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Identifying 2010 Xynthia storm signature in GNSS-R tide gauge records

Phuong Lan Vu (1), Minh Cuong Ha (1), José Darrozes (1), Frédéric Frappart (2), Guillaume Ramillien (1), Pascal Gégout (1), Grégory Dufréchou (1), Denis Morichon (3), and Philippe Bonneton (4)

(1) Geosciences Environnement Toulouse (GET), Toulouse, France , (2) LEGOS-GRGS, UMR 5566, CNES/CNRS/IRD/UPS, Observatoire Midi-Pyrénées, 14 Avenue Edouard Belin, 31400 Toulouse, France, (3) Université de Pau et des Pays de l'Adour, Laboratoire de Sciences Appliquées au Génie Civil et au Génie Côtier JE2519, Allée du parc Montaury, 64600 Anglet, France , (4) Université Bordeaux 1, CNRS, UMR 5805 EPOC, Allée Geoffroy Saint-Hilaire – CS 50023, F-33615 Pessac, France

Coastal areas are strongly affected by storm surges. Combined with the high tide and large waves, storm have devastating effects along the coasts. Sea surface height variations are measured by coastal tide gauges. These sensors are dampened to minimize the effects of wave on the measurements of the tide. Recently, Global Navigation Satellite System-Reflectometry (GNSS-R) demonstrated a strong potential for the monitoring changes of the Earth surface. Thanks to the deployment of permanent GNSS station networks in many countries, this technique can be applied when a permanent geodetic GNSS station is located on the shore. A new approach for real time GNSS-R using a single receiver was available at SOCOA (43° 23' 42.86"N; -1° 40' 53.83"W) GNSS tide gauge station to identify Xynthia storm signatures. The combination of the SSA (Singular Spectrum Analysis) and CWT (Continuous Wavelet Transform) method for GNSS-R signal analysis can improve the accuracy of this application. The performance of the new GNSS-R approach is evaluated by classical tide gauge and meteorological data, observed during the 2010 Xynthia storm in France.

In this study, we used 3 months of records (January-March 2010) from a GNSS geodetic station from the permanent network of RGP (Réseau GNSS Permanent), deployed by the French Geographic Institute (IGNF), located in Socoa, in the south of the Bay of Biscay, to determine the tide components in GNSS-R signals and identify Xynthia storm. During this period, the Xynthia storm hit the French Atlantic coast the 28th of February 2010 causing large floods and damages from the Gironde to the Loire estuaries.

Using both SSA and CWT methods, we demonstrated that we are able separate blindly the tide and the atmospheric pressure of the storm signatures from the raw GNSS-R signals. These SSA and CWT methods succeed to separate the contributions of periodic tides, atmospheric pressure (with the decrease due to the Xynthia storm), waves etc. Each contribution is compared with independent data for validation.

After separation, we found a correlation of 0.98/0.97 and RMSE of 0.21/0.28 m between the tide gauge records of Socoa and our estimates of the SSH using the SSA and the CWT respectively. A correlation of 0.7 between atmospheric pressure from a meteorological station and a mode of the SSA is found. Particularly, a correlation reach to 0.76 when combining the surge and atmospheric pressure.