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Coupling topography, surface erosion and tectonics
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Initial results from Topo-Iberia continuos GPS network

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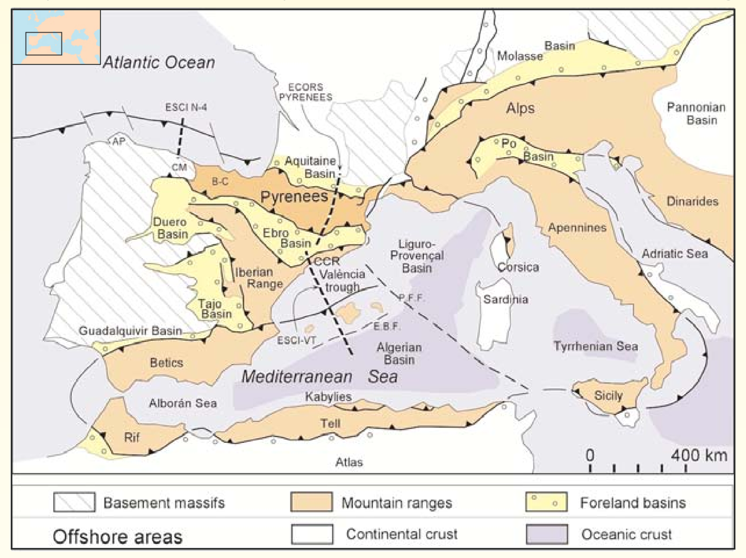
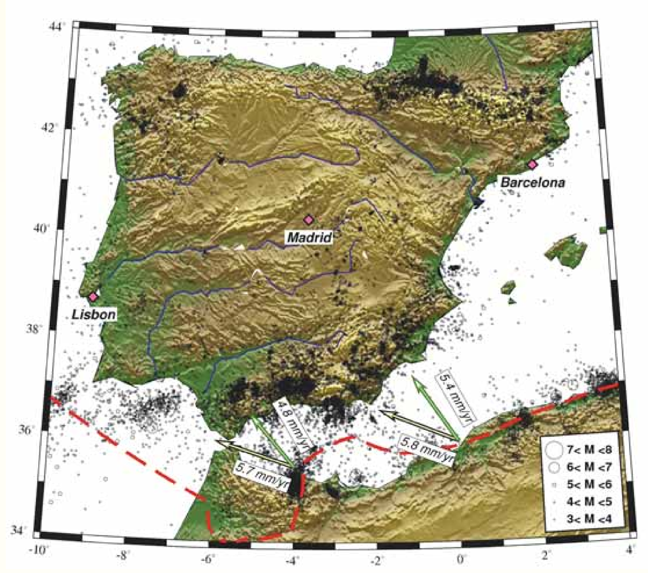
Tectonic Settings

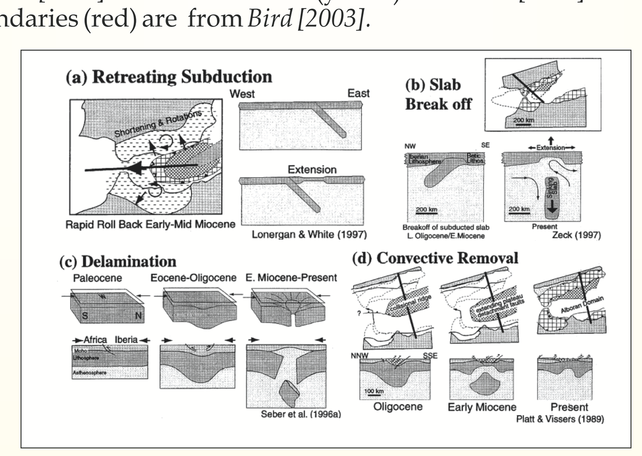
The Iberian Peninsula represents the westernmost extreme of the Alpine Himalayan Orogenic belt. It is characterized by the ongoing collision between the African (Nubian) and Eurasian plates. In terms of the tectonic regimes the area can be subdivided into three main domains: 1) South: Betic-Rif domain; 2) Central: Meseta-Central and Iberian systems; 3) North: Pyrenean -Cantabrian Mountain range.



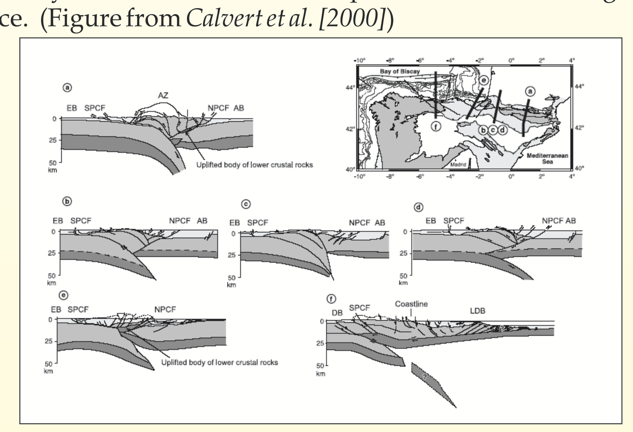
Map showing the principal tectonic features of the western Mediterranean from *Vergés & Sàbat (1999); Vergés et al. (JVE, 2002).*



Map showing instrumental seismicity of the Iberian Peninsula during the 1973-2010 time period. The earthquakes are from the USGS/NEIC catalogue. Nubia-Eurasia relative motion according to Nuvel-1A (green) *DeMets,et al. [1994]* and REVEL 2000 (yelow) *Sella et al.[2002]* models. The plate boundaries (red) are from *Bird [2003].*



The southern part of the GPS network, including Betic mountains, the Alboran sea and northern Morocco, is characterized by a complex tectonic evolution and a high rate of seismicity. Various conceptual tectonic models have been proposed for this region, that includes (a)Retreat from E to W of an E dipping subducting slab during the Early Miocene (b) Break off of a NW dipping slab at the Oligocene-Miocene boundary perhaps subducted during earlier (mainly Cretaceous) eastward movement of Iberia relative to Eurasia. (c)Delamination of lithosphere thickened during Paleogene convergence initiated during Early Miocene but still active today. (d) Convective removal during the Early Miocene of mantle lithosphere thickened during Paleogene convergence. (Figure from *Calvert et al. [2000]*)



The Cantabrian-Pyrenean chain is a collisional orogen with double vergence, resulting from the convergence of the Iberia and Europe plates and presents very different characteristics along the transect. The figure show schematic crustal cross sections along the Pyrenean-Cantabrian belt from *Pedreira et al. [2007].*

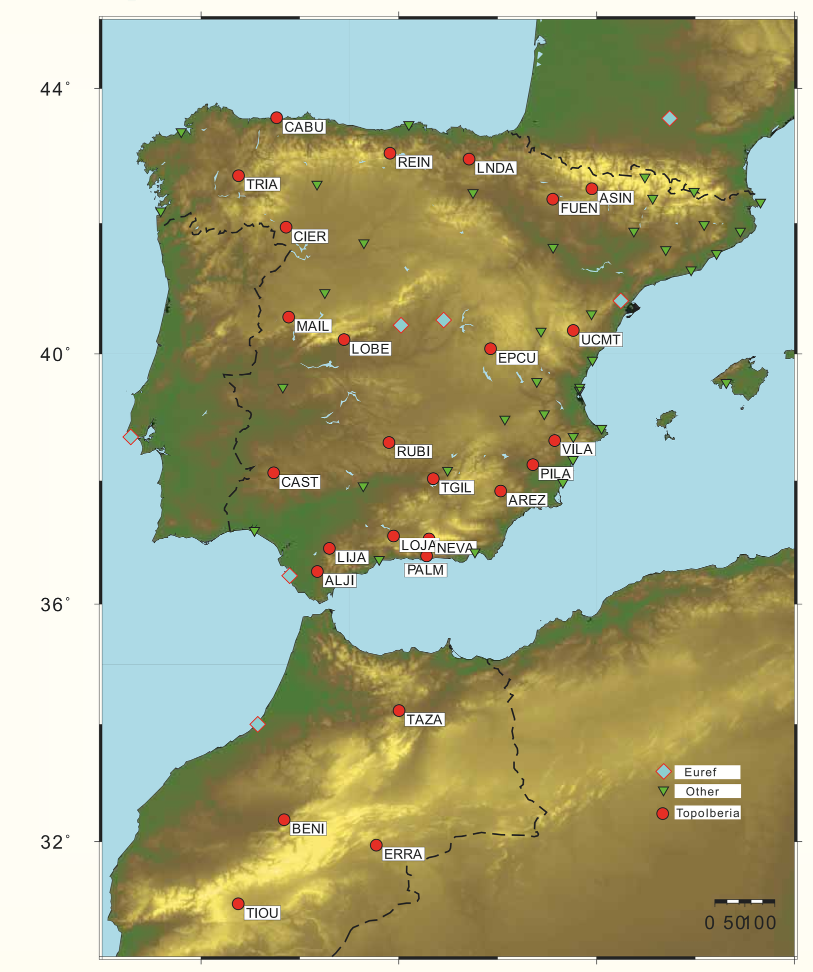
What is Topo-Iberia?

Topo-Iberia is a 5 year long project (2007-2011), titled: "Geosciences in Iberia: Integrated studies of topography and 4-D evolution" and funded by the Spanish Ministry of Science and Technology in the framework of CONSOLIDER-INGENIO 2010 program.
The project involves more than 100 PhD researchers from 10 different groups and its main objective is to better understand the interaction between the deep, surface and atmospheric processes by integrating research on geology, geophysics, geodesy and geotechnology. With this objective in mind the project involved the enhancement of the experimental observations through the installation and observations of the three types of data: seismic, Magnetotelluric and GPS. Three major domains of research have been identified: the southern and northern borders of the Iberian plate (the Betic-Rif system and the Pyrenean-Cantabrian system) and its central core (Meseta and Central -Iberian systems).

PI: Josep Gallart from the SCIC Institut de Ciencíes de la Terra "Jaume Almera" (Barcelona).

WWW Links
IJA: http://www.ija.csic.es/gt/rc/LSD/PRJ/indexTOPOIBERIA.htm
IGME:http://www.igme.es/internet/topoIberia/
Univ. Oviedo: http://www.geol.uniovi.es/Investigacion/Consolider/

Topo-Iberia CGPS Network



26 CGPS stations have been installed, 24 in the Iberian Peninsula and 4 in Morocco. The network has been designed as two X-shaped transects crossing the peninsula from NE to SW and NW to SE. The main objective is have a good coverage in the principal active areas; Betic System, the Pyrenean range and Cantabrian chains.

Table of the Topo-Iberia CGPS Stations

#	ID	Location	Latitude	Longitude	Elev.	Date installed	Monument type
1	**ALJI**	Sierra del Aljibe - Cadiz	36,5299	-5,6494	479	01/04/2008	Concrete pillar
2	**AREZ**	Sierra del Almirez - Murcia	37,8354	-1,9405	1060	08/05/2008	Concrete pillar
3	**ASIN**	Asín de Broto - Huesca	42,5167	-0,0983	1708	25/09/2008	SDBM
4	**BENI**	Beni-Mellal - Marruecos	32,3502	-6,3588	490	22/07/2008	Roof top
5	**CABU**	Faro Cabo Busto - Asturias	43,5690	-6,4700	119	18/03/2008	Concrete pillar
6	**CAST**	Castillo de Segura - Badajoz	38,1227	-6,5321	783	09/03/2008	Concrete pillar
7	**CIER**	Villardeciervos - Zamora	41,9411	-6,2807	850	10/07/2008	Concrete pillar
8	**EPCU**	Escuela Politecnica de Cuenca	40,0795	-2,1353	990	03/07/2008	Concrete pillar
9	**ERRA**	Errachidia - Marruecos	31,9329	-4,4531	1039	05/06/2008	Roof top
10	**FUEN**	Ayerbe - Huesca	42,3602	-0,8850	939	29/07/2008	Concrete pillar
11	**LIJA**	Sierra de Lijar - Cadiz	36,9061	-5,4038	1089	12/02/2008	Concrete pillar
12	**LNDA**	Landa - Vitoria	42,9601	-2,5779	821	10/08/2008	Concrete pillar
13	**LOBE**	Arenas de San Pedro - Salamanca	40,2204	-5,1104	650	09/07/2008	Concrete pillar
14	**LOJA**	Loja - Granada	37,1073	-4,1064	1340	15/04/2008	Concrete pillar
15	**MAIL**	Maillo - Peña de Francia - Salamanca	40,5119	-6,1680	1025	10/07/2008	Concrete pillar
16	**NEVA**	Sierra Nevada - Granada	37,0626	-3,3856	2200	31/10/2008	Concrete pillar
17	**PALM**	Sierra de los Guájares - Granada	36,8090	-3,5623	338	18/06/2008	Concrete pillar
18	**PILA**	Sierra de la Pila - Murcia	38,2543	-1,2894	833	26/06/2008	Concrete pillar
19	**REIN**	Pico Ropero - Cantabria	43,0459	-4,1771	1449	16/05/2008	Concrete pillar
20	**RUBI**	Cabezarrubias - Ciudad Real	38,6094	-4,1966	751	06/05/2008	Concrete pillar
21	**TAZA**	Taza - Marruecos	34,2295	-3,9964	466	22/07/2008	Roof top
22	**TGIL**	Torreperogil - Jaen	38,0342	-3,3026	761	21/04/2008	Concrete pillar
23	**TIOU**	Tiouine - Marruecos	30,9366	-7,2225	1268	04/06/2008	Roof top
24	**TRIA**	Sierra Oribio - Lugo	42,7148	-7,2415	1427	15/04/2008	Concrete pillar
25	**UCMT**	Mosqueruela - Teruel	40,3638	-0,4722	1690	15/07/2008	Concrete pillar
26	**VILA**	Sierra de la Villa - Alicante	38,6405	-0,8475	720	22/09/2008	Concrete pillar

GPS Instrumentation

The GPS receiver: Trimble NetRS;
The GPS Antenna: Trimble ChokeRing (TRM29659.00)
Radome: SCIGN tall (SCIT) or short (SCIS) domes.
Antenna mount: SCIGN adaptor
Communication: Siemens MTX63 mobile modem
Solar Panel: JuMao JMP 80Watt
Voltage regulator: Xantrex C12 | 12A | 12V

GPS monuments

Data Analysis

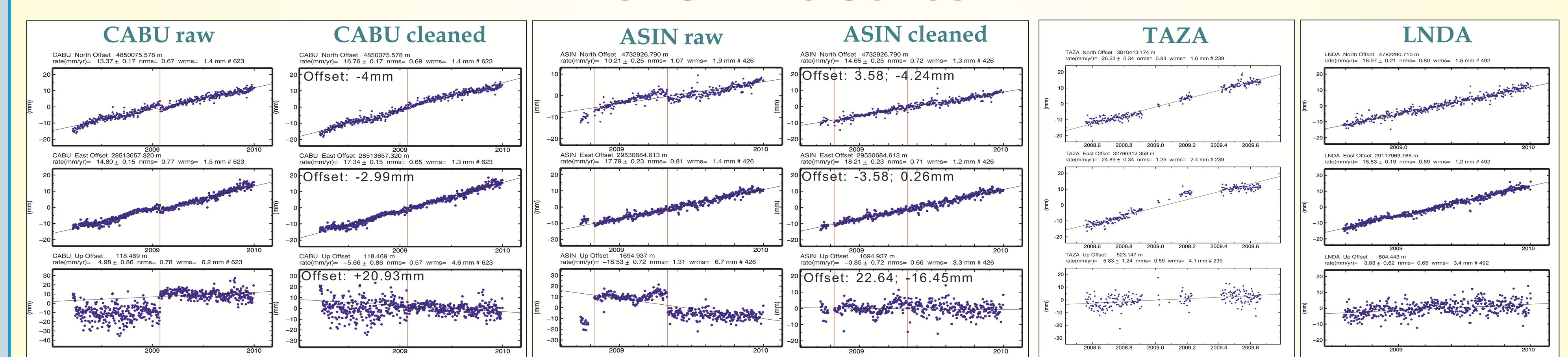
The data is analyzed using *three* analysis packages:
1) University of Barcelona (UB) using GAMIT/GLOBK software from MIT *[Herring et al., 1990; King and Bock, 2004]*.
2) San Fernando Naval Observatory (ROA) using GIPSY/OASIS from JPL *[Webb and Zumberge, 1997]* and CATS *[Williams, 2008]*. See poster A414 by J. Garate et el. in session TS6.1/GD5.4/G18 on Thursday.
3) University of Jaén using Bernese *[Hugentobler et al., 2006]* and NEVE *[Riguzzi et al., 2009]*. See poster XI279 by A.J. Gil et el. in session SM3.1/GD3.5 on Thursday.

UB Analysis Strategy

Software: GAMIT (King & Bock, 2001) GLOBK (Herring et al., 2006) from MIT
Strategy: Network mode
CGPS Stations Analyzed: 26 stations of Topo-Iberia + 22 IGS-Euref stations + 60 stations from spain
Time Period:
from 20/03/2008 (doy 080) to 31/12/2009 (doy 365) for Topo-Iberia
from XXX (doy 080) to 31/12/2009 (doy 365) fore core stations
Basic Observable: Double differenced carrier phases
Satellite Orbits: IGS final orbits from SOPAC
Elevation Cutoff: 10 degrees (default, autcln.cmd)
Antenna Phase center Variations (PCV): Used latest IGS absolute ANTEX file (absolute) with AZ/EL for ground antennas and ELEV (nadir angle) for SV antennas (MIT file augmented with NGS values for antennas missing from IGS).
Atmospheric Pressure Loading: not applied
Ambiguity Resolution: applied

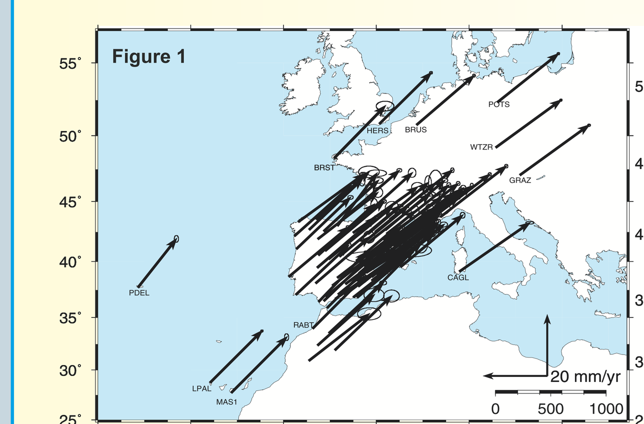
Earth Orientation Parameters (EOPs):
Multi-year EOP files: pmu.usno (bull_a)
TAI-UT1: ut1.usno
Polar Motion: pole.usno
Tidal Displacements:
Solid Earth Tides: IERS2003.
Ocean Loading: FES2004 *(Lyard et al., 2006)*
Troposphere:
Zenith delay: adjusted every 2 hour-intervals
Mapping function: Niell *(2000)*
GLOBK post-processing:
Tight constraints on orbital and EOP parameters
Combined daily solutions of the subnetworks (top1, top2 and top3) and transformed into ITRF2005 reference frame by minimizing the correction of 22core stations by estimating 7-parameter transformation.

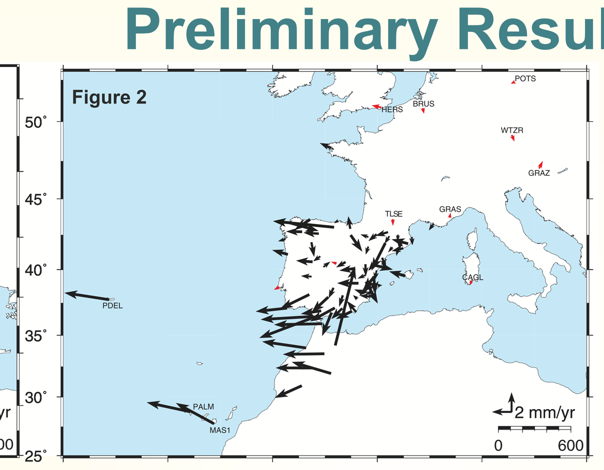
GPS Time Series



Sample of "good" and "bad" time series for the four CGPS Topo-Iberia stations analyzed at the UB. CABU and ASIN stations show obvious breaks due to antenna failures and consequent changes (at ASIN antenna was changed twice). TAZA has a short time-serie with data gaps. The "good" example LNDA station time-serie can be considered representative of the majority of the other stations, where no jumps or hardware changes were observed.

Preliminary Results





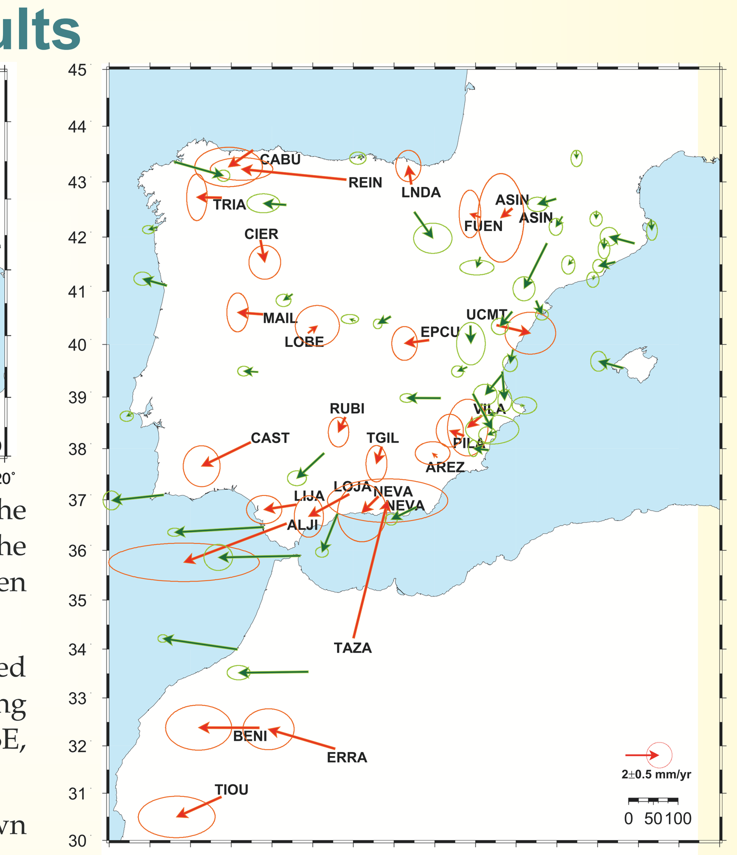


Figure 1: The preliminary velocities from the Iberian Peninsula and the adjacent regions. The velocity vectors are with respect to the ITRF05 (Altamini et al., 2007) reference frame. The data has been analyzed until the DOY: 365 of 2009. Core and Iberian stations have been analyzed from 2005 to 365 of 2009. The vectors are shown with 95% confidence limits.

Figure 2: The map shows the velocity vectors with respect to the stable Eurasia plate obtained by Helmert transformation using GLOBK package (Herring et al., 2006) by minimizing residuals for the 10 stations (red): BRUS, CAGL, CASC, GRAS, GRAZ, HERS, POTS, TLSE, VILL and WTZR. To ease the interpretation the map lacks confidence limits.

Figure 3: Zoom of the Topo-Iberia station velocities (red), Core and Iberian (green) shown with respect to the stable Eurasia plate. The ellipses represent 95% confidence limits

References

- Altamini, Z. et al. (2007) ITRF2005: A new release of the International Reference Frame based on time series of station position and Earth Orientation Parameters, *Journal of Geophysical Research*, 112.
-Bird, P. (2003) An updated digital model of plate boundaries, *Geochemistry Geophysics Geosystems*, 4(3), 1027,
-Calvert, A., Sandvol, E., Seber, D., Barazangi, M., Roecker S., Mourabit, T., Vidal, F., Alguacil, G., Jabour, N., Geodynamic evolution of the listosfere and upper mantle beneath the Alboran region of the western Mediterranean.*Journal of Geophysical Research* . Vol 105, 10.895-10.898.
-DeMets, C., Gordon, R.G., Argus, D.F., and Stein, S., 1994, Effect of recent revisions to the geomagnetic reversal time scale on estimates of current plate motion: *Geophysical Research Letters*, 21. 2191-2194.
- Herring, T. A., J. L. Davis, and I. I. Shapiro (1990), Geodesy by radio interferometry; the application of Kalman filtering to the analysis of very long baseline interferometry data, *Journal of Geophysical Research*, 95(8), 12,561-512,581.
- Hugentobler, U., R. Dach, P. Fridez, and M. Meindl (2006), Bernese GPS Software Version 5.0, 1-548 pp., Astronomical Institute, University of Berne, Bern, Switzerland.
- King, R. W. & Bock, Y. (2004) Documentation for gamit gps analysis software version 10.01. Report for Massachusetts Institute of Technology and Scripps
- Lyard, F., F. Lefevre, T. Letellier, and O. Francis (2006), Modelling the global ocean tides: Modern insights from FES2004, *Ocean Dynamics,* 56(5-6), 394-415.
- Pedreira, D. Pulgar J. A., Gallart, J., Torné, M. (2007) Three-dimensional gravity and magnetic modeling of crustal indentation and wedging in the western Pyrenees-Cantabrian Mountains, *Journal of Geophysical Research,*112.
- Sella, G. F., T. H. Dixon, and A. Mao (2002), REVEL: A model for Recent plate velocities from space geodesy, *J. Geophys. Res.*, 107(B4), 2081.
- Vergés, J., and F. Sàbat (1999), Constraints on the Neogene Mediterranean kinematic evolution along a 1000 km transect from Iberia to Africa, in The Mediterranean basins: Tertiary extension within the Alpine Orogen, edited by B. Durand, et al., pp. 63-80, *Geological Society, London*, Special Publications, London.
- Vergés, J. et al. (2002)The Pyrenean orogen: pre-, syn-, and post-collisional evolution. In: Rosenbaum, G. and Lister, G.S. 2002. Reconstruction of the evolution of the Alpine-Himalayan Orogen, *Journal of the Virtual Explorer*, 8, 57 - 76.
- Webb, F. H., and J. F. Zumberge (1997), An introduction to GIPSY/OASIS II, Jet Propulsion Laboratory, Pasadena, USA.
- Williams, S. (2008), CATS: GPS coordinate time series analysis software, *GPS Solutions,* 12(2), 147-153.

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