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Ocean dynamics during the passage of Xynthia storm recorded by GPS

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When computing the effect of atmospheric loading on geodetic coordinates, we must assign the response of the ocean to pressure loading. A pure inverted barometer and a solid Earth ocean response to pressure loading define the extremes of the response. At periods longer than a few days, the inverted barometer response is sufficient (Wunsch and Stammer, 1997). However, how does the ocean respond to fast moving storms? In this study we investigate the effect of a violent storm that progressed over Western Europe between the 27th of February and the 1st of March 2010 on sub-daily vertical GPS (Global Positioning System) position time series of the French GNSS permanent network (RGP). Xynthia was a huge low-pressure system (pressure drop of 40 mbar and a storm surge of 1.4 m (at La Rochelle tide gauge)) that crossed France from the southwest to the northeast over the course of about 20 hours. We study the different behaviour of the coastal and inland sites based on the comparison of the estimated 6-hourly stand-alone GPS position time series (GINS-PC software) with the local pressure and the predicted atmospheric pressure loading time series derived from the high resolution Modern-Era Retrospective Analysis for Research and Applications (NASA MERRA) and also the European Centre for Medium-Range Weather Forecasts (ECMWF) global dataset. We model the predicted displacements using the inverse barometer (IB) and the non-IB ocean response cases as endpoints. Predicted loading effects due to the atmospheric pressure and IB ocean reach up to 1.0, 1.3 and 13.7 mm for the east, north and up components, respectively. Then we attempt to use the GPS vertical surface displacements, the surface pressure, and tide gauge data (SONEL) to identify the true ocean dynamics on the continental shelf during the passage of this fast moving system.

Keywords: GPS, GINS-PC, Xynthia, ocean dynamics, atmospheric pressure loading, deformation