Reprocessing of IBERRED network at IGE LAC

J.A. Sanchez Sobrino
E. Azcue
V. Puente
U. Quintana
M. Valdés

INSTITUTO GEOGRAFICO NACIONAL

Motivation (I)

Networks in the Iberian area:

- ERGNSS: national network managed by IGN-E:
  - 105 stations (some of them shared with regional networks).
  - 29 EPN / 4 IGS.
  - Geodetic instrumentation & monumentation.
  - From 1998.
- 14 Regional networks(included in the EPN densification):
  - 220 stations (some of them common with IGN).
  - Main purpose: RTK, most of them installed from 2006.
- Private companies.
- Other public institutions: Port Authorities…
- Portuguese stations (IGP), north Pyrennees (IGN-F).

Public networks in Spain

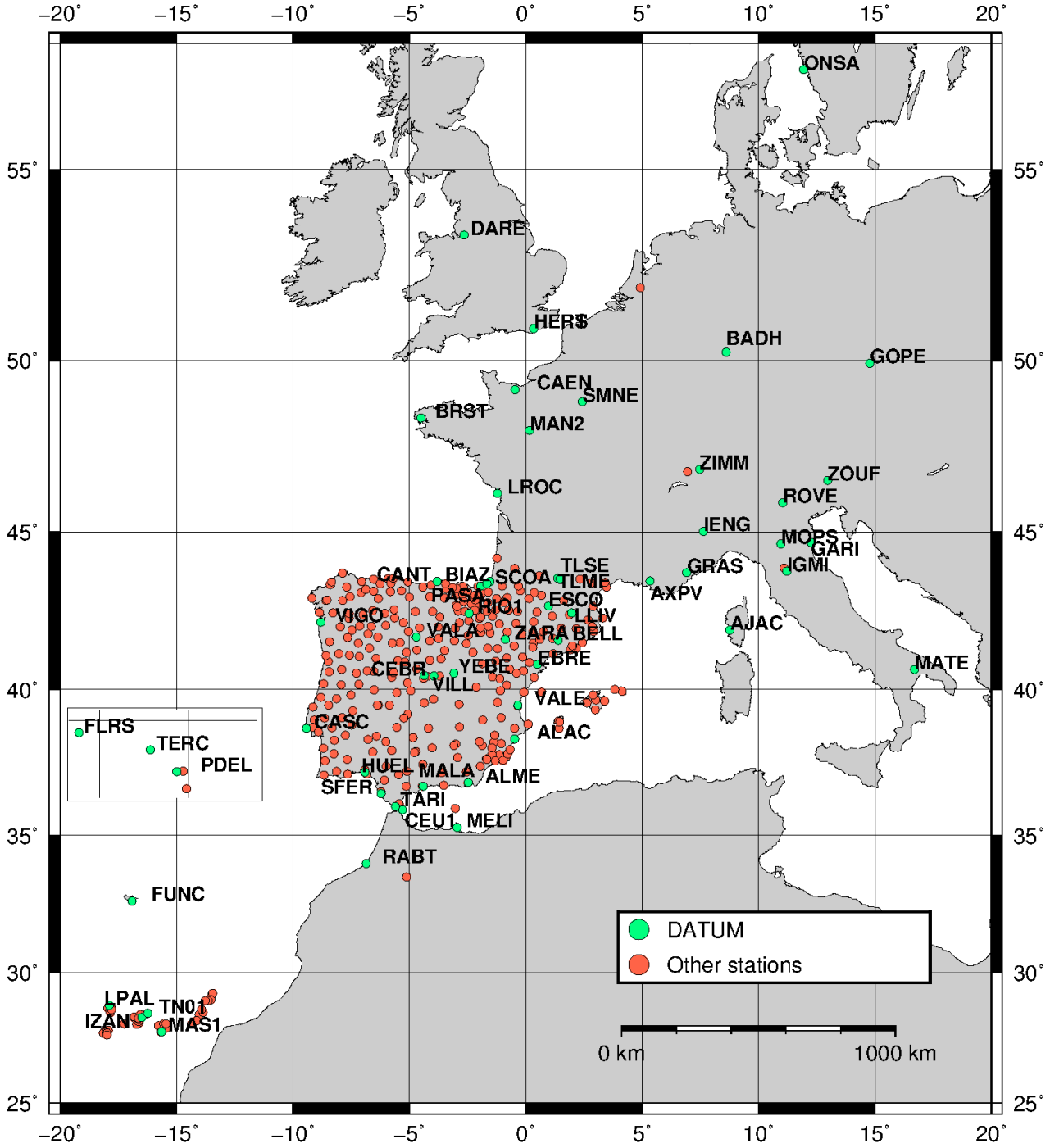
Motivation (II)

- All the existing networks had been processed regularly (weekly): "IBERRED" project.
  - Coordinates were used for E-GVAP Project, RTK services, monitoring.
  - Time series and velocities were estimated.
  - SNX files submitted to "EUREF Dense Velocities" Project.
- IBERRED not homogeneously processed:
  - Different Bernese versions used: 5.0 – 5.2
  - Different strategies and models along these years: GPS vs GPS+GLO, GMF vs VMF, orbits, ITRFyy, datum,…
  - Not all data were available at the continuous processing time (2 weeks delay).

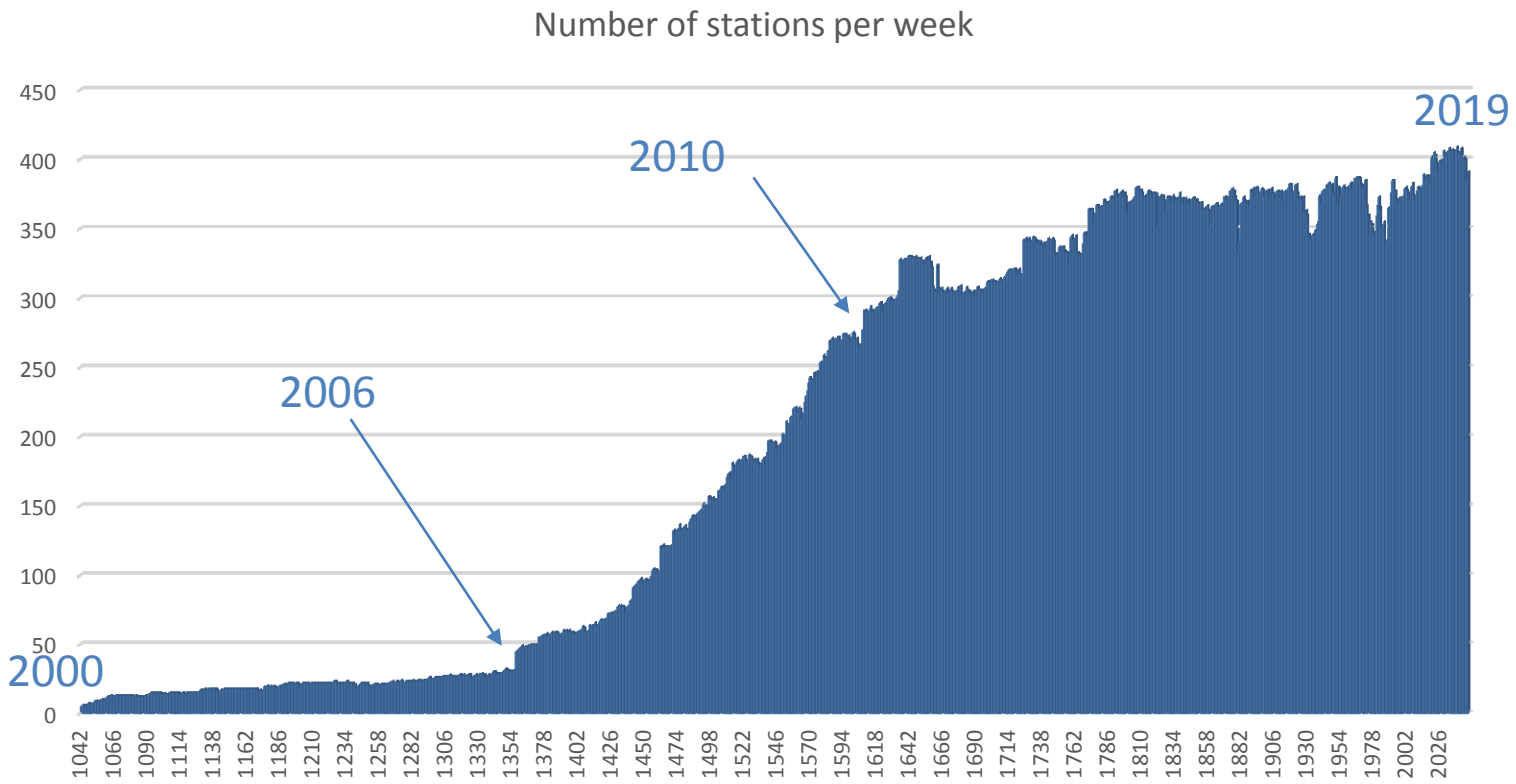
IBERRED reprocessing: overview (I)

- Objective: obtain homogeneous and complete products, mainly time series for monitoring and velocity estimation.
- A complete reproccessing has been carried out:
  - Time span: from 2000 until 2019.
  - Using all available data (public & no public) existing in Iberia & archipelagos: 480 stations.
  - BSW 5.2 and same strategy and models as EPN LAC.
  - ITRF14 & IGb08 reprocessed orbits & ITRF14 & IGb08 atx.
  - Datum: EPN A cumulative solution ≈ 50 stations have been used for the datum alignment.
- Products:
  - Daily SNX, CRD files and weekly CRDs, SUM (ITRF, ETRF00).
  - Time series: detection of strange behaviours and discontinuities (475 time series obtained)
  - ETRF00 velocities (380 reliable station velocities estimated, > 2,5 years of data).
  - ZTDs (still not analysed).

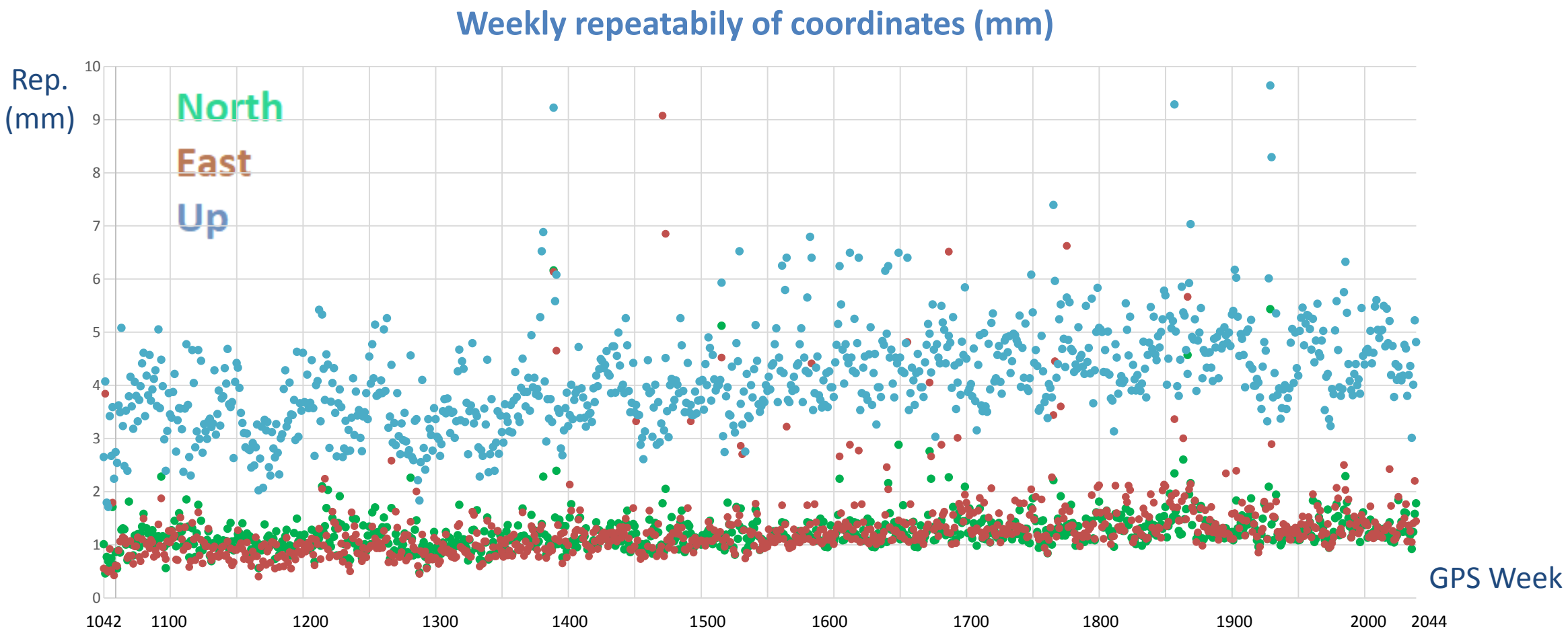
IBERRED network



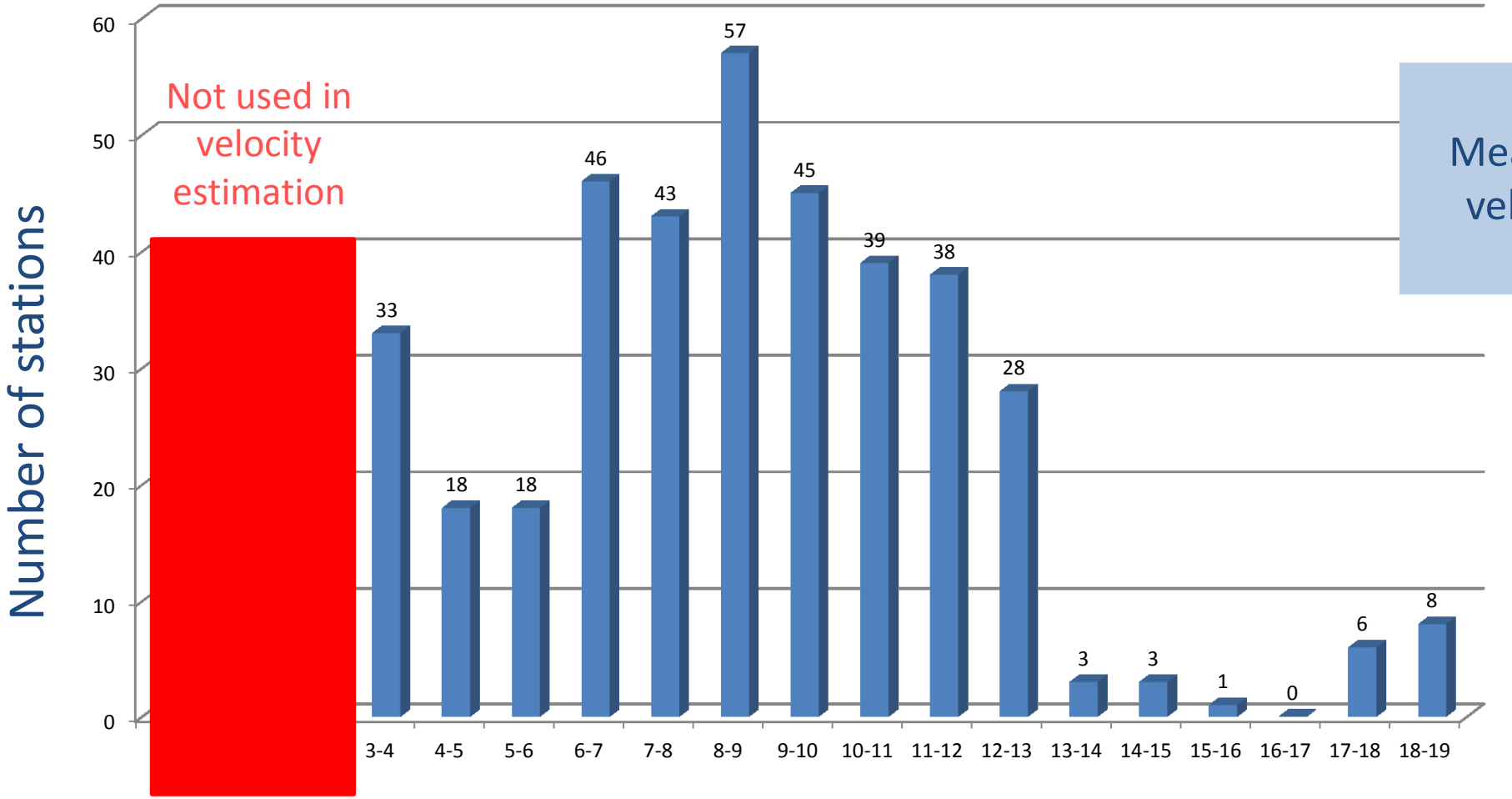
IBERRED reprocessing overview (III): nr. of stations



Processing overview (IV): repeatability



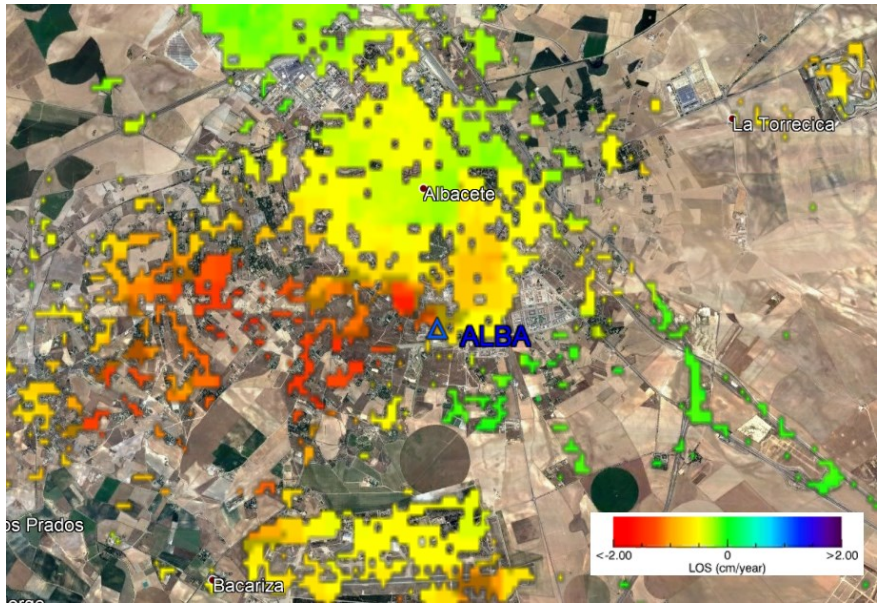
Processing overview (V): data time span of stations

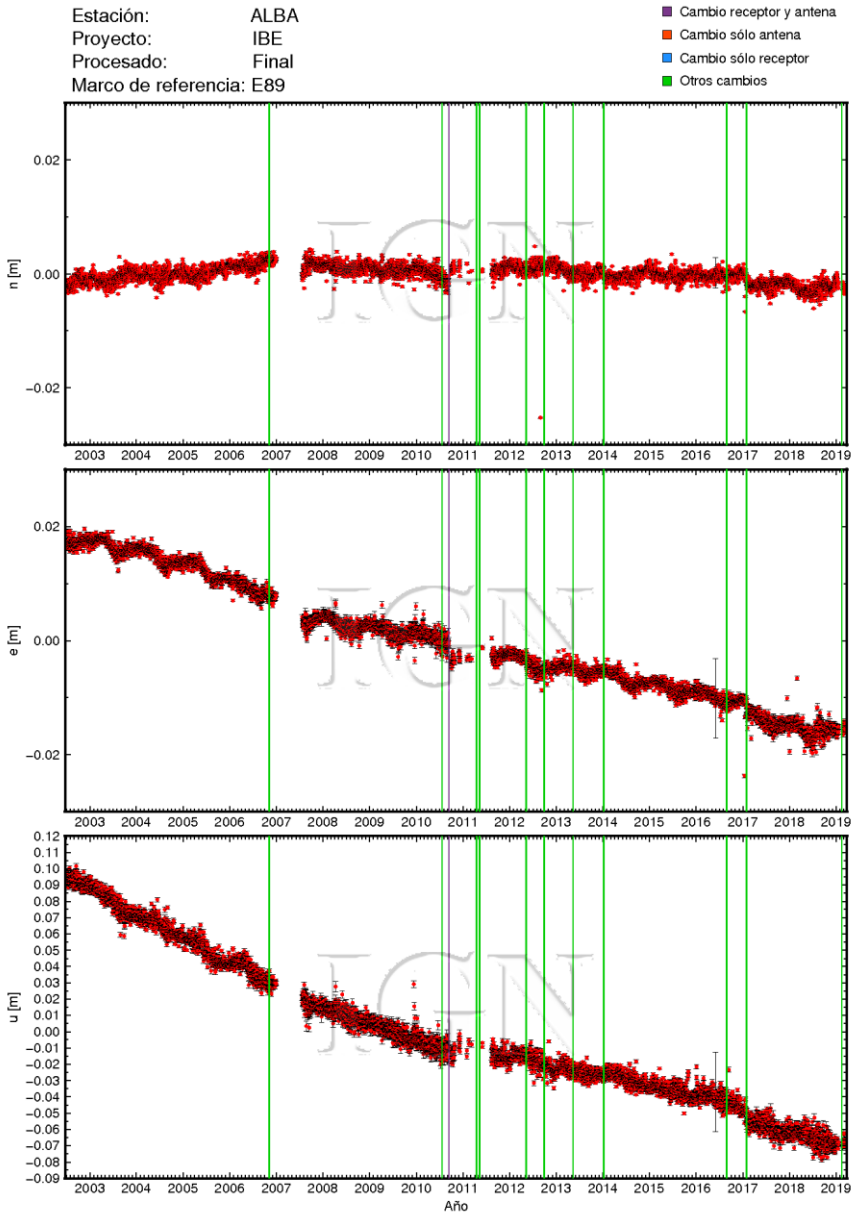


Mean time span for velocities: **9 years**

Results: time series examples (I)

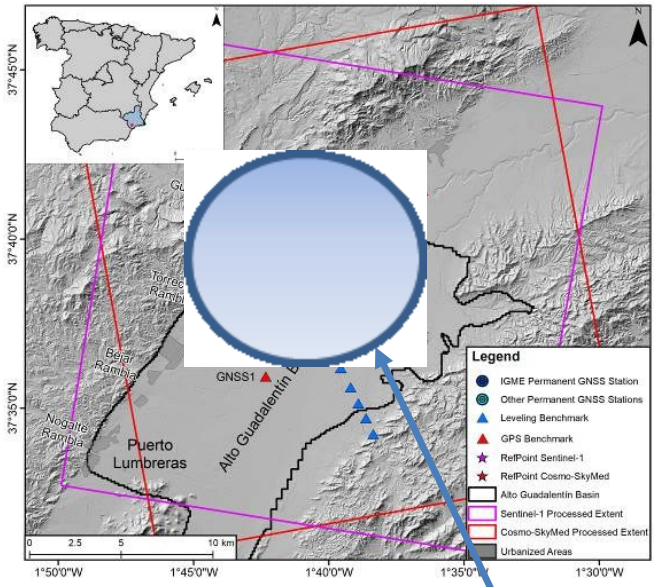
- ALBA (EPN) subsidence:
  - Estimated: -12.9mm/yr 2002-2011, -7.9 mm/yr 2011-2019
  - EPN estimation: -6.9 mm/yr.
  - InSAR analysis evidences this subsidence in a extense area

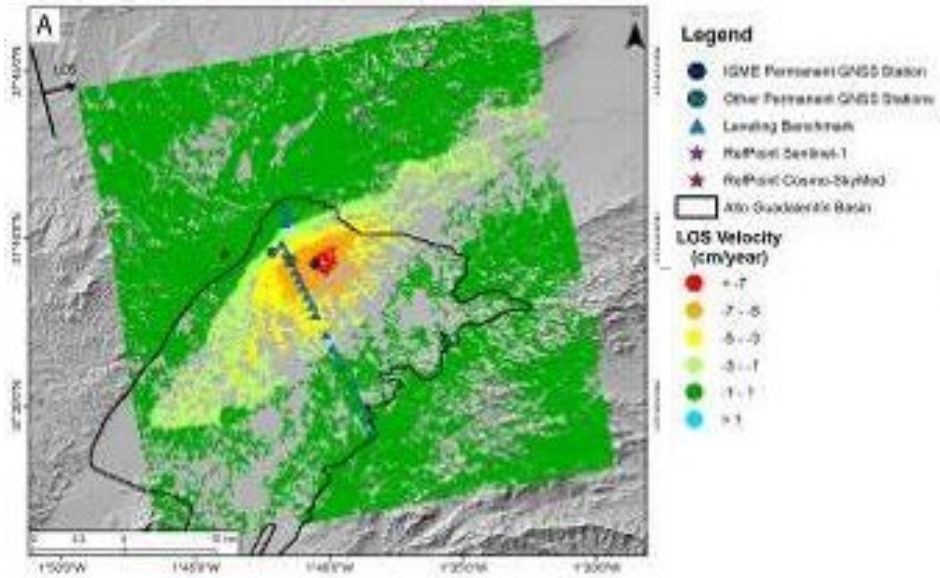




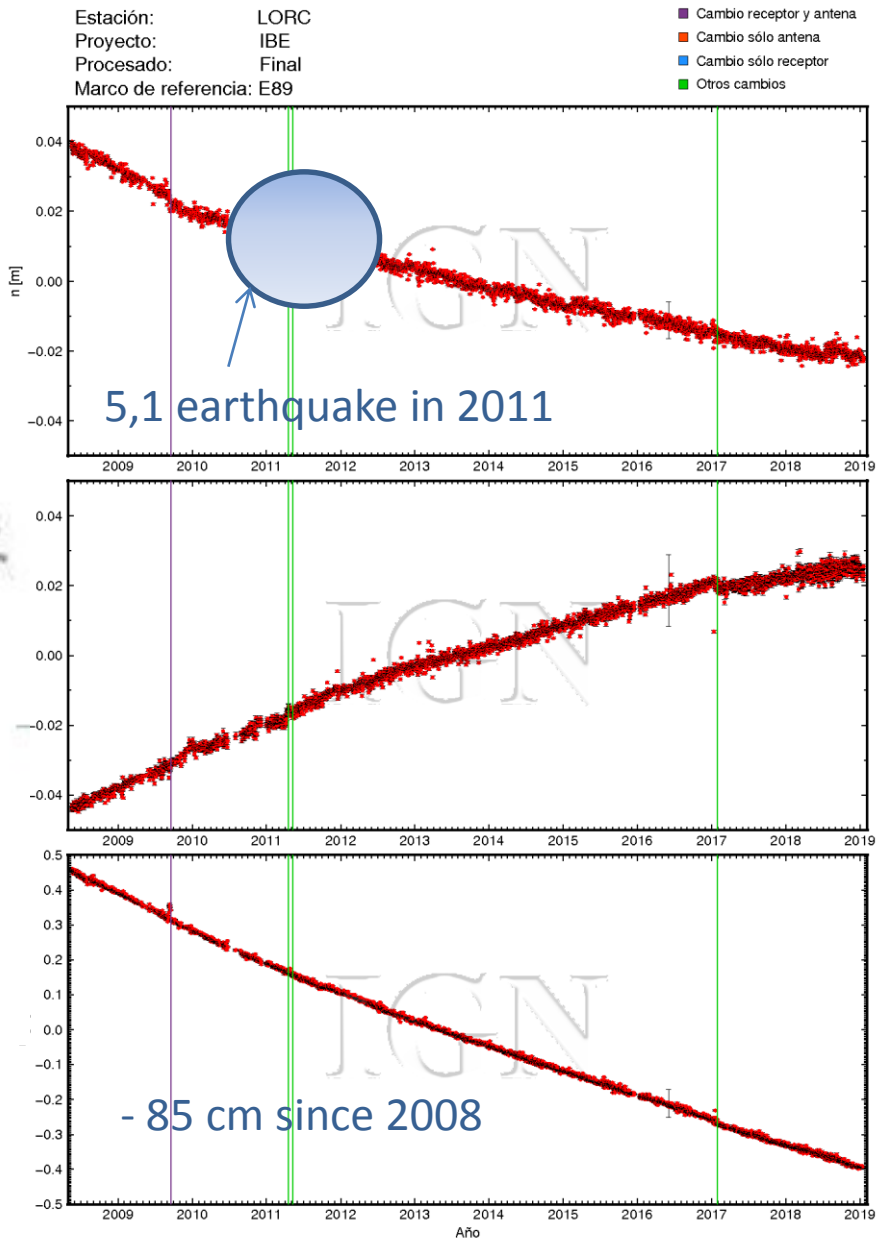
Results: time series examples (II)

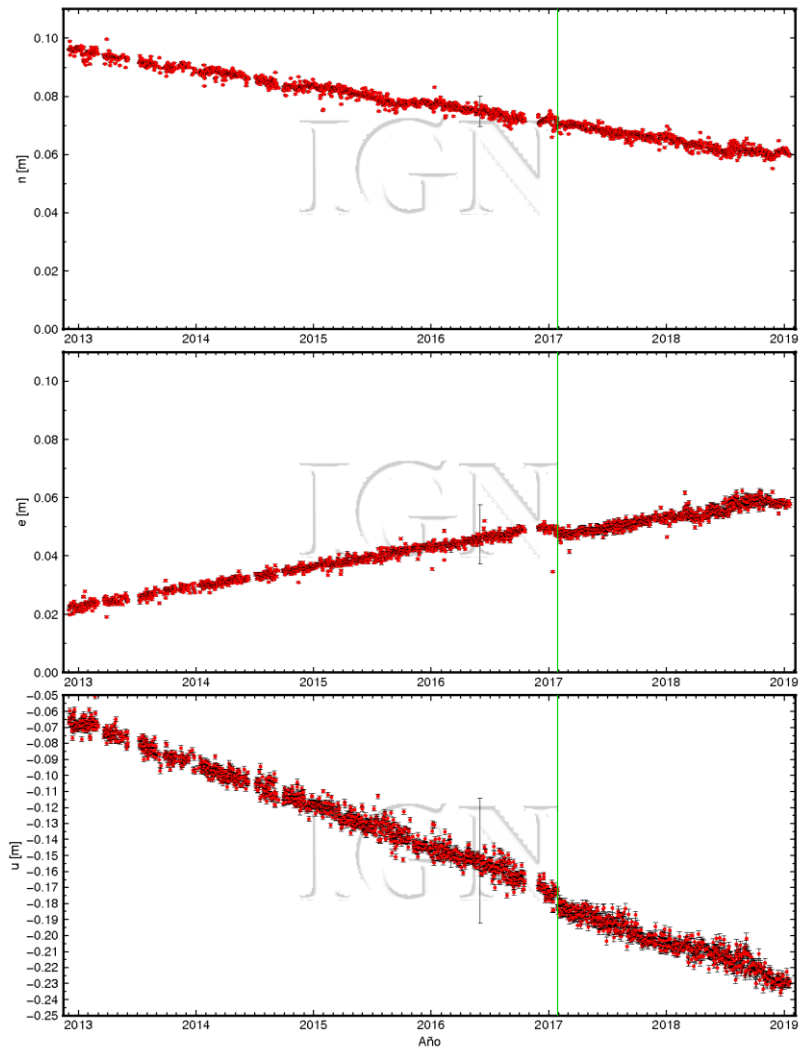
- Lorca area subsidence:
  - LORC: -72,7 mm/yr, lineal.
  - Area studied through InSAR, precise levelling, other GNSS





3 stations in the area





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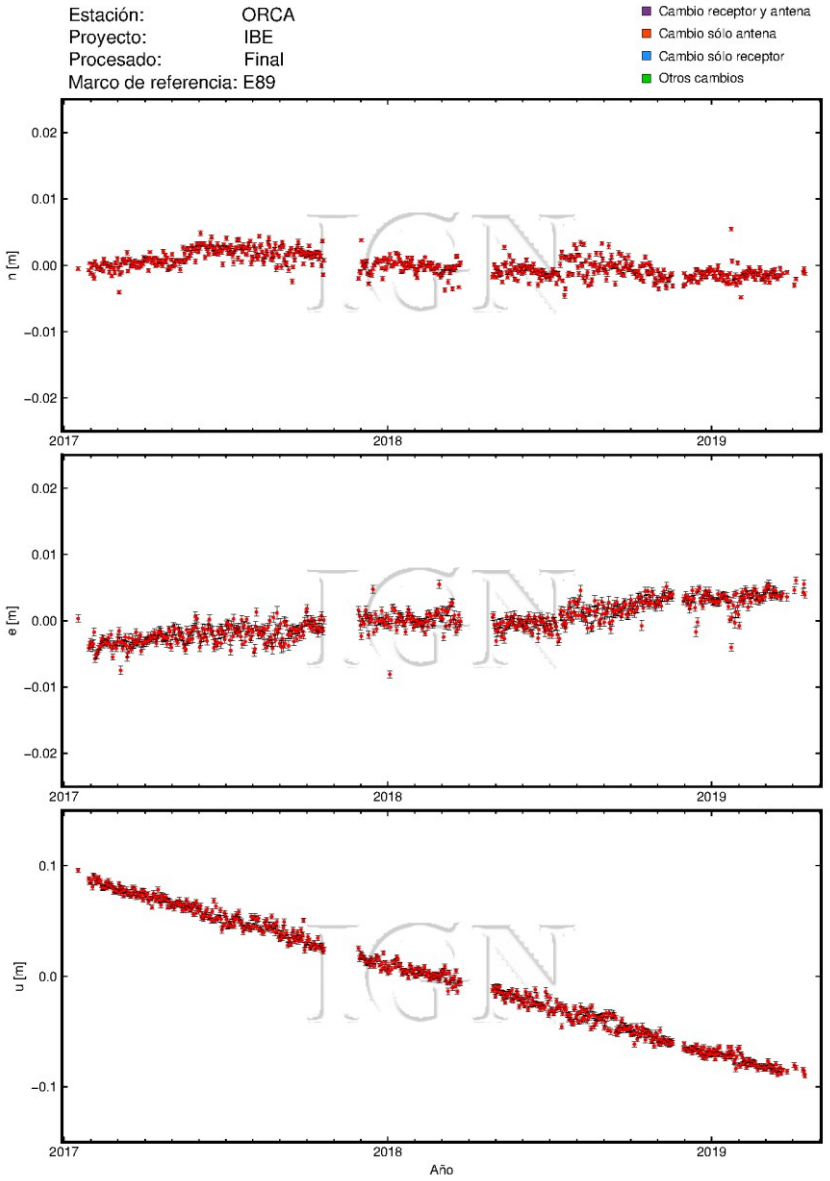
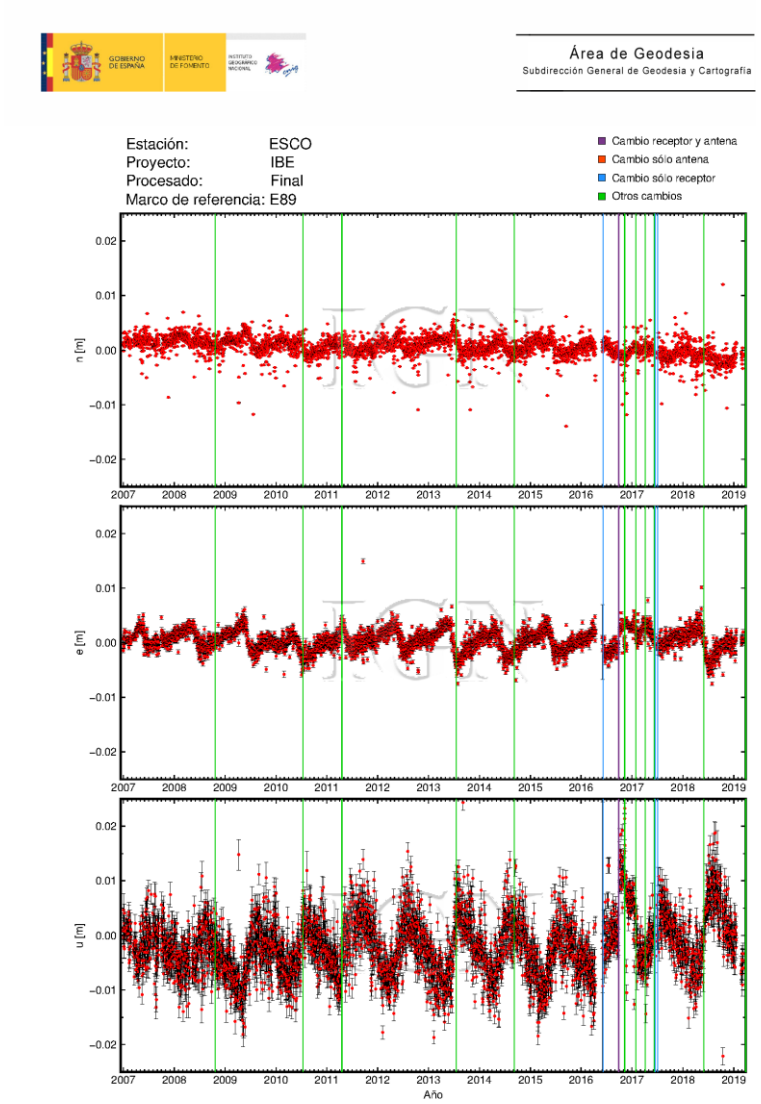


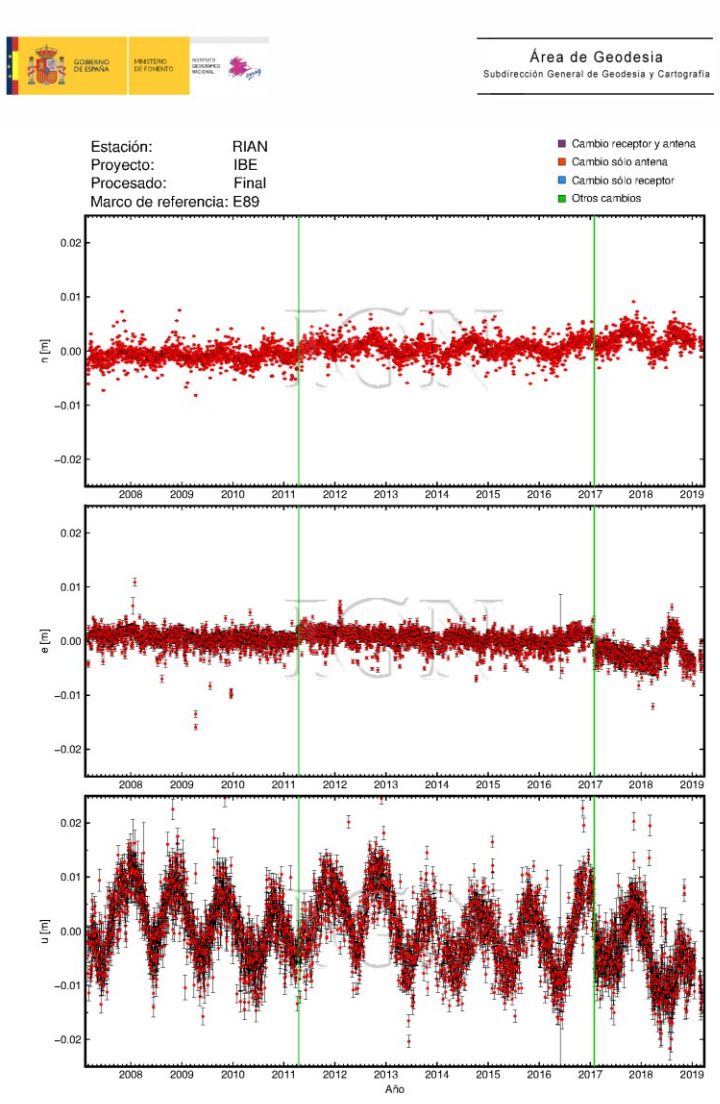
- Two additional stations in the area: LRCA (-25,5 mm/yr) and ORCA (85,8 mm/yr*)

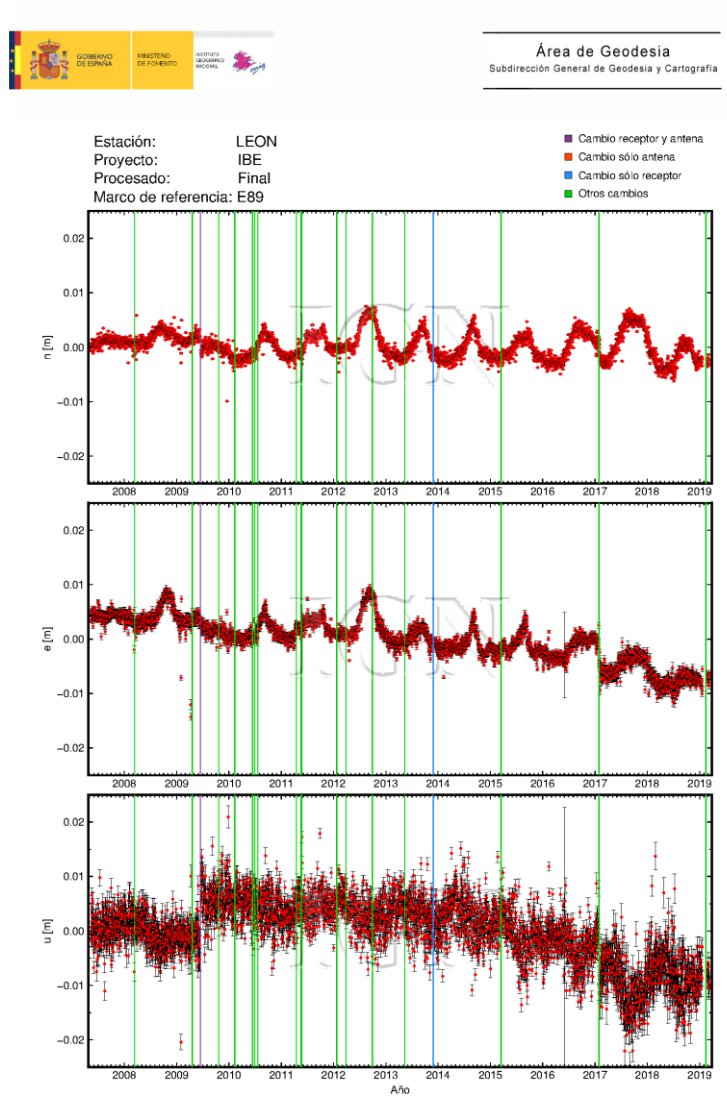
* Provisional velocity

Results: time series examples (III)

- Seasonal variations (mainly Up)

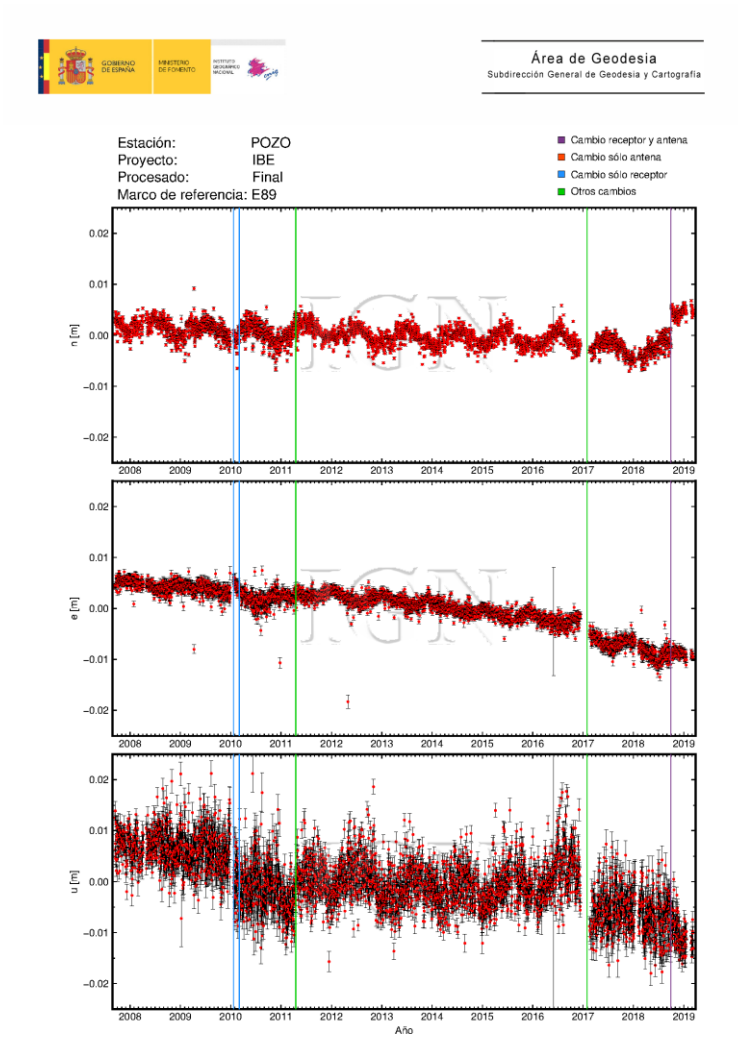


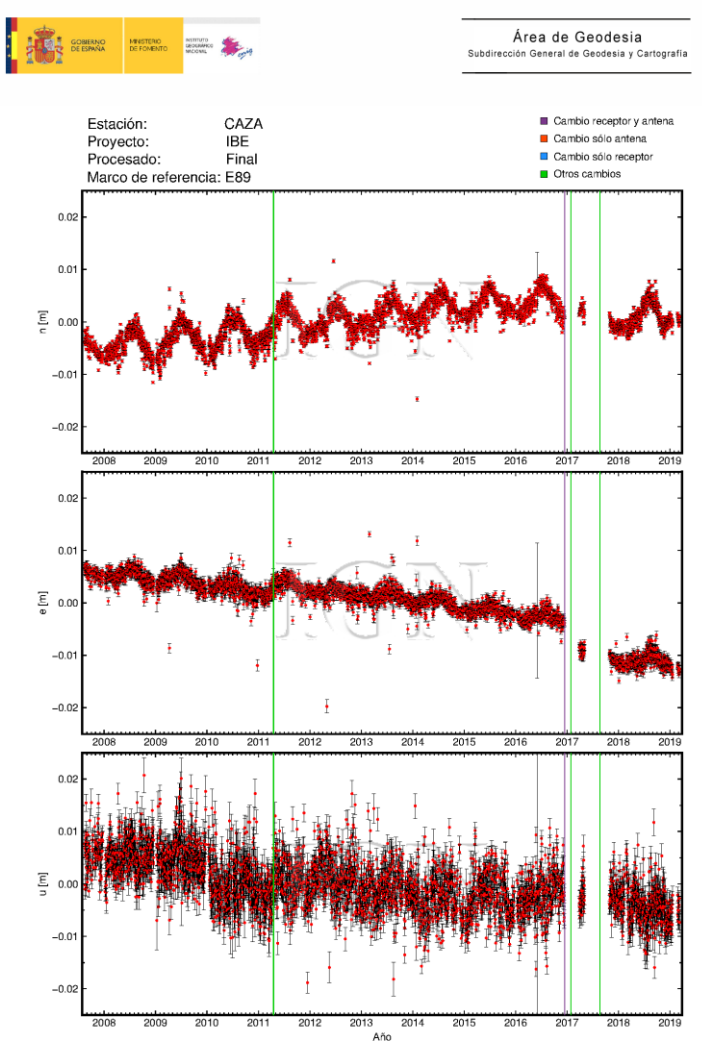


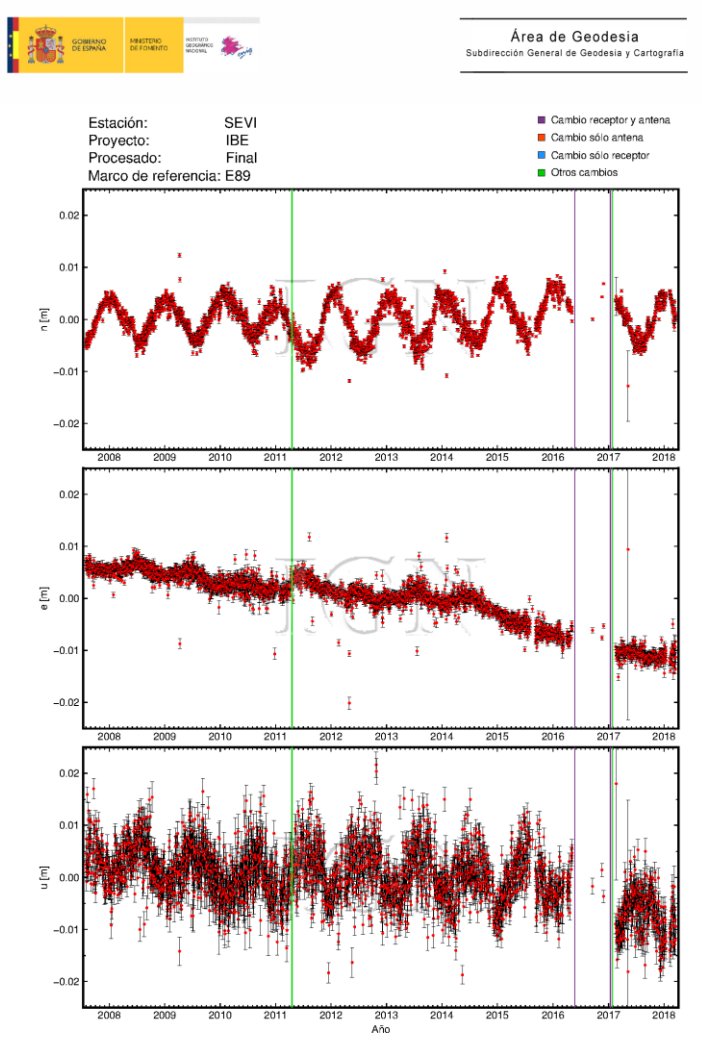


Results: time series examples (IV)

- Seasonal variations in N-S component, quite frequent in stations in southern region (Andalucia)

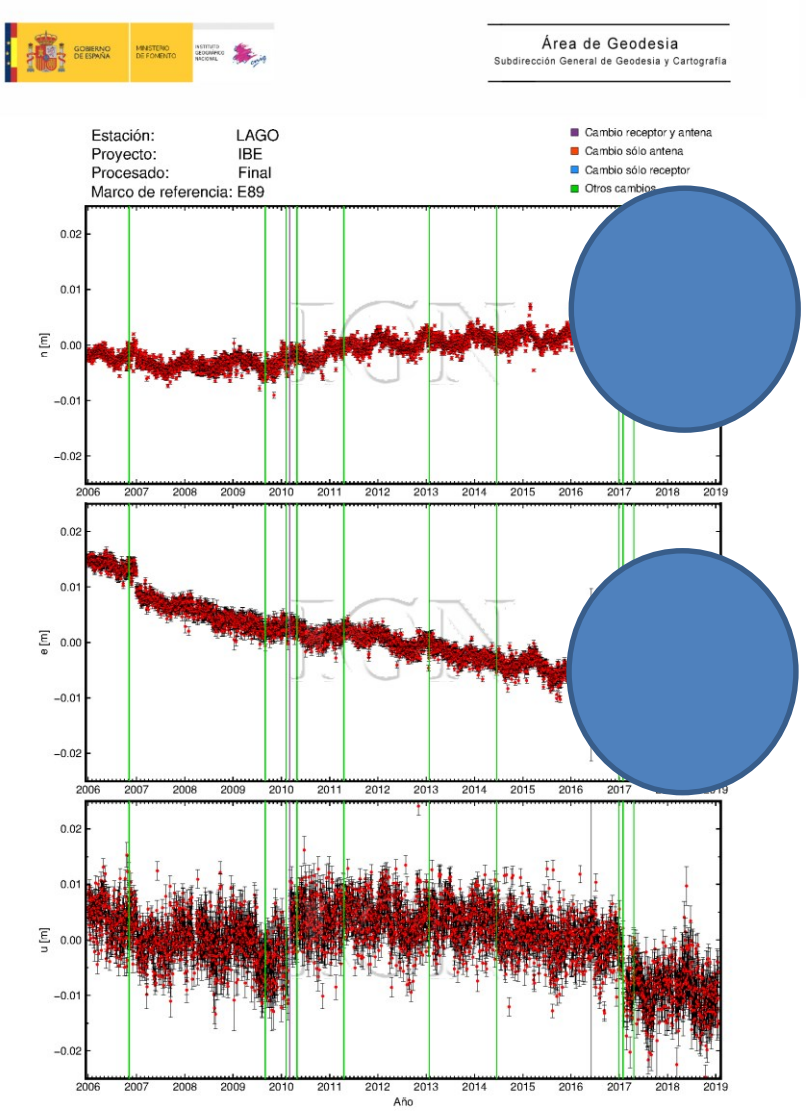


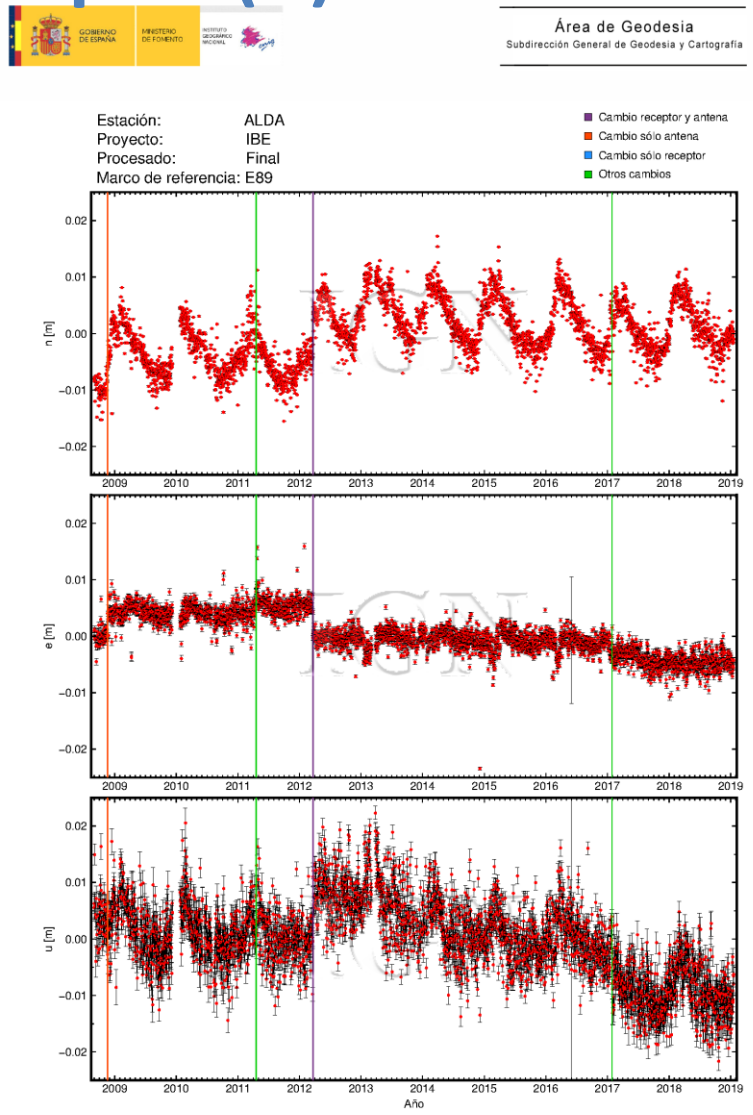


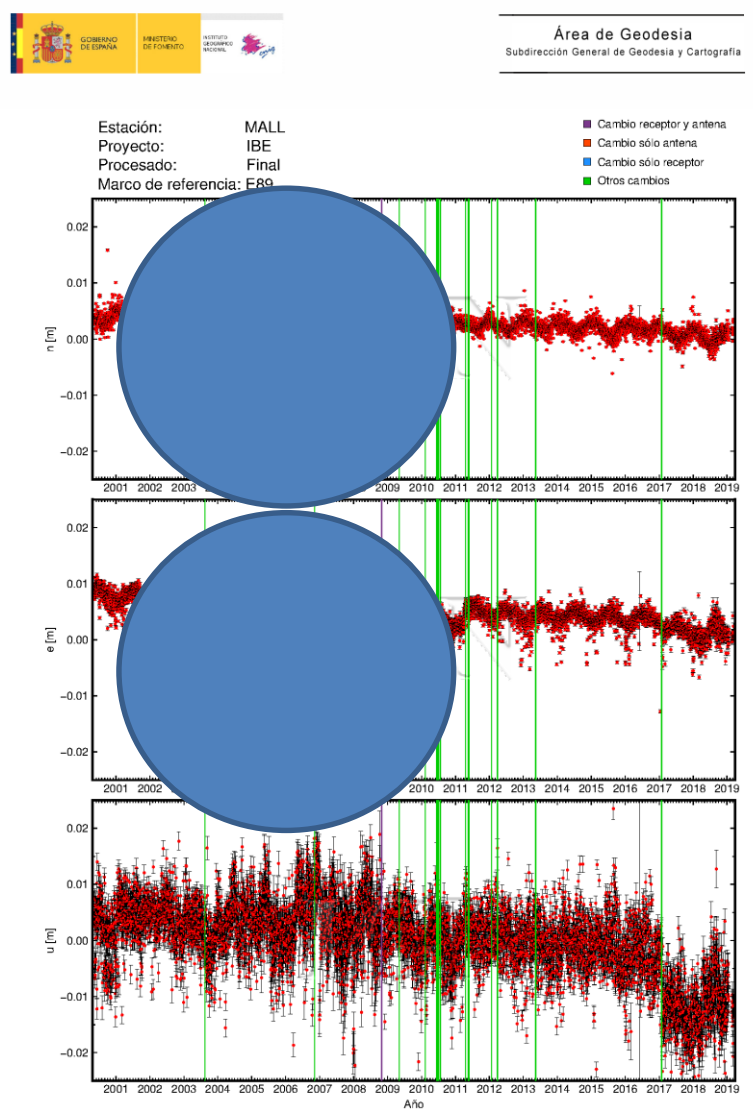


Results: time series examples (V)

- Other strange behaviours & discont.

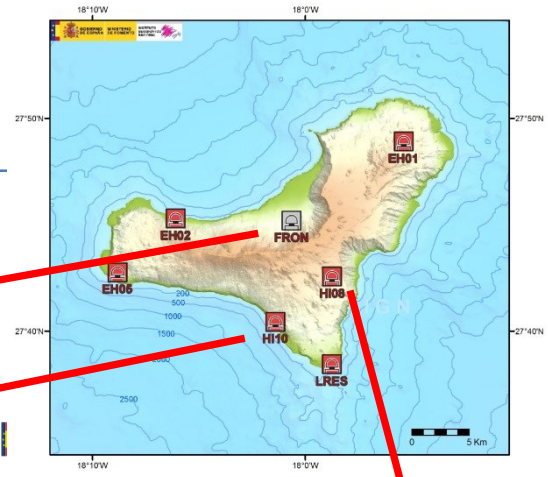


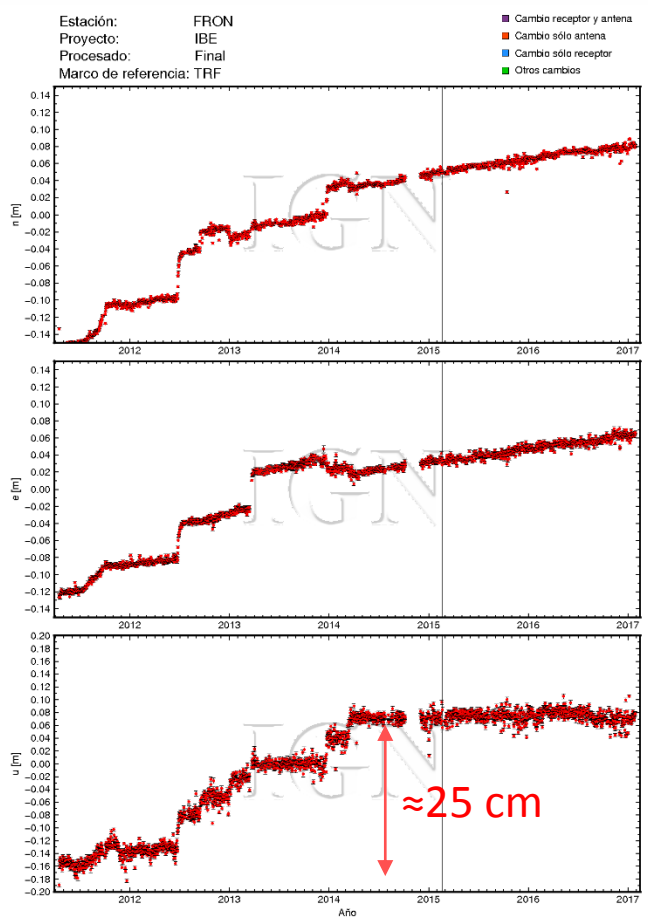


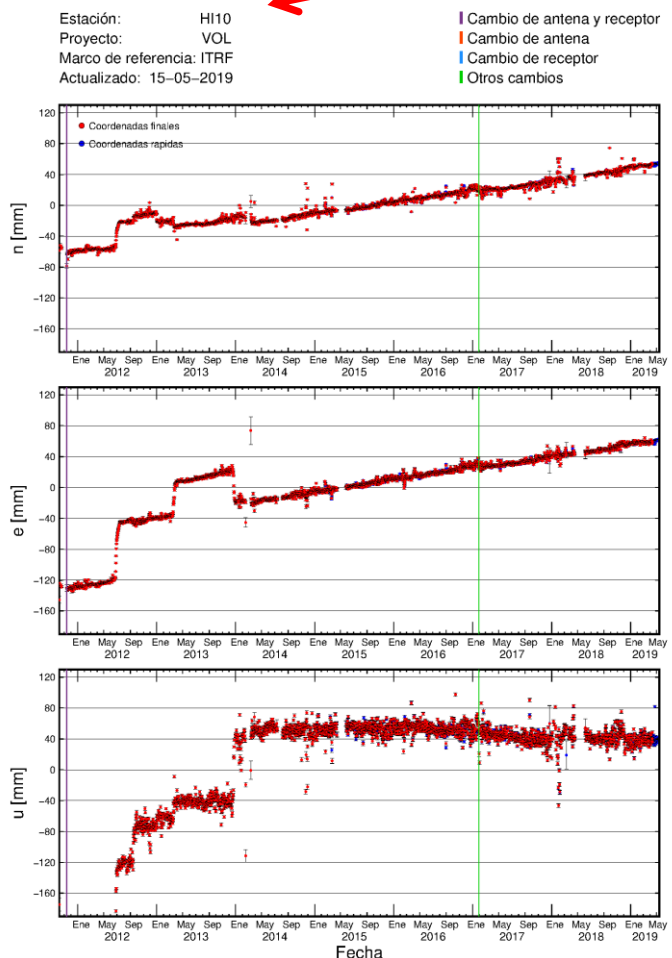


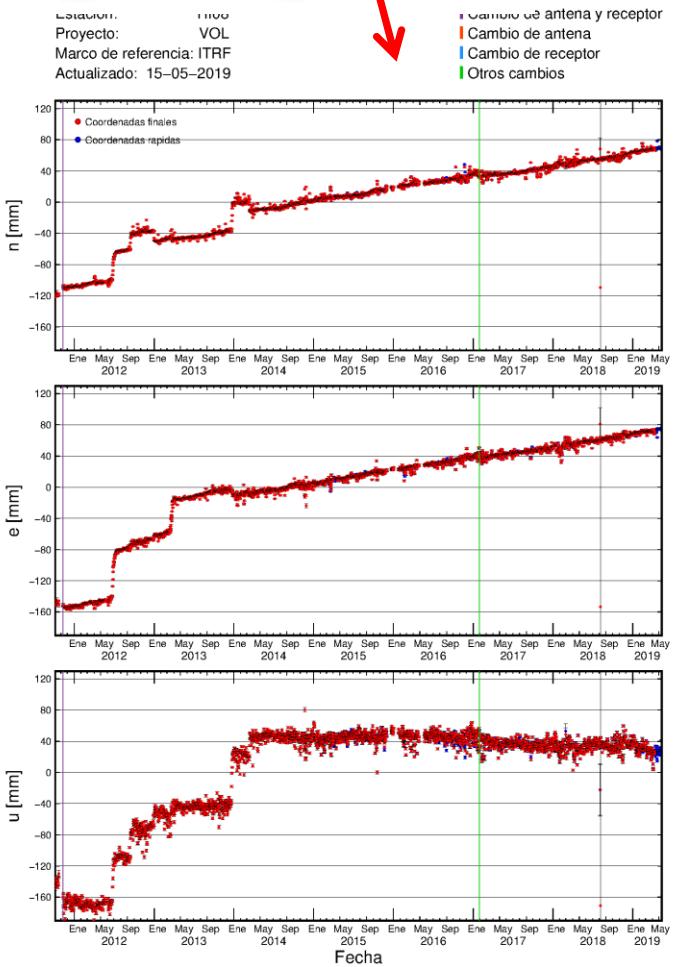
Results: time series examples (VI)

- Volcanic deformations in Canary (ITRF)





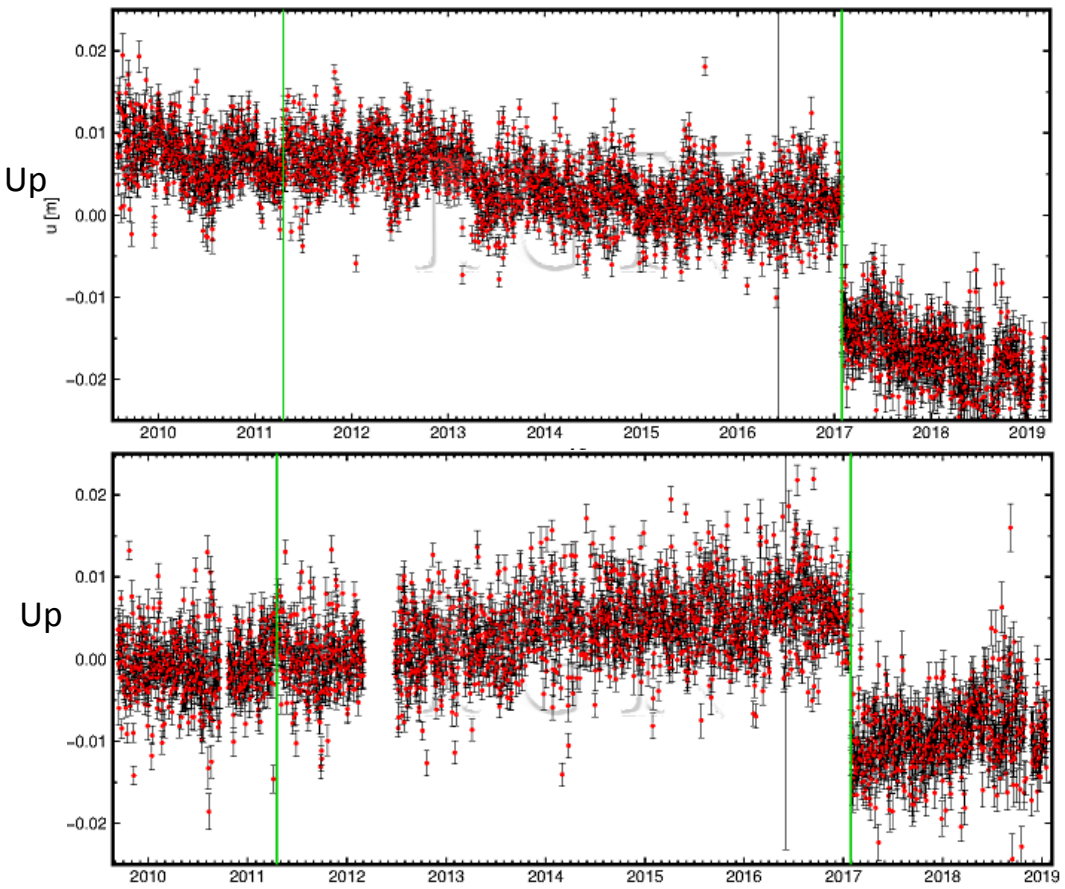




IGb08-ITRF14 antenna calibration offset (I)

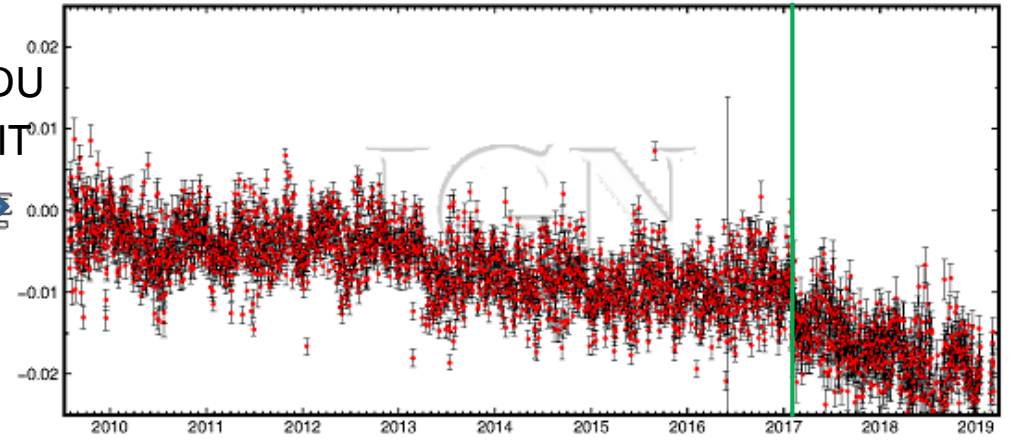
- Affected an important number of stations, mainly with Leica antenna (LEIAR10, LEIAR20, LEIAR25, LEIAR25.R4) and Trimble (TRM29659.00).
- Tested latitude model correction: ftp://igs-rf.ign.fr/pub/IGS14/lat_models.txt
- Offset not completely solved -> additional influence of ITRF change.
- Two posibilities:
  - Correction of offset and introduction of discontinuity anyway if the problem is not fixed.
  - No correction and introduction of a discontinuity.
- Detection & set up of discontinuities is a very important issue for velocities estimation and cumulative solutions.

IGb08-ITRF14 antenna calibration offset: examples (II)



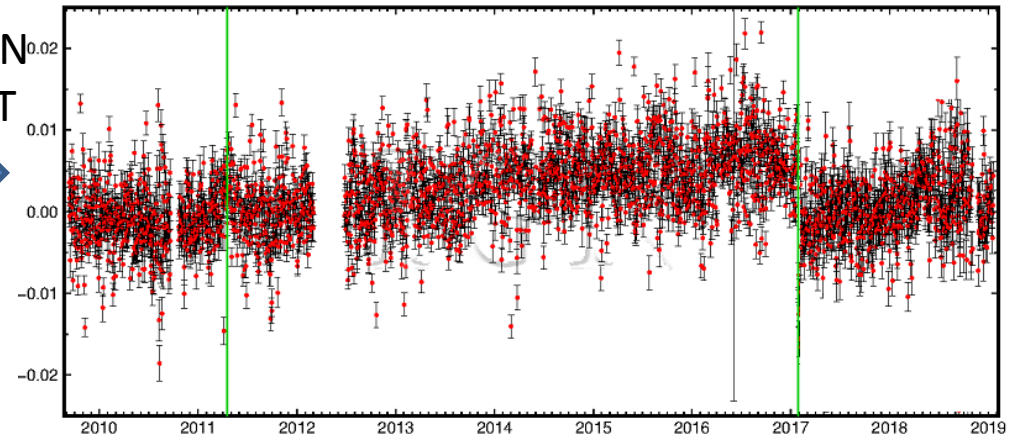
Station: ARDU
LEIAR25 LEIT

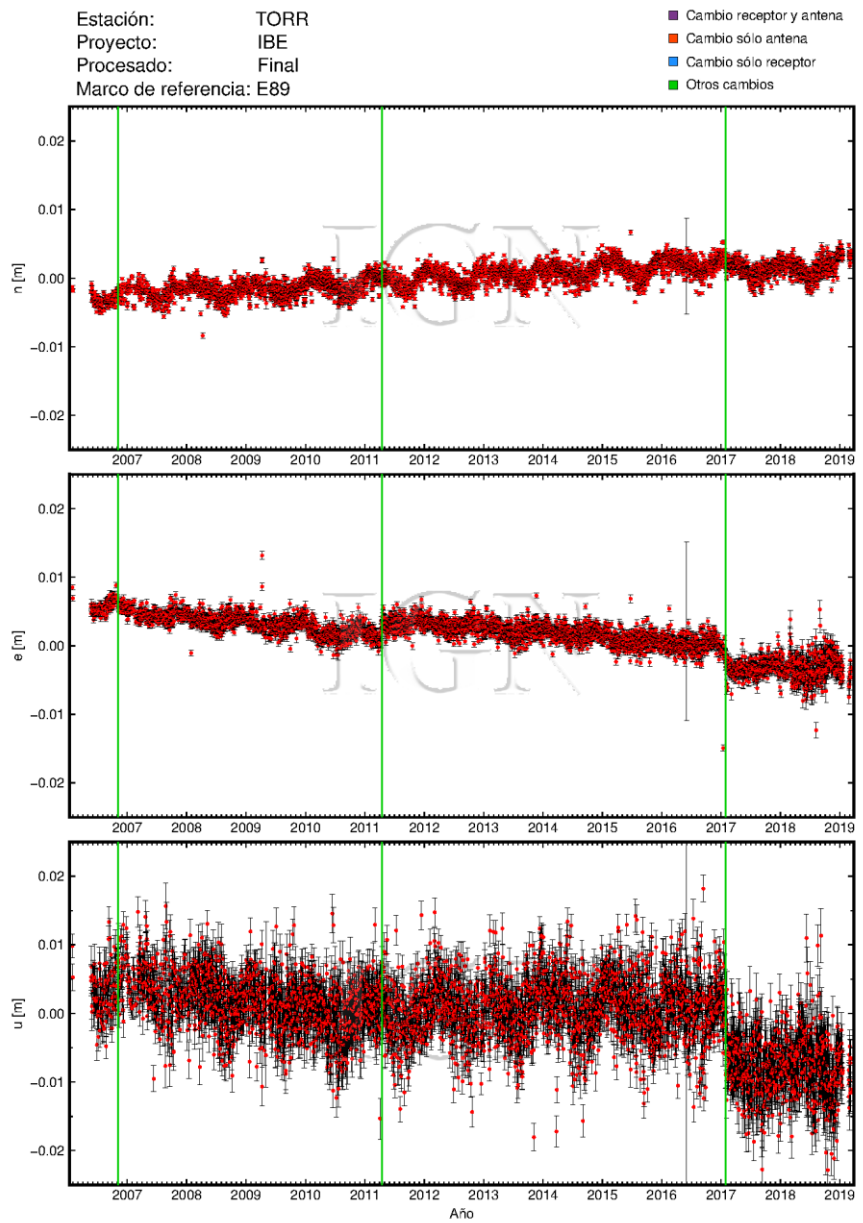
dN=0.89
dE=1.22
dU=-10.75



Station: ABAN
LEIAR25 LEIT

dN=0.73
dE=1.28
dU=-10.36





Station: TORR
TRM29659.00 UNAV

dN = 5.17
dE = 4.17
dU = -6.95

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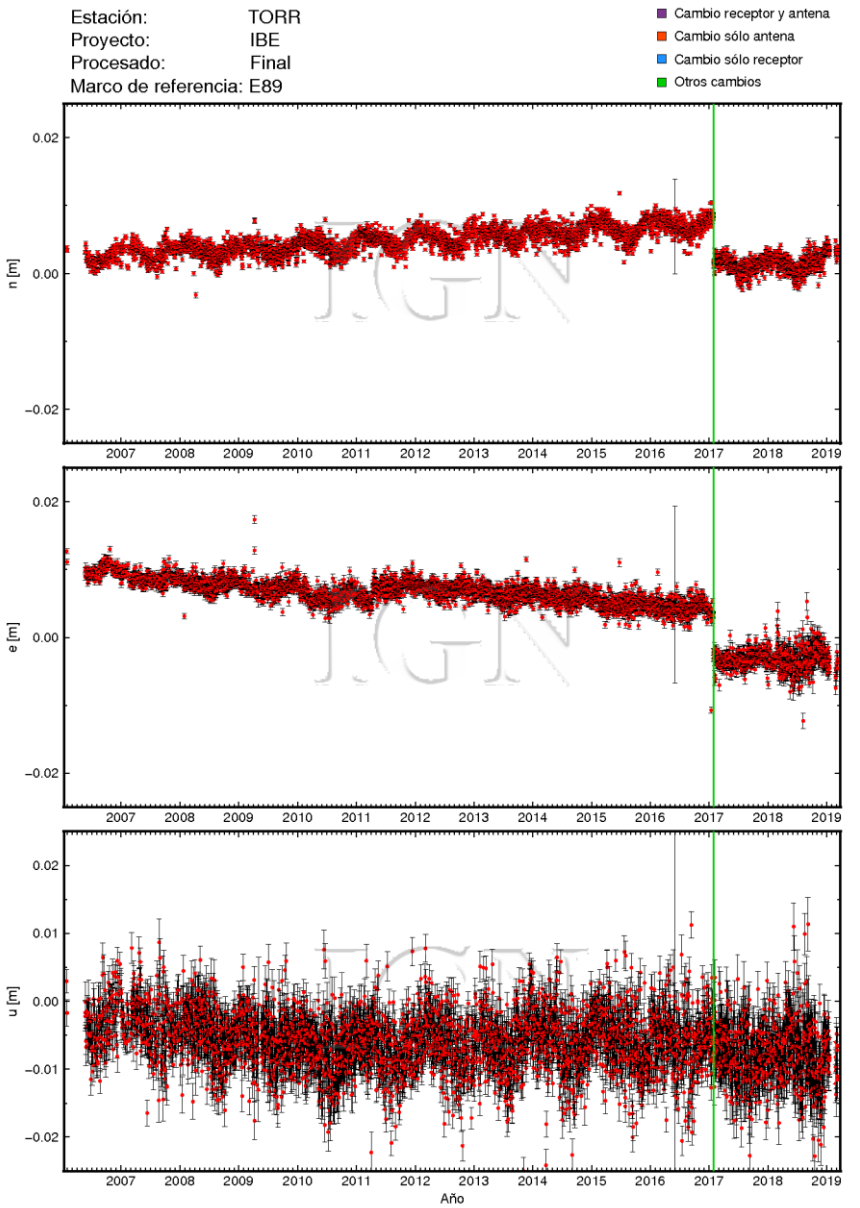


Results: ETRF00 velocities (I)

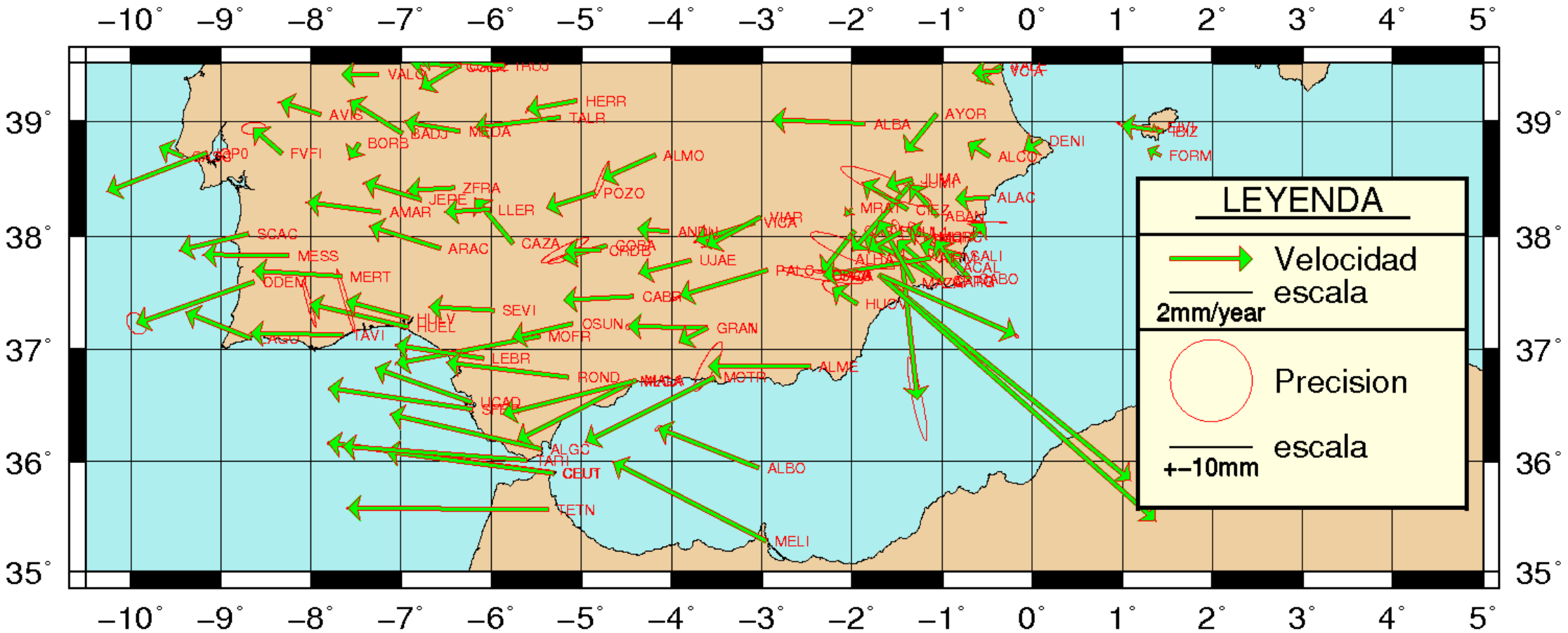
- ETRF00 velocities estimation (CATS, S. Williams)

Horizontal ETRF00 velocities

Vertical ETRF00 velocities

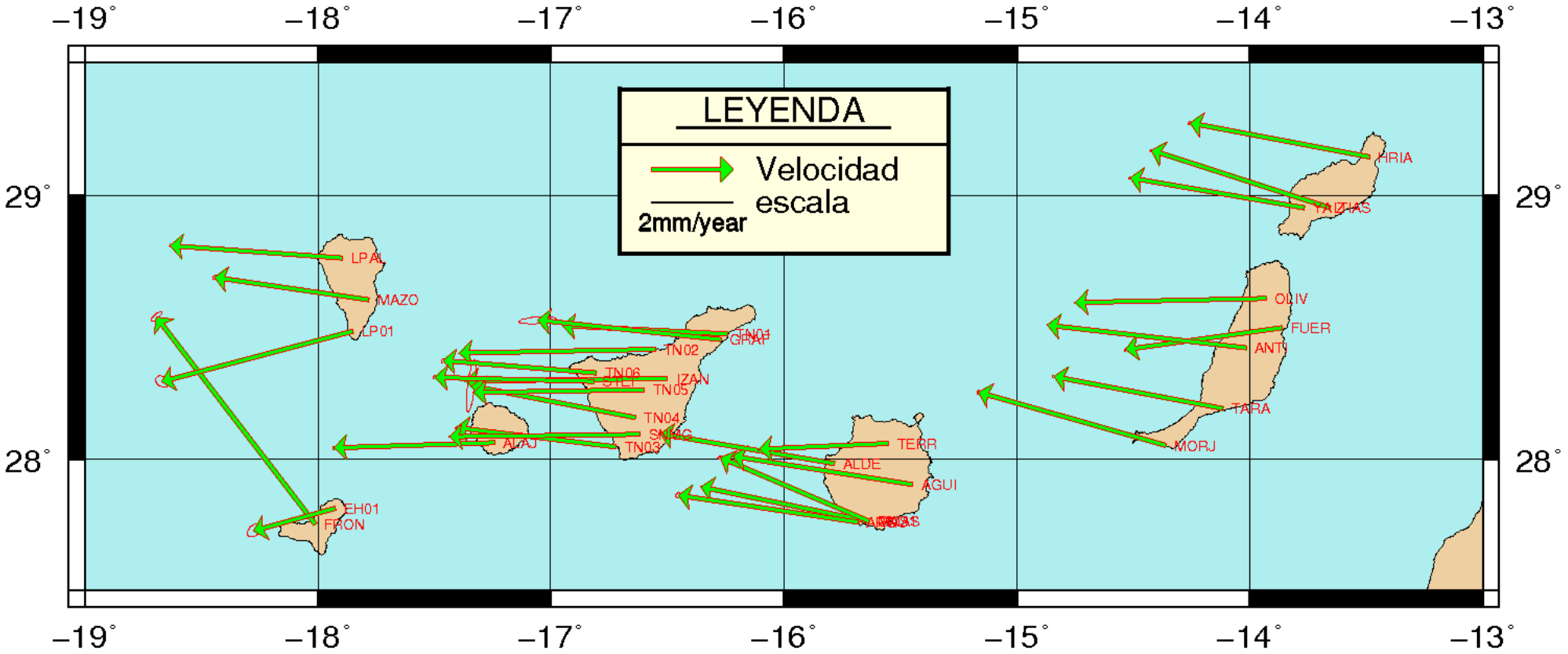
Results: ETRF00 velocities (II)

- West ETRF00 velocities in south region of Iberia (1 – 2 mm/yr), more in African plate.



Results: ETRF00 velocities (III)

- ETRS89 not valid in Canary, but velocities used to evaluate if there is diff. mov. between islands (essential knowledge for maintaining REGCAN95 reference frame).



Results: ETRF00 velocities comparison (IV)

	EUREF velocities			IBERRED velocities			*Diferences*		
	N	E	U	N	E	U	*dN*	*dE*	*dU*
ACOR	0.2	3.5	-2.3	0.0	3.3	-2.5	*0.2*	*0.2*	*0.2*
ALAC	0.3	-0.3	0.0	0.0	-0.8	-0.7	*0.3*	*0.5*	*0.7*
ALBA	0.1	-1.2	-6.9	0.1	-2.3	-7.9	*0.0*	*1.1*	*1.0*
ALME	-0.2	-1.5	0.1	0.0	-2.5	-0.6	*-0.2*	*1.0*	*0.7*
BELL	0.1	-0.2	0.1	-0.2	-0.5	-0.4	*0.3*	*0.3*	*0.5*
BORR	-0.1	0.2	-0.6	-0.3	0.1	0.0	*0.2*	*0.1*	*-0.6*
CACE	0.5	-0.5	-0.3	0.1	-1.2	-1.2	*0.4*	*0.7*	*0.9*
CANT	0.5	-0.5	-0.3	0.4	-0.8	-1.0	*0.1*	*0.3*	*0.7*
CASC	0.4	-0.6	-0.4	0.2	-0.6	-0.1	*0.2*	*0.0*	*-0.3*
CEBR	0.0	-0.4	-0.2	-0.4	-1.2	-0.4	*0.4*	*0.8*	*0.2*
CEU1	0.8	-4.1	-0.6	0.5	-4.1	-0.9	*0.3*	*0.0*	*0.3*
COBA	0.1	-0.9	-1.2	-0.3	-1.1	-2.0	*0.4*	*0.2*	*0.8*
CREU	-0.1	0.2	-0.2	-0.3	-0.1	0.3	*0.2*	*0.3*	*-0.5*
EBRE	-0.2	0.1	-0.3	-0.6	-0.2	0.3	*0.4*	*0.3*	*-0.6*
ESCO	0.1	-0.1	0.1	-0.2	-0.2	-0.7	*0.3*	*0.1*	*0.8*
FUNC	1.6	-4.4	-0.9	0.9	-4.7	-0.7	*0.7*	*0.3*	*-0.2*
HUEL	0.8	-1.6	-0.5	0.6	-2.4	-0.4	*0.2*	*0.8*	*-0.1*

	EUREF velocities			IBERRED velocities			*Differences*		
	N	E	U	N	E	U	*dN*	*dE*	*dU*
IENG	-0.2	0.2	0.3	-0.4	0.1	-0.4	*0.2*	*0.1*	*0.7*
IZAN	0.2	-4.7	-2.3	-0.1	-4.9	-2.3	*0.3*	*0.2*	*0.0*
LLIV	0.0	0.1	-0.1	-0.3	-0.3	-0.2	*0.3*	*0.4*	*0.1*
LPAL	0.7	-3.8	-1.4	0.3	-4.2	-1.4	*0.4*	*0.4*	*0.0*
MALA	-0.2	-3.1	0.4	-1.5	-2.9	-0.5	*1.3*	*-0.2*	*0.9*
MAS1	0.9	-3.8	-1.1	1.6	-3.6	-1.2	*-0.7*	*-0.2*	*0.1*
PDEL	0.3	-3.7	-2.0	0.0	-4.4	-2.9	*0.3*	*0.7*	*0.9*
RABT	1.5	-3.7	-1.2	1.1	-4.2	-0.1	*0.4*	*0.5*	*-1.1*
SALA	0.4	-0.1	-0.8	0.1	-0.2	-1.2	*0.3*	*0.1*	*0.4*
SFER	0.7	-3.5	0.4	0.5	-3.5	-0.7	*0.2*	*0.0*	*1.1*
SONS	-0.1	-0.5	-0.6	-0.5	-1.1	-0.6	*0.4*	*0.6*	*0.0*
TERC	0.1	-2.1	-3.5	0.1	-3.2	-4.2	*0.0*	*1.1*	*0.7*
VALA	0.3	-0.2	0.1	-0.3	-1.1	-0.4	*0.6*	*0.9*	*0.5*
VALE	0.1	-0.4	-1.0	-0.4	-0.6	-2.1	*0.5*	*0.2*	*1.1*
VIGO	0.3	0.0	-0.7	0.0	-0.7	-1.1	*0.3*	*0.7*	*0.4*
YEBE	-0.1	-0.3	0.0	-0.4	-0.9	-0.8	*0.3*	*0.6*	*0.8*
ZARA	-0.1	-0.2	-0.6	-0.4	-0.6	-0.5	*0.3*	*0.4*	*-0.1*

ETRF00 velocities comparison of EPN-A stations (mm/yr)

Other experiences in IBERRED network: GNSS-R (II)

GNSS reflectometry (GNSS-R) is a technique for sensing the near-field environment of a GNSS station based on the usage of reflected signals.

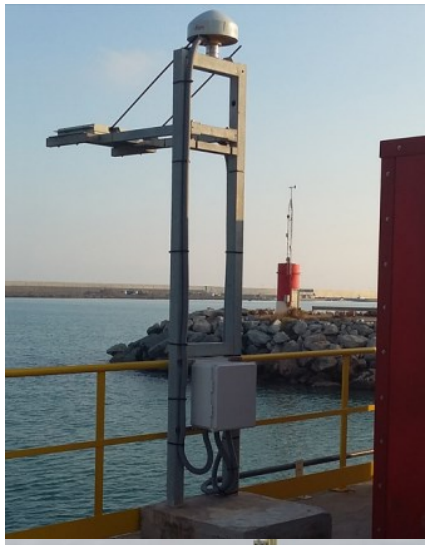
- Observable: SNR
- Needed data: measurement azimuth and elevation

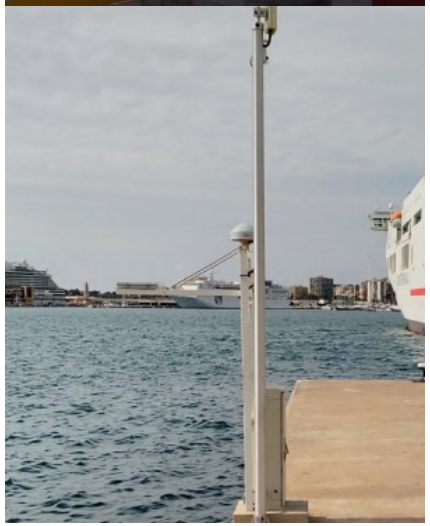
Strandberg et al. (2016) proposed a method known as Inverse Modelling method which models sea surface heights as a continuous function using B-splines.

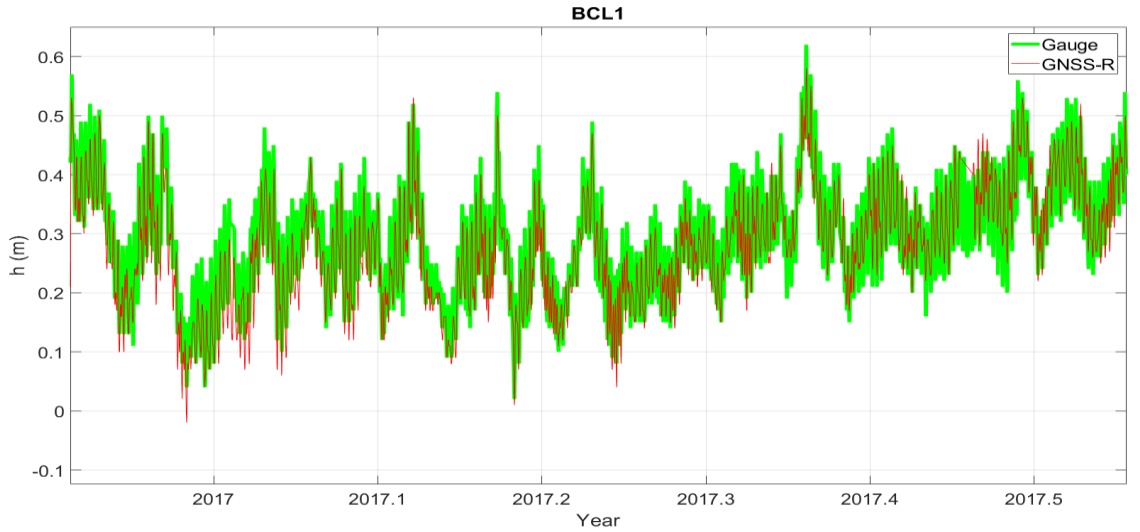
Results so far are within 3 cm of accuracy.

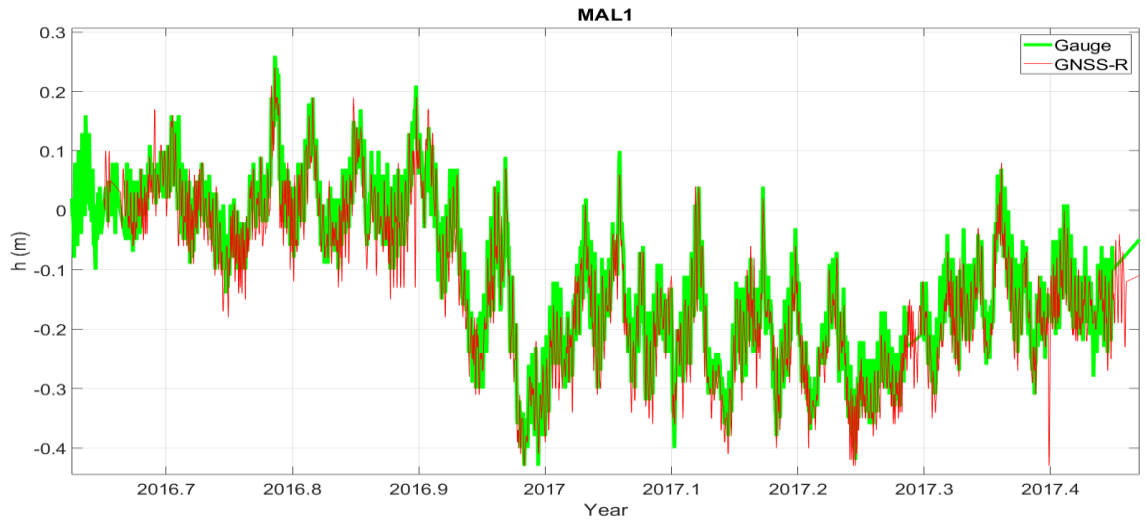
Other experiences in IBERRED network: GNSS-R (II)

GNSS stations co-located to tide gauge in Barcelona port (BCL1) and Mallorca (MAL1).







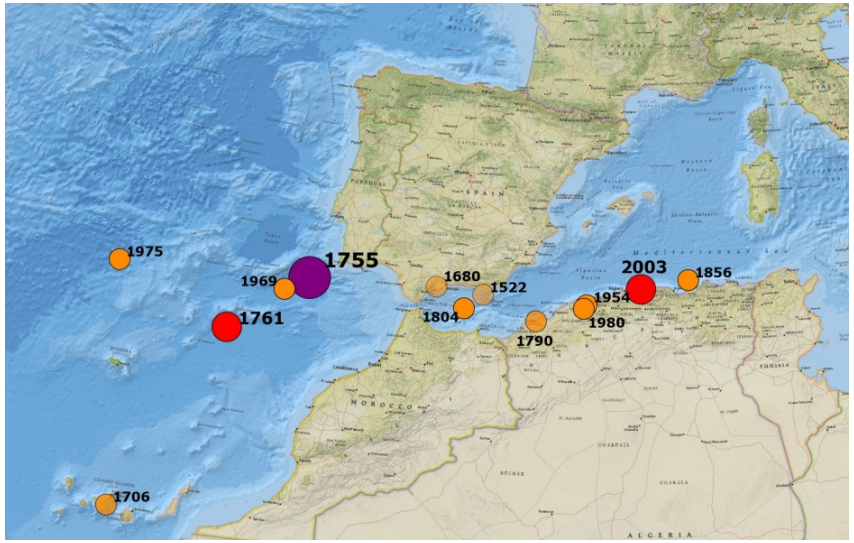


Other experiences in IBERRED network: tsunami alert (I)

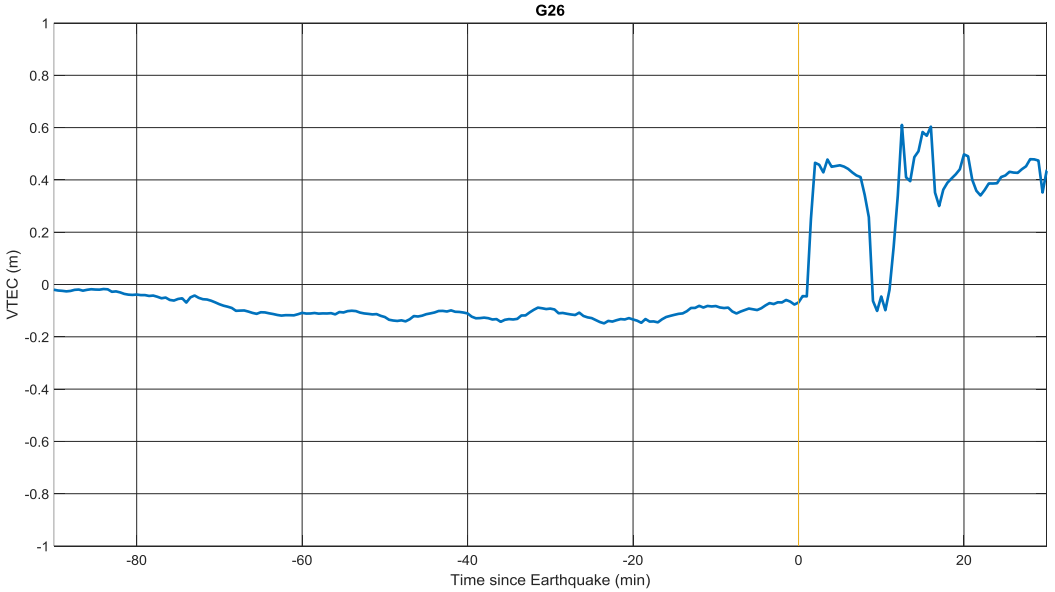
Prototype of an ionosphere-based tsunami waning system

- Kamogawa et al. (2017) reported that ionospheric TEC measurements could be used in an early warning system for near-field tsunamis that take more than 20 minutes to arrive in coastal area.

- A tsunami ionospheric hole (TIH) is formed above the tsunami source area and it can be monitored through GNSS.



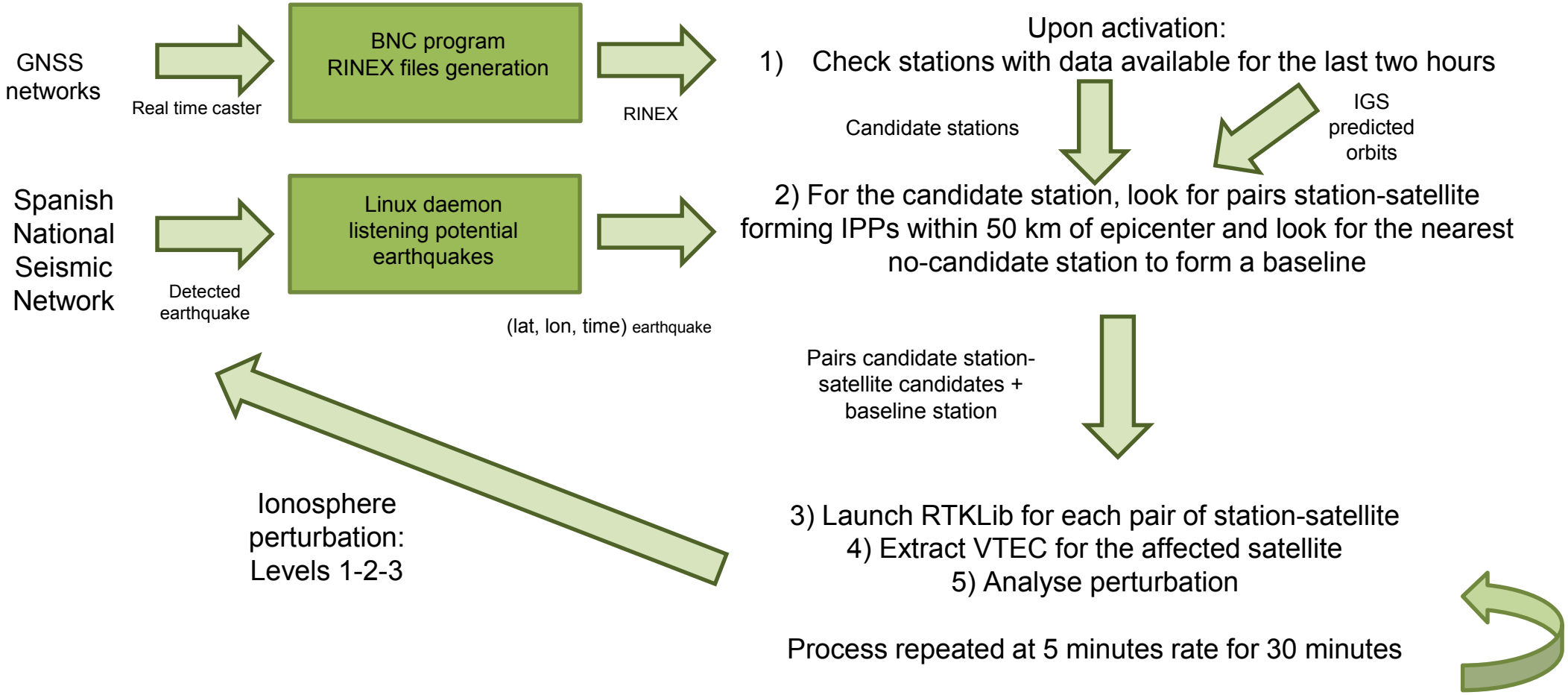
Tsunamis in the area



Ionospheric hole in Tohoku tsunami (2011). Line of sight between station 0214 of GEONET network and GPS26.

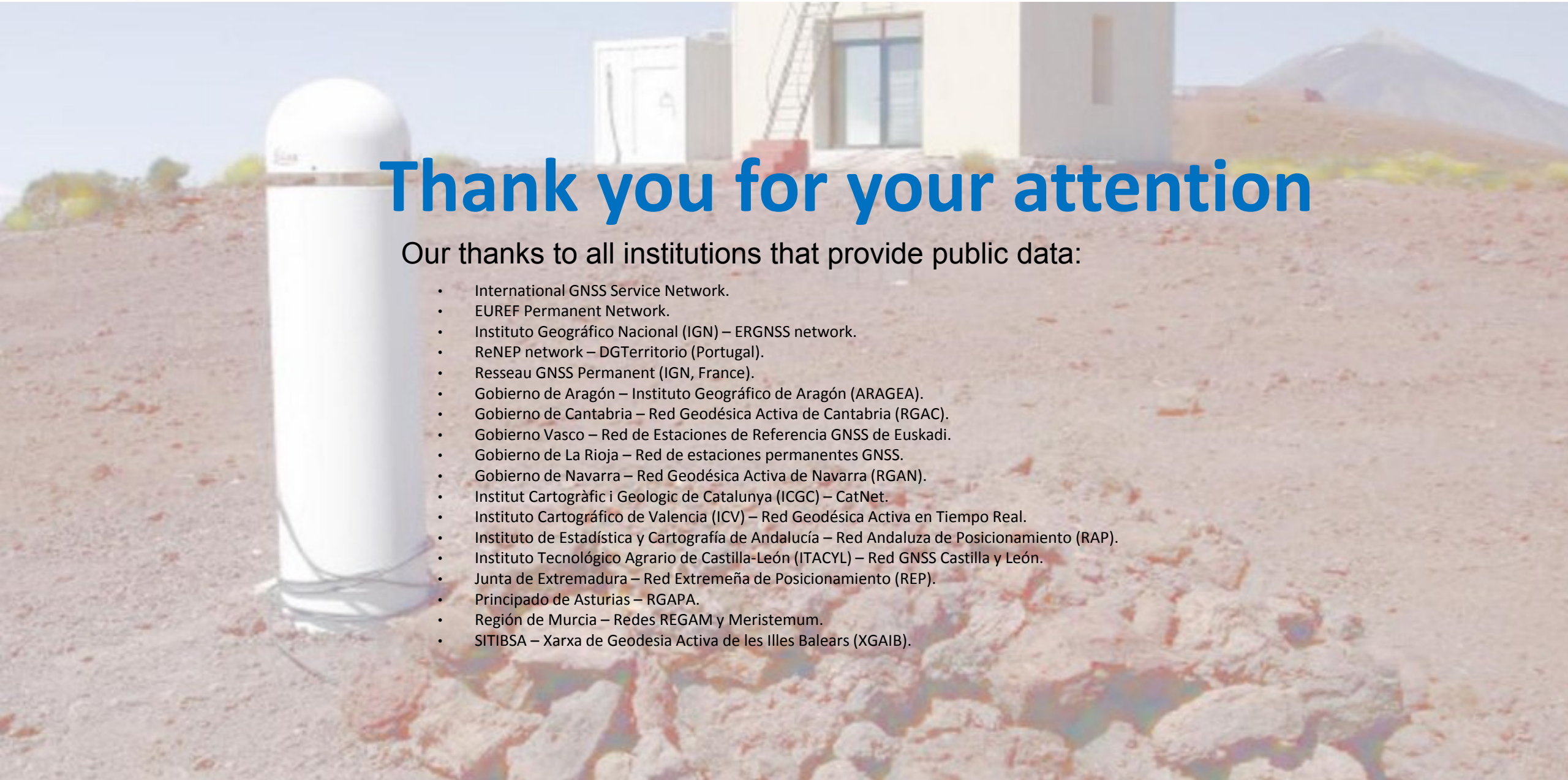
Other experiences in IBERRED network: tsunami alert (II)

Tsunami warning system prototype design:



Conclusions

- A complete reprocessing of all existing data/stations in Iberian area in the time span 2000-2019 has been done following EPN guidelines.
- Contribution to EPN densification Project (SNX) and Dense Velocities Project.
- 480 times series, discontinuities and 380 velocities have been estimated.
- The IBERRED project will continue in a routinary weekly process.
- From now: inclusion of GAL observations, no impact expected (see poster).
- No more stations expected in the area in the future, the most important issue is to maintain them.
- Other parallel activities are being carried out with the stations in the area that provide added values to the networks: E-GVAP, tsunamis, GNSS-R…



Thank you for your attention

Our thanks to all institutions that provide public data:

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- EUREF Permanent Network.
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- ReNEP network – DGTerritorio (Portugal).
- Resseau GNSS Permanent (IGN, France).
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- Gobierno Vasco – Red de Estaciones de Referencia GNSS de Euskadi.
- Gobierno de La Rioja – Red de estaciones permanentes GNSS.
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