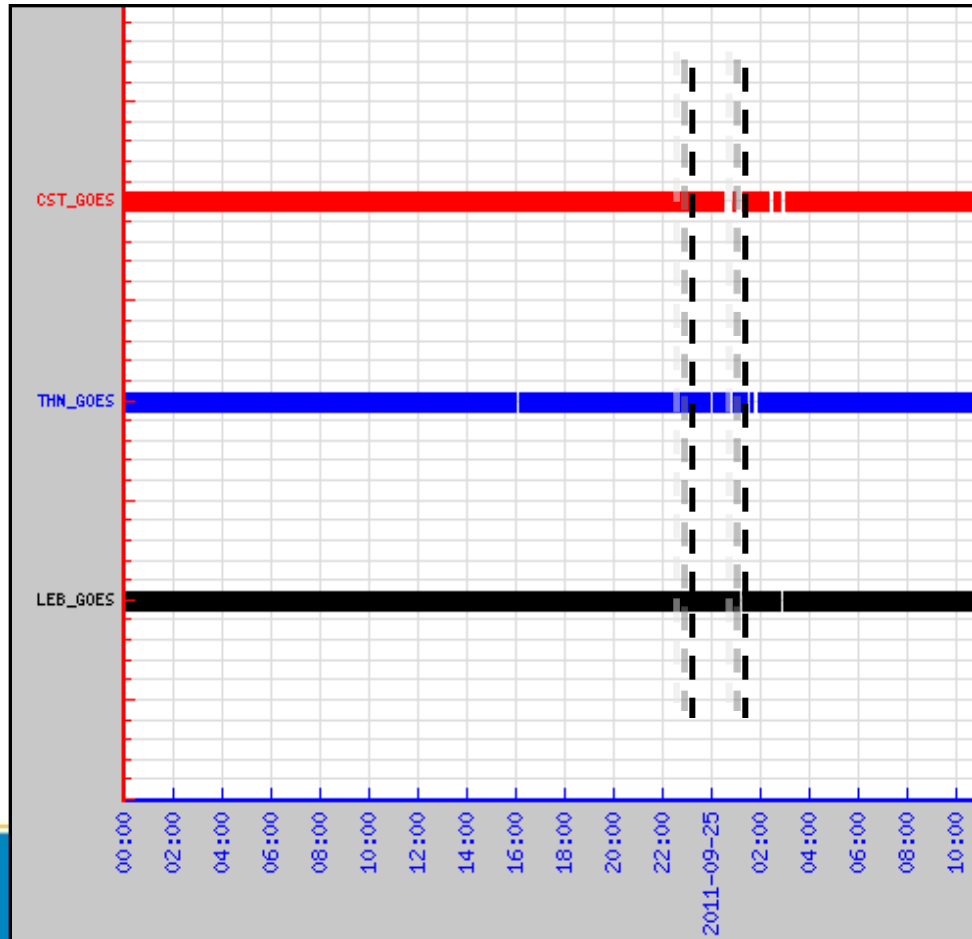
GPRS data availability

Average 100 %



GOES data availability

Average 98 %



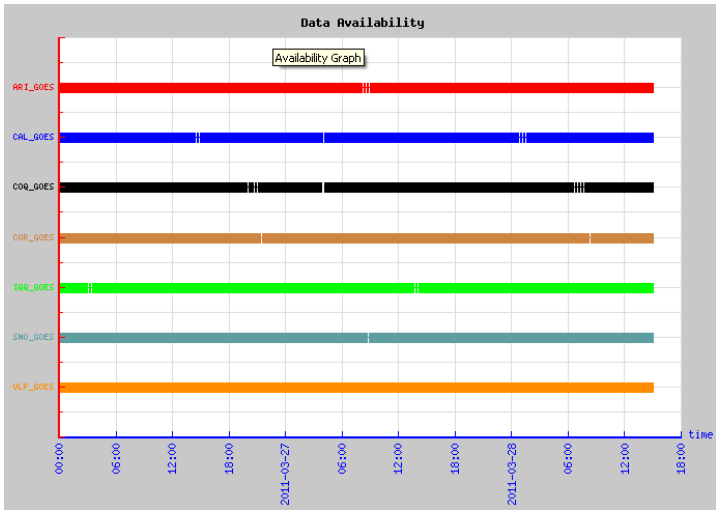
Current GOES and Internet VPN Status

VAISALA Dat

Back ? Print Draw Availability 1 Draw Availability 2

Selected time period: 2011-03-26 00:00:00 - 2011-03-28 15:07:47, Reference variable: V

Station	2011-03-26		2011-03-27		2011-03-28 !		Sum	Average
ARI_GOES	1425	99 %	1404	98 %	895	99 %	3724	98 %
CAL_GOES	1397	97 %	1426	99 %	863	95 %	3686	97 %
COQ_GOES	1394	97 %	1415	98 %	839	93 %	3648	96 %
COR_GOES	1408	98 %	1430	99 %	879	97 %	3717	98 %
IQQ_GOES	1389	96 %	1399	97 %	900	99 %	3688	98 %
SNO_GOES	1430	99 %	1414	98 %	895	99 %	3739	99 %
VLP_GOES	1424	99 %	1434	100 %	890	98 %	3748	99 %
Sum/Average	9867	98 %	9922	98 %	6161	97 %	25950	98 %

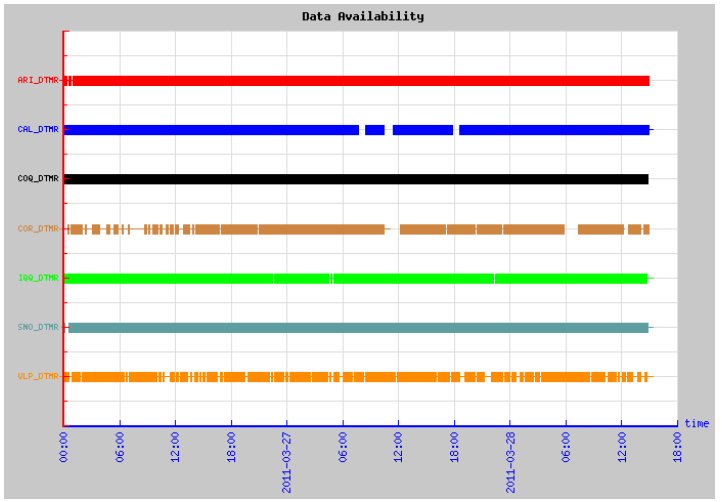


VAISALA Data

Back ? Print Draw Availability 1 Draw Availability 2

Selected time period: 2011-03-26 00:00:00 - 2011-03-28 14:59:28, Reference variable: W

Station	2011-03-26		2011-03-27		2011-03-28 !		Sum	Average
ARI_DTMR	1424	99 %	1439	100 %	888	99 %	3751	99 %
CAL_DTMR	1440	100 %	1290	90 %	887	99 %	3617	96 %
COQ_DTMR	1429	99 %	1439	100 %	889	99 %	3757	99 %
COR_DTMR	1072	74 %	1244	86 %	709	79 %	3025	80 %
IQQ_DTMR	1331	92 %	1326	92 %	833	93 %	3490	92 %
SNO_DTMR	1431	99 %	1439	100 %	888	99 %	3758	99 %
VLP_DTMR	1153	80 %	1163	81 %	714	79 %	3030	80 %
Sum/Average	9280	92 %	9340	93 %	5808	92 %	24428	92 %



BGAN with DXE-421 and current GPRS Status

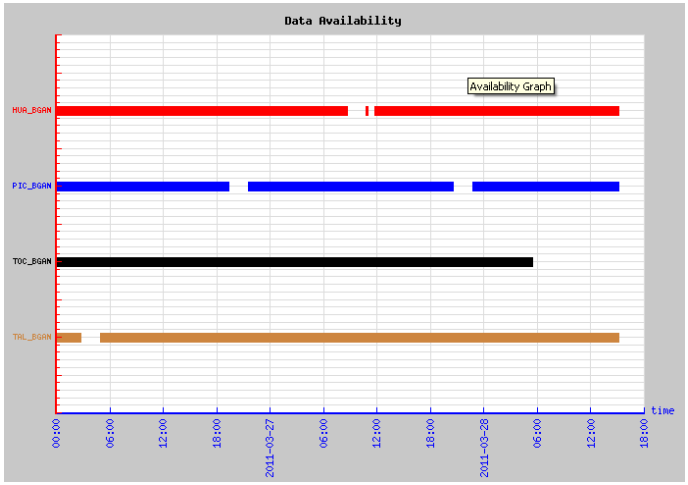
VAISALA

Data

Back | ? | Print | Draw Availability 1 | Draw Availability 2

Selected time period: 2011-03-26 00:00:00 - 2011-03-28 15:15:27, Reference variable: WL

Station	2011-03-26		2011-03-27		2011-03-28 !		Sum	Average
HUA_BGAN	1427	99 %	1274	88 %	900	98 %	3601	95 %
PIC_BGAN	1289	90 %	1294	90 %	903	99 %	3486	93 %
TOC_BGAN	1433	100 %	1428	99 %	321	35 %	3182	78 %
TAL_BGAN	1300	90 %	1428	99 %	900	98 %	3628	96 %
Sum/Average	5449	95 %	5424	94 %	3024	83 %	13897	90 %



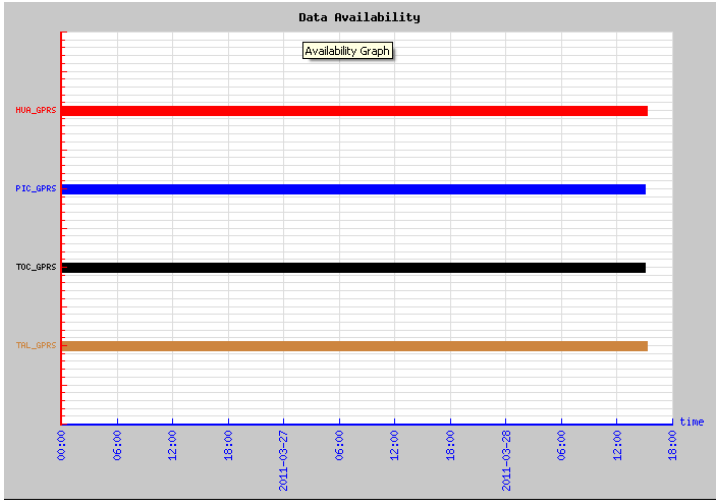
VAISALA

Data

Back | ? | Print | Draw Availability 1 | Draw Availability 2

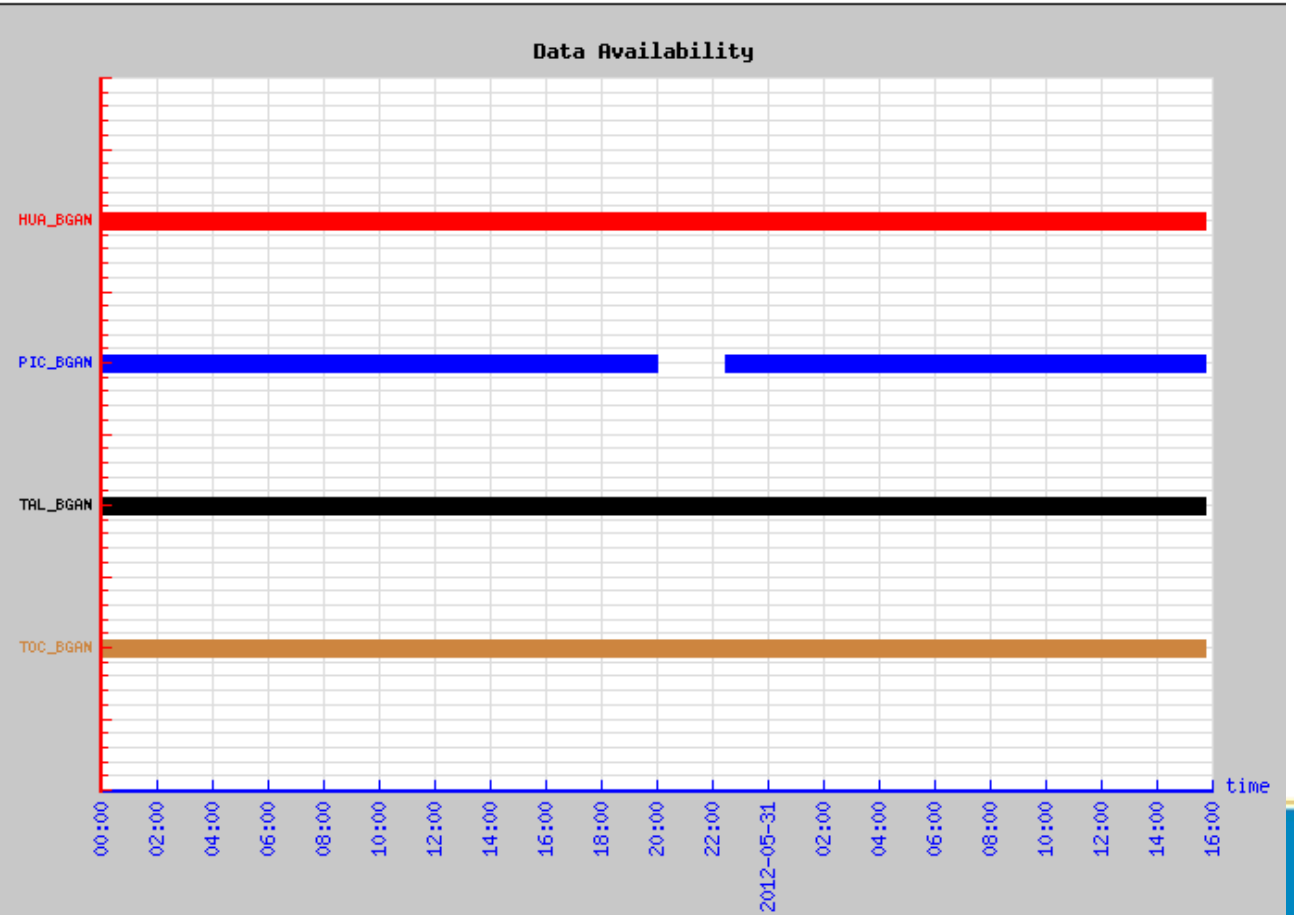
Selected time period: 2011-03-26 00:00:00 - 2011-03-28 15:18:35, Reference variable: W

Station	2011-03-26		2011-03-27		2011-03-28 !		Sum	Average
HUA_GPRS	1440	100 %	1440	100 %	906	99 %	3786	100 %
PIC_GPRS	1440	100 %	1440	100 %	906	99 %	3786	100 %
TOC_GPRS	1440	100 %	1435	100 %	906	99 %	3781	99 %
TAL_GPRS	1440	100 %	1440	100 %	916	100 %	3796	100 %
Sum/Average	5760	100 %	5755	100 %	3634	99 %	15149	100 %

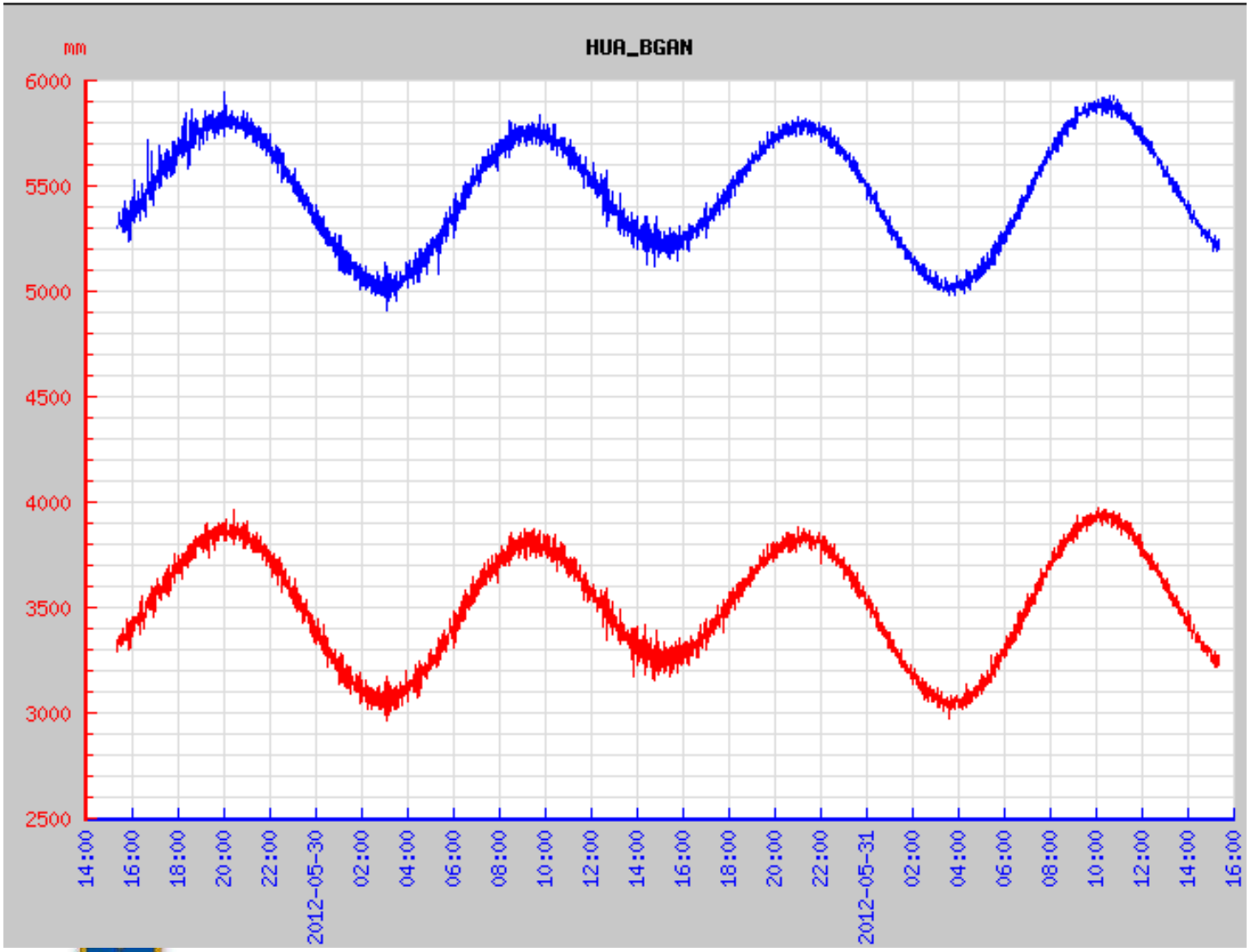


Current BGAN performance with Digi

Station	2012-05-30		2012-05-31 !		Sum	Average
HUA_BGAN	1439	100 %	934	99 %	2373	100 %
PIC_BGAN	1291	90 %	933	99 %	2224	94 %
TAL_BGAN	1439	100 %	935	99 %	2374	100 %
TOC_BGAN	1438	100 %	931	99 %	2369	99 %
Sum/Average	5607	97 %	3733	99 %	9340	98 %



Sea Level data (collected through BGAN)



Radar

Pressure

Conclusions

- Alternative systems for real time data transmission using several telemetry options (GOES, BGAN, GPRS and a Wide Area Network) has given powerful support to the National Tsunami Alarm System operation.

- Higher frecuency GOES transmision slots strengthens the capacity to monitor tsunamis in real time.

- VEGA radar sensor has demostrate high reliability in several sea conditions as a redundant sea level sensor (potencially primary sensor).

- Densification has improved the sea level data collecting network for operational and scientific purposes.

THANKS